State of California

Department of Fish and Wildlife

Memorandum

Date: 03/12/2025

To: Steve Tsao
Senior Environmental Scientist
Department of Fish and Wildlife

From: Ryan Kok
Environmental Scientist
Department of Fish and Wildlife

Subject: 2022 Stanislaus River Fall Chinook Escapement Survey

2022 Stanislaus River Fall Chinook Salmon Escapement Survey

Ryan Kok
California Department of Fish and Wildlife

H. Steve Tsao
California Department of Fish and Wildlife

March 2025

Central Region
Lower San Joaquin River Research and Restoration
PO Box 10, La Grange, CA 95329

Note to the readers:

2022 Stanislaus River Fall Chinook Salmon Escapement Survey summarizes our annual Chinook (*Oncorhynchus tshawytscha*) salmon escapement survey and analyzes fishery and environmental data on the Stanislaus River. The report documents salmon migration timing, spawning temporally and spatially and estimates 2022 fall Chinook salmon spawning population in the Stanislaus River. The report discusses challenges faced during our survey.

Information collected is used in the Department's Ocean Salmon Project Coded-Wire Tags recovery report and the California Central Valley Chinook Population Database Report known as GrandTab.

All data is reviewed by Christopher Diviney and Vanessa Kollmar, Central Region, Lower San Joaquin River Research and Restoration, PO Box 10 La Grange, CA 95329.

All questions and comments should be directed to Ryan Kok, Central Region, Lower San Joaquin River Research and Restoration, PO Box 10 La Grange, CA 95329, (209) 853-2533 ext 5#, ryan.kok@wildlife.ca.gov

Table of Contents

List of Figures

List of Tables

2022 Stanislaus River Fall Chinook Salmon Escapement Survey

Introduction

San Joaquin River fall-run Chinook salmon are considered a species of concern by the National Marine Fisheries Service (NMFS), meaning that NMFS has concern regarding their status and threats, but does not have enough information to list the species under the Endangered Species Act (NMFS, 2009). Population levels in the Stanislaus River, a tributary to the San Joaquin River, have fluctuated in the past 60 years but have overall declined from approximately 35,000 returning adults in 1953 to a low of 168 fish in 1996 (GrandTab, 2023). The decline of the population can be attributed to many factors in the Stanislaus River, San Joaquin River, Sacramento-San Joaquin Delta, and the Pacific Ocean. Reduction of spawning and rearing habitat as well as stream flow management practices are thought to be major factors limiting overall population numbers. Numerous additional factors such as predation, streambed alteration, water quality, water diversions, gravel mining, land use practices, and angler harvest contribute to a web of complex population dynamics which affect population numbers (Louie et al., 2019)..

Chinook salmon have commercial, ecologic, and cultural value so it was deemed necessary to monitor returning adult populations. Since 1952 the California Department of Fish and Wildlife (CDFW), previously known as California Department of Fish and Game, has been conducting annual escapement surveys to estimate and monitor the number of salmon that return to the Stanislaus River to spawn. Escapement refers to returning adult salmon that have escaped all the potential hazards of out migration and return to spawn in the river. Mark-recapture methods have been utilized since 1971 to estimate escapement. Various population models have previously been used including Schaefer (1951), Jolly-Seber (1973), and adjusted Peterson (Ricker 1975). The 2022 escapement estimate was made using the Cormack-Jolly-Seber (CJS) method.

The current objectives of the Stanislaus River escapement surveys are to:

- Estimate the escapement of fall-run Chinook salmon on the Stanislaus River.
- Evaluate the distribution of salmon redds throughout the study area.
- Collect fork-length and sex data.
- Collect scale and otolith samples to conduct age determination and subsequent cohort analysis.
- Collect and analyze coded wire tag data from marked adipose fin clipped fish to determine escapement contribution of hatchery produced salmon and evaluate smolt survival.

Study Area

The 2022 Stanislaus River escapement survey covered a 26-mile reach beginning below Goodwin Dam at river mile (RM) 58 and continuing downstream to Riverbank (RM 33). The survey is divided into four sections, with section 1 being the most upstream reach. Section 1 begins below

Goodwin Dam (RM 58) and extends downstream to Knight's Ferry (RM 55) and includes riffles A1-4, B1, and C1-2. Section 2 begins at Knight's Ferry (RM 55) and continues downstream to Horseshoe Road Recreation Area (RM 50) and includes riffles E1 through J3. Section 3 begins at Horseshoe Road Recreation Area (RM 50) and continues downstream to the Oakdale Recreation Area (RM 39) and includes riffles J4 through T4. Section 4 begins at Oakdale Recreation Area (RM 39) and continues downstream to Jacob Myers Park (RM 33) and includes riffles U1 through Z2 (Figure1).

