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CHINOOK SALMON SPAWNER STOCKS IN CALIFORNIA'S CENTRAL VALLEY, 2003

Edited by

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Native Anadromous Fish & Watershed Branch

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ABSTRACT

This report covers the 51st 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 2003 total escapement of Chinook salmon in the Central Valley was 624,808 fish, which was 7% lower than in 2002. The population consisted of 590,735 fall-, 17,564 spring-, 8,291 late-fall-, and 8,218 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 602,425 fish in the Sacramento River system and 21,383 fish in the San Joaquin River system. In the American River of the Sacramento system, a record high fall run occurred. The fall run in the San Joaquin tributaries still only contributed a small portion (3%) to the total Central Valley escapement.

[1/] Inland Fisheries Administrative Report No. 2006-02. Submitted for publication June 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 50th 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.

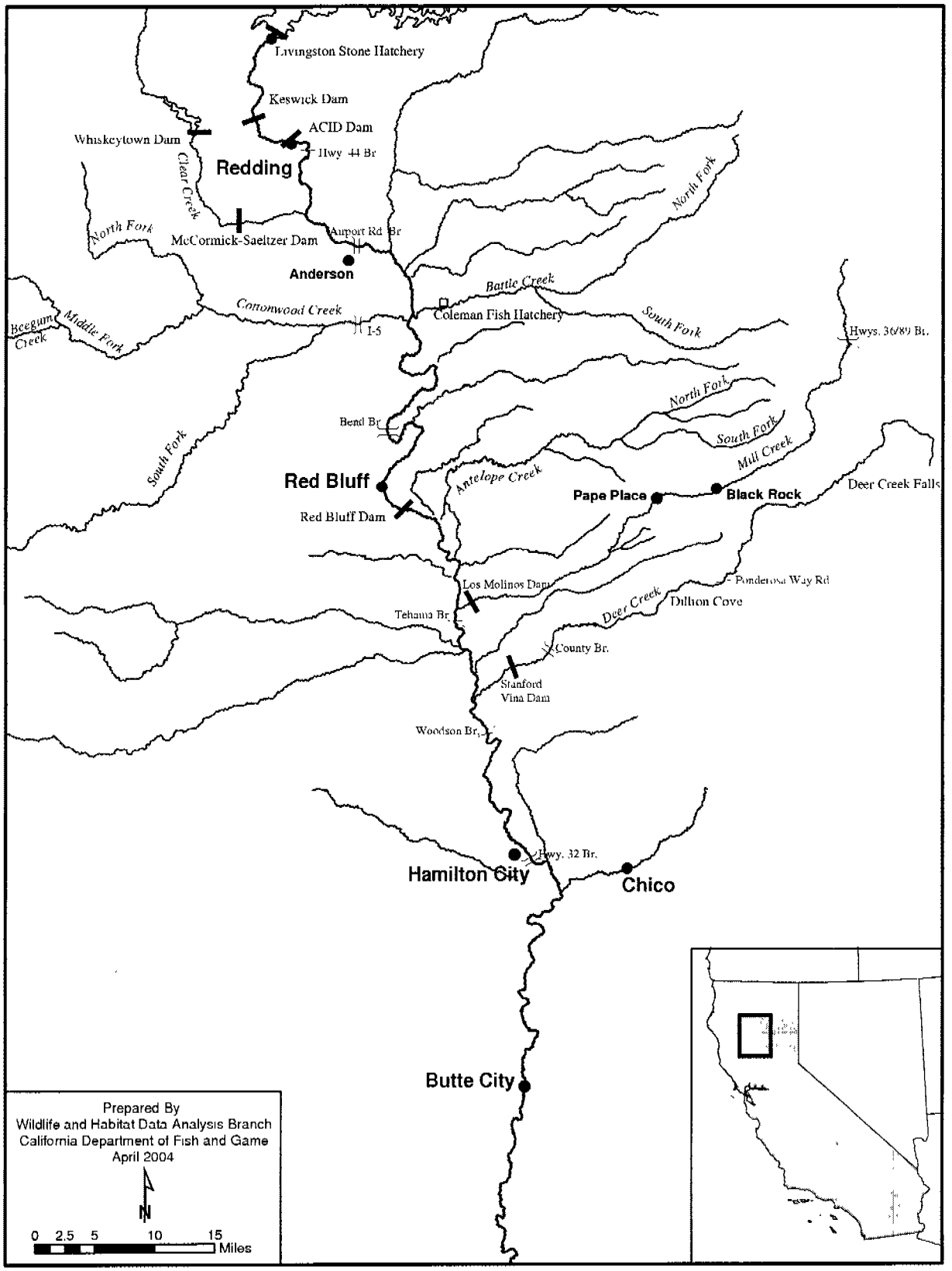

FIGURE 1. Sacramento-San Joaquin River System of California's Central Valley.

GENERAL METHODS

During 2003, 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 102,941 salmon was in the mainstem between Keswick Dam and Princeton Ferry (Figure 2), consisting of 89,229 fall-, 8,218 winter-, and 5,494 late-fall- fish.

Late-fall run. The late-fall spawner population was estimated from salmon carcass surveys in a portion of the mainstem, and from aerial redd surveys of the entire mainstem. Carcass surveys were conducted from 10 December 2002 through 28 April 2003, covering the 26.4-km (16.5-mi) stretch of the mainstem from Anderson-Cottonwood Irrigation District Dam (ACID) downstream to Anderson River Park [2/].

Salmon carcasses were marked with colored tags attached to their jaws with hog rings; for each week a different color was used. Marked carcasses were returned to running water for subsequent recovery. Carcasses that were not marked, as well as those that were recovered with marks, were chopped in half to prevent recounting. Measurements of fork length (FL), determination of gender, and relative egg retention of females were made for a subsample of fresh carcasses (those with a clear eye or pink gills).

The carcass processing protocols 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 population through several biometric models. Analysis of the data indicated the Jolly-Seber model (Appendix 1.C) was the most appropriate. Using the mark-and-recovery data for fresh and decayed carcasses, 1,353 carcasses were observed, 503 of which were marked and 92 subsequently recovered, for an estimate of 4,681 fish in the surveyed area upstream of Anderson River Park (Table 1).

An aerial survey of the mainstem from Keswick Dam downstream to Princeton Ferry was conducted on 6 March 2003 (Table 2). Based on data from these surveys, approximately 85.2% of the late-fall-run spawning occurred within the mark-and-recovery area, and 97.3% of the redds were upstream of Red Bluff Diversion Dam (RBDD). The carcass survey population estimate was therefore expanded to 5,494 fish for the entire mainstem, consisting of 5,346 spawners upstream of RBDD and 148 fish downstream.

The 2003 late-fall-run population of 5,346 fish for the Sacramento River mainstem upstream of RBDD was the lowest since 1998, when estimates of the population began being determined using carcass survey and redd data (Appendix 3).

[2/] Killam, D., and C. Harvey-Arrison. Chinook Salmon Spawner Populations for the Upper Sacramento River Basin, 2003. Technical Report No. 04-3. May 2005. CDFG-Northern California-North Coast Region (NCNCR), Sacramento River Salmon and Steelhead Assessment Project (SRSSAP).

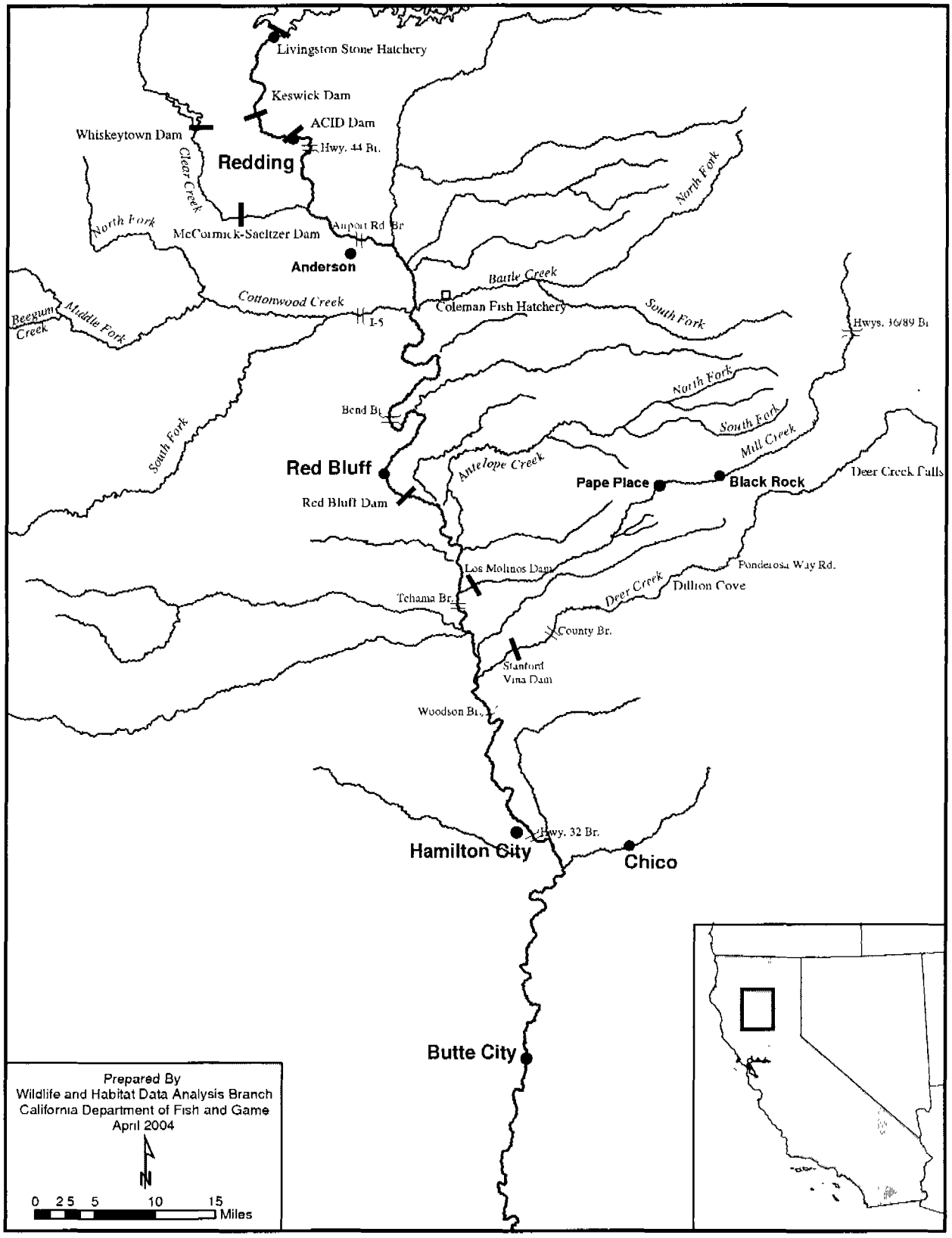

FIGURE 2. Sacramento River System from Keswick Dam downstream to Princeton Ferry.

