California Department of Fish and Wildlife
North Central Region

Lower American River Fall-run Chinook Salmon Escapement Survey October 2024 – January 2025

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 2024-2025 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 14, 2024, to January 23, 2025. 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 2024 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.

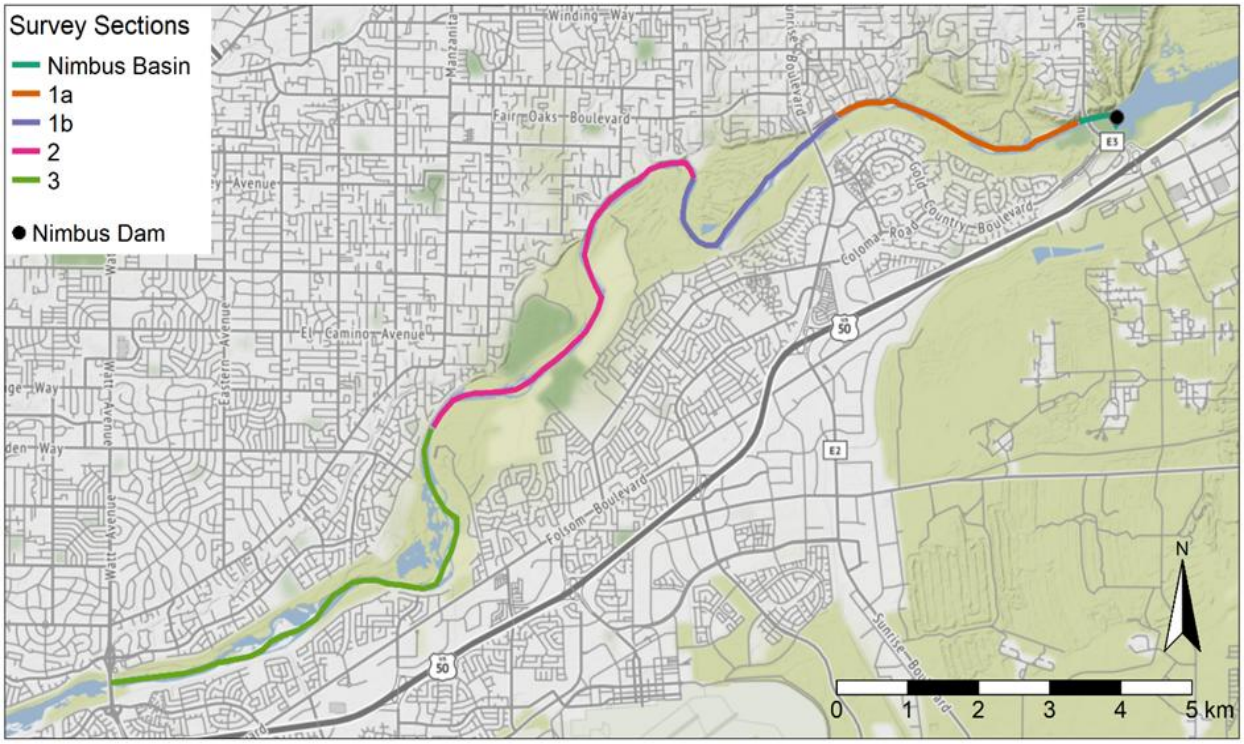

Figure 1. Survey sections for the lower American River Chinook salmon escapement survey.

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 or drift boat. NB was surveyed only on foot from the banks. Sections 1A and 1B were surveyed by jet boat and from the banks. Section 2 was surveyed by drift boat and kayaks during weeks 4 through 6, jet boat and kayaks during weeks 7 through 10, and surveyed only by kayaks in all other weeks. Section 3 was surveyed by drift boat and kayaks during weeks 4 and 6. In all other weeks, it was surveyed by only kayaks. 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 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 2024-2025 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.

During the 2024 LAR escapement survey, tissue samples were collected for the first time as part of the Parentage-Based Tagging (PBT) effort. Hatcheries began implementing PBT in a portion of the 2022 brood year fall-run Chinook Salmon as a less invasive tagging technique (CDFW 2023). Some of these fish may have returned to the LAR in 2024 as grilse. As a result, fin clips were collected from unclipped, fresh carcasses meeting a pre-determined grilse cutoff (females $\leq$68cm and males $\leq$70cm). Fin clips were collected from the least-decomposed fin (preferably the caudal fin but excluding the adipose fin) and placed on a piece of filter paper in an envelope. At the end of each field day, the samples were removed from their envelopes and laid out to dry as quickly as possible. Tissue samples will be analyzed post-season by CDFW's Central Valley Tissue Archive (CVTA).

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 2024 LAR survey consisted of 15 survey periods from October 14, 2024, to January 23, 2025. NB, section 1A, and section 1B were surveyed during each survey period. Section 2 was surveyed in each survey period except week 11 due to holiday interference. Section 3 was not surveyed in weeks 5 and 12 due to unsafe weather conditions and in weeks 7 and 11 due to holiday interference. (Table 2). No subsampling occurred at any time during the study.

Table 2. Survey dates and sampling regime for the 2024-2025 lower American River Chinook salmon escapement survey.

Survey Period	Date	Sections Not Surveyed
1	Oct. 14 to Oct. 17	None
2	Oct. 21 to Oct. 24	None
3	Oct. 28 to Oct. 31	None
4	Nov. 4 to Nov. 7	None
5	Nov. 11 to Nov. 14	3
6	Nov. 18 to Nov. 22	None
7	Nov. 25 to Nov. 27	3
8	Dec. 2 to Dec. 6	None
9	Dec. 9 to Dec. 13	None
10	Dec. 16 to Dec. 20	None
11	Dec. 22 to Dec. 23	2,3
12	Dec. 30 to Jan. 3	3
13	Jan. 6 to Jan. 9	None
14	Jan. 13 to Jan. 16	None
15	Jan. 20 to Jan. 23	None

Environmental Conditions

The US Bureau of Reclamation (USBR) initiated a power bypass of 66 cfs on October 18th, 2024, 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 a period of two days (196 cfs on October 19th), and averaged 250 cfs daily between October 20th and November 24th, before reducing to 200 cfs on November 25th and 76 cfs on the final day (November 26th).

Daily average LAR temperatures generally decreased over the duration of the survey season. The highest average daily temperature recorded was 65.3°F on October 14th, and the lowest average daily temperature was 48.6°F on January 22nd and 23rd (Figure 2). Water temperature decreased to a level suitable for spawning on November 27th when the daily maximum water temperature recorded at Fair Oaks reached and remained below 56°F.

For the first three weeks of the survey, average daily flow ranged between 1,504 and 1,523 cfs. From November 1st to December 31st, average flows increased and remained between 1,959 and 2,193 cfs with conditions averaging 2,066 cfs. For the remainder of the season, average flows decreased and remained between 1,765 and 1,859 cfs with an average of 1,808 cfs. The maximum average daily flow was 2,193 cfs on November 28th, 2024, and the minimum average daily flow was 1,504 cfs on October 29th, 2024.

