California Department of Fish and Wildlife
North Central Region

Lower American River Fall-Run Chinook Salmon Escapement Survey October 2017 - January 2018

Presented to the United States Bureau of Reclamation

By

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INTRODUCTION

The Central Valley of California consists of the Sacramento River watershed and the San Joaquin River watershed. Historically, these two watersheds allowed for the natural production of one of the most productive Chinook salmon (*Oncorhynchus tshawytscha*) fisheries on the west coast of the United States with an estimated population of 2 million individuals (100,000 late fall-run; 200,000 winter-run; 700,000 spring-run; and 900,000 fall-run) (CHSRG 2012). Many other species including steelhead trout (*Oncorhynchus mykiss*) were broadly distributed throughout the system, with a historical run that may have approached 1 to 2 million adults annually (McEwan 2001). Currently, the amount of Chinook salmon spawning and holding habitat lost in the Central Valley watershed exceeds 72%, and may be as high as 95%, as most of the prime spawning habitat is in inaccessible reaches of river (Yoshiyama et al. 2000, Moyle 2002). Within the Sacramento River Basin lies two of its largest tributaries, the Feather River and the American River, which drain 1,900 square miles.

The lower American River (LAR) is a 23-mile stretch extending from the base of Nimbus Dam downstream to the confluence of the Sacramento River. The LAR supports both wild and hatchery fall-run Chinook salmon (FRCS) spawning and rearing. Adult escapement to the LAR has historically represented an average of 14% of all returning FRCS runs to the Central Valley (Vincik and Mamola 2010). FRCS spawning typically starts in early November, or when water temperatures drop to 60°F or lower (Williams 2001). Federally endangered Sacramento River winter-run Chinook salmon also use the LAR as a critical rearing habitat during their outward migration to the Pacific Ocean (Phillis et al. 2018), and it is assumed that successful reproduction of this Environmentally Significant Unit (ESU) has occurred within the LAR (Silva and Bouton 2015).

Between the early 1940s and 1970s, five hatcheries were constructed in the Central Valley to mitigate for the loss of habitat associated with the construction of several major dams (CHSRG 2012). Presently, in the Sacramento River watershed, FRCS are propagated at Coleman National Fish Hatchery (CNFH), Feather River Hatchery (FRH), Nimbus Fish Hatchery (NFH), Mokelumne River Fish Installation (MRFI) and Merced River Fish Facility (MRFF); spring-run Chinook are propagated at FRH; late fall-run Chinook are propagated at CNFH; and winter-run Chinook are propagated at the Livingston Stone National Fish Hatchery (LSNFH) (CHSRG 2012). Annual FRCS juvenile production on the LAR is supplemented by the yearly release of salmon cohorts raised at the NFH. NFH was constructed in 1958 by the United States Bureau of Reclamation (USBR) to mitigate for the loss of spawning habitat upstream of Nimbus Dam (USFWS and CDFG 1953; CDFW 2017). Currently, the California Department of Fish and Wildlife (CDFW) oversees hatchery operations while funding for Nimbus Hatchery operations are provided by USBR (CDFW 2017).

Salmon escapement surveys have been conducted on the LAR since 1944 (Gerstung 1971). Annual escapement survey data are used extensively as an aid in preparing fishing regulations

and harvest limits, as an index to the status of the resource, as the basis for the planning and implementation of habitat restoration activities, to evaluate proposed water project developments, to monitor hatchery success, and as a factor to consider in seasonal water operations.

The objectives of this escapement survey are to estimate, (1) the size of FRCS escapement in the LAR; (2) age class (adult or grilse) and sexual composition; (3) female egg retention rate; and (4) the number and origin of hatchery-reared, coded-wire tagged (CWT) FRCS using spawning habitat in the LAR.

METHODS

The LAR escapement survey was initiated on October 17, 2017. During each survey week, the 13.1-mile stretch of river from the Nimbus Weir downstream to Watt Avenue was divided into four sections and surveyed for salmon carcasses once over a 3 to 4-day period (Figure 1, Table 1). Sections 1A and 1B are composed primarily of riffles, glides and backwater pools. Section 2 contains a few rapids, but consists mainly of large, deep water glides. Section 3 contains riffles, large deep-water glides, and several braided side-channels and requires crews to survey from the shore, jet boat, and kayaks. Section 1 (A+B) contains the greatest number of FRCS spawners (Snider and Vyverberg 1996), whereas the section of river between the mouth and Watt Avenue has very little spawning habitat and is primarily a migration corridor.

Survey crews consisting of 4 to 9 members searched for submerged salmon carcasses within each section while walking along the riverbanks, riding in a jet boat, or paddling a kayak. Crews started at the upstream border of each section and moved downstream and processed all carcasses encountered. Salmon carcasses found to be $\leq$50% submerged were not included in the escapement survey, because they do not present an equal probability of detection, and once dried and re-submerged in water, they require a longer time to decompose which can skew mark-recapture analyses (Bergman et al. 2012).

Each carcass was examined for the following: (1) presence of an external tag, (2) presence or absence of an adipose fin, (3) extent of carcass deterioration, and (4) extent of egg retention in females. Carcasses were processed for (1) the multiple mark-recapture study, (2) head collection for coded-wire tag (CWT) retrieval, or (3) chopped and tallied.

Covariate data were collected on all carcasses used in the mark-recapture study and adipose-clipped carcasses destined for CWT removal. Covariate data collected included sex, fork length, level of egg retention in females, and degree of decomposition. Sex was determined by a combination of distinguishing characteristics including presence or absence of a kype, body morphology, and the presence of eggs or milt. Fork length (FL) was measured from the tip of