TABLE 1. Chinook salmon fresh and decayed carcass mark-and-recovery data used to estimate the 2003 late-fall-run spawner population in the Sacramento River between the Anderson-Cottonwood Irrigation District Dam and Anderson River Park [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	(R_i) [2/]	(K_i) [3/]	(E_i) [4/]	(N1)	(D1) [9/]
1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	--	159	912	589
2	14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	14	6	149	--	597
3	2	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	4	100	--	-80
4	4		5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9	0	71	--	219
5				1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	1	37	--	323
6				1	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	1	89	--	207
7					1	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	2	35	--	173
8						0	2	--	--	--	--	--	--	--	--	--	--	--	--	--	2	4	31	--	337
9						1	1	0	--	--	--	--	--	--	--	--	--	--	--	--	2	2	71	--	220
10						1	0		2	--	--	--	--	--	--	--	--	--	--	--	3	2	94	--	364
11							1		0	1	--	--	--	--	--	--	--	--	--	--	2	9	52	--	28
12									1	4	5	--	--	--	--	--	--	--	--	--	10	10	94	--	217
13										3	3	5	--	--	--	--	--	--	--	--	11	9	106	--	53
14										1	3	2	5	--	--	--	--	--	--	--	11	6	72	--	411
15												0	1	2	--	--	--	--	--	--	3	11	32	--	-12
16												3	0	3	0	--	--	--	--	--	6	5	51	--	8
17													2	2		2	--	--	--	--	6	1	37	--	29
18														1			1	--	--	--	2	0	22	--	35
19																		1	--	--	1	1	16	--	52
20																		0	1	--	1	1	24	--	-2
21																		1		0	1	--	11		
																				Totals	92		1,353		
Total recovered (C_i) [7/]	20	1	5	2	3	2	4	0	3	9	11	10	8	8	0	2	1	2	1	0					
Total marked (T_i) [8/]	159	9	39	24	19	28	16	10	13	32	22	29	32	29	10	9	9	7	2	5	503 (Grand total marked)				
																					Jolly-Seber estimate [9/]:			**4,681**	

1/ Surveys were conducted from 10 December 2002 through 28 April 2003. 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/ $\Gamma = N_1 + D_1 + D_2 + \ldots D_{i-1}$ (As per cell 1 C). Total shown may be different than the sum of actual numbers shown due to spreadsheet calculations and rounding to whole number.

TABLE 2. Chinook salmon redd relative distribution observed during 2003 aerial surveys of the mainstem Sacramento River from Keswick Dam to Princeton Ferry.

River section	Late-fall run		Winter run		Spring run		Fall run	
	Redds counted [1/]	Proportional distribution	Redds counted [2/]	Proportional distribution	Redds counted [3/]	Proportional distribution	Redds counted [4/]	Proportional distribution
Keswick Dam to ACID Dam [5/]	87	58.4%	578	65.8%	5	22.7%	221	5.8%
ACID Dam to Highway 44 Bridge	18	12.1%	151	17.2%	7	31.8%	77	2.0%
Highway 44 Bridge to Airport Road Bridge	22	14.8%	143	16.3%	1	4.5%	183	4.8%
Airport Road Bridge to Balls Ferry Bridge	18	12.1%	3	0.3%	6	27.3%	739	19.3%
Balls Ferry Bridge to Battle Creek	0		0		3	13.6%	412	10.8%
Battle Creek to Jellys Ferry Bridge	0		0		0		644	16.8%
Jellys Ferry Bridge to Bend Bridge	0		0		0		370	9.7%
Bend Bridge to Red Bluff Dam	0		0		0		207	5.4%
Upstream proportion:		**97.3%**		**99.7%**		**100.0%**		**74.5%**
Red Bluff Dam to Tehama Bridge	0		1	0.1%	0		610	15.9%
Tehama Bridge to Woodson Bridge	4	2.7%	0		0		166	4.3%
Woodson Bridge to Hamilton City Bridge	0		0		0		95	2.5%
Hamilton City Bridge to Ord Ferry Bridge	0		0		0		93	2.4%
Ord Ferry Bridge to Princeton Ferry	0		0		0		12	0.3%
Downstream proportion:		**2.7%**		**0.3%**				**25.5%**
Total Redds:	**149**		**878**		**22**		**3,829**	

1/ Total count of new redds for one aerial survey made on 6 March 2003
2/ Total count of new redds for 12 aerial surveys made from 20 May through 6 August 2003
3/ Total count of new redds for three aerial surveys made on 3, 10, & 24 September 2003
4/ Total count of new redds for four aerial surveys made from 9 October through 18 November 2003
5/ Anderson-Cottonwood Irrigation District Dam

Winter run. The winter-run spawner population was estimated through 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. Surveys covered the 25.2-km (15.7-mi) stretch of the mainstem from Keswick Dam downstream to Anderson Mill Riffle [3/]. The study area was divided into three reaches, which were surveyed on two consecutive days starting with the upstream reach. After a one day pause, and the cycle was repeated, for 43 survey periods during 30 April through 4 September 2003. Mean survey-period river flow averaged 357 m^3/s (12.605 cfs), ranging from 228 m^3/s to 843 m^3/s (8,050 – 29,785 cfs). Mean survey-period temperature averaged 11.1 °C (52 °F), ranging from 10 °C to 12.2 °C (50 – 54°F). Water clarity, measured by secchi disk, averaged 4.2 m (14 ft), ranging from 2.4 m to more than 4.5 m (8 ft to >15 ft).

Most of the surveys were conducted using two boats, each with two samplers, which 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.

Collected carcasses were categorized as being either fresh or decayed, and either from 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 recorded.

For estimation of the spawner population, carcasses were marked with colored plastic 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. Tagged carcasses were returned to flowing water near the location where they were originally found. Hatchery-origin carcasses were excluded from marking, since their heads were removed and saved for retrieval of the coded-wire tag. Other carcasses not tagged, usually those in an advanced state of decay, were chopped in half. 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 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 4,549 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 2,884 fresh and decayed carcasses was tagged, and 1,896 of

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[3/] Killam, D. Sacramento River Winter-run Chinook Salmon Escapement Survey, April - September 2003. Technical Report No. 04-1. CDFG-NCNCR, SRSSAP.

those were subsequently recovered, resulting in a Jolly-Seber estimate of 4,903 adult female fish in the surveyed area (Table 3).

TABLE 3. Chinook salmon fresh and decayed carcass mark-and-recovery data used to estimate the 2003 winter-run natural-origin adult female spawner population in the Sacramento River between Keswick Dam and the Anderson Mill Riffle (at River Mile 286.4) [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	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	Marked Carcasses Recovered (R_i) [2/]	(K_i) [3/]	Carcasses Observed (E_i) [4/]	Estimate (N_i)	for Period (D_i)
1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	–	3	3	0
2	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0	7	–	–
3		3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	0	24	–	35
4			2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	5	12		29
5			1	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	11	20	–	-4
6			2	6	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13	7	29	-	67
7			1	1	0	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	8	22	-	13
8			1		1	3	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15	3	30		54
9					1			3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	5	25	–	53
10					0			2	9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	11	15	41	–	55
11					0			0	5	11	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	16	19	53		64
12					2			1	2	2	13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	20	21	63	-	86
13									2	2	2	13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	19	24	67	–	116
14									1	1	1	1	19	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	23	30	87	–	80
15									1	0	4	2	4	24	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	35	30	110		166
16									1	0	0	0	1	4	33	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	39	41	134	–	127
17										2	1	3	1	5	8	45	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	65	42	188	–	264
18										2	0	2	0	0	4	11	48	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	67	54	219	–	[illegible]
19											0	0	3	2	1	3	17	51	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	77	62	250	–	[illegible]
20											0	1	0		1	1	7	12	75	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	97	70	335	–	1
21											0		0		0	0	1	12	14	75	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	102	105	300	–	[illegible]
22											1		1		1	4	2	1	5	34	94	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	143	95	372	–	438
23															1	0	1	8	4	10	21	83	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	128	96	388	–	312
24															0	2	3	1	4	8	7	21	84	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	130	94	366	–	380
25															1				1	4	1	4	12	61	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	84	136	249	–	463
26																			1	2	3	6	11	24	59	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	106	130	371	–	201
27																			0	0	3	2	4	6	20	77	–	–	–	–	–	–	–	–	–	–	–	–	–	–	112	145	311	-	155
28																			1	2	3	5	6	10	9	23	61	–	–	–	–	–	–	–	–	–	–	–	–	–	120	122	302	–	192
29																				1	0	6	5	12	4	7	14	49	–	–	–	–	–	–	–	–	–	–	–	–	98	116	251		117
30																				1	1	1	4	5	2	7	6	23	43	–	–	–	–	–	–	–	–	–	–	–	93	99	227	-	138
31																						1	2	3	1	3	2	4	9	45	–	–	–	–	–	–	–	–	–	–	70	89	181	–	8
32																								4	2	3	6	3	8	5	28	–	–	–	–	–	–	–	–	–	59	68	121	-	11
33																								1	2	3	5	6	13	3	7	24	–	–	–	–	–	–	–	–	64	36	115		53
34																									0	4	0	1	2	3	1	4	10	–	–	–	–	–	–	–	25	25	62	-	33
35																									1		3	5	0	3	1	1	3	5	–	–	–	–	–	22	11	66	-	16
36																												1	1	0	0	0	0	1	6	–	–	–	–	9	10	25	-	15
37																														0	0	0	0	0	1	2		–	–	3	10	11	–	-8
38																														0	0	1	1	1	0	1	1	–	–	5	7	10	–	10
39																														1	0	2		0	0		0	1	–	4	4	12	–	-5
40																															0			1	1		0		0	2	2	3	–	2
41																															1						1			2	–	5	–	
Total recovered (C_i) [5/]	0	3	7	11	9	5	10	6	21	20	22	22	29	35	50	66	79	85	105	137	133	129	128	126	100	127	97	92	76	60	38	32	14	8	8	3	2	1	0	1,896 (Grand total recovered)				
Total marked (T_i) [6/]	2	3	15	9	14	13	17	14	21	28	35	36	40	56	73	84	114	141	159	213	182	209	219	209	149	217	158	132	100	77	56	38	20	9	12	6	2	1	1	2,884 (Grand total marked)				
																																										Jolly-Seber estimate [9/]:		4,903	

1/ Surveys were conducted from 30 April through 4 September 2003

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/ $E = N_1 + D_1 + D_2 + \ldots D_y$ (Appendix I.C)

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 4).

