2000 Annual Report of Winter Chinook Propagation Activities

USFWS Report

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

In 1989, due to severe declines in adult returns, Sacramento River winter Chinook salmon were listed as a threatened species under the California Endangered Species Act. In November of 1990, the National Marine Fisheries Service (NMFS) finalized an emergency rule that listed winter Chinook salmon as threatened under the federal Endangered Species Act (ESA). 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 US Fish and Wildlife Service (the Service) developed an artificial propagation program for winter Chinook salmon at the Coleman National Fish Hatchery 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 U.S. Fish and Wildlife 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), the Service developed a captive broodstock program 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 at captive facilities, currently 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 2000, the Service developed a broodstock collection plan that defined the timing and location of collection activities and the number of fish to be collected (see Attachment A). In 2000, the adult collection schedule was based on a pre-season run estimate of 1,260 adult winter Chinook salmon. Therefore, based on the broodstock collection guidelines allowing capture of up to 15% of the run size (a maximum of 120 fish), the service planned to collect 120 adult winter Chinook salmon, the maximum allowed. The scheduled timing of broodstock collection set forth in the adult collection plan 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

In 2000, broodstock for the winter Chinook propagation program were captured at both the Keswick Dam (RM 302) and Red Bluff Diversion Dam (RBDD) (RM 243) fish traps. Winter Chinook broodstock were collected between March 15 and July 5. A total of 188 Chinook salmon were captured at these sites, 180 at Keswick Dam and 8 at RBDD. Of these 188 fish, 109 were genetically determined to be winter Chinook salmon. Females comprised 54% (59 fish) and males comprised 46% (50 fish) of the total winter Chinook salmon captured

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, a brail-lift, and a 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 brail enclosure. Fish collected at the Keswick Dam fish trap remain in water at all times. When the trap brail 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.

The Keswick Dam fish trap was operated from March 15 through July 5, 2000. Winter Chinook salmon were captured between March 15 and July 5 in 2000 (Figure 1). During typical brood stock collection operations, the fish trap was used for at least two consecutive days every week

and was then inspected 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 in the trap.

Red Bluff Diversion Dam Trap

The California Department of Fish and Game (CDFG) operates a fish trap at the Red Bluff Diversion Dam (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 a fish 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 LSNFH propagation program when the number of adults collected from the Keswick trap 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_2 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

Chinook salmon collected at the Keswick Dam fish trap 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 in one of two 20-foot circular tanks. Phenotypic non-winter Chinook salmon were transported back into the Sacramento River and released. Due to a shortage of male winter Chinook collected at the Keswick fish trap, male winter Chinook salmon were targeted for collection at the RBDD fish trap in 2000. 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.

A total of 162 Chinook salmon collected at the Keswick Dam and RBDD fish traps were tissue sampled for genetic run determination and quarantined at the Livingston Stone NFH. Twenty-four Chinook salmon collected at the Keswick Dam fish trap were returned to the Sacramento River without being tissue sampled, primarily because they were deemed to be phenotypic non-winter Chinook. One unsampled Chinook salmon collected at Keswick died in the transport truck during transit. An unknown number of Chinook salmon were collected and released during fish trapping activities at RBDD. Unsampled salmon and genetic non-winter Chinook collected at the Keswick fish trap were marked with a floy tag and relocated to either the Caldwell Park boat ramp (RM 299) or the Bonnyview Road boat ramp (RM 292). Salmon captured before April 29 were released at the Bonnyview Road boat ramp, whereas those captured on or after April 29 were released at the boat ramp at Caldwell Park. The Anderson-Cottonwood Irrigation District

dam (RM 298.5) gates are raised on April 29, which sufficiently raises the water level in the Sacramento River as to allow the hatchery truck to access the river at the Caldwell Park boat ramp. 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. 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 USFWS'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 the Keswick Dam fish trap 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 the Keswick and RBDD traps 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 and 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 ≥ 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 ≥ 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. 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 180 Chinook salmon collected at the Keswick fish trap in 2000, 154 phenotypic winter Chinook were quarantined and tissue sampled for genetic run determination. One hundred two of these satisfied the genetic criteria to be classified as winter Chinook, including 42 males (41%) and 60 females (59%) (Table 1). Seventy nine of the genetic winter Chinook were retained for spawning. Eighteen of the winter Chinook collected at the Keswick fish trap were marked with an adipose fin-clip (11 jacks, 2 adult males, 5 females), representing 10% of the total fish and 18% of the genetic winter Chinook collected at the Keswick fish trap. Fifty-three Chinook salmon collected at Keswick were genetically determined to be non-winter Chinook; Fifty-two of these were returned to the river at the Caldwell Park boat ramp (24 males, 25 females, and 3 unknowns) and 1 Chinook of unknown run (failed genetic extraction) was found dead in the trap elevator.

Seven of the eight phenotypic winter Chinook salmon collected at the RBDD fish trap were genetically identified as winter Chinook salmon (all unmarked males). The seven genetic winter Chinook adults collected at the RBDD fish trap were collected in the latter stages of the trapping season: 2 on May 22, and 1 each on May 30, June 5, June 8, June 18, and June 26). One adult salmon collected at RBDD on May 25 was quarantined for genetic analysis but was later determined to be a non-winter Chinook.

Disposition of Quarantined Fish

Of the 162 Chinook salmon that were quarantined and sampled for genetic run determination in 2000 (Tables 1 and 2), 78 genetically identified winter Chinook salmon were spawned (73 from the Keswick trap [29 males and 44 females], including 12 of hatchery origin (8 males and 4 females), and 5 from the RBDD trap [all males]). Seventy-two of the quarantined salmon were returned to the Sacramento River at either the Bonnyview Road boat ramp or the Caldwell Park boat ramp, including 20 genetically identified winter Chinook (9 males [4 adipose-fin clipped jacks], 11 females [1 adipose-fin clipped]) (5 at the Bonnyview Road boat ramp and 15 at the Caldwell Park boat ramp) and 52 genetically identified non-winter Chinook (24 males, 25 females, and 3 of unknown sex). Three winter Chinook salmon (two males and one female) captured at the Keswick Dam fish trap died during quarantine. Two Chinook salmon (1 male non-winter and 1 male winter) captured at the RBDD fish trap died during quarantine.

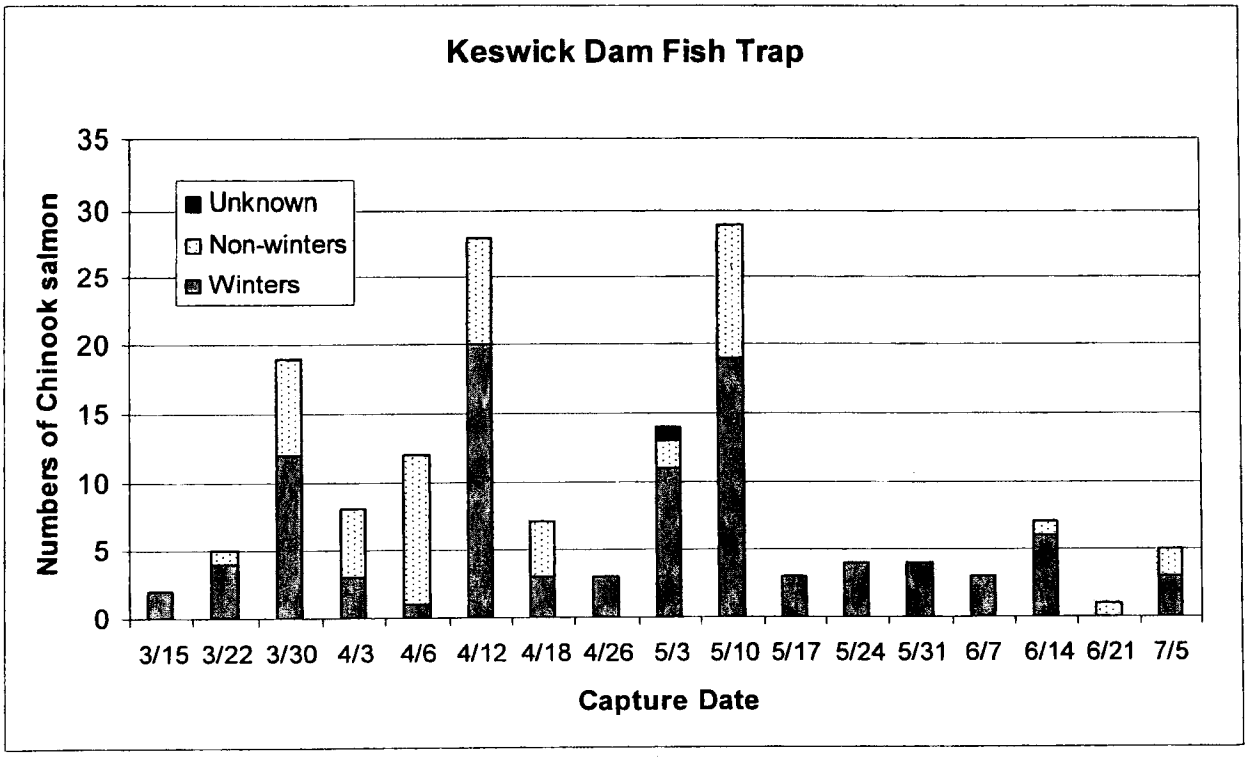

Figure 1 Numbers of winter and non-winter Chinook salmon captured at the Keswick Dam fish trap between March 15 and July 5, 2000.

Table 1 Disposition of winter and non-winter Chinook salmon captured at the Keswick Dam fish trap (Keswick) and the Red Bluff Diversion Dam fish trap (RBDD) in 2000.

Keswick, RBDD and CNFH Fish Traps
2000 Chinook Salmon Final Trapping Summary

Number of salmon captured at traps from 3/07/2000 through 07/07/2000		Keswick	RBDD
Salmon returned without tissue samples (phenotypically non-winter)	=	24	0
Mortalities during transit		1	0
Chinook salmon tissue sampled			
Unmarked	=	136	8
Ad-clipped	=	18	0
Dead in trap (unknown run)	=	1	0
Total captured (not including recaptures)	=	180	8
Recaptured salmon	=	3	0

Disposition of Chinook salmon tissue sampled and quarantined			Keswick	RBDD
Genetic non-winter Chinook salmon				
Returned/relocated	M	=	24	0
	F	=	25	0
	unk	=	3	0
Mortalities during quarantine	M	=	0	1
	F	=	0	0
Genetic Winter Chinook Salmon				
Returned/relocated	M	=	9	0
	F	=	11	0
Mortalities during quarantine	M	=	2	1
	F	=	1	0
Retained for spawning	M	=	31	6
	F	=	48	0
Total Chinook tissue sampled and quarantined			154	8

