

# 1998 Annual Report of Winter Chinook Propagation Activities

USFWS Report

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



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## Background

In 1989, due to drastic 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 Fisheries Service (NMFS) finalized an emergency rule that listed winter Chinook salmon as threatened under the federal Endangered Species Act (ESA). Despite continued restoration efforts, adult returns of winter Chinook salmon continued to decline, and in January of 1994 NMFS published its 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.

In 1989, in order to augment natural production and to protect against extinction, the Service developed an artificial propagation program at Coleman National Fish Hatchery. In 1998, because of concerns about adults imprinting on Battle Creek instead of the mainstem Sacramento River, the program was moved to a new facility at the base of Shasta Dam: Livingston Stone National Fish Hatchery (LSNFH).

1998 marked the first year in which juvenile winter Chinook salmon produced at the new Livingston Stone NFH were released into the Sacramento River. In 1996, a moratorium on hatchery winter Chinook releases was put into effect. One concern was the potential hybridization between spring Chinook and winter Chinook salmon due to the uncertainty surrounding the identification and selection of broodstock. Another concern was that despite releasing hatchery-origin juvenile winter Chinook into the mainstem Sacramento River, adults were returning primarily to Battle Creek. Since the intent of the hatchery program was to supplement the natural-origin population on the Sacramento River, the return of adults to Battle Creek was not the desired outcome.

Because of these concerns, the winter Chinook salmon program was moved to a new facility at the base of Shasta Dam; Livingston Stone NFH. It was felt that by incubating eggs and rearing juveniles in mainstem water rather than Battle Creek water, the hatchery fish would better imprint on mainstem water, and thus would be much more likely to return to upper mainstem spawning areas. Also, before any adults are spawned, a tissue sample is taken and tested to ensure that the fish is indeed a winter Chinook salmon. This will guard against any potential hybridization.

# Broodstock Collection

## Adult Collection Plan

Before the collection of broodstock began, the Service developed a broodstock collection plan that set out the timing of collection activities and the number of fish to be collected. In 1998, the adult collection schedule was based on a pre-season run estimate of 2,000 adult winter Chinook salmon, thus allowing the Service to collect 120 adult winter Chinook salmon, the maximum allowed. The scheduled timing of broodstock collection set out by 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 1998, broodstock for the winter Chinook propagation program were captured exclusively at the Keswick Dam fish trap (RM 302). Winter Chinook broodstock were collected between April 8 and May 21. Initiation of broodstock collection in 1998 was delayed this year for two reasons: 1) the Service was awaiting re-authorization of state and federal Endangered Species Act permits for the winter Chinook propagation program from the National Marine Fisheries Service (NMFS) and the California Department of Fish and Game (CDFG); and, 2) the Service was awaiting the results of bio-assessments being conducted to assess fish rearing conditions at Livingston Stone National Fish Hatchery.

### *Keswick Dam Fish Trap*

Three hundred and eighteen Chinook salmon were captured at the Keswick Dam fish trap from April 6 through June 2, 1998 (Table 1, Figure 1). Seventy six rainbow trout/steelhead were captured as the Keswick trap as well. The timing of operations at the Keswick Dam fish trap varied throughout the trapping season depending on the number of fish captured and water flows. Generally, the Keswick Dam fish trap was open for at least two consecutive days every week; on each of the last consecutive open days, the trap was checked and emptied. When the fish trap was not being used to collect broodstock it was raised out of the water to prevent fish from becoming entrapped.

### *Red Bluff Diversion Dam Trap*

Because winter Chinook broodstock needs were adequately met by trapping at the Keswick Dam site, no winter Chinook adults were collected from the fish trap located at the Red Bluff Diversion Dam in 1998.

### *Coleman National Fish Hatchery Battle Creek Fish Trap*

In 1998 the fish trap at the CNFH barrier weir was not used for winter Chinook broodstock collection. The CNFH barrier weir fish trap was operated from March 4 to June 1 1998 to monitor passage of naturally produced (unmarked) winter Chinook into upper Battle Creek and trap hatchery origin (marked) winter Chinook salmon in order to relocate them to more appropriate spawning habitats in the Sacramento River. Further description of the trapping

activities conducted at the CNFH fish trap can be found in the Research and Monitoring report and will not be further discussed here.

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

Chinook salmon collected at 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 tissue sample was collected from phenotypic winter Chinook. Phenotypic winter Chinook salmon were transported to the Coleman NFH in an aerated and insulated 1,200 or 1,600-gallon transport tank where they were initially quarantined in one of three 12-foot diameter tanks. A total of 152 Chinook salmon collected at the Keswick Dam fish trap were tissue sampled for genetic run determination and quarantined at the Coleman NFH.

One hundred seventy two 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. Unsampled salmon were marked with a floy tag and relocated to either the Caldwell Park boat ramp (RM 299) or the bridge at Ball's Ferry Road (RM 276). Salmon captured before April 29 were relocated to the bridge at Ball's Ferry Road to place them below the primary winter Chinook spawning areas, whereas those captured on or after April 29 were relocated to the boat ramp at Caldwell park so that they would not need to negotiate the Anderson Cottonwood Irrigation District (ACID) Dam fish ladder (RM 298.5) a second time. Five of the relocated salmon were subsequently recaptured at the Keswick trap (one fish was recaptured twice), three from releases at Ball's Ferry Road and two from releases at Caldwell Park.

#### *Genetic Stock Identification*

A sample of fin tissue collected from phenotypic winter Chinook salmon was sent to the genetics laboratory at the Bodega Marine Laboratory (BML) within 24-hours of collection. Stock determination from genetic analysis (i.e., winter Chinook or non-winter Chinook) was usually available 24 to 48 hours after tissue samples arrived at Bodega Marine Laboratory. Floy tags enabled quarantined fish to be matched with the results of genetic run call determinations.

One hundred and eight of the 152 phenotypic winter Chinook salmon collected at the Keswick Dam fish trap were genetically identified as winter Chinook salmon, including 36 males (34.3%) and 72 females (65.7%) (Table 1). Ten of the winter Chinook collected at the Keswick Dam fish trap were marked with an adipose fin-clip and coded-wire tag (2 males and 8 females) and ninety-eight were unmarked (35 males and 63 females). Forty-four Chinook salmon collected at the Keswick Dam fish trap were genetically determined to be non-winter Chinook; of these 42 were subsequently returned to Caldwell Park boat ramp (20 males, 17 females, and 5 unknowns) and 2 died while in the holding tanks (1 male and 1 female).

## Disposition of Quarantined Fish

It should be noted that because the adult holding tanks at LSNFH were not ready for operation in 1998, adult salmon collected at Keswick Dam were taken to Coleman NFH, where they were held in adult holding tanks. When the winter Chinook were ready to spawn, they were spawned at CNFH and the green eggs were then taken to LSNFH.

Of the 152 Chinook salmon collected at the Keswick Dam fish trap that were quarantined and sampled for genetic run determination in 1998 (Tables 1 and 2), ninety-six genetically identified winter Chinook salmon were spawned (35 males and 61 females), including 5 of hatchery origin (1 male and 4 females). Forty-four of the quarantined salmon were returned to the Sacramento River at Caldwell Park, including two genetically identified winter Chinook (both females) and forty-two genetically identified non-winter Chinook (20 males, 17 females, and 5 of undetermined gender). Nine Chinook salmon captured at the Keswick Dam fish trap died during quarantine; two were genetic non-winters (one male and one female) and seven were genetically identified as winter Chinook (one male and six females). Three genetically identified hatchery origin winter Chinook from the Keswick Dam fish trap were sacrificed for recovery of coded-wire tags, including one possible hybrid from brood year 1995.

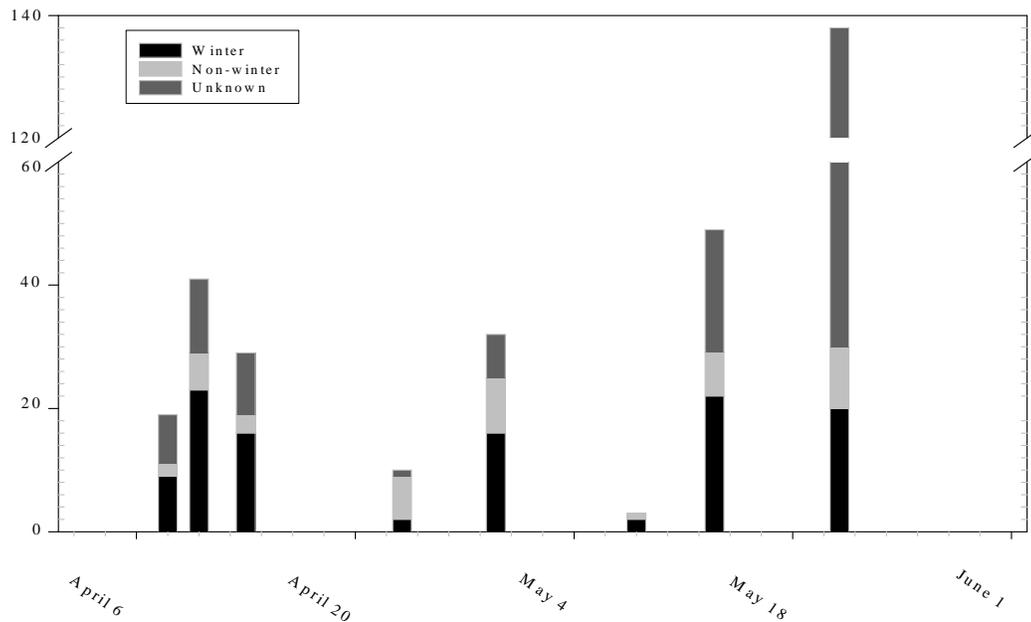


Figure 1 Number of winter, non-winter, and unknown-run Chinook salmon captured at the Keswick Dam fish trap between April 8 and June 2, 1998. Effort and trapping methods may greatly affect this data.

Table 1 Disposition of Chinook salmon captured at the Keswick Dam fish trap between April 6 and June 2, 1998. Marked salmon were considered to be of hatchery origin. Unmarked salmon were considered to be of natural-origin.

|  |       | <b>Keswick</b> |
|--|-------|----------------|
| Salmon returned without tissue samples (phenotypically non-winter)                                       | =     | 172            |
| Tissue sampled salmon  |       |                |
| Unmarked   | =     | 142            |
| Adipose fin-clipped (ad-clip)  | =     | 10             |
| Total captured (not including recaptures)  | =     | 324            |
| <b>Recaptured salmon</b>   | =     | <b>5</b>       |
| <b>Disposition of tissue sampled salmon</b>  |       |                |
|  |       | <b>Keswick</b> |
| Genetic non-winter salmon released/relocated<br>(all were unmarked and released)                         | M =   | 20             |
|  | F =   | 17             |
|  | unk = | 5              |
| Genetic winter chinook released/relocated  |       |                |
|  | M =   | 0              |
|  | F =   | 2              |
|  | unk = | 0              |
| Winter chinook salmon spawned<br>(1 male ad-clip)<br>(4 female ad-clips)                                 | M =   | 35             |
|  | F =   | 61             |
| <b>Mortalities</b>   |       |                |
| Non-winters found dead   |       |                |
|  | M =   | 1              |
|  | F =   | 1              |
| Non-winters sacrificed for CWT recovery (ad-clips)   |       |                |
|  | M =   | 0              |
|  | F =   | 0              |
|  | unk = | 0              |
| Winters sacrificed for CWT recovery (ad-clips)<br>(includes 1 possible hybrid {ad-clipped} from Keswick) |       |                |
|  | M =   | 0              |
|  | F =   | 3              |
|  | unk = | 0              |
| Winter mortalities   |       |                |
|  | M =   | 1              |
|  | F =   | 6              |
| <b>TOTAL</b>   |       | <b>152</b>     |

Table 2 Identification numbers, biological data, and coded-wire tag (CWT) code for tissue sampled Chinook salmon captured at the Keswick Dam fish trap, Sacramento River (RM 302). Salmon were captured between April 8 and June 2, 1998. 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 | Genetic ID | Floy tag number | Mark Status | Sex     | Fork length (mm) | Genetic Run | Final Disposition | CWT code   | Comment              |
|---------------|------------|-----------------|-------------|---------|------------------|-------------|-------------------|------------|----------------------|
| 04/08/98      | 98-3080    | Orange 051      | Unmarked    | Male    | 740              | Winter      | Spawned           |            |                      |
| 04/08/98      | 98-3081    | Orange 052      | Unmarked    | Male    | 765              | Winter      | Mortality         |            |                      |
| 04/08/98      | 98-3082    | Orange 053      | Unmarked    | Unknown | 748              | Non-winter  | Relocated         |            |                      |
| 04/08/98      | 98-3083    | Orange 054      | Ad-clip     | Male    | 722              | Winter      | Mortality         | 0501011307 | BY 1995              |
| 04/08/98      | 98-3084    | Orange 055      | Ad-clip     | Female  | 695              | Winter      | Sacrificed        | 0501011309 | BY 1995              |
| 04/08/98      | 98-3085    | Orange 056      | Unmarked    | Female  | 523              | Winter      | Relocated         |            |                      |
| 04/08/98      | 98-3086    | Orange 057      | Unmarked    | Female  | 560              | Winter      | Relocated         |            |                      |
| 04/08/98      | 98-3087    | Orange 058      | Ad-clip     | Female  | 685              | Winter      | Mortality         | N/A        | No tag was recovered |
| 04/08/98      | 98-3088    | Orange 059      | Unmarked    | Female  | 725              | Winter      | Mortality         |            |                      |
| 04/08/98      | 98-3089    | Orange 060      | Ad-clip     | Female  | 655              | Winter      | Sacrificed        | 0501011415 | BY 1995              |
| 04/08/98      | 98-3090    | Orange 061      | Unmarked    | Female  | 610              | Non-winter  | Relocated         |            |                      |
| 04/10/98      | 98-3092    | Orange 062      | Unmarked    | Female  | 750              | Non-winter  | Relocated         |            |                      |
| 04/10/98      | 98-3093    | Orange 063      | Unmarked    | Male    | 742              | Winter      | Spawned           |            |                      |
| 04/10/98      | 98-3094    | Orange 064      | Unmarked    | Unknown | 765              | Non-winter  | Relocated         |            |                      |
| 04/10/98      | 98-3095    | Orange 065      | Unmarked    | Female  | 690              | Winter      | Spawned           |            |                      |
| 04/10/98      | 98-3096    | Orange 066      | Unmarked    | Male    | 719              | Non-winter  | Relocated         |            | recaptured 5/21      |
| 04/10/98      | 98-3097    | Orange 068      | Unmarked    | Female  | 711              | Winter      | Spawned           |            |                      |
| 04/10/98      | 98-3098    | Orange 069      | Unmarked    | Unknown | 803              | Non-winter  | Relocated         |            | recaptured 5/21      |
| 04/10/98      | 98-3099    | Orange 070      | Unmarked    | Female  | 658              | Winter      | Spawned           |            |                      |
| 04/10/98      | 98-3100    | Orange 071      | Unmarked    | Female  | 732              | Winter      | Spawned           |            |                      |
| 04/10/98      | 98-3101    | Orange 072      | Unmarked    | Female  | 582              | Winter      | Spawned           |            |                      |
| 04/10/98      | 98-3102    | Orange 073      | Unmarked    | Male    | 622              | Non-winter  | Relocated         |            |                      |
| 04/10/98      | 98-3103    | Orange 074      | Ad-clip     | Male    | 733              | Winter      | Spawned           | N/A        | No tag was recovered |
| 04/10/98      | 98-3104    | Orange 075      | Unmarked    | Female  | 741              | Winter      | Spawned           |            |                      |
| 04/10/98      | 98-3105    | Orange 076      | Unmarked    | Female  | 702              | Winter      | Spawned           |            |                      |

Table 2 (cont.)

