

# 2001 Annual Report of Winter Chinook Propagation Activities

USFWS Report

U.S. Fish and Wildlife Service  
Red Bluff Fish and Wildlife Office  
Red Bluff, California 96080  
April 2003



### **Disclaimer**

The mention of trade names or commercial products in this report does not constitute endorsement or recommendation for use by the federal government.

## TABLE OF CONTENTS

<b>Background</b> .....	1
<b>Broodstock Collection</b>	
<u>Adult Collection Plan</u> .....	2
<u>Adult Trapping</u>	
Keswick Dam Fish Trap .....	2
Red Bluff Diversion Dam .....	3
<u>Identification of Winter Chinook Broodstock</u> .....	3
Sorting and initial disposition of captured fish.....	3
Genetic Stock Identification .....	4
Population Assignments of Captured Fish.....	5
Disposition of non-Quarantined Fish.....	5
Disposition of Quarantined Fish .....	5
<b>Fish Health Maintenance and Monitoring</b> .....	16
<u>Prespawning Mortality</u> .....	17
<b>Spawning</b>	
<u>Adults Collected at Keswick and RBDD</u> .....	24
<u>Captive Broodstock</u> .....	24
Captive-Origin x Natural-Origin Crosses .....	24
Captive-Origin x Captive-Origin Crosses.....	25
<b>Incubation and Rearing</b> .....	27
Prophylactic and Treatment of Eggs.....	27
Progeny of Adults Collected at Keswick and RBDD .....	27
Progeny of Captive-Origin x Natural-Origin Crosses .....	27
Progeny of Captive-Origin x Captive-Origin Crosses .....	27
<u>Juvenile Rearing</u> .....	27
Natural-Origin x Natural-Origin Crosses.....	27
Captive-Origin x Natural-Origin Crosses .....	28
Tanking .....	28
<u>Juvenile Fish Health Maintenance and Treatments</u> .....	39
<b>Juvenile Releases</b> .....	39
<u>Tagging</u> .....	39
<u>Distribution</u> .....	43
Effective Population Size.....	43
<u>Fish Health Maintenance and Monitoring</u> .....	43
<b>References</b> .....	44
<b>Attachment A</b> (2001 Adult Trapping Plan).....	A-1
<b>Attachment B</b> (2001 Effective Population Calculation).....	B-1
<b>Attachment C</b> (Winter Chinook Captive Broodstock Release Study Plan) .....	C-1

## Tables and Figures

### FIGURES

Figure 1	2001 Keswick Dam Trapping Operations and Flow Data.....	6
Figure 2	Spawning of winter Chinook salmon at Coleman National Fish Hatchery, June 5 through August 21, 2001.....	26

### TABLES

Table 1	Disposition of Chinook salmon captured at the Keswick Dam and RBDD fish traps .....	7
Table 2	Identification numbers and biological data for tissue sampled Chinook salmon captured at the Keswick Dam and RBDD fish traps.....	8-15
Table 3	Drugs and treatments that may be applied to maintain health of winter Chinook salmon.....	17
Table 4	Spawning and drug treatment history for female winter Chinook salmon held for spawning .....	18-19
Table 5	Spawning and drug treatment history for male winter Chinook salmon held for spawning .....	20-23
Table 6	Family groups, date spawned, egg counts and number tanked for brood year 2001 natural-origin x natural-origin crosses .....	29-32
Table 7	Family groups, date spawned, egg counts and number tanked for brood year 2001 captive-origin x natural-origin crosses .....	33-36
Table 8	Family groups, date spawned, and egg counts for brood year 2001 natural-origin x natural-origin crosses .....	37-38
Table 9	CWT code, associated family groups, number tagged with passive integrated transponders (PIT), and distribution for juvenile winter Chinook salmon retained for the captive broodstock program .....	40-41
Table 10	Tagging information for BY 2001 winter Chinook salmon.....	42

## Background

In 1989, due to severe declines in adult returns, the National Marine Fisheries Service (NMFS) listed winter Chinook salmon as threatened under the emergency listing procedures for the ESA (16 U.S.C.R. 1531-1543) on August 4, 1989 (54 Federal Register {FR} 32085). A proposed rule to add winter Chinook salmon to the list of threatened species beyond expiration of the emergency rule was published by the NMFS on March 20, 1990 (55 FR 10260). Winter Chinook salmon were formally added to the list of federally threatened species by final rule on November 5, 1990 (55 FR 46515). Despite early efforts to restore the run, adult returns of winter Chinook salmon continued to decline, and in January of 1994 NMFS published a final rule reclassifying winter Chinook salmon as federally endangered. The NMFS cited the following reasons for the reclassification: 1) the continued decline and increased variability of run sizes since its listing as a threatened species in 1989, 2) the expectation of weak returns in certain years as the result of two small year classes (1991 and 1993), and 3) continuing threats to the population.

To supplement natural production and reduce the risk of extinction, the U.S. Fish and Wildlife Service (Service) developed an artificial propagation program for winter Chinook salmon at the Coleman National Fish Hatchery (NFH) in 1989. Between brood years 1991 and 1995, an average of approximately 30,600 (range: 11,582-51,267) juvenile winter Chinook salmon were released from Coleman NFH annually.

In 1996, the Service enacted a self-imposed moratorium on the collection of adult salmon to use for broodstock. One reason for the moratorium was the finding of genetic evidence suggesting that hybridization may have occurred between spring and winter Chinook salmon at the hatchery. Another concern was that hatchery-origin adults were returning primarily to Battle Creek, rather than the Sacramento River where they were intended to spawn. These concerns were addressed during a two-year moratorium of the winter Chinook propagation program as follows: To address concerns of hybridization between runs, the Service implemented a rigorous genetic screening process to identify and select winter Chinook broodstock. Before a fish is used as hatchery broodstock, a tissue sample is collected and genetically analyzed to ensure that only winter Chinook salmon are spawned at the hatchery. To address concerns about hatchery-produced adults returning to Battle Creek rather than the Sacramento River, the winter Chinook supplementation program was moved in 1998 to a new facility located at the base of Shasta Dam; the Livingston Stone National Fish Hatchery (NFH). The Livingston Stone NFH is supplied with water taken directly from Shasta Reservoir. As a result, hatchery-produced juveniles imprint during the period of hatchery rearing to the Sacramento River rather than Battle Creek, thus increasing the likelihood that adults will return and spawn in the mainstem river. Calendar year 1998 marked the first year that juvenile winter Chinook salmon produced at the new Livingston Stone NFH were released into the Sacramento River. Between brood years 1998 and 1999, an average of approximately 90,200 (range: 26,522-153,908) juvenile winter Chinook were released from Livingston Stone NFH.

In response to winter Chinook abundance declining to extremely low levels (total run estimate of <200 in 1991), a captive broodstock program was cooperatively developed in 1991 to reduce the risk of extinction while those factors that caused the stock to decline are addressed. To maintain

the captive broodstock program, a small number of juveniles (currently approximately 400 per brood year) from the supplementation program are reared to maturity in captivity. The captive broodstock are currently held at the Livingston Stone NFH and the Bodega Marine Laboratory (BML). The primary objective of the winter Chinook captive broodstock program is to ensure a source of gametes for the supplementation program in the event that too few natural returns are available for hatchery broodstock. An average of 6,288 (range: 0-21,271) juvenile captive-origin winter Chinook salmon from brood years 1995 to 1999 were released into the Sacramento River to supplement natural production.

## **Broodstock Collection**

### **Adult Collection Plan**

Before the collection of broodstock began in 2001, the Service developed a broodstock collection plan that defined the timing and location of trapping activities and the number of fish to be collected (see Attachment A). In 2001, the adult collection schedule was based on a pre-season run estimate of 3,900 adult winter Chinook salmon. Therefore, based on the broodstock collection guidelines allowing capture of up to 15% of the run size up to a maximum of 120 fish, the service planned to collect the maximum allowed 120 adult winter Chinook salmon. The scheduled timing of broodstock collection based on historic migration timing past the Red Bluff Diversion Dam (RBDD) was as follows: December, 1.8% (2 fish); January, 5.1% (6 fish); February, 9.6% (12 fish); March, 36.0% (43 fish); April, 28.6% (34 fish); May, 8.9% (11 fish); June, 6.8% (8 fish); July, 3.4% (4 fish); and August, 0% (0 fish).

### **Adult Trapping**

Broodstock for the winter Chinook propagation program were captured at both the Keswick Dam (RM 302) and the RBDD (RM 243) fish traps between February 28 and July 2 in 2001. A total of 251 Chinook salmon were captured at these sites, 243 at the Keswick Dam fish trap (Keswick) and 8 at RBDD. Two hundred five of the captured fish were genetically determined to be winter Chinook salmon. Females comprised 43% (88 fish) and males comprised 57% (117 fish) of the total winter Chinook salmon captured. One hundred winter Chinook salmon adults were ultimately retained for the program.

#### *Keswick Dam Fish Trap*

The fish trapping facilities at the Keswick Dam are located in the center of the dam, between the powerhouse and the spillway. The trapping facilities consist of a twelve-step upstream fish ladder, rail-lift, and 1,000 gallon elevator. The fish ladder is approximately 170 ft long and 38 feet wide. Weirs spaced every 13 feet 7 inches create pools in the ladder. Fish approaching Keswick Dam are attracted to the fish ladder by means of a 340 cfs jet pump supplying water to the trap and fish ladder. Additional attraction is supplied through water diffusers in the ladder floor. The top of the ladder leads to a fyke weir. After passing through the fyke weir, adult salmonids are contained in a large fiberglass rail enclosure. Fish collected at Keswick remain in water at all times. When the trap rail is raised, trapped fish are directed into a 1,000-gallon fish tank elevator that transports them up the face of the dam. The fish tank is then dumped into a vehicle equipped with a distribution tank so the captured fishes can be transported to the Livingston Stone NFH.

Keswick was operated from February 27 through July 2, 2001 and flows ranged from 3,187 cfs to 14,669 cfs. Winter Chinook salmon were captured between February 28 and July 2 (Figure 1). During typical brood stock collection operations, the fish trap was used for at least two consecutive days every week before inspection for captured fish. However, operation of the fish trap varied throughout the trapping season depending on the number of fish captured, the trapping target, and river flows. When the fish trap was not in use, it was raised to prevent fish from collecting (Figure 1).

#### *Red Bluff Diversion Dam Trap*

The California Department of Fish and Game (CDFG) operates a fish trap at the RBDD from May 15 through September 15. The RBDD has three fish ladders; one on the west bank, one at the center of the dam, and one on the east bank. The fish trap at RBDD is located on the east fish ladder. The fish ladders and trap at RBDD are used to monitor passage of Chinook salmon. Counts of phenotypic winter Chinook have been used to generate run-size estimates since 1967. Additionally, the fish trap at RBDD is used to collect broodstock for the Livingston Stone NFH propagation program when the number of adults collected from Keswick is not sufficient to meet hatchery broodstock goals. When the trap is operating to collect adults for brood stock, fish ascending the east ladder are diverted (by a weir) into an examination area. Captured fish are anaesthetized with CO<sub>2</sub> and adult Chinook salmon are phenotypically identified to run. Phenotypic winter Chinook salmon are sorted from non-winter Chinook salmon, netted from the trap, and placed in a flow-through retention tube located on the fish ladder where they are detained for approximately one hour prior to transport to Livingston Stone NFH. Phenotypic non-winter Chinook salmon are not detained for the propagation program.

### **Identification of Winter Chinook Broodstock**

#### *Sorting and Initial Disposition of Captured Fish*

Chinook salmon collected at Keswick were initially identified to race (i.e., winter Chinook or non-winter Chinook) based on phenotypic characteristics including: color, degree of ripeness (firmness), size, amount of fungus, and collection date. A color-coded alphanumeric floy tag was attached to each salmon just below the dorsal fin and a fin-tissue sample was collected from phenotypic winter Chinook. Phenotypic winter Chinook salmon were transported to the Livingston Stone NFH in an aerated and insulated 1,200 or 1,600-gallon transport tank where they were initially quarantined during genetic analysis in one of two 20-foot circular tanks. Phenotypic non-winter Chinook salmon from Keswick were transported back to the Sacramento River and released.

At RBDD only phenotypic winter Chinook were targeted for collection, genetic analysis, and possible use as hatchery broodstock. As with fish from Keswick, phenotypic winter Chinook collected from RBDD were floy-tagged, fin-tissue sampled, and transported to Livingston Stone NFH for quarantine.

Unsampled salmon, genetic non-winter Chinook, and genetic winter Chinook in excess of monthly collection guidelines (all from Keswick), were marked with a floy tag and relocated back to the Sacramento River. Salmon captured before April 29 were released at the Bonnyview Road boat ramp (RM 292), whereas those captured on or after April 29 were released at the

Caldwell Park boat ramp (RM 299). The location of release is largely dependent on Anderson-Cottonwood Irrigation District (ACID) dam (RM 298.5) operations. ACID is a flashboard-type irrigation diversion dam that typically goes into operation on April 29. The dam raises the water level in the upper Sacramento River to provide head for the water diversion structure. During this period of increased water level, the hatchery's fish transportation truck can utilize the Caldwell Park boat ramp to safely return salmon to the upper Sacramento River. When water levels are inadequate to allow such access at Caldwell Park, fish are released at the Bonnyview Road boat ramp. Genetic non-winter Chinook salmon captured at the RBDD fish trap are taken to the boat ramp at Bend Bridge (RM 258) to allow them to continue their upstream migration.

### *Genetic Stock Identification*

Working in cooperation with the University of California's (Davis) BML genetics laboratory, potential winter Chinook broodstock are genetically screened to identify individuals of the winter Chinook population. A total of 236 Chinook salmon collected at Keswick and RBDD fish trap were tissue sampled for genetic run determination. Using a combination of molecular and statistical methods, potential hatchery broodstock are genotyped to distinguish winter Chinook from the other populations of salmon in the Sacramento River. By genotyping potential broodstock before they are spawned at the hatchery, the probability of hybridizing winter and non-winter Chinook in the Service's supplementation program is markedly reduced (Hedgecock et al. 2001).

To genetically identify winter Chinook broodstock for the hatchery supplementation program, a sample of fin tissue was collected from phenotypic winter Chinook salmon collected at Keswick and from fish collected for broodstock purposes at the RBDD. Tissue sampled fish were floy tagged to allow identification of individuals and potential broodstock were held at LSNFH while awaiting the results of genetic analysis. Fin-tissue samples from potential broodstock were sent to the BML, analyzed genetically for run assignment, and a genetically based population assignment was transmitted back to LSNFH within 24 to 48 hours. Genetic analysis for salmon captured at Keswick and RBDD trap but not retained as potential broodstock were typically processed at a slower rate, generally within 5-7 days. Floy tags enabled quarantined fish to be matched with the results of genetic run call determinations. Genetically identified winter Chinook were retained for brood stock, while non-winter Chinook were released into the Sacramento River.