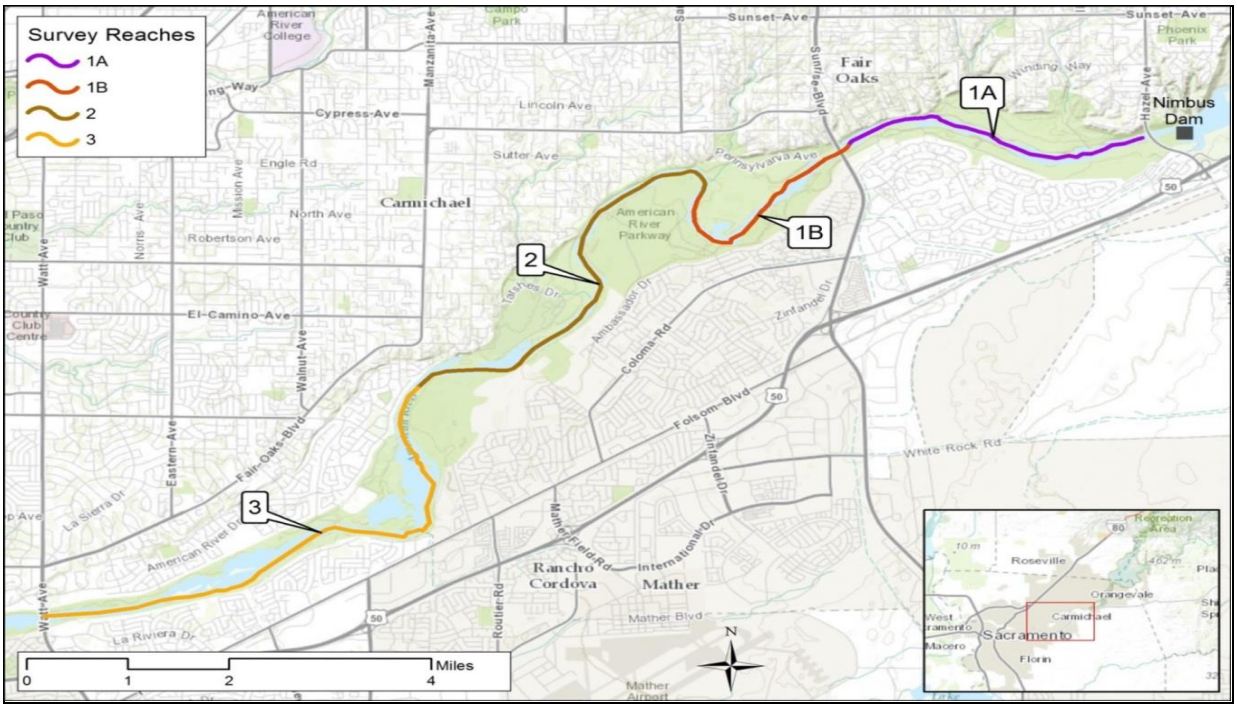

Figure 1. Survey sections of the lower American River salmon escapement survey.

Table 1. Survey section descriptions and their distances of the fall-run Chinook salmon escapement survey on the lower American River.

Section	Location	Miles
1A	Nimbus Hatchery Weir to Sunrise Blvd access	2.6
1B	Sunrise Blvd access to Elmanto Dr access	1.7
2	El Manto Dr access to River Bend Park	4.7
3	River Bend Park to Watt Ave access	4.1
	Total	13.1

the snout to the fork of the caudal fin and rounded to the nearest centimeter. At the conclusion of the survey, FL for each sex were pooled separately and plotted in a frequency distribution to determine the FL range used to classify carcasses as adult or grilse. The FL range was based on the FL collected from CWT carcasses of known-age. A grilse is a two-year-old sexually mature fish. The degree of carcass decomposition was determined by examining the condition of the eyes and gills. Salmon carcass condition was considered fresh if one clear eye or bright red gills were present and not fresh if one or both eyes were cloudy, or gills were pink or brown. The level of egg retention was determined by inspecting female carcasses and was recorded as unspawned if >70% of eggs were present, partially spawned if there was 30-70% egg retention, or spawned if there was <30% egg retention.

Only fresh salmon carcasses possessing an intact adipose fin were used in a multiple mark-recapture study while carcasses in an advanced state of decomposition were chopped and

tallied. Salmon carcasses used in the mark-recapture study were fitted with a hog ring on the left maxilla containing a uniquely numbered aluminum disk-tag and colored flagging specific to each survey period. Disk-tagged carcasses were deposited into the thalweg nearest to the area they were encountered. Upon the recovery of a disk-tagged carcass in a subsequent survey period, field staff recorded the disk-tag number and either chopped or released the carcass based on the level of decomposition.

Flow and water temperature data were obtained for each survey period from the United States Geological Survey gauge, 11446500 American River at Fair Oaks, by accessing the USGS website (USGS 2018). The Fair Oaks gauge is located a few hundred yards downstream of the Nimbus weir.

The 2017 LAR FRCS in-river escapement estimate was derived using the Cormack-Jolly-Seber (CJS) mark-recapture model for open populations (Cormack 1964; Bergman et al. 2012) using R statistical software, version 3.3.2 (R Core Team 2016).

RESULTS

Survey Periods

The survey was conducted over 14 weeks from October 17, 2017 to January 19, 2018. No subsampling was necessary during any of the survey periods (Table 2).

Table 2. Survey periods and sampling regime for the 2017 lower American River salmon escapement survey.

Survey period	Date range
1	Oct 17-19, 2017
2	Oct 23-27, 2017
3	Oct 30-Nov 2, 2017
4	Nov 6-9, 2017
5	Nov 13-16, 2017
6	Nov 20-22, 2017
7	Nov 27-30, 2017
8	Dec 4-7, 2017
9	Dec 11-14, 2017
10	Dec 18-21, 2017
11	Dec 27-29, 2017
12	Jan 2-5, 2018
13	Jan 8-11, 2018
14	Jan 16-19, 2018

Environmental Conditions

LAR water temperature decreased throughout the escapement survey. The maximum and minimum mean daily water temperatures were 62°F during survey period 1 and 50°F during survey periods 11-14, respectively, with an average temperature of 55°F (Figure 2). The LAR maximum and minimum mean daily flows were 3,760 cubic feet per second (cfs) on December 6 and 2,020 cfs on November 30, respectively. Flows increased from approximately 2,000 cfs to approximately 3,700 between November 30 and December 2 (Figure 2).

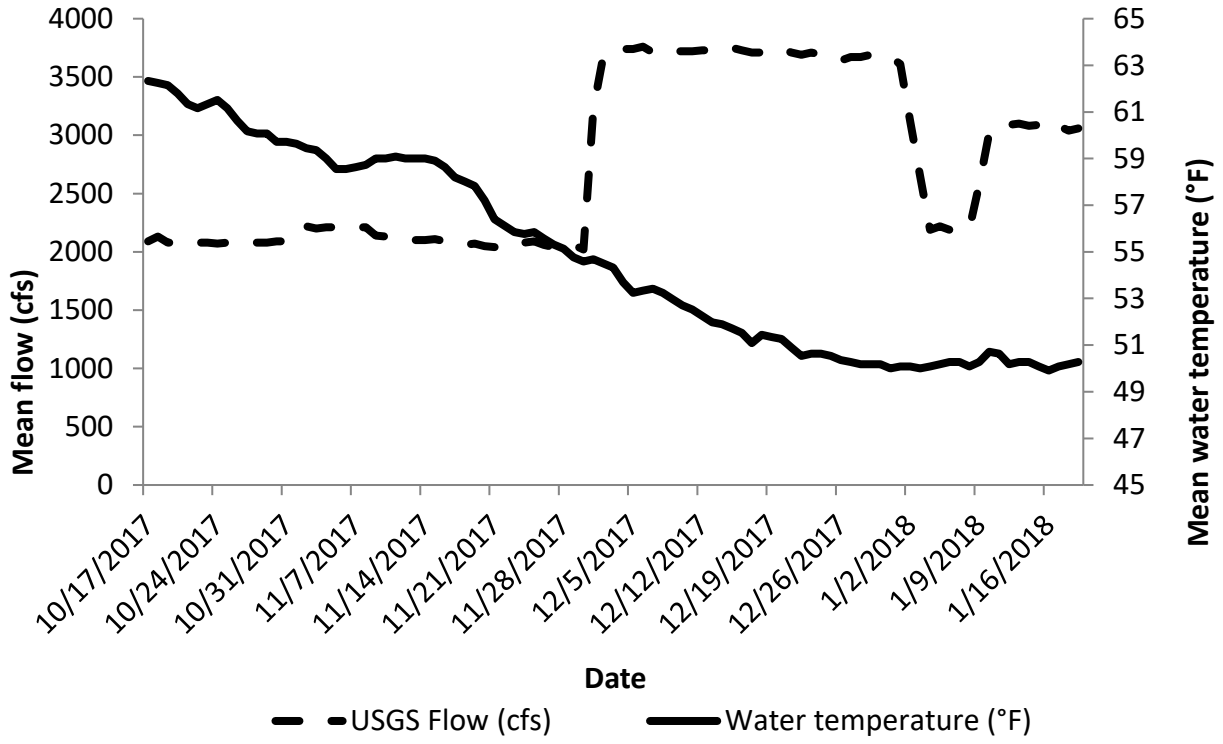

Figure 2. Mean daily river flow and mean daily water temperature observed during the 2017 lower American River salmon escapement survey.