Identification numbers, biological data, and coded-wire tag (CWT) code for tissue sampled Chinook salmon captured at the Keswick Dam fish trap, Sacramento River (RM 302). 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 | Genetic ID | Floy tag number | Mark Status | Sex    | Fork length | Genetic Run | Final Disposition | CWT code   | Comment                             |
|---------------|------------|-----------------|-------------|--------|-------------|-------------|-------------------|------------|-------------------------------------|
| 04/10/98      | 98-3106    | Orange 077      | Ad-clip     | Female | 642         | Winter      | Spawned           | 0501011301 | BY 1995                             |
| 04/10/98      | 98-3107    | Orange 078      | Unmarked    | Female | 693         | Winter      | Spawned           |            |                                     |
| 04/10/98      | 98-3108    | Orange 079      | Unmarked    | Female | 695         | Winter      | Spawned           |            |                                     |
| 04/10/98      | 98-3109    | Orange 080      | Ad-clip     | Female | 702         | Winter      | Spawned           | N/A        | Head not collected for CWT recovery |
| 04/10/98      | 98-3110    | Orange 081      | Unmarked    | Female | 708         | Winter      | Spawned           |            |                                     |
| 04/10/98      | 98-3111    | Orange 082      | Unmarked    | Female | 653         | Non-winter  | Relocated         |            |                                     |
| 04/10/98      | 98-3112    | Orange 084      | Unmarked    | Female | 728         | Winter      | Spawned           |            |                                     |
| 04/10/98      | 98-3113    | Orange 085      | Unmarked    | Female | 663         | Winter      | Spawned           |            |                                     |
| 04/10/98      | 98-3114    | Orange 086      | Unmarked    | Female | 692         | Winter      | Spawned           |            |                                     |
| 04/10/98      | 98-3115    | Orange 087      | Unmarked    | Female | 593         | Winter      | Mortality         |            |                                     |
| 04/10/98      | 98-3116    | Orange 088      | Unmarked    | Female | 688         | Winter      | Spawned           |            |                                     |
| 04/10/98      | 98-3117    | Orange 089      | Unmarked    | Female | 657         | Winter      | Spawned           |            |                                     |
| 04/10/98      | 98-3118    | Orange 090      | Unmarked    | Female | 628         | Winter      | Spawned           |            |                                     |
| 04/10/98      | 98-3138    | Orange 083      | Unmarked    | Female | 627         | Winter      | Spawned           |            |                                     |
| 04/13/98      | 98-3119    | Orange 091      | Unmarked    | Female | 702         | Winter      | Spawned           |            |                                     |
| 04/13/98      | 98-3120    | Orange 092      | Unmarked    | Male   | 753         | Winter      | Spawned           |            |                                     |
| 04/13/98      | 98-3121    | Orange 093      | Unmarked    | Female | 533         | Winter      | Mortality         |            |                                     |
| 04/13/98      | 98-3122    | Orange 094      | Unmarked    | Male   | 621         | Winter      | Spawned           |            |                                     |
| 04/13/98      | 98-3123    | Orange 095      | Unmarked    | Female | 707         | Winter      | Spawned           |            |                                     |
| 04/13/98      | 98-3124    | Orange 096      | Unmarked    | Female | 733         | Winter      | Spawned           |            |                                     |
| 04/13/98      | 98-3125    | Orange 097      | Unmarked    | Female | 672         | Winter      | Spawned           |            |                                     |
| 04/13/98      | 98-3126    | Orange 098      | Unmarked    | Female | 640         | Winter      | Spawned           |            |                                     |
| 04/13/98      | 98-3127    | Orange 099      | Unmarked    | Male   | 748         | Non-winter  | Relocated         |            |                                     |
| 04/13/98      | 98-3128    | Orange 100      | Unmarked    | Male   | 699         | Winter      | Spawned           |            |                                     |
| 04/13/98      | 98-3129    | Orange 101      | Unmarked    | Female | 695         | Winter      | Spawned           |            |                                     |

Table 2 (cont.)

Identification numbers, biological data, and coded-wire tag (CWT) code for tissue sampled Chinook salmon captured at the Keswick Dam fish trap, Sacramento River (RM 302). 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 | Genetic ID | Floy tag number | Mark Status | Sex     | Fork length | Genetic Run | Final Disposition | CWT code   | Comment                  |
|---------------|------------|-----------------|-------------|---------|-------------|-------------|-------------------|------------|--------------------------|
| 04/13/98      | 98-3130    | Orange 102      | Unmarked    | Female  | 718         | Winter      | Spawned           |            |                          |
| 04/13/98      | 98-3131    | Orange 103      | Unmarked    | Female  | 689         | Winter      | Spawned           |            |                          |
| 04/13/98      | 98-3132    | Orange 104      | Unmarked    | Male    | 770         | Winter      | Spawned           |            |                          |
| 04/13/98      | 98-3133    | Orange 105      | Unmarked    | Unknown | 755         | Non-winter  | Relocated         |            |                          |
| 04/13/98      | 98-3134    | Orange 106      | Unmarked    | Female  | 653         | Non-winter  | Relocated         |            |                          |
| 04/13/98      | 98-3135    | Orange 107      | Unmarked    | Female  | 693         | Winter      | Spawned           |            |                          |
| 04/13/98      | 98-3136    | Orange 108      | Unmarked    | Female  | 657         | Winter      | Spawned           |            |                          |
| 04/13/98      | 98-3137    | Orange 109      | Unmarked    | Female  | 617         | Winter      | Spawned           |            |                          |
| 04/23/98      | 98-3154    | Orange 110      | Unmarked    | Female  | 741         | Non-winter  | Relocated         |            |                          |
| 04/23/98      | 98-3155    | Orange 111      | Ad-clip     | Female  | 635         | Winter      | Spawned           | 0501011307 | BY 1995                  |
| 04/23/98      | 98-3156    | Orange 112      | Unmarked    | Unknown | 675         | Non-winter  | Relocated         |            | recaptured 5/13          |
| 04/23/98      | 98-3157    | Orange 113      | Unmarked    | Female  | 648         | Non-winter  | Relocated         |            |                          |
| 04/23/98      | 98-3158    | Orange 114      | Unmarked    | Male    | 741         | Non-winter  | Relocated         |            |                          |
| 04/23/98      | 98-3159    | Orange 115      | Unmarked    | Female  | 645         | Non-winter  | Relocated         |            |                          |
| 04/23/98      | 98-3160    | Orange 116      | Unmarked    | Female  | 680         | Winter      | Spawned           |            |                          |
| 04/23/98      | 98-3161    | Orange 117      | Unmarked    | Female  | 675         | Non-winter  | Mortality         |            |                          |
| 04/23/98      | 98-3162    | Orange 118      | Unmarked    | Female  | 735         | Non-winter  | Relocated         |            |                          |
| 04/29/98      | 98-3171    | Orange 119      | Unmarked    | Female  | 721         | Winter      | Spawned           |            |                          |
| 04/29/98      | 98-3172    | Orange 120      | Unmarked    | Male    | 743         | Winter      | Spawned           |            |                          |
| 04/29/98      | 98-3173    | Orange 121      | Unmarked    | Male    | 782         | Non-winter  | Relocated         |            |                          |
| 04/29/98      | 98-3174    | Orange 122      | Unmarked    | Male    | 667         | Winter      | Spawned           |            |                          |
| 04/29/98      | 98-3175    | Orange 123      | Unmarked    | Female  | 781         | Winter      | Mortality         |            |                          |
| 04/29/98      | 98-3176    | Orange 124      | Ad-clip     | Female  | 691         | Winter      | Spawned           | NTD        |                          |
| 04/29/98      | 98-3177    | Orange 125      | Unmarked    | Male    | 625         | Winter      | Spawned           |            |                          |
| 04/29/98      | 98-3178    | Orange 126      | Unmarked    | Male    | 693         | Non-winter  | Relocated         |            | recaptured 5/13 and 5/21 |

Table 2 (cont.)

Identification numbers, biological data, and coded-wire tag (CWT) code for tissue sampled Chinook salmon captured at the Keswick Dam fish trap, Sacramento River (RM 302). 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 | Genetic ID | Floy tag number | Mark Status | Sex    | Fork length | Genetic Run | Final Disposition | CWT code | Comment         |
|---------------|------------|-----------------|-------------|--------|-------------|-------------|-------------------|----------|-----------------|
| 04/29/98      | 98-3179    | Orange 127      | Unmarked    | Male   | 743         | Non-winter  | Relocated         |          |                 |
| 04/29/98      | 98-3180    | Orange 128      | Unmarked    | Female | 707         | Winter      | Spawned           |          |                 |
| 04/29/98      | 98-3181    | Orange 129      | Unmarked    | Male   | 767         | Winter      | Spawned           |          |                 |
| 04/29/98      | 98-3182    | Orange 130      | Unmarked    | Male   | 772         | Winter      | Spawned           |          |                 |
| 04/29/98      | 98-3183    | Orange 131      | Unmarked    | Female | 643         | Winter      | Spawned           |          |                 |
| 04/29/98      | 98-3184    | Orange 132      | Unmarked    | Female | 664         | Non-winter  | Relocated         |          |                 |
| 04/29/98      | 98-3185    | Orange 134      | Unmarked    | Female | 709         | Winter      | Spawned           |          |                 |
| 04/29/98      | 98-3186    | Orange 135      | Unmarked    | Female | 722         | Non-winter  | Relocated         |          |                 |
| 04/29/98      | 98-3187    | Orange 136      | Unmarked    | Female | 655         | Winter      | Spawned           |          |                 |
| 04/29/98      | 98-3188    | Orange 137      | Unmarked    | Female | 743         | Non-winter  | Relocated         |          |                 |
| 04/29/98      | 98-3189    | Orange 138      | Unmarked    | Female | 662         | Non-winter  | Relocated         |          |                 |
| 04/29/98      | 98-3190    | Orange 139      | Unmarked    | Male   | 683         | Winter      | Spawned           |          |                 |
| 04/29/98      | 98-3191    | Orange 140      | Unmarked    | Female | 691         | Winter      | Spawned           |          |                 |
| 04/29/98      | 98-3192    | Orange 141      | Unmarked    | Female | 663         | Non-winter  | Relocated         |          |                 |
| 04/29/98      | 98-3193    | Orange 142      | Unmarked    | Female | 647         | Non-winter  | Relocated         |          | recaptured 5/13 |
| 04/29/98      | 98-3194    | Orange 144      | Unmarked    | Female | 635         | Winter      | Spawned           |          |                 |
| 04/29/98      | 98-3195    | Orange 145      | Unmarked    | Female | 673         | Winter      | Spawned           |          |                 |
| 05/08/98      | 98-3206    | Orange 146      | Unmarked    | Male   | 776         | Winter      | Spawned           |          |                 |
| 05/08/98      | 98-3207    | Orange 147      | Unmarked    | Female | 663         | Non-winter  | Relocated         |          |                 |
| 05/08/98      | 98-3208    | Orange 148      | Unmarked    | Female | 683         | Winter      | Spawned           |          |                 |
| 05/13/98      | 98-3209    | Orange 149      | Unmarked    | Male   | 706         | Non-winter  | Relocated         |          |                 |
| 05/13/98      | 98-3210    | Orange 150      | Unmarked    | Male   | 632         | Non-winter  | Relocated         |          |                 |
| 05/13/98      | 98-3211    | Orange 151      | Unmarked    | Female | 728         | Winter      | Spawned           |          |                 |
| 05/13/98      | 98-3212    | Orange 152      | Unmarked    | Female | 708         | Non-winter  | Relocated         |          |                 |
| 05/13/98      | 98-3213    | Orange 153      | Unmarked    | Male   | 812         | Winter      | Spawned           |          |                 |

Table 2 (cont.)

