2006 Annual Report of Winter Chinook Propagation Activities

A U.S. Fish & Wildlife Service Report

U.S. Fish and Wildlife Service
Red Bluff Fish and Wildlife Office
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INTRODUCTION

Due to severe declines in adult returns, the National Marine Fisheries Service listed Sacramento River winter Chinook salmon as threatened under the emergency listing procedures for the Endangered Species Act (16 U.S.C.R. 1531-1543) on August 4, 1989 (54 Federal Register 32085). Winter Chinook were formally added to the list of federally threatened species by final rule on November 5, 1990 (55 Federal Register 46515). Despite early efforts to restore the population, adult returns of winter Chinook continued to decline. In January 1994, the National Marine Fisheries Service reclassified winter Chinook salmon as endangered.

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 in 1989. The program was located at Coleman National Fish Hatchery (NFH), on Battle Creek, a tributary of the Sacramento River. However, fish reared at Coleman NFH tended to return to Battle Creek rather than the Sacramento River as desired. To alleviate this problem, a new hatchery facility, Livingston Stone National Fish Hatchery (NFH), was established in 1998 along the Sacramento River at the base of Shasta Dam. To ensure that the hatchery program spawned only winter Chinook, the Service implemented a genetic-based screening process to identify winter Chinook salmon.

In addition to the hatchery supplementation program, an experimental captive broodstock program was cooperatively developed in 1991 with Bodega Marine Lab (BML) and partner agencies of the winter Chinook captive brood stock technical committee. The winter Chinook captive broodstock program is sustained by rearing a small number of hatchery-origin juveniles to maturity at Livingston Stone NFH or the BML. The primary objective of the winter Chinook captive broodstock program is to determine if a captive brood program could be used to prevent extinction of the run by ensuring a source of gametes for the supplementation program in the event that run sizes continue to decline and too few fish are available for hatchery broodstock (in 1991 the winter Chinook run estimate was less than 200 individuals). Brood year 2006 marks the sixth, and final, year of juvenile releases for a study to evaluate the efficacy of fish produced from the captive-brood program to produce returning adults (USFWS 2003).

METHODS

Broodstock

Collection

Before collection of winter Chinook broodstock began in 2006, the Service developed a broodstock collection plan that defined brood fish collection targets spread throughout the run. The broodstock collection guidelines for winter Chinook allow capture of up to 15% of the run size, up to a maximum of 120 fish. A run size of 800 or greater, would allow for 120 fish to be retained as brood stock. In 2006, the pre-season run estimate was much greater than 800; therefore, up to120 adult winter Chinook salmon could be collected. The timing of broodstock collection was scheduled to mimic the historic migration timing past the Red Bluff Diversion

Dam as follows: 1.8% (2 fish) in December, 5.1% (6 fish) in January, 9.6% (12 fish) in February, 36.0% (43 fish) in March, 28.6% (34 fish) in April, 8.9% (11 fish) in May, 6.8% (8 fish) in June, and 3.4% (4 fish) in July. Deviation from the broodstock collection plan can occur due to limitations of the available traps to function during the entire run, under all flow conditions, and other factors. The Keswick Dam trap is operational only when discharge from Keswick dam is less than 32,000 cubic feet per second. As such, trap operation is affected by reservoir management. The Keswick Dam fish trap was the only trap used to collect winter Chinook broodstock in 2006 and was operated by Service personnel. The alternate trap located at the Red Bluff Diversion Dam was not used in 2006 because sufficient numbers of broodstock were collected at the Keswick Dam trap.

Handling and Transportation

Once trapped in the Keswick Dam fish trap, the fish remained in water at all times. From the trap they swam into a 1,000 gallon brail-lift from which they were transferred directly into an aerated and insulated 1,200 or 1,600-gallon transport tank and driven a short distance to Livingston Stone NFH. At Livingston Stone NFH the fish were anaesthetized with CO_2 while still in the transport tank, after which they were handled and a preliminary run assignment was made (i.e., winter-run or non-winter-run) based on phenotypic characteristics (e.g., color, degree of ripeness, fish size, amount of fungus, and collection date). All fish received a floy tag below the dorsal fin, and a small piece of fin tissue was taken for genetic analysis. Fish classified as non-winter-run were transported back to the Sacramento River the same day they were removed from the trap, or were transported to Coleman NFH for use in the late-fall Chinook broodstock program. Fish classified as phenotypically winter-run were quarantined in a 20-foot circular tank pending genetic confirmation of their run type. Fish genetically confirmed as winter-run were transferred into a 20-foot circular adult holding tank until spawned. Those identified as non-winter-run were returned to the Sacramento River.

Run Identification

A genetic-based run assignment was used to classify fish as either winter-run or non-winter-run Chinook (University of California, Davis - Bodega Marine Laboratory 2001). Analyses were conducted at the Service's Abernathy Fish Technology Center. Tissue samples were analyzed at a suite of microsatellite markers selected for their diagnostic power in distinguishing winter Chinook from other Chinook salmon populations (University of California – Davis Bodega Marine Laboratory 2001). Following the methods described by Banks et al. (1999) and Greig and Banks (1999), extracted DNA from samples was amplified by polymerase chain reaction, analyzed, and overall genotypes converted to GENEPOP format. Duplicate samples were run to confirm genotypes. A log-of-the-odds (LOD) score was generated using the computer software WHICHRUN (Banks and Eichert 2000) and used to assign individual Chinook as either winter-run or non-winter-run. A LOD score of two or greater, based on seven loci, was used to determine which fish would be retained as broodstock. Run-assignments for individual fish were transmitted back to Livingston Stone NFH usually within 72 hours of receipt of the tissue sample by the Abernathy Fish Technology Center.

Health

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 1). Additionally, effects of stress on broodstock were reduced with salt, Poly Aqua, and anesthetics. Hatchery personnel and staff from the California-Nevada Fish Health Center closely monitored fish health. Broodstock were treated with malachite green to prevent fungal infections and erythromycin injections (target dosage of 20 mg/kg) were used to prevent transmission of *Renibacterium salmoninarum* to the progeny. No chemical treatments were administered to fish while held in quarantine and fish returned to the river were not subjected to chemical treatments. California-Nevada Fish Health Center personnel tested for the presence of pathogens in the broodstock.

Table 1. Drugs and treatments that may be applied to maintain the health of winter Chinook salmon held at Livingston Stone National Fish Hatchery.

Drug/Treatment	Dosage	Administered by	Use
Erythromycin	20 mg/kg	dorsal sinus injection	antibacterial
Iodophor	75 ppm	bath	antibacterial
Liquamycin	20 mg/kg	Intraperitoneal injection	antibacterial
Malachite green	1 ppm	bath	antifungal
Formalin	167 ppm	flow through	antifungal
MS-222		bath	anesthetic
Poly Aqua	1 qt/1,200 gallons	bath/flow through	stress reducer
Salt		bath/flow through	stress reducer
Chloramine-T	15 ppm	bath	antibacterial

Spawning

Winter Chinook held as broodstock were examined twice weekly to assess their state of sexual maturity. Fish 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.

Luteinizing Hormone-Releasing Hormone analogue (LH-RH_a) implants were administered to accelerate final gamete maturation in fish that had already undergone gametogenesis and to synchronize maturation of broodstock (Tables 2 and 3). The LH-RH_a 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. Eighteen females and two males received LH-RH_a injections.

When a female salmon was identified as being sexually mature, it was euthanized, 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 the female was severed so that blood would not mix into the eggs. Eggs were removed by making an incision from the vent to the pectoral fin and separated into two approximately equal groups. 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 groups" 1A and 1B were created. After mixing semen 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 euthanized. Males were spawned a maximum of four times. When possible, each fish captured from the Sacramento River was spawned with at least two others. Captive-origin females were only spawned with natural-origin males.

Table 2. Spawning and drug treatment history of individual female Chinook salmon held at Livingston Stone National Fish Hatchery, 2006.

Tag Number	Date Captured	Fork Length (mm)	Weight (lb)	Date Spawned	Date Died	Days in Captivity	Erythromycin Dose (ml)	Erythromycin Injections	Liquamycin Dose (ml)	Liquamycin Injections	LH-RHa Dose (ml)	LH-RHa Injections	No. of Malachite Green Treatments
OR-475	2/28/06	800	17.96	PSM[a]	4/26/06	56	n/a[b]	none	0.8	1	n/a	none	22
W-041	5/2/06	892	20.14	5/4/06	5/4/06	1	n/a	none	n/a	none	n/a	none	none
W-044	5/2/06	820	17.36	5/4/06	5/4/06	1	n/a	none	n/a	none	n/a	none	none
OR-479	2/28/06	800	15.68	5/9/06	5/9/06	69	0.75	1	0.75	2	250	2	23
OR-405	2/28/06	801	15.92	5/11/06	5/11/06	71	0.75	1	n/a	none	250	1	25
OR-420	2/28/06	735	12.06	5/16/06	5/16/06	76	0.65	1	n/a	none	250	2	26
W-047	5/2/06	795	14.36	5/16/06	5/16/06	13	0.65	1	n/a	none	250	1	3
W-258	5/16/06	784	13	5/18/06	5/18/06	1	n/a	none	n/a	none	n/a	none	none
W-197	5/16/06	849	17.16	5/18/06	5/18/06	1	n/a	none	n/a	none	n/a	none	none
W-267	5/16/06	798	13.26	5/18/06	5/18/06	1	n/a	none	n/a	none	n/a	none	none
W-241	5/16/06	815	13.9	5/18/06	5/18/06	1	n/a	none	n/a	none	n/a	none	none
W-202	5/16/06	820	15.8	5/25/06	5/25/06	8	0.75	1	n/a	none	n/a	none	2
W-110	5/2/06	717	11.2	5/25/06	5/25/06	22	0.5	1	n/a	none	250	1	6
W-298	5/23/06	788	15.76	5/25/06	5/25/06	1	n/a	none	n/a	none	n/a	none	none
W-293	5/23/06	787	16.24	5/25/06	5/25/06	1	n/a	none	n/a	none	n/a	none	none
W-221	5/16/06	868	19.52	5/30/06	5/30/06	13	0.9	1	0.9	1	n/a	none	2
W-076	5/2/06	828	16.32	5/30/06	5/30/06	27	0.75	1	0.75	1	250	1	7
W-274	5/23/06	815	17.6	6/1/06	6/1/06	8	n/a	none	0.75	1	n/a	none	3
W-244	5/16/06	795	18.32	6/1/06	6/1/06	15	0.9	1	0.9	1	250	1	5
OR-423	2/28/06	813	14.94	6/1/06	6/1/06	92	0.65	1	0.65	1	250	1	35
W-325	5/30/06	868	19.72	6/1/06	6/1/06	1	n/a	none	n/a	none	n/a	none	none
W-369	5/30/06	767	12.96	6/1/06	6/1/06	1	n/a	none	n/a	none	n/a	none	none
W-412	5/30/06	770	12.22	6/1/06	6/1/06	1	n/a	none	n/a	none	n/a	none	none
W-397	5/30/06	830	16.62	6/1/06	6/1/06	1	n/a	none	n/a	none	n/a	none	none
W-142	5/9/06	867	18.9	6/5/06	6/5/06	26	0.9	1	n/a	none	250	none	9
W-396	5/30/06	825	14.18	6/5/06	6/5/06	5	n/a	none	n/a	none	n/a	none	2
W-338	5/30/06	685	9.14	6/5/06	6/5/06	5	n/a	none	n/a	none	n/a	none	2
W-162	5/9/06	810	14.3	6/5/06	6/5/06	26	0.65	1	n/a	none	250	1	9

Table 2 (cont.)

Tag	Date	Fork		Date	Date	Days in	Erythromycin		Liquamycin		LH-RHa		No. of Malachite
Number	Captured	Length (mm)	Weight (lb)	Spawned	Died	Captivity	Dose (ml)	Injections	Dose (ml)	Injections	Dose (ml)	Injections	Green Treatments
W-355	5/30/06	777	11.58	6/5/06	6/5/06	5	n/a	none	n/a	none	n/a	none	2
OR-385	2/28/06	758	13.6	6/5/06	6/5/06	96	0.65	1	n/a	none	n/a	none	34
W-288	5/23/06	805	14.84	6/5/06	6/5/06	12	0.65	1	n/a	none	250	1	5
W-349	5/30/06	773	12.22	6/6/06	6/6/06	6	n/a	none	n/a	none	250	1	1
OR-402	2/28/06	655	6.8	6/8/06	6/8/06	99	0.3	1	n/a	none	n/a	none	35
W-088	5/2/06	721	10.64	6/8/06	6/8/06	36	0.5	1	n/a	none	250	1	12
W-341	5/30/06	742	10.82	6/8/06	6/8/06	8	0.5	1	n/a	none	n/a	none	3
W-075	5/2/06	777	13.7	6/8/06	6/8/06	36	0.65	1	n/a	none	n/a	none	12
W-177	5/9/06	828	14.9	6/8/06	6/8/06	29	0.65	1	n/a	none	n/a	none	10
W-329	5/30/06	792	14.16	6/12/06	6/12/06	12	0.65	1	n/a	none	250	1	4
W-465	6/13/06	820	15.38	6/15/06	6/15/06	1	n/a	none	n/a	none	n/a	none	none
W-440	6/13/06	741	10.62	6/15/06	6/15/06	1	n/a	none	n/a	none	n/a	none	none
W-287	5/23/06	803	13.62	6/15/06	6/15/06	22	0.65	1	0.65	1	250	1	8
OR-458	2/28/06	780	12.76	6/15/06	6/15/06	106	0.65	2	n/a	none	n/a	none	37
OR-432	2/28/06	770	13.94	6/19/06	6/19/06	110	0.65	2	n/a	none	n/a	none	38
W-103	5/2/06	735	10.18	6/19/06	6/19/06	47	0.5	2	n/a	none	n/a	none	15
W-364	5/30/06	826	15.52	6/22/06	6/22/06	22	0.75	1	n/a	none	n/a	none	7
W-413	5/30/06	809	13.56	6/22/06	6/22/06	22	0.65	1	n/a	none	n/a	none	7
OR-483	2/28/06	710	10.08	6/26/06	6/26/06	117	0.5	2	n/a	none	n/a	none	40
W-496	6/27/06	831	15.9	6/27/06	6/27/06	0	n/a	none	n/a	none	n/a	none	0
W-262	5/16/06	760	16.74	6/29/06	6/29/06	43	0.75	1	0.75	1	250	1	15
Y-020	7/11/06	830	16.72	7/13/06	7/13/06	1	n/a	none	n/a	none	n/a	none	none
Y-036	7/11/06	690	8.34	7/13/06	7/13/06	1	n/a	none	n/a	none	n/a	none	none
Y-14	7/11/06	750	10.3	7/20/06	7/20/06	8	n/a	none	n/a	none	250	1	2
W-402	5/30/06	808	14.84	7/20/06	7/20/06	50	0.75	1	0.75	1	250	1	16

[a] pre-spawn mortality; [b] not applicable

Table 3. Spawning and drug treatment history of individual male Chinook salmon held at Livingston Stone National Fish Hatchery, 2006.

