State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

ANNUAL REPORT
CHINOOK SALMON SPAWNER STOCKS IN CALIFORNIA'S CENTRAL VALLEY, 2004

Edited by

Robert M. Kano
Habitat Conservation Division
Native Anadromous Fish & Watershed Branch

Inland Fisheries
Administrative Report No. 2006-05

2006

CHINOOK SALMON SPAWNER STOCKS IN CALIFORNIA'S CENTRAL VALLEY, 2004[1/]

Edited by

Robert M. Kano

ABSTRACT

This report covers the 52nd annual inventory of Chinook salmon, Oncorhynchus tshawytscha, spawner populations in the Sacramento-San Joaquin River system. It is a compilation of sources estimating the late-fall-, winter-, spring-, and fall-run populations for streams which were surveyed. Estimates were based on counts of fish entering hatcheries and migrating past dams, from surveys of dead and live fish and redds in spawning areas, and from aerial counts.

The estimated 2004 total escapement of Chinook salmon in the Central Valley was 420,442 fish, which was 33% lower than in 2003. The population consisted of 384,727 fall-, 13,982 -spring, 13,864 late-fall-, and 7,869 winter-run spawners. All of the late-fall-, spring-, and winter-run salmon were in the Sacramento River system. The entire Central Valley fall run consisted of 398,179 fish in the Sacramento River system and 22,263 fish in the San Joaquin River system. The fall run in the San Joaquin tributaries still only contributed a small portion (5%) to the total Central Valley escapement.

1/ Inland Fisheries Administrative Report No. 2006-05. Submitted for publication December 2006. California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814.

INTRODUCTION

The Sacramento-San Joaquin River system (Figure 1), which flows through California's Central Valley, is the principle producer of Chinook salmon caught in the state's ocean fisheries; its salmon runs also contribute to the ocean fisheries of Oregon and Washington. This report is the 52nd compilation of Chinook salmon spawner stock surveys. The spring and fall runs have been monitored since 1953, and late-fall and winter runs since 1971. The four runs are distinguished as follows:

1) Late-fall run. These salmon spawn mainly in the upper Sacramento River and its tributaries near and upstream of Red Bluff. They arrive in this area in early November through February, with spawning occurring from January through mid-April. Adults of this run are usually larger in physical size than fall- and winter-run salmon spawning in the same area.

2) Winter run. These salmon spawn almost entirely in the Sacramento River and its tributaries upstream of Red Bluff, arriving there in December through early August, with spawning occurring from April through August.

3) Spring run. Once widespread in Central Valley tributaries, this run has disappeared from many of the streams in which dam construction has blocked access to spawning habitat. Spring-run spawners return to the system from the ocean in late January through August; early arrivals to their natal streams oversummer in holding pools. Spawning occurs from mid-August through October.

4) Fall run. These are presently the most numerous and widely distributed salmon in the Central Valley. They return from the ocean during June through November and spawn from early October through late December.

Monitoring of salmon spawner escapement in Central Valley tributaries is an important component of the California Department of Fish and Game's (CDFG) fishery management effort. The primary objectives of this work are to determine size and composition of spawner populations. Any changes in spawning distribution and habitat conditions that may adversely affect salmon are noted to determine if corrective action is necessary.

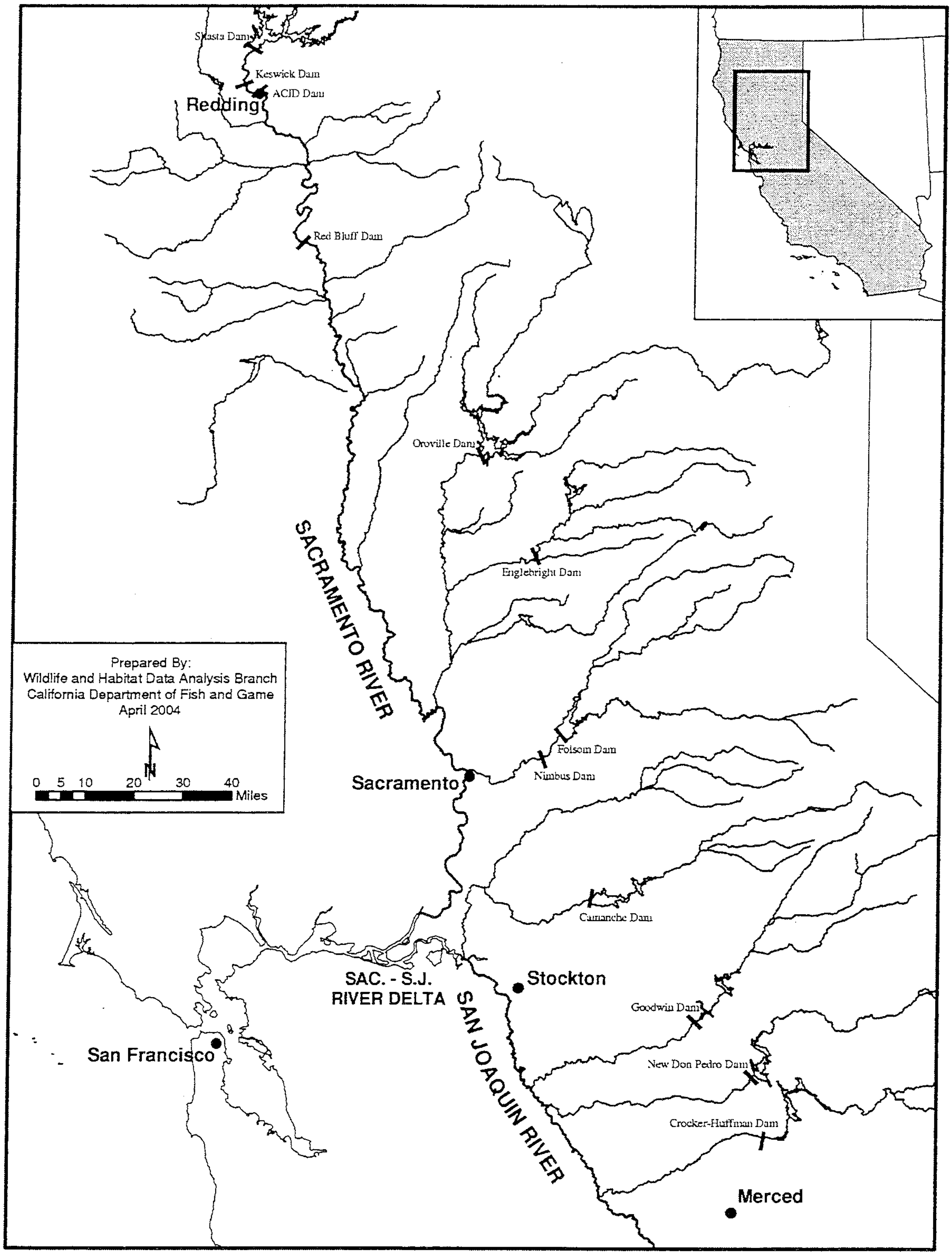

FIGURE 1. Sacramento-San Joaquin River System of California's Central Valley.

GENERAL METHODS

During 2004, spawner stock data were collected in some Central Valley tributaries known to support Chinook salmon runs by: monitoring fish entering hatcheries and migrating past dams; conducting stream surveys in holding or spawning areas for live fish, carcasses, and redds; or making aerial redd counts.

The data collected usually represented only a sampling of the tributaries' spawners. For some tributaries, data were not sufficient to calculate an estimate of the spawner population size; in some such cases, a decision of the number of spawners present was arrived at by "best professional judgment".

In other streams, salmon carcasses were marked throughout a series of survey periods. Discrete marks associated those carcasses with the individual surveys upon subsequent recovery trips. All counted carcasses were marked, or cut in half to prevent recounting. Estimated spawner numbers were calculated from mark-and-recovery data.

Specific details of surveys (e.g. timing, duration, location), or estimation methods are presented under the individual tributary sections.

In this report, adult salmon are considered those fish three years old and older. Two-year-old salmon, although sexually mature, are referred to as grilse.

CHINOOK SALMON SPAWNER POPULATIONS FOR THE SACRAMENTO RIVER SYSTEM

Sacramento River Mainstem

A total of 60,691 salmon was in the mainstem upstream of Red Bluff Diversion Dam (Figure 2), consisting of 43,604 fall-, 8,824 late-fall-, 7,869 winter- and 394 spring-run fish.

Late-fall run. The late-fall spawner population was estimated through a combination of salmon carcass surveys in a portion of the mainstem, aerial redd surveys of the entire mainstem, and sampling salmon at Keswick Dam. Carcass surveys were conducted from 15 December 2003 through 24 May 2004, covering the 15.6-km (9.7-mi) stretch of the mainstem between Anderson-Cottonwood Irrigation District Dam (ACID) and the powerlines just downstream of the mouth of Clear Creek [2/]. Several surveys during the middle of the period were hampered by high flows when Keswick Dam releases reached 1,416 m^3/s (50,000 cfs).

Surveys were conducted from boats, or on foot along the shore, during which salmon carcasses were collected. Before further processing carcasses were categorized as being either in fresh or decayed condition, and either from a fish of hatchery or natural origin. Fresh carcasses were those having at least one clear eye and reddish colored gills. Carcasses of hatchery origin were identified by missing adipose fins, indicating the possible presence of a coded-wire tag in its snout, inserted when the fish was a juvenile at the hatchery. It was assumed that any carcasses with adipose fins intact were salmon produced from in-river (natural) spawning.

For estimation of the spawner population, carcasses were marked with numbered tags attached with hog rings. Fresh carcasses were tagged in the upper jaw, and decayed carcasses were tagged in the lower jaw. Hatchery-origin carcasses were excluded from marking, since their heads were removed and saved for retrieval of the coded-wire tag. Length measurements, determination of gender, and female degree of egg retention were also recorded. Other carcasses not marked, usually those in an advanced state of decay, were chopped in half. Carcasses were then returned to flowing water near the location where they were originally found, in an attempt to simulate "natural" carcass dispersion. During subsequent surveys, previously marked carcasses that were recovered were also chopped.

The carcass processing protocols were intended to allow post-season distinction of age-class (adult or grilse, based on length), condition (fresh or decayed), and origin (hatchery or natural), so the data could be better compiled for estimating the population through several biometric models. Analysis of the data indicated the Jolly-Seber model (Appendix 1.C) was the most appropriate.

[2/] Killam, D., and C. Harvey-Arrison. Chinook Salmon Populations for the Upper Sacramento River Basin, 2004. Technical Report No. 05-2. Revised February 2006. CDFG-Northern California-North Coast Region (NCNCR), Sacramento River Salmon and Steelhead Assessment Project (SRSSAP).

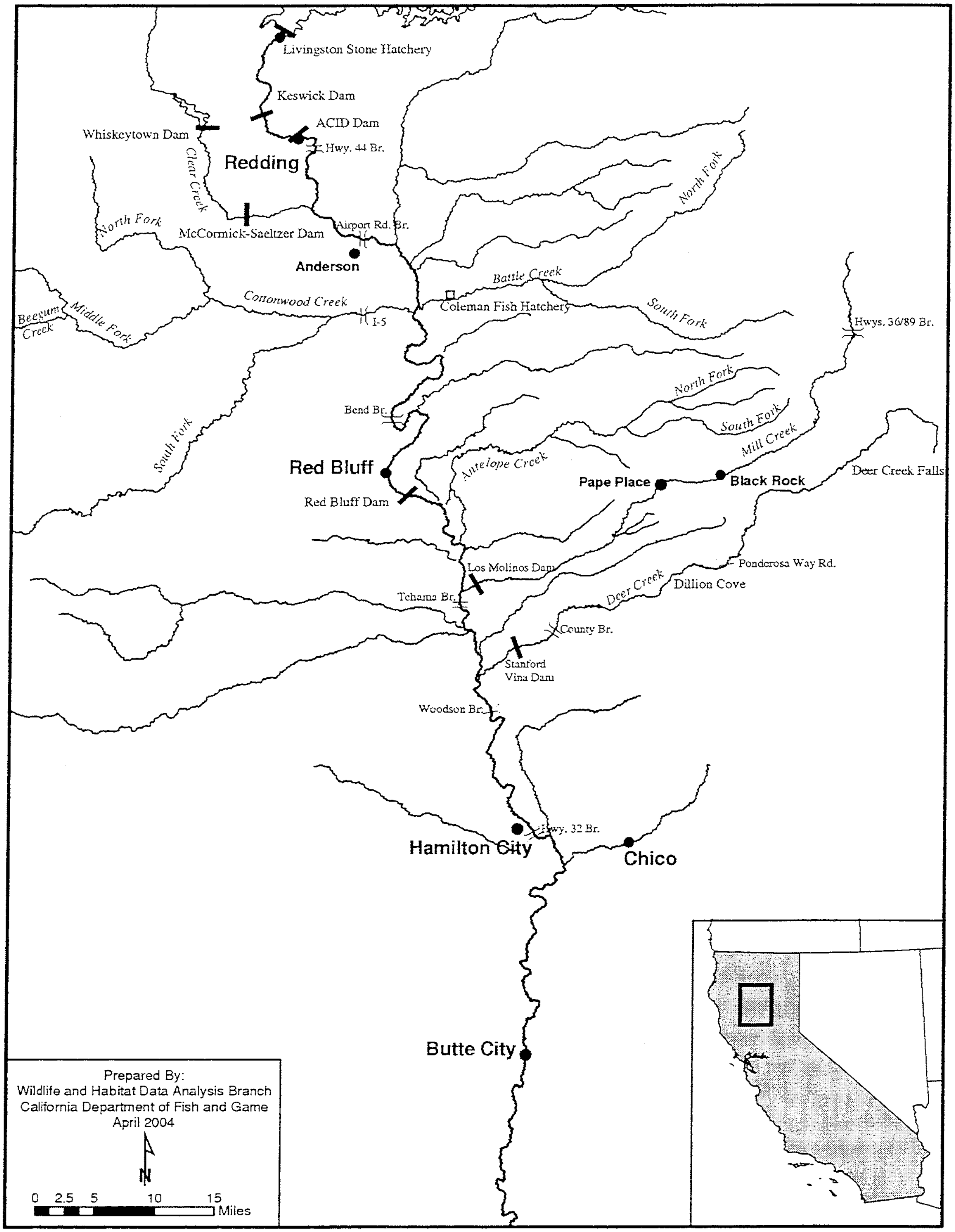

FIGURE 2. Upper Sacramento River System.

Only the mark-and-recovery data for carcasses of natural-origin females classified as adults (Fork length [FL] ≥ 61 cm [24 in]) were used to calculate an estimate. A total of 718 fresh and decayed carcasses was tagged, and 402 of those were subsequently recovered (Table 1), resulting in a estimate of 3,118 adult female fish in the surveyed area upstream of Clear Creek.

