California Department of Fish and Wildlife
North Central Region

Lower American River Fall-run Chinook Salmon Escapement Survey October 2023 – January 2024

Presented to the United States
Bureau of Reclamation
By

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INTRODUCTION

The American River is the second-largest tributary to the Sacramento River and flows through a highly developed urban environment (Williams 2001). The lower American River (LAR) is a 23-mile stretch of the American River starting at the base of Nimbus Dam and extending downstream to the confluence with the Sacramento River at Discovery Park. The LAR supports both wild and hatchery fall-run Chinook salmon (FRCS, *Oncorhynchus tshawytscha*) spawning and rearing life stages. Historically, the LAR supported spawning of fall, spring, and late fall runs of Chinook salmon (Yoshiyama et al. 2000); spring-run Chinook was extirpated from the LAR following the construction of Folsom Dam in 1955. The fall-run represents the largest run of Chinook salmon found in California's Central Valley, although current FRCS populations are heavily supported by hatchery production (Yoshiyama et al. 2000). Adult FRCS are typically found in the LAR from September to January, and generally begin to spawn in the LAR in early October, with the peak of the run occurring in late November to early December (Williams 2001).

The American River is heavily influenced by the presence of dams that limit salmon occurrence to the lowest 23 river miles. The Nimbus Fish Hatchery, constructed in 1958 to compensate for the loss of spawning and rearing habitat due to the construction of Nimbus Dam, releases approximately 4 million Chinook salmon annually (CDFW 2024). FRCS mark-recapture escapement surveys are performed to estimate spawner abundance and distribution, and have been conducted in the LAR since 1976, although escapement estimates of Central Valley salmon have been conducted since the 1940's and 1950's (Bergman et al. 2012). Data collected during escapement surveys are also used to examine life history traits, population age structure, pre-spawn mortality, the ratio of hatchery and natural origin FRCS on spawning grounds, and environmental effects on the population. Evaluation of stock-recruitment relationships from escapement survey data is used to aid in establishing harvest limits and fishing seasons. Because of environmental stochasticity and anthropogenic activity, salmon runs in California have exhibited a high degree of variation over time (Satterthwaite and Carlson 2015).

The primary objectives of the 2023-2024 escapement survey were to: 1) estimate the size of FRCS escapement in the LAR, 2) determine the ratio of adults to grilse, as well as the sex ratios of adults and grilse, 3) determine the degree of female pre-spawn mortality, and 4) collect coded-wire tags (CWT) to investigate the number and origin of hatchery-reared FRCS using spawning habitat in the LAR.

METHODS

A 13.4-mile section of the lower American River, beginning at the Nimbus Dam and ending at the Watt Avenue bridge, was surveyed from October 16, 2023, to January 24, 2024. The survey area was divided into five sections (Figure 1, Table 1), each surveyed once over a 3-to-5-day survey period. Nimbus Basin (NB) is composed of a deep pool at the base of the dam, a riffle and run in the main channel, and two side channels composed of riffles, runs, and pools. In 2021, a rock channel was constructed as an entrance to a new fish ladder for the Nimbus Fish Hatchery. The rock channel entrance is in the upstream portion of NB and was included in the survey of NB during the 2023 survey. The location of the historic Nimbus Fish Hatchery weir structure separates NB from section 1 and is located adjacent to the Nimbus Fish Hatchery. Section 1 has continuously had the highest number of FRCS spawning activity and is composed primarily of riffles, glides, and a few deep pools. This section is broken up into sections 1A and 1B for sampling purposes because of the high number of carcasses typically encountered. Section 2 contains a few riffles, but is composed primarily of large, deep-water glides. Section 3 consists of riffles, deep-water glides, and several stretches of braided side-channels. The LAR downstream of Watt Avenue has little spawning habitat and is primarily a migration corridor and, therefore, it is not included in the escapement survey.

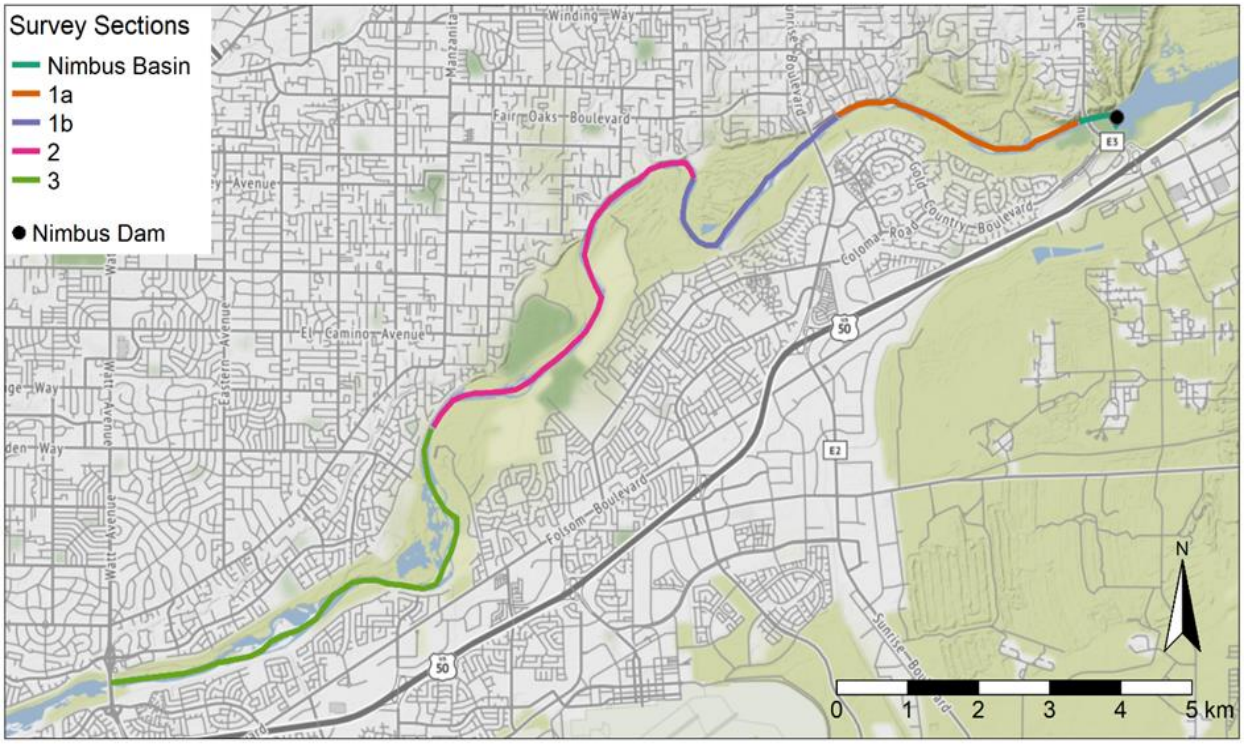

Figure 1. Survey sections for the lower American River Chinook salmon escapement survey.

Surveys were conducted by a crew consisting of 5-11 members searching for submerged salmon carcasses while walking the riverbanks, paddling kayaks, and/or operating a jet boat. NB was surveyed only on foot from the banks; sections 1A and 1B were surveyed by jet boat, from the banks, and occasionally by kayaks when the jet boat was unavailable; section 2 was surveyed by jet boat and kayaks during survey weeks 1 through 11, but it was surveyed only by kayaks for the remaining weeks due to low flows; section 3 was surveyed by jet boat and kayaks during survey weeks 1 through 3, but it was surveyed only by kayaks for the remaining weeks due to low flows. Surveys began at the upstream boundary of each river section and progressed downstream, with crew members processing each carcass encountered. Salmon carcasses ≤50% submerged were not included in the escapement survey, as these carcasses do not represent an equal probability of detection, and once dried require a longer time to decompose, which can skew mark-recapture analysis (Bergman et al. 2012). Each carcass was examined for the following: 1) presence of an external tag, 2) presence of an adipose fin, 3) extent of carcass degradation, and 4) extent of egg retention in females.

Table 1. Survey section distances and descriptions of the FRCS escapement survey on the lower American River.

Section	Description	Miles
NB	Nimbus Dam to Nimbus Fish Hatchery Weir	0.3
1A	Nimbus Fish Hatchery Weir to Sunrise Blvd. River Access	2.6
1B	Sunrise Blvd River Access to El Manto Dr. River Access	1.7
2	El Manto Dr. River Access to River Bend Park River Access	4.7
3	River Bend Park Access to Watt Ave. River Access	4.1
	Total	13.4

Carcasses were processed in one of three ways: 1) head collection for coded-wire tag (CWT) retrieval, 2) inclusion in the mark-recapture model, or 3) chopped in half and tallied. Heads were removed and retained from adipose fin clipped carcasses for CWT removal. Carcasses with an intact adipose fin were either included in the mark-recapture model or chopped and tallied. To be included in the mark-recapture model, a carcass must be in a fresh enough condition to be detected during subsequent survey periods; any carcasses not meeting these criteria were chopped in half to prevent inclusion in future surveys. The degree of carcass decomposition was determined by the examination of the eyes and gills. Carcasses were considered fresh if at least one eye was clear or the gills were red. Scale samples were also collected from fresh carcasses by removing a one-inch square scale sample from the left side of the carcass above the lateral line and posterior to the dorsal fin. Carcasses were chopped and tallied if they were in an advanced state of decomposition (i.e., not fresh)

Carcasses included in the mark-recapture model were fitted with a hog ring and numbered disk-tag on the left maxilla. Each tag was marked with colored flagging unique to the survey period and the tagged carcasses were deposited in the thalweg adjacent to the tagging location. The 2023-2024 LAR FRCS escapement estimate was derived using a Cormack-Jolly-Seber (CJS) mark-recapture model for open populations (Cormack 1964, Bergman et al. 2012) using the escapeMR package (McDonald 2021) in R version 4.3.2 (R Core Team 2023).