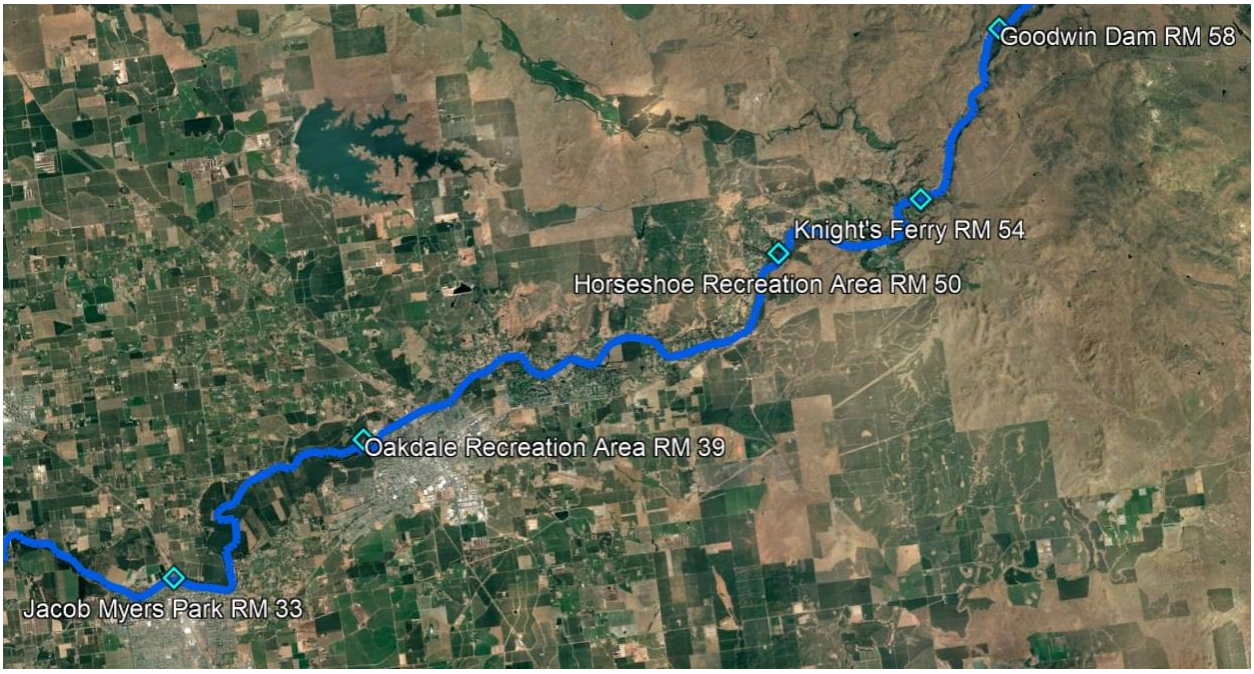


FIGURE 1: STANISLAUS RIVER MAP WITH RECREATION AREAS (MAP DATA: GOOGLE, IMAGE LANDSAT/COPERNICUS)

All riffles in the study area have been geo-referenced using a Trimble GPS TDC1 and mapped with the GIS computer program Arc View. In 2001, each riffle within the entire four section spawning reach was systematically re-named using sequential letter/number designations for river mile and riffle respectively. For example, the first riffle immediately below Goodwin Dam is named A1. Each letter designates a different river mile length (riffle A= RM 58, riffle B= RM 57 etc.). This numbering system is a departure from the historical riffle numbering system. However, the new riffle identification system is more logical and is more conducive to editing as river morphology changes.

In March of 2018 all riffles were once again mapped and named following the procedures used in 2016. Table 1 shows which riffles were changed during the 2018 riffle mapping project and the river mile for each riffle. Riffle R2A was created after week 1 of the 2018 survey as part of the Rodden Road restoration project. Riffle U1 was added back to the survey in 2018 and is surveyed by foot. Riffle B1 was added in 2022; however, there is no river access in this part of the canyon to collect carcasses and so the survey only consisted of visual counts of live fish and redds from the above hillside. For maps showing the locations of all the riffles in the 2022 survey, see Appendix 1. Table 1 lists all surveyed riffles by

section, river mile, and method. Riffles highlighted in blue are surveyed by foot, riffles highlighted in green are surveyed by kayak, and riffles highlighted in yellow are visual counts only.

Section 1		Section 2				Section 3				Section 4	
Riffle	River Mile	Riffle	River Mile	Riffle	River Mile	Riffle	River Mile	Riffle	River Mile	Riffle	River Mile
A1	58.3	E1	54.6	G5	52.4	J4	50.2	O3	45.6	U1	39.0
A2	58.2	E2	54.5	G6	52.3	K1	49.7	O4	45.5	V1	38.9
A3	58.1	E3	54.3	G7	52.2	K1S	49.6	O5	45.4	V2	38.7
A4	58.0	E4	54.2	G8	52.1	K2	49.5	O6	45.3	V3	38.5
B1	57.9	F1	53.9	G9	52.0	K3	49.3	O7	45.1	V4	38.4
C1	56.9	F2	53.8	H1	51.9	K4	49.2	P1	44.8	V5	38.3
C2	56.8	F3	53.7	H2	51.8	L1	48.9	P2	44.6	V6	38.2
		F4	53.6	H3	51.6	L2	48.7	P3	44.5	W1	37.6
		F5	53.5	H4	51.5	L3	48.3	P4	44.0	W2	37.4
		F6N	53.2	H5	51.5	L4	48.2	Q1	43.9	W3	37.2
		F6S	53.2	H6	51.4	L5	48.0	Q2	43.8	W4	37.1
		F7	53.1	H7	51.2	M1	47.9	Q3	43.6	X1	36.9
		G1	52.9	H8	51.1	M2	47.8	Q4	43.5	X2	36.7
		G2	52.7	J1	50.9	M3	47.4	Q5	43.3	X3	36.1
		G3	52.6	J2	50.8	M4	47.3	Q6	43.1	X4	36.0
		G4	52.5	J3	50.5	M5	47.0	Q7	43.0	Y1	35.9
						N1	46.9	R1	42.9	Y2	35.6
						N2	46.6	R2	42.5	Y3	35.5
						N3	46.5	R2A	42.1	Z1	34.6
						N4	46.2	R3	42.0	Z2	34.2
						N5	46.1	S1	41.9		
						N6	46.0	T1	40.8		
						O1	45.9	T2	40.6		
						O2	45.8	T3	40.4		
								T4	40.2		