- As only the mark-and-recovery data for natural-origin carcasses were used in the Jolly-Seber calculation, the estimated number of adult female fish in the survey area was expanded to include those of hatchery origin. Based on the relationship of 2,008 fresh female carcasses observed in the survey, of which 1,914 were of natural origin, the Jolly-Seber estimate was expanded to 5,143 adult females within the carcass survey area.

TABLE 4. Estimated Components of the 2003 Winter-run Salmon Population in the Mainstem Sacramento River.

Adult Female Salmon		
Within Carcass Survey Area		
Natural-origin spawners [1/]	4,903	
Natural and Hatchery-origin spawners [2/]		5,143
Mainstem Outside Carcass Survey Area [3/]		36
Total Adult Females:		**5,179**
Total Adult Male Salmon [4/]:		**2,419**
Total Grilse Female Salmon [5/]:		**39**
Total Grilse Male Salmon [6/]:		**496**
TOTAL RUN:		**8,133**

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
7/ Number of fish transferred from Keswick Dam

- 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 878 total redds observed in the mainstem, of which 872 were in the carcass survey area, it was calculated that 36 fish were outside the area, resulting in 5,179 total adult females for the entire mainstem.

- An estimate of adult male salmon 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 64 males and 137 females observed, it was calculated that a total of 2,419 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 15 grilse and 1,997 adults, 39 total female grilse were calculated. Likewise, based on the male salmon relationship of 64 grilse and 312 adults, a total of 496 male grilse was estimated.

Combining the estimates for each sex-age component of the run, a total of 8,133 salmon spawned in the mainstem. Based on 12 aerial surveys conducted during 20 May through 6 August 2003, the distribution of winter-run redds upstream and downstream of RBDD was about 99.7% and 0.3%, respectively (Table 2). This represented a population distribution of 8,105 fish upstream of RBDD and 28 fish downstream. An additional 85 fish were transferred from Keswick Dam to LSNFH, resulting in a total 8,218 winter-run salmon for 2003 (Appendix 3).

The winter-run population consisted of 29.7% male adults, 63.7% female adults, 6.1% male grilse (FL < 61 cm), and 0.5% female grilse.

The 2003 winter-run spawner population of 8,218 salmon in the mainstem upstream of RBDD was 9% higher than that of 2002. The 2003 population was also over three times higher than the average for 1993-2002, but estimates previous to 2000 were determined from RBDD counts rather than carcass surveys (Appendix 3).

Spring run. Mainstem salmon estimates were determined 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 2003 assumed that the total adjusted count represented the same proportion of the run as the period's historical distribution. Mainstem-only spawner populations were typically calculated by removing numbers harvested in the sport fishery and populations in upstream tributaries from a run's total estimated RBDD passage.

An estimated 145 salmon with spring-run characteristics passed RBDD in 2003 [4/]. However, the numbers of fish of this run accounted for in Cottonwood, Clear, and Battle creeks exceeded that estimated to have passed RBDD, so it was not possible to make an estimate of the mainstem spawner population. During aerial surveys conducted on 3, 10, and 24 September 2003, spring-run redds were not observed downstream of RBDD (Table 2), and it was assumed that there were no spawners of this run in that area.

Fall run. The fall-run spawner population was estimated through salmon carcass surveys conducted in a portion of the mainstem, aerial redd surveys of the entire mainstem, and data from sampling salmon at RBDD. Carcass surveys covered the 9.7-km (6-mi) stretch of the mainstem from ACID downstream to Bonneyview Bridge in Redding [4/].

Most of the surveys were conducted using two boats, each with two samplers, which covered opposite shorelines out to the middle of the river. Collected carcasses were categorized as being either fresh or decayed, and either from 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, and it was assumed that any carcasses with adipose fins intact were fall-run 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 colored plastic attached with hog rings; tag color was used to identify the survey period that the carcass was tagged.

[4/] Killam, D., and C. Harvey-Arrison. Chinook Salmon Spawner Populations for the Upper Sacramento River Basin, 2003. Technical Report No. 04-3. May 2005. CDFG-NCNCR, SRSSAP.

Fresh carcasses were tagged in the upper jaw, and decayed carcasses were tagged in the lower jaw. Tagged carcasses were returned to flowing water near the location where they were originally found. Hatchery-origin carcasses were excluded from marking, since their heads were removed and saved for retrieval of the coded-wire tag. Other carcasses not tagged, usually those in an advanced state of decay, were chopped in half. 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 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 from natural-origin female adults were used in the Jolly-Seber calculation. From a total of 1,246 carcasses marked, and 568 subsequently recovered, an adult female population of 4,808 fish was estimated (Table 5).

TABLE 5. Chinook salmon fresh carcass mark-and-recovery data used to estimate the 2003 fall-run natural-origin female adult spawner population in the Sacramento River between the Anderson-Cottonwood Irrigation District Dam and Bonneyview Bridge [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	(R_i) [2/]	(K_i) [3/]	(E_i) [4/]	($N1$) [5]	(D_1) [6]
1	--	--	--	--	--	--	--	--	--	--	--	0	--	36	184	132
2	16	--	--	--	--	--	--	--	--	--	--	16	5	100	--	463
3	4	27	--	--	--	--	--	--	--	--	--	31	12	271	--	523
4	0	9	64	--	--	--	--	--	--	--	--	73	25	405	--	785
5	1	2	14	79	--	--	--	--	--	--	--	96	50	496	--	711
6			7	35	67	--	--	--	--	--	--	109	27	615	--	759
7			0	4	8	45	--	--	--	--	--	57	40	360	--	364
8			1	3	7	19	31	--	--	--	--	61	35	334	--	324
9					4	6	17	41	--	--	--	68	17	332	--	239
10							8	7	15	--	--	30	4	171	--	223
11								1	1	6	--	8	12	51	--	61
12								1	1	7	3	12	7	74	--	23
13										3	2	5	2	49	--	17
14											2	2	--	34	--	
											Total:	568		3,328		
Total recovered (C_i) [7/]	21	38	86	121	86	70	56	50	17	16	7					
Total marked (T_i) [8/]	35	74	155	222	184	188	118	97	88	65	20	1,246 (Grand total marked)				
												Jolly-Seber estimate [9/]: 4,808				

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/ $E = N_1 + D_1 + D_2 + ... D_I$ (Appendix 1.C).

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 6).

TABLE 6. Estimated Components of the 2003 Fall-run Salmon Population in the Mainstem Sacramento River.

Adult Female Salmon		
Within Carcass Survey Area		
Natural-origin spawners [1/]	4,808	
Natural and Hatchery-origin spawners [2/]		5,178
Mainstem Outside Carcass Survey Area [3/]		43,773
Total Adult Females:		**48,951**
Total Adult Male Salmon [4/]:		**37,680**
Total Grilse Female Salmon [5/]:		**416**
Total Grilse Male Salmon [6/]:		**2,182**
TOTAL RUN:		**89,229**

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

- As only the mark-and-recovery data for natural-origin carcasses were used in the Jolly-Seber calculation, the estimated number of adult female fish in the survey area was expanded to include those of hatchery origin. Based on the relationship of 588 fresh female carcasses observed in the survey, of which 42 were of hatchery origin, the Jolly-Seber estimate was expanded to 5,178 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 3,829 total redds observed in the mainstem, of which 405 were in the carcass survey area, it was calculated that 43,773 fish were outside the area, resulting in 48,951 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 331 males and 430 females observed, it was calculated that a total of 37,680 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 5 grilse and 588 adults, 416 total female grilse were calculated. Likewise, based on the male salmon relationship of 15 grilse and 259 adults, 2,182 male grilse were estimated.

Combining the estimates for each sex-age component of the run, a total of 89,229 salmon spawned in the mainstem. Based on four aerial surveys conducted during 9 October through 18 November 2003, fall-run redds upstream and downstream of RBDD constituted about 74.5% and 25.5%, respectively, of the total mainstem spawning (Table 2). This represented a population distribution of 66,476 fish upstream of RBDD and 22,753 fish downstream.

The 2003 fall-run spawner population in the mainstem upstream of RBDD was 31% higher than that of 2002, while the downstream population was 11% higher than the previous year (Appendix 3).

Sacramento River Tributaries
Keswick Dam to Red Bluff Diversion Dam

In 2003, a total of 165,509 salmon was estimated for the Sacramento River system tributaries upstream of RBDD, consisting of 162,520 fall-, 2,797 late-fall-, and 192 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 2003.

Spring run. Snorkeling surveys were conducted by the U.S. Fish and Wildlife Service (FWS), Northern Central Valley Fishery Resource Office (NCVFRO) in Red Bluff. Based on the number of live fish observed during the August survey, which was regarded as an index of annual adult abundance, the spring-run spawner population was judged to be 25 salmon [5/].

Fall run. Nine spawner surveys of Clear Creek were conducted during 6 October through 1 December 2003, in the 6.7-km (4.2-mi) stretch downstream of the former site of McCormick-Saeltzer Dam [5/]. 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 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

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[5/] Killam, D., and C. Harvey-Arrison. Chinook Salmon Spawner Populations for the Upper Sacramento River Basin, 2003. Technical Report No. 04-3. May 2005. CDFG-NCNCR, SRSSAP.

spawner population in Clear Creek was estimated to be 9,475 fish (Table 7).

Based on examination of 4,609 salmon carcasses, the fall-run spawner population of Clear Creek consisted of 40% male adults (FL ≥ 61 cm [24 in.]), 57% female adults, and 3% grilse (FL < 61 cm).

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

TABLE 7. Chinook salmon fresh carcass mark-and-recovery data used to estimate the 2003 fall-run spawner population of Clear Creek in the reach 4.2 miles downstream from the former McCormick-Saeltzer Dam.

Recovery	Number of marked carcasses recovered from marking period (i)								Total marked carcasses recovered (R_j)	Total carcasses observed (C_j) [1/]	Population estimate (N) [2/]
	6-Oct	14-Oct	20-Oct	27-Oct	3-Nov	10-Nov	17-Nov	24-Nov			
14-Oct	6	--	--	--	--	--	--	--	6	304	884
20-Oct	1	44	--	--	--	--	--	--	45	607	1,255
27-Oct	4	12	72	--	--	--	--	--	88	1,133	2,209
3-Nov		6	11	60	--	--	--	--	77	1,141	2,216
10-Nov			7	19	64	--	--	--	90	878	1,474
17-Nov				6	16	74	--	--	96	659	1,336
24-Nov				2	3	15	27	--	47	329	824
1-Dec					0	0	1	0	1	38	147
Total recovered (Ri)	11	62	90	87	83	89	28	0			
Total carcasses marked (M_i)	32	127	173	169	131	190	80	0		Total estimate	10,345
										Adjusted estimate [3/]:	**9,475**

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 (M_i) from the second marking period on were subtracted from the total estimate (10,345 - 870 = 9,475)

Cottonwood Creek

Spring run. Four surveys were conducted for this run in Beegum Creek, a tributary to Cottonwood Creek [6/]. A total of 73 salmon was counted, and judged to constitute the 2003 spring run for the Cottonwood Creek system.

