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DEPARTMENT OF FISH AND GAME
Sacramento Valley-Central Sierra Region

**Lower American River Chinook Salmon Escapement Survey
October – December 2005**

By

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Introduction

Adult fall-run Chinook salmon ascend the American River for approximately 23 miles from the confluence of the Sacramento River near Discovery Park to the terminus of anadromous migration at the Nimbus fish weir, just below Nimbus Dam. Spawning occurs within the eighteen miles of river from about Paradise Beach to Nimbus fish weir. However, most spawning occurs in the uppermost three miles of the river near Sunrise Avenue Bridge upstream to the Nimbus fish weir.

Spawner escapement surveys have been conducted on the lower American River to estimate the number of returning adult Chinook salmon for nearly 60 years. This information is important in guiding development and evaluation of management decisions. The four goals of the 2005 lower American River spawner escapement survey were (1) estimate the number of spawners; (2) determine the sex and age composition; (3) determine the egg retention of the females in the run; and (4) determine the percentage of coded-wire tagged (CWT) fish within the fresh samples.

Materials and Methods:

The lower American River salmon escapement survey was conducted from the Nimbus weir downstream to the Watt Avenue Bridge; a distance of 12.9 river miles. The river was stratified into three reaches (Table 1). All reaches were surveyed once a week from October 17 through December 22, 2005. The survey was terminated after Week 10 because of extremely high river flow in excess of 25,000 cfs. Each weekly survey consisted of a crew of seven to nine people and took three to four days to complete.

Reach	Location	Miles
1	Nimbus Fish Weir to Elmanto Access	3.4
2	Elmanto Access to Goethe Park Footbridge	3.5
3	Goethe Park Footbridge to Watt Avenue Bridge	6.0
Total		12.9

Each week all fresh carcasses (either one clear eye or pink gills) were counted and tagged with a color-coded hog ring on the upper jaw for adults and lower jaw for grilse. A unique color was used each week to identify the carcasses to a specific tagging week. Each tagged carcass was returned to flowing water for dispersal. All

fresh carcasses below Gristmill Fishing Access were chopped to avoid tagged fish from floating out of the study area. Fresh carcasses with missing adipose fins were identified as carcasses with a CWT. Heads were removed from the CWT carcasses and affixed with a jaw tag for further analysis of any CWT's. In the course of this action, CWT carcasses were chopped in half and recorded as a fresh chopped carcass.

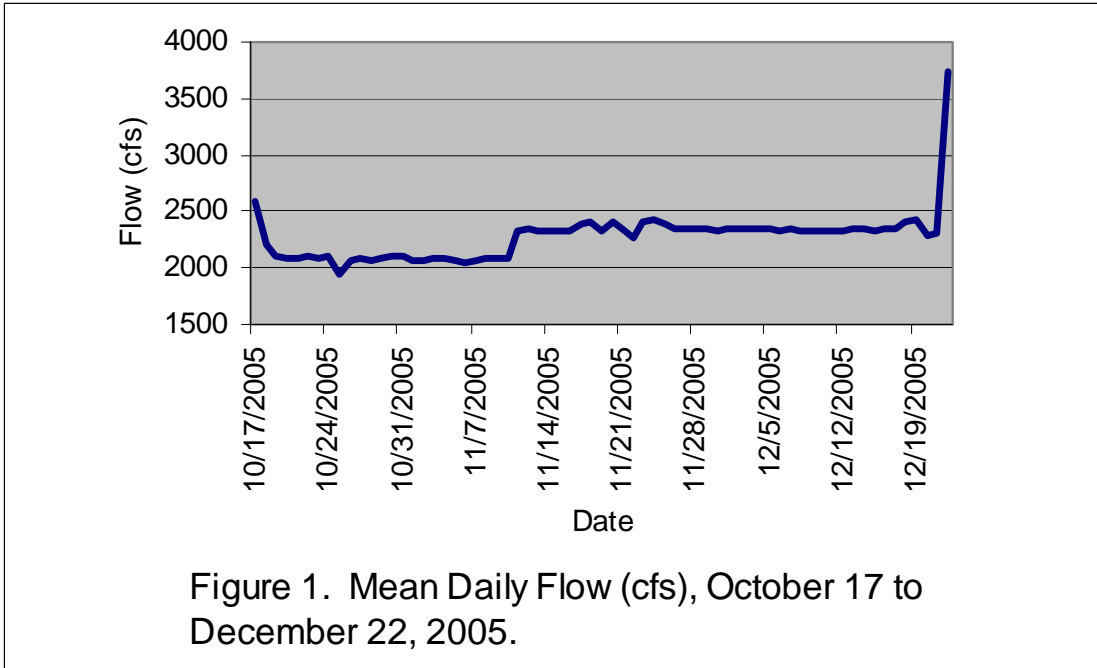
A subset (96%) of fresh carcasses and all CWT carcasses were identified to sex and measured to the nearest centimeter (cm) Total Length (TL). Fish ≥ 68 cm TL were considered adults, and those < 68 cm TL were classified as a grilse, or young adult. All fresh female carcasses measured were checked to determine the degree of egg retention. Each was identified as either completely spawned (0 to 30% eggs retained), partially spawned (>30 to 70% eggs retained), or un-spawned ($> 70\%$ retained).