Final Carcass Count

A total of 2,843 salmon carcasses were observed and processed during the survey. The maximum number of carcasses observed and processed in a single survey period was 440 during survey period 10 (Dec. 18-21, Figure 3).

Fresh salmon carcasses were processed every survey period (Table 3, Figure 4). The greatest number of fresh salmon carcasses was observed during survey period 6 when 49 fresh carcasses were processed, while the fewest number of fresh salmon carcasses was observed

during survey period 14. Condition was not recorded for four carcasess during survey periods 2, 4, and 6 and are noted in Table 3 as "Unknown".

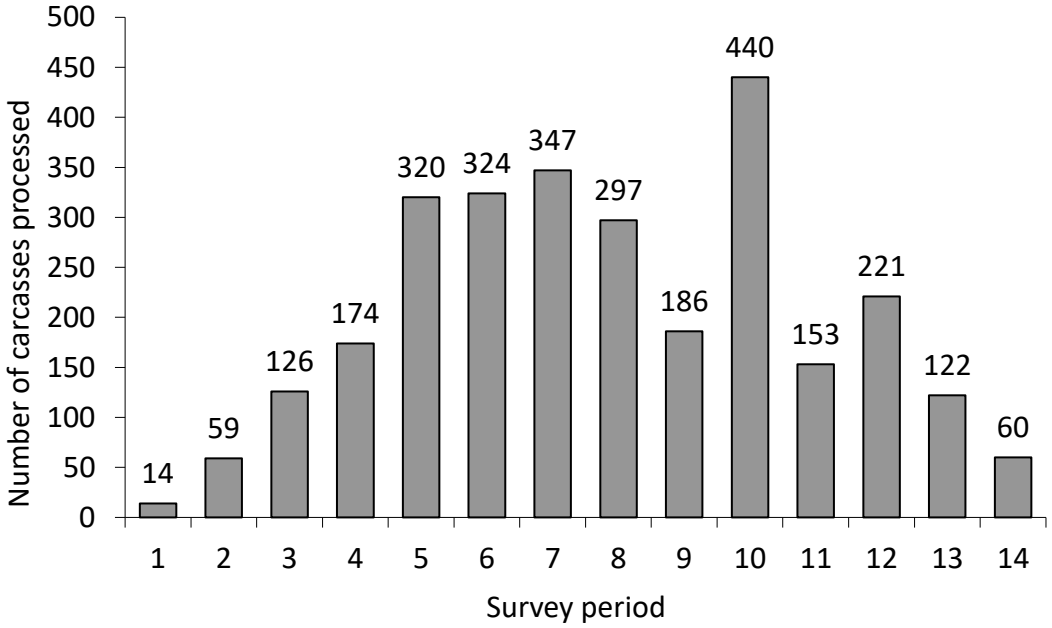

Figure 3. Number and temporal distribution of carcasses processed during the 2017 lower American River salmon escapement survey.

Table 3. Summary of carcass decomposition during the 2017 lower American River salmon escapement survey.

Survey Period	Dates	Fresh	Not Fresh or Skeletons	Unknown
1	Oct 17-29	6	8	0
2	Oct 23-27	9	49	1
3	Oct 30-Nov 2	23	103	0
4	Nov 6-9	40	132	2
5	Nov 13-16	46	274	0
6	Nov 20-22	49	274	1
7	Nov 27-Dec 30	46	301	0
8	Dec 4-7	37	260	0
9	Dec 11-14	31	155	0
10	Dec 18-21	43	397	0
11	Dec 27-29	25	128	0
12	Jan 2-5	29	192	0
13	Jan 8-11	13	109	0
14	Jan 16-19	1	59	0
	Total	**398**	**2,441**	**4**

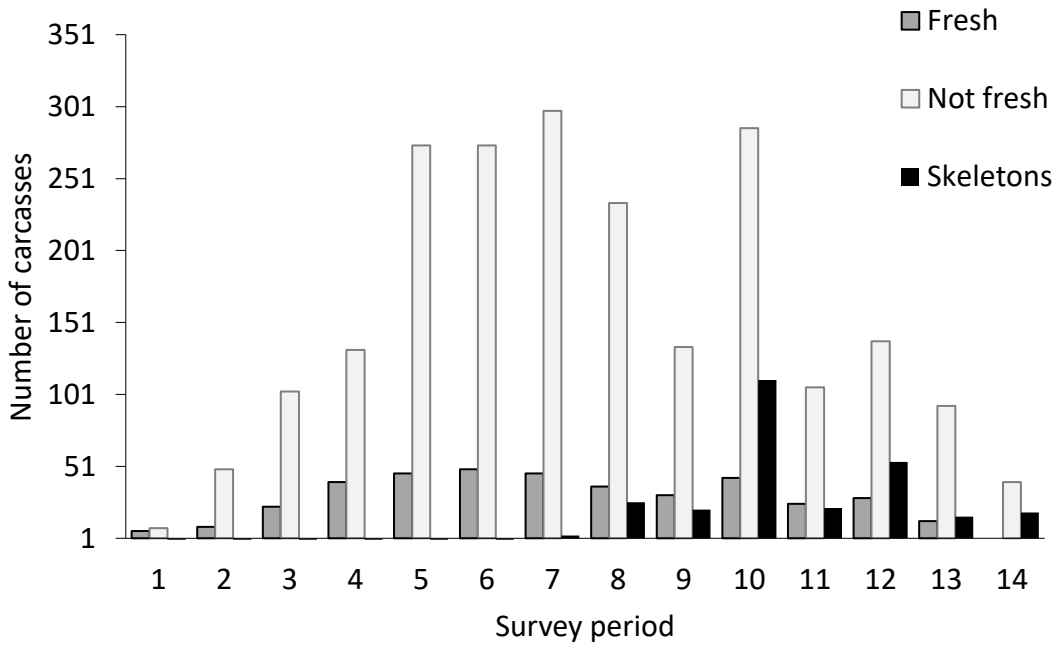

Figure 4. Number and temporal distribution of carcasses decomposition during the 2017 lower American River salmon escapement survey.

