MONITORING AND EVALUATION OF THE CHELAN AND GRANT COUNTY PUDs HATCHERY PROGRAMS

2015 ANNUAL REPORT

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PREFACE

This annual report is the result of coordinated field efforts conducted by Washington Department of Fish and Wildlife (WDFW), the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation), Chelan County Public Utility District (Chelan PUD), the Confederated Tribes of the Colville Reservation (Colville Tribes), the U.S. Fish and Wildlife Service (USFWS), and BioAnalysts, Inc. An extensive amount of work was conducted in 2006 through 2015 to collect the data needed to monitor the effects of the Chelan and Grant County PUD Hatchery Programs. This work was directed and coordinated by the Habitat Conservation Plans (HCP) Hatchery Committees, consisting of the following members: Bill Gale, USFWS; Craig Busack, Justin Yeager, and Lynn Hatcher, National Marine Fisheries Service (NMFS); Catherine Willard and Alene Underwood, Chelan PUD; Tom Scribner and Keely Murdoch, the Yakama Nation; Mike Tonseth, WDFW; Kirk Truscott, Colville Tribes; Mike Schiewe, Anchor QEA (former Chair); and Tracy Hillman, BioAnalysts (current Chair). This report also includes monitoring efforts funded by Grant County Public Utility District (Grant PUD). Grant PUD helps fund the spring and summer Chinook monitoring programs. Work funded by Grant PUD was directed and coordinated by the Priest Rapids Coordinating Committee (PRCC) Hatchery Sub-Committee, which consists of the same agency and tribal representatives listed for the HCP Hatchery Committee and replaces Chelan PUD representatives with Grant PUD representatives, Todd Pearsons, Peter Graf, and Deanne Pavlik-Kunkel.

The approach to monitoring the hatchery programs was guided by the updated monitoring and evaluation plan for PUD hatchery programs (Hillman et al. 2013). Technical aspects of the monitoring and evaluation program were developed by the Hatchery Evaluation Technical Team (HETT), which consisted of the following scientists: Carmen Andonaegui, WDFW; Matt Cooper, USFWS; Peter Graf, Grant PUD; Steve Hays, Chelan PUD; Tracy Hillman, BioAnalysts; Tom Kahler, Douglas PUD; Russell Langshaw, Grant PUD; Greg Mackey, Douglas PUD; Joe Miller, formerly Chelan PUD; Josh Murauskas, formerly Chelan PUD; Andrew Murdoch, WDFW; Keely Murdoch, Yakama Nation; Todd Pearsons, Grant PUD; Mike Tonseth, WDFW; and Catherine Willard, Chelan PUD. The updated plan also directs the analyses of hypotheses developed by the HETT. Most of the analyses outlined in the updated plan will be conducted in the five-year comprehensive reports.

Most of the work reported in this paper was funded by Chelan and Grant PUDs. Bonneville Power Administration purchased some of the Passive Integrated Transponder (PIT) tags that were used to mark juvenile Chinook and steelhead captured in tributaries and also helped fund a portion of the screw trap efforts in Nason Creek. We thank Charlie Paulsen for analyzing PIT-tag data for each program. This is the tenth annual report written under the direction of the HCP.

"I often say that when you can measure something and express it in numbers, you know something about it. When you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind. It may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the stage of science, whatever it may be."

Lord Kelvin

SECTION 1: INTRODUCTION

Chelan and Grant PUDs implement hatchery programs as part of their respective agreements related to the operation of Rocky Reach, Rock Island, Wanapum, and Priest Rapids Hydroelectric Projects. The fish resource management agencies developed the following general goal statements for the hatchery programs, which were adopted by the HCP Hatchery Committees and PRCC Hatchery Sub-Committee (hereafter, Hatchery Committees):

1. *Support the recovery of ESA-listed species by increasing the abundance of the natural adult population, while ensuring appropriate spatial distribution, genetic stock integrity, and adult spawner productivity.*

    Includes the Wenatchee spring Chinook, Wenatchee summer steelhead, and Methow spring Chinook programs.

2. *Increase the abundance of the natural adult population of unlisted plan species, while ensuring appropriate spatial distribution, genetic stock integrity, and adult spawner productivity. In addition, provide harvest opportunities in years when spawning escapement is sufficient to support harvest.*

    Includes the Wenatchee sockeye, Wenatchee summer/fall Chinook, Methow summer/fall Chinook, Okanogan summer/fall Chinook, and Okanogan sockeye programs.

3. *Provide salmon for harvest and increase harvest opportunities, while segregating returning adults from natural tributary spawning populations.*

    Includes the Chelan Falls summer Chinook program.

Following the development of the Hatchery and Genetic Management Plans (HGMPs), artificial propagation programs are now characterized into three categories. The first type, integrated conservation programs, are intended to support or restore natural populations. These programs focus on increasing the natural production of targeted fish populations. A fundamental assumption of this strategy is that adults spawned in the hatchery will produce more adult offspring than if they were left to spawn in the river and ultimately provide a demographic boost to the natural population. The second type, safety-net programs, are extensions of conservation programs, but are intended to function as reserve capacity for conservation programs in years of low returns. The safety-net provides a demographic and genetic reserve for the natural population. That is, in years of abundant returns, they function like segregated programs, and in years of low returns, they can be managed as conservation programs. Lastly, harvest augmentation programs are intended to increase harvest opportunities while limiting interactions with wild-origin counterparts.

Monitoring is needed to determine if the hatchery programs are meeting the intended management objectives of conservation, safety-net, or harvest augmentation programs. Objectives for hatchery programs are generally grouped into three categories of performance indicators:

1. In-Hatchery Indicators: Are the programs meeting the hatchery production objectives?

2. In-Nature Indicators: How do hatchery fish from the programs perform after release?

a. Conservation Programs:
   - How do the programs affect target population abundance and productivity?
   - How do the programs affect target population long-term fitness?

b. Safety-Net Programs:
   - How do the programs affect target population long-term fitness?

c. Harvest Augmentation Programs:
   - Do the programs provide harvest opportunities?

3. Risk Assessment Indicators: Do the programs pose risks to other populations?

The specific objectives identified in the updated monitoring and evaluation plan are as follows:

1. *Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.*
2. *Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.*
3. *Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.*
4. *Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.*
5. *Determine if the run timing, spawn timing, and spawning distribution of both the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.*
6. *Determine if stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.*
7. *Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.*
8. *Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.*
9. *Determine if hatchery fish were released at the programmed size and number.*
10. *Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations*

Two additional regional objectives that were not explicit in the goals specified above but were included in the updated monitoring and evaluation plan because they relate to goals and concerns of all artificial production programs include:

11. *Determine if the incidence of disease has increased in the natural and hatchery populations.*
12. *Determine if the release of hatchery fish affects non-target taxa of concern (NTTOC) within acceptable limits.*

Objective 12 was completed using an extensive risk assessment that concluded risks from the PUD hatchery programs were within containment objectives approved by the Hatchery Committees (Mackey et al. 2014; Pearsons et al. 2012).

Objectives in the updated plan have been organized in a hierarchy where productivity indicators are the primary metrics used to assess if conservation and safety-net program goals have been met; harvest rates and effects on non-targeted populations are used for harvest programs. In cases where productivity indicators are not available, or results are equivocal, monitoring indicators may be used to help evaluate the performance of the program. Evaluations of monitoring indicators may not provide sufficiently powerful conclusions on which to base management actions; although they may provide insight as to why a productivity indicator did or did not meet the program goal. Therefore, the relationship between hatchery programs and indicators can be viewed in a chain-of-causation: management actions within the hatchery programs affect the status of monitoring indicators, which in turn influence productivity indicators (Figure 1.1).

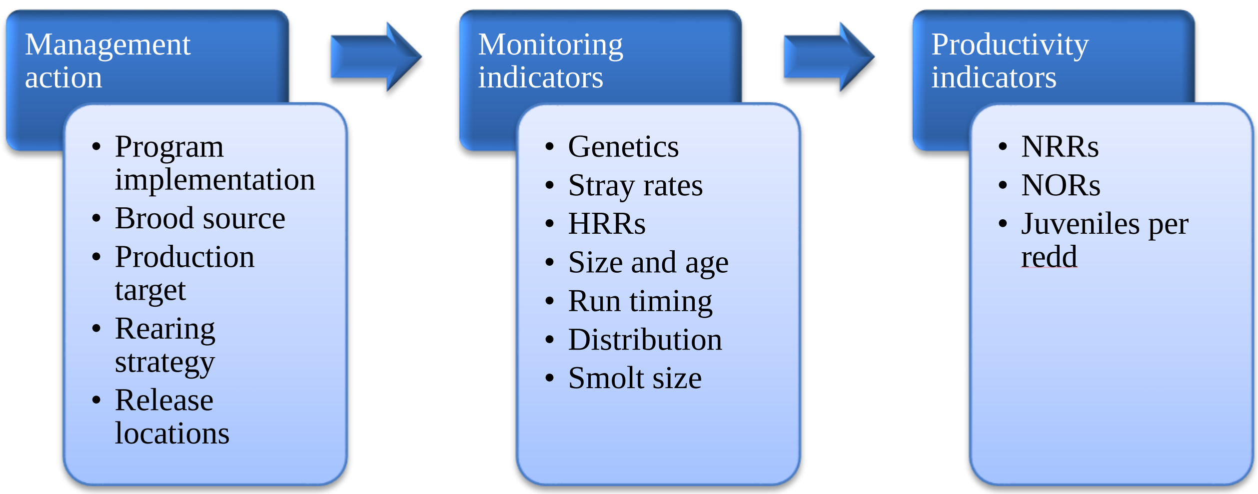

Figure 1.1. Relationship of indicators to the assessment of propagation programs. Management actions affect monitoring indicators, which influence productivity indicators. Monitoring indicators may be used to hypothesize the magnitude of influence on productivity.

Attending each objective is one or more testable hypotheses (see Hillman et al. 2013). Each hypothesis will be tested statistically following the routines identified in the updated monitoring and evaluation plan. Most of these analytical routines will be conducted at the end of five-year monitoring blocks, as outlined in the updated plan.

Both monitoring and productivity indicators will be used to evaluate the success of the hatchery programs. In the event that the statistical power of tests that involve productivity indicators is insufficient to inform sound management decisions, some of the monitoring indicators may be used to guide management. Figure 1.2 shows the categories of indicators associated with each component of monitoring.

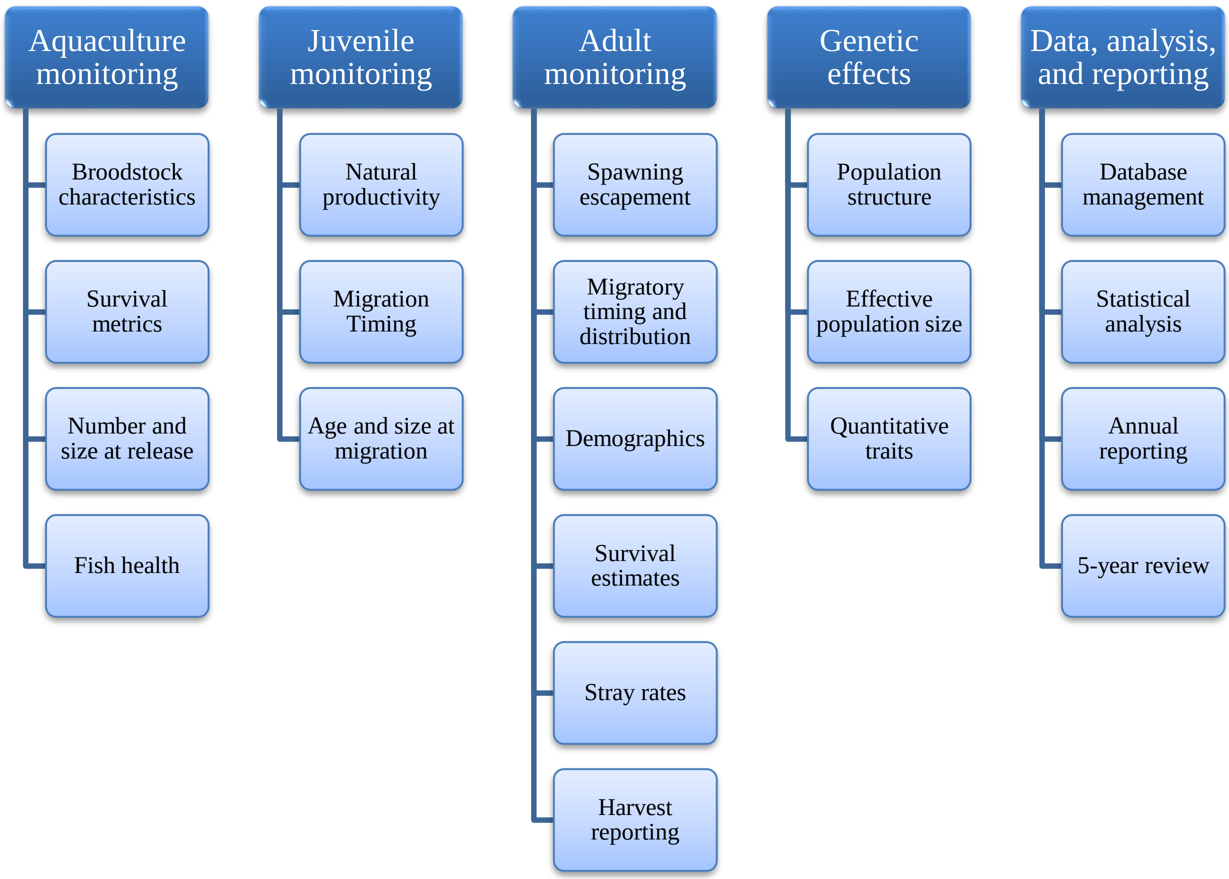

Figure 1.2. Overview of monitoring and evaluation plan categories and components (not including regional objectives).

Throughout each five-year monitoring period, annual reports will be generated that describe the monitoring and evaluation data collected during a specific year. This is the tenth annual report developed under the direction of the Hatchery Committees. The purpose of this report is to describe monitoring activities conducted in 2015. Activities included broodstock collection, collection of life-history information, within hatchery spawning and rearing activities, juvenile monitoring within streams, and redd and carcass surveys. Data from reference areas are not included in this annual report (reference data are in the five-year reports). To the extent currently possible, we have included information collected before 2015.

This report is divided into several sections, each representing a different species, stock, or spawning aggregate (i.e., steelhead, sockeye salmon, spring Chinook salmon, and summer Chinook salmon). For all species we provide annual broodstock information; hatchery rearing history, release data, and survival estimates; disease information; juvenile migration and productivity estimates; redd counts, distribution, and spawn timing; spawning escapements; and life-history characteristics. For salmon species, we also provide information on carcasses. Brood year 2011 was the final sockeye salmon hatchery release, and beginning in 2013, only natural adult and juvenile sockeye productivity monitoring results are reported. Beginning in 2013, we added a separate section on Nason Creek spring Chinook salmon and in 2014 we added a separate section on White River spring Chinook salmon. The Colville Tribes began conducting monitoring of Okanogan summer Chinook in 2013; however, we retained the Okanogan summer Chinook section in this report because the PUDs have summer Chinook mitigation obligations in the Okanogan River basin. The Okanogan summer Chinook section includes monitoring information up to the return of brood year 2013 Chinook. Monitoring results for brood years 2013 to present can be found in annual reports prepared by the Colville Tribes to Bonneville Power Administration (BPA). Monitoring results of Grant PUD's fall Chinook salmon mitigation produced at Priest Rapids Hatchery can be found in annual reports written by WDFW and Grant PUD.

Finally, we end each section by addressing compliance issues with ESA/HCP mandates. For each Hatchery Program, WDFW and the PUDs are authorized annual take of ESA-listed spring Chinook and steelhead through Section 10 of the Endangered Species Act (ESA), including:

1. ESA Section 10(a)(1)(A) Permit No. 1395, which authorizes the annual take of adult and juvenile endangered upper Columbia River (UCR) spring Chinook and endangered UCR steelhead associated with implementing artificial propagation programs for the enhancement of UCR steelhead. The authorization includes takes associated with adult broodstock collection, hatchery operations, juvenile fish releases, monitoring and evaluation activities, and management of adult returns related to UCR steelhead artificial propagation programs in the UCR region (NMFS 2003a).
2. ESA Section 10(a)(1)(A) Permit No. 18121, which authorizes the annual take of adult and juvenile endangered UCR spring Chinook and endangered UCR steelhead associated with implementing artificial propagation programs in the Chiwawa River for the enhancement of UCR spring Chinook. The authorization includes takes associated with adult broodstock collection, hatchery operations, juvenile fish releases, and monitoring and evaluation activities supporting UCR spring Chinook artificial propagation programs in the UCR region (NMFS 2004).
3. ESA Section 10(a)(1)(A) Permit No. 18118, which authorizes the annual take of adult and juvenile endangered UCR spring Chinook and endangered UCR steelhead associated with implementing artificial propagation programs in Nason Creek for the enhancement of UCR spring Chinook. The authorization includes takes associated with adult broodstock collection, hatchery operations, juvenile fish releases, and monitoring and evaluation activities supporting UCR spring Chinook artificial propagation programs in the UCR region (NMFS 2004).
4. ESA Section 10(a)(1)(A) Permit No. 18120, which authorizes the annual take of adult and juvenile endangered UCR spring Chinook and endangered UCR steelhead associated with implementing artificial propagation programs in the White River for the enhancement of UCR spring Chinook. The authorization includes takes associated with adult broodstock collection, hatchery operations, juvenile fish releases, and monitoring and evaluation activities supporting UCR spring Chinook artificial propagation programs in the UCR region (NMFS 2004).
5. ESA Section 10(a)(1)(A) Permit No. 1347, which authorizes the annual incidental take of adult and juvenile endangered UCR spring Chinook and endangered UCR steelhead through actions associated with implementing artificial propagation programs for the

enhancement of non-listed anadromous fish populations in the UCR. The authorization includes incidental takes associated with adult broodstock collection, hatchery operations, juvenile fish releases, and monitoring and evaluation activities associated with non-listed summer Chinook, fall Chinook, and sockeye salmon artificial propagation programs in the UCR region (NMFS 2003b).

SECTION 2: SUMMARY OF METHODS

Sampling in 2015 followed the methods and protocols described in Hillman et al. (2013). In this section we only briefly review the methods and protocols. More detailed information can be found in the updated monitoring and evaluation plan (Hillman et al. 2013).

2.1 Broodstock Collection and Sampling

Methods for collecting broodstock are described in the Annual Broodstock Collection Protocols (Appendix A in WDFW 2015). Generally, broodstock were collected over the migration period (to the extent allowed in ESA-permit provisions) in proportion to their temporal occurrence at collection sites, with in-season adjustments dictated by 2015 run timing and trapping success relative to achieving weekly and annual collection objectives. Pre-season weekly collection objectives are shown in Table 2.1 and assumptions associated with broodstock trapping are provided in Table 2.2.

Table 2.1. Weekly collection objectives for steelhead and Chinook in 2015.

Collection week beginning day	Chiwawa/Nason Spring Chinook[a]		Hatchery Chelan Falls Summer Chinook	Wild Wenatchee Summer Chinook	Wild Methow Summer Chinook	Wenatchee Steelhead	
	Hatchery	Wild				Hatchery	Wild
1-June	6	4					
8-June	10	6					
15-June	14	10					
22 June	20	16		48			
29 June	22	18	90	60	10	1	1
6 Jul	20	18	80	26	20	1	1
13 Jul	10	6	70	34	20	1	2
20 Jul			50	30	16	1	3
27 Jul			40	26	10	2	3
3 Aug			20	18	6	1	3
10 Aug				8	4	4	3
17 Aug				2	4	6	4
24 Aug					4	4	6
31 Aug					2	3	4
7 Sep					2	3	2
14 Sep						6	6
21 Sep						8	6
28 Sep						8	5
5 Oct						6	5
12 Oct						5	4
19 Oct						2	4
26 Oct						2	4
26 Oct						2	4
Total	**102**	**158**	**350**	**252**	**98**	**64**	**66**

[a] Chiwawa NOR spring Chinook (n = up to 80) were collected from the Chiwawa Weir with no specific weekly objectives generated, which is consistent with the Broodstock Collection Protocols. Previously PIT-tagged Chiwawa NOR spring Chinook were also targeted at Tumwater Dam. All Nason Creek spring Chinook were collected at Tumwater Dam from the week of 1 June through the week of 13 July proportionate to run timing. For 2015, HOR Chiwawa spring Chinook were collected for the Nason spring Chinook safety net program.

Table 2.2. Biological and trapping assumptions associated with collecting broodstock for the Chelan and Grant PUD Hatchery Programs.[1]

Assumptions	Wenatchee Steelhead	Chiwawa Spring Chinook	Nason Spring Chinook (Conservation)	Nason Spring Chinook (Safety Net)	Wenatchee Summer Chinook	Chelan Falls Summer Chinook	Methow Summer Chinook
Production level	247,300 yearling smolts	144,026 yearling smolts	125,000 yearling smolts	98,670 yearling smolts	500,001 yearling smolts	576,000 yearling smolts	200,000 yearling smolts
Broodstock required	130 adults (not to exceed 33% of population)	80 adults (not to exceed 33% of NOR population)	70 adults (not to exceed 33% of population)	66 adults	252 adults (not to exceed 33% of the population)	350 adults	100 adults (not to exceed 33% of the population)
Trapping period	1 July-14 Nov	1 June – 15 July (Tumwater) 15 June-1 Aug (Chiwawa Weir)	1 June – 15 July	1 June – 15 July	22 June – 15 Sept	29 June – 15 Sep	29 June – 30 Aug
# days/week	5	7 (Tumwater) Not to exceed 15 cumulative trapping days (Chiwawa Weir)	7	7	5	7	3
# hours/day	24	24 (Tumwater) 24 up/24 down (Chiwawa Weir)	24	24	24	24	16
Broodstock composition	49% wild; 51% WxW (hatchery)	69% wild; 31% hatchery	100% wild	100% hatchery	100% wild	100% hatchery	100% wild
Trapping site	Dryden Dam for WxW hatchery; Tumwater for wild. (Tumwater	Tumwater Dam and Chiwawa Weir	Tumwater Dam	Tumwater Dam	Dryden Dam (Tumwater will be used if weekly quota not achieved at	Eastbank Outfall	Wells Dam east or west ladder

[1] Throughout this document, "HxH" refers to hatchery by hatchery crosses and "WxW" refers to wild by wild crosses.

Assumptions	Wenatchee Steelhead	Chiwawa Spring Chinook	Nason Spring Chinook (Conservation)	Nason Spring Chinook (Safety Net)	Wenatchee Summer Chinook	Chelan Falls Summer Chinook	Methow Summer Chinook
	will be used if weekly quota not achieved for WxW (hatchery) at Dryden Dam)				Dryden Dam)		

Several biological parameters were measured during broodstock collection at adult collection sites. Those parameters included the date and start and stop time of trapping; number of each species collected for broodstock; origin, size, and sex of trapped fish; age from scale analysis; and pre-spawn mortality. For each species, trap efficiency, extraction rate, and trap operation effectiveness were estimated following procedures in Hillman et al. (2013). In addition, a representative sample of most species trapped but not taken for broodstock were sampled for origin, sex, age, and size (stock assessment).

2.2 Within Hatchery Monitoring

Methods for monitoring hatchery activities are described in Hillman et al. (2013). Biological information collected from all spawned adult fish included age at maturity, length at maturity, spawn time, and fecundity of females. In addition, all fish were checked for tags and females were sampled for pathogens.

Throughout the rearing period in the hatchery, fish were sampled for growth, health, and survival. Each month, lengths and weights were collected from a sample of fish and rearing density indices were calculated. In addition, fish were examined monthly for health problems following standard fish health monitoring practices for hatcheries. Various life-stage survivals were estimated for each hatchery stock. These estimates were then compared to the "standard" survival rates identified in Table 2.3 to provide insight as to how well the hatchery operations were performing. Failure to achieve a survival standard could indicate a problem with some part of the hatchery program. However, failure to meet a standard may not be indicative of the overall success of the program to meet the goals identified in Section 1.

Table 2.3. Standard life-stage survival rates for fish reared within the Chelan PUD hatchery programs (from Hillman et al. 2013).

Life stage	Standard survival rate (%)
Collection-to-spawning (females)	90
Collection-to-spawning (males)	85
Unfertilized egg-to-eyed	92
Unfertilized egg-to-ponding	98
30 d after ponding	97
100 d after ponding	93
Ponding-to-release	90
Transport-to-release	95

Life stage	Standard survival rate (%)
Unfertilized egg-to-release	81

Nearly all hatchery fish from each stock were marked (adipose fin clip) or tagged (coded-wire tag) in 2015. Different combinations of marks and tags were used depending on the stock. In addition, Chelan PUD personnel PIT tagged 10,200 juvenile hatchery Chiwawa spring Chinook (5,100 WxW and 5,100 HxH Chinook) and 5,010 juvenile Nason Creek WxW spring Chinook; 23,216 Wenatchee steelhead (12,101 WxW steelhead and 111,115 HxH steelhead); and 10,000 Chelan River summer Chinook, 5,000 Methow (Carlton) summer Chinook, and 21,000 Wenatchee summer Chinook. PIT tags will be used to estimate migration timing and survival rates (e.g., smolt-to-adult) outside the hatchery.

Lastly, the size and number of fish released were assessed and compared to programmed production levels. The goal of the program is that numbers released and their sizes should fall within 10% of the programmed targets identified in Table 2.4. However, because of constraints due to run size and proportions of wild and hatchery adults, production levels may not be met every year.

Table 2.4. Targets for fish released from the PUD hatchery programs; CV = coefficient of variation.

Hatchery stock	Release targets	Size targets		
		Fork length (CV)	Weight (g)	Fish/pound
Wenatchee Summer Chinook	500,001	163 (9.0)	45.4	10[a]
Methow Summer Chinook	200,000	163 (9.0)	45.4	15
Chelan Falls Summer Chinook (yearlings)	576,000	161 (9.0)	45.4	10[b]
Chiwawa Spring Chinook	144,026	155 (9.0)	37.8	18
Nason Spring Chinook	223,670	155 (9.0)	37.8	24
Wenatchee Steelhead	247,300	191 (9.0)	75.6	6

[a]An experimental release size of 30-45 grams (10-15 FPP) is in place for brood years 2012-2014.
[b]An experimental release size of 20-45 grams (10-22 FPP) is in place for brood years 2012-2014.

2.3 Juvenile Sampling

Juvenile sampling within streams included operation of rotary screw traps, snorkel observations, and PIT tagging. Methods for sampling juvenile fish are described in Hillman et al. (2013).

A smolt trap was located on the Wenatchee River near the town of Cashmere at RM 8.3 (Lower Wenatchee Trap), in Nason Creek about 0.6 miles upstream from the mouth, in the White River, and in the Chiwawa River about 0.4 miles upstream from the mouth (Chiwawa Trap). All traps operated throughout the smolt migration period. The Chiwawa Trap operated between 25 February and 24 November 2015. The Nason Creek Trap operated from 1 March to 18 July and from 20 October through November in 2015. The White River trap operated from 1 March through November 2015. The Lower Wenatchee Trap operated between 30 January and 28 June 2015. Throughout the trapping period, the traps were briefly inoperable during periods when flows were too high or low, during high water temperatures, during large hatchery releases, and because of heavy debris loads, ice, and mechanical malfunctions.

The following data were collected at each trap site: water temperature, discharge, number and identification of all species captured, degree of smoltification for anadromous fish, presence of marks and tags, size (fork lengths and weights), and scales from smolts. Trap efficiencies at each trap site were estimated by using mark-recapture trials conducted over a wide range of discharges. Linear regression models relating discharge and trap efficiencies were developed to estimate daily trap efficiencies during periods when no mark-recapture trials were conducted. The total number of fish migrating past the trap each day was estimated as the quotient of the daily number of fish captured and the estimated daily trap efficiency. Summing the daily totals resulted in the total emigration estimate.

Snorkel observations were used to estimate the number of juvenile spring Chinook salmon, juvenile rainbow/steelhead, and bull trout within the Chiwawa River basin. The focus of the study was on juvenile spring Chinook salmon. Sampling followed a stratified random design with proportional allocation of sites among strata. Strata were identified based on unique combinations of geology, land type, valley bottom type, stream state condition, and habitat types. A total of 199 randomly selected sites were surveyed during August (Table 2.5). Counts of fish within each sampling site were adjusted based on detection efficiencies, which were related to water temperature. That is, non-linear models that described relationships between water temperatures and detection efficiencies (Hillman et al. 1992) were used to estimate total numbers of fish within sampling sites. These numbers were then converted to densities by dividing total fish numbers by the wetted surface area and water volume of sample sites. Total numbers within a stratum were estimated as the product of fish densities times the total wetted surface or water volume for the stratum. The sum of fish numbers across strata resulted in the total number of fish within the basin. The calculation of total numbers, densities, and degrees of certainty are explained fully in Hillman and Miller (2004).

Working in collaboration with the Comparative Survival Study (CSS) funded by BPA, crews PIT tagged juvenile wild Chinook, wild steelhead, wild sockeye, and in some instances wild coho salmon collected at the smolt traps and collected within the Chiwawa River and Nason Creek using electrofishing techniques. The proposed number of wild spring Chinook and steelhead to be tagged at each location is provided in Table 2.6. The goal of this tagging program is to estimate freshwater juvenile productivity, better understand life-history characteristics, overwinter movement and survival of salmonids, and to calculate SARs of Chinook salmon in the Wenatchee River basin. The PIT tagging effort funded by the PUDs in the Chiwawa River and Nason Creek is specifically directed at addressing uncertainties of estimating abundance using screw traps (e.g., fish passage during times when trapping is not possible).

Table 2.5. Location of strata and numbers of randomly sampled snorkel sites within each stratum that were sampled in the Chiwawa River Basin in 2015.

Reach/stratum	River miles (RM)	Number of randomly selected sites
Chiwawa River		
1	0.0-3.8	11
2	3.8-5.5	5
3	5.5-7.9	8
4	7.9-8.9	6

Reach/stratum	River miles (RM)	Number of randomly selected sites
5	8.9-10.8	5
6	10.8-11.8	6
7	11.8-20.0	28
8	20.0-25.4	24
9	25.4-28.8	12
10	28.8-31.1	21
Phelps Creek		
1	0.0-0.4	1
Chikamin Creek (includes Minnow Creek)		
1	0.0-1.5	19
Rock Creek		
1	0.0-0.7	11
Unnamed stream on USGS map		
1	0.0-0.1	1
Big Meadow Creek		
1	0.0-1.0	14
Alder Creek		
1	0.0-0.1	2
Brush Creek		
1	0.0-0.1	4
Clear Creek		
1	0.0-0.1	4

Table 2.6. Number of wild spring Chinook, steelhead (≥65 mm), and sockeye proposed for PIT tagging at different locations within the Wenatchee River basin, 2015.

Sampling location	Target sample size		
	Wild spring Chinook	Wild steelhead	Wild Sockeye
Chiwawa Trap	2,500-8,000	500-2,000	NA
Nason Creek Trap	2,500-8,000	500-2,000	NA
Lower Wenatchee Trap	500-1,000	50-250	3,000-5,000
Chiwawa Remote Sampling	3,000	NA	NA
Nason Remote Sampling	3,000	NA	NA

Survival rates for various juvenile life-stages were calculated based on estimates of seeding levels (total egg deposition), parr abundance, numbers of emigrants, and smolt abundance. Total egg deposition was estimated as the product of the number of redds counted in the basin times the mean fecundity of female spawners. Fecundity was estimated from females collected for broodstock using an electronic egg counter. Numbers of emigrants and smolts were estimated at trapping sites and numbers of parr were estimated using snorkel observations only in the Chiwawa

River basin. Survival estimates could not be calculated for some stocks (e.g., summer Chinook) because specific life-stage abundance estimates were lacking.

2.4 Spawning/Carcass Surveys

Methods for conducting carcass and spawning ground surveys are detailed in Hillman et al. (2013). Information collected during spawning surveys included spawn time, redd distribution, and redd abundance. Data collected during carcass surveys included sex, size (fork length and postorbital-to-hypural length), scales for aging[2], degree of egg voidance, DNA samples, and identification of marks or tags. The sampling goal for carcasses was 20% of the spawning population.

Steelhead surveys were conducted throughout the mainstem Wenatchee River and downstream from PIT-tag interrogation systems on the Chiwawa River, Nason Creek, and Peshastin Creek. These surveys were conducted during March through June in reaches and index areas described in Table 2.7. Total redd counts in these reaches were estimated by expanding counts within non-index areas by expansion factors developed within index areas.

Table 2.7. Description of reaches and index areas surveyed for steelhead redds in the Wenatchee River basin.

Stream	Code	Reach*	Index/reference area
Wenatchee River	W1	Mouth to Sleepy Hollow Br	River Bend to Sleepy Hollow Br
	W2	Sleepy Hollow Br to L. Cashmere Br	Sleepy Hollow Br to Cashmere Boat Rmp
	W3	L. Cashmere Br to Dryden Dam	Williams Canyon to Dryden Dam
	W5	Peshastin Br to Leavenworth Br	Irrigation Flume to Leavenworth Br
	W6	Leavenworth Br to Icicle Rd Br	Leavenworth Boat Ramp to Icicle Ck
	W7	Icicle Rd Br to Tumwater Dam	Icicle Br to Penstock Br
	W8	Tumwater Dam to Tumwater Br	Island below Swiftwater to Swiftwater CG
	W9	Tumwater Br to Chiwawa R	Tumwater Br to Plain
	W10	Chiwawa R to Lk Wenatchee	Chiwawa Pump St. to Lk Wenatchee
Peshastin Creek	P1	Mouth to PIT Detection Site	Mouth to PIT Detection Site
Chiwawa River	C1	Mouth to Rd 62 Br RM 6.4	Mouth to PIT Detection Site
Nason Creek	N1	Mouth to PIT Detection Site	Mouth to PIT Detection Site

* Reaches 2, 6, 8, 9, and 10 (major spawning areas) are surveyed weekly, while Reaches 1, 3, 5, and 7 (minor survey areas) are surveyed during peak spawning.

Beginning in 2014, adult steelhead escapement estimates in the majority of tributaries in the Wenatchee River basin were generated using mark-recapture techniques based on steelhead PIT tagged at Priest Rapids Dam (funded by BPA). Mark-recapture estimates in the tributaries were then added to the estimates based on redd surveys to generate a total spawning escapement to the Wenatchee River basin.

[2] In this report we use two methods of describing age. One is termed the "European Method." This method has two digits, separated by a period. The first digit represents the number of winters the fish spent in freshwater before migrating to the sea. The second digit indicates the number of winters the fish spent in the ocean. For example, a fish designated as 1.2 spent one winter in freshwater and two in the ocean. A fish designated as 0.3 migrated to the ocean in its first year and spent three winters in the ocean. The other method describes the total age of the fish (egg-to-spawning adult, i.e., gravel-to-gravel), so fish demarcated as 0.3 or 1.2 are considered 4-year-olds, from the same brood.

Spring Chinook redd and carcass surveys were conducted during August through September in the Chiwawa River (including Rock and Chikamin creeks), Nason Creek, Icicle Creek, Peshastin Creek (including Ingalls Creek), upper Wenatchee River, Little Wenatchee River, and the White River (including the Napeequa River and Panther Creek). Survey reaches for spring Chinook are described in Table 2.8.

Table 2.8. Description of reaches surveyed for spring Chinook redds and carcasses in the Wenatchee River basin.

Stream	Code	Reach	River mile (RM)
Chiwawa River	C1	Mouth to Grouse Creek	0.0-11.7
	C2	Grouse Creek to Rock Creek	11.7-19.3
	C3	Rock Creek to Schaefer Creek	19.3-22.4
	C4	Schaefer Creek to Atkinson Flats	22.4-25.6
	C5	Atkinson Flats to Maple Creek	25.6-27.0
	C6	Maple Creek to Phelps Creek	27.0-30.3
	C7	Phelps Creek to Buck Creek	30.3-31.4
Rock Creek	R1	Mouth to Chiwawa River Road Bridge	0.0-0.5
Chikamin Creek	K1	Mouth to Chiwawa River Road Bridge	0.0-0.5
Nason Creek	N1	Mouth to Kahler Creek Bridge	0.0-3.9
	N2	Kahler Creek Bridge to Hwy 2 Bridge	3.9-8.3
	N3	Hwy 2 Bridge to Lower RR Bridge	8.3-13.2
	N4	Lower RR Bridge to Whitepine Creek	13.2-15.4
Little Wenatchee River	L2	Old Fish Weir to Lost Creek	2.7-5.2
	L3	Lost Creek to Rainy Creek	5.2-9.2
	L4	Rainy Creek to Falls	9.2-Falls
White River	H2	Sears Creek Bridge to Napeequa River	6.4-11.0
	H3	Napeequa River to Grasshopper Meadows	11.0-12.9
	H4	Grasshopper Meadows to Falls	12.9-16.1
Napeequa River	Q1	Mouth to Take Out	0.0-1.0
Panther Creek	T1	Mouth to Boulder Field	0.0-1.0
Wenatchee River	W8	Tumwater Dam to Tumwater Bridge	30.9-35.6
	W9	Tumwater Bridge to Chiwawa River	35.6-48.4
	W10	Chiwawa River to Lake Wenatchee	48.4-54.2
Chiwaukum Creek	U1	Mouth to Metal Bridge	0.0-1.0
Icicle Creek	I1	Mouth to Hatchery	0.0-2.8
	I2	Hatchery to Sleeping Lady	2.8-3.3
	I3	Sleeping Lady to Snow Creek	3.3-3.8
Peshastin Creek	P1	Mouth to Camas Creek	0.0-5.9
	P2	Camas Creek to Mouth of Scotty Creek	5.9-16.3
Ingalls Creek	D1	Mouth to Trailhead	0.0-1.0

The sockeye salmon hatchery program ended after the 2011 brood year. As a result, monitoring activities that focused on evaluating the effects of the supplementation program on the natural population switched to monitoring the abundance and productivity of the natural population (McElhaney et al. 2000). Thus, estimation of spawn time and carcass surveys were discontinued in 2014. Nevertheless, this report retains the results of carcass sampling during the period 1993-2013. Survey reaches in which carcasses and live fish (for area-under-the-curve estimates) were conducted are identified in Table 2.9.

From 2009-2013, mark-recapture methods were used to estimate sockeye spawning escapement within the White River, while area-under-the-curve (AUC) methods were used to estimate spawning escapement within the Little Wenatchee River. Beginning in 2014, mark-recapture methods were used to estimate the spawning escapement of sockeye in both the White River and Little Wenatchee watersheds.

Table 2.9. Description of reaches surveyed for sockeye salmon carcasses and live fish in the Wenatchee River basin during survey years 1993-2013.

Stream	Code	Reach	River mile (RM)
Little Wenatchee River	L1	Mouth to Old Fish Weir	0.0-2.7
	L2	Old Fish Weir to Lost Creek	2.7-5.2
	L3	Lost Creek to Rainy Creek	5.2-9.2
White River	H1	Mouth to Sears Creek Bridge	0.0-6.4
	H2	Sears Creek Bridge to Napeequa River	6.4-11.0
	H3	Napeequa River to Grasshopper Meadows	11.0-12.9
Napeequa River	Q1	Mouth to End	0.0-1.0

Wenatchee summer Chinook redd and carcass surveys were conducted from September through November throughout the entire mainstem Wenatchee River, which was divided into ten reaches (Table 2.10). Surveys were conducted weekly in all reaches. All redds were enumerated during weekly census counts.

Table 2.10. Description of reaches and index areas surveyed for summer Chinook redds in the Wenatchee River basin.

Code	Reach	River mile	Index/reference area (RM)
W1	Mouth to Sleepy Hollow Br	0.0-3.3	River Bend to Sleepy Hollow Br (1.7-3.3)
W2	Sleepy Hollow Br to L. Cashmere Br	3.3-9.5	L. Cashmere Br to Old Monitor Br (7.1-9.5)
W3	L. Cashmere Br to Dryden Dam	9.5-17.8	Williams Canyon to Dryden Dam (15.5-17.8)
W4	Dryden Dam to Peshastin Br	17.8-20.0	Dryden Dam to Peshastin Br (17.8-20.0)
W5	Peshastin Br to Leavenworth Br	20.0-23.9	Irrigation Flume to Leavenworth Br (22.8-23.9)
W6	Leavenworth Br to Icicle Rd Br	23.9-26.4	Icicle to Boat Takeout (24.5-25.6)
W7	Icicle Rd Br to Tumwater Dam	26.4-30.9	Icicle Br to Penstock Br (26.4-28.7)
W8	Tumwater Dam to Tumwater Br	30.9-35.6	Swiftwater Campgd to Tumwater Br (33.5-35.6)
W9	Tumwater Br to Chiwawa River	35.6-47.9	Swing Pool to Railroad Tunnel (36.7-39.3)
W10	Chiwawa River to Lake Wenatchee	47.9-54.2	Swamp to Bridge (52.7-53.6)

Summer Chinook redd and carcass surveys were also conducted in the Methow and Chelan rivers from September through November. Total (map) redd counts were conducted in these rivers. Table 2.11 describes the survey reaches on the Methow River. The Colville Tribes conducted summer Chinook redd and carcass surveys in the Okanogan River basin. Those results are reported in a separate report (annual report to BPA).

Table 2.11. Description of reaches surveyed for summer Chinook redds and carcasses on the Methow, Okanogan, and Similkameen rivers.

Stream	Code	Reach	River mile (RM)
Methow River	M1	Mouth to Methow Bridge	0.0-14.8
	M2	Methow Bridge to Carlton Bridge	14.8-27.2
	M3	Carlton Bridge to Twisp Bridge	27.2-39.6
	M4	Twisp Bridge to MVID	39.6-44.9
	M5	MVID to Winthrop Bridge	44.9-49.8
	M6	Winthrop Bridge to Hatchery Dam	49.8-51.6
Okanogan River	O1	Mouth to Mallot Bridge	0.0-16.9
	O2	Mallot Bridge to Okanogan Bridge	16.9-26.1
	O3	Okanogan Bridge to Omak Bridge	26.1-30.7
	O4	Omak Bridge to Riverside Bridge	30.7-40.7
	O5	Riverside Bridge to Tonasket Bridge	40.7-56.8
	O6	Tonasket Bridge to Zosel Dam	56.8-77.4
Similkameen River	S1	Driscoll Channel to Oroville Bridge	0.0-1.8
	S2	Oroville Bridge to Enloe Dam	1.8-5.7

For summer and spring Chinook, total spawning escapements for each population were estimated as the product of total number of redds times the ratio of fish per redd for a specific stock. Fish per redd ratios were estimated as the ratio of males to females sampled at broodstock collection sites and monitoring sites (e.g., Dryden Dam). For steelhead, spawning escapement was estimated with a combination of PIT-tag-based tributary and redd-based mainstem Wenatchee River estimates. Total spawning escapement for sockeye salmon in the Little Wenatchee and White River watersheds was estimated using mark-recapture methods. Adult sockeye were PIT tagged at Tumwater Dam and Bonneville Dam[3] and detected in the Little Wenatchee and White rivers with stationary PIT-tag interrogation systems.

Derived metrics calculated from carcass surveys, broodstock sampling, stock assessments, and harvest records included proportion of hatchery spawners, stray rates, age-at-maturity, length-at-age, smolt-to-adult survival (SAR), hatchery replacement rates (HRR), harvest rates, and natural replacement rates (NRR). The target HRRs (from Hillman et al. 2013) for different stocks raised in the PUD hatchery programs are provided in Table 2.12. Methods for calculating derived variables are described in Hillman et al. (2013) and in "White Papers" developed by the Hatchery

[3] Adult sockeye that were tagged at Bonneville Dam and detected at Tumwater Dam were included in the mark-recapture analyses.

Evaluation Technical Team (HETT) (see Appendices in Hillman et al. 2012). The abundance of hatchery and natural-origin Chinook salmon spawners was based upon the proportion of carcasses by origin that were collected on the spawning grounds.

Table 2.12. Hatchery replacement rate (HRR) targets for stocks raised in the PUD Hatchery Programs.

Program	Number of broodstock	Smolts released	HRR targets
Chiwawa Spring Chinook	74	144,026	6.7
Nason Creek Spring Chinook	66	125,000	6.7
Wenatchee Summer Chinook	278	500,001	5.7
Methow Summer Chinook	100	200,000	3.0
Wenatchee Steelhead	130	247,300	6.9

Derived data that rely on CWTs (e.g., HRR, SAR, stray rates, etc.) are five or more years behind release information because of the lag time for returning adult fish to enter the fishery and spawning grounds, and the processing of tags. Consequently, complete information on rates and ratios based on CWTs is generally only available for brood years before 2009.

SECTION 3: WENATCHEE STEELHEAD

The goal of summer steelhead supplementation in the Wenatchee Basin is to use artificial production to replace adult production lost because of mortality at Rock Island and Rocky Reach dams, as well as inundation compensation for Rocky Reach Dam, while not reducing the natural production or long-term fitness of steelhead in the basin. The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Rock Island and Rocky Reach Anadromous Fish Agreement and Habitat Conservation Plans.

Prior to 1998, steelhead eggs were received from Wells Hatchery (adult broodstock were collected at Wells Dam); fish were reared at Eastbank Fish Hatchery and then released into the Wenatchee River. Beginning in 1998, the program changed to collecting broodstock within the Wenatchee Basin. Currently, adult hatchery steelhead are collected from the run-at-large at the right and left-bank traps at Dryden Dam, and at Tumwater Dam if the weekly quotas cannot be achieved at Dryden Dam. Wild by wild (WxW) adult steelhead are collected from the run-at-large at Tumwater and Dryden dams if the weekly quotas cannot be achieved at Dryden Dam.

Before 2012, the goal was to collect up to 208 adult steelhead (50% natural-origin fish and 50% hatchery-origin fish) for the Wenatchee steelhead program. In 2011, the Hatchery Committees reevaluated the amount of hatchery compensation needed to achieve NNI. Based on that evaluation, the goal of the program was revised. The current goal (which began in 2012) is to collect 130 adult steelhead (64 natural-origin and 66 hatchery-origin fish) for a 247,300 smolt program, but the number of broodstock collected cannot exceed 33% of the natural Wenatchee steelhead population. Broodstock collection occurs from about 1 July through 15 November at Dryden and Tumwater dams, with trapping occurring up to 24 hours per day, five days a week. The intent of the current program is to target adults necessary to meet a 50% natural-origin, conservation-oriented program and a 50% hatchery-origin safety-net program.

Prior to the 2012 brood year, adult steelhead were held and spawned at Wells Fish Hatchery because of unsuitable adult holding temperatures at Eastbank Fish Hatchery. Beginning with the 2012 brood year, spawning has occurred at Eastbank Fish Hatchery. Before 2012, juvenile steelhead were reared at a combination of facilities including Eastbank, Chelan, Turtle Rock, Rocky Reach Annex, and Chiwawa facilities. Juvenile steelhead reared in these facilities were trucked to release locations on the Wenatchee River, Chiwawa River, and Nason Creek. A percentage of the fish have also been released volitionally from Blackbird Pond and Rolfing Pond. Beginning in the fall of 2012, the entire Wenatchee steelhead program overwinters at the Chiwawa Acclimation Facility. Some of these fish are transferred to short-term remote acclimation sites (e.g., Blackbird Pond and Rolfing Pond), while others are planted from trucks throughout the Wenatchee, Nason, and Chiwawa basins.

Before 2012, the production goal for the Wenatchee steelhead supplementation program was to release 400,000 yearling smolts into the Wenatchee Basin at six fish per pound. Since 2012, the revised production goal is to release 247,300 smolts (123,650 for conservation and 123,650 for safety net). Targets for fork length and weight are 191 mm (CV = 9.0) and 75.6 g, respectively; the target size at release is six fish per pound. Over 96% of these fish receive CWTs. In addition, since 2006, juvenile steelhead from different parental-cross groups (e.g., WxW, HxW, and HxH) have been PIT tagged annually. No HxW crosses have occurred since brood year 2009.

Beginning in 2010 and consistent with ESA Section 10(a)(1)(A) permit 1395, adult management activities have been conducted to remove excess hatchery-origin steelhead before they spawn in the natural environment. This is accomplished through removal at Tumwater Dam and/or through conservation fisheries. The objective of these activities is to achieve proportion of hatchery-origin spawners (pHOS) and Proportionate Natural Influence (PNI) goals for the Wenatchee steelhead program. Results of adult management activities are submitted to NOAA Fisheries in a separate annual report by 31 August of the year the adult management was concluded.

3.1 Broodstock Sampling

This section focuses on results from sampling 2014 and 2015 brood years of Wenatchee steelhead, which were collected at Dryden and Tumwater dams. The 2014 brood begins the tracking of the life cycle of steelhead released in 2015. The 2015 brood is included because juveniles from this brood are still maintained within the hatchery.

Origin of Broodstock

A total of 135 Wenatchee steelhead from the 2013 return (2014 brood) were collected at Dryden and Tumwater dams (Table 3.1). About 48% of these were natural-origin (adipose fin present, no CWT, and no elastomer tags) fish and the remaining 52% were hatchery-origin (elastomer tagged and/or CWT and adipose fin absent) adults. Origin was determined by analyzing scales and/or otoliths. The total number of steelhead spawned from the 2014 brood was 132 adults (48.5% natural-origin and 51.5% hatchery-origin).

A total of 136 steelhead were collected from the 2014 return (2015 brood) at Dryden and Tumwater dams; 76 (56%) natural-origin (adipose fin present, no CWT, and no elastomer tags) and 60 (44%) hatchery-origin (elastomer tagged and adipose present or CWT and adipose fin present) adults. A total of 110 steelhead were spawned; 52.7% were natural-origin fish and 47.3% were hatchery fish (Table 3.1). Origin was confirmed by sampling scales and/or otoliths.

Table 3.1. Numbers of wild and hatchery steelhead collected for broodstock, numbers that died before spawning, and numbers of steelhead spawned, 1998-2015. Unknown origin fish (i.e., undetermined by scale analysis, no elastomer, CWT, or fin clips, and no additional hatchery marks) were considered naturally produced. Mortality includes fish killed at spawning and surplus broodstock.

Brood year	Wild steelhead					Hatchery steelhead					Total number spawned
	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	
1998	35	0	0	35	0	43	4	2	37	0	72
1999	58	5	1	52	0	67	1	2	64	0	116
2000	39	2	1	36	0	101	9	12	60	20	96
2001	64	5	8	51	0	114	5	6	103	0	154
2002	99	0	1	96	2	113	1	0	64	48	160
2003	63	10	4	49	0	92	2	0	90	0	139
2004	85	3	0	75	7	132	1	0	61	70	136
2005	95	8	0	87	0	114	7	1	104	2	191
2006	101	5	0	93	3	98	0	0	69	29	162
2007	79	0	2	76	1	97	0	14	58	25	134

Brood year	Wild steelhead					Hatchery steelhead					Total number spawned
	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	
2008	104	0	3	77	22	107	0	28	54	25	131
2009	101	2	0	86	13	107	1	4	73	29	159
2010	106	1	1	96	8	105	2	23	75	5	171
2011	104	8	1	91	4	104	13	2	70	0	161
Average[b]	***81***	***4***	***2***	***71***	***4***	***100***	***3***	***7***	***70***	***18***	***142***
Median	***95***	***3***	***1***	***77***	***2***	***105***	***2***	***2***	***67***	***13***	***147***
2012	63	3	0	59	1	66	0	1	65	0	124
2013	63	8	1	49	5	84	9	7	68	0	117
2014	65	0	1	64	0	70	0	2	68	0	132
2015	76	5	0	58	13	60	0	8	52	0	110
Average[c]	***67***	***4***	***1***	***58***	***5***	***70***	***2***	***5***	***63***	***0***	***121***
Median	***64***	***4***	***1***	***59***	***3***	***68***	***0***	***5***	***67***	***0***	***121***

[a] Pre-spawn loss represents the number of fish that died during the holding period before spawning. Mortality is the number of fish that were surplused following spawning.
[b] This average and median represent the program before recalculation in 2011.
[c] This average and median represent the current program, which began in 2012.

Age/Length Data

Broodstock ages were determined from examination of scales and/or otoliths. For the 2014 brood year, both natural-origin and hatchery steelhead consisted primarily of 2-salt adults (Table 3.2). For the 2015 brood year, natural-origin steelhead consisted primarily of 2-salt adults and hatchery steelhead consisted almost equally of 1 and 2-salt adults (Table 3.2).

Table 3.2. Percent of hatchery and wild steelhead of different ages (saltwater ages) collected from broodstock, 1998-2015.

Brood year	Origin	Saltwater age		
		1	2	3
1998	Wild	39.4	60.6	0.0
	Hatchery	20.9	79.1	0.0
1999	Wild	50.0	48.3	1.7
	Hatchery	81.8	18.2	0.0
2000	Wild	56.4	43.6	0.0
	Hatchery	67.9	32.1	0.0
2001	Wild	51.7	48.3	0.0
	Hatchery	14.9	85.1	0.0
2002	Wild	55.6	44.4	0.0
	Hatchery	94.6	5.4	0.0
2003	Wild	13.1	85.3	1.6
	Hatchery	29.4	70.6	0.0
2004	Wild	94.8	5.2	0.0
	Hatchery	95.2	4.8	0.0
2005	Wild	22.1	77.9	0.0

Brood year	Origin	Saltwater age		
		1	2	3
	Hatchery	20.5	79.5	0.0
2006	Wild	28.7	71.3	0.0
	Hatchery	60.3	39.7	0.0
2007	Wild	40.3	59.3	0.0
	Hatchery	62.1	37.9	0.0
2008	Wild	65.4	33.7	0.9
	Hatchery	88.8	11.2	0.0
2009	Wild	39.8	57.8	2.4
	Hatchery	23.4	76.6	0.0
2010	Wild	65.2	33.7	1.1
	Hatchery	76.5	23.5	0.0
2011	Wild	27.5	72.5	0.0
	Hatchery	36.0	64.0	0.0
2012	Wild	42.4	52.5	5.1
	Hatchery	40.9	59.1	0.0
2013	Wild	40.7	57.4	1.9
	Hatchery	45.5	54.5	0.0
2014	Wild	47.5	50.8	1.6
	Hatchery	29.4	70.6	0.0
2015	Wild	15.9	82.5	1.6
	Hatchery	50.8	49.2	0.0
Average	***Wild***	***44.3***	***54.7***	***1.0***
	Hatchery	***52.2***	***47.8***	***0.0***
Median	***Wild***	***41.6***	***55.0***	***0.5***
	Hatchery	***48.2***	***51.9***	***0.0***

There was little difference between mean lengths of hatchery and natural-origin steelhead in the 2014 and 2015 brood years (Table 3.3). Natural-origin fish were on average 1 to 3 cm larger than hatchery-origin fish of the same age.

Table 3.3. Mean fork length (cm) at age (saltwater ages) of hatchery and wild steelhead collected from broodstock, 1998-2015; N = sample size and SD = 1 standard deviation.

Brood year	Origin	Steelhead fork length (cm)								
		1-Salt			2-Salt			3-Salt		
		Mean	N	SD	Mean	N	SD	Mean	N	SD
1998	Wild	63	15	4	79	20	5	-	0	-
	Hatchery	61	9	4	73	34	4	-	0	-
1999	Wild	65	29	5	74	28	5	77	1	-
	Hatchery	62	54	4	73	12	4	-	0	-

Brood year	Origin	Steelhead fork length (cm)								
		1-Salt			2-Salt			3-Salt		
		Mean	N	SD	Mean	N	SD	Mean	N	SD
2000	Wild	64	22	3	74	17	5	-	0	-
	Hatchery	60	57	3	71	27	4	-	0	-
2001	Wild	61	33	6	77	31	5	-	0	-
	Hatchery	62	17	4	72	97	4	-	0	-
2002	Wild	64	55	4	77	44	4	-	0	-
	Hatchery	63	106	4	73	6	4	-	0	-
2003	Wild	69	8	6	77	52	5	91	1	-
	Hatchery	66	27	4	75	65	4	-	0	-
2004	Wild	63	73	6	78	4	2	-	0	-
	Hatchery	61	59	3	73	3	1	-	0	-
2005	Wild	59	21	4	74	74	5	-	0	-
	Hatchery	59	23	4	72	89	4	-	0	-
2006	Wild	63	27	5	75	67	6	-	0	-
	Hatchery	61	41	4	72	27	5	-	0	-
2007	Wild	64	31	6	76	46	5	-	0	-
	Hatchery	60	60	4	71	36	5	-	0	-
2008	Wild	64	68	4	77	35	4	80	1	-
	Hatchery	60	95	4	72	12	2	-	0	-
2009	Wild	65	33	5	76	48	6	81	2	0
	Hatchery	63	18	4	75	59	5	-	-	-
2010	Wild	64	60	5	74	31	5	76	1	-
	Hatchery	61	53	5	73	23	5	-	-	-
2011	Wild	62	28	5	76	74	5	-	0	-
	Hatchery	60	36	4	74	64	4	-	0	-
2012	Wild	63	25	3	74	31	5	74	3	2
	Hatchery	59	27	3	74	39	4	-	0	-
2013	Wild	61	22	5	77	31	5	74	1	-
	Hatchery	60	35	3	74	42	4	-	0	-
2014	Wild	61	29	4	75	31	4	61	1	-
	Hatchery	60	20	3	72	48	4	-	0	-
2015	Wild	61	10	3	77	52	4	85	1	-
	Hatchery	59	30	3	76	29	5	-	0	-
Average	***Wild***	***63***	***33***	***5***	***76***	***40***	***5***	***78***	***1***	***1***
	Hatchery	***61***	***43***	***4***	***73***	***40***	***4***	***-***	***0***	***-***

Sex Ratios

Male steelhead in the 2014 brood year made up about 49% of the adults collected, resulting in an overall male to female ratio of 0.96:1.00 (Table 3.4). For the 2015 brood year, males made up about 50% of the adults collected, resulting in an overall male to female ratio of 1.00:1.00. On average (1998-2015), the sex ratio is slightly less than the 1:1 ratio assumed in the broodstock protocol (Table 3.4).

Table 3.4. Numbers of male and female wild and hatchery steelhead collected for broodstock, 1998-2015. Ratios of males to females are also provided.

Brood year	Number of wild steelhead			Number of hatchery steelhead			Total M/F ratio
	Males (M)	Females (F)	M/F	Males (M)	Females (F)	M/F	
1998	13	22	0.59:1.00	15	28	0.54:1.00	0.56:1.00
1999	22	36	0.61:1.00	35	32	1.09:1.00	0.84:1.00
2000	18	21	0.86:1.00	60	41	1.46:1.00	1.26:1.00
2001	38	26	1.46:1.00	40	74	0.54:1.00	0.78:1.00
2002	32	67	0.48:1.00	81	32	2.53:1.00	1.14:1.00
2003	19	44	0.43:1.00	44	48	0.92:1.00	0.68:1.0
2004	43	42	1.02:1.00	90	42	2.14:1.00	1.58:1.00
2005	36	59	0.61:1.00	46	68	0.68:1.00	0.65:1.00
2006	38	63	0.60:1.00	47	51	0.92:1.00	0.75:1.00
2007	36	43	0.84:1.00	49	48	1.02:1.00	0.93:1.00
2008	61	43	1.42:1.00	68	39	1.74:1.00	1.57:1.00
2009	44	57	0.77:1.00	54	53	1.02:1.00	0.89:1.00
2010	49	57	0.86:1.00	62	43	1.44:1.00	1.11:1.00
2011	44	60	0.73:1.00	50	54	0.93:1.00	0.82:1.00
2012	30	33	0.91:1.00	31	35	0.89:1.00	0.90:1.00
2013	33	30	1.10:1.00	38	46	0.83:1.00	0.93:1.00
2014	30	33	0.91:1:00	36	36	1.00:1.00	0.96:1.00
2015	34	42	0.81:1.00	34	26	1.31:1.00	1.00:1.00
Total	***620***	***778***	***0.80:1.00***	***880***	***796***	***1.11:1.00***	***0.95:1.00***

Fecundity

Fecundities for Wenatchee steelhead in brood years 2014 and 2015 averaged 5,839 and 5,895 eggs per female, respectively (Table 3.5). Mean fecundities for the 2014 and 2015 brood years were also greater than the 5,678 eggs per female assumed in the broodstock protocol.

Table 3.5. Mean fecundity of wild, hatchery, and all female steelhead collected for broodstock, 1998-2015.

Brood year	Mean fecundity		
	Wild	Hatchery	Total
1998	6,202	5,558	5,924
1999	5,691	5,186	5,424
2000	5,858	5,729	5,781

Brood year	Mean fecundity		
	Wild	Hatchery	Total
2001	5,951	6,359	6,270
2002	5,776	5,262	5,626
2003	6,561	6,666	6,621
2004	5,118	5,353	5,238
2005	5,545	6,061	5,832
2006	5,688	5,251	5,492
2007	5,840	5,485	5,660
2008	5,693	5,153	5,433
2009	6,199	6,586	6,408
2010	5,458	5,423	5,442
2011	6,276	6,100	6,203
2012	5,309	6,388	5,891
2013	5,749	5,770	5,762
2014	5,831	5,847	5,839
2015	6,220	5,532	5,895
Average	***5,831***	***5,762***	***5,819***
Median	***5,804***	***5,644***	***5,807***

3.2 Hatchery Rearing

Rearing History

Number of eggs taken

From 1998-2011, a total of 493,827 eggs were required to meet the program release goal of 400,000 smolts. This was based on the unfertilized egg-to-release survival standard of 81%. In 2012, the egg take target was reduced to 305,309, which is needed to meet the revised release target of 247,300 smolts. Between 1998 and 2011, the egg take goal was reached 57% of the time (Table 3.6). Since 2011, the target has been reached or exceeded 100% of the time (Table 3.6).

Table 3.6. Numbers of eggs taken from steelhead broodstock, 1998-2015.

Brood year	Number of eggs taken
1998	224,315
1999	303,083
2000	280,872
2001	549,464
2002	503,030
2003	532,708
2004	408,538
2005	672,667
2006	546,382

Brood year	Number of eggs taken
2007	462,662
2008	439,980
2009	633,229
2010	499,499
2011	522,049
Average (1998-2011)	***488,782***
Median (1998-2001)	***501,265***
2012	371,151
2013	339,949
2014	395,453
2015	324,212
Average (2012-present)	***357,691***
Median (2012-present)	***355,550***

Number of acclimation days

Juvenile WxW steelhead from the Chelan Fish Hatchery and HxH steelhead from the Eastbank Fish Hatchery were transferred to Chiwawa Acclimation Facility in November 2014. In March 2015, about 28,000 HxH steelhead were transferred to Blackbird Pond near Leavenworth for acclimation on Wenatchee River water. Fish were acclimated for 41d before a volitional release was initiated on 21 April. The remainder stayed at the Chiwawa Acclimation Facility until they were volitionally and forced released from the facility during late April to early-May.

Juvenile Wenatchee steelhead at the Chiwawa Acclimation Facility were acclimated and reared on Wenatchee and Chiwawa River water. Before 2012, Wenatchee steelhead were reared on Columbia River water from January through May before being trucked and released into the Wenatchee River basin (Table 3.7).

Table 3.7. Water source and mean acclimation period for Wenatchee steelhead, brood years 1998-2015.

Brood year	Release year	Parental origin	Water source	Number of Days
1998	1999	H x H	Wenatchee/Chiwawa	36
		H x W	Wenatchee/Chiwawa	36
		W x W	Wenatchee/Chiwawa	36
1999	2000	H x H	Wenatchee/Chiwawa	138
		H x W	Wenatchee/Chiwawa	138
		W x W	Wenatchee/Chiwawa	138
		H x W	Eastbank	0
		W x W	Eastbank	0
2000	2001	H x H	Wenatchee/Chiwawa	122
		H x W	Wenatchee/Chiwawa	122
		H x W	Wenatchee/Chiwawa	122

Brood year	Release year	Parental origin	Water source	Number of Days
		W x W	Wenatchee/Chiwawa	122
2001	2002	H x H	Columbia	92
		H x H	Wenatchee/Chiwawa	63
		H x W	Columbia	92
		H x W	Wenatchee/Chiwawa	63
		W x W	Columbia	153
2002	2003	H x H	Columbia	98
		H x W	Columbia	98
		W x W	Columbia	117
2003	2004	H x H	Columbia	88
		H x W	Wenatchee/Chiwawa	84
		W x W	Columbia	148
2004	2005	H x H	Columbia	160
		H x W	Columbia	160
		W x W	Columbia	160
2005	2006	H x H	Columbia	116
		H x W	Columbia	113
		W x W	Columbia	141
2006	2007	Early H x W	Columbia	111
		Late H x W	Columbia	112
		W x W	Columbia	148
2007	2008	Early H x W	Columbia	94-95
		Late H x W	Columbia	91-93
		W x W	Columbia	138
2008	2009	Early H x W	Columbia	120-121
		Early H x W	Columbia/Wenatchee	120-121/28-95
		Late H x W	Columbia	114-115
		W x W	Columbia	152-153
2009	2010	Early H x W	Columbia	93-94
		Early H x W	Columbia/Wenatchee	99-111
		Early H x W	Wenatchee	31-129
		Late H x W	Columbia	84-87
		W x W	Columbia/Nason	118-120/28
2010	2011	H x H	Wenatchee	188-192
		H x H	Wenatchee	37-87
		H x H	Columbia	181
		W x W	Columbia	148-149

Brood year	Release year	Parental origin	Water source	Number of Days
		W x W	Columbia/Nason	113-114/42-101
		W x W	Columbia	148-149
2011	2012	W x W	Wenatchee	160-201
		W x W	Wenatchee	179-188
		W x W	Wenatchee	21-72
		W x W	Nason	56-107
2012	2013	H x H	Wenatchee	168-189
		H x H	Wenatchee	168-225
		W x W	Wenatchee	168-225
		W x W	Wenatchee	168-189
		W x W	Chiwawa	187
2013	2014	H x H	Wenatchee[a]	7-67
		H x H	Wenatchee	168-169
		W x W	Wenatchee	176-197
		W x W	Wenatchee	179-204
2014	2015	H x H	Wenatchee[a]	41-110
		H x H	Wenatchee	161-179
		W x W	Wenatchee	157-172
		W x W	Wenatchee	168-171

[a] Steelhead over wintered in Pond 3 at the Chiwawa Acclimation Facility on Chiwawa River water before they were transferred to Blackbird Pond.

Release Information

Numbers released

In 2011, the HCP Hatchery Committee agreed to reduce the Wenatchee summer steelhead program from 400,000 smolts to 247,300 smolts. Based on this new goal and the number of WxW steelhead present, all HxH steelhead were transferred to the Ringold Fish Hatchery to be included in their production program.

The release of 2014 brood Wenatchee steelhead achieved 107% of the 247,300 target goal with about 264,758 smolts released into the Wenatchee and Chiwawa rivers and Nason Creek (Table 3.8). Distribution of juvenile steelhead released in each of the three streams was determined by the mean proportion of steelhead redds in each basin. About 32.2% and 13.2% of the steelhead were released in Nason Creek and the Chiwawa River, respectively. The balance of the program was split between the Wenatchee River downstream from Tumwater Dam (10.6%) and the Wenatchee River upstream from the dam (43.9%).

Table 3.8. Numbers of steelhead smolts released from the hatchery, brood years 1998-2014. Before brood year 2011, the release target for steelhead was 400,000 smolts. Beginning with brood year 2011, the release target is 247,300 smolts.

Brood year	Release year	Number of smolts
1998	1999	172,078
1999	2000	175,701
2000	2001	184,639
2001	2002	335,933
2002	2003	302,060
2003	2004	374,867
2004	2005	294,114
2005	2006	452,184
2006	2007	299,937
2007	2008	306,690
2008	2009	327,143
2009	2010	484,772
2010	2011	354,314
Average (1998-2010)		***312,649***
Median (1998-2010)		***306,690***
2011	2012	206,397
2012	2013	249,004
2013	2014	229,836
2014	2015	264,758
Average (2011-present)		***237,499***
Median (2011-present)		***239,420***

Numbers marked

Wenatchee hatchery steelhead from the 2014 brood were marked with coded wire tags (CWT) in the snout. About 49.4% of the juveniles released were also adipose fin clipped (Table 9).

Table 3.9. Release location and marking scheme for the 1998-2014 brood Wenatchee steelhead.

Brood year	Release location	Parental origin	Proportion Ad-clip	CWT or VIE color/side	Tag rate	Number released
1998	Chiwawa River	H x H	0.000	Red Left	0.994	52,765
	Chiwawa River	H x W	0.000	Green Left	0.990	37,013
	Chiwawa River	W x W	0.000	Orange Left	0.827	82,300
1999	Wenatchee River	H x H	0.000	Green Left	0.911	45,347
	Wenatchee River	H x W	0.000	Orange Left	0.927	30,713
	Chiwawa River	H x H	0.000	Red Right	0.936	25,622

Brood year	Release location	Parental origin	Proportion Ad-clip	CWT or VIE color/side	Tag rate	Number released
	Chiwawa River	H x W	0.000	Green Right	0.936	43,379
	Chiwawa River	W x W	0.000	Orange Right	0.936	30,600
2000	Chiwawa River	H x H	0.000	Red Left	0.963	33,417
	Chiwawa River	H x W	0.000	Green Left	0.963	57,716
	Chiwawa River	H x W	0.000	Green Right	0.949	48,029
	Chiwawa River	W x W	0.000	Orange Right	0.949	45,477
2001	Nason Creek	H x W	0.000	Green Right	0.934	75,276
	Nason Creek	W x W	0.000	Orange Right	0.934	48,115
	Chiwawa River	H x W	0.000	Green Left	0.895	92,487
	Chiwawa River	H x H	0.000	Red Left	0.895	120,055
2002	Chiwawa River	H x H	0.000	Red Left	0.920	156,145
	Chiwawa River	H x W	0.000	Green Left	0.928	33,528
	Nason Creek	W x W	0.000	Orange Right	0.928	112,387
2003	Wenatchee River	H x H	0.000	Red Left	0.968	117,663
	Chiwawa River	H x W	0.000	Green Left	0.927	191,796
	Nason Creek	W x W	0.000	Orange Right	0.962	65,408
2004	Wenatchee River	H x H	0.500	Red Left	0.804	39,636
	Chiwawa River	H x W	0.000	Green Left	0.977	153,959
	Nason Creek	W x W	0.000	Pink Right	0.940	100,519
2005	Wenatchee River	H x H	1.000	Red Left	0.983	104,552
	Wenatchee River	H x W	0.616	Green Left	0.979	190,319
	Chiwawa River	H x W	0.616	Green Left	0.979	18,634
	Chiwawa River	W x W	0.000	Pink Right	0.969	14,124
	Nason Creek	W x W	0.000	Pink Right	0.969	124,555
2006	Wenatchee River	H x W (early)	1.000	Green Right	0.918	66,022
	Wenatchee River	H x W (late)	0.671	Green Left	0.935	92,176
	Chiwawa River	H x W (late)	0.671	Green Left	0.935	41,240
	Chiwawa River	W x W	0.000	Pink Right	0.945	7,500
	Nason Creek	W x W	0.000	Pink Right	0.945	92,999
2007	Wenatchee River	H x W (early)	0.967	Green Right	0.950	64,310
	Wenatchee River	H x W (late)	0.586	Green Left	0.951	97,549
	Chiwawa River	H x W (late)	0.586	Green Left	0.951	43,011

Brood year	Release location	Parental origin	Proportion Ad-clip	CWT or VIE color/side	Tag rate	Number released
	Chiwawa River	W x W	0.000	Pink Right	0.952	7,026
	Nason Creek	W x W	0.000	Pink Right	0.952	94,794
2008	Blackbird Pond	HxW (early)	0.917	Green Right	0.910	49,878
	Wenatchee River	H x W (early)	0.917	Green Right	0.910	48,624
	Wenatchee River	H x W (late)	0.595	Green Left	0.908	74,848
	Chiwawa River	H x W (late)	0.595	Green Left	0.908	25,835
	Chiwawa River	W x W	0.000	Pink Right	0.904	25,778
	Nason Creek	W x W	0.000	Pink Right	0.904	102,170
2009	Blackbird Pond	H x W (early)	0.969	Green Right	0.934	50,248
	Wenatchee River	H x W (early)	0.969	Green Right	0.934	105,239
	Wenatchee River	H x W (late)	0.973	Green Left	0.975	27,612
	Wenatchee River	H x W (late)	0.000	Green Left	0.975	45,435
	Chiwawa River	H x W (early)	0.969	Green Right	0.934	23,835
	Chiwawa River	H x W (late)	0.973	Green Left	0.975	33,047
	Chiwawa River	H x W (late)	0.000	Green Left	0.975	54,381
	Nason Creek	W x W	0.000	Pink Right	0.979	145,029
2010	Wenatchee River	H x H	0.994	-	0.984	24,838
	Wenatchee River	H x H	0.994	-	0.984	45,000
	Wenatchee River	H x H	0.994	-	0.984	92,113
	Chiwawa River	W x W	0.000	Pink Right	0.917	81,174
	Nason Creek	W x W	0.000	Pink R/Pink L	0.884	20,000
	Nason Creek	W x W	0.000	Pink Right	0.917	91,189
2011	Wenatchee River	W x W	0.985	CWT	0.953	70,885
	Wenatchee River	W x W	0.985	CWT	0.953	24,992
	Wenatchee River	W x W	0.000	CWT	0.987	25,569
	Chiwawa River	W x W	0.985	CWT	0.953	31,050
	Nason Creek	W x W	0.000	CWT	0.989	18,254
	Nason Creek	W x W	0.985	CWT	0.953	36,225
2012	Wenatchee River	W x W	0.000	CWT	0.965	14,824
	Wenatchee River	H x H	1.000	AD/CWT	0.920	9,841
	Wenatchee River	W x W	0.000	CWT	0.965	28,362
	Wenatchee River	H x H	1.000	AD/CWT	0.920	76,695

Brood year	Release location	Parental origin	Proportion Ad-clip	CWT or VIE color/side	Tag rate	Number released
	Chiwawa River	W x W	0.000	CWT	0.965	12,760
	Chiwawa River	H x H	1.000	AD/CWT	0.920	34,503
	Nason Creek	W x W	0.000	CWT	0.965	43,854
	Nason Creek	W x W	0.000	CWT	0.965	28,165
2013	Wenatchee River	W x W	0.000	CWT	0.963	36,736
	Wenatchee River	H x H	0.998	AD/CWT	0.990	55,055
	Wenatchee River	H x H	0.998	AD/CWT	0.990	25,316
	Chiwawa River	W x W	0.000	CWT	0.963	9,360
	Chiwawa River	H x H	0.998	AD/CWT	0.990	14,040
	Nason Creek	W x W	0.000	CWT	0.963	50,503
	Nason Creek	H x H	0.998	AD/CWT	0.990	38,826
2014	Wenatchee River	W x W	0.000	CWT	0.968	72,345
	Wenatchee River	H x H	0.996	AD/CWT	0.996	58,130
	Wenatchee River	H x H	0.996	AD/CWT	0.996	28,122
	Chiwawa River	W x W	0.000	CWT	0.968	20,443
	Chiwawa River	H x H	0.996	AD/CWT	0.996	14,599
	Nason Creek	W x W	0.000	CWT	0.968	41,188
	Nason Creek	H x H	0.996	AD/CWT	0.996	29,931

Numbers PIT tagged

Table 3.10 summarizes the number of hatchery steelhead of different parental origins that have been PIT-tagged and released into the Wenatchee River basin.

Table 3.10. Summary of PIT-tagging activities for Wenatchee hatchery steelhead, brood years 2006-2014.

Brood year	Release location	Parental origin	Number of fish tagged	Number of tagged fish that died	Number of tags shed	Number of tagged fish released
2006	Wenatchee River	H x W (early)	10,036	479	24	9,533
	Wenatchee/Chiwawa rivers	H x W (late)	10,031	922	20	9,089
	Chiwawa River/Nason	W x W	10,019	152	352	9,515
2007	Wenatchee River	H x W (early)	9,852	22	10	9,820
	Wenatchee/Chiwawa rivers	H x W (late)	10,063	73	78	9,912
	Chiwawa River/Nason	W x W	10,038	55	1	9,982
2008	Wenatchee River	H x W (early)	10,101	59	15	10,027

Brood year	Release location	Parental origin	Number of fish tagged	Number of tagged fish that died	Number of tags shed	Number of tagged fish released
	Wenatchee/Chiwawa rivers	H x W (late)	10,104	106	17	9,981
	Chiwawa River/Nason	W x W	10,101	159	80	9,862
2009	Wenatchee/Chiwawa rivers	H x W (early)	10,114	574	11	9,529
	Wenatchee (Blackbird)	H x W (early)	8,100	0	0	8,100
	Wenatchee/Chiwawa rivers	H x W (late)	10,115	271	11	9,833
	Chiwawa pilot	H x W (early)	10,107	532	103	9,472
	Chiwawa River/Nason	W x W	10,101	38	3	10,060
2010	Wenatchee River	HxH	10,100	624	21	9,455
	Chiwawa River/Nason	WxW	10,100	206	0	9,894
	Wenatchee (Blackbird)	HxH	10,101	235	8	9,858
	Wenatchee River	HxH	10,100	46	28	10,026
2011	Wenatchee/Chiwawa/Nason	WxW (circular)	10,101	139	30	9,932
	Wenatchee/Chiwawa/Nason	WxW (raceway)	20,220	121	35	20,064
2012	Wenatchee/Chiwawa/Nason	WxW (circular)	15,244	176	4	15,064
	Wenatchee/Chiwawa/Nason	HxH (raceway)	10,223	140	13	10,070
2013	Wenatchee/Chiwawa/Nason	WxW	5,100	95	1	5,004
	Wenatchee/Chiwawa/Nason	HxH	10,201	84	12	10,105
2014	Wenatchee/Chiwawa/Nason	WxW	9,051	53	0	8,998
	Wenatchee/Chiwawa/Nason	HxH	10,129	243	76	9,810

2015 Brood Wenatchee WxW Summer Steelhead—A total of 10,100 Wenatchee WxW summer steelhead were PIT tagged at Chelan Hatchery on 8-15 September 2015. These fish were tagged in raceways #2 through #6. Fish were not fed during tagging or for two days before and after tagging. Fish averaged 89 mm in length and 8.5 g at time of tagging.

In March 2016, an additional 2,001 WxW summer steelhead were tagged at the Chiwawa Acclimation Facility. These fish were tagged in circular ponds #1 and #3. Fish were not fed during tagging or for two days before and after tagging. Fish averaged 163-168 mm in length and 53.0-57.0 g at time of tagging.

2015 Brood Wenatchee HxH Summer Steelhead—A total of 11,115 Wenatchee HxH summer steelhead were tagged PIT at Eastbank Hatchery on 31 August – 28 September 2015. These fish were tagged in raceway #3. Fish were not fed during tagging or for two days before and after tagging. Fish tagged in early September averaged 75 mm in length and 5.2 g. Those tagged on 28 September averaged 81 mm in length and 7.3 g.

Fish size and condition at release

With the exception of the Blackbird Pond release, all 2014 brood steelhead were trucked and released as yearling smolts in April and May 2015. The Blackbird Pond group was released volitionally beginning on 21 April. Both WxW and HxH fish did not meet the targets for length, weight, or coefficient of variation (CV) for fork length (Table 3.11). The HxH group was combined with the WxW group in Pond 2 once they were transferred to Chiwawa Acclimation Facility. The HxH fish were smaller than the WxW fish, both at transfer and at release.

Table 3.11. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of steelhead smolts released from the hatchery, brood years 1998-2014. Size targets are provided in the last row of the table.

Brood year	Release year	Parental origin	Fork length (mm)		Mean weight	
			Mean	CV	Grams (g)	Fish/pound
1998	1999	H x H	201	11.1	92.3	5
		H x W	190	12.8	76.9	6
		W x W	173	12.0	55.3	8
1999	2000	H x H	181	8.9	70.6	6
		H x W	187	7.2	75.3	6
		W x W	184	11.3	71.5	6
2000	2001	H x H	218	15.2	122.4	4
		H x W	209	10.6	107.5	4
		W x W	205	10.7	100.9	5
2001	2002	H x H	179	17.4	67.0	7
		H x W	192	15.6	82.8	6
		W x W	206	11.6	102.6	4
2002	2003	H x H	194	13.1	83.0	6
		H x W	191	13.0	77.4	6
		W x W	180	19.1	70.3	7
2003	2004	H x H	191	14.4	73.1	6
		H x W	199	12.9	83.9	5
		W x W	200	11.1	90.1	5
2004	2005	H x H	204	11.3	87.2	6
		H x W	202	13.5	71.9	5
		W x W	198	12.4	76.6	6
2005	2006	H x H	215	12.6	116.6	4
		H x W	198	11.8	86.3	5
		W x W	189	15.4	55.3	6
2006	2007	H x H (early)	213	12.1	109.6	4
		H x W (late)	186	11.8	68.3	7
		W x W	178	11.1	58.6	8

Brood year	Release year	Parental origin	Fork length (mm)		Mean weight	
			Mean	CV	Grams (g)	Fish/pound
2007	2008	H x W (early)	192	17.4	77.1	6
		H x W (late)	179	19.3	63.8	7
		W x W	183	12.3	62.8	7
2008	2009	H x W (early)	184	11.6	68.0	7
		H x W (late)	186	11.6	73.5	6
		W x W	181	13.0	59.7	8
2009	2010	H x W (early)	197	11.3	84.2	5
		H x W (late)	192	11.1	72.7	6
		W x W	190	9.6	70.5	6
2010	2011	H x H	183	14.1	68.9	4
		W x W	188	10.5	68.1	7
2011	2012	H x H	NA	NA	NA	NA
		W x W	156	17.1	45.2	10
2012	2013	H x H / W x W	150	16.1	40.8	11
		H x H / W x W	157	16.4	45.0	10
		W x W	156	18.7	49.0	9
2013	2014	H x H / W x W	157	14.5	49.4	9
		H x H	127	16.2	26.8	17
		W x W	162	20.4	55.8	8
2014	2015	H x H / W x W	152	15.4	40.9	11
		H x H	145	13.5	36.6	12
		W x W	162	15.3	50.6	9
Targets			***191***	***9.0***	***75.6***	***6***

Survival Estimates

Overall survival of Wenatchee steelhead (WxW and HxH) from green (unfertilized) egg to release was below the standard set for the program. This is largely because of lower unfertilized egg to eyed egg survival, and 100 days after ponding survival (Table 3.12).

The Wenatchee steelhead program, from its inception, has experienced highly variable fertilization rates. It is unknown at this time what mechanisms may be influencing stock performance at these stages.

Table 3.12. Hatchery life-stage survival rates (%) for steelhead, brood years 1998-2014. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
1998	92.0	100.0	85.5	91.7	99.2	98.8	97.8	99.9	76.7
1999	91.2	100.0	66.9	93.0	95.9	94.9	93.1	99.7	58.0
2000	83.9	96.2	77.6	86.7	99.3	98.9	97.7	99.5	65.7
2001	90.0	100.0	73.0	91.8	99.1	97.8	91.3	99.7	61.1
2002	99.0	100.0	69.2	93.1	95.9	94.4	89.6	89.6	60.0
2003	87.0	96.8	86.3	83.8	97.2	94.8	97.6	85.3	70.4
2004	97.6	98.5	83.4	93.7	97.8	94.1	92.2	99.9	72.0
2005	91.3	95.1	81.3	92.1	95.6	91.8	89.7	99.6	67.2
2006	99.1	95.3	73.2	85.4	95.4	94.6	87.8	98.5	54.9
2007	100.0	100.0	80.3	92.0	95.7	92.7	89.8	99.1	66.3
2008	100.0	100.0	87.1	88.4	99.0	97.4	96.6	99.5	74.4
2009	97.3	100.0	89.0	97.2	96.0	95.2	88.6	96.6	76.6
2010	96.7	100.0	93.8	93.9	91.0	86.2	80.6	96.0	70.9
2011[a]	96.3	94.4	74.2	97.7	96.6	89.5	86.4	98.4	62.7
2012	95.2	98.4	74.7	99.7	97.8	94.0	90.1	98.9	67.1
2013	80.8	97.0	75.0	96.5	97.8	96.6	93.4	99.2	67.6
2014	100.0	100.0	83.3	96.7	95.8	89.9	87.9	98.7	70.8
Average	***94.0***	***98.3***	***79.6***	***92.6***	***96.8***	***94.2***	***91.2***	***97.5***	***67.2***
Median	***96.3***	***100.0***	***80.3***	***93.0***	***96.6***	***94.6***	***90.1***	***99.1***	***67.2***
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

[a] Survival estimates are only for WxW steelhead.

3.3 Disease Monitoring

Rearing of the 2014 brood Wenatchee summer steelhead was similar to previous years with fish being held on Chelan spring water, Eastbank well water, and Chelan well water before being transferred for overwinter acclimation at the Chiwawa Acclimation Facility. Volitional and non-migratory released fish were released into Nason Creek, Chiwawa River, and the Wenatchee River. The 2014 WxW Wenatchee steelhead were treated for bacterial cold-water disease at Chelan Hatchery in August 2014. The mixed population of WxW and HxH 2014 Wenatchee steelhead was also treated for bacterial cold-water disease in February 2015 at Chiwawa Acclimation Facility.

3.4 Natural Juvenile Productivity

During 2015, juvenile steelhead were sampled at the Lower Wenatchee, Chiwawa, and Nason Creek traps and counted during snorkel surveys within the Chiwawa River basin. Because the snorkel surveys targeted juvenile Chinook salmon, the entire distribution of juvenile steelhead in the Chiwawa River basin was not surveyed. Therefore, the parr numbers presented below represent a minimum estimate.

Parr Estimates

A total of 10,208 (±11%) age-0 (<100 mm) and 754 (±26%) age-1+ (100-200 mm)[4] steelhead/rainbow were estimated in the Chiwawa River basin in August 2015 (Table 3.13 and 3.14). During the survey period 1992-2015, numbers of age-0 and 1+ steelhead/rainbow have ranged from 1,410 to 45,727 and 754 to 22,130, respectively, in the Chiwawa River basin (Table 3.13 and 3.14; Figure 3.1). The number of age-1+ steelhead/rainbow counted in 2015 was the lowest number recorded during the more than 20-year survey period. Numbers of all fish counted in the Chiwawa River basin are reported in Appendix A.

Juvenile steelhead/rainbow were distributed primarily throughout the lower seven reaches of the Chiwawa River (downstream from Rock Creek). Their densities were highest in the lower portions of the river and in tributaries. Age-0 steelhead/rainbow most often used riffle and multiple channel habitats in the Chiwawa River, although they also associated with woody debris in pool and glide habitat. In tributaries they were generally most abundant in small pools. Those that were observed in riffles selected stations in quiet water behind small and large boulders, or occupied stations in quiet water along the stream margin. In pool and multiple-channel habitats, age-0 steelhead/rainbow used the same kinds of habitat as age-0 Chinook salmon.

Age-1+ steelhead/rainbow most often used pool, riffle, and multiple-channel habitats. Those that used pools were usually in deeper water than subyearling steelhead/rainbow and Chinook salmon. Like age-0 steelhead/rainbow, age-1+ steelhead/rainbow generally selected stations in quiet water behind boulders in riffles, but the two age groups rarely occurred together. Age-1+ steelhead/rainbow used deeper and faster water than did subyearling steelhead/rainbow.

Table 3.13. Total numbers of age-0 steelhead/rainbow trout estimated in different steams in the Chiwawa River basin during snorkel surveys in August 1992-2015; NS = not sampled.

Sample Year	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Unnamed Creek	Big Meadow Creek	Alder Creek	Brush Creek	Clear Creek	Total
1992	4,927	NS	NS	NS	NS	NS	NS	NS	NS	**4,927**
1993	3,463	0	356	185	NS	NS	NS	NS	NS	**4,004**
1994	953	0	256	24	0	177	0	0	0	**1,410**
1995	6,005	0	744	90	0	371	40	107	0	**7,357**
1996	3,244	0	71	40	0	763	127	0	0	**4,245**
1997	6,959	224	84	324	0	1,124	58	50	0	**8,823**
1998	2,972	22	280	96	113	397	18	22	0	**3,921**
1999	5,060	20	253	189	0	255	34	27	0	**5,838**
2000	NS	NS	NS	NS	NS	NS	NS	NS	NS	**NS**
2001	35,759	192	1,449	1,826	0	6,345	156	0	0	**45,727**
2002	12,137	0	2,252	889	0	4,948	277	18	0	**20,521**
2003	9,911	296	996	1,166	96	5,366	73	116	0	**18,020**
2004	8,464	110	583	113	40	957	35	78	0	**10,380**
2005	4,852	120	2,931	477	45	2,973	65	0	0	**11,463**
2006	10,669	21	858	872	34	3,647	73	71	0	**16,245**
2007	8,442	53	2,137	348	11	2,955	65	28	34	**14,073**

4 A steelhead/rainbow trout larger than 200 mm (8 in) was considered a resident trout.

Sample Year	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Unnamed Creek	Big Meadow Creek	Alder Creek	Brush Creek	Clear Creek	Total
2008	9,863	0	2,260	859	0	1,987	57	168	36	**15,230**
2009	13,231	0	1,183	449	0	2,062	170	67	17	**17,179**
2010	17,572	0	2,870	1,478	5	2,843	182	35	33	**25,018**
2011	35,825	0	1,503	804	0	1,066	56	152	40	**39,446**
2012	21,537	0	1,817	1,501	0	2,164	42	54	19	**27,134**
2013	17,889	0	602	816	0	2,189	44	99	43	**21,682**
2014	12,256	21	1,617	1,039	0	1,005	32	56	57	**16,083**
2015	4,532	0	1,989	1,675	0	1,761	170	62	19	**10,208**
Average	***11,153***	***49***	***1,231***	***694***	***16***	***2,160***	***84***	***58***	***14***	***15,171***
Median	***8,464***	***0***	***1,090***	***641***	***0***	***1,987***	***58***	***54***	***0***	***14,073***

Table 3.14. Total numbers of age-1+ steelhead/rainbow trout estimated in different steams in the Chiwawa River basin during snorkel surveys in August 1992-2015; NS = not sampled.

Sample Year	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Unnamed Creek	Big Meadow Creek	Alder Creek	Brush Creek	Clear Creek	Total
1992	2,533	NS	NS	NS	NS	NS	NS	NS	NS	**2,533**
1993	2,530	0	228	102	NS	NS	NS	NS	NS	**2,860**
1994	4,972	0	476	296	5	107	0	0	0	**5,856**
1995	8,769	0	494	71	0	183	0	0	0	**9,517**
1996	11,381	0	6	27	0	435	0	0	0	**11,849**
1997	6,574	160	0	105	0	66	0	0	0	**6,905**
1998	10,403	0	133	49	0	0	0	0	0	**10,585**
1999	21,779	0	68	201	0	82	0	0	0	**22,130**
2000	NS	NS	NS	NS	NS	NS	NS	NS	NS	**NS**
2001	9,368	16	186	407	0	646	0	0	0	**10,623**
2002	7,200	0	199	165	0	1,526	0	0	0	**9,090**
2003	4,745	362	426	599	0	47	0	0	0	**6,179**
2004	7,700	107	209	0	0	174	0	0	0	**8,190**
2005	4,624	63	957	257	0	287	0	0	0	**6,188**
2006	7,538	76	748	1,186	0	985	0	0	0	**10,533**
2007	6,976	0	945	96	0	431	0	0	0	**8,448**
2008	8,317	0	1,168	298	0	793	0	0	0	**10,576**
2009	4,998	16	320	102	0	167	21	0	5	**5,629**
2010	8,324	32	366	393	0	780	21	0	0	**9,916**
2011	13,329	0	415	470	0	689	0	0	0	**14,903**
2012	7,671	0	285	410	0	210	0	0	0	**8,576**
2013	6,439	0	0	48	0	766	0	0	0	**7,253**
2014	4,568	13	96	211	0	165	0	0	31	**5,084**
2015	614	0	40	100	0	0	0	0	0	**754**
Average	***7,450***	***38***	***353***	***254***	***0***	***407***	***2***	***0***	***2***	***8,442***

Sample Year	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Unnamed Creek	Big Meadow Creek	Alder Creek	Brush Creek	Clear Creek	Total
Median	***7,200***	***0***	***257***	***183***	***0***	***210***	***0***	***0***	***0***	***8,448***

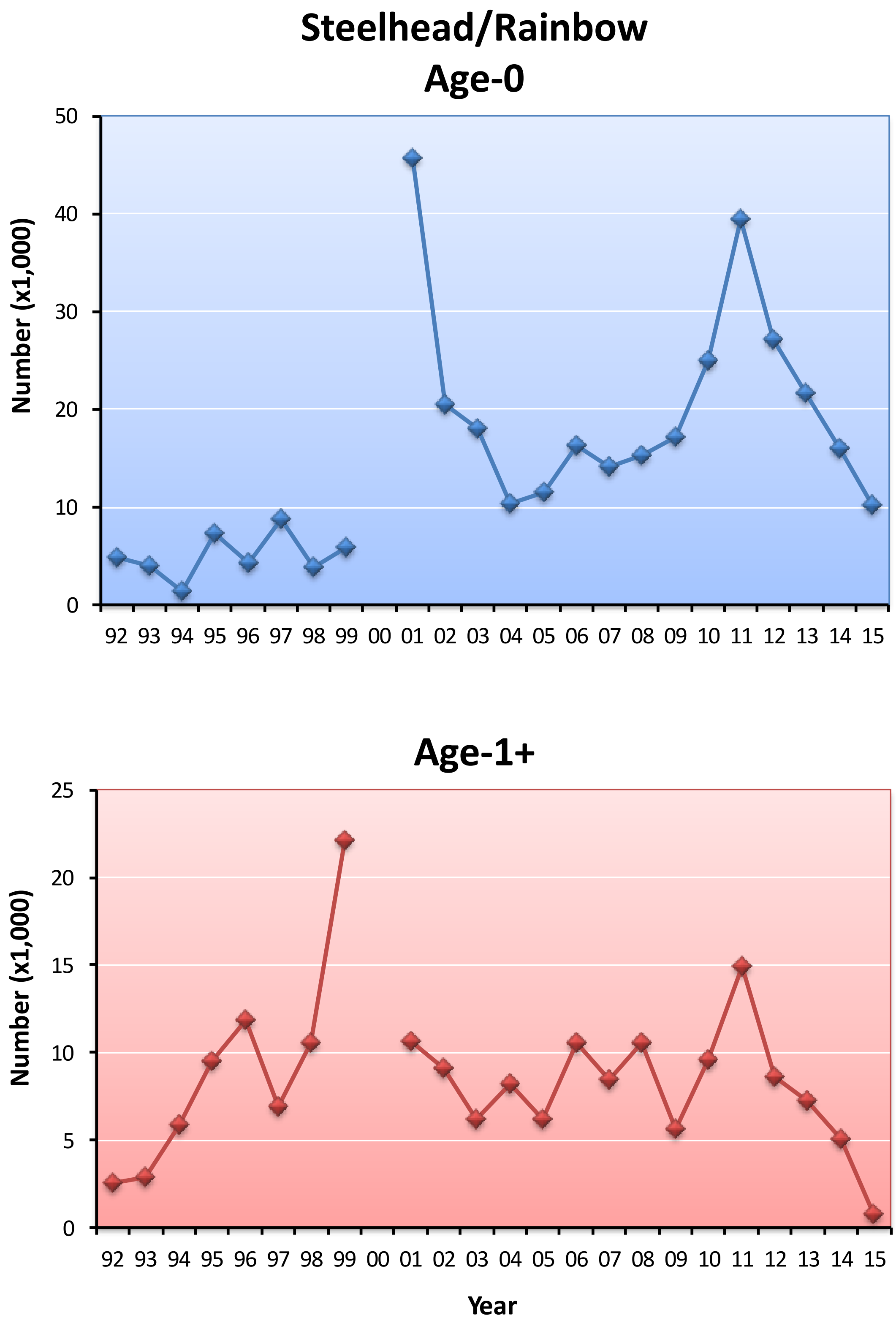

Figure 3.1. Numbers of subyearling and yearling steelhead/rainbow trout within the Chiwawa River basin in August 1992-2015; ND = no data.

Emigrant and Smolt Estimates

Numbers of steelhead smolts and emigrants were estimated at the Chiwawa, Nason, and Lower Wenatchee traps in 2015.

Chiwawa Trap

The Chiwawa Trap operated between 25 February and 24 November 2015. During the trapping period, the trap was inoperable for 29 days due to high or low river discharge, debris, and major hatchery releases. The trap operated in two different positions based on season and river discharge; lower position until 30 June and an upper position after 1 July. Monthly captures of all fish collected at the Chiwawa Trap are reported in Appendix B.

A total of 259 wild steelhead/rainbow smolts and transitionals, 3,151 hatchery smolts, transitionals, and parr, and 3,004 wild parr and fry were captured at the Chiwawa Trap. Most (77%) of the hatchery steelhead were collected in May, while most (86%) of the wild steelhead smolts were captured in April and May (Figure 3.2). Although steelhead/rainbow parr and fry emigrated throughout the sampling period, peaks in emigration were observed in May through June, August, and October through November (Figure 3.2). Of the total number of wild steelhead captured, 92% were classified as parr and fry. Because of low and inconsistent capture rates, no mark-recapture efficiency trials could be conducted with steelhead/rainbow at the Chiwawa Trap to estimate steelhead emigration.

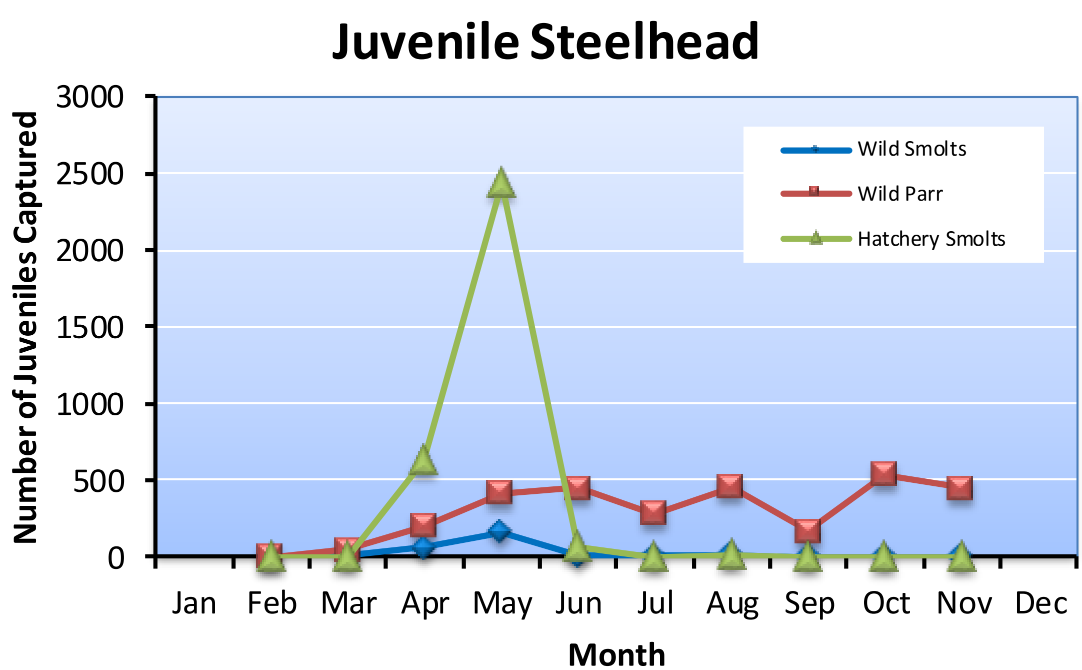

Figure 3.2. Monthly captures of wild smolts, wild parr, and hatchery smolt steelhead/rainbow at the Chiwawa Trap, 2015.

Nason Creek Trap

The Nason Creek Trap operated between 1 March and 30 November 2015. During the nine-month sampling period the trap was inoperable for 105 days because of low discharge and ice accumulation. The trap captured a total of 12 wild steelhead smolts, 448 hatchery steelhead smolts, 388 wild steelhead parr, and 30 wild steelhead fry. The estimated wild steelhead emigration for brood year 2012 was 25,566 (± 6,020). Egg-to-emigrant survival rate for brood year 2012 steelhead was 3.0% and the egg-to-emigrant survival rate for brood year 2011 was 0.9%. Productivity, measured as emigrants-per-redd, was 162.

Lower Wenatchee Trap

The Lower Wenatchee Trap operated between 30 January and 28 June 2015. During that time period the trap was inoperable for five days because of too high and low river discharge, debris, elevated river temperatures, and large hatchery releases. During the sampling period, a total of 100 wild steelhead parr and fry, 231 wild steelhead smolts, and 2,288 hatchery steelhead were captured at the trap. Because of the low numbers of steelhead encountered daily at the trap, it was not possible to carry out mark-recapture trials using steelhead. In addition, because there was a poor relationship between trap efficiency and river flow, a pooled estimate was used to derive the number of steelhead emigrants. Using this pooled method, it was estimated that 8,632 (±45,053) steelhead emigrated out of the Wenatchee during the trapping season. Figure 3.3 shows the monthly captures of steelhead collected at the Lower Wenatchee Trap. All fish captured in the trap are reported in Appendix B.

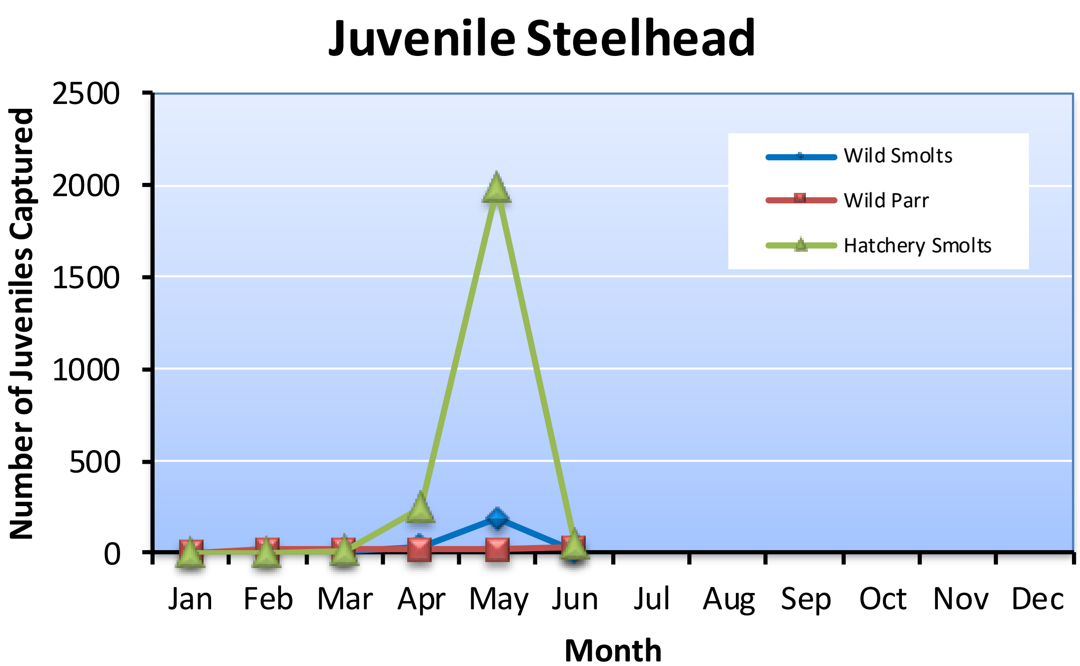

Figure 3.3. Monthly captures of wild smolts, wild parr, and hatchery smolt steelhead/rainbow at the Lower Wenatchee Trap, 2015.

PIT Tagging Activities

As part of the Comparative Survival Study (CSS) and PUD studies, a total of 2,476 juvenile steelhead/rainbow trout (2,474 wild and two hatchery) were PIT tagged and released in 2015 in the Wenatchee River basin (Table 3.15a). Most of these were tagged at the Chiwawa Trap. See Appendix C for a complete list of all fish captured, tagged, lost, and released.

Table 3.15a. Numbers of wild and hatchery steelhead/rainbow trout that were captured, tagged, and released at different locations within the Wenatchee River basin, 2015. Numbers of fish that died or shed tags are also given.

Sampling Location	Species and Life Stage	Number captured	Number of recaptures	Number tagged	Number died	Shed tags	Total tags released	Percent mortality
Chiwawa Trap	Wild Steelhead	3,262	6	1,795	23	0	1,795	0.69
	Hatchery Steelhead	3,152	2	1	0	0	1	0.00
	Total	**6,414**	**8**	**1,796**	**23**	**0**	**1,796**	**0.36**
Nason Creek Trap	Wild Steelhead	444	1	383	2	1	383	0.45
	Hatchery Steelhead	448	0	0	1	0	0	0.22
	Total	**892**	**1**	**383**	**3**	**1**	**383**	**0.34**
White River Trap	Wild Steelhead	6	0	6	0	0	6	0.00
	Hatchery Steelhead	0	0	0	0	0	0	--
	Total	**6**	**0**	**6**	**0**	**0**	**6**	**0.00**
Lower Wenatchee Trap	Wild Steelhead	311	0	290	2	0	290	0.64
	Hatchery Steelhead	2,288	0	1	0	0	1	0.00
	Total	**2,599**	**0**	**291**	**2**	**0**	**291**	**0.08**
Total:	**Wild Steelhead**	**4,023**	**7**	**2,474**	**27**	**1**	**2,474**	**0.67**
	Hatchery Steelhead	**5,888**	**2**	**2**	**1**	**0**	**2**	**0.02**
Grand Total:		**9,911**	**9**	**2,476**	**28**	**1**	**2,476**	**0.28**

Numbers of steelhead/rainbow PIT-tagged and released as part of CSS and PUD studies during the period 2006-2015 are shown in Table 3.15b.

Table 3.15b. Summary of the numbers of wild and hatchery steelhead/rainbow trout that were tagged and released at different locations within the Wenatchee River basin, 2006-2015.

Sampling Location	Species and Life Stage	Numbers of PIT-tagged steelhead/rainbow released									
		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Chiwawa Trap	Wild Steelhead	1,366	832	1,431	1,127	930	1,012	1,011	1,228	1,186	1,795
	Hatchery Steelhead	0	3	2	1	2	1	2	0	3	1
	Total	**1,366**	**835**	**1,433**	**1,128**	**932**	**1,013**	**1,013**	**1,228**	**1,189**	**1,796**
Chiwawa River (Angling or Electrofishing)	Wild Steelhead	33	167	94	35	99	0	0	0	23	0
	Hatchery Steelhead	1	47	35	43	64	0	0	0	0	0
	Total	**34**	**214**	**129**	**78**	**163**	**0**	**0**	**0**	**23**	**0**
Upper Wenatchee Trap[1]	Wild Steelhead	21	37	24	46	69	82	70	43	0	0
	Hatchery Steelhead	0	0	0	0	0	0	0	0	0	0
	Total	**21**	**37**	**24**	**46**	**69**	**82**	**70**	**43**	**0**	**0**
	Wild Steelhead	1,167	1,335	2,154	753	1,557	805	1,087	1,998	838	383

Sampling Location	Species and Life Stage	Numbers of PIT-tagged steelhead/rainbow released									
		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Nason Creek Trap	Hatchery Steelhead	0	0	0	0	0	0	538	0	0	0
	Total	**1,167**	**1,335**	**2,154**	**753**	**1,557**	**805**	**1,625**	**1,998**	**838**	**383**
Nason Creek (Angling or Electrofishing)	Wild Steelhead	174	452	255	459	318	0	0	0	0	0
	Hatchery Steelhead	26	75	87	197	32	0	0	0	0	0
	Total	**200**	**527**	**342**	**656**	**350**	**0**	**0**	**0**	**0**	**0**
White River Trap	Wild Steelhead	0	0	0	12	10	5	5	6	5	6
	Hatchery Steelhead	0	0	0	0	0	0	0	0	0	0
	Total	**0**	**0**	**0**	**12**	**10**	**5**	**5**	**6**	**5**	**6**
Upper Wenatchee (Angling or Electrofishing)	Wild Steelhead	413	1,001	21	7	30	0	0	0	0	0
	Hatchery Steelhead	2	64	26	23	9	0	0	0	0	0
	Total	**415**	**1,065**	**47**	**30**	**39**	**0**	**0**	**0**	**0**	**0**
Middle Wenatchee (Angling or Electrofishing)	Wild Steelhead	0	0	981	867	1,517	0	0	850	0	0
	Hatchery Steelhead	0	0	11	5	57	0	0	2	0	0
	Total	**0**	**0**	**992**	**872**	**1,574**	**0**	**0**	**852**	**0**	**0**
Lower Wenatchee (Angling or Electrofishing)	Wild Steelhead	0	0	102	69	0	0	0	0	0	0
	Hatchery Steelhead	0	0	10	9	0	0	0	0	0	0
	Total	**0**	**0**	**112**	**78**	**0**	**0**	**0**	**0**	**0**	**0**
Peshastin Creek (Angling or Electrofishing)	Wild Steelhead	0	0	0	92	307	0	0	0	0	0
	Hatchery Steelhead	0	0	0	0	0	0	0	0	0	0
	Total	**0**	**0**	**0**	**92**	**307**	**0**	**0**	**0**	**0**	**0**
Lower Wenatchee Trap	Wild Steelhead	131	461	285	227	465	0	0	613	133	290
	Hatchery Steelhead	0	0	0	1	0	0	0	0	4	1
	Total	**131**	**461**	**285**	**228**	**465**	**0**	**0**	**613**	**137**	**291**
Total:	**Wild Steelhead**	**3,305**	**4,285**	**5,347**	**3,694**	**5,302**	**1,904**	**2,173**	**4,738**	**2,185**	**2,474**
	Hatchery Steelhead	**29**	**189**	**171**	**279**	**164**	**1**	**540**	**2**	**7**	**2**
Grand Total:		**3,334**	**4,474**	**5,518**	**3,973**	**5,466**	**1,905**	**2,713**	**4,740**	**2,192**	**2,476**

[1] 2013 was the last year that the Upper Wenatchee Trap operated.

3.5 Spawning Surveys

Surveys for steelhead redds were conducted during March through early June, 2015, in the mainstem Wenatchee River and portions of select tributaries (Chiwawa River, Nason Creek, and Peshastin Creek). Beginning in 2014, adult steelhead escapement estimates in the majority of tributaries in the Wenatchee River basin were generated using mark-recapture techniques based on steelhead PIT tagged at Priest Rapids Dam (BPA funded; see Appendix D and Truscott et al. 2015 for details).

Redd Counts

A total of 249 steelhead redds were counted in the Wenatchee River and the lower portions of select tributaries in 2015 (Table 3.16). Because steelhead escapement estimates in tributaries are based on mark-recapture techniques, there are no or limited redd counts in tributaries beginning in 2014. Additionally, mainstem redd counts since 2014 were expanded based on estimates of observer efficiency (see Appendix D). Thus, evaluation of trends in redd counts is appropriate only before 2014.

Table 3.16. Numbers of steelhead redds estimated within different streams/watersheds within the Wenatchee River basin, 2001-2015; NS = not surveyed. Redd counts from 2004-2013 have been conducted within the same areas and with the same methods. Beginning in 2014, complete redd counts were conducted only within the mainstem Wenatchee River. Therefore, trends in redd counts are only appropriate for the mainstem Wenatchee River from 2004 through 2013.

Survey year	Number of steelhead redds							
	Chiwawa	Nason	Little Wenatchee	White	Wenatchee River[a]	Icicle	Peshastin	Total
2001	25	27	NS	NS	116	19	NS	**187**
2002	80	80	1	0	315	27	NS	**503**
2003	64	121	5	3	248	16	15	**472**
2004	62	127	0	0	151	23	34	**397**
2005	162	412	0	2	459	8	97	**1,140**
2006	19	77	NS	0	191	41	67	**395**
2007	11	78	0	1	46	6	17	**159**
2008	11	88	NS	1	100	37	49	**286**
2009	75	126	0	0	327	102	32	**662**
2010	74	270	4	3	380	120	118	**969**
2011	77	235	2	0	323	180	115	**932**
2012	8	158	0	0	137	47	65	**415**
2013	27	135	NS	NS	200	48	62	**472**
2014	5	0	NS	NS	195[b]	NS	5	**205**
2015	1	1	NS	NS	258[b]	NS	1	**262**

[a] Includes redds in Beaver and Chiwaukum creeks.
[b] Steelhead redd counts in the mainstem Wenatchee River were expanded based on estimated observer efficiency (see Appendix D).

Redd Distribution

Steelhead redds were not evenly distributed among survey reaches on the Wenatchee River in 2015 (Table 3.17). About 78.1% of the spawning in the Wenatchee River occurred upstream from Tumwater Dam (Table 3.17).

Table 3.17. Numbers and percentages of steelhead redds counted within different reaches on the Wenatchee River during March through early June, 2015; CV = coefficient of variation.

Reach	Reach type	Number of redds counted	Expanded redd counts		Percent of redds within stream/watershed
			Estimated	CV	
Wenatchee 1 (W1)	Non-index	0	0	NA	0.0
Wenatchee 2 (W2)	Index	2	3	1.50	1.0

Reach	Reach type	Number of redds counted	Expanded redd counts		Percent of redds within stream/watershed
			Estimated	CV	
Wenatchee 3 (W3)	Non-index	1	2	0.30	0.6
Wenatchee 4 (W4)	Non-index	0	0	NA	0.0
Wenatchee 5 (W5)	Non-index	5	10	0.22	3.2
Wenatchee 6 (W6)	Index	54	53	0.88	17.0
Wenatchee 6 (W6)	Non-index	0	0	NA	0.0
Wenatchee 7 (W7)	NS	NS	NS	NS	NS
Wenatchee 8 (W8)	Index	9	10	0.95	3.2
Wenatchee 9 (W9)	Index	81	102	0.91	32.8
Wenatchee 9 (W9)	Non-index	4	6	0.15	1.9
Wenatchee 10 (W10)	Index	99	120	0.65	38.6
Wenatchee 10 (W10)	Non-index	3	5	0.13	1.6
Total		**258**	**311**	**0.42**	**100.0**

Spawn Timing

Steelhead began spawning during the first week of March in the Wenatchee River. Spawning activity appeared to begin once the mean daily stream temperature reached about 5.5°C and was observed in water temperatures ranging from 3.7-8.8°C. Steelhead spawning peaked during the third week of April in the Wenatchee River (Figure 3.4).

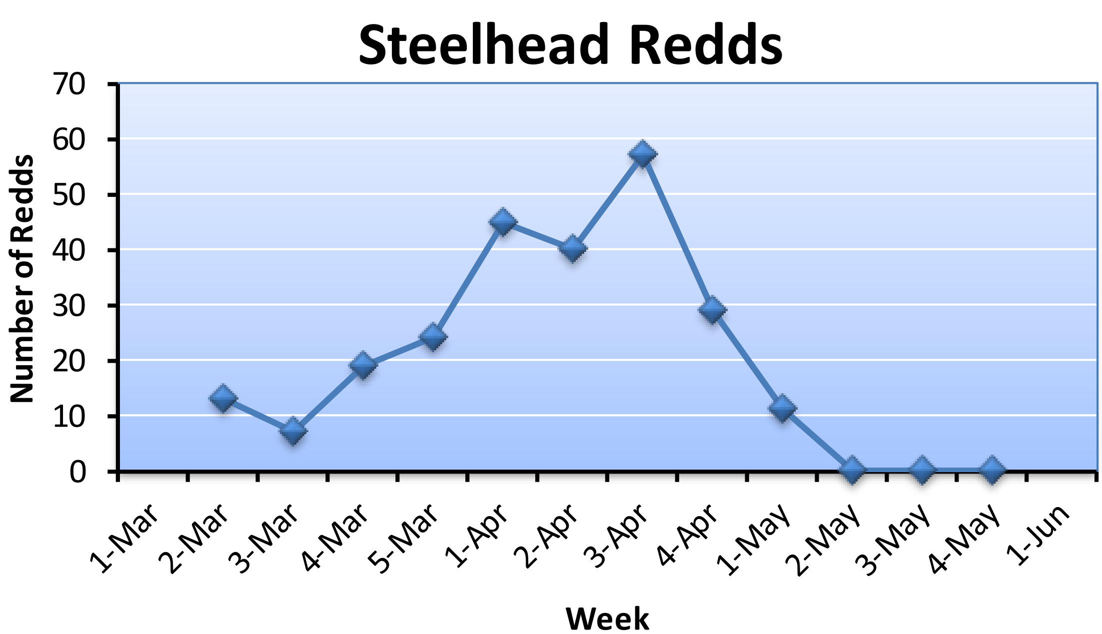

Figure 3.4. Numbers of steelhead redds counted during different weeks on the Wenatchee River, March through early June 2015.

Spawning Escapement

Before 2014, steelhead spawning escapement upstream from Tumwater Dam was calculated as the number of redds (in the Wenatchee River and tributaries upstream from the dam) times the fish per redd ratio (based on sex ratios estimated at Tumwater Dam using video surveillance). Beginning in 2014, escapement in tributaries was estimated using PIT-tag mark-recapture techniques (Truscott et al. 2015; Table 3.18), while observer efficiency expanded redd counts were used to estimate escapement in the mainstem Wenatchee River (Appendix D). Total redd counts were also used to estimate escapement in the lower portions of the main tributaries (downstream from the PIT interrogation sites).

Table 3.18. Spawning escapement estimates for natural-origin and hatchery-origin steelhead within tributaries of the Wenatchee River, brood year 2015. Escapement estimates were based on PIT-tag mark-recapture techniques (Truscott et al. 2015). CV = coefficient of variation and NA = no available.

Tributary	Natural-origin steelhead		Hatchery-origin steelhead	
	Estimate	CV	Estimate	CV
Mission Creek	71	0.28	23	0.49
Peshastin Creek	206	0.16	40	0.37
Chumstick Creek	38	0.39	0	NA
Icicle Creek	83	0.25	52	0.32
Chiwaukum Creek	48	0.34	12	0.72
Chiwawa River	168	0.21	168	0.23
Nason Creek	237	0.15	68	0.29

The estimated fish per redd ratio for steelhead in 2015 was 1.78 (Table 3.19). Multiplying this ratio by the total number of redds estimated in the Wenatchee River upstream from Tumwater Dam resulted in a spawning escapement of 422 steelhead (Table 3.19). Adding this estimate to the mark-recapture estimates of tributary escapement (248 hatchery + 453 wild = 701) indicates that 1,123 (CV = 0.299) escaped to spawning areas upstream from Tumwater Dam in 2015. The estimated spawning escapement is greater than fish observed at Tumwater Dam, and may be attributed to error bounds of the redd expansion and tributary estimate (see Appendix D).

