State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

Sacramento River
Winter-Run Chinook Salmon Escapement Survey
April–September 2004

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

SRSSAP Technical Report No. 05-1
2005

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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 2004. The survey was conducted from 30 April through 3 September over a 27.5-mile reach. The survey area was from Keswick Dam near Redding, CA at river mile (RM)-302 downstream to the mouth of Cottonwood Creek (Shasta-Tehama Counties) at RM-273.5. This area contains the majority (100% in 2004) of traditional winter-run spawning habitat and is the uppermost migratory limit for anadromous fish in the Sacramento River.

The 2004 spawner escapement estimate of 7,786 winter-run Chinook was developed through application of a Jolly-Seber model mark-recapture study, Keswick Dam Fish Trap data, and aerial redd counts. Adult females comprised 3,218 or 41.3% of the population.

Survey conditions were fair in 2004. A visibility of at least 15 feet is necessary for maximum carcass recovery. The visibility this year ranged from 8.5 to 16 feet with an average of 12 feet throughout the survey. River flows ranged from 8,053 to 16,309 cubic feet per second (cfs) during the entire survey, (43 periods). Water temperatures within the survey area ranged from 50 to 57 degrees Fahrenheit, (10–14^{o} C) with warmer temperatures being recorded as distance from Keswick Dam increased.

Crews encountered a total of 4,396 carcasses, 1,128 of which were recaptured after being tagged and released in prior periods. There were 250 carcasses that had questionable or clipped adipose fins indicating that they were probably of hatchery origin. Coded-wire tags were recovered from 168 of these. Biological measurements (including fork length, sex, location, and spawning condition) were collected from 1,651 carcasses. Genetic tissue samples were collected from 870 carcasses.

This report details the mark-recapture study and associated data collection efforts necessary to produce the annual winter-run salmon escapement estimate. The U.S. Fish and Wildlife Service will prepare an additional report using these data to evaluate the winter-run hatchery supplementation program at Livingston Stone National Fish Hatchery and characterize the genetic composition of the population.

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 2004. The objectives of the survey included evaluation of the 2004 winter-run population characteristics and evaluation of the hatchery supplementation program conducted at Livingston Stone 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 fourth 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, data from winter-run collections at the Keswick Dam Fish Trap (Keswick Trap) have been integrated into the calculation of the winter-run population estimate to determine the gender ratio of the adult population.

Objectives

The objectives of the Department's 2004 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 273.5–RM 302) based on a carcass mark-recapture survey.

- 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.

- To determine if the Global Positioning System (GPS) data collected on individually marked carcasses could be used to reveal differences in movement patterns among carcasses of different groups and survey areas.

- To determine the rate at which carcasses released in the deep bedrock pools of the uppermost river section would be recovered.

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. The status of winter-run population trends since the construction of Shasta Dam is discussed 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, and then re-classified 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 the fish ladders 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 continue to 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.

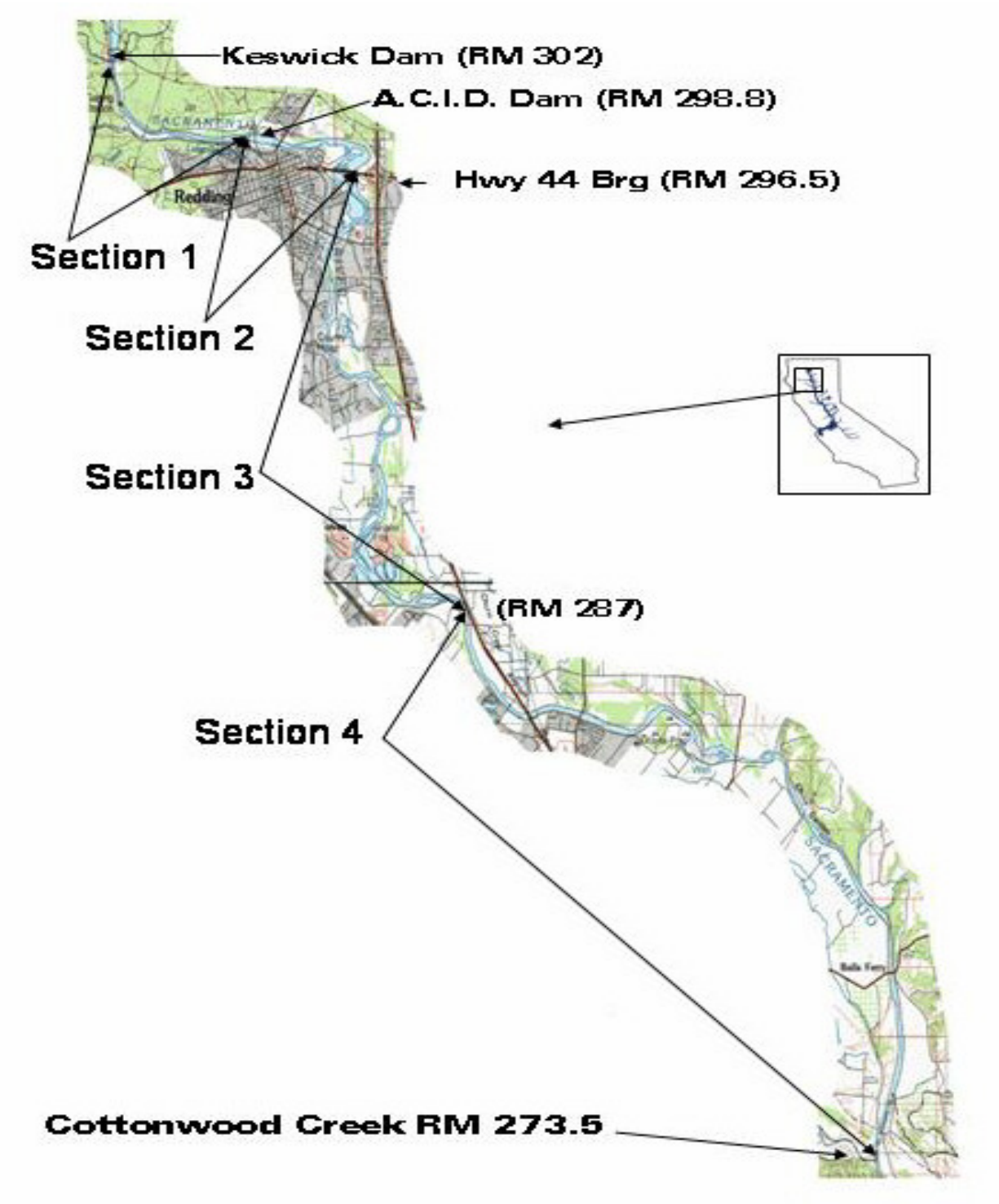

Figure 1 Map of 2004 Winter-run carcass survey area showing prominent landmarks, survey sections and river miles.

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 2004 winter-run Chinook salmon spawner escapement survey was conducted from 30 April through 3 September 2004.

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 (one from the Service and one from the Department) were used. 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. Carcasses were not accessible in some sections of the river due to hazards or deep water. In addition, crews were instructed to search all areas of the visible river bottom to avoid pre-determining search patterns based upon their prior experiences in locating carcasses.

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

1--Keswick Dam to ACID DAM - RM 302.1 to RM 298.8,
2--ACID Dam to Highway 44 Bridge - RM 298.8 to RM 296.5
3--Cypress Street Bridge to Anderson Mill Riffle - RM 296.5 to RM 286.4
4--Anderson Mill Riffle to Cottonwood Creek – RM 286.4 to 273.5

These sections differ from previous Winter-run surveys and were determined to best represent a full day for crews on each section of river, (Section 1 and 2 completed on same day). Section 4 was surveyed beginning on 10 June after several carcasses were recovered during reconnaissance of the area.

The entire survey consisted of 43 survey periods. Each period typically consisted of 3 sampling days. 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 Jolly-Seber mark-recapture design. Typically, all carcasses not in an advanced state of decay were marked (tagged). Carcasses not receiving tags were counted then cut in two (chopped). All chopped carcasses were disregarded in subsequent surveys. All carcasses upon tagging were returned to flowing water near where

they were collected in an attempt to simulate "natural" carcass dispersion. All carcasses, including adult males and grilse were sampled. The Jolly-Seber estimate was produced from adult female carcasses only. The adult male component of the population estimate was derived from a proportion using the number of adult females and the sex ratios of adults from the Keswick Trap data. Grilse numbers were estimated from the number of adults and the proportions of adults to grilse found in the sample of fresh carcasses measured in the carcass survey, (separate estimate for both male and female grilse).

Carcass Data

Carcasses were collected using 15-foot (4.6m) long wooden poles 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 (natural), or unknown.
2. Male or female.
3. Recaptured (previously tagged) or new encounter.
4. Fresh (recently died-with clear eyes) or non-fresh (decayed).
5. Spawned or not spawned (eggs present in females).
6. Fork length and genetic samples taken or not taken.
7. Location (river mile and GPS waypoint)
8. 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 recovery. The remaining headless carcasses were then chopped in half and returned to the river. Adipose fin clipped carcasses are not part of the mark-recapture portion of the survey since they are chopped upon their first encounter.

A carcass with the adipose fin present (natural fish) was processed (steps 2-8) and returned to the river either chopped in half or with a tag (i.e. mark) placed in the upper or lower jaw. Carcasses to be tagged were typically classified as fresh or 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 attached to 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.

Additionally, over half of the fresh carcasses encountered were also tagged with a 1.25" round aluminum "**disc tag**" bearing a unique number. These tags allowed data to be collected on individual carcasses movements (via GPS) and also on the length of time and number of times individual carcasses could be recovered.

