California Department of Fish and Wildlife
North Central Region

Lower American River Fall-run Chinook Salmon Escapement Survey October 2022 - December 2022

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 2022). 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, 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 2022-2023 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 17, 2022, to December 29, 2022. The survey area was divided into five sections (Figure 1, Table 1), each surveyed once over a 3 to 4-

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 2022 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.

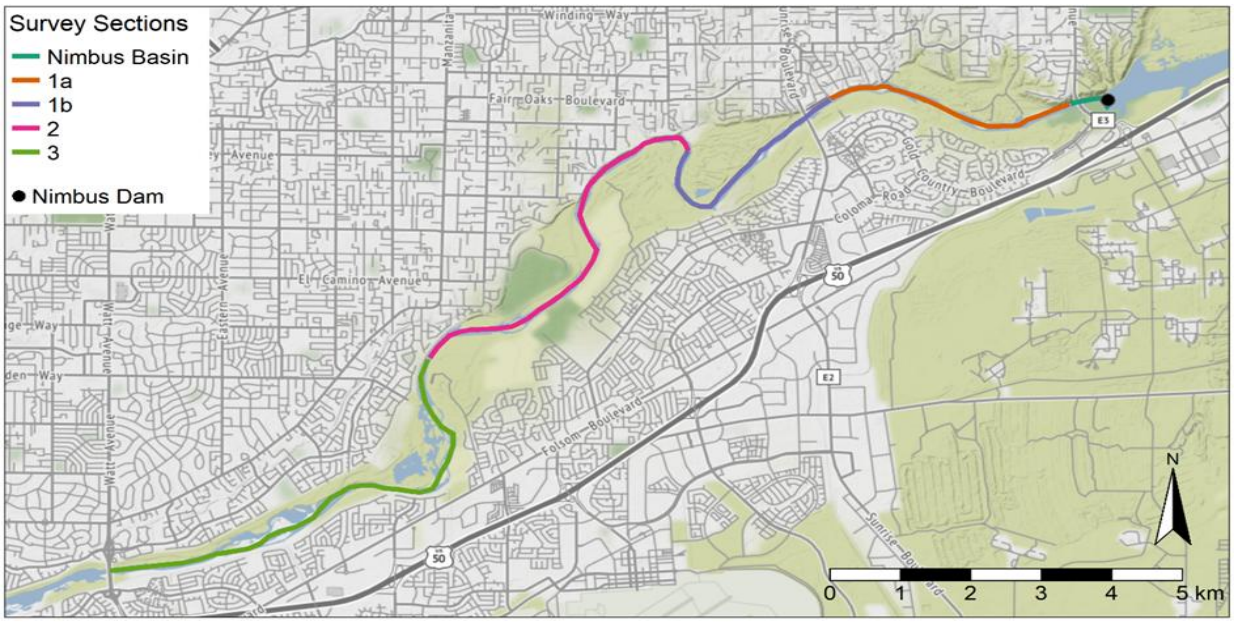

Figure 1. Survey sections for the lower American River Chinook salmon escapement survey.

Surveys were conducted by a crew consisting of 5-9 members searching for submerged salmon carcasses while walking the riverbanks, paddling kayaks, and/or surveying from jet boat. Each river section was surveyed once per survey period. NB was surveyed only on foot from the banks; section 1 was surveyed by jet boat and from the banks; section 2 was surveyed by jet boat and from the banks during survey weeks 1 and 2, but due to habitat complexity for the remaining weeks, both sections 2 and 3 were surveyed by kayaks and walking portions of the banks. 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 fall-run Chinook salmon escapement survey on the lower American River.

Section	Description	Miles
NB	Nimbus Dam to Nimbus Fish Hatchery Weir	0.3
1a + 1b	Nimbus Fish Hatchery Weir to Sunrise Blvd River Access (1a)	4.3
	Sunrise Blvd. River Access to El Manto Dr. River Access (1b)	
2	El Manto Dr River Access to River Bend Park River Access	4.7
3	River Bend Park River 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 2022-2023 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 4.1.2 (R Core Team 2021).

Covariate data were 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 were pooled by sex and plotted in a frequency distribution 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 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 2023). The Fair Oaks gauge is located at the upper end of section 1 approximately one hundred meters downstream of the 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 2022 LAR survey consisted of 11 survey periods from October 17, 2022 to December 29, 2022. All sections were surveyed in each survey period, with the exceptions of weeks 6 and 8, where sections 2 and 3 were not surveyed due to holiday interference and an insufficient number of crew members, and week 7, which section 3 was not surveyed due to high wind speeds and shortage of daylight. In survey period 11, sections 2 and 3 were not surveyed due to a rapid increase in discharge that created a potentially dangerous environment for crews to survey (Table 2), resulting in the end of surveying for the 2022 season. No subsampling was required at any time during the study.

Table 2. Survey dates and sampling regime for the 2022 lower American River Chinook salmon escapement survey.

Survey Period	Dates	Sections Not Surveyed
1	Oct 17-20	None
2	Oct 24-27	None
3	Oct 31-Nov 4	None
4	Nov 7-10	None
5	Nov 14-18	None
6	Nov 21-25	2,3
7	Nov 28 – Dec 2	3
8	Dec 5-9	2,3
9	Dec 12-16	None
10	Dec 19-22	None
11	Dec 27-29	2,3

Environmental Conditions

Daily average LAR temperatures generally decreased over the duration of the survey season. The maximum mean daily temperature recorded was 66°F on October 18th and 20th, and the minimum mean daily temperature was 49°F on December 18-29 (Figure 2). Water temperature decreased to a level suitable for spawning on November 20, when the mean daily temperature dropped below 56°F.

The US Bureau of Reclamation (USBR) initiated a power bypass of 100 cfs beginning on October 20, 2022 to access the cold water pool (CWP) at Folsom Dam for the purpose of providing suitable holding and spawning temperatures for Fall-run Chinook salmon. The power bypass was increased incrementally 100 cfs per day (not to exceed 500 cfs) with the objective of reducing water temperatures at Hazel Avenue with targets of 62°F starting October 20th, 60°F beginning October 29th, and 56°F starting November 1st. The power bypass ended on November 23rd.

Discharge consistently held at approximately 1350 cfs through the survey with the exception of an increase of mean daily flow on December 29, 2022 to 2980 cfs. The maximum daily flow recorded was 7,640 cfs on December 29, 2022 and the minimum daily flow was 1210 cfs on November 9, 2022 (Figure 2).