TABLE 1. Chinook salmon fresh and decayed carcass mark-and-recovery data used to estimate the 2004 late-fall-run adult female spawner population in the Sacramento River from the Anderson-Cottonwood Irrigation District Dam to the powerlines downstream of Clear Creek [1/].

Survey Period	Carcasses Recovered from Period: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Marked Carcasses Recovered (R_i) [2]	(K_i) [3]	Carcasses Observed (E_i) [4]	Estimate for Period (Ni)	(Di) [6]
1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	–	28	606	524
2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	4	102		490
3	3	18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	21	10	312		400
4	1	3	49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	53	49	277		267
5		5	36	64	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	105	30	429		223
6		1	4	17	84	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	106	21	328		147
7			2	2	11	34	–	–	–	–	–	–	–	–	–	–	–	–	–	–	49	22	139		125
8			1	2	0	6	6	–	–	–	–	–	–	–	–	–	–	–	–	–	15	20	62		96
9				0	2	9	7	10	–	–	–	–	–	–	–	–	–	–	–	–	28	2	123		36
10				0		1			0	–	–	–	–	–	–	–	–	–	–	–	1	1	9		-4
11				0						0	–	–	–	–	–	–	–	–	–	–	0	1	0		0
12				0							0	–	–	–	–	–	–	–	–	–	0	1	0		1
13				0								0	–	–	–	–	–	–	–	–	0	1	1		38
14				0									0	–	–	–	–	–	–	–	0	1	28		9
15				1										4	–	–	–	–	–	–	5	1	23		33
16														1	3	–	–	–	–	–	4	1	25		29
17															0	1	–	–	–	–	1	1	12		156
18															0		0	–	–	–	0	3	23		-72
19															1		1	1	–	–	3	2	16		11
20																	0	1	0	–	1	1	11		1
21																	1			1	2	6	2		0
22																				2	2	4	2		0
23																				4	4	–	4		
																				Totals:	402		1,956		
Total recovered (C_i) [7]:	6	27	92	86	97	50	13	10	0	0	0	0	0	5	4	1	2	2	0	7					
Total marked	26	66	135	124	138	97	37	17	32	2	0	0	0	10	6	9	6	5	2	6	718 (Grand total marked)				
																					Jolly-Seber estimate [9/]:			**3,118**	

1 Surveys were conducted from 15 December 2003 through 24 May 2004. Data shown from D. Killam, CDFG-NCNCR, Red Bluff office. Personal communication.
2 Total recovered marked carcasses for the *i* th period
3 Total marked carcasses recovered after the *i* th period, that were marked before the *i* th period.
4 Includes salmon carcasses which were marked, marked carcasses that were recovered, and unmarked carcasses that were chopped.
5 Number of carcasses in the population at the start of survey period 1.
6 Number of carcasses "joining" the population between periods *I* and *I* + *1*.
7 Total recovered marked carcasses that were marked during the *i* th period
8 Number of carcasses marked in the *i* th period
9 $= N_1 + D_1 + D_2 + \dots D_i$ (Appendix 1.C). Total shown may be different than the sum of actual numbers shown due to spreadsheet calculations and rounding to whole number.

Since the estimate from the Jolly-Seber calculations represented only a portion of the adult female population in the mainstem late-fall run, expansions/extrapolations were made to obtain the total in-river spawner population (Table 2).

- As only the mark-and-recovery data for natural-origin carcasses were used, the estimated number of adult female fish in the survey area was expanded to include those of hatchery origin. Based on the relationship of 359 fresh female carcasses observed in the survey, eight of which were of hatchery origin, the Jolly-Seber estimate was expanded to 3,189 adult females within the carcass survey area.

- The number of adult females in the survey area was then extrapolated to the entire mainstem through aerial redd count data. Using the relationship of 458 total redds observed in the mainstem, of which 422 were in the carcass survey area, it was calculated that 273 fish were outside the area, resulting in 3,462 total adult females for the entire mainstem.

TABLE 2. Estimated Components of the 2004 Late-Fall-run Salmon Population in the Mainstem Sacramento River.

Adult Female Salmon		
Within Carcass Survey Area		
Natural-origin spawners [1/]	3,118	
Natural and Hatchery-origin spawners [2/]		3,189
Mainstem Outside Carcass Survey Area [3/]		273
Total Adult Females:		**3,462**
Total Adult Male Salmon [4/]:		**5,069**
Total Grilse Female Salmon [5/]:		**29**
Total Grilse Male Salmon [6/]:		**205**
TOTAL RUN:		**8,765**

1/ Jolly-Seber estimate calculated using mark-recovery data of natural-origin (non-adipose-fin-clipped) adult female salmon carcasses.
2/ Expansion of Jolly-Seber estimate to include hatchery-origin (adipose fin-clipped) fish.
3/ Estimate derived from number of female salmon within the carcass survey area, based on relative proportions of redds.
4/ Estimate derived from number of total adult females, based on female-male proportions at Keswick Dam.
5/ Estimate derived from number of total adult females, based on adult-grilse porportions in the carcass survey.
6/ Estimate derived from number of total adult males, based on adult-grilse porportions in the carcass survey.

- An estimate of adult male salmon was derived from the total number of adult females using the late-fall-run male-to-female sex-ratio at the Keswick Dam trapping station. Based on the 41 males and 28 females observed, it was calculated that a total of 5,069 adult males were in the mainstem.

- Estimates of grilse (FL < 61 cm) salmon for each gender were derived from the respective total numbers of adults using the proportions of grilse and adults observed in fresh carcasses sampled during the survey. Based on the female salmon relationship of three grilse and 359 adults, 29 total female grilse were calculated. Likewise, based on the male salmon relationship of nine grilse and 222 adults, a total of 205 male grilse was estimated.

Combining the estimates for each sex-age component of the run, 8,765 salmon spawned in the mainstem. All of these spawners were upstream of Red Bluff Diversion Dam (RBDD), since during four aerial surveys conducted from 5 January through 15 April 2004, no late-fall-run redds were observed downstream (Table 3). An additional 59 fish were transferred from Keswick Dam to Coleman National Fish Hatchery (CNFH), resulting in a total 8,824 late-fall-run salmon for 2004 (Appendix 2).

The late-fall-run population consisted of 36% male adults, 24.6% female adults, 1.5% male grilse, and 0.2% female grilse.

TABLE 3. Chinook salmon redd relative distribution observed during 2004 aerial surveys of the mainstem Sacramento River from Keswick Dam to Princeton Ferry.

River section	Late-fall run Redds counted 1/	Late-fall run Proportional distribution	Winter run Redds counted 2/	Winter run Proportional distribution	Spring run Redds counted 3/	Spring run Proportional distribution	Fall run Redds counted 4/	Fall run Proportional distribution
Keswick Dam to A.C.I.D. Dam 5/	385	84.1%	102	16.4%	0	0.0%	160	9.9%
A.C.I.D. Dam to Highway 44 Bridge	16	3.5%	215	34.6%	12	27.3%	70	4.3%
Highway 44 Bridge to Airport Road Bridge	27	5.9%	302	48.6%	30	68.2%	92	5.7%
Airport Road Bridge to Balls Ferry Bridge	28	6.1%	2	0.3%	0	0.0%	366	22.7%
Balls Ferry Bridge to Battle Creek	2	0.4%	0		2	4.5%	208	12.9%
Battle Creek to Jellys Ferry Bridge	0		0		0		201	12.4%
Jellys Ferry Bridge to Bend Bridge	0		0		0		85	5.3%
Bend Bridge to Red Bluff Dam	0		0		0		79	4.9%
Upstream proportion:		**100.0%**		**100.0%**		**100.0%**		**78.1%**
Red Bluff Dam to Tehama Bridge	0		0		0		176	10.9%
Tehama Bridge to Woodson Bridge	0		0		0		57	3.5%
Woodson Bridge to Hamilton City Bridge	0		0		0		81	5.0%
Hamilton City Bridge to Ord Ferry Bridge	0		0		0		36	2.2%
Ord Ferry Bridge to Princeton Ferry	0		0		0		4	0.2%
Downstream proportion:								**21.9%**
Total Redds:	**458**		**621**		**44**		**1,615**	

1/ Total count of new redds for four aerial surveys made from 5 January through 15 April 2004.
2/ Total count of new redds for 12 aerial surveys made from 29 April through 25 August 2004.
3/ Total count of new redds for four aerial surveys made during 1-29 September 2004.
4/ Total count of new redds for four aerial surveys made from 5 October through 30 November 2004.
5/ Anderson-Cottonwood Irrigation District Dam.

The 2004 late-fall-run population of 8,824 fish for the Sacramento River mainstem upstream of RBDD was 65% higher than that of 2003, but only 46% of the population average for 1998-2003; during that period estimates were also determined using carcass survey and redd data (Appendix 3).

Winter run. The winter-run spawner population was estimated through a combination of salmon carcass surveys in a portion of the Sacramento River mainstem, aerial redd surveys of the entire mainstem, and data from sampling salmon at Keswick Dam. Carcass surveys, conducted by CDFG and the U.S. Fish and Wildlife Service's Red Bluff Fish and Wildlife Office (FWS-RBFWO), covered the 46-km (28.6-mi) stretch of the mainstem from Keswick Dam downstream to the mouth of Cottonwood Creek [3/]. The study area was divided into four reaches, which were surveyed during 30 April through 3 September 2004. The two upstream-most reaches (from Keswick Dam to the Hwy-44 bridge) were both sampled on the same day throughout the period. Surveys in the downstream reach (Anderson Mill riffle to Cottonwood Creek) began on 10 June. Mean survey-period river flow averaged 355 m^3/s (12,537 cfs), ranging from 227 m^3/s to 462 m^3/s (8053–16,309 cfs) at Keswick Dam. Mean survey-period temperature averaged 11.8 °C (53.3 °F), ranging from 11 °C to 13.9 °C (50 – 57°F). Water clarity, measured by secchi disk, averaged 3.7 m (12 ft), ranging from 2.6 m to 4.9 m (8.5-16 ft).

[3/] Killam, D. Sacramento River Winter-run Chinook Salmon Escapement Survey, April - September 2004. Technical Report No. 06-1. Revised February 2006. CDFG-NCNCR, SRSSAP.

Most of the surveys were conducted from two boats, each with at least two observers, and generally covered opposite shorelines out to the middle of the river. Collected carcasses were categorized as being either in fresh or decayed condition, and either from a fish of hatchery or natural origin. Fresh carcasses were those having at least one clear eye and reddish colored gills. A carcass of hatchery origin was identified by a missing adipose fin. Livingston Stone National Fish Hatchery (LSNFH) had been the exclusive winter-run salmon rearing facility in the upper Sacramento river system since 1998, and all of its juvenile fish were released with adipose fin-clips, and coded-wire tags (identifying their race, age, and origin) implanted in their snouts. It was therefore assumed that any carcasses with adipose fins intact were winter-run salmon produced from in-river (natural) spawning. Length measurements, determination of gender, and female degree of egg retention were also obtained.

For estimation of the spawner population, carcasses were marked with colored plastic attached with hog rings; color was used to identify the survey period that the carcass was tagged. Fresh carcasses were tagged in the upper jaw, and decayed carcasses were tagged in the lower jaw. Hatchery-origin carcasses were excluded from marking, since their heads were removed and saved for retrieval of the coded-wire tag. Other carcasses not marked, usually those in an advanced state of decay, were chopped in half. Carcasses were returned to flowing water near the location where they were originally found, in an attempt to simulate "natural" carcass dispersion. During subsequent surveys, previously marked carcasses that were recovered were also chopped.

The carcass processing protocols were intended to allow post-season distinction of age-class (adult or grilse, based on length), condition (fresh or decayed), and origin (hatchery or natural), so the data could be better compiled for estimating the population through several biometric models. Analysis of the data indicated the Jolly-Seber model (Appendix 1.C) was the most appropriate.

A total of 3,280 individual salmon carcasses was observed, but only the mark-and-recovery data for those of natural-origin females classified as adults (FL $\geq$ 61 cm [24 in]) were used to calculate an estimate. A total of 1,436 of these, both fresh and decayed carcasses, was tagged, and 828 were subsequently recovered, resulting in an estimate of 3,025 adult female fish in the surveyed area (Table 4).

Since the estimate from the Jolly-Seber calculations represented only a portion of the adult female population in the mainstem winter run, expansions/extrapolations were made to obtain the total in-river spawner population (Table 5).

- As only the mark-and-recovery data for natural-origin carcasses were used, the estimated number of adult female fish in the survey area was expanded to include those of hatchery origin. Based on the relationship of 1,058 fresh female carcasses observed in the survey, of which 74 were of hatchery origin, the Jolly-Seber estimate was expanded to 3,252 adult females within the carcass survey area.

- Extrapolation of the number of adult females in the survey area to that for the entire mainstem was not necessary, since aerial surveys revealed that all of the mainstem redds were within the carcass survey area. It was assumed that no fish spawned outside the survey area, and the 3,252 adult females was the total for the entire mainstem.

TABLE 4. Chinook salmon fresh and decayed carcass mark-and-recovery data used to estimate the 2004 winter-run natural-origin adult female spawner population in the Sacramento River between Keswick Dam and the mouth of Cottonwood Creek 1/.