TABLE 1: RIFFLES SURVEYED BY SECTION, RIVER MILE, AND SURVEY METHOD

Methods

Carcass Collection

Traditional mark-recapture methods were used to estimate fall-run escapement on the Stanislaus River. Using these methods, carcasses are marked and subsequently recovered during weekly surveys of the spawning reach. A ratio of total fish handled to number of recoveries is used to calculate the total spawning population. The CDFW survey began on October 4, 2022 (Week 1) and concluded on January 12, 2023 (Week 15). Weekly drift boat surveys were conducted in sections 2, 3, and 4 using a two or three-person crew that usually consisted of an environmental scientist and two scientific aids.

All visible carcasses were collected from each riffle and the pool immediately below (riffle complex). When a carcass was discovered, it was retrieved using a sharpened gaff and held on the boat until the entire riffle complex had been completely surveyed. Pools need to be adequately searched and

sometimes require unique search patterns (circling, zigzag, parallel transects, etc.) that will be determined by the environmental scientist and repeated throughout the season.

Every carcass handled was designated as fresh, decayed, skeleton, or recovery depending on the degree of decomposition or the presence of an aluminum jaw tag in the case of recoveries. The fresh carcass designation criterion for 2022 was at least one clear eye and firm tissue (Figure 2.1). Decayed fish had cloudy eyes and slightly less firm tissue (Figure 2.2). Skeletons were fish judged to be in an advanced state of decay and unlikely to have the same probability of recapture as fresh and decayed specimens. Criteria for skeleton designation during the 2022 survey included fish that had been scavenged upon, and fish that had become so decayed that body tissue became soft (Figures 2.3 and 2.4). All skeletons were enumerated and then chopped in half prior to being returned to the river to avoid double counting.

FIGURE 2: CARCASS EXAMPLES

1. Fresh carcass with a clear eye
2. Decayed carcass with a cloudy eye
3. Skeletons with evidence of predation
4. Skeleton with missing eyes and mushy tissue

All fresh and decayed carcasses were given a unique number by attaching an aluminum tag with an identification number to the lower jaw. These newly tagged carcasses were put back into the river in

swift current near the lower end of the riffle for recovery in subsequent weeks. Carcasses collected that already had tags were classified as recoveries. The tag number was recorded and if the fish was still intact it was returned to the river. If it was no longer intact, it was chopped.

Section 1 is too dangerous to survey by drift boat, therefore this section was surveyed by foot and consisted of a two or three-person crew walking to accessible pool and riffle combination areas that have suitable spawning habitat. In 2022, riffles H2 and H5 were surveyed by kayak, and riffles K1S and U1 were surveyed by foot because they are side channels that cannot be surveyed by drift boat. Riffle B1 was added to the 2022 survey due to restoration gravel being deposited downstream and creating suitable spawning habitat. However, there is no access down to the river in that area and so it was limited to live fish and redd counts from the surrounding hillsides; no carcasses could be collected from B1.

During the 2022 survey, high flows were not an issue until late December (week 13). Riffle K1S was not surveyed during weeks 1-2, 6-10, and 12 due to the side channel being disconnected (see discussion for additional details). As shown in table 2, rain events with increased flow and high turbidity during weeks 13-15 prevented several riffles from being surveyed. Due to the poor visibility, it is likely that most fresh carcasses and recaptures were not found during these weeks.

Week	Riffles
1	H2, H5, K1S
2	K1S
3	U1
6	K1S
7	K1S
8	K1S
9	K1S
10	K1S
12	K1S
13	B1, C1-2*, H2, H5, K1S, U1
14	B1, H5, K1S, U1
15	A1-4, B1, C1-2, H2, H5, K1S, U1
*Partial Survey	

TABLE 2: RIFFLES NOT SURVEYED

Weekly Fish Observations and Redd Counts

Weekly live fish observations and redd counts were conducted during the entire 15-week escapement survey period. These counts were conducted for each riffle and subsequent pool unless the riffle was not surveyed as noted above. Counts were made using tally counters as the field crew drifted downstream through the riffles and pools. The single pass method is used for conducting redd and live fish counts. Live fish are counted once they swim upstream past the boat to prevent double counting. During the fall pulse flow (weeks 3-5), it was sometimes more challenging to conduct counts as the boat was moving faster through the riffles, the water was more turbid, and the riffles were deeper than usual.

Chinook redds are characterized by gravel that is noticeably cleaner than the surrounding area and usually cover an area of 1 m^2 to 12 m^2. Redds will have a noticeable depression (pot) covered with larger gravel, that is formed by the female turning on her side and digging the gravel with her tail. Downstream of the pot, there will be a tail spill that is composed of smaller gravel and sediment that was removed during the construction of the pot. Redds can also be built on top of or next to existing redds, and the clean gravel will gradually fade over time. All crew members are trained to accurately count and identify redds to reduce variability in the data.