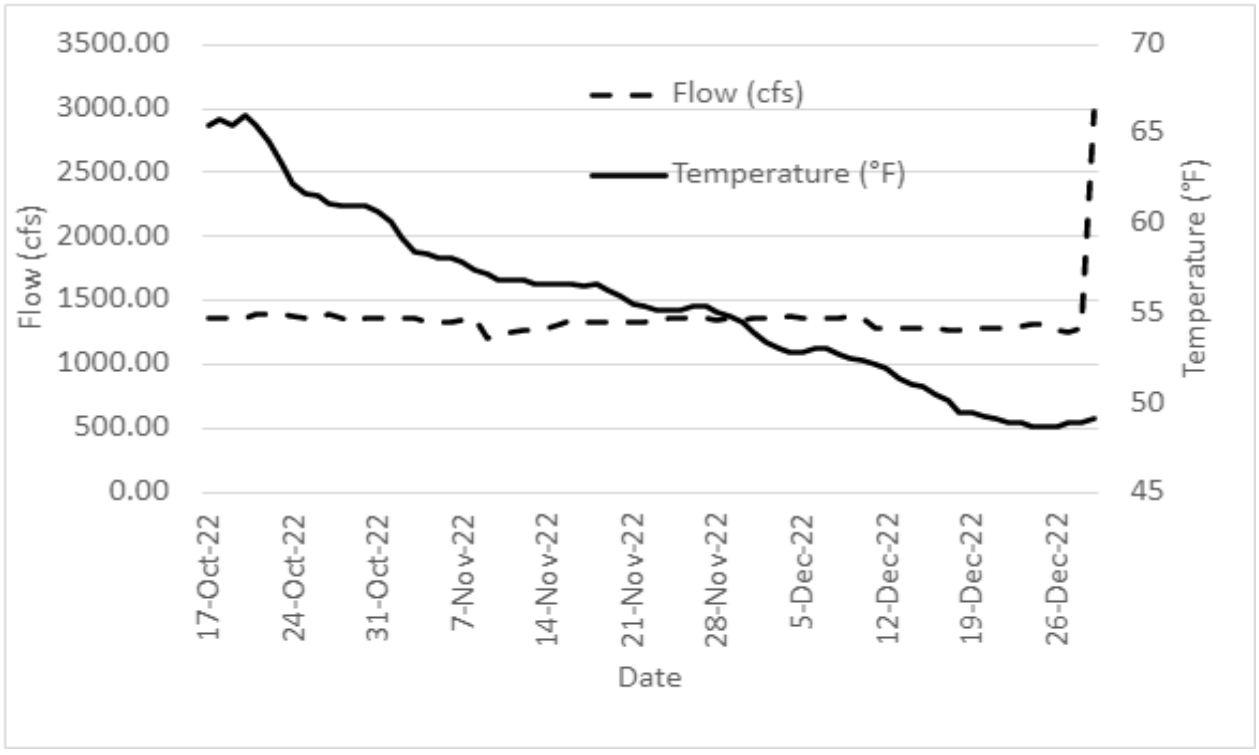

Figure 2. Daily average flow and water temperatures encountered during the 2022 lower American River Chinook salmon escapement survey. Temperature and flow were reported by USGS, American River at Fair Oaks gauge (USGS 2023).

Final Carcass Count

During the 2022 lower American River escapement survey, 9,681 carcasses were observed and processed (Figure 3). The highest number of carcasses processed in a single survey period (n = 2,273) occurred during survey period 7 (November 28 - December 2). Of the carcasses processed during the season, 864 fresh carcasses were encountered (Figure 4). Fresh carcasses were observed during each of the 11 sampling periods, reaching a high of 232 fresh carcasses processed during sampling period 6 (November 21 - November 25).

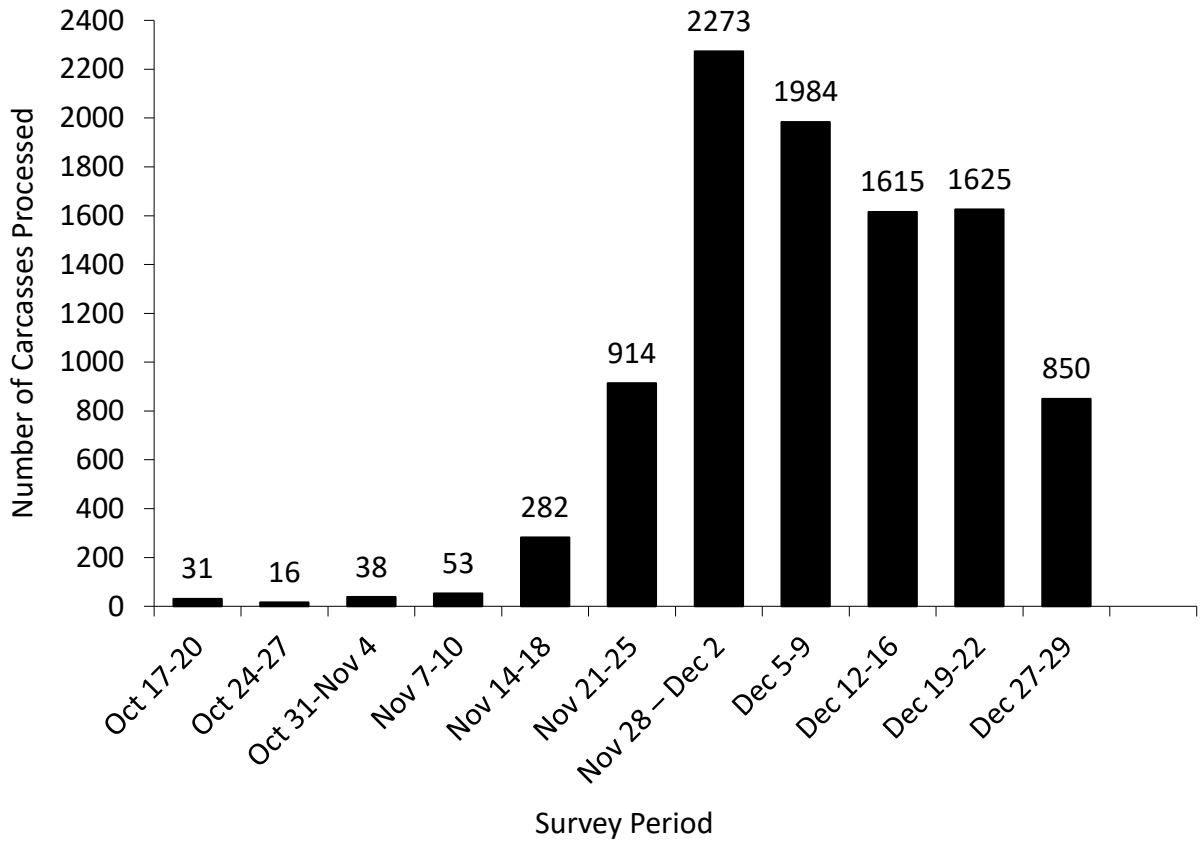

Figure 3. Numbers of carcasses observed and processed during the 2022 lower American River Chinook salmon escapement survey.

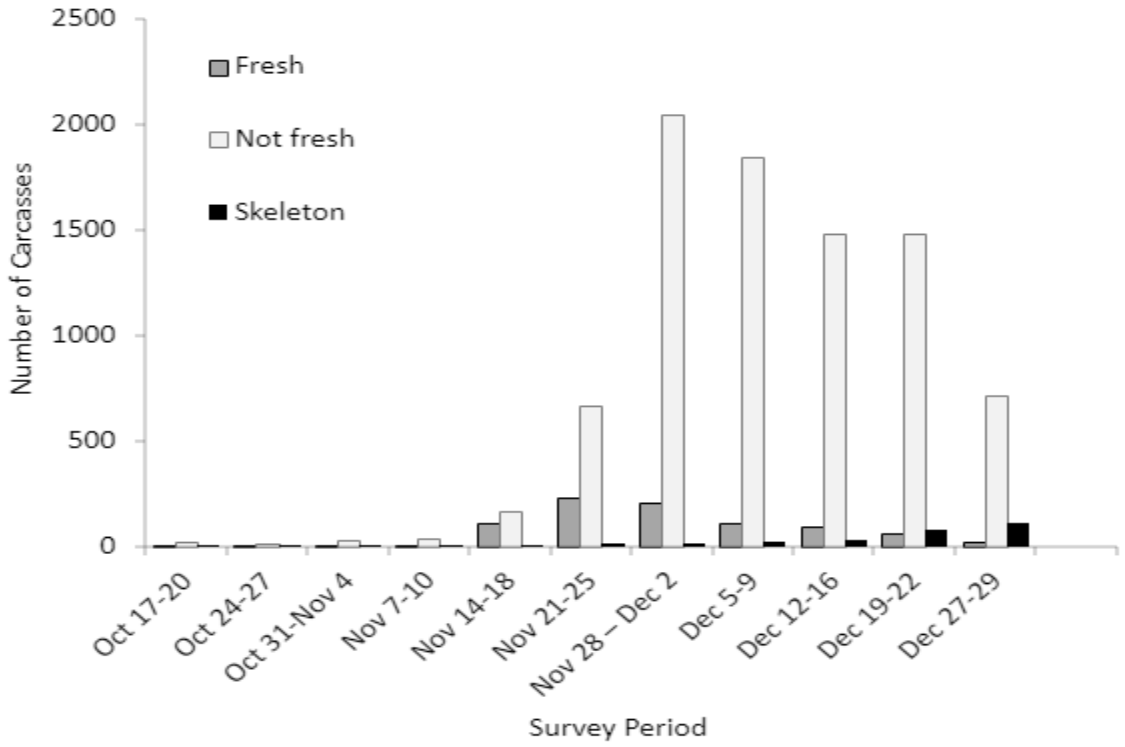

Figure 4. Number of fresh, not fresh, and skeleton carcasses processed in each survey period for the 2022 lower American River Chinook salmon escapement survey.