Survey Period	Carcasses Recovered from Period:																																						Marked Carcasses Recovered		Carcasses Observed	Estimate for 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	(R_i) 2/	(K_i) 3/	(E_i) 4/	(N1) 5/	(Di) 6/
1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	–	7	11	5
2	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	0	7	–	4
3		1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	3	–	2
4		1	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	0	4	–	2
5				2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	0	3	–	1
6					0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1	1	–	2
7					0	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	3	–	8
8					0		0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1	4	–	7
9					0			1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	7	–	9
10					0				1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	6	–	24
11					0				1	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	4	10	–	11
12					0					2	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	3	23	–	35
13					1					0	0	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	5	15	–	7
14										1	1	0	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	5	15	–	45
15												1	1	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	3	29	–	29
16												0	0		6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	4	24	–	88
17												0	0		0	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	6	43	–	45
18												2	0		1	0	12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15	11	50	–	117
19													0			0	4	12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	16	9	80	–	88
20													1			1	1	1	27	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	31	12	102	–	201
21																1	0	0	2	28	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	31	23	131	–	145
22																	1	0	0	6	34	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	41	37	128	–	330
23																	0	1	1	4	6	20	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	32	41	156	–	161
24																	0		1	2	3	6	50	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	62	54	207	–	279
25																	0		1	0	2	7	11	47	–	–	–	–	–	–	–	–	–	–	–	–	–	–	68	63	235	–	267
26																	1		1	2	5	2	5	9	62	–	–	–	–	–	–	–	–	–	–	–	–	–	87	61	285	–	235
27																	0		1		1	0	3	7	8	55	–	–	–	–	–	–	–	–	–	–	–	–	75	70	229	–	215
28																	1				2	1	1	2	6	12	46	–	–	–	–	–	–	–	–	–	–	–	71	74	211	–	262
29																					1		3	3	4	4	9	29	–	–	–	–	–	–	–	–	–	–	53	75	181	–	51
30																					0		2	5	2	3	5	10	26	–	–	–	–	–	–	–	–	–	53	67	147	–	116
31																					1			3	0	5	6	3	8	17	–	–	–	–	–	–	–	–	43	54	128	–	45
32																								0	1	3	3	5	3	6	14	–	–	–	–	–	–	–	35	38	97	–	157
33																								1	0	0	2	0	2	1	1	7	–	–	–	–	–	–	14	36	56	–	-15
34																									1	0	1	4	1	0	2	3	5	–	–	–	–	–	17	29	52	–	-26
35																									0	2	1	2	2	3	1	0	4	3	–	–	–	–	18	15	40	–	30
36																									1		2	1	3	2	0	1	1	0	2	–	–	–	13	5	43	–	21
37																														0	1	0		0	1	5	–	–	7	4	24	–	5
38																														1		1		0		0		–	2	2	9	–	5
39																																		1		0			1	1	7	–	1
40																																				1			1	–	3	–	–
Total recovered (C_i) 7/:	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	828 (Grand total recovered)				
Total marked (Ti) 8/:	5	4	0	3	1	1	1	2	4	3	8	12	11	7	18	16	33	31	56	65	90	77	115	120	142	143	121	101	78	51	38	35	18	9	5	10	1	1	1,436 (Grand total marked)				

Jolly-Seber estimate 9/: 3,025

1/ Surveys were conducted from 30 April through 3 September 2003.
2/ Total recovered marked carcasses for the i th period.
3/ Total marked carcasses recovered after the i th period, that were marked before the i th period.
4/ Includes salmon carcasses which were marked, marked carcasses that were recovered, and unmarked carcasses that were chopped.
5/ Number of carcasses in the population at the start of survey period 1.
6/ Number of carcasses "joining" the population between periods i and i - 1.
7/ Total recovered marked carcasses that were marked during the i th period
8/ Number of carcasses marked in the i th period.
9/ E = N1 + D1 + D2 + ... Dj (Appendix 1.C).

TABLE 5. Estimated Components of the 2004 Winter-run Salmon Population in the Mainstem Sacramento River.

Adult Female Salmon		
Within Carcass Survey Area		
Natural-origin spawners 1/	3,025	
Natural and Hatchery-origin spawners 2/		3,252
Mainstem Outside Carcass Survey Area 3/		0
Total Adult Females:		**3,252**
Total Adult Male Salmon 4/:		**3,052**
Total Grilse Female Salmon 5/:		**40**
Total Grilse Male Salmon 6/:		**1,440**
TOTAL RUN:		**7,784**

1/ Jolly-Seber estimate calculated using mark-recovery data of natural-origin (non-adipose-fin-clipped) adult female salmon carcasses.
2/ Expansion of Jolly-Seber estimate to include hatchery-origin (adipose fin-clipped) fish.
3/ Estimate derived from number of female salmon within the carcass survey area and the relative distribution of mainstem redds.
4/ Estimate derived from number of total adult females, based on female-male proportions at Keswick Dam.
5/ Estimate derived from number of total adult females, based on adult-grilse porportions in the carcass survey.
6/ Estimate derived from number of total adult males, based on adult-grilse porportions in the carcass survey.
7/ Number of fish transferred from Keswick Dam.

- An estimate of adult male salmon (FL $\geq$ 71 cm [28 in]) was derived from the total number of adult females using the winter-run male-to-female sex-ratio at the Keswick Dam trapping station. Based on the 61 males and 65 females observed, it was calculated that a total of 3,052 adult males were in the mainstem.

- Estimates of grilse salmon for each gender were derived from the respective total numbers of adults using the proportions of grilse and adults observed in fresh carcasses sampled during the survey. Based on the female salmon relationship of 13 grilse (FL< 61 cm) and 1,058 adults, 40 total female grilse were calculated. Likewise, based on the male salmon relationship of 150 grilse (FL< 71 cm) and 318 adults, a total of 1,440 male grilse was estimated.

Combining the estimates for each sex-age component of the run, a total of 7,784 salmon spawned in the mainstem. All of these spawners were upstream of RBDD since during 12 aerial surveys conducted from 29 April through 25 August 2004, no winter-run redds were observed in the downstream stretch (Table 3). An additional 85 fish were transferred from Keswick Dam to LSNFH, resulting in a total 7,869 winter-run salmon for 2004 (Appendix 2).

The winter-run population consisted of 39.2% male adults, 41.8% female adults, 18.5% male grilse, and 0.5% female grilse.

The 2004 winter-run spawner population of 7,869 salmon in the mainstem upstream of RBDD was 4% lower than that of 2003. The 2004 population was also over 2¾ times higher than the average for 1994-2003, but estimates previous to 2000 were determined from RBDD counts rather than carcass surveys (Appendix 3).

Spring run. Mainstem spring-run salmon estimates were determined, as in past years, by methodology which involved expansion of sampling the salmon passage at RBDD during mid-May through mid-September. This interval was when the dam's gates were lowered, and its fishways were operable. Briefly, numbers of salmon counted weekly during discrete periods were adjusted for unsampled periods, then apportioned to an individual run. The total of a run's adjusted counts was further expanded using historical distributions of migration past RBDD. For the spring run this distribution was an average run timing from year-round samplings during 1970-1988. Expansion to include passage during the gates-up period in 2004 assumed that the total adjusted count represented the same proportion of the run as the period's historical distribution. The mainstem-only spawner population was calculated by removing estimated populations for upstream tributaries from the run's total estimated RBDD passage.

An estimated 575 salmon with spring-run characteristics passed RBDD in 2004 [4/]. Cottonwood, Clear, and Battle creeks accounted for 181 fish in the tributaries, so 394 fish were the mainstem spawner population. During aerial surveys conducted on 1-29 September 2004, spring-run redds were not observed downstream of RBDD (Table 3), and it was assumed that there were no spawners of this run in that area.

[4/] Killam, D., and C. Harvey-Arrison. Chinook Salmon Populations for the Upper Sacramento River Basin, 2004. Technical Report No. 05-2. Revised February 2006. CDFG-NCNCR, SRSSAP.

The spring run consisted of 29.7% male adults, 16.7% female adults, and 53.6% grilse, based on samplings at RBDD.

The mainstem spawner population was 25% lower than the average for 1994-2003 (Appendix 3).

Fall run. The fall-run spawner population was estimated through a combination of salmon carcass surveys in a portion of the mainstem, aerial redd surveys of the entire mainstem, and data from sampling salmon at RBDD. Carcass surveys covered the 15.6-km (9.7-mi) stretch of the mainstem between ACID and the powerlines just downstream of Clear Creek [5/].

Surveys were conducted from boats, or on foot along the shore, during which salmon carcasses were collected. Before further processing carcasses were categorized as being either in fresh or decayed condition, and either from a fish of hatchery or natural origin. Fresh carcasses were those having at least one clear eye and reddish colored gills. Carcasses of hatchery origin were identified by missing adipose fins, indicating the possible presence of a coded-wire tag in its snout, inserted when the fish was a juvenile in the hatchery. It was assumed that any carcasses with adipose fins intact were salmon produced from in-river (natural) spawning. Length measurements, determination of gender, and female degree of egg retention were also recorded.

For estimation of the spawner population, carcasses were marked with numbered tags attached with hog rings. Fresh carcasses were tagged in the upper jaw, and decayed carcasses were tagged in the lower jaw. Hatchery-origin carcasses were excluded from marking, since their heads were removed and saved for retrieval of the coded-wire tag. Other carcasses not marked, usually those in an advanced state of decay, were chopped in half. Carcasses were returned to flowing water near the location where they were originally found, in an attempt to simulate "natural" carcass dispersion. During subsequent surveys, previously marked carcasses that were recovered were also chopped.

The carcass processing protocols were intended to allow post-season distinction of age-class (adult or grilse, based on length), condition (fresh or decayed), and origin (hatchery or natural), so the data could be better compiled for estimating the population through several biometric models. Analysis of the data indicated the Jolly-Seber model (Appendix 1.C) was the most appropriate.

Only the mark-and-recovery data for fresh carcasses of natural-origin female adults were used for calculation of an estimate. From a total of 736 carcasses marked, and 299 subsequently recovered, an adult female population of 3,297 fish was estimated (Table 6).

Since the estimate from the Jolly-Seber calculations represented only a portion of the adult female population in the mainstem fall run, expansions/extrapolations were made to obtain the total in-river spawner population (Table 7).

[5/] Killam, D., and C. Harvey-Arrison. Chinook Salmon Populations for the Upper Sacramento River Basin, 2004. Technical Report No. 05-2. Revised February 2006. CDFG-NCNCR, SRSSAP.

- As only the mark-and-recovery data for natural-origin carcasses were used, the estimated number of adult female fish in the survey area was expanded to include those of hatchery origin. Based on the relationship of 395 fresh female carcasses observed in the survey, of which 31 were of hatchery origin, the Jolly-Seber estimate was expanded to 3,578 adult females within the carcass survey area.

- The survey area adult females was extrapolated to the entire mainstem through aerial redd count data. Using the relationship of 1,615 total redds observed in the mainstem, of which 311 were in the carcass survey area, it was calculated that 15,002 fish were outside the area, resulting in 18,580 total adult females for the entire mainstem.

- An estimate of adult male salmon was derived from the total number of adult females using the fall-run male-to-female sex-ratio at the RBDD trapping station. Based on the 225 males and 210 females observed, it was calculated that a total of 19,907 adult males were in the mainstem.

- Estimates of grilse salmon for each gender were derived from the respective total numbers of adults using the proportions of grilse and adults observed in fresh carcasses sampled during the survey. Based on the female salmon relationship of 12 grilse and 395 adults, 564 total female grilse were calculated. Likewise, based on the male salmon relationship of 43 grilse and 188 adults, 4,553 male grilse were estimated.

Combining the estimates for each sex-age component of the run, a total of 43,604 salmon spawned in the mainstem. Based on four aerial surveys conducted during 5 October through 30 November 2004, fall-run redds upstream and downstream of RBDD constituted about 78.1% and 21.9%, respectively, of the total mainstem spawning (Table 3). This represented a population distribution of 34,050 fish upstream of RBDD and 9,554 fish downstream (Appendix 2).

The fall-run spawner population consisted of 45.7% male adults, 42.6% female adults, 10.4% male grilse (FL $\leq$ 61 cm), and 1.3% female grilse

The 2004 fall-run spawner population in the mainstem upstream of RBDD was about 49% lower than that in 2003, and 61% of the average population for 1994-2003. The downstream population was about 42% of that in 2003, and 74% of its 1994-2003 average (Appendix 3).

TABLE 6. Chinook salmon fresh carcass mark-and-recovery data used to estimate the 2004 fall-run natural-origin female adult spawner population in the Sacramento River from Anderson-Cottonwood Irrigation District Dam to the powerlines downstream of Clear Creek 1/.

Survey Period	Carcasses Recovered from Period: 1	2	3	4	5	6	7	8	9	10	11	12	13	Marked Carcasses Recovered (R_i) 2/	(K_i) 3/	Carcasses Observed (E_i) 4/	Estimate for Period (N1) 5/	(Di) 6/
1	--	--	--	--	--	--	--	--	--	--	--	--	--	0	--	4	4	0
2	0	--	--	--	--	--	--	--	--	--	--	--	--	0	0	4	--	19
3		0	--	--	--	--	--	--	--	--	--	--	--	0	0	19	--	229
4			1	--	--	--	--	--	--	--	--	--	--	1	4	40	--	31
5			3	12	--	--	--	--	--	--	--	--	--	15	1	101	--	542
6			1		3	--	--	--	--	--	--	--	--	4	15	64	--	347
7					14	17	--	--	--	--	--	--	--	31	11	342	--	528
8					1	7	55	--	--	--	--	--	--	63	25	361	--	347
9						1	20	34	--	--	--	--	--	55	20	288	--	338
10						2	2	14	30	--	--	--	--	48	14	272	--	347
11								1	7	15	--	--	--	23	17	163	--	235
12								1	5	11	15	--	--	32	10	191	--	301
13											5	2	--	7	13	60	--	4
14											5	7	5	17	3	92	--	25
15												1	2	3	--	45	--	
													Total:	299		2,046		
Total recovered (C_i) 7/:	0	0	5	12	18	27	77	50	42	26	25	10	7					
Total marked (Ti) 8/:	1	4	13	27	70	45	163	120	87	67	61	56	22	736 (Grand total marked)				

Jolly-Seber estimate 9/: 3,297

1/ *Data shown from D. Killam, CDFG-NCNCR, Red Bluff office.* Personal communication.
2/ Total recovered marked carcasses for the ith period
3/ Total marked carcasses recovered after the ith period, that were marked before the ith period.
4/ Includes salmon carcasses which were marked, marked carcasses that were recovered, and unmarked carcasses that were chopped.
5/ Number of carcasses in the population at the start of survey period 1.
6/ Number of carcasses "joining" the population between periods I and I + 1.
7/ Total recovered marked carcasses that were marked during the ith period
8/ Number of carcasses marked in the ith period.
9/ $E = N_1 + D_1 + D_2 + \ldots D_i$ (Appendix 1.C).

TABLE 7. *Estimated Components of the 2004 Fall-run Salmon Population in the Mainstem Sacramento River.*

Adult Female Salmon		
Within Carcass Survey Area		
Natural-origin spawners 1/	3,297	
Natural and Hatchery-origin spawners 2/		3,578
Mainstem Outside Carcass Survey Area 3/		15,002
Total Adult Females:		**18,580**
Total Adult Male Salmon 4/:		**19,907**
Total Grilse Female Salmon 5/:		**564**
Total Grilse Male Salmon 6/:		**4,553**
TOTAL RUN:		**43,604**

1/ Jolly-Seber estimate calculated using mark-recovery data of non-adipose-fin-clipped adult female salmon carcasses.
2/ Expansion of Jolly-Seber estimate to include hatchery-origin (adipose fin-clipped) fish.
3/ Estimate derived from number of female salmon in the carcass survey area, based on relative proportions of redds.
4/ Estimate derived from number of total adult females, based on female-male proportions at Keswick Dam.
5/ Estimate derived from number of total adult females, based on adult-grilse porportions in the carcass survey.
6/ Estimate derived from number of total adult males, based on adult-grilse porportions in the carcass survey.