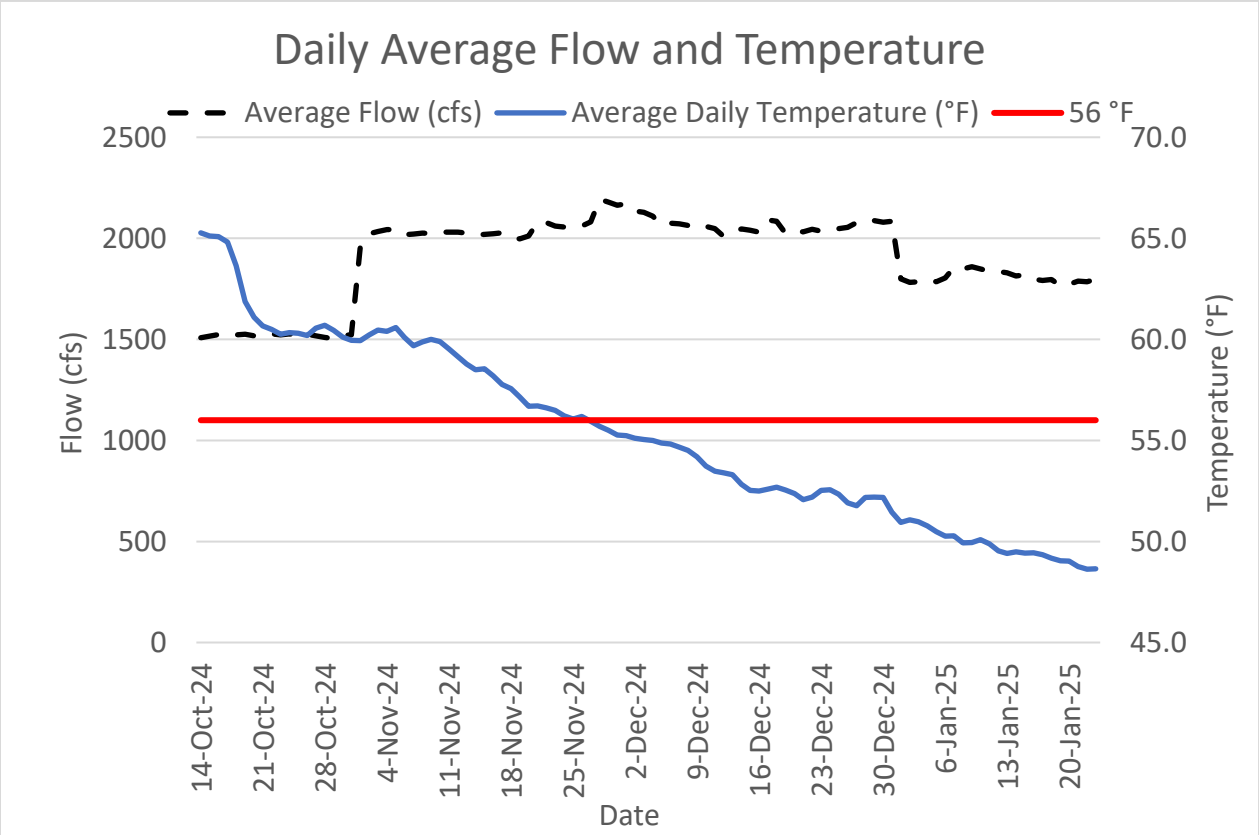

Figure 2. Daily average flow (left y-axis) and water temperatures (right y-axis) encountered during the 2024-2025 lower American River Chinook salmon escapement survey. The red line indicates 56°F, which is considered the daily average temperature suitable for spawning and egg survival. Temperature and flow were reported by USGS, American River at Fair Oaks gauge (USGS 2025).

Final Carcass Count

During the 2024 lower American River escapement survey, 16,765 carcasses were observed and processed (Figure 3). The highest number of carcasses processed in a single survey period was 3,524 and occurred during survey period 9 (December 9 - 13). Of the 16,765 carcasses processed during the season, 2,322 fresh carcasses were encountered (Figure 4). Fresh carcasses were observed during the first 14 survey periods, reaching a high of 487 fresh carcasses processed during sampling period 8 (December 2 –6). No fresh fish were encountered during week 15, signaling the end of the survey.

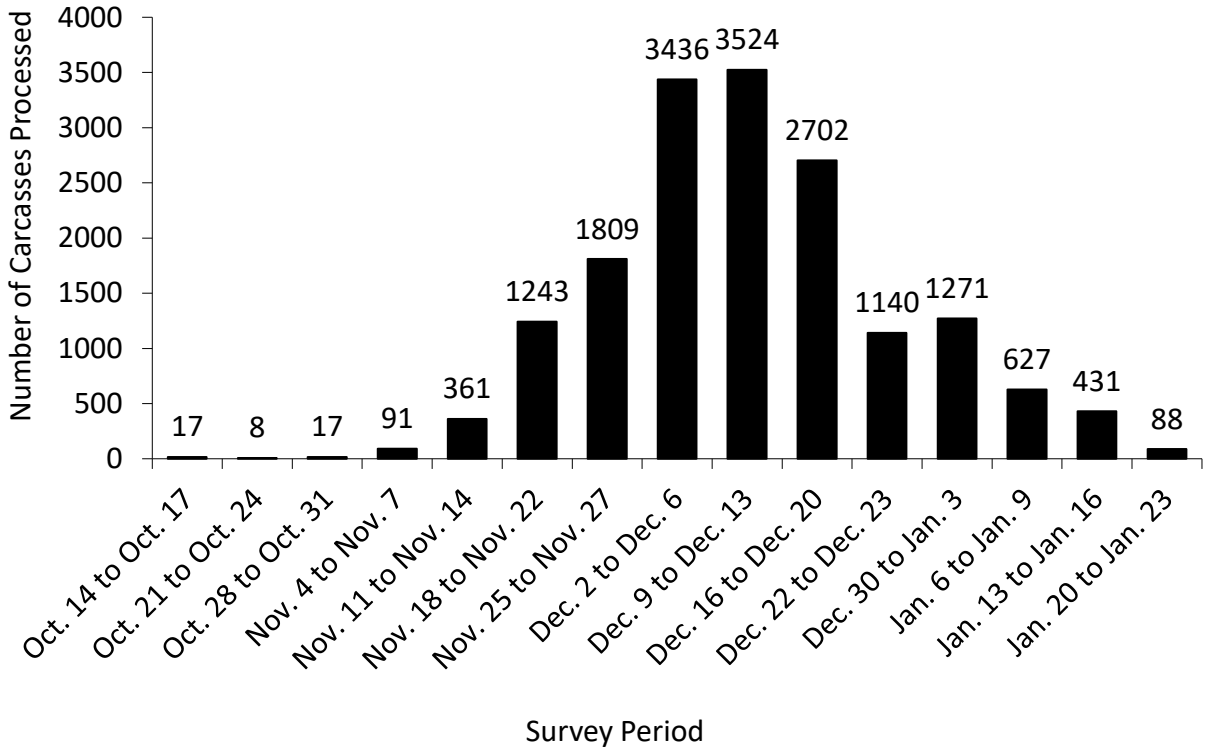

Figure 3. Numbers of carcasses observed and processed during the 2024-2025 lower American River Chinook salmon escapement survey