Fall run. Three surveys were conducted for this run in the stretch adjacent to the Cottonwood Creek Wildlife Area, downstream of the Interstate-5 bridge crossing [6/]. A total of 210 salmon carcasses was counted, and examined primarily for adipose-fin clips. An estimate of the fall-run spawner population was not made.

Battle Creek

Late-fall run. No surveys were made for late-fall-run Chinook salmon spawning naturally in Battle Creek during 2003. The only available spawner data were for 2,797

[6/] Killam, D., and C. Harvey-Arrison. Chinook Salmon Spawner Populations for the Upper Sacramento River Basin, 2003. Technical Report No. 04-3. May 2005. CDFG-NCNCR, SRSSAP.

late-fall-run salmon which entered CNFH [7]. These fish consisted of 39% male adults, 46% female adults, and 15% grilse. Adipose fin-clipped salmon constituted 98% of the hatchery fish.

Spring run. The FWS-NCVFRO monitored fish passage at the CNFH barrier weir. From a combination of live trapping during 3 March through 30 May, and subsequent underwater video counts through 13 July, it was estimated that 94 spring-run adult salmon passed upstream of the barrier weir [8]. Since the monitoring period covered the entire spring-run migration, it was judged that this estimate constituted the Battle Creek spring-run population for 2003.

Fall run. Carcass surveys were conducted during 8 October through 26 November 2003, covering the 5.6-km (3.5-mi) stretch of river from CNFH downstream to the old hatchery site [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 of tape were used to identify carcasses with distinct marking periods.

Using carcass mark-and-recovery data with the Schaefer model (Appendix 1.B), the spawner population in the surveyed sections was estimated to be 64,764 fish (Table 8). Combined with an additional 88,281 fish which entered CNFH, the total Battle Creek fall-run population was 153,045 salmon (Appendix 2).

Based on examination of 30,005 salmon carcasses, the in-river fall run consisted of 28% male adults (FL $\geq$ 61 cm [24 in.]), 70% female adults, and 2% grilse (FL<61 cm). In comparison, fall-run fish entering CNFH consisted of 47% male adults, 47% female adults, and 6% grilse.

TABLE 8. Chinook salmon carcass mark-and-recovery data used to estimate the 2003 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).							Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [1]	Population estimate (N) [2]
	8-Oct	16-Oct	22-Oct	29-Oct	5-Nov	14-Nov	20-Nov			
16-Oct	49	--	--	--	--	--	--	49	2,300	5,573
22-Oct	3	260	--	--	--	--	--	263	6,572	11,619
29-Oct		23	137	--	--	--	--	160	9,025	18,433
5-Nov		3	18	52	--	--	--	73	4,911	11,758
14-Nov		0	0	10	37	--	--	47	3,193	9,749
20-Nov		0	1	5	14	87	--	107	3,325	6,479
26-Nov		2		2	6	14	91	115	1,393	2,686
Total recovered (Ri)	52	288	156	69	57	101	91			
Total carcasses marked (Mi)	126	507	326	175	182	173	170		Total estimate	66,297
									Adjusted estimate [3]:	**64,764**

[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 (66,297 - 1,533 = 64,764)

[7] Null, R. FWS, NCVFRO. Personal communication.

[8] Killam, D., and C. Harvey-Arrison. Chinook Salmon Spawner Populations for the Upper Sacramento River Basin, 2003. Technical Report No. 04-3. May 2005. CDFG-NCNCR, SRSSAP.

Pre-spawning mortality of female fall-run salmon in Battle Creek averaged 60% in 2003.

The 2003 fall-run spawner population in Battle Creek of 153,045 fish was only one-third of that in 2002, but still 27% higher than the average population for 1993-2002 (Appendix 3).

Sacramento River Tributaries
Red Bluff Diversion Dam to Princeton Ferry

A total of 6,657 Chinook salmon spawners, consisting of 4,231 spring-, and 2,246 fall-run fish, was estimated for 2003 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 28 July 2003 [9/]. 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 Antelope Gun Club. A total of 46 adult salmon was observed, and judged to be the 2003 spring run for this system; while six salmon were seen in the North Fork, none were observed in the South Fork.

Fall run. No surveys were conducted for this run in 2003.

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 to downstream 4.8 km (3 mi) from Little Mill Creek, at the steel tower transmission line crossing [10/]. The reach from Hwy-36 to Buckhorn Gulch was surveyed from the ground during 1-9 October 2003, while an aerial survey was made from Buckhorn Gulch to the powerlines on 26 September. Totals of 204 live fish, 70 carcasses, and 713 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 1,426 fish.

[9/] Harvey-Arrison, C. 2003 Antelope Creek Spring-run Chinook Salmon Survey. Memorandum to files. 29 July 2003. CDFG – NCNCR, SRSSAP, Red Bluff Office.

[10/] Harvey-Arrison, C. Mill Creek Spring-run Chinook Salmon Surveys for 2003. Memorandum to files. 17 December 2003. CDFG – NCNCR, SRSSAP, Red Bluff Office.

Fall run. Four weekly spawner surveys of Mill Creek were conducted between the Los Molinos Mutual Water Company's Upper Diversion Dam and the confluence with the Sacramento River during 20 October through 19 November 2003 [11/]; high flows and limited personnel prevented surveys through the end of spawning. Salmon carcasses were marked by attaching colored tags to the jaw with a hog-ring and replacing the fish back into running water for recovery during following surveys. No surveys were made upstream of the Upper Dam for spawning fall-run salmon. Using fresh carcass mark-and-recovery data with the Schaefer (Appendix 1.B) model, the spawner population in Mill Creek was estimated to be 2,426 fish (Table 9).

The composition of natural spawning fall-run salmon in Mill Creek was 48% male adults (FL ≥ 61cm, [24 in], 46% female adults and 6% grilse (FL < 61cm), based on an examination of 1,295 carcasses. Pre-spawning mortality of female salmon in Mill Creek this season averaged 7%.

TABLE 9. Chinook salmon fresh carcass mark-and-recovery data used to estimate the 2003 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):			Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [1/]	Population estimate (N) [2/]
	20-Oct	4-Nov	13-Nov			
4-Nov	15	--	--	15	328	449
13-Nov	2	40	--	42	434	870
19-Nov	2	15	58	75	648	1,342
Total recovered (Ri):	19	55	58			
Total carcasses marked (Mi):	26	112	122		Total estimate:	2,660
				Adjusted estimate [3/]:		**2,426**

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 (2,660 - 234 = 2,426).

Deer Creek

Spring run . Snorkeling surveys of upper Deer Creek were conducted on 5 and 11 August 2003 covering the 40-km (25-mi) stretch from Upper Deer Creek Falls downstream to Dillon Cove [12/]. Surveys only extended to Dillon Cove since few salmon were observed in the

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[11/] Killam, D,. and C. Harvey-Arrison. Chinook Salmon Spawner Populations for the Upper Sacramento River Basin, 2003. Technical Report No. 04-3. May 2005. CDFG-NCNCR, SRSSAP.

[12/] Harvey-Arrison, C. 2003 Annual Deer Creek Adult Spring-run Chinook Salmon Survey. Memorandum to files. 22 August 2003. CDFG – NCNCR, SRSSAP, Red Bluff Office.

preceeding three-mile reach; 97% of the fish were holding in pools upstream of Ponderosa Way. A total of 2,759 adult salmon was counted, and judged to be the 2003 spring run in this tributary.

Fall run. A survey was conducted in Deer Creek on 12 November 2003 covering the stretch from Leninger Road bridge to the Hwy-99 crossing [13/]. Totals of 22 salmon carcasses and 22 live fish were observed, but an estimate of the fall-run population was not made.

Sacramento River Tributaries
Big Chico Creek to the American River

A total of 328,318 Chinook salmon was estimated for 2003 in the Sacramento River tributaries from Big Chico Creek to the American River (Figure 3). This total consisted of 315,177 fall-run and 13,141 spring-run fish (Appendix 2).

Big Chico Creek

Spring run. A snorkeling survey was conducted on 11 August 2003 in three reaches of Chico Creek between Higgin's Hole and Iron Canyon (Ward et al. 2004). Four surveyors each made individual estimates of the salmon holding in pools. Based on this survey, a population of 81 spring-run spawners were in the creek.

Fall run. No surveys were conducted for this run in 2003.

Butte Creek

Spring run. A snorkeling survey was conducted during 18-27 August 2003, covering four stretches of the creek from Quartz Bowl downstream to Parrott-Phelan Diversion Dam [14/]. Total independent counts of live salmon by four observers ranged from 4,109 to 4,707 fish. All of the fish observed were upstream of the covered bridge. Based on these surveys, a population of 4,398 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 from Parrott-Phelan Diversion Dam downstream to Gorrill Ranch Dam. and included a 0.8-km (0.5-mi) section near the Western Canal Siphon (Ward et. al. 2004). Surveys were conducted during 20 October through 4 December 2003. 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.

[13/] Killam, D., and C. Harvey-Arrison. Chinook Salmon Spawner Populations for the Upper Sacramento River Basin, 2003. Technical Report No. 04-3. May 2005. CDFG-NCNCR, SRSSAP.

[14/] Garmin, C. Butte Creek Spring-run Chinook Salmon Spawning Escapement Survey, 2003. Memorandum to files. 28 August 2003. CDFG – Sacramento Valley and Central Sierra Region (SVCSR), Chico office.