Sacramento River Tributaries
Keswick Dam to Red Bluff Diversion Dam

In 2004, a total of 103,679 salmon was estimated for the Sacramento River system tributaries upstream of RBDD, consisting of 98,458 fall-, 5,040 late-fall-, and 181 spring-run fish. Clear and Battle creeks were the only tributaries in this area for which individual fall-run population estimates were made.

Clear Creek

Late-fall run. No surveys were conducted for this run in 2004.

Spring run. Based on a snorkeling survey conducted by the FWS-RBFWO during August, which was regarded as an index of annual adult abundance, the spring-run spawner population was judged to be 98 salmon [6/].

Fall run. Nine spawner surveys of Clear Creek were conducted during 12 October through 6 December 2004, in the 6.7-km (4.2-mi) stretch downstream from the former location of the McCormick-Saeltzer Dam [6/]. Salmon carcasses were marked by attaching colored tags to their jaws with hog rings, and replacing them back into running water for recovery during following surveys; different colors were used to identify carcasses with distinct marking periods.

Using fresh carcass mark-and-recovery data with the Schaefer model (Appendix 1.B), the spawner population in Clear Creek was estimated to be 6,365 fish (Table 8).

Based on examination of 3,225 salmon carcasses, the fall-run spawner population of Clear Creek consisted of 36% male adults (FL $\geq$ 61 cm [24 in.]), 58% female adults, and 6% grilse (FL < 61 cm).

Cottonwood Creek

Late-fall run. No surveys were conducted for this run in 2004.

Spring run. Four surveys were conducted for this run in Beegum Creek, a tributary to Cottonwood Creek [6/]. A total of 17 salmon was counted, and judged to constitute the 2004 spring run for the Cottonwood Creek system.

Fall run. No surveys were conducted for this run in 2004.

[6/] Killam, D., and C. Harvey-Arrison. Chinook Salmon Populations for the Upper Sacramento River Basin, 2004. Technical Report No. 05-2. Revised February 2006. CDFG-NCNCR.

TABLE 8. Chinook salmon fresh carcass mark-and-recovery data used to estimate the 2004 fall-run spawner population of Clear Creek in the reach from McCormick-Saeltzer Dam to 4.2 miles downstream.

Recovery period (j):	Number of marked carcasses recovered from marking period (i): 12-Oct	18-Oct	25-Oct	1-Nov	8-Nov	15-Nov	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) 1/	Population estimate (N) 2/
18-Oct	14	--	--	--	--	--	14	306	682
25-Oct	7	49	--	--	--	--	56	717	1,224
1-Nov	1	9	86	--	--	--	96	808	1,492
8-Nov		9	31	92	--	--	132	953	1,652
15-Nov		1	7	18	36	--	62	394	786
22-Nov			0	2	14	15	31	159	362
29-Nov			1	1	11	12	25	203	665
6-Dec					1	2	3	73	245
Total recovered (Ri):	22	68	125	113	62	29			
Total carcasses marked (Mi):	49	111	233	192	135	71		Total estimate:	7,107
								Adjusted estimate 3/:	**6,365**

1/ Includes salmon carcasses which were marked and marked carcasses that were recovered.
2/ Schaefer (1951) estimate equation: N = SUM(Rij x (Mi/Ri) x (Cj/Rj)) .
3/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (7,107 - 742 = 6,365).

Battle Creek

Late-fall run. No surveys were made for late-fall-run salmon spawning naturally in Battle Creek during 2004. The only available spawner data were for 5,040 salmon which entered CNFH [7/]. These fish consisted of 39.5% male adults, 33.6% female adults, and 26.9% grilse.

Spring run. Based on FWS-RBFWO fish passage monitoring conducted at the CNFH barrier weir, it was estimated that 66 spring-run adult salmon passed upstream of the barrier weir [8/].

Fall run. Carcass surveys were conducted during 14 October through 9 December 2004, covering the 5.6-km (3.5-mi) stretch of river from CNFH downstream to the old hatchery location [8/]; Grover's Ditch was also surveyed. Salmon carcasses were marked by attaching colored tags to their jaws with hog rings, and placed into running water for recovery; different colors were used to identify carcasses with distinct marking periods.

Using fresh carcass mark-and-recovery data with the Schaefer model (Appendix 1.B), the spawner population in the surveyed sections was estimated to be 23,861 fish (Table 9). Combined with an additional 68,232 fish which entered CNFH, the total Battle Creek fall-run population was 92,093 salmon (Appendix 2).

[7/] Null, R. USFWS, RBFWO. Personal communication.

[8/] Killam, D., and C. Harvey-Arrison. Chinook Salmon Spawner Populations for the Upper Sacramento River Basin, 2004. Technical Report No. 05-2. Revised February 2006. CDFG-NCNCR, SRSSAP.

TABLE 9. Chinook salmon carcass mark-and-recovery data used to estimate the 2004 fall-run spawner population in Battle Creek from Coleman National Fish Hatchery to the old hatchery location.

Recovery period (j):	Number of marked carcasses recovered from marking period (i): 14-Oct	21-Oct	28-Oct	4-Nov	9-Nov	18-Nov	24-Nov	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [1/]	Population estimate (N) [2/]
21-Oct	91	--	--	--	--	--	--	91	1,915	2,807
28-Oct	12	127	--	--	--	--	--	139	3,324	7,102
4-Nov		17	141	--	--	--	--	158	3,113	5,979
9-Nov		5	34	105	--	--	--	144	1,693	2,932
18-Nov		1	8	29	51	--	--	89	1,725	3,421
24-Nov			1	5	16	78	--	100	737	1,282
1-Dec			0	2	6	15	62	85	588	1,174
9-Dec			2			5	7	14	187	542
Total recovered (Ri):	103	150	186	141	73	98	69			
Total carcasses marked (Mi):	151	330	351	234	159	162	143		Total estimate:	25,240
									Adjusted estimate [3/]:	**23,861**

1/ Includes salmon carcasses which were marked and marked carcasses that were recovered.
2/ Schaefer (1951) estimate equation: $N = \sum(R_{ij} \times (M_i/R_i) \times (C_j/R_j))$.
3/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (25,240 - 1,379 = 23,861).

Based on examination of 12,612 salmon carcasses, the in-river fall run consisted of 32% male adults (FL ≥ 61 cm [24 in.]), 62% female adults, and 6% grilse (FL<61 cm). In comparison, fall-run fish entering CNFH consisted of 45% male adults, 31% female adults, and 24% grilse.

Pre-spawning mortality of female fall-run salmon in Battle Creek averaged 16% in 2004.

The 2004 fall-run spawner population in Battle Creek of 92,093 fish was only 60% of that in 2003, and 31% lower than the average population for 1994-2003 (Appendix 3).

Sacramento River Tributaries
Red Bluff Diversion Dam to Princeton Ferry

A total of 3,297 Chinook salmon spawners, consisting of 1,805 spring-, and 1,492 fall-run fish, was estimated for 2004 in the tributaries of the Sacramento River system between Red Bluff and Princeton Ferry (Figure 2).

Antelope Creek

Spring run. A snorkeling-survey of the holding habitat of adult spring-run salmon in the upper Antelope Creek system was made on 26 July 2004 [9/]. A total stream length of 22.5 km (14 mi) was covered, in the mainstem from the confluence of Little Grapevine Creek upstream, to Judd Creek on the North Fork, and into the south fork to South Antelope Gun Club. A total of

[9/] Harvey-Arrison, C. 2004 Antelope Creek Spring-run Chinook Salmon Survey. Memorandum to files. 14 March 2005. CDFG – NCNCR, SRSSAP.

three adult salmon was observed, and judged to be the 2004 spring run for this system; all fish were observed in the mainstem upstream of Paynes crossing.

Fall run. No surveys were conducted for this run in 2004.

Mill Creek

Spring run. Surveys of Upper Mill Creek covered a stream length of approximately 66 km (41 mi) from just upstream of the Hwy-36 Bridge crossing downstream to the steel tower transmission line crossing, located 4.8 km (3 mi) downstream from the mouth of Little Mill Creek [10/]. The reach from Hwy-36 to Buckhorn Gulch was surveyed from the ground during 29 September through 7 October 2004, while an aerial survey was made from Buckhorn Gulch to the powerlines on 27 September. Totals of 88 live fish, 50 carcasses, and 499 redds were observed. Based on the redds seen during the combined ground and aerial surveys, the total counted was determined to be the maximum number present, and judged to represent a spring-run population of 998 fish.

Fall run. Four weekly spawner surveys of Mill Creek were conducted from 4 km (2.5 mi) upstream of the Los Molinos Mutual Water Company's Upper Diversion Dam to the confluence with the Sacramento River during 5-29 November 2004 [10/]. Salmon carcasses were marked by attaching colored tags to their jaws with a hog-rings and replacing the fish back into running water for recovery during following surveys. Using carcass mark-and-recovery data with the Schaefer (Appendix 1.B) model, the spawner population in Mill Creek was estimated to be 1,192 fish (Table 10).

The composition of natural spawning fall-run salmon in Mill Creek was 42% male adults (FL ≥ 61cm, [24 in], 41% female adults and 17% grilse (FL < 61cm), based on an examination of 405 carcasses. Pre-spawning mortality of female salmon in Mill Creek this season averaged 2%.

TABLE 10. Chinook salmon carcass mark-and-recovery data used to estimate the 2004 fall-run spawner population in Mill Creek from the Upper Diversion Dam to the Sacramento River.

Recovery period (j):	Number of marked carcasses recovered from marking period (i): 5-Nov	12-Nov	19-Nov	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) 1/	Population estimate (N) 2/
12-Nov	5	--	--	5	131	415
19-Nov	6	12	--	18	165	371
29-Nov	1	2	8	11	105	475
Total recovered (Ri):	12	14	8			
Total carcasses marked (Mi):	38	25	43		Total estimate:	1,260
					Adjusted estimate 3/:	**1,192**

1/ Includes salmon carcasses which were marked and marked carcasses that were recovered.
2/ Schaefer (1951) estimate equation: $N = \sum(Rj \times (Mi/Ri) \times (Cj/Rj))$.
3/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (1,260 - 68 = 1,192).

[10/] Harvey-Arrison, C. Mill Creek Spring- and Fall-run Chinook Escapement Surveys for 2004. Memorandum to files. 14 March 2005. CDFG – NCNCR, SRSSAP.

Deer Creek

Spring run . Snorkeling surveys of upper Deer Creek were conducted on 3 August 2004 covering the 35.4-km (22-mi) stretch from Upper Deer Creek Falls downstream to Trail 2E17 [11/]. Surveys only extended to Trail 2E17 since few salmon were observed in the three-mile reach upstream of this point; 98% of the fish were holding in pools upstream of Ponderosa Way. A total of 804 adult salmon was counted, and judged to be the 2004 spring run in this tributary.

During spawning surveys for this run from 7-9 October, 394 redds were observed.

Fall run. Five spawner surveys were conducted during 28 October and 22 November 2004 between the gaging station upstream of the Deer Creek Irrigation District's upper diversion dam and the Southern Pacific Railroad crossing below Highway 99 Bridge [11/]. A total of 131 carcasses and 149 redds were counted. It was judged that at least 300 fish spawned in Deer Creek in 2004; assuming that each redd observed represented at least two salmon (one male and one female).

Based on carcasses examined, the composition of natural spawning fall-run salmon in Deer Creek was 53% male adults (FL $\geq$ 61 cm [24 in]), 36% female adults, and 11% grilse (FL < 61 cm).

Surveys for the fall run in Deer Creek are not routinely made, unless a significant rain event produces increased flows to attract salmon into the tributary. Since 1990, surveys have been conducted for fall-run Chinook only during five years, with estimated populations ranging from around 70 to 1,200 fish.

[11/] Harvey-Arrison, C. 2004 Annual Deer Creek Spring- and Fall-run Chinook Salmon Survey Results. Memorandum to files. 14 March 2005. CDFG – NCNCR, SRSSAP.

Sacramento River Tributaries
Big Chico Creek to the American River

A total of 230,512 Chinook salmon was estimated for 2004 in the Sacramento River tributaries from Big Chico Creek to the American River (Figure 3). This total consisted of 218,910 fall-run and 11,602 spring-run fish (Appendix 2).

Big Chico Creek

Spring run. Snorkeling surveys were conducted on 11 and 13 August 2004 in three reaches of Chico Creek between Higgin's Hole and Salmon Hole [12/]. No adult salmon were observed, and it was judged that spring-run spawners did not use this tributary in 2004.

Fall run. No surveys were conducted for this run in 2004.

Butte Creek

Spring run. A snorkeling survey was conducted during 12-16 July 2004, covering four stretches from Quartz Bowl downstream to Parrott-Phelan Diversion Dam (PPDD) [13/]. Total independent counts of live salmon by four observers ranged from 6,575 to 8,252 fish. All of the fish observed were upstream of the covered bridge. Based on these surveys, a population of 7,390 spring-run salmon were in the creek.

Fall run. Surveys in Butte Creek were conducted during 3 November through 23 December 2004 (McReynolds et. al. 2005). Carcass mark-and-recovery surveys covered the approximately 15.3-km (9.5-mi) stretch of river from PPDD downstream to Gorrill Ranch Dam, and included a 0.8-km (0.5-mi) section near the Western Canal Siphon. Upstream of PPDD, spawning was assessed through observations made by kayak.

Fresh salmon carcasses (those with at least one clear eye and firm flesh) were marked by attaching colored ribbon to their lower jaws with hog rings, and replaced into running water near the location originally found. Different colors of marks were used to identify carcasses with distinct marking periods. Carcasses that were not marked were chopped in half, as were recoveries of previously marked ones.

Using carcass mark-and-recovery data with the Schaefer model (Appendix 1.B), the spawner population in the surveyed sections was estimated to be 2,415 fish (Table 11). Combined with an additional 41 carcasses counted during the initial survey week and 60 fish estimated to be upstream of PPDD, the total fall run population was 2,516 salmon spawners.

[12/] Garmin, C. Big Chico Creek Adult Escapement Estimate. Memorandum to files. 19 August 2004. CDFG-Sacramento Valley and Central Sierra Region (SVCSR), Chico office.

[13/] Garmin, C. Butte Creek Spring-run Chinook Salmon Spawning Escapement Survey, 2004. Memorandum to files. 27 July 2004. CDFG – SVCSR, Chico office.