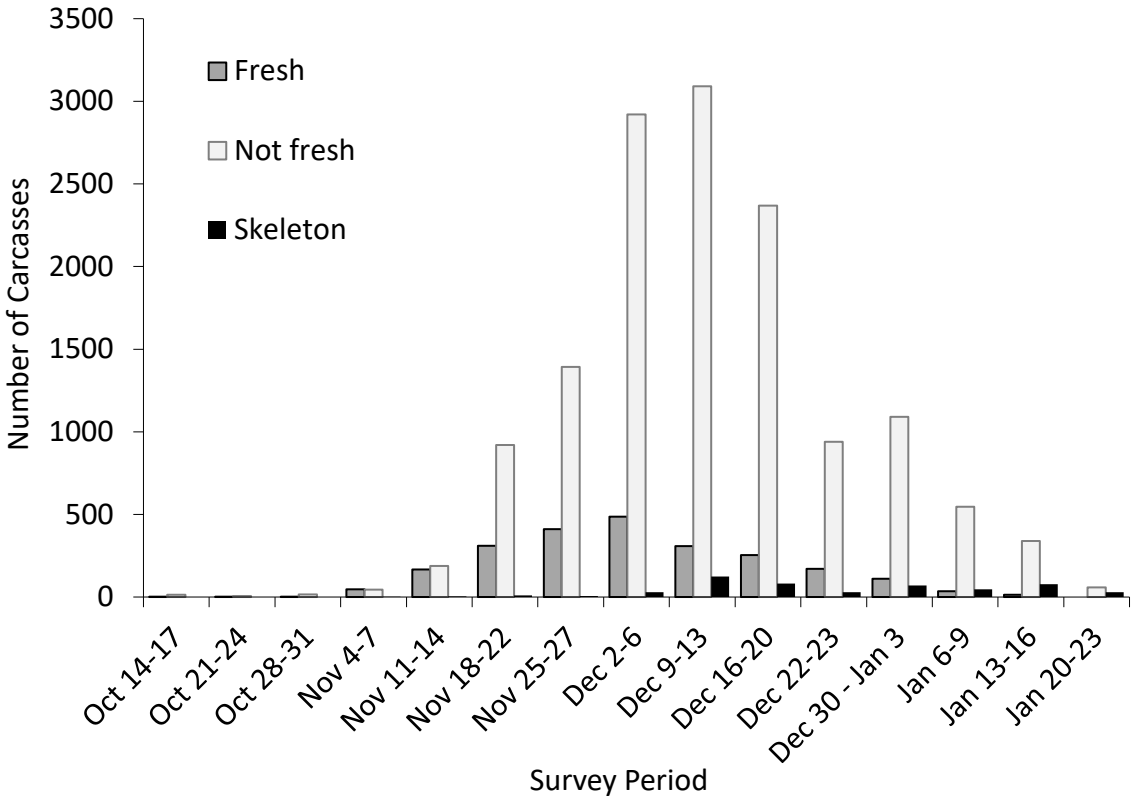

Figure 4. Number of fresh, not fresh, and skeleton carcasses processed in each survey period for the 2024-2025 lower American River Chinook salmon escapement survey.

Carcass Processing

Of the 16,765 carcasses processed, 13,511 (81%) were in an advanced stage of decomposition and were chopped and tallied. Of the remaining carcasses, 1,423 (8%) were processed for covariate data collection and chopped, including 1,275 heads retained for CWT extraction, while 1,831 (11%) were disk-tagged and included in the mark-recapture study (Figure 5).

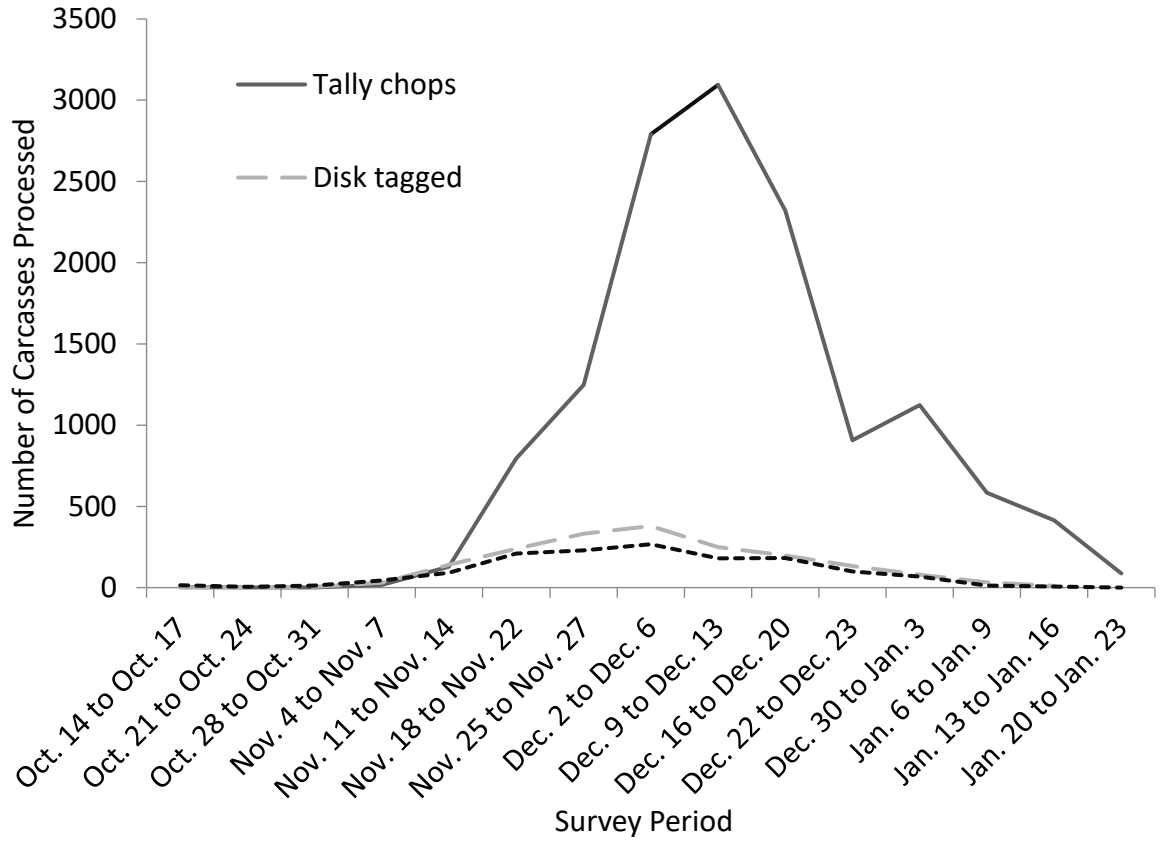

Figure 5. Frequency of processing method for carcasses collected during the 2024-2025 lower American River Chinook salmon escapement survey.

Spatial Distribution

Of the total number of carcasses processed during the survey, 7% were detected in NB (n = 1,172), 49% in section 1A (n = 8,145), 22% in section 1B (n = 3,761), 17% in section 2 (n = 2,769), and 5% in section 3 (n = 918) (Figure 6, Table 3).

