

DEPARTMENT OF FISH AND GAME  
Sacramento Valley-Central Sierra Region

**Lower American River Chinook Salmon Escapement Survey  
October 2002– January 2003**

By

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## Introduction

Adult fall-run Chinook salmon ascend up the American River for approximately 23 miles from the confluence of the Sacramento River near Discovery Park to the terminus of anadromous migration at Nimbus Dam. Spawning occurs within the eighteen miles of river from about Paradise Beach to Nimbus Dam. However, most spawning occurs in the uppermost three miles of the river near Sunrise Avenue Bridge upstream to the Nimbus 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 2002 lower American River spawner escapement survey were (1) estimate the number of spawners; (2) determine the sex and age composition of the fall run; (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 15, 2002 through January 2, 2003. Each weekly survey consisted of a crew of six to seven people and took four days to complete.

Reach	Location	Miles
1	Sailor Bar 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. 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. Scale samples were taken from the CWT carcasses and the heads removed for analysis of any CWT's. The remaining portion of the CWT carcasses were tagged with a color-coded hog ring in front of the dorsal fin and returned to flowing water for dispersal.

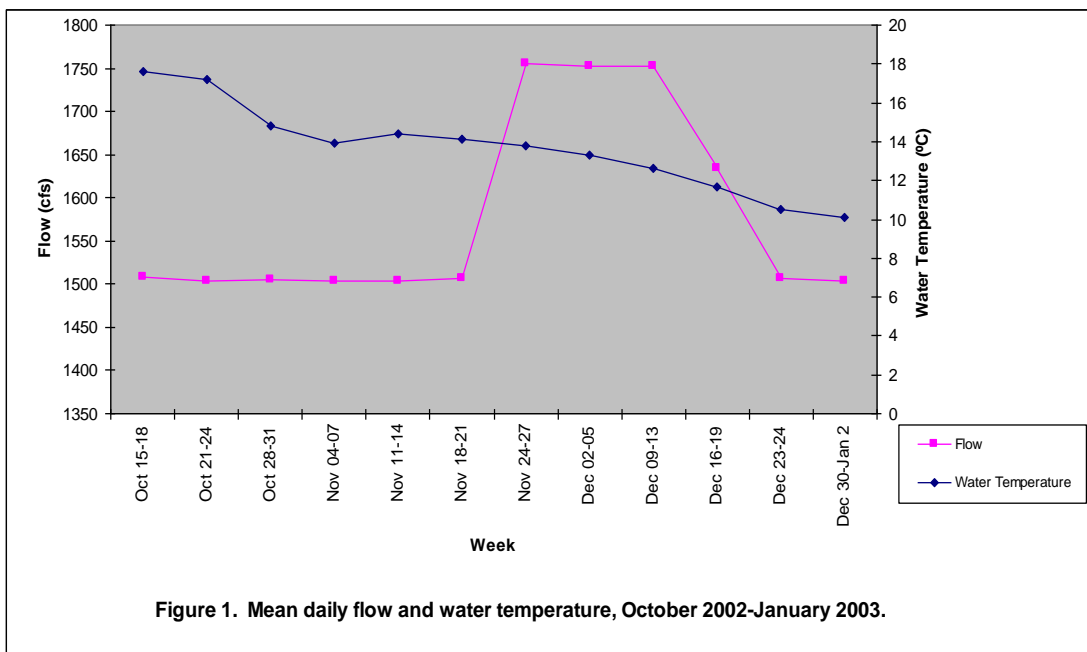
Fresh carcasses (including all CWT carcasses) were sexed and a subset was measured to the nearest centimeter (cm) Fork Length (FL). Fish > 68 cm FL were considered adults, and those  $\leq$  68 cm FL were classified as a grilse, or young adult. All fresh female carcasses were identified as either completely spawned (0 to 30% eggs remaining), partially spawned (>30 to 70% eggs remaining), or unspawned (nearly full ovaries) to determine the degree of egg retention.

All observed decomposing carcasses were counted but not tagged. Decomposing and recovered (previously tagged) carcasses were chopped in half to prevent recounting. The Schaefer mark-recovery method (Schaefer, 1951) as modified by Taylor (1974) was used to produce an escapement estimate. The grilse population was determined by the ratio of grilse to adults from the fresh carcasses measured. The total Chinook salmon escapement is calculated by summing the in-river population estimate with the total number collected at Nimbus Fish Hatchery.