To perform genetically based population assignment, DNA was extracted from tissue samples and amplified at established loci. A Log of the Odds (LOD) score was generated for each sample using the genotype data. The LOD score (also called the likelihood ratio or the assignment ratio) indicates the likelihood that a specific fish is a winter Chinook. Generally, a LOD score less than 0 indicates that a fish is likely not a winter Chinook whereas a LOD score greater than 0 indicates that a fish is likely a winter Chinook. However, in selecting winter Chinook broodstock for the hatchery supplementation program at LSNFH, we err on the side of caution by setting more stringent selection criteria. Prior to 1999, winter Chinook hatchery broodstock were required to have an  $LOD \geq 2$  with five loci. In February 1999, the criteria for a fish to be assigned as winter Chinook was updated to include those that had a LOD score  $\geq 1.0$  with 7 loci being amplified. In the latter case, the additional 2 loci were only analyzed if the original LOD score (based on 5 loci) was between 0 and 2.0. In 2001 the criteria was again



updated as follows: when possible, all 7 loci are initially amplified and the 5 loci criterion is only utilized if amplification of all 7 loci is not possible. These stringent criteria may actually exclude some winter Chinook from inclusion into the propagation program, but by adhering to these criteria we reduce the risk of hybridizing winter and non-winter Chinook at LSNFH.

#### *Population Assignments of Captured Fish*

Of the 243 Chinook salmon collected at Keswick in 2001, 228 were tissue sampled for genetic run determination. Two hundred five of these satisfied the genetic criteria to be classified as winter Chinook, including 117 males (57%) and 88 females (43%) (Table 1). One hundred two of the genetically identified winter Chinook collected at Keswick were marked with an adipose fin-clip representing 45% of the total fish collected and tissue sampled at Keswick and 50% of the genetic winter Chinook collected at Keswick. Twenty three Chinook salmon collected at Keswick were genetically determined to be non-winter Chinook. Two unmarked Chinook salmon were not assigned a run type. Fifteen Chinook salmon were not tissue sampled.

Three of the eight phenotypic winter Chinook salmon collected at the RBDD fish trap were genetically identified as winter Chinook salmon (all unmarked) and 5 were genetically identified as non-winter Chinook. The three genetic winter Chinook adults collected at the RBDD fish trap were collected in the latter stages of the trapping season: 1 on May 30, and 2 on June 6.

#### *Disposition of Non-Quarantined Fish*

Of the 243 Chinook salmon collected at Keswick in 2001, 90 were not put into quarantine: Twelve genetic non-winter Chinook salmon and 61 genetic winter Chinook were returned to the river without being quarantined; fifteen Chinook salmon were returned to the Sacramento River without being tissue sampled (primarily because there was an unusually large number of fish in the trap that day); one adipose-fin clipped male winter Chinook died in the transport truck en route to LSNFH; and one adipose-fin clipped female winter Chinook was killed during operation of the Keswick fish trap.

#### *Disposition of Quarantined Fish*

Of the 161 Chinook salmon collected at Keswick and RBDD fish trap that were quarantined in 2001 (Tables 1 and 2), 100 genetically identified winter Chinook were retained for spawning. Of these, 97 were spawned (94 from Keswick and 3 from the RBDD trap) and 3 (from Keswick) died during quarantine. Fifty six of the quarantined salmon collected at Keswick were returned to the Sacramento River, including 45 genetically identified winter Chinook, 9 genetically identified non-winter Chinook, and 2 of undetermined run type. Five non-winter Chinook collected at the RBDD fish trap were quarantined, and subsequently released at the Bend Bridge boat ramp (RM 258).

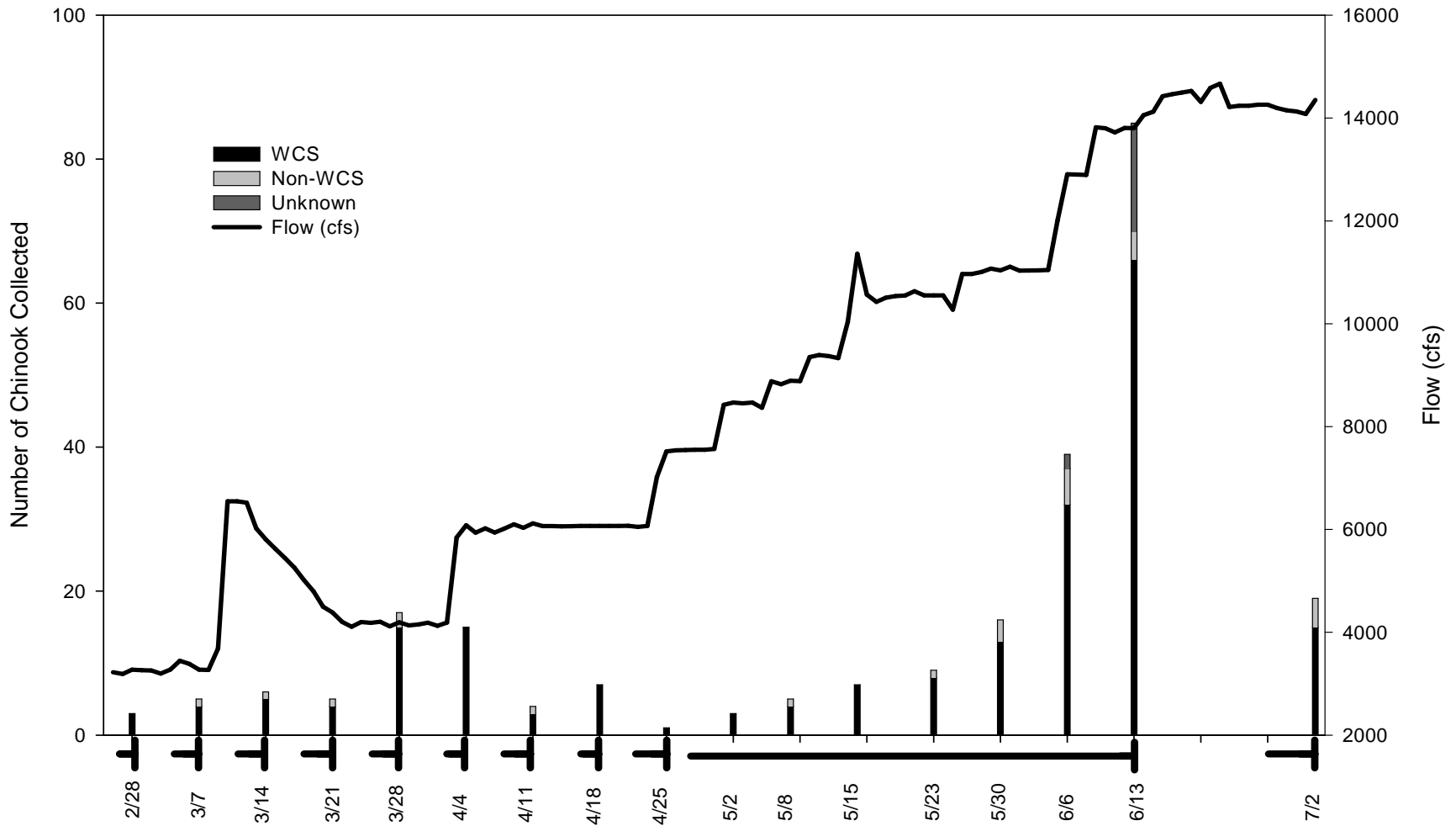


Figure 1 2001 Keswick trapping operations and Keswick Reservoir discharge. Vertical bars correspond to days when the trap was emptied (i.e. fish were collected). Horizontal lines above dates correspond to days in which the trap was in operation (i.e. trap was “fished”).

Table 1 Disposition of winter and non-winter Chinook salmon captured at Keswick and RBDD fish trap in 2001. The numbers of adipose-fin clipped Chinook collected at Keswick are shown in parentheses and are included in the total. No adipose-fin clipped Chinook were collected at RBDD.

<b>2001 Winter Chinook Broodstock Collection Trapping Summary</b>				
<b>Number of salmon captured at traps from 2/28 through 7/2</b>				
			<b>Keswick</b>	<b>RBDD</b>
Salmon returned without tissue samples		=	15 (unk)	0
Non-winter chinook salmon tissue sampled and returned without being quarantined		=	12 (0)	0
Winter Chinook tissue sampled and returned without being quarantined	M	=	47 (31)	0
	F	=	14 (14)	
Winter Chinook trapping mortalities	M	=	1 (1)	0
	F	=	1 (1)	0
Salmon put into quarantine		=	<u>153 (55)</u>	<u>8</u>
<b>Total captured (not including recaptures)</b>		=	<u>243 (102)</u>	<u>8</u>
<b>Recaptured salmon</b>		=	5	0
<b>Disposition of quarantined Chinook salmon</b>				
			<b>Keswick</b>	<b>RBDD</b>
<b>Genetic non-winter Chinook salmon</b>				
Returned/relocated	M	=	3 (0)	0
	F	=	6 (0)	4
	unk	=	0 (0)	1
<b>Undetermined run</b>				
Returned/relocated	M	=	1 (0)	0
	F	=	1 (0)	0
<b>Genetic Winter Chinook Salmon</b>				
Returned/relocated	M	=	21 (21)	0
	F	=	24 (24)	0
Retained for spawning	M	=	48 (4)	1
	F	=	<u>49 (6)</u>	<u>2</u>
<b>Total Chinook tissue sampled and quarantined</b>			<b>153 (55)</b>	<b>8</b>
<b>Disposition of Winter Chinook retained for spawning</b>				
Number spawned	M	=	46 (4)	1
	F	=	48 (6)	2
Prespawn mortalities	M	=	2 (0)	0
	F	=	1 (0)	0

Table 2 Identification numbers and biological data for tissue sampled Chinook salmon captured at the Keswick Dam fish trap (RM 302) and Red Bluff Diversion Dam (RBDD) (RM 243). Salmon with adipose fin-clips (ad-clip) were considered to be of hatchery origin. Salmon without adipose fin-clips were considered to be of natural origin. Coded-wire tag data were not available (N/A) for all marked salmon.

Date Captured	Location	Genetic ID	Floy Tag Number	Adipose Fin Status	Sex	Fork Length (mm)	Genetic Run	Final Disposition	Comments
2/28/2001	Keswick Trap	1801	W-061	Absent	Female	754	Winter	Released	
2/28/2001	Keswick Trap	1802	W-062	Absent	Male	667	Winter	Released	
2/28/2001	Keswick Trap	1803	W-060	Absent	Female	787	Winter	Released	
3/7/2001	Keswick Trap	1804	W-064	Present	Male	757	Winter	Mortality	Prespawn Mortality
3/7/2001	Keswick Trap	1805	W-065	Absent	Female	690	Winter	Released	
3/7/2001	Keswick Trap	1806	W-066	Absent	Female	797	Winter	Released	
3/7/2001	Keswick Trap	1807	W-067	Absent	Female	785	Winter	Released	
3/7/2001	Keswick Trap	1808	O-11503	Present	Male	1054	Non-Winter	Released	
3/14/2001	Keswick Trap	1809	O-11504	Present	Female	817	Non-Winter	Released	
3/14/2001	Keswick Trap	1810	W-068	Present	Female	772	Winter	Spawned	
3/14/2001	Keswick Trap	1811	W-069	Absent	Male	825	Winter	Released	
3/14/2001	Keswick Trap	1812	W-070	Absent	Female	770	Winter	Released	
3/14/2001	Keswick Trap	1813	W-072	Absent	Male	792	Winter	Released	
3/14/2001	Keswick Trap	1814	W-073	Absent	Female	729	Winter	Released	
3/21/2001	Keswick Trap	1815	W-074	Absent	Male	818	Winter	Released	
3/21/2001	Keswick Trap	1816	W-075	Absent	Male	662	Winter	Released	
3/21/2001	Keswick Trap	1817	W-076	Absent	Male	743	Winter	Released	
3/21/2001	Keswick Trap	1818	W-077	Absent	Female	692	Winter	Released	
3/21/2001	Keswick Trap	1819	O-11505	Present	Male	1005	Non-Winter	Released	
3/28/2001	Keswick Trap	1820	W-078	Absent	Female	772	Winter	Released	
3/28/2001	Keswick Trap	1821	W-079	Absent	Male	794	Winter	Released	
3/28/2001	Keswick Trap	1822	W-080	Absent	Male	708	Winter	Released	
3/28/2001	Keswick Trap	1823	W-081	Absent	Male	834	Winter	Released	
3/28/2001	Keswick Trap	1824	W-082	Absent	Male	796	Winter	Released	
3/28/2001	Keswick Trap	1825	W-083	Absent	Female	736	Winter	Released	
3/28/2001	Keswick Trap	1826	W-084	Absent	Male	762	Winter	Released	
3/28/2001	Keswick Trap	1827	W-085	Absent	Female	811	Winter	Released	

Table 2 (cont.)

Identification numbers and biological data for tissue sampled Chinook salmon captured at the Keswick Dam fish trap (RM 302) and Red Bluff Diversion Dam (RBDD) (RM 243). Salmon with adipose fin-clips (ad-clip) were considered to be of hatchery origin. Salmon without adipose fin-clips were considered to be of natural origin. Coded-wire tag data were not available (N/A) for all marked salmon.

Date Captured	Location	Genetic ID	Floy Tag Number	Adipose Fin Status	Sex	Fork Length (mm)	Genetic Run	Final Disposition	Comments
3/28/2001	Keswick Trap	1828	W-086	Absent	Male	476	Winter	Released	
3/28/2001	Keswick Trap	1829	W-087	Absent	Female	696	Winter	Released	
3/28/2001	Keswick Trap	1830	W-088	Absent	Female	741	Winter	Released	
3/28/2001	Keswick Trap	1831	W-089	Absent	Female	672	Winter	Released	
3/28/2001	Keswick Trap	1832	W-090	Absent	Female	793	Winter	Released	
3/28/2001	Keswick Trap	1833	O-11506	Present	Male	1151	Winter	Released	
3/28/2001	Keswick Trap	1834	O-11507	Present	Female	1000	Non-Winter	Released	
3/28/2001	Keswick Trap	1835	W-091	Present	Male	965	Winter	Spawned	
3/28/2001	Keswick Trap	1836	O-11508	Present	Male	1005	Non-Winter	Released	
4/4/2001	Keswick Trap	1837	W-092	Present	Female	822	Winter	Mortality	Prespawm Mortality
4/4/2001	Keswick Trap	1838	W-093	Absent	Female	762	Winter	Released	
4/4/2001	Keswick Trap	1839	W-094	Present	Female	782	Winter	Spawned	
4/4/2001	Keswick Trap	1840	W-095	Absent	Female	822	Winter	Released	
4/4/2001	Keswick Trap	1841	W-096	Absent	Male	761	Winter	Released	
4/4/2001	Keswick Trap	1842	W-097	Absent	Male	692	Winter	Released	
4/4/2001	Keswick Trap	1843	W-098	Absent	Male	754	Winter	Released	
4/4/2001	Keswick Trap	1844	W-099	Absent	Male	754	Winter	Released	
4/4/2001	Keswick Trap	1845	W-101	Absent	Female	595	Winter	Released	
4/4/2001	Keswick Trap	1846	W-102	Absent	Female	758	Winter	Released	
4/4/2001	Keswick Trap	1847	W-103	Absent	Male	823	Winter	Released	
4/4/2001	Keswick Trap	1848	W-104	Absent	Female	683	Winter	Released	
4/4/2001	Keswick Trap	1849	W-105	Absent	Female	760	Winter	Released	
4/4/2001	Keswick Trap	1850	W-106	Absent	Female	584	Winter	Released	
4/4/2001	Keswick Trap	1851	W-107	Absent	Male	809	Winter	Released	
4/11/2001	Keswick Trap	1852	W-108	Absent	Female	746	Winter	Released	
4/11/2001	Keswick Trap	1853	W-109	Absent	Female	731	Winter	Released	
4/11/2001	Keswick Trap	1854	W-110	Absent	Male	701	Winter	Released	
4/11/2001	Keswick Trap	1855	W-111	Present	Female	868	Non-Winter	Released	
4/18/2001	Keswick Trap	1856	W-112	Present	Male	900	Winter	Spawned	
4/18/2001	Keswick Trap	1857	O-11509	Absent	Male	770	Winter	Released	

Table 2 (cont.)