All observed decomposing carcasses were counted but not tagged. Decomposing and recovered (previously tagged) carcasses were chopped in half to prevent recounting. Fresh adult carcass data was used in the Schaefer mark-recovery method (Schaefer, 1951) as modified by Taylor (1974) to produce an escapement estimate. The grilse population was determined by the proportion of grilse from the total number of fresh carcasses observed. The total Chinook salmon escapement was calculated by summing the in-river population estimate with the total number collected at Nimbus Fish Hatchery and the number of salmon carcasses that get impinged on the upstream side of the Nimbus fish weir. The Nimbus fish weir is not totally effective at blocking 100% of the salmon and some fish are able to move upstream of the weir. These fish that escape around the fish weir eventually die and are impinged on the upstream side of the weir.

Daily water temperature, flow, and clarity were collected throughout the sampling period. Mean daily water temperature and flow were obtained from U.S. Bureau of Reclamation gauging stations located on the lower American River at Hazel Avenue, William Pond Park, and Watt Avenue. Water clarity was measured with a secchi disk to the nearest 0.25 meter.

Results

Mean daily flow ranged from 1,944 cubic feet per second (cfs) to 3,728 cfs during the ten week survey period (Figure 1). Flow was on a declining trend from 2,500 cfs during the first two days of the survey and remained constant around 2,000 cfs through November 10, 2005. After, flow was then increase to around 2,300 cfs through the week of December 19, 2005 (Week 10). Water temperature in the American River ranged from 17.4 °C (63.4 °F) to 10.8 °C (51.5 °F). Water clarity ranged from 1 to 4.75 meters during the survey. Water clarity was lowest during the week of December 19, 2005.



Temporal Distribution

A total of 21,980 salmon were observed during the 2005 American River escapement survey, including 2,835 fresh and 19,145 non-fresh carcasses (Table 2). Fresh carcasses were first observed during the week of October 17 (Week 1) and were present throughout the survey period (Figure 2). The number of fresh carcasses observed increased through the week of December 5 and then decreased. The number of non-fresh carcasses observed exhibited a similar trend (Figure 3).

Table 2. General survey information for the American River fall-run Chinook salmon escapement survey, October 17-December 22, 2005.

Week	Date	Carcasses Observed	
		Fresh	Non-fresh
1	Oct 17-Oct 20	6	25
2	Oct 24-Oct 26	14	46
3	Oct 31-Nov 2	37	130
4	Nov 7-Nov 9	119	282
5	Nov 14-Nov 16	216	717
6	Nov 21-Nov 23	376	1,795
7	Nov 28-Dec 1	525	3,309
8	Dec 5-Dec 8	735	4,609
9	Dec 12-Dec 15	510	4,645
10	Dec 19-Dec 22	297	3,587
Total		2,835	19,145

