Department of Fish and Game
Fisheries Branch
North-Central Region

Lower American River Chinook Salmon Escapement Survey October 2008 – January 2009

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2009

Introduction

The lower American River supports a mixed run of natural and hatchery produced fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and is considered to be the second largest tributary of the Sacramento River (Williams 2001). According to Healey and Redding (2008), the lower American River has historically contributed up to 37% and no less than 9% of the Central Valley fall-run Chinook salmon stock estimates since 1970.

The lower American River consists of 23 river miles extending from the Sacramento confluence to Nimbus Dam. Snider and Vyverberg (1996) have shown through redd surveys that Chinook salmon spawning occurs upstream of Paradise Beach to the Nimbus Weir, totaling approximately 18 river miles. The fish rack, or weir, stops the upstream migration of fish because of the limited spawning area between this spot and Nimbus Dam. The rack also guides fish to the ladder entrance. The weir is located approximately 580 yards below Nimbus Dam.

Most redds have been documented upstream of Ancil Hoffman Park, river mile 16. This spawning preference in spatial distribution is reflective of the abundance of riffle, run, and glide habitat types (Snider and Vyverberg 1996).

The California Department of Fish and Game has conducted Chinook salmon escapement surveys on the lower American River since 1944 (Gerstung 1971). Using carcass Mark-Release-Recapture methodology, the lower American River escapement survey attempts to estimate the number of fall-run Chinook salmon that escape the fishery and return to the lower American River in an attempt to spawn. The information garnered by the lower American River escapement surveys is used to evaluate fishery management practices, impacts on spawning from abiotic variables, and to monitor salmon population trends (Snider and Badner 1996, Williams 2001).

The primary goals of the 2008-2009 lower American River fall-run Chinook salmon escapement survey were to (1) calculate the total fall-run escapement for the lower American River; (2) determine the spatial and temporal distribution of carcasses; (3) evaluate egg retention among females; and (4) determine the percentage of coded-wire tagged (CWT) salmon within the population observed.

Materials and Methods

The lower American River fall-run Chinook 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 21 October, 2008 through 26 January, 2009. The survey was initiated once spawning was first observed (21 October, 2008) and was terminated after Week 15 (26 January, 2009) because of the lack of funding and the nominal recovery rate of fresh carcasses. Each weekly survey was conducted with a crew of four to seven crew members and took three to four days to complete.

Table 1. Lower American River fall-run Chinook salmon escapement survey reaches.

Reach	Location	River Miles
1	Nimbus 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**

All carcasses observed within the lower American River escapement survey were assessed for the presence of a coded-wire tag and status of decomposition. Decomposition was determined by the presence of one clear eye or pink coloration within a carcass' gills. Carcasses that withheld one clear eye or pink coloration within the gills were deemed "fresh," otherwise carcasses were identified as "non-fresh." All fresh carcasses with a clipped adipose fin were identified as carcasses with a coded-wire tag. Heads were immediately removed from the adipose-clipped carcasses and affixed with a jaw tag, containing information such as date, location, sex, and size, for further analysis. In the course of this action, adipose-clipped carcasses were chopped in half and tallied.

All fresh and adipose-clipped carcasses were identified to sex and had their fork lengths (FL) measured to the nearest millimeter (mm). Carcasses with a fork length ≥680mm were considered adult, and those whose fork lengths were <680mm were classified as grilse. All female carcasses processed were also checked to determine the degree of egg retention via palpitation. Each female carcass was identified as either completely spawned (0 to 30% of eggs retained), partially spawned (31 to 70% of eggs retained), or unspawned (71 to 100% of eggs retained).

All fresh adult-sized carcasses were counted weekly and tagged with a color-coded tape attached to a hog ring on the maxilla. A unique color was used each week in order to distinguish tagged carcasses from other survey weeks. Once carcasses were tagged they were returned to flowing water to simulate natural dispersal. Fresh carcasses were tagged from the Nimbus Weir downstream to the Gristmill Fishing Access in Reach 3 to prevent tagged carcasses from floating out of the study area downstream of the Watt Avenue Bridge. Fresh carcasses observed downstream of the Gristmill Fishing Access while not tagged, were processed, tallied, and chopped. All previously tagged carcasses recovered in subsequent weeks were identified as recaptures, recorded by tag color, and chopped.

Observed non-fresh carcasses were not tagged, but counted and chopped. These carcasses were identified as adult or grilse and tallied accordingly on a weekly basis.

Fresh adult tagged carcass data, tag recovery data, and non-fresh chopped adult carcass data were analyzed in the Schaefer mark-release-recapture survey (Schaefer 1951), as modified by Taylor (1974), to produce an adult in-river escapement estimate. The grilse in-river escapement estimate was determined by an expansion of the proportion of adults to grilse within the observed population. The total lower American River fall-run Chinook salmon escapement was calculated by summing the adult in-river escapement estimate, the carcasses observed but not included within the adult escapement estimate (adipose-clipped carcasses and fresh chopped carcasses), the grilse in-river escapement estimate, the total number of Chinook salmon collected at the Nimbus Fish Hatchery, and the number of carcasses that got impinged on the upstream side of the Nimbus Weir (the Nimbus Weir is not effective at blocking all salmon).