Disposition of Winter Chinook retained for spawning				
Number spawned	M	=	29	5
	F	=	44	0
Prespawn mortalities	M	=	2	1
	F	=	4	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	Mark Status	Sex	Fork Length (mm)	Genetic Run	Final Disposition	Comments
3/15/2000	Keswick	00-2451	Y-094	Unmarked	Female	808	WCS	Mortality	Prespawning Mortality
3/15/2000	Keswick	00-2452	Y-095	Unmarked	Male	840	WCS	Spawned	
3/22/2000	Keswick	00-2453	Y-096	Unmarked	Female	711	WCS	Spawned	
3/22/2000	Keswick	00-2454	Y-097	Unmarked	Female	676	NON-WCS	Relocated	
3/22/2000	Keswick	00-2455	Y-098	Unmarked	Female	800	WCS	Mortality	Prespawning Mortality
3/22/2000	Keswick	00-2456	Y-099	Unmarked	Female	782	WCS	Spawned	
3/22/2000	Keswick	00-2457	Y-100	Unmarked	Male	440	WCS	Spawned	
3/30/2000	Keswick	00-2458	Y-101	Unmarked	Female	768	WCS	Spawned	
3/30/2000	Keswick	00-2459	Y-102	Unmarked	Female	794	WCS	Spawned	
3/30/2000	Keswick	00-2460	Y-103	Unmarked	Male	612	NON-WCS	Relocated	
3/30/2000	Keswick	00-2461	Y-104	Unmarked	Male	681	NON-WCS	Relocated	
3/30/2000	Keswick	00-2462	Y-105	Unmarked	Female	835	WCS	Spawned	
3/30/2000	Keswick	00-2463	Y-106	Unmarked	Female	671	NON-WCS	Relocated	
3/30/2000	Keswick	00-2464	Y-107	Unmarked	Female	732	NON-WCS	Relocated	
3/30/2000	Keswick	00-2465	Y-108	Unmarked	Male	809	WCS	Spawned	
3/30/2000	Keswick	00-2466	Y-109	Unmarked	Female	800	WCS	Spawned	
3/30/2000	Keswick	00-2467	Y-110	Unmarked	Female	708	NON-WCS	Relocated	
3/30/2000	Keswick	00-2468	Y-111	Unmarked	Female	757	WCS	Mortality	Prespawning Mortality
3/30/2000	Keswick	00-2469	Y-112	Unmarked	Male	770	WCS	Spawned	
3/30/2000	Keswick	00-2470	Y-113	Unmarked	Female	772	WCS	Spawned	
3/30/2000	Keswick	00-2471	Y-114	Unmarked	Male	632	NON-WCS	Relocated	
3/30/2000	Keswick	00-2472	Y-115	Unmarked	Female	780	WCS	Spawned	
3/30/2000	Keswick	00-2473	Y-116	Unmarked	Female	770	WCS	Spawned	
3/30/2000	Keswick	00-2474	Y-117	Unmarked	Male	718	WCS	Spawned	
3/30/2000	Keswick	00-2475	Y-118	Unmarked	Female	720	WCS	Spawned	
3/30/2000	Keswick	00-2476	Y-119	Unmarked	Male	597	NON-WCS	Relocated	
4/3/2000	Keswick	00-2477	Y-120	Unmarked	Female	720	NON-WCS	Relocated	
4/3/2000	Keswick	00-2478	Y-121	Unmarked	Female	843	WCS	Spawned	
4/3/2000	Keswick	00-2479	Y-122	Unmarked	Female	662	NON-WCS	Relocated	

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	Mark Status	Sex	Fork Length (mm)	Genetic Run	Final Disposition	Comments
4/3/2000	Keswick	00-2480	Y-123	Unmarked	Male	643	NON-WCS	Relocated	
4/3/2000	Keswick	00-2481	Y-124	Unmarked	Male	663	NON-WCS	Relocated	
4/3/2000	Keswick	00-2482	Y-125	Unmarked	Male	714	NON-WCS	Relocated	
4/3/2000	Keswick	00-2483	Y-126	Unmarked	Male	530	WCS	Spawned	
4/3/2000	Keswick	00-2484	Y-127	Unmarked	Female	701	WCS	Spawned	
4/6/2000	Keswick	00-2485	Y-128	Unmarked	Female	765	NON-WCS	Relocated	
4/6/2000	Keswick	00-2486	Y-129	Unmarked	Female	739	WCS	Spawned	
4/6/2000	Keswick	00-2487	Y-130	Unmarked	Female	708	NON-WCS	Relocated	
4/6/2000	Keswick	00-2488	Y-131	Unmarked	Female	680	NON-WCS	Relocated	
4/6/2000	Keswick	00-2489	Y-132	Unmarked	Male	670	NON-WCS	Relocated	
4/6/2000	Keswick	00-2490	Y-133	Unmarked	Female	742	NON-WCS	Relocated	
4/6/2000	Keswick	00-2491	Y-134	Unmarked	Male	728	NON-WCS	Relocated	
4/6/2000	Keswick	00-2492	Y-135	Unmarked	Female	724	NON-WCS	Relocated	
4/6/2000	Keswick	00-2493	Y-136	Unmarked	Male	730	NON-WCS	Relocated	
4/6/2000	Keswick	00-2494	Y-137	Unmarked	Female	722	NON-WCS	Relocated	
4/6/2000	Keswick	00-2495	Y-138	Unmarked	Male	767	NON-WCS	Relocated	
4/6/2000	Keswick	00-2496	Y-139	Unmarked	Male	648	NON-WCS	Relocated	
4/12/2000	Keswick	00-2497	Y-140	Unmarked	Female	800	WCS	Spawned	
4/12/2000	Keswick	00-2498	Y-141	Marked	Female	695	WCS	Spawned	
4/12/2000	Keswick	00-2499	Y-142	Unmarked	Male	862	WCS	Spawned	
4/12/2000	Keswick	00-2500	Y-145	Marked	Male	506	WCS	Spawned	
4/12/2000	Keswick	00-2501	Y-146	Marked	Male	438	WCS	Spawned	
4/12/2000	Keswick	00-2502	Y-147	Unmarked	Male	880	WCS	Spawned	
4/12/2000	Keswick	00-2503	Y-148	Unmarked	Female	875	WCS	Spawned	
4/12/2000	Keswick	00-2504	Y-149	Marked	Male	800	WCS	Spawned	
4/12/2000	Keswick	00-2505	Y-150	Unmarked	Female	746	WCS	Spawned	
4/12/2000	Keswick	00-2507	Y-165	Unmarked	Female	785	WCS	Spawned	
4/12/2000	Keswick	00-2508	Y-166	Unmarked	Female	738	WCS	Spawned	
4/12/2000	Keswick	00-2509	Y-167	Unmarked	Female	683	NON-WCS	Relocated	

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	Mark Status	Sex	Fork Length (mm)	Genetic Run	Final Disposition	Comments
4/12/2000	Keswick	00-2510	Y-168	Unmarked	Female	710	WCS	Mortality	Prespawning Mortality
4/12/2000	Keswick	00-2511	Y-169	Unmarked	Unknown	618	NON-WCS	Relocated	
4/12/2000	Keswick	00-2512	Y-170	Unmarked	Female	719	NON-WCS	Relocated	
4/12/2000	Keswick	00-2513	Y-171	Unmarked	Female	810	WCS	Spawned	
4/12/2000	Keswick	00-2514	Y-172	Unmarked	Female	695	WCS	Spawned	
4/12/2000	Keswick	00-2515	Y-173	Unmarked	Unknown	769	NON-WCS	Relocated	
4/12/2000	Keswick	00-2516	Y-174	Unmarked	Female	730	WCS	Spawned	
4/12/2000	Keswick	00-2517	Y-175	Marked	Male	490	WCS	Spawned	
4/12/2000	Keswick	00-2518	Y-176	Marked	Male	480	WCS	Spawned	
4/12/2000	Keswick	00-2519	Y-177	Marked	Male	500	WCS	Spawned	
4/12/2000	Keswick	00-2521	Y-178	Unmarked	Female	749	NON-WCS	Relocated	
4/12/2000	Keswick	00-2522	Y-179	Unmarked	Male	658	NON-WCS	Relocated	
4/12/2000	Keswick	00-2523	Y-180	Unmarked	Male	701	NON-WCS	Relocated	
4/12/2000	Keswick	00-2524	Y-181	Unmarked	Female	713	NON-WCS	Relocated	
4/12/2000	Keswick	00-2525	Y-182	Marked	Male	391	WCS	Relocated	
4/12/2000	Keswick	00-2526	Y-183	Marked	Male	401	WCS	Relocated	
4/18/2000	Keswick	00-2527	Y-184	Unmarked	Male	845	WCS	Relocated	
4/18/2000	Keswick	00-2528	Y-185	Unmarked	Female	727	WCS	Relocated	
4/18/2000	Keswick	00-2529	Y-186	Unmarked	Female	702	NON-WCS	Relocated	
4/18/2000	Keswick	00-2530	Y-187	Unmarked	Female	727	NON-WCS	Relocated	
4/18/2000	Keswick	00-2531	Y-188	Marked	Male	487	WCS	Mortality	Prespawning Mortality
4/18/2000	Keswick	00-2532	Y-189	Unmarked	Male	760	NON-WCS	Relocated	
4/18/2000	Keswick	00-2533	0-11896	Unmarked	Male	543	NON-WCS	Relocated	Recapture
4/26/2000	Keswick	00-2534	0-11894	Unmarked	Male	958	WCS	Relocated	
4/26/2000	Keswick	00-2535	Y-192	Unmarked	Female	750	WCS	Spawned	
4/26/2000	Keswick	00-2536	Y-193	Unmarked	Female	778	WCS	Spawned	
5/3/2000	Keswick	00-2537	Y-194	Unmarked	Male	840	WCS	Spawned	
5/3/2000	Keswick	00-2538	Y-195	Unmarked	Male	675	NON-WCS	Relocated	

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	Mark Status	Sex	Fork Length (mm)	Genetic Run	Final Disposition	Comments
5/3/2000	Keswick	00-2539	Y-196	Unmarked	Female	845	WCS	Spawned	
5/3/2000	Keswick	00-2540	Y-197	Unmarked	Male	878	WCS	Spawned	
5/3/2000	Keswick	00-2541	Y-198	Unmarked	Male	745	WCS	Spawned	
5/3/2000	Keswick	00-2542	Y-199	Marked	Female	707	WCS	Spawned	
5/3/2000	Keswick	00-2543	Y-200	Unmarked	Male	665	NON-WCS	Relocated	
5/3/2000	Keswick	00-2544	Y-201	Unmarked	Male	795	WCS	Spawned	
5/3/2000	Keswick	00-2545	Y-202	Marked	Female	704	WCS	Spawned	
5/3/2000	Keswick	00-2546	Y-203	Marked	Male	527	WCS	Spawned	
5/3/2000	Keswick	00-2547	O-11893	Unmarked	Male	435	WCS	Relocated	
5/3/2000	Keswick	00-2548	O-11892	Unmarked	Male	880	WCS	Relocated	
5/3/2000	Keswick	00-2549	O-11891	Unmarked	Male	885	WCS	Relocated	
5/3/2000	Keswick	00-2550		Unmarked	Female	686	UNK	Mortality	Dead in Keswick elevator
5/10/2000	Keswick	00-2551	Y-204	Unmarked	Male	842	WCS	Spawned	
5/10/2000	Keswick	00-2552	Y-205	Unmarked	Male	830	WCS	Spawned	
5/10/2000	Keswick	00-2553	Y-206	Unmarked	Female	709	NON-WCS	Relocated	
5/10/2000	Keswick	00-2554	Y-207	Unmarked	Female	781	WCS	Spawned	
5/10/2000	Keswick	00-2555	Y-208	Unmarked	Female	830	WCS	Spawned	
5/10/2000	Keswick	00-2556	Y-209	Unmarked	Female	739	WCS	Spawned	
5/10/2000	Keswick	00-2557	Y-210	Unmarked	Male	685	NON-WCS	Relocated	
5/10/2000	Keswick	00-2558	Y-211	Unmarked	Female	757	WCS	Spawned	
5/10/2000	Keswick	00-2559	Y-212	Unmarked	Male	800	WCS	Spawned	
5/10/2000	Keswick	00-2560	Y-213	Unmarked	Male	796	WCS	Mortality	Died During Quarantine
5/10/2000	Keswick	00-2561	Y-214	Unmarked	Male	700	NON-WCS	Relocated	
5/10/2000	Keswick	00-2562	Y-215	Unmarked	Female	638	NON-WCS	Relocated	
5/10/2000	Keswick	00-2563	Y-216	Unmarked	Female	782	WCS	Spawned	
5/10/2000	Keswick	00-2564	Y-217	Marked	Male	520	WCS	Spawned	
5/10/2000	Keswick	00-2565	Y-218	Unmarked	Female	718	WCS	Spawned	
5/10/2000	Keswick	00-2566	Y-219	Unmarked	Female	781	WCS	Spawned	Recapture