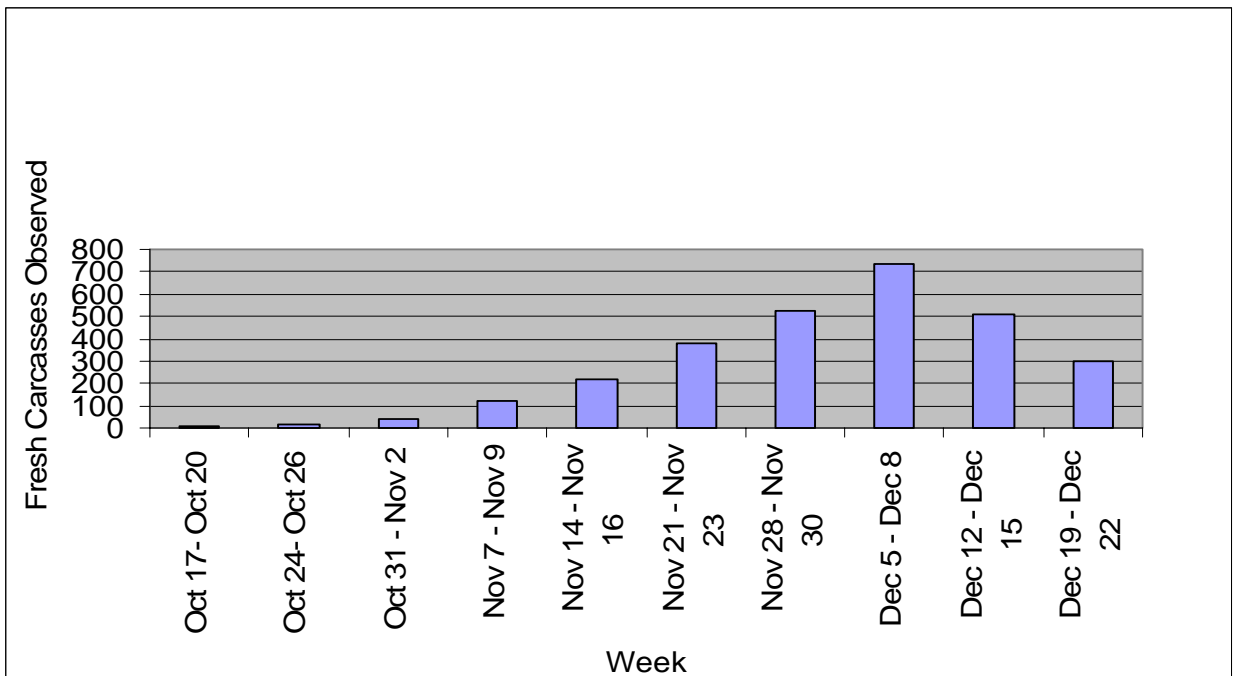
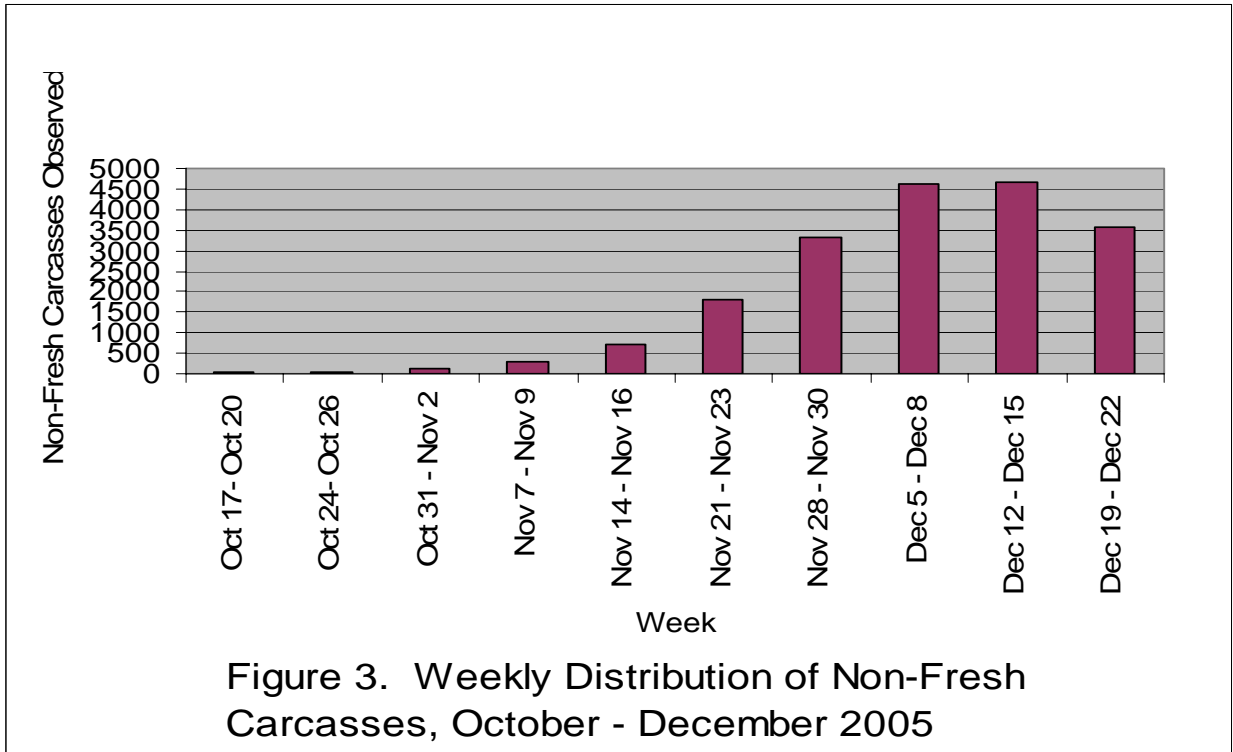


