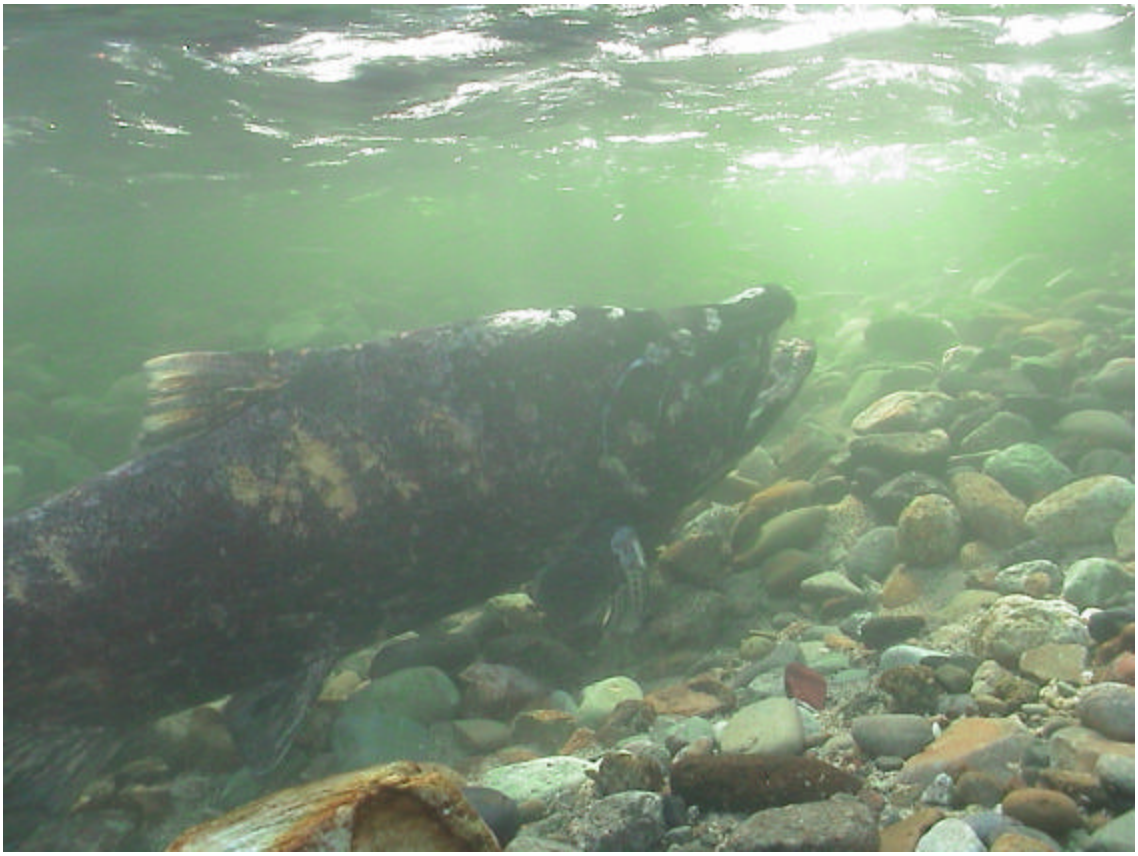
State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

Sacramento River
Winter-Run Chinook Salmon Escapement Survey
April–September 2003



by
Douglas Killam
Northern California-North Coast Region
Sacramento River Salmon and Steelhead Assessment Project

SRSSAP Technical Report No. 04-1
2004

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1/ This was a cooperative investigation with the U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office and was supported by funding administered by the National Fish and Wildlife Foundation and provided by CALFED as part of a cooperative agreement with the California Department of Fish and Game pursuant to the California Bay-Delta Environmental Enhancement and Water Security Act (PL. 104-333).

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SUMMARY

The California Department of Fish and Game's Sacramento River Salmon and Steelhead Assessment Project and the U.S. Fish and Wildlife Service's Red Bluff Fish and Wildlife Office jointly conducted a winter-run Chinook salmon carcass survey on the mainstem Sacramento River in the spring and summer of 2003. The survey was conducted from 30 April through 4 September over a fifteen-mile reach. This survey area (Keswick Dam in Redding California downstream to the northern city limit of Anderson) contains the highest concentration of winter-run spawning activity and is the uppermost migratory limit for anadromous fish in the Sacramento River.

A 2003 spawner escapement estimate of 8,218 winter-run Chinook was developed through application of a Jolly-Seber model mark-recapture study, Keswick Dam's Fish Trap data, and aerial redd counts. Adult females comprised 5,226 or 67.1 % of the population based on sex ratio data from the Keswick Trap. Additionally 65.8% of the population was determined to have spawned in the uppermost four-mile section from the Anderson-Cottonwood Irrigation District's (ACID) dam upstream to Keswick Dam.

Survey conditions were good in 2003. Visibility ranged from 8' to well above the necessary 15' for maximum carcass recovery, with an overall survey average of 14 feet. River flows started out extremely high (nearly 30,000 cfs-cubic feet per second) during the first 2 survey periods, essentially washing out any remaining late-fall-run carcasses. Following this high flow event, the flow stabilized and averaged 12,605 cfs for the remaining 41 survey periods. Water temperatures within the spawning area were ideal for spawning salmon, averaging 52 degrees Fahrenheit, (range 50^{o}-54^{o}).

Crews encountered a total of 4,549 carcasses, 2,175 of which were recaptured after being tagged and released. Two hundred ten (210) of the total carcasses had questionable or clipped adipose fins indicating that they were probably of hatchery origin. Coded wire tag recoveries were made on 134 of these. Biological measurements (including fork length, sex, location, and spawning condition) were made on 2,521 carcasses. Genetic tissue and scale samples were collected on 1,584 carcasses.

This report details the mark-recapture study and associated data collection efforts necessary to produce the annual winter-run salmon escapement estimate. Additional details on the winter-run hatchery supplementation program at Livingston Stone National Fish Hatchery, and the genetic characterization of the spawner population are available in the US Fish and Wildlife Service's 2003 Winter Chinook Salmon Carcass Survey Annual Report.

INTRODUCTION

A winter-run Chinook salmon (winter-run), *Oncorhynchus tshawytscha*, carcass survey (survey) was conducted on the mainstem Sacramento River during spring and summer of 2003. The objectives of the survey included evaluation of the population characteristics of the 2003 winter-run and evaluation of the hatchery supplementation program conducted at Livingston National Fish hatchery (LSNFH). The survey was conducted through a cooperative agreement between the California Department of Fish and Game (Department) and the U.S. Fish and Wildlife Service (Service).

The Department and Service have conducted joint winter-run carcass surveys since 1996. This is the third year that the survey was funded through the California Bay-Delta Authority (CALFED). This report is submitted to satisfy annual reporting requirements for those portions of the survey that fall within the Department's annual reporting responsibilities to describe population characteristics including run size, age and sex composition, spawning success and spatial and temporal distribution.

The survey is used in conjunction with several other data sources to produce a population estimate. The results of the Department's Aerial Redd Survey are used to determine the winter-run population spawning outside the range of the carcass survey. Additionally, this is the first year that data from winter-run collections at the Keswick Dam Fish Trap (Keswick Trap) have been integrated into the generation of the winter-run population estimate.

Objectives

The objectives of the Department's 2003 winter-run salmon carcass survey were:

- To estimate the in-river, winter-run spawner population in the upper Sacramento River within the established survey reach (RM 286–RM 302) based on a carcass mark-recapture survey.

- To examine the occurrence of higher than expected female to male sex ratios in the survey and to modify mark-recapture techniques and calculations used to estimate winter-run escapement to reduce possible bias associated with these ratios.

- To obtain baseline information on the following: spawning distributions (both temporal and spatial), environmental conditions during spawning, and characteristics (origin, length, age, sex composition, and spawning success) of the winter-run spawner population in the upper Sacramento River.

Background

Winter-run are one of four distinct Chinook salmon runs present in California's Central Valley. The other three runs are fall, late-fall, and spring. Winter-run generally leave the ocean and enter fresh water to begin their upstream migration from December through June. The peak of the run normally passes Red Bluff Diversion Dam (RBDD) in March and April (Hallock and Fisher 1985). Winter-run typically spawn from late-April through mid-August.

The earliest references to winter-run salmon have been summarized by Fisher (1993). In 1874, Livingston Stone noted winter-run in the Sacramento River near Mount Shasta and in the McCloud River, a tributary to the Sacramento River that presently drains into Shasta Lake. Discussions of winter-run status since the construction of Shasta Dam are available in Slater (1963), Hallock and Fisher (1985), and Fisher (1993). Since Shasta Dam has blocked the winter-run's access to most of its historic spawning habitat, they now predominantly spawn immediately downstream of Keswick Dam which is the upstream barrier to migration on the Sacramento River (Figure 1). Due to a drastically declining population, the California Fish and Game Commission listed winter-run as endangered under the California Endangered Species Act in 1989. Winter-run were federally listed as threatened in 1990, then as endangered in 1994 under the Endangered Species Act by the National Marine Fisheries Service (NMFS).

The NMFS (1997) and Botsford and Brittnacher (1998) developed a winter-run extinction model that identifies population conditions corresponding to an acceptable low probability of population extinction. Using the model, NMFS determined that the population will have recovered when the mean annual spawning abundance over any 13 consecutive years is at least 10,000 females. This population level assumes that the male: female ratio is 1:1 and that the age structure is comparable to that observed by Hallock and Fisher (1985) over three brood years. The assumed age structure is 50% 2-year-olds, 44% 3-year-olds, and 6% 4-year-olds for males; and 89% 3-year-olds and 11% 4-year-olds for females. The population criteria also require that annual escapement will be estimated with a precision of $\pm$ 25%. These draft recovery criteria for winter-run are currently under review by the NOAA Fisheries Central Valley Technical Recovery Team.

From 1969 through 2000, winter-run escapement estimates were based upon counts of salmon in fishways that provide passage over the Red Bluff Diversion Dam (RBDD). Starting in 2001, data from the carcass survey was used to provide the Department's "official" winter-run estimate, although the RBDD counts still provide an annual estimate. Counts at RBDD can only be made when the diversion is in operation and the gates are down, requiring all fish migrating upstream of RBDD to use the three fish ladders available at the dam. From 1969 through 1985, RBDD was typically operated throughout the entire winter-run migration period allowing a complete accounting of winter-run escapement. Beginning in 1986, the operation of RBDD was modified to improve winter-run migration. Since 1986, the gates are typically raised from mid-September through mid-May of the following year to allow unimpeded upstream passage of most winter run adults and the subsequent downstream migration of their juvenile offspring.