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	Mark Status	Sex	Fork Length (mm)	Genetic Run	Final Disposition	Comments
5/10/2000	Keswick	00-2567	Y-220	Unmarked	Female	771	WCS	Spawned	
5/10/2000	Keswick	00-2568	Y-221	Unmarked	Female	808	WCS	Mortality	Died During Quarantine
5/10/2000	Keswick	00-2569	Y-222	Unmarked	Male	626	WCS	Spawned	
5/10/2000	Keswick	00-2570	Y-223	Unmarked	Unknown	480	NON-WCS	Relocated	
5/10/2000	Keswick	00-2571	Y-224	Unmarked	Male	633	NON-WCS	Relocated	
5/10/2000	Keswick	00-2572	Y-225	Unmarked	Female	795	WCS	Spawned	
5/10/2000	Keswick	00-2573	Y-226	Unmarked	Male	827	WCS	Spawned	
5/10/2000	Keswick	00-2574	Y-227	Unmarked	Female	779	WCS	Spawned	
5/10/2000	Keswick	00-2575	Y-228	Unmarked	Male	650	NON-WCS	Relocated	
5/10/2000	Keswick	00-2576	Y-229	Unmarked	Female	693	NON-WCS	Relocated	
5/10/2000	Keswick	00-2577	Y-230	Unmarked	Female	690	NON-WCS	Relocated	
5/10/2000	Keswick	00-2578	Y-231	Unmarked	Male	480	WCS	Mortality	Prespawning Mortality
5/10/2000	Keswick	00-2579	Y-232	Unmarked	Female	660	NON-WCS	Relocated	
5/17/2000	Keswick	00-2580	Y-233	Unmarked	Female	753	WCS	Spawned	
5/17/2000	Keswick	00-2581	Y-234	Unmarked	Female	681	WCS	Spawned	
5/17/2000	Keswick	00-2582	Y-235	Unmarked	Female	792	WCS	Spawned	
5/22/2000	RBDD	00-2583	Y-236	Unmarked	Male	527	WCS	Mortality	Prespawning Mortality
5/22/2000	RBDD	00-2584	Y-237	Unmarked	Male	581	WCS	Spawned	
5/24/2000	Keswick	00-2585	O-11890	Unmarked	Female	771	WCS	Released	
5/24/2000	Keswick	00-2586	O-11889	Unmarked	Female	765	WCS	Released	
5/24/2000	Keswick	00-2587	Y-238	Unmarked	Female	830	WCS	Spawned	
5/24/2000	Keswick	00-2588	Y-239	Unmarked	Male	832	WCS	Spawned	
5/24/2000	Keswick	00-2589	Y-240	Unmarked	Male	857	WCS	Spawned	
5/25/2000	RBDD	00-2590	Y-241	Unmarked	Male	690	NON-WCS	Mortality	Died During Quarantine
5/30/2000	RBDD	00-2591	Y-242	Unmarked	Male	760	WCS	Spawned	
5/31/2000	Keswick	00-2592	O-11888	Unmarked	Female	742	WCS	Released	
5/31/2000	Keswick	00-2593	Y-243	Marked	Female	706	WCS	Spawned	
5/31/2000	Keswick	00-2594	O-11887	Unmarked	Female	750	WCS	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	Mark Status	Sex	Fork Length (mm)	Genetic Run	Final Disposition	Comments
5/31/2000	Keswick	00-2595	O-11886	Unmarked	Female	788	WCS	Released	
6/5/2000	RBDD	00-2596	Y-245	Unmarked	Male	561	WCS	Spawned	
6/7/2000	Keswick	00-2597	O-11885	Unmarked	Female	734	WCS	Released	
6/7/2000	Keswick	00-2598	O-11884	Unmarked	Female	800	WCS	Released	
6/7/2000	Keswick	00-2599	O-11882	Marked	Male	439	WCS	Released	
6/8/2000	RBDD	00-2600	Y-246	Unmarked	Male	543	WCS	Spawned	
6/14/2000	Keswick	00-2601	O-11881	Marked	Female	683	WCS	Released	
6/14/2000	Keswick	00-2602	O-11880	Unmarked	Female	754	WCS	Released	
6/14/2000	Keswick	00-2603	O-11879	Marked	Male	502	WCS	Released	
6/14/2000	Keswick	00-2604	O-11878	Unmarked	Female	752	WCS	Released	Recaptured and returned 6/21/00
6/14/2000	Keswick	00-2605	Y-247	Unmarked	Male	819	WCS	Spawned	
6/14/2000	Keswick	00-2606	Y-248	Unmarked	Male	618	NON-WCS	Relocated	
6/14/2000	Keswick	00-2607	Y-249	Unmarked	Male	850	WCS	Spawned	
6/18/2000	RBDD	00-2608	Y-250	Unmarked	Male	490	WCS	Mortality	Died During Quarantine
6/21/2000	Keswick	00-2609	O-11500	Unmarked	Female	816	NON-WCS	Released	
6/26/2000	RBDD	00-2610	Y-251	Unmarked	Male	550	WCS	Spawned	
7/5/2000	Keswick	00-2611	Y-252	Unmarked	Male	835	WCS	Mortality	Died During Quarantine
7/5/2000	Keswick	00-2612	O-11501	Unmarked	Male	773	NON-WCS	Relocated	
7/5/2000	Keswick	00-2613	Y-253	Unmarked	Female	775	WCS	Spawned	
7/5/2000	Keswick	00-2614	Y-255	Unmarked	Female	777	WCS	Spawned	
7/5/2000	Keswick	00-2615	O-11502	Unmarked	Female	715	NON-WCS	Relocated	

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 closely monitored fish health.

Phenotypic winter Chinook salmon captured at the Keswick Dam or Red Bluff Diversion Dam fish traps 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_2 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 from quarantine 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 that were retained for use as broodstock were treated with malachite green to reduce or eliminate fungal infections. A total of 507 g of malachite green was used for 26 treatments in 2000. 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 2000, no deaths were attributed to fungal infection.

The CA-NV FHC tested 69 winter Chinook adults for *R. salmoninarum* using an enzyme-linked immunosorbent assay (ELISA). The results indicated suspected *R. salmoninarum* infection in 55 of 69 (80%) of the salmon tested while the remaining 14 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 *Renibacterium salmoninarum* (the organism responsible for bacterial kidney disease). Females were targeted for treatment; however, salmon of unknown sex were treated as well. Thirty-seven of the 44 females spawned received one to four injections, with at least fourteen days between injections (Table 4). The remaining seven females were in captivity for less than seven days before they were spawned. Only one of the 37 males received an erythromycin injection and it only received one injection (Table 5).

Luteinizing Hormone - Releasing Hormone analogue (LH-RH_a) was administered to accelerate final gamete maturation in fish that had already undergone gametogenesis. Similar to previous years, LH-RH_a was 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 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. Fifty-one fish were given LH-RH_a therapy from April 18 through June 29 (13 males, 38 females). The fish all reached sexual

maturation. The fish took an average of 10.5 days post-injection (range 6 to 21 days) to reach maturity.

Prespawning Mortality

Seven of eighty-five adults (8.24%) died prior to spawning. Prespawning mortality rates for brood years 1998 and 1999 were 6.5% and 4.17%, 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 2000.

Genetic ID	Date Captured	Location	length (mm)	Weight (lbs)	Date Spawned	Date of death	Days in Captivity	Erythromycin[1]		LH-RHa[2]		Number of MG[3]	Comments
								Dose (mls)	Injections	Dose (µg)	Injections		
00-2451	03/15/00	Keswick	808	14.6		3/20/2000	4					0	Prespawn mortality
00-2453	03/22/00	Keswick	712	9.8	06/12/00	6/12/2000	81	0.5	3	250	1	21	
00-2455	03/22/00	Keswick	788	14.8		5/9/2000	47	0.6	2	250	1	11	Prespawn mortality
00-2456	03/22/00	Keswick	785	14.8	06/08/00	6/8/2000	77	0.6	3	250	1	20	
00-2458	03/30/00	Keswick	770	11.7	06/19/00	6/19/2000	80	0.5	3	250	1	23	
00-2459	03/30/00	Keswick	800	12.1	06/22/00	6/22/2000	83	0.6	4	250	1	24	
00-2462	03/30/00	Keswick	830	16.2	06/22/00	6/22/2000	83	0.6	4	250	1	23	
00-2466	03/30/00	Keswick	800	14.4	06/19/00	6/19/2000	80	0.6	4	250	1	23	
00-2468	03/30/00	Keswick	765	12.0		5/19/2000	49	0.5	2	250	1	15	Prespawn mortality
00-2470	03/30/00	Keswick	800	11.2	05/08/00	5/8/2000	38	0.5	2	250	1	9	
00-2472	03/30/00	Keswick	784	13.5	06/15/00	6/15/2000	76	0.6	3	250	1	22	
00-2473	03/30/00	Keswick	781	13.5	05/22/00	5/22/2000	52	0.6	2	250	1	15	
00-2475	03/30/00	Keswick	733	11.8	06/05/00	6/5/2000	66	0.5	3	250	1	19	
00-2478	04/03/00	Keswick	851	19.2	05/18/00	5/18/2000	44	0.6	3	250	1	11	
00-2484	04/03/00	Keswick	701	9.8	05/22/00	5/22/2000	48	0.5	3	250	2	14	
00-2486	04/06/00	Keswick	736	10.3	06/26/00	6/26/2000	80	0.5	3	250	1	21	
00-2497	04/12/00	Keswick	805	12.0	05/18/00	5/18/2000	35	0.6	2	250	1	11	
00-2498	04/12/00	Keswick	684	9.3	07/03/00	7/3/2000	81	0.5	3	150	1	22	
00-2503	04/12/00	Keswick	886	18.8	06/19/00	6/19/2000	67	0.6	4	250	1	20	
00-2505	04/12/00	Keswick	746	11.2	04/25/00	4/25/2000	12	0.6	1	250	1	3	
00-2507	04/12/00	Keswick	785	10.3	04/25/00	4/25/2000	12	0.6	1	250	1	3	
00-2508	04/12/00	Keswick	743	12.2	06/19/00	6/19/2000	67	0.6	4	250	1	19	
00-2510	04/12/00	Keswick	714	6.3		5/27/2000	44	0.5	2	250	3	14	Prespawn mortality
00-2513	04/12/00	Keswick	810	15.2	05/08/00	5/8/2000	25	0.6	2	250	1	7	
00-2514	04/12/00	Keswick	695	8.9	06/05/00	6/5/2000	53	0.5	3	250	1	16	
00-2516	04/12/00	Keswick	730	10.8	06/29/00	6/29/2000	77	0.5	4	250	1	22	
00-2535	04/26/00	Keswick	756	11.2	05/25/00	5/25/2000	28	0.5	1	250	2	8	
00-2536	04/26/00	Keswick	776	12.9	06/26/00	6/26/2000	60	0.6	3	250	1	16	

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 2000.