Tag Number	Date Captured	Fork Length (mm)	Weight (lb)	Date Spawned	Date Died	Days in Captivity	Liquamycin		LH-RHa		No. of Malachite Green Treatments
							Dose (ml)	Injections	Dose (ml)	Injections	
OR-386	2/28/06	810	19.22	PSM[a]	3/20/06	19	n/a[b]	none	n/a	none	8
OR-478	2/28/06	785	13.3	PSM[a]	4/7/06	37	n/a	none	n/a	none	14
W-328	5/30/06	760	11.56	PSM[a]	7/6/06	36	n/a	none	250	1	11
OR-440	2/28/06	918	23.24	5/4/06 5/9/06 5/25/06	5/25/06	85	n/a	none	n/a	none	29
OR-389	2/28/06	758	12.72	5/4/06 5/9/06 5/25/06	5/25/06	85	n/a	none	n/a	none	29
OR-441	2/28/06	801	13.96	5/4/06 5/16/06 5/30/06	6/5/06	96	n/a	none	n/a	none	34
W-050	5/2/06	890	19.74	5/4/06 5/16/06 5/18/06	5/25/06	22	n/a	none	n/a	none	6
OR-396	2/28/06	798	14.62	5/11/06 5/16/06 5/25/06	5/25/06	85	0.8	2	250	1	29
W-129	5/9/06	876	21.62	5/16/06 5/18/06 5/25/06	5/29/06	19	n/a	none	n/a	none	6
W-128	5/9/06	878	16.4	5/16/06 5/18/06 5/25/06	5/31/06	21	n/a	none	n/a	none	6
W-257	5/16/06	893	19.52	5/18/06 5/18/06 5/25/06	6/1/06	15	n/a	none	n/a	none	5
W-256	5/16/06	760	17.16	5/18/06 5/18/06 5/25/06	6/1/06	15	n/a	none	n/a	none	5
W-080	5/2/06	757	10.38	5/18/06 5/25/06 5/30/06	6/5/06	33	n/a	none	n/a	none	11

Table 3 (cont.)

Tag Number	Date Captured	Fork Length (mm)	Weight (lb)	Date Spawned	Date Died	Days in Captivity	Liquamycin		LH-RHa		No. of Malachite Green Treatments
							Dose (ml)	Injections	Dose (ml)	Injections	
W-175	5/9/06	834	16.1	5/30/06	5/30/06	20	n/a	none	n/a	none	6
W-238	5/16/06	818	18.86	5/30/06 6/1/06	6/7/06	21	n/a	none	n/a	none	7
W-259	5/16/06	790	11.7	6/1/06 6/5/06	6/7/06	21	n/a	none	n/a	none	7
W-176	5/9/06	957	23.82	6/1/06 6/5/06	6/7/06	28	n/a	none	n/a	none	10
W-196	5/16/06	880	23.6	6/1/06 6/5/06	6/12/06	26	n/a	none	n/a	none	9
W-411	5/30/06	880	15	6/1/06 6/1/06 6/5/06	6/7/06	7	n/a	none	n/a	none	2
W-330	5/30/06	910	23.2	6/1/06 6/1/06 6/5/06	6/7/06	7	n/a	none	n/a	none	2
W-310	5/30/06	950	22.3	6/1/06 6/1/06 6/5/06	6/7/06	7	n/a	none	n/a	none	2
W-432	5/30/06	865	15.94	6/1/06 6/1/06 6/5/06	6/7/06	7	n/a	none	n/a	none	2
W-358	5/30/06	904	18.62	6/5/06 6/5/06 6/8/06	6/12/06	12	n/a	none	n/a	none	4
W-081	5/2/06	857	16.84	6/5/06 6/8/06 6/8/06	6/12/06	40	n/a	none	n/a	none	13
W-324	5/30/06	978	25.96	6/5/06 6/5/06 6/8/06	6/12/06	12	n/a	none	n/a	none	4

Table 3 (cont.)

Tag Number	Date Captured	Fork Length (mm)	Weight (lb)	Date Spawned	Date Died	Days in Captivity	Liquamycin		LH-RHa		No. of Malachite Green Treatments
							Dose (ml)	Injections	Dose (ml)	Injections	
W-359	5/30/06	843	16.82	6/5/06 6/8/06 6/8/06	6/12/06	12	n/a	none	n/a	none	4
W-354	5/30/06	915	18.62	6/5/06 6/8/06	6/12/06	12	n/a	none	n/a	none	4
W-170	5/9/06	856	15.68	6/8/06 6/15/06	6/19/06	40	n/a	none	n/a	none	13
W-431	5/30/06	865	17.52	6/8/06 6/15/06	6/19/06	19	n/a	none	n/a	none	6
W-163	5/9/06	808	14.8	6/12/06 6/15/06 6/19/06	6/22/06	43	n/a	none	n/a	none	14
OR-394	2/28/06	780	13.78	6/12/06 6/15/06	6/19/06	110	n/a	none	n/a	none	38
W-473	6/13/06	905	18.24	6/15/06 6/15/06 6/19/06	6/22/06	8	n/a	none	n/a	none	2
W-116	5/9/06	881	18.96	6/15/06 6/19/06	6/19/06	40	n/a	none	n/a	none	13
W-428	5/30/06	695	8.3	6/19/06 6/22/06 6/26/06	7/9/06	39	n/a	none	n/a	none	11
OR-395	2/28/06	786	12.62	6/22/06 6/26/06 6/29/06	7/19/06	140	n/a	none	n/a	none	47
W-337	5/30/06	838	16.18	6/22/06 6/26/06 6/27/06	7/7/06	37	n/a	none	n/a	none	13
W-209	5/16/06	842	17.8	6/22/06 6/29/06	7/18/06	62	n/a	none	n/a	none	21
W-251	5/16/06	818	14.72	7/13/06 7/13/06 7/20/06 7/20/06	7/26/06	70	n/a	none	n/a	none	23

Table 3 (cont.)

Tag Number	Date Captured	Fork Length (mm)	Weight (lb)	Date Spawned	Date Died	Days in Captivity	Liquamycin		LH-RHa		No. of Malachite Green Treatments
							Dose (ml)	Injections	Dose (ml)	Injections	
Y-061	7/11/06	793	12.92	7/13/06 7/20/06 7/20/06	7/26/06	14	n/a	none	n/a	none	3
Y-017	7/11/06	668	5.8	7/13/06	7/17/06	5	n/a	none	n/a	none	2

[a] Pre-spawn mortality; [b] not applicable

Progeny

Eggs and Juvenile Rearing

After fertilization, winter Chinook eggs were placed in Heath incubator trays and disinfected with a 75 parts per million (ppm) iodophor bath for 15 minutes. Incubating eggs were treated twice a week with a 15 minute flow-through treatment of 1,400 ppm formalin to prevent excessive fungus. 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.

Juveniles were initially fed Bio-Oregon's starter #1. *Artemia nauplii* (Cyclop-eeze™ from Argent Chemical Laboratories) were added to increase interest in the feed. The fish were subsequently fed Bio-Oregon's starter #2 and starter #3 fish feed. Once they attained a size of approximately 500 to-the-pound, they were fed Bio-Oregon's Biodiet grower, size 1.3 mm pellets. At a size of about 250 to-the-pound they were switched to Nelson and Son's Silvercup Soft Moist #2 feed. At 100 to-the-pound the diet was changed to Nelson and Son's Silvercup slow sink 1.0mm. Feeding rates were determined using Bio-Oregon's and Silvercup's feeding guidelines, which indicate the appropriate feed ration based on average monthly water temperature. Due to tank space limitations at Livingston Stone NFH, family groups were combined as fish size increased.

Health

To maintain sanitary rearing environments, rearing units were typically cleaned two to five times per week. Juvenile winter Chinook were tested for the presence of pathogens by California-Nevada Fish Health Center personnel.

Marking and Tagging

All winter Chinook juveniles were coded-wire tagged between January 3, 2007 and January 19, 2007. Each of the 16 natural-origin by natural-origin family group combinations received a unique tag code. During tagging, tag shortages occurred for three of the natural-origin by natural-origin tag groups. Fish that were initially left untagged from these groups were grouped together and subsequently tagged with a separate tag code (053867) making 17 natural-origin by natural-origin coded-wire tag groups. There was one hatchery-origin by natural-origin family group combination and one captive-origin by natural-origin family group combination (Table 4).

Table 4. Brood year 2006 winter Chinook salmon released by coded-wire tag (CWT) code, family group, and parental origin and length (mm).

Tag Code	Family Group	Parental Origin	Number Tagged	Tagging Mortalities	Proportion Tags Retained	Tagged Fish Released	Number Released	Avg. Fork Length (mm)	Min. Fork Length (mm)	Max. Fork Length (mm)
051680	45EE, 48HH, 51II, 52II	N x N	9,162	4	0.93	8,471	9,158	86	68	106
051682	51JJ, 49JJ, 52JJ, 50KK	N x N	8,783	12	0.95	8,289	8,771	84	73	98
051697	29V, 30W, 30X, 31Q, 32T, 32X, 26M, 27S, 27T, 28O, 29U, 50II, 49II	N x N	8,967	3	0.95	8,471	8,964	88	71	102
052490	38CC, 39Y, 35U	N x N	9,190	95	0.81	7,367	9,095	91	65	108
052491	40DD, 42DD, 43AA, 43EE, 41BB	N x N	9,061	4	0.88	7,925	9,057	91	74	103
052492	47GG, 47EE, 44FF, 46GG	N x N	9,597	2	0.93	8,875	9,595	90	73	105
052493	44GG, 48FF, 46FF, 45HH	N x N	8,408	4	0.96	8,068	8,404	92	70	108
053399	34V,38Z,33V,33W,34W,39CC	N x N	9,923	18	0.84	8,320	9,905	88	70	112
053466	5E, 5F, 7I, 6G,	N x N	9,155	3	0.93	8,511	9,152	96	75	112
053467	4E, 4D, 3A, 3B, 10J, 12J, 14J	N x N	9,499	0	0.95	9,024	9,499	97	87	112
053468	9G, 11B, 9D, 10F, 15J, 16C, 18L, 18M	N x N	10,019	8	0.92	9,160	10,011	94	77	109
053469	11A, 12E, 13H, 14F	N x N	9,699	3	0.98	9,454	9,696	93	78	113
053470	13I, 17M, 20Q, 17L, 26T	N x N	9,988	55	0.99	9,834	9,933	92	77	108
053471	20P, 21P, 21Q, 22R, 22S, 23R, 23S, 24Q, 24L, 25R	N x N	9,601	8	0.87	8,346	9,593	91	69	110
053472	19N, 28N, 37AA, 37BB, 19O, 25P	N x N	9,965	12	0.98	9,704	9,953	93	73	112
053473	6C, 7H, 8H, 8I	N x N	10,953	1	0.95	10,404	10,952	99	71	113
053867[a]	9D, 10F, 15J, 16C, 18L, 18M, 24L, 25R, 19O, 25P	N x N	428	0	0.99	424	428	84	56	100
		Subtotal	152,398	232	.	140,647	152,166			
051698	1A, 1B, 2C, 2D	H x N	9,049	3	0.93	8,413	9,046	103	81	123
052368	Progeny of captive females L1 - L60	C x N	35,098	22	0.93	32,621	35,076	83	57	101
		Total	196,545	257	.	181,680	196,288	.	.	.

[a] Due to a tag shortage during initial tagging with tag codes 053468, 053471, and 053472, untagged individuals from those groups were combined and tagged at a later date with tag code 053867.

Assessment of Potential Genetic Impacts

Prior to and following the release of juvenile winter Chinook into the Sacramento River, the Service estimated 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) measures the rate of genetic drift within a population and provides an assessment of risk of inbreeding resulting from the release of the juveniles from the hatchery propagation 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 was based on the estimated total run size of winter Chinook salmon to the Sacramento River in 2006. Two estimates of N_e were calculated: one assuming genetic contribution by 10% of the run size estimate (Bartley et al., 1992) and one assuming genetic contribution by 33% of the run size estimate (Robin Waples, NMFS, Northwest Fisheries Center, Seattle, WA, personal communication). The Service's estimate of effective population size was sent to NOAA Fisheries and the California Department of Fish and Game for review and approval prior to releasing juvenile winter Chinook.

