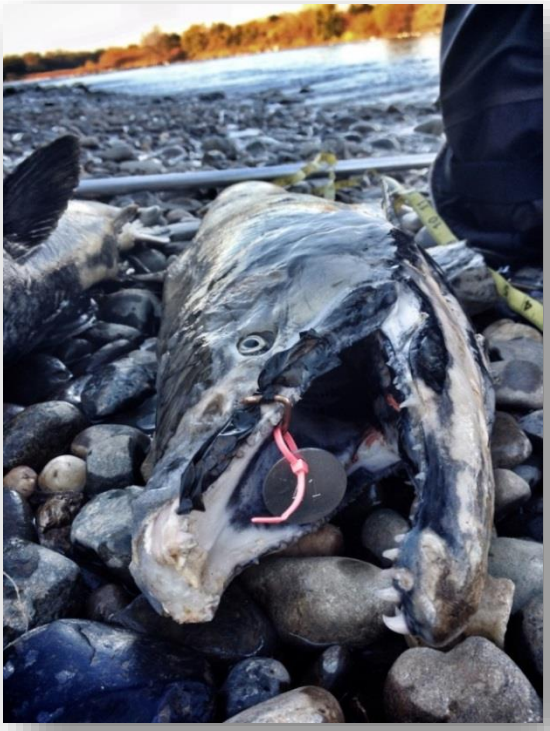
California Department of Fish and Wildlife
North Central Region

Lower American River Fall-Run Chinook Salmon Escapement Survey October 2013 – January 2014



Presented to the United States Bureau of Reclamation

By

Jeanine Phillips
California Department of Fish and Wildlife
1701 Nimbus Road, Suite A
Rancho Cordova, CA 95670

Kari Marie Gahan
Pacific States Marine Fisheries Commission
205 SE Spokane Street, Suite 100
Portland, OR 97302

2014

TABLE OF CONTENTS

TABLES AND FIGURES

ACCRONYMS

BOR	United States Bureau of Reclamation
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
USGS	United State Geological Survey

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 (Figure 1). 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 Nimbus Hatchery. The Bureau of Reclamation (BOR) created Nimbus Fish Hatchery in 1958 as a mitigation measure to compensate for loss of spawning habitat caused by the creation of Nimbus Dam (USFWS 1953). Although the California Department of Fish and Wildlife (CDFW) manages and operates Nimbus Hatchery, funding for hatchery operations and carcass surveys are provided by the BOR (CDFW 2014).

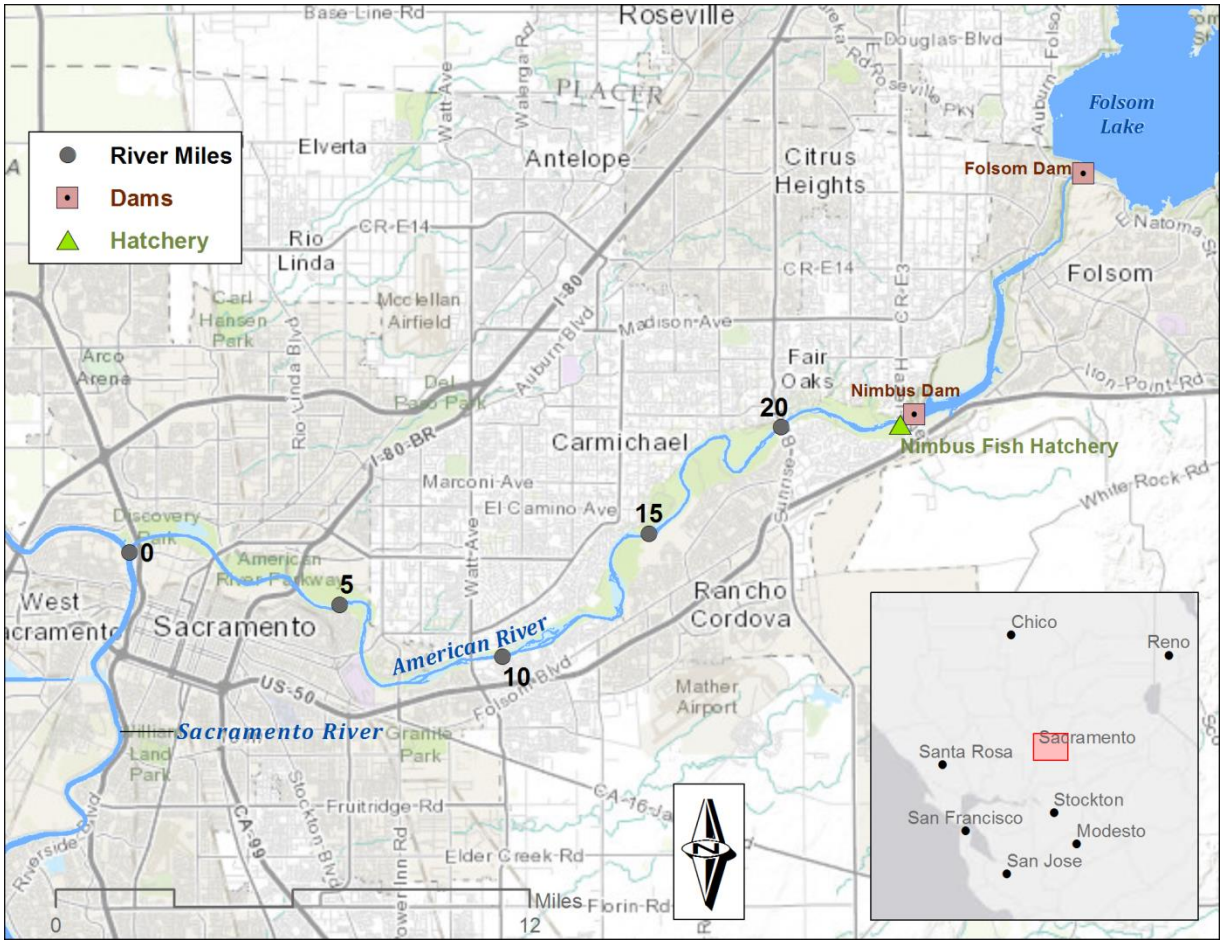


Figure 1. Map of the lower American River.

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 escapement of fall-run Chinook salmon returning to the LAR by surveying a 13.1-mile section of the river from the Nimbus Hatchery weir downstream to Watt Avenue (Table 1). The objectives of the survey were, (1) estimate the population size of returning Chinook salmon to the LAR; (2) determine the general age and sex of 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 2013 LAR escapement survey was conducted over a 12-week period between October 21, 2013 and January 8, 2014. The survey area was comprised of 13.1 miles of river from the Nimbus Hatchery weir downstream to the Watt Avenue bridge (Figure 2). 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 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 for subsections 1A and 1B were combined for analysis.