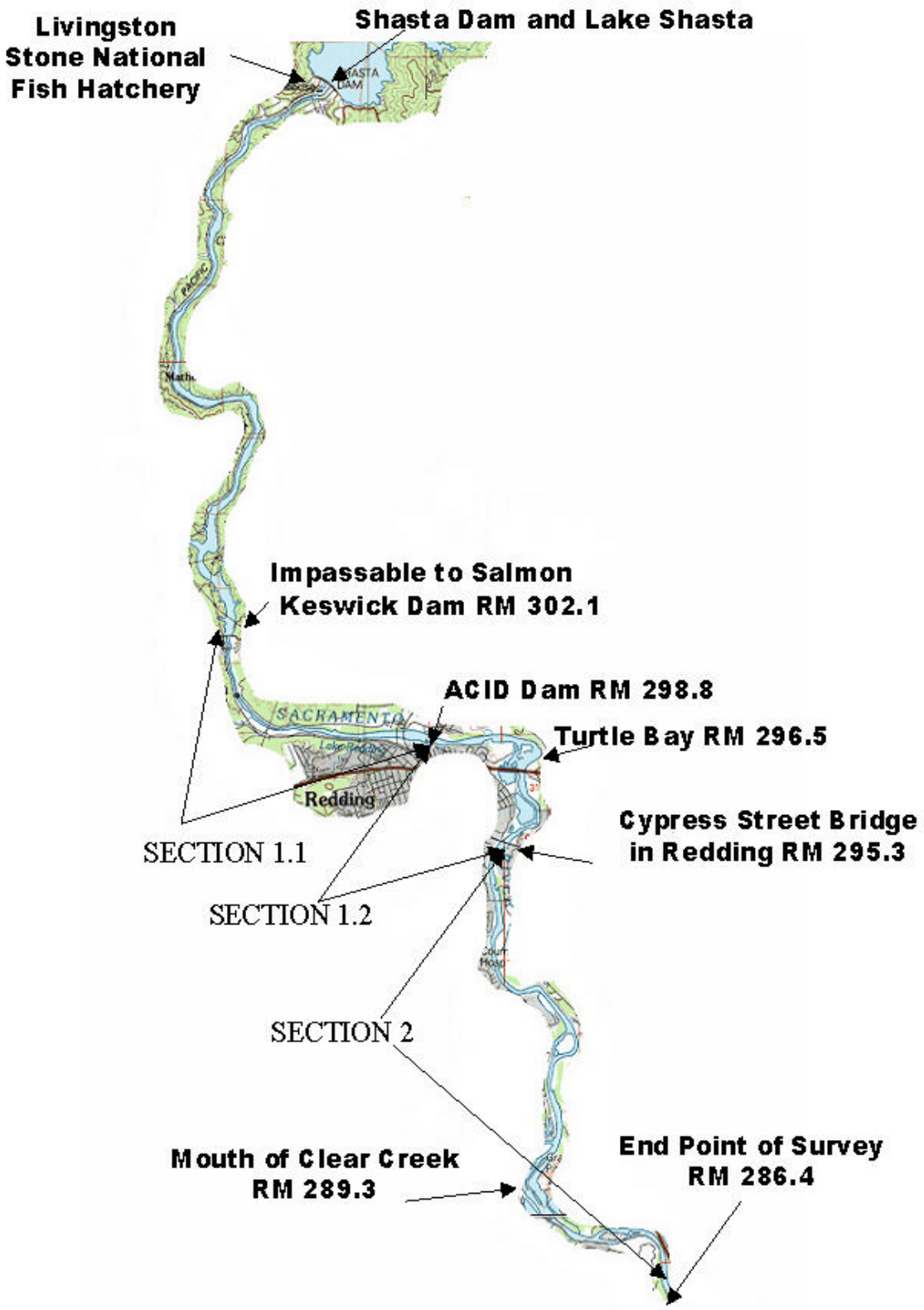

Figure 1 Map of survey area showing prominent landmarks, survey sections and river miles.

Winter-run counts made when season-long counts were possible (1969–1985) indicate that 13-19% of the winter-run migration occurs during the mid-May through mid-September period. Annual RBDD escapement is now estimated by expanding the abbreviated season-long count, and assuming it is proportionate to the average historic migration pattern for winter-run from 1982 through 1986.

METHODS

The 2003 winter-run Chinook salmon spawner escapement survey was conducted from 30 April through 4 September 2003.

Figure 1 shows the survey's location and prominent landmarks. The survey was conducted from boats, each having two or more observers. Typically, two boats were used. On some days a third boat was sent out behind the two primary boats to determine if a third boat would be useful in future surveys in recovering carcasses that the primary boats had missed. Each boat usually surveyed the areas from one shore out to the center of the river. In some areas of high carcass concentrations (e.g. Turtle Bay at RM 296.5) the boats would work side by side to process the carcasses. Crews were requested to search the entire river bottom and to not pre-determine where they would search based on prior experience. Some sections of the river were naturally not accessible for viewing due to hazards or deep water.

The survey was divided into three sections. Sections were chosen as convenient areas for crews to start or stop work for the day. The sections were as follows:

1.1 --Keswick Dam to ACID DAM - RM 302.1 to RM 298.8,
1.2 --ACID Dam to Cypress Street Bridge - RM 298.8 to RM 295.3
2.0 --Cypress Street Bridge to Anderson Mill Riffle - RM 295.3 to RM 286.4

The lower most point of the survey (RM 286.4) was chosen based on previous winter-run surveys. Few carcasses are encountered downstream of Clear Creek (RM 289.5) but in 2002 some were observed at RM 287.4 so the survey was extended downstream to encompass this area.

The entire survey consisted of 43 survey periods. Each period consisted of two sampling days and a third day of no sampling. A new period was started every fourth day. During periods and days with low numbers of carcasses, crews would attempt to collect data from all carcasses encountered. During busy periods, crews would sub-sample the amount of data collected from carcasses to allow for completion of the survey section by the end of the day.

Population Estimate

The winter-run spawner population was estimated using a mark and recapture design. Typically, all carcasses not in an advanced state of decay were marked (tagged). Carcasses not tagged were counted then cut in two (chopped). All chopped carcasses were disregarded in subsequent

surveys. All tagged carcasses were returned to flowing water near where they were collected in an attempt to simulate "natural" carcass dispersion.

Carcass Data

Carcasses were collected using a 15-foot (4.6m) long wooden pole with a five-pronged gig attached to one end. Data was collected from carcasses after they were speared and lifted onto the deck of the boat. Each carcass was then categorized using the following criteria:

1. Adipose fin absent, (hatchery), present, partial, or unknown.
2. Male or female.
3. Recaptured (previously tagged) or new encounter.
4. Fresh (recently died) or non-fresh (decayed).
5. Spawned or not spawned (eggs present in females).
6. Fork length and genetic samples taken or not taken.
7. Carcass to be tagged or chopped.

In accordance with the Service's task to evaluate the hatchery supplementation at LSNFH, the heads of all carcasses with adipose fins missing, partially present, or unknown, were collected for coded-wire-tag (CWT) analysis. The remaining headless carcasses were then chopped in half and returned to the river.

A carcass with the adipose fin present (natural fish) was processed (steps 2-7) and returned to the river either chopped in half or with a tag (i.e. mark) placed in the upper or lower jaw. All carcasses handled were accounted for in this manner. Carcasses to be tagged were typically classified as fresh or recently non-fresh. A fresh carcass was one with at least one clear eye or red/pink gills. Fresh carcasses were tagged in the upper jaw and non-fresh carcasses were tagged in the lower jaw if they were deemed suitable for tagging (not too decayed).

Tags were aluminum or copper coated steel hog ring staples with a small (1-2 cm) square piece of thin colored plastic sheet pushed onto them. Tags were applied with hog-ring pliers to the carcass by squeezing the ends of the staple around the jaw. The tags of each sample period had a unique color to enable the subsequent analysis of recaptured carcasses by period.

Spawn condition was determined for female carcasses only. Female carcasses were classified as spawned if few eggs remained in the carcass and the caudal (tail) fin was worn from redd construction. Unspawned females typically were those with unworn caudal fins indicating they had not constructed redds or those where numerous eggs remained in the carcass after it had died.

A recaptured carcass was one that had been previously tagged and was recaptured on a subsequent survey. Sex, tag color, and location of the tag (upper or lower jaw) were recorded for all recaptured carcasses. (Note: In previous surveys, sex was not recorded for recaptures allowing population estimates only to be done on adult fish, i.e. male and female combined. Recording the sex of the recaptures allows estimation of the population of adult female fish separate from male fish). Recaptured carcasses were chopped and returned to the river.

Most fresh carcasses were measured for fork length to determine age structure of the population. Additionally, tissue samples were collected from many fresh carcasses for genetic analysis. For each carcass that was measured the river mile was recorded. (This allows analysis of carcass distribution to determine if differences exist between male and female distribution).

Sub-sampling for biological samples (tissue, scales) occurred when carcass counts were expected to be high. For example, a sub-sample ratio (e.g. 1:3) was chosen at the start of the day and every third fresh carcass would be tissue sampled.

Environmental Data

Other data collected by survey period included the following:

1. Flow from Keswick Dam.
2. Water temperature.
3. Water clarity.
4. Weather conditions.

River flow based on the outflow from Keswick Dam was obtained from the California Data Exchange Center at www.cdec.water.ca.gov. Water temperature was collected for each survey section via a handheld thermometer and recorded in degrees Fahrenheit. Water clarity was measured by lowering a Secchi disc attached to a measuring tape graduated in tenths of a foot into the water column. When the Secchi disc disappeared from view the measurement at the water surface was recorded. Water clarity distances above 15 feet were recorded as 15+ for survey purposes. Weather conditions were noted as to the daily conditions (rain, clear, etc) encountered for each section.

RESULTS and DISCUSSION

Population Estimate

The Jolly-Seber model was used to calculate winter-run spawner escapement (Seber 1982), and described by Boydstun (1994). Data from female adult carcasses, (both fresh and decayed), was used as a starting point to calculate the winter-run population estimate. The following steps were used to arrive at the final estimate:

1. Jolly-Seber model calculation of adult females in carcass survey area.
2. Expansion for marked (adipose fin clipped) adult females removed for CWT analysis.
3. Expansion for adult females spawning outside of carcass survey boundaries.
4. Expansion for adult males.
5. Expansions for grilse (separate expansions for jacks and jills)
6. Addition of winter-run fish that were collected for the LSNFH brood stock.

All of the steps except 4 and 6 above were based solely on survey data. Adult males (Step 4 above) were expanded based on male to female ratios observed during collections at the Keswick Trap. Step 6 was the number of fish removed from the river for brood stock purposes at LSFNH. The final estimate was calculated by adding the calculated values in steps 3 though 6 above. Table 1 provides the results of the Jolly-Seber model calculation and the subsequent adjustments made to develop the 2003 final winter-run spawner population estimate.

Table 1. Adjustments made to Jolly-Seber model results to determine final winter-run 2003 spawner estimate.

