MONITORING AND EVALUATION OF THE CHELAN COUNTY PUD HATCHERY PROGRAMS

2006 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), and BioAnalysts. An extensive amount of work was conducted in 2005 and 2006 to collect the data needed to monitor the effects of the Chelan County PUD Hatchery Programs. This work was directed and coordinated by the Habitat Conservation Plan (HCP) Hatchery Committee, consisting of the following members: Brian Cates, U.S. Fish and Wildlife Service (USFWS); Jerry Marco, Confederated Tribes of the Colville Reservation (Colville Tribes); Kristine Petersen, National Marine Fisheries Service (NMFS); Shaun Seaman, Chelan County PUD; Tom Scribner, the Yakama Nation; and Kirk Truscott, WDFW.

The approach to monitoring the hatchery programs was guided by the "*Conceptual Approach to Monitoring and Evaluating the Chelan County Public Utility District Programs*" written by Andrew Murdoch and Chuck Peven. Technical aspects of the monitoring and evaluation program were developed by the Hatchery Evaluation Technical Team (HETT), which consists of the following scientists: Steve Hays, Chelan PUD; Tracy Hillman, BioAnalysts; Tom Kahler, Douglas PUD; Rick Klinge, Douglas PUD; Russell Langshaw, Grant PUD; Ben Lenz, Grant PUD; Andrew Murdoch, WDFW; Keely Murdoch, Yakama Nation; Kristine Petersen, NMFS; and Chuck Peven, Chelan PUD. The HETT developed an "*Analytical Framework for Monitoring and Evaluating PUD Hatchery Programs*" (Hays et al. 2006), which directs the analyses of hypotheses developed under the conceptual approach. Most of the analyses outlined in the Analytical Framework paper will be conducted after the fifth year of monitoring.

Most of the work reported in this paper was funded by Chelan PUD. Bonneville Power Administration purchased the Passive Integrated Transponder (PIT) tags that were used to mark juvenile Chinook and steelhead. This is the first annual report written under the direction of the HCP.

SECTION 1: INTRODUCTION

Chelan PUD implements hatchery programs as part of two Habitat Conservation Plan (HCP) agreements related to the operation of Rocky Reach and Rock Island dams. The HCPs define the goal of achieving no net impact to spring Chinook, summer/fall Chinook, sockeye salmon, steelhead, and coho salmon affected by the operation of these dams. The two HCPs identify general program objectives as "*contributing to the rebuilding and recovery of naturally reproducing populations in their native habitats, while maintaining genetic and ecologic integrity, and supporting harvest*." The fish resource management agencies initially developed the following general goal statements for each hatchery program, which were adopted by the Hatchery Committee:

(1) Support the recovery of ESA listed species by increasing the abundance of 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 Turtle Rock summer/fall Chinook program.

Thus, there are two different types of artificial propagation strategies that address the different goals of the program: supplementation and harvest augmentation. The supplementation programs primarily focus on increasing the natural production of fish in tributaries. A fundamental assumption of this strategy is that hatchery fish returning to the spawning grounds are "reproductively similar" to naturally produced fish. The second program type, harvest augmentation, focuses on increasing harvest opportunities. This is accomplished by releasing hatchery fish directly into the Columbia River with the intent that returning adults remain segregated from the naturally spawning populations in tributaries.

Monitoring is needed to determine if the programs are performing properly. The HCP Hatchery Committee adopted a monitoring and evaluation (M&E) approach that will guide the assessment of the hatchery programs. The approach, developed by Murdoch and Peven (2005), identified the following objectives:

(1) Determine if supplementation programs have increased the number of naturally spawning and naturally produced adults of the target population relative to a non-supplemented population (i.e., reference stream) and the changes in the natural replacement rate (NRR) of the supplemented population is similar to that of the non-supplemented population.

(2) Determine if the run timing, spawn timing, and spawning distribution of both the natural and hatchery components of the target population are similar.

(3) Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program. Additionally, determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.

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

(5) Determine if the stray rate of hatchery fish is below the acceptable levels to maintain genetic variation between stocks.

(6) Determine if hatchery fish were released at the programmed size and number.

(7) Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity (i.e., number of juveniles per redd) of supplemented streams when compared to non-supplemented streams.

(8) Determine if harvest opportunities have been provided using hatchery returning adults where appropriate (e.g., Turtle Rock program).

Two additional objectives that were not explicit in the goals specified above but were included in the M&E approach because they relate to goals and concerns of all artificial production programs include:

(9) Determine whether bacterial kidney disease (BKD) management actions lower the prevalence of disease in hatchery fish and subsequently in the naturally spawning population. In addition, when feasible, assess the transfer of *Renibacterium salmoninarum* (Rs) infection at various life stages from hatchery fish to naturally produced fish.

(10) Determine if the release of hatchery fish impact non-target taxa of concern (NTTOC) within acceptable limits.

Attending each objective is one or more testable hypotheses (see Murdoch and Peven 2005). Each hypothesis will be tested statistically following the routines identified in Hays et al. (2006). Most of these analytical routines will be conducted at the end of five-year monitoring blocks, as outlined in the M&E plan (Murdoch and Peven 2005; Hays et al. 2006).

Throughout each five-year monitoring period, annual reports will be generated that describe the M&E data collected during a specific year. This is the first annual report developed under the direction of the M&E guidance approach (Murdoch and Peven 2005). The purpose of this report is to describe monitoring activities conducted in 2006. 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, because the process of selecting reference areas is still occurring. To the extent currently possible, we have included information collected before 2006.

This report is divided into several sections, each representing a different species (i.e., steelhead, sockeye salmon, spring Chinook, and summer Chinook). For all species we provide broodstock information; hatchery rearing history, release data, and survival estimates; 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.

Finally, we end each section by addressing compliance issues with ESA/HCP mandates. For each Chelan PUD Hatchery Program, WDFW and the PUD 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 threatened 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. 1196, which authorizes the annual take of adult and juvenile endangered UCR spring Chinook and threatened UCR steelhead associated with implementing artificial propagation programs 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. 1347, which authorizes the annual incidental take of adult and juvenile endangered UCR spring Chinook and threatened 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 2006 followed the methods and protocols described in Murdoch and Peven (2005) and Peven (2006). In this section we only briefly review the methods and protocols. More detailed information can be found in Murdoch and Peven (2005) and Peven (2006).

2.1 Broodstock Sampling

Methods for collecting broodstock during 2006 are described in Appendix A in WDFW (2006). Methods for sampling broodstock are described in Appendices A and B in Murdoch and Peven (2006). Generally, 2006 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 2006 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, sockeye, and Chinook in 2006.

Collection week beginning day	Chiwawa Spring Chinook[a]		Wild Wenatchee Summer Chinook	Wild ME/OK Summer Chinook	Wenatchee Steelhead		Wild Wenatchee Sockeye[b]	
	Hatchery	Wild			Hatchery	Wild	Male	Female
12 Jun								
19 Jun	20							
26 Jun	23	68						
3 Jul	17	68	126	87	1	1		
10 Jul	12	57	98	83	1	1		
17 Jul	9	40	82	83	1	1	20	20
24 Jul	4	28	63	73	1	1	41	41
31 Jul	3	11	44	59	1	1	25	25
7 Aug	1	6	29	44	4	4	20	20
14 Aug	1	6	21	40	7	7	16	16
21 Aug		6	16	26	8	8	8	8
28 Aug			13	24	7	7		
4 Sep				23	6	6		
11 Sep				14	6	6		
18 Sep					8	8		
25 Sep					9	9		
2 Oct					17	17		
9 Oct					15	15		
16 Oct					8	8		
23 Oct					4	4		
Total	**90**	**289**	**492**	**556**	**104**	**104**	**130**	**130**

[a] Collection quota based on 6 May 2006 run-escapement abundance and migration timing estimate.
[b] Collection targeted equal numbers of males and females.

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

Assumptions	Wenatchee Steelhead	Wenatchee Sockeye	Chiwawa Spring Chinook	Wenatchee Summer Chinook	ME/OK Summer Chinook
Production level	400,000 yearling smolts	200,000 subyearlings	672,000 yearling smolts	864,000 yearling smolts	976,000 yearling smolts
Broodstock required	208 adults (not to exceed 33% of population)	260 adults (not to exceed 33% of population)	379 adults (not to exceed 33% of population)	492 adults (not to exceed 33% of the population)	556 adults (not to exceed 33% of the population)
Trapping period	7 July – 12 Nov	7 July – 28 Aug	1 May – 12 Sep	7 Jul – 12 Sep	7 Jul – 15 Sep
# days/week	5	3	4	5	3
# hours/day	24	16	24	24	16
Broodstock composition	50% wild; 50% WxW and/or HxW	100% wild	Sliding scale; minimum 33% wild (depends on the number of wild fish)	100% wild	100% wild
Trapping site	Dryden Dam (Tumwater will be used if weekly quota not achieved at Dryden Dam)	Tumwater Dam	Tumwater Dam (hatchery fish only) and the Chiwawa Weir (both hatchery and wild fish)	Dryden Dam (Tumwater will be used if weekly quota not achieved at Dryden Dam)	Wells Dam east ladder

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 Appendix B in Murdoch and Peven (2006). In addition, a random sample of most species trapped but not taken for broodstock were sampled for origin, sex, age, and size. All steelhead trapped were sampled.

2.2 Within Hatchery Monitoring

Methods for monitoring hatchery activities are described in Appendix C in Murdoch and Peven (2005). Biological information collected from all spawned adult fish included age at maturity, length at maturity, spawn timing, and fecundity of females. In addition, all fish were checked for tags and females were sampled for disease.

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 are 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.

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
Unfertilized egg-to-release	81

Nearly all hatchery fish from each stock were marked (adipose fin clip) or tagged (coded-wire tag or elastomer tag). Different combinations of marks and tags were used depending on the stock. In addition, about 10,000 juvenile hatchery fish from each stock of steelhead (HxH, HxW, and WxW) and spring Chinook were PIT tagged during late August and early September to aid in estimating survival rates (e.g., smolt-to-adult) outside the hatchery. About 15,000 juvenile sockeye were PIT tagged.

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 Chelan PUD hatchery programs; CV = coefficient of variation.

Hatchery stock	Release targets	Size targets		
		Fork length (CV)	Weight (g)	Fish/pound
Wenatchee Summer Chinook	864,000	176 (9.0)	45.4	10
Okanogan Summer Chinook	576,000	176 (9.0)	45.4	10
Methow Summer Chinook	400,000	176 (9.0)	45.4	10
Turtle Rock Summer Chinook (yearlings)	200,000	176 (9.0)	45.4	10
Turtle Rock Summer Chinook (subyearlings)	1,620,000	112 (9.0)	11.4	40
Chiwawa Spring Chinook	672,000	176 (9.0)	37.8	12
Wenatchee Sockeye	200,000	133 (9.0)	22.7	20
Wenatchee Steelhead	400,000	198 (9.0)	75.6	6

2.3 Juvenile Sampling

Juvenile sampling within streams included operation of rotary smolt traps, snorkel observations, and PIT tagging. Methods for sampling juvenile fish are described in Appendix E in Murdoch and Peven (2005).

Smolt traps were located on the Wenatchee River at river km 9.6 at the West Monitor Bridge (Lower Wenatchee Trap) and about 0.5 km downstream from the mouth of Lake Wenatchee (Upper Wenatchee Trap), and in the Chiwawa River about 1 km upstream from the mouth (Chiwawa Trap). All traps operated throughout the smolt migration period. The Chiwawa Trap operated throughout most of the year (February through November) and not during icing or extreme high flow conditions. 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 steelhead and sockeye salmon smolts. Trap efficiencies at each trap site were estimated by using mark-recapture trials conducted over a wide range of discharges. Linear 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 total 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 196 randomly selected sites were surveyed during August (Table 2.5). Counts of fish within each sampling site were adjusted based on water temperatures. 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 fully explained in Hillman and Miller (2004).

Working in collaboration with the Integrated Status and Effectiveness Monitoring Program (ISEMP) funded by NOAA Fisheries and Bonneville Power Administration (BPA), crews PIT tagged juvenile wild Chinook, wild coho, wild and hatchery steelhead, and bull trout throughout the Wenatchee basin. Tags were injected into juvenile fish collected at the Chiwawa Trap, Upper Wenatchee Trap, and the Lower Wenatchee Trap. In addition, fish were collected and tagged in the Chiwawa River upstream from the trap, in Nason Creek, and in the upper Wenatchee River between Tumwater and Lake Wenatchee. 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 work was to better understand the life-history characteristics of fish in the Wenatchee Basin, which in turn improves the ability to detect potential impacts of the hatchery program on wild fish.

Table 2.5. Location of strata and numbers of randomly sampled sites within each strata that were sampled in the Chiwawa River basin in 2006.

Reach/stratum	River kilometers (RKm)	Number of randomly selected sites
Chiwawa River		
1	0.0-6.1	12
2	6.1-8.9	6
3	8.9-12.7	8
4	12.7-14.3	6
5	14.3-17.4	4
6	17.4-19.0	7
7	19.0-32.2	39
8	32.2-40.9	22
9	40.9-46.4	11
10	46.4-50.1	8
Phelps Creek		
1	0.0-0.6	3
Chikamin Creek (includes Minnow Creek)		
1	0.0-1.5	29
Rock Creek		
1	0.0-1.2	12
Peven Creek (unnamed stream on USGS map)		
1	0.0-0.1	6
Big Meadow Creek		
1	0.0-1.6	21
Alder Creek		
1	0.0-0.1	2
Brush Creek		
1	0.0-0.1	4
Y Creek		
1	0.0-0.1	2

Table 2.6. Number of wild spring Chinook and steelhead proposed for tagging at different locations within the Wenatchee Basin, 2006.

Sampling location	Target sample size	
	Wild spring Chinook	Wild steelhead
Chiwawa Trap	2,500-8,000	500-2,000
Chiwawa River	500-2,000	500-2,000
Upper Wenatchee Trap	500-1,000	50-250
Upper Wenatchee	500-2,000	500-2,000
Nason Creek	500-2,000	500-2,000
Lower Wenatchee Trap	1,000-2,000	500-2,500

Survival rates for various juvenile life-stages were calculated based on estimates of seeding levels (total egg deposition), numbers of parr, numbers of emigrants, and numbers of smolts. 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 Basin. Survival estimates could not be calculated for some stocks (e.g., summer Chinook) because life-stage abundance estimates were lacking.

2.4 Spawning/Carcass Surveys

Methods for conducting carcass and spawning ground surveys are detailed in Appendix F in Murdoch and Peven (2005). Information collected during spawning surveys included spawn timing, redd distribution, and redd abundance. Data collected during carcass surveys included sex, size (fork length and postorbital-to-hypural length), scales for aging[1], degree of egg voidance, DNA samples, and identification of marks or tags. The sampling goal for carcasses was 20% of the spawning population. Crews also conducted snorkel surveys to assess the incidence of precocial fish spawning naturally in streams.

Both redd and carcass surveys were conducted in reaches that captured the spawning distribution of most populations. Steelhead surveys were the exception. These surveys were conducted within major spawning areas in the basin and therefore may not capture the entire spawning distribution of the population. Steelhead surveys were conducted during March through June in reaches and index areas described in Table 2.7. Total redd counts were estimated by expanding counts within non-index areas by expansion factors developed within index areas.

[1] 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 emigrating 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 emigrated 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.

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

Stream	Code	Reach	Index/reference area
Wenatchee River	W2	Sleepy Hollow Br to L. Cashmere Br	Monitor Boat Rmp to Cashmere Boat Rmp
	W6	Leavenworth Br to Icicle Rd Br	Leavenworth Boat Ramp to Icicle Ck
	W8	Tumwater Dam to Tumwater Br	Swift Boat Ramp to Tumwater Br
	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 Camas Cr	Kings Br to Camas Cr
	P2A	Camas Cr to Mouth of Scotty Cr	Ingalls Cr to Ruby Cr
	P2	Camas Cr to Mouth of Scotty Cr	FR7620 to Shaser Cr
Ingalls Creek	D1	Mouth to Trailhead RM 1	Mouth to Trailhead RM 1
	D2	Trailhead to Wilderness Bd RM 1.5	Trailhead to Wilderness Bd RM 1.5
Chiwawa River	C1	Mouth to Grouse Cr	Mouth to Rd 62 Br RM 6.4
	C2	Grouse Cr to Rock Cr	Chikamin Cr to Log Jam
Clear Creek	V1	Mouth to Hwy 22	Mouth to Hwy 22
	V2	Hwy 22 to Lower Culvert RM 2	Hwy 22 to Lower Culvert
Nason Creek	N1	Mouth to Kahler Cr Br	Mouth to Swamp Cr
	N3	Hwy 2 Br to Lower RR Br	Hwy 2 Br to Merrit Br
	N4	Lower RR Br to Whitepine Cr	Rayrock to Church Camp
Icicle River	I1	Mouth to Hatchery	Mouth to Boulder Block
Little Wenatchee	L2	Mouth to Lost Cr	Old Fish Weir to Lost Cr
	L3	Lost Cr to Rainy Cr Br	Lost Cr to Rainy Cr Br
White River	H2	Sears Cr Br to Napeequa R	Riprap Bank to Napeequa R
	H3	Napeequa R to Mouth of Panther Cr	Napeequa R to Grasshopper Meadows
Napeequa River	Q1	Mouth to RM 1	Mouth to RM1

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 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 Trinity	27.0-30.3
Rock Creek	R1	Mouth to End	0.0-0.5
Chikamin Creek	K1	Mouth to End	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
Napeequa River	Q1	Mouth to End	0.0-1.0
Panther Creek	T1	Mouth to End	0.0-0.7
Wenatchee River	W9	Tumwater Bridge to Chiwawa River	35.6-48.4
	W10	Chiwawa River to Lake Wenatchee	48.4-54.2
Icicle Creek	I1	Mouth to Boulder Block	0.0-4.0
Peshastin Creek	P1	Mouth to Camas Creek	0.0-
	P2	Camas Creek to Mouth of Scotty Creek	
Ingalls Creek	D1	Mouth to Trailhead	0.0-1.0

Surveys for live sockeye, redds, and carcass were conducted during August through October in the White, Napeequa, and Little Wenatchee rivers. Survey reaches for sockeye are described in Table 2.9. During redd surveys, both numbers of redds and numbers of live fish were recorded. The latter were used to estimate spawning escapements using area-under-the-curve (AUC) methods.

Table 2.9. Description of reaches surveyed for sockeye salmon redds, carcasses, and live fish in the Wenatchee Basin.

Stream	Code	Reach	River mile (RM)
Little Wenatchee River	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 surveys were conducted during September through November within ten reaches on the Wenatchee River (Table 2.10). Both peak redd counts and total redd counts were estimated in the Wenatchee River. Total redd counts were only conducted within index areas, not throughout the entire river. Total redd counts for the entire river were estimated by expanding the peak counts within non-index areas by expansion factors developed within index areas.

Table 2.10. Description of reaches and index areas surveyed for spring Chinook redds in the Wenatchee Basin.

Code	Reach	River mile	Index/reference area
W1	Mouth to Sleepy Hollow Br	0.0-3.5	Monitor Br to L. Cashmere Br
W2	Sleepy Hollow Br to L. Cashmere Br	3.5-9.5	
W3	L. Cashmere Br to Dryden Dam	9.5-17.5	
W4	Dryden Dam to Peshastin Br	17.5-20.0	Dryden Dam to Peshastin Br
W5	Peshastin Br to Leavenworth Br	20.0-23.9	
W6	Leavenworth Br to Icicle Rd Br	23.9-26.4	Icicle to Takeout
W7	Icicle Rd Br to Tumwater Dam	26.4-30.9	Swiftwater Campground to Tumwater Br
W8	Tumwater Dam to Tumwater Br	30.9-35.6	
W9	Tumwater Br to Chiwawa River	35.6-48.4	Swing Pool to Railroad Tunnel
W10	Chiwawa River to Lake Wenatchee	48.4-54.2	Swamp to Bridge

Summer Chinook surveys were also conducted in the Methow, Okanogan, and Similkameen rivers during September through November. Total redd counts were conducted in these rivers. Table 2.11 describes the survey reaches in these rivers.

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	0.0-19.6
	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

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. Two different methods were used to estimate total spawning escapement for sockeye salmon. The first method applied a fish per redd ratio to the estimated number of redds counted in the upper Wenatchee basin. The second used the AUC approach (where escapement = (AUC/redd residence time) x observer efficiency) to estimate sockeye escapement. This method relied on weekly counts of live sockeye and assumed a redd residence time of 11 days (from Hyatt et al. 2006) and an observer efficiency of 100%.

During spring and summer Chinook and sockeye carcass surveys, crews collected tissue samples for genetic analysis. Tissue was collected from the operculum of 144 wild and 144 hatchery carcasses from each population. Sampling within a population was proportional to the distribution of carcasses across survey reaches. That is, samples were collected in all reaches but the number collected within a given reach was proportional to the density of carcasses within that reach. Methods for analyzing these samples are described in Appendix H in Murdoch and Peven (2005). Results from this work are not available at this time and therefore will not be described in this report.

Derived metrics calculated from carcass surveys, broodstock sampling, 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), exploitation rates, harvest rates, and natural replacement rates (NRR). The expected SARs and HRRs for different stocks raised in the Chelan PUD hatchery programs are provided in Table 2.12. Methods for calculating these variables are described in Appendices D, F, and G in Murdoch and Peven (2005).

Table 2.12. Expected smolt-to-adult (SAR) and hatchery replacement rates (HRR) for stocks raised in the Chelan PUD Hatchery Programs (from Table 6 in Appendix D in Murdoch and Peven 2005).

Program	Number of broodstock	Smolts released	SAR	Adult equivalents	Number of smolts/adult	HRR
Chiwawa Spring Chinook	379	672,000	0.003	2,016	333	5.3
Wenatchee Summer Chinook	492	864,000	0.003	2,592	333	5.3
Similkameen Summer Chinook	328	576,000	0.003	1,728	333	5.3
Methow Summer Chinook	228	400,000	0.003	1,200	333	5.3
Wenatchee Sockeye	260	200,000	0.007	1,400	143	5.4
Wenatchee Steelhead	208	400,000	0.010	4,000	100	19.2

Derived data that rely on CWTs (e.g., HRR, SAR, stray rates, etc.) are two to four years behind release information because of the lag time for returning adult fish to enter the fishery and the processing of tags. Consequently, complete information on rates and ratios based on CWTs is generally only available for years prior to 1999-2000. In addition, methods for calculating derived variables are still being developed by the Hatchery Evaluation Technical Team (HETT). Therefore, estimates of derived data in this report are subject to change after the HETT and Hatchery Committee decide on standard methods for calculating derived data.

SECTION 3: WENATCHEE STEELHEAD

3.1 Broodstock Sampling

This section focuses on results from sampling 2005 and 2006 returns of Wenatchee steelhead, which were collected at Dryden and Tumwater dams. The 2005 return begins the tracking of the life cycle of steelhead that were released in 2006. The 2006 return is included because juveniles from this brood are still maintained within the hatchery.

Origin of Broodstock

A total of 209 Wenatchee steelhead from the 2005 return were collected at Dryden and Tumwater dams (Table 3.1). About 45% of these were natural origin (adipose fin present, no CWT, and no elastomer tags) fish and the remaining 55% were hatchery origin (pink right, orange right, or green left elastomer tagged) adults. Origin was determined by analyzing scales and/or otoliths. The total number of steelhead spawned from the 2005 return was 191 adults (46% natural origin and 54% hatchery origin).

A total of 194 steelhead were collected from the 2006 return at Dryden and Tumwater dams; 96 natural origin (adipose fin present, no CWT and no elastomer tags) and 98 hatchery origin (pink right, orange right, or green left elastomer tagged) adults. A total of 162 steelhead were spawned; 57% were natural origin fish and 43% were hatchery fish (Table 3.1). Origins were 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, 1998-2006. Unknown origin fish (i.e., undetermined by scale analysis, no elastomer, CWT, or fin clips, and no additional hatchery marks) were considered naturally produced. Pre-spawning loss does not include all mortality.

Return year	Wild steelhead			Hatchery steelhead			Total number spawned
	Number collected	Prespawn loss	Number spawned	Number collected	Prespawn loss	Number spawned	
1998	35	0	35	43	4	37	72
1999	58	5	52	67	1	64	116
2000	39	2	36	101	9	60	96
2001	64	5	51	114	5	103	154
2002	99	0	96	113	1	64	160
2003	61	10	49	92	2	90	139
2004	85	3	75	132	1	61	136
2005	95	8	87	114	7	104	191
2006	96	0	93	98	0	69	162
Average	***70***	***4***	***64***	***97***	***3***	***72***	***136***

Age/Length Data

Broodstock ages were determined from examination of scales and/or otoliths. For both the 2005 and 2006 returns, natural origin steelhead consisted primarily of 2-salt adults (Table 3.2). For hatchery origin adults, however, the 2005 return consisted mostly of 2-salt fish, while the 2006 return consisted mostly of 1-salt fish (Table 3.2).

Table 3.2. Percent of hatchery and wild steelhead of different ages (saltwater ages) collected from broodstock, 1998-2006.

Return year	Origin	Saltwater age		
		1	2	3
1998	Wild	42.9	57.1	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	11.7	86.6	1.7
	Hatchery	29.7	70.3	0.0
2004	Wild	94.9	5.1	0.0
	Hatchery	95.2	4.8	0.0
2005	Wild	22.1	77.9	0.0
	Hatchery	20.5	79.5	0.0
2006	Wild	28.6	71.4	0.0
	Hatchery	60.3	39.7	0.0
Average	***Wild***	***46.0***	***53.6***	***0.4***
	Hatchery	***54.0***	***46.0***	***0.0***

There was little difference between mean lengths of hatchery and natural origin steelhead for both the 2005 and 2006 return 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, 1998-2006; N = sample size and SD = 1 standard deviation.

Return 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	30	6	78	28	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	7	6	77	52	5	91	1	-
	Hatchery	66	27	4	75	64	4	-	0	-
2004	Wild	63	74	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	26	5	75	65	6	-	0	-
	Hatchery	61	41	4	72	27	5	-	0	-

Sex Ratios

Male steelhead in the 2005 return made up about 39% of the adults collected, resulting in an overall male to female ratio of 0.41:1.00 (Table 3.4). In 2006, males made up about 43% of the adults collected, resulting in an overall male to female ratio of 0.75:1.00. These ratios are less than the 1:1 ratio assumed in the broodstock protocol. For both return years, males made up a smaller proportion of the natural origin fish than did males of hatchery origin (Table 3.4).

Table 3.4. Numbers of male and female wild and hatchery steelhead collected for broodstock, 1998-2006. Ratios of males to females are also provided.

Return 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	0.41:1.00
2006	38	63	0.60:1.00	47	51	0.92:1.00	0.75:1.00
Total	***259***	***380***	***1.47:1.00***	***458***	***416***	***1.10:1.00***	***0.90:1.00***

Fecundity

Fecundities for Wenatchee steelhead returning in 2005 and 2006 averaged 5,832 and 5,366 eggs per female, respectively, which were not greatly different than the 9-year average (Table 3.5). Mean fecundity for the 2006 return was slightly less than the 5,400 eggs per female assumed in the broodstock protocol.

Table 3.5. Mean fecundity of wild, hatchery, and all female steelhead collected for broodstock, 1998-2006.

Return 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
2001	5,765	6,293	6,174
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	5,454	5,251	5,366
Average	***5,774***	***5,707***	***5,776***

3.2 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 are required to meet the program release goal of 400,000 smolts. Between 1998 and 2006, the egg take goal was reached in most years (Table 3.6).

Table 3.6. Numbers of eggs taken from steelhead broodstock, 1998-2006.

Return 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
Average	***446,784***

Disease

Rearing of the 2005 brood Wenatchee summer steelhead was typical to previous years with fish being held on Chelan spring, Eastbank well, and Columbia River water before being released directly into Nason Creek and the Chiwawa and Wenatchee rivers. Mortality due to bacterial cold water disease (BCWD) began to increase in the HxH and HxW juveniles at Eastbank in late April, shortly after ponding. Despite numerous attempts to control the BCWD with TM-100 and/or Florfenicol, chronic mortality due to the disease continued through release; however, it appeared to primarily affect smaller-sized fish.

Number of acclimation days

Juvenile steelhead were transferred from Eastbank FH and Chelan FH to Turtle Rock FH in January 2006. At Turtle FH juvenile steelhead were reared on Columbia River (range, 133-141 d) before being trucked and released into the Wenatchee River and tributaries.

Acclimation of Wenatchee juvenile steelhead has occurred on occasion in the Chiwawa Ponds when space is available. At Chiwawa Ponds, steelhead were reared under the same water source as spring Chinook (Chiwawa and Wenatchee River water). Typically, Wenatchee steelhead are reared on Columbia River water from January through April before being trucked and released into the Wenatchee Basin (Table 3.7).

Table 3.7. Water source and mean acclimation period for Wenatchee steelhead, brood years 1998-2005.

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
		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

Release Information

Numbers released

The release of 2005 brood Wenatchee steelhead achieved 113% of the 400,000 target goal with about 452,184 fish released directly into the Wenatchee and Chiwawa rivers and Nason Creek

(Table 3.8). Distribution of juvenile steelhead released in each of the three basins was determined by the mean proportion of steelhead redds in each basin. About 27.5% and 14.2% 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 (23.1%) and the Wenatchee River upstream from the dam (35.2%).

Table 3.8. Numbers of steelhead smolts released from the hatchery, brood years 1998-2005. The release target for steelhead is 400,000 smolts.

Brood year	Release year	Number of smolts
1998	1999	172,078
1999	2000	175,661
2000	2001	184,639
2001	2002	335,933
2002	2003	302,060
2003	2004	374,867
2004	2005	294,114
2005	2006	452,184
Average		***286,442***

Numbers elastomer tagged

Wenatchee hatchery steelhead of the 2005 brood were marked with elastomer tags in the clear tissue posterior of the eye to denote parental origin. About 50% of the juveniles released were also adipose fin clipped (Table 9).

Table 3.9. Release location and marking scheme for the 2005 brood Wenatchee steelhead that were released in 2006.

Release location	Parental origin	Ad-clip (%)	VIE color/side	Tag rate	Number released
Wenatchee River	H x H	100.0	Red Left	0.983	104,552
Wenatchee River	H x W	61.6	Green Left	0.979	190,319
Chiwawa River	H x W	61.6	Green Left	0.979	18,634
Chiwawa River	W x W	0.0	Pink Right	0.969	14,124
Nason Creek	W x W	0.0	Pink Right	0.969	124,555

Numbers PIT tagged

2006 Brood Wenatchee Summer Steelhead (WxW)—A total of 10,019 WxW steelhead were PIT tagged at the Chelan Falls Hatchery on 21-23 August 2006 (Table 3.10). The mean size of steelhead tagged was 72 mm; no fish smaller than 60 mm were tagged. Fish were not fed for 24 hours before or after tagging. Four days following tagging, the fish were transferred to raceways outside the hatchery complex. These fish were transported to the Turtle Rock Hatchery on 4 December. None of these fish were adipose fin clipped.

A total of 9,515 PIT-tagged WxW steelhead were released during spring 2007 (Table 3.10). Of the 10,019 WxW steelhead tagged, 152 died. Most of these (47%) were fish tagged on the third day (23 August). Another 352 shed their tags. Most of these (61%) were also fish tagged on the third day. Most shedding occurred within three weeks after tagging.

The relatively large loss of steelhead and PIT tags from the third tagging group may be related to the short period of time between tagging and being transferred to another raceway. These fish were also off food for a shorter period of time than the other two tagging groups. It is recommended that the time period between tagging and moving be increased for future tagging events.

Table 3.10. Summary of PIT-tagging activities for WxW steelhead from the Chelan Falls Hatchery, 2006. Dead fish counted before 15 September likely represent deaths associated with tagging; deaths after 15 September were probably not related to tagging.

Tagging date	Number of fish tagged	Number of fish that died		Number of tags shed	Number of tagged fish alive
		Before 9/15	After 9/15		
8/21	3,301	24	16	74	3,187
8/22	3,418	24	17	64	3,313
8/23	3,300	57	14	214	3,015
Total	***10,019***	***105***	***47***	***352***	***9,515***

2006 Brood Wenatchee Summer Steelhead (early-spawn HxW)[2]—A total of 10,035 early-spawn HxW steelhead were PIT tagged at the Eastbank Hatchery (raceway 4) on 5-7 September 2006 (Table 3.11). The mean size of steelhead tagged was 85 mm; no fish smaller than 60 mm were tagged. Fish were not fed for 24 hours before or after tagging. These fish were transported to the Turtle Rock Hatchery in early January 2007. All of these fish were adipose fin clipped.

A total of 9,533 PIT-tagged HxW steelhead were released during spring 2007 (Table 3.11). Of the 10,035 steelhead tagged, 479 died and another 24 shed their tags. The relatively high mortality rate may have been associated with a viral infection (i.e., IHN).

Table 3.11. Summary of PIT-tagging activities for early-spawn HxW steelhead from the Eastbank Hatchery, 2006. Dead fish counted before 15 September likely represent deaths associated with tagging; deaths after 15 September were probably not related to tagging.

Tagging date	Number of fish tagged	Number of fish that died		Number of tags shed	Number of tagged fish alive
		Before 9/15	After 9/15		
9/5	3,331	2	151	6	3,172
9/6	3,504	5	173	9	3,317
9/7	3,200	2	146	9	3,044
Total	***10,035***	***9***	***470***	***24***	***9,533***

[2] This is a mixed group consisting of about 55,000 early-spawn HxW and about 15,000 HxH steelhead. Because most (78%) of the fish are HxW juveniles, the group is referred to as "early-spawn HxW."

2006 Brood Wenatchee Summer Steelhead (HxW)—A total of 10,031 HxW steelhead were PIT tagged at the Eastbank Hatchery (raceway 3) on 11-13 September 2006 (Table 3.12). The mean size of steelhead tagged was 80 mm; no fish smaller than 60 mm were tagged. Fish were not fed for 24 hours before or after tagging. These fish were transported to the Turtle Rock Hatchery in early January 2007. None of these fish were adipose fin clipped.

A total of 9,089 PIT-tagged HxW steelhead were released during spring 2007 (Table 3.12). Of the 10,031 steelhead tagged, 922 died and another 20 shed their tags. The relatively high mortality rate was associated with a power outage on 7 January 2007, which caused a dissolved oxygen sag that killed at least 836 tagged fish in the hatchery.[3]

Table 3.12. Summary of PIT-tagging activities for HxW steelhead from the Eastbank Hatchery, 2006. Dead fish counted before 15 September likely represent deaths associated with tagging; deaths after 15 September were probably not related to tagging. A power outage on 7 January 2007 killed about 836 PIT-tagged fish.

Tagging date	Number of fish tagged	Number of fish that died		Number of tags shed	Number of tagged fish alive
		Before 9/15	After 9/15		
9/11	3,315	1	279	6	3,029
9/12	3,552	1	346	6	3,199
9/13	3,164	2	293	8	2,861
Total	***10,031***	***4***	***918***	***20***	***9,089***

Fish size and condition at release

All 2005 brood steelhead were trucked and released as yearling smolts in May of 2006. Both the H x H and H x W groups exceeded length and weight targets, but did not meet the target for coefficient of variation of fork length. The W x W group is typically the last group ponded and as a result of a shorter rearing period did not meet size at release targets (Table 3.13).

Table 3.13. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of steelhead smolts released from the hatchery, brood years 1998-2005. 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

[3] Because of the length of the power outage, hatchery personnel began releasing steelhead into the Columbia River. During the release, power was restored and the release ceased. An underdetermined (assumed small) number of steelhead was released into the Columbia River.

Brood year	Release year	Parental origin	Fork length (mm)		Mean weight	
			Mean	CV	Grams (g)	Fish/pound
		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
Targets			***198***	***9.0***	***75.6***	***6***

Survival Estimates

Overall survival of Wenatchee steelhead from green (unfertilized) egg to release was below the standard set for the program primarily as a result of poor green egg-to-eyed egg and eyed egg-to-ponding survival (Table 3.14). 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. Mortality after ponding resulting from chronic bacterial cold water disease continued to impact the overall survival performance of the 2005 brood.

Table 3.14. Hatchery life-stage survival rates (%) for steelhead, brood years 1998-2005. 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	57.7
2003	87.0	96.8	86.3	83.8	97.2	94.8	97.6	85.3	70.6
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
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

3.3 Natural Juvenile Productivity

During 2006, juvenile steelhead were sampled at the Upper Wenatchee, Lower Wenatchee, and Chiwawa traps and counted during snorkel surveys within the Chiwawa basin.

Parr Estimates

A total of 16,245 (±12.7%) subyearling (<100 mm) and 10,533 (±10.7%) yearling (100-200 mm)[4] steelhead/rainbow were estimated in the Chiwawa River basin in August 2006 (Table 3.15 and 3.16). During the survey period 1992-2006, numbers of subyearling and yearling steelhead/rainbow have ranged from 1,410 to 45,727 and 2,533 to 22,128, respectively, in the Chiwawa basin (Table 3.15 and 3.16; Figure 3.1). Numbers of all fish counted in the Chiwawa basin are reported in Appendix A.

Juvenile steelhead/rainbow were distributed 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. Subyearling 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 we 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, we found subyearling steelhead/rainbow using the same kinds of habitat as subyearling Chinook.

Yearling 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. Like subyearling steelhead/rainbow, yearling steelhead/rainbow selected stations in quiet water behind boulders in riffles, but the two age groups did not occur together. Yearling steelhead/rainbow appeared to use deeper and faster water than did subyearling steelhead/rainbow.

[4] Steelhead/rainbow trout larger than 200 mm (8 in) was considered a resident trout.

Table 3.15. Total numbers of subyearling steelhead/rainbow trout estimated in different steams in the Chiwawa Basin during snorkel surveys in August 1992-2006; NS = not sampled.

Sample Year	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Peven Creek	Big Meadow Creek	Alder Creek	Brush Creek	Y 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**
Average	***8,241***	***77***	***855***	***484***	***27***	***2,277***	***80***	***41***	***0***	***11,634***

Table 3.16. Total numbers of yearling steelhead/rainbow trout estimated in different steams in the Chiwawa Basin during snorkel surveys in August 1992-2006; NS = not sampled.

Sample Year	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Peven Creek	Big Meadow Creek	Alder Creek	Brush Creek	Y 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**
Average	***7,865***	***60***	***318***	***267***	***0***	***378***	***0***	***0***	***0***	***8,788***

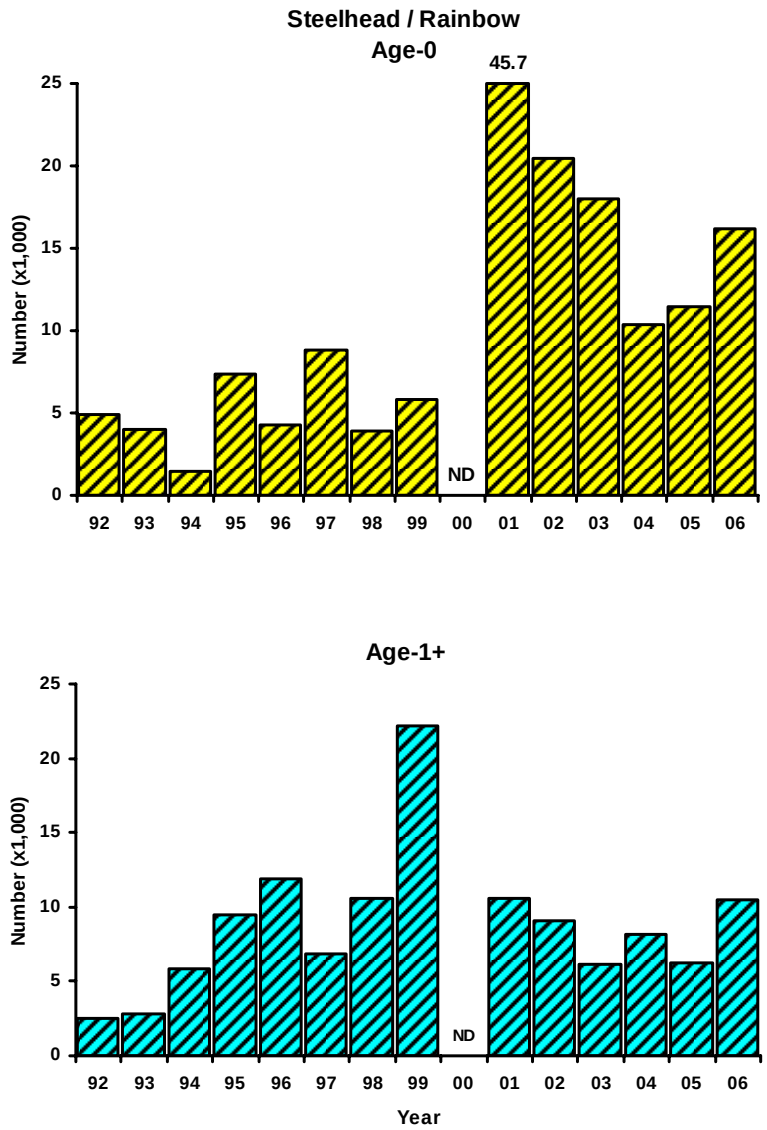


Figure 5.1. Numbers of subyearling and yearling steelhead/rainbow trout within the Chiwawa River Basin in August 1992-2006; ND = no data.

Emigrant and Smolt Estimates

Numbers of steelhead smolts and emigrants were estimated at the Upper Wenatchee, Chiwawa, and Lower Wenatchee traps in 2006.

Chiwawa Trap

The Chiwawa Trap operated between 28 February and 27 November 2006. During that time period the trap was inoperable for 9 days because of high river flows, debris, snow/ice, or mechanical failure. The trap operated in two different positions depending on stream flow; lower position at

flows greater than 12 m^3/s and an upper position at flows less than 12 m^3/s. Monthly captures of all fish collected at the Chiwawa Trap are reported in Appendix B.

