California Department of Fish and Wildlife
North Central Region

Lower American River Fall-Run Chinook Salmon Escapement Survey October 2012 – January 2013

Presented to the United States Bureau of Reclamation

By

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ACCRONYMS

BOR	United States Bureau of Reclamantion
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
CFS	Cubic feet per second
CJS	Cormack-Jolly-Seber
CM	Centimeters
CWT	Coded wire tag
FL	Fork length
LAR	Lower American River

INTRODUCTION

The portion of the American River system known as the lower American River (LAR) consists of a 22-mile stretch between the confluence of the Sacramento River and Nimbus Dam to the east. Fall-run Chinook salmon (*Oncorhynchus tshawytscha*) traditionally enter the LAR in mid-September and continue their run through January with the heaviest migration occurring November through December. Spawning generally begins when the water temperature drops below 60 °F (Williams 2001). Historically, the LAR has supported three seasonal runs of Chinook salmon of which the spring-run is believed to have been extirpated (Zeug, et. al. 2010).

In addition to the in-river production of the fall-run population, Chinook salmon in the LAR are artificially supplemented by populations raised at the Nimbus Hatchery. The Bureau of Reclamation (BOR) created the Nimbus Fish Hatchery in 1958 as a mitigation measure to compensate for the loss of spawning habitat caused by the creation of Nimbus Dam. Although the California Department of Fish and Wildlife (CDFW) manages and operates the Nimbus Hatchery, funding for hatchery operations and the carcass survey are provided by the BOR (CDFW 2012).

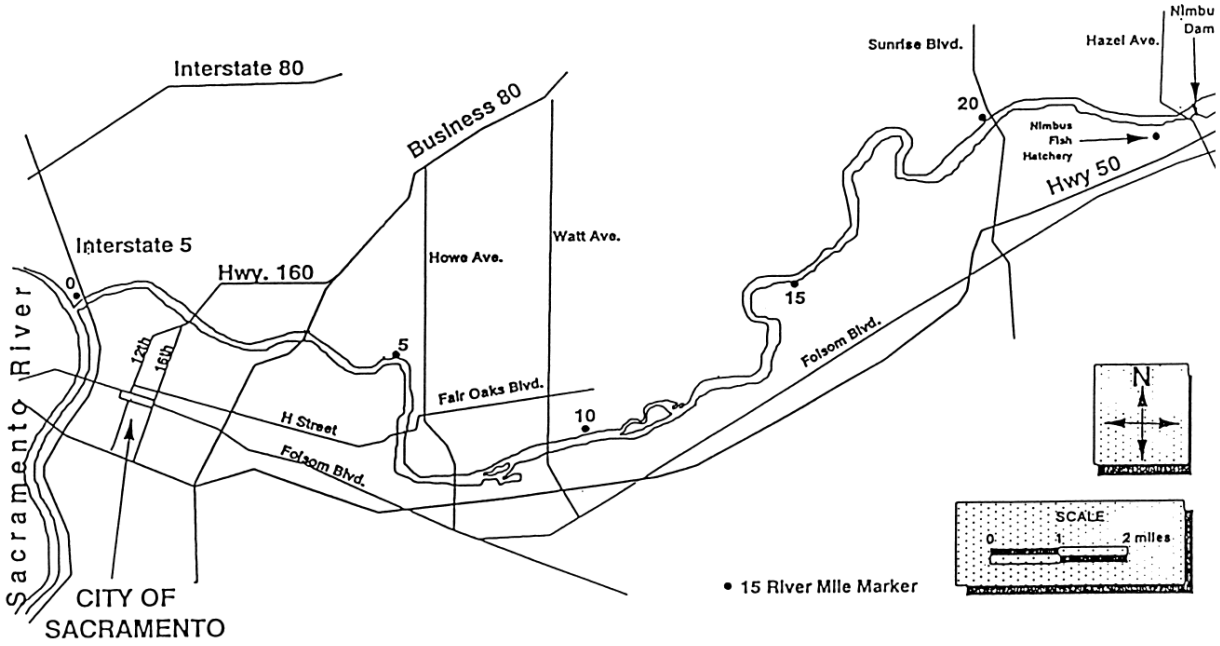

Figure 1. Map of the lower American River (Williams 2001).

Chinook salmon escapement surveys have been conducted on the LAR for nearly 70 years beginning in 1944 (Gerstung 1971). The goal of this survey was to estimate the escapement of fall-run Chinook salmon in a 13.1-mile section of the LAR. The objectives of the survey were, (1) estimate the population size of returning Chinook salmon spawning in a 13.1-mile section of the LAR; (2) determine the general age and sex of the returning Chinook salmon; (3) determine the level of female egg retention; and (4) determine the ratio of returning hatchery-reared, coded-wire tagged (CWT) salmon.

METHODS

The 2012-2013 LAR escapement survey was conducted over a 12-week period from October 22, 2012 to January 10, 2013. The survey area was comprised of 13.1 miles of river from the Nimbus Hatchery weir downstream to the Watt Avenue bridge (Appendix A). This stretch of the LAR was found to contain the greatest concentration of fall-run Chinook spawning activity by Snider and Vyverburg (1996). The survey area is typically divided into 4 sections to allow for each section to be surveyed in a single day once per survey period (week). Due to the density of observed carcasses in section 1, it was split into two sub-sections (1A and 1B) (Table 1); however, the data were combined for analysis.

Table 1. Lower American River escapement survey sections.

Section	Locations	Miles
1A	Nimbus Hatchery weir to Sunrise Blvd Access	2.6
1B	Sunrise Blvd Access to Elmanto Dr Access	1.7
2	Elmanto Dr Access to River Bend Park	4.7
3	River Bend Park to Watt Ave Access	4.1
	Total	**13.1**

Systematic and unbiased subsampling was required during survey periods 3 through 8 due to the large number of observed carcasses. During survey periods 3,4,7 and 8, every other fish observed was processed, and during survey periods 5 and 6, every third fish observed was processed (Table 2). The determination for subsampling was made at the start of each survey period and was based on the trend of total number of carcasses processed over the previous survey period. Once it was determined that subsampling was necessary, it was carried out for the entire survey period.

Table 2. Lower American River survey periods and sampling regimes for 2012-2013. * = every 2nd carcass processed. ** = every 3rd carcass processed.

Survey period	Dates	Sampling regimes: processed/observed
1	Oct. 22 to Oct. 25	1
2	Oct. 29 to Nov. 1	1
3*	Nov. 5 to Nov. 8	1/2
4*	Nov. 13 to Nov. 16	1/2
5**	Nov. 19 to Nov. 21	1/3
6**	Nov. 26 to Nov. 29	1/3
7*	Dec. 3 to Dec. 6	1/2
8*	Dec. 10 to Dec. 13	1/2
9	Dec. 17 to Dec. 20	1
10	Dec. 26 to Dec. 28	1
11	Dec. 31 to Jan. 4	1
12	Jan. 7 to Jan. 10	1

The survey crew was comprised of 6-7 members: 2-3 on each bank, except for right bank in section 3 which requires survey via canoe, and 2 in a jet-boat for deep-water survey. The bank crews moved down stream processing every carcass in accordance with the week's sampling regime.

Each processed carcass was first examined for the following: (1) presence of an external tag, (2) presence or absence of an adipose fin and (3) extent of carcass deterioration. Processing types included: (1) mark/capture, (2) coded-wire tag (CWT) head collection, and (3) tally chop.