Daily water temperatures, flow, and clarity were also collected throughout the sampling period. Mean daily water temperatures were obtained from the U.S. Geological Survey gauging station at Hazel Ave Bridge and flow data were obtained from the U.S. Geological Survey gauging station at Fair Oaks. Water clarity was measured within each reach every survey week with a secchi disk to the nearest centimeter.

Results and Discussion

Environmental Conditions

During the survey period, mean daily water temperatures ranged from 63.5ºF on 21 October, 2008 to 47.9ºF on 10 January, 2009 (Figure 1). Water temperatures declined throughout most of the survey period and reached 60ºF by 10 November, 2008. Flows ranged from 745 cubic feet per second (cfs) to 1,230cfs. Withholding some anomalies in the flow data, the flows were recorded between 900cfs and 1,230cfs throughout most of the survey period (Figure 2). Water clarity ranged from 114cm to 400cm and was taken within each survey section. The average secchi measurement was 252cm.

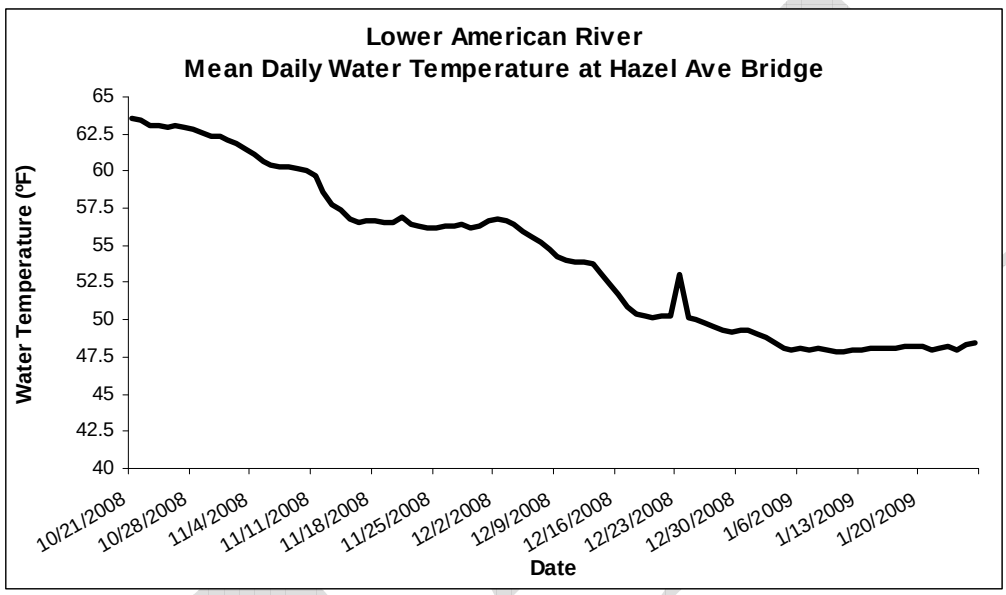

Figure 1. Mean daily water temperatures measured at the Hazel Ave. Bridge gauging station during the lower American River escapement survey, October 21, 2008 – January 26, 2009.

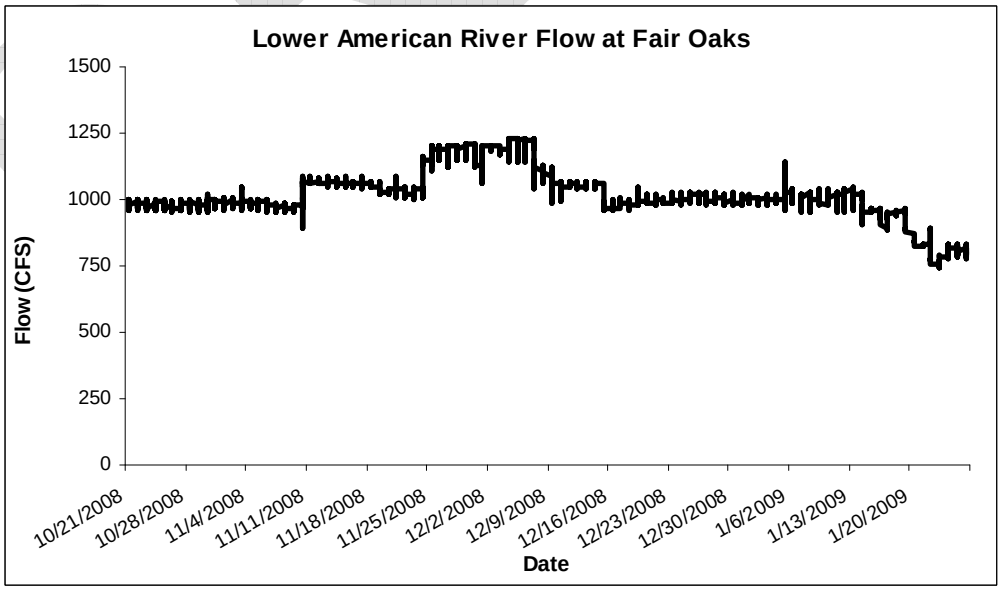

Figure 2. Flow measured at the Fair Oaks gauging station during the lower American River escapement survey, October 21, 2008 – January 26, 2009.