CATEGORY CALCULATION	RESULTS	FACTOR	ADJUSTMENT DESCRIPTION
Jolly-Seber Model Calculation for Adult Females	4,903	4,903	
Adult Female Ad-Clipped Fish Adjustment	5,143	1.0491	2008 adult females were observed / 1914 were not ad-clipped
Total Adult Females: Downstream Redds Factor	5,179	1.0069	878 redds were counted / 872 were in the survey area
Total Adult Males Adjustment Factor	2,419	0.4672	At Keswick Dam there were 64 males / 137 female adults
Total Grilse Female Adjustment Factor	39	0.0075	In the survey, 15 grilse female / 1997 adult "fresh" females
Total Grilse Male Adjustment Factor	496	0.2051	In the survey, 64 grilse male / 312 adult "fresh" males
Fish Removed from Population by LSNFH	85	85	Number of Salmon taken into LSNFH Hatchery
Final Estimate is	**8,218**		

The 2003 estimate of winter-run salmon spawning in the Upper Sacramento River and collected for brood stock for LSNFH was **8,218**. For fish spawning in the river (not including LSFNH), the Jolly-Seber Model produced an estimate of 4,903 adult females based on the mark-recapture methods used in the survey. Appendix Tables 1A through 1D and Appendix 1E provide a summary of the data and calculations used in developing the Jolly-Seber estimate for adult females and the expansions for other groups (adult males and grilse). The model's female adult number was expanded to account for other adult females including marked (adipose fin clipped), and fish downstream of the survey area. The final in-river adult female estimate was 5,179. Adult males numbered 2,419, while grilse females and grilse males numbered 39 and 496 respectively. Crews from LSNFH retained 85 winter-run for hatchery brood stock.

Carcass Survey Results

Crews handled a total of 6,724 carcasses from 30 April through 4 September 2003. When recaptured fish are not included, a total of 4,549 individual carcasses were handled. Of these, 210 were potentially marked fish (hatchery), 3,457 were tagged and 882 were chopped. Another 2,175 carcasses were repeat observations (recaptures). Overall recapture percentage of tagged fish was 62.9%. Table 2 presents a summary of the number of carcasses observed for each data category.

Table 2. Summary of carcasses observed during 2003 winter-run survey.

Category	Non-Fresh Adult Female	Non-Fresh Adult Male	Fresh Adult Female	Fresh Adult Male	Non-Fresh Grilse Female	Non-Fresh Grilse Male	Fresh Grilse Female	Fresh Grilse Male	***TOTAL***
Tagged	986	191	1,898	293	9	15	14	51	**3,457**
Chopped	671	167	16	11	3	12	0	2	**882**
Hatchery	65	5	112	12	0	3	1	12	**210**
Recaptured	632	93	1,264	161	2	3	5	15	**2,175**
TOTAL	**2,354**	**456**	**3,290**	**477**	**14**	**33**	**20**	**80**	**6,724**

Survey Conditions

Water clarity was very good with over 76 percent of the survey periods reporting 15 or more feet of visibility, allowing observers to gather all carcasses observed in water up to 15 feet deep (length of spear was 15 feet). Visibility averaged 14 feet, with only 28 of 123 readings (23%) being less than 15' (range: 8' to >15'). Mean river flows from Keswick dam averaged 12,605 cfs (range: 8,050 to 29,785). Mean water temperature for the survey averaged 52 ^{o}F (range: 50 ^{o}F to 54 ^{o}F). Appendix Table 2 presents a summary of environmental data encountered over the survey.

Biological Carcass Data

Biological data (origin, sex, length, spawn condition, freshness, and location) was collected from a total of 2,521 carcasses during the survey (55.4% of the 4,549 encountered). Most biological data was obtained from fresh carcasses (n = 2,388). Non-fresh carcasses (n = 133) were typically sampled during the "slow" workload periods when carcass numbers were low or when a non-fresh carcass with an adipose fin that was missing, partial, or unknown was encountered (n = 72). It is important to note that sub-sampling of some biological data, but not ad-clip data, occurred during periods of high numbers of carcasses, thus comparisons for analysis between ad-clipped (marked) carcass numbers and natural (unmarked) carcass numbers must be done with care. There are a few irreconcilable differences between the mark-recapture database (Department) and the biological sampling database (Service) that cause slight discrepancies between the totals for some categories in both databases.

Marked (adipose fin-clipped) Carcasses

On all carcasses encountered without a full and natural looking adipose fin, the head was removed and retained for coded wire tag analysis. Two hundred and ten carcasses were encountered that crews suspected might be of hatchery-origin during the survey. The heads were removed and frozen for analysis. The Department's Ocean Salmon Project dissected the heads from these carcasses for CWT extraction and reading. One hundred thirty-four of these heads had CWT's in them. Nine of them were unreadable due to bad marks on the tag and the other 125 were successfully decoded. Appendix Table 3 provides a summary of the CWT data collected from the survey.

Crews collected heads from 39 carcasses (6 partial and 33 unknown) that they were unsure of the adipose fin status. Carcasses that were tallied as unknown or partial were re-tallied in the final database as natural fish if no CWT was detected in the head. After analysis for CWT's the survey's database was adjusted to reflect the results of the CWT findings. Six carcasses were re-labeled as hatchery (5 unknowns and 1 partial). In addition, two carcasses that were released from LSNFH (floy-tagged) and originally labeled as not-clipped by survey crews were subsequently re-labeled in the database as ad-clipped after analysis of the LSNFH data indicated they were clipped when released.

Collection of non-fresh carcasses (n = 72) resulted in 41 CWT detections, a 57% success rate for this group. Collection of fresh carcasses (n = 138) resulted in 84 CWT detections a 61% success rate for these carcasses. Adjustments to the survey's database after CWT analysis resulted in the reduction of observed hatchery fish from 210 to 179, (Appendix Table 3).

Sex Composition

Data collected on fresh carcasses is more reliable for determining biological characteristics of the population. The decay process can make measuring, sexing and determining spawn condition difficult. For these reasons, the fresh carcass data is used to characterize the population. Crews sampled 2,388 fresh carcasses. Overall sex composition of these was 84.3% female (n = 2,012) vs. 15.7% male (n = 376). Table 3 provides a summary of sex composition of the carcass survey's winter-run population for various categories.

Table 3. Winter-run carcass survey sex composition results for various categories.

Category	Total	**FEMALE %**	Count	**MALE %**	Count
Total carcasses (fresh + non-fresh)	2,521	83.6%	2,107	16.4%	414
Fresh carcasses	**2,388**	84.3%	**2,012**	**15.7%**	**376**
Natural (unmarked) fresh carcasses	2,270	84.4%	1,917	15.6%	353
Hatchery (marked) fresh carcasses	118	80.5%	95	19.5%	23
All Adult fresh carcasses	2,309	86.5%	1,997	13.5%	312
Adult Natural fresh carcasses	2,204	86.3%	1,903	13.7%	301
Adult Hatchery fresh carcasses	105	89.5%	94	10.5%	11
All Grilse fresh carcasses	79	19.0%	15	81.0%	64
Grilse Natural fresh carcasses	66	21.2%	14	78.8%	52
Grilse Hatchery fresh carcasses	13	7.7%	1	92.3%	12

The data from Table 3 shows that adult males represent only 15.7% of the survey's sample of fresh carcasses. Previous winter-run surveys (1996-2002) have produced similar results (Appendix Table 4). Observations by this author, data on other Central Valley salmon races, and the recent increases in the winter-run population suggest male salmon may be leaving the survey area before death, and that consequently the survey may underestimate adult male numbers. An objective of the 2003 survey was to investigate if the sex ratio of carcasses represents the "true" sex ratio of the spawner population before death. Observations during the survey and subsequent

analysis of data provided three indications that adult male winter-run salmon may be leaving the survey area before death.

In 2003, crews observed male adult fish slowly swimming out of the survey area with bite scars, worn fins, and other wounds that would indicate that they had spawned. These fish were found facing upstream, but moving slowly downstream losing ground to the strong current, and would not attempt to avoid overhead boat traffic in contrast to the avoidance behavior of a healthy male found near the spawning redds. A second indication of adult males leaving the survey area was that the average river mile (RM) of fresh adult male carcasses (n = 312) encountered was at RM 294.6 whereas the fresh adult female carcasses (n = 1,997) were found on average at RM 297; a difference of 2.4 miles further downstream for the male carcasses. A third indication that adult males are leaving the survey area is that the recapture rate of fresh adult females (67%) and fresh adult male (55%) carcasses are both high, indicating that once dead, male and female fish do not exhibit much difference in behavior (floating or sinking) that would lead to the large difference between male and female counts.

The Department's internal Winter-run Technical Team discusses technical issues regarding winter-run salmon. The team agreed that the sex differential on the survey warrants additional study and that the survey data likely under represents adult male numbers. The team recommended the use of an alternative source of data to estimate adult male numbers. These decisions led to the use of the data from the Keswick Trap to determine the sex ratio in the population. Table 4 presents data from winter-run salmon sampled at the Keswick Trap in 2003.

Table 4. Summary of characteristics of winter-run salmon trapped at Keswick Trap.

Category	Total	**FEMALE %**	Count	**MALE %**	Count	**# Unknown**
All Salmon	294	**56.2%**	164	**43.8%**	128	2
Natural (unmarked)	145	**63.6%**	91	**36.4%**	52	2
Hatchery (marked ad-clip)	149	**49.0%**	73	**51.0%**	76	0
All Adults (>609mm)	202	**66.2%**	133	**33.8%**	68	1
Adult Natural	98	**70.1%**	68	**29.9%**	29	1
Adult hatchery	104	**62.5%**	65	**37.5%**	39	0
All Grilse (<610mm)	43	**2.3%**	1	**97.7%**	42	0
Grilse Natural	9	**0.0%**	0	**100.0%**	9	0
Grilse Hatchery	34	**2.9%**	1	**97.1%**	33	0

In 2003, the Keswick Trap data was not collected for the purpose of describing the winter-run population. Therefore, some fish trapped at Keswick were excluded from Table 4 because not all biological data was collected from these fish (unknown lengths-55, sexes-2 and ad-clips-1). Eighty-Five of the winter-run trapped at Keswick (n = 294) were retained by the USFWS personnel for brood stock purposes at LSNFH. The other 209 winter-run were floy-tagged and released into the Sacramento River. Twenty-four of these floy-tagged fish were recovered during the survey. Analysis of the Keswick Trap data and the carcass data revealed that 5 of the 24 (20.8%) were identified as males at Keswick, but were identified as females during the survey (there were no male floy-tagged fish recovered). Other changes to the Keswick Trap data were

made to reflect data collected from floy-tagged Keswick salmon on the carcass survey. These included 7 length changes, 1 run call change, and 1 adipose fin change.

The ability to phenotypically determine the sex of winter-run salmon correctly is dependent upon the sexual maturation of the fish and the experience of the biologist. The data from the carcass survey showed that some fish were called males when in fact they were females (5 of 24 recovered). This highlights the difficulty in sexing early arriving (non-ripe) fish. As a result of this, the Keswick Trap data was further adjusted for estimation purposes. Four females were added to the adult female total (n = 137) and four males subtracted from the adult male total (n = 64) in Table 4 to adjust for incorrect identification of females at the Keswick Trap, (9 of the 44 males released (20.8%) from LSFNH = 9 total miscalls – 5 recovered = 4 more females). The Keswick Trap data in Table 4 for "All Adults" was adjusted accordingly (updated to female = 137, male = 64) and the final estimate used (Table 1) was that the adult winter-run population spawning in the river was **31.8% male** and **68.2% female**.