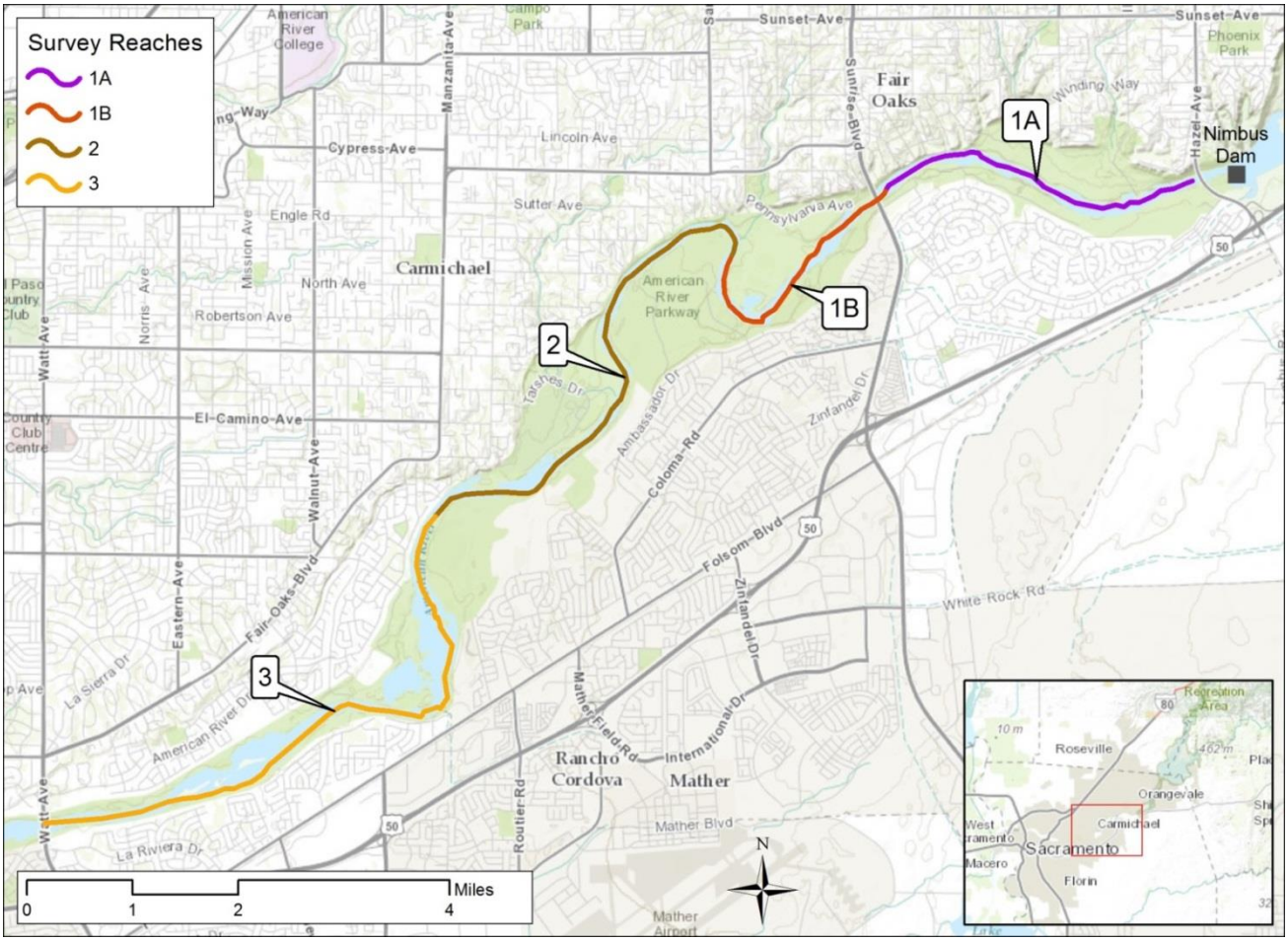


Figure 2. Lower American River Chinook escapment survey sections map.

Table 1. Lower American River escapement survey sections.

Section	Location	Miles
1A	Nimbus Hatchery weir to Sunrise Boat Launch	2.3
1B	Sunrise Boat Launch to Elmanto Dr Access	2.0
2	Elmanto Dr Access to River Bend Park	4.7
3	River Bend Park to Watt Ave Access	4.1
	Total	**13.1**

All carcasses encountered during survey periods 1 through 4 and 10 through 12 were processed according to methods described below; however, systematic and unbiased subsampling was required during survey periods 5 through 9 due to the large number of carcasses encountered. During survey periods 5, 6, and 9, every second carcass was processed and every second CWT head was collected. During survey periods 7 and 8, every second carcass was processed and every third CWT head was collected (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 subsampling was necessary, subsampling was carried out for the entire survey period.

Table 2. Lower American River survey periods and sampling regimes from October 2013 to January 2014.
* Indicates every 2nd carcass processed, then every 2nd CWT head collected.
** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

Survey period	Dates	Sampling regime: processed/observed
1	Oct. 21 - 24	1/1
2	Oct. 28 - 31	1/1
3	Nov. 4 - 7	1/1
4	Nov. 12 - 15	1/1
5*	Nov. 18 - 21	1/2
6*	Nov. 25 - 27	1/2
7**	Dec. 2 - 5	1/2
8**	Dec. 9 - 12	1/2
9*	Dec. 16 - 19	1/2
10	Dec. 23, 26-27	1/1
11	Dec. 30-31, Jan.2-3	1/1
12	Jan. 6 - 8	1/1

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

Carcasses were examined for the following characteristics: (1) presence of an external tag, (2) presence or absence of an adipose fin and (3) determination of carcass freshness. Processing types included: (1) mark/recapture, (2) CWT head collection, and (3) tally chop.

Covariate data were collected on all carcasses processed. Covariate data consisted of adipose fin status, sex, fork length, freshness, and degree of egg retention for females. Sex was determined by a combination of distinguishing characteristics which included presence/absence of a kype, laterally compressed body, and presence of eggs or milt. Fork length (FL) was measured in centimeters from the tip of the snout to the caudal fin fork. 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 physically probing the abdomen, or by dissection, and was recorded as unspawned if approximately more than 70 percent of eggs retained, partially spawned if approximately 30-70 percent of eggs retained, or spawned if approximately less than 30 percent of eggs retained. Covariate data were collected on all mark/recapture carcasses prior to initial release and CWT carcasses prior to head removal. Adipose fin status was the only covariate data collected for tally chops.

In general, fresh carcasses with an intact adipose fin were utilized for a mark/recapture study. 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 prior to re-releasing or chopping the carcass, depending on perceived probability of additional recaptures in subsequent survey periods. Carcasses with an intact adipose fin that were deemed unsuitable for mark/recapture tagging due to lack of freshness were chopped and tallied.

Carcasses with missing adipose fins were assumed to contain a CWT in their snouts. Heads were either, 1) removed and retained for CWT retrieval at a later date, or 2) chopped and tallied during subsampling periods, or if the carcass was determined to be too deteriorated for CWT removal. During subsampling periods, freshness data were not collected for adipose-clipped carcasses that were tallied and chopped.

The 2013 LAR fall-run Chinook salmon escapement estimate was derived using the superpopluation Cormack-Jolly-Seber (CJS) escapement estimation model for open populations (Cormack 1964; Bergman, et. al. 2012). The model was run on R statistical computing software, version 3.0.2 (www.r-project.org).

Water clarity, flow, and temperature data were collected daily during the course of the survey. Flow and water temperature data were obtained via the internet from the United States Geological Survey (USGS) station (11446500 American R A Fair Oaks CA) on the LAR near the Nimbus weir (USGS 2014). Water clarity was measured once per day with a secchi disk at a specific location in each section and measured to the nearest centimeter (cm).

RESULTS

Final Carcass Count

Over the 12-week survey, 48,745 fall-run Chinook salmon carcasses were observed and 27,685 were processed (Table 3). The greatest number of carcasses observed and processed in a single survey period were 11,150 and 5,575, respectively, and occurred during survey period 7 (Dec. 2 - Dec. 5) (Table 3, Figure 3).

Table 3. Total salmon carcasses processed and observed from October 2013 to January 2014, on the lower American River.
* Indicates every 2nd carcass processed, then every 2nd CWT head collected.
** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

Survey period	Dates	Salmon carcasses processed	Salmon carcasses observed
1	Oct. 21 - 24	68	68
2	Oct. 28 - 31	113	113
3	Nov. 4 - 7	381	381
4	Nov. 12 - 15	2,719	2,719
5*	Nov. 18 - 21	2,863	5,726
6*	Nov. 25 - 27	4,788	9,576
7**	Dec. 2 - 5	5,575	11,150
8**	Dec. 9 - 12	4,544	9,088
9*	Dec. 16 - 19	2,806	5,612
10	Dec. 23, 26-27	2,763	2,763
11	Dec. 30-31, Jan.2-3	695	695
12	Jan. 6 - 8	370	370
	Totals	**27,685**	**48,261**

