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ANNUAL REPORT CHINOOK SALMON SPAWNER STOCKS IN CALIFORNIA'S CENTRAL VALLEY, 1998

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Edited by

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

Inland Fisheries

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CHINOOK SALMON SPAWNER STOCKS IN CALIFORNIA'S CENTRAL VALLEY, 1998^{1/}

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ABSTRACT

This report covers the 46th annual inventory of Chinook salmon, <u>Oncorhynchus tshawytscha</u>, spawner populations in the Sacramento-San Joaquin River system. It is a compilation of sources estimating the fall-, winter-, late-fall-, and spring-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 1998 total escapement of Chinook salmon in the Central Valley was 327,242 fish, which was 22% lower than in 1997. The population consisted of 250,350 fall-, 31,471 spring-, 3,002 winter-, and 42,419 late-fall-run spawners. All of the spring-, late-fall-, and winter-run salmon were in the Sacramento River system. In the upper mainstem of that system, the winter run was two times higher, and the spring run was eight times higher, than their respective 1997 population. The fall run consisted of 303,652 fish in the Sacramento River system and 23,590 fish in the San Joaquin River system.

The total San Joaquin tributary population still only contributed a small portion (9%) of the total Central Valley escapement, and showed a decrease of 12% from that of 1997.

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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 46th 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) <u>Winter run</u>. 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) <u>Spring run</u>. 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) <u>Fall run</u>. 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

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GENERAL METHODS

During 1998, 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 judgement".

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

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

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

CHINOOK SALMON SPAWNER POPULATIONS FOR THE SACRAMENTO RIVER SYSTEM

Keswick Dam to Red Bluff Diversion Dam 2/

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

In 1998, 154,172 salmon were estimated for the Sacramento River system between upstream of Red Bluff, consisting of 108,285 fall-, 41,318 late-fall-, 2,930 winter- and 1,639 spring-run fish. The mainstem portion of the fall- run spawner population was 5,718 fish. The mainstem totals which are reported include fish for tributaries in which a run might have occurred, but where no estimates were possible; e.g. the late-fall run in Clear Creek, and the fall run in Cottonwood Creek.

Sacramento River Mainstem

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

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

The adjusted weekly number of fish was apportioned among the winter, spring, and fall runs based on their relative ratios seen that week in samples of salmon from the dam's east-bank trapping facility. These sampled fish were assigned to a run by assessing

^{2/} Killam, D., and C.D. Harvey-Arrison. Chinook Salmon Spawner Populations for the Upper Sacramento River System, 1998. File Report. October 2001. CDFG-Northern California and North Coast Region (NCNCR), Red Bluff Office.



Figure 2. Sacramento River system from Keswick Dam downstream to Princeton Ferry

when they would spawn, as indicated by physiological characteristics (coloration, scale absorption, secondary sexual developement, and relative degree of ripeness).

To facilitate upstream migration of winter-run salmon, the RBDD gates were raised from the beginning of the year through 14 May, and from 15 September through the end of the year. When the dam gates are up, the fishways are essentially inoperable, and counts are not possible. To account for salmon passing the dam when the gates were up, total adjusted numbers from actual counts were expanded, using migrational distributions for each run based on historical data. v

Distributions were an average timing derived from RBDD data when the gates were down year-round, based on the 1982-1986 winter runs, and the 1970-1988 spring and fall runs (Table 1). Numbers of fish estimated from actual counts for the gates-down period in 1998 were assumed to represent the same proportion of the run as the period's historical distribution, and expanded accordingly.

The estimated salmon passing upstream of RBDD (potential spawners) was reduced by the number of fish taken in the sport fishery between Keswick Dam and Red Bluff; no attempt was made to account for any other prespawning mortality in the upper river. An estimation of sport-caught fall-run salmon was based on the average harvest rate (8%) seen during 1991-1994, when angler surveys were conducted by CDFG upstream of RBDD. It was assumed that no winter- or spring-run fish were harvested, due to an angling closure in effect from 15 January through 16 July.

To obtain only the upper mainstem Sacramento River population of spring- and fall-run salmon, the number of potential spawners was also reduced by each run's population in upstream tributaries. To obtain the winter-run's upstream mainstem population, those potential spawners were reduced by numbers of fish transferred from RBDD and Keswick Dam to Livingston Stone National Fish Hatchery.

Late-fall run. The RBDD gates were raised during the entire late-fall migration period, so counts of this run's fish passing the dam were not possible. However, the mainstem population was estimated based on carcass surveys made in a portion of the latefall mainstem spawning area, and on aerial redd counts of the mainstem from Keswick Dam downstream to Hamilton City.

Weekly carcass surveys were conducted from 29 December 1997 through 1 May 1998, covering the stretch of the mainstem from Anderson-Cottonwood Irrigation District Dam (ACID) at river mile

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

Approximate		Proportion of run (%) 1/										
monthly	Concurrent											
period	weeks	Winter run	Spring run	Fall run								
	1	1.70										
Tanuami	1	1.70										
January	2	1.70										
	2	0.55										
	4 <u> </u>											
P-1	2	2.38										
rebruary	07	3.12										
	/	3.08										
	8 <u> </u>	0.97										
	9	0.33										
March	10	1.12										
	11	9.23	0.10									
	12	7.79	0.10									
	13	4.91	0.25									
	14	7.64	0.59									
April	15	8.26	0.96									
	16	9.19	1.38									
	17	3.47	1.63									
	18	2.02	1.60									
Мау	19	1.60	1./1									
	20	2.17	2.16									
	21	3.09	2.63									
_	22	2.03	2.86	0.01								
June	23	1.63	2.61	0.00								
	24	1.84	2.93	0.01								
	25	0.51	3.50	0.03								
	26	0.76	3.10	0.08								
	27	-1.60	3.67	0.10								
July	28	0.31	6.02	0.29								
	29	1.04	4.75	0.49								
	30	0.44	3.21	0.70								
	31	0.01	4.12	0.96								
August	32		6.97	1.68								
	33		6.07	2.95								
	34		6.75	3.53								
	35		5.74	3.91								
	36		7.22	4.54								
September	37		6.68	5.59								
-	38		5.23	8.58								
	39		3.70	9.24								
	40		1.19	10.49								
October	41		0.69	10.59								
	42			8.97								
	43			6.99								
	44			6.70								
November	45			4.67								
	46			2.71								
	47			2.23								
	48			1.68								
December	49	0.17		0.90								
	50	0.38		0.66								
	51	0.49		0.51								
	52	0.71		0.19								

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

(RM) 298.5 downstream to Anderson River Park (RM 282)^{3/}. During the surveys, mean river flows at Keswick Dam, 5.6 km (3.5 mi) upstream from ACID, ranged from 119 to 1495 m³/s (4200-52,800 cfs). Weekly average water clarity in the surveyed section, measured by secchi disk, ranged from 0.6 to 3.7 m (2-12 ft). Water temperatures in the survey area ranged from 8.3 to 12.2°C (47-54°F).

Most of the salmon carcasses observed were marked with colored ribbon attached to the jaw with a hog ring; for each week a different color was used. Carcasses that were not marked included those that were headless, those on shore in a "leathery" condition, and those at the downstream end of the survey area which would have drifted out of the area. Unmarked carcasses, as well as those that were recovered with marks, were chopped in half to prevent recounting. Marked carcasses were returned to running water for subsequent recovery. A subsample of fresh carcasses (those with clear eyes or pink gills) were sexed and measured.

The high flow and turbid conditions adversely affected carcass location and collection; flow was greater than 566 m³/s (20,000 cfs) during half of the periods surveyed, while threequarters of the periods had water clarity less than 1.2 m (4 ft). A total of 847 carcasses was observed, of which 682 were marked. Recoveries were made from only five of the 16 weekly marked groups of fish.

Data from adult salmon (fork length $[FL] \ge 70$ cm [27.6 in]) fresh and decayed carcasses were used to calculate an estimate of 8,648 fish using the Petersen formula (Appendix 1.A). The adult estimate was expanded to include a 11% grilse proportion, for a population of 9,717 fish from ACID to Anderson River Park.

Based on an aerial survey of the mainstem up- and downstream of RBDD conducted on 23 December 1997, 24.7% of the late-fall-run redds occurred within the mark-and-recovery area, and 97.2% of the total redds were upstream of RBDD. The carcass survey population estimate was further expanded for an entire mainstem spawner population (39,340 fish), which was then proportioned to 38,239 fish for only the mainstem upstream of RBDD.

The late-fall population consisted of 40% male adults, 49% female adults, 7% male grilse (FL < 70 cm), and 4% female grilse. This composition was based on 179 fresh carcasses examined during the mark-and-recovery surveys.