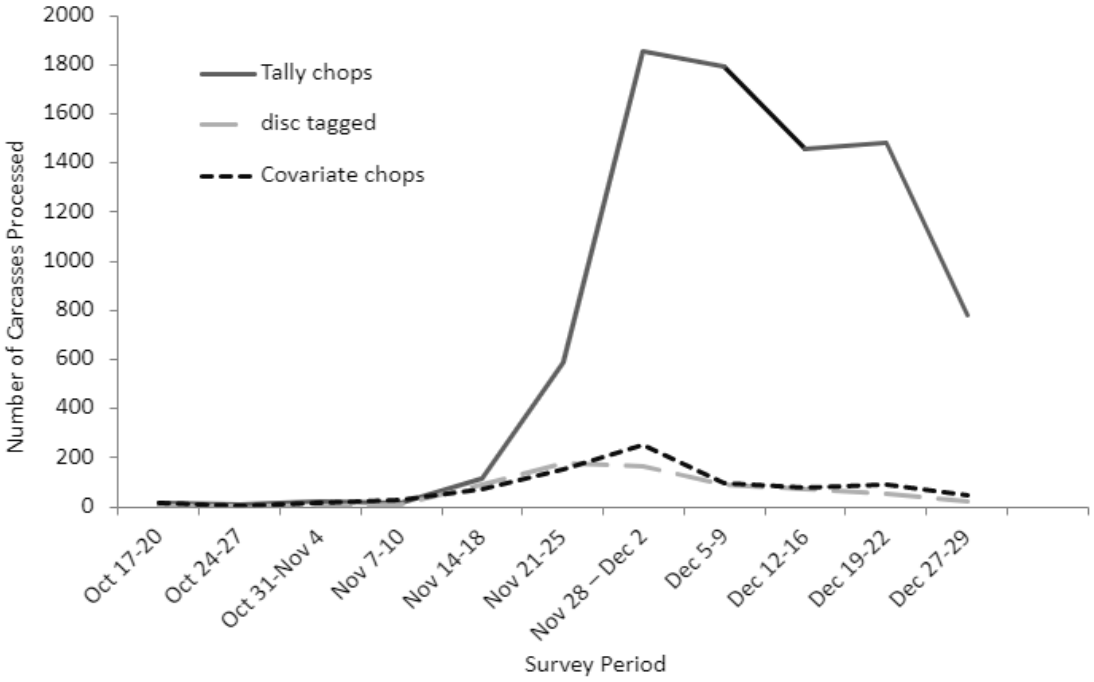

Figure 5. Frequency of processing method for carcasses collected during the 2022 lower American River Chinook salmon escapement survey.

Carcass Processing

Of the 9,681 carcasses processed, 8,143 (84%) were in an advanced stage of decomposition and were chopped and tallied. Of the remaining carcasses, 855 (9%) were processed for covariate data collection and chopped, including 777 heads retained for CWT extraction, while 683 - (7%) were disk-tagged and included in the mark-recapture study (Figure 5).

Spatial Distribution

Of the total number of carcasses processed during the survey, 8% were detected in NB (n = 763), 84% in section 1 (n = 8,106), 8% in section 2 (n = 765), and less than 1% in section 3 (n = 47) (Figure 6, Table 3).

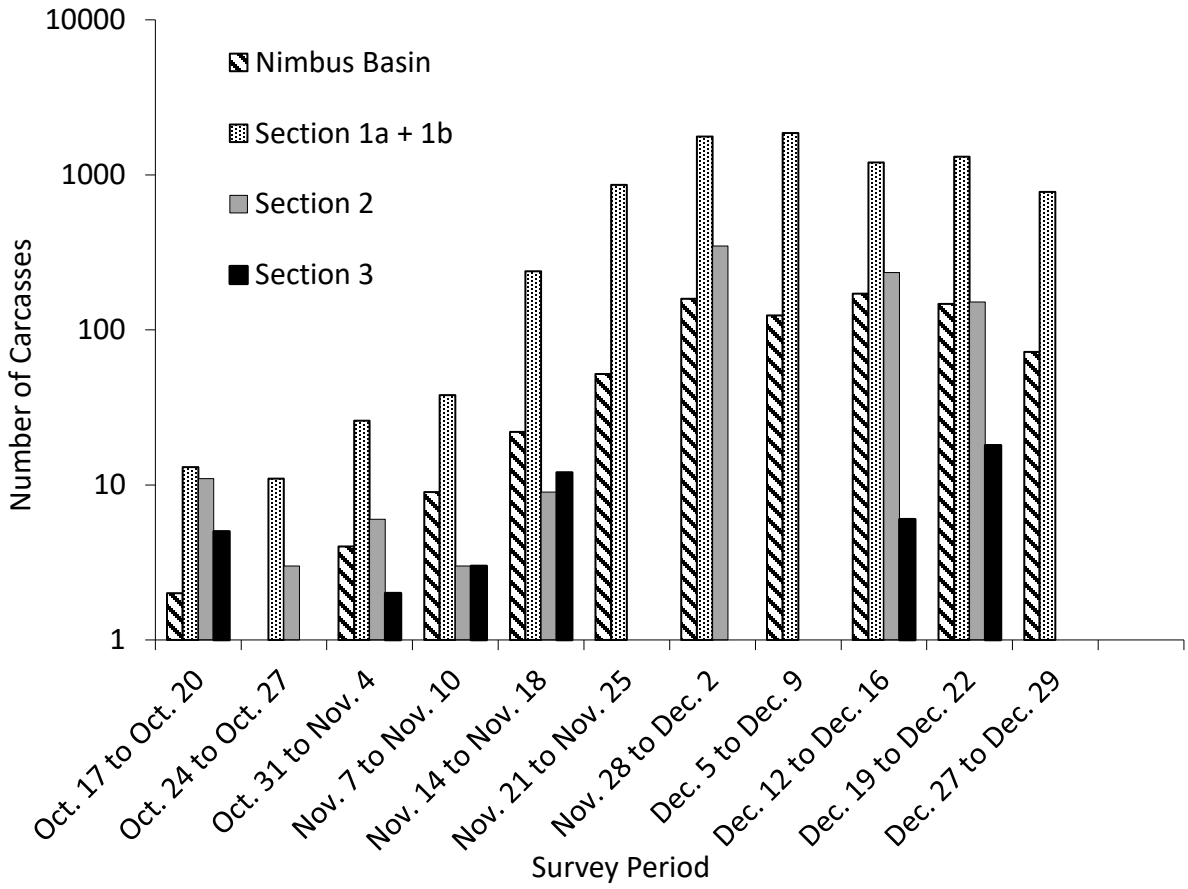

Figure 6. Spatial distribution of carcasses by survey period for the 2022 lower American River Chinook salmon escapement survey. Please note the log scale on the y axis.

Table 3. Spatial distribution of carcasses processed by survey period during the 2022 lower American River Chinook salmon escapement survey.