Identification numbers, biological data, and coded-wire tag (CWT) code for tissue sampled Chinook salmon captured at the Keswick Dam fish trap, Sacramento River (RM 302). 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 | Genetic ID | Floy tag number | Mark Status | Sex    | Fork length | Genetic Run | Final Disposition | CWT code | Comment |
|---------------|------------|-----------------|-------------|--------|-------------|-------------|-------------------|----------|---------|
| 05/13/98      | 98-3214    | Orange 154      | Unmarked    | Female | 692         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3215    | Orange 155      | Unmarked    | Female | 608         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3216    | Orange 156      | Unmarked    | Female | 652         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3217    | Orange 157      | Unmarked    | Male   | 653         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3218    | Orange 158      | Unmarked    | Male   | 795         | Non-winter  | Relocated         |          |         |
| 05/13/98      | 98-3219    | Orange 159      | Unmarked    | Female | 665         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3220    | Orange 160      | Unmarked    | Female | 673         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3221    | Orange 162      | Unmarked    | Female | 690         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3222    | Orange 163      | Unmarked    | Female | 750         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3223    | Orange 164      | Unmarked    | Male   | 773         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3224    | Orange 165      | Unmarked    | Male   | 654         | Non-winter  | Relocated         |          |         |
| 05/13/98      | 98-3225    | Orange 166      | Unmarked    | Female | 666         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3226    | Orange 167      | Unmarked    | Female | 632         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3227    | Orange 168      | Unmarked    | Female | 628         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3228    | Orange 169      | Unmarked    | Male   | 597         | Non-winter  | Relocated         |          |         |
| 05/13/98      | 98-3229    | Orange 170      | Unmarked    | Female | 697         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3230    | Orange 171      | Unmarked    | Female | 643         | Non-winter  | Relocated         |          |         |
| 05/13/98      | 98-3231    | Orange 172      | Unmarked    | Female | 672         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3232    | Orange 173      | Unmarked    | Female | 660         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3233    | Orange 174      | Unmarked    | Female | 612         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3234    | Orange 175      | Unmarked    | Female | 627         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3235    | Orange 176      | Unmarked    | Female | 650         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3236    | Orange 177      | Unmarked    | Female | 710         | Winter      | Spawned           |          |         |
| 05/13/98      | 98-3237    | Orange 178      | Unmarked    | Female | 665         | Winter      | Spawned           |          |         |
| 05/21/98      | 98-3240    | Orange 179      | Unmarked    | Male   | 765         | Non-winter  | Relocated         |          |         |

Table 2 (cont.)

Identification numbers, biological data, and coded-wire tag (CWT) code for tissue sampled Chinook salmon captured at the Keswick Dam fish trap, Sacramento River (RM 302). 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 | Genetic ID | Floy tag number | Mark Status | Sex    | Fork length | Genetic Run | Final Disposition | CWT code   | Comment                                 |
|---------------|------------|-----------------|-------------|--------|-------------|-------------|-------------------|------------|---|
| 05/21/98      | 98-3241    | Orange 180      | Unmarked    | Male   | 756         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3242    | Orange 181      | Unmarked    | Male   | 761         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3243    | Orange 182      | Unmarked    | Male   | 808         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3244    | Orange 183      | Unmarked    | Male   | 670         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3245    | Orange 184      | Unmarked    | Male   | 748         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3246    | Orange 186      | Unmarked    | Male   | 677         | Non-winter  | Mortality         |            |   |
| 05/21/98      | 98-3247    | Orange 187      | Unmarked    | Male   | 738         | Non-winter  | Relocated         |            |   |
| 05/21/98      | 98-3248    | Orange 188      | Unmarked    | Male   | 732         | Non-winter  | Relocated         |            |   |
| 05/21/98      | 98-3249    | Orange 189      | Unmarked    | Male   | 762         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3250    | Orange 190      | Unmarked    | Male   | 750         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3251    | Orange 191      | Unmarked    | Male   | 729         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3252    | Orange 192      | Unmarked    | Male   | 808         | Non-winter  | Relocated         |            |   |
| 05/21/98      | 98-3253    | Orange 193      | Unmarked    | Male   | 749         | Non-winter  | Relocated         |            |   |
| 05/21/98      | 98-3254    | Orange 195      | Unmarked    | Male   | 732         | Non-winter  | Relocated         |            |   |
| 05/21/98      | 98-3255    | Orange 196      | Unmarked    | Male   | 684         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3256    | Orange 197      | Unmarked    | Male   | 668         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3257    | Orange 198      | Unmarked    | Male   | 761         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3258    | Orange 199      | Ad-clip     | Female | 658         | Winter      | Sacrificed        | 0501011501 | BY 1995 - Possible winter-spring hybrid |
| 05/21/98      | 98-3259    | Orange 200      | Unmarked    | Male   | 718         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3260    | Yellow 151      | Unmarked    | Male   | 732         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3261    | Yellow 152      | Unmarked    | Male   | 746         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3262    | Yellow 153      | Unmarked    | Male   | 833         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3263    | Yellow 154      | Unmarked    | Male   | 753         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3264    | Yellow 158      | Unmarked    | Male   | 748         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3265    | Yellow 160      | Unmarked    | Male   | 699         | Non-winter  | Relocated         |            |   |
| 05/21/98      | 98-3266    | Yellow 161      | Unmarked    | Male   | 742         | Winter      | Spawned           |            |   |
| 05/21/98      | 98-3267    | Yellow 162      | Unmarked    | Male   | 584         | Non-winter  | Relocated         |            |   |

## Fish Health Maintenance and Monitoring

As stated previously, because the adult holding tanks at Livingston Stone NFH were not ready for operation in 1998, adult salmon collected at Keswick Dam were taken to Coleman NFH, where they were held in adult holding tanks. When the winter Chinook were ready to spawn, they were spawned at Coleman NFH and the green eggs were then taken to Livingston Stone NFH.

Water temperatures in the adult holding tanks at Coleman NFH were monitored continuously using a Weksler thermograph. Chilled water was not used for two reasons: 1) water temperatures were cooler than normal; and, 2) fertilized eggs were scheduled to be immediately transferred to Livingston Stone NFH.

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, artificial slime, 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 monitored fish health closely.

In the adult holding tanks at Coleman NFH, malachite green was used to treat all adult winter Chinook salmon that were captured to reduce or eliminate fungal infections. Based on previous mortality rates of winter Chinook in untreated holding ponds at 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). Five deaths were attributed to fungal infection; all of these salmon were heavily infected when captured. A total of 409.5 g of malachite green was used for 22 treatments in 1998.

Adults were given dorsal sinus injections of erythromycin 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 gender were treated as well. Of the 61 females spawned, 59 received one to four injections with at least fourteen days between injections (Table 4). Two females were not injected because of their advanced maturation. Eleven of 37 males received erythromycin injections prior to sex determination; none received more than one injection (Table 5). The CA-NV FHC tested 76 winter Chinook adults for *R. salmoninarum* using an enzyme-linked immunosorbent assay (ELISA). The results indicated suspected *R. salmoninarum* infection in 71% (56) of the salmon tested while the remaining 29% (22) tested negative for the bacteria.

Luteinizing Hormone - Releasing Hormone analogue (LH-RH<sub>a</sub>) was administered in 1998 to accelerate final gamete maturation in fish that had already undergone gametogenesis. Similar to previous years, LH-RH<sub>a</sub> was used to synchronize maturation of broodstock. These Ovaplant 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. All implants contained 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.

Fourteen fish were given LH-RH<sub>a</sub> therapy from May 7 through June 22, 1998. The fourteen fish consisted of one male and thirteen females. One female was a potential hybrid, and was therefore sacrificed. The remaining fish all reached sexual maturation. The fish took an average of 8.3 days post-injection (range 7 to 11 days) to reach maturity.

Oxytetracycline (terramycin) was not used in 1998 to treat winter Chinook broodstock. In the past, oxytetracycline had been used to treat for infection by gram-negative bacteria, particularly *Aeromonas* spp. and *Pseudomonas* spp. However, benefits of these treatments have not been demonstrated. Treatments for erythema using oxytetracycline have had mixed results in previous years.

### Prespawning Mortality

Prespawning mortality of winter Chinook broodstock was 6.5% (7 of 108) in 1998. Six of seven pre-spawn mortalities were in poor condition at time of capture. Prespawning mortality for brood years 1994 and 1995 was 6.9% and 7.1%, respectively.

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  |
| <i>vibrio</i> spp. vaccine |                    | bath                   | vaccination against salt-water <i>vibrio</i> spp. |
| artificial slime           | 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 Coleman National Fish Hatchery in 1998.

| Genetic ID | Date Captured | Fork length (mm) | Weight (lbs) | Date Spawned | Date of death | Days in Captivity | Erythromycin <sup>1</sup> |            | LH-RHa <sup>2</sup> |            | Number of MG <sup>3</sup> treatments | Comments               |
|------------|---------------|------------------|--------------|--------------|---------------|-------------------|---------------------------|------------|---------------------|------------|--------------------------------------|------------------------|
|            |               |                  |              |              |               |                   | Dose (mls)                | Injections | Dose (µg)           | Injections |                                      |                        |
| 98-3087    | 04/08/98      | 685              | 7.7          | N/A          | 04/27/98      | 18                |                           |            |                     |            | 3                                    | Pre-spawning mortality |
| 98-3088    | 04/08/98      | 725              | 11.0         | N/A          | 04/20/98      | 11                |                           |            |                     |            | 1                                    | Pre-spawning mortality |
| 98-3095    | 04/10/98      | 690              | 9.1          | 05/11/98     | 05/11/98      | 30                | 0.5                       | 1          |                     |            | 8                                    |                        |
| 98-3097    | 04/10/98      | 711              | 8.1          | 05/21/98     | 05/21/98      | 40                | 0.4                       | 2          |                     |            | 11                                   |                        |
| 98-3099    | 04/10/98      | 658              | 7.1          | 06/04/98     | 06/04/98      | 54                | 0.4                       | 3          |                     |            | 15                                   |                        |
| 98-3100    | 04/10/98      | 732              | 10.8         | 05/04/98     | 05/04/98      | 23                | 0.5                       | 1          |                     |            | 6                                    |                        |
| 98-3101    | 04/10/98      | 582              | 4.5          | 05/18/98     | 05/18/98      | 37                | 0.3                       | 2          |                     |            | 10                                   |                        |
| 98-3104    | 04/10/98      | 741              | 6.5          | 05/26/98     | 05/26/98      | 45                | 0.4                       | 2          |                     |            | 12                                   |                        |
| 98-3105    | 04/10/98      | 702              | 8.9          | 05/26/98     | 05/26/98      | 45                | 0.4                       | 2          |                     |            | 12                                   |                        |
| 98-3106    | 04/10/98      | 642              | 6.2          | 05/26/98     | 05/26/98      | 45                | 0.4                       | 2          |                     |            | 12                                   |                        |
| 98-3107    | 04/10/98      | 693              | 7.7          | 05/04/98     | 05/04/98      | 23                | 0.5                       | 1          |                     |            | 6                                    |                        |
| 98-3108    | 04/10/98      | 695              | 8.4          | 05/11/98     | 05/11/98      | 30                | 0.4                       | 1          |                     |            | 8                                    |                        |
| 98-3109    | 04/10/98      | 702              | 8.9          | 06/25/98     | 06/25/98      | 75                | 0.4                       | 4          | 250                 | 1          | 20                                   |                        |
| 98-3110    | 04/10/98      | 708              | 10.1         | 05/04/98     | 05/04/98      | 23                | 0.5                       | 1          |                     |            | 6                                    |                        |
| 98-3112    | 04/10/98      | 728              | 10.5         | 05/11/98     | 05/11/98      | 30                | 0.5                       | 1          |                     |            | 8                                    |                        |
| 98-3113    | 04/10/98      | 663              | 7.8          | 06/22/98     | 06/22/98      | 72                | 0.4                       | 3          | 250                 | 1          | 20                                   |                        |
| 98-3114    | 04/10/98      | 692              | 7.4          | 05/01/98     | 05/01/98      | 20                | 0.4                       | 1          |                     |            | 6                                    |                        |
| 98-3115    | 04/10/98      | 593              | 5.2          | N/A          | 04/27/98      | 16                |                           |            |                     |            | 3                                    | Pre-spawning mortality |
| 98-3116    | 04/10/98      | 688              | 9.0          | 05/01/98     | 05/01/98      | 20                | 0.5                       | 1          |                     |            | 6                                    |                        |
| 98-3117    | 04/10/98      | 657              | 6.8          | 05/07/98     | 05/07/98      | 26                | 0.4                       | 1          |                     |            | 7                                    |                        |
| 98-3118    | 04/10/98      | 628              | 6.3          | 05/07/98     | 05/07/98      | 26                | 0.4                       | 1          |                     |            | 7                                    |                        |
| 98-3119    | 04/13/98      | 702              | 9.1          | 06/22/98     | 06/22/98      | 69                | 0.4                       | 4          | 250                 | 1          | 20                                   |                        |
| 98-3121    | 04/10/98      | 533              | 3.4          | N/A          | 04/27/98      | 16                |                           |            |                     |            | 3                                    | Pre-spawning mortality |

1 Erythromycin dose was based on 20 mg/kg.

2 LH-RHa = Luteinizing Hormone - Releasing Hormone analogue. Each capsule contained 250 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 Coleman National Fish Hatchery in 1998.