Table 3.19. Numbers of steelhead counted at Tumwater Dam, fish/redd estimates (based on male-to-female ratios estimated at Tumwater Dam), numbers of steelhead redds counted upstream from Tumwater Dam, total spawning escapement upstream from Tumwater Dam (estimated as the total number of redds times the fish/redd ratio), and the proportion of the Tumwater Dam count that made up the spawning escapement. Beginning in 2014, escapements include estimates from redd counts in the Wenatchee River and mark-recapture techniques in tributaries.

Survey year	Total count at Tumwater Dam	Fish/redd	Number of redds			Spawning escapement[a]	Proportion of Tumwater count that spawned
			Index area	Non-index area	Total redds		
2001	820	2.08	118	19	137	285	0.35
2002	1,720	2.68	296	179	475	1,273	0.74
2003	1,810	1.60	353	88	441	706	0.39
2004	1,869	2.21	277	92	369	815	0.44

Survey year	Total count at Tumwater Dam	Fish/redd	Number of redds			Spawning escapement[a]	Proportion of Tumwater count that spawned
			Index area	Non-index area	Total redds		
2005	2,650	1.61	828	136	964	1,552	0.59
2006	1,053	2.05	192	34	226	463	0.44
2007	657	1.94	105	29	134	260	0.40
2008	1,328	2.81	124	35	159	447	0.34
2009	1,781	1.83	284	107	391	716	0.40
2010	2,270	2.33	546	95	641	1,494	0.66
2011	1,130	1.79	427	33	460	823	0.73
2012	1,055	2.00	273	22	295	590	0.56
2013	1,087	1.65	276	9	285	470	0.43
Average[b]	***1,488***	***2.02***	***333***	***59***	***392***	***763***	***0.50***
Median	***1,328***	***2.00***	***277***	***35***	***369***	***706***	***0.44***
2014	865	1.70	124	0	124	839	0.97
2015	1,009	1.78	232	11	243	1,123	1.11
Average[c]	***937***	***1.74***	***178***	***5.5***	***183.5***	***981***	***1.04***
Median	***937***	***1.74***	***178***	***5.5***	***183.5***	***981***	***1.04***

[a] Escapement estimates before 2014 were based on expanded redd counts in the Wenatchee River and tributaries; escapement estimates beginning in 2014 were based on expanded redd counts within the Wenatchee River and mark-recapture techniques in tributaries.
[b] The average and median are based on estimates from 2004 to 2013.
[c] The average and median are based on estimates from 2014 to present.

3.6 Life History Monitoring

Life history characteristics of steelhead were assessed by examining fish collected at broodstock collection sites, examining videotape at Tumwater Dam, and by reviewing tagging data and fisheries statistics. Prior to brood year 2011, some statistics could not be calculated because few steelhead were tagged with CWTs. Since brood year 2011, all steelhead released from the hatchery program are tagged with CWTs. In addition, about 18,808 of the 2014 brood were PIT tagged. With the placement of remote PIT tag detectors in spawning streams in 2007 and 2008, statistics such as origin on spawning grounds, stray rates, and SARs can be estimated more accurately.

Migration Timing

Sampling at Tumwater Dam indicates that steelhead migrate throughout the year; however, the migration distribution is bimodal, indicating that steelhead migrate past Tumwater Dam in two pulses: one pulse during summer-autumn the year before spawning and another during winter-spring the year of spawning (Figure 3.5). Most steelhead passed Tumwater Dam during July through October and April. The highest proportion of both wild and hatchery fish migrated during October.

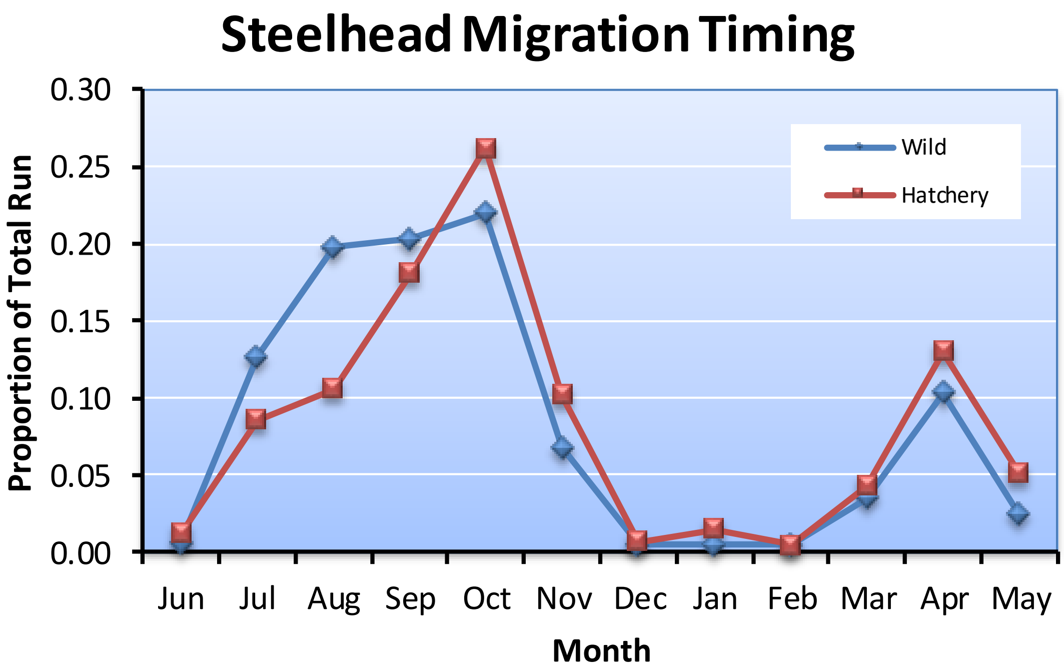

Figure 3.5. Proportion of wild and hatchery steelhead sampled at Tumwater Dam for the combined brood years of 1999-2015.

Because the migration of steelhead is bimodal, we estimated migration statistics separately for each migration pulse (i.e., summer-autumn migration and winter-spring migration). That is, we compared migration statistics for wild and hatchery steelhead passing Tumwater Dam during the summer-autumn period independent of those for the winter-spring migration period. We estimated the week and month that 10%, 50% (median), and 90% of the wild and hatchery steelhead passed Tumwater Dam during the two migration periods. We also estimated the mean weekly and monthly migration timing for wild and hatchery steelhead.

Overall, there was little difference in migration timing of wild and hatchery fish at Tumwater Dam (Table 3.20a and b; Figure 3.5). For both the summer-autumn and winter-spring migration periods, wild and hatchery steelhead arrived at the dam during the same week. The mean and median migration timing for wild and hatchery steelhead were also similar. However, during the summer-autumn migration period, on average, wild steelhead appeared to end their migration about one-two weeks earlier than hatchery steelhead.

Table 3.20a. The week that 10%, 50% (median), and 90% of the wild and hatchery steelhead passed Tumwater Dam during their summer-autumn migration (June through December) and during their winter-spring migration (January through May), 1999-2015. The average week is also provided for both migration periods. Migration timing is based on video sampling at Tumwater. The presence of eroded fins and/or missing adipose fins was used to distinguish hatchery fish from wild fish during video monitoring at Tumwater Dam. Estimates also include steelhead collected for broodstock.

Spawn year	Origin	Steelhead Migration Time (week)									
		Summer-Autumn Migration (Jun-Dec)					Winter-Spring Migration (Jan-May)				
		10%	50%	90%	Mean	Sample size	10%	50%	90%	Mean	Sample size
1999	Wild	27	32	47	35	81	12	16	17	15	29
	Hatchery	25	31	47	34	47	12	16	18	15	27
2000	Wild	31	36	41	36	238	11	14	18	14	40
	Hatchery	31	34	41	36	194	12	14	16	14	69
2001	Wild	29	34	41	35	391	13	15	17	15	84
	Hatchery	30	38	41	36	227	12	16	17	15	156
2002	Wild	29	39	46	38	810	13	14	17	14	181
	Hatchery	35	42	46	41	610	12	15	18	15	124
2003	Wild	30	33	40	35	731	3	9	16	9	193
	Hatchery	30	35	51	37	372	3	9	15	9	538
2004	Wild	30	40	45	39	644	13	16	18	16	222
	Hatchery	29	40	44	38	677	11	17	19	16	361
2005	Wild	30	39	43	38	986	10	15	17	15	206
	Hatchery	27	38	42	36	1112	12	16	18	15	377
2006	Wild	29	40	43	39	428	12	15	17	15	191
	Hatchery	29	41	43	39	334	4	13	16	12	181
2007	Wild	30	36	41	35	277	11	17	17	15	108
	Hatchery	29	38	43	36	90	11	17	18	16	214
2008	Wild	30	38	43	38	397	13	15	18	16	123
	Hatchery	33	41	45	40	554	14	18	19	17	311
2009	Wild	30	37	46	37	338	13	15	19	15	87
	Hatchery	29	35	46	36	1133	13	16	19	16	229
2010	Wild	31	37	45	38	648	11	15	18	15	171
	Hatchery	31	40	45	40	1207	12	16	19	16	309
2011	Wild	29	36	44	36	797	13	17	19	17	118
	Hatchery	31	39	45	39	991	15	18	19	18	240
2012	Wild	31	34	41	35	642	15	20	20	17	83
	Hatchery	32	39	43	38	715	15	19	19	17	223
2013	Wild	31	36	43	37	755	13	16	18	15	55
	Hatchery	31	42	45	40	1431	16	17	18	16	210
2014	Wild	29	35	41	35	549	14	18	19	17	57

Spawn year	Origin	Steelhead Migration Time (week)									
		Summer-Autumn Migration (Jun-Dec)					Winter-Spring Migration (Jan-May)				
		10%	50%	90%	Mean	Sample size	10%	50%	90%	Mean	Sample size
	Hatchery	32	40	42	38	511	15	17	19	17	78
2015	Wild	29	38	43	37	714	11	14	17	14	48
	Hatchery	32	39	43	39	928	12	16	17	15	57
Average	***Wild***	***30***	***36***	***43***	***37***	***554***	***12***	***15***	***18***	***15***	***117***
	Hatchery	***30***	***38***	***44***	***38***	***655***	***12***	***16***	***18***	***15***	***218***
Median	***Wild***	***30***	***36***	***43***	***37***	***642***	***13***	***15***	***18***	***15***	***108***
	Hatchery	***31***	***39***	***44***	***38***	***610***	***12***	***16***	***18***	***16***	***214***

Table 3.20b. The month that 10%, 50% (median), and 90% of the wild and hatchery steelhead passed Tumwater Dam during their summer-autumn migration (June through December) and during their winter-spring migration (January through May), 1999-2015. The average month is also provided for both migration periods. Migration timing is based on video sampling at Tumwater. The presence of eroded fins and/or missing adipose fins was used to distinguish hatchery fish from wild fish during video monitoring at Tumwater Dam. Estimates also include steelhead collected for broodstock.

Spawn year	Origin	Steelhead Migration Time (month)									
		Summer-Autumn Migration (Jun-Dec)					Winter-Spring Migration (Jan-May)				
		10%	50%	90%	Mean	Sample size	10%	50%	90%	Mean	Sample size
1999	Wild	7	8	11	8	81	3	4	4	4	29
	Hatchery	6	8	11	8	47	3	4	4	4	27
2000	Wild	8	9	10	9	238	3	4	5	4	40
	Hatchery	8	8	10	9	194	3	4	4	4	69
2001	Wild	7	8	10	8	391	3	4	4	4	84
	Hatchery	7	9	10	9	227	3	4	4	4	156
2002	Wild	7	9	11	9	810	3	4	4	4	181
	Hatchery	9	10	11	10	610	3	4	5	4	124
2003	Wild	7	8	10	8	731	1	3	4	3	193
	Hatchery	7	8	12	9	372	1	3	4	2	538
2004	Wild	7	10	11	9	644	3	4	4	4	222
	Hatchery	7	10	10	9	677	3	4	5	4	361
2005	Wild	7	9	10	9	986	3	4	4	4	206
	Hatchery	7	9	10	9	1112	3	4	5	4	377
2006	Wild	7	10	10	10	428	3	4	4	4	191
	Hatchery	7	10	10	9	334	1	3	4	3	181
2007	Wild	7	9	10	9	277	3	4	4	4	108
	Hatchery	7	9	10	9	90	3	4	5	4	214
2008	Wild	7	9	10	9	397	3	4	5	4	123
	Hatchery	8	10	11	10	554	4	4	5	4	311

Spawn year	Origin	Steelhead Migration Time (month)									
		Summer-Autumn Migration (Jun-Dec)					Winter-Spring Migration (Jan-May)				
		10%	50%	90%	Mean	Sample size	10%	50%	90%	Mean	Sample size
2009	Wild	7	9	11	9	338	3	4	5	4	87
	Hatchery	7	8	11	9	1133	3	4	5	4	229
2010	Wild	8	9	11	9	648	3	4	5	4	171
	Hatchery	8	10	11	10	1207	3	4	5	4	309
2011	Wild	7	9	11	9	797	4	4	5	4	118
	Hatchery	8	9	11	9	991	4	5	5	5	240
2012	Wild	8	8	10	9	642	4	4	5	4	83
	Hatchery	8	9	10	9	715	4	4	5	4	223
2013	Wild	8	9	10	9	755	4	4	5	4	55
	Hatchery	8	10	11	10	1431	4	4	5	4	210
2014	Wild	7	9	10	9	549	4	4	5	4	57
	Hatchery	8	10	10	9	511	4	4	5	4	78
2015	Wild	7	9	10	9	714	3	4	4	4	48
	Hatchery	8	9	10	9	928	3	4	4	4	57
Average	***Wild***	***7***	***9***	***10***	***9***	***554***	***3***	***4***	***4***	***4***	***117***
	Hatchery	***8***	***9***	***11***	***9***	***655***	***3***	***4***	***5***	***4***	***218***
Median	***Wild***	***7***	***9***	***10***	***9***	***642***	***3***	***4***	***4***	***4***	***108***
	Hatchery	***8***	***9***	***10***	***9***	***610***	***3***	***4***	***5***	***4***	***214***

Age at Maturity

Nearly all steelhead broodstock collected at Tumwater and Dryden dams lived in saltwater 1 to 2 years (saltwater age) (Table 3.21). Very few saltwater age-3 fish returned and those that did were wild fish. On average, there was a difference between the saltwater age at return of wild and hatchery fish. A greater proportion of hatchery fish returned as saltwater age-1 fish than did wild fish. In contrast, a greater number of wild fish returned as saltwater-2 fish than did hatchery fish (Figure 3.6).

Table 3.21. Proportions of wild and hatchery steelhead broodstock of different ages collected at Tumwater and Dryden dams, brood years 1998-2015. Age represents the number of years the fish lived in salt water.

Brood year	Origin	Saltwater age			Sample size
		1	2	3	
1998	Wild	0.39	0.61	0.00	35
	Hatchery	0.21	0.79	0.00	43
1999	Wild	0.50	0.48	0.02	58
	Hatchery	0.82	0.18	0.00	67
2000	Wild	0.56	0.44	0.00	39
	Hatchery	0.68	0.32	0.00	101

Brood year	Origin	Saltwater age			Sample size
		1	2	3	
2001	Wild	0.52	0.48	0.00	64
	Hatchery	0.15	0.85	0.00	114
2002	Wild	0.56	0.44	0.00	99
	Hatchery	0.95	0.05	0.00	113
2003	Wild	0.13	0.85	0.02	63
	Hatchery	0.29	0.71	0.00	92
2004	Wild	0.95	0.05	0.00	85
	Hatchery	0.95	0.05	0.00	132
2005	Wild	0.22	0.78	0.00	95
	Hatchery	0.21	0.79	0.00	114
2006	Wild	0.29	0.71	0.00	101
	Hatchery	0.60	0.40	0.00	98
2007	Wild	0.40	0.59	0.00	79
	Hatchery	0.62	0.38	0.00	97
2008	Wild	0.65	0.34	0.01	104
	Hatchery	0.89	0.11	0.00	107
2009	Wild	0.40	0.58	0.20	83
	Hatchery	0.23	0.77	0.0	77
2010	Wild	0.65	0.34	0.01	92
	Hatchery	0.77	0.23	0.00	98
2011	Wild	0.28	0.73	0.00	102
	Hatchery	0.36	0.64	0.00	100
2012	Wild	0.42	0.53	0.05	59
	Hatchery	0.41	0.59	0.00	66
2013	Wild	0.41	0.57	0.02	54
	Hatchery	0.46	0.55	0.00	77
2014	Wild	0.48	0.51	0.02	61
	Hatchery	0.29	0.71	0.00	68
2015	Wild	0.16	0.83	0.02	63
	Hatchery	0.51	0.49	0.00	60
Average	***Wild***	***0.44***	***0.54***	***0.02***	***75***
	Hatchery	***0.55***	***0.45***	***0.00***	***90***
Median	***Wild***	***0.46***	***0.53***	***0.01***	***72***
	Hatchery	***0.49***	***0.51***	***0.00***	***98***

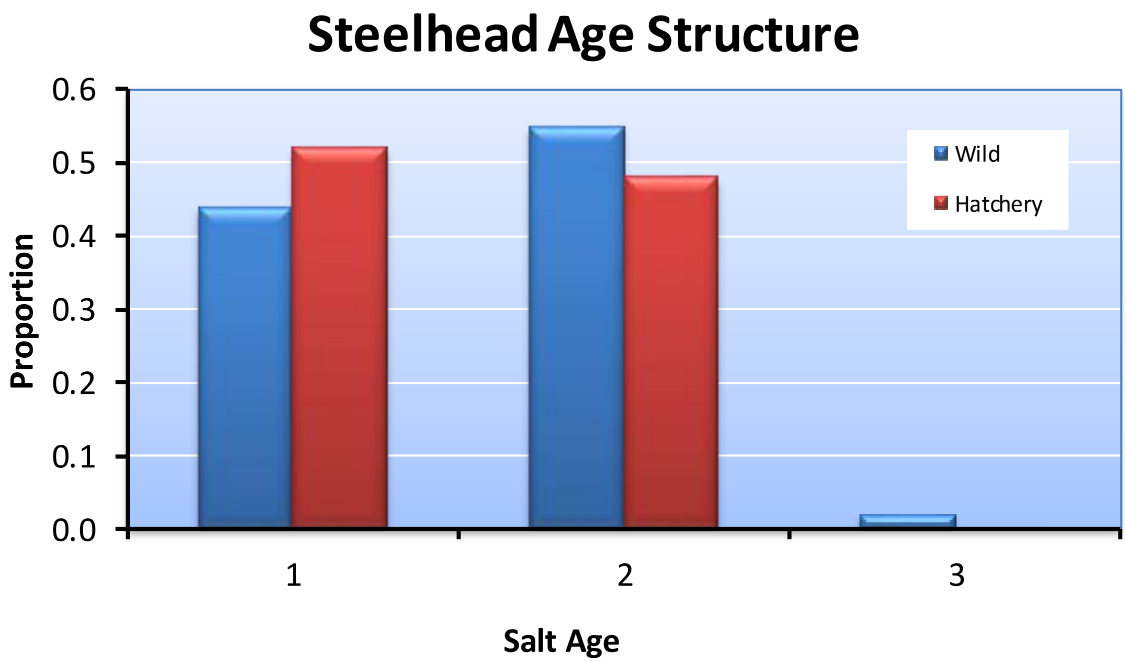

Figure 3.6. Proportions of wild and hatchery steelhead of different saltwater ages sampled at Tumwater Dam for the combined years 1998-2015.

Size at Maturity

On average, hatchery steelhead collected at Tumwater and Dryden dams were about 2 to 3 cm smaller than wild steelhead (Table 3.22).

Table 3.22. Mean fork length (cm) at age (saltwater ages) of hatchery and wild steelhead collected from broodstock, brood years 1998-2015; N = sample size and SD = 1 standard deviation.

Brood year	Origin	Steelhead fork length (cm)								
		1-Salt			2-Salt			3-Salt		
		Mean	N	SD	Mean	N	SD	Mean	N	SD
1998	Wild	63	15	4	79	20	5	-	0	-
	Hatchery	61	9	4	73	34	4	-	0	-
1999	Wild	65	29	5	74	28	5	77	1	-
	Hatchery	62	54	4	73	12	4	-	0	-
2000	Wild	64	22	3	74	17	5	-	0	-
	Hatchery	60	57	3	71	27	4	-	0	-
2001	Wild	61	33	6	77	31	5	-	0	-
	Hatchery	62	17	4	72	97	4	-	0	-
2002	Wild	64	55	4	77	44	4	-	0	-
	Hatchery	63	106	4	73	6	4	-	0	-
2003	Wild	69	8	6	77	52	5	91	1	-
	Hatchery	66	27	4	75	65	4	-	0	-

Brood year	Origin	Steelhead fork length (cm)								
		1-Salt			2-Salt			3-Salt		
		Mean	N	SD	Mean	N	SD	Mean	N	SD
2004	Wild	63	73	6	78	4	2	-	0	-
	Hatchery	61	59	3	73	3	1	-	0	-
2005	Wild	59	21	4	74	74	5	-	0	-
	Hatchery	59	23	4	72	89	4	-	0	-
2006	Wild	63	27	5	75	67	6	-	0	-
	Hatchery	61	41	4	72	27	5	-	0	-
2007	Wild	64	31	6	76	46	5	-	0	-
	Hatchery	60	60	4	71	36	5	-	0	-
2008	Wild	64	68	4	77	35	4	80	2	-
	Hatchery	60	95	4	72	12	2	-	0	-
2009	Wild	65	33	5	76	48	6	81	2	0
	Hatchery	63	18	4	75	59	5	-	0	-
2010	Wild	64	60	5	74	31	5	76	1	-
	Hatchery	61	53	5	73	23	5	-	0	-
2011	Wild	62	28	5	76	74	5	-	0	-
	Hatchery	60	36	4	74	64	4	-	0	-
2012	Wild	63	25	3	74	31	5	74	3	2
	Hatchery	59	27	3	74	39	4	-	0	-
2013	Wild	61	22	5	77	31	5	74	1	-
	Hatchery	60	35	3	74	42	4	-	0	-
2014	Wild	61	29	4	75	31	4	61	1	-
	Hatchery	60	20	3	72	48	4	-	0	-
2015	Wild	61	10	3	77	52	4	85	1	-
	Hatchery	59	30	3	76	29	5	-	0	-
Average	***Wild***	***63***	***33***	***5***	***76***	***40***	***5***	***78***	***1***	***1***
	Hatchery	***61***	***43***	***47***	***73***	***40***	***4***	***-***	***0***	***-***
Median	***Wild***	***63***	***29***	***5***	***76***	***33***	***5***	***77***	***1***	***1***
	Hatchery	***61***	***36***	***4***	***73***	***35***	***4***	***-***	***0***	***-***

Contribution to Fisheries

Nearly all harvest on Wenatchee steelhead occurs within the Columbia basin. Harvest rates on steelhead in the Lower Columbia River fisheries (both tribal and non-tribal) are generally less than 5-10% (NOAA 2008; TAG 2008). WDFW regulates steelhead harvest in the Upper Columbia. Under certain conditions, WDFW may allow a harvest on hatchery steelhead (adipose fin clipped fish). The intent is to reduce the number of hatchery steelhead that exceed habitat seeding levels in spawning areas and to increase the proportion of wild steelhead in spawning populations.

Origin on Spawning Grounds

With the implementation of PIT-tag mark-recapture techniques in 2014, we can estimate the contribution of natural-origin and hatchery-origin fish on the spawning grounds (Table 3.23). Based on mark-recapture estimates, naturally produced steelhead made up about 62.5% of the escapement in 2015. Importantly, the abundance of hatchery fish in the upper Wenatchee Basin was regulated through surplusing at Tumwater Dam. A total of 645 hatchery steelhead were surplused at the dam resulting in the passage of 1,009 steelhead over the dam in 2015. Natural-origin steelhead comprised 69.4% (N = 700) of the steelhead that passed the dam.

Table 3.23. Spawning escapement estimates for natural-origin and hatchery-origin steelhead within the Wenatchee River, brood years 2014-2015. Escapement estimates were based on PIT-tag mark-recapture techniques (Truscott et al. 2015).

Tributary	Natural-origin steelhead		Hatchery-origin steelhead	
	2014	2015	2014	2015
Mission Creek	94	71	31	23
Peshastin Creek	226	206	6	40
Chumstick Creek	78	38	7	0
Icicle Creek	76	83	45	52
Chiwaukum Creek	37	48	9	12
Chiwawa River	142	168	103	168
Nason Creek	190	237	148	68
Wenatchee River	340	252	251	298
Total	***978***	***1,103***	***545***	***661***

Straying

Stray rates of Wenatchee steelhead can be estimated by examining the locations where PIT-tagged hatchery steelhead were last detected. PIT tagging of steelhead began with brood year 2005, which allows estimation of stray rates by brood return. These data only provide estimates for brood years 2005 through 2011, because later brood years are still rearing in the ocean. The most recent completed brood year is 2011. The target for brood year stray rates should be less than 5%.

Based on PIT-tag analyses, about 3.2% of brood year 2011 was last detected in streams outside of the Wenatchee River basin. Brood year 2011 was the first brood year overwinter acclimated at the Chiwawa Acclimation Facility and this may have resulted in the observed reduction in stray rate. On average, for brood years 2005 through 2011, about 21% of the hatchery steelhead returns were last detected in streams outside the Wenatchee River basin (Table 3.24). Steelhead have been detected in the Entiat and Methow rivers as well as in the Deschutes and Tucannon rivers. Several were last detected at Wells Dam. The numbers in Table 3.24 should be considered rough estimates because they are not based on confirmed spawning (only last detections).

Table 3.24. Number and percent of hatchery-origin Wenatchee steelhead that homed to target spawning areas and the target hatchery program, and number and percent that strayed to non-target spawning areas and hatchery programs for brood years 2005-2011. Estimates were based on last detections of PIT-tagged hatchery steelhead. Percent strays should be less than 5%.

Brood Year	Homing				Straying			
	Target streams		Target hatchery*		Non-target stream		Non-target hatchery	
	Number	%	Number	%	Number	%	Number	%
2005	76	75.5	0	0.0	27	24.5	0	0.0
2006	72	61.7	1	0.9	43	37.4	0	0.0
2007	171	60.6	0	0.0	110	39.4	0	0.0
2008	79	88.8	0	0.0	10	11.2	0	0.0
2009	185	84.3	0	0.0	35	15.7	0	0.0
2010	79	81.4	0	0.0	18	18.6	0	0.0
2011	120	96.8	0	0.0	4	3.2	0	0.0
Average	***112***	***78.4***	***0***	***0.1***	***35***	***21.4***	***0***	***0.0***
Median	***79***	***81.4***	***0***	***0.0***	***27***	***18.6***	***0***	***0.0***

* Homing to the target hatchery includes Wenatchee hatchery steelhead that are captured and included as broodstock in the Wenatchee Hatchery program. These hatchery fish are typically collected at Dryden and Tumwater dams.

Genetics

Genetic studies were conducted in 2012 to determine the potential effects of the Wenatchee Supplementation Program on natural-origin summer steelhead in the Wenatchee River basin (Seamons et al. 2012; the entire report is appended as Appendix E). Temporal collections were obtained from hatchery and natural-origin adult summer steelhead captured at Dryden and Tumwater dams during summer and fall of 1997 through 2009 (excepting 2004 and 2005). Natural-origin steelhead consisted of a mixed collection representing all the spawning subpopulations located upstream. Therefore, to determine population substructure within the basin, samples were also taken from juvenile steelhead collected at smolt traps located within the Chiwawa River, Nason Creek, and Peshastin Creek, and from the Entiat River. Samples were also taken from juvenile steelhead collected at the smolt trap in the lower Wenatchee River. These, like natural-origin adult collections, consisted of a mixed collection representing all subpopulations located upstream. A total of 1,468 hatchery-origin and natural-origin adults were processed and 1,542 juvenile steelhead from the Wenatchee and Entiat Rivers were processed for genetic variation with 132 genetic (single nucleotide polymorphism loci; SNPs) markers. Peshastin Creek and the Entiat River served as no-hatchery-outplant controls. Genetic data were interrogated for the presence or absence of spatial and temporal trends in allele frequencies, genetic distances, and effective population size.

Allele Frequencies—Changes to the summer steelhead hatchery supplementation program had no detectable effect on genetic diversity of wild populations. On average, hatchery-origin adults had higher minor allele frequencies (MAF) than natural-origin adults, which may simply reflect the mixed ancestry of hatchery adults. Both hatchery and natural-origin adults had MAF similar to juveniles collected in spawning tributaries and in the Entiat River. There was no temporal trend in allele frequencies or observed heterozygosity in adult or juvenile collections and allele frequencies in control populations were no different than those still receiving hatchery outplants. This suggests that the hatchery program has had little effect on allele frequencies since broodstock sources changed in 1998 from mixed-ancestry broodstock collected in the Columbia River to using broodstock collected in the Wenatchee River.

Genetic Distances—As intended, interbreeding of Wenatchee River hatchery and natural-origin adults reduced the genetic differences between Wells Hatchery adults and Wenatchee River natural-origin adults observed in the first few years after changing the broodstock collection protocol. Although there were detectable genetic differences between hatchery and natural-origin adults, the magnitude of that difference declined over time. Hatchery adults were genetically different from natural-origin adults and juveniles based on pair-wise F_{ST} and principal components analysis, most likely because of the smaller effective population size (N_b) in the hatchery population (see below). Pair-wise F_{ST} estimates and genetic distances between hatchery and natural-origin adults collected the same year declined over time suggesting that the interbreeding of hatchery and natural-origin adults in the hatchery (and presumably in the wild) is slowly homogenizing Wenatchee River summer steelhead. Analyses using brood year were inconclusive because of limitations in the data.

Effective Population Size—Although the effective population size of the Wenatchee River hatchery steelhead program was consistently small, it does not appear to have caused a reduction in the effective population size of wild populations. On average, estimates of N_b were much lower and varied less for hatchery adults than for natural-origin adults and juveniles. Estimates of N_b for hatchery adults declined from the earliest brood years to a stable new low value after broodstock practices were changed in 1998. There was no indication that this had any effect on N_b in natural-origin adults and juveniles; N_b estimates for natural-origin adults and juveniles were, on average, higher and varied considerably over the 1998-2010 time period and showed no temporal trend.

It is important to note that no new information will be reported on genetics until the next five-year report (2018).

Proportionate Natural Influence

Another method for assessing the genetic risk of a supplementation program is to determine the influence of the hatchery and natural environments on the adaptation of the composite population. This is estimated by the proportion of natural-origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery-origin fish in the natural spawning escapement (pHOS). We calculated Proportionate Natural Influence (PNI) by iterating Ford's (2002) equations 5 and 6 to equilibrium, using a heritability of 0.3 and a selection strength of three standard deviations.[5] The larger the PNI value, the greater the strength of selection in the natural environment relative to that of the hatchery environment. In order for the natural environment to dominate selection, PNI should be greater than 0.50, and important integrated populations should have a PNI of at least 0.67 (HSRG/WDFW/NWIFC 2004).

[5] According to authorized annual take permits, PNI is calculated using the PNI approximate equation 11 (HSRG 2009; Appendix A). However, in this report, we used Ford's (2002) equations 5 and 6 with a heritability of 0.3 and a selection strength of three standard deviations to calculate PNI (C. Busack, NOAA Fisheries, 21 March 2016, provided the model for calculating PNI). This approach is more accurate than using the PNI approximate equation.

For brood years 2001-2015, PNI values were less than 0.67 (Table 3.25), suggesting that the hatchery environment has a greater influence on adaptation of Wenatchee steelhead than does the natural environment.

Table 3.25. Proportionate Natural Influence (PNI) values for the Wenatchee steelhead supplementation program for brood years 2001-2015. NOS = number of natural-origin steelhead on the spawning grounds; HOS = number of hatchery-origin steelhead on the spawning grounds; NOB = number of natural-origin steelhead collected for broodstock; and HOB = number of hatchery-origin steelhead included in hatchery broodstock.

Brood year	Spawners[a]			Broodstock			PNI[b]
	NOS	HOS	pHOS	NOB	HOB	pNOB	
2001	158	127	0.45	51	103	0.33	0.45
2002	731	542	0.43	96	64	0.60	0.59
2003	355	350	0.50	49	90	0.35	0.43
2004	371	445	0.55	75	61	0.55	0.51
2005	690	862	0.56	87	104	0.46	0.47
2006	253	210	0.45	93	69	0.57	0.57
2007	145	115	0.44	76	58	0.57	0.58
2008	168	279	0.62	77	54	0.59	0.50
2009	171	545	0.76	86	73	0.54	0.43
2010	524	970	0.65	96	75	0.56	0.48
2011	351	472	0.57	91	70	0.57	0.51
2012	381	209	0.35	59	65	0.48	0.59
2013	322	148	0.31	49	68	0.42	0.59
2014	476	363	0.46	64	68	0.48	0.54
2015	639	484	0.43	58	52	0.53	0.57
Average	***382***	***408***	***0.50***	***74***	***72***	***0.51***	***0.52***
Median	***355***	***363***	***0.46***	***76***	***68***	***0.54***	***0.51***

[a] The presence of eroded fins or missing adipose fins was used to distinguish hatchery fish from wild fish during video monitoring at Tumwater Dam. The PNI estimates are appropriate for steelhead spawning upstream from Tumwater Dam. They may not represent PNI for steelhead spawning downstream from Tumwater Dam.
[b] PNI was calculated previously using PNI approximate equation 11 (HSRG 2009; Appendix A). All PNI values presented here were recalculated by iterating Ford's (2002) equations 5 and 6 to equilibrium using a heritability of 0.3 and a selection strength of three standard deviations. C. Busack, NOAA Fisheries, 21 March 2016, provided the model for calculating PNI.

Post-Release Survival and Travel Time

We used PIT-tagged fish to estimate survival rates and travel time (arithmetic mean days) of hatchery steelhead from release sites (e.g., Chiwawa River, Nason Creek, and Wenatchee River) to McNary Dam, and smolt to adult ratios (SARs) from release to detection at Bonneville Dam (Table 3.26).[6] Over the ten brood years for which PIT-tagged hatchery fish are available, survival rates from the release sites to McNary Dam ranged from 0.055 to 0.785 (note that survival rates of 0.000 were associated with very small sample sizes); SARs from release to detection at Bonneville

[6] It is important to point out that because of fish size differences among rearing tanks or raceways, fish PIT tagged in one tank or raceway may not represent untagged fish rearing in other tanks or raceways.

Dam ranged from 0.001 to 0.038. Average travel time from the release sites to McNary Dam ranged from 14 to 100 days.

Some of the variation in survival rates and travel time was related to release location, type of release, and rearing scenario. For example, on average, steelhead released in the Chiwawa River appeared to have higher survival rates to McNary Dam than did steelhead released in the lower and upper Wenatchee River or Nason Creek. Within the Chiwawa River, steelhead identified as "movers" had the highest survival rates to McNary Dam, while those identified as "non-screened" had the lowest survival. For steelhead released into Nason Creek and the Wenatchee River, fish released from circulars had higher survival rates than those released from raceways. On average, steelhead released from Blackbird Pond had lower survival rates to McNary Dam than those released from circulars. Based on the available data, SARs varied little among the release locations or rearing scenarios.

Travel time from release to McNary Dam varied among release locations and rearing scenario. In general, steelhead released into the Chiwawa River and Nason Creek appeared to travel more quickly to McNary Dam than did steelhead released into the Wenatchee River. Of those released into the Chiwawa River, steelhead released volitionally from raceways appeared to travel to McNary Dam more quickly than those forced released; although there are few replicates and differences in travel times are small. On average, steelhead released from Blackbird Pond took about twice as long to reach McNary Dam than did steelhead released from circulars. In contrast, there appeared to be little differences in travel times for steelhead reared in raceways or circulars that were released into Nason Creek.

Table 3.26. Total number of Wenatchee hatchery summer steelhead released with PIT tags, their survival and travel times (mean days) to McNary Dam, and smolt-to-adult (SAR) ratios for brood years 2005-2013. SARs were estimated to Bonneville Dam. Standard errors are shown in parentheses. NA = not available (i.e., for SARs, not all the adults from the release groups have returned to the Columbia River).

Brood year	Release location[a]	Crosses[b]	Type of release	Rearing scenario[c]	Number of tagged fish released	Survival to McNary Dam	Travel time to McNary Dam (d)	SAR to Bonneville Dam (%)
2003	Chiwawa	HxW	NA	Turtle Rock	29,801	0.755 (0.029)	18.2 (16.7)	0.003 (0.000)
	Nason	WxW	NA	Turtle Rock	34,823	0.648 (0.026)	19.3 (19.6)	0.004 (0.000)
	Wenatchee	HxH	NA	Turtle Rock	30,018	0.767 (0.030)	18.1 (20.6)	0.003 (0.000)
2004	Chiwawa	HxW	NA	Turtle Rock	2,439	0.480 (0.037)	26.9 (59.5)	0.011 (0.002)
	Chiwawa	WxW	NA	Turtle Rock	853	0.485 (0.054)	21.1 (8.8)	0.008 (0.003)
	Nason	WxW	NA	Turtle Rock	8,826	0.412 (0.017)	26.7 (56.1)	0.010 (0.001)
	Wenatchee	HxH	NA	Turtle Rock	9,705	0.621 (0.022)	15.8 (6.3)	0.033 (0.002)
	Wenatchee	HxW	NA	Turtle Rock	7,379	0.606 (0.029)	19.3 (7.4)	0.013 (0.001)
2005	Chiwawa	HxW	NA	Turtle Rock	3,448	0.540 (0.065)	22.6 (27.2)	0.017 (0.002)
	Chiwawa	WxW	NA	Turtle Rock	717	0.521 (0.128)	22.2 (8.0)	0.013 (0.004)
	Nason	WxW	NA	Turtle Rock	7,306	0.416 (0.031)	21.3 (9.2)	0.009 (0.001)
	Wenatchee	HxH	NA	Turtle Rock	8,610	0.656 (0.057)	20.1 (35.8)	0.017 (0.001)
	Wenatchee	HxW	NA	Turtle Rock	5,021	0.649 (0.074)	20.2 (9.0)	0.014 (0.002)

Brood year	Release location[a]	Crosses[b]	Type of release	Rearing scenario[c]	Number of tagged fish released	Survival to McNary Dam	Travel time to McNary Dam (d)	SAR to Bonneville Dam (%)
2006	NA	NA	NA	NA	NA	NA	NA	NA
2007	Chiwawa	HxW	NA	Turtle Rock	2,882	0.520 (0.057)	22.3 (7.9)	0.020 (0.003)
	Chiwawa	WxW	NA	Turtle Rock	785	0.467 (0.069)	18.7 (9.0)	0.038 (0.007)
	Nason	WxW	NA	Turtle Rock	8,060	0.505 (0.030)	22.3 (24.1)	0.030 (0.002)
	Wenatchee	HxW	NA	Turtle Rock	9,047	0.631 (0.041)	18.2 (17.2)	0.038 (0.002)
2008	Chiwawa	HxW L	NA	Turtle Rock	2,008	0.574 (0.080)	20.3 (7.0)	0.006 (0.002)
	Chiwawa	WxW	NA	Turtle Rock	1,457	0.546 (0.090)	31.6 (108.5)	0.010 (0.003)
	Nason	WxW	NA	Turtle Rock	7,951	0.500 (0.037)	21.4 (17.5)	0.014 (0.001)
	Wenatchee	HxW E	NA	Turtle Rock	4,517	0.511 (0.044)	19.5 (7.7)	0.008 (0.001)
	Wenatchee	HxW L	NA	Turtle Rock	6,710	0.545 (0.038)	19.3 (6.8)	0.010 (0.001)
2009	Chiwawa	HxW E	Forced	Turtle Rock	4,874	0.576 (0.076)	24.3 (8.3)	0.012 (0.002)
	Chiwawa	HxW E	Volitional	Chiwawa Circ	8,653	0.785 (0.100)	19.4 (26.0)	0.007 (0.001)
	Nason	WxW	Forced	Turtle Rock	8,918	0.504 (0.042)	27.2 (26.6)	0.017 (0.001)
	Wenatchee	HxW E	Forced	Turtle Rock	11,300	0.543 (0.041)	25.8 (54.8)	0.014 (0.001)
	Wenatchee	HxW E	Forced	Turtle Rock	6,681	0.597 (0.063)	28.9 (72.2)	0.013 (0.001)
	Wenatchee	HxW L	Forced	Turtle Rock	4,619	0.478 (0.052)	21.7 (7.6)	0.015 (0.002)
	Wenatchee	HxW E	Volitional	Blackbird	2,184	0.317 (0.054)	80.4 (11.7)	0.010 (0.002)
	Wenatchee	WxW	Volitional	Rohlfing	566	0.443 (0.187)	78.1 (8.6)	0.014 (0.005)
2010	Chiwawa	WxW	Forced	Turtle Rock	4,226	0.586 (0.057)	24.4 (60.1)	0.009 (0.001)
	Nason	WxW	Forced	Turtle Rock	5,256	0.548 (0.044)	23.5 (53.3)	0.010 (0.001)
	Wenatchee	HxH	Forced	Turtle Rock	8,506	0.583 (0.053)	30.2 (50.1)	0.004 (0.001)
	Wenatchee	HxH	Volitional	Blackbird	9,858	0.629 (0.046)	17.9 (17.4)	0.006 (0.001)
	Wenatchee	HxH	Volitional	Chiwawa Circ	10,031	0.413 (0.043)	21.6 (66.1)	0.001 (0.000)
2011	Chiwawa	WxW	Volitional	RCY	3,603	0.407 (0.056)	15.1 (8.3)	NA
	Nason	WxW	Volitional	RCY	4,065	0.334 (0.042)	20.9 (60.9)	NA
	Wenatchee	WxW	Non-movers	Circular	1,122	0.354 (0.228)	40.6 (89.1)	NA
	Wenatchee	WxW	Non-movers	RCY	2,395	0.368 (0.084)	22.7 (57.0)	NA
	Wenatchee	WxW	Volitional	Blackbird	2,099	0.660 (0.016)	48.2 (90.0)	NA
	Wenatchee	WxW	Volitional	Circular	7,206	0.277 (0.042)	31.6 (74.3)	NA
	Wenatchee	WxW	Volitional	RCY	4,422	0.327 (0.032)	15.2 (25.6)	NA
	All	WxW	NA	Circular	1,628	0.055 (0.016)	--	NA
	All	WxW	NA	RCY	3,479	0.289 (0.034)	--	NA
2012	Chiwawa	HxH	Volitional	RCY	2,891	0.407 (0.057)	15.2 (7.2)	NA

Brood year	Release location[a]	Crosses[b]	Type of release	Rearing scenario[c]	Number of tagged fish released	Survival to McNary Dam	Travel time to McNary Dam (d)	SAR to Bonneville Dam (%)
	Nason	WxW	Forced	Circular	4,271	0.378 (0.065)	25.0 (33.1)	NA
	Nason	WxW	Volitional	Circular	5,404	0.364 (0.048)	24.9 (31.6)	NA
	L. Wenatchee	HxH	Forced	RCY	587	0.164 (0.074)	52.2 (114.7)	NA
	U. Wenatchee	HxH	Volitional	RCY	2,224	0.573 (0.138)	18.7 (8.4)	NA
	U. Wenatchee	HxH	Forced	RCY	1,969	0.603 (0.140)	24.7 (42.5)	NA
	Wenatchee	HxH	Volitional	Blackbird	1,658	0.428 (0.092)	--	NA
	All	HxH	NA	RCY	769	0.455 (0.291)	--	NA
	All	WxW	NA	Circular	5,397	0.327 (0.049)	25.4 (45.0)	NA
2013	Chiwawa	Mixed	Volitional	RCY	1,567	0.354 (0.063)	15.2 (7.0)	NA
	Nason	Mixed	Volitional	RCY	3,796	0.447 (0.115)	20.2 (9.4)	NA
	Nason	Mixed	Volitional	Circ or RCY	308	0.146 (0.053)	17.4 (2.9)	NA
	Nason	WxW	Non-movers	Circular	74	0.000 (-)	0.0 (-)	NA
	Nason	WxW	Volitional	Circular	1,286	0.192 (0.063)	18.4 (6.4)	NA
	L. Wenatchee	Mixed	Non-movers	RCY	3,275	0.317 (0.131)	35.3 (69.5)	NA
	U. Wenatchee	Mixed	Volitional	RCY	2,862	0.457 (0.080)	16.3 (9.7)	NA
	Wenatchee	HxH	Volitional	Blackbird	819	0.337 (0.128)	--	NA
	All	HxH	NA	RCY	907	0.000 (-)	--	NA
	All	WxW	NA	Circ or RCY	232	0.000 (-)	--	NA
2014	Chiwawa	Mixed	Movers	RCY	793	0.754 (0.497)	27.7 (7.6)	NA
	Chiwawa	Mixed	Non-screen	RCY	915	0.358 (0.230)	25.0 (8.1)	NA
	Nason	Mixed	Movers	RCY	1,553	0.212 (0.082)	28.4 (29.4)	NA
	Nason	Mixed	Non-screen	RCY	1,653	0.075 (0.017)	24.2 (7.1)	NA
	Nason	WxW	Movers	Circular	949	0.291 (0.148)	21.3 (8.2)	NA
	Nason	WxW	Non-screen	Circular	873	0.369 (0.190)	20.8 (6.9)	NA
	L. Wenatchee	Mixed	Non-movers	RCY	2,596	0.133 (0.025)	16.0 (7.1)	NA
	U. Wenatchee	Mixed	Movers	RCY	2,042	0.278 (0.051)	21.9 (8.2)	NA
	U. Wenatchee	Mixed	Non-screen	RCY	1,563	0.126 (0.026)	28.7 (8.2)	NA
	U. Wenatchee	WxW	Movers	Circular	356	0.278 (0.165)	17.0 (6.5)	NA
	U. Wenatchee	WxW	Non-movers	Circular	596	0.381 (0.192)	15.8 (6.8)	NA
	U. Wenatchee	WxW	Non-screen	Circular	1,230	0.340 (0.102)	16.7 (6.6)	NA
	Wenatchee	HxH	Volitional	Blackbird	1,814	0.221 (0.054)	--	NA
	All	Mixed	NA	Circ or RCY	1,884	0.119 (0.034)	--	NA

[a] All = Chiwawa River, Nason Creek, and the Wenatchee River.

[b] HxH = hatchery by hatchery cross; WxW = wild by wild cross; Mixed = both HxH and WxW crosses; E = early; and L = late.
[c] Circ = circulars; RCY = raceway.

Natural and Hatchery Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural-origin recruits (NOR) to the parent spawning population (spawning escapement). Natural-origin recruits are naturally produced (wild) fish that survive to contribute to harvest (directly or indirectly), to broodstock, and to spawning grounds. We do not account for fish that died in route to the spawning grounds (migration mortality) or died just before spawning (pre-spawn mortality) (see Appendix B in Hillman et al. 2012). For brood years 1998-2011, NRR for summer steelhead in the Wenatchee River basin averaged 0.66 (range, 0.13-3.10) if harvested fish were included in the estimate (Table 3.27).

Hatchery replacement rates (HRR) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HOR) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 6.9 (the calculated target value in Hillman et al. 2013). The target value of 6.9 includes harvest. In nearly all years, HRRs were greater than NRRs (Table 3.27). HRRs exceeded the estimated target value of 6.9 in 10 of the 14 years.

Table 3.27. Broodstock collected, spawning escapements, natural and hatchery-origin recruits (NOR and HOR), and natural and hatchery replacement rates (NRR and HRR with harvest) for summer steelhead in the Wenatchee River basin, brood years 1998-2011.

Brood year	Broodstock Collected	Spawning Escapement	Harvest included			
			HOR	NOR	HRR	NRR
1998	78	602	148	1,867	1.89	3.10
1999	125	343	1,944	334	15.55	0.97
2000	120	1,030	312	878	2.60	0.85
2001	178	1,655	10,335	1,050	58.06	0.66
2002	162	5,000	1,905	515	11.76	0.13
2003	155	2,598	956	504	6.17	0.27
2004	217	2,949	2,538	728	11.70	0.25
2005	209	3,609	3,106	904	14.86	0.25
2006	199	2,219	1,454	1,007	7.31	0.45
2007	176	880	535	430	3.04	0.49
2008	107	1,835	1,121	714	10.48	0.39
2009	107	1,733	1,024	709	9.57	0.41
2010	105	6,236	3,999	2,237	38.09	0.36
2011	104	3,049	859	2,189	8.26	0.72
Average	***146***	***2,410***	***2160***	***1005***	***14.24***	***0.66***
Median	***140***	***2,027***	***1,288***	***803***	***10.02***	***0.43***

Smolt-to-Adult Survivals

Smolt-to-adult ratios (SARs) are calculated as the number of returning hatchery adults divided by the number of tagged hatchery smolts released. SARs are generally based on CWT returns. However, prior to brood year 2011, Wenatchee steelhead were not extensively tagged with CWTs. Therefore, elastomer-tagged fish were used to estimate SARs from release to capture at Priest Rapids Dam. With the return of brood year 2011, SARs will be based on PIT-tag detections at Bonneville Dam.

SARs (not adjusted for tag loss) for Wenatchee steelhead ranged from 0.0009 to 0.0315 (mean = 0.0093) for brood years 1996-2010 (Table 3.28). For brood years 2011 to present, SARs (to Bonneville Dam) averaged 0.0057 (Table 3.28).

Table 3.28. Smolt-to-adult ratios (SARs) for Wenatchee hatchery steelhead. Estimates for brood years 1996-2010 were based on elastomer tags recaptured at Priest Rapids Dam. SARs were not adjusted for tag loss after release. For brood years 2011 to present, SARs are based on PIT-tag detections to Bonneville Dam.

Brood year	Number of tagged smolts released	SAR
1996	348,693	0.0034
1997	429,422	0.0041
1998	172,078	0.0009
1999	175,661	0.0111
2000	184,639	0.0017
2001	335,933	0.0308
2002	302,060	0.0063
2003	374,867	0.0025
2004	294,114	0.0038
2005	452,184	0.0107
2006	258,697	0.0100
2007	306,690	0.0315
2008	327,133	0.0090
2009	484,826	0.0080
2010[a]	192,363	0.0054
Average	***309,291***	***0.0093***
Median	***306,690***	***0.0063***
2011	30,019	0.0057
Average	***27,924***	***0.0057***
Median	***27,924***	***0.0057***

[a] Only 192,363 WxW progeny from brood year 2010 were elastomer tagged; 161,951 HxH steelhead were released.

3.7 ESA/HCP Compliance

Broodstock Collection

Collection of brood year 2014 broodstock for Wenatchee summer steelhead at Dryden and Tumwater dams began on 1 July and ended on 4 October 2013 at Dryden Dam and 8 October 2013 at Tumwater Dam consistent with the collection period identified in the 2013 broodstock collection protocol. The broodstock collection achieved a total collection of 135 steelhead, including 65 natural-origin steelhead.

About 1,338 steelhead were handled and released (or surplused) at Tumwater and Dryden dams during brood year 2014 Wenatchee steelhead broodstock collection. Most were hatchery-origin fish handled at Tumwater Dam and ultimately surplused to meet the pHOS objective upstream from Tumwater Dam. Fish released at Dryden Dam were released because the weekly quota for hatchery or wild steelhead had been attained, but not for both hatchery and wild fish, or because they were non-target fish (adipose clipped), or they were unidentifiable hatchery-origin steelhead. All steelhead released were allowed to fully recover from the anesthesia and released immediately upstream from the trap sites.

In addition to steelhead encountered at Dryden Dam during steelhead broodstock collection, an estimated 42 spring Chinook salmon were captured and released unharmed immediately upstream from the trap facility. Consistent with ESA Section 10 Permit 1395 impact minimization measures, all ESA species handled were subject of water-to-water transfers.

Hatchery Rearing and Release

The 2014 brood Wenatchee steelhead reared throughout all life stages without significant mortality (defined as >10% population mortality associated with a single event). However, the 2014 brood had poor fertilization to eyed-egg survival combined with somewhat low eyed-egg to ponding survival resulting in an unfertilized-to-release survival of 70.8%, which was less than the program target of 81% (see Section 3.2).

Juvenile rearing occurred at three separate facilities including Eastbank Fish Hatchery, Chelan Fish Hatchery, and the Chiwawa Acclimation Facility. Multiple facilities were used to take advantage of variable water temperatures to manipulate growth of juveniles from different parental crosses. Typically, wild steelhead spawn later than their hatchery cohort and are therefore reared at Chelan Fish Hatchery on warmer water to accelerate their growth so they achieve a size-at-release similar to HxH parental cross progeny reared on cooler water at Eastbank Fish Hatchery. All parental cross groups received final rearing and over-winter acclimation at the Chiwawa Acclimation Facility on Wenatchee River and Chiwawa River surface water before direct release (scatter planting) in the Wenatchee River basin.

The 2014 brood steelhead smolt release in the Wenatchee River basin totaled 264,758 smolts, representing about 107.1% of the program target of 247,300 smolts identified in the Rocky Reach and Rock Island Dam HCPs and within the maximum 110% allowed in ESA Section 10 Permit 1395. As specified in ESA Section 10 Permit 1395, all steelhead smolts released were externally marked or internally tagged and a representative number were PIT tagged (see Section 3.2).

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, 1395, 18118, 18119, and 18121, permit holders shall monitor and report hatchery effluents in compliance with applicable National Pollution Discharge Elimination Systems (NPDES) (EPA 1999) permit limitations. There was no NPDES violations reported at PUD Hatchery facilities during the period 1 January 2014 through 31 December 2014. NPDES monitoring and reporting for Chelan PUD Hatchery Programs during 2014 are provided in Appendix F.

Smolt and Emigrant Trapping

Per ESA Section 10 Permit No. 1395, the permit holders are authorized a direct take of up to 20% of the emigrating steelhead population and a lethal take not to exceed 2% of the fish captured (NMFS 2003). Based on the estimated wild steelhead population (smolt trap expansion) and hatchery juvenile steelhead population estimate (hatchery release data) for the Wenatchee River basin, the reported steelhead encounters during the 2015 emigration complied with take provisions in the Section 10 permit and are detailed in Table 3.29. Additionally, juvenile fish captured at the trap locations were handled consistent with provisions in ESA Section 10 Permit 1395 Section B.

Table 3.29. Estimated take of Upper Columbia River steelhead resulting from juvenile emigration monitoring in the Wenatchee River basin, 2015. NA = not available.

Trap location	Population estimate				Number trapped				Total	Take allowed by Permit
	Wild	Hatchery[a]	Parr	Fry	Wild	Hatchery	Parr	Fry		
Chiwawa Trap										
Population	NA	35,042	NA	NA	259	3,151	2,624	380	6,414	
Encounter rate	NA	NA	NA	NA	NA	0.0899	NA	NA	NA	0.20
Mortality[b]	NA	NA	NA	NA	5	1	29	11	46	
Mortality rate	NA	NA	NA	NA	0.0193	0.0003	0.0111	0.0289	0.0072	0.02
Lower Wenatchee Trap										
Population	NA	264,758	NA	NA	231	2,288	75	25	2,619	
Encounter rate	NA	NA	NA	NA	NA	0.0086	NA	NA	NA	0.20
Mortality[b]	NA	NA	NA	NA	2	0	0	0	2	
Mortality rate	NA	NA	NA	NA	0.0087	0.000	0.0000	0.0000	0.0008	0.02
Wenatchee River Basin Total										
Population	NA	264,758	NA	NA	490	5,439	2,699	405	9,033	
Encounter rate	NA	NA	NA	NA	NA	0.0205	NA	NA	NA	0.20
Mortality[b]	NA	NA	NA	NA	7	1	29	11	48	
Mortality rate	NA	NA	NA	NA	0.0143	0.0002	0.0108	0.0272	0.0053	0.02

[a] 2015 smolt release data for the Wenatchee River basin.

[b] Mortality includes trapping and PIT-tag mortalities.

Spawning Surveys

Steelhead spawning ground surveys were conducted in the Wenatchee River basin during 2015, as authorized by ESA Section 10 Permit No. 1395. Because of the difficulty of quantifying the level of take associated with spawning ground surveys, the Permit does not specify a take level associated with these activities, even though it does authorize implementation of spawning ground surveys. Therefore, no take levels are reported. However, to minimize potential effects to established redds, wading was restricted to the extent practical, and extreme caution was used to avoid established redds when wading was required.

Stock Assessment at Priest Rapids Dam

Upper Columbia River steelhead stock assessment sampling at Priest Rapids Dam (PRD) is authorized through ESA Section 10 Permit No. 1395 (NMFS 2003). Permit authorizations include interception and biological sampling of up to 15% of the Upper Columbia River steelhead passing PRD to determine upriver adult population size, estimate hatchery to wild ratios, determine age-class contribution, and evaluate the need for managing hatchery steelhead consistent with ESA recovery objectives, which include fully seeding spawning habitat with naturally produced Upper Columbia River steelhead supplemented with artificially propagated steelhead (NMFS 2003). The 2013-2014 run-cycle report (BY 2014) for stock assessment sampling at Priest Rapids Dam was compiled under provisions of ESA Section 10 Permit 1395. Data and reporting information are included in Appendix G.

SECTION 4: WENATCHEE SOCKEYE SALMON

The goal of sockeye salmon supplementation in the Wenatchee Basin was to use artificial production to replace adult production lost because of mortality at Rock Island Dam, while not reducing the natural production or long-term fitness of sockeye in the basin. The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Anadromous Fish Agreement and Habitat Conservation Plans.

Adult sockeye were collected for broodstock from the run-at-large at Tumwater Dam. Beginning in 2011, because of passage delays at Tumwater Dam during trapping operations, sockeye broodstock were collected at Dryden Dam. The goal was to collect up to 260 natural-origin adult sockeye for the program. Broodstock collection occurred from about 7 July through 28 August with trapping occurring no more than 16 hours per day, three days a week at Tumwater Dam and up to seven days per week at the Dryden Dam left and right-bank facilities.

Adult sockeye were held and spawned at Eastbank Fish Hatchery. The fertilized eggs were also incubated at the hatchery. For brood years 1989 through 1998, unfed fry were transferred from the hatchery to Lake Wenatchee net pens. From 1998 to 2011, juvenile sockeye were reared at Eastbank Fish Hatchery until July when they were transferred to the net pens. The initial rearing at Eastbank was to increase growth rates. During most years up through 2005, juvenile sockeye were released from net pens at two different times, August and November. Since 2006, all juvenile sockeye were released in late October.

The production goal for the Wenatchee sockeye supplementation program was to release 200,000 subyearlings into Lake Wenatchee at 20 fish per pound. Targets for fork length and weight were 133 mm (CV = 9.0) and 22.7 g, respectively. Over 90% of these fish were marked with CWTs. In addition, from 2006-2011, about 15,000 juvenile sockeye were PIT tagged annually. Following an evaluation of the supplementation program in 2011, the Hatchery Committees decided to convert the Wenatchee sockeye hatchery program to summer steelhead in 2012. Monitoring occurs annually to track the status of the natural sockeye population.

4.1 Broodstock Sampling

As noted above, the Wenatchee sockeye program was terminated in 2012. Thus, no broodstock have been collected since 2011 and the release of juvenile sockeye into Lake Wenatchee in 2012 (2011 brood) was the last. Therefore, this section presents the history of the program and tracks the juveniles from the 2011 brood that were released as parr into Lake Wenatchee in 2012. Some of these fish began their smolt migrations in 2013.

Origin of Broodstock

Wenatchee sockeye broodstock have not been collected since 2011. Table 4.1 shows the history of the number of broodstock that were collected during the period 1989 to 2011.

Table 4.1. Numbers of wild and hatchery sockeye salmon collected for broodstock, numbers that died before spawning, and numbers of sockeye spawned, 1989-2011. Unknown origin fish (i.e., undetermined by scale analysis, no CWT or fin clips, and no additional hatchery marks) were considered naturally produced. Mortality includes sockeye that died of natural causes typically near the end of spawning and were not needed for the program, surplus sockeye killed at spawning, sockeye that died but were not recovered from the net pens, and sockeye that may have jumped out of the net pens.

Brood year	Wild sockeye					Hatchery sockeye					Total number spawned
	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	
1989	299	93	47	115	44	0	0	0	0	0	115
1990	333	7	7	302	17	0	0	0	0	0	302
1991	357	18	16	199	124	0	0	0	0	0	199
1992	362	18	5	320	19	0	0	0	0	0	320
1993	307	79	21	207	0	0	0	0	0	0	207
1994	329	15	9	236	69	5	0	0	5	0	241
1995	218	5	7	194	12	3	0	0	3	0	197
1996	291	2	0	225	64	20	0	0	0	20	225
1997	283	12	3	192	76	19	0	0	19	0	211
1998	225	37	25	122	41	6	0	0	6	0	128
1999	90	7	1	79	3	60	0	0	60	0	139
2000	256	19	1	170	66	5	0	0	5	0	175
2001	252	27	10	200	15	8	1	0	7	0	207
2002	257	0	1	256	0	0	0	0	0	0	256
2003	261	12	9	198	42	0	0	0	0	0	198
2004	211	13	12	177	9	0	0	0	0	0	177
2005	243	29	12	166	36	0	0	0	0	0	166
2006	260	2	4	214	40	0	0	0	0	0	214
2007	248	15	3	210	20	0	0	0	0	0	210
2008	258	4	11	243	0	2	0	0	2	0	245
2009	258	5	14	239	0	3	0	3	0	0	239
2010	256	3	0	198	55	0	0	0	0	0	256
2011	204	0	8	196	0	0	0	0	0	0	196
Average	***263***	***18***	***10***	***203***	***33***	***6***	***0***	***0***	***5***	***1***	***210***
Median	***258***	***12***	***8***	***199***	***20***	***0***	***0***	***0***	***0***	***0***	***207***

[a] Pre-spawn loss represents the number of fish that died during the holding period before spawning. Mortality is the number of fish that were surplused following spawning.

Age/Length Data

Ages of sockeye were determined from scales and otoliths collected from broodstock and are shown in Table 4.2.

Table 4.2. Percent of hatchery and wild sockeye salmon of different ages (total age) collected from broodstock, 1994-2011.

Return year	Origin	Total age		
		4	5	6
1994	Wild	57.3	41.7	1.0
	Hatchery	40.0	60.0	0.0
1995	Wild	77.3	20.7	2.0
	Hatchery	66.7	33.3	0.0
1996	Wild	65.8	34.2	0.0
	Hatchery	0.0	0.0	0.0
1997	Wild	86.5	13.5	0.0
	Hatchery	57.9	42.1	0.0
1998	Wild	9.9	88.6	1.5
	Hatchery	66.7	33.3	0.0
1999	Wild	21.8	74.7	3.5
	Hatchery	90.0	8.3	1.7
2000	Wild	97.7	2.3	0.0
	Hatchery	100.0	0.0	0.0
2001	Wild	69.9	29.6	0.5
	Hatchery	71.4	28.6	0.0
2002	Wild	31.6	67.6	0.8
	Hatchery	0.0	0.0	0.0
2003	Wild	2.6	90.5	6.9
	Hatchery	0.0	0.0	0.0
2004	Wild	97.5	2.0	0.5
	Hatchery	0.0	0.0	0.0
2005	Wild	74.2	25.8	0.0
	Hatchery	0.0	0.0	0.0
2006	Wild	34.0	65.5	0.5
	Hatchery	0.0	0.0	0.0
2007	Wild	1.9	88.4	9.7
	Hatchery	0.0	0.0	0.0
2008	Wild	95.0	4.0	1.0
	Hatchery	100.0	0.0	0.0
2009	Wild	78.5	21.5	0.0
	Hatchery	100.0	0.0	0.0
2010	Wild	67.4	32.6	0.0
	Hatchery	0.0	0.0	0.0
2011	Wild	53.7	44.3	2.0
	Hatchery	0.0	0.0	0.0

Return year	Origin	Total age		
		4	5	6
Average	***Wild***	***56.8***	***41.5***	***1.7***
	Hatchery	***38.5***	***11.4***	***0.1***
Median	***Wild***	***66.6***	***33.4***	***0.7***
	Hatchery	***20.0***	***0.0***	***0.0***

Lengths and ages of sockeye sampled during the life of the program are provided in Table 4.3.

Table 4.3. Mean fork length (cm) at age (total age) of hatchery and wild sockeye salmon collected for broodstock, 1994-2011; SD = 1 standard deviation.

Return year	Origin	Sockeye fork length (cm)								
		Age-4			Age-5			Age-6		
		Mean	N	SD	Mean	N	SD	Mean	N	SD
1994	Wild	56	125	3	55	91	3	54	2	3
	Hatchery	57	2	1	56	3	1	-	0	-
1995	Wild	51	153	2	55	41	4	54	4	5
	Hatchery	53	2	4	59	1	-	-	0	-
1996	Wild	52	146	4	53	76	3	-	0	-
	Hatchery	-	0	-	-	0	-	-	0	-
1997	Wild	50	166	3	53	26	5	-	0	-
	Hatchery	54	11	4	59	8	2	-	0	-
1998	Wild	51	13	4	55	117	3	53	2	3
	Hatchery	52	4	2	55	2	8	-	0	-
1999	Wild	52	19	4	50	65	4	56	3	1
	Hatchery	50	54	3	56	5	4	56	1	-
2000	Wild	52	167	2	54	4	3	-	0	-
	Hatchery	54	5	1	-	0	-	-	0	-
2001	Wild	54	151	3	56	65	4	58	1	-
	Hatchery	51	5	5	55	2	4	-	0	-
2002	Wild	54	77	2	56	165	4	57	2	0
	Hatchery	-	0	-	-	0	-	-	0	-
2003	Wild	54	5	4	60	172	2	60	13	4
	Hatchery	-	0	-	-	0	-	-	0	-
2004	Wild	53	192	3	56	4	3	63	1	-
	Hatchery	-	0	-	-	0	-	-	0	-
2005	Wild	51	132	3	57	46	4	-	0	-
	Hatchery	-	0	-	-	0	-	-	0	-
2006	Wild	52	70	3	56	135	4	54	2	3
	Hatchery	-	0	-	-	0	-	-	0	-
2007	Wild	57	4	2	58	182	5	58	20	5

Return year	Origin	Sockeye fork length (cm)								
		Age-4			Age-5			Age-6		
		Mean	N	SD	Mean	N	SD	Mean	N	SD
	Hatchery	-	0	-	-	0	-	-	0	-
2008	Wild	52	245	3	52	11	3	62	2	6
	Hatchery	53	2	3	-	-	-	-	-	-
2009	Wild	54	197	3	59	54	4	-	-	-
	Hatchery	54	2	1	-	-	-	-	-	-
2010	Wild	56	130	2	57	63	4	-	-	-
	Hatchery	-	-	-	-	-	-	-	-	-
2011	Wild	55	109	2	59	90	3	61	4	3
	Hatchery	-	-	-	-	-	-	-	-	-
Average	***Wild***	***53***	***116***	***3***	***55***	***78***	***4***	***57***	***3***	***3***
	Hatchery	***53***	***5***	***3***	***57***	***2***	***4***	***56***	***1***	***-***

Sex Ratios

Sex ratios of wild and hatchery sockeye collected during the life of the sockeye hatchery program are presented in Table 4.4.

Table 4.4. Numbers of male and female wild and hatchery sockeye collected for broodstock, 1989-2011. Ratios of males to females are also provided.

Return year	Number of wild sockeye			Number of hatchery sockeye			Total M/F ratio
	Males (M)	Females (F)	M/F	Males (M)	Females (F)	M/F	
1989	162	137	1.18:1.00	0	0	-	1.18:1.00
1990	177	156	1.13:1.00	0	0	-	1.13:1.00
1991	260	97	2.68:1.00	0	0	-	2.68:1.00
1992	180	182	0.99:1.00	0	0	-	0.99:1.00
1993	130	177	0.73:1.00	0	0	-	0.73:1.00
1994	162	167	0.97:1.00	1	4	0.25:1.00	0.95:1.00
1995	102	116	0.88:1.00	1	2	0.50:1.00	0.87:1.00
1996	150	161	0.93:1.00	0	0	-	0.93:1.00
1997	139	144	0.97:1.00	10	9	1.11:1.00	0.97:1.00
1998	115	110	1.05:1.00	2	4	0.50:1.00	1.03:1.00
1999	22	68	0.32:1.00	37	23	1.61:1.00	0.65:1.00
2000	155	101	1.53:1.00	3	2	1.50:1.00	1.53:1.00
2001	114	138	0.83:1.00	4	4	1.00:1.00	0.83:1.00
2002	128	129	0.99:1.00	0	0	-	0.99:1.00
2003	161	100	1.61:1.00	0	0	-	1.61:1.00
2004	108	103	1.05:1.00	0	0	-	1.05:1.00
2005	130	113	1.15:1.00	0	0	-	1.15:1.00
2006	130	130	1.00:1.00	0	0	-	1.00:1.00

Return year	Number of wild sockeye			Number of hatchery sockeye			Total M/F ratio
	Males (M)	Females (F)	M/F	Males (M)	Females (F)	M/F	
2007	127	121	1.05:1.00	0	0	-	1.05:1.00
2008	127	131	0.97:1.00	1	1	1.00:1.00	0.97:1.00
2009	133	125	1.06:1.00	0	3	0.00:1.00	1.04:1.00
2010	127	129	0.98:1.00	0	0	-	0.98:1.00
2011	106	98	1.08:1.00	0	0	-	1.08:1.00
Total	***2,074***	***2,017***	***1.03:1.00***	***58***	***48***	***1.21***	***1.03:1.00***

Fecundity

Fecundities of sockeye collected during the life of the hatchery program are presented in Table 4.5.

Table 4.5. Mean fecundity of female sockeye salmon collected for broodstock, 1989-2011. Fecundities were determined from pooled egg lots and were not identified for individual females.

Return year	Mean fecundity
1989	2,344
1990	2,225
1991	2,598
1992	2,341
1993	2,340
1994	2,798
1995	2,295
1996	2,664
1997	2,447
1998	2,813
1999	2,319
2000	2,673
2001	2,960
2002	2,856
2003	3,511
2004	2,505
2005	2,718
2006	2,656
2007	3,115
2008	2,555
2009	2,459
2010	2,782
2011	2,960
Average	***2,649***
Median	***2,656***

4.2 Hatchery Rearing

Rearing History

Number of eggs taken

Numbers of eggs taken from sockeye broodstock during the life of the sockeye hatchery program are shown in Table 4.6.

Table 4.6. Numbers of eggs taken from sockeye broodstock, 1989-2011.

Return year	Number of eggs taken
1989	133,600
1990	326,267
1991	231,254
1992	381,561
1993	231,700
1994	338,562
1995	247,900
1996	314,390
1997	254,459
1998	163,278
1999	190,732
2000	227,234
2001	301,925
2002	356,982
2003	319,470
2004	225,499
2005	211,985
2006	292,136
2007	302,363
2008	316,476
2009	304,963
2010	278,171
2011	290,046
Average	***271,389***
Median	***290,046***

Number of acclimation days

During the life of the program, Wenatchee sockeye were only acclimated on Lake Wenatchee water in net pens. Acclimation days are presented in Table 4.7.

Table 4.7. Water source and mean acclimation period for Wenatchee sockeye, brood years 1989-2011.

Brood year	Release year	Transfer date	Release date	Number of Days	Water source
1989	1990	5-Apr	24-Oct	202	Lake Wenatchee
1990	1991	10-Apr	19-Oct	192	Lake Wenatchee
1991	1992	1-Apr	20-Oct	202	Lake Wenatchee
1992	1993	5-Apr	7-Sep	155	Lake Wenatchee
		5-Apr	26-Oct	204	Lake Wenatchee
1993	1994	5-Apr	1-Sep	149	Lake Wenatchee
		5-Apr	17-Oct	195	Lake Wenatchee
1994	1995	4-Apr	15-Sep	164	Lake Wenatchee
		4-Apr	23-Oct	202	Lake Wenatchee
1995	1996	4-Apr	25-Oct	204	Lake Wenatchee
1996	1997	4-Apr	22-Oct	201	Lake Wenatchee
1997	1998	1-Apr	9-Nov	222	Lake Wenatchee
1998	1999	1-Apr	29-Oct	211	Lake Wenatchee
1999	2000	25-Jul	28-Aug	34	Lake Wenatchee
		26-Jul	1-Nov	98	Lake Wenatchee
2000	2001	2-Jul	27-Aug	56	Lake Wenatchee
		3-Jul	27-Sep	86	Lake Wenatchee
2001	2002	15-Jul	28-Aug	44	Lake Wenatchee
		16-Jul	22-Sep	68	Lake Wenatchee
2002	2003	30-Jun	25-Aug	56	Lake Wenatchee
		1-Jul	22-Oct	113	Lake Wenatchee
2003	2004	6-Jul	25-Aug	50	Lake Wenatchee
		7-Jul	3-Nov	119	Lake Wenatchee
2004	2005	5-Jul	29-Aug	55	Lake Wenatchee
		6-Jul	2-Nov	120	Lake Wenatchee
2005	2006	11-Jul	30-Oct	111	Lake Wenatchee
2006	2007	9-10 Jul	31-Oct	113-114	Lake Wenatchee
2007	2008	7-8 Jul	29-Oct	113-114	Lake Wenatchee
2008	2009	21-Jul	28-Oct	100	Lake Wenatchee
2009	2010	19-20, 23-Jul	27-Oct	97-101	Lake Wenatchee
2010	2011	6, 11-12-Jul	26-Oct	107-113	Lake Wenatchee
2011	2012	9-10-Jul	29-Oct	112-113	Lake Wenatchee

Release Information

Numbers released

Numbers of juvenile sockeye released into Lake Wenatchee during the life of the program are shown in Table 4.8. Coded wire tag marking rates and numbers of PIT-tagged juvenile sockeye released are also shown in Table 4.8.

Table 4.8. Total number of sockeye parr released and numbers of released fish with CWTs and PIT tags for brood years 1989-2011. The release target for sockeye was 200,000 fish.

Brood year	Release year	CWT mark rate	Number of released fish with PIT tags	Number released
1989	1990	Not marked	0	108,400
1990	1991	0.9308	0	270,802
1991	1992	0.8940	0	167,523
1992	1993	0.9240	0	340,597
1993	1994	0.7278	0	190,443
1994	1995	0.8869	0	252,859
1995[a]	1996	1.0000	0	150,808
1996[a]	1997	0.9680	0	284,630
1997[a]	1998	0.9642	0	197,195
1998[a]	1999	0.8713	0	121,344
1999	2000	0.9527	0	167,955
2000	2001	0.9558	0	190,174
2001	2002	0.9911	0	200,938
2002	2003	0.9306	0	315,783
2003	2004	0.9291	0	240,459
2004	2005	0.8995	0	172,923
2005	2006	0.9811	14,859	140,542
2006	2007	0.9735	14,764	225,670
2007	2008	0.9863	14,947	252,133
2008	2009	0.9576	14,858	154,772
2009	2010	0.9847	14,486	227,743
2010	2011	0.9564	5,039	243,260
2011	2012	0.9690	5,074	241,918
Average		***0.9379***	***11,994[b]***	***211,255***
Median		***0.9561***	***14,764[b]***	***200,938***

[a] These groups were only adipose fin clipped.
[b] Average and median are based on brood years 2004 to 2010.

Fish size and condition at release

The size and condition of the juvenile sockeye released into Lake Wenatchee during the life of the program are presented in Table 4.9.

Table 4.9. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of sockeye released, brood years 1989-2011. Size targets are provided in the last row of the table.

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1989	1990	128	-	18.2	25
1990	1991	131	-	18.9	24
1991	1992	117	3.0	20.6	22
1992	1993	73	6.8	4.2	44
1993	1994	103	-	13.6	40
1994	1995	75	6.1	4.5	38
1995	1996	137	8.2	14.7	30
1996	1997	107	5.6	15.1	30
1997	1998	122	6.1	21.3	21
1998	1999	112	5.4	17.0	27
1999	2000	94	9.5	9.5	48
		134	11.5	31.3	15
2000	2001	123	6.5	22.3	20
		146	8.4	26.0	12
2001	2002	118	7.4	20.7	22
		135	7.3	30.5	15
2002	2003	73	5.6	4.4	104
		118	7.7	13.7	23
		145	9.4	38.6	13
2003	2004	79	4.6	4.8	96
		118	5.9	17.0	26
		158	8.1	44.3	10
2004	2005	116	4.5	17.2	18
		151	7.0	39.3	12
2005	2006	149	7.5	43.7	10
2006	2007	138	10.6	32.4	14
2007	2008	137	9.3	33.0	14
2008	2009	138	9.6	34.6	13

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
2009	2010	143	8.9	35.5	13
2010	2011	132	14.3	30.7	15
2011	2012	142	9.6	35.3	13
Targets		***133***	***9.0***	***22.7***	***20***

Survival Estimates

Life-stage survival estimates for juvenile sockeye during the life of the hatchery program are shown in Table 4.10.

Table 4.10. Hatchery life-stage survival rates (%) for sockeye salmon, brood years 1989-2011. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
1989	41.6	100.0	88.1	63.9	99.2	98.9	98.1	65.2	83.0
1990	96.2	99.4	90.8	96.3	99.9	99.2	98.4	98.4	81.1
1991	91.8	94.1	79.2	94.8	99.8	99.3	96.4	96.4	72.4
1992	91.1	98.8	92.3	98.0	99.9	99.8	98.6	98.8	89.2
1993	57.1	99.2	89.2	98.3	99.6	99.1	93.7	93.8	82.2
1994	89.8	99.2	79.2	96.0	99.5	98.6	98.3	98.2	74.7
1995	97.5	99.1	87.5	95.0	99.0	93.3	73.2	73.2	60.8
1996	99.2	100.0	95.1	98.7	99.7	99.3	96.4	96.5	90.5
1997	92.8	99.3	84.8	97.9	97.9	97.6	95.5	94.9	77.5
1998	75.4	95.5	77.7	98.4	98.6	98.2	97.1	97.2	74.3
1999	92.3	100.0	92.2	97.3	99.6	99.3	98.2	99.7	88.1
2000	84.5	98.1	93.8	97.7	96.7	96.1	91.4	96.8	83.7
2001	75.4	99.2	78.5	97.6	98.0	97.6	86.9	95.1	66.6
2002	100.0	100.0	95.7	97.8	99.6	99.2	94.6	99.8	88.5
2003	91.0	98.1	87.2	96.9	99.0	98.2	94.8	95.5	74.6
2004	88.7	92.6	88.0	93.1	97.9	97.4	93.7	96.1	76.7
2005	98.5	98.5	85.3	94.9	97.8	96.6	95.5	99.2	66.3
2006	95.3	99.1	73.2	85.4	95.4	94.6	87.8	98.5	54.9
2007	88.4	99.2	89.1	98.6	97.0	95.9	94.9	99.0	83.4
2008	97.0	100.0	59.0	88.3	99.1	97.2	93.8	97.4	48.9
2009	95.8	98.3	89.1	94.8	96.9	96.2	88.4	92.3	74.7
2010	99.0	98.0	92.6	98.2	97.5	96.5	95.6	99.6	87.0
2011	100.0	100.0	92.6	100.0	96.8	96.0	95.4	99.7	88.3
Average	***88.6***	***98.5***	***86.1***	***94.7***	***98.5***	***97.6***	***93.8***	***94.8***	***76.8***

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
Median	***92.3***	***99.2***	***88.1***	***97.3***	***99.0***	***97.6***	***95.4***	***97.2***	***77.5***
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

4.3 Disease Monitoring

Because the sockeye hatchery program was terminated in 2012, there are no disease-monitoring results.

4.4 Natural Juvenile Productivity

Sockeye smolt abundance was estimated at a trap located near the mouth of Lake Wenatchee during the period 1997 to 2011. Because the efficiency of the trap was difficult to assess, the operation was terminated in 2011. In 2012, the trap was relocated downstream near the mouth of the Chiwawa River and operated there for two years. Again, because few marked sockeye smolts were recaptured, the operation was terminated in 2013. Beginning in 2013, smolt abundance has been estimated at the Lower Wenatchee Trap.

Emigrant and Smolt Estimates

The Lower Wenatchee Trap operated between 30 January and 28 June 2015. During that time period the trap was inoperable for five days because of high and low river discharge, debris, elevated river temperature, and major hatchery releases. During the eight-month sampling period, a total of 4,178 wild juvenile sockeye were captured at the Lower Wenatchee Trap. No hatchery juvenile sockeye were captured in 2015. A significant relationship between trap efficiency and river discharge was created ($R^2 = 0.52$, $P < 0.043$). Using this model, the number of juvenile sockeye emigrants was estimated at 1,065,614 (±238,901; 95% CI) during the 2015 trapping season (Table 4.11). Figure 4.1 shows the monthly captures of sockeye collected at the Lower Wenatchee Trap in 2015. All fish captured in the Lower Wenatchee trap are reported in Appendix B.

Table 4.11. Estimated numbers of wild and hatchery sockeye smolts that emigrated from Lake Wenatchee during run years 1997-2011; ND = no data. Estimates for the run years 1997-2011 were based on sampling at the Upper Wenatchee smolt trap; estimates beginning in 2013 were based on sampling at the Lower Wenatchee smolt trap.

Run year	Numbers of sockeye smolts	
	Wild smolts	Hatchery smolts
1997	55,359	28,828
1998	1,447,259	55,985
1999	1,944,966	112,524
2000	985,490	24,684
2001	39,353	94,046
2002	729,716	121,511
2003	5,439,032	140,322

Run year	Numbers of sockeye smolts	
	Wild smolts	Hatchery smolts
2004	5,771,187	216,023
2005	723,413	122,399
2006	1,266,971	159,500
2007	2,797,313	140,542
2008[a]	549,682	121,843
2009[a]	355,549	119,908
2010[a]	3,958,888	126,326
2011	1,500,730	159,089
2012	ND	ND
2013	873,096	No program
2014	1,275,027	No program
2015	1,065,614	No program
Average	***1,709,925***	***116,235[b]***
Median	***1,065,614***	***121.511[b]***

[a] Estimates refined based on PIT tag survival to McNary Dam.
[b] Summary statistics were calculated for years in which hatchery fish were being released (1997-2011).

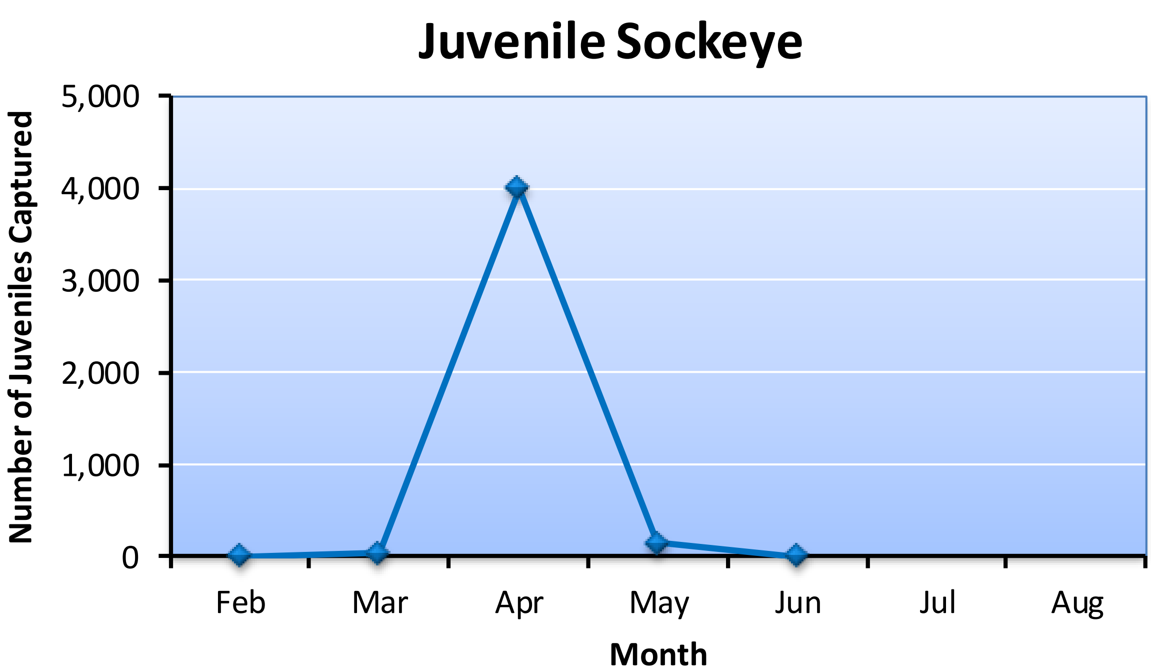

Figure 4.1. Monthly captures of wild sockeye salmon smolts at the Lower Wenatchee Trap, 2015.

Age classes of wild sockeye smolts were determined from a length frequency analysis based on scales collected randomly each year since 1997 (Table 4.12). For the available run years, most wild sockeye smolts migrated as age 1+ fish. Only in two years (1997 and 2005) did more smolts migrate as age 2+ fish. Relatively few smolts migrated at age 3+.

Table 4.12. Age structure and estimated number of wild sockeye smolts that emigrated from Lake Wenatchee, 1997-2015; ND = no data. Estimates for the run years 1997-2011 were based on sampling at the Upper Wenatchee smolt trap; estimates beginning in 2013 were based on sampling at the Lower Wenatchee smolt trap.

Run year	Proportion of wild smolts			Total wild emigrants
	Age 1+	Age 2+	Age 3+	
1997	0.075	0.906	0.019	55,359
1998	0.955	0.037	0.008	1,447,259
1999	0.619	0.381	0.000	1,944,966
2000	0.599	0.400	0.001	985,490
2001	0.943	0.051	0.006	39,353
2002	0.961	0.039	0.000	729,716
2003	0.740	0.026	0.000	5,439,032
2004	0.929	0.071	0.000	5,771,187
2005	0.230	0.748	0.022	723,413
2006	0.994	0.006	0.000	1,266,971
2007	0.996	0.004	0.000	2,797,313
2008	0.804	0.195	0.001	549,682
2009	0.927	0.073	0.000	355,549
2010	0.963	0.036	0.001	3,958,888
2011	0.786	0.214	0.000	1,500,730
2012	ND	ND	ND	ND
2013	0.933	0.067	0.000	873,096
2014	0.924	0.076	0.000	1,275,027
2015	TBD	TBD	TBD	1,065,614
Average	***0.786***	***0.194***	***0.003***	***1,709,924***
Median	***0.927***	***0.067***	***0.000***	***985,490***

Freshwater Productivity

Egg-smolt survival estimates for wild sockeye salmon are provided in Table 4.13. Estimates of egg deposition were calculated based on the spawner escapement at Tumwater Dam and the sex ratio and fecundity of the broodstock. For the 2012 brood year (a year where brood was not collected), a linear relationship with post-orbital to hypural length as the independent variable was used to calculate average fecundity of sockeye sampled at Tumwater Dam ($r^2 = 0.40$, $P < 0.01$). Smolts for brood years 1995-2009 were based on captures at the Upper Wenatchee Trap. No smolt estimates are available for brood year 2010. Smolt estimates for brood years since 2012 are derived from captures made at the Lower Wenatchee Trap. Egg-smolt survival rates for brood years 1995-2013 have ranged from 0.012 to 0.212 (mean = 0.087).

Table 4.13. Estimated egg deposition (estimated as mean fecundity times estimated number of females), numbers of smolts, and survival rates for wild Wenatchee sockeye salmon, brood years 1995-2013; NA = not available.

Brood year	Number of females	Mean fecundity	Total eggs	Numbers of wild smolts				Egg-smolt survival
				Age 1+	Age 2+	Age 3+	Total	
1995	2,136	2,295	4,902,120	4,174	53,549	0	57,723	0.012
1996	3,767	2,664	10,035,288	1,382,133	741,032	985	2,124,150	0.212
1997	5,404	2,447	13,223,588	1,203,934	394,196	236	1,598,366	0.121
1998	2,024	2,813	5,693,512	590,309	2,007	0	592,316	0.104
1999	513	2,319	1,189,647	37,110	28,459	0	65,569	0.055
2000	11,413	2,673	30,506,949	701,257	1,414,148	0	2,115,405	0.069
2001	21,685	2,960	64,187,600	4,024,884	409,754	15,915	4,450,553	0.069
2002	17,226	2,856	49,197,456	5,361,433	541,113	0	5,902,546	0.120
2003	2,158	3,511	7,576,738	166,385	7,602	0	173,987	0.023
2004	15,469	2,505	38,749,845	1,259,369	11,189	275	1,270,833	0.033
2005	5,867	2,718	15,946,506	2,786,123	107,243	0	2,893,366	0.181
2006	2,747	2,656	7,296,032	442,164	25,919	1,507	469,590	0.064
2007	2,001	3,115	6,232,804	329,629	142,916	594	473,139	0.076
2008	11,775	2,555	30,084,691	3,814,226	320,567	NA	4,134,794	0.137
2009	3,939	2,459	9,684,965	1,179,569	NA	0	NA	NA
2010	11,918	2,785	33,190,467	NA[a]	58,497	0	NA	NA
2011	9,722	2,970	28,873,491	816,836[b]	96,902	0	913,738	0.032
2012	14,753	2,745	40,496,573	1,178,125[b]	--	0	--	--
2013	9,477	2,732	25,891,164	--	--	0	--	--
Average	***8,105***	***2,725***	***22,261,023***	***1,578,795***	***272,193***	***1,084***	***1,815,738***	***0.087***
Median	***5,404***	***2,673***	***15,946,506***	***1,203,934***	***96,902***	***0***	***913,738***	***0.069***

[a] There is no emigrant estimate for trapping during 2012.
[b] Emigrant estimates are derived from captures at the Lower Wenatchee Trap.

Juvenile survival rates for hatchery sockeye salmon are provided in Table 4.14. Release-smolt survival rates for brood years 1995-2009 have ranged from 0.000 to 1.000 (mean = 0.570). Egg-smolt survival rates for the same brood years ranged from 0.000 to 0.710 (mean = 0.294). On average, egg-smolt survival of hatchery sockeye is about three times greater than egg-smolt survival of wild sockeye.

Table 4.14. Juvenile survival rates for hatchery Wenatchee sockeye, brood years 1995-2009.

Brood year	Number of eggs	Number of parr released	Date of release	Estimated number of smolts	Egg-smolt survival	Release-smolt survival
1995	247,900	150,808	10/25/96	28,828	0.116	0.191
1996	314,390	284,630	10/22/97	55,985	0.178	0.197
1997	254,459	197,195	11/9/98	112,524	0.442	0.571
1998	163,278	121,344	10/27/99	24,684	0.151	0.203

Brood year	Number of eggs	Number of parr released	Date of release	Estimated number of smolts	Egg-smolt survival	Release-smolt survival
1999	190,732	84,466	8/28/00	30,326	0.159	0.359
		83,489	11/1/00	63,720	0.334	0.763
2000	227,234	92,055	8/27/01	30,918	0.136	0.336
		98,119	9/27/01	90,593	0.399	0.923
2001	301,925	96,486	8/28/02	36,484	0.121	0.378
		104,452	9/23/02	103,838	0.344	0.994
2002	356,982	98,509	6/16/03	5,192	0.015	0.053
		104,855	8/25/03	98,412	0.276	0.939
		112,419	10/22/03	112,419	0.315	1.000
2003	319,470	32,755	6/15/04	0	0.000	0.000
		104,879	8/25/04	19,574	0.061	0.187
		102,825	11/3/04	102,825	0.322	1.000
2004	225,499	81,428	8/29/05	159,500	0.707	0.922
		91,495	11/2/05			
2005	211,985	70,386	10/30/06	140,542	0.663	1.000
		70,156	10/30/06			
2006	292,136	225,670	10/31/07	121,843	0.412	0.540
2007	302,363	252,133	10/29/08	119,908	0.397	0.476
2008	316,476	154,772	10/28/09	126,326	0.399	0.813
2009	304,963	227,743	10/27/10	159,089	0.522	0.699

[a] There is no emigrant estimate for the 2010 or 2011 brood years.

PIT Tagging Activities

A total of 3,922 wild juvenile sockeye salmon were PIT tagged and released in 2015 at the Lower Wenatchee Trap. Numbers of wild sockeye salmon PIT-tagged and released as part of the Comparative Survival Study and PUD studies during the period 2006-2015 are shown in Table 4.15. See Appendix C for a complete list of all fish captured, tagged, lost, and released.

Table 4.15. Summary of the numbers of wild sockeye salmon that were tagged and released at the Upper and Lower Wenatchee Traps within the Wenatchee River basin, 2006-2015.

Sampling Location	Numbers of PIT-tagged sockeye salmon released							
	2008	2009	2010	2011	2012	2013	2014	2015
Upper Wenatchee Trap	3,165	3,683	10,006	--	--	--	--	--
Lower Wenatchee Trap	0	0	0	0	0	0	4,821	3,922

4.5 Spawning Escapement

The sockeye salmon hatchery program ended after the 2011 brood year. As a result, monitoring activities that focused on evaluating the effects of the supplementation program on the natural population switched to monitoring the abundance and productivity of the natural population. Thus, spawn time estimating and carcass surveys were discontinued.

From 2009-2013, mark-recapture methods were used to estimate spawning escapement within the White River, while area-under-the-curve (AUC) methods were used to estimate spawning escapement within the Little Wenatchee River. Beginning in 2014, mark-recapture methods were used to estimate the spawning escapement of sockeye in the White River and Little Wenatchee watersheds (see Appendix H for more details).

Mark-Recapture Estimates

Spawning escapement of sockeye salmon in 2015 was estimated using mark-recapture methods. This method relied on PIT tags to estimate sockeye spawning escapement (see Appendix H for more details).

Using mark-recapture methods, the estimated total escapement of sockeye in the Upper Wenatchee River basin in 2015 was 24,200 (Table 4.16). About 83% of the escapement entered the White River watershed (including the Napeequa River).

Table 4.16. Estimated escapement of adult sockeye into the Little Wenatchee and White River watersheds for return years 2009-2015. Escapement was based on recapture of PIT-tagged fish.

Return year	Tumwater Dam count	Recreational harvest	Little Wenatchee escapement	White River escapement	Total spawning escapement
2009	16,034	2,285	576	13,876	14,452
2010	35,821	4,129	2,062	19,542	21,604
2011[a]	18,634	0	2,431	14,582	17,013
2012	66,520	12,107	4,607	23,866	28,473
2013[a]	29,015	6,262	2,426	14,294	16,720
2014	99,898	16,281	4,319	49,021	53,340
2015	51,435	7,916	4,115	20,097	24,212
Average	***45,337***	***6,989***	***2,934***	***22,183***	***25,116***
Median	***35,821***	***6,262***	***2,431***	***19,542***	***21,604***

[a] Spawning escapements in 2011 and 2013 were calculated using AUC counts and a regression model.

The spawning escapement of 24,200 Wenatchee sockeye was greater than the overall average of 17,535 (Table 4.17).

Table 4.17. Spawning escapements for sockeye salmon in the Wenatchee River basin for return years 1989-2015; NA = not available and AUC = area under the curve.

Return year	Escapement estimation method	Spawning escapement		
		Little Wenatchee	White	Total
1989	Counts at Tumwater Dam	NA	NA	**21,802**
1990	Counts at Tumwater Dam	NA	NA	**27,325**
1991	Counts at Tumwater Dam	NA	NA	**26,689**
1992	Counts at Tumwater Dam	NA	NA	**16,461**
1993	Counts at Tumwater Dam	NA	NA	**27,726**

Return year	Escapement estimation method	Spawning escapement		
		Little Wenatchee	White	Total
1994	Counts at Tumwater Dam	NA	NA	**7,330**
1995	Counts at Tumwater Dam	NA	NA	**3,448**
1996	Counts at Tumwater Dam	NA	NA	**6,573**
1997	Counts at Tumwater Dam	NA	NA	**9,693**
1998	Counts at Tumwater Dam	NA	NA	**4,014**
1999	Counts at Tumwater Dam	NA	NA	**1,025**
2000	Counts at Tumwater Dam	NA	NA	**20,735**
2001	Counts at Tumwater Dam	NA	NA	**29,103**
2002	Counts at Tumwater Dam	NA	NA	**27,565**
2003	Counts at Tumwater Dam	NA	NA	**4,855**
2004	Counts at Tumwater Dam	NA	NA	**27,556**
2005	Counts at Tumwater Dam	NA	NA	**14,011**
2006	AUC	574	5,634	**6,208**
2007	AUC	150	1,720	**1,870**
2008	AUC	3,491	16,757	**20,248**
2009	AUC and Mark-Recap	763	7,004	**7,767**
2010	AUC and Mark-Recap	2,543	19,157	**21,700**
2011	AUC and Mark-Recap	2,431	14,582	**17,013**
2012	AUC and Mark-Recap	4,607	23,866	**28,473**
2013	AUC and Mark-Recap	2,426	14,294	**16,720**
2014	Mark-Recapture	4,391	49,021	**53,340**
2015	Mark-Recapture	4,115	20,097	**24,212**
Average		***2,549***	***17,213***	***18,965***
Median		***2,487***	***15,670***	***20,248***

4.6 Carcass Surveys

As described earlier, carcass surveys were not conducted in 2015. The information contained in this section represents carcass data collected before 2014.

Number sampled

Table 4.18 shows the number of carcasses sampled within different survey streams during the period 1993-2013.

Table 4.18. Numbers of sockeye carcasses sampled within different streams/watersheds within the Wenatchee River basin, 1989-2013.

Survey year	Numbers of sockeye carcasses			
	Little Wenatchee	White	Napeequa	Total
1993	90	195	0	**285**
1994	121	165	0	**286**
1995	0	56	0	**56**
1996	43	1,387	3	**1,433**
1997	69	1,425	41	**1,535**
1998	61	524	4	**589**
1999	40	186	0	**226**
2000	821	5,494	0	**6,315**
2001	650	3,127	0	**3,777**
2002	506	7,258	55	**7,819**
2003	86	1,002	14	**1,102**
2004	625	6,960	138	**7,723**
2005	1	7	0	**8**
2006	101	2,158	38	**2,297**
2007	17	363	3	**383**
2008	476	5,132	125	**5,733**
2009	84	3,103	103	**3,290**
2010	217	7,832	70	**8,119**
2011	372	3,322	48	**3,742**
2012	1,309	7,479	31	**8,819**
2013	179	2,996	27	**3,202**
Average	***279***	***2,865***	***33***	***3,178***
Median	***101***	***2,158***	***14***	***2,297***

Carcass Distribution and Origin

Based on the available data (1993-2013), the largest percentage of both wild and hatchery sockeye spawned in Reach 2 on the White River (Table 4.19 and Figure 4.2). However, a greater percentage of wild fish was found in Reach 2 than hatchery fish.

Table 4.19. Numbers of wild and hatchery sockeye carcasses sampled within different reaches in the Wenatchee River basin, 1993-2013. Reach codes are described in Table 2.9.

Survey year	Origin	Numbers of sockeye carcasses					
		Little Wenatchee		White River			Total
		L2	L3	H1	H2	Q1	
1993	Wild	86	0	0	183	0	**269**
	Hatchery	4	0	0	12	0	**16**
1994	Wild	112	0	0	155	0	**267**

Survey year	Origin	Numbers of sockeye carcasses					
		Little Wenatchee		White River			Total
		L2	L3	H1	H2	Q1	
	Hatchery	9	0	0	9	0	**18**
1995	Wild	0	0	0	55	0	**55**
	Hatchery	0	0	0	1	0	**1**
1996	Wild	41	0	0	1,299	3	**1,343**
	Hatchery	2	0	0	88	0	**90**
1997	Wild	65	0	0	1,411	40	**1,516**
	Hatchery	4	0	0	11	1	**16**
1998	Wild	61	0	0	515	4	**580**
	Hatchery	0	0	0	9	0	**9**
1999	Wild	30	0	0	164	0	**194**
	Hatchery	10	0	0	22	0	**32**
2000	Wild	694	0	3	5,239	0	**5,936**
	Hatchery	127	0	0	252	0	**379**
2001	Wild	625	0	0	3,063	0	**3,688**
	Hatchery	25	0	0	64	0	**89**
2002	Wild	504	0	0	7,207	55	**7,766**
	Hatchery	2	0	0	51	0	**53**
2003	Wild	81	0	0	993	14	**1,088**
	Hatchery	5	0	0	9	0	**14**
2004	Wild	606	0	0	6,755	166	**7,527**
	Hatchery	19	0	0	205	22	**246**
2005	Wild	201	0	5	2,966	21	**3,193**
	Hatchery	1	0	0	8	0	**9**
2006	Wild	80	0	0	2,112	36	**2,228**
	Hatchery	21	0	0	46	2	**69**
2007	Wild	17	0	0	346	3	**366**
	Hatchery	0	0	0	17	0	**17**
2008	Wild	472	0	0	5,118	124	**5,714**
	Hatchery	4	0	0	14	1	**19**
2009	Wild	80	0	0	3,084	103	**3,267**
	Hatchery	4	0	0	19	0	**23**
2010	Wild	210	0	0	7,711	69	**7,990**
	Hatchery	7	0	0	121	1	**129**
2011	Wild	266	0	0	3,079	43	**3,388**
	Hatchery	106	0	0	243	5	**354**
2012	Wild	1,270	0	21	7,368	30	**8,689**
	Hatchery	39	0	3	87	1	**130**
2013	Wild	174	0	1	2,936	26	**3,137**
	Hatchery	3	0	0	56	1	**60**
Average	***Wild***	***270***	***0***	***1***	***2,941***	***35***	***3,248***

Survey year	Origin	Numbers of sockeye carcasses					
		Little Wenatchee		White River			Total
		L2	L3	H1	H2	Q1	
	Hatchery	*18*	*0*	*0*	*61*	*2*	*81*
Median	*Wild*	*112*	*0*	*0*	*2,936*	*21*	*3,137*
	Hatchery	*4*	*0*	*0*	*22*	*0*	*32*

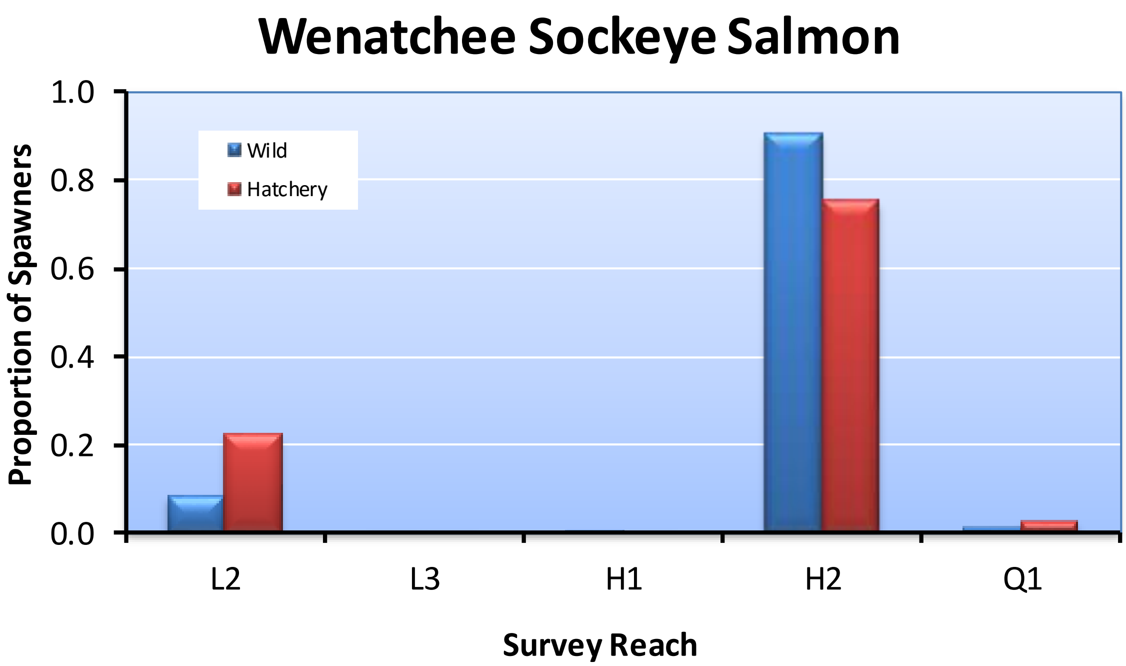

Figure 4.2. Distribution of wild and hatchery produced carcasses in different reaches in the Wenatchee River basin, pooled data from 1993-2013. Reach codes are described in Table 2.9; L = Little Wenatchee, H = White River, and Q = Napeequa River.

4.7 Life History Monitoring

Life history characteristics of Wenatchee sockeye were assessed by examining carcasses on spawning grounds and fish sampled at broodstock collection sites or during stock assessment, and by reviewing tagging data and fisheries statistics.

Migration Timing

There was little difference in migration timing of hatchery and wild sockeye past Tumwater Dam (Table 4.20a and b; Figure 4.3). On average, early in the run, hatchery and wild sockeye arrived at the dam at about the same time. Toward the end of the migration period, hatchery sockeye tended to arrive at the dam slightly later than did wild sockeye. Most hatchery and wild sockeye migrated upstream past Tumwater Dam during July through early August. The peak migration time for both hatchery and wild sockeye was the last two weeks of July (Figure 4.3).

Table 4.20a. The Julian day and date that 10%, 50% (median), and 90% of the wild and hatchery sockeye salmon passed Tumwater Dam, 1998-2015. The average Julian day and date are also provided. Migration timing is based on video sampling at Tumwater. Data for 1998 through 2003 were based on videotapes and broodstock trapping and may not reflect the actual number of hatchery sockeye salmon. All sockeye were visually examined during trapping from 2004 to present.

Survey year	Origin	Sockeye Migration Time (days)								Sample size
		10 Percentile		50 Percentile		90 Percentile		Mean		
		Julian	Date	Julian	Date	Julian	Date	Julian	Date	
1998	Wild	195	14-Jul	201	20-Jul	208	27-Jul	202	21-Jul	4,173
	Hatchery	196	15-Jul	204	23-Jul	220	8-Aug	206	25-Jul	31
1999	Wild	226	14-Aug	233	21-Aug	241	29-Aug	234	22-Aug	908
	Hatchery	228	16-Aug	234	22-Aug	242	30-Aug	235	23-Aug	264
2000	Wild	200	18-Jul	206	24-Jul	213	31-Jul	207	25-Jul	18,390
	Hatchery	199	17-Jul	206	24-Jul	213	31-Jul	206	24-Jul	2,589
2001	Wild	189	8-Jul	194	13-Jul	214	2-Aug	198	17-Jul	32,554
	Hatchery	199	18-Jul	212	31-Jul	240	28-Aug	214	2-Aug	79
2002	Wild	204	23-Jul	208	27-Jul	219	7-Aug	210	29-Jul	27,241
	Hatchery	204	23-Jul	209	28-Jul	222	10-Aug	211	30-Jul	580
2003	Wild	194	13-Jul	200	19-Jul	208	27-Jul	201	20-Jul	4,699
	Hatchery	194	13-Jul	201	20-Jul	211	30-Jul	203	22-Jul	375
2004	Wild	191	9-Jul	196	14-Jul	207	25-Jul	198	16-Jul	31,408
	Hatchery	189	7-Jul	194	12-Jul	203	21-Jul	196	14-Jul	1,758
2005	Wild	192	11-Jul	199	18-Jul	227	15-Aug	204	23-Jul	14,176
	Hatchery	187	6-Jul	200	19-Jul	251	8-Sep	212	31-Jul	42
2006	Wild	201	20-Jul	204	23-Jul	214	2-Aug	206	25-Jul	9,151
	Hatchery	202	21-Jul	219	7-Aug	228	16-Aug	215	3-Aug	507
2007	Wild	201	20-Jul	210	29-Jul	227	15-Aug	213	1-Aug	2,542
	Hatchery	205	24-Jul	213	1-Aug	231	19-Aug	216	4-Aug	65
2008	Wild	200	18-Jul	207	25-Jul	219	6-Aug	208	26-Jul	29,229
	Hatchery	201	19-Jul	206	24-Jul	215	2-Aug	208	26-Jul	103
2009	Wild	198	17-Jul	204	23-Jul	213	1-Aug	206	25-Jul	15,552
	Hatchery	199	18-Jul	205	24-Jul	215	3-Aug	207	26-Jul	534
2010	Wild	199	18-Jul	205	24-Jul	220	8-Aug	208	27-Jul	34,519
	Hatchery	200	19-Jul	215	3-Aug	244	1-Sep	218	6-Aug	1,302
2011	Wild	213	1-Aug	216	4-Aug	224	12-Aug	217	5-Aug	17,680
	Hatchery	213	1-Aug	213	1-Aug	231	19-Aug	216	4-Aug	954
2012[a]	Wild	207	25-Jul	212	30-Jul	216	3-Aug	212	30-Jul	21,246
	Hatchery	207	25-Jul	207	25-Jul	228	15-Aug	213	31-Jul	348
2013	Wild	196	15-Jul	200	19-Jul	207	26-Jul	201	20-Jul	28,245
	Hatchery	197	16-Jul	201	20-Jul	211	30-Jul	203	22-Jul	770
2014	Wild	194	13-Jul	199	18-Jul	210	29-Jul	201	20-Jul	97,670

Survey year	Origin	Sockeye Migration Time (days)								Sample size
		10 Percentile		50 Percentile		90 Percentile		Mean		
		Julian	Date	Julian	Date	Julian	Date	Julian	Date	
	Hatchery	196	15-Jul	201	20-Jul	211	30-Jul	203	22-Jul	2,229
2015	Wild	191	10-Jul	199	18-Jul	215	3-Aug	203	22-Jul	49,650
	Hatchery	181	30-Jun	199	18-Jul	212	31-Jul	200	19-Jul	1,785
Average	***Wild***	***200***		***205***		***217***		***207***		***24,391***
	Hatchery	***200***		***208***		***224***		***210***		***795***
Median	***Wild***	***199***		***204***		***215***		***206***		***19,818***
	Hatchery	***199***		***206***		***221***		***210***		***521***

[a] The origin of sockeye passing Tumwater Dam during 8 through 11 August 2012 was not assessed. The total number of sockeye passing Tumwater Dam in 2012 was 30,617 adults. Thus, about 9,023 adults of unknown origin passed Tumwater Dam in 2012.

Table 4.20b. The week that 10%, 50% (median), and 90% of the wild and hatchery sockeye salmon passed Tumwater Dam, 1998-2015. The average week is also provided. Migration timing is based on video sampling at Tumwater. Data for 1998 through 2003 were based on videotapes and broodstock trapping and may not reflect the actual number of hatchery sockeye salmon. All sockeye were visually examined during trapping from 2004 to present.

Survey year	Origin	Sockeye Migration Time (week)				Sample size
		10 Percentile	50 Percentile	90 Percentile	Mean	
1998	Wild	28	29	30	29	4,173
	Hatchery	28	30	32	30	31
1999	Wild	33	34	35	34	908
	Hatchery	33	34	35	34	264
2000	Wild	29	30	31	30	18,390
	Hatchery	29	30	31	30	2,589
2001	Wild	27	28	31	29	32,554
	Hatchery	29	31	35	31	79
2002	Wild	30	30	32	30	27,241
	Hatchery	30	30	32	31	580
2003	Wild	28	29	30	29	4,699
	Hatchery	28	29	31	29	375
2004	Wild	28	28	28	29	31,408
	Hatchery	27	28	29	28	1,758
2005	Wild	28	29	33	30	14,176
	Hatchery	27	29	36	31	42
2006	Wild	29	29	31	30	9,151
	Hatchery	29	32	33	31	507
2007	Wild	29	30	33	31	2,542
	Hatchery	30	31	33	31	65
2008	Wild	29	30	32	30	29,229

Survey year	Origin	Sockeye Migration Time (week)				Sample size
		10 Percentile	50 Percentile	90 Percentile	Mean	
	Hatchery	29	30	31	30	103
2009	Wild	29	30	31	30	15,552
	Hatchery	29	29	31	30	534
2010	Wild	29	30	32	30	34,519
	Hatchery	29	31	35	32	1,302
2011	Wild	31	31	32	31	17,680
	Hatchery	31	31	33	31	954
2012[a]	Wild	30	31	31	31	21,246
	Hatchery	30	30	33	31	348
2013	Wild	28	29	30	29	28,245
	Hatchery	29	29	31	29	770
2014	Wild	28	29	30	29	97,670
	Hatchery	28	29	29	29	2,229
2015	Wild	28	29	31	30	49,650
	Hatchery	26	29	31	29	1,785
Average	***Wild***	***29***	***30***	***31***	***30***	***24,391***
	Hatchery	***29***	***30***	***32***	***30***	***795***
Median	***Wild***	***29***	***30***	***31***	***30***	***19,818***
	Hatchery	***29***	***30***	***32***	***31***	***521***

[a] The origin of sockeye passing Tumwater Dam during 8 through 11 August 2012 was not assessed. The total number of sockeye passing Tumwater Dam in 2012 was 30,617 adults. Thus, about 9,023 adults of unknown origin passed Tumwater Dam in 2012.

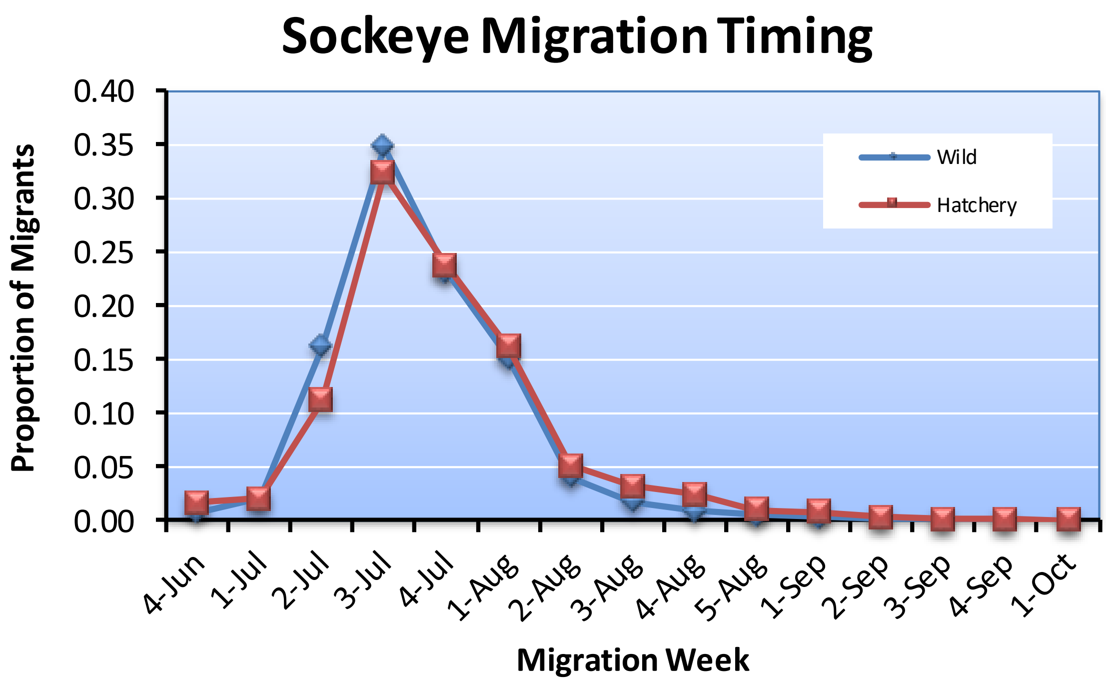

Figure 4.3. Proportion of wild and hatchery sockeye observed (using video) passing Tumwater Dam each week during their migration period late-June through early-October; data were pooled over survey years 1998-2015.

Age at Maturity

Although sample sizes are small, most hatchery sockeye returned as age-4 fish, while most wild sockeye returned as age-4 and 5 fish (Table 4.21; Figure 4.4). Only wild fish have returned at age-6.

Table 4.21. Proportions of wild and hatchery sockeye of different ages (total age) sampled in broodstock (1994-2011), on spawning grounds (1994-2012), and at Tumwater Dam (2013-2014).