A total of 53 wild steelhead/rainbow smolts, 1,384 hatchery smolts, and 1,736 wild parr were captured at the Chiwawa Trap. Nearly all (98%) of the hatchery smolts were collected in May, while most (62%) of the wild steelhead smolts were captured during April and May (Figure 3.2). Although steelhead/rainbow parr emigrated throughout the sampling period, most emigrated during April through June and in November (Figure 3.2). No mark-recapture efficiency trials were conducted with steelhead/rainbow at the Chiwawa Trap to estimate total population sizes.

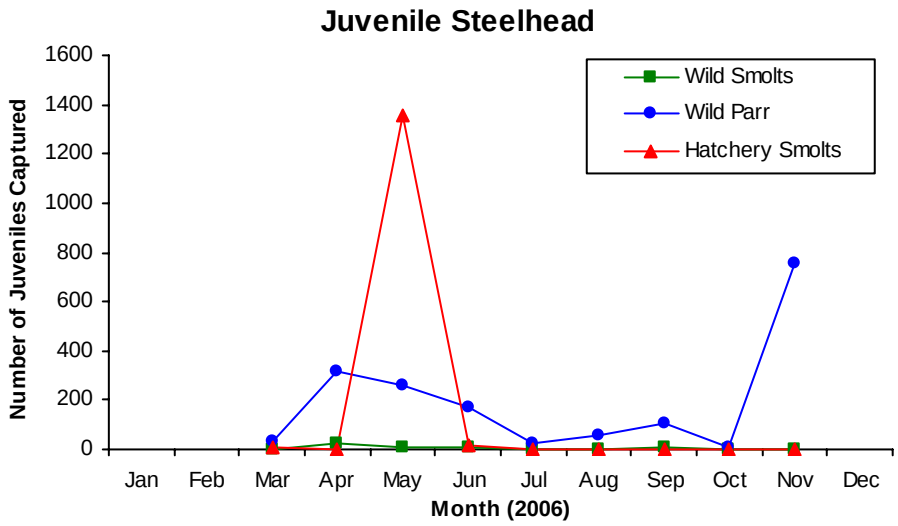


Figure 3.2. Monthly captures of wild smolts, wild parr, and hatchery smolt steelhead/rainbow at the Chiwawa Trap, 2006.

Upper Wenatchee Trap

The Upper Wenatchee Trap operated nightly between 3 March and 17 May 2006. During the three-month sampling period, a total of 10 wild steelhead/rainbow smolts, 160 hatchery smolts, and 32 wild parr were captured at the Upper Wenatchee Trap. Monthly captures of all fish collected at the Upper Wenatchee Trap are reported in Appendix B.

Lower Wenatchee Trap

The Lower Wenatchee Trap operated nightly between 8 February and 5 August 2006. During that time period the trap was inoperable for 27 days because of high river flows, debris, snow/ice, or mechanical failure. During the seven-month sampling period, a total of 105 wild steelhead/rainbow smolts, 3,769 hatchery smolts, and 45 wild parr were captured at the Lower Wenatchee Trap. Based on capture efficiencies estimated from the flow model, the total number of wild yearling steelhead/rainbow that emigrated past the Lower Wenatchee Trap was 17,499 (±33,554). Most of the wild yearling steelhead/rainbow migrated during April and May. Nearly all (99%) the hatchery yearling steelhead/rainbow migrated during May. Monthly captures of all fish collected at the Lower Wenatchee Trap are reported in Appendix B.

PIT Tagging Activities

A total of 2,167 juvenile steelhead/rainbow trout (2,138 wild and 29 hatchery) were PIT tagged and released in 2006 throughout the Wenatchee basin (Table 3.17). Most of these (65%) were tagged in the Chiwawa basin (1,366 at the trap and 34 upstream from the trap). Few were tagged and released at the Upper Wenatchee trap. A total of 131 juvenile steelhead/rainbow trout were tagged and released at the Lower Wenatchee trap. See Appendix C for a complete list of all fish captured, tagged, lost, and released.

Table 3.17. Numbers of wild and hatchery steelhead/rainbow trout that were captured, tagged, and released at different locations within the Wenatchee basin, 2006. Numbers of fish that died or shed tags are also given.

Sampling location	Origin	Number captured for tagging	Number tagged	Number that died	Number of shed tags	Total number of fish released
Chiwawa Trap	Wild	1,376	1,366	10	0	1,366
	Hatchery	0	0	0	0	0
	Total	**1,376**	**1,366**	**10**	**0**	**1,366**
Chiwawa River	Wild	43	33	0	0	33
	Hatchery	32	1	0	0	1
	Total	**75**	**34**	**0**	**0**	**34**
Upper Wenatchee Trap	Wild	22	22	1	0	21
	Hatchery	0	0	0	0	0
	Total	**22**	**22**	**1**	**0**	**21**
Upper Wenatchee River	Wild	435	413	0	0	413
	Hatchery	32	2	0	0	2
	Total	**467**	**415**	**0**	**0**	**415**
Nason Creek	Wild	211	174	0	0	174
	Hatchery	117	26	0	0	26
	Total	**328**	**200**	**0**	**0**	**200**
Lower Wenatchee Trap	Wild	131	131	0	0	131
	Hatchery	0	0	0	0	0
	Total	**131**	**131**	**0**	**0**	**131**
Totals	***Wild***	***2,218***	***2,139***	***11***	***0***	***2,138***
	Hatchery	***181***	***29***	***0***	***0***	***29***
	Total	***2,399***	***2,168***	***11***	***0***	***2,167***

3.4 Spawning Surveys

Surveys for steelhead redds were conducted during March through mid-May, 2006, in the Wenatchee River (including Beaver and Chiwaukum creeks), Chiwawa River (including Rock, Chikamin, Meadow, Twin, Alder, and Clear creeks), Nason Creek (including White Pine, Roaring, and an un-named stream), Icicle Creek, Peshastin Creek (including Mill, Ingalls, Ruby, Tronsen, Scotty, Shaser, and Schafer creeks), Little Wenatchee River, and White River (including the Napeequa River and Panther Creek). Surveys were conducted in both index and non-index areas throughout the Wenatchee basin (see Appendix D for more details).

Redd Counts

A total of 395 steelhead redds were counted in the Wenatchee basin in 2006 (Table 3.18). This is about one-third the estimate in 2005, but similar to the estimate in 2004. Most spawning occurred in the Wenatchee River (48%) (Table 3.18; Figure 3.3). Nason and Peshastin creeks contained 17% and 19%, respectively, of all redds in the Wenatchee basin. No redds were observed in the White River and the number of redds in the Chiwawa basin was lower than the five-year average for that area.

Table 3.18. Numbers of steelhead redds estimated within different streams/watersheds within the Wenatchee basin, 2001-2006; NS = not sampled. Redd counts beginning in 2004 have been conducted within the same areas and with the same methods. Therefore, comparing redd numbers before 2004 with estimates since may not be valid.

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**
Average	***69***	***141***	***2***	***1***	***247***	***22***	***53***	***516***

[a] Includes redds in Beaver and Chiwaukum creeks.

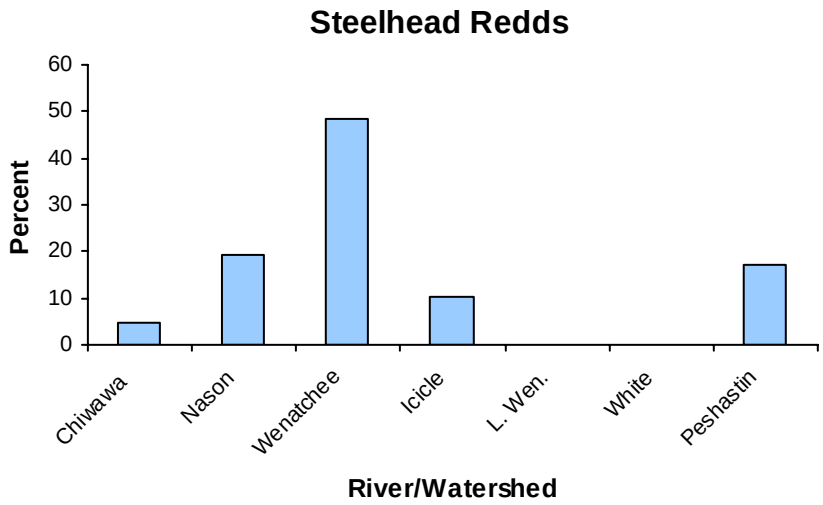


Figure 3.3. Percent of the total number of steelhead redds counted in different streams/watersheds within the Wenatchee basin during March through mid-May, 2006.

Redd Distribution

Steelhead redds were not evenly distributed among reaches within survey streams in 2006 (Table 3.19). Most of the spawning in the Chiwawa basin occurred in Reach 1 and in Clear Creek. No redds were observed in Rock or Alder creeks. Most of the spawning in the Nason Creek basin occurred in Nason Creek (primarily in Reaches 2 and 3), with little spawning in tributaries. All spawning in the Peshastin Creek basin occurred in Peshastin Creek (mostly in Reach 1). No redds were found in Peshastin Creek tributaries. About 70% of the spawning in the Wenatchee River occurred upstream from Tumwater Dam (Reaches 8-10). Of the 395 total redds estimated in the Wenatchee basin in 2006, 57% (226 redds) occurred upstream from Tumwater Dam. The remaining 169 redds occurred in the lower Wenatchee River, Peshastin Creek, and Icicle Creek.

Table 3.19. Numbers and percentages of steelhead redds counted within different streams/watersheds within the Wenatchee basin during March through mid-May, 2006.

Stream/watershed	Reach	Number of redds	Percent of redds within stream/watershed
Chiwawa	Chiwawa 1	8	42.1
	Rock Creek	0	0.0
	Chikamin Creek	1	5.3
	Meadow Creek	3	15.8
	Alder Creek	0	0.0
	Clear Creek	7	36.8
	Total	**19**	**100**
Nason	Nason 1	8	10.4
	Nason 2	27	35.0
	Nason 3	32	41.6
	Nason 4	7	9.1

Stream/watershed	Reach	Number of redds	Percent of redds within stream/watershed
	White Pine Creek	0	0.0
	Un-named Creek	3	3.9
	Roaring Creek	0	0.0
	Total	**77**	**100**
White	White 2	0	0.0
	White 3	0	0.0
	Panther Creek	0	0.0
	Naqeequa River	0	0.0
	Total	**0**	**0**
Icicle	Icicle	41	100
	Total	**41**	**100**
Peshastin	Peshastin 1	53	79.1
	Peshastin 2	14	20.9
	Mill Creek	0	0.0
	Ingalls Creek	0	0.0
	Tronsen Creek	0	0.0
	Scotty Creek	0	0.0
	Shaser Creek	0	0.0
	Schafer Creek	0	0.0
	Total	**67**	**100**
Wenatchee	Wenatchee 1	6	3.1
	Wenatchee 2	7	3.7
	Wenatchee 3	15	7.9
	Wenatchee 4	0	0.0
	Wenatchee 5	1	0.5
	Wenatchee 6	28	14.6
	Wenatchee 8	12	6.3
	Wenatchee 9	43	22.5
	Wenatchee 10	79	41.4
	Beaver Creek	0	0.0
	Chiwaukum Creek	0	0.0
	Total	**191**	**100**

Spawn Timing

Steelhead began spawning during the third week of March in the Wenatchee River and progressed upstream as water temperatures increased. Spawning occurred at temperatures between 3.3 and 7.1°C. Most spawning began when mean daily temperatures reached about 4.3°C. Peak spawning in the Wenatchee River, Nason Creek, and the Chiwawa River occurred the third week of April (Figure 3.4).

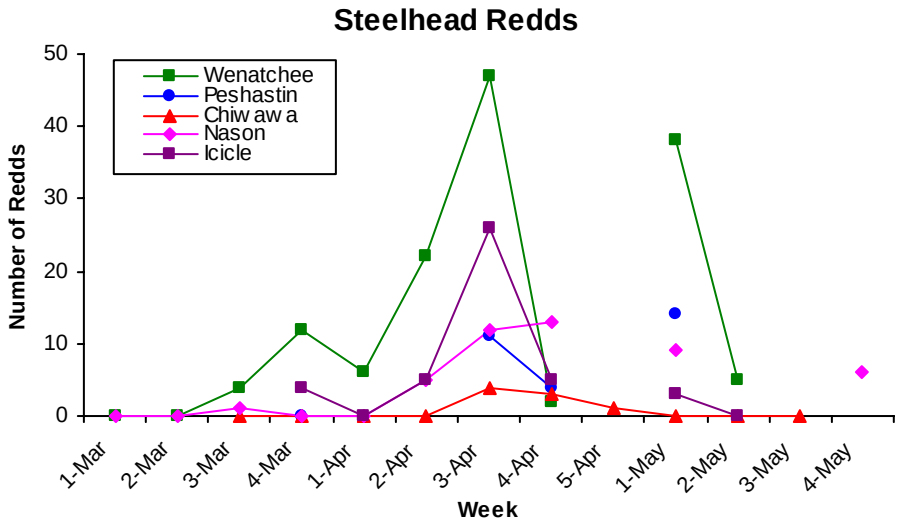


Figure 3.4. Numbers of steelhead redds counted during different weeks in different index areas within the Wenatchee basin, March through May 2006.

Spawning Escapement

Spawning escapement for steelhead upstream from Tumwater Dam was calculated as the number of redds (upstream from the dam) times the fish per redd ratio (based on sex ratios estimated at Tumwater Dam using video surveillance). The estimated fish per redd ratio for steelhead in 2006 was 2.05 (Table 3.20). Multiplying this ratio by the total number of redds upstream from the dam resulted in a total spawning escapement of 463 steelhead (Table 3.20). This means that of the 1,053 steelhead counted at Tumwater, only about 44% of them spawned upstream from the dam. This estimate was slightly lower than the six-year average of 49%.

The low estimated spawning escapement may have resulted from the difficult survey conditions (i.e., numerous freshets) that biologists experienced in 2006. That is, poor survey conditions may have obscured redds that were missed by the biologists. The effect of other factors, such as pre-spawning mortality, fallback, illegal harvest, etc. remain unknown.

Table 3.20. 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.

Survey year	Total count at Tumwater Dam	Fish/redd	Number of redds			Spawning escapement	Proportion of Tumwater count that spawned
			Index area	Non-index area	Total redds		
2001	820	1.92	118	19	137	263	0.32
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
2005	2,650	1.61	828	136	964	1,552	0.59
2006	1,053	2.05	192	34	226	463	0.44
Average	***1,654***	***2.01***	***344***	***91***	***435***	***845***	***0.49***

3.5 Life History Monitoring

Life history characteristics of steelhead were assessed by examining fish collected at broodstock collection sites, examining video tap at Tumwater Dam, and by reviewing tagging data and fisheries statistics. Some statistics could not be calculated at this time because few fish have been tagged with CWTs. All steelhead released from the hatchery received elastomer tags and about 30,000 were PIT tagged. With the placement of remote PIT tag detectors in spawning streams in 2007, statistics such as origin on spawning grounds, stray rates, and SARs can be estimated more accurately.

Migration Timing

There was little difference in migration timing of wild and hatchery fish sampled at Tumwater Dam (Table 3.21; Figure 3.5). Most steelhead migrated upstream past Tumwater dam during July through October. The highest proportion of both wild and hatchery fish migrated during October.

Table 3.21. The proportion of wild and hatchery steelhead sampled at Tumwater Dam during different months of the migration period, 1999-2006; NS = not sampled, N = sample size. 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. Proportions include steelhead collected for broodstock.

Brood year	Origin	Proportion of steelhead sampled at Tumwater Dam												N
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	
1999	Wild	0.02	0.25	0.18	0.10	0.03	0.16	0.00	0.00	0.00	0.05	0.20	0.01	110
	Hatch	0.01	0.20	0.19	0.03	0.00	0.17	0.00	0.00	0.00	0.10	0.25	0.04	69
2000	Wild	0.01	0.06	0.31	0.25	0.19	0.04	0.00	0.00	0.00	0.05	0.07	0.02	278
	Hatch	0.00	0.06	0.32	0.22	0.13	0.01	0.00	0.00	0.00	0.11	0.14	0.01	263
2001	Wild	0.01	0.20	0.26	0.17	0.18	0.00	0.00	0.00	0.00	0.04	0.12	0.01	475
	Hatch	0.00	0.12	0.13	0.10	0.22	0.02	0.00	0.00	0.00	0.11	0.26	0.04	383
2002	Wild	0.00	0.14	0.13	0.16	0.22	0.16	0.01	0.00	0.00	0.07	0.10	0.02	991
	Hatch	0.00	0.01	0.06	0.19	0.37	0.20	0.00	0.00	0.00	0.04	0.10	0.03	734

2003	Wild	0.00	0.15	0.38	0.15	0.07	0.00	0.04	0.06	0.04	0.05	0.05	0.01	924
	Hatch	0.00	0.07	0.14	0.09	0.05	0.01	0.05	0.21	0.07	0.21	0.11	0.00	910
2004	Wild	0.01	0.10	0.11	0.13	0.31	0.08	NS	NS	0.00	0.03	0.21	0.01	862
	Hatch	0.01	0.11	0.09	0.12	0.30	0.04	NS	NS	0.00	0.06	0.23	0.05	1,022
2005	Wild	0.02	0.08	0.07	0.36	0.26	0.04	0.00	NS	0.00	0.04	0.12	0.01	1,196
	Hatch	0.05	0.15	0.02	0.31	0.17	0.02	0.00	NS	0.00	0.03	0.17	0.05	1,505
2006	Wild	0.01	0.08	0.03	0.05	0.48	0.05	0.00	0.00	0.00	0.09	0.20	0.02	616
	Hatch	0.00	0.09	0.01	0.09	0.42	0.04	0.00	0.06	0.01	0.16	0.11	0.02	514
Average	***Wild***	***0.01***	***0.13***	***0.18***	***0.21***	***0.21***	***0.06***	***0.01***	***0.02***	***0.01***	***0.05***	***0.12***	***0.01***	***682***
	Hatch	***0.02***	***0.11***	***0.09***	***0.19***	***0.21***	***0.05***	***0.01***	***0.06***	***0.01***	***0.09***	***0.17***	***0.03***	***675***

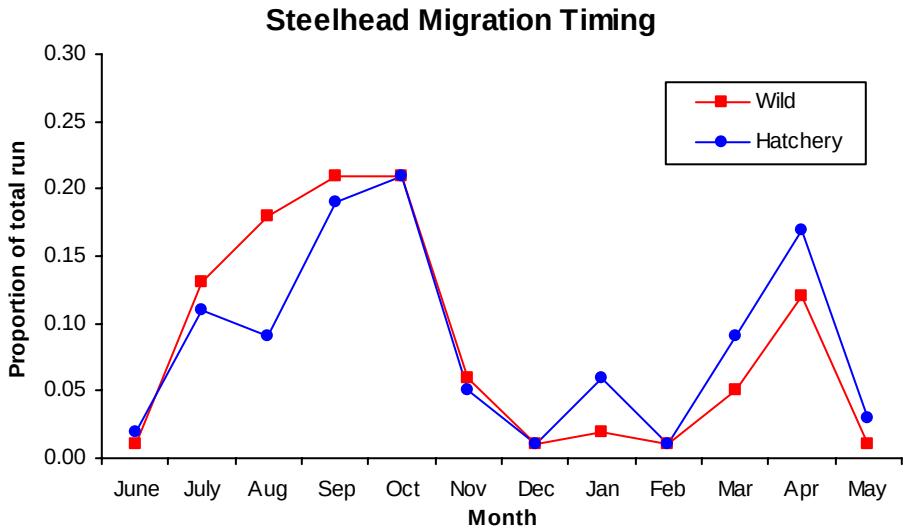


Figure 3.5. Proportion of wild and hatchery steelhead sampled at Tumwater Dam for the combined brood years of 1999-2006.

Age at Maturity

Nearly all steelhead sampled at Tumwater and Dryden dams lived in saltwater 1 to 2 years (saltwater age) (Table 3.22; Figure 3.6). Very few saltwater age-3 fish returned and those that did were wild fish. In general there was little difference between the saltwater age of wild and hatchery fish. A slightly greater number of wild fish returned as saltwater age-2 fish than age-1 fish. In contrast, a slightly greater number of hatchery fish returned as saltwater-1 fish.

Table 3.22. Proportions of wild and hatchery steelhead of different ages sampled at Tumwater Dam, 1998-2005. Age represents the number of years the fish lived in salt water.

Sample year	Origin	Saltwater age			Sample size
		1	2	3	
1998	Wild	0.43	0.57	0.00	35
	Hatchery	0.21	0.79	0.00	43
1999	Wild	0.50	0.48	0.02	58
	Hatchery	0.95	0.05	0.00	21
2000	Wild	0.56	0.44	0.00	39
	Hatchery	0.78	0.22	0.00	41
2001	Wild	0.52	0.48	0.00	58
	Hatchery	0.15	0.85	0.00	84
2002	Wild	0.56	0.44	0.00	99
	Hatchery	0.95	0.05	0.00	112
2003	Wild	0.12	0.87	0.02	60
	Hatchery	0.30	0.70	0.00	91
2004	Wild	0.95	0.05	0.00	78
	Hatchery	0.95	0.05	0.00	62
2005	Wild	0.22	0.78	0.00	95
	Hatchery	0.21	0.79	0.00	108
Average	***Wild***	***0.48***	***0.51***	***0.01***	***65***
	Hatchery	***0.56***	***0.44***	***0.00***	***70***

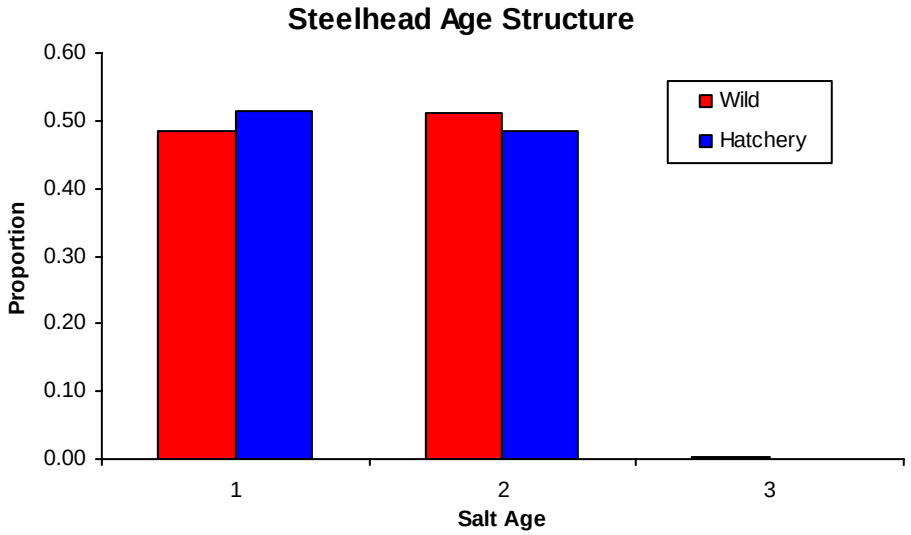


Figure 3.6. Proportions of wild and hatchery steelhead of different saltwater ages sampled at Tumwater Dam for the combined years 1998-2005.

Size at Maturity

On average, hatchery steelhead sampled at Tumwater and Dryden dams were about 2 cm smaller than wild steelhead sampled at the dam (Table 3.23). This may be related to the fact that slightly more wild steelhead return as saltwater age-2 fish than hatchery steelhead. Future analyses will compare sizes of hatchery and wild fish of the same age group and gender.

Table 3.23. Mean lengths (POH; cm) and variability statistics for wild and hatchery steelhead sampled at Tumwater Dam, 1998-2005; SD = 1 standard deviation.

Sample year	Origin	Sample size	Steelhead length (POH; cm)			
			Mean	SD	Minimum	Maximum
1998	Wild	35	57	7	47	72
	Hatchery	43	57	6	45	66
1999	Wild	58	55	6	44	66
	Hatchery	21	50	4	45	62
2000	Wild	39	54	5	44	66
	Hatchery	41	49	4	43	61
2001	Wild	58	55	7	43	69
	Hatchery	84	57	5	44	68
2002	Wild	99	56	6	46	72
	Hatchery	112	50	4	41	61
2003	Wild	60	61	4	49	71
	Hatchery	91	58	5	42	66
2004	Wild	78	52	5	42	69
	Hatchery	62	50	4	44	63
2005	Wild	95	57	6	40	70
	Hatchery	108	55	7	46	65
Pooled	***Wild***	***522***	***56***	***6***	***40***	***72***
	Hatchery	***562***	***54***	***6***	***41***	***68***

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% (NMFS 2004). 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.

The Hatchery Evaluation Technical Team (HETT) is currently developing methods for calculating harvest rates on Wenatchee steelhead. These methods will be presented to the Hatchery Committee for their review in 2007.

Origin on Spawning Grounds

At this time origin of steelhead (wild or hatchery) on spawning grounds cannot be determined. After remote PIT tag detectors are installed within spawning tributaries, we should be able to identify the origin of steelhead spawners within different spawning streams in the Wenatchee basin.

Straying

Stray rates are currently difficult to assess because fish are not handled on spawning grounds. As remote PIT tag detectors are installed in spawning streams, we will be able to more accurately determine steelhead stray rates.

Genetics

Genetic analysis on Wenatchee steelhead will be completed in 2007.

Natural Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural origin recruits (NOR) to the parent spawning population. For brood years 1989-1999, NRR in the Wenatchee averaged 0.84 (range, 0.08-5.56) (Table 3.24). NRRs for more recent brood years will be calculated as soon as the data are available.

Table 3.24. Spawning escapements, natural origin recruits (NOR), and natural replacement rates (NRR) for Wenatchee steelhead, 1989-2000. *(The numbers in this table may change as the HETT and HC refine the methods for estimating steelhead escapement, NORs, and NRRs.)*

Brood year	Spawning escapement	NOR	NRR
1989	3,236	1,663	0.19
1990	2,748	1,556	0.20
1991	1,678	953	0.30
1992	2,551	1,612	0.16
1993	4,153	1,050	0.08
1994	1,517	510	0.34
1995	2,806	454	0.21
1996	2,321	709	0.76
1997	1,515	351	2.01
1998	962	495	2.56
1999	564	488	2.41
2000	1,546	515	-
Average	***2,133***	***863***	***0.84***

Hatchery Replacement Rates

Hatchery replacement rates were estimated as hatchery adult-to-adult returns. These rates should be greater than the NRRs and greater than or equal to 19.2 (the value in BAMP; Murdoch and Peven 2005). In years with data, HRRs were greater than NRRs (Table 3.25). In contrast, HRRs have not exceeded the BAMP target of 19.2.

Table 3.25. Hatchery replacement rates (HRR), NRR, and BAMP target (19.2) for Wenatchee steelhead, 1998-2000. *(The numbers in this table may change as the HETT and HC refine the methods for estimating steelhead HRRs and NRRs.)*

Brood year	HRR	NRR	BAMP
1998	2.62	2.56	19.2
1999	17.37	2.41	19.2
Average	***10.00***	***2.49***	***19.2***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) are calculated as the number of returning hatchery adults divided by the number of hatchery smolts released. SARs are generally based on CWT returns. However, Wenatchee steelhead have not been extensively tagged with CWTs. Therefore elastomer-tagged fish were used to estimate SARs from release to capture at Priest Rapids Dam. Two different estimates are provided. One (unadjusted) is based on elastomer tag recaptures at Priest Rapids Dam; the other (adjusted) is corrected for tag loss after release (based on the number of elastomer tags found in holding tanks).

Unadjusted SARs for Wenatchee steelhead ranged from 0.0017 to 0.0307 (mean = 0.0083) for brood years 1996-2002 (Table 3.26). Accounting for post-release tag loss, SARs ranged from 0.0016 to 0.0336 (mean = 0.0121) for brood years 1998-2002.

Table 5.26. Smolt-to-adult ratios (SARs) for Wenatchee hatchery steelhead, 1996-2002; NA = not available. Unadjusted estimates were based on elastomer tags recaptured at Priest Rapids Dam. Adjusted estimates were corrected for tag loss after release.

Brood year	Number released	SAR (unadjusted)	SAR (adjusted)
1996	348,693	0.0034	NA
1997	429,422	0.0041	NA
1998	172,078	0.0009	0.0016
1999	175,661	0.0110	0.0165
2000	184,639	0.0017	0.0022
2001	335,933	0.0307	0.0336
2002	302,060	0.0063	0.0065
Average	***278,355***	***0.0083***	***0.0121***

3.6 ESA/HCP Compliance

Broodstock Collection

Collection protocols for the 2005 Wenatchee steelhead broodstock specified steelhead collection at Tumwater and Dryden dams between 4 July and 10 Oct 2004. The protocols called for a total collection of 208 steelhead, including 104 natural origin steelhead. Actual broodstock trapping began 6 July 2004 and concluded 23 September 2004, representing a shortened collection period from that specified in the 2004 broodstock collection protocol. Broodstock collection totaled 209 steelhead collected at Tumwater, Dryden, and Wells dams, including 95 natural origin fish (45.5% of the total collection), slightly less than the 2004 protocol and ESA Permit 1395 target of 50% natural origin broodstock composition.

Wenatchee hatchery origin steelhead were also collected at Wells Dam between 8 September and 16 September 2004 as a supplement to the Wenatchee basin collection. This was in response to an apparent mid-season shortfall in Wenatchee hatchery origin steelhead collected at Tumwater and Dryden dams. The mid-season shortfall indicated a potential shortfall in the overall broodstock collection and was supported by substantial numbers of unknown hatchery steelhead encounters in the Wenatchee basin that were precluded from the broodstock collection per the 2004 broodstock collection protocol and an estimated Wenatchee hatchery origin steelhead stray rate above the Wenatchee River confluence of 0.34 (Columbia River Dart PIT tag data analysis). Wenatchee hatchery origin steelhead retained at Wells Dam and included in the Wenatchee steelhead program totaled 27 fish, including 17 HxW and 10 WxW parental cross adults, consistent with program and ESA Permit parental cross priorities for hatchery fish.

In addition to steelhead encountered at Dryden Dam during steelhead broodstock collection, 43 spring Chinook and one bull trout 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 at this site were subject of water-to-water transfers or anesthetized if removed from water during handling.

Hatchery Rearing and Release

The 2005 brood Wenatchee steelhead reared throughout all life-stages without significant mortality events (defined as >10% population mortality associated with a single event). However, they did suffer chronic mortality associated with bacterial coldwater disease and failed to meet several life-stage survival objectives resulting in an unfertilized-to-release survival of 67.2% (see Section 3.2).

Juvenile rearing occurred at three separate facilities; Eastbank Fish Hatchery, Chelan Falls Fish Hatchery, and Turtle Rock Fish Hatchery. 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 Falls Fish Hatchery on warmer water to accelerate their growth so they achieve a size at release similar to HxH and HxW parental cross progeny reared on cooler water at Eastbank Fish Hatchery. All parental cross groups receive final rearing at Turtle Rock Fish Hatchery on Columbia River surface water before direct release (scatter planting) in the Wenatchee River basin.

The 2005 brood steelhead smolt release in the Wenatchee basin totaled 452,184 smolts, exceeding the program target of 400,000 smolts and was 1.5% greater than the 10% production overage authorized in ESA Permit 1395. The production overage was a result of a skewed female sex ratio in the broodstock and slightly more fecund females than expected (see Section 3.1). The production overage was identified in a memo from K. Truscott (WDFW) to the HCP Hatchery Committee, dated 28 February 2006, detailing proposed 2005-2013 Wenatchee steelhead stocking allotments (Truscott 2006).

All steelhead smolts released were tagged with a visual implant elastomer tag. In addition, 100% of HxH and about 62% of HxW parental cross progeny were adipose-clipped, to aid in removal of adults in selective fisheries in years of excessive adult escapements (see Section 3.2). External marking, including adipose fin clips to aid in adult removal, was consistent with provisions in ESA Section 10 Permit 1395.

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, and 1395, permit holders shall monitor and report hatchery effluents in compliance with applicable National Pollution Discharge Elimination Systems (NPDES) (EPA 1999) permit limitations. NPDES monitoring and reporting for Chelan PUD Hatchery Programs during 2006 are provided in Appendix E.

Smolt and Emigrant Trapping

Per ESA Section 10 Permit No. 1395, the permit holders are authorized a direct take of 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 basin, the reported steelhead encounters during 2006 emigration monitoring complied with take provisions in the Section 10 permit and are detailed in Table 3.27. Additionally, juvenile fish captured at the trap locations were handled consistent with provisions in ESA Section 10 Permit 1395 Section B.

Table 3.27. Estimated take of UCR steelhead resulting from juvenile emigration monitoring in the Wenatchee basin, 2006.

Trap location	Population estimate				Number trapped				Total	Take allowed by Permit
	Wild[a]	Hatchery[b]	Parr	Fry	Wild[a]	Hatchery[a]	Parr	Fry		
Chiwawa Trap										
Population	NA	32,758	NA	NA	53	1,384	1,736	0	3,173	
Encounter rate	NA	NA	NA	NA	NA	0.0422	NA	NA	0.0969	0.20
Mortality	NA	NA	NA	NA	NA	NA	NA	NA	5	
Mortality rate	NA	NA	NA	NA	NA	NA	NA	NA	0.0016	0.02
Upper Wenatchee Trap										
Population	780	452,184	1,820	NA	12	162	28	0	202	
Encounter rate	NA	NA	NA	NA	0.0154	0.0004	0.0154	NA	0.0004	0.20
Mortality	NA	NA	NA	NA	0	0	0	0	0	
Mortality rate	NA	NA	NA	NA	0.0000	0.0000	0.0000	NA	0.0000	0.02
Lower Wenatchee Trap										

Population	16,824	452,184	NA	NA	112	3,769	51	0	3,932	
Encounter rate	NA	NA	NA	NA	0.0067	0.0083	NA	NA	0.0084	0.20
Mortality	NA	NA	NA	NA	1	0	1	NA	2	
Mortality rate	NA	NA	NA	NA	0.0089	0.0000	0.0196	NA	0.0005	0.02
Wenatchee Basin Total										
Population	16,824	452,184	NA	NA	177	5,315	1,815	0	7,307	
Encounter rate	NA	NA	NA	NA	0.0105	0.0118	NA	NA	0.0156	0.20
Mortality	NA	NA	NA	NA	NA	NA	NA	NA	7	
Mortality rate	NA	NA	NA	NA	NA	NA	NA	NA	0.0010	0.02

[a] Smolt.

[b] 2006 smolt release data for the Wenatchee basin.

Spawning Surveys

Steelhead spawning ground surveys were conducted in the Wenatchee basin during 2006, 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 impacts 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 10% of the UCR 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 UCR steelhead supplemented with artificially propagated enhancement steelhead (NMFS 2003). The 2005-06 run and 2006-07 run estimates and stock assessment sampling rates were 6.6% and 8.7%, respectively. In both years, the take was at or below authorized levels. Methods and results of the 2005-06 and 2006-07 steelhead run-cycle assessment at Priest Rapids Dam are provided in Appendix F.

SECTION 4: WENATCHEE SOCKEYE SALMON

4.1 Broodstock Sampling

This section focuses on results from sampling 2004 and 2005 Wenatchee sockeye broodstock, which were collected at Tumwater Dam. The 2004 return begins the tracking of the life cycle of sockeye that were released as parr into Lake Wenatchee in 2005 and some of which began smolt migrations in 2006. The 2005 return is included because juveniles from this brood were released as parr in the lake in 2006. Complete information is not currently available for the 2006 return (this information will be provided in the 2007 annual report). Collection of sockeye broodstock targets naturally produced fish and equal numbers of male and female fish.

Origin of Broodstock

The 2004 broodstock consisted entirely of naturally produced sockeye collected at Tumwater Dam between 19 and 21 July 2004 (Table 4.1). A total of 177 sockeye were spawned in 2004. The 2005 broodstock consisted of mostly naturally produced Wenatchee sockeye salmon collected at Tumwater Dam (Table 4.1). A total of 165 sockeye were spawned of which 159 were naturally produced fish. The remaining six fish were of unknown origin.

Table 4.1. Numbers of wild and hatchery sockeye salmon collected for broodstock, numbers that died before spawning, and numbers of sockeye spawned, 1989-2005. Unknown origin fish (i.e., undetermined by scale analysis, no CWT or fin clips, and no additional hatchery marks) were considered naturally produced. Pre-spawning loss does not include all mortality.

Return year	Wild sockeye			Hatchery sockeye			Total number spawned
	Number collected	Prespawn loss	Number spawned	Number collected	Prespawn loss	Number spawned	
1989	291	80	115	0	0	0	115
1990	331	7	302	0	0	0	302
1991	233	16	199	0	0	0	199
1992	343	18	320	0	0	0	320
1993	307	77	207	0	0	0	207
1994	259	15	236	5	0	5	241
1995	223	4	199	3	0	3	202
1996	227	1	225	0	0	0	225
1997	283	12	192	19	0	19	211
1998	254	37	151	6	0	6	157
1999	89	7	68	60	0	60	128
2000	256	19	170	5	0	5	175
2001	252	35	200	8	1	7	207
2002	257	0	256	0	0	0	256
2003	258	12	198	0	0	0	198
2004	214	20	180	0	0	0	180

2005	243	31	166	0	0	0	166
Average	***254***	***23***	***199***	***6***	***0***	***6***	***205***

Age/Length Data

Ages of sockeye were determined from scales and otoliths collected from broodstock. The 2004 return consisted primarily (97.5%) of age-4 adults (Table 4.2). Age-5 and 6 sockeye collectively made up 2.5% of the 2004 return. The 2005 return was comprised primarily (74.2%) of age-4 returning adults (Table 4.2). Age-5 adults made up 25.8% of the remaining broodstock. No age-6 fish were collected.

Table 4.2. Percent of hatchery and wild sockeye salmon of different ages (total age) collected from broodstock, 1994-2005.

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	14.8	81.1	4.1
	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
Average	***Wild***	***59.9***	***38.8***	***1.3***
	Hatchery	***79.0***	***20.0***	***1.0***

Lengths of sockeye for the 2004 and 2005 return years are provided in (Table 4.3). Lengths of age-4, 5, and 6 sockeye sampled in 2004 averaged 53, 56, and 63 cm, respectively.

Table 4.3. Mean fork length (cm) at age (total age) of hatchery and wild sockeye salmon collected for broodstock, 1994-2005; 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	11	4	50	60	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	64	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	-

Sex Ratios

Male sockeye in the 2004 return made up about 51% of the adults collected, resulting in an overall male to female ratio of 1.02:1.00 (Table 4.4). In 2005, males made up about 53% of the adults collected, resulting in an overall male to female ratio of 1.15:1.00. Both ratios are close to the 1:1 ratio target in the broodstock protocol.

Table 4.4. Numbers of male and female wild and hatchery sockeye collected for broodstock, 1989-2005. 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	154	137	1.12:1.00	-	-	-	1.12:1.00
1990	175	156	1.12:1.00	-	-	-	1.12:1.00
1991	136	97	1.40:1.00	-	-	-	1.40:1.00
1992	163	180	0.91:1.00	-	-	-	0.91:1.00
1993	130	177	0.73:1.00	-	-	-	0.73:1.00
1994	126	133	0.95:1.00	1	4	0.25:1.00	0.93:1.00
1995	104	119	0.87:1.00	1	2	0.50:1.00	0.87:1.00
1996	108	119	0.91:1.00	-	-	-	0.91:1.00
1997	139	144	0.97:1.00	10	9	1.11:1.00	0.97:1.00
1998	132	122	1.08:1.00	2	4	0.50:1.00	1.06:1.00
1999	17	65	0.26:1.00	41	26	1.58:1.00	0.64:1.00
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	-	-	-	0.99:1.00
2003	158	100	1.58:1.00	-	-	-	1.58:1.00
2004	108	106	1.02:1.00	-	-	-	1.02:1.00
2005	130	113	1.15:1.00	-	-	-	1.15:1.00
Total	***2,177***	***2,136***	***1.02:1.00***	***62***	***51***	***1.22:1.00***	***1.02:1.00***

Fecundity

Fecundities for the 2004 and 2005 returns of sockeye salmon averaged 2,505 and 2,718 eggs per female, respectively (Table 4.5). These fecundities are close to the 17-year average of 2,612. Fecundities for this program are based upon the total (pooled) number of eyed eggs divided by the number of females spawned. Mean fecundities derived from individual fecundities cannot be calculated because of the need to pool three females per incubation tray.

Table 4.5. Mean fecundity of female sockeye salmon collected for broodstock, 1989-2005. 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

Return year	Mean fecundity
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
Average	***2,612***

4.2 Hatchery Rearing

Rearing History

Number of eggs taken

Based on the unfertilized egg-to-release survival standard of 81%, a total of 246,914 eggs are required to meet the program release goal of 200,000 smolts. Between 1989 and 2006, the egg take goal was reached in most years (Table 4.6). The number of eggs taken in 2005 was below the egg take target.

Table 4.6. Numbers of eggs taken from sockeye broodstock, 1989-2006.

Return year	Number of eggs taken
1989	133,600
1990	333,779
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

Return year	Number of eggs taken
2004	225,499
2005	211,985
2006	292,136
Average	***264,247***

Disease

Rearing of the 2004 brood sockeye was typical to previous years with fish being held on Lake Wenatchee water in net pens for 55 to 120 days before being released directly into the lake. Mortality due to Columnaris began to increase in the juveniles in late July about 2 weeks after adult sockeye broodstock were transferred from Tumwater Dam to holding pens at lake Wenatchee. A 2% TM-100 treatment was initiated for control, which abated the condition. No further outbreaks or disease issues were observed or detected.

Number of acclimation days

Wenatchee sockeye have only been acclimated on Lake Wenatchee water. For brood years 1989 through 1998 unfed fry were transferred from Eastbank FH to Lake Wenatchee Net Pens until release (Table 4.7). Juvenile sockeye were reared at Eastbank FH (1999 brood – present) until July in an effort to increase growth before release.