| Genetic ID | Date Captured | Fork length (mm) | Weight (lbs) | Date Spawned | Date of death | Days in Captivity | Erythromycin <sup>1</sup> |            | LH-RHa <sup>2</sup> |            | Number of MG <sup>3</sup> treatments | Comments |
|------------|---------------|------------------|--------------|--------------|---------------|-------------------|---------------------------|------------|---------------------|------------|--------------------------------------|----------|
|            |               |                  |              |              |               |                   | Dose (mls)                | Injections | Dose (µg)           | Injections |                                      |          |
| 98-3123    | 04/13/98      | 707              | 8.9          | 06/11/98     | 06/11/98      | 58                | 0.4                       | 2          |                     |            | 17                                   |          |
| 98-3124    | 04/13/98      | 733              | 10.4         | 05/07/98     | 05/07/98      | 23                | 0.5                       | 1          |                     |            | 7                                    |          |
| 98-3125    | 04/13/98      | 672              | 8.0          | 05/01/98     | 05/01/98      | 17                | 0.5                       | 1          |                     |            | 6                                    |          |
| 98-3126    | 04/13/98      | 640              | 6.2          | 05/26/98     | 05/26/98      | 42                | 0.4                       | 2          |                     |            | 12                                   |          |
| 98-3129    | 04/13/98      | 695              | 8.3          | 05/04/98     | 05/04/98      | 20                | 0.5                       | 1          |                     |            | 6                                    |          |
| 98-3130    | 04/13/98      | 718              | 10.0         | 06/25/98     | 06/25/98      | 72                | 0.5                       | 4          | 250                 | 1          | 20                                   |          |
| 98-3131    | 04/13/98      | 689              | 6.8          | 06/08/98     | 06/08/98      | 55                | 0.4                       | 2          |                     |            | 16                                   |          |
| 98-3135    | 04/13/98      | 693              | 9.0          | 05/28/98     | 05/28/98      | 44                | 0.5                       | 2          |                     |            | 13                                   |          |
| 98-3136    | 04/13/98      | 657              | 6.7          | 05/18/98     | 05/18/98      | 34                | 0.4                       | 2          | 250                 | 1          | 10                                   |          |
| 98-3137    | 04/13/98      | 617              | 6.1          | 05/07/98     | 05/07/98      | 23                | 0.4                       | 1          |                     |            | 7                                    |          |
| 98-3138    | 04/10/98      | 627              | 6.3          | 05/07/98     | 05/07/98      | 26                | 0.4                       | 1          |                     |            | 7                                    |          |
| 98-3155    | 04/23/98      | 635              | 6.7          | 05/07/98     | 05/07/98      | 13                | 0.4                       | 1          |                     |            | 2                                    |          |
| 98-3160    | 04/23/98      | 680              | 7.5          | 06/01/98     | 06/01/98      | 38                | 0.4                       | 2          |                     |            | 10                                   |          |
| 98-3171    | 04/29/98      | 721              | 10.3         | 06/15/98     | 06/15/98      | 46                | 0.5                       | 3          |                     |            | 12                                   |          |
| 98-3176    | 04/29/98      | 691              | 8.6          | 05/28/98     | 05/28/98      | 28                | 0.4                       | 2          |                     |            | 7                                    |          |
| 98-3180    | 04/29/98      | 707              | 8.3          | 05/14/98     | 05/14/98      | 14                | 0.4                       | 1          |                     |            | 3                                    |          |
| 98-3183    | 04/29/98      | 643              | 6.2          | 06/01/98     | 06/01/98      | 32                | 0.4                       | 2          |                     |            | 8                                    |          |
| 98-3185    | 04/29/98      | 709              | 9.3          | 06/08/98     | 06/08/98      | 39                | 0.4                       | 2          |                     |            | 10                                   |          |
| 98-3187    | 04/29/98      | 655              | 7.6          | 06/22/98     | 06/22/98      | 53                | 0.4                       | 3          | 250                 | 1          | 14                                   |          |
| 98-3191    | 04/29/98      | 691              | 8.6          | 06/29/98     | 06/29/98      | 60                | 0.4                       | 3          | 250                 | 1          | 15                                   |          |
| 98-3194    | 04/29/98      | 635              | 7.2          | 07/02/98     | 07/02/98      | 63                | 0.4                       | 3          | 250                 | 1          | 16                                   |          |
| 98-3195    | 04/29/98      | 673              | 7.7          | 06/15/98     | 06/15/98      | 46                | 0.4                       | 3          |                     |            | 12                                   |          |
| 98-3208    | 05/08/98      | 683              | 7.3          | 06/18/98     | 06/18/98      | 40                | 0.4                       | 2          |                     |            | 11                                   |          |

1 Erythromycin dose was based on 20 mg/kg.

2 LH-RHa = Luteinizing Hormone - Releasing Hormone analogue. Each capsule contained 250 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 Coleman National Fish Hatchery in 1998.

| Genetic ID | Date Captured | Fork length (mm) | Weight (lbs) | Date Spawned | Date of death | Days in Captivity | Erythromycin <sup>1</sup> |            | LH-RHa <sup>2</sup> |            | Number of MG <sup>3</sup> treatments | Comments                    |
|------------|---------------|------------------|--------------|--------------|---------------|-------------------|---------------------------|------------|---------------------|------------|--------------------------------------|-----------------------------|
|            |               |                  |              |              |               |                   | Dose (mls)                | Injections | Dose (µg)           | Injections |                                      |                             |
| 98-3211    | 05/13/98      | 728              | 9.8          | 05/28/98     | 05/28/98      | 14                | 0.5                       | 1          |                     |            | 3                                    |                             |
| 98-3214    | 05/13/98      | 692              | 8.9          | 05/26/98     | 05/26/98      | 12                | 0.4                       | 1          |                     |            | 2                                    |                             |
| 98-3215    | 05/13/98      | 608              | 5.5          | 06/22/98     | 06/22/98      | 39                | 0.3                       | 2          |                     |            | 10                                   |                             |
| 98-3216    | 05/13/98      | 652              | 8.3          | 05/21/98     | 05/21/98      | 7                 | 0.4                       | 1          |                     |            | 1                                    |                             |
| 98-3219    | 05/13/98      | 665              | 7.8          | 05/28/98     | 05/28/98      | 14                | 0.4                       | 1          |                     |            | 3                                    |                             |
| 98-3220    | 05/13/98      | 673              | 8.8          | 05/21/98     | 05/21/98      | 7                 | 0.4                       | 1          |                     |            | 1                                    |                             |
| 98-3221    | 05/13/98      | 690              | 10.1         | 05/18/98     | 05/18/98      | 4                 |                           |            |                     |            |                                      |                             |
| 98-3222    | 05/13/98      | 750              | 10.5         | 06/08/98     | 06/08/98      | 25                | 0.5                       | 1          |                     |            | 6                                    |                             |
| 98-3225    | 05/13/98      | 666              | 8.0          | 06/22/98     | 06/22/98      | 39                | 0.4                       | 2          |                     |            | 10                                   |                             |
| 98-3226    | 05/13/98      | 632              | 6.2          | 06/22/98     | 06/22/98      | 39                | 0.3                       | 2          | 250                 | 1          | 10                                   |                             |
| 98-3227    | 05/13/98      | 628              | 5.3          | 05/26/98     | 05/26/98      | 12                | 0.3                       | 1          | 250                 | 1          | 2                                    |                             |
| 98-3229    | 05/13/98      | 697              | 8.8          | 06/04/98     | 06/04/98      | 21                | 0.4                       | 1          |                     |            | 5                                    |                             |
| 98-3231    | 05/13/98      | 672              | 9.4          | 05/18/98     | 05/18/98      | 4                 |                           |            |                     |            |                                      |                             |
| 98-3232    | 05/13/98      | 660              | 6.9          | 06/15/98     | 06/15/98      | 32                | 0.4                       | 2          |                     |            | 8                                    |                             |
| 98-3233    | 05/13/98      | 612              | 6.1          | 05/28/98     | 05/28/98      | 14                | 0.4                       | 1          |                     |            | 3                                    |                             |
| 98-3234    | 05/13/98      | 627              | 6.1          | 06/25/98     | 06/29/98      | 42                | 0.3                       | 2          | 250                 | 1          | 10                                   |                             |
| 98-3235    | 05/13/98      | 650              | 6.2          | 06/01/98     | 06/01/98      | 18                | 0.4                       | 1          |                     |            | 4                                    |                             |
| 98-3236    | 05/13/98      | 710              | 8.7          | 05/26/98     | 05/26/98      | 12                | 0.4                       | 1          | 250                 | 1          | 2                                    |                             |
| 98-3237    | 05/13/98      | 665              | 7.6          | 05/21/98     | 05/21/98      | 7                 | 0.4                       | 1          |                     |            | 1                                    |                             |
| 98-3258    | 05/21/98      | 658              | 7.1          | N/A          | 06/08/98      | 17                | 0.4                       | 1          | 250                 | 1          | 4                                    | Possible hybrid, sacrificed |

1 Erythromycin dose was based on 20 mg/kg.

2 LH-RHa = Luteinizing Hormone - Releasing Hormone analogue. Each capsule contained 250 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 Coleman National Fish Hatchery in 1998.

| Genetic ID | Date captured | length (mm) | Weight (lbs) | Date Spawned                                 | Date of death | Days in Captivity | Erythromycin |            | LH-RHa    |            | MG Treatments          | Comments |
|------------|---------------|-------------|--------------|--|---------------|-------------------|--------------|------------|-----------|------------|------------------------|----------|
|            |               |             |              |  |               |                   | Dose (mls)   | Injections | Dose (mg) | Injections |                        |          |
| 98-3080    | 04/08/98      | 740         | 11.6         | 05/07/98<br>05/07/98<br>05/11/98<br>05/11/98 | 05/11/98      | 32                | 0.5          | 1          |           | 7          |                        |          |
| 98-3081    | 04/08/98      | 765         | 11.3         | N/A  | 04/20/98      | 11                | 0            | 0          |           | 1          | Pre-spawning mortality |          |
| 98-3083    | 04/08/98      | 722         | 10.2         | N/A  | 04/21/98      | 12                | 0            | 0          |           | 2          | Pre-spawning mortality |          |
| 98-3093    | 04/10/98      | 742         | 9.7          | 05/01/98<br>05/04/98<br>05/07/98<br>05/11/98 | 05/11/98      | 30                | 0.5          | 1          |           | 7          |                        |          |
| 98-3103    | 04/10/98      | 733         | 9.8          | 05/14/98<br>05/18/98<br>05/21/98<br>05/21/98 | 05/28/98      | 47                | 0.4          | 1          |           | 13         |                        |          |
| 98-3120    | 04/13/98      | 753         | 11.0         | 05/21/98<br>05/21/98<br>05/26/98<br>05/26/98 | 05/28/98      | 44                | 0.6          | 1          |           | 13         |                        |          |
| 98-3122    | 04/13/98      | 621         | 5.3          | 05/07/98<br>05/07/98<br>05/11/98<br>05/18/98 | 05/26/98      | 42                | 0.3          | 1          |           | 12         |                        |          |
| 98-3128    | 04/13/98      | 699         | 7.2          | 05/01/98<br>05/04/98<br>05/07/98<br>05/07/98 | 05/11/98      | 27                | 0.4          | 1          |           | 7          |                        |          |

- 1 Erythromycin dose was based on 20 mg/kg.
- 2 LH-RHa = Luteinizing Hormone - Releasing Hormone analogue. Each capsule contained 250 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 Coleman National Fish Hatchery in 1998.

| Genetic ID | Date captured | length (mm) | Weight (lbs) | Date Spawned                                 | Date of death | Days in Captivity | Erythromycin |            | LH-RHa    |            | MG | Comments |
|------------|---------------|-------------|--------------|--|---------------|-------------------|--------------|------------|-----------|------------|----|----------|
|            |               |             |              |  |               |                   | Dose (mls)   | Injections | Dose (mg) | Injections |    |          |
| 98-3132    | 04/13/98      | 770         | 11.5         | 05/01/98<br>05/01/98<br>05/04/98<br>05/07/98 | 05/11/98      | 27                | 0.6          | 1          |           |            | 7  |          |
| 98-3172    | 04/29/98      | 743         | 10.2         | 05/18/98<br>05/21/98<br>05/26/98<br>05/28/98 | 05/28/98      | 28                | 0.5          | 1          |           |            | 6  |          |
| 98-3174    | 04/29/98      | 667         | 6.3          | 06/22/98<br>06/22/98                         | 07/02/98      | 63                | 0.4          | 1          |           |            | 16 |          |
| 98-3177    | 04/29/98      | 625         | 5.2          | 05/04/98<br>05/04/98<br>05/04/98<br>05/07/98 | 05/07/98      | 7                 | 0            | 0          |           |            | 1  |          |
| 98-3181    | 04/29/98      | 767         | 11.5         | 05/07/98<br>05/11/98<br>05/18/98<br>05/21/98 | 05/26/98      | 26                | 0.5          | 1          |           |            | 6  |          |
| 98-3182    | 04/29/98      | 772         | 11.9         | 06/29/98<br>07/02/98                         | 07/06/98      | 67                | 0            | 0          | 125       | 1          | 16 |          |
| 98-3190    | 04/29/98      | 683         | 7.9          | 05/04/98<br>05/04/98<br>05/07/98<br>05/07/98 | 05/11/98      | 11                | 0.4          | 1          |           |            | 1  |          |
| 98-3206    | 05/08/98      | 776         | 9.5          | 05/14/98                                     | 05/18/98      | 9                 | 0.0          | 0          |           |            | 2  |          |

- 1 Erythromycin dose was based on 20 mg/kg.
- 2 LH-RHa = Luteinizing Hormone - Releasing Hormone analogue. Each capsule contained 250 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 Coleman National Fish Hatchery in 1998.