^{3/} Snider, B., B. Reavis, and S. Hill. 1998. Upper Sacramento River Late-fall-run Chinook salmon escapement survey, December 1997 - May 1998. CDFG, Environmental Services Division, Stream Evaluation Program. 29 p.

The 1998 late-fall run of 38,239 fish in the mainstem upstream of RBDD was the highest since estimates of the population were begun in 1971. All of these previous estimates were derived from counts of fish passing RBDD.

<u>Winter run</u>. The 1998 winter run at RBDD was estimated to be 2,930 salmon (Table 2); due to the RBDD gates being open, only 15.4% of this estimate was derived from actual counts at the dam. It was assumed that no winter-run salmon were caught in the sport-fishery upstream of RBDD. A total of 99 winter-run fish (95 from Keswick Dam and four from RBDD) were transferred to the Livingston Stone National Fish Hatchery broodstock program, leaving 2,831 salmon as the upper mainstem spawner population (Appendix 2).

Based on 63 winter-run salmon sampled at RBDD, the run consisted of 68% adults and 32% grilse.

The 1998 winter-run spawner population of 2,831 salmon in the mainstem upstream of RBDD was over three times higher than the 1997 population and the average population for 1988-1997 (Appendix 3).

Spring run. The 1998 spring run at RBDD was estimated to be 1,639 salmon (Table 2); 74.3% of this estimate was derived from actual counts at the dam. It was assumed that no spring-run salmon were caught in the sport-fishery upstream of RBDD, but a total of 524 fish constituted the spring runs in Clear and Cottonwood creeks, leaving 1,115 fish as the mainstem population.

Based on a sample of 163 spring-run salmon at RBDD, the run consisted of 56% adults and 44% grilse.

The 1998 spring-run population of 1,115 fish in the mainstem upstream of RBDD was almost eight times higher than the 1997 population, and 49% of the average population for 1988-1997 (Appendix 3).

<u>Fall run</u>. An estimated 117,700 fall-run potential spawners passed RBDD in 1998 (Table 2); due to the RBDD gates being open, only 19.3% of this estimate was derived from actual counts at the dam. The fall-run sport-harvest was estimated to be 9,415 salmon, leaving 108,285 fish as a spawner population in the system upstream of Red Bluff. A total of 102,566 spawners was estimated for Clear and Battle creeks, and the upper mainstem population was 5,718 salmon (Appendix 2). This estimated population includes salmon in other upper mainstem tributaries that were not surveyed.

Based on a sample of 1,966 fall-run salmon sampled at RBDD, the run consisted of 91% adults and 9% grilse.

	k	Fi	shway tr	apping ob	servations	3			Calcula	ted No. salm	on passing o	lam
	N	Number of	f salmon			Weekly				Adj	usted count	
Week No.		assigned t	o run_2/		run p	roportion	s (%)		Weekly	apportic	oned by run	4/
of RBDD	Winter-	Spring-	Fall-	-	Winter-	Spring-	Fall-		adjusted	Winter-	Spring-	Fall-
operation 1/	run	run	run	Total	run	run	run		count 3/	run	run	<u>run</u>
20	21	46	0	67	31.3	68.7			325	102	223	0
21	13	34	0	47	27.7	72.3			510	141	369	0
22					22.3	77.7			438	98	340	0
23	9	44	0	53	17.0	83.0			160	27	133	0
24	6	18	0	24	25.0	75.0			50	13	38	0
25	5	16	8	29	17.2	55.2	27.6		175	30	97	48
26	5	1	60	66	7.6	1.5	90.9		298	23	5	271
27	5	1	89	95	5.3	1.1	93.7		257	14	3	241
28	1	1	48	50	2.0	2.0	96.0		269	5	5	258
29	0	0	95	95			100.0		460	0	0	460
30	0	0	141	141			100.0		254	0	0	254
31	0	0	129	129			100.0		835	0	0	835
32	0	1	272	273		0.4	99.6		1,565	0	6	1,559
33	0	0	143	143			100.0		562	0	0	562
34	0	0	47	47			100.0		830	0	0	830
35	0	0	490	490		1	100.0		7,535	0	0	7,535
36	0	0	278	278			100.0	ł	9,849	0	0	9,849
Totals:	65	162	1,800	2,027					24,371	452	1,218	22,701
			Portion	of each ru	in represe	nted by c	alculated I	No	. of fish 5/:	15.43%	74.31%	19.28%
					ESTIM	ATED T	OTAL 19	98	RUN 6/:	2,930	1,639	117,700

TABLE 2. Estimation of 1998 winter-, spring- and fall-run Chinook salmon spawners passing Red Bluff Diversion Dam (RBDD).

1/ Covers the period from 15 May through 14 September 1998, when the dam gates were in.

2/ Fish were assigned to a run based on coloration, scale absorption, secondary sexual characteristics, and spawning readiness. Data includes both adipose fin-clipped and non-fin-clipped salmon.

3/ Video counts expanded to adjust for periods when no counts were made.

4/ Weekly run proportion x Adjusted count.

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5/ Based on historical average run distributions (Table 1).

6/ Calculated total for period of gates-in / Proportion of run represented = Run size of spawners migrating past RBDD.

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The 1998 fall run in the mainstem Sacramento River upstream of Red Bluff was 94% lower than the 1997 population, and only 12% of the 1988-1997 average population (Appendix 3).

<u>Mainstem spawning distribution</u>. The 1998 relative salmon redd distribution in the mainstem Sacramento River from Keswick Dam downstream to RBDD was determined from data collected by airplane flights during the late-fall-, winter-, spring-, and fall-run spawning seasons. All of the spring-run spawning in the mainstem occurred upstream from Red Bluff (Table 3). Late-fall-, winter-, and fall-run spawning in this river stretch constituted 97.2%, 97.5%, and 90.5%, respectively, of that observed for the entire mainstem.

<u>Clear Creek</u>

<u>Late-fall run</u>. No surveys were conducted for this run in 1998.

Spring run. The creek was surveyed for this run on 17 and 23 September 1988. Each day, aerial redd counts were made from Whiskeytown Dam downstream to the confluence with the Sacramento River. Ground surveys to count fish were also conducted in the 6.4-km (4-mi) stretch downstream of McCormick-Saeltzer Dam. Totals of 19 redds, four salmon carcasses, and 47 live fish were observed, all of which were downstream of McCormick-Saeltzer Dam. Water temperatures ranged from 21.1 to 26.6°C (70-80°F), and it was unlikely that any eggs survived. The Clear Creek spring run was judged to be 47 fish.

Fall run. Five spawner surveys of Clear Creek were made during 20 October through 19 November 1998 in the 6.4-km (4-mi) stretch downstream of McCormick-Saeltzer Dam. Salmon carcasses were marked by attaching colored tape to the jaw with a hog ring, and replacing them back into running water for recovery during following surveys.

Using fresh carcass mark-and-recovery data with the Schaefer model (Appendix 1.B), the spawner population in Clear Creek downstream of McCormick-Saeltzer Dam was estimated to be 4,259 fish (Table 4).

Based on examination of 1,875 salmon carcasses, the fall-run spawner population of Clear Creek consisted of 39% male adults (fork length [FL] > 61 cm [24 in.]), 58% female adults, and 3% grilse (FL \leq 61 cm).

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

TABLE 3. Chinook salmon relative redd distribution observed during 1998 aerial surveys of the mainstem Sacramento River from Keswick Dam to Princeton Ferry.

	Late-fa	ll) run	Winte	er run	Spring	g run	Fail	run
River section	Redds counted a/	Proportional distribution	Redds counted b/	Proportional distribution	Redds counted c/	Proportional distribution	Redds counted d/	Proportional distribution
Keswick Dam to A.C.I.D. Dam e/	402	65.3%	4	3.3%	0		137	6.5%
A.C.I.D. Dam to Highway 44	76	12.3%	93	76.9%	12	40.0%	471	22.5%
Highway 44 to Airport Road Bridge	74	12.0%	19	15.7%	14	46.7%	721	34.4%
Airport Road Bridge to Balls Ferry Bridge	40	6.5%	1	0.8%	4	13.3%	214	10.2%
Balls Ferry Bridge to Battle Creek	0		1	0.8%	0		77	3.7%
Battle Creek to Jellys Ferry Bridge	0		0		0		154	7.4%
Jellys Ferry Bridge to Bend Bridge	7	1.1%	0		0		91	4.3%
Bend Bridge to Red Bluff Dam	0		0		0		31	1.5%
Upstream proportion		97.2%		97.5%		100.0%		90.5%
Red Bluff Dam to Tehama Bridge		2 8%	3	2 5%	0		125	6.0%
Tehama Bridge to Woodson Bridge	0		0		0		9	0 4%
Woodson Bridge to Hamilton City Bridge	0				0		34	1.6%
Hamilton City Bridge to Ord Ferry Bridge			**		0		18	0.9%
Ord Ferry Bridge to Princeton Ferry							12	0.6%
Downstream proportion	:	2.8%		2.5%				9.5%
Total Redds	: 616		121		30	-	2,094	

a/ Count made on 23 December 1997.