Covariate data was collected from all carcasses utilized in the mark-recapture model and those destined for CWT retrieval. Covariate data included sex, fork length (FL), level of egg retention in females, and degree of decomposition. Sex was determined through a combination of characteristics including body morphology, presence or absence of a kype, and examination of gametes. If no gametes were present, sex was determined by examination of remaining internal reproductive organs. FL was measured from the tip of the snout to the fork of the caudal fin and rounded to the nearest centimeter. At the end of the survey season, FLs of fish with CWTs were pooled by sex and plotted in a frequency distribution. This was then compared to a similar frequency distribution of all fish that FL were collected from and used to classify carcasses as grilse (a two-year old, sexually mature fish) or adults. The level of egg retention was determined by examining female carcasses, classifying each female as unspawned if >70% of eggs were present, partially spawned if 30-70% of eggs were retained, or spawned if <30% of eggs were retained.

Water temperature and discharge data were obtained for each survey period from the United States Geological Survey gauge for the American River at Fair Oaks (Gauge ID 11446500) through the USGS website (USGS 2024). The Fair Oaks gauge is located at the upper end of section 1A approximately one hundred meters downstream of the historic weir structure. Daily average temperature and discharge recordings were selected to best measure changes in water temperature and flow through the duration of the study.

RESULTS

Survey Periods

The 2023 LAR survey consisted of 15 survey periods from October 16, 2023, to January 24, 2024. All sections were surveyed in each survey period, with the exception of weeks 6 and 11, where section 3 was not surveyed due to holiday interference and an insufficient number of crew members. In survey periods 4 and 5, section 3 was only partially surveyed due to a shortage of daylight. In survey periods 7 and 8, sections 2 and 3 were only partially surveyed due to a shortage of staff and daylight to handle the high number of fish encountered (Table 2). No subsampling occurred at any time during the study.

Table 2. Survey dates and sampling regime for the 2023 lower American River Chinook salmon escapement survey.

Survey Period	Date	Sections Partially Surveyed	Sections Not Surveyed
1	Oct. 16 to Oct. 19	None	None
2	Oct. 23 to Oct. 26	None	None
3	Oct. 30 to Nov. 2	None	None
4	Nov. 6 to Nov. 9	3	None
5	Nov. 13 to Nov. 16	3	None
6	Nov. 20 to Nov. 22	None	3
7	Nov. 27 to Nov. 30	2, 3	None
8	Dec. 4 to Dec. 7	2, 3	None
9	Dec. 11 to Dec. 15	None	None
10	Dec. 18 to Dec. 22	None	None
11	Dec. 27 to Dec. 29	None	3
12	Jan. 2 to Jan. 5	None	None
13	Jan. 8 to Jan. 11	None	None
14	Jan. 16 to Jan. 18	None	None
15	Jan. 22 to Jan. 24	None	None

Environmental Conditions

Water entering the Lower American River in October, from Lake Natoma, had low levels of dissolved oxygen (DO), which was identified during monitoring efforts within Nimbus Basin and at Nimbus Hatchery. Low dissolved oxygen can negatively impact fish holding in the river and can be harmful to fish in the ladder. During the October 19th American River Group (ARG) meeting, CDFW reported DO levels of roughly 5.4 mg/L at the hatchery, which was far below the guidance of 7 mg/L necessary for bringing salmon into the hatchery. Due to continued low DO, Nimbus Hatchery pushed back the opening of the ladder for several days (10/31 to 11/3) until conditions improved, following changes in operations at Folsom Dam including the implementation of a power bypass.

The US Bureau of Reclamation (USBR) initiated a power bypass of 140 cfs on October 30th, 2023 to access the cold water pool at Folsom Dam for the purpose of providing suitable holding and spawning temperatures for FRCS. The bypass increased incrementally over the next two days (297 cfs on October 31st and 493 cfs on November 1st), and averaged 511 cfs daily between November 1st and December 8th, before being reduced the final day to 294 cfs on December 9th.

Daily average LAR temperatures generally decreased over the duration of the survey season. The maximum mean daily temperature recorded was 62.3°F on October 24th, and the minimum mean daily temperature was 50.2°F on January 12th and 13th (Figure 2). Water temperature decreased to a level suitable for spawning on December 6th when the daily maximum water temperature recorded at Fair Oaks reached and remained below 56°F.

For the first two weeks of the survey, average daily flow ranged between 2,519-2,622 cfs. During weeks 3 through 12, flow conditions decreased, with conditions averaging 2,064 cfs. Flows dropped slightly again in the last two weeks of the survey to an average of 1,791 cfs. The maximum average daily flow was 2,622 cfs on October 25, 2023, and the minimum average daily flow was 1,728 cfs on January 10, 2024 (Figure 2).

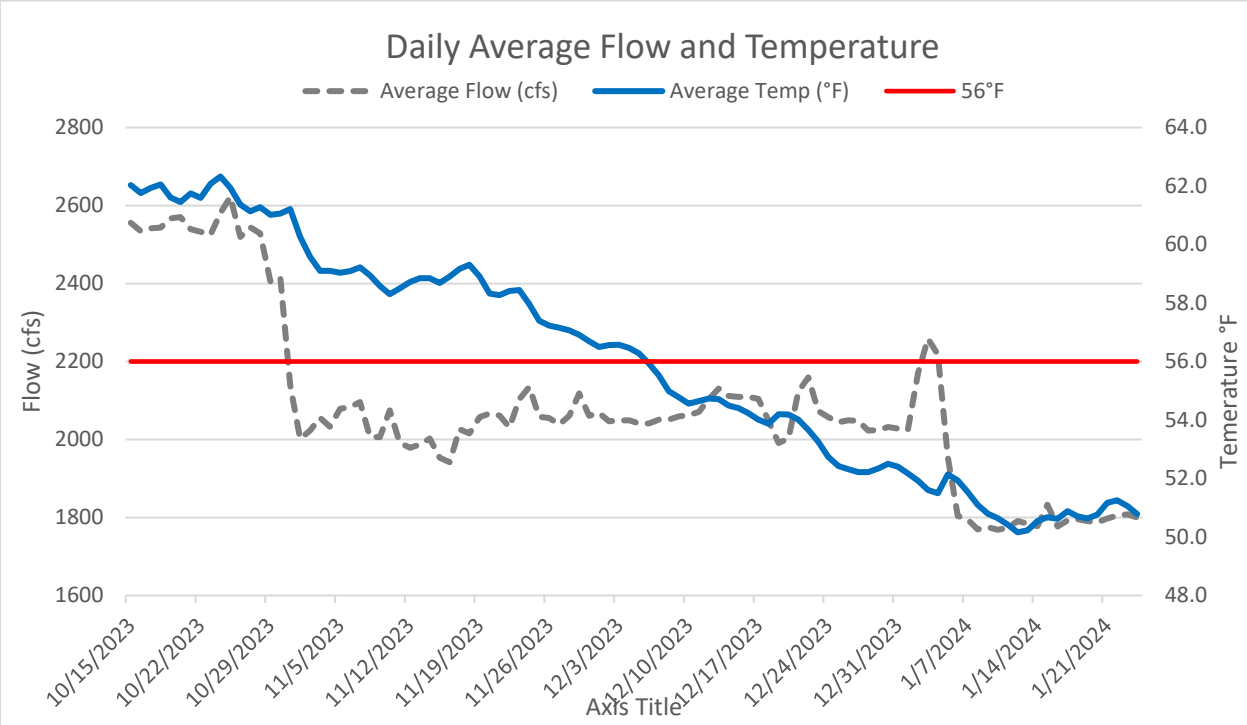

Figure 2. Daily average flow (left y-axis) and water temperatures (right y-axis) encountered during the 2023-2024 lower American River Chinook salmon escapement survey. The red line indicates 56°F, which is considered the daily average temperature suitable for spawning and egg survival. Temperature and flow were reported by USGS, American River at Fair Oaks gauge (USGS 2024).

Final Carcass Count

During the 2023 lower American River escapement survey, 18,809 carcasses were observed and processed (Figure 3). The highest number of carcasses processed in a single survey period was 4,101 and occurred during survey period 8 (December 4 - 7). Of the 18,809 carcasses processed during the season, 2,109 fresh carcasses were encountered (Figure 4). Fresh carcasses were observed during each of the 15 sampling periods, reaching a high of 386 fresh carcasses processed during sampling period 7 (November 27 – 30).