Age Composition

The age composition of the winter-run population was determined by the fresh carcass data from the survey. Snider et al. 2002 determined that utilizing length frequency data from the survey provided an adequate means of characterizing the age structure of the winter run population in comparison to scale ageing and known age analysis from CWT's of hatchery fish. Crews measured 2,388 fresh carcasses. Overall age compositions of these were **96.7% Adult** (3-4 year old) vs. **3.3 % Grilse** (2 year old). The length cut-off for the survey was chosen at 610 mm. This is the historic cut-off for fish at the RBDD Fish Trap for winter-run and allows comparison between the two counts (Keswick Trap data is similar). Typically, carcasses will be slightly different in length than live fish. Physiological changes that occur prior to spawning for males include an elongated upper jaw that may result in male carcasses being slightly longer than they were when passing RBDD. Female carcasses on the other hand may be slightly shorter than they were when passing RBDD due to the physical deterioration of the caudal fin during redd construction which makes obtaining accurate fork lengths difficult.

Previous surveys (Snider et al. 2002) have utilized a length-frequency table to determine the cut-off with separate lengths for male and female grilse. The small number of carcasses found at or near the cut-off lengths makes this determination a subjective exercise that is open to different interpretation. Regardless of which method is used, the larger number of adult carcasses drives the overall population estimate. Scale samples were taken from each fish sampled for genetic analysis (n = 1,584) and are currently archived with the Service.

Grilse sex composition was different from that of adults. Overall fresh grilse (<610 mm) sex composition was 81% male (n = 64) vs. 19% female (n = 15) (Table 3). The survey's fresh carcass data was used to generate a population estimate separately for both male grilse (jacks) and female grilse (jills) (Appendix 1-E). Keswick Trap data was not used to generate the final estimate for grilse because of small sample sizes and a likely bias towards sexing unripe grilse as males when they were actually females.

Spawning Success

Of the 2,012 fresh female carcasses examined (Table 3) only 11 (0.55%) were classified as unspawned based on egg retention and deteriorated caudal fins from digging redds. The category of "partial" spawned fish was eliminated due to the subjective nature of the category. If the caudal fin was worn from digging and few or no eggs were present when examined then the carcass was tallied as spawned. If eggs were present in the carcass (a handful or greater) then the carcass was tallied as unspawned.

Temporal Distribution

The survey began in late-April, immediately following the Department's late-fall-run survey. Heavy rains late in April resulted in the Keswick release flow to increase to nearly 30,000 cfs, essentially flushing out the few remaining late-fall carcasses. Table 5 presents the percentage of carcasses encountered by period during the survey. The peak carcass total for all categories (6.9%) was during survey period 26 or 20-21 July. The temporal distribution by month for all carcasses was as follows: May 4.6%, June 26.4%, July 56.7%, August 12.2% and early September 0.1 %. Spawning salmon die and become available as carcasses approximately 2 weeks after the onset of spawning (Snider and Vyverberg 1995). Table 5 shows that peak spawning (two weeks prior to peak carcasses) occurred from approximately mid-June to early-July.

Spatial Distribution

The spatial distribution of carcasses (n = 2,521,Table 3) is presented by river mile in Table 6. River mile 296 contained 28.2% of the carcasses observed during the survey. Turtle Bay is located near RM 296.5 and is a wide shallow borrow pit that was used to provide aggregate for the construction of Shasta Dam. The hydrological pattern of the Sacramento River in Redding makes Turtle Bay a stopping point for many of the carcasses washing out of the river from upstream. Another natural carcass fallout point is located in the pool created by the ACID Dam (RM 299) and held 20.0% of the carcasses encountered (Table 6). Carcass distribution does not accurately reflect spawning distribution since carcasses tend to collect in slow moving water.

Winter-run spawning distribution is determined by aerial redd surveys conducted weekly by helicopter from May until August. Aerial redd flights are used to provide an index of spawning distribution rather than a complete count. Riparian vegetation, and cloudy or deep water prevent viewing of all areas, so the total redd numbers are less than the total female spawner estimate. Table 7 provides a summary of the twelve winter run aerial redd flights made in 2003. Over 65 percent of the total redds counted were located in the uppermost four miles of the Sacramento River between ACID Dam and the Keswick Dam. New fish ladders at the ACID dam were finished in 2001, and spawning gravel injections at two sites near Keswick dam have led to increased use of this area by winter-run spawners. Appendix Table 5 provides a summary of historical winter-run spawner distributions from 1981 through the present for all years surveyed, and shows the increased spawning distribution above the ACID Dam from 2001 to present.

Table 5. The temporal distribution of winter-run carcasses from the 2003 carcass survey by period

Period	Female Adults	Male Adults	Grilse	Ad-Clips	All carcasses	Date
1	0.1%	0.3%	0.0%	0.0%	0.1%	May 6 - 7
2	0.2%	0.5%	0.0%	0.0%	0.2%	May 9 - 10
3	0.6%	0.9%	0.0%	0.5%	0.6%	May 12 - 13
4	0.3%	2.0%	0.0%	1.0%	0.5%	May 15 - 16
5	0.4%	0.3%	0.0%	0.5%	0.4%	May 18 - 19
6	0.4%	1.5%	0.0%	0.5%	0.6%	May 21 - 22
7	0.5%	1.1%	0.0%	0.5%	0.6%	May 24 - 25
8	0.4%	2.1%	0.9%	1.0%	0.7%	May 27 - 28
9	0.6%	2.0%	1.9%	0.5%	0.8%	May 30 - 31
10	0.8%	2.1%	0.9%	2.9%	1.1%	June 2 - 3
11	1.0%	2.0%	0.0%	1.9%	1.2%	June 5 - 6
12	1.2%	3.0%	0.9%	0.5%	1.4%	June 8 - 9
13	1.3%	2.7%	0.0%	1.4%	1.5%	June 11 - 12
14	1.8%	3.0%	1.9%	0.5%	1.9%	June 14 - 15
15	2.1%	3.8%	1.9%	4.8%	2.5%	June 17 - 18
16	2.7%	3.9%	3.8%	1.4%	2.8%	June 20 - 21
17	3.4%	5.7%	3.8%	3.8%	3.8%	June 23 - 24
18	4.3%	7.1%	11.3%	1.9%	4.7%	June 26 - 27
19	4.8%	8.2%	8.5%	5.2%	5.4%	June 29 - 30
20	6.7%	6.8%	7.5%	6.7%	6.7%	July 2 - 3
21	5.5%	6.8%	12.3%	5.2%	5.9%	July 5 -6
22	6.4%	7.7%	6.6%	8.6%	6.7%	July 8 - 9
23	7.3%	4.1%	2.8%	8.6%	6.8%	July 11 - 12
24	6.6%	3.5%	7.5%	4.3%	6.1%	July 14 - 15
25	4.6%	2.6%	1.9%	3.3%	4.2%	July 17 - 18
26	7.4%	4.4%	4.7%	6.2%	**6.9%**	**July 20 - 21**
27	5.6%	2.4%	7.5%	7.6%	5.3%	July 23 - 24
28	5.1%	1.1%	0.9%	5.2%	4.4%	July 26 - 27
29	4.3%	2.1%	1.9%	3.3%	3.9%	July 29 - 30
30	3.8%	2.1%	4.7%	3.3%	3.5%	Aug 1 - 2
31	3.1%	1.4%	0.9%	3.8%	2.8%	Aug 4 - 5
32	1.7%	0.9%	0.9%	3.3%	1.7%	Aug 7 - 8
33	1.4%	1.1%	1.9%	0.5%	1.3%	Aug 10 - 11
34	1.0%	0.3%	0.0%	1.0%	0.9%	Aug 13 - 14
35	1.2%	0.6%	0.9%	0.0%	1.1%	Aug 16 - 17
36	0.4%	0.0%	0.0%	0.0%	0.4%	Aug 19 - 20
37	0.2%	0.0%	0.0%	0.0%	0.2%	Aug 22 - 23
38	0.1%	0.0%	0.9%	0.0%	0.1%	Aug 25 - 26
39	0.2%	0.0%	0.0%	0.0%	0.2%	Aug 28 - 29
40	0.0%	0.2%	0.0%	0.5%	0.1%	Sep 1 - 2
41	0.1%	0.0%	0.0%	0.0%	0.1%	Sep 4 - 5
TOTAL #	**3,571**	**662**	**106**	**210**	**4,549**	

Table 6. The spatial distribution of winter-run carcasses from the 2003 carcass survey by river mile.

River Mile	Female Adults	Male Adults	Grilse	Ad-Clips	All carcasses
286	0.0%	0.6%	0.0%	0.0%	0.1%
287	0.1%	1.2%	1.5%	0.0%	0.3%
288	0.9%	6.3%	4.5%	1.7%	1.8%
289	1.1%	3.9%	10.4%	4.0%	1.9%
290	1.4%	5.4%	7.5%	0.6%	2.0%
291	1.7%	3.3%	1.5%	3.4%	2.0%
292	0.8%	3.6%	1.5%	0.6%	1.2%
293	0.4%	1.8%	0.0%	0.6%	0.6%
294	5.8%	10.6%	10.4%	5.1%	6.5%
295	5.9%	10.9%	11.9%	1.1%	6.4%
296	28.1%	28.4%	28.4%	29.4%	**28.2%**
297	13.7%	9.1%	6.0%	7.3%	12.4%
298	10.3%	5.1%	1.5%	10.7%	9.4%
299	22.1%	6.9%	10.4%	24.3%	**20.0%**
300	4.5%	2.4%	4.5%	5.1%	4.2%
301	3.0%	0.3%	0.0%	6.2%	2.8%
302	0.2%	0.0%	0.0%	0.0%	0.1%

Table 7. Summary of twelve aerial redd flights for the 2003 winter-run spawners.

New Redds	% Dist.	LOCATION	RIVER MILE
578	**65.8%**	Keswick Dam to A.C.I.D. Dam	RM 302-298
151	17.2%	A.C.I.D. Dam to Highway 44 Bridge	RM 298-296
143	16.3%	Highway 44 Bridge to Airport Rd. Bridge	RM 296-284
3	0.3%	Airport Rd. Bridge to Balls Ferry Bridge	RM 284-276
0	0.0%	Balls Ferry Bridge to Battle Creek	RM 276-271
0	0.0%	Battle Creek to Jellys Ferry Bridge	RM 276-266
0	0.0%	Jellys Ferry Bridge. to Bend Bridge	RM 266-257
0	0.0%	Bend Bridge to Red Bluff Diversion Dam	RM 257-242
3	0.3%	Red Bluff Diversion Dam to Tehama Bridge	RM 242-229
0	0.0%	Tehama Bridge To Woodson Bridge	RM 229-218
878	100.0%	TOTALS	

Other Winter-Run Population Estimates

The Jolly-Seber model was used to calculate the Department's "official" estimate of 8,218 for the 2003 winter-run escapement. Based upon discussions in the Department's internal Winter-run Project Work Team the winter-run estimate based on the Jolly-Seber model was deemed most accurate. Other estimates include those based on RBDD counts, and the application of the Peterson and Schaefer Models using the carcass survey data . The RBDD and Peterson estimates are used to provide trend information on winter-run since the Jolly-Seber estimate was not available prior to 2001 (Snider et al. 2002). The Schaefer estimate was not developed in this report to simplify reporting results. Appendix 6 provides the data on the Peterson estimate and provides information on some revisions made to the way the Peterson estimate has been calculated in this report compared to previous winter-run surveys. The Peterson estimate was 7,397 based on fresh female adults and adjustments similar to the Jolly Seber estimate methods.