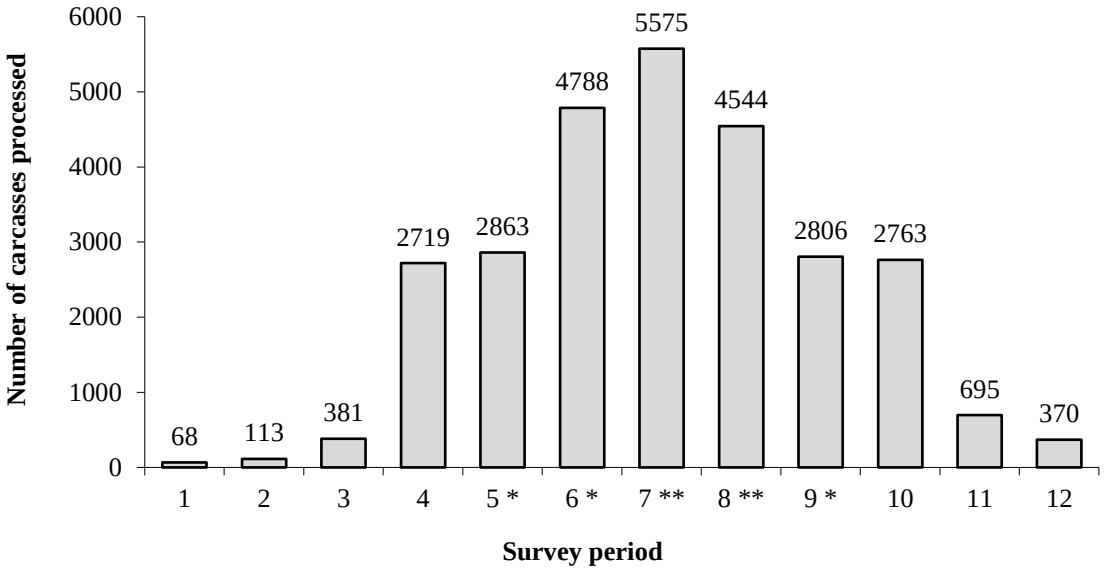


Figure 3. Temporal distribution of total salmon carcasses processed (disk-tagged, CWT chop, or tally chop) from October 2013 to January 2014, on the lower American River. * Indicates every 2nd carcass processed, then every 2nd CWT head collected. ** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

Freshness

Fresh carcasses were processed during each survey period. The greatest number of fresh carcasses processed was during survey period 4 when 707 were processed (Table 4, Figure 4). The vast majority of carcasses chosen for the mark/recapture survey were fresh (99.7 percent, *n* = 1,733), whereas the majority of adipose-clipped carcasses from which heads were collected were not fresh (81 percent, *n* = 1,753).

Table 4. Summary of salmon carcass freshness from October 2013 to January 2014, on the lower American River. * Indicates every 2nd carcass processed, then every 2nd CWT head collected. ** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

Survey period	Dates	Fresh	Not fresh	Total (%)
1	Oct. 21 - 24	15	53	**68 (0.3)**
2	Oct. 28 - 31	36	77	**113 (0.4)**
3	Nov. 4 - 7	140	241	**381 (1)**
4	Nov. 12 - 15	707	2,012	**2,719 (11)**
5*	Nov. 18 - 21	434	2,208	**2,642 (10)**
6*	Nov. 25 - 27	283	4,104	**4,387 (17)**
7**	Dec. 2 - 5	239	4,763	**5,002 (19)**
8**	Dec. 9 - 12	179	3,886	**4,065 (16)**
9*	Dec. 16 - 19	53	2,556	**2,609 (10)**
10	Dec. 23, 26-27	41	2,721	**2,762 (11)**
11	Dec. 30-31, Jan.2-3	28	667	**695 (3)**
12	Jan. 6 - 8	1	369	**370 (1)**
	Total	**2,156**	**23,657**	**25,813**
	(%)	(8)	(92)	

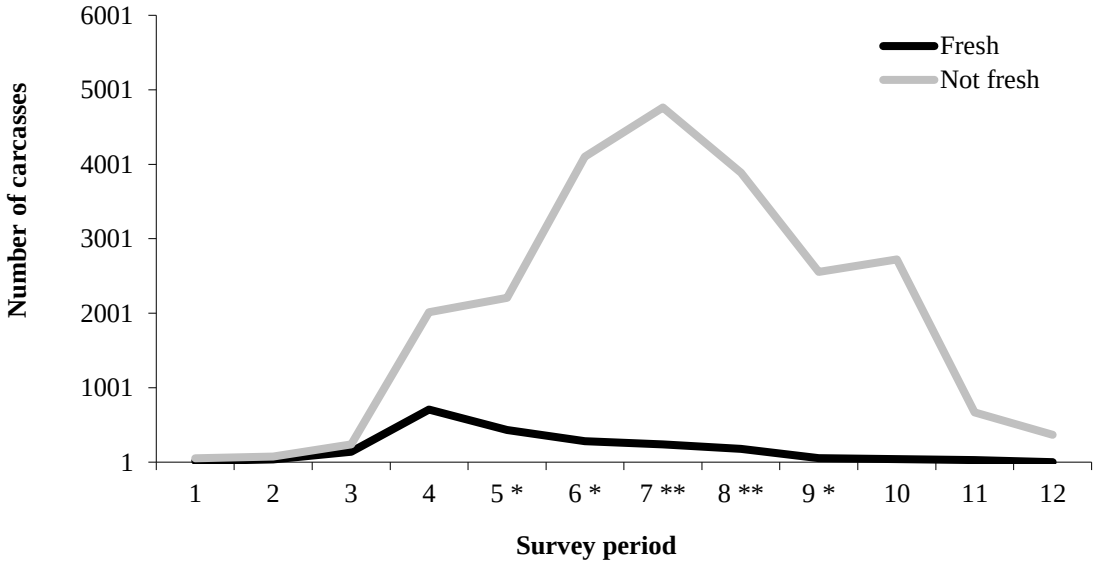


Figure 4. Temporal distribution of carcass freshness from October 2013 to January 2014, on the lower American River. * Indicates every 2nd carcass processed, then every 2nd CWT head collected. ** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

Processing Type

Of the 27,685 salmon carcasses processed, 1,738 (6 percent) were disk-tagged for mark/recapture, 2,179 heads (8 percent) were collected for CWT retrieval and 23,768 (86 percent) were chopped and tallied (Table 5, Figure 5).

Table 5. Total salmon carcasses by processing type from October 2013 to January 2014, on the lower American River. * Indicates every 2nd carcass processed, then every 2nd CWT head collected. ** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

Survey period	Dates	Tally chops	Disk-tagged	CWT chops	Weekly total (%)
1	Oct 21-24	45	10	13	**68 (0.2)**
2	Oct 2-Oct 31	63	27	23	**113 (0.4)**
3	Nov 4-7	189	121	71	**381 (1)**
4	Nov 12-15	1,650	565	504	**2,719 (10)**
5 *	Nov 18-21	2,247	360	256	**2,863 (10)**
6 *	Nov 25-27	4,169	225	394	**4,788 (17)**
7 **	Dec 2-5	5,121	193	261	**5,575 (20)**
8 **	Dec 9-12	4,180	141	223	**4,544 (16)**
9 *	Dec 16-19	2,569	40	197	**2,806 (10)**
10	Dec 23, 26-27	2,537	36	190	**2,763 (10)**
11	Dec 30-31, Jan 2-3	636	20	39	**695 (3)**
12	Jan 6-8	362	0	8	**370 (1)**
	Total	**23,768**	**1,738**	**2,179**	**27,685**
	(%)	(86)	(6)	(8)	

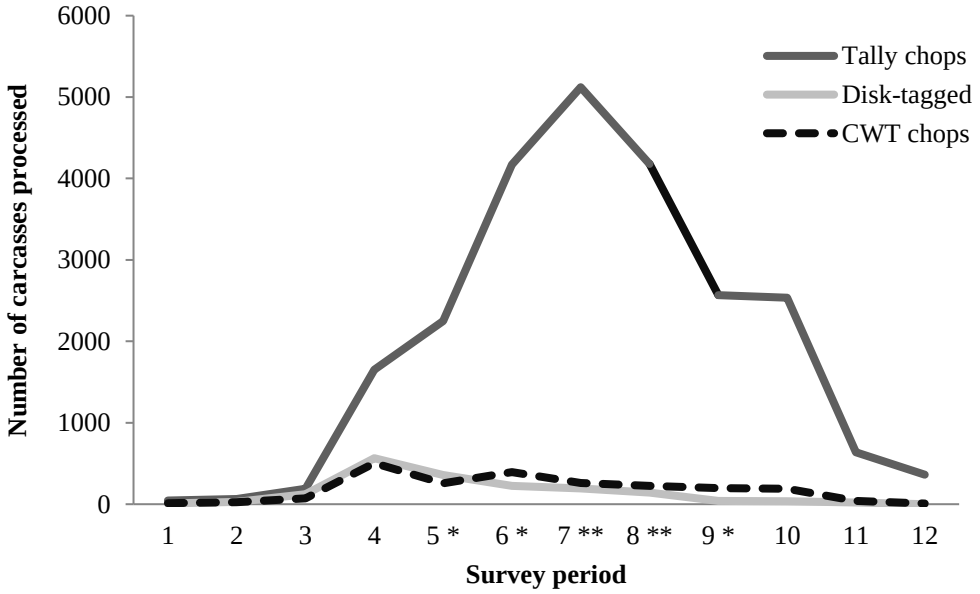


Figure 5. Temporal distribution of salmon carcass processing type from October 2013 to January 2014, on the lower American River. * Indicates every 2nd carcass processed, then every 2nd CWT head collected. ** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

Spatial Distribution

The majority of all carcasses observed occurred in sections 1A/1B (78 percent, *n* = 21,471) with a diminishing number of detections as the survey progressed downstream. Nineteen percent (*n* = 5,297) of carcasses were encountered in Section 2, and 3 percent (*n* = 917) were encountered in Section 3. Seventy-four percent of all carcasses were processed during subsampling periods 5 through 9 (Nov 18 – Dec 19) (Table 6, Figure 6). Section 3 was not surveyed during survey period 6 due to the Thanksgiving holiday.