Processing Type

Of the 2,843 carcasses processed, 42% (*n*=1,187) were chopped and tallied, and 36% (*n*=1,021) were disk tagged and used in the mark-recapture study. Covariate data were collected from 22% (*n*=635) carcasses missing adipose fins or carcasses that were not used in the mark-recapture study. This group consisted of 63 fish which were chopped directly after retrieving covariate data, and 572 carcasses in which heads were collected for CWT retrieval (Table 4, Figure 5).

Spatial Distribution

Most salmon carcasses were observed in sections 1A and 1B (89%, *n*=2,539). Nine percent (*n*=255) of carcasses were observed in Section 2 and 2% (*n*=49) in Section 3 (Table 5, Figure 6).

Table 4. Processing types for salmon carcasses encountered on the 2017 lower American River salmon escapement survey.

Survey period	Dates	Tally chops	Mark-recapture	Covariate data	Period total	%
1	Oct 17 to 29	2	10	2	14	0.5
2	Oct 23 to 27	15	32	12	59	2.1
3	Oct 30 to Nov 2	26	55	45	126	4.4
4	Nov 6 to 9	45	65	64	174	6.1
5	Nov 13 to 16	84	137	99	320	11.3
6	Nov 20 to 22	111	130	83	324	11.4
7	Nov 27 to Dec 30	116	153	78	347	12.2
8	Dec 4 to 7	124	105	68	297	10.4
9	Dec 11 to 14	78	68	40	186	6.5
10	Dec 18-21	305	84	51	440	15.5
11	Dec 27-29	68	57	28	153	5.4
12	Jan 2-5	113	75	33	221	7.8
13	Jan 8-11	63	39	20	122	4.3
14	Jan 16-19	37	11	12	60	2.1
	Total	**1,187**	**1,021**	**635**	**2,843**	**100**
	(%)	(42)	(36)	(22)		

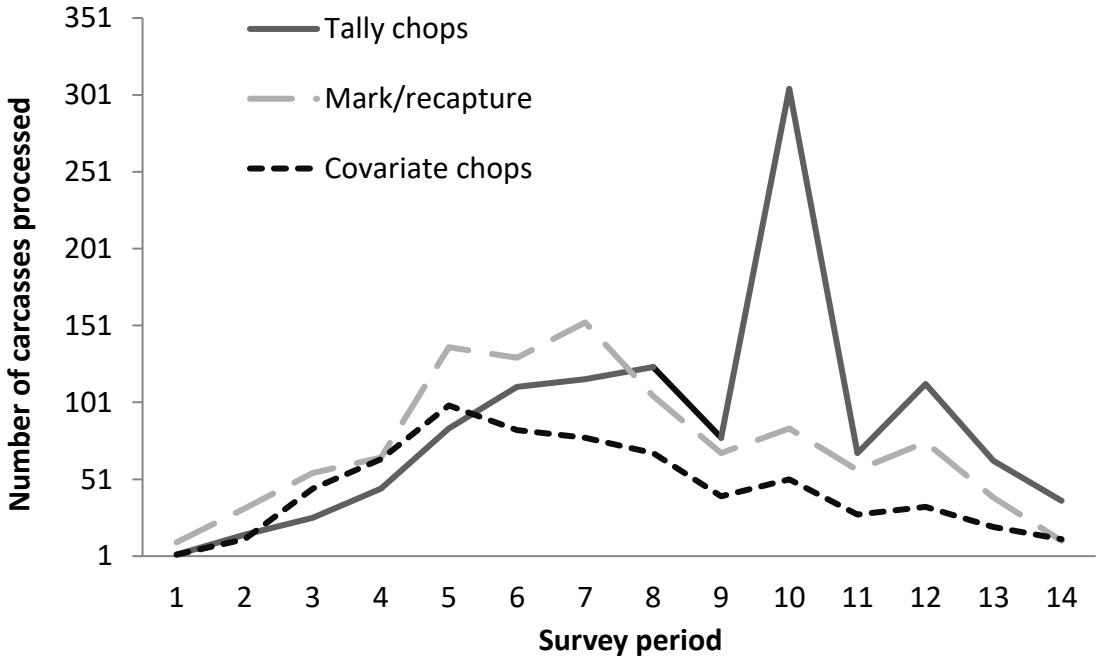

Figure 5. Number and temporal distribution of salmon carcasses processing type during the 2017 lower American River escapement survey.

Table 5. Number of salmon carcasses processed by river section during the 2017 lower American River escapement survey.

Survey period	Dates	Section		
		1A/1B	2	3
1	Oct 17-19	14	N/A	N/A
2	Oct 23-27	49	6	4
3	Oct 30 - Nov 2	105	17	4
4	Nov 6-9	147	22	5
5	Nov 13-16	283	32	5
6	Nov 20-22	290	34	N/A
7	Nov 27-30	315	25	7
8	Dec 4-7	253	38	6
9	Dec 11-14	164	21	1
10	Dec 18-21	402	29	9
11	Dec 27-29	137	12	4
12	Jan 2-5	204	15	2
13	Jan 8-11	119	2	1
14	Jan 16-19	57	2	1
	Total	**2,539**	**255**	**49**
	(%)	(89)	(9)	(2)

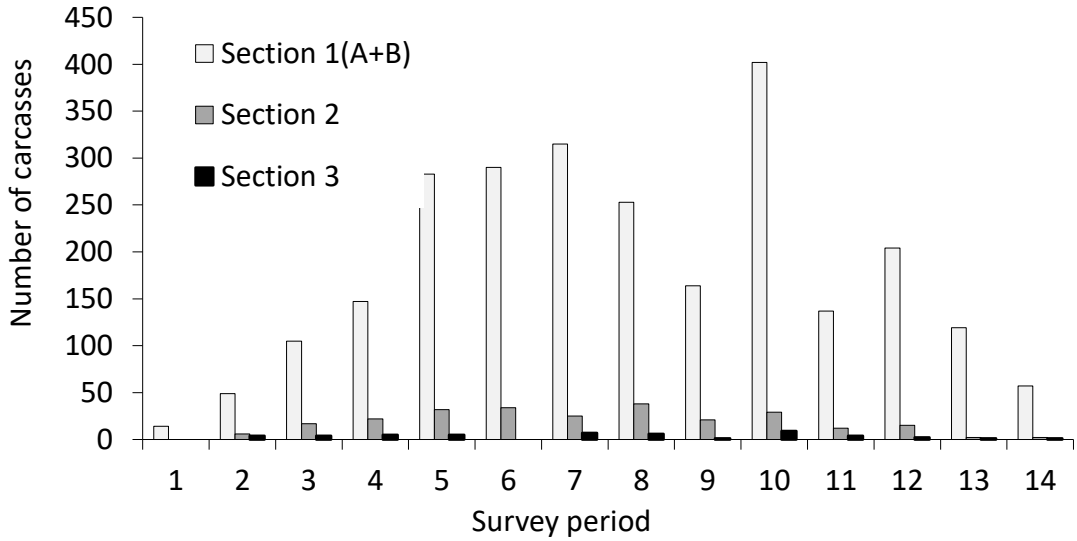

Figure 6. Number and temporal distribution of salmon carcasses processed by river section during the 2017 lower American River escapement survey.