Genetic ID	Date Captured	Location	length (mm)	Weight (lbs)	Date Spawned	Date of death	Days in Captivity	Erythromycin[1]		LH-RHa[2]		Number of MG[3]	Comments
								Dose (mls)	Injections	Dose (µg)	Injections		
00-2539	05/03/00	Keswick	845	12.1	05/08/00	5/8/2000	4					0	
00-2542	05/03/00	Keswick	705	10.2	05/18/00	5/18/2000	14	0.5	1	250	1	3	
00-2545	05/03/00	Keswick	711	10.5	05/18/00	5/18/2000	14	0.5	1	250	1	3	
00-2554	05/10/00	Keswick	778	12.4	06/19/00	6/19/2000	39	0.6	2	250	1	10	
00-2555	05/10/00	Keswick	830	15.8	05/18/00	5/18/2000	7					1	
00-2556	05/10/00	Keswick	775	13.6	06/08/00	6/8/2000	28	0.6	2	250	1	7	
00-2558	05/10/00	Keswick	758	12.8	06/26/00	6/26/2000	46	0.6	1	250	1	10	
00-2563	05/10/00	Keswick	782	14.4	05/15/00	5/15/2000	4	0.0				1	
00-2565	05/10/00	Keswick	723	10.0	05/30/00	5/30/2000	19	0.5	1	150	1	4	
00-2566	05/10/00	Keswick	780	13.6	05/25/00	5/25/2000	14	0.6	1	250	1	4	
00-2567	05/10/00	Keswick	771	12.0	05/15/00	5/15/2000	4	0.0				0	
00-2572	05/10/00	Keswick	792	14.4	06/01/00	6/1/2000	21	0.6	1	250	1	5	
00-2574	05/10/00	Keswick	784	12.5	06/08/00	6/8/2000	28	0.6	1	250	1	7	
00-2580	05/17/00	Keswick	770	12.5	05/30/00	5/30/2000	12	0.6	1	250	1	2	
00-2581	05/17/00	Keswick	673	9.4	06/12/00	6/12/2000	25	0.5	1	250/150	1/1	6	
00-2582	05/17/00	Keswick	790	14.6	05/22/00	5/22/2000	4					0	
00-2587	05/24/00	Keswick	830	12.2	05/25/00	5/25/2000	0					0	
00-2593	05/31/00	Keswick	713	10.4	06/15/00	6/15/2000	14	0.5	1			4	
00-2613	07/05/00	Keswick	775	12.8	07/05/00	7/5/2000	0	0	0			0	
00-2614	07/05/00	Keswick	777	12.8	07/10/00	7/10/2000	4	0	0			0	

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 2000.

Genetic ID	Date Captured	Location	length (mm)	Weight (lbs)	Date Spawned	Date of death	Days in Captivity	Erythromycin[1]		LH-RHa[2]		Number of MG[3]	Comments
								Dose (mls)	Injections	Dose (µg)	Injections		
00-2452	03/15/00	Keswick	845	16.7	05/08/00	05/22/00	67			250	1	16	
					05/15/00								
					05/18/00								
					05/22/00								
00-2457	03/22/00	Keswick	433	2.2	06/26/00	07/10/00	109			150	1	26	
					06/29/00								
					07/05/00								
00-2465	03/30/00	Keswick	811	15.1	05/08/00	05/08/00	38					10	
00-2469	03/30/00	Keswick	770	13.2	05/08/00	05/23/00	53			250	1	7	
					05/18/00								
00-2474	03/30/00	Keswick	721	9.5	06/08/00	07/10/00	101					25	
					06/12/00								
					06/15/00								
					06/22/00								
00-2483	04/03/00	Keswick	538	4.4	06/01/00	06/07/00	64					20	
					06/05/00								
00-2499	04/12/00	Keswick	860	16.7	04/25/00	05/15/00	32			250	1	10	
					04/25/00								
00-2500	04/12/00	Keswick	510	3.0	06/01/00	06/14/00	62					19	
					06/05/00								
					06/08/00								
00-2501	04/12/00	Keswick	438	2.1	05/25/00	05/25/00	42					13	
00-2502	04/12/00	Keswick	878	17.9	04/25/00	05/15/00	32			250	1	10	
					05/08/00								
00-2504	04/12/00	Keswick	800	12.2	04/25/00	05/18/00	35			250	1	11	
					05/18/00								
00-2517	04/12/00	Keswick	495	3.0	06/26/00	07/10/00	88					22	

1 Erythromycin 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 2000.

Genetic ID	Date Captured	Location	Fork length (mm)	Weight (lbs)	Date Spawned	Date of death	Days in Captivity	Erythromycin[1]		LH-RHa[2]		Number of MG[3] treatments	Comments
								Dose (mls)	Injections	Dose (μg)	Injections		
00-2518	04/12/00	Keswick	467	2.4	06/15/00 06/19/00 06/22/00	07/05/00	83			150	1	22	
00-2519	04/12/00	Keswick	500	3.7	06/12/00 06/15/00 06/19/00	06/19/00	67			150	1	20	
00-2531	04/18/00	Keswick	488	3.2		05/22/00	33	0.4	1	150	1	12	Prespwn mortality
00-2537	05/03/00	Keswick	835	17.6	05/18/00 05/22/00	05/24/00	20					5	
00-2540	05/03/00	Keswick	878	18.3	05/08/00 05/08/00 05/15/00	05/15/00	11					2	
00-2541	05/03/00	Keswick	743	10.3	05/25/00 06/08/00 06/12/00 06/19/00	06/19/00	46					12	
00-2544	05/03/00	Keswick	805	13.1	05/18/00 05/18/00 05/25/00 05/25/00	06/01/00	28					7	
00-2546	05/03/00	Keswick	526	4.3	05/22/00 05/25/00	05/25/00	21					5	
00-2551	05/10/00	Keswick	842	14.2	05/18/00 05/18/00 05/22/00 05/22/00	05/22/00	11					2	
00-2552	05/10/00	Keswick	827	15.0	06/08/00 06/08/00 06/12/00 06/15/00	06/15/00	35					10	

1 Erythromycin 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 2000.

Genetic ID	Date Captured	Location	Fork length (mm)	Weight (lbs)	Date Spawned	Date of death	Days in Captivity	Erythromycin[1]		LH-RHa[2]		Number of MG[3] treatments	Comments
								Dose (mls)	Injections	Dose (μg)	Injections		
00-2559	05/10/00	Keswick	800	13.0	05/15/00 05/15/00	05/15/00	4					0	
00-2564	05/10/00	Keswick	525	3.9	06/01/00 06/05/00 06/08/00	06/20/00	40					10	
00-2569	05/10/00	Keswick	626	7.3	06/22/00 06/26/00 06/26/00	07/10/00	60			150	1	12	
00-2573	05/10/00	Keswick	827	15.1	05/18/00 05/18/00 05/25/00 05/25/00	05/25/00	14					3	
00-2578	05/30/00	Keswick	488	5.2		05/31/00	0			150	1	4	Prespawn mortality
00-2583	05/22/00	RBDD	NA	NA		05/31/00	8					0	Prespawn mortality
00-2584	05/22/00	RBDD	577	5.6	06/22/00 06/25/00	06/27/00	35					7	
00-2588	05/24/00	Keswick	832	18.4	05/30/00 05/30/00	05/30/00	5					0	
00-2589	05/24/00	Keswick	857	19.5	05/30/00 05/30/00	05/30/00	5					0	
00-2591	05/30/00	RBDD	760	12.9	06/05/00 06/05/00	06/05/00	5					0	
00-2596	06/05/00	RBDD	560	4.5	06/15/00 06/19/00 06/19/00	06/22/00	16					3	
00-2600	06/08/00	RBDD	533	4.9	06/22/00 06/26/00 06/29/00 07/10/00	07/10/00	31			150	1	3	

1 Erythromycin 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 2000.

Genetic ID	Date Captured	Location	Fork length (mm)	Weight (lbs)	Date Spawned	Date of death	Days in Captivity	Erythromycin[1]		LH-RHa[2]		Number of MG[3] treatments	Comments
								Dose (mls)	Injections	Dose (µg)	Injections		
00-2605	06/14/00	Keswick	819	13.8	06/19/00	06/19/00	4					0	
00-2607	06/14/00	Keswick	820	14.5	06/19/00	06/19/00	4					0	
00-2610	06/26/00	RBDD	550	4.1	07/03/00 07/05/00 07/10/00	07/10/00	13			150	1	0	

1 Erythromycin 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 a 20-foot diameter 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 20-foot circular 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 spawn between April and early August, peaking near the end of May and the beginning of June (Vogel and Marine 1991). Hatchery spawning of winter Chinook salmon occurred between April 25 and July 10, 2000 (Figure 2) roughly corresponding to the historical natural spawn timing. A total of 44 female (Table 4) and 38 male (including 4 cryo-preserved samples) (Table 5) winter Chinook salmon were spawned in 2000 producing 96 family groups (Table 7). Females produced an average of 4,801 eggs (SD 690) yielding a total collection of over 216,000 eggs. Lengths of spawned females ranged from 673 to 886 mm (fork length) and averaged 770 mm (SD 46 mm). Lengths of spawned males ranged from 433 to 878 mm and averaged 683 mm (SD 158 mm).

Captive Broodstock

Spawning of captive broodstock occurred at the Bodega Marine Lab (BML) between July 14 and August 15, 2000 (Table 6). All captive broodstock spawning occurred after the final spawning date of natural-origin broodstock used in the supplementation program and later than the historical spawn timing of winter Chinook salmon (Figure 2). This phenomenon of delayed maturation timing for winter Chinook captive broodstock has been typical of the program at the BML (Arkush et al, 1997) as well as other captive broodstock programs for Pacific salmonids (Bumgarner and Gallinat, 2001). Although the maturation timing of the captive broodstock adults is delayed in comparison to naturally produced adults, substantial improvement in spawn timing and synchrony with natural-origin adults has been achieved through 1) early examination of gonadal development using ultrasound techniques 2) early entry in freshwater to promote maturation, and 3) photoperiod control. Sixty-six captive broodstock females were spawned (all

from brood year 1996) with 60 captive broodstock males (28 from brood year 1995 and 32 from brood year 1998) producing 93 total crosses. Over 88,000 eggs were collected giving an average of 1,333 eggs per female. Thirty-seven crosses were created using fresh milt and 56 using cryo-preserved milt.