Carcass Processing

Fork length (to the nearest centimeter) and sex data are recorded for all tagged carcasses. Scale samples and otoliths are collected from all tagged carcasses. This data is used to determine the size and age composition of annual spawning runs. Fish that had adipose fins removed were assumed to contain coded wire tags (CWT) and the upper portion of the head was removed from these fish, leaving behind the lower jaw with the jaw tag (Figure 3). Each CWT head was individually bagged with a tag that contains information about the fish. In 2022, CWT heads were brought back to La Grange and then later transported to the Central Valley Tissue Archive in West Sacramento for CWT extraction and analysis. These CWT's contain information including which hatchery the fish came from, when it was released, and where it was released. CWT specimens are also used to validate scale and otolith age determination work by comparing known brood year to annuli counts.

FIGURE 3: CWT CARCASS WITH TOP HALF OF HEAD REMOVED

Scale samples were collected from tagged carcasses by scraping from tail to head direction with a serrated knife above the lateral line between the adipose and dorsal fins. When possible, scales were collected from an area within this region that appeared cleaner or showing less signs of decay. Scale samples were brought back to La Grange at the end of the day to be air dried for at least 48 hours before storage. Once the survey is completed the scales are cleaned, mounted on slides, and read using a microfiche to determine the age of each fish.

Otoliths (Figure 4) are taken in the field by cutting an opening in the skull that exposes the brain cavity. A horizontal incision is made above the eyes and nostrils towards the posterior end of the fish ending slightly above the gill cover. A vertical cut can then be made to join with the horizontal cut to remove the "head cap". Otoliths are then removed with forceps, cleaned of any adhering tissue, and placed in labeled vials. All fish samples are catalogued by the fish's unique jaw tag number, which allows the samples to be tracked to the specific date and riffle number of collection.

FIGURE 4: A PAIR OF SALMON OTOLITHS

Carcasses were also examined for signs that the fish died before spawning. When a female released eggs when handled or had an enlarged body cavity, it was squeezed or cut open to check for eggs. If a female fish was found to be full of eggs, it was considered an unspawned mortality and was noted on the data sheet. If a female fish was found to have a moderate number of eggs, it was considered a partially spawned fish and was also noted on the data sheet. When a male fish released large amounts of milt during processing or retrieval, it was classified as either an unspawned or partially spawned mortality and was noted on the data sheet.

All dead rainbow trout that are found during the survey are retained for sample collection and DNA analysis. Each fish was checked for an adipose fin and measured in the field. Upon return to the CDFW La Grange lab, scale samples, otoliths, and a fin clip were collected. In 2022, heart tissue was also collected for further DNA analysis. Each fish was cut open to check for sex and presence of eggs. If eggs were found, it was noted on the data sheet, and they were left inside the body cavity for future egg counting.

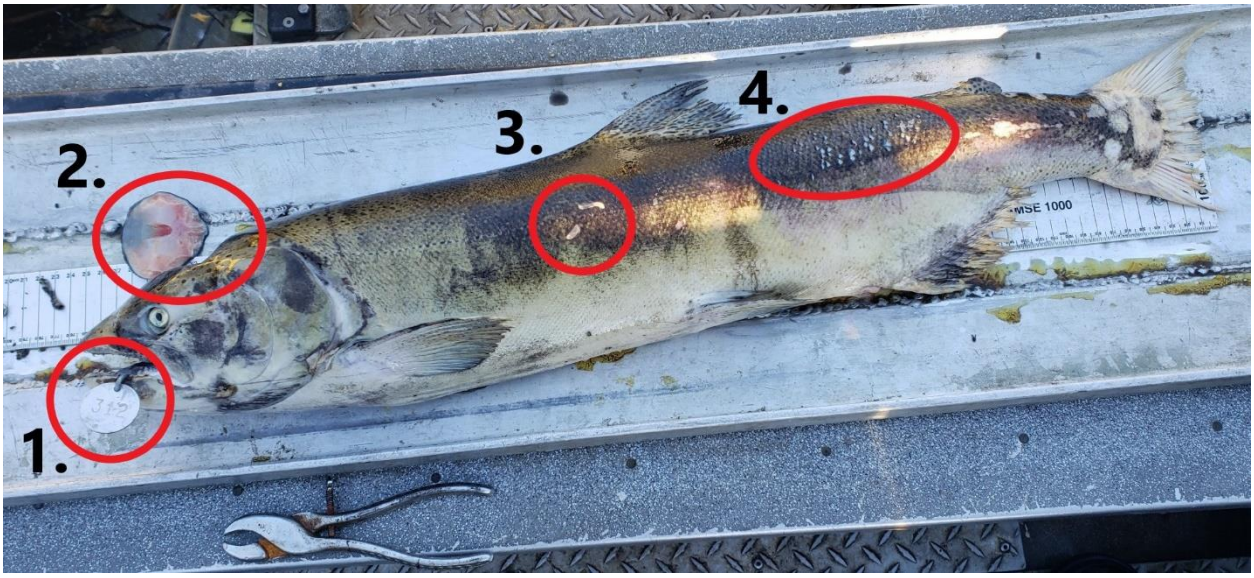


FIGURE 5: A PROCESSED SALMON CARCASS

1. Numbered aluminum tag attached to lower jaw
2. Head cut open to expose brain cavity and remove otoliths
3. Sacs removed from otoliths prior to storage
4. Scales collected above the lateral line between the adipose and dorsal fins

Data Management and Analysis

At the end of each survey day, the field crew double checked all tag numbers recorded on the data sheet against scale envelopes, head bags, and otolith vials. All information for each fish must match before the samples can be stored. The datasheets were reviewed by the environmental scientist and placed into the data entry folder. Datasheets were also reviewed by the data entry technician prior to being entered into a Microsoft Access database. All newly entered data goes through a quality control process in which a second individual prints out line-by-lines to check for any data entry errors. The environmental scientist receives a copy of the database after all data entry errors have been corrected. Microsoft Access, Excel and the statistical software package R are the current programs being utilized for data analysis.