Sex Ratios

Sex was recorded for 1,640 carcasses. Females comprised 50% (*n*=825) of the total and males comprised the remaining 50% (*n*=815, Table 6). Female and male carcasses were encountered in relatively equal numbers throughout the survey (Figure 7).

Table 6. Sex ratio of carcasses processed during the 2017 lower American River salmon escapement survey.

Survey Period	Dates	Females	Males
1	Oct 17-19	6	5
2	Oct 23-27	22	21
3	Oct 30 - Nov 2	41	57
4	Nov 6-9	64	65
5	Nov 13-16	124	108
6	Nov 20-22	100	111
7	Nov 27-30	115	116
8	Dec 4-7	85	86
9	Dec 11-14	60	47
10	Dec 18-21	50	83
11	Dec 27-29	45	39
12	Jan 2-5	68	40
13	Jan 8-11	32	27
14	Jan 16-19	13	10
	Total	**825**	**815**
	(%)	(50)	(50)

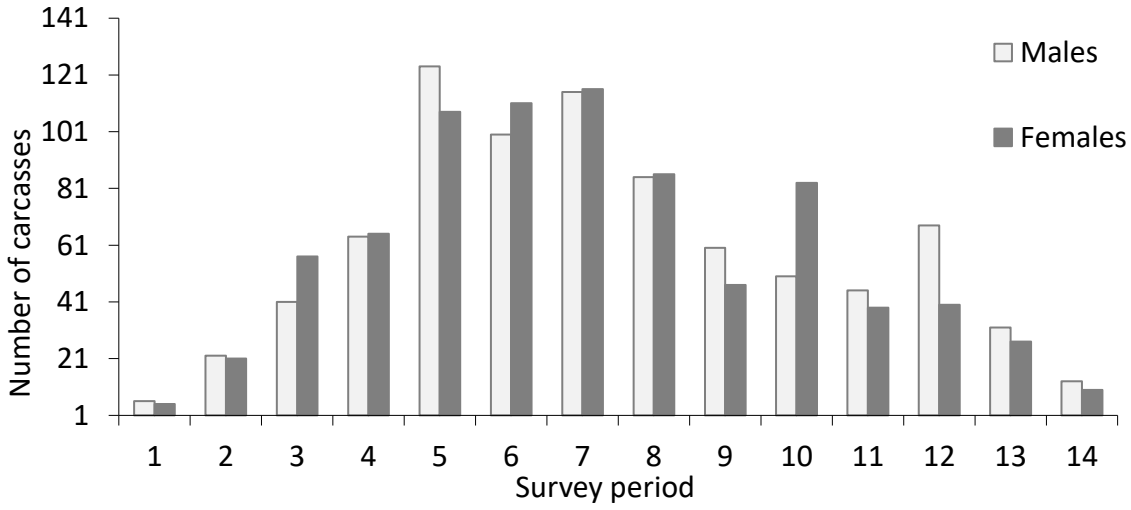

Figure 7. Number and temporal distribution of female and male carcasses processed during the 2017 lower American River salmon escapement survey.

Length Composition

Fork length was recorded for 1,650 carcasses. The minimum and maximum FL for male carcasses were 44 cm and 107 cm, respectively, with a mean of 79 cm and a mode of 87 cm. Minimum and maximum recorded FL for female carcasses were 50 cm and 95 cm, respectively, with a mean of 76 cm and a mode of 79 cm (Figure 8).

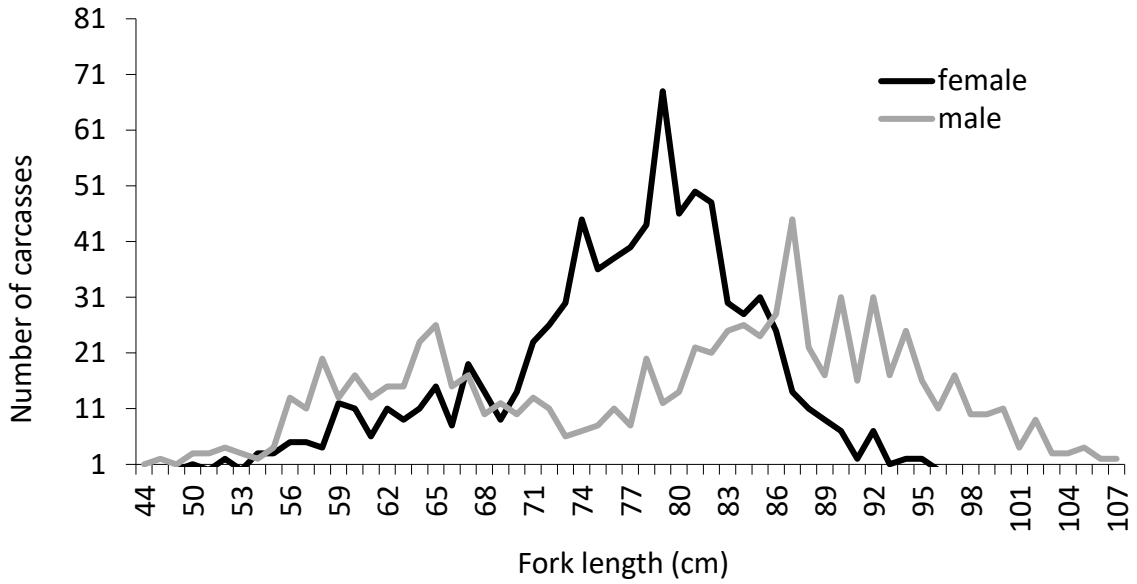

Figure 8. Fork length frequency by sex of carcasses processed during the 2017 lower American River salmon escapement survey.

Age Classification

A total of 1,650 salmon carcasses was assigned to one of two distinct age classes based on a length frequency distribution calculated from all FLs recorded during the survey (Figure 7), including 10 carcasses in which sex could not be determined. Carcasses were classified as adults (≥ 3 years old) if females had a FL ≥ 66 cm and males had a FL ≥ 74 cm. Carcasses were classified as grilse (≤ 2 years old) if female FLs were ≤ 65 cm and male FLs were ≤ 73 cm. Seventy-seven percent (*n*= 1,264) were classified as adults while 23% (*n*=386) were classified as grilse. Both age classes were observed during each survey period. The adult contribution to the LAR escapement survey peaked during survey period 5 (Nov. 13-16) while total grilse peaked during survey period 10 (Dec 18-21) (Table 7, Figure 9).

The proportions of each sex were also determined within each age class. Of the 386 grilse carcasses, 73.3% (*n*=283) were male, 25.4% (*n*=98) were female, and 1.3% (*n*=5; not shown in figure) were of unknown sex. Of the 1,264 adult carcasses 42% (*n*=532) were male, 58% (*n*=727) were female, and < 1% (*n*=5) were of unknown sex (Figure 10).

Table 7. Age-class assignments for carcasses processed during the 2017 lower American River salmon escapement survey and percent of total for the carcasses recovered during that survey period.

