State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

ANNUAL REPORT
CHINOOK SALMON SPAWNER STOCKS IN CALIFORNIA'S CENTRAL VALLEY, 2001

Edited by

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

Inland Fisheries
Administrative Report No. 2005-3

2005

CHINOOK SALMON SPAWNER STOCKS IN CALIFORNIA'S CENTRAL VALLEY, 2001[1/]

Edited by

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

ABSTRACT

This report covers the 49th 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 2001 total escapement of Chinook salmon in the Central Valley was 672,583 fish, which was 33% higher than in 2000. The population consisted of 624,947 fall-, 22,603 late-fall-, 16,809 spring-, and 8,224 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 590,174 fish in the Sacramento River system and 34,773 fish in the San Joaquin River system. In the Feather and American rivers of the Sacramento system, record high fall runs occurred. The fall run in the San Joaquin tributaries still only contributed a small portion (5.2%) to the total Central Valley escapement.

[1/] Inland Fisheries Administrative Report No. 2005-3. Submitted for publication June 2005. 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 49th 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.

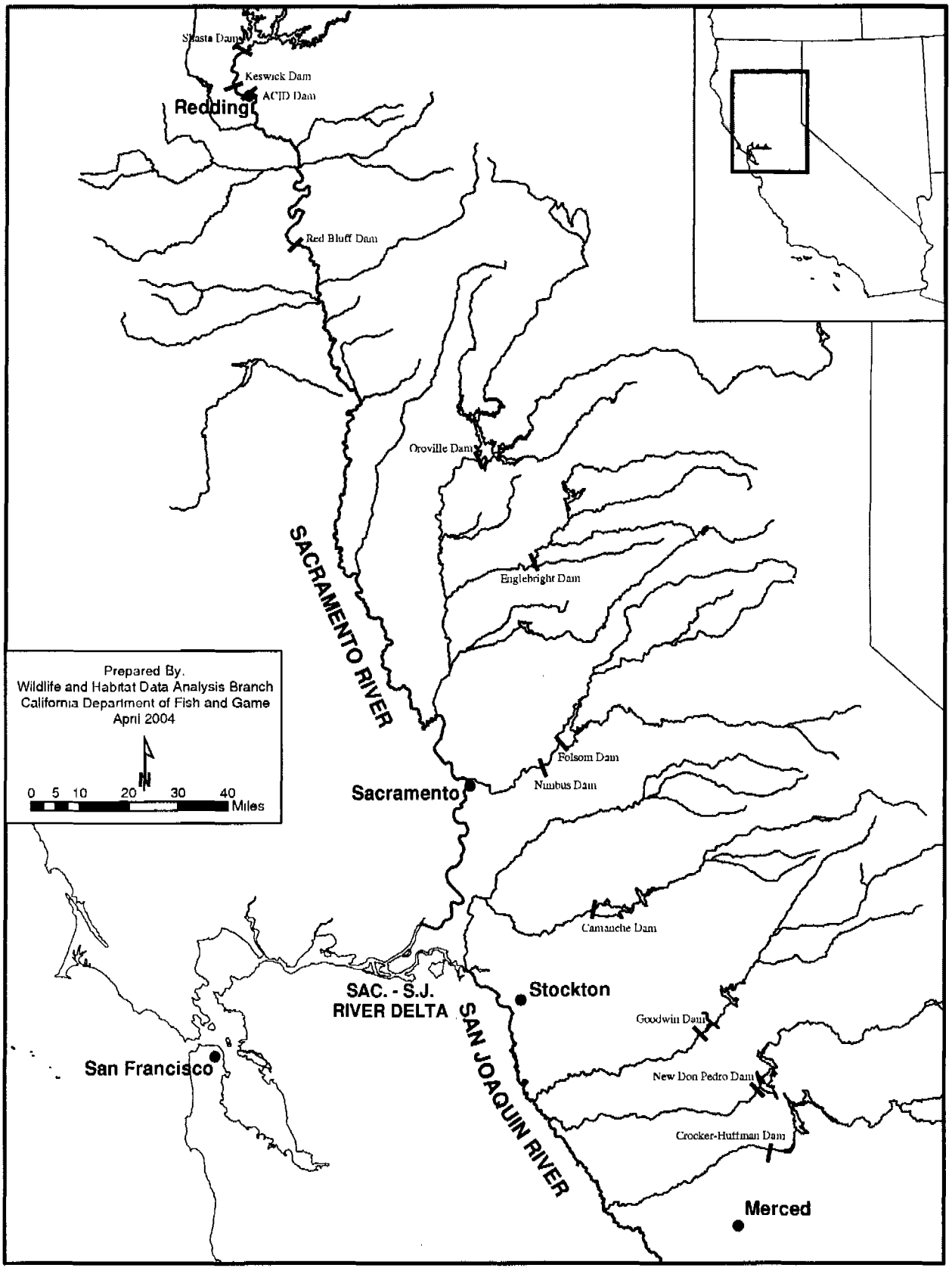


FIGURE 1. Sacramento-San Joaquin River System of California's Central Valley.

GENERAL METHODS

During 2001, 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

Keswick Dam to Red Bluff Diversion Dam [2/]

Spawner population sizes were estimated for the late-fall, winter, and fall runs of Chinook salmon in the Sacramento River mainstem (Figure 2) upstream of Red Bluff Diversion Dam (RBDD). Clear and Battle creeks were the only tributaries in this area for which individual fall-run population estimates were made. Spawning distribution in the mainstem was determined from aerial redd counts.

In 2001, a total of 224,455 salmon was estimated for the Sacramento River system upstream of Red Bluff, consisting of 194,343 fall-, 21,678 late-fall-, 8,189 winter- and 245 spring-run fish. The mainstem portion of the fall- run spawner population was 57,792 fish. The mainstem totals which are reported include fish for tributaries in which a run might have occurred, but where no estimates were possible; e.g., the spring runs in Clear and Battle creeks, and the fall run in Cottonwood Creek.

Sacramento River Mainstem

RBDD monitoring. Numbers of winter-, spring-, and fall-run salmon passing RBDD were based on daily counts made by the U.S. Fish and Wildlife Service (USFWS) and on sampling of fish at the dam by CDFG. Counts were obtained through video monitoring of salmon passing through the fishway ladders.

Numbers of fish counted each week were adjusted for those periods when the fishways remained open but no counts were possible (e.g., turbid conditions, when no observations were made at night, and when counting took place during only part of a week due to temporary opening of the dam gates). Adjustments to lapses in daytime counts were made by interpolation. Adjustments for the non-monitored nighttime hours were made by multiplying the 14-h day counts by a "night-factor", which was generated from night counts made twice a week.

The adjusted weekly number of fish was apportioned among the runs based on their relative proportions seen that week in samples of salmon from the dam's east-bank trapping facility. These sampled fish were assigned to a run by assessing when they would spawn, as indicated by physiological characteristics (coloration, scale absorption, secondary sexual development, and relative degree of ripeness).

To facilitate upstream migration of winter-run salmon, the RBDD gates were raised from the beginning of the year to 15 May, and from 15 September through the end of the year. When the

---

[2/] Killam, D. and C. Harvey-Arrison. Chinook Salmon Spawner Populations for the Upper Sacramento River System, 2001. File Report. June 2002. CDFG-Northern California-North Coast Region (NCNCR), Red Bluff Office.

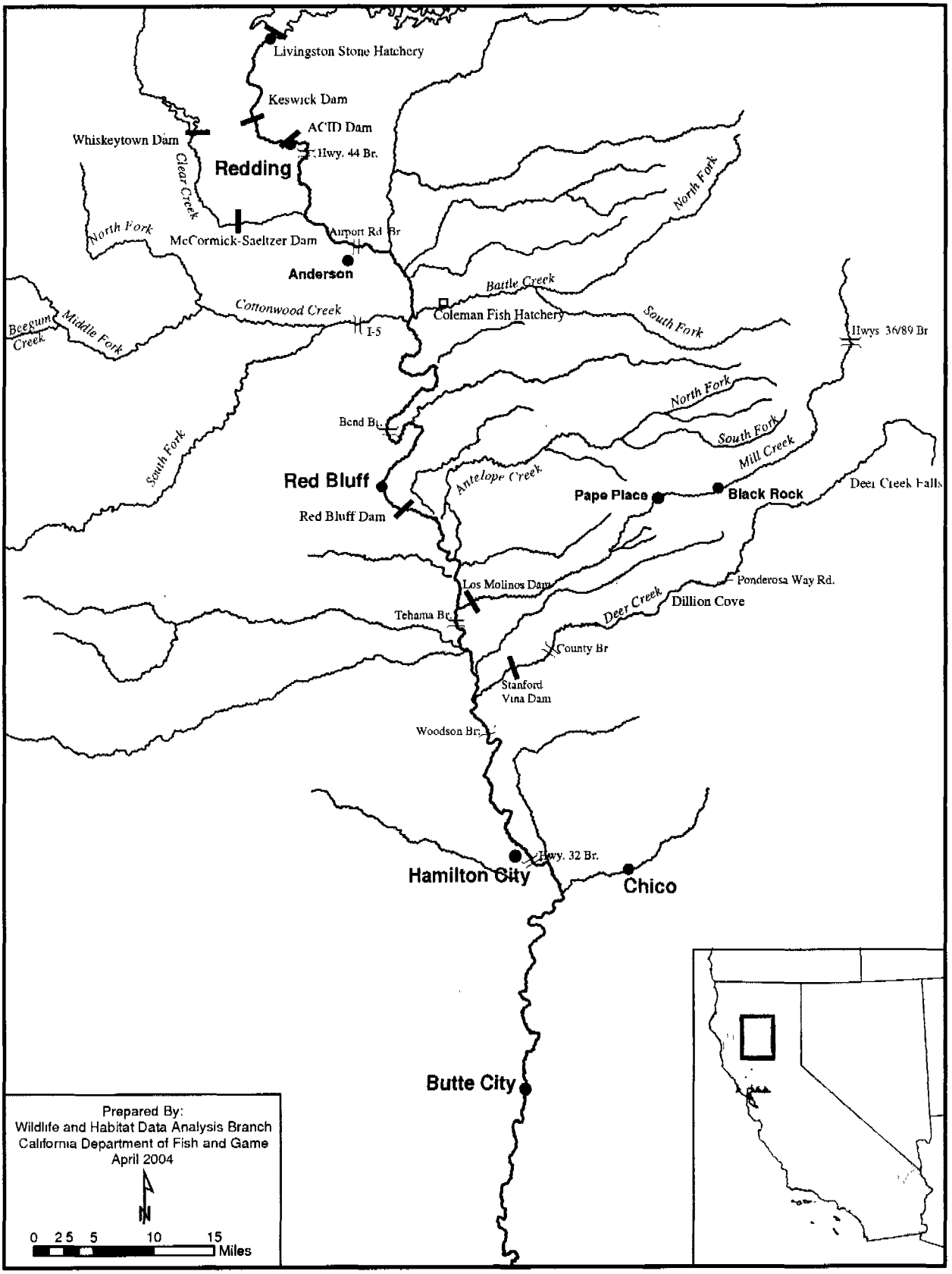


FIGURE 2. Sacramento River System from Keswick Dam downstream to Princeton Ferry.

dam gates are up, the fishways are essentially inoperable, and counts are not possible. To account for salmon passing the dam when the gates were up, total adjusted numbers from actual counts were expanded, using migrational distributions for each run based on historical data.