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. Recaptured disc tagged carcasses were immediately returned to the river after the disc number and GPS location were noted. Recaptured carcasses **without** disc tags were chopped and returned to the river. In subsequent analysis of disc tagged recaptured fish only the first incidence of an individual carcass's recapture was used in the calculation of a population estimate. Further incidences of recaptures of disc tagged carcasses were used to analyze carcass "survival" and the distance traveled in the survey.

Most fresh (and some non-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. Sub-sampling for tissues 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.

For each carcass that was measured the river mile and GPS location was recorded. This allows analysis of carcass distribution to determine if differences exist between male and female distribution.

A number of carcasses were tagged with orange disc tags. These disc tags were used to determine if fish spawning in the gorge area just downstream from Keswick Dam were recoverable to the carcass crews searching for them. The river in this area (RM 301) is very deep and is characterized by large bed-rock formations with many likely areas for carcasses to be trapped and permanently unavailable for collection. The number of fish spawning in this area is uncertain and a sub-study was implemented to check if known carcasses released in this area could be recovered. Samples of recovered carcasses in reasonably fresh condition and with no regular disc tags were tagged with orange disc tags. These fish were hauled to Keswick dam in the survey boats and released immediately downstream of the dam with subsequent recaptures noted.

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 http://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/reappeared 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 adipose fin clipped (hatchery) adult females removed for tag 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 adult 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 2004 final winter-run spawner population estimate.

Table 1. Adjustments made to Jolly-Seber model results to determine final winter-run 2004 spawner estimate.

CATEGORY CALCULATION	RESULTS	FACTOR	ADJUSTMENT DESCRIPTION
Jolly-Seber Model Calculation for Adult Females	2,993	2993	This number comes from Jolly-Seber formulas
Adult Female Ad-Clipped Fish Adjustment	3,218	1.075	1058 adult females were seen / 984 were not ad-clipped
Total Adult Females: Downstream Redds Factor	3,218	1.0000	621 redds were seen / 621 were in the survey area
Total Adult Males Adjustment Factor	3,020	0.9385	At Keswick Dam there were 61 males / 65 female adults
Total Grilse Female Adjustment Factor	40	0.0123	In the survey, 13 grilse female / 1058 adult "fresh" females
Total Grilse Male Adjustment Factor	1,424	0.4717	In the survey, 150 grilse male / 318 adult "fresh" males
Fish Removed from Population by LSNFH	85	85	Number of Salmon taken into LSNFH Hatchery
Final Estimate is	**7,786**		

The 2004 estimate of winter-run salmon spawning in the Upper Sacramento River and collected for brood stock for LSNFH was **7,786**. For fish spawning in the river (not including LSFNH), the Jolly-Seber Model produced an estimate of 2,993 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 adipose fin clipped fish (hatchery), and fish downstream of the survey area. The final in-river adult female estimate was 3,218. Adult males numbered 3,020, while grilse females and grilse males numbered 40 and 1,724 respectively. Personnel from LSNFH retained 85 winter-run for hatchery brood stock.

Carcass Survey Results

Crews handled a total of 4,396 carcasses from 30 April through 3 September 2004. When recaptured fish are not included, a total of 3,268 individual carcasses were handled. Of these, 250 were potentially adipose fin clipped (hatchery) fish, 2,062 were tagged and 956 were chopped. Another 1,128 carcasses were repeat observations (recaptures-single incident). The overall recapture rate of tagged fish was 54.7%. Table 2 presents a summary of the number of carcasses observed for each data category.

Table 2. Summary of carcasses observed during 2004 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	459	167	967	293	6	49	11	110	**2,062**
Chopped	523	260	20	49	7	77	0	20	**956**
Hatchery	63	16	82	18	3	27	1	40	**250**
Recaptured	260	86	568	171	1	13	5	24	**1,128**
TOTAL	**1,305**	**529**	**1,637**	**531**	**17**	**166**	**17**	**194**	**4,396**

Survey Conditions

Water clarity was fair (not as good as previous 2 years) with only 6.9% of the periods reporting 15 or more feet of visibility, (76 percent of the 2003 survey periods reported 15 or more feet of visibility). Visibility averaged 12.2 feet, (range: 8.5 to 16) with 5.6 % of the readings beneath 10 feet. Mean river flows from Keswick dam averaged 12,258 cfs (range: 8,001 to 16,309). Mean water temperature for the survey periods averaged 53.3 ^{o}F (range: 50 ^{o}F to 57 ^{o}F). Appendix Table 2 presents a summary of environmental data encountered over the survey.

Biological Carcass Data

Biological data was collected from a total of 1,651 carcasses during the survey (50.5% of the 3,268 encountered). Most biological data, (includes: origin, sex, length, spawn condition, freshness, and location) was obtained from fresh carcasses (n = 1,539). Non-fresh carcasses (n = 112) were typically sampled during the "slow" workload periods when carcass numbers were low or when a non-fresh carcass with an adipose fin clip was encountered (n = 109). It is important to note that sub-sampling of some biological data, but not adipose fin clip data, occurred during periods with high numbers of carcasses, thus comparisons between clipped (hatchery) carcass numbers and non-clipped (natural) carcass data must be done with care.

Adipose Fin Clipped (Hatchery) Carcasses

On all carcasses encountered without a full and natural looking adipose fin, the head was removed and retained for coded-wire tag (CWT) analysis. Crews encountered 250 carcasses that were suspected to 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. There were 168 CWT's recovered from the 250 heads. Four of these were unreadable; the other 164 were successfully decoded. Of the eighty-two other heads, 1 head was lost overboard, and the remaining 81 heads had no CWT detected. Appendix Table 3 provides a summary of the CWT data collected from the survey.

Crews collected heads from 23 carcasses (4 partial and 19 unknown: e.g. otter eaten) that they were unsure of the adipose fin status. Carcasses that were tallied as unknown were re-tallied in the final database (n = 19) 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. Four carcasses were re-labeled as hatchery (2 partial and 2 unknowns), (Appendix Table 3).

The detection of CWT's was lower (64%) for non-fresh adipose fin clipped carcasses (70 of 109) compared to the 70% detection rate of fresh adipose fin clipped carcasses collected (98 of 141).

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 determine the biological characteristics of the winter-run population, (the data on both fresh and non-fresh carcasses is used to estimate the overall population size). Crews sampled 1,539 fresh carcasses for biological characteristics. The sex composition of these was 69.6% female (n = 1,071) vs. 30.4% male (n = 468). Table 3 provides a summary of sex composition of the carcass survey's winter-run population for various categories.

The data from Table 3 shows that adult males represent only 30.4% of the survey's sample of fresh carcasses. Previous winter-run surveys (1996-2003) 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. 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.

The first indication is that in the 2004 (and prior) survey crews frequently observed adult male salmon 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 encountered (n = 468) was at RM 293.4 whereas the fresh

adult female carcasses (n = 1,071) were found on average at RM 296.0; a difference of 2.6 miles further downstream for the male carcasses. A third indication that adult males were leaving the survey area is that the recapture rate of fresh adult female (58.7%) and fresh adult male (58.4%) carcasses were similar, (Table 2: recaptured/tagged) 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.

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

Category	TOTAL	FEMALE %	Count	MALE %	Count
Total carcasses (fresh + non-fresh)	1651	**69.0%**	1140	**31.0%**	511
Fresh carcasses	1539	**69.6%**	1071	**30.4%**	468
Natural (unmarked) fresh carcasses	1408	**70.7%**	996	**29.3%**	412
Hatchery (marked) fresh carcasses	131	**57.3%**	75	**42.7%**	56
Adult fresh carcasses	1376	**76.9%**	1058	**23.1%**	318
Natural Adult fresh carcasses	1284	**76.6%**	984	**23.4%**	300
Hatchery Adult fresh carcasses	92	**80.4%**	74	**19.6%**	18
All Grilse fresh carcasses	163	**8.0%**	13	**92.0%**	150
Grilse Natural fresh carcasses	124	**9.7%**	12	**90.3%**	112
Grilse Hatchery fresh carcasses	39	**2.6%**	1	**97.4%**	38

The Department's internal Winter-run Technical Team discusses technical issues regarding winter-run salmon. In 2003 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 in 2003 to the use of the data from the Keswick Trap to determine the sex ratio in the population. This method was again utilized in 2004. Table 4 presents data from winter-run salmon sampled at the Keswick Trap in 2004.

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

Category	Total	FEMALE %	Count	MALE %	Count
All Salmon	346	**21.1%**	73	**78.9%**	273
Natural (unmarked)	122	**30.3%**	37	**69.7%**	85
Hatchery (marked ad-clip)	224	**16.1%**	36	**83.9%**	188
All Adults (>609mm)	126	**51.6%**	65	**48.4%**	61
Adult Natural	66	**54.5%**	36	**45.5%**	30
Adult hatchery	60	**48.3%**	29	**51.7%**	31
All Grilse (<610mm)	220	**3.6%**	8	**96.4%**	212
Grilse Natural	56	**1.8%**	1	**98.2%**	55
Grilse Hatchery	164	**4.3%**	7	**95.7%**	157

Eighty-five of the winter-run trapped at Keswick (n = 346) were retained by the USFWS personnel for brood stock purposes at LSNFH. Of these, 73 were spawned successfully. The other 261 winter-run were floy-tagged and released into the Sacramento River. Eight of these floy-tagged winter-run were recovered during the survey.