Temporal Distribution

A total of 899 Chinook salmon carcasses were observed during the 2008-2009 lower American River escapement survey (Table 2). Of the 899 carcasses observed, 138 (15%) were identified as fresh, 697 (78%) were identified as non-fresh, and 64 (7%) were identified as coded-wire tagged by the absence of an adipose fin. The total number of carcasses observed increased from the first survey week (21-13 October), peaked in Week 8 (8-10 December), experienced a decline through Week 13, and peaked again during Week 14 (19-22 January). This bimodal distribution was due in part to the occurrence of an increase in adipose fin-clipped salmon (Table 2 and Figure 3).

Table 2. General results for the lower American River Chinook salmon escapement survey, October 21, 2008 – January 26, 2009.

Week	Survey Dates	Carcasses Observed			
		Fresh	Non-fresh	CWT	All
1	10/21-10/23	1	7	0	8
2	10/27-10/29	2	6	0	8
3	11/3-11/6	3	7	0	10
4	11/10-11/12	8	13	0	21
5	11/17-11/19	7	36	2	45
6	11/24-11/26	11	44	1	56
7	12/1-12/3	17	68	0	85
8	12/8-12/10	20	96	3	119
9	12/15-12/17	14	79	0	93
10	12/22-12/24	14	60	1	75
11	12/29-12/31	15	54	0	69
12	1/5-1/7	9	53	3	65
13	1/12-1/14	4	47	10	61
14	1/19-1/22	8	76	14	98
15	1/26	5	51	30	86
Total		138	697	64	899

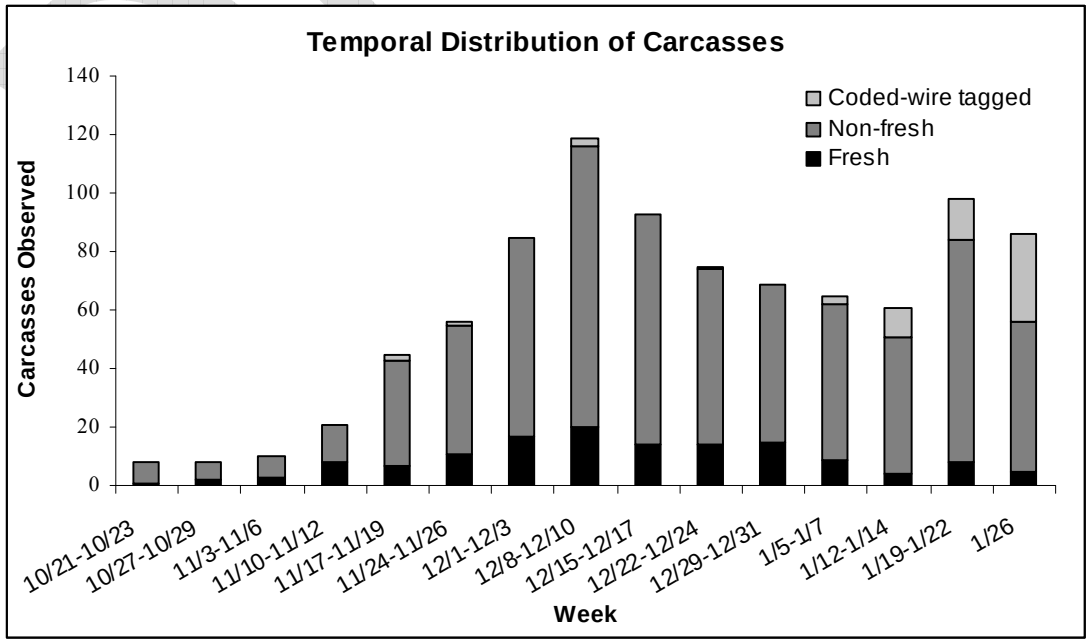

Figure 3. Weekly distribution of carcasses observed during the lower American River Chinook salmon escapement survey, October 21, 2008 – January 26, 2009.

Spatial Distribution

The majority of all carcasses (93%) were observed in Reach 1; Elmanto Access upstream to the Nimbus Weir (Table 3). Reaches 2 and 3 collectively comprised only 7% of all carcasses observed. Throughout the survey, 50-100% of all weekly observations were located in Reach 1. These calculations may be affected by the absence of sampling in Reaches 2 and 3 during Week 15.

Table 3. Spatial distribution of all carcasses observed during the lower American River Chinook salmon escapement survey, October 21, 2008 – January 26, 2009.