Table 4.7. Water source and mean acclimation period for Wenatchee sockeye, brood years 1989-2004.

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

Brood year	Release year	Transfer date	Release date	Number of Days	Water source
		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

Release Information

Numbers released

The 2004 Wenatchee sockeye program achieved 86.5% of the 200,000 target goal (in part because the egg take did not meet the target level) with about 172,923 fish being released in two groups (Table 4.8). This was the last brood year released to evaluate the overwinter survival between two size/time at release groups (i.e., earlier and smaller versus late and large). It was determined by the HCP Hatchery Committee that sufficient information had been collected and all future broods are to be released at the larger size later in the season. Although data suggest that larger sockeye parr released at a later date result in a significantly higher over-winter survival, causation has not been determined.

Table 4.8. Numbers of sockeye released, brood years 1989-2004. The release target for sockeye is 200,000 fish.

Brood year	Release year	Number released
1989	1990	260,400
1990	1991	372,102
1991	1992	167,523
1992	1993	340,557
1993	1994	190,443
1994	1995	252,859
1995	1996	150,808
1996	1997	284,630
1997	1998	197,195
1998	1999	121,344
1999	2000	167,955
2000	2001	190,174
2001	2002	200,938

Brood year	Release year	Number released
2002	2003	316,698
2003	2004	240,459
2004	2005	172,923
Average		***226,688***

Numbers tagged

A total of 15,000 juvenile sockeye were PIT tagged in June 2006. A total of 136 tagged sockeye died and another 73 shed their tags. Thus, a total of 14,791 juvenile sockeye were released into the lake on 30 October 2006.

Fish size and condition at release

The 2004 brood sockeye were released as parr in 2005 and emigrated as yearling smolts in spring of 2006. Size at release for the early release groups was 87.1% and 75.8% of the fork length and weight goals, respectively. While the late release groups were 113.3% and 173.1% of the fork length and weight goals, respectively. The 2004 brood year was below the CV of length goal by 50.0% and 77.8% of the early and late release groups, respectively (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 1989-2004. 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

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
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
Targets		***133***	***9.0***	***22.7***	***20***

Survival Estimates

Overall survival of Wenatchee sockeye from green (unfertilized) egg to release was below the standard set for the program as a result of poor green egg-to-eye and eye-to-ponding survival. Investigations to determine the effects of holding adults on warm surface water at Lake Wenatchee on gamete maturation/viability in addition to reducing negative phototactic behavior at swim up (potential influences on survival at the fertilization to ponding stages) should be considered (Table 4.10).

Table 4.10. Hatchery life-stage survival rates (%) for sockeye salmon, brood years 1989-2004. 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	55.2
1990	96.2	99.4	90.8	96.3	99.9	99.2	95.0	98.4	83.0
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	79.3
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	80.1
2004	88.7	92.6	88.0	93.1	97.9	97.4	93.7	96.1	76.7
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

4.3 Natural Juvenile Productivity

During 2006, juvenile sockeye salmon were sampled at the Upper Wenatchee and Lower Wenatchee traps.

Emigrant and Smolt Estimates

Upper Wenatchee Trap

The Upper Wenatchee Trap operated nightly between 3 March and 17 May 2006. During the three-month sampling period, a total of 20,309 wild sockeye and 1,500 hatchery sockeye smolts were captured at the Upper Wenatchee Trap. Based on a pooled daily trap efficiency of 1.6% for wild sockeye (based on 6 mark-recapture trials) and 0.9% for hatchery sockeye (based on 6 mark-recapture trials), the total number of smolts that emigrated past the trap in 2006 was 1,266,971 (±103,466) wild and 159,500 (±15,405) hatchery sockeye (Table 4.11). Monthly captures of all fish and results of capture efficiency tests at the Upper 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 1997-2006.

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
2004	5,771,187	216,023
2005	723,413	122,399
2006	1,266,971	159,500
Average	***1,840,275***	***107,582***

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, 1997-2006.

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	0.260	0.000	5,439,032
2004	0.929	0.071	0.000	5,771,187
2005	0.168	0.707	0.125	723,413
2006	0.994	0.006	0.000	1,266,971
Average	***0.698***	***0.286***	***0.016***	***1,840,275***

Lower Wenatchee Trap

The Lower Wenatchee Trap operated nightly between 8 February and 5 August 2006. During that time period the trap was inoperable for 27 days because of high river flows, debris, snow/ice, or mechanical failure. During the seven-month sampling period, a total of 5,204 wild sockeye smolts and 68 hatchery sockeye smolts were captured at the Lower Wenatchee Trap. Most of the smolts migrated during April and May. Monthly captures and mortalities of all fish collected at the Lower Wenatchee Trap are reported in Appendix B.

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. Egg-smolt survival rates for brood years 1995-2002 have ranged from 0.012 to 0.212 (mean = 0.098).

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, 1995-2005; 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	11,796,932	1,203,934	394,196	236	1,598,366	0.136
1998	2,024	2,813	5,505,944	590,309	2,007	0	592,316	0.108
1999	513	2,319	1,188,488	37,110	28,459	0	65,569	0.055
2000	11,413	2,673	30,506,949	701,257	1,378,795	0	2,080,052	0.068
2001	21,685	2,960	64,100,860	4,024,884	409,754	90,427	4,525,065	0.071

2002	17,226	2,856	49,197,456	5,361,433	511,453	0	5,872,886	0.120
2003	2,158	3,511	7,576,738	166,385	7,602	NA	NA	NA
2004	15,469	2,505	38,332,182	1,259,369	NA	NA	NA	NA
2005	5,867	2,718	14,667,500	NA	NA	NA	NA	NA
Average	***7,969***	***2,706***	***21,619,132***	***1,473,099***	***395,800***	***11,456***	***2,114,516***	***0.098***

Juvenile survival rates for hatchery sockeye salmon are provided in Table 4.14. Release-smolt survival rates for brood years 1995-2003 have ranged from 0.000 to 1.000 (mean = 0.506). Egg-smolt survival rates for the same brood years ranged from 0.000 to 0.442 (mean = 0.211). On average, egg-smolt survival of hatchery sockeye is about two times greater than egg-smolt survival of wild sockeye. On two separate occasions the estimated number of hatchery smolts equaled or exceeded the number of hatchery parr released in the lake. This suggests that the pooled trap efficiency for wild sockeye may have overestimated the trap efficiency for larger hatchery smolts (i.e., size-dependent bias).

Table 4.14. Juvenile survival rates for hatchery Wenatchee sockeye, brood years 1995-2004; NA = not available.

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
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	NA	NA	NA
		91,495	11/2/05	NA	NA	NA

4.4 Spawning Surveys

Spawning surveys were conducted in the Little Wenatchee and White (including the Napeequa River) rivers from 29 August to 24 October 2006. Surveys included counting numbers of live sockeye spawners and numbers of redds (see Appendix G for more details).

Redd Counts

A total of 2,747 sockeye redds were counted in the Wenatchee basin in 2006 (Table 4.15). Most spawning occurred in the White River basin (91%) (Table 4.15; Figure 4.1). The Little Wenatchee River contained 254 redds.

Table 4.15. Numbers of sockeye redds counted within different streams/watersheds within the Wenatchee basin, 2006.

Survey year	Numbers of sockeye redds		
	Little Wenatchee	White	Total
2006	254	2,493	**2,747**
Average	***254***	***2,493***	***2,747***

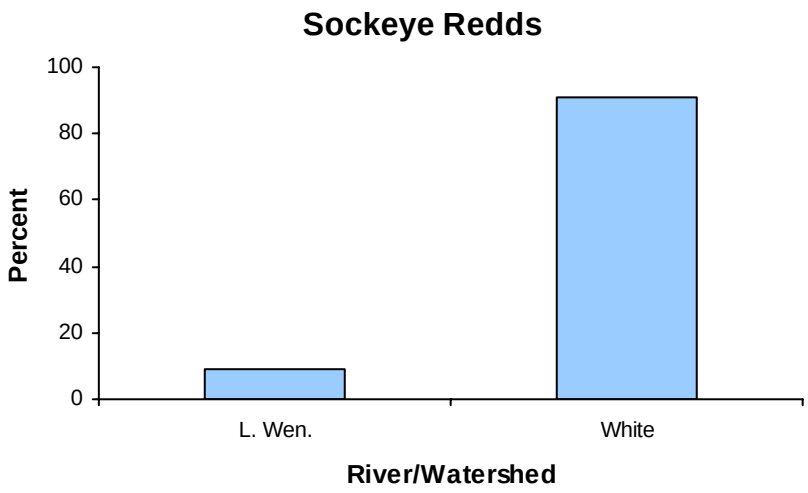


Figure 4.1. Percent of the total number of sockeye redds counted in different streams/watersheds within the Wenatchee basin during August through October, 2006.

Redd Distribution

Sockeye redds were not evenly distributed among reaches within survey streams in 2006 (Table 4.16). All the spawning in the Little Wenatchee occurred in Reaches 2 (Lost Creek to Rainy Creek). Nearly all the spawning in the White River occurred in Reach 2 (Sears Creek Bridge to Napeequa River). Only 7% of the redds in the White River basin occurred in the Napeequa River.

Table 4.16. Numbers and percentages of sockeye redds counted within different streams/watersheds within the Wenatchee basin during August through October, 2006.

Stream/watershed	Reach	Number of redds	Percent of redds within stream/watershed
Little Wenatchee	Little Wen 2	254	100
	Little Wen 3	0	0
	Total	**254**	**100**
White	White 1	3	0
	White 2	2,313	93
	Napeequa 1	177	7
	Total	**2,493**	**100**
Grand Total		***2,747***	**-**

Spawn Timing

Sockeye began spawning during the first week of September and peaked around the fourth week of September (Figure 4.2). Peak spawning was determined using the total number of spawners observed on the spawning grounds.

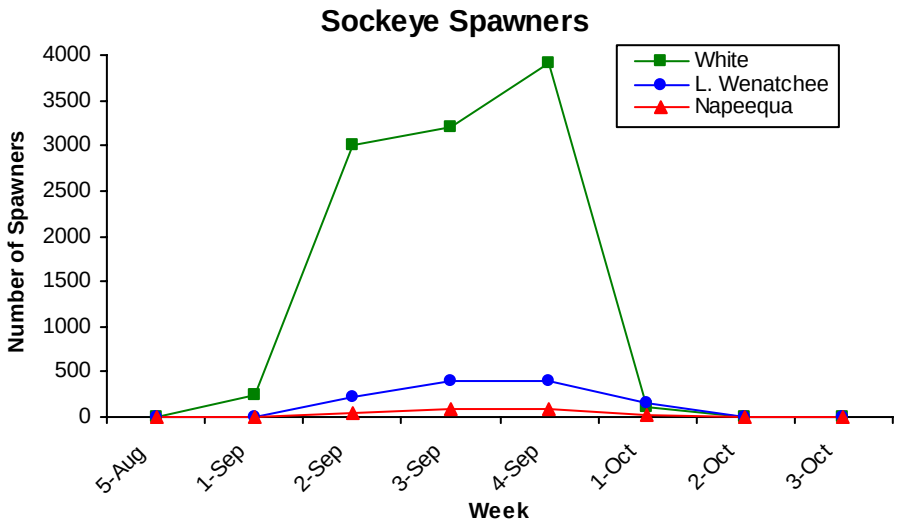


Figure 4.2. Numbers of sockeye spawners counted during different weeks in different sampling streams within the Wenatchee basin, August through October 2006.

Spawning Escapement

Two different methods were used in 2006 to estimate sockeye spawning escapements. The first applied a fish/redd ratio to the estimated number of redds counted in each subbasin (i.e., escapement = fish/redd x redds). The second used the area-under-the-curve (AUC) method to estimate sockeye escapement (i.e., escapement = (AUC/redd residence time) x observer efficiency). The latter relied on weekly counts of live sockeye and assumed a redd residence time of 11 days and an observer efficiency of 100%.

Fish/redds

Using the fish/redd approach, the estimated total spawning escapement of sockeye in the Wenatchee Basin was 6,208 (Table 4.17). This was estimated using a fish/redd ratio of 2.26, which was based on counts of male and female sockeye sampled at Tumwater Dam.

Table 4.17. Number of redds, peak numbers of live spawners, and total spawning escapement estimates for sockeye salmon in the Wenatchee basin, August through October 2006; AUC = area-under-the-curve.

Sampling area	Total number of redds	Peak number of live fish	Spawning escapement	
			Fish/redd method	AUC method
Little Wenatchee	254	400	574	710
White River	2,493	3,998	5,634	7,103
Total	***2,747***	***4,398***	***6,208***	***7,813***

The spawning escapement of 6,208 Wenatchee sockeye is less than the 1989-2005 average of 16,871 (Table 4.18).

Table 4.18. Spawning escapements for sockeye salmon in the Wenatchee basin for brood years 1989-2006; NA = not available. Total escapements before 2003 were based on counts at Tumwater Dam.

Brood year	Fish/Redd	Spawning escapement		
		Little Wenatchee	White	Total
1989	NA	NA	NA	**28,778**
1990	NA	NA	NA	**25,177**
1991	NA	NA	NA	**26,565**
1992	NA	NA	NA	**22,628**
1993	NA	NA	NA	**29,952**
1994	NA	NA	NA	**9,447**
1995	NA	NA	NA	**4,272**
1996	NA	NA	NA	**7,534**
1997	NA	NA	NA	**10,808**
1998	NA	NA	NA	**4,047**
1999	NA	NA	NA	**1,025**
2000	NA	NA	NA	**20,751**
2001	NA	NA	NA	**29,134**

Brood year	Fish/Redd	Spawning escapement		
		Little Wenatchee	White	Total
2002	NA	NA	NA	**27,565**
2003	NA	NA	NA	**4,704**
2004	NA	NA	NA	**25,834**
2005	NA	NA	NA	**8,582**
2006	2.26	574	5,634	**6,208**
Average	***2.26***	***574***	***5,634***	***16,278***

Area-under-the-curve

Based on the AUC approach, the estimated total spawning escapement of sockeye in the Wenatchee basin was 7,813 (Table 4.17). This estimate is about 1.3 times greater than the estimate based on the fish/redd method.

4.5 Carcass Surveys

Carcass surveys were conducted in the Little Wenatchee and White (including the Napeequa River) rivers from 29 August to 24 October 2006.

Number sampled

A total of 2,297 sockeye carcasses were sampled during August through October, 2006, in the Wenatchee Basin (Table 4.19). This is slightly less than the 14-year average of 2,389 carcasses. Most of the carcasses sampled in 2006 were collected in the White River basin (96% or 2,196 carcasses) (Figure 4.3). The remaining 4% were sampled in the Little Wenatchee River (101 carcasses).

Table 4.19. Numbers of sockeye carcasses sampled within different streams/watersheds within the Wenatchee basin, 1989-2006.

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**

Survey year	Numbers of sockeye carcasses			
	Little Wenatchee	White	Napeequa	Total
2005	1	7	0	**8**
2006	101	2,158	38	**2,297**
Average	***230***	***2,139***	***21***	***2,389***

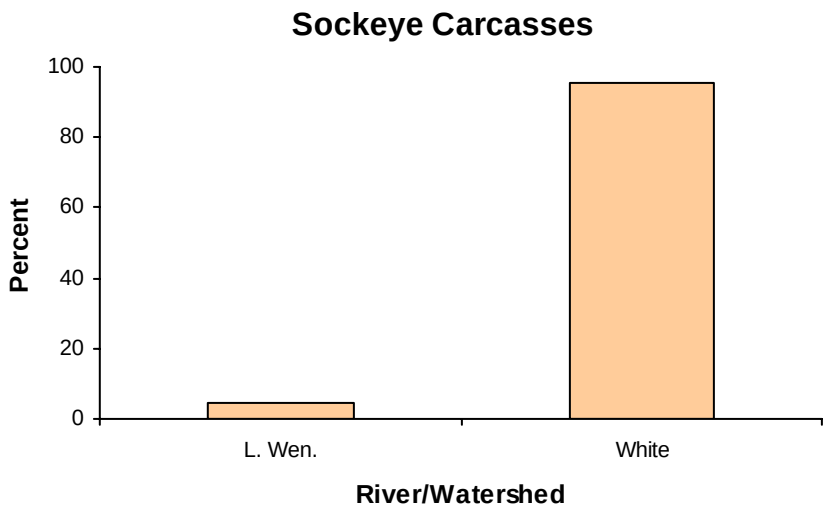


Figure 4.3. Percent of the total number of sockeye carcasses sampled in different streams/watersheds within the Wenatchee basin during August through October, 2006.

Carcass Distribution and Origin

Sockeye carcasses were not evenly distributed among reaches within survey streams in 2006 (Table 4.20). Carcasses were only found in Reaches 2 (Lost Creek to Rainy Creek) on the Little Wenatchee. Most (98%) of the carcasses sampled in the White River were in Reach 2 (Sears Creek Bridge to Napeequa River). About 2% of the carcasses sampled in the White River basin were in the Napeequa River.

Table 4.20. Numbers of carcasses sampled within different streams/watersheds within the Wenatchee basin during August through September, 2006.

Stream/watershed	Reach	Total carcasses
Little Wenatchee	Little Wen 2	101
	Little Wen 3	0
	Total	**101**
White	White 1	3
	White 2	2,155
	Napeequa 1	38
	Total	**2,196**
Grand Total		***2,297***

Numbers of wild and hatchery origin sockeye carcasses sampled in 2005 and 2006 will be available after analysis of marks/tags and scales. In general, the largest percentage of both wild and hatchery sockeye spawned in Reach 2 on the White River (Table 4.21 and Figure 4.4). However, a greater percentage of wild fish were found in Reach 2 than hatchery fish. The opposite occurred in Reach 2 on the Little Wenatchee. A larger percentage of hatchery fish were found there compared to wild fish.

Table 4.21. Numbers of wild and hatchery sockeye carcasses sampled within different reaches in the Wenatchee basin, 1993-2004. 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	**368**
	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	**1,519**
	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	**7,477**
	Hatchery	19	0	0	205	22	**246**
Average	***Wild***	***242***	***0***	***0***	***2,253***	***24***	***2,519***
	Hatchery	***17***	***0***	***0***	***61***	***2***	***80***

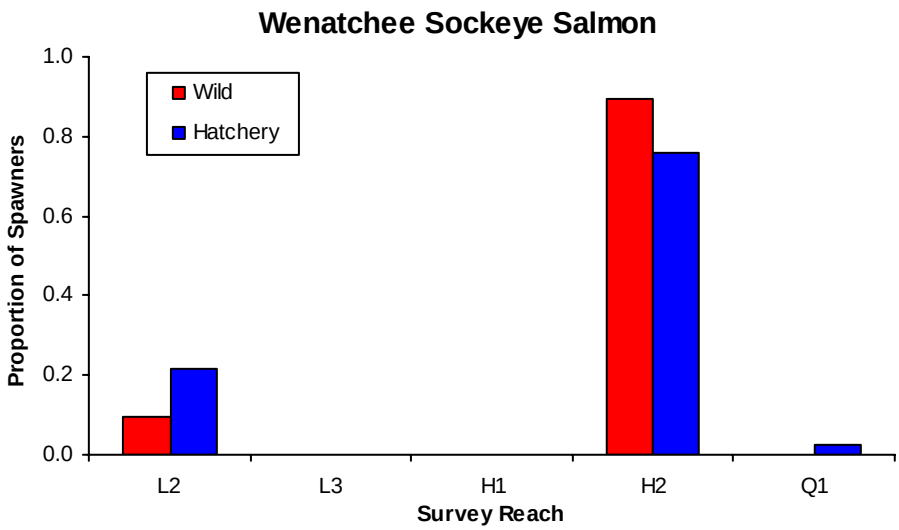


Figure 4.4. Distribution of wild and hatchery produced carcasses in different reaches in the Wenatchee basin, pooled data from 1993-2004. Reach codes are described in Table 2.9; L = Little Wenatchee, H = White River, and Q = Napeequa River.

Sampling Rate

The sampling rate of sockeye carcasses varied depending on the method used to estimate spawning escapement (Table 4.22). Based on the fish/redd method, the overall sampling rate was 37%. That is, 37% of the spawning escapement was sampled in 2006. If escapement is estimated with the AUC approach, the overall sampling rate was 29%. Regardless of which approach is used to estimate spawning escapement, the overall sampling rate was greater than the target of 20%.

Table 4.22. Numbers of redds and carcasses, estimated spawning escapements, and sampling rates for sockeye salmon in the Wenatchee basin, 2006; AUC = area-under-the-curve.

Sampling basin	Total number of redds	Total number of carcasses	Fish/redd method		AUC method	
			Escapement	Sampling rate	Escapement	Sampling rate
L. Wenatchee	254	101	574	0.18	710	0.14
White	2,493	2,196	5,634	0.39	7,103	0.31
Total	***2,747***	***2,297***	***6,208***	***0.37***	***7,813***	***0.29***

Length Data

Mean lengths (POH, cm) of male and female sockeye carcasses sampled during surveys in the Wenatchee basin in 2006 are provided in Table 4.23. On average, males were slightly larger than females.

Table 4.23. Mean lengths (postorbital-to-hypural length; cm) and standard deviations (in parentheses) of male and female sockeye carcasses sampled in different streams/watersheds in the Wenatchee basin, 2006; N = number of fish sampled.

Stream/watershed	Male		Female	
	N	Length (cm)	N	Length (cm)
Little Wenatchee River	200	42 (3)	243	41 (3)
White River	710	43 (3)	991	41 (3)
Napeequa River	10	42 (2)	23	40 (2)
Wenatchee River	15	44 (3)	40	42 (2)
Total	***935***	***43 (3)***	***1,297***	***41 (3)***

4.6 Life History Monitoring

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

Migration Timing

There was little difference in migration timing of wild and hatchery sockeye sampled at Tumwater Dam (Table 4.24; Figure 4.5). Most hatchery and wild sockeye migrated upstream past Tumwater dam during July through early August. The highest proportion of both wild and hatchery fish migrated during the last week of July and the first week of August.

Table 4.24. The proportion of wild and hatchery sockeye sampled at Tumwater Dam weekly during the migration period, 1998-2004.

Survey year	Origin	Proportion of sockeye sampled at Tumwater Dam weekly															Sample size
		Jun	Jul				Aug					Sep					
		1	2	3	4	5	6	7	8	9	10	11	12	12	14	15	
1998	Wild	-	0.00	0.11	0.54	0.29	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4,173
	Hatch	-	0.00	0.06	0.26	0.42	0.03	0.16	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31
1999	Wild	-	-	-	-	-	0.00	0.03	0.25	0.44	0.20	0.05	0.02	0.01	-	-	908
	Hatch	-	-	-	-	-	0.00	0.02	0.23	0.45	0.24	0.04	0.02	0.01	-	-	264
2000	Wild	0.00	0.00	0.00	0.01	0.29	0.50	0.16	0.03	0.00	0.00	0.00	0.00	0.00	-	-	18,365
	Hatch	0.00	0.00	0.00	0.03	0.29	0.46	0.18	0.04	0.00	0.00	0.00	0.00	0.00	-	-	2,566
2001	Wild	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Hatch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002	Wild	-	-	-	0.02	0.59	0.26	0.08	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	27,241
	Hatch	-	-	-	0.01	0.56	0.24	0.12	0.05	0.01	0.00	0.01	0.00	0.00	0.00	0.00	579
2003	Wild	-	0.00	0.19	0.48	0.26	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-	4,699
	Hatch	-	0.00	0.14	0.40	0.32	0.10	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-	375
2004	Wild	0.00	0.06	0.47	0.30	0.11	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31,409
	Hatch	0.00	0.10	0.55	0.25	0.07	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,758

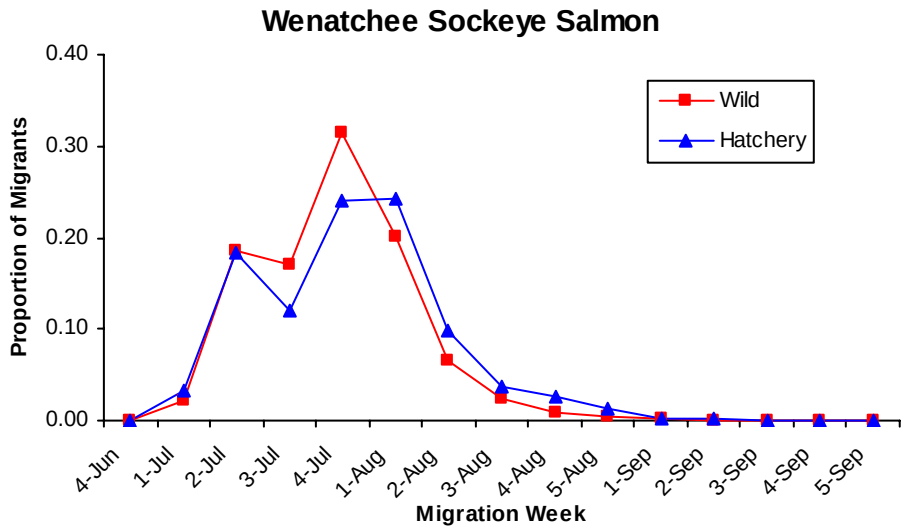


Figure 4.5. Proportion of wild and hatchery sockeye sampled at Tumwater Dam each week during their migration period late-June through September; data were pooled over survey years 1998-2004.

Age at Maturity

Although sample sizes are small, it appears that most wild sockeye returned as age-5 fish, while most hatchery sockeye returned as age-4 fish (Table 4.25; Figure 4.6). Only wild fish have returned at age-6.

Table 4.25. Proportions of wild and hatchery sockeye of different ages (total age) sampled at Tumwater Dam and on spawning grounds, 1994-2005.

Survey year	Origin	Total age						Sample size
		2	3	4	5	6	7	
1994	Wild	-	-	-	-	-	-	0
	Hatchery	0.00	0.00	0.88	0.13	0.00	0.00	16
1995	Wild	-	-	-	-	-	-	0
	Hatchery	0.00	0.00	0.00	1.00	0.00	0.00	1
1996	Wild	-	-	-	-	-	-	0
	Hatchery	0.00	0.00	1.00	0.00	0.00	0.00	82
1997	Wild	-	-	-	-	-	-	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
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
	Hatchery	0.00	0.02	0.93	0.05	0.00	0.00	244
2005	Wild	-	-	-	-	-	-	0
	Hatchery	0.00	0.13	0.75	0.13	0.00	0.00	8
Average	***Wild***	***0.00***	***0.01***	***0.36***	***0.58***	***0.06***	***0.00***	***179***
	Hatchery	***0.00***	***0.01***	***0.87***	***0.13***	***0.00***	***0.00***	***1,005***

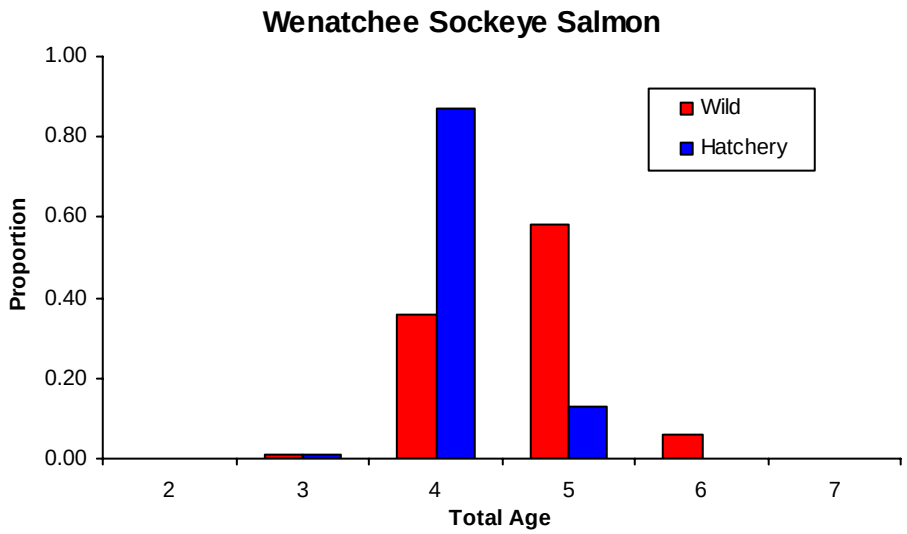


Figure 4.6. Proportions of wild and hatchery sockeye salmon of different total ages sampled at Tumwater Dam and on spawning grounds in the Wenatchee basin for the combined years 1994-2005.

Size at Maturity

Although sample sizes are low, there was virtually no difference in mean sizes of hatchery and wild sockeye salmon sampled in the Wenatchee basin (Table 4.26). Wild fish were only slightly larger on average than hatchery fish. Future analyses will compare sizes of hatchery and wild fish of the same age groups and gender.

Table 4.26. Mean lengths (POH; cm) and variability statistics for wild and hatchery sockeye salmon sampled at Tumwater Dam and on spawning grounds in the Wenatchee basin, 1994-2005; SD = 1 standard deviation.

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
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
Pooled	***Wild***	***730***	***43***	***3***	***34***	***50***
	Hatchery	***961***	***41***	***3***	***30***	***64***

Contribution to Fisheries

The total number of hatchery and wild sockeye captured in different fisheries is provided in Tables 4.27 and 4.28. Harvest on hatchery sockeye was minimal during brood years 1989-2000. In contrast, harvest on wild sockeye was relatively high for brood years 1989-1993. Thereafter, harvest was low.

Table 4.27. Estimated number and percent (in parentheses) of hatchery Wenatchee sockeye captured in different fisheries; NA = not available.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal (Zone 6)	Commercial (Zones 1-5)	Recreational[a] (sport)	
1989	NA	0 (0)	0 (0)	0 (0)	0
1990	NA	0 (0)	0 (0)	0 (0)	0
1991	NA	0 (0)	0 (0)	0 (0)	0
1992	NA	0 (0)	0 (0)	0 (0)	0
1993	NA	0 (0)	0 (0)	639 (100)	639
1994	NA	0 (0)	0 (0)	0 (0)	0
1995	NA	0 (0)	0 (0)	0 (0)	0
1996	NA	0 (0)	0 (0)	0 (0)	0
1997	NA	0 (0)	0 (0)	0 (0)	0
1998	NA	0 (0)	0 (0)	0 (0)	0
1999	NA	0 (0)	0 (0)	0 (0)	0
2000	NA	-	-	0 (0)	145

[a] Includes the Lake Wenatchee fishery.

Table 4.28. Estimated number and percent (in parentheses) of wild Wenatchee sockeye captured in different fisheries; NA = not available.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal (Zone 6)	Commercial (Zones 1-5)	Recreational[a] (sport)	
1989	NA	1,247 (96)	57 (4)	0 (0)	1,304
1990	NA	1,973 (23)	79 (1)	6,523 (76)	8,575
1991	NA	1,898 (23)	56 (1)	6,311 (76)	8,265
1992	NA	893 (20)	39 (1)	3,565 (79)	4,497
1993	NA	341 (5)	57 (1)	6,400 (94)	6,798
1994	NA	0 (0)	85 (100)	0 (0)	85
1995	NA	0 (0)	0 (0)	0 (0)	0
1996	NA	0 (0)	0 (0)	0 (0)	0
1997	NA	0 (0)	0 (0)	0 (0)	0
1998	NA	0 (0)	0 (0)	0 (0)	0
1999	NA	0 (0)	0 (0)	0 (0)	0
2000	NA	-	-	0 (0)	566

[a] Includes the Lake Wenatchee fishery.

Straying

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Wenatchee basin. Targets for strays based on return year (recovery year) outside the Wenatchee basin should be less than 0.050. The target for brood year stray rates also should be less than 0.050.

Stray rates for available brood years have not exceeded the target of 0.050 (Table 4.29). Stray rates of Wenatchee sockeye were generally less than 1%.

Table 4.29. Stray rates by brood year for Wenatchee sockeye salmon, 1989-2000; NA = not available. Target is stray rate less than 0.05. *(The numbers in this table may change as the HETT and HC refine the methods for estimating sockeye stray rates)*

Brood year	Stray rate
1989	NA
1990	0.000
1991	0.000
1992	0.012
1993	0.000
1994	0.000
Average	***0.002***

Genetics

Tissue (operculum) samples were collected from 144 wild and 144 hatchery Sockeye in the Wenatchee basin in 2006. These samples have not been processed. Results from these samples should be available next year.

Natural Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural origin recruits (NOR) to the parent spawning population. For brood years 1989-1999, NRR in the Wenatchee averaged 1.18 (range, 0.09-4.21) if harvested fish were not included in the estimate and 1.24 (range, 0.09-4.46) if harvested fish were included in the estimate (Table 4.30). 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 4.30. Spawning escapements, natural origin recruits (NOR), and natural replacement rates (NRR; with and without harvest) for wild sockeye salmon in the Wenatchee basin, 1989-2000. *(The numbers in this table may change as the HETT and HC refine the methods for estimating sockeye NORs, and NRRs.)*

Brood year	Escapement	NOR	NRR	
			Harvest not included	Harvest included
1989	28,778	29,077	1.04	1.04
1990	25,177	32,033	0.24	0.24
1991	26,565	33,233	0.22	0.22
1992	22,628	26,555	0.29	0.29
1993	29,952	33,946	0.43	0.43

Brood year	Escapement	NOR	NRR	
			Harvest not included	Harvest included
1994	9,447	9,076	0.11	0.11
1995	4,272	4,415	0.18	0.19
1996	7,534	7,292	4.21	4.46
1997	10,808	10,914	3.31	3.61
1998	4,047	4,166	2.82	3.01
1999	1,025	1,041	0.09	0.09
2000	20,751	19,763	-	-
Average	***15,915***	***17,626***	***1.18***	***1.24***

Hatchery Replacement Rates

Hatchery replacement rates were estimated as hatchery adult-to-adult returns. These rates should be greater than the NRRs and greater than or equal to 5.40 (the value in BAMP; Murdoch and Peven 2005). HRRs exceeded NRRs in five of the 11 years of data (including harvest in the estimates) (Table 4.31). If harvest was not included in the estimates, HRRs exceeded NRRs in only two out of the 11 years of data. Hatchery replacement rates for Wenatchee sockeye have not equaled or exceeded the BAMP target of 5.40.

Table 4.31. Hatchery replacement rates (HRR), NRR, and BAMP target (5.40) for sockeye salmon in the Wenatchee basin, 1989-2000; NA = not available. *(The numbers in this table may change as the HETT and HC refine the methods for estimating sockeye HRRs and NRRs.)*

Brood year	Harvest not included			Harvest included		
	HRR	NRR	BAMP	HRR	NRR	BAMP
1989	0.01	1.04	5.40	2.15	1.04	5.40
1990	1.22	0.24	5.40	1.23	0.24	5.40
1991	0.01	0.22	5.40	0.01	0.22	5.40
1992	0.28	0.29	5.40	0.30	0.29	5.40
1993	0.11	0.43	5.40	0.16	0.43	5.40
1994	0.21	0.11	5.40	0.22	0.11	5.40
1995	0.00	0.18	5.40	0.01	0.19	5.40
1996	0.02	4.21	5.40	0.90	4.46	5.40
1997	0.02	3.31	5.40	1.07	3.61	5.40
1998	0.00	2.82	5.40	0.09	3.01	5.40
1999	0.00	0.09	5.40	3.66	0.09	5.40
Average	***0.17***	***1.18***	***5.40***	***0.89***	***1.24***	***5.40***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adults divided by the number of hatchery smolts released. SARs were based on CWT returns. For the available brood years, SARs have ranged from 0.0000 to 0.0015 for hatchery sockeye salmon (Table 4.32).

Table 4.32. Smolt-to-adult ratios (SARs) for Wenatchee sockeye salmon; NA = not available.

Brood year	Number released	SAR
1990	252,071	0.001486
1991	149,761	0.000000
1992	243,202	0.000004
1993	138,637	0.000082
1994	211,462	0.000287
1995	NA	NA
1996	NA	NA
1997	NA	NA
1998	159,051	NA
1999	NA	NA
Average	***192,364***	***0.000372***

4.7 ESA/HCP Compliance

Broodstock Collection

The 2004 Lake Wenatchee broodstock collection totaled 210 fish and encompassed three days of collection between 12 July and 21 July 2004. This was a compressed collection schedule compared to that outlined in the 2004 broodstock collection protocol. The collection period was compressed because of the early run-timing of the 2004 brood. The 1999-2003 average cumulative 75% passage date was 8 August. During 2004, sockeye run-timing past Tumwater dam was substantially earlier with 24 July representing the 90% cumulative passage date. This earlier run timing in 2004 necessitated the advanced broodstock collection.

The 2004 sockeye broodstock collections at Tumwater Dam occurred concurrently with spring Chinook reproductive success monitoring and evaluation activities (BPA project No. 2003-039-00) and Wenatchee steelhead broodstock collection activities authorized through ESA permits 1196 and 1395, respectively. No ESA-listed spring Chinook or steelhead takes occurred during sockeye broodstock collections at Tumwater Dam that were outside those authorized through ESA Section 10 permits 1196 and 1395.

Hatchery Rearing and Release

The 2004 Wenatchee sockeye program released 172,923 juveniles, representing 86.5% of the program production objective. The release was also below the ESA Permit 1347 production level limitation of 200,000 juveniles.

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, and 1395, permit holders shall monitor and report hatchery effluents in compliance with applicable National Pollution Discharge Elimination Systems (NPDES) (EPA 1999) permit limitations. NPDES monitoring and reporting for Chelan PUD Hatchery Programs during 2006 are provided in Appendix E.

Smolt and Emigrant Trapping

ESA-listed spring Chinook and steelhead were encountered during operation of the upper and lower Wenatchee traps. ESA takes are reported in the steelhead (Section 3.7) and spring Chinook (Section 5.7) sections and will not be repeated here.

Spawning Surveys

Sockeye spawning ground surveys conducted in the Wenatchee basin during 2006 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 impacts 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

Although this section of the report focuses on results from monitoring the Chiwawa spring Chinook program, information on spring Chinook collected throughout the Wenatchee basin is also provided.

5.1 Broodstock Sampling

This section focuses on results from sampling 2004-2006 Chiwawa spring Chinook broodstock, which were collected at the Chiwawa weir and at Tumwater Dam. Some information for the 2006 return is not available at this time (e.g., age structure). This information will be provided in the 2007 annual report.

Origin of Broodstock

Hatchery origin adults made up between 60-70% of the Chiwawa spring Chinook broodstock for return years 2004-2006 (Table 5.1). Hatchery origin adults were targeted at both Tumwater Dam and the Chiwawa weir. In an effort to partially address straying of Chiwawa spring Chinook to other tributaries in the basin and secondarily to ensure meeting adult collection quotas, hatchery origin adults were collected to the greatest extent possible at Tumwater Dam. Natural origin fish were collected only at the Chiwawa weir. Broodstock were trapped at Tumwater Dam from late May through August and at the Chiwawa weir from mid June to early September.

Table 5.1. Numbers of wild and hatchery Chiwawa spring Chinook collected for broodstock, numbers that died before spawning, and numbers of Chinook spawned, 1989-2006. Unknown origin fish (i.e., undetermined by scale analysis, no CWT or fin clips, and no additional hatchery marks) were considered naturally produced. Pre-spawning loss does not include all mortality.

Return year	Wild spring Chinook			Hatchery spring Chinook			Total number spawned
	Number collected	Pre-spawn loss	Number spawned	Number collected	Pre-spawn loss	Number spawned	
1989	28	0	28	0	0	0	28
1990	19	1	18	0	0	0	18
1991	32	0	32	0	0	0	32
1992	39	0	39	39	0	39	78
1993	100	3	94	0	0	0	94
1994	9	0	7	4	0	4	11
1995	No program						
1996	8	0	8	10	0	10	18
1997	37	0	32	83	1	79	111
1998	13	0	13	35	1	34	47
1999	No program						
2000	10	0	9	38	1	21	30
2001	114	2	107	267	8	265	372
2002	21	0	20	63	1	51	71
2003	44	1	41	75	2	53	94

2004	100	1	83	196	30	132	215
2005	96	1	90	185	3	181	271
2006	96	0	93	300	0	222	315
Average	***48***	***1***	***45***	***81***	***3***	***68***	***113***

Age/Length Data

Ages were determined from scales and/or coded wire tags (CWT) collected from broodstock. For both the 2004 and 2005 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, 1991-2005.

Return year	Origin	Total age			
		2	3	4	5
1991	Wild	0.0	15.6	59.4	25.0
	Hatchery	0.0	0.0	0.0	0.0
1992	Wild	0.0	0.0	0.0	0.0
	Hatchery	0.0	0.0	0.0	0.0
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
	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	76.3	23.7	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

Return year	Origin	Total age			
		2	3	4	5
	Hatchery	0.0	21.3	5.3	73.3
2004	Wild	1.1	4.3	89.4	5.3
	Hatchery	0.0	36.9	63.1	0.0
2005	Wild	0.0	1.1	84.2	14.7
	Hatchery	0.0	4.3	94.6	1.1
Average	***Wild***	***0.2***	***4.9***	***66.9***	***28.0***
	Hatchery	***0.0***	***14.2***	***77.8***	***8.0***

There was little difference in mean lengths between hatchery and natural origin broodstock of age-4 and 5 Chinook in 2004 and 2005 (Table 5.3). The greatest difference in lengths between hatchery and natural origin Chinook was observed within age-3 fish. Depending on the return year, mean lengths differed by as much as 6.8 to 7.6 cm between hatchery and natural origin fish. Interestingly, however, age-3 natural origin fish were larger than hatchery fish in 2004, but the opposite was true in 2005 (Table 5.3).