The ability to phenotypically determine the correct sex of winter-run salmon is dependent upon the sexual maturation of the fish and the experience of the biologist. The data from the carcass survey's recapture of floy-tagged released Keswick fish showed that some fish were "called" males when in fact they were actually females (2 of 8 recovered). This highlights the difficulty in sexing early arriving (non-ripe) fish. In 2004 the biologist at LSNFH rated the phenotypic gender data as either confident or non-confident for each fish handled, (John Reuth, USFWS personal comm.). This was an attempt to document the problem of early arriving fish being difficult to sex. Of the 8 recovered floy tagged fish 7 had confident calls and 1 was non-confident. The non-confident call was incorrect and one of the confident calls was incorrect. In addition, six of the "non-confident" labeled males that were held at LSNFH for spawning were determined to be females at the time of spawning. In future years the ability to sex fish through genetic sex markers will be explored. In comparison to the carcass survey however, the Keswick Dam data (in spite of the gender-related difficulties) appears to better reflect the overall sex ratio of the adult winter-run population.

Because of the apparent tendency of adult males to leave the system before death the Keswick trap data on fresh adult fish was used to estimate the number of adult males in the 2004 winter-run population. Adult males (n = 3,020) were calculated to represent 38.8% of the winter-run in the overall population in Table 1.

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 1,539 fresh carcasses. Overall age compositions of these were **89.4% Adult** (3-4 year old: n = 1,376) vs. **10.6% Grilse** (2 year old: n = 163). 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 (Killam, 2004) 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.

Grilse sex composition was different from that of adults. The overall fresh grilse (< 610 mm) sex composition was 92% male (n = 150) vs. 8% female (n = 13) (Table 3). The survey's fresh carcass data was used to generate a population number 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 1,071 fresh female carcasses examined (Table 3) only 11 (1 %) 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 2004 Late-fall-run survey. There is some temporal overlap with the late-fall run Chinook salmon but typically by mid-April there are very few fresh late-fall carcasses encountered. In 2004 we encountered only seven fresh carcasses in two complete late-fall survey periods in mid-to-late April. The scarcity of fresh carcasses from mid-April to mid-May indicates that there is a good (but not complete) temporal separation between the winter and late-fall runs. All fresh carcasses were tissue sampled in April and the results of genetic testing for these suspected late-fall fish are available in the USFWS's Upper Sacramento River Winter Chinook Salmon Carcass Survey 2004 Annual Report.

Table 5 presents the percentages for female and male adults, grilse, and adipose fin clipped carcasses encountered by period during the survey. Collection of carcasses peaked during survey period 26 or 13-15 July. The temporal distribution by month for all carcasses was as follows: late April-May-3.3%, June-22.2%, July-64.9%, August and early September-9.5 %. 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 sampled carcasses (n = 1,651, Table 3) is presented by river mile in Table 6. River mile 296 contained 34% of the carcasses sampled 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. 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 or plane from late April until August. Aerial redd flights are used to provide an index of spawning distribution rather than a complete count.

Table 5. The temporal distribution of various winter-run carcass categories from the 2004 carcass survey by tagging period.

Period	Female Adults	Male Adults	Grilse	Ad-Clips	ALL % By Period	ALL % Cumulative	Dates
1	0.4%	0.5%	0.0%	0.4%	0.4%	0.4%	Apr 30 - 5/1
2	0.2%	1.2%	0.0%	0.0%	0.4%	0.8%	May 3 - 4
3	0.1%	0.0%	0.0%	0.0%	0.1%	0.8%	May 6 - 7
4	0.2%	0.8%	0.0%	0.0%	0.3%	1.1%	May 9 - 10
5	0.1%	0.4%	0.0%	0.4%	0.2%	1.3%	May 12 - 13
6	0.1%	0.4%	0.0%	0.0%	0.1%	1.4%	May 15 - 16
7	0.1%	0.5%	0.0%	0.0%	0.2%	1.6%	May 18 - 19
8	0.2%	0.7%	0.0%	0.4%	0.3%	1.9%	May 21 - 22
9	0.3%	0.5%	0.0%	0.4%	0.3%	2.2%	May 24 - 25
10	0.3%	1.4%	0.0%	0.0%	0.5%	2.7%	May 27 - 28
11	0.5%	1.3%	0.7%	0.0%	0.6%	3.3%	May 30 - 31
12	0.9%	2.2%	0.0%	0.4%	1.1%	4.4%	Jun 2 - 3
13	0.6%	0.8%	0.0%	0.8%	0.6%	5.0%	Jun 5 - 6
14	0.5%	1.4%	0.0%	0.0%	0.6%	5.7%	Jun 8 - 9
15	1.2%	2.0%	1.1%	0.4%	1.3%	7.0%	Jun 11 - 12
16	0.9%	2.0%	1.8%	0.4%	1.2%	8.2%	Jun 14 - 15
17	1.9%	3.3%	1.1%	2.0%	2.1%	10.3%	Jun 16 - 18
18	1.8%	3.6%	2.1%	0.8%	2.2%	12.5%	Jun 19 - 21
19	3.3%	5.1%	2.9%	2.0%	3.5%	16.0%	Jun 22 - 24
20	3.6%	4.9%	2.1%	4.8%	3.9%	19.9%	Jun 25 - 27
21	5.1%	7.2%	7.1%	4.0%	5.7%	25.6%	Jun 28 - 30
22	4.4%	5.9%	6.4%	7.2%	5.1%	30.7%	July 1 - 3
23	6.3%	7.4%	8.2%	6.0%	6.7%	37.4%	July 4 - 6
24	7.4%	7.4%	5.7%	7.2%	7.2%	44.6%	July 7 - 9
25	8.0%	7.4%	9.6%	9.2%	8.1%	52.7%	July 10 - 12
26	10.0%	7.8%	13.2%	12.0%	9.9%	62.6%	July 13 - 15
27	7.8%	6.1%	6.8%	9.2%	7.4%	70.0%	July 16 - 18
28	7.1%	3.9%	8.2%	9.6%	6.6%	76.7%	July 19 - 21
29	6.5%	3.0%	5.0%	6.4%	5.5%	82.2%	July 22 - 24
30	4.8%	3.1%	6.4%	3.6%	4.4%	86.7%	July 25 - 27
31	4.3%	2.0%	3.9%	5.2%	3.8%	90.5%	July 28 - 30
32	3.1%	2.3%	3.2%	4.8%	3.1%	93.5%	July 31 - 8/2
33	2.1%	1.2%	1.4%	0.4%	1.7%	95.3%	Aug 3 - 5
34	1.8%	0.8%	1.1%	2.0%	1.5%	96.8%	Aug 6 - 8
35	1.1%	0.7%	0.7%	0.0%	0.9%	97.6%	Aug 9 - 11
36	1.5%	0.4%	0.4%	0.0%	1.0%	98.7%	Aug 12 - 14
37	0.9%	0.5%	0.4%	0.0%	0.7%	99.4%	Aug 15 - 17
38	0.4%	0.1%	0.0%	0.0%	0.2%	99.6%	Aug 18 - 20
39	0.3%	0.0%	0.4%	0.0%	0.2%	99.8%	Aug 21 - 23
40	0.1%	0.0%	0.0%	0.0%	0.1%	99.9%	Aug 24 - 26
41	0.2%	0.0%	0.0%	0.0%	0.1%	100.0%	Aug 27 - 29
42	0.1%	0.0%	0.0%	0.0%	0.0%	100.0%	Aug 30 - 31
43	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	Sep 2 - 3
TOTALS	**1,969**	**769**	**280**	**250**	**3,268**		

Table 6. The spatial distribution of sampled winter-run carcasses from the 2004 carcass survey by river mile and survey section.

River Mile	Female Adults	Male Adults	Grilse	Ad-Clips	All Carcasses	Section
276	0.0%	1.0%	0.8%	0.0%	0.2%	4
277	0.0%	0.0%	0.0%	0.0%	0.0%	4
278	0.0%	0.3%	0.0%	1.2%	0.2%	4
279	0.1%	0.0%	1.6%	0.8%	0.3%	4
280	0.1%	1.0%	0.0%	0.8%	0.4%	4
281	0.1%	0.0%	1.6%	0.8%	0.3%	4
282	0.0%	0.7%	1.6%	1.2%	0.4%	4
283	0.0%	1.7%	1.6%	0.8%	0.5%	4
284	0.0%	0.0%	1.6%	0.0%	0.1%	4
285	0.0%	0.7%	0.0%	0.0%	0.1%	4
286	0.2%	2.0%	2.5%	1.6%	0.9%	4
287	1.3%	4.7%	7.4%	3.6%	2.7%	4 -- 3
288	2.7%	9.3%	8.2%	3.6%	4.4%	3
289	0.7%	3.7%	6.6%	0.8%	1.7%	3
290	0.4%	0.3%	0.8%	0.8%	0.5%	3
291	0.7%	3.3%	3.3%	2.4%	1.6%	3
292	0.3%	3.7%	0.8%	2.0%	1.2%	3
293	1.1%	1.0%	0.8%	0.8%	1.0%	3
294	8.4%	10.3%	9.0%	6.4%	8.5%	3
295	13.7%	8.7%	13.9%	10.4%	12.3%	3
296	38.6%	26.7%	19.7%	32.0%	34.0%	3 -- 2
297	14.3%	8.3%	4.9%	12.0%	12.2%	2
298	4.5%	6.0%	4.9%	6.4%	5.1%	2 -- 1
299	5.9%	3.7%	5.7%	5.2%	5.4%	1
300	4.3%	2.0%	1.6%	4.0%	3.6%	1
301	2.6%	1.0%	0.8%	2.4%	2.1%	1
TOTALS	**979**	**300**	**122**	**250**	**1,651**	
Section	**Female Adults**	**Male Adults**	**Grilse**	**Ad-Clips**	**All Carcasses**	**Section**
1	148 15.1%	27 9.0%	14 11.5%	39 15.6%	228 13.8%	**1**
2	494 **50.5%**	107 35.7%	29 23.8%	105 **42.0%**	735 44.5%	**2**
3	332 33.9%	144 **48.0%**	65 **53.3%**	87 34.8%	628 38.0%	**3**
4	5 0.5%	22 7.3%	14 11.5%	19 7.6%	60 3.6%	**4**

* Adult and grilse categories do not include any ad-clip carcasses.