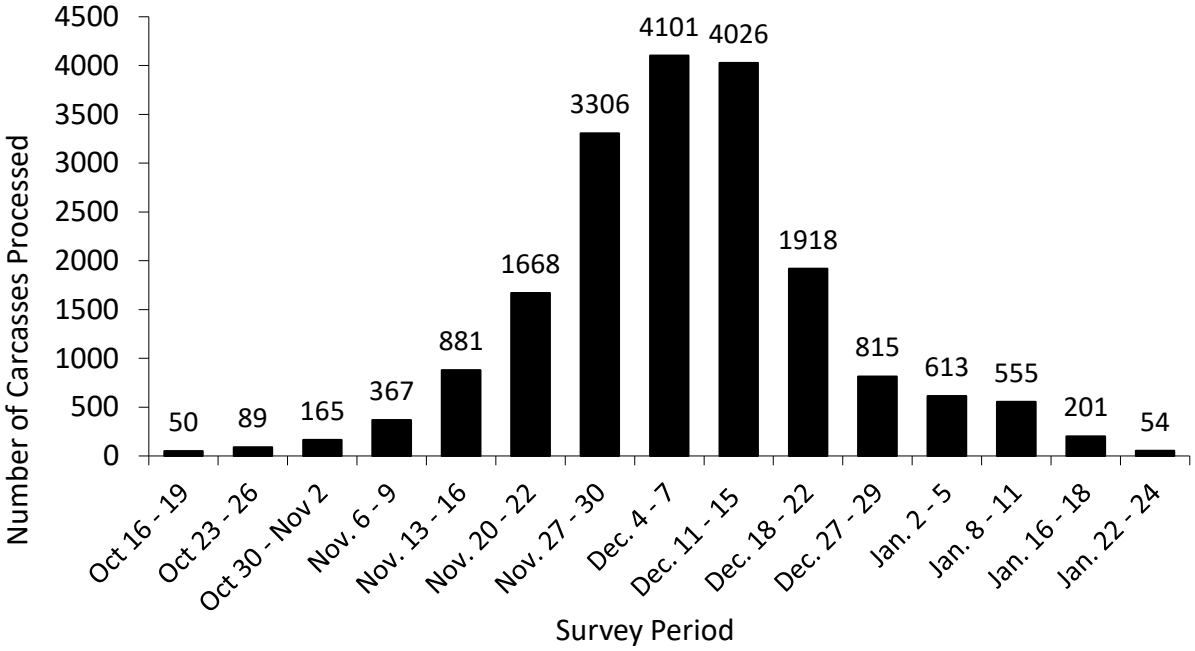

Figure 3. Numbers of carcasses observed and processed during the 2023-2024 lower American River Chinook salmon escapement survey.

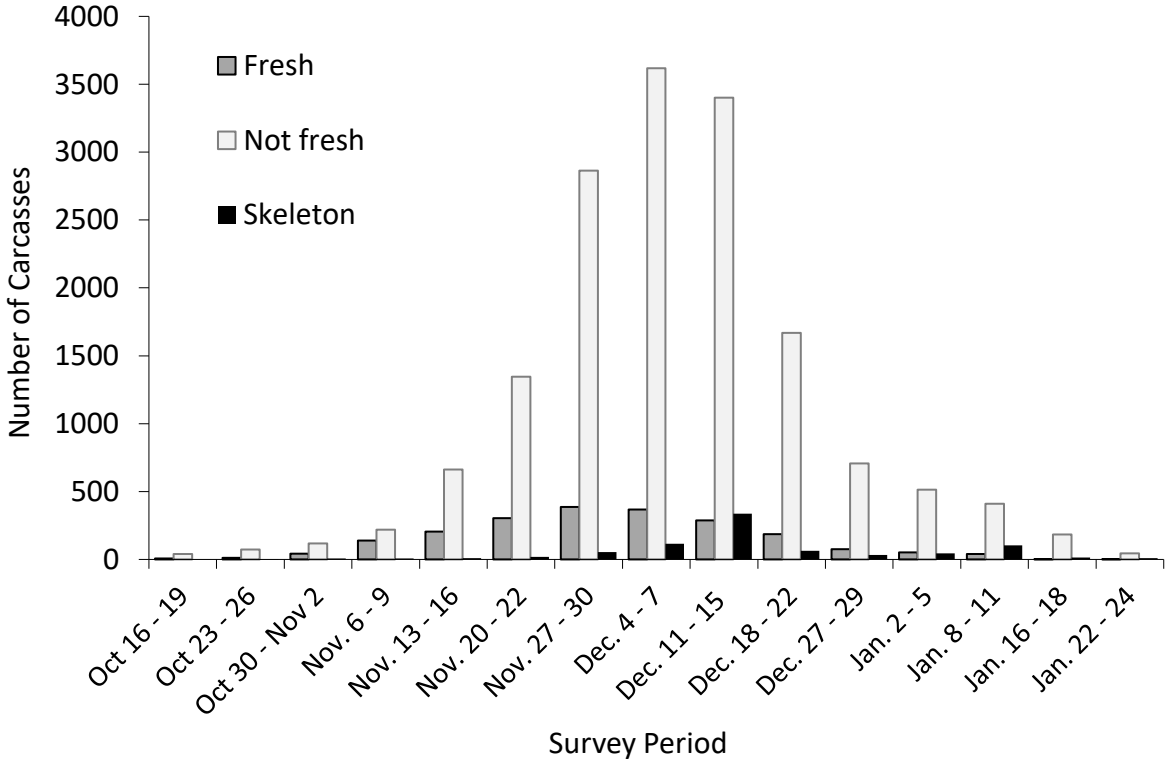

Figure 4. Number of fresh, not fresh, and skeleton carcasses processed in each survey period for the 2023-2024 lower American River Chinook salmon escapement survey.

Carcass Processing

Of the 18,809 carcasses processed, 15,942 (85%) were in an advanced stage of decomposition and were chopped and tallied. Of the remaining carcasses, 1,172 (6%) were processed for covariate data collection and chopped, including 1,079 heads retained for CWT extraction, while 1,695 (9%) were disk-tagged and included in the mark-recapture study (Figure 5).

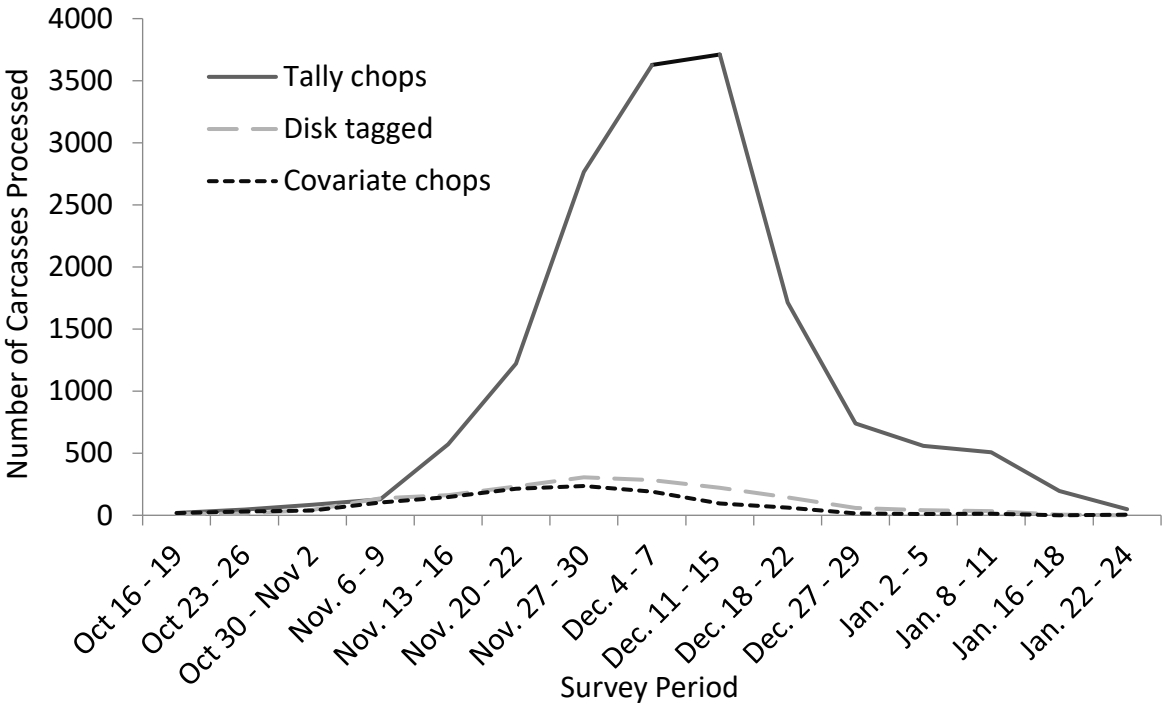

Figure 5. Frequency of processing method for carcasses collected during the 2023-2024 lower American River Chinook salmon escapement survey.

Spatial Distribution

Of the total number of carcasses processed during the survey, 5% were detected in NB (n = 912), 41% in section 1A (n = 7,642), 25% in section 1B (n = 4,622), 22% in section 2 (n = 4,162), and 8% in section 3 (n = 1,471) (Figure 6, Table 3).