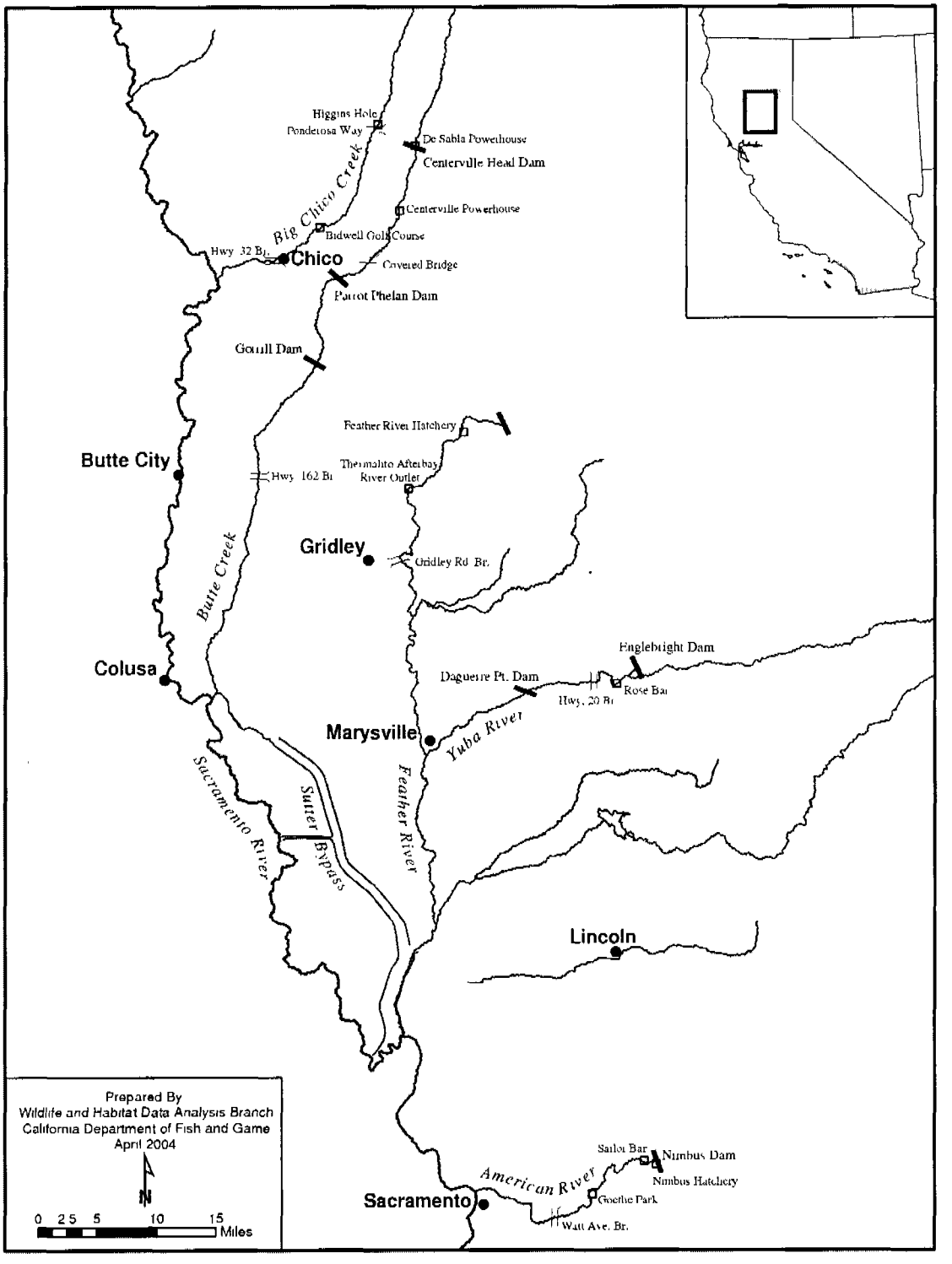

FIGURE 3. Sacramento River System from Big Chico Creek to the American River.

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 3,284 fish (Table 10). Combined with an additional 26 carcasses counted during the initial survey week, the total fall run population was 3,310 salmon spawners.

TABLE 10 Chinook salmon fresh carcass mark-and-recovery data used to estimate the 2003 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)						Total marked carcasses recovered (R_j)	Total carcasses observed (C_j) [1/]	Population estimate (N) [2/]
	20-22 Oct	27-29 Oct	4-6 Nov	11-13 Nov	18-20 Nov	24-26 Nov			
27-29 Oct	1	--	--	--	--	--	1	76	152
4-6 Nov		9	--	--	--	--	9	177	496
11-13 Nov		1	22	--	--	--	23	313	517
18-20 Nov			6	26	--	--	32	478	909
24-26 Nov			1	7	25	--	33	384	865
2-4 Dec			1	3	3	30	37	296	621
Total recovered (R_i)	1	10	30	36	28	30			
Total carcasses marked (M_i)	2	28	48	71	66	63		Total estimate	3,560
							Adjusted estimate [3/]:		**3,284**

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 (3,560 - 276 = 3,284)

Feather River

Spring run. A total of 8,662 salmon classified as spring-run fish entered Feather River Hatchery (FRH) during 3-15 September 2003 [15/]. These fish consisted of 52.6% male adults, 42.9% female adults, and 4.5% grilse. In the river itself, no attempt was made to estimate numbers of spring-run salmon.

The 8,662 spring-run salmon at FRH in 2003 was the highest recorded, being two times higher than in 2002, and 87% higher than the average for 1993-2002 (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 2003 [16/]. This stretch of river was surveyed in two sections, upstream (Section 1)

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

[16/] Cavallo, B., A. Seesholtz, J. Kindopp, and R. Kurth. 2003 Feather River Salmon Spawning Escapement Surveys Summary. File report. California Department of Water Resources, Division of Environmental Services (CDWR-DES), Sacramento.

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 marks.

Schaefer (Appendix 1.B) estimates, calculated from the mark-and-recovery data, were 51,674 salmon for Section 1, and 37,962 fish for Section 2 (Table 11). Combining both estimates, along with an additional 310 carcasses counted during the initial survey week, resulted in a total in-river population of 89,946 fish. A total of 14,976 fall-run salmon entered FRH [17/], bringing the 2003 fall run in the Feather River to 104,922 salmon (Appendix 2).

TABLE 11. Chinook salmon carcass mark-and-recovery data used to estimate the 2003 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 (i)	Number of marked carcasses recovered from marking period (i)															Total marked carcasses recovered (Ri)	Total carcasses observed (Ci) [2/]	Population estimate (N) [3/]
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
2	47	--	--	--	--	--	--	--	--	--	--	--	--	--	--	47	302	619
3	13	51	--	--	--	--	--	--	--	--	--	--	--	--	--	64	722	1,597
4	1	10	111	--	--	--	--	--	--	--	--	--	--	--	--	122	1,451	2,702
5	1	4	23	186	--	--	--	--	--	--	--	--	--	--	--	214	2,762	5 604
6		1	7	33	222	--	--	--	--	--	--	--	--	--	--	263	4,314	9 079
7		1	3	4	40	337	--	--	--	--	--	--	--	--	--	385	4,566	8 787
8			5		10	101	381	--	--	--	--	--	--	--	--	497	4 797	8,905
9					1	13	71	347	--	--	--	--	--	--	--	432	3,392	6 131
10						3	15	99	324	--	--	--	--	--	--	441	2,470	4 839
11						3	2	16	61	206	--	--	--	--	--	288	1,655	3,237
12						1	1	1	11	46	145	--	--	--	--	205	1 355	2,617
13									2	16	56	139	--	--	--	213	981	1 910
14									1	3	7	31	66	--	--	108	792	885
15									2		2	8	26	13	--	51	222	689
16												3	3	2	2	10	96	539
Total recovered (Ri)	62	67	149	223	273	458	470	463	401	271	210	181	95	15	2		Total estimate	58 141
Total carcasses marked (Mi)	127	151	272	457	579	870	864	832	808	530	403	354	233	82	32			
																	Adjusted estimate [4/]:	51,674

SECTION 2. Thermalito Afterbay Outlet to Gridley Bridge

Recovery period (i)	Number of marked carcasses recovered from marking period (i)															Total marked carcasses recovered (Ri)	Total carcasses observed (Ci) [2/]	Population estimate (N) [3/]
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
2	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	31	248
3		1	--	--	--	--	--	--	--	--	--	--	--	--	--	1	79	1,185
4			3	--	--	--	--	--	--	--	--	--	--	--	--	3	126	966
5				6	--	--	--	--	--	--	--	--	--	--	--	6	225	1,125
6				1	6	--	--	--	--	--	--	--	--	--	--	7	247	1,810
7					1	9	--	--	--	--	--	--	--	--	--	10	278	1,358
8						5	11	--	--	--	--	--	--	--	--	16	294	1,524
9							2	9	--	--	--	--	--	--	--	11	353	2,863
10								1	10	--	--	--	--	--	--	11	616	3,882
11									4	36	--	--	--	--	--	40	901	3 291
12									1	13	45	--	--	--	--	59	1,890	5 602
13									0	3	26	113	--	--	--	142	2,020	5 438
14									0		13	49	67	--	--	129	1 714	5 010
15									1			6	11	21	--	39	660	3 145
16												6	3	5	2	16	476	2 265
Total recovered (Ri)	1	1	3	7	7	14	13	10	16	52	84	174	81	26	2		Total estimate	39 714
Total carcasses marked (Mi)	8	15	23	35	54	64	71	87	97	176	233	462	255	160	20			
																	Adjusted estimate [5/]:	37,962

1/ Surveys were conducted from 2 September through 17 December 2003

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

3/ Schaefer (1951) estimate equation $N = \sum(Ri \times (Mi/Ri) \times (Ci/Ri))$

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 (58,141 - 6,467 = 51,674)

5/ Adjusted estimate where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (39,714 - 1,752 = 37,962)

17/ Kastner, A. CDFG – SVCSR, Feather River Hatchery. Personal communication.

The overall composition of fall-run salmon in the river was 95.1% adults (FL ≥ 68 cm [26.8 in]), and 4.9% grilse (FL < 68 cm), based on carcasses examined during the surveys [18]. Salmon which entered FRH consisted of 47.5% male adults (FL ≥ 61 cm [24 in]), 43.5% female adults, and 9.0% grilse (FL < 61 cm).

The 2003 total Feather River population of 104,922 salmon was 20% lower than in 2002, but still 10% higher than the average for 1993-2002 (Appendix 3); 1998 and 1999 populations are not included in the average as in-river estimates were not possible for those years.

Yuba River

Spring run. Surveys were conducted weekly during 21 August through 3 October 2003, to determine the extent of spring-run salmon spawning in the Yuba River [19]. 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 212 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 2003 were conducted in the Yuba River from the Narrows at Rose Bar downstream to Simpson Lane bridge in Marysville [20]. 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 1 October through 16 December, in Section 2 during 2 October through 16 December, and in Section 3 from 9 October through 17 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 19.8 m^3/s (500-700 cfs). The mean daily water temperature ranged from the lower 50-degree to lower 60-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 ≥ 64.8 cm (25.5 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

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[18] Seesholtz, A. CDWR-DES. Personal communication.

[19] Drury, I. 2003 Spring-run Chinook Salmon Spawning Survey. Memorandum to files. CDFG-SVCSR, Rancho Cordova office.

[20] Jones & Stokes. 2003 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.

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 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 8,841 adults and 460 grilse were calculated for Section 1 (Table 12), 11,142 adults and 684 grilse in Section 2 (Table 13), and 6,844 adults and 345 grilse in Section 3 (Table 14). Combining these estimates gave 28,316 total salmon as the 2003 Yuba River population.

Based on fresh carcasses observed during the surveys, the fall run population consisted of 40% adult males and 60% adult females. Although grilse salmon composed 5.3% of the estimated numbers of fish, they constituted 7% of the total fresh carcasses examined.