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b/ Total count made for 13 aerial surveys from 28 April through 11 August 1998. c/ Total count made for four aerial surveys from 25 August through 22 September 1998.

d/ Total count made for four aerial surveys from 1 October through 19 November 1998.

e/ Anderson-Cottonwood Irrigation District Dam

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Recovery	Number o	f marked carc	casses recove period (i):	ered	Total marked carcasses recovered	Total carcasses observed	Population estimate
period (j)	1	2	3	4	(Rj)	(Cj) b/	(N) c/
2	12				12	358	907
3	2	20			22	440	890
4	1	10	20		31	412	939
5		5	11	27	43	542	1,771
Total recovered (Ri):	15	35	31	27		Total:	4,507
Total carcasses marked (Mi):	38	69	75	104			
					Adjusted es	stimate d/:	4,259

TABLE 4.	Chinook salmon carcass mark-and-recovery data used to estimate the 1998 fall-run spawner
	population in Clear Creek from McCormick-Saeltzer Dam to 6.4 km downstream. a/

a/ Surveys were conducted from 20 October to 19 November 1998.

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

c/ Schaefer (1951) estimate equation: $N = \pounds$ (Rij x (Mi/Ri) x (Cj/Rj)).

d/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (4,507 - 248 = 4,259).

Cow Creek

Fall run. An aerial survey was made on 2 November 1998 from the creek's confluence with the Sacramento River upstream for 21 km (13 mi) into North Fork Clear Creek. Although 152 redds were seen, no estimate of the fall-run spawner population was made.

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Cottonwood Creek

<u>Spring run</u>. A snorkeling-survey of the South Fork Cottonwood Creek was made on 10 August 1998, from Shackelford Place upstream to the Boulder Jumbles, a distance of 0.8 km (0.5 mi). No adult salmon were seen.

Surveys were also made of Beegum Creek, a tributary to Cottonwood Creek, during 3-24 September 1998. Adult salmon were counted by snorkeling in the North Fork Beegum Creek (NF) to about 0.4 km (0.3 mi) upstream of its confluence with the South Fork Beegum Creek (SF); in the SF for about 3 km (2 mi) upstream from its confluence with the NF; and in the mainstem from the NF and SF confluence downstream to the Hwy. 36 Bridge crossing. The total distance surveyed was about 21 km (13 mi), and the total 477 salmon observed was judged to represent the 1998 spring-run spawner population for the Cottonwood Creek system.

<u>Fall run</u>. An aerial survey of this tributary was made on 19 November 1998, during which 191 redds were observed in the 42-km (26-mi) stretch from the creek's mouth upstream to the confluence with the North Fork. An estimate of the fall-run spawner population was not made.

Battle Creek

Late-fall run. No surveys were conducted for this run spawning naturally in Battle Creek during 1998. The only available spawner data were for 3,079 late-fall-run salmon whch entered Coleman National Fish Hatchery (CNFH). These fish consisted of 41% male adults, 43% female adults, and 16% grilse.

<u>Winter and spring runs</u>. No in-river spawner surveys were conducted for either of these runs during 1998.

<u>Fall run</u>. Six carcass surveys were conducted during 7 October through 16 November 1998, covering the 5.6-km (3.5-mi) stretch of river between CNFH and the old hatchery location. Fresh salmon carcasses were marked by attaching colored tape to the jaw with a hog ring, and placed into running water for recovery. No surveys were made of the creek upstream of the CNFH barrier dam.

Using carcass mark-and-recovery data with the Schaefer model (Appendix 1.B), the spawner population in Battle Creek downstream of CNFH was estimated to be 53,957 fish (Table 5). Combined with an additional 44,351 fish which entered CNFH, the total 1998 Battle Creek fall-run population was 98,308 salmon (Appendix 2).

The 1998 fall-run spawner population in Battle Creek of 98,308 fish was a decrease of 3% from the 1997 run size, but was still over twice the 1988-1997 average run size (Appendix 3).

Red Bluff Diversion Dam to Princeton Ferry 4/

A total of 5,047 Chinook salmon spawners, consisting of 1,101 late-fall-, 72 winter-, 2,458 spring- and 1,416 fall-run fish, was estimated for 1998 in the Sacramento River system between Red Bluff and Princeton Ferry (Figure 2).

Sacramento River Mainstem

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

Late-fall run. During an aerial flight made on 23 December 1997, 2.8% of the entire mainstem redds were downstream of RBDD (Table 3). It was estimated that the late-fall salmon population in this area was 1,101 fish.

<u>Winter run</u>. Only three redds were observed in the mainstem downstream of RBDD during 13 aerial surveys from 28 April through 11 August 1998 (Table 3). This represented 2.5% of the entire mainstem winter-run spawning, or a spawner population of 72 fish for this area.

<u>Spring run</u>. During four aerial surveys conducted from 25 August through 22 September 1998, no redds were observed in the mainstem downstream of RBDD (Table 3). It was judged that

⁴/ Killam, D. and C.D. Harvey-Arrison. Chinook Salmon Spawner Populations for the Sacramento River System, 1998. File Report. October 2001. CDFG-NCNCR, Red Bluff Office.

Recovery period (j)	1	Number o	of marked car 3	casses recovered	ered from mark	Total marked carcasses recovered (RJ)	Total carcasses observed (Cj) b/	Population estimate (N) c/
2	46					46	1,901	5,093
3	6	184				190	3,620	8,551
4	1	26	308			335	5,343	13,582
5		5	80	270		355	5,895	17,013
6		1	3	22	167	193	3,055	12,835
Total recovered (Ri):	53	216	391	292	167		Total:	57,074
Total carcasses marked (Mi):	142	508	1000	874	735			

TABLE 5. Chinook salmon carcass mark-and-recovery data used to estimate the 1998 fall-run spawner population in Battle Creek from Coleman Hatchery to the old hatchery site. a/

a/ Surveys were conducted from 7 October to 16 November 1998.

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

c/ Schaefer (1951) estimate equation: $N = \vec{z}$ (Rij x (Mi/Ri) x (Cj/Rj)).

d/ 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 (57,074 - 3,117 = 53,957).

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spring-run salmon did not spawn this year in the mainstem downstream of Red Bluff.

Fall run. Four aerial surveys of fall-run spawning were made from 1 October through 19 November 1998. Fall-run redds downstream of RBDD constituted 9.5% of the total mainstem spawning (Table 3), and a spawner population of 600 fish was estimated for this stretch of river. This population was only 3% of that for 1997, and only 5% of the average run size from 1988 to 1997 (Appendix 3).

Antelope Creek

Spring run. A snorkeling-survey of the upper Antelope Creek system was made from 30 July through 11 August 1998. A total stream length of 20 km (12.4 mi) was covered, from the mouth of Little Grapevine Creek in the mainstem upstream into the North Fork Antelope Creek to North Fork Falls, and into sections of the South Fork Antelope Creek to South Fork Falls. A total of 154 adult salmon was observed, and judged to be the 1998 spring run for this system.

Mill Creek

<u>Spring run</u>. Surveys of Upper Mill Creek were made during 22 September through 23 October 1998, covering a stream length of approximately 93 km (58 mi). Salmon carcasses, live fish, and redds were counted while walking the creek from the Hwr. 36 Bridge crossing downstream to Pape Place, while an aerial survey covered the stretch from Pape Place to the powerline crossing downstream of the confluence with Little Mill Creek.

A total of 150 live salmon was counted, but probably was not an accurate count of the fish present since turbidity limited the visibility. Only 26 salmon carcasses were observed, an insufficient number for estimating the population through mark-and-recapture methods. A total of 212 redds was counted, assumed to be the maximum number constructed, and judged to represent a spring-run population of 424 fish for 1998.

<u>Fall run.</u> Three surveys of Mill Creek were made during 29 October through 9 November 1998, covering the stretch from the canyon mouth downstream for a distance of 11.3 km (7 mi). High streamflows and the resulting turbidity prevented continuation of the surveys after the first week of November. Salmon carcasses were marked by attaching colored tape to the jaws with hog rings, and replacing them back into running water for later recovery. Of the 112 carcasses observed, 28 were marked, with five subsequently recovered. A Petersen estimate (Appendix 1.A) of 546 spawners was calculated for the 1998 fall run.