Table 5.3. Mean fork length (cm) at age (total age) of hatchery and wild spring Chinook collected from broodstock, 1991-2005; 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	22	3	92	78	4
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-
1994	Wild	-	0	-	-	0	-	79	2	3	96	5	6
	Hatchery	-	0	-	-	0	-	82	2	11	91	2	3
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	-

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	-	58	29	7	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
	Hatchery	-	0	-	59	16	5	86	4	18	96	55	6
2004	Wild	47	1	-	57	4	4	80	84	5	95	5	9
	Hatchery	-	0	-	49	72	6	79	123	6	-	0	-
2005	Wild	-	0	-	49	1	-	80	80	6	96	14	8
	Hatchery	-	0	-	56	8	5	82	175	6	93	2	2

Sex Ratios

Male spring Chinook in 2004-2006 return years made up about 54%, 52%, and 43%, respectively, of the adults collected. This resulted in overall male to female ratios of 1.18:1.00, 1.08:1.00, and 0.77:1.00, respectively (Table 5.4). Only returns in 2006 were below the 1:1 ratio target in the broodstock protocol. During the three return years, natural origin fish consisted of a slightly higher proportion of males than did hatchery origin fish (Table 5.4.).

Table 5.4. Numbers of male and female wild and hatchery spring Chinook collected for broodstock, 1989-2006. 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	0.64:1.00	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	50	47	1.06:1.00	123	178	0.69:1.00	0.77:1.00
Total	***407***	***402***	***1.01:1.00***	***570***	***687***	***0.83:1.00***	***0.90:1.00***

Fecundity

Mean fecundities for the 2004-2006 returns of spring Chinook ranged from 4,320-4,800 eggs per female (Table 5.5). These fecundities were less than the 16-year average of 4,810 eggs per female, but were close to the expected fecundity of 4,400 eggs per female assumed in the broodstock protocol. For the three return years, natural origin Chinook produced more eggs per female than did hatchery origin fish (Table 5.5). This is probably related to differences in size and age of hatchery and natural origin fish described above.

Table 5.5. Mean fecundity of wild, hatchery, and all female spring Chinook collected for broodstock, 1989-2006; 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	4,505	4,654
2003	6,191	5,561	5,844
2004	4,846	4,775	4,799
2005	4,365	4,311	4,327
2006	4,778	4,144	4,324
Average	***4,963***	***4,759***	***4,810***

* 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 are required to meet the program release goal of 672,000 smolts. Between 1989 and 2006, the egg take goal was reached in one year (Table 5.6).

ESA Permit 1196 sets limits on the percentage of the total run, natural origin run, and a minimum contribution of natural origin fish that must be in the broodstock. Applying these criteria to the low total abundance of spring Chinook salmon to the Chiwawa 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, 1989-2006.

Return year	Number of eggs taken
1989	45,311
1990	60,287
1991	73,601
1992	111,624
1993	257,208
1994	35,539
1995	No program
1996	18,579
1997	312,182
1998	90,521
1999	No program
2000	55,256
2001	1,099,630
2002	196,186
2003	247,501
2004	538,176
2005	536,490
2006	744,344
Average	***276,402***

Disease

Mortality from external fungus within the 2004 brood began to increase in juveniles in early November 2005, about the same time water sources were switched from Chiwawa River to the

Wenatchee River. A 20-day formalin treatment was initiated to control the fungus. In early January 2006, *Dermocystidium* was detected at light levels and a series of trials were conducted on small test lots to determine if the drug Ivermectin, which is used to control sea lice in ocean net pen programs, would be effective. These trials were terminated shortly after initiation because of the toxicity of the drug. Mortality was maintained at a relatively low level for the duration of acclimation.

Number of acclimation days

Rearing of the 2004 brood Chiwawa spring Chinook was similar to previous years with fish being held on well water before being transferred to Chiwawa Ponds for final acclimation. Fish were acclimated for 124 days on Wenatchee River water and between 88 to 104 days on Chiwawa River water, depending on volitional or forced release (Table 5.7). Fish were initially on Chiwawa River water for 37 days before being switched to Wenatchee River water for 120 days during the frazil ice period. The 2004 brood were switched back to Chiwawa River water for one day in mid February before they switched back for four days, again due to frazil ice. After 12 February 2006 the 2004 brood remained on Chiwawa River water for the duration of their rearing.

Table 5.7. Number of days spring Chinook broods were acclimated and water source, brood years 1989-2004; 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
2004	2006	3 –Sep	1-May	220	88-104	124
Average				***210***	***88-104***	***124***

Release Information

Numbers released

The 2004 brood Chiwawa spring Chinook program achieved 73.6% of the 672,000 target goal with about 494,517 fish being released into the Chiwawa River (Table 5.8). Fish were released in two groups; a volitional release for about one month with the mid-point coinciding with a new moon phase and a forced release also coinciding with the new moon phase. The intent of the two releases is to evaluate the efficacy of release methodology on smolt to adult survival as well as decrease the potential for interactions with naturally produced fish. Fish that were allowed to volitionally migrate on their own may have faster emigration rates, higher smolt to smolt survival, and may be less likely to interact with their natural cohorts.

Table 5.8. Numbers of spring Chinook smolts released from the hatchery, 1989-2004. The release target for Chiwawa spring Chinook is 672,000 smolts.

Brood year	Release year	Number of smolts
1989	1991	43,000
1990	1992	53,170
1991	1993	62,138
1992	1994	85,113
1993	1995	223,610
1994	1996	27,226
1995	1997	No program
1996	1998	15,176
1997	1999	266,148
1998	2000	75,906
1999	2001	No program
2000	2002	47,104
2001	2003	377,544
2002	2004	149,668
2003	2005	222,131
2004	2006	494,517
Average		***153,032***

Numbers tagged

The 2004 brood Chiwawa spring Chinook were 100% CWT and adipose fin clipped. For the 2005 brood spring Chinook, a total of 10,063 juveniles were PIT tagged and adipose-fin clipped at Eastbank Hatchery during 28-30 August 2006 (Table 5.9). Of these, 5,032 came from pond 12 and 5,031 from pond 13. Tagged fish from pond 12 were transported to the Chiwawa Hatchery on 25 and 26 September, while those from pond 13 were transported on 27 and 28 September. During spring, 2007, one group of 4,988 tagged Chinook was released volitionally and another group of 4,993 was

forced released. Of the total number of spring Chinook PIT tagged (10,063), 74 died and eight others shed their tags (Table 5.9). Some of the mortality was associated with a river otter that was observed moving in and out of the raceways during the winter.[5]

Table 5.9. Summary of PIT tagging activities for spring Chinook (2005 brood) at the Eastbank Hatchery, 2006. Dead fish counted before 15 September likely represent deaths associated with tagging; deaths after 15 September were probably not related to tagging.

Rearing Pond	Number of fish tagged	Number of fish that died		Number of tags shed	Number of tagged fish released
		Before 9/15	After 9/15		
12	5,032	4	32	3	4,993
13	5,031	5	33	5	4,988
Total	***10,063***	***9***	***65***	***8***	***9,981***

Fish size and condition at release

Spring Chinook from the 2004 brood were released as yearling smolts between April and May of 2006. Size at release of both groups was below the targets established for the program. However, the coefficient of variation of fork length was below the target indicating fish were released with an acceptable size distribution (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, 1989-2004. 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	161	6.1	50.2	9

[5] PIT tags were found in otter scat. These tags were removed from the data files.

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
2004	2006	143	4.9	36.7	12
Targets		***176***	***9.0***	***37.8***	***12***

Survival Estimates

Overall survival of Chiwawa spring Chinook from green (unfertilized) egg to release was above the standard set for the program. Pre-spawn survival of males was slightly below the program standard. These males were age-3 fish. The mortality was the result of Erythromycin toxicity prescribed to minimize vertical transmission of bacterial kidney disease (Table 5.11).

Table 5.11. Hatchery life-stage survival rates (%) for spring Chinook, brood years 1989-2004; NA = not available (these survivals will be provided in the 2007 annual report). 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	93.6
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	84.5
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	75.9
1995	No program								
1996	100.0	100.0	88.3	100.0	93.8	93.0	89.9	97.7	79.4
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
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	44.7
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	86.2
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

5.3 Natural Juvenile Productivity

During 2006, juvenile spring Chinook were sampled at the Upper Wenatchee, Lower Wenatchee, and Chiwawa traps and counted during snorkel surveys within the Chiwawa basin.

Parr Estimates

A total of 79,902 (±17.9%) subyearling and 388 (±29.9%) yearling spring Chinook were estimated in the Chiwawa River basin in August 2006 (Table 5.12 and 5.13). During the survey period 1992-2006, numbers of subyearling and yearling Chinook have ranged from 5,815 to 134,872 and 5 to 563, respectively, in the Chiwawa basin (Table 5.12 and 5.13; Figure 5.1). Numbers of all fish counted in the Chiwawa basin are reported in Appendix A.

Table 5.12. Total numbers of subyearling spring Chinook estimated in different steams in the Chiwawa Basin during snorkel surveys in August 1992-2006; NS = not sampled.

Sample Year	Number of subyearling spring Chinook									
	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Peven Creek	Big Meadow Creek	Alder Creek	Brush Creek	Y 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**

Table 5.13. Total numbers of yearling spring Chinook estimated in different steams in the Chiwawa Basin during snorkel surveys in August 1992-2006; NS = not sampled.

Sample Year	Number of yearling spring Chinook									
	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Peven 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**
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**

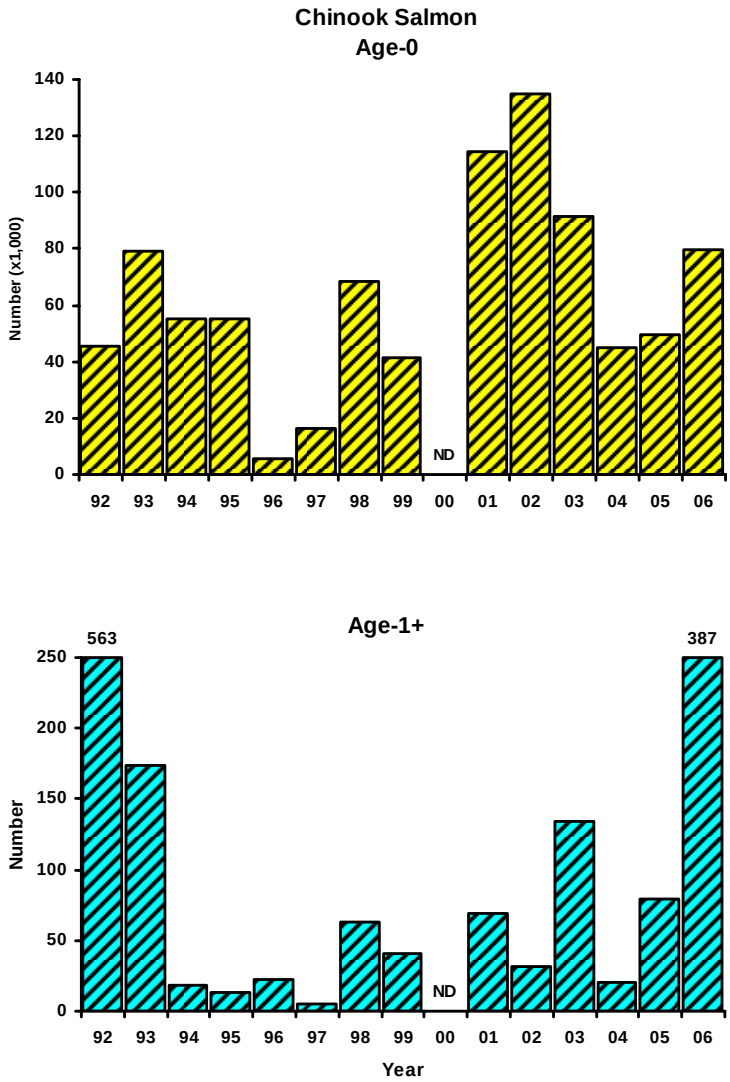


Figure 5.1. Numbers of subyearling and yearling Chinook salmon within the Chiwawa River Basin in August 1992-2006; ND = no data.

Juvenile Chinook were distributed contagiously among reaches in the Chiwawa River. Their densities were highest in the upper portions of the basin; although the highest density occurred in Brush Creek (24,494 fish/ha). Juvenile Chinook were most abundant in multiple channels and least abundant in glides. Most Chinook associated closely with woody debris in multiple channels. These sites (multiple channels) made up 29% of the total area of the Chiwawa Basin, but they provided habitat for 54% of all the subyearling Chinook in the basin in 2006. In contrast, riffles made up 47% of the total area, but provided habitat for only 12% of all juvenile Chinook in the Chiwawa Basin. Pools made up 16% 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 less than those in corresponding reference areas (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.

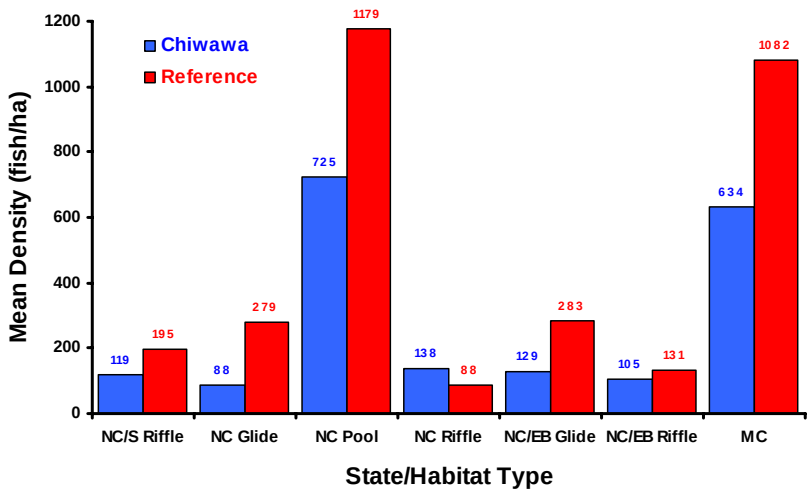


Figure 5.2. Comparison of the thirteen-year means of subyearling spring Chinook densities within state/habitat types in reaches 3 and 8 of the Chiwawa River and their matched reference areas on Nason Creek and the Little Wenatchee River. NC = natural channel; S = straight channel; EB = eroded banks; MC = multiple channel.

Smolt and Emigrant Estimates

Numbers of spring Chinook smolts and emigrants were estimated at the Upper Wenatchee, Chiwawa, and Lower Wenatchee traps in 2006.

Chiwawa Trap

The Chiwawa Trap operated between 28 February and 27 November 2006. During that time period the trap was inoperable for 9 days because of high river flows, debris, snow/ice, or mechanical failure. The trap operated in two different positions depending on stream flow; lower position at flows greater than 12 m^3/s and an upper position at flows less than 12 m^3/s. 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 (2004 brood year) were primarily captured from March to June 2006 (Figure 5.3). Based on capture efficiencies estimated from the flow model, the total number of wild yearling Chinook emigrating from the Chiwawa River was 72,080 (±330,373). Combining the total number of subyearling spring Chinook (44,079) that emigrated during the fall of 2005 with the total number of yearling Chinook (72,080) that emigrated during 2006 resulted in a total emigrant estimate of 116,158 (±334,054) spring Chinook for the 2004 brood year (Table 5.14).

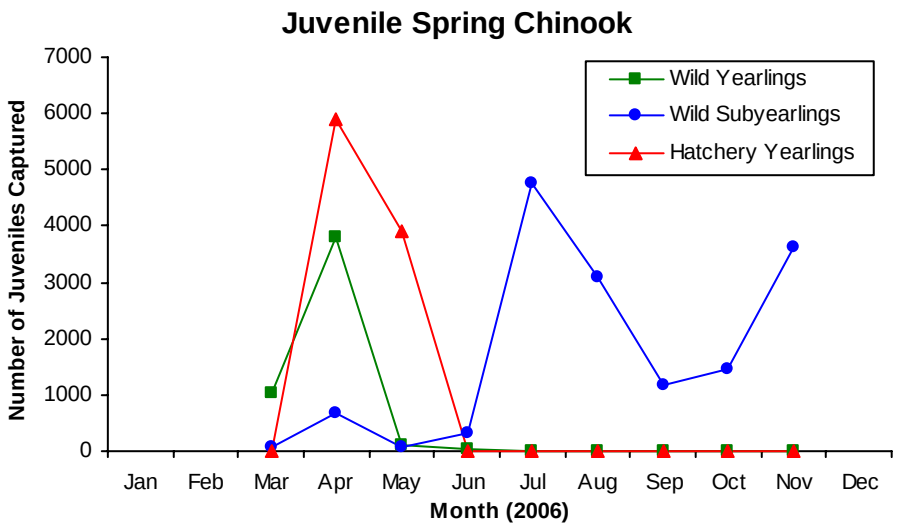


Figure 5.3. Monthly captures of wild subyearling, wild yearling, and hatchery yearling spring Chinook at the Chiwawa Trap, 2006.

Table 5.14. Numbers of juvenile spring Chinook at different life stages in the Chiwawa basin for brood years 1991-2006; NS = not sampled.

Brood year	Number of redds	Egg deposition	Number of parr	Number of smolts produced within Chiwawa basin[a]	Total number of smolts[b]	Number of emigrants
1991	104	478,400	45,483[c]	42,525	42,525	42,525[d]
1992	302	1,570,098	79,113	39,723	56,763	65,541
1993	106	556,394	55,056	8,662	17,926	22,698
1994	82	485,686	55,240	16,472	22,145	25,067
1995	13	66,248	5,815	3,830	5,230	5,951
1996	23	106,835	16,066	15,475	17,922	19,183
1997	82	374,740	68,415	28,334	39,044	44,562
1998	41	218,325	41,629	23,068	24,953	25,923
1999	34	166,090	NS	10,661	13,953	15,649
2000	128	642,944	114,617	40,831	50,634	55,685
2001	1,046	4,836,704	134,874	86,482	389,940	546,266
2002	345	1,605,630	91,278	90,948	152,547	184,279
2003	111	648,684	45,177	16,755	27,897	33,637
2004	253	1,214,147	49,631	72,080	101,172	116,158
2005	362	1,566,374	79,902	-	-	-
2006	297	1,284,228	-	-	-	-
Average	***208***	***988,845***	***63,021***	***35,418***	***68,761***	***85,937***

[a] The estimated number of smolts (yearlings) that are produced entirely within the Chiwawa basin. Smolt estimates for brood years 1992-1996 were calculated with a mark-recapture model; brood years 1997-2005 were calculated with a flow model.
[b] These numbers represent Chiwawa smolts produced within the entire Wenatchee basin. This assumes that 66% of the subyearling migrants from the Chiwawa basin survive to smolt in the Wenatchee basin, regardless of the number of subyearling migrants (i.e., no density dependence). Smolt estimates for brood years 1992-1996 were calculated with a mark-recapture model; brood years 1997-2005 were calculated with a flow model.
[c] Estimate only includes numbers of Chinook in the Chiwawa River. Tributaries were not sampled at that time.
[d] Estimate only includes numbers of yearling migrants. Subyearlings were not sampled at that time.

Wild subyearling spring Chinook (2005 brood year) were captured throughout the sampling period 6 March to 28 November 2006. Based on capture efficiencies estimated from the flow model for both the upper position and lower position, the total number of wild subyearling (fry and parr) Chinook from the Chiwawa River was 133,758 (±42,159). Removing fry from the estimate, a total of 108,595 (±38,362) parr emigrated from the Chiwawa Basin in 2006. Although subyearlings migrated during all months of sampling, most (75%) migrated during July, August, and September (Figure 5.3).

Yearling spring Chinook sampled in 2006 averaged 95 mm in length, 9.4 g in weight, and had a mean condition of 1.10 (Table 5.15). These size estimates were similar to the overall mean of yearling spring Chinook sampled in previous years (overall means: 95 mm, 9.9 g, and condition of 1.10). Subyearling spring Chinook sampled in 2006 at the Chiwawa Trap averaged 76 mm in length, averaged 5.1 g, and had a mean condition of 1.12 (Table 5.15). These sizes comport well with the overall mean of subyearling spring Chinook sampled in previous years (overall means, 78 mm, 5.8 g, and condition of 1.09).

Table 5.15. Mean fork length (mm), weight (g), and condition factor of subyearling and yearling spring Chinook collected in the Chiwawa Trap, 1996-2006. 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)

Sample year	Life stage	Sample size[a]	Mean size		
			Length (mm)	Weight (g)	Condition (K)
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)
Average	***Subyearling***	***2,762***	***78***	***5.8***	***1.10***
	Yearling	***2,248***	***95***	***9.5***	***1.10***

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

Upper Wenatchee Trap

The Upper Wenatchee Trap operated nightly between 3 March and 17 May 2006. During the three-month sampling period, a total of 138 wild yearling Chinook, 2,012 wild subyearling Chinook, and 10 hatchery yearling Chinook were captured at the Upper Wenatchee Trap. Monthly captures of all fish collected at the Upper Wenatchee Trap are reported in Appendix B.

Lower Wenatchee Trap

The Lower Wenatchee Trap operated nightly between 8 February and 5 August 2006. During that time period the trap was inoperable for 27 days because of high river flows, debris, snow/ice, or mechanical failure. During the seven-month sampling period, a total of 652 wild yearling Chinook, 63,580 wild subyearling Chinook (mostly summer Chinook), and 35,261hatchery yearling Chinook were captured at the Lower Wenatchee Trap. Based on capture efficiencies estimated from the flow model, the total number of wild yearling Chinook that emigrated past the Lower Wenatchee Trap was 55,619 (±81,310). Most (89%) of these fish emigrated during April. Monthly captures of all fish collected at the Lower Wenatchee Trap are reported in Appendix B.

PIT Tagging Activities

A total of 8,733 juvenile spring Chinook (5,309 subyearling and 3,424 yearlings) were PIT tagged and released in 2006 throughout the Wenatchee basin (Table 5.16). Most of these (92%) were tagged in the Chiwawa basin (7,923 at the trap and 111 upstream from the trap). Few were tagged and released in Nason Creek, the upper Wenatchee River, or at the Upper Wenatchee trap. A total of 522 yearling spring Chinook were tagged and released at the Lower Wenatchee trap. See Appendix C for a complete list of all fish captured, tagged, lost, and released.

Table 5.16. Numbers of wild spring Chinook that were captured, tagged, and released at different locations within the Wenatchee basin, 2006. Numbers of fish that died or shed tags are also given.

Sampling location	Life stage	Number captured for tagging	Number tagged	Number that died	Number of shed tags	Total number of fish released
Chiwawa Trap	Subyearling	5,159	5,130	29	1	5,130
	Yearling	2,813	2,793	20	3	2,793
	Total	**7,972**	**7,923**	**49**	**4**	**7,923**
Chiwawa River	Subyearling	207	111	0	0	111
	Yearling	0	0	0	0	0
	Total	**207**	**111**	**0**	**0**	**111**
Upper Wenatchee Trap	Subyearling	0	0	0	0	0
	Yearling	83	83	2	0	81
	Total	**83**	**83**	**2**	**0**	**81**
Upper Wenatchee River	Subyearling	0	0	0	0	0
	Yearling	28	27	0	0	27
	Total	**28**	**27**	**0**	**0**	**27**
Nason Creek	Subyearling	229	70	2	0	68
	Yearling	1	1	0	0	1
	Total	**230**	**71**	**2**	**0**	**69**
Lower Wenatchee Trap	Subyearling	0	0	0	0	0
	Yearling	522	522	0	0	522
	Total	**522**	**522**	**0**	**0**	**522**
Totals	***Subyearling***	***5,595***	***5,311***	***31***	***1***	***5,309***
	Yearling	***3,447***	***3,426***	***22***	***3***	***3,424***
	Total	***9,042***	***8,737***	***53***	***4***	***8,733***

Freshwater Productivity

Both productivity and survival estimates for different life-stages of spring Chinook in the Chiwawa basin are provided in Table 5.17. Estimates for brood year 2004 fall within the ranges estimated over the period of brood years 1991-2003. During that period, freshwater productivities ranged from 129-1,015 for parr/redd, 169-779 for smolts/redd, and 214-834 for emigrants/redd. Survivals during the same period ranged from 2.7-22.1% for egg-parr, 3.7-16.9% for egg-smolt, and 4.7-18.1% for egg-emigrants. Overwinter survival rates for juvenile spring Chinook within the Chiwawa basin have ranged from 15.7-99.8%.

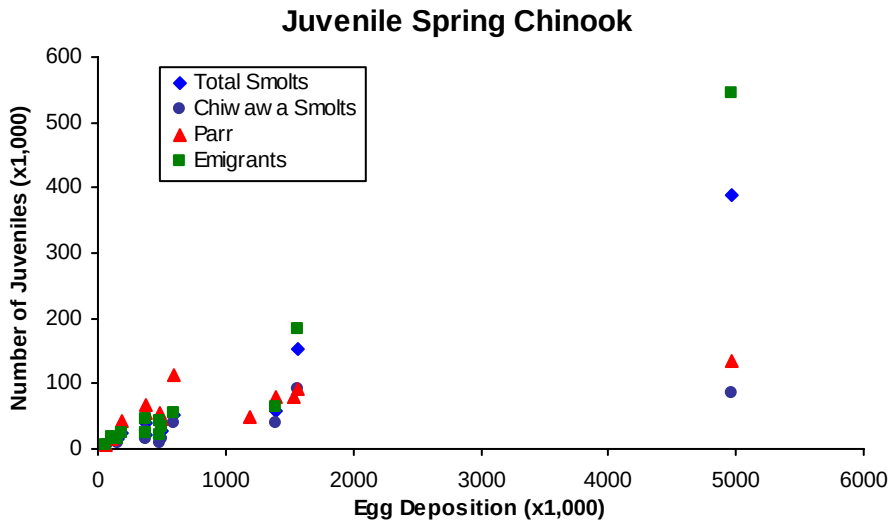
Table 5.17. Productivity (fish/redd) and survival (%) estimates for different juvenile life stages of spring Chinook in the Chiwawa basin for brood years 1991-2005; ND = no data. These estimates were derived from data in Table 5.14.

Brood year	Parr/Redd	Smolts/Redd[a]	Emigrants/ Redd	Egg-Parr (%)	Parr-Smolt[b] (%)	Egg-Smolt[a] (%)	Egg-Emigrant (%)
1991	437	409	409	9.5	93.5	8.9	8.9
1992	262	188	217	5.0	50.2	3.6	4.2
1993	519	169	214	9.9	15.7	3.2	4.1
1994	674	270	306	11.4	29.8	4.6	5.2
1995	447	402	458	8.8	65.9	7.9	9.0
1996	699	779	834	15.0	96.3	16.8	18.0
1997	834	476	543	18.3	41.4	10.4	11.9
1998	1,015	609	632	19.1	55.4	11.4	11.9
1999	ND	410	460	ND	ND	8.4	9.4
2000	895	396	435	17.8	35.6	7.9	8.7
2001	129	373	522	2.8	64.1	8.1	11.3
2002	265	442	534	5.7	99.6	9.5	11.5
2003	407	251	303	7.0	37.1	4.3	5.2
2004	196	400	459	4.1	145.2	8.3	9.6
2005	221			5.1			
Average	***291***	***361***	***451***	***6.1***	***60.5***	***7.4***	***9.3***

[a] These estimates include Chiwawa smolts produced within the Wenatchee basin. This assumes that 66% of the subyearling migrants survive to smolt, regardless of the number of subyearling migrants (i.e., no density dependence). Smolt estimates for brood years 1992-1996 were calculated with a mark-recapture model; brood years 1997-2005 were calculated with a flow model.

[b] These estimates represent overwinter survival within the Chiwawa basin. It does not include Chiwawa smolts produced outside the Chiwawa basin. As noted in footnote 1, smolts/redd and egg-smolt survival include Chiwawa smolts produced in the Wenatchee basin.

Seeding level (egg deposition) explained most of the variability in productivity and survival of juvenile spring Chinook in the Chiwawa basin. That is, for estimates based on "within-Chiwawa-basin" life stages (e.g., parr and within-Chiwawa-basin 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 basin. This form of population regulation is less apparent with total smolts (i.e., Chiwawa smolts produced within the Wenatchee basin) and total emigrants. However, one would expect the number of emigrants to increases as seeding levels exceed the capacity of the Chiwawa basin.



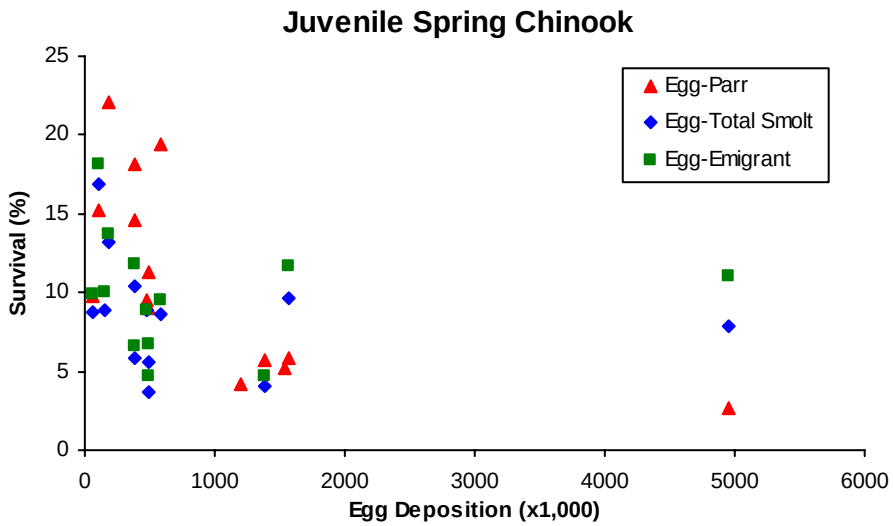


Figure 5.4. Relationships between seeding levels (egg deposition) and juvenile life-stage survivals and productivities for Chiwawa spring Chinook, 1991-2005. Total smolts are Chiwawa smolts produced within and outside the Chiwawa basin (assumes a 66% survival on subyearling emigrants). Chiwawa smolts are smolts produced only in the Chiwawa basin.

5.4 Spawning Surveys

Surveys for spring Chinook redds were conducted during August through September, 2006, 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 White River (including the Napeequa River and Panther Creek).

Redd Counts

A total of 585 spring Chinook redds were counted in the Wenatchee basin in 2006 (Table 5.18). This is higher than the average of 488 redds counted during the period 1989-2006 in the Wenatchee basin. Most spawning occurred in the Chiwawa River (51% or 297 redds) (Table 5.18; Figure 5.5). Nason Creek contained 26% (152 redds), Icicle contained 9% (50 redds), White River contained 5% (31 redds), Upper Wenatchee River contained 4% (24 redds), Little Wenatchee contained 4% (21 redds), and Peshastin Creek contained 2% (10 redds).

Table 5.18. Numbers of spring Chinook redds counted within different streams/watersheds within the Wenatchee basin, 1989-2006. 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.

Sample year	Number of spring Chinook redds							
	Chiwawa	Nason	Little Wenatchee	White	Wenatchee River	Icicle	Peshastin	Total
1989	314	98	45	62	94	24	NS	**637**
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	60	86	53	5	**594**
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	1,046	367	74	93	208	88	158*	**1876**
2002	345	294	42	42	55	245	109*	**1,023**
2003	111	83	12	15	24	18	60	**323**
2004	253	159	12	22	49	30	55	**580**
2005	362	186	69	86	168	8	3	**882**
2006	297	152	21	31	24	50	10	**585**
Average	***217***	***115***	***25***	***30***	***49***	***44***	***9***	***488***

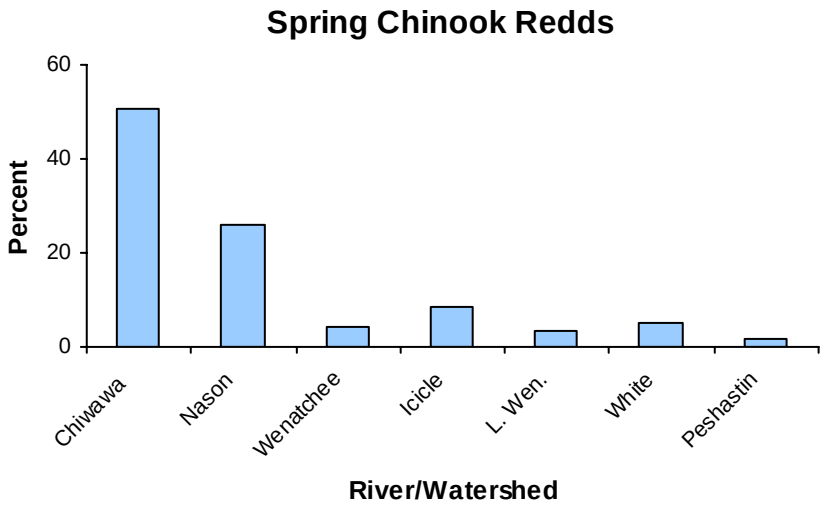


Figure 5.5. Percent of the total number of spring Chinook redds counted in different streams/watersheds within the Wenatchee basin during August through September, 2006.

Redd Distribution

Spring Chinook redds were not evenly distributed among reaches within survey streams in 2006 (Table 5.19). Most of the spawning in the Chiwawa basin occurred in Reaches 1, 2, and 6. Nearly half of all the spawning in the Chiwawa basin occurred in Reach 2 (RM 11.7-19.3; Grouse Creek to Rock Creek). Few fish spawned in Rock and Chikamin creeks. The spatial distribution of redds in Nason Creek was more even than in the Chiwawa basin, with the proportion of redds ranging from 0.17 to 0.32 among the four reaches in Nason Creek. Nearly 81% of all spawning in the Little Wenatchee River occurred in Reach 3 (RM 5.2-9.2; Lost Creek to Rainy Creek). On the White River, about 97% occurred in Reach 3 (RM 11.0-12.9; Napeequa River to Grasshopper Meadows). All spawning in the Wenatchee River occurred upstream from the mouth of the Chiwawa River. Of the few fish that spawned in the Peshastin Creek watershed, equal numbers of redds occurred in Ingalls Creek and the lower reach of Peshastin Creek.

Table 5.19. Numbers and percentages of spring Chinook redds counted within different streams/watersheds within the Wenatchee basin during August through September, 2006.

Stream/watershed	Reach	Number of redds	Percent of redds within stream/watershed
Chiwawa	Chiwawa 1	51	17.2
	Chiwawa 2	146	49.2
	Chiwawa 3	10	3.4
	Chiwawa 4	25	8.4
	Chiwawa 5	24	8.1
	Chiwawa 6	31	10.4
	Rock 1	5	1.7
	Chikamin 1	5	1.7
	Total	**297**	**100.0**
Nason	Nason 1	44	28.9
	Nason 2	34	22.4
	Nason 3	48	31.6
	Nason 4	26	17.1
	Total	**152**	**100.0**
Little Wenatchee	Little Wen 2	4	19.0
	Little Wen 3	17	81.0
	Total	**21**	**100.0**
White	White 2	0	0.0
	White 3	30	96.8
	Napeequa 1	1	3.2
	Total	**31**	**100.0**
Wenatchee River	Wen 9	0	0.0
	Wen 10	24	100.0
	Total	**24**	**100.0**
Icicle	Icicle 1	50	100.0
	Total	**50**	**100.0**
Peshastin	Peshastin 1	5	50.0
	Peshastin 2	0	0.0
	Ingalls	5	50.0
	Total	**10**	**100.0**
Grand Total		***585***	

Spawn Timing

Spring Chinook began spawning during the second week of August in the Nason Creek and the third week in other streams (Figure 5.6). Peak spawning generally peaked the third or fourth week of August in all systems. Because of warmer water temperatures, peak spawning in the Wenatchee

River probably occurred during the first week of September. All spawning was completed by the end of September.

The temporal distribution of spawning activity in the Chiwawa River in 2006 was similar to the eight-year distribution (Figure 5.7). The greatest difference in distributions was noted in late August. Compared with the eight-year distribution, the 2006 distribution showed a higher spike in spawning activity during the fourth-week of August and lower activity during the last week of August.

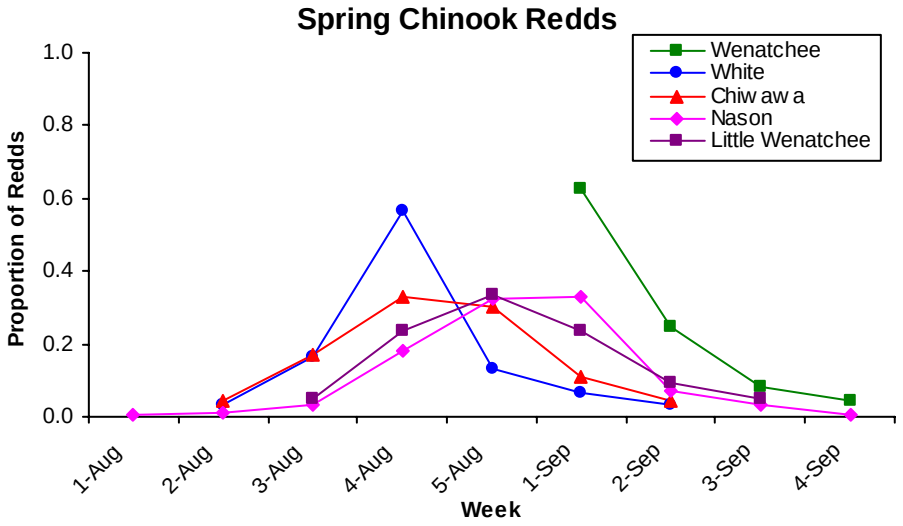


Figure 5.6. Proportion of spring Chinook redds counted during different weeks in different sampling streams within the Wenatchee basin, August through September 2006.

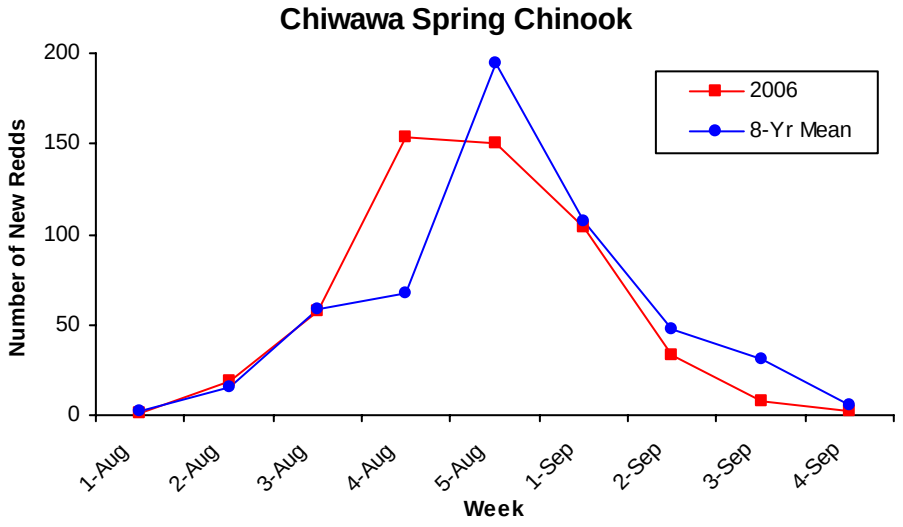


Figure 5.7. Number of new spring Chinook redds counted during different weeks in the Chiwawa basin, August through September 2006.

Spawning Escapement

Spawning escapement for spring Chinook was calculated as the number of redds times the fish per redd ratio estimated from broodstock and fish sampled at adult trapping sites. The estimated fish per redd ratio for spring Chinook in 2006 was 1.78. Multiplying this ratio by the number of redds counted in the Wenatchee basin resulted in a total spawning escapement of 1,042 spring Chinook (Table 5.20). The Chiwawa basin had the highest spawning escapement (529 Chinook), while Peshastin Creek had the lowest.

Table 5.20. Number of redds and total spawning escapement for spring Chinook in the Wenatchee basin, 2006. Spawning escapement was based on a fish/redd ratio of 1.78.

Sampling area	Total number of redds	Total spawning escapement
Chiwawa	297	529
Nason	152	271
Upper Wenatchee River	24	43
Icicle	50	89
Little Wenatchee	21	37
White	31	55
Peshastin	10	18
Total	***585***	***1,042***

The estimated total spawning escapement of 1,042 spring Chinook in 2006 was slightly less than the 1989-2005 average of 1,081 spring Chinook (Table 5.21). The largest spawning escapement in 2006 occurred in the Chiwawa basin, which was nearly twice the escapement of the second most abundant stream, Nason Creek (Table 5.21).

Table 5.21. Spawning escapements for spring Chinook in the Wenatchee basin for return years 1989-2006; NA = not available.

Return year	Fish/Redd	Spawning escapement							
		Chiwawa	Nason	Upper Wenatchee	Icicle	Little Wenatchee	White	Peshastin	Total
1989	2.27	713	222	213	54	102	141	NA	**1,445**
1990	2.24	347	231	81	112	67	49	9	**896**
1991	2.33	242	156	96	93	42	49	2	**680**
1992	2.24	676	181	85	83	78	78	0	**1,181**
1993	2.20	222	491	189	117	134	132	NA	**1,285**
1994	2.24	184	60	13	34	16	7	0	**314**
1995	2.51	33	18	3	23	0	5	0	**82**
1996	2.53	58	83	3	30	8	30	2	**214**
1997	2.22	182	122	33	73	18	33	2	**463**
1998	2.21	86	64	0	24	18	11	0	**203**
1999	2.77	94	22	6	17	8	3	0	**150**
2000	2.44	312	244	90	166	22	20	0	**854**
2001	2.31	2,416	848	480	203	171	215	192	**4,525**
2002	2.05	707	603	131	502	86	86	92	**2,207**

Return year	Fish/Redd	Spawning escapement							
		Chiwawa	Nason	Upper Wenatchee	Icicle	Little Wenatchee	White	Peshastin	Total
2003	2.43	270	202	58	44	29	44	54	**701**
2004	3.46	858	507	138	54	39	66	61	**1,723**
2005	1.80	598	347	257	54	115	155	5	**1,531**
2006	1.78	529	271	43	89	37	55	18	**1,042**
Average	***2.34***	***474***	***260***	***107***	***98***	***55***	***66***	***27***	***1,081***

5.5 Carcass Surveys

Surveys for spring Chinook carcasses 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 White River (including the Napeequa River and Panther Creek).