The 2003 Yuba River fall run of 28,316 salmon was 15% higher than in 2002, and 39% higher than the 1993-2002 average population (Appendix 3).

TABLE 12 Chinook salmon fresh carcass mark-and-recovery data used to estimate the 2003 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)'											Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [1]	Population estimate (N) [2]
	1-Oct	7-Oct	14-Oct	21-Oct	28-Oct	4-Nov	11-Nov	18-Nov	24-Nov	2-Dec	9-Dec			
7-Oct	25	--	--	--	--	--	--	--	--	--	--	25	464	1,160
14-Oct	9	25	--	--	--	--	--	--	--	--	--	34	761	2,047
21-Oct	4	7	44	--	--	--	--	--	--	--	--	55	635	1,994
28-Oct		0	9	27	--	--	--	--	--	--	--	36	370	1,150
4-Nov		1	1	8	12	--	--	--	--	--	--	22	332	1,073
11-Nov					1	20	--	--	--	--	--	21	251	758
18-Nov						7	11	--	--	--	--	18	146	438
24-Nov						2	8	8	--	--	--	18	135	423
2-Dec							2	2	6	--	--	10	75	242
9-Dec									1	2	--	3	34	196
16-Dec											0	0	3	3
Total recovered (Ri)	38	33	54	35	13	29	21	10	7	2	0			
Total carcasses marked (Mi)	95	91	176	107	44	87	63	33	23	14	4		Total estimate:	9,483
													Adjusted estimate [3]:	**8,841**

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]
	1-Oct	7-Oct	14-Oct	21-Oct	28-Oct	4-Nov	11-Nov	18-Nov	24-Nov	2-Dec			
7-Oct	1	--	--	--	--	--	--	--	--	--	1	25	75
14-Oct	0	0	--	--	--	--	--	--	--	--	0	65	65
21-Oct	1		7	--	--	--	--	--	--	--	8	51	96
28-Oct				0	--	--	--	--	--	--	0	16	96
4-Nov					2	--	--	--	--	--	2	24	48
11-Nov						1	--	--	--	--	1	14	84
18-Nov							1	--	--	--	1	11	11
24-Nov							1	0	--	--	1	7	14
2-Dec									0	--	0	3	3
9-Dec										0	0	4	4
Total recovered (Ri)	2	0	7	0	2	1	2	0	0	0			
Total carcasses marked (Mi).	6	3	12	6	4	6	2	1	1	1		Total estimate.	496
												Adjusted estimate [4]:	**460**

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 (9,483 - 642 = 8,841)

4/ Adjusted estimate where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (496 - 36 = 460)

TABLE 13 Chinook salmon fresh carcass mark-and-recovery data used to estimate the 2003 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]
	2-Oct	8-Oct	15-Oct	22-Oct	29-Oct	5-Nov	12-Nov	19-Nov	25-Nov	3-Dec	10-Dec			
8-Oct	8	--	--	--	--	--	--	--	--	--	--	8	221	746
15-Oct		7	--	--	--	--	--	--	--	--	--	7	358	2,088
22-Oct		3	6	--	--	--	--	--	--	--	--	9	398	2,366
29-Oct		2	4	12	--	--	--	--	--	--	--	18	475	1,931
5-Nov				3	28	--	--	--	--	--	--	31	358	687
12-Nov				0	10	40	--	--	--	--	--	50	540	1,074
19-Nov				1	5	7	45	--	--	--	--	58	567	1,153
25-Nov						3	12	26	--	--	--	41	372	968
3-Dec						1	1	2	8	--	--	12	123	430
10-Dec									5	0	--	5	65	325
16-Dec											0	0	7	7
Total recovered (Ri)	8	12	10	16	43	51	58	28	13	0	0			
Total carcasses marked (Mi).	27	70	60	50	77	104	118	82	52	15	5		Total estimate	11,775
													Adjusted estimate [3/]:	**11,142**

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]
	2-Oct	8-Oct	15-Oct	22-Oct	29-Oct	5-Nov	12-Nov	19-Nov	25-Nov	3-Dec	10-Dec			
8-Oct	0	--	--	--	--	--	--	--	--	--	--	0	13	13
15-Oct		1	--	--	--	--	--	--	--	--	--	1	32	32
22-Oct			1	--	--	--	--	--	--	--	--	1	37	148
29-Oct				3	--	--	--	--	--	--	--	3	37	111
5-Nov					2	--	--	--	--	--	--	2	54	108
12-Nov						1	--	--	--	--	--	1	26	85
19-Nov						2	2	--	--	--	--	4	33	120
25-Nov						1		2	--	--	--	3	33	102
3-Dec									0	--	--	0	10	10
10-Dec										0	--	0	3	3
16-Dec											0	0	1	1
Total recovered (Ri)	0	1	1	3	2	4	2	2	0	0	0			
Total carcasses marked (Mi)	3	1	4	9	4	13	8	6	2	0	1		Total estimate	732
													Adjusted estimate [4/]:	**684**

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 (11,775 - 633 = 11,142)

4/ Adjusted estimate where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (732 - 49 = 684)

TABLE 14 Chinook salmon fresh carcass mark-and-recovery data used to estimate the 2003 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)										Total marked carcasses recovered (Rj)	Total carcasses observed (Cj) [1/]	Population estimate (N) [2/]
	9-Oct	16-Oct	23-Oct	30-Oct	6-Nov	13-Nov	20-Nov	26-Nov	4-Dec	11-Dec			
16-Oct	0	--	--	--	--	--	--	--	--	--	0	52	52
23-Oct		2	--	--	--	--	--	--	--	--	2	93	434
30-Oct		1	2	--	--	--	--	--	--	--	3	128	825
6-Nov			1	5	--	--	--	--	--	--	6	122	505
13-Nov				3	9	--	--	--	--	--	12	348	1,349
20-Nov					1	16	--	--	--	--	17	432	1,337
26-Nov					3	8	14	--	--	--	25	442	1,092
4-Dec						2	8	12	--	--	22	286	834
11-Dec								2	1	--	3	34	192
17-Dec								2	2	0	4	72	551
Total recovered (Ri)	0	3	3	8	13	26	22	16	3	0			
Total carcasses marked (Mi)	5	14	22	28	52	79	40	58	29	3		Total estimate	7,169
												Adjusted estimate [3/]:	**6,844**

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/]
	9-Oct	16-Oct	23-Oct	30-Oct	6-Nov	13-Nov	20-Nov	26-Nov	4-Dec			
16-Oct	0	--	--	--	--	--	--	--	--	0	3	3
23-Oct		0	--	--	--	--	--	--	--	0	5	5
30-Oct			1	--	--	--	--	--	--	1	20	40
6-Nov				0	--	--	--	--	--	0	8	8
13-Nov					0	--	--	--	--	0	32	32
20-Nov					0	0	--	--	--	0	48	48
26-Nov					1		3	--	--	4	51	108
4-Dec							1	1	--	2	45	124
11-Dec									0	0	2	2
17-Dec										0	9	9
Total recovered (Ri)	0	0	1	0	1	0	4	1	0			
Total carcasses marked (Mi).	0	0	2	7	4	7	6	4	4		Total estimate	379
											Adjusted estimate [4/]:	**345**

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 (7,169 - 325 6,844)

4/ Adjusted estimate where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (379 - 34 = 345)

American River

Fall run. Salmon carcass mark-and-recovery surveys in the American River were conducted from 14 October 2003 through 14 January 2004, covering the 20.8-km (12.9-mi) stretch from Sailor Bar downstream to the Watt Avenue bridge [21/]. This stretch of river was covered in three reaches, each surveyed weekly. Mean daily river flow was relatively constant at around 56.5 m^3/sec (2000 cfs) throughout most of the survey period, except for the third and the final weeks when flows were over 70.8 m^3/sec (2500 cfs). Visibility through the water, measured by secchi disk, ranged from 4.7 m to 2.0 m (15.5-6.6 ft). Water temperature ranged from 17.7 °C to 9.7 °C (63.9-49.5 °F).

This season fresh adult salmon carcasses were distinctly marked by attaching colored hog rings to their upper 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 total length (TL) > 68 cm (26.8 in). Fresh carcasses with missing adipose fins (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. Any carcass 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.

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 146,945 fish (Table 15). This adult estimate was expanded for a 7.3% grilse proportion to 158,516 fish in the surveyed reaches. In addition, 14,887 fish entered Nimbus Hatchery [22/], and 5,226 salmon carcasses were removed from the Nimbus Racks, bringing the total American River 2003 fall-run population to 178,629 fish (Appendix 2).

Based on examination of 2,469 fresh carcasses, the run consisted of 33.5% male adults, 59.2% female adults, 5.5% male grilse (TL ≤ 68 cm), and 1.8% female grilse. Salmon entering Nimbus Hatchery consisted of 46% male adults (FL > 61 cm [24 in]), 34% female adults, and 20% grilse (FL ≤ 61 cm).

The 2003 run of 178,629 salmon in the American River was the highest ever recorded, increasing 25% over the previous year's population, and over twice the average for 1993-2002 (Appendix 3).

[21/] Healey, M. Lower American River Chinook Salmon Escapement Survey, October 2003-January 2004. File report. September 2004. CDFG-SVCSR, Rancho Cordova office.

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

TABLE 15 Chinook salmon fresh carcass mark-and-recovery data used to estimate the 2003 fall-run adult spawner population in the American River from Watt Avenue to Sailor Bar [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	9	--	--	--	--	--	--	--	--	--	--	--	9	162	360
3		6	--	--	--	--	--	--	--	--	--	--	6	251	711
4			4	--	--	--	--	--	--	--	--	--	4	531	3,823
5			0	34	--	--	--	--	--	--	--	--	34	1,364	4,377
6			1	9	111	--	--	--	--	--	--	--	121	6,090	18,263
7					11	304	--	--	--	--	--	--	315	7,393	20,565
8					3	67	257	--	--	--	--	--	327	12,889	33,469
9						15	55	189	--	--	--	--	259	11 456	29 501
10						1	4	31	133	--	--	--	169	7,431	19,860
11						0	8	4	33	104	--	--	149	3.881	10,788
12						1	0	4	12	40	44	--	101	2,142	6 128
13							2	0	0	1	7	14	24	861	2,682
14								1	2	3		3	9	199	582
Total recovered (Ri)	9	6	5	43	125	388	326	229	180	148	51	17			
Total carcasses marked (Mi)	20	17	36	138	368	1,077	830	588	486	419	151	56		Total estimate	151,111
														Adjusted estimate [4/]:	**146,945**

1/ Surveys were conducted from 14 October 2003 through 14 January 2004

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

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

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 (151,111 - 4 166 = 146 945)

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 21,383 salmon, consisting entirely of fall-run fish, was estimated to be in this system for 2003 (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 2003 through 31 July 2003 [23/]. 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 15 December, after which only the video monitoring continued; monitoring was switched back to the high-stage fishway on 18 April 2004.