Table 6. Total salmon carcasses processed by survey section from October 2013 to January 2014, on the lower American River. Section 3 not surveyed during survey period 6. * Indicates every 2nd carcass processed, then every 2nd CWT head collected. ** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

Survey period	Dates	Survey section			Weekly total
		1 (A+B)	2	3	
1	Oct 21-24	49	17	2	**68**
2	Oct 2-Oct 31	83	23	7	**113**
3	Nov 4-7	326	36	19	**381**
4	Nov 12-15	2,149	481	89	**2,719**
5 *	Nov 18-21	2,245	530	88	**2,863**
6 *	Nov 25-27	3,918	870	n/a	**4,788**
7 **	Dec 2-5	4,133	1,214	228	**5,575**
8 **	Dec 9-12	3,475	853	216	**4,544**
9 *	Dec 16-19	2,156	524	126	**2,806**
10	Dec 23, 26-27	2,149	507	107	**2,763**
11	Dec 30-31, Jan 2-3	599	72	24	**695**
12	Jan 6-8	189	170	11	**370**
	Total	**21,471**	**5,297**	**917**	**27,685**
	(%)	(78)	(19)	(3)	

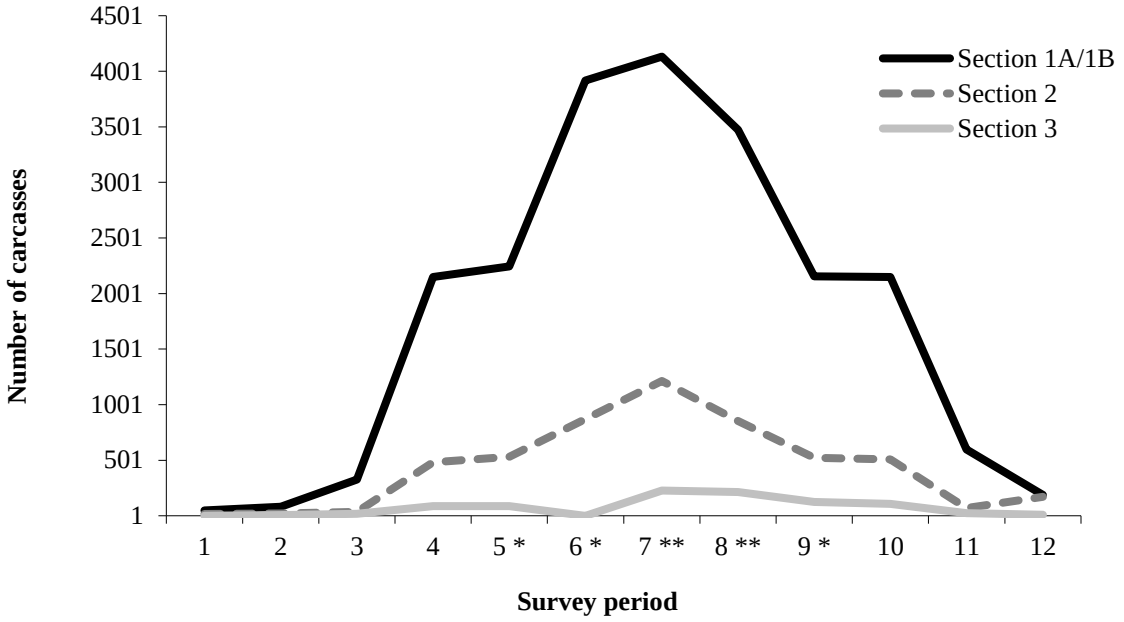


Figure 6. Temporal distribution of salmon carcasses processed by survey section from October 2013 to January 2014, on the lower American River. * Indicates every 2nd carcass processed, then every 2nd CWT head collected. ** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

Length Composition

Fork length data were recorded for 3,917 carcasses (Figure 7). The minimum and maximum FLs for male carcasses were 48 cm and 112 cm, respectively, with a mean and mode of 87 cm. Minimum and maximum recorded FLs for female carcasses were 49 cm and 104 cm, respectively, with a mean of 83 cm and a mode of 79 cm. Length data were not recorded for 3 carcasses.

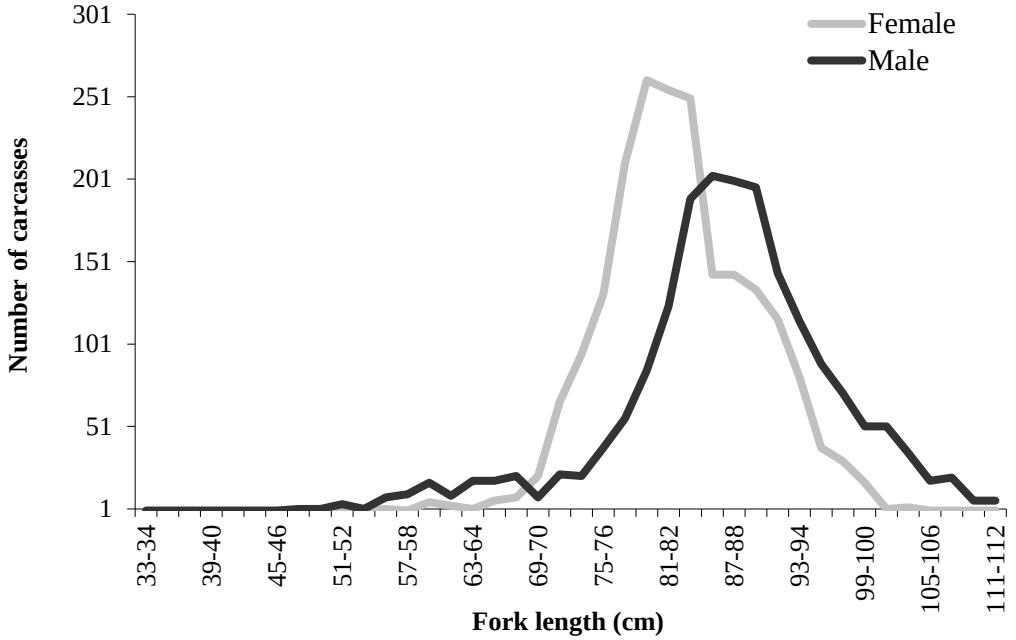


Figure 7. Salmon carcass fork length frequency distribution by sex from October 2013 to January 2014, on the lower American River.

Sex and Age Composition

Sex data were recorded for a total of 3,786 carcasses. Females comprised 52 percent (*n* = 2,020) and males comprised 48 percent (*n* = 1,858; Table 7) of processed carcasses. Sex data were not recorded for 48 carcasses.