Carcasses with an intact adipose fin were utilized for a mark/recapture study, if it was thought the extent of deterioration would allow the carcass to remain intact while in-river for at least an additional survey period. All carcasses with an intact adipose fin deemed unsuitable for mark/recapture tagging were chopped and tallied to eliminate redundant counts. Carcasses used in the mark/recapture study were affixed with a hog ring on the left maxilla. Each ring contained a uniquely-numbered disk tag and colored flagging unique to the survey period. Disk-tagged carcasses were released nearest to the thalweg and to their initial point of detection. All disk-tagged recaptures were first examined for flag color, and only those colors indicating the carcass was marked during a previous survey period were processed. Disk tag numbers were recorded on all recaptures before either re-releasing or chopping the carcass, depending on perceived probability of additional recaptures in subsequent survey periods.

Carcasses with missing adipose fins were assumed to contain a CWT in their heads. Heads were either removed and retained for CWT retrieval at a later date or chopped and tallied, if the head was determined to be too deteriorated for CWT removal.

Covariate data were collected on all mark/recapture carcasses prior to initial release and CWT carcasses prior to head removal. Covariate data included sex, fork length, carcass freshness and degree of egg retention for females. Sex was determined by a combination of distinguishing characteristics which included presence/absence of a kype (generally male), laterally compressed body (generally male), and the presence of eggs or milt. Fork length (FL) was measured in centimeters from the tip of the snout to the fork of the caudal fin. A carcass was determined to be *fresh* if it had at least one clear eye or red gills, and *not fresh* if in any other condition. Egg retention was determined by physical probing or by dissection and was scored as *unspawned* (>70% retention), *partially spawned* (30-70% retention), or *spawned* (<30% retention).

The 2012-2013 LAR fall-run Chinook salmon population estimate was derived using the Cormack-Jolly-Seber (CJS) mark and recapture model for open populations (Cormack 1964; Bergman, et. al. 2012). Data collected during this survey were also utilized to obtain an escapement estimate using the modified Schaefer population estimation model (Schaefer 1951). The Schaefer model was previously used to estimate Chinook salmon escapement on the LAR for several decades, but was replaced by the CJS during the 2011 escapement survey in order to derive a less biased population estimate. The Schaefer matices and population estimate are located in Appendix C for comparison purposes only and are excluded from further discussion in this report.

Environmental data were collected during the course of the survey to assess possible effects on carcass detectability. Flow and water temperature data were gathered from the California Data Exchange Center (CDEC) website (DWR 2013) which obtains data from the USGS survey stations at Fair Oaks (flows) and Hazel Avenue bridges (water temperatures) (USGS 2013).

RESULTS

Final Carcass Count

A total 10,558 salmon carcasses were processed and 22,578 were observed over the 12-week survey (Table 3). The maximum number of carcasses observed and processed in a single survey period was 6,108 and 2,036, respectively, and occurred during survey period 6 (Nov. 26 - Nov. 29) (Table 3 and Figure 2). Section 3 was not surveyed during periods 4,5 and 10 due to holidays.

Table 3. Total salmon carcasses processed and observed from October 2012 to January 2013, on the lower American River.

Survey period	Dates	Salmon carcasses processed	Salmon carcasses observed
1	Oct. 22 to Oct. 25	81	81
2	Oct. 29 to Nov. 1	278	278
3*	Nov. 5 to Nov. 8	1,105	1,682
4*	Nov. 13 to Nov. 16	1,937	4,219
5**	Nov. 19 to Nov. 21	1,586	4,758
6**	Nov. 26 to Nov. 29	2,036	6,108
7*	Dec. 3 to Dec. 6	1,020	2,040
8*	Dec. 10 to Dec. 13	897	1,794
9	Dec. 17 to Dec. 20	1,015	1,015
10	Dec. 26 to Dec. 28	136	136
11	Dec. 31 to Jan. 4	300	300
12	Jan. 7 to Jan. 10	167	167
	Total	**10,558**	**22,578**

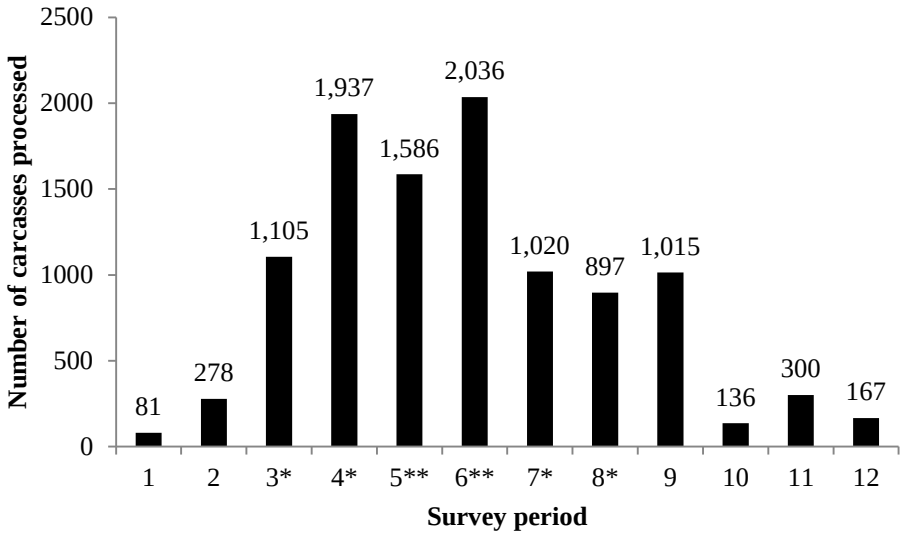

Figure 2. Temporal distribution of total salmon carcasses processed (disk-tagged, CWT chop, and tally chop) from October 2012 to January 2013, on the lower American River.

Fresh carcasses were processed during each survey period. The greatest number of fresh carcasses occurred during survey period 3 when 383 were processed. A majority of all disk-tagged and CWT head processed carcasses were not fresh (63%, *n*=2,237), while only 37% (*n*=1,305) were recorded as fresh (Table 4 and Figure 3). Freshness data were not collected from 4 carcasses.

Table 4. Summary of salmon carcass freshness from October 2012 to January 2013, on the lower American River.