A total of 10,239 salmon was counted migrating past the dam [24/] during 4 August 2003 through 14 January 2004. Mokelumne River Hatchery took in 8,117 salmon [25/], and the in-river fall-run spawner population was assumed to be 2,122 fish (Appendix 2).

Based on examination of 9,997 salmon at the dam, the run consisted of 33% male adults (FL > 60 cm [23.6 in]), 41% female adults, 20% male grilse (FL ≤ 60 cm), and 6% female grilse. The composition of the salmon entering the hatchery was 28.1% male adults (FL > 61 cm [24 in]), 34.8% female adults, and 37.1% grilse (FL ≤ 61 cm).

The 2003 spawner population of 10,239 fish in the Mokelumne River was only 5% lower than the previous year's run, but still almost 50% higher than the average population size for the 1993-2002 period (Appendix 3).

[23/] Workman, M. Lower Mokelumne River Upstream Fish Migration Monitoring. File Report. August 2004. EBMUD Fisheries and Wildlife Division. Lodi Office.

[24/] Workman, M. EBMUD. Personal communication.

[25/] Cochran, K. CDFG – San Joaquin Valley/Southern Sierra Region (SJVSSR), Mokelumne River Hatchery. Personal communication.

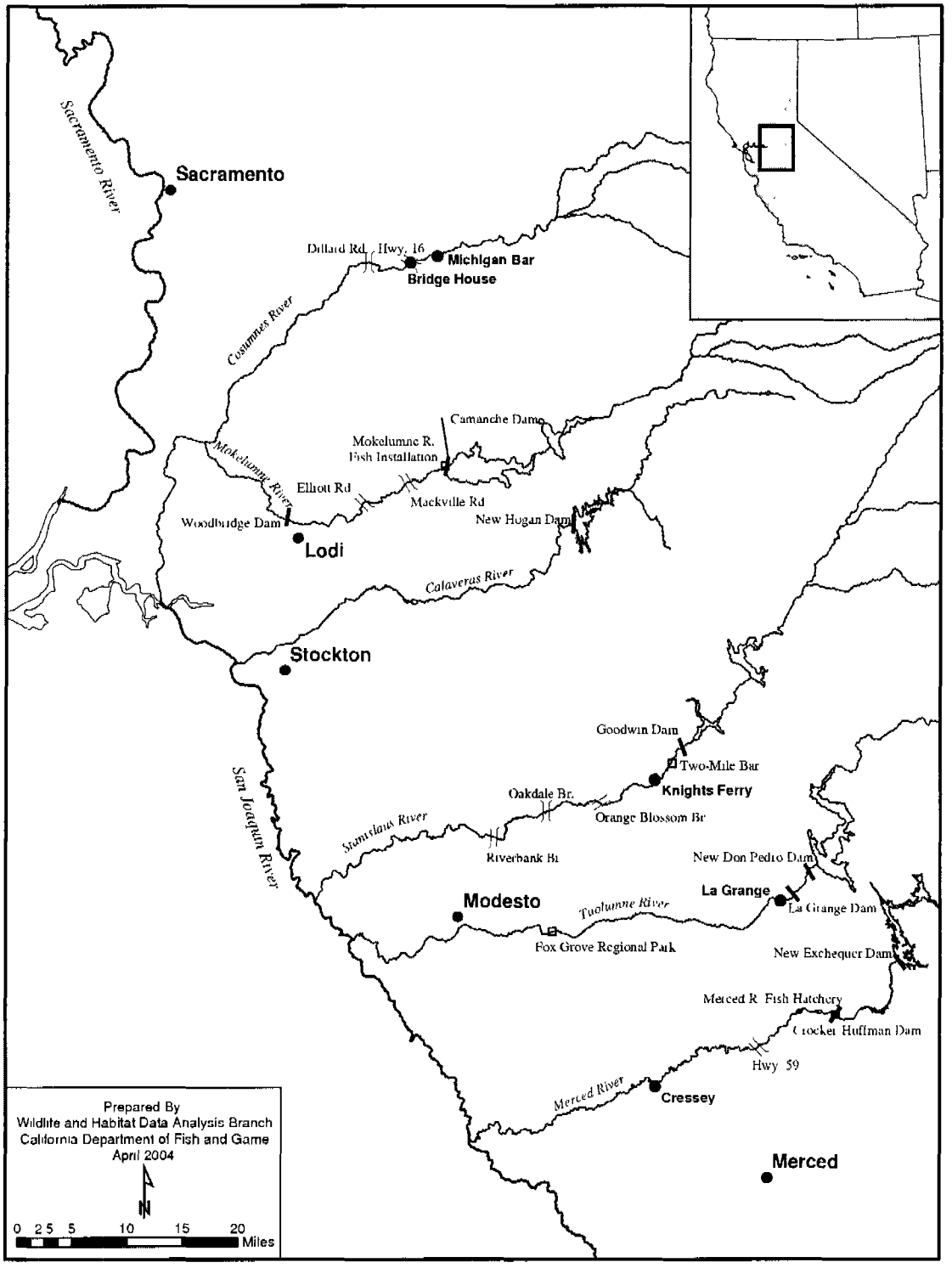

FIGURE 4. San Joaquin River System.

Stanislaus River

Fall run. Spawner surveys in the Stanislaus River were conducted weekly during 22 September 2003 through 13 January 2004 [26]; marking-and-recovery surveys began during the third week. The 35.4-km (22-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, and salmon carcasses were only counted in this section.

River flows were increased, four weeks after the carcass surveys began, to attract salmon into the tributary and improve spawning conditions. The higher flows were continued for ten days with a maximum discharge from Goodwin Dam of 27.7 m^3/s (980 cfs). Flows at the Orange Blossom Bridge gauge during the spawning period ranged from 6.2 m^3/s to 10.2 m^3/s (220-360 cfs).

During the mark-and-recovery surveys, salmon carcasses in both fresh and decayed condition had 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, 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), so the data could be better compiled for estimating the salmon population through several biometric models. Analysis of the data indicated the Jolly-Seber estimate (Appendix 1.C) was the most appropriate.

A population of 5,141 fish was estimated for the Knight's Ferry to Riverbank stretch of the river, using the mark-and-recovery data for fresh and decayed carcasses (Table 16). The data from surveys in the Goodwin Canyon area were not included in the Jolly-Seber estimate calculations. The spawner population for this area was determined by expanding the 191 carcasses which were actually observed there to an estimated 761 fish, using the overall recovery rate of 25.1% for marked fish in the Knight's Ferry to Riverbank stretch. The combined estimates were a total of 5,902 salmon for the 2003 fall run.

The adult-grilse composition of the population was determined from frequency distributions of length measurements from 1,922 carcasses taken this season. 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

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[26] Guignard, J. Stanislaus River Fall Chinook Salmon Escapement Survey, 2003. File Report. March 2004. CDFG – San Joaquin Valley-Southern Sierra Region (SJVSSR).

TABLE 16. Chinook salmon fresh and decayed carcass mark-and-recovery data used to estimate the 2003 fall-run spawner population in the Stanislaus River between Knights Ferry and Riverbank [1/].

Survey Period	Carcasses Recovered from Period													Marked Carcasses Recovered (R_i) [2/]	(K_i) [3]	Carcasses Observed (E_i) [4/]	Estimate for Period
	1	2	3	4	5	6	7	8	9	10	11	12	13				
1	--	--	--	--	--	--	--	--	--	--	--	--	--	0	--	1	0
2	0	--	--	--	--	--	--	--	--	--	--	--	--	0	0	0	0
3		0	--	--	--	--	--	--	--	--	--	--	--	0	0	2	0
4			0	--	--	--	--	--	--	--	--	--	--	0	0	15	52
5				5	--	--	--	--	--	--	--	--	--	5	0	33	39
6					5	--	--	--	--	--	--	--	--	5	2	363	163
7					1	108	--	--	--	--	--	--	--	109	42	861	833
8					1	33	151	--	--	--	--	--	--	185	71	1,079	1,095
9						6	51	238	--	--	--	--	--	295	73	1,159	1,663
10						2	10	40	95	--	--	--	--	147	81	441	490
11							2	18	49	45	--	--	--	114	30	336	381
12								1	11	16	8	--	--	36	3	158	419
13										1	1	1	--	3	6	14	5
14										0		4	0	4	2	1	1
15										1		1		2	--	2	0
													Total.	905		4,468	
Total recovered (C_i) [5/]	0	0	0	5	7	149	214	297	155	63	9	6	0				
Total marked (Ti) [6/]	1	0	1	15	20	228	435	543	323	111	34	24	3	1,738 (Grand total marked)			
														Jolly-Seber estimate :			**5,141**

1/ Surveys were conducted from 22 September 2003 through 13 January 2004; marking and recovery began during the third week
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

grilse salmon was a FL ≥ 65 cm (25.6 in) for natural-origin females, a FL ≥ 67 cm (26.4 in) for hatchery-origin females, a FL ≥ 71 cm (28 in) for natural-origin males, and a FL ≥ 66 cm (26 in) for hatchery-origin males. Based on these criteria, the run consisted of 32.3% male adults, 53.8% female adults, 8.3% male grilse, and 5.6% female grilse.

The 2003 Stanislaus River fall-run spawner population of 5,902 salmon was a decreasc of 32% from the previous year's run, but still 52% higher than the average for 1993 -2002 (Appendix 3).

Tuolumne River

Fall run. Chinook salmon spawner surveys in the Tuolumne River were conducted weekly from 30 September 2003 through 6 January 2004 [27/]; marking-and-recovery surveys started during the second week. The river stretch from the riffles at river mile 51.6 near LaGrange Dam downstream to Fox Grove Regional Park, a distance of 41.2 km (25.6 mi), was covered by both boat and ground surveys.

[27/] Blakeman, D. 2003 Tuolumne River Fall Chinook Salmon Escapement Survey. File Report. March 2004. CDFG - SJVSSR.

River flows were increased, two weeks after the carcass surveys began, to attract salmon into the tributary and improve spawning conditions. The higher flows were continued for about two weeks (16-28 October) at about 13.3 m^3/s (470 cfs). Flows were decreased and ranged from 5.9 m^3/s to 6.5 m^3/s (210-230 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 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-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 Jolly-Seber estimate (Appendix 1.C) was the most appropriate. The salmon population in the Tuolumne River upstream of Fox Grove Park was estimated at 2,163 fish, using the mark-and-recovery data for fresh and decayed carcasses (Table 17).