Survey Period	Date	Nimbus Basin	Section 1a +1b	Section 2	Section 3	Total
1	Oct 17-20	2	13	11	5	31
2	Oct 24-27	1	11	3	1	16
3	Oct 31-Nov 4	4	26	6	2	38
4	Nov 7-10	9	38	3	3	53
5	Nov 14-18	22	239	9	12	282
6	Nov 21-25	52	862	0	0	914
7	Nov 28-Dec 2	159	1766	348	0	2273
8	Dec 5-9	124	1860	0	0	1984
9	Dec 12-16	171	1204	234	6	1615
10	Dec 19-22	147	1309	151	18	1625
11	Dec 27-29	72	778	0	0	850
Total		763	8106	765	47	9681
Total (%)		8	84	8	<1	

Sex Ratios

Sex data were recorded for 1,516 carcasses. Females represented 57% (n = 868) of the carcasses and males represented 43% (n = 648). Sex could not be determined for the remaining 8,165 carcasses because gonads were too deteriorated. Females were consistently found more frequently through the 11-week survey (Figure 7).

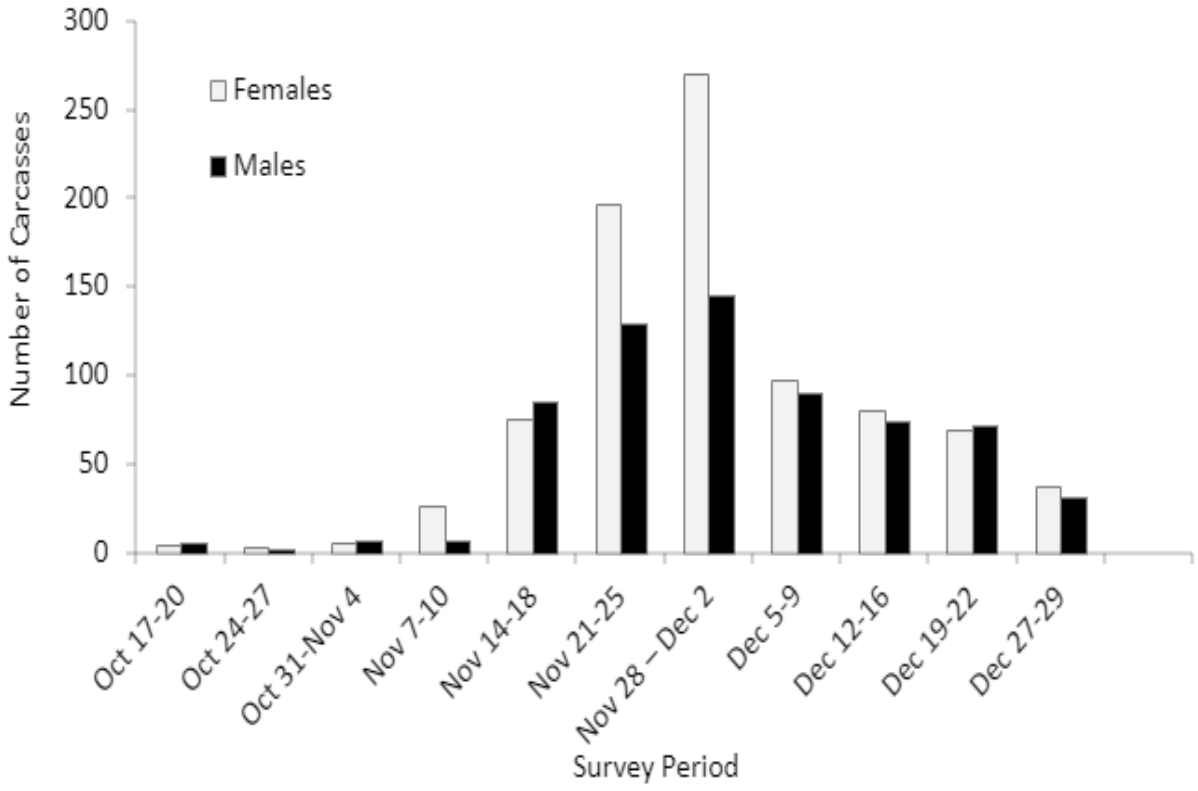

Figure 7. Number of male and female carcasses by survey period processed during the 2022 lower American River Chinook salmon escapement survey.

Length Distributions

Fork length was recorded for 1,512 carcasses of known sex (Figure 8). The average length for females (n = 865) was 79 cm with a range of 51 cm to 98 cm. The average length for males (n = 647) was 84 cm with a range of 49 cm to 110 cm. There were 21 unknown sex carcasses with an average of 75 cm in the range of 50 cm to 97 cm.

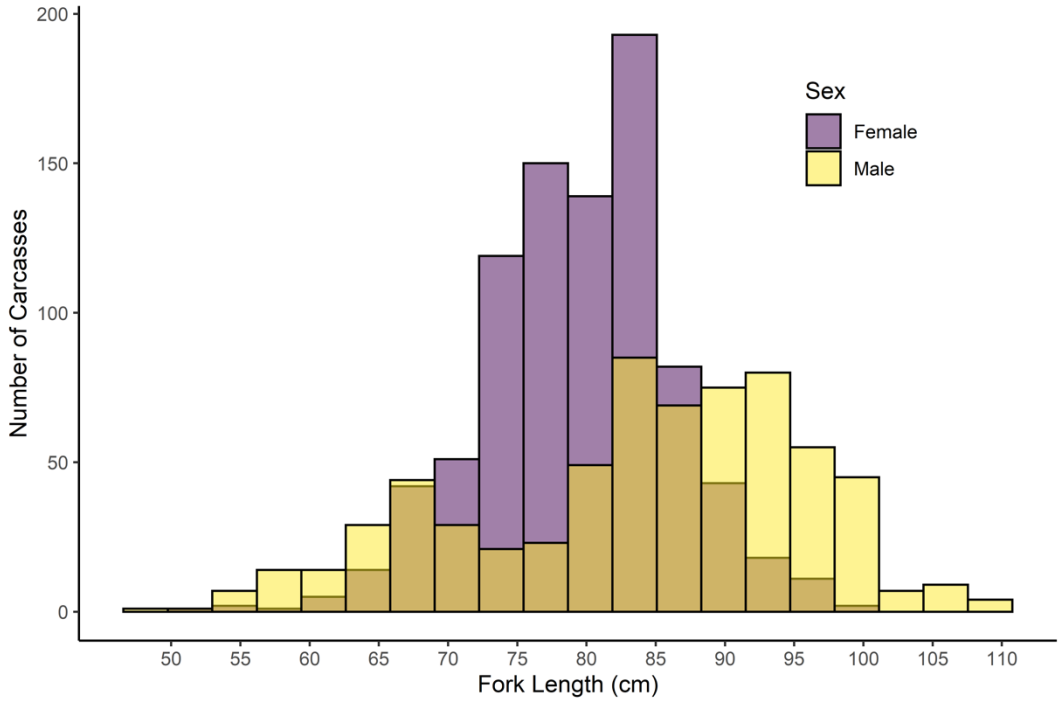

Figure 8. Fork length frequency histogram by sex for carcasses processed during the 2022 lower American River Chinook salmon escapement survey.

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 ≥66 cm and males had a FL ≥73 cm. Fish were classified as grilse (≤2 years-old) if females had a FL of ≤65 cm and males had a FL of ≤72 cm. These cut-off lengths were determined to reduce age class misclassifications at a rate of 3.1% for males and 1.8% for females for known-age CWT carcasses.

A total of 1,367 (89%) carcasses were classified as adult and 164 (11%) carcasses were classified as grilse. The adult age class consisted of 843 (62%) females, 510 (37%) males, and 14 adults of unknown sex (1%). The grilse age class consisted of 137 (83%) males, 22 (13%) females, and 7 grilse of unknown sex (4%) (Figure 11). The number of grilse peaked in week 6, and the number of adults peaked in week 7. (Table 4).