CDFW has used a variety of population models since escapement surveys began in 1953. These equations include the Schaeffer, Jolly-Seber, and the Adjusted Peterson. Currently the Cormack-Jolly-

Seber (CJS) population estimate model is used to produce an estimate of spawning adults. Traditionally, this model takes three data files into account to produce an estimate. The first spreadsheet contains tag and recapture events, the second contains skeleton counts by week, and the third contains sex and fork length information. In 2018, a fourth spreadsheet containing intervals between sampling periods was added to the model.

Results

Escapement Estimate

1,122 carcasses were processed during the 2022 Stanislaus River escapement survey. An additional 790 skeletons were tallied and chopped, giving a total of 1,912 individual Chinook salmon handled during the escapement survey. 405 tagged carcasses were recovered at least once, and the recapture rate was 36.1%. Of these fish, there were 100 instances where a fish was recovered twice, and 11 instances where a fish was recovered three times for a total of 527 recaptures. Recaptures are essential in calculating annual population estimates because they help determine the overall success rate of the field crew's ability to locate carcasses in the river.

As described above, the Cormack-Jolly-Seber population estimate model was used to produce an estimate of spawning adults returning to the Stanislaus River in 2022. Using option six of the model in which capture probability is related to the sex of the carcass and survival probability is related to the length of the carcass, the estimate produced was 3,646 fish (95% confidence interval, 5000 repetitions) with a lower confidence of 3,450 fish and an upper confidence of 3,965 fish (Figure 6).

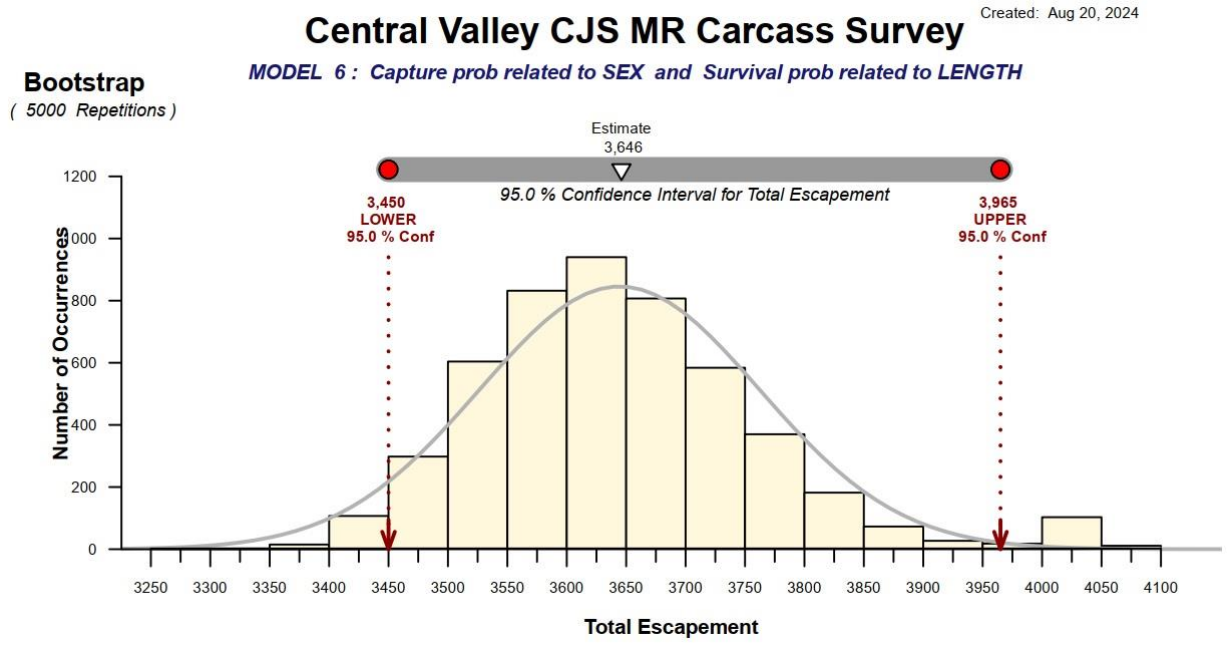


FIGURE 6: CJS ESTIMATE USING MODEL 6

Year	Estimate	Year	Estimate	Year	Estimate
1969	12,327	**1987**	6,292	**2005**	3,315
1970	9,297	**1988**	10,212	**2006**	1,923
1971	13,621	**1989**	1,510	**2007**	443
1972	4,298	**1990**	480	**2008**	1,305
1973	1,234	**1991**	394	**2009**	597
1974	750	**1992**	255	**2010**	858
1975	1,200	**1993**	677	**2011**	1,391
1976	600	**1994**	1,031	**2012**	4,020
1977	-	**1995**	619	**2013**	2,846
1978	50	**1996**	168	**2014**	3,064
1979	110	**1997**	5,588	**2015**	6,195
1980	100	**1998**	3,087	**2016**	9,482
1981	1,000	**1999**	4,349	**2017**	3,314
1982	-	**2000**	8,498	**2018**	2,377
1983	500	**2001**	7,033	**2019**	1,504
1984	11,439	**2002**	7,787	**2020**	541
1985	13,473	**2003**	5,902	**2021**	4,301
1986	6,497	**2004**	4,015	**2022**	3,646