Survey year	Origin	Total age						Sample size
		2	3	4	5	6	7	
1994	Wild	0.00	0.00	0.00	0.00	0.00	0.00	0
	Hatchery	0.00	0.00	0.88	0.13	0.00	0.00	16
1995	Wild	0.00	0.00	0.00	0.00	0.00	0.00	0
	Hatchery	0.00	0.00	0.00	1.00	0.00	0.00	1
1996	Wild	0.00	0.00	0.00	0.00	0.00	0.00	0
	Hatchery	0.00	0.00	1.00	0.00	0.00	0.00	82
1997	Wild	0.00	0.00	0.00	0.00	0.00	0.00	0
	Hatchery	0.00	0.00	0.77	0.23	0.00	0.00	13
1998	Wild	0.00	0.08	0.85	0.08	0.00	0.00	26
	Hatchery	0.00	0.00	0.64	0.36	0.00	0.00	11

Survey year	Origin	Total age						Sample size
		2	3	4	5	6	7	
1999	Wild	0.00	0.00	0.18	0.73	0.10	0.00	113
	Hatchery	0.00	0.00	0.65	0.35	0.00	0.00	31
2000	Wild	0.00	0.00	0.00	1.00	0.00	0.00	1
	Hatchery	0.00	0.00	0.98	0.02	0.00	0.00	359
2001	Wild	0.00	0.00	0.76	0.24	0.00	0.00	29
	Hatchery	0.00	0.00	0.75	0.25	0.00	0.00	171
2002	Wild	0.00	0.00	0.20	0.80	0.00	0.00	5
	Hatchery	0.00	0.00	0.29	0.71	0.00	0.00	63
2003	Wild	0.00	0.00	0.00	1.00	0.00	0.00	5
	Hatchery	0.00	0.33	0.67	0.00	0.00	0.00	6
2004	Wild	0.00	0.00	0.00	0.00	0.00	0.00	0
	Hatchery	0.00	0.02	0.93	0.05	0.00	0.00	244
2005	Wild	0.00	0.00	0.00	0.00	0.00	0.00	0
	Hatchery	0.00	0.13	0.75	0.13	0.00	0.00	8
2006	Wild	0.00	0.00	0.34	0.65	0.01	0.00	207
	Hatchery	0.00	0.00	1.00	0.00	0.00	0.00	65
2007	Wild	0.00	0.00	0.02	0.88	0.10	0.00	206
	Hatchery	0.00	0.00	0.35	0.65	0.00	0.00	17
2008	Wild	0.00	0.00	0.95	0.04	0.01	0.00	258
	Hatchery	0.00	0.08	0.92	0.00	0.00	0.00	12
2009	Wild	0.00	0.00	0.79	0.21	0.00	0.00	251
	Hatchery	0.00	0.00	1.00	0.00	0.00	0.00	2
2010	Wild	0.00	0.00	0.67	0.33	0.00	0.00	193
	Hatchery	0.00	0.00	0.98	0.02	0.00	0.00	130
2011	Wild	0.00	0.00	0.63	0.36	0.01	0.00	270
	Hatchery	0.00	0.02	0.96	0.02	0.00	0.00	274
2012	Wild	0.00	0.00	0.92	0.08	0.00	0.00	13
	Hatchery	0.00	0.00	0.96	0.03	0.01	0.00	128
2013	Wild	0.00	0.002	0.56	0.44	0.002	0.00	457
	Hatchery	0.00	0.00	0.50	0.50	0.00	0.00	2
2014	Wild	0.00	0.00	0.88	0.12	0.001	0.00	1,335
	Hatchery	0.00	0.03	0.97	0.00	0.00	0.00	35
Average	***Wild***	***0.00***	***0.00***	***0.69***	***0.30***	***0.01***	***0.00***	***161***
	Hatchery	***0.00***	***0.01***	***0.90***	***0.09***	***0.00***	***0.00***	***80***
Median	***Wild***	***0.00***	***0.00***	***0.71***	***0.29***	***0.00***	***0.00***	***26***
	Hatchery	***0.00***	***0.00***	***0.88***	***0.12***	***0.00***	***0.00***	***31***

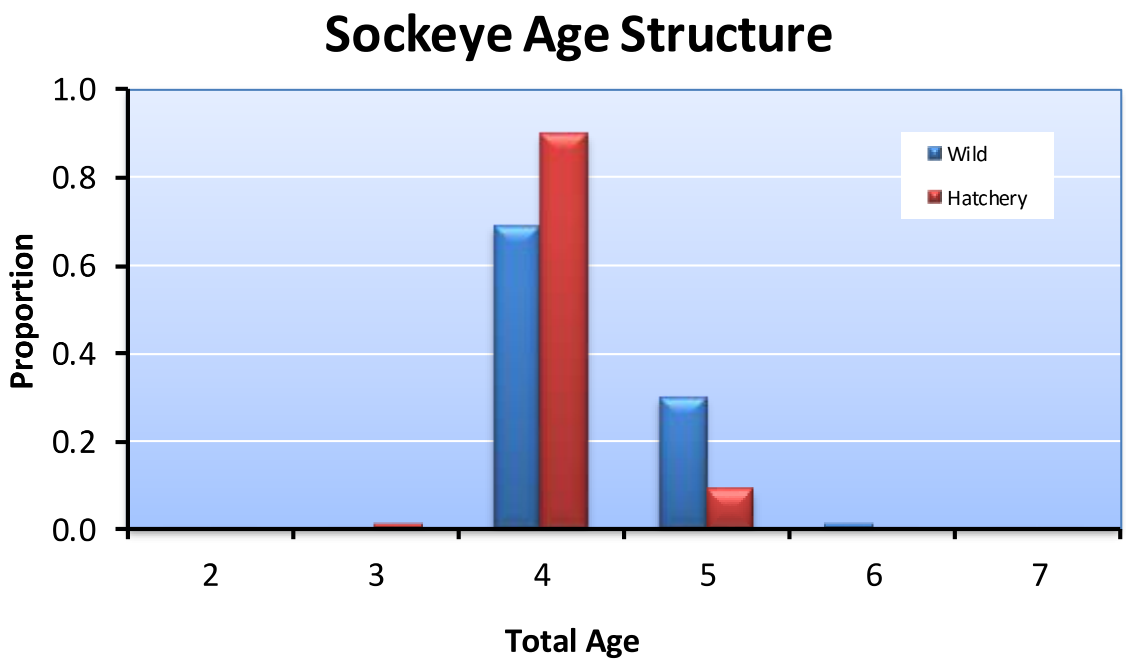

Figure 4.4. Proportions of wild and hatchery sockeye salmon of different total ages sampled at Tumwater Dam and on spawning grounds in the Wenatchee River basin for the combined years 1994-2014.

Size at Maturity

Although sample sizes are small, wild and hatchery sockeye were similar in size in 2015 (Table 4.22). In addition, the pooled data indicate that there is little difference in mean sizes of hatchery and wild sockeye salmon sampled in the Wenatchee River basin (Table 4.22). Analyses for the five-year reports will compare sizes of hatchery and wild fish of the same age groups and sex.

Table 4.22. Mean lengths (POH; cm) and variability statistics for wild and hatchery sockeye salmon sampled at Dryden Dam (broodstock) and on spawning grounds in the Wenatchee River basin, 1994-2014; SD = 1 standard deviation. From 2014 to present, data are collected from sockeye sampled at Tumwater Dam.

Survey year	Origin	Sample size	Sockeye length (POH; cm)			
			Mean	SD	Minimum	Maximum
1994	Wild	0	-	-	-	-
	Hatchery	14	42	3	37	47
1995	Wild	0	-	-	-	-
	Hatchery	1	53	-	53	53
1996	Wild	0	-	-	-	-
	Hatchery	5	51	3	49	55
1997	Wild	6	40	3	38	45
	Hatchery	17	41	3	37	50
1998	Wild	585	43	3	34	50
	Hatchery	20	43	3	40	51

Survey year	Origin	Sample size	Sockeye length (POH; cm)			
			Mean	SD	Minimum	Maximum
1999	Wild	99	42	3	36	50
	Hatchery	31	41	3	36	47
2000	Wild	1	48	-	48	48
	Hatchery	377	40	2	30	49
2001	Wild	29	42	2	38	47
	Hatchery	184	43	3	35	51
2002	Wild	5	42	1	40	43
	Hatchery	52	44	3	37	49
2003	Wild	5	44	4	38	47
	Hatchery	13	42	5	30	48
2004	Wild	0	-	-	-	-
	Hatchery	230	40	3	33	49
2005	Wild	0	-	-	-	-
	Hatchery	8	43	9	35	64
2006	Wild	248	45	4	34	52
	Hatchery	17	41	5	31	48
2007	Wild	248	45	3	32	52
	Hatchery	16	41	5	31	48
2008	Wild	261	52	3	44	66
	Hatchery	20	39	3	30	41
2009	Wild	260	43	3	33	53
	Hatchery	22	41	2	36	46
2010	Wild	200	56	3	48	66
	Hatchery	131	41	2	35	45
2011	Wild	277	43	3	35	51
	Hatchery	282	40	3	32	49
2012	Wild	15	40	4	34	48
	Hatchery	130	40	3	31	48
2013	Wild	2	49	3	47	51
	Hatchery	64	50	4	43	65
2014	Wild	1,367	42	2	31	51
	Hatchery	43	41	3	32	45
2015	Wild	898	43	2	37	53
	Hatchery	51	43	2	39	47
Pooled	***Wild***	***4,506***	***43***	***3***	***31***	***53***
	Hatchery	***1.728***	***45***	***4***	***30***	***65***

Contribution to Fisheries

The total number of hatchery and wild sockeye captured in different fisheries is provided in Tables 4.23 and 4.24. Harvest on hatchery-origin sockeye has been less than the harvest on wild sockeye.

Table 4.23. Estimated number and percent (in parentheses) of hatchery-origin Wenatchee sockeye captured in different fisheries, 1989-2009.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational[a] (sport)	
1989	0 (0)	279 (30)	4 (0)	639 (69)	922
1990	0 (0)	23 (100)	0 (0)	0 (0)	23
1991	0 (0)	6 (100)	0 (0)	0 (0)	6
1992	0 (0)	38 (97)	1 (3)	0 (0)	39
1993	0 (0)	4 (100)	0 (0)	0 (0)	4
1994	0 (0)	3 (100)	0 (0)	0 (0)	3
1995	0 (0)	10 (100)	0 (0)	0 (0)	10
1996	0 (0)	62 (82)	9 (12)	5 (7)	76
1997	0 (0)	69 (73)	11 (12)	15 (16)	95
1998	0 (0)	7 (100)	0 (0)	0 (0)	7
1999	0 (0)	3 (20)	0 (0)	12 (80)	15
2000	0 (0)	59 (12)	9 (2)	414 (86)	482
2001	0 (0)	0 (0)	0 (0)	3 (100)	3
2002	0 (0)	16 (100)	0 (0)	0 (0)	16
2003	0 (0)	3 (100)	0 (0)	0 (0)	3
2004	0 (0)	6 (3)	1 (1)	192 (96)	199
2005	3 (2)	61 (41)	7 (5)	79 (53)	147
2006	2 (0)	124 (23)	2 (0)	409 (76)	535
2007	2 (2)	96 (80)	13 (11)	9 (8)	118
2008	0 (0)	82 (20)	10 (2)	322 (78)	414
2009	1 (0)	31 (15)	3 (1)	177 (83)	211
Average	***0 (0)***	***47 (62)***	***3 (2)***	***108 (36)***	***159***
Median	***0 (0)***	***23 (80)***	***1 (0)***	***5 (8)***	***39***

[a] Includes the Lake Wenatchee fishery.

Table 4.24. Estimated number and percent (in parentheses) of wild Wenatchee sockeye captured in different fisheries, 1989-2010.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational[a] (sport)	
1989	0 (0)	2,192 (31)	26 (0)	4,838 (69)	7,056
1990	0 (0)	191 (100)	0 (0)	0 (0)	191
1991	0 (0)	293 (99)	2 (1)	0 (0)	295

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational[a] (sport)	
1992	0 (0)	345 (99)	5 (1)	0 (0)	350
1993	0 (0)	661 (99)	4 (1)	0 (0)	665
1994	0 (0)	146 (100)	0 (0)	0 (0)	146
1995	0 (0)	63 (85)	4 (5)	7 (9)	74
1996	0 (0)	1,553 (56)	247 (9)	993 (36)	2,793
1997	0 (0)	3,060 (54)	376 (6)	2,266 (40)	5,702
1998	0 (0)	937 (98)	7 (1)	10 (1)	954
1999	0 (0)	22 (19)	3 (3)	90 (78)	115
2000	0 (0)	1,189 (19)	165 (3)	4,881 (78)	6,234
2001	0 (0)	827 (100)	1 (0)	0 (0)	828
2002	0 (0)	379 (83)	2 (0)	73 (16)	454
2003	0 (0)	129 (24)	15 (3)	383 (73)	527
2004	0 (0)	1,559 (24)	174 (3)	4,825 (74)	6,558
2005	0 (0)	2,498 (44)	198 (3)	2,996 (53)	5,692
2006	0 (0)	2,844 (52)	135 (2)	2,505 (46)	5,484
2007	0 (0)	1,536 (57)	214 (8)	960 (35)	2,710
2008	0 (0)	5,066 (25)	596 (3)	13,544 (72)	19,206
2009	0 (0)	1,240 (19)	88 (1)	5,336 (80)	6,664
Average	***0 (0)***	***1,273 (61)***	***108 (2)***	***2,081 (36)***	***3,462***
Median	***0 (0)***	***937 (56)***	***15 (2)***	***383 (36)***	***954***

[a] Includes the Lake Wenatchee fishery.

Straying

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Wenatchee River basin. In addition, PIT tagging of hatchery sockeye, which began with brood year 2005, allows estimation of stray rates by brood return. Targets for strays based on return year (recovery year) outside the Wenatchee River basin should be less than 5%. The target for brood year strays should also be less than 5%.

Based on CWTs and brood year analysis, virtually no hatchery-origin Wenatchee sockeye strayed into non-target spawning areas or hatchery programs before brood year 2006 (Table 4.25). However, sockeye from brood years 2006 and 2007 strayed into the Entiat River and a few into the Methow River (non-target streams) and a non-target hatchery (Umpqua Trap) (Table 4.25). Stray rates of Wenatchee sockeye from brood year 2006, 2008, and 2009 exceeded the target of 5%.

Table 4.25. Number and percent of hatchery-origin Wenatchee sockeye that homed to target spawning areas and the target hatchery program, and number and percent that strayed to non-target spawning areas and hatchery programs, by brood years 1990-2009. Hatchery-origin sockeye from brood years 1995-1998 were not tagged because of columnaris disease (NA = not available). Percent stays should be less than 5%.

Brood year	Homing				Straying			
	Target streams		Target hatchery*		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1990	402	99.5	2	0.5	0	0.0	0	0.0
1991	1	100.0	0	0.0	0	0.0	0	0.0
1992	92	98.9	0	0.0	0	0.0	1	1.1
1993	29	96.7	1	3.3	0	0.0	0	0.0
1994	66	94.3	4	5.7	0	0.0	0	0.0
1995	NA	NA	NA	NA	NA	NA	NA	NA
1996	NA	NA	NA	NA	NA	NA	NA	NA
1997	NA	NA	NA	NA	NA	NA	NA	NA
1998	NA	NA	NA	NA	NA	NA	NA	NA
1999	65	100.0	0	0.0	0	0.0	0	0.0
2000	571	100.0	0	0.0	0	0.0	0	0.0
2001	17	100.0	0	0.0	0	0.0	0	0.0
2002	251	100.0	0	0.0	0	0.0	0	0.0
2003	11	100.0	0	0.0	0	0.0	0	0.0
2004	56	100.0	0	0.0	0	0.0	0	0.0
2005	67	97.1	2	2.9	0	0.0	0	0.0
2006	117	41.9	0	0.0	160	57.3	2	0.7
2007	260	97.4	1	0.4	56	2.2	0	0.0
2008	86	90.5	0	0.0	9	9.6	0	0.0
2009	11	73.3	0	0.0	4	26.6	0	0.0
Average	***131***	***92.1***	***1***	***0.8***	***14***	***6.9***	***0***	***0.1***
Median	***67***	***99.2***	***0***	***0.0***	***0***	***0.0***	***0***	***0.0***

* Homing to the target hatchery includes Wenatchee hatchery sockeye that are captured and included as broodstock in the Wenatchee Hatchery program. These hatchery fish were collected at Tumwater Dam.

Based on PIT-tag analyses, on average, about 11% of the hatchery sockeye returns were last detected in streams outside the Wenatchee River basin (Table 4.26). The numbers in Table 4.26 should be considered rough estimates because they are not based on confirmed spawning (only last detections). Nevertheless, these data do indicate that some hatchery sockeye from the Wenatchee program have wandered or strayed into the Entiat and Methow rivers and possibly into the Okanogan system (based on sockeye detected at Wells Dam but not in the Methow River).

Table 4.26. Number and percent of hatchery-origin Wenatchee sockeye that homed to target spawning areas and the target hatchery program, and number and percent that strayed to non-target spawning areas and hatchery programs for brood years 2005-2011. Estimates were based on last detections of PIT-tagged hatchery sockeye. Percent strays should be less than 5%.

Brood Year	Homing				Straying			
	Target streams		Target hatchery*		Non-target stream		Non-target hatchery	
	Number	%	Number	%	Number	%	Number	%
2005	166	92.2	0	0	14	7.8	0	0
2006	440	94.6	0	0	25	5.4	0	0
2007	192	95.0	0	0	10	5.0	0	0
2008	127	89.4	0	0	15	10.6	0	0
2009	41	82.0	0	0	9	18.0	0	0
2010	53	100.0	0	0	0	0.0	0	0
2011	63	71.6	0	0	25	28.4	0	0
Average	***155***	***89.3***	***0***	***0***	***14***	***10.7***	***0***	***0***
Median	***127***	***92.2***	***0***	***0***	***14***	***7.8***	***0***	***0***

* Homing to the target hatchery includes Wenatchee hatchery sockeye that are captured and included as broodstock in the Wenatchee Hatchery program. These hatchery fish were collected at Tumwater Dam.

Genetics

Genetic studies were conducted in 2008 to determine the potential effects of the Wenatchee sockeye supplementation program on natural-origin sockeye in the upper Wenatchee River basin (Blankenship et al. 2008; the entire report is appended as Appendix I). Specifically, the objective of the study was to determine if the genetic composition of the Lake Wenatchee sockeye population had been altered by the supplementation program, which was based on the artificial propagation of a small subset of the Wenatchee population. Microsatellite DNA allele frequencies were used to differentiate between temporally replicated collections of natural and hatchery-origin sockeye in the Wenatchee River basin. A total of 13 collections of Wenatchee sockeye were analyzed; eight temporally replicated collections of natural-origin sockeye (N = 786) and five temporally replicated collections of hatchery-origin sockeye (N = 248). Paired natural-hatchery collections were available from return years 2000, 2001, 2004, 2006, and 2007. All collections were taken at Tumwater Dam and consisted of dried scales and fin clips.

Overall, the study showed that allele frequency distributions were consistent over time, regardless of origin, resulting in small, insignificant measures of genetic differentiation among collections. This indicates that there were no year-to-year differences in allele frequencies between natural and hatchery-origin sockeye. In addition, the analyses found no differences between pre- and post-supplementation collections. Thus, it was concluded that the allele frequencies of the broodstock collections equaled the allele frequency of the natural collections.

It is important to note that no new information will be reported on genetics until the next five-year report (2018).

Proportionate Natural Influence

Another method for assessing the genetic risk of a supplementation program is to determine the influence of the hatchery and natural environments on the adaptation of the composite population. This is estimated by the proportion of natural-origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery-origin fish in the natural spawning escapement (pHOS). We calculated Proportionate Natural Influence (PNI) by iterating Ford's (2002) equations 5 and 6 to equilibrium, using a heritability of 0.3 and a selection strength of three standard deviations. The larger the PNI value, the greater the strength of selection in the natural environment relative to that of the hatchery environment. In order for the natural environment to dominate selection, PNI should be greater than 0.50, and important integrated populations should have a PNI of at least 0.67 (HSRG/WDFW/NWIFC 2004).

The PNI values for the life of the program (brood years 1989-2011) are shown in Table 4.27. Throughout the program, PNI was consistently greater than 0.67. The hatchery program was terminated in 2012.

Table 4.27. Proportionate Natural Influence (PNI) values for the Wenatchee sockeye supplementation program for brood years 1989-2015. NOS = number of natural-origin sockeye counted at Tumwater Dam; HOS = number of hatchery-origin sockeye counted at Tumwater Dam; NOB = number of natural-origin sockeye collected for broodstock; and HOB = number of hatchery-origin sockeye included in hatchery broodstock. NP = no hatchery program.

Brood year	Escapement[a]			Broodstock			PNI[b]
	NOS	HOS	pHOS	NOB	HOB	pNOB	
1989	21,802	0	0.00	115	0	1.00	1.00
1990	27,325	0	0.00	302	0	1.00	1.00
1991	26,689	0	0.00	199	0	1.00	1.00
1992	16,461	0	0.00	320	0	1.00	1.00
1993	25,064	2,662	0.10	207	0	1.00	0.91
1994	6,934	396	0.05	236	5	0.98	0.95
1995	3,262	186	0.05	194	3	0.98	0.95
1996	6,027	546	0.08	225	0	1.00	0.93
1997	8,376	68	0.01	192	19	0.91	0.99
1998	3,982	32	0.01	122	6	0.95	0.99
1999	961	64	0.06	79	60	0.57	0.91
2000	19,620	1,164	0.06	170	5	0.97	0.94
2001	28,288	815	0.03	200	7	0.97	0.97
2002	27,371	193	0.01	256	0	1.00	0.99
2003	4,797	58	0.01	198	0	1.00	0.99
2004	26,095	1,460	0.05	177	0	1.00	0.95
2005	13,983	28	0.00	166	0	1.00	1.00
2006	9,182	255	0.03	214	0	1.00	0.97
2007	2,320	59	0.02	210	0	1.00	0.98
2008	22,931	92	0.00	243	2	0.99	1.00
2009	13,043	445	0.03	239	0	1.00	0.97

Brood year	Escapement[a]			Broodstock			PNI[b]
	NOS	HOS	pHOS	NOB	HOB	pNOB	
2010	30,357	1,134	0.04	198	0	1.00	0.96
2011	17,490	940	0.05	196	0	1.00	0.95
Average	***15,755***	***461***	***0.03***	***203***	***5***	***0.97***	***0.97***
Median	***16,461***	***186***	***0.03***	***199***	***0***	***1.00***	***0.97***
2012	30,903	502	0.02	NP	NP	NP	NP
2013	22,118	614	0.03	NP	NP	NP	NP
2014	81,803	1,840	0.02	NP	NP	NP	NP
2015	49,650	1,785	0.03	NP	NP	NP	NP
Average	***44,233***	***1,121***	***0.02***	***NP***	***NP***	***NP***	***NP***
Median	***36,506***	***1,071***	***0.02***	***NP***	***NP***	***NP***	***NP***

[a] Proportions of natural-origin and hatchery-origin spawners were determined from video tape at Tumwater Dam.

[b] PNI was calculated previously using PNI approximate equation 11 (HSRG 2009; Appendix A). All PNI values presented here were recalculated by iterating Ford's (2002) equations 5 and 6 to equilibrium using a heritability of 0.3 and a selection strength of three standard deviations. C. Busack, NOAA Fisheries, 21 March 2016, provided the model for calculating PNI.

Post-Release Survival and Travel Time

We used PIT-tagged fish to estimate survival rates and travel time (arithmetic mean days) of hatchery sockeye salmon from Lake Wenatchee to McNary Dam, and smolt to adult ratios (SARs) from release to detection at Bonneville Dam (Table 4.28).[7] Over the seven brood years for which PIT-tagged hatchery fish were released, survival rates from Lake Wenatchee to McNary Dam ranged from 0.211 to 0.370; SARs from release to detection at Bonneville Dam ranged from 0.005 to 0.044. Average travel time from Lake Wenatchee to McNary Dam ranged from 176 to 202 days.

Table 4.28. Total number of hatchery sockeye parr released with PIT tags, their survival and travel times (mean days) to McNary Dam, and smolt-to-adult (SAR) ratios for brood years 2005-2011. Standard errors are shown in parentheses.

Brood year	Number of sockeye released with PIT tags	Survival to McNary Dam	Travel time[1] to McNary Dam (d)	SAR to Bonneville Dam (%)
2005	14,859	0.334 (0.013)	176.4 (61.9)	0.020 (0.001)
2006	14,764	0.370 (0.030)	202.0 (9.1)	0.044 (0.002)
2007	14,947	0.312 (0.013)	199.9 (8.6)	0.024 (0.001)
2008	14,858	0.307 (0.020)	192.9 (35.7)	0.015 (0.001)
2009	14,486	0.211 (0.015)	194.2 (29.1)	0.005 (0.001)
2010	5,039	0.302 (0.048)	191.7 (26.6)	0.014 (0.002)
2011	5,074	0.315 (0.038)	196.7 (7.3)	0.034 (0.003)

[1] Travel time is calculated from the date of release from the net pens in the fall, overwintering in Lake Wenatchee, to spring outmigration.

[7] It is important to point out that because of fish size differences among rearing tanks or raceways, fish PIT tagged in one tank or raceway may not represent untagged fish rearing in other tanks or raceways.

Natural and Hatchery Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural-origin recruits (NOR) to the parent spawning population. Natural-origin recruits are naturally produced (wild) fish that survive to contribute to harvest (directly or indirectly), to broodstock, and to spawning grounds. We do not account for fish that died in route to the spawning grounds (migration mortality) or died just before spawning (pre-spawn mortality) (see Appendix B in Hillman et al. 2012). We calculated NORs with and without harvest. NORs without harvest include all returning fish that either returned to the basin or were collected as wild broodstock. NORs with harvest include all fish harvested and are based on a brood year harvest rates from the hatchery program. For brood years 1989-2009, NRR in the Wenatchee averaged 1.55 (range, 0.13-5.74) if harvested fish were not included in the estimate and 1.84 (range, 0.14-6.88) if harvested fish were included in the estimate (Table 4.29).

Hatchery replacement rates (HRR) were estimated as hatchery adult-to-adult returns. These rates should be greater than the NRRs and greater than or equal to 5.4 (the calculated target value in Hillman et al. 2013). The target value of 5.4 includes harvest. HRRs exceeded NRRs in 13 or 14 of the 21 years of data depending on if harvest was or was not included in the estimates (Table 4.29). Hatchery replacement rates for Wenatchee sockeye have equaled or exceeded the estimated target value of 5.4 in five of the 21 years (Table 4.29).

Table 4.29. Broodstock collected, spawning escapements, natural and hatchery-origin recruits (NOR and HOR), and natural and hatchery replacement rates (NRR and HRR; with and without harvest) for sockeye salmon in the Wenatchee River basin, 1989-2009.

Brood year	Broodstock Collected	Spawning Escapement	Harvest not included				Harvest included			
			HOR	NOR	HRR	NRR	HOR	NOR	HRR	NRR
1989	255	21,802	2,757	23,616	10.81	1.08	3,680	30,672	14.43	1.41
1990	316	27,325	401	3,509	1.27	0.13	423	3,701	1.34	0.14
1991	233	26,689	95	4,820	0.41	0.18	101	5,116	0.43	0.19
1992	343	16,461	576	5,336	1.68	0.32	615	5,685	1.79	0.35
1993	307	27,726	71	11,151	0.23	0.40	75	11,815	0.24	0.43
1994	265	7,330	47	1,191	0.18	0.16	50	1,337	0.19	0.18
1995	209	3,448	121	840	0.58	0.24	131	913	0.63	0.26
1996	227	6,573	1,351	28,093	5.95	4.27	1,427	30,886	6.29	4.70
1997	226	8,444	739	36,097	3.27	4.27	834	41,798	3.69	4.95
1998	190	4,014	104	16,165	0.55	4.03	111	17,120	0.58	4.27
1999	147	1,025	68	566	0.46	0.55	83	682	0.56	0.67
2000	195	20,784	1,425	29,082	7.31	1.40	1,907	35,316	9.78	1.70
2001	245	29,103	24	17,241	0.10	0.59	28	18,068	0.11	0.62
2002	257	27,564	281	5,752	1.09	0.21	297	6,207	1.16	0.23
2003	219	4,855	32	2,054	0.15	0.42	35	2,590	0.16	0.53
2004	202	27,555	94	23,589	0.47	0.86	293	30,149	1.45	1.09
2005	207	14,011	460	20,793	2.22	1.48	606	26,486	2.93	1.89
2006	220	9,437	1,147	26,966	5.21	2.86	1,682	32,450	7.65	3.44
2007	228	2,379	917	13,663	4.02	5.74	1,037	16,370	4.55	6.88
2008	260	23,023	808	38,245	3.11	1.66	1,314	57,451	5.05	2.50

Brood year	Broodstock Collected	Spawning Escapement	Harvest not included				Harvest included			
			HOR	NOR	HRR	NRR	HOR	NOR	HRR	NRR
2009	261	13,488	2,092	22,202	8.02	1.65	2,488	28,867	9.53	2.14
Average	***239***	***15,383***	***648***	***15,761***	***2.72***	***1.55***	***820***	***19,223***	***3.45***	***1.84***
Median	***228***	***14,011***	***401***	***16,165***	***1.27***	***0.86***	***423***	***17,120***	***1.45***	***1.09***

Juvenile-to-Adult Survivals

When possible, both parr-to-adult ratios (PAR) and smolt-to-adult ratios (SAR) were calculated for hatchery sockeye salmon. Ratios were calculated as the number of hatchery adult recaptures divided by the number of tagged hatchery parr released or the estimated number of smolts emigrating from Lake Wenatchee. Here, survival ratios were based on CWT returns, when available, or on the estimated number of hatchery adults recovered on the spawning grounds, in broodstock, and harvested. For the available brood years, PARs have ranged from 0.0001 to 0.0339 for hatchery sockeye salmon and SARs have ranged from 0.0002 to 0.0255 (Table 4.30).

Table 4.30. Parr-to-adult ratios (PAR) and smolt-to-adult ratios (SAR) for Wenatchee hatchery sockeye salmon, brood years 1990-2007; NA = not available.

Brood year	Number of parr released	Number of smolts	Estimated adult recaptures	PAR	SAR
1989	108,400	NA	3,680	0.0339	NA
1990	270,802	NA	423	0.0016	NA
1991	167,523	NA	101	0.0006	NA
1992	340,597	NA	615	0.0018	NA
1993	190,443	NA	75	0.0004	NA
1994	252,859	NA	50	0.0002	NA
1995	150,808	28,828	131	0.0009	0.0045
1996	284,630	55,985	1,427	0.0050	0.0255
1997	197,195	112,524	834	0.0042	0.0074
1998	121,344	24,684	111	0.0009	0.0045
1999	167,955	94,046	83	0.0005	0.0009
2000	190,174	121,511	1,907	0.0100	0.0157
2001	200,938	140,322	28	0.0001	0.0002
2002	315,783	216,023	297	0.0009	0.0014
2003	240,459	122,399	35	0.0001	0.0003
2004	172,923	159,500	293	0.0017	0.0018
2005	140,542	140,542	606	0.0043	0.0043
2006	225,670	121,843	1,682	0.0075	0.0138
2007	252,133	119,908	1,037	0.0041	0.0086
2008	154,772	126,326	1,314	0.0085	0.0104
2009	227,743	159,089	2,488	0.0109	0.0156

Brood year	Number of parr released	Number of smolts	Estimated adult recaptures	PAR	SAR
Average	***208,271***	***116,235***	***820***	***0.0047***	***0.0077***
Median	***197,195***	***121,843***	***423***	***0.0017***	***0.0045***

4.8 ESA/HCP Compliance

Smolt and Emigrant Trapping

ESA-listed spring Chinook and steelhead were encountered during operation of the Lower Wenatchee trap. ESA takes are reported in the steelhead (Section 3.8) and spring Chinook (Section 5.8) sections and will not be repeated here.

Spawning Surveys

Sockeye spawning ground surveys conducted in the Wenatchee River basin during 2015 were consistent with ESA Section 10 Permit No. 1347. Because of the difficulty of quantifying the level of take associated with spawning ground surveys, the Permit does not specify a take level associated with these activities, even though it does authorize implementation of spawning ground surveys. Therefore, no take levels are reported. However, to minimize potential effects to established redds, wading was restricted to the extent practical and extreme caution was used to avoid established redds when wading was required.

SECTION 5: WENATCHEE (CHIWAWA) SPRING CHINOOK

The goal of Chiwawa spring Chinook salmon supplementation is to achieve "No Net Impact" to the productivity of spring Chinook caused by the operation of the Rock Island Hydroelectric Project. The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Rock Island and Rocky Reach Anadromous Fish Agreement and Habitat Conservation Plans.

Adult spring Chinook are collected for broodstock at the Chiwawa Weir and Tumwater Dam. From 2011 through 2013, all spring Chinook broodstock were collected at the Chiwawa Weir in order to reduce passage delays caused by trapping at Tumwater Dam. Prior to 2009, the goal was to collect up to 379 adult spring Chinook for the program with natural-origin fish making up not less than 33% of the broodstock. In 2011, the Hatchery Committees reevaluated the amount of hatchery compensation needed to achieve NNI. Based on that evaluation, the goal of the program was revised. The current goal (beginning with brood year 2013) is to collect 74 natural-origin spring Chinook. The number collected cannot exceed 33% of the natural-origin spring Chinook returns to Tumwater. Beginning in 2014, previously PIT-tagged hatchery-origin Chiwawa spring Chinook are collected at Tumwater Dam, while the Chiwawa Weir is used to collect natural-origin brood for the Chiwawa spring Chinook program. Broodstock collection occurs from May through July at Tumwater with trapping occurring up to 24 hours per day, seven days a week and at the Chiwawa Weir with trapping occurring from 15 June to 1 August (not to exceed 15 cumulative trapping days) on a 24-hour-up/24-hour-down schedule consistent with annual broodstock collection protocols.

Adult spring Chinook are spawned and reared at Eastbank Fish Hatchery. Juvenile spring Chinook are transferred from the hatchery to the Chiwawa Acclimation Facility in late September or early October. They are released volitionally from the Chiwawa Acclimation Facility during April the following year.

The production goal for the Chiwawa spring Chinook supplementation program up to brood year 2009 was to release 672,000 yearling smolts into the Chiwawa River at 12 fish per pound. Brood years 2010-2011, and 2012 were transition years to a reduced program of 298,000 smolts and 205,000 smolts, respectively. Beginning with the 2013 brood, the revised production goal is to release 144,026 smolts as part of a conservation program at 18 fish per pound. The Wenatchee spring Chinook safety-net program is now part of the Nason Creek spring Chinook program. Targets for fork length and weight are 155 mm (CV = 9.0) and 37.8 g, respectively. Over 90% of these fish are marked with CWTs. In addition, since 2006, juvenile spring Chinook have been PIT tagged annually.

With issuance of new ESA Section 10 permits in 2013, it is anticipated that beginning in 2014, adult management (i.e., removal of excess hatchery-origin adults at dams, traps, and weirs, and in conservation fisheries) will be implemented to achieve pHOS and PNI goals for the Wenatchee spring Chinook programs.

Although this section of the report focuses on results from monitoring the Chiwawa spring Chinook program, information on spring Chinook collected throughout the Wenatchee River basin is also provided. Information specific to the Nason Creek spring Chinook conservation program is presented in Section 6 and the White River Captive Broodstock Program is presented in Section 7.

5.1 Broodstock Sampling

This section focuses on results from sampling 2013-2015 Chiwawa spring Chinook broodstock, which were collected at the Chiwawa Weir and at Tumwater Dam, consistent with methods in the broodstock collections protocols (Tonseth 2013, 2014, and 2015). Some information for the 2015 return is not available at this time (e.g., age structure and final origin determination). This information will be provided in the 2016 annual report.

Origin of Broodstock

Natural-origin adults made up between 31.3% and 100.0% of the Chiwawa spring Chinook broodstock for return years 2013-2015 (Table 5.1). Natural and hatchery-origin adults were collected at Tumwater Dam and the Chiwawa Weir for return year 2015. Early run timing of spring Chinook in 2015 required initiating broodstock collections about two weeks earlier than usual. Broodstock were trapped at Tumwater Dam from mid-May through mid-July 2015, and at the Chiwawa Weir from mid-June through late-July. Hatchery-origin broodstock were collected at Tumwater Dam in 2015 to meet the Nason Creek Safety Net requirements. Additional hatchery-origin broodstock were collected to ensure production obligations were achieved in the event that insufficient natural-origin collections could be made. A total of 10 hatchery-origin fish collected in 2015 were surplused at Eastbank Fish Hatchery.

Table 5.1. Numbers of wild and hatchery Chiwawa spring Chinook collected for broodstock, numbers that died before spawning, and numbers of Chinook spawned, 1989-2015. Unknown origin fish (i.e., undetermined by scale analysis, no CWT or fin clips, and no additional hatchery marks) were considered naturally produced.

Brood year	Wild spring Chinook					Hatchery spring Chinook					Total number spawned
	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	
1989	28	0	0	28	0	0	0	0	0	0	28
1990	19	1	0	18	0	0	0	0	0	0	18
1991	32	0	5	27	0	0	0	0	0	0	27
1992	113	0	0	78	35	0	0	0	0	0	78
1993	100	3	3	94	0	0	0	0	0	0	94
1994	9	0	1	8	0	4	0	0	4	0	12
1995	No Program										
1996	8	0	0	8	0	10	0	0	10	0	18
1997	37	0	5	32	0	83	1	3	79	0	111
1998	13	0	0	13	0	35	1	0	34	0	47
1999	No Program										
2000	10	0	1	9	0	38	1	16	21	0	30
2001	115	2	0	113	0	267	8	0	259	0	372
2002	21	0	1	20	0	63	1	11	51	0	71
2003	44	1	2	41	0	75	2	20	53	0	94
2004	100	1	16	83	0	196	30	34	132	0	215
2005	98	1	6	91	0	185	3	1	181	0	279
2006	95	0	4	91	0	303	0	29	224	50	315
2007	45	1	1	43	0	124	2	18	104	0	147

Brood year	Wild spring Chinook					Hatchery spring Chinook					Total number spawned
	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	
2008	88	2	3	83	0	241	5	16	220	0	303
2009	113	6	11	96	0	151	3	37	111	0	207
2010	83	0	6	77	0	103	0	5	98	0	175
2011	80	0	0	80	0	101	2	6	93	0	173
Average[b]	***60***	***1***	***3***	***54***	***2***	***94***	***3***	***9***	***80***	***2***	***134***
Median[b]	***45***	***0***	***1***	***43***	***0***	***75***	***1***	***3***	***53***	***0***	***94***
2012	75	1	1	73	0	41	3	0	38	0	111
2013	170	5	0	70	95	52	1	50	0	1	70
2014[d]	61	0	0	61	0	203	1	68	134	0	195
2015[e]	81	1	7	72	1	47	0	3	37	7	109
Average[c]	***97***	***2***	***2***	***69***	***24***	***86***	***1***	***30***	***52***	***2***	***121***
Median[c]	***78***	***1***	***1***	***71***	***1***	***50***	***1***	***27***	***38***	***1***	***110***

[a] Pre-spawn loss represents the number of fish that died during the holding period before spawning. Mortality is the number of fish that were surplused following spawning.
[b] The average and median represent the program before recalculation in 2011.
[c] The average and median represent the current program, which began in 2012. Origin determinations should be considered preliminary pending scale analyses.
[d] HOR Chiwawa spring Chinook were collected to meet both Chiwawa and Nason Creek obligations; broodstock and subsequent progeny were pooled together in the hatchery. About 12 Chiwawa HOR's were used to fulfill the Chiwawa Program; about 122 Chiwawa HOR's were used to fulfill the Nason Creek safety net obligation.
[e] For the Chiwawa program, 36 hatchery-origin recruits were collected in case the program fell short on natural-origin recruits. After eye-up, all of the hatchery-origin recruit eggs were culled because fecundity of natural-origin recruits was high enough to meet the WxW program.

Age/Length Data

Ages were determined from scales and/or coded wire tags (CWT) collected from broodstock. For both the 2013 and 2014 returns, most adults, regardless of origin, were age-4 Chinook (Table 5.2). A larger percentage of the age-5 Chinook were natural-origin fish, whereas a larger percentage of the age-3 fish were hatchery-origin fish.

Table 5.2. Percent of hatchery and wild spring Chinook of different ages (total age) collected from broodstock, 1991-2014.

Return year	Origin	Total age			
		2	3	4	5
1991	Wild	0.0	0.0	22.0	78.0
	Hatchery	0.0	0.0	0.0	0.0
1992	Wild	0.0	0.0	28.6	71.4
	Hatchery	0.0	0.0	50.0	50.0
1993	Wild	0.0	0.0	22.0	78.0
	Hatchery	0.0	0.0	0.0	0.0
1994	Wild	0.0	0.0	28.6	71.4
	Hatchery	0.0	0.0	50.0	50.0
1995	Wild	No program			
	Hatchery				
1996	Wild	0.0	28.6	71.4	0.0

Return year	Origin	Total age			
		2	3	4	5
	Hatchery	0.0	50.0	50.0	0.0
1997	Wild	0.0	0.0	87.5	12.5
	Hatchery	0.0	1.2	98.8	0.0
1998	Wild	0.0	0.0	63.6	36.4
	Hatchery	0.0	0.0	62.9	37.1
1999	Wild	No program			
	Hatchery				
2000	Wild	0.0	20.0	70.0	10.0
	Hatchery	0.0	59.1	40.9	0.0
2001	Wild	0.0	2.8	94.4	2.8
	Hatchery	0.0	1.5	98.5	0.0
2002	Wild	0.0	0.0	66.7	33.3
	Hatchery	0.0	0.0	93.4	6.6
2003	Wild	0.0	27.0	2.7	70.3
	Hatchery	0.0	21.3	5.3	73.3
2004	Wild	1.0	6.1	88.8	4.1
	Hatchery	0.0	40.4	59.6	0.0
2005	Wild	0.0	1.0	85.0	14.0
	Hatchery	0.0	4.4	95.6	0.0
2006	Wild	0.0	2.0	70.4	27.6
	Hatchery	0.0	1.3	81.2	17.4
2007	Wild	0.0	15.6	53.3	31.1
	Hatchery	0.0	27.4	60.5	12.1
2008	Wild	0.0	6.3	78.8	15.0
	Hatchery	0.0	8.2	86.8	4.9
2009	Wild	0.0	8.6	79.0	12.4
	Hatchery	0.0	18.5	79.5	2.0
2010	Wild	0.0	5.3	94.7	0.0
	Hatchery	0.0	0.0	99.0	1.0
2011	Wild	0.0	2.7	52.7	44.6
	Hatchery	0.0	20.4	60.2	19.4
2012	Wild	0.0	0.0	79.0	21.0
	Hatchery	0.0	4.3	95.7	0.0
2013	Wild	0.0	0.0	65.7	34.3
	Hatchery	0.0	2.2	86.7	11.1
2014	Wild	0.0	0.0	91.2	8.8
	Hatchery[a]	0.0	0.0	98.5	1.5
Average	***Wild***	***0.0***	***5.7***	***63.5***	***30.8***

Return year	Origin	Total age			
		2	3	4	5
	Hatchery	***0.0***	***11.8***	***66.1***	***13.0***
Median	***Wild***	***0.0***	***1.5***	***70.2***	***24.3***
	Hatchery	***0.0***	***1.9***	***71.2***	***1.8***

[a] Comprised of age results for both Chiwawa and Nason Creek obligations.

There was little difference in mean lengths between hatchery and natural-origin broodstock of age-4 and age-5 Chinook in 2013; however, age-5 natural-origin Chinook in 2014 were larger than hatchery-origin broodstock (Table 5.3).

Table 5.3. Mean fork length (cm) at age (total age) of hatchery and wild spring Chinook collected from broodstock, 1991-2014; N = sample size and SD = 1 standard deviation.

Return year	Origin	Spring Chinook fork length (cm)											
		Age-2			Age-3			Age-4			Age-5		
		Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD
1991	Wild	-	0	-	-	5	-	-	19	-	-	8	-
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-
1992	Wild	-	0	-	-	0	-	-	0	-	-	0	-
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-
1993	Wild	-	0	-	-	0	-	79	4	3	92	8	4
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-
1994	Wild	-	0	-	-	0	-	79	2	3	96	5	6
	Hatchery	-	0	-	-	0	-	82	2	11	92	2	2
1995	Wild	No program											
	Hatchery												
1996	Wild	-	0	-	51	2	1	79	5	7	-	0	-
	Hatchery	-	0	-	56	5	4	74	5	6	-	0	-
1997	Wild	-	0	-	-	0	-	80	28	5	99	4	8
	Hatchery	-	0	-	56	1	-	82	82	4	-	0	-
1998	Wild	-	0	-	-	0	-	78	7	13	83	4	18
	Hatchery	-	0	-	-	0	-	77	22	8	93	13	7
1999	Wild	No program											
	Hatchery												
2000	Wild	-	0	-	51	2	3	82	7	4	98	1	-
	Hatchery	-	0	-	59	13	4	79	9	8	-	0	-
2001	Wild	-	0	-	49	3	6	82	101	6	95	3	3
	Hatchery	-	0	-	56	4	7	83	261	5	-	0	-
2002	Wild	-	0	-	-	0	-	79	12	4	96	6	10
	Hatchery	-	0	-	-	0	-	81	57	6	94	4	9
2003	Wild	-	0	-	55	10	5	83	1	-	99	26	6

Return year	Origin	Spring Chinook fork length (cm)											
		Age-2			Age-3			Age-4			Age-5		
		Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD
	Hatchery	-	0	-	59	16	5	86	4	18	96	55	6
2004	Wild	47	1	-	60	6	6	80	87	5	99	4	3
	Hatchery	-	0	-	51	80	7	80	118	5	-	0	-
2005	Wild	-	0	-	49	1	-	80	85	6	96	14	8
	Hatchery	-	0	-	56	8	5	82	175	6	-	0	-
2006	Wild	-	0	-	50	2	2	79	69	7	97	27	5
	Hatchery	-	0	-	46	1	-	80	205	6	95	43	7
2007	Wild	-	0	-	54	7	3	79	24	6	93	14	7
	Hatchery	-	0	-	59	34	8	81	75	5	93	15	7
2008	Wild	-	0	-	54	5	9	83	63	5	93	12	6
	Hatchery	-	0	-	56	20	10	82	211	6	96	12	7
2009	Wild	-	0	-	52	9	6	81	83	5	94	13	6
	Hatchery	-	0	-	56	28	6	82	120	5	87	3	11
2010	Wild	-	0	-	58	4	9	80	72	6	-	0	-
	Hatchery	-	0	-	-	0	-	82	102	6	101	1	-
2011	Wild	-	0	-	56	2	3	79	39	5	95	33	7
	Hatchery	-	0	-	63	21	7	80	62	6	95	20	6
2012	Wild	-	0	-	-	0	-	81	49	6	97	13	8
	Hatchery	-	0	-	51	2	0	80	41	5	-	0	-
2013	Wild	-	0	-	-	1	-	74	44	6	92	23	8
	Hatchery	-	0	-	60	1	-	78	39	6	88	5	7
2014	Wild	-	0	-	-	0	-	82	52	7	93	5	6
	Hatchery[a]	-	0	-	-	0	-	81	192	6	85	3	2
Average	***Wild***	***47***	***0***	***-***	***53***	***3***	***5***	***80***	***39***	***6***	***95***	***10***	***7***
	Hatchery	***-***	***0***	***-***	***56***	***11***	***6***	***81***	***81***	***7***	***93***	***8***	***6***

[a] Comprised of age results from HOR's used for both Chiwawa and Nason Creek obligations.

Sex Ratios

Male spring Chinook in the 2013-2015 return years made up 49.1%, 49.2%, and 53.5%, respectively, of the adults collected. This resulted in overall male to female ratios of 0.96:1.00, 0.97:1.00, and 1.15:1.00, respectively (Table 5.4). For the 2015 return year, natural-origin and hatchery-origin fish both consisted of a slightly higher proportion of males than females (Table 5.4).

Table 5.4. Numbers of male and female wild and hatchery spring Chinook collected for broodstock, 1989-2015. Ratios of males to females are also provided.

Return year	Number of wild spring Chinook			Number of hatchery spring Chinook			Total M/F ratio
	Males (M)	Females (F)	M/F	Males (M)	Females (F)	M/F	
1989	11	17	0.65:1.00	-	-	-	0.65:1.00
1990	7	12	0.58:1.00	-	-	-	0.58:1.00
1991	13	19	0.68:1.00	-	-	-	0.68:1.00
1992	39	39	1.00:1.00	-	-	-	1.00:1.00
1993	50	50	1.00:1.00	-	-	-	1.00:1.00
1994	5	4	1.25:1.00	2	2	1.00:1.00	1.17:1.00
1995	No program						
1996	6	2	3.00:1.00	8	2	4.00:1.00	3.50:1.00
1997	14	23	0.61:1.00	34	49	0.69:1.00	0.67:1.00
1998	9	4	2.25:1.00	18	17	1.06:1.00	1.29:1.00
1999	No program						
2000	5	5	1.00:1.00	32	6	5.33:1.00	3.36:1.00
2001	45	70	0.64:1.00	90	177	0.51:1.00	0.55:1.00
2002	9	12	0.75:1.00	30	33	0.91:1.00	0.87:1.00
2003	28	16	1.75:1.00	42	33	1.27:1.00	1.43:1.00
2004	58	42	1.38:1.00	102	94	1.09:1.00	1.18:1.00
2005	58	40	1.45:1.00	89	96	0.93:1.00	1.08:1.00
2006	49	46	1.07:1.00	123	179	0.69:1.00	0.77:1.00
2007	20	25	0.80:1.00	66	58	1.14:1.00	1.04:1.00
2008	41	47	0.87:1.00	109	132	0.83:1.00	0.84:1.00
2009	53	60	0.88:1.00	79	72	1.10:1.00	1.00:1.00
2010	41	42	0.98:1.00	53	50	1.06:1.00	1.02:1.00
2011	38	42	0.90:1.00	53	48	1.10:1.00	1.01:1.00
2012	35	40	0.87:1.00	20	21	0.95:1.00	0.90:1.00
2013	83	87	0.95:1.00	26	26	1.00:1.00	0.96:1.00
2014[a]	29	32	0.91:1.00	101	102	0.99:1.00	0.97:100
2015	44	36	1.22:1.00	24	23	1.04:1.00	1.15:1.00
Total	***790***	***812***	***0.97:1.00***	***1101***	***1220***	***0.90:1.00***	***0.93:1.00***

[a] Comprised of HOR's used for both Chiwawa and Nason Creek obligations.

Fecundity

Mean fecundities for the 2013-2015 returns of spring Chinook ranged from 4,045-4,847 eggs per female (Table 5.5). These fecundities were generally more than the overall average of 4,684 eggs per female, but were close to the expected fecundity of 4,400 eggs per female assumed in the broodstock protocols. For the 2015 return year, natural-origin Chinook produced more eggs per female than did hatchery-origin fish. This could be attributed to differences in size and age of hatchery and natural-origin fish described above (Tables 5.2 and 5.3).

Table 5.5. Mean fecundity of wild, hatchery, and all female spring Chinook collected for broodstock, 1989-2015; NA = not available.

Return year	Mean fecundity		
	Wild	Hatchery	Total
1989*	NA	NA	2,832
1990*	NA	NA	5,024
1991*	NA	NA	4,600
1992*	NA	NA	5,199[a]
1993*	NA	NA	5,249
1994*	NA	NA	5,923
1995	No program		
1996*	NA	NA	4,645
1997	4,752	4,479	4,570
1998	5,157	5,376	5,325
1999	No program		
2000	5,028	5,019	5,023
2001	4,530	4,663	4,624
2002	5,024	4,506	4,654
2003	6,191	5,651	5,844
2004	4,846	4,775	4,799
2005	4,365	4,312	4,327
2006	4,773	4,151	4,324
2007	4,656	4,351	4,441
2008	4,691	4,560	4,592
2009	4,691	4,487	4,573
2010	4,548	4,114	4,314
2011	4,969	3,884	4,385
2012	4,522	3,682	4,223
2013	4,716	No program	4,716
2014	4,467	3,834	4,045
2015	5,132	4,278	4,847
Average	***4,837***	***4,478***	***4,684***
Median	***4,734***	***4,479***	***4,624***

* Individual fecundities were not tracked with females until 1997.
[a] Estimated as the mean of fecundities two years before and two years after 1992.

5.2 Hatchery Rearing

Rearing History

Number of eggs taken

Based on the unfertilized egg-to-release survival standard of 81%, a total of 829,630 eggs were required to meet the program release goal of 672,000 smolts for brood years 1989-2010. For the

2011 and 2012 brood years, a total of 367,536 and 252,410 eggs were required to meet the release goals of 298,000 and 204,452 smolts, respectively. Since 2013, 169,442 eggs have been required to achieve a release goal of 144,026 smolts for the Chiwawa spring Chinook Program. Between 1989 and 2015, the egg take goal was reached only in 2001 and 2015 (Table 5.6). The green egg takes for 2013-2015 brood years were 97.4%, 99.7%, and 109.0% of program goals, respectively.

ESA Permit 18121 sets limits on the percentage of the total run and natural-origin fish in the broodstock to meet the conservation program. Applying these criteria to the low total abundance of spring Chinook salmon to the Chiwawa River basin and the low abundance of natural-origin fish returning to the basin has resulted in the program not meeting production goals.

Table 5.6. Numbers of eggs taken from spring Chinook broodstock, 1989-2015; NP = no program.

Return year	Number of eggs taken for the Chiwawa Program
1989	45,311
1990	60,287
1991	73,601
1992	111,624
1993	257,208
1994	35,539
1995	NP
1996	18,579
1997	312,182
1998	90,521
1999	NP
2000	55,256
2001	1,099,630
2002	196,186
2003	247,501
2004	538,176
2005	536,490
2006	744,344
2007	359,739
2008	761,821
2009	564,912
2010	383,944
2011	366,244
Average (1989-2011)	***326,624***
Median (1989-2011)	***257,208***

Return year	Number of eggs taken for the Chiwawa Program
2012	250,695
2013	165,047
2014	163,358
2015	184,734
Average (2012-present)	***192,371***
Median (2012-present)	***176,871***

Number of acclimation days

Early rearing of the 2013 brood Chiwawa spring Chinook was similar to previous years with fish being held on well water before being transferred to the Chiwawa Acclimation Facility for final acclimation. Beginning in 2006 (2005 brood acclimation), modifications were made to the Chiwawa Acclimation Facility intakes so that Wenatchee River water could be applied to the Chiwawa River intakes during severe cold periods to prevent the formation of frazzle ice. During acclimation of the 2013 brood, fish were acclimated for 196 to 203 days on Chiwawa River water (Table 5.7).

Table 5.7. Number of days spring Chinook broods were acclimated and water source, brood years 1989-2013; NA = not available.

Brood year	Release year	Transfer date	Release date	Number of days and water source		
				Total	Chiwawa	Wenatchee
1989	1991	19-Oct	11-May	204	NA	NA
1990	1992	13-Sep	27-Apr	227	NA	NA
1991	1993	24-Sep	24-Apr	212	NA	NA
1992	1994	30-Sep	20-Apr	202	NA	NA
1993	1995	28-Sep	20-Apr	204	NA	NA
1994	1996	1-Oct	25-Apr	207	NA	NA
1995	1997	No Program				
1996	1998	25-Sep	29-Apr	216	NA	NA
1997	1999	28-Sep	22-Apr	206	NA	NA
1998	2000	27-Sep	24-Apr	210	NA	NA
1999	2001	No Program				
2000	2002	26-Sep	25-Apr	211	NA	NA
2001	2003	22-Oct	1-May	191	NA	NA
2002	2004	25-Sep	2-May	220	NA	NA
2003	2005	30-Sep	3-May	215	NA	NA
		30-Sep	18-Apr-18-May	200	NA	NA

Brood year	Release year	Transfer date	Release date	Number of days and water source		
				Total	Chiwawa	Wenatchee
2004	2006	3-Sep	1-May	240	88-104	124
		3-Sep	17-Apr-17-May	226	NA	NA
2005	2007	25-Sep	1-May	217	217	98[a]
		26-Sep	16-Apr-15-May	202-232	202-232	98[a]
2006	2008	24-27-Sep	14-Apr-13-May	231	231	95[a]
2007	2009	1-Oct	15-Apr-13-May	223	223	103[a]
2008	2010	14-15-Sep	14-Apr-12-May	212-241	212-241	129
2009	2011	14-15-Sep	26-Apr-19-May	225-249	225-249	88
2010	2012	3, 5-6-Oct	17-Apr-1-May	195-212	195-212	132
2011	2013	24-26-Sep	16-22-Apr	202-210	202-210	40
2012	2014	23-25 Sep	14-21 Apr	204-211	204-211	107[a]
2013	2015	29-Sep	13-20-Apr	196-203	196-203	0

[a] Represents the number of days Wenatchee River water was applied to the Chiwawa River intake screen to prevent the formation of frazzle ice.

Release Information

Numbers released

The 2013 brood Chiwawa spring Chinook program achieved 102.4% of the 144,026 target goal with about 147,480 smolts being released volitionally into the Chiwawa River in 2015 (Table 5.8).

Table 5.8. Numbers of spring Chinook smolts tagged and released from the hatchery, brood years 1989-2013. The release target for Chiwawa spring Chinook is 144,026 smolts. For brood years 2012 to present, conservation program fish are not adipose fin clipped (they receive CWT only).

Brood year	Release year	Type of release	CWT mark rate	Number released that were PIT tagged	Number of smolts released	Total number of smolts released
1989	1991	Volitional	0.9932	0	43,000	43,000
1990	1992	Volitional	0.9931	0	53,170	53,170
1991	1993	Volitional	0.9831	0	62,138	62,138
1992	1994	Volitional	0.9747	0	85,113	85,113
1993	1995	Volitional	0.9892	0	223,610	223,610
1994	1996	Volitional	0.9967	0	27,226	27,226
1995	1997	No program				
1996	1998	Forced	0.8413	0	15,176	15,176
1997	1999	Volitional	0.9753	0	266,148	266,148
1998	2000	Volitional	0.9429	0	75,906	75,906
1999	2001	No program				

Brood year	Release year	Type of release	CWT mark rate	Number released that were PIT tagged	Number of smolts released	Total number of smolts released
2000	2002	Volitional	0.9920	0	47,104	47,104
2001	2003	Forced	0.9961	0	192,490[a]	377,544
		Volitional	0.9856	0	185,054[a]	
2002	2004	Volitional	0.9693	0	149,668	149,668
2003	2005	Forced	0.9783	0	69,907	222,131
		Volitional	0.9743	0	152,224	
2004	2006	Forced	0.9533	0	243,505	494,517
		Volitional	0.9493	0	251,012	
2005	2007	Forced	0.9882	4,993	245,406	494,012
		Volitional	0.9864	4,988	248,606	
2006	2007	Direct	0.0000	0	12,977[b]	612,482
	2008	Volitional	0.9795	9,894	612,482	
2007	2008	Direct	0.0000	0	9,494	305,542
	2009	Volitional	0.9948	10,035	296,048	
2008	2010	Volitional	0.9835	10,006	609,789	609,789
2009	2011	Forced	0.9874	0	241,181	438,561
		Volitional	0.9874	9,412	197,380	
2010[c]	2012	Volitional	0.9904	5,020	346,248	346,248
2011	2013	Volitional	0.9902	9,945	281,821	281,821
2012[d]	2014	Volitional	0.9841	5,061	222,504	222,504
2013[d]	2015	Volitional	0.9753	10,021	147,480	147,480

[a] This does not include the 226,456 eyed eggs that were planted in the Chiwawa River.
[b] This high ELISA group was only adipose fin clipped and directly planted into Big Meadow Creek in May.
[c] This does not include 18,480 eyed eggs that were culled because of high ELISA.
[d] Brood years 2012 to present are not adipose fin clipped (they receive CWT only).

Numbers tagged

The 2013 brood Chiwawa spring Chinook were 98% CWT (Table 5.8).

In 2015, a total of 10,200 spring Chinook from the 2014 brood were PIT tagged at Eastbank Hatchery on 6-10 July. Both the HxH and WxW fish were tagged and released into raceway #11A. Fish were not fed during tagging or for two days before and after tagging. Fish averaged 83 mm in length and 7.0 g at time of tagging. These fish were transferred to the Chiwawa Acclimation Facility in October 2015. These fish will be released in the Chiwawa River during spring 2016.

Table 5.9 summarizes the number of hatchery spring Chinook that have been PIT-tagged and released into the Chiwawa River.

Table 5.9. Summary of PIT-tagging activities for Chiwawa hatchery spring Chinook, brood years 2005-2013.

Brood year	Release year	Number of fish tagged	Number of tagged fish that died	Number of tags shed	Number of tagged fish released
2005	2007	10,063	74	8	9,981[a]
2006	2008	10,055	134	27	9,894
2007	2009	10,112	61	16	10,035
2008	2010	10,101	81	14	10,006
2009	2011	10,101	655	34	9,412
2010	2012	5,102	82	0	5,020
2011	2013	10,200	254	1	9,945
2012	2014	5,100	37	2	5,061
2013	2015	10,114	93	0	10,021

[a] This release consisted of 4,988 tagged Chinook that were released volitionally and 4,993 that were forced released.

Fish size and condition at release

Spring Chinook from the 2013 brood were released as yearling smolts between 13 and 20 April 2015. Size at release was equal to the target of 18 fpp established for the program. The CV for fork length was 9% short of the target (Table 5.10).

Table 5.10. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of spring Chinook smolts released from the hatchery, brood years 1989-2013. Size targets are provided in the last row of the table.

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1989	1991	147	4.4	37.8	12
1990	1992	137	5.0	32.4	14
1991	1993	135	4.2	30.3	15
1992	1994	133	5.0	28.4	16
1993	1995	136	4.5	30.2	15
1994	1996	139	7.1	34.4	13
1995	1997	No Program			
1996	1998	157	5.3	52.1	9
1997	1999	146	7.2	38.7	12
1998	2000	143	9.1	39.5	12
1999	2001	No Program			
2000	2002	150	6.8	46.7	10
2001	2003	142	7.1	37.6	12
2002	2004	146	8.5	40.3	11
2003	2005	167[a]	5.9	59.4	8

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
		151[b]	7.4	44.2	10
2004	2006	146[a]	6.4	39.1	12
		139[b]	5.7	34.3	13
2005	2007	136[a]	4.6	30.8	15
		129[b]	5.8	26.6	17
2006	2008	124	8.8	23.5	19
2007	2008	70[a]	4.0	3.7	122
	2009	140[b]	11.0	33.6	14
2008	2010	141	10.7	36.0	13
2009	2011	167	12.9	56.8	8
2010	2012	129	8.1	25.8	18
2011	2013	134	6.4	29.5	15
2012	2014	130	6.7	28.5	16
2013	2015	130	8.2	25.3	18
Average		***139***	***6.9***	***35.0***	***17***
Median		***139***	***6.7***	***34.3***	***13***
Targets		***155***	***9.0***	***37.8***	***18***

[a] Forced release group.
[b] Volitional release group.

Survival Estimates

Overall survival of Chiwawa spring Chinook from green (unfertilized) egg to release was above the standard set for the program (Table 5.11). There was higher than expected survivals throughout most stages, except for eyed-egg to ponding, contributing to increased program performance. Pre-spawn survival of adults was also above the standard set for the program.

Table 5.11. Hatchery life-stage survival rates (%) for spring Chinook, brood years 1989-2013. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
1989	100.0	100.0	98.0	99.1	99.1	99.0	96.4	99.3	94.8
1990	100.0	85.7	91.8	98.1	99.5	98.9	97.9	99.2	88.2
1991	100.0	100.0	94.4	96.1	99.6	97.9	93.2	95.0	84.4
1992	100.0	100.0	98.4	96.7	99.9	99.9	80.0	80.6	76.2
1993	96.0	98.0	89.7	98.0	99.7	99.3	98.9	99.7	86.9
1994	100.0	100.0	98.6	100.0	99.8	99.4	77.0	78.9	76.6
1995	No program								
1996	100.0	100.0	88.3	100.0	93.8	93.0	89.9	97.7	81.7
1997	98.6	100.0	93.2	95.7	98.3	99.6	95.6	99.3	85.3
1998	95.2	100.0	94.5	99.0	98.5	98.3	89.6	99.1	83.9

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
1999	No program								
2000	100.0	100.0	91.0	98.1	97.2	96.6	95.4	99.3	85.2
2001	97.6	97.0	88.9	98.1	99.7	99.6	51.3	51.8	34.3
2002	97.8	100.0	82.1	98.0	97.4	96.7	94.8	99.1	76.3
2003	93.9	100.0	93.2	97.7	99.5	99.3	98.5	98.1	89.7
2004	97.8	82.5	93.3	98.4	98.8	94.3	93.9	97.2	91.9
2005	97.1	100.0	95.9	98.0	99.2	99.0	97.9	99.1	92.1
2006	100.0	100.0	90.1	98.1	99.2	99.0	95.3	97.7	84.2
2007	98.8	97.7	92.9	97.2	99.4	99.0	98.0	99.4	88.5
2008	96.6	99.3	90.8	93.2	97.4	97.1	95.6	97.6	80.0
2009	94.4	97.6	92.5	88.3	97.6	97.4	89.2	92.8	77.6
2010[a]	98.9	100.0	99.2	100.0	97.9	97.5	95.6	98.2	94.8
2011	98.9	98.9	93.2	88.4	96.8	96.4	93.4	97.1	76.9
2012	98.3	100.0	94.6	98.3	99.7	99.3	98.5	99.4	91.6
2013	91.7	94.6	96.5	97.0	97.9	96.8	95.5	98.9	89.4
Average	***97.9***	***97.9***	***93.1***	***97.0***	***98.5***	***98.0***	***91.8***	***94.5***	***83.1***
Median	***98.6***	***100.0***	***93.2***	***98.0***	***99.1***	***98.9***	***95.4***	***98.2***	***85.2***
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

[a] Survival estimates do not include the 18,840 eyed eggs that were culled because of high ELISA levels.

5.3 Disease Monitoring

Results of 2015 adult broodstock bacterial kidney disease (BKD) monitoring indicated that nearly all females had ELISA values less than 0.199. About 98.2% of females had ELISA values less than 0.120, which would have required about 1.8% of the progeny to be reared at densities not to exceed 0.06 fish per pound (Table 5.12).

For the 2013 brood, mortalities resulting from external fungal infections began increasing shortly after transfer to the Chiwawa Acclimation Facility. A formalin drip treatments was used to control the infection. No significant health issues were encountered for the remainder of juvenile rearing.

Table 5.12. Proportion of bacterial kidney disease (BKD) titer groups for the Chiwawa spring Chinook broodstock, brood years 1996-2015. Also included are the proportions to be reared at either 0.125 fish per pound or 0.060 fish per pound.

Brood year[a]	Optical density values by titer group				Proportion at rearing densities (fish per pound, fpp)[b]	
	Very Low (≤ 0.099)	Low (0.1-0.199)	Moderate (0.2-0.449)	High (≥ 0.450)	≤ 0.125 fpp (<0.119)	≤ 0.060 fpp (>0.120)
1996	0.0000	0.2500	0.2500	0.5000	0.0000	1.0000
1997	0.1176	0.7353	0.0588	0.0882	0.3529	0.6471
1998	0.1176	0.8235	0.0588	0.0000	0.4706	0.5294
1999	No Program					

Brood year[a]	Optical density values by titer group				Proportion at rearing densities (fish per pound, fpp)[b]	
	Very Low (≤ 0.099)	Low (0.1-0.199)	Moderate (0.2-0.449)	High (≥ 0.450)	≤ 0.125 fpp (<0.119)	≤ 0.060 fpp (>0.120)
2000	0.0000	0.9091	0.0909	0.0000	0.1818	0.8182
2001	0.4066	0.5436	0.0373	0.0124	0.6515	0.3485
2002	0.2195	0.6585	0.0732	0.0488	0.5610	0.4390
2003	0.6957	0.1087	0.0652	0.1304	0.7174	0.2826
2004	0.8182	0.1515	0.0227	0.0076	0.8939	0.1061
2005	0.9084	0.0916	0.0000	0.0000	0.9695	0.0305
2006	0.7222	0.2556	0.0000	0.0222	0.8444	0.1556
2007	0.5854	0.3415	0.0244	0.0488	0.7073	0.2927
2008	0.8304	0.1520	0.0058	0.0117	0.9357	0.0643
2009	0.7600	0.1840	0.0080	0.0480	0.8480	0.1520
2010	0.8791	0.0769	0.0000	0.0439	0.9451	0.0549
2011	0.7640	0.2022	0.0000	0.0337	0.8764	0.1236
2012	0.8333	0.1333	0.0167	0.0167	0.9170	0.0830
2013	0.0829	0.1429	0.0286	0.0000	0.8857	0.1143
2014[c]	0.8282	0.1720	0.0000	0.0000	0.8889	0.1111
2015	0.9818	0.0000	0.0000	0.0182	0.9818	0.0182
Average	***0.5553***	***0.3122***	***0.0390***	***0.0542***	***0.7173***	***0.2827***
Median	***0.7222***	***0.1840***	***0.0227***	***0.0182***	***0.8480***	***0.1520***

[a] Individual ELISA samples were not collected before the 1996 brood.
[b] ELISA values from broodstock BKD testing dictate what density the progeny of the broodstock are reared. Progeny of broodstock with high ELISA values are reared at lower density.
[c] Comprised of HOR's used for both Chiwawa and Nason Creek obligations.

5.4 Natural Juvenile Productivity

During 2015, juvenile spring Chinook were sampled at the Lower Wenatchee, Nason Creek, White River, and Chiwawa River traps and counted during snorkel surveys within the Chiwawa River basin. Results from sampling at the Nason Creek Trap are provided in Section 6 and from the White River Trap in Section 7.

Parr Estimates

Based on snorkel surveys, a total of 111,224 (±7%) subyearling and 620 (±43%) yearling spring Chinook were estimated in the Chiwawa River basin in August 2015 (Table 5.13 and 5.14). During the survey period 1992-2015, numbers of subyearling and yearling Chinook have ranged from 5,815 to 149,563 and 5 to 967, respectively, in the Chiwawa River basin (Table 5.13 and 5.14; Figure 5.1). Numbers of all fish counted in the Chiwawa River basin are reported in Appendix A.

Table 5.13. Total numbers of subyearling spring Chinook estimated in different streams in the Chiwawa River basin during snorkel surveys in August 1992-2015; NS = not sampled.

Sample Year	Number of subyearling spring Chinook									
	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Unnamed Creek	Big Meadow Creek	Alder Creek	Brush Creek	Clear Creek	Total
1992	45,483	NS	NS	NS	NS	NS	NS	NS	NS	**45,483**
1993	77,269	0	1,258	586	NS	NS	NS	NS	NS	**79,113**
1994	53,492	0	398	474	68	624	0	0	0	**55,056**
1995	52,775	0	1,346	210	0	683	67	160	0	**55,241**
1996	5,500	0	29	10	0	248	28	0	0	**5,815**
1997	15,438	0	56	92	0	480	0	0	0	**16,066**
1998	65,875	0	1,468	496	57	506	0	13	0	**68,415**
1999	40,051	0	366	592	0	598	22	0	0	**41,629**
2000	NS	NS	NS	NS	NS	NS	NS	NS	NS	**NS**
2001	106,753	168	2,077	2,855	354	2,332	78	0	0	**114,617**
2002	117,230	75	8,233	2,953	636	5,021	429	0	297	**134,874**
2003	80,250	4,508	1,570	3,255	118	1,510	22	45	0	**91,278**
2004	43,360	102	717	215	54	637	21	71	0	**45,177**
2005	45,999	71	2,092	660	17	792	0	0	0	**49,631**
2006	73,478	113	2,500	1,681	51	1,890	62	127	0	**79,902**
2007	53,863	125	5,235	870	51	538	20	28	22	**60,752**
2008	72,431	214	3,287	4,730	163	1,221	28	255	22	**82,351**
2009	101,085	125	2,486	1,849	14	1,082	29	18	17	**106,705**
2010	117,499	526	4,571	4,052	0	1,449	56	42	25	**128,220**
2011	136,424	64	2,762	1,330	53	581	42	214	40	**141,510**
2012	96,036	78	4,125	2,227	49	1,322	35	31	37	**103,940**
2013	140,485	120	3,301	3,214	0	2,345	31	21	46	**149,563**
2014	113,869	361	2,384	3,124	28	1,367	11	28	68	**121,240**
2015	103,710	285	1,917	4,158	0	1,013	71	62	8	**111,224**
Average	***76,450***	***315***	***2,372***	***1,802***	***82***	***1,249***	***50***	***53***	***28***	***82,078***
Median	***73,478***	***90***	***2,085***	***1,506***	***49***	***1,013***	***28***	***28***	***0***	***79,902***

Table 5.14. Total numbers of yearling spring Chinook estimated in different streams in the Chiwawa River basin during snorkel surveys in August 1992-2015; NS = not sampled.

Sample Year	Number of yearling spring Chinook									
	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Unnamed Creek	Big Meadow Creek	Alder Creek	Brush Creek	Y Creek	Total
1992	563	NS	NS	NS	NS	NS	NS	NS	NS	**563**
1993	174	0	0	0	NS	NS	NS	NS	NS	**174**
1994	14	0	0	4	0	0	0	0	0	**18**
1995	13	0	0	0	0	0	0	0	0	**13**
1996	22	0	0	0	0	0	0	0	0	**22**
1997	5	0	0	0	0	0	0	0	0	**5**

Sample Year	Number of yearling spring Chinook									
	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Unnamed Creek	Big Meadow Creek	Alder Creek	Brush Creek	Y Creek	Total
1998	63	0	0	0	0	0	0	0	0	**63**
1999	41	0	0	0	0	0	0	0	0	**41**
2000	NS	NS	NS	NS	NS	NS	NS	NS	NS	**NS**
2001	66	0	3	0	0	0	0	0	0	**69**
2002	32	0	0	0	0	0	0	0	0	**32**
2003	134	0	0	0	0	0	0	0	0	**134**
2004	14	0	0	0	0	7	0	0	0	**21**
2005	62	0	17	0	0	0	0	0	0	**79**
2006	345	0	0	43	0	0	0	0	0	**388**
2007	41	0	0	0	0	0	0	0	0	**41**
2008	144	0	45	0	0	0	0	0	0	**189**
2009	49	0	0	5	0	0	0	0	0	**54**
2010	207	27	19	38	0	0	0	0	0	**291**
2011	645	0	71	194	0	57	0	0	0	**967**
2012	748	0	0	19	0	0	0	0	0	**767**
2013	836	0	0	8	0	8	0	0	0	**852**
2014	867	28	4	38	0	2	0	0	0	**939**
2015	488	0	22	110	0	0	0	0	0	**620**
Average	***242***	***3***	***8***	***21***	***0***	***4***	***0***	***0***	***0***	***276***
Median	***66***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***79***

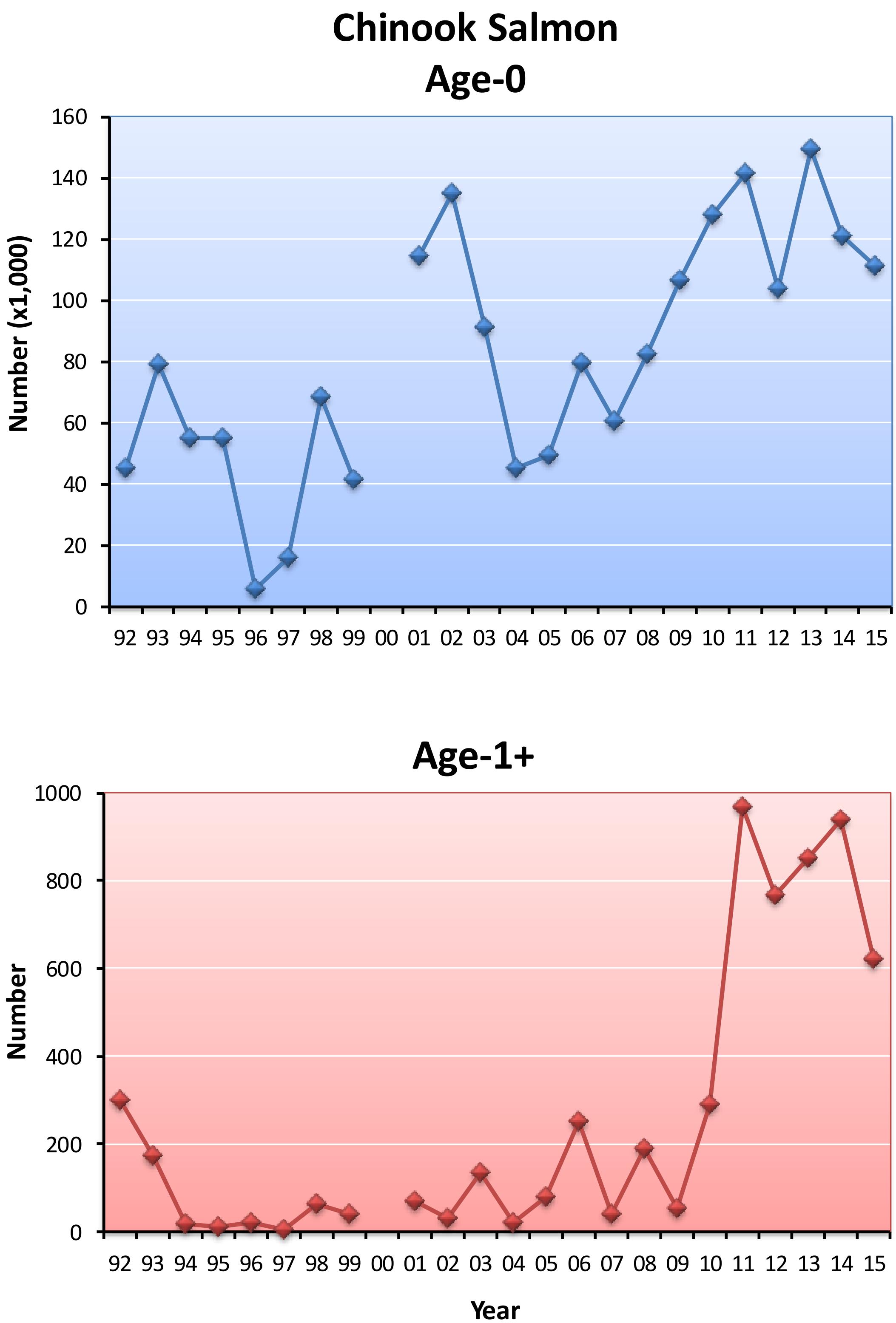

Figure 5.1. Numbers of subyearling and yearling Chinook salmon within the Chiwawa River Basin in August 1992-2015; ND = no data.

Juvenile Chinook were distributed contagiously among reaches in the Chiwawa River. Their densities were highest in the upper portions of the basin, with the highest densities within tributaries. Juvenile Chinook were most abundant in multiple channels and least abundant in glides and riffles. Most Chinook associated closely with woody debris in multiple channels. These sites (multiple channels) made up 16% of the total area of the Chiwawa River basin, but they provided habitat for 63% of all subyearling Chinook in the basin in 2015. In contrast, riffles made up 53% of the total area, but provided habitat for only 5% of all juvenile Chinook in the Chiwawa River basin. Pools made up 24% of the total area and provided habitat for 31% of all juvenile Chinook in the basin. Virtually no Chinook used glides that lacked woody debris.

Mean densities of juvenile Chinook in two reaches of the Chiwawa River were generally less than those in corresponding reference areas on Nason Creek and the Little Wenatchee River (Figure 5.2). Within both the Chiwawa River and its reference areas, pools and multiple channels consistently had the highest densities of juvenile Chinook.

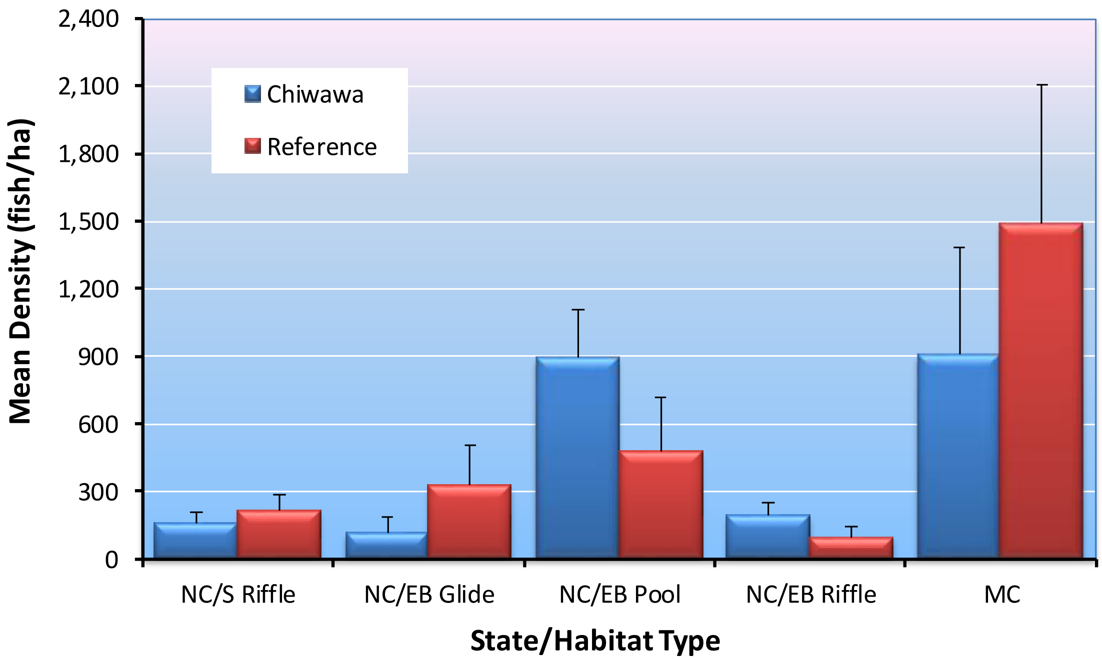

Figure 5.2. Comparison of the 22-year means of subyearling spring Chinook densities within state/habitat types in reaches 3 and 8 of the Chiwawa River and their matched reference areas on Nason Creek and the Little Wenatchee River. NC = natural channel; S = straight channel; EB = eroded banks; MC = multiple channel. There was no sampling in 2000 and no sampling within reference areas in 1992.

Smolt and Emigrant Estimates

Numbers of spring Chinook smolts and emigrants were estimated at the Chiwawa and Lower Wenatchee traps in 2015.

Chiwawa Trap

The Chiwawa Trap operated between 25 February and 24 November 2015. During that time period the trap was inoperable for 29 days because of high and low river flows, debris, and major hatchery releases. The trap operated in two different positions based on season and river discharge; lower position until 30 June and an upper position after 1 July. Daily trap efficiencies were estimated from two regression models depending on trap position and age class of fish (e.g., subyearling and yearling). The daily number of fish captured was expanded by the estimated trap efficiency to estimate daily total emigration. Monthly captures of all fish and results of mark-recapture efficiency tests at the Chiwawa Trap are reported in Appendix B.

Wild yearling spring Chinook (2013 brood year) were primarily captured from March through May 2015 (Figure 5.3). A significant relationship between trap efficiency and river flow could not be found, therefore a pooled trap efficiency was used and the total number of wild yearling Chinook emigrating from the Chiwawa River was estimated at 39,396 (±8,399). Combining the total number of subyearling spring Chinook (73,695 ±8,464) that emigrated during the fall of 2014 with the total number of yearling Chinook (39,396 ±8,399) that emigrated during 2015, and the number of estimated Chinook that were not trapped (55,971), resulted in a total emigrant estimate of 180,037 spring Chinook for the 2013 brood year (Table 5.15). The method for estimating emigration during the non-trapping period is explained in Appendix B.

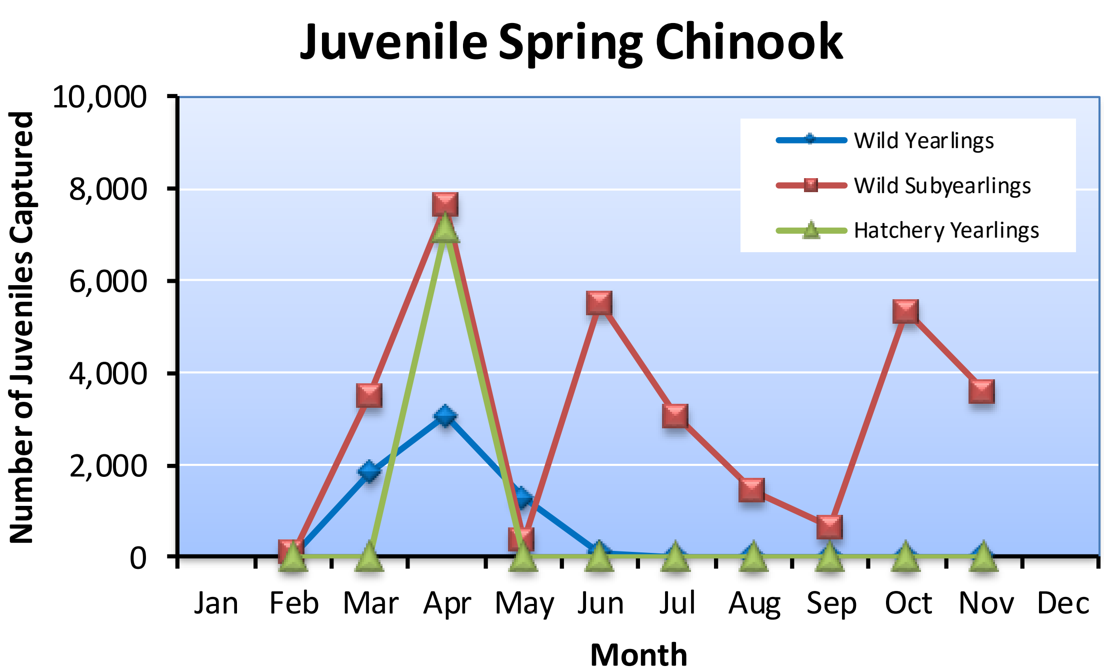

Figure 5.3. Monthly captures of wild subyearling, wild yearling, and hatchery yearling spring Chinook at the Chiwawa Trap, 2015.

Table 5.15. Numbers of redds and juvenile spring Chinook at different life stages in the Chiwawa River basin for brood years 1991-2015; NS = not sampled.

Brood year	Number of redds	Egg deposition	Number of parr	Number of smolts produced within Chiwawa River basin[a]	Number of emigrants
1991	104	478,400	45,483[b]	42,525	NS
1992	302	1,570,098	79,113	39,723	65,541
1993	106	556,394	55,056	8,662	22,698
1994	82	485,686	55,240	16,472	25,067
1995	13	66,248	5,815	3,830	5,951
1996	23	106,835	16,066	15,475	19,183
1997	82	374,740	68,415	28,334	44,562
1998	41	218,325	41,629	23,068	25,923
1999	34	166,090	NS	10,661	15,649
2000	128	642,944	114,617	40,831	55,685
2001	1,078	4,984,672	134,874	86,482	546,266
2002	345	1,605,630	91,278	90,948	184,279
2003	111	648,684	45,177	16,755	33,637
2004	241	1,156,559	49,631	72,080	116,158
2005	332	1,436,564	79,902	69,064	177,659
2006	297	1,284,228	60,752	45,050	107,972
2007	283	1,256,803	82,351	25,809	86,006
2008	689	3,163,888	106,705	35,023	120,184
2009	421	1,925,233	128,220	30,959	61,955
2010	502	2,165,628	141,510	47,511	101,130
2011	492	2,157,420	103,940	37,185	108,832
2012	880	3,412,184	149,563	34,334	109,413
2013	714	3,367,224	121,240	39,396	180,091
2014	485	1,961,825	111,224	-	-
Average	***324***	***1,466,346***	***82,078***	***37,399***	***100,629***
Median	***290***	***1,270,516***	***79,902***	***35,023***	***75,774***

[a] The estimated number of smolts (yearlings) that are produced entirely within the Chiwawa River basin. Smolt estimates for brood years 1992-1996 were calculated with a mark-recapture model; brood years 1997-present were calculated with a flow model.
[b] Estimate only includes numbers of Chinook in the Chiwawa River. Tributaries were not sampled at that time.

Wild subyearling spring Chinook (2014 brood year) were captured between February and November 2015. Based on capture efficiencies estimated from the flow model for both the upper trap position and lower position, the total number of wild subyearling (fry and parr) Chinook from the Chiwawa River basin was 153,038 (±17,101). Removing fry from the estimate, a total of 77,510 (±9,074) subyearling parr emigrated from the Chiwawa River basin in 2015. Although subyearling parr migrated during all months of sampling, the majority (82%) migrated during March, April, June, October, and November (Figure 5.3).

Yearling spring Chinook sampled in 2015 averaged 93 mm in length, 8.8 g in weight, and had a mean condition of 1.09 (Table 5.16). These size estimates were similar to the overall mean of yearling spring Chinook sampled in previous years (overall means: 93 mm, 9.1 g, and condition of 1.08). Subyearling spring Chinook sampled in 2015 at the Chiwawa Trap averaged 71 mm in length, averaged 4.2 g, and had a mean condition of 1.10 (Table 5.16). In general, subyearlings were a little smaller than previous years (overall means, 76 mm, 5.3 g, and condition of 1.09).

Table 5.16. Mean fork length (mm), weight (g), and condition factor of subyearling (excluding fry) and yearling spring Chinook collected in the Chiwawa Trap, 1996-2015. Numbers in parentheses indicate 1 standard deviation.

Sample year	Life stage	Sample size[a]	Mean size		
			Length (mm)	Weight (g)	Condition (K)
1996	Subyearling	514	78 (25)	6.9 (4.2)	1.11 (0.11)
	Yearling	1,589	94 (9)	9.5 (3.0)	1.11 (0.08)
1997	Subyearling	840	86 (8)	7.5 (2.1)	1.16 (0.08)
	Yearling	1,114	100 (7)	10.2 (2.6)	1.02 (0.10)
1998	Subyearling	3,743	82 (11)	6.2 (2.2)	1.08 (0.09)
	Yearling	2,663	97 (7)	10.3 (2.8)	1.12 (0.23)
1999	Subyearling	569	89 (9)	8.5 (2.4)	1.15 (0.07)
	Yearling	3,664	95 (8)	9.6 (3.4)	1.09 (0.19)
2000	Subyearling	1,810	85 (10)	7.4 (2.4)	1.15 (0.10)
	Yearling	1,891	97 (8)	10.5 (5.2)	1.13 (0.07)
2001	Subyearling	4,657	82 (11)	6.6 (3.4)	1.14 (0.09)
	Yearling	2,935	97 (7)	10.5 (2.4)	1.15 (0.08)
2002	Subyearling	6,130	64 (12)	3.0 (1.6)	1.06 (0.10)
	Yearling	1,735	94 (8)	9.0 (2.3)	1.09 (0.08)
2003	Subyearling	3,679	64 (12)	3.2 (1.7)	1.08 (0.10)
	Yearling	2,657	87 (9)	7.2 (3.5)	1.07 (0.10)
2004	Subyearling	2,278	75 (16)	4.3 (2.1)	0.92 (0.16)
	Yearling	1,032	91 (9)	8.5 (2.7)	1.09 (0.10)
2005	Subyearling	2,702	73 (12)	4.6 (2.2)	1.08 (0.09)
	Yearling	803	96 (9)	9.9 (2.8)	1.08 (0.08)
2006	Subyearling	3,462	76 (11)	5.1 (2.0)	1.12 (0.21)
	Yearling	4,645	95 (7)	9.4 (2.3)	1.10 (0.13)
2007	Subyearling	1,718	72 (12)	4.5 (2.1)	1.13 (0.16)
	Yearling	2,245	91 (8)	8.6 (2.5)	1.10 (0.09)
2008	Subyearling	10,443	79 (12)	5.9 (2.3)	1.15 (0.15)
	Yearling	8,792	93 (7)	8.8 (2.1)	1.08 (0.10)
2009	Subyearling	10,536	75 (10)	5.0 (2.2)	0.91 (0.11)
	Yearling	3,630	92 (7)	8.8 (2.1)	0.89 (0.07)
2010	Subyearling	3,888	77 (12)	5.4 (2.3)	1.11 (0.16)
	Yearling	5,799	91 (8)	8.9 (2.2)	1.15 (0.14)

Sample year	Life stage	Sample size[a]	Mean size		
			Length (mm)	Weight (g)	Condition (K)
2011	Subyearling	6,870	73 (11)	4.8 (2.2)	1.15 (0.16)
	Yearling	4,734	94 (8)	8.7 (2.2)	1.04 (0.10)
2012	Subyearling	8,756	75 (10)	4.8 (2.2)	1.13 (0.28)
	Yearling	7,290	90 (7)	8.0 (2.6)	1.06 (0.24)
2013	Subyearling	10,181	71 (10)	4.1 (1.7)	1.09 (0.39)
	Yearling	3,135	88 (9)	7.7 (2.8)	1.09 (0.20)
2014	Subyearling	7,122	71 (10)	3.7 (1.6)	1.08 (0.10)
	Yearling	3,956	89 (8)	7.7 (2.2)	1.05 (0.08)
2015	Subyearling	15,241	71 (11)	4.2 (2.4)	1.10 (0.39)
	Yearling	6,304	93 (9)	8.8 (2.9)	1.09 (0.15)
Average	***Subyearling***	***5,257***	***76 (12)***	***5 (2.3)***	***1.10 (0.16)***
	Yearling	***3,531***	***93 (8)***	***9 (2.7)***	***1.08 (0.12)***
Median	***Subyearling***	***3,816***	***75 (11)***	***5 (2.2)***	***1.11 (0.11)***
	Yearling	***3,035***	***94 (8)***	***9 (2.6)***	***1.09 (0.10)***

[a] Sample size represents the number of fish that were measured for both length and weight.

Lower Wenatchee Trap

The lower Wenatchee Trap operated in a new location beginning in 2013. Hence, historic flow-discharge relationships are invalid and new models to estimate trap efficiency are being developed for all species.

The Lower Wenatchee Trap operated between 30 January and 28 June 2015. During that time period the trap was inoperable for five days because of high and low river discharge, debris, elevated river temperature, and major hatchery releases. During the sampling period, a total of 1,559 wild yearling Chinook, 252,293 wild subyearling Chinook (mostly summer Chinook), and 9,921 hatchery yearling Chinook were captured at the Lower Wenatchee Trap. Based on capture efficiencies using the flow efficiency model, the total number of wild yearling Chinook that emigrated past the Lower Wenatchee Trap was 58,595 (±6,731). Monthly captures of all fish collected at the Lower Wenatchee Trap are reported in Appendix B.

PIT Tagging Activities

As part of the Comparative Survival Study (CSS) and PUD studies, a total of 20,663 wild juvenile Chinook (12,982 subyearling and 7,681 yearlings) were PIT tagged and released in 2015 in the Wenatchee River basin (Table 5.17a). Most of these (82.9%) were tagged at the Chiwawa trap. See Appendix C for a complete list of all fish captured, tagged, lost, and released.

Table 5.17a. Numbers of wild Chinook that were captured, tagged, and released at different locations within the Wenatchee River basin, 2015. Numbers of fish that died or shed tags are also given.

Sampling Location	Species and Life Stage	Number captured	Number of recaptures	Number tagged	Number died	Shed tags	Total tags released	Percent mortality
Chiwawa Trap	Wild Subyearling Chinook	31,152	169	10,471	414	0	10,471	1.33
	Wild Yearling Chinook	6,350	218	6,204	44	0	6,204	0.69

Sampling Location	Species and Life Stage	Number captured	Number of recaptures	Number tagged	Number died	Shed tags	Total tags released	Percent mortality
	Total	**37,502**	**387**	**16,675**	**458**	**0**	**16,675**	**1.22**
Chiwawa River (Electrofishing)	Wild Subyearling Chinook	1,103	0	1,054	20	0	1,054	1.81
	Wild Yearling Chinook	0	0	0	0	0	0	--
	Total	1,103	0	1,054	20	0	1,054	1.81
Nason Creek Trap	Wild Subyearling Chinook	548	0	219	9	0	219	1.64
	Wild Yearling Chinook	152	0	142	5	0	142	3.29
	Total	**700**	**0**	**361**	**14**	**0**	**361**	**2.00**
Nason Creek (Electrofishing)	Wild Subyearling Chinook	1,143	10	1,089	46	0	1,089	4.02
	Wild Yearling Chinook	0	0	0	0	0	0	--
	Total	1,143	10	1,089	46	0	1,089	4.02
White River Trap	Wild Subyearling Chinook	162	1	150	0	1	149	0.00
	Wild Yearling Chinook	34	0	34	0	0	34	0.00
	Total	**196**	**1**	**184**	**0**	**1**	**183**	**0.00**
Lower Wenatchee Trap	Wild Subyearling Chinook	252,293	83	0	282	0	0	0.11
	Wild Yearling Chinook	1,559	1	1,301	17	0	1,301	1.09
	Total	**253,852**	**84**	**1,301**	**299**	**0**	**1,301**	**0.12**
Total:	**Wild Subyearling Chinook**	**286,401**	**263**	**12,983**	**771**	**1**	**12,982**	**0.27**
	Wild Yearling Chinook	**8,095**	**219**	**7,681**	**66**	**0**	**7,681**	**0.82**
Grand Total:		***294,496***	***482***	***20,664***	***837***	***1***	***20,663***	***0.28***

Numbers of wild Chinook salmon PIT-tagged and released as part of CSS and PUD studies during the period 2006-2015 are shown in Table 5.17b.

Table 5.17b. Summary of the numbers of wild Chinook that were tagged and released at different locations within the Wenatchee River basin, 2006-2015. ND = no data because the trap was removed.

Sampling Location	Species and Life Stage	Numbers of PIT-tagged Chinook salmon released									
		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Chiwawa Trap	Wild Subyr Chinook	5,130	6,137	8,755	8,765	3,324	6,030	7,644	9,086	11,358	10,471
	Wild Yearling Chinook	2,793	4,659	8,397	3,694	6,281	4,318	7,980	3,093	4,383	6,204
	Total	**7,923**	**10,796**	**17,152**	**12,459**	**9,605**	**10,348**	**15,624**	**12,179**	**15,741**	**16,675**
Chiwawa River (Angling or Electrofishing)	Wild Subyr Chinook	111	20	43	128	531	0	3,181	3,017	1,032	1,054
	Wild Yearling Chinook	0	0	0	3	4	0	0	0	0	0
	Total	**111**	**20**	**43**	**131**	**535**	**0**	**3,181**	**3,017**	**1,032**	**1,054**
Upper Wenatchee Trap	Wild Subyr Chinook	0	15	0	37	3	1	1	0	ND	ND
	Wild Yearling Chinook	81	1,434	159	296	486	714	75	94	ND	ND
	Total	**81**	**1,449**	**159**	**333**	**489**	**715**	**76**	**94**	**ND**	**ND**
Nason Creek Trap	Wild Subyr Chinook	1,434	545	1,741	1,890	2,828	822	1,939	3,290	1,113	219
	Wild Yearling Chinook	365	577	894	185	364	147	357	237	456	142

Sampling Location	Species and Life Stage	Numbers of PIT-tagged Chinook salmon released									
		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	Total	**1,799**	**1,122**	**2,635**	**2,075**	**3,192**	**969**	**2,296**	**3,527**	**1,569**	**361**
Nason Creek (Angling or Electrofishing)	Wild Subyr Chinook	68	6	4	701	595	0	0	0	1,816	1,089
	Wild Yearling Chinook	1	7	0	13	3	0	0	0	0	0
	Total	**69**	**13**	**4**	**714**	**598**	**0**	**0**	**0**	**1,816**	**1,089**
White River Trap	Wild Subyr Chinook	0	0	0	441	143	144	285	374	156	149
	Wild Yearling Chinook	0	0	0	265	359	65	180	22	49	34
	Total	**0**	**0**	**0**	**706**	**502**	**209**	**465**	**396**	**205**	**183**
Upper Wenatchee (Angling or Electrofishing)	Wild Subyr Chinook	0	61	1	0	2	0	0	0	0	0
	Wild Yearling Chinook	27	0	0	0	0	0	0	0	0	0
	Total	**27**	**61**	**1**	**0**	**2**	**0**	**0**	**0**	**0**	**0**
Middle Wenatchee (Angling or Electrofishing)	Wild Subyr Chinook	0	0	65	284	233	0	0	0	0	0
	Wild Yearling Chinook	0	0	0	0	0	0	0	0	0	0
	Total	**0**	**0**	**65**	**284**	**233**	**0**	**0**	**0**	**0**	**0**
Lower Wenatchee (Angling or Electrofishing)	Wild Subyr Chinook	0	0	0	0	0	0	0	0	0	0
	Wild Yearling Chinook	0	0	0	0	0	0	0	0	0	0
	Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Peshastin Creek (Angling or Electrofishing)	Wild Subyr Chinook	0	0	0	0	1	0	0	0	0	0
	Wild Yearling Chinook	0	0	0	0	0	0	0	0	0	0
	Total	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
Lower Wenatchee Trap	Wild Subyr Chinook	0	0	2	0	0	0	0	0	36	0
	Wild Yearling Chinook	522	1,641	506	468	917	0	0	1,712	1,506	1,301
	Total	**522**	**1,641**	**508**	**468**	**917**	**0**	**0**	**1,712**	**1,542**	**1,301**
Total:	**Wild Subyr Chinook**	**6,743**	**6,784**	**10,611**	**12,246**	**7,660**	**6,997**	**13,050**	**15,767**	**15,511**	**12,982**
	Wild Yearling Chinook	**3,789**	**8,318**	**9,956**	**4,924**	**8,414**	**5,244**	**8,592**	**5,158**	**6,394**	**7,681**
Grand Total:		***10,532***	***15,102***	***20,567***	***17,170***	***16,074***	***12,241***	***21,642***	***20,925***	***21,905***	***20,663***

Freshwater Productivity

Both productivity and survival estimates for different life stages of spring Chinook in the Chiwawa River basin are provided in Table 5.18. Estimates for brood year 2013 fall within the ranges estimated over the period of brood years 1991-2013. During that period, freshwater productivities ranged from 125-1,015 parr/redd, 39-673 smolts/redd, and 124-834 emigrants/redd. Survivals during the same period ranged from 2.7-19.1% for egg-parr, 0.9-14.5% for egg-smolt, and 2.9-18.0% for egg-emigrants. Overwinter survival rates for juvenile spring Chinook within the Chiwawa River basin have ranged from 15.7-100.0%.

Table 5.18. Productivity (fish/redd) and survival (%) estimates for different juvenile life stages of spring Chinook in the Chiwawa River basin for brood years 1991-2014; ND = no data. These estimates were derived from data in Table 5.15.

Brood year	Parr/Redd	Smolts/Redd[a]	Emigrants/ Redd	Egg-Parr (%)	Parr-Smolt[b] (%)	Egg-Smolt[a] (%)	Egg-Emigrant (%)
1991	437	409	ND	9.5	93.5	8.9	ND
1992	262	132	217	5.0	50.2	2.5	4.2
1993	519	82	214	9.9	15.7	1.6	4.1
1994	674	201	306	11.4	29.8	3.4	5.2
1995	447	295	458	8.8	65.9	5.8	9.0
1996	699	673	834	15.0	96.3	14.5	18.0
1997	834	346	543	18.3	41.4	7.6	11.9
1998	1,015	563	632	19.1	55.4	10.6	11.9
1999	ND	314	460	ND	ND	6.4	9.4
2000	895	319	435	17.8	35.6	6.4	8.7
2001	125	80	507	2.7	64.1	1.7	11.0
2002	265	264	534	5.7	99.6	5.7	11.5
2003	407	151	303	7.0	37.1	2.6	5.2
2004	206	299	482	4.3	100.0	6.2	10.0
2005	241	208	535	5.6	86.4	4.8	12.4
2006	205	152	364	4.7	74.2	3.5	8.4
2007	291	91	304	6.6	31.3	2.1	6.8
2008	155	51	174	3.4	32.8	1.1	3.8
2009	305	74	147	6.7	24.1	1.6	3.2
2010	282	95	201	6.5	33.6	2.2	4.7
2011	211	76	221	4.8	35.8	1.7	5.0
2012	170	39	124	4.0	23.0	0.9	2.9
2013	170	55	158	3.6	32.5	1.2	3.4
2014	229	--	--	5.7	--	--	--
Average	***393***	***216***	***371***	***8.1***	***52.7***	***4.5***	***7.8***
Median	***282***	***152***	***335***	***6.5***	***39.3***	***3.4***	***7.6***

[a] These estimates include Chiwawa smolts produced only within the Chiwawa River basin.
[b] These estimates represent overwinter survival within the Chiwawa River basin. It does not include Chiwawa smolts produced outside the Chiwawa River basin.

Seeding level (egg deposition) explained most of the variability in productivity and survival of juvenile spring Chinook in the Chiwawa River basin. That is, for estimates based on "within-Chiwawa-Basin" life stages (e.g., parr and smolts), survival and productivity decreased as seeding levels increased (Figure 5.4). This suggests that density dependence regulates juvenile productivity and survival within the Chiwawa River basin. This form of population regulation is less apparent with total emigrants. However, one would expect the number of emigrants to increase as seeding levels exceed the rearing capacity of the Chiwawa River basin.

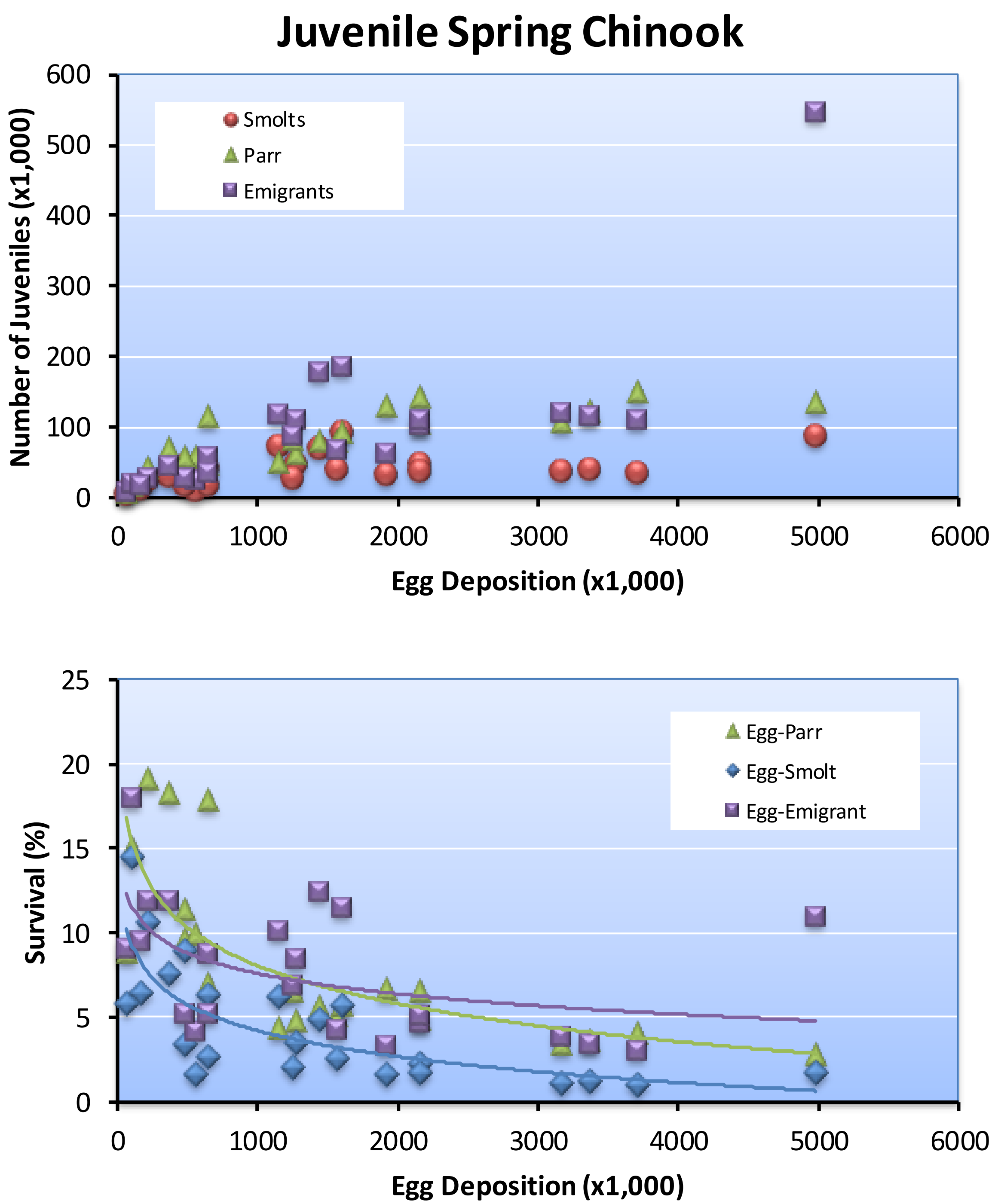

Figure 5.4. Relationships between seeding levels (egg deposition) and juvenile life-stage survivals and productivities for Chiwawa spring Chinook, brood years 1991-2013. Smolts represent yearling Chinook produced within the Chiwawa River basin.

Population Carrying Capacity

Population carrying capacity (*K*) is defined as the maximum equilibrium population size estimated with population models (e.g., logistic equation, Beverton-Holt model, hockey stick model, and the Ricker model).[8] Maximum equilibrium population size is generated from density dependent mechanisms that reduce population growth rates as population size increases (negative density dependence). This is referred to as compensation. Population size fluctuates about the maximum equilibrium size because of variability in vital rates that are unrelated to density (density independent factors) and measurement error. In this section, we estimate parr and smolt carrying capacities using the smooth hockey stick stock-recruitment model (see Appendix C in Hillman et al. 2012 for a detailed description of methods). This model explains most of the information contained in the juvenile spring Chinook data (see Appendix A).

Based on the smooth hockey stick model, the population carrying capacity for spring Chinook parr in the Chiwawa River basin is 110,747 parr (95% CI: 93,130 – 135,644) (Figure 5.5). The capacity for spring Chinook smolts is 45,815 (95% CI: 34,050 – 57,412) (Figure 5.6). Here, smolts are defined as the number of yearling spring Chinook produced entirely within the Chiwawa River basin. These estimates reflect current conditions (most recent two decades) within the Chiwawa River basin. Land use activities such as logging, mining, roads, development, and recreation have altered the historical conditions of the watershed. Thus, the estimated population capacity estimates may not reflect historical capacities for spring Chinook parr and smolts in the Chiwawa River basin.

[8] Population carrying capacity (*K*) should not be confused with habitat carrying capacity (*C*), which is defined as the maximum population of a given species that a particular environment can sustain.

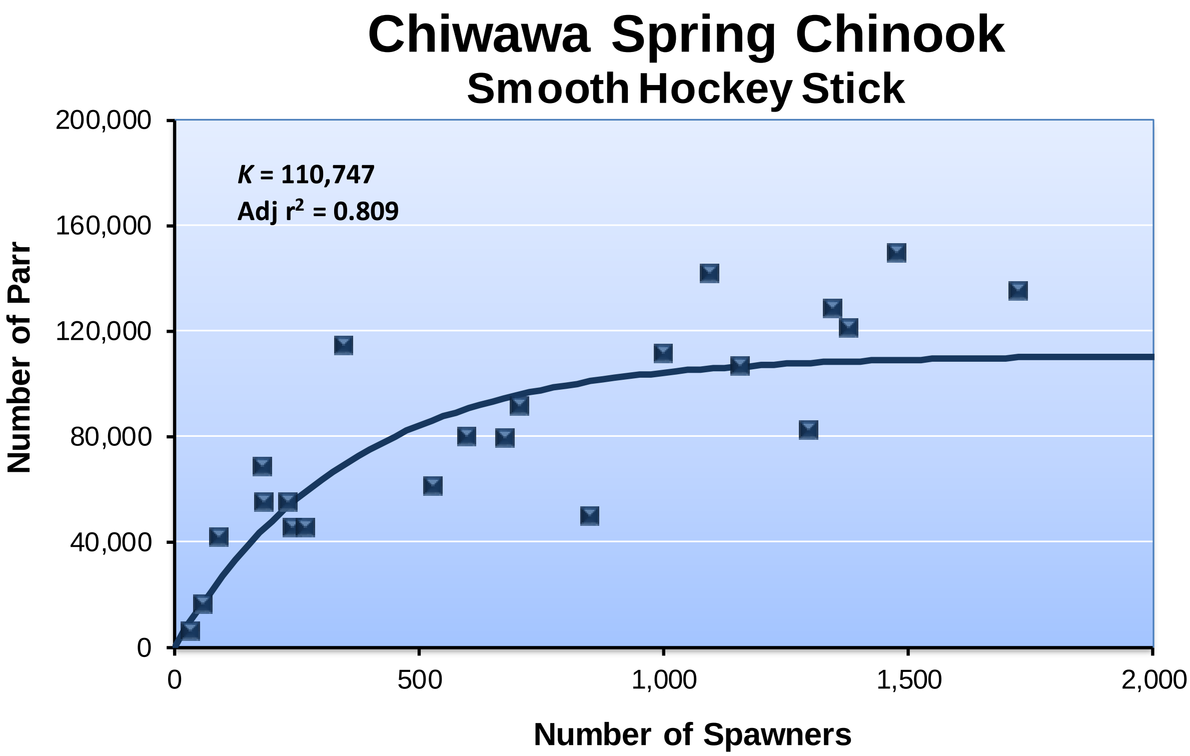

Figure 5.5. Relationship between spawners and number of parr produced in the Chiwawa River basin. Population carrying capacity (*K*) was estimated using the smooth hockey stick model, which explained most of the information in the data.

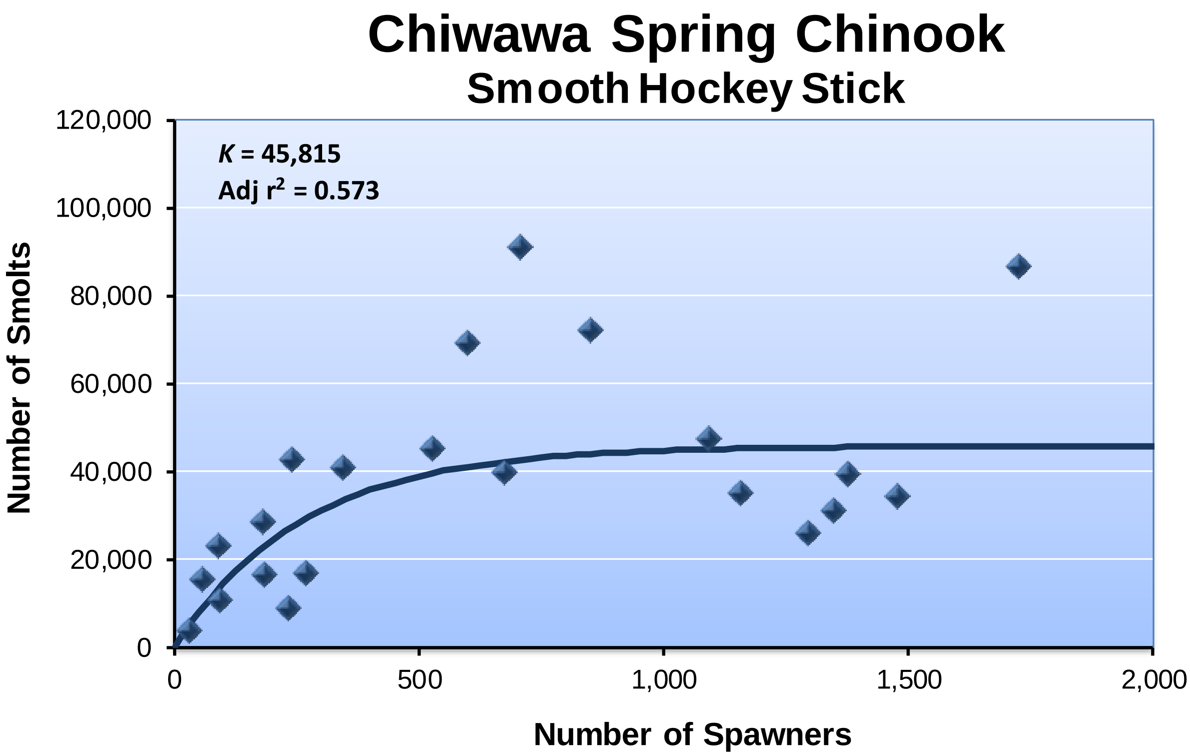

Figure 5.6. Relationship between spawners and number of yearling smolts produced in the Chiwawa River basin. Population carrying capacity (*K*) was estimated using the smooth hockey stick model, which explained most of the information in the data.

We tracked the precision of the smooth hockey stick parameters for Chiwawa spring Chinook smolts over time to see if precision improves with additional years of data, and the parameters and statistics stabilize over time. Examination of variation in the alpha (*A*) and beta (*B*) parameters of the smooth hockey stick model and their associated standard errors and confidence intervals indicates that the parameters appear to stabilize after 19 years of smolt and spawning escapement data (Table 5.19; Figure 5.7). This was also apparent in the estimates of population carrying capacity (Figure 5.8). That is, after 19 years of data, additional years of data had relatively little effect on the parameters of the smooth hockey stick model and its statistics. This observation will change if more extreme spawning escapements occur in the future or density independent factors overwhelm the influence of density dependent factors.

Table 5.19. Estimated parameters and statistics associated with fitting the smooth hockey stick model to spawning escapement and smolt data. Smolts represent numbers of smolts produced entirely within the Chiwawa River basin. *A* = alpha parameter; *B* = beta parameter; SE = standard error (estimated from 5,000 bootstrap samples); and r^2 = coefficient of determination. Spawners represent the stock size needed to achieve population capacity.

Years of data	Parameter				Population capacity	Intrinsic productivity	Spawners	r^2
	A	SE	*B*	SE				
5	10.80	11.51	110.23	942.46	49,257	110	1,339	0.706
6	10.43	30.61	163.03	28174.86	34,022	163	625	0.562
7	10.47	70.66	173.00	1918.57	35,362	173	613	0.567
8	10.40	13.26	206.97	41705.63	32,750	207	474	0.513
9	10.43	16.70	190.98	96463.71	33,727	191	529	0.518
10	10.56	41.60	184.83	719.39	38,590	185	625	0.564
11	11.10	8.98	154.07	246309.06	66,371	154	1,291	0.653
12	11.31	71.48	150.98	2254.06	81,605	151	1,620	0.701
13	11.28	43.85	142.41	236.06	79,572	142	1,674	0.664
14	11.34	5.26	141.43	118.39	84,292	141	1,786	0.699
15	11.40	15.61	141.76	35.71	89,256	142	1,887	0.718
16	11.38	2.77	141.35	37.66	87,522	141	1,856	0.723
17	11.02	3.10	155.71	38.89	60,965	156	1,173	0.651
18	10.92	0.79	160.92	38.85	55,020	161	1,023	0.635
19	10.82	0.25	166.78	39.68	50,150	167	901	0.614
20	10.82	0.20	166.99	39.58	49,972	167	897	0.622
21	10.78	0.17	169.82	38.50	48,142	170	849	0.618
22	10.75	0.15	172.32	39.35	46,494	172	809	0.611
23	10.73	0.13	173.36	40.07	45,815	173	792	0.612
24	10.73	0.13	173.36	39.82	45,815	173	792	0.612

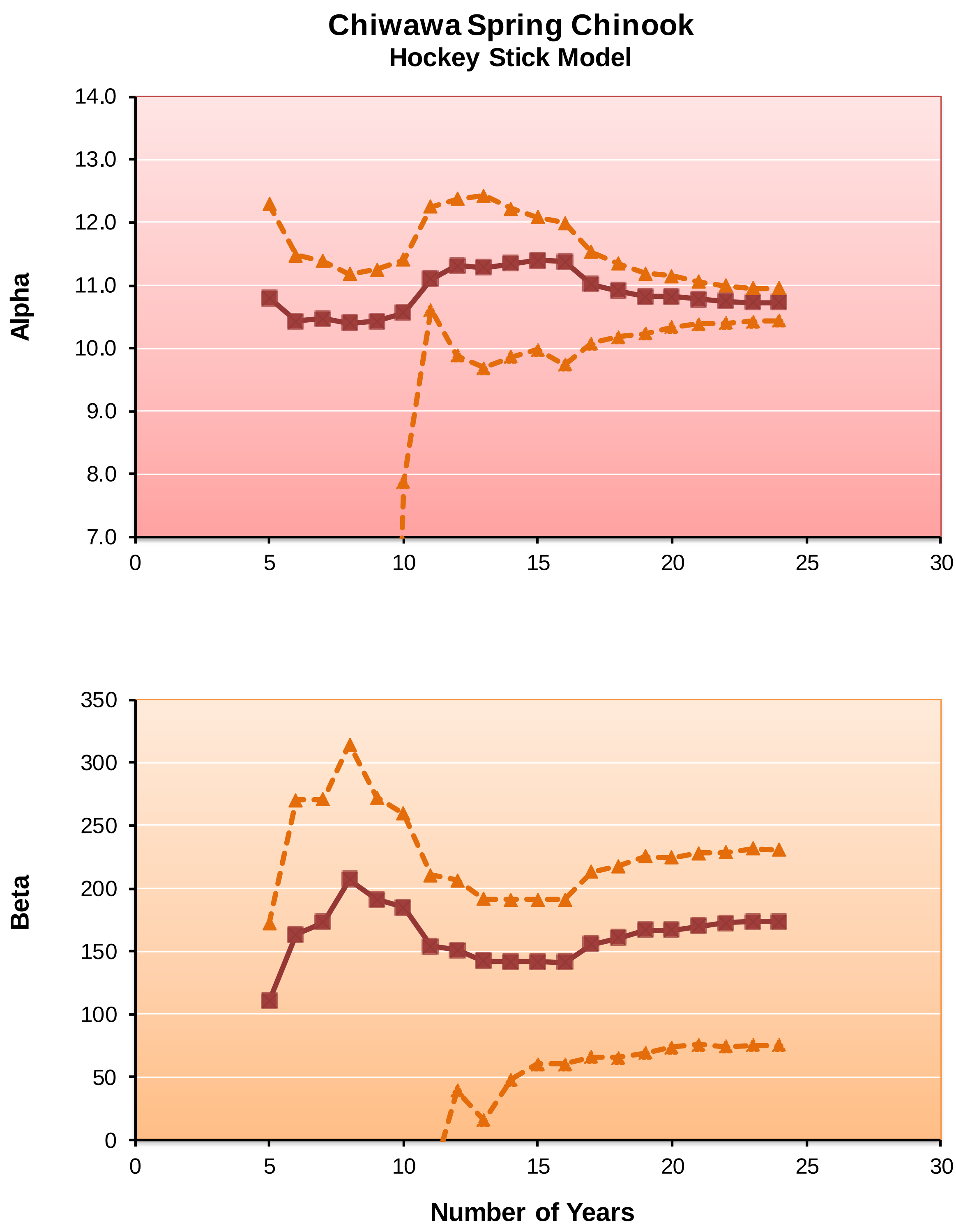

Figure 5.7. Time series of alpha and beta parameters and 95% confidence intervals for the smooth hockey stick model that was fit to Chiwawa spring Chinook smolt and spawning escapement data. Confidence intervals were estimated from 5,000 bootstrap samples.