Table 6 Summary of captive broodstock spawning activities in 2000

Females Spawned	
BY 1996	66
Total	**66**
Males Spawned	
BY 1995	28
BY 1998	32
Total	**60**
Crosses	
using fresh milt	37
using cryo milt	56
Total	**93**
Green Eggs	88,001
Eyed Eggs	62,403
No. Hatched	n/a*
No. Tanked	11,895

* culled before counts

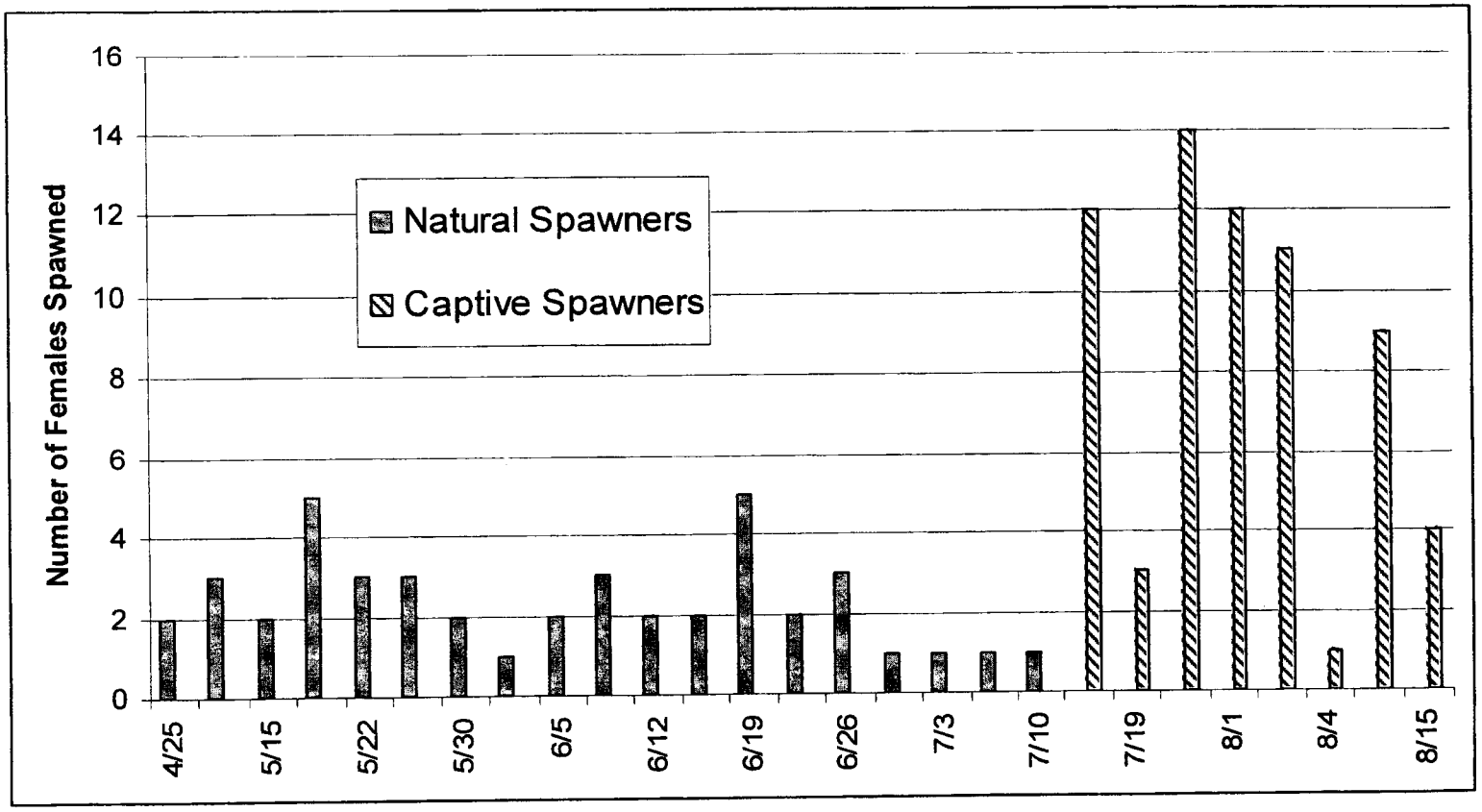

Figure 2 Spawning of winter Chinook salmon at Livingston Stone National Fish Hatchery and Bodega Marine Lab, April 25 through August 15, 2000. Bars correspond to numbers of females spawned per day.

Incubation and Rearing

Progeny of Adults Collected at the Keswick Dam and RBDD fish traps
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. Percent eye-up ranged from 20.9% to 99.9%, averaging 91.4% across family groups. 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 Captive adults
Captive matings at BML produced 62,403 eyed-eggs (70.9% eye-up). Before hatching, an unknown number of eggs were culled, so egg to juvenile survival rates are not available. From the remaining eggs, 37,927 fry were produced, resulting in 11,895 juveniles.

Juvenile Rearing

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 1964.9 pounds (lbs.) of feed was used resulting in a total weight gain of 1995.4 pounds between July 12 and release on February 1. This provided a feed conversion of 0.98 (food fed/weight gain). The total length increase was 1.567 inches (39.8 mm). Growth was at it highest in November with a length increase of 0.474 inches (12.0 mm), and at its lowest in January at 0.245 inches (6.2 mm). The January numbers do not include fish held for the captive broodstock program.

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 uses average monthly water temperatures to determine the appropriate percent body weight to feed.

Juvenile winter Chinook salmon were tanked according to family group combinations. This year, with 96 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. Therefore, several family groups were combined, and some family group combinations were moved to the larger tanks before optimal densities were achieved. The 96 original family groups were eventually combined to form 30 distinct group combinations that were held separately until release. All progeny from captive broodstock were eventually combined into one tank.

Table 7 Family groups, date spawned, egg counts, and number tanked for brood year 2000 winter Chinook salmon spawned at Livingston Stone NFH.

Crosses (by floy tag number)			Family	Date	Number of		Percent	Number	Percent	Number	Precent tanked
Female		Male	group	spawned	Green eggs	Eyed eggs	eye-up	hatched	hatched	tanked	from eyed eggs
Y-150	X	Y-142	1A	04/25/00	2208	1877	85.01	1832	82.97	1862	99.20
Y-150	X	Y-149	1B	04/25/00	1688	1289	76.36	1230	72.87	986	76.49
Y-165	X	Y-142	2A	04/25/00	2272	2254	99.21	2223	97.84	2194	97.34
Y-165	X	Y-147	2C	04/25/00	2286	2266	99.13	2210	96.68	2161	95.37
Y-196	X	Y-108	3D	05/08/00	3426	3404	99.36	3389	98.92	3382	99.35
Y-196	X	Y-197	3E	05/08/00	3012	2950	97.94	2946	97.81	2944	99.80
Y-171	X	Y-197	4E	05/08/00	3465	3406	98.30	3399	98.10	3367	98.85
Y-171	X	Y-095	4F	05/08/00	2493	2470	99.08	2466	98.92	2441	98.83
Y-113	X	Y-147	5C	05/08/00	2432	2411	99.14	2407	98.97	2378	98.63
Y-113	X	Y-112	5G	05/08/00	2607	2599	99.69	2594	99.50	2582	99.35
Y-216	X	Y-197	6E	05/15/00	2368	2337	98.69	2333	98.52	2210	94.57
Y-216	X	Y-212	6H	05/15/00	2494	2465	98.84	2462	98.72	2272	92.17
Y-220	X	Y-095	7F	05/15/00	2829	2802	99.05	2796	98.83	2780	99.21
Y-220	X	Y-212	^7H	05/15/00	2556	2541	99.41	2535	99.18	2618	103.03
Y-199	X	Y-204	8I	05/18/00	2823	2717	96.25	2565	90.86	2517	92.64
Y-199	X	Y-226	8J	05/18/00	1946	1892	97.23	1817	93.37	1787	94.45
Y-202	X	Y-112	9G	05/18/00	1643	1303	79.31	1264	76.93	1241	95.24
Y-202	X	Y-201	9K	05/18/00	1927	1268	65.80	1205	62.53	1184	93.38
Y-121	X	Y-149	10B	05/18/00	2976	2375	79.81	2218	74.53	2079	87.54
Y-121	X	Y-095	10F	05/18/00	2842	1856	65.31	1675	58.94	1618	87.18
Y-208	X	Y-201	11K	05/18/00	2531	2502	98.85	2500	98.78	2477	99.00
Y-208	X	Y-194	11L	05/18/00	3079	3058	99.32	3054	99.19	3020	98.76
Y-140	X	Y-204	12I	05/18/00	2837	2723	95.98	2705	95.35	2682	98.49
Y-140	X	Y-226	12J	05/18/00	2833	2738	96.65	2713	95.76	2537	92.66
Y-235	X	Y-204	13I	05/22/00	3104	3099	99.84	3093	99.65	3074	99.19
Y-235	X	Y-203	13M	05/22/00	2860	2853	99.76	2844	99.44	2735	95.86
Y-127	X	Y-095	14F	05/22/00	1545	1128	73.01	1002	64.85	1485	131.65
Y-116	X	Y-204	15I	05/22/00	2304	2201	95.53	2128	92.36	2347	106.63
Y-116	X	Y-194	15L	05/22/00	2366	2285	96.58	2189	92.52	2182	95.49
Y-238	X	Y-226	16J	05/25/00	3069	3051	99.41	3049	99.35	2891	94.76
Y-238	X	Y-201	16K	05/25/00	2650	2624	99.02	2620	98.87	2663	101.49

Table 7 (cont.) Family groups, date spawned, egg counts, and number tanked for brood year 2000 winter Chinook salmon spawned at Livingston Stone NFH.

Crosses (by floy tag number)			Family	Date	Number of		Percent	Number	Percent	Number	Precent tanked
Female		Male	group	spawned	Green eggs	Eyed eggs	eye-up	hatched	hatched	tanked	from eyed eggs
Y-219	X	Y-226	17J	05/25/00	3031	2991	98.68	2983	98.42	1189	39.75
Y-219	X	Y-203	17M	05/25/00	1403	1380	98.36	1365	97.29	1371	99.35
Y-219	X	Y-146	17N	05/25/00	1361	1334	98.02	1331	97.80	1319	98.88
Y-192	X	Y-201	18K	05/25/00	2342	2203	94.06	2109	90.05	2038	92.51
Y-192	X	Y-198	18O	05/25/00	2018	1820	90.19	1949	96.58	400	21.98
Y-218	X	Y-240	19P	05/30/00	2393	2310	96.53	2299	96.07	2174	94.11
Y-218	X	Y-239	19Q	05/30/00	1862	1796	96.46	1794	96.35	1751	97.49
Y-233	X	Y-240	20P	05/30/00	2452	2425	98.90	2421	98.74	2367	97.61
Y-233	X	Y-239	20Q	05/30/00	2509	2499	99.60	2494	99.40	2359	94.40
Y-225	X	Y-126	21R	06/01/00	2851	2710	95.05	2680	94.00	2576	95.06
Y-225	X	Y-217	21S	06/01/00	1267	1202	94.87	1181	93.21	1111	92.43
Y-225	X	Y-145	21T	06/01/00	908	846	93.17	835	91.96	786	92.91
Y-172	X	Y-242	22U	06/05/00	2553	2513	98.43	2493	97.65	2481	98.73
Y-172	X	Y-217	22S	06/05/00	1139	1107	97.19	1100	96.58	1085	98.01
Y-172	X	Y-145	22T	06/05/00	990	967	97.68	956	96.57	944	97.62
Y-118	X	Y-126	23R	06/05/00	2025	1961	96.84	1961	96.84	1746	89.04
Y-118	X	Y-242	23U	06/05/00	2505	2439	97.37	2336	93.25	2238	91.76
Y-209	X	Y-217	24S	06/08/00	1254	1034	82.46	949	75.68	921	89.07
Y-209	X	Y-145	24T	06/08/00	1164	965	82.90	847	72.77	838	86.84
Y-209	X	Y-117	24V	06/08/00	2295	1871	81.53	1643	71.59	1252	66.92
Y-227	X	Y-205	25W	06/08/00	3295	2746	83.34	2266	68.77	2004	72.98
Y-99	X	Y-198	26O	06/08/00	2994	2740	91.52	2623	87.61	1621	59.16
Y-99	X	Y-205	26W	06/08/00	3027	2593	85.66	2357	77.87	2012	77.59
Y-234	X	Y-198	27O	06/12/00	1864	721	38.68	558	29.94	463	64.22
Y-234	X	Y-205	27W	06/12/00	1346	876	65.08	665	49.41	532	60.73
Y-96	X	Y-117	28V	06/12/00	2324	2276	97.93	2269	97.63	951	41.78
Y-96	X	Y-177	28X	06/12/00	1189	1147	96.47	1135	95.46	1136	99.04
Y-96	X	CRYO	28-99K	06/12/00	1029	215	20.89	213	20.70	210	97.67
Y-243	X	Y-205	29W	06/15/00	2386	2372	99.41	2363	99.04	1205	50.80
Y-243	X	Y-245	29Y	06/15/00	1580	1576	99.75	1572	99.49	402	25.51
Y-243	X	CRYO	29-99I	06/15/00	1287	546	42.42	544	42.27	521	95.42