Week	Survey Dates	Carcasses Observed		
		Reach 1	Reach 2	Reach 3
1	10/21-10/23	7	1	0
2	10/27-10/29	4	4	0
3	11/3-11/6	9	1	0
4	11/10-11/12	16	5	0
5	11/17-11/19	35	5	5
6	11/24-11/26	52	2	2
7	12/1-12/3	73	11	1
8	12/8-12/10	108	8	3
9	12/15-12/17	87	6	0
10	12/22-12/24	75	0	0
11	12/29-12/31	67	2	0
12	1/5-1/7	64	1	0
13	1/12-1/14	56	4	1
14	1/19-1/22	94	4	0
15	1/26	86	N/A	N/A
Total (%)		833 (93)	54 (6)	12 (1)

Age and Sex Composition

Adults (carcasses with fork lengths ≥ 680mm) comprised 92.1% (828) and grilse (carcasses with fork lengths < 680mm) comprised 7.9% (71) of the 899 carcasses observed throughout the survey (Table 4). Adults were observed in all weeks. Grilse were not observed until Week 3, but observed in all subsequent weeks. The largest number of both adult and grilse carcasses were observed during Week 8. Grilse constituted no more than 22% of weekly observations.

A total of 199 carcasses were sampled for sex-determination. Males comprised 53% (106) of the carcasses examined and females comprised 47% (93) of the carcasses examined (Table 5). The overall sex ratio of sampled carcasses was 1 to 0.88 male to female.

Of the 106 carcasses identified as male, 17 (16%) were grilse and 89 (84%) were adults (Table 5). Of the 93 carcasses identified as female, 7 (8%) were grilse and 86 (92%) were adults. Seventy-one percent (17) of grilse examined were male and 29% (7) were female. Of the adults examined, 51% (89) were male and 49% (86) were female.

Table 4. Age composition (adult and grilse) of all carcasses observed during the lower American River Chinook salmon escapement survey, October 21, 2008 – January 26, 2009.

Week	Survey Dates	Carcasses Observed	
		Adult	Grilse
1	10/21-10/23	8	0
2	10/27-10/29	8	0
3	11/3-11/6	9	1
4	11/10-11/12	18	3
5	11/17-11/19	35	10
6	11/24-11/26	51	5
7	12/1-12/3	78	7
8	12/8-12/10	102	17
9	12/15-12/17	86	7
10	12/22-12/24	70	5
11	12/29-12/31	63	6
12	1/5-1/7	63	2
13	1/12-1/14	60	1
14	1/19-1/22	97	1
15	1/26	80	6
Total (%)		828 (92.1)	71 (7.9)

Table 5. Sex composition of processed carcasses during the lower American River Chinook salmon escapement survey, October 21, 2008 – January 26, 2009.

Week	Grilse				Adult			
	Male		Female		Male		Female	
	Carcasses	%	Carcasses	%	Carcasses	%	Carcasses	%
1	0	-	0	-	1	50	1	50
2	0	-	0	-	1	50	1	50
3	1	100	0	0	1	50	1	50
4	1	50	1	50	4	67	2	33
5	3	75	1	25	3	60	2	40
6	1	100	0	0	7	64	4	36
7	1	100	0	0	10	67	5	33
8	6	100	0	0	12	71	5	29
9	2	100	0	0	5	50	5	50
10	1	100	0	0	3	21	11	79
11	0	-	0	-	5	33	10	67
12	0	-	0	-	7	58	5	42
13	0	0	2	100	3	25	9	75
14	0	0	2	100	11	55	9	45
15	1	50	1	50	16	50	16	50
Total	17	71	7	29	89	51	86	49

Fork Length Distribution

Fork lengths were recorded for a total of 199 carcasses (Table 6 and Figure 4). Overall, the fork lengths ranged from 323mm to 1,120mm and averaged 837.5mm (SD = 139.0). Fork lengths for

males (n = 106) ranged from 430mm to 1,120mm and averaged 857.6mm (SD = 163.1). Fork lengths for females (n = 93) averaged 814.6mm (SD = 101.2) and ranged from 323mm to 1,020mm.

Table 6. Summary of fork length measurements for processed carcasses during the lower American River Chinook salmon escapement survey, October 21, 2008 – January 26, 2009.

	Fork Length Measurements		
	All	Male	Female
Number	199	106	93
Range (mm)	323-1,120	430-1,120	323-1,020
Average (mm)	837.5	857.6	814.6
Standard Deviation (mm)	139.0	163.1	101.2