Number sampled

A total of 491 spring Chinook carcasses were sampled during August through September in the Wenatchee Basin (Table 5.22). Most (49% or 241 carcasses) were sampled in the Chiwawa Basin, 39% (190 carcasses) in Nason Creek, 5% (25 carcasses) in the White River, 3% (15 carcasses) in the Upper Wenatchee, 3% (13 carcasses) in the Little Wenatchee, and 1% (7 carcasses) in Icicle Creek (Figure 5.8). No carcasses were sampled in Peshastin Creek.

Table 5.22. Numbers of spring Chinook carcasses sampled within different streams/watersheds within the Wenatchee basin, 1996-2006.

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	13	42	3	8	1	28	1	**96**
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	751	388	68	74	213	163	63	**1,720**
2002	190	292	30	24	34	91	49	**710**
2003	70	100	8	8	12	37	42	**277**
2004	176	186	1	12	31	16	28	**450**
2005	389	217	48	51	120	2	0	**827**
2006	241	190	13	25	15	7	0	**491**
Average	***183***	***142***	***17***	***19***	***42***	***37***	***17***	***456***

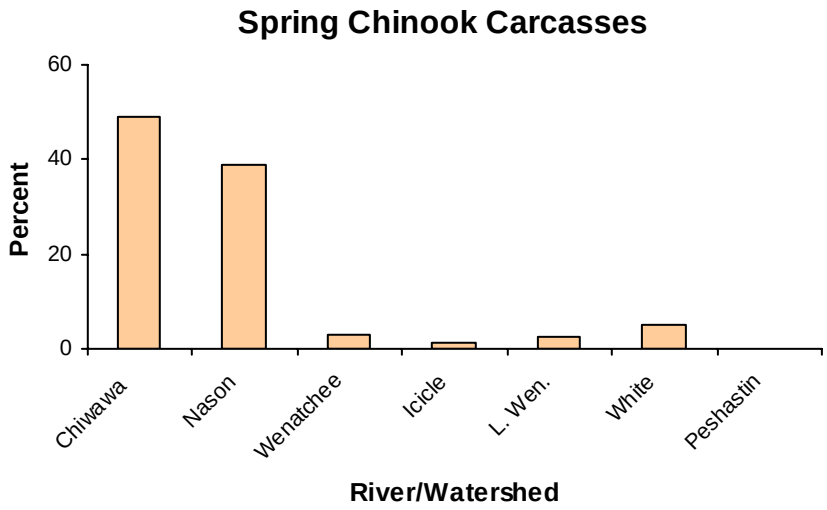


Figure 5.8. Percent of the total number of spring Chinook carcasses sampled in different streams/watersheds within the Wenatchee basin during August through September, 2006.

Carcass Distribution and Origin

Spring Chinook carcasses were not evenly distributed among reaches within survey streams in 2006 (Table 5.23). Most of the carcasses in the Chiwawa basin occurred in Reaches 1 and 2 (downstream from Rock Creek). In Nason Creek, most carcasses (39%) were collected in Reach 1 and the fewest (12%) in Reach 4. Nearly 77% of all carcasses sampled in the Little Wenatchee River occurred in Reach 3 (Lost Creek to Rainy Creek). On the White River, about 88% occurred in Reach 3 (Napeequa River to Grasshopper Meadows). All carcasses sampled in the Wenatchee River were found upstream from the mouth of the Chiwawa River. No fish were sampled in the Peshastin Creek watershed.

Table 5.23. Numbers of carcasses sampled within different streams/watersheds within the Wenatchee basin during August through September, 2006.

Stream/watershed	Reach	Total carcasses
Chiwawa	Chiwawa 1	94
	Chiwawa 2	92
	Chiwawa 3	7
	Chiwawa 4	15
	Chiwawa 5	10
	Chiwawa 6	16
	Rock 1	3
	Chikamin 1	4
	Total	**241**
Nason	Nason 1	74
	Nason 2	48
	Nason 3	45

Stream/watershed	Reach	Total carcasses
	Nason 4	23
	Total	**190**
Little Wenatchee	Little Wen 2	3
	Little Wen 3	10
	Total	**13**
White	White 2	2
	White 3	22
	Napeequa 1	1
	Total	**25**
Wenatchee River	Wen 9	0
	Wen 10	15
	Total	**15**
Icicle	Icicle 1	7
	Total	**7**
Peshastin	Peshastin 1	0
	Peshastin 2	0
	Ingalls	0
	Total	**0**
Grand Total		***491***

Numbers of wild and hatchery origin Chinook carcasses sampled in 2006 will be available after analysis of CWTs and scales. Of the 1,209 carcasses sampled in 2005, 61% were hatchery produced fish (Table 5.24). Most fish, regardless of origin, spawned in the lower reaches of the Chiwawa River. However, a larger percentage of hatchery fish were found in the lower reaches than were wild fish (77% hatchery and 59% wild). Consequently, a greater percentage of wild fish were found in the upper reaches than were hatchery fish. This general trend was also apparent in the pooled data (Figure 5.9).

Table 5.24. Numbers of wild and hatchery spring Chinook carcasses sampled within different reaches in the Chiwawa basin, 1993-2005.

Survey year	Origin	Survey Reach								Total
		C-1	C-2	C-3	C-4	C-5	C-6	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	1	0	0	**9**
	Hatchery	0	0	0	0	0	0	0	0	**0**
1995	Wild	0	0	0	0	0	0	0	0	**0**
	Hatchery	0	1	0	1	0	0	0	0	**2**
1996	Wild	11	1	1	1	0	0	0	0	**14**
	Hatchery	4	0	0	0	0	0	0	0	**4**
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	5	1	2	4	0	0	**15**
	Hatchery	1	2	2	0	1	1	0	0	**7**
1999	Wild	1	8	0	5	0	0	0	0	**14**
	Hatchery	0	0	0	0	0	0	0	0	**0**
2000	Wild	25	27	1	1	1	1	0	0	**56**
	Hatchery	21	10	0	0	0	2	0	0	**33**
2001	Wild	24	57	15	40	16	20	1	3	**176**
	Hatchery	142	253	17	45	11	21	7	0	**496**
2002	Wild	15	11	9	6	7	5	2	0	**55**
	Hatchery	34	33	12	3	1	14	9	4	**110**
2003	Wild	7	13	0	11	3	2	0	0	**36**
	Hatchery	11	10	0	3	0	0	0	0	**24**
2004	Wild	24	46	2	11	7	3	0	1	**94**
	Hatchery	32	9	0	1	1	1	0	2	**46**
2005	Wild	112	174	33	79	36	36	3	4	**477**
	Hatchery	249	319	31	53	14	40	17	9	**732**
Average	***Wild***	***17***	***27***	***5***	***12***	***6***	***6***	***0***	***1***	***73***
	Hatchery	***38***	***49***	***5***	***8***	***2***	***6***	***3***	***1***	***113***

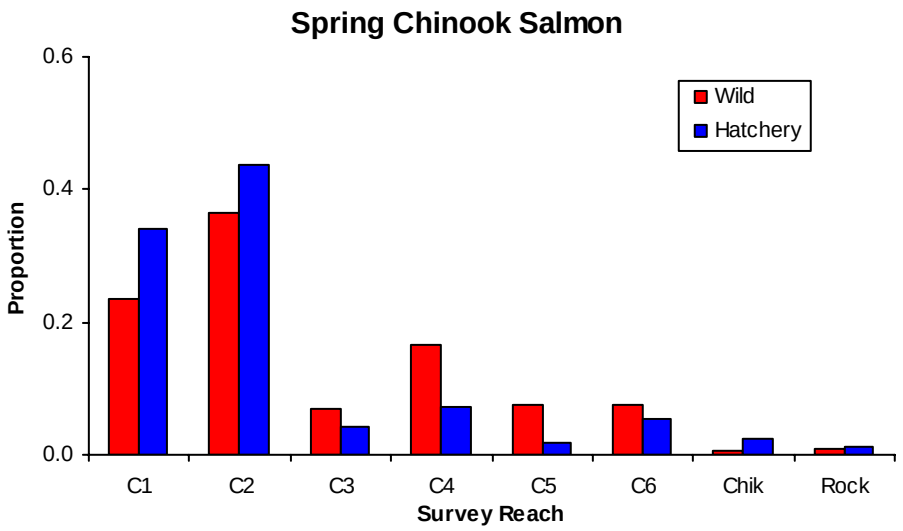


Figure 5.9. Distribution of wild and hatchery produced carcasses in different reaches in the Chiwawa basin, 1993-2005; Chik = Chikamin Creek. Reach codes are described in Table 2.8.

Sampling Rate

Overall, 47% of the total estimated spawning escapement of spring Chinook in the Wenatchee basin was sampled in 2006 (Table 5.25). Sampling rates among streams/watershed varied from 0 to 70%.

Table 5.25. Number of redds and carcasses, total spawning escapement, and sampling rates for spring Chinook salmon in the Wenatchee Basin, 2006.

Sampling area	Total number of redds	Total number of carcasses	Total spawning escapement	Sampling rate
Chiwawa	297	241	529	0.46
Nason	152	190	271	0.70
Upper Wenatchee	24	15	43	0.35
Icicle	50	7	89	0.08
Little Wenatchee	21	13	37	0.35
White	31	25	55	0.45
Peshastin	10	0	18	0.00
Total	***585***	***491***	***1,042***	***0.47***

Length Data

Mean lengths (POH, cm) of male and female spring Chinook carcasses sampled during surveys in the Wenatchee basin in 2006 are provided in Table 5.26. The average size of males and females sampled in the Wenatchee basin were nearly equal (males = 61.3 and females = 61.9).

Table 5.26. 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 basin, 2006; NA = not available.

Stream/watershed	Mean lengths (cm)	
	Male	Female
Chiwawa	62 (13)	62 (6)
Nason	60 (10)	62 (6)
Upper Wenatchee	64 (16)	63 (7)
Icicle	71 (5)	60 (6)
Little Wenatchee	57 (16)	65 (6)
White	67 (4)	65 (6)
Peshastin	NA	NA
Total	***61 (12)***	***62 (6)***

5.6 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.

Age at Maturity

Most of the wild and hatchery spring Chinook sampled during the period 1994-2005 in the Chiwawa basin were age-4 fish (total age) (Table 5.27; Figure 5.10). On average, hatchery fish made up a higher percentage of age-3 and 4 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 5.27. Proportions of wild and hatchery spring Chinook of different ages (total age) sampled at broodstock collection sites and on spawning grounds in the Chiwawa basin, 1994-2005; ND = no data.

Sample year	Origin	Total age						Sample size
		2	3	4	5	6	7	
1994	Wild	0.00	0.00	0.33	0.67	0.00	0.00	9
	Hatchery	ND	ND	ND	ND	ND	ND	ND
1995	Wild	ND	ND	ND	ND	ND	ND	ND
	Hatchery	0.00	0.00	1.00	0.00	0.00	0.00	2
1996	Wild	0.00	0.38	0.62	0.00	0.00	0.00	13
	Hatchery	0.00	1.00	0.00	0.00	0.00	0.00	4
1997	Wild	0.00	0.00	0.71	0.29	0.00	0.00	7
	Hatchery	0.00	0.00	1.00	0.00	0.00	0.00	9
1998	Wild	0.00	0.00	0.00	1.00	0.00	0.00	15
	Hatchery	0.00	0.00	0.14	0.86	0.00	0.00	7
1999	Wild	0.00	0.07	0.50	0.43	0.00	0.00	14
	Hatchery	ND	ND	ND	ND	ND	ND	ND
2000	Wild	0.00	0.00	0.96	0.04	0.00	0.00	51
	Hatchery	0.00	0.46	0.54	0.00	0.00	0.00	28
2001	Wild	0.00	0.01	0.95	0.04	0.00	0.00	172
	Hatchery	0.00	0.02	0.98	0.00	0.00	0.00	500
2002	Wild	0.00	0.00	0.56	0.44	0.00	0.00	52
	Hatchery	0.00	0.00	0.94	0.06	0.00	0.00	110
2003	Wild	0.00	0.09	0.00	0.91	0.00	0.00	34
	Hatchery	0.00	0.17	0.00	0.83	0.00	0.00	24
2004	Wild	0.00	0.02	0.97	0.01	0.00	0.00	92
	Hatchery	0.00	0.44	0.56	0.00	0.00	0.00	45
2005	Wild	0.00	0.01	0.76	0.24	0.00	0.00	131
	Hatchery	0.00	0.02	0.98	0.00	0.00	0.00	685
Average	***Wild***	***0.00***	***0.05***	***0.58***	***0.37***	***0.00***	***0.00***	***54***
	Hatchery	***0.00***	***0.21***	***0.61***	***0.18***	***0.00***	***0.00***	***141***

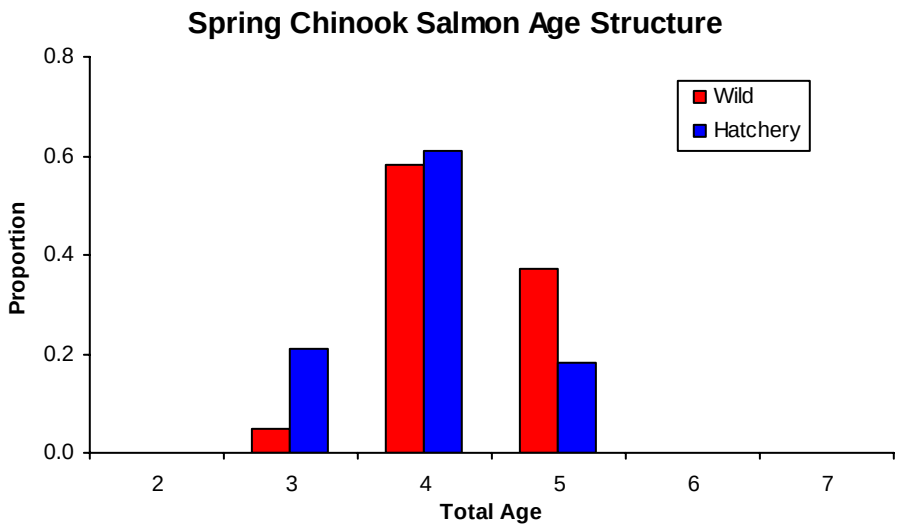


Figure 5.10. Proportions of wild and hatchery spring Chinook of different total ages sampled at broodstock collection sites and on spawning grounds in the Chiwawa basin for the combined years 1994-2005.

Size at Maturity

On average, hatchery spring Chinook were about 2 cm smaller than wild spring Chinook in the Chiwawa basin (Table 5.28). This may be related to the fact that slightly more wild Chinook returned as age-5 fish than did hatchery Chinook. The wild age-5 fish were larger on average than the age-5 hatchery fish. In contrast, hatchery age-3 and 4 Chinook were generally larger than age-3 and 4 wild fish.

Table 5.28. 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 basin, 1994-2005.

Brood year	Total age	Mean length (cm)			
		Male		Female	
		Wild	Hatchery	Wild	Hatchery
1994	3				
	4			62 ±3 (3)	
	5	76 ±0 (1)		73 ±2 (5)	
	6				
1995	3				
	4		62 ±6 (2)		
	5				
	6				
1996	3	45 ±3 (5)	50 ±7 (4)		
	4	69 ±4 (6)		67 ±8 (2)	
	5				
	6				
1997	3				
	4	60 ±1 (2)	68 ±0 (1)	67 ±5 (3)	63 ±3 (8)

Brood year	Total age	Mean length (cm)			
		Male		Female	
		Wild	Hatchery	Wild	Hatchery
	5	67 ±5 (2)			
	6				
1998	3				
	4				54 ±0 (1)
	5	77 ±7 (8)	75 ±4 (4)	74 ±4 (7)	79 ±1 (2)
	6				
1999	3	44 ±0 (1)			
	4	61 ±0 (1)		64 ±3 (6)	
	5	76 ±5 (3)		72 ±5 (3)	
	6				
2000	3		46 ±3 (11)		52 ±9 (2)
	4	60 ±8 (23)	61 ±4 (3)	61 ±5 (26)	60 ±5 (12)
	5	77 ±1 (2)			
	6				
2001	3	37 ±0 (1)	43 ±3 (9)	41 ±0 (1)	
	4	63 ±5 (56)	65 ±5 (130)	62 ±4 (107)	63 ±4 (361)
	5	75 ±5 (2)		76 ±1 (5)	
	6				
2002	3				
	4	64 ±4 (14)	66 ±5 (38)	60 ±4 (15)	63 ±4 (65)
	5	80 ±6 (13)	75 ±6 (3)	73 ±3 (10)	72 ±7 (4)
	6				
2003	3	45 ±2 (3)	44 ±1 (4)		
	4				
	5	78 ±5 (12)	72 ±4 (8)	75 ±4 (19)	72 ±6 (12)
	6				
2004	3	43 ±3 (2)	43 ±4 (20)		
	4	62 ±7 (44)	67 ±5 (3)	62 ±3 (45)	64 ±5 (22)
	5			74 ±0 (1)	
	6				
2005	3		43 ±5 (11)		
	4	61 ±5 (17)	64 ±6 (101)	61 ±4 (34)	61 ±4 (206)
	5	74 ±5 (4)		71 ±3 (9)	
	6				

Contribution to Fisheries

Nearly all the harvest on Chiwawa spring Chinook occurs within the Columbia basin. Ocean catch records (Pacific Fishery Management Council) indicate that virtually no Upper Columbia spring Chinook are taken in ocean fisheries. Most of the harvest on 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 July 31 of each year. The treaty fishery occurs exclusively 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 spring Chinook captured in different fisheries has been relatively low (Table 5.29). Larger numbers of spring Chinook were taken from the 1997 and 1988 brood years because those years produced large escapements.

Table 5.29. Estimated number and percent (in parentheses) of Chiwawa spring Chinook captured in different fisheries; NA = not available.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal (Zone 6)	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 (13)	1 (25)	0 (0)	0 (0)	4
1994	0 (0)	1 (100)	0 (0)	0 (0)	1
1995	NA	NA	NA	NA	NA
1996	0 (0)	1 (50)	0 (0)	1 (50)	2
1997	0 (0)	1 (0)	291 (72)	114 (28)	406
1998	9 (38)	0 (0)	58 (33)	108 (62)	175
1999	NA	NA	NA	NA	NA
2000	0 (0)	0 (0)	17 (74)	6 (26)	23

[a] Includes the Wanapum fishery.

Straying

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Wenatchee basin. Targets for strays based on return year (recovery year) within the Wenatchee basin should be less than 0.100 and targets for strays outside the Wenatchee basin should be less than 0.050. The target for brood year stray rates should be less than 0.050.

Rates of spring Chinook straying into basins outside the Wenatchee have been relatively low (Table 5.30). Chiwawa spring Chinook have strayed into the Entiat basin, and during return years 2002 and 2003, their stray rates exceeded the target of 0.05. Chiwawa spring Chinook have strayed into other spawning streams within the Wenatchee basin (Table 5.30). They have strayed into spawning areas on Nason Creek, the White River, the Little Wenatchee River, and the Upper Wenatchee River at rates greater than 0.100. On average, stray rates are typically highest in Nason Creek and the Upper Wenatchee River. Total stray rates by brood year have exceeded the target of 0.050 (Table 5.31).

Stray rates of Chiwawa spring Chinook should decrease with the change in source water that was implemented in 2006-2007 for the Chiwawa rearing ponds.

Table 5.30. Proportion of Chiwawa spring Chinook that strayed onto spawning grounds within and outside the Wenatchee basin, 1992-2005. *(The numbers in this table may change as the HETT and HC refine the methods for estimating stray rates.)*

Return year	Within Wenatchee Basin					Outside Wenatchee Basin
	Nason Creek	White River	Little Wenatchee River	Upper Wenatchee River	Icicle Creek	Entiat River
1992	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.124	0.053	0.000	0.018	0.000	0.000
1994	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.000	0.000	0.000	0.667	0.000	0.000
1996	0.289	0.000	0.000	0.000	0.000	0.000
1997	0.451	0.000	0.000	0.000	0.110	0.000
1998	0.047	0.000	0.000	0.000	0.000	0.000
1999	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.176	0.000	0.273	0.322	0.000	0.014
2001	0.243	0.209	0.298	0.550	0.000	0.020
2002	0.295	0.151	0.233	0.443	0.018	0.223
2003	0.064	0.000	0.000	0.500	0.000	0.056
Average	***0.141***	***0.034***	***0.067***	***0.208***	***0.011***	***0.026***

Table 5.31. Stray rates by brood year for Chiwawa spring Chinook, 1989-2000. Target is stray rate less than 0.05. *(The numbers in this table may change as the HETT and HC refine the methods for estimating stray rates.)*

Brood year	Stray rate
1989	0.640
1990	0.000
1991	0.094
1992	0.800
1993	0.236
1994	0.143
1995	No Program
1996	0.169
1997	0.313
1998	0.328
1999	No Program
Average	***0.303***

Genetics

Genetic studies were conducted to determine the potential impacts of the Chiwawa Supplementation Program on natural origin spring Chinook in the upper Wenatchee basin (Blankenship et al. 2007; the entire report is appended as Appendix H). Microsatellite DNA allele frequencies collected from temporally replicated natural and hatchery origin spring Chinook 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 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.

Natural Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural origin recruits (NOR) to the parent spawning population. For brood years 1989-1999, NRR in the Chiwawa averaged 0.63 (range, 0.07-4.51) if harvested fish were not include in the estimate and 0.74 (range, 0.07-5.22) if harvested fish were included in the estimate (Table 5.32). 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 5.32. Spawning escapements, natural origin recruits (NOR), and natural replacement rates (NRR) for spring Chinook in the Chiwawa basin, 1989-2000. *(The numbers in this table may change as the HETT and HC refine the methods for estimating Chiwawa spring Chinook NORs, and NRRs.)*

Brood year	Spawning escapement	Harvest not included		Harvest included	
		NOR	NRR	NOR	NRR
1989	713	177	0.25	248	0.35
1990	347	33	0.10	39	0.11
1991	242	17	0.07	19	0.08
1992	676	48	0.07	51	0.07
1993	222	102	0.46	106	0.48

Brood year	Spawning escapement	Harvest not included		Harvest included	
		NOR	NRR	NOR	NRR
1994	184	53	0.29	55	0.30
1995	33	48	1.46	50	1.53
1996	58	162	2.80	175	3.02
1997	182	820	4.51	950	5.22
1998	86	330	3.83	388	4.51
1999	94	10	0.11	12	0.13
Average	***262***	***164***	***0.63***	***190***	***0.74***

Hatchery Replacement Rates

Hatchery replacement rates were estimated as hatchery adult-to-adult returns. These rates should be greater than the NRRs and greater than or equal to 5.30 (the value in BAMP; Murdoch and Peven 2005). In most years, HRRs were greater than NRRs, regardless if harvest was or was not included (Table 5.33). In contrast, HRRs for only two brood years (1997 and 1998) exceeded the BAMP target of 5.3.

Table 5.33. Hatchery replacement rates (HRR), NRR, and BAMP target (5.30) for spring Chinook in the Chiwawa basin, 1989-2000; NA = not available. *(The numbers in this table may change as the HETT and HC refine the methods for estimating Chiwawa spring Chinook HRRs and NRRs.)*

Brood year	Harvest not included			Harvest included		
	HRR	NRR	BAMP	HRR	NRR	BAMP
1989	3.17	0.25	5.30	3.63	0.35	5.30
1990	0.05	0.10	5.30	1.00	0.11	5.30
1991	0.97	0.07	5.30	1.06	0.08	5.30
1992	0.28	0.07	5.30	0.28	0.07	5.30
1993	2.68	0.46	5.30	2.69	0.48	5.30
1994	1.33	0.29	5.30	1.33	0.30	5.30
1995	NA	1.46	5.30	NA	1.53	5.30
1996	4.28	2.80	5.30	4.39	3.02	5.30
1997	19.31	4.51	5.30	22.69	5.22	5.30
1998	20.20	3.83	5.30	23.71	4.51	5.30
1999	NA	0.11	5.30	NA	0.13	5.30
Average	***5.81***	***0.63***	***5.3***	***6.75***	***0.74***	***5.3***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adults divided by the number of hatchery smolts released. SARs were based on CWT returns. For the available brood years, SARs have ranged from 0.0003 to 0.0152 for hatchery spring Chinook (Table 5.34).

Table 5.34. Smolt-to-adult ratios (SARs) for Chiwawa hatchery spring Chinook; NA = not available.

Brood year	Number released	SAR
1989	42,707	0.004343
1990	52,798	0.000363
1991	61,088	0.000579
1992	82,976	0.000335
1993	221,316	0.001259
1994	27,135	0.000748
1995	NA	NA
1996	12,767	0.005169
1997	259,585	0.009922
1998	71,571	0.015202
1999	NA	NA
Average	***87,867***	***0.004213***

5.7 ESA/HCP Compliance

Broodstock Collection

The collection of 2004 Chiwawa River spring Chinook broodstock was consistent with the 2004 Upper Columbia River Salmon and Steelhead Broodstock Objectives and site-based broodstock collection protocols. Specifically, broodstock collection for hatchery origin fish occurred at Tumwater Dam and the Chiwawa Weir, while natural origin spring Chinook were collected only at the Chiwawa Weir. Broodstock collection at Tumwater Dam began 20 May 2004 and concluded on 26 August 2004, and was implemented concurrent with trapping, sampling, and tagging associated with the spring Chinook reproductive success study (BPA project No. 2003-039-00). Trapping at the Chiwawa Weir began on 19 May 2004 and concluded on 8 September 2004. Broodstock were collected between 17 June 2004 and 8 September 2004. Trapping generally followed a 4-up and 3-down schedule, and operated only as needed to meet weekly collection objectives, consistent with the 2004 collection protocol and ESA Section 10 Permit 1196.

Both passive (used during low abundance periods) and active (used during high abundance periods) trapping were used to collect spring Chinook at Tumwater Dam. During passive trapping, the trap was checked and fish processed several times per day. At the Chiwawa Weir, the trap was operated passively, checked several times per day, and fish processed once daily. 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 escapement of 2004 spring Chinook past Tumwater Dam totaled 2,261 fish. The estimated escapement of 2004 Chiwawa River spring Chinook totaled 1,330 fish (expanded Chiwawa basin spawning escapement estimate + broodstock extraction). Based on 2004 spawning ground data and 2004 hatchery broodstock composition, 687 (51.7%) and 643 (48.3%) of the 1,330

Chiwawa spring Chinook escapement were natural and hatchery origin fish, respectively. 2004 broodstock collection of 296 spring Chinook (100 natural origin and 196 hatchery origin represents 13% of the estimated 2004 spring Chinook escapement upstream from Tumwater Dam, 14.6% of the estimated Chiwawa natural origin escapement past Tumwater Dam, and 33.7% natural origin composition in the Chiwawa broodstock, all conforming to provisions of ESA Permit 1196. Dispositions of the 296 spring Chinook retained for the Chiwawa spring Chinook hatchery program are detailed in Table 5.35.

Table 5.35. Disposition of the 2004 brood spring Chinook captured and retained for Chiwawa Hatchery broodstock purposes.

Number spawned			Mortality			Surplused[a]			Total			Total
Males	Females	Jacks	Males	Females	Jacks	Males	Females	Jacks	Males	Females	Jacks	
72	133	10	8	3	42	8	0	20	88	136	72	296

[a] Although not used for spawning and categorized as "surplused," the majority of these fish were in poor condition and died shortly after the last spawning date (21 September). Those fish alive after 21 September were in a condition not likely to survive after release. All surplused fish were biologically sampled.

In addition to spring Chinook encountered at the Chiwawa Weir, 65 steelhead and 503 bull trout were also captured and released. To minimize fallback or impingement on the weir, all spring Chinook, steelhead, and bull trout were released unharmed about 10 kilometers upstream from the weir.

Hatchery Rearing and Release

The rearing and release of 2004 Chiwawa spring Chinook was completed without incident. No mortality events occurred that exceeded 10% of the population. Fish were acclimated on Wenatchee River water and to the extent possible on Chiwawa River water (see Section 5.2).

The release of 2004 brood Chiwawa spring Chinook smolts totaled 494,517 fish (73.6% of program objective); complying with ESA Section 10 Permit 1196 take level of 672,000 smolts.

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, and 1395, permit holders shall monitor and report hatchery effluents in compliance with applicable National Pollution Discharge Elimination Systems (NPDES) (EPA 1999) permit limitations. NPDES monitoring and reporting for Chelan PUD Hatchery Programs during 2006 are provided in Appendix E.

Smolt and Emigrant Trapping

Per ESA Section 10 Permit No. 1196, 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 basin, the reported spring Chinook encounters during 2006 emigration monitoring complied with take provisions in the Section 10 permit and are detailed in Table 5.36. Additionally, juvenile fish captured at the trap locations were handled consistent with provisions in ESA Section 10 Permit 1196, Section B.

The majority of trapping occurred when the river discharge was outside the calculated regression (i.e., too high or too low). Efficiency trials were not performed at low discharge because fish numbers were insufficient; trials at high discharge were not performed because the trap was not operated for fish health concerns. Due to the stream flow effects on efficiency trials during the peak migration, the reported estimated yearling and subyearling population emigrating past the Lower Wenatchee Trap is likely underestimated. Because population estimates derived from trapping data likely underestimated the actual population, encounter rates reported in Table 5.36 should be considered a maximum estimate.

Table 5.36. Estimated take of UCR spring Chinook resulting from juvenile emigration monitoring in the Wenatchee basin, 2006.

Trap location	Population estimate			Number trapped			Total	Take allowed under Permit
	Wild[a]	Hatchery[b]	Subyearling	Wild[a]	Hatchery[b]	Subyearling		
Chiwawa Trap								
Population	72,080	494,517	108,595	4,974	9,796	15,221	29,991	
Encounter rate	NA	NA	NA	0.0690	0.0198	0.1402	0.0444	0.20
Mortality[e]	NA	NA	NA	39	0	124	163	
Mortality rate	NA	NA	NA	0.0078	0.0000	0.0081	0.0054	0.02
Upper Wenatchee Trap								
Population	8,964	1,639	NA	137	10	2,012	2,159	
Encounter rate	NA	NA	NA	0.0153	0.0061	NA	NA	0.20
Mortality	NA	NA	NA	0	0	0	0	
Mortality rate	NA	NA	NA	0.0000	0.0000	0.0000	0.0000	0.02
Lower Wenatchee Trap								
Population	55,619	496,157	NA	652	7,306[c]	NA[d]	7,958	
Encounter rate	NA	NA	NA	0.0117	0.0147	NA	0.0144	0.20
Mortality[e]	NA	NA	NA	1	0	0	1	
Mortality rate	NA	NA	NA	0.0015	0.0000	0.0000	0.0001	0.02
Wenatchee Basin Total								
Population	55,619	496,157	NA	5,763	17,112	17,233	40,108	
Encounter rate	NA	NA	NA	0.1036	0.0345	NA	0.0727	0.20
Mortality[e]	NA	NA	NA	40	0	124	164	
Mortality rate	NA	NA	NA	NA	NA	NA	0.0041	0.02

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

[b] 2006 smolt release data for the Wenatchee basin.

[c] Derived estimate based on the proportion of ESA-listed hatchery spring Chinook within the total hatchery yearling Chinook released in the Wenatchee basin during 2006.

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

[e] Combined trapping and PIT tagging mortality.

Spawning Surveys

Spring Chinook spawning ground surveys were conducted in the Wenatchee basin during 2006, as authorized by ESA Section 10 Permit No. 1196. 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 impacts 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 specifically provides 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 2004, all spring Chinook passing Tumwater Dam were enumerated, anesthetize, biologically sampled, PIT tagged, and released (not withstanding hatchery origin Chinook retained for broodstock purposes) as a component of the reproductive success study (BPA Project No. 2003-039-00).

SECTION 6: WENATCHEE SUMMER CHINOOK

6.1 Broodstock Sampling

This section focuses on results from sampling 2004-2005 Wenatchee summer Chinook broodstock, which were collected at Dryden and Tumwater dams. Complete information is not currently available for the 2006 brood (this information will be provided in the 2007 annual report).

Origin of Broodstock

Both the 2004 and 2005 broodstock consisted almost entirely of natural origin (adipose fin present) summer Chinook (Table 6.1). Less than 1% of the fish spawned were hatchery origin fish (hatchery origin was determined by examination of scales and/or CWTs). About 5-6% of the fish spawned were of unknown origin.

Table 6.1. Numbers of wild and hatchery summer Chinook collected for broodstock, numbers that died before spawning, and numbers of Chinook spawned in the Wenatchee basin, 1989-2005. Unknown origin fish (i.e., undetermined by scale analysis, no CWT or fin clips, and no additional hatchery marks) were considered naturally produced. Pre-spawning loss does not include all mortality.

Return year	Wild summer Chinook			Hatchery summer Chinook			Total number spawned
	Number collected	Pre-spawn loss	Number spawned	Number collected	Pre-spawn loss	Number spawned	
1989	346	29	290	0	0	0	290
1990	84	6	61	0	0	0	61
1991	128	9	104	0	0	0	104
1992	341	41	274	0	0	0	274
1993	480	28	406	44	0	44	450
1994	363	29	333	55	1	54	387
1995	382	15	363	16	0	16	378
1996	331	34	263	3	0	3	266
1997	225	14	205	15	1	13	218
1998	378	40	299	94	4	78	377
1999	250	7	242	238	1	236	478
2000	298	18	275	194	7	180	455
2001	311	41	210	182	8	136	346
2002	469	28	409	13	1	10	419
2003	488	90	337	8	1	7	344
2004	494	24	424	2	0	2	426
2005	491	29	397	3	0	3	400
Average	***345***	***28***	***288***	***51***	***1***	***46***	***328***

Age/Length Data

Ages of summer Chinook broodstock were determined from analysis of scales and/or CWTs. Broodstock collected from the 2004 return consisted primarily of age-5 natural origin adults (84%) (Table 6.2). Age 4 natural origin Chinook made up 10% of the broodstock, while age-2, 3, and 6 fish collectively made up 6% of the broodstock. Note that according to broodstock protocol, age-2 males are limited to no more than 10% of the total broodstock collection. One age-4 and one age-5 hatchery Chinook were included in the 2004 broodstock.

Broodstock collected from the 2005 return consisted primarily of age-4 natural origin Chinook (54%). Age-5 natural origin fish made up 35% of the broodstock, while age-3 and 6 fish collectively made up 11% (Table 6.2). The three hatchery Chinook included in the broodstock were age-5 fish.

Table 6.2. Percent of hatchery and wild Wenatchee summer Chinook of different ages (total age) collected from broodstock in the Wenatchee basin, 1991-2005; NA = not available.

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	NA	NA	NA	NA	NA
	Hatchery	NA	NA	NA	NA	NA
1993	Wild	0.0	1.5	36.0	60.3	2.2
	Hatchery	0.0	0.0	100.0	0.0	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	18.9	76.6	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	6.6	0.0
1998	Wild	0.0	5.5	34.8	58.6	1.1
	Hatchery	0.0	5.4	68.5	19.6	6.5
1999	Wild	0.5	1.9	39.0	56.3	2.4
	Hatchery	0.0	1.3	23.2	72.1	2.4
2000	Wild	2.5	6.9	24.4	66.2	0.0
	Hatchery	0.0	23.6	15.2	42.9	18.3
2001	Wild	0.3	16.4	53.9	27.7	1.7
	Hatchery	0.0	6.3	80.6	10.0	3.1
2002	Wild	1.6	8.4	61.1	28.3	0.6
	Hatchery	0.0	0.0	41.7	58.3	0.0
2003	Wild	0.9	2.8	31.4	64.9	0.0

Return Year	Origin	Total age				
		2	3	4	5	6
	Hatchery	0.0	12.5	25.0	62.5	0.0
2004	Wild	0.2	3.6	10.1	84.0	2.1
	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
Average	***Wild***	***0.46***	***4.80***	***36.77***	***56.08***	***1.90***
	Hatchery	***0.00***	***8.18***	***40.19***	***43.20***	***8.42***

Mean lengths of natural origin summer Chinook of a given age differed little between 2004 and 2005 (Table 6.3). Mean lengths of age-3 to 6 Chinook differed between years by about 1 cm, 1 cm, 5 cm, and 8 cm, respectively. What few hatchery fish that were included in broodstock were similar in size to natural origin fish (Table 6.3).

Table 6.3. Mean fork length (cm) at age (total age) of hatchery and wild Wenatchee summer Chinook collected from broodstock in the Wenatchee basin, 1991-2005; 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	-
1992	Wild	-	NA	-	-	NA	-	-	NA	-	-	NA	-	-	NA	-
	Hatchery	-	NA	-	-	NA	-	-	NA	-	-	NA	-	-	NA	-
1993	Wild	-	0	-	68	6	10	84	142	9	98	238	6	100	9	6
	Hatchery	-	0	-	-	0	-	79	38	8	-	0	-	-	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	86	63	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	7	97	4	9
	Hatchery	-	0	-	46	4	2	74	10	4	98	1	-	-	0	-
1998	Wild	-	0	-	66	19	9	85	120	7	99	202	7	106	4	7
	Hatchery	-	0	-	53	5	2	77	63	8	95	18	8	98	6	8
1999	Wild	42	1	-	65	4	6	86	83	6	97	120	7	103	5	8

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	-	52	3	6	79	55	7	90	171	6	100	8	6
2000	Wild	43	7	4	60	19	7	84	67	5	98	182	6	-	0	-
	Hatchery	-	0	-	53	45	7	76	29	8	93	82	7	102	35	9
2001	Wild	48	1	-	66	48	7	88	158	7	97	81	6	102	5	3
	Hatchery	-	0	-	51	10	3	75	129	8	91	16	8	100	5	8
2002	Wild	48	7	4	64	37	8	89	270	7	100	125	7	99	3	13
	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	-			
2005	Wild	-	0	-	68	20	7	86	247	8	95	162	6	101	33	6
	Hatchery	-	0	-	-	0	-	-	0	-	90	3	9	-	0	-

Sex Ratios

Male summer Chinook in the 2004 broodstock made up about 47% of the adults collected, resulting in an overall male to female ratio of 0.87:1.00 (Table 6.4.). In 2005, males made up about 59% of the adults collected, resulting in an overall male to female ratio of 1.46:1.00 (Table 6.4). These ratios differ from the 1:1 ratio goal in the broodstock protocol.

Table 6.4. Numbers of male and female wild and hatchery summer Chinook collected for broodstock in the Wenatchee basin, 1989-2005. 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	0.78:1.00
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	NA	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
Total	***2,952***	***2,837***	***1.04:1.00***	***506***	***361***	***1.40:1.00***	***1.08:1.00***

Fecundity

Fecundities for the 2004 and 2005 returns of summer Chinook averaged 5,380 and 5,050 eggs per female, respectively (Table 6.5). These values are close to the 17-year average of 5,192 eggs per female. Mean observed fecundities for the 2004 and 2005 returns were above the expected fecundity of 5,000 eggs per female assumed in the broodstock protocol.

Table 6.5. Mean fecundity of wild, hatchery, and all female summer Chinook collected for broodstock in the Wenatchee basin, 1989-2005; 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	4,824	5,300
1999	5,036	4,942	4,990
2000	5,467	5,396	5,440
2001	5,248	4,666	5,100
2002	5,502	5,027	5,480
2003	5,357	5,696	5,360
2004	5,375	6,681	5,380
2005	5,053	6,391	5,050
Average	***5,313***	***5,433***	***5,192***

* Individual fecundities were not tracked with females until 1997.

6.2 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 are required to meet the program release goal of 864,000 smolts. Between 1989 and 2005, the egg take goal was reached in four years (Table 6.6).

Table 6.6. Numbers of eggs taken from Wenatchee summer Chinook broodstock, 1989-2005.

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
2002	1,049,255
2003	901,095
2004	1,311,051
2005	883,669
Average	***852,331***

Disease

Rearing of the 2004 brood Wenatchee summer Chinook was similar to previous years with fish being held on well water before being transferred to Dryden Pond for final acclimation in March 2006. Mortality from BKD began to increase in late November at Eastbank FH. Medicated feed became available from the manufacturer in January and the entire population received a 14-day Erythromycin treatment. Fish began being transferred to Dryden pond in late February and ended early March. As a preventative measure, a 14-day formalin treatment was initiated at the start of the transfers to control fungus, which in recent years has been a significant source of mortality. The 2004 brood Wenatchee summer Chinook continued to experience losses resulting from BKD until release.[6] One pond of Chinook experiencing the highest losses to BKD was not transferred to Dryden pond, but was planted directly into the Wenatchee River. This group represented 4.4% of the program.

Number of acclimation days

Wenatchee summer Chinook are typically transferred to Dryden Pond in late February or early March. Fish receive about two months of acclimation on Wenatchee River water before being released (Table 6.7). In recent years, a small proportion of the brood has been reared separately

[6] Based on fish health reports, about 77% of fish examined between November 2005 and April 2006 were BKD-related deaths. Between January and April 2006, 100% of the fish examined were BKD-related deaths.

(high ELISA) and has received no acclimated period (i.e., these fish are released directly into the Columbia River from the Eastbank FH). These data are not shown in Table 6.7.

Table 6.7. Number of days Wenatchee summer Chinook were acclimated at Dryden Pond, brood years 1989-2004. Numbers in parenthesis represents the number of days fish reared at Chiwawa Ponds.

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
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
Average				***82***

Release Information

Numbers released

The 2004 Wenatchee summer Chinook program achieved 103.4% of the 864,000 target goal with about 892,926 fish being released (Table 6.8). The overage was related to the large number of females with higher than expected fecundities.

Table 6.8. Numbers of Wenatchee summer Chinook smolts released from the hatchery, 1989-2004. The release target for Wenatchee summer Chinook is 864,000 smolts.

Brood year	Release year	Number of smolts
1989	1991	720,000
1990	1992	124,440
1991	1993	191,179
1992	1994	627,331
1993	1995	900,429
1994	1996	797,350
1995	1997	687,439
1996	1998	600,127
1997	1999	438,223
1998	2000	649,612
1999	2001	1,005,554
2000	2002	929,496
2001	2003	604,668
2002	2004	835,645
2003	2005	653,764
2004	2006	892,926
Average		***666,136***

Numbers tagged

The 2004 brood Wenatchee summer Chinook were 100% CWT and adipose fin-clipped, but were not PIT tagged.