Thomes Creek

<u>Spring run</u>. Snorkeling-surveys of Upper Thomes Creek were made from 11 August through 17 September 1998, by the CDFG Bay-Delta and Special Water Project's Red Bluff field office. Surveys covered the stretch of stream from Hatch Flat upstream for approximately 5 km (3 mi). One adult salmon was observed and judged to be the 1998 spring run for this tributary.

Deer Creek

<u>Spring run</u>. Snorkeling surveys of Upper Deer Creek were made from 26 August through 9 September 1998 covering the 53-km (33-mi) stretch from Upper Deer Creek Falls downstream to Dillon Cove. A total of 1,879 adult salmon was observed, and judged to be the 1998 spring run in this tributary.

<u>Fall run</u>. Three surveys of Deer Creek were made during 30 October through 17 November 1998, in the 18-km (11-mi) stretch from the Upper Deer Creek Diversion Dam to the confluence with the Sacramento River. High flows prevented surveys from the latter part of November on. Salmon carcasses were marked by attaching colored tape to the jaw with a hog ring, and replacing them back into running water for later recovery. Of the 89 carcasses observed, 14 were marked, with 4 subsequently recovered. A Petersen estimate (Appendix 1.A) of 270 spawners was calculated for the 1998 fall run.

Big Chico Creek to the American River

A total of 144,433 Chinook salmon was estimated for 1998 in the Sacramento River tributaries from Big Chico Creek to the American River (Figure 3). This total consisted of 27,374 spring-run and 117,059 fall-run fish (Appendix 2).

Big Chico Creek

<u>Late-fall run</u>. On 3 March 1998, the stretch of Chico Creek from the 5-Mile Recreation Area to 3 km (2 mi) upstream was surveyed.^{5/} A total of five redds and three live salmon was observed, but no carcasses were found. An estimate of the latefall run was not made.

⁵/ Killam, D. and C.D. Harvey-Arrison. Chinook Salmon Spawner Populations for the Sacramento River System, 1998. File Report. October 2001. CDFG-NCNCR, Red Bluff Office.5



Figure 3. Sacramento River system from Big Chico Creek downstream to American River.

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Spring run. Based on snorkeling-survey observations 369 fish were judged to be the 1998 spring run in Big Chico Creek. $^{\underline{6}'}$

Fall run. No surveys were conducted for this run in 1998.

<u>Butte Creek</u>

Spring run. Five snorkeling surveys were conducted during 18-24 August 1998 from Centerville Head Dam to Parrot-Phelan Dam.^{2/} Based on survey counts, it was judged that a maximum of 20,259 salmon were holding in the creek.

<u>Fall run</u>. Based on counts of live salmon and carcasses during the spawner season, a minimum of 500 fish constituted the 1998 fall run in Butte Creek.^{$\frac{8}{}$}

Feather River

<u>Spring run</u>. A total of 6,746 salmon classified as springrun fish entered Feather River Hatchery (FRH) during 1-28 September 1998.^{2/} These fish consisted of 44.3% male adults (FL > 55.9 cm [22 in.]), 48.2% female adults, and 7.5% grilse (FL \leq 55.9 cm). In the river itself, no attempt was made to estimate numbers of spring-run salmon.

The 6,746 spring-run salmon at FRH in 1998 was 85% higher than in 1997, and 56% higher than the average run size observed in the past ten years (Appendix 3).

Fall run. Surveys of Feather River fall-run Chinook salmon were made during 5 October through 2 December 1998. Carcass mark-and-recovery was conducted in two sections, from the Hatchery to Thermalito Afterbay (Section 1), and from the Afterbay to the Gridley boat ramp (Section 2). Salmon carcasses were marked, with a colored ribbon attached to the lower jaw by a hog ring, and released into flowing water for later recovery; for each marking period a different ribbon color was used.

^{2/} Hill, K. Butte Creek Spring Run Chinook Salmon Survey, August 18-24, 1998. Memorandum to files. 10 September 1998. CDFG-SVCSR, Rancho Cordova Office.

^g/ Hill, K. CDFG-SVCSR. Personal communication.

⁹/ Kastner, A. CDFG-SVCSR. Personal communication.

⁶/ Hill, K. CDFG-Sacramento Valley and Central Sierra Region (SVCSR), Rancho Cordova Office. Personal communication.

A total of 18,410 carcasses was counted, of which 1,246 were marked, with 149 subsequently recovered (Table 6). Section 1 was not or only partially surveyed during several of the periods, and no recoveries of marked carcasses were made during the latter surveys. Recovery of marked carcasses was very low in Section 2. An estimate of the 1998 fall-run spawner population in the Feather River was not made.

A total of 18,889 fall-run salmon entered FRH, consisting of 45.1% male adults (FL \ge 55.9 cm [22 in.]), 47.9% female adults, and 7% grilse (FL < 55.9 cm)^{10/}.

Yuba River

<u>Fall_run</u>. During 1998, salmon carcass mark-and-recovery surveys were made in the Yuba River from Rose Bar downstream to Simpson Lane in Marysville $\frac{11}{}$. The surveyed reach was covered in three sections: Rose Bar to Parks Bar (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 Rose Bar to Englebright Dam, although suitable habitat is scarce in that area. Weekly surveys were conducted in Section 1 during 6 October through 1 December 1998, in Section 2 during 7 October through 15 December, and in Section 3 from 15 October through 23 December.

Yuba River average flows below Englebright Dam ranged from 34.1 m^3/s (1206 cfs) in October, to 72.2 m^3/s (2550 cfs) in December. Flows near Marysville averaged 30 m^3/s (1059 cfs) in October, to 67.1 m^3/s (2369 cfs) by December. Mean daily flow peaked at 113.3 m^3/s (4000 cfs) in late November for both areas. The mean daily water temperature in Section 3 in early October was 13.9°C (57°F) and declined to below 7.2°C (45°F) by mid-December. Visibility through the water ranged from 0.3 to 3 m (1-10 ft) during the surveys.

This season, both adult and grilse fresh salmon carcasses were marked; carcasses were considered fresh if they were clear-eyed, while the adult designation was a $FL \ge 64.8$ cm (25.5 in). The length distinguishing adults and grilse was based on data from salmon entering Feather River Hatchery in October 1998. Length

^{10/} Kastner, A. CDFG-SVCSR. Personal communication.

Jones & Stokes Associates, Inc. 1999. 1998 Fall-run Chinook Salmon Spawning Escapement in the Yuba River (JSA 97-238). Sacramento CA. Report to the Yuba County Water Agency, Marysville, CA. 21 p.

Table 6. Chinook salmon carcass mark-and-recovery data collected during surveys of the 1998 fall run in the Feather River. _____

Section 1: Feather River Hatchery to Thermalito Afterbay.

	Carcasses	Carcasses		R	ecovered	<u>marks</u> fro	<u>m week n</u>	umber:			
Week no. (Date)	marked	chopped	1	2	3	4	5	6	7	8	Total
1 (5 Oct.)	360	1,230									
2 (12 Oct.)	314	2,836	64								64
3 (19 Oct.)	158	2,672	8	23							31
4 (26 Oct.)	80	3,602		10	19						29
5 a/	1	1									
6 (9 Nov.) b/	7	643				1					1
7 (16 Nov.)	49	2,510						0			0
8 a/											
9 (2 Dec.)	3	178						0	0		0
Totals:	971	13,671	72	33	19	1		0	0		125

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a/ Not surveyed.b/ Limited survey.

Section 2: Thermalito Afterbay to Gridley Boat Ramp.

	Carcasses	Carcasses		R	ecovered	marks fro	om week :	number:			
Week no. (Date)	marked	chopped	1	2	3	4	5	6	7	8	Total
1 (7 Oct.)	25	45						••			
2 (14 Oct.)	19	132	0								0
3 (21 Oct.)	32	227		2							2
4 (28 Oct.)	31	579		7	1						8
5 (3 Nov.)	29	323			1	2					3
6 (11 Nov.)	49	900					2				2
7 (18 Nov.)	51	763				2		4			6
8 (25 Nov.)	36	470		1				1	1		3
9 (1 Dec.)	3	54								0	0
Totals:	275	3,493	0	10	2	4	2	5	1	Õ	24

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data collected during the first three weeks of the Yuba River surveys corroborated that the 64-cm criterion was reasonable for this tributary's fish also.