The adult-grilse composition of the population was determined from frequency distributions of length measurements taken from 584 carcasses during the season. 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 (26.0 in) for natural-origin females, a FL $\geq$ 68 cm (26.8 in) for hatchery-origin females, a FL $\geq$ 72 cm (28.4 in) for natural-origin males, and a FL $\geq$ 67 cm (26.4 in) hatchery-origin males. Based on these criteria, the run consisted of 33% male adults, 57% female adults, 7% male grilse, and 3% female grilse.

The 2003 fall run of salmon in the Tuolumne River was only 30% of that in 2002, and 33% of the average for 1993-2002 (Appendix 3).

Merced River

Fall run. Weekly salmon surveys were conducted from 30 September through 30 December 2003, 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 [28/]; marking-and-recovery surveys started during the sixth week. River flows were increased, two weeks after the carcass surveys began, to

[28/] Johnson, K. 2003 Merced River Fall Chinook Salmon Escapement Survey. File Report. March 2003. CDFG - SJVSSR.

TABLE 17. Chinook salmon fresh and decayed carcass mark-and-recovery data used to estimate the 2003 fall-run spawner population in the Tuolumne River from LaGrange Dam to Fox Grove Park [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	(R_i) [2/]	(K_i) [3/]	(E_i) [4/]	
1	--	--	--	--	--	--	--	--	--	--	0	--	6	32
2	1	--	--	--	--	--	--	--	--	--	1	0	24	164
3		4	--	--	--	--	--	--	--	--	4	0	104	315
4			19	--	--	--	--	--	--	--	19	6	182	534
5			4	38	--	--	--	--	--	--	42	11	409	349
6			2	8	83	--	--	--	--	--	93	5	457	372
7				1	2	49	--	--	--	--	52	13	289	171
8					2	8	16	--	--	--	26	12	143	86
9						3	8	13	--	--	24	1	111	128
10							1		1	--	2	2	30	5
11									1	1	2	1	14	6
12									1		1	--	10	0
										Total:	266		1,779	
Total recovered (C_i) [5/]	1	4	25	47	87	60	25	13	3	1				
Total marked (Ti) [6/]	2	16	52	78	157	134	80	34	21	10	584 (Grand total marked)			
											Jolly-Seber estimate :			**2,163**

1/ Surveys were conducted from 30 September 2003 through 6 January 2004; marking and recovery began during the second week
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.

attract salmon into the tributary and improve spawning conditions. The higher flows were continued for about two weeks (19-22 October) and ranged from 17.7 m^3/s to 18.4 m^3/s (626-649 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, 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-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 2,530 salmon was calculated for the river stretch from Merced River Hatchery to Santa Fe Road (Table 18). Merced River Hatchery took in 549

salmon [29], for a total fall-run spawner population of 3,079 fish (Appendix 2).

The adult-grilse composition of the population was determined from frequency distributions of length measurements from 412 carcasses taken during the 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 ≥ 68 cm (26.8 in) for hatchery-origin females, a FL ≥ 72 cm (29.3 in) for natural-origin males, and a FL ≥ 67 cm (26.4 in) for hatchery-origin males. The in-river run of the Merced River consisted of 25.2% male adults, 56.1% female adults, 13.1% male grilse, and 5.6% female grilse. Salmon which entered Merced River Hatchery consisted of 30.8% male adults (FL ≥ 65 cm [25.6 in]), 40.6% female adults (FL ≥ 62 cm [24.4 in]), 28.6% grilse (FL < 65 cm).

The 2003 Merced River fall run was only 29% of that in 2002, and 51% of the average population for 1993-2002 (Appendix 3).

TABLE 18. Chinook salmon fresh and decayed carcass mark-and-recovery data used to estimate the 2003 fall-run spawner population in the Merced River from Merced River Hatchery to Cressey [1].

Survey Period	Carcasses Recovered from Period: 1	2	3	4	5	6	7	Marked Carcasses Recovered (R_i) [2]	(K_i) [3]	Carcasses Observed (E_i) [4]	Estimate for Period
1	--	--	--	--	--	--	--	0	--	13	460
2	4	--	--	--	--	--	--	4	1	150	615
3	1	49	--	--	--	--	--	50	5	467	578
4		5	106	--	--	--	--	111	17	525	402
5			11	62	--	--	--	73	18	346	255
6			6	9	25	--	--	40	9	227	155
7				3	2	10	--	15	10	82	65
8					3	4	1	8	3	65	0
9					1	2		3	--	20	0
							Total:	304		1,895	
Total recovered (C_i) [5]	5	54	123	74	31	16	1				
Total marked (T_i) [6]	10	102	195	132	63	40	7	549 (Grand total marked)			
								Jolly-Seber estimate :			**2,530**

1/ Surveys were conducted from 30 September through 30 December 2003 ; marking and recovery began during the sixth week.
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.

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

SUMMARY

The total estimated 2003 Central Valley Chinook salmon spawner population was 624,808 fish, consisting of 603,425 fish in the Sacramento River system and 21,383 fish in the San Joaquin River system (Table 19). This total was 7% lower than the 672,583 salmon estimated in 2002.

All of the late-fall, winter, and spring runs, and the majority of the fall run were in the Sacramento River system. In the American River a record high fall run occurred. The fall run in the San Joaquin tributaries continued to contribute only a small portion (3%) to the total Central Valley escapement.

TABLE 19. Summary of the 2003 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	5,494	8,218	0	89,229	102,941
Sacramento River tributaries	2,797	--	17,564	480,123	500,484
San Joaquin River tributaries	--	--	--	21,383	21,383
Totals:	8,291	8,218	17,564	590,735	624,808

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

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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);

$$N = \Sigma \left(R_{ij} \times \frac{M_i}{R_i} \times \frac{C_j}{R_j}\right) - \Sigma\ {}^{1}{}_{2}M_i$$

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) [30/]:

The estimated spawner population = $N_1 + D_1 + D_2 + \ldots D_j$, where

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

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

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;

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

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

APPENDIX 2. 2003 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/	5,346	8,105	b/	66,476	79,927
Livingstone Stone National Fish Hatchery	--	85	--	--	85
-Downstream of Red Bluff Diversion Dam a/	148	28	0	22,753	22,929
Totals :	**5,494**	**8,218**		**89,229**	**102,941**
Sacramento River Tributaries					
Keswick Dam to Red Bluff					
-Clear Creek	c/	--	25	9,475	9,500
-Cottonwood (Beegum) Creek	c/	--	73	b/	73
-Battle Creek					
Coleman National Fish Hatchery	2,797	--	--	88,281	91,078
In-river	c/	--	94	64,764	64,858
(Tributary total):	(2,797)		(94)	(153,045)	(155,936)
Totals for area:	**2,797**		**192**	**162,520**	**165,509**
Red Bluff to Princeton Ferry					
-Antelope Creek	--	--	46	c/	46
-Mill Creek	--	--	1,426	2,426	3,852
-Deer Creek	--	--	2,759	b/	2,759
Totals for area:			**4,231**	**2,426**	**6,657**
Big Chico Creek to American River					
-Big Chico Creek	--	--	81	c/	81
-Butte Creek	--	--	4,398	3,310	7,708
-Feather River					
Feather River Hatchery	--	--	8,662	14,976	23,638
In-river	--	--	c/	89,946	89,946
(Tributary total).			(8,662)	(104,922)	(113,584)
-Yuba River	--	--	b/	28,316	28,316
-American River					
Nimbus Hatchery	--	--	--	14,887	14,887
Nimbus Basin	--	--	--	5,226	5,226
In-river	--	--	--	158,516	158,516
(Tributary total)				(178,629)	(178,629)
Totals for area:			**13,141**	**315,177**	**328,318**
Sacramento River System Totals:	**8,291**	**8,218**	**17,564**	**569,352**	**603,425**
SAN JOAQUIN RIVER SYSTEM					
-Mokelumne River					
Mokelumne River Hatchery	--	--	--	8,117	
In-river	--	--	--	2,122	
(Tributary total):				(10,239)	
-Stanislaus River	--	--	--	5,902	
-Tuolumne River	--	--	--	2,163	
-Merced River					
Merced River Hatchery	--	--	--	549	
In-river	--	--	--	2,530	
(Tributary total)				(3,079)	
San Joaquin River System Total:				**21,383**	

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

APPENDIX 3. Chinook salmon spawner population estimates from 1993 through 2003 in California's Central Valley major tributaries.

Tributary	Run	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	1993-2002 average
Sacramento River mainstem upstream of Red Bluff	Late-fall	739	291	166 a/	48 a/	b/	38,239 c/	8,683 d/	8,632 c/	18 351 c/	36,004 c/	**5,346** c/	---
	Winter	378	186	1 202	1,012	836	2,930	3,264	1,352	8 189 c/	7 452 c/	**8,218** c/	2,436
	Spring	391	862	349	378	126	1,115	b/	71	711	293	b/	47[illegible]
	Fall	33,471	44,729	53,385	71,725	98,765	5,718	133,365	87,793	57,792 c/	45,523 c/	**66,476** c	65,194
Sacramento River mainstem downstream of Red Bluff	Fall	12,760	13,817	10 549	12,361	20,531	600	27,827	8,895	17,360 c/	20,167 c	**22,753** c/	13,170
Battle Creek	Fall e/	18,616	43,265	83 192	73,587	101,414	98,308	119,899	75,106	125,686	463,296	**153,045**	120,237
Feather River	Spring f/	4,672	3,641	5,414	6,381	3,653	6,746	3,731	3 657	4 135	4,189	**8,662**	4,622
	Fall c/	42 914	53 584	72,061	65,277	65 675	18,889 f/	12,927 f/	132 863	203 515	125 670	**104,922**	95 195 g/
Yuba River	Fall	6,703	10,890	14 237	27,900	25,948	31,090	24,230	14,995	23,392	24,051	**28,316**	20,344
American River	Fall e/	39,410	40,087	86 828	82,396	57,845	66,580	65,099	110 219	147,134	134,069	**178,629**	82,967
Mokelumne River	Fall e/	3,157	3,157	5,517	7,921	10,175	7,213	5,333	7,423	8,035	10,753	**10,239**	6,868
Stanislaus River	Fall	677	1,031	619	168	5,588	3,087	4,349	8,498	7 033	7 787	**5,902**	3,884
Tuolumne River	Fall	471	506	827	4,362	7,146	8,910	8,232	17,873	8,782	7,173	**2,163**	6,428
Merced River	Fall c/	1,678	3,589	2,922	4,432	3,660	4,091	4,766	13 076	10 844	10,706	**3,079**	5 97[illegible]

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/ Estimate includes numbers of salmon at the tributary's hatchery
f/ Numbers are only those salmon which entered Feather River Hatchery, in-river spawner estimates were not made
g/ Average does not include the 1998 and 1999 estimates.