Identification numbers and biological data for tissue sampled Chinook salmon captured at the Keswick Dam fish trap (RM 302) and Red Bluff Diversion Dam (RBDD) (RM 243). Salmon with adipose fin-clips (ad-clip) were considered to be of hatchery origin. Salmon without adipose fin-clips were considered to be of natural origin. Coded-wire tag data were not available (N/A) for all marked salmon.

Date Captured	Location	Genetic ID	Floy Tag Number	Adipose Fin Status	Sex	Fork Length (mm)	Genetic Run	Final Disposition	Comments
4/18/2001	Keswick Trap	1858	O-11510	Absent	Female	724	Winter	Released	
4/18/2001	Keswick Trap	1859	O-11511	Absent	Female	783	Winter	Released	
4/18/2001	Keswick Trap	1860	O-11512	Absent	Female	708	Winter	Released	
4/18/2001	Keswick Trap	1861	O-11513	Absent	Male	712	Winter	Released	
4/18/2001	Keswick Trap	1862	O-11514	Absent	Male	782	Winter	Released	
4/25/2001	Keswick Trap	1863	W-0113	Absent	Female	657	Winter	Released	
5/2/2001	Keswick Trap	1864	O-11518	Absent	Male	723	Winter	Released	
5/2/2001	Keswick Trap	1865	O-11519	Absent	Female	796	Winter	Released	
5/2/2001	Keswick Trap	1866	W-114	Present	Male	578	Winter	Spawned	
5/8/2001	Keswick Trap	1867	W-115	Present	Male	553	Winter	Spawned	
5/8/2001	Keswick Trap	1868	W-116	Present	Male	819	Winter	Spawned	
5/8/2001	Keswick Trap	1869	W-117	Present	Female	776	Non-Winter	Released	
5/8/2001	Keswick Trap	1870	W-118	Absent	Male	688	Winter	Released	
5/8/2001	Keswick Trap	1871	W-119	Absent	Male	725	Winter	Released	
5/15/2001	Keswick Trap	1872	W-120	Present	Male	793	Winter	Spawned	
5/15/2001	Keswick Trap	1873	W-121	Present	Male	569	Winter	Spawned	
5/15/2001	Keswick Trap	1874	O-11520	Absent	Male	715	Winter	Released	
5/15/2001	Keswick Trap	1875	O-11523	Absent	Male	637	Winter	Released	
5/15/2001	Keswick Trap	1876	O-11522	Absent	Male	772	Winter	Released	
5/15/2001	Keswick Trap	1877		Present	Male	445	Winter	Spawned	
5/15/2001	Keswick Trap	1878	O-11528	Absent	Male	448	Winter	Released	
5/22/2001	RBDD Trap	1879	W-122	Present	Female	688	Non-Winter	Released	
5/23/2001	Keswick Trap	1880	O-11529	Absent	Male	853	Winter	Released	
5/23/2001	Keswick Trap	1881	W-123	Present	Female	643	Winter	Spawned	
5/23/2001	Keswick Trap	1882	O-11530	Absent	Male	561	Winter	Released	
5/23/2001	Keswick Trap	1883	O-11531	Absent	Male	571	Winter	Released	
5/23/2001	Keswick Trap	1884	W-124	Present	Female	761	Non-Winter	Released	
5/23/2001	Keswick Trap	1885	W-125	Present	Female	832	Winter	Spawned	
5/23/2001	Keswick Trap	1886	W-126	Present	Male	837	Winter	Spawned	
5/23/2001	Keswick Trap	1887	W-127	Present	Male	562	Winter	Spawned	

Table 2 (cont.)

Identification numbers and biological data for tissue sampled Chinook salmon captured at the Keswick Dam fish trap (RM 302) and Red Bluff Diversion Dam (RBDD) (RM 243). Salmon with adipose fin-clips (ad-clip) were considered to be of hatchery origin. Salmon without adipose fin-clips were considered to be of natural origin. Coded-wire tag data were not available (N/A) for all marked salmon.

Date Captured	Location	Genetic ID	Floy Tag Number	Adipose Fin Status	Sex	Fork Length (mm)	Genetic Run	Final Disposition	Comments
5/23/2001	Keswick Trap	1888	O-11532	Absent	Male	491	Winter	Released	
5/30/2001	Keswick Trap	1889	W-132	Present	Male	847	Winter	Spawned	
5/30/2001	Keswick Trap	1890	W-133	Present	Male	692	Non-Winter	Released	
5/30/2001	Keswick Trap	1891	W-134	Present	Male	842	Winter	Spawned	
5/30/2001	Keswick Trap	1892	W-135	Present	Male	872	Winter	Spawned	
5/30/2001	Keswick Trap	1893	W-136	Present	Female	932	Non-Winter	Sacrificed	Sacrificed for CWT Recovery
5/30/2001	Keswick Trap	1894	O-11533	Absent	Male	652	Winter	Released	
5/30/2001	Keswick Trap	1895	O-11534	Absent	Male	839	Winter	Released	
5/30/2001	Keswick Trap	1896	W-137	Present	Male	576	Winter	Spawned	
5/30/2001	Keswick Trap	1897	W-138	Present	Male	543	Winter	Spawned	
5/30/2001	Keswick Trap	1898	O-11535	Present	Male	510	Winter	Released	
5/30/2001	Keswick Trap	1899	O-11537	Present	Male	543	Winter	Released	
5/30/2001	Keswick Trap	1900	W-139	Present	Male	456	Non-Winter	Released	
5/30/2001	Keswick Trap	1901	O-11538	Present	Male	496	Winter	Released	
5/30/2001	Keswick Trap	1902	W-140	Present	Male	541	Winter	Mortality	Prespawm Mortality
5/30/2001	Keswick Trap	1903	O-11539	Present	Male	486	Winter	Released	
5/30/2001	Keswick Trap	1904	W-141	Present	Male	520	winter	Spawned	
5/30/2001	RBDD Trap	1905	W-128	Present	Female	693	Non-Winter	Released	
5/30/2001	RBDD Trap	1906	W-129	Present	Female	793	Non-Winter	Released	
5/30/2001	RBDD Trap	1907	W-130	Present	Female	675	Non-Winter	Released	
5/30/2001	RBDD Trap	1908	W-131	Present	Male	525	Winter	Spawned	
6/6/2001	RBDD Trap	1909	W-142	Present	Unknown	639	Non-Winter	Released	
6/6/2001	Keswick Trap	1910	O-11540	Absent	Male	790	Winter	Released	
6/6/2001	Keswick Trap	1911	W-146	Present	Female	822	Non-Winter	Released	
6/6/2001	Keswick Trap	1912	O-11541	Present	Male	751	Winter	Released	
6/6/2001	Keswick Trap	1913	W-147	Absent	Female	781	Winter	Spawned	
6/6/2001	Keswick Trap	1914	W-148	Absent	Female	710	Winter	Spawned	
6/6/2001	Keswick Trap	1915	W-149	Present	Female	740	Winter	Spawned	
6/6/2001	Keswick Trap	1916	W-150	Present	Female	720	Winter	Spawned	
6/6/2001	Keswick Trap	1917	O-11542	Absent	Male	862	Winter	Released	

Table 2 (cont.)

Identification numbers and biological data for tissue sampled Chinook salmon captured at the Keswick Dam fish trap (RM 302) and Red Bluff Diversion Dam (RBDD) (RM 243). Salmon with adipose fin-clips (ad-clip) were considered to be of hatchery origin. Salmon without adipose fin-clips were considered to be of natural origin. Coded-wire tag data were not available (N/A) for all marked salmon.

Date Captured	Location	Genetic ID	Floy Tag Number	Adipose Fin Status	Sex	Fork Length (mm)	Genetic Run	Final Disposition	Comments
6/6/2001	Keswick Trap	1918	O-11543	Absent	Male	902	Winter	Released	
6/6/2001	Keswick Trap	1919	W-151	Present	Female	691	No Call	Released	
6/6/2001	Keswick Trap	1920	O-11544	Absent	Male	862	Winter	Released	
6/6/2001	Keswick Trap	1921	W-152	Present	Female	722	Non-Winter	Released	
6/6/2001	Keswick Trap	1922	O-11545	Absent	Male	768	Winter	Released	
6/6/2001	Keswick Trap	1923	O-11546	Absent	Male	712	Winter	Released	
6/6/2001	Keswick Trap	1924	W-153	Absent	Female	755	Winter	Spawned	
6/6/2001	Keswick Trap	1925	W-154	Present	Female	721	Winter	Spawned	
6/6/2001	Keswick Trap	1926	O-11547	Absent	Male	722	Winter	Released	
6/6/2001	Keswick Trap	1927	O-11548	Absent	Female	708	Winter	Released	
6/6/2001	Keswick Trap	1928	O-11549	Absent	Female	702	Winter	Released	
6/6/2001	Keswick Trap	1929	W-155	Present	Male	802	Winter	Spawned	
6/6/2001	Keswick Trap	1930	W-156	Present	Female	731	Winter	Spawned	
6/6/2001	Keswick Trap	1931	O-115075	Present	Male	462	Winter	Released	
6/6/2001	Keswick Trap	1932	W-157	Present	Male	544	Winter	Spawned	
6/6/2001	Keswick Trap	1933	W-158	Present	Male	542	Winter	Spawned	
6/6/2001	Keswick Trap	1934	W-159	Present	Male	500	Winter	Spawned	
6/6/2001	Keswick Trap	1935	O-11576	Absent	Male	880	Winter	Released	
6/6/2001	Keswick Trap	1936	W-160	Absent	Female	738	Winter	Spawned	
6/6/2001	Keswick Trap	1937	O-11577	Absent	Female	758	Winter	Released	
6/6/2001	Keswick Trap	1938	O-11579	Present	Male	452	Non-Winter	Released	
6/6/2001	Keswick Trap	1939	O-11580	Absent	Male	470	Winter	Released	
6/6/2001	Keswick Trap	1940	W-161	Present	Male	511	Winter	Spawned	
6/6/2001	Keswick Trap	1941	W-162	Present	Male	683	NO CALL	Released	
6/6/2001	Keswick Trap	1942	O-11583	Absent	Male	752	Winter	Released	
6/6/2001	Keswick Trap	1943	O-11584	Absent	Female	722	Winter	Released	
6/6/2001	Keswick Trap	1944	O-11585	Present	Male	522	Winter	Released	
6/6/2001	Keswick Trap	1945	O-11586	Present	Male	488	Non-Winter	Released	
6/6/2001	Keswick Trap	1946	O-11587	Present	Male	477	Non-Winter	Released	
6/6/2001	Keswick Trap	1947	O-11588	Present	Male	462	Winter	Released	



Table 2 (cont.)

Identification numbers and biological data for tissue sampled Chinook salmon captured at the Keswick Dam fish trap (RM 302) and Red Bluff Diversion Dam (RBDD) (RM 243). Salmon with adipose fin-clips (ad-clip) were considered to be of hatchery origin. Salmon without adipose fin-clips were considered to be of natural origin. Coded-wire tag data were not available (N/A) for all marked salmon.

Date Captured	Location	Genetic ID	Floy Tag Number	Adipose Fin Status	Sex	Fork Length (mm)	Genetic Run	Final Disposition	Comments
6/6/2001	Keswick Trap	1948	O-11589	Present	Male	476	Winter	Released	
6/6/2001	RBDD Trap	1949	W-143	Present	Female	720	Winter	Spawned	
6/6/2001	RBDD Trap	1950	W-144	Present	Female	738	Winter	Spawned	
6/13/2001	Keswick Trap	1951	W-163	Present	Female	780	Winter	Spawned	
6/13/2001	Keswick Trap	1952	W-164	Present	Female	611	Winter	Spawned	
6/13/2001	Keswick Trap	1953	W-165	Present	Female	765	Winter	Spawned	
6/13/2001	Keswick Trap	1954	W-166	Present	Male	775	Winter	Spawned	
6/13/2001	Keswick Trap	1955	W-167	Present	Male	771	Winter	Spawned	
6/13/2001	Keswick Trap	1956	W-168	Present	Female	761	Winter	Spawned	
6/13/2001	Keswick Trap	1957	W-169	Present	Female	754	Winter	Spawned	
6/13/2001	Keswick Trap	1958	W-170	Present	Female	711	Winter	Spawned	
6/13/2001	Keswick Trap	1959	W-171	Present	Male	747	Winter	Spawned	
6/13/2001	Keswick Trap	1960	W-172	Present	Male	907	Winter	Spawned	
6/13/2001	Keswick Trap	1961	W-173	Present	Male	741	Winter	Spawned	
6/13/2001	Keswick Trap	1962	W-174	Present	Female	787	Winter	Spawned	
6/13/2001	Keswick Trap	1963	W-175	Present	Female	740	Winter	Spawned	
6/13/2001	Keswick Trap	1964	W-176	Present	Female	792	Winter	Spawned	
6/13/2001	Keswick Trap	1965	W-177	Present	Female	782	Winter	Spawned	
6/13/2001	Keswick Trap	1966	W-178	Present	Female	762	Winter	Spawned	
6/13/2001	Keswick Trap	1967	W-179	Present	Male	830	Winter	Spawned	
6/13/2001	Keswick Trap	1968	W-180	Present	Female	706	Winter	Spawned	
6/13/2001	Keswick Trap	1969	W-181	Present	Female	730	Winter	Spawned	
6/13/2001	Keswick Trap	1970	W-182	Present	Male	758	Winter	Spawned	
6/13/2001	Keswick Trap	1971	W-183	Present	Female	762	Winter	Spawned	
6/13/2001	Keswick Trap	1972	W-184	Present	Female	672	Non-Winter	Sacrificed	Sacrificed for CWT Recovery
6/13/2001	Keswick Trap	1973	W-185	Present	Male	850	Winter	Spawned	
6/13/2001	Keswick Trap	1974	W-186	Present	Female	770	Winter	Spawned	
6/13/2001	Keswick Trap	1975	W-187	Present	Male	698	Winter	Spawned	
6/13/2001	Keswick Trap	1976	W-188	Present	Female	746	Winter	Spawned	
6/13/2001	Keswick Trap	1977	W-189	Present	Female	692	Winter	Spawned	

Table 2 (cont.)

Identification numbers and biological data for tissue sampled Chinook salmon captured at the Keswick Dam fish trap (RM 302) and Red Bluff Diversion Dam (RBDD) (RM 243). Salmon with adipose fin-clips (ad-clip) were considered to be of hatchery origin. Salmon without adipose fin-clips were considered to be of natural origin. Coded-wire tag data were not available (N/A) for all marked salmon.