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 cm.

## Results

Mean daily flow and water temperature in the American River ranged from 1,503 cfs to 1,756 cfs and 17.6 °C (63.7 °F) to 10.1 °C (50.1 °F), respectively (Figure 1). Water clarity ranged from 1 to 4.1 meters during the survey (Table 2). Water clarity was lowest during Week 10 and 11 (December 16-24).

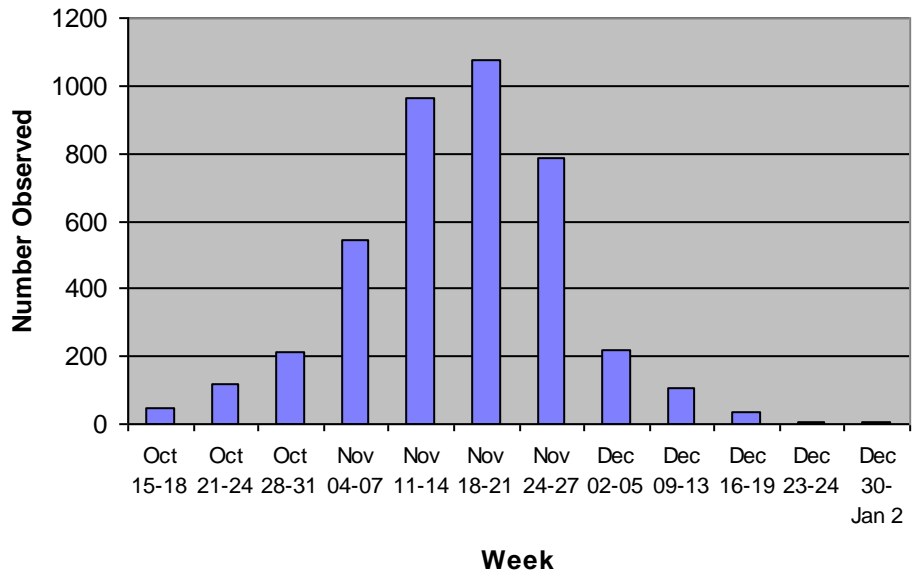


## Temporal Distribution

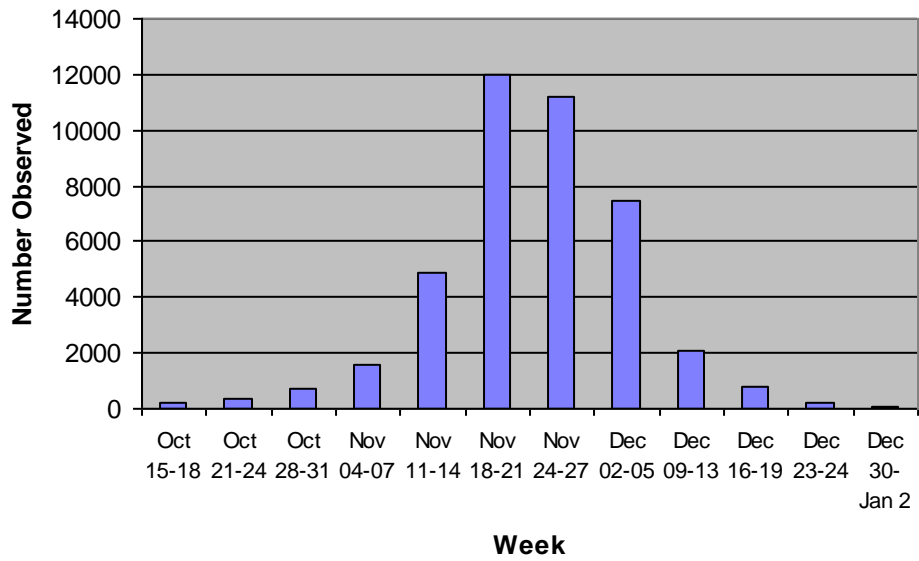
A total 45,620 salmon were observed during the 2002 American River spawner escapement survey, including 4,125 fresh and 41,495 non-fresh carcasses (Table 2). Fresh carcasses were observed during Week 1 and were present throughout the survey period (Figure 2). The number of fresh carcasses observed increased through Week 6 and then decreased. The number of non-fresh carcasses observed exhibited a similar trend (Figure 3). Given an estimated 2 week delay for spawning and mortality (Snider and Vyverberg, 1995), these results indicate that the bulk of spawning occurred during Weeks 3 through 5 (October 28 through November 15, 2002).