The migrational distributions were an average timing derived from RBDD data when the gates were down year-round, based on the 1982-1986 winter runs, and the 1970-1988 spring and fall runs (Table 1). Numbers of fish estimated from actual counts for the gates-down period in 2001 were assumed to represent the same proportion of the run as the period's historical distribution, and expanded accordingly.

Mainstem spawner populations were typically determined from the estimated RBDD passage by adjusting for harvest in the sport fishery, and for populations in upstream tributaries. Sport-caught fall-run salmon were estimated from angler census surveys conducted by CDFG upstream of RBDD. However, no winter- or spring-run fish were assumed harvested, due to an angling closure in effect from 15 January through 16 July. Upper Sacramento River system tributary populations included estimated numbers in streams which were surveyed and counts made at upstream hatcheries.

Late-fall run. The RBDD gates were raised during the entire late-fall migration period, so counts of this run's fish passing the dam were not possible. Instead, the population was estimated from salmon carcass surveys in a portion of the mainstem, and from aerial redd surveys of the entire mainstem.

Weekly carcass surveys were conducted from 3 January through 26 April 2001, covering the 26.5-km (16.5-mi) stretch of the mainstem from Anderson-Cottonwood Irrigation District Dam (ACID) downstream to Anderson River Park [3/]. This stretch of river was covered weekly in three reaches, each surveyed on one day. Mean river flows upstream from ACID were more stable than during previous years' surveys, ranging from 93.4 m^3/s to 195.4 m^3/s (3300-6900 cfs). Weekly average water clarity in the surveyed section, measured by secchi disk, ranged from 1.8 m to 5.1 m (6-17 ft). Water temperatures in the survey area ranged from 7.8 °C to 11.7 °C (46-53 °F).

Salmon carcasses were marked with colored ribbon attached to their jaws with hog rings; for each week a different color was used. Carcasses that were not marked included those that were headless, those on shore in a dessicated condition, and those at the downstream end of the survey area which would have drifted out of the area. Unmarked carcasses, as well as those that were recovered with marks, were chopped in half to prevent recounting. Marked carcasses were returned to running water for subsequent recovery. Measurements of fork length (FL), and determination of gender were made for a subsample of fresh carcasses (those with a clear eye or pink gills).

[3/] Snider, B., B. Reavis, and S. Hill. Upper Sacramento River Late-fall-run Chinook Salmon Escapement Survey, January - April 2001. CDFG, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program. December 2001. Technical Report No. 01-5. 33 p.

TABLE 1. Distribution of migration for Chinook salmon runs past Red Bluff Diversion Dam. Proportions were used to expand estimated numbers of fish passing the dam for gates-down periods, to include numbers passing during gates-up periods.

Approximate monthly period	Concurrent week	Proportion of run (%) [1/]		
		Winter run	Spring run	Fall run
	1	1 70		
January	2	1.78		
	3	0.35		
	4	1.28		
	5	2.38		
February	6	3.12		
	7	3.08		
	8	0 97		
	9	6.35		
March	10	7.72		
	11	9.23		
	12	7.79	0 10	
	13	4.91	0.25	
	14	7.64	0.59	
April	15	8.26	0 96	
	16	9.19	1.38	
	17	3.47	1.63	
	18	2.02	1 60	
May	19	1.60	1.71	
	20	2.17	2 16	
	21	3.09	2 63	
	22	2.03	2 86	0.01
June	23	1 63	2.61	0.00
	24	1 84	2.93	0.01
	25	0 51	3.50	0.03
	26	0.76	3 10	0.08
	27	1.60	3 67	0.10
July	28	0.31	6.02	0.29
	29	1.04	4.75	0.49
	30	0.44	3 21	0.70
	31	0.01	4.12	0.96
August	32		6.97	1.68
	33		6 07	2.95
	34		6.75	3.53
	35		5.74	3.91
	36		7 22	4.54
September	37		6 68	5.59
	38		5.23	8.58
	39		3 70	9.24
	40		1 19	10.49
October	41		0 69	10.59
	42			8.97
	43			6.99
	44			6 70
November	45			4 67
	46			2 71
	47			2.23
	48			1.68
December	49	0.17		0.90
	50	0.38		0.66
	51	0.49		0.51
	52	0.71		0.19

1/ Distributions are averages based on the following years of data:
-Winter-run, 1982 through 1986.
-Spring-run, 1970 through 1988.
-Fall-run, 1970 through 1988.

A total of 4,694 salmon carcasses was observed, but only the mark-and-recovery data for those fresh carcasses classified as adults (FL > 67 cm [26.4 in]) were used to calculate an estimate using the Petersen formula (Appendix 1.A). Adults comprised 4,573 of the observed carcasses, of which 560 were marked and 212 subsequently recovered, for an estimate of 12,605 adult fish in the surveyed area. The adult estimate was expanded to include an approximately 4.1% grilse proportion, for a population of 13,148 salmon from ACID to Anderson River Park.

Five aerial surveys of the mainstem up- and downstream of RBDD were conducted from 12 December 2000 through 4 April 2001 (Table 2). Based on data from these surveys, approximately 68.2% of the late-fall-run spawning occurred within the mark-and-recovery area, and 95.2% of those total redds were upstream of RBDD. The carcass survey population estimate was therefore expanded for an entire mainstem spawner population (19,276 fish), which was then proportioned to 18,351 fish for only the mainstem upstream of RBDD.

The late-fall population consisted of 46.9% male adults, 48.9% female adults, 3.6% male grilse (FL $\leq$ 67 cm), and 0.6% female grilse. This composition was based on 533 fresh carcasses examined during the mark-and-recovery surveys.

The 2001 late-fall-run population of 18,351 fish for the mainstem upstream of RBDD was over twice that for the year 2000, but only about half that of 1998; for both these other years, estimates were also made from carcass survey and redd data (Appendix 3).

Winter run. The 2001 winter run passing upstream of RBDD was estimated to be 5,499 salmon; due to the dam gates being open, only 15% of this estimate was derived from actual counts at the dam (Table 3). In previous years, Sacramento River mainstem spawner populations were determined from these estimates at the dam. However, for the 2001 population, carcass survey data were used. Carcass surveys of the winter-run mainstem spawner populations had been conducted since 1996, and had been used primarily to study the age and sex composition of the population, pre-spawning mortality, and temporal and spatial distribution of spawning activity. Evaluation by CDFG's Winter-run Technical Team supported the recommendation to use the carcass surveys also for estimating the mainstem population.

The carcass surveys covered the 22.5-km (14-mi) stretch of the mainstem from Keswick Dam downstream to the Redding Water Treatment Plant, and were conducted from 2 May through 29 August 2001 [4/]. The study area was divided into two equal-length reaches, which were surveyed on consecutive days starting with the upstream reach. After a one day pause, and the cycle was repeated, for 40 survey periods. Mean survey-period river flow averaged more than 348 m^3/s (12,300 cfs), ranging from 241 m^3/s to 430 m^3/s (8500 – 15,200 cfs). Mean survey-period temperature averaged 11.6 °C (52.8 °F), ranging from 10 °C to 12.8 °C (50 – 55 °F). Water clarity, measured by secchi disk, averaged 5.9 m (19.5 ft), ranging from 4.4 m to 6.4 m (14.4 – 21.2 ft).

Most of the surveys were conducted from two boats, each with two observers, and generally covered opposite shorelines out to the middle of the river. Efforts were made to assure adequate coverage of areas where carcasses were known to accumulate, and several short stretches of river were surveyed on foot.

Carcasses were collected using a gaff or gig, and before further processing were categorized as being either fresh or decayed, and either from a fish of hatchery or natural origin. Fresh carcasses were those having firm flesh and at least one clear eye. A carcass of hatchery origin was

---

[4/] Snider, B., B. Reavis, R.G. Titus, and S. Hill. Upper Sacramento River Winter-run Chinook Salmon Escapement Survey, May - August 2001. CDFG, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program. August 2002. Technical Report No. 02-1. 61 p.

TABLE 2. Chinook salmon redd relative distribution observed during 2001 aerial surveys of the mainstem Sacramento River from Keswick Dam to Princeton Ferry.

	Late-fall run		Winter run		Spring run		Fall run	
River section	Redds counted [1/]	Proportional distribution	Redds counted [2/]	Proportional distribution	Redds counted [3/]	Proportional distribution	Redds counted [4/]	Proportional distribution
Keswick Dam to A C I D. Dam [5/]	444	25 6%	484	34 7%	0		256	6 8%
A.C I D Dam to Highway 44 Bridge	311	17 9%	215	15 4%	0		206	5 5%
Highway 44 Bridge to Airport Road Bridge	427	24 6%	624	44 7%	7	24 1%	381	10 1%
Airport Road Bridge to Balls Ferry Bridge	246	14 2%	55	3 9%	7	24 1%	449	12 0%
Balls Ferry Bridge to Battle Creek	82	4 7%	2	0.1%	5	17.2%	347	9 2%
Battle Creek to Jellys Ferry Bridge	84	4 8%	2	0.1%	8	27.6%	536	14 3%
Jellys Ferry Bridge to Bend Bridge	39	2 3%	8	0.6%	1	3.4%	414	11 0%
Bend Bridge to Red Bluff Dam	17	1 0%	0		0		301	8 0%
Upstream proportion:		**95.2%**		**99.6%**		**96.6%**		**76.9%**
Red Bluff Dam to Tehama Bridge	67	3 9%	6	0 4%	1	3.4%	503	13 4%
Tehama Bridge to Woodson Bridge	16	0.9%	0		0		140	3 7%
Woodson Bridge to Hamilton City Bridge	0		0		--		153	4.1%
Hamilton City Bridge to Ord Ferry Bridge	0		0		--		60	1 6%
Ord Ferry Bridge to Princeton Ferry	0		0		--		11	0 3%
Downstream proportion:		**4.8%**		**0.4%**		**3.4%**		**23.1%**
Total Redds:	**1,733**		**1,396**		**29**		**3,757**	

1/ Total count for five aerial surveys made from 12 December 2000 through 4 April 2001.
2/ Total count for 15 aerial surveys made from 4 May through 14 August 2001.
3/ Count for survey made on 18 September 2001
4/ Total count for three aerial surveys made from 4 October through 1 November 2001
5/ Anderson-Cottonwood Irrigation District Dam

identified by a missing adipose fin. Livingston Stone National Fish Hatchery (LSNFH) had been the exclusive winter-run salmon 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 spawning.