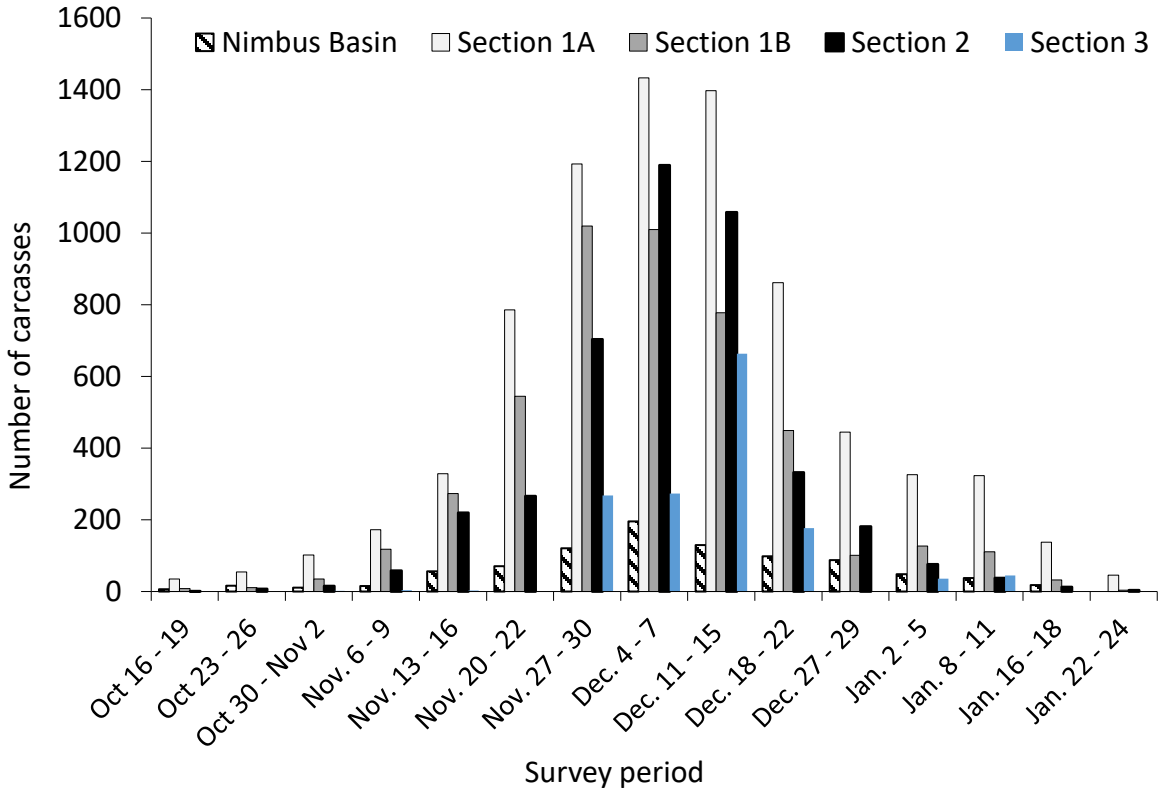

Figure 6. Spatial distribution of carcasses by survey period for the 2023-2024 lower American River Chinook salmon escapement survey.

Table 3. Spatial distribution of carcasses processed by survey period during the 2023-2024 lower American River Chinook salmon escapement survey.

Survey Period	Date	Nimbus Basin	Section 1A	Section 1B	Section 2	Section 3	Total
1	Oct. 16 to Oct. 19	6	35	8	1	0	50
2	Oct. 23 to Oct. 26	16	55	11	7	0	89
3	Oct. 30 to Nov. 2	11	102	35	15	2	165
4	Nov. 6 to Nov. 9	15	172	118	58	4	367
5	Nov. 13 to Nov. 16	56	329	273	220	3	881
6	Nov. 20 to Nov. 22	71	786	545	266	0	1668
7	Nov. 27 to Nov. 30	121	1193	1020	704	268	3306
8	Dec. 4 to Dec. 7	196	1433	1010	1189	273	4101
9	Dec. 11 to Dec. 15	130	1397	778	1058	663	4026
10	Dec. 18 to Dec. 22	98	862	449	332	177	1918
11	Dec. 27 to Dec. 29	88	445	101	181	0	815
12	Jan. 2 to Jan. 5	48	326	127	76	36	613
13	Jan. 8 to Jan. 11	38	323	111	38	45	555
14	Jan. 16 to Jan. 18	18	138	32	13	0	201
15	Jan. 22 to Jan. 24	0	46	4	4	0	54
Total		912	7642	4622	4162	1471	18809
Total (%)		5	41	25	22	8	

Sex Ratios

Sex data were recorded for 2,856 carcasses. Females represented 55% (n = 1,568) of the carcasses and males represented 45% (n = 1,288). Sex could not be determined for the remaining 15,953 carcasses because gonads were too deteriorated. Females were found more frequently than males throughout most of the 15-week survey (Figure 7).

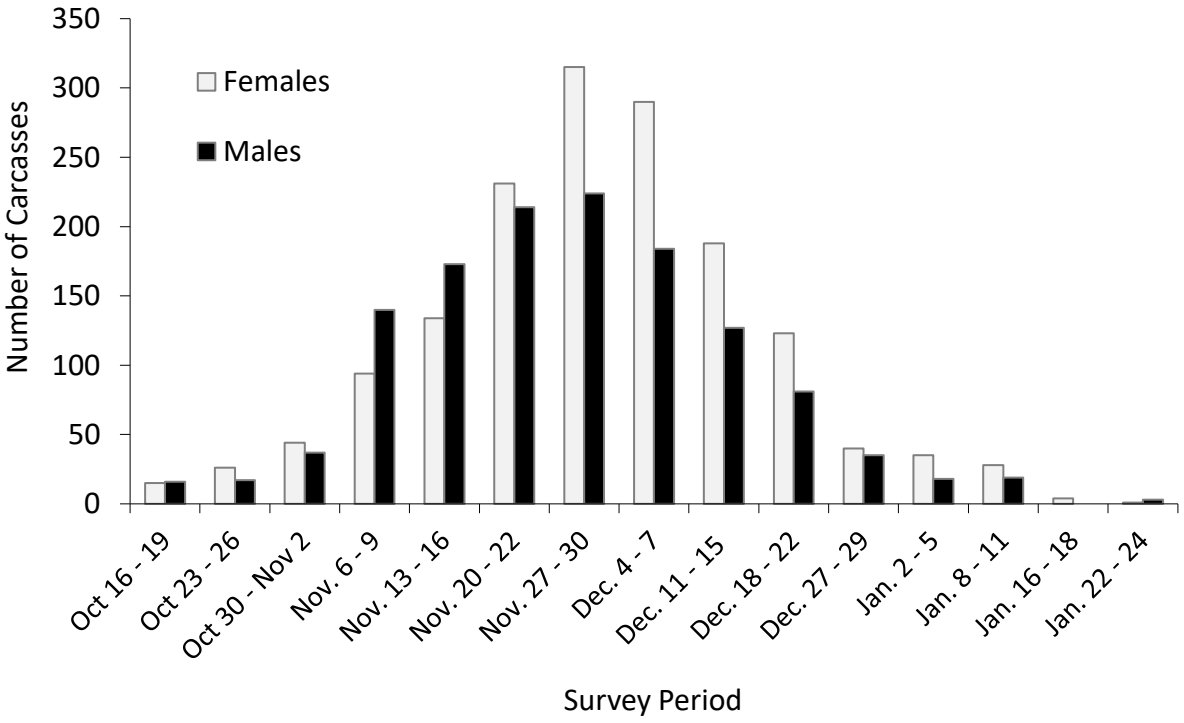

Figure 7. Number of male and female carcasses by survey period processed during the 2023-2024 lower American River Chinook salmon escapement survey

Length Distributions

Fork length was recorded for 2,853 carcasses of known sex (Figure 8). The average length for females (n = 1566) was 83 cm with a range of 52 cm to 106 cm. The average length for males (n = 1287) was 87 cm with a range of 51 cm to 114 cm. There were 10 unknown sex carcasses with an average of 74 cm in the range of 52 cm to 87 cm.

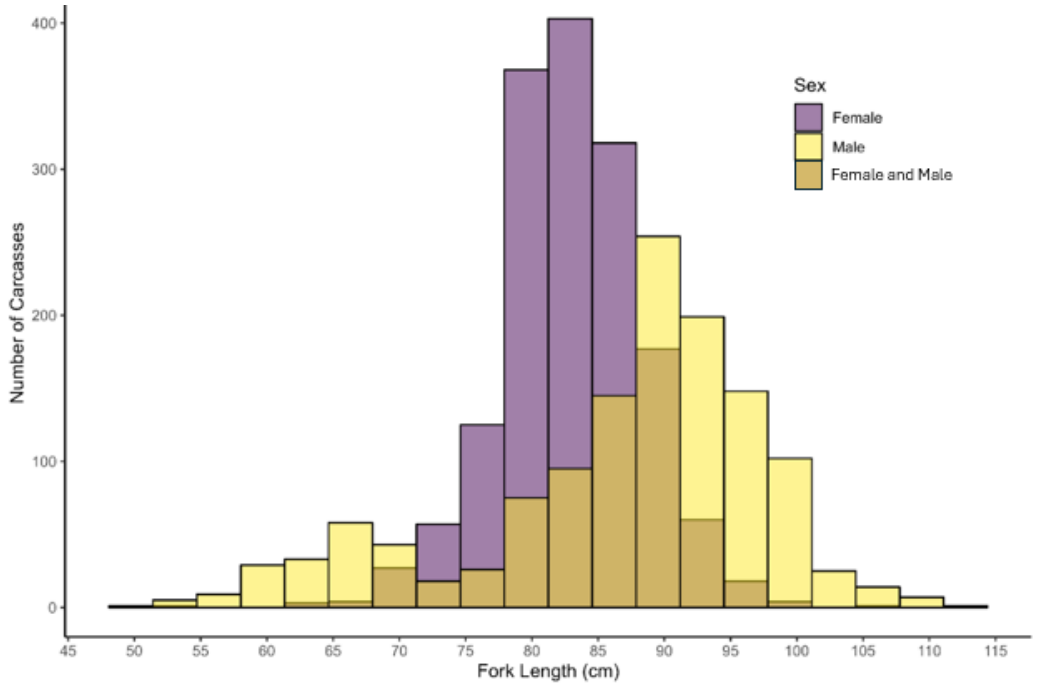

Figure 8. Fork length frequency histogram by sex for carcasses processed during the 2023-2024 lower American River Chinook salmon escapement survey.