RESULTS

Broodstock

Collection and Disposition

The first winter Chinook was captured on February 21 and the last was captured on July 11 (Table 5, Figure 1). Winter Chinook collection was slow early in the collection year due to high river flows preventing the Keswick Dam trap from being run. Most of the brood year 2006 winter Chinook were collected during May (Table 5, Figure 1). The pattern of collection for non-winter Chinook was similar to that of winter Chinook (Table 5, Figure 1). A total of 494 Chinook salmon were captured at the Keswick Dam trap (Table 6). Of those, 63% (n = 312) were identified as winter-run based on genetic data or phenotypic characteristics. Females comprised 48% (n = 149) of the winter Chinook salmon captured, males comprised 52% (n = 163). Hatchery-origin fish comprised 58% (n = 180) of the winter Chinook captured and 51% (n = 250) of all Chinook captured.

Two hundred thirteen winter-run Chinook, 80 non-winter-run Chinook, and 63 Chinook of undetermined run were collected and released without being quarantined (Table 6). Thirty-three Chinook were held in quarantine and later released back into the Sacramento River; six of these fish were winter-run, seven were non-winter-run, and 20 were of undetermined run (Table 6). Quarantined fish were held for no more than six days. Ninety-three winter Chinook salmon were retained for broodstock. Among these, 89 were spawned and four died before they could be

spawned. Five non-winter Chinook were transferred to Coleman NFH for use as late-fall Chinook salmon broodstock and seven non-winter Chinook were euthanized.

Table 5. Brood year 2006 Chinook salmon captured and tissue sampled for genetic run assignment and final disposition[a]. Fish with the adipose fin present were natural-origin, fish with the adipose fin absent were hatchery-origin.

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Sex	Fork Length (mm)	Run Assignment	Final Disposition[b]
12/27/05	80001	OR-305	Present	Female	900	Non-Winter	Released@Caldwell
12/27/05	80002	OR-307	Present	Female	820	Non-Winter	Released@Caldwell
12/27/05	80003	OR-311	Present	Female	950	Non-Winter	Released@Caldwell
12/27/05	80004	OR-314	Present	Female	900	Non-Winter	Released@Caldwell
12/27/05	80005	OR-318	Present	Female	840	Non-Winter	Released@Caldwell
12/27/05	80006	OR-327	Present	Female	880	Non-Winter	Released@Caldwell
12/27/05	80007	OR-329	Present	Female	810	Non-Winter	Released@Caldwell
12/27/05	80008	OR-331	Present	Female	900	Non-Winter	Released@Caldwell
12/27/05	80009	OR-335	Present	Female	780	Non-Winter	Released@Caldwell
12/27/05	80010	OR-338	Present	Male	720	Non-Winter	Released@Caldwell
12/27/05	80011	OR-340	Present	Female	780	Non-Winter	Released@Caldwell
12/27/05	80012	none	Present	Female	960	Non-Winter	Released@Caldwell
12/27/05	80013	OR-346	Present	Male	810	Non-Winter	Released@Caldwell
12/27/05	80014	OR-348	Present	Male	770	Non-Winter	Released@Caldwell
12/27/05	80015	OR-350	Present	Female	910	Non-Winter	Released@Caldwell
12/27/05	81001	none	Present	Male	480	undetermined	Released@Caldwell
12/27/05	81002	none	Present	Male	510	undetermined	Released@Caldwell
12/27/05	81003	none	Present	Female	580	undetermined	Released@Caldwell
12/27/05	81004	none	Present	Male	590	undetermined	Released@Caldwell
12/27/05	81005	none	Present	Female	390	undetermined	Released@Caldwell
12/27/05	81006	none	Present	Male	390	undetermined	Released@Caldwell
12/27/05	81007	none	Present	Male	543	undetermined	Released@Caldwell
12/27/05	81008	none	Present	Male	480	undetermined	Released@Caldwell
12/27/05	81009	none	Present	Female	407	undetermined	Released@Caldwell
12/27/05	81010	none	Present	Male	390	undetermined	Released@Caldwell
12/27/05	81011	none	Present	Male	450	undetermined	Released@Caldwell
12/27/05	81501	OR-326	Present	Female	880	undetermined	TransferredCNFH
2/14/06	80016	OR-355	Absent	Female	770	Non-Winter	Sacrificed
2/14/06	80017	OR-357	Absent	Female	820	Non-Winter	Sacrificed
2/14/06	80018	OR-359	Absent	Female	750	Non-Winter	Sacrificed
2/14/06	81012	none	Present	Male	490	undetermined	Released@Posse
2/14/06	81013	none	Present	Male	535	undetermined	Released@Posse
2/14/06	81014	none	Present	Male	460	undetermined	Released@Posse
2/14/06	81015	none	Present	Male	540	undetermined	Released@Posse
2/14/06	81503	OR-361	Present	Female	590	undetermined	TransferredCNFH
2/14/06	81502	OR-360	Present	Male	1000	undetermined	TransferredCNFH
2/14/06	81504	OR-356	Present	Male	920	undetermined	TransferredCNFH
2/14/06	81505	OR-358	Present	Male	870	undetermined	TransferredCNFH
2/21/06	80019	OR-362	Absent	Male	920	Winter	Released@Caldwell
2/21/06	80020	OR-363	Absent	Male	820	Winter	Released@Caldwell

Table 5 (cont.)

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Sex	Fork Length (mm)	Run Assignment	Final Disposition[b]
2/21/06	80021	OR-365	Absent	Male	750	Non-Winter	Sacrificed
2/21/06	80022	OR-366	Absent	Female	745	Non-Winter	Sacrificed
2/28/06	80057	OR-410	Present	Female	920	Non-Winter	Released@Posse
2/28/06	80058	OR-412	Absent	Female	760	Winter	Released@Posse
2/28/06	80059	OR-414	Present	Female	770	Winter	Released@Posse
2/28/06	80060	OR-416	Absent	Male	840	Winter	Released@Posse
2/28/06	80061	OR-418	Absent	Female	890	Winter	Released@Posse
2/28/06	80033	OR-420	Present	Female	735	Winter	Spawned
2/28/06	80062	OR-421	Present	Male	1000	Non-Winter	Released@Posse
2/28/06	80034	OR-423	Present	Female	813	Winter	Spawned
2/28/06	80063	OR-424	Absent	Female	710	Winter	Released@Posse
2/28/06	80064	OR-427	Absent	Male	870	Winter	Released@Posse
2/28/06	80065	OR-429	Absent	Female	760	Winter	Released@Posse
2/28/06	80035	OR-432	Present	Female	770	Winter	Spawned
2/28/06	80066	OR-433	Present	Male	760	Non-Winter	Released@Posse
2/28/06	80067	OR-435	Absent	Female	760	Winter	Released@Posse
2/28/06	80068	OR-437	Absent	Male	770	Winter	Released@Posse
2/28/06	80036	OR-440	Present	Male	918	Winter	Spawned
2/28/06	80037	OR-441	Present	Male	801	Winter	Spawned
2/28/06	80069	OR-442	Absent	Female	760	Winter	Released@Posse
2/28/06	80070	OR-444	Present	Female	790	undetermined	Released@Posse
2/28/06	80071	OR-446	Absent	Female	760	Winter	Released@Posse
2/28/06	80072	OR-448	Absent	Female	620	Winter	Released@Posse
2/28/06	80073	OR-450	Absent	Female	730	Winter	Released@Posse
2/28/06	80074	OR-452	Absent	Female	760	Winter	Released@Posse
2/28/06	80075	OR-454	Absent	Male	790	Winter	Released@Posse
2/28/06	80030	OR-396	Present	Male	798	Winter	Spawned
2/28/06	80052	OR-398	Absent	Female	830	Winter	Released@Caldwell
2/28/06	80053	OR-400	Absent	Female	850	Winter	Released@Caldwell
2/28/06	80031	OR-402	Present	Female	655	Winter	Spawned
2/28/06	80054	OR-403	Absent	Male	810	Winter	Released@Caldwell
2/28/06	80032	OR-405	Present	Female	801	Winter	Spawned
2/28/06	80055	OR-406	Absent	Female	770	Winter	Released@Caldwell
2/28/06	80023	OR-370	Absent	Female	810	Winter	Released@Posse
2/28/06	80045	OR-372	Absent	Female	730	Winter	Released@Posse
2/28/06	80046	OR-374	Absent	Female	795	Winter	Released@Posse
2/28/06	80047	OR-377	Absent	Male	790	Winter	Released@Posse
2/28/06	80048	OR-379	Absent	Male	810	undetermined	Released@Posse
2/28/06	80024	OR-381	Absent	Female	770	Winter	Released@Posse
2/28/06	80025	OR-385	Present	Female	758	Winter	Spawned
2/28/06	80026	OR-386	Present	Male	810	Winter	Prespawn
2/28/06	80049	OR-387	Absent	Male	750	Winter	Released@Posse
2/28/06	80027	OR-389	Present	Male	758	Winter	Spawned
2/28/06	80050	OR-390	Absent	Male	790	Winter	Released@Posse

Table 5 (cont.)

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Sex	Fork Length (mm)	Run Assignment	Final Disposition[b]
2/28/06	80051	OR-392	Absent	Male	770	Winter	Released@Posse
2/28/06	80028	OR-394	Present	Male	780	Winter	Spawned
2/28/06	80029	OR-395	Present	Male	786	Winter	Spawned
2/28/06	80056	OR-408	Present	Male	1000	Non-Winter	Released@Posse
2/28/06	80076	OR-456	Absent	Female	770	Winter	Released@Posse
2/28/06	80038	OR-458	Present	Female	780	Winter	Spawned
2/28/06	80077	OR-397	Absent	Female	775	Winter	Released@Posse
2/28/06	80078	OR-460	Absent	Male	840	Winter	Released@Posse
2/28/06	80079	OR-462	Present	Female	750	Winter	Released@Posse
2/28/06	80039	OR-494	Present	Female	820	Winter	Released@Posse
2/28/06	80080	OR-465	Absent	Female	710	Winter	Released@Posse
2/28/06	80081	OR-467	Absent	Female	870	Winter	Released@Posse
2/28/06	80082	OR-469	Present	Female	920	Non-Winter	Released@Posse
2/28/06	80083	OR-471	Absent	Male	850	Winter	Released@Posse
2/28/06	80084	OR-473	Absent	Male	900	Winter	Released@Posse
2/28/06	80040	OR-475	Present	Male	800	Winter	Prespawn
2/28/06	80085	OR-476	Absent	Female	680	Winter	Released@Posse
2/28/06	80041	OR-478	Present	Male	785	Winter	Prespawn
2/28/06	80042	OR-479	Present	Female	800	Winter	Spawned
2/28/06	80086	OR-480	Absent	Male	820	Winter	Released@Posse
2/28/06	80087	OR-482	Present	Male	1000	Non-Winter	Released@Posse
2/28/06	80043	OR-483	Present	Female	710	Winter	Spawned
2/28/06	80088	OR-484	Absent	Male	760	Winter	Released@Posse
2/28/06	80089	OR-489	Absent	Female	680	Winter	Released@Posse
2/28/06	80044	OR-492	Present	Male	740	Winter	Released@Posse
4/25/06	80090	OR-497	Absent	Male	780	Winter	Released@Caldwell
4/25/06	80091	OR-499	Absent	Female	900	Winter	Released@Caldwell
4/25/06	80092	W-001	Absent	Male	790	Winter	Released@Caldwell
4/25/06	80093	W-003	Absent	Male	820	Winter	Released@Caldwell
4/25/06	80094	W-005	Absent	Female	730	Winter	Released@Caldwell
5/2/06	80111	W-007	Absent	Female	810	Winter	Released@Caldwell
5/2/06	80112	W-009	Absent	Male	910	Winter	Released@Caldwell
5/2/06	80113	W-011	Absent	Male	840	Winter	Released@Caldwell
5/2/06	80114	W-013	Present	Male	1000	undetermined	Released@Caldwell
5/2/06	80115	W-015	Present	Male	1000	Winter	Released@Caldwell
5/2/06	80116	W-017	Absent	Male	810	Winter	Released@Caldwell
5/2/06	80117	W-019	Absent	Male	860	Winter	Released@Caldwell
5/2/06	80118	W-021	Absent	Female	830	Winter	Released@Caldwell
5/2/06	80119	W-023	Absent	Male	900	Winter	Released@Caldwell
5/2/06	80120	W-025	Absent	Male	880	Winter	Released@Caldwell
5/2/06	80121	W-027	Present	Male	740	Winter	Released@Caldwell
5/2/06	80122	W-029	Absent	Male	750	Winter	Released@Caldwell
5/2/06	80123	W-031	Absent	Male	920	Winter	Released@Caldwell
5/2/06	80124	W-033	Absent	Male	860	Winter	Released@Caldwell
5/2/06	80125	W-035	Absent	Female	800	Winter	Released@Caldwell

Table 5 (cont.)