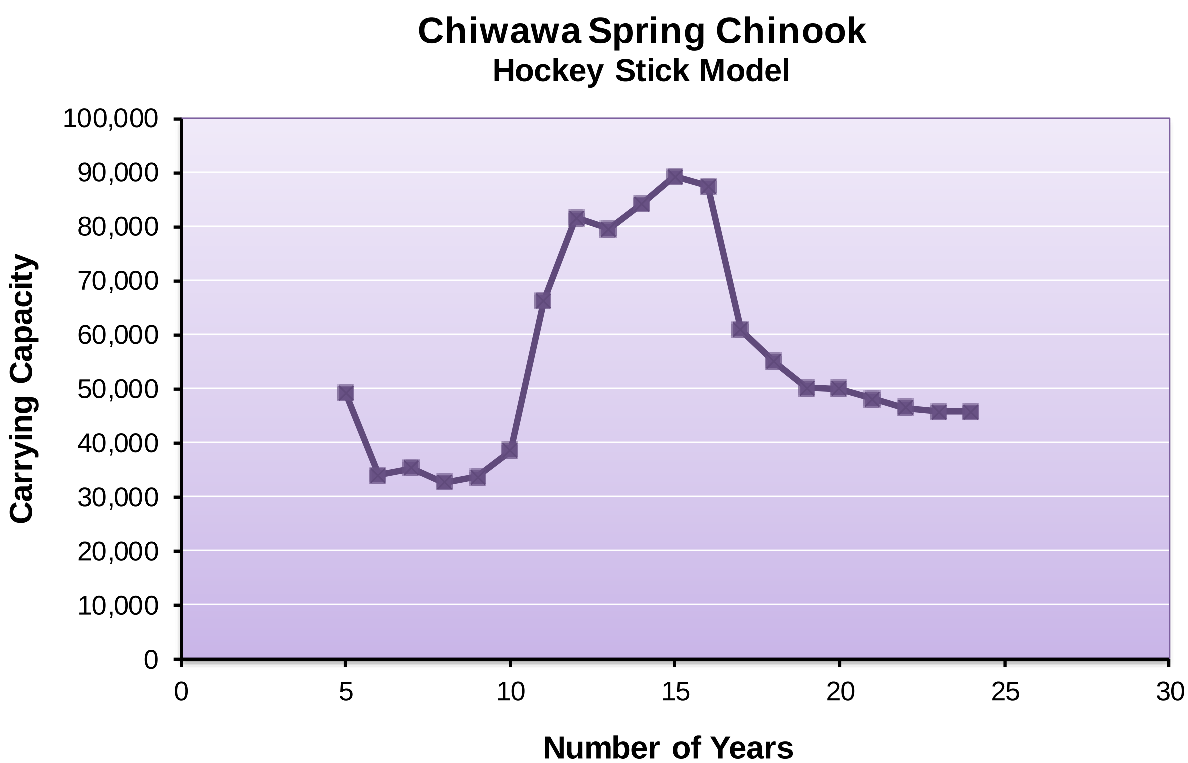

Figure 5.8. Time series of population carrying capacity estimates derived from fitting the smooth hockey stick model to Chiwawa spring Chinook smolt and spawning escapement data.

5.5 Spawning Surveys

Surveys for spring Chinook redds were conducted during August through September, 2015, in the Chiwawa River (including Rock and Chikamin creeks), Nason Creek, Icicle Creek, Peshastin Creek, Upper Wenatchee River (including Chiwaukum Creek), Little Wenatchee River, and the White River (including the Napeequa River and Panther Creek).

Spawning escapement for spring Chinook was calculated as the number of redds times the male-to-female ratio (i.e., fish per redd expansion factor) estimated from broodstock and fish sampled at adult trapping sites. WDFW is currently developing a method to estimate spawning escapement using the area-under-the-curve (AUC) method (Millar et al. 2012). Model development is currently underway.

Redd Counts

A total of 923 spring Chinook redds were counted in the Wenatchee River basin in 2015 (Table 5.20). This is higher than the average of 665 redds counted during the period 1989-2014 in the Wenatchee River basin. Most spawning occurred in the Chiwawa River (58.8% or 543 redds) (Table 5.20; Figure 5.9). Nason Creek contained 9.2% (85 redds), Icicle Creek contained 14.3% (132 redds), White River contained 7.6% (70 redds), Little Wenatchee contained 3.0% (28 redds), the Upper Wenatchee River 6.0% (55 redds), and Peshastin Creek contained 1.1% (10 redds).

Table 5.20. Numbers of spring Chinook redds counted within different streams/watersheds within the Wenatchee River basin, 1989-2015. Redd counts in Peshastin Creek in 2001 and 2002 (*) were elevated because the U.S. Fish and Wildlife Service planted 487 and 350 spring Chinook adults, respectively, into the stream. These counts were not included in the total or average calculations. WDFW began full implementation of adult management in 2014.

Sample year	Number of spring Chinook redds							
	Chiwawa	Nason	Little Wenatchee	White	Wenatchee River	Icicle	Peshastin	Total
1989	314	98	45	64	94	24	NS	**639**
1990	255	103	30	22	36	50	4	**500**
1991	104	67	18	21	41	40	1	**292**
1992	302	81	35	35	38	37	0	**528**
1993	106	223	61	66	86	53	5	**600**
1994	82	27	7	3	6	15	0	**140**
1995	13	7	0	2	1	9	0	**32**
1996	23	33	3	12	1	12	1	**85**
1997	82	55	8	15	15	33	1	**209**
1998	41	29	8	5	0	11	0	**94**
1999	34	8	3	1	2	6	0	**54**
2000	128	100	9	8	37	68	0	**350**
2001	1,078	374	74	104	218	88	173*	**2,109**
2002	345	294	42	42	64	245	107*	**1,139**
2003	111	83	12	15	24	18	60	**323**
2004	239	169	13	22	46	30	55	**574**
2005	333	193	64	86	143	8	3	**830**
2006	297	152	21	31	27	50	10	**588**
2007	283	101	22	20	12	17	11	**466**
2008	689	336	38	31	180	116	21	**1,411**
2009	421	167	39	54	5	32	15	**733**
2010	502	188	38	33	47	155	5	**968**
2011	492	170	30	20	12	122	26	**872**
2012	880	413	43	86	73	199	10	**1,704**
2013	714	212	51	54	17	107	4	**1,159**
2014	485	115	25	26	23	211	0	**885**
2015	543	85	28	70	55	132	10	**923**
Average	***329***	***144***	***28***	***35***	***48***	***70***	***10***	***674***
Median	***297***	***103***	***28***	***26***	***36***	***40***	***4***	***588***

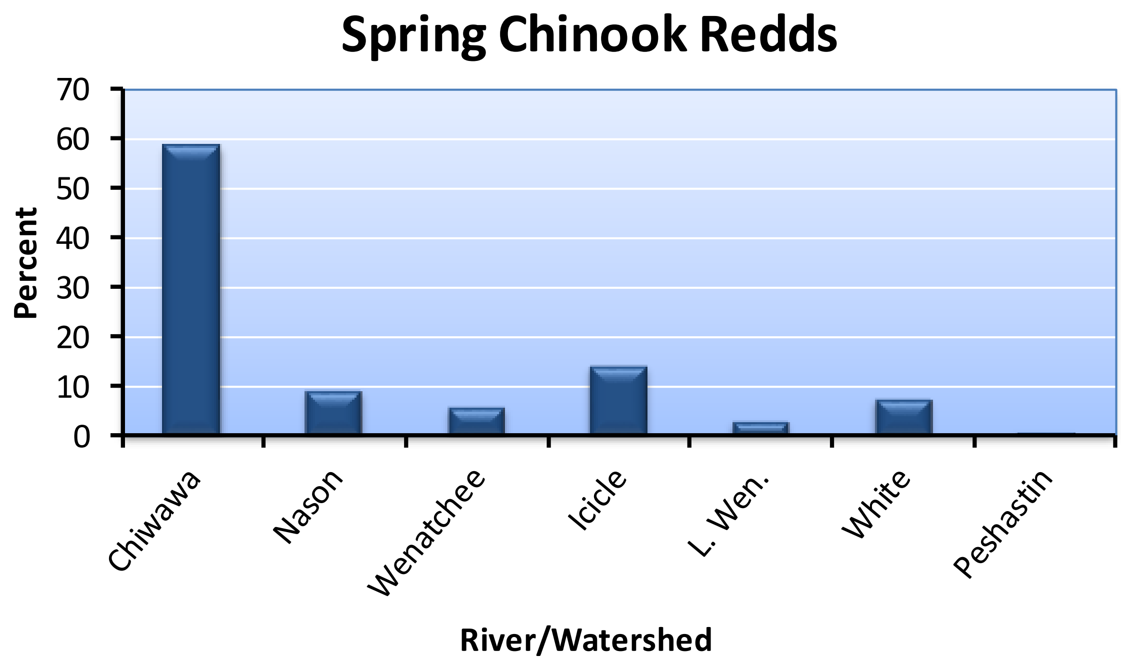

Figure 5.9. Percent of the total number of spring Chinook redds counted in different streams/watersheds within the Wenatchee River basin during August through September, 2015.

Redd Distribution

Spring Chinook redds were not evenly distributed among reaches within survey streams in 2015 (Table 5.21). Most of the spawning in the Chiwawa River basin occurred in Reaches 1 through 6. About 73% of the spawning in the Chiwawa River basin occurred in the lower two reaches (RKM 0.0-36.97; from the mouth to Rock Creek). Relatively few fish spawned in Rock and Chikamin creeks. The spatial distribution of redds in Nason Creek was weighted towards Reach 3, having 40% of the Nason Creek redds. In the Little Wenatchee River, about 89% of all spawning occurred in Reach 3 (RKM 9.2-14.0; Lost Creek to Falls). On the White River, 90% of the spawning occurred in Reach 3 (RKM 20.3-23.3; Napeequa River to Grasshopper Meadows). About 78% of all the spawning in the Wenatchee River occurred upstream from the mouth of the Chiwawa River. In Icicle Creek, about 73% of spawning occurred in Reach 2 (RKM 4.9-6.7; Hatchery to Sleeping Lady). All the spawning in Peshastin Creek occurred above Camas Creek (RKM 9.0).

Table 5.21. Numbers and proportions of spring Chinook redds counted within different streams/watersheds within the Wenatchee River basin during August through September, 2015. NS = not surveyed. See Table 2.8 for description of survey reaches.

Stream/watershed	Reach	Number of redds	Proportion of redds within stream/watershed
Chiwawa	Chiwawa 1 (C1)	173	0.32
	Chiwawa 2 (C2)	222	0.41
	Chiwawa 3 (C3)	22	0.04
	Chiwawa 4 (C4)	35	0.06
	Chiwawa 5 (C5)	33	0.06

Stream/watershed	Reach	Number of redds	Proportion of redds within stream/watershed
	Chiwawa 6 (C6)	52	0.10
	Chiwawa 7 (C7)	2	0.00
	Phelps 1 (S1)	NS	--
	Rock 1 (R1)	3	0.01
	Chikamin 1 (K1)	1	0.00
	Total	**543**	**1.00**
Nason	Nason 1 (N1)	15	0.18
	Nason 2 (N2)	23	0.27
	Nason 3 (N3)	34	0.40
	Nason 4 (N4)	13	0.15
	Total	**85**	**1.00**
Little Wenatchee	Little Wen 2 (L2)	3	0.11
	Little Wen 3 (L3)	25	0.89
	Total	**28**	**1.00**
White	White 2 (H2)	4	0.06
	White 3 (H3)	63	0.90
	White 4 (H4)	2	0.03
	Napeequa 1 (Q1)	1	0.01
	Panther 1 (T1)	0	0.00
	Total	**70**	**1.00**
Wenatchee River	Wen 9 (W9)	12	0.22
	Wen 10 (W10)	43	0.78
	Chiwaukum (U1)	0	0.00
	Total	**55**	**1.00**
Icicle	Icicle 1 (I1)	10	0.08
	Icicle 2 (I2)	96	0.73
	Icicle 3 (I3)	26	0.20
	Total	**132**	**1.00**
Peshastin	Peshastin 1 (P1)	0	0.00
	Peshastin 2 (P2)	10	1.00
	Ingalls (D1)	0	0.00
	Total	**10**	**1.00**
Grand Total		***923***	***1.00***

Spawn Timing

Spring Chinook began spawning during the first week of August in the Chiwawa and White rivers, the second week of August in Nason Creek, and the end of August in Icicle Creek, Peshastin Creek, Little Wenatchee River, and the Wenatchee River (Figure 5.10). Spawning peaked the first week of September in Icicle Creek and Peshastin Creek. The Chiwawa River, White River, and the Little

Wenatchee River experienced peak spawning during the second week of September. Spawning in the Chiwawa River may have peaked during the first week of September, but because of wildfires, no surveys were conducted in the Chiwawa River basin at that time. Spawning in the Wenatchee River and Nason Creek peaked the third week of September. All spawning was completed by the end of September.

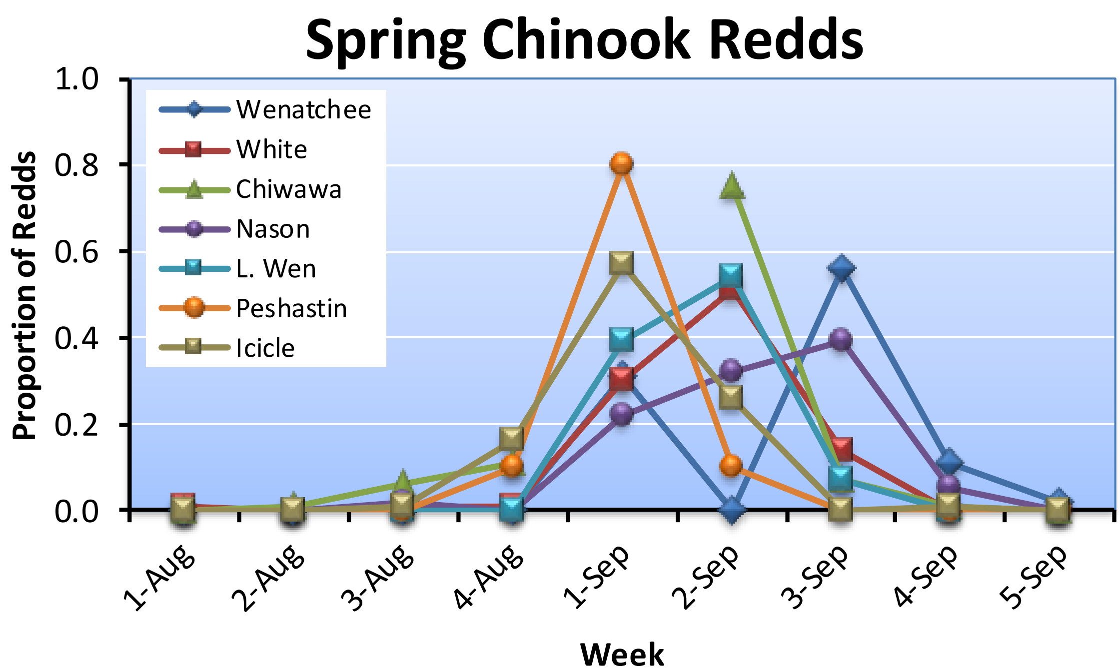

Figure 5.10. Proportion of spring Chinook redds counted during different weeks in different sampling streams within the Wenatchee River basin, August through September 2015.

Spawning Escapement

Spawning escapement for spring Chinook was calculated as the number of redds times the male-to-female ratio (i.e., fish per redd expansion factor) estimated from broodstock and fish sampled at adult trapping sites. The estimated fish per redd ratio for spring Chinook upstream from Tumwater in 2015 was 1.78 (based on sex ratios estimated at Tumwater Dam). The estimated fish per redd ratio for spring Chinook downstream from Tumwater (Icicle and Peshastin creeks) was 1.92 (derived from broodstock collected at the Leavenworth National Fish Hatchery). Multiplying these ratios by the number of redds counted in the Wenatchee River basin resulted in a total spawning escapement of 1,663 spring Chinook (Table 5.22). The Chiwawa River basin had the highest spawning escapement (967 Chinook), while Peshastin Creek had the lowest (19 Chinook).

Table 5.22. Number of redds, fish per redd ratios, and total spawning escapement for spring Chinook in the Wenatchee River basin, 2015. Spawning escapement was estimated as the product of redds times fish per redd.

Sampling area	Total number of redds	Fish/redd	Total spawning escapement*
Chiwawa	543	1.78	967
Nason	85	1.78	151

Sampling area	Total number of redds	Fish/redd	Total spawning escapement*
Upper Wenatchee River	55	1.78	98
Icicle	132	1.92	253
Little Wenatchee	28	1.78	50
White	70	1.78	125
Peshastin	10	1.92	19
Total	***923***	**--**	***1,663***

* Spawning escapement estimate is based on total number of redds by stream. If escapement is calculated at the reach scale, then the total escapement may vary from what is shown here because of rounding errors.

The estimated total spawning escapement of 1,663 spring Chinook in 2015 was greater than the overall average of 1,476 spring Chinook (Table 5.23). The escapement in the Chiwawa River basin in 2015 was 3.8 times the escapement in Icicle Creek, the second most abundant escapement in the Wenatchee River basin (Table 5.23).

Table 5.23. Spawning escapements for spring Chinook in the Wenatchee River basin for return years 1989-2015; NA = not available.

Return year	Upper basin spawning escapement						Lower basin spawning escapement			Total
	Fish/redd	Chiwawa	Nason	Little Wenatchee	White	Wenatchee River	Fish/redd	Icicle	Peshastin	
1989	2.27	713	222	102	145	213	2.27	54	NA	**1,449**
1990	2.24	571	231	67	49	81	2.24	112	9	**1,120**
1991	2.33	242	156	42	49	96	2.33	93	2	**680**
1992	2.24	676	181	78	78	85	2.24	83	0	**1,181**
1993	2.20	233	491	134	145	189	2.20	117	11	**1,320**
1994	2.24	184	60	16	7	13	2.24	34	0	**314**
1995	2.51	33	18	0	5	3	2.51	23	0	**82**
1996	2.53	58	83	8	30	3	2.53	30	3	**215**
1997	2.22	182	122	18	33	33	2.22	73	2	**463**
1998	2.21	91	64	18	11	0	2.21	24	0	**208**
1999	2.77	94	22	8	3	6	2.77	17	0	**150**
2000	2.70	346	270	24	22	100	2.70	184	0	**946**
2001	1.60	1,725	598	118	166	349	1.60	141	277	**3,374**
2002	2.05	707	603	86	86	131	2.05	502	219	**2,334**
2003	2.43	270	202	29	36	58	2.43	44	146	**785**
2004[a]	3.56/3.00	851	507	39	66	138	1.79	54	98	**1,753**
2005	1.80	599	347	115	155	257	1.75	14	5	**1,492**
2006	1.78	529	271	37	55	48	1.80	90	18	**1,048**
2007	4.58	1,296	463	101	92	55	1.86	32	20	**2,059**
2008	1.68	1,158	565	64	52	302	1.77	205	37	**2,383**
2009	3.20	1,347	534	125	173	16	2.72	87	41	**2,323**
2010	2.18	1,094	410	83	72	102	2.72	422	14	**2,197**
2011	4.13	2,032	702	124	83	50	2.66	325	69	**3,385**
2012	1.68	1,478	694	72	144	123	1.90	378	19	**2,908**
2013	1.93	1,378	409	98	104	33	1.75	187	7	**2,216**

Return year	Upper basin spawning escapement						Lower basin spawning escapement			Total
	Fish/redd	Chiwawa	Nason	Little Wenatchee	White	Wenatchee River	Fish/redd	Icicle	Peshastin	
2014	2.06	999	237	52	54	47	2.01	424	0	**1,813**
2015	1.78	967	151	50	125	98	1.92	253	19	**1,663**
Average	**--**	***735***	***319***	***63***	***76***	***97***	**--**	***148***	***39***	***1,476***
Median	**--**	***676***	***270***	***64***	***66***	***81***	**--**	***90***	***10***	***1,449***

[a] In 2004, the fish/redd expansion estimate of 3.56 was applied to the Chiwawa River only and 3.00 fish/redd was applied to the rest of the upper basin.

5.6 Carcass Surveys

Surveys for spring Chinook carcasses were conducted during August through September, 2015, in the Chiwawa River (including Rock and Chikamin creeks), Nason Creek, Icicle Creek, Peshastin Creek, Upper Wenatchee River (including Chiwaukum Creek), Little Wenatchee River, and White River (including the Napeequa River and Panther Creek).

Number sampled

A total of 450 spring Chinook carcasses were sampled during August through September in the Wenatchee River basin (Table 5.24). Most were sampled in the Chiwawa River basin (61% or 275 carcasses) and Icicle Creek (15% or 67 carcasses) (Figure 5.11). A total of 43 carcasses were sampled in Nason Creek, 25 in the upper Wenatchee River, 25 in the White River, 12 in the Little Wenatchee River, and 3 in Peshastin Creek.

Table 5.24. Numbers of spring Chinook carcasses sampled within different streams/watersheds within the Wenatchee River basin, 1996-2015.

Survey year	Number of spring Chinook carcasses							
	Chiwawa	Nason	Little Wenatchee	White	Wenatchee River	Icicle	Peshastin	Total
1996	22	3	0	2	0	1	0	**28**
1997	17	42	3	8	1	28	1	**100**
1998	24	25	3	2	1	6	0	**61**
1999	15	5	0	0	2	1	0	**23**
2000	122	110	8	1	37	52	0	**330**
2001	763	388	68	81	213	163	63	**1,739**
2002	210	292	30	25	34	91	65	**747**
2003	70	100	8	8	11	37	64	**298**
2004	178	186	1	13	29	16	40	**463**
2005	391	217	48	52	120	2	0	**830**
2006	241	190	13	25	15	7	0	**491**
2007	250	201	16	13	24	15	6	**525**
2008	386	243	15	13	94	67	5	**823**
2009	240	128	20	20	1	67	2	**478**
2010	192	141	7	11	29	39	2	**421**
2011	177	98	7	4	3	40	3	**332**

Survey year	Number of spring Chinook carcasses							
	Chiwawa	Nason	Little Wenatchee	White	Wenatchee River	Icicle	Peshastin	Total
2012	390	332	24	21	23	61	3	**854**
2013	396	142	20	22	8	28	1	**671**
2014	320	68	15	8	19	44	0	**474**
2015	275	43	12	25	25	67	3	**450**
Average	***234***	***148***	***16***	***18***	***34***	***42***	***13***	***505***
Median	***225***	***135***	***13***	***13***	***21***	***38***	***2***	***469***

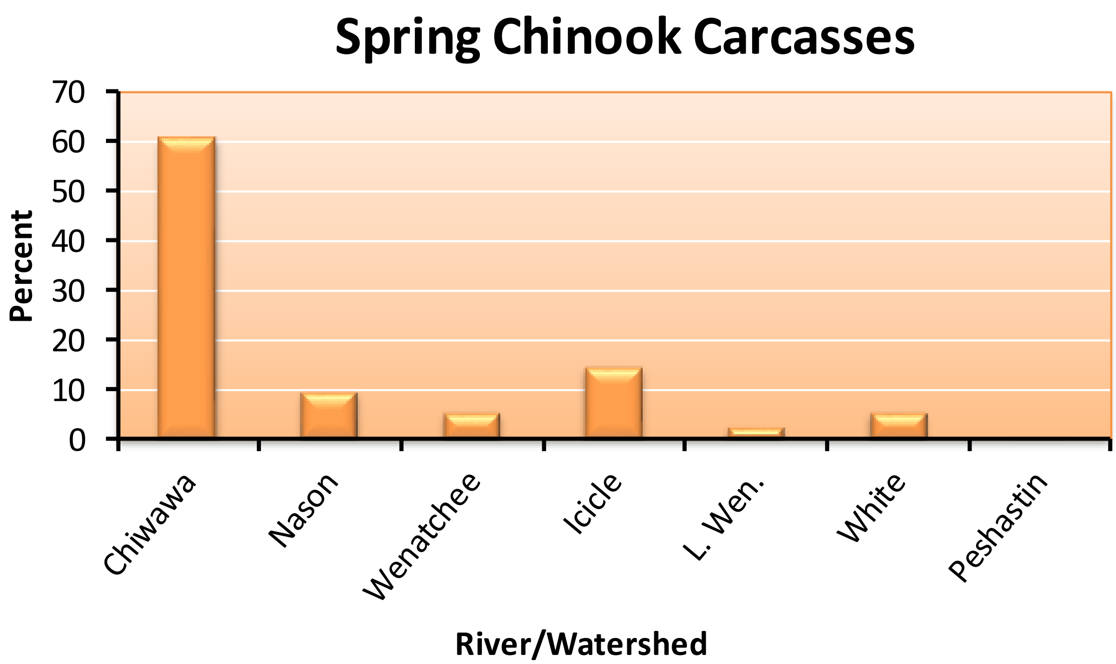

Figure 5.11. Percent of the total number of spring Chinook carcasses sampled in different streams/watersheds within the Wenatchee River basin during August through September, 2015.

Carcass Distribution and Origin

Spring Chinook carcasses were not evenly distributed among reaches within survey streams in 2015 (Table 5.25). Most of the carcasses (75%) in the Chiwawa River basin occurred in Reaches 1 and 2 (downstream from Rock Creek). In Nason Creek, most carcasses (63%) were collected in Reach 3 and the fewest (5%) in Reach 4. All of the carcasses in the Little Wenatchee River were sampled in Reach 3 (Lost Creek to Rainy Creek). On the White River, most (80%) occurred in Reach 3 (Napeequa River to Grasshopper Meadows). On the Wenatchee River, 84% of the carcasses were found upstream from the confluence of the Chiwawa River and 16% were found downstream from the confluence. Most of the carcasses in Icicle Creek (67%) were found in Reach 2 (Hatchery to Sleeping Lady). All the carcasses in Peshastin Creek were found in Reach 2.

Table 5.25. Numbers and proportions of carcasses sampled within different streams/watersheds within the Wenatchee River basin during August through September, 2015. See Table 2.8 for description of survey reaches.

Stream/watershed	Reach	Number of carcasses	Proportion of carcasses within stream/watershed
Chiwawa	Chiwawa 1 (C1)	79	0.29
	Chiwawa 2 (C2)	126	0.46
	Chiwawa 3 (C3)	13	0.05
	Chiwawa 4 (C4)	21	0.08
	Chiwawa 5 (C5)	18	0.07
	Chiwawa 6 (C6)	18	0.07
	Chiwawa 7 (C7)	0	0.00
	Phelps 1 (S1)	NS	--
	Rock 1 (R1)	0	0.00
	Chikamin 1 (K1)	0	0.00
	Total	**275**	**1.00**
Nason	Nason 1 (N1)	10	0.23
	Nason 2 (N2)	4	0.09
	Nason 3 (N3)	27	0.63
	Nason 4 (N4)	2	0.05
	Total	**43**	**1.00**
Little Wenatchee	Little Wen 2 (L2)	0	0.00
	Little Wen 3 (L3)	12	1.00
	Total	**12**	**1.00**
White	White 2 (H2)	5	0.20
	White 3 (H3)	20	0.80
	White 4 (H4)	0	0.00
	Napeequa 1 (Q1)	0	0.00
	Panther 1 (T1)	0	0.00
	Total	**25**	**1.00**
Wenatchee River	Wen 9 (W9)	4	0.16
	Wen 10 (W10)	21	0.84
	Chiwaukum 1	0	0.00
	Total	**25**	**1.00**
Icicle	Icicle 1 (I1)	7	0.10
	Icicle 2 (I2)	45	0.67
	Icicle 3 (I3)	15	0.22
	Total	**67**	**1.00**
Peshastin	Peshastin 1 (P1)	0	0.00
	Peshastin 2 (P2)	3	1.00
	Ingalls (D1)	0	0.00

Stream/watershed	Reach	Number of carcasses	Proportion of carcasses within stream/watershed
	Total	**3**	**1.00**
Grand Total		**450**	**1.00**

Of the 272 carcasses sampled in the Chiwawa River basin in 2015, 66% were hatchery fish (Table 5.26). In the Chiwawa River basin, the spatial distribution of hatchery and wild fish was not equal (Table 5.26). A larger percentage of hatchery fish were found in the lower reaches (C1 and C2; i.e., Mouth to Rock Creek) than were wild fish. This general trend was also apparent in the pooled data (Figure 5.12).

Table 5.26. Numbers of wild and hatchery spring Chinook carcasses sampled within different reaches in the Chiwawa River basin, 1993-2015. See Table 2.8 for description of survey reaches.

Survey year	Origin	Survey Reach									Total
		C-1	C-2	C-3	C-4	C-5	C-6	C-7	Chikamin	Rock	
1993	Wild	0	0	0	0	0	0	--	0	0	**0**
	Hatchery	1	0	0	0	0	0	--	0	0	**1**
1994	Wild	0	6	0	2	0	2	--	0	0	**10**
	Hatchery	1	1	0	2	0	0	--	0	0	**4**
1995	Wild	0	0	0	0	0	0	--	0	0	**0**
	Hatchery	2	3	0	1	0	0	--	0	0	**6**
1996	Wild	13	1	1	1	0	0	--	0	0	**16**
	Hatchery	6	0	0	0	0	0	--	0	0	**6**
1997	Wild	5	2	0	1	0	0	--	0	0	**8**
	Hatchery	3	1	0	0	0	1	--	1	3	**9**
1998	Wild	0	3	6	1	2	4	--	0	0	**16**
	Hatchery	1	3	2	0	1	1	--	0	0	**8**
1999	Wild	1	8	0	5	0	0	--	0	0	**14**
	Hatchery	0	0	0	0	1	0	--	0	0	**1**
2000	Wild	29	29	1	1	1	1	--	0	0	**62**
	Hatchery	42	12	0	0	0	2	--	0	0	**56**
2001	Wild	27	60	15	43	16	21	--	1	3	**186**
	Hatchery	164	284	19	58	14	21	--	8	0	**568**
2002	Wild	22	15	10	6	9	7	--	1	0	**70**
	Hatchery	46	41	12	5	1	15	--	15	4	**139**
2003	Wild	7	13	0	12	4	2	--	0	0	**38**
	Hatchery	14	14	0	3	1	0	--	0	0	**32**
2004	Wild	25	50	2	12	7	2	--	0	1	**99**
	Hatchery	48	21	1	1	1	4	--	0	2	**78**
2005	Wild	18	36	3	5	3	2	--	0	0	**67**
	Hatchery	170	132	7	7	4	3	--	0	1	**324**
2006	Wild	10	17	2	8	4	3	--	1	0	**45**
	Hatchery	84	75	5	7	6	13	--	3	3	**196**
2007	Wild	3	15	3	4	2	2	--	0	0	**29**

Survey year	**Origin**	**Survey Reach**									**Total**
		C-1	**C-2**	**C-3**	**C-4**	**C-5**	**C-6**	**C-7**	**Chikamin**	**Rock**	
	Hatchery	42	118	15	14	18	12	--	2	0	**221**
2008	Wild	4	23	0	4	4	8	--	0	0	**43**
	Hatchery	174	122	2	9	15	15	--	4	1	**342**
2009	Wild	3	21	4	8	4	1	--	0	3	**44**
	Hatchery	89	70	6	14	7	5	--	0	5	**196**
2010	Wild	4	30	7	8	10	3	--	0	0	**62**
	Hatchery	64	35	2	10	7	5	--	0	5	**128**
2011	Wild	8	26	10	6	8	6	--	0	1	**65**
	Hatchery	43	40	4	5	5	10	--	1	4	**112**
2012	Wild	11	74	6	21	13	18	0	0	3	**146**
	Hatchery	94	91	9	13	16	16	0	0	6	**245**
2013	Wild	8	38	7	21	16	14	1	0	3	**108**
	Hatchery	101	112	19	23	13	15	0	5	3	**291**
2014	Wild	18	77	9	28	19	21	0	0	0	**172**
	Hatchery	64	48	6	10	6	9	1	2	2	**148**
2015	Wild	15	37	6	12	12	13	0	0	0	**95**
	Hatchery	64	89	7	9	6	5	0	0	0	**180**
Average	***Wild***	***10***	***25***	***4***	***9***	***6***	***6***	***0***	***0***	***0***	***61***
	Hatchery	***57***	***57***	***5***	***8***	***5***	***7***	***0***	***2***	***2***	***143***
Median	***Wild***	***8***	***21***	***3***	***6***	***4***	***2***	***0***	***0***	***0***	***45***
	Hatchery	***46***	***40***	***2***	***5***	***4***	***5***	***0***	***0***	***1***	***128***

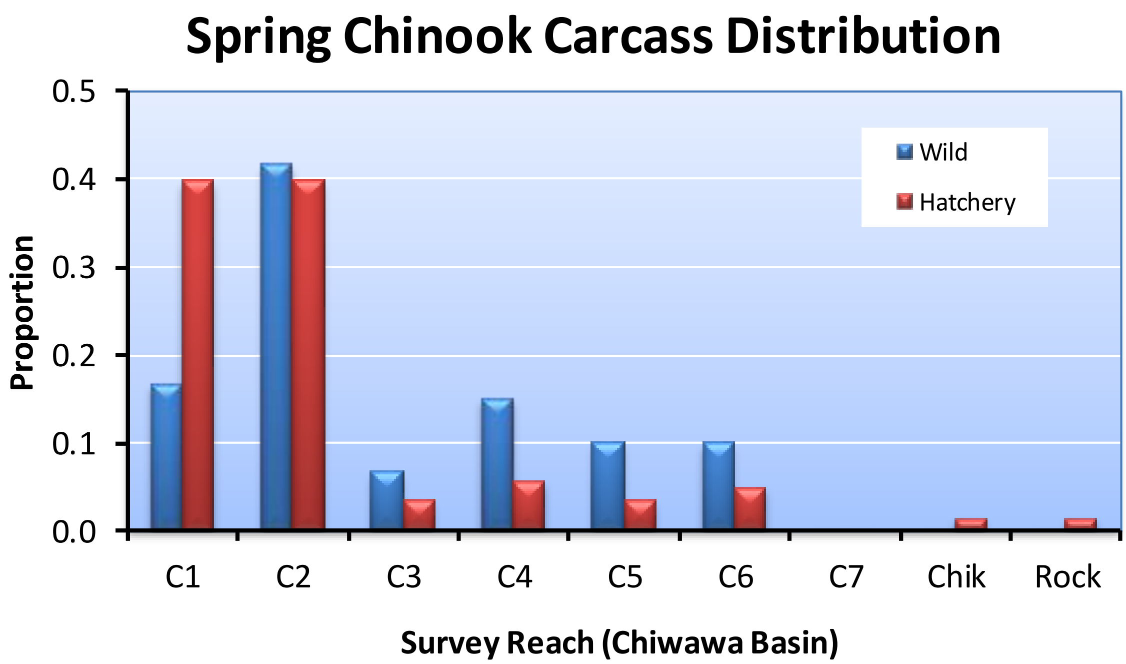

Figure 5.12. Distribution of wild and hatchery produced carcasses in different reaches in the Chiwawa River basin, 1993-2015; Chik = Chikamin Creek and Rock = Rock Creek. Reach codes are described in Table 2.8.

Sampling Rate

Overall, 27% of the estimated total spawning escapement of spring Chinook in the Wenatchee River basin was sampled in 2015 (Table 5.27). Sampling rates among streams/watershed varied from 16 to 28%.

Table 5.27. Number of redds and carcasses, total spawning escapement, and sampling rates for spring Chinook salmon in the Wenatchee River basin, 2015.

Sampling area	Total number of redds	Total number of carcasses	Total spawning escapement	Sampling rate
Chiwawa	543	275	967	0.28
Nason	85	43	151	0.28
Upper Wenatchee	55	25	98	0.26
Icicle	132	67	253	0.26
Little Wenatchee	28	12	50	0.24
White	70	25	125	0.20
Peshastin	10	3	19	0.16
Total	***923***	***450***	***1,663***	***0.27***

Length Data

Mean lengths (POH, cm) of male and female spring Chinook carcasses sampled during surveys in the Wenatchee River basin in 2015 are provided in Table 5.28. The average size of males and females sampled in the Wenatchee River basin was 63 cm.

Table 5.28. Mean lengths (postorbital-to-hypural length; cm) and standard deviations (in parentheses) of male and female spring Chinook carcasses sampled in different streams/watersheds in the Wenatchee River basin, 2015.

Stream/watershed	Mean lengths (cm)	
	Male	Female
Chiwawa	63 (8.5)	63 (4.4)
Nason	59 (9.9)	61 (4.7)
Upper Wenatchee	61 (7.6)	61 (4.6)
Icicle	67 (9.5)	64 (4.2)
Little Wenatchee	62 (9.2)	61 (5.2)
White	62 (7.3)	64 (4.9)
Peshastin	--	60 (2.9)
Total	***63 (9.0)***	***63 (4.5)***

5.7 Life History Monitoring

Life history characteristics of spring Chinook were assessed by examining carcasses on spawning grounds and fish collected at broodstock collection sites, and by reviewing tagging data and fisheries statistics.

Migration Timing

In 2015, there was a difference in migration timing of hatchery and wild spring Chinook past Tumwater Dam (Table 5.29a and b; Figure 5.13). Hatchery fish arrived at the dam earlier than did wild fish. On average, however, early in the migration, wild Chinook arrived at Tumwater Dam slightly earlier than hatchery fish, but by the end of the migration, both were arriving at about the same time. Most hatchery and wild spring Chinook migrated upstream past Tumwater Dam during June and July (Figure 5.13).

Table 5.29a. The Julian day and date that 10%, 50% (median), and 90% of the wild and hatchery spring Chinook salmon passed Tumwater Dam, 1998-2015. The average Julian day and date are also provided. Migration timing is based on video sampling at Tumwater. Data for 1998 through 2003 were based on videotapes and broodstock trapping and may not reflect the actual number of hatchery spring Chinook. All spring Chinook were visually examined during trapping from 2004 to present.

Survey year	Origin	Spring Chinook Migration Time (days)								Sample size
		10 Percentile		50 Percentile		90 Percentile		Mean		
		Julian	Date	Julian	Date	Julian	Date	Julian	Date	
1998	Wild	156	5-Jun	156	5-Jun	156	5-Jun	156	5-Jun	49
	Hatchery	156	5-Jun	156	5-Jun	156	5-Jun	156	5-Jun	25
1999	Wild	192	11-Jul	207	26-Jul	224	12-Aug	207	26-Jul	173

Survey year	Origin	Spring Chinook Migration Time (days)								Sample size
		10 Percentile		50 Percentile		90 Percentile		Mean		
		Julian	Date	Julian	Date	Julian	Date	Julian	Date	
	Hatchery	200	19-Jul	211	30-Jul	229	17-Aug	213	1-Aug	25
2000	Wild	171	19-Jun	186	4-Jul	194	12-Jul	184	2-Jul	651
	Hatchery	179	27-Jun	189	7-Jul	201	19-Jul	190	8-Jul	357
2001	Wild	154	3-Jun	166	15-Jun	185	4-Jul	167	16-Jun	2,073
	Hatchery	157	6-Jun	169	18-Jun	185	4-Jul	170	19-Jun	4,244
2002	Wild	174	23-Jun	189	8-Jul	204	23-Jul	189	8-Jul	1,033
	Hatchery	178	27-Jun	189	8-Jul	199	18-Jul	189	8-Jul	1,363
2003	Wild	162	11-Jun	181	30-Jun	200	19-Jul	181	30-Jun	919
	Hatchery	157	6-Jun	179	28-Jun	192	11-Jul	178	27-Jun	423
2004	Wild	156	4-Jun	172	20-Jun	189	7-Jul	172	20-Jun	969
	Hatchery	161	9-Jun	177	25-Jun	189	7-Jul	177	25-Jun	1,295
2005	Wild	153	2-Jun	172	21-Jun	193	12-Jul	173	22-Jun	1,038
	Hatchery	153	2-Jun	173	22-Jun	187	6-Jul	172	21-Jun	2,808
2006	Wild	177	26-Jun	184	3-Jul	193	12-Jul	185	4-Jul	577
	Hatchery	178	27-Jun	185	4-Jul	194	13-Jul	186	5-Jul	1601
2007	Wild	169	18-Jun	185	4-Jul	203	22-Jul	185	4-Jul	351
	Hatchery	174	23-Jun	192	11-Jul	209	28-Jul	192	11-Jul	3,232
2008	Wild	173	21-Jun	188	6-Jul	209	27-Jul	189	7-Jul	634
	Hatchery	177	25-Jun	193	11-Jul	210	28-Jul	193	11-Jul	5,368
2009	Wild	174	23-Jun	186	5-Jul	201	20-Jul	187	6-Jul	1,008
	Hatchery	175	24-Jun	187	6-Jul	202	21-Jul	188	7-Jul	4,106
2010	Wild	173	22-Jun	190	9-Jul	214	2-Aug	191	10-Jul	977
	Hatchery	180	29-Jun	194	13-Jul	213	1-Aug	195	14-Jul	4,450
2011	Wild	183	2-Jul	198	17-Jul	213	1-Aug	198	17-Jul	1,433
	Hatchery	187	6-Jul	200	19-Jul	210	29-Jul	199	18-Jul	4,707
2012	Wild	180	28-Jun	191	9-Jul	205	23-Jul	192	10-Jul	1,482
	Hatchery	182	30-Jun	194	12-Jul	206	24-Jul	194	12-Jul	4,449
2013	Wild	163	12-Jun	182	1-Jul	199	18-Jul	183	2-Jul	1,106
	Hatchery	164	13-Jun	181	30-Jun	195	14-Jul	181	30-Jun	3,681
2014	Wild	171	20-Jun	188	7-Jul	202	21-Jul	187	6-Jul	1,329
	Hatchery	167	16-Jun	182	1-Jul	195	14-Jul	181	30-Jun	2,510
2015	Wild	150	30-May	170	19-Jun	184	3-Jul	170	19-Jun	1,370
	Hatchery	148	28-May	168	17-Jun	180	29-Jun	167	16-Jun	1,773
Average	Wild	***168***	-	***183***	-	***198***	-	***183***	-	***954***
	Hatchery	***171***	-	***184***	-	***197***	-	***185***	-	***2,579***
Median	Wild	***171***	-	***186***	-	***201***	-	***185***	-	***993***

Survey year	Origin	Spring Chinook Migration Time (days)								Sample size
		10 Percentile		50 Percentile		90 Percentile		Mean		
		Julian	Date	Julian	Date	Julian	Date	Julian	Date	
	Hatchery	***175***	**-**	***186***	**-**	***197***	**-**	***187***	**-**	***2,659***

Table 5.29b. The week that 10%, 50% (median), and 90% of the wild and hatchery spring Chinook salmon passed Tumwater Dam, 1998-2015. The average week is also provided. Migration timing is based on video sampling at Tumwater. Data for 1998 through 2003 were based on videotapes and broodstock trapping and may not reflect the actual number of hatchery spring Chinook. All spring Chinook were visually examined during trapping from 2004 to present.

Survey year	Origin	Spring Chinook Migration Time (week)				Sample size
		10 Percentile	50 Percentile	90 Percentile	Mean	
1998	Wild	23	23	23	23	49
	Hatchery	23	23	23	23	25
1999	Wild	28	30	32	30	173
	Hatchery	29	31	34	31	25
2000	Wild	24	27	27	27	651
	Hatchery	26	27	29	28	357
2001	Wild	22	24	27	24	2,073
	Hatchery	23	25	27	25	4,244
2002	Wild	25	27	30	27	1,033
	Hatchery	26	27	29	27	1,363
2003	Wild	24	26	29	26	919
	Hatchery	23	26	28	26	423
2004	Wild	23	25	27	25	969
	Hatchery	23	26	27	26	1,295
2005	Wild	22	25	28	25	1,038
	Hatchery	22	25	27	25	2,808
2006	Wild	26	27	28	27	577
	Hatchery	26	27	28	27	1,601
2007	Wild	25	27	29	27	351
	Hatchery	25	28	30	28	3,232
2008	Wild	25	27	30	27	634
	Hatchery	26	28	30	28	5,368
2009	Wild	25	27	29	27	1,008
	Hatchery	25	27	29	27	4,106
2010	Wild	25	28	31	28	977
	Hatchery	26	28	31	28	4,450
2011	Wild	27	29	31	29	1,433
	Hatchery	27	29	30	29	4,707
2012	Wild	26	28	30	28	1,482

Survey year	Origin	Spring Chinook Migration Time (week)				Sample size
		10 Percentile	50 Percentile	90 Percentile	Mean	
	Hatchery	26	28	30	28	4,449
2013	Wild	24	26	29	27	1,106
	Hatchery	24	26	28	26	3,681
2014	Wild	25	27	29	27	1,329
	Hatchery	24	26	28	26	2,510
2015	Wild	22	25	27	25	1,370
	Hatchery	22	24	26	24	1,773
Average	Wild	***25***	***27***	***29***	***27***	***954***
	Hatchery	***25***	***27***	***29***	***27***	***2,579***
Median	Wild	***25***	***27***	***29***	***27***	***993***
	Hatchery	***25***	***27***	***29***	***27***	***2,659***

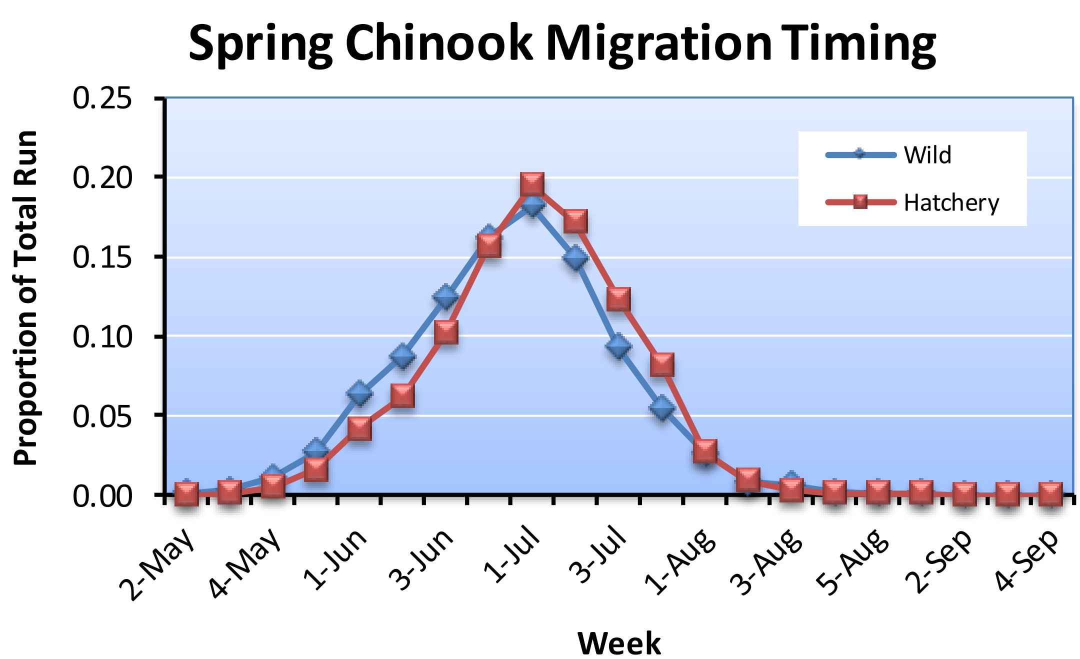

Figure 5.13. Proportion of wild and hatchery spring Chinook observed (using video) passing Tumwater Dam each week during their migration period May through September; data were pooled over survey years 1998-2015.

Age at Maturity

Most of the wild and hatchery spring Chinook sampled during the period 1994-2015 in the Chiwawa River basin were age-4 fish (total age) (Table 5.30; Figure 5.14). On average, hatchery fish made up a higher percentage of age-3 Chinook than did wild fish. In contrast, a higher proportion of age-5 wild fish returned than did age-5 hatchery fish. Thus, wild fish tended to return at an older age than hatchery fish.

Table 5.30. Proportions of wild and hatchery spring Chinook of different ages (total age) sampled on spawning grounds in the Chiwawa River basin, 1994-2015.

Sample year	Origin	Total age					Sample size
		2	3	4	5	6	
1994	Wild	0.00	0.00	0.33	0.67	0.00	9
	Hatchery	0.00	0.20	0.00	0.80	0.00	5
1995	Wild	0.00	0.00	0.00	0.00	0.00	0
	Hatchery	0.00	0.00	1.00	0.00	0.00	5
1996	Wild	0.00	0.36	0.64	0.00	0.00	14
	Hatchery	0.00	0.83	0.17	0.00	0.00	6
1997	Wild	0.00	0.00	0.75	0.25	0.00	8
	Hatchery	0.00	0.00	1.00	0.00	0.00	9
1998	Wild	0.00	0.00	0.00	1.00	0.00	15
	Hatchery	0.00	0.00	0.13	0.88	0.00	8
1999	Wild	0.00	0.07	0.50	0.43	0.00	14
	Hatchery	0.00	0.00	0.00	1.00	0.00	1
2000	Wild	0.00	0.02	0.95	0.04	0.00	56
	Hatchery	0.00	0.50	0.50	0.00	0.00	52
2001	Wild	0.00	0.01	0.95	0.04	0.00	176
	Hatchery	0.00	0.02	0.98	0.00	0.00	571
2002	Wild	0.00	0.00	0.56	0.44	0.00	54
	Hatchery	0.00	0.00	0.91	0.09	0.00	129
2003	Wild	0.00	0.08	0.00	0.92	0.00	36
	Hatchery	0.00	0.19	0.03	0.78	0.00	32
2004	Wild	0.00	0.05	0.94	0.01	0.00	99
	Hatchery	0.00	0.42	0.58	0.00	0.00	78
2005	Wild	0.00	0.02	0.78	0.21	0.00	67
	Hatchery	0.00	0.04	0.96	0.00	0.00	324
2006	Wild	0.02	0.02	0.51	0.44	0.00	45
	Hatchery	0.01	0.04	0.78	0.18	0.00	196
2007	Wild	0.00	0.10	0.24	0.67	0.00	29
	Hatchery	0.00	0.35	0.59	0.06	0.00	221
2008	Wild	0.02	0.02	0.81	0.14	0.00	43
	Hatchery	0.00	0.07	0.89	0.05	0.00	340
2009	Wild	0.00	0.09	0.86	0.05	0.00	44
	Hatchery	0.00	0.24	0.75	0.02	0.00	196
2010	Wild	0.00	0.00	0.90	0.10	0.00	63
	Hatchery	0.00	0.07	0.91	0.02	0.00	127

Sample year	Origin	Total age					Sample size
		2	**3**	**4**	**5**	**6**	
2011	Wild	0.00	0.08	0.38	0.54	0.00	65
	Hatchery	0.00	0.26	0.45	0.30	0.00	112
2012	Wild	0.00	0.01	0.80	0.19	0.00	141
	Hatchery	0.00	0.03	0.96	0.02	0.00	243
2013	Wild	0.00	0.09	0.60	0.31	0.00	105
	Hatchery	0.00	0.13	0.78	0.09	0.00	275
2014	Wild	0.00	0.04	0.89	0.07	0.00	169
	Hatchery	0.00	0.08	0.90	0.02	0.00	148
2015	Wild	0.00	0.01	0.83	0.16	0.00	95
	Hatchery	0.00	0.07	0.92	0.01	0.00	180
Average	***Wild***	***0.00***	***0.04***	***0.75***	***0.21***	***0.00***	***61***
	Hatchery	***0.00***	***0.11***	***0.83***	***0.06***	***0.00***	***149***
Median	***Wild***	***0.00***	***0.03***	***0.75***	***0.22***	***0.00***	***50***
	Hatchery	***0.00***	***0.08***	***0.90***	***0.03***	***0.00***	***128***

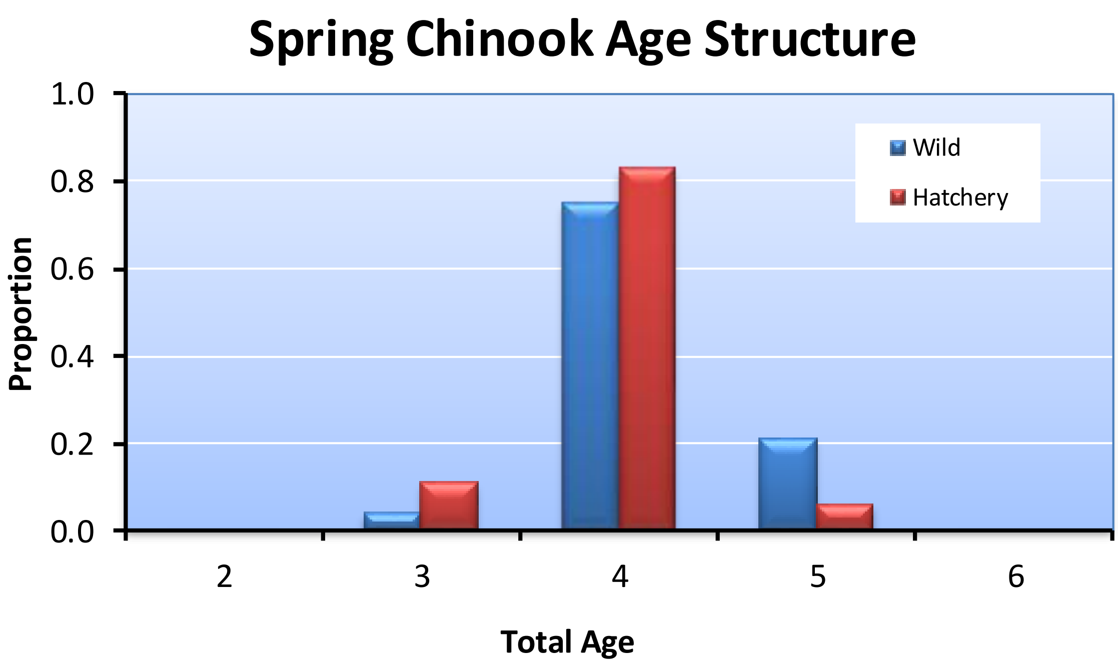

Figure 5.14. Proportions of wild and hatchery spring Chinook of different total ages sampled at the Chiwawa Weir and on spawning grounds in the Chiwawa River basin for the combined years 1994-2014.

Size at Maturity

On average, hatchery and wild spring Chinook of a given age differed slightly in length (Table 5.31). Differences were usually no more than 1-3 cm between hatchery and wild fish of the same age.

Table 5.31. Mean lengths (POH in cm; ±1SD) and sample sizes (in parentheses) of different ages (total age) of male and female spring Chinook of wild and hatchery-origin sampled in the Chiwawa River basin, 1994-2014. Return years 2004-2014 include carcasses and live fish PIT-tag detections. In addition, 2005 and 2006 include fish released at the weir.

Return year	Total age	Mean length (cm)			
		Male		Female	
		Wild	Hatchery	Wild	Hatchery
1994	3				43 ±0 (1)
	4			62 ±3 (3)	
	5	76 ±0 (1)		73 ±2 (5)	
	6				
1995	3				
	4		61 ±5 (5)		
	5				
	6				
1996	3	45 ±3 (5)	49 ±7 (10)		
	4	69 ±4 (6)	69 ±0 (1)	67 ±8 (2)	
	5				
	6				
1997	3				
	4	61 ±1 (2)	68 ±0 (1)	67 ±5 (3)	63 ±3 (8)
	5	67 ±5 (2)			
	6				
1998	3				
	4				54 ±0 (1)
	5	77 ±7 (8)	75 ±4 (4)	74 ±4 (7)	76 ±4 (3)
	6				
1999	3	44 ±0 (1)			
	4	61 ±0 (1)		64 ±3 (6)	
	5	76 ±5 (3)		72 ±5 (3)	66 ±0 (1)
	6				
2000	3		46 ±3 (17)		50 ±7 (3)
	4	60 ±8 (23)	62 ±5 (5)	61 ±5 (26)	62 ±3 (20)
	5	77 ±1 (2)			
	6				
2001	3	37 ±0 (1)	42 ±4 (11)	41 ±0 (1)	60 ±0 (1)
	4	63 ±5 (57)	65 ±5 (151)	62 ±4 (110)	63 ±4 (407)
	5	75 ±5 (2)	83 ±0 (1)	76 ±1 (5)	
	6				
2002	3				
	4	64 ±4 (14)	66 ±5 (46)	60 ±4 (15)	63 ±4 (71)
	5	80 ±6 (13)	75 ±5 (4)	72 ±3 (12)	73 ±6 (6)
	6				
2003	3	45 ±2 (3)	45 ±1 (6)		

Return year	Total age	Mean length (cm)			
		Male		Female	
		Wild	Hatchery	Wild	Hatchery
	4		63 ±0 (1)		
	5	78 ±5 (12)	74 ±8 (11)	75 ±3 (19)	72 ±5 (14)
	6				
2004	3	42 ±3 (3)	44 ±5 (33)		
	4	63 ±7 (60)	66 ±5 (9)	63 ±4 (59)	63 ±6 (36)
	5			74 ±0 (1)	
	6				
2005	3		43 ±5 (48)		
	4	61 ±5 (32)	65 ±5 (224)	62 ±4 (61)	62 ±4 (382)
	5	74 ±5 (6)	54±0 (1)	71 ±3 (11)	
	6				
2006	3	45 ±3 (3)	43 ±3 (73)		
	4	64 ±3 (7)	62 ±6 (91)	63 ±5 (41)	60 ±4 (227)
	5	74 ±6 (8)	75 ±6 (17)	71 ±4 (26)	71± 4 (37)
	6				
2007	3	39 ±3 (5)	45 ±6 (90)		50 ±3 (7)
	4	60 ±4 (4)	66 ±5 (45)	61 ±4 (10)	63 ±3 (142)
	5	78 ±6 (15)	76 ±5 (8)	74 ±3 (20)	73 ±5 (12)
	6				
2008	3	43 ±0 (1)	44 ±5 (22)		
	4	65 ±4 (9)	64 ±6 (73)	62 ±4 (26)	64 ±4 (229)
	5	65 ±5 (3)	79 ±5 (10)	73 ±3 (4)	72 ±3 (5)
	6				
2009	3	45 ±3 (8)	46 ±6 (68)		65 ±0 (1)
	4	64 ±4 (38)	65 ±5 (136)	63 ±3 (67)	64 ±4 (202)
	5	79 ±0 (1)		72 ±2 (4)	71 ±4 (10)
	6				
2010	3		46 ±4 (11)		65 ±3 (3)
	4	64 ±5 (31)	66 ±5 (74)	64 ±4 (82)	65 ±3 (196)
	5	77 ±4 (6)		73 ±5 (9)	73 ±6 (4)
	6				
2011	3	43 ±4 (133)	44 ±4 (1374)		53 ±4 (17)
	4	62 ±5 (137)	64 ±5 (169)	64 ±3 (94)	64 ±3 (258)
	5	80 ±5 (78)	79 ±4 (85)	75 ±3 (116)	75 ±3 (63)
	6				
2012	3	56 ±0 (1)	52 ±7 (7)		
	4	79 ± 6 (37)	80 ±6 (49)	79 ±3 (76)	78 ±4 (180)
	5	97 ±7 (11)	96 ±3 (4)	93 ±4 (16)	87 ±0 (1)
	6				
2013	3	45 ±4 (8)	43 ±4 (32)	35 ±0 (1)	49 ±12 (3)
	4	60 ±6 (29)	63 ±7 (41)	61 ±6 (34)	61 ±4 (171)

Return year	Total age	Mean length (cm)			
		Male		Female	
		Wild	Hatchery	Wild	Hatchery
	5	75 ±5 (9)	71 ±2 (7)	71 ±3 (24)	69 ±4 (18)
	6				
2014	3	45 ±7 (5)	45±4 (11)	50±0 (1)	47±0 (1)
	4	64 ±7 (60)	62 ±7 (30)	63 ±4 (91)	61 ±4 (99)
	5	81 ±4 (4)		72 ±6 (8)	69 ±4 (3)
	6				
2015	3	56 ±0 (1)	48 ±4 (11)		52 ±0 (1)
	4	65 ±5 (23)	65 ±6 (41)	63 ±5 (56)	63 ±4 (120)
	5	75 ±7 (6)	71 ±1 (1)	69 ±6 (9)	73 ±1 (1)
	6				

Contribution to Fisheries

Nearly all the harvest on hatchery-origin Chiwawa spring Chinook occurs within the Columbia River basin. Ocean catch records (Pacific Fishery Management Council) indicate that very few Upper Columbia spring Chinook are taken in ocean fisheries. Most of the harvest on hatchery-origin Chiwawa spring Chinook occurs in the Lower Columbia River fisheries, which are managed by the states and tribes pursuant to management plans developed in *U.S. v Oregon*. The Lower Columbia River fisheries occur during what is referred to in *U.S. v Oregon* as the winter, spring, and summer seasons, which begin in February and ends 31 July of each year. The Tribal fishery occurs upstream from Bonneville Dam, but primarily in Zone 6, the area between Bonneville and McNary dams; the non-treaty commercial fisheries occur in Zones 1-5, which are downstream from Bonneville Dam. The non-treaty recreational (sport) fishery occurs in the lower mainstem.

The total number of hatchery-origin spring Chinook captured in different fisheries has been relatively low (Table 5.32). The largest harvests occurred on the 1997, 1998, and 2004-2009 brood years.

Table 5.32. Estimated number and percent (in parentheses) of hatchery-origin Chiwawa spring Chinook captured in different fisheries, brood years 1989-2010; NP = no hatchery program.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational[a] (sport)	
1989	3 (13)	5 (21)	0 (0)	16 (67)	24
1990	0 (0)	0 (0)	0 (0)	18 (100)	18
1991	0 (0)	3 (100)	0 (0)	0 (0)	3
1992	0 (0)	1 (100)	0 (0)	0 (0)	1
1993	3 (75)	1 (25)	0 (0)	0 (0)	4
1994	0 (0)	0 (0)	0 (0)	0 (0)	0
1995	NP	NP	NP	NP	NP
1996	0 (0)	2 (100)	0 (0)	0 (0)	2
1997	1 (0)	193 (51)	68 (18)	115 (31)	377

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational[a] (sport)	
1998	10 (5)	47 (24)	12 (6)	126 (65)	195
1999	NP	NP	NP	NP	NP
2000	0 (0)	17 (74)	0 (0)	6 (26)	23
2001	36 (64)	8 (14)	1 (2)	11 (20)	56
2002	12 (17)	11 (15)	22 (31)	26 (37)	71
2003	18 (21)	29 (35)	11 (13)	26 (31)	84
2004	3 (1)	188 (40)	31 (7)	253 (53)	475
2005	18 (14)	31 (24)	6 (5)	74 (57)	129
2006	32 (4)	469 (60)	77 (10)	201 (26)	779
2007	14 (3)	180 (43)	74 (18)	151 (36)	419
2008	8 (1)	298 (21)	41 (3)	1,047 (75)	1,394
2009	8 (2)	85 (23)	69 (18)	215 (57)	377
2010	0 (0)	370 (64)	45 (8)	163 (28)	578
Average	***8 (11)***	***97 (42)***	***23 (7)***	***122 (35)***	***250***
Median	***3 (1)***	***23 (30)***	***9 (4)***	***26 (31)***	***78***

[a] Includes the Wanapum fishery and the Icicle and Wenatchee fisheries when they occurred.

Straying

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Wenatchee River basin. Targets for strays based on return year (recovery year) within the Wenatchee River basin should be less than 10% and targets for strays outside the Wenatchee River basin should be less than 5%. The target for brood year stray rates should be less than 5%.

The percentage of the spawning escapement made up of hatchery-origin Chiwawa spring Chinook in non-target spawning areas within the Wenatchee River basin has been high in some years and exceeded the target of 10% (Table 5.33). Chiwawa spring Chinook have strayed into spawning areas on Nason Creek, the White River, the Little Wenatchee River, and the Upper Wenatchee River. On average, Chiwawa spring Chinook made up the highest percentage of the spawning escapement within Nason Creek and the Upper Wenatchee River.

Table 5.33. Number (No.) and percent (%) of the spawning escapement in other non-target spawning streams within the Wenatchee River basin that consisted of hatchery-origin Chiwawa spring Chinook, return years 1992-2014. For example, for return year 2001, 35.3% of the spring Chinook spawning escapement in Nason Creek consisted of hatchery-origin Chiwawa spring Chinook. Percent strays should be less than 10%.

Return year	Nason Creek		Icicle Creek		Peshastin Creek		Upper Wenatchee		White River		Little Wenatchee	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1992	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1993	61	12.4	0	0.0	0	0.0	34	18.0	7	4.8	0	0.0
1994	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1995	0	0.0	0	0.0	0	0.0	2	66.7	0	0.0	0	0.0

Return year	Nason Creek		Icicle Creek		Peshastin Creek		Upper Wenatchee		White River		Little Wenatchee	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1996	25	30.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1997	55	45.1	8	11.0	0	0.0	0	0.0	0	0.0	0	0.0
1998	3	4.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1999	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2000	45	16.7	0	0.0	0	0.0	31	31.0	0	0.0	6	27.3
2001	211	35.3	0	0.0	0	0.0	271	77.7	46	39.0	52	31.3
2002	188	31.2	10	2.0	0	0.0	60	45.8	14	16.3	21	24.4
2003	14	6.9	0	0.0	0	0.0	30	51.7	0	0.0	0	0.0
2004	139	27.4	0	0.0	0	0.0	54	39.1	6	9.1	0	0.0
2005	252	72.6	7	50.0	0	0.0	256	99.6	106	68.4	65	56.5
2006	131	48.3	13	14.4	0	0.0	28	58.3	9	16.4	12	32.4
2007	303	65.4	0	0.0	0	0.0	37	67.3	7	7.6	6	5.9
2008	381	67.4	48	23.4	29	78.4	258	85.4	30	57.7	52	81.3
2009	289	54.1	8	9.2	0	0.0	16	100.0	63	36.4	56	44.8
2010	272	66.3	58	13.7	11	78.6	86	84.3	23	31.9	59	71.1
2011	397	56.6	61	18.8	0	0.0	41	82.0	0	0.0	53	42.7
2012	398	59.1	49	13.0	7	36.8	98	82.4	45	32.1	15	21.4
2013	281	68.4	15	8.0	0	0.0	24	72.7	5	4.8	10	10.1
2014	204	86.1	19	4.5	0	0.0	41	87.2	0	0.0	1	1.9
Average	***159***	***37.1***	***13***	***7.3***	***2***	***8.4***	***59***	***49.8***	***16***	***13.6***	***18***	***20.0***
Median	***139***	***35.3***	***0***	***0.0***	***0***	***0.0***	***31***	***58.3***	***5***	***4.8***	***6***	***5.9***

Hatchery-origin Chiwawa spring Chinook have strayed into the Methow and Entiat basins (Table 5.34). Based on return year analyses, rates of hatchery-origin Chiwawa spring Chinook straying into these populations have been low in most years. However, during return years 2002, 2006, 2008-2009, and 2011-2013, Chiwawa spring Chinook made up more than 5% of the spawning escapement in the Entiat River basin. In three years, Chiwawa spring Chinook hatchery fish made up more than 20% of the spawning escapement in the Entiat River basin; however, in return year 2014, no strays were detected in the Entiat or Methow River basins.

Table 5.34. Number and percent of spawning escapements within other non-target basins that consisted of hatchery-origin Chiwawa spring Chinook, return years 1992-2014. For example, for return year 2002, 9.2% of the spring Chinook spawning escapement in the Entiat River basin consisted of hatchery-origin Chiwawa spring Chinook. Percent strays should be less than 5%. NS = not sampled.

Return year	Methow River basin		Entiat River basin	
	Number	%	Number	%
1992	0	0.0	0	0.0
1993	0	0.0	0	0.0
1994	0	0.0	0	0.0
1995	0	0.0	0	0.0
1996	NS	NS	0	0.0

Return year	Methow River basin		Entiat River basin	
	Number	%	Number	%
1997	0	0.0	0	0.0
1998	NS	NS	0	0.0
1999	0	0.0	0	0.0
2000	0	0.0	1	0.6
2001	0	0.0	1	0.2
2002	0	0.0	34	9.2
2003	0	0.0	6	2.3
2004	0	0.0	0	0.0
2005	10	0.7	15	4.2
2006	8	0.5	24	9.3
2007	9	0.8	4	1.6
2008	12	1.2	61	21.9
2009	9	0.3	15	5.4
2010	10	0.4	18	3.7
2011	51	1.7	190	31.9
2012	13	1.0	133	23.5
2013	9	0.8	24	10.1
2014	0	0.0	0	0.0
Average	***6***	***0.4***	***24***	***5.4***
Median	***0***	***0.0***	***1***	***0.6***

Based on brood year analyses, on average, about 31% of the hatchery returns have strayed into non-target spawning areas, exceeding the target of 5% (Table 5.35). Depending on brood year, percent strays into non-target spawning areas have ranged from 0-81%. In most years, few (<1%) have strayed into non-target hatchery programs.

Table 5.35. Number and percent of hatchery-origin Chiwawa spring Chinook that homed to target spawning areas and the target hatchery program, and number and percent that strayed to non-target spawning areas and non-target hatchery programs, by brood years 1989-2010. Percent strays should be less than 5%.

Brood year	Homing				Straying			
	Target stream		Target hatchery*		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1989	74	41.1	1	0.6	102	56.7	3	1.7
1990	0	0.0	1	100.0	0	0.0	0	0.0
1991	29	90.6	0	0.0	2	6.3	1	3.1
1992	2	6.5	4	12.9	25	80.6	0	0.0
1993	134	47.5	82	29.1	63	22.3	3	1.1
1994	4	19.0	14	66.7	3	14.3	0	0.0

Brood year	Homing				Straying			
	Target stream		Target hatchery*		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1995	No program							
1996	58	75.3	7	9.1	12	15.6	0	0.0
1997	1,242	55.6	298	13.4	687	30.8	5	0.2
1998	553	55.8	109	11.0	329	33.2	0	0.0
1999	No program							
2000	149	42.1	115	32.5	90	25.4	0	0.0
2001	647	35.8	276	15.3	881	48.7	4	0.2
2002	314	44.3	238	33.6	156	22.0	1	0.1
2003	556	78.6	11	1.6	133	18.8	7	1.0
2004	1,198	47.4	203	8.0	1104	43.7	23	0.9
2005	822	59.3	139	10.0	415	29.9	10	0.7
2006	1,007	54.8	147	8.0	669	36.4	14	0.8
2007	510	57.8	60	6.8	294	33.3	19	2.2
2008	1,160	47.1	62	2.5	1,144	46.4	99	4.0
2009	746	63.1	53	4.5	356	30.1	27	2.3
2010	790	51.7	365	23.9	348	22.8	25	1.6
Average	***500***	***48.7***	***109***	***19.5***	***341***	***30.9***	***12***	***1.0***
Median	***532***	***49.6***	***72***	***10.5***	***225***	***30.0***	***4***	***0.8***

* Homing to the target hatchery includes Chiwawa hatchery spring Chinook that are captured and included as broodstock in the Chiwawa Hatchery program. These hatchery fish are typically collected at the Chiwawa weir and Tumwater Dam.

Recently, Ford et al. (2015) used parentage analysis to estimate rates of straying and homing of spring Chinook within the Wenatchee River basin. They found that stray rates of hatchery spring Chinook based on parentage analysis were consistent with rates estimated using physical tag recoveries (the latter estimates are shown in the tables above). They also found that stray rates among the major spawning tributaries were higher than stray rates of tagged fish to areas outside of the Wenatchee River basin (e.g., Entiat and Methow basins), which is consistent with the results shown in the tables above. Finally, the researchers noted that hatchery spring Chinook homed at a far lower rate than natural-origin fish. Rates of straying of natural-origin spring Chinook were affected by spawning tributary and by parental origin (i.e., progeny of naturally spawning hatchery-produced fish strayed at higher rates than progeny whose parents were of natural origin).

Genetics

Genetic studies were conducted in 2007 to determine the potential effects of the Chiwawa Supplementation Program on natural-origin spring Chinook in the upper Wenatchee River basin (Blankenship et al. 2007; the entire report is appended as Appendix J). A total of 32 population collections of adult spring Chinook were obtained from the Wenatchee River basin between 1989 and 2006. This included nine collections of natural-origin Chinook adults from the Chiwawa River (N = 501) and nine collections of Chiwawa hatchery-origin Chinook (N = 595) at the Chiwawa weir. Collections in 1993 and 1994 included hatchery-origin smolts. Additional samples were collected from the White River, Little Wenatchee River, and Nason Creek; six collections of natural-origin Chinook from the White River (N = 179), one collection from the Little Wenatchee (N = 19), and six collections from Nason Creek (N = 268). A single collection was obtained for Chinook spawning in the mainstem Wenatchee River and from the Leavenworth National Fish Hatchery. Finally, an out-of-basin collection from the Entiat River was included in the analysis. Scale, fin clips, or operculum punches were collected from each sample. Microsatellite DNA allele frequencies were used to statistically assign individual fish to specific demes (locations) within the Wenatchee population. In addition, genetic effects of the hatchery program were assessed by examining relationships between census and effective population sizes (N_e) from samples collected before and after supplementation.

Overall, this work showed that although allele frequencies within and between natural and hatchery-origin spring Chinook were significantly different, there was no evidence (i.e., robust signal) that the difference was the result of the hatchery program. Rather, the differences were more likely the result of life history characteristics. However, there was an increasing trend toward homogenization of the allele frequencies of the natural and hatchery-origin fish that comprised the broodstock, even though there was consistent year-to-year variation in allele frequencies among hatchery and natural-origin fish. In addition, there were no robust signals indicating that hatchery-origin hatchery broodstock, hatchery-origin natural spawners, natural-origin hatchery broodstock, and natural-origin natural spawners were substantially different from each other. Finally, the N_e estimate of 387 was only slightly larger than the pre-hatchery N_e (based on demographic data from 1989-1992), which means that the Chiwawa hatchery program has not reduced the N_e of the Wenatchee spring Chinook population.

Significant differences in allele frequencies were observed within and among major spawning areas in the Upper Wenatchee River basin. However, these differences made up only a very small portion of the overall variation, indicating genetic similarity among the major spawning areas. There was no evidence that the Chiwawa program has changed the genetic structure (allele frequency) of spring Chinook in Nason Creek and the White River, despite the presence of hatchery-origin spawners in both systems.

It is important to note that no new information will be reported on genetics until the next five-year report (2018).

Proportionate Natural Influence

Another method for assessing the genetic risk of a supplementation program is to determine the influence of the hatchery and natural environments on the adaptation of the composite population. This is estimated by the proportion of natural-origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery-origin fish in the natural spawning escapement (pHOS). We calculated Proportionate Natural Influence (PNI) by iterating Ford’s (2002) equations 5 and 6 to equilibrium, using a heritability of 0.3 and a selection strength of three standard deviations.[9] The larger the PNI value, the greater the strength of selection in the natural environment relative to that of the hatchery environment. In order for the natural environment to dominate selection, PNI should be greater

[9] According to authorized annual take permits, PNI is calculated using the PNI approximate equation 11 (HSRG 2009; Appendix A). However, in this report, we used Ford's (2002) equations 5 and 6 with a heritability of 0.3 and a selection strength of three standard deviations to calculate PNI (C. Busack, NOAA Fisheries, 21 March 2016, provided the model for calculating PNI). This approach is more accurate than using the PNI approximate equation.

than 0.50, and important integrated populations should have a PNI of at least 0.67 (HSRG/WDFW/NWIFC 2004).

For brood years 1989-1994, PNI values were greater than or equal to 0.67 (Table 5.36). Since brood year 1994, PNI has been less than 0.67.

Table 5.36. Proportionate Natural Influence (PNI) values for the Chiwawa spring Chinook supplementation program for brood years 1989-2015. NOS = number of natural-origin Chinook on the spawning grounds; HOS = number of hatchery-origin Chinook on the spawning grounds; NOB = number of natural-origin Chinook collected for broodstock; and HOB = number of hatchery-origin Chinook included in hatchery broodstock.

Brood year	Spawners			Broodstock			PNI[a]
	NOS	HOS	pHOS	NOB	HOB	pNOB	
1989	713	0	0.00	28	0	1.00	1.00
1990	571	0	0.00	18	0	1.00	1.00
1991	242	0	0.00	27	0	1.00	1.00
1992	676	0	0.00	78	0	1.00	1.00
1993	231	2	0.01	94	0	1.00	0.99
1994	123	61	0.33	8	4	0.67	0.68
1995	0	33	1.00	No Program			
1996	41	17	0.29	8	10	0.44	0.62
1997	60	122	0.67	32	79	0.29	0.32
1998	59	32	0.35	13	34	0.28	0.47
1999	87	7	0.07	No Program			
2000	233	113	0.33	9	21	0.30	0.50
2001	506	1219	0.71	113	259	0.30	0.32
2002	254	453	0.64	20	51	0.28	0.33
2003	168	102	0.38	41	53	0.44	0.55
2004	575	276	0.32	83	132	0.39	0.57
2005	139	460	0.77	91	181	0.33	0.32
2006	114	415	0.78	91	224	0.29	0.29
2007	155	1141	0.88	43	104	0.29	0.27
2008	190	968	0.84	83	220	0.27	0.26
2009	297	1050	0.78	96	111	0.46	0.39
2010	419	675	0.62	77	98	0.44	0.43
2011	801	1231	0.61	80	93	0.46	0.45
2012	574	904	0.61	73	38	0.66	0.53
2013	422	956	0.69	70	0	1.00	0.60
2014	538	461	0.46	61	134	0.31	0.43
2015	337	630	0.65	72	0	1.00	0.61
Average	***316***	***420***	***0.47***	***56***	***75***	***0.56***	***0.56***
Median	***242***	***276***	***0.61***	***70***	***51***	***0.44***	***0.50***

[a] PNI was calculated previously using PNI approximate equation 11 (HSRG 2009; Appendix A). All PNI values presented here were recalculated by iterating Ford's (2002) equations 5 and 6 to equilibrium using a heritability of 0.3 and a selection strength of three standard deviations. C. Busack, NOAA Fisheries, 21 March 2016, provided the model for calculating PNI.

Post-Release Survival and Travel Time

We used PIT-tagged fish to estimate survival rates and travel time (arithmetic mean days) of hatchery spring Chinook from the Chiwawa River release site to McNary Dam, and smolt to adult ratios (SARs) from release to detection at Bonneville Dam (Table 5.37).[10] Over the nine brood years for which PIT-tagged hatchery fish were released, survival rates from the Chiwawa River to McNary Dam ranged from 0.435 to 0.662; SARs from release to detection at Bonneville Dam ranged from 0.003 to 0.018. Average travel time from the Chiwawa River to McNary Dam ranged from 14 to 44 days. Although there is only one year in which a forced release was compared to a volitional release (brood year 2005), hatchery spring Chinook that were forced out of the Chiwawa Acclimation Facility had slightly higher survival rates and SARs, and a faster travel time to McNary Dam, than did the volitional release.

Table 5.37. Total number of Chiwawa hatchery spring Chinook released with PIT tags, their survival and travel times (mean days) to McNary Dam, and smolt-to-adult (SAR) ratios for brood years 2005-2013. Standard errors are shown in parentheses. NA = not available (i.e., not all the adults from the release groups have returned to the Columbia River).

Brood year	Number of tagged fish released	Survival to McNary Dam	Travel time to McNary Dam (d)	SAR to Bonneville Dam (%)
2005	4,993 (forced)	0.662 (0.027)	22.9 (6.6)	0.008 (0.001)
2005	4,988 (volitional)	0.638 (0.027)	43.6 (6.9)	0.003 (0.001)
2006	9,894	0.619 (0.038)	30.6 (7.6)	0.011 (0.001)
2007	10,031	0.435 (0.019)	32.9 (7.7)	0.007 (0.001)
2008	10,006	0.631 (0.038)	39.9 (10.3)	0.018 (0.001)
2009	9,412	0.547 (0.044)	30.2 (6.7)	0.006 (0.001)
2010	5,020	0.548 (0.038)	18.9 (7.3)	0.008 (0.001)
2011	9,987	0.458 (0.029)	14.2 (7.5)	NA
2012	5,061	0.478 (0.043)	30.9 (6.5)	NA
2013	10,021	0.438 (0.041)	29.5 (5.9)	NA

Natural and Hatchery Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural-origin recruits (NOR) to the parent spawning population (spawning escapement). Natural-origin recruits are naturally produced (wild) fish that survive to contribute to harvest (directly or indirectly), to broodstock, and to spawning grounds. We do not account for fish that died in route to the spawning grounds (migration mortality) or died just before spawning (pre-spawn mortality) (see Appendix B in Hillman et al. 2012). We calculated NORs with and without harvest. NORs without harvest include

[10] It is important to point out that because of fish size differences among rearing tanks or raceways, fish PIT tagged in one tank or raceway may not represent untagged fish rearing in other tanks or raceways.

all returning fish that either returned to the basin or were collected as wild broodstock. NORs with harvest include all fish harvested and are based on a brood year harvest rates from the hatchery program. For brood years 1989-2009, NRR for spring Chinook in the Chiwawa averaged 1.07 (range, 0.01-4.40) if harvested fish were not included in the estimate and 1.18 (range, 0.01-4.81) if harvested fish were included in the estimate (Table 5.38). NRRs for more recent brood years will be calculated as soon as all tag recoveries and sampling rates have been loaded into the database.

Hatchery replacement rates (HRR) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HOR) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 6.7 (the calculated target value in Hillman et al. 2013). The target value of 6.7 includes harvest. In nearly all years, HRRs were greater than NRRs, regardless if harvest was or was not included (Table 5.38). HRRs exceeded the estimated target value of 6.7 in 8 of the 19 years.

Table 5.38. Broodstock collected, spawning escapements, natural and hatchery-origin recruits (NOR and HOR), and natural and hatchery replacement rates (NRR and HRR; with and without harvest) for spring Chinook in the Chiwawa River basin, brood years 1989-2009; NP = no hatchery program.

Brood year	Broodstock Collected	Spawning Escapement	Harvest not included				Harvest included			
			HOR	NOR	HRR	NRR	HOR	NOR	HRR	NRR
1989	28	713	180	194	6.43	0.27	204	282	7.29	0.40
1990	19	571	1	34	0.05	0.06	19	40	1.00	0.07
1991	32	242	32	2	1.00	0.01	35	2	1.09	0.01
1992	78	676	31	46	0.40	0.07	32	48	0.41	0.07
1993	100	233	282	159	2.82	0.68	286	163	2.86	0.70
1994	13	184	21	37	1.62	0.20	21	38	1.62	0.21
1995	NP	33	--	66	--	2.00	--	69	--	2.09
1996	18	58	77	255	4.28	4.40	79	279	4.39	4.81
1997	120	182	2,232	714	18.60	3.92	2,609	792	21.74	4.35
1998	48	91	991	349	20.65	3.84	1,186	373	24.71	4.10
1999	NP	94	--	10	--	0.11	--	11	--	0.12
2000	48	346	354	695	7.38	2.01	377	729	7.85	2.11
2001	382	1,725	1,808	309	4.73	0.18	1,864	317	4.88	0.18
2002	84	707	709	244	8.44	0.35	780	254	9.29	0.36
2003	119	270	707	107	5.94	0.40	791	115	6.65	0.43
2004	296	851	2,528	276	8.54	0.32	3,003	298	10.15	0.35
2005	283	599	1,386	396	4.90	0.66	1,515	409	5.35	0.68
2006	398	529	1,837	967	4.62	1.83	2,616	1,215	6.57	2.30
2007	169	1,296	883	478	5.22	0.37	1,302	571	7.70	0.44
2008	329	1,158	2,465	740	7.49	0.64	3,859	830	11.73	0.72
2009	264	1,347	1,182	349	4.48	0.26	1,559	378	5.91	0.28
Average	***149***	***567***	***932***	***306***	***6.19***	***1.07***	***1,165***	***343***	***7.43***	***1.18***
Median	***100***	***529***	***709***	***255***	***4.90***	***0.37***	***791***	***282***	***6.57***	***0.43***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adult recaptures divided by the number of tagged hatchery smolts released. Here, SARs were based on CWT returns. For the available brood years, SARs have ranged from 0.00036 to 0.01563 for hatchery spring Chinook (Table 5.39).

Table 5.39. Smolt-to-adult ratios (SARs) for Chiwawa hatchery spring Chinook, brood years 1989-2010.

Brood year	Number of tagged smolts released[a]	Estimated adult captures[b]	SAR
1989	42,707	204	0.00478
1990	52,798	19	0.00036
1991	61,088	35	0.00057
1992	82,976	31	0.00037
1993	221,316	284	0.00128
1994	27,135	21	0.00077
1995	No hatchery program		
1996	12,767	67	0.00525
1997	259,585	2,549	0.00982
1998	71,571	1,119	0.01563
1999	No hatchery program		
2000	46,726	375	0.00803
2001	374,129	1,849	0.00494
2002	145,074	760	0.00524
2003	216,702	775	0.00358
2004	491,987	2,992	0.00608
2005	489,664	1,506	0.00308
2006	548,777	2,604	0.00475
2007	292,682	1,300	0.00444
2008	609,286	3,859	0.00633
2009	433,608	1,545	0.00356
2010	342,778	2,092	0.00610
Average	***241,168***	***1,199***	***0.00475***
Median	***219,009***	***947***	***0.00477***

[a] Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).

[b] Includes estimated recoveries (spawning ground, hatcheries, harvest, etc.) and observed recoveries if estimated recoveries were unavailable.

5.8 ESA/HCP Compliance

Broodstock Collection

The collection of 2013 Brood Chiwawa River spring Chinook broodstock was consistent with the 2013 Upper Columbia River salmon and steelhead broodstock objectives and site-based broodstock collection protocols. Specifically, broodstock collection targeted natural-origin fish at Tumwater Dam using genetic assignments. In-season adjustments were made to the natural-origin spring Chinook collected for broodstock as needed and were based on in-season escapement monitoring at Tumwater Dam and estimated Chiwawa run-escapement.

Trapping at Tumwater Dam began on 15 May 2013 and concluded on 16 July 2013. Broodstock collection targeted natural-origin spring Chinook and hatchery-origin spring Chinook as needed to attain a minimum 33% natural-origin broodstock and a maximum 33% extraction of the estimated natural-origin return to the Chiwawa River.

The 2013 brood collection retained a total of 75 natural-origin spring Chinook. The brood successfully met the minimum targeted 33% natural-origin composition. All spring Chinook, steelhead, and bull trout that were captured were anesthetized with tricaine methanesulfonate (MS-222) and subject to water-to-water transfers during handling. All fish were allowed to fully recover before release.

The estimated broodstock extraction rate of natural-origin Chiwawa spring Chinook and overall extraction of spring Chinook upstream from Tumwater Dam comply with provisions of ESA Permit 1196 (expired).

No additional spring Chinook were handled and released as a function of maintaining, at minimum, 33% natural-origin spring Chinook in the broodstock.

Hatchery Rearing and Release

The rearing and release of 2013 brood Chiwawa spring Chinook was completed without incident. No mortality events occurred that exceeded 10% of the population. Fish were acclimated on Chiwawa River water with regulated amounts of Wenatchee River water to prevent frazzle ice formation during the winter months (see Section 5.2).

The release of 2013 brood Chiwawa spring Chinook smolts totaled 147,480 fish, representing 102.4% of the program objective of 144,023 smolts and complied with the ESA Section 10 Permit 18121 program not to exceed level of 158,425 smolts.

Hatchery Effluent Monitoring

Per ESA Permits 1196 (expired), 1347, 1395, 18118, 18119, and 18121, 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 the Chelan PUD Hatchery facilities during the period 1 January through 31 December 2015. NPDES monitoring and reporting for Chelan PUD Hatchery Programs during 2015 are provided in Appendix F.

Smolt and Emigrant Trapping

Per ESA Section 10 Permit No. 1196 (expired) and 18121, the permit holders are authorized a direct take of up to 20% of the emigrating spring Chinook population during juvenile emigration monitoring and a lethal take not to exceed 2% of the fish captured (NMFS 2003). Based on the estimated wild spring Chinook population (smolt trap expansion) and hatchery juvenile spring Chinook population estimate (hatchery release data) for the Wenatchee River basin, the reported spring Chinook encounters during 2015 emigration monitoring complied with take provisions in the Section 10 permit. Spring Chinook encounter and mortality rates for each trap site (including PIT tag mortalities) are detailed in Table 5.40. Additionally, juvenile fish captured at the trap locations were handled consistent with provisions in ESA Section 10 Permit 1196, Section B.

Table 5.40. Estimated take of Upper Columbia River spring Chinook resulting from juvenile emigration monitoring in the Wenatchee River basin, 2015.

Trap location	Population estimate			Number trapped			Total	Take allowed under Permit
	Wild[a]	Hatchery[b]	Sub-yearling[c]	Wild	Hatchery	Sub-yearling		
Chiwawa Trap								
Population	39,396	147,480	77,510	6,350	7,148	31,152	44,650	
Encounter rate	NA	NA	NA	0.1612	0.0485	0.4019	0.1667	0.20
Mortality[e]	NA	NA	NA	42	0	414	456	
Mortality rate	NA	NA	NA	0.0066	0.0000	0.0133	0.0102	0.02
Lower Wenatchee Trap								
Population	58,595	235,184	14,157,778	1,559	9,920	252,293	263,772	
Encounter rate	NA	NA	NA	0.0266	0.0422	0.0178	0.0183	0.20
Mortality[d]	NA	NA	NA	17	2	282	301	
Mortality rate	NA	NA	NA	0.0109	0.0002	0.0011	0.0011	0.02
Wenatchee River Basin Total								
Population	97,991	235,184	14,235,288	7,909	17,068	283,445	308,422	
Encounter rate	NA	NA	NA	0.0807	0.0726	0.0199	0.0211	0.20
Mortality[d]	NA	NA	NA	59	2	696	757	
Mortality rate	NA	NA	NA	0.0075	0.0001	0.0025	0.0025	0.02

[a] Smolt population estimate derived from juvenile emigration trap data.

[b] 2015 BY smolt release data for the Wenatchee River basin.

[c] Based on size, date of capture and location of capture, subyearling Chinook encountered at the Lower Wenatchee Trap are categorized as summer Chinook salmon.

[d] Combined trapping and PIT tagging mortality.

Spawning Surveys

Spring Chinook spawning ground surveys were conducted in the Wenatchee River basin during 2015, as authorized by ESA Section 10 Permits 18118, 18119, and 18121. Because of the difficulty of quantifying the level of take associated with spawning ground surveys, the Permit does not specify a take level associated with these activities, even though it does authorize implementation of spawning ground surveys. Therefore, no take levels are reported. However, to minimize potential effects to established redds, wading was restricted to the extent practical, and extreme caution was used to avoid established redds when wading was required.

Spring Chinook Reproductive Success Study

ESA Section 10 Permit 1196 (expired) and new Section 10 Permits 18118, 18119, and 18121 specifically provide authorization to capture, anesthetize, biologically sample, PIT tag, and release adult spring Chinook at Tumwater Dam for reproductive success studies and general program monitoring. During 2010 through 2015, all spring Chinook passing Tumwater Dam were enumerated, anesthetize, biologically sampled, PIT tagged, and released (not including hatchery-origin Chinook retained for broodstock) as a component of the reproductive success study (BPA Project No. 2003-039-00). Please refer to Ford et al. (2010, 2011, 2012, 2013, 2014, and 2015) for complete details on the methods and results of the spring Chinook reproductive success study for the period 2010-2015.

SECTION 6: NASON CREEK SPRING CHINOOK

The goals of the Nason Creek spring Chinook salmon supplementation program are to conserve, aid in the recovery, and prevent the extinction of naturally spawning spring Chinook in Nason Creek, and to meet the mitigation responsibilities of Grant County PUD. In 1997, a spring Chinook captive-broodstock program was initiated for the Nason Creek population to reduce the risk of extinction. Improvements in adult escapement in Nason Creek have reduced the near-term risk of extinction and therefore the captive-broodstock program was discontinued. An adult-based supplementation program began with the collection of broodstock in 2013. The first releases of the program occurred from the Nason Creek Acclimation Facility in the spring of 2015.

In 2013, natural-origin adult spring Chinook were collected for broodstock at Tumwater Dam and from Nason Creek using tangle and dip nets. In 2014, all natural-origin broodstock were collected from Nason Creek using tangle and dip nets. While these brood collection methods were successful at collecting adults from the Nason Creek spawning aggregate, they were unable to collect the necessary number of adults to meet mitigation production goals in 2013 and 2014. The production goal for the Nason Creek program requires collection of 126 adult spring Chinook (64 natural-origin fish and 66 hatchery-origin fish). However, the Section 10 permit requirements restrict the number of natural-origin adults collected and cannot exceed 33% of the natural-origin spring Chinook estimates to Tumwater Dam.

The PRCC Hatchery Subcommittee decided to composite the Nason and Chiwawa natural-origin broodstock beginning with brood year 2015. The decision was also made to collect all the brood at Tumwater Dam. Adult spring Chinook broodstock are spawned and reared at Eastbank Fish Hatchery. Juvenile spring Chinook are transferred from the hatchery to the Nason Creek Acclimation Facility in late September or early October. Fish are reared in 30-foot dual-drain circular tanks throughout winter at the Nason Creek Acclimation Facility. Yearling Chinook have been released volitionally during April and May the following year up until 2015. Beginning in 2016, all fish will be force released at night to improve survival.

The current production goal is to release 223,670 smolts (125,000 for conservation and 98,670 for safety net). Juveniles released from the Nason facility will be 100% marked with CWTs and a minimum of 5,000 fish will be PIT tagged annually.

The following information focuses on results from monitoring the Nason Creek spring Chinook program. Information on spring Chinook collected throughout the Wenatchee River basin is presented in Section 5.

6.1 Broodstock Sampling

This section focuses on results from sampling 2013-2015 Nason Creek spring Chinook broodstock, which were collected in Nason Creek and at Tumwater Dam. Some information for the 2015 return is not available at this time (e.g., age structure and final origin determination). This information will be provided in the 2016 annual report.

Origin of Broodstock

Natural-origin adults made up between 18% and 84% of the Nason Creek spring Chinook broodstock for return years 2013-2015 (Table 6.1). For brood year 2015, natural-origin adults were targeted for collection at Tumwater Dam during trapping operations. Natural-origin fish collected at Tumwater Dam were used for broodstock if genotyping confirmed they were natural-origin fish from the Wenatchee population and they were not White River fish. Fish that were genotyped to the White River were returned to the upper Wenatchee River basin to spawn naturally.

Table 6.1. Numbers of wild and hatchery Nason Creek spring Chinook collected for broodstock, numbers that died before spawning, and numbers of Chinook spawned, 2013-2015. Unknown origin fish (i.e., undetermined by scale analysis, no CWT or fin clips, and no additional hatchery marks) were considered naturally produced. Mortality includes fish that died of natural causes typically near the end of spawning and were not needed for the program or were surplus fish killed at spawning.

Brood year	Wild spring Chinook					Hatchery spring Chinook					Total number spawned
	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	
2013	22	0	1	21	0	4	0	0	4	0	25
2014[b]	28	2	5	21	0	0	0	0	0	0	21
2015	78	1	6	59	12	63	0	0	63	0	122
Average[c]	***43***	***1***	***4***	***34***	***4***	***22***	***0***	***0***	***22***	***0***	***56***
Median[c]	***28***	***1***	***5***	***21***	***0***	***4***	***0***	***0***	***4***	***0***	***25***

[a] Pre-spawn loss represents the number of fish that died during the holding period before spawning. Mortality is the number of fish that were surplused following spawning.
[b] Until sufficient Nason Creek Spring Chinook HOR's are collected to meet broodstock objectives, Chiwawa Spring Chinook HOR's are utilized to fulfill program goals (see table 5.1 and the 2014 Broodstock Protocols). About 12 Chiwawa HORs were used to fulfill the Chiwawa Program; about 122 Chiwawa HORs were used to fulfill the Nason Creek safety-net obligation.
[c] Origin determinations should be considered preliminary pending scale analyses.

Age/Length Data

Ages were determined from scales and/or coded wire tags (CWT) collected from broodstock. For both the 2013 and 2014 returns, most adults, regardless of origin, were age-4 Chinook (Table 6.2). A larger percentage of the age-5 Chinook were natural-origin fish, whereas a larger percentage of the age-3 fish were hatchery-origin fish.

Table 6.2. Percent of hatchery and wild spring Chinook of different ages (total age) collected from broodstock, 2013-2014.

Return year	Origin	Total age			
		2	3	4	5
2013	Wild	0.0	14.3	85.7	0.0
	Hatchery	0.0	0.0	100.0	0.0
2014	Wild	0.0	18.2	68.2	13.6
	Hatchery[a]	0.0	0.0	98.5	1.5
Average	***Wild***	***0.0***	***16.3***	***77.0***	***6.8***
	Hatchery	***0.0***	***0.0***	***99.3***	***0.8***
Median	***Wild***	***0.0***	***16.3***	***77.0***	***6.8***
	Hatchery	***0.0***	***0.0***	***99.3***	***0.8***

[a] Data from Table 5.2.

Length at age for Nason Creek wild spring Chinook are shown in Table 6.3.

Table 6.3. Mean fork length (cm) at age (total age) of hatchery and wild spring Chinook collected from broodstock, 2013-2014; N = sample size and SD = 1 standard deviation.

Return year	Origin	Spring Chinook fork length (cm)											
		Age-2			Age-3			Age-4			Age-5		
		Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD
2013	Wild	-	0	-	56	3	2	75	16	6	-	0	-
	Hatchery	-	0	-	-	0	-	79	5	6	-	0	-
2014	Wild	-	0	-	57	4	6	82	15	7	86	3	8
	Hatchery[a]	-	0	-	-	0	-	81	192	6	85	3	2
Average	***Wild***	*-*	*0*	*-*	*57*	*4*	*4*	*79*	*16*	*7*	*86*	*2*	*8*
	Hatchery	*-*	*0*	*-*	*-*	*0*	*-*	*80*	*98.5*	*6*	*85*	*1.5*	*2*

[a] Data from Table 5.3.

Sex Ratios

Male spring Chinook in the 2013-2015 return years made up 50%, 60%, and 50%, respectively, of the adults collected. This resulted in overall male to female ratios of 1.00:1.00, 1.50:1.00, and 1.01:1.00, respectively (Table 6.4).

Table 6.4. Numbers of male and female wild and hatchery spring Chinook collected for broodstock, 2013-2015. Ratios of males to females are also provided.

Return year	Number of wild spring Chinook			Number of hatchery spring Chinook			Total M/F ratio
	Males (M)	Females (F)	M/F	Males (M)	Females (F)	M/F	
2013	12	10	1.20:1:00	1	3	0.33:1.00	1.00:1.00
2014[a]	18	12	1.50:1.00	0	0	-	1.50:1.00
2015	40	38	1.05:1.00	31	32	0.97:1.00	1.01:1.00
Total	*70*	*60*	*1.17:1.00*	*32*	*35*	*0.91:1.00*	*1.07:1.00*

[a] Data for HOR brood are in Table 5.4.

Fecundity

The mean fecundities for the 2013-2015 returns of Nason Creek spring Chinook ranged from 3,787-4,494 eggs per female (Table 6.5). Fecundities in the 2013 and 2015 natural-origin brood, and in the 2013 and 2014 hatchery-origin brood were less than the expected fecundity of 4,400 eggs per female assumed in the broodstock protocol.

Table 6.5. Mean fecundity of wild, hatchery, and all female spring Chinook collected for broodstock, 2013-2015.

Return year	Mean fecundity		
	Wild	Hatchery	Total
2013	4,047	4,069	4,052
2014[a]	4,484	3,834	3,787
2015	4,380	4,535	4,463
Average	***4,304***	***4,302***	***4,333***

[a] Average fecundities are from Table 5.5.

6.2 Hatchery Rearing

Rearing History

Number of eggs taken

Based on the unfertilized egg-to-release survival standard of 85%, a total of 263,141 eggs are required to meet the program release goal of 223,670 smolts (Table 6.6). The green egg take for the 2013-2015 brood years was 30%, 102%, and 102% of program goal, respectively.

Table 6.6. Numbers of eggs taken from spring Chinook broodstock, 2013-2015.

Return year	Number of eggs taken
2013[a]	49,720
2014[b]	267,783
2015	268,247
Average	***195,250***
Median	***267,783***

[a] Safety-net obligation met through the White River Program. Conservation egg take goal was 116,082.
[b] Includes surrogate Chiwawa HxH egg take calculated from tagging proportions.

Number of acclimation days

Fish from the 2013 brood were acclimated for 182 to 200 days on Nason Creek water (Table 6.7).

Table 6.7. Number of days spring Chinook broods were acclimated and water source, brood year 2013.

Brood year	Release year	Transfer date	Release date	Number of days and water source	
				Total	Nason Creek
2013	2015	13 Oct	13 Apr – 1 May	182-200	182-200

Release Information

Numbers released

The 2013 brood Nason Creek spring Chinook program achieved 34.5% of the 125,000 target goal with about 43,082 smolts being released volitionally into Nason Creek in 2015 (Table 6.8).

Table 6.8. Numbers of spring Chinook smolts tagged and released from the hatchery, brood year 2013. The release target for Nason Creek spring Chinook is 125,000 smolts.

Brood year	Release year	Type of release	CWT mark rate	Number released that were PIT tagged	Number of smolts released	Total number of smolts released
2013	2015	Volitional	0.9303	20,139	43,082	43,082

Numbers tagged

The 2013 brood Chiwawa spring Chinook were 93% CWT and adipose fin clipped (Table 6.8).

In 2016, a total of 5,010 Nason Creek spring Chinook from the 2014 brood were PIT tagged at the Nason Creek Acclimation Facility on 29 February to 3 March. Fish were tagged in circular pond #8 where all of the fish were rearing and then subsequently distributed into multiple ponds. Fish were not fed during tagging or for two days before and after tagging. Fish averaged 111 mm in length and 17.0 g at time of tagging.

Table 6.9 summarizes the number of hatchery spring Chinook that have been PIT-tagged and released into Nason Creek.

Table 6.9. Summary of PIT-tagging activities for Nason Creek hatchery spring Chinook, brood year 2013.

Brood year	Release year	Number of fish tagged	Number of tagged fish that died	Number of tags shed	Number of tagged fish released
2013	2015	20,234	94	1	20,139

Fish size and condition at release

Spring Chinook from the 2013 brood were released as yearling smolts between 13 April and 1 May 2015. Size at release (16 fpp) was larger than the approximate target of 24 fpp established for the program. The CV for fork length was just short of the target (Table 6.10).

Table 6.10. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of spring Chinook smolts released from the hatchery, brood year 2013. Size targets are provided in the last row of the table.

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
2013	2015	129	8.3	27.6	16
Average		***129***	***8.3***	***27.6***	***16***
Median		***129***	***8.3***	***27.6***	***16***
Targets		***155***	***9.0***	***37.8***	***24***

Survival Estimates

Overall survival of Nason Creek spring Chinook from green (unfertilized) egg to release was above the standard set for the program (Table 6.11). There was higher than expected survivals throughout all stages contributing to increased program performance. Pre-spawn survival of adults was also above the standard set for the program.

Table 6.11. Hatchery life-stage survival rates (%) for spring Chinook, brood year 2013. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
2013	100.0	100.0	93.5	98.8	99.4	98.2	93.8	99.1	86.6
Average	***100.0***	***100.0***	***93.5***	***98.8***	***99.4***	***98.2***	***93.8***	***99.1***	***86.6***
Median	***100.0***	***100.0***	***93.5***	***98.8***	***99.4***	***98.2***	***93.8***	***99.1***	***86.6***

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

6.3 Disease Monitoring

Results of 2015 adult broodstock bacterial kidney disease (BKD) monitoring indicated that all females (100%) had ELISA values less than 0.199. None of the females had ELISA values less than 0.120, resulting in no limitations to rearing densities (Table 6.12).

For the 2013 brood, a formalin drip treatment was used shortly after transfer to the Nason Creek Acclimation Facility to prevent infection associated with stress caused by the transfer. No significant health issues were encountered for the remainder of juvenile rearing.

Table 6.12. Proportion of bacterial kidney disease (BKD) titer groups for the Nason Creek spring Chinook broodstock by origin, brood years 2013-2015. Also included are the proportions to be reared at either 0.125 fish per pound or 0.060 fish per pound.

Brood year	Optical density values by titer group								Proportion at rearing densities (fish per pound, fpp)[b]			
	Very Low (≤ 0.099)		Low (0.1-0.199)		Moderate (0.2-0.449)		High (≥ 0.450)		≤ 0.125 fpp (<0.119)		≤ 0.060 fpp (>0.120)	
	Wild	Hatch	Wild	Hatch	Wild	Hatch	Wild	Hatch	Wild	Hatch	Wild	Hatch
2013	0.7000	0.3333	0.3000	0.6666	0.0000	0.0000	0.0000	0.0000	0.9231	0.1000	0.0769	0.0000
2014	0.5000	--	0.3000	--	0.0000	--	0.2000	--	0.8000	--	0.2000	--
2015[a]	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	1.000	0.0000	0.0000
Average	0.7333	0.6667	0.2000	0.3333	0.0000	0.0000	0.0667	0.0000	0.9077	0.5500	0.0923	0.0000
Median	0.7000	0.6667	0.3000	0.3333	0.0000	0.0000	0.0000	0.0000	0.9231	0.5500	0.0769	0.0000

[a] Determination of origin should be considered preliminary pending scale analyses.
[b] ELISA values from broodstock BKD testing dictate what density the progeny of the broodstock are reared. Progeny of broodstock with high ELISA values are reared at lower density.

6.4 Natural Juvenile Productivity

During 2015, juvenile spring Chinook were sampled at the Nason Creek trap.

Smolt and Emigrant Estimates

Numbers of spring Chinook smolts and emigrants were estimated at the Nason Creek trap in 2015. A complete description of trapping operations on Nason Creek can be found in Appendix K.

Nason Creek Trap

The Nason Creek Trap operated between 1 March and 30 November 2015. During that time period the trap was inoperable for 105 days because of low stream discharge or ice accumulation. Daily trap efficiencies were estimated from a flow-efficiency regression model. The daily number of fish captured was expanded by the estimated trap efficiency to estimate daily total emigration. In the event that a viable flow-efficiency regression could not be developed, a pooled efficiency was used to expand daily catch. All pooled estimates will be recalculated as flow-efficiency models are developed.

Wild yearling spring Chinook (2013 brood year) were primarily captured from March through May 2015 (Figure 6.1). Because a viable yearling emigrant flow-efficiency regression model could not be established at the new downstream trap location, a pooled estimate was employed as a temporary method of expansion. Based on this pooled efficiency, the total number of wild yearling Chinook from the Nason Creek basin was 6,992 (±32,823). Combining the number of subyearling spring Chinook (43,711) that emigrated during the fall of 2014 with the total number of yearling Chinook (6,992) that emigrated during 2015 resulted in an emigrant estimate of 50,703 (±38,852) spring Chinook (Table 6.13). Based on PIT-tag analysis, an additional 6,822 (±9,035) spring Chinook immigrated during the winter (1 Dec – 28 Feb) when the trap was inoperable. Thus, the total number of emigrants was 57,525 (±39,889) spring Chinook for the 2013 brood year.

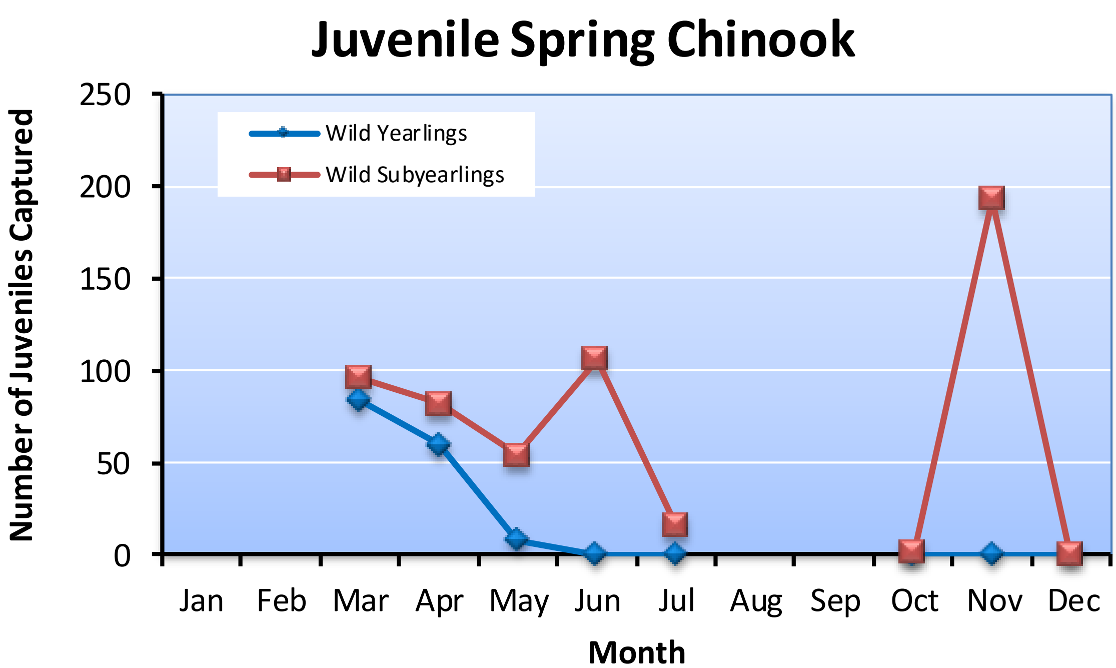

Figure 6.1. Monthly captures of wild subyearling and yearling spring Chinook at the Nason Creek Trap, 2015.

Table 6.13. Numbers of redds and juvenile spring Chinook at different life stages in the Nason Creek basin for brood years 2002-2014; ND = no data.

Brood year	Number of redds	Egg deposition[a]	Number of subyearling emigrants[b]	Number of smolts produced within Nason Creek basin	Number of emigrants[c]
2002	294	1,368,276	ND	4,683	ND
2003	83	485,052	8,829	6,358	15,187
2004	169	811,031	11,822	2,597	14,419
2005	193	835,111	11,814	8,696	20,510
2006	152	657,248	4,144	7,798	11,942
2007	101	448,541	15,556	5,679	21,235
2008	336	1,542,912	23,182	3,611	26,793
2009	167	763,691	27,720	1,705	29,425

Brood year	Number of redds	Egg deposition[a]	Number of subyearling emigrants[b]	Number of smolts produced within Nason Creek basin	Number of emigrants[c]
2010	188	811,032	8,491	3,535	12,026
2011	170	745,450	17,991	2,422	20,413
2012	413	1,744,099	28,110	4,561	32,671
2013	212	999,792	43,711	6,992	57,525
2014	115	513,705	13,903	--	--
Average	***199***	***961,578***	***17,939***	***4,886***	***23,211***
Median	***170***	***811,031***	***14,730***	***4,622***	***20,510***

[a] Egg deposition is calculated as the number of redds times the fecundity of both wild and hatchery spring Chinook salmon (from Table 5.5.

[b] Subyearling emigrants does not include fry that left the watershed before 1 July.

[c] Brood years 2002-2012 do not include estimates of numbers of juvenile spring Chinook that emigrated during non-trapping periods (1 Dec to 28 Feb). Brood years 2013 to present include estimates of numbers of juvenile spring Chinook that emigrated during non-trapping periods.

Wild subyearling spring Chinook (2014 brood year) were captured between 1 March and 27 November 2015 (Figure 6.1). Based on capture efficiencies estimated from the flow model, the total number of wild subyearling Chinook emigrating from Nason Creek was 13,903 (±11,963).

Yearling spring Chinook sampled in 2015 averaged 93 mm in length, 8.4 g in weight, and had a mean condition of 1.03 (Table 6.14). Weight and condition estimates for these fish were less than the overall mean of yearling spring Chinook sampled in previous years (overall means, 8.5 g and 1.05), while the estimated length equaled the overall mean (overall mean, 93 mm). Subyearling spring Chinook sampled in 2015 at the Nason Creek Trap averaged 84 mm in length, averaged 6.5 g, and had a mean condition of 1.08 (Table 6.14). These size estimates were greater than the overall mean of subyearling spring Chinook sampled in previous years (overall means, 76 mm, 5.0 g, and condition of 1.07).

Table 6.14. Mean fork length (mm), weight (g), and condition factor of subyearling and yearling spring Chinook collected in the Nason Creek Trap, 2004-2015. Numbers in parentheses indicate 1 standard deviation.

Sample year	Life stage	Sample size[a]	Mean size		
			Length (mm)	Weight (g)	Condition (K)
2004	Subyearling	656	82 (7)	5.9 (1.7)	1.04 (0.11)
	Yearling	323	92 (8)	8.2 (2.3)	1.04 (0.08)
2005	Subyearling	872	76 (9)	4.8 (1.7)	1.02 (0.13)
	Yearling	276	94 (7)	8.7 (2.0)	1.04 (0.12)
2006	Subyearling	1422	73 (9)	3.9 (1.9)	0.92 (0.16)
	Yearling	362	91 (7)	7.5 (1.8)	0.98 (0.11)
2007	Subyearling	609	78 (14)	5.9 (2.6)	1.15 (0.16)
	Yearling	678	88 (9)	7.4 (2.4)	1.05 (0.13)
2008	Subyearling	1,001	75 (14)	5.0 (2.5)	1.10 (0.11)
	Yearling	881	96 (6)	9.5 (2.0)	1.06 (0.09)

Sample year	Life stage	Sample size[a]	Mean size		
			Length (mm)	Weight (g)	Condition (K)
2009	Subyearling	2,147	72 (11)	4.4 (2.1)	1.08 (0.08)
	Yearling	162	96 (8)	9.6 (2.4)	1.08 (0.09)
2010	Subyearling	3,032	81 (11)	6.2 (2.3)	1.13 (0.10)
	Yearling	366	97 (7)	10.2 (2.3)	1.10 (0.09)
2011	Subyearling	1,064	72 (13)	4.7 (2.5)	1.13 (0.12)
	Yearling	150	89 (10)	7.7 (1.8)	1.09 (0.12)
2012	Subyearling	2,141	78 (11)	5.3 (2.0)	1.05 (0.09)
	Yearling	363	93 (6)	9.3 (2.2)	1.11 (0.08)
2013	Subyearling	4,408	70 (11)	3.8 (1.7)	1.03 (0.10)
	Yearling	239	91 (7)	7.9 (2.1)	1.03 (0.07)
2014	Subyearling	1,543	69 (12)	3.8 (2.3)	1.05 (0.06)
	Yearling	464	90 (7)	7.5 (1.8)	1.03 (0.06)
2015	Subyearling	209	84 (8)	6.5 (1.7)	1.08 (0.08)
	Yearling	152	93 (7)	8.4 (2.1)	1.03 (0.09)
Average	***Subyearling***	***1,592***	***76 (5)***	***5.0 (1.0)***	***1.07 (0.06)***
	Yearling	***368***	***93 (3)***	***8.5 (1.0)***	***1.05 (0.04)***
Median	***Subyearling***	***1,243***	***76 (5)***	***4.9 (1.0)***	***1.07 (0.06)***
	Yearling	***343***	***93 (3)***	***8.3 (1.0)***	***1.05 (0.04)***

[a] Sample size represents the number of fish that were measured for both length and weight.

Freshwater Productivity

Both productivity and survival estimates for different life stages of spring Chinook in the Nason Creek watershed are provided in Table 6.15. Estimates for brood year 2013 were generally higher than estimates for brood years 2002-2012, even if numbers of juvenile spring Chinook estimated during non-trapping periods were not included in the estimate. During the period 2002-2013, freshwater productivities ranged from 10-77 smolts/redd and 64-271 emigrants/redd. Survivals during the same period ranged from 0.2-1.3% for egg-smolt and 1.5-5.8% for egg-emigrants.

Table 6.15. Productivity (fish/redd) and survival (%) estimates for different juvenile life stages of spring Chinook in the Nason Creek watershed for brood years 2002-2013; ND = no data. These estimates were derived from data in Table 6.13.

Brood year	Smolts/Redd[a]	Emigrants/ Redd	Egg-Smolt[a] (%)	Egg-Emigrant (%)
2002	16	ND	0.3	ND
2003	77	183	1.3	3.1
2004	15	85	0.3	1.8
2005	45	106	1.0	2.5
2006	51	79	1.2	1.8
2007	56	210	1.3	4.7
2008	11	80	0.2	1.7
2009	10	176	0.2	3.9

Brood year	Smolts/Redd[a]	Emigrants/ Redd	Egg-Smolt[a] (%)	Egg-Emigrant (%)
2010	19	64	0.4	1.5
2011	14	120	0.3	2.7
2012	11	79	0.3	1.9
2013	33	271	0.7	5.8
Average	***30***	***132***	***0.6***	***2.9***
Median	***18***	***106***	***0.4***	***2.5***

[a] These estimates include Nason Creek smolts produced only within the Nason Creek basin.