Survey period	Dates	Fresh	Not fresh	Total	%
1	Oct. 22 to Oct. 25	31	48	**79**	1%
2	Oct. 29 to Nov. 1	105	173	**278**	3%
3*	Nov. 5 to Nov. 8	383	722	**1,105**	10%
4*	Nov. 13 to Nov. 16	304	1,631	**1,935**	18%
5**	Nov. 19 to Nov. 21	170	1,416	**1,586**	15%
6**	Nov. 26 to Nov. 29	164	1,872	**2,036**	19%
7*	Dec. 3 to Dec. 6	71	949	**1,020**	10%
8*	Dec. 10 to Dec. 13	37	860	**897**	8%
9	Dec. 17 to Dec. 20	26	989	**1,015**	10%
10	Dec. 26 to Dec. 28	9	127	**136**	1%
11	Dec. 31 to Jan. 4	3	297	**300**	3%
12	Jan. 7 to Jan. 10	2	165	**167**	2%
	Total	**1,305**	**9,249**	**10,554**	
	%	12	88		

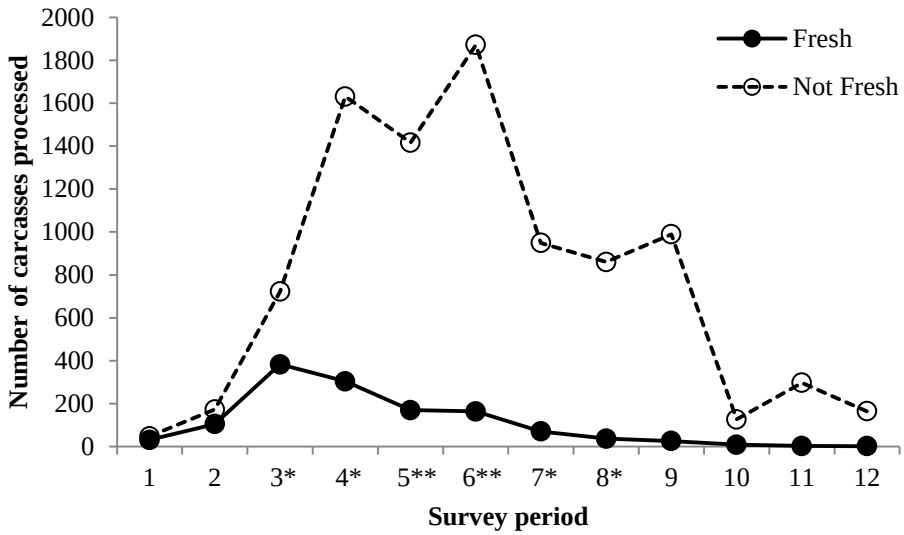

Figure 3. Temporal distribution of carcass freshness from October 2012 to January 2013, on the lower American River.

Processing Type

Of the 10,558 total processed carcasses, 2,168 (21%) were disk tagged, 1,378 (13%) heads were collected for CWT retrieval and 7,012 (66%) were chopped and tallied (Table 5 and Figure 4).

Table 5. Total salmon carcasses processed by type from October 2012 to January 2013, on the lower American River.

Survey period	Dates	Disk-tagged	CWT heads	Tally chops	Totals	%
1	Oct. 22 to Oct. 25	46	22	13	**81**	1%
2	Oct. 29 to Nov. 1	178	59	41	**278**	3%
3*	Nov. 5 to Nov. 8	656	248	201	**1,105**	10%
4*	Nov. 13 to Nov. 16	556	328	1,053	**1,937**	18%
5**	Nov. 19 to Nov. 21	241	153	1,192	**1,586**	15%
6**	Nov. 26 to Nov. 29	239	179	1,618	**2,036**	19%
7*	Dec. 3 to Dec. 6	99	104	817	**1,020**	10%
8*	Dec. 10 to Dec. 13	77	102	718	**897**	8%
9	Dec. 17 to Dec. 20	48	148	819	**1,015**	10%
10	Dec. 26 to Dec. 28	14	22	100	**136**	1%
11	Dec. 31 to Jan. 4	10	11	279	**300**	3%
12	Jan. 7 to Jan. 10	4	2	161	**167**	2%
	Totals	**2,168**	**1,378**	**7,012**	**10,558**	
	%	21	13	66		

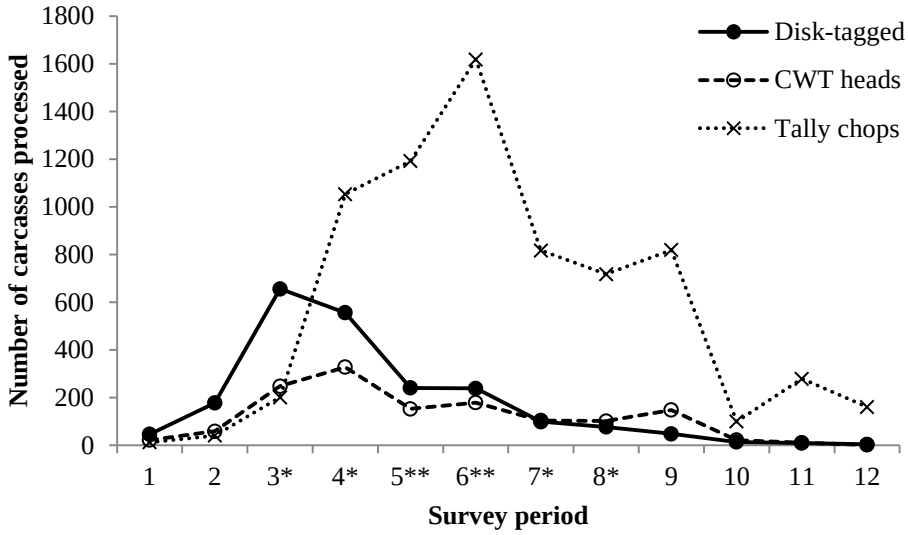

Figure 4. Temporal distribution of salmon carcass processing type from October 2012 to January 2013, on the lower American River.

Spatial Distribution

The majority of the carcasses observed occurred in sections 1A/1B (74%, *n*= 7,853) with a diminishing number of detections as the survey progressed downstream. Twenty-two percent (*n*= 2,276) of the detected carcasses occurred in Section 2 and 4% (*n*= 429) in Section 3. Ninety-one percent of carcasses were processed between survey periods 3 and 9 (Nov. 5 to Dec. 20) (Table 6 and Figure 5). Section 3 was not surveyed during survey periods 4, 5 and 10 due to holidays.

Table 6. Total salmon carcasses processed by survey section from October 2012 to January 2013, on the lower American River. Section 3 not surveyed during survey periods 4, 5 and 10.

Survey period	Dates	Sections 1A/1B	Section 2	Section 3	Totals	%
1	Oct. 22 to Oct. 25	64	12	5	**81**	1%
2	Oct. 29 to Nov. 1	210	48	20	**278**	3%
3*	Nov. 5 to Nov. 8	889	165	51	**1,105**	10%
4*	Nov. 13 to Nov. 16	1,569	368	n/a	**1,937**	18%
5**	Nov. 19 to Nov. 21	1,227	359	n/a	**1,586**	15%
6**	Nov. 26 to Nov. 29	1,394	507	135	**2,036**	19%
7*	Dec. 3 to Dec. 6	696	233	91	**1,020**	10%
8*	Dec. 10 to Dec. 13	620	204	73	**897**	8%
9	Dec. 17 to Dec. 20	840	148	27	**1,015**	10%
10	Dec. 26 to Dec. 28	87	49	n/a	**136**	1%
11	Dec. 31 to Jan. 4	137	143	20	**300**	3%
12	Jan. 7 to Jan. 10	120	40	7	**167**	2%
	Totals	**7,853**	**2,276**	**429**	**10,558**	
	%	74	22	4		