Survey Period	Dates	Grilse		Adult	
		n	%	*n*	%
1	Oct 17-19	0	0	11	100
2	Oct 23-27	1	2	43	98
3	Oct 30 - Nov 2	2	2	98	98
4	Nov 6-9	10	8	118	92
5	Nov 13-16	28	12	208	88
6	Nov 20-22	46	22	166	78
7	Nov 27-30	57	25	174	75
8	Dec 4-7	62	36	111	64
9	Dec 11-14	41	38	67	62
10	Dec 18-21	63	47	70	53
11	Dec 27-29	31	37	53	63
12	Jan 2-5	26	24	82	76
13	Jan 8-11	15	25	44	75
14	Jan 16-19	4	17	19	83
	Total	**386**		**1,264**	
	(%)	(23)		(77)	

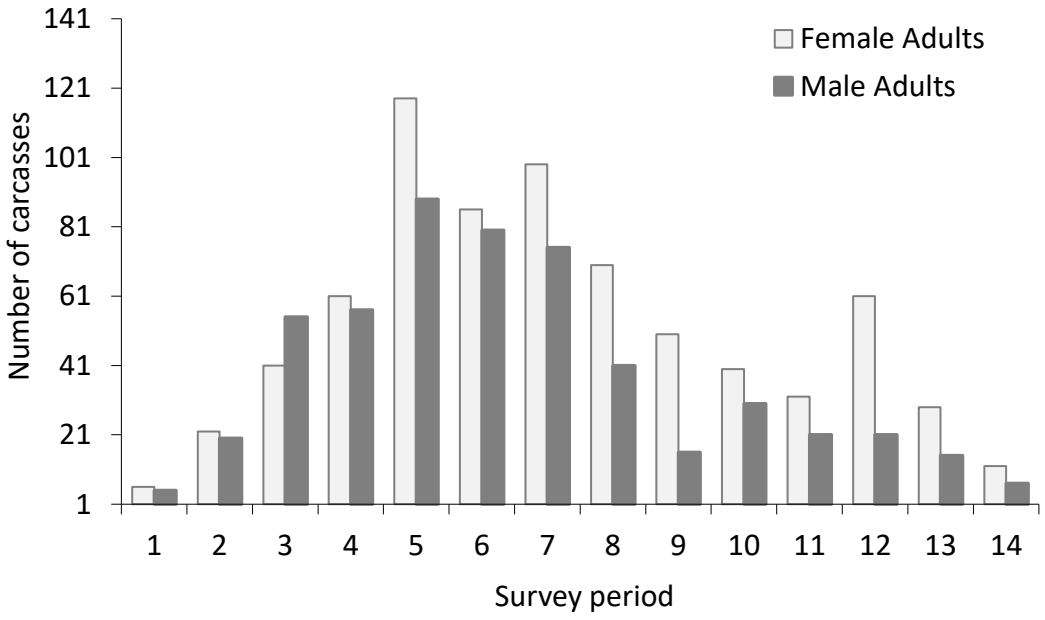

Figure 9. Number and temporal distribution of age classes assigned to carcasses processed during the 2017 lower American River salmon escapement survey.

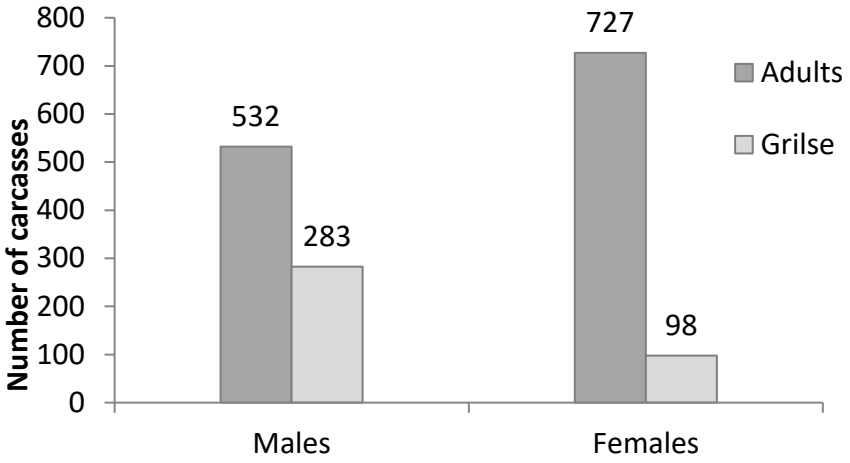

Figure 10. Number of male and female carcasses assigned to adult or grilse age classes during the 2017 lower American River salmon escapement survey.

Egg Retention

A total of 724 female carcasses were assessed for egg retention (Table 8, Figure 11). Seventy-four percent (*n*=534) of female salmon processed were spawned, 10% (*n*=74) partially spawned, and 16% (*n*=116) were unspawned. The proportion of spawned females was highest (>50%) during survey periods 5 through 14 (Figure 11).

Table 8. Egg retention status by survey period of female carcasses processed during the 2017 lower American River salmon escapement survey.

Survey period	Date	Unspawned	Partial	Spawned	Period total
1	Oct 17-19	4	0	1	**5**
2	Oct 23-27	8	4	7	**19**
3	Oct 30 - Nov 2	15	4	17	**36**
4	Nov 6-9	14	15	26	**55**
5	Nov 13-16	18	16	75	**109**
6	Nov 20-22	11	8	74	**93**
7	Nov 27-30	13	6	83	**102**
8	Dec 4-7	12	5	59	**76**
9	Dec 11-14	5	3	48	**56**
10	Dec 18-21	6	3	36	**45**
11	Dec 27-29	6	0	32	**38**
12	Jan 2-5	4	9	46	**59**
13	Jan 8-11	0	0	23	**23**
14	Jan 16-19	0	1	7	**8**
	Total	**116**	**74**	**534**	**724**
	(%)	(16)	(10)	(74)	