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Sex	Fork Length (mm)	Run Assignment	Final Disposition[b]
5/2/06	80126	W-037	Partial	Male	860	Winter	Released@Caldwell
5/2/06	80127	W-039	Absent	Female	680	Winter	Released@Caldwell
5/2/06	80095	W-041	Absent	Female	892	Winter	Spawned
5/2/06	80128	W-042	Absent	Male	1000	undetermined	Released@Caldwell
5/2/06	80096	W-044	Absent	Female	820	Winter	Spawned
5/2/06	80097	W-047	Present	Female	795	Winter	Spawned
5/2/06	80129	W-048	Absent	Male	860	Winter	Released@Caldwell
5/2/06	80098	W-050	Present	Male	890	Winter	Spawned
5/2/06	80099	W-051	Present	Female	680	Winter	Released@Caldwell
5/2/06	80130	W-052	Absent	Male	780	Winter	Released@Caldwell
5/2/06	80131	W-054	Absent	Female	900	Winter	Released@Caldwell
5/2/06	80132	W-056	Absent	Male	800	Non-Winter	Released@Caldwell
5/2/06	80133	W-059	Absent	Male	810	Winter	Released@Caldwell
5/2/06	80134	W-061	Absent	Male	780	Winter	Released@Caldwell
5/2/06	80135	W-063	Absent	Male	770	Winter	Released@Caldwell
5/2/06	80136	W-065	Absent	Male	800	Winter	Released@Caldwell
5/2/06	80137	W-067	Absent	Male	870	Winter	Released@Caldwell
5/2/06	80138	W-069	Present	Unknown	680	Non-Winter	Released@Caldwell
5/2/06	80139	W-071	Absent	Male	800	Winter	Released@Caldwell
5/2/06	80140	W-073	Absent	Male	830	undetermined	Released@Caldwell
5/2/06	80100	W-075	Present	Female	777	Winter	Spawned
5/2/06	80101	W-076	Present	Female	828	Winter	Spawned
5/2/06	80141	W-077	Present	Male	1000	Winter	Released@Caldwell
5/2/06	80102	W-079	Present	Female	690	Non-Winter	Released@Caldwell
5/2/06	80103	W-080	Present	Male	757	Winter	Spawned
5/2/06	80104	W-081	Present	Male	857	Winter	Spawned
5/2/06	80142	W-082	Present	Male	920	Winter	Released@Caldwell
5/2/06	80143	W-084	Present	Male	880	Non-Winter	Released@Caldwell
5/2/06	80144	W-086	Present	Male	910	Non-Winter	Released@Caldwell
5/2/06	80105	W-088	Present	Female	721	Winter	Spawned
5/2/06	80145	W-089	Present	Female	640	Winter	Released@Caldwell
5/2/06	80106	W-091	Partial	Female	810	Winter	Released@Caldwell
5/2/06	80146	W-093	Present	Female	710	Winter	Released@Caldwell
5/2/06	80147	W-095	Present	Male	820	Non-Winter	Released@Caldwell
5/2/06	80107	W-097	Present	Female	710	Non-Winter	Released@Caldwell
5/2/06	80149	W-100	Present	Female	690	Winter	Released@Caldwell
5/2/06	80108	W-102	Present	Female	685	Non-Winter	Released@Caldwell
5/2/06	80109	W-103	Present	Female	735	Winter	Spawned
5/2/06	80150	W-104	Present	Male	not measured	Winter	Released@Caldwell
5/2/06	80151	W-106	Present	Male	770	Winter	Released@Caldwell
5/2/06	80152	W-108	Present	Male	900	Winter	Released@Caldwell
5/2/06	80110	W-110	Present	Female	717	Winter	Spawned
5/9/06	80153	W-116	Present	Male	881	Winter	Spawned
5/9/06	80154	W-117	Present	Male	640	Non-Winter	Released@Caldwell
5/9/06	80155	W-119	Absent	Male	not measured	Winter	Released@Caldwell

Table 5 (cont.)

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Sex	Fork Length (mm)	Run Assignment	Final Disposition[b]
5/9/06	80156	W-121	Absent	Male	875	Winter	Released@Caldwell
5/9/06	80168	W-124	Absent	Male	970	Winter	Released@Caldwell
5/9/06	80169	W-126	Absent	Male	770	Winter	Released@Caldwell
5/9/06	80157	W-128	Present	Male	878	Winter	Spawned
5/9/06	80158	W-129	Present	Male	876	Winter	Spawned
5/9/06	80170	W-130	Present	Female	728	Non-Winter	Released@Caldwell
5/9/06	80171	W-132	Absent	Male	900	Winter	Released@Caldwell
5/9/06	80172	W-134	Absent	Male	870	undetermined	Released@Caldwell
5/9/06	80173	W-136	Present	Female	752	Non-Winter	Released@Caldwell
5/9/06	80174	W-138	Absent	Female	828	Winter	Released@Caldwell
5/9/06	80175	W-140	Absent	Female	809	Winter	Released@Caldwell
5/9/06	80159	W-142	Present	Female	867	Winter	Spawned
5/9/06	80176	W-143	Partial	Male	767	Winter	Released@Caldwell
5/9/06	80177	W-146	Absent	Female	770	Non-Winter	Released@Caldwell
5/9/06	80178	W-148	Absent	Male	1000	Winter	Released@Caldwell
5/9/06	80179	W-150	Absent	Female	701	Winter	Released@Caldwell
5/9/06	80180	W-153	Absent	Female	743	Winter	Released@Caldwell
5/9/06	80181	W-155	Absent	Male	778	Winter	Released@Caldwell
5/9/06	80182	W-157	Absent	Male	992	Winter	Released@Caldwell
5/9/06	80183	W-159	Absent	Female	779	Winter	Released@Caldwell
5/9/06	80160	W-162	Present	Female	810	Winter	Spawned
5/9/06	80161	W-163	Present	Male	808	Winter	Spawned
5/9/06	80162	W-164	Present	Female	600	Non-Winter	Released@Caldwell
5/9/06	80184	W-165	Present	Female	738	Non-Winter	Released@Caldwell
5/9/06	80185	W-167	Absent	Male	881	Winter	Released@Caldwell
5/9/06	80163	W-170	Present	Male	856	Winter	Spawned
5/9/06	80186	W-171	Present	Male	725	Non-Winter	Released@Caldwell
5/9/06	80187	W-173	Present	Male	1000	Winter	Released@Caldwell
5/9/06	80164	W-175	Present	Male	834	Winter	Spawned
5/9/06	80165	W-176	Present	Male	957	Winter	Spawned
5/9/06	80166	W-177	Present	Female	828	Winter	Spawned
5/9/06	80188	W-178	Absent	Female	775	Non-Winter	Released@Caldwell
5/9/06	80189	W-180	Absent	Male	1000	Winter	Released@Caldwell
5/9/06	80167	W-182	Present	Male	620	Non-Winter	Released@Caldwell
5/9/06	80190	W-183	Absent	Male	648	Winter	Released@Caldwell
5/16/06	80207	W-187	Absent	Female	780	Winter	Released@Caldwell
5/16/06	80208	W-190	Absent	Female	720	Winter	Released@Caldwell
5/16/06	80209	W-192	Absent	Male	970	Winter	Released@Caldwell
5/16/06	80210	W-194	Present	Male	830	Winter	Released@Caldwell
5/16/06	80191	W-196	Present	Male	880	Winter	Spawned
5/16/06	80192	W-197	Present	Female	849	Winter	Spawned
5/16/06	80211	W-198	Absent	Male	800	Winter	Released@Caldwell
5/16/06	80212	W-200	Absent	Male	870	Winter	Released@Caldwell
5/16/06	80193	W-202	Present	Female	820	Winter	Spawned
5/16/06	80213	W-203	Absent	Female	820	Winter	Released@Caldwell

Table 5 (cont.)

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Sex	Fork Length (mm)	Run Assignment	Final Disposition[b]
5/16/06	80214	W-205	Present	Male	825	Winter	Released@Caldwell
5/16/06	80215	W-207	Absent	Male	820	Winter	Released@Caldwell
5/16/06	80194	W-209	Present	Male	842	Winter	Spawned
5/16/06	80216	W-210	Present	Male	780	Non-Winter	Released@Caldwell
5/16/06	80195	W-212	Present	Female	780	Winter	Released@Caldwell
5/16/06	80217	W-213	Absent	Female	730	Winter	Released@Caldwell
5/16/06	80218	W-215	Absent	Male	710	Winter	Released@Caldwell
5/16/06	80219	W-217	Present	Female	770	Non-Winter	Released@Caldwell
5/16/06	80220	W-219	Present	Male	760	Non-Winter	Released@Caldwell
5/16/06	80196	W-221	Present	Female	868	Winter	Spawned
5/16/06	80221	W-222	Absent	Male	890	Winter	Released@Caldwell
5/16/06	80222	W-224	Present	Male	750	Winter	Released@Caldwell
5/16/06	80223	W-226	Absent	Female	820	Winter	Released@Caldwell
5/16/06	80224	W-228	Absent	Male	710	Winter	Released@Caldwell
5/16/06	80225	W-230	Present	Male	800	Non-Winter	Released@Caldwell
5/16/06	80226	W-232	Absent	Female	755	Winter	Released@Caldwell
5/16/06	80227	W-234	Absent	Male	810	Winter	Released@Caldwell
5/16/06	80228	W-236	Absent	Female	630	Winter	Released@Caldwell
5/16/06	80197	W-238	Present	Male	818	Winter	Spawned
5/16/06	80229	W-239	Present	Male	1000	Winter	Released@Caldwell
5/16/06	80198	W-241	Present	Female	815	Winter	Spawned
5/16/06	80230	W-242	Absent	Female	740	Winter	Released@Caldwell
5/16/06	80199	W-244	Present	Female	795	Winter	Spawned
5/16/06	80231	W-245	Absent	Female	640	Winter	Released@Caldwell
5/16/06	80232	W-247	Absent	Male	700	Winter	Released@Caldwell
5/16/06	80233	W-249	Absent	Male	not measured	Winter	Released@Caldwell
5/16/06	80200	W-251	Present	Male	818	Winter	Spawned
5/16/06	80234	W-252	Absent	Female	720	Non-Winter	Released@Caldwell
5/16/06	80235	W-254	Absent	Female	780	Winter	Released@Caldwell
5/16/06	80201	W-256	Present	Male	760	Winter	Spawned
5/16/06	80202	W-257	Present	Male	893	Winter	Spawned
5/16/06	81019	none	Present	Male	270	undetermined	Released@Caldwell
5/16/06	81020	none	Present	Male	530	undetermined	Released@Caldwell
5/16/06	81021	none	Present	Male	340	undetermined	Released@Caldwell
5/16/06	81022	none	Present	Male	320	undetermined	Released@Caldwell
5/16/06	80203	W-258	Present	Female	784	Winter	Spawned
5/16/06	80204	W-259	Present	Male	790	Winter	Spawned
5/16/06	80236	W-260	Present	Male	780	Winter	Released@Caldwell
5/16/06	80205	W-262	Present	Female	760	Winter	Spawned
5/16/06	80237	W-263	Present	Male	820	Winter	Released@Caldwell
5/16/06	80238	W-265	Present	Male	750	Winter	Released@Caldwell
5/16/06	80206	W-267	Present	Female	798	Winter	Spawned
5/23/06	81023	none	Present	Male	380	undetermined	Released@Caldwell
5/23/06	81024	none	Present	Male	385	undetermined	Released@Caldwell
5/23/06	81025	none	Present	Female	416	undetermined	Released@Caldwell

Table 5	(cont.)						
Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Sex	Fork Length (mm)	Run Assignment	Final Disposition[b]
5/23/06	81026	none	Present	Unknown	251	undetermined	Released@Caldwell
5/23/06	80245	W-270	Absent	Female	720	Winter	Released@Caldwell
5/23/06	80246	W-272	Present	Male	810	Winter	Released@Caldwell
5/23/06	80239	W-274	Present	Female	815	Winter	Spawned
5/23/06	80240	W-277	Present	Male	781	Non-Winter	Released@Caldwell
5/23/06	80247	W-278	Present	Male	802	Winter	Released@Caldwell
5/23/06	80248	W-281	Absent	Male	851	Winter	Released@Caldwell
5/23/06	80249	W-283	Absent	Male	655	Winter	Released@Caldwell
5/23/06	80250	W-285	Absent	Female	675	Winter	Released@Caldwell
5/23/06	80241	W-287	Present	Female	803	Winter	Spawned
5/23/06	80242	W-288	Present	Female	805	Winter	Spawned
5/23/06	80251	W-289	Absent	Male	810	Winter	Released@Caldwell
5/23/06	80252	W-291	Present	Female	705	Non-Winter	Released@Caldwell
5/23/06	80243	W-293	Present	Female	787	Winter	Spawned
5/23/06	80253	W-294	Absent	Male	878	Winter	Released@Caldwell
5/23/06	80254	W-296	Absent	Female	782	Winter	Released@Caldwell
5/23/06	80244	W-298	Present	Female	788	Winter	Spawned
5/23/06	80255	W-299	Present	Male	905	Winter	Released@Caldwell
5/23/06	80256	W-301	Absent	Male	765	Winter	Released@Caldwell
5/23/06	80257	W-303	Absent	Male	818	Winter	Released@Caldwell
5/23/06	80258	W-305	Absent	Female	801	Winter	Released@Caldwell
5/30/06	80266	W-338	Present	Female	685	Winter	Spawned
5/30/06	80283	W-308	Present	Female	830	undetermined	Released@Caldwell
5/30/06	80259	W-310	Present	Male	950	Winter	Spawned
5/30/06	80284	W-311	Absent	Female	870	Winter	Released@Caldwell
5/30/06	80285	W-313	Absent	Female	740	Winter	Released@Caldwell
5/30/06	80286	W-315	Absent	Female	810	Winter	Released@Caldwell
5/30/06	80287	W-317	Absent	Male	830	Winter	Released@Caldwell
5/30/06	80288	W-320	Absent	Male	860	Winter	Released@Caldwell
5/30/06	80289	W-322	Absent	Female	860	Winter	Released@Caldwell
5/30/06	80260	W-324	Present	Male	978	Winter	Spawned
5/30/06	80261	W-325	Present	Female	868	Winter	Spawned
5/30/06	80290	W-326	Absent	Female	760	Winter	Released@Caldwell
5/30/06	80262	W-328	Present	Male	760	Winter	Prespawn mortality
5/30/06	80263	W-329	Present	Female	792	Winter	Spawned
5/30/06	80264	W-330	Present	Male	910	Winter	Spawned
5/30/06	80291	W-331	Absent	Female	810	Winter	Released@Caldwell
5/30/06	80292	W-333	Absent	Female	790	undetermined	Released@Caldwell
5/30/06	80293	W-335	Present	Female	770	Non-Winter	Released@Caldwell
5/30/06	80265	W-337	Present	Male	838	Winter	Spawned
5/30/06	80294	W-339	Absent	Male	1000	Winter	Released@Caldwell
5/30/06	80267	W-341	Present	Female	742	Winter	Spawned
5/30/06	80295	W-342	Present	Male	940	Winter	Released@Caldwell
5/30/06	80296	W-344	Absent	Male	910	Winter	Released@Caldwell
5/30/06	80297	W-347	Absent	Female	800	Winter	Released@Caldwell