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 2004. Over 83 percent of the total winter-run redds counted were located between the city of Anderson (RM-284) and the A.C.I.D. Dam in Redding (RM 298). The spawning distribution of winter-run can vary widely from year-to-year. In 2003 over 65% of the new redds were above A.C.I.D. Dam, (Killam, 2004). The reasons for the redd distribution shifts from year-to-year are unknown. Appendix Table 5 provides a summary of historical winter-run spawner distributions from 1982 through the present for all years surveyed.

Table 7. Summary of twelve aerial redd flights for the 2004 winter-run spawners.

New Redds	% Distribution	LOCATION	RIVER MILE
102	16.4%	Keswick Dam to A.C.I.D. Dam	RM 302-298
215	34.6%	A.C.I.D. Dam to Highway 44 Bridge	RM 298-296
302	48.6%	Highway 44 Bridge to Airport Rd. Bridge	RM 296-284
2	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
0	0.0%	Red Bluff Diversion Dam to Tehama Bridge	RM 242-229
0	0.0%	Tehama Bridge To Woodson Bridge	RM 229-218
621	**100%**	**TOTALS**	

Disc Tagging Data

During the survey crews placed individually numbered disc tags on 764 fresh carcasses. Crews subsequently recovered 404 (52.9%) of these at least once. Since these disc-tagged carcasses were not chopped upon recapture many of these, (n = 237), were recaptured multiple times during subsequent survey periods. A summary of the disc tag results is presented in Table 8. In order to avoid conflicts with the mark-recapture methodology used by the Jolly-Seber formulas the recaptured disc-tagged carcasses were only counted once (on the first incidence of recapture) as part of the mark-recapture study. Subsequent multiple recaptures (in later periods) of disc-tagged carcasses were tallied in a separate table. This allowed analysis of both the population estimate and the survival characteristics of winter-run carcasses.

Survival of carcasses (from period to period) in a mark-recapture study is the length of time a carcass is available for crews to encounter them. Factors affecting carcass survival include river flow, depth, and visibility, (e.g. a carcass that is too deep to see has not survived). The decay of carcasses also directly influences the survival from one period to the next. The survival range of disc-tagged recaptured carcasses in 2004 was from 2 to 44 days. The 764 disc-tagged carcasses were recaptured an average of one time. Of the 404 carcasses that were recaptured the average number of times recaptured was 2.2, and 5 carcasses were recaptured a total of 7 times. The average time between the initial tagging date and the first recapture date was 5.9 days or 2 survey periods, (range of 2 to 33 days). The average time between the initial tagging date and the last recapture date was 11.8 days or 4 survey periods, (range of 2 to 44 days).

The use of GPS data for the first time on the winter-run carcass survey allows the calculation of distances traveled and spatial distribution in a great degree of detail. Table 8 provides some information on distance traveled for the disc-tagged carcasses. The GPS methodology that was used for calculating distances is explained in Appendix 6. Table 8 provides some interesting information with regards to distance traveled comparisons for between adult males and adult females. The average first encounter distance traveled for adult females was 1,069 meters while the same distance for recaptured adult male carcasses was 2,203 meters.

Table 8. Summary of disc tagged winter-run carcasses showing recapture information including counts, days and distances traveled for a variety of categories.

# Times Recapured in later survey periods	# of ALL Individual Carcasses	# Female Adults	% Female Adults	# Male Adults	% Male Adults	# Girlse	% of Grilse
0	360	226	44.0%	88	46.8%	46	74.2%
1	167	119	23.2%	35	18.6%	13	21.0%
2	115	84	16.3%	28	14.9%	3	4.8%
3	58	40	7.8%	18	9.6%	0	0.0%
4	33	22	4.3%	11	5.9%	0	0.0%
5	19	15	2.9%	4	2.1%	0	0.0%
6	7	5	1.0%	2	1.1%	0	0.0%
7	5	3	0.6%	2	1.1%	0	0.0%
TOTALS	**764**	**514**		**188**		**62**	
The 404 Recaptures	**404**	**288**		**100**		**16**	
Avg. 1st Distance *	1,363	1,069		2,203		1,410	
Avg. Maximum Distance	2,098	1,768		3,141		1,424	
Avg. Days to 1st Recap	5.9	5.5		7.2		4.0	
Avg. Days to last Recap	11.8	11.4		13.9		5.5	
* all distances in meters and are from original tagging GPS points to recapture GPS points.							

The reason for this difference is unclear since the overall recapture rate for both groups are nearly equal (58.4% fresh male adult to 58.7% fresh female adult-Table 2). The equal recapture rates indicate that male and female carcasses behave similarly with regards to mixing and survival, but the GPS distance data demonstrates that male adults traveled much further (twice as far) on average as the adult females. The male carcasses had a longer time period between tag and recapture (7.2 days) than the females (5.5 days) and this explains some of the difference but still the males traveled an average of 269 meters per day and the females 194 meters per day. Another possible explanation is that the males are found predominantly in section 3, (Table 6), while the females are primarily in section 2. The river morphology of the survey sections has not been analyzed to determine if this is playing a part in the distances traveled by carcasses but as more GPS data is collected in future years this could be incorporated into the survey. There are many possibilities for this data to be utilized for the benefit and understanding of the survey and future use of the GPS data is planned. One example of how GPS data was used to better understand the winter-run survey was a sub-study conducted on the river reach near Keswick Dam.

Upper River Gorge Study

The river immediately below Keswick Dam is characterized by a deep scoured bedrock gorge that extends downstream for about 1 mile before broadening out to include visible gravel beds and spawning locations. Crews are unable to see the bottom in most of the upper mile and are limited to checking the shorelines for carcasses in this area. In 2004 a study using orange disc tags was implemented to determine if this gorge area could be a “carcass trap” that prevented crews from encountering carcasses that had spawned there. Since crews are unable to see into the depths of this area it was theorized that salmon may be utilizing unknown spawning beds in

deep water and their carcasses subsequently trapped in deep bedrock sinks. If this was the case then the carcass survey would be underestimating the overall population. To test this theory a sub-sample of 111 carcasses were tagged with orange disc tags (to distinguish them from the normal blue disc tags). To avoid compromising the overall study only fresh carcasses that were destined to be chopped after recapture were used. The 111 carcasses were recaptures of non-disc-tagged fresh carcasses from the period immediately before. Each of the carcasses was tagged with an individually numbered orange disc tag and released in a deep pool near Keswick Dam. The carcasses were released over a 1 month period from 3 July through 2 August. Crews were instructed to release as many of these carcasses as they could during this period. The relatively low number of non disc-tagged fresh recaptures in 2004 prevented a greater sample size. Crews were then instructed to collect data (tag number and GPS location) on any of the orange disc tag carcasses they encountered downriver in subsequent periods of the main population survey.

Crews recovered 18 of the orange disc-tagged carcasses downstream providing a recapture rate of 16.2% for carcasses released at Keswick Dam. Eight of the 18 carcasses were recaptured multiple times further downstream. The overall recapture rate for the gorge study was about one-third of that for the main population study (54.7% - Table 2). Although the gorge study resulted in a lower recapture rate than the main population study, enough carcasses did pass through the gorge to demonstrate that it is not a complete carcass trap and therefore should not be treated differently than other areas of the river during the survey. Other areas of the river are similar in conditions (but not as long) and probably result in similar lower recapture rates for carcasses drifting into them. The main population study recapture rate is the average of all parts of the river and no other studies have been undertaken to study the recapture rate variance among river sections stratified for river geomorphology (pools, riffles, etc).

Other Winter-Run Population Estimates

The Jolly-Seber model was used to calculate the Department's "official" estimate of 7,786 for the 2004 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 calculation of the Peterson Model 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. The Peterson estimate was 6,154 based on all female adults with adjustments similar to the Jolly Seber estimate methods. The Peterson method in the past was based only on fresh female carcasses (Peterson = 6,945), but it is recommended to use the estimate based on fresh and non-fresh female carcasses for comparative purposes to the Jolly-Seber estimate, (Killam, 2004).

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 2004 was 7,192. RBDD historical winter-run data is provided in Appendix Table 7.

Hatchery Contributions

More details of the hatchery contributions are available in the Upper Sacramento River Winter Chinook Salmon Carcass Survey 2004 Annual Report (Service). Table 9 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, and male grilse) to the ratio of adipose fin-clipped to not-clipped carcasses present in the fresh carcass sample from the survey. Additionally an average adjustment of 0.38% 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 9. Summary of the 2004 hatchery and natural winter-run salmon numbers for selected categories. Hatchery data is based on average mark loss rates.

CATEGORY	Hatchery Component	Natural Component
Number of adult females	232	3,028
Number of adult males	174	2,868
Number of grilse females	3	37
Number of grilse males	362	1,086
Totals	**771**	**7,018**

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). Addition of genetic markers to identify sex should be investigated and implemented if possible.