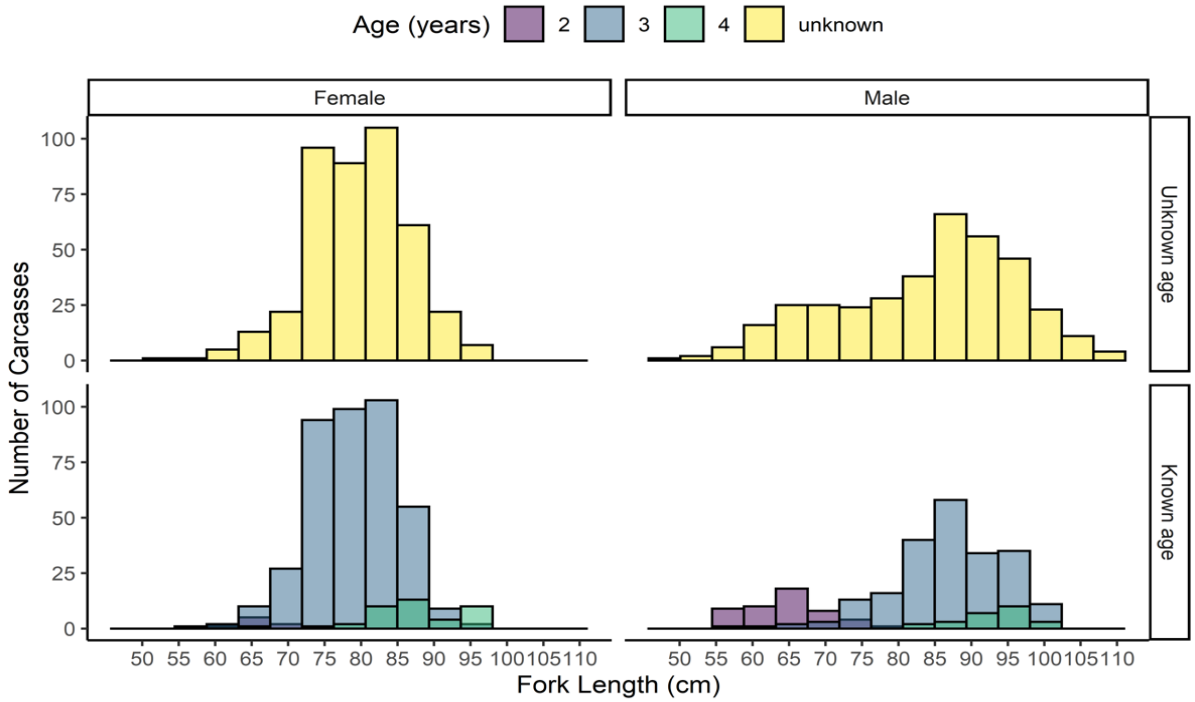

Figure 9. Fork length-frequency distribution of known-age coded wire tagged carcasses and unknown age carcasses processed during the 2022 lower American River Chinook salmon escapement survey.

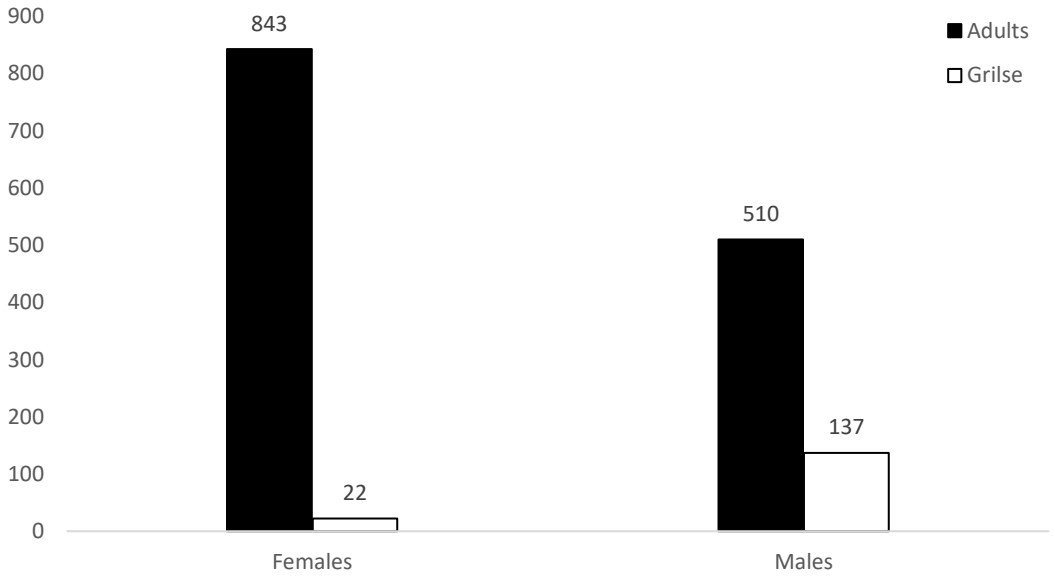

Figure 10. Number of male and female carcasses assigned to adult or grilse age classes during the 2022 lower American River Chinook salmon escapement survey.

Table 4. Summary of processed salmon carcasses by age class during the 2022 lower American River Chinook salmon escapement survey.

Survey Period	Date	Grilse		Adult	
		n	%	n	%
1	Oct 17-20	0	0	15	100
2	Oct 24-27	0	0	3	100
3	Oct 31-Nov 4	0	0	15	100
4	Nov 7-10	4	11	32	89
5	Nov 14-18	25	15	139	85
6	Nov 21-25	41	12	286	88
7	Nov 28-Dec 2	37	8	383	92
8	Dec 5-9	21	11	167	89
9	Dec 12-16	9	6	145	94
10	Dec 19-22	20	14	121	86
11	Dec 27-29	7	10	61	90
	Total	164		1,367	
	Total (%)	11		89	

Pre-spawn Mortality

Degree of egg retention was determined for 840 female carcasses (Table 5). Spawned females accounted for 74% (n = 620), partially spawned accounted for 11% (n = 90), and unspawned accounted for 15% (n = 130) of examined female carcasses.

Only 5 female carcasses were classified as spawned during the first four weeks of the survey (October 17th to November 10th). The proportion of spawned females varied throughout the survey period but began to increase starting in week 5. By week 6 (November 21st-25th), 146 females were classified as spawned, representing 76% of the total female carcasses examined during that survey week (Figure 11).

Table 5. Egg retention status of female carcasses and mean water temperature by survey period during the 2022 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 2023).

Survey Period	Date	Mean Water Temperature	Unspawned	Partial	Spawned	Total
1	Oct 17-20	65.7°F	2	1	1	4
2	Oct 24-27	61.7°F	2	0	0	2
3	Oct 31-Nov 4	59.3°F	2	1	0	3
4	Nov 7-10	57.4°F	18	3	4	25
5	Nov 14-18	56.7°F	14	14	45	73
6	Nov 21-25	55.4°F	25	22	146	193
7	Nov 28 – Dec 2	54.6°F	49	22	196	267
8	Dec 5-9	52.9°F	6	10	76	92
9	Dec 12-16	51.2°F	4	7	69	80
10	Dec 19-22	49.2°F	5	5	58	68
11	Dec 27-29	49.0°F	3	5	25	33
	Total		130	90	620	840
	Total (%)		15	11	74	