Seeding level (egg deposition) explained most of the variability in productivity and survival of juvenile spring Chinook in the Nason Creek watershed. That is, for estimates based on smolts produced within the Nason Creek watershed, survival and productivity decreased as seeding levels increased (Figure 6.2). This suggests that density dependence regulates juvenile productivity and survival within the Nason Creek watershed.

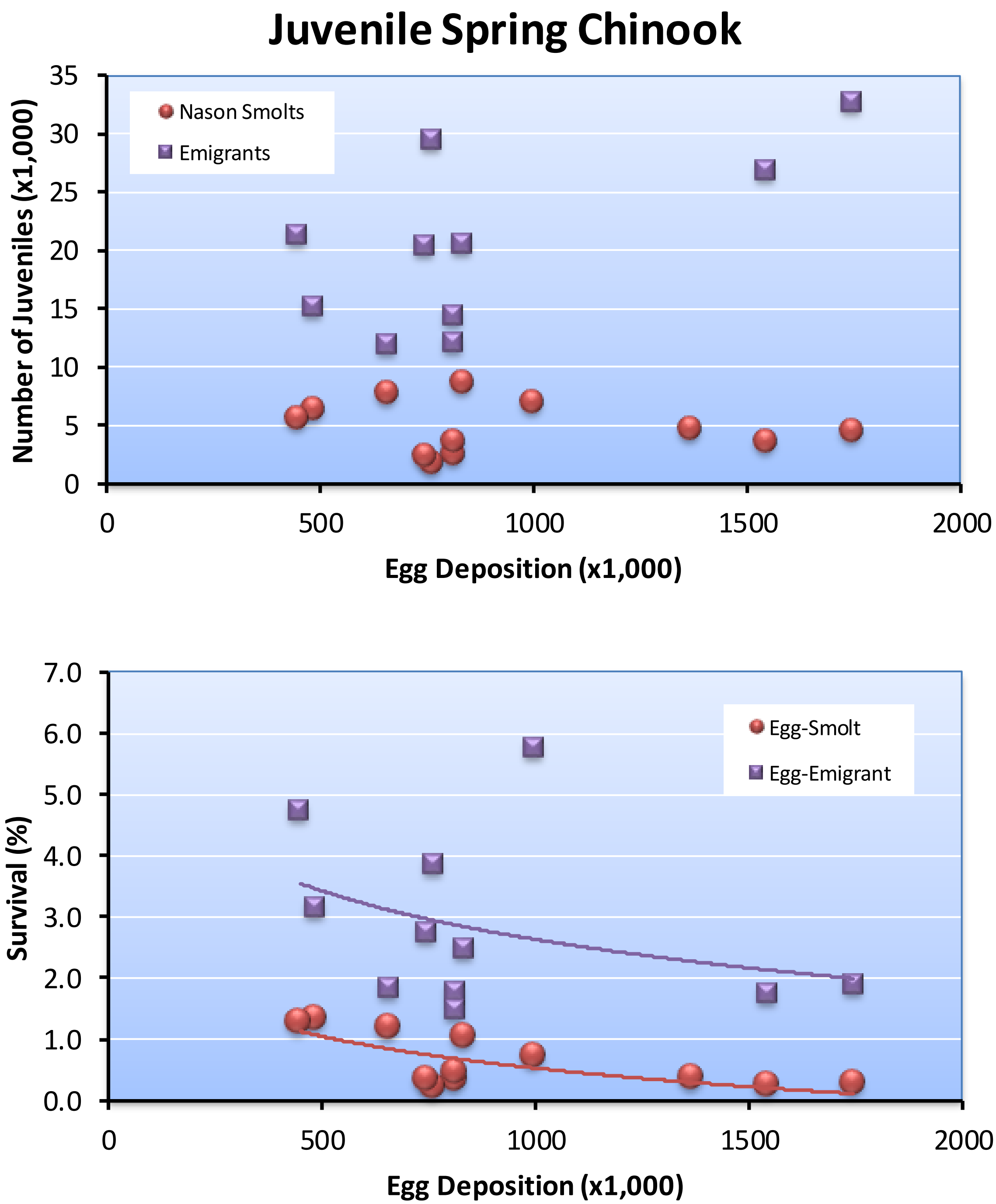

Figure 6.2. Relationships between seeding levels (egg deposition) and juvenile life-stage survivals and productivities for Nason Creek spring Chinook, brood years 2002-2013. Nason Creek smolts are smolts produced only in the Nason Creek watershed.

Population Carrying Capacity

Population carrying capacity (*K*) is defined as the maximum equilibrium population size estimated with population models (e.g., logistic equation, Beverton-Holt model, hockey stick model, and the

Ricker model).[11] Maximum equilibrium population size is generated from density dependent mechanisms that reduce population growth rates as population size increases (negative density dependence). This is referred to as compensation. Population size fluctuates about the maximum equilibrium size because of variability in vital rates that are unrelated to density (density independent factors) and measurement error. In this section, we estimate smolt carrying capacities using the Ricker stock-recruitment model (see Appendix C in Hillman et al. 2012 for a detailed description of methods). The Ricker model was the only stock-recruitment model that could be fit to the juvenile spring Chinook data.

Based on the Ricker model, the population carrying capacity for spring Chinook smolts in the Nason Creek watershed is 6,522 smolts (95% CI: 0 – 9,970) (Figure 6.3). Here, smolts are defined as the number of yearling spring Chinook produced entirely within Nason Creek. These estimates reflect current environmental conditions (most recent 12 years) within the Nason Creek watershed. Land use activities such as logging, roads, railways, development, and recreation have altered the historical conditions of the watershed. Thus, the estimated population capacity estimates may not reflect historical capacities for spring Chinook smolts in Nason Creek.

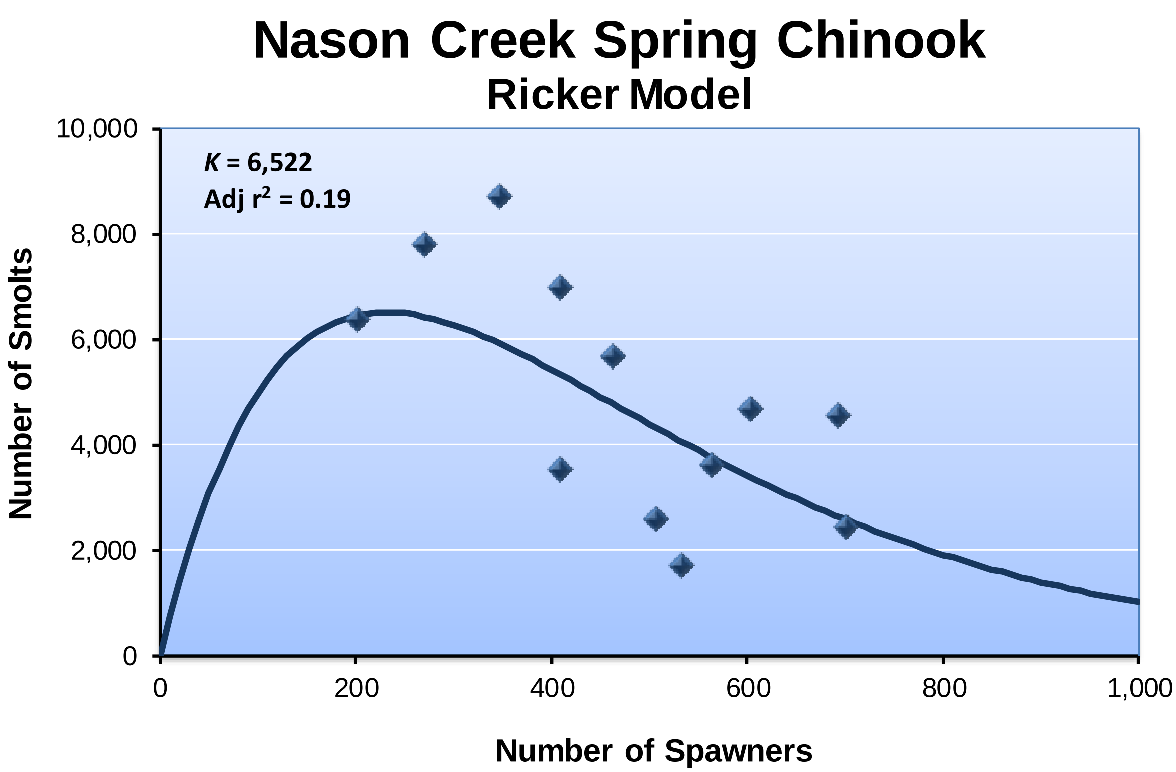

Figure 6.3. Relationship between spawners and number of yearling smolts produced in the Nason Creek watershed. Population carrying capacity (*K*) was estimated using the Ricker model.

[11] Population carrying capacity (*K*) should not be confused with habitat carrying capacity (*C*), which is defined as the maximum population of a given species that a particular environment can sustain.

We tracked the precision of the Ricker parameters for Nason Creek spring Chinook smolts over time to see if precision improves with additional years of data, and the parameters and statistics stabilize over time. Examination of variation in the alpha (*A*) and beta (*B*) parameters of the Ricker model and their associated standard errors and confidence intervals indicates that the parameters appear to be stabilizing, but they still lack precision (Table 6.16; Figure 6.4). This was also apparent in the estimates of population carrying capacity (Figure 6.5).

Table 6.16. Estimated parameters and statistics associated with fitting the Ricker model to spawning escapement and smolt data. Smolts represent numbers of smolts produced entirely within the Nason Creek watershed. *A* = alpha parameter; *B* = beta parameter; SE = standard error (estimated from 5,000 bootstrap samples); and r^2 = coefficient of determination. Spawners represent the stock size needed to achieve population capacity.

Years of data	Parameter				Population capacity	Intrinsic productivity	Spawners	r^2
	A	**SE**	***B***	**SE**				
5	90.60	87.13	0.0046	0.0015	7,293	91	219	0.453
6	90.02	5618.57	0.0045	0.0014	7,360	90	222	0.442
7	92.67	1696.44	0.0046	0.0009	7,395	93	217	0.517
8	107.07	1208.15	0.0052	0.0012	7,575	107	192	0.454
9	99.89	1125.42	0.0051	0.0012	7,149	100	195	0.409
10	90.35	50.04	0.0049	0.0008	6,825	90	205	0.470
11	72.26	34.50	0.0043	0.0009	6,240	72	235	0.308
12	76.76	31.24	0.0043	0.0008	6,522	77	231	0.337

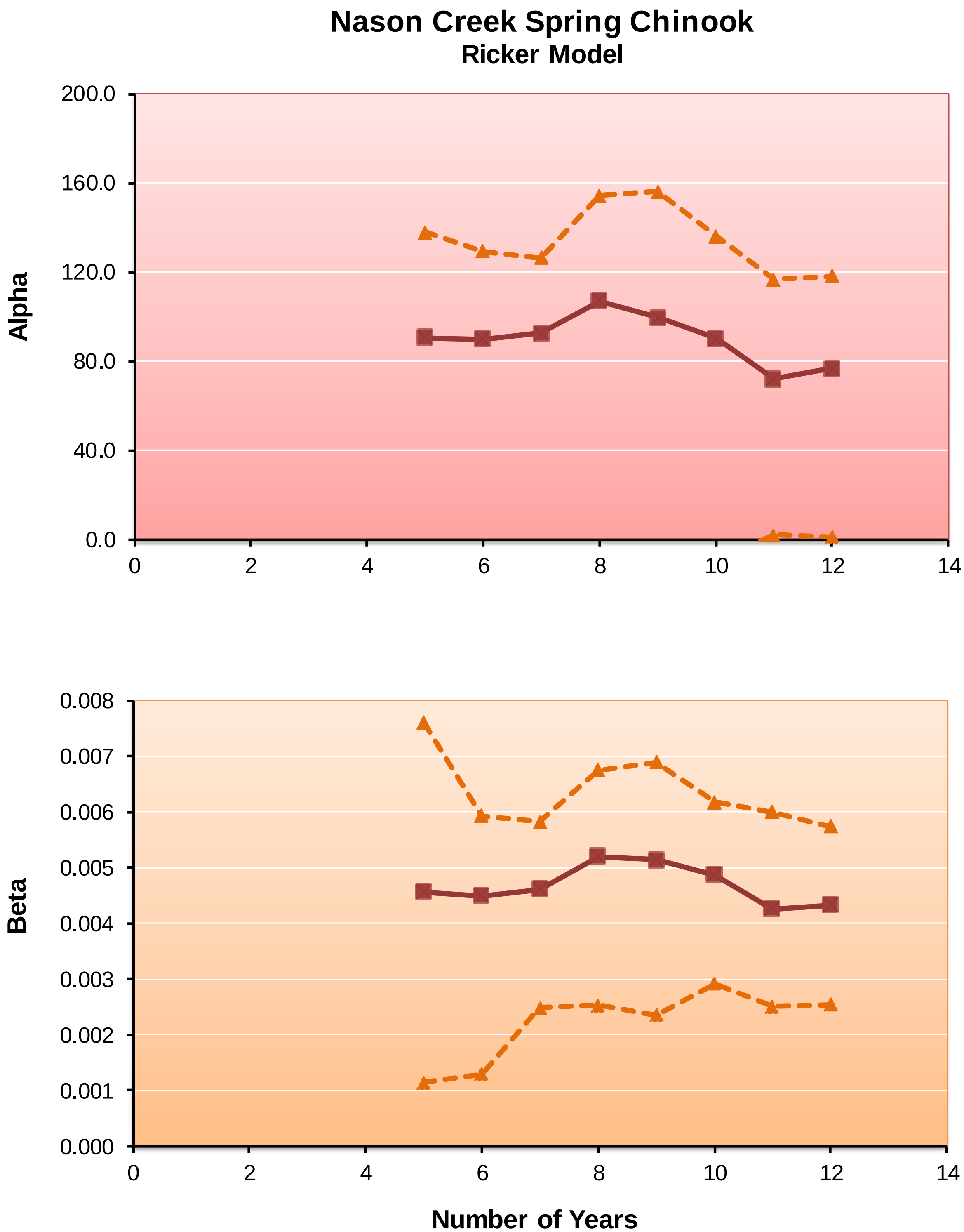

Figure 6.4. Time series of alpha and beta parameters and 95% confidence intervals for the Ricker model that was fit to Nason Creek spring Chinook smolt and spawning escapement data. Confidence intervals were estimated from 5,000 bootstrap samples.

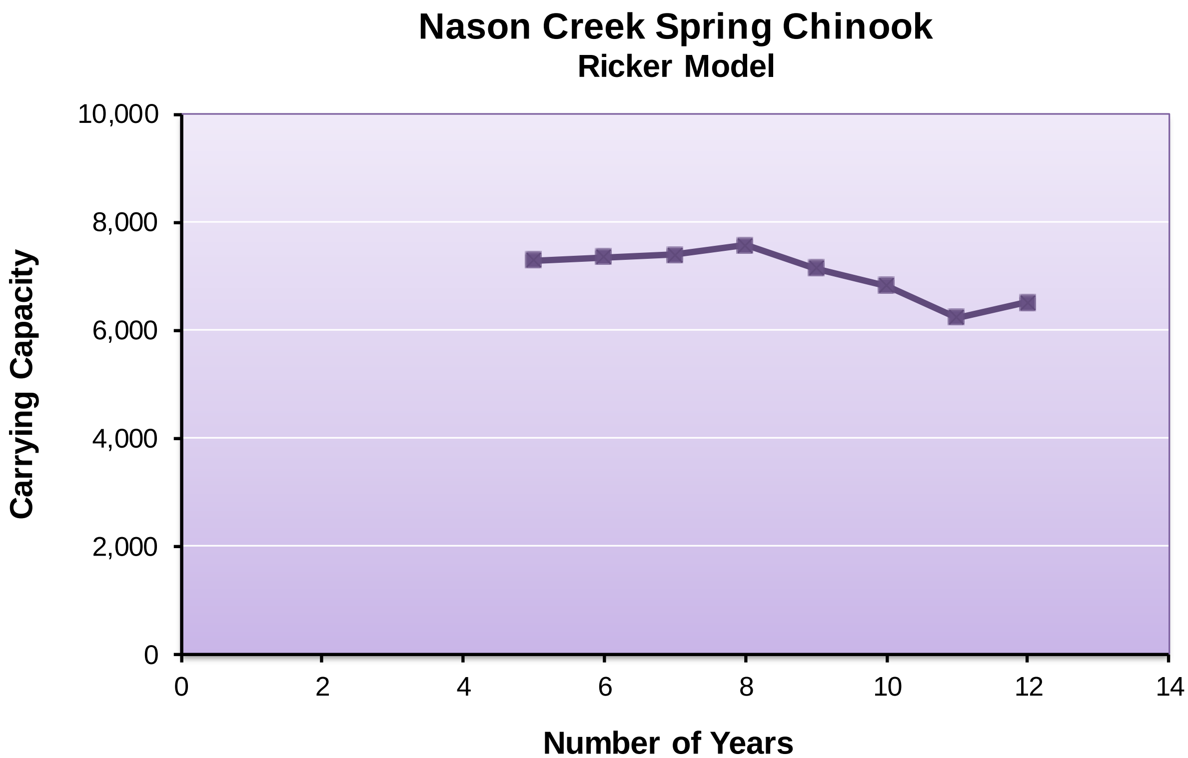

Figure 6.5. Time series of population carrying capacity estimates derived from fitting the Ricker model to Nason Creek spring Chinook smolt and spawning escapement data.

6.5 Spawning Surveys

Surveys for spring Chinook redds were conducted during August through September, 2015, in the Chiwawa River (including Rock and Chikamin creeks), Nason Creek, Icicle Creek, Peshastin Creek (including Ingalls Creek), Upper Wenatchee River (including Chiwaukum Creek), Little Wenatchee River, and White River (including the Napeequa River and Panther Creek). See Section 5.5 for a complete coverage of spring Chinook redd surveys in the Wenatchee River basin. In the following section we describe the number and distribution of redds within the Nason Creek basin.

Redd Counts and Distribution

A total of 85 spring Chinook redds were counted in Nason Creek in 2015 (Table 6.17; see Table 5.20 for the complete time series of redd counts). This is lower than the average of 146 redds counted during the period 1989-2014 in Nason Creek. Redds were not distributed evenly among the four reaches in Nason Creek. Most were located in Reach 2 and Reach 3 (Table 6.17).

Table 6.17. Numbers and proportions of spring Chinook redds counted within different reaches within Nason Creek during August through September, 2015. See Table 2.8 for description of survey reaches.

Stream/watershed	Reach	Number of redds	Proportion of redds within stream/watershed
Nason	Nason 1 (N1)	15	0.18
	Nason 2 (N2)	23	0.27
	Nason 3 (N3)	34	0.40
	Nason 4 (N4)	13	0.15
Total		***85***	***1.00***

Spawn Timing

Spring Chinook began spawning during the third week of August in Nason Creek and peaked the third week of September (Figure 6.6). Spawning in Nason Creek ended the fourth week of September.

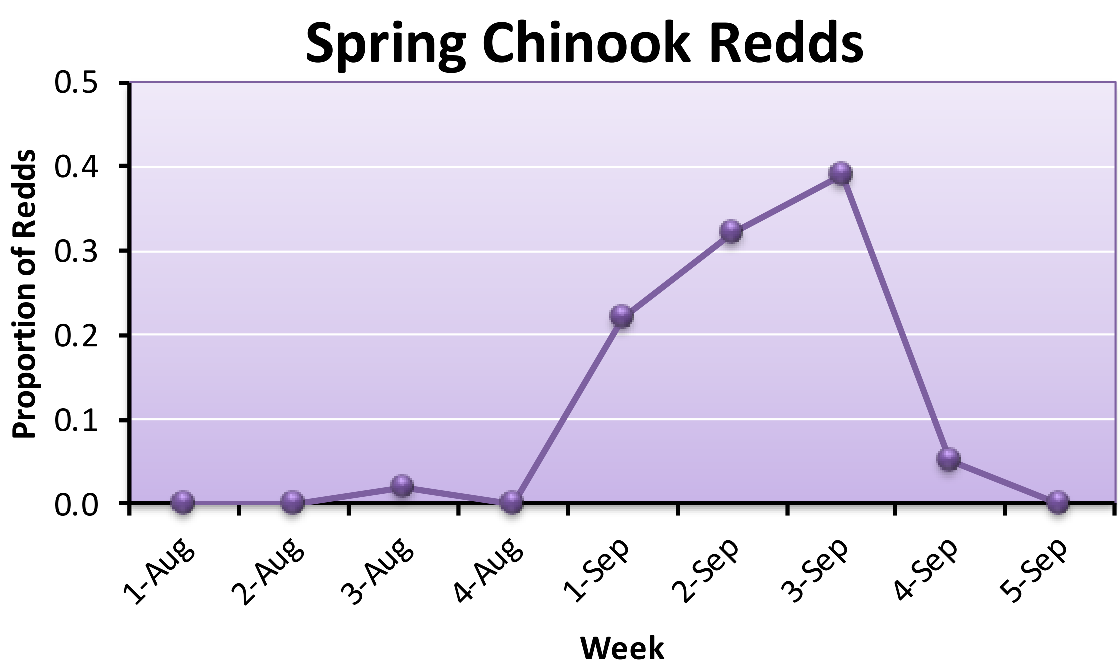

Figure 6.6. Proportion of spring Chinook redds counted during different weeks within Nason Creek, August through September 2015.

Spawning Escapement

Spawning escapement for spring Chinook was calculated as the number of redds times the male-to-female ratio (i.e., fish per redd expansion factor) estimated from broodstock and fish sampled at adult trapping sites. The estimated fish per redd ratio for spring Chinook upstream from Tumwater in 2015 was 1.78 (based on sex ratios estimated at Tumwater Dam). Multiplying this ratio by the number of redds counted in Nason Creek resulted in a total spawning escapement of

151 spring Chinook. The estimated total spawning escapement of spring Chinook in 2015 was less than the overall average of 319 spring Chinook in Nason Creek (see Table 5.23).

6.6 Carcass Surveys

Surveys for spring Chinook carcasses were conducted during August through September, 2015, in the Chiwawa River (including Rock and Chikamin creeks), Nason Creek, Icicle Creek, Peshastin Creek, Upper Wenatchee River, Little Wenatchee River (including Chiwaukum Creek), and White River (including the Napeequa River and Panther Creek). In 2015, 43 spring Chinook carcasses were sampled in Nason Creek. Most of these were sampled in Reach 3. The number of carcasses sampled in 2015 was less than the overall average of 153 carcasses sampled during the period 1996-2014. See Section 5.6 for a complete coverage of spring Chinook carcass surveys in the Wenatchee River basin.

In the Nason Creek watershed, the spatial distribution of hatchery and wild fish was not equal among survey reaches (Table 6.18). In 2015, more wild fish were collected during surveys than hatchery fish and more wild fish were collected than hatchery fish in each of the reaches. This general trend was also apparent in the pooled data (Figure 6.7). It should be noted that the hatchery fish spawning in Nason Creek are strays from the Chiwawa spring Chinook Program. Nason Creek hatchery fish will return to Nason Creek beginning in 2016 as age-3 fish.

Table 6.18. Numbers of wild and hatchery spring Chinook carcasses sampled within different reaches in the Nason Creek watershed, 1999-2015. See Table 2.8 for description of survey reaches.

Survey year	Origin	Survey Reach				Total
		N-1	N-2	N-3	N-4	
1999	Wild	2	3	0	0	**5**
	Hatchery	0	0	0	0	**0**
2000	Wild	19	21	0	9	**49**
	Hatchery	11	9	0	1	**21**
2001	Wild	25	22	0	41	**88**
	Hatchery	91	54	0	22	**167**
2002	Wild	16	34	0	37	**87**
	Hatchery	33	29	0	35	**97**
2003	Wild	6	19	0	22	**47**
	Hatchery	3	9	0	3	**15**
2004	Wild	29	33	18	24	**104**
	Hatchery	42	26	11	3	**82**
2005	Wild	19	6	11	7	**43**
	Hatchery	130	17	22	4	**173**
2006	Wild	24	17	28	9	**78**
	Hatchery	50	31	17	14	**112**
2007	Wild	2	13	8	6	**29**
	Hatchery	54	77	26	15	**172**
2008	Wild	14	13	16	10	**53**
	Hatchery	102	39	36	13	**190**
2009	Wild	1	12	10	16	**39**

Survey year	Origin	Survey Reach				Total
		N-1	N-2	N-3	N-4	
	Hatchery	25	21	20	23	**89**
2010	Wild	3	6	6	4	**19**
	Hatchery	47	29	30	16	**122**
2011	Wild	8	11	11	5	**35**
	Hatchery	22	12	21	8	**63**
2012	Wild	24	11	65	7	**107**
	Hatchery	95	37	70	23	**225**
2013	Wild	4	2	9	8	**23**
	Hatchery	51	12	28	27	**118**
2014	Wild	19	5	13	2	**39**
	Hatchery	25	1	3	0	**29**
2015	Wild	8	4	20	2	**34**
	Hatchery	2	0	7	0	**9**
Average	***Wild***	***13***	***14***	***13***	***12***	***52***
	Hatchery	***46***	***24***	***17***	***12***	***99***
Median	***Wild***	***14***	***12***	***10***	***8***	***43***
	Hatchery	***42***	***21***	***17***	***13***	***97***

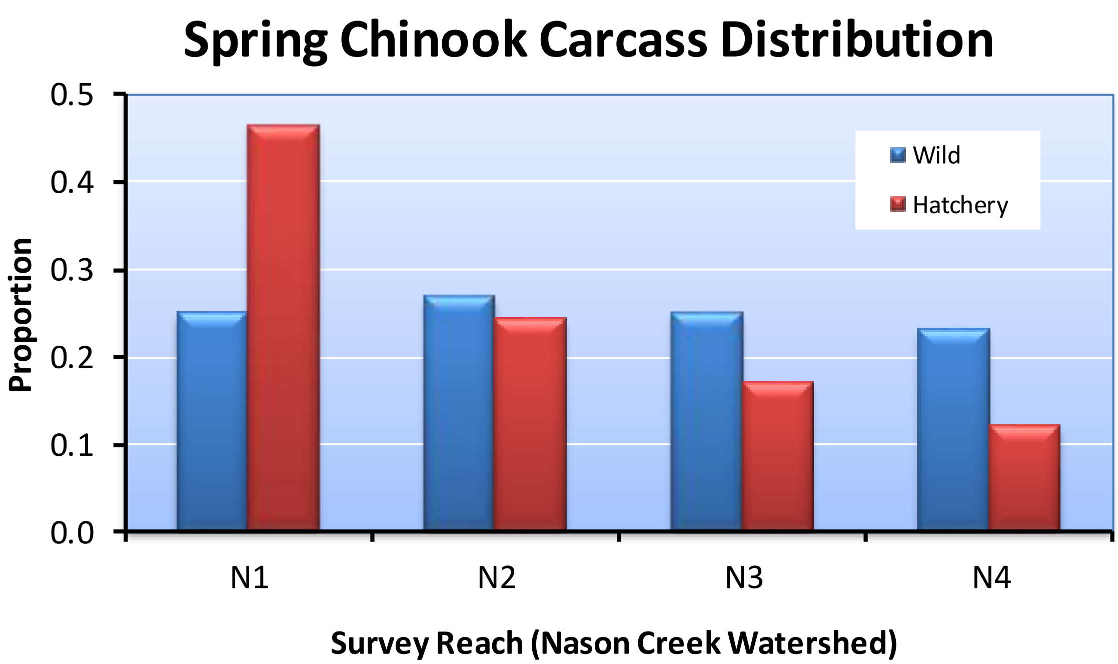

Figure 6.7. Distribution of wild and hatchery produced carcasses in different reaches in the Nason Creek watershed, 1999-2015. Reach codes are described in Table 2.8.

6.7 Life History Monitoring

Life history characteristics of spring Chinook were assessed by examining carcasses on spawning grounds and fish collected at broodstock collection sites, and by reviewing tagging data and fisheries statistics.

Migration Timing

See Section 5.7 for a description of migration timing of spring Chinook at Tumwater Dam.

Age at Maturity

Most of the wild and hatchery spring Chinook sampled during the period 1999-2015 in the Nason Creek watershed were age-4 fish (total age) (Table 6.19; Figure 6.8). Until 2014, hatchery fish made up a higher percentage of age-3 Chinook than did wild fish. As in other years, a higher proportion of age-5 wild fish returned than did age-5 hatchery fish. Thus, wild fish tended to return at an older age than hatchery fish.

Table 6.19. Numbers of wild and hatchery spring Chinook of different ages (total age) sampled on spawning grounds in the Nason Creek watershed, 1999-2015.

Sample year	Origin	Total age					Sample size
		2	3	4	5	6	
1999	Wild	0	0	5	0	0	**5**
	Hatchery	0	0	0	0	0	**0**
2000	Wild	0	1	45	0	0	**46**
	Hatchery	0	18	3	0	0	**21**
2001	Wild	0	0	63	13	0	**76**
	Hatchery	0	5	159	3	0	**167**
2002	Wild	0	0	58	23	0	**81**
	Hatchery	0	0	85	11	0	**96**
2003	Wild	0	4	3	36	0	**43**
	Hatchery	0	3	1	5	0	**9**
2004	Wild	0	1	101	1	0	**103**
	Hatchery	0	57	23	2	0	**82**
2005	Wild	0	1	25	17	0	**43**
	Hatchery	0	3	170	0	0	**173**
2006	Wild	0	0	60	18	0	**78**
	Hatchery	0	12	78	22	0	**112**
2007	Wild	0	0	18	11	0	**29**
	Hatchery	0	123	40	9	0	**172**
2008	Wild	0	2	46	4	0	**52**
	Hatchery	0	21	163	6	0	**190**
2009	Wild	0	1	36	2	0	**39**
	Hatchery	0	19	65	4	0	**88**
2010	Wild	0	1	18	0	0	**19**

Sample year	Origin	Total age					Sample size
		2	3	4	5	6	
	Hatchery	0	5	116	1	0	**122**
2011	Wild	0	3	24	8	0	**35**
	Hatchery	0	33	17	13	0	**63**
2012	Wild	0	1	89	17	0	**107**
	Hatchery	0	25	198	2	0	**225**
2013	Wild	0	0	16	7	0	**23**
	Hatchery	0	22	92	5	0	**119**
2014	Wild	0	16	19	3	0	**38**
	Hatchery	0	9	20	0	0	**29**
2015	Wild	0	1	25	4	0	**30**
	Hatchery	0	4	9	0	0	**13**
Average	***Wild***	***0***	***2***	***38***	***10***	***0***	***50***
	Hatchery	***0***	***21***	***73***	***5***	***0***	***99***
Median	***Wild***	***0***	***1***	***25***	***7***	***0***	***33***
	Hatchery	***0***	***12***	***65***	***3***	***0***	***96***

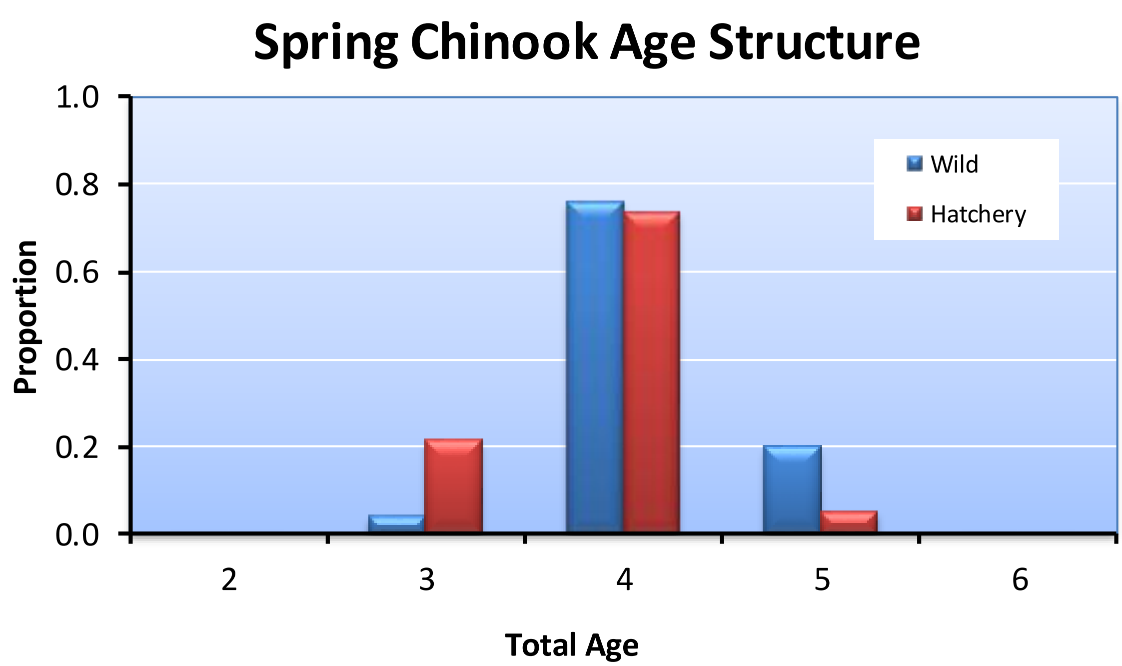

Figure 6.8. Proportions of wild and hatchery spring Chinook of different total ages sampled on spawning grounds in the Nason Creek watershed for the combined years 1999-2015.

Size at Maturity

On average, hatchery and wild spring Chinook of a given age differed little in length (Table 6.20). Differences were usually no more than 3-5 cm between hatchery and wild fish of the same age.

Table 6.20. Mean lengths (POH in cm; ±1SD) and sample sizes (in parentheses) of different ages (total age) of male and female spring Chinook of wild and hatchery-origin sampled in the Nason Creek watershed, 1999-2015.

Return year	Total age	Mean length (cm)			
		Male		Female	
		Wild	Hatchery	Wild	Hatchery
1999	3	0	0	0	0
	4	71 ±2 (2)	0	64 ±2 (3)	0
	5	0	0	0	0
	6	0	0	0	0
2000	3	46 ±0 (1)	44 ±4 (14)	0	52 ±10 (4)
	4	62 ±4 (19)	0	63 ±3 (25)	60 ±1 (3)
	5	0	0	0	0
	6	0	0	0	0
2001	3	0	47 ±12 (5)	0	0
	4	65 ±4 (21)	66 ±5 (36)	63 ±4 (42)	63 ±4 (123)
	5	81 ±5 (3)	0	72 ±3 (10)	71 ±7 (3)
	6	0	0	0	0
2002	3	0	0	0	0
	4	62 ±6 (24)	66 ±5 (35)	63 ±4 (34)	62 ±5 (50)
	5	77 ±4 (12)	81 ±7 (8)	75 ±3 (11)	71 ±5 (3)
	6	0	0	0	0
2003	3	44 ±7 (3)	43 ±5 (3)	0	0
	4	58 ±7 (2)	79 ±0 (1)	67 ±0 (1)	0
	5	75 ±9 (11)	81 ±6 (2)	72 ±6 (25)	71 ±2 (3)
	6	0	0	0	0
2004	3	46 ±0 (1)	43 ±4 (56)	0	0
	4	61 ±4 (35)	60 ±3 (6)	61 ±3 (66)	62 ±4 (17)
	5	0	0	81 ±0 (1)	73 ±4 (2)
	6	0	0	0	0
2005	3	37 ±0 (1)	41 ±7 (3)	0	0
	4	59 ±6 (8)	63 ±4 (54)	61 ±3 (17)	61 ±3 (116)
	5	73 ±5 (4)	0	71 ±1 (13)	0
	6	0	0	0	0
2006	3	0	41 ±3 (12)	0	0
	4	60 ±5 (26)	62 ±3 (29)	61 ±3 (34)	59 ±4 (49)
	5	72 ±5 (10)	73 ±5 (6)	69 ±4 (8)	70 ±4 (16)
	6	0	0	0	0
2007	3	0	44 ±4 (122)	0	51 ±0 (1)
	4	62 ±4 (6)	60 ±7 (13)	63 ±4 (12)	61 ±4 (27)
	5	77 ±5 (7)	67 ±5 (3)	68 ±2 (4)	70 ±2 (6)
	6	0	0	0	0
2008	3	51 ±21 (2)	45 ±5 (20)	0	45 ±0 (1)
	4	60 ±5 (15)	63 ±4 (42)	61 ±3 (31)	63 ±3 (121)

Return year	Total age	Mean length (cm)			
		Male		Female	
		Wild	Hatchery	Wild	Hatchery
	5	0	77 ±2 (3)	71 ±3 (4)	64 ±7 (3)
	6	0	0	0	0
2009	3	41 ±0 (1)	46 ±5 (18)	0	65 ±0 (1)
	4	60 ±5 (12)	63 ±4 (19)	60 ±3 (24)	61 ±4 (46)
	5	0	71 ±1 (2)	72 ±4 (2)	73 ±3 (2)
	6	0	0	0	0
2010	3	44 ±0 (1)	45 ±5 (5)	0	0
	4	62 ±5 (7)	63 ±4 (42)	61 ±3 (10)	62 ±4 (74)
	5	0	75 ±0 (1)	0	0
	6	0	0	0	0
2011	3	48 ±11 (3)	43 ±4 (31)	0	48 ±2 (2)
	4	61 ±5 (11)	59 ±11 (6)	60 ±5 (12)	63 ±5 (11)
	5	79 ±2 (3)	73 ±3 (6)	75 ±4 (5)	70 ±3 (7)
	6	0	0	0	0
2012	3	41 ±0 (1)	42 ±3 (24)	0	0
	4	61 ±7 (35)	60 ±5 (45)	61 ±4 (54)	60 ±4 (151)
	5	77 ±4 (6)	0	66 ±5 (11)	70 ±3 (2)
	6	0	0	0	0
2013	3	0	42 ±4 (21)	0	0
	4	60 ±6 (5)	62 ±4 (23)	60 ±4 (10)	60 ±4 (69)
	5	71 ±0 (1)	75 ±0 (1)	68 ±3 (6)	70 ±4 (4)
	6	0	0	0	0
2014	3	44 ±5 (15)	49 ±4 (9)	60 ±0 (1)	0
	4	64 ±7 (8)	59 ±4 (8)	63 ±3 (11)	60 ±3 (12)
	5	0	0	69 ±8 (3)	0
	6	0	0	0	0
2015	3	44 ±0 (1)	45 ±1 (4)	0	0
	4	61 ±7 (15)	56±4 (3)	63 ±5 (10)	58 ±2 (6)
	5	72 ±7 (3)	0	65 ±0 (1)	0
	6	0	0	0	0

Contribution to Fisheries

Because the Nason Creek program began in 2013, there will be no harvest information on Nason Creek hatchery spring Chinook until about 2017.

Straying

Stray rates will be determined by examining CWTs and PIT tags recovered on spawning grounds within and outside the Wenatchee River basin. Targets for strays based on return year (recovery year) within the Wenatchee River basin should be less than 10% and targets for strays outside the Wenatchee River basin should be less than 5%. The target for brood year stray rates should be less than 5%. Straying of Nason Creek spring Chinook will be estimated beginning in 2016 or 2017 when the 2013 brood fish return.

Genetics

Because the Nason Creek spring Chinook program began in 2013 with the collection of broodstock, there are no studies that examine the effects of the program on the genetics of natural-origin spring Chinook in the Wenatchee River basin. However, genetic studies were conducted to determine the potential effects of the Chiwawa Supplementation Program on natural-origin spring Chinook in the upper Wenatchee River basin (Blankenship et al. 2007; the entire report is appended as Appendix J). This work included the analysis of Nason Creek spring Chinook. Researchers collected microsatellite DNA allele frequencies from temporally replicated natural and hatchery-origin spring Chinook to statistically assign individual fish to specific demes (locations) within the Wenatchee population.

Significant differences in allele frequencies were observed within and among major spawning areas in the Upper Wenatchee River basin. However, these differences made up only a very small portion of the overall variation, indicating genetic similarity among the major spawning areas. There was no evidence that the Chiwawa program has changed the genetic structure (allele frequency) of spring Chinook in Nason Creek and the White River, despite the presence of hatchery-origin spawners in both systems.

Proportionate Natural Influence

Another method for assessing the genetic risk of a supplementation program is to determine the influence of the hatchery and natural environments on the adaptation of the composite population. This is estimated by the proportion of natural-origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery-origin fish in the natural spawning escapement (pHOS). We calculated Proportionate Natural Influence (PNI) by iterating Ford's (2002) equations 5 and 6 to equilibrium, using a heritability of 0.3 and a selection strength of three standard deviations.[12] The larger the PNI value, the greater the strength of selection in the natural environment relative to that of the hatchery environment. In order for the natural environment to dominate selection, PNI should be greater than 0.50, and important integrated populations should have a PNI of at least 0.67 (HSRG/WDFW/NWIFC 2004).

For brood years 1989-2012, when no brood stock were collected for the Nason Creek Program, the PNI values ranged from 0.28 to 1.00 (Table 6.21). During this period, PNI values varied over time because of Chiwawa spring Chinook straying into Nason Creek. For brood years 2013-2015, a period when brood stock was collected for the Nason Creek Program, PNI values for the Nason Creek Program were less than 0.67 and ranged from 0.46 to 0.55 (Table 6.21).

[12] According to authorized annual take permits, PNI is calculated using the PNI approximate equation 11 (HSRG 2009; Appendix A). However, in this report, we used Ford's (2002) equations 5 and 6 with a heritability of 0.3 and a selection strength of three standard deviations to calculate PNI (C. Busack, NOAA Fisheries, 21 March 2016, provided the model for calculating PNI). This approach is more accurate than using the PNI approximate equation.

Table 6.21. Proportionate Natural Influence (PNI) Index of hatchery spring Chinook spawning in Nason Creek, brood years 1989-2015. See notes below the table for description of each metric.

Brood year	Spawners					Broodstock			PNI
	NOS	HOS_N	HOS_S	$pHOS_N$	$pHOS_{N+S}$	NOB_N	HOB_N	pNOB	
1989	222	0	0	0.00	0.00	0	0	*1.00*	1.00
1990	231	0	0	0.00	0.00	0	0	*1.00*	1.00
1991	156	0	0	0.00	0.00	0	0	*1.00*	1.00
1992	181	0	0	0.00	0.00	0	0	*1.00*	1.00
1993	430	0	61	0.00	0.12	0	0	*1.00*	0.90
1994	60	0	0	0.00	0.00	0	0	*0.67*	1.00
1995	18	0	0	0.00	0.00	0	0	*0.00*	1.00
1996	58	0	25	0.00	0.30	0	0	*0.44*	0.61
1997	67	0	55	0.00	0.45	0	0	*0.29*	0.42
1998	61	0	3	0.00	0.05	0	0	*0.28*	0.86
1999	22	0	0	0.00	0.00	0	0	*0.00*	1.00
2000	189	0	81	0.00	0.30	0	0	*0.30*	0.52
2001	257	0	341	0.00	0.57	0	0	*0.30*	0.37
2002	313	0	290	0.00	0.48	0	0	*0.28*	0.39
2003	152	0	50	0.00	0.25	0	0	*0.44*	0.65
2004	297	0	210	0.00	0.41	0	0	*0.39*	0.51
2005	81	0	266	0.00	0.77	0	0	*0.33*	0.32
2006	117	0	154	0.00	0.57	0	0	*0.29*	0.36
2007	83	0	380	0.00	0.82	0	0	*0.29*	0.28
2008	139	0	426	0.00	0.75	0	0	*0.27*	0.29
2009	163	0	371	0.00	0.69	0	0	*0.46*	0.42
2010	59	0	351	0.00	0.86	0	0	*0.44*	0.35
2011	250	0	452	0.00	0.64	0	0	*0.46*	0.43
2012	220	0	474	0.00	0.68	0	0	*0.66*	0.50
Average*	***159***	***0***	***166***	***0.00***	***0.36***	***0***	***0***	***0.48***	***0.63***
Median*	***154***	***0***	***71***	***0.00***	***0.36***	***0***	***0***	***0.42***	***0.52***
2013	70	0	339	0.00	0.83	21	4	0.84	0.55
2014	169	0	68	0.00	0.29	21	0	1.00	0.54
2015	28	0	123	0.00	0.81	59	63	0.48	0.46
Average**	***89***	***0***	***177***	***0.00***	***0.64***	***34***	***22***	***0.77***	***0.52***
Median**	***70***	***0***	***123***	***0.00***	***0.81***	***21***	***4***	***0.84***	***0.54***

HOS_N = hatchery-origin spawners in Nason Creek from the Nason Creek spring Chinook Supplementation Program.
$pHOS_N$ = proportion of hatchery-origin spawners from Nason Creek spring Chinook Supplementation Program.
HOS_S = stray hatchery-origin spawners in Nason Creek.
$pHOS_S$ = proportion of stray hatchery-origin spawners.
NOB_N = natural-origin broodstock spawned in the Nason Creek spring Chinook Supplementation Program.
HOB_N = hatchery-origin broodstock spawned in the Nason Creek spring Chinook Supplementation Program.
pNOB = proportion of hatchery-origin broodstock. Because of the high incidence of strays to Nason Creek from the Chiwawa River spring Chinook program, pNOB values from the Chiwawa program were used to estimate PNI values during the period from 1989 to 2012 (*italicized*). The weighting for those years was 100% based on the Chiwawa program broodstock selection, because there have been no hatchery returns from the Nason Creek spring Chinook program (see Table 5.1 for Chiwawa broodstock selection).

PNI_N = Proportionate Natural Influence for Nason Creek spring Chinook calculated using the gene-flow model for multiple programs.
* Average and median for the period 1989-2012, a period when no brood stock were collected for the Nason Creek Program.
** Average and median for the period 2013-present, a period when brood stock was collected for the Nason Creek Program.

Natural and Hatchery Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural-origin recruits (NOR) to the parent spawning population (spawning escapement). Natural-origin recruits are naturally produced (wild) fish that survive to contribute to harvest (directly or indirectly), to broodstock, and to spawning grounds. We do not account for fish that died in route to the spawning grounds (migration mortality) or died just before spawning (pre-spawn mortality) (see Appendix B in Hillman et al. 2012). We calculated NORs with and without harvest. NORs without harvest include all returning fish that either returned to the basin or were collected as wild broodstock. NORs with harvest include all fish harvested and are based on brood-year harvest rates from the Chiwawa Hatchery program. For brood years 1989-2009, NRR for spring Chinook in Nason Creek averaged 0.87 (range, 0.05-5.48) if harvested fish were not included in the estimate and 0.95 (range, 0.05-5.86) if harvested fish were included in the estimate (Table 6.22). NRRs for more recent brood years will be calculated as soon as all tag recoveries and sampling rates have been loaded into the database.

Hatchery replacement rates (HRR) are the hatchery adult-to-adult returns and will be calculated as the ratio of hatchery-origin recruits (HOR) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 6.7 (the calculated target value in Hillman et al. 2013). The target value of 6.7 includes harvest and was based on HRRs for Chiwawa spring Chinook salmon. HRRs will be calculated beginning with the return of 2013 brood fish.

Table 6.22. Spawning escapements, natural-origin recruits (NOR), and natural replacement rates (NRR; with and without harvest) for spring Chinook in the Nason Creek watershed, brood years 1989-2009.

Brood year	Spawning Escapement	Harvest not included		Harvest included	
		NOR	NRR	NOR	NRR
1989	222	171	0.77	249	1.12
1990	231	15	0.06	18	0.08
1991	156	21	0.13	23	0.15
1992	181	47	0.26	49	0.27
1993	491	133	0.27	137	0.28
1994	60	3	0.05	3	0.05
1995	18	22	1.22	23	1.28
1996	83	229	2.76	250	3.01
1997	122	306	2.51	339	2.78
1998	64	351	5.48	375	5.86
1999	22	14	0.64	15	0.68
2000	270	337	1.25	354	1.31
2001	598	77	0.13	79	0.13
2002	603	123	0.20	128	0.21
2003	202	63	0.31	67	0.33
2004	507	131	0.26	141	0.28
2005	347	155	0.45	160	0.46

Brood year	Spawning Escapement	Harvest not included		Harvest included	
		NOR	NRR	NOR	NRR
2006	271	118	0.44	148	0.55
2007	463	210	0.45	251	0.54
2008	565	244	0.43	274	0.48
2009	534	71	0.13	77	0.14
Average	***286***	***135***	***0.87***	***150***	***0.95***
Median	***231***	***123***	***0.43***	***137***	***0.46***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) will be calculated as the number of hatchery adult recaptures divided by the number of tagged hatchery smolts released. SARs will be calculated with the return of the 2013 brood fish.

6.8 ESA/HCP Compliance

Broodstock Collection

Collection of brood year 2013 broodstock for Nason Creek spring Chinook was to use genetic assignments to target 36 natural-origin broodstock for the Nason Conservation program. Because of poor assignments rates, only two adults were assigned to the Nason program. To increase the probability of meeting broodstock requirements for the current year, the parties initiated a tangle netting effort in Nason Creek, which resulted in an additional 24 adults for the program. Total broodstock achieved for the 2013 brood Nason Creek spring Chinook program was 26 adults.

Hatchery Rearing and Release

The 2013 brood Nason Creek spring Chinook reared throughout all life stages without significant mortality (defined as >10% population mortality associated with a single event). A total of 43,082 smolts were released (57.4% of 2013 goal and 34.5% of the overall Nason conservation program goal). Survival from green-egg through release survival was 86.6%, well above the 81.0% target.

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, 1395, 18118, 18119, and 18121, 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 PUD Hatchery facilities during the period 1 January through 31 December 2015. NPDES monitoring and reporting for PUD Hatchery Programs during 2015 are provided in Appendix F.

Smolt and Emigrant Trapping

Per ESA Section 10 Permit No. 1196, 18118, 18120, and 18121 the permit holders are authorized a direct take of 20% of the emigrating spring Chinook population during juvenile emigration monitoring and a lethal take not to exceed 2% of the fish captured (NMFS 2003). Based on the estimated wild spring Chinook population (smolt trap expansion) and hatchery juvenile spring Chinook population estimate (hatchery release data) for the Wenatchee River basin, the reported spring Chinook encounters during 2015 emigration monitoring complied with take provisions in the Section 10 permit. Spring Chinook encounter and mortality rates for each trap site (including PIT tag mortalities) are detailed in Table 6.23. Additionally, juvenile fish captured at the trap locations were handled consistent with provisions in ESA Section 10 Permit 1196, 18118, 18120, and 18121, Section B. Table 6.23 does not include incidental or direct take associated with the Nason Creek smolt trap operated by the Yakama Nation.

Table 6.23. Estimated take of Upper Columbia River spring Chinook resulting from juvenile emigration monitoring in the Wenatchee River basin, 2015.

Trap location	Population estimate			Number trapped			Total	Take allowed under Permit
	Wild[a]	Hatchery[b]	Sub-yearling[c]	Wild	Hatchery	Sub-yearling		
Chiwawa Trap								
Population	39,396	147,480	77,510	6,350	7,148	31,152	44,650	
Encounter rate	NA	NA	NA	0.1612	0.0485	0.4019	0.1667	0.20
Mortality[e]	NA	NA	NA	42	0	414	456	
Mortality rate	NA	NA	NA	0.0066	0.0000	0.0133	0.0102	0.02
Lower Wenatchee Trap								
Population	58,595	235,184	14,157,778	1,559	9,920	252,293	263,772	
Encounter rate	NA	NA	NA	0.0266	0.0422	0.0178	0.0183	0.20
Mortality[d]	NA	NA	NA	17	2	282	301	
Mortality rate	NA	NA	NA	0.0109	0.0002	0.0011	0.0011	0.02
Wenatchee River Basin Total								
Population	97,991	235,184	14,235,288	7,909	17,068	283,445	308,422	
Encounter rate	NA	NA	NA	0.0807	0.0726	0.0199	0.0211	0.20
Mortality[d]	NA	NA	NA	59	2	696	757	
Mortality rate	NA	NA	NA	0.0075	0.0001	0.0025	0.0025	0.02

[a] Smolt population estimate derived from juvenile emigration trap data.

[b] 2015 BY smolt release data for the Wenatchee River basin.

[c] Based on size, date of capture and location of capture, subyearling Chinook encountered at the Lower Wenatchee Trap are categorized as summer Chinook salmon.

[d] Combined trapping and PIT tagging mortality.

Spawning Surveys

Spring Chinook spawning ground surveys were conducted in the Wenatchee River basin during 2015, as authorized by ESA Section 10 Permits 18118, 18119, and 18121. Because of the difficulty of quantifying the level of take associated with spawning ground surveys, the Permit does not specify a take level associated with these activities, even though it does authorize implementation of spawning ground surveys. Therefore, no take levels are reported. However, to minimize potential effects to established redds, wading was restricted to the extent practical, and extreme caution was used to avoid established redds when wading was required.

Spring Chinook Reproductive Success Study

ESA Section 10 Permit 1196 (expired) and new Section 10 Permits 18118, 18119, and 18121 specifically provide authorization to capture, anesthetize, biologically sample, PIT tag, and release adult spring Chinook at Tumwater Dam for reproductive success studies and general program monitoring. During 2010 through 2015, all spring Chinook passing Tumwater Dam were enumerated, anesthetized, biologically sampled, PIT tagged, and released (not including hatchery-origin and natural-origin Chinook retained for broodstock) as a component of the reproductive success study (BPA Project No. 2003-039-00). Please refer to Ford et al. (2010, 2011, 2012, 2013, 2014, and 2015) for complete details on the methods and results of the spring Chinook reproductive success study for the period 2010-2015.

SECTION 7: WHITE RIVER SPRING CHINOOK

The White River spring Chinook salmon captive brood program began in 1997 with goals to conserve, aid in the recovery, and prevent the extinction of naturally spawning spring Chinook in the White River, and to meet the mitigation responsibilities of Grant County PUD. Collection of eggs or juveniles from the White River (brood years 1997-2009) made up the first-generation (F_1) component of the White River captive brood program. Initially, rearing occurred at AquaSeed in Rochester, Washington, but transitioned to the Little White Salmon National Fish Hatchery near Cook, Washington, in 2006. The F_1 component was reared to maturation and spawned within the hatchery. The resulting progeny (F_2) were then reared in the hatchery until final acclimation and release in the upper Wenatchee Basin. The first large release of F_2 juveniles was in 2008. The last release of juveniles from the captive brood program occurred in 2015.

The production goal for the White River captive brood program following the 2013 hatchery recalculation is to release 74,556 yearling smolts into the upper Wenatchee River basin at 18-24 fish per pound. Fish lengths and weights for the recent broods have been manipulated to evaluate different approaches to reduce precocious maturation. All of the fish are marked with CWTs. In addition, since 2008, juvenile spring Chinook have been PIT tagged annually.

Since its inception, the captive brood program has undergone several adaptive changes designed to improve program success. These changes included: (1) use of a pedigree approach to reduce the use of stray fish in the broodstock, (2) transfer of fish from Aquaseed to the Little White Salmon National Fish Hatchery to improve fish quality, (3) injection of hormones into F_1 females to improve maturation of eggs, (4) manipulation of diet and ration for the F_2 fish to reduce precocious maturation of males, (5) use of temporary tanks and natural enclosures during acclimation to improve homing, and (6) trucking fish around Lake Wenatchee to improve survival.

The following information focuses on results from monitoring the White River spring Chinook program. More detailed information on the White River program can be found in Lauver et al. (2012). Information on spring Chinook collected throughout the Wenatchee River basin is presented in Section 5.

7.1 Captive Brood Collection

The captive brood program was designed to provide a rapid, short-term demographic boost to the White River spring Chinook spawning aggregate, which was at a high risk of local extinction (Lauver et al. 2012). This section describes the collection of broodstock for the White River program.

Brood Collection and Rearing

A primary objective of the White River program was to collect progeny of naturally spawning spring Chinook in the White River. The progeny (eggs or juveniles) make up the first-generation (F_1) of the captive brood program. However, strays from the Chiwawa supplementation program made this a challenge. As a result, researchers attempted to identify the origin of spawners on redds in the White River and then focused egg and juvenile collection efforts on those redds that had the highest likelihood of being produced from White River parents. During most years, this limited the number of redds from which eggs or juveniles could be collected. Starting with brood year 2006, a pedigree approach was adopted to improve the likelihood that eggs or juveniles used in the captive brood program were of White River origin.

During 1997 to 2009, first-generation broodstock for the captive brood program originated from about 10,353 natural-origin eggs and juveniles collected from 122 redds in the White River. Broodstock from brood year 1997 were trapped as parr with nets in the fall of 1998. Broodstock from brood year 2006 were trapped as fry with nets in the spring of 2007. It was assumed that the parr and fry in close proximity of known redds were produced from those redds, and origin was confirmed with pedigree analyses. All other brood years were collected as eggs in the fall using redd pumping techniques. Broodstock collection levels were calculated based on the following assumptions and the known number of suitable redds each year (Tonseth and Maitland 2011):

1. 150,000 smolt target/0.70 (green egg to release survival) = 214,000 green eggs
2. 214,000 green eggs/1,500 eggs per female = 143 females/0.50 (sex ratio) = 286 fish
3. 286 fish/0.30 (eyed egg to maturity survival) = 953 eyed eggs
4. 953 eyed eggs/**X** redds = **Y** eyed-eggs per redd

Eyed eggs or juveniles collected in the White River were transported to Aquaseed (brood years 1997-2007) or to the Little White Salmon Hatchery (brood years 2008-2009) and reared to adults. Table 7.1 summarizes the collection of eyed eggs or juveniles for the captive brood program.

Table 7.1. Numbers of eyed eggs or juvenile brood stock collected for the White River captive brood program, brood years 1997-2009 (2009 was the last year for broodstock collection). Also shown are the number of redds that were sampled for eggs or juveniles and the hatchery in which the fish were reared (LWSFH = Little White Salmon Fish Hatchery); NS = no sample.

Brood year	Number of eyed eggs collected	Number of juvenile Chinook collected	Number of redds sampled	Rearing facility
1997	0	527 (parr)	8	Aquaseed
1998	182	0	4	Aquaseed
1999	NS	NS	NS	--
2000	272	0	NS	Aquaseed
2001	NS	NS	NS	--
2002	167	0	3	Aquaseed
2003	250	0	8	Aquaseed
2004	1,216	0	10	Aquaseed
2005	2,733	0	21	Aquaseed/LWSFH[1]
2006	0	1,487 (fry)	29	Aquaseed/ LWSFH[2]
2007	1,153	0	13	Aquaseed/ LWSFH[3]
2008	933	0	11	LWSFH
2009	1,433	0	15	LWSFH
Average	***927***	***1,007***	***12***	

[1] Fish were transferred on 30 June and 2 July 2008 and 20 January 2009.
[2] Fish were transferred on 21 October and 13 November 2008.
[3] Fish were transferred on 26 September and 21 October 2008.

7.2 Hatchery Spawning and Release

Captive Brood Spawning

As noted above, eyed eggs or juveniles collected in the White River were transported to Aquaseed (for brood years 1997-2007) or to the Little White Salmon Hatchery (for brood years 2008-2009) and reared to adults (Lauver et al. 2012). After rearing broodstock to maturity in captivity, adult spring Chinook were spawned and their progeny were grown to smolt size for release into the White River.

During spawning, eggs and sperm were collected and those gametes were crossed based on a 2x2 factorial spawning matrix. That is, each female was spawned with two males and each male was spawned with two females. Using pedigree analysis, spawning crosses were arranged to maximize genetic diversity. Because incomplete ripening of ova has been an issue in the program, implementation of hormone treatments began in 2011 to facilitate ripening. In addition, following spawning, milt from excess males was collected for cryopreservation. Based on a pilot study, the cryopreserved milt was relatively ineffective at fertilizing eggs, so it was not used widely in the program. There are no plans to use the cryopreserved milt in the future. Table 7.2 shows the ages of first-generation males and females spawned for the captive brood program.

Table 7.2. Total ages of first-generation (F_1) male and female spring Chinook spawned for the White River captive brood program, spawning years 2001-2011; NA = not available.

Spawning year	Sex	Total age				Total
		2	3	4	5	
2001	Female	0	0	3	0	3
	Male	0	2	0	0	2
2002	Female	0	0	4	4	8
	Male	10	0	0	0	10
2003	Female	0	5	0	0	5
	Male	0	2	0	0	2
2004	Female	0	0	2	0	2
	Male	4	0	0	0	4
2005	Female	0	85*	0	0	85
	Male	90	1	0	0	91
2006	Female	2	104	110	0	216
	Male	104	6	0	0	110
2007	Female	0	21	118	1	140
	Male	113	7	0	0	120
2008	Female	0	58	0	0	58
	Male	NA	NA	NA	NA	NA
2009	Female	0	0	119	0	119
	Male	65	54	0	0	119
2010	Female	0	0	42	0	42

Spawning year	Sex	Total age				Total
		2	3	4	5	
	Male	22	23	0	0	45
2011	Female	0	0	0	150	150
	Male	0	148	2	0	150
Average	***Female***	***0***	***25***	***36***	***14***	***75***
	Male	***41***	***24***	***0***	***0***	***65***
Median	***Female***	***0***	***0***	***3***	***0***	***58***
	Male	***16***	***4***	***0***	***0***	***68***

* Included some unknown number of second-generation females.

Release Information

Numbers released

Several different acclimation and release scenarios have been conducted since 1997. Acclimation scenarios have involved naturalized features such as in-channel enclosures, stream-side tanks supplied with pass-through surface water, and net pens in Lake Wenatchee near the mouth of the White River. Release scenarios have included on-site releases from tanks, in-channel enclosures, and net pens in Lake Wenatchee. In 2010, acclimated fish were towed in net pens to the mouth of the lake and released there. In 2011, tank and net-pen acclimated fish were loaded into transport trucks and released into the Wenatchee River. In addition, subyearling and yearling Chinook with no acclimation have been released from transport trucks directly into Lake Wenatchee and the White River. A total of 944,591 second-generation (F_2) juvenile spring Chinook have been released from the captive brood program. Table 7.3 summarizes the acclimation and release history of F_2 spring Chinook released into the upper Wenatchee River basin.

Table 7.3. Numbers of White River juvenile spring Chinook released and their acclimation histories for brood years 2002-2014.

Brood year	Acclimation site	Acclimation vessel	Number of smolts released	Release scenario	Release date	Number of acclimation days
2002	WR RM 11.5	Tanks	2,589	White River	4/22/2004	17
2003	WR RM 11.5	Tanks	2,096	White River	5/2/2005	47
2004	WR RM 11.5	Tanks	1,639	White River	4/4/2006	0
2005	Lake Wen	Net Pens	69,032	Lake Wen	5/2/2007	34
2006	NA	NA	139,644*	White River	4/17, 4/25/2007	0
	NA	NA	142,033	White River	3/18, 3/20/2008	0
2007	Lake Wen	Net Pens	87,671	Lake Wen	5/5/2009	35-40
	None	None	44,172	Lake Wen	4/1/2009	0
2008	WR Bridge	Eddy Pen	10,156	Escape	~4/12/2010	~10
	Lake Wen	Net Pens	38,400	Mouth of lake	5/5, 5/6/2010	38-41
2009	WR RM 11.5	Side Channel	12,000	Escape	~3/31/2011	~7

Brood year	Acclimation site	Acclimation vessel	Number of smolts released	Release scenario	Release date	Number of acclimation days
	WR RM 11.5	Tanks	10,000	White River	5/12/2011	49
	WR Bridge	Tanks	28,000	White River	5/14/2011	51
	WR Bridge	Tanks		Wen River	5/13/2011	50
	WR Bridge	Eddy Pen	14,596	Escape	~3/27/2011	~3
	Lake Wen	Net Pens	48,000	Wen River	5/14/2011	46
	Lake Wen	Net Pens		Wen River	5/14/2011	44
2010	WR Bridge	Tanks	18,850	Wen River	5/9/2012	44
2011	WR Bridge	Tanks	42,000	Wen & White R	5/6, 5/7, 5/8/13	49, 50, 51
	Lake Wen	Net Pens	105,000	Wen River	5/8, 5/13, 5/14/13	51, 56, 57
2012	WR Bridge	Tanks	42,000	Wen River	5/6/14	50
	Lake Wen	Net Pens	55,713	Wen River	5/8/14	49
2013	WR Bridge	Tanks	31,000	Wen River	5/4/15	56

* Subyearling release.

Numbers tagged

Brood years 2005 and 2007-2014 spring Chinook were tagged with a CWT in their peduncle. None of these fish were adipose fin clipped.[13] Subyearling fish from the 2006 brood year were tagged with half of a CWT in their snouts. Yearling fish from the 2006 brood year were tagged with CWTs in the peduncle. None of these fish were adipose fin clipped. In addition, beginning in 2008 (brood year 2006), 303,207 juvenile spring Chinook have been PIT tagged before release. Table 7.4 identifies the number of second-generation (F_2) juvenile spring Chinook tagged with PIT tags.

Table 7.4. Numbers of second-generation (F2) White River spring Chinook smolts tagged and released in the upper Wenatchee River basin, brood years 2002-2014.

Brood year	Acclimation site	Acclimation vessel	Release scenario	CWT mark rate	Number released that were PIT tagged	Number of smolts released
2002	WR RM 11.5	Tanks	White River	0.00	0	2,589
2003	WR RM 11.5	Tanks	White River	0.00	0	2,096
2004	WR RM 11.5	Tanks	White River	0.00	0	1,639
2005	Lake Wen	Net Pens	Lake Wen	1.00	0	69,032
2006	NA	NA	White River	0.00	29,881	139,644*
	NA	NA	White River	0.00		142,033
2007	Lake Wen	Net Pens	Lake Wen	1.00	29,863	87,671

[13] Given that juvenile spring Chinook were tagged with CWTs in the peduncle and were not ad-clipped, it is possible that field crews missed hatchery-origin adults on the spawning grounds because they did not know they were supposed to sample fish with adipose fins. Thus, this bias in carcass sampling may bias derived metrics such as spawning distribution of hatchery and natural-origin fish, spawn timing of hatchery and natural-origin fish, age at maturity, size at maturity, contributions to fisheries, HOR, NOR, HRR, NRR, PNI, straying, and SARs.

Brood year	Acclimation site	Acclimation vessel	Release scenario	CWT mark rate	Number released that were PIT tagged	Number of smolts released
	None	None	Lake Wen	1.00	9,957	44,172
2008	WR Bridge	Eddy Pen	Escape	1.00	38,148	10,156
	Lake Wen	Net Pens	Lake Mouth	1.00		38,400
2009	WR RM 11.5	Side Channel	Escape	1.00	41,886	12,000
	WR RM 11.5	Tanks	White River	1.00		10,000
	WR Bridge	Tanks	White River	1.00		28,000
	WR Bridge	Tanks	Wen River	1.00		
	WR Bridge	Eddy Pen	Escape	1.00		14,596
	Lake Wen	Net Pens	Wen River	1.00		48,000
	Lake Wen	Net Pens	Wen River	1.00		
2010	WR Bridge	Tanks	Wen River	1.00	12,283	18,850
2011	WR Bridge	Tanks	Wen & White	1.00	2,490	42,000
	Lake Wen	Net Pens	Wen River	1.00	51,697	105,000
2012	WR Bridge	Tanks	Wen River	1.00	52,097	42,000
	Lake Wen	Net Pens	Wen River	1.00		55,713
2013	WR Bridge	Tanks	Wen River	1.00	34,905	31,000

* Subyearling release.

Fish size and condition at release

Table 7.5 summarizes the size and condition of second-generation White River juvenile spring Chinook released in the upper Wenatchee River basin.

Table 7.5. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of second-generation White River (WR) juvenile spring Chinook released in the upper Wenatchee River basin, brood years 2002-2014. Size targets are provided in the last row of the table. NA = not available.

Brood year	Acclimation site	Release scenario	Fork length (mm)		Mean weight	
			Mean	CV	Grams (g)	Fish/pound
2002	WR RM 11.5	White River	NA	NA	NA	NA
2003	WR RM 11.5	White River	166	12.4	53.7	8
2004	WR RM 11.5	White River	207	11.6	117.7	4
2005	Lake Wen	Lake Wen	145	9.7	36.9	31
2006	NA	White River	NA	NA	NA	NA
	NA	White River	NA	NA	NA	NA
2007	Lake Wen	Lake Wen	135	7.8	29.2	29
	None	Lake Wen	NA	NA	NA	NA
2008	WR Bridge	Escape	--	--	--	--
	Lake Wen	Mouth of lake	138	10.0	32.5	14

Brood year	Acclimation site	Release scenario	Fork length (mm)		Mean weight	
			Mean	CV	Grams (g)	Fish/pound
2009	WR RM 11.5	Escape	--	--	--	--
	WR RM 11.5	White River	134	8.7	29.3	16
	WR Bridge	White River	138	9.3	28.6	16
	WR Bridge	Wen River	NA	NA	NA	NA
	WR Bridge	Escape	--	--	--	--
	Lake Wen	Wen River	140	8.9	31.6	14
	Lake Wen	Wen River	142	9.8	39.3	12
2010	WR Bridge	Wen River	125	8.0	22.8	20
2011	WR Bridge	Wen & White	130	8.4	24.1	19
	Lake Wen	Wen River	128	8.2	24.0	19
2012	WR Bridge	Wen River	131	8.1	24.2	18.8
	Lake Wen	Wen River	NA	NA	NA	NA
2013	WR Bridge	Wen River	132	8.7	24.5	19
Average			142	9.3	37.0	17

Post-Release Survival

We used PIT-tagged fish to estimate survival rates and travel time (arithmetic mean days) of released second-generation (F_2) White River spring Chinook smolts to McNary Dam, and smolt to adult ratios (SARs) from release to detection at Bonneville Dam.[14] Based on the available data, post-release survival has been low for fish released into the White River and Lake Wenatchee (Table 7.6). In contrast, survival of fish released in the Wenatchee River tends to be higher than those released in the White River or in Lake Wenatchee. These results suggest that high mortality in Lake Wenatchee may explain why adult returns of program fish have been consistently poor; however, other factors such as high precocious maturation may also contribute to the estimated low survival (e.g., see Ford et al. 2015).

Average travel time from release to McNary Dam ranged from 23 to 82 days (Table 7.6). Spring Chinook released in the Wenatchee River typically traveled faster to McNary Dam than those released in the White River or in Lake Wenatchee. Because of uncertain release times for several groups, we were unable to estimate travel times for all release groups.

[14] It is important to point out that because of fish size differences among rearing net pens, tanks, or raceways, fish PIT tagged in one pen, tank, or raceway may not represent untagged fish rearing in other pens, tanks, or raceways.

Table 7.6. Survival and travel times (mean days) of second-generation (F2) White River spring Chinook smolts to McNary Dam and SARs to Bonneville Dam for different release scenarios, brood years 2006-2013. Values in parentheses represent the standard error of the estimate. NA = not available (i.e., not all the fish from the release groups have returned to the Columbia River).

Brood year	Release scenario	Number of Chinook released with PIT tags	Survival to McNary Dam (d)	Travel time to McNary Dam (d)	SAR to Bonneville Dam (%)
2006	White River	29,881	0.037 (0.008)	82.3 (16.1)	0.000 (0.000)
2007	Lake Wen Pens	29,863	0.096 (0.010)	NA	0.000 (--)
	Lake Wenatchee	9,957	0.080 (0.015)	NA	0.000 (--)
2008	Lake Wenatchee	38,146	0.065 (0.010)	65.2 (14.0)	0.001 (0.000)
2009	White and Wenatchee rivers	19,913	0.269 (0.027)	22.9 (9.2)	0.002 (0.000)
	White River	21,829	0.055 (0.013)	48.1 (20.4)	0.000 (0.000)
2010	Wenatchee River	12,283	0.267 (0.017)	NA	0.001 (0.000)
2011	Wenatchee River	2,490	0.385 (0.042)	NA	NA
	White and Wenatchee rivers	51,697	0.434 (0.010)	NA	NA
2012	Wenatchee River	52,440	0.351 (0.013)	NA	NA
2013	Wenatchee River	49,703	0.365 (0.020)	43.8 (10.3)	NA

7.3 Disease Monitoring

First-Generation Health Maintenance

First-generation (F_1) adults were fed an azithromycin-medicated feed in the spring to prevent bacterial kidney disease (BKD), which is a common affliction of spring Chinook salmon. As needed, fish received a dose of 20 mg/kg of body weight. The fish also received formalin treatments as needed throughout the year to prevent and treat fungus infections. This was especially important during the pre-spawning period when individual fish were maturing in preparation for spawning. Formalin treatments were conducted three times per week and consist of one hour of flow-through at a concentration of 167 parts per million (ppm).

Second-Generation Health Maintenance

Following fertilization and initial incubation in September, second-generation (F_2) eggs were shocked in October. Eggs were treated with a 1,667 ppm formalin solution in a 15-minute flow-through treatment three times a week to prevent fungus growth. Formalin treatments ended after hatching, and water flow was increased from three to five gallons per minute. Dead and deformed fry were removed before relocating the fry to nursery tanks in late January or early February. Fry were then relocated to raceways in July, where they remained until transfer to the White River for acclimation the following March. Coded-wire tagging was typically conducted in July, and PIT tagging occurred the following January or February, just before the fish were transferred to acclimation facilities on the White River in March.

7.4 Natural Juvenile Productivity

Juvenile productivity estimation began with the monitoring of emigration of spring Chinook in the White River in 2007 (Lauver et al. 2012). A five-foot diameter rotary screw trap is operated annually from about 1 March through November. The purpose of the program is to estimate the number and timing of subyearlings and yearling spring Chinook emigrating from the White River basin.

Smolt and Emigrant Estimates

In 2015, the White River Trap operated between 1 March and 30 November 2015. During that time period the trap was inoperable for 42 days because of ice or debris accumulation, unsafe working conditions, or administrative reasons. Daily trap efficiencies were estimated by conducting mark-recapture trials. The daily number of fish captured was expanded by the estimated trap efficiency to estimate daily total emigration. In the event that trap efficiencies could not be assessed because of low numbers of juvenile Chinook trapped, a composite model based on efficiency trials from previous years was used to calculate abundance. Daily captures of fish and results of mark-recapture efficiency tests at the White River trap are reported in Appendix L.

Wild yearling spring Chinook (2013 brood year) were primarily captured from March through April 2015 (Figure 7.1). Based on a composite regression model, the total number of wild yearling Chinook emigrating from the White River was 3,023 (±2,728). Combining the total number of subyearling spring Chinook (2,461 ±779) that emigrated during the fall of 2014 with the total number of yearling Chinook (3,023) that emigrated during 2015 resulted in a total emigrant estimate of 5,484 (±2,836) spring Chinook for the 2013 brood year (Table 7.7).

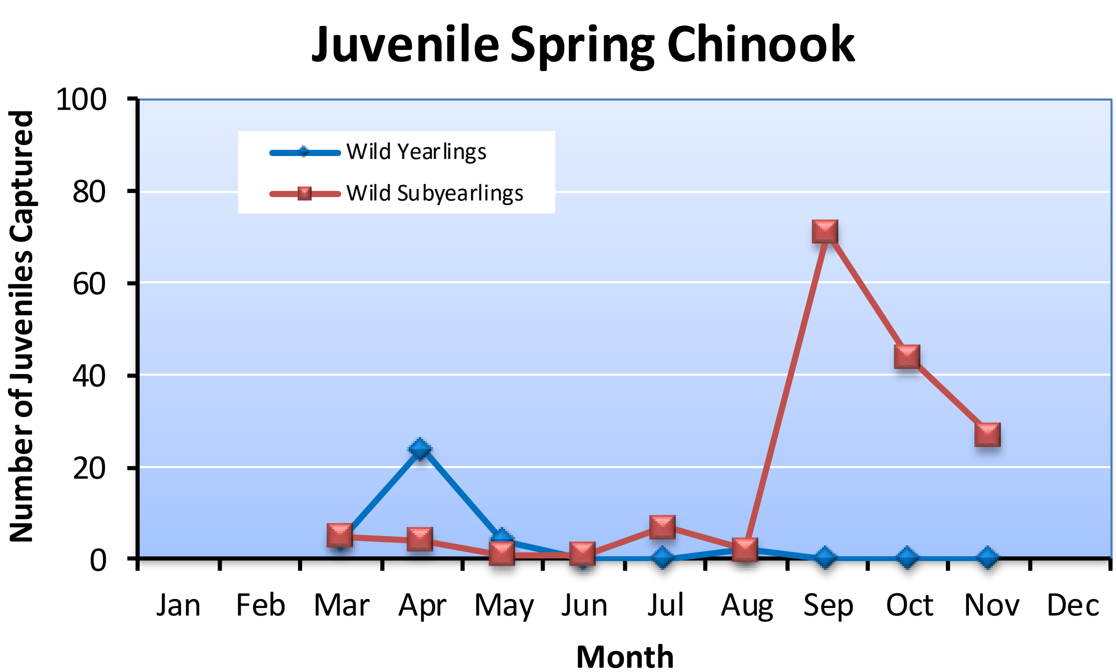

Figure 7.1. Monthly captures of wild subyearling (parr) and yearling spring Chinook at the White River Trap, 2015.

Table 7.7. Numbers of redds and juvenile spring Chinook at different life stages in the White River basin for brood years 2005-2014; ND = no data.

Brood year	Number of redds	Egg deposition[a]	Number of subyearling emigrants[b]	Number of smolts produced within White River basin	Number of emigrants
2005	86	372,122	ND	4,856	ND
2006	31	134,044	642	2,004	2,646
2007	20	88,820	2,293	3,399	5,692
2008	31	142,352	5,552	5,193	10,745
2009	54	246,942	2,485	2,939	5,424
2010	33	142,362	1,859	4,121	5,980
2011	20	87,700	3,128	1,659	4,787
2012	86	363,178	3,905	3,995	7,900
2013	54	254,664	2,461	3,023	5,484
2014	26	105,170	1,449	--	--
Average[c]	***42***	***193,735***	***2,642***	***3,465***	***6,082***
Median[c]	***32***	***142,357***	***2,461***	***3,399***	***5,588***

[a] Egg deposition is calculated as the number of redds times the fecundity of both wild and hatchery spring Chinook salmon (from Table 5.5.

[b] Subyearling emigrants do not include fry that left the watershed before 1 July.

[c] Average and median are based on the entire time series of data, not just the period 2006 through 2012.

Wild subyearling spring Chinook (2014 brood year) were captured between 26 July and 30 November 2015, with peak catch during September (Figure 7.1). Based on a composite regression model, the total number of wild subyearling Chinook emigrating from the White River was 1,449 (±421).

Yearling spring Chinook sampled in 2015 averaged 104 mm in length, 13.0 g in weight, and had a mean condition of 1.14 (Table 7.8). These estimates were greater than the overall mean of yearling spring Chinook sampled in previous years (overall means, 99 mm, 11.2 g, and 1.11). Subyearling spring Chinook parr sampled in 2015 at the White River Trap averaged 96 mm in length, averaged 9.9 g, and had a mean condition of 1.11 (Table 7.8). These estimates were greater than the overall mean of subyearling spring Chinook sampled in previous years (overall means, 90 mm, 8.5 g, and 1.09).

Table 7.8. Mean fork length (mm), weight (g), and condition factor of subyearling (parr) and yearling spring Chinook collected in the White River Trap, 2007-2015. Numbers in parentheses indicate 1 standard deviation.

Sample year	Life stage	Sample size[a]	Mean size		
			Length (mm)	Weight (g)	Condition (K)
2007	Subyearling	33	95 (12)	9.8 (4.1)	1.07 (0.11)
	Yearling	173	93 (9)	8.6 (2.2)	1.03 (0.09)
2008	Subyearling	202	95 (9)	9.4 (2.5)	1.08 (0.13)
	Yearling	105	100 (12)	11.3 (3.3)	1.07 (0.13)

Sample year	Life stage	Sample size[a]	Mean size		
			Length (mm)	Weight (g)	Condition (K)
2009	Subyearling	499	85 (11)	7.1 (2.6)	1.09 (0.11)
	Yearling	274	104 (6)	12.5 (2.6)	1.11 (0.10)
2010	Subyearling	168	87 (13)	7.8 (3.1)	1.12 (0.11)
	Yearling	346	100 (7)	11.2 (2.4)	1.12 (0.09)
2011	Subyearling	145	94 (9)	9.3 (2.5)	1.10 (0.10)
	Yearling	64	99 (8)	11.3 (2.8)	1.14 (0.09)
2012	Subyearling	285	91 (10)	8.9 (2.7)	1.13 (0.09)
	Yearling	179	98 (8)	10.9 (2.8)	1.14 (0.08)
2013	Subyearling	444	84 (12)	6.6 (2.5)	1.05 (0.09)
	Yearling	20	102 (7)	12.3 (3.0)	1.12 (0.14)
2014	Subyearling	185	86 (14)	7.5 (3.3)	1.10 (0.11)
	Yearling	43	94 (7)	9.4 (2.2)	1.11 (0.13)
2015	Subyearling	148	96 (8)	9.9 (2.3)	1.11 (0.07)
	Yearling	31	104 (7)	13.0 (2.8)	1.14 (0.07)
Average	***Subyearling***	***234***	***90 (5)***	***8.5 (1.2)***	***1.09 (0.03)***
	Yearling	***137***	***99 (4)***	***11.2 (1.4)***	***1.11 (0.04)***
Median	***Subyearling***	***185***	***91 (5)***	***8.9 (1.2)***	***1.10 (0.03)***
	Yearling	***105***	***100 (4)***	***11.3 (1.4)***	***1.12 (0.04)***

[a] Sample size represents the number of fish that were measured for both length and weight.

Freshwater Productivity

Both productivity and survival estimates for different life stages of spring Chinook in the White River basin are provided in Table 7.9. Estimates for brood year 2013 fall within the range of productivity and survival estimates for brood years 2005-2013. During that period, freshwater productivities ranged from 46-170 smolts/redd and 85-347 emigrants/redd. Survivals during the same period ranged from 1.1-3.8% for egg-smolt and 2.0-7.5% for egg-emigrants.

Table 7.9. Productivity (fish/redd) and survival (%) estimates for different juvenile life stages of spring Chinook in the White River basin for brood years 2005-2013. These estimates were derived from data in Table 7.7.

Brood year	Smolts/Redd[a]	Emigrants/ Redd	Egg-Smolt[a] (%)	Egg-Emigrant (%)
2005	56	ND	1.3	ND
2006	65	85	1.5	2.0
2007	170	285	3.8	6.4
2008	168	347	3.6	7.5
2009	54	100	1.2	2.2
2010	125	181	2.9	4.2
2011	83	239	1.9	5.5
2012	46	92	1.1	2.2
2013	56	102	1.2	2.2

Brood year	Smolts/Redd[a]	Emigrants/ Redd	Egg-Smolt[a] (%)	Egg-Emigrant (%)
Average	***91***	***179***	***2.1***	***4.0***
Median	***65***	***141***	***1.5***	***3.2***

[a] These estimates include White River smolts produced only within the White River basin.

Seeding level (egg deposition) explained part of the variability in productivity and survival of juvenile spring Chinook in the White River basin. That is, for estimates based on smolts produced within the White River basin, survival and productivity decreased as seeding levels increased (Figure 7.2). This suggests that density dependence in part regulates juvenile productivity and survival within the White River basin.

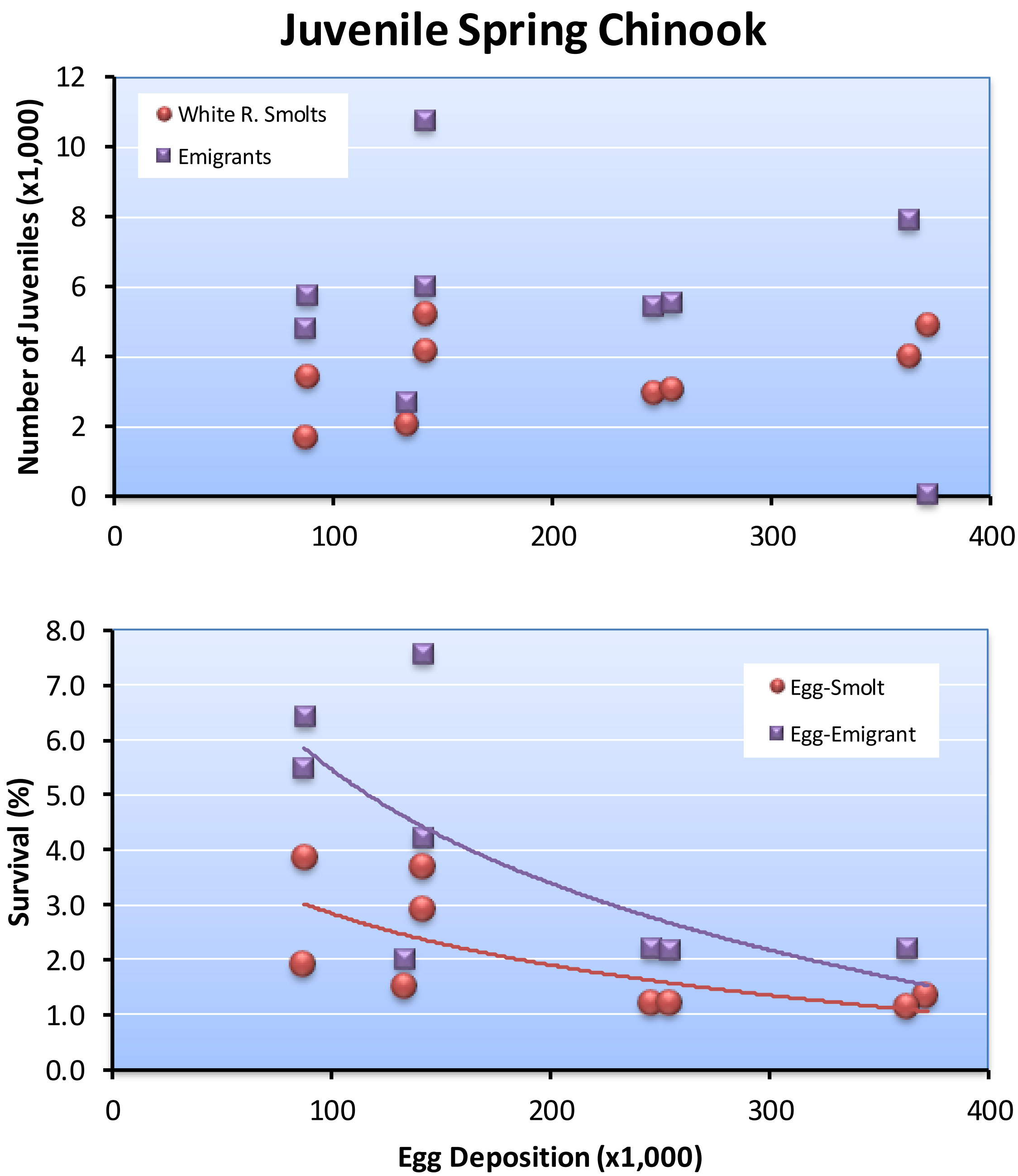

Figure 7.2. Relationships between seeding levels (egg deposition) and juvenile life-stage survivals and productivities for White River spring Chinook, brood years 2005-2013. White River smolts are smolts produced only within the White River basin.

Population Carrying Capacity

Population carrying capacity (*K*) is defined as the maximum equilibrium population size estimated with population models (e.g., logistic equation, Beverton-Holt model, hockey stick model, and the

Ricker model).[15] Maximum equilibrium population size is generated from density dependent mechanisms that reduce population growth rates as population size increases (negative density dependence). This is referred to as compensation. Population size fluctuates about the maximum equilibrium size because of variability in vital rates that are unrelated to density (density independent factors) and measurement error. In this section, we estimate smolt carrying capacities using the Ricker stock-recruitment model (see Appendix C in Hillman et al. 2012 for a detailed description of methods). The Ricker model was the only stock-recruitment model that could be fit to the juvenile spring Chinook data.

Based on the Ricker model, the population carrying capacity for spring Chinook smolts in the White River basin is 3,605 smolts (95% CI: 0 – 5,762) (Figure 7.3). Here, smolts are defined as the number of yearling spring Chinook produced entirely within the White River basin. These estimates reflect current conditions (most recent decades) within the White River basin. Land use activities such as logging, roads, development, and recreation have altered the historical conditions of the watershed. Thus, the estimated population capacity estimates may not reflect historical capacities for spring Chinook smolts in the White River basin.

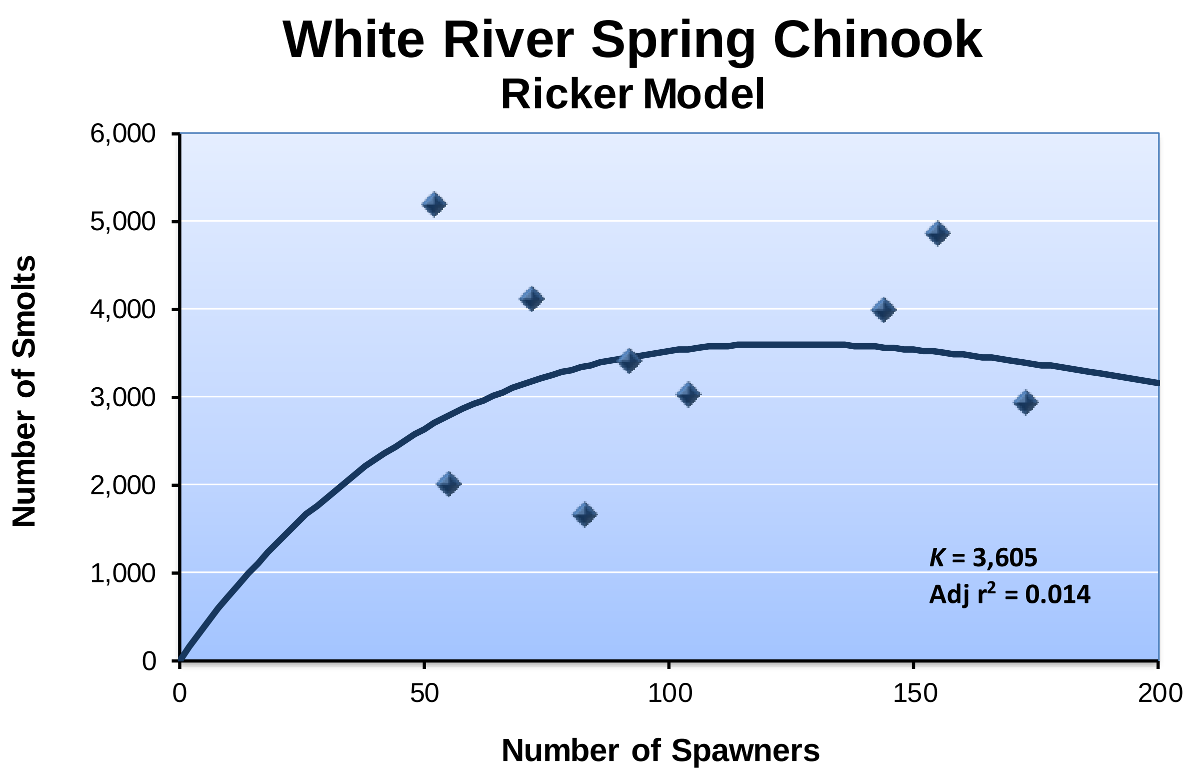

Figure 7.3. Relationship between spawners and number of smolts produced in the White River basin. Population carrying capacity (*K*) was estimated using the Ricker model.

15 Population carrying capacity (*K*) should not be confused with habitat carrying capacity (*C*), which is defined as the maximum population of a given species that a particular environment can sustain.

We tracked the precision of the Ricker parameters for White River spring Chinook smolts over time to see if precision improves with additional years of data, and the parameters and statistics stabilize over time. Examination of variation in the alpha (*A*) and beta (*B*) parameters of the Ricker model and their associated standard errors and confidence intervals indicates that the parameters appear to be stabilizing, but they still lack precision (Table 7.10; Figure 7.4). This was also apparent in the estimates of population carrying capacity (Figure 7.5).

Table 7.10. Estimated parameters and statistics associated with fitting the Ricker model to spawning escapement and smolt data. Smolts represent numbers of smolts produced entirely within the White River basin. *A* = alpha parameter; *B* = beta parameter; SE = standard error (estimated from 5,000 bootstrap samples); and r^2 = coefficient of determination. Spawners represent the stock size needed to achieve population capacity.

Years of data	Parameter				Population capacity	Intrinsic productivity	Spawners	r^2
	A	SE	*B*	SE				
5	95.89	44.84	0.0090	0.0040	3,928	96	111	0.001
6	100.65	37.65	0.0092	0.0034	4,007	101	108	0.019
7	81.75	36.97	0.0084	0.0042	3,602	82	120	0.001
8	80.32	32.78	0.0080	0.0036	3,675	80	124	0.009
9	78.79	42.85	0.0080	0.0037	3,605	79	124	0.014

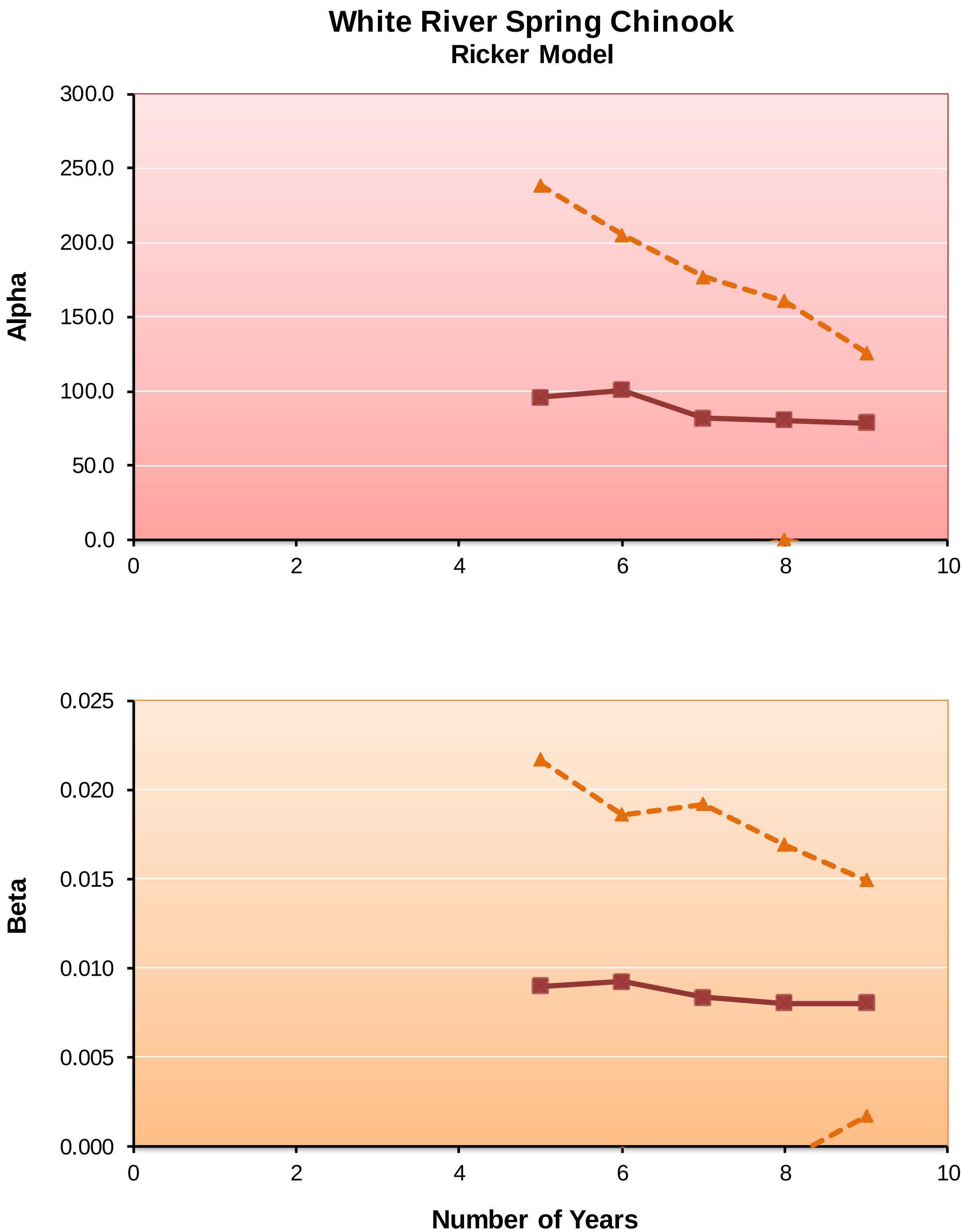

Figure 7.4. Time series of alpha and beta parameters and 95% confidence intervals for the Ricker model that was fit to White River spring Chinook smolt and spawning escapement data. Confidence intervals were estimated from 5,000 bootstrap samples.

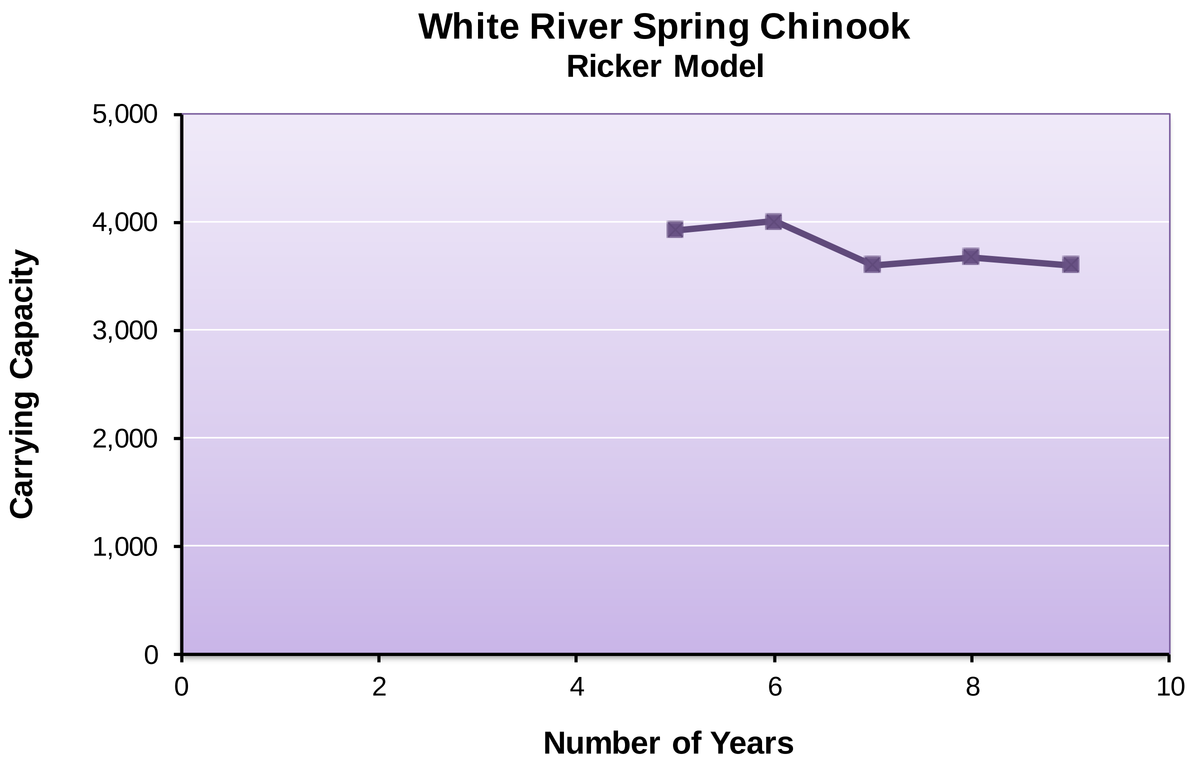

Figure 7.5. Time series of population carrying capacity estimates derived from fitting the Ricker model to White River spring Chinook smolt and spawning escapement data.

7.5 Spawning Surveys

Surveys for spring Chinook redds were conducted during August through September, 2015, in the Chiwawa River (including Rock and Chikamin creeks), Nason Creek, Icicle Creek, Peshastin Creek (including Ingalls Creek), Upper Wenatchee River (including Chiwaukum Creek), Little Wenatchee River, and White River (including the Napeequa River and Panther Creek). See Section 5.5 for a complete coverage of spring Chinook redd surveys in the Wenatchee River basin. In the following section we describe the number and distribution of redds within the White River basin.

Redd Counts and Distribution

A total of 70 spring Chinook redds were counted in the White River basin in 2015 (Table 7.11; see Table 5.20 for the complete time series of redd counts). This is higher than the average of 34 redds counted during the period 1989-2014 in the White River. Redds were not distributed evenly among the six survey areas in the White River basin. Most were located in Reach 3 (Napeequa River to Grasshopper Meadows) in the White River (Table 7.11).

Table 7.11. Numbers and proportions of spring Chinook redds counted within different survey areas within the White River basin during August through September, 2015. See Table 2.8 for description of survey reaches.

Stream/watershed	Reach	Number of redds	Proportion of redds within stream/watershed
White River	White 2 (H2)	4	0.06
	White 3 (H3)	63	0.90
	White 4 (H4)	2	0.03
	Napeequa 1 (Q1)	1	0.01
	Panther 1 (T1)	0	0.00
Total		***70***	***1.00***

Spawn Timing

Spring Chinook began spawning during the first week of August in the White River and peaked the second week of September (Figure 7.6). Spawning in the White River ended the third week of September.

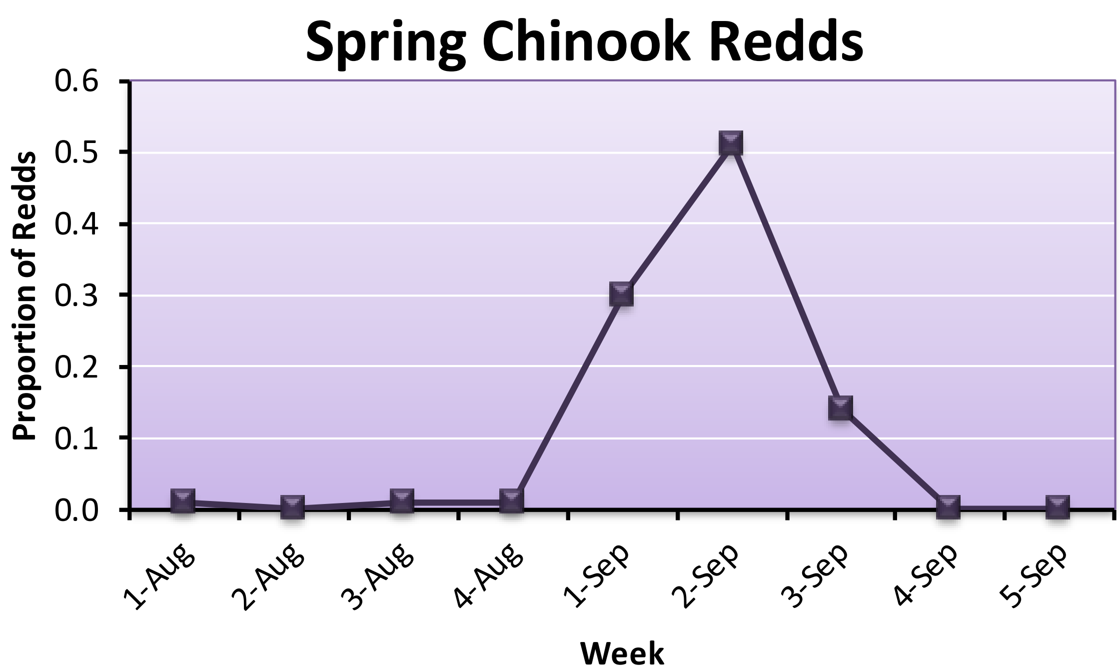

Figure 7.6. Proportion of spring Chinook redds counted during different weeks within the White River basin, August through September 2015.

Spawning Escapement

Spawning escapement for spring Chinook was calculated as the number of redds times the male-to-female ratio (i.e., fish per redd expansion factor) estimated from broodstock and fish sampled at adult trapping sites. The estimated fish per redd ratio for spring Chinook upstream from Tumwater in 2015 was 1.78 (based on sex ratios estimated at Tumwater Dam). Multiplying this ratio by the number of redds counted in the White River basin resulted in a total spawning escapement of 125 spring Chinook. The estimated total spawning escapement of spring Chinook in 2015 was greater than the overall average of 76 spring Chinook in the White River basin (see Table 5.23).

7.6 Carcass Surveys

Surveys for spring Chinook carcasses were conducted during August through September, 2015, in the Chiwawa River (including Rock and Chikamin creeks), Nason Creek, Icicle Creek, Peshastin Creek, Upper Wenatchee River (including Chiwaukum Creek), Little Wenatchee River, and White River (including the Napeequa River and Panther Creek). In 2015, 25 spring Chinook carcasses were sampled in the White River basin. Most of these were sampled in Reach 3. The total number of carcasses sampled in 2015 was more than the overall average of 17 carcasses sampled during the period 1996-2014. See Section 5.6 for a complete coverage of spring Chinook carcass surveys in the Wenatchee River basin.

In the White River basin, the spatial distribution of hatchery strays (primarily from the Chiwawa Spring Chinook program) and wild spring Chinook was not equal (Table 7.12). Reach 2 had a higher proportion of hatchery fish (80%), while Reach 3 had primarily wild fish (70%). In 2015, most carcasses (80%) were observed in the reach between the Napeequa River and Grasshopper Meadows (Reach 3) (Table 7.12). Over the years, spring Chinook have spawned more often in this reach than in other reaches (Figure 7.7). A total of nine captive brood carcasses have been identified on the spawning grounds. They were found in Reaches 2 and 3. The low recoveries of captive brood fish may be because captive brood returns were not adipose-fin clipped and therefore any returns from the captive brood program may have been included inadvertently with wild fish.

Table 7.12. Numbers of wild, hatchery strays, and captive brood spring Chinook carcasses sampled within different reaches in the White River basin, 2000-2015. See Table 2.8 for description of survey reaches.

Survey year	Origin	Survey Reach					Total
		H-2	H-3	H-4	Napeequa	Panther	
2000	Wild	1	0	0	0	0	**1**
	Hatchery Strays	0	0	0	0	0	**0**
2001	Wild	5	40	5	3	1	**54**
	Hatchery Strays	1	19	3	1	2	**26**
2002	Wild	3	15	0	0	0	**18**
	Hatchery Strays	0	6	0	0	1	**7**
2003	Wild	0	6	0	0	0	**6**
	Hatchery Strays	0	1	1	0	0	**2**
2004	Wild	1	9	1	0	0	**11**
	Hatchery Strays	0	1	0	0	1	**2**
2005	Wild	1	10	0	1	0	**12**
	Hatchery Strays	3	37	0	0	0	**40**
	Captive Brood	0	0	0	0	0	**0**
2006	Wild	2	16	0	1	0	**19**
	Hatchery Strays	0	6	0	0	0	**6**
	Captive Brood	0	0	0	0	0	**0**
2007	Wild	1	6	0	0	2	**9**

Survey year	Origin	Survey Reach					Total
		H-2	H-3	H-4	Napeequa	Panther	
	Hatchery Strays	0	4	0	0	0	**4**
	Captive Brood	0	0	0	0	0	**0**
2008	Wild	1	3	0	0	1	**5**
	Hatchery Strays	2	5	0	0	1	**8**
	Captive Brood	0	0	0	0	0	**0**
2009	Wild	0	9	0	0	0	**9**
	Hatchery Strays	0	8	0	0	3	**11**
	Captive Brood	0	0	0	0	0	**0**
2010	Wild	0	4	0	0	0	**4**
	Hatchery Strays	0	7	0	0	0	**7**
	Captive Brood	0	0	0	0	0	**0**
2011	Wild	0	4	0	0	0	**4**
	Hatchery Strays	0	0	0	0	0	**0**
	Captive Brood	0	0	0	0	0	**0**
2012	Wild	0	13	0	0	0	**13**
	Hatchery Strays	0	8	0	0	0	**8**
	Captive Brood	0	0	0	0	0	**0**
2013	Wild	0	8	0	0	0	**8**
	Hatchery Strays	0	10	0	0	3	**13**
	Captive Brood	0	2	0	0	0	**2**
2014	Wild	0	6	0	0	0	**6**
	Hatchery Strays	0	2	0	0	0	**2**
	Captive Brood	0	0	0	0	0	**0**
2015	Wild	0	14	0	0	0	**14**
	Hatchery Strays	1	3	0	0	0	**4**
	Captive Brood	3	4	0	0	0	**7**
Average	***Wild***	***1***	***10***	***0***	***0***	***0***	***11***
	Hatchery Stray	***0***	***7***	***0***	***0***	***1***	***8***
	Captive Brood	***0***	***1***	***0***	***0***	***0***	***1***
Median	***Wild***	***1***	***9***	***0***	***0***	***0***	***10***
	Hatchery Stray	***0***	***6***	***0***	***0***	***0***	***6***
	Captive Brood	***0***	***0***	***0***	***0***	***0***	***1***

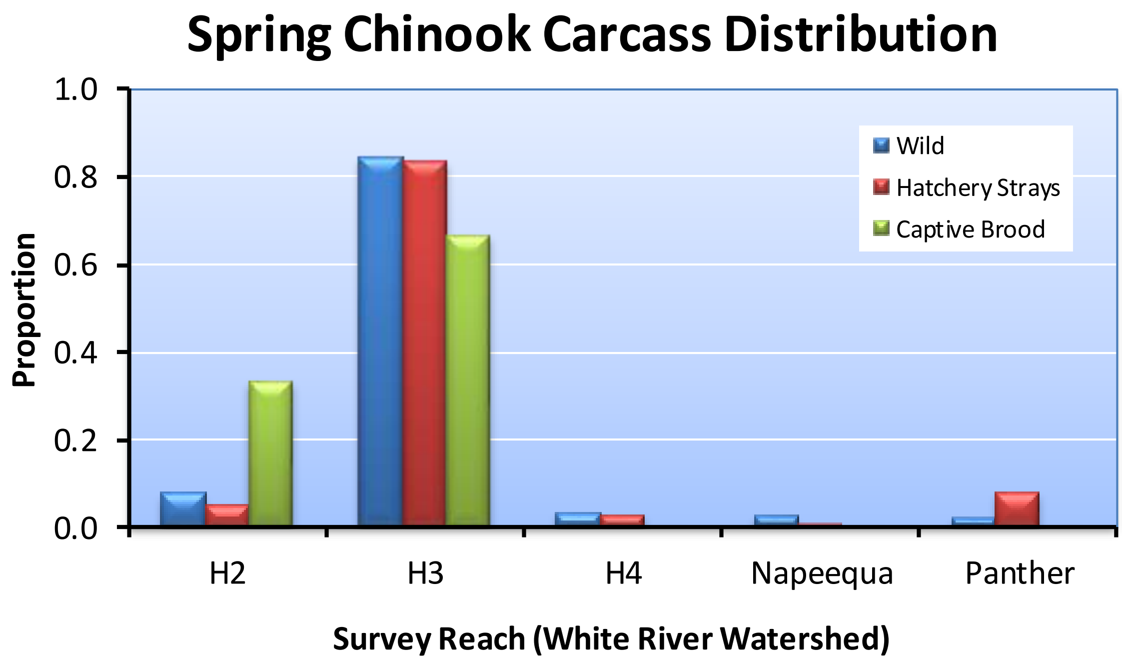

Figure 7.7. Distribution of wild, hatchery strays, and captive brood produced carcasses in different reaches in the White River basin, 2000-2015. Reach codes are described in Table 2.8.

7.7 Life History Monitoring

Life history characteristics of spring Chinook were assessed by examining carcasses on spawning grounds and fish collected at broodstock collection sites, and by reviewing tagging data and fisheries statistics.

Migration Timing

See Section 5.7 for a description of migration timing of spring Chinook at Tumwater Dam.

Age at Maturity

Most of the wild and hatchery stray spring Chinook sampled during the period 2001-2015 in the White River basin were age-4 fish (total age) (Table 7.13; Figure 7.8). A higher proportion of age-5 wild fish returned than did age-5 hatchery strays. Thus, wild fish tended to return at an older age than hatchery strays. At this time, few captive brood carcasses have been identified on the spawning grounds; most were age-4 and one was age-5. There has been a conspicuous absence of age-3 fish recovered as carcasses. In all years except 2007, no age-3 carcasses have been recovered.

Table 7.13. Numbers of wild, hatchery strays, and captive brood spring Chinook of different ages (total age) sampled on spawning grounds in the White River basin, 2001-2015.

Sample year	Origin	Total age					Sample size
		2	3	4	5	6	
2001	Wild	0	0	47	0	0	**47**
	Hatchery Strays	0	0	27	0	0	**27**
2002	Wild	0	0	7	11	0	**18**

Sample year	Origin	Total age					Sample size
		2	3	4	5	6	
	Hatchery Strays	0	0	6	1	0	**7**
2003	Wild	0	0	0	6	0	**6**
	Hatchery Strays	0	0	0	1	0	**1**
2004	Wild	0	0	9	0	0	**9**
	Hatchery Stray	0	0	2	0	0	**2**
2005	Wild	0	0	12	0	0	**12**
	Hatchery Strays	0	0	40	0	0	**40**
	Captive Brood	0	0	0	0	0	**0**
2006	Wild	0	0	7	12	0	**19**
	Hatchery Strays	0	0	3	3	0	**6**
	Captive Brood	0	0	0	0	0	**0**
2007	Wild	0	0	1	8	0	**9**
	Hatchery Strays	0	2	2	0	0	**4**
	Captive Brood	0	0	0	0	0	**0**
2008	Wild	0	0	4	1	0	**5**
	Hatchery Strays	0	0	8	0	0	**8**
	Captive Brood	0	0	0	0	0	**0**
2009	Wild	0	0	8	1	0	**9**
	Hatchery Strays	1	0	10	0	0	**11**
	Captive Brood	0	0	0	0	0	**0**
2010	Wild	0	0	4	0	0	**4**
	Hatchery Strays	0	0	6	0	0	**6**
	Captive Brood	0	0	0	0	0	**0**
2011	Wild	0	0	0	4	0	**4**
	Hatchery Strays	0	0	0	0	0	**0**
	Captive Brood	0	0	0	0	0	**0**
2012	Wild	0	0	13	0	0	**13**
	Hatchery Strays	0	0	8	0	0	**8**
	Captive Brood	0	0	0	0	0	**0**
2013	Wild	0	0	6	2	0	**8**
	Hatchery Strays	0	0	11	1	0	**12**
	Captive Brood	0	0	1	1	0	**2**
2014	Wild	0	0	54	10	0	**64**
	Hatchery Strays	0	0	21	0	0	**21**
	Captive Brood	0	0	0	0	0	**0**
2015	Wild	0	0	13	1	0	**14**
	Hatchery Strays	0	0	4	0	0	**4**
	Captive Brood	0	0	7	0	0	**7**

Sample year	Origin	Total age					Sample size
		2	3	4	5	6	
Average	*Wild*	*0*	*0*	*9*	*3*	*0*	*12*
	Hatchery Strays	*0*	*0*	*9*	*0*	*0*	*9*
	Captive Brood	*0*	*0*	*1*	*0*	*0*	*1*
Median	*Wild*	*0*	*0*	*7*	*1*	*0*	*8*
	Hatchery Strays	*0*	*0*	*6*	*0*	*0*	*6*
	Captive Brood	*0*	*0*	*0*	*0*	*0*	*0*

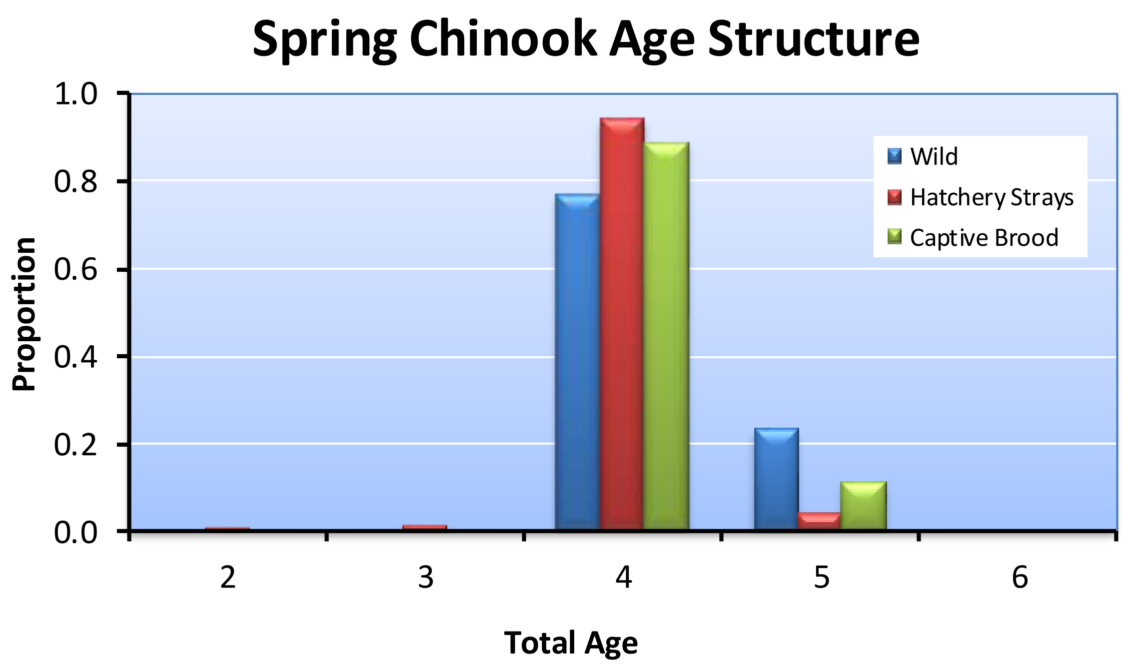

Figure 7.8. Proportions of wild, hatchery strays, and captive brood spring Chinook of different total ages sampled on spawning grounds in the White River basin for the combined years 2000-2015.

For comparison, Table 7.14 and Figure 7.9 show the age structure of spring Chinook carcasses sampled in the Little Wenatchee River. Similar to the White River, most of the wild and hatchery stray spring Chinook sampled during the period 2001-2015 in the Little Wenatchee River basin were age-4 fish (total age). A higher proportion of age-5 wild fish returned than did age-5 hatchery strays. Thus, wild fish tended to return at an older age than hatchery strays. As in the White River, very few age-3 fish have been recovered in the Little Wenatchee River.

Table 7.14. Numbers of wild and hatchery stray spring Chinook of different ages (total age) sampled on spawning grounds in the Little Wenatchee River basin, 2001-2015.