Week	Dates	Flow (cfs) <sup>1/</sup>	Secchi (meters) <sup>1/</sup>	Water Temp. <sup>1/</sup>		Carcasses Observed	
				°C	°F	Fresh	Non-fresh
1	Oct 15-Oct 18	1,508	4.0	17.6	63.7	50	186
2	Oct 21- Oct 24	1,504	4.1	17.2	62.9	120	332
3	Oct 28- Oct 31	1,505	3.3	14.8	58.6	214	689
4	Nov 4-Nov 7	1,503	2.9	13.9	57.0	543	1,612
5	Nov 11-Nov 14	1,504	2.0	14.4	57.9	965	4,858
6	Nov 18-Nov 21	1,506	2.6	14.1	57.3	1,074	12,020
7	Nov 24-Nov 27	1,756	3.5	13.8	56.8	789	11,169
8	Dec 2-Dec 5	1,753	4.0	13.3	55.9	218	7,493
9	Dec 9-Dec 13	1,753	2.8	12.6	54.6	106	2,070
10	Dec 16-Dec 19	1,634	1.3	11.7	53.0	35	759
11	Dec 23-Dec 24	1,506	1.0	10.5	50.9	8	201
12	Dec 30-Jan 2	1,503	2.1	10.1	50.1	3	106
Total						4,125	41,495

<sup>1/</sup> Mean daily measurement.



**Figure 2. Weekly distribution of fresh carcasses, October 2002-January 2003.**



**Figure 3. Weekly distribution of non-fresh carcasses, October 2002-January 2003.**

## Age Composition

Grilse comprised 10% (219) of the total catch of fresh measured carcasses (Table 3) and weekly percent composition ranged from 4% to 43%. The greatest number of grilse was observed during Week 5 (105). Adults comprised 90% (2,635) of the measured carcasses. The greatest number of adults (799) was observed during Week 5.

Week	Grilse		Adult	
	Number	Percent	Number	Percent
1	4	8	44	92
2	6	5	107	95
3	9	4	202	96
4	46	9	495	91
5	105	12	799	88
6	32	7	415	93
7	46	13	322	87
8	24	14	143	86
9	11	12	78	88
10	5	17	25	83
11	3	43	4	57
12	0		1	100
Total (Mean)	291	(10)	2,635	(90)

## Sex Composition

Female Chinook salmon comprised 55% (1,601) of the 2,926 fresh carcasses examined, while male Chinook salmon comprised 45% (1,325) (Table 4). Most female (78%) and male (68%) fresh carcasses were collected in Reach 1.

Reach	Male	Female	Total
1	909	1,250	2,153
2	315	294	609
3	107	57	164
Total	1,325	1,601	2,926

Fourteen percent of the 1,325 fresh male carcasses and 6% of the 1,601 fresh female carcasses aged were grilse (Table 5). The overall ratio of adult male to adult female spawners was 1 to 1.3. Adult females were most abundant every week except for Week 12. The overall ratio of male grilse to female grilse was 1.8 to 1. Female grilse were most abundant only during week's 9 and 11.

Week	Grilse				Adult			
	Male		Female		Male		Female	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1	3	75	1	25	21	48	23	52
2	4	67	2	33	50	47	57	53
3	6	67	3	33	84	42	118	58
4	26	57	20	43	213	43	282	57
5	73	70	32	30	384	48	415	52
6	20	63	12	37	167	40	248	60
7	34	74	12	26	127	39	195	61
8	14	58	10	42	48	34	95	66
9	5	45	6	55	32	41	46	59
10	3	60	2	40	7	28	18	72
11	1	33	2	67	2	50	2	50
12	0	0	0	0	1	100	0	0
Total (Mean)	189	(65)	102	(35)	1,136	(43)	1,499	(57)

## Spawning Success

Of the 1,561 fresh adult and grilse female carcasses that were observed for egg retention, 55% had completely spawned, 16% were partially spawned, and 29% were unspawned (Table 6). Unspawned and partially spawned female salmon were observed nearly each week through Week 10. A high percentage (99.5%) of unspawned females was counted through week 3, but decreased as the season progressed. The percentage of females classified as unspawned or partially spawned was higher than spawned females through Week 4. However, an increase in the number of unspawned females was observed during Week 7 and Week 8. From Week 5 through Week 11, completely spawned females ranged from 63 to 100 percent of the female carcasses examined during a given week.