Date Captured	Location	Genetic ID	Floy Tag Number	Adipose Fin Status	Sex	Fork Length (mm)	Genetic Run	Final Disposition	Comments
6/13/2001	Keswick Trap	1978	W-190	Present	Male	807	Winter	Spawned	
6/13/2001	Keswick Trap	1979	W-191	Present	Female	743	Winter	Spawned	
6/13/2001	Keswick Trap	1980	W-193	Absent	Male	748	Winter	Spawned	
6/13/2001	Keswick Trap	1981	W-194	Present	Female	690	Winter	Spawned	
6/13/2001	Keswick Trap	1982	W-195	Present	Male	790	Winter	Spawned	
6/13/2001	Keswick Trap	1983	W-196	Present	Female	777	Winter	Spawned	
6/13/2001	Keswick Trap	1984	W-197	Present	Male	909	Winter	Spawned	
6/13/2001	Keswick Trap	1985	W-198	Present	Female	739	Winter	Spawned	
6/13/2001	Keswick Trap	1986	W-199	Present	Female	784	Winter	Spawned	
6/13/2001	Keswick Trap	1987	W-200	Present	Female	771	Winter	Spawned	
6/13/2001	Keswick Trap	1988	OR-202	Present	Female	690	Winter	Spawned	
6/13/2001	Keswick Trap	1989	OR-203	Present	Male	566	Winter	Spawned	
6/13/2001	Keswick Trap	1990	OR-204	Present	Male	837	Winter	Spawned	
6/13/2001	Keswick Trap	1991	OR-205	Present	Female	691	Winter	Spawned	
6/13/2001	Keswick Trap	1992	OR-206	Present	Male	738	Non-Winter	Released	
6/13/2001	Keswick Trap	1993	OR-207	Present	Male	591	Winter	Spawned	
6/13/2001	Keswick Trap	1994	OR-208	Present	Male	546	Winter	Spawned	
6/13/2001	Keswick Trap	1995	OR-209	Present	Male	533	Winter	Spawned	
6/13/2001	Keswick Trap	1996	OR-210	Present	Male	530	Winter	Spawned	
6/13/2001	Keswick Trap	1997	OR-211	Absent	Female	730	Winter	Spawned	
6/13/2001	Keswick Trap	1998	OR-212	Absent	Male	838	Winter	Spawned	
6/13/2001	Keswick Trap	1999	OR-213	Absent	Male	560	Winter	Released	
6/13/2001	Keswick Trap	2000	OR-214	Absent	Male	795	Winter	Released	
6/13/2001	Keswick Trap	2001	OR-215	Absent	Male	711	Winter	Spawned	
6/13/2001	Keswick Trap	2002	O-11590	Present	Male	500	Winter	Released	
6/13/2001	Keswick Trap	2003	O-11591	Absent	Male	485	Winter	Released	
6/13/2001	Keswick Trap	2004	O-11592	Present	Male	532	Winter	Released	
6/13/2001	Keswick Trap	2005	O-11593	Present	Male	490	Winter	Released	
6/13/2001	Keswick Trap	2006	O-11594	Absent	Male	525	Winter	Released	
6/13/2001	Keswick Trap	2007	O-11595	Present	Male	0	Winter	Released	

Table 2 (cont.)

Identification numbers and biological data for tissue sampled Chinook salmon captured at the Keswick Dam fish trap (RM 302) and Red Bluff Diversion Dam (RBDD) (RM 243). Salmon with adipose fin-clips (ad-clip) were considered to be of hatchery origin. Salmon without adipose fin-clips were considered to be of natural origin. Coded-wire tag data were not available (N/A) for all marked salmon.

Date Captured	Location	Genetic ID	Floy Tag Number	Adipose Fin Status	Sex	Fork Length (mm)	Genetic Run	Final Disposition	Comments
6/13/2001	Keswick Trap	2008	O-11596	Present	Male	480	Winter	Released	
6/13/2001	Keswick Trap	2009	O-11597	Present	Male	805	Winter	Released	
6/13/2001	Keswick Trap	2010	O-11598	Absent	Female	770	Winter	Released	
6/13/2001	Keswick Trap	2011	O-11599	Absent	Female	0	Winter	Released	
6/13/2001	Keswick Trap	2012	O-11457	Absent	Female	830	Winter	Released	
6/13/2001	Keswick Trap	2013	O-11458	Present	Female	675	Non-Winter	Released	
6/13/2001	Keswick Trap	2014	O-11459	Absent	Male	732	Winter	Released	
6/13/2001	Keswick Trap	2015	O-11461	Absent	Male	650	Winter	Released	
6/13/2001	Keswick Trap	2016	O-11462	Present	Male	545	Non-Winter	Released	
6/13/2001	Keswick Trap	2017	O-11464	Absent	Female	660	Winter	Released	
6/13/2001	Keswick Trap	2018	O-11466	Absent	Female	720	Winter	Released	
6/13/2001	Keswick Trap	2019		Absent	Female	795	Winter	Mortality	Found Dead in Trap
6/13/2001	Keswick Trap	2020		Absent	Male	720	Winter	Mortality	Died in Truck during Transit
7/2/2001	Keswick Trap	2021	OR-218	Present	Female	660	Winter	Spawned	
7/2/2001	Keswick Trap	2022	OR-219	Present	Female	813	Non-Winter	Released	
7/2/2001	Keswick Trap	2023	OR-220	Present	Female	730	Winter	Spawned	
7/2/2001	Keswick Trap	2024	OR-221	Present	Female	676	Winter	Spawned	
7/2/2001	Keswick Trap	2025	OR-222	Absent	Female	657	Winter	Spawned	
7/2/2001	Keswick Trap	2026	OR-223	Present	Female	845	Winter	Spawned	
7/2/2001	Keswick Trap	2027	OR-224	Present	Female	741	Winter	Spawned	
7/2/2001	Keswick Trap	2028	OR-225	Present	Male	557	Winter	Spawned	
7/2/2001	Keswick Trap	2029	OR-226	Present	Male	530	Winter	Spawned	
7/2/2001	Keswick Trap	2030	OR-04050	Absent	Male	498	Winter	Released	
7/2/2001	Keswick Trap	2031	OR-229	Present	Female	605	Winter	Spawned	
7/2/2001	Keswick Trap	2032	OR-227	Present	Male	565	Winter	Spawned	
7/2/2001	Keswick Trap	2033	OR-228	Present	Female	728	Winter	Spawned	
7/2/2001	Keswick Trap	2034	OR-230	Present	Female	676	Winter	Spawned	
7/2/2001	Keswick Trap	2035	OR-231	Present	Female	825	Winter	Spawned	
7/2/2001	Keswick Trap	2036	OR-232	Absent	Male	780	Winter	Spawned	
7/2/2001	Keswick Trap	2037	RED-04051	Present	Male	690	Non-Winter	Released	
7/2/2001	Keswick Trap	2038	RED-04052	Present	Female	698	Non-Winter	Released	

## Fish Health Maintenance and Monitoring

Various therapeutic and prophylactic treatments were used on winter Chinook salmon broodstock to increase survival of adults and reduce risks of disease transmission to offspring (Table 3). Additionally, salt, Poly Aqua, and anesthetics were used to reduce effects of stress on broodstock. The application of drugs followed the “Unapproved Drugs for Use on Threatened and Endangered Fish Species” guidelines from the Food and Drug Administration (FDA 2696). Hatchery personnel and staff from the California-Nevada Fish Health Center (CA-NV FCH) closely monitored fish health.

Phenotypic winter Chinook salmon captured at Keswick or the Red Bluff Diversion Dam fish trap were transported directly to the Livingston Stone NFH using transport vehicles equipped with either a 1,200 or 1,600 gallon aerated and insulated transport tank. Upon arrival at the Livingston Stone NFH, most of the water was drained from the transport tank and CO<sub>2</sub> was infused into the water to anaesthetize collected fish during sorting, tagging and fin-tissue collection. Quarantined fish were initially held in one of the 20-foot circular tanks at Livingston Stone NFH. No chemical treatments were administered to fish while held in quarantine. Genetically identified winter Chinook salmon were then moved into the 20-foot circular adult holding tanks. Fish returned to the river were not subjected to chemical treatments.

All genetically identified winter Chinook salmon retained for use as broodstock were treated with malachite green to reduce or eliminate fungal infections. A total of 663 g of malachite green was used for 34 treatments in 2001. Based on previous mortality rates of winter Chinook in untreated holding ponds at the Coleman NFH, treatments with malachite green appeared to be effective in reducing the number of fungus-related deaths (when fish did not arrive heavily infected). In 2001, no deaths were attributed to fungal infection.

The CA-NV FHC tested 81 winter Chinook adults for *Renibacterium salmoninarum* (the organism responsible for bacterial kidney disease) using an enzyme-linked immunosorbent assay (ELISA). The results indicated suspected *R. salmoninarum* infection in 11 of 81 (13.6%) of the salmon tested while the remaining 70 tested negative for the bacteria. Adults were given injections of erythromycin in the dorsal sinus at a target dosage of 20 mg/kg to help prevent vertical transmission of *R. salmoninarum*. Females were targeted for treatment; however, salmon of unknown sex were treated as well. Twenty seven of the 50 females spawned received one to four injections with at least fourteen days between injections (Table 4). The remaining 23 females were in captivity for less than 12 days before they were spawned. No males received an erythromycin injection.

Luteinizing Hormone - Releasing Hormone analogue (LH-RH<sub>a</sub>) was administered in 2001 to accelerate final gamete maturation in fish that had already undergone gametogenesis. Similar to previous years, LH-RH<sub>a</sub> implants were used to synchronize maturation of broodstock. These implants release 30% of their content in the first three days after injection and the remaining hormone over a 20-day period to sustain an effective concentration within the fish. The implant dosage was 150 or 250 µg (supplied by Syndel International Inc.). Implants were injected into the dorsal muscle lateral and anterior to the dorsal fin with the use of a Ralgro pellet injector.

Fifteen fish were given LH-RH<sub>a</sub> therapy from May 3 through July 5 (all females). The fish all reached sexual maturation in an average of 9 days post-injection (range 4 to 33 days)

### Prespawning Mortality

Three of 100 adults (3.00%) died prior to spawning. Prespawning mortality for brood years 1999 and 2000 was 4.17% and 8.24%, respectively. Adults that died prior to spawning are identified in the comments field of Table 4, and/or the disposition field of Table 2.

Table 3 Drugs and treatments that may be applied to maintain health of winter Chinook salmon at Livingston Stone National Fish Hatchery.

Type	Dosage	Method	Application
erythromycin	20 mg/kg	dorsal sinus injection	antibacterial
iodophor	75 ppm	bath	antibacterial
malachite green	1 ppm	bath	antifungal
formalin	167 ppm	flow through	antifungal
MS-222		bath	anesthetic
vibrio spp. vaccine		bath	vaccination against salt-water vibrio spp.
Poly Aqua	1 qt/1,200 gallons	bath/flow through	stress reducer
salt		bath/flow through	stress reducer
Chloramine-T	15 ppm	Bath	antibacterial

Table 4 Spawning and drug treatment history for female winter Chinook salmon held for spawning at Livingston Stone National Fish Hatchery in 2001.

Genetic ID	Date		length (mm)	Weight (lbs)	Date Spawmed	Date of death	Days in Captivity	Erythromycin <sup>1</sup>		LH-RHa <sup>2</sup>		Number of MG <sup>3</sup>	Comments
	Captured	Location						Dose (mls)	Injections	Dose (µg)	Injections		
01-1913	6/6/01	KESWICK	781	12.0	6/28/01	6/28/01	21	0.6	1			5	
01-1914	6/6/01	KESWICK	710	9.9	6/7/01	6/7/01	0						
01-1915	6/6/01	KESWICK	740	11.5	6/7/01	6/7/01	0						
01-1916	6/6/01	KESWICK	720	10.5	7/9/01	7/9/01	32	0.5	1			8	
01-1924	6/6/01	KESWICK	755	12.9	6/7/01	6/7/01	0						
01-1925	6/6/01	KESWICK	721	9.4	7/12/01	7/12/01	35	0.5	1	150	1	8	
01-1930	6/6/01	KESWICK	731	10.5	6/19/01	6/19/01	12			250	1	2	
01-1936	6/6/01	KESWICK	738	9.6	7/12/01	7/12/01	35	0.5	1	250	1	8	
01-1949	6/6/01	RBDD	720	10.4	7/5/01	7/5/01	28	0.5	1	250	1	7	
01-1950	6/6/01	RBDD	738	11.2	6/28/01	6/28/01	21	0.5	1			5	
01-1951	6/13/01	KESWICK	780	12.3	6/14/01	6/14/01	0						
01-1952	6/13/01	KESWICK	611	7.2	6/19/01	6/19/01	5						
01-1953	6/13/01	KESWICK	765	12.8	6/14/01	6/14/01	0						
01-1956	6/13/01	KESWICK	761	12.3	6/28/01	6/28/01	14	0.6	1			3	
01-1957	6/13/01	KESWICK	754	12.5	6/28/01	6/28/01	14	0.6	1	250	1	3	
01-1958	6/13/01	KESWICK	711	10.6	6/19/01	6/19/01	5						
01-1962	6/13/01	KESWICK	787	14.6	7/12/01	7/12/01	28	0.6	1	250	1	6	
01-1963	6/13/01	KESWICK	740	10.4	6/19/01	6/19/01	5						
01-1964	6/13/01	KESWICK	792	14.2	6/25/01	6/25/01	11	0.6	1			2	
01-1965	6/13/01	KESWICK	782	14.3	6/14/01	6/14/01	0						
01-1966	6/13/01	KESWICK	762	12.2	6/28/01	6/28/01	14	0.6	1			3	
01-1968	6/13/01	KESWICK	706	7.6	7/5/01	7/5/01	21	0.5	1	250/150	1/1	5	
01-1969	6/13/01	KESWICK	730	11.1	7/2/01	7/2/01	18	0.5	1			4	
01-1971	6/13/01	KESWICK	762	12.8	6/25/01	6/25/01	11	0.6	1	250	1	2	
01-1974	6/13/01	KESWICK	770	13.9	6/28/01	6/28/01	14	0.6	1			3	
01-1976	6/13/01	KESWICK	746	12.2	6/28/01	6/28/01	14	0.6	1			3	
01-1977	6/13/01	KESWICK	692	10.2	6/14/01	6/14/01	0						
01-1979	6/13/01	KESWICK	743	11.2	7/9/01	7/9/01	25	0.5	1	250	1	6	
01-1981	6/13/01	KESWICK	690	9.4	7/2/01	7/2/01	18	0.5	1	250	1	4	
01-1983	6/13/01	KESWICK	777	12.0	6/25/01	6/25/01	11					2	
01-1985	6/13/01	KESWICK	739	12.2	6/19/01	6/19/01	5						

1 Erythromycin dose was based on 20 mg/kg.

2 LH-RHa = Luteinizing Hormone - Releasing Hormone analogue. Each capsule contained either 250 or 150 µg.

3 MG = Malachite green. Fish were immersed in a 1 ppm bath.

Table 4 (cont.) Spawning and drug treatment history for female winter Chinook salmon held for spawning at Livingston Stone National Fish Hatchery in 2001.