Table 7. Summary of processed salmon carcasses by age class and sex from October 2013 to January 2014, on the lower American River. * Indicates every 2nd carcass processed, then every 2nd CWT head collected. ** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

Survey period	Dates	Grilse		Adults		Weekly total	
		Females	Males	Females	Males	Females	Males
1	Oct 21-24	0	1	14	6	14	7
2	Oct 2-Oct 31	0	0	31	14	31	14
3	Nov 4-7	0	10	105	68	105	78
4	Nov 12-15	2	27	556	478	558	505
5 *	Nov 18-21	3	12	330	269	333	283
6 *	Nov 25-27	1	19	310	279	311	298
7 **	Dec 2-5	0	11	226	212	226	223
8 **	Dec 9-12	0	11	184	168	184	179
9 *	Dec 16-19	3	8	110	116	113	124
10	Dec 23, 26-27	2	16	103	104	105	120
11	Dec 30-31, Jan 2-3	0	1	37	21	37	22
12	Jan 6-8	0	0	3	5	3	5
	Total	**11**	**116**	**2,009**	**1,740**	**2,020**	**1,858**
	(%)	(8)	(89)	(53)	(46)	(52)	(48)

Age class assignment was determined via a length frequency analysis using length data collected from 3,914 carcasses (Figure 7). Males were classified as adults if FL was > 70 cm, or grilse if FL was ≤ 70 cm. Females were classified as adults if FL was > 64 cm, or grilse if FL was ≤ 64 cm. Ninety-seven percent (*n* = 3,781) of carcasses were categorized as adults and 3 percent (*n* = 130) were classified as grilse (Figure 8, Table 8). Adult Chinook salmon accounted for at least 92 percent of carcasses processed during each survey period. No grilse were encountered during survey periods 2 and 12 (Figure 9). Over the course of the survey, sex was not recorded or could not be determined for 38 carcasses; however, of these 38, three carcasses were classified as grilse (< 64 cm) and 32 were classified as adults (> 70 cm).

Adult carcass proportions were 53 percent female (*n* = 2,009) and 46 percent male (*n* = 1,740). Grilse carcass proportions were 89 percent male (*n* = 116) and 8 percent female (*n* = 11).

Figure 8. Total salmon carcasses processed by age class and sex from October 2013 to January 2014, on the lower American River.

Table 8. Summary of processed salmon carcasses by age class from October 2013 to January 2014, on the lower American River. * Indicates every 2nd carcass processed, then every 2nd CWT head collected. ** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

Survey period	Dates	Grilse	Adults
		n (%)	*n* (%)
1	Oct 21-24	1 (4)	22 (96)
2	Oct 2-Oct 31	0 (0)	50 (100)
3	Nov 4-7	10 (5)	181 (95)
4	Nov 12-15	29 (3)	1,039 (97)
5 *	Nov 18-21	15 (2)	599 (98)
6 *	Nov 25-27	22 (4)	597 (96)
7 **	Dec 2-5	12 (3)	441 (97)
8 **	Dec 9-12	11 (3)	352 (97)
9 *	Dec 16-19	11 (5)	226 (95)
10	Dec 23, 26-27	18 (8)	208 (92)
11	Dec 30-31, Jan 2-3	1 (2)	58 (98)
12	Jan 6-8	0 (0)	8 (100)
	Total (%)	**130 (3)**	**3,781 (97)**

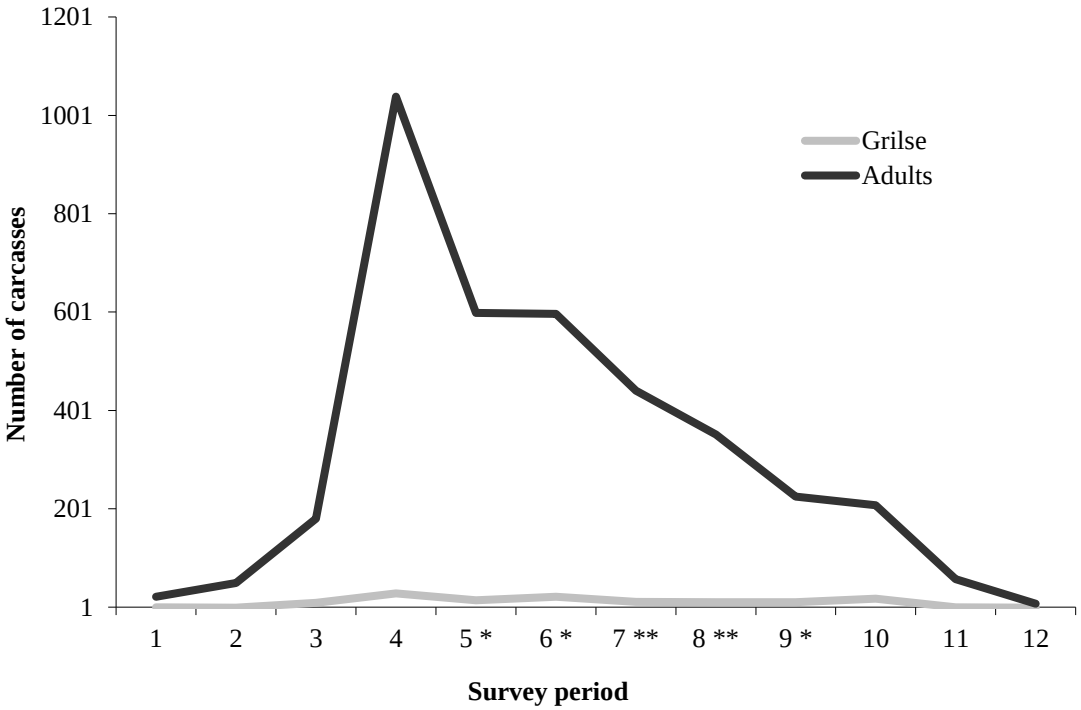


Figure 9. Temporal distribution of salmon age classes from October 2013 to January 2014, on the lower American River. * Indicates every 2nd carcass processed, then every 2nd CWT head collected. ** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

Egg Retention

A total of 1,901 adult and grilse female carcasses were examined for egg retention (Table 9, Figure 10). Seventy-six percent (*n* = 1,442) of female carcasses were spawned, 12 percent (*n* = 234) partially spawned, and 12 percent (*n* = 225) unspawned. During the survey, the percentage of spawned female carcasses increased from 0-21 percent in survey periods 1 and 2, and from 97-100 percent during survey periods 11 and 12.

Table 9. Female egg retention from October 2013 to January 2014, on the lower American River. * Indicates every 2nd carcass processed, then every 2nd CWT head collected. ** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

Survey period	Dates	Female egg retention			Weekly total
		0 to 29%	30 to 69%	70 to 100%	
		n (%)	*n* (%)	*n* (%)	
1	Oct 21-24	0 (0)	2 (25)	6 (75)	**8**
2	Oct 2-Oct 31	6 (21)	6 (21)	17 (59)	**29**
3	Nov 4-7	44 (45)	30 (31)	24 (24)	**98**
4	Nov 12-15	404 (73)	81 (15)	67 (12)	**552**
5 *	Nov 18-21	249 (76)	43 (13)	36 (11)	**328**
6 *	Nov 25-27	239 (83)	22 (8)	28 (10)	**289**
7 **	Dec 2-5	184 (84)	22 (10)	14 (6)	**220**
8 **	Dec 9-12	128 (76)	19 (11)	21 (13)	**168**
9 *	Dec 16-19	79 (88)	2 (2)	9 (10)	**90**
10	Dec 23, 26-27	75 (89)	6 (7)	3 (4)	**84**
11	Dec 30-31, Jan 2-3	31 (97)	1 (3)	0 (0)	**32**
12	Jan 6-8	3 (100)	0 (0)	0 (0)	**3**
	Total (%)	**1,442 (76)**	**234 (12)**	**225 (12)**	**1,901**