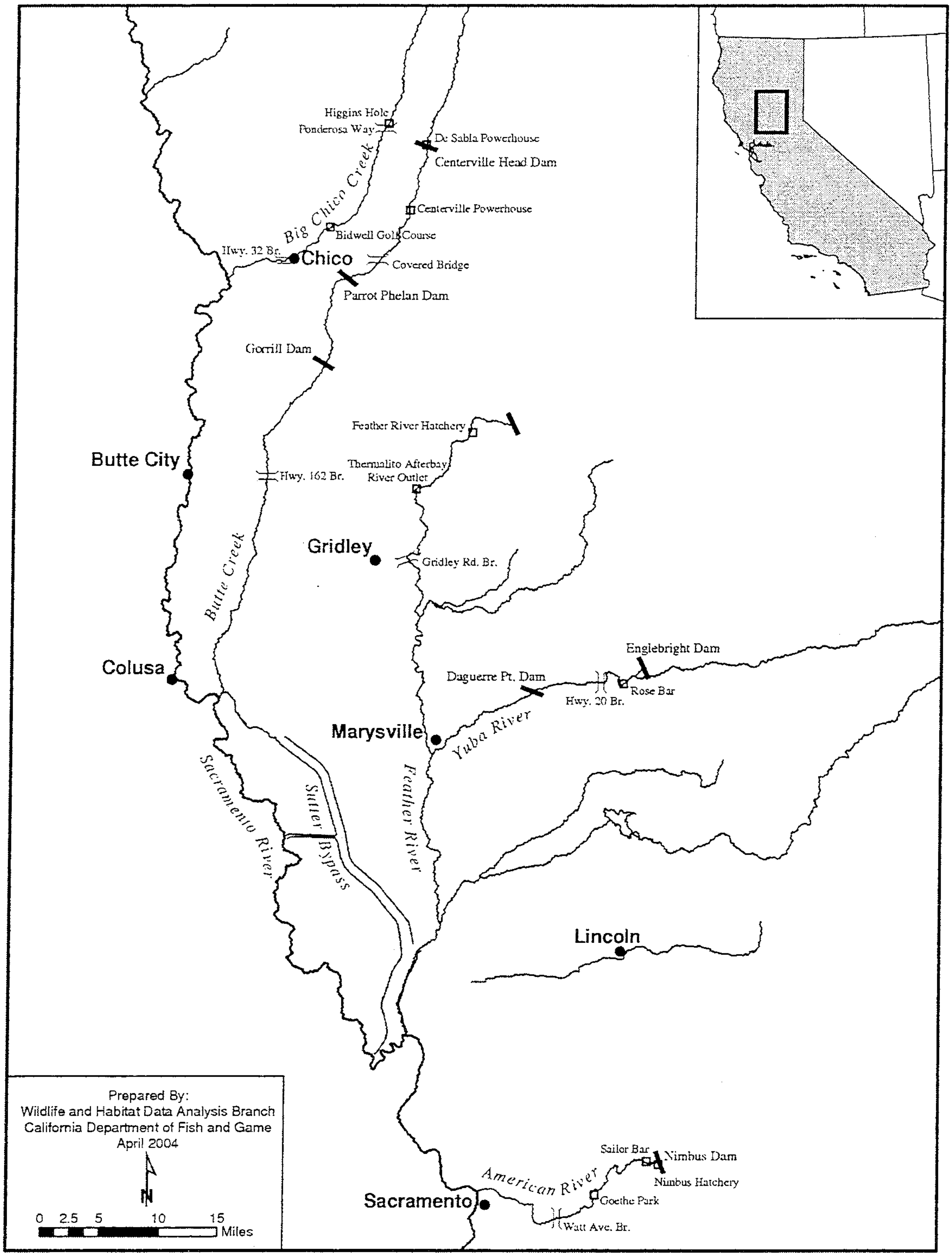

FIGURE 3. Sacramento River System from Big Chico Creek to the American River.

TABLE 11. Chinook salmon carcass mark-and-recovery data used to estimate the 2004 fall-run spawner population in Butte Creek from Parrot-Phelan Diversion Dam to Gorrill Ranch Dam, and in the Western Canal Siphon.

Recovery period (j):	Number of marked carcasses recovered from marking period (i): 3-5 Nov	9-11 Nov	16-18 Nov	22-24 Nov	30 Nov - 16 Dec	21-23 Dec	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) 1/	Population estimate (N) 2/
9-11 Nov	13	--	--	--	--	--	13	204	312
16-18 Nov	3	58	--	--	--	--	61	461	688
22-24 Nov	0	0	75	--	--	--	75	418	556
30 Nov - 16 Dec	1	1	7	24	--	--	33	275	949
21-23 Dec	0	0	0	2	5	--	7	75	230
Total recovered (Ri):	17	59	82	26	5	0			
Total carcasses marked (Mi):	26	88	109	110	13	0		Total estimate:	2,735
								Adjusted estimate 3/:	**2,415**

1/ Includes salmon carcasses which were marked and marked carcasses that were recovered.

2/ Schaefer (1951) estimate equation: $N = \sum(Rij \times (Mi/Rj) \times (Cj/Rj))$.

3/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (2,735 - 320 = 2,415).

Feather River

Spring run. A total of 4,212 salmon classified as spring-run fish entered Feather River Hatchery (FRH), consisting of 50.1% male adults, 36.3% female adults, and 13.6% grilse 14/. In the river itself, no attempt was made to estimate numbers of spring-run salmon.

The 4,212 spring-run salmon at FRH in 2004 was less than half of that in 2003, and 77% of the average for 1994-2003 (Appendix 3).

Fall run. Salmon carcass mark-and-recovery surveys were conducted in the Feather River between the hatchery barrier dam and Gridley Road bridge during 2 September through 17 December 2004 15/. This stretch of river was surveyed in two sections, upstream (Section 1) and downstream (Section 2) of Thermalito Afterbay Outlet. Carcasses were marked with colored flagging, identifying them with a specific marking period, and released into flowing water for later recovery. Carcasses not marked were counted and then chopped in half, as were those that were recovered with previous marks.

Schaefer (Appendix 1.B) estimates, calculated from the mark-and-recovery data, were 36,986 salmon for Section 1, and 17,098 fish for Section 2 (Table 12). Combining both estimates, along with an additional 87 carcasses counted during the initial survey week, resulted in a total in-river population of 54,171 fish. A total of 21,297 fall-run salmon entered FRH 14/, bringing the 2004 fall run in the Feather River to 75,468 fish (Appendix 2).

14/ Kastner, A. CDFG-SVCSR, Feather River Hatchery. Personnel communication.

15/ Seesholtz, A., B. Cavallo, J. Kindopp, and R. Kurth. 2004 Feather River Salmon Spawning Escapement Survey Summary. File report. California Department of Water Resources, Division of Environmental Services (CDWR-DES), Sacramento.

The overall composition of fall-run salmon in the river was 89.7% adults (FL $\geq$ 68 cm [26.8 in]), and 10.3% grilse (FL < 68 cm), based on carcasses examined during the surveys [16/]. Salmon which entered FRH consisted of 40.3% male adults (FL $\geq$ 61 cm [24 in]), 33.7% female adults, and 26% grilse (FL < 61 cm).

The 2004 total Feather River population of 75,468 salmon was 28% lower than in 2003, and 27% lower than the average for 1994-2003 (Appendix 3); 1998 and 1999 populations are not included in the average, since it was not possible to make in-river estimates for those years.

TABLE 12. Chinook salmon carcass mark-and-recovery data used to estimate the 2004 fall-run spawner population in the Feather River from the hatchery barrier dam to Gridley [1/].

SECTION 1: Feather River Hatchery Barrier Dam to Thermalito Afterbay Outlet

Recovery period (j):	Number of marked carcasses recovered from marking period (i): 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [2/]	Population estimate (N) [3/]
2	9	–	–	–	–	–	–	–	–	–	–	–	–	–	9	119	347
3	0	8	–	–	–	–	–	–	–	–	–	–	–	–	8	480	2,160
4	3	5	86	–	–	–	–	–	–	–	–	–	–	–	94	1,659	3,982
5		1	10	192	–	–	–	–	–	–	–	–	–	–	203	3,487	6,311
6			4	34	284	–	–	–	–	–	–	–	–	–	322	3,740	7,465
7				7	61	206	–	–	–	–	–	–	–	–	274	2,849	6,461
8					21	64	207	–	–	–	–	–	–	–	292	2,170	4,386
9					1	8	49	158	–	–	–	–	–	–	216	1,665	3,118
10						1	19	23	129	–	–	–	–	–	172	1,081	2,080
11							2	10	44	73	–	–	–	–	129	787	1,695
12								1	5	10	60	–	–	–	76	503	1,191
13										6	11	42	–	–	59	348	909
14										1	2	11	8	–	22	122	446
15											1	1	6	4	12	82	394
16														2	2	0	0
Total recovered (Ri):	12	14	100	233	367	279	277	192	178	90	74	54	14	6		Total estimate:	40,946
Total carcasses marked (Mi):	35	63	226	413	741	658	531	352	345	210	179	146	76	20			
															Adjusted estimate [4/]:		**36,986**

SECTION 2: Thermalito Afterbay Outlet to Gridley Bridge

Recovery period (j):	Number of marked carcasses recovered from marking period (i): 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [2/]	Population estimate (N) [3/]
2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1	11	55
3		1	–	–	–	–	–	–	–	–	–	–	–	–	1	23	138
4			1	–	–	–	–	–	–	–	–	–	–	–	1	63	756
5				1	–	–	–	–	–	–	–	–	–	–	1	116	2,552
6					4	–	–	–	–	–	–	–	–	–	4	143	1,311
7					1	2	–	–	–	–	–	–	–	–	3	108	1,122
8							2	–	–	–	–	–	–	–	2	111	734
9							4	11	–	–	–	–	–	–	15	297	1,040
10								1	21	–	–	–	–	–	22	595	2,313
11									6	57	–	–	–	–	63	965	2,819
12									4	12	72	–	–	–	88	831	1,980
13									1	1	22	39	–	–	63	509	1,524
14											4	8	9	–	21	213	999
15												2	4	1	7	115	748
Total recovered (Ri):	1	1	1	1	5	2	6	12	32	70	98	49	13	1			
Total carcasses marked (Mi):	5	6	12	22	55	22	32	34	126	197	218	167	90	11		Total estimate:	18,090
															Adjusted estimate [5/]:		**17,098**

1/ Surveys were conducted from 2 September through 17 December 2004.
2/ Includes salmon carcasses which were marked and marked carcasses that were recovered.
3/ Schaefer (1951) estimate equation: $N = \sum(R_{ij} \times (M_i/R_i) \times (C_j/R_j))$.
4/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (40,946 - 3,960 = 36,986).
5/ Adjusted estimate where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (18,090 - 992 = 17,098).

16/ Seesholtz, A. CDWR-DES. Personal communication.

Yuba River

Spring run. Surveys were conducted weekly during 25 August through 1 October 2004, to determine the extent of spring-run salmon spawning in the Yuba River [17/]. The approximately 16-km (10-mi) stretch from the Narrows pool downstream to Daguerre Point Dam was covered in four reaches, surveyed during two days each week. A total of 99 new redds was counted for the period, but an estimate of the spawner population was not made.

Fall run. Salmon carcass mark-and-recovery surveys for this run during 2004 were conducted in the Yuba River from the Narrows at Rose Bar downstream to Simpson Lane bridge in Marysville [18/]. The surveyed reach was covered in three sections: the Narrows to Parks Bar at the Hwy. 20 bridge (Section 1), Parks Bar to Daguerre Point Dam (Section 2), and Daguerre Point Dam to Marysville (Section 3). These reaches included nearly all of the spawning areas used by Chinook salmon in the Yuba River. Some fish may have spawned upstream of the Narrows to Englebright Dam, although suitable habitat is scarce in that area. Weekly surveys were conducted in Section 1 during 7 October through 14 December, in Section 2 during 13 October through 21 December, and in Section 3 from 21 October through 22 December.

Yuba River flows below Englebright Dam ranged from 19.8 m^3/s to 28.3 m^3/s (700-1000 cfs) throughout the spawning season. Flows near Marysville ranged between 14.2 m^3/s and 25.5 m^3/s (500-900 cfs). The mean daily water temperature ranged from the mid 50-degree to upper 40-degree Fahrenheit, while visibility through the water averaged 3.6 m (12 ft).

This season, both adult and grilse fresh salmon carcasses were marked; carcasses were considered fresh if they had firm flesh, at least one clear eye, and pink gills, while the adult designation was a FL $\geq$ 64.5 cm (25.4 in). The length distinguishing adults and grilse was based on length frequency data from previous seasons' samplings.

Marking consisted of colored flagging attached to the fish's lower jaw with a hog ring; different colors were used to identify carcasses with distinct marking periods and survey reaches. Marked carcasses were returned into flowing water for subsequent recovery. Non-fresh carcasses and recovered marked carcasses were counted and then chopped in half. Length measurements and determination of gender were made for fresh adult carcasses.

Using carcass mark-and-recovery data with the Schaefer model (Appendix 1.B), estimates of 2,819 adults and 1,424 grilse were calculated for Section 1 (Table 13), 3,929 adults and 1,827 grilse in Section 2 (Table 14), and 2,840 adults and 2,457 grilse in Section 3 (Table 15). Combining these estimates gave 15,296 total salmon as the 2004 Yuba River population.

[17/] Massa, D. 2004 Spring-run Chinook Salmon Spawning Survey. Memorandum to files. CDFG-SVCSR, Rancho Cordova office.

[18/] Jones & Stokes. 2004 Fall-run Chinook Salmon Spawning Escapement in the Yuba River. Report to the Yuba County Water Agency, Marysville, CA. January 2006. J&S 03-240.

Based on fresh carcasses observed during the surveys, the fall run population consisted of 45% adult males and 55% adult females. Although grilse salmon composed 37% of the estimated numbers of fish, they constituted 21% of the total fresh carcasses examined.

The 2004 Yuba River fall run of 15,296 salmon was a decrease of 46% from that in 2003, and 32% lower than the average population for 1994-2003 (Appendix 3).

TABLE 13. Chinook salmon fresh carcass mark-and-recovery data used to estimate the 2004 fall-run spawner population in the Yuba River from the Narrows at Rose Bar to Parks Bar (Section 1).