Age Classification

Length-frequency distributions of known-age CWT carcasses were used to determine the size boundaries for adult and grilse carcasses for each sex (Figure 9). Fish were classified as adults (≥3 years-old) if females had a FL ≥ 69 cm and males had a FL ≥ 76 cm. Fish were classified as grilse (≤2 years-old) if females had a FL of ≤68 cm and males had a FL of ≤75 cm.

A total of 2,637 (92%) carcasses were classified as adult and 226 (8%) carcasses were classified as grilse. The adult age class consisted of 1,552 (59%) females, 1,078 (41%) males, and 7 adults of unknown sex (<1%). The grilse age class consisted of 14 (6%) females, 209 (92%) males, and 3 grilse of unknown sex (1%) (Figure 10). The number of grilse peaked in week 6, and the number of adults peaked in week 7 (Table 4).

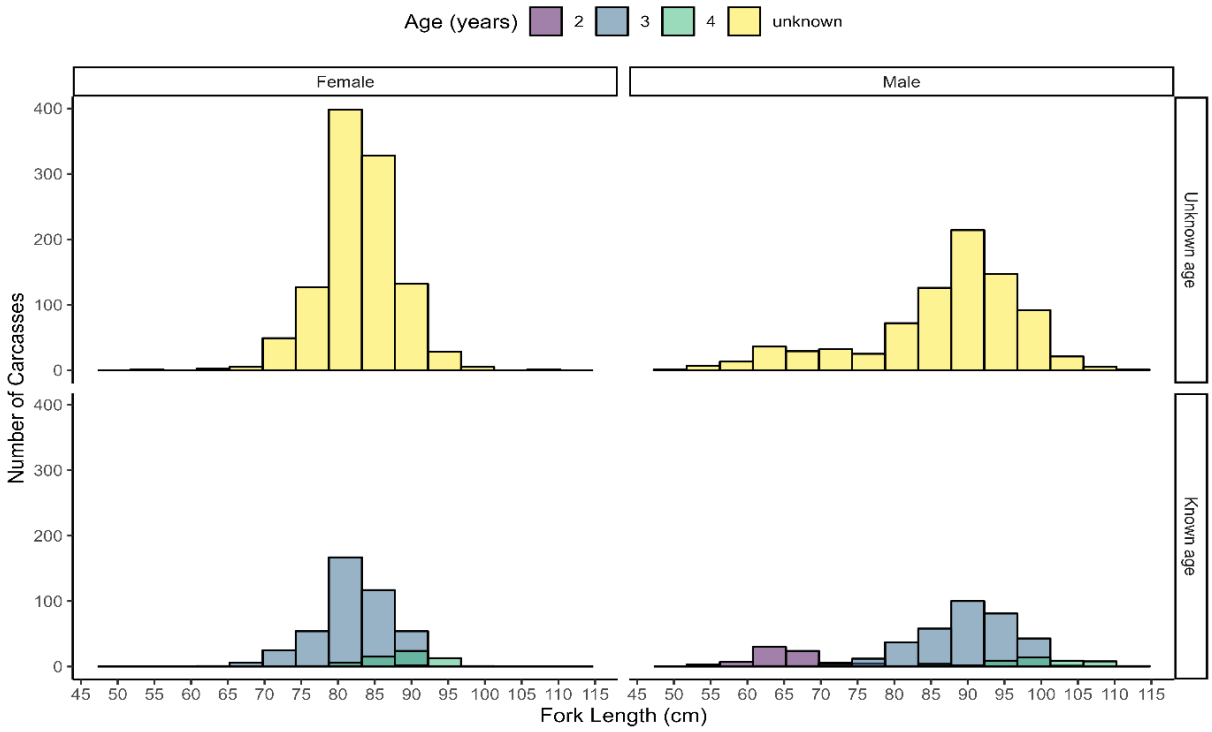

Figure 9. Fork length-frequency distribution of known-age coded wire tagged carcasses and unknown age carcasses processed during the 2023-2024 lower American River Chinook salmon escapement survey.

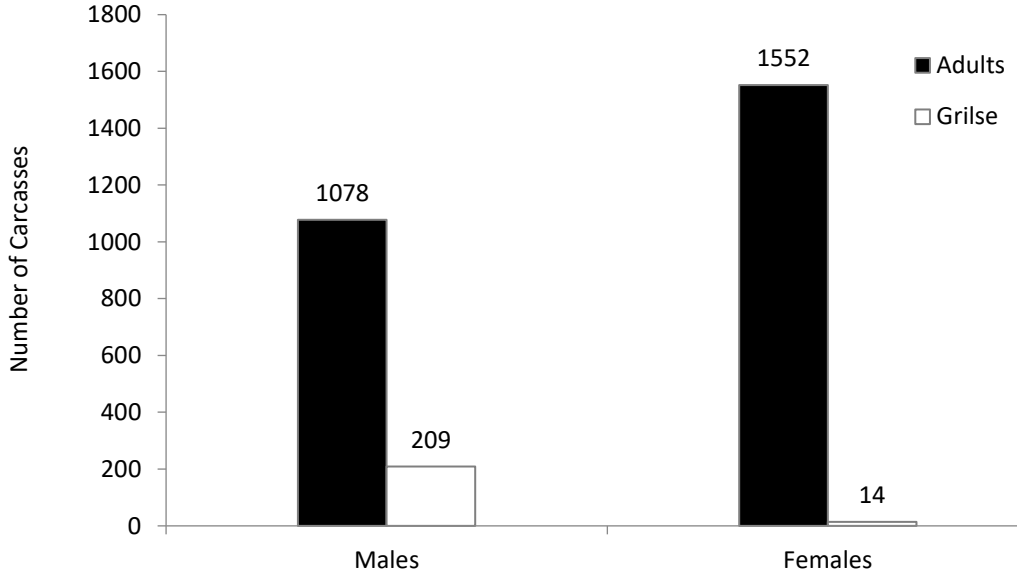

Figure 10. Number of male and female carcasses assigned to adult or grilse age classes during the 2023-2024 lower American River Chinook salmon escapement survey.

Table 4. Summary of processed salmon carcasses by age class during the 2023-2024 lower American River Chinook salmon escapement survey.

Survey Period	Date	Grilse		Adult	
		n	%	n	%
1	Oct. 16-19	3	10	28	90
2	Oct. 23-26	5	12	38	88
3	Oct. 30 – Nov. 2	10	12	71	88
4	Nov. 6-9	32	14	204	86
5	Nov. 13-16	36	12	272	88
6	Nov. 20-22	51	11	395	89
7	Nov. 27-30	34	6	508	94
8	Dec. 4-7	24	5	450	95
9	Dec. 11-15	21	7	294	93
10	Dec. 18-22	5	2	199	98
11	Dec. 27-29	3	4	72	96
12	Jan. 2-5	0	0	53	100
13	Jan. 8-11	2	4	45	96
14	Jan. 16-18	0	0	4	100
15	Jan. 22-24	0	0	4	100
	Total	226		2637	
	Total (%)	8		92	

Since 2011, cutoff lengths between grilse and adult age classes have ranged between 68 cm and 76 cm FL for males, and between 60 cm and 70 cm FL for females (Figure 11). In 2023, cutoff lengths occurred at the higher end of this range for both sexes, 76 cm for adult males (5 cm longer than the brood season) and 69 cm for adult females (4 cm longer than the brood season) (Kelly and Phillips 2020). The adults to grilse ratio in 2023 is within the range exhibited in prior surveys (Figure 12). Chinook salmon have been known to exhibit density dependent reproductive success, with larger fish often being most successful resulting in population level size selection (Roni and Quinn 1995).