Table 5 (cont.)							
Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Sex	Fork Length (mm)	Run Assignment	Final Disposition[b]
5/30/06	80268	W-349	Present	Female	773	Winter	Spawned
5/30/06	80298	W-350	Absent	Male	790	Winter	Released@Caldwell
5/30/06	80299	W-352	Absent	Female	820	Winter	Released@Caldwell
5/30/06	80269	W-354	Present	Male	915	Winter	Spawned
5/30/06	80300	W-355	Present	Female	777	Winter	Spawned
5/30/06	80301	W-356	Absent	Female	810	Winter	Released@Caldwell
5/30/06	80270	W-358	Present	Male	904	Winter	Spawned
5/30/06	80271	W-359	Present	Male	843	Winter	Spawned
5/30/06	80302	W-360	Present	Male	900	Winter	Released@Caldwell
5/30/06	80303	W-362	Absent	Female	760	Winter	Released@Caldwell
5/30/06	80272	W-364	Present	Female	826	Winter	Spawned
5/30/06	80304	W-365	Partial	Male	780	Winter	Released@Caldwell
5/30/06	80305	W-367	Absent	Female	840	Winter	Released@Caldwell
5/30/06	80273	W-369	Present	Female	767	Winter	Spawned
5/30/06	80306	W-370	Absent	Male	880	Winter	Released@Caldwell
5/30/06	80307	W-372	Absent	Male	900	Winter	Released@Caldwell
5/30/06	80308	W-374	Absent	Female	890	Winter	Released@Caldwell
5/30/06	80309	W-376	Absent	Male	910	Winter	Released@Caldwell
5/30/06	80310	W-378	Present	Female	650	Non-Winter	Released@Caldwell
5/30/06	80311	W-380	Absent	Male	920	Winter	Released@Caldwell
5/30/06	80312	W-382	Absent	Female	800	Winter	Released@Caldwell
5/30/06	80313	W-384	Absent	Female	790	Winter	Released@Caldwell
5/30/06	80314	W-386	Partial	Female	710	Winter	Released@Caldwell
5/30/06	80315	W-388	Absent	Female	810	Winter	Released@Caldwell
5/30/06	80316	W-390	Absent	Female	770	Winter	Released@Caldwell
5/30/06	80317	W-392	Absent	Female	750	Winter	Released@Caldwell
5/30/06	80318	W-394	Absent	Female	700	Winter	Released@Caldwell
5/30/06	80274	W-396	Present	Female	825	Winter	Spawned
5/30/06	80275	W-397	Present	Female	830	Winter	Spawned
5/30/06	80319	W-398	Absent	Male	740	Winter	Released@Caldwell
5/30/06	80320	W-400	Absent	Female	840	Winter	Released@Caldwell
5/30/06	80276	W-402	Present	Female	808	Winter	Spawned
5/30/06	80321	W-403	Absent	Female	690	Winter	Released@Caldwell
5/30/06	80322	W-405	Absent	Female	760	Winter	Released@Caldwell
5/30/06	80323	W-407	Absent	Male	820	Winter	Released@Caldwell
5/30/06	80324	W-409	Absent	Female	840	Winter	Released@Caldwell
5/30/06	80277	W-411	Present	Male	880	Winter	Spawned
5/30/06	80278	W-412	Present	Female	770	Winter	Spawned
5/30/06	80279	W-413	Present	Female	809	Winter	Spawned
5/30/06	80325	W-414	Absent	Female	780	Winter	Released@Caldwell
5/30/06	80326	W-416	Absent	Male	800	Winter	Released@Caldwell
5/30/06	80327	W-418	Present	Female	630	Non-Winter	Released@Caldwell
5/30/06	80328	W-420	Present	Female	780	Winter	Released@Caldwell
5/30/06	80329	W-422	Present	Male	780	Non-Winter	Released@Caldwell
5/30/06	80330	W-424	Present	Female	790	Winter	Released@Caldwell

Table 5 (cont.)

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Sex	Fork Length (mm)	Run Assignment	Final Disposition[b]
5/30/06	80331	W-426	Present	Female	700	Non-Winter	Released@Caldwell
5/30/06	80332	W-429	Present	Female	700	Non-Winter	Released@Caldwell
5/30/06	80281	W-431	Present	Male	865	Winter	Spawned
5/30/06	80282	W-432	Present	Male	865	Winter	Spawned
5/30/06	80333	W-433	Present	Male	not measured	Non-Winter	Released@Caldwell
5/30/06	81027	none	Present	Female	430	undetermined	Released@Caldwell
5/30/06	81028	none	Present	Female	300	undetermined	Released@Caldwell
5/30/06	80280	W-428	Present	Male	695	Winter	Spawned
6/13/06	80338	W-435	Absent	Male	780	Winter	Released@Caldwell
6/13/06	80339	W-438	Absent	Male	780	Winter	Released@Caldwell
6/13/06	80334	W-440	Present	Female	741	Winter	Spawned
6/13/06	80340	W-441	Absent	Female	830	Winter	Released@Caldwell
6/13/06	80341	W-443	Present	Male	930	Winter	Released@Caldwell
6/13/06	80342	W-445	Absent	Female	800	Winter	Released@Caldwell
6/13/06	80343	W-447	Absent	Female	780	Winter	Released@Caldwell
6/13/06	80344	W-449	Absent	Male	850	Winter	Released@Caldwell
6/13/06	80345	W-451	Absent	Male	730	Winter	Released@Caldwell
6/13/06	80346	W-453	Present	Female	800	Winter	Released@Caldwell
6/13/06	80347	W-455	Absent	Male	780	Winter	Released@Caldwell
6/13/06	80348	W-457	Absent	Female	720	Winter	Released@Caldwell
6/13/06	80349	W-459	Absent	Female	830	Winter	Released@Caldwell
6/13/06	80350	W-461	Present	Male	900	Winter	Released@Caldwell
6/13/06	80351	W-463	Present	Female	740	Winter	Released@Caldwell
6/13/06	80335	W-465	Present	Female	820	Winter	Spawned
6/13/06	80352	W-466	Absent	Male	880	Winter	Released@Caldwell
6/13/06	80336	W-468	Present	Male	787	Non-Winter	Released@Caldwell
6/13/06	80353	W-469	Present	Male	710	Non-Winter	Released@Caldwell
6/13/06	80354	W-471	Absent	Male	540	Winter	Released@Caldwell
6/13/06	80337	W-473	Present	Male	905	Winter	Spawned
6/13/06	80355	W-474	Absent	Male	850	Winter	Released@Caldwell
6/13/06	80356	W-476	Absent	Female	770	Winter	Released@Caldwell
6/27/06	80357	W-480	Absent	Female	780	Winter	Released@Caldwell
6/27/06	80358	W-482	Absent	Male	505	Winter	Released@Caldwell
6/27/06	80359	W-485	Absent	Male	690	Winter	Released@Caldwell
6/27/06	80360	W-488	Present	Male	690	Non-Winter	Released@Caldwell
6/27/06	80361	W-490	Absent	Male	700	Winter	Released@Caldwell
6/27/06	80362	W-492	Present	Male	870	Winter	Released@Caldwell
6/27/06	80363	W-494	Absent	Male	930	Winter	Released@Caldwell
6/27/06	80364	W-496	Present	Female	831	Winter	Spawned
6/27/06	80365	W-497	Partial	Male	630	Winter	Released@Caldwell
6/27/06	80366	W-499	Absent	Male	795	Winter	Released@Caldwell
6/27/06	81030	none	Present	Male	355	undetermined	Released@Caldwell
7/11/06	80385	Y-030	Present	Male	520	Non-Winter	Released@Caldwell
7/11/06	80384	Y-027	Present	Female	735	Non-Winter	Released@Caldwell
7/11/06	80383	Y-025	Absent	Male	1000	Winter	Released@Caldwell

Table 5 (cont.)

Date Captured	Genetic Sample ID	Individual Tag Code	Adipose Fin Status	Sex	Fork Length (mm)	Run Assignment	Final Disposition[b]
7/11/06	80382	Y-023	Absent	Female	770	Winter	Released@Caldwell
7/11/06	80381	Y-021	Present	Female	755	Non-Winter	Released@Caldwell
7/11/06	80370	Y-020	Present	Female	830	Winter	Spawned
7/11/06	80380	Y-018	Present	Female	720	Non-Winter	Released@Caldwell
7/11/06	80369	Y-017	Present	Male	668	Winter	Spawned
7/11/06	80379	Y-015	Absent	Female	670	Winter	Released@Caldwell
7/11/06	80368	Y-014	Present	Female	750	Winter	Spawned
7/11/06	80378	Y-012	Absent	Male	760	Non-Winter	Released@Caldwell
7/11/06	80377	Y-010	Present	Female	750	Non-Winter	Released@Caldwell
7/11/06	80376	Y-008	Partial	Male	710	Winter	Released@Caldwell
7/11/06	80375	Y-006	Present	Male	670	Non-Winter	Released@Caldwell
7/11/06	80374	Y-04	Present	Male	740	Non-Winter	Released@Caldwell
7/11/06	80367	Y-01	Present	Male	800	Non-Winter	Released@Caldwell
7/11/06	80386	Y-032	Present	Male	725	Winter	Released@Caldwell
7/11/06	80387	Y-034	Present	Male	690	Non-Winter	Released@Caldwell
7/11/06	80371	Y-036	Present	Female	690	Winter	Spawned
7/11/06	80388	Y-037	Present	Male	750	Non-Winter	Released@Caldwell
7/11/06	80389	Y-039	Present	Female	690	Non-Winter	Released@Caldwell
7/11/06	80390	Y-041	Present	Female	850	Non-Winter	Released@Caldwell
7/11/06	80391	Y-043	Present	Male	725	Non-Winter	Released@Caldwell
7/11/06	80392	Y-045	Present	Female	685	Non-Winter	Released@Caldwell
7/11/06	80393	Y-047	Present	Female	760	Non-Winter	Released@Caldwell
7/11/06	80394	Y-049	Present	Female	670	Non-Winter	Released@Caldwell
7/11/06	80372	Y-052	Present	Male	715	Non-Winter	Released@Caldwell
7/11/06	80395	Y-053	Present	Female	760	Non-Winter	Released@Caldwell
7/11/06	80396	Y-055	Present	Male	850	Winter	Released@Caldwell
7/11/06	80397	Y-057	Present	Male	800	Non-Winter	Released@Caldwell
7/11/06	80398	Y-059	Present	Female	710	Winter	Released@Caldwell
7/11/06	80373	Y-061	Present	Male	793	Winter	Spawned
7/11/06	80399	Y-062	Present	Female	890	Non-Winter	Released@Caldwell
7/11/06	80400	Y-064	Present	Male	520	Non-Winter	Released@Caldwell
7/11/06	80401	Y-066	Present	Male	515	Non-Winter	Released@Caldwell
7/11/06	80402	Y-068	Present	Female	740	Winter	Released@Caldwell
7/11/06	80403	Y-070	Present	Male	670	Non-Winter	Released@Caldwell
7/11/06	80404	Y-073	Present	Female	680	Non-Winter	Released@Caldwell
7/11/06	80405	Y-075	Present	Male	740	Non-Winter	Released@Caldwell
7/11/06	80406	Y-077	Present	Male	850	Winter	Released@Caldwell
7/11/06	80407	Y-079	Present	Male	690	Non-Winter	Released@Caldwell
7/11/06	80408	Y-081	Present	Male	560	Non-Winter	Released@Caldwell
7/11/06	80409	Y-083	Present	Female	730	Non-Winter	Released@Caldwell
7/11/06	80410	Y-085	Absent	Male	490	Winter	Released@Caldwell
7/11/06	80411	Y-087	Present	Male	370	Non-Winter	Released@Caldwell
7/11/06	80412	Y-089	Present	Female	680	Non-Winter	Released@Caldwell

[a] An additional 52 fish were captured but not tissue sampled. Those fish are not included in this table.