For estimation of the spawner population, carcasses were tagged with small colored plastic ribbons attached with hog rings; tag 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. The exceptions were fresh, hatchery-origin carcasses, which had the ribbon attached to the anterior portion of the backbone, 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. Carcasses not tagged, usually those in an advanced state of decay, were chopped in half. Tagged 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 tagged 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 in-river), 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.

TABLE 3. Estimation of 2001 winter-, spring- and fall-run Chinook salmon spawners passing Red Bluff Diversion Dam (RBDD).

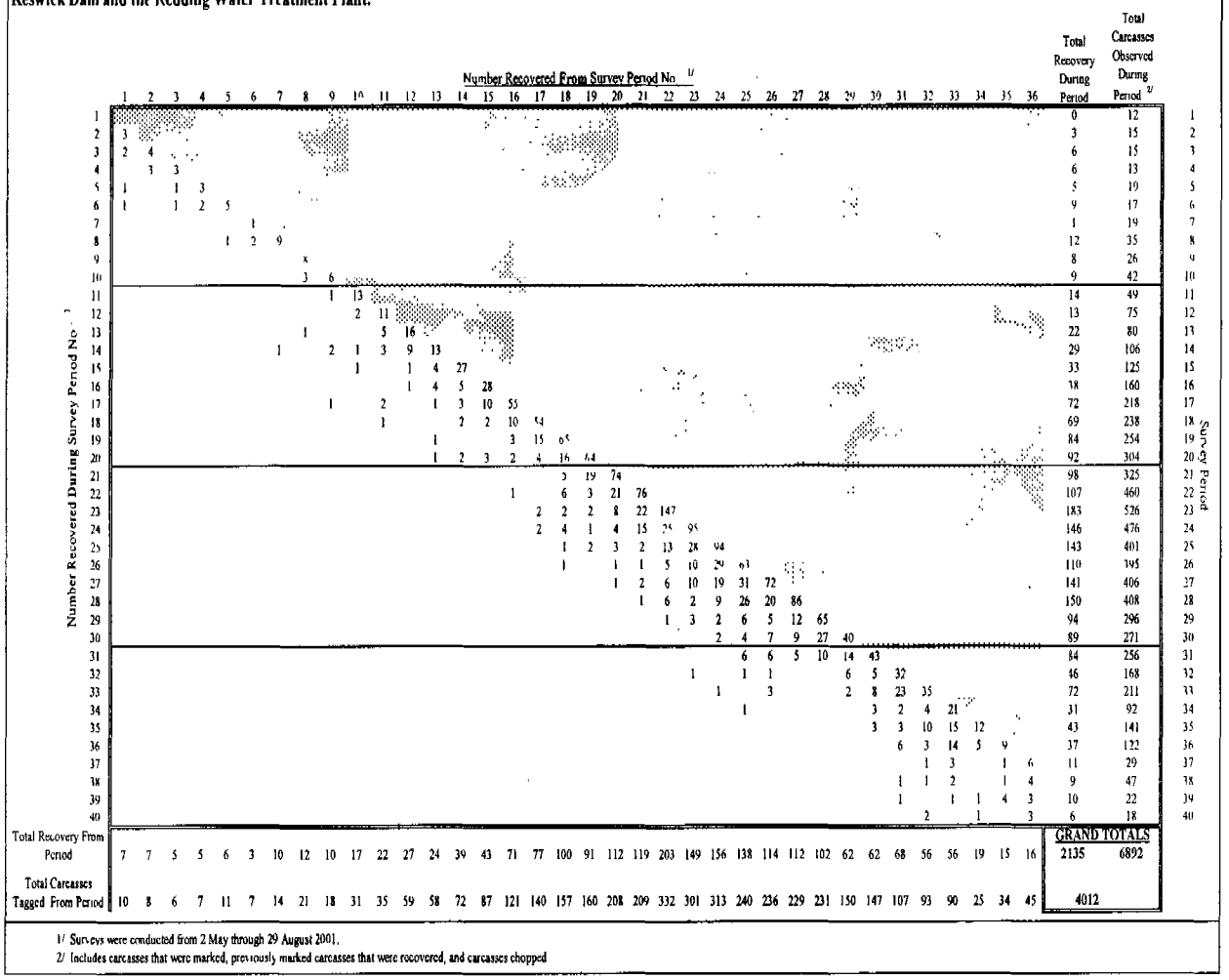
	Fishway trapping observations							Calculated No. salmon passing dam			
	Number of salmon assigned to run [2/]				Weekly run proportions (%)				Adjusted count apportioned by run [4/]		
Week No. of RBDD operation [1/]	Winter-run	Spring-run	Fall-run	Total	Winter-run	Spring-run	Fall-run	Weekly adjusted count [3/]	Winter-run	Spring-run	Fall-run
20	8	4	0	12	66.7	33.3	0.0	148	98	49	0
21	8	7	0	15	53.3	46.7	0 0	187	100	87	0
22	22	38	0	60	36.7	63 3	0 0	168	62	106	0
23	33	56	1	90	36.7	62 2	1 1	426	156	265	5
24	7	12	11	30	23.3	40.0	36.7	441	103	176	162
25	11	5	20	36	30.6	13.9	55.6	300	92	42	167
26	8	4	28	40	20 0	10.0	70 0	307	61	31	215
27	13	1	29	43	30.2	2.3	67.4	238	72	6	161
28	5	1	30	36	13.9	2 8	83 3	408	57	11	340
29	6	0	98	104	5.8	0 0	94.2	381	22	0	359
30	5	0	82	87	5.7	0 0	94.3	289	17	0	272
31	1	0	53	54	1.9	0 0	98.1	495	9	0	485
32	0	0	186	186	0 0	0 0	100 0	1069	0	0	1,069
33	0	0	100	100	0.0	0 0	100.0	1027	0	0	1,027
34	0	0	193	193	0.0	0 0	100.0	1471	0	0	1,471
35	0	0	163	163	0.0	0.0	100.0	1629	0	0	1,629
36	0	0	225	225	0 0	0.0	100 0	3195	0	0	3,195
37	0	0	589	589	0 0	0 0	100.0	7915	0	0	7,915
Totals	127	128	1,808	2,063			Totals [5/]	20,093	849	774	18,470
					Portion of each run represented by calculated No. of fish [6/]:				15.43%	80.99%	24 88%
					ESTIMATED TOTAL 2001 RUN [7/]:				**5,499**	**956**	**74,246**

1/ Covers the period from 15 May through 15 September 2000, when the dam gates were in.
2/ Fish were assigned to a run based on coloration, scale absorption, secondary sexual characteristics, and spawning readiness Data includes both adipose fin-clipped and non-fin-clipped salmon
3/ Video counts expanded to adjust for periods when no counts were made.
4/ Weekly run proportion x Adjusted count
5/ Totals shown may be different than the sum of the numbers in the column due to spreadsheet calculations and rounding to whole numbers.
6/ Based on historical average run distributions (Table 1)
7/ Calculated total for period of gates-in ÷ Proportion of run represented = Run size of spawners migrating past RBDD.

A total of 5,145 salmon carcasses was observed, but only the mark-and-recovery data for those classified as adults (FL ≥ 61 cm [24 in] for females, and FL ≥ 67 cm [26.4 in] for males) were used to calculate the Jolly-Seber estimate. A total of 4,012 hatchery- and natural-origin adult carcasses (both fresh and decayed) were tagged and 2,135 of those were subsequently recovered (Table 4), resulting in an estimate of 6,489 adult fish in the surveyed area. The adult estimate was expanded to include an approximately 9.7% grilse proportion, for a population of 7,186 salmon from Keswick Dam to the Redding Water Treatment Plant.

Fifteen aerial surveys of the mainstem up- and downstream of RBDD were conducted from 4 May through 14 August 2001 (Table 2). Based on data from these surveys, approximately 88.5% of the winter-run spawning occurred within the survey area, and approximately 99.6% of the total redds were upstream of RBDD. The carcass survey population estimate was further expanded for an entire mainstem spawner population (8,120 fish), which was then proportioned to 8,085 fish for only the mainstem upstream of RBDD. A total of 104 fish (100 from Keswick

Table 4. Chinook salmon fresh and decayed adult carcass data used for the Jolly-Seber estimate of the 2001 winter-run spawner population in the mainstem Sacramento River between Keswick Dam and the Redding Water Treatment Plant.



1/ Surveys were conducted from 2 May through 29 August 2001.
2/ Includes carcasses that were marked, previously marked carcasses that were recovered, and carcasses chopped

Dam and four from RBDD traps) were transferred to the Livingston Stone National Fish Hatchery winter-run broodstock program.

The winter-run population consisted of 26.6% male adults, 64.8% female adults, 8.2% male grilse (FL < 67 cm), and 0.4% female grilse (Fl < 61 cm). This composition was based on 1,842 fresh carcasses examined during the mark-and-recovery surveys.

The 2001 winter-run spawner population of 8,085 salmon in the mainstem upstream of RBDD was 6½ times higher than the average for 1991-2000 (Appendix 3); however, those previous estimates were determined from RBDD counts rather than carcass surveys.

Spring run. An estimated 956 salmon with spring-run characteristics passed RBDD in 2001; 81% of this estimate was derived from actual counts at the dam (Table 2). It was assumed that no spring-run salmon were caught in the sport-fishery upstream of RBDD, and a total of 245 fish, most of which were considered to be of this run, were accounted for in the upper reach of Cottonwood Creek. The remaining 711 salmon may have spawned in the mainstem and in

tributaries upstream of RBDD. However, CDFG considers this to be unlikely, as available spawning habitat in those areas are also utilized by fall-run salmon during the same periods. Therefore, an estimate of the spawner population was not made. Based on 128 salmon sampled at RBDD, the spring run consisted of 52% adults and 48% grilse.

Fall run. An estimated 74,246 fall-run potential spawners passed RBDD in 2001; due to the RBDD gates being open, only 25% of this estimate was derived from actual counts at the dam (Table 2). This estimate, however, was judged to be inappropriate for determining the mainstem population as was done in past years, since it was less than the total population estimated for the upstream tributaries which were surveyed (Battle and Clear creeks). Instead, salmon carcass surveys conducted in a portion of the mainstem, and aerial redd surveys of the entire mainstem were used to estimate the population.