Table 7 (cont.) Family groups, date spawned, egg counts and number tanked for brood year 2000 winter Chinook salmon spawned at Livingston Stone NFH.

Crosses (by floy tag number)			Family	Date	Number of		Percent	Number	Percent	Number	Precent tanked
Female		Male	group	spawned	Green eggs	Eyed eggs	eye-up	hatched	hatched	tanked	from eyed eggs
Y-115	X	Y-117	30V	06/15/00	2440	2390	97.95	2357	96.60	2307	96.53
Y-115	X	Y-177	30X	06/15/00	1162	1145	98.54	1142	98.28	1141	99.65
Y-115	X	Y-176	30Z	06/15/00	1041	1018	97.79	1012	97.21	1036	101.77
Y-148	X	Y-249	31AA	06/19/00	2928	2732	93.31	2728	93.17	2663	97.47
Y-148	X	Y-247	31BB	06/19/00	3098	2926	94.45	2918	94.19	2903	99.21
Y-207	X	Y-249	32AA	06/19/00	2399	1889	78.74	1819	75.82	1441	76.28
Y-207	X	Y-247	32BB	06/19/00	2337	1968	84.21	1894	81.04	1843	93.65
Y-101	X	Y-249	33AA	06/19/00	2984	2452	82.17	2430	81.43	2297	93.68
Y-101	X	Y-247	33BB	06/19/00	2705	2612	96.56	2595	95.93	2539	97.21
Y-109	X	Y-198	34O	06/19/00	2627	2591	98.63	2557	97.34	1683	64.96
Y-109	X	Y-245	34Y	06/19/00	2769	2744	99.10	2708	97.80	2609	95.08
Y-166	X	Y-245	35Y	06/19/00	2038	2017	98.97	2011	98.68	1999	99.11
Y-166	X	Y-177	35X	06/19/00	1101	1089	98.91	1087	98.73	1075	98.71
Y-166	X	Y-176	35Z	06/19/00	1350	1331	98.59	1328	98.37	1305	98.05
Y-105	X	Y-237	36CC	06/22/00	2859	1566	54.77	1553	54.32	1537	98.15
Y-105	X	Y-117	36V	06/22/00	1161	756	65.12	750	64.60	531	70.24
Y-105	X	Y-176	36Z	06/22/00	1034	457	44.20	453	43.81	448	98.03
Y-102	X	Y-222	37DD	06/22/00	3413	3365	98.59	3361	98.48	3336	99.14
Y-102	X	Y-246	37EE	06/22/00	3179	3019	94.97	3002	94.43	2848	94.34
Y-129	X	Y-237	38CC	06/26/00	1887	1806	95.71	1789	94.81	1778	98.45
Y-129	X	Y-100	38FF	06/26/00	1756	1730	98.52	1712	97.49	1679	97.05
Y-211	X	Y-222	39DD	06/26/00	2794	2761	98.82	2743	98.17	2718	98.44
Y-211	X	Y-175	39GG	06/26/00	2432	2341	96.26	2039	83.84	1707	72.92
Y-193	X	Y-222	40DD	06/26/00	2471	1983	80.25	1941	78.55	1859	93.75
Y-193	X	Y-246	40EE	06/26/00	2533	2180	86.06	2118	83.62	2043	93.72
Y-174	X	Y-246	41EE	06/29/00	1764	1716	97.28	1695	96.09	1621	94.46
Y-174	X	Y-100	41FF	06/29/00	2273	2256	99.25	2246	98.81	2233	98.98
Y-141	X	Y-251	42HH	07/03/00	2155	2110	97.91	2085	96.75	2101	99.57
Y-141	X	CRYO	42-99E	07/03/00	1436	805	56.06	801	55.78	792	98.39
Y-141	X	CRYO	42-99B	07/03/00	1042	327	31.38	317	30.42	305	93.27

Table 7 (cont.) Family groups, dates spawned, egg counts, and number tanked for brood year 2000 winter Chinook salmon spawned at Livingston Stone National Fish Hatchery.

Crosses (by floy tag number)			Family	Date	Number of		Percent	Number	Percent	Number	Precent tanked
Female		Male	group	spawned	Green eggs	Eyed eggs	eye-up	hatched	hatched	tanked	from eyed eggs
Y-253	X	Y-251	43HH	188	3128	2997	95.81	2957	94.53	2948	98.37
Y-253	X	Y-100	43FF	188	2921	2832	96.95	2799	95.82	2786	98.38
Y-255	X	Y-251	44HH	192	2641	2600	98.45	2600	98.45	2038	78.38
Y-255	X	Y-246	44EE	192	2103	2075	98.67	2062	98.05	2551	122.94
TOTALS					**216075**	**197511**	**91.41**	**193363**	**89.49**	**179399**	**90.83**
Eggs per female					**4801.67**						

Juvenile Fish Health Maintenance and Treatments

To maintain sanitary rearing environments, rearing units were typically cleaned two to five times per week. No therapeutic or prophylactic treatments were necessary on any of the juveniles scheduled for the general release. A total of 1,224 juveniles retained for the captive broodstock program, representing 23 natural-origin family groups, were vaccinated against *Vibrio* on March 22, 2001. Vaccinations were performed by mixing the formalin-inactivated bacteria solution with the appropriate amount of 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.

Juvenile Releases

Tagging

All winter Chinook juveniles were coded-wire tagged between December 27 and January 4, 2000. Each of the 30 final family group combinations received a unique tag code (Table 8). On January 19 and 20, 2001, juveniles retained for the captive broodstock program were tagged with passive integrated transponder (PIT) tags. Fish ranged in length from 57 mm to 98 mm, and averaged 78.6 mm at the time of tagging.

Table 8 Coded-wire tag (CWT) codes, associated family groups, number tagged with passive integrated transponders (PIT), and distribution of juvenile winter Chinook salmon brood year 2000.

CWT Code	Family Group	Number PIT Tagged	Retained for Captive Broodstock Program
0501030107	1B, 8I, 8J, 9G, 9K, 10B	0	N/A
0501030108	21S, 21Y, 22S, 22T, 24S, 24T	0	N/A
0501030109	40EE, 40DD, 41FF	51	9 LSNFH 42 BML
0501030201	43FF, 43HH	51	9 LSNFH 42 BML
0501030202	10F, 13I, 14F	51	9 LSNFH 42 BML
0501030203	5C, 5G, 6E, 6H	51	9 LSNFH 42 BML

Table 8 (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 2000.

CWT Code	Family Group	Number PIT Tagged	Retained for Captive Broodstock Program
0501030204	4E, 4F	51	9 LSNFH 42 BML
0501030205	3D, 3E	51	9 LSNFH 42 BML
0501030206	18K, 18O, 20O, 20P	51	9 LSNFH 42 BML
0501030207	26W, 26O, 24V, 25W	51	9 LSNFH 42 BML
0501030208	23R, 23U, 27O, 27W, 28V, 28-99K	51	9 LSNFH 42 BML
0501030209	19P, 19Q, 35Y	51	9 LSNFH 42 BML
0501030301	31AA, 31BB	51	9 LSNFH 42 BML
0501030302	34Y, 34O, 36CC, 36V	51	9 LSNFH 42 BML
0501030303	37DD, 37EE	51	9 LSNFH 42 BML
0501030304	39DD, 38CC, 38FF	51	9 LSNFH 42 BML
0501030305	39GG, 42HH, 4S-99B, 42-99H	0	N/A
0501030306	17M, 17N, 13M	0	N/A
0501030307	28X, 30X, 30Z, 29W, 29Y, 29-99I	0	N/A
0501030308	41EE, 44EE, 44HH	51	9 LSNFH 42 BML

Table 8 (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 2000.

CWT Code	Family Group	Number PIT Tagged	Retained for Captive Broodstock Program
0501030309	12I, 12J	51	9 LSNFH 42 BML
0501030401	11K, 11L	51	9 LSNFH 42 BML
0501030402	7F, 7H	51	9 LSNFH 42 BML
0501030403	1A, 2A, 2C	51	9 LSNFH 42 BML
0501030404	15I, 15L, 17J	51	9 LSNFH 42 BML
0501030405	16J, 16K	51	9 LSNFH 42 BML
0501030406	22U, 21R	51	9 LSNFH 42 BML
0501030407	30V, 32AA, 32BB	51	9 LSNFH 42 BML
0501030408	32AA, 33BB	51	9 LSNFH 42 BML
0501030409	35X, 35Z, 36Z	0	N/A