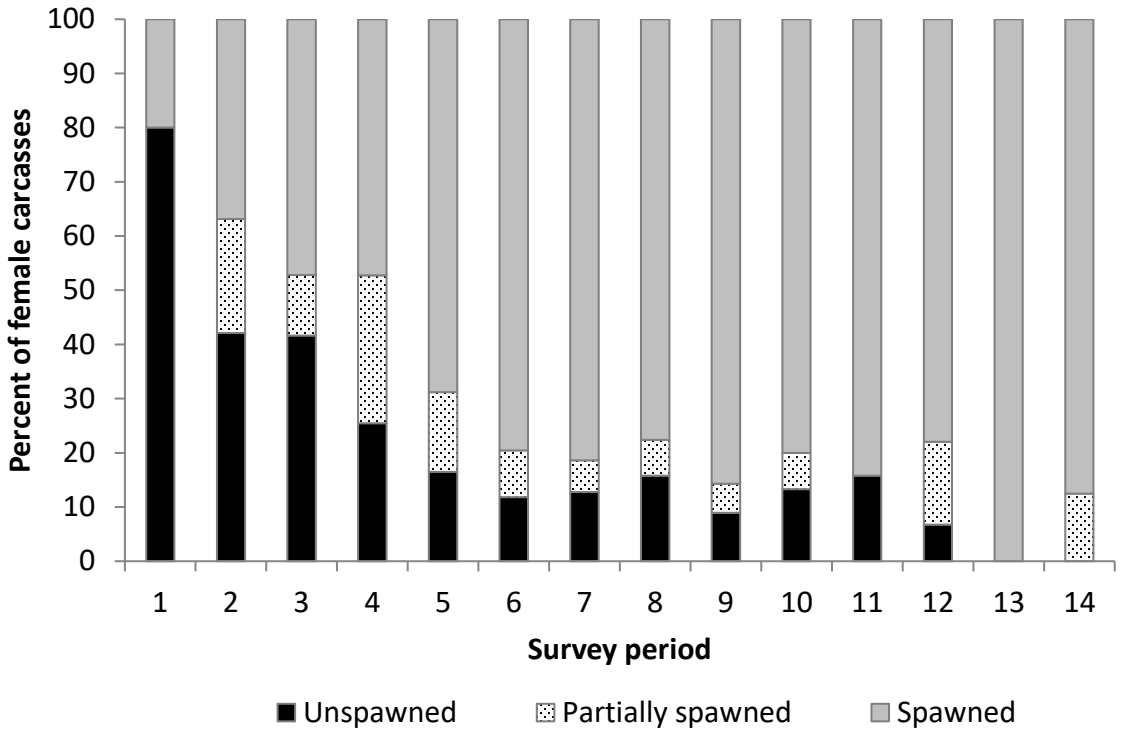

Figure 11. Temporal distribution of egg retention status for female carcasses processed during the 2017 lower American River salmon escapement survey.

CWT Carcasses

All salmon carcasses encountered were examined for the presence of an adipose fin. Twenty-two percent (*n*=629) of processed carcasses were found to be missing an adipose fin. Of those salmon missing an adipose fin, 572 heads were collected for CWT retrieval. Adipose-clipped salmon were observed each week of the survey (Table 9, Figure 12) and ranged from 12% to 32% of the total carcasses examined for each survey period. The largest proportion of adipose-clipped carcasses were observed during survey periods 3 through 9.

Table 9. Adipose condition of carcasses during each survey period of the 2017 lower American River salmon escapement survey.

Survey period	Dates	Adipose Intact	Adipose clipped	Skeletons
1	Oct 17-19	11	2	1
2	Oct 23-27	44	11	4
3	Oct 30 - Nov 2	92	26	8
4	Nov 6-9	108	56	10
5	Nov 13-16	211	83	26
6	Nov 20-22	212	92	20
7	Nov 27-30	236	90	21
8	Dec 4-7	185	77	35
9	Dec 11-14	104	43	39
10	Dec 18-21	172	52	216
11	Dec 27-29	98	29	26
12	Jan 2-5	114	37	70
13	Jan 8-11	76	22	24
14	Jan 16-19	27	9	24
	Total	**1,690**	**629**	**524**
	(%)	(59)	(22)	(18)

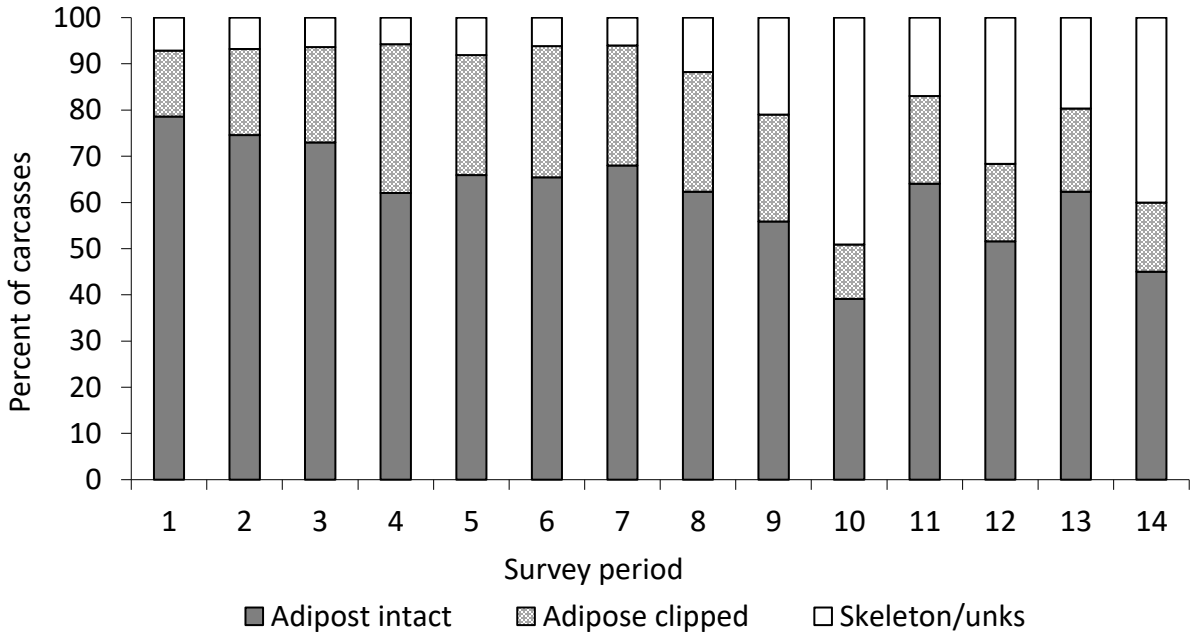

Figure 12. Temporal distribution of adipose fin status of carcasses processed during the 2017 lower American River salmon escapement survey.

Population Estimate

The CJS population model was used to estimate the 2017 in-river FRCS escapement (Cormack 1964; Bergman et al. 2012). A total of 1,021 salmon carcasses were disk-tagged for the mark-recapture study and there were 256 recapture events. The in-river FRCS escapement estimate for the LAR is 7,234 FRCS. The bootstrap estimate of the standard error of estimated total escapement is 346 FRCS (*n*=5,000 bootstraps). The 90% bootstrap percentile confidence interval is 6,769 to 7,928. In addition to the in-river estimates, 10,579 carcasses (8,564 adults and 2,015 grilse) were trapped at the Nimbus Hatchery and 2,429 (1,428 adults and 1,001 grilse) were collected above the weir by Nimbus Hatchery staff. The combined 2017 LAR fall-run salmon escapement estimate from the in-river survey, Nimbus Hatchery, and weir collection is 20,242 FRCS.

DISCUSSION

The 2017 LAR in-river salmon escapement estimate of 7,234 is the lowest on record since 2010 when the in-river estimate was 5,832 (Figure 13). Since 2010, LAR escapement estimates steadily increased until a peak occurred in 2013 (54,259) and have then declined each year thereafter. Most salmon that returned to the LAR in 2017 are expected to be from the 2014 brood year (i.e., 3 years old) based on historical trends from CWT data from past escapement surveys. Although 2014 experienced an estimated escapement of 24,503 FRCS to the LAR, the offspring from this brood year did not return in large numbers, perhaps due to a low survival during the prolonged drought, which has resulted in higher water temperatures and lower flows during critical migration, spawning, and rearing periods. These prolonged periods of drought will be expected in higher frequency and duration throughout the future, and without proper water temperatures, the survival of FRCS and other Central Valley salmon runs will be jeopardized.