The carcass surveys were conducted from 1 October through 20 December 2001, covering the 25.5-mi stretch of the mainstem from ACID downstream to the mouth of Cottonwood Creek [5/]. This stretch of river was covered weekly in four separate reaches, each surveyed on one day; during four of the weeks some of the reaches were not covered. Mean weekly river flows decreased from 215 m^3/s (7600 cfs) at the beginning of the surveys to 108 m^3/s (3800 cfs) at the end. Weekly average water clarity in the surveyed section, measured by secchi disk, ranged from 1.8 m to 7.3 m (6-24 ft). Mean weekly water temperatures in the survey area ranged from 11.7 °C to 13.9 °C (53-57 °F).

Most of the salmon carcasses observed were marked with colored ribbon attached to their jaws with hog rings; for each week a different color was used. Carcasses that were not marked included those that were headless, those on shore in a dessicated condition, those at the downstream end of the survey area which would have drifted out of the area, and those that were in excess of what could be processed in a day. Unmarked carcasses, as well as those that were recovered with marks, were chopped in half to prevent recounting. Marked carcasses were returned to running water for subsequent recovery. Length measurements and determination of gender were made for a subsample of fresh carcasses (those with a clear eye or pink gills).

A total of 7,785 carcasses was observed, but only the mark-and-recovery data for fresh, adult carcasses were used in the Schaefer (Appendix 1.B) calculation; the adult distinction was a FL > 76 cm [29.9 in] for males, and FL > 64 cm [25.2 in] for females. For a total of 1,805 carcasses marked, and 291 subsequently recovered, an adult population of 26,001 fish was estimated (Table 5). This estimate was expanded to include an approximately 10.6% grilse proportion, for a population of 29,084 salmon for the mainstem between ACID and Cottonwood Creek.

Three aerial surveys of the mainstem up- and downstream of RBDD were conducted from 4 October through 1 November 2001 (Table 2). Based on data from these surveys, approximately 38.7% of the fall-run spawning occurred within the mark-and-recovery area, and 76.9% of the total redds were upstream of RBDD. The carcass survey population estimate was

---

[5/] Snider, B., B. Reavis, and J. Lyons. Sacramento River Fall-run Chinook Salmon Escapement Survey, October-December 2001. CDFG, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program. December 2002. Technical Report No. 02-03. 38 p.

TABLE 5. Chinook salmon fresh adult carcass mark-and-recovery data used to estimate the 2001 fall-run spawner population in the mainstem Sacramento River from Anderson Irrigation District Dam to the mouth of Cottonwood Creek [1/].

Recovery period (j).	Number of marked carcasses recovered from marking period (i):										Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [2/]	Population estimate (N) [3/]
	1	2	3	4	5	6	7	8	9	10			
2	13	--	--	--	--	--	--	--	--	--	13	520	1,820
3	5	23	--	--	--	--	--	--	--	--	28	745	2,225
4	3	3	59	--	--	--	--	--	--	--	65	1,045	2,696
5	1	4	19	39	--	--	--	--	--	--	63	1,306	4,857
6		2	6	12	23	--	--	--	--	--	43	661	3,456
7			1	2	8	9	--	--	--	--	20	576	2,964
8					1	5	6	--	--	--	12	270	1,340
9					1	3	3	2	--	--	9	503	2,901
10						1		0	10	--	11	314	1,361
11								1	4	17	22	605	1,530
12									1	4	5	817	1,860
Total recovered	22	32	85	53	33	17	9	2	0	0			
Total carcasses marked (M1).	77	92	214	233	217	78	47	25	65	37	Total estimate [4/].		27,009
											Adjusted estimate [5/]:		**26,001**

1/ Surveys were conducted from 1 October through 20 December 2001

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

3/ Schaefer (1951) estimate equation: $N = \Sigma(Rj \times (M1/Ri) \times (Cj/Rj))$.

4/ Total may not correspond to the actual sum of the weekly estimates shown, due to spreadsheet rounding.

5/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (M1) from the second marking period on were subtracted from the total estimate (27,009 - 1,008 = 26,001)

therefore expanded to an entire mainstem spawner population (75,152 fish), which was then proportioned to 57,792 fish for only the mainstem upstream of RBDD.

The fall-run population consisted of 33% male adults, 56.4% female adults, 9.8% male grilse (FL ≤ 76 cm), and 0.8% female grilse (FL ≤ 64 cm). This composition was based on 1,277 fresh carcasses examined during the mark-and-recovery surveys.

The 2001 fall-run spawner population of 57,792 salmon in the mainstem upstream of RBDD was slightly higher than the average for 1991-2000 populations (Appendix 3). However, estimates for those previous years, ranging from 5,718 to 133,365 fish, were determined from RBDD counts rather than carcass surveys.

Clear Creek

Late-fall run. No surveys were conducted for this run in 2001.

Spring run. The USFWS conducted surveys in Clear Creek primarily to determine presence of spring-run salmon, but an estimate of the spawner population was not made.

Fall run. Eight spawner surveys of Clear Creek were conducted during 9 October through 26 November 2001, in the 6.7-km (4.2-mi) stretch downstream of the McCormick-Saeltzer Dam site. Salmon carcasses were marked by attaching colored tape to their jaws with hog rings, and replacing them back into running water for recovery during following surveys; different colors of tape 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 downstream of McCormick-Saeltzer Dam was estimated to be 10,865 fish (Table 6). Although the population upstream of the dam site was not estimated, 34 redds, 15 live fish, and 16 carcasses were observed in that area.

Based on examination of 3,868 salmon carcasses, the fall-run spawner population of Clear Creek consisted of 41% male adults (FL $\geq$ 61 cm [24 in.]), 51% female adults, and 8% grilse (FL < 61 cm).

Pre-spawning mortality of female salmon in Clear Creek this season was less than one percent.

Cow Creek

Late-fall run. No surveys for this run in this tributary were made in 2001.

Fall run. An aerial redd survey was conducted on 1 November 2001, covering the creek from its confluence with the Sacramento River upstream, into the North Fork to Cow Creek School, and into the South Fork to Clover. A total of 31 redds was counted in the mainstem, but none were seen in the North and South forks. An estimate of the fall-run spawner population was not made.

Cottonwood Creek

Late-fall run. No surveys were conducted for this run in 2001.

Spring run. Beegum Creek, a tributary to Cottonwood Creek, was surveyed monthly during March through October 2001. The 12.2-km (7.5-mi) stretch of the creek from upstream of the North and South forks' confluence to the Hwy-36 Bridge crossing was covered by snorkeling. A total of 245 salmon was counted, and judged to constitute the 2001 spring run for the Cottonwood Creek system; water temperatures in the upper 70-degree Fahrenheit may have reduced the number of actual spawners.

Fall run. An aerial redd survey was conducted on 1 November 2001, covering the creek from its confluence with the Sacramento River upstream to Little Dry Creek. A total of 116 redds was counted, all of which were downstream of the power line crossing. An estimate of the fall-run spawner population was not made.

TABLE 6. Chinook salmon carcass mark-and-recovery data used to estimate the 2001 fall-run spawner population in Clear Creek from the site of McCormick-Saeltzer Dam to 4.2 miles downstream [1/].

Recovery period (j):	Number of marked carcasses recovered from marking period (i).							Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [2/]	Population estimate (N) [3/]
	1	2	3	4	5	6	7			
2	11	--	--	--	--	--	--	11	323	646
3	3	33	--	--	--	--	--	36	839	1,892
4		2	55	--	--	--	--	57	1,201	3,536
5			15	38	--	--	--	53	813	2,272
6				2	1	--	--	3	102	337
7				9	29	5	--	43	472	1,773
8				5		0	12	17	312	1,045
Total recovered (Ri)	14	35	70	54	30	5	12			
Total carcasses marked (Mi)	32	82	209	148	146	10	40	Total estimate [4/].		11,500
								Adjusted estimate [5/]:		**10,865**

1/ Surveys were conducted from 9 October through 26 November 2001

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

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

4/ Total may not correspond to the actual sum of the weekly estimates shown, due to spreadsheet rounding.

5/ 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 (11,500 - 635 = 10,865)

Battle Creek

Late-fall run. No surveys were conducted for this run spawning naturally in Battle Creek during 2001. The only available spawner data were for 3,327 late-fall-run salmon which entered Coleman National Fish Hatchery (CNFH). These fish consisted of 50% male adults, 44% female adults, and 6% grilse.

Spring run. The USFWS conducted surveys in Battle Creek primarily to determine presence of spring-run salmon, but an estimate of the spawner population was not made.

Fall run. Six carcass surveys were conducted during 2 October through 28 November 2001, covering the 5.6-km (3.5-mi) stretch of river from CNFH downstream to the old hatchery location. Salmon carcasses were marked by attaching colored tape to their jaws with hog rings, and placed into running water for recovery; different colors of tape 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 Battle Creek downstream of CNFH was estimated to be 100,604 fish (Table 7). Combined with an additional 25,082 fish which entered CNFH, the total 2001 Battle Creek fall-run population was 125,686 salmon (Appendix 2); although the creek upstream of CNFH was not surveyed, some fall-run adults may have passed the barrier dam.

Based on examination of 24,558 salmon carcasses, the fall run consisted of 39% male adults (FL $\geq$ 61 cm [24 in.]), 58% female adults, and 3% grilse (FL< 61 cm). In comparison, fall-run fish entering CNFH consisted of 48% male adults, 28% female adults, and 24% grilse.

Pre-spawning mortality of female fall-run salmon in Battle Creek averaged 29% in 2001.

TABLE 7. Chinook salmon carcass mark-and-recovery data used to estimate the 2001 fall-run spawner population in Battle Creek from Coleman National Fish Hatchery downstream to the old hatchery location [1/].

Recovery period (j)	Number of marked carcasses recovered from marking period (i): 1	2	3	4	5	Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [2/]	Population estimate (N) [3/]
2	7	--	--	--	--	7	1,287	5,720
3	2	161	--	--	--	163	7,311	16,710
4		9	409	--	--	418	8,873	25,652
5			22	43	--	65	7,573	39,485
6					2	2	150	15,150
Total recovered (Ri):	9	170	431	43	2			
Total carcasses marked (Mi):	40	384	1,252	275	202	Total estimate [4/]:		102,717
						Adjusted estimate [5/]:		**100,604**

1/ Surveys were conducted from 2 October through 28 November 2001.

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

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

4/ Total may not correspond to the actual sum of the weekly estimates shown, due to spreadsheet rounding.

5/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (M1) from the second marking period on were subtracted from the total estimate (102,717 - 2,113 = 100,604).

The 2001 fall-run spawner population in Battle Creek of 125,686 fish was over 1½ times higher than in 2000, and almost twice the population average for 1991-2000 (Appendix 3).