Figure 2. Weekly Distribution of Fresh Carcasses, October - December 2005



Age Composition

Grilse comprised 5% (137) of the total catch of fresh carcasses measured (Table 3) and weekly percent composition ranged from 0% to 17%. The greatest number of grilse (37) was observed during the week of December 5, 2005. Adults comprised 95% (2,698) of the fresh carcasses. The greatest number of adults (698) was observed during the week of December 5, 2005.

Date	Grilse		Adult	
	Number	Percent	Number	Percent
Oct 17-Oct 20	1	17	5	83
Oct 24-Oct 26	0	0	14	100
Oct 31-Nov 2	4	11	33	89
Nov 7-Nov 9	9	8	110	92
Nov 14-Nov 16	13	6	203	94
Nov 21-Nov 23	18	5	358	95
Nov 28-Dec 1	24	5	501	95
Dec 5-Dec 8	37	5	698	95
Dec 12-Dec 15	26	5	484	95
Dec 19-Dec 22	5	2	292	98
Total (Percent)	137	(5)	2,698	(95)

Sex Composition

Female Chinook salmon comprised 62% (1,699) of the 2,721 fresh carcasses (adult and grilse) examined for sex composition, while male Chinook salmon comprised 38% (1,022) (Table 4). Most female (84%) and male (71%) fresh carcasses were collected in Reach 1.

Reach	Male	Female	Total
1	722	1,425	2,147
2	246	227	473
3	54	47	101
Total	1,022	1,699	2,721

Nine percent of the 1,022 fresh male carcasses and 2.5% of the 1,699 fresh female carcasses were grilse (Table 5). The overall ratio of adult male to adult female was 1 to 1.8. Adult females were most abundant every week except during the week of October 17, 2005 of the carcass survey. The overall ratio of male grilse to female grilse was 2.2 to 1.

Date	Grilse				Adult			
	Male		Female		Male		Female	
	Number	%	Number	%	Number	%	Number	%
Oct 17-Oct 20	1	100	0	0	3	60	2	40
Oct 24-Oct 26	0	0	0	0	4	29	10	71
Oct 31-Nov 2	4	100	0	0	12	36	21	64
Nov 7-Nov 9	8	89	1	11	37	35	70	65
Nov 14-Nov 16	13	100	0	0	88	44	111	56
Nov 21-Nov 23	11	61	7	39	128	36	223	64
Nov 28-Dec 1	17	77	5	23	171	36	301	64
Dec 5-Dec 8	21	57	16	43	241	35	439	65
Dec 12-Dec 15	14	56	11	44	148	34	286	66
Dec 19-Dec 22	3	60	2	40	98	34	194	66
Total (Percent of age class)	92	(69)	42	(31)	930	(36)	1,657	(64)

Egg Retention

Of the 1,699 fresh adult and grilse female carcasses that were observed for egg retention, 68% were completely spawned, 18% were unspawned, and 14% were partially spawned (Table 6). Female salmon carcasses with high egg retention were observed each week during the survey. High egg retention in females was greatest during the first three weeks of the survey (October 17 – November 2, 2005, but fell well below 50% as the season progressed.