Sample year	Origin	Total age					Sample size
		2	3	4	5	6	
2001	Wild	0	0	31	2	0	**33**
	Hatchery Strays	0	0	33	1	0	**34**
2002	Wild	0	0	6	8	0	**14**
	Hatchery Strays	0	0	12	2	0	**14**
2003	Wild	0	0	1	3	0	**4**
	Hatchery Strays	0	0	0	4	0	**4**
2004	Wild	0	0	1	0	0	**1**
	Hatchery Stray	0	0	0	0	0	**0**
2005	Wild	0	0	16	0	0	**16**
	Hatchery Strays	0	0	32	0	0	**32**
2006	Wild	0	0	4	4	0	**8**
	Hatchery Stray	0	1	0	3	0	**4**
2007	Wild	0	0	2	10	0	**12**
	Hatchery Strays	0	1	2	0	0	**3**
2008	Wild	0	0	3	0	0	**3**
	Hatchery Stray	0	0	12	0	0	**12**
2009	Wild	0	0	6	0	0	**6**
	Hatchery Strays	0	1	12	0	0	**13**
2010	Wild	0	0	2	0	0	**2**
	Hatchery Stray	0	0	5	0	0	**5**
2011	Wild	0	0	3	1	0	**4**
	Hatchery Strays	0	2	1	0	0	**3**
2012	Wild	0	0	12	2	0	**14**
	Hatchery Stray	0	0	9	1	0	**10**
2013	Wild	0	0	9	7	0	**16**
	Hatchery Strays	0	0	4	0	0	**4**
2014	Wild	0	1	8	2	0	**11**
	Hatchery Stray	0	0	1	0	0	**1**
2015	Wild	0	0	8	3	0	**11**
	Hatchery Strays	0	0	1	0	0	**1**
Average	***Wild***	***0***	***0***	***7***	***3***	***0***	***10***
	Hatchery Strays	***0***	***0***	***8***	***1***	***0***	***9***
Median	***Wild***	***0***	***0***	***6***	***2***	***0***	***11***
	Hatchery Strays	***0***	***0***	***8***	***1***	***0***	***9***

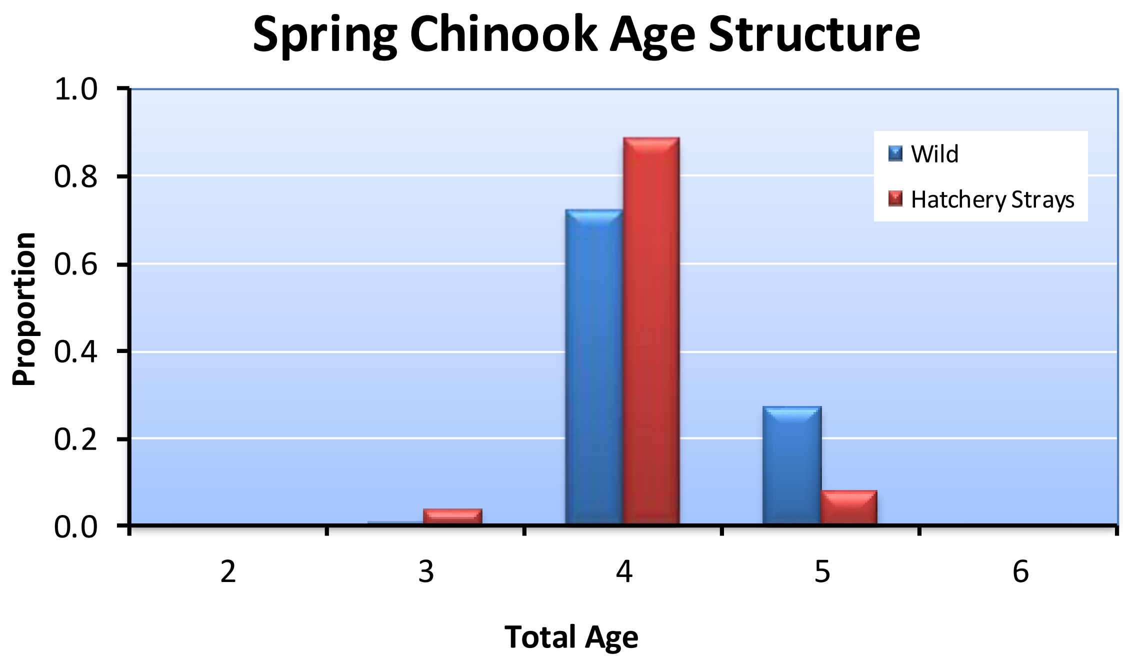

Figure 7.9. Proportions of wild and hatchery stray spring Chinook of different total ages sampled on spawning grounds in the Little Wenatchee River basin for the combined years 2000-2015.

Size at Maturity

On average, hatchery strays and wild spring Chinook of a given age differed little in length (Table 7.15). Differences were usually no more than 8 cm between hatchery strays and wild fish of the same age. Few captive brood carcasses have been identified on the spawning grounds; most were females. Those fish were the same size as wild and hatchery strays of the same age.

Table 7.15. Mean lengths (POH in cm; ±1SD) and sample sizes (in parentheses) of different ages (total age) of male and female spring Chinook of wild, hatchery strays, and captive brood origin sampled in the White River basin, 2001-2015.

Return year	Total age	Mean length (cm)					
		Male			Female		
		Wild	Hatchery stray	Captive brood	Wild	Hatchery stray	Captive brood
2001	3	0	0	0	0	0	0
	4	65 ±3 (17)	66 ±4 (5)	0	63 ±3 (30)	63 ±4 (21)	0
	5	0	0	0	0	0	0
	6	0	0	0	0	0	0
2002	3	0	0	0	0	0	0
	4	66 ±0 (1)	69 ±0 (1)	0	63 ±4 (6)	59 ±6 (5)	0
	5	75 ±11 (2)	0	0	72 ±3 (9)	72 ±0 (1)	0
	6	0	0	0	0	0	0
2003	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	0	0	0	75 ±5 (6)	73 ±0 (1)	0

Return year	Total age	Mean length (cm)					
		Male			Female		
		Wild	Hatchery stray	Captive brood	Wild	Hatchery stray	Captive brood
	6	0	0	0	0	0	0
2004	3	0	0	0	0	0	0
	4	68 ±3 (3)	0	0	63 ±3 (6)	59 ±2 (2)	0
	5	0	0	0	0	0	0
	6	0	0	0	0	0	0
2005	3	0	0	0	0	0	0
	4	64 ±5 (3)	62 ±7 (5)	0	63 ±5 (8)	62 ±4 (33)	0
	5	0	0	0	0	0	0
	6	0	0	0	0	0	0
2006	3	0	0	0	0	0	0
	4	65 ±2 (3)	0	0	61 ±4 (4)	60 ±2 (3)	0
	5	69 ±4 (4)	0	0	67 ±5 (8)	70 ±5 (3)	0
	6	0	0	0	0	0	0
2007	3	0	49 ±5 (2)	0	0	0	0
	4	0	0	0	58 ±0 (1)	66 ±2 (2)	0
	5	75 ±5 (3)	0	0	75 ±1 (5)	0	0
	6	0	0	0	0	0	0
2008	3	0	0	0	0	0	0
	4	56 ±0 (1)	61 ±0 (1)	0	63 ±8 (2)	61 ±2 (7)	0
	5	0	0	0	75 ±0 (1)	0	0
	6	0	0	0	0	0	0
2009	3	0	0	0	0	0	0
	4	61 ±5 (3)	68 ±4 (2)	0	63 ±2 (5)	62 ±2 (8)	0
	5	0	0	0	78 ±0 (1)	0	0
	6	0	0	0	0	0	0
2010	3	0	0	0	0	0	0
	4	0	67 ±0 (1)	0	60 ±3 (3)	61 ±6 (5)	0
	5	0	0	0	0	0	0
	6	0	0	0	0	0	0
2011	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	0	0	0	73 ±5 (4)	0	0
	6	0	0	0	0	0	0
2012	3	0	0	0	0	0	0
	4	47 ±0 (1)	0	0	62 ±4 (12)	60 ±4 (8)	0
	5	0	0	0	0	0	0
	6	0	0	0	0	0	0
2013	3	0	0	0	0	0	0
	4	64 ±4 (3)	60 ±4 (2)	0	61 ±2 (3)	61 ±4 (7)	63 ±0 (1)
	5	0	0	0	67 ±1 (2)	71 ±0 (1)	71 ±0 (1)

Return year	Total age	Mean length (cm)					
		Male			Female		
		Wild	Hatchery stray	Captive brood	Wild	Hatchery stray	Captive brood
	6	0	0	0	0	0	0
2014	3	0	0	0	0	0	0
	4	0	54 ±0 (1)	0	60 ±2 (4)	58 ±0 (1)	0
	5	0	0	0	74 ±0 (1)	0	0
	6	0	0	0	0	0	0
2015	3	0	0	0	0	0	0
	4	60 ±6 (5)	74 ±0 (1)	61 ±0 (1)	64 ±5 (8)	64 ±4 (3)	64 ±5 (6)
	5	0	0	0	75 ±0 (1)	0	0
	6	0	0	0	0	0	0

Contribution to Fisheries

No White River spring Chinook from the captive brood program tagged with CWTs or PIT tags have been recaptured (or reported) in ocean or Columbia River (tribal, commercial, or recreational) fisheries.

Straying

Stray rates of White River spring Chinook from the captive brood program were determined by examining the locations where PIT-tagged Chinook demonstrating anadromy (based on detections at Bonneville Dam) were last detected. PIT tagging of White River spring Chinook began with release year 2008, which allows estimation of stray rates by brood return. Targets for strays based on return year (recovery year) within the Wenatchee River basin should be less than 10% and targets for strays outside the Wenatchee River basin should be less than 5%. The target for brood year stray rates should be less than 5%.

Based on PIT-tag analyses, on average, about 57% of the White River spring Chinook returns were last detected in streams outside the White River (Table 7.16). The numbers in Table 7.16 should be considered rough estimates because they are not based on confirmed spawning (only last detections) and they represent small sample sizes. In addition, last detections in adult fishways (i.e., Bonneville, Rock Island, and Tumwater dams) were not included, nor were detections in areas outside the distribution of known spring Chinook spawning (i.e., Lower and Middle Wenatchee River). All fish reported in Table 7.16 are at least age-3 fish (total age) and some of them may not have migrated to the ocean but rather resided completely in freshwater.

Table 7.16. Number and percent of White River spring Chinook from the captive brood program that homed to target spawning areas on the White River and the target hatchery program (Little White Salmon Fish Hatchery), and number and percent that strayed to non-target spawning areas and hatchery programs for brood years 2006-2010. Only PIT-tagged fish demonstrating anadromy were included in the analysis. Estimates were based on last detections of PIT-tagged spring Chinook. Percent strays should be less than 5%.

Brood year	Homing				Straying			
	Target stream		Target hatchery*		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
2006	1	100.0	0	0.0	0	0.0	0	0.0
2007	0	0.0	0	0.0	0	0.0	0	0.0
2008	0	0.0	0	0.0	15	100.0	0	0.0
2009	4	14.3	0	0.0	25	85.7	0	0.0
2010	0	0.0	0	0.0	6	100.0	0	0.0
Average	***1***	***22.9***	***0***	***0.0***	***9.2***	***57.1***	***0***	***0.0***
Median	***0***	***0.0***	***0***	***0.0***	***6***	***85.7***	***0***	***0.0***

* Homing to the target hatchery includes White River hatchery spring Chinook that are captured and included as broodstock in the White River Hatchery program.

The percentage of the PIT-tagged White River spring Chinook from the captive brood program that were last detected in different watersheds within and outside the Wenatchee River basin are shown in Table 7.17. On average, a small percentage of the PIT-tagged White River spring Chinook homed to the White River. Relatively high percentages of them were last detected in the Little Wenatchee River, Upper Wenatchee River, Nason Creek, and the Chiwawa River.

Few returning adults have strayed into spawning areas outside the Wenatchee River basin. One was last detected in the Entiat River. No other returning adults were detected outside the Wenatchee River basin. On the other hand, several juveniles were last detected in rivers outside the Wenatchee River basin. Juveniles were last detected in the Deschutes, Walla Walla, Hood, and North Fork Teanaway rivers. Juveniles were also last detected at the Little White Salmon Fish Hatchery. There is no evidence that these fish entered the ocean and returned as adults.

Table 7.17. Number and percent (in parentheses) of PIT-tagged White River spring Chinook from the captive brood program that were last detected in different tributaries within the Wenatchee River basin, return years 2010-2015. Only PIT-tagged fish demonstrating anadromy were included in the analysis.

Return year	Homing	Straying							
	White River	Chiwawa River	Chiwaukum Creek	Icicle Creek	Little Wenatchee	Nason Creek	Peshastin Creek	Upper Wenatchee	Entiat River
2010	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
2011	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)
2012	2 (16.7)	1 (8.3)	0 (0.0)	0 (0.0)	8 (66.7)	1 (8.3)	0 (0.0)	0 (0.0)	0 (0.0)
2013	2 (6.7)	8 (26.7)	1 (3.3)	2 (6.7)	7 (23.3)	8 (26.7)	0 (0.0)	2 (6.7)	0 (0.0)
2014	4 (8.3)	17 (35.4)	0 (0.0)	1 (2.1)	3 (6.3)	17 (35.4)	0 (0.0)	5 (10.4)	1 (2.1)
2015	10 (23.3)	24 (55.8)	1 (2.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (.0.0)	8 (18.6)	0 (0.0)
Average	***3 (25.8)***	***8 (21.0)***	***0 (0.9)***	***1(1.5)***	***3 (24.4)***	***5 (20.1)***	***0 (.0.0)***	***3 (5.9)***	***0 (0.3)***
Median	***2 (12.5)***	***5 (17.5)***	***0 (0.0)***	***0 (0.0)***	***2 (14.8)***	***1 (17.5)***	***0 (.0.0)***	***1(3.3)***	***0 (0.0)***

Genetics

At this time, there are no studies that examine the effects of the White River captive brood program on the genetics of natural-origin spring Chinook in the Wenatchee River basin. However, genetic studies were conducted to determine the potential effects of the Chiwawa Supplementation Program on natural-origin spring Chinook in the upper Wenatchee River basin (Blankenship et al. 2007; the entire report is appended as Appendix J). This work included the analysis of White River spring Chinook. Researchers collected microsatellite DNA allele frequencies from temporally replicated natural and hatchery-origin spring Chinook to statistically assign individual fish to specific demes (locations) within the Wenatchee population.

Significant differences in allele frequencies were observed within and among major spawning areas in the Upper Wenatchee River basin. However, these differences made up only a very small portion of the overall variation, indicating genetic similarity among the major spawning areas. There was no evidence that the Chiwawa program has changed the genetic structure (allele frequency) of spring Chinook in the White River, despite the presence of hatchery-origin spawners in both systems.

Proportionate Natural Influence

Another method for assessing the genetic risk of a supplementation program is to determine the influence of the hatchery and natural environments on the adaptation of the composite population. This is estimated by the proportion of natural-origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery-origin fish in the natural spawning escapement (pHOS). We calculated Proportionate Natural Influence (PNI) by iterating Ford's (2002) equations 5 and 6 to equilibrium, using a heritability of 0.3 and a selection strength of three standard deviations.[16] The larger the PNI value, the greater the strength of selection in the natural environment relative to that of the hatchery environment. In order for the natural environment to dominate selection, PNI should be greater than 0.50, and important integrated populations should have a PNI of at least 0.67 (HSRG/WDFW/NWIFC 2004).

For brood years 1989-2000, PNI values ranged from 0.95 to 1.00 (Table 7.18). For brood years 2001-2013, PNI for the White River Program averaged 0.60 (range, 0.33-1.00) (Table 7.18).

Table 7.18. Proportionate Natural Influence (PNI) values for hatchery spring Chinook spawning in the White River, brood years 1989-2013. See notes below the table for description of each metric.

Brood year	Spawners					Broodstock			PNI
	NOS	HOS_W	HOS_S	$pHOS_W$	$pHOS_S$	NOB_N	HOB_N	pNOB	
1989	145	0	0	0.00	0.00	0	0	*1.00*	1.00
1990	49	0	0	0.00	0.00	0	0	*1.00*	1.00
1991	49	0	0	0.00	0.00	0	0	*1.00*	1.00
1992	78	0	0	0.00	0.00	0	0	*1.00*	1.00

16 According to authorized annual take permits, PNI is calculated using the PNI approximate equation 11 (HSRG 2009; Appendix A). However, in this report, we used Ford's (2002) equations 5 and 6 with a heritability of 0.3 and a selection strength of three standard deviations to calculate PNI (C. Busack, NOAA Fisheries, 21 March 2016, provided the model for calculating PNI). This approach is more accurate than using the PNI approximate equation.

Brood year	Spawners					Broodstock			PNI
	NOS	HOS_W	HOS_S	$pHOS_W$	$pHOS_S$	NOB_N	HOB_N	pNOB	
1993	138	0	7	0.00	0.05	0	0	*0.99*	0.95
1994	7	0	0	0.00	0.00	0	0	*0.67*	1.00
1995	5	0	0	0.00	0.00	0	0	*1.00*	1.00
1996	30	0	0	0.00	0.00	0	0	*0.60*	1.00
1997	33	0	0	0.00	0.00	0	0	*0.30*	1.00
1998	11	0	0	0.00	0.00	0	0	*0.44*	1.00
1999	3	0	0	0.00	0.00	0	0	*1.00*	1.00
2000	22	0	0	0.00	0.00	0	0	*0.48*	1.00
Average*	***48***	***0***	***1***	***0.00***	***0.00***	***0***	***0***	***0.79***	***1.00***
Median*	***32***	***0***	***0***	***0.00***	***0.00***	***0***	***0***	***1.00***	***1.00***
2001	111	0	55	0.00	0.33	5	0	1.00	0.50
2002	60	0	26	0.00	0.30	18	0	1.00	0.51
2003	31	0	5	0.00	0.14	7	0	1.00	0.77
2004	54	0	12	0.00	0.18	6	0	1.00	0.70
2005	38	11	106	0.07	0.68	103	73	0.59	0.33
2006	41	5	9	0.09	0.16	191	135	0.59	0.61
2007	62	23	7	0.25	0.08	254	6	0.98	0.67
2008	20	2	30	0.04	0.58	116	0	1.00	0.34
2009	81	29	63	0.17	0.36	238	0	1.00	0.53
2010	27	22	23	0.31	0.32	90	0	1.00	0.50
2011	83	0	0	0.00	0.00	306	0	1.00	1.00
2012	89	10	45	0.07	0.31	390	0	1.00	0.73
2013	44	55	5	0.53	0.05	383	0	1.00	0.64
Average**	***57***	***12***	***30***	***0.12***	***0.27***	***162***	***16***	***0.94***	***0.60***
Median**	***54***	***5***	***23***	***0.07***	***0.30***	***116***	***0***	***1.00***	***0.61***

HOS_W = hatchery-origin spawners in White River from the White River spring Chinook Supplementation Program.
$pHOS_W$ = proportion of hatchery-origin spawners from White River spring Chinook Supplementation Program.
HOS_S = stray hatchery-origin spawners in the White River.
$pHOS_S$ = proportion of stray hatchery-origin spawners.
NOB_W = natural origin broodstock spawned for the White River spring Chinook Supplementation Program.
HOB_W = hatchery-origin broodstock spawned in the White River spring Chinook Supplementation Program.
pNOB = proportion of hatchery-origin broodstock. Because of the high incidence of strays to the White River from the Chiwawa River spring Chinook program, pNOB values from the Chiwawa program were used to estimate PNI values during the period from 1989 to 2000 (*italicized*). The weighting for those years was 100% based on the Chiwawa program broodstock selection, because there have been no hatchery returns from the White River spring Chinook program during this period (see Table 5.1 for Chiwawa broodstock selection).
PNI = Proportionate Natural Influence for White River spring Chinook calculated using the gene-flow model for multiple programs.
* Average and median for the period 1989-2000.
** Average and median for the period 2001-2013.

Natural and Hatchery Replacement Rates

In general, natural replacement rates (NRR) are calculated as the ratio of natural-origin recruits (NOR) to the parent spawning population (spawning escapement). Natural-origin recruits are naturally produced (wild) fish that survive to contribute to harvest (directly or indirectly), to broodstock, and to spawning grounds. We do not account for fish that died in route to the spawning grounds (migration mortality) or died just before spawning (pre-spawn mortality) (see Appendix

B in Hillman et al. 2012). We calculated NORs with and without harvest. NORs include all returning fish that either returned to the basin or were collected as wild broodstock. For brood years 1989-2009, NRR for spring Chinook in the White River basin averaged 1.05 (range, 0.00-4.91) if harvested fish were not included in the estimate and 1.27 (range, 0.00-5.91) if harvested fish were included in the estimate (Table 7.19). NRRs for more recent brood years will be calculated as soon as all tag recoveries and sampling rates have been loaded into the database.

Hatchery replacement rates (HRR) are the hatchery adult-to-adult returns and are calculated as the ratio of hatchery-origin recruits (HOR) to the parent broodstock collected. For brood years 2006-2009, hatchery replacement rates averaged 0.17 (range, 0.00-0.41) (Table 7.19). Only for brood year 2009 was HRR greater than the NRR. The HRR values would be much higher if they were calculated using the number of adult equivalents taken from the natural environment to initiate the captive brood program.

Table 7.19. Numbers of brood stock spawned, spawning escapements, hatchery origin recruits (HOR), natural-origin recruits (NOR), hatchery replacement rates (HRR), and natural replacement rates (NRR) with and without harvest for spring Chinook in the White River basin, brood years 1989-2009.

Brood year	Brood stock spawned	Spawning Escapement	Harvest not included				Harvest included			
			HOR[1]	NOR[2]	HRR[1]	NRR[2]	NOR[3]	NOR[4]	HRR[3]	NRR[4]
1989	--	145	--	81	--	0.56	--	118	--	0.81
1990	--	49	--	2	--	0.04	--	2	--	0.04
1991	--	49	--	3	--	0.06	--	3	--	0.06
1992	--	78	--	30	--	0.38	--	32	--	0.41
1993	--	145	--	44	--	0.30	--	45	--	0.31
1994	--	7	--	1	--	0.14	--	1	--	0.14
1995	--	5	--	9	--	1.80	--	9	--	1.80
1996	--	30	--	15	--	0.50	--	16	--	0.53
1997	--	33	--	148	--	4.48	--	173	--	5.24
1998	--	11	--	54	--	4.91	--	65	--	5.91
1999	--	3	--	0	--	0.00	--	0	--	0.00
2000	--	22	--	54	--	2.45	--	58	--	2.64
2001	5	166	--	64	--	0.39	--	66	--	0.40
2002	18	86	--	70	--	0.81	--	77	--	0.90
2003	7	36	--	11	--	0.31	--	12	--	0.33
2004	6	66	--	25	--	0.38	--	30	--	0.45
2005	176	155	--	72	--	0.46	--	79	--	0.51
2006	326	55	5	110	0.02	2.00	5	157	0.02	2.85
2007	260	92	0	0	0.00	0.00	0	0	0.00	0.00
2008	116	52	30	100	0.26	1.92	30	156	0.26	3.00
2009	238	173	98	39	0.41	0.23	98	52	0.41	0.30
Average	***128***	***69***	***33***	***44***	***0.17***	***1.05***	***33***	***55***	***0.17***	***1.27***
Median	***116***	***52***	***18***	***39***	***0.14***	***0.39***	***18***	***45***	***0.14***	***0.45***

[1] HOR and HRR values represented here are detections of PIT-tag hatchery fish detected at Tumwater Dam. These values have not been expanded based on the untagged proportion of fish released from the White River spring Chinook Program or the sampling rate at Tumwater Dam.
[2] NOR and NRR values represented here are based on carcasses recovery in the White River adjusted by H:W ratios and age composition and expanded to the escapement in the White River.
[3] Harvest rates on hatchery-origin White River spring Chinook have not yet been estimated but will be expanded based on harvest rates observed for Chiwawa spring Chinook.
[4] Expanded NORs for harvest were based on harvest rates from Chiwawa River spring Chinook.

For comparison, we calculated NRR for spring Chinook within the Little Wenatchee River basin. Fish from both the White River and Little Wenatchee River must migrate through Lake Wenatchee. Therefore, a comparison between the two subpopulations is appropriate.

NRRs for spring Chinook in the Little Wenatchee River basin were generally less than those for spring Chinook in the White River basin. For brood years 1989-2009, NRR for spring Chinook in the Little Wenatchee River basin averaged 0.85 (range, 0.00-4.50) if harvested fish were not included in the estimate and 1.02 (range, 0.00-5.28) if harvested fish were included in the estimate (Table 7.20). NRRs for more recent brood years will be calculated as soon as all tag recoveries and sampling rates have been loaded into the database.

Table 7.20. Spawning escapements, natural-origin recruits (NOR), and natural replacement rates (NRR) with and without harvest for spring Chinook in the Little Wenatchee River basin, brood years 1989-2009.

Brood year	Spawning Escapement	Harvest not included		Harvest included	
		NOR	NRR	NOR	NRR
1989	102	84	0.82	122	1.20
1990	67	0	0.00	0	0.00
1991	42	0	0.00	0	0.00
1992	78	8	0.10	8	0.10
1993	134	21	0.16	22	0.16
1994	16	11	0.69	11	0.69
1995	0	10	0.00	10	0.00
1996	8	14	1.75	15	1.88
1997	18	81	4.50	95	5.28
1998	18	31	1.72	37	2.06
1999	8	4	0.50	4	0.50
2000	24	39	1.63	42	1.75
2001	118	51	0.43	53	0.45
2002	86	79	0.92	87	1.01
2003	29	13	0.45	15	0.52
2004	39	13	0.33	15	0.38
2005	115	43	0.37	47	0.41
2006	37	49	1.32	70	1.89
2007	101	59	0.58	87	0.86
2008	64	73	1.14	114	1.78
2009	125	52	0.42	69	0.55
Average	***59***	***35***	***0.85***	***44***	***1.02***
Median	***42***	***31***	***0.50***	***37***	***0.55***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adults detected at Tumwater Dam divided by the number of tagged hatchery smolts released. SARs were based on PIT-tag detections. For the available brood years, SARs have ranged from 0.00000 to 0.00086 (Table 7.21).

Table 7.21. Smolt-to-adult ratios (SARs) for White River spring Chinook from the captive brood program, brood years 2006-2010. Detections at Tumwater Dam are adjusted for PIT-tag detection efficiency.

Brood year	Number of smolts released	Number of PIT-tagged smolts released	PIT-tags	
			Adjusted Tumwater Detections	SAR
2006	142,033	29,881	1	0.00003
2007	131,843	39,820	0	0.00000
2008	48,556	38,650	23	0.00060
2009	112,596	41,742	36	0.00086
2010	18,850	12,283	6	0.00049
Average	***90,776***	***32,475***	***13***	***0.00040***
Median	***112,596***	***38,650***	***6***	***0.00049***

7.8 ESA/HCP Compliance

Brood Collection

The last collection of eggs or fry for this program occurred in 2010 (brood year 2009). From 2011 to 2013, the White River Captive Brood Program operated without ESA permit coverage. The hatchery program ended with the last release of juveniles in 2015 (brood year 2013).

Hatchery Rearing, Spawning, and Release

From 2011 to 2013, the White River Captive Brood Program has operated without ESA permit coverage. The hatchery program ended with the last release of juveniles in 2015 (brood year 2013). Release of juveniles in 2015 was consistent with the terms and conditions of Section 10(a)(1)(A) Permit 18120.

Hatchery Effluent Monitoring

Per ESA Permits 1196 (expired), 1347, 1395, 18118, 18119, and 18121, permit holders shall monitor and report hatchery effluents in compliance with applicable National Pollution Discharge Elimination Systems (NPDES) (EPA 1999) permit limitations. There was one NPDES violation reported at PUD Hatchery facilities during the period 1 January through 31 December 2014. NPDES monitoring and reporting for Grant PUD Hatchery Programs during 2014 are provided in Appendix F.

This report does not cover hatchery rearing of the White River Captive Brood Program (adults and juveniles) at the Little White Salmon National Fish Hatchery, operated by the U.S. Fish and Wildlife Service.

Smolt and Emigrant Trapping

Per ESA Section 10 Permit No. 1196 (expired), 18118, 18120, and 18121, the permit holders are authorized a direct take of 20% of the emigrating spring Chinook population during juvenile emigration monitoring and a lethal take not to exceed 2% of the fish captured (NMFS 2003). Based on the estimated wild spring Chinook population (smolt trap expansion) and hatchery juvenile spring Chinook population estimate (hatchery release data) for the Wenatchee River basin, the reported spring Chinook encounters during 2015 emigration monitoring complied with take provisions in the Section 10 permit. Spring Chinook encounter and mortality rates for each trap site (including PIT tag mortalities) are detailed in Table 7.22. Additionally, juvenile fish captured at the trap locations were handled consistent with provisions in ESA Section 10 Permit 1196 (expired), 18118, 18120, and 18121, Section B. Table 7.22 does not include incidental or direct take associated with the White River smolt trap operated by the Yakama Nation.

Table 7.22. Estimated take of Upper Columbia River spring Chinook resulting from juvenile emigration monitoring in the Wenatchee River basin, 2015.

Trap location	Population estimate			Number trapped			Total	Take allowed under Permit
	Wild[a]	Hatchery[b]	Sub-yearling[c]	Wild	Hatchery	Sub-yearling		
Chiwawa Trap								
Population	39,396	147,480	77,510	6,350	7,148	31,152	44,650	
Encounter rate	NA	NA	NA	0.1612	0.0485	0.4019	0.1667	0.20
Mortality[e]	NA	NA	NA	42	0	414	456	
Mortality rate	NA	NA	NA	0.0066	0.0000	0.0133	0.0102	0.02
Lower Wenatchee Trap								
Population	58,595	235,184	14,157,778	1,559	9,920	252,293	263,772	
Encounter rate	NA	NA	NA	0.0266	0.0422	0.0178	0.0183	0.20
Mortality[d]	NA	NA	NA	17	2	282	301	
Mortality rate	NA	NA	NA	0.0109	0.0002	0.0011	0.0011	0.02
Wenatchee River Basin Total								
Population	97,991	235,184	14,235,288	7,909	17,068	283,445	308,422	
Encounter rate	NA	NA	NA	0.0807	0.0726	0.0199	0.0211	0.20
Mortality[d]	NA	NA	NA	59	2	696	757	
Mortality rate	NA	NA	NA	0.0075	0.0001	0.0025	0.0025	0.02

[a] Smolt population estimate derived from juvenile emigration trap data.

[b] 2015 BY smolt release data for the Wenatchee River basin.

[c] Based on size, date of capture and location of capture, subyearling Chinook encountered at the Lower Wenatchee Trap are categorized as summer Chinook salmon.

[d] Combined trapping and PIT tagging mortality.

Spawning Surveys

Spring Chinook spawning ground surveys were conducted in the Wenatchee River basin during 2015, as authorized by ESA Section 10 Permits 18118, 18119, and 18121. Because of the difficulty of quantifying the level of take associated with spawning ground surveys, the Permit does not specify a take level associated with these activities, even though it does authorize implementation of spawning ground surveys. Therefore, no take levels are reported. However, to minimize potential effects to established redds, wading was restricted to the extent practical, and extreme caution was used to avoid established redds when wading was required.

Spring Chinook Reproductive Success Study

ESA Section 10 Permit 1196 (expired) and new Section 10 Permits 18118, 18119, and 18121 specifically provide authorization to capture, anesthetize, biologically sample, PIT tag, and release adult spring Chinook at Tumwater Dam for reproductive success studies and general program monitoring. During 2010 through 2015, all spring Chinook passing Tumwater Dam were enumerated, anesthetized, biologically sampled, PIT tagged, and released (not including hatchery-origin and natural-origin Chinook retained for broodstock) as a component of the reproductive success study (BPA Project No. 2003-039-00). Please refer to Ford et al. (2010, 2011, 2012, 2013, 2014, and 2015) for complete details on the methods and results of the spring Chinook reproductive success study for the period 2010-2014.

SECTION 8: WENATCHEE SUMMER CHINOOK

The goal of summer Chinook salmon supplementation in the Wenatchee Basin is to use artificial production to replace adult production lost because of mortality at Rock Island, Wanapum, and Priest Rapids dams, while not reducing the natural production or long-term fitness of summer Chinook in the basin. The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD and subsequently Grant PUD began cost-sharing the program in 2012. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Anadromous Fish Agreement and Habitat Conservation Plans as well as the Priest Rapids Project Salmon and Steelhead Settlement Agreement.

Adult summer Chinook are collected for broodstock from the run-at-large at the right and left-bank traps at Dryden Dam, and at Tumwater Dam if the weekly quotas cannot be achieved at Dryden Dam. Prior to 2012, the goal was to collect up to 492 natural-origin adult summer Chinook for the Wenatchee program for an annual release of 864,000 smolts. In 2011, the Hatchery Committees reevaluated the amount of hatchery compensation needed to achieve NNI. Based on that evaluation, the goal of the program was revised. The current goal (beginning in 2012) is to collect up to 256 adult natural-origin summer Chinook for an annual release of 500,001 smolts. Broodstock collection occurs from about 1 July through 15 September with trapping occurring up to 24 hours per day, seven days a week. If natural-origin broodstock collection falls short of expectation, hatchery-origin adults can be collected to make up the difference.

Adult summer Chinook are spawned and reared at Eastbank Fish Hatchery. Juvenile summer Chinook are transferred from the hatchery to Dryden Acclimation Pond in March. They are released from the pond in late April to early May.

Before 2012, the production goal for the Wenatchee summer Chinook supplementation program was to release 864,000 yearling smolts into the Wenatchee River at ten fish per pound. Beginning with the 2012 brood, the revised production goal is to release 500,001 yearling smolts into the Wenatchee River at 10 and 15 fish per pound. Targets for fork length and weight are 163 mm (CV = 9.0) and 45.4 g, respectively. Over 95% of these fish are marked with CWTs. In addition, since 2009, about 10,000 juvenile summer Chinook have been PIT tagged annually.

8.1 Broodstock Sampling

This section focuses on results from sampling 2013-2015 Wenatchee summer Chinook broodstock, which were collected at Dryden and Tumwater dams.

Origin of Broodstock

Consistent with the broodstock collection protocol, the 2013-2015 broodstock consisted primarily of natural-origin (adipose fin present and no CWT) summer Chinook (Table 8.1). Less than 1% of the 2013-2015 broodstock was comprised of hatchery-origin fish (hatchery-origin was determined by examination of scales and/or CWTs).

Table 8.1. Numbers of wild and hatchery summer Chinook collected for broodstock, numbers that died before spawning, and numbers of Chinook spawned, 1989-2015. Unknown origin fish (i.e., undetermined by scale analysis, no CWT or fin clips, and no additional hatchery marks) were considered naturally produced. Mortality includes fish that died of natural causes typically near the end of spawning and were not needed for the program and surplus fish killed at spawning.

Brood year	Wild summer Chinook					Hatchery summer Chinook					Total number spawned
	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	
1989	346	29	27	290	0	0	0	0	0	0	290
1990	87	6	24	57	0	0	0	0	0	0	57
1991	128	9	14	105	0	0	0	0	0	0	105
1992	341	48	19	274	0	0	0	0	0	0	274
1993	480	28	46	406	0	44	0	0	44	0	450
1994	363	29	1	333	0	55	1	0	54	0	387
1995	382	15	4	363	0	16	0	0	16	0	378
1996	331	34	34	263	0	3	0	0	3	0	266
1997	225	14	6	205	0	15	1	1	13	0	218
1998	378	40	39	299	0	94	4	12	78	0	377
1999	250	7	1	242	0	238	1	1	236	0	478
2000	298	18	5	275	0	194	7	7	180	0	455
2001	311	41	60	210	0	182	8	38	136	0	346
2002	469	28	32	409	0	13	1	2	10	0	419
2003	488	90	61	337	0	8	1	0	7	0	344
2004	494	24	46	424	0	2	0	0	2	0	426
2005	491	29	19	397	46	3	0	0	3	0	400
2006	483	29	21	433	0	5	1	0	4	0	437
2007	415	53	99	263	0	4	0	1	3	0	266
2008	400	11	11	378	0	72	2	1	69	0	447
2009	482	22	8	452	0	9	1	0	8	0	460
2010	427	14	25	388	0	7	2	0	5	0	393
2011	398	11	11	376	0	7	0	0	7	0	405
Average[b]	***368***	***27***	***27***	***312***	***2***	***42***	***1***	***3***	***38***	***0***	***351***
Median[b]	***382***	***28***	***21***	***333***	***0***	***8***	***1***	***0***	***7***	***0***	***387***
2012	273	5	1	267	0	1	0	0	1	0	268
2013	256	12	10	234	0	2	0	0	2	0	236
2014	279	18	0	261	0	2	0	0	2	0	263
2015	252	0	0	245	0	0	0	0	0	0	245
Average[c]	***266***	***9***	***5***	***252***	***0***	***1***	***0***	***0***	***1***	***0***	***253***
Median[c]	***265***	***9***	***5***	***253***	***0***	***2***	***0***	***0***	***2***	***0***	***254***

[a] Pre-spawn loss represents the number of fish that died during the holding period before spawning. Mortality is the number of fish that were surplused following spawning.
[a] This average represents the program before recalculation in 2011.
[b] This average represents the current program, which began in 2012.

Age/Length Data

Ages of summer Chinook broodstock were determined from analysis of scales and/or CWTs. Broodstock collected from the 2013 return consisted primarily of age-4 and age-5 natural-origin Chinook (86%). Age-3 and age-6 natural-origin fish made up 12% and 2% of the broodstock, respectively (Table 8.2). The two hatchery Chinook included in the broodstock were age-4 and age-5 fish.

Broodstock collected from the 2014 return consisted primarily of age-4 and age-5 natural-origin Chinook (94.7%). Age-3 and age-6 natural-origin fish made up 4.5% and 0% of the broodstock, respectively (Table 8.2). The two hatchery Chinook included in the broodstock were age-4 and age-5 fish.

Broodstock collected from the 2015 return consisted primarily of age-4 and age-5 natural-origin Chinook (92.1%). Age-3 and age-6 natural-origin fish made up 7.8% and 0% of the broodstock, respectively (Table 8.2). No hatchery Chinook were included in broodstock.

Table 8.2. Percent of hatchery and wild Wenatchee summer Chinook of different ages (total age) collected from broodstock in the Wenatchee River basin, 1991-2015.

Return Year	Origin	Total age				
		2	3	4	5	6
1991	Wild	0.0	4.6	36.8	57.5	1.1
	Hatchery	0.0	0.0	0.0	0.0	0.0
1992	Wild	0.0	2.6	40.4	50.9	6.1
	Hatchery	0.0	0.0	0.0	0.0	0.0
1993	Wild	0.0	1.5	35.7	60.4	2.3
	Hatchery	0.0	0.0	93.2	6.8	0.0
1994	Wild	0.0	1.0	33.7	64.3	1.0
	Hatchery	0.0	0.0	1.9	98.1	0.0
1995	Wild	0.0	3.3	19.2	76.3	1.2
	Hatchery	0.0	0.0	0.0	0.0	100.0
1996	Wild	0.0	4.6	40.1	53.3	2.0
	Hatchery	0.0	0.0	33.3	66.7	0.0
1997	Wild	0.0	2.3	42.6	53.2	1.9
	Hatchery	0.0	26.7	66.7	6.7	0.0
1998	Wild	0.0	5.5	34.7	58.6	1.2
	Hatchery	0.0	5.3	68.1	20.2	6.4
1999	Wild	0.5	1.9	39.0	56.3	2.3
	Hatchery	0.0	1.3	23.2	72.2	3.4
2000	Wild	2.6	6.3	24.6	66.5	0.0
	Hatchery	0.0	24.2	14.9	42.8	18.0
2001	Wild	0.3	16.6	53.6	27.7	1.7
	Hatchery	0.0	6.1	80.5	10.4	3.0
2002	Wild	0.7	8.4	61.6	28.5	0.7
	Hatchery	0.0	0.0	41.7	58.3	0.0
2003	Wild	0.9	2.8	31.4	64.8	0.0
	Hatchery	0.0	12.5	25.0	62.5	0.0
2004	Wild	0.2	3.6	10.1	83.9	2.1

Return Year	Origin	Total age				
		2	3	4	5	6
	Hatchery	0.0	0.0	50.0	50.0	0.0
2005	Wild	0.0	4.3	53.5	35.1	7.1
	Hatchery	0.0	0.0	0.0	100.0	0.0
2006	Wild	0.9	0.9	14.9	82.1	1.1
	Hatchery	0.0	0.0	0.0	80.0	20.0
2007	Wild	3.1	15.0	18.7	46.6	16.6
	Hatchery	0.0	0.0	0.0	100.0	0.0
2008	Wild	0.5	6.4	65.5	26.0	1.6
	Hatchery	0.0	2.9	13.0	69.6	14.5
2009	Wild	1.1	6.9	45.8	46.8	0.0
	Hatchery	0.0	0.0	11.1	88.9	0.0
2010	Wild	1.0	6.3	66.1	26.6	0.0
	Hatchery	0.0	0.0	62.5	37.5	0.0
2011	Wild	0.8	8.2	50.3	40.4	0.3
	Hatchery	0.0	42.9	14.3	42.9	0.0
2012	Wild	0.0	3.5	47.2	49.2	0.0
	Hatchery	0.0	0.0	0.0	100.0	0.0
2013	Wild	0.0	12.1	57.1	29.1	1.6
	Hatchery	0.0	0.0	50.0	50.0	0.0
2014	Wild	0.0	4.5	74.7	20.0	0.0
	Hatchery	0.0	0.0	100.0	0.0	0.0
2015	Wild	0.0	7.8	33.0	59.1	0.0
	Hatchery	0.0	0.0	0.0	0.0	0.0
Average	***Wild***	***0.5***	***5.6***	***41.2***	***50.5***	***2.1***
	Hatchery	***0.0***	***4.9***	***30.0***	***46.5***	***6.6***
Median	***Wild***	***0.0***	***4.6***	***40.1***	***53.2***	***1.2***
	Hatchery	***0.0***	***0.0***	***14.9***	***50.0***	***0.0***

Mean lengths of natural-origin summer Chinook of a given age differed little among return years 2013-2015 (Table 8.3).

Table 8.3. Mean fork length (cm) at age (total age) of hatchery and wild Wenatchee summer Chinook collected from broodstock in the Wenatchee River basin, 1991-2015; N = sample size and SD = 1 standard deviation.

Return year	Origin	Summer Chinook fork length (cm)														
		Age-2			Age-3			Age-4			Age-5			Age-6		
		Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD
1991	Wild	-	0	-	-	4	-	-	32	-	-	50	-	-	1	-
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-

Return year	Origin	Summer Chinook fork length (cm)														
		Age-2			Age-3			Age-4			Age-5			Age-6		
		Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD
1992	Wild	-	0	-	66	3	10	69	46	5	81	58	3	87	7	1
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-
1993	Wild	-	0	-	68	6	10	84	138	9	98	235	6	100	9	6
	Hatchery	-	0	-	-	0	-	79	41	8	101	3	8	-	0	-
1994	Wild	-	0	-	74	3	5	86	101	8	96	193	7	106	3	7
	Hatchery	-	0	-	-	0	-	75	1	-	90	53	8	-	0	-
1995	Wild	-	0	-	66	11	8	85	64	7	97	255	6	106	4	7
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-	91	16	8
1996	Wild	-	0	-	69	14	5	86	121	6	97	161	6	104	6	5
	Hatchery	-	0	-	-	0	-	63	1	-	96	2	4	-	0	-
1997	Wild	-	0	-	54	5	10	85	92	7	98	115	6	97	4	9
	Hatchery	-	0	-	46	4	2	74	10	4	98	1	-	-	0	-
1998	Wild	-	0	-	66	19	9	85	119	7	99	201	7	106	4	7
	Hatchery	-	0	-	53	5	2	77	64	8	95	19	8	98	6	8
1999	Wild	42	1	-	65	4	6	86	83	6	97	120	7	103	5	8
	Hatchery	-	0	-	52	3	6	79	55	7	90	171	6	100	8	6
2000	Wild	43	7	3	60	17	7	84	67	5	98	181	6	-	0	-
	Hatchery	-	0	-	53	47	7	76	29	8	93	83	7	102	35	9
2001	Wild	48	1	-	66	48	7	88	155	7	97	80	6	102	5	3
	Hatchery	-	0	-	51	10	3	75	132	8	91	17	8	100	5	8
2002	Wild	51	3	3	64	37	8	89	270	7	100	125	7	99	7	5
	Hatchery	-	0	-	-	0	-	78	5	8	95	7	5	-	0	-
2003	Wild	41	4	2	58	13	4	87	144	8	100	297	7	-	0	-
	Hatchery	-	0	-	40	1	-	78	2	4	101	5	8	-	0	-
2004	Wild	51	1	-	69	17	5	84	47	8	99	392	6	109	10	7
	Hatchery	-	0	-	-	0	-	84	1	-	108	1	-	-	0	-
2005	Wild	-	0	-	68	20	7	86	247	8	95	162	6	101	33	6
	Hatchery	-	0	-	-	0	-	-	0	-	90	3	9	-	0	-
2006	Wild	44	4	7	63	4	11	88	66	7	99	363	6	96	5	7
	Hatchery	-	0	-	-	0	-	-	0	-	99	4	7	100	1	-
2007	Wild	44	12	5	65	58	7	89	72	8	99	180	7	102	64	6
	Hatchery	-	0	-	-	0	-	-	0	-	90	4	5	-	0	-
2008	Wild	46	2	3	69	24	7	90	247	6	98	98	7	105	6	9
	Hatchery	-	0	-	63	2	14	81	9	7	93	48	6	99	10	5
2009	Wild	46	5	5	68	31	8	89	207	8	101	209	6	-	0	-
	Hatchery	-	0	-	61	4	7	81	1	-	98	8	14	-	0	-
2010	Wild	45	4	4	70	26	9	89	273	7	99	110	6	-	0	-
	Hatchery	-	0	-	-	0	-	72	5	8	88	3	7	-	0	-
2011	Wild	49	3	3	66	30	7	88	183	7	98	147	7	114	1	-
	Hatchery	-	0	-	55	3	2	90	1	-	81	3	5	-	0	-

Return year	Origin	Summer Chinook fork length (cm)														
		Age-2			Age-3			Age-4			Age-5			Age-6		
		Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD
2012	Wild	-	0	-	71	9	4	87	120	7	96	125	7	-	0	-
	Hatchery	-	0	-	-	0	-	-	0	-	83	1	-	-	0	-
2013	Wild	-	0	-	72	30	3	87	141	7	98	72	7	97	4	6
	Hatchery	-	0	-	-	0	-	79	1	-	96	1	-	-	0	-
2014	Wild	-	0	-	74	12	5	88	198	6	98	53	7	-	0	-
	Hatchery	-	0	-	-	0	-	86	2	6	-	0	-	-	0	-
2015	Wild	-	0	-	72	18	3	86	76	6	98	136	6	-	0	-
	Hatchery	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Average	***Wild***	***46***	***2***	***4***	***67***	***19***	***7***	***86***	***132***	***7***	***97***	***165***	***6***	***102***	***8***	***6***
	Hatchery	***0***	***0***	***0***	***47***	***4***	***5***	***74***	***16***	***6***	***89***	***18***	***7***	***86***	***5***	***6***

Sex Ratios

Male summer Chinook in the 2013 and 2014 broodstock made up about 50% of the adults collected, resulting in overall male to female ratios of 0.98:1.00 and 0.99:1.00, respectively (Table 8.4). In 2015, males made up just under 50% of the adults collected, resulting in an overall male to female ratio of 0.99:1.00 (Table 8.4). The ratios in 2013-2015 were nearly equal to the 1:1 ratio goal in the broodstock protocol.

Table 8.4. Numbers of male and female wild and hatchery summer Chinook collected for broodstock in the Wenatchee River basin, 1989-2015. Ratios of males to females are also provided.

Return year	Number of wild summer Chinook			Number of hatchery summer Chinook			Total M/F ratio
	Males (M)	Females (F)	M/F	Males (M)	Females (F)	M/F	
1989	166	180	0.92:1.00	0	0	-	0.92:1.00
1990	45	39	1.15:1.00	0	0	-	1.15:1.00
1991	60	68	0.88:1.00	0	0	-	0.88:1.00
1992	154	187	0.82:1.00	0	0	-	0.82:1.00
1993	208	228	0.91:1.00	35	9	3.89:1.00	1.03:1.00
1994	158	179	0.88:1.00	24	31	0.77:1.00	0.87:1.00
1995	169	213	0.79:1.00	1	15	0.07:1.00	0.75:1.00
1996	150	181	0.83:1.00	2	1	2.00:1.00	0.84:1.00
1997	104	121	0.86:1.00	15	0	-	0.98:1.00
1998	211	167	1.26:1.00	64	30	2.13:1.00	1.40:1.00
1999	130	120	1.08:1.00	108	130	0.83:1.00	0.95:1.00
2000	153	145	1.06:1.00	112	82	1.37:1.00	1.17:1.00
2001	187	124	1.51:1.00	132	50	2.64:1.00	1.83:1.00
2002	266	203	1.31:1.00	5	8	0.63:1.00	1.28:1.00
2003	270	218	1.24:1.00	5	3	1.67:1.00	1.24:1.00
2004	230	264	0.87:1.00	1	1	1.00:1.00	0.87:1.00
2005	291	200	1.46:1.00	2	1	2.00:1.00	1.46:1.00

Return year	Number of wild summer Chinook			Number of hatchery summer Chinook			Total M/F ratio
	Males (M)	Females (F)	M/F	Males (M)	Females (F)	M/F	
2006	237	246	0.96:1.00	1	4	0.25:1.00	0.95:1.00
2007	239	176	1.36:1.00	2	2	1.00:1.00	1.35:1.00
2008	208	192	1.08:1.00	29	43	0.67:1.00	1.01:1.00
2009	223	236	0.94:1.00	25	7	3.57:1.00	1.02:1.00
2010	217	198	1.10:1.00	5	2	2.50:1.00	1.12:1.00
2011	198	200	0.99:1.00	4	3	1.33:1.00	0.99:1.00
2012	138	135	1.02:1.00	1	0	-	1.03:1.00
2013	127	130	0.98:1.00	1	1	1.00:1.00	0.98:1.00
2014	140	139	1.01:1.00	0	2	0.00:1.00	0.99:1.00
2015	122	123	0.99:1.00	0	0	0.00:0.00	0.99:1.00
Total	***4801***	***4612***	***1.01:1.00***	***574***	***425***	***1.35:1.00***	***1.07:1.00***

Fecundity

Fecundities for the 2013-2015 returns of summer Chinook averaged 4,990, 4,756, and 4,982 eggs per female, respectively (Table 8.5). These values are close to the overall average of 5,158 eggs per female. Mean observed fecundities for the 2013-2015 returns were near the expected fecundity of 5,031 eggs per female assumed in the broodstock protocol.

Table 8.5. Mean fecundity of wild, hatchery, and all female summer Chinook collected for broodstock in the Wenatchee River basin, 1989-2015; NA = not available.

Return year	Mean fecundity		
	Wild	Hatchery	Total
1989*	NA	NA	5,280
1990*	NA	NA	5,436
1991*	NA	NA	4,333
1992*	NA	NA	5,307
1993*	NA	NA	5,177
1994*	NA	NA	5,899
1995*	NA	NA	4,402
1996*	NA	NA	4,941
1997	5,385	5,272	5,390
1998	5,393	4,825	5,297
1999	5,036	4,942	4,987
2000	5,464	5,403	5,441
2001	5,280	4,647	5,097
2002	5,502	5,027	5,484
2003	5,357	5,696	5,361
2004	5,372	6,681	5,377
2005	5,045	6,391	5,053

Return year	Mean fecundity		
	Wild	Hatchery	Total
2006	5,126	5,633	5,133
2007	5,124	4,510	5,115
2008	5,147	4,919	5,108
2009	5,308	4,765	5,291
2010	4,971	3,323	4,963
2011	4,943	2,983	4,913
2012	4,801	NA	4,801
2013	4,987	5,272	4,990
2014	4,788	4,429	4,756
2015	4,982	NA	4,982
Average	***5,158***	***4,983***	***5,123***
Median	***5,137***	***4,963***	***5,119***

* Individual fecundities were not tracked with females until 1997.

8.2 Hatchery Rearing

Rearing History

Number of eggs taken

Based on the unfertilized egg-to-release survival standard of 81%, a total of 1,066,667 eggs were required to meet the program release goal of 864,000 smolts for brood years 1989-2011. An evaluation of the program in 2011 determined that 617,285 eggs are needed to meet the revised release goal of 500,001 smolts. This revised goal began with brood year 2012. From 1989 to 2011, the egg take goal was reached in seven of those years (Table 8.6). The egg take in 2013 and 2014 were lower than the revised goal of 617,285 eggs.

Table 8.6. Numbers of eggs taken from Wenatchee summer Chinook broodstock, 1989-2014.

Return year	Number of eggs taken
1989	829,012
1990	163,109
1991	247,000
1992	827,911
1993	1,133,852
1994	999,364
1995	949,531
1996	756,000
1997	554,617
1998	854,997
1999	1,182,130
2000	1,113,159
2001	733,882

Return year	Number of eggs taken
2002	1,049,255
2003	901,095
2004	1,311,051
2005	883,669
2006	1,190,757
2007	655,201
2008	1,145,330
2009	1,217,028
2010	947,875
2011	959,202
Average (1989-2011)	***895,871***
Median (1989-2011)	***947,875***
2012	633,677
2013	578,513
2014	612,422
Average (2012-present)	***608,204***
Median (2012-present)	***612,422***

Number of acclimation days

The 2013 brood Wenatchee summer Chinook were transferred to Dryden Acclimation Pond between 9 and 13 March 2015, including a small group of less than 200 fish that were transferred on 17 April. These fish received 11-50 days of acclimation on Wenatchee River water before being released on 28 April 2015 (Table 8.7).

Table 8.7. Number of days Wenatchee summer Chinook were acclimated at Dryden Acclimation Pond, brood years 1989-2013. Numbers in parenthesis represents the number of days fish reared at Chiwawa Acclimation Facility.

Brood year	Release year	Transfer date	Release date	Number of days
1989	1991	2-Mar	7-May	66
1990	1992	19-Feb	2-May	73
1991	1993	10-Mar	8-May	59
1992	1994	1-Mar	6-May	66
1993	1995	3-Mar	1-May	59
1994	1996	2-Oct	6-May	217 (154)
		5-Mar	6-May	62
1995	1997	16-Oct	8-May	205 (139)
		27-Feb	8-May	70

Brood year	Release year	Transfer date	Release date	Number of days
1996	1998	6-Oct	28-Apr	204 (142)
		25-Feb	28-Apr	62
1997	1999	23-Feb	27-Apr	63
1998	2000	5-Mar	1-May	57
1999	2001	8-Mar	23-Apr	46
2000	2002	1-Mar	6-May	66
2001	2003	19-Feb	23-Apr	63
2002	2004	5-Mar	23-Apr	49
2003	2005	15-Mar	25-Apr	41
2004	2006	25-Mar	27-Apr	33
2005	2007	15-Mar	30-Apr	46
2006	2008	11-14-Mar	28-Apr	45-48
2007	2009	30-31-Mar	29-Apr	29-30
2008	2010	9-12, 15, 22-Mar	28-Apr	38-51
2009	2011	15-18, 21-Mar, 22-Apr	26-Apr	5-43
2010	2012	26-30-Mar	25-Apr	26-30
2011	2013	25-29-Mar	24-Apr	26-30
2012	2014	17-27-Mar	30-Apr	34-44
2013	2015	9-13-Mar, 17-Apr	28-Apr	11-50

Release Information

Numbers released

The 2013 Wenatchee summer Chinook program achieved 94.1% of the 500,001 target goal with about 470,570 fish being released in 2015 (Table 8.8).

Table 8.8. Numbers of Wenatchee summer Chinook smolts released from the hatchery, 1989-2013. Up to 2012, the release target for Wenatchee summer Chinook was 864,000 smolts. Beginning in 2012, the release target is 500,001 smolts.

Brood year	Release year	CWT mark rate	Number released with PIT tags	Number of smolts released
1989	1991	0.2013	0	720,000
1990	1992	0.9597	0	124,440
1991	1993	0.9957	0	191,179
1992	1994	0.9645	0	627,331
1993	1995	0.9881	0	900,429
1994	1996	0.9697	0	797,350

Brood year	Release year	CWT mark rate	Number released with PIT tags	Number of smolts released
1995	1997	0.9725	0	687,439
1996	1998	0.9758	0	600,127
1997	1999	0.9913	0	438,223
1998	2000	0.9869	0	649,612
1999	2001	0.9728	0	1,005,554
2000	2002	0.9723	0	929,496
2001	2003	0.9868	0	604,668
2002	2004	0.9644	0	835,645
2003	2005	0.9778	0	653,764
2004	2006	0.9698	0	892,926
2005	2007	0.9596	0	644,182
2006	2008	0.9676	0	51,550[a]
		0.9676	0	899,107
2007	2009	0.9768	0	456,805
2008	2010	0.9664	10,035	888,811
2009	2011	0.9767	29,930	843,866
2010	2012	0.9964	0	792,746
2011	2013	0.9904	5,020	827,709
Average (1989-2011)		***0.9761***	***1,874***	***667,085***
Median (1989-2011)		***0.9727***	***0***	***720,000***
2012	2014	0.9700	19,911	550,877
2013	2015	0.9872	20,486	470,570
Average (2012-present)		***0.9786***	***20,199***	***510,724***
Median (2012-present)		***0.9786***	***20,199***	***510,724***

[a] Represents high ELISA group planted directly in the Wenatchee River at Leavenworth Boat Launch.

Numbers tagged

The 2013 brood Wenatchee summer Chinook were 98.7% CWT and adipose fin-clipped (Table 8.8).

In 2015, a total of 10,500 Wenatchee summer Chinook (brood year 2014) were tagged at Eastbank Hatchery in September. These fish were tagged in water-reuse circular ponds #1 and #2. This is part of the size-target study. Fish were not fed during tagging or for two days before and after tagging. Fish in the small-fish group averaged 74 mm in length and 5.5 g at time of tagging, while those in the big-fish group averaged 78 mm in length and 5.6 g.

An additional 5,500 Wenatchee summer Chinook (2,250 small-size fish and 2,250 big-size fish) were PIT tagged in March 2016. These fish were tagged in raceways #11 and #12. This is also part of the size-target study. Fish were not fed during tagging or for two days before and after tagging. Fish in the small-fish group averaged 129 mm in length and 23.0 g at time of tagging, while those in the big-fish group averaged 136 mm in length and 27.0 g.

Table 8.9 summarizes the number of hatchery summer Chinook that have been PIT-tagged and released into the Wenatchee River.

Table 8.9. Summary of PIT-tagging activities for Wenatchee hatchery summer Chinook, brood years 2008-2013.

Brood year	Release year	Number of fish tagged	Number of tagged fish that died	Number of tags shed	Number of tagged fish released
2008	2010	10,100	64	1	10,035
2009	2011	10,108 (Control)	140	3	9,965
		10,100 (R1)	129	0	9,971
		10,099 (R2)	105	0	9,994
2010	2012	0	0	0	0
2011	2013	5,100	80	0	5,020
2012	2014 (Raceway)	5,150 (small-size)	90	12	5,048
		5,153 (big-size)	379	34	4,740
	2014 (Reuse Circular)	5,150 (small-size)	109	0	5,041
		5,151 (big-size)	69	0	5,082
2013	2015 (Raceway)	5,150 (small-size)	44	0	5,116
		5,153 (big-size)	31	0	5,129
	2015 (Reuse Circular)	5,150 (small-size)	41	0	5,120
		5,151 (big-size)	38	1	5,121

Fish size and condition at release

About 470,570 summer Chinook from the 2013 brood were force-released from Dryden Acclimation Pond on 28 April 2015. Assessing size-target achievement from pre-release sampling was not practical because of size-target studies on the 2012 and 2013 brood years. However, since the program began, Wenatchee summer Chinook have not met the target length and CV values. The target weight (fish/pound or FPP) of juvenile fish has been met occasionally.

Table 8.10. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of Wenatchee summer Chinook smolts released from the hatchery, brood years 1989-2013; NA = not available. Size targets are provided in the last row of the table.

Brood year	Release year	Fork length (cm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1989	1991	158	13.7	45.4	10
1990	1992	155	14.2	45.4	10
1991	1993	156	15.5	42.3	11
1992	1994	152	13.1	40.1	10
1993	1995	149	NA	34.9	13

Brood year	Release year	Fork length (cm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1994	1996	138	NA	21.7	21
1995	1997	149	12.2	42.5	11
1996	1998	151	16.6	43.2	10
1997	1999	154	10.1	42.8	11
1998	2000	166	9.7	53.1	9
1999	2001	137	16.1	29.0	16
2000	2002	148	14.6	37.1	12
2001	2003	148	NA	38.9	12
2002	2004	146	15.1	37.3	14
2003	2005	147	13.2	36.5	12
2004	2006	147	10.7	35.4	13
2005	2007	153	16.3	40.6	11
2006	2008	136	21.5	29.2	16
2007	2009	163	21.6	49.7	9
2008	2010	166	15.0	52.0	9
2009	2011	152	15.9	39.0	12
2010	2012	154	17.2	43.1	11
2011	2013	149	13.8	41.4	11
Average (1989-2011)		***151***	***14.8***	***40.0***	***12***
Targets (1989-2011)		***176***	***9.0***	***45.4***	***10***
2012	2014	158	12.6	40.7	11
2013	2015	156	10.1	40.7	11
Average (2012-present)		***157***	***11.4***	***40.7***	***11***
Targets (2012-present)[a]		***163***	***9.0***	***45.4***	***10, 15***

[a] For brood year 2012, the fish per pound (fpp) targets were 10 fpp and 15 fpp.

Survival Estimates

Overall survival of the 2013 brood Wenatchee summer Chinook from green (unfertilized) egg to release was higher than the standard set for the program. This was in part because of a high survival at all stages with the exception of unfertilized egg to eyed stage. (Table 8.11).

Table 8.11. Hatchery life-stage survival rates (%) for Wenatchee summer Chinook, brood years 1989-2013. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
1989	90.0	93.4	90.9	97.0	99.7	99.3	98.5	99.4	86.9
1990	89.7	95.6	80.9	96.6	99.6	99.2	97.7	98.8	76.3
1991	88.2	98.3	86.9	96.1	99.3	98.5	94.9	98.1	77.4

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
1992	84.3	92.2	79.8	97.8	99.9	99.9	97.1	98.1	75.8
1993	92.4	95.9	84.2	97.5	99.6	99.3	96.7	98.8	79.4
1994	90.7	95.3	83.7	100	99.2	97.0	95.3	98.4	79.8
1995	94.7	98.2	86.0	100	96.7	96.4	74.9	90.8	72.4
1996	84.6	96.1	84.1	100	97.9	97.7	94.4	97.7	79.4
1997	89.3	98.3	82.6	97.3	97.1	96.9	98.3	98.2	79.0
1998	85.3	94.6	80.9	98.3	99.4	98.6	95.6	99.8	76.0
1999	98.4	98.3	90.4	97.9	98.1	97.9	96.2	99.4	85.1
2000	93.0	96.6	88.3	98.0	99.6	99.3	96.5	98.9	83.5
2001	87.4	91.5	90.6	97.7	99.8	99.6	93.1	93.3	82.4
2002	93.8	94.1	85.1	99.8	98.1	97.6	93.7	96.5	79.6
2003	77.4	85.1	80.5	98.1	99.6	99.1	91.9	93.5	72.6
2004	92.8	97.8	85.7	87.8	99.9	99.6	86.6	92.1	65.1
2005	97.3	89.6	83.5	98.0	99.7	99.4	89.1	99.5	72.9
2006	92.4	95.2	85.6	98.4	99.3	98.4	94.8	97.2	79.8
2007	73.6	97.5	73.7	97.9	99.5	98.7	96.6	99.1	69.7
2008	96.6	97.9	90.4	97.3	99.4	98.7	88.2	89.6	77.6
2009	95.1	95.6	92.0	99.6	97.3	97.3	84.8	98.2	78.1
2010	94.7	97.8	96.1	99.3	97.6	97.1	87.2	90.3	83.2
2011	98.0	96.4	92.3	97.9	99.5	98.9	95.9	97.3	86.7
2012	97.8	97.2	92.3	98.1	99.7	99.1	96.1	97.3	86.9
2013	91.5	98.4	87.5	98.8	97.1	96.6	94.1	98.4	81.3
Average	***90.8***	***95.5***	***86.2***	***97.8***	***98.9***	***98.4***	***93.1***	***96.7***	***78.7***
Median	***92.4***	***96.1***	***85.7***	***98.0***	***99.4***	***98.7***	***94.9***	***98.1***	***79.4***
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

8.3 Disease Monitoring

Rearing of the 2013 brood Wenatchee summer Chinook was similar to previous years with fish being held on well water before being transferred to Dryden Acclimation Pond for final acclimation in March 2015. Fish were transferred to Dryden Acclimation Pond from 9-13 March and on 17 April. Increased mortality caused by external fungus and bacterial cold water disease began to occur during the acclimation period at Dryden Acclimation Pond at which time a formalin treatment was initiated to prevent the fungus from proliferating.

Results of the 2015 adult broodstock bacterial kidney disease (BKD) monitoring indicated that most females (99.2%) had ELISA values less than 0.199. The one female that had an ELISA value greater than 0.120 was not included in the program and the eggs were culled. All remaining females had ELISA values less than 0.120, which means that none of the progeny needed to be reared at densities less than 0.06 fish per pound (Table 8.12).

Table 8.12. Proportion of bacterial kidney disease (BKD) titer groups for the Wenatchee summer Chinook broodstock, brood years 1997-2015. Also included are the proportions to be reared at either 0.125 fish per pound or 0.060 fish per pound.

Brood year[a]	Optical density values by titer group				Proportion at rearing densities (fish per pound, fpp)[b]	
	Very Low (≤ 0.099)	Low (0.1-0.199)	Moderate (0.2-0.449)	High (≥ 0.450)	≤ 0.125 fpp (<0.119)	≤ 0.060 fpp (>0.120)
1997	0.7714	0.0857	0.0381	0.1048	0.8095	0.1905
1998	0.3067	0.2393	0.1656	0.2883	0.4479	0.5521
1999	0.9590	0.0123	0.0123	0.0164	0.9713	0.0287
2000	0.6268	0.1053	0.1627	0.1053	0.7321	0.2679
2001	0.6513	0.0263	0.0987	0.2237	0.6776	0.3224
2002	0.7868	0.0457	0.0711	0.0964	0.8325	0.1675
2003	0.9825	0.0000	0.0058	0.0117	0.9825	0.0175
2004	0.9593	0.0081	0.0163	0.0163	0.9675	0.0325
2005	0.9833	0.0056	0.0000	0.0111	0.9833	0.0167
2006	0.9134	0.0563	0.0000	0.0303	0.9351	0.0649
2007	0.9535	0.0078	0.0078	0.0310	0.9535	0.0465
2008	0.9868	0.0088	0.0044	0.0000	0.9868	0.0132
2009	0.9957	0.0000	0.0000	0.0043	0.9957	0.0043
2010	0.9897	0.0025	0.0000	0.0025	0.9949	0.0051
2011	0.9585	0.0363	0.0000	0.0052	0.9896	0.0104
2012	0.9697	0.0303	0.0000	0.0000	1.0000	0.0000
2013	0.8120	0.1790	0.0000	0.0090	0.8890	0.1110
2014	0.9462	0.0154	0.0000	0.0385	0.9462	0.0538
2015	0.9919	0.0000	0.0000	0.0081	0.9919	0.0081
Average	***0.8708***	***0.0455***	***0.0307***	***0.0528***	***0.8993***	***0.1007***
Median	***0.9585***	***0.0154***	***0.0044***	***0.0163***	***0.9675***	***0.0325***

[a] Individual ELISA samples were not collected before the 1997 brood.
[b] ELISA values from broodstock BKD testing dictate what density the progeny of the broodstock are reared. Progeny of broodstock with high ELISA values are reared at lower density.

8.4 Natural Juvenile Productivity

During 2015, juvenile summer Chinook were sampled at the Lower Wenatchee Trap located near the town of Cashmere. Because the Lower Wenatchee Trap began operation in a new location in 2013, the historic flow-discharge relationships are invalid and new models to estimate trap efficiency must be developed for all species. Relationships and models between discharge and trap efficiencies are continuing to be developed and improved.

Emigrant Estimates

Lower Wenatchee Trap

The Lower Wenatchee Trap operated between 30 January and 28 June 2015. During that time period, the trap was inoperable for five days because of high and low river discharge, debris, elevated river temperatures, and major hatchery releases. During the five-month sampling period, a total of 252,204 wild subyearling Chinook were captured at the Lower Wenatchee Trap. Based on 23 capture efficiencies, a significant relationship between trap efficiency and river discharge was created ($R^2 = 0.61$, $P < 0.005$) and an estimate (95% C.I.) of 13,679,013 (±2,089,329) wild subyearling Chinook passed the trap within the sampling period. However, because of abnormal environmental conditions (low discharge and elevated river temperatures) the trap was pulled early.

Based on historical averages, about 3.5% of subyearling Chinook emigrate after 28 June. Therefore, to account for the trap being pulled early, we expanded our point estimate by 3.5%. This resulted in a new estimate of 14,157,778 (±2,125,578) subyearling Chinook. Because 142 summer Chinook redds were observed downstream from the trap in 2015, the total number of summer Chinook emigrating from the Wenatchee River in 2015 was expanded using the ratio of the number of redds downstream from the trap to the number upstream from the trap. This resulted in a total summer Chinook emigrant estimate of 14,763,064 fish. Most of the fish emigrated during April (Figure 8.1). Monthly captures and mortalities of all fish collected at the Lower Wenatchee Trap are reported in Appendix B.

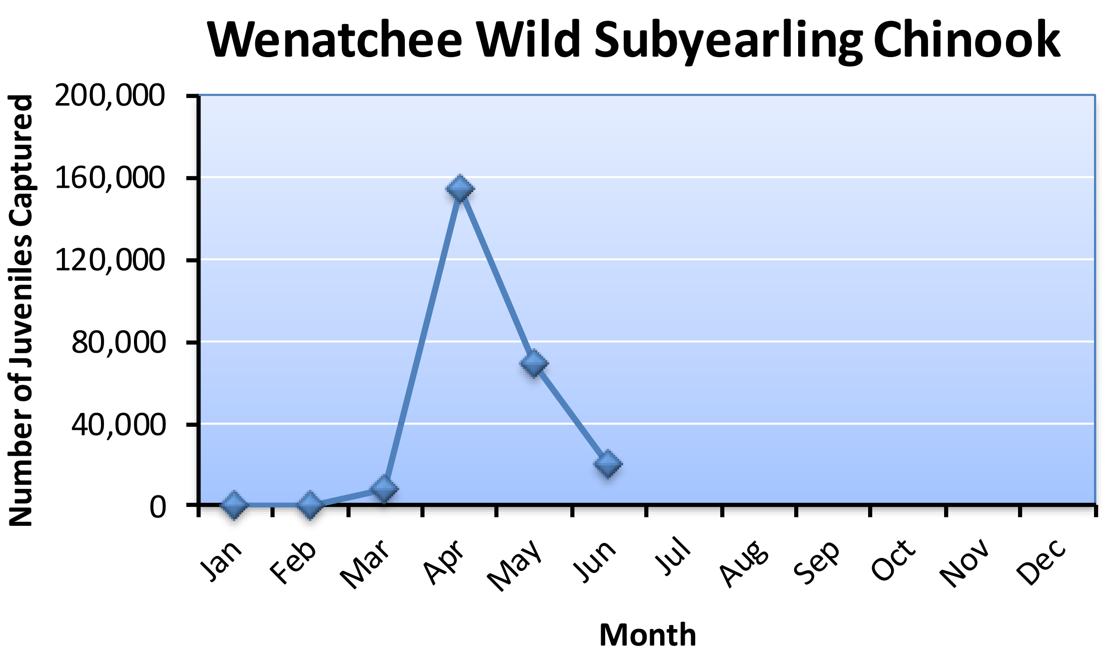

Figure 8.1. Numbers of wild subyearling Chinook captured at the Lower Wenatchee Trap during late January through June, 2015.

8.5 Spawning Surveys

Surveys for Wenatchee summer Chinook redds were conducted from 15 September to 5 November 2015 in the Wenatchee River and Icicle Creek.

Redd Counts

A total count of summer Chinook redds was estimated in 2015 based on weekly census surveys conducted in the Wenatchee River. Redds were counted in Icicle Creek when feasible. A total of 1,804 summer Chinook redds were counted in the Wenatchee River basin in 2015 (Table 8.13). This is one of the lowest counts on record.

In the future, spawning escapement estimates will be derived using the area-under-the-curve (AUC) method (described in Millar et al. 2012). WDFW now has two years of data (2014 and 2015) to inform model parameters (e.g., observer efficiency of redd counts and habitat characteristics). After the conclusion of 2016 surveys, WDFW will begin calibrating the model to generate preliminary spawning escapements and associated variance.

Table 8.13. Numbers of redds counted in the Wenatchee River basin, 1989-2015; ND = no data. From 1989-2013, numbers of redds were based on expanding "peak counts" to generate a Total Count. Since 2014, numbers of redds were based on weekly census surveys that encompass all reaches.

Survey year	Redd counts		Total count
	Wenatchee River	Icicle Creek	
1989	3,331	ND	4,215
1990	2,479	ND	3,103
1991	2,180	ND	2,748
1992	2,328	ND	2,913
1993	2,334	ND	2,953
1994	2,426	ND	3,077
1995	1,872	ND	2,350
1996	1,435	ND	1,814
1997	1,388	ND	1,739
1998	1,660	ND	2,230
1999	2,188	ND	2,738
2000	2,022	ND	2,540
2001	2,857	ND	3,550
2002	5,419	ND	6,836
2003	4,281	ND	5,268
2004	4,003	ND	4,874
2005	2,895	ND	3,538
2006	7,165	68	8,896
2007	1,857	13	1,970
2008	2,338	23	2,800
2009	2,667	21	3,441
2010	2,553	11	3,261

Survey year	Redd counts		Total count
	Wenatchee River	Icicle Creek	
2011	2,583	9	3,078
2012	2,301	2	2,504
2013	2,875	42	3,241
2014	3,383	75	3,458
2015	1,781	23	1,804
Average			***3,368***
Median			***3,077***

Redd Distribution

Summer Chinook redds were not evenly distributed among reaches within the Wenatchee River basin in 2015 (Table 8.14; Figure 8.2). Most of the spawning occurred upstream from the Leavenworth Bridge in Reaches 6, 9, and 10. The highest density of redds occurred in Reach 6 near the confluence of the Icicle River.

Table 8.14. Total numbers of summer Chinook redds counted in different reaches in the Wenatchee River basin during September through mid-November, 2015. Reach codes are described in Table 2.10.

Survey reach	Total redd count
Wenatchee 1 (W1)	3
Wenatchee 2 (W2)	54
Wenatchee 3 (W3)	85
Wenatchee 4 (W4)	25
Wenatchee 5 (W5)	16
Wenatchee 6 (W6)	535
Wenatchee 7 (W7)	118
Wenatchee 8 (W8)	226
Wenatchee 9 (W9)	464
Wenatchee 10 (W10)	255
Icicle Creek (I1)	23
Totals	***1,804***

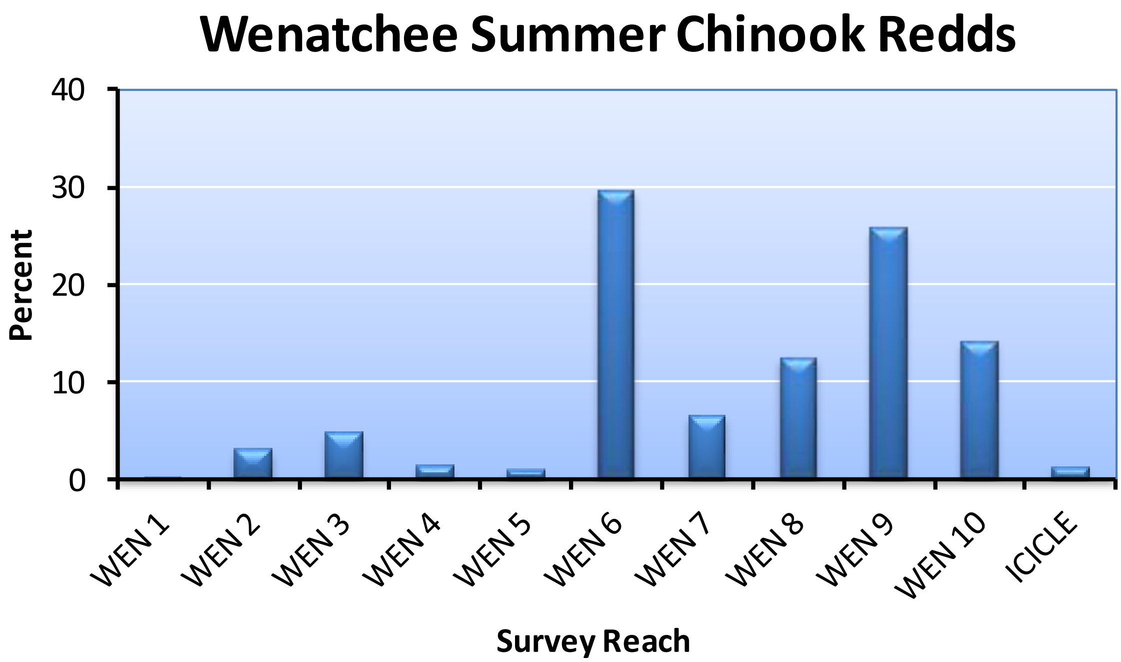

Figure 8.2. Percent of the total number of summer Chinook redds counted in different reaches in the Wenatchee River basin during September through early-November, 2015. Reach codes are described in Table 2.10.

Spawn Timing

In 2015, spawning in the Wenatchee River began during the fourth week of September, peaked the first week of October, and ended the first week of November (Figure 8.3).

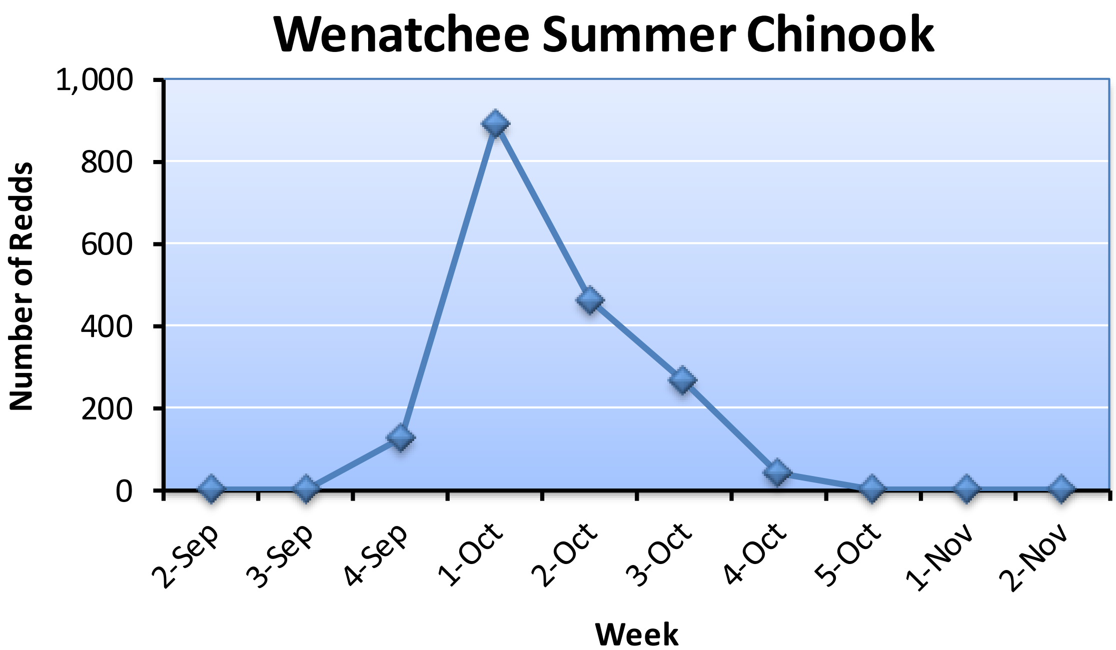

Figure 8.3. Number of new summer Chinook redds counted during different weeks in the Wenatchee River, September through mid-November 2015.

Spawning Escapement

Spawning escapement for Wenatchee summer Chinook was calculated as the total number of redds (expanded peak counts for return years 1989-2013) times the fish per redd ratio estimated from broodstock and fish sampled at adult trapping sites. The estimated fish per redd ratio for summer Chinook in 2015 was 2.40. Multiplying this ratio by the number of redds counted in the Wenatchee River basin resulted in a total spawning escapement of 4,330 summer Chinook (Table 8.15). This is the lowest escapement on record.

Table 8.15. Spawning escapements for summer Chinook in the Wenatchee River basin, return years 1989-2015. Number of redds is based on expanded peak redd counts for the period 1989-2013.

Return year	Fish/Redd	Redds	Total spawning escapement
1989	3.40	4,215	14,331
1990	3.50	3,103	10,861
1991	3.70	2,748	10,168
1992	4.00	2,913	11,652
1993	3.20	2,953	9,450
1994	3.30	3,077	10,154
1995	3.30	2,350	7,755
1996	3.40	1,814	6,168
1997	3.40	1,739	5,913
1998	2.40	2,230	5,352
1999	2.00	2,738	5,476

Return year	Fish/Redd	Redds	Total spawning escapement
2000	2.17	2,540	5,512
2001	3.20	3,550	11,360
2002	2.30	6,836	15,723
2003	2.24	5,268	11,800
2004	2.15	4,874	10,479
2005	2.46	3,538	8,703
2006	2.00	8,896	17,792
2007	2.33	1,970	4,590
2008	2.32	2,800	6,496
2009	2.42	3,441	8,327
2010	2.29	3,261	7,468
2011	3.20	3,078	9,850
2012	3.41	2,504	8,539
2013	3.15	3,241	10,209
2014	3.02	3,458	10,443
2015	2.40	1,804	4,330
Average	***2.84***	***3,368***	***9,219***
Median	***3.02***	***3,077***	***9,450***

8.6 Carcass Surveys

Surveys for Wenatchee summer Chinook carcasses were conducted during late September to early November 2015 in the Wenatchee River and Icicle Creek.

Number sampled

A total of 988 summer Chinook carcasses were sampled during October through early November in the Wenatchee River basin in 2015 (Table 8.16).

Table 8.16. Numbers of summer Chinook carcasses sampled within each survey reach in the Wenatchee River basin, 1993-2015. Reach codes are described in Table 2.10.

Survey year	Number of summer Chinook carcasses											
	W-1	W-2	W-3	W-4	W-5	W-6	W-7	W-8	W-9	W-10	Icicle	Total
1993	68	151	696	13	82	150	215	41	0	0	0	**1,416**
1994	0	6	25	1	21	50	20	49	131	1	0	**304**
1995	0	10	14	0	0	117	50	37	20	0	0	**248**
1996	0	5	84	42	10	206	27	37	43	0	0	**454**
1997	1	47	127	5	29	312	8	80	70	13	0	**692**
1998	6	81	159	4	1	270	32	395	354	65	0	**1,367**
1999	0	169	112	16	35	932	68	146	185	79	0	**1,742**
2000	8	118	178	9	85	693	82	121	172	208	0	**1,674**

Survey year	Number of summer Chinook carcasses											
	W-1	W-2	W-3	W-4	W-5	W-6	W-7	W-8	W-9	W-10	Icicle	Total
2001	0	49	138	31	0	338	36	124	101	94	0	**911**
2002	0	249	189	0	205	848	0	341	564	166	6	**2,568**
2003	6	369	195	72	149	768	66	266	537	58	40	**2,526**
2004	8	157	193	177	173	1,086	103	346	493	409	16	**3,161**
2005	8	85	106	39	46	709	70	140	353	258	7	**1,821**
2006	22	140	160	64	112	953	435	343	703	658	18	**3,608**
2007	3	15	49	10	26	475	38	38	96	91	8	**849**
2008	10	34	63	38	36	676	47	42	106	144	8	**1,204**
2009	11	29	43	32	27	389	16	58	240	175	6	**1,026**
2010	3	31	98	57	122	681	135	49	124	194	15	**1,509**
2011	5	88	126	19	38	1,332	77	45	211	289	9	**2,239**
2012	8	82	95	22	40	600	53	62	173	183	0	**1,318**
2013	3	100	149	22	109	767	5	60	353	265	14	**1,847**
2014	3	42	64	18	59	659	89	160	329	282	34	**1,739**
2015	9	7	36	15	19	296	27	110	314	150	5	**988**
Average	***8***	***90***	***135***	***31***	***62***	***579***	***74***	***134***	***247***	***164***	***8***	***1,531***
Median	***5***	***81***	***112***	***19***	***38***	***659***	***50***	***80***	***185***	***150***	***6***	***1,416***

Carcass Distribution and Origin

Summer Chinook carcasses were not evenly distributed among reaches within the Wenatchee River basin in 2015 (Table 8.16; Figure 8.4). Most of the carcasses in the Wenatchee River basin were found upstream from the Leavenworth Bridge. The highest percentage of carcasses (31%) was sampled in Reach 9 upstream of Tumwater Canyon.

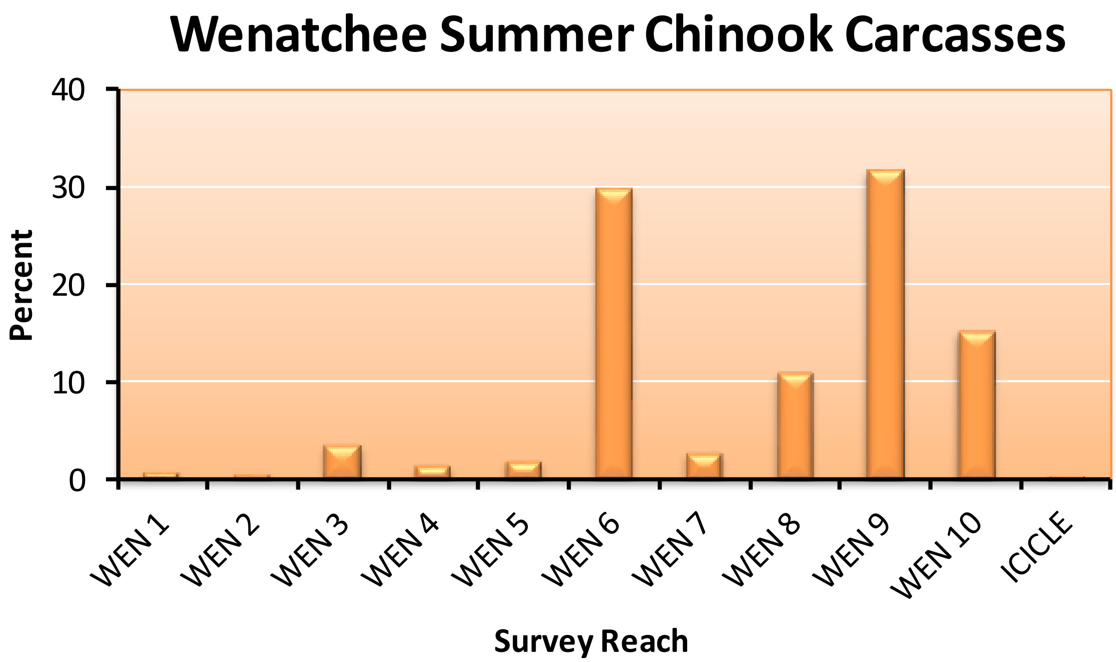

Figure 8.4. Percent of summer Chinook carcasses sampled within different reaches in the Wenatchee River basin during September through mid-November, 2015. Reach codes are described in Table 2.10.

Numbers of wild and hatchery-origin summer Chinook carcasses sampled in 2015 will be available after analysis of CWTs and scales. Based on the available data (1993-2014), most fish, regardless of origin, were found in Reach 6 (Leavenworth Bridge to Icicle Road Bridge) (Table 8.17). In general, a larger percentage of wild fish were found in the upper reaches than were hatchery fish (Figure 8.5). In contrast, a larger percentage of hatchery fish were found in reaches downstream from the Icicle Road Bridge.

Table 8.17. Numbers of wild and hatchery summer Chinook carcasses sampled within different reaches in the Wenatchee River basin, 1993-2014.

Survey year	Origin	Survey reach											Total
		W-1	W-2	W-3	W-4	W-5	W-6	W-7	W-8	W-9	W-10	Icicle	
1993	Wild	59	146	660	12	82	133	213	40	0	0	0	**1,345**
	Hatchery	9	5	36	1	0	17	2	1	0	0	0	**71**
1994	Wild	0	2	18	1	19	36	20	49	130	1	0	**276**
	Hatchery	0	4	7	0	2	14	0	0	1	0	0	**28**
1995	Wild	0	4	11	0	0	105	50	35	20	0	0	**225**
	Hatchery	0	6	3	0	0	12	0	2	0	0	0	**23**
1996	Wild	0	5	82	40	9	196	27	37	43	0	0	**439**
	Hatchery	0	0	2	2	1	10	0	0	0	0	0	**15**
1997	Wild	1	38	112	5	22	266	8	80	69	13	0	**614**
	Hatchery	0	9	15	0	7	46	0	0	1	0	0	**78**
1998	Wild	6	62	124	3	1	191	29	374	327	62	0	**1,179**
	Hatchery	0	19	35	1	0	79	3	21	27	3	0	**188**

Survey year	Origin	Survey reach											Total
		W-1	W-2	W-3	W-4	W-5	W-6	W-7	W-8	W-9	W-10	Icicle	
1999	Wild	0	88	70	8	18	600	58	137	169	75	0	**1,223**
	Hatchery	0	81	42	8	17	332	10	9	16	4	0	**519**
2000	Wild	5	78	115	8	57	485	75	110	167	200	0	**1,300**
	Hatchery	3	40	63	1	28	208	7	11	5	8	0	**374**
2001	Wild	0	37	100	9	0	245	32	122	97	91	0	**733**
	Hatchery	0	12	38	22	0	93	4	2	4	3	0	**178**
2002	Wild	0	151	127	0	103	479	0	330	558	161	3	**1,912**
	Hatchery	0	98	62	0	102	369	0	11	6	5	3	**656**
2003	Wild	5	261	147	32	111	519	62	252	498	57	15	**1,959**
	Hatchery	1	108	48	40	38	249	4	14	39	1	25	**567**
2004	Wild	7	124	163	120	112	749	90	316	481	399	11	**2,572**
	Hatchery	1	33	30	56	61	337	13	30	12	10	5	**588**
2005	Wild	4	49	78	24	26	399	66	125	336	244	0	**1,351**
	Hatchery	4	36	28	15	20	310	4	15	17	14	7	**470**
2006	Wild	15	91	122	44	75	688	388	309	646	593	5	**2,976**
	Hatchery	7	49	38	20	37	265	47	34	57	65	13	**632**
2007	Wild	1	7	24	1	10	197	34	30	95	81	3	**483**
	Hatchery	2	8	25	9	16	278	4	8	1	10	5	**366**
2008	Wild	7	15	38	24	21	361	41	31	98	133	2	**771**
	Hatchery	3	19	25	14	15	315	6	11	8	11	6	**433**
2009	Wild	6	22	32	23	19	288	13	55	236	173	4	**871**
	Hatchery	5	7	11	9	8	101	3	3	4	2	2	**155**
2010	Wild	2	22	62	44	64	477	125	47	121	192	0	**1,156**
	Hatchery	1	9	36	13	58	204	10	2	3	2	15	**353**
2011	Wild	4	46	75	11	25	914	74	45	211	287	3	**1,695**
	Hatchery	1	42	51	7	13	418	3	0	0	2	6	**543**
2012	Wild	4	49	72	13	24	490	47	62	173	182	0	**1,116**
	Hatchery	4	33	23	9	16	110	6	0	0	1	0	**202**
2013	Wild	1	63	89	16	69	374	5	59	340	261	0	**1,277**
	Hatchery	2	52	60	6	40	395	0	1	13	4	0	**573**
2014	Wild	3	35	57	16	48	572	89	158	329	281	12	**1,600**
	Hatchery	0	7	7	2	11	87	0	2	0	1	22	**139**
Average	***Wild***	***6***	***63***	***108***	***21***	***42***	***398***	***70***	***127***	***234***	***158***	***3***	***1,231***
	Hatchery	***2***	***31***	***31***	***11***	***22***	***193***	***6***	***8***	***10***	***7***	***5***	***325***
Median	***Wild***	***4***	***48***	***80***	***13***	***25***	***387***	***49***	***71***	***171***	***147***	***0***	***1,201***
	Hatchery	***1***	***19***	***33***	***8***	***16***	***206***	***4***	***3***	***4***	***3***	***1***	***360***

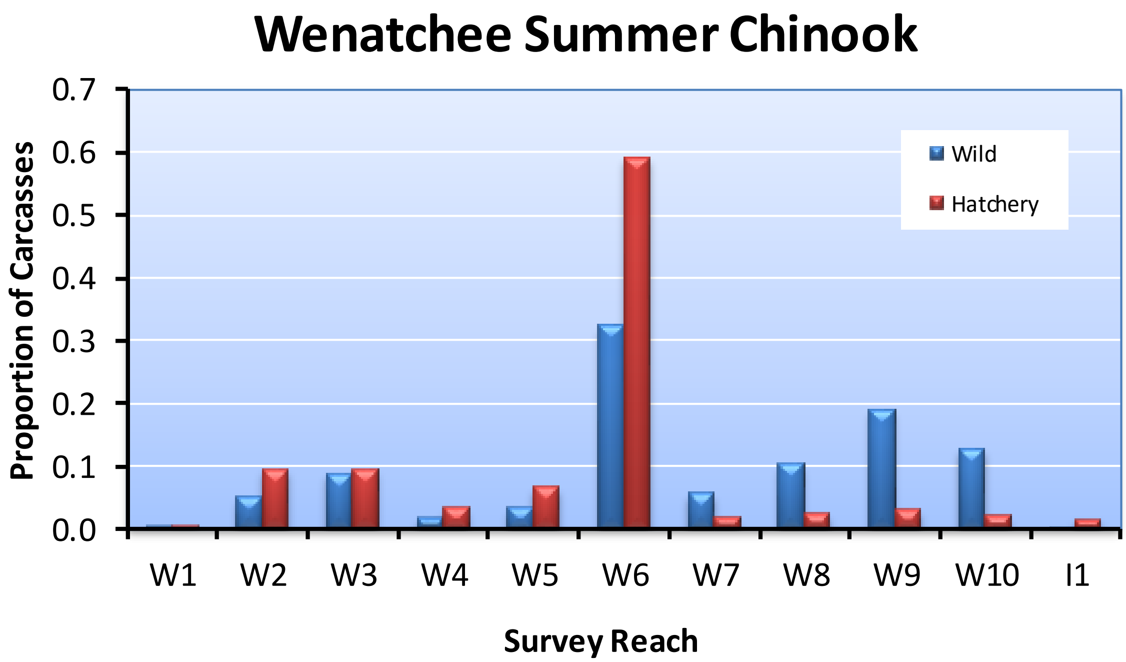

Figure 8.5. Distribution of wild and hatchery produced carcasses in different reaches in the Wenatchee River basin, 1993-2014. Reach codes are described in Table 2.10.

Sampling Rate

If escapement is based on total numbers of redds, then about 23% of the total spawning escapement of summer Chinook in the Wenatchee River basin was sampled in 2015 (Table 8.18). Sampling rates among survey reaches varied from 5 to 125%.

Table 8.18. Number of redds and carcasses, total spawning escapement, and sampling rates for summer Chinook in the Wenatchee River basin, 2015.

Sampling reach	Total number of redds	Total number of carcasses	Total spawning escapement	Sampling rate
Wenatchee 1 (W1)	3	9	7	1.25
Wenatchee 2 (W2)	54	7	130	0.05
Wenatchee 3 (W3)	85	36	204	0.18
Wenatchee 4 (W4)	25	15	60	0.25
Wenatchee 5 (W5)	16	19	38	0.49
Wenatchee 6 (W6)	535	296	1,284	0.23
Wenatchee 7 (W7)	118	27	283	0.10
Wenatchee 8 (W8)	226	110	542	0.20
Wenatchee 9 (W9)	464	314	1,114	0.28
Wenatchee 10 (W10)	255	150	612	0.25
Icicle Creek (I1)	23	5	55	0.09
Total	***1,804***	***988***	***4,330***	***0.23***

Length Data

Mean lengths (POH, cm) of male and female summer Chinook carcasses sampled during surveys in the Wenatchee River basin in 2015 are provided in Table 8.19. The average size of males and females sampled in the Wenatchee River basin were 65 cm and 70 cm, respectively.

Table 8.19. Mean lengths (postorbital-to-hypural length; cm) and standard deviations (in parentheses) of male and female summer Chinook carcasses sampled in different streams/watersheds in the Wenatchee River basin, 2015.

Stream/watershed	Mean length (cm)	
	Male	Female
Wenatchee 1 (W1)	64.0 (9.9)	64.8 (5.1)
Wenatchee 2 (W2)	78.7 (7.8)	75.0 (2.4)
Wenatchee 3 (W3)	65.7 (11.1)	75.6 (2.9)
Wenatchee 4 (W4)	73.3 (7.1)	72.8 (7.5)
Wenatchee 5 (W5)	62.9 (11.7)	73.5 (6.0)
Wenatchee 6 (W6)	65.8 (11.3)	70.3 (5.8)
Wenatchee 7 (W7)	75.0 (16.6)	69.7 (4.6)
Wenatchee 8 (W8)	64.4 (8.8)	70.3 (6.0)
Wenatchee 9 (W9)	64.7 (9.1)	70.3 (5.9)
Wenatchee 10 (W10)	61.5 (8.9)	69.2 (5.0)
Icicle Creek (I1)	60.0 (12.7)	68.0 (1.7)
Total	***64.5 (10.0)***	***70.4 (5.7)***

8.7 Life History Monitoring

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

Migration Timing

Migration timing of hatchery and wild Wenatchee summer Chinook was determined from broodstock data and stock assessment data collected at Dryden Dam. Sampling at Dryden Dam occurs from early July through mid-October. On average, during the early part of the migration, hatchery summer Chinook arrived about two weeks later than wild Chinook (Table 8.20). This pattern carried through the migration distribution of summer Chinook at Dryden Dam. By the end of the migration, hatchery fish passed Dryden Dam about three weeks after 90% of the wild fish passed the dam.

Table 8.20. The week that 10%, 50% (median), and 90% of the wild and hatchery summer Chinook salmon passed Dryden Dam, 2007-2015. The average week is also provided. Migration timing is based on collection of summer Chinook broodstock at Dryden Dam.

Survey year	Origin	Wenatchee Summer Chinook Migration Time (week)				Sample size
		10 Percentile	50 Percentile	90 Percentile	Mean	
2007	Wild	28	31	37	31	274
	Hatchery	30	33	41	35	305
2008	Wild	29	31	40	32	219
	Hatchery	32	37	41	37	576
2009	Wild	27	29	41	31	469
	Hatchery	28	34	42	35	382
2010	Wild	30	33	35	32	403
	Hatchery	29	30	33	30	268
2011	Wild	30	31	34	32	293
	Hatchery	32	34	39	35	304
2012	Wild	30	32	39	33	247
	Hatchery	31	37	41	36	366
2013	Wild	28	30	34	31	494
	Hatchery	29	33	39	33	570
2014	Wild	29	31	37	32	512
	Hatchery	29	32	40	33	338
2015	Wild	25	30	40	31	511
	Hatchery	28	35	40	35	88
Average	***Wild***	***28***	***31***	***37***	***32***	***380***
	Hatchery	***30***	***34***	***40***	***34***	***355***
Median	***Wild***	***29***	***31***	***37***	***32***	***403***
	Hatchery	***29***	***34***	***40***	***35***	***338***

Age at Maturity

Because hatchery summer Chinook are released after one year of rearing and natural-origin summer Chinook migrate primarily as age-0 fish, total ages will differ between hatchery and natural-origin Chinook (see Hillman et al. 2011). Therefore, in this section, we evaluated age at maturity by comparing differences in salt (ocean) ages between the two groups.

Most of the wild and hatchery summer Chinook sampled during the period 1993-2014 in the Wenatchee River basin were salt age-3 fish (Table 8.21; Figure 8.6). Over the survey years, a higher percentage of salt age-4 wild Chinook returned to the basin than did salt age-4 hatchery Chinook. In contrast, a higher proportion of salt age-1 and 2 hatchery fish returned than did salt age-1 and 2 wild fish. Thus, a higher percentage of wild fish returned at an older age than did hatchery fish.

Table 8.21. Proportions of wild and hatchery summer Chinook of different salt (ocean) ages sampled on spawning grounds in the Wenatchee River basin, 1993-2014.

Sample year	Origin	Salt age					Sample size
		1	2	3	4	5	
1993	Wild	0.02	0.24	0.62	0.12	0.00	1,224
	Hatchery	0.03	0.91	0.03	0.03	0.00	64
1994	Wild	0.02	0.21	0.45	0.32	0.00	257
	Hatchery	0.00	0.14	0.86	0.00	0.00	21
1995	Wild	0.02	0.15	0.65	0.18	0.00	216
	Hatchery	0.00	0.00	0.05	0.95	0.00	21
1996	Wild	0.01	0.25	0.66	0.08	0.00	512
	Hatchery	0.00	0.33	0.33	0.29	0.05	21
1997	Wild	0.01	0.24	0.57	0.18	0.00	561
	Hatchery	0.05	0.20	0.67	0.08	0.00	75
1998	Wild	0.02	0.23	0.66	0.09	0.00	1,041
	Hatchery	0.03	0.49	0.38	0.10	0.00	187
1999	Wild	0.01	0.34	0.55	0.10	0.00	1,087
	Hatchery	0.01	0.15	0.79	0.05	0.00	510
2000	Wild	0.02	0.20	0.64	0.15	0.00	1,181
	Hatchery	0.07	0.11	0.66	0.15	0.00	342
2001	Wild	0.01	0.16	0.74	0.08	0.00	653
	Hatchery	0.05	0.76	0.14	0.04	0.00	181
2002	Wild	0.00	0.14	0.62	0.24	0.00	1,744
	Hatchery	0.01	0.16	0.80	0.02	0.00	646
2003	Wild	0.01	0.07	0.51	0.41	0.00	1,653
	Hatchery	0.05	0.07	0.75	0.12	0.00	530
2004	Wild	0.00	0.12	0.32	0.54	0.01	2,233
	Hatchery	0.08	0.57	0.25	0.10	0.00	566
2005	Wild	0.00	0.12	0.75	0.13	0.00	1,190
	Hatchery	0.02	0.09	0.86	0.03	0.00	450
2006	Wild	0.00	0.02	0.27	0.71	0.00	2,972
	Hatchery	0.02	0.16	0.24	0.57	0.00	299
2007	Wild	0.01	0.09	0.31	0.53	0.07	480
	Hatchery	0.00	0.15	0.75	0.07	0.03	275
2008	Wild	0.01	0.06	0.76	0.17	0.00	767
	Hatchery	0.02	0.12	0.76	0.11	0.00	329
2009	Wild	0.01	0.07	0.51	0.41	0.00	797
	Hatchery	0.10	0.36	0.49	0.05	0.00	132
2010	Wild	0.01	0.18	0.65	0.16	0.00	1,068
	Hatchery	0.00	0.49	0.47	0.03	0.00	294

Sample year	Origin	Salt age					Sample size
		1	2	3	4	5	
2011	Wild	0.01	0.11	0.60	0.29	0.00	1,533
	Hatchery	0.06	0.04	0.90	0.01	0.00	472
2012	Wild	0.00	0.04	0.48	0.48	0.00	1,017
	Hatchery	0.00	0.03	0.88	0.08	0.03	200
2013	Wild	0.00	0.07	0.58	0.34	0.01	1,277
	Hatchery	0.00	0.01	0.13	0.86	0.00	573
2014	Wild	0.00	0.04	0.66	0.30	0.00	1,599
	Hatchery	0.00	0.05	0.22	0.70	0.03	139
Average	***Wild***	***0.01***	***0.12***	***0.54***	***0.32***	***0.00***	***1,139***
	Hatchery	***0.03***	***0.20***	***0.58***	***0.18***	***0.00***	***287***
Median	***Wild***	***0.01***	***0.12***	***0.70***	***0.18***	***0.00***	***1,078***
	Hatchery	***0.03***	***0.24***	***0.63***	***0.10***	***0.00***	***285***

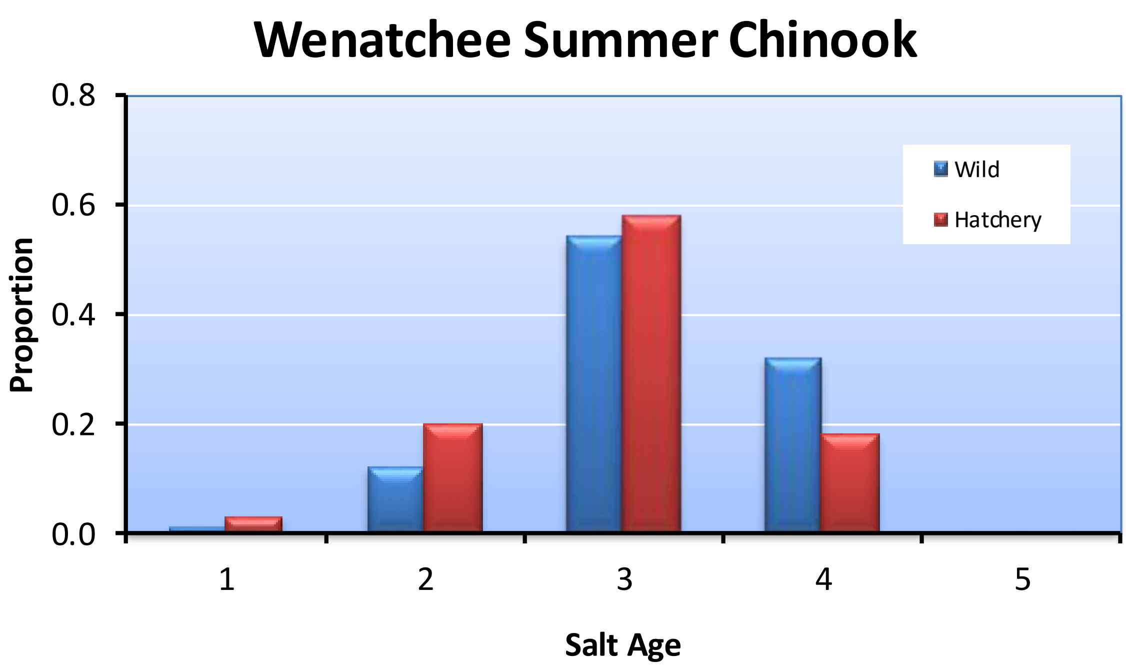

Figure 8.6. Proportions of wild and hatchery summer Chinook of different salt (ocean) ages sampled at broodstock collection sites and on spawning grounds in the Wenatchee River basin for the combined years 1993-2014.

Size at Maturity

On average, hatchery summer Chinook were about 4 cm smaller than wild summer Chinook sampled in the Wenatchee River basin (Table 8.22). This is likely because a higher percentage of hatchery fish returned as salt age-2 and 3 fish than did wild fish. In contrast, a higher percentage of wild fish returned as salt age-4 fish than did hatchery fish. Analyses for the five-year reports will compare sizes of hatchery and wild fish of the same age groups and sex.

Table 8.22. Mean lengths (POH; cm) and variability statistics for wild and hatchery summer Chinook sampled in the Wenatchee River basin, 1993-2014; SD = 1 standard deviation.

Sample year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
1993[a]	Wild	1,344	73	8	33	94
	Hatchery	68	61	9	37	83
1994[a]	Wild	276	73	8	31	89
	Hatchery	25	70	8	54	85
1995[a]	Wild	225	75	7	48	87
	Hatchery	23	74	7	57	85
1996[a]	Wild	210	74	7	43	92
	Hatchery	9	66	12	52	84
1997	Wild	614	74	8	29	99
	Hatchery	79	69	10	29	83
1998	Wild	1,179	73	8	28	97
	Hatchery	188	67	10	37	87
1999	Wild	1,217	72	8	29	95
	Hatchery	518	71	8	26	94
2000	Wild	1,301	71	10	24	94
	Hatchery	369	69	11	33	91
2001	Wild	728	70	9	30	93
	Hatchery	178	63	10	28	86
2002	Wild	1,911	72	8	39	94
	Hatchery	656	71	8	34	95
2003	Wild	1,943	74	9	24	105
	Hatchery	554	69	10	26	97
2004	Wild	2,570	72	9	32	98
	Hatchery	584	59	11	25	91
2005	Wild	1,352	69	7	41	92
	Hatchery	469	69	8	39	91
2006	Wild	3,249	74	6	29	99
	Hatchery	350	71	9	35	90
2007	Wild	566	73	9	29	92
	Hatchery	269	70	7	45	87
2008	Wild	836	69	8	29	89
	Hatchery	363	70	9	24	94
2009	Wild	872	71	8	30	94
	Hatchery	153	64	11	32	84

Sample year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
2010	Wild	1,147	68	8	32	92
	Hatchery	351	65	10	25	87
2011	Wild	1,698	68	8	33	101
	Hatchery	541	66	9	34	85
2012	Wild	1,116	70	7	29	91
	Hatchery	202	60	7	40	79
2013	Wild	1,277	66	9	24	95
	Hatchery	573	67	7	24	85
2014	Wild	1,599	68	7	29	98
	Hatchery	139	66	10	26	85
Pooled	***Wild***	***1,238***	***71***	***8***	***32***	***95***
	Hatchery	***303***	***67***	***9***	***35***	***88***

[a] These years include sizes reported in annual reports. The data contained in the WDFW database do not include all these data.

Contribution to Fisheries

Most of the harvest on hatchery-origin Wenatchee summer Chinook occurred in the ocean (Table 8.23). Ocean harvest has made up 47% to 100% of all hatchery Wenatchee summer Chinook harvested. Total harvest on early brood years (1990-1996 and 2007) was lower than for brood years 1997-2008.

Table 8.23. Estimated number and percent (in parentheses) of hatchery-origin Wenatchee summer Chinook captured in different fisheries, brood years 1989-2009.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
1989	1,510 (51)	1,432 (48)	0 (0)	20 (1)	2,962
1990	30 (100)	0 (0)	0 (0)	0 (0)	30
1991	30 (63)	0 (0)	0 (0)	18 (38)	48
1992	147 (79)	39 (21)	0 (0)	0 (0)	186
1993	35 (58)	25 (42)	0 (0)	0 (0)	60
1994	642 (91)	62 (9)	2 (0)	0 (0)	706
1995	561 (98)	9 (2)	5 (1)	0 (0)	575
1996	196 (96)	3 (1)	0 (0)	6 (3)	205
1997	2,991 (95)	49 (2)	12 (0)	106 (3)	3,158
1998	4,984 (92)	128 (2)	15 (0)	287 (5)	5,414
1999	1,550 (84)	168 (9)	21 (1)	104 (6)	1,843
2000	7,955 (73)	1,248 (11)	447 (4)	1,224 (11)	10,874
2001	1,062 (60)	238 (13)	106 (6)	364 (21)	1,770
2002	1,489 (56)	557 (21)	189 (7)	430 (16)	2,665
2003	816 (50)	484 (29)	89 (5)	257 (16)	1,646

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
2004	409 (47)	218 (25)	70 (8)	167 (19)	864
2005	1,333 (58)	481 (21)	186 (8)	287 (13)	2,287
2006	3,808 (52)	1,969 (27)	406 (6)	1,142 (16)	7,325
2007	212 (60)	81 (23)	8 (2)	53 (15)	354
2008	3,870 (60)	1,042 (16)	227 (4)	1,345 (21)	6,484
2009	1,710 (64)	454 (17)	97 (4)	430 (16)	2,691
Average	***1,683 (71)***	***414 (16)***	***90 (3)***	***297 (10)***	***2,483***
Median	***1,062 (63)***	***168 (16)***	***15 (1)***	***106 (11)***	***1,770***

Straying

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Wenatchee River basin. Targets for strays based on return year (recovery year) and brood year should be less than 5%.

Hatchery-origin Wenatchee summer Chinook have strayed into the Entiat, Chelan, Methow, and Okanogan River basins and into the Hanford Reach (Table 8.24). In five different years, Wenatchee summer Chinook strays have made up more than 5% of the spawning escapement in the Chelan Tailrace. They have made up more than 5% of the spawning escapement in the Entiat River basin in nine different years and in the Methow River basins in eight different years. With the exception of the Entiat River basin (6.7% average stray rate), the average stray rate for Wenatchee summer Chinook during return years 1994-2012 has been less than 5%. Few have strayed into the Okanogan River basin or into the Hanford Reach.

Table 8.24. Number and percent of spawning escapements within other non-target basins that consisted of hatchery-origin Wenatchee summer Chinook, return years 1994-2014. For example, for return year 2000, 3% of the summer Chinook escapement in the Methow River basin consisted of hatchery-origin Wenatchee summer Chinook. Percent strays should be less than 5%.

Return year	Methow		Okanogan		Chelan		Entiat		Hanford Reach	
	Number	%	Number	%	Number	%	Number	%	Number	%
1994	0	0.0	75	1.9	--	--	--	--	--	--
1995	0	0.0	0	0.0	--	--	--	--	--	--
1996	0	0.0	0	0.0	--	--	--	--	--	--
1997	0	0.0	0	0.0	--	--	--	--	--	--
1998	25	3.7	0	0.0	0	0.0	0	0.0	0	0.0
1999	20	2.0	3	0.1	0	0.0	0	0.0	13	0.0
2000	36	3.0	13	0.4	0	0.0	0	0.0	0	0.0
2001	163	5.9	57	0.5	30	3.0	0	0.0	0	0.0
2002	153	3.3	53	0.4	40	6.9	74	14.8	0	0.0
2003	80	2.0	24	0.7	44	10.5	132	19.1	26	0.0
2004	113	5.2	42	0.6	30	7.1	0	0.0	0	0.0

Return year	Methow		Okanogan		Chelan		Entiat		Hanford Reach	
	Number	%	Number	%	Number	%	Number	%	Number	%
2005	245	9.6	67	0.8	51	9.7	49	13.4	0	0.0
2006	170	6.2	12	0.1	12	2.9	61	11.2	0	0.0
2007	127	9.3	5	0.1	9	4.8	49	20.2	20	0.1
2008	87	4.5	24	0.3	10	2.0	31	9.7	0	0.0
2009	101	5.7	13	0.2	2	0.3	12	4.8	0	0.0
2010	208	8.3	35	0.6	55	4.9	34	7.8	0	0.0
2011	258	8.8	5	0.1	78	6.1	15	3.2	0	0.0
2012	109	3.7	24	0.3	53	4.1	54	6.0	0	0.0
2013	252	7.0	57	0.7	2	0.1	8	1.1	0	0.0
2014	15	0.9	0	0.0	4	0.4	12	2.2	0	0.0
Average	***103***	***4.3***	***24***	***0.4***	***25***	***3.7***	***31***	***6.7***	***3***	***0.0***
Median	***101***	***3.7***	***13***	***0.3***	***12***	***3.0***	***15***	***4.8***	***0***	***0.0***

Based on brood year analyses, on average, about 11% of the hatchery-origin Wenatchee summer Chinook returns have strayed into non-target spawning areas, exceeding the target of 5% (Table 8.25). Depending on brood year, percent strays into non-target spawning areas have ranged from 0-20%. In addition, on average, about 8% have strayed into non-target hatchery programs, but straying into non-target programs has declined over time.

Table 8.25. Number and percent of hatchery-origin Wenatchee summer Chinook that homed to target spawning areas and the target hatchery program, and number and percent that strayed to non-target spawning areas and non-target hatchery programs, by brood years 1989-2009. Percent stays should be less than 5%.

Brood year	Homing				Straying			
	Target stream		Target hatchery*		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1989	1,352	62.9	60	2.8	75	3.5	662	30.8
1990	74	84.1	1	1.1	0	0.0	13	14.8
1991	15	65.2	0	0.0	0	0.0	8	34.8
1992	375	84.8	7	1.6	0	0.0	60	13.6
1993	67	72.8	9	9.8	4	4.3	12	13.0
1994	890	71.8	207	16.7	61	4.9	81	6.5
1995	748	74.8	139	13.9	48	4.8	65	6.5
1996	261	70.4	42	11.3	53	14.3	15	4.0
1997	3,609	83.0	171	3.9	397	9.1	170	3.9
1998	1,790	78.2	11	0.5	416	18.2	72	3.1
1999	507	79.7	0	0.0	121	19.0	8	1.3
2000	2,745	82.3	0	0.0	545	16.3	44	1.3
2001	521	80.4	0	0.0	118	18.2	9	1.4

Brood year	Homing				Straying			
	Target stream		Target hatchery*		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
2002	1,521	83.4	10	0.5	284	15.6	8	0.4
2003	1,268	88.5	42	2.9	114	8.0	9	0.6
2004	497	84.2	3	0.5	72	12.2	18	3.1
2005	1,126	83.7	1	0.1	193	14.3	25	1.9
2006	2,693	79.3	0	0.0	623	18.4	78	2.3
2007	99	78.0	0	0.0	25	19.7	3	2.4
2008	3,264	84.0	0	0.0	458	11.8	165	4.2
2009	758	78.1	0	0.0	103	10.6	110	11.3
Average	***1,151***	***78.6***	***33***	***3.1***	***177***	***10.6***	***78***	***7.7***
Median	***758***	***79.7***	***3***	***0.5***	***103***	***11.8***	***25***	***3.9***

* Homing to the target hatchery includes Wenatchee hatchery summer Chinook that are captured and included as broodstock in the Wenatchee Hatchery program. These hatchery fish are typically collected at Dryden and Tumwater dams.

Genetics

Genetic studies were conducted in 2011 to investigate relationships among temporally replicated collections of summer Chinook from the Wenatchee River, Methow River, and Okanogan River in the upper Columbia River basin (Kassler et al. 2011; the entire report is appended as Appendix M). A total of 2,416 summer Chinook were collected from tributaries in the upper Columbia River basin. Two collections of natural-origin summer Chinook from 1993 (prior to the supplementation program) were taken from the Wenatchee River basin (N = 139) and compared to collections of hatchery and natural-origin Chinook from 2006 and 2008 (N = 380). Two pre-supplementation collections from the Methow River (1991 and 1993) were compared to supplementation collections from 2006 and 2008 (N = 362). Three pre-supplementation collections from the Okanogan River Basin (1991, 1992, and 1993) were compared with supplementation collections from 2006 and 2008 (N = 669). A collection of natural-origin summer Chinook from the Chelan River was also analyzed (N = 70). Additionally, hatchery collections from Eastbank Hatchery (Wenatchee and Methow/Okanogan stock; N = 221) and Wells Hatchery (N = 294) were analyzed and compared to the in-river collections. Summer Chinook data (provided by the USFWS) from the Entiat River (N = 190) were used for comparison. Lastly, data from eight collections of fall Chinook (N = 2,408) were compared to the collections of summer Chinook. Samples of natural and hatchery-origin summer Chinook were analyzed and compared to determine if the supplementation programs have affected the genetic structure of these populations. The study also calculated the effective number of breeders for collection locations of natural and hatchery-origin summer Chinook from 1993 and 2008.