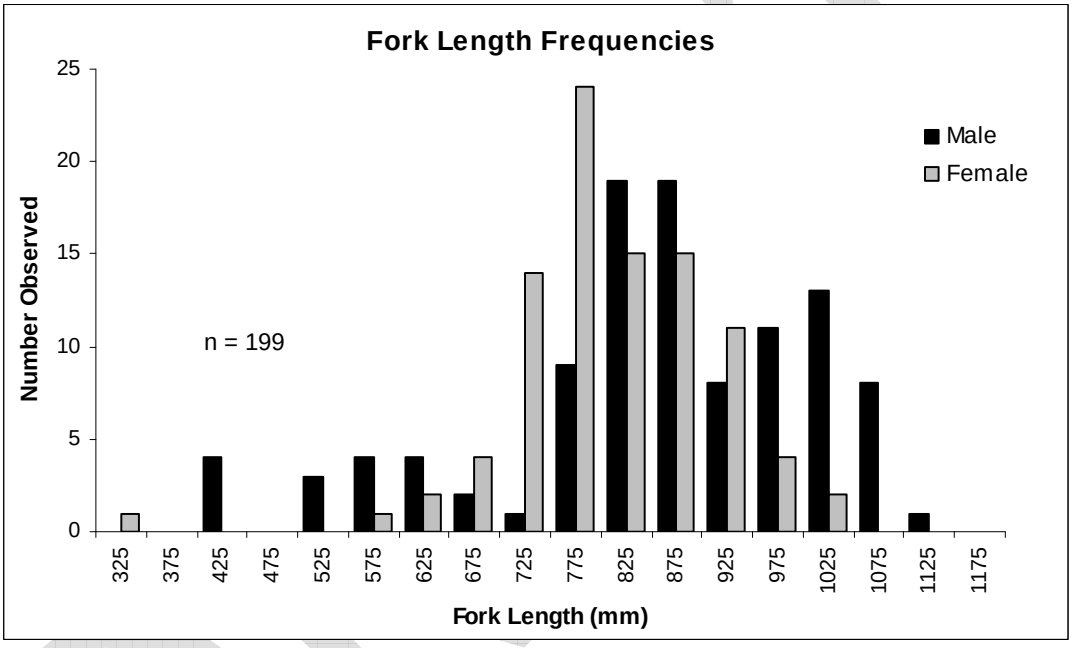

Figure 4. Fork length frequencies of processed male and female carcasses during the lower American River Chinook salmon escapement survey, October 21, 2008 – January 26, 2009.

Egg Retention

Ninety-three female carcasses were assessed for their degree of egg retention (Table 7). Of the 93 female carcasses assessed, 82 (88%) were completely spawned (0 to 30% of eggs retained), 2 (2%) were partially spawned (31 to 70% of eggs retained), and 9 (10%) were unspawned (71 to 100% of eggs retained).

Spawned females were not observed until Week 4, but were observed in all subsequent sampling periods (Table 7). Spawned females constituted no less than 80% of weekly observations after Week 6. The majority of females with high egg retention (71 to 100% of eggs retained) were observed within the first seven weeks; 67% of unspawned females and 50% of partially spawned females. No unspawned females were observed in Weeks 5, 8, 9, 10, 11, 12, and 15.

Table 7. Summary of female egg retention for the lower American River Chinook salmon escapement survey, October 21, 2008 – January 26, 2009.

Week	Survey Dates	Females Processed	Number Observed (%)		
			Spawned	Partially Spawned	Unspawned
1	10/21-10/23	1	0 (0)	0 (0)	1 (100)
2	10/27-10/29	1	0 (0)	0 (0)	1 (100)
3	11/3-11/6	1	0 (0)	0 (0)	1 (100)
4	11/10-11/12	3	2 (67)	0 (0)	1 (33)
5	11/17-11/19	3	3 (100)	0 (0)	0 (0)
6	11/24-11/26	4	2 (50)	1 (25)	1 (25)
7	12/1-12/3	5	4 (80)	0 (0)	1 (20)
8	12/8-12/10	5	5 (100)	0 (0)	0 (0)
9	12/15-12/17	5	5 (100)	0 (0)	0 (0)
10	12/22-12/24	11	11 (100)	0 (0)	0 (0)
11	12/29-12/31	10	10 (100)	0 (0)	0 (0)
12	1/5-1/7	5	4 (80)	1 (20)	0 (0)
13	1/12-1/14	11	9 (82)	0 (0)	2 (18)
14	1/19-1/22	11	10 (91)	0 (0)	1 (9)
15	1/26	17	17 (100)	0 (0)	0 (0)
Total (%)		93	82 (88)	2 (2)	9 (10)

Coded-Wire Tagged Carcasses

During our survey, a total of 64 carcasses were identified by the absence of an adipose fin and were presumed to possess a coded-wire tag (Table 2). Coded-wire tagged carcasses were first observed in Week 5 and were periodically present in low numbers through Week 12. During Weeks 13, 14, and 15, the number of observed coded-wire tagged carcasses increased substantially. Of the 64 coded-wire tagged carcasses observed throughout the survey, 84.4% (54) were observed during the last three sampling weeks. In regards to spatial distribution, nearly all (98.4%) of the coded-wire tagged carcasses were observed in Reach 1.

All coded-wire tagged carcasses (n=64) were identified to sex and had their fork lengths measured. Males constituted 55% (35) of the observed coded-wire tagged carcasses and females constituted 45% (29); giving a male to female sex ratio of 1 to 0.83 . Of the 29 coded-wire tagged females observed, 28 (97%) were deemed spawned and 1 (3%) was considered unspawned. Fork lengths for males (n = 35) ranged from 430mm to 1,010mm and averaged 790.4mm (SD = 133.7). Fork lengths for females (n = 29) averaged 753.6mm (SD = 60.2) and ranged from 570mm to 920mm.