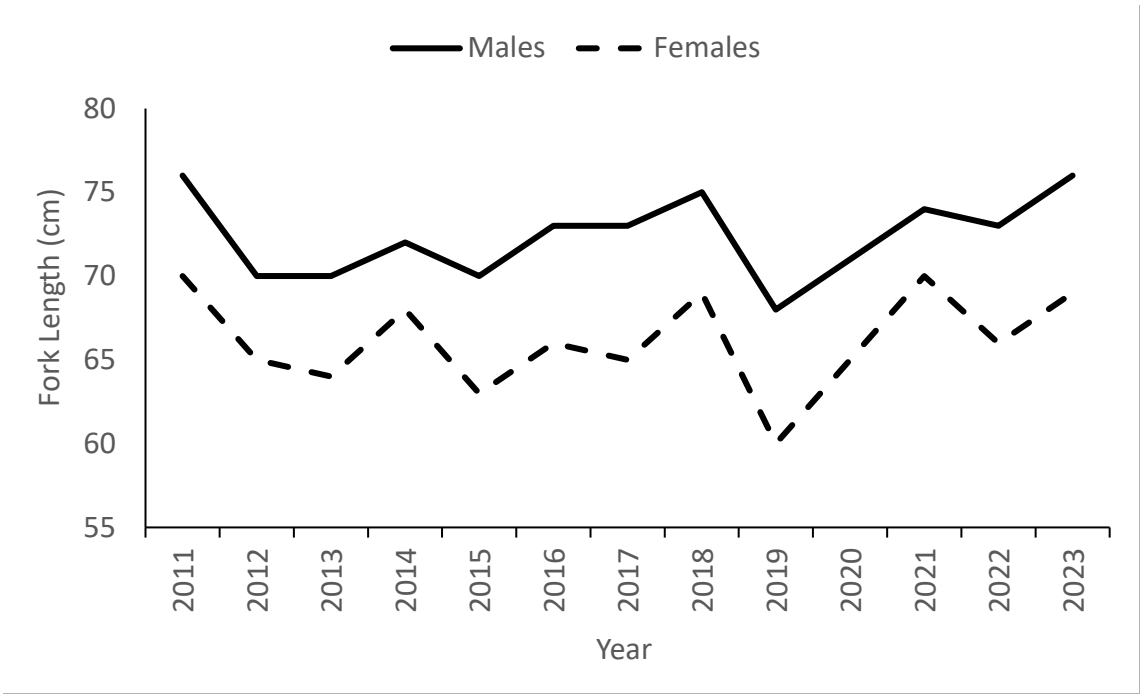

Figure 11. Minimum fork lengths for adult Chinook salmon of both sexes observed from 2011-2023 during the lower American River escapement survey.

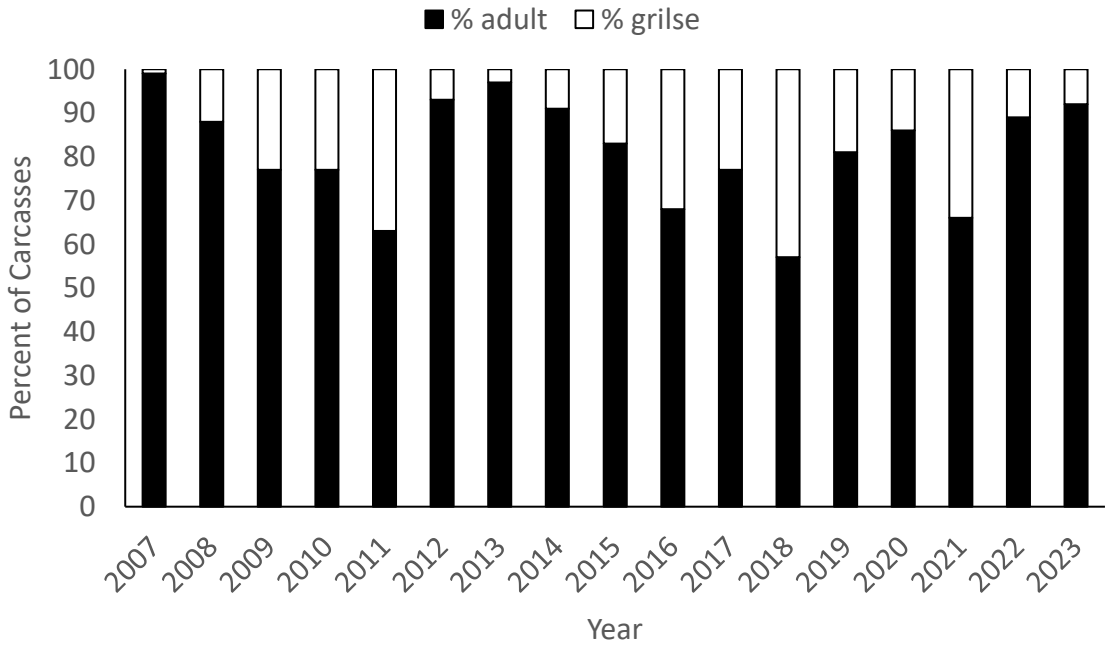

Figure 12. Proportion of adult and grilse carcasses observed each year from 2007 to 2023 during the lower American River escapement survey.

Pre-spawn Mortality

Degree of egg retention was determined for 1,516 female carcasses (Table 5). Spawned females accounted for 73% (n = 1,105), partially spawned accounted for 7% (n = 104), and unspawned accounted for 20% (n = 307) of examined female carcasses. The proportion of spawned females varied throughout the survey period. Through the first three weeks of the survey, most females assessed for egg retention were unspawned; however, for the rest of the survey the majority of females were spawned. During the last two weeks of the survey, all recovered females were spawned (Figure 13).

Table 5. Egg retention status of female carcasses and mean water temperature by survey period during the 2023-2024 lower American River Chinook salmon escapement survey. Unspawned females retained >70% of eggs, partially spawned females retained 30-70% of eggs and spawned females retained <30% of eggs. Water temperature data were reported by USGS, American River at Fair Oaks gauge (USGS 2024).

Survey Dates	Survey Week	Mean Water Temperature °F	Unspawned Females		Partially Spawned Females		Spawned Females		Total
			n	%	n	%	n	%	
Oct 16 - 19	1	61.8	10	77	3	23	0	0	13
Oct 23 - 26	2	61.9	19	76	4	16	2	8	25
Oct 30 - Nov 2	3	60.5	21	57	3	8	13	35	37
Nov. 6 - 9	4	59.0	21	24	11	12	57	64	89
Nov. 13 - 16	5	58.8	27	21	5	4	95	75	127
Nov. 20 - 22	6	58.3	32	14	15	7	177	79	224
Nov. 27 - 30	7	57.0	63	21	23	8	220	72	306
Dec. 4 - 7	8	56.1	67	23	20	7	199	70	286
Dec. 11 - 15	9	54.6	26	14	7	4	151	82	184
Dec. 18 - 22	10	54.0	13	11	8	7	100	83	121
Dec. 27 - 29	11	52.3	3	8	3	8	32	84	38
Jan. 2 - 5	12	51.8	2	6	1	3	32	91	35
Jan. 8 - 11	13	50.7	3	12	1	4	22	85	26
Jan. 16 - 18	14	50.8	0	0	0	0	4	100	4
Jan. 22 - 24	15	51.0	0	0	0	0	1	100	1
Total			307	**20**	104	**7**	1105	**73**	1516

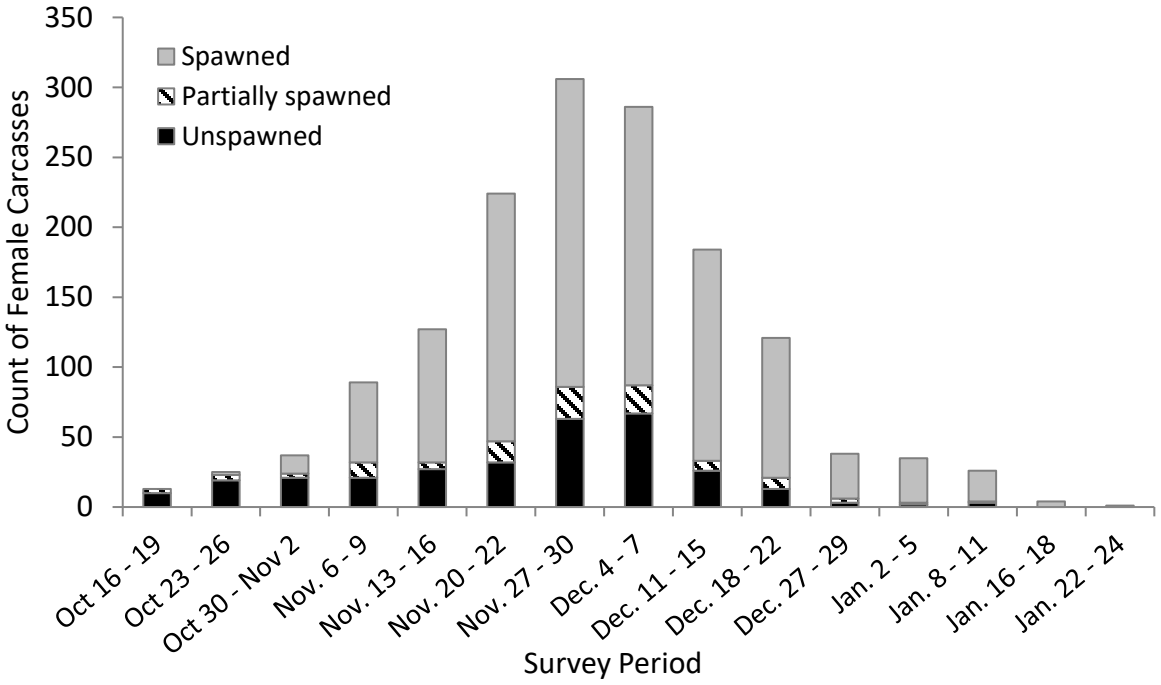

Figure 13. Egg retention status of female carcasses per survey period for the 2023-2024 lower American River Chinook salmon escapement survey.

CWT Carcasses

Hatcheries in the Central Valley generally tag approximately 25% of hatchery-reared FRCS with CWT's and mark these fish by clipping their adipose fin. All Chinook salmon carcasses were inspected for the presence or absence of an adipose fin. Adipose fin clipped carcasses were recovered during all weeks of the survey (Table 6, Figure 14). A total of 3,416 (18%) carcasses had an adipose fin clip, which is lower than the rate observed from fish that entered the Nimbus Fish Hatchery (26%). Of those adipose fin-clipped fish, heads were collected from 1,079 for CWT recovery. Adipose fins were intact for 14,173 (75%) of carcasses and presence or absence could not be determined for 1,220 (7%) of carcasses.