Fish size and condition at release

Summer Chinook from the 2004 brood were released as yearling smolts in April of 2006. Size at release of the acclimated population was 83.6% and 78.0% of the target fork length and weight goals, respectively. This brood year exceeded the CV of length goal by 18.9% (Table 6.9). Since the program began, Wenatchee summer Chinook have not met the target length and CV values. The target weight (FPP) of juvenile fish has been met occasionally.

Table 6.9. 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 1989-2004; 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
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
Targets		***176***	***9.0***	***45.4***	***10***

Survival Estimates

Overall survival of the 2004 brood Wenatchee summer Chinook from green (unfertilized) egg to release was below the standard set for the program primarily because of poor green egg-to-eye survival. Additionally, poor survival post-transfer to Dryden Pond resulting from BKD further reduced the expected program performance (Table 6.10). However, as reported above, the release target was met because of a higher than expected egg-take for the 2004 brood.

Table 6.10. Hatchery life-stage survival rates (%) for Wenatchee summer Chinook, brood years 1989-2004. 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	79.2
1992	84.3	92.2	79.8	97.8	99.9	99.9	97.1	98.1	75.7
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	64.4
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
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

6.3 Natural Juvenile Productivity

During 2006, juvenile summer Chinook were sampled at the Lower Wenatchee Trap located at the West Monitor Bridge.

Emigrant Estimates

The Lower Wenatchee Trap operated nightly between 8 February and 5 August 2006. During that time period the trap was inoperable for 27 days because of high river flows, debris, snow/ice, or mechanical failure. During the seven-month sampling period, a total of 63,580 wild subyearling Chinook were captured at the Lower Wenatchee Trap. Based on capture efficiencies estimated from the flow model, the total number of wild subyearling Chinook that emigrated past the Lower Wenatchee Trap was 11,612,939 (±3,022,607). Most of these fish emigrated during May (Figure 6.1). Monthly captures and mortalities of all fish collected at the Lower Wenatchee Trap are reported in Appendix B.

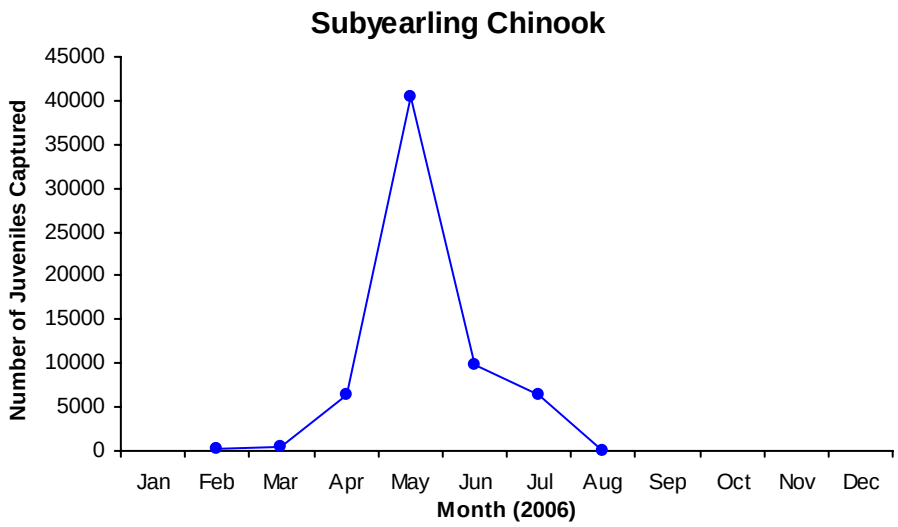


Figure 6.1. Numbers of wild subyearling Chinook captured at the Lower Wenatchee Trap during February through August, 2006.

6.4 Spawning Surveys

Surveys for Wenatchee summer Chinook redds were conducted from late September to early November, 2006, in the Wenatchee River and Icicle Creek. Surveys were cut short because of flood conditions in early November. Both peak counts and total counts were conducted in the river (see Appendix G for more details).

Redd Counts

A peak count of 7,233 summer Chinook redds was estimated in 2006 based on ground surveys conducted in the Wenatchee River and Icicle Creek (Table 6.11). A total redd count of 8,896 redds was estimated in 2006 based on partially expanded ground counts in the Wenatchee River and Icicle Creek (Table 6.11). Expansions were not possible for the lower three reaches on the Wenatchee River because flood conditions prevented crews from conducting reliable naïve surveys in these reaches. Nevertheless, the peak and total redd counts in 2006 were the highest on record.

Table 6.11. Peak and total numbers of redds counted in the Wenatchee River, 1989-2006; NA = not available.

Survey year	Peak redd count	Total redd count
1989	3,331	NA
1990	2,479	NA
1991	2,180	NA
1992	2,328	NA
1993	2,334	NA
1994	2,426	NA
1995	1,872	NA
1996	1,435	NA
1997	1,388	NA

Survey year	Peak redd count	Total redd count
1998	1,660	NA
1999	2,188	NA
2000	2,022	NA
2001	2,857	NA
2002	5,419	NA
2003	4,281	NA
2004	3,764	5,804
2005	3,327	NA
2006*	7,233	8,896
Average	***2,918***	***7,350***

* Peak and total counts include 68 redds counted in Icicle Creek.

Redd Distribution

Summer Chinook redds were not evenly distributed among reaches within the Wenatchee basin in 2006 (Table 6.12; Figure 6.2). 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 6.12. Peak and total numbers of summer Chinook redds counted in different reaches in the Wenatchee basin during September through early November, 2006. Reach codes are described in Table 2.10.

Survey reach	Peak redd count	Total redd count
Wenatchee 1	79	79
Wenatchee 2	346	346
Wenatchee 3	392	392
Wenatchee 4	152	155
Wenatchee 5	157	604
Wenatchee 6	1,789	1,789
Wenatchee 7	535	1,029
Wenatchee 8	577	814
Wenatchee 9	1,684	1,786
Wenatchee 10	1,454	1,834
Icicle Creek	68	68
Totals	***7,233***	***8,896***

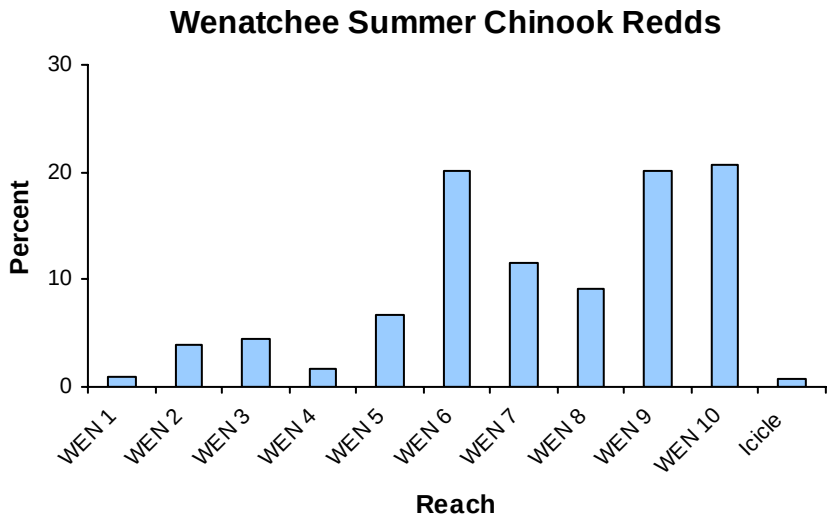


Figure 6.2. Percent of the total number of summer Chinook redds counted in different reaches in the Wenatchee basin during September through early November, 2006. Reach codes are described in Table 2.10.

Spawn Timing

In 2006, spawning in the Wenatchee River began the last week of September, peaked in the middle of October, and ended after the first week of November because of high water (Figure 6.3).

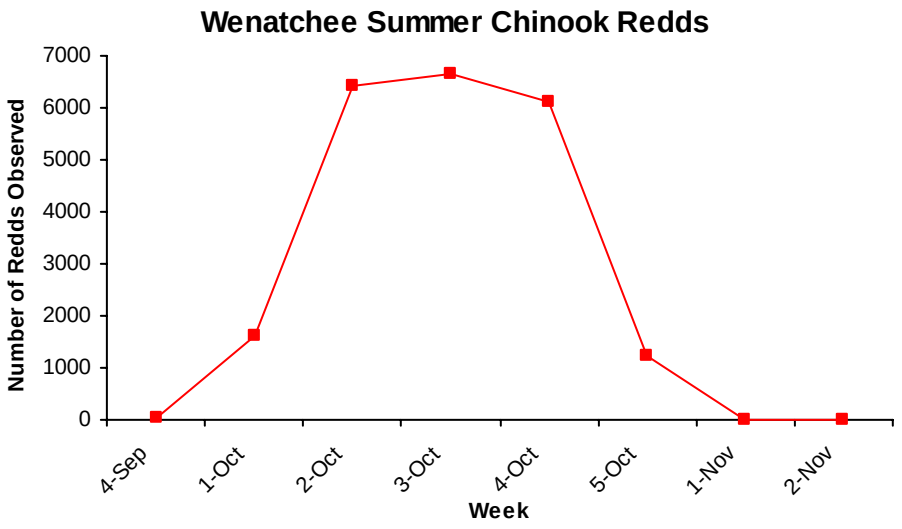


Figure 6.3. Number of summer Chinook redds counted during different weeks in the Wenatchee River, September through early November 2006.

Spawning Escapement

Spawning escapement for Wenatchee summer Chinook was calculated as the total number of redds 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 2006 was 2.00. Multiplying this ratio by the number of redds counted in the Wenatchee basin resulted in a total spawning escapement of 17,792 summer Chinook (Table 6.13). This was the highest spawning escapement on record.

Table 6.13. Spawning escapements for summer Chinook in the Wenatchee basin, 1989-2006.

Survey year	Fish/Redd	Total spawning escapement
1989	3.40	11,325
1990	3.50	8,677
1991	3.70	8,066
1992	4.00	9,312
1993	3.20	7,469
1994	3.30	8,006
1995	3.30	6,178
1996	3.40	4,879
1997	3.40	4,719
1998	2.40	3,984
1999	2.00	4,376
2000	2.17	4,448
2001	3.20	9,142
2002	2.30	12,464
2003	2.24	9,695
2004	2.15	8,093
2005	2.46	8,184
2006	2.00	17,792
Average	***2.90***	***8,156***

6.5 Carcass Surveys

Surveys for Wenatchee summer Chinook carcasses were conducted during late September to early November, 2006, in the Wenatchee River and Icicle Creek. Surveys were cut short because of flood conditions in early November.

Number sampled

A total of 3,600 summer Chinook carcasses were sampled during September through early October in the Wenatchee basin in 2006 (Table 6.14).

Table 6.14. Numbers of summer Chinook carcasses sampled within each survey reach in the Wenatchee basin, 1993-2006. 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	53	134	594	11	77	135	200	37	0	0	0	**1,241**
1994	0	2	16	1	15	37	18	47	124	1	0	**261**
1995	0	6	11	0	0	102	49	34	19	0	0	**221**
1996	0	5	66	38	9	186	26	30	41	0	0	**401**
1997	1	41	112	4	25	269	7	71	66	13	0	**609**
1998	6	65	125	2	0	201	27	333	300	56	0	**1,115**
1999	0	122	79	14	24	751	55	126	164	68	0	**1,403**
2000	7	93	140	7	72	601	72	103	154	188	0	**1,437**
2001	0	40	118	7	0	309	31	110	85	78	0	**778**
2002	0	216	159	0	188	773	0	302	517	150	6	**2,311**
2003	5	287	153	47	126	608	52	232	459	45	4	**2,018**
2004	7	132	170	149	145	898	81	295	417	359	0	**2,653**
2005	8	84	105	39	46	709	70	138	353	258	14	**1,824**
2006	22	139	160	56	112	954	435	343	703	658	18	**3,600**
Mean	***8***	***98***	***143***	***27***	***60***	***467***	***80***	***157***	***243***	***134***	***3***	***1,419***

Carcass Distribution and Origin

Summer Chinook carcasses were not evenly distributed among reaches within survey streams in the Wenatchee basin in 2006 (Table 6.14; Figure 6.4). Most of the carcasses in the Wenatchee basin were found upstream from the Leavenworth Bridge. The highest percentage of carcasses (27%) was sampled in Reach 6 near the confluence of the Icicle River.

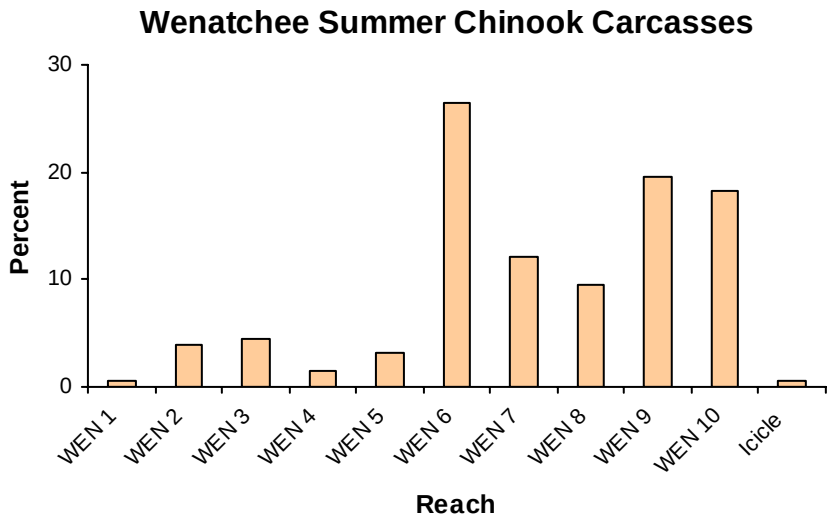


Figure 6.4. Percent of summer Chinook carcasses sampled within different reaches in the Wenatchee basin during September through early November, 2006. Reach codes are described in Table 2.10.

Numbers of wild and hatchery origin summer Chinook carcasses sampled in 2006 will be available after analysis of CWTs and scales. Most fish, regardless of origin, were found in Reach 6 (Leavenworth Bridge to Icicle Road Bridge) (Table 6.15). However, a larger percentage of hatchery fish were found in that reach than were wild fish (Figure 6.5). In contrast, a larger percentage of wild fish were found in reaches upstream from the Icicle Road Bridge.

Table 6.15. Numbers of wild and hatchery summer Chinook carcasses sampled within different reaches in the Wenatchee basin, 1993-2005.

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	53	133	591	11	77	124	200	37	0	0	0	**1,226**
	Hatchery	0	1	3	0	0	11	0	0	0	0	0	**15**
1994	Wild	0	2	15	1	15	34	18	47	124	1	0	**257**
	Hatchery	0	0	1	0	0	3	0	0	0	0	0	**4**
1995	Wild	0	4	11	0	0	99	49	34	19	0	0	**216**
	Hatchery	0	2	0	0	0	3	0	0	0	0	0	**5**
1996	Wild	0	5	65	37	8	181	26	30	41	0	0	**393**
	Hatchery	0	0	1	1	1	5	0	0	0	0	0	**8**
1997	Wild	1	35	104	4	21	242	7	71	66	13	0	**564**
	Hatchery	0	6	8	0	4	27	0	0	0	0	0	**45**
1998	Wild	6	55	106	2	0	169	25	325	297	56	0	**1,041**
	Hatchery	0	10	19	0	0	32	2	8	3	0	0	**74**
1999	Wild	0	79	55	7	14	526	51	124	159	68	0	**1,083**
	Hatchery	0	43	24	7	10	225	4	2	5	0	0	**320**
2000	Wild	4	68	102	6	51	443	68	100	154	186	0	**1,182**

	Hatchery	3	25	38	1	21	158	4	3	0	2	0	**255**
2001	Wild	0	33	89	4	0	231	29	108	83	78	0	**655**
	Hatchery	0	7	29	3	0	78	2	2	2	0	0	**123**
2002	Wild	0	140	112	0	95	441	0	295	514	150	0	**1,747**
	Hatchery	0	76	47	0	93	332	0	7	3	0	2	**560**
2003	Wild	5	226	120	21	96	427	52	223	455	45	4	**1,674**
	Hatchery	0	61	33	26	30	181	0	9	4	0	0	**344**
2004	Wild	7	107	151	102	97	640	77	282	416	357	0	**2,236**
	Hatchery	0	25	19	47	48	258	4	13	1	2	0	**417**
2005	Wild	4	47	78	24	26	397	66	124	336	243	0	**1,345**
	Hatchery	4	36	27	15	20	310	4	14	17	14	7	**468**
Average	***Wild***	***6***	***72***	***123***	***17***	***38***	***304***	***51***	***138***	***205***	***92***	***0***	***1,048***
	Hatchery	***1***	***22***	***19***	***8***	***17***	***125***	***2***	***4***	***3***	***1***	***1***	***203***

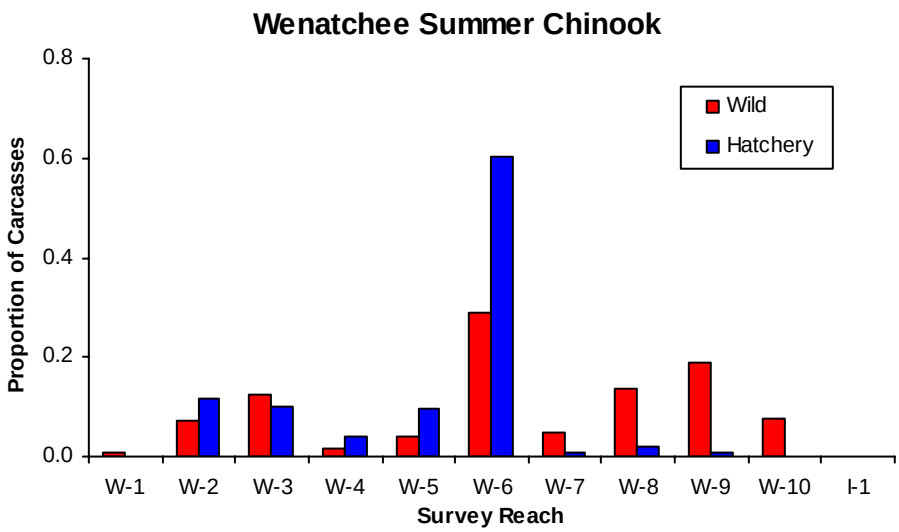


Figure 6.5. Distribution of wild and hatchery produced carcasses in different reaches in the Wenatchee basin, 1993-2005. Reach codes are described in Table 2.10.

Sampling Rate

Overall, 20% of the total spawning escapement of summer Chinook in the Wenatchee basin was sampled in 2006 (Table 6.16). Sampling rates among survey reaches varied from 9 to 27%.

Table 6.16. Number of redds and carcasses, total spawning escapement, and sampling rates for summer Chinook in the Wenatchee basin, 2006.

Sampling reach	Total number of redds	Total number of carcasses	Total spawning escapement	Sampling rate
Wenatchee 1	79	22	158	0.14
Wenatchee 2	346	139	692	0.20
Wenatchee 3	392	160	784	0.20
Wenatchee 4	155	56	310	0.18
Wenatchee 5	604	112	1,208	0.09
Wenatchee 6	1,789	954	3,578	0.27
Wenatchee 7	1,029	435	2,058	0.21
Wenatchee 8	814	343	1,628	0.21
Wenatchee 9	1,786	703	3,572	0.20
Wenatchee 10	1,834	658	3,668	0.18
Icicle Creek	68	18	136	0.13
Total	***8,896***	***3,600***	***17,792***	***0.20***

Length Data

Mean lengths (POH, cm) of male and female summer Chinook carcasses sampled during surveys in the Wenatchee basin in 2006 are provided in Table 6.17. The average size of males and females sampled in the Wenatchee basin were 73 cm and 75 cm, respectively.

Table 6.17. 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 basin, 2006.

Stream/watershed	Mean length (cm)	
	Male	Female
Wenatchee 1	73 (5)	76 (3)
Wenatchee 2	74 (7)	75 (5)
Wenatchee 3	75 (9)	76 (4)
Wenatchee 4	73 (9)	77 (5)
Wenatchee 5	68 (12)	75 (5)
Wenatchee 6	72 (9)	75 (5)
Wenatchee 7	73 (11)	75 (5)
Wenatchee 8	72 (11)	76 (5)
Wenatchee 9	75 (7)	76 (5)
Wenatchee 10	73 (7)	74 (5)
Icicle Creek	70 (7)	72 (7)
Total	***73 (9)***	***75 (5)***

6.6 Life History Monitoring

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

Age at Maturity

Most of the wild and hatchery summer Chinook sampled during the period 1993-2005 in the Wenatchee basin were age-5 fish (total age) (Table 6.18; Figure 6.6). A higher percentage of age-4 wild Chinook returned to the basin than did age-4 hatchery Chinook. In contrast, a higher proportion of age-6 hatchery fish returned than did age-6 wild fish. Thus, a higher percentage of hatchery fish returned at an older age than did wild fish.

Table 6.18. Proportions of wild and hatchery summer Chinook of different ages (total age) sampled at broodstock collection sites and on spawning grounds in the Wenatchee basin, 1993-2005; NA = not available.

Sample year	Origin	Total age						Sample size
		2	3	4	5	6	7	
1993	Wild	0.00	0.03	0.42	0.55	0.00	0.00	1,226
	Hatchery	0.00	0.07	0.93	0.00	0.00	0.00	15
1994	Wild	0.01	0.03	0.44	0.51	0.00	0.00	257
	Hatchery	0.00	0.00	0.00	1.00	0.00	0.00	1
1995	Wild	0.00	0.03	0.18	0.75	0.05	0.00	216
	Hatchery	0.00	0.00	0.00	0.20	0.80	0.00	5
1996	Wild	0.00	0.01	0.44	0.53	0.01	0.00	203
	Hatchery	0.00	0.00	0.50	0.00	0.33	0.17	6
1997	Wild	0.01	0.01	0.38	0.57	0.03	0.00	566
	Hatchery	0.00	0.02	0.04	0.89	0.04	0.00	45
1998	Wild	0.00	0.03	0.34	0.62	0.01	0.00	1,049
	Hatchery	0.00	0.04	0.69	0.16	0.11	0.00	74
1999	Wild	0.00	0.01	0.42	0.56	0.01	0.00	1,086
	Hatchery	0.00	0.01	0.18	0.79	0.02	0.00	320
2000	Wild	0.01	0.04	0.27	0.68	0.00	0.00	1,181
	Hatchery	0.00	0.07	0.07	0.74	0.11	0.00	254
2001	Wild	0.00	0.08	0.58	0.32	0.01	0.00	654
	Hatchery	0.00	0.06	0.81	0.08	0.05	0.00	126
2002	Wild	0.00	0.03	0.66	0.31	0.00	0.00	1,747
	Hatchery	0.00	0.01	0.16	0.82	0.02	0.00	560
2003	Wild	0.00	0.01	0.35	0.63	0.00	0.00	1,668
	Hatchery	0.00	0.06	0.07	0.76	0.10	0.00	344
2004	Wild	0.00	0.06	0.13	0.80	0.01	0.00	2,232
	Hatchery	0.00	0.06	0.58	0.25	0.11	0.00	416
2005	Wild	NA	NA	NA	NA	NA	NA	NA

	Hatchery	NA	NA	NA	NA	NA	NA	NA
Average	***Wild***	***0.00***	***0.03***	***0.37***	***0.58***	***0.01***	***0.00***	***1,007***
	Hatchery	***0.00***	***0.04***	***0.28***	***0.61***	***0.07***	***0.00***	***181***

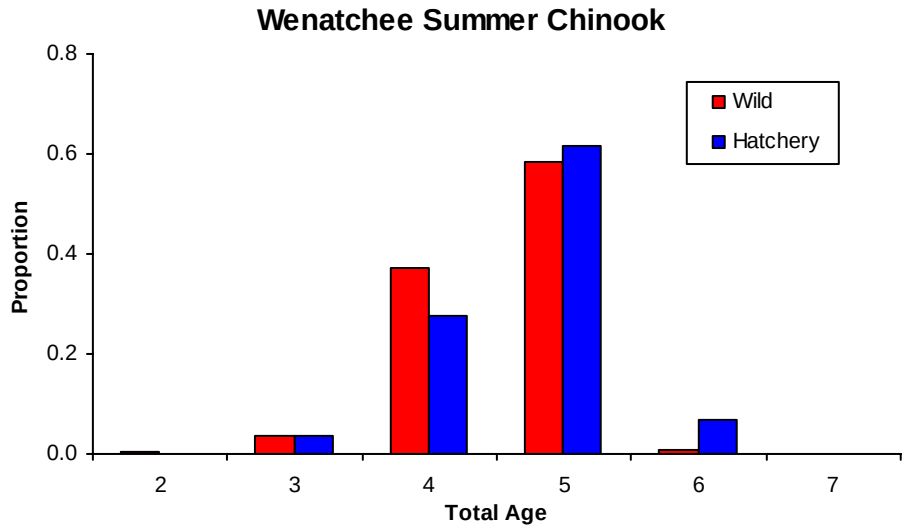


Figure 6.6. Proportions of wild and hatchery summer Chinook of different total ages sampled at broodstock collection sites and on spawning grounds in the Wenatchee basin for the combined years 1993-2005.

Size at Maturity

On average, hatchery summer Chinook were about 5 cm smaller than wild summer Chinook sampled in the Wenatchee basin (Table 6.19). This is interesting given that a slightly higher percentage of hatchery fish returned as age-5 and 6 fish than did wild fish. Future analyses will compare sizes of hatchery and wild fish of the same age groups and gender.

Table 6.19. Mean lengths (POH; cm) and variability statistics for wild and hatchery summer Chinook sampled in the Wenatchee basin, 1993-2005; SD = 1 standard deviation.

Sample year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
1993	Wild	1,224	73	8	33	94
	Hatchery	68	61	9	37	83
1994	Wild	257	74	8	31	89
	Hatchery	25	70	8	54	85
1995	Wild	216	75	7	48	87
	Hatchery	23	74	7	57	85
1996	Wild	202	75	7	43	92
	Hatchery	9	66	12	52	84
1997	Wild	564	74	8	29	99
	Hatchery	78	69	11	29	83

Sample year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
1998	Wild	1,041	73	8	28	97
	Hatchery	188	67	10	37	87
1999	Wild	1,080	72	8	29	95
	Hatchery	518	71	7.5	26	94
2000	Wild	1,181	72	10	24	94
	Hatchery	369	69	11	33	91
2001	Wild	649	70	9	30	93
	Hatchery	176	63	10	28	86
2002	Wild	1,742	73	8	39	94
	Hatchery	651	71	8	34	95
2003	Wild	1,663	74	8	24	102
	Hatchery	521	69	10	26	97
2004	Wild	2,231	73	9	32	98
	Hatchery	575	59	11	25	91
2005	Wild	1,346	69	8	41	92
	Hatchery	463	69	8	39	91
Pooled	***Wild***	***13,367***	***72***	***8***	***24***	***102***
	Hatchery	***3,664***	***67***	***10***	***25***	***97***

Contribution to Fisheries

Most of the harvest on Wenatchee summer Chinook occurred in the ocean (Table 6.20). Ocean harvest has made up 50% to 100% of all Wenatchee summer Chinook harvested. Total harvest on early brood years (1990-1993) was much lower than for later brood years (1997-2000).

Table 6.20. Estimated number and percent (in parentheses) of Wenatchee summer Chinook captured in different fisheries.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal (Zone 6)	Commercial (Zones 1-5)	Recreational (sport)	
1989	1,451 (50)	1,287 (44)	149 (5)	20 (1)	2,907
1990	30 (100)	0 (0)	0 (0)	0 (0)	30
1991	29 (62)	0 (0)	0 (0)	18 (38)	47
1992	143 (76)	44 (24)	0 (0)	0 (0)	187
1993	44 (64)	25 (36)	0 (0)	0 (0)	69
1994	758 (89)	83 (10)	7 (1)	1 (0)	849
1995	482 (93)	28 (5)	10 (2)	0 (0)	520
1996	199 (94)	3 (1)	3 (1)	6 (3)	211
1997	3,173 (93)	86 (3)	45 (1)	107 (3)	3,411

1998	5,144 (93)	109 (2)	106 (2)	175 (3)	5,534
1999	1,462 (86)	51 (3)	131 (8)	52 (3)	1,696
2000	2,390 (77)	274 (9)	268 (9)	162 (5)	3,094

Straying

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Wenatchee basin. The target for strays based on return year (recovery year) outside the Wenatchee basin should be less than 0.050. Likewise the target for brood year stray rates should be less than 0.050.

Stray rates for available brood years have exceeded the target of 0.050 (Table 6.21). Stray rates of Wenatchee summer Chinook have averaged about 19%. These fish have ended up in the Entiat, Methow, and Okanogan rivers and the Chelan tailrace.

Table 6.21. Stray rates by brood year for Wenatchee hatchery summer Chinook, 1989-2000. Target is a stray rate less than 0.050. *(The numbers in this table may change as the HETT and HC refine the methods for estimating summer Chinook stray rates)*

Brood year	Stray rate
1989	0.343
1990	0.153
1991	0.348
1992	0.140
1993	0.174
1994	0.116
1995	0.120
1996	0.205
1997	0.106
1998	0.208
Average	***0.191***

Genetics

Tissue (operculum) samples were collected from 144 wild and 144 hatchery summer Chinook in the Wenatchee basin in 2006. These samples have not been processed. Results from these samples should be available next year.

Natural Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural origin recruits (NOR) to the parent spawning population. For brood years 1989-1999, NRR for summer Chinook in the Wenatchee averaged 0.98 (range, 0.40-3.04) if harvested fish were not include in the estimate and 1.79 (range, 0.58-7.84) 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.

Table 6.22. Spawning escapements, natural origin recruits (NOR), and natural replacement rates (NRR; with and without harvest) for wild summer Chinook in the Wenatchee basin, 1989-2000. *(The numbers in this table may change as the HETT and HC refine the methods for estimating summer Chinook NORs and NRRs.)*

Brood year	Escapement	NOR	NRR	
			Harvest not included	Harvest included
1989	11,325	11,671	0.80	1.27
1990	8,677	8,764	0.95	1.26
1991	8,066	8,194	0.57	0.76
1992	9,312	9,647	0.49	0.65
1993	7,469	7,559	0.56	0.70
1994	8,006	7,683	0.40	0.58
1995	6,178	6,005	0.67	1.13
1996	4,879	5,020	0.72	1.13
1997	4,719	4,456	1.62	2.60
1998	3,984	3,868	3.04	7.84
Average	***6,787***	***6,663***	***0.98***	***1.79***

Hatchery Replacement Rates

Hatchery replacement rates were estimated as hatchery adult-to-adult returns. These rates should be greater than the NRRs and greater than or equal to 5.30 (the value in BAMP; Murdoch and Peven 2005). HRRs exceeded NRRs in eight of the 10 years of data, regardless if harvest was or was not included in the estimate (Table 6.23). Hatchery replacement rates (harvest included in the estimate) for Wenatchee summer Chinook have exceeded the BAMP target of 5.30 in four of the 11 years of data.

Table 6.23. Hatchery replacement rates (HRR), NRR, and BAMP target (5.30) for summer Chinook in the Wenatchee basin, 1989-2000. *(The numbers in this table may change as the HETT and HC refine the methods for estimating summer Chinook HRRs and NRRs.)*

Brood year	Harvest not included			Harvest included		
	HRR	NRR	BAMP	HRR	NRR	BAMP
1989	6.20	0.80	5.30	14.60	1.27	5.30
1990	1.02	0.95	5.30	1.37	1.26	5.30
1991	0.18	0.57	5.30	0.55	0.76	5.30
1992	1.32	0.49	5.30	1.80	0.65	5.30
1993	0.19	0.56	5.30	0.34	0.70	5.30
1994	3.48	0.40	5.30	5.52	0.58	5.30
1995	2.49	0.67	5.30	3.79	1.13	5.30
1996	1.11	0.72	5.30	1.74	1.13	5.30
1997	17.54	1.62	5.30	31.77	2.60	5.30

Brood year	Harvest not included			Harvest included		
	HRR	NRR	BAMP	HRR	NRR	BAMP
1998	4.31	3.04	5.30	16.01	7.84	5.30
1999	0.26		5.30	3.59		5.30
Average	***3.46***	***0.98***	***5.30***	***7.37***	***1.79***	***5.30***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adults divided by the number of hatchery smolts released. SARs were based on CWT returns. For the available brood years, SARs have ranged from 0.0004 to 0.0184 for hatchery summer Chinook in the Wenatchee basin (Table 6.24).

Table 6.24. Smolt-to-adult ratios (SARs) for Wenatchee hatchery summer Chinook.

Brood year	Number released	SAR
1989	144,905	0.006757
1990	119,214	0.000943
1991	190,371	0.000364
1992	605,055	0.001006
1993	210,626	0.000754
1994	452,340	0.003044
1995	668,409	0.002203
1996	585,590	0.000942
1997	388,626	0.018439
1998	641,109	0.011573
1999	988,328	0.002517
Average	***454,052***	***0.004413***

6.7 ESA/HCP Compliance

Broodstock Collection

Per the 2004 broodstock collection protocol, 492 natural origin (adipose fin present) adults were targeted for collection at Dryden and Tumwater dams. Because of inventory errors during collection, the actual 2004 collection totaled 496 fish. Collection at Dryden Dam began 21 June 2004, ten days earlier than anticipated based in the 2004 collection protocol and the July-August trapping period specified in ESA Permit 1347. The early start date for summer Chinook broodstock collection at Dryden Dam was an error in implementing the 2004 protocol and resulted in the unanticipated capture of 54 spring Chinook, all of which were released unharmed immediately upstream of the trap site.

No steelhead takes were associated with the Wenatchee summer Chinook collection. Summer Chinook and steelhead broodstock collections were concurrent at Tumwater and Dryden dams; therefore, steelhead encounters are attributable to ESA Permit 1395 take authorizations.

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 water during handling.

Hatchery Rearing and Release

The 2004 Wenatchee summer Chinook program released an estimated 892,926 smolts, representing 103.4% of the 864,000 programmed production. Although the program achieved 103% of its programmed production, the program was compliant with 10% allowance for production levels identified in ESA Section 10 Permit 1347. A greater proportion of females in the broodstock, and greater than anticipated fecundities resulted in the production overage. For more details on rearing, disease, marking/tagging, and release see Section 6.2

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, and 1395, permit holders shall monitor and report hatchery effluents in compliance with applicable National Pollution Discharge Elimination Systems (NPDES) (EPA 1999) permit limitations. NPDES monitoring and reporting for Chelan PUD Hatchery Programs during 2006 are provided in Appendix E.

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 3.7) and spring Chinook (Section 5.7) sections and are not repeated here.

Spawning Surveys

Summer Chinook spawning ground surveys conducted in the Wenatchee basin during 2006 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 impacts to established redds, wading was restricted to the extent practical, and extreme caution was used to avoid established redds when wading was required.

SECTION 7: METHOW SUMMER CHINOOK

7.1 Broodstock Sampling

This section focuses on results from sampling 2004-2005 Methow summer Chinook broodstock, which were collected in the East Ladder of Wells Dam. Summer Chinook adults collected at Wells Dam are also used in the Okanogan/Similkameen supplementation program. Complete information is not currently available for the 2006 return (this information will be provided in the 2007 annual report).

Origin of Broodstock

Both 2004 and 2005 broodstock consisted almost entirely of natural origin (adipose fin present) summer Chinook (Table 7.1). These fish were used for both the Methow and Okanogan supplementation programs. Less than 3% of the fish spawned were hatchery origin fish (hatchery origin was determined by examination of scales and CWTs). About 6% of the fish spawned in both years were of unknown origin.

Table 7.1. 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, 1989-2005. Unknown origin fish (i.e., undetermined by scale analysis, no CWT or fin clips, and no additional hatchery marks) were considered naturally produced. Pre-spawning loss does not include all mortality.

Return year	Number of wild summer Chinook			Number of hatchery summer Chinook			Total number spawned
	Number collected	Pre-spawn loss	Number spawned	Number collected	Pre-spawn loss	Number spawned	
1989[a]	1,419	72	1,297	341	17	312	1,609
1990[a]	864	34	828	214	8	206	1,034
1991[a]	1,003	59	924	341	20	314	1,238
1992[a]	312	6	297	428	9	406	703
1993[a]	813	48	681	464	28	388	1,069
1994	385	33	341	266	15	244	585
1995	254	6	173	353	22	240	413
1996	316	15	290	234	2	223	513
1997	214	11	198	308	24	264	462
1998	239	28	153	348	18	211	364
1999	248	5	224	307	2	289	513
2000	184	15	164	373	17	339	503
2001	135	8	91	423	29	266	357
2002	270	2	247	285	11	241	488
2003	449	14	381	112	2	101	482
2004	541	23	506	17	0	16	522
2005	551	29	391	12	2	9	400
Average[b]	***316***	***16***	***263***	***253***	***12***	***204***	***467***

[a] 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).

[b] Because of bias from aggregating the spawning population from 1989-1993, averages are based on adult numbers collected from 1994-2005.

Age/Length Data

Ages of summer Chinook broodstock were determined from analysis of scales and/or CWTs. Broodstock collected from the 2004 return consisted primarily of age-5 natural origin adults (72%) (Table 7.2). Age 3 natural origin Chinook made up 15% of the broodstock, age-4 made up 12%, while age-2 and 6 fish collectively made up 1% of the broodstock. Note that according to broodstock protocol, age-2 males are limited to no more than 10% of the total broodstock collection. Most (86%) of the hatchery fish included in the broodstock were age-4 and 5 fish. The remaining 14% were age-3 and 6 summer Chinook.

Broodstock collected from the 2005 return consisted primarily of age-4 natural origin Chinook (70%). Age-4 natural origin fish made up 17% of the broodstock and age-5 and 6 fish collectively made up 13% (Table 7.2). The three hatchery Chinook included in the broodstock were age-5 fish.

Table 7.2. Percent of hatchery and wild summer Chinook of different ages (total age) collected from broodstock for the Methow/Okanogan programs, 1991-2005.

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	50.0	9.2
1992	Wild	0.0	13.1	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	85.9	13.1	0.0
1994	Wild	3.1	9.7	26.3	60.3	0.6
	Hatchery	0.0	14.7	11.3	74.0	0.0
1995	Wild	0.0	4.6	15.2	75.6	4.6
	Hatchery	0.0	0.4	13.0	25.6	61.0
1996	Wild	0.0	8.6	56.4	30.5	4.5
	Hatchery	0.0	2.6	31.0	47.2	19.2
1997	Wild	1.0	9.3	52.9	34.8	2.0
	Hatchery	0.0	20.7	10.8	62.0	6.5
1998	Wild	2.1	12.0	55.7	30.2	0.0
	Hatchery	2.4	18.9	56.0	15.9	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

Return Year	Origin	Total age				
		2	3	4	5	6
	Hatchery	0.0	27.0	14.3	54.3	4.3
2001	Wild	7.1	26.0	52.0	11.8	3.2
	Hatchery	0.2	19.6	68.3	9.6	2.3
2002	Wild	0.4	17.4	66.0	16.2	0.0
	Hatchery	0.0	2.4	39.4	58.2	0.0
2003	Wild	0.7	3.9	65.9	29.5	0.0
	Hatchery	0.9	5.6	18.5	69.5	5.6
2004	Wild	0.8	15.3	11.6	72.1	0.2
	Hatchery	0.0	7.1	57.1	28.6	7.2
2005	Wild	0.0	17.2	69.9	11.0	1.9
	Hatchery	0.0	1.0	40.0	50.0	0.0
Average	***Wild***	***1.40***	***11.13***	***46.73***	***39.40***	***1.35***
	Hatchery	***0.29***	***8.64***	***34.07***	***41.53***	***8.27***

Mean lengths of natural origin summer Chinook of a given age differed little between 2004 and 2005 (Table 7.3). For most age groups, mean lengths of natural origin adults were larger than hatchery origin fish of the same age (Table 7.3). These differences may be related to the small sample size hatchery origin fish (i.e., few hatchery fish were included in the broodstock).

Table 7.3. Mean fork length (cm) at age (total age) of hatchery and wild Methow/Okanogan summer Chinook collected from broodstock for the Methow program, 1991-2005; 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	-	76	85	8	88	13	6	-	0	-
1994	Wild	42	10	6	51	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	8
1996	Wild	-	0	-	68	23	9	83	150	8	95	81	7	101	12	5
	Hatchery	-	0	-	50	6	8	77	71	7	90	108	8	100	44	7

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
1997	Wild	36	2	6	60	19	7	85	108	8	96	71	7	98	4	11
	Hatchery	-	0	-	45	63	5	71	33	9	92	189	7	97	20	7
1998	Wild	43	4	6	59	23	6	83	107	7	96	58	7	-	0	-
	Hatchery	42	8	7	50	64	6	74	190	8	92	54	8	98	23	5
1999	Wild	38	10	3	64	11	8	82	115	8	96	77	6	104	1	-
	Hatchery	37	1	-	53	11	9	75	15	9	91	204	6	98	6	5
2000	Wild	39	1	-	66	23	7	88	47	6	96	92	5	95	1	-
	Hatchery	-	0	-	54	100	7	78	53	8	93	201	6	99	16	6
2001	Wild	40	9	3	65	33	8	87	66	8	93	15	5	97	4	16
	Hatchery	44	1	-	51	78	6	78	271	8	93	38	7	102	9	5
2002	Wild	56	1	-	65	44	7	88	167	6	100	41	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	49	1	-	55	6	9	73	20	8	91	75	7	102	6	9
2004	Wild	51	4	4	67	78	6	81	59	6	97	368	7	99	1	-
	Hatchery	-	0	-	52	1	-	70	8	5	97	4	9	109	1	-
2005	Wild	-	0	-	68	89	6	83	363	8	94	57	6	101	10	7
	Hatchery	-	0	-	55	1	-	70	4	4	89	5	4	-	0	-

Sex Ratios

Male summer Chinook in the 2004 broodstock made up about 49% of the adults collected, resulting in an overall male to female ratio of 0.97:1.00 (Table 7.4.). In 2005, males made up about 66% of the adults collected, resulting in an overall male to female ratio of 1.93:1.00 (Table 7.4). The ratio for the 2004 broodstock was close to the 1:1 ratio goal in the broodstock protocol; the ratio for the 2005 broodstock was larger than the assumed 1:1 ratio.