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 2004 Winter-run adult female carcasses. Note that last 3 periods not included due to low numbers of carcasses and lack of carcasses recaptured

SURVEY PERIOD	T(i) NUMBER TAGGED	NUMBER CHOPPED	E(i) TOTAL EXAMINED	R(i) NUMBER RECAPTURED
1	5	2	7	0
2	4	0	7	3
3	0	2	3	1
4	3	0	4	1
5	1	0	3	2
6	1	0	1	0
7	1	1	3	1
8	2	2	4	0
9	4	2	7	1
10	3	2	6	1
11	8	1	10	1
12	12	5	23	6
13	11	1	15	3
14	7	3	15	5
15	18	6	29	5
16	16	2	24	6
17	33	4	43	6
18	31	4	50	15
19	56	8	80	16
20	65	6	102	31
21	90	10	131	31
22	77	10	128	41
23	115	9	156	32
24	120	25	207	62
25	132	25	225	68
26	143	53	283	87
27	121	33	229	75
28	101	39	211	71
29	78	50	181	53
30	51	43	147	53
31	38	47	128	43
32	35	27	97	35
33	18	24	56	14
34	9	26	52	17
35	5	17	40	18
36	10	20	43	13
37	1	16	24	7
38	1	6	9	2
39	0	6	7	1
40	0	2	3	1
TOTALS	**1,426**	**539**	**2,793**	**828**

Appendix Table 1-C. The recapture matrix for the 2004 winter-run adult female carcasses.

	RECAPTURE MATRIX OF TAGGED FISH MARKED IN SURVEY PERIOD (columns) and RECOVERED DURING RECOVERY PERIODS (rows)																																									
Recovery 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	3																																								
2		1																																							
3		1	0																																						
4				2																																					
5					0																																				
6						1																																			
7							0																																		
8								1																																	
9									1																																
10									1	0																															
11										2	4																														
12					1					0		2																													
13										1	1		3																												
14												1	1	3																												
15												0		0	6																											
16										0				0	0	6																										
17												2	0		1		12																									
18										0				0			4	12																								
19										0			1			1	1	1	27																						
20																1	0	0	2	28																					
21																	1	0	0	6	34																				
22																		1	1	4	6	20																			
23																0		0	1	2	3	6	50																		
24																			1		2	7	11	47																	
25																	1	0	1	2	5	2	5	9	62																
26																			1		1		3	7	8	55															
27																	1	0			2	1	1	2	6	12	46														
28																					1	0	3	3	4	4	9	29													
29																							2	5	2	3	5	10	26												
30																					1		0	3	0	5	6	3	8	17											
31																									1	3	3	5	3	6	14										
32																								1		0	2	0	2	1	1	7									
33																									1		1	4	1		2	3	5								
34																										2	1	2	2	3	1		4	3							
35																									1		2	1	3	2	0	1	1		2						
36																													0		1				1	5					
37																														1		1					0				
38																																		1				0			
39																																				1			0		
C(i) Sums	**3**	**2**	**0**	**2**	**1**	**1**	**0**	**1**	**2**	**3**	**5**	**5**	**5**	**3**	**7**	**8**	**20**	**14**	**34**	**42**	**55**	**36**	**75**	**77**	**85**	**84**	**75**	**54**	**45**	**30**	**19**	**12**	**10**	**4**	**3**	**6**	**0**	**0**	**0**	**0**

Appendix Table 1-D. The Jolly-Seber Model calculations for the 2004 Winter-run adult female carcasses.

JOLLY SEBER CALCULATIONS								
i	K(i)	b(i)	S(i)	N(i)	B(i)		N(1)	D(i)
-	-	-	-	-	-	-	-	-
1			0.6000	6	4		10.873	5
2	0	3.0	0.5000	6	3			4
3	1	2.0	1.0000	4	2			2
4	0	1.0	0.6667	3	2			2
5	0	2.0	1.0000	3	1			1
6	1	1.0	1.5000	2	3			2
7	1	3.0	0.5000	6	6			8
8	1	1.5	0.7619	8	6			7
9	1	2.7	0.5294	11	6			9
10	2	3.0	1.4000	11	28			24
11	4	7.0	0.8929	39	10			11
12	3	12.5	0.7027	43	30			35
13	5	13.0	0.7143	52	6			7
14	5	15.0	0.7132	40	38			45
15	3	12.1	0.5395	61	22			29
16	4	13.6	0.6671	48	72			88
17	6	15.7	0.9006	99	43			45
18	11	38.5	0.5629	123	88			117
19	9	30.7	0.6994	146	74			88
20	12	49.4	0.8197	159	182			201
21	23	68.4	0.9342	282	140			145
22	37	119.0	0.6102	366	258			330
23	41	94.6	0.8209	450	146			161
24	54	145.8	0.8119	481	222			246
25	63	165.4	0.8296	542	242			266
26	61	190.3	0.7606	614	206			237
27	70	187.4	0.8923	567	204			215
28	74	208.2	0.7631	613	229			262
29	75	181.8	0.7997	613	46			51
30	67	165.4	0.9077	453	110			116
31	54	148.3	0.9786	435	44			45
32	38	140.2	0.5433	382	116			157
33	36	76.2	0.9354	289	-14			-15
34	29	75.0	0.6045	221	-20			-26
35	15	40.5	0.7584	87	26			30
36	5	20.9	0.8400	66	20			21
37	4	15.0	0.6667	47	4			5
38	2	6.0	0.4000	20	3			5
39	1	2.0	2.0000	8	2			1
40		2.0		4				
						ESTIMATE =		**2993**

Appendix 1-E. Calculations and adjustments used for determining the entire winter-run spawner population based on the 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 2,993 as the total of adult females in the tag and recapture survey. Adjustments to this number result in the overall escapement estimate (7,786) for 2004 and are shown in Table 1. **Note:** individual steps in calculations can lead to category summaries involving totals that do not add up exactly. This is due to the rounding errors associated with presenting calculated totals in intermediate steps (e.g. 3.2 hatchery jills + 37.4 natural jills = 3 + 37 = 40 fish, but final calculated total = 41 fish)

Adult Females

Adipose fin-clipped adult female carcasses were not included in the mark-recapture study since their heads were removed for CWT analysis. Adipose fin-clipped females are accounted for by expanding the estimated number of fresh adult females based on the number of fresh adult natural (1,058) and hatchery (74) females. An adjustment factor of 1.0752 (1058 / 984) is multiplied by Jolly-Seber estimate of natural adult females (2,993) to arrive at the total number of adult females within the carcass survey area (3,218). Next, the fish that spawned outside of the survey area are accounted for. The number of redds outside of the survey area in 2004 was 0 out of a total 621 redds (Table 7). The adjustment factor of 1.0000 (621 / 621), is multiplied by 3,218 to estimate the in-river adult female escapement estimate at **3,218**. In addition, LSNFH retained 41 adult females so the 2004 estimate of escapement for adult females is **3,259.**

Adult Males

The number of adult males (Table 1) was derived from data from the Keswick Trap. Adult salmon data from Keswick (Table 4) resulted in 126 adults, (65 females and 61 males). 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 0.9385 (61 / 65) and was multiplied by 3,218 to generate and estimate of **3,020** in-river adult males. The LSNFH retained 21 adult males so the 2004 total estimate for adult males is **3,041**.

Grilse Females (Jills)

To estimate the total number of female grilse (Table 1), the fresh adult female carcass estimate (3,218) was expanded based on the number of fresh adult females (1,058) and fresh jills (13) in the carcasses examined. The adjustment factor of 0.0123 (13 / 1058) resulted in an in-river estimate of 40 jills (3,218 x 0.0123). One jill was retained at LSNFH so the 2004 total estimate is **41** female grilse.

Grilse Males (Jacks)

To estimate the total number of male grilse (Table 1), the fresh adult male carcass estimate (3,020) was expanded based on the number of fresh adult males (318) and fresh jacks (150) in the carcasses examined. The adjustment factor of 0.4717 (150 / 318) resulted in an in-river estimate of 1,424 jacks (3,020 x 0.4717). Twenty-two jacks were retained at LSNFH so the 2004 total estimate is **1,446** male grilse.

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

Date	Water Temp.	Visibility (ft)	Weather	Flow (cfs)	max Air temp.
4/30/2004	53	10	Clear	8,478	93
5/1/2004	50	12	Clear	8,951	92
5/3/2004	53	10	Clear	9,164	96
5/4/2004	50	12	Clear	9,590	90
5/6/2004	52	9.8	Clear	11,186	79
5/7/2004	50	8.75	Cloudy	10,808	74
5/9/2004	52	9	Clear	10,430	81
5/10/2004	50	9	Part Cloudy	10,363	73
5/12/2004	52	11	Clear	9,001	85
5/13/2004	52	10	Clear	9,016	86
5/15/2004	53	11	Clear	9,019	90
5/16/2004	51	11	Clear	9,020	88
5/18/2004	52	11	Part Cloudy	8,373	77
5/19/2004	51	11	Clear	8,339	82
5/21/2004	53	11	Clear	8,053	80
5/22/2004	51	11	Cloudy	8,463	77
5/24/2004	53	13	Clear	8,595	89
5/25/2004	51	11	Clear	9,525	93
5/27/2004	53	10.5	Cloudy	10,503	81
5/28/2004	51	9	Rain	10,483	79
5/30/2004	53	13	Clear	11,032	93
5/31/2004	51	11	Clear	11,009	99
6/2/2004	53	13	Clear	11,017	100
6/3/2004	51	11	Clear	11,036	93
6/5/2004	53	11	Clear	13,449	95
6/6/2004	51	10.5	Clear	13,489	89
6/8/2004	52.5	10.5	Part Cloudy	13,634	79
6/9/2004	52	11	Part Cloudy	13,917	82
6/10/2004	54	9	Clear	13,934	85
6/11/2004	53	13	Clear	13,910	92
6/12/2004	52	11	Clear	13,915	95
6/14/2004	54	11.5	Clear	13,900	100
6/15/2004	52	12	Clear	14,562	103
6/16/2004	56	12	Clear	14,900	103
6/17/2004	52	12	Clear	14,972	95
6/18/2004	53	12	Clear	14,631	93
6/19/2004	56	13	Clear	14,970	96
6/20/2004	53	13	Clear	14,809	100
6/21/2004	53	11	Clear	14,679	105
6/22/2004	52	10	Clear	14,635	97
6/23/2004	53	15	Clear	14,728	96
6/24/2004	53	13	Clear	14,806	97
6/25/2004	55	13	Clear	14,730	99
6/26/2004	55	14	Clear	14,876	101