Red Bluff Diversion Dam to Princeton Ferry

A total of 21,054 Chinook salmon spawners, consisting of 17,360 fall-, 2,734 spring-, 925 late-fall-, and 35 winter-run fish, was estimated for 2001 in the Sacramento River system between Red Bluff and Princeton Ferry (Figure 2).

Sacramento River Mainstem

Estimates of salmon spawner populations in the Sacramento River mainstem downstream of RBDD were derived from aerial redd counts for the entire mainstem and from the upstream mainstem population estimates. The proportional distribution of a run's redds that were upstream and downstream of RBDD was assumed to represent the distribution of that run's entire mainstem population.

Late-fall run. Five aerial surveys were conducted during 12 December 2000 through 4 April 2001. Late-fall-run redds downstream of RBDD constituted about 4.8% of the total mainstem spawning (Table 2), which was estimated to represent a spawner population of 925 fish.

Winter run. Based on 15 aerial surveys conducted during 4 May through 14 August 2001, winter-run redds downstream of RBDD constituted about 0.4% of the total mainstem spawning (Table 2). This was estimated to represent a spawner population of 35 fish.

Spring run. An aerial survey was conducted on 18 September 2001. Spring-run redds downstream of RBDD constituted about 3.4% of the total mainstem spawning (Table 2), but an estimate of the spawner population was not made.

Fall run. Based on three aerial surveys conducted during 4 October through 1 November 2001, fall-run redds downstream of RBDD constituted about 23.1% of the total mainstem spawning (Table 2), which was estimated to represent a spawner population of 17,360 fish. This estimate was almost twice that for the year 2000, and was 38% higher than the population average for 1991 to 2000 (Appendix 3).

Antelope Creek

Spring run. Snorkeling-surveys of the holding habitat of adult spring-run salmon in the upper Antelope Creek system were made on 23 and 26 July 2001. A total stream length of 23.5 km (14.6 mi) was covered, from Facht Place on the mainstem upstream, to Judd Creek on the North Fork, and into sections of the south fork to South Fork Falls. A total of 8 adult salmon was observed, and judged to be the 2001 spring run for this system.

Fall run. No surveys were conducted for this run in 2001.

Mill Creek

Spring run. Surveys of Upper Mill Creek were made during 3-11 October 2001, covering a stream length of approximately 41 km (25 mi) from the Hwy-36 Bridge crossing downstream to the powerline crossing located 4.8 km (3 mi) downstream from Little Mill Creek [6/]. The reach from Hwy-36 to the ranch house downstream of Black Rock was surveyed from the ground, while aerial surveys were made from Black Rock to the powerlines. Total of 167 live salmon and 54 carcasses were observed. Based on redd counts made through the combined ground and aerial surveys, a total of 552 redds was determined to be the maximum number present, and judged to represent a spring-run population of 1,104 fish.

Fall run. Surveys of Mill Creek were conducted on 20 and 26 November 2001 primarily to count redds and determine spawning distribution. Surveys extended from the canyon mouth downstream to the confluence with the Sacramento River. Most of the fall run spawning (97%) occurred downstream of Los Molinos Mutual Water District Dam. Totals of 236 redds, 120 live salmon, and 84 carcasses were observed. An estimate of the fall-run population was not made.

[6/] Harvey-Arrison, C. Mill Creek Spring-run Chinook Salmon Surveys for 2001. Memorandum to files. 6 December 2001. CDFG – NCNCR, Red Bluff Office.

Deer Creek

Spring run . Snorkeling surveys of upper Deer Creek were conducted on 8 and 20 August 2001 covering the 38.6-km (24-mi) stretch from Upper Deer Creek Falls to downstream of Trail 2E17 [7/]. A total of 1,622 adult salmon was counted, and judged to be the 2001 spring run in this tributary.

Fall run. A ground survey was conducted in Deer Creek on 27 November 2001 to count redds and determine spawning distribution. Surveys covered the area from the Deer Creek Irrigation District upper diversion dam to the confluence with the Sacramento River. Totals of 61 redds, 25 live salmon, and 35 carcasses were observed. An estimate of the fall-run population was not made.

[7/] Harvey-Arrison, C. 2001 Annual Deer Creek Spring-run Chinook Salmon Survey. Memorandum to files. 5 September 2001. CDFG – NCNCR, Red Bluff Office.

A total of 392,301 Chinook salmon was estimated for 2001 in the Sacramento River tributaries from Big Chico Creek to the American River (Figure 3). This total consisted of 13,830 spring-run and 378,471 fall-run fish (Appendix 2).

Big Chico Creek

Spring run. A snorkeling survey was conducted on 8 August 2001 in the stretch of Chico Creek from Higgin's Hole downstream to Salmon Hole in Bidwell Park [8/]. A total of 39 salmon was counted, and judged to be the spring-run spawner population in this tributary for 2001.

Fall run. No surveys were conducted for this run in 2001.

Butte Creek

Spring run. A snorkeling survey was conducted during 13-16 August 2001 covering the stretch from Quartz Bowl downstream to Parrott-Phelan Diversion Dam [9/]. Total counts of live salmon by four independent observers ranged from 7,435 to 11,066 fish. All of the salmon observed were upstream of the covered bridge. Based on these surveys, a population of 9,605 spring-run salmon were in the creek.

Fall run. Carcass surveys for fall-run salmon in Butte Creek covered the approximately 15.3-km (9.5-mi) stretch of river from Parrott-Phelan Diversion Dam downstream to Gorrill Ranch Dam, and a 0.8-km (0.5-mi) section near the Western Canal Siphon (Ward et. al. 2004). Surveys were conducted during 22 October through 4 December 2001, terminating before spawning was completed. Fresh salmon carcasses (those with at least one clear eye and firm flesh) were marked by attaching colored tape to their lower jaws with hog rings, and replaced into running water near the location originally found. Different colors of tape 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.

An estimate of the spawner population was based on the total of all carcasses observed, and the recovery rate of marked carcasses. A total of 1,476 carcasses was examined, of which 225 fresh carcasses were marked, with 81 subsequently recovered, for about 4,100 fish in the surveyed area. In addition, it was judged that an additional 330 salmon were upstream of Parrott-Phelan Dam (from limited observations made there), for a total of 4,430 fish in the fall run.

[8/] Garmin, C. Big Chico Creek Spawning Escapement. Memorandum to files. 13 August 2001. CDFG-Sacramento Valley and Central Sierra Region (SVCSR), Chico office.

[9/] Garmin, C. Butte Creek Spawning Escapement Survey, 2001. Memorandum to files. 17 September 2001. CDFG – SVCSR, Chico office.

Feather River

Spring run. A total of 4,078 salmon classified as spring-run fish entered Feather River Hatchery (FRH) during 1-15 September 2001 [10/]. These fish consisted of 52.9% male adults, 46.4% female adults, and 0.7% grilse. In the river itself, no attempt was made to estimate numbers of spring-run salmon.

The 4,078 spring-run salmon at FRH in 2001 was 3% higher than in 2000, and 15% lower than the average for 1991-2000 (Appendix 3).

Fall run. Salmon carcass mark-and-recovery surveys were conducted in the Feather River between the hatchery barrier dam and East Gridley Road bridge during 3 September through 10 December 2001 [11/]. This stretch of river was surveyed in two sections, characterized by different flow regimes. The reach between the hatchery and Thermalito Afterbay Outlet (Section 1) had constant mean daily flows of 17 m^3/s (600 cfs) throughout the survey periods. Flows downstream of Thermalito Afterbay to Gridley (Section 2) ranged from 23.8 m^3/s (839 cfs) to 45.1 m^3/s (1593 cfs).

Only fresh carcasses were marked, with numbered tags attached to the lower jaws with hog rings. Each carcass' tag had a unique number identifying it with a specific marking period and survey section. Fresh carcasses were identified by having at least one clear eye or pink gills. Marked carcasses were released into flowing water for later recovery. Carcasses not marked were counted and then chopped in half, as were non-fresh carcasses and those that were recovered with marks. The length and gender of fresh carcasses was also recorded. Adult salmon carcasses were classified by a FL $\geq$ 68 cm (26.8 in).

Schaefer (Appendix 1.B) estimates, calculated from the mark-and-recovery data, were 106,969 salmon for Section 1, and 71,503 fish for Section 2 (Table 8). Combining both estimates, along with an additional 173 carcasses counted during the initial survey week, resulted in a total in-river population of 178,645 fish. A total of 24,870 fall-run salmon entered FRH [10/], bringing the 2001 fall run in the Feather River to 203,515 salmon (Appendix 2).

The composition of fall-run salmon in the river was 39.4% male adults, 55.5% female adults, and 5.1% grilse (FL < 68 cm). Salmon which entered FRH consisted of 55.7% male adults (FL $\geq$ 55.9 cm [22 in]), 40.8% female adults, and 3.5% grilse (FL < 55.9 cm).

The 2001 total Feather River population of 203,515 salmon was the highest recorded for that tributary, and over 1½ times that of the previous year (Appendix 3).

[10/] Kastner, A. CDFG – SVCSR, Feather River Hatchery. Personal communication.

[11/] Navicky, J. 2001 Feather River Spawning Stock Escapement. Memorandum to files. 16 July 2002. CDFG-SVCSR, Rancho Cordova office.

TABLE 8. Chinook salmon carcass mark-and-recovery data used to estimate the 2001 fall-run spawner population in the Feather River from Feather River Hatchery to East Gridley Road Bridge [1/].