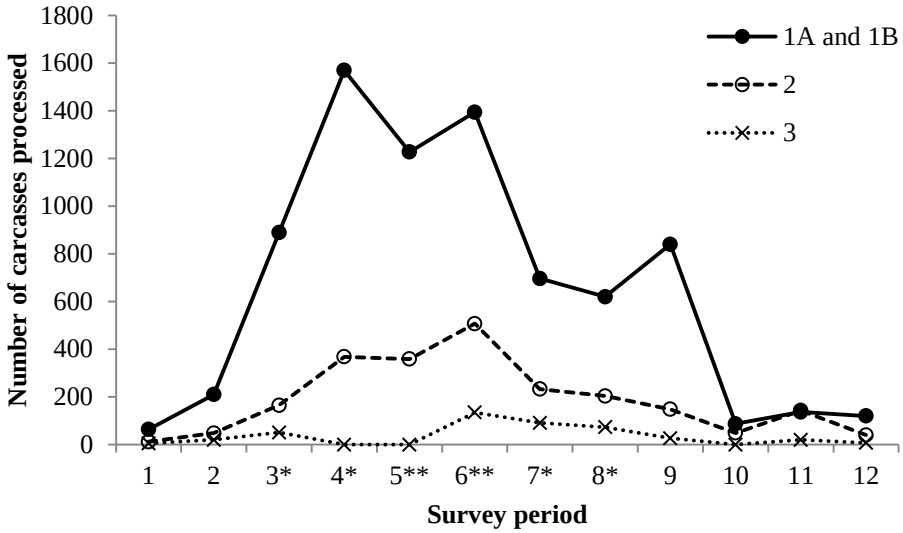

Figure 5. Temporal distribution of salmon carcasses processed by survey section from October 2012 to January 2013, on the lower American River.

Length Composition

A total of 3,533 carcasses were processed for FL and 3,535 for sex (Figure 6). Male carcass minimum and maximum FL were 33 cm and 116 cm, respectively, with a mean of 83 cm. The male carcass frequency distribution has a bimodal distribution with modes at 62 cm and 89 cm, respectively. Minimum and maximum recorded FL for female carcasses were 41 cm and 97 cm, respectively, with a mean of 81 cm and a mode of 79 cm.

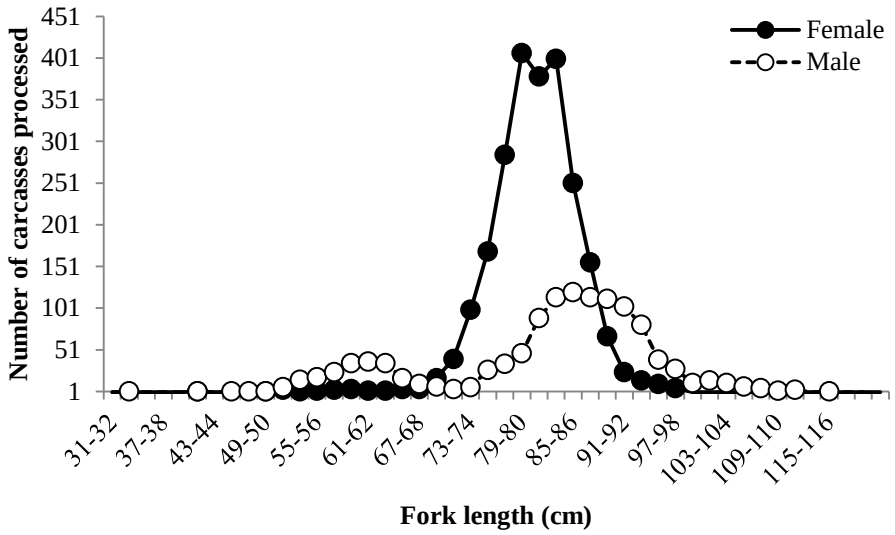

Figure 6. Salmon carcass fork length frequency distribution by sex from October 2012 to January 2013, on the lower American River.

Age Structure

LAR fall-run Chinook salmon are categorized by two age classes determined by a length frequency histogram (Figure 6) and corroborated with actual ages obtained from CWT data. A female grilse ($\leq$ 2 years old) is identified by a FL of $\leq$ 65 cm and a male grilse is determined by a FL of $\leq$ 70 cm. Adults (3+ years old) are determined by a FL of >65 cm for females or >70 cm for males.

A total of 3,533 fresh carcasses were processed for age class (Table 7, Figure 7). Ninety-three percent (*n*= 3,302) were of the adult size class while only 7% (*n*= 231) were classified as grilse. Both age classes were detected during each survey period. The proportion of grilse increased slightly during the latter half of the escapement survey.

Table 7. Summary of processed salmon carcasses by age class from October 2012 to January 2013, on the lower American River.

		Grilse		Adult	
Survey period	**Dates**	***n***	**%**	***n***	**%**
1	Oct. 22 to Oct. 25	3	5%	63	95%
2	Oct. 29 to Nov. 1	14	6%	217	94%
3*	Nov. 5 to Nov. 8	48	5%	854	95%
4*	Nov. 13 to Nov. 16	29	3%	854	97%
5**	Nov. 19 to Nov. 21	27	7%	366	93%
6**	Nov. 26 to Nov. 29	35	8%	382	92%
7*	Dec. 3 to Dec. 6	26	13%	177	87%
8*	Dec. 10 to Dec. 13	21	12%	158	88%
9	Dec. 17 to Dec. 20	22	11%	174	89%
10	Dec. 26 to Dec. 28	3	8%	33	92%
11	Dec. 31 to Jan. 4	2	10%	19	90%
12	Jan. 7 to Jan. 10	1	17%	5	83%
	Totals	**231**		**3,302**	
	%	7		93	

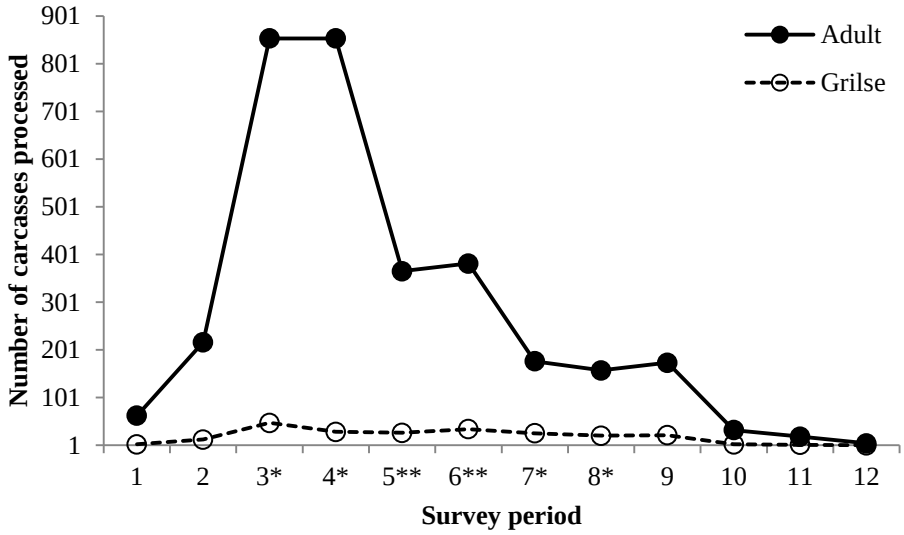

Figure 7. Temporal distribution of salmon age classes from October 2012 to January 2013, on the lower American River.

Sex Composition

Sex ratio of Chinook salmon varied with survey period and age class. The majority of all carcasses processed for sex composition were adult females (67%, *n*=2,353) (Table 8 and Figure 8). Adult age class was 71% (*n*=2,329) female, and 29% (*n*=973) male. In contrast, grilse age class was 90% (*n*=209) male, and 10% (*n*=22) female.