Appendix Table 2. continued

Date	Water Temp.	Visibility (ft)	Weather	Flow (cfs)	max Air temp.
6/27/2004	54	13	Clear	14,758	104
6/28/2004	56	10.75	Clear	14,736	100
6/29/2004	54	13.25	Clear	14,513	98
6/30/2004	54	13	Clear	14,591	91
7/1/2004	56	13	Clear	14,638	101
7/2/2004	56	13	Clear	14,726	105
7/3/2004	52	11.75	Clear	14,735	102
7/4/2004	54	12	Clear	14,677	103
7/5/2004	54	12	Clear	14,688	110
7/6/2004	53	13	Clear	14,619	111
7/7/2004	55	12	Clear	14,509	97
7/8/2004	55	14	Clear	14,682	93
7/9/2004	54	12	Clear	14,878	89
7/10/2004	55	12	Clear	15,530	93
7/11/2004	54	14	Clear	14,954	99
7/12/2004	54	15	Clear	14,888	101
7/13/2004	57	13	Clear	14,929	99
7/14/2004	55	16	Clear	14,881	99
7/15/2004	54	16	Clear	14,804	100
7/16/2004	57	11	Clear	14,847	101
7/17/2004	55	11	Clear	14,713	101
7/18/2004	54	11	Part Cloudy	14,752	101
7/19/2004	57	11	Part Cloudy	14,638	100
7/20/2004	54	15	Clear	14,817	103
7/21/2004	55	13	Clear	15,629	106
7/22/2004	55	11.5	Clear	16,059	109
7/23/2004	54	11.5	Clear	16,309	108
7/24/2004	54	13	Part Cloudy	16,084	104
7/25/2004	55	13	Clear	16,051	105
7/26/2004	54	13	Clear	15,998	107
7/27/2004	53	13	Clear	15,631	107
7/28/2004	56	13	Clear	15,466	103
7/29/2004	55	14	Clear	14,472	99
7/30/2004	54	13.5	Clear	14,410	100
7/31/2004	55	12	Clear	14,484	99
8/1/2004	54	11	Clear	14,386	97
8/2/2004	53	14	Clear	14,398	90
8/3/2004	55	13	Clear	13,905	96
8/4/2004	54	13	Clear	13,419	96
8/5/2004	55	12.25	Clear	13,279	89
8/6/2004	56	13	Clear	13,027	94
8/7/2004	55	14	Clear	12,432	104
8/8/2004	54	13	Clear	12,480	104
8/9/2004	56	13	Clear	12,518	105
8/10/2004	56	14	Clear	12,476	110
8/11/2004	54	13.5	Clear	12,055	109
8/12/2004	56	13	Clear	11,568	110

Appendix Table 2. continued

Date	Water Temp.	Visibility (ft)	Weather	Flow (cfs)	max Air temp.
8/13/2004	54	13	Clear	10,959	105
8/14/2004	53	13.45	Clear	10,573	99
8/15/2004	53	13	Clear	10,520	97
8/16/2004	54	14	Clear	10,505	100
8/17/2004	54	12	Clear	10,441	106
8/18/2004	54	13	Clear	10,075	109
8/19/2004	55	11	Part Cloudy	9,582	102
8/20/2004	51.25	10	Clear	9,542	105
8/21/2004	56	10.8	Clear	9,495	100
8/22/2004	53	10	Cloudy	9,520	82
8/23/2004	52.25	11.5	Part Cloudy	9,354	89
8/24/2004	54	14	Clear	9,049	91
8/25/2004	54	13	Part Cloudy	9,477	88
8/26/2004	52	13	Clear	10,031	90
8/27/2004	54	13	Clear	10,007	100
8/28/2004	54	13	Clear	9,547	106
8/29/2004	54	14	Clear	9,510	105
8/30/2004	54	13	Clear	9,525	103
8/31/2004	55	15	Clear	9,027	101
9/2/2004	55	12	Clear	8,480	90
9/3/2004	55	14	Clear	8,963	91
AVERAGE	**54**	**12**		**12,537**	**96**

Appendix Table 3. Summary of results for 2004 winter run carcasses suspected of having coded-wire tags.

Date	Fork length	Sex	River Mile	Ad-Fin*	Final Ad-fin^	CWT Code	Brood Year
4/30/2004	780	M	290	1	1	no tag found	
5/12/2004	760	F	299	1	1	Late fall- 050768	2001
5/22/2004	710	F	300	1	1	no tag found	
5/25/2004	705	F	300	1	1	0501040103	2001
6/2/2004	765	F	295	1	1	0501040102	2001
6/5/2004	540	M	291	1	1	no tag found	
6/6/2004	720	F	296.5	1	1	0501030705	2001
6/12/2004	659	F	301	1	1	no tag found	
6/15/2004	551	M	299	1	1	051284	2002
6/17/2004	850	M	287	1	1	0501030706	2001
6/17/2004	690	F	295	1	1	unreadable	
6/18/2004	763	F	301	1	1	no tag found	
6/18/2004	788	F	297	1	1	no tag found	
6/18/2004	730	F	296.5	1	1	unreadable	
6/20/2004	781	F	291	1	1	0501040101	2001
6/21/2004	575	M	296.5	1	1	051284	2002
6/22/2004	540	M	281	1	1	no tag found	
6/23/2004	540	M	294	1	1	051284	2002
6/23/2004	751	F	288	1	1	no tag found	
6/24/2004	793	F	297	1	1	0501030706	2001
6/24/2004	790	F	296	1	1	no tag found	
6/26/2004	535	M	296	1	1	051284	2002
6/26/2004	806	M	296	1	1	0501030707	2001
6/26/2004	710	M	288	1	1	0501030709	2001
6/26/2004	640	M	295	1	1	head lost	
6/26/2004	915	M	294	1	1	no tag found	
6/27/2004	710	F	298	1	1	0501030707	2001
6/27/2004	708	F	296.5	1	1	0501030803	2001
6/27/2004	855	F	296.5	1	1	no tag found	
6/27/2004	718	F	296.5	1	1	no tag found	
6/27/2004	820	F	296.5	2	0	no tag found	
6/27/2004	844	F	296.5	2	0	no tag found	
6/27/2004	530	M	298	1	1	no tag found	
6/28/2004	530	M	286	1	1	051284	2002
6/28/2004	643	F	278	1	1	0501040101	2001
6/29/2004	510	M	294	1	1	051282	2002
6/29/2004	580	M	295	1	1	051284	2002
6/29/2004	570	M	296	1	1	051297	2002
6/29/2004	738	F	288	1	1	0501030705	2001
6/29/2004	750	F	294	3	0	no tag found	
6/30/2004	700	F	300	1	1	0501040104	2001
6/30/2004	710	F	296.5	1	1	no tag found	
6/30/2004	720	F	296	1	1	no tag found	

Appendix Table 3. continued

Date	Fork length	Sex	River Mile	Ad-Fin*	Final Ad-fin^	CWT Code	Brood Year
7/1/2004	520	M	282	1	1	051299	2002
7/1/2004	778	F	282	1	1	no tag found	
7/2/2004	590	F	291	1	1	0501030709	2001
7/2/2004	830	M	288	1	1	0501030908	2001
7/2/2004	729	F	295	1	1	no tag found	
7/2/2004	755	F	295	2	0	no tag found	
7/2/2004	489	M	292	1	1	no tag found	
7/2/2004	769	F	295	1	1	no tag found	
7/2/2004	761	F	295	1	1	no tag found	
7/3/2004	610	M	297	1	1	051284	2002
7/3/2004	540	M	296.5	1	1	051296	2002
7/3/2004	490	M	300	1	1	051299	2002
7/3/2004	800	M	296	1	1	0501030807	2001
7/3/2004	690	F	298	2	0	no tag found	
7/3/2004	680	F	298	1	1	no tag found	
7/3/2004	930	F	296.5	1	1	no tag found	
7/3/2004	840	M	296.5	1	1	no tag found	
7/3/2004	790	F	297	2	0	no tag found	
7/4/2004	775	M	286	1	1	no tag found	
7/5/2004	580	M	295	1	1	051291	2002
7/5/2004	580	M	296	1	1	051298	2002
7/5/2004	530	M	291	1	1	051299	2002
7/5/2004	625	F	287	1	1	0501030707	2001
7/5/2004	700	F	295	1	1	0501030807	2001
7/5/2004	640	M	294	1	1	no tag found	
7/5/2004	845	M	294	1	1	no tag found	
7/6/2004	615	M	299	1	1	051291	2002
7/6/2004	859	F	296.5	1	1	0501030108	2000
7/6/2004	670	F	297	1	1	0501030705	2001
7/6/2004	660	M	297	1	1	0501030709	2001
7/6/2004	680	F	296.5	1	1	0501030903	2001
7/6/2004	748	F	297	1	1	no tag found	
7/6/2004	790	F	296.5	1	1	no tag found	
7/8/2004	462	M	295	1	1	051280	2002
7/8/2004	470	M	289	1	1	051282	2002
7/8/2004	545	M	294	1	1	053737	2002
7/8/2004	880	M	294	1	1	501030707	2001
7/8/2004	678	F	295	1	1	501030806	2001
7/8/2004	890	M	287	2	0	no tag found	
7/8/2004	769	F	295	1	1	no tag found	
7/9/2004	510	M	296.5	1	1	051279	2002
7/9/2004	615	M	296.5	1	1	051286	2002
7/9/2004	480	M	298	1	1	051294	2002
7/9/2004	503	M	296.5	1	1	051294	2002
7/9/2004	745	F	299	1	1	0501030707	2001
7/9/2004	800	F	296.5	1	1	0501030802	2001