ADULT ESTIMATE

Recovery period (j):	Number of marked carcasses recovered from marking period (i): 7-Oct	12-Oct	19-Oct	26-Oct	1-Nov	9-Nov	16-Nov	22-Nov	30-Nov	7-Dec	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) 1/	Population estimate (N) 2/
12-Oct	10	--	--	--	--	--	--	--	--	--	10	88	238
19-Oct		4	--	--	--	--	--	--	--	--	4	87	294
26-Oct		2	2	--	--	--	--	--	--	--	4	70	173
1-Nov		2	5	6	--	--	--	--	--	--	13	161	391
9-Nov					18	--	--	--	--	--	18	388	667
16-Nov					4	32	--	--	--	--	36	316	604
22-Nov					2	10	24	--	--	--	36	177	336
30-Nov					1	3	3	5	--	--	12	93	224
7-Dec						1	3	3	1	--	8	42	142
14-Dec						1				0	1	12	35
Total recovered (Ri):	10	8	7	6	25	47	30	8	1	0			
Total carcasses marked (Mi):	27	27	11	17	43	91	57	25	10	4		Total estimate:	3,104
												Adjusted estimate 3/:	**2,819**

GRILSE ESTIMATE

Recovery period (j):	Number of marked carcasses recovered from marking period (i): 7-Oct	12-Oct	19-Oct	26-Oct	1-Nov	9-Nov	16-Nov	22-Nov	30-Nov	7-Dec	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) 1/	Population estimate (N) 2/
12-Oct	0	--	--	--	--	--	--	--	--	--	0	20	20
19-Oct		1	--	--	--	--	--	--	--	--	1	30	180
26-Oct			1	--	--	--	--	--	--	--	1	16	128
1-Nov				1	--	--	--	--	--	--	1	49	392
9-Nov					5	--	--	--	--	--	5	98	425
16-Nov					1	6	--	--	--	--	7	60	217
22-Nov						2	6	--	--	--	8	47	90
30-Nov							0	0	--	--	0	34	34
7-Dec							1		1	--	2	16	27
14-Dec							1			0	1	6	14
Total recovered (Ri):	0	1	1	1	6	8	8	0	1	0			
Total carcasses marked (Mi):	4	6	8	8	26	28	11	8	6	2		Total estimate:	1,527
												Adjusted estimate 4/:	**1,424**

1/ Includes salmon carcasses which were marked and marked carcasses that were recovered.

2/ Schaefer (1951) estimate equation: $N = \sum(Rij \times (Mi/Ri) \times (Cj/Rj))$.

3/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (3,104 - 285 = 2,819).

4/ Adjusted estimate where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (1,527 - 103 = 1,424).

TABLE 14. Chinook salmon fresh carcass mark-and-recovery data used to estimate the 2004 fall-run spawner population in the Yuba River from Parks Bar to Dagurre Point Dam (Section 2).

ADULT ESTIMATE

Recovery period (j):	Number of marked carcasses recovered from marking period (i):										Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [1/]	Population estimate (N) [2/]
	13-Oct	20-Oct	27-Oct	2-Nov	10-Nov	17-Nov	23-Nov	1-Dec	8-Nov	15-Dec			
20-Oct	1	--	--	--	--	--	--	--	--	--	1	59	413
27-Oct		3	--	--	--	--	--	--	--	--	3	133	421
2-Nov		3	14	--	--	--	--	--	--	--	17	194	401
10-Nov			9	27	--	--	--	--	--	--	36	505	680
17-Nov			1	9	56	--	--	--	--	--	66	615	951
23-Nov				2	5	46	--	--	--	--	53	373	691
1-Dec					4	8	16	--	--	--	28	176	443
8-Nov						0	0	0	--	--	0	7	7
15-Dec						1	2	3	0	--	6	45	293
21-Dec							1			2	3	12	36
Total recovered (Ri):	1	6	24	38	65	55	19	3	0	2			
Total carcasses marked (Mi):	7	19	44	45	104	105	58	25	2	6		Total estimate:	4,337
												Adjusted estimate [3/]:	**3,929**

GRILSE ESTIMATE

Recovery period (j):	Number of marked carcasses recovered from marking period (i):										Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [1/]	Population estimate (N) [2/]
	13-Oct	20-Oct	27-Oct	2-Nov	10-Nov	17-Nov	23-Nov	1-Dec	8-Nov	15-Dec			
20-Oct	0	--	--	--	--	--	--	--	--	--	0	16	16
27-Oct		1	--	--	--	--	--	--	--	--	1	36	288
2-Nov			3	--	--	--	--	--	--	--	3	52	130
10-Nov			1	7	--	--	--	--	--	--	8	160	314
17-Nov				2	8	--	--	--	--	--	10	185	514
23-Nov					1	12	--	--	--	--	13	128	242
1-Dec						2	5	--	--	--	7	84	295
8-Nov						0		0	--	--	0	2	2
15-Dec						1		1	0	--	2	20	148
21-Dec										0	0	1	1
Total recovered (Ri):	0	1	4	9	9	14	5	0	0	0			
Total carcasses marked (Mi):	3	8	10	17	27	27	21	11	0	3		Total estimate:	1,951
												Adjusted estimate [4/]:	**1,827**

1/ Includes salmon carcasses which were marked and marked carcasses that were recovered.

2/ Schaefer (1951) estimate equation: $N = \sum(Rij \times (Mi/Ri) \times (Cj/Rj))$.

3/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (4,337 - 408 = 3,929).

4/ Adjusted estimate where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (1,951 - 124 = 1,827).

TABLE 15. Chinook salmon fresh carcass mark-and-recovery data used to estimate the 2004 fall-run spawner population in the Yuba River from Daguerre Point Dam to Marysville (Section 3).

ADULT ESTIMATE

Recovery period (j):	Number of marked carcasses recovered from marking period (i): 21-Oct	28-Oct	3-Nov	11-Nov	18-Nov	24-Nov	2-Dec	9-Dec	16-Dec	22-Dec	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) 1/	Population estimate (N) 2/
28-Oct	0	--	--	--	--	--	--	--	--	--	0	21	21
3-Nov		2	--	--	--	--	--	--	--	--	2	48	168
11-Nov			5	--	--	--	--	--	--	--	5	181	398
18-Nov			4	13	--	--	--	--	--	--	17	337	856
24-Nov			1	1	19	--	--	--	--	--	21	217	533
2-Dec					7	8	--	--	--	--	15	122	487
9-Dec						0	1	--	--	--	1	2	20
16-Dec						1	1	0	--	--	2	42	364
22-Dec									1	--	1	26	208
Total recovered (Ri):	0	2	10	14	26	9	2	0	1	0			
Total carcasses marked (Mi):	4	7	22	37	64	48	20	0	8	9		Total estimate:	3,055
												Adjusted estimate 3/:	**2,840**

GRILSE ESTIMATE

Recovery period (j):	Number of marked carcasses recovered from marking period (i): 21-Oct	28-Oct	3-Nov	11-Nov	18-Nov	24-Nov	2-Dec	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) 1/	Population estimate (N) 2/
28-Oct	0	--	--	--	--	--	--	0	7	7
3-Nov		0	--	--	--	--	--	0	25	25
11-Nov			0	--	--	--	--	0	81	81
18-Nov			1	2	--	--	--	3	164	1,749
24-Nov					9	--	--	9	120	251
2-Dec					2	2	--	4	60	303
9-Dec						0	0	0	0	0
16-Dec						1		1	15	135
22-Dec								0	5	5
Total recovered (Ri):	0	0	1	2	11	3	0			
Total carcasses marked (Mi):	1	4	9	23	23	24	16		Total estimate:	2,556
									Adjusted estimate 4/:	**2,457**

1/ Includes salmon carcasses which were marked and marked carcasses that were recovered.

2/ Schaefer (1951) estimate equation: $N = \sum(R_{ij} \times (M_i/R_i) \times (C_j/R_j))$.

3/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (3,055 - 215 = 2,840).

4/ Adjusted estimate where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (2,556 - 99 = 2,457).

American River

Fall run. Surveys of fall-run salmon in the American River, during 18 October 2004 through 13 January 2005, covered the 20.8-km (12.9-mi) stretch from Nimbus Weir downstream to the Watt Avenue bridge [19/]. This stretch of river was devided into three reaches, each surveyed weekly. Mean daily river flow ranged from 42.9 m^3/sec to 51.2 m^3/sec (1514-1809 cfs) during the surveys. Visibility through the water, measured by secchi disk, ranged from 0.5 m to 4.0 m (1.7-13.2 ft). Water temperature ranged from 17.3 °C to 9.0 °C (63.1-48.2 °F).

Marking-and-recovery of salmon carcasses was conducted in the period from 25 October through 6 January. All fresh carcasses were marked by attaching colored hog rings to their jaws; different colors were used each marking period. A carcass was considered fresh if it had either one clear eye or pink gills. Carcasses from adult fish (total length [TL] > 68 cm [26.8 in]) were tagged on their upper jaws, while grilse carcasses (TL ≤ 68 cm) were tagged on their lower jaws. Any fresh carcass with a missing adipose fin (indicating possible presence of a coded-wire tag), and those carcasses found downstream of Gristmill Fishing Access were not marked. Marked carcasses were replaced into running water for later recovery. Carcasses not marked, as well as those recovered with marks were counted and cut in half. Length measurements and determination of gender were made for a sample of the fresh carcasses.

Totals of 4,695 fresh and 36,211 non-fresh carcasses were observed, but only the mark-and-recovery data for fresh adult carcasses were used in the Schaefer calculation (Appendix 1.B). The estimated adult salmon population of the Watt Avenue to Sailor Bar section of the river was 74,991 fish (Table 16). This adult estimate was expanded for a 15.5% grilse proportion to 88,747 fish in the surveyed area. In addition, 26,400 fish entered Nimbus Hatchery [20/], and 10,483 salmon carcasses were removed from the Nimbus Racks, bringing the total American River 2004 fall-run population to 125,630 fish (Appendix 2).

TABLE 16. Chinook salmon fresh carcass mark-and-recovery data used to estimate the 2004 fall-run spawner population in the American River from Watt Avenue to Nimbus Weir.

Recovery period (j):	Number of marked carcasses recovered from marking period (i):										Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [1/]	Population estimate (N) [2/]
	25-28 Oct	1-3 Nov	8-10 Nov	15-18 Nov	22-24 Nov	29 Nov - 2 Dec	6-9 Dec	13-16 Dec	20-22 Dec	27-29 Dec			
1-3 Nov	2	--	--	--	--	--	--	--	--	--	2	94	141
8-10 Nov		4	--	--	--	--	--	--	--	--	4	897	5,382
15-18 Nov		1	122	--	--	--	--	--	--	--	123	4,533	11,381
22-24 Nov			11	231	--	--	--	--	--	--	242	6,058	14,485
29 Nov - 2 Dec			1	51	238	--	--	--	--	--	290	6,615	14,578
6-9 Dec			1	4	55	180	--	--	--	--	240	5,514	11,578
13-16 Dec			4	1	12	45	237	--	--	--	299	5,498	9,107
20-22 Dec					1	10	46	72	--	--	129	2,764	6,111
27-29 Dec						2	3	11	40	--	56	1,238	3,143
3-6 Jan								3	13	25	41	942	2,156
Total recovered (Ri)	2	5	139	287	306	237	286	86	53	25			
Total carcasses marked (Mi):	3	30	345	685	662	491	439	229	138	52		Total estimate:	78,062
												Adjusted estimate [3/]:	**74,991**

1/ Includes salmon carcasses which were marked and marked carcasses that were recovered.
2/ Schaefer (1951) estimate equation: $N = \sum(R_{ij} \times (M_i/R_i) \times (C_j/R_j))$.
3/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (78,062 - 3,071 = 74,991).

19/ Healey, M. Lower American River Chinook Salmon Escapement Survey, October 2004-January 2005. File report. September 2005. CDFG-SVCSR, Rancho Cordova office.

20/ West, T. CDFG – SVCSR, Nimbus Hatchery. Personal communication.

Based on examination of 4,277 fresh carcasses, the run consisted of 35.6% male adults, 49% female adults, 9.5% male grilse, and 5.9% female grilse. Salmon entering Nimbus Hatchery consisted of 27.8% male adults (FL > 61 cm [24 in]), 20.5% female adults, and 51.7% grilse (FL ≤ 61 cm).

The 2004 run of 125,630 salmon in the American River was a decrease of 30% from the previous year's population, but still 30% higher than the average for 1994-2003 (Appendix 3).

CHINOOK SALMON SPAWNER POPULATIONS FOR THE SAN JOAQUIN RIVER SYSTEM

The Mokelumne, Stanislaus, Tuolumne, and Merced rivers of the San Joaquin River system (Figure 4) were surveyed for Chinook salmon spawners. A total of 22,263 salmon, consisting entirely of fall-run fish, was estimated to be in this system for 2004 (Appendix 2).

Mokelumne River

Fall run. Fish passage at Woodbridge Irrigation District Dam was monitored by East Bay Municipal Utilities District (EBMUD), during 1 August 2004 through 5 April 2005 [21/]. Passage through the high-stage fishway was monitored with a closed-circuit, underwater video system through 1 November, after which the lake behind the dam was drawn down for the winter. Subsequently, a combination of the video system and upstream migrant trapping was used in the low-stage fishway through 9 December, after which only the video monitoring continued. A total of 11,416 salmon was counted migrating past the dam.

An estimate of the in-river spawner population was made from salmon carcass surveys conducted during 18 October 2004 through 10 January 2005. The surveyed reach from Comanche Dam to Elliot Road was covered by boat or on foot along the shore, during one or two days each week.

Collected carcasses, in both fresh and decayed condition, were marked using uniquely numbered tags and colored flagging attached to their lower jaws. Fresh carcasses were identified as having clear eyes and blood still in the gills, while decayed ones had cloudy eyes and no blood. Extremely decayed carcasses (completely covered with fungus) and skeletons were not marked. Marked carcasses were redistributed into running water for subsequent recovery. Carcasses not marked, as well as those previously marked carcasses which were recovered, were counted and chopped in half. During the initial handling of each carcass, its condition of decomposition was recorded, and if possible it was measured and its gender determined.

The carcass marking protocol and use of numbered tags were intended to allow post-season distinction of age-class (adult or grilse, based on length) and condition (fresh or decayed). The salmon population was estimated using the Jolly- Dickson open population mark-recapture model through a POPAN 5 statistical package [22/].

From a total of 770 distinct carcasses observed, of which 624 were tagged, and 172 subsequently recaptured (Table 17), an estimate of 1,588 in-river spawners was calculated. An additional 10,356 entered Mokelumne River Fish Hatchery (MRFH), for a total fall run of 11,944 fish (Appendix 2)

[21/] Workman, M.L. Lower Mokelumne River Upstream Fish Migration Monitoring. File Report. August 2005. EBMUD Fisheries and Wildlife Division. Lodi Office.

[22/] Arnason, A.N., C.J. Schwarz, and G. Boyer. 1998. POPAN-5: A data maintenance and analysis system for mark-recapture data. Scientific Report, Department of Computer Science, University of Manitoba, Winnipeg.