Marking consisted of surveyor's tape tied to a hog ring and attached to the fish's jaw; different colors of tape were used to identify carcasses with distinct marking periods. Marked carcasses were returned into flowing water for subsequent recovery. Decayed carcasses and recovered marked carcasses were counted and then chopped in half. The sex of fresh adult carcasses was noted for determination of the male to female ratio in the population.

Using carcass mark-and-recovery data with the Schaefer model (Appendix 1.B), estimates of 6,514 adults and 1,403 grilse were calculated for Section 1 (Table 7), 8,871 adults and 1,711 grilse in Section 2 (Table 8), and 10,424 adults and 2,167 grilse in Section 3 (Table 9). Combining these estimates gave 31,090 total salmon (25,809 adults and 5,281 grilse) as the 1998 Yuba River run.

Based on fresh carcasses observed during the surveys, the fall run consisted of 40% male adults, 46% female adults, and 14% grilse.

The 1998 Yuba River fall run of 31,090 salmon was 20% higher than the 1997 population, and over twice the average run size from 1988 through 1997 (Appendix 3).

American River

<u>Fall run</u>. Weekly salmon carcass mark-and-recovery surveys in the American River were conducted between 4 November and 22 December 1998, covering the 11-km (7-mi) reach from Goethe Park upstream to Sailor Bar.^{12/} This season, the river stretch downstream of Goethe Park to Watt Avenue was not surveyed. Water clarity, measured by secchi disk, ranged from 1.3-2.9 m (4.5-9.5 ft). Water temperature ranged from 16.1 to 9.4°C (61-49°F).

This season fresh adult salmon carcasses were distinctly marked by attaching a hog ring and colored engineers' flagging to their jaws; different colors were used each marking period. A carcass was considered fresh if it had at least one clear eye or pink gills. Marked carcasses were replaced into running water near the location where originally found, or left in place in backwater areas. Any carcass not tagged, as well as those recovered with tags were counted and cut in half. Length and sex

^{12/} Fjelstadt, M. and J. Hanson. American River Salmon Spawning Stock Estimate, 1998. Memorandum to files. 31 December 1998. CDFG-SVCSR, Rancho Cordova office.

ADULT ESTIMATE									Total marked	Total	
Recovery		Number of	marked care	asses recove	ered from ma	rking period	(i):		carcasses recovered	carcasses observed	Population estimate
period (j)	1	2	3	4	5	6	7	8	(Rj)	(Сј) Ъ/	(N) c/
2	6	-	-	_		_	-	-	6	149	577
3	2	9		•••		-		-	11	270	1,405
4		1	21			-		-	22	489	1,307
5			4	31	-		_		35	410	972
6			1	4	19		_		24	339	1,076
7				4	2	14		+	20	239	885
8				1		1	10	•	12	153	616
9							1	0	1	17	88
Total recovered (Ri):		10	26	40	21	15	11	0		Tot	al 6,926
Total carcasses marked (Mi):	31	55	66	94	71	62	46	18			
									Adjusted e	stimate d/:	6,514

TABLE 7.	Chinook salmon	carcass mark-a	nd-recovery	data used to	estimate the	1998 fall-rur	a spawner po	pulation in the
	Yuba River from	Rose Bar to Pa	arks Bar (Se	ction 1). a/				

GRILSE ESTIMATE	Nu	mber of mari	ked carcasses	s recovered fr	om marking	period (i):		Total marked carcasses recovered	Total carcasses observed	Population estimate
period (j)	1	2	3	4	5	6	7	(Rj)	(Cj) b/	(N) c/
2	0			-	**	-		0	43	43
3		0		-	_	-		0	70	70
4			2	-	-			2	81	405
5				5				5	101	465
6					2	-		2	75	350
7					0	6		6	55	71
8					1	1	2	4	35	70
9							1	1	2	2
Total recovered (Ri):	0	0	2	5	3	7	3		Tota	1: 1,476
Total carcasses marked (Mi):	7	14	10	23	14	9	3			
								Adjusted es	stimate e/:	1,403

a/ Surveys were conducted from 6 October to 1 December 1998.

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

c/ Schaefer (1951) estimate equation: $N = \pounds$ (Rij x (Mi/Ri) x (Cj/Rj)).

d/ Adjusted estimate reflects the modified Schaefer equation (Hoopaugh 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the tot total estimate (6,926 - 412 = 6,514).

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e/ Adjusted estimate where marked carcasses (M1) from the second marking period on were subtracted from the total estimate (1,476 - 73 = 1,403).

ADULT ESTIMATE Recovery		Numb	erofm	arked c	arcasse	Tecove	red fro	m mark	ing per	 iod (i):	- , -	Total marked carcasses recovered	Total carcasses observed	Population estimate
period (j)	1	2	3	4	5	6	7	8	9	10	11	<u>(Rj)</u>	<u>(Сј)</u> b/	(N) c/
2	3	-		-			_	_		_		3	157	942
3		13	_	-	-	-	-		-		-	13	332	1,071
4		6	29	-			-			-		35	597	1,469
5		3	8	28			-				-	39	521	1,650
6			4	4	34		-		_	-		42	435	1,227
7			2		5	23		_	-			30	480	1,149
8					4	5	17	-		-		26	273	953
9						0	0	0				0	59	59
10						1	1	1	1			3	86	910
11										0		0	22	22
12											0	0	0	0
Total recovered (Ri):	3	22	43	32	43	29	18	1	1	0	0		Total:	9,452
Total carcasses marked (M1):	18	71	99	109	121	67	72	32	4	3	3			
												Adjusted e	stimate d/:	8,871

TABLE 8. Chinook salmon carcass mark-and-recovery data used to estimate the 1998 fall-run spawner population in the Yuba River from Parks Bar to Daguerre Point Dam (Section 2). a/

GRILSE ESTIMAT	E										Total marked	Total	Population
Recovery	Numb	er of m	arked c	arcasse	s recovi	ered fro	m mark	ing per	iod (i):		recovered	observed	estimate
penod (j)	1	2	3	4	5	6	7	8	9	10	(RJ)	(Cj) b/	<u>(N)</u> c/
2	0				-		-	-			0	37	37
3	1	3		-					-		4	69	279
4		2	3		-			-			5	115	335
5			I	3	-					-	4	112	301
6				1	5			~			6	106	29 7
7				2	2	4	-	-	-	-	8	91	270
8							1	-	-		1	54	189
9							0	0	-	-	0	33	33
10							0		0	-		23	23
11							1			0		7	32
Total recovered (R1):	1	5	4	6	7	4	2	0	0	0		Tot	al. 1,796
Total carcasses marked (Mi):	9	12	13	15	20	13	7	4	D	1	·		<u></u> ;
											Adjusted e	stimate E/:	1.711

a/ Surveys were conducted from 7 October to 15 December 1998.

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

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

d/ 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 (9,452 - 581 = 8,871).

e/ Adjusted estimate where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (1,796 - 85 = 1,711).

<u>ADULT ESTIMATE</u>												Total marked	Total	Population
Recovery		Numbe	erofm	arked c	arcasse	s recove	red from	m mark	ing per	iod (i):		recovered	observed	estimate
period (j)	1	2	3	4	5	6	7	8	9	10	11	(Rj)	(Cj) b/	(N) c/
2	19	-	-		-				-			19	337	772
3	4	25	•									29	363	980
4	0	5	16					-	-	-	-	21	518	1,586
5	1	4	5	20		-		-		-		30	610	1,925
6			1	13	37	-	-		-	-		51	716	2,437
7			0	3	6	30	-	-	-	-	-	39	316	1,408
8			4		0	1	2		-			7	109	1,039
9					1		0	1	-			2	78	330
10							1		3			4	64	555
11										2		2	28	84
Total recovered (Ri):	24	34	26	36	44	31	3	1	3	2	0		Total:	11,116
Total carcasses	55	94	87	118	157	148	74	ç	10	6	2			
markea (ivir):		74	02	110		140	/4		10		5	Adjusted e	stimate d/:	10,424

TABLE 9 Chinook salmon carcass mark-and-recovery data used to estimate the 1998 fall-run spawner population in the Yuba River from Daguerre Point Dam to Marysville (Section 3). a/

GRILSE ESTIMATE Recovery		Numb	er of ma	arked ca	arcasses	recove	red from	m mark	ing per	iod (1).	Total marked carcasses recovered	Total carcasses observed	Population estimate
period (j)	1	2	3	4	5	6	7	8	9	10	(Rj)	(Cj) b/	(N) c/
2	2	_	-	_		-	-	-	_	-	2	55	165
3		3	-	+					-	-	3	83	443
4			4	-	-				-	 .	4	83	311
5.				3	-				-	-	3	93	260
6				2	5	-	•-			-	7	158	446
7					1	6		-	-	-	7	70	318
8							0	-		-	0	56	56
9							1	0		-	1	33	231
10									2		2	23	35
11										0	0	11	11
Total recovered (Ri):	2	3	4	5	6	6	1	0	2	0		Ťo	tal. 2,276
Total carcasses marked (Mi):	6	16	15	14	17	29	6	7	3	2			
											Adjusted e	stimate e/:	2,167

a/ Surveys were conducted from 15 October to 23 December 1998.

b/ includes salmon carcasses which were marked and marked carcasses that were recovered.

c/Schaefer (1951) estimate equation. $N = \boldsymbol{\leq} (Rij \times (Mi/Ri) \times (Cj/Rj))$.

d/ 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 (11,116 - 692 = 10,424).

e/ Adjusted estimate, where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate (2,276 - 109 = 2,167).

were recorded for a sample of the fresh carcasses.