Prior to 2001, the Department used the results of the ladder counts and fish trap data from RBDD to produce the winter-run escapement estimate. The RBDD estimate for 2003 was 9,757. RBDD historical winter-run data is provided in Appendix Table 7.

Hatchery Contributions

More details of the hatchery contributions are available in the 2003 Winter Chinook Salmon Carcass Survey Annual Report (Service) presently (4/04) in draft form. Table 8 provides the estimated hatchery and natural components of the winter-run population as determined by analysis of the mark-recapture survey data.

The escapement estimate for hatchery (LSNFH) winter-run was determined by multiplying the results of the in-river escapements for the four categories (female adult, male adult, female grilse, males grilse) to the ratio of ad-clipped to not clipped carcasses present in the fresh carcass sample from the survey. Additionally an average adjustment of 0.21% was applied to ad-clipped totals to account for the number of hatchery fish released that did not receive an ad-clip (Robert Null, USFWS personal. comm.) This adjustment factor is an average of brood years and release groups.

Table 8. Summary of the 2003 hatchery and natural winter-run salmon numbers for selected categories. Hatchery data is based on average mark loss rates.

CATEGORY	Hatchery Origin	Natural Origin	Totals
Number of adult females	243	4,983	5,226
Number of adult males	94	2,354	2,449
Number of grilse females	3	36	39
Number of grilse males	94	410	504
Totals	434	7,784	8,218

RECOMMENDATIONS

1. The mark-recapture carcass study should be continued to provide important information on the status of winter-run populations.

2. A long-term funding source needs to be identified for the carcass survey as a replacement for the RBDD counts.

3. The sex ratio of the adult winter-run population needs to be investigated more thoroughly to determine the potential biases in our current methods of sampling of adult winter-run (RBDD, Keswick Dam, and the carcass survey).

4. The possibility of sampling/handling winter-run salmon at the ACID Dam in Redding should be investigated to provide an alternative to the logistical problems of trapping salmon at Keswick Dam.

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APPENDIX

Appendix Table 1-A. The Jolly-Seber Model variables and formulas defined. Data and variables shown in Appendix Tables 1B-1E.

VARIABLE EXPLANATIONS	
T(i)	The number of caracsses **T**agged in period i
E(i)	The total number of carcasses **E**xamined in period i including tagged, chops and recaptures.
R(i)	The sum of all recaptures in a single period i regardless of which survey period it was tagged in. (**R**ow sums)
C(i)	The sum of all recaptures over all periods for a survey period i. (**C**olumn sums)
K(i)	Sum of all recaptures made later than period i of carcasses tagged before period i
b(i)	The estimate of the number of tags available for recapture in each survey period
S(i)	The survivial rate of tagged carcasses from period i to period i + 1
N(i)	The estimate of the total number of carcasses in the population immediately prior to each survey
B(i)	The number of carcasses that joined the population between periods i and i+1: Does not account for carcasses leaving population between surveys like Di
N(1)	The number of carcasses in the population at the start of the survey period number 1
D(i)	The number of carcasses that joined the population between periods i and i + 1 : Accounts for carcasses leaving population between survey periods.
ESTIMATE =	The sum of N1 and all the Di's
bi = (Ti + 1)* Ki / (Ci + 1) + Ri	
Si = b_{i+1} / (bi - Ri + Ti)	
Ni = bi (Ei + 1) / (Ri + 1)	**Note that N1 = E1 + (N2- T1 * S1) / SQRT (S1)**
Bi = N_{i+1} - Si (Ni - Ei + Ti)	
Di = Bi / (SQRT Si)	

Appendix Table 1-B. Summary of carcass mark-recapture results for 2003 Winter-run adult female carcasses.

SURVEY PERIOD	**T(i)** NUMBER TAGGED	NUMBER CHOPPED	**E(i)** TOTAL EXAMINED	**R(i)** NUMBER RECAPTURED
1	2	1	3	0
2	3	4	7	0
3	15	6	24	3
4	9	1	12	2
5	14	1	20	5
6	13	3	29	13
7	17	1	22	4
8	14	1	30	15
9	21	0	25	4
10	28	2	41	11
11	35	2	53	16
12	36	7	63	20
13	40	8	67	19
14	56	8	87	23
15	73	2	110	35
16	84	11	134	39
17	114	9	188	65
18	141	11	219	67
19	159	14	250	77
20	213	25	335	97
21	182	16	300	102
22	209	20	372	143
23	219	41	388	128
24	209	27	366	130
25	149	16	249	84
26	217	48	371	106
27	158	41	311	112
28	132	50	302	120
29	100	53	251	98
30	77	57	227	93
31	56	55	181	70
32	38	24	121	59
33	20	31	115	64
34	9	28	62	25
35	12	32	66	22
36	6	10	25	9
37	2	6	11	3
38	1	4	10	5
39	1	7	12	4
40	0	1	3	2
41	0	3	5	2
TOTALS	**2,884**	**687**	**5,467**	**1,896**
Fresh:	**1,898**	**See appendix 6**		**1,264**

Appendix Table 1-C. The recapture matrix for the 2003 winter-run adult female carcasses.

MATRIX OF RECAPTURED FISH: Recovery period Rows vs Survey Period Columns

Recovery Period	Numbers of Tagged Fish Recovered that were Marked in Survey Period:																																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1	0																																												
2		3																																											
3			2																																									
4			1	4																																							
5			2	6	5																																							
6			1	1		2																																						
7			1		1	3	10																																					
8					1	0	0	3																																					
9								2	9																																			
10									5	11																																		
11					2			1	2	2	13																																	
12						0		0	2	2	2	13																																	
13									1	1	1	1	19																																
14									1		4	2	4	24																														
15									1			0	1	4	33																													
16										2	1	3	1	5	8	45																													
17										2		2			4	11	48																												
18													3	2	1	3	17	51																											
19												1			1	1	7	12	75																											
20															0	0	1	12	14	75																										
21											1		1		1	4	2	1	5	34	94																								
22														0	1		1	8	4	10	21	83																								
23																2	3	1	4	8	7	21	84																							
24															1				1	4	1	4	12	61																							
25																			1	2	3	6	11	24	59																						
26																					3	2	4	6	20	77																					
27																			1	2	3	5	6	10	9	23	61																			
28																				1		6	5	12	4	7	14	49																		
29																				1	1	1	4	5	2	7	6	23	43																	
30																						1	2	3	1	3	2	4	9	45																
31																								4	2	3	6	3	8	5	28															
32																						0		1	2	3	5	6	13	3	7	24														
33																										4		1	2	3	1	4	10													
34																									1		3	5		3	1	1	3	5											
35																												1	1					1	6										
36																																			1	2									
37																																1	1	1	0	1	1							
38																														1		2						1						
39																																		1	1				0					
40																															1						1			0				
C(i) Sums	**0**	**3**	**7**	**11**	**9**	**5**	**10**	**6**	**21**	**20**	**22**	**22**	**29**	**35**	**50**	**66**	**79**	**85**	**105**	**137**	**133**	**129**	**128**	**126**	**100**	**127**	**97**	**92**	**76**	**60**	**38**	**32**	**14**	**8**	**8**	**3**	**2**	**1**	**0**	**0**				

Appendix Table 1-D. The Jolly-Seber Model calculations for the 2003 Winter-run adult female carcasses.

JOLLY SEBER CALCULATIONS							
i	**K(i)**	**b(i)**	**S(i)**	**N(i)**	**B(i)**	**N(1)**	**D(i)**
1			0.0000	0	0	3	0
2	0	0.0	1.0000	0	23		23
3	0	3.0	0.4111	19	23		35
4	5	6.2	1.6329	27	37		29
5	11	21.5	0.9617	75	-4		-4
6	7	29.3	0.5826	63	51		67
7	8	17.1	0.7121	79	-11		-13
8	3	21.4	0.4406	42	36		54
9	5	9.0	1.2198	47	59		53
10	15	31.7	0.9389	111	53		55
11	19	45.7	0.8308	145	58		64
12	21	53.8	0.7423	164	74		86
13	24	51.8	0.9684	176	114		116
14	30	70.5	0.7587	259	70		80
15	30	78.5	0.7810	242	147		166
16	41	91.0	0.9218	307	122		127
17	42	125.4	0.8956	359	250		264
18	54	156.2	0.7411	505	232		270
19	62	170.6	0.8138	549	332		368
20	70	205.6	0.7632	705	272		312
21	105	245.4	0.9111	717	222		233
22	95	296.5	0.8048	768	393		438
23	96	291.7	0.7458	880	270		312
24	94	285.4	0.7847	800	337		380
25	136	286.0	0.9328	841	447		463
26	130	327.4	0.7921	1138	179		201
27	145	347.3	0.7488	959	134		155
28	122	294.5	0.8162	737	174		192
29	116	250.2	0.8709	637	110		117
30	99	219.6	0.9827	533	137		138
31	89	200.1	0.7490	513	-7		-8
32	68	139.4	0.9665	283	10		11
33	36	114.4	0.7497	204	46		53
34	25	52.8	1.0302	128	33		33
35	11	37.9	0.9502	110	15		16
36	10	26.5	0.5532	69	11		15
37	10	13.0	1.0000	39	-8		-8
38	7	12.0	1.5000	22	12		10
39	4	12.0	0.4444	31	-4		-5
40	2	4.0	2.0000	5	3		2
41		4.0		8			
					ESTIMATE =		**4903**

Appendix 1-E. Calculations and adjustments used for determining the entire winter-run spawner population based on the initial Jolly-Seber estimate of female adults from the carcass survey.

The Jolly-Seber model was applied to only adult female carcasses encountered. The model estimated 4,903 as the total of adult females in the tag and recapture survey. This number represents a starting point for the total estimate. Adjustments to this number result in the overall escapement estimate (8,218) for 2003 and are shown in Table 1.

Adult Females

Ad-clipped adult female carcasses were not included in the mark-recapture study since their heads were removed for CWT analysis. Ad-clipped females are accounted for by expanding the estimated number of fresh adult females based on the number of fresh adult natural (1,914) and hatchery (94) females. An adjustment factor of 1.0491 (2008 / 1914) is multiplied by Jolly-Seber estimate of natural adult females (4,903) to arrive at the total number of adult females within the carcass survey area (5,143).

Next, the fish that spawned outside of the survey area are accounted for. The number of redds outside of the survey was 6 out of a total 878 redds (Table 7). The adjustment factor of 1.0069 (878 / 872), is multiplied by 5,143 to estimate the in-river adult female escapement estimate at **5,179**. In addition, LSNFH retained 48 adult females so the **2003 estimate of escapement for adult females is 5,227.**

Adult Males

The number of adult males (Table 1) was derived from data from the Keswick Trap. To account for the difficulty in determining males from females in non-ripe fish arriving early in the season the Keswick Trap data (Table 4) was adjusted which resulted in 201 adults used to estimate gender ratios, (64 males and 137 females). No adjustment for males outside of the carcass survey area was necessary since these had already been accounted for in the female total. The adjustment factor used to produce the final estimate was 0.4672 (64 /137) and was multiplied by 5,179 to generate and estimate of **2,419 in-river adult males**. The LSNFH retained 29 adult males so the **2003 total estimate for adult males is 2,448**.