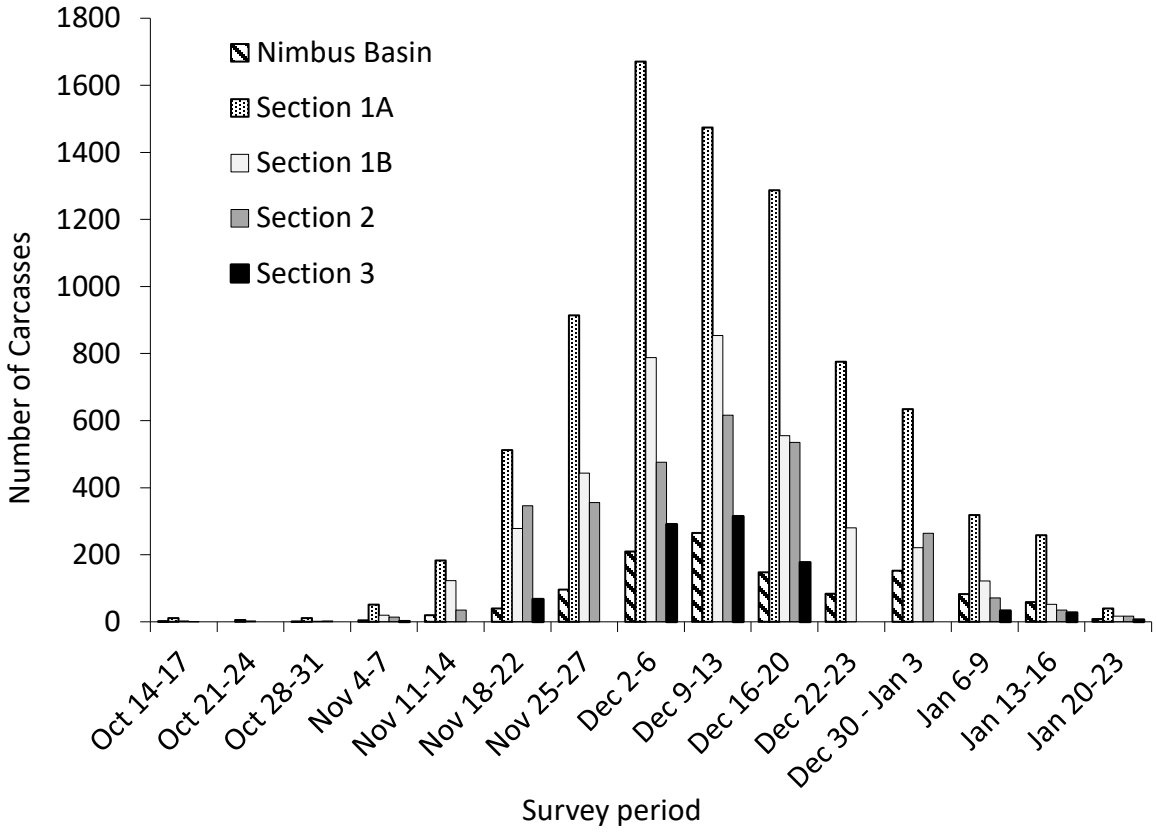

Figure 6. Spatial distribution of carcasses by survey period for the 2024-2025 lower American River Chinook salmon escapement survey.

Table 3. Spatial distribution of carcasses processed by survey period during the 2024-2025 lower American River Chinook salmon escapement survey.

Survey Period	Date	Nimbus Basin	Section 1A	Section 1B	Section 2	Section 3	Total
1	Oct. 14 to Oct. 17	2	11	3	1	0	17
2	Oct. 21 to Oct. 24	0	5	3	0	0	8
3	Oct. 28 to Oct. 31	1	11	2	3	0	17
4	Nov. 4 to Nov. 7	4	51	20	14	2	91
5	Nov. 11 to Nov. 14	20	183	123	35	NS	361
6	Nov. 18 to Nov. 22	40	512	278	346	67	1243
7	Nov. 25 to Nov. 27	96	914	443	356	NS	1809
8	Dec. 2 to Dec. 6	210	1671	788	476	291	3436
9	Dec. 9 to Dec. 13	265	1474	854	616	315	3524
10	Dec. 16 to Dec. 20	148	1287	555	535	177	2702
11	Dec. 22 to Dec. 23	84	776	280	NS	NS	1140
12	Dec. 30 to Jan. 3	152	634	221	264	NS	1271
13	Jan. 6 to Jan. 9	83	318	122	71	33	627
14	Jan. 13 to Jan.16	59	258	52	35	27	431
15	Jan. 20 to Jan. 23	8	40	17	17	6	88
Total		1172	8145	3761	2769	918	16765
Total (%)		7	49	22	17	5	

Sex Ratios

Sex data were recorded for 3,238 carcasses. Females represented 52% (n = 1,682) of the carcasses and males represented 48% (n = 1,556). Sex could not be determined for the remaining 13,527 carcasses because gonads were too deteriorated. Males were found more frequently than females for most of the first 7 weeks of the survey; however, females were found more frequently than males for most of the remainder of the season (Figure 7).

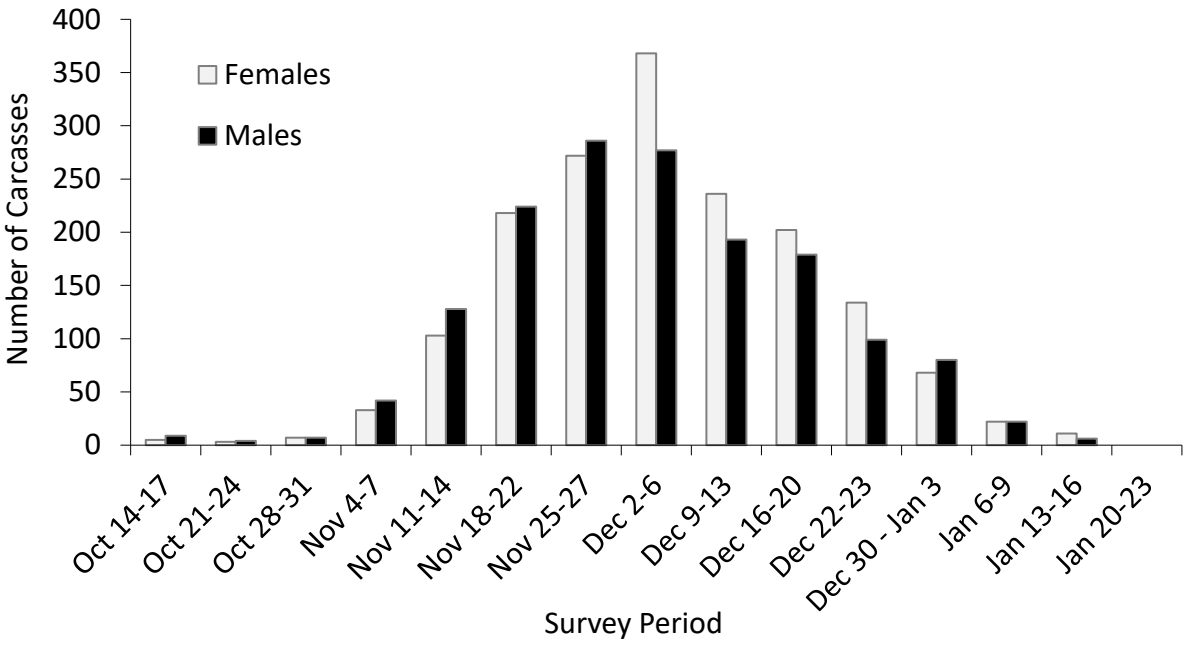

Figure 7. Number of male and female carcasses by survey period processed during the 2024-2025 lower American River Chinook salmon escapement survey

Length Distributions

Fork length was recorded for 3,238 carcasses of known sex (Figure 8). The average length for females (n = 1,682) was 81 cm with a range of 48 cm to 101 cm. The average length for males (n = 1,556) was 85 cm with a range of 46 cm to 112 cm. There were 16 unknown sex carcasses with an average of 70cm in the range of 30 cm to 91 cm.