Feather River Hatchery to Thermalito Afterbay Outlet (Section 1)

Recovery period (j)	Number of marked carcasses recovered from marking period (i):													Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [2/]	Population estimate (N) [3/]
	1	2	3	4	5	6	7	8	9	10	11	12	13			
2	11	--	--	--	--	--	--	--	--	--	--	--	--	11	250	750
3	2	48	--	--	--	--	--	--	--	--	--	--	--	50	693	1,595
4		5	64	--	--	--	--	--	--	--	--	--	--	69	2,145	5,509
5		1	25	101	--	--	--	--	--	--	--	--	--	127	4,792	12,577
6			1	50	139	--	--	--	--	--	--	--	--	190	4,929	13,797
7			1	3	33	125	--	--	--	--	--	--	--	162	4,609	14,426
8			2		3	29	178	--	--	--	--	--	--	212	7,182	18,048
9						3	48	174	--	--	--	--	--	225	6,029	15,822
10							6	22	143	--	--	--	--	171	4,235	12,231
11							1	3	25	97	--	--	--	126	2,759	7,824
12							2			10	33	--	--	45	978	4,102
13										2	15	9	--	26	720	3,064
14										1	2	6	5	14	280	1,221
Total recovered (Ri):	13	54	93	154	175	157	235	199	168	110	50	15	5			
Total carcasses marked (Mi)	42	125	241	406	501	505	562	533	494	310	236	57	26	Total estimate [4/].		110,965
														Adjusted estimate [5/]:		**106,969**

Thermalito Afterbay Outlet to East Gridley Road Bridge (Section 2)

Recovery period (j)	Number of marked carcasses recovered from marking period (i):													Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [2/]	Population estimate (N) [3/]
	1	2	3	4	5	6	7	8	9	10	11	12	13			
2	3	--	--	--	--	--	--	--	--	--	--	--	--	3	38	241
3		1	--	--	--	--	--	--	--	--	--	--	--	1	102	1,836
4			1	--	--	--	--	--	--	--	--	--	--	1	167	3,173
5				2	--	--	--	--	--	--	--	--	--	2	163	1,467
6					2	--	--	--	--	--	--	--	--	2	297	3,366
7						4	--	--	--	--	--	--	--	4	315	3,129
8						1	6	--	--	--	--	--	--	7	860	7,494
9							2	17	--	--	--	--	--	19	1,800	11,225
10								3	16	--	--	--	--	19	2,024	12,669
11									1	30	--	--	--	31	2,357	10,454
12									1	12	23	--	--	36	2,444	9,562
13											8	7	--	15	912	5,416
14											4	4	2	10	324	2,387
Total recovered (Ri).	3	1	1	2	2	5	8	20	18	42	35	11	2			
Total carcasses marked (Mi)	19	18	19	36	41	45	78	119	111	197	125	100	26	Total estimate [4/]:		72,418
														Adjusted estimate [6/]:		**71,503**

1/ Surveys were conducted from 3 September through 10 December 2001

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

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

4/ Total may not correspond to the actual sum of the weekly estimates shown, due to spreadsheet rounding .

5/ 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 (110,965 - 3,996 = 106,969).

6/ Adjusted estimate where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (72,418 - 915 = 71,503)

Yuba River

Spring run. Chinook salmon emigrating in the Yuba River during 1 March through 31 July 2001 were monitored by trapping at Daguerre Point Dam [12/]. Fish were trapped in holding cages placed in the top bays of each of the dam's two fish ladders. Fish entered the cages voluntarily though "one-way" doors, which prevented them from exiting. Movable trap floors were raised allowing captured fish to be examined, counted, and released without handling. Trapping was conducted on a schedule of five randomly chosen days each week for five-hour periods each day. Sampling periods consisted of dawn (0300-0900 hr), afternoon (0900-1500 hr), dusk (1500-2100 hr), and night (2100-0300 hr), systematically rotated from day to day; trapping in each of the ladders was staggered by one hour.

A total of 15 salmon was captured for the season, with the majority (73%) caught in July, when river flows exceeded 42.5 m^3/s (1500 cfs). It was assumed that the population followed a Poisson distribution, and the fish observed represented a total of 108 salmon passing the dam ($\pm$ 56 fish variance) during the 2001 emigration.

Fall run. Salmon carcass mark-and-recovery surveys for this run during 2001 were conducted in the Yuba River from Rose Bar downstream to Simpson Lane in Marysville [13/]. The surveyed reach was covered in three sections: Rose Bar 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 in the Narrows upstream of Rose Bar to Englebright Dam, although suitable habitat is scarce in that area. Weekly surveys were conducted in Section 1 during 2 October through 4 December, in Section 2 during 3 October through 19 December, and in Section 3 from 11 October through 20 December.

Yuba River flows below Englebright Dam ranged from 26.7 m^3/s to 31.3 m^3/s (944-1107 cfs) during the survey periods, and remained relatively stable throughout the spawning season. Flows near Marysville ranged between 16.8 m^3/s and 27.9 m^3/s (594-985 cfs). The mean daily water temperature ranged from the lower 60-degree to upper 40-degree Fahrenheit, while visibility through the water averaged 3m (10 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 $\geq$ 55.9 cm (22 in). The length distinguishing adults and grilse was based on data from Feather River Hatchery salmon collected at the beginning of the 2001 season.

Marking consisted of colored flagging attached to the fish's jaw with a hog ring; different colors of tape 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

---

[12/] Nelson, J. CDFG-SVCSR, Rancho Cordova office. Personal communication.

[13/] Jones & Stokes. 2001 Fall-run Chinook Salmon Spawning Escapement in the Yuba River. Report to the Yuba County Water Agency, Marysville, CA. May 2002. J&S 00-402.

TABLE 10. Chinook salmon carcass mark-and-recovery data used to estimate the 2001 fall-run spawner population in the Yuba River from Parks Bar at the Highway 20 Bridge to Daguerre Point Dam [1/].

ADULT ESTIMATE

Recovery period (j)	Number of marked carcasses recovered from marking period (i)											Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [2/]	Population estimate (N) [3/]
	1	2	3	4	5	6	7	8	9	10	11			
2	6	--	--	--	--	--	--	--	--	--	--	6	221	921
3		23	--	--	--	--	--	--	--	--	--	23	625	1,271
4		7	67	--	--	--	--	--	--	--	--	74	1,048	1,360
5			10	68	--	--	--	--	--	--	--	78	812	881
6			6	9	45	--	--	--	--	--	--	60	870	983
7			3	9	22	50	--	--	--	--	--	84	569	1,088
8				7	9	10	42	--	--	--	--	68	541	929
9							12	29	--	--	--	41	239	516
10								5	6	--	--	11	68	175
11								1	3	1	--	5	91	321
12											1	1	44	748
Total recovered (R1)	6	30	86	93	76	60	54	35	9	1	1			
Total carcasses marked (M1)	25	61	105	99	86	147	96	81	25	7	17	Total estimate [4/]		9,193
												Adjusted estimate [5/]:		**8,469**

GRILSE ESTIMATE

Recovery period (j)	Number of marked carcasses recovered from marking period (i):											Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [2/]	Population estimate (N) [3/]
	1	2	3	4	5	6	7	8	9	10	11			
2	0	--	--	--	--	--	--	--	--	--	--	0	18	18
3		2	--	--	--	--	--	--	--	--	--	2	76	114
4			6	--	--	--	--	--	--	--	--	6	113	226
5			1	1	--	--	--	--	--	--	--	2	36	114
6				2	0	--	--	--	--	--	--	2	105	560
7						0	--	--	--	--	--	0	12	12
8							0	--	--	--	--	0	28	28
9							1	1	--	--	--	2	8	48
10									0	--	--	0	2	2
11										0	--	0	2	2
12											0	0	0	0
Total recovered (R1).	0	2	7	3	0	0	1	1	0	0	0			
Total carcasses marked (M1)	0	3	14	13	5	21	4	8	2	1	1	Total estimate [4/]		1,124
												Adjusted estimate [6/]:		**1,052**

1/ Surveys were conducted from 3 October through 19 December 2001.

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

3/ Schaefer (1951) estimate equation $N = \Sigma(Ri) \times (Mi/Ri) \times (Cj/Rj))$

4/ Total may not correspond to the actual sum of the weekly estimates shown, due to spreadsheet rounding .

5/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (M1) from the second marking period on were subtracted from the total estimate (9,193 - 724 = 8,469)

6/ Adjusted estimate where marked carcasses (M1) from the second marking period on were subtracted from the total estimate (1,124 - 72 = 1,052).

TABLE 11. Chinook salmon carcass mark-and-recovery data used to estimate the 2001 fall-run spawner population in the Yuba River from Daguerre Point Dam to the Simpson Lane Bridge in Marysville [1/].

ADULT ESTIMATE

Recovery period (j)	Number of marked carcasses recovered from marking period (i)										Total marked carcasses recovered (R_j)	Total carcasses observed (C_j) [2/]	Population estimate (N_j) [3/]
	1	2	3	4	5	6	7	8	9	10			
2	0	--	--	--	--	--	--	--	--	--	0	79	79
3		3	--	--	--	--	--	--	--	--	3	120	760
4			3	--	--	--	--	--	--	--	3	167	969
5			2	24	--	--	--	--	--	--	26	406	667
6				3	19	--	--	--	--	--	22	377	1,454
7					4	27	--	--	--	--	31	336	799
8						3	11	--	--	--	14	164	525
9							0	2	--	--	2	18	153
10							1		0	--	1	47	212
11										0	0	6	6
Total recovered (Ri)	0	3	5	27	23	30	12	2	0	0			
Total carcasses marked (M_i)	3	19	29	35	98	63	42	17	0	7	Total estimate [4/]:		5,623
											Adjusted estimate [5/]:		**5,313**

GRILSE ESTIMATE

Recovery period (j)	Number of marked carcasses recovered from marking period (i)										Total marked carcasses recovered (R_j)	Total carcasses observed (C_j) [2/]
	1	2	3	4	5	6	7	8	9	10		
2	0	--	--	--	--	--	--	--	--	--	0	9
3		0	--	--	--	--	--	--	--	--	0	9
4			0	--	--	--	--	--	--	--	0	10
5				0	--	--	--	--	--	--	0	35
6					0	--	--	--	--	--	0	18
7						0	--	--	--	--	0	5
8							0	--	--	--	0	2
9								0	--	--	0	0
10									0	--	0	0
Total recovered (Ri).	0	0	0	0	0	0	0	0	0	0		
Total carcasses marked (M_i)	1	1	4	5	13	3	1	0	0	1		
											Estimate [6/]:	**88**

1/ Surveys were conducted from 12 October through 21 December 2000

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

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

4/ Total may not correspond to the actual sum of the weekly estimates shown, due to spreadsheet rounding .

5/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (M_i) from the second marking period on were subtracted from the total estimate 4,169 - 327 = 3,842)

6/ Since no marked carcasses were recovered, the total number of carcasses observed was used as the estimate of the spawner population.

American River

Fall run. Salmon carcass mark-and-recovery surveys in the American River were conducted from 29 October through 28 December 2001, covering the 20.8-km (12.9-mi) stretch from Sailor Bar downstream to the Watt Avenue bridge [14/]. This stretch of river was covered in three reaches, each surveyed weekly; during several weeks it was not possible to make complete surveys. Mean daily river flow ranged from 28 m^3/s (988 cfs) in early November to 43.3 m^3/s (1528 cfs) during December. Average water turbidity increased throughout the surveys, ranging from 1.8 ntu to 10.7 ntu. Water temperature ranged from 19 °C to 10.6 °C (66-51 °F).

This season only fresh adult salmon carcasses were distinctly marked by attaching colored hog rings to their lower jaws; different colors were used each marking period. A carcass was considered fresh if it had either one clear eye or pink gills, and the adult distinction was a FL $\geq$ 70 cm (27.6 in). Marked carcasses were replaced into running water for later recovery. Any carcass not tagged, as well as those recovered with tags were counted and cut in half. Those carcasses found downstream of Gristmill Fishing Access were not marked, but only counted and chopped. Length measurements and determination of gender were made for a sample of the fresh carcasses.