Of the 64 heads collected for coded-wire tag verification, 60 heads contained a coded-wire tag. One head was not analyzed and three heads did not possess a coded-wire tag. Analysis of the 60 coded-wire tags showed that 6.7% (4) of the tagged salmon were of Mokelumne River Hatchery origin, 1.6% (1) were of Feather River Hatchery origin, and 91.7% (55) were of Coleman National Fish Hatchery origin. Carcasses, with analyzed coded-wire tags, that were collected between 21 October, 2008 and 8 December, 2008 (n = 6) were all identified as Central Valley fall-run Chinook salmon. Carcasses, with analyzed coded-wire tags, that were collected after 8 December, 2008 (n = 54) were identified as Central Valley late fall-run Chinook salmon. All coded-wire tagged salmon analyzed were translocated from their hatchery of origin to alternative locations for release (Table 8).

Table 8. Summary of preliminary coded-wire tag analysis for the lower American River Chinook salmon escapement survey, October 21, 2008 – January 26, 2009.

Recovery Date	Head Tag Number	CWT Code	Run	Brood Year	Hatchery of Origin	Release Location	Date of Release
11/17/2009	67720	67000	Fall	2006	Feather River Hatchery	San Pablo Bay	5/12/2007
11/17/2008	67724	067011	Fall	2006	Mokelumne R Fish Ins	Wickland oil termina	5/10/2007
11/24/2008	67499	0501040801	Fall	2006	Coleman Nfh	Clarksburg	3/15/2007
12/8/2008	67462	067014	Fall	2006	Mokelumne R Fish Ins	CA Ocean locations	6/4/2007
12/8/2008	67463	067014	Fall	2006	Mokelumne R Fish Ins	CA Ocean locations	6/4/2007
12/8/2008	67498	067014	Fall	2006	Mokelumne R Fish Ins	CA Ocean locations	6/4/2007
1/5/2009	67748	053379	Late Fall	2006	Coleman Nfh	Discovery Park	1/16/2007
1/5/2009	67749	052784	Late Fall	2005	Coleman Nfh	Georgianna Slough	12/8/2005
1/12/2009	67465	052989	Late Fall	2006	Coleman Nfh	Ryde-koket	1/18/2007
1/12/2009	67468	053378	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/12/2009	67469	053373	Late Fall	2006	Coleman Nfh	Ryde-koket	12/6/2006
1/12/2009	67470	052989	Late Fall	2006	Coleman Nfh	Ryde-koket	1/18/2007
1/12/2009	67471	053371	Late Fall	2006	Coleman Nfh	Ryde-koket	12/6/2006
1/12/2009	67472	053378	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/12/2009	67706	052992	Late Fall	2006	Coleman Nfh	Discovery Park	1/16/2007
1/12/2009	67725	053378	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/13/2009	67464	053378	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/13/2009	67747	052990	Late Fall	2006	Coleman Nfh	Ryde-koket	1/18/2007
1/19/2009	67480	053375	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/19/2009	67701	053379	Late Fall	2006	Coleman Nfh	Discovery Park	1/16/2007
1/19/2009	67702	053376	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/19/2009	67703	052992	Late Fall	2006	Coleman Nfh	Discovery Park	1/16/2007
1/19/2009	67705	053379	Late Fall	2006	Coleman Nfh	Discovery Park	1/16/2007
1/19/2009	67707	053377	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/19/2009	67708	053375	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/19/2009	67721	052990	Late Fall	2006	Coleman Nfh	Ryde-koket	1/18/2007
1/19/2009	67722	053379	Late Fall	2006	Coleman Nfh	Discovery Park	1/16/2007
1/19/2009	67723	052993	Late Fall	2006	Coleman Nfh	Discovery Park	1/16/2007
1/19/2009	67726	053378	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/19/2009	67739	053378	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/19/2009	67740	053378	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/19/2009	67741	052992	Late Fall	2006	Coleman Nfh	Discovery Park	1/16/2007
1/26/2009	67476	053377	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/26/2009	67477	052993	Late Fall	2006	Coleman Nfh	Discovery Park	1/16/2007
1/26/2009	67478	053378	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/26/2009	67486	053380	Late Fall	2006	Coleman Nfh	Discovery Park	1/16/2007
1/26/2009	67487	053377	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/26/2009	67709	053371	Late Fall	2006	Coleman Nfh	Ryde-koket	12/6/2006
1/26/2009	67710	053378	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/26/2009	67711	052993	Late Fall	2006	Coleman Nfh	Discovery Park	1/16/2007
1/26/2009	67712	053376	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/26/2009	67713	053375	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/26/2009	67714	052989	Late Fall	2006	Coleman Nfh	Ryde-koket	1/18/2007
1/26/2009	67715	052992	Late Fall	2006	Coleman Nfh	Discovery Park	1/16/2007
1/26/2009	67716	053377	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/26/2009	67717	053375	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/26/2009	67718	052993	Late Fall	2006	Coleman Nfh	Discovery Park	1/16/2007
1/26/2009	67727	053373	Late Fall	2006	Coleman Nfh	Ryde-koket	12/6/2006
1/26/2009	67728	052989	Late Fall	2006	Coleman Nfh	Ryde-koket	1/18/2007
1/26/2009	67729	052990	Late Fall	2006	Coleman Nfh	Ryde-koket	1/18/2007
1/26/2009	67731	053380	Late Fall	2006	Coleman Nfh	Discovery Park	1/16/2007
1/26/2009	67732	052992	Late Fall	2006	Coleman Nfh	Discovery Park	1/16/2007
1/26/2009	67733	053378	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/26/2009	67734	053380	Late Fall	2006	Coleman Nfh	Discovery Park	1/16//2007
1/26/2009	67735	053376	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/26/2009	67736	053374	Late Fall	2006	Coleman Nfh	Benicia	12/11/2006
1/26/2009	67738	053373	Late Fall	2006	Coleman Nfh	Ryde-koket	12/6/2006
1/26/2009	67745	053377	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/26/2009	67746	053375	Late Fall	2006	Coleman Nfh	West Sacramento	12/4/2006
1/26/2009	67750	053371	Late Fall	2006	Coleman Nfh	Ryde-koket	12/6/2006