Table 8. Summary of processed salmon carcasses by age class and sex from October 2012 to January 2013, on the lower American River.

		Grilse		Adult	
Survey period	**Dates**	**Female**	**Male**	**Female**	**Male**
1	Oct. 22 to Oct. 25	0	3	51	12
2	Oct. 29 to Nov. 1	4	10	164	53
3*	Nov. 5 to Nov. 8	3	45	657	197
4*	Nov. 13 to Nov. 16	2	27	686	168
5**	Nov. 19 to Nov. 21	2	25	272	94
6**	Nov. 26 to Nov. 29	2	33	251	131
7*	Dec. 3 to Dec. 6	2	24	90	87
8*	Dec. 10 to Dec. 13	3	18	63	95
9	Dec. 17 to Dec. 20	3	19	64	110
10	Dec. 26 to Dec. 28	0	3	12	21
11	Dec. 31 to Jan. 4	1	1	17	2
12	Jan. 7 to Jan. 10	0	1	2	3
	Totals	**22**	**209**	**2,329**	**973**
	%	1	6	66	28

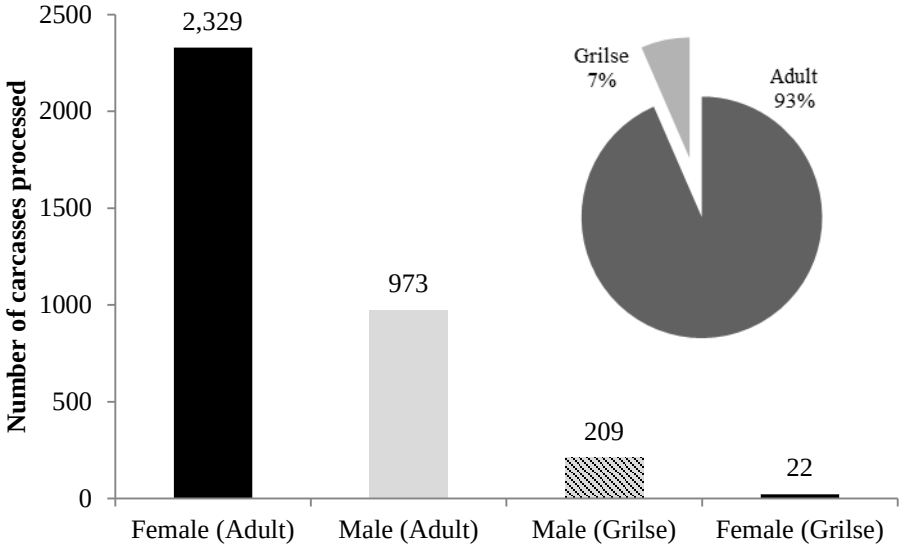

Figure 8. Total salmon carcasses processed by age class and sex from October 2012 to January 2013, on the lower American River.

Egg Retention

A total of 2,297 adult and grilse female carcasses were assessed for egg retention (Table 9 and Figure 9). Fifty percent (*n*=1,155) of female carcasses were spawned, 21% (n=485) partially spawned, and 29% (*n*= 657) unspawned. The percentage of spawned female carcasses increased from 11% in survey period 1 to 100% during survey periods 11 and 12.

Table 9. Salmon egg retention from October 2012 to January 2013, on the lower American River.

		Egg retention						
		0 to ≤30%		>30 to 70%		>70%		
Survey period	**Dates**	***n***	**%**	***n***	**%**	***n***	**%**	**Totals**
1	Oct. 22 to Oct. 25	5	11%	9	20%	31	69%	**45**
2	Oct. 29 to Nov. 1	32	21%	43	28%	81	52%	**156**
3*	Nov. 5 to Nov. 8	256	40%	145	22%	244	38%	**645**
4*	Nov. 13 to Nov. 16	328	48%	184	27%	174	25%	**686**
5**	Nov. 19 to Nov. 21	160	60%	46	17%	63	23%	**269**
6**	Nov. 26 to Nov. 29	176	71%	34	14%	39	16%	**249**
7*	Dec. 3 to Dec. 6	62	70%	10	11%	17	19%	**89**
8*	Dec. 10 to Dec. 13	58	91%	2	3%	4	6%	**64**
9	Dec. 17 to Dec. 20	47	76%	11	18%	4	6%	**62**
10	Dec. 26 to Dec. 28	11	92%	1	8%	0	0%	**12**
11	Dec. 31 to Jan. 4	18	100%	0	0%	0	0%	**18**
12	Jan. 7 to Jan. 10	2	100%	0	0%	0	0%	**2**
	Totals	**1,155**		**485**		**657**		**2,297**
	%	50		21		29		

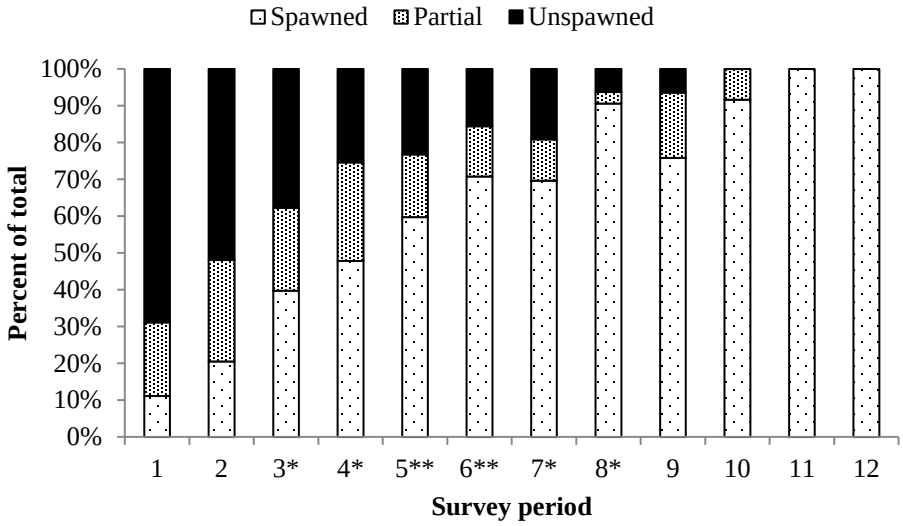

Figure 9. Temporal distribution of salmon egg retention from October 2012 to January 2013, on the lower American River.

CWT Carcasses[1]

A total of 8,600 carcasses were examined for the presence of an adipose fin. Twenty-five percent (*n*=2,144) were missing an adipose fin and, from these, 1,354 heads were collected for CWT extraction (Table 10). The remaining carcasses were chopped and tallied. During survey periods 5 through 8, heads were collected from every other adipose-clipped carcass observed due to the large amount of carcasses being processed by the survey crews. Adipose-clipped carcasses were observed during each survey period (Table 10 and Figure 10) and ranged from 8 to 30% of the total carcasses examined for adipose status during a particular survey period (Figure 10). The largest number of adipose-clipped carcasses observed was 421 during survey period 6 (Table 10), although, the highest percentage of adipose-clipped carcasses was observed during survey period 4 (30%) (Figure 10).

Table 10. Summary of adipose fin condition from October 2012 to January 2013, on the lower American River.