Grilse Females (Jills)

To estimate the total number of female grilse (Table 1), the fresh adult female carcass estimate (5,197) was expanded based on the number of fresh adult females (1,997) and fresh jills (15) in the carcasses examined. The adjustment factor of 0.0075 (15 / 1997) resulted in an in-river estimate of 39 jills (5,197 x 0.0075). No jills were retained at LSNFH so the **2003 total estimate is 39 female grilse.**

Grilse Males (Jacks)

To estimate the total number of male grilse (Table 1), the fresh adult male carcass estimate (2,419) was expanded based on the number of fresh adult males (312) and fresh jacks (64) in the carcasses examined. The adjustment factor of 0.2051 (64 / 312) resulted in an in-river estimate of 496 jacks (2,419 x 0.2051). Eight jacks were retained at LSNFH so the **2003 total estimate is 504 male grilse.**

Appendix Table 2. Summary of the measured environmental conditions encountered during each survey period.

Period	Date	Flow (cfs)	Water Temp.	Visibility (ft)	Weather	max Air temp.
A*	4/30/2003	29,663	51.0	7	Clear	69
A*	5/1/2003	29,576	51.0	7	Clear	73
B*	5/3/2003	29,785	51.0	?	Clear	63
B*	5/4/2003	27,366	51.0	?	Clear	64
1	5/6/2003	21,121	51.0	8	Rain	65
1	5/7/2003	17,999	52.0	9.5	Partly Cloudy	66
2	5/9/2003	13,795	51.0	8.75	Partly Cloudy	67
2	5/10/2003	11,742	54.0	12.5	Clear	75
3	5/12/2003	9,753	54.0	9.5	Clear	76
3	5/13/2003	12,534	54.0	10	Partly Cloudy	86
4	5/15/2003	14,378	52.0	8.5	Partly Cloudy	74
4	5/16/2003	14,350	53.0	13	Clear	83
5	5/18/2003	14,111	51.0	11.5	Clear	76
5	5/19/2003	14,112	53.0	12	Clear	90
6	5/21/2003	14,159	51.0	10	Clear	97
6	5/22/2003	14,259	52.0	9	Clear	99
7	5/24/2003	12,756	50.5	13.5	Clear	85
7	5/25/2003	12,701	52.0	11.5	Partly Cloudy	79
8	5/27/2003	13,538	52.0	12.5	Clear	103
8	5/28/2003	13,440	54.0	10	Partly Cloudy	98
9	5/30/2003	13,145	50.5	15	Clear	83
9	5/31/2003	12,130	52.0	11	Clear	94
10	6/2/2003	13,034	51.5	15	Clear	101
10	6/3/2003	13,041	53.0	15	Clear	110
11	6/5/2003	13,041	51.5	15	Clear	107
11	6/6/2003	13,146	54.0	15	Clear	96
12	6/8/2003	13,015	52.0	15	Clear	95
12	6/9/2003	13,018	52.0	14.5	Clear	93
13	6/11/2003	14,002	50.5	15	Clear	87
13	6/12/2003	13,957	52.0	12	Clear	83
14	6/14/2003	13,949	50.5	15	Clear	94
14	6/15/2003	13,994	52.0	15	Clear	101
15	6/17/2003	14,074	50.5	15	Clear	103
15	6/18/2003	14,005	52.0	15	Partly Cloudy	92
16	6/20/2003	13,137	50.5	15	Clear	90
16	6/21/2003	12,536	51.0	15	Clear	90
17	6/23/2003	11,561	51.0	15	Clear	85
17	6/24/2003	11,554	53.0	15	Clear	91
18	6/26/2003	11,555	51.5	15	Clear	108
18	6/27/2003	11,847	53.0	15	Clear	114
19	6/29/2003	12,385	53.0	15	Clear	97
19	6/30/2003	12,459	53.0	15	Clear	94
20	7/2/2003	11,509	51.5	15	Clear	94
20	7/3/2003	11,532	53.0	15	Clear	95

Appendix Table 2 continued

Period	Date	Flow (cfs)	Water Temp.	Visibility (ft)	Weather	max Air temp.
21	7/5/2003	12,015	52.0	15	Clear	103
21	7/6/2003	12,006	52.0	15	Clear	101
22	7/8/2003	12,524	52.0	15	Clear	100
22	7/9/2003	13,391	52.0	15	Clear	106
23	7/11/2003	14,428	50.0	15	Clear	106
23	7/12/2003	14,408	52.0	15	Clear	101
24	7/14/2003	14,332	52.0	15	Clear	106
24	7/15/2003	14,351	53.0	15	Clear	102
25	7/17/2003	14,405	52.0	15	Clear	109
25	7/18/2003	14,412	53.0	15	Clear	111
26	7/20/2003	14,407	53.0	15	Clear	112
26	7/21/2003	14,314	54.0	15	Clear	108
27	7/23/2003	14,393	52.0	15	Clear	110
27	7/24/2003	14,369	53.0	12	Partly Cloudy	95
28	7/26/2003	14,900	52.0	15	Clear	104
28	7/27/2003	14,995	53.0	15	Partly Cloudy	114
29	7/29/2003	15,036	52.0	15	Clear	119
29	7/30/2003	15,151	53.0	15	Clear	110
30	8/1/2003	14,701	52.0	15	Clear	98
30	8/2/2003	14,312	53.0	15	Partly Cloudy	75
31	8/4/2003	14,084	53.0	15	Clear	96
31	8/5/2003	14,025	53.0	15	Clear	85
32	8/7/2003	12,981	52.0	15	Clear	90
32	8/8/2003	11,632	52.0	15	Clear	91
33	8/10/2003	10,032	52.0	15	Clear	95
33	8/11/2003	10,025	53.0	15	Clear	95
34	8/13/2003	10,009	53.0	15	Clear	99
34	8/14/2003	10,015	53.0	15	Clear	97
35	8/16/2003	9,016	53.0	15	Clear	105
35	8/17/2003	8,943	53.0	15	Clear	106
36	8/19/2003	8,939	52.0	15	Clear	102
36	8/20/2003	8,934	53.0	15	Clear	104
37	8/22/2003	8,205	53.0	15	Partly Cloudy	80
37	8/23/2003	8,195	54.0	15	Clear	95
38	8/25/2003	8,537	53.0	15	Clear	104
38	8/26/2003	8,945	53.0	15	Partly Cloudy	101
39	8/28/2003	8,917	53.0	15	Clear	96
39	8/29/2003	8,879	54.0	15	Clear	103
40	9/1/2003	8,908	52.7	15	Clear	108
41	9/3/2003	8,550	53.0	15	Partly Cloudy	93
41	9/4/2003	8,050	54.0	15	Clear	102
AVERAGE		**12,605**	**52.3**	**14.0**		**95.7**

* These periods not included in mark-recapture study since no carcasses were observed

Appendix Table 3. Summary of results for 2003 winter run carcasses suspected of having coded wire tags.

Fork length+	Sex	River Mile	CWT Code	Brood Year	Adipose Fin Original*	Adipose Fin Final^	Date
820	F	300	501021305	1999	1	1	7/17/03
860	M	298	501030107	2000	1	1	5/15/03
740	F	296.5	501030107	2000	1	1	6/8/03
790.6	F	296.5	501030107	2000	2	1	5/15/03
730	F	296.5	501030107	2000	1	1	7/23/03
700	F	299	501030108	2000	1	1	7/5/03
660	F	299	501030108	2000	1	1	6/23/03
750	M	299	501030108	2000	1	1	7/5/03
680	F	296.5	501030109	2000	1	1	7/26/03
710	F	298	501030201	2000	1	1	7/29/03
800	F	296.5	501030202	2000	1	1	7/14/03
680	F	296.5	501030202	2000	1	1	7/20/03
650	F	299	501030202	2000	1	1	7/20/03
680	F	296	501030202	2000	1	1	7/11/03
750	F	298	501030202	2000	1	1	7/11/03
730	F	296.5	501030203	2000	1	1	7/2/03
720	F	297	501030203	2000	1	1	7/8/03
690	F	299	501030203	2000	1	1	7/8/03
730	F	296.5	501030203	2000	1	1	7/5/03
700	F	296.5	501030203	2000	1	1	7/14/03
680	F	299	501030203	2000	1	1	7/20/03
750	F	299	501030203	2000	1	1	7/11/03
690	F	296.5	501030204	2000	1	1	7/11/03
860	M	299	501030204	2000	1	1	7/14/03
780	F	299	501030204	2000	1	1	7/17/03
830	M	294	501030204	2000	1	1	7/21/03
690	F	300	501030204	2000	1	1	7/8/03
800	F	297	501030205	2000	1	1	5/21/03
720	F	298	501030205	2000	1	1	7/11/03
860	M	288	501030206	2000	1	1	6/27/03
770	F	299	501030206	2000	1	1	7/20/03
710	F	296.5	501030206	2000	1	1	7/23/03
770	F	299	501030206	2000	1	1	7/8/03
790	M	299	501030206	2000	1	1	7/11/03
810	F	299	501030206	2000	1	1	7/11/03
700	F	299	501030206	2000	1	1	7/29/03
870	F	299	501030206	2000	1	1	7/2/03
680	F	299	501030206	2000	1	1	7/8/03
720	F	297	501030207	2000	1	1	6/17/03
720	F	296.5	501030207	2000	1	1	7/29/03
790	F	296.5	501030207	2000	1	1	7/17/03
770	F	298	501030207	2000	1	1	7/17/03
630	F	291	501030207	2000	1	1	7/6/03

Appendix Table 3. continued

Fork length+	Sex	River Mile	CWT Code	Brood Year	Adipose Fin Original*	Adipose Fin Final^	Date
720	F	299	501030208	2000	1	1	6/17/03
650	F	299	501030208	2000	1	1	7/5/03
750	F	299	501030208	2000	1	1	6/29/03
660.6	F	289	501030209	2000	2	1	7/30/03
800	F	296.5	501030209	2000	1	1	8/4/03
700	F	298	501030209	2000	1	1	7/2/03
700	F	296.5	501030209	2000	1	1	7/23/03
750	M	289	501030301	2000	1	1	6/24/03
760	M	298	501030301	2000	1	1	7/11/03
750	F	297	501030302	2000	1	1	7/23/03
720	F	296.5	501030302	2000	1	1	9/1/03
720	F	298	501030302	2000	1	1	7/2/03
760	F	298	501030302	2000	1	1	7/20/03
710	F	299	501030302	2000	1	1	8/1/03
790	F	296.5	501030303	2000	1	1	7/23/03
740	F	299	501030303	2000	1	1	7/26/03
750	F	299	501030303	2000	1	1	8/7/03
740	F	296.5	501030304	2000	1	1	7/11/03
650	F	299	501030304	2000	1	1	7/20/03
720	F	298	501030304	2000	1	1	8/4/03
770	F	299	501030305	2000	1	1	7/2/03
710	F	296.5	501030306	2000	1	1	6/23/03
730	F	292	501030306	2000	1	1	7/9/03
800	F	299	501030306	2000	1	1	6/29/03
770.6	F	298	501030306	2000	3	1	7/29/03
670	F	297	501030307	2000	1	1	6/29/03
730	F	294	501030307	2000	1	1	7/18/03
740	F	301	501030307	2000	1	1	6/29/03
710	F	299	501030307	2000	1	1	7/29/03
720	F	299	501030307	2000	1	1	8/4/03
700	F	296.5	501030308	2000	1	1	7/8/03
690	F	301	501030308	2000	1	1	7/23/03
740.6	F	299	501030308	2000	2	1	8/7/03
740	F	301	501030309	2000	1	1	7/2/03
700	F	288	501030401	2000	1	1	7/9/03
690	F	296.5	501030401	2000	1	1	6/29/03
690	F	296.5	501030401	2000	1	1	7/23/03
740	F	299	501030401	2000	1	1	7/8/03
670	F	298	501030401	2000	1	1	7/11/03
840	M	298	501030402	2000	1	1	7/2/03
910.6	M	289	501030402	2000	2	1	7/12/03
760	M	296.5	501030402	2000	1	1	7/2/03
780	F	296	501030402	2000	1	1	7/8/03
710	F	296.5	501030403	2000	1	1	6/2/03
880	M	294	501030403	2000	1	1	7/9/03
760	F	296.5	501030403	2000	1	1	5/27/03