The adult salmon population of the Watt Avenue to Sailor Bar section of the river, estimated from carcass mark-and-recovery data using the Schaefer calculation (Appendix 1.B), was 120,365 fish (Table 12). This adult estimate was expanded for an 8% grilse proportion to 130,832 fish in the surveyed reaches. In addition, 11,750 fish entered Nimbus Hatchery [15/], and 4,552 salmon carcasses were removed from the Nimbus Racks, bringing the total American River 2001 fall-run population to 147,134 fish (Appendix 2).

Based on examination of 1,064 fresh carcasses, the run consisted of 37.4% male adults, 54.6% female adults, 4.8% male grilse (FL < 70 cm), and 3.2% female grilse. Salmon entering Nimbus Hatchery consisted of 55.9% male adults (FL > 60 cm [23.6 in.]), 27.4% female adults, 15.6% male grilse (FL < 60 cm), and 1.1% female grilse.

The 2001 run of 147,134 salmon in the American River was an increase of 33% from the previous year's population (Appendix 3), and the highest ever recorded for that tributary.

[14/] Healey, M. Lower American River Chinook Salmon Escapement Survey, October-December, 2001. File report. December 2002. CDFG-SVCSR, Rancho Cordova office.

[15/] West, T. CDFG – SVCSR, Nimbus Hatchery. Personal communication.

TABLE 12. Chinook salmon carcass mark-and-recovery data used to estimate the 2001 fall-run spawner population in the American River from Sailor Bar to Watt Avenue [1/].

Recovery period (j):	Number of marked carcasses recovered from marking period (i):				Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [2/]	Population estimate (N) [3/]
	1	2	3	4			
2	22	--	--	--	22	3,261	6,374
3		59	--	--	59	7,558	27,255
4		7	232	--	239	19,848	46,997
5			1	85	86	11,925	40,813
Total recovered (Ri):	22	66	233	85			
Total carcasses marked (Mi):	43	238	543	292	Total estimate [4/]:		121,438
					Adjusted estimate [5/]:		**120,365**

1/ Surveys were conducted from 29 October through 28 December 2001.

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

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

4/ Total may not correspond to the actual sum of the weekly estimates shown, due to spreadsheet rounding .

5/ 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 (121,438 - 1,073 = 120,365).

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 34,773 salmon, consisting entirely of fall-run fish, was estimated to be in this system for 2001 (Appendix 2).

Mokelumne River

Fall run. Fish passage at Woodbridge Irrigation District Dam was monitored by East Bay Municipal Utilities District (EBMUD), during 13 August 2001 through 31 March 2002 [16/]. Passage through the high-stage fishway was monitored with a closed-circuit, underwater video system through 6 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 6 December, after which only the video monitoring continued. However, during most of November and the beginning of December, accurate counts of salmon passing upstream in the ladder were hampered by poor visibility and trap malfunctions. Estimates of fish passage for this period were therefore based on ratios of counts at Mokelumne River Fish Hatchery (MRFH) to those observed at the dam.

A total of 5,183 salmon was actually observed during 27 September 2001 through 18 February 2002, from which 8,114 fish was estimated to have passed upstream of the dam. MRFH took in 5,809 salmon [17/], and the in-river fall-run spawner population was assumed to be 2,305 fish (Appendix 2).

Based on examination of 4,782 salmon at the dam, the run consisted of 39% male adults (FL > 60 cm [23.6 in]), 41% female adults, and 12% male grilse (FL ≤ 60 cm), and 8% female grilse. The composition of the salmon entering the hatchery was 34.8% male adults, 40.6% female adults, and 24.6% grilse.

The 2001 spawner population of 8,114 fish in the Mokelumne River was an increase of 9% from the previous year's run, and 56% higher than the average population size for the 1991-2000 period (Appendix 3).

[16/] EBMUD Fisheries and Wildlife Division. Lower Mokelumne River Upstream Fish Migration Monitoring. File Report. Lodi Office.

[17/] Anderson, B. CDFG – San Joaquin Valley/Southern Sierra Region (SJVSSR), Mokelumne River Hatchery. Personal communication.

Stanislaus River

Fall run. Spawner surveys of the Stanislaus River were conducted weekly during 23 October through 28 December 2001 [18]. The 22.5-km (14-mi) stretch of the river from Knight's Ferry to Oakdale Recreation Area was covered by drift boat, while surveys were made on foot upstream of Knight's Ferry in the 6.4-km (4-mi) section of the Goodwin Canyon area.

All salmon carcasses, except skeletons, were marked using numbered aluminum tags attached to their lower jaws with hog-rings; skeletons also included carcasses completely covered with fungus. 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, it was measured and its gender determined, and its condition was determined as either fresh or decayed; fresh carcasses were identified as having at least one clear eye.

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 Oakdale Recreation Area stretch was estimated to be 6,387 fish [19], using the fresh carcass mark-and-recovery data in the Schaefer model (Table 13). The data from surveys in the Goodwin Canyon area were not included in the Schaefer estimate calculations. The spawner population for this area was instead determined by expanding the 155 carcasses observed to an estimated 646 fish, using the overall marked fish recovery rate for the mark-and recovery surveys. The combined estimates were a total of 7,033 salmon for the 2001 fall run.

The adult-grilse composition of the population was determined from frequency distributions of fresh carcass length measurements taken this season. The length criteria used to distinguish adult from grilse salmon was a FL $\geq$ 64 cm (25.2 in), on which basis the run consisted of 34.5% male adults, 55.1% female adults, 4.9% male grilse, and 5.6% female grilse.

The 2001 Stanislaus River fall-run spawner population of 7,033 salmon was 21% lower than the previous year's run, but still over 2½ times higher than the average for 1991 -2000 (Appendix 3).

---

[18] Marston, D., T. Heyne, and S. Baumgartner. Stanislaus River Fall Chinook Salmon Escapement Survey, 2001. Sportfish Restoration Act (SFRA) Annual Report. Project 26, Job 2. November 2002. CDFG - SJVSSR.

[19] Heyne, T. CDFG-SJVSSR. Personal communication.

TABLE 13. Chinook salmon carcass mark-and-recovery data used to estimate the 2001 fall-run spawner population in the Stanislaus River between Knight's Ferry and Oakdale Recreation Area [1/].

Recovery period (j):	Number of marked carcasses recovered from marking period (i):									Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [2/]	Population estimate (N) [3/]
	1	2	3	4	5	6	7	8	9			
2	0	--	--	--	--	--	--	--	--	0	58	58
3		0	--	--	--	--	--	--	--	0	181	845
4			9	--	--	--	--	--	--	9	221	1,012
5			5	12	--	--	--	--	--	17	305	1,241
6					5	--	--	--	--	5	128	829
7					6	5	--	--	--	11	446	2,038
8					2	7	0	--	--	9	57	241
9							1	0	--	1	21	420
10									0	0	5	35
Total recovered (Ri):	0	0	14	12	13	12	1	0	0			
Total carcasses marked (Mi):	1	28	64	80	98	23	19	12	6	Total estimate [4/]:		6,718
										Adjusted estimate [5/]:		**6,387**

1/ Surveys were conducted from 23 October through 28 December 2001.

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

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

4/ Total may not correspond to the actual sum of the weekly estimates shown, due to spreadsheet rounding.

5/ 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 (6,718 - 331 = 6,387).

Tuolumne River

Fall run. Chinook salmon spawner surveys in the Tuolumne River were conducted weekly from 4 October 2001 through 5 January 2002 [20/]. The river stretch from the riffles at river mile 51.6 downstream to Fox Grove Regional Park, a distance of 41.2 km (25.6 mi), was covered by both boat and ground surveys.

This season all sampled carcasses, except skeletons, were marked using numbered aluminum tags attached to their lower jaws with hog-rings; skeletons also included carcasses so decomposed or covered with fungus that it was judged they would not be recoverable. Marked carcasses were released, into running water at the lower end of the riffle where they were initially found, 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 gender was determined, a length measurement was made, and a condition of either fresh or decayed was assigned; fresh carcasses were identified as having clear eyes, and blood remaining in their gills.

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

[20/] Lower Tuolumne River Fall Chinook Salmon Escapement Survey, 2001. SFRA Annual Report. Project 26, Job 2. CDFG - SJVSSR.

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 Regional Park was estimated at 8,782 fish, using the fresh carcass mark-and-recovery data in the Schaefer model (Table 14). The run consisted of 35.9% male adults, 49.3% female adults, 10.1% male grilse, and 4.7% female grilse.

The 2001 fall run of salmon in the Tuolumne River was only 49% of that in 2000, but still 80% higher than the average for 1991-2000 (Appendix 3).

Merced River

Fall run. Weekly salmon surveys were conducted from 16 October 2001 through 4 January 2002, 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 [21/]. River flows were increased, about the same time that the carcass surveys began, to attract salmon into the tributary and improve spawning conditions. The higher flows were continued for about three weeks (14 October through 1 November) and ranged from 20.5 m^3/s to 22.5 m^3/s (724-795 cfs).

All salmon carcasses, except skeletons, were marked using numbered aluminum tags attached to their lower jaws, or near the dorsal fins, with hog-rings; skeletons included carcasses completely covered with fungus. Marked carcasses were released, into running water at the lower end of the riffle where they were initially found, 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, it was measured and its gender determined, and a condition of either fresh or decayed was assigned to it; fresh carcasses were identified as having at least one clear eye.

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 Schaefer estimate (Appendix 1.B) was the most appropriate.

A Schaefer estimate of 9,181 salmon was calculated for the river stretch from Merced River Hatchery to Santa Fe Road (Table 15). Merced River Hatchery took in 1,663 salmon [22/], for a total 2001 fall-run spawner population of 10,844 fish (Appendix 2).

The in-river run of the Merced River consisted of 35.1% male adults, 52.6% female adults, 9.1% male grilse, and 3.2% female grilse. Salmon which entered Merced River Hatchery consisted of 28.4% male adults (FL $\geq$ 65 cm [25.6 in]), 39.5% female adults (FL $\geq$ 62 cm [24.4 in]), 24.8% male grilse (FL < 65 cm), and 7.3% female grilse (FL < 62 cm).

[21/] Johnson, K. 2001 Merced River Chinook Salmon Escapement Survey Report. SFRA Annual Report. Project 26, Job 2. CDFG - SJVSSR.

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

The 2001 Merced River fall run was a decrease of 17% from the record run seen in 2000, but was still over 2½ times higher than the average for 1991-2000 (Appendix 3).

TABLE 14. Chinook salmon carcass mark-and-recovery data used to estimate the 2001 fall-run spawner population in the Tuolumne River between the riffles at river mile 51.6 and Fox Grove Regional Park [1/].