Table 6. Spawning completion (egg retention) summary for female Chinook salmon carcasses, October 2002-January 2003.

Week	# females checked for egg retention	Spawned	Unspawned	Partially Spawned
		Number (%)	Number (%)	Number (%)
1	24	0 (0)	24 (100)	0 (0)
2	59	0 (0)	56 (95)	3 (5)
3	121	1 (1)	99 (82)	21 (17)
4	302	97 (32)	116 (38)	89 (30)
5	441	299 (68)	71 (16)	71 (16)
6	229	177 (77)	22 (10)	30 (13)
7	204	147 (72)	36 (18)	21 (10)
8	105	66 (63)	30 (29)	9 (8)
9	52	42 (81)	7 (13)	3 (6)
10	20	19 (95)	1 (5)	0 (0)
11	4	4 (100)	0 (0)	0 (0)
12	0	0	0	0
Total		852 (55)	462 (30)	247 (15)



## Coded-wire tagged fish

Of the 4,125 fresh carcasses that were observed during the survey, 73 were observed with missing adipose fins and classified as CWT fish. Weekly percentage of CWT fish ranged from 0 to 12% and averaged 1.8% (Table 7). The highest percentage of CWT fish was observed during Weeks 1 and 2.

Week	Number of fresh carcasses observed	Number of CWT fish observed (Percent)
1	50	5 (10)
2	120	14 (12)
3	214	5 (2)
4	543	7 (1)
5	965	5 (0.5)
6	1,074	7 (0.6)
7	789	19 (2)
8	218	6 (3)
9	106	3 (3)
10	35	2 (6)
11	8	0
12	3	0
Total	4,125	73 (1.8)

Grilse comprised 27% of the total number of CWT Chinook salmon and weekly percent composition ranged from 0 to 67% (Table 8). The greatest number of grilse (5) was observed during Week 7. Adult CWT Chinook salmon comprised 73 % (53) of the measured carcasses. The greatest number of adult CWT Chinook salmon was observed during Week 7.

Table 8. Age composition (grilse and adult) of CWT carcasses measured, October 2002-January 2003.					
Week	Number of fresh carcasses observed	Grilse		Adult	
		Number	Percent	Number	Percent
1	50	1	20	4	80
2	120	4	29	10	71
3	214	0	0	5	100
4	543	1	14	6	86
5	965	1	20	4	80
6	1,074	3	43	4	57
7	789	5	26	14	74
8	218	2	33	4	67
9	106	1	67	1	33
10	35	1	50	1	50
11	8	0	0	0	0
12	3	0	0	0	0
Total (Mean)	4,125	20	(27)	53	(73)

There were more adult CWT female Chinook salmon (68%) observed than adult male CWT Chinook salmon (Table 9). In contrast, there were more male CWT grilse (70%) than female CWT grilse.

Week	Grilse				Adult			
	Male		Female		Male		Female	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1	1	100	0	0	2	50	2	50
2	2	50	2	50	5	50	5	50
3	0	0	0	0	3	60	2	40
4	0	0	1	100	2	33	4	67
5	1	100	0	0	2	50	2	50
6	2	67	1	33	1	25	3	75
7	4	80	1	20	1	7	13	93
8	1	50	1	50	1	25	3	75
9	2	100	0	0	0	0	1	100
10	1	100	0	0	0	0	1	100
11	0		0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
Total (Mean)	14	(70)	6	(30)	17	(32)	36	(68)

## Population Estimate

A total of 3,333 fresh adult carcasses were tagged from Week 1 through Week 11 of which 1,308 tags were subsequently recovered (Table 10). Overall tag recovery rate was 39% and ranged from 20 to 47 percent. The modified Schaefer model produced an adult spawner in-river escapement estimate of 106,303 (Table 11). Since adults made up 90% of the escapement, a total escapement (adult and grilse) of 118,114 was calculated by dividing the adult estimate by 0.90.