| Genetic ID | Date captured | length (mm) | Weight (lbs) | Date Spawned | Date of death | Days in Captivity | Erythromycin |            | LH-RHa    |            | MG Treatments | Comments |
|------------|---------------|-------------|--------------|--------------|---------------|-------------------|--------------|------------|-----------|------------|---------------|----------|
|            |               |             |              |              |               |                   | Dose (mls)   | Injections | Dose (mg) | Injections |               |          |
| 98-3213    | 05/13/98      | 812         | 13.5         | 06/22/98     | 07/06/98      | 53                | 0            | 0          |           |            | 12            |          |
|            |               |             |              | 06/22/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 06/25/98     |               |                   |              |            |           |            |               |          |
| 98-3217    | 05/13/98      | 653         | 7.3          | 05/18/98     | 05/26/98      | 12                | 0.0          | 0          |           |            | 2             |          |
|            |               |             |              | 05/18/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 05/18/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 05/21/98     |               |                   |              |            |           |            |               |          |
| 98-3223    | 05/13/98      | 773         | 11.3         | 05/18/98     | 05/28/98      | 14                | 0.0          | 0          |           |            | 3             |          |
|            |               |             |              | 05/21/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 05/26/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 05/28/98     |               |                   |              |            |           |            |               |          |
| 98-3241    | 05/21/98      | 756         | 10.0         | 05/28/98     | 06/01/98      | 10                | 0            | 0          |           |            | 2             |          |
|            |               |             |              | 05/28/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 06/01/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 06/01/98     |               |                   |              |            |           |            |               |          |
| 98-3242    | 05/21/98      | 761         | 11.3         | 06/15/98     | 06/22/98      | 31                | 0            | 0          |           |            | 7             |          |
|            |               |             |              | 06/15/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 06/18/98     |               |                   |              |            |           |            |               |          |
| 98-3243    | 05/21/98      | 808         | 12.1         | 06/01/98     | 06/18/98      | 27                | 0            | 0          |           |            | 7             |          |
|            |               |             |              | 06/08/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 06/15/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 06/18/98     |               |                   |              |            |           |            |               |          |
| 98-3244    | 05/21/98      | 670         | 6.7          | 06/25/98     | 07/02/98      | 41                | 0            | 0          |           |            | 10            |          |
|            |               |             |              | 06/25/98     |               |                   |              |            |           |            |               |          |
| 98-3245    | 05/21/98      | 748         | 10.5         | 05/26/98     | 06/01/98      | 10                | 0            | 0          |           |            | 2             |          |
|            |               |             |              | 05/26/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 05/28/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 05/28/98     |               |                   |              |            |           |            |               |          |

- 1 Erythromycin dose was based on 20 mg/kg.
- 2 LH-RHa = Luteinizing Hormone - Releasing Hormone analogue. Each capsule contained 250 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 Coleman National Fish Hatchery in 1998.

| Genetic ID | Date captured | length (mm) | Weight (lbs) | Date Spawned | Date of death | Days in Captivity | Erythromycin |            | LH-RHa    |            | MG Treatments | Comments |
|------------|---------------|-------------|--------------|--------------|---------------|-------------------|--------------|------------|-----------|------------|---------------|----------|
|            |               |             |              |              |               |                   | Dose (mls)   | Injections | Dose (mg) | Injections |               |          |
| 98-3249    | 05/21/98      | 762         | 9.9          | 06/29/98     | 07/06/98      | 45                | 0            | 0          |           |            | 10            |          |
|            |               |             |              | 07/02/98     |               |                   |              |            |           |            |               |          |
| 98-3250    | 05/21/98      | 750         | 10.2         | 05/26/98     | 06/08/98      | 17                | 0            | 0          |           |            | 4             |          |
|            |               |             |              | 05/26/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 06/01/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 06/08/98     |               |                   |              |            |           |            |               |          |
| 98-3251    | 05/21/98      | 729         | 8.9          | 06/15/98     | 06/22/98      | 31                | 0            | 0          |           |            | 8             |          |
|            |               |             |              | 06/15/98     |               |                   |              |            |           |            |               |          |
| 98-3255    | 05/21/98      | 684         | 7.1          | 06/04/98     | 06/15/98      | 24                | 0            | 0          |           |            | 6             |          |
|            |               |             |              | 06/04/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 06/11/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 06/15/98     |               |                   |              |            |           |            |               |          |
| 98-3256    | 05/21/98      | 668         | 6.6          | 06/22/98     | 06/30/98      | 39                | 0            | 0          |           |            | 9             |          |
|            |               |             |              | 06/22/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 06/25/98     |               |                   |              |            |           |            |               |          |
| 98-3257    | 05/21/98      | 761         | 10.3         | 06/08/98     | 06/22/98      | 31                | 0            | 0          |           |            | 8             |          |
|            |               |             |              | 06/11/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 06/22/98     |               |                   |              |            |           |            |               |          |
| 98-3259    | 05/21/98      | 718         | 8.2          | 06/04/98     | 06/22/98      | 31                | 0            | 0          |           |            | 8             |          |
|            |               |             |              | 06/08/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 06/22/98     |               |                   |              |            |           |            |               |          |
| 98-3260    | 05/21/98      | 732         | 9.4          | 06/22/98     | 07/06/98      | 45                | 0            | 0          |           |            | 10            |          |
|            |               |             |              | 06/22/98     |               |                   |              |            |           |            |               |          |
|            |               |             |              | 06/25/98     |               |                   |              |            |           |            |               |          |

- 1 Erythromycin dose was based on 20 mg/kg.
- 2 LH-RHa = Luteinizing Hormone - Releasing Hormone analogue. Each capsule contained 250 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 Coleman National Fish Hatchery in 1998.

| Genetic ID | Date captured | length (mm) | Weight (lbs) | Date Spawned                                 | Date of death | Days in Captivity | Erythromycin |            | LH-RHa    |            | MG Treatments | Comments |
|------------|---------------|-------------|--------------|--|---------------|-------------------|--------------|------------|-----------|------------|---------------|----------|
|            |               |             |              |  |               |                   | Dose (mls)   | Injections | Dose (mg) | Injections |               |          |
| 98-3261    | 05/21/98      | 746         | 9.3          | 05/28/98<br>05/28/98<br>06/08/98<br>06/08/98 | 06/08/98      | 17                | 0            | 0          |           |            | 4             |          |
| 98-3262    | 05/21/98      | 833         | 13.8         | 05/26/98<br>05/26/98<br>05/28/98<br>06/04/98 | 06/04/98      | 13                | 0            | 0          |           |            | 3             |          |
| 98-3263    | 05/21/98      | 753         | 9.8          | 06/22/98<br>06/22/98<br>06/25/98             | 07/02/98      | 41                | 0            | 0          |           |            | 10            |          |
| 98-3264    | 05/21/98      | 748         | 10.3         | 05/26/98<br>05/26/98<br>05/28/98             | 05/28/98      | 6                 | 0            | 0          |           |            | 1             |          |
| 98-3267    | 05/21/98      | 584         | 9.6          | 05/26/98<br>05/26/98<br>06/01/98<br>06/01/98 | 06/01/98      | 10                | 0            | 0          |           |            | 2             |          |

- 1 Erythromycin dose was based on 20 mg/kg.
- 2 LH-RHa = Luteinizing Hormone - Releasing Hormone analogue. Each capsule contained 250 µg.
- 3 MG = Malachite green. Fish were immersed in a 1 ppm bath.

# Spawning

## **Adults Collected at Keswick**

When genetic analysis indicated that a quarantined fish was a winter Chinook salmon, that fish was identified using a uniquely numbered floy tag and transferred to a 20-foot diameter tank where it was held until ripe for spawning. Winter Chinook were examined twice a week 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. Tricaine 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. The caudal artery was severed to bleed out the females 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 from females were separated into two approximately equal groups, when possible, and each group was fertilized with semen from a different male. 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. After the fourth spawning event, males were sacrificed. Each fish, if possible, was spawned with at least two others for two reasons: 1) to increase the effective population size, and 2) to prevent losing all of the gametes from a spawner if the other spawner did not have viable gametes. Due to a shortage of mature males, half of the eggs from the first two females spawned were fertilized with cryopreserved semen from two males that returned in brood year 1994.

To aid in the effective population calculation, a “family group” concept was utilized. Each female was assigned a number and each male was assigned a letter. Thus each spawning cross resulted in a specific “family group”. For example, when female 1 was spawned with male A, “family group” 1A was created.

Hatchery spawning of winter Chinook salmon occurred between May 1 and July 2, 1998 (Figure 2) roughly corresponding to the historical natural spawn timing. 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). A total of 61 female (Table 4) and 35 male (Table 5) winter Chinook salmon were spawned in 1998. Almost 206,000 eggs were collected from 61 females, producing 121 family groups (Table 6), giving an average of 3,372 green eggs per female. Lengths of spawned females ranged from 555 to 750 mm (fork length) and averaged 674 mm. Lengths of spawned males ranged from 618 to 825 mm and averaged 735 mm.

## **Captive Broodstock**

Captive broodstock spawning occurred between July 16 and October 22, 1998 (Table 6). One hundred and one captive broodstock females were spawned, including 2 from brood year 1993, 27 from brood year 1994, and 72 from brood year 1995. Twenty two captive broodstock males were spawned, including 17 from brood year 1994 and 5 from brood year 1995. Fertilized eggs from 101 of the crosses were allowed to survive. Sixty two crosses were created using fresh milt

and 39 using cryo-preserved milt, producing 115,654 green eggs. Not all potential family groups were produced. Individual crosses were intentionally selected for a research project (see attachment A). These matings produced 70,038 eyed eggs. Before hatching, an unknown number of eggs were culled, so egg to juvenile survival rates are not available. From the eggs that were not culled, 27,047 juveniles were produced for research purposes (see attachment A). All 27,047 fish were eventually destroyed (i.e., no BY 1998 juveniles resulting from matings of captive broodstock were released into the Sacramento River).

Table 6 Summary of captive broodstock spawning activities in 1998

|                        |            |
|------------------------|------------|
| <b>Females Spawned</b> |            |
| BY 1993                | 2          |
| BY 1994                | 27         |
| BY 1995                | 72         |
| <b>Total</b>           | <b>101</b> |
| <b>Males Spawned</b>   |            |
| BY 1994                | 17         |
| BY 1995                | 5          |
| <b>Total</b>           | <b>22</b>  |
| <b>Crosses</b>         |            |
| using fresh milt       | 62         |
| using cryo milt        | 39         |
| <b>Total</b>           | <b>101</b> |
| <b>Green Eggs</b>      | 115,654    |
| <b>Eyed Eggs</b>       | 70,038     |
| <b>No. Hatched</b>     | n/a*       |
| <b>No. Tanked</b>      | 27,047     |

\* An unknown number of eggs were culled before counting

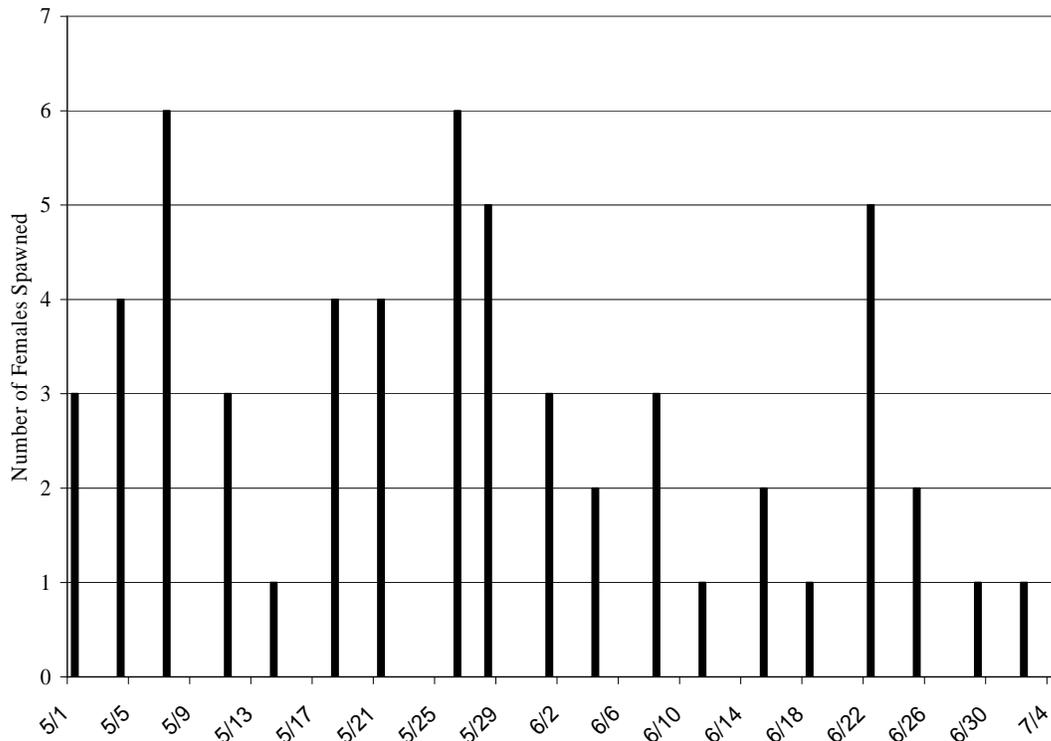


Figure 2 Spawning of winter Chinook salmon at Coleman National Fish Hatchery, May 1 through July 2, 1998. Bars correspond to numbers of females spawned per day.

## Incubation and Rearing

After fertilization, the eggs were placed in a plastic container and transported directly to Livingston Stone NFH for incubation and rearing. Upon arrival, each pan of eggs was poured into a Heath incubator tray 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 1400 ppm formalin for 15 minutes as a flow-through treatment. This proved very successful as a prophylactic. Formalin treatments were discontinued once eggs had hatched. 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 4.7 to 99.5%, averaging 90.3%; for crosses utilizing cryo-preserved semen, percent eye-up ranged from 16.1% to 75.4%, and averaged 44.2%. Egg to release survival also varied, ranging between 0 and 97.4%; for crosses utilizing cryo-preserved semen egg to release survival ranged from 7.3% to 34.5% and averaged 20.2%. After eye-up, eggs were shocked and non-viable eggs were removed. 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.