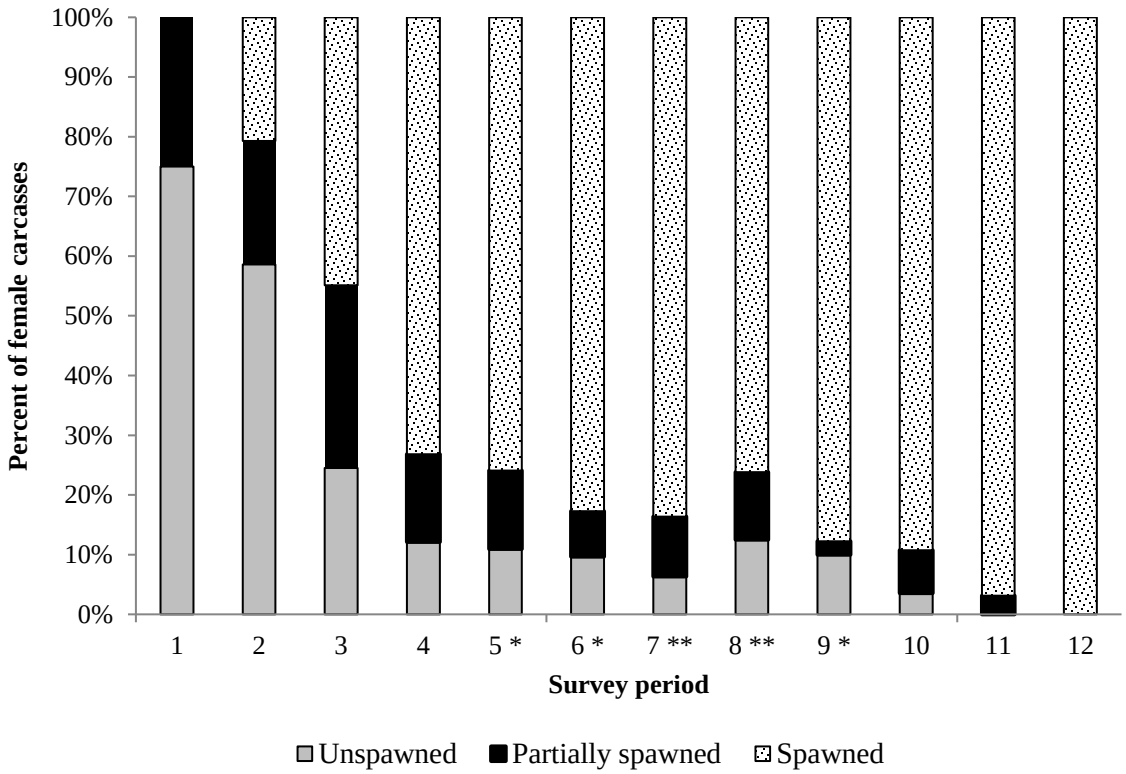


Figure 10. Temporal distribution of female egg retention from October 2013 to January 2014, on the lower American River. * Indicates every 2nd carcass processed, then every 2nd CWT head collected. ** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

CWT Carcasses[1]

A total of 27,685 carcasses were examined for the presence of an adipose fin. Fifteen percent (*n* = 4,148) were missing an adipose fin and, of these, 2,177 heads were collected for CWT extraction (Table 10). The remaining 1,971 adipose-clipped carcasses were chopped and tallied. The adipose fin status could not be determined definitively on 3,408 carcasses (12 percent); these carcasses were chopped, tallied and recorded as skeletons (unknown adipose fin status). Seventy-three percent of carcasses had an intact adipose fin (*n* = 20,129). During survey periods 5, 6 and 9, heads were collected from every other adipose-clipped carcass observed. During survey periods 7 and 8, heads were collected from every third adipose-clipped carcass observed. The largest number of adipose-clipped carcasses were processed during survey period 7 (*n* = 839) (Table 10, Figure 11).

[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. To query specific CWT data from this survey, visit www.rmpc.org.

Table 10. Summary of adipose fin condition from October 2013 to January 2014, on the lower American River. * Indicates every 2nd carcass processed, then every 2nd CWT head collected. ** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

Survey period	Dates	Adipose status			Heads collected
		Intact	Clipped	Skeleton	
1	Oct 21-24	38	14	16	12
2	Oct 2-Oct 31	73	24	16	23
3	Nov 4-7	301	71	9	71
4	Nov 12-15	2,202	511	6	503
5 *	Nov 18-21	2,350	497	16	256
6 *	Nov 25-27	3,961	807	20	394
7 **	Dec 2-5	4,569	839	167	261
8 **	Dec 9-12	3,402	708	434	223
9 *	Dec 16-19	1,739	394	673	197
10	Dec 23, 26-27	1,176	226	1,361	190
11	Dec 30-31, Jan 2-3	235	47	413	39
12	Jan 6-8	83	10	277	8
	Total	**20,129**	**4,148**	**3,408**	**2,177**
	(%)	(73)	(15)	(12)	

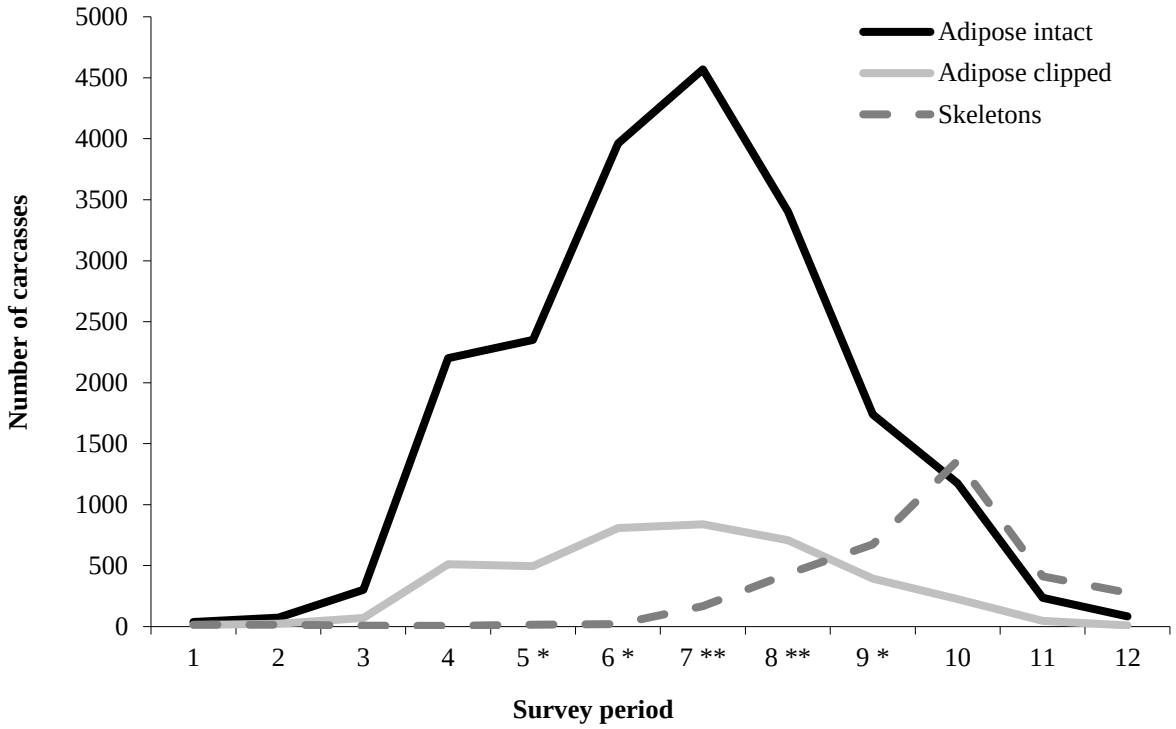


Figure 11. Temporal distribution of processed salmon with adipose fin intact or clipped from October 2013 to January 2014, on the lower American River. * Indicates every 2nd carcass processed, then every 2nd CWT head collected. ** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

Escapement Estimate

A total of 1,738 carcasses were disk-tagged and released from October 21, 2013 to January 3, 2014. The total number of disk-tagged carcasses recaptured was 836. The capture rate reported by the CJS model was positively related to length and varied from 30-45 percent. The in-river fall-run LAR Chinook salmon escapement estimate from the CJS model is 54,259. The bootstrap estimate of the standard error of estimated total escapement is 1,168 (n = 1,000). The 90 percent bootstrap percentile confidence interval is 52,221 to 56,083.

In addition to the in-river estimates, 9,076 carcasses (8,301 adults and 775 grilse) were collected at Nimbus Hatchery, and 3,969 carcasses (3,405 adult and 564 grilse) were collected above Nimbus weir by hatchery personnel. The hatchery uses a standard 68 cm as the cutoff for male and female grilse.

The combined 2013 LAR fall-run Chinook salmon escapement estimate from the in-river survey, Nimbus Hatchery and weir collections is 67,304.

Environmental Conditions

LAR water temperature decreased an average of 0.2°F per day over the length of the survey. The minimum and maximum water temperatures recorded by the USGS gauge were 48.8°F (1/7/2014) and 62.7°F (10/23/2013), respectively, with an average temperature of 54.8°F. (Figure 12)

The LAR minimum and maximum flows during the survey were 692 cfs (1/08/2014) and 1,389 cfs (12/07/2013), respectively (Figure 12). Flow remained relatively consistent during the initial 10 survey periods. Flow releases from Folsom and Nimbus dams were reduced during the months of December and January due to low storage conditions in Folsom Lake and the statewide drought. On December 29th (survey period 11), flows were reduced by 200 cfs, from 1300 to 1100 cfs. During the time period between January 7 – 10, flows were further reduced from 1100 to 500 cfs (survey period 12).