The population estimates for salmon spawning in the American River below the Nimbus weir are as follows:

Total estimate: 118,114  
 Adult estimate: 106,303  
 Grilse estimate: 11,811

Table 10. Weekly summary of tagging and recapture of fresh adult Chinook salmon carcasses, October 2002-January 2003.

Week of recovery (i)	Week of tagging											Tags recovered R <sub>(j)</sub>	Carcasses counted C <sub>(j)</sub>	Ratio C <sub>(j)</sub> /R <sub>(j)</sub>
	1	2	3	4	5	6	7	8	9	10	11			
2	11											11	614	55.8
3	1	16										17	861	50.6
4		6	81									87	2,041	23.5
5		3	7	124								134	5,368	40.1
6				25	297							322	14,115	37.6
7				2	30	374						406	11,298	27.8
8				1	1	51	165					218	7,042	32.3
9					3	3	13	53				72	1999	27.7
10						1	1	5	24			31	684	22.1
11									1	7		8	188	23.5
12										1	1	2	99	49.5
R <sub>(i)</sub>	12	25	88	152	331	429	179	58	25	8	1	(Tagged fish recovered) = 1,308		
T <sub>(i)</sub>	42	108	195	490	800	913	491	172	87	30	5	(Total fish tagged) = 3,333		
T <sub>(i)</sub> /R <sub>(i)</sub>	3.5	4.3	2.2	3.2	2.4	2.1	2.7	2.9	3.5	3.8	5	(Ratio)		

Table 11. Lower American River adult Chinook salmon population estimate using the Schaefer model based on tagging fresh carcasses with all captured untagged carcasses removed, October 2002-January 2003.

Population Estimate (i)												
Week of recovery (j)	Week of tagging											
	1	2	3	4	5	6	7	8	9	10	11	Totals
2	2,149											
3	177	3,501										
4		608	4,211									
5		519	621	16,013								
6				3,032	27,008							
7				179	2,018	22,149						
8				104	78	3,506	14,620					
9					201	177	990	4,364				
10						47	61	327	1,843			
11									82	617		
12										186	248	
Subtotals	2,326	4,628	4,832	19,328	29,305	25,879	15,671	4,691	1,925	803	248	109,636
Tagged	42	108	195	490	800	913	491	172	87	30	5	3,333
Estimated population of natural spawning adults												106,303

In addition to the 118,114 salmon that spawned in the lower American River downstream of Nimbus weir, there were 9,817 salmon that entered Nimbus Hatchery. The total number of adult and grilse Chinook salmon collected at the Nimbus Fish Hatchery was 6,231 and 3,586, respectively.

There were an additional 6,091 adult and grilse carcasses removed from the Nimbus weir. By combining the in-river escapement (118,114) with the total number of Chinook salmon collected at the Nimbus Fish Hatchery (9,817) and at the weir (6,091), the 2002 fall-run Chinook salmon escapement for the lower American River was estimated to be 134,022.

### Conclusion and Discussion

A Chinook salmon spawner escapement survey was conducted on the lower American River in 2002. Three reaches in the lower American River took four days to complete. Equal effort was applied to each reach by maintaining a consistent crew of six people throughout the survey period.