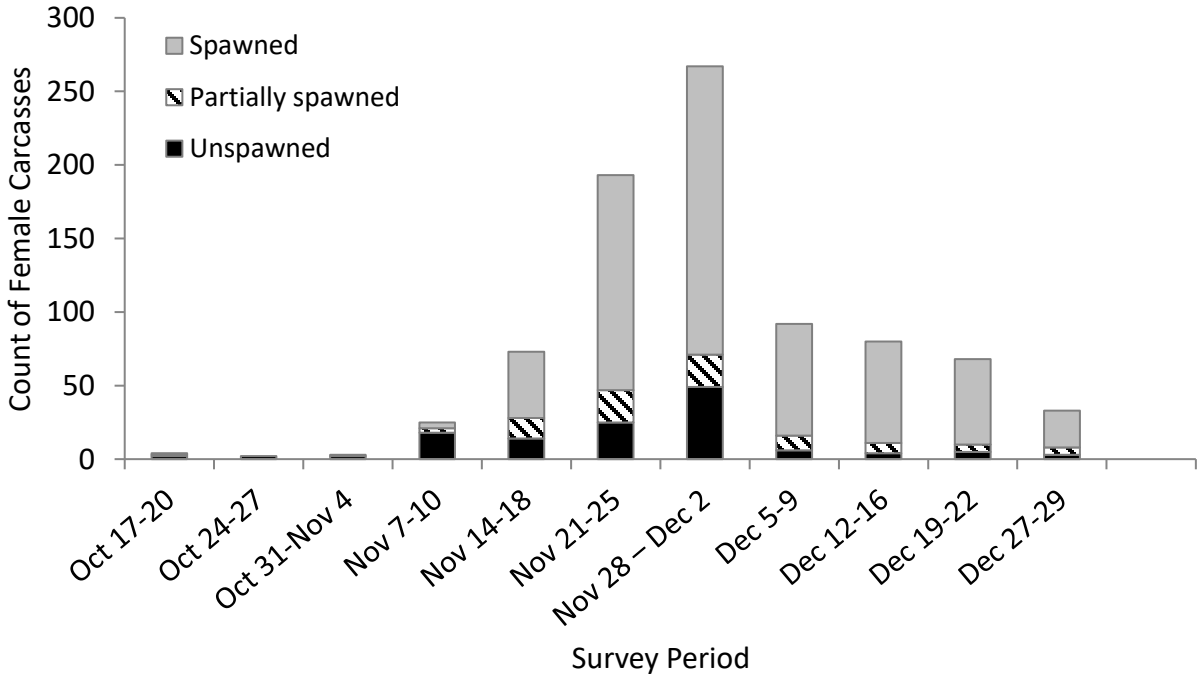

Figure 11. Egg retention status of female carcasses per survey period for the 2022 lower American River Chinook salmon escapement survey.

CWT Carcasses

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 1,727 (18%) carcasses had an adipose fin clip, of those, heads were collected from 777 for CWT recovery. Adipose fins were intact for 7,431 (77%) of carcasses and presence or absence could not be determined for 523 (5%) of carcasses. Of the carcasses that could be assessed, 19% had a clipped adipose fin, which is a similar rate to what was observed from fish that entered the Nimbus Fish Hatchery (22%).

Preliminary data from CWTs recovered by the CDFW Central Valley Salmonid Archive staff indicates a high proportion of FRCS produced at hatcheries other than Nimbus Fish Hatchery strayed into the LAR. Hatcheries in the Central Valley generally mark and tag approximately 25% of hatchery-reared FRCS with CWTs. Of the 777 carcass heads collected for CWT extraction, 62.5% (486) originated from Nimbus Fish Hatchery, 22.4% (174) from Mokelumne River Hatchery, 0.8% (6) from Merced River Fish Facility, 10.4% (81) from Feather River Hatchery, and 0.8% (6) from Coleman National Fish Hatchery. The remaining 3.1% (24) Chinook salmon heads collected either had no CWT or the CWT was lost during extraction. Of the CWT returns for FRCS, approximately 35% (267 of 777) originated from hatcheries outside of the American River watershed.

Table 6. Adipose condition of carcasses by survey period for the 2022 lower American River escapement survey.

Survey Period	Date	Adipose Intact	Adipose Clipped	Skeleton/Unknown	Total
1	Oct 17-20	19	1	11	31
2	Oct 24-27	14	1	1	16
3	Oct 31-Nov 4	24	5	9	38
4	Nov 7-10	39	8	6	53
5	Nov 14-18	225	51	6	282
6	Nov 21-25	731	167	16	914
7	Nov 28 – Dec 2	1791	460	22	2273
8	Dec 5-9	1575	346	63	1984
9	Dec 12-16	1255	268	92	1615
10	Dec 19-22	1211	290	124	1625
11	Dec 27-29	547	130	173	850
	Total	7431	1727	523	9681
	Total (%)	77	18	5	

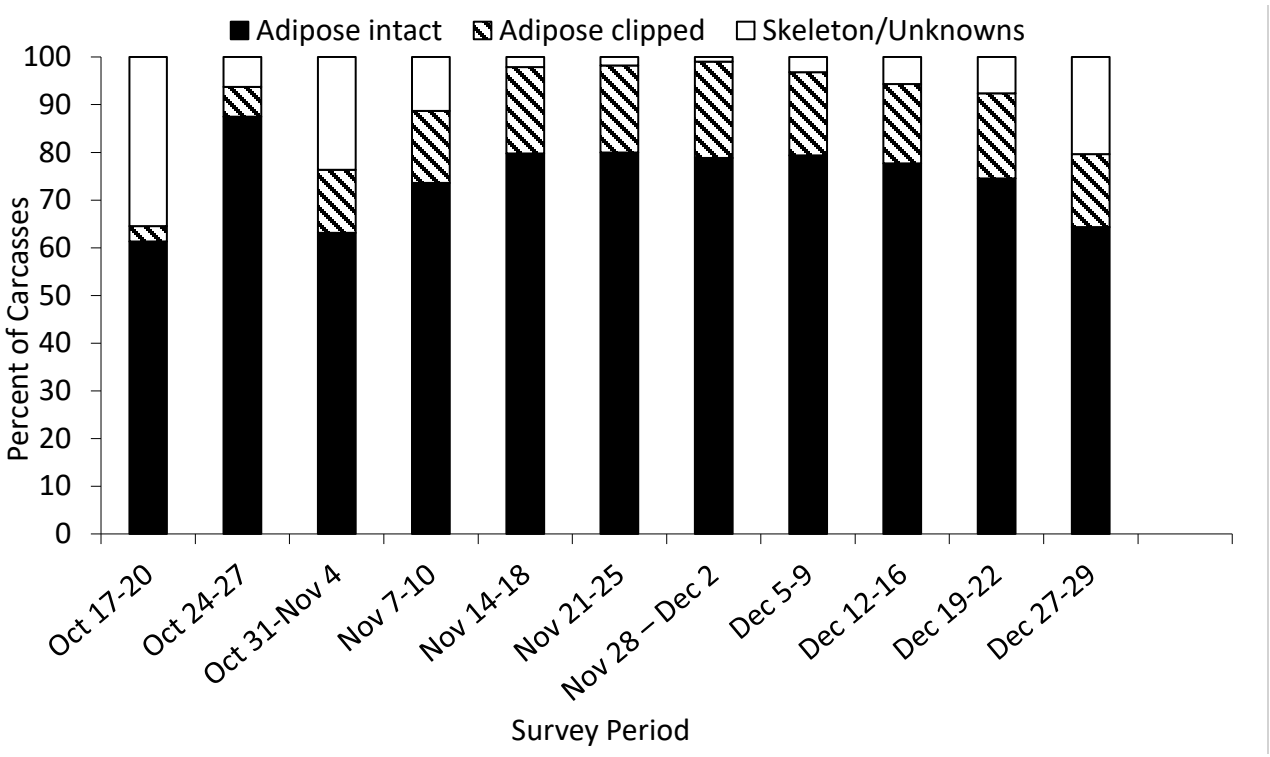

Figure 12. Temporal distribution of adipose fin condition for carcasses processed during the 2022 lower American River escapement survey.