The minimum and maximum recorded secchi depths were 196 cm (11/25/2013) and 543 cm (10/31/2013), respectively, with a mean of 333 cm (Figure 13). Mean water clarity declined by 256 cm over the first 6 survey periods. Water clarity increased during survey periods 7 – 10 by 175 cm. During the concluding two survey periods, 11 and 12, water clarity decreased once again by 88 cm (Figure 13).

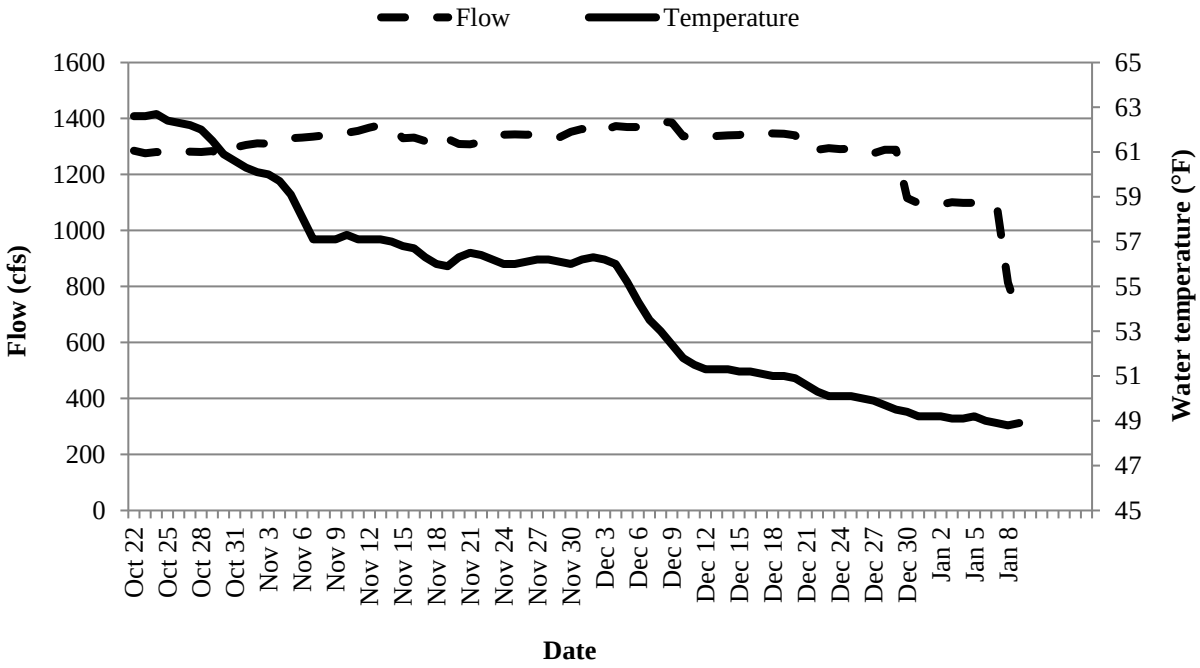


Figure 12. Lower American River average daily flow (cubic feet per second) and average daily water temperature (°F) from October 2013 to January 2014. (Data source: USGS 2014.)

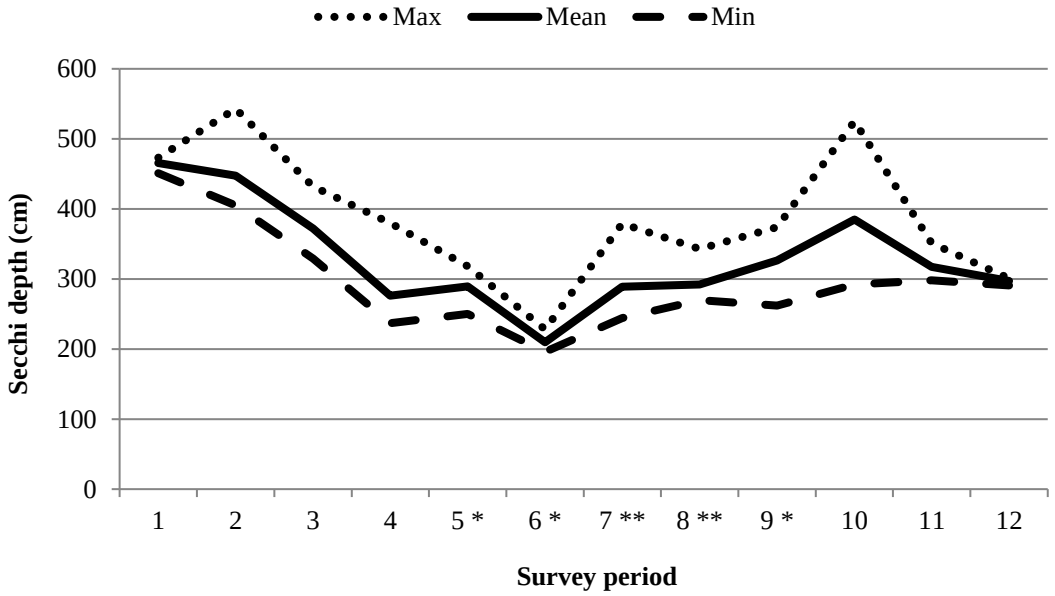


Figure 13. Lower American River water clarity data obtained from secchi measurements (cm) from October 2013 to January 2014. * Indicates every 2nd carcass processed, then every 2nd CWT head collected. ** Indicates every 2nd carcass processed, then every 3rd CWT head collected.

CONCLUSIONS

Very few carcasses were observed at the beginning of the 2013 LAR carcass survey compared to previous years. Approximately 12 percent of the total carcasses processed had been encountered by the middle of November. In comparision, 27 to 32 percent of total carcasses processed had been encountered by mid-November during the years 2010 to 2012 (Maher, et al. 2011; Phillips and Maher 2012; Phillips and Helstab 2013). Reasons for the slow beginning to migration is unclear, but might be attributed to the lower-than-normal flows in the LAR (USGS 2014).

Over the past 7 survey seasons, the survey period in which the largest number of carcasses have been observed by survey crews has ranged from mid-November to mid-December. Peak carcass observations and numbers processed occurred within the normal time-frame during the first week of December 2013 (survey period 7).

The proportion of fresh carcasses (92 percent) was the lowest since at least 2007. However, the temporal distribution of fresh carcasses throughout the survey has remained relatively stable over the past 3 years. Typically, the number of fresh carcasses encountered increases over the first 2-5 survey periods, peaks, then gradually declines over the remainder of the survey.

From 2008 to 2011, the number of carcasses encountered in section 1A/B steadily declined; however, in 2012, the numbers began to rise again. The number of carcasses encountered in section 1A/B this season was the highest (78 percent) since 2009. This season's increase in carcasses in the upper survey section may be due to the absence of high flows in excess of 5,000 cfs from dam releases or storm events which typically push many carcasses onto the banks or farther downstream out of the survey area. In addition, gravel restoration activities in the upper river section over the past 6 years has increased the amount of salmonid spawning habitat.

Egg retention by female carcasses can vary greatly from season to season. The number of spawned females ranged from 80 to 88 percent during 2007 to 2009 (Healey and Redding 2008; Vincik and Kirsch 2009; Vincik and Mammola 2010), and from 48 to 76 percent during 2010 to 2013 (Maher, et al. 2011; Phillips and Maher 2012; Phillips and Helstab 2013). During 2013, 76 percent of females examined for egg retention were fully spawned: the highest proportion since 2009. Most spawning occurs after water temperatures fall below 60°F which typically occurs at the beginning of November. Due to the late timing of the river temperature decrease, i.e., after salmon have been in the river for approximately 2 months, most unspawned females are encountered during the first few survey periods, then gradually decline throughout the remainder of the survey. The number of unspawned female carcasses processed this season followed a similar trend.

The proportion of adipose-clipped carcasses processed during the survey equaled 17 percent. However, salmon spawned and raised at Nimbus Fish Hatchery on the LAR are clipped at a rate of 25 percent. In comparison, during the 2011 and 2012 surveys, adipose-clipped carcasses accounted for 24 and 25 percent of total carcasses processed, respectively. In addition, the proportions of adipose-clipped carcasses trapped in the hatchery and recovered from the weir during 2013 were 26 percent and 21 percent, respectively. Adipose-clipped proportions in excess of 25 percent are usually attributed to

hatchery-raised salmon straying into the LAR. At the time this report was drafted, CWT recovery data were not available, thus the origins of the adipose-clipped carcasses could not be examined.