The International Panel on Climate Change (IPCC) notes that since the start of the 20th century the global average surface temperature has risen between 0.6°C and 0.7°C, and since 1976, the global average temperature has risen sharply, at 0.18°C per decade (Cayan 2008). Simulations of California's climate show significant end of century increases of +1.5°C under the lower emissions B1 scenario in the less responsive Parallel Climate Model (PCM1) to +4.5°C in the higher emissions A2 scenario (Cayan 2008). Decreased annual snowpack and earlier runoff in the Sierra Nevada mountain range have also been detected along with increased rain-to-snow ratios (Diffenbaugh et al. 2015). These shifts in climate may create significant changes in overall Pacific salmon abundances and distribution. In addition, it is critically important to note that these changes may affect future FRCS escapement, fitness, and hatchery production in the LAR.

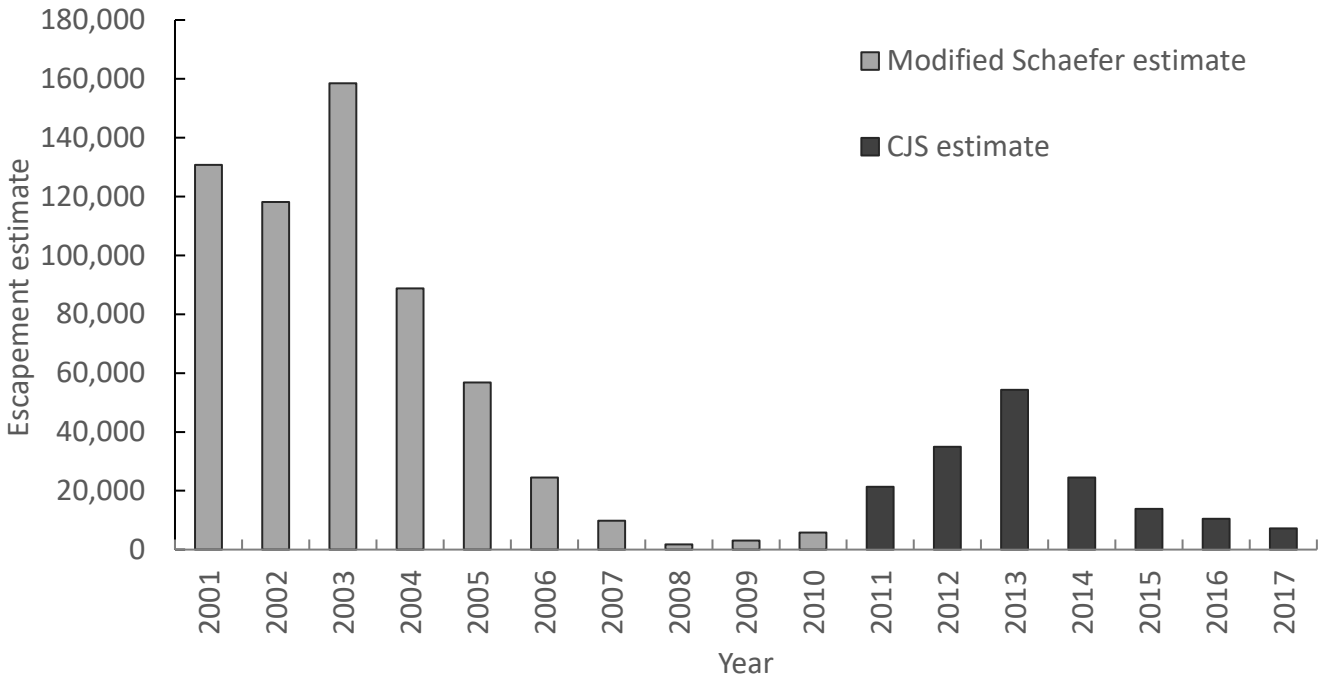

Figure 13. Comparison of lower American River fall-run Chinook salmon escapement estimates from 2001 to 2017 calculated using the modified Schaefer or Cormack-Jolly-Seber models.

Water temperature decreased to a favorable spawning temperatures during survey period 6 (Nov. 20-22). Minimal redd building was observed prior to early November. Water temperatures higher than 61.7°F decrease survival of Chinook salmon eggs (Geist et al. 2006) and 100% mortality prior to the eyed-egg stage of FRCS eggs in the American River at a water temperature above 62°F has been reported (Hinze 1959). FRCS spawned at Nimbus Hatchery during the first week or two of November often contain dead eggs (P. Hoover, Nimbus Hatchery Manger, pers. comm), presumably due to adults staging in the LAR during elevated water temperatures. This temporal selection for later migrants may result in a shift in run timing (Quinn et al. 2007), lower phenotypic variability, and reduced recruitment.

Based on CWT data, there was a marked increase in the stray rate of FRCS produced at CNFH, FRH, MRFI and MRFF for brood years when the majority of hatchery produced smolts were transported and released in the Delta or Bay rather than released in-river (Lasko 2014; CDFW 2016). In particular, the CNFH 2014 brood year were released during the height of the drought in 2014 at Rio Vista on the Sacramento River and at San Pablo Bay. Preliminary CWT data recovered from carcasses processed during the survey revealed that approximately 34% (*n*=197) of the FRCS originated at CNFH, 24% (*n*=140) from NFH, 19% (*n*=111) from MRFI, 4% (*n*=24) from FRH, 2% (*n*=10) from MRFF. CWTs were either not recovered or unreadable for 16% *(n*=90) of the adipose fin-clipped carcasses processed.

On October 9, 2017, the NFH opened its fish ladder to allow expected strays from the CNFH to enter the hatchery. CNFH salmon, identified by on-site CWT extraction and reading, were spawned and the eggs transported to CNFH for rearing (Finalized CWT extraction data can be downloaded at rmpc.org).

Straying hatchery-origin salmonids can place natural populations at risk both through potential interbreeding and through ecological interactions with natural-origin spawners (CHSRG 2012). Unintended genetic changes have been documented in cultured populations as a result of historical hatchery practices, with loss of alleles through drift, artificial selection, non-random mating, and the relaxation of sexual selection (Lasko 2014).

Efforts to increase hatchery success and to reduce straying fish are outlined in the California Hatchery Review Project (cahatcheryreview.com). It has been determined that FRCS throughout the Central Valley comprise a genetically homogeneous population that has lower among-population genetic diversity than FRCS populations examined elsewhere over similar geographic scales (Williamson and May 2005). Due to the prevalence of off-site releases of hatchery-reared juveniles and the history of inter-basin hatchery transfers and stocking within the Central Valley, homogenization of Central Valley fall-run populations is most likely the result of hatchery practices for the past 140 years (Williamson and May 2005). Thus, future collection of CWT tag recoveries in the Central Valley and the LAR is vital for understanding the number of hatchery-reared, CWT FRCS utilizing these various spawning habitats.

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