Appendix Table 3. continued

Date	Fork length	Sex	River Mile	Ad-Fin*	Final Ad-fin^	CWT Code	Brood Year
7/9/2004	690	F	299	1	1	0501030803	2001
7/9/2004	740	F	298	1	1	0501030804	2001
7/9/2004	527	M	296.5	2	0	**no tag found**	
7/9/2004	780	F	297	1	1	**no tag found**	
7/9/2004	820	F	296.5	2	0	**no tag found**	
7/10/2004	577	M	286	1	1	051296	2002
7/10/2004	495	M	287	3	1	051365	2002
7/10/2004	462	M	286	1	1	051365	2002
7/10/2004	825	M	279	1	1	**no tag found**	
7/11/2004	580	M	288	1	1	051278	2002
7/11/2004	575	M	287	1	1	051287	2002
7/11/2004	505	M	296	1	1	051372	2002
7/11/2004	736	F	293	1	1	0501030705	2001
7/11/2004	729	F	296	1	1	0501030705	2001
7/11/2004	700	F	294	1	1	0501030709	2001
7/11/2004	750	F	288	1	1	0501030907	2001
7/11/2004	602	M	294	2	0	**no tag found**	
7/11/2004	740	F	294	1	1	**unreadable**	
7/12/2004	570	M	298	1	1	051288	2002
7/12/2004	635	M	300	1	1	051297	2002
7/12/2004	800	F	296.5	1	1	0501030706	2001
7/12/2004	686	F	298	1	1	0501030707	2001
7/12/2004	735	F	301	1	1	0501030802	2001
7/12/2004	820	M	296.5	1	1	0501030807	2001
7/12/2004	831	M	296.5	1	1	0501030903	2001
7/12/2004	654	F	298	1	1	0501040102	2001
7/12/2004	718	F	296.5	1	1	**no tag found**	
7/12/2004	731	F	300	1	1	**no tag found**	
7/13/2004	585	M	283	1	1	051297	2002
7/13/2004	751	M	282	1	1	0501030706	2001
7/14/2004	462	M	288	1	1	051280	2002
7/14/2004	630	M	296	1	1	051286	2002
7/14/2004	490	M	294	1	1	051294	2002
7/14/2004	581	M	295	1	1	051298	2002
7/14/2004	604	M	287	1	1	051367	2002
7/14/2004	739	F	295	1	1	0501030705	2001
7/14/2004	740	F	295	1	1	0501030903	2001
7/14/2004	739	F	295	1	1	0501030908	2001
7/14/2004	588	M	288	1	1	**no tag found**	
7/14/2004	525	M	294	1	1	**no tag found**	
7/14/2004	495	F	295	2	0	**no tag found**	
7/14/2004	559	M	295	1	1	**no tag found**	
7/15/2004	470	M	297	1	1	051287	2002
7/15/2004	585	M	297	1	1	051288	2002
7/15/2004	441	M	297	1	1	053737	2002
7/15/2004	760	F	296.5	1	1	0501030705	2001

Appendix Table 3. continued

Date	Fork length	Sex	River Mile	Ad-Fin*	Final Ad-fin^	CWT Code	Brood Year
7/15/2004	870	M	296.5	1	1	0501030706	2001
7/15/2004	720	F	299	1	1	0501030706	2001
7/15/2004	738	F	296.5	1	1	0501030707	2001
7/15/2004	740	F	298	1	1	0501030803	2001
7/15/2004	850	M	297	1	1	0501030906	2001
7/15/2004	750	F	296.5	1	1	0501030908	2001
7/15/2004	790	F	296.5	1	1	0501040103	2001
7/15/2004	775	F	299	2	0	no tag found	
7/15/2004	789	F	297	1	1	no tag found	
7/15/2004	645	F	297	1	1	no tag found	
7/15/2004	752	F	296.5	1	1	no tag found	
7/15/2004	751	F	297	2	0	no tag found	
7/16/2004	482	M	280	1	1	no tag found	
7/17/2004	570	M	288	1	1	051284	2002
7/17/2004	640	M	291	1	1	051296	2002
7/17/2004	740	F	292	1	1	0501030707	2001
7/17/2004	773	F	295	1	1	0501030806	2001
7/17/2004	770	F	295	1	1	0501030808	2001
7/18/2004	720	F	300	1	1	0501030705	2001
7/18/2004	742	F	296.5	1	1	0501030705	2001
7/18/2004	680	F	296.5	1	1	0501030705	2001
7/18/2004	758	F	296	1	1	0501030706	2001
7/18/2004	700	F	297	1	1	0501030706	2001
7/18/2004	696	F	300	1	1	0501030707	2001
7/18/2004	810	F	296	1	1	0501030709	2001
7/18/2004	757	F	297	1	1	0501030903	2001
7/18/2004	640	F	296.5	1	1	0501030903	2001
7/18/2004	720	F	296.5	1	1	0501030908	2001
7/18/2004	793	F	296.5	1	1	0501040104	2001
7/18/2004	940	M	296.5	1	1	no tag found	
7/18/2004	718	F	296.5	1	1	no tag found	
7/18/2004	520	M	297	1	1	no tag found	
7/18/2004	630	F	296.5	1	1	no tag found	
7/18/2004	710	F	296.5	1	1	no tag found	
7/18/2004	770	F	297	1	1	no tag found	
7/19/2004	791	F	279	1	1	0501030805	2001
7/19/2004	565	M	283	1	1	no tag found	
7/20/2004	515	M	294	1	1	051294	2002
7/20/2004	510	M	293	1	1	051371	2002
7/20/2004	705	F	290	1	1	0501030705	2001
7/20/2004	780	F	294	1	1	0501030705	2001
7/20/2004	839	M	289	1	1	0501030706	2001
7/20/2004	896	M	295	1	1	0501030707	2001
7/20/2004	860	M	287	1	1	no tag found	
7/21/2004	450	M	299	1	1	051296	2002
7/21/2004	460	M	296.5	1	1	053737	2002

Appendix Table 3. continued

Date	Fork length	Sex	River Mile	Ad-Fin*	Final Ad-fin^	CWT Code	Brood Year
7/21/2004	680	F	298	1	1	0501030705	2001
7/21/2004	722	F	301	1	1	0501030706	2001
7/21/2004	669	F	296.5	1	1	0501030706	2001
7/21/2004	741	F	296.5	1	1	0501030706	2001
7/21/2004	760	F	296.5	1	1	0501030804	2001
7/21/2004	735	M	297	1	1	0501030807	2001
7/21/2004	721	F	296.5	1	1	0501030904	2001
7/21/2004	730	F	298	2	0	no tag found	
7/21/2004	750	F	301	1	1	no tag found	
7/21/2004	740	F	300	1	1	no tag found	
7/21/2004	707	F	296.5	1	1	no tag found	
7/21/2004	690	F	296.5	1	1	no tag found	
7/21/2004	738	F	299	1	1	unreadable	
7/23/2004	591	M	296	1	1	051283	2002
7/23/2004	550	M	296	1	1	053737	2002
7/23/2004	740	F	287	1	1	0501030805	2001
7/23/2004	750	F	295	1	1	0501030908	2001
7/23/2004	754	F	292	2	0	no tag found	
7/24/2004	550	M	296.5	1	1	051280	2002
7/24/2004	510	M	296.5	1	1	053737	2002
7/24/2004	612	F	296.5	2	1	0501030705	2001
7/24/2004	670	F	297	1	1	0501030705	2001
7/24/2004	770	F	301	1	1	0501030706	2001
7/24/2004	701	F	298	1	1	0501030902	2001
7/24/2004	708	F	297	1	1	0501030907	2001
7/24/2004	680	F	299	1	1	no tag found	
7/24/2004	498	M	297	1	1	no tag found	
7/24/2004	740	F	297	2	0	no tag found	
7/24/2004	630	F	296.5	1	1	no tag found	
7/25/2004	802	M	281	1	1	0501030903	2001
7/25/2004	505	M	280	1	1	no tag found	
7/26/2004	607	M	291	1	1	051291	2002
7/26/2004	750	F	292	1	1	no tag found	
7/27/2004	540	M	296.5	1	1	051280	2002
7/27/2004	550	M	296.5	1	1	051372	2002
7/27/2004	760	F	297	1	1	0501030706	2001
7/27/2004	520	F	296.5	1	1	0501030706	2001
7/27/2004	670	F	296.5	1	1	no tag found	
7/28/2004	735	M	278	1	1	0501040101	2001
7/29/2004	539	M	294	1	1	051280	2002
7/29/2004	760	F	295	1	1	0501030705	2001
7/29/2004	719	F	296	1	1	0501030706	2001
7/29/2004	560	M	292	1	1	no tag found	
7/29/2004	741	F	287	1	1	no tag found	
7/30/2004	520	M	297	1	1	051280	2002
7/30/2004	557	F	299	1	1	051288	2002