In general, population differentiation was not observed among the temporally replicated collection locations. A single collection from the Okanogan River (1993) was the only collection showing statistically significant differences. The effective number of breeders was not statistically different from the early collection in 1993 in comparison to the late collection in 2008. Overall, these analyses revealed a lack of differentiation among the temporal replicates from the same locations and among the collection from different locations, suggesting the populations have been homogenized or that there has been substantial gene flow among populations. Additional comparisons among summer-run and fall-run Chinook populations in the upper Columbia River were conducted to determine if there was any differentiation between Chinook with different run timing. These analyses revealed pairwise F_{ST} values that were less than 0.01 for the collections of summer Chinook to collections of fall Chinook from Hanford Reach, lower Yakima River, Priest Rapids, and Umatilla. Collections of fall Chinook from Crab Creek, Lyons Ferry Hatchery, Marion Drain, and Snake River had pairwise F_{ST} values that were higher in comparison to the collections of summer Chinook. The consensus clustering analysis did not provide good statistical support to the groupings, but did show relationships among collections based on geographic proximity. Overall the summer and fall run Chinook that have historically been spawned together were not differentiated while fall Chinook from greater geographic distances were differentiated.

It is important to note that no new information will be reported on genetics until the next five-year report (2018).

Proportionate Natural Influence

Another method for assessing the genetic risk of a supplementation program is to determine the influence of the hatchery and natural environments on the adaptation of the composite population. This is estimated by the proportion of natural-origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery-origin fish in the natural spawning escapement (pHOS). We calculated Proportionate Natural Influence (PNI) by iterating Ford's (2002) equations 5 and 6 to equilibrium, using a heritability of 0.3 and a selection strength of three standard deviations. The larger the PNI value, the greater the strength of selection in the natural environment relative to that of the hatchery environment. In order for the natural environment to dominate selection, PNI should be greater than 0.50, and important integrated populations should have a PNI of at least 0.67 (HSRG/WDFW/NWIFC 2004).

For all brood years the PNI value has been greater than or equal to 0.67 (Table 8.26). This suggests that the natural environment has a greater influence on adaptation of Wenatchee summer Chinook than does the hatchery environment.

Table 8.26. Proportionate Natural Influence (PNI) values for the Wenatchee summer Chinook supplementation program for brood years 1989-2014. NOS = number of natural-origin Chinook on the spawning grounds; HOS = number of hatchery-origin Chinook on the spawning grounds; NOB = number of natural-origin Chinook collected for broodstock; and HOB = number of hatchery-origin Chinook included in hatchery broodstock.

Brood year	Spawners			Broodstock			PNI[a]
	NOS	HOS	pHOS	NOB	HOB	pNOB	
1989	14,331	0	0.00	290	0	1.00	1.00
1990	10,861	0	0.00	57	0	1.00	1.00
1991	10,168	0	0.00	105	0	1.00	1.00
1992	11,652	0	0.00	274	0	1.00	1.00
1993	8,849	600	0.06	406	44	0.90	0.94
1994	8,476	1,678	0.17	333	54	0.86	0.84
1995	6,862	894	0.12	363	16	0.96	0.89
1996	6,004	165	0.03	263	3	0.99	0.97

Brood year	Spawners			Broodstock			PNI[a]
	NOS	HOS	pHOS	NOB	HOB	pNOB	
1997	5,408	505	0.09	205	13	0.94	0.92
1998	4,611	741	0.14	299	78	0.79	0.85
1999	4,101	1,375	0.25	242	236	0.51	0.68
2000	4,462	1,051	0.19	275	180	0.60	0.77
2001	9,414	1,946	0.17	210	136	0.61	0.79
2002	11,892	3,831	0.24	409	10	0.98	0.81
2003	10,025	1,775	0.15	337	7	0.98	0.87
2004	9,220	1,259	0.12	424	2	1.00	0.90
2005	6,862	1,841	0.21	397	3	0.99	0.83
2006	16,060	1,732	0.10	433	4	0.99	0.91
2007	3,173	1,417	0.31	263	3	0.99	0.77
2008	4,794	1,702	0.26	378	69	0.85	0.77
2009	7,113	1,214	0.15	452	8	0.98	0.87
2010	5,879	1,589	0.21	388	5	0.99	0.83
2011	8,155	1,695	0.17	376	7	0.98	0.86
2012	7,327	1,212	0.14	267	1	1.00	0.88
2013	7,449	2,760	0.27	234	2	0.99	0.79
2014	9,676	767	0.07	261	2	0.99	0.94
Average	***8,186***	***1,221***	***0.14***	***305***	***34***	***0.92***	***0.87***
Median	***7,802***	***1,237***	***0.15***	***295***	***6***	***0.99***	***0.87***

[a] PNI was calculated previously using PNI approximate equation 11 (HSRG 2009; Appendix A). All PNI values presented here were recalculated by iterating Ford's (2002) equations 5 and 6 to equilibrium using a heritability of 0.3 and a selection strength of three standard deviations. C. Busack, NOAA Fisheries, 21 March 2016, provided the model for calculating PNI.

Post-Release Survival and Travel Time

We used PIT-tagged fish to estimate survival rates and travel time (arithmetic mean days) of hatchery summer Chinook from the Wenatchee River release site to McNary Dam, and smolt to adult ratios (SARs) from release to detection at Bonneville Dam (Table 8.27).[17] Over the five brood years for which PIT-tagged hatchery fish were released, survival rates from the Wenatchee River to McNary Dam ranged from 0.619 to 0.910; SARs from release to detection at Bonneville Dam ranged from 0.004 to 0.017. Average travel time from the Wenatchee River to McNary Dam ranged from 11 to 29 days.

Most of the variation in survival rates and travel time resulted from releases of different experimental groups (Table 8.27). For example, brood year 2009 was split into three groups (control raceway group, long-term recirculating aquaculture system (RAS) group (R1), and short-term RAS group (R2)). In this case, the control group appeared to have a higher survival rate but a longer travel time from release to McNary Dam than did the two treatment groups. SARs varied little among the three groups.

[17] It is important to point out that because of fish size differences among rearing tanks or raceways, fish PIT tagged in one tank or raceway may not represent untagged fish rearing in other tanks or raceways.

Another experiment was conducted with brood years 2012 and 2013. These brood years were split into four different treatment groups (small-size fish in raceway, large-size fish in raceway, small-size fish in RAS, and large-size fish in RAS). Although the number of replicates is small, releases from the RAS had higher survival rates to McNary Dam and faster travel times. Large-size fish from the RAS had the highest survival rates and fastest travel times.

Table 8.27. Total number of Wenatchee hatchery summer Chinook released with PIT tags, their survival and travel times (mean days) to McNary Dam, and smolt-to-adult (SAR) ratios for brood years 2008-2013. Standard errors are shown in parentheses. RAS = recirculating aquaculture system; NA = not available (i.e., not all the fish from the release groups have returned to the Columbia River).

Brood year	Number of tagged fish released	Survival to McNary Dam	Travel time to McNary Dam (d)	SAR to Bonneville Dam (%)
2008	10,035	0.847 (0.054)	28.9 (9.6)	0.017 (0.001)
2009	9,965 (Control)	0.702 (0.039)	19.3 (10.3)	0.006 (0.001)
	9,971 (R1)	0.646 (0.030)	16.4 (8.8)	0.005 (0.001)
	9,994 (R2)	0.648 (0.031)	16.0 (8.4)	0.004 (0.001)
2010	0	--	--	--
2011	5,018	0.753 (0.070)	20.9 (8.9)	0.006 (0.001)
2012 (Raceway)	5,047 (small size)	0.724 (0.066)	18.9 (9.2)	NA
	4,740 (large size)	0.619 (0.061)	16.9 (8.6)	NA
2012 (RAS)	5,041 (small size)	0.784 (0.060)	11.8 (5.0)	NA
	5,082 (large size)	0.910 (0.077)	11.1 (4.6)	NA
2013 (Raceway)	5,116 (small size)	0.770 (0.101)	17.5 (6.0)	NA
	5,127 (large size)	0.704 (0.085)	16.7 (6.2)	NA
2013 (RAS)	5,120 (small size)	0.834 (0.124)	15.6 (5.3)	NA
	5,121 (large size)	0.768 (0.112)	14.7 (4.4)	NA

Natural and Hatchery Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural-origin recruits (NOR) to the parent spawning population (spawning escapement). Natural-origin recruits are naturally produced (wild) fish that survive to contribute to harvest (directly or indirectly), to broodstock, and to spawning grounds. We do not account for fish that died in route to the spawning grounds (migration mortality) or died just before spawning (pre-spawn mortality) (see Appendix B in Hillman et al. 2012). We calculated NORs with and without harvest. NORs without harvest include all returning fish that either returned to the basin or were collected as wild broodstock. NORs with harvest include all fish harvested and are based on brood year harvest rates from the hatchery program. For brood years 1989-2008, NRR for summer Chinook in the Wenatchee averaged 0.98 (range, 0.16-2.95) if harvested fish were not included in the estimate and 2.85 (range, 0.34-10.00) if harvested fish were included in the estimate (Table 8.28). NRRs for more recent brood years will be calculated as soon as all tag recoveries and sampling rates have been loaded into the database.

Hatchery replacement rates (HRR) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HOR) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 5.7 (the calculated target value in Hillman et al. 2013). The target value of 5.7 includes harvest. HRRs exceeded NRRs in 15 of the 20 years of data, regardless if harvest was or was not included in the estimate (Table 8.28). Hatchery replacement rates for Wenatchee summer Chinook have exceeded the estimated target value of 5.7 in eight of the 20 years of data.

Table 8.28. Broodstock collected, spawning escapements, natural and hatchery-origin recruits (NOR and HOR), and natural and hatchery replacement rates (NRR and HRR; with and without harvest) for summer Chinook in the Wenatchee River basin, brood years 1989-2008.

Brood year	Broodstock Collected	Spawning Escapement	Harvest not included				Harvest included			
			HOR	NOR	HRR	NRR	HOR	NOR	HRR	NRR
1989	346	14,331	2,149	9,181	6.21	0.64	5,111	21,808	14.77	1.52
1990	87	10,861	88	9,595	1.01	0.88	118	12,984	1.36	1.20
1991	128	10,168	23	5,562	0.18	0.55	71	17,167	0.55	1.69
1992	341	11,652	442	5,858	1.30	0.50	628	8,393	1.84	0.72
1993	524	9,450	92	5,385	0.18	0.57	152	8,901	0.29	0.94
1994	418	10,154	1,239	4,219	2.96	0.42	1,945	6,644	4.65	0.65
1995	398	7,755	1,000	5,329	2.51	0.69	1,575	8,459	3.96	1.09
1996	334	6,168	371	4,441	1.11	0.72	576	6,950	1.72	1.13
1997	240	5,913	4,347	9,761	18.11	1.65	7,505	16,888	31.27	2.86
1998	472	5,352	2,289	15,795	4.85	2.95	7,703	53,542	16.32	10.00
1999	488	5,476	636	12,081	1.30	2.21	2,479	47,376	5.08	8.65
2000	492	5,512	3,334	3,885	6.78	0.70	14,208	16,603	28.88	3.01
2001	493	11,360	648	19,209	1.31	1.69	2,418	72,214	4.90	6.36
2002	482	15,723	1,823	4,956	3.78	0.32	4,488	12,267	9.31	0.78
2003	496	11,800	1,433	1,845	2.89	0.16	3,079	3,985	6.21	0.34
2004	496	10,479	590	7,429	1.19	0.71	1,454	18,434	2.93	1.76
2005	494	8,703	1,345	5,177	2.72	0.59	3,632	14,106	7.35	1.62
2006	488	17,792	3,394	6,796	6.95	0.38	10,719	21,506	21.97	1.21
2007	419	4,590	127	10,761	0.30	2.34	481	40,761	1.15	8.88
2008	472	6,496	3,887	6,288	8.24	0.97	10,371	16,949	21.97	2.61
Average	***405***	***9,487***	***1,463***	***7,678***	***3.69***	***0.98***	***3,936***	***21,297***	***9.32***	***2.85***
Median	***472***	***9,802***	***1,120***	***6,073***	***2.62***	***0.70***	***2,449***	***16,746***	***4.99***	***1.57***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adult recaptures divided by the number of tagged hatchery smolts released. Here, SARs were based on CWT returns. For the available brood years, SARs have ranged from 0.00037 to 0.01554 for hatchery summer Chinook in the Wenatchee River basin (Table 8.29).

Table 8.29. Smolt-to-adult ratios (SARs) for Wenatchee hatchery summer Chinook, brood years 1989-2009.

Brood year	Number of tagged smolts released[a]	Estimated adult captures[b]	SAR
1989	144,905	1,027	0.00709
1990	119,214	115	0.00096
1991	190,371	71	0.00037
1992	605,055	613	0.00101
1993	210,626	152	0.00072
1994	452,340	1,920	0.00424
1995	668,409	1,541	0.00231
1996	585,590	568	0.00097
1997	480,418	7,465	0.01554
1998	641,109	7,630	0.01190
1999	988,328	2,457	0.00249
2000	903,368	13,856	0.01534
2001	596,618	2,404	0.00403
2002	805,919	4,358	0.00541
2003	639,381	3,031	0.00474
2004	875,758	1,439	0.00164
2005	631,492	3,585	0.00568
2006	931,880	10,539	0.01131
2007	453,719	481	0.00106
2008	859,401	10,061	0.01171
2009	830,419	3,631	0.00437
Average	***600,682***	***3,664***	***0.00538***
Median	***631,492***	***2,404***	***0.00424***

[a] Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).

[b] Includes estimated recoveries (spawning ground, hatcheries, harvest, etc.) and observed recoveries if estimated recoveries were unavailable.

8.8 ESA/HCP Compliance

Broodstock Collection

Per the 2013 broodstock collection protocol, 256 natural-origin (adipose fin present) summer Chinook adults were targeted for collection at Dryden and Tumwater dams. The actual 2013 collection totaled 258 summer Chinook (256 natural-origin and two hatchery-origin; the hatchery-origin fish were not direct collections but rather adipose-present non-wired fish with a hatchery scale pattern) in combination from Dryden and Tumwater dams. Trapping began 1 July and ended 13 September 2013.

Summer Chinook and steelhead broodstock collections occurred concurrently at Dryden Dam. Thus, steelhead and spring Chinook encounters at Dryden Dam during Wenatchee summer Chinook broodstock collection were attributable to steelhead broodstock collections authorized under ESA Permit 1395 take authorizations. No steelhead or spring Chinook takes were associated with the Wenatchee summer Chinook collection.

Consistent with impact minimization measures in ESA Permit 1347, all ESA-listed species handled during summer Chinook broodstock collection were subject to water-to-water transfers or anesthetized if removed from the water during handling.

Hatchery Rearing and Release

The 2013 Wenatchee summer Chinook program released an estimated 470,570 smolts, representing 94.1% of the 500,001 programmed production, and was within the 110% overage allowance identified in ESA permit 1347.

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, 1395, 18118, 18119, and 18121, 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 PUD Hatchery facilities during the period 1 January through 31 December 2015. NPDES monitoring and reporting for Chelan PUD Hatchery Programs during 2015 are provided in Appendix F.

Smolt and Emigrant Trapping

ESA-listed spring Chinook and steelhead were encountered during operation of the Lower Wenatchee Trap. ESA takes are reported in the steelhead (Section 3.8) and spring Chinook (Section 5.8) sections and are not repeated here.

Spawning Surveys

Summer Chinook spawning ground surveys conducted in the Wenatchee River basin during 2015 were consistent with ESA Section 10 Permit No. 1347. Because of the difficulty of quantifying the level of take associated with spawning ground surveys, the Permit does not specify a take level associated with these activities, even though it does authorize implementation of spawning ground surveys. Therefore, no take levels are reported. However, to minimize potential effects to established redds, wading was restricted to the extent practical, and extreme caution was used to avoid established redds when wading was required.

SECTION 9: METHOW SUMMER CHINOOK

The original goal of summer Chinook salmon supplementation in the Methow Basin was in part to use artificial production to replace adult production lost because of mortality at Wells, Rocky Reach, and Rock Island dams[18], while not reducing the natural production or long-term fitness of summer Chinook in the basin. The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Anadromous Fish Agreement and Habitat Conservation Plans. Beginning with broodstock collection in 2012, Grant PUD took over the summer Chinook salmon supplementation program in the Methow Basin. Grant PUD constructed a new overwinter acclimation facility adjacent to the Carlton Acclimation Pond and the first fish released from this facility was 2014. The first fish that were overwintered acclimated in the facility were released in 2015. The new facility includes eight, 30-foot diameter dual-drain circular tanks.

Presently, adult summer Chinook are collected for broodstock from the run-at-large at the west-ladder trapping facility at Wells Dam. Prior to 2012, the goal was to collect up to 222 natural-origin adult summer Chinook for the Methow program. In 2011, the Hatchery Committees reevaluated that amount of hatchery compensation needed to achieve NNI. Based on that evaluation, the goal of the program was revised. The current goal (beginning in 2012) is to collect up to 102 natural-origin summer Chinook for the Methow program. Broodstock collection occurs from about 1 July through 15 September with trapping occurring no more than 16 hours per day, three days a week. If natural-origin broodstock collection falls short of expectation, hatchery-origin adults can be collected to make up the difference.

Adult summer Chinook are spawned and reared at Eastbank Fish Hatchery. Juvenile summer Chinook were transferred from the hatchery to Carlton Acclimation Pond in March until overwinter acclimation was initiated with the 2013 brood year. They are now released from the new facility in late April to early May.

Before 2012, the production goal for the Methow summer Chinook supplementation program was to release 400,000 yearling smolts into the Methow River at ten fish per pound. Beginning with the 2012 brood, the revised goal is to release 200,000 yearling smolts at 15 fish per pound. Targets for fork length and weight are 163 mm (CV = 9.0) and 45.4 g, respectively. Over 90% of these fish are marked with CWTs. In addition, since 2009, juvenile summer Chinook have been PIT tagged annually.

9.1 Broodstock Sampling

This section focuses on results from sampling 2013-2015 Methow summer Chinook broodstock that were collected in the West Ladder of Wells Dam during 2013-2015.

[18] The majority of the production at Carlton Acclimation Pond is initial production, which terminated in 2013, and is not necessarily tied to hydro facility mortality. The balance of the production is the result of a swap between spring and summer Chinook. That is, Chelan PUD is currently producing summer Chinook at Carlton for Douglas PUD in exchange for Douglas PUD producing spring Chinook at the Methow Fish Hatchery for Chelan PUD.

Origin of Broodstock

Broodstock collected in 2013, 2014, and 2015 consisted almost entirely of natural-origin (adipose fin present) summer Chinook (Table 9.1). In 2013, to meet production goals, hatchery-origin adults were collected in concert with natural-origin fish.

Table 9.1. Numbers of wild and hatchery summer Chinook collected for broodstock, numbers that died before spawning, and numbers of Chinook spawned for the Methow/Okanogan programs during 1989-2012. Numbers of broodstock collected from 2013 to present are only for the Methow summer Chinook Program. Unknown origin fish (i.e., undetermined by scale analysis, no CWT or fin clips, and no additional hatchery marks) were considered naturally produced. Mortality includes fish that died of natural causes typically near the end of spawning and were not needed for the program and surplus fish killed at spawning.

Brood year	Wild summer Chinook					Hatchery summer Chinook					Total number spawned
	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	Number collected	Prespawn loss[a]	Mortality	Number spawned	Number released	
1989[b]	1,419	72	-	1,297	-	341	17	-	312	-	1,609
1990[b]	864	34	-	828	-	214	8	-	206	-	1,034
1991[b]	1,003	59	-	924	-	341	20	-	314	-	1,238
1992[b]	312	6	-	297	-	428	9	-	406	-	703
1993[b]	813	48	-	681	-	464	28	-	388	-	1,069
1994	385	33	11	341	12	266	15	7	244	1	585
1995	254	13	10	173	58	351	28	9	240	74	413
1996	316	15	11	290	0	234	2	9	223	0	513
1997	214	11	5	198	0	308	24	20	264	0	462
1998	239	28	58	153	0	348	18	119	211	0	364
1999	248	5	19	224	0	307	2	16	289	0	513
2000	184	15	5	164	0	373	17	17	339	0	503
2001	135	8	36	91	0	423	29	128	266	0	357
2002	270	2	21	247	0	285	11	33	241	0	488
2003	449	14	53	381	0	112	2	9	101	0	482
2004	541	23	12	506	0	17	0	1	16	0	522
2005	551	29	76	391	55	12	2	0	9	1	400
2006	579	50	10	500	19	12	2	0	10	0	510
2007	504	22	26	456	0	19	0	2	17	0	473
2008	418	5	9	404	0	41	0	0	41	0	445
2009	553	31	15	507	0	5	5	0	0	0	507
2010	503	13	6	484	0	8	0	0	8	0	492
2011	498	18	13	467	0	30	4	0	26	0	493
Average[c]	***380***	***19***	***22***	***332***	***8***	***175***	***9***	***21***	***141***	***4***	***473***
Median[c]	***434***	***18***	***13***	***391***	***0***	***266***	***8***	***8***	***223***	***0***	***503***
2012	125	5	0	98	22	3	0	0	1	2	99
2013	98	1	0	97	0	4	0	0	4	0	101
2014	100	4	0	96	0	0	0	0	0	0	96
2015	97	0	0	97	0	1	0	0	1	0	98
Average[d]	***105***	***3***	***0***	***97***	***6***	***2***	***0***	***0***	***2***	***1***	***99***
Median[d]	***99***	***3***	***0***	***97***	***0***	***2***	***0***	***0***	***1***	***0***	***99***

[a] Pre-spawn loss represents the number of fish that died during the holding period before spawning. Mortality is the number of fish that were surplused following spawning.

[b] Number of fish spawned and collected during these years included fish retained from the right- and left-bank ladder traps at Wells Dam and fish collected from the volunteer channel. There was no distinction made between fish collected at trap locations and program (i.e., aggregated population used for Wells, Methow, and Okanogan summer Chinook programs).
[c] The average and median represent broodstock collected for the combined Methow and Okanogan programs. Because of bias from aggregating the spawning population from 1989-1993, averages are based on adult numbers collected from 1994-2011.
[d] The average and median represent broodstock collected only for the Methow program.

Age/Length Data

Ages of summer Chinook broodstock were determined from analysis of scales and/or CWTs. Broodstock collected from the 2013 return consisted primarily of age-4 and 5 natural-origin Chinook (84.8%) and age-5 hatchery-origin Chinook (100%). Age-3 natural-origin fish made up 15.2% of the broodstock (Table 9.2).

Broodstock collected from the 2014 return consisted primarily of age-4 and 5 natural-origin Chinook (95.8%). Age-3 natural-origin Chinook made up 4.1% of the broodstock (Table 9.2).

Broodstock collected from the 2015 return consisted primarily of age-4 and 5 natural-origin Chinook (87.8%). Age-3 natural-origin Chinook made up 12.2% of the broodstock (Table 9.2).

Table 9.2. Percent of hatchery and wild summer Chinook of different ages (total age) collected from broodstock for the Methow/Okanogan programs, 1991-2015.

Return Year	Origin	Total age				
		2	3	4	5	6
1991	Wild	0.5	6.8	35.1	55.4	2.2
	Hatchery	0.5	5.1	36.2	49.0	9.2
1992	Wild	0.0	13.0	36.2	50.7	0.0
	Hatchery	0.0	0.0	0.0	0.0	0.0
1993	Wild	0.0	3.9	75.3	20.8	0.0
	Hatchery	0.0	1.0	85.7	13.3	0.0
1994	Wild	3.1	9.7	26.3	60.3	0.6
	Hatchery	0.0	14.7	11.2	74.0	0.0
1995	Wild	0.0	4.6	15.3	75.6	4.6
	Hatchery	0.0	0.4	13.0	25.6	61.0
1996	Wild	0.0	8.4	56.7	30.4	4.6
	Hatchery	0.0	3.0	31.0	47.0	19.0
1997	Wild	0.5	9.4	53.0	35.1	2.0
	Hatchery	0.0	20.6	11.1	61.8	6.5
1998	Wild	1.1	12.1	56.3	30.5	0.0
	Hatchery	2.1	18.9	56.2	16.0	6.8
1999	Wild	4.7	5.1	53.7	36.0	0.5
	Hatchery	0.3	3.5	29.3	65.0	1.9
2000	Wild	0.6	14.0	28.7	56.1	0.6
	Hatchery	0.0	27.0	14.3	54.3	4.3
2001	Wild	0.0	23.5	58.8	11.8	5.9
	Hatchery	1.8	21.1	64.6	10.1	2.4

Return Year	Origin	Total age				
		2	3	4	5	6
2002	Wild	0.4	17.4	65.6	16.6	0.0
	Hatchery	0.0	2.4	39.4	58.3	0.0
2003	Wild	0.7	3.9	65.8	29.5	0.0
	Hatchery	0.0	5.6	18.7	70.1	5.6
2004	Wild	0.6	15.4	11.6	72.2	0.2
	Hatchery	0.0	6.7	53.3	33.3	6.7
2005	Wild	0.0	17.1	69.9	11.0	1.9
	Hatchery	0.0	10.0	40.0	50.0	0.0
2006	Wild	1.7	3.0	41.0	52.9	1.5
	Hatchery	0.0	16.7	25.0	50.0	8.3
2007	Wild	1.8	15.3	8.2	70.3	4.4
	Hatchery	0.0	0.0	21.1	57.9	21.1
2008	Wild	0.3	17.9	67.1	13.3	1.4
	Hatchery	0.0	7.2	62.7	47.7	2.4
2009	Wild	1.3	10.1	68.7	19.9	0.0
	Hatchery	0.0	0.0	16.7	83.3	0.0
2010	Wild	0.2	16.2	51.0	32.6	0.0
	Hatchery	0.0	12.5	50.0	25.0	12.5
2011	Wild	0.1	7.1	75.5	17.0	0.0
	Hatchery	0.0	30.0	20.0	40.0	0.0
2012	Wild	0.0	3.9	49.0	46.1	1.0
	Hatchery	0.0	0.0	0.0	100.0	0.0
2013	Wild	0.0	15.2	70.7	14.1	0.0
	Hatchery	0.0	0.0	50.0	50.0	0.0
2014	Wild	0.0	4.1	71.1	24.7	0.0
	Hatchery	0.0	0.0	0.0	0.0	0.0
2015	Wild	0.0	12.2	42.2	45.6	0.0
	Hatchery	0.0	0.0	100.0	0.0	0.0
Average	***Wild***	***0.7***	***10.8***	***50.1***	***37.1***	***1.3***
	Hatchery	***0.2***	***8.3***	***34.0***	***43.3***	***6.7***
Median	***Wild***	***0.3***	***10.1***	***53.7***	***32.6***	***0.5***
	Hatchery	***0.0***	***5.1***	***29.3***	***49.0***	***2.4***

Mean lengths of natural-origin summer Chinook of a given age differed little among return years 2013-2015 (Table 9.3). For 2013, average fork lengths for age-5 natural-origin adults were 5 cm longer than that of age-5 hatchery fish (Table 9.3). There were no hatchery-origin adults collected for the 2014 brood. Differences in hatchery-origin and natural-origin fish were hard to assess given the small sample size of hatchery-origin fish (i.e., few hatchery fish were included in the broodstock).

Table 9.3. Mean fork length (cm) at age (total age) of hatchery and wild Methow/Okanogan summer Chinook collected from broodstock for the Methow/Okanogan programs, 1991-2015; N = sample size and SD = 1 standard deviation.

Return year	Origin	Summer Chinook fork length (cm)														
		Age-2			Age-3			Age-4			Age-5			Age-6		
		Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD
1991	Wild	47	1	-	68	15	6	82	78	10	94	123	8	97	5	5
	Hatchery	47	1	-	49	10	6	78	71	5	91	96	8	96	18	6
1992	Wild	-	0	-	55	9	5	69	25	6	78	35	6	-	0	-
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-
1993	Wild	-	0	-	72	3	4	86	58	7	98	16	5	-	0	-
	Hatchery	-	0	-	42	1	-	75	84	8	88	13	6	-	0	-
1994	Wild	42	10	6	50	31	7	80	84	9	93	193	8	104	2	13
	Hatchery	-	0	-	49	38	5	76	29	7	88	191	7	-	0	-
1995	Wild	-	0	-	67	6	8	79	20	9	96	99	5	94	6	5
	Hatchery	-	0	-	52	1	-	73	32	9	89	63	9	95	150	7
1996	Wild	-	0	-	68	22	9	83	149	8	95	79	7	101	12	5
	Hatchery	-	0	-	52	7	10	77	72	7	90	109	8	100	44	6
1997	Wild	31	1	-	60	19	7	85	107	8	96	71	7	98	4	11
	Hatchery	-	0	-	45	63	5	72	34	9	92	189	7	97	20	7
1998	Wild	39	2	1	59	23	6	83	107	7	96	58	7	-	0	-
	Hatchery	43	7	6	50	64	6	74	190	7	92	54	8	98	23	5
1999	Wild	38	10	3	64	11	8	82	115	7	96	76	6	104	1	-
	Hatchery	37	1	-	53	11	9	75	92	6	91	204	6	98	6	5
2000	Wild	39	1	-	66	23	7	83	47	6	96	92	5	95	1	-
	Hatchery	-	0	-	54	100	7	78	53	8	92	201	6	99	16	6
2001	Wild	-	0	-	63	4	12	88	10	9	90	2	4	94	1	-
	Hatchery	41	9	3	55	107	9	79	327	8	93	51	7	101	12	9
2002	Wild	56	1	-	65	44	7	88	166	6	100	42	7	-	0	-
	Hatchery	-	0	-	45	6	5	76	100	7	95	148	5	-	0	-
2003	Wild	43	3	6	61	16	6	87	268	7	99	120	6	-	0	-
	Hatchery	-	0	-	55	6	9	73	20	8	91	75	7	102	6	9
2004	Wild	51	3	5	67	78	6	81	59	6	97	367	7	99	1	-
	Hatchery	-	0	-	52	1	-	70	8	5	97	5	8	109	1	-
2005	Wild	-	0	-	68	89	6	83	363	7	94	57	6	101	10	7
	Hatchery	-	0	-	55	1	-	70	4	4	89	5	4	-	0	-
2006	Wild	38	9	3	54	16	4	69	221	6	77	286	5	78	8	4
	Hatchery	-	0	-	42	2	1	62	3	2	69	6	6	76	1	-
2007	Wild	39	8	5	53	69	5	67	37	6	78	317	5	77	20	7
	Hatchery	-	0	-	-	0	-	54	4	2	75	11	5	78	4	3
2008	Wild	41	1	-	55	62	4	69	233	6	76	46	4	82	5	3
	Hatchery	-	0	-	59	6	9	67	52	5	73	23	6	79	2	8
2009	Wild	38	7	5	54	54	5	72	367	5	79	106	5	-	0	-

Return year	Origin	Summer Chinook fork length (cm)														
		Age-2			Age-3			Age-4			Age-5			Age-6		
		Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD
	Hatchery	-	0	-	-	0	-	59	1	-	71	5	7	-	0	-
2010	Wild	43	1	-	54	78	5	71	246	5	78	157	5	-	0	-
	Hatchery	-	0	-	57	1	-	67	4	5	79	2	1	89	1	-
2011	Wild	43	2	3	66	32	8	87	338	7	97	76	5	-	0	-
	Hatchery	-	0	-	63	9	11	78	9	6	92	12	9	-	0	-
2012	Wild	-	0	-	70	10	3	84	62	5	96	54	6	-	0	-
	Hatchery	-	0	-	-	0	-	-	0	-	90	1	-	-	0	-
2013	Wild	-	0	-	72	14	5	86	65	7	97	13	5	-	0	-
	Hatchery	-	0	-	-	0	-	76	2	6	92	2	0	-	0	-
2014	Wild	-	0	-	75	4	3	88	69	6	94	24	4	-	0	-
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-
2015	Wild	-	-	-	71	11	4	83	38	5	94	41	6	-	-	-
	Hatchery	-	-	-	-	-	-	75	1	0	-	-	-	-	-	-
Average	***Wild***	***42***	***3***	***4***	***63***	***30***	***6***	***81***	***133***	***7***	***91***	***102***	***6***	***94***	***3***	***7***
	Hatchery	***42***	***1***	***5***	***52***	***18***	***7***	***72***	***48***	***6***	***87***	***61***	***6***	***94***	***13***	***6***

Sex Ratios

Male summer Chinook in the 2013 broodstock made up about 51.0% of the adults collected, resulting in an overall male to female ratio of 1.04:1.00 (Table 9.4.). In 2014, males made up about 50.0% of the adults collected, resulting in an overall male to female ratio of 1.00:1.00 (Table 9.4). In 2015, males made up about 51.0% of the adults collected, resulting in an overall male to female ratio of 1.02:1.00 (Table 9.4). The ratios for 2013, 2014, and 2015 broodstock were above or at the assumed 1:1 ratio goal in the broodstock protocol.

Table 9.4. Numbers of male and female wild and hatchery summer Chinook collected for broodstock at Wells Dam for the Methow/Okanogan programs, 1991-2015. Ratios of males to females are also provided.

Return year	Number of wild summer Chinook			Number of hatchery summer Chinook			Total M/F ratio
	Males (M)	Females (F)	M/F	Males (M)	Females (F)	M/F	
1989[a]	752	667	1.13:1.00	181	160	1.13:1.00	1.13:1.00
1990[a]	381	482	0.79:1.00	95	120	0.79:1.00	0.79:1.00
1991[a]	443	559	0.79:1.00	151	191	0.79:1.00	0.79:1.00
1992[a]	349	318	1.10:1.00	38	35	1.09:1.00	1.10:1.00
1993[a]	513	300	1.71:1.00	293	171	1.71:1.00	1.71:1.00
1994	205	180	1.14:1.00	165	101	1.63:1.00	1.32:1.00
1995	103	149	0.69:1.00	158	197	0.80:1.00	0.75:1.00
1996	178	138	1.29:1.00	132	102	1.29:1.00	1.29:1.00
1997	102	112	0.91:1.00	174	134	1.30:1.00	1.12:1.00
1998	130	109	1.19:1.00	263	85	3.09:1.00	2.03:1.00
1999	138	110	1.25:1.00	161	146	1.10:1.00	1.17:1.00

Return year	Number of wild summer Chinook			Number of hatchery summer Chinook			Total M/F ratio
	Males (M)	Females (F)	M/F	Males (M)	Females (F)	M/F	
2000	82	102	0.80:1.00	243	130	1.87:1.00	1.40:1.00
2001	89	46	1.93:1.00	311	112	2.78:1.00	2.53:1.00
2002	166	104	1.60:1.00	149	136	1.10:1.00	1.31:1.00
2003	255	194	1.31:1.00	61	51	1.20:1.00	1.29:1.00
2004	263	278	0.95:1.00	12	5	2.40:1.00	0.97:1.00
2005	365	186	1.96:1.00	6	6	1.00:1.00	1.93:1.00
2006	287	292	0.98:1.00	9	3	3.00:1.00	1.00:1.00
2007	228	276	0.83:1.00	11	8	1.38:1.00	0.84:1.00
2008	210	208	1.01:1.00	13	28	0.46:1.00	0.94:1.00
2009	261	292	0.89:1.00	2	3	0.67:1.00	0.89:1.00
2010	248	255	0.97:1.00	5	3	1.67:1.00	0.98:1.00
2011	236	262	0.90:1.00	23	7	3.29:1.00	0.96:1.00
2012	50	53	0.94:1.00	1	0	-	0.96:1.00
2013	49	49	1.00:1.00	3	1	3.00:1.00	1.04:1.00
2014	50	50	1.00:1.00	0	0	-	1.00:1.00
2015	49	49	1.00:1.00	1	0	-	1.02:1.00
Total[b]	***6,182***	***5820***	***1.06:1.00***	***2661***	***1935***	***1.36:1.00***	***1.14:1.00***

[a] Numbers and male to female ratios were derived from the aggregate population collected at Wells Fish Hatchery volunteer channel and left- and right-ladder traps at Wells Dam.
[b] Total values were derived from 1994-present data to exclude aggregate population bias from 1989-1993 returns.

Fecundity

Fecundities for the 2013, 2014, and 2015 summer Chinook broodstock averaged 4,700, 4,685, and 4,410 eggs per female, respectively (Table 9.5). These values are close to the overall average of 4,914 eggs per female. Mean observed fecundities for the 2013, 2014, and 2015 returns were slightly below the expected fecundity of 4,982 eggs per female assumed in the broodstock protocol.

Table 9.5. Mean fecundity of wild, hatchery, and all female summer Chinook collected for broodstock at Wells Dam for the Methow/Okanogan programs, 1989-2014; NA = not available.

Return year	Mean fecundity		
	Wild	Hatchery	Total
1989*	NA	NA	4,750
1990*	NA	NA	4,838
1991*	NA	NA	4,819
1992*	NA	NA	4,804
1993*	NA	NA	4,849
1994*	NA	NA	5,907
1995*	NA	NA	4,930
1996*	NA	NA	4,870
1997	5,166	5,296	5,237

Return year	Mean fecundity		
	Wild	Hatchery	Total
1998	5,043	4,595	4,833
1999	4,897	4,923	4,912
2000	5,122	5,206	5,170
2001	5,040	4,608	4,735
2002	5,306	5,258	5,279
2003	5,090	4,941	5,059
2004	5,130	5,118	5,130
2005	4,545	4,889	4,553
2006	4,854	4,824	4,854
2007	5,265	5,093	5,260
2008	4,814	4,588	4,787
2009	5,115	--	5,115
2010	5,124	4,717	5,116
2011	4,594	3,915	4,578
2012	4,470	--	4,470
2013	4,700	5,490	4,717
2014	4,685	--	4,685
2015	4,410	--	4,410
Average	***4,914***	***4,897***	***4,914***
Median	***5,040***	***4,923***	***4,849***

* Individual fecundities were not assigned to females until 1997 brood.

9.2 Hatchery Rearing

Rearing History

Number of eggs taken

Based on the unfertilized egg-to-release survival standard of 81%, a total of 493,827 eggs were needed to meet the program release goal of 400,000 smolts for brood years 1989-2011. An evaluation of the program in 2011 determined that 246,913 eggs are needed to meet the revised release goal of 200,000 smolts. This revised goal began with brood year 2012. From 1989 through 2011, the egg take goal was reached in eight of those years (Table 9.6). From 2012 to present, the egg take goal was not achieved (Table 9.6).

Table 9.6. Numbers of eggs taken from summer Chinook broodstock collected at Wells Dam for the Methow/Okanogan programs, 1989-2015.

Return year	Number of eggs taken
1989	482,800
1990	464,097
1991	586,594
1992	486,260

Return year	Number of eggs taken
1993	531,490
1994	595,390
1995	491,000
1996	448,000
1997	401,162
1998	389,346
1999	483,726
2000	403,268
2001	279,272
2002	466,530
2003	473,681
2004	537,210
2005	305,826
2006	509,334
2007	549,802
2008	441,778
2009	560,602
2010	505,188
2011	488,747
Average (1989-2011)	***473,091***
Median (1989-2011)	***483,726***
2012	245,245
2013	231,136
2014	223,839
2015	216,098
Average (2012-present)	***229,080***
Median (2012-present)	***227,488***

Number of acclimation days

Rearing of the 2013 brood Methow summer Chinook was different than previous years with fish being held on well water before being transferred to Carlton Acclimation Pond for final acclimation on Methow River water in October of 2014 (Table 9.7). Groups of the 1994 and 1995 broods were reared for longer durations at the Methow Fish Hatchery on Methow River water.

Table 9.7. Number of days Methow summer Chinook were acclimated at Carlton Acclimation Pond, brood years 1989-2013.

Brood year	Release year	Transfer date	Release date	Number of days
1989	1991	15-Mar	6-May	52
1990	1992	26-Feb	28-Apr	61

Brood year	Release year	Transfer date	Release date	Number of days
1991	1993	10-Mar	23-Apr	44
1992	1994	4-Mar	21-Apr	48
1993	1995	18-Mar	2-May	45
1994	1996	25-Sep	28-Apr	215
		19-Mar	28-Apr	40
1995	1997	22-Oct	8-Apr	168
		19-Mar	22-Apr	34
1996	1998	9-Mar	14-Apr	36
1997	1999	10-Mar	20-Apr	41
1998	2000	19-Mar	2-May	44
1999	2001	18-Mar	18-Apr	31
2000	2002	28-Mar	1-May	34
2001	2003	27-Mar	24-Apr	28
2002	2004	16-Mar	24-Apr	39
2003	2005	18-Mar	21-Apr	34
2004	2006	12-Mar	22-Apr	41
2005	2007	12-Mar	15-Apr – 8-May	34-57
2006	2008	4-7-Mar	16-Apr – 2 May	40-59
2007	2009	18-24-Mar	21-Apr	28-34
2008	2010	4-5, 8-9-Mar	4-21-Apr	33-50
2009	2011	25, 29, 31-Mar & 4-Apr	11-25-Apr	8-31
2010	2012	19-21, 24-Mar	23-24-Apr	31-37
2011	2013	13-21-Mar	15-23-Apr	25-41
2012	2014	19-21-Mar	7-Apr – 14 May	18-57
2013	2015	20-21-Oct	13-May	204-205

Release Information

Numbers released

The 2013 brood Methow summer Chinook program achieved 94.4% of the 200,000 target goal with about 188,834 fish being volitionally released from the circular ponds. Most of the fish were force released on 13 May 2015 (Table 9.8).

Table 9.8. Numbers of Methow summer Chinook smolts released from the hatchery, brood years 1989-2013. Beginning with the 2014 release, the release target for Methow summer Chinook is 200,000 smolts.

Brood year	Release year	CWT mark rate	Number of smolts released
1989	1991	0.8529	420,000
1990	1992	0.9485	391,650
1991	1993	0.6972	540,900
1992	1994	0.9752	402,641
1993	1995	0.4623	433,375
1994	1996	0.9851	406,560
1995	1997	0.9768	353,182
1996	1998	0.9221	298,844
1997	1999	0.9884	384,909
1998	2000	0.9429	205,269
1999	2001	0.9955	424,363
2000	2002	0.9928	336,762
2001	2003	0.9902	248,595
2002	2004	0.9913	399,975
2003	2005	0.9872	354,699
2004	2006	0.9848	400,579
2005	2007	0.9897	263,723
2006	2008	0.9783	419,734
2007	2009	0.9837	433,256
2008	2010	0.9394	397,554
2009	2011	0.9862	404,956
2010	2012	0.9962	439,000
2011	2013	0.9734	436,092
Average (1989-2011)		***0.9365***	***382,462***
Median (1989-2011)		***0.9837***	***400,579***
2012	2014	0.9987	197,391
2013	2015	0.9903	188,834
Average (2012-present)		***0.9945***	***193,113***
Median (2012-present)		***0.9945***	***193,113***

Numbers tagged

The 2013 brood Methow summer Chinook were 99% CWT and adipose fin-clipped (Table 9.8).

A total of 5,000 Methow summer Chinook (brood 2014) were PIT tagged at the Carlton Acclimation Facility on 14-16 March 2016. These fish were tagged in circular ponds #1 through #8. Fish were not fed during tagging or for two days before and after tagging. Fish averaged 116 mm in length and 17.0 g at time of tagging.

Table 9.9 summarizes the number of hatchery summer Chinook that have been PIT-tagged and released into the Methow River.

Table 9.9. Summary of PIT-tagging activities for Methow hatchery summer Chinook, brood years 2008-2013.

Brood year	Release year	Number of fish tagged	Number of tagged fish that died	Number of tags shed	Number of tagged fish released
2008	2010	10,100	4	0	10,096
2009	2011	5,050	17	9	5,024
2010	2012	0	0	0	0
2011	2013	0	0	0	0
2012	2014	10,099	41	7	10,051
2013	2015	10,159	35	1	10,123

Fish size and condition at release

A volitional release of yearling smolts took place beginning on 13 April and ending on 13 May 2015 (remaining fish were forced out of the facility on 13 May). Size at release from the acclimated population was 79.8% and 59.9% of the respective target fork length and weight goals (Table 9.10). This brood year exceeded the target CV for length by 40%.

Table 9.10. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of Methow summer Chinook smolts released from the hatchery, brood years 1991-2013. Size targets are provided in the last row of the table.

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1991	1993	152	13.6	40.3	11
1992	1994	145	16.0	37.2	12
1993	1995	154	8.6	37.1	12
1994	1996	163	8.2	48.2	9
1995	1997	141	9.6	37.0	12
1996	1998	199	13.1	105.1	4
1997	1999	153	7.6	39.5	12
1998	2000	164	8.7	51.7	9
1999	2001	153	9.3	41.5	11
2000	2002	170	10.2	54.2	8
2001	2003	167	7.4	52.7	9
2002	2004	148	13.1	35.7	13
2003	2005	148	10.1	35.5	13
2004	2006	142	9.8	31.1	15
2005	2007	158	15.0	42.2	11
2006	2008	156	18.0	42.8	11

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
2007	2009	138	21.0	32.1	14
2008	2010	155	14.2	42.0	11
2009	2011	170	15.8	56.9	8
2010	2012	145	16.7	34.5	13
2011	2013	160	13.0	43.6	6
Average		***156***	***12.3***	***44.8***	***11***
Targets		***163***	***9.0***	***45.4***	***10***
2012	2014	158	12.1	41.6	11
2013	2015	130	12.6	27.2	17
Average		***144***	***12.4***	***34.4***	***14***
Targets		***163***	***9.0***	***45.4***	***15***

Survival Estimates

Overall survival of the Methow summer Chinook from green (unfertilized) egg-to-release was above the standard set for the program (Table 9.11). High hatchery survival can be attributed to exceeding the survival standards set for the program at almost every life stage.

Table 9.11. Hatchery life-stage survival rates (%) for Methow summer Chinook, brood years 1989-2013. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
1989[a]	89.8	99.5	89.9	96.7	99.7	99.4	73.3	98.5	87.0
1990[a]	93.9	99.0	84.9	97.1	81.2	80.6	97.7	99.5	84.4
1991[a]	93.1	95.5	88.2	98.0	99.4	99.1	97.5	99.6	92.2
1992[a]	96.9	99.0	87.8	98.0	99.9	99.9	90.9	98.3	82.8
1993[a]	82.2	99.4	85.4	97.6	99.8	99.5	92.0	99.4	81.5
1994	96.1	90.0	86.6	100.0	98.1	97.4	73.1	99.1	68.3
1995	91.9	96.2	98.2	84.1	96.5	96.2	92.7	89.6	71.9
1996	95.4	98.1	83.2	100.0	97.7	96.9	86.5	89.0	66.7
1997	91.9	94.6	86.1	98.4	98.7	98.3	98.8	99.7	95.9
1998	84.0	96.2	54.1	98.0	99.4	98.9	96.6	99.9	52.7
1999	98.8	98.7	92.9	96.9	98.0	97.6	96.9	99.9	87.7
2000	90.5	96.9	89.2	98.1	98.5	98.3	94.6	94.4	83.5
2001	96.2	92.3	89.1	97.6	97.2	97.1	97.5	99.8	89.0
2002	97.1	98.1	88.3	99.9	97.7	97.5	96.7	99.9	85.7
2003	96.7	97.5	82.8	98.2	99.7	99.2	93.7	99.9	74.9

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
2004	93.6	98.2	84.0	97.8	99.6	99.2	98.3	98.5	74.6
2005	97.0	89.6	88.0	95.5	99.6	98.9	96.6	99.9	86.2
2006	92.9	89.5	86.3	98.3	99.6	98.7	97.2	99.5	82.4
2007	92.6	99.6	84.1	98.5	99.7	99.5	98.9	99.8	81.9
2008	99.6	97.9	91.9	99.5	99.3	98.9	98.5	99.9	90.0
2009[b]	93.6	93.5	91.0	97.7	99.7	99.2	98.8	100.0	87.9
2010[c]	96.5	100.0	91.1	100.0	96.4	96.1	95.4	99.5	86.9
2011	94.9	96.4	93.8	97.8	99.7	99.1	98.6	99.9	90.4
2012	94.3	94.2	93.1	97.8	99.4	99.0	97.0	98.3	88.3
2013	98.0	100.0	89.5	97.8	99.9	99.2	93.4	94.2	81.7
Average	***93.9***	***96.4***	***87.2***	***97.6***	***98.2***	***97.7***	***94.0***	***98.2***	***82.2***
Median	***94.3***	***97.5***	***88.2***	***98.0***	***99.4***	***98.9***	***96.7***	***99.5***	***84.4***
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

[a] Survival rates were calculated from aggregate population collected at Wells Fish Hatchery volunteer channel and left- and right-ladder traps at Wells Dam.

[b] Survival rates were calculated from aggregate collections at Wells east fish ladder for the Methow and Okanogan/Similkameen programs. About 41% of the total fish collected were used to estimate survival rates.

[c] Survival rates were calculated from aggregate collections at Wells West Ladder for the Methow and Similkameen programs. About 71% of the total fish collected were used to estimate survival rates.

9.3 Disease Monitoring

Results of 2015 adult broodstock bacterial kidney disease (BKD) monitoring indicated that all females had ELISA values less than 0.120 (Table 9.12).

Table 9.12. Proportion of bacterial kidney disease (BKD) titer groups for the Methow/Okanogan summer Chinook broodstock, brood years 1997-2015. Also included are the proportions to be reared at either 0.125 fish per pound or 0.060 fish per pound.

Brood year[a]	Optical density values by titer group				Proportion at rearing densities (fish per pound, fpp)[b]	
	Very Low (≤ 0.099)	Low (0.1-0.199)	Moderate (0.2-0.449)	High (≥ 0.450)	≤ 0.125 fpp (<0.119)	≤ 0.060 fpp (>0.120)
1997	0.6267	0.1333	0.0622	0.1778	0.6844	0.3156
1998	0.9632	0.0184	0.0123	0.0061	0.9816	0.0184
1999	0.9444	0.0198	0.0238	0.0119	0.9643	0.0357
2000	0.7476	0.0952	0.0238	0.1333	0.8000	0.2000
2001	0.9801	0.0199	0.0000	0.0000	1.0000	0.0000
2002	0.9567	0.0130	0.0130	0.0173	0.9740	0.0260
2003	0.9620	0.0127	0.0169	0.0084	0.9747	0.0253
2004	0.9585	0.0151	0.0075	0.0189	0.9736	0.0264

Brood year[a]	Optical density values by titer group				Proportion at rearing densities (fish per pound, fpp)[b]	
	Very Low (≤ 0.099)	**Low (0.1-0.199)**	**Moderate (0.2-0.449)**	**High (≥ 0.450)**	**≤ 0.125 fpp (<0.119)**	**≤ 0.060 fpp (>0.120)**
2005	0.9884	0.0000	0.0000	0.0116	0.9884	0.0116
2006	0.9962	0.0038	0.0000	0.0000	0.9962	0.0038
2007	0.9202	0.0266	0.0152	0.0380	0.9354	0.0646
2008	1.0000	0.0000	0.0000	0.0000	1.0000	0.0000
2009	0.9891	0.0073	0.0037	0.0000	0.9927	0.0073
2010	0.9960	0.0040	0.0000	0.0000	1.0000	0.0000
2011	0.9766	0.0140	0.0000	0.0093	0.9860	0.0140
2012	0.9341	0.0440	0.0110	0.0110	0.9780	0.0220
2013	0.8776	0.1224	0.0000	0.0000	0.9388	0.0612
2014	0.9170	0.0210	0.0210	0.0420	0.9381	0.0630
2015	1.0000	0.0000	0.0000	0.0000	1.0000	0.0000
Average	***0.9334***	***0.0300***	***0.0111***	***0.0256***	***0.9530***	***0.0471***
Median	***0.9620***	***0.0151***	***0.0075***	***0.0093***	***0.9780***	***0.0220***

[a] Individual ELISA samples were not collected before the 1997 brood.
[b] ELISA values from broodstock BKD testing dictate what density the progeny of the broodstock are reared. Progeny of broodstock with high ELISA values are reared at lower density.

9.4 Natural Juvenile Productivity

During 2015, juvenile summer Chinook were sampled at the Methow Trap located near RM 18.6. Trapping has occurred in this location since 2004.

Emigrant Estimates

Methow Trap

On the Methow River, WDFW used traps with cone diameters of 2.4 m and 1.5 m to increase trap efficiency over a greater range of river discharge. Large variation in discharge and channel configuration required the use of two trapping positions. The 1.5-m trap was deployed in the lower position at discharges less than 45.3 m^3/s. At discharges greater than 45.3 m^3/s, the 2.4-m trap was installed and operated in tandem with the 1.5 m trap.

A pooled-efficiency model estimated the total number of emigrants when the trap was operated in the low trapping position. A flow-efficiency model estimated the total number of emigrants when the trap was operated in the upper trapping position. The pooled-efficiency estimate was based on three mark-recapture release groups in 2015. The flow-efficiency estimate was based on 12 mark-recapture release groups that were conducted over the period 2008-2011.

The Methow Trap operated at night between 18 February and 25 November 2015. During that time period the trap was inoperable for three days because of fire activity. During the ten-month sampling period, a total of 12,914 wild subyearling summer Chinook were captured at the Methow Trap. Based on the pooled-efficiency model and the flow efficiency model, the total number of wild subyearling summer Chinook that emigrated past the Methow Trap in 2015 was 706,071

(±578,674). Because 29 summer Chinook redds were observed downstream from the trap in 2014, the total number of summer Chinook emigrating from the Methow River in 2015 was expanded using the ratio of the number of redds downstream from the trap to the number upstream from the trap. This resulted in a total summer Chinook emigrant estimate of 742,505 fish. Most of these fish emigrated during May and June (Figure 9.1).

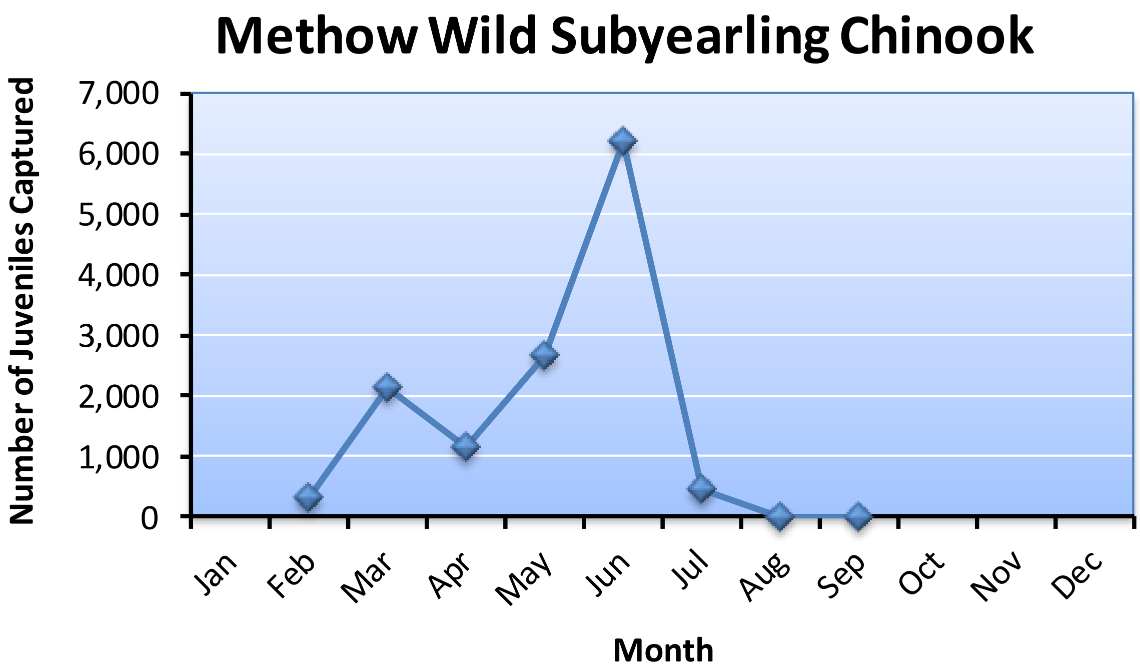

Figure 9.1. Numbers of wild subyearling Chinook captured at the Methow Trap during February through September, 2015.

9.5 Spawning Surveys

Surveys for Methow summer Chinook redds were conducted from late September to mid-November 2015 in the Methow River. Total redd counts (not peak counts) were conducted in the river (see Appendix N for more details).

Redd Counts

A total of 1,231 summer Chinook redds were counted in the Methow River in 2015 (Table 9.13). This is greater than the overall average of 696 redds.

Table 9.13. Total number of redds counted in the Methow River, 1989-2015.

Survey year	Total redd count
1989	149*
1990	418*
1991	153
1992	107

Survey year	Total redd count
1993	154
1994	310
1995	357
1996	181
1997	205
1998	225
1999	448
2000	500
2001	675
2002	2,013
2003	1,624
2004	973
2005	874
2006	1,353
2007	620
2008	599
2009	692
2010	887
2011	941
2012	960
2013	1,551
2014	591
2015	1,231
Average	***696***
Median	***599***

* Total counts based on expanded aerial counts.

Redd Distribution

Summer Chinook redds were not evenly distributed among the seven reaches in the Methow River. Most redds (78%) were located within the lower three reaches (downstream from Twisp) (Table 9.14; Figure 9.2). Few Chinook spawned upstream from Winthrop (Reaches 6 and 7).

Table 9.14. Total number of summer Chinook redds counted in different reaches on the Methow River during September through early November, 2015. Reach codes are described in Table 2.11.

Survey reach	Total redd count	Percent
Methow 1 (M1)	350	28.4
Methow 2 (M2)	309	25.1
Methow 3 (M3)	307	24.9
Methow 4 (M4)	72	5.8
Methow 5 (M5)	146	11.9
Methow 6 (M6)	13	1.1

Survey reach	Total redd count	Percent
Methow 7 (M7)	34	2.8
Totals	***1,231***	***100***

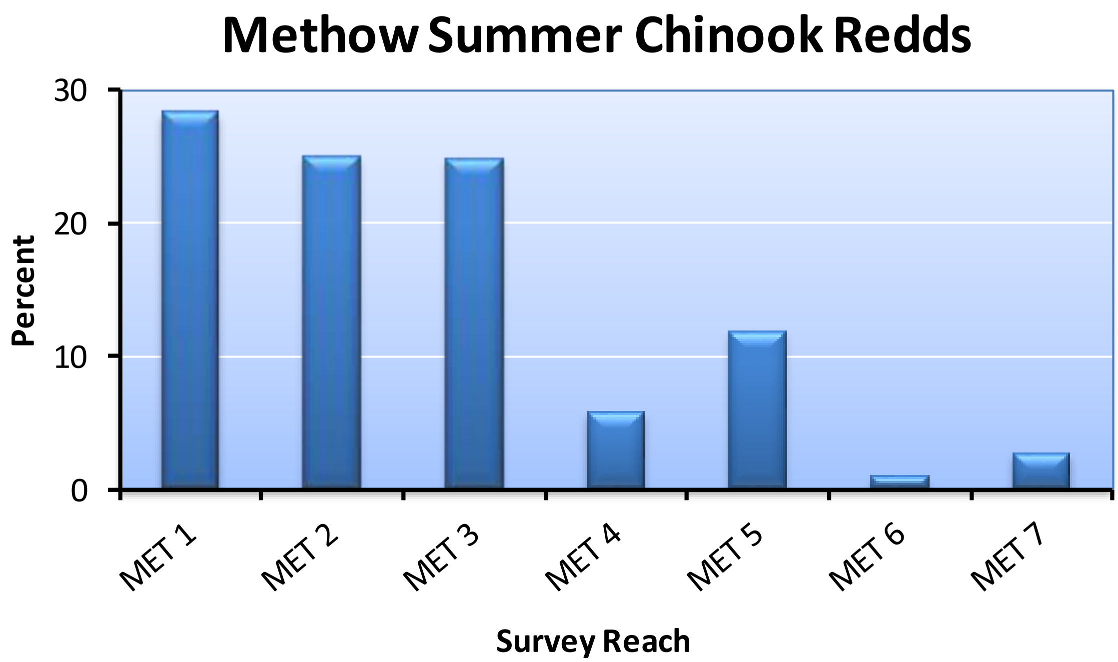

Figure 9.2. Percent of the total number of summer Chinook redds counted in different reaches on the Methow River during September through mid-November, 2015. Reach codes are described in Table 2.11.

Spawn Timing

Spawning in 2015 began the last week of September, peaked in early October, and ended the third week of November (Figure 9.3). Stream temperatures in the Methow River, when spawning began, varied from 9.0-10.0°C. Peak spawning occurred during the first week of October in the upper reaches of the Methow River and one week later in the lower reaches.

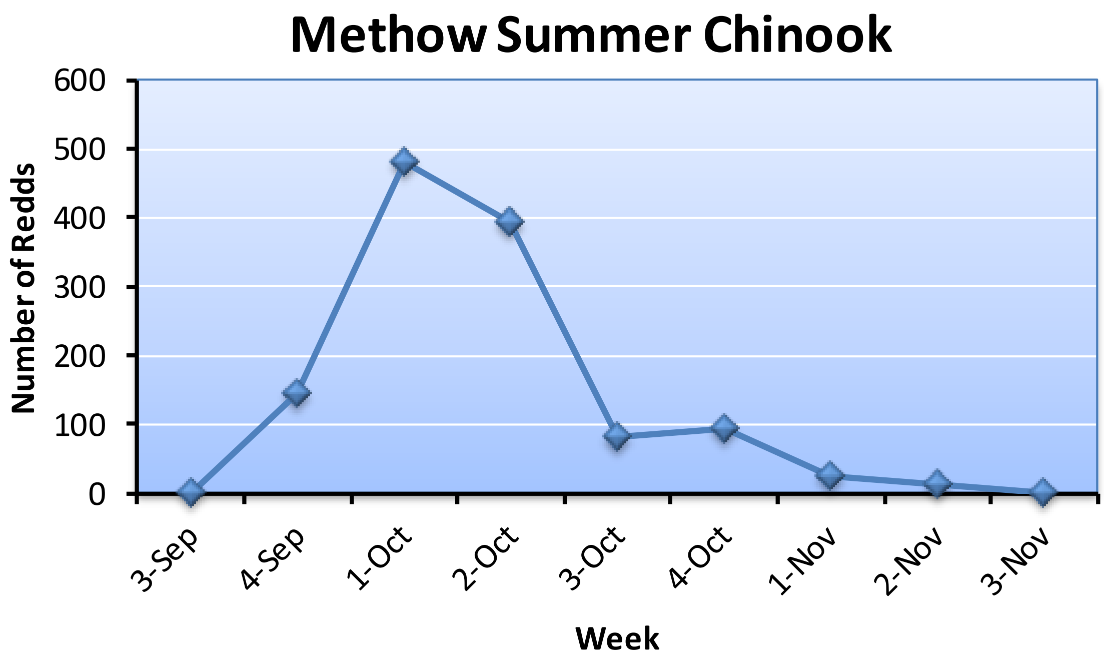

Figure 9.3. Number of new summer Chinook redds counted during different weeks in the Methow River, September through mid-November 2015.

Spawning Escapement

Spawning escapement for Methow summer Chinook was calculated as the total number of redds times the fish per redd ratio estimated from fish sampled at Wells Dam. The estimated fish per redd ratio for Methow summer Chinook in 2015 was 3.21. Multiplying this ratio by the number of redds counted in the Methow River resulted in a total spawning escapement of 3,952 summer Chinook (Table 9.15).

Table 9.15. Spawning escapements for summer Chinook in the Methow River for return years 1989-2015.

Return year	Fish/Redd	Redds	Total spawning escapement
1989*	3.30	149	492
1990*	3.40	418	1,421
1991*	3.70	153	566
1992*	4.30	107	460
1993*	3.30	154	508
1994*	3.50	310	1,085
1995*	3.40	357	1,214
1996*	3.40	181	615
1997*	3.40	205	697
1998	3.00	225	675
1999	2.20	448	986

Return year	Fish/Redd	Redds	Total spawning escapement
2000	2.40	500	1,200
2001	4.10	675	2,768
2002	2.30	2,013	4,630
2003	2.42	1,624	3,930
2004	2.25	973	2,189
2005	2.93	874	2,561
2006	2.02	1,353	2,733
2007	2.20	620	1,364
2008	3.25	599	1,947
2009	2.54	692	1,758
2010	2.81	887	2,492
2011	3.10	941	2,917
2012	3.07	960	2,947
2013	2.31	1,551	3,583
2014	2.75	591	1,625
2015	3.21	1,231	3,952
Average	***2.98***	***696***	***1,901***
Median	***3.07***	***599***	***1,625***

* Spawning escapement was calculated using the "Modified Meekin Method" (i.e., 3.1 x jack multiplier).

9.6 Carcass Surveys

Surveys for Methow summer Chinook carcasses were conducted during late September to mid-November 2015 in the Methow River (see Appendix N for more details).

Number sampled

A total of 839 summer Chinook carcasses were sampled during September through mid-November in the Methow River (Table 9.16). This was greater than the overall average of 520 carcasses sampled since 1991.

Table 9.16. Numbers of summer Chinook carcasses sampled within each survey reach on the Methow River, 1991-2015. Reach codes are described in Table 2.11.

Survey year	Number of summer Chinook carcasses							
	M-1	M-2	M-3	M-4	M-5	M-6	M-7	Total
1991	0	12	8	4	2	0	0	**26**
1992	8	8	19	0	17	1	0	**53**
1993	19	25	14	2	5	0	0	**65**
1994[a]	43	33	20	5	13	0	0	**114**
1995	14	33	58	7	7	0	0	**119**
1996	6	30	46	5	2	0	0	**89**
1997	6	12	38	2	19	1	0	**78**
1998	90	84	99	17	30	0	0	**320**

Survey year	Number of summer Chinook carcasses							
	M-1	**M-2**	**M-3**	**M-4**	**M-5**	**M-6**	**M-7**	**Total**
1999	47	144	232	32	37	12	2	**506**
2000	62	118	105	9	99	5	0	**398**
2001	392	275	88	14	76	11	1	**857**
2002	551	318	518	164	219	34	10	**1,814**
2003	115	268	317	115	128	5	0	**948**
2004	40	173	187	82	92	2	1	**577**
2005	154	173	182	42	112	3	0	**666**
2006	121	148	110	56	144	3	1	**583**
2007	142	132	108	27	53	0	0	**462**
2008	64	128	197	33	57	3	0	**482**
2009	144	158	159	36	94	0	0	**591**
2010	105	180	184	38	63	5	1	**576**
2011	56	134	201	78	83	5	1	**558**
2012	127	154	169	75	82	14	7	**628**
2013	296	287	385	90	100	7	5	**1,170**
2014	6	14	176	53	148	73	17	**487**
2015	229	194	221	56	95	19	25	**839**
Average	***113***	***129***	***154***	***42***	***71***	***8***	***3***	***520***
Median	***64***	***134***	***159***	***33***	***76***	***3***	***0***	***506***

[a] An additional 113 carcasses were sampled, but reach was not identified.

Carcass Distribution and Origin

Summer Chinook carcasses were not evenly distributed among reaches within the Methow River in 2015 (Table 9.15; Figure 9.4). Most of the carcasses were found in the lower three reaches (downstream from Twisp). Few carcasses were observed upstream from Winthrop (Reaches 6 and 7).

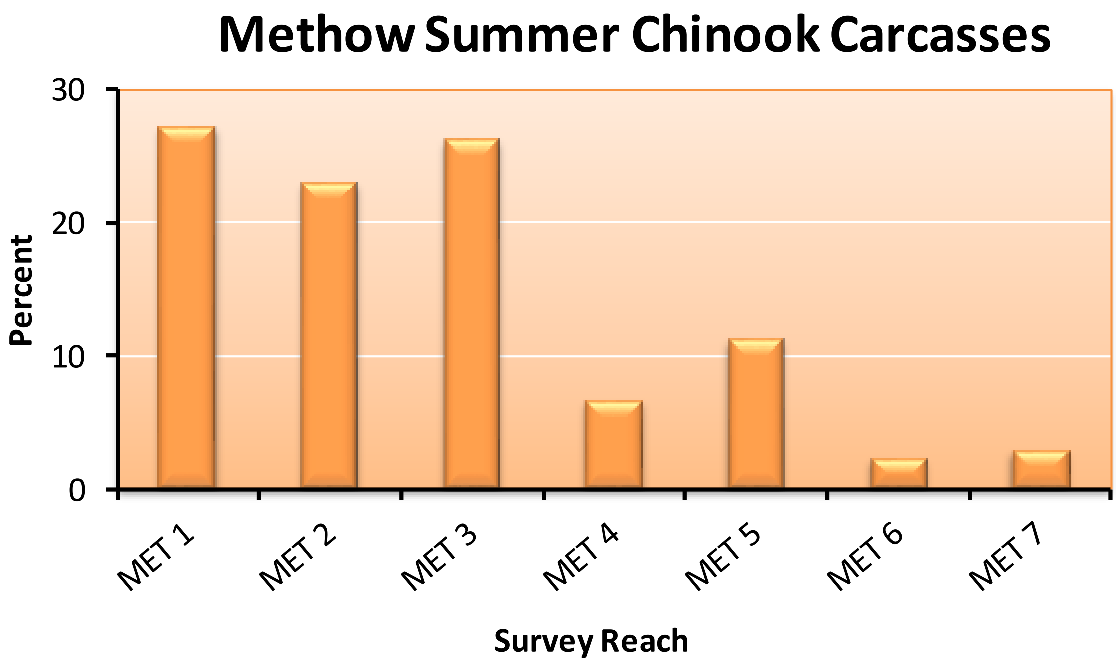

Figure 9.4. Percent of summer Chinook carcasses sampled within different reaches on the Methow River during September through mid-November, 2015. Reach codes are described in Table 2.11.

Numbers of wild and hatchery-origin summer Chinook carcasses sampled in 2015 will be available after analysis of CWTs and scales. Based on the available data (1991-2014), hatchery and wild summer Chinook carcasses were not distributed equally among the reaches in the Methow River (Table 9.17). A larger percentage of hatchery carcasses occurred in the lower reaches, while a larger percentage of wild summer Chinook carcasses occurred in upstream reaches (Figure 9.5).

Table 9.17. Numbers of wild and hatchery summer Chinook carcasses sampled within different reaches on the Methow River, 1991-2014.

Survey year	Origin	Survey reach							Total
		M-1	M-2	M-3	M-4	M-5	M-6	M-7	
1991	Wild	0	12	8	4	2	0	0	**26**
	Hatchery	0	0	0	0	0	0	0	**0**
1992	Wild	8	8	19	0	17	1	0	**53**
	Hatchery	0	0	0	0	0	0	0	**0**
1993	Wild	11	18	9	0	3	0	0	**41**
	Hatchery	8	7	5	2	2	0	0	**24**
1994	Wild	23	18	9	5	10	0	0	**65**
	Hatchery	20	15	11	0	3	0	0	**49**
1995	Wild	7	9	33	7	6	0	0	**62**
	Hatchery	7	24	25	0	1	0	0	**57**
1996	Wild	1	23	35	4	2	0	0	**65**
	Hatchery	5	7	11	1	0	0	0	**24**

Survey year	Origin	Survey reach							Total
		M-1	M-2	M-3	M-4	M-5	M-6	M-7	
1997	Wild	5	8	31	1	17	0	0	**62**
	Hatchery	1	4	7	1	2	1	0	**16**
1998	Wild	42	48	71	11	25	0	0	**197**
	Hatchery	48	36	28	6	5	0	0	**123**
1999	Wild	32	87	130	15	24	4	2	**294**
	Hatchery	15	57	102	17	13	8	0	**212**
2000	Wild	25	85	85	8	83	3	0	**289**
	Hatchery	37	33	20	1	16	2	0	**109**
2001	Wild	62	118	56	10	70	11	1	**328**
	Hatchery	330	157	32	4	6	0	0	**529**
2002	Wild	138	177	380	140	197	34	9	**1,075**
	Hatchery	413	141	138	24	22	0	1	**739**
2003	Wild	33	146	188	76	92	3	0	**538**
	Hatchery	82	122	129	39	36	2	0	**410**
2004	Wild	16	120	155	65	78	1	0	**435**
	Hatchery	24	53	32	17	14	1	1	**142**
2005	Wild	62	99	133	33	107	3	0	**437**
	Hatchery	92	74	49	9	5	0	0	**229**
2006	Wild	52	82	67	44	109	2	1	**357**
	Hatchery	69	66	43	12	35	1	0	**226**
2007	Wild	35	58	59	16	40	0	0	**208**
	Hatchery	107	74	49	11	13	0	0	**254**
2008	Wild	13	62	146	27	52	2	0	**302**
	Hatchery	51	66	51	6	5	1	0	**180**
2009	Wild	45	87	103	27	84	0	0	**346**
	Hatchery	99	71	56	9	10	0	0	**245**
2010	Wild	33	79	101	24	53	5	1	**296**
	Hatchery	72	101	83	14	10	0	0	**280**
2011	Wild	21	56	87	54	56	5	1	**280**
	Hatchery	35	78	114	24	27	0	0	**278**
2012	Wild	59	53	96	58	74	13	7	**355**
	Hatchery	73	101	73	17	8	1	0	**273**
2013	Wild	110	128	178	67	64	7	5	**559**
	Hatchery	186	160	208	23	36	0	0	**613**
2014	Wild	5	10	148	48	140	70	17	**438**
	Hatchery	2	4	27	5	8	3	0	**49**
Average	***Wild***	***35***	***66***	***97***	***31***	***59***	***7***	***2***	***296***
	Hatchery	***74***	***60***	***54***	***10***	***12***	***1***	***0***	***211***
Median	***Wild***	***29***	***60***	***86***	***20***	***55***	***2***	***0***	***295***
	Hatchery	***43***	***62***	***38***	***8***	***8***	***0***	***0***	***196***

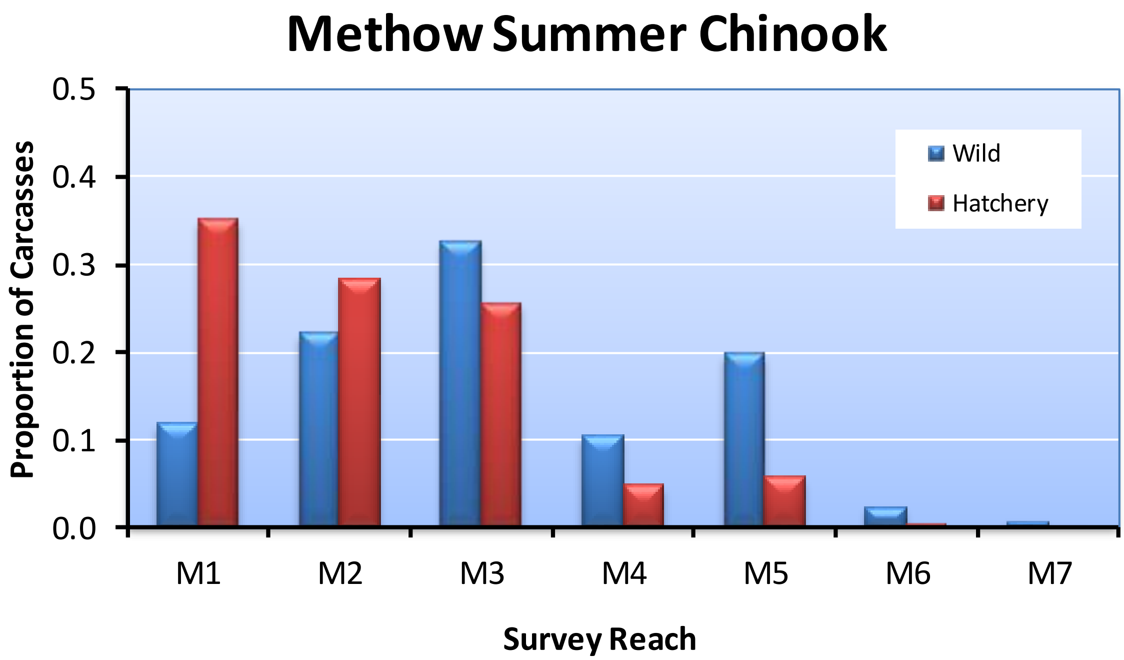

Figure 9.5. Distribution of wild and hatchery produced carcasses in different reaches on the Methow River, 1993-2014. Reach codes are described in Table 2.11.

Sampling Rate

Overall, 21% of the total spawning escapement of summer Chinook in the Methow River basin was sampled in 2015 (Table 9.18). Sampling rates among survey reaches varied from 20 to 46%.

Table 9.18. Number of redds and carcasses, total spawning escapement, and sampling rates for summer Chinook in the Methow River basin, 2015. Reach codes are described in Table 2.11.

Survey reach	Total number of redds	Total number of carcasses	Total spawning escapement	Sampling rate
Methow 1 (M1)	350	229	1,124	0.20
Methow 2 (M2)	309	194	992	0.20
Methow 3 (M3)	307	221	985	0.22
Methow 4 (M4)	72	56	231	0.24
Methow 5 (M5)	146	95	469	0.20
Methow 6 (M6)	13	19	42	0.46
Methow 7 (M7)	34	25	109	0.23
Total	***1,231***	***839***	***3,952***	***0.21***

Length Data

Mean lengths (POH, cm) of male and female summer Chinook carcasses sampled during surveys on the Methow River in 2015 are provided in Table 9.19. The average size of males and females sampled in the Methow River were 61 cm and 68 cm, respectively.

Table 9.19. Mean lengths (postorbital-to-hypural length; cm) and standard deviations (in parentheses) of male and female summer Chinook carcasses sampled in different reaches on the Methow River, 2015. Reach codes are described in Table 2.11.

Stream/watershed	Mean length (cm)	
	Male	Female
Methow 1 (M1)	59.7 (9.3)	67.0 (6.0)
Methow 2 (M2)	60.0 (8.6)	66.8 (5.7)
Methow 3 (M3)	61.7 (9.7)	67.8 (5.6)
Methow 4 (M4)	59.0 (9.0)	68.2 (6.1)
Methow 5 (M5)	64.3 (10.0)	69.3 (4.3)
Methow 6 (M6)	65.9 (8.8)	67.1 (7.9)
Methow 7 (M7)	61.9 (9.3)	69.0 (5.9)
Total	***60.9 (9.3)***	***67.6 (5.7)***

9.7 Life History Monitoring

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

Migration Timing

Migration timing of hatchery and wild Methow/Okanogan summer Chinook was determined from broodstock data collected at Wells Dam. Counting of summer/fall Chinook at Wells Dam occurs from 29 June to 15 November. Broodstock collection at the Dam occurs from early July (week 27) to mid-September (week 37) (Table 2.1). Based on broodstock sampling in 2015, hatchery summer Chinook generally arrived at Wells Dam later than wild summer Chinook (Table 9.20). This was true throughout most of the migration period. In contrast, there was little difference in migration timing between wild and hatchery summer Chinook when data were pooled for the 2007-2015 survey period.

Table 9.20. The week that 10%, 50% (median), and 90% of the wild and hatchery summer Chinook salmon passed Wells Dam, 2007-2015. The average week is also provided. Migration timing is based on collection of summer Chinook broodstock at Wells Dam.

Survey year	Origin	Methow/Okanogan Summer Chinook Migration Time (week)				Sample size
		10 Percentile	50 Percentile	90 Percentile	Mean	
2007	Wild	27	30	34	30	485
	Hatchery	27	30	33	30	433
2008	Wild	28	30	34	30	542
	Hatchery	28	30	36	31	884

Survey year	Origin	Methow/Okanogan Summer Chinook Migration Time (week)				Sample size
		10 Percentile	50 Percentile	90 Percentile	Mean	
2009	Wild	27	29	34	30	585
	Hatchery	27	29	33	29	708
2010	Wild	27	29	33	29	377
	Hatchery	27	29	32	29	801
2011	Wild	30	32	36	32	516
	Hatchery	30	32	35	33	1223
2012	Wild	28	30	34	31	192
	Hatchery	28	31	34	31	591
2013	Wild	27	30	33	30	229
	Hatchery	27	30	33	30	282
2014	Wild	27	31	40	32	316
	Hatchery	27	30	35	30	208
2015	Wild	26	28	30	28	217
	Hatchery	27	28	31	29	164
Average	***Wild***	***27***	***30***	***34***	***30***	***384***
	Hatchery	***28***	***30***	***34***	***30***	***588***
Median	***Wild***	***27***	***30***	***34***	***30***	***377***
	Hatchery	***27***	***30***	***33***	***30***	***591***

Age at Maturity

Because hatchery summer Chinook are released after one year of rearing and natural-origin summer Chinook migrate primarily as age-0 fish, total ages will differ between hatchery and natural-origin Chinook (see Hillman et al. 2011). Therefore, in this section, we evaluated age at maturity by comparing differences in salt (ocean) ages between the two groups.

Most of the wild and hatchery summer Chinook sampled during the period 1993-2014 in the Methow River were salt age-3 fish (Table 9.21; Figure 9.6). A higher percentage of salt age-4 wild Chinook returned to the basin than did salt age-4 hatchery Chinook. In contrast, a higher proportion of salt age-1 and 2 hatchery fish returned than did salt age-1 and 2 wild fish. Thus, a higher percentage of wild fish returned at an older age than did hatchery fish.

Table 9.21. Proportions of wild and hatchery summer Chinook of different salt (ocean) ages sampled on spawning grounds in the Methow River, 1993-2014.

Sample year	Origin	Salt age						Sample size
		1	2	3	4	5	6	
1993	Wild	0.05	0.08	0.76	0.11	0.00	0.00	38
	Hatchery	0.00	1.00	0.00	0.00	0.00	0.00	20
1994	Wild	0.03	0.26	0.51	0.20	0.00	0.00	101
	Hatchery	0.00	0.07	0.93	0.00	0.00	0.00	111
1995	Wild	0.00	0.09	0.70	0.20	0.00	0.00	54

Sample year	Origin	Salt age						Sample size
		1	2	3	4	5	6	
	Hatchery	0.02	0.04	0.44	0.51	0.00	0.00	55
1996	Wild	0.04	0.30	0.54	0.13	0.00	0.00	56
	Hatchery	0.00	0.05	0.50	0.41	0.05	0.00	22
1997	Wild	0.00	0.22	0.51	0.27	0.00	0.00	55
	Hatchery	0.13	0.06	0.56	0.25	0.00	0.00	16
1998	Wild	0.09	0.38	0.45	0.09	0.00	0.00	188
	Hatchery	0.02	0.52	0.41	0.04	0.00	0.00	123
1999	Wild	0.01	0.51	0.43	0.05	0.00	0.00	252
	Hatchery	0.00	0.07	0.90	0.03	0.00	0.00	210
2000	Wild	0.01	0.09	0.75	0.16	0.00	0.00	257
	Hatchery	0.10	0.16	0.62	0.11	0.00	0.00	97
2001	Wild	0.02	0.20	0.72	0.07	0.00	0.00	292
	Hatchery	0.10	0.60	0.26	0.04	0.00	0.00	526
2002	Wild	0.01	0.17	0.61	0.21	0.00	0.00	1,003
	Hatchery	0.01	0.41	0.57	0.01	0.00	0.00	734
2003	Wild	0.01	0.11	0.50	0.37	0.00	0.00	478
	Hatchery	0.02	0.03	0.90	0.04	0.00	0.00	399
2004	Wild	0.00	0.09	0.35	0.56	0.00	0.00	394
	Hatchery	0.07	0.28	0.30	0.35	0.00	0.00	141
2005	Wild	0.11	0.74	0.14	0.01	0.00	0.00	410
	Hatchery	0.06	0.26	0.65	0.02	0.00	0.00	220
2006	Wild	0.00	0.02	0.33	0.64	0.00	0.00	356
	Hatchery	0.01	0.19	0.50	0.30	0.00	0.00	164
2007	Wild	0.03	0.09	0.24	0.59	0.05	0.00	208
	Hatchery	0.07	0.09	0.75	0.09	0.01	0.00	213
2008	Wild	0.01	0.14	0.71	0.13	0.01	0.00	298
	Hatchery	0.10	0.45	0.30	0.15	0.00	0.00	138
2009	Wild	0.00	0.11	0.41	0.48	0.00	0.00	317
	Hatchery	0.17	0.26	0.53	0.04	0.00	0.00	242
2010	Wild	0.01	0.16	0.59	0.24	0.00	0.00	269
	Hatchery	0.01	0.69	0.29	0.02	0.00	0.00	247
2011	Wild	0.02	0.09	0.60	0.30	0.00	0.00	255
	Hatchery	0.16	0.10	0.74	0.01	0.00	0.00	261
2012	Wild	0.03	0.24	0.53	0.21	0.00	0.00	315
	Hatchery	0.09	0.71	0.16	0.04	0.00	0.00	243
2013	Wild	0.02	0.25	0.62	0.11	0.00	0.00	533
	Hatchery	0.02	0.18	0.79	0.01	0.00	0.00	570
2014	Wild	0.01	0.12	0.69	0.18	0.00	0.00	412

Sample year	Origin	Salt age						Sample size
		1	2	3	4	5	6	
	Hatchery	0.06	0.43	0.47	0.04	0.00	0.00	47
Average	***Wild***	***0.02***	***0.20***	***0.52***	***0.25***	***0.00***	***0.00***	***298***
	Hatchery	***0.05***	***0.32***	***0.57***	***0.06***	***0.00***	***0.00***	***218***
Median	***Wild***	***0.01***	***0.17***	***0.59***	***0.22***	***0.00***	***0.00***	***281***
	Hatchery	***0.06***	***0.24***	***0.63***	***0.07***	***0.00***	***0.00***	***187***

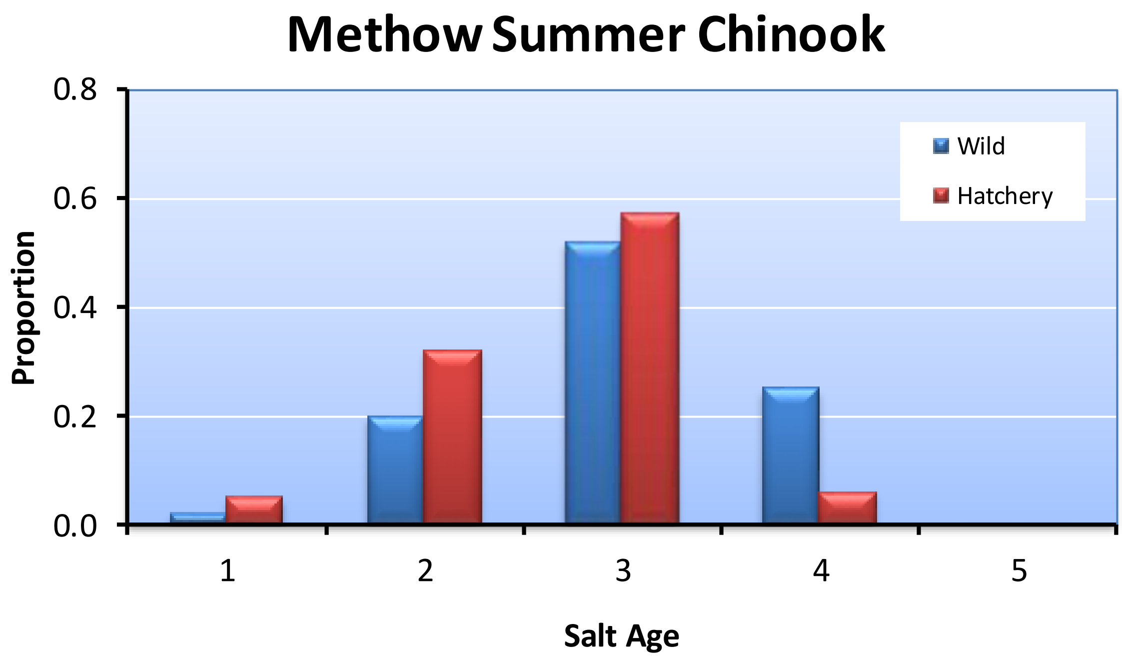

Figure 9.6. Proportions of wild and hatchery summer Chinook of different salt (ocean) ages sampled at broodstock collection sites and on spawning grounds in the Methow River for the combined years 1993-2014.

Size at Maturity

On average, hatchery summer Chinook were about 4 cm smaller than wild summer Chinook sampled in the Methow River basin (Table 9.22). This is likely because a higher percentage of wild fish returned as salt age-4 fish than did hatchery fish. Future analyses will compare sizes of hatchery and wild fish of the same age groups and sex.

Table 9.22. Mean lengths (POH; cm) and variability statistics for wild and hatchery summer Chinook sampled in the Methow River basin, 1993-2013; SD = 1 standard deviation.

Survey year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
1993[a]	Wild	41	74	9	51	89
	Hatchery	24	62	8	36	80
1994[a]	Wild	112	69	8	35	87

Survey year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
	Hatchery	114	67	5	43	77
1995	Wild	62	74	6	52	88
	Hatchery	56	73	7	46	85
1996	Wild	64	70	11	34	91
	Hatchery	23	72	7	58	85
1997	Wild	62	76	9	35	90
	Hatchery	16	68	15	33	87
1998	Wild	196	67	10	38	97
	Hatchery	123	63	10	37	87
1999	Wild	292	66	8	43	99
	Hatchery	212	66	7	26	89
2000	Wild	288	74	8	37	89
	Hatchery	109	68	12	24	87
2001	Wild	328	67	10	29	86
	Hatchery	529	63	10	31	87
2002	Wild	1,075	70	8	37	94
	Hatchery	739	67	9	33	87
2003	Wild	538	71	8	35	88
	Hatchery	410	69	8	35	89
2004	Wild	435	73	7	38	89
	Hatchery	142	65	12	34	85
2005	Wild	437	69	8	45	86
	Hatchery	229	64	9	36	79
2006	Wild	438	73	7	35	92
	Hatchery	149	69	8	38	91
2007	Wild	249	72	11	33	89
	Hatchery	219	69	9	22	84
2008	Wild	384	69	8	30	90
	Hatchery	210	63	15	23	86
2009	Wild	363	71	9	32	88
	Hatchery	228	63	12	30	83
2010	Wild	296	69	8	33	90
	Hatchery	280	62	9	39	81
2011	Wild	280	70	9	31	89
	Hatchery	278	64	11	26	82
2012	Wild	355	68	8	36	85
	Hatchery	273	59	9	21	81
2013	Wild	559	65	9	31	89

Survey year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
	Hatchery	613	66	8	27	83
2014	Wild	438	67	7	31	88
	Hatchery	49	60	10	35	76
Pooled	***Wild***	***7,292***	***70***	***8***	***29***	***99***
	Hatchery	***5,025***	***66***	***10***	***21***	***91***

[a] These years include sizes reported in annual reports. The data contained in the WDFW database do not include all these data.

Contribution to Fisheries

Most of the harvest on hatchery-origin Methow summer Chinook occurred in the Ocean (Table 9.23). Ocean harvest has made up 13% to 99% of all hatchery-origin Methow summer Chinook harvested. Brood years 1989, 1998, 2006, 2008, and 2009 provided the largest harvests, while brood years 1996 and 1999 provided the lowest.

Table 9.23. Estimated number and percent (in parentheses) of hatchery-origin Methow summer Chinook captured in different fisheries, brood years 1989-2009.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
1989	1,043 (52)	884 (44)	0 (0)	66 (3)	1,993
1990	55 (57)	41 (43)	0 (0)	0 (0)	96
1991	12 (20)	49 (80)	0 (0)	0 (0)	61
1992	17 (55)	14 (45)	0 (0)	0 (0)	31
1993	29 (58)	17 (34)	4 (8)	0 (0)	50
1994	153 (81)	34 (18)	1 (1)	1 (1)	189
1995	77 (99)	0 (0)	1 (1)	0 (0)	78
1996	12 (92)	1 (8)	0 (0)	0 (0)	13
1997	216 (89)	7 (3)	0 (0)	21 (9)	244
1998	1,755 (83)	101 (5)	14 (1)	234 (11)	2,104
1999	2 (13)	13 (87)	0 (0)	0 (0)	15
2000	364 (71)	88 (17)	27 (5)	33 (6)	512
2001	321 (52)	97 (16)	43 (7)	160 (26)	621
2002	272 (48)	96 (17)	61 (11)	137 (24)	566
2003	58 (58)	17 (17)	7 (7)	18 (18)	100
2004	133 (49)	55 (20)	16 (6)	68 (25)	272
2005	298 (54)	137 (25)	50 (9)	66 (12)	551
2006	1,128 (48)	811 (34)	100 (4)	314 (13)	2,353
2007	205 (60)	69 (20)	16 (5)	54 (16)	344
2008	1,656 (59)	366 (13)	65 (2)	705 (25)	2,792
2009	805 (67)	203 (17)	27 (2)	175 (14)	1,210
Average	***410 (60)***	***148 (27)***	***21 (3)***	***98 (10)***	***676***

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
Median	***205 (58)***	***55 (18)***	***7 (2)***	***33 (9)***	***272***

Straying

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Methow River basin. Targets for strays based on return year (recovery year) and brood year should be less than 5%.

Few hatchery-origin Methow summer Chinook have strayed into basins outside the Methow (Table 9.24). Although hatchery-origin Methow summer Chinook have strayed into the Wenatchee River basin, Okanogan River basin, Entiat River basin, Chelan tailrace, and Hanford Reach, on average, they have made up less than 1% of the spawning escapement within those areas.

Table 9.24. Number and percent of spawning escapements within other non-target basins that consisted of hatchery-origin Methow summer Chinook, return years 1994-2014. For example, for return year 2002, 0.4% of the summer Chinook escapement in the Okanogan River basin consisted of hatchery-origin Methow summer Chinook. Percent strays should be less than 5%.

Return year	Wenatchee		Okanogan		Chelan		Entiat		Hanford Reach	
	Number	%	Number	%	Number	%	Number	%	Number	%
1994	0	0.0	72	1.8	-	-	-	-	-	-
1995	0	0.0	9	0.3	-	-	-	-	-	-
1996	0	0.0	0	0.0	-	-	-	-	-	-
1997	0	0.0	0	0.0	-	-	-	-	-	-
1998	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1999	0	0.0	9	0.2	0	0.0	0	0.0	7	0.0
2000	0	0.0	3	0.1	0	0.0	0	0.0	0	0.0
2001	0	0.0	0	0.0	0	0.0	0	0.0	7	0.0
2002	0	0.0	54	0.4	0	0.0	0	0.0	0	0.0
2003	0	0.0	1	0.0	6	1.4	0	0.0	0	0.0
2004	0	0.0	7	0.1	3	0.7	0	0.0	0	0.0
2005	0	0.0	24	0.3	0	0.0	0	0.0	0	0.0
2006	0	0.0	12	0.1	0	0.0	0	0.0	0	0.0
2007	0	0.0	17	0.4	2	1.1	3	1.2	0	0.0
2008	0	0.0	12	0.2	0	0.0	0	0.0	0	0.0
2009	0	0.0	14	0.2	0	0.0	0	0.0	0	0.0
2010	6	0.1	44	0.7	22	2.0	0	0.0	0	0.0
2011	0	0.0	45	0.5	8	0.6	0	0.0	0	0.0
2012	0	0.0	31	0.4	0	0.0	0	0.0	0	0.0
2013	0	0.0	10	0.1	0	0.0	0	0.0	0	0.0
2014	0	0.0	17	0.1	0	0.0	0	0.0	0	0.0
Average	***0***	***0.0***	***18***	***0.3***	***2***	***0.3***	***0***	***0.1***	***1***	***0.0***

Return year	Wenatchee		Okanogan		Chelan		Entiat		Hanford Reach	
	Number	%	Number	%	Number	%	Number	%	Number	%
Median	***0***	***0.0***	***12***	***0.2***	***0***	***0.0***	***0***	***0.0***	***0***	***0.0***

Based on brood year analyses, on average, about 3% of the returns have strayed into non-target spawning areas, falling within the acceptable level of less than 5% (Table 9.25). Depending on brood year, percent strays into non-target spawning areas have ranged from 0-11.9%. Few (<1% on average) have strayed into non-target hatchery programs.

Table 9.25. Number and percent of hatchery-origin Methow summer Chinook that homed to target spawning areas and the target hatchery program, and number and percent that strayed to non-target spawning areas and non-target hatchery programs, by brood years 1989-2009. Percent stays should be less than 5%.

Brood year	Homing				Straying			
	Target stream		Target hatchery*		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1989	773	55.7	459	33.0	81	5.8	76	5.5
1990	199	70.6	81	28.7	0	0.0	2	0.7
1991	82	65.6	43	34.4	0	0.0	0	0.0
1992	68	63.0	40	37.0	0	0.0	0	0.0
1993	25	65.8	10	26.3	3	7.9	0	0.0
1994	419	79.7	94	17.9	13	2.5	0	0.0
1995	126	81.8	28	18.2	0	0.0	0	0.0
1996	57	93.4	4	6.6	0	0.0	0	0.0
1997	379	93.8	7	1.7	18	4.5	0	0.0
1998	1,653	94.7	32	1.8	60	3.4	0	0.0
1999	18	100.0	0	0.0	0	0.0	0	0.0
2000	239	93.0	4	1.6	14	5.4	0	0.0
2001	272	88.3	6	1.9	29	9.4	1	0.3
2002	315	94.6	4	1.2	14	4.2	0	0.0
2003	131	99.2	1	0.8	0	0.0	0	0.0
2004	194	85.5	6	2.6	27	11.9	0	0.0
2005	373	90.5	13	3.2	23	5.6	3	0.7
2006	1,317	91.4	15	1.0	109	7.6	0	0.0
2007	134	98.5	2	1.5	0	0.0	0	0.0
2008	1,871	97.9	13	0.7	25	1.3	3	0.2
2009	170	92.4	14	7.6	0	0.0	0	0.0
Average	***420***	***85.5***	***42***	***10.8***	***20***	***3.3***	***4***	***0.4***
Median	***199***	***91.4***	***13***	***2.6***	***13***	***2.5***	***0***	***0.0***

* Homing to the target hatchery includes Methow hatchery summer Chinook that are captured and included as broodstock in the Methow Hatchery program. These hatchery fish are typically collected at Wells Dam.

Genetics

Genetic studies were conducted to investigate relationships among temporally replicated collections of summer Chinook from the Wenatchee River, Methow River, and Okanogan River in the upper Columbia River basin (Kassler et al. 2011; the entire report is appended as Appendix M). A total of 2,416 summer Chinook were collected from tributaries in the upper Columbia River basin. Two collections of natural-origin summer Chinook from 1993 (prior to the supplementation program) were taken from the Wenatchee River basin (N = 139) and compared to collections of hatchery and natural-origin Chinook from 2006 and 2008 (N = 380). Two pre-supplementation collections from the Methow River (1991 and 1993) were compared to supplementation collections from 2006 and 2008 (N = 362). Three pre-supplementation collections from the Okanogan River Basin (1991, 1992, and 1993) were compared with supplementation collections from 2006 and 2008 (N = 669). A collection of natural-origin summer Chinook from the Chelan River was also analyzed (N = 70). Additionally, hatchery collections from Eastbank Hatchery (Wenatchee and Methow/Okanogan stock; N = 221) and Wells Hatchery (N = 294) were analyzed and compared to the in-river collections. Summer Chinook data (provided by the USFWS) from the Entiat River (N = 190) were used for comparison. Lastly, data from eight collections of fall Chinook (N = 2,408) were compared to the collections of summer Chinook. Samples of natural and hatchery-origin summer Chinook were analyzed and compared to determine if the supplementation programs have affected the genetic structure of these populations. The study also calculated the effective number of breeders for collection locations of natural and hatchery-origin summer Chinook from 1993 and 2008.

In general, population differentiation was not observed among the temporally replicated collection locations. A single collection from the Okanogan River (1993) was the only collection showing statistically significant differences. The effective number of breeders was not statistically different from the early collection in 1993 in comparison to the late collection in 2008. Overall, these analyses revealed a lack of differentiation among the temporal replicates from the same locations and among the collection from different locations, suggesting the populations have been homogenized or that there has been substantial gene flow among populations. Additional comparisons among summer-run and fall-run Chinook populations in the upper Columbia River were conducted to determine if there was any differentiation between Chinook with different run timing. These analyses revealed pairwise F_{ST} values that were less than 0.01 for the collections of summer Chinook to collections of fall Chinook from Hanford Reach, lower Yakima River, Priest Rapids, and Umatilla. Collections of fall Chinook from Crab Creek, Lyons Ferry Hatchery, Marion Drain, and Snake River had pairwise F_{ST} values that were higher in comparison to the collections of summer Chinook. The consensus clustering analysis did not provide good statistical support to the groupings, but did show relationships among collections based on geographic proximity. Overall the summer and fall run Chinook that have historically been spawned together were not differentiated while fall Chinook from greater geographic distances were differentiated.

Proportionate Natural Influence

Another method for assessing the genetic risk of a supplementation program is to determine the influence of the hatchery and natural environments on the adaptation of the composite population. This is estimated by the proportion of natural-origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery-origin fish in the natural spawning escapement (pHOS). We calculated Proportionate Natural Influence (PNI) by iterating Ford's (2002) equations 5 and 6 to equilibrium, using a heritability of 0.3 and a selection strength of three standard deviations. The larger the PNI value, the greater the strength of selection in the natural environment relative to that of the hatchery environment. In order for the natural environment to dominate selection, PNI should be greater than 0.50, and important integrated populations should have a PNI of at least 0.67 (HSRG/WDFW/NWIFC 2004).

For brood years 1993-2003, the PNI values were generally less than 0.67 (Table 9.26). However, since brood year 2003, PNI has generally been greater than 0.67; brood year 2014 had a PNI value of 0.90.

Table 9.26. Proportionate Natural Influence (PNI) values for the Methow summer Chinook supplementation program for brood years 1989-2014. NOS = number of natural-origin Chinook on the spawning grounds; HOS = number of hatchery-origin Chinook on the spawning grounds; NOB = number of natural-origin Chinook collected for broodstock; and HOB = number of hatchery-origin Chinook included in hatchery broodstock.

Brood year	Spawners			Broodstock			PNI[a]
	NOS	HOS	pHOS	NOB	HOB	pNOB	
1989	492	0	0.00	1,297	312	0.81	1.00
1990	1,421	0	0.00	828	206	0.80	1.00
1991	566	0	0.00	924	314	0.75	1.00
1992	460	0	0.00	297	406	0.42	1.00
1993	314	194	0.38	681	388	0.64	0.64
1994	596	489	0.45	341	244	0.58	0.58
1995	596	618	0.51	173	240	0.42	0.47
1996	435	180	0.29	287	155	0.65	0.70
1997	529	168	0.24	197	265	0.43	0.66
1998	437	238	0.35	153	211	0.42	0.56
1999	573	413	0.42	224	289	0.44	0.53
2000	861	339	0.28	164	337	0.33	0.56
2001	1,122	1,646	0.59	12	345	0.03	0.09
2002	2,572	2,058	0.44	247	241	0.51	0.55
2003	2,307	1,623	0.41	381	101	0.79	0.67
2004	1,622	567	0.26	506	16	0.97	0.79
2005	1,672	889	0.35	391	9	0.98	0.74
2006	2,039	694	0.25	500	10	0.98	0.80
2007	764	600	0.44	456	17	0.96	0.69
2008	1,293	654	0.34	359	86	0.81	0.71
2009	1,093	665	0.38	503	4	0.99	0.73
2010	1,326	1,166	0.47	484	8	0.98	0.68
2011	1,503	1,414	0.48	467	26	0.95	0.67
2012	1,593	1,354	0.46	98	1	0.99	0.69
2013	1,807	1,776	0.50	97	4	0.96	0.66

Brood year	Spawners			Broodstock			PNI[a]
	NOS	HOS	pHOS	NOB	HOB	pNOB	
2014	1,451	174	0.11	96	0	1.00	0.90
Average	***1,132***	***689***	***0.32***	***391***	***163***	***0.72***	***0.70***
Median	***1,108***	***584***	***0.37***	***350***	***181***	***0.80***	***0.69***

[a] PNI was calculated previously using PNI approximate equation 11 (HSRG 2009; Appendix A). All PNI values presented here were recalculated by iterating Ford's (2002) equations 5 and 6 to equilibrium using a heritability of 0.3 and a selection strength of three standard deviations. C. Busack, NOAA Fisheries, 21 March 2016, provided the model for calculating PNI.

Post-Release Survival and Travel Time

We used PIT-tagged fish to estimate survival rates and travel time (arithmetic mean days) of hatchery summer Chinook from the Methow River release site to McNary Dam, and smolt to adult ratios (SARs) from release to detection at Bonneville Dam (Table 9.27).[19] Over the four brood years for which PIT-tagged hatchery fish were released, survival rates from the Methow River to McNary Dam ranged from 0.485 to 0.747; SARs from release to detection at Bonneville Dam ranged from 0.002 to 0.016. Average travel time from the Methow River to McNary Dam ranged from 17 to 55 days.

Table 9.27. Total number of Methow hatchery summer Chinook released with PIT tags, their survival and travel times (mean days) to McNary Dam, and smolt-to-adult (SAR) ratios for brood years 2008-2013. Standard errors are shown in parentheses. NA = not available (i.e., not all the fish from the release groups have returned to the Columbia River).

Brood year	Number of tagged fish released	Survival to McNary Dam	Travel time to McNary Dam (d)	SAR to Bonneville Dam (%)
2008	10,094	0.747 (0.055)	39.1 (13.0)	0.016 (0.001)
2009	5,020	0.485 (0.037)	30.2 (11.1)	0.002 (0.001)
2010	0	--	--	--
2011	0	--	--	--
2012	9,801	0.545 (0.046)	17.0 (8.1)	NA
2013	9,825	0.560 (0.101)	54.5 (8.3)	NA

Natural and Hatchery Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural-origin recruits (NOR) to the parent spawning population (spawning escapement). Natural-origin recruits are naturally produced (wild) fish that survive to contribute to harvest (directly or indirectly), to broodstock, and to spawning grounds. We do not account for fish that died in route to the spawning grounds (migration mortality) or died just before spawning (pre-spawn mortality) (see Appendix B in Hillman et al. 2012). We calculated NORs with and without harvest. NORs without harvest include all returning fish that either returned to the basin or were collected as wild broodstock. NORs with harvest include all fish harvested and are based on a brood year harvest rates from the hatchery program. For brood years 1989-2008, NRR for summer Chinook in the Methow averaged 1.13

[19] It is important to point out that because of fish size differences among rearing tanks or raceways, fish PIT tagged in one tank or raceway may not represent untagged fish rearing in other tanks or raceways.

(range, 0.10-4.90) if harvested fish were not included in the estimate and 2.34 (range, 0.18-10.84) if harvested fish were included in the estimate (Table 9.28). NRRs for more recent brood years will be calculated as soon as all tag recoveries and sampling rates have been loaded into the database.

Hatchery replacement rates (HRR) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HOR) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 3.0 (the calculated target value in Hillman et al. 2013). The target value of 3.0 includes harvest. HRRs exceeded NRRs in 12 out of the 20 years of data, regardless if harvest was or was not included in the estimate (Table 9.28). Hatchery replacement rates for Methow summer Chinook have exceeded the estimated target value of 3.0 in nine of the 20 years of data.

Table 9.28. Broodstock collected, spawning escapements, natural and hatchery-origin recruits (NOR and HOR), and natural and hatchery replacement rates (NRR and HRR; with and without harvest) for wild summer Chinook in the Methow River basin, brood years 1989-2008.

Brood year	Broodstock Collected	Spawning Escapement	Harvest not included				Harvest included			
			HOR	NOR	HRR	NRR	HOR	NOR	HRR	NRR
1989	202	492	1,389	631	6.88	1.28	3,382	1,532	16.74	3.11
1990	202	1,421	282	978	1.40	0.69	378	1,318	1.87	0.93
1991	266	566	125	287	0.47	0.51	186	429	0.70	0.76
1992	214	460	108	614	0.50	1.33	139	792	0.65	1.72
1993	234	508	82	430	0.35	0.85	132	701	0.56	1.38
1994	260	1,085	526	545	2.02	0.50	715	743	2.75	0.68
1995	242	1,214	154	1,201	0.64	0.99	232	1,809	0.96	1.49
1996	220	615	61	445	0.28	0.72	74	541	0.34	0.88
1997	209	697	404	1,493	1.93	2.14	648	2,404	3.10	3.45
1998	235	675	1,745	3,307	7.43	4.90	3,849	7,316	16.38	10.84
1999	222	986	18	2,862	0.08	2.90	33	5,251	0.15	5.33
2000	222	1,200	257	808	1.16	0.67	769	2,426	3.46	2.02
2001	223	2,768	308	2,877	1.38	1.04	929	8,718	4.17	3.15
2002	222	4,630	333	1,072	1.50	0.23	899	2,913	4.05	0.63
2003	224	3,930	132	397	0.59	0.10	232	698	1.04	0.18
2004	223	2,189	227	1,646	1.02	0.75	499	3,626	2.24	1.66
2005	225	2,561	412	1,159	1.83	0.45	963	2,714	4.28	1.06
2006	236	2,733	1,441	1,714	6.11	0.63	3,794	4,522	16.08	1.65
2007	209	1,364	136	1,510	0.65	1.11	480	5,355	2.30	3.93
2008	184	1,947	1,929	1,498	10.48	0.77	4,721	3,699	25.66	1.90
Average	***224***	***1,602***	***503***	***1,274***	***2.33***	***1.13***	***1,153***	***2,875***	***5.37***	***2.34***
Median	***223***	***1,207***	***270***	***1,116***	***1.27***	***0.76***	***574***	***2,415***	***2.52***	***1.66***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adult recaptures divided by the number of tagged hatchery smolts released. Here, SARs were based on CWT returns. For the available brood years, SARs have ranged from 0.00008 to 0.01883 for hatchery summer Chinook in the Methow River basin (Table 9.29).

Table 9.29. Smolt-to-adult ratios (SARs) for Methow summer Chinook, brood years 1989-2009.

Brood year	Number of tagged smolts released[a]	Estimated adult captures[b]	SAR
1989	358,237	2,871	0.008010
1990	371,483	361	0.000970
1991	377,097	130	0.000340
1992	392,636	138	0.000350
1993	200,345	62	0.000310
1994	400,488	710	0.001770
1995	344,974	229	0.000660
1996	289,880	73	0.000250
1997	380,430	644	0.001690
1998	202,559	3,815	0.018830
1999	422,473	33	0.000080
2000	334,337	768	0.002300
2001	246,159	925	0.003760
2002	310,846	896	0.002880
2003	353,495	232	0.000660
2004	394,490	496	0.001260
2005	262,496	961	0.003660
2006	417,795	3,786	0.009060
2007	426,188	479	0.001120
2008	373,234	4,472	0.011980
2009	450,237	1,382	0.003070
Average	***348,089***	***1,117***	***0.00348***
Median	***371,483***	***644***	***0.00169***

[a] Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).

[b] Includes estimated recoveries (spawning ground, hatcheries, harvest, etc.) and observed recoveries if estimated recoveries were unavailable.

9.8 ESA/HCP Compliance

Broodstock Collection

Summer Chinook adults collected at Wells Dam are used primarily for the Methow supplementation programs. On an as needed basis, adults collected at Wells Dam may be used to augment adult collections for the Okanogan summer Chinook supplementation program. Per the 2013 broodstock collection protocol, 102 natural-origin (adipose fin present) adults were targeted for collection between 1 July and 15 September at the West Ladder of Wells Dam. Actual collections occurred between 2 July and 13 September and totaled 102 summer Chinook (including four unmarked hatchery adults identified through scale patter analysis). ESA Permit 1347 provides authorization to collect Methow and Okanogan summer Chinook at Wells Dam three days per week and up to 16 hours per day from July through November. During 2013, broodstock collection activities were accomplished within the allowable trapping days authorized under ESA Permit 1347.

Collection of Methow and Okanogan summer Chinook broodstock at Wells Dam occurred concurrently with collection of summer steelhead for the Wells steelhead program authorized under ESA Section 10 Permit 1395. Encounters with steelhead and spring Chinook during Methow and Okanogan summer Chinook broodstock collections did not result in takes that were outside those authorized in Permit 1347 and in Permit 1395 for the Wells Steelhead program. Steelhead encountered during summer Chinook collections that were not required for steelhead broodstock were passed at the trap site and were not physically handled. Any spring Chinook encountered during summer Chinook broodstock activities were also passed without handling.

Hatchery Rearing and Release

The 2013 brood Methow/Okanogan summer Chinook reared throughout their juvenile life-stages at Eastbank Fish Hatchery and the Carlton Acclimation Pond without incident (see Section 9.2). The 2013 brood smolt release totaled 188,834 summer Chinook, representing 94.4% of the 200,000 production objective and was compliant with the 10% overage allowable in ESA Section 10 Permit 1347. Lower than anticipated fecundity (94% of the biological assumption used in the 2013 broodstock collection protocols) was the largest factor in not meeting the full program.

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, 1395, 18118, 18119, and 18121, 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 PUD Hatchery facilities during the period 1 January through 31 December 2015. NPDES monitoring and reporting for PUD Hatchery Programs during 2015 are provided in Appendix F.

Spawning Surveys

Summer Chinook spawning ground surveys conducted in the Methow River basin during 2015 were consistent with ESA Section 10 Permit No. 1347. Because of the difficulty of quantifying the level of take associated with spawning ground surveys, the Permit does not specify a take level associated with these activities, even though it does authorize implementation of spawning ground surveys. Therefore, no take levels are reported. However, to minimize potential effects to established redds, wading was restricted to the extent practical, and extreme caution was used to avoid established redds when wading was required.

SECTION 10: OKANOGAN/SIMILKAMEEN SUMMER CHINOOK

The goal of summer Chinook salmon supplementation in the Okanogan Basin is to use artificial production to replace adult production lost because of mortality at Wells, Rocky Reach, and Rock Island dams, while not reducing the natural production or long-term fitness of summer Chinook in the basin. The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Anadromous Fish Agreement and Habitat Conservation Plans.

Before 2012, adult summer Chinook were collected for broodstock from the run-at-large at the east ladder trapping facility at Wells Dam. Since then, the Colville Tribes collect broodstock using purse seines in the Okanogan and Columbia rivers. The goal was to collect up to 334 adult summer Chinook for the Okanogan program. Broodstock collection occurred from about 7 July through 15 September with trapping occurring no more than 16 hours per day, three days a week. If natural-origin broodstock collection fell short of expectation, hatchery-origin adults could be collected to make up the difference.

Before 2012, adult summer Chinook were spawned and reared at Eastbank Fish Hatchery. Juvenile summer Chinook were transferred from the hatchery to Similkameen Acclimation Pond in October. In addition, since 2005, about 20% (100,000) of the juveniles were transferred to Bonaparte Pond. Chinook were released from the ponds in April to early May.

Prior to 2012, the production goal for the Okanogan summer Chinook supplementation program was to release 576,000 yearling smolts into the Similkameen and Okanogan rivers at ten fish per pound. Beginning with the 2012 brood, the revised production goal is to release 166,569 yearling smolts into the rivers. Targets for fork length and weight are 176 mm (CV = 9.0) and 45.4 g, respectively. Over 90% of these fish are marked with CWTs. In addition, since 2009, juvenile summer Chinook have been PIT tagged annually.

The Colville Tribes began monitoring the Okanogan/Similkameen summer Chinook program in 2013. Their monitoring results will be published in annual reports to Bonneville Power Administration (BPA). The purpose of retaining this section is to provide readers with monitoring data collected with Chelan PUD funding through brood year 2012. Thus, this section tracks the status and life histories of summer Chinook up to and including brood year 2012. Results from monitoring brood year 2013 and beyond will be included in annual reports to BPA.

10.1 Broodstock Sampling

Summer Chinook broodstock for the Okanogan/Similkameen and Methow programs was typically collected at the East and West Ladders of Wells Dam. In 2012, broodstock was also collected at the mouth of the Okanogan River via purse seine. In 2012, a total of 81 summer Chinook (79 wild Chinook and two hatchery Chinook)[20] were spawned for the Okanogan program. Refer to Section

[20] It is important to point out that some summer Chinook were used for both the Methow and Okanogan programs in 2012 because of the availability of ripe adults at the time of spawning. In addition, some eyed-eggs were split between the two programs

9.1 for information on the origin, age and length, sex ratios, and fecundity of summer Chinook broodstock collected at Wells Dam prior to 2013.

10.2 Hatchery Rearing

Rearing History

Number of eggs taken

Based on the unfertilized egg-to-release survival standard of 81%, a total of 711,111 eggs were required to meet the program release goal of 576,000 smolts through the 2011 brood year. An evaluation of the program in 2012 determined that 205,134 eggs were needed to meet the revised release goal of 166,569 smolts. This revised goal began with brood year 2012. From 1989 through 2012, the egg take goal was reached in 13 of those years (Table 10.1).

Table 10.1. Numbers of eggs taken from summer Chinook broodstock for the Okanogan program during 1989-2012. From 1989-2011, broodstock were collected at Wells Dam. In 2012, broodstock were collected in purse seines in the Okanogan River.

Return year	Number of eggs taken
1989	724,200
1990	696,144
1991	879,892
1992	729,389
1993	797,234
1994	893,086
1995	736,500
1996	672,000
1997	601,744
1998	584,018
1999	725,589
2000	645,403
2001	418,907
2002	718,599
2003	710,521
2004	805,814
2005	452,928
2006	757,350
2007	824,703
2008	662,668
2009	840,902
2010	726,979
2011	683,419
Average (1989-2011)	***708,173***
Median (1989-2011)	***724,200***

Return year	Number of eggs taken
2012	201,295
Average (2012)	***201,295***
Median (2012)	***201,295***

Number of acclimation days

Summer Chinook were released volitionally from Similkameen Pond as yearling smolts. Transfer dates, release dates, and the number of acclimation days for Okanogan summer Chinook are shown in Table 10.2.

Table 10.2. Number of days Okanogan summer Chinook broods were acclimated at Similkameen and Bonaparte ponds, brood years 1989-2012.