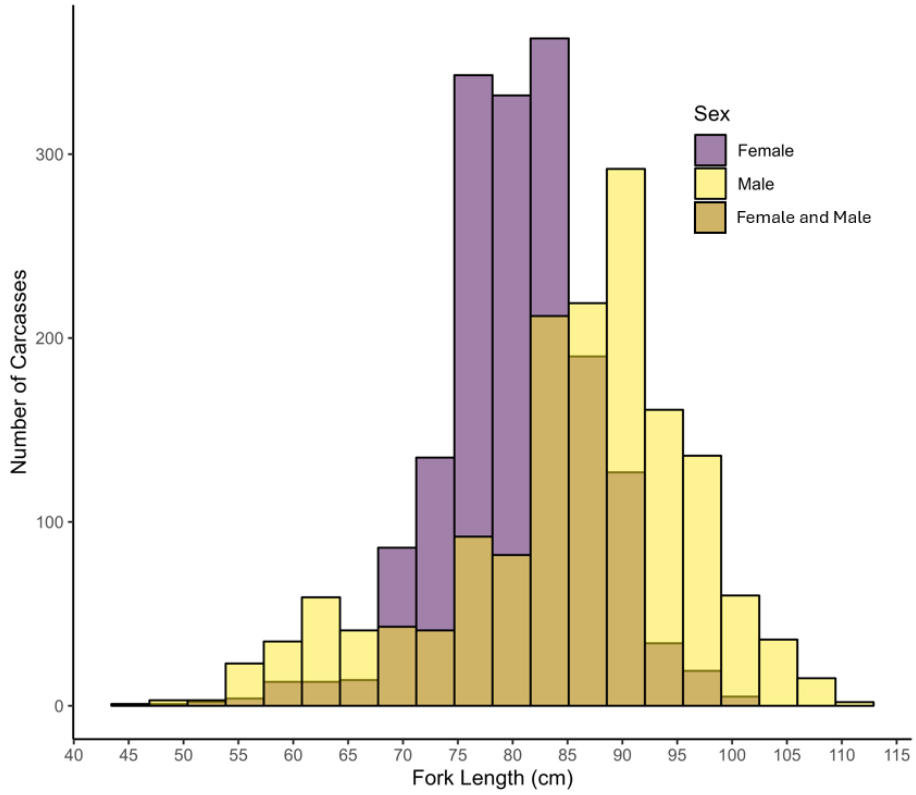

Figure 8. Fork length frequency histogram by sex for carcasses processed during the 2024-2025 lower American River Chinook salmon escapement survey.

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 ≥ 62 cm and males had a FL ≥ 72 cm. Fish were classified as grilse (≤2 years-old) if females had a FL of ≤61 cm and males had a FL of ≤71 cm.

A total of 3,018 (93%) carcasses were classified as adult and 235 (7%) carcasses were classified as grilse. One carcass (<1%) of unknown sex could not be classified as adult or grilse. The adult age class consisted of 1,661 (55%) females, 1,347 (45%) males, and 10 adults of unknown sex (<1%). The grilse age class consisted of 21 (9%) females, 209 (89%) males, and 5 grilse of unknown sex (2%) (Figure 10). The number of grilse peaked in week 6, and the number of adults peaked in week 8 (Table 4).

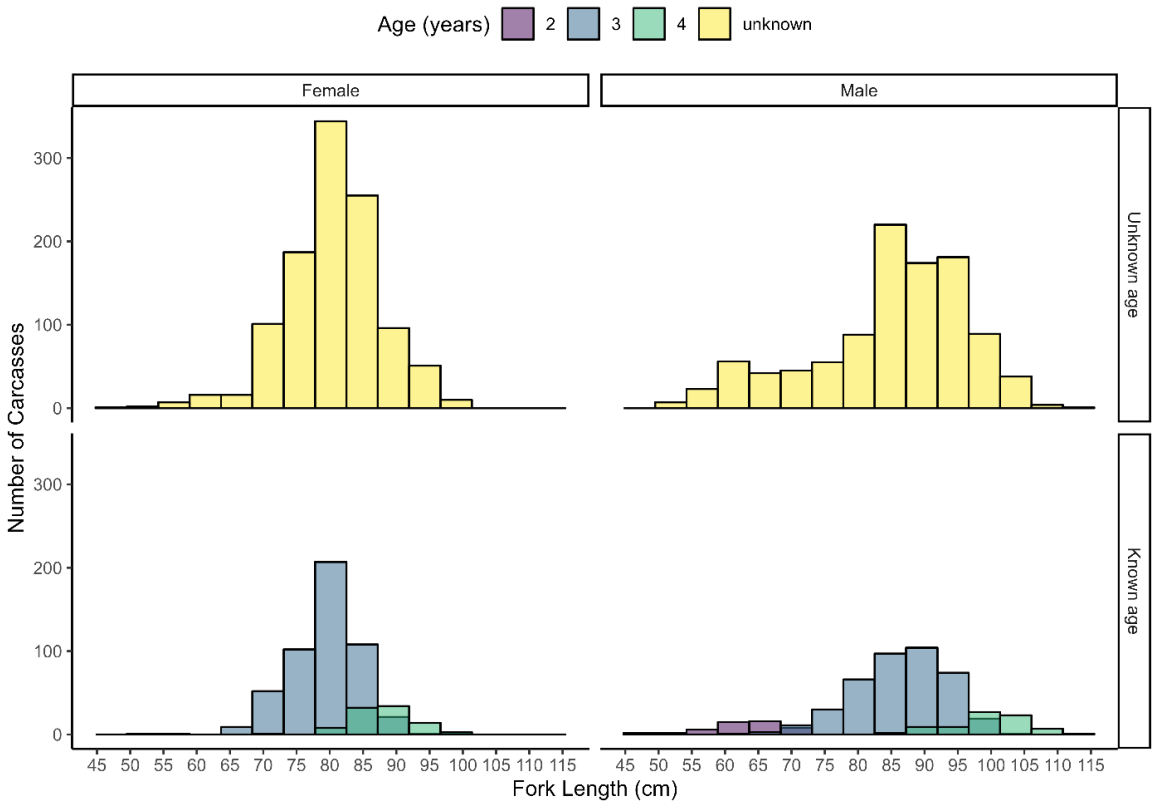

Figure 9. Fork length-frequency distribution of known-age coded wire tagged carcasses and unknown age carcasses processed during the 2024-2025 lower American River Chinook salmon escapement survey.