TABLE 3: ANNUAL SALMON POPULATION ESTIMATE (CDFW FILES, GRANDTAB)

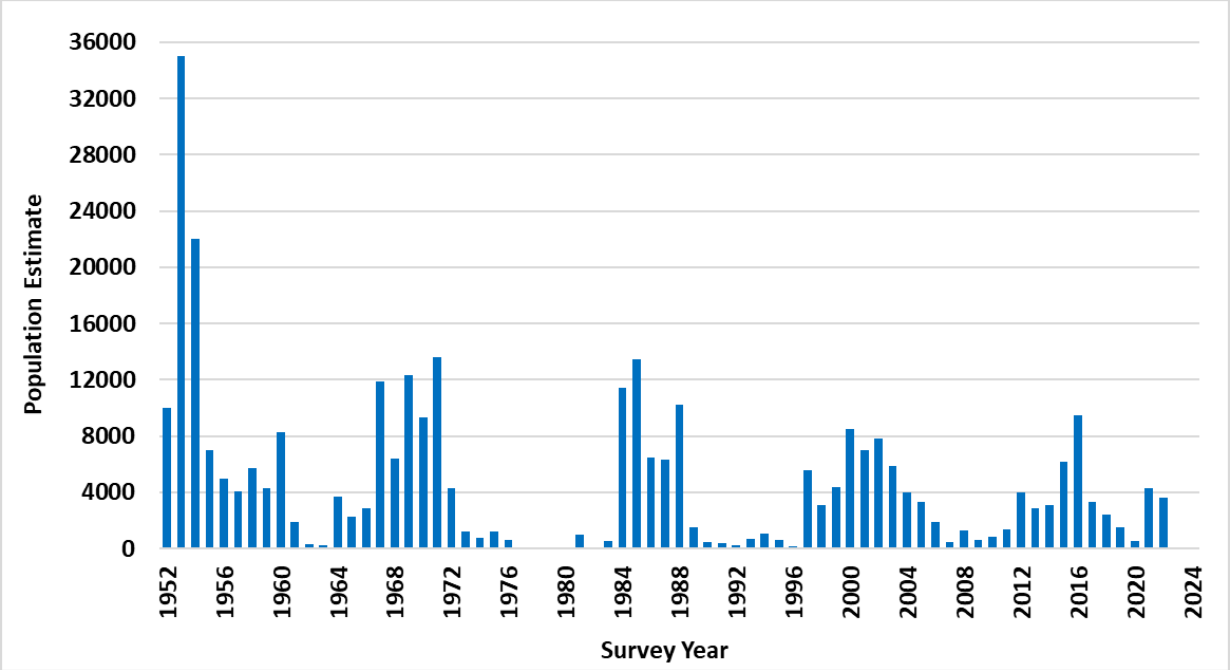


FIGURE 7: CDFW SALMON POPULATION ESTIMATE BY YEAR

Live Salmon, Redd, and Carcass Count

Weekly live fish observations peaked during weeks 6 through 8 and weekly redd observations peaked in weeks 8 through 10, with counts gradually dropping off in the following weeks (Table 4, Figure 8). These peaks are likely related to the fall pulse flow, as it contributed to a decrease in water temperature to suitable spawning levels, and the number of live fish observed greatly increased following this period in early November. During the survey, individual redds are not marked, and so they are likely counted during consecutive weeks until the redd no longer appears to be fresh or clean. For this reason, a maximum observed redd count is used to determine how much spawning occurred in each riffle or section (Table 5, Figures 9 and 10).

Week	# Live	# Redds	# Skeletons	# Tagged	# Recovered	# Carcasses Handled	# CWT
1	1	7	0	0	0	0	0
2	31	9	0	0	0	0	0
3	43	4	0	0	0	0	0
4	32	8	0	0	0	0	0
5	189	91	0	2	0	2	0
6	720	389	8	26	1	35	7
7	1045	691	41	128	9	178	22
8	929	775	86	254	48	388	51
9	621	727	188	247	130	565	56
10	654	835	173	200	150	523	51
11	313	595	116	165	61	342	42
12	231	583	154	98	115	367	36
13	9	50	18	2	11	31	0
14	1	2	6	0	2	8	0
15	0	0	0	0	0	0	0