Brood year	Release year	Rearing facility	Transfer date	Release date	Number of days
1989	1991	Similkameen	29-Oct	7-May	190
1990	1992	Similkameen	5-Nov	25-Apr	171
1991	1993	Similkameen	1-Nov	9-Apr	159
1992	1994	Similkameen	2-Nov	1-Apr	150
			26-Feb	1-Apr	34
1993	1995	Similkameen	24-Oct	1-Apr	159
			24-Feb	1-Apr	36
1994	1996	Similkameen	30-Oct	6-Apr	158
			14-Mar	6-Apr	23
1995	1997	Similkameen	1-Oct	1-Apr	182
1996	1998	Similkameen	10-Oct	15-Mar	156
1997	1999	Similkameen	7-Oct	19-Apr	194
1998	2000	Similkameen	5-Oct	19-Apr	196
1999	2001	Similkameen	5-Oct	18-Apr	195
2000	2002	Similkameen	10-Oct	8-Apr	180
2001	2003	Similkameen	1-Oct	29-Apr	210
2002	2004	Similkameen	9-Nov	23-Apr	165
2003	2005	Similkameen	19-Oct	28-Apr	191
2004	2006	Similkameen	26-Oct	23-Apr	179
2005	2007	Bonaparte	6-Nov	11-Apr	156
		Similkameen	25-Oct	18-Apr – 9-May	179-200
2006	2008	Similkameen	15-17-Oct	16-Apr – 7-May	182-205
2007	2009	Bonaparte	3-4-Nov	10-22-Apr	157-170

Brood year	Release year	Rearing facility	Transfer date	Release date	Number of days
		Similkameen	20-24-Oct	14-Apr – 9-May	172-201
2008	2010	Bonaparte	2-4-Nov	19-Apr – 5-May	167-185
		Similkameen	26-28-Oct	19-Apr – 14-May	176-201
2009	2011	Bonaparte	8-9-Nov	12-Apr	155-156
		Similkameen	25-27-Oct	13-Apr – 5-May	169-193
2010	2012	Bonaparte	No program	No program	No program
		Similkameen	25-27 Oct	16-Apr – 7-May	173-196
2011	2013	Bonaparte	No program	No program	No program
		Similkameen	23-26 Oct	16-Apr – 8-May	175-197
2012	2014	Bonaparte	No program	No program	No program
		Similkameen	28-30 Oct	15 Apr – 5 May	167-189

Release Information

Numbers released

The 2012 Okanogan summer Chinook program achieved 68.4% of the 166,569 target goal with about 114,000 fish being released volitionally into the Similkameen River (Table 10.3).

Table 10.3. Numbers of Okanogan summer Chinook smolts released from the Similkameen and Bonaparte ponds, brood years 1989-2012; NA = not available. For brood years 1998-2012, the release target was 576,000 smolts. Since brood year 2013, the release target for Okanogan summer Chinook is 114,000 smolts.

Brood year	Release year	Rearing facility	CWT mark rate	Number of smolts released
1989	1991	Similkameen	0.5732	352,600
1990	1992	Similkameen	0.6800	540,000
1991	1993	Similkameen	0.5335	675,500
1992	1994	Similkameen	0.9819	548,182
1993	1995	Similkameen	0.6470	586,000
1994	1996	Similkameen	0.4176	536,299
1995	1997	Similkameen	0.9785	587,000
1996	1998	Similkameen	0.9769	507,913
1997	1999	Similkameen	0.9711	589,591
1998	2000	Similkameen	0.9825	293,191
1999	2001	Similkameen	0.9689	630,463
2000	2002	Similkameen	0.9928	532,453
2001	2003	Similkameen	0.9877	26,642
2002	2004	Similkameen	0.9204	388,589
2003	2005	Similkameen	0.9929	579,019
2004	2006	Similkameen	0.9425	703,359

Brood year	Release year	Rearing facility	CWT mark rate	Number of smolts released
2005	2007	Bonaparte	0	0 (assumed)
		Similkameen	0.9862	275,919
2006	2008	Similkameen	0.9878	604,035
2007	2009	Bonaparte	0.9920	102,099
		Similkameen	0.9914	513,039
2008	2010	Bonaparte	0.9947	175,729
		Similkameen	0.9947	343,628
2009	2011	Bonaparte	0.9981	151,382
		Similkameen	0.9953	524,521
2010	2012	Similkameen	0.9886	617,950
2011	2013	Similkameen	0.9956	627,978
Average (1989-2011)		***Bonaparte***	***0.7462***	***143,070***
		Similkameen	***0.8907***	***503,647***
Median (1989-2011)		***Bonaparte***	***0.9819***	***540,000***
		Similkameen	***0.9934***	***151,382***
2012	2014	Bonaparte	No program	No program
		Similkameen	0.9939	114,000
Average (2012-present)		***Bonaparte***	***No program***	***No program***
		Similkameen	***0.9939***	***114,000***
Median (2012-present)		***Bonaparte***	***No program***	***No program***
		Similkameen	***0.9939***	***114,000***

Numbers tagged

The 2012 brood Okanogan summer Chinook from the Similkameen facility were 99.4% CWT and adipose fin-clipped (Table 10.3). Table 10.4 summarizes the number of hatchery summer Chinook that have been PIT-tagged and released into the Okanogan River basin. No fish from the 2012 brood year were PIT tagged.

Table 10.4. Summary of PIT-tagging activities for Okanogan hatchery summer Chinook, brood years 2008-2011.

Brood year	Release year	Number of fish tagged	Number of tagged fish that died	Number of tags shed	Number of tagged fish released
2008	2010	5,700 (high density)	1,169	0	4,531
		5,700 (low density)	1,407	0	4,293
2009	2011	5,100	11	0	5,089
2010	2012	0	0	0	0
2011	2013	5,100	64	0	5,036

Fish size and condition at release

Size at release of the Similkameen population was 73.3% and 56.8% of the fork length and weight targets, respectively. The CV for fork length exceeded the target by 18.9% (Table 10.5). There was no Bonaparte program for the 2014 release year.

Table 10.5. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of Okanogan summer Chinook smolts released from the hatchery, brood years 1989-2012. Size targets are provided in the last row of the table.

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1989	1991	-	-	41.3	11
1990	1992	143	9.5	37.8	12
1991	1993	125	15.5	22.4	20
1992	1994	120	15.4	20.7	22
1993	1995	132	-	23.2	20
1994	1996	136	16.0	29.6	15
1995	1997	137	8.2	32.8	14
1996	1998	127	12.8	26.2	17
1997	1999	144	9.9	36.0	13
1998	2000	148	5.9	41.0	11
1999	2001	141	15.7	35.4	13
2000	2002	121	13.4	20.4	22
2001	2003	132	8.2	25.7	18
2002	2004	119	13.4	20.8	22
2003	2005	133	10.6	28.9	16
2004	2006	132	9.9	29.8	15
2005	2007	132	9.6	25.9	18
2006	2008	120	12.3	20.9	22
2007	2009	124	12.6	21.9	21
2008	2010	140	12.3	35.1	13
2009	2011	132	11.6	24.7	18
2010	2012	125	10.1	23.2	20
2011	2013	132	9.5	27.9	16
2012	2014	129	7.3	25.8	18
Average		***131***	***11.4***	***28.2***	***17***
Median		***132***	***11.1***	***26.1***	***18***
Targets		***176***	***9.0***	***45.4***	***10***

Survival Estimates

Overall survival of Okanogan summer Chinook from green (unfertilized) egg to release was above the standard set for the program (Table 10.6). Low survival can be attributed to high mortality after ponding through release because of external fungus. Currently, it is unknown if gamete viability is sex biased or is uniform between sexes and more influenced by between-year environmental variations.

Table 10.6. Hatchery life-stage survival rates (%) for Okanogan summer Chinook, brood years 1989-2012. Survival standards or targets are provided in the last row of the table.

Brood year	Rearing facility	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
		Female	Male							
1989[a]	Similkameen	89.8	99.5	89.9	96.7	99.7	99.4	73.3	57.4	48.7
1990[a]	Similkameen	93.9	99.0	84.9	97.1	81.2	80.6	97.7	98.6	77.6
1991[a]	Similkameen	93.1	95.5	88.2	97.1	99.4	99.1	98.4	97.1	76.8
1992[a]	Similkameen	96.9	99.0	87.0	98.0	99.9	99.9	91.7	92.6	75.2
1993[a]	Similkameen	82.2	99.4	85.4	97.6	99.8	99.5	92.0	90.2	73.5
1994	Similkameen	96.1	90.0	86.6	100.0	98.1	97.4	73.1	89.8	60.1
1995	Similkameen	91.9	96.2	98.2	84.1	96.5	96.2	92.7	98.2	79.7
1996	Similkameen	95.4	98.1	83.2	100.0	97.7	96.9	86.5	92.5	75.6
1997	Similkameen	91.9	94.6	86.1	98.4	98.7	98.3	98.8	99.4	98.0
1998	Similkameen	84.0	96.2	54.1	98.0	99.4	98.9	96.6	99.6	50.2
1999	Similkameen	98.8	98.7	92.9	96.9	98.0	97.6	96.9	99.0	86.9
2000	Similkameen	90.5	96.9	89.2	98.5	98.2	98.0	93.6	97.2	82.5
2001	Similkameen	96.2	92.3	89.1	97.6	99.7	99.5	7.4	11.9	6.4
2002	Similkameen	97.1	98.1	89.8	98.0	99.7	99.5	51.6	52.2	54.1
2003	Similkameen	96.7	97.5	86.8	97.6	99.3	98.5	98.0	98.8	81.5
2004	Similkameen	93.6	98.2	84.0	97.6	99.6	99.3	97.8	98.8	80.2
	Bonaparte	93.6	98.2	84.0	97.6	99.6	99.3	97.9	98.9	80.3
2005	Similkameen	97.0	89.6	88.0	99.5	99.5	99.0	93.5	94.6	81.8
	Bonaparte	97.0	89.6	88.0	99.5	99.5	99.0	0.0	0.0	0.0
2006	Similkameen	92.9	89.5	86.3	98.3	99.6	99.3	94.1	95.5	79.8
2007	Similkameen	92.6	99.6	80.8	99.1	99.5	99.1	97.0	98.1	77.7
	Bonaparte	92.6	99.6	80.8	99.1	99.5	99.1	95.6	96.7	76.6
2008	Similkameen	97.9	99.6	91.2	96.8	99.7	99.3	89.8	90.5	79.3
	Bonaparte	97.9	99.6	91.2	96.8	99.7	99.3	86.9	87.8	76.7
2009[b]	Similkameen	93.6	93.5	91.0	98.2	99.7	99.5	97.8	98.6	87.4
	Bonaparte	93.6	93.5	91.0	98.2	99.7	99.5	74.8	75.3	66.8
2010	Similkameen	96.5	100.0	91.2	99.9	97.4	97.1	93.3	96.3	85.0
2011	Similkameen	100.0	90.2	95.9	98.3	99.8	99.1	97.8	98.8	92.2
2012	Similkameen	100.0	100.0	85.1	98.6	99.7	99.3	70.6	71.2	59.3
Mean	***Similkameen***	***94.1***	***96.3***	***86.9***	***97.6***	***98.3***	***97.9***	***86.7***	***88.2***	***72.9***
	Bonaparte	***94.9***	***96.1***	***87.0***	***98.2***	***99.6***	***99.2***	***71.0***	***71.7***	***60.1***
Median	***Similkameen***	***94.7***	***97.8***	***87.5***	***98.0***	***99.5***	***99.1***	***93.6***	***96.7***	***78.5***
	Bonaparte	***93.6***	***98.2***	***88.0***	***98.2***	***99.6***	***99.3***	***86.9***	***87.8***	***76.6***
Standard		***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

[a] Survival rates were calculated from the aggregate population collected at Wells Fish Hatchery volunteer channel and left- and right-ladder traps at Wells Dam.

[b] Survival rates were calculated from aggregate collections at Wells east fish ladder for the Methow and Okanogan/Similkameen programs. About 59% of the total fish collected were used to estimate survival rates.

10.3 Disease Monitoring

Results of adult broodstock bacterial kidney disease (BKD) monitoring for Methow/Okanogan summer Chinook are shown in Table 9.12 in Section 9.3.

10.4 Spawning Surveys

Surveys for Okanogan/Similkameen summer Chinook redds were conducted from late September to mid-November in the Okanogan and Similkameen rivers. Total redd counts (not peak counts) were conducted in the rivers.

Redd Counts

During the survey period 1989 through 2015, the number of summer Chinook redds in the Okanogan River basin averaged 2,064 and ranged from 110 to 6,025 (Table 10.7).

Table 10.7. Total number of redds counted in the Okanogan River basin, 1989-2015. The Colville Tribes provided data for survey years 2013 to present.

Survey year	Number of summer Chinook redds		
	Okanogan River	Similkameen River	Total count
1989	151	370	521
1990	99	147	246
1991	64	91	155
1992	53	57	110
1993	162	288	450
1994	375*	777	1,152
1995	267*	616	883
1996	116	419	535
1997	158	486	644
1998	88	276	364
1999	369	1,275	1,644
2000	549	993	1,542
2001	1,108	1,540	2,648
2002	2,667	3,358	6,025
2003	1,035	378	1,413
2004	1,327	1,660	2,987
2005	1,611	1,423	3,034
2006	2,592	1,666	4,258
2007	1,301	707	2,008
2008	1,146	1,000	2,146
2009	1,672	1,298	2,970
2010	1,011	1,107	2,118
2011	1,714	1,409	3,123
2012	1,613	1,066	2,679
2013	2,267	1,280	3,547

Survey year	Number of summer Chinook redds		
	Okanogan River	Similkameen River	Total count
2014	2,231	2,022	4,253
2015	2,379	1,897	4,276
Average	***1,042***	***1,022***	***2,064***
Median	***1,035***	***1,000***	***2,008***

* Reach-expanded aerial counts.

Spawning Escapement

Spawning escapement for Okanogan/Similkameen summer Chinook was calculated as the total number of redds times the fish per redd ratio estimated from fish sampled at Wells Dam. During the survey period 1989 through 2015, the summer Chinook spawning escapement within the Okanogan River basin averaged 5,695 and ranged from 473 to 13,857 (Table 10.8).

Table 10.8. Spawning escapements for summer Chinook in the Okanogan and Similkameen rivers for return years 1989-2015. The Colville Tribes provided data for return years 2013 to present.

Return year	Fish/Redd	Spawning escapement		
		Okanogan	Similkameen	Total
1989*	3.30	498	1,221	1,719
1990*	3.40	337	500	837
1991*	3.70	237	337	574
1992*	4.30	228	245	473
1993*	3.30	535	950	1,485
1994*	3.50	1,313	2,720	4,033
1995*	3.40	908	2,094	3,002
1996*	3.40	394	1,425	1,819
1997*	3.40	537	1,652	2,189
1998	3.00	264	828	1,092
1999	2.20	812	2,805	3,617
2000	2.40	1,318	2,383	3,701
2001	4.10	4,543	6,314	10,857
2002	2.30	6,134	7,723	13,857
2003	2.42	2,505	915	3,420
2004	2.25	2,986	3,735	6,721
2005	2.93	4,720	4,169	8,889
2006	2.02	5,236	3,365	8,601
2007	2.20	2,862	1,555	4,417
2008	3.25	3,725	3,250	6,975
2009	2.54	4,247	3,297	7,544
2010	2.81	2,841	3,111	5,952
2011	3.10	5,313	4,368	9,681

Return year	Fish/Redd	Spawning escapement		
		Okanogan	Similkameen	Total
2012	3.07	4,952	3,273	8,225
2013	2.31	5,237	2,957	8,194
2014	2.86	6,381	5,783	12,164
2015	3.21	7,637	6,089	13,726
Average	***2.99***	***2,841***	***2,854***	***5,695***
Median	***3.07***	***2,841***	***2,805***	***4,417***

* Spawning escapement was calculated using the "Modified Meekin Method" (i.e., 3.1 x jack multiplier).

10.5 Carcass Surveys

Surveys for summer Chinook carcasses were conducted during late September to mid-November in the Okanogan and Similkameen rivers.

Number sampled

During the survey period 1993 through 2015, the number of summer Chinook carcasses sampled in the Okanogan River basin averaged 1,337 and ranged from 115 to 3,293 (Table 10.9). In all years, most were sampled in the upper Okanogan River and lower Similkameen River (Table 10.9).

Table 10.9. Numbers of summer Chinook carcasses sampled within each survey reach in the Okanogan River basin, 1993-2015. Reach codes are described in Table 2.11. The Colville Tribes provided data for survey years 2013 to present.

Survey year	Number of summer Chinook carcasses								
	Okanogan						Similkameen		Total
	O-1	O-2	O-3	O-4	O-5	O-6	S-1	S-2	
1993[a]	0	2	3	0	23	13	73	1	115
1994[b]	0	4	4	0	27	5	318	60	418
1995	0	0	2	0	30	0	239	15	286
1996	0	0	0	2	5	2	226	0	235
1997	0	0	2	0	9	3	225	1	240
1998	0	1	8	1	7	7	340	4	368
1999	0	0	3	2	23	53	766	48	895
2000	0	2	20	15	47	16	727	41	868
2001	0	26	75	10	127	112	1,141	105	1,596
2002	10	32	83	35	204	572	1,265	259	2,460
2003[c]	0	0	28	0	17	243	596	381	1,265
2004	0	4	31	24	146	283	1,392	298	2,178
2005	0	8	93	37	371	434	731	276	1,950
2006	4	3	31	16	120	291	508	106	1,079
2007	2	0	55	1	453	519	658	29	1,717
2008	4	10	40	36	248	665	859	157	2,019

Survey year	Number of summer Chinook carcasses								
	Okanogan						Similkameen		Total
	O-1	O-2	O-3	O-4	O-5	O-6	S-1	S-2	
2009	2	7	31	32	348	500	703	150	1,773
2010	3	10	30	42	241	352	627	148	1,453
2011	0	0	55	14	361	478	753	114	1,775
2012	1	0	56	15	256	537	495	54	1,414
2013[d]	0	0	30	9	52	432	380	7	910
2014	0	2	79	54	275	783	770	489	2,452
2015	0	10	61	11	283	994	1702	232	3,293
Average	***1***	***5***	***36***	***15***	***160***	***317***	***674***	***129***	***1,337***
Median	***0***	***2***	***31***	***11***	***127***	***291***	***658***	***105***	***1,414***

[a] 25 additional carcasses were sampled on the Similkameen and 46 on the Okanogan without any reach designation.
[b] One additional carcasses was sampled on the Similkameen without any reach designation.
[c] 793 carcasses were sampled on the Similkameen before initiation of spawning (pre-spawn mortality) and an additional 40 carcasses were sampled on the Okanogan. The cause of the high mortality (*Ichthyophthirius multifilis* and *Flavobacterium columnarae*) was exacerbated by high river temperatures.
[d] In 2013, the Colville Tribes combined survey reaches O-3 and O-4, and S-1 and S-2. Carcass totals in these reaches were re-apportioned based on redd counts within each reach.

Carcass Distribution and Origin

Based on the available data (1991-2014), most fish, regardless of origin, were found in Reach 1 on the Similkameen River (Driscoll Channel to Oroville Bridge) (Table 10.10). However, a slightly larger percentage of hatchery fish were found in reaches on the Similkameen River than were wild fish (Figure 10.1). In contrast, a larger percentage of wild fish were found in reaches on the Okanogan River.

Table 10.10. Numbers of wild and hatchery summer Chinook carcasses sampled within different reaches in the Okanogan River basin, 1993-2014.

Survey year	Origin	Survey reach								Total
		O-1	O-2	O-3	O-4	O-5	O-6	S-1	S-2	
1993	Wild	0	0	3	0	13	4	48	1	69
	Hatchery	0	2	0	0	10	9	25	0	46
1994	Wild	0	0	1	0	7	1	113	22	144
	Hatchery	0	4	3	0	20	4	205	38	274
1995	Wild	0	0	1	0	10	0	66	4	81
	Hatchery	0	0	1	0	20	0	173	11	205
1996	Wild	0	0	0	1	3	1	53	0	58
	Hatchery	0	0	0	1	2	1	173	0	177
1997	Wild	0	0	1	0	0	3	83	0	87
	Hatchery	0	0	1	0	9	0	142	1	153
1998	Wild	0	1	3	1	6	5	162	4	182
	Hatchery	0	0	5	0	1	2	178	0	186
1999	Wild	0	0	0	0	9	23	293	9	334
	Hatchery	0	0	3	2	14	30	473	39	561

Survey year	Origin	Survey reach								Total
		O-1	O-2	O-3	O-4	O-5	O-6	S-1	S-2	
2000	Wild	0	0	8	8	24	11	189	4	244
	Hatchery	0	2	12	7	23	5	538	37	624
2001	Wild	0	10	23	5	67	42	390	54	591
	Hatchery	0	16	52	5	60	70	751	51	1,005
2002	Wild	6	14	20	10	81	212	340	72	755
	Hatchery	4	18	63	25	123	360	925	187	1,705
2003	Wild	0	0	13	0	12	152	231	124	532
	Hatchery	0	0	15	0	5	91	365	257	733
2004	Wild	0	2	19	19	108	225	1,125	260	1,758
	Hatchery	0	2	12	5	38	58	267	38	420
2005	Wild	0	5	51	21	256	364	531	176	1,404
	Hatchery	0	3	42	16	115	70	200	100	546
2006	Wild	2	2	22	10	105	247	370	73	831
	Hatchery	2	1	9	6	15	44	138	33	248
2007	Wild	1	0	30	1	284	322	405	20	1,063
	Hatchery	1	0	25	0	169	197	253	9	654
2008	Wild	2	1	14	11	107	324	347	41	847
	Hatchery	2	9	26	25	141	341	512	116	1,172
2009	Wild	2	3	13	14	189	347	330	75	973
	Hatchery	0	4	18	18	159	153	373	75	800
2010	Wild	1	5	19	18	154	180	329	69	775
	Hatchery	2	5	11	24	87	172	296	79	676
2011	Wild	0	0	21	4	201	362	216	19	823
	Hatchery	0	0	34	10	160	116	537	95	952
2012	Wild	0	0	18	9	133	427	206	23	816
	Hatchery	1	0	38	6	123	110	288	31	597
2013	Wild	0	0	23	7	37	360	216	4	647
	Hatchery	0	0	7	2	15	72	164	3	263
2014	Wild	0	1	62	47	233	717	648	426	2,134
	Hatchery	0	1	17	7	42	66	122	63	318
Average	***Wild***	***1***	***2***	***17***	***8***	***93***	***197***	***304***	***67***	***689***
	Hatchery	***1***	***3***	***18***	***7***	***61***	***90***	***323***	***57***	***560***
Median	***Wild***	***1***	***5***	***19***	***18***	***154***	***180***	***329***	***69***	***775***
	Hatchery	***2***	***5***	***11***	***24***	***87***	***172***	***296***	***79***	***676***

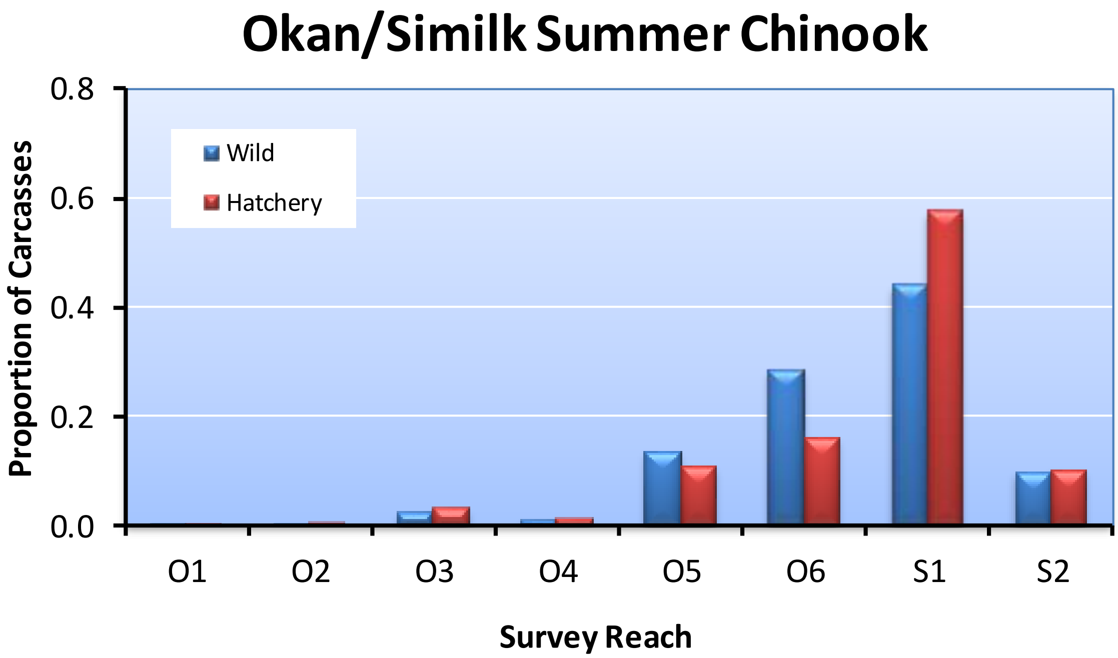

Figure 10.1. Distribution of wild and hatchery produced carcasses in different reaches in the Okanogan River basin, 1993-2014. Reach codes are described in Table 2.11.

10.6 Life History Monitoring

Life history characteristics of Okanogan/Similkameen summer Chinook were assessed by examining carcasses on spawning grounds and fish collected or examined at broodstock collection sites, and by reviewing tagging data and fisheries statistics.

Migration Timing

Migration timing for Okanogan/Similkameen summer Chinook is described in Section 9.6.

Age at Maturity

Because hatchery summer Chinook are released after one year of rearing and natural-origin summer Chinook migrate primarily as age-0 fish, total ages will differ between hatchery and natural-origin Chinook (see Hillman et al. 2011). Therefore, in this section, we evaluated age at maturity by comparing differences in salt (ocean) ages between the two groups.

Most of the wild and hatchery summer Chinook sampled during the period 1993-2014 in the Okanogan River basin were salt age-3 fish (Table 10.11; Figure 10.2). A higher percentage of salt age-4 wild Chinook returned to the basin than did salt age-4 hatchery Chinook. In contrast, a higher proportion of salt age-1 and 2 hatchery fish returned than did salt age-1 and 2 wild fish. Thus, a higher percentage of wild fish returned at an older age than did hatchery fish.

Table 10.11. Proportions of wild and hatchery summer Chinook of different salt (ocean) ages sampled on spawning grounds in the Okanogan River basin, 1993-2014.

Sample year	Origin	Salt age					Sample size
		1	2	3	4	5	
1993	Wild	0.00	0.21	0.70	0.10	0.00	63
	Hatchery	0.00	0.98	0.02	0.00	0.00	44
1994	Wild	0.02	0.13	0.54	0.31	0.00	134
	Hatchery	0.02	0.09	0.89	0.00	0.00	290
1995	Wild	0.00	0.19	0.59	0.22	0.00	68
	Hatchery	0.01	0.15	0.36	0.49	0.00	200
1996	Wild	0.03	0.28	0.61	0.08	0.00	36
	Hatchery	0.02	0.22	0.56	0.20	0.01	174
1997	Wild	0.04	0.27	0.53	0.15	0.00	73
	Hatchery	0.00	0.02	0.87	0.11	0.00	148
1998	Wild	0.02	0.35	0.52	0.11	0.00	151
	Hatchery	0.05	0.50	0.23	0.22	0.00	185
1999	Wild	0.00	0.20	0.64	0.16	0.00	268
	Hatchery	0.00	0.12	0.85	0.02	0.00	552
2000	Wild	0.03	0.15	0.62	0.20	0.00	216
	Hatchery	0.12	0.02	0.76	0.10	0.00	545
2001	Wild	0.02	0.18	0.76	0.04	0.00	531
	Hatchery	0.05	0.88	0.02	0.05	0.00	1,005
2002	Wild	0.02	0.15	0.62	0.21	0.00	692
	Hatchery	0.01	0.19	0.80	0.01	0.00	1,681
2003	Wild	0.03	0.18	0.63	0.17	0.00	477
	Hatchery	0.03	0.06	0.79	0.12	0.00	653
2004	Wild	0.01	0.17	0.26	0.55	0.00	1,528
	Hatchery	0.01	0.32	0.45	0.23	0.00	382
2005	Wild	0.00	0.12	0.79	0.08	0.01	1,281
	Hatchery	0.02	0.06	0.77	0.15	0.00	530
2006	Wild	0.00	0.02	0.53	0.45	0.00	830
	Hatchery	0.05	0.18	0.24	0.53	0.00	139
2007	Wild	0.02	0.07	0.12	0.78	0.02	1,061
	Hatchery	0.22	0.30	0.42	0.05	0.01	559
2008	Wild	0.01	0.32	0.63	0.04	0.01	846
	Hatchery	0.02	0.60	0.36	0.02	0.00	1,108
2009	Wild	0.01	0.03	0.81	0.15	0.00	926
	Hatchery	0.05	0.05	0.86	0.03	0.00	783
2010	Wild	0.00	0.16	0.45	0.39	0.00	708
	Hatchery	0.02	0.65	0.27	0.06	0.00	619

Sample year	Origin	Salt age					Sample size
		1	2	3	4	5	
2011	Wild	0.01	0.07	0.82	0.10	0.00	787
	Hatchery[a]	0.16	0.08	0.76	0.00	0.00	873
2012	Wild	0.02	0.23	0.41	0.34	0.00	750
	Hatchery	0.05	0.55	0.35	0.05	0.00	532
2013	Wild	0.01	0.17	0.75	0.07	0.00	520
	Hatchery	0.03	0.21	0.74	0.02	0.00	252
2014	Wild	0.02	0.08	0.76	0.14	0.00	1892
	Hatchery	0.18	0.26	0.55	0.02	0.00	300
Average	***Wild***	***0.01***	***0.14***	***0.58***	***0.26***	***0.00***	***629***
	Hatchery	***0.05***	***0.30***	***0.58***	***0.07***	***0.00***	***526***
Median	***Wild***	***0.01***	***0.15***	***0.70***	***0.14***	***0.00***	***612***
	Hatchery	***0.04***	***0.21***	***0.65***	***0.10***	***0.00***	***531***

[a] There was one salt age-6 hatchery fish that was not included in this table.

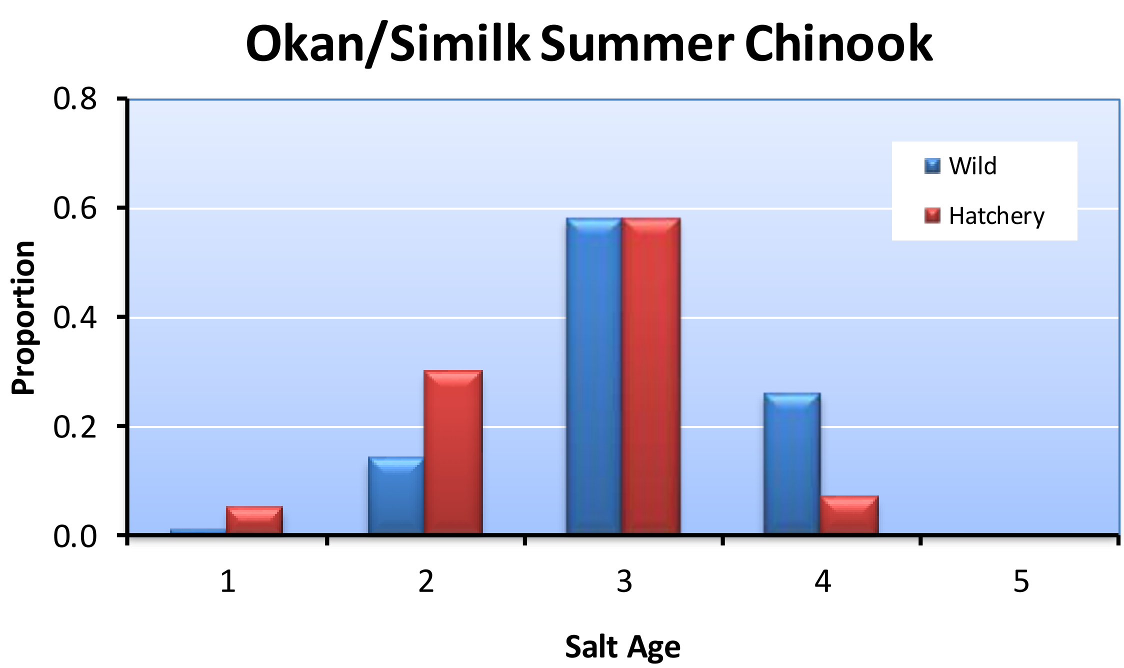

Figure 10.2. Proportions of wild and hatchery summer Chinook of different salt (ocean) ages sampled at broodstock collection sites and on spawning grounds in the Okanogan River basin for the combined years 1993-2014.

Size at Maturity

For the period 1993 through 2014, on average, hatchery summer Chinook were about 2 cm smaller than wild summer Chinook sampled in the Okanogan River basin (Table 10.12). This is likely because a higher percentage of wild fish returned as salt age-4 fish than did hatchery fish.

Table 10.12. Mean lengths (POH; cm) and variability statistics for wild and hatchery summer Chinook sampled in the Okanogan River basin, 1993-2014; SD = 1 standard deviation.

Sample year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
1993[a]	Wild	69	73	7	52	90
	Hatchery	59	62	6	47	75
1994	Wild	136	71	7	40	86
	Hatchery	268	69	8	30	84
1995	Wild	81	75	6	54	87
	Hatchery	201	73	8	39	87
1996	Wild	22	68	14	22	85
	Hatchery	26	75	8	60	88
1997	Wild	87	70	7	44	84
	Hatchery	148	74	6	48	88
1998	Wild	182	70	8	45	94
	Hatchery	186	65	12	30	87
1999	Wild	333	73	7	56	91
	Hatchery	559	71	7	23	84
2000	Wild	241	70	10	32	86
	Hatchery	624	69	12	24	92
2001	Wild	578	67	9	26	86
	Hatchery	997	61	8	32	90
2002	Wild	755	69	9	28	91
	Hatchery	1705	70	8	33	87
2003	Wild	532	68	9	30	93
	Hatchery	733	69	10	26	90
2004	Wild	1756	71	10	33	94
	Hatchery	417	66	9	41	92
2005	Wild	1403	66	7	41	99
	Hatchery	546	68	8	31	85
2006	Wild	831	72	6	31	91
	Hatchery	248	71	9	33	87
2007	Wild	1063	75	9	27	99
	Hatchery	654	64	13	30	87
2008	Wild	847	65	9	29	86
	Hatchery	1172	65	8	32	89
2009	Wild	973	70	7	28	89
	Hatchery	799	70	9	35	86
2010	Wild	775	71	9	43	90
	Hatchery	676	64	10	22	87

Sample year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
2011	Wild	823	68	7	29	89
	Hatchery	952	66	11	26	86
2012	Wild	816	67	10	27	93
	Hatchery	597	63	9	23	86
2013	Wild	642	67	8	23	87
	Hatchery	267	71	8	36	88
2014	Wild	2,134	68	8	30	83
	Hatchery	318	64	13	30	89
Pooled	***Wild***	***15,079***	***70***	***8***	***22***	***99***
	Hatchery	***12,152***	***68***	***9***	***22***	***92***

[a] This year includes sizes reported in the annual report. The data contained in the WDFW database do not include all these data.

Contribution to Fisheries

Most of the harvest on hatchery-origin Okanogan/Similkameen summer Chinook occurred in the Ocean (Table 10.13). Ocean harvest has made up 37-100% of all hatchery-origin Okanogan/Similkameen summer Chinook harvested. Brood years 1997, 1998, 2000, 2004, 2006, 2008, and 2009 provided the largest harvests, while brood years 1993 and 1996 provided the lowest.

Table 10.13. Estimated number and percent (in parentheses) of hatchery-origin Okanogan/Similkameen summer Chinook captured in different fisheries, brood years 1989-2009.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
1989	2,371 (80)	553 (19)	0 (0)	42 (1)	2,966
1990	355 (89)	34 (8)	0 (0)	12 (3)	401
1991	220 (86)	37 (14)	0 (0)	0 (0)	257
1992	422 (91)	28 (6)	2 (0)	10 (2)	462
1993	24 (80)	6 (20)	0 (0)	0 (0)	30
1994	374 (92)	23 (6)	2 (0)	7 (2)	406
1995	652 (93)	9 (1)	12 (2)	25 (4)	698
1996	6 (100)	0 (0)	0 (0)	0 (0)	6
1997	6,493 (92)	136 (2)	36 (1)	416 (6)	7,081
1998	4,374 (89)	251 (5)	45 (1)	219 (4)	4,889
1999	1,353 (68)	224 (11)	31 (2)	384 (19)	1,992
2000	3,142 (69)	533 (12)	222 (5)	665 (15)	4,562
2001	184 (58)	81 (25)	31 (10)	23 (7)	319
2002	696 (56)	200 (16)	90 (7)	258 (21)	1,244
2003	692 (37)	568 (31)	130 (7)	466 (25)	1,856
2004	3,087 (38)	2,162 (27)	694 (9)	2,165 (27)	8,108

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
2005	468 (46)	306 (30)	79 (8)	167 (16)	1,022
2006	3,153 (38)	3,352 (40)	469 (6)	1,419 (17)	8,393
2007	1,549 (45)	951 (27)	67 (2)	910 (26)	3,477
2008	4,529 (43)	1,963 (18)	217 (2)	3,948 (37)	10,637
2009	2,009 (47)	976 (23)	205 (5)	1,085 (25	4,275
Average	***1,722 (68)***	***590 (16)***	***111 (3)***	***581 (12)***	***3,004***
Median	***696 (69)***	***224 (16)***	***36 (2)***	***219 (7)***	***1,856***

Straying

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Okanogan River basin. Targets for strays based on return year (recovery year) and brood year should be less than 5%.

Few hatchery-origin Okanogan summer Chinook have strayed into basins outside the Okanogan (Table 10.14). Although hatchery-origin Okanogan summer Chinook have strayed into other spawning areas, they usually made up less than 5% of the spawning escapement within those areas. The Chelan tailrace has received the largest number of Okanogan strays.

Table 10.14. Number and percent of spawning escapements within other non-target basins that consisted of hatchery-origin Okanogan summer Chinook, return years 1994-2014. For example, for return year 2002, 1% of the summer Chinook spawning escapement in the Entiat Basin consisted of hatchery-origin Okanogan summer Chinook. Percent strays should be less than 5%.

Return year	Wenatchee		Methow		Chelan		Entiat		Hanford Reach	
	Number	%	Number	%	Number	%	Number	%	Number	%
1994	0	0.0	0	0.0	-	-	-	-	-	-
1995	0	0.0	0	0.0	-	-	-	-	-	-
1996	0	0.0	0	0.0	-	-	-	-	-	-
1997	0	0.0	0	0.0	-	-	-	-	-	-
1998	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1999	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2000	0	0.0	6	0.5	30	4.5	0	0.0	3	0.0
2001	12	0.1	0	0.0	10	1.0	0	0.0	0	0.0
2002	0	0.0	3	0.1	4	0.7	5	1.0	0	0.0
2003	0	0.0	8	0.2	22	5.3	14	2.0	0	0.0
2004	0	0.0	0	0.0	5	1.2	0	0.0	0	0.0
2005	5	0.1	27	1.1	36	6.9	7	1.9	8	0.0
2006	0	0.0	5	0.2	4	1.0	7	1.2	0	0.0
2007	0	0.0	3	0.2	4	2.1	0	0.0	0	0.0
2008	0	0.0	9	0.5	46	9.3	4	1.3	0	0.0
2009	15	0.2	3	0.2	11	1.8	18	7.2	0	0.0

Return year	Wenatchee		Methow		Chelan		Entiat		Hanford Reach	
	Number	%	Number	%	Number	%	Number	%	Number	%
2010	6	0.1	0	0.0	33	3.0	0	0.0	0	0.0
2011	0	0.0	0	0.0	46	3.6	0	0.0	0	0.0
2012	7	0.1	5	0.2	19	1.5	0	0.0	0	0.0
2013	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2014	0	0.0	4	0.2	8	0.7	0	0.0	0	0.0
Average	**2**	**0.0**	**3**	**0.2**	**16**	**2.5**	**3**	**0.9**	**1**	**0.0**
Median	**0**	**0.0**	**0**	**0.0**	**10**	**1.5**	**0**	**0.0**	**0**	**0.0**

On average, about 1% of the returns have strayed into non-target spawning areas, falling within the acceptable level of less than 5% (Table 10.15). Depending on brood year, percent strays into non-target spawning areas have ranged from 0-4.4%. Few (<1% on average) have strayed into non-target hatchery programs.

Table 10.15. Number and percent of hatchery-origin Okanogan summer Chinook that homed to target spawning areas and the target hatchery, and number and percent that strayed to non-target spawning areas and non-target hatchery programs, by brood years 1989-2009. Percent stays should be less than 5%.

Brood year	Homing				Straying			
	Target stream		Target hatchery*		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1989	3,132	69.7	1,328	29.6	2	0.0	31	0.7
1990	729	71.4	291	28.5	0	0.0	1	0.1
1991	1,125	71.3	453	28.7	0	0.0	0	0.0
1992	1,264	68.5	572	31.0	8	0.4	1	0.1
1993	54	62.1	32	36.8	0	0.0	1	1.1
1994	924	80.8	203	17.7	16	1.4	1	0.1
1995	1,883	85.4	271	12.3	50	2.3	0	0.0
1996	27	100.0	0	0.0	0	0.0	0	0.0
1997	11,629	97.1	309	2.6	34	0.3	3	0.0
1998	2,727	95.3	102	3.6	31	1.1	2	0.1
1999	828	96.7	18	2.1	10	1.2	0	0.0
2000	2,088	93.6	29	1.3	99	4.4	15	0.7
2001	105	98.1	2	1.9	0	0.0	0	0.0
2002	702	96.2	17	2.3	11	1.5	0	0.0
2003	1,580	96.2	47	2.9	16	1.0	0	0.0
2004	4,947	94.4	206	3.9	85	1.6	2	0.0
2005	606	93.2	22	3.4	22	3.4	0	0.0
2006	5,220	97.6	60	1.1	68	1.3	0	0.0
2007	1,396	97.8	21	1.5	10	0.7	0	0.0

Brood year	Homing				Straying			
	Target stream		Target hatchery*		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
2008	3,600	98.3	36	1.0	23	0.6	4	0.1
2009	993	91.9	75	6.9	12	1.1	1	0.1
Average	**2,169**	**88.4**	**195**	**10.4**	**24**	**1.1**	**3**	**0.1**
Median	**1,264**	**94.4**	**60**	**3.4**	**12**	**1.0**	**1**	**0.0**

* Homing to the target hatchery includes Okanogan/Similkameen hatchery summer Chinook that are captured and included as broodstock in the Okanogan/Similkameen Hatchery program. These hatchery fish were typically collected at Wells Dam.

Genetics

Genetic studies were conducted to investigate relationships among temporally replicated collections of summer Chinook from the Wenatchee River, Methow River, and Okanogan River in the upper Columbia River basin (Kassler et al. 2011; the entire report is appended as Appendix M). A total of 2,416 summer Chinook were collected from tributaries in the upper Columbia River basin. Two collections of natural-origin summer Chinook from 1993 (prior to the supplementation program) were taken from the Wenatchee River basin (N = 139) and compared to collections of hatchery and natural-origin Chinook from 2006 and 2008 (N = 380). Two pre-supplementation collections from the Methow River (1991 and 1993) were compared to supplementation collections from 2006 and 2008 (N = 362). Three pre-supplementation collections from the Okanogan River Basin (1991, 1992, and 1993) were compared with supplementation collections from 2006 and 2008 (N = 669). A collection of natural-origin summer Chinook from the Chelan River was also analyzed (N = 70). Additionally, hatchery collections from Eastbank Hatchery (Wenatchee and Methow/Okanogan stock; N = 221) and Wells Hatchery (N = 294) were analyzed and compared to the in-river collections. Summer Chinook data (provided by the USFWS) from the Entiat River (N = 190) were used for comparison. Lastly, data from eight collections of fall Chinook (N = 2,408) were compared to the collections of summer Chinook. Samples of natural and hatchery-origin summer Chinook were analyzed and compared to determine if the supplementation programs have affected the genetic structure of these populations. The study also calculated the effective number of breeders for collection locations of natural and hatchery-origin summer Chinook from 1993 and 2008.

In general, population differentiation was not observed among the temporally replicated collection locations. A single collection from the Okanogan River (1993) was the only collection showing statistically significant differences. The effective number of breeders was not statistically different from the early collection in 1993 in comparison to the late collection in 2008. Overall, these analyses revealed a lack of differentiation among the temporal replicates from the same locations and among the collection from different locations, suggesting the populations have been homogenized or that there has been substantial gene flow among populations. Additional comparisons among summer-run and fall-run Chinook populations in the upper Columbia River were conducted to determine if there was any differentiation between Chinook with different run timing. These analyses revealed pairwise F_{ST} values that were less than 0.01 for the collections of summer Chinook to collections of fall Chinook from Hanford Reach, lower Yakima River, Priest Rapids, and Umatilla. Collections of fall Chinook from Crab Creek, Lyons Ferry Hatchery, Marion Drain, and Snake River had pairwise F_{ST} values that were higher in comparison to the collections of summer Chinook. The consensus clustering analysis did not provide good statistical support to the groupings, but did show relationships among collections based on geographic proximity. Overall the summer and fall run Chinook that have historically been spawned together were not differentiated while fall Chinook from greater geographic distances were differentiated.

Proportionate Natural Influence

Another method for assessing the genetic risk of a supplementation program is to determine the influence of the hatchery and natural environments on the adaptation of the composite population. This is estimated by the proportion of natural-origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery-origin fish in the natural spawning escapement (pHOS). We calculated Proportionate Natural Influence (PNI) by iterating Ford's (2002) equations 5 and 6 to equilibrium, using a heritability of 0.3 and a selection strength of three standard deviations. The larger the PNI value, the greater the strength of selection in the natural environment relative to that of the hatchery environment. In order for the natural environment to dominate selection, PNI should be greater than 0.50, and important integrated populations should have a PNI of at least 0.67 (HSRG/WDFW/NWIFC 2004).

For brood years 1993-2003, the PNI values were less than 0.67 (Table 10.16). However, since brood year 2003, PNI has generally been greater than 0.67, save 2008 and 2011. PNI results reported here end with brood year 2012. Beginning with brood year 2013, the Colville Confederated Tribes report PNI values for Okanogan summer Chinook in their annual reports to BPA.

Table 10.16. Proportionate Natural Influence (PNI) values for the Okanogan/Similkameen summer Chinook supplementation program for brood years 1989-2012. NOS = number of natural-origin Chinook on the spawning grounds; HOS = number of hatchery-origin Chinook on the spawning grounds; NOB = number of natural-origin Chinook collected for broodstock; and HOB = number of hatchery-origin Chinook included in hatchery broodstock.

Brood year	Spawners			Broodstock			PNI[a]
	NOS	HOS	pHOS	NOB	HOB	pNOB	
1989	1,719	0	0	1,297	312	0.81	1.00
1990	837	0	0	828	206	0.80	1.00
1991	574	0	0	924	314	0.75	1.00
1992	473	0	0	297	406	0.42	1.00
1993	915	570	0.38	681	388	0.64	0.64
1994	1,323	2,710	0.67	341	244	0.58	0.48
1995	979	2,023	0.67	173	240	0.42	0.40
1996	568	1,251	0.69	287	155	0.65	0.50
1997	862	1,327	0.61	197	265	0.43	0.43
1998	600	492	0.45	153	211	0.42	0.50
1999	1,274	2,343	0.65	224	289	0.44	0.42
2000	1,174	2,527	0.68	164	337	0.33	0.35
2001	4,306	6,551	0.6	12	345	0.03	0.09
2002	4,346	9,511	0.69	247	241	0.51	0.44
2003	1,933	1,487	0.43	381	101	0.79	0.66
2004	5,309	1,412	0.21	506	16	0.97	0.83

Brood year	Spawners			Broodstock			PNI[a]
	NOS	HOS	pHOS	NOB	HOB	pNOB	
2005	6,441	2,448	0.28	391	9	0.98	0.78
2006	5,507	3,094	0.36	500	10	0.98	0.74
2007	2,983	1,434	0.32	456	17	0.96	0.76
2008	2,998	3,977	0.57	359	86	0.81	0.60
2009	4,204	3,340	0.44	503	4	0.99	0.70
2010	3,189	2,763	0.46	484	8	0.98	0.69
2011	4,642	5,039	0.52	467	26	0.95	0.65
2012	4,494	3,731	0.45	79	2	0.98	0.69
Average	***2,569***	***2,418***	***0.42***	***415***	***176***	***0.69***	***0.64***
Median	***1,826***	***2,183***	***0.45***	***370***	***209***	***0.77***	***0.66***

[a] PNI was calculated previously using PNI approximate equation 11 (HSRG 2009; Appendix A). All PNI values presented here were recalculated by iterating Ford's (2002) equations 5 and 6 to equilibrium using a heritability of 0.3 and a selection strength of three standard deviations. C. Busack, NOAA Fisheries, 21 March 2016, provided the model for calculating PNI.

Post-Release Survival and Travel Time

We used PIT-tagged fish to estimate survival rates and travel times (arithmetic mean days) of hatchery summer Chinook from the Similkameen River release site to McNary Dam, and smolt to adult ratios (SARs) from release to detection at Bonneville Dam (Table 10.17).[21] Over the three brood years for which PIT-tagged hatchery fish were released, survival rates from the Similkameen River to McNary Dam ranged from 0.432 to 0.720; SARs from release to detection at Bonneville Dam ranged from 0.016 to 0.030. Average travel time from the Similkameen River to McNary Dam ranged from 41 to 44 days. Although there is only one year in which low densities were compared to high densities (brood year 2008), there was little difference in survival rates and travel times between the two groups (Table 10.17).

Table 10.17. Total number of Okanogan hatchery summer Chinook released with PIT tags, their survival and travel times (mean days) to McNary Dam, and smolt-to-adult (SAR) ratios for brood years 2008-2011. Standard errors are shown in parentheses. NA = not available (i.e., not all the fish from the release groups have returned to the Columbia River).

Brood year	Number of tagged fish released	Survival to McNary Dam	Travel time to McNary Dam (d)	SAR to Bonneville Dam (%)
2008	4,531 (high density)	0.445 (0.061)	44.0 (10.2)	0.028 (0.002)
	4,293 (low density)	0.432 (0.050)	41.4 (9.7)	0.030 (0.003)
2009	5,089	0.720 (0.102)	41.5 (10.1)	0.016 (0.002)
2010	0	--	--	--
2011	5,036	0.682 (0.064)	41.9 (12.3)	NA

[21] It is important to point out that because of fish size differences among rearing tanks or raceways, fish PIT tagged in one tank or raceway may not represent untagged fish rearing in other tanks or raceways.

Natural and Hatchery Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural-origin recruits (NOR) to the parent spawning population (spawning escapement). Natural-origin recruits are naturally produced (wild) fish that survive to contribute to harvest (directly or indirectly), to broodstock, and to spawning grounds. We do not account for fish that died in route to the spawning grounds (migration mortality) or died just before spawning (pre-spawn mortality) (see Appendix B in Hillman et al. 2012). We calculated NORs with and without harvest. NORs without harvest include all returning fish that either returned to the basin or were collected as wild broodstock. NORs with harvest include all fish harvested and are based on brood year harvest rates from the hatchery program. For brood years 1989-2008, NRR for summer Chinook in the Okanogan averaged 1.01 (range, 0.17-3.82) if harvested fish were not included in the estimate and 2.31 (range, 0.32-10.26) if harvested fish were included in the estimate (Table 10.18). NRRs for more recent brood years will be calculated as soon as all tag recoveries and sampling rates have been loaded into the database.

Hatchery replacement rates (HRR) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HOR) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 8.6 (the calculated target value in Hillman et al. 2013). The target value of 8.6 includes harvest. HRRs exceeded NRRs in 17 of the 20 years of data, regardless if harvest was or was not included in the estimate (Table 10.18). Hatchery replacement rates for Okanogan summer Chinook have exceeded the estimated target value of 8.6 in 9 of the 20 years of data.

Table 10.18. Broodstock collected, spawning escapements, natural and hatchery-origin recruits (NOR and HOR), and natural and hatchery replacement rates (NRR and HRR; with and without harvest) for wild summer Chinook in the Okanogan River basin, brood years 1989-2009.

Brood year	Broodstock Collected	Spawning Escapement	Harvest not included				Harvest included			
			HOR	NOR	HRR	NRR	HOR	NOR	HRR	NRR
1989	304	1,719	4,493	2,146	14.78	1.25	7,459	3,577	24.54	2.08
1990	288	837	1,021	1,477	3.55	1.76	1,422	2,063	4.94	2.46
1991	364	574	1,578	629	4.34	1.10	1,835	728	5.04	1.27
1992	304	473	1,845	752	6.07	1.59	2,307	942	7.59	1.99
1993	328	1,485	87	1,003	0.27	0.68	117	1,348	0.36	0.91
1994	302	4,033	1,144	2,168	3.79	0.54	1,550	2,946	5.13	0.73
1995	385	3,002	2,204	959	5.72	0.32	2,902	1,267	7.54	0.42
1996	330	1,819	27	466	0.08	0.26	33	574	0.10	0.32
1997	313	2,189	12,005	4,363	38.35	1.99	19,113	6,959	61.06	3.18
1998	352	1,092	2,919	4,166	8.29	3.82	7,817	11,199	22.21	10.26
1999	333	3,617	856	6,641	2.57	1.84	2,848	22,211	8.55	6.14
2000	334	3,701	2,234	1,716	6.69	0.46	6,795	5,232	20.34	1.41
2001	335	10,857	107	8,959	0.32	0.83	426	35,784	1.27	3.3
2002	333	13,857	730	6,077	2.19	0.44	1,980	16,470	5.95	1.19
2003	337	3,420	1,643	566	4.88	0.17	3,504	1,201	10.40	0.35
2004	335	6,721	5,240	3,119	15.64	0.46	13,352	7,959	39.86	1.18

Brood year	Broodstock Collected	Spawning Escapement	Harvest not included				Harvest included			
			HOR	NOR	HRR	NRR	HOR	NOR	HRR	NRR
2005	338	8,889	650	6,177	1.92	0.69	1,670	15,951	4.94	1.79
2006	355	8,601	5,348	2,421	15.06	0.28	13,752	6,242	38.74	0.73
2007	314	4,417	1,426	6,233	4.54	1.41	4,908	21,841	15.63	4.94
2008	276	6,975	3,663	2,674	13.27	0.38	14,300	10,445	51.81	1.50
Average	***328***	***4,414***	***2,461***	***3,136***	***7.62***	***1.01***	***5,405***	***8,747***	***16.80***	***2.31***
Median	***333***	***3,519***	***1,611***	***2,295***	***4.71***	***0.69***	***2,875***	***5,737***	***8.07***	***1.46***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adult recaptures divided by the number of tagged hatchery smolts released. Here, SARs were based on CWT returns. For the available brood years, SARs have ranged from 0.00007 to 0.03239 for hatchery summer Chinook in the Okanogan River basin (Table 10.19).

Table 10.19. Smolt-to-adult ratios (SARs) for Okanogan/Similkameen summer Chinook, brood years 1989-2009.

Brood year	Number of tagged smolts released[a]	Estimated adult captures[b]	SAR
1989	202,125	4,293	0.02124
1990	367,207	972	0.00265
1991	360,380	975	0.00271
1992	537,190	2,282	0.00425
1993	379,139	117	0.00031
1994	217,818	1,528	0.00702
1995	574,197	2,851	0.00497
1996	487,776	32	0.00007
1997	572,531	18,543	0.03239
1998	287,948	7,641	0.02654
1999	610,868	2,776	0.00454
2000	528,639	6,765	0.01280
2001	26,315	424	0.01611
2002	245,997	1,969	0.00800
2003	574,908	3,484	0.00606
2004	676,222	12,892	0.01906
2005	273,512	1,662	0.00608
2006	597,276	13,622	0.02281
2007	610,379	4,886	0.00800
2008	516,533	14,242	0.02757
2009	522,295	5,348	0.01024

Brood year	Number of tagged smolts released[a]	Estimated adult captures[b]	SAR
Average	***436,631***	***5,110***	***0.01159***
Median	***516,533***	***2,851***	***0.00800***

[a] Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).

[b] Includes estimated recoveries (spawning ground, hatcheries, harvest, etc.) and observed recoveries if estimated recoveries were unavailable.

10.7 ESA/HCP Compliance

Broodstock Collection

Because summer Chinook adults collected at Wells Dam are used for both the Methow and Okanogan supplementation programs, please refer to Section 9.7 for information on ESA compliance during broodstock collection. Direct and/or indirect take of ESA-listed species during broodstock collection for the Okanogan summer Chinook outside of Wells Dam is covered by permits held by the Colville Tribes.

Hatchery Rearing and Release

Activities associated with the spawning, rearing, and release of Okanogan summer Chinook that could result in either direct or incidental take of listed species is covered under ESA permits held by the Colville Tribes.

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, 1395, 18118, 18120, and 18121, 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 PUD Hatchery facilities during the period 1 January through 31 December 2015. NPDES monitoring and reporting for PUD Hatchery Programs during 2015 are provided in Appendix F. NPDES reporting for Okanogan summer Chinook only covers the Similkameen acclimation facility and only during the time fish are present.

SECTION 11: CHELAN FALLS SUMMER CHINOOK

Although the Chelan Falls summer Chinook program (formerly the Turtle Rock program) is an augmentation program, the production of 200,000 fish is No Net Impact (NNI) compensation for passage mortalities associated with Rocky Reach Dam. In addition, the conversion of the subyearling program to a 400,000 yearling program is compensation for lost spawning habitat as a result of the construction of Rocky Reach Dam. In 2011, as part of the periodic recalculation of NNI for Rocky Reach Dam, the previous 200,000 NNI program was reduced to 176,000 fish. This reduced the combined Chelan Falls summer Chinook production from 600,000 to 576,000 beginning with the 2012 brood.

Before 2012, broodstock were collected at Wells Dam and consisted of volunteers to the Wells Fish Hatchery. Summer Chinook were spawned at Wells Fish Hatchery and fertilized eggs were then transferred to Eastbank Fish Hatchery for hatching and rearing. In 2012, adults were collected at Wells Fish Hatchery and then transferred to Eastbank Fish Hatchery for spawning, hatching, and rearing. Beginning in 2013, broodstock collection has been piloted at the Eastbank Hatchery Outfall.

The original program consisted of both subyearling (normal and accelerated groups) and yearling releases. Subyearlings were transferred to Turtle Rock Fish Hatchery for acclimation in May. These fish were released in June after about 30 days of acclimation on Columbia River water. The goal of this program was to release 1,620,000 subyearling summer Chinook (810,000 normal and 810,000 accelerated subyearlings) into the Columbia River at 40 fish per pound. Targets for fork length and weight were 112 mm (CV = 9.0) and 11.4 g, respectively. Over 50% of both subyearling groups were marked with CWTs. In 2010, the subyearling program was converted to a 400,000 yearling program.

The goal of the yearling program was to release 200,000 summer Chinook smolts into the Columbia River from Turtle Rock Fish Hatchery at 10 fish per pound. Targets for fork length and weight were 176 mm (CV = 9.0) and 45.4 g, respectively. Beginning with the 2006 brood year, yearling summer Chinook were acclimated at both Turtle Rock Fish Hatchery and the Chelan River net pens. With the conversion of the subyearling program to a yearling program and the reduction of the NNI component to 176,000, the current goal is to release 576,000 yearling summer Chinook smolts (176,000 from the NNI program plus 400,000 from the converted subyearling program). Beginning in 2012, the 576,000 yearlings are acclimated overwinter at facilities at Chelan Hatchery on Chelan River water. In 2012, the Turtle Rock program officially became the Chelan Falls summer Chinook program.

Over 90% of yearling summer Chinook have been marked with CWTs and all are ad-clipped. In addition, juvenile summer Chinook were PIT tagged within each of the circular and standard raceways.

11.1 Broodstock Sampling

Before 2013, broodstock for the program were collected as part of the Wells summer Chinook volunteer program. Refer to Snow et al. (2012) for information related to adults collected for these programs. Beginning in 2013, broodstock collection for the Chelan Falls program is being piloted at the Eastbank Hatchery Outfall.

11.2 Hatchery Rearing

Rearing History

Number of eggs taken

Based on the unfertilized egg-to-release standard of 81%, a total of 688,995 eggs were needed to meet the program goal of 576,000 smolts for brood years 2012 and 2013. An evaluation of the program in 2014 concluded that 696,493 eggs were needed to attain the 576,000 smolts. From 2012-2015, the egg take goal was only reached in 2013.

Disease

There were no significant health concerns encountered during rearing of Chelan Falls summer Chinook in 2015 (BY 2013) at Eastbank Fish Hatchery or at Chelan Falls Acclimation Facility.

Number of acclimation days

Rearing of the 2013-brood Chelan Falls summer Chinook was similar to previous years with fish being held on well water at Eastbank Hatchery until transfer to the Chelan Falls Acclimation Facility for overwinter acclimation. This was the third year that the whole program was transferred to the Chelan Falls Acclimation Facility for final overwinter acclimation on Chelan River water. Transfer occurred on 3-6 November 2014. Fish were force released on 15 April 2015 after 160-163 days of acclimation.

Release Information

Numbers released

The subyearling Turtle Rock summer Chinook program was discontinued in 2010; however, releases of subyearling Chinook in past years are shown in Tables 11.1 and 11.2. Production from the subyearling programs was converted to the yearling program.

The 2013 yearling summer Chinook program achieved 99.9% of the 600,000 target goal with about 599,584 fish being released from the Chelan River Acclimation Ponds (Table 11.3). Releases of 2014 yearling Chinook will be reported in the 2016 report.

Table 11.1. Numbers of Turtle Rock summer Chinook subyearlings released from the hatchery, brood years 1995-2009. The release target for Turtle Rock summer Chinook subyearlings was 810,000 fish.

Brood year	Release year	CWT mark rate	Number of subyearlings released
1995	1996	0.1873	1,074,600
1996	1997	0.9653	385,215
1997	1998	0.9780	508,060
1998	1999	0.6453	301,777
1999	2000	0.9748	369,026
2000	2001	0.3678	604,892
2001	2002	0.9871	214,059
2002	2003	0.3070	656,399
2003	2004	0.4138	491,480
2004	2005	0.4591	411,707

Brood year	Release year	CWT mark rate	Number of subyearlings released
2005	2006	0.4337	490,074
2006	2007	0.3388	538,392
2007	2008	0.4385	439,806
2008	2009	0.6355	309,003
2009	2010	NA	713,130
Average		***0.6111***	***500,508***
Median		***0.4488***	***490.074***

Table 11.2. Numbers of Turtle Rock summer Chinook accelerated subyearlings released from the hatchery, brood years 1995-2008. The release target for Turtle Rock summer Chinook accelerated subyearlings was 810,000 fish.

Brood year	Release year	CWT mark rate	Number of subyearlings released
1995	1996	0.9834	169,000
1996	1997	0.4163	477,300
1997	1998	0.3767	521,480
1998	1999	0.6033	307,571
1999	2000	0.9556	347,946
2000	2001	0.4331	449,329
2001	2002	0.4086	480,584
2002	2003	0.5492	364,461
2003	2004	0.6414	289,696
2004	2005	0.5471	364,453
2005	2006	0.9783	457,340
2006	2007	0.5510	342,273
2007	2008	0.4745	392,024
2008	2009	0.5295	372,320
Average		***0.6034***	***381,127***
Median		***0.5482***	***368,391***

Table 11.3. Numbers of Turtle Rock summer Chinook yearling smolts released from the hatchery, brood years 1995-2013. The release target for Turtle Rock summer Chinook was 200,000 smolts for the period before brood year 2010. The current release target is 600,000 smolts.

Brood year	Release year	Acclimation facility	CWT mark rate	Number of smolts released
1995	1997	Turtle Rock	0.9688	150,000
1996	1998	Turtle Rock	0.9582	202,727
1997	1999	Turtle Rock	0.9800	202,989
1998	2000	Turtle Rock	0.9337	217,797

Brood year	Release year	Acclimation facility	CWT mark rate	Number of smolts released
1999	2001	Turtle Rock	0.9824	285,707
2000	2002	Turtle Rock	0.9941	279,969
2001	2003	Turtle Rock	0.9824	203,279
2002	2004	Turtle Rock	0.9799	195,851
2003	2005	Turtle Rock	0.9258	215,366
2004	2006	Turtle Rock	0.9578	206,734
2005	2007	Chelan	0.9810	204,644
2006	2008	Chelan	0.9752	99,271
		Turtle Rock	0.9752	43,943
2007	2009	Chelan Falls	0.9426	112,604
		Turtle Rock	0.9426	61,003
2008	2010	Chelan Falls	0.9818	200,999
		Turtle Rock	0.9818	252,762
2009	2011	Chelan Falls[a]	-	190,449
		Turtle Rock	0.9721	250,667
Average (1995-2009)		***Chelan Falls***	***0.9665***	***137,625***
		Turtle Rock	***0.9745***	***233,429***
Median (1995-2009)		***Chelan Falls***	***0.9737***	***205,007***
		Turtle Rock	***0.9781***	***190,449***
2010	2012	Chelan Falls	0.9702	563,824
2011	2013	Chelan Falls	0.9859	582,460
2012	2014	Chelan Falls	0.9879	566,188
2013	2015	Chelan Falls	0.9917	599,584
Average (2010-present)		***Chelan Falls***	***0.9839***	***578,014***
Median (2010-present)		***Chelan Falls***	***0.9869***	***574,324***

[a] No CWT mark rate was provided because of the early release of this group.

Numbers tagged

Brood year 2013 yearling Chinook were 98.4% CWT and adipose fin-clipped.

In 2015, a total of 10,000 summer Chinook from the 2014 brood were PIT tagged at the Chelan Hatchery during 16-19 March 2016. These fish are part of a size target at release evaluation. The fish were tagged in four different circular ponds representing different size targets at release groups (based on fish per pound; fpp). Pond #1 consisted of fish at 22 fpp, pond #2 consisted of fish at 18 fpp, pond #3 consisted of fish at 13 fpp, and pond #4 consisted of fish at 10 fpp. Fish were not fed during tagging or for two days before and after tagging. Within the respective ponds, fish averaged 118, 116, 136, and 139 mm in length and 19, 18, 26, and 31 g at time of tagging.

Table 11.4 summarizes the number of yearling summer Chinook that have been PIT-tagged and released from the Turtle Rock/Chelan Falls Program.

Table 11.4. Summary of PIT-tagging activities for Turtle Rock/Chelan Falls yearling summer Chinook, brood years 2007-2013; fpp = fish per pound.

Brood year	Release year	Raceway/Program	Number of fish tagged	Number of tagged fish that died	Number of tags shed	Number of tagged fish released
2007	2009	Circular Reuse	10,104	128	1	9,975
		Standard	10,102	162	3	9,937
2008	2010	Circular Reuse	11,102	15	0	11,087
		Standard	11,100	18	2	11,080
2009	2011	Turtle Rock	5,051	106	0	4,945
		Chelan Net Pens	5,050	2	0	5,048
2010	2012	Chelan Falls	4,200	10	0	4,190
2011	2013	Chelan Falls	4,101	26	0	4,075
2012	2014	Chelan Falls (18 fpp)	2,500	17	0	2,483
		Chelan Falls (22 fpp)	2,500	23	0	2,477
		Chelan Falls (10 fpp)	2,500	6	0	2,494
		Chelan Falls (13 fpp)	2,500	11	0	2,489
2013	2015	Chelan Falls (18 fpp)	2,500	14	0	2,486
		Chelan Falls (22 fpp)	2,500	27	0	2,473
		Chelan Falls (10 fpp)	2,500	15	0	2,485
		Chelan Falls (13 fpp)	2,500	22	0	2,478

Fish size and condition at release

Although the subyearling summer Chinook program was discontinued, sizes of subyearlings released from Turtle Rock Hatchery before 2010 are shown in Tables 11.5 and 11.6.

Table 11.5. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of Turtle Rock summer Chinook subyearlings released from the hatchery, brood years 1995-2009. Size targets are provided in the last row of the table.

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1995	1996	102	6.3	12.6	36
1996	1997	87	8.0	7.4	62
1997	1998	98	6.2	10.2	45
1998	1999	96	6.3	10.7	43
1999	2000	90	9.0	9.8	46
2000	2001	100	7.1	11.3	40
2001	2002	104	7.2	13.4	34
2002	2003	97	7.3	11.8	39

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
2003	2004	101	8.0	12.0	43
2004	2005	100	7.8	11.4	40
2005	2006	100	6.5	12.5	36
2006	2007	95	7.2	9.5	48
2007	2008	79	7.4	5.6	81
2008	2009	86	7.9	7.9	57
2009[a]	2010	89	7.1	7.0	65
Average		***95***	***7.3***	***10.2***	***48***
Targets		***112***	***9.0***	***11.4***	***40***

[a] Pre-release growth sample was conducted using pond mortalities.

Table 11.6. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of Turtle Rock summer Chinook accelerated subyearlings released from the hatchery, brood years 1995-2008. Size targets are provided in the last row of the table.

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1995	1996	129	7.1	27.3	17
1996	1997	107	6.5	15.6	29
1997	1998	117	6.0	18.9	24
1998	1999	119	8.0	18.9	24
1999	2000	114	6.7	19.0	24
2000	2001	111	7.0	16.8	27
2001	2002	117	8.4	19.5	23
2002	2003	116	11.3	21.2	21
2003	2004	113	14.9	17.0	30
2004	2005	117	11.3	20.1	23
2005	2006	119	9.1	22.2	21
2006	2007	118	8.3	19.1	24
2007	2008	95	7.7	10.0	45
2008[a]	2009	97	8.6	10.6	43
Average		***114***	***8.6***	***18.3***	***27***
Targets		***112***	***9.0***	***11.4***	***40***

[a] The 2008 brood year was the last year of the accelerated subyearling program.

Size at release of the brood year 2013 yearling summer Chinook was 85.1% and 59.0% of the fork length and weight targets, respectively, for the Chelan Falls group. This group exceeded the target CV for length (Table 11.7).

Table 11.7. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of Turtle Rock/Chelan summer Chinook yearling releases, brood years 1995-2013. Size targets are provided in the last row of the table.

Brood year	Release year	Acclimation facility	Fork length (mm)		Mean weight	
			Mean	CV	Grams (g)	Fish/pound
1995	1997	Turtle Rock	-	-	-	-
1996	1998	Turtle Rock	166	14.2	60.9	7
1997	1999	Turtle Rock	198	4.6	91.3	5
1998	2000	Turtle Rock	161	11.9	53.9	8
1999	2001	Turtle Rock	164	18.6	59.0	8
2000	2002	Turtle Rock	170	15.3	59.0	8
2001	2003	Turtle Rock	154	22.3	48.6	9
2002	2004	Turtle Rock	157	16.7	44.0	12
2003	2005	Turtle Rock	173	13.8	54.7	8
2004	2006	Turtle Rock	176	20.6	45.3	7
2005	2007	Turtle Rock	158	11.0	43.5	10
2006	2008	Chelan Nets	172	14.5	58.4	8
		Turtle Rock	157	25.8	54.1	8
2007	2009	Chelan Nets	153	18.8	45.7	10
		Turtle Rock	167	14.6	49.3	9
2008	2010	Chelan Nets	146	22.9	40.6	11
		Turtle Rock	172	15.9	58.5	8
2009	2011	Chelan Nets	158	15.1	46.6	10
		Turtle Rock	174	17.5	59.3	8
2010	2012	Chelan Falls	132	27.4	33.2	14
2011	2013	Chelan Falls	148	18.6	42.6	11
2012	2014	Chelan Falls	129	17.1	24.5	19
2013	2015	Chelan Falls	137	9.8	26.8	17
Average			***160***	***16.7***	***50.0***	***10***
Targets[a]			***161***	***9.0***	***45.4***	***10***

[a] For size-target studies, fish per pound (fpp) targets for brood year 2012 were 10, 13, 18, 22 fpp.

Survival Estimates

Normal subyearling releases

Overall survival of the normal subyearling Turtle Rock summer Chinook program from green egg to release was below the standard set for the program (Table 11.8). Lower than expected survival at ponding and post-ponding reduced the overall program performance. This program was discontinued in 2010.

Table 11.8. Hatchery life-stage survival rates (%) for Turtle Rock subyearling (zero program) summer Chinook, brood years 2004-2009. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
2004	NA	NA	93.5	74.4	93.9	91.4	90.8	99.7	63.1
2005	NA	NA	94.4	87.9	85	84.8	84.2	99.4	69.8
2006	NA	NA	97.8	87.9	85.0	84.8	84.2	99.4	72.4
2007	NA	NA	92.7	84.9	88.5	86.7	84.8	99.6	66.7
2008	NA	NA	78.8	95.0	80.7	79.3	79.9	99.8	59.8
2009	NA	NA	95.0	89.4	89.5	89.2	79.7	89.5	67.7
Average	***NA***	***NA***	***92.0***	***86.6***	***87.1***	***86.0***	***83.9***	***97.9***	***66.6***
Median	***NA***	***NA***	***94.0***	***87.9***	***86.8***	***85.8***	***84.2***	***99.5***	***67.2***
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

Accelerated subyearling releases

Overall survival of the accelerated subyearling Turtle Rock summer Chinook program from green egg to release was below the standard set for the program (Table 11.9). Lower than expected survival in post-ponding reduced the overall program performance. This program was discontinued in 2010.

Table 11.9. Hatchery life-stage survival rates (%) for Turtle Rock subyearling (accelerated program) summer Chinook, brood years 2004-2009. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
2004	NA	NA	92.5	98.3	93.4	92.4	90.0	97.8	81.8
2005	NA	NA	93.8	94.6	83.7	83.4	81.7	98.8	72.5
2006	NA	NA	86.1	94.6	83.7	83.4	81.7	98.8	66.5
2007	NA	NA	93.4	95.4	78.4	77.5	76.3	98.9	67.9
2008[a]	NA	NA	93.4	95.0	79.8	78.8	78.2	99.3	67.1
Average	***NA***	***NA***	***91.8***	***95.6***	***83.8***	***83.1***	***81.6***	***98.7***	***71.2***
Median	***NA***	***NA***	***93.4***	***95.0***	***83.7***	***83.4***	***81.7***	***98.8***	***67.9***
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

[a] The 2008 brood year was the last year of the accelerated subyearling program.

Yearling releases

Overall survival of the yearling Chelan Falls summer Chinook program from green egg to release was above the standard set for the program (Table 11.10). Higher than expected survivals in most life stages contributed to the increased program performance.

Table 11.10. Hatchery life-stage survival rates (%) for Turtle Rock/Chelan Falls yearling summer Chinook, brood years 2004-2013. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Un-fertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Un-fertilized egg-release
	Female	Male							
2004	NA	NA	92.9	97.7	96.8	96.4	95.5	99.6	86.7
2005	NA	NA	89.1	97.5	98.1	97.8	96.6	99.1	83.9
2006	NA	NA	86.2	78.8	97.6	97.1	95.2	98.7	64.8
2007 (Turtle Rock)	NA	NA	80.3	97.6	98.8	98.2	95.4	99.1	74.8
2007 (Chelan Falls)	NA	NA	80.3	97.6	98.8	98.2	94.9	97.1	74.4
2008 (Turtle Rock)	NA	NA	93.5	98.0	99.4	97.2	95.9	98.8	87.8
2008 (Chelan Falls)	NA	NA	93.5	98.0	97.6	98.7	96.4	99.3	88.2
2009 (Turtle Rock)	NA	NA	90.8	96.8	99.7	99.0	97.2	98.1	85.5
2009 (Chelan Falls)	NA	NA	90.9	96.9	99.8	99.0	96.7	97.7	85.2
2010 (Chelan Falls)	NA	NA	94.8	97.7	99.4	95.2	92.4	97.6	85.5
2011 (Chelan Falls)	NA	NA	90.0	99.4	91.7	98.2	83.4	85.2	74.6
2012 (Chelan Falls)	NA	NA	93.5	98.5	99.8	99.3	95.9	96.7	88.3
2013 (Chelan Falls)	100.0	98.1	90.6	96.5	99.5	98.9	98.5	99.7	86.1
Average (Chelan)	***NA***	***NA***	***89.7***	***96.2***	***98.2***	***97.9***	***94.9***	***97.4***	***82.0***
Median (Chelan)	***NA***	***NA***	***90.8***	***97.6***	***98.8***	***98.2***	***95.9***	***98.7***	***85.5***
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

11.3 Spawning Surveys

Surveys for summer Chinook redds in the Chelan River were conducted from late September to late-November 2015. Total redd counts were conducted in the river (see Appendix N for more details).

Redd Counts

A total of 448 summer Chinook redds were counted in the Chelan River in 2015 (Table 11.11). This was higher than the overall average of 296 redds.

Table 11.11. Total number of redds counted in the Chelan River, 2000-2015.

Survey year	Total redd count
2000	196
2001	240
2002	253
2003	173
2004	185
2005	179
2006	208
2007	86
2008	153

Survey year	Total redd count
2009	246
2010	398
2011	413
2012	426
2013	729
2014	400
2015	448
Average	***296***
Median	***243***

Redd Distribution

Summer Chinook redds were not evenly distributed among the four sampling areas within the Chelan River. Most redds (48%) were located in the Chelan Tailrace (Table 11.12). Few summer Chinook spawned in the Habitat Pool.

Table 11.12. Total number of summer Chinook redds counted in different survey areas within the Chelan River during September through early November, 2015.

Survey area	Total redd count	Percent
Chelan Tailrace	217	48
Columbia Tailrace	106	24
Habitat Channel	91	20
Habitat Pool	34	8
Totals	***448***	***100***

Spawn Timing

Spawning in 2015 began the first week of October, peaked in late October, and ended late November. Peak spawning occurred in the Chelan Tailrace, Habitat Channel, and Habitat Pool during late October and in the Columbia Tailrace in early November (Figure 11.1).

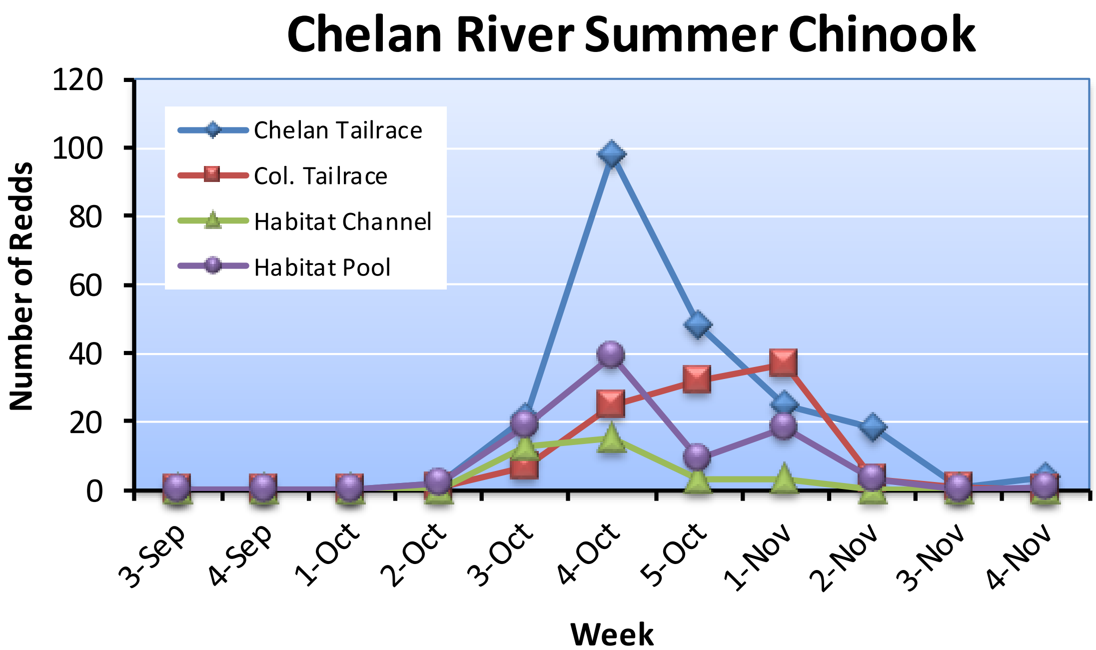

Figure 11.1. Number of new summer Chinook redds counted during different weeks within different sections of the Chelan River, September through November 2015.

Spawning Escapement

Spawning escapement for summer Chinook in the Chelan River was calculated as the total number of redds times the fish per redd ratio estimated from fish sampled at Wells Dam. The estimated fish per redd ratio for Methow summer Chinook in 2015 was 3.21. Multiplying this ratio by the number of redds counted in the Chelan River resulted in a total spawning escapement of 1,438 summer Chinook (Table 11.13).

Table 11.13. Spawning escapements for summer Chinook in the Chelan River for return years 2000-2015.

Return year	Fish/Redd	Redds	Total spawning escapement
2000	2.40	196	470
2001	4.10	240	984
2002	2.30	253	582
2003	2.42	173	419
2004	2.25	185	416
2005	2.93	179	524
2006	2.02	208	420
2007	2.20	86	189
2008	3.25	153	497
2009	2.54	246	625
2010	2.81	398	1,118

Return year	Fish/Redd	Redds	Total spawning escapement
2011	3.10	413	1,280
2012	3.07	426	1,308
2013	2.31	729	1,684
2014	2.75	400	1,100
2015	3.21	448	1,438
Average	***2.73***	***296***	***816***
Median	***2.65***	***243***	***604***

11.4 Carcass Surveys

Surveys for summer Chinook carcasses within the Chelan River were conducted during late September to mid-November 2015 (see Appendix N for more details).

Number sampled

A total of 363 summer Chinook carcasses were sampled during September through late-November in the Chelan River (Table 11.14). This was higher than the overall average of 173 carcasses sampled since 2000.

Table 11.14. Numbers of summer Chinook carcasses sampled within each survey area within the Chelan River, 2000-2015; ND = no data.

Survey year	Number of summer Chinook carcasses				
	Chelan Tailrace	Columbia Tailrace	Habitat Channel	Habitat Pool	Total
2000	ND	ND	ND	ND	**48**
2001	ND	ND	ND	ND	**101**
2002	ND	ND	ND	ND	**145**
2003	ND	ND	ND	ND	**168**
2004	ND	ND	ND	ND	**159**
2005	ND	ND	ND	ND	**103**
2006	ND	ND	ND	ND	**107**
2007	ND	ND	ND	ND	**106**
2008	ND	ND	ND	ND	**132**
2009	ND	ND	ND	ND	**51**
2010	ND	ND	ND	ND	**106**
2011	ND	ND	ND	ND	**201**
2012	ND	ND	ND	ND	**317**
2013	50	120	157	28	**355**
2014	171	82	50	6	**309**
2015	49	255	41	18	**363**
Average	***90***	***152***	***83***	***17***	***173***
Median	***50***	***120***	***50***	***18***	***139***

Carcass Distribution and Origin

Summer Chinook carcasses were not evenly distributed among survey areas within the Chelan River in 2015 (Table 11.14). Most of the carcasses in the Chelan River were found in the Columbia Tailrace.

Numbers of wild and hatchery-origin summer Chinook carcasses sampled in 2015 will be available after analysis of CWTs and scales. Based on the available data, hatchery and wild summer Chinook carcasses were not distributed equally among the survey areas within the Chelan River (Table 11.15; Figure 11.2). A larger percentage of hatchery carcasses occurred in the Habitat Channel and Habitat Pool, while a larger percentage of wild summer Chinook carcasses occurred in the Chelan and Columbia River tailraces.

Table 11.15. Numbers of wild and hatchery summer Chinook carcasses sampled within different survey areas on the Chelan River, 2000-2014; ND = no data.

Survey year	Origin	Survey reach				Total
		Chelan Tailrace	Columbia Tailrace	Habitat Channel	Habitat Pool	
2000	Wild	ND	ND	ND	ND	**17**
	Hatchery	ND	ND	ND	ND	**31**
2001	Wild	ND	ND	ND	ND	**26**
	Hatchery	ND	ND	ND	ND	**75**
2002	Wild	ND	ND	ND	ND	**37**
	Hatchery	ND	ND	ND	ND	**108**
2003	Wild	ND	ND	ND	ND	**33**
	Hatchery	ND	ND	ND	ND	**135**
2004	Wild	ND	ND	ND	ND	**91**
	Hatchery	ND	ND	ND	ND	**68**
2005	Wild	ND	ND	ND	ND	**42**
	Hatchery	ND	ND	ND	ND	**61**
2006	Wild	ND	ND	ND	ND	**69**
	Hatchery	ND	ND	ND	ND	**38**
2007	Wild	ND	ND	ND	ND	**35**
	Hatchery	ND	ND	ND	ND	**71**
2008	Wild	ND	ND	ND	ND	**69**
	Hatchery	ND	ND	ND	ND	**63**
2009	Wild	ND	ND	ND	ND	**2**
	Hatchery	ND	ND	ND	ND	**49**
2010	Wild	ND	ND	ND	ND	**46**
	Hatchery	ND	ND	ND	ND	**60**
2011	Wild	ND	ND	ND	ND	**89**
	Hatchery	ND	ND	ND	ND	**112**
2012	Wild	ND	ND	ND	ND	**64**
	Hatchery	ND	ND	ND	ND	**253**
2013	Wild	18	55	51	6	**130**

Survey year	Origin	Survey reach				Total
		Chelan Tailrace	Columbia Tailrace	Habitat Channel	Habitat Pool	
	Hatchery	23	65	106	22	**225**
2014	Wild	32	142	18	1	**193**
	Hatchery	17	113	23	17	**170**
Average	***Wild***	***25***	***99***	***35***	***4***	***63***
	Hatchery	***20***	***89***	***65***	***20***	***101***
Median	***Wild***	***25***	***99***	***35***	***4***	***46***
	Hatchery	***20***	***89***	***65***	***20***	***71***

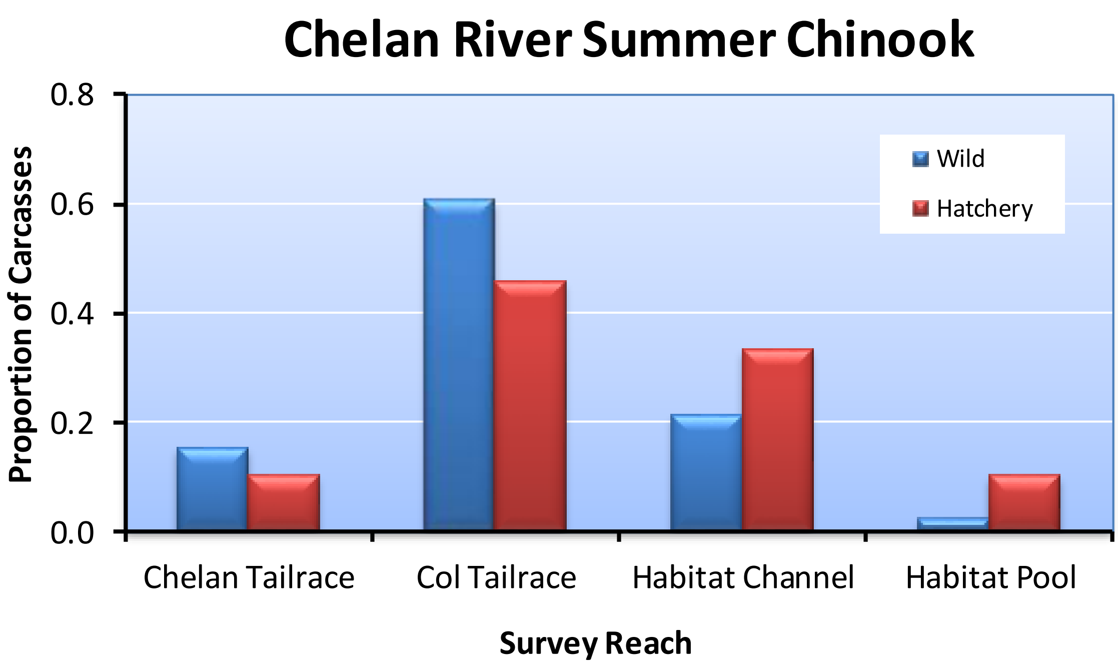

Figure 11.2. Distribution of wild and hatchery produced carcasses in different survey areas within the Chelan River, 2015.

Sampling Rate

Overall, 25% of the total spawning escapement of summer Chinook in the Chelan River was sampled in 2015 (Table 11.16). Sampling rates among survey reaches varied from 7 to 75%.

Table 11.16. Number of redds and carcasses, total spawning escapement, and sampling rates for summer Chinook in the Chelan River, 2015.

Survey reach	Total number of redds	Total number of carcasses	Total spawning escapement	Sampling rate
Chelan Tailrace	217	49	697	0.07
Columbia Tailrace	106	255	340	0.75
Habitat Channel	91	41	292	0.14

Survey reach	Total number of redds	Total number of carcasses	Total spawning escapement	Sampling rate
Habitat Pool	34	18	109	0.16
Total	***448***	***363***	***1,438***	***0.25***

Length Data

Mean lengths (POH, cm) of male and female summer Chinook carcasses sampled during surveys on the Chelan River in 2015 are provided in Table 11.17. The average size of males and females sampled in the Chelan River were 60 cm and 66 cm, respectively.

Table 11.17. Mean lengths (postorbital-to-hypural length; cm) and standard deviations (in parentheses) of male and female summer Chinook carcasses sampled in different areas on the Chelan River, 2015.

Stream/watershed	Mean length (cm)	
	Male	Female
Chelan Tailrace	67.0 (5.4)	66.9 (4.9)
Columbia Tailrace	59.6 (7.8)	66.0 (5.0)
Habitat Channel	62.4 (5.0)	65.4 (4.7)
Habitat Pool	61.7 (10.6)	66.6 (4.3)
Total	***60.4 (7.9)***	***66.1 (4.9)***

11.5 Life History Monitoring

Life history characteristics of Chelan Falls and Turtle Rock summer Chinook were assessed by examining carcasses on spawning grounds and by reviewing tagging data and fisheries statistics.

Contribution to Fisheries

Normal subyearling releases

Most of the harvest on Turtle Rock summer Chinook (normal subyearling releases) occurred in the Ocean (10-100% of the fish harvested; Table 11.18). Brood years 1995 and 2006 provided the largest total harvests, while brood year 1997 and 1998 provided the lowest. The subyearling hatchery program was discontinued after brood year 2009.

Table 11.18. Estimated number and percent (in parentheses) of Turtle Rock summer Chinook (normal subyearling releases) captured in different fisheries, brood years 1995-2009.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
1995	688 (84)	106 (13)	11 (1)	16 (2)	821
1996	72 (80)	0 (0)	5 (6)	13 (14)	90
1997	10 (100)	0 (0)	0 (0)	0 (0)	10
1998	21 (100)	0 (0)	0 (0)	0 (0)	21
1999	184 (64)	26 (9)	4 (1)	75 (26)	289

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
2000	36 (55)	8 (12)	8 (12)	14 (21)	66
2001	164 (64)	30 (12)	20 (8)	44 (17)	258
2002	23 (20)	33 (29)	3 (3)	56 (49)	115
2003	9 (10)	55 (61)	2 (2)	24 (27)	90
2004	42 (37)	29 (25)	2 (2)	42 (37)	115
2005	100 (38)	95 (36)	24 (9)	44 (17)	263
2006	305 (41)	288 (38)	53 (7)	104 (14)	750
2007	110 (34)	91 (28)	21 (6)	104 (32)	326
2008	42 (31)	32 (24)	4 (3)	56 (42)	134
2009	82 (39)	68 (33)	6 (3)	52 (25)	208
Average	***126 (53)***	***57 (21)***	***11 (4)***	***43 (21)***	***237***
Median	***72 (41)***	***32 (24)***	***5 (3)***	***44 (21)***	***134***

Accelerated subyearling releases

Most of the harvest on Turtle Rock summer Chinook (accelerated subyearling releases) occurred in ocean fisheries (Table 11.19). Ocean harvest has made up 0% to 100% of all Turtle Rock summer Chinook harvested. Brood year 1999 provided the largest total harvest, while brood years 1995, 1997, 2002, and 2003 provided the lowest. This program was discontinued after brood year 2008.

Table 11.19. Estimated number and percent (in parentheses) of Turtle Rock summer Chinook (accelerated subyearling releases) captured in different fisheries, brood years 1995-2008.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
1995	3 (100)	0 (0)	0 (0)	0 (0)	3
1996	77 (89)	5 (6)	5 (6)	0 (0)	87
1997	3 (100)	0 (0)	0 (0)	0 (0)	3
1998	97 (95)	2 (2)	3 (3)	0 (0)	102
1999	1,025 (76)	142 (10)	12 (1)	178 (13)	1,357
2000	117 (100)	0 (0)	0 (0)	0 (0)	117
2001	205 (59)	49 (14)	13 (4)	80 (23)	347
2002	9 (100)	0 (0)	0 (0)	0 (0)	9
2003	0 (0)	0 (0)	0 (0)	0 (0)	0
2004	45 (27)	79 (48)	6 (4)	34 (21)	164
2005	65 (59)	12 (11)	26 (24)	7 (6)	110
2006	130 (43)	113 (37)	16 (5)	43 (14)	302
2007	169 (41)	168 (41)	12 (3)	59 (14)	408
2008	20 (54)	2 (5)	4 (11)	11 (30)	37

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
Average	***140 (67)***	***41 (13)***	***7 (4)***	***29 (9)***	***218***
Median	***71 (67)***	***4 (6)***	***5 (3)***	***4 (3)***	***106***

Yearling releases

Most of the harvest on Turtle Rock/Chelan Falls summer Chinook (yearling releases) occurred in ocean fisheries (Table 11.20). Ocean harvest has made up 39% to 95% of all Turtle Rock summer Chinook harvested. Brood years 1998 and 2008 provided the largest harvest, while brood years 1995 and 2005 provided the lowest.

Table 11.20. Estimated number and percent (in parentheses) of Turtle Rock/Chelan Falls summer Chinook (yearling releases) captured in different fisheries, brood years 1995-2009.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
1995	457 (75)	51 (8)	31 (5)	70 (11)	609
1996	766 (95)	14 (2)	2 (0)	21 (3)	803
1997	2,797 (91)	61 (2)	27 (1)	176 (6)	3,061
1998	4,292 (90)	224 (5)	16 (0)	230 (5)	4,762
1999	1,655 (73)	233 (10)	7 (0)	383 (17)	2,278
2000	1,205 (72)	147 (9)	54 (3)	273 (16)	1,679
2001	1,937 (59)	453 (14)	178 (5)	729 (22)	3,298
2002	1,004 (50)	384 (19)	102 (5)	536 (26)	2,026
2003	738 (45)	449 (27)	70 (4)	378 (23)	1,635
2004	838 (39)	560 (26)	127 (6)	605 (28)	2,130
2005	501 (44)	303 (27)	123 (11)	206 (18)	1,133
2006	1,168 (39)	880 (30)	231 (8)	688 (23)	2,967
2007	753 (49)	367 (24)	66 (4)	349 (23)	1,535
2008	4,096 (54)	1,144 (15)	245 (3)	2,036 (27)	7,521
2009	1,702 (52)	771 (23)	122 (4)	686 (21)	3,281
Average	***1,594 (62)***	***403 (16)***	***93 (4)***	***491 (18)***	***2,581***
Median	***1,168 (54)***	***367 (15)***	***70 (4)***	***378 (21)***	***2,130***

Straying

Normal subyearling releases

Assessment of straying was based on evaluating the location of CWT recoveries. There were 17 tag codes used to differentiate Turtle Rock/Chelan normal subyearling releases by brood year, release type, and location. There was one subyearling group released into the Chelan River in 2010 (brood year 2009). There were also six non-associated releases.[22] All tag codes, except brood year 2009, recovered in the Chelan River or other tributaries in the Upper Columbia were considered strays.

Rates of Turtle Rock summer Chinook (normal subyearling releases) straying into spawning areas in the upper basin have been low. Although Turtle Rock summer Chinook have strayed into other spawning areas, they made up less than 5% of the spawning escapement within those areas (Table 11.21). The Chelan tailrace has received the largest number of Turtle Rock strays. This hatchery program was discontinued after brood year 2009.

Table 11.21. Number (No.) and percent of spawning escapements within other non-target basins that consisted of Turtle Rock summer Chinook (normal subyearling releases), return years 1998-2014. For example, for return year 2003, 0.6% of the summer Chinook spawning escapement in the Okanogan River basin consisted of Turtle Rock summer Chinook. Percent strays should be less than 5%.

Return year	Wenatchee		Methow		Okanogan		Chelan		Entiat		Hanford Reach	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1998	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1999	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2000	8	0.1	3	0.3	13	0.4	63	9.5	0	0.0	0	0.0
2001	0	0.0	5	0.2	13	0.1	0	0.0	0	0.0	0	0.0
2002	0	0.0	0	0.0	13	0.1	0	0.0	0	0.0	0	0.0
2003	7	0.1	7	0.2	19	0.6	6	1.4	0	0.0	0	0.0
2004	5	0.0	4	0.2	13	0.2	6	1.4	0	0.0	0	0.0
2005	5	0.1	0	0.0	5	0.1	0	0.0	2	0.5	0	0.0
2006	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2007	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2008	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2009	0	0.0	16	0.9	0	0.0	2	0.3	9	3.6	0	0.0
2010	0	0.0	26	1.0	0	0.0	0	0.0	14	3.2	0	0.0
2011	0	0.0	14	0.5	0	0.0	34	2.7	0	0.0	0	0.0
2012	0	0.0	0	0.0	0	0.0	0	0.0	8	0.9	0	0.0
2013	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2014	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Average	***1***	***0.0***	***4***	***0.2***	***4***	***0.1***	***7***	***0.9***	***2***	***0.5***	***0***	***0.0***
Median	***0***	***0.0***	***0***	***0.0***	***0***	***0.0***	***0***	***0.0***	***0***	***0.0***	***0***	***0.0***

On average, about 29% of the brood year returns have strayed into spawning areas in the upper basin (Table 11.22). Depending on brood year, percent strays into spawning areas have ranged from 0-100%. Few (2.3% on average) have strayed into non-target hatchery programs.

22 Non-associated releases are release groups not containing any coded-wire tagged fish.

Table 11.22. Number and percent of Turtle Rock summer Chinook (normal subyearling releases) that homed to the target hatchery and strayed to non-target spawning areas and non-target hatchery programs, by brood years 1995-2009.

Brood year	Homing				Straying			
	Target stream		Target hatchery*		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1995	-	-	197	74.1	64	24.1	5	1.9
1996	-	-	54	54.5	44	44.4	1	1.0
1997	-	-	2	28.6	5	71.4	0	0.0
1998	-	-	0	0.0	24	100.0	0	0.0
1999	-	-	40	43.5	52	56.5	0	0.0
2000	-	-	5	50.0	5	50.0	0	0.0
2001	-	-	56	77.8	16	22.2	0	0.0
2002	-	-	10	100.0	0	0.0	0	0.0
2003	-	-	27	100.0	0	0.0	0	0.0
2004	-	-	71	97.3	2	2.7	0	0.0
2005	-	-	80	92.0	7	8.0	0	0.0
2006	-	-	194	72.1	72	26.8	3	1.1
2007	-	-	113	68.5	34	20.6	18	10.9
2008	-	-	16	80.0	0	0.0	4	20.0
2009	27	42.2	29	45.3	8	12.5	0	0.0
Average	***27***	***42.2***	***60***	***65.6***	***22***	***29.3***	***2***	***2.3***
Median	***27***	***42.2***	***40***	***72.1***	***8***	***22.2***	***0***	***0.0***

* Homing to the target hatchery includes Turtle Rock hatchery fish that were captured and included as broodstock in the Turtle Rock Hatchery program. These hatchery fish were typically collected at Wells Dam and Wells Hatchery.

Accelerated subyearling releases

Assessment of straying was based on evaluating the location of CWT recoveries. There were 16 tag codes used to differentiate Turtle Rock accelerated subyearling releases by brood year and release type. There were also four non-associated releases. All tag codes recovered in the Chelan River or other tributaries in the Upper Columbia were considered strays.

Rates of Turtle Rock summer Chinook (accelerated subyearling releases) straying into spawning areas in the upper basin have been low. Although Turtle Rock summer Chinook have strayed into other spawning areas, they made up less than 5% of the spawning escapement within those areas (Table 11.23). The Chelan tailrace, Entiat Basin, and Methow River basin have received the largest numbers of Turtle Rock strays. This hatchery program was discontinued after brood year 2008.

Table 11.23. Number (No.) and percent of spawning escapements within other non-target basins that consisted of Turtle Rock summer Chinook (accelerated subyearling releases), return years 1998-2014. For example, for return year 2001, 0.2% of the summer Chinook spawning escapement in the Methow River basin consisted of Turtle Rock summer Chinook. Percent strays should be less than 5%.

Return year	Wenatchee		Methow		Okanogan		Chelan		Entiat		Hanford Reach	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1998	3	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1999	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2000	7	0.1	0	0.0	0	0.0	24	3.6	0	0.0	0	0.0
2001	0	0.0	12	0.4	31	0.3	0	0.0	0	0.0	0	0.0
2002	0	0.0	5	0.1	0	0.0	0	0.0	0	0.0	0	0.0
2003	0	0.0	45	1.1	0	0.0	22	5.3	13	1.9	16	0.0
2004	0	0.0	7	0.3	0	0.0	14	3.3	0	0.0	18	0.0
2005	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2006	0	0.0	0	0.0	0	0.0	0	0.0	7	1.3	0	0.0
2007	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2008	0	0.0	7	0.4	0	0.0	27	5.4	0	0.0	0	0.0
2009	19	0.2	0	0.0	0	0.0	2	0.3	0	0.0	0	0.0
2010	0	0.0	19	0.8	0	0.0	0	0.0	10	2.3	0	0.0
2011	17	0.2	10	0.3	10	0.1	0	0.0	15	3.2	0	0.0
2012	0	0.0	0	0.0	0	0.0	0	0.0	8	0.9	0	0.0
2013	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2014	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Average	***3***	***0.0***	***6***	***0.2***	***2***	***0.0***	***5***	***1.1***	***3***	***0.6***	***2***	***0.0***
Median	***0***	***0.0***	***0***	***0.0***	***0***	***0.0***	***0***	***0.0***	***0***	***0.0***	***0***	***0.0***

On average, about 29% of the brood year returns have strayed into spawning areas in the upper basin (Table 11.24). Depending on brood year, percent strays into spawning areas have ranged from 0-83%. Few (1.3% on average) have strayed into non-target hatchery programs.

Table 11.24. Number and percent of Turtle Rock summer Chinook (accelerated subyearling releases) that homed to the target hatchery and strayed to non-target spawning areas and non-target hatchery programs, by brood years 1995-2008.

Brood year	Homing				Straying			
	Target stream		Target hatchery*		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1995	-	-	7	70.0	3	30.0	0	0.0
1996	-	-	33	32.4	69	67.6	0	0.0
1997	-	-	6	100.0	0	0.0	0	0.0
1998	-	-	2	16.7	10	83.3	0	0.0
1999	-	-	138	54.1	117	45.9	0	0.0

Brood year	Homing				Straying			
	Target stream		Target hatchery*		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
2000	-	-	12	40.0	18	60.0	0	0.0
2001	-	-	57	89.1	7	10.9	0	0.0
2002	-	-	0	0.0	0	0.0	0	0.0
2003	-	-	3	100.0	0	0.0	0	0.0
2004	-	-	90	75.6	29	24.4	0	0.0
2005	-	-	64	75.3	19	22.4	2	2.4
2006	-	-	88	88.9	7	7.1	4	4.0
2007	-	-	133	61.9	81	35.8	12	5.3
2008	-	-	21	84.0	8	25.8	2	6.5
Average	**-**	**-**	***47***	***63.4***	***26***	***29.5***	***1***	***1.3***
Median	**-**	**-**	***27***	***72.7***	***9***	***25.1***	***0***	***0.0***

* Homing to the target hatchery includes Turtle Rock hatchery fish that were captured and included as broodstock in the Turtle Rock Hatchery program. These hatchery fish were typically collected at Wells Dam and Wells Hatchery.

Yearling releases

Assessment of straying was based on evaluating the location of CWT recoveries. Yearlings have been released in the Columbia River and in the Chelan River. There were 16 tag codes used to differentiate Turtle Rock yearling releases by brood year, release type, and location. All these fish were released into the Columbia River and therefore any tag recoveries in the Chelan River or other tributaries were considered strays. In contrast, there were 21 tag codes[23] used to differentiate Chelan River yearling releases by brood year, release type, and location (there were four non-associated releases). All these fish were released into the Chelan River and therefore any tag recoveries in tributaries other than the Chelan River were considered strays.

Rates of Turtle Rock/Chelan Falls summer Chinook (yearling releases) straying into spawning areas in the upper basin have varied widely depending on spawning area. Most of these fish strayed to spawning areas within the Chelan tailrace (Turtle Rock released fish), Entiat Basin, and Methow River basin. On average, Turtle Rock summer Chinook have made up 4-13% of the spawning escapement within those basins (Table 11.25). Relatively few, on average, have strayed to spawning areas in the Okanogan River basin, Wenatchee River basin, and the Hanford Reach (i.e., they made up less than 5% of the spawning escapement in these areas).

23 The Regional Mark Information System (RMIS) indicates that one tag code was released into Lake Chelan. Interestingly, some of these fish have been reported in ocean and Columbia River fisheries.

Table 11.25. Number (No.) and percent of spawning escapements within other non-target basins that consisted of Turtle Rock/Chelan Falls summer Chinook (yearling releases), return years 1998-2014. For example, for return year 2003, 4.3% of the summer Chinook spawning escapement in the Methow River basin consisted of Turtle Rock summer Chinook. Percent strays should be less than 5%.

Return year	Wenatchee		Methow		Okanogan		Chelan		Entiat		Hanford Reach	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1998	0	0.0	2	0.3	0	0.0	0	0.0	0	0.0	0	0.0
1999	3	0.1	2	0.2	0	0.0	0	0.0	0	0.0	0	0.0
2000	18	0.3	57	4.8	167	4.5	73	11.0	0	0.0	10	0.0
2001	109	1.0	523	18.9	334	3.1	316	32.1	0	0.0	7	0.0
2002	92	0.6	437	9.4	194	1.4	191	32.8	136	27.1	0	0.0
2003	64	0.5	170	4.3	14	0.4	165	39.4	180	26.0	9	0.0
2004	10	0.1	55	2.5	116	1.7	75	17.9	0	0.0	0	0.0
2005	5	0.1	73	2.9	78	0.9	88	16.8	46	12.5	0	0.0
2006	0	0.0	100	3.7	25	0.3	64	15.2	30	5.5	0	0.0
2007	0	0.0	65	4.8	31	0.7	40	21.2	58	24.0	19	0.1
2008	18	0.3	72	3.7	60	0.9	110	22.1	46	14.4	0	0.0
2009	8	0.1	95	5.4	32	0.4	5	0.8	18	7.1	0	0.0
2010	12	0.2	105	4.2	111	1.9	0	0.0	30	6.9	0	0.0
2011	8	0.1	88	3.0	35	0.4	15	1.2	12	2.6	0	0.0
2012	21	0.2	33	1.1	43	0.5	110	8.4	29	3.2	0	0.0
2013	0	0.0	128	3.6	20	0.2	14	0.8	0	0.0	0	0.0
2014	7	0.1	22	1.4	24	0.2	16	1.5	18	3.2	0	0.0
Average	***22***	***0.2***	***119***	***4.4***	***76***	***1.0***	***75***	***13.0***	***35***	***7.8***	***3***	***0.0***
Median	***8***	***0.1***	***73***	***3.7***	***35***	***0.5***	***64***	***11.0***	***18***	***3.2***	***0***	***0.0***

On average, about 46% of the brood year returns have strayed into spawning areas in the upper basin (Table 11.26). Depending on brood year, percent strays into spawning areas have ranged from 8-86%. Few (1.4% on average) have strayed into non-target hatchery programs.

Table 11.26. Number and percent of Turtle Rock/Chelan Falls summer Chinook (yearling releases) that homed to the target hatchery and strayed to non-target spawning areas and non-target hatchery programs, by brood years 1995-2009.

Brood year	Homing				Straying			
	Target stream		Target hatchery[a]		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1995	-	-	180	39.3	278	60.7	0	0.0
1996	-	-	218	27.2	583	72.8	0	0.0
1997	-	-	254	14.2	1,531	85.6	3	0.2
1998	-	-	166	16.1	864	83.8	1	0.1
1999	-	-	181	42.7	243	57.3	0	0.0

Brood year	Homing				Straying			
	Target stream		Target hatchery[a]		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
2000	-	-	102	29.1	249	70.9	0	0.0
2001	-	-	389	58.2	279	41.8	0	0.0
2002	-	-	303	54.2	255	45.6	1	0.2
2003	-	-	373	62.3	225	37.6	1	0.2
2004	-	-	287	56.6	219	43.2	1	0.2
Average[b]	**-**	**-**	***245***	***40.0***	***473***	***59.9***	***1***	***0.1***
Median[b]	**-**	**-**	***236***	***41.0***	***267***	***59.0***	***1***	***0.1***
2005	149	29.4	202	39.9	144	28.5	11	2.2
2006	429	40.3	376	35.3	223	21.0	36	3.4
2007	123	27.8	218	49.3	69	15.6	32	7.2
2008	889	43.9	736	36.3	315	15.6	85	4.2
2009	115	10.3	870	78.0	92	8.2	39	3.5
Average[c]	***341***	***30.3***	***480***	***47.8***	***171***	***17.8***	***39***	***4.1***
Median[c]	***149***	***29.4***	***376***	***39.9***	***144***	***15.6***	***36***	***3.5***

[a] Homing to the target hatchery includes Turtle Rock/Chelan Hatchery fish that were captured and included as broodstock in the Turtle Rock/Chelan Hatchery program. These hatchery fish are typically collected at Wells Dam, Wells Hatchery, and the Eastbank Hatchery Outfall.
[b] Summary statistics for yearling Turtle Rock summer Chinook released into the Columbia River (brood years 1995-2004).
[c] Summary statistics for yearling Turtle Rock/Chelan River summer Chinook released into the Chelan River (brood years 2005 to present).

Post-Release Survival and Travel Time

We used PIT-tagged fish to estimate survival rates and travel times (arithmetic mean days) of hatchery summer Chinook from the Turtle Rock/Chelan River release sites to McNary Dam, and smolt to adult ratios (SARs) from release to detection at Bonneville Dam (Table 10.27).[24] Over the seven brood years for which PIT-tagged hatchery fish were released, survival rates from the release sites to McNary Dam ranged from 0.423 to 0.760; SARs from release to detection at Bonneville Dam ranged from 0.009 to 0.028. Average travel times from release sites to McNary Dam ranged from 15 to 33 days.

Much of the variation in survival rates and travel time among brood years resulted from releases of different experimental groups (Table 10.27). For example, brood years 2007 and 2008 were each split into two experimental groups (Circular Reuse group and Standard Raceway group). For both brood years, survival from the release site to McNary Dam and SARs appeared to be greater for the Circular Reuse fish than for the Standard Raceway fish. However, the differences between groups were small for brood year 2008. For both brood years, travel time from release to McNary Dam appeared to be longer for the Standard Raceway fish than for the Circular Reuse fish.

24 It is important to point out that because of fish size differences among rearing tanks or raceways, fish PIT tagged in one tank or raceway may not represent untagged fish rearing in other tanks or raceways.

Another experiment was conducted with brood years 2012 and 2013 (Table 10.27). Those brood years were split into two different treatment groups (small-size fish and large-size fish). The big-size fish appeared to have a higher survival rate to McNary Dam and faster travel time than did the small-size fish. SARs for these fish will be calculated after all fish have returned to the Columbia River.

Table 10.27. Total number of Turtle Rock/Chelan Falls yearling summer Chinook released with PIT tags, their survival and travel times (mean days) to McNary Dam, and smolt-to-adult (SAR) ratios for brood years 2007-2013. Standard errors are shown in parentheses. NA = not available (i.e., not all the fish from the release groups have returned to the Columbia River).

Brood year	Raceway/Program	Number of tagged fish released	Survival to McNary Dam	Travel time to McNary Dam	SAR to Bonneville Dam
2007	Circular Reuse	9,975	0.722 (0.036)	22.4 (8.6)	0.017 (0.001)
	Standard	9,546	0.564 (0.037)	28.4 (11.7)	0.009 (0.001)
2008	Circular Reuse	11,082	0.631 (0.040)	26.5 (9.8)	0.028 (0.002)
	Standard	11,070	0.581 (0.038)	27.9 (18.7)	0.025 (0.001)
2009	Turtle Rock	4,945	0.603 (0.061)	15.4 (8.6)	0.018 (0.002)
	Chelan Net Pens	5,048	0.616 (0.059)	19.5 (10.2)	0.012 (0.002)
2010	Chelan Falls	3,141	0.641 (0.055)	22.6 (12.2)	0.022 (0.003)
2011*	Chelan Falls	4,075	0.552 (0.054)	27.2 (11.5)	NA
2012	Chelan Falls (Small Fish)	4,983	0.590 (0.049)	25.0 (11.2)	NA
	Chelan Falls (Big Fish)	4,960	0.578 (0.043)	24.4 (10.1)	NA
2013	Chelan Falls (Small Fish)	4,958	0.423 (0.068)	33.0 (13.6)	NA
	Chelan Falls (Big Fish)	4,963	0.760 (0.175)	28.6 (12.4)	NA

* Brood year 2011 experienced high mortality due to fungus, bacterial cold-water disease, bacterial gill disease, and erythrocytic inclusion body syndrome during April 2013.

Smolt-to-Adult Survivals

Subyearling-to-adult and smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adult recaptures divided by the number of tagged hatchery subyearling or yearling Chinook released. For these analyses, SARs were based on CWT returns.

Normal subyearling releases

For the available brood years, SARs for normal subyearling-released Chinook have ranged from 0.000034 to 0.001886 (Table 11.28). This hatchery program was discontinued after brood year 2009.

Table 11.28. Subyearling-to-adult ratios (SARs) for Turtle Rock normal subyearling-released summer Chinook, brood years 1995-2009.

Brood year	Number released[a]	Estimated adult captures[b]	SAR
1995	201,230	204	0.001014
1996	371,848	188	0.000506
1997	496,904	17	0.000034
1998	194,723	28	0.000144
1999	197,793	203	0.001026
2000	222,460	28	0.000126
2001	211,306	330	0.001562
2002	200,163	38	0.000190
2003	203,410	49	0.000241
2004	198,019	91	0.000460
2005	197,135	143	0.000725
2006	188,250	355	0.001886
2007	194,437	216	0.001111
2008	152,993	77	0.000503
2009	341,928	133	0.000389
Average	***238,173***	***140***	***0.000661***
Median	***200,163***	***133***	***0.000503***

[a] Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).

[b] Includes estimated recoveries (spawning ground, hatcheries, harvest, etc.) and observed recoveries if estimated recoveries were unavailable.

Accelerated subyearling releases

For the available brood years, SARs for accelerated subyearling-released Chinook have ranged from 0.000011 to 0.004609 (Table 11.29). This hatchery program was discontinued after brood year 2008.

Table 11.29. Subyearling-to-adult ratios (SARs) for Turtle Rock accelerated subyearling-released summer Chinook, brood years 1995-2008.

Brood year	Number released[a]	Estimated adult captures[b]	SAR
1995	166,203	13	0.000078
1996	198,720	79	0.000398
1997	196,459	3	0.000015
1998	185,551	69	0.000372
1999	192,665	888	0.004609
2000	194,603	63	0.000324
2001	196,355	169	0.000861

Brood year	Number released[a]	Estimated adult captures[b]	SAR
2002	200,165	5	0.000025
2003	185,834	2	0.000011
2004	203,255	156	0.000768
2005	192,045	82	0.000427
2006	186,324	217	0.001165
2007	188,328	308	0.001635
2008	197,136	35	0.000178
Average	***191,689***	***149***	***0.000776***
Median	***193,634***	***74***	***0.000385***

[a] Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).

[b] Includes estimated recoveries (spawning ground, hatcheries, harvest, etc.) and observed recoveries if estimated recoveries were unavailable.

Yearling releases

For the available brood years, SARs for yearling-released Chinook have ranged from 0.00721 to 0.02820 (Table 11.30).

Table 11.30. Smolt-to-adult ratios (SARs) for Turtle Rock/Chelan Falls yearling-released summer Chinook, brood years 1995-2009.

Brood year	Number released[a]	Estimated adult captures[b]	SAR
1995	145,318	1,048	0.00721
1996	194,251	1,553	0.00800
1997	198,924	4,775	0.02400
1998	215,646	5,772	0.02677
1999	280,683	2,670	0.00951
2000	278,308	2,029	0.00729
2001	199,694	3,922	0.01964
2002	192,234	2,556	0.01330
2003	199,386	2,083	0.01045
2004	202,682	2,605	0.01285
2005	202,329	1,631	0.00806
2006	142,699	4,024	0.02820
2007	161,071	1,872	0.01162
2008	447,155	9,473	0.02119
2009	423,565	4,312	0.01018
Average	***232,263***	***3,355***	***0.01455***
Median	***199,694***	***2,605***	***0.01162***

[a] Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).

[b] Includes estimated recoveries (spawning ground, hatcheries, harvest, etc.) and observed recoveries if estimated recoveries were unavailable.

11.6 ESA/HCP Compliance

Broodstock Collection

The 2013 brood Chelan Falls (formerly Turtle Rock) summer Chinook program was supported through adult collections at the Eastbank outfall with the option of using the volunteer trap at Wells Fish Hatchery as backup. During 2013, broodstock collections at the Eastbank outfall were consistent with the 2013 Upper Columbia River Salmon and Steelhead Broodstock Objectives and site-based broodstock collection protocols as required in ESA permit 1347. The 2013 collection target totaled 318 summer Chinook.

Hatchery Rearing and Release

The brood year 2013 release totaled 599,584 yearling fish. These releases represented 104.1% of the 576,000 Rocky Reach HCP and ESA Section 10 Permit 1347 production for the Chelan Falls yearling summer Chinook production.

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, 1395, 18118, 18119, and 18121, 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 PUD Hatchery facilities during the period 1 January through 31 December 2015. NPDES monitoring and reporting for Chelan PUD Hatchery Programs during 2015 are provided in Appendix F.

SECTION 12: REFERENCES

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SECTION 13: APPENDICES

Appendix A: **Abundance and Total Numbers of Chinook Salmon and Trout in the Chiwawa River Basin, Washington, 2015.**

Appendix B: **Fish Trapping at the Chiwawa and Wenatchee Smolt Traps during 2015.**

Appendix C: **Summary of CSS PIT-Tagging Activities in the Wenatchee River Basin, 2015.**

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Appendix N: **Summer Chinook Spawning Ground Surveys in the Methow and Chelan Rivers, 2015.**