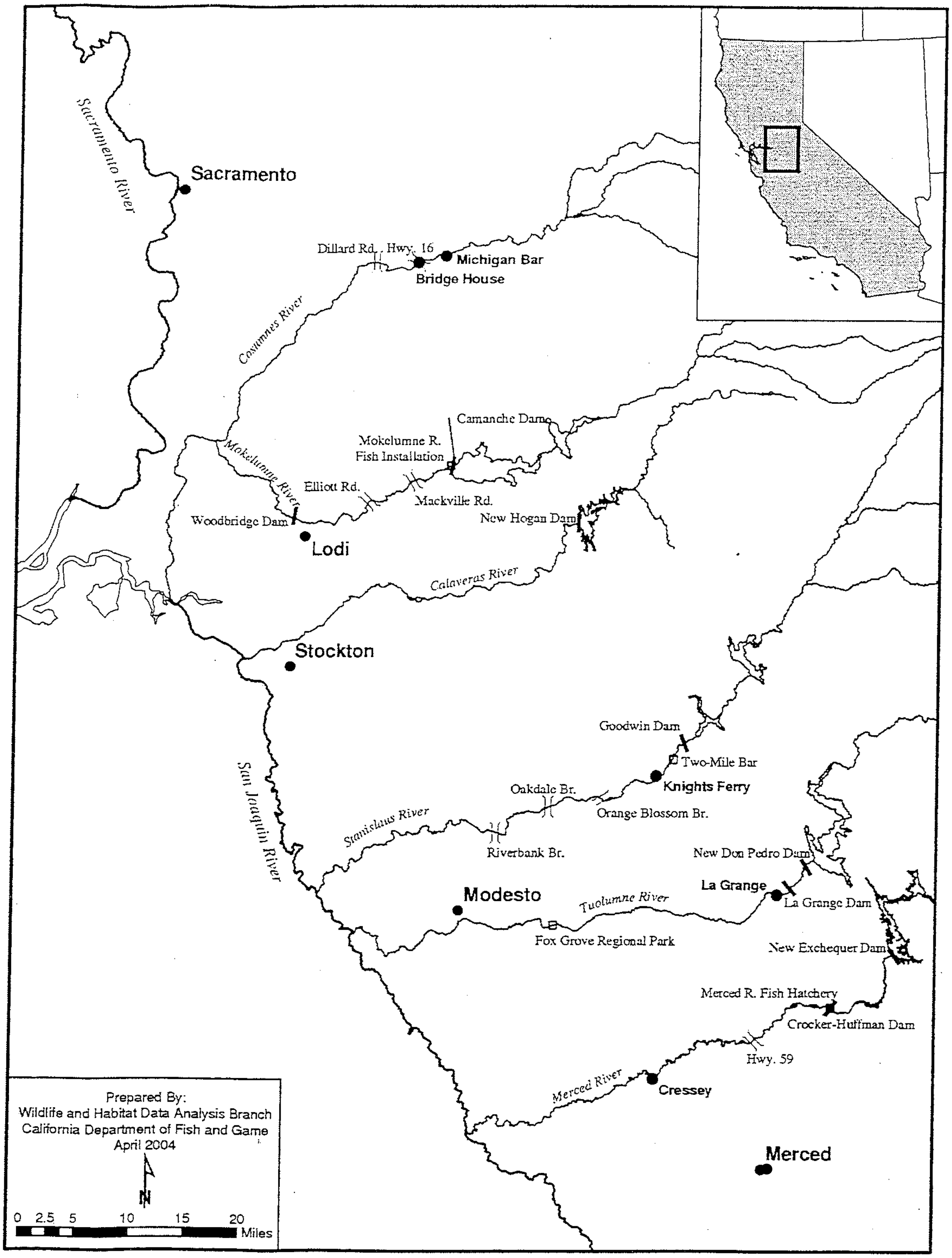

FIGURE 4. San Joaquin River System.

Based on examination of 9,586 salmon at the dam, the run consisted of 43% male adults (FL > 60 cm [23.6 in]), 22% female adults, 25% male grilse (FL ≤ 60 cm), and 10% female grilse. The composition of the salmon entering the hatchery was 35.3% male adults (FL > 61 cm [24 in]), 17.6% female adults, and 47.1% grilse (FL ≤ 61 cm) [23/].

The 2004 spawner population of 11,944 fish in the Mokelumne River was 17% higher than the previous year's run, and 1½ times higher than the average for the 1994-2003 period; determination of previous years' populations were based on counts at Woodbridge Dam (Appendix 3).

Table 17. Chinook Salmon Carcasses Observed During the 2004 Mark-and-recovery Surveys in the Mokelumne River from Camanche Dam to Elliot Road.

Survey Date	Carcasses Tagged	Carcasses Chopped	Total Observed		Marked Recoveries [1/]
18-Oct-04	40	1	41		0
25-Oct-04	43	0	43		5
1-Nov-04	40	0	40		13
8-Nov-04	44	3	47		12
15-Nov-04	71	7	78		6
22-Nov-04	130	14	144		24
29-Nov-04	127	42	169		32
9-Dec-04	80	38	118		47
13-Dec-04	28	12	40		27
20-Dec-04	19	18	37		3
27-Dec-04	0	6	6		3
3-Jan-05	2	4	6		0
10-Jan-05	0	1	1		0
Totals:	**624**	**146**	**770**		**172**

1/ Numbers are not included in total observed.

Stanislaus River

Fall run. Spawner surveys in the Stanislaus River were conducted weekly during 4 October 2004 through 5 January 2005 [24/]; marking-and-recovery surveys began during the fourth week. The 40.2-km (25-mi) stretch of the river from Knight's Ferry to Jacob Meyers Park in Riverbank was covered by drift boat. Surveys upstream of Knight's Ferry in the 4.8-km (3-mi) section of the Goodwin Canyon area were made on foot; salmon carcasses were only counted in this section.

[23/] Cochran, K. CDFG-SVCSR, Mokelumne River Hatchery. Personal communication.

[24/] Guignard, J. Stanislaus River Fall Chinook Salmon Escapement Survey, 2004. File Report. March 2005. CDFG – San Joaquin Valley-Southern Sierra Region (SJVSSR).

River flows were increased, three weeks after the surveys began, to attract salmon into the tributary and improve spawning conditions. The higher flows were continued for five days (25-30 October), with a maximum discharge from Goodwin Dam of 22.6 m^3/s (800 cfs). Flows at the Orange Blossom Bridge gauge during the spawning period ranged from 7.9 m^3/s to 18.4 m^3/s (280-650 cfs).

During the mark-and-recovery surveys, salmon carcasses in both fresh and decayed condition were marked using numbered aluminum tags attached to their lower jaws with hog-rings. Fresh carcasses were identified as having at least one clear eye and blood still in the gills, while decayed ones had cloudy eyes and no blood. Extremely decayed carcasses (completely covered with fungus) and skeletons were not marked. Marked carcasses were redistributed into running water for subsequent recovery. Carcasses not marked, as well as those previously marked carcasses which were recovered, were counted and chopped in half. During the initial handling of each carcass, if possible, it was also measured and its gender determined.

The carcass marking protocol and use of numbered tags were intended to allow post-season distinction of age-class (adult or grilse, based on length) and condition (fresh or decayed), so the data could be better compiled for estimating the salmon population through several biometric models. Analysis of the data indicated the Schaefer estimate (Appendix 1.B) was the most appropriate.

The population in the Knight's Ferry to Riverbank stretch of the river was estimated to be 3,405 fish, using the mark-and-recovery data for fresh and decayed carcasses (Table 18). The data from surveys in the Goodwin Canyon area were not included in the Schaefer estimate calculations. The spawner population for this area was determined by expanding the 322 carcasses which were actually observed to an estimated 610 fish, using the overall mark recovery rate of 52.8% for the Knight's Ferry to Riverbank stretch. The combined estimates were a total of 4,015 salmon for the 2004 fall run.

TABLE 18. Chinook salmon fresh and decayed carcass mark-and-recovery data used to estimate the 2004 fall-run spawner population in the Stanislaus River from Knights Ferry to Jacob Meyers Park in Riverbank [1/].

Recovery period (j):	Number of marked carcasses recovered from marking period (i): 1	2	3	4	5	6	7	8	9	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [2/]	Population estimate (N) [3/]
2	3	--	--	--	--	--	--	--	--	3	124	413
3		36	--	--	--	--	--	--	--	36	402	745
4		5	89	--	--	--	--	--	--	94	439	727
5			33	72	--	--	--	--	--	105	524	1,032
6			15	18	90	--	--	--	--	123	371	636
7			1	11	36	37	--	--	--	85	253	481
8				1	3	7	10	--	--	21	74	207
9								2	--	2	5	43
Total recovered (Ri):	3	41	138	102	129	44	10	2	0			
Total carcasses marked (Mi):	10	76	227	216	212	92	37	17	1		Total estimate:	4,283
											Adjusted estimate [4/]:	**3,405**

1/ Surveys were conducted from 4 October 2004 through 5 January 2005; marking-and-recovery began with the fourth week.

2/ Includes salmon carcasses which were marked and marked carcasses that were recovered.

3/ Schaefer (1951) estimate equation: $N = \sum(R_{ij} \times (M_i/R_i) \times (C_j/R_j))$.

4/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (4,283 - 878 = 3,405).

The adult-grilse composition of the population was determined from frequency distributions of length measurements taken from carcasses during this season's San Joaquin basin-wide surveys. Distribution data was compiled separately for each gender of hatchery- and natural-origin fish. Hatchery origin salmon were identified as carcasses with missing adipose fins, indicating the possible presence of a coded-wire tag which was inserted at the hatchery. The length criteria used to distinguish adult from grilse salmon was a FL $\geq$ 66 cm (26 in) for natural-origin females, a FL $\geq$ 63 cm (24.8 in) for hatchery-origin females, a FL $\geq$ 74 cm (29.1 in) for natural-origin males, and a FL $\geq$ 70 cm (27.6 in) for hatchery-origin males. Based on these criteria, the Stanislaus River run consisted of 28% male adults, 42% female adults, 12% male grilse, and 18% female grilse.

The 2004 Stanislaus River fall-run spawner population of 4,015 salmon was a decrease of 32% from the previous year's run, and 9% lower than the average for 1994 -2003 (Appendix 3).

Tuolumne River

Fall run. Chinook salmon spawner surveys in the Tuolumne River were conducted weekly from 4 October 2004 through 6 January 2005 [25/]; marking-and-recovery surveys started during the fifth week. The river stretch from the riffles at river-mile-52 near LaGrange Dam downstream to Fox Grove, a distance of 41.8 km (26 mi), was covered both by boat and on foot.

River flows were increased, three weeks after the surveys began, to attract salmon into the tributary and improve spawning conditions. The higher flows were continued for about three days (27-30 October) at about 13.9 m^3/s (490 cfs), then were decreased to 5 m^3/s (175 cfs) for the remainder of the spawning season.

During the mark-and-recovery surveys, salmon carcasses in both fresh and decayed condition were marked using numbered aluminum tags attached to their lower jaws with hog-rings. Fresh carcasses were identified as having at least one clear eye, while decayed ones had cloudy eyes. Extremely decayed carcasses (completely covered with fungus) and skeletons were not marked. Marked carcasses were redistributed into running water for subsequent recovery. Carcasses not marked, as well as those previously marked carcasses which were recovered, were counted and chopped in half. During the initial handling of each carcass, if possible, it was also measured and its gender determined.

The carcass marking protocol and use of numbered tags were intended to allow post-season distinction of age-class (adult-grilse, based on length) and condition (fresh or decayed), so the data could be better compiled for estimating the salmon population through several biometric models. Analysis of the data indicated that the Schaefer estimate (Appendix 1.B) was the most appropriate. The salmon population in the Tuolumne River upstream of Fox Grove Park was estimated at 1,984 fish, using the mark-and-recovery data for fresh and decayed carcasses (Table 19).

[25/] Blakeman, D. 2004 Tuolumne River Fall Chinook Salmon Escapement Survey. File Report. March 2005. CDFG - SJVSSR.

The adult-grilse composition of the population was determined from frequency distributions of length measurements taken from carcasses during this season's San Joaquin basin-wide surveys. Distribution data was compiled separately for each gender of hatchery- and natural-origin fish. Hatchery origin salmon were identified as carcasses with missing adipose fins, indicating the possible presence of a coded-wire tag which was inserted at the hatchery. The length criteria used to distinguish adult from grilse salmon was a FL ≥ 66 cm (26 in) for natural-origin females, a FL ≥ 63 cm (24.8 in) for hatchery-origin females, a FL ≥ 74 cm (29.1 in) for natural-origin males, and a FL ≥ 70 cm (27.6 in) for hatchery-origin males. Based on these criteria, the Stanislaus River run consisted of 28% male adults, 42% female adults, 12% male grilse, and 18% female grilse.

The 2004 Stanislaus River fall-run spawner population of 4,015 salmon was a decrease of 32% from the previous year's run, and 9% lower than the average for 1994 -2003 (Appendix 3).

Tuolumne River

Fall run. Chinook salmon spawner surveys in the Tuolumne River were conducted weekly from 4 October 2004 through 6 January 2005 [25/]; marking-and-recovery surveys started during the fifth week. The river stretch from the riffles at river-mile-52 near LaGrange Dam downstream to Fox Grove, a distance of 41.8 km (26 mi), was covered both by boat and on foot.

River flows were increased, three weeks after the surveys began, to attract salmon into the tributary and improve spawning conditions. The higher flows were continued for about three days (27-30 October) at about 13.9 m^3/s (490 cfs), then were decreased to 5 m^3/s (175 cfs) for the remainder of the spawning season.

During the mark-and-recovery surveys, salmon carcasses in both fresh and decayed condition were marked using numbered aluminum tags attached to their lower jaws with hog-rings. Fresh carcasses were identified as having at least one clear eye, while decayed ones had cloudy eyes. Extremely decayed carcasses (completely covered with fungus) and skeletons were not marked. Marked carcasses were redistributed into running water for subsequent recovery. Carcasses not marked, as well as those previously marked carcasses which were recovered, were counted and chopped in half. During the initial handling of each carcass, if possible, it was also measured and its gender determined.

The carcass marking protocol and use of numbered tags were intended to allow post-season distinction of age-class (adult-grilse, based on length) and condition (fresh or decayed), so the data could be better compiled for estimating the salmon population through several biometric models. Analysis of the data indicated that the Schaefer estimate (Appendix 1.B) was the most appropriate. The salmon population in the Tuolumne River upstream of Fox Grove Park was estimated at 1,984 fish, using the mark-and-recovery data for fresh and decayed carcasses (Table 19).

[25/] Blakeman, D. 2004 Tuolumne River Fall Chinook Salmon Escapement Survey. File Report. March 2005. CDFG - SJVSSR.

The adult-grilse composition of the population was determined from frequency distributions of length measurements taken from carcasses during this season's San Joaquin basin-wide surveys. Distribution data was compiled separately for each gender of hatchery- and natural-origin fish. Hatchery origin salmon were identified as carcasses with missing adipose fins, indicating the possible presence of a coded-wire tag which was inserted at the hatchery. The length criteria used to distinguish adult from grilse salmon was a FL ≥ 66 cm (26 in) for natural-origin females, a FL ≥ 63 cm (24.8 in) for hatchery-origin females, a FL ≥ 74 cm (29.1 in) for natural-origin males, and a FL ≥ 70 cm (27.6 in) for hatchery-origin males. Based on these criteria, the run consisted of 18% male adults, 45% female adults, 23% male grilse, and 14% female grilse.