Survey period	Dates	Adipose intact	Adipose clipped	Heads collected
1	Oct. 22 to Oct. 25	49	20	20
2	Oct. 29 to Nov. 1	205	55	55
3*	Nov. 5 to Nov. 8	721	248	244
4*	Nov. 13 to Nov. 16	842	369	323
5**	Nov. 19 to Nov. 21	927	381	148
6**	Nov. 26 to Nov. 29	1,606	421	176
7*	Dec. 3 to Dec. 6	801	216	104
8*	Dec. 10 to Dec. 13	617	215	102
9	Dec. 17 to Dec. 20	571	184	148
10	Dec. 26 to Dec. 28	55	22	22
11	Dec. 31 to Jan. 4	40	11	10
12	Jan. 7 to Jan. 10	22	2	2
	Totals	**6,456**	**2,144**	**1,354**
	%	75	25	

[1] All salmon carcass heads collected during Central Valley salmon escapement surveys for CWT removal are processed by the CDFW's Ocean Salmon Project in Santa Rosa, CA. Tag data are finalized and uploaded to the Regional Mark Information System (RMIS) on the Regional Mark Processing Center's website during the summer months following the escapement surveys. For more information about specific CWT data, visit www.rmpc.org.

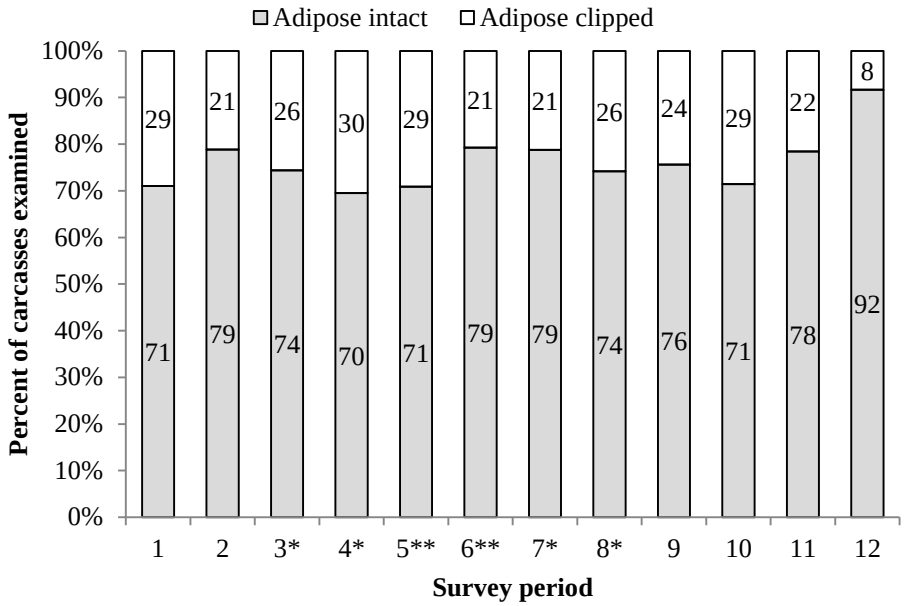

Figure 10. Temporal distribution of processed salmon with adipose fin intact or clipped from October 2012 to January 2013, on the lower American River.

Population Estimate

The CJS model was used to estimate the 2012-2013 in-river fall-run Chinook salmon escapement (Cormack 1964; Bergman, et. al. 2012).

A total of 2,168 carcasses were disk-tagged and released from October 22, 2012 to January 10, 2013 (Appendix C). The total number of disk-tagged carcasses recaptured was 429 (Appendix C). The weekly recapture rate reported by the CJS model was 32%. The in-river fall-run LAR Chinook escapement estimate from the CJS model is 34,900. The bootstrap estimate of the standard error of estimated total escapement is 1,747 (n=1,000). The 90% bootstrap percentile confidence interval is 31,933 to 37,513.

In addition to the in-river estimates, 9,257 carcasses (8,250 adult and 1,007 grilse) were collected at the Nimbus Hatchery, and 3,427 (2,773 adult and 654 grilse) were collected above the weir by hatchery personnel.

The combined 2012-2013 LAR fall-run Chinook salmon escapement estimate from the in-river survey, Nimbus Hatchery and weir collections is 47,584.

Environmental Conditions

LAR water temperature decreased an average of 0.2°F per day over the length of the survey. The minimum and maximum recorded water temperatures were 46.4°F (1/10/2013) and 61.3°F (10/22/2012), respectively, with an average temperature of 55.2°F. (Figure 11)

The LAR minimum and maximum flows (cfs) were 1,680 cfs (10/31/2012) and 10,100 cfs (12/24/2012), respectively. Flow remained relatively consistent during the first 5 survey periods with a total increase of 190 cfs. Heavy rain in the American River basin led to a pulse event between survey periods 6 and 7 (11/30/2012 to 12/2/2012) which increased flow from 1,920 cfs (11/30/2012) to 5,090 cfs (12/1/2012) and back down to 2,010 cfs (12/3/2012) by the start of survey period 7. Flow increased by approximately 1,000 cfs during survey periods 8 and 9 before increasing to 4,050 cfs at the start of survey period 9 (12/17/2012) and continued to increase to the maximum recorded flow of 10,100 cfs (12/24/2012) just prior to the start of survey period 10 (12/26/2012). Flow then decreased daily during survey periods 10, 11 and 12, for a total change of 6,220 cfs by the end of survey period 12 (1/10/2013). (Figure 11)

Water clarity was measured daily with a secchi disk at a designated location for each survey section (Figure 12). The minimum and maximum recorded water clarity depth was 48 cm (12/10/2012) and 468 cm (10/25/2012), respectively, with a mean of 219 cm. Water clarity steadily decreased by an average of 14 cm per survey period over the first 6 survey periods before dropping sharply during survey period 7 (69 cm) and then reaching the minimum recorded visibility of 48 cm during survey period 8. Water clarity steadily increased over the remaining 4 survey periods by an average of 27 cm (Figure 12).