[b] Released@Caldwell = Caldwell Park, ~river mile 298.5; Released@Posse = Posse Grounds Ramp, ~river mile 298

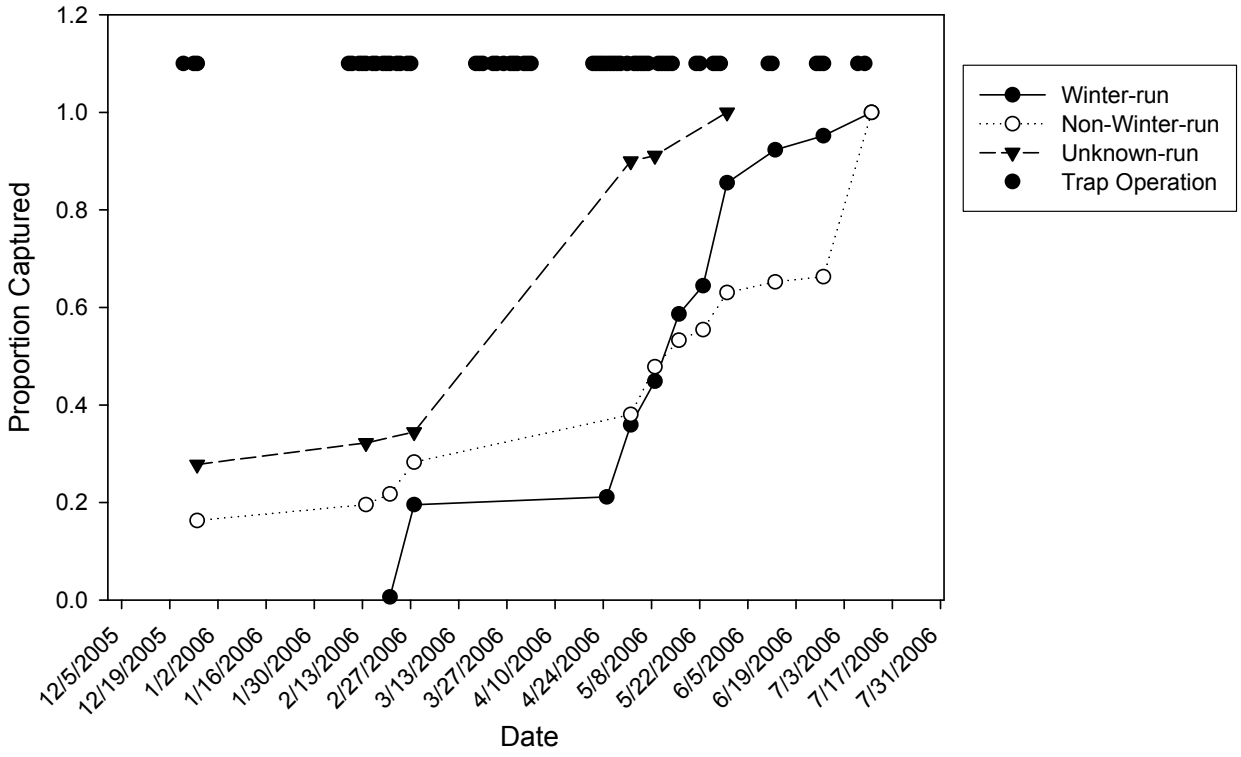

Figure 1. Capture timing of Chinook salmon from the Keswick Dam trap by run-type, brood year 2006.

Table 6. Disposition of chinook salmon trapped at the Keswick Dam trap, December, 2005 - July, 2006, by run identity and gender. Numbers in parentheses indicate the number of hatchery-origin fish included in the category total.

Run Identity	Disposition	Keswick Trap			
		Total	Males	Females	Unknown
Winter	Trapped and spawned	89 (2)	37 (0)	52 (2)	0 (0)
Winter	Pre-spawn mortality	4 (0)	4 (0)	0 (0)	0 (0)
Winter	Trapped, quarantined, and released back into river	6 (2)	3 (2)	3 0	0 (0)
Winter	Trapped and released back into river without quarantine	213 (176)	119 (93)	94 (83)	0 (0)
	Subtotal	312 (180)	163 (95)	149 (85)	0 (0)
Non-winter	Pre-spawn mortality	0 (0)	0 (0)	0 (0)	0 (0)
Non-winter	Trapped, quarantined, and released back into river	7 (0)	4 (0)	3 (0)	0 (0)
Non-winter	Trapped and released back into river without quarantine	80 (5)	37 (2)	42 (3)	1 (0)
Non-winter	Transferred to Coleman National Fish Hatchery	5 (0)	3 (0)	2 (0)	0 (0)
Non-winter	Euthanized	7 (7)	2 (2)	5 (5)	0 (0)
	Subtotal	99 (12)	46 (4)	52 (8)	1 (0)
Undetermined	Pre-spawn mortality	0 (0)	0 (0)	0 (0)	0 (0)
Undetermined	Trapped, quarantined, and released back into river	20 (0)	8 (0)	12 (0)	0 (0)
Undetermined	Trapped and released back into river without quarantine	63 (58)	35 (33)	28 (25)	0 (0)
	Subtotal	83 (58)	43 (33)	40 (25)	0 (0)
	Total	494 (250)	252 (132)	241 (118)	1 (0)

Health

The causative agent of bacterial kidney disease (*Renibacterium salmoninarum*) was present in broodstock from the Sacramento River and Livingston Stone NFH (Table 7). Sacramento River broodstock also tested positive for infectious hematopoietic necrosis virus, *Ceratomyxa shasta,* and *Parvicapsula minibicornis* (Table 7).

Table 7. Test results (positive or negative) for fish pathogens in brood year 2006 winter Chinook salmon brood stock and juveniles, conducted by the USFWS California - Nevada Fish Health Center.

	Brood stock origin		
	Sacramento River	Livingston Stone Captive	Juveniles[a]
Pathogen	positive / negative	positive / negative	positive / negative
Aeromonas salmonicida	negative	negative	negative
Yersinia ruckeri	negative	negative	negative
Renibacterium salmoninarum	positive	positive	positive
Infectious hematopoietic necrosis virus	positive	negative	negative
Viral hemorrhagic septicemia virus	negative	negative	negative
Infectious pancreatic necrosis virus	negative	negative	negative
Ceratomyxa shasta	positive	no test	no test
Parvicapsula minibicornis	positive	no test	no test
Myxobolus cerebralis	no test	no test	negative

[a] Juvenile progeny of the brood stock origin types were combined for the assay.

Spawning & Production- Non-captive Broodstock

Brood year 2006 winter Chinook salmon were spawned between May 5, 2006 and July 20, 2006 (Tables 2 and 3, Figure 2). A total of 52 female (Table 2) and 37 male (Table 3) winter Chinook salmon were spawned producing 102 family groups (Table 8). Fork length of spawned females ranged from 655 to 892 mm and averaged 789 mm (Table 2). Fork length of spawned males ranged from 668 to 978 mm and averaged 844 mm (Table 3). Females produced an average of 5,382 green eggs yielding a total of 279,853 green eggs with 93% of these developing into eyed eggs (Table 8). The percent of green eggs that hatched averaged 91%, and 68% of the green eggs resulted in juveniles that were transferred to rearing tanks (Table 8).

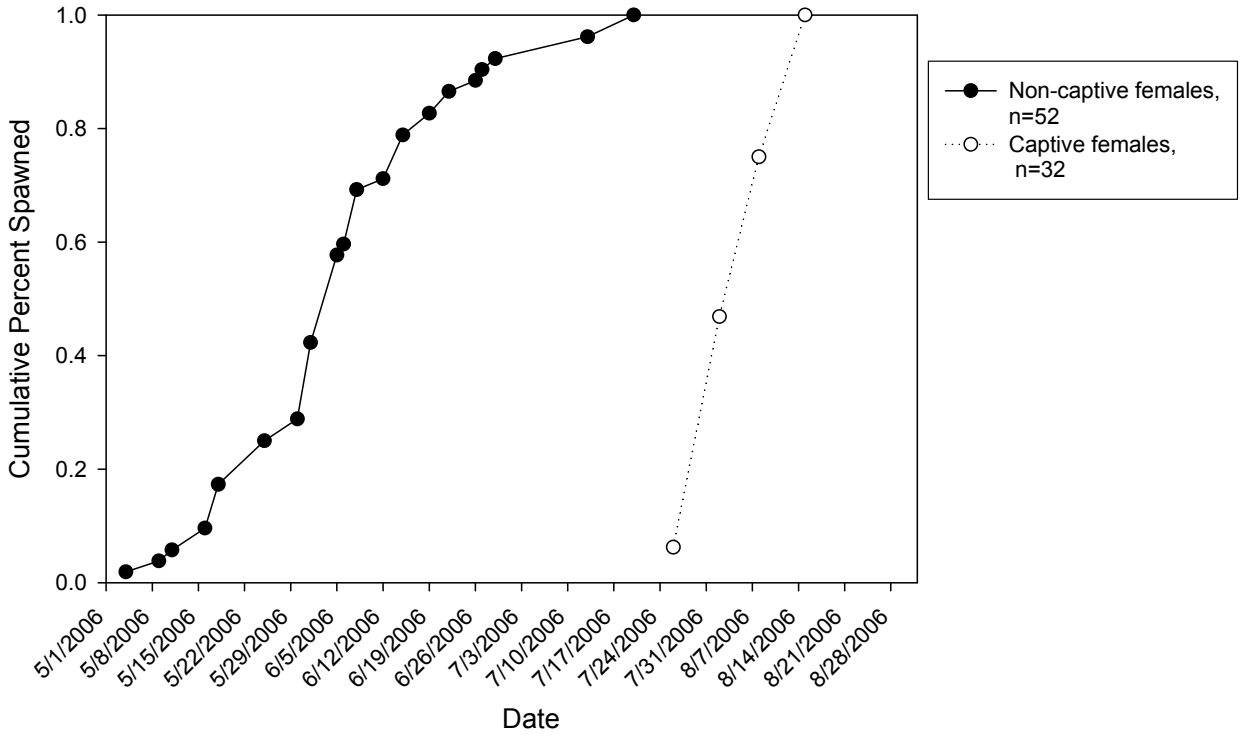

Figure 2. Spawning of winter Chinook salmon at Livingston Stone National Fish Hatchery, brood year 2006.

Table 8. Early survival[a] of eggs and fry from winter Chinook salmon captured from the wild and spawned at Livingston Stone National Fish Hatchery, 2006.

Crosses by tag number		Family	Date	Green	Eyed	Percent	Number	Percent Green	Number	Percent Green	Percent Eyed
Female	Male	Group	Spawned	Eggs	Eggs	Eyed	Hatched	Eggs Hatched	Tanked	Eggs Tanked	Eggs Tanked
W-041	OR-440	1A	5/4/06	3100	3008	97	2991	96	2972	96	99
W-041	OR-389	1B	5/4/06	3211	3136	98	3116	97	3110	97	99
W-044	OR-441	2C	5/4/06	2587	2563	99	2558	99	2516	97	98
W-044	W-050	2D	5/4/06	3378	3258	96	3252	96	3069	91	94
OR-479	OR-440	3A	5/9/06	2586	2108	82	1773	69	1744	67	83
OR-479	OR-389	3B	5/9/06	2282	1780	78	1637	72	1569	69	88
OR-405	W-050	4D	5/11/06	3145	2836	90	2590	82	2508	80	88
OR-405	OR-396	4E	5/11/06	2896	2601	90	2292	79	1644	57	63
OR-420	OR-396	5E	5/16/06	2342	2188	93	2112	90	2069	88	95
OR-420	W-129	5F	5/16/06	2464	2182	89	2106	85	2076	84	95
W-047	OR-441	6C	5/16/06	2708	2638	97	2624	97	2603	96	99
W-047	W-128	6G	5/16/06	2571	2507	98	2499	97	2483	97	99
W-258	W-257	7H	5/18/06	3091	3054	99	3046	99	3037	98	99
W-258	W-256	7I	5/18/06	3175	3156	99	3148	99	3080	97	98
W-197	W-257	8H	5/18/06	3671	3650	99	3640	99	3624	99	99
W-197	W-256	8I	5/18/06	3781	3766	100	3758	99	3723	98	99
W-267	W-050	9D	5/18/06	2801	2781	99	2778	99	2747	98	99
W-267	W-128	9G	5/18/06	2521	2491	99	2483	98	2468	98	99
W-241	W-129	10F	5/18/06	2741	2729	100	2721	99	2666	97	98
W-241	W-080	10J	5/18/06	2918	2900	99	2891	99	2872	98	99
W-202	OR-440	11A	5/25/06	2995	2955	99	2943	98	2985	100	101
W-202	OR-389	11B	5/25/06	3014	2978	99	2968	98	2943	98	99
W-110	OR-396	12E	5/25/06	2230	2200	99	2185	98	2164	97	98
W-110	W-080	12J	5/25/06	1870	1846	99	1834	98	1797	96	97
W-298	W-257	13H	5/25/06	3152	3115	99	3111	99	2720	86	87
W-298	W-256	13I	5/25/06	3065	3007	98	2920	95	2581	84	86
W-293	W-129	14F	5/25/06	3522	3502	99	3493	99	3231	92	92
W-293	W-128	14G	5/25/06	2495	2484	100	2477	99	2020	81	81
W-221	W-080	15J	5/30/06	4080	4042	99	4018	98	154	4	4
W-221	W-175	15K	5/30/06	3776	0	0	0	0	0	0	.

Table 8 (cont.)