TABLE 4: WEEKLY COUNTS

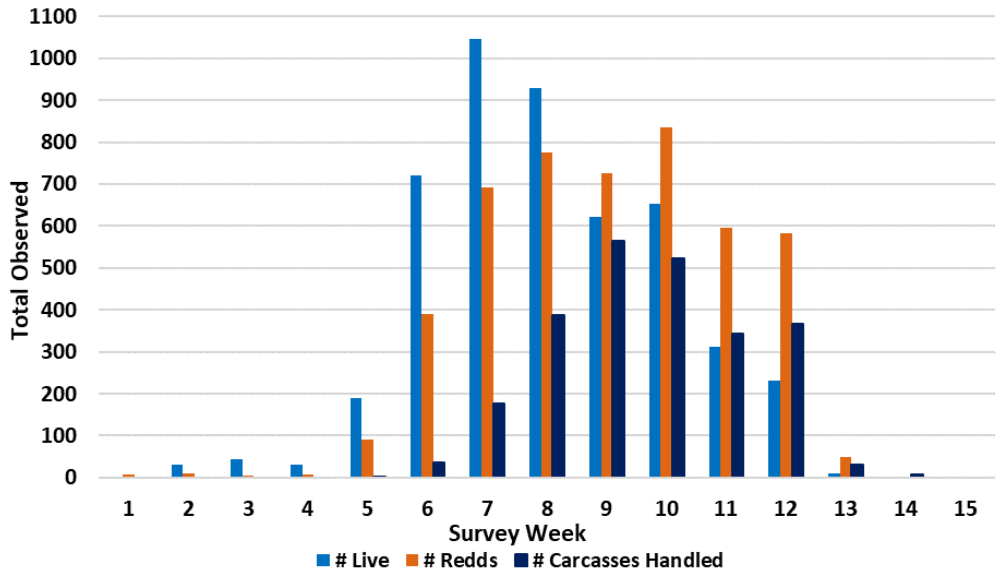


FIGURE 8: WEEKLY LIVE FISH, REDDS, AND CARCASSES

Section 1		Section 2				Section 3				Section 4	
Riffle	Max Redds	Riffle	Max Redds	Riffle	Max Redds	Riffle	Max Redds	Riffle	Max Redds	Riffle	Max Redds
A1	89	E1	20	G5	10	J4	3	O3	0	U1	1
A2	5	E2	13	G6	5	K1	9	O4	1	V1	5
A3	10	E3	41	G7	3	K1S	4	O5	5	V2	9
A4	40	E4	21	G8	19	K2	21	O6	9	V3	5
B1	6	F1	6	G9	6	K3	9	O7	7	V4	7
C1	16	F2	7	H1	15	K4	20	P1	4	V5	11
C2	48	F3	14	H2	2	L1	8	P2	3	V6	2
		F4	6	H3	7	L2	2	P3	7	W1	23
		F5	6	H4	4	L3	1	P4	4	W2	3
		F6N	4	H5	12	L4	15	Q1	4	W3	1
		F6S	5	H6	10	L5	6	Q2	11	W4	20
		F7	8	H7	4	M1	3	Q3	17	X1	19
		G1	17	H8	7	M2	2	Q4	14	X2	2
		G2	7	J1	2	M3	22	Q5	6	X3	4
		G3	21	J2	7	M4	20	Q6	3	X4	11
		G4	7	J3	3	M5	7	Q7	11	Y1	25
						N1	10	R1	3	Y2	5
						N2	2	R2	6	Y3	8
						N3	8	R2A	4	Z1	14
						N4	4	R3	27	Z2	15
						N5	5	S1	7		
						N6	6	T1	7		
						O1	4	T2	10		
						O2	1	T3	9		
								T4	10		