The staff at the CDFW Central Valley Salmonid Archive and the Ocean Salmon Project processed 1,074 carcass heads for CWT extraction. Of the 1,074 carcass heads processed, 72.8% (782) originated from Nimbus Fish Hatchery, 9.3% (100) from Mokelumne River Hatchery, 7.9% (85) from Coleman National Fish Hatchery, 4.6% (49) from Feather River Hatchery, and 0.7% (7) from Merced River Fish Facility. The remaining 4.6% (49) Chinook salmon heads collected either had no CWT or the CWT was unreadable. A portion of the FRCS from Nimbus Fish Hatchery (n = 66) were part of a release in which duplicates of previously used CWTs were used; therefore, we are unable to be certain of their age, but we can include them in hatchery-origin data. Approximately 22.6% (243 of 1,074) of CWT FRCS originated from hatcheries outside of the American River watershed.

Table 6. Adipose condition of carcasses by survey period for the 2023-2024 lower American River escapement survey.

Survey Period	Date	Adipose Intact	Adipose Clipped	Skeleton/Unknown	Total
1	Oct. 16-19	40	8	2	50
2	Oct. 23-26	69	17	3	89
3	Oct. 30 -Nov. 2	134	26	5	165
4	Nov. 6-9	258	101	8	367
5	Nov. 13-16	708	161	12	881
6	Nov. 20-22	1349	301	18	1668
7	Nov. 27-30	2686	556	64	3306
8	Dec. 4-7	3245	724	132	4101
9	Dec. 11-15	2916	694	416	4026
10	Dec. 18-22	1364	389	165	1918
11	Dec. 27-29	566	168	81	815
12	Jan. 2-5	403	102	108	613
13	Jan. 8-11	286	120	149	555
14	Jan. 16-18	120	41	40	201
15	Jan. 22-24	29	8	17	54
	Total	14173	3416	1220	18809
	Total (%)	75	18	7	

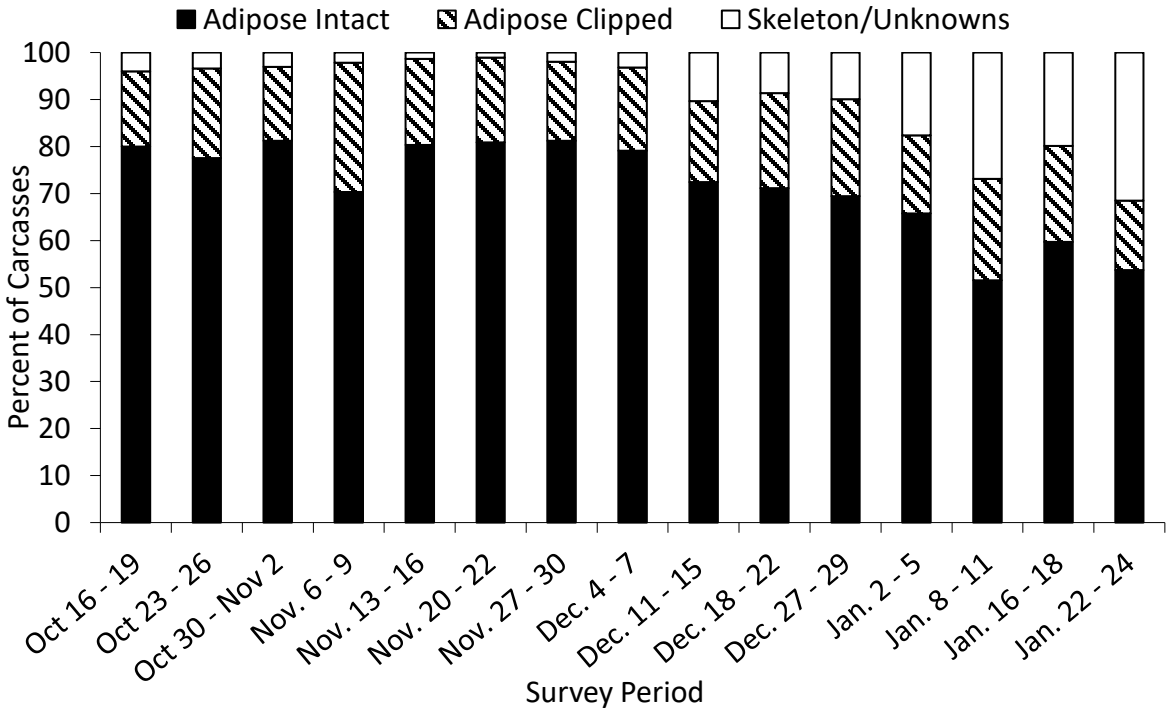

Figure 14. Temporal distribution of adipose fin condition for carcasses processed 2023-2024 lower American River escapement survey.

Escapement Estimate

To calculate an escapement estimate, 1,695 fresh carcasses were marked with uniquely numbered disk tags for inclusion in the CJS population model. Of the tagged carcasses, 593 carcasses (35%) were recaptured at least once, with 617 recapture events in total. The LAR escapement estimate for 2023 was 37,321 FRCS (95% CI = 35,600 to 39,264). The bootstrap (n = 1,000) estimate of standard error was 1,020 FRCS. The total escapement estimate was multiplied by the fraction of adults and grilse (approximately 92% and 8%, respectively) to obtain an escapement estimate of 34,375 and 2,946 for adults and grilse, respectively. In addition to the in-river escapement, 9,299 Chinook (6,503 adults and 2,796 grilse) entered Nimbus Fish Hatchery via a fish ladder. After spawning concluded at the hatchery, 17 adults were marked with floy tags to prevent being double counted, before being released back into the river. The hatchery uses a static length boundary of 68 cm to assign an age class for both sexes.

DISCUSSION

Salmon Fishery Closure and 2023's Escapement Estimate

Prolonged drought, severe wildfires and associated impacts to spawning and rearing habitat, harmful algal blooms and ocean forage shifts combined resulted in some of the lowest stock abundance forecasts on record for California's Chinook salmon (CDFW 2023). As a result, in May 2023, the California Fish and Game Commission acted unanimously to enact a full closure of California's inland recreational salmon fishing season in the Klamath River Basin and Central Valley rivers (CDFW, 2023). The Commission's actions followed the recommended closure of both commercial and recreational ocean salmon fisheries off the California coast by the Pacific Fishery Management Council due to projections showing Chinook salmon abundance at historic lows (CDFW, 2023)

Various factors influence annual LAR escapement estimates, including escapement and spawning success of previous brood years, juvenile survival during emigration, ocean conditions, predation and harvest of adults, and river conditions (e.g., flow and water temperature). The 2023 LAR escapement estimate (37,321 FRCS) is a significant increase as compared to the previous year (16,383 FRCS) and was likely positively impacted by the commercial and sport salmon fishery closure (Figure 15). The majority of salmon that returned to the LAR in 2023 were expected to be from brood year 2020 which had a reported escapement estimate of 22,456 FRCS.

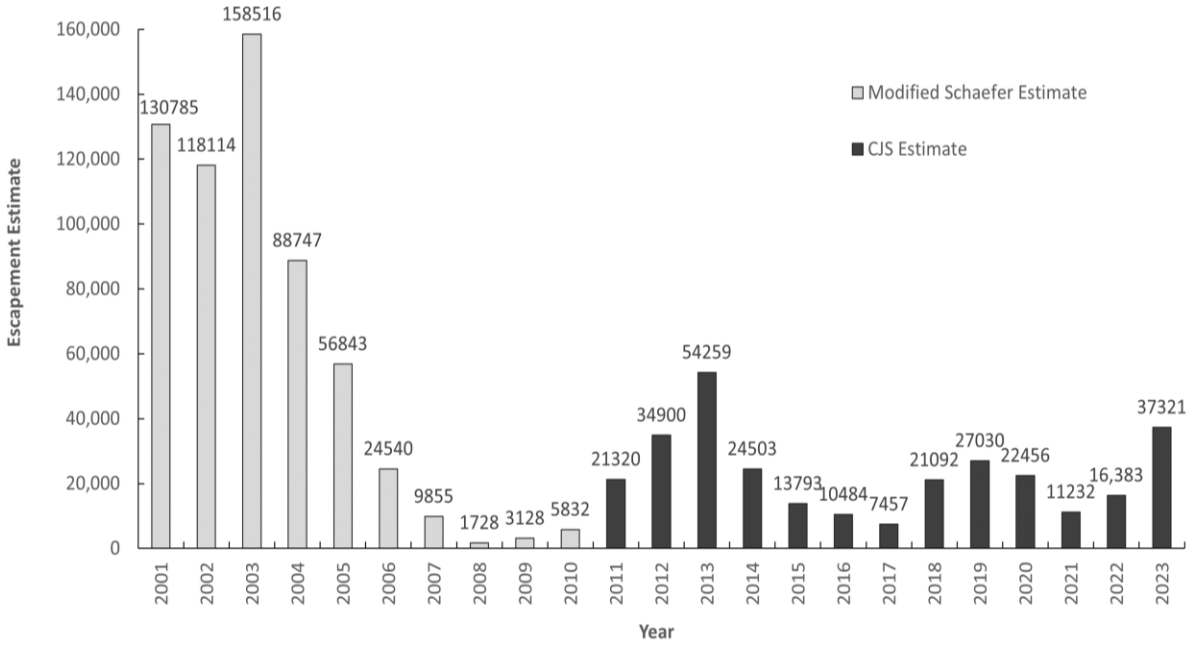

Figure 15. Historical in-river escapement estimates for the lower American River from 2001-2023

Peak carcass recovery occurred during survey period 8 (December 4-7), which is consistent with the historical average for LAR FRCS. Spawn timing of Chinook salmon is associated with environmental conditions, and higher water temperatures are correlated with later spawning (Quinn et. Al. 2002; Carter 2005; Goniea et. Al 2006) and higher pre-spawn mortality (Carter 2005). Climate driven variations in temperature are of increasing relevance for the Central Valley population of FRCS, which spawn at the southern extent of the species' range, therefore making it more susceptible to climate change (Williams 2006). Maintenance of the cold-water pool (CWP) behind Folsom Dam and cold-water releases have become increasingly relevant for survival of LAR FRCS stocks (Yates et al. 2008).