The adult salmon spawner population of the Goethe Park to Sailor Bar section of the river, estimated from carcass mark-andrecovery data using the Schaefer model (Appendix 1.B) was 28,227 fish (Table 10)^{13/}. The adult estimate was expanded for a grilse proportion of 25%, to 37,636 fish in the surveyed sections. During the 1993-1997 seasons, an average of 7% of the total carcasses observed were in the Goethe Park to Watt Avenue section that was not surveyed this year. It was assumed that section's population was 2,833 fish, bringing the total in-river spawners to 40,469 salmon.

An estimated 14,323 fish were entrained on the Nimbus Racks or passed upstream to Nimbus Basin. In addition, 11,788 salmon entered Nimbus Hatchery^{14/}, bringing the total American River 1998 fall-run population to 66,580 fish (Appendix 2).

Based on examination of 961 fresh carcasses, the run consisted of 39.3% male adults (FL > 64 cm [25.2 in.]), 35.6% female adults, and 25.1% grilse (FL \leq 64 cm). Salmon entering Nimbus Hatchery consisted of 42.3% male adults (FL \geq 60 cm [23.6 in.]), 42.1% female adults, and 15.6% grilse (FL < 60 cm).

The 1998 run of 66,580 salmon in the American River was 15% higher than the previous year's population, and 60% higher than the average population for 1988-1997 (Appendix 3).

^{13/} Hanson, J. CDFG - SVCSR. Personal communication.

^{14/} Barngrover, B. CDFG-SVCSR. Personal communication.

Recovery period (j)	<u></u>	Number of	f marked carc 3	asses recove	red from mar 5	king period (6	(i): 7	Total marked carcasses recovered (Ri)	Total carcasses observed (Ci) b/	Population estimate (N) c/
2	27							27	1,117	2,919
3	4	44						48	2,039	5,042
4		3	60					63	1,927	6,460
5		2	7	70				79	2,475	6,051
6		0	1	11	69			81	1,400	3,361
7		1		I	6	15		23	748	2,331
8				1	1	1	4	7	411	2,891
Total recovered (Ri):	31	50	68	83	76	16	4		Total:	29,055
Total carcasses										
marked (Mi):	81	123	231	195	182	56	41			
								Adjusted e	stimate d/:	28,227

TABLE 10. Chinook salmon carcass mark-and-recovery data used to estimate the 1998 fall-run spawner population in the American River from Goethe Park to Sailor Bar. a/

a/ Surveys were conducted from 4 November to 22 December 1998.

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

c/ Schaefer (1951) estimate equation: N = ∠(Rij x (Mi/Ri) x (Cj/Rj))

d/ 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 (29,055 - 828 = 28,227).

CHINOOK SALMON SPAWNER POPULATIONS FOR THE SAN JOAQUIN RIVER SYSTEM

The Cosumnes, Mokelumne, Stanislaus, Tuolumne, and Merced rivers of the San Joaquin River system (Figure 4) were surveyed for Chinook salmon spawners. A total of 23,590 salmon, consisting entirely of fall-run fish, was estimated to be in this system for 1998 (Appendix 2).

Cosumnes River

Fall-run salmon surveys were conducted in the Cosumnes River between Michigan Bar and the Meiss Road bridge during 12 November through 23 December 1998^{15/}. River flows during the surveys ranged from 2.9 m³/s (105 cfs) during the first week, to 5.7 m³/s (200 cfs) in mid-surveys, and 3.9 m³/s (138 cfs) during the final week. Water temperatures declined from 32.2°C (50°F) to 18.2°C (36°F) throughout the survey period.

Salmon carcass marking and recovery were made every other week in an attempt to estimate the spawner abundance. Complete carcasses (those with heads) were tagged by attaching colored ribbons to their jaws with hog rings; a different color designated each week of marking. Tagged carcasses were released into running water for subsequent recovery. Upon recovery, marked carcasses were chopped in half. Carcasses that were not suitable for marking were also chopped, as well as those on shore in a "leathery" condition, and those in the downstream-most portion that would likely have drifted out of the area and not be recoverable. Data on gender, length, and female egg retention were also collected, primarily from fresh carcasses; a carcass was considered fresh if either eye was clear or gills were pink.

A total of 105 carcasses was observed, of which 33 were marked, and six subsequently recovered. Although a estimate of 544 salmon could be calculated using the Petersen formula, it was considered to be an overestimation, and the population was judged to be more around 300 fish.

Forty carcasses were measured and sexed. Length distribution analysis determined that 72 cm FL (28.3 in) was the size distinction between adults and grilse. Only one of the carcasses was classified as a grilse (<72 cm FL), and proportions of adult salmon carcasses were 41% males and 59% females. Ninety-one percent of the females examined were determined to be completely

^{15/} Snider, B. and B. Reavis. 2000. Cosumnes River Chinook Salmon Spawner Escapement, Rearing, and Emigration Surveys, 1998-1999. CDFG, Habitat Conservation Division, Stream Evaluation Program. Technical Report No. 00-07. 28 p.



Figure 4. San Joaquin River system from the Merced River to the Cosumnes River.

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spawned.

Mokelumne River

<u>Fall run</u>. In 1998, the upstream migration of fall-run salmon was monitored by Natural Resources Scientists, Inc. under contract to East Bay Municipal Utilities District ^{16/}. Counts of salmon were made, using video equipment and trapping, in the Woodbridge Irrigation District Dam fish ladders during 19 August 1998 through 31 January 1999.

A total of 7,202 salmon was counted migrating past or relocated upstream of the dam. Of these salmon, 3,090 fish entered the Mokelumne River Fish Installation, so the 1998 in-river fall-run spawner population was assumed to be 4,112 fish (Appendix 2).

Based on composition of the run at Woodbridge Dam and at the hatchery, the in-river run consisted of 35.1% male adults, 43.4% female adults, and 21.5% grilse. The composition of the salmon entering the hatchery was 38.7% male adults (FL > 61 cm [24 in]), 42.4% female adults, and 18.9% grilse (FL \leq 61 cm).

The 1998 spawner population of 7,202 fish in the Mokelumne River was a decrease of 29% from the previous year's run, but was still still over twice the average run size for the 1988-1997 period (Appendix 3).

Stanislaus River

Fall run. Spawner surveys were conducted during 10 October through 19 December 1998 ^{12/}. The 30.6-km (19-mi) stretch of the river from Knights Ferry to Riverbank was covered by drift boat, and surveys were made on foot in the Goodwin Dam and Two-Mile Bar areas.

Salmon carcasses, regardless of condition or age-class, were marked using serially-numbered tags attached to their jaws with hog-rings. Marked carcasses were released into running water for subsequent recovery. Carcasses not marked and skeletons, as well as those marked carcasses which were recovered, were counted and chopped in half to prevent recounting.

^{16/} Setka, J.D. Fall-run Chinook salmon and steelhead trout spawning survey, September 1998 through January 1999, Mokelumne River, California. East Bay Municipal Utility District. 32 p.

^{17/} Heyne, T. and D. Marston. Sportfish Restoration Act Annual Performance Report 1998-1999. Grant F-51-R6, Project 5, Job 2. California Department of Fish and Game. San Joaquin Valley/Southern Sierra Region (SJVSSR), Fresno Office. 32 p. The carcass marking protocol and use of numbered tags were intended to allow post-season distinction of age-class and condition, so the data could be better compiled for estimating the population through several biometric models. Analysis of the data indicated the Schaefer estimate (Appendix 1.B) was the most appropriate.

The population in the Knights Ferry to Riverbank stretch was estimated to be 3,087 fish $\frac{18}{}$, using the fresh carcass markand-recovery data in the Schaefer model (Table 11).