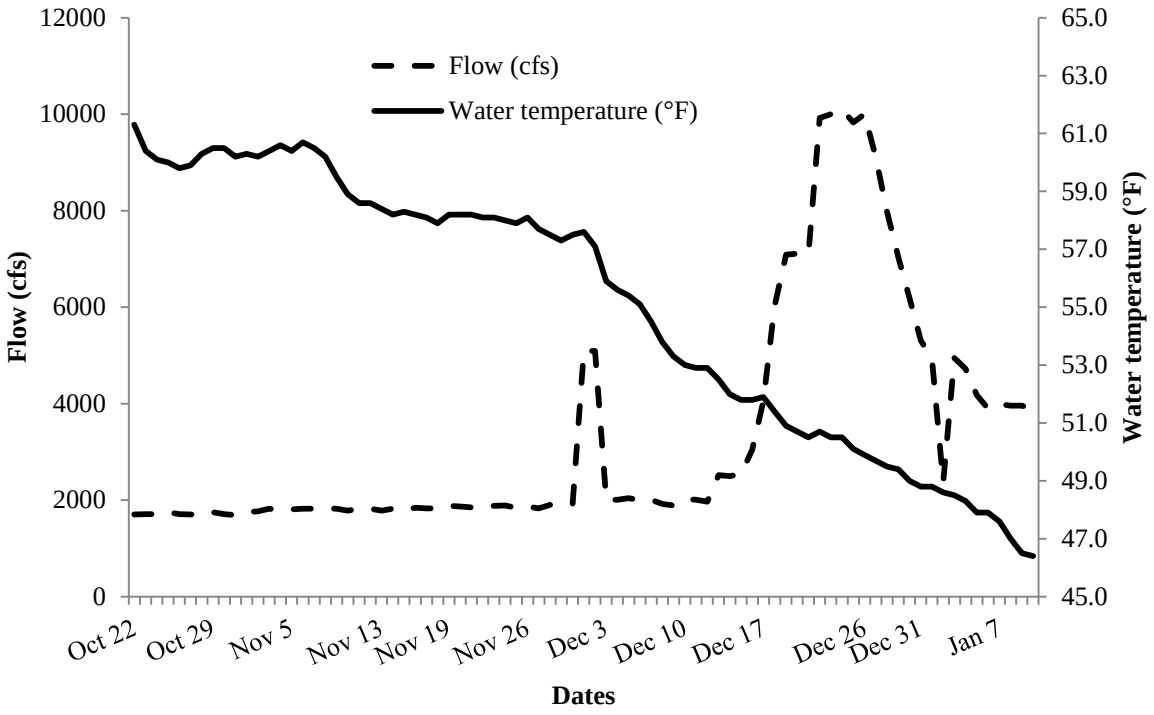

Figure 11. Lower American River noon flow (cubic feet per second) and daily average water temperature (F°) from October 2012 to January 2013 (DWR 2013), on the lower American River.

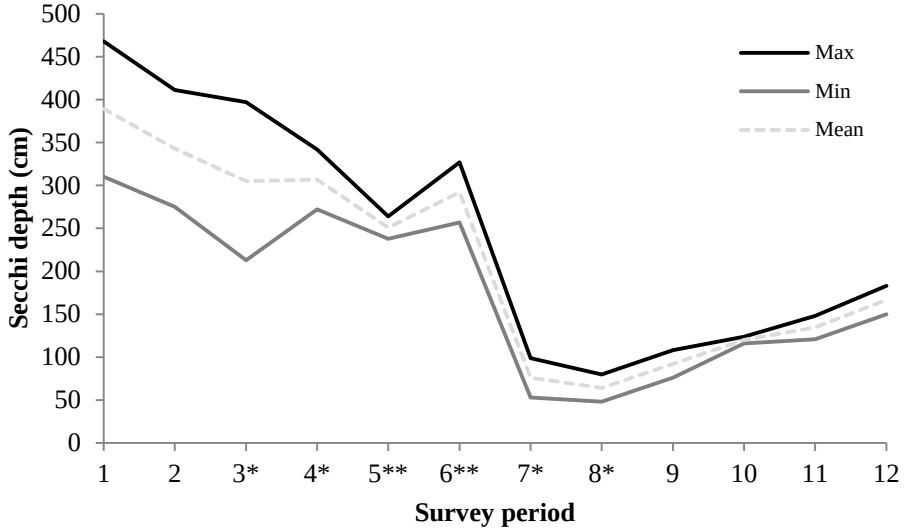

Figure 12. Lower American River water clarity data obtained from secchi measurements (cm) from October 2012 to January 2013, on the lower American River.

CONCLUSION

Environmental conditions appear to have affected the final escapement estimates of fall-run Chinook salmon in the lower American River. Heavy rains within the American River basin during late November caused the LAR to pulse from 1,920 cfs (11/30/2012) to 5,090 cfs (12/1/2012) and back down to 2,010 cfs (12/3/2012). This rapid change in flow greatly reduced water clarity from storm run-off. The pulse of flow caused many carcasses to be stranded on the shoreline, while possibly also flushing carcasses below the survey area. This removed many carcasses from the survey given that only those carcasses detected with at least 50% of their body within the wetted channel were to be included in the survey. Carcass detectability was greatly reduced by decreased water clarity and increased flow for the remainder of the survey (periods 7 to 12). Therefore, the 2012-2013 LAR fall-run Chinook salmon in-river population estimate of 34,900 (CJS) is likely low when compared to previous years' surveys with more stable environmental conditions.

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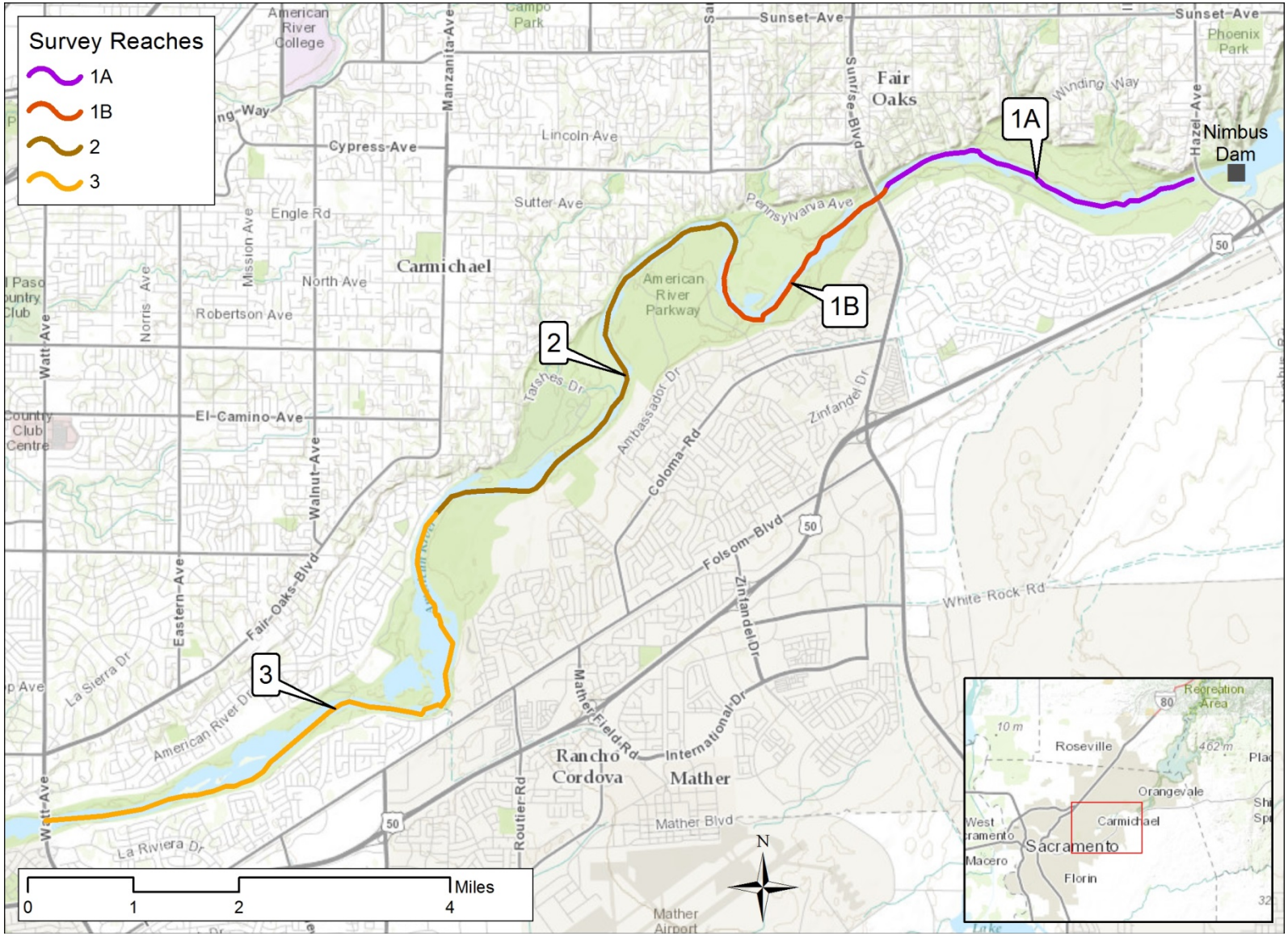
Appendix A. American River Escapement Survey Reach Map



Appendix A. Lower American River fall-run Chinook salmon escapement survey sections.