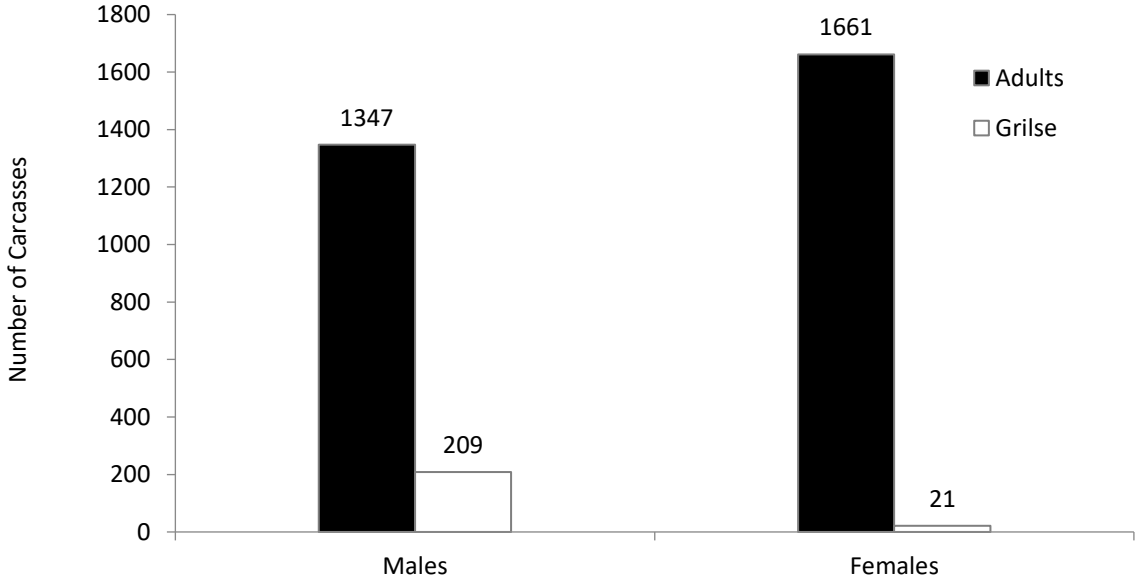

Figure 10. Number of male and female carcasses assigned to adult or grilse age classes during the 2024-2025 lower American River Chinook salmon escapement survey.

Table 4. Summary of processed salmon carcasses by age class during the 2024-2025 lower American River Chinook salmon escapement survey.

Survey Period	Date	Grilse		Adult	
		n	%	n	%
1	Oct. 14-17	1	7	14	93
2	Oct. 21-24	0	0	7	100
3	Oct. 28-31	1	6	15	94
4	Nov. 4-7	19	25	56	75
5	Nov. 11-14	47	20	186	80
6	Nov. 18-22	60	13	387	87
7	Nov. 25-27	52	9	509	91
8	Dec. 2-6	29	4	617	96
9	Dec. 9-13	16	4	414	96
10	Dec. 16-20	4	1	377	99
11	Dec. 22-23	2	1	231	99
12	Dec. 30 – Jan. 3	4	3	144	97
13	Jan. 6-9	0	0	44	100
14	Jan. 13-16	0	0	17	100
15	Jan. 20-23	0	-	0	-
	Total	235		3018	
	Total (%)	7		93	

Pre-spawn Mortality

Degree of egg retention was determined for 1,620 female carcasses (Table 5). Spawned females accounted for 82% (n = 1,329), partially spawned accounted for 6% (n = 104), and unspawned accounted for 12% (n = 187) of examined female carcasses. The proportion of spawned females varied throughout the survey period. Through the first four weeks of the survey, most females assessed for egg retention were either unspawned or partially spawned; however, for the rest of the survey the majority of females were spawned. There were no females assessed for spawn status during the final week of the survey (Figure 11).

Table 5. Egg retention status of female carcasses and mean water temperature by survey period during the 2024-2025 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 14 - 17	1	65.1	2	50	1	25	1	25	4
Oct 21 - 24	2	60.4	2	100	0	0	0	0	2
Oct 28 - 31	3	60.5	2	40	0	0	3	60	5
Nov. 4 - 7	4	60.2	12	41	3	10	14	48	29
Nov. 11 - 14	5	59.0	18	19	6	6	73	75	97
Nov. 18 - 22	6	56.9	23	11	20	10	165	79	208
Nov. 25 - 27	7	56.1	22	8	20	8	221	84	263
Dec. 2 - 6	8	55.0	37	10	24	7	294	83	355
Dec. 9 - 13	9	53.6	27	12	12	5	190	83	229
Dec. 16 - 20	10	52.5	22	11	6	3	172	86	200
Dec. 22 - 23	11	52.4	15	11	5	4	112	85	132
Dec. 30 – Jan. 3	12	51.3	3	5	4	6	57	89	64
Jan. 6 - 9	13	50.1	1	5	3	14	18	82	22
Jan. 13 - 16	14	49.4	1	10	0	0	9	90	10
Jan. 20 - 23	15	48.8	0	-	0	-	0	-	0
Total			187	**12**	104	**6**	1329	**82**	1620

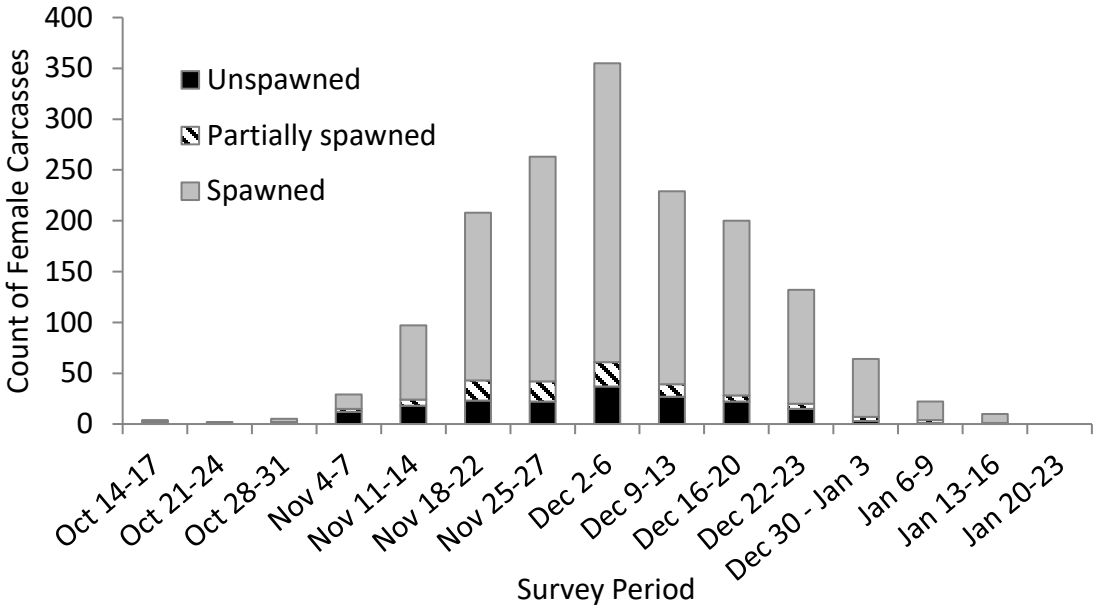

Figure 11. Egg retention status of female carcasses per survey period for the 2024-2025 lower American River Chinook salmon escapement survey.

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 12). A total of 2,811 (17%) carcasses had an adipose fin clip, which is lower than the rate observed from fish that entered the Nimbus Fish Hatchery (22.8%). Of those adipose fin-clipped fish, heads were collected from 1,275 for CWT recovery. Adipose fins were intact for 13,046 (78%) of carcasses and presence or absence could not be determined for 908 (5%) of carcasses.

The staff at the CDFW Central Valley Salmonid Archive processed 1,275 carcass heads for CWT extraction. Of these 1,275 heads, 91% (1160) were fall-run, 0.7% (9) were spring-run, and the remaining 8.3% (106) either had no CWT, the CWT was unreadable, or the CWT was lost during extraction. Of the 1,160 FRCS, 83.5% (969) originated from Nimbus Fish Hatchery, 13.4% (155) from Mokelumne River Hatchery, 1.6% (19) from Coleman National Fish Hatchery, 0.9% (11) from Feather River Hatchery, 0.5% (6) from Merced River Fish Facility. A portion of the FRCS from Nimbus Fish Hatchery (n = 31) 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 16.6% (192 of 1,160) of CWT FRCS originated from hatcheries outside of the American River watershed. Additionally, 9 spring-run Chinook salmon heads were collected with 8 originating from Feather River Hatchery and 1 originating from San Joaquin Hatchery.