The adult-grilse composition of the population was determined from frequency distributions of length measurements for fresh carcasses taken this season during all of the San Joaquin River tributary surveys and Merced River Hatchery returns. The length criteria used to distinguish adult from grilse salmon was calculated separately for males and females of both hatchery- and naturally-spawned-origin; salmon carcasses of hatchery-origin were identified as those having an adipose fin-clip (Ad-clip) or a coded-wire tag (CWT), while those with neither an Ad-clip or CWT were classified as being of natural origin. Hatchery-origin male salmon with a FL \geq 71 cm (30 in) and female fish with a FL \geq 62 cm (24.4 in) were considered adults. Natural-origin males with a FL \geq 69 cm (27.2 in) and females with a FL \geq 60 cm (23.6 in) were considered adults. Based on these length criteria, the Stanislaus River fall run consisted of 26% male adults, 35.3% female adults, 25% male grilse, and 13.7% female grilse.

The 1998 Stanislaus River fall-run spawner population of 3,087 salmon was 45% lower than the previous year's run, but still 47% higher than the 1988-1997 average run size (Appendix 3).

Tuolumne River

Fall run. Fall-run Chinook salmon spawner surveys in the Tuolumne River were conducted from 7 October through 22 December 1998 ^{19/}. Surveys covered the river stretch from LaGrange Dam downstream to Fox Grove Regional Park, a distance of 37 km (23 mi).

Salmon carcasses, regardless of condition or age-class, were marked using serially-numbered tags attached to their jaws with hog-rings. Marked carcasses were released into running water for

¹⁸/ Heyne, T. CDFG-SJVSSR. Personal communication.

¹⁹⁷ Heyne, T. and D. Marston. Sportfish Restoration Act Annual Performance Report 1998-1999. Grant F-51-R6, Project 5, Job 2. California Department of Fish and Game. San Joaquin Valley/Southern Sierra Region (SJVSSR), Fresno Office. 32 p.

Recovery	Number of	marked card	asses recove	red from mar	king period ((i).	Total marked carcasses recovered	Total carcasses observed	Population estimate
period (j)	1	2	3	4	5	6	(Rj)	(Cj) b/	(N) c/
2	0						0	86	86
3	1	6					7	67	309
4	0	2	I				3	103	541
5	1		1	0			2	129	1,226
6				2	2		4	84	924
7						1	1	16	96
Total recovered (Ri):	2	8	2	2	2	1		Total:	3,182
Total carcasses	11	20	17	21	12	¢			
	21	29	17	21	23	3	Adjusted e	stimate d/:	3,087

TABLE 11.	Chinook salmon carcass mark-and-recovery data used to estimate the 1998 fall-run spawner population in the
	Stanislaus River from Knights Ferry to Riverbank. a/

a/ Surveys were conducted from 10 October to 19 December 1998.

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

c/ Schaefer (1951) estimate equation: $N = \measuredangle$ (Rij x (Mi/Ri) x (Cj/Rj)).

d/ 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 (3,182 - 95 = 3,087).

subsequent recovery. Carcasses not marked and skeletons, as well as those marked carcasses which were recovered, were counted and chopped in half to prevent recounting.

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

The salmon population in the river section between LaGrange Dam and Fox Grove Regional Park was estimated at 8,910 fish 20/, using the fresh carcass mark-and-recovery data in the Schaefer model (Table 12).

The adult-grilse composition of the population was determined from frequency distributions of length measurements for fresh carcasses taken this season during all of the San Joaquin River tributary surveys and Merced River Hatchery returns. The length criteria used to distinguish adult from grilse salmon was calculated separately for males and females of both hatchery- and naturally-spawned-origin; salmon carcasses of hatchery-origin were identified as those having an adipose fin-clip (Ad-clip) or a coded-wire tag (CWT), while those with neither an Ad-clip or CWT were classified as being of natural origin. Hatchery-origin male salmon with a FL \geq 71 cm (30 in) and female fish with a FL \geq 62 cm (24.4 in) were considered adults. Natural-origin males with a FL \geq 69 cm (27.7 in) and females with a FL \geq 60 cm (23.6 in) were considered adults. Based on these length criteria, the run in the Tuolumne River consisted of 26.1% male adults, 39.1% female adults, 23.4% male grilse, and 11.4% female grilse.

The 1998 fall run of 8,910 salmon in the Tuolumne River was an increase of 25% from the previous year's population, and over four times higher than the average run size for 1988-1997 (Appendix 3).

Merced River

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<u>Fall run</u>. Weekly carcass mark-and-recovery surveys were conducted in the 37-km (23-mi) stretch of the Merced River from <u>Crocker-Huffman Dam downstream to Cressy</u>. Surveys were conducted from 19 October through 21 December 1998 ^{21/}.

20/ Heyne, T. CDFG-SJVSSR. Personal communication.

^{21/} Heyne, T. and D. Marston. Sportfish Restoration Act Annual Performance Report 1998-1999. Grant F-51-R6, Project 5, Job 2. California Department of Fish and Game. San Joaquin Valley/Southern Sierra Region (SJVSSR), Fresno Office. 32 p.

Recovery		Nu	mber of marl	ked carcasses	recovered fr	om marking	period (i):			Total marked carcasses recovered	Total carcasses observed	Population estimate
period (j)	1	2	3	4	5	6	7	8	9	(Rj)	<u>(Cj) b/</u>	(N) c/
2	5			••						5	116	219
3	4	18								22	349	702
4		9	61							70	621	1,413
5			6	22			••			28	425	1,546
6			1	12	15					28	372	1,526
7			3	19	9	26				57	558	1,837
8				3	9	12	10			34	325	1,292
9						1	5	4		10	138	1,180
10									0	0	27	27
Total recovered (Ri):	9	27	71	56	33	39	15	4	0		Total:	9,742
Total carcasses marked (Mi):	17	55	164	224	142	99	81	56	11			
										Adjusted es	timate d/:	8,910

TABLE 12. Chinook salmon carcass mark-and-recovery data used to estimate the 1998 fall-run spawner population in the Tuolumne River from LaGrange to Fox Grove Regional Park. a/

a/ Surveys were conducted from 7 October to 22 December 1998.

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

c/ Schaefer (1951) estimate equation: $N = \measuredangle$ (Rij x (Mi/Ri) x (Cj/Rj)).

d/ 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 (9,742 - 832 = 8,910).

х Р. А Salmon carcasses, regardless of condition or age-class, were marked using serially-numbered tags attached to their jaws with hog-rings. Marked carcasses were released into running water for subsequent recovery. Carcasses not marked and skeletons, as well as those marked carcasses which were recovered, were counted and chopped in half to prevent recounting.

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

A Schaefer estimate of 3,292 salmon was calculated^{22/} for the river stretch from Crocker-Huffman Dam to Cressey (Table 13). Merced River Hatchery took in 799 salmon, for a total 1998 fallrun spawner population of 4,091 fish (Appendix 2).

The adult-grilse composition of the population was determined from frequency distributions of length measurements for fresh carcasses taken this season during all of the San Joaquin River tributary surveys and Merced River Hatchery returns. The length criteria used to distinguish adult from grilse salmon was calculated separately for males and females of both hatchery- and naturally-spawned-origin; salmon carcasses of hatchery-origin were identified as those having an adipose fin-clip (Ad-clip) or a coded-wire tag (CWT), while those with neither an Ad-clip or CWT were classified as being of natural origin. Hatchery-origin male salmon with a FL \geq 71 cm (30 in) and female fish with a FL \geq 62 cm (24.4 in) were considered adults. Natural-origin males with a FL \geq 69 cm (27.2 in) and females with a FL \geq 60 cm (23.6 in) were considered adults. Based on these length criteria, the in-river run of the Merced River consisted of 25.3% male adults, 39.1% female adults, 23.1% male grilse, and 12.5% female grilse. Salmon which entered Merced River Hatchery consisted of 17.1% male adults, 26.3% female adults, 41.4% male grilse, and 15.2% female grilse.

The 1998 Merced River fall run of 4,091 salmon was an increase of 12% from the previous year's run size, and almost twice the average population size from 1988 through 1997 (Appendix 3).

^{22/} Heyne, T. CDFG-SJVSSR. Personal communication.