Table 7.4. Numbers of male and female wild and hatchery summer Chinook collected for broodstock at Wells Dam for the Methow and Okanogan programs, 1991-2005. 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
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
Total[b]	***2,076***	***1,708***	***1.22:1.00***	***1,835***	***1,205***	***1.52:1.00***	***1.34:1.00***

[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 1994-2005 data to exclude aggregate population bias from 1989-1993 returns.

Fecundity

Fecundities for the 2004 and 2005 returns of summer Chinook averaged 5,130 and 4,550 eggs per female, respectively (Table 7.5). These values are close to the 17-year average of 4,980 eggs per female. Mean observed fecundity for the 2005 return fell short of the expected fecundity of 5,000 eggs per female assumed in the broodstock protocol.

Table 7.5. Mean fecundity of wild, hatchery, and all female summer Chinook collected for broodstock at Wells Dam for the Methow and Okanogan programs, 1989-2005; 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	5,240
1998	5,043	4,595	4,830
1999	4,897	4,923	4,910
2000	5,122	5,206	5,170
2001	5,030	4,608	4,730
2002	5,306	5,258	5,280

Return year	Mean fecundity		
	Wild	Hatchery	Total
2003	5,132	4,941	5,060
2004	5,162	5,012	5,130
2005	4,535	4,889	4,550
Average	***5,044***	***4,970***	***4,980***

* Individual fecundities were not assigned to females until 1997 brood.

7.2 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 are needed to meet the program release goal of 400,000 smolts. Between 1989 and 2005, the egg take goal was reached in four years (Table 7.6).

Table 7.6. Numbers of eggs taken from summer Chinook broodstock collected at Wells Dam for the Methow program, 1989-2005.

Return year	Number of eggs taken
1989	482,800
1990	464,097
1991	586,594
1992	486,260
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
Average	***460,332***

Disease

No disease concerns were detected or observed in the 2004 brood.

Number of acclimation days

Rearing of the 2004 brood Methow summer Chinook was similar to previous years with fish being held on well water before being transferred to Carlton Pond for final acclimation on Methow River water in March 2006 (Table 7.7). Groups of the 1994 and 1995 broods were reared for longer durations at Methow FH on Methow River water.

Table 7.7. Number of days Methow summer Chinook were acclimated at Carlton Pond, brood years 1989-2004.

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
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
Average				***58***

Release Information

Numbers released

The 2004 Methow summer Chinook program achieved 100.1% of the 400,000 target goal with about 400,579 fish being released in April 2006 (Table 7.8). A volitional release was expected to be conducted beginning mid-April and continue for about one month with the mid-point coinciding with a new moon phase at the end of the month. As a result of heavy winter snow pack and significant runoff, the volitional release was terminated and remaining fish were forced out of the acclimation site. Had the release continued as planned, significant mortalities may have occurred because of inundation of the acclimation site with flood waters, which back up into the facility through the out-fall channel during extreme high water events.

Table 7.8. Numbers of Methow summer Chinook smolts released from the hatchery, brood years 1989-2004. The release target for Methow summer Chinook is 400,000 smolts.

Brood year	Release year	Number of smolts
1989	1991	420,000
1990	1992	391,650
1991	1993	540,900
1992	1994	402,641
1993	1995	433,375
1994	1996	406,560
1995	1997	353,182
1996	1998	298,844
1997	1999	384,909
1998	2000	205,269
1999	2001	424,363
2000	2002	336,762
2001	2003	248,595
2002	2004	399,975
2003	2005	354,699
2004	2006	400,579
Average		***375,144***

Numbers tagged

The 2004 brood Methow summer Chinook were 100% CWT and adipose fin-clipped, but were not PIT tagged.

Fish size and condition at release

Fish were volitionally released as yearling smolts in April 2006. Size at release of the acclimated population was 80.5% and 68.5% of the target fork length and weight goals, respectively (Table 7.9). This brood year exceeded the CV of length goal by 9%.

Table 7.9. 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 1991-2004. 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

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
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
Targets		***176***	***9.0***	***45.4***	***10***

Survival Estimates

Overall survival of the Methow summer Chinook from green (unfertilized) egg to release was at the standard set for the program (Table 7.10). Lower than anticipated survival at the fertilized to eyed-egg stage prevented the program from exceeding target survival rates. Currently it is unknown if gamete viability is gender biased or is uniform between sexes and more influenced by between-year environmental variations.

Table 7.10. Hatchery life-stage survival rates (%) for Methow summer Chinook, brood years 1989-2004. 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	63.7
1990[a]	93.9	99.0	84.9	97.1	81.2	80.6	97.7	99.5	80.5
1991[a]	93.1	95.5	88.2	98.0	99.4	99.1	97.5	99.6	84.2
1992[a]	96.9	99.0	87.8	98.0	99.9	99.9	90.9	98.3	78.2
1993[a]	82.2	99.4	85.4	97.6	99.8	99.5	92.0	99.4	76.7
1994	96.1	90.0	86.6	100.0	98.1	97.4	73.1	99.1	63.3
1995	91.9	96.2	98.2	84.1	96.5	96.2	92.7	89.6	76.6
1996	95.4	98.1	83.2	100.0	97.7	96.9	86.5	89.0	72.0
1997	91.9	94.6	86.1	98.4	98.7	98.3	98.8	99.7	83.7
1998	84.0	96.2	54.1	98.0	99.4	98.9	96.6	99.9	51.2
1999	98.8	98.7	92.9	96.9	98.0	97.6	96.9	99.9	87.2
2000	90.5	96.9	89.2	98.1	98.5	98.3	94.6	94.4	82.6
2001	96.2	92.3	89.1	97.6	97.2	97.1	97.5	99.8	84.8
2002	97.1	98.1	88.3	99.9	97.7	97.5	96.7	99.9	85.3
2003	96.7	97.5	82.8	98.2	99.7	99.2	93.7	99.9	76.2
2004	93.6	98.2	84.0	97.8	99.6	99.2	98.3	98.5	80.8

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.

7.3 Spawning Surveys

Surveys for Methow summer Chinook redds were conducted from late September to early November, 2006, in the Methow River. Surveys were cut short because of flood conditions in early November. Total redd counts were conducted in the river (see Appendix I for more details).

Redd Counts

A total of 1,353 summer Chinook redds were counted in the Methow River (Table 7.11). This was the third highest redd count observed in the Methow River.

Table 7.11. Total number of redds counted in the Methow River, 1989-2006.

Survey year	Total redd count
1989	126*
1990	229*
1991	153
1992	107
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
Average	***584***

* Total counts based on aerial surveys.

Redd Distribution

Summer Chinook redds were not evenly distributed among the seven reaches in the Methow River. Most redds (64%) were located in reaches downstream from the town of Twisp and in Reach 5 between Methow Valley Irrigation Diversion (MVID) and the Winthrop Bridge (Table 7.12; Figure 7.1). Few summer Chinook spawned upstream from the Winthrop Bridge in Reaches 6 and 7.

Table 7.12. Total number of summer Chinook redds counted in different reaches on the Methow River during September through early November, 2006. Reach codes are described in Table 2.11.

Survey reach	Total redd count	Percent
Methow 1	306	22.6
Methow 2	270	20.0
Methow 3	294	21.7
Methow 4	113	8.4
Methow 5	366	27.1
Methow 6	2	0.1
Methow 7	2	0.1
Totals	***1,353***	***100***

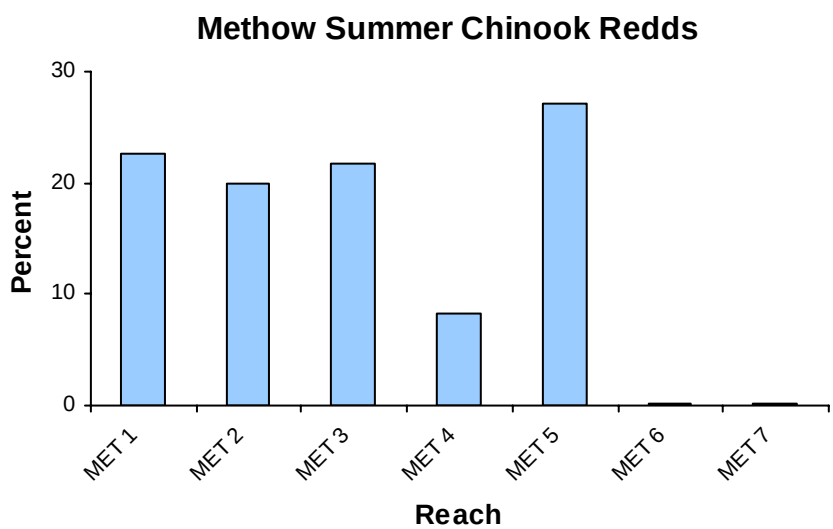


Figure 7.1. Percent of the total number of summer Chinook redds counted in different reaches on the Methow River during September through early November, 2006. Reach codes are described in Table 2.11.

Spawn Timing

Spawning in 2006 began the last week of September, peaked in the middle of October, and ended after the first week of November because of high water (Figure 7.2). Stream temperatures in the Methow River, when spawning began, varied from 10-13°C. Peak spawning occurred in the upper reaches of the Methow River during the second week of October and in the lower reaches the following week. When compared with the eight-year average, the temporal distribution of spawning activity in 2006 was shifted slightly to the right (i.e., more active spawning later in the spawning period).

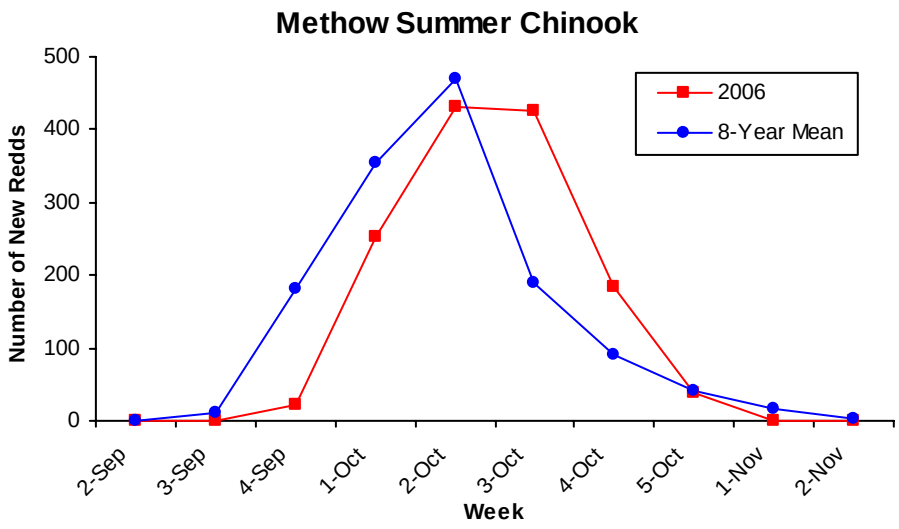


Figure 7.2. Number of new summer Chinook redds counted during different weeks in the Methow River, September through early November 2006.

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 2006 was 2.02. Multiplying this ratio by the number of redds counted in the Methow River resulted in a total spawning escapement of 2,733 summer Chinook (Table 7.13).

Table 7.13. Spawning escapements for summer Chinook in the Methow River for brood years 1989-2006.

Survey year	Fish/Redd	Total spawning escapement
1989*	3.30	620
1990*	3.40	1,391
1991*	3.70	566
1992*	4.30	460
1993*	3.30	508
1994*	3.50	1,085
1995*	3.40	1,214
1996*	3.40	615
1997*	3.40	697
1998	3.00	675
1999	2.20	986
2000	2.40	1,200
2001	4.10	2,768
2002	2.30	4,630
2003	2.42	3,930

Survey year	Fish/Redd	Total spawning escapement
2004	2.27	2,209
2005	2.93	2,561
2006	2.02	2,733
Average	***3.07***	***1,603***

* Spawning escapement was calculated using the "Modified Meekin Method" (i.e., 3.1 x jack multiplier).

7.4 Carcass Surveys

Surveys for Methow summer Chinook carcasses were conducted during late September to early November, 2006, in the Methow River. Surveys were cut short because of flood conditions in early November (see Appendix I for more details).

Number sampled

A total of 587 summer Chinook carcasses were sampled during September through early October in the Methow River (Table 7.14).

Table 7.14. Numbers of summer Chinook carcasses sampled within each survey reach on the Methow River, 1991-2006. 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	11	15	9	0	3	0	0	**38**
1994	26	22	15	4	10	0	0	**77**
1995	7	13	38	7	5	0	0	**70**
1996	3	22	34	4	2	0	0	**65**
1997	5	8	31	1	17	1	0	**63**
1998	47	71	88	12	27	0	0	**245**
1999	35	117	194	30	26	9	2	**413**
2000	25	89	88	8	81	5	0	**296**
2001	62	163	76	12	72	11	1	**397**
2002	150	235	472	147	200	34	10	**1,248**
2003	42	201	278	93	112	3	0	**729**
2004	15	123	158	72	84	1	0	**453**
2005	153	173	182	42	112	3	1	**666**
2006	121	149	111	56	146	3	1	**587**
Average	***44***	***89***	***113***	***31***	***57***	***4***	***1***	***339***

Carcass Distribution and Origin

Summer Chinook carcasses were not evenly distributed among reaches within the Methow River in 2006 (Table 7.14; Figure 7.3). Most of the carcasses in the Methow River were found downstream from Twisp. The highest percentage of carcasses (25%) was sampled in Reach 2 between the towns of Methow and Carlton.

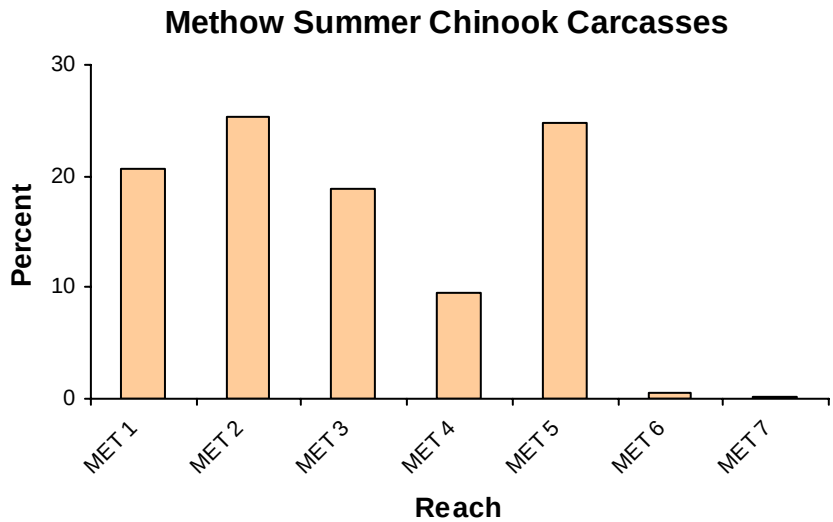


Figure 7.3. Percent of summer Chinook carcasses sampled within different reaches on the Methow River during September through early November, 2006. Reach codes are described in Table 2.11.

Numbers of wild and hatchery origin summer Chinook carcasses sampled in 2006 will be available after analysis of CWTs and scales. Most fish, regardless of origin, were found in Reaches 2 and 3 (Methow Bridge to the Twisp Bridge) (Table 7.15). However, a larger percentage of hatchery fish were found in those two reaches than were wild fish (Figure 7.4). In contrast, a larger percentage of wild fish were found in the other reaches.

Table 7.15. Numbers of wild and hatchery summer Chinook carcasses sampled within different reaches on the Methow River, 1991-2005.

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	15	9	0	3	0	0	**38**
	Hatchery	0	0	0	0	0	0	0	**0**
1994	Wild	21	17	8	4	9	0	0	**59**
	Hatchery	5	5	7	0	1	0	0	**18**
1995	Wild	6	9	27	7	5	0	0	**54**

	Hatchery	1	4	11	0	0	0	0	**16**
1996	Wild	1	20	29	4	2	0	0	**56**
	Hatchery	2	2	5	0	0	0	0	**9**
1997	Wild	5	5	28	1	17	0	0	**56**
	Hatchery	0	3	3	0	0	1	0	**7**
1998	Wild	41	46	70	9	23	0	0	**189**
	Hatchery	6	25	18	3	4	0	0	**56**
1999	Wild	27	79	110	14	17	4	2	**253**
	Hatchery	8	38	84	16	9	5	0	**160**
2000	Wild	23	78	74	7	72	3	0	**257**
	Hatchery	2	11	14	1	9	2	0	**39**
2001	Wild	49	102	54	9	66	11	1	**292**
	Hatchery	13	61	22	3	6	0	0	**105**
2002	Wild	125	163	362	129	186	34	10	**1,009**
	Hatchery	25	72	110	18	14	0	0	**239**
2003	Wild	35	126	179	63	85	3	0	**491**
	Hatchery	7	75	99	30	27	0	0	**238**
2004	Wild	14	108	145	61	73	1	0	**402**
	Hatchery	1	15	13	11	11	0	0	**51**
2005	Wild	61	99	133	33	107	3	1	**437**
	Hatchery	92	74	49	9	5	0	0	**229**
Average	***Wild***	***28***	***59***	***84***	***23***	***46***	***4***	***1***	***245***
	Hatchery	***11***	***26***	***29***	***6***	***6***	***1***	***0***	***78***

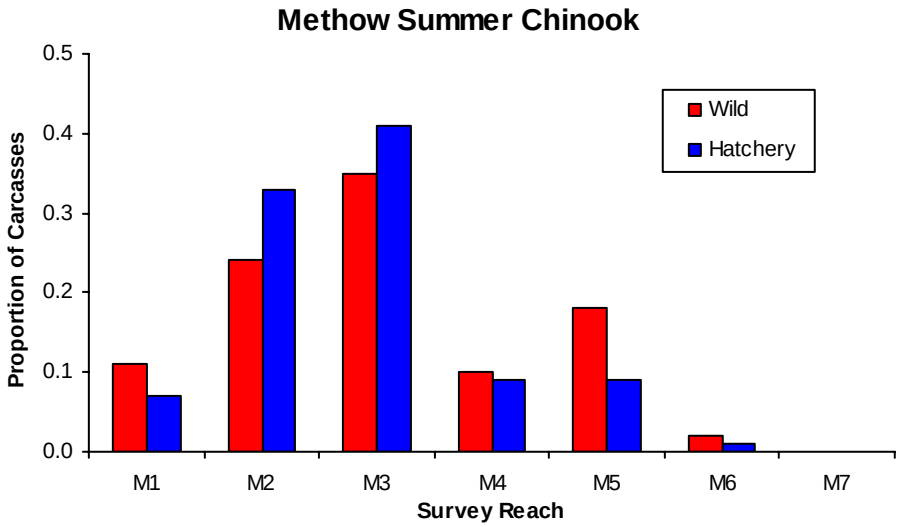


Figure 7.4. Distribution of wild and hatchery produced carcasses in different reaches on the Methow River, 1993-2005. Reach codes are described in Table 2.11.

Sampling Rate

Overall, 21% of the total spawning escapement of summer Chinook in the Methow basin was sampled in 2006 (Table 7.16). Sampling rates among survey reaches varied from 19 to 74%.

Table 7.16. Number of redds and carcasses, total spawning escapement, and sampling rates for summer Chinook in the Methow basin, 2006.

Survey reach	Total number of redds	Total number of carcasses	Total spawning escapement	Sampling rate
Methow 1	306	121	618	0.20
Methow 2	270	149	545	0.27
Methow 3	294	111	594	0.19
Methow 4	113	56	228	0.25
Methow 5	366	146	739	0.20
Methow 6	2	3	4	0.74
Methow 7	2	1	4	0.25
Total	***1,353***	***587***	***2,733***	***0.21***

Length Data

Mean lengths (POH, cm) of male and female summer Chinook carcasses sampled during surveys on the Methow River in 2006 are provided in Table 7.17. The average size of males and females sampled in the Methow River were 70 cm and 73 cm, respectively.

Table 7.17. 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, 2006.

Stream/watershed	Mean length (cm)	
	Male	Female
Methow 1	69 (7)	73 (6)
Methow 2	68 (11)	72 (7)
Methow 3	71 (7)	71 (5)
Methow 4	76 (7)	72 (6)
Methow 5	72 (10)	75 (4)
Methow 6	-	70 (4)
Methow 7	68 (0)	-
Total	***70 (9)***	***79 (6)***

7.5 Life History Monitoring

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

Age at Maturity

Most of the wild and hatchery summer Chinook sampled during the period 1993-2005 in the Methow River were age-4 and 5 fish (total age) (Table 7.18; Figure 7.5). A higher percentage of age-4 wild Chinook returned to the basin than did age-4 hatchery Chinook. In contrast, a higher proportion of age-5 and 6 hatchery fish returned than did age-5 and 6 wild fish. Thus, a higher percentage of hatchery fish returned at an older age than did wild fish.

Table 7.18. Proportions of wild and hatchery summer Chinook of different ages (total age) sampled at broodstock collection sites and on spawning grounds in the Methow River, 1993-2004; NA = not available.

Survey year	Origin	Total age						Sample size
		2	3	4	5	6	7	
1993	Wild	0.00	0.05	0.34	0.58	0.03	0.00	38
	Hatchery	0.00	0.00	0.00	0.00	0.00	0.00	0
1994	Wild	0.01	0.02	0.53	0.44	0.00	0.00	100
	Hatchery	0.00	0.00	0.11	0.89	0.00	0.00	37
1995	Wild	0.00	0.02	0.07	0.89	0.02	0.00	54
	Hatchery	0.00	0.00	0.13	0.81	0.06	0.00	16
1996	Wild	0.00	0.04	0.46	0.41	0.09	0.00	56
	Hatchery	0.00	0.00	0.00	0.40	0.60	0.00	10
1997	Wild	0.00	0.00	0.36	0.63	0.02	0.00	56
	Hatchery	0.00	0.14	0.00	0.71	0.14	0.00	7
1998	Wild	0.01	0.13	0.52	0.34	0.00	0.00	189
	Hatchery	0.00	0.02	0.73	0.20	0.05	0.00	56
1999	Wild	0.00	0.02	0.59	0.39	0.00	0.00	252
	Hatchery	0.00	0.00	0.03	0.96	0.01	0.00	160
2000	Wild	0.00	0.05	0.15	0.80	0.00	0.00	257
	Hatchery	0.00	0.03	0.05	0.77	0.15	0.00	39
2001	Wild	0.01	0.15	0.59	0.24	0.02	0.00	292
	Hatchery	0.00	0.32	0.50	0.11	0.06	0.00	105
2002	Wild	0.00	0.04	0.66	0.29	0.00	0.00	1,009
	Hatchery	0.00	0.00	0.68	0.30	0.02	0.00	239
2003	Wild	0.00	0.01	0.43	0.55	0.00	0.00	492
	Hatchery	0.00	0.00	0.00	0.97	0.02	0.00	238
2004	Wild	0.00	0.04	0.08	0.86	0.01	0.00	402
	Hatchery	0.00	0.00	0.25	0.06	0.69	0.00	51
2005	Wild	NA	NA	NA	NA	NA	NA	NA
	Hatchery	NA	NA	NA	NA	NA	NA	NA
Average	***Wild***	***0.00***	***0.05***	***0.47***	***0.48***	***0.01***	***0.00***	***266***
	Hatchery	***0.00***	***0.04***	***0.30***	***0.59***	***0.07***	***0.00***	***80***

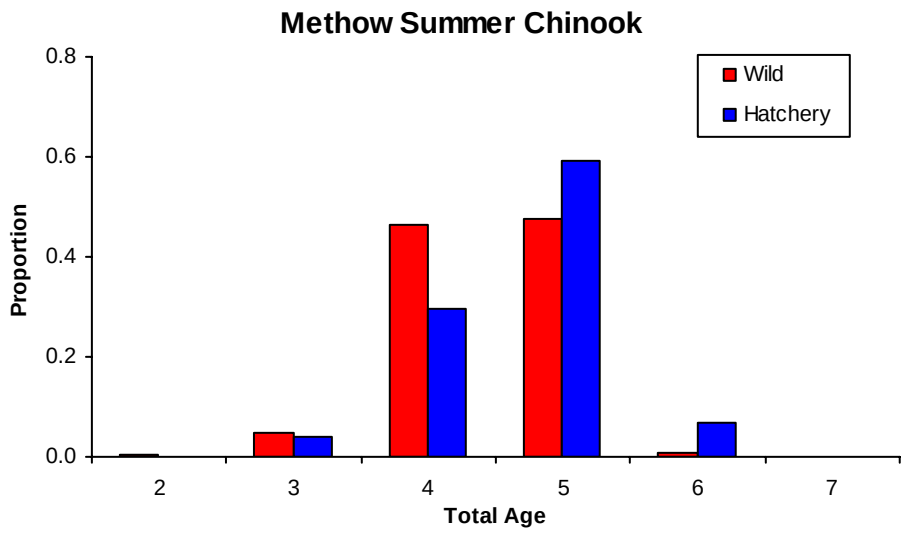


Figure 7.5. Proportions of wild and hatchery summer Chinook of different total ages sampled at broodstock collection sites and on spawning grounds in the Methow River for the combined years 1993-2004.

Size at Maturity

On average, hatchery summer Chinook were about 5 cm smaller than wild summer Chinook sampled in the Methow basin (Table 7.19). This is interesting given that a slightly higher percentage of hatchery fish returned as age-5 and 6 fish than did wild fish. Future analyses will compare sizes of hatchery and wild fish of the same age groups and gender.

Table 7.19. Mean lengths (POH; cm) and variability statistics for wild and hatchery summer Chinook sampled in the Methow basin, 1993-2005; SD = 1 standard deviation.

Survey year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
1993	Wild	38	75	9	51	89
	Hatchery	0	-	-	-	-
1994	Wild	100	69	8	35	87
	Hatchery	37	66	7	43	76
1995	Wild	54	74	6	52	88
	Hatchery	16	70	6	53	78
1996	Wild	56	69	11	34	89
	Hatchery	10	73	7	64	84
1997	Wild	56	77	7	64	90
	Hatchery	7	66	15	35	81
1998	Wild	189	67	10	38	97
	Hatchery	56	60	10	37	87
1999	Wild	251	66	8	43	99
	Hatchery	160	66	6	49	89

Survey year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
2000	Wild	256	74	8	37	89
	Hatchery	39	70	8	33	80
2001	Wild	292	67	10	29	86
	Hatchery	105	55	12	35	87
2002	Wild	1,009	70	8	37	94
	Hatchery	239	62	8	33	83
2003	Wild	492	71	8	35	87
	Hatchery	238	68	6	43	86
2004	Wild	402	73	7	38	89
	Hatchery	51	69	10	41	82
2005	Wild	437	69	8	45	86
	Hatchery	229	64	9	36	79
Pooled	***Wild***	***3,632***	***71***	***8***	***41***	***90***
	Hatchery	***1,187***	***66***	***9***	***42***	***83***

Contribution to Fisheries

Most of the harvest on Methow summer Chinook occurred in the Ocean (Table 7.20). Ocean harvest has made up 13% to 97% of all Methow summer Chinook harvested. Brood year 1998 provided the largest harvest, while brood year 1999 provided the lowest.

Table 7.20. Estimated number and percent (in parentheses) of Methow summer Chinook captured in different fisheries.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal (Zone 6)	Commercial (Zones 1-5)	Recreational (sport)	
1989	382 (47)	378 (46)	39 (5)	21 (3)	820
1990	63 (60)	38 (36)	4 (4)	0 (0)	105
1991	12 (20)	49 (80)	0 (0)	0 (0)	61
1992	17 (55)	14 (45)	0 (0)	0 (0)	31
1993	30 (59)	17 (33)	4 (8)	0 (0)	51
1994	132 (78)	34 (20)	3 (2)	1 (1)	170
1995	56 (97)	1 (2)	1 (2)	0 (0)	58
1996	15 (94)	0 (0)	1 (6)	0 (0)	16
1997	225 (89)	2 (1)	5 (2)	21 (8)	253
1998	1,953 (84)	40 (2)	103 (4)	230 (10)	2,326
1999	2 (13)	0 (0)	13 (87)	0 (0)	15
2000	64 (65)	12 (12)	18 (18)	5 (5)	99

Straying

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Methow basin. Targets for strays based on return year (recovery year) and brood year should be less than 0.050.

Stray rates for most brood years have exceeded the target of 0.050 (Table 7.21). Stray rates of Methow summer Chinook have averaged about 19%. These fish have ended up in the Okanogan basin, the Chelan tailrace, and in the Hanford Reach.

Table 7.21. Stray rates by brood year for Methow summer Chinook, 1989-2000. Target is a stray rate less than 0.05. *(The numbers in this table may change as the HETT and HC refine the methods for estimating summer Chinook stray rates.)*

Brood year	Stray rate
1989	0.458
1990	0.122
1991	0.281
1992	0.601
1993	0.239
1994	0.081
1995	0.000
1996	0.000
1997	0.050
1998	0.033
Average	***0.187***

Genetics

Tissue (operculum) samples were collected from 144 wild and 144 hatchery summer Chinook in the Methow basin in 2006. These samples have not been processed. Results from these samples should be available next year.

Natural Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural origin recruits (NOR) to the parent spawning population. For brood years 1989-1999, NRR for summer Chinook in the Methow averaged 1.47 (range, 0.53-5.02) if harvested fish were not include in the estimate and 2.72 (range, 0.73-12.69) if harvested fish were included in the estimate (Table 7.22). NRRs for more recent brood years will be calculated as soon as all tag recoveries and sampling rates have been loaded into the database.

Table 7.22. Spawning escapements, natural origin recruits (NOR), and natural replacement rates (NRR; with and without harvest) for wild summer Chinook in the Methow basin, 1989-2000. *(The numbers in this table may change as the HETT and HC refine the methods for estimating summer Chinook NORs and NRRs.)*

Brood year	Escapement	NOR	NRR	
			Harvest not included	Harvest included
1989	620	989	1.43	2.25
1990	1,391	2,010	0.59	0.73
1991	566	722	0.66	0.89
1992	460	614	1.33	1.79
1993	508	528	1.08	1.37
1994	1,085	657	0.53	0.74
1995	1,214	796	0.98	1.65
1996	615	583	0.79	1.25
1997	697	644	2.33	3.79
1998	675	504	5.02	12.69
1999	986	645		
Average	***802***	***790***	***1.47***	***2.72***

Hatchery Replacement Rates

Hatchery replacement rates were estimated as hatchery adult-to-adult returns. These rates should be greater than the NRRs and greater than or equal to 5.30 (the value in BAMP; Murdoch and Peven 2005). HRRs exceeded NRRs in four of the 10 years of data, regardless if harvest was or was not included in the estimate (Table 7.23). Hatchery replacement rates (harvest included in the estimate) for Methow summer Chinook have exceeded the BAMP target of 5.30 in two of the 10 years of data.

Table 7.23. Hatchery replacement rates (HRR), NRR, and BAMP target (5.30) for summer Chinook in the Methow basin, 1989-2000. *(The numbers in this table may change as the HETT and HC refine the methods for estimating summer Chinook HRRs and NRRs.)*

Brood year	Harvest not included			Harvest included		
	HRR	NRR	BAMP	HRR	NRR	BAMP
1989	2.66	1.43	5.30	6.72	2.25	5.30
1990	1.40	0.59	5.30	1.90	0.73	5.30
1991	0.47	0.66	5.30	0.70	0.89	5.30
1992	0.50	1.33	5.30	0.65	1.79	5.30
1993	0.35	1.08	5.30	0.57	1.37	5.30
1994	1.89	0.53	5.30	2.50	0.74	5.30
1995	0.61	0.98	5.30	0.83	1.65	5.30
1996	0.28	0.79	5.30	0.35	1.25	5.30
1997	1.94	2.33	5.30	3.15	3.79	5.30
1998	6.80	5.02	5.30	16.70	12.69	5.30
Average	***1.69***	***1.47***	***5.30***	***3.41***	***2.72***	***5.30***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adults divided by the number of hatchery smolts released. SARs were based on CWT returns. For the available brood years, SARs have ranged from 0.0001 to 0.0189 for hatchery summer Chinook in the Methow basin (Table 7.24).

Table 7.24. Smolt-to-adult ratios (SARs) for Methow summer Chinook; NA = not available.

Brood year	Number released	SAR
1989	NA	NA
1990	371,483	0.000983
1991	NA	NA
1992	392,636	0.000349
1993	200,345	0.000311
1994	400,488	0.001726
1995	344,974	0.000598
1996	289,880	0.000260
1997	380,430	0.001645
1998	202,559	0.018948
1999	422,473	0.000080
Average	***333,960***	***0.002767***

7.6 ESA/HCP Compliance

Broodstock Collection

Summer Chinook adults collected at Wells Dam are used for both the Methow and Okanogan supplementation programs. Per the 2004 broodstock collection protocol, 556 natural origin (adipose fin present) adults were targeted for collection between 6 July and 25 August at the East Ladder of Wells Dam. The actual collection totaled 558 fish in 2004. The overage was attributable to errors in enumeration during collection. 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 2004, the total permissible days of trapping allowed under provisions of Permit 1347 and within the established 2004 collection protocol was 25 days. The actual number of trapping days in 2004 was 12 (about 50% of the total identified in the 2004 broodstock protocol and 18% of the maximum 65 days allowed 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 during Methow and Okanogan summer

Chinook broodstock collections did not result in takes that were outside those authorized in Permits 1347 and 1395 for the Wells Steelhead program.

Hatchery Rearing and Release

The 2004 brood Okanogan/Similkameen summer Chinook reared throughout their juvenile life-stages at Eastbank Fish Hatchery and the Carlton Acclimation pond without incident (see section 7.2). The 2004 brood smolt release totaled 400,579 fish, representing 100.1% of the production objective and achieving smolt levels identified in ESA Section 10 Permit 1347.

Spawning Surveys

Summer Chinook spawning ground surveys conducted in the Methow basin during 2006 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 impacts to established redds, wading was restricted to the extent practical, and extreme caution was used to avoid established redds when wading was required.

SECTION 8: OKANOGAN/SIMILKAMEEN SUMMER CHINOOK

8.1 Broodstock Sampling

Summer Chinook broodstock for the Okanogan/Similkameen and Methow programs is collected in the East Ladder of Wells Dam. Refer to Section 7.1 for information on the origin, age and length, sex ratios, and fecundity of summer Chinook broodstock collected at Wells Dam.

8.2 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 are required to meet the program release goal of 576,000 smolts. Between 1989 and 2005, the egg take goal was reached in nine years (Table 8.1).

Table 8.1. Numbers of eggs taken from summer Chinook broodstock collected at Wells Dam for the Okanogan program, 1989-2005.

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	458,738
Average	***693,987***

Disease

Rearing of the 2004 brood Okanogan summer Chinook was similar to previous years with fish being held on well water before being transferred for final acclimation on Similkameen or Okanogan river water. The Similkameen population was transferred in early October 2005. Fish were prophylactically treated upon transfer with formalin to control external parasites (*Ich* and *Dermocystidium*), which in recent years has led to significant losses in this program. In late January 2006, parasite loads of *Dermocystidium* began to increase in the Similkameen group in addition to the presence of bacterial gill disease (BGD). The use of Chloramine-T was recommended for control of BGD and pond flows were increased and pond volume lowered to increase turnover rate in an attempt to control *Dermocystidium* infection rate. This group continued to experience chronic exposure to the *Dermocystidium*; however, losses continued to remain low. It was expected that the parasite infection would clear once fish were released.

The Bonaparte Pond population was transferred and reared on Okanogan River water from late October 2005 until release. No fish health concerns were identified until late January 2006 when BGD was detected. The recommendation was to treat with $KMnO_4$ for three days to prevent losses. In early April 2006, light levels of *Dermocystidium* became visible in this group. However, these fish were scheduled to be released within two weeks and would result in clearing of the parasite once released.

Number of acclimation days

Fish were volitionally released from Similkameen Pond as yearling smolts in April of 2006. Size at release of the Similkameen population was 74.7% and 65.6% of the expected fork length and weight goals, respectively. This group exceeded the CV of length goal by 10% (Table 8.2). Bonaparte Chinook were forced out of the acclimation site on 11 April 2006. Size-at-release data were not collected for the Bonaparte fish, but will be in the future.

Table 8.2. Number of days Okanogan summer Chinook broods were acclimated at Similkameen Pond, brood years 1989-2004.

Brood year	Release year	Transfer date	Release date	Number of days
1989	1991	29-Oct	7-May	190
1990	1992	5-Nov	25-Apr	171
1991	1993	1-Nov	9-Apr	159
1992	1994	2-Nov	1-Apr	150
		26-Feb	1-Apr	34
1993	1995	24-Oct	1-Apr	159
		24-Feb	1-Apr	36
1994	1996	30-Oct	6-Apr	158
		14-Mar	6-Apr	23
1995	1997	1-Oct	1-Apr	182
1996	1998	10-Oct	15-Mar	156
1997	1999	7-Oct	19-Apr	194

Brood year	Release year	Transfer date	Release date	Number of days
1998	2000	5-Oct	19-Apr	196
1999	2001	5-Oct	18-Apr	195
2000	2002	10-Oct	8-Apr	180
2001	2003	1-Oct	29-Apr	210
2002	2004	9-Nov	23-Apr	165
2003	2005	19-Oct	28-Apr	191
2004	2006	26-Oct	23-Apr	179
Average				***154***

Release Information

Numbers released

The 2004 Okanogan summer Chinook program achieved 122.1% of the 576,000 target goal with about 703,359 fish being released in two groups (Table 8.3). On 11 April 2006, about 99,293 fish were forced from the Bonaparte Pond into the Okanogan River. The remaining 604,066 fish were volitionally released from the Similkameen Pond between 17 and 27 April 2006.

Table 8.3. Numbers of Okanogan summer Chinook smolts released from the hatchery, brood years 1989-2004. The release target for Okanogan summer Chinook is 576,000 smolts.

Brood year	Release year	Number of smolts
1989	1991	352,600
1990	1992	540,000
1991	1993	675,500
1992	1994	548,182
1993	1995	586,000
1994	1996	536,299
1995	1997	587,000
1996	1998	507,913
1997	1999	589,591
1998	2000	293,191
1999	2001	630,463
2000	2002	532,453
2001	2003	26,642
2002	2004	388,589
2003	2005	579,019
2004	2006	703,359
Average		***504,800***

Numbers tagged

The 2004 brood Okanogan summer Chinook were 100% CWT and adipose fin-clipped, but were not PIT tagged.

Fish size and condition at release

Size at release of the Similkameen population was 74.7% and 65.6% of the target fork length and weight, respectively. The CV of fork length target was exceeded by 10% (Table 8.4). Size-at-release data were not collected for the Bonaparte fish.

Table 8.4. 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 1989-2004. 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
Targets		***176***	***9.0***	***45.4***	***10***

Survival Estimates

Overall survival of Okanogan summer Chinook from green (unfertilized) egg to release was slightly below the standard set for the program as a result of poor green egg-to-eye survival. Currently it is unknown if gamete viability is gender biased or is uniform between sexes and more influenced by between-year environmental variations (Table 8.5).

Table 8.5. Hatchery life-stage survival rates (%) for Okanogan summer Chinook, brood years 1989-2004. 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	57.4	63.7
1990[a]	93.9	99.0	84.9	97.1	81.2	80.6	97.7	98.6	80.5
1991[a]	93.1	95.5	88.2	97.1	99.4	99.1	98.4	97.1	84.2
1992[a]	96.9	99.0	87.0	98.0	99.9	99.9	91.7	92.6	78.2
1993[a]	82.2	99.4	85.4	97.6	99.8	99.5	92.0	90.2	76.7
1994	96.1	90.0	86.6	100.0	98.1	97.4	73.1	89.8	63.3
1995	91.9	96.2	98.2	84.1	96.5	96.2	92.7	98.2	76.6
1996	95.4	98.1	83.2	100.0	97.7	96.9	86.5	92.5	72.0
1997	91.9	94.6	86.1	98.4	98.7	98.3	98.8	99.4	83.7
1998	84.0	96.2	54.1	98.0	99.4	98.9	96.6	99.6	51.2
1999	98.8	98.7	92.9	96.9	98.0	97.6	96.9	99.0	87.2
2000	90.5	96.9	89.2	98.5	98.2	98.0	93.6	97.2	82.6
2001	96.2	92.3	89.1	97.6	99.7	99.5	7.4	11.9	6.4
2002	97.1	98.1	89.8	98.0	99.7	99.5	51.6	52.2	45.4
2003	96.7	97.5	86.8	97.6	99.3	98.5	98.0	98.8	83.0
2004	93.6	98.2	84.0	97.6	99.6	99.3	97.8	98.8	80.2
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.

8.3 Spawning Surveys

Surveys for Okanogan/Similkameen summer Chinook redds were conducted from late September to early November, 2006, in the Okanogan and Similkameen rivers. Surveys were cut short because of flood conditions in early November. Total redd counts were conducted in the rivers (see Appendix I for more details).

Redd Counts

A total of 4,258 summer Chinook redds were counted in the Okanogan basin in 2006 (Table 8.6). This was the second highest redd count observed in the Okanogan basin.

Table 8.6. Total number of redds counted in the Okanogan basin, 1989-2006.

Survey year	Number of summer Chinook redds		
	Okanogan River	Similkameen River	Total count
1989	134*	370	504
1990	47	147	194
1991	64	91	155

Survey year	Number of summer Chinook redds		
	Okanogan River	Similkameen River	Total count
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
Average	***706***	***879***	***1,586***

* Peak count based on an aerial survey.