Table 6. Adipose condition of carcasses by survey period for the 2024-2025 lower American River escapement survey.

Survey Period	Date	Adipose Intact	Adipose Clipped	Skeleton/Unknown	Total
1	Oct. 14-17	7	9	1	17
2	Oct. 21-24	5	3	0	8
3	Oct. 28 -31	13	4	0	17
4	Nov. 4-7	65	23	3	91
5	Nov. 11-14	289	67	5	361
6	Nov. 18-22	1002	226	15	1243
7	Nov. 25-27	1502	290	17	1809
8	Dec. 2-6	2799	570	67	3436
9	Dec. 9-13	2717	607	200	3524
10	Dec. 16-20	2165	405	132	2702
11	Dec. 22-23	865	211	64	1140
12	Dec. 30 – Jan. 3	911	237	123	1271
13	Jan. 6-9	425	93	109	627
14	Jan. 13-16	241	57	133	431
15	Jan. 20-23	40	9	39	88
	Total	13046	2811	908	16765
	Total (%)	78%	17%	5%	

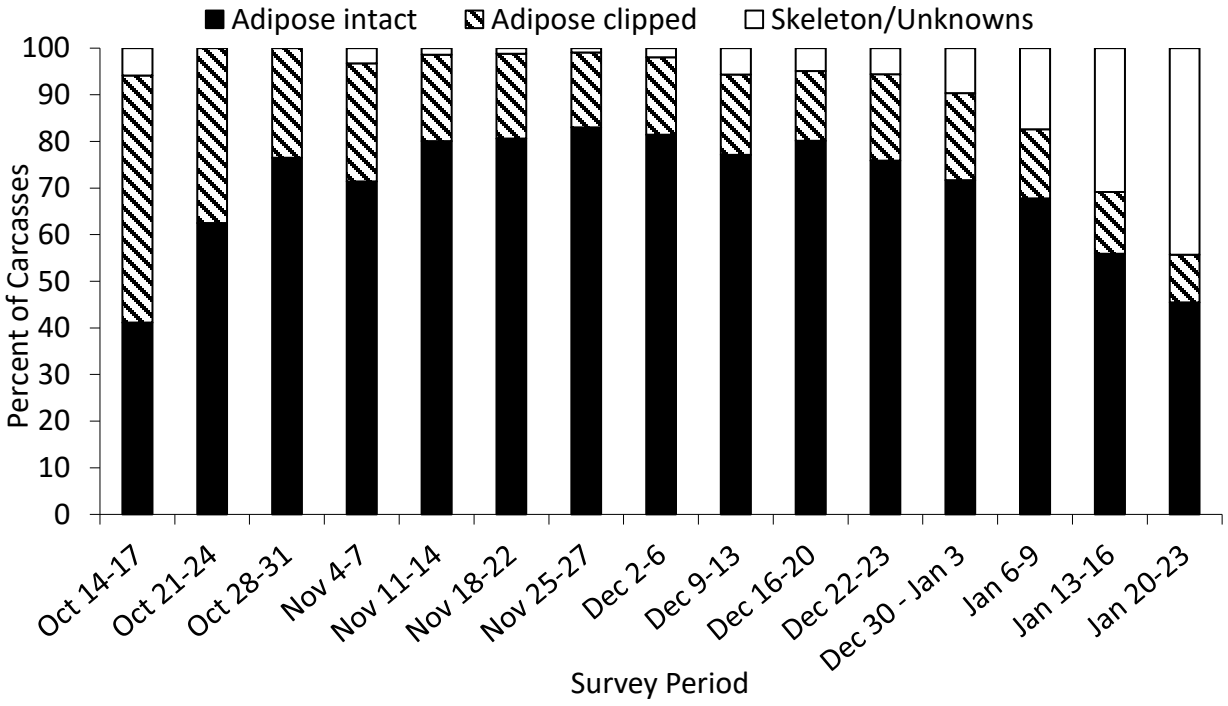

Figure 12. Temporal distribution of adipose fin condition for carcasses processed 2024-2025 lower American River escapement survey.

Escapement Estimate

To calculate an escapement estimate, 1,831 fresh carcasses were marked with uniquely numbered disk tags for inclusion in the CJS population model. Of the tagged carcasses, 442 carcasses (24%) were recaptured at least once, with 494 recapture events in total. The LAR escapement estimate for 2024 was 45,541 FRCS (95% CI = 41,806 to 49,016). The bootstrap (n = 1,000) estimate of standard error was 1,839 FRCS. The total escapement estimate was multiplied by the fraction of adults and grilse (approximately 93% and 7%, respectively) to obtain an escapement estimate of 42,251 and 3,290 for adults and grilse, respectively. In addition to the in-river escapement, 12,213 Chinook entered Nimbus Fish Hatchery via the fish ladder. Of those, length and sex were recorded for 11,842 FRCS (9,282 adults and 2,550 grilse). The hatchery uses a static length boundary of 68.5 cm to assign an age class for both sexes.

DISCUSSION

Salmon Fishery Closure and 2024's Escapement Estimate

In 2024, Salmon stocks continued to be impacted in California from ongoing issues associated with drought and climate disruption. Salmon returning to California's coast and rivers were impacted by a multi-year drought, severe wildfires and associated impacts to spawning and rearing habitat, harmful algal blooms and ocean forage shifts (CDFW 2024). The low ocean abundance forecasts, coupled with low 2023 returns, led the Pacific Fishery Management Council (PFMC) to recommend full closure of California's commercial and recreational salmon fisheries (CDFW 2024) for the second consecutive year.

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 2024 LAR escapement estimate (45,541 FRCS) is an increase as compared to the previous year (37,321 FRCS) and was likely positively impacted by the commercial and sport salmon fishery closure (Figure 13). The majority of salmon that returned to the LAR in 2024 were expected to be from brood year 2021 which had a reported escapement estimate of 11,232 FRCS.

Peak carcass recovery occurred during survey period 9 (December 9-13), 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).

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 14). In 2024, cutoff lengths occurred at the lower end of this range for both sexes, 71 cm for adult males (3 cm shorter than the brood season) and 61 cm for adult females (4 cm shorter than the brood season) (Grimes, 2022). The adults to grilse ratio in 2024 is within the range exhibited in prior surveys (Figure 15). 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).