Table 6. Egg retention summary for female Chinook salmon carcasses, October 17-December 22, 2005.

Date	# females checked for egg retention	0 to 30% eggs retained	>30 to 70% eggs retained	>70% eggs retained
		Number (%)	Number (%)	Number (%)
Oct 17-Oct 20	2	0	0	2 (100)
Oct 24-Oct 26	10	2 (20)	1 (10)	7 (70)
Oct 31-Nov 2	21	2 (10)	1 (5)	18 (86)
Nov 7-Nov 9	71	23 (32)	14 (20)	34 (48)
Nov 14-Nov 16	111	55 (50)	16 (14)	40 (36)
Nov 21-Nov 23	230	132 (57)	48 (21)	50 (22)
Nov 28-Dec 1	306	215 (70)	47 (15)	44 (14)
Dec 5-Dec 8	455	316 (69)	76 (17)	63 (14)
Dec 12-Dec 15	297	250 (84)	19 (6)	28 (9)
Dec 19-Dec 22	196	160 (82)	9 (5)	27 (14)
Total (Percent of Total)	1,699	1,155 (68)	231 (14)	313 (18)

Coded-wire tagged fish

Of the 2,835 fresh carcasses that were observed during the survey, 39 (1.4%) were observed with missing adipose fins and classified as CWT fish. Weekly percentage of CWT fish ranged from 0 to 5% (Table 7). The highest weekly percentage of CWT fish was observed during the week of November 7, 2005.

Adult CWT Chinook salmon comprised 100% of the CWT carcasses observed. The greatest number of adult CWT Chinook salmon (10) was observed during the week of December 5, 2005, with the majority comprised of females (82%) (Table 8).

Date	Number of fresh carcasses observed	Number of CWT fish observed (Percent)
Oct 17-Oct 20	6	0 (0)
Oct 24-Oct 26	14	0 (0)
Oct 31-Nov 2	37	0 (0)
Nov 7-Nov 9	119	6 (5.0)
Nov 14-Nov 16	216	7 (3.2)
Nov 21-Nov 23	376	7 (1.9)
Nov 28-Dec 1	525	5 (1.0)
Dec 5-Dec 8	735	10 (1.4)
Dec 12-Dec 15	510	3 (0.6)
Dec 19-Dec 22	297	1 (0.3)
Total (Percent of total)	2,835	39 (1.4)

Date	Male		Female	
	Number	%	Number	%
Oct 17-Oct 20	0	-	0	-
Oct 24-Oct 26	0	-	0	-
Oct 31-Nov 2	0	-	0	-
Nov 7-Nov 9	0	0	6	100
Nov 14-Nov 16	3	43	4	57
Nov 21-Nov 23	1	14	6	86
Nov 28-Dec 1	0	0	5	100
Dec 5-Dec 8	3	30	7	70
Dec 12-Dec 15	0	0	3	100
Dec 19-Dec 22	0	0	1	100
Total (Percent)	7	(18)	32	(82)

Population Estimate

A total of 1,755 fresh adult carcasses was tagged from October 17 (Week 1) through December 8, 2005 (Week 8) of which 693 tags were subsequently recovered (Table 9). Overall tag recovery rate was 39.5% and weekly recovery rates ranged from 25 to 60%. The modified Schaefer model produced an adult in-river escapement estimate of 54,001 (Table 10). Since adults made up 95% of the escapement, a total escapement (adult and grilse) of 56,843 was calculated by dividing the adult estimate by 0.95. Grilse comprised 5% (2,842) of the population.