Genetic ID	Date		length (mm)	Weight (lbs)	Date Spawmed	Date of death	Days in Captivity	Erythromycin <sup>1</sup>		LH-RHa <sup>2</sup>		Number of MG <sup>3</sup>	Comments
	Captured	Location						Dose (mls)	Injections	Dose (µg)	Injections		
01-1986	6/13/01	KESWICK	784	15.4	6/25/01	6/25/01	11	0.6	1			2	
01-1987	6/13/01	KESWICK	771	11.9	6/25/01	6/25/01	11	0.5	1			2	
01-1988	6/13/01	KESWICK	690	9.2	6/28/01	6/28/01	14	0.5	1			3	
01-1991	6/13/01	KESWICK	691	10.2	6/21/01	6/21/01	7	0.5	1			1	
01-1997	6/13/01	KESWICK	730	10.7	7/9/01	7/9/01	25	0.5	1	250	1	6	
01-2021	7/2/01	KESWICK	660	13.6	7/9/01	7/9/01	6						
01-2023	7/2/01	KESWICK	730	10.8	7/9/01	7/9/01	6						
01-2024	7/2/01	KESWICK	676	8.9	7/12/01	7/12/01	9						
01-2025	7/2/01	KESWICK	657	7.3	7/12/01	7/12/01	9						
01-2026	7/2/01	KESWICK	845	16.8	7/12/01	7/12/01	9						
01-2027	7/2/01	KESWICK	741	17.2	7/9/01	7/9/01	6						
01-2031	7/2/01	KESWICK	605	6.0	7/2/01	7/2/01	0						
01-2033	7/2/01	KESWICK	728	15.1	7/9/01	7/9/01	6						
01-2034	7/2/01	KESWICK	676	9.2	7/2/01	7/2/01	0						
01-2035	7/2/01	KESWICK	825	21.4	7/9/01	7/9/01	6						
01-1810	3/14/01	KESWICK	772	11.8	6/14/01	6/14/01	91	0.6	1			24	
01-1837	4/4/01	KESWICK	822	22.1	n/a	4/12/01	7					6	Prespaw Mortality
01-1839	4/4/01	KESWICK	782	13.2	6/5/01	6/5/01	61	0.6	1	250	2	14	
01-1881	5/23/01	KESWICK	643	8.5	6/5/01	6/5/01	12	0.5	1	250	1	2	
01-1885	5/23/01	KESWICK	832	16.5	6/19/01	6/19/01	26	0.6	1	250	1	6	

1 Erythromycin dose was based on 20 mg/kg.

2 LH-RHa = Luteinizing Hormone - Releasing Hormone analogue. Each capsule contained either 250 or 150 µg.

3 MG = Malachite green. Fish were immersed in a 1 ppm bath.

Table 5 Spawning and drug treatment history for male winter Chinook salmon held for spawning at Livingston Stone National Fish Hatchery in 2001.

Genetic ID	Date Captured	Location	length (mm)	Weight (lbs)	Date Spawmed	Date of death	Days in Captivity	Erythromycin <sup>1</sup>		LH-RHa <sup>2</sup>		Number of MG <sup>3</sup>	Comments
								Dose (mls)	Injections	Dose (µg)	Injections		
01-1902	5/30/01	KESWICK	541	4.1		6/25/01	25					6	Prespawn Mortality
01-1904	5/30/01	KESWICK	520	3.5	6/14/01	6/25/01	25					6	
01-1908	5/30/01	RBDD	525	3.96	6/9/01 6/28/01	7/5/01	35					8	
01-1929	6/6/01	KESWICK	802	12.1	6/11/01 6/14/01	6/21/01	14					3	
01-1932	6/6/01	KESWICK	544	4.5	7/9/01 7/9/01	7/10/01	33					8	
01-1933	6/6/01	KESWICK	542	3.2	6/21/01 6/21/01	6/25/01	18					4	
01-1934	6/6/01	KESWICK	500	3.7	6/25/01 6/28/01	7/5/01	28					6	
01-1940	6/6/01	KESWICK	511	3.8	6/19/01	6/25/01	18					4	
01-1954	6/13/01	KESWICK	775	12.2	7/12/01 7/12/01	7/17/01	33					7	
01-1955	6/13/01	KESWICK	771	11.4	6/19/01 6/19/01	6/25/01	11					2	
01-1959	6/13/01	KESWICK	747	13.5	6/28/02 6/28/01 7/9/01	7/16/01	32					7	
01-1960	6/13/01	KESWICK	907	19.6	6/19/01 6/19/01 7/2/02	7/2/01	18					4	
01-1961	6/13/01	KESWICK	741	12	6/28/01 6/28/01 7/9/01	7/16/01	32					7	
01-1967	6/13/01	KESWICK	830	14.2	7/9/01 7/12/01	7/16/01	32					7	

1 Erythromycin dose was based on 20 mg/kg.

2 LH-RHa = Luteinizing Hormone - Releasing Hormone analogue. Each capsule contained either 250 or 150 µg.

3 MG = Malachite green. Fish were immersed in a 1 ppm bath.



Table 5 (cont.) Spawning and drug treatment history for male winter Chinook salmon held for spawning at Livingston Stone National Fish Hatchery in 2001.

Genetic ID	Date Captured	Location	length (mm)	Weight (lbs)	Date Spawmed	Date of death	Days in Captivity	Erythromycin <sup>1</sup>		LH-RHa <sup>2</sup>		Number of MG <sup>3</sup>	Comments
								Dose (mls)	Injections	Dose (µg)	Injections		
01-1970	6/13/01	KESWICK	758	12.4	7/2/01	7/10/01	26					6	
					7/2/01								
					7/9/01								
01-1973	6/13/01	KESWICK	850	16.5	7/9/01	7/16/01	32					7	
					7/9/01								
01-1975	6/13/01	KESWICK	698	9.6	7/9/01	7/12/01	28					6	
					7/9/01								
01-1978	6/13/01	KESWICK	807	15.4	6/28/01	7/9/01	25					6	
					7/5/01								
01-1980	6/13/01	KESWICK	748	12.8	6/25/01	7/9/01	25					6	
					6/25/01								
01-1982	6/13/01	KESWICK	790	2.75	6/28/01	7/9/01	25					6	
					7/2/01								
					7/5/01								
01-1984	6/13/01	KESWICK	909	19.1	6/28/01	7/17/01	33					7	
					7/9/01								
					7/12/01								
01-1989	6/13/01	KESWICK	566	5.6	6/28/01	7/5/01	21					4	
					7/2/01								
01-1990	6/13/01	KESWICK	837	14.5	7/5/01	7/16/01	32					7	
					7/9/01								
					7/9/01								
01-1993	6/13/01	KESWICK	591	5.6	6/28/01	7/6/01	22					5	
					6/28/01								
01-1994	6/13/01	KESWICK	546	4.3	7/2/01	7/3/01	19					4	
					7/2/01								
01-1995	6/13/01	KESWICK	533	4.0	6/19/01	6/21/01	7					1	
					6/19/01								
01-1996	6/13/01	KESWICK	530	3.3	6/21/01	6/25/01	11					2	
					6/21/01								

1 Erythromycin dose was based on 20 mg/kg.

2 LH-RHa = Luteinizing Hormone - Releasing Hormone analogue. Each capsule contained either 250 or 150 µg.

3 MG = Malachite green. Fish were immersed in a 1 ppm bath.

Table 5 (cont.) Spawning and drug treatment history for male winter Chinook salmon held for spawning at Livingston Stone National Fish Hatchery in 2001.

Genetic ID	Date Captured	Location	length (mm)	Weight (lbs)	Date Spawmed	Date of death	Days in Captivity	Erythromycin <sup>1</sup>		LH-RHa <sup>2</sup>		Number of MG <sup>3</sup>	Comments
								Dose (mls)	Injections	Dose (µg)	Injections		
01-1998	6/13/01	KESWICK	838	15.7	6/25/01	7/9/01	25					6	
01-2001	6/13/01	KESWICK	711	9.4	6/25/01	7/9/01	25					6	
01-2028	7/2/01	KESWICK	557	4.8	6/28/01	7/9/01	14					2	
01-2029	7/2/01	KESWICK	530	4	7/12/01	7/17/01	14					2	
01-2032	7/2/01	KESWICK	565	4.7	7/12/01	7/17/01	14					2	
01-2036	7/2/01	KESWICK	780	10.6	7/12/01	7/12/01	9					0	
01-1804	3/7/01	KESWICK	757	13.0		5/21/01	74					18	Prespaw Mortality
01-1835	3/28/01	KESWICK	965	27.5	6/5/01	5/21/01	53					13	
01-1856	4/18/01	KESWICK	900	19.0	6/5/01	5/24/01	35					8	
01-1866	5/2/01	KESWICK	578	5.6	6/19/01	7/9/01	67					18	
01-1867	5/8/01	KESWICK	553	4.5	6/28/01	6/21/01	43					11	
01-1868	5/8/01	KESWICK	819	14.2	6/14/01	6/19/01	41					10	
01-1872	5/15/01	KESWICK	793	14.4	6/19/01	6/14/01							
01-1873	5/15/01	KESWICK	569	5.1	6/14/01	6/28/01	43					10	
01-1877	5/15/01	KESWICK	445	2.4	6/14/01	6/10/01	25					7	
					7/9/01	7/16/01	61					16	
					7/12/01								

1 Erythromycin dose was based on 20 mg/kg.

2 LH-RHa = Luteinizing Hormone - Releasing Hormone analogue. Each capsule contained either 250 or 150 µg.

3 MG = Malachite green. Fish were immersed in a 1 ppm bath.

Table 5 (cont.) Spawning and drug treatment history for male winter Chinook salmon held for spawning at Livingston Stone National Fish Hatchery in 2001.

Genetic ID	Date Captured	Location	length (mm)	Weight (lbs)	Date Spawmed	Date of death	Days in Captivity	Erythromycin <sup>1</sup>		LH-RHa <sup>2</sup>		Number of MG <sup>3</sup>	Comments
								Dose (mls)	Injections	Dose (µg)	Injections		
01-1886	5/23/01	KESWICK	837	15.3	6/5/01	6/21/01	28					7	
					6/11/01								
					6/14/01								
01-1887	5/23/01	KESWICK	562	4.2	6/5/01	6/13/01	20					4	
01-1889	5/30/01	KESWICK	847	15.6	6/7/01	6/19/01	19					4	
					6/14/01								
01-1891	5/30/01	KESWICK	842	16.8	6/25/01	6/28/01	28					7	
					6/25/01								
01-1892	5/30/01	KESWICK	872	19.8	6/7/01	6/19/01	19					4	
					6/11/01								
					6/14/01								
01-1896	5/30/01	KESWICK	576	5.7	6/14/01	6/28/01	28					7	
					6/25/01								
01-1897	5/30/01	KESWICK	543	4.22	6/28/01	7/9/01	39					10	
					7/9/01								

1 Erythromycin dose was based on 20 mg/kg.

2 LH-RHa = Luteinizing Hormone - Releasing Hormone analogue. Each capsule contained either 250 or 150 µg.

3 MG = Malachite green. Fish were immersed in a 1 ppm bath.

# Spawning

## **Adults Collected at Keswick and RBDD**

When genetic analysis indicated that a quarantined fish was a winter Chinook salmon, the fish was transferred to the holding tank where it was held until ripe for spawning. Winter Chinook were examined twice weekly to assess their state of sexual maturity. To assess sexual maturity of salmon in the holding tank, several salmon were crowded into a pie-shaped containment area using a hinged crowder consisting of two solid vinyl-covered screens. Tricane methanesulfonate (MS-222) was added to anaesthetize the fish so they could be examined for maturity and overall fish health. When a female salmon was identified as being sexually mature, it was sacrificed with a blow to the head, removed from the tank and rinsed in fresh water to remove any remaining MS-222. Each female was assigned a number and each male was assigned a letter. The caudal artery of females was severed so that blood would not mix into the eggs. The eggs were removed by making an incision from the vent to the pectoral fin. Eggs were separated into two approximately equal groups when possible, and each group was fertilized with semen from a different male, forming two half-sibling family groups. For example, when female 1 was spawned with males A and B, “family group” 1A and 1B were created. After mixing the sperm and eggs, tris-glycine buffer was added to extend sperm life and motility. Spawned males were either returned to the holding tank for additional spawning or sacrificed. Males were used a maximum of four times, then sacrificed. Each fish, if possible, was spawned with at least two others for two reasons: 1) to increase the genetic diversity of offspring, and 2) to prevent losing all of the gametes from a spawner if the other spawner did not have viable gametes.

Naturally reproducing winter Chinook typically spawn between April and early August, peaking near the end of May and the beginning of June (Vogel and Marine 1991). In 2001, hatchery spawning of winter Chinook salmon occurred between June 5 and July 12 (Figure 2) which is later than in previous years. However, the hatchery spawn-timing did correspond to the observed spawn timing of natural-spawning winter Chinook as indicated by the upper Sacramento River aerial redd surveys conducted by the CDFG. 2001 survey data indicated that winter Chinook spawning in the upper Sacramento River peaked in mid to late June (Doug Killam CDFG, personal communication).

A total of 50 female (Table 4) and 47 male (Table 5) winter Chinook salmon were spawned in 2001 producing 101 family groups (Table 6). Females produced an average of 4,737 eggs (SD 923) yielding a total collection of over 236,000 eggs. Lengths of spawned females ranged from 605 to 845 mm (fork length) and averaged 738 mm (SD 52 mm). Lengths of spawned males ranged from 445 to 965 mm and averaged 691 mm (SD 145 mm).

## **Captive Broodstock**

### *Captive-origin x Natural-origin crosses*

In 2001, the Service, and its partners (BML and partner agencies of the Winter Chinook Captive Brood Stock Technical Committee) began a multi-year investigation to evaluate the ability of the winter Chinook captive broodstock program to potentially contribute to the recovery of winter Chinook salmon. The goal of the study is to determine if juveniles produced from captive-origin females return as adults to the mainstem of the Sacramento River and integrate into the naturally

spawning population. Further, the study will assess the efficacy of the winter Chinook captive broodstock program to serve as “insurance” against extinction by evaluating the relative rates of contribution for progeny of captive-origin and naturally produced females.

During this study, captive-origin females will be mated with naturally produced males collected at Keswick to produce captive x natural juveniles. During the first three years of the investigation captive broodstock females will come from the BML and during the last three years of the study captive-origin females will come from the captive population at the Livingston Stone NFH. Captive x natural juveniles will be given a unique coded-wire tag code and released at the same time and location as the winter Chinook production group (e.g., natural x natural). 2001 marked the first year that juveniles were released for the purposes of this study. Evaluation of the relative rates of contribution by captive- and natural-origin study groups will be based on recovery of coded-wire tags from adults returning to the Sacramento River. For a more detailed description of the release study objectives and methodologies, see the study plan in attachment C.

Captive-origin females from BML were spawned with natural-origin males at Livingston Stone NFH July 3 through 31 (Table 7). A total of 100 captive-origin female and 32 natural-origin male (Table 7) winter Chinook salmon were spawned in 2001 producing 100 family groups (Table 7). Females produced an average of 1,060 eggs (SD 332) yielding a total collection of over 105,000 eggs. Lengths of spawned females ranged from 335 to 492 mm (fork length) and averaged 407 mm (SD 32 mm). Lengths of spawned males ranged from 445 to 909 mm and averaged 672 mm (SD 143 mm).

#### *Captive-origin x Captive-origin crosses*

In order to evaluate maturation rates of captive winter Chinook salmon reared entirely in fresh water and to estimate fecundity and gamete viability of these fish, captive-origin females were spawned with captive-origin males (both from LSNFH) July 31 through August 21 (Table 8). A total of 37 captive-origin female and 37 captive-origin male winter Chinook were spawned producing 37 family groups (Table 8). Females produced an average of 1,732 eggs (SD 422) yielding a total collection of over 64,000 eggs. Lengths of C x C broodstock are unavailable.