Recovery		Nu	mber of mark	Total marked carcasses recovered	Total carcasses observed	Population estimate						
period (j)	1	2	3	4	5	6	7	8	9	(Rj)	(Cj) b/	(N) c/
2	1			-						1	62	186
3		5								5	152	361
4		2	5							7	254	766
5		0	4	22						26	244	515
6		1	2	6	14					23	324	790
7				2	4	6				12	189	504
8						2	6			8	111	278
9								0		0	16	16
10								1	0	1	10	80
Total recovered (Ri):	1	8	11	30	18	8	6	1	0		Total:	3,496
Total carcasses marked (Mi):	3	19	36	57	46	24	14	7	1			
										Adjusted e	stimate d/:	3,292

TABLE 13. Chinook salmon carcass mark-and-recovery data used to estimate the 1998 fall-run spawner population in the Merced River from Crocker-Huffman Dam to Cressey. a/

a/ Surveys were conducted from 19 October to 21 December 1998.

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

c/ Schaefer (1951) estimate equation: N = \measuredangle (Rij x (Mi/Ri) x (Cj/Rj)).

d/ 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 (3,496 - 204 = 3,292).

SUMMARY

The total estimated 1998 Central Valley Chinook salmon spawner population was 327,242 fish (Table 14). This was 22% lower than the 1997 total of 421,691 salmon.

All of the late-fall, winter, and spring runs, and the majority of the fall run were in the Sacramento River system. In the upper mainstem, the winter and spring runs were two times and eight times higher, respectively, than the 1997 populations. The upper mainstem late-fall run was the highest since estimates of the population were begun in 1971; all of the previous estimates were derived from counts of fish passing RBDD, while this year's estimate was made using carcass survey and redd count data.

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The San Joaquin River tributaries total fall run was 12% lower than the 1997 run size, and this system still only contributed a small portion (9%) of the total Central Valley escapement.

Spawning area	Late-fall run	Winter run	Spring run	Fall run	Total
Sacramento mainstem	39,340	2,903	1,115	6,318	49,676
Sacramento tributaries	3,079 ^{ª/}	99	30,356	220,442	253,976
San Joaquin tributaries				23,590	23,590
Totals:	42,419	3,002	31,471	250,350	327,242

TABLE 14. Summary of the 1998 Sacramento-San Joaquin river system Chinook salmon spawner populations.

a/ Consists only of fish which entered Coleman National Fish Hatchery (Battle Creek).

ACKNOWLEDGEMENTS

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

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REFERENCES

Hoopaugh, David A. (ed.). 1978. King (Chinook) salmon spawning stocks in California's Central Valley, 1976. Calif. Dept. of Fish and Game, Anad. Fish. Br. Admin. Rep. No. 78-19. 33 p.

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- Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Res. Bd. Canada, Bull. 191. 382 p.
- Schaefer, M.D. 1951. Estimation of size of animal populations by marking experiments. U. S. Fish and Wildl. Serv., Fish. Bull. 52: 189-203.

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

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

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);

$$N = \sum \left(R_{ij} \times \frac{M_i}{R_i} \times \frac{C_j}{R_j} \right) - \sum_{i=1}^{j} M_i$$

where N = the estimated spawner population,

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- R_{ii} = carcasses marked in the *i*th marking period which were recovered in the *j*th recovery period,
- M_i = carcasses marked in the *i*th marking period,
- R_i = total marked carcasses recovered from the *i*th marking period,
- C_j = total carcasses observed in the jth recovery period, including those with marks, and
- $\Sigma_2{}^iM_i$ = total carcasses marked from the second marking period on. Subtraction of this factor adjusted for replacement of recovered marked fish.

River System		Es	timated number of	fish	
River area	Late-	Winter	Spring	Fall	Total for
Tributary	fall run		กมก	านก	all runs
Sacramento River System:					
Keswick Dam to Red Bluff					
Sacramento River mainstem a/	38,239	2,831	1,115	5,718	47,903
Livingstone Stone National Fish Hatchery		99			99
Clear Creek	Ъ/	<u></u>	47	4.259	4,306
Cottonwood (Beegum) Creek	÷-	'	477	c/	477
Battle Creek					
Coleman National Fish Hatchery	3.079	_	-	44.351	47.430
In-river	b/	b/	b/	53,957	53.957
(Totals for tributary):	(3,079)			(98,308)	(101,387)
Totals for area:	41,318	2,930	1,639	108,285	154,172
Red Bluff to Princeton Ferry	1 101	77	0	600	1 773
Sacramento River mainstem	1,101	12	164	000	1,773
Antelope Creek			154		154
Mill Creek	-		424	540	970
Thomes Creek		-	1	-	1
Deer Creek			1,879	270	2,149
Totals for area:	1,101	72	2,458	1,416	5,047
Big Chico Creek to American River					
Big Chico Creek	c/		369	b/	369
Butte Creek	- U,		20 259	500	20 759
Footbor Biver			20,205	500	20,727
France River Hatchen	-		6 746	18 889	25 635
	-	-	0,740 b/	r0,007	25,055
(Totals for tributary):			(6.746)	(18,889)	(25,635)
(,-,-,-,-,-,-,-,-,-,-,-,-,-,-,-,-			L /	23,000	21,000
Yuba River	-	-	D/	51,090	51,090
American River					
Nimbus Hatchery	-	-		11,788	11,788
Nimbus Basin	-	-	-	14,323	14,323
In-river	-	-	-	40,469	40,469
(Totals for tributary)				(66,580)	(66,580)
Totals for area:			27,374	117,059	144,433
Sacramento River System Totals:	42,419	3,002	31,471	226,760	303,652
San Joaquin River System:					
Cosymnes River	-	-	~	300	
Makalumaa Divar					
Makelumne River Eich Installation			-	3 090	
Moretunnie River Fish histanation	-	-	-	4 117	
In-fiver	-		-	(7707)	
(Totals for thoulary):				(7,202)	
Stanislaus River	-		**	3,087	
Tuolumne River	-			8,910	
Merced River					
Merced River Hatcheryr	_	-	-	799	
In-river	_		-	3,292	
(Totals for tributary):				(4,091)	
				- 22 200	
<u>San Joaquin River System Total:</u>				23,390	

APPENDIX 2. 1998 Chinook salmon spawner population estimates for the Central Valley river system.

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a/ Late-fall run estimate based on carcass survey and aerial redd count data. Other runs estimated from Red Bluff Diversion Dam counts.

b/ Tributary was not surveyed for this run.

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

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Tributary				E	stimated numb	er of fish						1988-1997
Race	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	average
Sacramento River												
mainstem upstream												
of Red Bluff												
Late-fall run	12,507	12,807	6,892	6,611	9,356	739	a/	a/	a/	a/	38,239 b/	4,891
Winter run	2,129	633	384	192	1,164	349	144	1,159	1,001	836	2,831	799
Spring run	9,867	5,131	4,198	825	371	391	862	426	378	128	1,115	2,258
Fall run	63,998	48,968	32,109	20,523	23,914	33,471	44,729	53,385	71,725	98,764	5,718	49,159
Battle Creek												
Fall run c/	67,475	31,048	21,088	17,241	12,708	18,616	43,265	83,192	73,587	101,414	98,308	46,963
<u>Sacramento River</u> mainstem downstream of Red Bluff												
Fall run	18,262	10,101	16,175	10,108	8,315	12,760	13,817	10,549	12,361	20,531	600	13,298
Feather River												
Spring run d/	6,833	5,078	1,893	4,303	1,497	4,672	3,641	5,414	6,381	3,653	6,746	4,337
Fall run c/	49,036	48,119	6,126 d/	42,062	40,545	42,914	53,584	72,061	65,277	65,627	18,889 d/	53,247 e/
Yuba River												
Fall run	9,000	7,622	f/	14,008	6,362	6,703	10,890	14,237	27,900	25,964	31,090	13,632
American River												
Fall run c/	33,514	28,923	10,239	25,211	11,267	39,410	39,817	86,828	82,396	57,845	66,580	41,545
<u>Mokelumne River</u>												
Fall run c/	528	281	499	410	1,645	3,157	3,421	5,417	7,775	10,163	7,202	3,330
Stanislaus River												
Fall run	10,212	1,510	480	394	255	677	1,031	619	168	5,588	3,087	2,093
Tuolumne River												
Fall run	5,779	1,275	96	77	132	471	506	827	4,362	7,146	8,910	2,067
Merced River												
Fall run c/	4,592	427	82	119	986	1,678	3,589	2,922	4,432	3,660	4,091	2,249
			·									

APPENDIX 3. Chinook salmon spawner population estimates from 1988 through 1998 in California's Central Valley major tributaries.

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

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b/ Estimate based on carcass survey and aerial redd counts. All other years' estimates based on Red Bluff Diversion Dam counts.

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

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

e/ Average does not include the 1990 estimate

f/ Tributary was not surveyed.