Appendix B. GrandTab: Central Valley Chinook Salmon Escapement Estimates 1967-2011

Appendix B. GrandTab Chinook salmon escapement estimates for the lower American River and Central Valley, 1967 – 2011 (Azat 2012). * = draft data.

		Escapement estimate			Total estimated Central Valley	Estimated American River escapement
Year	**Method of estimate**	**Grilse**	**Adult**	**Total**	**escapement**	**contribution (%)**
1967	Expanded Direct Counts	3,132	14,868	18,000	180,428	9.98
1968	Expanded Direct Counts	2,777	23,423	26,200	210,314	12.46
1969	Expanded Direct Counts	8,208	35,452	43,660	320,390	13.63
1970	Expanded Direct Counts	2,753	25,927	28,680	235,493	12.18
1971	Expanded Direct Counts	5,210	36,470	41,680	238,619	17.47
1972	Expanded Direct Counts	3,352	14,107	17,459	153,063	11.41
1973	Expanded Direct Counts	4,688	77,554	82,242	271,320	30.31
1974	Schaefer	1,769	51,827	53,596	234,626	22.84
1975	Expanded Direct Counts	2,699	29,433	32,132	195,389	16.45
1976	Schaefer	1,181	21,978	23,159	195,208	11.86
1977	Schaefer	4,701	36,904	41,605	185,663	22.41
1978	Schaefer	595	12,334	12,929	156,962	8.24
1979	Schaefer	896	36,419	37,315	227,646	16.39
1980	Schaefer	8,805	25,454	34,259	172,137	19.90
1981	Schaefer	2,521	40,941	43,462	260,259	16.70
1982	Expanded Direct Counts	4,323	28,677	33,000	230,706	14.30
1983	Expanded Direct Counts	7,313	19,087	26,400	205,290	12.86
1984	Petersen	2,196	25,251	27,447	262,907	10.44
1985	Schaefer	11,392	44,728	56,120	356,304	15.75
1986	Schaefer	4,443	44,929	49,372	297,820	16.58
1987	Schaefer	2,960	18,185	21,145	301,583	7.01
1988	Jolly-Seber	1,905	13,974	15,879	268,436	5.92
1989	Schaefer	2,459	14,619	17,078	182,350	9.37
1990	Schaefer	1,167	5,541	6,708	87,853	7.64
1991	Schaefer	1,506	16,639	18,145	132,455	13.70
1992	Schaefer	1,297	3,175	4,472	110,413	4.05
1993	Schaefer	6,162	20,624	26,786	165,423	16.19
1994	Schaefer	2,927	28,405	31,332	220,667	14.20
1995	Schaefer	7,010	63,086	70,069	330,168	21.22
1996	Schaefer	6,592	59,323	65,915	351,551	18.75
1997	Schaefer	4,220	42,668	46,888	402,797	11.64
1998	Schaefer	10,760	32,289	43,042	246,026	17.49
1999	Schaefer	7,716	40,509	48,225	414,259	11.64
2000	Schaefer	5,922	92,783	98,705	485,681	20.32
2001	Schaefer	10,463	120,322	130,785	624,631	20.94
2002	Schaefer	11,811	106,303	118,114	872,669	13.53
2003	Schaefer	11,571	146,945	158,516	590,992	26.82
2004	Schaefer	13,756	74,991	88,747	386,848	22.94
2005	Schaefer	2,842	54,001	56,843	437,693	12.99
2006	Schaefer	1,025	21,755	22,780	292,875	7.78
2007*	Schaefer	151	14,519	14,670	96,141	15.26
2008*	Schaefer	607	5,118	5,725	71,870	7.97
2009*	Schaefer	2,338	11,464	13,802	53,129	25.98
2010*	Schaefer	3,831	19,953	23,784	163,181	14.58
2011*	Cormack-Jolly-Seber	N/A	N/A	38,306	227,889	16.81
Average		**4,635**	**38,022**	**42,656**	**270,005**	**15.80**

Appendix C. Modified Schaefer-Derived Population Estimate for 2012-2013 Lower American River Fall-Run Chinook Salmon

Appendix C. Summary of marked and recaptured salmon carcasses from October 2012 to January 2013, on the lower American River.

Survey period	Dates	No. of carcasses tagged	Matrix of weekly recaptures										
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	Oct. 22 to Oct. 25	46											
2	Oct. 29 to Nov. 1	178	10										
3*	Nov. 5 to Nov. 8	656	1	33									
4*	Nov. 13 to Nov. 16	556	1	5	111								
5**	Nov. 19 to Nov. 21	241	0	0	18	78							
6**	Nov. 26 to Nov. 29	239	0	0	5	34	27						
7*	Dec. 3 to Dec. 6	99	0	0	1	16	10	12					
8*	Dec. 10 to Dec. 13	77	0	0	0	0	1	3	12				
9	Dec. 17 to Dec. 20	48	0	0	0	0	2	12	6	7			
10	Dec. 26 to Dec. 28	14	0	0	0	1	0	1	0	1	4		
11	Dec. 31 to Jan. 4	10	0	0	0	1	1	2	0	4	2	3	
12	Jan. 7 to Jan. 10	4	0	0	0	0	0	1	0	0	0	3	0
	Totals	**2,168**										**Total**	**429**

Appendix C. Modified Schaefer matrix for in-river fall-run Chinook salmon escapement from October 2012 to January 2013, on the lower American River.

Survey period	Dates	Matrix of population estimates												Weekly total
		1	2	3	4	5	6	7	8	9	10	11	12	
1	Oct. 22 to Oct. 25													0
2	Oct. 29 to Nov. 1	1,415												1,415
3*	Nov. 5 to Nov. 8	128	5,178											5,307
4*	Nov. 13 to Nov. 16	67	411	9,469										9,948
5**	Nov. 19 to Nov. 21	0	0	1,532	5,845									7,377
6**	Nov. 26 to Nov. 29	0	0	774	4,631	5,055								10,460
7*	Dec. 3 to Dec. 6	0	0	132	1,858	1,596	2,512							6,098
8*	Dec. 10 to Dec. 13	0	0	0	0	335	1,320	3,766						5,421
9	Dec. 17 to Dec. 20	0	0	0	0	454	3,570	1,274	1,733					7,031
10	Dec. 26 to Dec. 28	0	0	0	87	0	157	0	131	654				1,030
11	Dec. 31 to Jan. 4	0	0	0	103	142	371	0	618	385	169			1,787
12	Jan. 7 to Jan. 10	0	0	0	0	0	330	0	0	0	299	0		629
													Total estimate	56,503
													Minus number of carcasses tagged (periods 2 to 12)	-2,122
													Total in-river modified Schaefer estimate	54,381