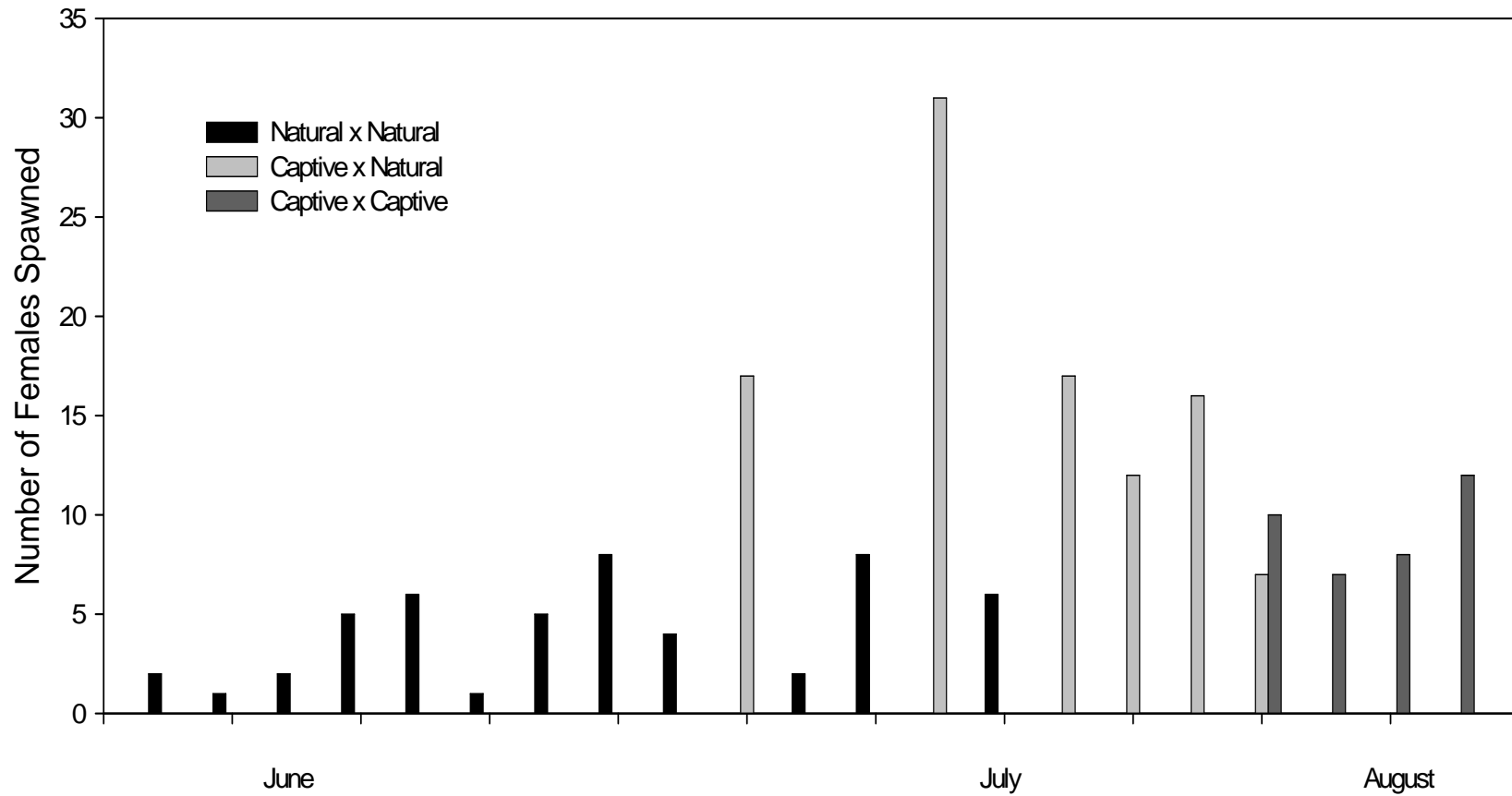


Figure 2 Spawning of winter Chinook salmon at Livingston Stone National Fish Hatchery, June 5 through August 21, 2001. Bars correspond to numbers of females spawned per day.

## Incubation and Rearing

### *Prophylactic and therapeutic treatment of eggs*

After fertilization, winter Chinook eggs were placed in Heath incubator trays and disinfected with 75 parts per million (ppm) iodophor bath for 15 minutes. To help prevent excessive fungus, incubating eggs were treated twice a week with 1,400 ppm formalin for 15 minutes as a flow-through treatment. Initial water flow in the incubator trays was four gallons per minute (gpm) and later increased to six gpm at eye-up. After eye-up, eggs were shocked and non-viable eggs were removed. Formalin treatments were discontinued once eggs had hatched. Sac fry were left in the incubator trays until button-up, at which time they were transferred to 30-inch diameter (10.2 cubic foot) circular tanks and started on commercial feed.

### *Progeny of Natural-origin x Natural-origin crosses*

Matings of N x N fish at LSNFH produced 225,845 eyed-eggs. Percent eye-up ranged from 0.0% to 99.7%, averaging 94.7% (SD 14%) across family groups (Table 6).

### *Progeny of Captive-origin x Natural-origin crosses*

Matings of C x N fish at LSNFH for the release study produced 105,958 eyed-eggs. Percent eye-up ranged from 0.0% to 98.7%, averaging 77.8% (SD 23%) across family groups (Table 7).

### *Progeny of Captive-origin x Captive-origin crosses*

Matings of C x C fish at LSNFH produced 57,227 eyed-eggs. Percent eye-up ranged from 5.0% to 99.2%, averaging 89.3% (SD 20%) across family groups (Table 8).

## Juvenile Rearing

Initial feeding began on July 12, 2000 using Bio-Oregon's starter #1, then #2, and finally #3. *Artemia nauplii* (Cyclop-eeze™ from Argent Chemical Laboratories) were added to increase interest in the feed. At approximately 500 fish to the pound the diet was changed to BioOregon's Biodiet grower (BDG) 1.3 mm pellets and at 250 to the pound BDG 1.5 mm pellets. The fish remained on BDG 1.5 mm pellets until release. Feeding rates were determined using the Bio-Oregon's feeding guidelines. This method determines the appropriate percent body weight to feed based on average monthly water temperatures.

### *Natural-origin x natural-origin crosses*

The small circular tanks and the Zeilger 12-hour belt feeders provided an excellent environment for starting and separating small groups of fish. A total of 1644.3 pounds (lbs.) of feed was used resulting in a total weight gain of 2027.3 pounds between July 12 and release on January 30. This provided a feed conversion (food fed/weight gain) of 0.81. For N x N crosses, the overall average length increase was 1.864 inches (47.3 mm). Growth was at it greatest in January with an average length increase of 0.503 inches (12.8 mm), and at its smallest in December at 0.353 inches (9.0 mm)<sup>1</sup>.

---

<sup>1</sup> Length increase reported for January excludes fish held for the captive broodstock program

*Captive-origin x natural-origin crosses*

A total of 499.6 pounds (lbs.) of feed was used resulting in a total weight gain of 593.7 pounds between July 12 and release on January 30. This provided a feed conversion of 0.84. For C x C crosses, the overall average length increase was 1.743 inches (44.2 mm). Growth was at its greatest in January with an average length increase of 0.649 inches (16.5 mm), and at its smallest in December at 0.317 inches (8.1 mm).

*Tanking*

Juvenile winter Chinook salmon were tanked according to family group combinations. This year, with 101 different natural-origin family groups, the 60 small circular tanks at Livingston Stone NFH were insufficient to maintain all family groups separately throughout the entire duration of hatchery rearing. As in previous years when this occurred, several family groups were combined, and some family group combinations were moved to larger tanks before optimal densities were achieved. The 101 original N x N family groups were eventually combined to form 28 distinct group combinations that were held separately until release. All progeny from C x N matings were held separately.



Table 6 Family groups, date spawned, egg counts, and number tanked for brood year 2001 N x N winter Chinook salmon spawned at Livingston Stone NFH.

Crosses (by floy tag number)		Family group	Date spawned	Number of		Percent eye-up	Number hatched	Percent hatched	Number tanked	Precent tanked from eyed eggs
Female	Male			Green eggs	Eyed eggs					
W-094	W-112	1A	6/5/01	1302	82	6.30	78	5.99	72	5.53
W-094	W-127	1C	6/5/01	1813	1676	92.44	1556	85.82	1578	87.04
W-094	W-126	1D	6/5/01	1924	1732	90.02	1595	82.90	1488	77.34
W-123	W-091	2B	6/5/01	924	0	0.00	0	0.00	0	0.00
W-123	W-116	2E	6/5/01	1420	1410	99.30	1407	99.08	1409	99.23
W-123	W-121	2F	6/5/01	1214	1198	98.68	1197	98.60	1198	98.68
W-149	W-132	3G	6/7/01	2887	2867	99.31	2863	99.17	2751	95.29
W-149	W-135	3H	6/7/01	2554	2538	99.37	2530	99.06	2525	98.86
W-148	W-116	4E	6/11/01	2717	2614	96.21	2604	95.84	2590	95.33
W-148	W-155	4I	6/11/01	2593	2554	98.50	2549	98.30	2569	99.07
W-153	W-135	5H	6/11/01	2614	2562	98.01	2555	97.74	2533	96.90
W-153	W-126	5D	6/11/01	2599	2556	98.35	2547	98.00	2530	97.35
W-163	W-135	6H	6/14/01	2236	2224	99.46	2216	99.11	2197	98.26
W-163	W-155	6I	6/14/01	2518	2505	99.48	2499	99.25	2507	99.56
W-068	W-132	7G	6/14/01	2361	2261	95.76	2239	94.83	2240	94.88
W-068	W-120	7J	6/14/01	2724	2577	94.60	2542	93.32	2525	92.69
W-177	W-120	8J	6/14/01	3317	3268	98.52	3263	98.37	3266	98.46
W-177	W-137	8K	6/14/01	3150	3121	99.08	3114	98.86	3097	98.32
W-165	W-126	9D	6/14/01	2215	2193	99.01	2185	98.65	2166	97.79
W-165	W-116	9E	6/14/01	2674	2621	98.02	2615	97.79	2597	97.12
W-189	W-141	10L	6/14/01	2229	2220	99.60	2202	98.79	2173	97.49
W-189	W-115	10M	6/14/01	2025	2010	99.26	1992	98.37	1962	96.89
W-125	W-120	11J	6/19/01	3546	2228	62.83	1047	29.53	996	28.09
W-125	W-115	11M	6/19/01	3594	2161	60.13	861	23.96	812	22.59
W-175	W-115	12M	6/19/01	2483	2351	94.68	2334	94.00	2311	93.07
W-175	W-167	12N	6/19/01	2322	2212	95.26	2184	94.06	2168	93.37
W-156	W-141	13L	6/19/01	2146	2106	98.14	2074	96.64	2066	96.27
W-156	W-167	13N	6/19/01	2202	2158	98.00	2101	95.41	2153	97.77
W-164	W-161	14O	6/19/01	1973	1836	93.06	1879	95.24	1874	94.98
W-164	OR-209	14P	6/19/01	1661	1626	97.89	1577	94.94	1529	92.05
W-170	OR-209	15P	6/19/01	2458	2414	98.21	2344	95.36	2281	92.80
W-170	W-172	15R	6/19/01	2294	2241	97.69	2129	92.81	2114	92.15

Table 6 (cont.) Family groups, date spawned, egg counts, and number tanked for brood year 2001 N x N winter Chinook salmon spawned at Livingston Stone NFH.

Crosses (by floy tag number)		Family group	Date spawned	Number of		Percent eye-up	Number hatched	Percent hatched	Number tanked	Percent tanked from eyed eggs
Female	Male			Green eggs	Eyed eggs					
W-198	W-114	16Q	6/19/01	2207	2190	99.23	2180	98.78	2200	99.68
W-198	W-172	16R	6/19/01	2912	2879	98.87	2866	98.42	2803	96.26
OR-205	W-158	17S	6/21/01	2135	2038	95.46	1979	92.69	1951	91.38
OR-205	OR-210	17T	6/21/01	2227	2129	95.60	2028	91.06	1992	89.45
W-200	W-137	18K	6/25/01	2531	2518	99.49	2512	99.25	2522	99.64
W-200	OR-212	18U	6/25/01	2337	2331	99.74	2321	99.32	2330	99.70
W-199	OR-212	19U	6/25/01	2947	2880	97.73	2859	97.01	2836	96.23
W-199	W-134	19V	6/25/01	2538	2486	97.95	2465	97.12	2436	95.98
W-176	W-134	20V	6/25/01	2685	2658	98.99	2647	98.58	2636	98.18
W-176	W-193	20W	6/25/01	2587	2557	98.84	2544	98.34	2558	98.88
W-183	OR-210	21T	6/25/01	2688	2646	98.44	2638	98.14	2463	91.63
W-183	W-193	21W	6/25/01	2171	2147	98.89	2132	98.20	2160	99.49
W-196	W-158	22S	6/25/01	2622	2605	99.35	2589	98.74	2476	94.43
W-196	W-159	22X	6/25/01	2294	2278	99.30	2269	98.91	2266	98.78
W-169	OR-215	23 Z	6/28/01	2859	2775	97.06	2758	96.47	2726	95.35
W-169	OR-203	23AA	6/28/01	2709	2649	97.79	2636	97.31	2501	92.32
W-188	W-173	24Y	6/28/01	1488	1391	93.48	1362	91.53	1360	91.40
W-188	OR-215	24Z	6/28/01	1526	1480	96.99	1444	94.63	1429	93.64
W-178	W-159	25X	6/28/01	2496	2482	99.44	2477	99.24	2466	98.80
W-178	W-173	25Y	6/28/01	2185	2172	99.41	2163	98.99	2150	98.40
W-168	W-197	26BB	6/28/01	2770	2755	99.46	2744	99.06	2579	93.10
W-168	OR-207	26CC	6/28/01	2810	2792	99.36	2787	99.18	2403	85.52
OR-202	OR-207	27CC	6/28/01	1853	1723	92.98	1754	94.66	1647	88.88
OR-202	W-114	27Q	6/28/01	1846	1754	95.02	1700	92.09	1687	91.39
W-186	W-131	28DD	6/28/01	2425	2358	97.24	2351	96.95	2334	96.25
W-186	W-171	28EE	6/28/01	2631	2533	96.28	2532	96.24	2500	95.02
W-147	W-171	29EE	6/28/01	2178	2133	97.93	2132	97.89	2028	93.11
W-147	W-195	29FF	6/28/01	2377	2331	98.06	2327	97.90	2230	93.82
W-144	W-190	30GG	6/28/01	2737	2656	97.04	2628	96.02	2660	97.19
W-144	W-138	30HH	6/28/01	2156	2142	99.35	2107	97.73	2042	94.71
OR-229	OR-203	31AA	7/2/01	1473	1432	97.22	1423	96.61	1250	84.86

Table 6 (cont.) Family groups, date spawned, egg counts, and number tanked for brood year 2001 N x N winter Chinook salmon spawned at Livingston Stone NFH.