Crosses by tag number		Family	Date	Green	Eyed	Percent	Number	Percent Green	Number	Percent Green	Percent Eyed
Female	Male	Group	Spawned	Eggs	Eggs	Eyed	Hatched	Eggs Hatched	Tanked	Eggs Tanked	Eggs Tanked
W-076	OR-441	16C	5/30/06	2569	2184	85	1958	76	21	1	1
W-076	W-175	16K	5/30/06	3128	0	0	0	0	0	0	.
W-274	W-238	17L	6/1/06	3814	3784	99	3776	99	3766	99	100
W-274	W-259	17M	6/1/06	2747	2736	100	2731	99	2665	97	97
W-244	W-238	18L	6/1/06	2928	2636	90	2410	82	234	8	9
W-244	W-259	18M	6/1/06	2688	2050	76	1793	67	17	1	1
OR-423	W-176	19N	6/1/06	2810	2774	99	2731	97	2779	99	100
OR-423	W-196	19O	6/1/06	2686	2647	99	2583	96	2612	97	99
W-325	W-411	20P	6/1/06	3420	3379	99	3317	97	2874	84	85
W-325	W-330	20Q	6/1/06	3554	3541	100	3455	97	1602	45	45
W-369	W-411	21P	6/1/06	2615	2572	98	2550	98	260	10	10
W-369	W-330	21Q	6/1/06	2160	2122	98	2097	97	17	1	1
W-412	W-310	22R	6/1/06	2563	2553	100	2542	99	19	1	1
W-412	W-432	22S	6/1/06	2194	2172	99	2158	98	18	1	1
W-397	W-310	23R	6/1/06	2864	2792	97	2769	97	121	4	4
W-397	W-432	23S	6/1/06	2568	2508	98	2489	97	8	0	0
W-142	W-238	24L	6/5/06	3595	3392	94	3323	92	3281	91	97
W-142	W-330	24Q	6/5/06	3252	3159	97	3103	95	3042	94	96
W-396	W-310	25P	6/5/06	3034	2981	98	2941	97	2958	97	99
W-396	W-310	25R	6/5/06	3039	2864	94	2770	91	2641	87	92
W-338	W-259	26M	6/5/06	2252	2230	99	2224	99	2170	96	97
W-338	W-358	26T	6/5/06	2182	2165	99	2159	99	2132	98	98
W-162	W-432	27S	6/5/06	2794	2786	100	2776	99	598	21	21
W-162	W-358	27T	6/5/06	2620	2349	90	2344	89	514	20	22
W-355	W-176	28N	6/5/06	2872	2850	99	2834	99	1146	40	40
W-355	W-196	28O	6/5/06	2516	2490	99	2414	96	917	36	37
OR-385	W-081	29U	6/5/06	2688	2659	99	2654	99	562	21	21
OR-385	W-324	29V	6/5/06	2501	2479	99	2475	99	907	36	37
W-288	W-359	30W	6/5/06	2523	2485	98	2462	98	115	5	5
W-288	W-354	30X	6/5/06	2967	2910	98	2871	97	241	8	8
W-349	W-330	31Q	6/6/06	2347	827	35	806	34	74	3	9
OR-402	W-358	32T	6/8/06	1695	1678	99	1678	99	600	35	36
OR-402	W-354	32X	6/8/06	1494	1478	99	1472	99	641	43	43

Table 8 (cont.)

Crosses by tag number		Family	Date	Green	Eyed	Percent	Number	Percent Green	Number	Percent Green	Percent Eyed
Female	Male	Group	Spawned	Eggs	Eggs	Eyed	Hatched	Eggs Hatched	Tanked	Eggs Tanked	Eggs Tanked
W-088	W-324	33V	6/8/06	1721	431	25	400	23	382	22	89
W-088	W-359	33W	6/8/06	1793	739	41	588	33	555	31	75
W-341	W-324	34V	6/8/06	2163	1980	92	1973	91	1963	91	99
W-341	W-359	34W	6/8/06	2299	2206	96	2193	95	2084	91	94
W-075	W-081	35U	6/8/06	2650	2566	97	2509	95	42	2	2
W-075	W-170	35Y	6/8/06	3185	3086	97	3067	96	42	1	1
W-177	W-081	36U	6/8/06	2744	2724	99	2718	99	383	14	14
W-177	W-431	36Z	6/8/06	2777	2769	100	2763	99	150	5	5
W-329	W-163	37AA	6/12/06	3076	2925	95	2784	91	823	27	28
W-329	OR-394	37BB	6/12/06	2715	2540	94	2323	86	715	26	28
W-465	W-431	38Z	6/15/06	3579	3554	99	3539	99	3546	99	100
W-465	W-473	38CC	6/15/06	3605	3581	99	3570	99	3565	99	100
W-440	W-170	39Y	6/15/06	2584	2562	99	2553	99	2556	99	100
W-440	W-473	39CC	6/15/06	2037	2027	100	2024	99	2021	99	100
W-287	W-116	40DD	6/15/06	3303	2808	85	2793	85	2782	84	99
OR-458	W-163	41AA	6/15/06	2958	2936	99	2922	99	2905	98	99
OR-458	OR-394	41BB	6/15/06	2906	2881	99	2854	98	2834	98	98
OR-432	W-473	42CC	6/19/06	2941	2933	100	2929	100	2910	99	99
OR-432	W-116	42DD	6/19/06	2603	1307	50	1306	50	1289	50	99
W-103	W-163	43AA	6/19/06	2149	2141	100	2137	99	1211	56	57
W-103	W-428	43EE	6/19/06	2183	2179	100	2168	99	1633	75	75
W-364	OR-395	44FF	6/22/06	2985	2820	94	2732	92	2654	89	94
W-364	W-337	44GG	6/22/06	2953	2884	98	2841	96	2801	95	97
W-413	W-428	45EE	6/22/06	3166	3145	99	3134	99	3129	99	99
W-413	W-209	45HH	6/22/06	2915	2865	98	2859	98	2862	98	100
OR-483	OR-395	46FF	6/26/06	1989	1952	98	1933	97	1273	64	65
OR-483	W-337	46GG	6/26/06	2400	2386	99	2355	98	2353	98	99
W-496	W-428	47EE	6/27/06	2982	2915	98	2896	97	2946	99	101
W-496	W-337	47GG	6/27/06	2069	2006	97	2000	97	1988	96	99
W-262	OR-395	48FF	6/29/06	1966	1730	88	1719	87	1587	81	92
W-262	W-209	48HH	6/29/06	1911	1703	89	1648	86	1597	84	94
Y-020	W-251	49II	7/13/06	3257	3234	99	3185	98	3136	96	97
Y-020	Y-061	49JJ	7/13/06	2910	2897	100	2800	96	2642	91	91

Table 8 (cont.)

Crosses by tag number		Family	Date	Green	Eyed	Percent	Number	Percent Green	Number	Percent Green	Percent Eyed
Female	Male	Group	Spawned	Eggs	Eggs	Eyed	Hatched	Eggs Hatched	Tanked	Eggs Tanked	Eggs Tanked
Y-036	W-251	50II	7/13/06	1697	1693	100	1690	100	1678	99	99
Y-036	Y-017	50KK	7/13/06	1653	1650	100	1643	99	1636	99	99
Y-014	W-251	51II	7/20/06	2608	2469	95	2395	92	2344	90	95
Y-014	Y-061	51JJ	7/20/06	2563	2455	96	2417	94	2391	93	97
W-402	W-251	52II	7/20/06	2489	2474	99	2458	99	2335	94	94
W-402	Y-061	52JJ	7/20/06	3522	3502	99	3480	99	3411	97	97
			Totals	279,853	259,348	.	254,927	.	189,881	.	.
			Averages[a]	5,484	4,987	93	4,902	91	3,652	68	73

[a] Averages derived from the number of females spawned (n = 52), not the number of family groups. Average eggs per female does not include females 31 and 40 which were not representative of the population (one was spawned post-mortem, the other had only one ripe skein).

Spawning & Production- Captive Broodstock

Captive-origin females were spawned with natural-origin males at Livingston Stone NFH July 26 through August 15 (Table 9, Figure 2). Spawn timing of captive-origin females was much more truncated than that observed in natural-origin females. A total of 60 captive-origin female and 31 natural-origin male winter Chinook salmon were spawned producing 60 family groups (Table 9). Fifty-eight of the 60 family groups were created with cryopreserved sperm. Females produced an average of 1,364 green eggs yielding a total of 81,814 green eggs with 47% of these developing into eyed eggs (Table 9). The percent of green eggs that hatched averaged 45%, and 45% of the green eggs resulted in juveniles that were transferred to rearing tanks (Table 9).

Table 9. Early survival of eggs and fry from winter Chinook salmon crosses of captive-brood females and natural-origin males, 2006.

Family Group	Date Spawned	Green Eggs	Eyed Eggs	Percent Eyed	Number Hatched	Percent Green Eggs Hatched	Number Tanked	Percent Tanked from Green Eggs	Percent Tanked from Eyed Eggs
L1II	7/26/06	1,666	1,557	93	1,428	86	1,402	84	90
L2JJ	7/26/06	1,191	1,166	98	1,157	97	1,143	96	98
L3Bcryo	8/2/06	2,324	917	39	891	38	880	38	96
L4Bcryo	8/2/06	2,140	831	39	823	38	819	38	99
L5Ecryo	8/2/06	2,063	1,183	57	1,163	56	1,144	55	97
L6Ecryo	8/2/06	655	127	19	121	18	117	18	92
L7Acryo	8/2/06	1,850	812	44	793	43	773	42	95
L8Acryo	8/2/06	1,957	357	18	339	17	349	18	98
L9Dcryo	8/2/06	1,752	1,326	76	1,310	75	1,305	74	98
L10Dcryo	8/2/06	1,401	1,047	75	1,021	73	1,015	72	97
L11Icryo	8/2/06	1,186	966	81	948	80	932	79	96
L12Icryo	8/2/06	1,003	445	44	430	43	417	42	94
L13Hcryo	8/2/06	978	205	21	170	17	165	17	80
L14Hcryo	8/2/06	1,103	455	41	449	41	443	40	97
L15Ycryo	8/2/06	350	9	3	5	1	4	1	44
L16Ycryo	8/2/06	1,271	273	21	262	21	255	20	93
L17Gcryo	8/2/06	1,555	512	33	502	32	496	32	97
L18Gcryo	8/2/06	1,853	568	31	547	30	533	29	94
L19Jcryo	8/2/06	1,691	730	43	717	42	712	42	98
L20Jcryo	8/2/06	1,445	557	39	542	38	523	36	94
L21Ccryo	8/2/06	1,831	422	23	400	22	396	22	94
L22Ccryo	8/2/06	1,237	189	15	180	15	180	15	95
L23Lcryo	8/2/06	1,557	1,327	85	1,306	84	1,301	84	98
L24Lcryo	8/2/06	1,884	1,202	64	1,185	63	1,162	62	97
L25Qcryo	8/2/06	1,751	442	25	376	21	352	20	80
L26Qcryo	8/2/06	964	806	84	797	83	685	71	85
L27Zcryo	8/2/06	1,707	1,126	66	1,098	64	1,108	65	98
L28Scryo	8/8/06	1,251	520	42	507	41	496	40	95
L29Scryo	8/8/06	1,101	169	15	147	13	139	13	82
L30Rcryo	8/8/06	1,342	930	69	906	68	878	65	94
L31Rcryo	8/8/06	1,016	157	15	128	13	128	13	82
L32Tcryo	8/8/06	960	308	32	302	31	302	31	98

Table 9 (cont.)

Family Group	Date Spawned	Green Eggs	Eyed Eggs	Percent Eyed	Number Hatched	Percent Green Eggs Hatched	Number Tanked	Percent Tanked from Green Eggs	Percent Tanked from Eyed Eggs
L33Tcryo	8/8/06	1,248	560	45	531	43	523	42	93
L34Wcryo	8/8/06	1,529	834	55	809	53	795	52	95
L35Wcryo	8/8/06	1,475	892	60	747	51	728	49	82
L36Ocryo	8/8/06	1,215	27	2	27	2	23	2	85
L37Ocryo	8/8/06	1,444	3	0	3	0	3	0	100
L38Ucryo	8/8/06	1,531	83	5	75	5	64	4	77
L39Ucryo	8/8/06	1,222	395	32	389	32	307	25	78
L40Vcryo	8/8/06	1,382	896	65	860	62	856	62	96
L41Vcryo	8/8/06	1,096	715	65	706	64	693	63	97
L42Xcryo	8/8/06	1,678	1,400	83	1,379	82	1,373	82	98
L43Xcryo	8/8/06	1,221	466	38	454	37	453	37	97
L44BBcryo	8/8/06	1,336	270	20	256	19	236	18	87
L45BBcryo	8/8/06	1,301	1,065	82	1,047	80	1,037	80	97
L46Mcryo	8/15/06	949	617	65	599	63	594	63	96
L47Mcryo	8/15/06	1,398	436	31	419	30	452	32	104
L48Pcryo	8/15/06	901	639	71	632	70	625	69	98
L49Pcryo	8/15/06	1,029	748	73	733	71	721	70	96
L50HHcryo	8/15/06	925	476	51	460	50	432	47	91
L51HHcryo	8/15/06	1,353	30	2	30	2	30	2	100
L52FFcryo	8/15/06	1,517	1,035	68	993	65	982	65	95
L53FFcryo	8/15/06	1,298	406	31	379	29	370	29	91
L54EEcryo	8/15/06	1,137	829	73	814	72	806	71	97
L55EEcryo	8/15/06	1,114	864	78	833	75	833	75	96
L56GGcryo	8/15/06	860	368	43	353	41	348	40	95
L57GGcryo	8/15/06	1,241	204	16	197	16	197	16	97
L58AAcryo	8/15/06	1,154	665	58	659	57	655	57	98
L59AAcryo	8/15/06	2,027	1,018	50	1,014	50	999	49	98
L60Zcryo	8/15/06	1,198	893	75	862	72	856	71	96
	Totals	81,814	38,475	.	37,210	.	36,545	.	.
	Averages[a]	1,364	641	47	620	45	609	45	95

[a] Averages derived from the number of females spawned (n = 60), not the number of family groups.