### **Juvenile Rearing**

The small circular tanks and Zeilger 12-hour belt feeders provided an excellent environment for starting and separating small groups of fish. A total of 1,842.4 pounds (lbs.) of feed was used, resulting in a weight gain of 1680.5 pounds between July 6 and release on January 28. This provided a feed conversion of 1.1 (food fed/weight gain). This was the best conversion seen to date in the winter Chinook production program. Growth was highest in October with a fork length increase of 0.454 inches (11.4 mm), and lowest in January at 0.227 inches (5.8 mm). Throughout the period of hatchery rearing, brood year 1998 winter Chinook salmon increased an average of 1.850 inches (47.0 mm). The juvenile rearing numbers do not include any fish held for the captive broodstock program.

Initial feeding began on July 6, 1998 using Bio-Oregon's Biodiet starter #1, #2, and #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 Biodiet grower (BMG) 1.3 mm pellets. At 250 fish to the pound, feed was changed to BMG 1.5 mm pellets. The fish remained on BMG 1.5 mm pellets until release.

Feeding rates were determined using Bio-Oregon feeding guidelines. This method uses average monthly water temperatures to determine the appropriate percent body weight to feed. Feed rates were reduced in November and December for two reasons: 1) to reduce growth which conserved tank space and, 2) CANV FHC recommended reduced feed rates based on the observation of excessive visceral fat during a November examination. It appeared that the fish were converting a large portion of the high energy diet into fat. Feeding returned to full rations prior to release in January, in order to stimulate smolt development via an elevation in growth hormone.

Juvenile winter Chinook salmon were tanked according to family group combinations. This year, with 121 different wild x wild family groups, the 60 small circular tanks at Livingston Stone NFH were not sufficient 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 121 original family groups were eventually combined to form 21 distinct groups that were held separately until release.

Table 7

Family groups, date spawned, egg counts and number tanked for brood year 1998 winter Chinook salmon. Individuals were spawned at Coleman National Fish Hatchery (NFH) and fertilized eggs were transported immediately to Livingston Stone NFH.

| Crosses (by floy tag number) |              | Family group | Date spawned | Number of  |           | Percent eye-up | Number hatched | Percent hatched | Number tanked | Precent tanked from eyed eggs |
|------------------------------|--------------|--------------|--------------|------------|-----------|----------------|----------------|-----------------|---------------|-------------------------------|
| Female                       | Male         |              |              | Green eggs | Eyed eggs |                |                |                 |               |                               |
| Orange 088                   | X Orange 100 | 1A           | 05/01/98     | 3243       | 2745      | 84.6           | 2686           | 82.8            | 2431          | 75.0                          |
|                              | X CRYO 94F   | 194F         | 05/01/98     | 1256       | 202       | 16.1           | 192            | 15.3            | 183           | 14.6                          |
| Orange 086                   | X Orange 104 | 2B           | 05/01/98     | 2013       | 1628      | 80.9           | 1546           | 76.8            | 1452          | 72.1                          |
|                              | X CRYO 94G   | 294G         | 05/01/98     | 1136       | 856       | 75.4           | 849            | 74.7            | 810           | 71.3                          |
| Orange 097                   | X Orange 063 | 3C           | 05/01/98     | 1409       | 1349      | 95.7           | 1345           | 95.5            | 1345          | 95.5                          |
|                              | X Orange 104 | 3B           | 05/01/98     | 1833       | 1590      | 86.7           | 1588           | 86.6            | 1492          | 81.4                          |
| Orange 078                   | X Orange 125 | 4E           | 05/04/98     | 1500       | 1390      | 92.7           | 1360           | 90.7            | 1156          | 77.1                          |
|                              | X Orange 063 | 4C           | 05/04/98     | 2235       | 2095      | 93.7           | 2055           | 91.9            | 1724          | 77.1                          |
| Orange 081                   | X Orange 125 | 5E           | 05/04/98     | 2531       | 2267      | 89.6           | 1958           | 77.4            | 1701          | 67.2                          |
|                              | X Orange 104 | 5B           | 05/04/98     | 1779       | 1579      | 88.8           | 1429           | 80.3            | 1385          | 77.9                          |
| Orange 101                   | X Orange 125 | 6E           | 05/04/98     | 2120       | 1938      | 91.4           | 1870           | 88.2            | 1792          | 84.5                          |
|                              | X Orange 139 | 6D           | 05/04/98     | 2205       | 1681      | 76.2           | 1600           | 72.6            | 1302          | 59.0                          |
| Orange 071                   | X Orange 139 | 7D           | 05/04/98     | 1854       | 1716      | 92.6           | 1671           | 90.1            | 1355          | 73.1                          |
|                              | X Orange 100 | 7A           | 05/04/98     | 2153       | 2110      | 98.0           | 2096           | 97.4            | 1946          | 90.4                          |
| Orange 089                   | X Orange 125 | 8E           | 05/07/98     | 835        | 341       | 40.8           | 250            | 29.9            | 202           | 24.2                          |
|                              | X Orange 129 | 8F           | 05/07/98     | 938        | 294       | 31.3           | 209            | 22.3            | 192           | 20.5                          |
| Orange 109                   | X Orange 051 | 9G           | 05/07/98     | 1111       | 1055      | 95.0           | 1045           | 94.1            | 1017          | 91.5                          |
|                              | X Orange 139 | 9D           | 05/07/98     | 1323       | 1178      | 89.0           | 1167           | 88.2            | 1100          | 83.1                          |
| Orange 090                   | X Orange 139 | 10D          | 05/07/98     | 1754       | 1428      | 81.4           | 1409           | 80.3            | 1273          | 72.6                          |
|                              | X Orange 051 | 10G          | 05/07/98     | 1503       | 1219      | 81.1           | 1193           | 79.4            | 1146          | 76.2                          |
| Orange 111                   | X Orange 094 | 11H          | 05/07/98     | 1620       | 1585      | 97.8           | 1578           | 97.4            | 1529          | 94.4                          |
|                              | X Orange 100 | 11A          | 05/07/98     | 1234       | 1204      | 97.6           | 1197           | 97.0            | 1220          | 98.9                          |

Table 7 (cont.)

Family groups, date spawned, egg counts and number tanked for brood year 1998 winter Chinook salmon. Individuals were spawned at Coleman National Fish Hatchery (NFH) and fertilized eggs were transported immediately to Livingston Stone NFH.

| Crosses (by floy tag number) |      |            | Family group | Date spawned | Number of  |           | Percent eye-up | Number hatched | Percent hatched | Number tanked | Precent tanked from eyed eggs |
|------------------------------|------|------------|--------------|--------------|------------|-----------|----------------|----------------|-----------------|---------------|-------------------------------|
| Female                       | Male |            |              |              | Green eggs | Eyed eggs |                |                |                 |               |                               |
| Orange 096                   | X    | Orange 094 | 12H          | 05/07/98     | 2306       | 2133      | 92.5           | 2023           | 87.7            | 2048          | 88.8                          |
|                              | X    | Orange 100 | 12A          | 05/07/98     | 2673       | 2293      | 85.8           | 2143           | 80.2            | 2098          | 78.5                          |
| Orange 083                   | X    | Orange 104 | 13B          | 05/07/98     | 1432       | 1418      | 99.0           | 1356           | 94.7            | 1216          | 84.9                          |
|                              | X    | Orange 063 | 13C          | 05/07/98     | 1325       | 1308      | 98.7           | 1243           | 93.8            | 1093          | 82.5                          |
| Orange 084                   | X    | Orange 129 | 14F          | 05/11/98     | 712        | 644       | 90.4           | 637            | 89.5            | 622           | 87.4                          |
| Orange 065                   | X    | Orange 051 | 15G          | 05/11/98     | 1830       | 1538      | 84.0           | 1530           | 83.6            | 1481          | 80.9                          |
|                              | X    | Orange 063 | 15C          | 05/11/98     | 1868       | 1511      | 80.9           | 1500           | 80.3            | 1561          | 83.6                          |
| Orange 079                   | X    | Orange 094 | 16H          | 05/11/98     | 1708       | 1645      | 96.3           | 1630           | 95.4            | 1555          | 91.0                          |
|                              | X    | Orange 051 | 16G          | 05/11/98     | 1920       | 1879      | 97.9           | 1868           | 97.3            | 1827          | 95.2                          |
| Orange 128                   | X    | Orange 074 | 17I          | 05/14/98     | 1615       | 1545      | 95.7           | 1536           | 95.1            | 1437          | 89.0                          |
|                              | X    | Orange 146 | 17J          | 05/14/98     | 1894       | 1807      | 95.4           | 1782           | 94.1            | 1613          | 85.2                          |
| Orange 072                   | X    | Orange 157 | 18K          | 05/18/98     | 1128       | 1108      | 98.2           | 1097           | 97.3            | 1067          | 94.6                          |
|                              | X    | Orange 120 | 18L          | 05/18/98     | 1126       | 1113      | 98.8           | 1099           | 97.6            | 1066          | 94.7                          |
| Orange 162                   | X    | Orange 157 | 19K          | 05/18/98     | 1493       | 1352      | 90.6           | 1336           | 89.5            | 1311          | 87.8                          |
|                              | X    | Orange 164 | 19M          | 05/18/98     | 2053       | 1997      | 97.3           | 1989           | 96.9            | 1996          | 97.2                          |
| Orange 108                   | X    | Orange 157 | 20K          | 05/18/98     | 789        | 335       | 42.5           | 238            | 30.2            | 214           | 27.1                          |
|                              | X    | Orange 129 | 20F          | 05/18/98     | 763        | 263       | 34.5           | 201            | 26.3            | 191           | 25.0                          |
| Orange 172                   | X    | Orange 074 | 21I          | 05/18/98     | 1815       | 1710      | 94.2           | 1700           | 93.7            | 1624          | 89.5                          |
|                              | X    | Orange 094 | 21H          | 05/18/98     | 1892       | 1626      | 85.9           | 1619           | 85.6            | 1608          | 85.0                          |
| Orange 160                   | X    | Orange 129 | 22F          | 05/21/98     | 1601       | 1519      | 94.9           | 1505           | 94.0            | 1495          | 93.4                          |
|                              | X    | Orange 074 | 22I          | 05/21/98     | 1989       | 1973      | 99.2           | 1965           | 98.8            | 1721          | 86.5                          |
| Orange 156                   | X    | Orange 157 | 23K          | 05/21/98     | 1682       | 1516      | 90.1           | 1504           | 89.4            | 1510          | 89.8                          |
|                              | X    | Orange 074 | 23I          | 05/21/98     | 1611       | 1549      | 96.2           | 1535           | 95.3            | 1515          | 94.0                          |

Table 7 (cont.)

Family groups, date spawned, egg counts and number tanked for brood year 1998 winter Chinook salmon. Individuals were spawned at Coleman National Fish Hatchery (NFH) and fertilized eggs were transported immediately to Livingston Stone NFH.

| Crosses (by floy tag number) |      | Family group | Date spawned | Number of  |           | Percent eye-up | Number hatched | Percent hatched | Number tanked | Precent tanked from eyed eggs |       |
|------------------------------|------|--------------|--------------|------------|-----------|----------------|----------------|-----------------|---------------|-------------------------------|-------|
| Female                       | Male |              |              | Green eggs | Eyed eggs |                |                |                 |               |                               |       |
| Orange 178                   | X    | Orange 120   | 24L          | 05/21/98   | 1347      | 1336           | 99.2           | 1332            | 98.9          | 1323                          | 98.2  |
|                              | X    | Orange 092   | 24N          | 05/21/98   | 1923      | 1873           | 97.4           | 1871            | 97.3          | 1863                          | 96.9  |
| Orange 068                   | X    | Orange 092   | 25N          | 05/21/98   | 2027      | 1948           | 96.1           | 1932            | 95.3          | 1989                          | 98.1  |
|                              | X    | Orange 164   | 25M          | 05/21/98   | 2039      | 1977           | 97.0           | 1968            | 96.5          | 1938                          | 95.0  |
| Orange 177                   | X    | Orange 184   | 26P          | 05/26/98   | 1952      | 1885           | 96.6           | 1869            | 95.7          | 1934                          | 99.1  |
|                              | X    | Yellow 158   | 26O          | 05/26/98   | 1844      | 1401           | 76.0           | 1388            | 75.3          | 1148                          | 62.3  |
| Orange 154                   | X    | Yellow 158   | 27O          | 05/26/98   | 1773      | 1374           | 77.5           | 1354            | 76.4          | 1320                          | 74.5  |
|                              | X    | Orange 184   | 27P          | 05/26/98   | 1729      | 1475           | 85.3           | 1431            | 82.8          | 1391                          | 80.5  |
| Orange 168                   | X    | Yellow 153   | 28Q          | 05/26/98   | 2016      | 1990           | 98.7           | 1983            | 98.4          | 1948                          | 96.6  |
|                              | X    | Orange 120   | 28L          | 05/26/98   | 1447      | 1428           | 98.7           | 1411            | 97.5          | 1390                          | 96.1  |
| Orange 076                   | X    | Yellow 153   | 29Q          | 05/26/98   | 1184      | 790            | 66.7           | 669             | 56.5          | 620                           | 52.4  |
|                              | X    | Yellow 161   | 29R          | 05/26/98   | 1502      | 916            | 61.0           | 720             | 47.9          | 672                           | 44.7  |
| Orange 075                   | X    | Orange 164   | 30M          | 05/26/98   | 1821      | 1777           | 97.6           | 1742            | 95.7          | 1798                          | 98.7  |
|                              | X    | Yellow 161   | 30R          | 05/26/98   | 1287      | 1245           | 96.7           | 1203            | 93.5          | 1211                          | 94.1  |
| Orange 098                   | X    | Orange 190   | 31S          | 05/26/98   | 1575      | 1263           | 80.2           | 1132            | 71.9          | 1148                          | 72.9  |
|                              | X    | Orange 092   | 31N          | 05/26/98   | 1404      | 1100           | 78.3           | 1048            | 74.6          | 923                           | 65.7  |
| Orange 077                   | X    | Orange 092   | 32N          | 05/26/98   | 1294      | 1264           | 97.7           | 1225            | 94.7          | 1276                          | 98.6  |
|                              | X    | Orange 190   | 32S          | 05/26/98   | 1638      | 1524           | 93.0           | 1473            | 89.9          | 1363                          | 83.2  |
| Orange 107                   | X    | Yellow 158   | 33O          | 05/28/98   | 1947      | 91             | 4.7            | 89              | 4.6           | 81                            | 4.2   |
|                              | X    | Orange 184   | 33P          | 05/28/98   | 2029      | 1987           | 97.9           | 1951            | 96.2          | 2033                          | 100.2 |
| Orange 124                   | X    | Orange 180   | 34T          | 05/28/98   | 1965      | 1886           | 96.0           | 1870            | 95.2          | 1872                          | 95.3  |
|                              | X    | Orange 184   | 34P          | 05/28/98   | 2272      | 2104           | 92.6           | 2063            | 90.8          | 1998                          | 87.9  |

Table 7 (cont.)