The 2013 escapement estimate of 54,259 is the highest estimate since 2005 (Appendix A). LAR escapement estimates have increased steadily since the population crash in 2008 when only 1,728 salmon were estimated to have returned to the river.

Lack of rain and relatively low water flows provided optimal conditions for carcass detection which may have, in turn, increased the accuracy of the 2013 escapement estimate. While these environmental conditions were favorable for survey work, the low flows resulted in redd superimosition, and may adversely affect hatching, rearing and out-migration of juvenile salmon. Further flow reductions since the conclusion of the 2013 escapement survey during incubation and rearing periods have resulted in redd de-watering, side channel and pool isolation, and juvenile stranding. Juvenile salmon may also be subjected to increased predation and higher water temperatures.

ACKNOWLEDGMENTS

Special thanks are due to the Bureau of Reclamation for funding. Credit for the successful survey rests on the commitment and dedication of the 2013 field crew: Lee Duckwall, Kassie Hickey, Hideaki (Shig) Kubo, Michael Paccassi, and Jamie Sweeney. Amy Roberts with Pacific States Marine Fisheries Commission was instrumental in the completion of administrative tasks.

LITERATURE CITED

Azat, J. California Department of Fish and Wildlife. Anadromous Resources Assessment: Grand Tab. http://www.calfish.org/Programs/CDFGAnadromousResourcesAssessment/tabid/213/Default.aspx. Report Compiled April 18, 2013.

Bergman, J. M., R. M. Nielson and A. Low. 2012. Central Valley in-river Chinook Salmon escapement monitoring plan. Fisheries Branch Administrative Report Number: 2012-1. California Department of Fish and Game. Sacramento, California.

Cormack, R. M. 1964. Estimates of survival from the sightings of marked animals. Biometrika 51:429 – 438.

[CDFW] California Department of Fish and Wildlife. Nimbus Fish Hatchery History. https://www.dfg.ca.gov/fish/Hatcheries/Nimbus/History.asp. Accessed January 2014.

Gerstung, E.R. 1971. Fish and wildlife resources of the American River. California Department of Fish and Game, Technical Report.

Healey, M. and J. Redding. 2008. Lower American River Chinook salmon escapement survey October 2007 – January 2008. California Department of Fish and Game. Rancho Cordova, California.

Maher, M., R. Vincik and J. Phillips. 2011. Lower American River fall-run Chinook salmon escapement survey 19 October – 15 December 2010. California Department of Fish and Game. Rancho Cordova, California.

Phillips, J. and J. M. Helstab. 2013. Lower American River fall-run Chinook salmon escapement survey October 2012 – January 2013. California Department of Fish and Wildlife. Rancho Cordova, California.

Phillips, J. and M. Maher. 2012. Lower American River fall-run Chinook salmon escapement survey October 2011 – January 2012. California Department of Fish and Game. Rancho Cordova, California.

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

Snider, B. and K. Vyverberg. 1996. Chinook salmon redd survey lower American River 1995. California Department of Fish and Game, Environmental Sciences Division, Stream Flow and Habitat Evaluation Program.

[USGS] U.S. Geological Survey. 2014. USGS 11446500 AMERICAN R A FAIR OAKS California. http://waterdata.usgs.gov/ca/nwis/uv/?site_no=11446500&PARAmeter_cd=00065,00060.

Accessed 2014 January.

[USFWS] U.S. Fish and Wildlife Service and California Department of Fish and Game. A plan for the protection and maintenance of salmon and steelhead in the American River, California, together with recommendations for action. Prepared jointly by U.S. Fish and Wildlife Service and California Department of Fish and Game. June 20, 1953. 47 pages. Available from: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=68916

Vincik, R. and J. Kirsch. 2010. Lower American River Chinook salmon escapement survey October 2008 – January 2009. California Department of Fish and Game. Rancho Cordova, California.

Williams, J.G. 2001. Chinook salmon in the Lower American River, California's largest urban stream. Contributions to the Biology of Central Valley Salmonids. State of California, The Resources Agency, Department of Fish and Game. Fish Bulletin 179(2):1-38.

Zeug, S.C., L. K. Albertson, H. Lenihan, H. Hardy and B. Cardinale. 2010. Predictors of Chinook salmon extirpation in California's Central Valley. Fisheries Management and Ecology 18(1):61-71.

Appendix A. GrandTab: Central Valley Chinook Salmon Escapement Estimates 1967-2012

Appendix A. GrandTab Chinook salmon escapement estimates for the lower American River and Central Valley, 1967 – 2012 (Azat 2013). * Indicates draft data.

Year	Method of estimate	Lower American River escapement estimate			Total Central Valley escapement estimate	Lower American River estimated escapement contribution (%)
		Hatchery	In-River	Total		
1967	Expanded Direct Counts	5,147	18,000	23,147	180,428	12.8
1968	Expanded Direct Counts	5,233	26,100	31,333	210,314	14.9
1969	Expanded Direct Counts	3,065	44,200	47,265	320,390	14.8
1970	Expanded Direct Counts	8,629	28,680	37,309	235,493	15.8
1971	Expanded Direct Counts	10,110	41,680	51,790	238,619	21.7
1972	Expanded Direct Counts	7,042	17,459	24,501	153,063	16.0
1973	Expanded Direct Counts	12,535	82,252	94,777	271,320	34.9
1974	Schaefer	8,200	53,596	61,796	234,626	26.3
1975	Expanded Direct Counts	7,412	32,132	39,544	195,389	20.2
1976	Schaefer	5,215	23,159	28,374	195,208	14.5
1977	Schaefer	6,868	41,605	48,473	185,663	26.1
1978	Schaefer	8,162	12,929	21,091	156,962	13.4
1979	Schaefer	10,351	37,315	47,666	227,646	20.9
1980	Schaefer	15,543	34,259	49,802	172,137	28.9
1981	Schaefer	20,593	43,462	64,055	260,259	24.6
1982	Expanded Direct Counts	10,898	33,000	43,898	230,706	19.0
1983	Expanded Direct Counts	8,900	26,400	35,300	205,290	17.2
1984	Petersen	12,249	27,447	39,696	262,907	15.1
1985	Schaefer	9,093	56,120	65,213	356,304	18.3
1986	Schaefer	5,695	49,372	55,067	297,820	18.5
1987	Schaefer	6,258	39,885	46,143	301,583	15.3
1988	Jolly-Seber	8,625	24,889	33,514	268,436	12.5
1989	Schaefer	9,741	19,183	28,924	182,350	15.9
1990	Schaefer	4,850	5,339	10,189	87,853	11.6
1991	Schaefer	7,128	17,683	24,811	132,455	18.7
1992	Schaefer	6,456	5,911	12,367	110,413	11.2
1993	Schaefer	10,656	31,027	41,683	165,423	25.2
1994	Schaefer	8,567	33,598	42,165	220,667	19.1
1995	Schaefer	6,498	70,618	77,116	330,168	23.4
1996	Schaefer	7,651	69,745	77,396	351,551	22.0
1997	Schaefer	5,650	47,195	52,845	402,797	13.1
1998	Schaefer	11,788	50,457	62,245	246,026	25.3
1999	Schaefer	9,760	55,339	65,099	414,259	15.7
2000	Schaefer	11,160	100,852	112,012	485,681	23.1
2001	Schaefer	11,750	135,384	147,134	624,631	23.6
2002	Schaefer	9,817	124,252	134,069	872,669	15.4
2003	Schaefer	14,887	163,742	178,629	590,992	30.2
2004	Schaefer	26,400	99,230	125,630	386,848	32.5
2005	Schaefer	22,349	62,679	85,028	437,693	19.4
2006	Schaefer	8,728	24,540	33,268	292,954	11.4
2007*	Schaefer	4,597	10,120	14,717	97,168	15.1
2008*	Schaefer	3,232	2,514	5,746	71,291	8.1
2009*	Schaefer	4,789	5,297	10,086	53,129	19.0
2010*	Schaefer	9,095	14,688	23,783	163,190	14.6
2011*	Cormack-Jolly-Seber	12,680	25,626	38,306	227,889	16.8
2012*	Cormack-Jolly-Seber	9,257	38,328	47,585	341,759	13.9
	Average	**9,420**	**43,637**	**53,056**	**270,661**	**18.8**