Escapement Estimate

To calculate an escapement estimate, 683 fresh carcasses were marked with uniquely numbered disk tags for inclusion in the CJS population model. Of the tagged carcasses, 292 carcasses (43%) were recaptured at least once, with 328 recapture events in total. The LAR escapement estimate for 2022 was 16,383 fall-run Chinook salmon (90% CI = 15,494 to 17,183). The bootstrap (n = 1,000) estimate of standard error was 536 FRCS. The total escapement estimate was multiplied by the fraction of adults and grilse (approximately 89% and 11%, respectively) to obtain an escapement estimate of 14,631 and 1,752 for adults and grilse, respectively. In addition to the in-river escapement, 9,544 Chinook (8,331 adults and 1,213 grilse) entered Nimbus Fish Hatchery via a fish ladder. The hatchery uses a length boundary of 68 cm to assign an age class for both sexes.

DISCUSSION

Various factors influence the 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 2022 LAR escapement estimate (16,383 FRCS) is an increase compared to the previous year (11,232 FRCS) which was the lowest since 2017 (7,457 FRCS) (Figure 13).

Further exacerbating the stressful river conditions, 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 female salmon can impact 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 impact this may have on in-river juvenile production is still being investigated.

The majority of salmon that returned to the LAR in 2022 were expected to be from brood year 2019. The reported 2019 escapement estimate (27,030 FRCS) included the Nimbus Basin and weir for the in-river escapement estimate, although the weir no longer represented a complete barrier into Nimbus Basin, due to decades of deterioration. Additionally, the low flow on the LAR and prolonged periods of water temperatures exceeding 56°F during spawning periods likely created stressful river conditions for returning adult FRCS (Carter 2005).

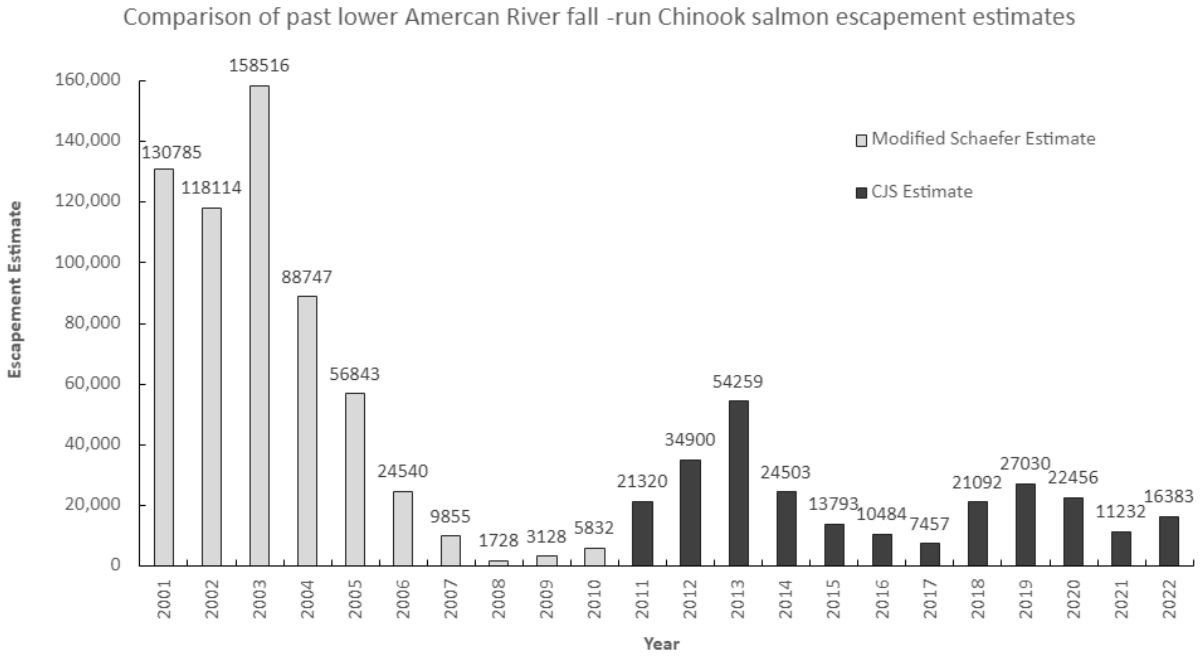

Figure 13. Historical in-river escapement estimates for the lower American River escapement survey from 2001-2022.

The cutoff length between grilse and adult age classes for both sexes in 2022 occurred at a greater FL than in the brood year, 2019. (Figure 14). The 2022 cutoff FL for male adults was 73 cm, 4 cm longer than the brood season. The cutoff for female adults was 66 cm, 4 cm shorter than the previous season. The 2022 FRCS escapement consisted of 89% adults and 11% grilse, within the range exhibited in prior surveys (Figure 15). Chinook returns and size at return has shown to be correlated with ocean conditions (Wells et al. 2006, Peterson et al. 2006 and Wells et al. 2007). 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).

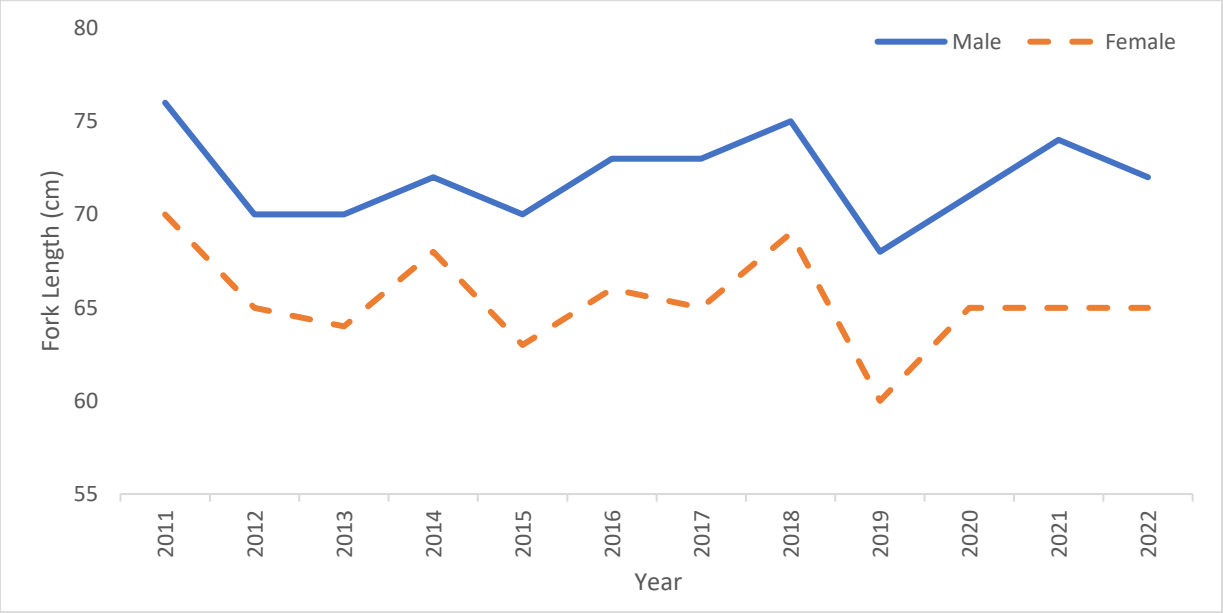

Figure 14. Minimum fork lengths for adult Chinook salmon of both sexes observed from 2011-2022 during the lower American River escapement survey.