Accidental Release of Cold-Water Pool at Folsom Dam

Following several years of severe drought conditions, California experienced one of the largest snowpack years on record in the winter of 2023. As a result, the cold-water pool (CWP) volume in Folsom Lake was anticipated to be higher than average, which would have led to better temperature management for Chinook salmon returning to the LAR in the fall. However, during routine temperature profiles of Folsom Lake in mid-August 2023, the Bureau of Reclamation (BOR) identified warmer than expected water temperatures in the reservoir. Further investigation resulted in the discovery that the temperature shutters had been accidentally placed in the wrong configuration since April or May and were not in their lowermost positions,

resulting in the premature release of cold water and the depleting of cold-water pool (CWP) volume. Approximately 70,000 acre-feet (70 TAF) of CWP (< 58°F) was estimated to have been lost as a result of the shutter configuration mistake. With the loss of CWP, less cold water was available in the fall for spawning adults and egg incubation, which may have resulted in higher pre-spawn mortality and in river egg mortality as compared to if the integrity of the CWP had not been impacted by the BOR shutter configuration mistake.

Water Temperature and Pre-Spawn Mortality

During the 2023 LAR FRCS spawning season, daily maximum water temperature recorded at Fair Oaks reached and remained below 56°F starting on December 6, 2023, and the percentage of females classified as spawned remained above 80% in the following survey weeks (Figure 16). Pre-spawn mortality of females (20%) is within the historical range, and the percentage of fully spawned females (73%) is only down 1% from the previous two years (both 74%).

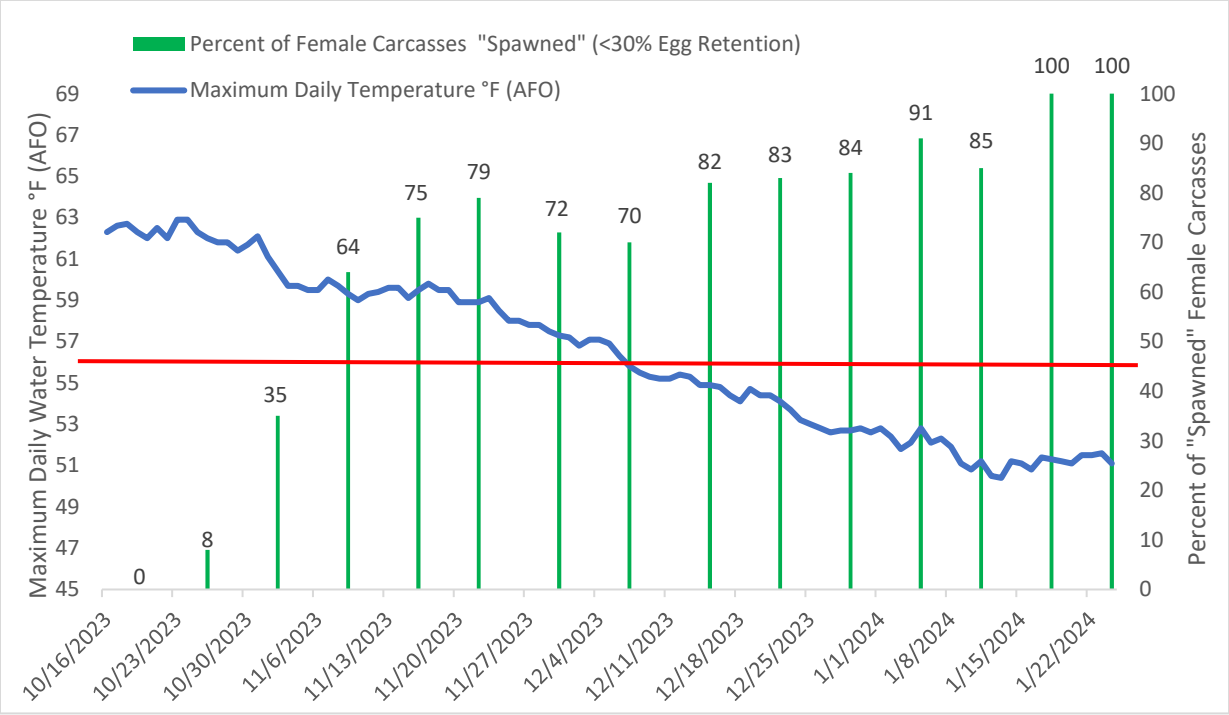

Figure 16. Maximum daily water temperature recorded at the Fair Oaks (AFO) gauge and the percentage of females classified as spawned by the final day of each survey week. 56°F is considered ideal for spawning and egg survival and is highlighted in red. Egg retention status was determined for a total of 1,516 female carcasses during the 2023 LAR escapement survey. Of these, 1,105 (73%) were classified as spawned (<30% egg retention)

Nimbus Fish Hatchery Releases and CWT Returns

There were six LAR 2020 brood year FRCS releases in April and May 2021, resulting in a total of 4,068,394 juvenile chinook salmon released in San Pablo and San Fransisco Bays (PSMFC, 2021). Of the fish released, 25% (1,011,755) were coded wire tagged and marked with an adipose fin clip. Preliminary CWT data indicates the overall proportion of fish that strayed to the LAR in 2023 decreased, with 73% of returning adults originating from Nimbus Fish Hatchery, compared to only 63% the previous year. Mokelumne Fish Hatchery and Coleman National Fish Hatchery comprised the majority of fish that strayed to the LAR (n = 185, 17.2%). The proportion of fish from Mokelumne Fish Hatchery decreased from 22% in 2022 to 9.3% in 2023. In contrast, the proportion of fish from Coleman National Fish Hatchery increased from 0.8% in 2022 to 7.9% in 2023. Juvenile release location has a strong correlation with return and stray rates and can dramatically influence salmon survival rates (Palmer-Zwahlen and Kormos 2012).

Thiamine Deficiency

Returning adult Chinook salmon that fed off the coast of central California may have been susceptible to a deficiency of thiamine (vitamin B1). Previous studies have shown there was a high abundance of anchovy off the coast of central California in recent years. Anchovies produce an enzyme called thiaminase which breaks down thiamine, an essential vitamin that supports metabolic function. Thiamine deficiency in returning adult salmon can impact prespawn mortality and juvenile survival and is currently being investigated by researchers (Mantua et al. 2021). In 2023, 55% of Nimbus Fish Hatchery Fall Run Chinook Salmon that were tested indicated that they were impacted by thiamine deficiency, and an additional 12% were likely impacted (NOAA ERD). Central Valley hatcheries have been successful in treating hatchery produced salmon for thiamine deficiency but the sub-lethal effects and impacts this may have on in-river juvenile production is still being investigated.

Escapement Estimate as Compared to CVPIA's Doubling Goal

The Central Valley Project Improvement Act (CVPIA) established the goal to double the number of naturally spawning anadromous fish in the Central Valley based on a baseline period of 1967-1991. Mark-recapture efforts during the 2023-2024 lower American River escapement survey produced an escapement estimate of 37,321 fall-run Chinook salmon which is more than double the previous year (16,383 FRCS) and is the highest estimate since 2015 (54,259 FRCS) (Figure 13). However, this estimate is still far below the CVPIA doubling goal of 160,000 fall-run Chinook salmon on the American River (U.S. Fish and Wildlife Service 2015).

ACKNOWLEDGMENTS

The successful completion of the LAR escapement survey is a direct result of the dedication of the 2023 survey crew: Veronica Carruth, Katie Giuffre, Brooke Greer, Matthew Kendall, Jennifer O'Brien, Amanda Rae, Christopher Townsend, and Austin Trenkamp. We received additional help from the following individuals: Arthur Barros, Lucas Brattesani, Marvin Castaneda, Kyle Cen, Christian Clayton, Melissa Coyoy, Hailey Donaldson, Eliana Gossard, Tracy Grimes, Audrey Heath, Kim Hoffman, Shane Jurado, Jerson Keomanivong, Daniel Lopez, Hunter Morris, Benjamin Rivera, Bree Shima, Bryan Steurer, Grace Stieglitz, and James Tilton and all the crew at the CDFW CWT lab. Additionally, the voluntary assistance of the Cramer Fish Sciences staff proved valuable in daily data collection. We extend our appreciation to the United States Bureau of Reclamation for funding the survey. Stan Allen, Amy Roberts, and Kathy Ameral with the Pacific States Marine Fisheries Commission, and Nick Bauer, with CDFW, were instrumental in the completion of supervisory and administrative duties.

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