Crosses (by floy tag number)		Family group	Date spawned	Number of		Percent eye-up	Number hatched	Percent hatched	Number tanked	Percent tanked from eyed eggs
Female	Male			Green eggs	Eyed eggs					
OR-229	W-195	31FF	7/2/01	1469	1435	97.69	1435	97.69	1408	95.85
OR-230	W-172	32R	7/2/01	1823	1763	96.71	1748	95.89	1722	94.46
OR-230	OR-208	32II	7/2/01	1915	1866	97.44	1851	96.66	1844	96.29
W-181	W-182	33JJ	7/2/01	2632	2594	98.56	2580	98.02	2548	96.81
W-181	OR-208	33II	7/2/01	2421	2334	96.41	2315	95.62	2334	96.41
W-194	W-131	34DD	7/2/01	1745	1588	91.00	1568	89.86	1556	89.17
W-194	W-182	34JJ	7/2/01	2006	1854	92.42	1825	90.98	1812	90.33
W-180	W-195	35FF	7/5/01	2399	2073	86.41	1647	68.65	1619	67.49
W-143	W-190	36GG	7/5/01	2579	2503	97.05	2492	96.63	2452	95.08
W-143	OR-204	36KK	7/5/01	2005	1956	97.56	1952	97.36	1955	97.51
OR-220	W-173	37Y	7/9/01	2025	1981	97.83	1978	97.68	1939	95.75
OR-220	W-138	37HH	7/9/01	2498	2463	98.60	2459	98.44	2435	97.48
OR-211	W-182	38JJ	7/9/01	2437	2417	99.18	2406	98.73	2327	95.49
OR-211	NO TAG	38LL	7/9/01	2334	2301	98.59	2295	98.33	2213	94.82
W-150	OR-204	39KK	7/9/01	2120	2090	98.58	2088	98.49	2011	94.86
W-150	OR-225	39MM	7/9/01	2319	2288	98.66	2286	98.58	2216	95.56
OR-228	OR-204	40KK	7/9/01	1920	1891	98.49	1861	96.93	1844	96.04
OR-228	W-157	40NN	7/9/01	1976	1934	97.87	1913	96.81	1901	96.20
OR-218	W-197	41BB	7/9/01	2237	2219	99.20	2215	99.02	2156	96.38
OR-218	W-157	41NN	7/9/01	1706	1682	98.59	1681	98.53	1667	97.71
OR-231	W-187	42OO	7/9/01	2631	2603	98.94	2588	98.37	2587	98.33
OR-231	W-185	42PP	7/9/01	3016	2917	96.72	2907	96.39	2895	95.99
OR-224	W-187	43OO	7/9/01	2191	1846	84.25	1717	78.37	1599	72.98
OR-224	W-185	43PP	7/9/01	2714	2282	84.08	2178	80.25	2089	76.97
W-191	W-171	44EE	7/9/01	2449	2405	98.20	2400	98.00	2331	95.18
W-191	W-179	44QQ	7/9/01	1912	1887	98.69	1878	98.22	1872	97.91
W-154	NO TAG	45LL	7/12/01	2560	2504	97.81	2470	96.48	2453	95.82
W-154	OR-232	45RR	7/12/01	2882	2819	97.81	2780	96.46	2424	84.11
W-174	OR-225	46MM	7/12/01	2994	2896	96.73	2879	96.16	2623	87.61
W-174	OR-232	46RR	7/12/01	2951	2838	96.17	2833	96.00	2349	79.60
W-160	OR-227	47SS	7/12/01	2717	2695	99.19	2690	99.01	2516	92.60

Table 6 (cont.) Family groups, date spawned, egg counts, and number tanked for brood year 2001 N x N winter Chinook salmon spawned at Livingston Stone NFH.

Crosses (by floy tag number)		Family group	Date spawned	Number of		Percent eye-up	Number hatched	Percent hatched	Number tanked	Precent tanked from eyed eggs
Female	Male			Green eggs	Eyed eggs					
W-160	W-166	47TT	7/12/01	2621	2586	98.66	2586	98.66	2543	97.02
OR-221	OR-227	48SS	7/12/01	2269	2251	99.21	2244	98.90	2195	96.74
OR-221	W-166	48TT	7/12/01	1992	1963	98.54	1945	97.64	1942	97.49
OR-223	W-197	49BB	7/12/01	3523	3464	98.33	3454	98.04	3342	94.86
OR-223	OR-226	49UU	7/12/01	3330	3247	97.51	3243	97.39	2213	66.46
OR-222	W-179	50QQ	7/12/01	1667	1629	97.72	1626	97.54	1467	88.00
OR-222	OR-226	50UU	7/12/01	1790	1759	98.27	1753	97.93	1657	92.57
<b>TOTALS</b>				<b>236864</b>	<b>225845</b>	<b>94.66</b>	<b>220998</b>	<b>92.93</b>	<b>214954</b>	<b>90.58</b>
<b>Eggs per female</b>				<b>4737</b>						

Table 7 Family groups, date spawned, egg counts, and number tanked for C x N brood year 2001 crosses spawned at Livingston Stone NFH.

Crosses (by floy tag number)		Family group	Date spawned	Number of		Percent eye-up	Number hatched	Percent hatched	Number tanked	Percent tanked from eyed eggs
Female	Male			Green eggs	Eyed eggs					
10807523	OR-203	B1AA	7/3/01	1929	1828	94.76	1580	81.91	1459	75.64
10800623	OR-203	B2AA	7/3/01	1493	1328	88.95	1222	81.85	1104	73.95
407F1B6207	W-171	B3EE	7/3/01	2457	2112	85.96	1736	70.66	1615	65.73
407F2F0B6F	W-171	B4EE	7/3/01	1630	1540	94.48	1420	87.12	1364	83.68
11101840	W-131	B5DD	7/3/01	1439	1384	96.18	1155	80.26	1096	76.16
407F2E3FIC	W-131	B6DD	7/3/01	1452	1152	79.34	841	57.92	709	48.83
11114041	W-114	B7Q	7/3/01	1154	1012	87.69	962	83.36	836	72.44
407F135C45	W-114	B8Q	7/3/01	1387	1320	95.17	1097	79.09	1167	84.14
11051272	W-138	B9HH	7/3/01	988	973	98.48	938	94.94	922	93.32
407F2F4F0C	W-138	B10HH	7/3/01	942	907	96.28	724	76.86	709	75.27
11102036	W-159	B11X	7/3/01	910	852	93.63	755	82.97	713	78.35
10868785	W-159	B12X	7/3/01	1005	924	91.94	873	86.87	773	76.92
11055256	OR-201	B13CC	7/3/01	2184	2136	97.80	1669	76.42	1681	76.97
407F307464	OR-201	B14CC	7/3/01	1211	823	67.96	427	35.26	369	30.47
11021008	W-195	B15FF	7/3/01	1245	1196	96.06	1064	85.46	989	79.44
11303122	W-195	B16FF	7/3/01	1416	1388	98.02	1180	83.33	1005	70.97
11115354	W-195	B17FF	7/3/01	942	915	97.13	895	95.01	873	92.68
11048600	W-157	B18NN	7/10/01	710	346	48.73	20	2.82	15	2.11
10276534	W-157	B19NN	7/10/01	1205	550	45.64	429	35.60	422	35.02
407F356715	W-157	B20NN	7/10/01	955	526	55.08	476	49.84	401	41.99
407F322404	W-187	B21OO	7/10/01	1089	936	85.95	573	52.62	438	40.22
407F395424	W-187	B22OO	7/10/01	867	818	94.35	594	68.51	529	61.01
11360622	W-187	B23OO	7/10/01	921	779	84.58	666	72.31	634	68.84
10598024	OR-204	B24KK	7/10/01	1494	1409	94.31	1135	75.97	1072	71.75
407F2F787C	OR-204	B25KK	7/10/01	981	881	89.81	765	77.98	751	76.55
11360326	OR-204	B26KK	7/10/01	753	0	0.00		0.00	0	0.00
10289097	W-179	B27QQ	7/10/01	1129	1021	90.43	972	86.09	947	83.88
10573265	W-179	B28QQ	7/10/01	702	656	93.45	648	92.31	641	91.31
407F112654	W-179	B29QQ	7/10/01	1121	1077	96.07	944	84.21	899	80.20

Table 7 (cont.) Family groups, date spawned, egg counts, and number tanked for C x N brood year 2001 crosses spawned at Livingston Stone NFH.

Crosses (by floy tag number)		Family group	Date spawned	Number of		Percent eye-up	Number hatched	Percent hatched	Number tanked	Percent tanked from eyed eggs
Female	Male			Green eggs	Eyed eggs					
10638565	W-173	B30Y	7/10/01	997	495	49.65	412	41.32	368	36.91
11114618	W-173	B31Y	7/10/01	829	386	46.56	366	44.15	353	42.58
11289833	W-173	B32Y	7/10/01	1150	394	34.26	342	29.74	288	25.04
407F1F6E57	W-185	B33Y	7/10/01	1073	938	87.42	878	81.83	848	79.03
11018332	W-185	B34PP	7/10/01	700	0	0.00	0	0.00	0	0.00
407F2E5C71	W-185	B35PP	7/10/01	1232	1216	98.70	1121	90.99	1101	89.37
11288865	W-185	B36PP	7/10/01	1077	976	90.62	942	87.47	853	79.20
11020024	W-185	B37PP	7/10/01	670	657	98.06	531	79.25	556	82.99
407F2E5A5F	W-197	B38BB	7/10/01	1260	1197	95.00	1172	93.02	1140	90.48
10870569	W-197	B39BB	7/10/01	1205	1177	97.68	870	72.20	804	66.72
407F1D5A57	W-197	B40BB	7/10/01	713	0	0.00	0	0.00	0	0.00
11296294	W-197	B41BB	7/10/01	962	944	98.13	908	94.39	873	90.75
11108053	W-171	B42EE	7/10/01	1231	1176	95.53	1080	87.73	985	80.02
407F192948	W-171	B43EE	7/10/01	1418	1380	97.32	1345	94.85	1210	85.33
10771095	W-171	B44EE	7/10/01	1135	371	32.69	191	16.83	136	11.98
10592024	NO TAG	B45LL	7/10/01	985	761	77.26	243	24.67	164	16.65
407F0E3A32	NO TAG	B46LL	7/10/01	820	739	90.12	690	84.15	591	72.07
11117773	OR-225	B47MM	7/10/01	1130	1109	98.14	1090	96.46	955	84.51
407F336D0C	OR-225	B48MM	7/10/01	1269	1236	97.40	1171	92.28	1058	83.37
10892618	OR-227	B49SS	7/16/01	925	799	86.38	738	79.78	708	76.54
11289297	OR-227	B50SS	7/16/01	469	401	85.50	386	82.30	382	81.45
10888874	OR-227	B51SS	7/16/01	1324	1293	97.66	1283	96.90	1272	96.07
10568849	OR-227	B52SS	7/16/01	1483	1373	92.58	1275	85.97	1234	83.21
11089010	OR-225	B53MM	7/16/01	1123	528	47.02	450	40.07	437	38.91
407F122C55	OR-225	B54MM	7/16/01	976	909	93.14	863	88.42	847	86.78
407F303C5B	OR-225	B55MM	7/16/01	956	909	95.08	894	93.51	882	92.26
11098052	OR-226	B56UU	7/16/01	1132	1032	91.17	977	86.31	947	83.66
10560798	OR-226	B57UU	7/16/01	846	734	86.76	689	81.44	651	76.95
10613769	W-166	B58TT	7/16/01	1100	1079	98.09	930	84.55	862	78.36
11297302	W-166	B59TT	7/16/01	1189	1171	98.49	1062	89.32	918	77.21
10881563	W-166	B60TT	7/16/01	1084	1015	93.63	815	75.18	811	74.82
11323551	OR-226	B61UU	7/16/01	857	832	97.08	693	80.86	641	74.80

Table 7 (cont.) Family groups, dates spawned, egg counts, and number tanked for C x N brood year 2001 crosses spawned at LSNFH.

Crosses (by floy tag number)		Family group	Date spawned	Number of		Percent eye-up	Number hatched	Percent hatched	Number tanked	Percent tanked from eyed eggs
Female	Male			Green eggs	Eyed eggs					
11316819	W-197	B62BB	7/16/01	1270	1233	97.09	1197	94.25	1171	92.20
10289849	W-197	B63BB	7/16/01	1757	1700	96.76	1674	95.28	1604	91.29
11102540	W-197	B64BB	7/16/01	859	6	0.70	3	0.35	2	0.23
10880059	W-197	B65BB	7/16/01	826	716	86.68	653	79.06	616	74.58
11112798	OR-225	B66MM	7/17/01	1396	1290	92.41	1114	79.80	901	64.54
11052276	OR-225	B67MM	7/17/01	1299	1264	97.31	1108	85.30	bkd	0.00
407F367718	OR-225	B68MM	7/17/01	966	939	97.20	937	97.00	919	95.13
11101052	OR-225	B69MM	7/17/01	1167	1025	87.83	920	78.83	bkd	0.00
407F302E11	OR-226	B70UU	7/17/01	982	960	97.76	942	95.93	909	92.57
11325011	OR-226	B71UU	7/17/01	1104	1048	94.93	1022	92.57	980	88.77
407F186357	OR-226	B72UU	7/17/01	706	672	95.18	626	88.67	586	83.00
11301086	OR-225	B73MM	7/17/01	849	768	90.46	755	88.93	709	83.51
407F30162A	W-166	B74TT	7/17/01	619	541	87.40	511	82.55	459	74.15
11295297	W-166	B75TT	7/17/01	831	721	86.76	643	77.38	577	69.43
10842865	W-166	B76TT	7/17/01	711	589	82.84	548	77.07	498	70.04
407F1E6D54	W-166	B77TT	7/17/01	587	565	96.25	560	95.40	523	89.10
11100124	W-137	B78KCR	7/24/01	697	615	88.24	604	86.66	611	87.66
11097564	W-137	B79KCR	7/24/01	1239	1100	88.78	1020	82.32	977	78.85
11103276	W-134	B80VCR	7/24/01	725	600	82.76	575	79.31	544	75.03
10317051	W-134	B81VCR	7/24/01	598	0	0.00	0	0.00	0	0.00
10880611	W-115	B82MCR	7/24/01	895	505	56.42	484	54.08	483	53.97
407F2C3955	W-115	B83MCR	7/24/01	533	314	58.91	298	55.91	267	50.09
10877580	W-120	B84JCR	7/24/01	1165	765	65.67	644	55.28	601	51.59
407F36382A	W-120	B85JCR	7/24/01	1086	768	70.72	665	61.23	640	58.93
407F30670D	OR-209	B86PCR	7/24/01	1267	1047	82.64	888	70.09	bkd	0.00
407F173378	OR-209	B87PCR	7/24/01	663	541	81.60	524	79.03	516	77.83
10867578	W-155	B88ICR	7/24/01	800	623	77.88	619	77.38	612	76.50
10792044	W-155	B89ICR	7/24/01	1003	483	48.16	439	43.77	419	41.77
407F275640	W-132	B90GCR	7/24/01	878	519	59.11	493	56.15	485	55.24
407F3B093B	W-132	B91GCR	7/24/01	753	580	77.03	537	71.31	528	70.12
407F3C7E4D	W-135	B92HCR	7/24/01	1291	903	69.95	781	60.50	679	52.59
11126275	W-135	B93HCR	7/24/01	673	404	60.03	382	56.76	374	55.57

Table 7 (cont.)