Appendix Table 3. continued

Fork length+	Sex	River Mile	CWT Code	Brood Year	Adipose Fin Original*	Adipose Fin Final^	Date
720	F	294	501030404	2000	1	1	5/19/03
750	F	296.5	501030404	2000	1	1	6/2/03
740	F	298	501030404	2000	1	1	6/29/03
720	F	294	501030404	2000	1	1	7/24/03
780	F	296.5	501030404	2000	1	1	7/2/03
720	F	296.5	501030404	2000	1	1	7/29/03
700	F	294	501030405	2000	1	1	6/18/03
750	F	299	501030405	2000	1	1	6/29/03
770	F	299	501030405	2000	1	1	6/23/03
780.6	F	296.5	501030406	2000	2	1	6/5/03
740	F	301	501030406	2000	1	1	7/8/03
690	F	299	501030406	2000	1	1	8/1/03
750	M	289	501030406	2000	1	1	6/12/03
710	F	301	501030406	2000	1	1	8/1/03
740	F	299	501030406	2000	1	1	8/7/03
710	F	297	501030408	2000	1	1	6/17/03
640	F	299	501030408	2000	1	1	7/26/03
710	F	299	501030408	2000	1	1	8/4/03
720	F	301	501030408	2000	1	1	6/2/03
680	F	296.5	501030408	2000	1	1	7/14/03
720	F	291	501030408	2000	1	1	7/6/03
750	F	298	501030408	2000	1	1	7/8/03
760	F	297	501030409	2000	1	1	7/8/03
690	F	296.5	501030409	2000	1	1	8/7/03
730	F	299	501030409	2000	1	1	7/8/03
560	M	297	501030705	2001	1	1	7/20/03
470	M	293	501030705	2001	1	1	7/24/03
550	M	296.5	501030705	2001	1	1	8/1/03
540	M	299	501030705	2001	1	1	6/5/03
550	M	299	501030705	2001	1	1	6/29/03
540	M	294	501030705	2001	1	1	7/3/03
450	M	298	501030802	2001	1	1	7/14/03
420	M	299	501030802	2001	1	1	6/29/03
420	M	296.5	501030803	2001	1	1	6/14/03
580	M	288	501030806	2001	1	1	7/24/03
520	M	289	501030903	2001	1	1	7/6/03
780	M	296.5	Unreadable		1	1	6/17/03
750	F	300	Unreadable		1	1	6/23/03
730	F	300	Unreadable		1	1	7/2/03
720	F	300	Unreadable		1	1	7/11/03
810	F	301	Unreadable		1	1	7/26/03
730	F	301	Unreadable		1	1	7/17/03
700	F	291	Unreadable		1	1	7/21/03
710	F	300	Unreadable		1	1	8/4/03
760	F	300	Unreadable		1	1	8/7/03
710.6	F	299	no tag found		2	0	5/12/03

Appendix Table 3. continued

Fork length+	Sex	River Mile	CWT Code	Brood Year	Adipose Fin Original*	Adipose Fin Final^	Date
700.6	F	296.5	no tag found		3	0	5/27/03
860.6	F	300	no tag found		2	0	6/2/03
800.6	M	288	no tag found		2	0	6/3/03
710.6	F	294	no tag found		3	0	6/3/03
830.6	F	295	no tag found		2	0	6/5/03
770.6	F	296.5	no tag found		2	0	6/5/03
620	F	296.5	no tag found		1	1	6/11/03
700	F	297	no tag found		1	1	6/11/03
750	F	300	no tag found		1	1	6/20/03
670	F	296.5	no tag found		1	1	6/23/03
700.6	F	297	no tag found		2	0	6/26/03
700.6	F	299	no tag found		2	0	6/26/03
680.6	F	296	no tag found		2	0	7/2/03
740.6	F	293	no tag found		2	0	7/3/03
860	M	296.5	no tag found		1	1	7/5/03
690.6	F	296.5	no tag found		2	0	7/5/03
780.6	F	299	no tag found		2	0	7/5/03
680	F	296.5	no tag found		1	1	7/14/03
760	F	296.5	no tag found		1	1	7/14/03
720	F	301	no tag found		1	1	7/14/03
660.6	F	294	no tag found		2	0	7/15/03
710	F	291	no tag found		1	1	7/21/03
770	F	296	no tag found		1	1	7/23/03
750.6	F	299	no tag found		2	0	7/23/03
790.6	F	298	no tag found		2	0	7/8/03
710	F	296.5	no tag found		1	1	7/11/03
740.6	F	298	no tag found		2	0	7/11/03
870	M	299	no tag found		1	1	7/11/03
700.6	F	291	no tag found		2	0	7/24/03
700	F	299	no tag found		1	1	7/26/03
500.6	M	288	no tag found		2	0	7/27/03
710	F	299	no tag found		1	1	8/1/03
700	F	296	no tag found		1	1	8/7/03
780.6	F	291	no tag found		2	0	8/8/03
710	F	296.5	no tag found		1	1	5/24/03
780	F	296	no tag found		1	1	5/30/03
670	F	296.5	no tag found		1	1	6/17/03
790	F	296.5	no tag found		1	1	6/17/03
730	F	296.5	no tag found		1	1	6/17/03
880	F	296.5	no tag found		1	1	6/17/03
670.6	F	294	no tag found		2	0	6/18/03
680.6	F	296.5	no tag found		2	0	6/20/03
760	F	299	no tag found		1	1	6/20/03
750	F	298	no tag found		1	1	6/23/03
720.6	F	294	no tag found		2	0	6/24/03
730	F	295	no tag found		1	1	6/26/03

Appendix Table 3. continued

Fork length+	Sex	River Mile	CWT Code	Brood Year	Adipose Fin Original*	Adipose Fin Final^	Date
770	F	297	no tag found		1	1	6/29/03
760	F	301	no tag found		1	1	6/29/03
530	M	295	no tag found		1	1	7/2/03
670	F	297	no tag found		1	1	7/20/03
680	F	298	no tag found		1	1	7/20/03
700	F	291	no tag found		1	1	7/21/03
680	F	298	no tag found		1	1	7/23/03
690	F	289	no tag found		1	1	7/24/03
530	M	289	no tag found		1	1	7/24/03
710	F	297	no tag found		1	1	7/26/03
760.6	F	296.5	no tag found		2	0	7/17/03
690	F	301	no tag found		1	1	7/5/03
570	F	296	no tag found		1	1	7/8/03
720	F	300	no tag found		1	1	7/8/03
730.6	F	294	no tag found		2	0	7/12/03
690	F	294	no tag found		1	1	7/12/03
510	M	294	no tag found		1	1	7/12/03
810	F	297	no tag found		1	1	7/26/03
750.6	F	298	no tag found		3	0	7/26/03
700.6	F	299	no tag found		3	0	7/26/03
740	F	291	no tag found		1	1	7/27/03
740.6	F	295	no tag found		3	0	8/1/03
750.6	F	295	no tag found		2	0	8/1/03
750.6	F	291	no tag found		2	0	8/5/03
680	F	296	no tag found		1	1	8/13/03
710.6	F	298	no tag found		2	0	8/4/03
810.6	F	294	no tag found		2	0	8/5/03
810.6	F	298	no tag found		2	0	8/10/03
710	F	296.5	no tag found		1	1	8/13/03

+ Fork lengths with decimals indicate that the status of the original "call" by field crews was changed upon subsequent database analysis.

* Adipose Fin Original refers to the original data tally made by boat crews. A one (1) is a complete adipose fin clip, a two (2) is an unknown adipose fin (missing: otter eaten, etc), a three is a partial adipose fin clip which crews were not sure of.

^ Adipose Fin Final refers to the final tally in the database for analysis purposes after coded wire tag analysis was done. A one (1) is a hatchery origin fish and a zero (0) is a natural origin fish.

Appendix Table 4. Summary of past results for the Winter-run carcass survey for the years 1996 to 2003.

Parameter	WINTER-RUN CARCASS SURVEY RESULTS							
Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002[#]**	**2003**
Survey Dates	4/29 - 9/5	4/30 - 8/29	5/5 - 8/28	5/5 - 8/27	5/3 - 8/29	5/2 - 8/29	5/1 - 8/27	4/30 - 9/4
Carcasses counted	118	239	785	475	2,482	5,145	4,959	4,549
Percent recaptured	15%	12%	15%	22%	45%	57%	59%	50%
Reported Population*^	820*	2,053*	5,501*	2,262*	6,647*	8,224^	7,441^	8,218^
Percent grilse	19.0%	8.0%	0.2%	19.5%	2.7%	9.7%	5.2%	3.3%
Percent male	16%	31%	11%	12%	20%	42%	22%	16%
Spawning % success	94%	96%	95%	97%	100%	99%	99%	100%
Percent carcasses in Reach 1[&]	50%	48%	58%	73%	80%	72%	87%	88%
Flow range (cfs x 1000)	7.2 - 16.2	8 - 15	10 - 23.5	9.3 - 13.7	8.4 - 15.7	8.5 - 15.2	7.8 - 15	8.1 - 29.8
Water temp (^{o}F) range	52 - 59	49 - 52	50 - 54	50 - 54	51 - 54	50 - 55	50 - 56	50 - 54
Visibility range (ft)	n/a	3 - 10	4.5 - 11	6 - 11	9 - 20	14 - 20	17 - 22	8 - >15

2002 Data is preliminary

* Peterson Model

^ Jolly Seber Model

[&] Reach 1 is from Keswick Dam to the Cypress Street Bridge in Redding.

Appendix Table 5. Aerial Redd summary for new winter-run redds counted for years surveyed from 1981 through 2003.