Table 9 Tagging information and length data at time of release for BY 2000 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			
0501030107	8291	19	0	0.970	47	97	75	9	8023	248	8271
0501030108	5513	8	0	0.960	50	94	79	8	5284	220	5504
0501030109	5775	2	51	0.970	46	85	70	5	5550	172	5722
0501030201	5830	3	51	0.940	38	81	68	6	5429	347	5776
0501030202	5691	4	51	0.930	40	90	75	9	5241	395	5636
0501030203	6624	6	51	0.975	42	94	79	7	6403	164	6567
0501030204	5841	1	51	0.965	62	90	78	5	5586	203	5789
0501030205	6379	4	51	0.975	47	101	75	7	6166	158	6324
0501030206	7023	1	51	0.990	52	85	72	6	6901	70	6971
0501030207	6067	3	51	1.000	49	89	75	6	6013	0	6013
0501030208	5789	12	51	0.990	42	87	71	8	5667	57	5724
0501030209	5922	2	51	0.960	41	92	67	11	5634	235	5869
0501030301	5609	2	51	0.990	49	90	75	6	5500	56	5556
0501030302	5923	8	51	0.980	52	84	70	6	5747	117	5864
0501030303	6110	2	51	0.985	39	80	70	5	5966	91	6057
0501030304	5941	2	51	0.990	47	85	72	6	5829	59	5888
0501030305	5373	13	0	0.995	41	82	66	7	5333	27	5360
0501030306	5465	3	0	0.975	52	93	77	5	5325	137	5462
0501030307	5117	8	0	0.980	63	91	78	5	5007	102	5109
0501030308	5435	8	51	0.980	48	87	69	6	5268	108	5376
0501030309	4947	49	51	0.990	54	98	80	6	4798	48	4846
0501030401	5332	23	51	0.975	40	93	74	11	5126	131	5257
0501030402	4975	0	51	0.980	65	94	80	6	4826	98	4924
0501030403	5536	1	51	0.970	53	99	80	6	5319	164	5483
0501030404	4653	2	51	0.965	56	100	81	5	4439	161	4600
0501030405	5656	2	51	0.970	49	90	75	8	5435	168	5603
0501030406	4887	0	51	0.985	66	91	80	5	4763	73	4836
0501030407	4726	2	51	0.985	43	89	75	8	4603	70	4673
0501030408	4747	7	51	0.995	47	85	74	7	4666	23	4689
0501030409	2750	3	0	0.960	65	90	79	4	2637	110	2747
										Total Released	**166495**

Distribution

A total of 166,495[1] fish (79.5 per pound) from natural x natural-origin crosses were released at the Caldwell Park on February 1. 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 77.1% for natural-origin crosses. One thousand and two fish at 36.7 per pound were transferred for the captive broodstock program to Bodega Bay Marine Lab for smolting on March 22, 2001. Two hundred and fifteen fish 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.

Of the 11,895 juveniles produced by captive x captive-origin matings, 200 were sent to Steinhart Aquarium on July 25, 2001 for display purposes. The remaining juveniles were euthanized.

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 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 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 2000 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 135 to 182 ($N_{ew} = 0.10 \times N_s$) or 450 to 532 ($N_{ew} = 0.33 \times N_s$) 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 2000 release.

[1] the total release number reported here differs from the total of 166,206 that was initially reported to the Pacific States Marine Fisheries Council; an error associated with tag code 0501030208 was discovered in preparing this report

Fish Health Maintenance and Monitoring

At the time of release, CA-NV FHC personnel tested 30 juvenile Chinook for *R. salmoninarum* using ELISA. Sixty percent were negative (optical density value ≤ 0.083); the remaining 40% were in the low positive range (with the highest optical density value = 0.384). Because of the occurrence of false positive readings, optical density values that are within two standard deviations of the negative reference tissue are considered negative.

References

Arkush, K.D., M.A. Banks, D. Hedgecock, P.A. Siri, and S. Hamelberg. 1997. Winter-run chinook salmon captive broodstock program: progress report through April 1996. Interagency Ecological Program for the San Francisco Bay/Delta Estuary Technical Report 49: 1-42.

Bumgarner, Joseph D., Michael P. Gallinat - Washington Department of Fish and Wildlife, 2001, Tucannon River Spring Chinook Salmon Captive Brood Program FY2000 Annual Report, Report to Bonneville Power Administration, Contract No. 00000074, Project No. 200001901, 34 electronic pages (BPA Report DOE/BP-00000074-1)

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

2000 Winter Chinook Adult Trapping Plan

Year 2000 Adult winter-run Chinook salmon trapping plan/schedule

In 2000, the U.S. Fish and Wildlife Service (Service) intends to capture 120 adult Chinook winter-run Chinook salmon for the propagation program. A preseason run-size estimate of approximately 1,260 has been generated using an average replacement rate of 1.5:1 and a three year maturation schedule (Table 1). Run sizes over 800 allow the Service to collect the maximum number of adults requested (120) based on the 15% capture limit. The schedule for monthly collection targets is presented in Table1. Trapping will not likely occur in 2000 until late January or early February.

The preseason run-size estimates generated by the Service have generally been conservative. Last year was relatively accurate when compared to the post season estimate. The preseason run-size estimate generated in 1998 was 2,000, while the post season run-size estimate generated by the California Department of Fish and Game (CDFG) was 2,612. Likewise in 1999, the preseason run size estimate generated by the Service was 1,400, while the post season run-size estimate generated by CDFG was approximately 3,000. As seen, the run size estimate generated by the Service has been conservative when compared to the post season estimate, indicating fewer fish would have been collected for the program. However, the Service has placed an upper limit on broodstock collection at 120*. This means that if the run size estimate exceeds 800 only 120 fish will be collected regardless of the actual run size.

The trapping schedule has monthly collection targets throughout the trapping season. However, consistent with past operations, if monthly targets are not met, efforts will be made to attain the cumulative trapping number during the following month. For example, assume 50 adults are collected through March. This year's trap schedule (Table 1) calls for a cumulative target value of 63 through March (5th column, March entry). Although only 34 adults are targeted for collection in April (4th column, April entry), the target will be adjusted to 47 to attempt to hit the cumulative value of 97 (5th column, April entry) at the end of April.

All fish collected will be held in detention/quarantine for 3 to 5 days while awaiting the results of genetic analysis. This protocol is consistent with that executed in previous years. As described in the Service's 1998 Section 10 permit application supplement and addendum, all collected fish will be subjected to a 3-5 day quarantine/detention period. At the time of capture at the Keswick Dam fish trap, a tissue sample will be collected and a floy tag affixed to the specific individual. The tissue sample will be shipped to the Bodega Marine Laboratory for genetic analysis. If the results of the analysis are favorable (i.e., high probability of being a winter-run Chinook salmon {LOD>=1}), the fish will be maintained for the propagation program. If the results are not favorable, the individual fish will be transported back to the mainstem Sacramento River at Caldwell Park and released. In 1998, a LOD score >= 2 was the genetic criteria to retain an individual for the spawning program (see amendment of ESA section 10 permit supplement dated June 30, 1998 for a complete description of LOD scores and genetic and phenotypic selection criteria). In 1999, a LOD score of >=1 was adopted. Refinement of baseline genetic data suggested this reduction in the LOD would not result in selection of "non" winter-run Chinook salmon for the propagation program, while, at the same time, reducing the unnecessary rejection of actual winter-run Chinook salmon adults. The alteration and adoption of the LOD>=1 criteria for broodstock collection was thoroughly discussed at the February 26, 1999 meeting of the Genetics Subcommittee of the Winter-run Chinook Salmon Captive Broodstock Committee.

*The Livingston Stone National Fish Hatchery was designed to have an adult holding capacity of approximately 120 winter-run Chinook salmon adults.

Table 1.—Livingston Stone National Fish Hatchery winter-run Chinook salmon adult collection strategy for brood year **2000** based on a pre-season run-size estimate of 1,260 and a target collection of 120 fish.

Month	Percent Distribution[a]	Estimated Number[b]	Target Capture[c]		Actual Capture[e]		
			Number[d]	Cumulative Number	Number	Cumulative Number	Cumulative Percent of Total Estimated Run
Dec	1.8	23	2	2			0
Jan	5.1	64	6	8			
Feb	9.6	121	12	20			
Mar	36.0	454	43	63			
Apr	28.6	360	34	97			
May	8.9	112	11	108			
Jun	6.8	86	8	116			
Jul	3.4	43	4	120			
Aug	0.0	0	0	120			
Total	100	1260	120				

a-Historic percent distribution timing from December through July (displayed) based on fish counts at Red Bluff Diversion Dam.

b-The estimated run-size of 1,260 for 1999 is initially predicted based on:

1) an estimated population of 841 in 1997 (most salmon return at age three);
2) an estimated replacement level of 1.5 to 1 (recent replacement levels include: 1.2 to 1 [1992 - 1995]; 2.8 to 1 [1993 - 1996]; 4.4 to 1 [1994 - 1997]; 1.9 to 1 [1995 - 1998]; and 3.2 to 1 [1996 - 1999].

Estimated run-size values will be updated with actual in-season predictions based on counts at the Red Bluff Diversion Dam, aerial redd surveys, and trapping success at the Keswick Dam fish trap.

c-The target capture rate is 15% of the estimated run-size. However, to maintain genetic diversity, no less than 20 will be taken regardless of the run-size (i.e., run-size<135). Additionally, due to spatial constrains, no more than 120 will be collected regardless of the run-size estimate (i.e., > 800)

d-Monthly target numbers are generated by multiplying the total target capture (see footnote c) by the percent distribution value (see footnote a).

e-Actual number captured will be included in a post season report.

Attachment B

Brood Year 2000 Final Effective Population Calculation

Release Report for brood year 2000 winter Chinook salmon juveniles propagated at the U.S. Fish and Wildlife Service's Livingston Stone National Fish Hatchery

The U.S. Fish and Wildlife Service (Service) released endangered winter Chinook salmon from the Livingston Stone National Fish Hatchery on February 1, 2001. The number released was 166,206, the largest number of winter Chinook salmon juveniles released from a single brood year to date. Consistent with the Special Conditions in the Service's Section 10 Permit (# 1,027), the fish were transported to the release site (mainstem Sacramento River at Caldwell Park) in two vehicles, and were released at dusk. An estimate of the effective population size indicates negative genetic impacts on the winter Chinook salmon population as a consequence of this release are unlikely (see discussion below).

Broodstock Collection

During the months of March through July 2000, 85 adult winter Chinook salmon were collected from the fish traps at Keswick Dam and Red Bluff Diversion Dam and retained for use as broodstock[1]. All fish collected were subjected to genetic analysis for run determination and retained only after meeting the genetic selection criterion (LOD≥1).

Spawning

Gametes from 82 adults contributed to the brood year 2000 progeny. Eleven of the 89 adults retained for broodstock died prior to spawning. Therefore, the number of adults actually spawned was 78. Cryopreseved semen from four adults collected in 1999 was used to fertilize eggs from three females, so a total of 82 adults contributed to brood year 2000 juvenile production. Twelve of the adults retained for the program had adipose fin-clips, indicating they were of hatchery-origin. Consistent with past efforts, matings were conducted by splitting the eggs collected from individual females into two or more lots and fertilizing those lots with semen from different males.

Incubation and Rearing

A total of 216,075 eggs were collected and the number of juveniles released was 166,206 (approximately 1,200 additional juveniles were withheld from the general release for the captive broodstock program). Survival from green-egg to release was therefore 77.5%. All juveniles were coded-wire tagged. Prior to tagging, progeny from the 96 matings had been combined into 30 groups to facilitate spatial requirements of the Livingston Stone National Fish Hatchery. At the time of tagging, a unique tag code was applied to each of the 30 groups.

[1] Four winter Chinook salmon adults died while awaiting genetic results, bringing the total number of adults removed from the population to 89.

Effective Population Size Calculation

Based on an estimate of the effective population size, the release of 166,206 brood year 2000 winter Chinook salmon juveniles is not likely to result in genetic impacts to the population as a whole. A final release number for each mating was derived by distributing mortality proportionately between all family groups within a rearing unit. The number of juveniles from each family group prior to combining with other family groups was known. After combining, mortality was distributed proportionally, relative to the number of salmon from each family group. This was done every time rearing units were combined. This method assumes equal rates of survival for all family groups combined in a common rearing unit.