Family groups, dates spawned, egg counts, and number tanked for C x N brood year 2001 crosses spawned at LSNFH.

Crosses (by floy tag number)		Family group	Date spawned	Number of		Percent eye-up	Number hatched	Percent hatched	Number tanked	Precent tanked from eyed eggs
Female	Male			Green eggs	Eyed eggs					
407F197E42	W-127	B94CCR	7/31/01	1235	851	68.91	400	32.39	293	23.72
407F307838	W-127	B95CCR	7/31/01	1266	184	14.53	174	13.74	bkd	0.00
10554524	W-121	B96FCR	7/31/01	804	380	47.26	362	45.02	349	43.41
407F2F0878	W-121	B97FCR	7/31/01	1156	584	50.52	483	41.78	443	38.32
10300606	W-116	B98ECR	7/31/01	700	144	20.57	136	19.43	127	18.14
10882883	W-116	B99ECR	7/31/01	1055	798	75.64	587	55.64	561	53.18
10564014	W-141	B100LCR	7/31/01	516	338	65.50	304	58.91	299	57.95
-----										
<b>TOTALS</b>				<b>105958</b>	<b>85099</b>	<b>77.84</b>	<b>74779</b>	<b>70.57</b>	<b>67270</b>	<b>79.05</b>
<b>Eggs per female</b>				<b>1060</b>						



Table 8 Family groups, date spawned, and egg counts for C x C brood year 2001 crosses spawned at LSNFH. All adults spawned were brood year 1998. All juveniles were euthanized.

Family Group	Date Spawned	Number of		Percent Eye-Up	Number Hatched	Percent Hatched
		Green Eggs	Eyed Eggs			
L1	7/31/01	1868	1752	93.79	1689	90.42
L2	7/31/01	2236	2204	98.57	2072	92.67
L3	7/31/01	2751	2514	91.38	2231	81.10
L4	7/31/01	1695	1162	68.55	988	58.29
L5	7/31/01	1871	668	35.70	352	18.81
L6	7/31/01	1326	1039	78.36	791	59.65
L7	7/31/01	1403	1232	87.81	870	62.01
L8	7/31/01	953	48	5.04	21	2.20
L9	7/31/01	1618	1580	97.65	1456	89.99
L10	7/31/01	1246	1224	98.23	1183	94.94
L11	8/7/01	1998	1918	96.00	1794	89.79
L12	8/7/01	1913	1889	98.75	1782	93.15
L13	8/7/01	1635	1526	93.33	1509	92.29
L14	8/7/01	2133	2057	96.44	2034	95.36
L15	8/7/01	1315	1293	98.33	1277	97.11
L16	8/7/01	2508	2411	96.13	2334	93.06
L17	8/7/01	1997	942	47.17	410	20.53
L18	8/13/01	2224	2141	96.27	1933	86.92
L19	8/13/01	1979	1803	91.11	1637	82.72
L20	8/13/01	1297	1271	98.00	1256	96.84
L21	8/13/01	1382	1307	94.57	1271	91.97
L22	8/13/01	1418	1398	98.59	1255	88.50
L23	8/13/01	1736	1722	99.19	1715	98.79
L24	8/13/01	2276	2253	98.99	2071	90.99
L25	8/13/01	1331	1256	94.37	1133	85.12
L26	8/21/01	1652	1558	94.31	1480	89.59
L27	8/21/01	1613	1589	98.51	1559	96.65
L28	8/21/01	1756	1739	99.03	1714	97.61
L29	8/21/01	1212	1187	97.94	1159	95.63
L30	8/21/01	1372	824	60.06	0	0.00
L31	8/21/01	1633	1592	97.49	1532	93.82
L32	8/21/01	1921	1903	99.06	1883	98.02

Table 8 (cont.) Family groups, date spawned, and egg counts for C x C brood year 2001 crosses spawned at LSNFH. All adults spawned were brood year 1998. All juveniles were euthanized.

Family Group	Date Spawned	Number of		Percent Eye-Up	Number Hatched	Percent Hatched
		Green Eggs	Eyed Eggs			
L33	8/21/01	1534	1522	99.22	1519	99.02
L34	8/21/01	2627	2187	83.25	1621	61.71
L35	8/21/01	1231	1189	96.59	1124	91.31
L36	8/21/01	1931	1908	98.81	1877	97.20
L37	8/21/01	1487	1419	95.43	1391	93.54
----- Totals		<b>64078</b>	<b>57227</b>	<b>88.43</b>	<b>51923</b>	<b>80.20</b>
Eggs per Female		<b>1732</b>				

## **Juvenile Fish Health Maintenance and Treatments**

To maintain sanitary rearing environments, rearing units were typically cleaned two to five times per week. In 2001, two tanks of juvenile winter Chinook were diagnosed with bacterial gill disease (BGD). The fish were given a 30 minute bath of Chloramine-T at 15 ppm on January 2 and January 4, 2002.

A total of 207 juveniles retained for the captive broodstock program at BML, representing 26 natural-origin family group combinations, were vaccinated against *Vibrio* on April 2, 2002. Vaccinations were performed by mixing the formalin-inactivated bacteria solution with water (one to ten ratio), then dipping the fish in this solution for 20 seconds. After the 20-second dip, the juveniles were loaded into transport trucks and transported to BLM.

## **Juvenile Releases**

### **Tagging**

All winter Chinook juveniles were coded-wire tagged between December 14 and December 31, 2001. Each of the 28 final family group combinations received a unique tag code (Table 9).

On January 22 and 23, 2002, 417 juveniles retained for the captive broodstock program were tagged with passive integrated transponder (PIT) tags and then placed into two separate tanks (one for BML and one for LSNFH) (Table 9). Fish ranged in length from 43 mm to 107 mm, and averaged 74.8 mm at the time of tagging.

Table 9

Coded-wire tag (CWT) codes, associated family groups, number tagged with passive integrated transponders (PIT), and distribution of juvenile winter Chinook salmon brood year 2001.

<b>CWT code</b>	<b>Family group</b>	<b>Number PIT Tagged</b>	<b>Retained for Captive Broodstock Program</b>
0501020507	46MM, 48SS, 48TT, 49UU	16	8 BML 8 LSNFH
0501030705	C x N (release group)	0	N/A
0501030706	4E, 4I, 5D, 5H, 18U, 19U, 20W, 21W, 23Z, 24Z, 29EE, 29FF, 38JJ, 38LL, 45RR, 46RR, 47SS, 47TT, 50QQ, 50UU	0	N/A
0501030707	1A, 1D, 2E, 3G, 7J, 8J, 12N, 13N	16	8 BML 8 LSNFH
0501030708	15P, 16Q, 19V	16	8 BML 8 LSNFH
0501030709	14P, 18K, 20V	16	8 BML 8 LSNFH
0501030801	37Y, 39KK, 40KK	16	8 BML 8 LSNFH
0501030802	11M, 11J, 12M, 13L	16	8 BML 8 LSNFH
0501030803	6I, 8K	16	8 BML 8 LSNFH
0501030804	7G, 9E, 10M	16	8 BML 8 LSNFH
0501030805	1C, 2F, 3H	16	8 BML 8 LSNFH
0501030806	6H, 9D, 10L	16	8 BML 8 LSNFH
0501030807	33JJ, 44EE	16	8 BML 8 LSNFH

Table 9 (cont.)

Coded-wire tag (CWT) codes, associated family groups, number tagged with passive integrated transponders (PIT), and distribution of juvenile winter Chinook salmon brood year 2001.

<b>CWT code</b>	<b>Family group</b>	<b>Number PIT Tagged</b>	<b>Retained for Captive Broodstock Program</b>
0501030808	40NN, 41BB, 43PP	16	8 BML 8 LSNFH
0501030809	32II, 34JJ, 39MM	16	8 BML 8 LSNFH
0501030901	30GG, 33II	16	8 BML 8 LSNFH
0501030902	34DD, 35FF, 36KK	16	8 BML 8 LSNFH
0501030903	28EE, 30HH, 31FF	16	8 BML 8 LSNFH
0501030904	24Y, 26BB, 27CC	16	8 BML 8 LSNFH
0501030905	22X, 23AA, 25Y	16	8 BML 8 LSNFH
0501030906	27Q, 28DD, 32R	16	8 BML 8 LSNFH
0501030907	25X, 26CC, 31AA	16	8 BML 8 LSNFH
0501030908	16R, 17S, 17T	16	8 BML 8 LSNFH
0501030909	14O, 15R, 21T, 22S	16	8 BML 8 LSNFH
0501040101	36GG, 37HH	16	8 BML 8 LSNFH
0501040102	41NN, 43OO, 44QQ	16	8 BML 8 LSNFH
0501040103	42OO, 49BB	17	8 BML 9 LSNFH
0501040104	42PP, 45LL	16	8 BML 8 LSNFH

Table 10 Tagging information and length data at time of release for BY 2001 winter Chinook salmon.

Tag Code	Number Tagged	Mortalities	Number held for Captive program	Tag Retention (%)	Length				Number Released w/Tags	Number Shed Tag	Total Released
					Min	Max	Mean	SD			
0501020507	4307	7	16	99.5	58	85	69	5	4263	21	4284
0501030705	62138	186	0	99.8	55	89	74	7	61828	124	61952
0501030706	38800	96	0	97.3	46	107	76	7	37659	1045	38704
0501030707	15106	11	16	100.0	55	98	79	7	15079	0	15079
0501030708	6751	10	16	90.0	48	88	76	6	6053	673	6725
0501030709	6782	4	16	90.0	60	90	75	5	6086	676	6762
0501030801	5444	264	16	97.0	48	87	69	8	5009	155	5164
0501030802	5873	11	16	94.0	66	90	79	4	5495	351	5846
0501030803	5327	5	16	92.0	54	96	81	6	4882	424	5306
0501030804	6676	8	16	89.0	51	86	76	5	5920	732	6652
0501030805	4872	6	16	97.0	64	101	85	6	4705	146	4850
0501030806	6670	10	16	94.0	55	90	75	4	6245	399	6644
0501030807	4669	15	16	97.0	57	89	72	5	4499	139	4638
0501030808	4877	21	16	99.5	51	83	71	5	4816	24	4840
0501030809	5430	4	16	96.0	52	84	73	5	5194	216	5410
0501030901	4907	3	16	92.0	62	90	77	5	4497	391	4888
0501030902	5022	8	16	93.5	61	92	78	5	4673	325	4998
0501030903	5130	19	16	96.5	43	89	75	8	4917	178	5095
0501030904	5643	7	16	95.0	50	94	77	7	5339	281	5620
0501030905	5944	18	16	93.0	45	90	77	7	5496	414	5910
0501030906	5592	2	16	92.5	53	89	73	6	5156	418	5574
0501030907	5335	11	16	89.0	56	90	75	6	4724	584	5308
0501030908	6394	10	16	90.0	57	90	77	6	5731	637	6368
0501030909	6840	14	16	92.0	57	98	77	6	6265	545	6810
0501040101	4657	8	16	99.5	58	84	72	5	4610	23	4633
0501040102	4992	12	16	99.5	44	84	70	7	4939	25	4964
0501040103	4855	18	17	97.0	46	81	68	6	4675	145	4820
0501040104	4868	13	16	99.0	46	81	69	5	4791	48	4839
<b>Total/Average</b>	<b>253901</b>	<b>801</b>	<b>417</b>	<b>95.02</b>	<b>54</b>	<b>90</b>	<b>75</b>		<b>243545</b>	<b>9138</b>	<b>252683</b>

## **Distribution**

A total of 190,732 fish (88.2 per pound) from N x N crosses and 61,952 fish (97.6 per pound) from N x C crosses were released at the Caldwell Park on January 30, 2002. The fish were released at dusk thus allowing them to acclimate through the night in order to reduce possible losses from predation. Average survival from egg to release was 80.5% for N x N crosses and 58.6% for C x N crosses. Two hundred eight fish representing 26 family group combinations at 47.2 per pound were transferred to BML for the captive broodstock program on April 2, 2002. Two hundred nine fish representing 26 family group combinations were retained at Livingston Stone NFH for the captive broodstock program. At the time of tagging, a small piece of fin was removed from these fish allowing genetic determination of sex. Captive broodstock males and females are reared separately so that feeding schedules and feed amounts can be modified between genders. This is done primarily to limit growth and fat deposition in males, resulting in a reduced likelihood of precocious maturation.

The 51,923 juveniles produced by C x C matings were all euthanized soon after hatching.

### *Effective population size*

Before and after hatchery juvenile winter Chinook are released into the Sacramento River, the Service estimates the “effective population size” of the winter Chinook salmon population, both with and without the influence of hatchery-origin fish. The effective population size estimate ( $N_e$ ) is a measure of the rate of genetic drift within a population and provides an assessment of potential genetic risk to the natural population as a result of the release of the juveniles from the production program. The  $N_e$  is directly related to the rate of loss of genetic diversity and the rate of increase in inbreeding within a population (Riemann and Allendorf 2001), and is an important concept in managing conservation programs for threatened or endangered salmonid populations, including Sacramento River winter Chinook. In most cases  $N_e$  is expected to be smaller than the actual number of adults in a spawning population.

The estimation of  $N_e$  is based on the estimated total run size of winter Chinook salmon to the Sacramento River. Two estimates of  $N_e$  are generated: one using 10% of the run size estimate and one using 33% of the run size estimate. Each value is an estimate of the proportion of the total spawner population that contributes to effective population of natural spawners. When brood year 2001 hatchery propagation data was applied to the population genetics model (Hedrick et al. 1995) genetic impacts were not apparent (Attachment B). The model indicates the effective population size increased from 757 to 828 ( $N_{ew} = 0.10 \times N_s$ ) or 2,521 to 2,622 ( $N_{ew} = 0.33 \times N_s$ ) with hatchery influence (Attachment B). The effective population size of the hatchery component as derived by estimating the number released via this method was 113 (Attachment B). The increase in the overall effective population size due to hatchery influence suggests the winter-run Chinook salmon population was not likely to incur negative impacts from genetic drift as consequence of the brood year 2001 release.

## **Fish Health Maintenance and Monitoring**

At the time of release, CA-NV FHC personnel tested 120 natural-origin x natural-origin and captive-origin x captive-origin juvenile Chinook for *R. salmoninarum* using ELISA. One hundred percent were negative.

## References

- Hedgecock, D., M. Banks, V. Rashbrook, H. Fitzgerald, S. Sabatino, D. Churikov, W. Eichert, P. Hedrick. 2001. Genetic Maintenance of Hatchery- and Natural-Origin Winter-Run Chinook Salmon. Final Report. January 1998 – September 2001.
- Hedrick, P.W., D. Hedgecock, and S. Hamelberg. 1995. Effective population size in winter-run Chinook salmon. *Conservation Biology*. vol 9, num.3. pp 615-624.
- Rieman, B.E. and F.W. Allendorf. 2001. Effective population size and genetic conservation criteria for bull trout. *North American Journal of Fisheries Management* 21: 756-764.
- Vogel, D.A. and K.R. Marine. 1991. Guide to upper Sacramento River Chinook salmon life history. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. 55 pp.



# **Attachment A**

## **2001 Winter Chinook Adult Trapping Plan**

# **Attachment B**

## **Brood Year 2000 Final Effective Population Calculation**

# **Attachment C**

## **Winter Chinook Captive Broodstock Release Study Plan**