The 2004 fall run of salmon in the Tuolumne River was 8% lower than that of 2003, and 70% lower than the average for 1994-2003 (Appendix 3).

TABLE 19. Chinook salmon carcass mark-and-recovery data used to estimate the 2004 fall-run spawner population in the Tuolumne River from LaGrange Dam to Fox Grove [1/].

Recovery period (j):	Number of marked carcasses recovered from marking period (i):							Total marked carcasses recovered	Total carcasses observed	Population estimate
	1	2	3	4	5	6	7	(Rj)	(Cj) [2/]	(N) [3/]
2	13	--	--	--	--	--	--	13	339	605
3	1	88	--	--	--	--	--	89	480	703
4		9	107	--	--	--	--	116	354	494
5		2	13	61	--	--	--	76	195	301
6		1	5	8	19	--	--	33	132	200
7			1	2	3	4	--	10	42	105
8					3		2	5	24	75
Total recovered (Ri):	14	100	126	71	25	4	2			
Total carcasses marked (Mi):	25	146	175	112	38	16	11		Total estimate:	2,482
									Adjusted estimate [4/]:	**1,984**

1/ Surveys were conducted from 4 October through 6 January 2005; marking-and-recovery began with the fifth week.
2/ Includes salmon carcasses which were marked and marked carcasses that were recovered.
3/ Schaefer (1951) estimate equation: $N = \sum(Rij \times (Mi/Ri) \times (Cj/Rj))$.
4/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (2,482 - 498 = 1,984).

Merced River

Fall run. Weekly salmon surveys were conducted from 28 September 2004 through 6 January 2005, in the 39.7-km (24.7-mi) stretch of the Merced River from the Merced River Hatchery downstream to Santa Fe Road near Cressey [26/]. River flows were increased, three weeks after the surveys began, to attract salmon into the tributary and improve spawning conditions. The higher flows were continued for about two weeks (15-28 October) and ranged

[26/] Johnson, K. 2004 Merced River Fall Chinook Salmon Escapement Survey. File Report. March 2005. CDFG - SJVSSR.

from 19.6 m^3/s to 19.9 m^3/s (694-704 cfs). Flows were decreased and stabilized at around 7.1 m^3/s (250 cfs) for the remainder of the spawning season.

During the mark-and-recovery surveys, salmon carcasses in both fresh and decayed condition were marked using numbered aluminum tags attached to their lower jaws with hog-rings. Fresh carcasses were identified as having at least one clear eye, while decayed ones had cloudy eyes. Extremely decayed carcasses (completely covered with fungus) and skeletons were not marked. Marked carcasses were redistributed into running water for subsequent recovery. Carcasses not marked, as well as those previously marked carcasses which were recovered, were counted and chopped in half. During the initial handling of each carcass, if possible, it was also measured and its gender determined.

The carcass marking protocol and use of numbered tags were intended to allow post-season distinction of age-class (adult-grilse, based on length) and condition, so the data could be better compiled for estimating the population through several biometric models. Analysis of the data indicated that the Jolly-Seber estimate (Appendix 1.C), using fresh and decayed carcass data, was the most appropriate. An estimate of 3,270 salmon was calculated for the river stretch from Merced River Hatchery to Santa Fe Road (Table 20). Merced River Hatchery took in 1,050 salmon [27/], for a total 2004 fall-run spawner population of 4,320 fish (Appendix 2).

The adult-grilse composition of the population was determined from frequency distributions of length measurements taken from carcasses during this season's San Joaquin basin-wide surveys. Distribution data was compiled separately for each gender of hatchery- and natural-origin fish. Hatchery-origin salmon were identified as carcasses with missing adipose fins, indicating the possible presence of a coded-wire tag which was inserted at the hatchery. The length criteria used to distinguish adult from grilse salmon was a FL $\geq$ 66 cm (26 in) for natural-origin females, a FL $\geq$ 63 cm (24.8 in) for hatchery-origin females, a FL $\geq$ 74 cm (29.1 in) for natural-origin males, and a FL $\geq$ 70 cm (27.6 in) for hatchery-origin males. Based on these criteria, the in-river run of the Merced River consisted of 23.4% male adults, 43.8% female adults, 21.1% male grilse, and 11.7% female grilse. Salmon which entered Merced River Hatchery consisted of 17.8% male adults (FL $\geq$ 65 cm [25.6 in]), 25.6% female adults, 56.6% grilse (FL $<$ 65 cm)**"**.

The 2004 Merced River fall run was 29% higher than that in 2003, but 29% lower than the average population for 1994-2003 (Appendix 3).

[27/] Cozart, M. CDFG – SJVSSR, Merced River Hatchery. Personal communication.

TABLE 20. Chinook salmon fresh and decayed carcass mark-and-recovery data used to estimate the 2004 fall-run spawner population in the Merced River from the Merced River Hatchery to Cressey [1/].

Survey Period	Carcasses Recovered from Period: 1	2	3	4	5	6	7	8	9	10	11	12	13	Marked Carcasses Recovered (R_i) [2/]	(K_i) [3/]	Carcasses Observed (E_i) [4/]	Estimate for Period
1	--	--	--	--	--	--	--	--	--	--	--	--	--	0	--	0	0
2	0	--	--	--	--	--	--	--	--	--	--	--	--	0	0	1	0
3		0	--	--	--	--	--	--	--	--	--	--	--	0	0	1	0
4			0	--	--	--	--	--	--	--	--	--	--	0	0	0	0
5				0	--	--	--	--	--	--	--	--	--	0	0	0	0
6					0	--	--	--	--	--	--	--	--	0	0	4	144
7						1	--	--	--	--	--	--	--	1	0	114	140
8							29	--	--	--	--	--	--	29	7	386	673
9							7	61	--	--	--	--	--	68	29	557	815
10								24	140	--	--	--	--	164	39	878	827
11								4	24	106	--	--	--	134	51	436	300
12								1	10	28	37	--	--	76	25	338	285
13										12	13	25	--	50	0	170	45
14													1	1	0	19	40
15														0	--	1	0
													Total:	523		2,905	
Total recovered (C_i) [5/]:	0	0	0	0	0	1	36	90	174	146	50	25	1				
Total marked (Ti) [6/]:	0	1	1	0	0	4	70	143	243	196	66	41	19	784 (Grand total marked)			
														Jolly-Seber estimate :			**3,270**

1/ Surveys were conducted from 28 September 2004 through 6 January 2005.
2/ Total recovered marked carcasses for the *i* th period
3/ Total marked carcasses recovered after the *i* th period, that were marked before the *i* th period.
4/ Includes salmon carcasses which were marked, marked carcasses that were recovered, and unmarked carcasses that were chopped.
5/ Total recovered marked carcasses that were marked during the *i* th period
6/ Number of carcasses marked in the *i* th period.

SUMMARY

The total estimated 2004 Central Valley Chinook salmon spawner population was 420,442 fish, consisting of 398,179 fish in the Sacramento River system and 22,263 fish in the San Joaquin River system (Table 21). This total was 33% lower than the 624,808 salmon estimated in 2003.

All of the late-fall, winter, and spring runs, and the majority of the fall run were in the Sacramento River system. The fall run in the San Joaquin tributaries continued to contribute only a small portion (5%) to the total Central Valley escapement.

TABLE 21. Summary of the 2004 Sacramento-San Joaquin river system Chinook salmon spawner populations.

Spawning area	Late-fall run [1/]	Winter run	Spring run	Fall run	Total
Sacramento River mainstem	8,824	7,869	394	43,604	60,691
Sacramento River tributaries	5,040	--	13,588	318,860	337,488
San Joaquin River tributaries	--	--	--	22,263	22,263
Totals:	13,864	7,869	13,982	384,727	420,442

1/ Tributary data consists only of fish which entered Coleman National Fish Hatchery (Battle Creek).

ACKNOWLEDGEMENTS

The editor thanks the individuals, and their affiliations, who are cited as sources for the data presented. That information, collected through their efforts, and provided through their cooperation has made this report possible.

REFERENCES

Boydstun, L.B. 1994. Analysis of two mark-recapture methods to estimate the fall chinook salmon (Oncorhynchus tshawytscha) spawning run in Bogus Creek, California. Calif. Fish and Game. 80(1)). 13 p.

Hoopaugh, David A. (ed.). 1978. King (Chinook) salmon spawning stocks in California's Central Valley, 1976. Calif. Dept. of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 78-19. 33 p.

McReynolds T.R., C.E. Garmin, P.D. Ward, and M.C. Schommer. 2005. Butte and Big Chico creeks spring-run Chinook salmon, Oncoryhnchus tshawytscha, life history investigation, 2003-2004. Calif. Dept. of Fish and Game, Inland Fisheries Administrative Report No. 2005-1. 52 p.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Res. Bd. Canada, Bull. 191. 382 p.

Schaefer, M.D. 1951. Estimation of size of animal populations by marking experiments. U. S. Fish and Wildl. Serv., Fish. Bull. 52: 189-203.

APPENDIX 1. Calculation methods used with carcass mark-and-recovery data to estimate Chinook salmon spawner populations.

A. The Petersen equation as revised by Chapman (Ricker 1975):

$$N = \frac{(M + 1)(C + 1)}{(R + 1)}$$

where N = estimated spawner population,

M = number of carcasses marked,

C = number of carcasses observed, including those marked and those recovered with marks, and

R = number of marked carcasses recovered.

B. A modification of the Schaefer (1951) equation, which was initially used in the 1976 Central Valley spawner stock report (Hoopaugh 1978);

$$N = \Sigma\left(R_{ij} \times \frac{M_i}{R_i} \times \frac{C_j}{R_j}\right) - \Sigma\, {}^{i}_{2}M_i$$

where N = the estimated spawner population,

R_{ij} = carcasses marked in the ith marking period which were recovered in the jth recovery period,

M_i = carcasses marked in the ith marking period,

R_i = total marked carcasses recovered from the ith marking period,

R_j = total marked carcasses recovered during the jth recovery period,

C_j = total carcasses observed in the jth recovery period, including those with marks, and

${}^{i}_{2}M_i$ = total carcasses marked from the second marking period on. Subtraction of this factor adjusted for replacement of recovered marked fish.

APPENDIX 1 (continued).

C. The Jolly-Seber calculations as modified by Boydston (1994) [28/]:

The estimated spawner population **= N_1 + D_1 +D_2 + ... D_j** , where

N_1 = number of carcasses in the surveyed population in period 1, the first period of sampling;

$$N_1 = \frac{E_1 + (N_2 - T_1 * S_1)}{\sqrt{S_1}}$$

and,

D_i = number of carcasses joining the population between period *i* and *i+1*, with *j* being the last survey period. This accounts for carcasses "leaving" the population between survey periods.

$$D_i = \frac{(N_{i+1} - S_i)*(N_i - E_i + T_i)}{\sqrt{S_i}}$$

Variables used in the calculations are:

E_i = total number of carcasses examined for marks during the i^{th} period, including those that were marked, those with marks that were recovered, and those that were not marked.

N_i = estimated number of carcasses in the population immediately prior to each survey period.

$$N_i = \frac{b_i * (E_i + 1)}{R_i + 1}$$

where,

b_i = estimated number of marked carcasses available for recovery during each survey;

$$b_i = \frac{(T_i + 1)*(K_i)}{(C_i + 1)} + R_i$$

and,

R_i = total number of marked carcasses that were recovered during the i^{th} period.

T_i = number of carcasses marked during the i^{th} period.

S_i = survival rate of marked carcasses from period *i* to *i+1;*

$$S_i = \frac{b_{i+1}}{b_i - R_i + T_i}$$

[28/] Symbols for variables are notation provided by D. Killam. CDFG-NCNCR. Personal communication.

APPENDIX 2. 2004 Chinook Salmon Spawner Population Estimates for the Central Valley River Systems.

	Estimated number of fish				
	Late-fall run	Winter run	Spring run	Fall run	Total For All Runs
SACRAMENTO RIVER SYSTEM					
Sacramento River Mainstem					
-Upstream of Red Bluff Diversion Dam					
In-river a/	8,765	7,784	394	34,050	50,993
Livingstone Stone National Fish Hatchery	--	85	--	--	85
Transferred to Coleman NFH from Keswick Dam	59	--	--	--	59
-Downstream of Red Bluff Diversion Dam	0	0	0	9,554	9,554
Totals :	**8,824**	**7,869**	**394**	**43,604**	**60,691**
Sacramento River Tributaries					
Keswick Dam to Red Bluff					
-Clear Creek	c/	--	98	6,365	6,463
-Cottonwood (Beegum) Creek	c/	--	17	c/	17
-Battle Creek					
Coleman National Fish Hatchery	5,040	--	--	68,232	73,272
In-river	c/	--	66	23,861	23,927
(Tributary total):	(5,040)		(66)	(92,093)	(97,199)
Totals for area:	**5,040**		**181**	**98,458**	**103,679**
Red Bluff to Princeton Ferry					
-Antelope Creek	--	--	3	c/	3
-Mill Creek	--	--	998	1,192	2,190
-Deer Creek	--	--	804	300	1,104
Totals for area:			**1,805**	**1,492**	**3,297**
Big Chico Creek to American River					
-Big Chico Creek	--	--	0	c/	0
-Butte Creek	--	--	7,390	2,516	9,906
-Feather River					
Feather River Hatchery	--	--	4,212	21,297	25,509
In-river	--	--	c/	54,171	54,171
(Tributary total):			(4,212)	(75,468)	(79,680)
-Yuba River	--	--	b/	15,296	15,296
-American River					
Nimbus Hatchery	--	--	--	26,400	26,400
Nimbus Basin	--	--	--	10,483	10,483
In-river	--	--	--	88,747	88,747
(Tributary total):				(125,630)	(125,630)
Totals for area:			**11,602**	**218,910**	**230,512**
Sacramento River System Totals:	**13,864**	**7,869**	**13,982**	**362,464**	**398,179**
SAN JOAQUIN RIVER SYSTEM					
-Mokelumne River					
Mokelumne River Hatchery	--	--	--	10,356	
In-river	--	--	--	1,588	
(Tributary total):				(11,944)	
-Stanislaus River	--	--	--	4,015	
-Tuolumne River	--	--	--	1,984	
-Merced River					
Merced River Hatchery	--	--	--	3,270	
In-river	--	--	--	1,050	
(Tributary total):				(4,320)	
San Joaquin River System Total:				**22,263**	

a/ Estimates based on carcass survey and redd count data. Winter- and fall-run estimates also based on sampling at Keswick and Red Bluff Diversion dams.
b/ An estimate of the run size was not made.
c/ Tributary was not surveyed for this run.