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| Crosses (by floy tag number) |      | Family group | Date spawned | Number of  |           | Percent eye-up | Number hatched | Percent hatched | Number tanked | Precent tanked from eyed eggs |       |
|------------------------------|------|--------------|--------------|------------|-----------|----------------|----------------|-----------------|---------------|-------------------------------|-------|
| Female                       | Male |              |              | Green eggs | Eyed eggs |                |                |                 |               |                               |       |
| Orange 151                   | X    | Orange 180   | 35T          | 05/28/98   | 1878      | 1851           | 98.6           | 1829            | 97.4          | 1673                          | 89.1  |
|                              | X    | Yellow 153   | 35Q          | 05/28/98   | 1981      | 1949           | 98.4           | 1935            | 97.7          | 1781                          | 89.9  |
| Orange 159                   | X    | Orange 120   | 36L          | 05/28/98   | 1739      | 1704           | 98.0           | 1694            | 97.4          | 1667                          | 95.9  |
|                              | X    | Yellow 152   | 36U          | 05/28/98   | 1763      | 1639           | 93.0           | 1627            | 92.3          | 1467                          | 83.2  |
| Orange 174                   | X    | Yellow 152   | 37U          | 05/28/98   | 1345      | 988            | 73.5           | 982             | 73.0          | 942                           | 70.0  |
|                              | X    | Orange 164   | 37M          | 05/28/98   | 1032      | 968            | 93.8           | 962             | 93.2          | 1054                          | 102.1 |
| Orange 131                   | X    | Yellow 161   | 38R          | 06/01/98   | 1394      | 1307           | 93.8           | 1283            | 92.0          | 1248                          | 89.5  |
|                              | X    | Orange 180   | 38T          | 06/01/98   | 1315      | 1211           | 92.1           | 1192            | 90.6          | 1083                          | 82.4  |
| Orange 116                   | X    | Yellow 161   | 39R          | 06/01/98   | 1547      | 1533           | 99.1           | 1523            | 98.4          | 1489                          | 96.3  |
|                              | X    | Orange 180   | 39T          | 06/01/98   | 1644      | 1634           | 99.4           | 1626            | 98.9          | 1535                          | 93.4  |
| Orange 176                   | X    | Orange 182   | 40V          | 06/01/98   | 1474      | 1444           | 98.0           | 1427            | 96.8          | 1165                          | 79.0  |
|                              | X    | Orange 190   | 40S          | 06/01/98   | 1643      | 1535           | 93.4           | 1455            | 88.6          | 1430                          | 87.0  |
| Orange 170                   | X    | Yellow 153   | 41Q          | 06/04/98   | 1531      | 1509           | 98.6           | 1469            | 96.0          | 1457                          | 95.2  |
|                              | X    | Orange 196   | 41W          | 06/04/98   | 1877      | 1849           | 98.5           | 1803            | 96.1          | 1769                          | 94.2  |
| Orange 070                   | X    | Orange 200   | 42X          | 06/04/98   | 1820      | 1742           | 95.7           | 1718            | 94.4          | 1674                          | 92.0  |
|                              | X    | Orange 196   | 42W          | 06/04/98   | 1238      | 1184           | 95.6           | 1175            | 94.9          | 1057                          | 85.4  |
| Orange 134                   | X    | Orange 198   | 43Y          | 06/08/98   | 1902      | 1892           | 99.5           | 1865            | 98.1          | 1858                          | 97.7  |
|                              | X    | Yellow 152   | 43U          | 06/08/98   | 1704      | 1692           | 99.3           | 1674            | 98.2          | 1576                          | 92.5  |
| Orange 163                   | X    | Yellow 152   | 44U          | 06/08/98   | 2663      | 2650           | 99.5           | 2588            | 97.2          | 2543                          | 95.5  |
|                              | X    | Orange 182   | 44V          | 06/08/98   | 2221      | 2203           | 99.2           | 2127            | 95.8          | 2026                          | 91.2  |
| Orange 103                   | X    | Orange 190   | 45S          | 06/08/98   | 1506      | 1036           | 68.8           | 998             | 66.3          | 973                           | 64.6  |
|                              | X    | Orange 200   | 45X          | 06/08/98   | 1823      | 1608           | 88.2           | 1566            | 85.9          | 1522                          | 83.5  |

Table 7 (cont.)

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| Crosses (by floy tag number) |      | Family group | Date spawned | Number of  |           | Percent eye-up | Number hatched | Percent hatched | Number tanked | Percent tanked from eyed eggs |       |
|------------------------------|------|--------------|--------------|------------|-----------|----------------|----------------|-----------------|---------------|-------------------------------|-------|
| Female                       | Male |              |              | Green eggs | Eyed eggs |                |                |                 |               |                               |       |
| Orange 095                   | X    | Orange 196   | 46W          | 06/11/98   | 1777      | 1745           | 98.2           | 1691            | 95.2          | 1746                          | 98.3  |
|                              | X    | Orange 198   | 46Y          | 06/11/98   | 2142      | 2117           | 98.8           | 2056            | 96.0          | 2018                          | 94.2  |
| Orange 173                   | X    | Orange 196   | 47W          | 06/15/98   | 1652      | 1630           | 98.7           | 1533            | 92.8          | 1347                          | 81.5  |
|                              | X    | Orange 181   | 47Z          | 06/15/98   | 1524      | 1503           | 98.6           | 1411            | 92.6          | 1401                          | 91.9  |
| Orange 145                   | X    | Orange 181   | 48Z          | 06/15/98   | 1468      | 1443           | 98.3           | 1425            | 97.1          | 1397                          | 95.2  |
|                              | X    | Orange 191   | 48AA         | 06/15/98   | 1767      | 1733           | 98.1           | 1676            | 94.9          | 1666                          | 94.3  |
| Orange 119                   | X    | Orange 191   | 49AA         | 06/15/98   | 2201      | 2167           | 98.5           | 2127            | 96.6          | 2087                          | 94.8  |
|                              | X    | Orange 182   | 49V          | 06/15/98   | 2030      | 1956           | 96.4           | 1917            | 94.4          | 1835                          | 90.4  |
| Orange 148                   | X    | Orange 182   | 50V          | 06/18/98   | 1715      | 1675           | 97.7           | 1637            | 95.5          | 1736                          | 101.2 |
|                              | X    | Orange 181   | 50Z          | 06/18/98   | 1301      | 1286           | 98.8           | 1146            | 88.1          | 1117                          | 85.9  |
| Orange 166                   | X    | Orange 198   | 51Y          | 06/22/98   | 1470      | 1302           | 88.6           | 1285            | 87.4          | 1256                          | 85.4  |
|                              | X    | Yellow 151   | 51AB         | 06/22/98   | 1800      | 1581           | 87.8           | 1532            | 85.1          | 1488                          | 82.7  |
| Orange 091                   | X    | Yellow 151   | 52AB         | 06/22/98   | 1841      | 1794           | 97.4           | 1756            | 95.4          | 1718                          | 93.3  |
|                              | X    | Orange 153   | 52AC         | 06/22/98   | 2047      | 1981           | 96.8           | 1925            | 94.0          | 1944                          | 95.0  |
| Orange 136                   | X    | Orange 153   | 53AC         | 06/22/98   | 1822      | 1706           | 93.6           | 1643            | 90.2          | 1727                          | 94.8  |
|                              | X    | Yellow 154   | 53AD         | 06/22/98   | 2007      | 1834           | 91.4           | 1763            | 87.8          | 1716                          | 85.5  |
| Orange 167                   | X    | Yellow 154   | 54AD         | 06/22/98   | 1245      | 1140           | 91.6           | 909             | 73.0          | 886                           | 71.2  |
|                              | X    | Orange 200   | 54X          | 06/22/98   | 1288      | 1141           | 88.6           | 1118            | 86.8          | 1107                          | 85.9  |
| Orange 155                   | X    | Orange 122   | 55AE         | 06/22/98   | 1168      | 1087           | 93.1           | 1060            | 90.8          | 1149                          | 98.4  |
|                              | X    | Orange 197   | 55AF         | 06/22/98   | 1650      | 1440           | 87.3           | 1426            | 86.4          | 1401                          | 84.9  |
| Orange 085                   | X    | Orange 122   | 56AE         | 06/22/98   | 2645      | 2609           | 98.6           | 2331            | 88.1          | 2305                          | 87.1  |
|                              | X    | Orange 197   | 56AF         | 06/22/98   | 1696      | 1614           | 95.2           | 1482            | 87.4          | *****0                        | 0.0   |

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| Crosses (by floy tag number) |      | Family group | Date spawned | Number of  |               | Percent eye-up | Number hatched | Percent hatched | Number tanked | Precent tanked from eyed eggs |             |
|------------------------------|------|--------------|--------------|------------|---------------|----------------|----------------|-----------------|---------------|-------------------------------|-------------|
| Female                       | Male |              |              | Green eggs | Eyed eggs     |                |                |                 |               |                               |             |
| Orange 102                   | X    | Orange 183   | 57AG         | 06/25/98   | 2266          | 2094           | 92.4           | 2080            | 91.8          | 1951                          | 86.1        |
|                              | X    | Yellow 154   | 57AD         | 06/25/98   | 1970          | 1733           | 88.0           | 1707            | 86.6          | 1759                          | 89.3        |
| Orange 080                   | X    | Orange 183   | 58AG         | 06/25/98   | 1904          | 1875           | 98.5           | 1865            | 98.0          | 1771                          | 93.0        |
|                              | X    | Yellow 151   | 58AB         | 06/25/98   | 1863          | 1849           | 99.2           | 1832            | 98.3          | 1812                          | 97.3        |
| Orange 175                   | X    | Orange 153   | 59AC         | 06/25/98   | 1510          | 1150           | 76.2           | 1134            | 75.1          | 1121                          | 74.2        |
|                              | X    | Orange 197   | 59AF         | 06/25/98   | 1478          | 1333           | 90.2           | 1300            | 88.0          | 1290                          | 87.3        |
| Orange 140                   | X    | Orange 130   | 60AH         | 06/29/98   | 2241          | 2120           | 94.6           | 2053            | 91.6          | 2045                          | 91.3        |
|                              | X    | Orange 189   | 60AI         | 06/29/98   | 1778          | 1636           | 92.0           | 1580            | 88.9          | 1639                          | 92.2        |
| Orange 144                   | X    | Orange 189   | 61AI         | 07/02/98   | 1208          | 1191           | 98.6           | 1144            | 94.7          | 1119                          | 92.6        |
|                              | X    | Orange 130   | 61AH         | 07/02/98   | 1329          | 1271           | 95.6           | 1242            | 93.5          | 1236                          | 93.0        |
| <b>TOTALS</b>                |      |              |              |            | <b>205668</b> | <b>185730</b>  | <b>90.3</b>    | <b>180357</b>   | <b>87.7</b>   | <b>172640</b>                 | <b>83.9</b> |

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

Early in the rearing period, an outbreak of bacterial gill disease occurred in several rearing units. The outbreak at Livingston Stone NFH was attributed to poor water quality caused by overfeeding. Improving water quality conditions and treating fish with Chloroamine-T quickly corrected this problem. Fish were placed in a Chloroamine-T static bath treatment at 15 parts per million (ppm) for 30 minutes, followed by a 0.5% salt bath before fish were returned to their rearing tanks. This treatment was repeated after 48 hours.

Brood year 1998 captive broodstock juveniles were vaccinated against *Vibrio* spp. on February 9, 1999. Vaccinations were performed by mixing the formalin-inactivated bacteria solution with the appropriate amount of water (1:10) and then dipping the fish in this solution for 20 seconds. After immersion in the treatment solution for 20 seconds, fish were returned to their rearing tanks.

## **Juvenile Releases**

### **Tagging**

All hatchery origin winter Chinook juveniles were coded-wire tagged between December 16, 1998 and January 4, 1999. Each of the 21 final family group combinations received a unique tag code (Table 8). A total of 1,226 juveniles retained for the captive broodstock program were also tagged with passive integrated transponder (PIT) tags. Of these fish, 214 were reared at Livingston Stone NFH as part of the captive broodstock program. The remaining fish were transferred to BML and Steinhart Aquarium for rearing. Two fish lost their PIT tags before being transferred to BML. Tagging with PIT tags occurred on January 23 and 24, 1999. Fish ranged in length from 54 mm to 105 mm at the time of tagging.