Progeny

Rearing

Between the dates of initial feeding (July 21, 2006) and release (February 8, 2007), progeny of non-captive parents were fed a total of 2,454 pounds of fish feed, resulting in a total weight gain by the fish of 3,139 pounds (food conversion rate of 0.78). The average length increase of the fish from time of initial feeding to release was 65 mm.

Between the dates of initial feeding (October 9, 2006) and release (February 8, 2007), progeny of captive-females were fed a total of 414 pounds of fish feed, resulting in a total weight gain by the fish of 484 pounds (food conversion rate 0.86). The average length increase of the fish from time of initial feeding to release was 52 mm.

Marking and Tagging

Coded-wire tagging of juvenile winter Chinook occurred between January 3, 2007 and January 19, 2007. At the time of tagging, adipose fins were removed from all fish so they could easily be identified as hatchery-origin fish upon return. Juveniles tagged and marked included: 152,398 natural-origin × natural-origin progeny, 9,049 natural-origin × hatchery-origin progeny, and 35,098 captive-origin × natural-origin progeny (Table 4). The marking and tagging mortality rate for all groups combined was less than 0.2%.

Health

Juvenile progeny from all broodstock types (i.e., Sacramento River, Livingston Stone captive brood stock) were combined and tested for seven different pathogens. The only positive test result was for *Renibacterium salmoninarum* (Table 7). Much of the early life stage mortality that occurred in brood year 2006 progeny was the result of a bacterial gill infection. It has been postulated that the fry are predisposed to infection due to mechanical damage of the gills, perhaps from coagulated yolk particles. Percent mortality was greater in the bottom trays of the incubator stacks than toward the top of the stack (water in each stack flows through each tray from the top to the bottom).

Released

A total of 196,288 juvenile winter Chinook were released at Caldwell Park (river mile 298) on February 8, 2007. After accounting for mortality after tagging and tag retention, an estimated 181,680 marked and tagged winter Chinook were released (Table 4). Most (78%) of the fish released were from natural-origin × natural-origin parents, 5% were from natural-origin × hatchery-origin crosses and 18% were captive-origin × natural-origin crosses.

Assessment of Potential Genetic Impacts

When brood year 2006 hatchery propagation data was applied to the population genetics model (Hedrick et al. 1995), the model indicated loss of genetic variation due to genetic drift was not

likely to occur (Attachment A). Under the scenario that 10% of the naturally-spawning population was successful at producing progeny, the hatchery program increased the effective population size from 1,730 to 1,774 spawners. Under the scenario that 33% of the population was successful at producing progeny, the hatchery program increased the effective population size from 5,760 to 5,874 individuals.

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Attachment A-- Brood Year 2006 Effective Population Size Methodology, Estimates, and Assumptions

Effective Population Size Calculation

The effective population size (N_e) is a measure of the rate of genetic drift within a population. The N_e is directly related to the rate of loss of genetic diversity and the rate of increase in inbreeding within a population (Rieman 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. We used a tripartite model to estimate the effective population size. This model incorporates the joint effects of finite population size of wild, hatchery-reared, and captive broodstock individuals on the overall effective population size (Hedgecock et al 2002).

Our approximation of N_e for winter Chinook salmon is based on the estimated total run size to the Upper Sacramento River. Since 2001, the winter Chinook run size estimate has been derived from carcass survey data using the Jolly-Seber formula (Height 2002). Beginning in 2003 estimates were made using only the adult female data from this survey and expanding the adult female estimate using the male-to-female ratio for winter Chinook salmon observed at the Keswick Dam fish trap (Manji 2006). Prior to 2001, run size estimates were derived from Red Bluff Diversion Dam (RBDD) counts. Two estimates of natural-origin winter Chinook N_e were 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 spawning population that contributed to the effective population of natural spawners. The lower value ($0.10N_s$) was estimated by Bartley et al. (1992), while the upper value was estimated from an analysis of Snake River, Idaho data (Robin Waples, NMFS, Northwest Fisheries Center, Seattle, WA, personal communication). The effective population sizes bounded by these two values is consistent with that presented by Hedrick et al. (1995 and 2000) and decisions reached at the February 27, 1998 meeting of the winter Chinook salmon captive broodstock genetics subcommittee.

The brood year 2006 release group, consisted of 196,288 juveniles, and was the progeny of 112 females and 36 males (60 of the females were captive broodstock from Livingston Stone NFH). A final release number for each mating was derived by apportioning mortality between all family groups within a rearing unit. For example, when two family groups were combined into a single rearing unit mortality was allocated proportionally, relative to the number of salmon from each family group. This method assumes equal rates of survival for all family groups combined in a common rearing unit.

The hatchery component of the effective population is an estimated 98 for adults collected from the Sacramento River and 101 for captive broodstock (Tables 5 & 6). The model indicates the overall effective population size would increase from 1,730 to 1,774 ($N_{ew} = 0.10 \times N_s$) or 5,760 to 5,874 ($N_{ew} = 0.33 \times N_s$) as a result of the hatchery supplementation program (Tables 5 & 6). This suggests the effect of the brood year 2006 release on the winter Chinook salmon population will be negligible from genetic drift. Model assumptions for these calculations are presented in Appendix I.

Table 5.– Estimated genetic impact of the release of brood year 2006 juvenile winter Chinook salmon propagated at Livingston Stone National Fish Hatchery on the effective population size (N_e). The calculation assumes N_e(wild) = 0.10 multiplied by the estimated run size.

	2006 Run Size 17,298[1]		
	Captured Adults	Captive Adults	Natural Spawners
Available Adults	93	60	17,205
Pre-Spawn Mortality Rate	0.05		0.05
Est. Effective Population Size	98	101	1,730
Number of Females	52	60	8,811[2]
Eggs per Female	5,484[3]	1,364	5,484[3]
Total Eggs	279,853	81,814	48,319,524
Survival to Fry			12,079,881
Survival to Pre-Smolt, Release	161,212	35,076	
Survival to Smolt, Post-Release	80,606	17,538	7,127,130
Total Smolt Production			7,225,274
Percentage of Production	1.12%	0.24%	98.64%
Effective Population Size	1,774	(with hatchery influence)	
	1,730	(without hatchery influence)	

[1] Year 2006 run-size estimate of winter Chinook salmon generated by the California Department of Fish and Game. Since 2001, the Jolly-Seber formula has been used to estimate run-size and, beginning in 2003, only the adult female data from the carcass survey was used in this formula and the total population estimate was derived by expanding the adult female estimate using the male-to-female ratio for winter Chinook salmon observed at the Keswick Dam fish trap. This value includes the estimates of returning hatchery-origin winter Chinook salmon.

[2] Since 2003, the California Department of Fish and Game has estimated the number of adult females using only the adult female data from the carcass survey and applying the Jolly-Seber model. Prior to 2003, the number of adult females was estimated at 40% of the total adult population.

[3] Number of eggs per female was calculated based on data collected at Livingston Stone NFH. Females 31 and 40 were excluded from this calculation due to their condition that rendered their fecundity unrepresentative of the population.

Table 6.– Estimated genetic impact of the release of brood year 2006 juvenile winter Chinook salmon propagated at Livingston Stone National Fish Hatchery on the effective population size (N_e). The calculation assumes N_e(wild) = 0.33 multiplied by the estimated run size.

2006 Run Size 17,298[1]

	Captured Adults	Captive Adults	Natural Spawners
Available Adults	93	60	17,205
Pre-Spawn Mortality Rate	0.05		0.05
Est. Effective Population Size	98	101	5,760
Number of Females	52	60	8811 [2]
Eggs per Female	5,484 [3]	1,364	5,484 [3]
Total Eggs	279,853	81,814	48,319,524
Survival to Fry			12,079,881
Survival to Pre-Smolt, Release	161,212	35,076	
Survival to Smolt, Post-Release	80,606	17,538	7,127,130
Total Smolt Production			7,225,274
Percentage of Production	1.12%	0.24%	98.64%

Effective Populaton Size	5,874	(with hatchery influence)
	5,760	(without hatchery influence)

[1] Year 2006 run-size estimate of winter Chinook salmon generated by the California Department of Fish and Game. Since 2001, the Jolly-Seber formula has been used to estimate run-size and, beginning in 2003, only the adult female data from the carcass survey was used in this formula and the total population estimate was derived by expanding the adult female estimate using the male-to-female ratio for winter Chinook salmon observed at the Keswick Dam fish trap. This value includes the estimates of returning hatchery-origin winter Chinook salmon.

[2] Since 2003, the California Department of Fish and Game has estimated the number of adult females using only the adult female data from the carcass survey and applying the Jolly-Seber model. Prior to 2003, the number of adult females was estimated at 40% of the total adult population.

[3] Number of eggs per female was calculated based on data collected at Livingston Stone NFH. Females 31 and 40 were excluded from this calculation due to their condition that rendered their fecundity unrepresentative of the population.

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Appendix I

Assumptions for the population genetics model used to determine effective population size with and without hatchery influence.

Assumptions for the population genetics model are based on the following best available information:

- Estimated run size for 2006 (17,298) was based on data collected in the Upper Sacramento River Winter-run Escapement Survey (Manji, 2006).

- Two estimates of the effective population size were generated: one using 10% of the run size estimate and one using 33% of the run size estimate. The lower value ($0.10N_s$) was estimated by Bartley et al. (1992), while the upper value was estimated from Snake River data (Robin Waples, NMFS, Northwest Fisheries Center, Seattle, WA, personal communication). Presentation of the effective population sizes bounded by these two values is consistent with that presented by Hedrick et al. (1995) and decisions reached at the February 27, 1998 meeting of the winter Chinook salmon captive broodstock genetics subcommittee. This value takes into consideration factors reducing N_{ew} such as unequal sex ratios, differential fecundity rates, and the inability of some individuals to spawn.

- Number of females spawning naturally in the upper Sacramento River (8,811) was based on data collected in the Upper Sacramento River Winter-run Escapement Survey (Manji, 2006) with an additional 5% pre-spawning mortality (Frank Fisher, retired CDFG, Red Bluff, CA, personal communication).

- The proportion of male and females was assumed to be 0.4 and 0.6, respectively. This was based on information published in Hedrick et al. (2000b).

- Number of eggs per female is consistent with measures of fecundity noted at the Livingston Stone National Fish Hatchery in 2006.

- 25% survival from egg to fry stage for the wild population.

- 59% survival from fry to smolt stage for the wild population (Hallock, undated[5]).

Assumptions for hatchery production which differ from wild production include:

- 50% survival from pre-smolt to smolt stage for the hatchery population.

- Effective population sizes for the hatchery (N_{eh}) and captive broodstock (N_{eb}) portions of the run are calculated using:

[5] Hallock, R.J. Undated. The Status of Inland Habitat and Factors Adversely Impacting Salmon Resources.

Appendix I (cont.)

$$N_{eh} = \frac{4N_{fh}\ N_{mh}}{xN_{fh} + yN_{mh}} \quad \text{and} \quad Neb = \frac{4N_{fb}\ N_{mb}}{xN_{fb} + yN_{mb}}$$

where

$$x_h = f_h + m_h \frac{\sigma^2_{kmh}}{k_{mh}} \quad \text{and} \quad x_b = f_b + m_b \frac{\sigma^2_{kmb}}{k_{mb}}$$

where

$$y_h = m_h + f_h \frac{\sigma^2_{kfh}}{k_{fh}} \quad \text{and} \quad y_b = m_b + f_b \frac{\sigma^2_{kfb}}{k_{fb}}$$

N_{fh}, N_{fb}, N_{mh}, and N_{mb} are the actual numbers of breeding females and males in the hatchery and captive broodstock programs, k_{fh}, k_{fb}, σ^2_{kfh}, and σ^2_{kfb} are the mean and variance of the number of progeny produced by females in the hatchery and captive broodstock programs and k_{mh}, k_{mb}, σ^2_{kmh}, and σ^2_{kmb} are the mean and variance of progeny numbers for the males in the hatchery and captive broodstock programs, and m_h, f_h, m_b, and f_b are the proportion of male (m) to female (f) spawners in the hatchery and captive broodstock programs, where $m + f = 1$.

Information from wild and hatchery production is then incorporated into the following formula to calculate N_e:

$$\frac{N_{ew}\ N_{eh}\ N_{eb}}{x_w^2\ N_{eh}\ N_{eb} + x_h^2\ N_{ew}\ N_{eb} + x_b^2\ N_{ew}\ N_{eh}}$$

where N_{eh}, N_{eb}, and N_{ew} are the effective population sizes in the hatchery, captive broodstock, and the wild-run adults, respectively, and x_h, x_b and x_w are the proportions of progeny coming from the hatchery, captive broodstock, and wild adults, respectively ($x_h + x_b + x_w = 1$).

Further assumptions for this formula include:

(1) N_{eh}, N_{eb}, and N_{ew} are known;

(2) x_h, x_b, and x_w, the proportions of spawners from hatchery, captive broodstock, and wild production are known;

(3) if (2) is not known, the hatchery, captive broodstock, and wild fish have equal survival to spawning and the initial proportion from each source is known;

(4) hatchery, captive broodstock, and wild fish mate at random; and,

(5) progeny from hatchery, captive broodstock, and wild females, have equal smolt to adult survival.