Table 9. Weekly summary of tagging and recapture of fresh adult Chinook carcasses, October - December, 2005.											Carcasses Recovered	Carcasses Counted
Week of Recovery (j)	Week of Tagging											
	1	2	3	4	5	6	7	8	10			
-	-	-	-	-	-	-	-	-	-	-	-	-
2	3										3	89
3		2									2	155
4		1	5								6	379
5			3	31							34	911
6			1	8	64						73	2,136
7				1	7	128					136	3,773
8						17	160				177	5,303
9				1		6	19	236			262	9,083
-	-	-	-	-	-	-	-	-	-	-		-
Recovery R(i)	3	3	9	41	71	151	179	236			Total Tags Recovered: 693	Total Counted: 21,829
Tagged M(i)	5	12	29	99	191	327	481	611			Total Fish Tagged: 1,755	
M(i)/R(i)	1.7	4.0	3.2	2.4	2.7	2.2	2.7	2.6			Recovery: 39.5%	

Table 10. Lower American River adult Chinook salmon population estimate using the Schaefer model based on tagging fresh adult carcasses with all captured untagged carcasses removed, October - December, 2005.									
Week of Recovery (j)	Week of Tagging								Totals
	1	2	3	4	5	6	7	8	
2	148								
3		620							
4		253	1,018						
5			259	2,006					
6			94	565	5,038				
7				67	522	7,690			
8						1,103	12,881		
9						450	1,770	21,182	
Subtotals	148	873	1,371	2,722	5,560	9,243	14,651	21,182	
Tags		-12	-29	-99	-191	-327	-481	-611	-1,750
Estimated Population of natural spawning adults									54,001

In addition to the 56,843 salmon that returned to the lower American River downstream of Nimbus weir, there were 22,349 salmon (20,569 adult and 1,780 grilse) that entered Nimbus Hatchery. There were an additional 4,179 adult and 1,657 grilse carcasses removed from the upstream side of the Nimbus fish weir. By combining the in-river escapement (56,843) with the total number of Chinook salmon collected at the Nimbus Fish Hatchery (22,349) and at the Nimbus fish weir (5,836), the 2005 fall-run Chinook salmon escapement for the lower American River was estimated to be 85,028 (78,749 adult; 6,279 grilse).

Conclusion and Discussion

Since 2003, there has been a declining trend in the number of returning fall-run Chinook salmon in the lower American River. Although, the in-river escapement of Chinook salmon in the lower American River derived from the modified Schaefer method (56,843) has declined since 2003, the adult escapement estimate is still above the previous 38 year (1967-2004) average of 45,771 fish (Table 12).

The percentage of grilse Chinook salmon collected in the 2005 escapement survey made up 5% of the population. The number of grilse returning to the Nimbus Fish Hatchery was slightly higher (8%).

The percent of all fresh female Chinook salmon with high egg retention (18%) during the 2005 escapement survey is lower than the previous four years. Since 2001, the peak of spawning typically occurred during the end of October or the first week of November. This is based on spawning activity taking place two weeks prior to the collection of a fresh carcass (Snider and Vyverberg, 1995). During the 2005 escapement survey, very few fresh carcasses were observed until early December indicating that the peak of spawning occurred around the third week of November (November 21-23). This comparatively late spawning run, coupled with lower numbers of fish in the early part of the run, and with cool water temperatures (<15.5 °C) may explain the higher spawning success in female Chinook salmon in the lower American River during the 2005 escapement survey.

Higher than normal egg retention found among female Chinook salmon carcasses continues to be a concern in the American River as this may have an impact on the cohort for future escapement returns. Typically in the lower American River, egg retention for female Chinook salmon carcasses has been highest during the beginning of the run. However, with the exception of 2001, the percent of the overall population that had high egg retention is low because of the lesser number of fish that entered the river in this early period. Furthermore, water temperatures above 16 °C have been common in the lower American River during the beginning of the escapement runs (Healey, 2004) which can delay migration and can contribute to female Chinook salmon to retain their eggs until suitable spawning temperatures are reached (Cuenco and McCullough, 1996). Also, temperatures above 15.5 °C support several diseases, parasites, and fungus already common in the environment (McCullough, 1999) and can contribute to the mortality rate of Chinook salmon retaining eggs. The incidence of disease and mortality rate in Chinook salmon retaining eggs is enhanced by other stress factors such as low flow, extended periods of unfavorable water temperature, crowding, injury, and other diseases present (EPA and NMFS, 1971). Therefore, if unfavorable water temperatures are prolonged, pre-spawning Chinook salmon can potentially become more susceptible to diseases and mortality which may be detrimental to future escapement returns on the American River.