Table 8 Coded-wire tag (CWT) code, associated family groups, number tagged with passive integrated transponders (PIT), mean fork length, and distribution for juvenile winter Chinook salmon retained for the captive broodstock program, brood year 1998.

| CWT code   | Family groups                            | Number PIT tagged | Mean fork length (mm) | Distribution of PIT tagged fish  |
|------------|--|-------------------|-----------------------|--|
| 0501020811 | 15C, 16G, 17J, 19K, 23I, 25N, 25M        | 72                | 77                    | 30 Steinhart Aquarium<br>30 Bodega Marine Lab<br>12 Livingston Stone NFH |
| 0501020812 | 54AD, 56AE, 57AG, 58AG, 58AB, 61AI, 61AH | 72                | 70                    | 30 Steinhart Aquarium<br>30 Bodega Marine Lab<br>12 Livingston Stone NFH |
| 0501020813 | 42X, 42W, 43U, 45S, 46Y, 49AA, 49V       | 72                | 75                    | 30 Steinhart Aquarium<br>29 Bodega Marine Lab<br>13 Livingston Stone NFH |
| 0501020814 | 15G, 16H, 17I, 19M, 23K                  | 53                | 84                    | 22 Steinhart Aquarium<br>22 Bodega Marine Lab<br>9 Livingston Stone NFH  |
| 0501020815 | 18K, 21I, 24L, 34T, 34P                  | 55                | 80                    | 24 Steinhart Aquarium<br>22 Bodega Marine Lab<br>9 Livingston Stone NFH  |
| 0501020901 | 28Q, 30M, 30R, 32N, 35T, 35Q             | 61                | 75                    | 25 Steinhart Aquarium<br>25 Bodega Marine Lab<br>11 Livingston Stone NFH |
| 0501020902 | 33P, 38R, 38T, 43Y, 47W, 48Z             | 61                | 75                    | 25 Steinhart Aquarium<br>25 Bodega Marine Lab<br>11 Livingston Stone NFH |
| 0501020903 | 39R, 39T, 50V, 50Z, 52AB                 | 53                | 75                    | 22 Steinhart Aquarium<br>22 Bodega Marine Lab<br>9 Livingston Stone NFH  |
| 0501020904 | 1A, 194F, 2B, 294G, 4E, 4C, 9G, 9D       | 62                | 86                    | 25 Steinhart Aquarium<br>25 Bodega Marine Lab<br>12 Livingston Stone NFH |
| 0501020905 | 18L, 21H, 22F, 22I, 24N                  | 53                | 83                    | 22 Steinhart Aquarium<br>22 Bodega Marine Lab<br>9 Livingston Stone NFH  |

Table 8 (cont)

Coded-wire tag (CWT) code, associated family groups, number tagged with passive integrated transponders (PIT), mean fork length, and distribution for juvenile winter Chinook salmon retained for the captive broodstock program, brood year 1998.

| CWT code   | Family groups                            | Number PIT tagged | Mean fork length (mm) | Distribution of PIT tagged fish  |
|------------|--|-------------------|-----------------------|--|
| 0501020906 | 3B, 10D, 10G, 12H, 12A, 13B, 13C, 14F    | 82                | 87                    | 34 Steinhart Aquarium<br>34 Bodega Marine Lab<br>14 Livingston Stone NFH |
| 0501020907 | 55AE, 55AF, 57AD, 59AC, 59AF, 60AH, 60AI | 72                | 71                    | 30 Steinhart Aquarium<br>30 Bodega Marine Lab<br>12 Livingston Stone NFH |
| 0501020908 | 51Y, 51AB, 52AC, 53AC, 53AD, 54X         | 61                | 74                    | 25 Steinhart Aquarium<br>25 Bodega Marine Lab<br>11 Livingston Stone NFH |
| 0501020909 | 36L, 36U, 37U, 46W, 47Z, 48AA            | 61                | 75                    | 25 Steinhart Aquarium<br>25 Bodega Marine Lab<br>11 Livingston Stone NFH |
| 0501020910 | 27P, 31N, 37M, 40V, 40S                  | 53                | 73                    | 22 Steinhart Aquarium<br>22 Bodega Marine Lab<br>9 Livingston Stone NFH  |
| 0501020911 | 27O, 28L, 29Q, 29R, 41Q, 41W, 45X        | 72                | 75                    | 30 Steinhart Aquarium<br>30 Bodega Marine Lab<br>12 Livingston Stone NFH |
| 0501020912 | 26O, 32S, 44U, 44V                       | 41                | 78 (5)                | 17 Steinhart Aquarium<br>17 Bodega Marine Lab<br>7 Livingston Stone NFH  |
| 0501020913 | 5B, 6E, 6D, 11H, 11A                     | 53                | 87                    | 22 Steinhart Aquarium<br>22 Bodega Marine Lab<br>9 Livingston Stone NFH  |
| 0501020914 | 3C, 5E, 7D, 7A, 8E                       | 61                | 88                    | 25 Steinhart Aquarium<br>25 Bodega Marine Lab<br>11 Livingston Stone NFH |

Table 8 (cont) Coded-wire tag (CWT) code, associated family groups, number tagged with passive integrated transponders (PIT), mean fork length, and distribution for juvenile winter Chinook salmon retained for the captive broodstock program, brood year 1998.

| CWT code   | Family groups | Number PIT tagged | Mean fork length (mm) | Distribution of PIT tagged fish   |
|------------|---------------|-------------------|-----------------------|---|
| 0501020915 | 26P, 31S, 33O | 33                | 83                    | 13 Steinhart Aquarium<br>13 Bodega Marine Lab<br>7 Livingston Stone NFH |
| 0501021001 | 20K, 20F      | 23                | 86                    | 9 Steinhart Aquarium<br>9 Bodega Marine Lab<br>5 Livingston Stone NFH   |

### Distribution

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 ( $N_e$ ) is a measure of the rate of genetic drift within a population. The  $N_e$  is directly related to the rate of loss of genetic diversity and the rate of increase in inbreeding within a population (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.

The brood year 1998 release group was the progeny of 61 females and 37 males (2 males were cryo-preserved semen). When brood year 1998 hatchery propagation data was applied to the population genetics model (Hedrick et al. 1995) genetic impacts were not apparent. The model indicates the effective population size increased from 261 to 323 ( $N_{ew} = 0.10 \times N_s$ ) or 870 to 980 ( $N_{ew} = 0.33 \times N_s$ ) with hatchery influence (Table 10; Table 11). The effective population size of the hatchery component as derived by estimating the number released via this method was 143 (Table 10; Table 11). The increase in the overall effective population size due to hatchery influence suggests the winter-run Chinook salmon population did not incur negative genetic impacts as consequence of the brood year 1998 release.

Table 9 Tagging information for BY 1998 winter Chinook salmon

| Tag Code   | Number Tagged | Mortalities | Number held for Captive program | Tag Retention | Length |     |      | Number Released |
|------------|---------------|-------------|---------------------------------|---------------|--------|-----|------|-----------------|
|            |               |             |                                 |               | Min    | Max | Mean |                 |
| 0501020811 | 11420         | 7           | 72                              | 0.92          | 56     | 97  | 82   | 10434           |
| 0501020812 | 10546         | 22          | 72                              | 0.98          | 58     | 78  | 70   | 10243           |
| 0501020813 | 10064         | 7           | 72                              | 0.97          | 51     | 90  | 74   | 9685            |
| 0501020814 | 7493          | 13          | 53                              | 0.96          | 67     | 102 | 86   | 7130            |
| 0501020815 | 7378          | 6           | 55                              | 0.99          | 67     | 98  | 82   | 7244            |
| 0501020901 | 8240          | 22          | 61                              | 0.99          | 47     | 88  | 76   | 8075            |
| 0501020902 | 7784          | 32          | 61                              | 0.99          | 45     | 92  | 75   | 7614            |
| 0501020903 | 6981          | 4           | 53                              | 1.0           | 69     | 88  | 78   | 6924            |
| 0501020904 | 6603          | 4           | 62                              | 0.97          | 69     | 107 | 88   | 6341            |
| 0501020905 | 7859          | 12          | 53                              | 0.78          | 72     | 102 | 84   | 6079            |
| 0501020906 | 10104         | 7           | 82                              | 0.94          | 50     | 98  | 84   | 9414            |
| 0501020907 | 9830          | 7           | 72                              | 0.95          | 42     | 82  | 70   | 9263            |
| 0501020908 | 8398          | 11          | 61                              | 0.95          | 55     | 82  | 70   | 7910            |
| 0501020909 | 7787          | 15          | 61                              | 0.96          | 42     | 87  | 73   | 7403            |
| 0501020910 | 5311          | 4           | 53                              | 0.97          | 65     | 105 | 84   | 5096            |
| 0501020911 | 8269          | 0           | 72                              | 0.96          | 51     | 87  | 74   | 7869            |
| 0501020912 | 6405          | 6           | 41                              | 0.97          | 41     | 90  | 78   | 6167            |
| 0501020913 | 5588          | 9           | 53                              | 0.98          | 78     | 111 | 91   | 5415            |
| 0501020914 | 6008          | 16          | 61                              | 1.0           | 73     | 99  | 89   | 5931            |
| 0501020915 | 2893          | 0           | 33                              | 0.98          | 73     | 99  | 87   | 2803            |
| 0501021001 | 381           | 1           | 23                              | 0.99          | 60     | 98  | 87   | 353             |

Table 10. Estimated impact of the release of brood year 1998 juvenile winter Chinook salmon propagated at Livingston Stone National Fish Hatchery on the Effective Population Size. The calculation assumes  $N_e(\text{wild}) = .10 \times$  the estimated run size.

|                                 | 1998 Run Size*                   | 2612             |
|---------------------------------|----------------------------------|------------------|
|                                 | Hatchery Capture Rate            | 0.036            |
|                                 | Captured Adults                  | Natural Spawners |
| Available Adults                | 104**                            | 2,517            |
| Pre-Spawn Mortality Rate        | 0.06                             | 0.05             |
| Est. Effective Population Size  | 143                              | 252              |
| Number of Females               | 61                               | 956              |
| Eggs per Female                 | 3,372                            | 3,500            |
| Total Eggs                      | 205,668                          | 3,346,000        |
| Survival to Fry                 |                                  | 836,500          |
| Survival to Pre-Smolt, Release  | 153,908                          |                  |
| Survival to Smolt, Post-Release | 76,954                           | 493,535          |
| Total Smolt Production          |                                  | 570,489          |
| Percentage of Production        | 13.49 %                          | 86.51%           |
| Effective Population Size       | 323 (WITH HATCHERY INFLUENCE)    |                  |
|                                 | 261 (WITHOUT HATCHERY INFLUENCE) |                  |

\* Preliminary 1998 run-size estimate of naturally produced winter Chinook salmon generated by the California Department of Fish and Game. This value does not include estimates of hatchery-origin winter Chinook salmon that returned to Battle Creek.

\*\* 103 adults were originally collected. One was later sacrificed as it was considered a suspect hybrid. Cryopreserved semen from two males collected in 1994 was used in two matings. Therefore,  $103 - 1 + 2 = 104$  adults available.

Table 11. Estimated impact of the release of brood year 1998 juvenile winter Chinook salmon propagated at Livingston Stone National Fish Hatchery on the Effective Population Size. The calculation assumes  $N_e$  (wild) = .333 x the estimated run size.

|                                 | 1996 Run Size*                   | 2612             |
|---------------------------------|----------------------------------|------------------|
|                                 | Hatchery Capture Rate            | 0.036            |
|                                 | Captured Adults                  | Natural Spawners |
| Available Adults                | 104**                            | 2,517            |
| Pre-Spawn Mortality Rate        | 0.06                             | 0.05             |
| Est. Effective Population Size  | 143                              | 838              |
| Number of Females               | 61                               | 956              |
| Eggs per Female                 | 3,372                            | 3,500            |
| Total Eggs                      | 205,668                          | 3,346,000        |
| Survival to Fry                 |                                  | 846,500          |
| Survival to Pre-Smolt, Release  | 153,908                          |                  |
| Survival to Smolt, Post-Release | 76,954                           | 493,535          |
| Total Smolt Production          |                                  | 570,849          |
| Percentage of Production        | 13.49 %                          | 86.51%           |
| Effective Population Size       | 980 (WITH HATCHERY INFLUENCE)    |                  |
|                                 | 870 (WITHOUT HATCHERY INFLUENCE) |                  |

\* Preliminary 1998 run-size estimate of naturally produced winter Chinook salmon generated by the California Department of Fish and Game. This value does not include estimates of hatchery-origin winter Chinook salmon that returned to Battle Creek.

\*\* 103 adults were originally collected. One was later sacrificed as it was considered a suspect hybrid. Cryopreserved semen from two males collected in 1994 was used in two matings. Therefore, 103-1+2=104 adults available.

A total of 153,908 winter Chinook salmon (87.1 per pound) were released at Caldwell Park on January 28, 1999 (147,395 with coded-wire tags, Table 9). The salmon were released at dusk, allowing them to acclimate through the night in order to reduce possible losses from predation. Average survival from egg to release was 74.7%. The majority of juvenile mortality occurred during the egg stage and the sac fry stage. A total of 1,010 winter Chinook salmon (44.9 per pound) were transferred to Steinhart Aquarium (506) and BML (504) on March 18, 1999 for the captive broodstock program.

In 1998, juveniles from the supplementation program were retained at Livingston Stone NFH for captive rearing; a total of 214 fish were retained at Livingston Stone NFH for this purpose. At the time of tagging, a small piece of fin was removed from each of the captive broodstock candidates to allow genetic determination of sex. Males and females were reared in separate tanks. Separate rearing was conducted to reduce precocious maturation in the males by limiting their feed rates, thus reducing their growth and fat deposition.

### **Fish Health Maintenance and Monitoring**

At the time of release, CA-NV FHC personnel tested 48 juvenile winter Chinook for *R. salmoninarum* using ELISA. Sixty-three percent (30) of these fish were negative (optical density value < 0.083). The remaining 37% (18) were in the low positive range (with the highest optical density value = 0.090). 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

- 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**

**Research utilizing BY 1998 captive-origin juvenile  
winter Chinook salmon**