Population Estimate

Within the mark-release-recapture study, a total of 117 fresh adult carcasses were tagged from Week 1 (21 October, 2008) through Week 14 (19 January, 2009) (Table 9). Of the 117 carcasses tagged, 42 were subsequently recovered which yielded a 35.9% recovery rate. The modified Schaefer model, using fresh adult tagged carcass data, tag recovery data, and non-fresh chopped adult carcass data, produced an adult escapement estimate of 1,728 Chinook salmon (Table 10). Another 63 adults that were not included within the model's calculations were added to the Schaefer estimate leading to a final adult in-river escapement estimate of 1,791 fall-run Chinook salmon.

Table 9. Mark-release-recapture data used within the modified Schaefer method, October 21, 2008 – January 26, 2009.

Survey Period	Number Tagged	Number Chopped	Recaptures of Tagged Fish in Survey Period														Total Examined
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	1	7															8
2	2	6															8
3	2	7															9
4	6	12															18
5	5	30															35
6	11	40				2											53
7	15	62						3									80
8	17	85						1	1								104
9	10	74						1	1	3							89
10	14	56								3	6						79
11	15	48									1						64
12	9	51									1		3				64
13	3	47								1			1	2			54
14	7	76											3	2	3		91
15	0	47											1	1		2	51

Table 10. Matrix of population estimates from the modified Schaefer method for in-river adult Chinook salmon, October 21, 2008 – January 26, 2009.

Survey Period	Estimates from Recaptures in Survey Period														Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1															0
2	0														0
3	0	0													0
4	0	0	0												0
5	0	0	0	0											0
6	0	0	0	159	0										159
7	0	0	0	0	0	176									176
8	0	0	0	0	0	114	390								504
9	0	0	0	0	0	39	134	130							302
10	0	0	0	0	0	0	0	64	66						130
11	0	0	0	0	0	0	0	0	80	0					80
12	0	0	0	0	0	0	0	0	20	0	90				110
13	0	0	0	0	0	0	0	33	0	0	25	49			107
14	0	0	0	0	0	0	0	0	0	0	64	41	34		139
15	0	0	0	0	0	0	0	0	0	0	24	23	0	89	136
								Total							1844
								Number of Tagged Fish (Period 2 to 15)							-116
								Total Adult in-river Schaefer Estimate							1728

Since adults made up 92.1% of the observed escapement (Table 4), we calculated the total in-river estimate (adults and grilse) by dividing the final adult estimate by 0.921. This calculation resulted in a total in-river escapement estimate of 1,945 fall-run Chinook salmon; 1,791 adults and 154 grilse.

In addition to the estimated 1,945 fall-run Chinook salmon escapement downstream of the Nimbus Weir, there were 3,211 Chinook salmon (2,863 adults and 348 grilse) collected at the Nimbus Fish Hatchery and 569 Chinook salmon carcasses (464 adults and 105 grilse) removed from the upstream side of the Nimbus Weir. By combining the total in-river escapement estimate with the total number of Chinook salmon collected at the Nimbus Fish Hatchery and the Nimbus Weir, the total 2008-2009 fall-run Chinook salmon escapement estimate for the lower American River was 5,725; 5,118 adults and 607 grilse.

Conclusions

Throughout the 2008-2009 fall-run Chinook salmon escapement survey, river flow and water clarity were generally consistent and can be considered conducive for locating carcasses within the lower American River. Therefore, environmental conditions were believed to have not substantially impacted the survey's results.