Table 12. In-river American River Chinook salmon escapement estimates, 1967-2005.

Year	Grilse	Adult	Total
1967 ^a	3,132	14,868	18,000
1968 ^a	2,777	23,423	26,200
1969 ^a	8,208	35,452	43,660
1970 ^a	2,753	25,927	28,680
1971 ^a	5,210	36,470	41,680
1972 ^a	3,352	14,107	17,459
1973 ^a	4,688	77,554	82,242
1974 ^b	1,769	51,827	53,596
1975 ^a	2,699	29,433	32,132
1976 ^b	1,181	21,978	23,159
1977 ^b	4,701	36,904	41,605
1978 ^b	595	12,334	12,929
1979 ^b	896	36,419	37,315
1980 ^b	8,805	25,454	34,259
1981 ^b	2,521	40,941	43,462
1982 ^a	4,323	28,677	33,000
1983 ^a	7,313	19,087	26,400
1984 ^c	2,196	25,251	27,447
1985 ^b	11,392	44,728	56,120
1986 ^b	4,443	44,929	49,372
1987 ^b	2,960	18,185	24,145
1988 ^d	1,905	13,974	15,879
1989 ^b	2,459	14,619	17,078
1990 ^b	1,167	5,541	6,708
1991 ^b	1,506	16,639	18,145
1992 ^b	1,297	3,175	4,472
1993 ^b	6,162	20,624	26,786
1994 ^b	2,927	28,405	31,332
1995 ^b	7,010	63,086	70,096
1996 ^b	6,592	59,323	65,915
1997 ^b	4,220	42,668	46,888
1998 ^b	10,760	32,282	43,042
1999 ^b	7,716	40,509	48,225
2000 ^b	5,922	92,783	98,705
2001 ^b	10,463	120,322	130,785
2002 ^b	11,811	106,303	118,114
2003 ^b	11,571	146,945	158,516
2004 ^b	13,756	74,991	88,747
Average	5,083	40,688	45,771
^a Expanded direct counts; ^b Schaefer method; ^c Petersen method; ^d Jolly-Seber method			

Literature Cited

Cuenco, M.L. and D.A. McCullough. 1996. Framework for estimating salmon survival as a function of habitat condition. Columbia River Inter-Tribal Fish Commission. Technical Report 96-4. 119 pp.

Environmental Protection Agency and National Marine Fisheries Service (EPA and NMFS). 1971. Columbia River Thermal Effects Study. Volume 1. Biological Effects Study. U.S. Environmental Protection Agency and National Marine Fisheries Service.

Healey, M.P. 2004. Lower American River Chinook salmon escapement survey, October 2003-January. Department of Fish and Game, Rancho Cordova, CA. File Memorandum, April 7, 2004.

Healey, T.P. 1979. The Effects of High Temperature on the Survival of Sacramento River Chinook Salmon, *Oncorhynchus tshawytscha*, Eggs and Fry. Department of Fish and Game, Anadromous Fisheries Branch. Administrative Report No. 79-10.

McCullough, D.A. 1999. A review and synthesis of effects of alterations to the water temperature Regime on freshwater life stages of salmonids, with special reference to Chinook salmon. U.S. EPA report number EPA 910-R-99-010. 291 pp.

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

Snider, W.M. and K. Vyverberg. 1995. Chinook salmon redd survey, Lower American River, Fall 1993. Department of Fish and Game, Environmental Services Division, Stream Flow and Habitat Evaluation Program. 34 pp.

Taylor, S.N. (Editor). 1974. King (Chinook) salmon spawning stocks in California's Central Valley, 1973. California Department of Fish and Game, Anadromous Fisheries Administrative Report. No. 74-12. 32 pp.