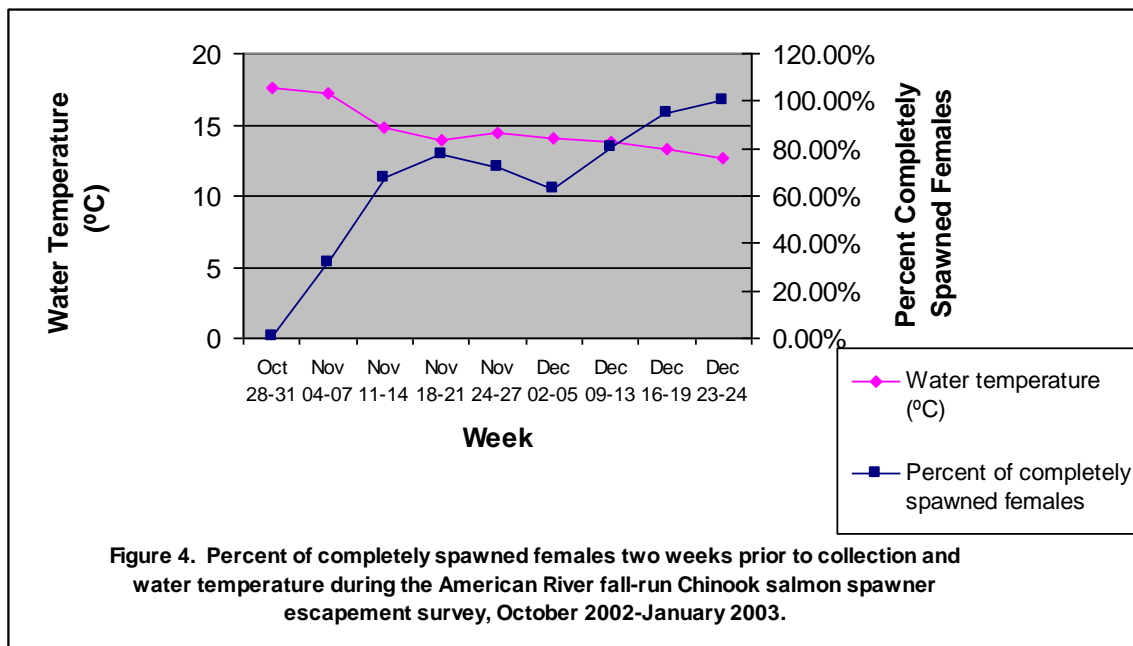
The escapement of adult Chinook salmon in the lower American River derived from the modified Schaefer method was estimated to be 106,303. The adult escapement estimate was nearly three times higher than the previous 34 year (1967-2001) average of 39,255 fish (Table 12). However, the above normal estimate has been similar since 2000.

Year	Grilse	Adult	Total
1967 <sup>a</sup>	3,132	14,868	18,000
1968 <sup>a</sup>	2,777	23,423,	26,200
1969 <sup>a</sup>	8,208	35,452	43,660
1970 <sup>a</sup>	2,753	25,927	28,680
1971 <sup>a</sup>	5,210	36,470	41,680
1972 <sup>a</sup>	3,352	14,107	17,459
1973 <sup>a</sup>	4,688	77,554	82,242
1974 <sup>b</sup>	1,769	51,827	53,596
1975 <sup>a</sup>	2,699	29,433	32,132
1976 <sup>b</sup>	1,181	21,978	23,159
1977 <sup>b</sup>	4,701	36,904	41,605
1978 <sup>b</sup>	595	12,334	12,929
1979 <sup>b</sup>	896	36,419	37,315
1980 <sup>b</sup>	8,805	25,454	34,259
1981 <sup>b</sup>	2,521	40,941	43,462
1982 <sup>a</sup>	4,323	28,677	33,000
1983 <sup>a</sup>	7,313	19,087	26,400
1984 <sup>c</sup>	2,196	25,251	27,447
1985 <sup>b</sup>	11,392	44,728	56,120
1986 <sup>b</sup>	4,443	44,929	49,372
1987 <sup>b</sup>	2,960	18,185	24,145
1988 <sup>d</sup>	1,905	13,974	15,879
1989 <sup>b</sup>	2,459	14,619	17,078
1990 <sup>b</sup>	1,167	5,541	6,708
1991 <sup>b</sup>	1,506	16,639	18,145
1992 <sup>b</sup>	1,297	3,175	4,472
1993 <sup>b</sup>	6,162	20,624	26,786
1994 <sup>b</sup>	2,927	28,405	31,332
1995 <sup>b</sup>	7,010	63,086	70,096
1996 <sup>b</sup>	6,592	59,323	65,915
1997 <sup>b</sup>	4,220	42,668	46,888
1998 <sup>b</sup>	10,760	32,282	43,042
1999 <sup>b</sup>	7,716	40,509	48,225
2000 <sup>b</sup>	5,922	92,783	98,705
2001 <sup>b</sup>	10,463	120,322	130,785
Average	4,458	34,797	39,255