	YEAR																			
River Section	**03**	**02**	**01**	**00**	**99**	**98**	**97**	**96**	**95**	**94**	**93**	**92**	**91**	**90**	**89**	**88**	**87**	**85**	**82**	**81**
Keswick to A.C.I.D. Dam.	66%	49%	35%	6%	0%	3%	0%	3%	7%	0%	5%	2%	0%	0%	6%	1%	0%	6%	0%	2%
A.C.I.D. Dam to Highway 44 Bridge	17%	22%	15%	27%	31%	77%	83%	71%	83%	29%	61%	20%	70%	35%	30%	23%	15%	13%	58%	0%
Highway 44 Br. to Airport Rd. Br.	16%	28%	45%	47%	65%	16%	17%	26%	9%	24%	25%	49%	20%	51%	47%	30%	17%	29%	36%	86%
Airport Rd. Br. to Balls Ferry Br.	0%	1%	4%	5%	1%	1%	0%	0%	0%	41%	2%	15%	10%	6%	2%	7%	18%	14%	3%	0%
Balls Ferry Br. to Battle Creek.	0%	0%	0%	6%	2%	1%	0%	0%	0%	6%	0%	5%	0%	1%	0%	2%	9%	0%	0%	0%
Battle Creek to Jellys Ferry Br.	0%	0%	0%	2%	0%	0%	0%	0%	1%	0%	2%	0%	0%	1%	0%	2%	21%	1%	0%	0%
Jellys Ferry Br. to Bend Bridge	0%	0%	1%	8%	0%	0%	0%	0%	0%	0%	2%	5%	0%	0%	13%	9%	14%	4%	0%	0%
Bend Bridge to RBDD	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	6%	0%	0%
RBDD to Tehama Br.	0%	0%	0%	0%	0%	2%	0%	0%	1%	0%	2%	4%	0%	5%	0%	16%	4%	28%	3%	12%
Tehama Br. To Woodson Bridge	0%	0%	0%	0%	0%	0%	n/s	n/s	0%	0%	0%	0%	0%	2%	2%	9%	0%	0%	n/s	0%
Woodson Bridge to Hamilton City Br.	0%	0%	0%	0%	0%	0%	n/s	n/s	n/s	n/s	n/s	n/s	0%	n/s	0%	0%	n/s	0%	n/s	n/s
Hamilton City Bridge to Ord Ferry Br.	0%	0%	0%	0%	0%	0%	n/s	n/s	n/s	n/s	n/s	n/s	0%	n/s	0%	n/s	n/s	n/s	n/s	n/s
Ord Ferry Br. To Princeton Ferry.	0%	0%	0%	0%	0%	0%	n/s	n/s	n/s	n/s	n/s	n/s	0%	n/s	n/s	n/s	n/s	n/s	n/s	n/s
Total New Redds Counted	**878**	**610**	**1,396**	**588**	**1,144**	**121**	**30**	**70**	**175**	**17**	**44**	**55**	**10**	**104**	**47**	**1,295**	**313**	**103**	**33**	**90**

Note: Some years (1986, 1984, 1983) and some areas not sampled (n/s).

Appendix 6. Results and Discussion of the Peterson estimate.

The Peterson Model is (Ricker 1975, formula no 3.7)

$N = (T+1) \times (E + 1) / (R + 1)$

Where:

N = Population estimate.
T = Number of carcasses tagged.
E = Number of carcasses examined for tags.
R = Number of carcasses examined (E) which had been previously tagged (Recaptured).

For the 2003 winter-run Peterson estimate **(7,397)** the number of in-river female adults were estimated and then adjustments were made to account for other groups in the winter-run population similar to the procedure used for the Jolly Seber estimate. The Peterson estimate was calculated based on fresh carcasses only estimates to be consistent with previous years.

The in-river female adult estimate is:
N = 4,407
Where:
T = 1,898 + 1 (see Appendix Table 1-B)
E = 2,935 (number chopped (687) + number fresh recaptured (1,264) + number of non-fresh tagged that would have been chopped (986) – number chopped in first survey period (1) – number non-fresh tagged in first survey (1)) + 1
R = 1,264 + 1 (see Appendix Table 1-B)

Adjustments to the Peterson in-river female adult estimate are identical to those used for the Jolly-Seber estimate in Table 1. After adjustments for ad-clipped adult females, downstream redd adult females (4,656), male adults (2,175), female grilse (35), male grilse (446) and fish retained at LSNFH (85) **the final Peterson estimate is 7,397.**

The Peterson estimate was calculated differently in two significant ways this year. The first change was that tagged carcasses were not counted in the Examined category. During the survey, a carcass was first examined to see if it was a recaptured carcass when it was brought to the boat. If it was, it was tallied as Examined and as Recaptured, and the carcass was chopped in half. If it was not a recapture, then a decision was made to either tag it or chop it based on condition. Carcasses that were too decayed to put a tag in were chopped and tallied as Examined. For carcasses that received a tag it would essentially be double counting them to tally them both as Tagged and as Examined. Instead, they were tallied **only** as Tagged and returned to the river without chopping them. The carcasses chopped (recaptures or not) make up the Examined category. This is different from previous years in which tagged carcasses were included both as Tagged and as Examined tallies.

The second change involves the use of fresh and non-fresh carcasses to determine the Peterson estimate. In previous years the Peterson estimate was calculated using data from fresh carcasses only. Since non-fresh carcasses were also tagged it is necessary to tally these carcasses as examined. These

non-fresh tagged carcasses (n = 986) would have been chopped and tallied as examined if the survey was only tagging fresh carcasses.

Both changes are concerned with the Examined variable of the Peterson estimate. The term "examined" is an unfortunate over simplification of the variable used in the formula. Examining a carcass on the boat does not automatically place it in the Examined tally. Examined carcasses are only those that are chopped when returned to the river. In a fresh carcass "only" estimate, the non-fresh tagged carcasses must also have been assumed chopped and added to the "chopped" tally. Finally, the Examined variable must not include the chopped carcasses from the first period since these never had a chance of being tagged. For the 2003 winter-run, only 2 carcasses (1-chop, 1 non-fresh tag) were subtracted for being in the first period, since the survey began at the start of the run. For surveys that start after spawning has commenced, these first period corrections can be substantial.

I recommend using both fresh and non-fresh data to provide a Peterson estimate for long-term trend data. This would allow direct comparisons between the data used for the Jolly-Seber and the Peterson estimate. The Peterson estimate using both types of data is 6,602, as compared to the fresh only data of 7,397. In years of low carcass abundance due to depressed populations, floods, or other survey problems, the use of both fresh and non-fresh carcasses would provide a bigger sample size with which to conduct the mark-recapture study. By tagging both types of carcasses an assumption is made of equal survival probabilities. This assumption is probably true for the winter-run because crews survey the same area every third day. With such frequent surveys the likelihood of a non-fresh carcass being recaptured is similar to a fresh one.

Appendix Table 7. A summary of the Red Bluff Diversion Dam historical winter-run population data.

YEAR	TOTAL	Natural	Ad-Clip	% Natural	% Ad-Clip	Adults	Grilse	% Adults	% Grilse	Male	Female	% Male	% Female	Removal*
1967	57,306	57,306	0	100%	0%	32,321	24,985	56%	44%	n/a	n/a	n/a	n/a	n/a
1968	84,414	84,414	0	100%	0%	74,115	10,299	88%	12%	n/a	n/a	n/a	n/a	n/a
1969	117,808	117,808	0	100%	0%	108,855	8,953	92%	8%	n/a	n/a	n/a	n/a	n/a
1970	40,409	40,409	0	100%	0%	32,085	8,324	79%	21%	n/a	n/a	n/a	n/a	n/a
1971	53,089	53,089	0	100%	0%	32,225	20,864	61%	39%	n/a	n/a	n/a	n/a	n/a
1972	37,133	37,133	0	100%	0%	28,592	8,541	77%	23%	n/a	n/a	n/a	n/a	n/a
1973	24,079	24,079	0	100%	0%	19,456	4,623	81%	19%	n/a	n/a	n/a	n/a	n/a
1974	21,897	21,897	0	100%	0%	18,109	3,788	83%	17%	n/a	n/a	n/a	n/a	n/a
1975	23,430	23,430	0	100%	0%	15,932	7,498	68%	32%	n/a	n/a	n/a	n/a	n/a
1976	35,096	35,096	0	100%	0%	26,462	8,634	75%	25%	n/a	n/a	n/a	n/a	n/a
1977	17,214	17,214	0	100%	0%	15,028	2,186	87%	13%	n/a	n/a	n/a	n/a	n/a
1978	24,862	24,862	0	100%	0%	23,669	1,193	95%	5%	n/a	n/a	n/a	n/a	n/a
1979	2,364	2,364	0	100%	0%	2,251	113	95%	5%	n/a	n/a	n/a	n/a	n/a
1980	1,156	1,156	n/a	+95%	>5%	84	1,072	7%	93%	n/a	n/a	n/a	n/a	n/a
1981	22,832	22,832	n/a	+95%	>5%	18,297	1,744	91%	9%	n/a	n/a	n/a	n/a	n/a
1982	1,281	1,281	n/a	+95%	>5%	972	270	78%	22%	n/a	n/a	n/a	n/a	n/a
1983	1,831	1,831	0	100%	0%	1,439	392	79%	21%	n/a	n/a	n/a	n/a	n/a
1984	2,663	2,663	0	100%	0%	794	1,869	30%	70%	n/a	n/a	n/a	n/a	n/a
1985	5,515	5,515	n/a	+95%	>5%	3,633	329	92%	8%	n/a	n/a	n/a	n/a	n/a
1986^	2,596	2,596	0	100%	0%	2,101	496	81%	19%	1,623	974	63%	38%	0
1987	2,186	2,186	0	100%	0%	1,909	277	87%	13%	n/a	n/a	n/a	n/a	0
1988	2,886	2,886	0	100%	0%	1,878	1,008	65%	35%	962	1,924	33%	67%	0
1989	696	696	0	100%	0%	571	125	82%	18%	232	464	33%	67%	42
1990	430	430	0	100%	0%	387	43	90%	10%	168	262	39%	61%	14
1991	211	211	0	100%	0%	192	19	91%	9%	35	176	17%	83%	33
1992	1,240	1,240	0	100%	0%	1,160	80	94%	6%	531	709	43%	57%	34
1993	387	387	0	100%	0%	250	137	65%	35%	193	193	50%	50%	0
1994	186	148	38	80%	20%	62	124	33%	67%	152	34	82%	18%	42
1995	1,297	1,261	35	97%	3%	1,267	29	98%	2%	501	796	39%	61%	131
1996	1,337	1,022	315	76%	24%	708	629	53%	47%	810	527	61%	39%	325
1997	880	835	44	95%	5%	528	352	60%	40%	541	338	62%	38%	44
1998	3,002	2,948	54	98%	2%	2,079	924	69%	31%	1,419	1,583	47%	53%	99
1999	3,288	3,262	26	99%	1%	822	2,466	25%	75%	2,301	986	70%	30%	24
2000	1,352	1,206	146	89%	11%	563	789	42%	58%	789	563	58%	42%	89
2001	5,523	5,254	268	95%	5%	1,696	3,827	31%	69%	4,262	1,261	77%	23%	104
2002	9,169	7,908	1,261	86%	14%	7,614	1,555	83%	17%	4,424	4,745	48%	52%	104
2003	9,757	8,297	1,460	85%	15%	6,172	3,585	63%	37%	6,247	3,510	64%	36%	85

^ Data from 1986 to Present was revised from earlier reports based on a quality control review of historical data. Dam gates were raised during winter-run migration from 1986 to Present requiring estimation of actual numbers.

* Removal indicates the number of salmon estimated to have been removed from the river by anglers or for hatchery brood stock (Livingston Stone or Coleman National Fish Hatcheries).