Recovery period (j).	Number of marked carcasses recovered from marking period (i):												Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [2/]	Population estimate (N) [3/]
	1	2	3	4	5	6	7	8	9	10	11	12			
2	3	--	--	--	--	--	--	--	--	--	--	--	3	15	15
3	2	2	--	--	--	--	--	--	--	--	--	--	4	18	27
4			1	--	--	--	--	--	--	--	--	--	1	39	78
5				8	--	--	--	--	--	--	--	--	8	158	263
6				3	52	--	--	--	--	--	--	--	55	709	999
7				1	9	139	--	--	--	--	--	--	149	1,267	1,992
8						25	85	--	--	--	--	--	110	1,248	2,021
9						10	29	110	--	--	--	--	149	1,340	2,188
10						1	3	36	87	--	--	--	127	656	1,065
11							2	5	33	35	--	--	75	368	615
12								1	2	9	16	--	28	212	471
13									1		2	3	6	66	174
14												1	1	13	39
Total recovered (Ri).	5	2	1	12	61	175	119	152	123	44	18	4			
Total carcasses marked (Mi):	5	4	2	20	85	277	194	249	199	76	47	12	Total estimate [4/]:		9,947
													Adjusted estimate [5/]:		**8,782**

1/ Surveys were conducted from 4 October 2001 through 5 January 2002.

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

3/ Schaefer (1951) estimate equation $N = \Sigma(Rij \times (Mi/Ri) \times (Cj/Rj))$

4/ Total may not correspond to the actual sum of the weekly estimates shown, due to spreadsheet rounding .

5/ 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 (9,947 - 1,165 = 8,782)

TABLE 15. Chinook salmon carcass mark-and-recovery data used to estimate the 2001 fall-run spawner population in the Merced River between Merced River Hatchery and Santa Fe Road near Cressey [1/].

Recovery period (j).	Number of marked carcasses recovered from marking period (i):										Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [2/]	Population estimate (N) [3/]
	1	2	3	4	5	6	7	8	9	10			
2	0	--	--	--	--	--	--	--	--	--	0	2	2
3		0	--	--	--	--	--	--	--	--	0	4	4
4			0	--	--	--	--	--	--	--	0	142	142
5			1	9	--	--	--	--	--	--	10	582	2,167
6				4	104	--	--	--	--	--	108	858	1,834
7					7	23	--	--	--	--	30	383	962
8					5	53	24	--	--	--	82	1,079	2,694
9						14	11	29	--	--	54	613	1,510
10							4	3	7	--	14	122	375
11								1	3	0	4	52	232
12										0	0	2	2
Total recovered (Ri):	0	0	1	13	116	90	39	33	10	0			
Total carcasses marked (Mi)	0	2	4	48	241	238	88	81	38	4	Total estimate [4/].		9,923
											Adjusted estimate [5/]:		**9,181**

1/ Surveys were conducted from 16 October 2001 through 4 January 2002.

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

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

4/ Total may not correspond to the actual sum of the weekly estimates shown, due to spreadsheet rounding .

5/ 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 (9,923 - 742 = 9,181)

SUMMARY

The total estimated 2001 Central Valley Chinook salmon spawner population was 672,583 fish, consisting of 637,810 fish in the Sacramento River system and 34,773 fish in the San Joaquin River system (Table 16). This total was 33% higher than the 507,149 salmon estimated in 2000.

All of the late-fall, winter, and spring runs, and the majority of the fall run were in the Sacramento River system. In the Feather and American rivers of that system, record high fall runs occurred for a second year. The fall run in the San Joaquin tributaries continued to contribute only a small portion (5.2%) to the total Central Valley escapement.

TABLE 16. Summary of the 2001 Sacramento-San Joaquin river system Chinook salmon spawner populations.

Spawning area	Late-fall run [1/]	Winter run	Spring run [2/]	Fall run	Total
Sacramento River mainstem	19,276	8,224	--	75,152	102,652
Sacramento River tributaries	3,327	--	16,809	515,022	535,158
San Joaquin River tributaries	--	--	--	34,773	34,773
Totals:	22,603	8,224	16,809	624,947	672,583

1/ Tributary data consists only of fish which entered Coleman National Fish Hatchery (Battle Creek).
2/ Estimate not made for Sacramento River mainstem.

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

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

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

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Research Board Canada, Bulletin 191. 382 p.

Schaefer, M.D. 1951. Estimation of size of animal populations by marking experiments. U. S. Fish and Wildlife Service, Fisheries Bulletin 52: 189-203.

Ward, P.D., T.R. McReynolds, and C.E. Garmin. 2004. Butte and Big Chico creeks spring-run Chinook salmon, Oncoryhnchus tshawytscha, life history investigation, 2000-2001. California Department of Fish and Game, Inland Fisheries Administrative Report No. 2004-3. 47 p.

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 Boydstun (1994):

$$\boldsymbol{E = N_1 + D_1 + D_2 + \ldots D_j}, \quad \text{where}$$

E = the estimated spawner population

N_1 = number of carcasses in the surveyed population in period 1, the first "week" of spawning and dying, and

D_i = number of carcasses joining the population between period i and i+1, with j being the last survey period.

APPENDIX 2. 2001 Chinook salmon spawner population estimates for the Central Valley river system.

River System: River area / Tributary	Estimated number of fish: Late-fall run	Winter run	Spring run	Fall run	Total all runs
Sacramento River System:					
Keswick Dam to Red Bluff					
Sacramento River mainstem					
Livingstone Stone National Fish Hatchery	--	104	--	--	104
In-river a/	18,351	8,085	b/	57,792	84,228
(Totals for tributary):	(18,351)	(8,189)		(57,792)	(84,332)
Clear Creek	c/	--	b/	10,865	10,865
Cottonwood (Beegum) Creek	c/	--	245	b/	245
Battle Creek					
Coleman National Fish Hatchery	3,327	--	--	25,082	28,409
In-river	c/	--	b/	100,604	100,604
(Totals for tributary):	(3,327)			(125,686)	(129,013)
Paynes Creek	--	--	--	b/	--
Totals for area:	**21,678**	**8,189**	**245**	**194,343**	**224,455**
Red Bluff to Princeton Ferry					
Sacramento River mainstem	925	35	b/	17,360	18,320
Antelope Creek	--	--	8	c/	8
Mill Creek	--	--	1,104	b/	1,104
Deer Creek	--	--	1,622	b/	1,622
Totals for area:	**925**	**35**	**2,734**	**17,360**	**21,054**
Big Chico Creek to American River					
Big Chico Creek	--	--	39	c/	39
Butte Creek	--	--	9,605	4,430	14,035
Feather River					
Feather River Hatchery	--	--	4,078	24,870	28,948
In-river	--	--	c/	178,645	178,645
(Totals for tributary):				(203,515)	(207,593)
Yuba River	--	--	108	23,392	23,500
American River					
Nimbus Hatchery	--	--	--	11,750	11,750
Nimbus Basin				4,552	4,552
In-river	--	--	--	130,832	130,832
(Totals for tributary):				(147,134)	(147,134)
Totals for area:			**13,830**	**378,471**	**392,301**
Sacramento River System Totals:	**22,603**	**8,224**	**16,809**	**590,174**	**637,810**
San Joaquin River System:					
Mokelumne River					
Mokelumne River Hatchery	--	--	--	5,809	
In-river	--	--	--	2,305	
(Totals for tributary):				(8,114)	
Stanislaus River	--	--	--	7,033	
Tuolumne River	--	--	--	8,782	
Merced River					
Merced River Hatchery	--	--	--	1,663	
In-river	--	--	--	9,181	
(Totals for tributary).				(10,844)	
San Joaquin River System Total:				**34,773**	

a/ Estimates based on carcass survey and redd count data.
b/ An estimate of the run size was not made.
c/ Tributary was not surveyed for this run

APPENDIX 3. Chinook salmon spawner population estimates from 1991 through 2001 in California's Central Valley major tributaries.

Tributary	Run	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	1991-2000 average
	Late-fall	6,611	9,356	739	291	166 a/	48 a/	b/	38,239 c/	8,683 d/	8,632 c/	**18,351** c/	—
Sacramento River mainstem	Winter	211	1,196	378	186	1,202	1,012	836	2,930	3,264	1,261	**8,085** c/	1,248
upstream of Red Bluff	Spring	825	371	391	862	426	378	128	1,115	b/	b/	b/	562 e/
	Fall	20,523	23,914	33,471	44,729	53,385	71,725	98,765	5,718	133,365	87,793	**57,792** c/	53,955
Battle Creek	Fall f/	17,241	12,708	18,616	43,265	83,192	73,587	**101,414**	98,308	119,899	75,106	**125,686**	64,334
Sacramento River mainstem downstream of Red Bluff	Fall	10,108	8,315	12,760	13,817	10,549	12,361	**20,531**	600	27,827	8,895	**17,360** c/	12,576
Feather River	Spring g/	4,303	1,497	4,672	3,641	5,414	6,381	7,017	6,746	4,534	3,972	**4,078**	4,818
	Fall f/	42,062	40,545	42,914	53,584	72,061	65,277	65,675	18,889 g/	12,927 g/	132,863	**203,515**	64,373 h/
Yuba River	Fall	**14,008**	6,362	6,703	10,890	14,237	27,900	25,948	31,090	24,230	14,995	**23,392**	17,636
American River	Fall f/	25,211	11,267	39,410	40,087	86,828	82,396	57,845	66,580	65,099	110,219	**147,134**	58,494
Mokelumne River	Fall f/	410	1,645	3,157	3,421	5,417	7,775	**10,163**	7,202	5,332	7,418	**8,114**	5,194
Stanislaus River	Fall	394	255	677	**1,031**	619	168	5,588	3,087	4,349	8,498	**7,033**	2,467
Tuolumne River	Fall	77	132	471	506	827	4,362	7,146	8,910	8,232	17,873	**8,782**	4,854
Merced River	Fall f/	119	986	1,678	3,589	2,922	4,432	3,660	4,091	4,766	13,076	**10,844**	3,932

a/ Only the number of salmon transferred to Coleman National Fish Hatchery; in-river estimates not made.

b/ An estimate of the run size was not made.

c/ Estimate based on carcass survey and aerial redd counts; unless noted other estimates were based on Red Bluff Diversion Dam counts.

d/ Estimate is not for the entire mainstem, but for the carcass survey area only; aerial redd counts were not available to allow expansion.

e/ 1991-1998 average.

f/ Estimate includes numbers of salmon at the tributary's hatchery.

g/ Numbers are only those salmon which entered Feather River Hatchery; in-river spawner estimates were not made.

h/ Average does not include the 1998 and 1999 estimates.