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 2000) and decisions reached at the February 27, 1998 meeting of the winter Chinook salmon captive broodstock genetics subcommittee.

When applying brood year 2000 hatchery propagation data to the population genetics model (see Hedrick et al. 1995), genetic impacts are not apparent. The brood year 2000 release group was the progeny of 44 females and 38 males (4 cryo-preserved semen samples), and the effective population size of the hatchery component is estimated at 113 (Table 1; Table 2; Figure 1). **The model indicates the overall effective population size would increase from 135 to 182 (N_{ew} = 0.10 x N_s) or 450 to 532 (N_{ew} = 0.33 x N_s) as a result of the hatchery supplementation program (Table 1; Table 2; Figure 1).** The increase noted in the overall effective population size from hatchery progeny suggests the winter Chinook salmon population will not incur negative genetic impacts as a consequence of the brood year 2000 release. Model assumptions for these calculations are presented in Appendix I.

Captive Broodstock

Approximately 1,200 of the brood year 2000 juveniles were PIT tagged on the 17th and 18th of January 2001 for the captive broodstock program. Of these, 1,000 will be transferred to the Bodega Marine Laboratory and Steinhart Aquarium. The remaining 200 will be retained at Livingston Stone NFH as part of the captive broodstock program at this location. Family groups containing progeny resulting from matings of hatchery-origin adults were ***not*** included as candidates for the captive broodstock program.

Table 1.- Estimated genetic impact of the release of brood year 2000 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.

2000 Run Size*	1350	
Hatchery Capture Rate	0.066	

	Captured Adults	Natural Spawners
Available Adults	93**	1,261
Pre-Spawn Mortality Rate	0.12	0.05
Est. Effective Population Size	113	126
Number of Females	44	479
Eggs per Female	4,911	4,900
Total Eggs	216,075	2,347,100
Survival to Fry		586,775
Survival to Pre-Smolt, Release	166,206	
Survival to Smolt, Post-Release	83,103	346,197
Total Smolt Production	429,368	
Percentage of Production	19.36 %	80.64%

Effective Population Size	185 (WITH HATCHERY INFLUENCE)
	138 (WITHOUT HATCHERY INFLUENCE)

* Year 2000 run-size estimate of winter Chinook salmon generated by the California Department of Fish and Game. This value includes the estimates of returning hatchery-origin winter Chinook salmon.

** 85 adults were collected and retained for the program. Four additional adults died while awaiting the results of the genetic analysis. Cryopreserved semen from four males collected in 1999 was used in four matings. The number displayed represents all winter Chinook salmon removed from the natural spawning population (89), plus the four 1999 cryopreserved samples.

Table 2. Estimated impact of the release of brood year 2000 juvenile winter Chinook salmon propagated at Livingston Stone National Fish Hatchery on the effective population size (N_e). The calculation assumes N_e(wild) = 0.333 multiplied by the estimated run size.

2000 Run Size*	1350
Hatchery Capture Rate	0.066

	Captured Adults		Natural Spawners
Available Adults	93**		1,261
Pre-Spawn Mortality Rate	0.12		0.05
Est. Effective Population Size	113		420
Number of Females	44		479
Eggs per Female	4,911		4,900
Total Eggs	216,075		2,347,100
Survival to Fry			586,775
Survival to Pre-Smolt, Release	166,206		
Survival to Smolt, Post-Release	83,103		346,197
Total Smolt Production		429,368	
Percentage of Production	19.36 %		80.64%
Effective Population Size	532 (WITH HATCHERY INFLUENCE)		
	450 (WITHOUT HATCHERY INFLUENCE)		

* Year 2000 run-size estimate of winter Chinook salmon generated by the California Department of Fish and Game. This value includes the estimates of returning hatchery-origin winter Chinook salmon.

** 85 adults were collected and retained for the program. Four additional adults died while awaiting the results of the genetic analysis. Cryopreserved semen from four males collected in 1999 was used in four matings. The number displayed represents all winter Chinook salmon removed from the natural spawning population (89), plus the four 1999 cryopreserved samples.

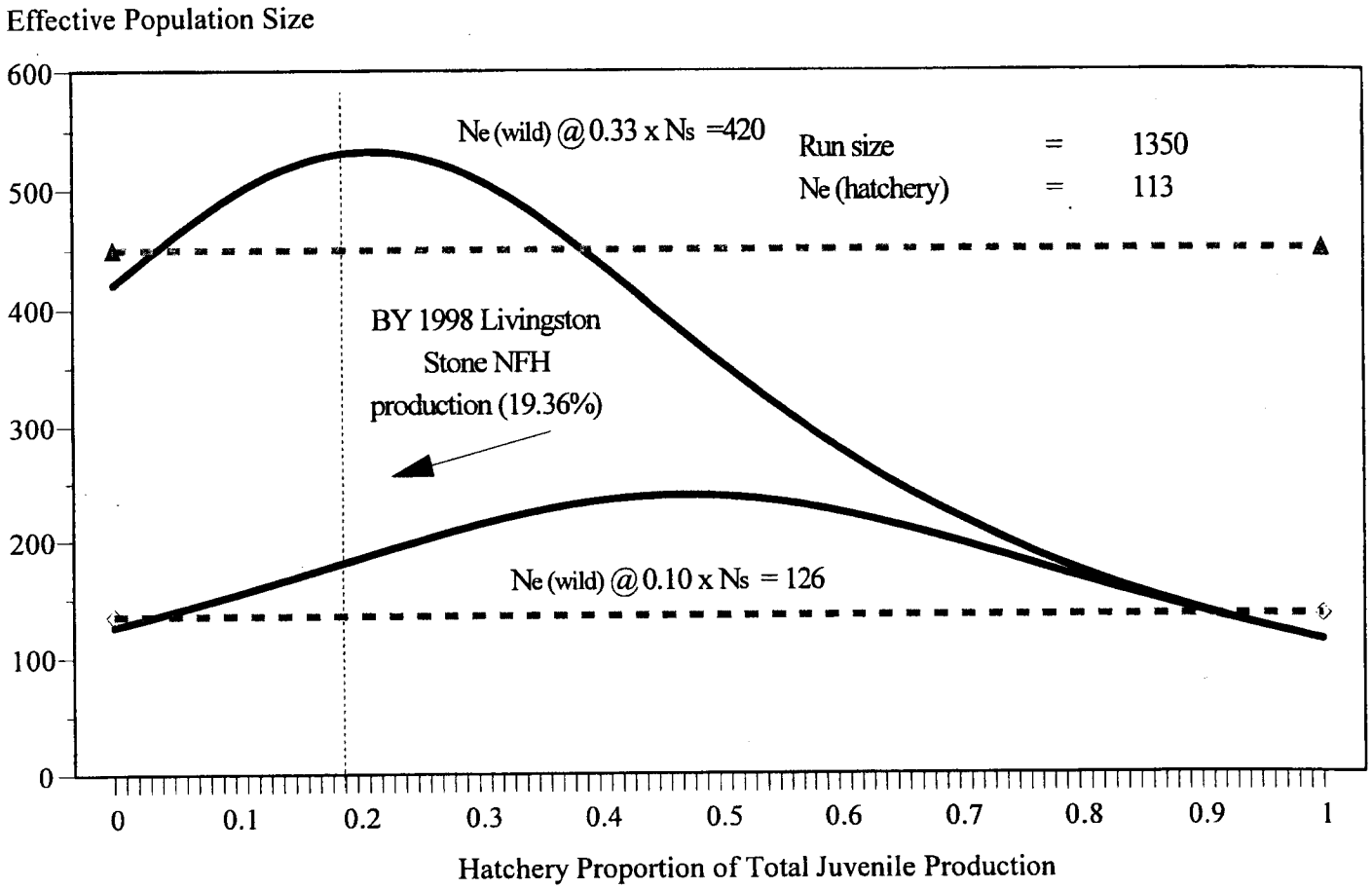

Figure 1.- Estimated effect of brood year 2000 juvenile production of winter Chinook salmon at Livingston Stone National Fish Hatchery on the overall effective population size. The top curve depicts $N_e(wild) = 0.33 \times N_s$ where N_s is the total number of spawners, and the bottom curve displays $N_e(wild) = 0.10 \times N_s$. The proportion of brood year 2000 hatchery production, in terms of all estimated juvenile production (i.e., hatchery and natural), is represented by the vertical dashed line. The intersection of the vertical dashed line with the two curved lines are estimates of the combined hatchery and natural effective population size. The horizontal dashed lines indicate expected effective population size of the natural population in the absence of the hatchery program at the $N_e(wild) = 0.33 \times N_s$ level (top dashed line) and at the $N_e(wild) = 0.10 \times N_s$ level (bottom dashed line). Displayed information is based on release numbers and assumptions on natural population production as outlined in the U.S. Fish and Wildlife Service's 1993 *Biological Assessment on the Effect of Coleman National Fish Hatchery Operations on Winter-Run Chinook Salmon* and Hedrick et al. (1995 and 2000).

References

Bartley, D., M. Bagley, G. Gall, and B. Bentley. 1992. Use of disequilibrium data to estimate effective population size of hatchery and natural fish populations. Conservation Biology 6:365-375.

Hallock, R.J., and F.W. Fisher. 1985. Status of winter-run chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento River, California. California Department of Fish and Game, Anadromous Fisheries Branch. Administrative Report. January 25, 1985.

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.

Hedrick, P.W., D. Hedgecock, S. Hamelberg, and S.J. Croci. 2000. The impact of supplementation in winter-run chinook salmon on effective population size. The Journal of Heredity. 91:112-116.

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 2000 (1350) was based on fish count data at Red Bluff Diversion Dam (Colleen Harvey-Arrison, CDFG, Red Bluff).

- 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 wild females is 40% of the estimated run size with an additional 5% pre-spawning mortality (Frank Fisher, CDFG, Red Bluff, CA, personal communication).

- Number of eggs per female is consistent with measures of fecundity noted at the Livingston Stone National Fish Hatchery in 2000, and considered information from females spawned at Coleman and Livingston Stone National Fish Hatcheries since 1989 (U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, CA, unpublished data) and 234 females spawned between 1956 and 1982 (Hallock and Fisher 1985).

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

- 59% survival from fry to smolt stage for the wild population (Hallock personal communication via D. McKee, CDFG, Sacramento CA).

Assumptions for hatchery production which differ from wild production include:

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

- Effective population size for the hatchery portion of the run (N_{ec}) is calculated using:

$$N_{ec} = \frac{4 N_f N_m}{x N_f + y N_m}$$

where

$$x = f + m \frac{\sigma^2_{km}}{k_m}$$

and

$$y = m + f \frac{\sigma^2_{kf}}{k_f}$$

where N_f and N_m are the actual numbers of breeding females and males in the captive program, k_f and σ^2_{kf} are the mean and variance of the number of progeny produced by females and k_m and σ^2_{km} are the mean and variance of progeny numbers for the males, and m and f are the proportion of male (m) to female (f) spawners, where $m + f = 1$.

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

$$N_e = \frac{N_{ew} N_{ec}}{x_w^2 N_{ec} + x_c^2 N_{ew}}$$

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

Further assumptions for this formula include:

(1) N_{ec} and N_{ew} are known;

(2) x_c and x_w, the proportions of spawners from wild and hatchery production are known;

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

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

(5) hatchery and wild females have equal egg numbers and survival of the next generation is the same in both groups.