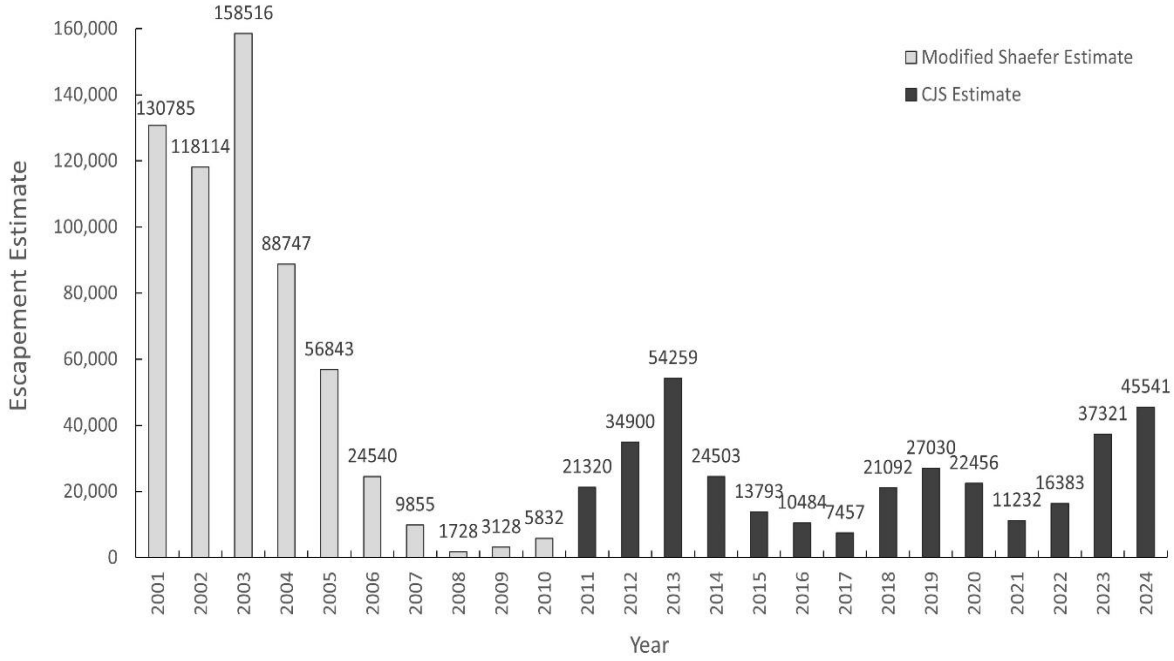

Figure 13. Historical in-river escapement estimates for the lower American River from 2001-2024.

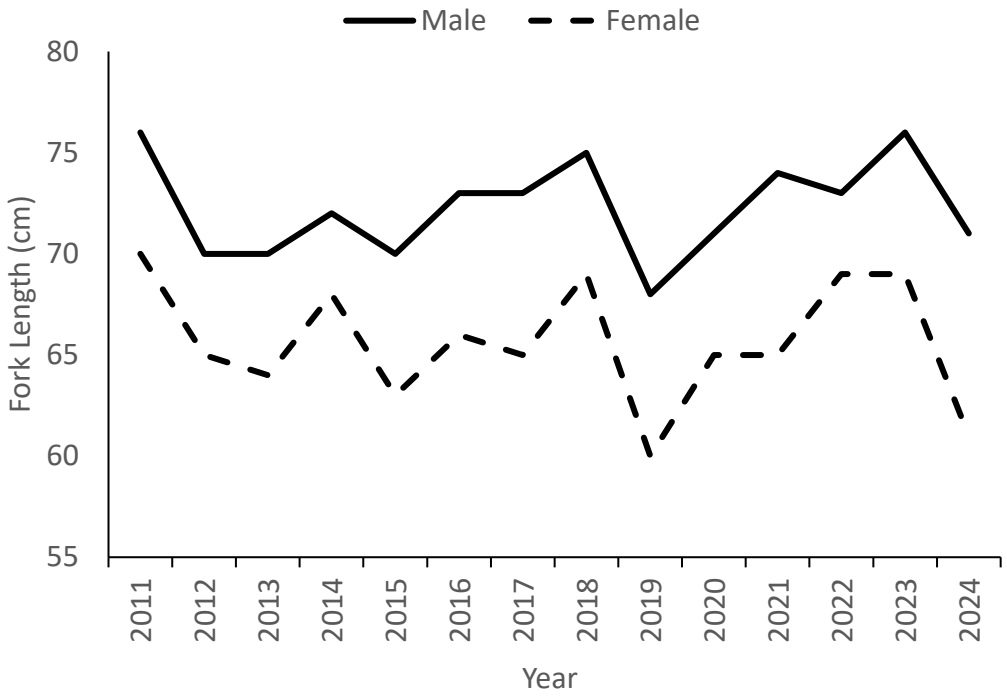

Figure 14. Minimum fork lengths for adult Chinook salmon of both sexes observed from 2011-2024 during the lower American River escapement survey.

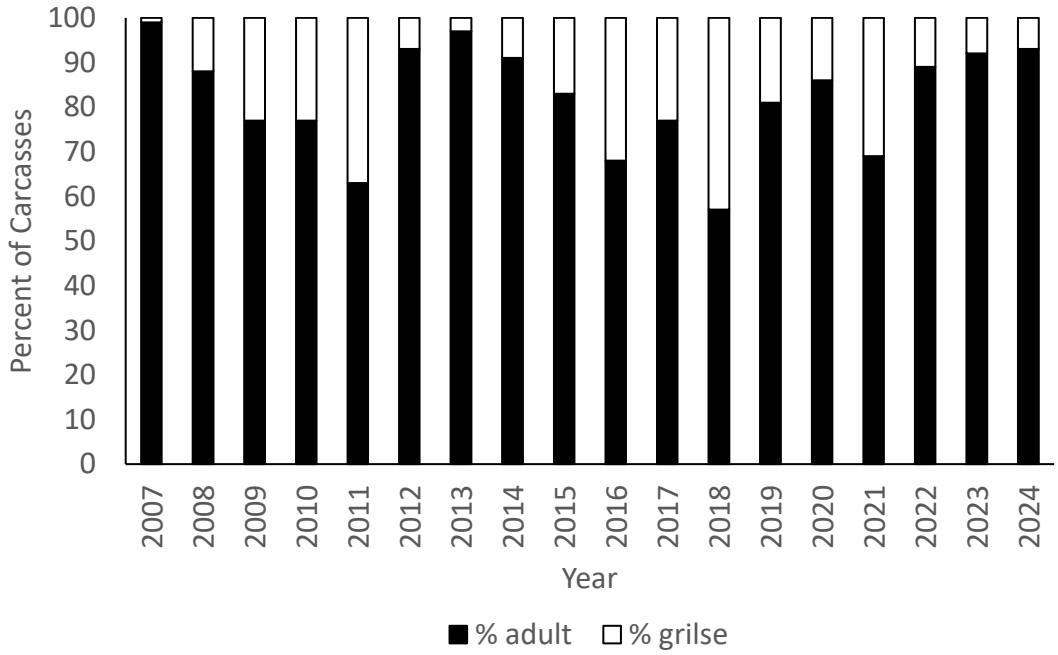

Figure 15. Proportion of adult and grilse carcasses observed each year from 2007 to 2024 during the lower American River escapement survey.

Nimbus Fish Hatchery Releases and CWT Returns

There were six LAR 2021 brood year FRCS releases in April, May, and June 2022, resulting in a total of 4,667,171 juvenile chinook salmon released in San Pablo Bay (PSMFC, 2022). Of the fish released, 25% (1,161,702) 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 2024 decreased, with 83% of returning adults originating from Nimbus Fish Hatchery, compared to 73% the previous year. Mokelumne Fish Hatchery comprised the majority of fish that strayed to the LAR (n = 155, 13.%). The proportion of fish from Mokelumne Fish Hatchery increased from 9% in 2023 to 13% 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) 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 2024-2025 lower American River escapement survey produced an escapement estimate of 45,541 fall-run Chinook salmon which is more than the previous year (37,321 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).

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