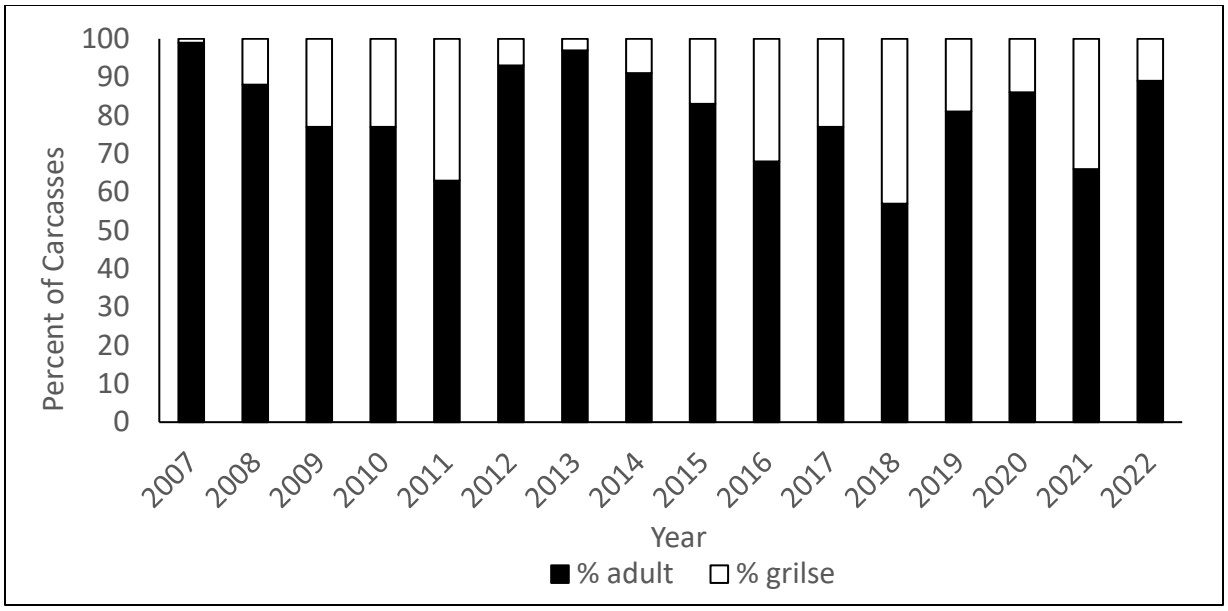

Figure 15. Proportion of adult and grilse carcasses observed each year from 2007 to 2022 during the lower American River escapement survey.

Daily maximum water temperature recorded at Fair Oaks reached and remained below 56°F starting on November 22, 2022, and was soon followed by a significant increase in the number of female carcasses classified as spawned (<30% eggs retained) (Table 7, Figure 16).

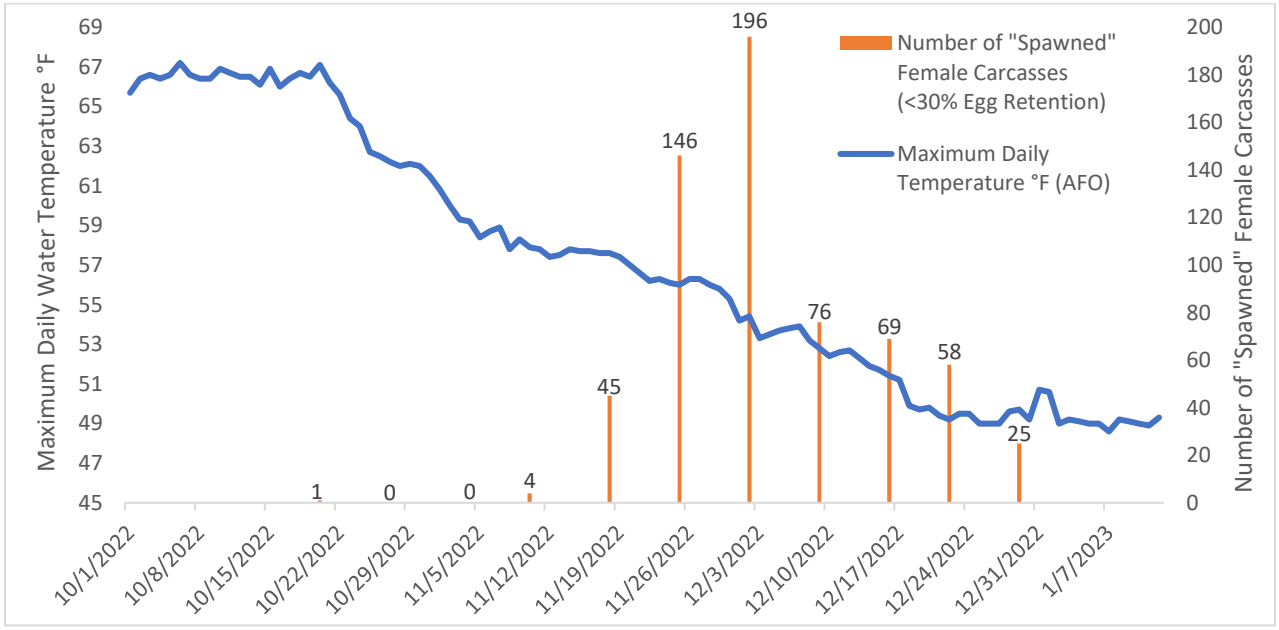

Figure 16. Maximum daily water temperature recorded at the Fair Oaks (AFO) gauge and the number of females classified as spawned by the final day of each survey week. Egg retention status was determined for a total of 840 female carcasses during the 2022 LAR escapement survey. Of these, 620 (74%) were classified as spawned (<30% egg retention).

Table 7. Egg retention status of 840 female carcasses by survey period during the 2022 Lower American River escapement survey. Unspawned females retained >70% of eggs, partially spawned females retained 30-70% of eggs, and spawned females retained <30% of eggs.

Survey Dates	Survey Week	Number of Unspawned Females	Percentage of Unspawned Females	Number of Partially Spawned Females	Percentage of Partially Spawned Females	Number of Spawned Females	Percentage of Spawned Females	Total
Oct 17-20	1	2	50%	1	25%	1	25%	4
Oct 24-27	2	2	100%		0%		0%	2
Oct 31-Nov 4	3	2	67%	1	33%		0%	3
Nov 7-10	4	18	72%	3	12%	4	16%	25
Nov 14-18	5	14	19%	14	19%	45	62%	73
Nov 21-25	6	25	13%	22	11%	146	76%	193
Nov 28 – Dec 2	7	49	18%	22	8%	196	73%	267
Dec 5-9	8	6	7%	10	11%	76	83%	92
Dec 12-16	9	4	5%	7	9%	69	86%	80
Dec 19-22	10	5	7%	5	7%	58	85%	68
Dec 27-29	11	3	9%	5	15%	25	76%	33

Unique to this survey were a number of newly constructed juvenile rearing habitat channels. Low water levels in the fall resulted in the creation of some riffle habitat within the restoration area, which was utilized by spawning salmon. Unfortunately, due to high water releases at the end of the season to mitigate flooding, these redds may have been damaged or destroyed. Additionally, flood releases at the end of December resulted in an abrupt end to the 2022 escapement survey.

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). The 2022 LAR FRCS spawning season began slowly with only 420 carcasses processed over the first 5 survey periods. Water conditions reached a maximum suitable spawning temperature of 56°F during survey period 6. Pre-spawn mortality of females (15%) matched the previous year's rate remaining the lowest rate since 2015 (6%). However, both 2015 and 2021 had low escapement estimates and poor river conditions so it is unlikely either of these years would result in a significant increase to juvenile recruitment. Releases of cool water from reservoirs has been identified as an important management practice for providing suitable spawning and rearing habitat for Chinook salmon in the Sacramento basin (Yates et al. 2008). The maintenance of the CWP behind Folsom Dam and cold-water releases continues to be increasingly relevant for survival of FRCS stocks in the LAR.

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 2022 lower American River escapement survey produced an escapement estimate of 16,383 fall-run Chinook salmon and is still far below the doubling goal of 160,000 fall-run Chinook salmon on the American River (U.S. Fish and Wildlife Service 2015). Peak carcass recovery occurred during survey period 7 (November 28 - December 2), which is consistent with the historical average for LAR FRCS, although earlier than the peak spawn timing from 2019 (December 16 - 20), the brood year for most of the 2022 spawners. Although the reported escapement estimate for 2019 was over 60% larger than 2022, the inclusion of fish recovered from the Nimbus Basin and the weir in the 2019 estimate were not likely to contribute to juvenile recruitment and adult returns during the 2022 survey.

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