Appendix Table 3. continued

Date	Fork length	Sex	River Mile	Ad-Fin*	Final Ad-fin^	CWT Code	Brood Year
7/30/2004	840	F	297	1	1	0501030307	2000
7/30/2004	711	F	296.5	1	1	0501030705	2001
7/30/2004	670	F	296.5	1	1	0501030706	2001
7/30/2004	682	F	296.5	2	0	no tag found	
7/30/2004	732	F	296.5	3	0	no tag found	
8/1/2004	740	F	296	2	0	no tag found	
8/2/2004	770	F	299	1	1	0501030705	2001
8/2/2004	810	F	300	1	1	0501030706	2001
8/2/2004	762	F	299	1	1	0501030706	2001
8/2/2004	700	F	296	3	1	0501030706	2001
8/2/2004	775	F	296.5	1	1	0501030805	2001
8/2/2004	752	F	297	1	1	0501030807	2001
8/2/2004	753	F	296.5	1	1	0501030904	2001
8/2/2004	730	F	297	1	1	0501040103	2001
8/2/2004	725	F	297	1	1	0501040104	2001
8/2/2004	800	F	296.5	1	1	no tag found	
8/2/2004	690	F	298	1	1	no tag found	
8/5/2004	570	M	298	1	1	053737	2002
8/6/2004	546	M	278	1	1	051298	2002
8/7/2004	780	F	295	2	1	0501030705	2001
8/7/2004	711	F	295	1	1	0501030905	2001
8/8/2004	589	M	298	1	1	053737	2002
8/8/2004	750	F	296	1	1	0501030902	2001

* Ad-Fin 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 (3) is a partial adipose fin clip which crews were not sure of.

^ Final Ad-fin 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. Typically, partial and unknown ad-clipped carcasses were re-tallied as natural fish (0) if no tag was found in them.

Appendix Table 4. Summary of past results for the Winter-run carcass survey for the years 1996 to 2004.

Parameter	WINTER-RUN CARCASS SURVEY RESULTS								
Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002[#]**	**2003**	**2004**
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	**4/30 - 9/3**
Carcasses counted	118	239	785	475	2,482	5,145	4,959	4,549	**3,268**
Percent recaptured	15%	12%	15%	22%	45%	57%	59%	50%	**55%**
Reported Population*^	820*	2,053*	5,501*	2,262*	6,647*	8,224^	7,441^	8,218^	**7,786^**
Percent grilse	19.00%	8.00%	0.20%	19.50%	2.70%	9.70%	5.20%	3.30%	**10.60%**
Percent male	16%	31%	11%	12%	20%	42%	22%	16%	**30%**
Spawning % success	94%	96%	95%	97%	100%	99%	99%	100%	**99%**
Percent carcasses in Upper Area[&]	50%	48%	58%	73%	80%	72%	87%	88%	**75%**
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	**8.1 - 16.3**
Water temp (^{o}F) range	52 - 59	49 - 52	50 - 54	50 - 54	51 - 54	50 - 55	50 - 56	50 - 54	**50 - 57**
Visibility range (ft)	n/a	3 - 10	4.5 - 11	6 - 11	9 - 20	14 - 20	17 - 22	8 - >15	**8.5 - 16**

2002 Data is preliminary

* Peterson Model

^ Jolly Seber Model

[&] Upper Area 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 1982 through 2004.

	YEAR																			
River Section	**04**	**03**	**02**	**01**	**00**	**99**	**98**	**97**	**96**	**95**	**94**	**93**	**92**	**91**	**90**	**89**	**88**	**87**	**85**	**82**
Keswick to A.C.I.D. Dam.	**16%**	66%	49%	35%	6%	0%	3%	0%	3%	7%	0%	5%	2%	0%	0%	6%	1%	0%	6%	0%
A.C.I.D. Dam to Highway 44 Bridge	**35%**	17%	22%	15%	27%	31%	77%	83%	71%	83%	29%	61%	20%	70%	35%	30%	23%	15%	13%	58%
Highway 44 Br. to Airport Rd. Br.	**49%**	16%	28%	45%	47%	65%	16%	17%	26%	9%	24%	25%	49%	20%	51%	47%	30%	17%	29%	36%
Airport Rd. Br. to Balls Ferry Br.	**0%**	0%	1%	4%	5%	1%	1%	0%	0%	0%	41%	2%	15%	10%	6%	2%	7%	18%	14%	3%
Balls Ferry Br. to Battle Creek.	**0%**	0%	0%	0%	6%	2%	1%	0%	0%	0%	6%	0%	5%	0%	1%	0%	2%	9%	0%	0%
Battle Creek to Jellys Ferry Br.	**0%**	0%	0%	0%	2%	0%	0%	0%	0%	1%	0%	2%	0%	0%	1%	0%	2%	21%	1%	0%
Jellys Ferry Br. to Bend Bridge	**0%**	0%	0%	1%	8%	0%	0%	0%	0%	0%	0%	2%	5%	0%	0%	13%	9%	14%	4%	0%
Bend Bridge to RBDD	**0%**	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	6%	0%
RBDD to Tehama Br.	**0%**	0%	0%	0%	0%	0%	2%	0%	0%	1%	0%	2%	4%	0%	5%	0%	16%	4%	28%	3%
Tehama Br. To Woodson Bridge	**0%**	0%	0%	0%	0%	0%	0%	n/s	n/s	0%	0%	0%	0%	0%	2%	2%	9%	0%	0%	n/s
Woodson Bridge to Hamilton City Br.	**0%**	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
Hamilton City Bridge to Ord Ferry Br.	**0%**	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
Ord Ferry Br. To Princeton Ferry.	**0%**	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
Total New Redds Counted	**621**	**878**	**610**	**1,396**	**588**	**1,144**	**121**	**30**	**70**	**175**	**17**	**44**	**55**	**10**	**104**	**47**	**1,295**	**313**	**103**	**33**

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

Appendix Table 6. The methodology used to determine GPS calculated distances.

Data for the GPS analysis was collected using Garmin Model 76 handheld units. Three units were deployed at the beginning of the survey. A "grid-like pattern" of random waypoints were placed over the survey sections of the Upper Sacramento River on Terrain Navigator (Mapping software) and were uploaded to the GPS units. These waypoints were then uploaded to the GPS units via serial port cable. It was known that additional "field collected" waypoints were going to be required so each unit was assigned a unique series of numbers to avoid waypoint overlap. GPS unit "DFG-1" began compiling new waypoints at 700, "DFG-2" began compiling new waypoints at 800, and "DFG-3" began compiling new waypoints at 900. Acquisition of field data was done at standard range of 80 ft. New waypoints were necessary in the field when no waypoint was available on the screen at the 80 foot range. If there were multiple waypoints on the screen within the 80 foot range then the point closest to the boat was recorded.

A waypoint was typically recorded for all carcasses that were disc-tagged, recaptured disc-tagged, rainbow trout and suspected adipose fin-clips. Data analysis was conducted using MapSource, ArcView 3.1, Microsoft Excel, and Access. The first step was downloading the GPS units using MapSource software into UTM NAD-83 coordinates. Once the units were downloaded they were exported from MapSource as a text file and imported into Excel. The data from the three GPS units were combined and a master list was created. This file was then saved as a Dbase file and imported into ArcView 3.1. These points were imported as a table and plotted as an event theme. They were then converted to a shape file.

Even though carcasses and the corresponding waypoints were encountered all over the river it was reasoned that a river centerline overlaid on aerial photographs of the river would allow analysis of distances. Typically the river flow transports carcasses directly downstream (linearly) from one point to another rather than drifting from river side to side. We assumed that this was the case so that an imaginary centerline would accurately reflect the distance moved in most river sections even though the carcass may have been encountered on one shoreline or the other. By drawing the centerline in the middle of the river on linear sections and on the fast moving flow areas of non-linear sections we feel that we accurately portrayed "general distance" for each waypoint in the study. Three different lines were drawn from Keswick reservoir to the mouth of Cottonwood Creek down the center of the river deviating from each other only in the Turtle Bay area (RM 296.5). Line One later noted as "route 1" was drawn down the side channel of Turtle Bay, Line Two later noted as "route 2" was drawn into Turtle Bay between the island and the side channel, and Line Three later noted as "route 3" was drawn around the point bar and past Turtle Bay. These lines were then converted to polyline M lines that prepare the line for distances to be calculated. Three separate centerlines were used so accurate distances could be calculated in the Turtle Bay area. Points were assigned (snapped) to a certain centerline based on their proximity (and to field experience of river flow patterns) to the three centerlines. As each waypoint then had a corresponding location on the centerlines it was possible to run a "script" program which calculated the distance of the now "snapped" waypoints. Three separate distance estimates from Keswick Dam in meters for each waypoint were then created based on each of the 3 routes. Since most carcasses are encountered in Turtle Bay this route (2) was used as the default route for all carcasses except those encountered in either route 1 or route 3. If any carcass was encountered at any waypoint in those routes, (1 or 3), it was assigned to that routes instead of route 2. This data was used to calculate the distance a carcass moved by taking the difference of the distance estimates for each waypoint the carcass was encountered at.

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

YEAR	TOTAL	Natural	Ad-Clip	% Nat	% Ad	Adults	Grilse	% A	% G	Male	Female	% M	% F	Hatchery*
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
2004	**7,192**	5,675	1,516	79%	21%	2,588	4,604	36%	64%	5,881	1,311	82%	18%	87
AVG	**16,526**	**16,390**	**152**	**96%**	**4%**	**12,812**	**3,599**	**70%**	**30%**	**1,726**	**1,131**	**54%**	**46%**	**66**

^ 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.

* Hatchery indicates the number of salmon estimated to have been removed from the river by for hatchery brood stock (Livingston Stone or Coleman National Fish Hatcheries), or in some earlier years the combination of hatchery and angler removals.