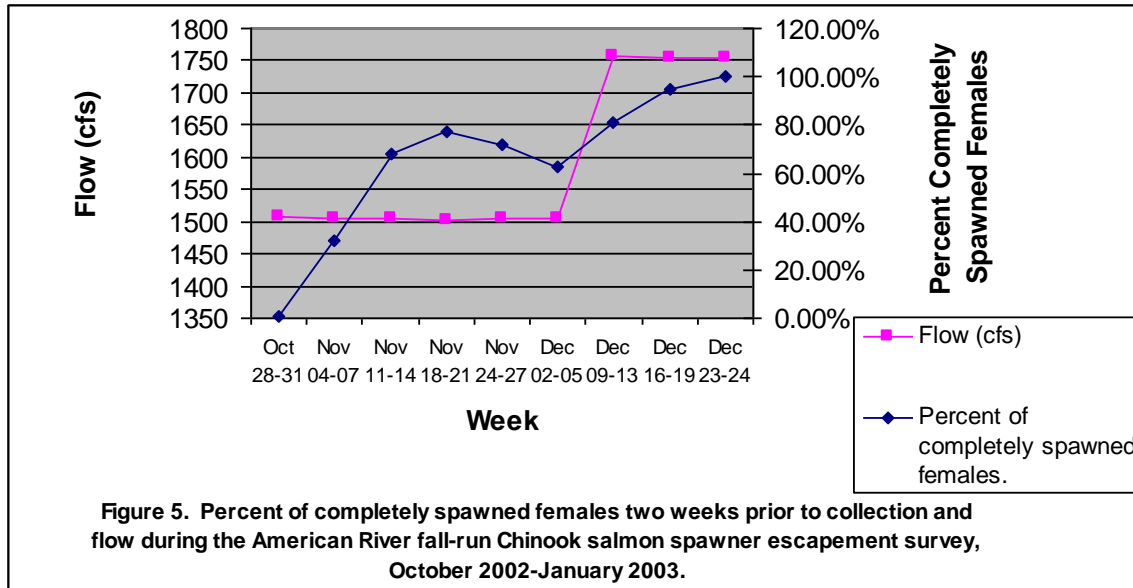
<sup>a</sup> Expanded direct counts; <sup>b</sup> Schaefer method; <sup>c</sup> Petersen method; <sup>d</sup> Jolly-Seber method

Snider and Vyverberg (1996) noticed that initiation of American River Chinook salmon spawning coincided with a decrease in water temperature from 17.8 °C to 15.6 °C (64 °F to 60 °F). Water temperatures in the lower American River were above 17.2 °C (62.9 °F) during the first 2 weeks of the survey (October 15-24). Beginning on October 25, 2002, the US Bureau of Reclamation began blending 500 cfs through the lower-tier river outlet tubes of Folsom Dam with releases (1,000 cfs) made through the power penstocks. The blending of 500 cfs through the lower-tier river outlet tubes utilized the cold water pool in Folsom Reservoir and resulted in an immediate decrease in water temperature over night (17.1 °C to 15.5 °C, or 62.9°F to 59.9 °F). During Week 3 (October 28, 2002), water temperatures in the lower American River were below 14.8 °C (58.6 °F) and declined through the end of the survey.

Since the majority of spawned female carcasses was observed during Week 6, and given a two week period from spawning to observation of carcasses, the peak of spawning likely occurred during Week 4. Therefore, the increase in number of spawned females likely occurred during Week 3 and Week 4 when water temperatures began to decrease in the lower American River (Figure 4).







Since water temperatures were optimal for salmon egg survival ( $\leq 14.4$  °C) (Wang, 1986) from Week 5 through the end of the survey, and spawning activity had already been initiated, the sudden decrease in spawning success from Week 5 through Week 6 may have been related to the high density of the spawner population and the amount of available spawning habitat at flows near 1,500 cfs (Figure 5). As flow increased in the lower American River from 1,500 up to 1,750 during Week 7, the number of spawned females increased as well. Snider and Vyverberg (1996) indicated that most spawning in the lower American River occurred in bar-complex runs at flows of 1,500 cfs, and that a change in flow from 1,500 to 1,750 increased the amount of spawning use in bar-complex riffles and flatwater glides by 3 and 5%, respectively. Schroder (1973) and Semenchenko (1989) found that as density of chum and sockeye salmon increased, competition for spawning habitat also increased. Semenchenko (1989) found that the physiological condition of most females competing for spawning habitat deteriorates due to stress which decreases their life span and increases the rate of egg retention. As female densities increased in the American River during the 2002 spawner survey, competition for suitable spawning sites likely increased and may have contributed to the decrease in the number of completely spawned females that was observed during Week 5 and Week 6. Therefore, an increase in flow from 1,500 cfs to 1,750 cfs in the lower American River most likely expanded the available spawning habitat, and may have contributed to enhanced spawning success through the end of the survey.

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