Redd Distribution

Summer Chinook redds were not evenly distributed among the survey reaches in the Okanogan basin. Most redds (64%) were located in the upper Okanogan and lower Similkameen reaches (reaches upstream of the Tonasket Bridge) (Table 8.7; Figure 8.1). Relatively few summer Chinook spawned downstream of the Riverside Bridge on the Okanogan River (Reaches 1-4).

Table 8.7. Total number of summer Chinook redds counted in different reaches in the Okanogan basin during September through early November, 2006. Reach codes are described in Table 2.11.

Survey reach	Total redd count	Percent
Okanogan 1	10	0.2
Okanogan 2	56	1.3
Okanogan 3	175	4.1
Okanogan 4	145	3.4
Okanogan 5	840	19.7
Okanogan 6	1,366	32.1
Similkameen 1	1,388	32.6
Similkameen 2	278	6.5
Totals	***4,258***	***100***

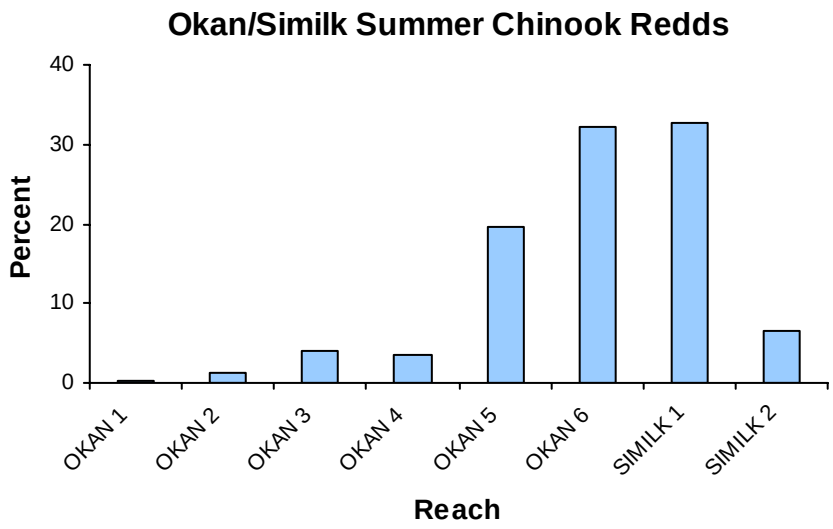


Figure 8.1. Percent of the total number of summer Chinook redds counted in different reaches in the Okanogan basin during September through early November, 2006. Reach codes are described in Table 2.11.

Spawn Timing

Spawning in 2006 began the last week in September in the Similkameen and the first week of October in the Okanogan, and peaked during the second week of October (Figure 8.2). Spawning began when stream temperature varied from 10-14°C. Compared with the eight-year average, the temporal distribution of spawning activity in 2006 was more leptokurtic (i.e., less "tailedness" and more "peakedness").

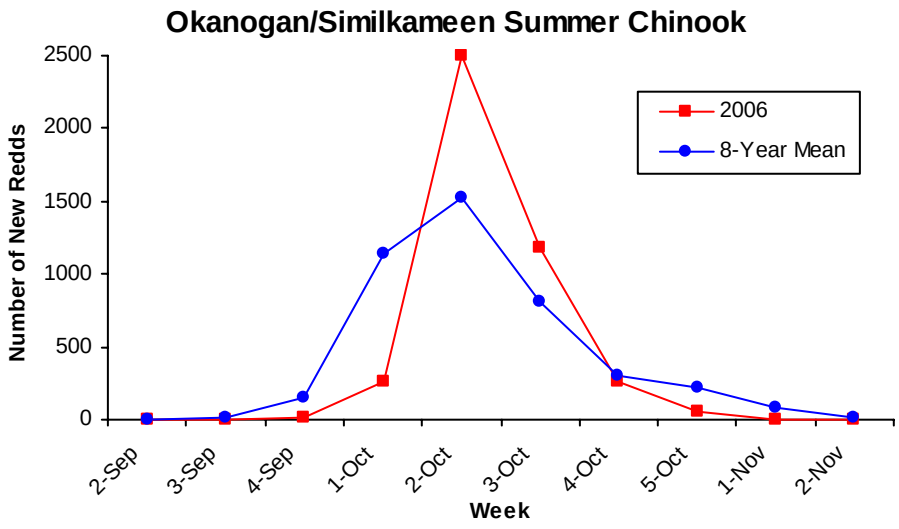


Figure 8.2. Number of new summer Chinook redds counted during different weeks in the Okanogan basin, September through early November 2006.

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. The estimated fish per redd ratio for Okanogan/Similkameen summer Chinook in 2006 was 2.02. Multiplying this ratio by the number of redds counted in the Okanogan and Similkameen rivers resulted in a total spawning escapement of 8,601 summer Chinook (Table 8.8).

Table 8.8. Spawning escapements for summer Chinook in the Okanogan and Similkameen rivers for brood years 1989-2006.

Survey year	Fish/Redd	Spawning escapement		
		Okanogan	Similkameen	Total
1989*	3.30	561	1,221	1,782
1990*	3.40	381	500	881
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	4,032
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	2.27	3,012	3,768	6,780
2005	2.93	4,720	4,169	8,889
2006	2.02	5,236	3,365	8,601
Average	***3.07***	***1,869***	***2,412***	***4,281***

* Spawning escapement was calculated using the "Modified Meekin Method" (i.e., 3.1 x jack multiplier).

8.4 Carcass Surveys

Surveys for summer Chinook carcasses were conducted during late September to early November, 2006, in the Okanogan and Similkameen rivers. Surveys were cut short because of flood conditions in early November (see Appendix I for more details).

Number sampled

A total of 1,078 summer Chinook carcasses were sampled during September through early October in the Okanogan basin (Table 8.9). A total of 465 were sampled in the Okanogan River and 613 in the Similkameen River.

Table 8.9. Numbers of summer Chinook carcasses sampled within each survey reach in the Okanogan basin, 1993-2006. Reach codes are described in Table 2.11.

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	0	2	1	0	22	11	68	1	**105**
1994	0	0	1	0	15	3	192	34	**245**
1995	0	0	2	0	16	0	138	9	**165**
1996	0	0	0	2	3	2	125	0	**132**
1997	0	0	1	0	7	2	180	0	**190**
1998	0	1	2	0	5	5	205	4	**222**
1999	0	0	0	0	13	31	475	17	**536**
2000	0	0	8	9	39	15	594	32	**697**
2001	0	13	40	5	105	98	1,009	92	**1,362**
2002	6	14	35	15	163	487	1,096	227	**2,043**
2003	0	0	18	0	10	211	527	325	**1,091**
2004	0	2	21	19	118	240	1,222	190	**1,812**
2005	0	8	93	37	371	431	729	276	**1,945**
2006	4	3	31	16	120	291	513	100	**1,078**
Average	***1***	***3***	***18***	***7***	***72***	***131***	***505***	***93***	***830***

Carcass Distribution and Origin

Summer Chinook carcasses were not evenly distributed among reaches within the Okanogan basin in 2006 (Table 8.9; Figure 8.3). Most of the carcasses in the basin were found in the upper Okanogan River and lower Similkameen River. The highest percentage of carcasses (48%) was sampled in Reach 1 on the Similkameen River between the Driscoll Channel and Oroville Bridge.

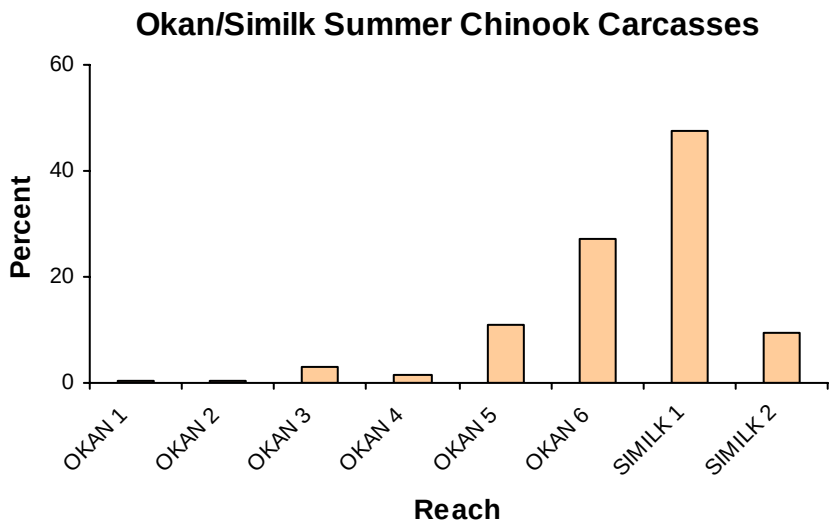


Figure 8.3. Percent of summer Chinook carcasses sampled within different reaches in the Okanogan basin during September through early November, 2006. Reach codes are described in Table 2.11.

Numbers of wild and hatchery origin summer Chinook carcasses sampled in 2006 will be available after analysis of CWTs and scales. Most fish, regardless of origin, were found in Reach 1 on the Similkameen River (Driscoll Channel to Oroville Bridge) (Table 8.10). However, a slightly larger percentage of hatchery fish were found in reaches on the Similkameen River than were wild fish (Figure 8.4). In contrast, a larger percentage of wild fish were found in reaches on the Okanogan River.

Table 8.10. Numbers of wild and hatchery summer Chinook carcasses sampled within different reaches in the Okanogan basin, 1993-2005.

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	1	0	12	4	45	1	**63**
	Hatchery	0	2	0	0	10	7	23	0	**42**
1994	Wild	0	0	0	0	8	1	92	15	**116**
	Hatchery	0	0	1	0	7	2	100	19	**129**
1995	Wild	0	0	1	0	9	0	55	3	**68**
	Hatchery	0	0	1	0	7	0	83	6	**97**
1996	Wild	0	0	0	1	2	1	33	0	**37**
	Hatchery	0	0	0	1	1	1	92	0	**95**
1997	Wild	0	0	1	0	0	2	70	0	**73**
	Hatchery	0	0	0	0	7	0	110	0	**117**
1998	Wild	0	1	2	0	5	5	134	4	**151**
	Hatchery	0	0	0	0	0	0	71	0	**71**
1999	Wild	0	0	0	0	9	22	245	5	**281**
	Hatchery	0	0	0	0	4	9	230	12	**255**
2000	Wild	0	0	7	8	20	11	167	4	**217**
	Hatchery	0	0	1	1	19	4	427	28	**480**

2001	Wild	0	9	21	5	64	40	343	50	**532**
	Hatchery	0	4	19	0	41	58	666	42	**830**
2002	Wild	5	12	20	9	73	194	315	65	**693**
	Hatchery	1	2	15	6	90	293	781	162	**1,350**
2003	Wild	0	0	11	0	8	147	216	115	**497**
	Hatchery	0	0	7	0	2	64	311	210	**594**
2004	Wild	0	2	18	19	104	203	1,020	158	**1,524**
	Hatchery	0	0	3	0	14	37	202	32	**288**
2005	Wild	0	5	51	21	256	364	530	176	**1,403**
	Hatchery	0	3	42	16	115	67	199	100	**542**
Average	***Wild***	***0***	***2***	***10***	***5***	***44***	***76***	***251***	***46***	***435***
	Hatchery	***0***	***1***	***7***	***2***	***24***	***42***	***253***	***47***	***376***

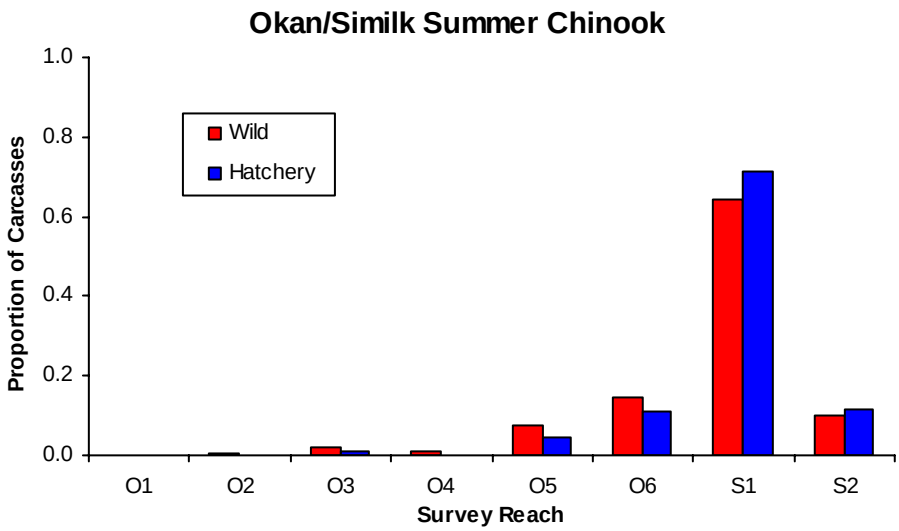


Figure 8.4. Distribution of wild and hatchery produced carcasses in different reaches in the Okanogan basin, 1993-2005. Reach codes are described in Table 2.11.

Sampling Rate

Overall, 13% of the total spawning escapement of summer Chinook in the Okanogan basin was sampled in 2006 (Table 8.11). This was below the target of 20%. Sampling rates among survey reaches varied from 3 to 20%.

Table 8.11. Number of redds and carcasses, total spawning escapement, and sampling rates for summer Chinook in the Okanogan basin, 2006.

Sampling reach	Total number of redds	Total number of carcasses	Total spawning escapement	Sampling rate
Okanogan 1	10	4	20	0.20
Okanogan 2	56	3	113	0.03
Okanogan 3	175	31	354	0.09
Okanogan 4	145	16	293	0.05
Okanogan 5	840	120	1,697	0.07
Okanogan 6	1,366	291	2,759	0.11
Similkameen 1	1,388	513	2,804	0.18
Similkameen 2	278	100	562	0.18
Total	***4,258***	***1,078***	***8,601***	***0.13***

Length Data

Mean lengths (POH, cm) of male and female summer Chinook carcasses sampled during surveys on the Okanogan and Similkameen rives in 2006 are provided in Table 8.12. The average size of males and females sampled in the Okanogan basin were 70 cm and 73 cm, respectively.

Table 8.12. Mean lengths (postorbital-to-hypural length; cm) and standard deviations (in parentheses) of male and female summer Chinook carcasses sampled in different reaches in the Okanogan basin, 2006.

Stream/watershed	Mean length (cm)	
	Male	Female
Okanogan 1	74 (7)	71 (5)
Okanogan 2	61 (6)	82 (0)
Okanogan 3	67 (8)	72 (5)
Okanogan 4	69 (7)	75 (3)
Okanogan 5	69 (8)	74 (5)
Okanogan 6	70 (9)	73 (4)
Similkameen 1	70 (9)	73 (5)
Similkameen 2	74 (10)	72 (5)
Total	***70 (9)***	***73 (5)***

8.5 Life History Monitoring

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

Age at Maturity

Most of the wild and hatchery summer Chinook sampled during the period 1993-2005 in the Okanogan basin were age-4 and 5 fish (total age) (Table 8.13; Figure 8.5). A higher percentage of age-4 wild Chinook returned to the basin than did age-4 hatchery Chinook. In contrast, a higher proportion of age-5 and 6 hatchery fish returned than did age-5 and 6 wild fish. Thus, a higher percentage of hatchery fish returned at an older age than did wild fish.

Table 8.13. Proportions of wild and hatchery summer Chinook of different ages (total age) sampled at broodstock collection sites and on spawning grounds in the Okanogan basin, 1993-2005.

Sample year	Origin	Total age						Sample size
		2	3	4	5	6	7	
1993	Wild	0.00	0.00	0.65	0.35	0.00	0.00	17
	Hatchery	0.00	0.00	1.00	0.00	0.00	0.00	47
1994	Wild	0.00	0.00	0.39	0.61	0.00	0.00	28
	Hatchery	0.00	0.03	0.05	0.92	0.00	0.00	147
1995	Wild	0.00	0.00	0.20	0.80	0.00	0.00	10
	Hatchery	0.00	0.02	0.18	0.31	0.48	0.00	93
1996	Wild	0.00	0.50	0.25	0.25	0.00	0.00	4
	Hatchery	0.00	0.00	0.15	0.38	0.38	0.08	13
1997	Wild	0.00	0.00	0.33	0.67	0.00	0.00	3
	Hatchery	0.00	0.00	0.02	0.92	0.06	0.00	112
1998	Wild	0.00	0.08	0.54	0.38	0.00	0.00	13
	Hatchery	0.00	0.10	0.39	0.15	0.35	0.00	71
1999	Wild	0.00	0.00	0.55	0.45	0.00	0.00	31
	Hatchery	0.00	0.10	0.76	0.13	0.01	0.00	255
2000	Wild	0.00	0.05	0.16	0.77	0.02	0.00	44
	Hatchery	0.01	0.13	0.00	0.79	0.07	0.00	479
2001	Wild	0.05	0.10	0.71	0.13	0.01	0.00	139
	Hatchery	0.00	0.05	0.90	0.00	0.05	0.00	830
2002	Wild	0.01	0.11	0.65	0.23	0.01	0.00	313
	Hatchery	0.00	0.01	0.18	0.81	0.00	0.00	1,350
2003	Wild	0.01	0.01	0.80	0.19	0.00	0.00	166
	Hatchery	0.00	0.03	0.06	0.79	0.12	0.00	594
2004	Wild	0.02	0.18	0.15	0.64	0.01	0.00	346
	Hatchery	0.00	0.00	0.29	0.48	0.23	0.00	288
2005	Wild	0.00	0.08	0.76	0.14	0.02	0.00	1,281
	Hatchery	0.00	0.03	0.13	0.69	0.14	0.00	526
Average	***Wild***	***0.01***	***0.09***	***0.45***	***0.46***	***0.00***	***0.00***	***184***
	Hatchery	***0.00***	***0.04***	***0.33***	***0.47***	***0.15***	***0.01***	***370***

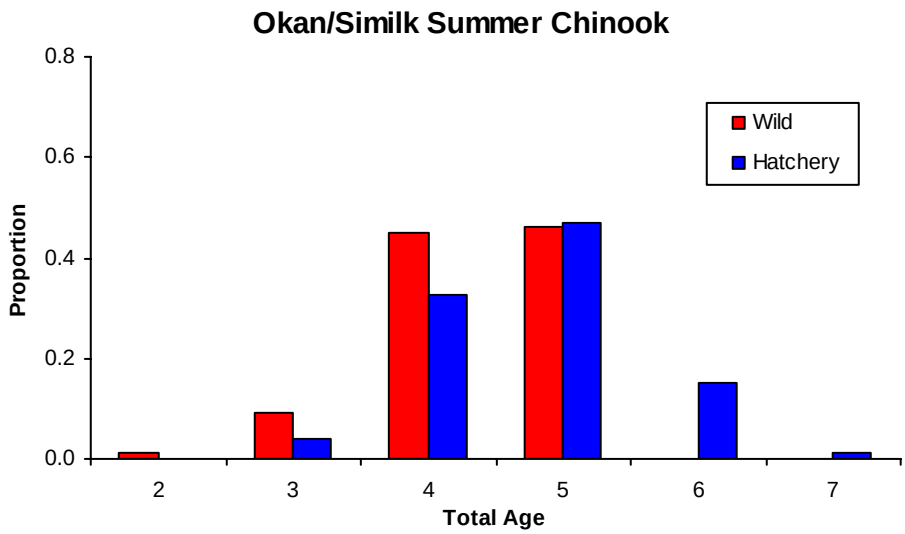


Figure 8.5. Proportions of wild and hatchery summer Chinook of different total ages sampled at broodstock collection sites and on spawning grounds in the Okanogan basin for the combined years 1993-2005.

Size at Maturity

On average, hatchery summer Chinook were about 1 cm smaller than wild summer Chinook sampled in the Okanogan basin (Table 8.14). This is interesting given that a slightly higher percentage of hatchery fish returned as age-5 and 6 fish than did wild fish. Future analyses will compare sizes of hatchery and wild fish of the same age groups and gender.

Table 8.14. Mean lengths (POH; cm) and variability statistics for wild and hatchery summer Chinook sampled in the Okanogan basin, 1993-2005; SD = 1 standard deviation.

Sample year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
1993	Wild	17	73	6	59	84
	Hatchery	47	63	6	47	75
1994	Wild	28	71	6	60	84
	Hatchery	147	69	8	33	81
1995	Wild	10	76	7	57	83
	Hatchery	93	72	9	39	87
1996	Wild	4	62	13	50	77
	Hatchery	13	75	7	60	83
1997	Wild	3	72	5	67	76
	Hatchery	112	73	6	48	85
1998	Wild	13	69	9	46	80
	Hatchery	71	65	14	33	87
1999	Wild	31	71	6	59	79
	Hatchery	255	69	7	23	84

Sample year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
2000	Wild	44	73	7	50	85
	Hatchery	479	68	13	24	92
2001	Wild	137	66	9	31	86
	Hatchery	830	61	8	36	90
2002	Wild	313	68	9	28	87
	Hatchery	1,350	70	8	33	87
2003	Wild	166	69	8	36	93
	Hatchery	594	70	9	28	87
2004	Wild	346	68	12	33	93
	Hatchery	288	66	9	43	92
2005	Wild	1,398	66	7	41	99
	Hatchery	531	68	8	31	85
Pooled	***Wild***	***2,404***	***68***	***9***	***37***	***91***
	Hatchery	***4,072***	***67***	***9***	***33***	***89***

Contribution to Fisheries

Most of the harvest on Okanogan/Similkameen summer Chinook occurred in the Ocean (Table 8.15). Ocean harvest has made up 71% to 100% of all Okanogan/Similkameen summer Chinook harvested. Brood years 1997-1999 provided the largest harvests, while brood year 1996 provided the lowest.

Table 8.15. Estimated number and percent (in parentheses) of Okanogan/Similkameen summer Chinook captured in different fisheries, 1989-2000.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal (Zone 6)	Commercial (Zones 1-5)	Recreational (sport)	
1989	2,255 (79)	365 (13)	204 (7)	26 (1)	2,850
1990	332 (88)	28 (7)	7 (2)	12 (3)	379
1991	206 (71)	84 (29)	0 (0)	0 (0)	290
1992	420 (89)	36 (8)	6 (1)	10 (2)	472
1993	36 (78)	10 (22)	0 (0)	0 (0)	46
1994	845 (90)	60 (6)	22 (2)	17 (2)	944
1995	583 (92)	12 (2)	19 (3)	18 (3)	632
1996	3 (100)	0 (0)	0 (0)	0 (0)	3
1997	2,426 (92)	68 (3)	20 (1)	122 (5)	2,636
1998	4,891 (90)	89 (2)	315 (6)	125 (2)	5,420
1999	1,221 (78)	39 (3)	199 (13)	99 (6)	1,558
2000	772 (80)	49 (5)	94 (10)	49 (5)	964

Straying

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Okanogan basin. Targets for strays based on return year (recovery year) and brood year should be less than 0.050.

Stray rates for most brood years have been less than the target of 0.050 (Table 8.16). Stray rates of Okanogan/Similkameen summer Chinook have averaged about 3%. These fish have ended up in the Entiat, Klickitat, Methow, and Wenatchee rivers and in the Chelan tailrace.

Table 8.16. Stray rates by brood year for Okanogan/Similkameen summer Chinook, 1989-2000. Target is a stray rate less than 0.05. *(The numbers in this table may change as the HETT and HC refine the methods for estimating summer Chinook stray rates.)*

Brood year	Stray rate
1989	0.076
1990	0.027
1991	0.023
1992	0.018
1993	0.075
1994	0.030
1995	0.025
1996	0.000
1997	0.007
1998	0.020
Average	***0.030***

Genetics

Tissue (operculum) samples were collected from 144 wild and 144 hatchery summer Chinook in the Okanogan basin in 2006. These samples have not been processed. Results from these samples should be available next year.

Natural Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural origin recruits (NOR) to the parent spawning population. For brood years 1989-1999, NRR for summer Chinook in the Okanogan basin averaged 1.36 (range, 0.27-3.62) if harvested fish were not include in the estimate and 2.08 (range, 0.38-6.92) if harvested fish were included in the estimate (Table 8.17). 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 8.17. Spawning escapements, natural origin recruits (NOR), and natural replacement rates (NRR; with and without harvest) for wild summer Chinook in the Okanogan basin, 1989-2000. *(The numbers in this table may change as the HETT and HC refine the methods for estimating summer Chinook NORs and NRRs.)*

Brood year	Escapement	NOR	NRR	
			Harvest not included	Harvest included
1989	1,782	2,821	1.18	1.87
1990	881	1,175	1.57	2.03
1991	574	732	1.02	1.40
1992	473	631	1.78	2.41
1993	1,485	1,204	0.51	0.65
1994	4,032	1,729	0.27	0.38
1995	3,002	1,119	0.63	1.05
1996	1,819	760	0.48	0.77
1997	2,190	884	2.13	3.30
1998	1,092	714	3.62	6.92
1999	3,617	1,598	1.77	
Average	***1,904***	***1,215***	***1.36***	***2.08***

Hatchery Replacement Rates

Hatchery replacement rates were estimated as hatchery adult-to-adult returns. These rates should be greater than the NRRs and greater than or equal to 5.30 (the value in BAMP; Murdoch and Peven 2005). HRRs exceeded NRRs in eight of the 10 years of data, regardless if harvest was or was not included in the estimate (Table 8.18). Hatchery replacement rates (harvest included in the estimate) for Okanogan/Similkameen summer Chinook have exceeded the BAMP target of 5.30 in six of the 11 years of data.

Table 8.18. Hatchery replacement rates (HRR), NRR, and BAMP target (5.30) for summer Chinook in the Okanogan basin, 1989-2000. *(The numbers in this table may change as the HETT and HC refine the methods for estimating summer Chinook HRRs and NRRs.)*

Brood year	Harvest not included			Harvest included		
	HRR	NRR	BAMP	HRR	NRR	BAMP
1989	14.75	1.18	5.30	24.45	1.87	5.30
1990	3.42	1.57	5.30	4.88	2.03	5.30
1991	3.94	1.02	5.30	4.99	1.40	5.30
1992	5.88	1.78	5.30	7.62	2.41	5.30
1993	0.41	0.51	5.30	0.55	0.65	5.30
1994	8.92	0.27	5.30	12.05	0.38	5.30
1995	5.74	0.63	5.30	7.38	1.05	5.30
1996	0.08	0.48	5.30	0.09	0.77	5.30
1997	17.25	2.13	5.30	25.71	3.30	5.30
1998	7.58	3.62	5.30	23.00	6.92	5.30

Brood year	Harvest not included			Harvest included		
	HRR	NRR	BAMP	HRR	NRR	BAMP
1999	0.50	1.77	5.30	5.19		5.30
Average	***6.22***	***1.36***	***5.30***	***10.54***	***2.08***	***5.30***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adults divided by the number of hatchery smolts released. SARs were based on CWT returns. For the available brood years, SARs have ranged from 0.0001 to 0.0318 for hatchery summer Chinook in the Okanogan basin (Table 8.19).

Table 8.19. Smolt-to-adult ratios (SARs) for Okanogan/Similkameen summer Chinook; NA = not available.

Brood year	Number released	SAR
1989	202,125	0.020957
1990	367,207	0.002610
1991	360,380	0.002691
1992	537,190	0.004246
1993	379,139	0.000311
1994	217,818	0.006960
1995	574,197	0.004830
1996	487,776	0.000060
1997	572,531	0.031811
1998	287,948	0.027180
1999	610,868	0.004505
Average	***427,152***	***0.009651***

8.6 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 7.6 for information on ESA compliance during broodstock collection.

Hatchery Rearing and Release

The 2004 brood Okanogan/Similkameen summer Chinook reared throughout their juvenile life-stages at Eastbank Fish Hatchery and Similkameen and Bonaparte Acclimation ponds without incident (see Section 8.2). The 2004 brood smolt release totaled 703,359 fish, representing 122.1% of the production objective and exceeding the 576,000 smolt level identified in ESA Section 10 Permit 1347. As required by ESA permit 1347, NMFS was notified of the production overage in a

memo from K. Truscott (WDFW) to K. Petersen (NMFS) dated 26 September 2005 (Truscott 2005). The combined release of Okanogan/Similkameen/Methow summer Chinook (MEOK program) totaled 1,103,938 smolts (703,359 Okanogan/Similkameen and 400,579 Methow), representing 112% of the overall MEOK summer Chinook program, slightly greater than the 10% overage allowed under ESA Permit 1347. The MEOK overage was apportioned to the Okanogan and Similkameen River basins because rearing space was available at Bonaparte Acclimation Pond and it provided a lower aquaculture health risk than increasing production about 10% at the Similkameen and Carlton Acclimation ponds. Additionally, 2002 and 2003 brood summer Chinook reared at Similkameen and Bonaparte ponds have suffered mortalities above program expectations, further supporting apportioning excess MEOK production to the Okanogan/Similkameen basin.

Spawning Surveys

Summer Chinook spawning ground surveys conducted in the Okanogan basin during 2006 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 impacts 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: TURTLE ROCK SUMMER CHINOOK

9.1 Broodstock Sampling

Broodstock for the Turtle Rock programs (yearling and sub-yearling) are collected as part of the Wells summer Chinook volunteer program. Refer to Snow et al. (2003) for information related to adults collected for these programs.

9.2 Hatchery Rearing

Rearing History

Number of eggs taken

Broodstock for the Turtle Rock summer Chinook are collected at Wells Dam and consist of volunteers to the hatchery. In recent years some naturally produced fish have been incorporated into the brood. Eyed eggs are transferred from Wells FH to Eastbank FH for rearing. As such, the number of green (unfertilized) eggs collected for this program is reported as part of the Wells summer Chinook program.

Disease

Within the normal and accelerated subyearling program, as well as the yearling program, the cause of mortality in the early life stages (swim-up to early ponding) continues to be coagulated yolk as a result of elevated incubation water temperature. Post-transfer mortalities were primarily the result of gill fungus and/or injuries sustained during transfer. No post-transfer treatment was recommended.

Number of acclimation days

Rearing of the 2004 brood normal and accelerated sub-yearling Turtle Rock summer Chinook was similar to previous years with fish being held on well water before being transferred to Turtle Rock for final acclimation in May 2005. Fish were released on 27 June 2005 after 38 days of acclimation on Columbia River water. Yearling Turtle rock summer Chinook were released on 1 May 2006 after 188 days of acclimation on Columbia River water.

Release Information

Numbers released

The 2004 subyearling Turtle Rock summer Chinook program achieved 50.8% of the 810,000 target goal with about 411,707 fish being released. The 2004 accelerated subyearling summer Chinook program achieved 45.0% of the 810,000 target goal with about 364,453 fish being released. The 2004 yearling summer Chinook program achieved 103.4% of the 200,000 target goal with about 206,734 fish being released.

Numbers tagged

A total of 200,000 normal and accelerated subyearling Chinook were 100% adipose fin clipped and CWT. The remainder of the fish was released untagged and unmarked. The yearling Chinook were 100% CWT and adipose fin-clipped. No 2004 brood Turtle Rock summer Chinook were PIT tagged.

Fish size and condition at release

Size at release of the normal subyearling Turtle Rock summer Chinook was 89.1% and 100.0% of the target fork length and weight, respectively. This brood year was below the CV of length target by 16% (Table 9.1).

Table 9.1. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of Turtle Rock summer Chinook subyearlings released from the hatchery, 2004. 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
2004	2005	100	7.8	11.4	40
Targets		***112***	***9.0***	***11.4***	***40***

Size at release of the accelerated subyearling Turtle Rock Chinook was 104.5% and 176.3% of the target fork length and weight, respectively. This brood year exceeded the CV of length goal by 26% (Table 9.2).

Table 9.2. 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, 2004. 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
2004	2005	117	11.3	20.1	23
Targets		***112***	***9.0***	***11.4***	***40***

Size at release of the yearling Turtle Rock summer Chinook was 100.1% and 144.3% of the target fork length and weight, respectively. This brood year exceeded the CV of length target by 129% (Table 9.3).

Table 9.3. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of Turtle Rock summer Chinook yearlings released from the hatchery, 2004. 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
2004	2006	176	20.6	65.5	7
Targets		***176.0***	***9.0***	***45.4***	***10.0***

Survival Estimates

Overall survival of the accelerated subyearling Turtle Rock summer Chinook program from green egg to release was at the standard set for the program. Lower than expected survival at ponding due to coagulated yolk reduced the overall program performance (Table 9.4).

Table 9.4. Hatchery life-stage survival rates (%) for Turtle Rock subyearling (zero program) summer Chinook, brood year 2004. 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			93.5	74.4	93.9	91.4	90.8	99.7	63.1
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

Overall survival of the accelerated subyearling Turtle Rock summer Chinook program from green egg to release was at the standard set for the program. Lower than expected survival at ponding due to coagulated yolk reduced the overall program performance (Table 9.5).

Table 9.5. Hatchery life-stage survival rates (%) for Turtle Rock subyearling (accelerated program) summer Chinook, brood year 2004. 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			92.5	98.3	93.4	92.4	90.0	97.8	81.8
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

Survival of the yearling Turtle Rock summer Chinook program in all categories from green egg to release was above the standard set for the program (Table 9.6).

Table 9.6. Hatchery life-stage survival rates (%) for Turtle Rock yearling summer Chinook, brood year 2004. 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			92.9	97.7	96.8	96.4	95.5	99.6	86.7
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

9.3 Life History Monitoring

Life history characteristics of Turtle Rock summer Chinook were assessed by examining carcasses on spawning grounds and by reviewing tagging data and fisheries statistics.

Contribution to Fisheries

Most of the harvest on Turtle Rock summer Chinook (released as subyearlings) occurred in the Ocean (Table 9.7). Ocean harvest has made up 75% to 100% of all Turtle Rock summer Chinook harvested. Brood year 1999 provided the largest harvest, while brood year 1997 provided the lowest.

Table 9.7. Estimated number and percent (in parentheses) of Turtle Rock summer Chinook (released as subyearlings) captured in different fisheries.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal (Zone 6)	Commercial (Zones 1-5)	Recreational (sport)	
1995	690 (84)	0 (0)	117 (14)	16 (2)	823
1996	117 (88)	0 (0)	9 (7)	7 (5)	133
1997	10 (100)	0 (0)	0 (0)	0 (0)	10
1998	116 (96)	2 (2)	3 (2)	0 (0)	121
1999	707 (75)	9 (1)	90 (10)	141 (15)	947
2000	169 (87)	0 (0)	11 (6)	14 (7)	194

Most of the harvest on Turtle Rock summer Chinook (released as yearlings) occurred in the Ocean (Table 9.8). Ocean harvest has made up 73% to 95% of all Turtle Rock summer Chinook harvested. Brood year 1998 provided the largest harvest, while brood year 1995 provided the lowest.

Table 9.8. Estimated number and percent (in parentheses) of Turtle Rock summer Chinook (released as yearlings) captured in different fisheries.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal (Zone 6)	Commercial (Zones 1-5)	Recreational (sport)	
1995	444 (75)	6 (1)	78 (13)	67 (11)	595
1996	747 (95)	0 (0)	17 (2)	20 (3)	784
1997	2,794 (90)	28 (1)	103 (3)	171 (6)	3,096
1998	4,785 (91)	24 (0)	226 (4)	243 (5)	5,278
1999	1,678 (73)	42 (2)	234 (10)	339 (15)	2,292
2000	1,219 (76)	1 (0)	138 (9)	246 (15)	1,604

Straying

Rates of Turtle Rock summer Chinook (subyearling releases) straying into spawning areas in the upper basin have been relatively low (Table 9.9). Most of these strays have ended in the Chelan

tailrace and the Methow and Okanogan basins. Few have strayed into the Wenatchee and Entiat basins.

Table 9.9. Proportion of Turtle Rock summer Chinook (subyearling releases) that strayed onto spawning grounds within the basin, 1998-2005; ND = no data. *(The numbers in this table may change as the HETT and HC refine the methods for estimating summer Chinook stray rates.)*

Return year	Chelan Tailrace	Entiat	Hanford	Methow	Okanogan	Wenatchee
1998	ND	0.000	0.000	0.000	0.000	0.001
1999	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.064	0.000	0.000	0.003	0.010	0.002
2001	0.000	0.006	0.000	0.003	0.006	0.000
2002	0.000	0.000	0.000	0.001	0.001	0.000
2003	0.019	0.010	0.000	0.007	0.005	0.000
Average	***0.017***	***0.003***	***0.000***	***0.002***	***0.004***	***0.001***

Rates of Turtle Rock summer Chinook (yearling releases) straying into spawning areas in some areas has been relatively high (Table 9.10). For example, high stray rates occur in the Chelan tailrace and Entiat basin. These fish also stray into the Methow, Okanogan, and Wenatchee basins.

Table 9.10. Proportion of Turtle Rock summer Chinook (yearling releases) that strayed onto spawning grounds within the basin, 1998-2005; ND = no data. *(The numbers in this table may change as the HETT and HC refine the methods for estimating summer Chinook stray rates.)*

Return year	Chelan Tailrace	Entiat	Hanford	Methow	Okanogan	Wenatchee
1998	ND	0.000	0.000	0.003	0.000	0.000
1999	0.000	0.000	0.000	0.002	0.000	0.001
2000	0.151	0.000	0.000	0.046	0.044	0.004
2001	0.312	0.321	0.000	0.184	0.030	0.012
2002	0.323	0.190	0.000	0.093	0.014	0.007
2003	0.396	0.244	0.000	0.043	0.004	0.005
Average	***0.236***	***0.126***	***0.000***	***0.062***	***0.015***	***0.005***

Hatchery Replacement Rates

Hatchery replacement rates were estimated as hatchery adult-to-adult returns. In all years, HRRs for summer Chinook released as yearlings were greater than HRRs for Chinook released as subyearlings (Table 9.11). HRRs based on subyearling releases were consistently less than 5.3, whereas those for yearling releases were consistently greater than 5.3.

Table 9.11. Hatchery replacement rates (HRR) for Turtle Rock summer Chinook released as subyearlings or yearlings, 1995-2000. *(The numbers in this table may change as the HETT and HC refine the methods for estimating summer Chinook HRRs.)*

Brood year	Subyearling releases		Yearling releases	
	HRR (harvest not included)	HRR (harvest included)	HRR (harvest not included)	HRR (harvest included)
1995	0.79	2.11	7.31	12.27
1996	0.66	1.03	8.14	14.98
1997	0.03	0.08	24.79	56.48
1998	0.09	0.17	17.31	71.00
1999	0.97	3.72	1.72	9.02
Average	***0.51***	***1.42***	***11.85***	***32.75***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adults divided by the number of hatchery subyearling or yearling Chinook released. SARs were based on CWT returns. For the available brood years, SARs for subyearling Chinook have ranged from 0.0006 to 0.0067 (Table 9.12).

Table 9.12. Smolt-to-adult ratios (SARs) for Turtle Rock subyearling summer Chinook.

Brood year	Number released	SAR
1989	90,306	0.006691
1990	90,100	0.001148
1991	87,515	0.002290
1992	159,837	0.003187
1993	392,601	0.003728
1994	387,918	0.000684
Average	***201,380***	***0.002955***

For the available brood years, SARs for yearling Chinook have ranged from 0.0023 to 0.0096 (Table 9.13).

Table 9.13. Smolt-to-adult ratios (SARs) for Turtle Rock yearling summer Chinook.

Brood year	Number released	SAR
1995	512,751	0.002368
1996	764,819	0.002287
1997	892,287	0.005262
1998	595,920	0.009640
1999	671,141	0.005477
Average	***688,715***	***0.005007***

9.4 ESA/HCP Compliance

Broodstock Collection

The 2004 brood Turtle Rock summer Chinook program is supported through adult collections at the volunteer trap at Wells Fish Hatchery and in conjunction with the Wells summer Chinook collections. During 2004, broodstock collections at the volunteer trap were consistent with the 2004 Upper Columbia River Salmon and Steelhead Broodstock Objectives and site-based broodstock collection protocols as required in ESA permit 1347. The 2004 collection totaled 1,205 summer Chinook (combined Wells Fish Hatchery and Turtle Rock Fish Hatchery programs).

Hatchery Rearing and Release

Brood year 2004 releases totaled 982,894 fish, including yearling, regular sub-yearling, and accelerated sub-yearling releases (206,734; 411,707 and 364,453 juveniles, respectively). These releases represented 103.4% and 47.9% of the Rocky Reach HCP and ESA Section 10 Permit 1347 production for Turtle Rock yearling and sub-yearling production, respectively.

Consistent with ESA Permit 1347, a total of 200,000 normal and accelerated sub-yearling Chinook were adipose fin clipped and coded-wire tagged. The remainder of the sub-yearling production was released untagged and unmarked. The yearling Chinook were 100% CWT and adipose fin-clipped. No 2004 brood Turtle Rock summer Chinook were PIT tagged. See Section 9.2 for specific rearing, tagging, and release information related to the 2004 brood Turtle Rock summer Chinook program.

SECTION 10: REFERENCES

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SECTION 11: APPENDICES

Appendix A: **Abundance and Total Numbers of Chinook Salmon and Trout in the Chiwawa River Basin, Washington, 2006.**

Appendix B: **Fish Trapping at the Chiwawa, Upper Wenatchee, and Lower Wenatchee Smolt Traps during 2006.**

Appendix C: **Summary of ISEMP PIT Tagging Activities in the Wenatchee Basin, 2006.**

Appendix D: **Wenatchee Steelhead Spawning Ground Surveys, 2006.**

Appendix E: **NPDES Hatchery Effluent Monitoring, 2006.**

Appendix F: **Steelhead Stock Assessment at Priest Rapids Dam, 2006.**

Appendix G: **Wenatchee Sockeye and Summer Chinook Spawning Ground Surveys, 2006.**

Appendix H: **Genetic Diversity of Natural Chiwawa River Spring Chinook Salmon, 2007.**

Appendix I: **Summer Chinook Spawning Ground Surveys in the Methow and Okanogan Basin, 2006.**