The spatial distribution of observed carcasses within the 2008-2009 lower American River escapement survey was typical of previous surveys. Aerial redd surveys in the past have shown that most redds are formed upstream of river-mile 18 (Snider and Vyverberg 1996), which encompasses Reach 1, where 93% of the carcasses were observed during the 2008-2009 survey. Assuming that spawning occurs nearby or upstream of the location of observed carcasses, we can suggest that there has not been any notable change in spawning preference in the lower American River since 1995.

The 2008-2009 fall-run Chinook salmon escapement survey did yield a unique temporal distribution of observed carcasses not seen in previous years. Though the peak of carcass observation for the 2008-2009 fall-run escapement survey occurred during the week of December 8-10, which coincides with last year's peak during the week of December 3-6 (Healey and Redding 2008), a unique second peak in carcass observation was observed during the month of January. Knowing that the influx of the coded-wire tagged carcasses (n = 53) observed during the month of January were all identified as late fall-run strays from the Coleman National Fish Hatchery on Battle Creek, another tributary to the Sacramento River, we can assume that our fall-run survey results, particularly during the month of January, may be influenced by the presence of a late fall-run within the lower American River. Given that an increase in both adipose clipped (hatchery) and adipose intact (presumed wild) salmon carcasses were observed within the later peak in question, we cannot speculate that the second "late fall-run" peak was sole caused by the straying of translocated hatchery reared salmon because the Coleman National Fish Hatchery, which is the only facility within the Central Valley that rears late fall-run Chinook salmon, attempts to tag 100% of their late fall-run juveniles prior to release. Though we speculate that this phenomenon was created by the straying of hatchery and presumed wild Chinook salmon from other systems and was likely not a self-sustaining run within the lower American River, we must factor this phenomenon into future monitoring studies. Further investigation is deemed necessary and therefore recommended based on the implications that a late fall-run would have in terms of future fall-run escapement surveys and river management practices.

The total 2008-2009 fall-run Chinook salmon escapement estimate is the second lowest stock estimate since 1967 and is 12.8% of the 41 year average of 44,722 (Table 11). Though the number of grilse estimated during the 2008-2009 Chinook salmon escapement survey (607) increased from last year's estimate of 151, the adult estimate declined by 64.7% in comparison to last year (Healey

and Redding 2008). Since the record high fall-run escapement estimate of 158,516 Chinook salmon in 2003, the fall-run escapement estimates for the lower American River have continually declined. Although these trends are alarming in terms of the sustainability of this fishery, there is no evidence that recent management practices of the lower American River are responsible for the steady decline of returning Chinook salmon. Recent declines in Chinook salmon stocks have been observed throughout the Central Valley and therefore we assume that the major cause(s) are from variables outside of the lower American River.

Table 11. Total Chinook salmon escapement estimates for the lower American River, 1967-2007.

Year	Method of Estimate	Escapement Estimate		
		Grilse	Adult	Total
1967	Expanded Direct Counts	3,132	14,868	18,000
1968	Expanded Direct Counts	2,777	23,423	26,200
1969	Expanded Direct Counts	8,208	35,452	43,660
1970	Expanded Direct Counts	2,753	25,927	28,680
1971	Expanded Direct Counts	5,210	36,470	41,680
1972	Expanded Direct Counts	3,352	14,107	17,459
1973	Expanded Direct Counts	4,688	77,554	82,242
1974	Schaefer	1,769	51,827	53,596
1975	Expanded Direct Counts	2,699	29,433	32,132
1976	Schaefer	1,181	21,978	23,159
1977	Schaefer	4,701	36,904	41,605
1978	Schaefer	595	12,334	12,929
1979	Schaefer	896	36,419	37,315
1980	Schaefer	8,805	25,454	34,259
1981	Schaefer	2,521	40,941	43,462
1982	Expanded Direct Counts	4,323	28,677	33,000
1983	Expanded Direct Counts	7,313	19,087	26,400
1984	Petersen	2,196	25,251	27,447
1985	Schaefer	11,392	44,728	56,120
1986	Schaefer	4,443	44,929	49,372
1987	Schaefer	2,960	18,185	21,145
1988	Jolly-Seber	1,905	13,974	15,879
1989	Schaefer	2,459	14,619	17,078
1990	Schaefer	1,167	5,541	6,708
1991	Schaefer	1,506	16,639	18,145
1992	Schaefer	1,297	3,175	4,472
1993	Schaefer	6,162	20,624	26,786
1994	Schaefer	2,927	28,405	31,332
1995	Schaefer	7,010	63,086	70,096
1996	Schaefer	6,592	59,323	65,915
1997	Schaefer	4,220	42,668	46,888
1998	Schaefer	10,760	32,282	43,042
1999	Schaefer	7,716	40,509	48,225
2000	Schaefer	5,922	92,783	98,705
2001	Schaefer	10,463	120,322	130,785
2002	Schaefer	11,811	106,303	118,114
2003	Schaefer	11,571	146,945	158,516
2004	Schaefer	13,756	74,991	88,747
2005	Schaefer	2,842	54,001	56,843
2006	Schaefer	1,025	21,755	22,780
2007	Schaefer	151	14,519	14,670
Average		4,809	39,912	44,722

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