TABLE 5: MAXIMUM REDD OBSERVATIONS PER RIFFLE

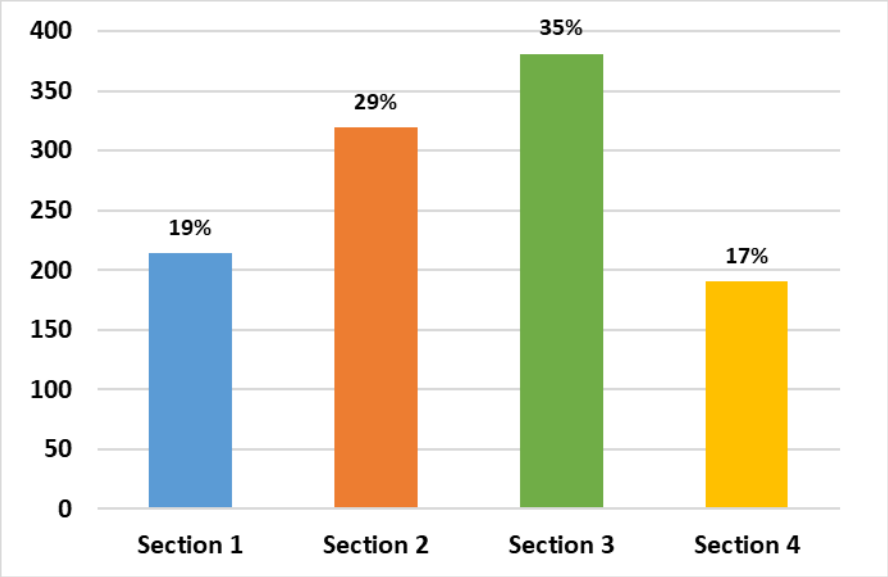


FIGURE 9: MAXIMUM REDDS OBSERVED BY SURVEY SECTION

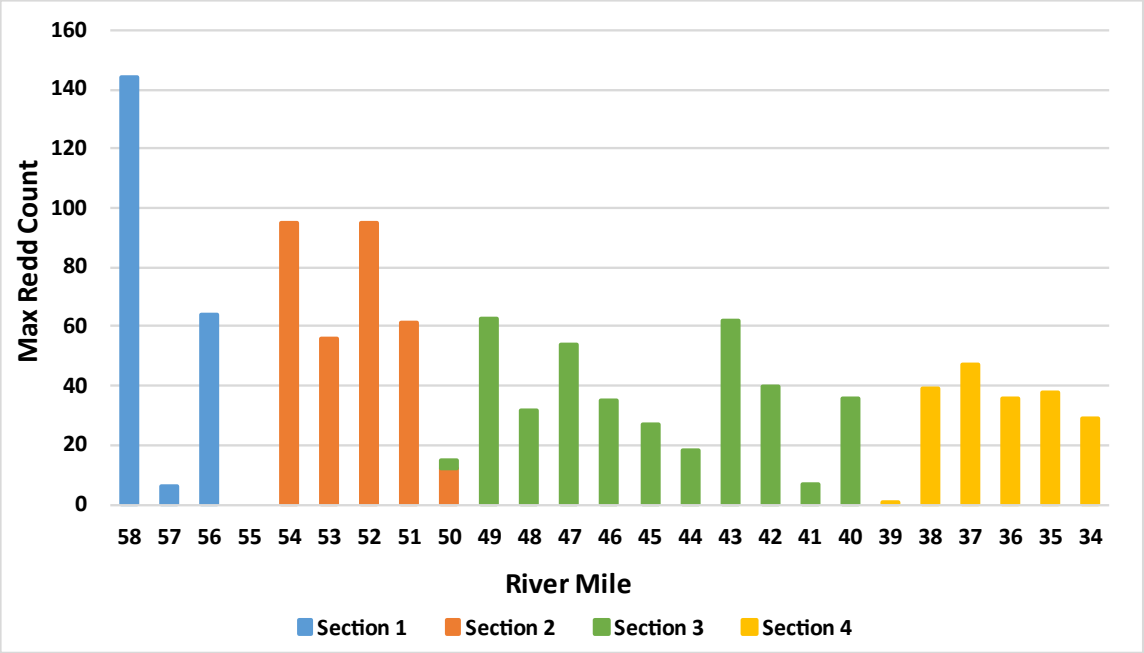


FIGURE 10: MAXIMUM REDDS OBSERVED BY RIVER MILE

Fork Length and Sex Distribution

Data from the three San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced) was pooled to analyze the population composition. Length frequency histograms of male and female fish show the difference in fork length for grilse and adult fish (Figures 11 and 12). The first peaks are likely grilse (age 1 and 2) and the second peaks are likely adults (age 3, 4, and 5). Based on the San Joaquin River Basin length frequency histograms, the 2022 breakpoint between grilse and adults was 70 cm for males. Grilse accounted for 27.0% of the male tagged fish. The 2022 breakpoint for females was 61 cm. Grilse accounted for 1.7% of the female tagged fish. 57.5% of the tagged carcasses were female and 42.5% were male. Figure 13 shows sex and grilse distribution as a percentage of all tagged fish during the 2022 survey.

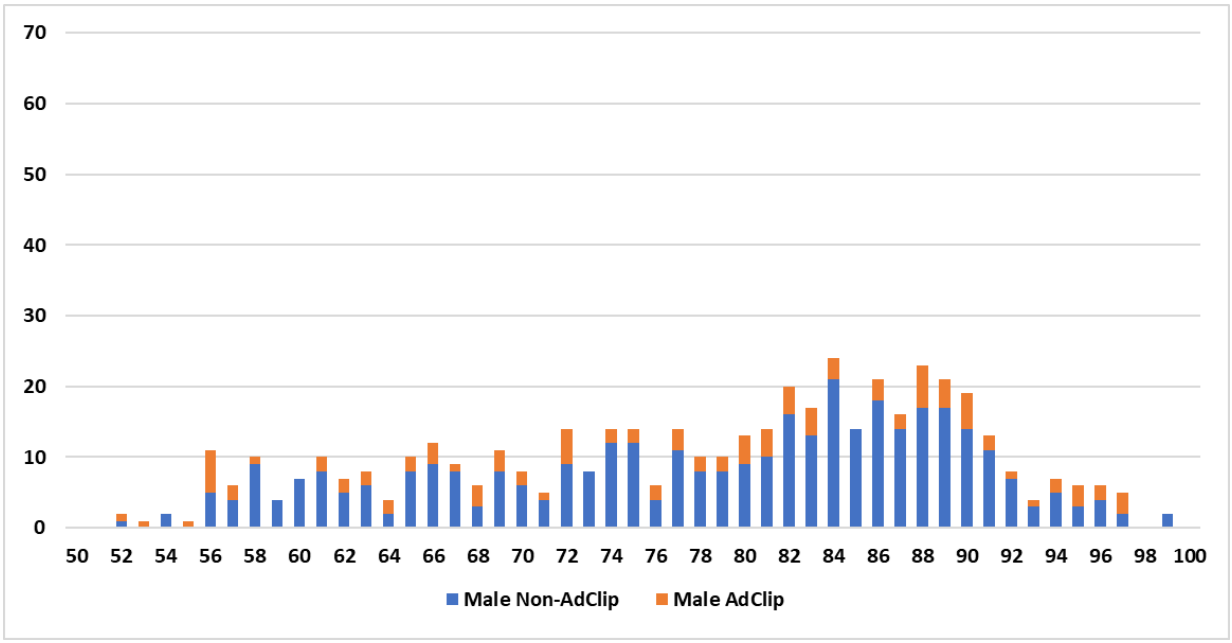


FIGURE 12: MALE FORK LENGTH HISTOGRAM

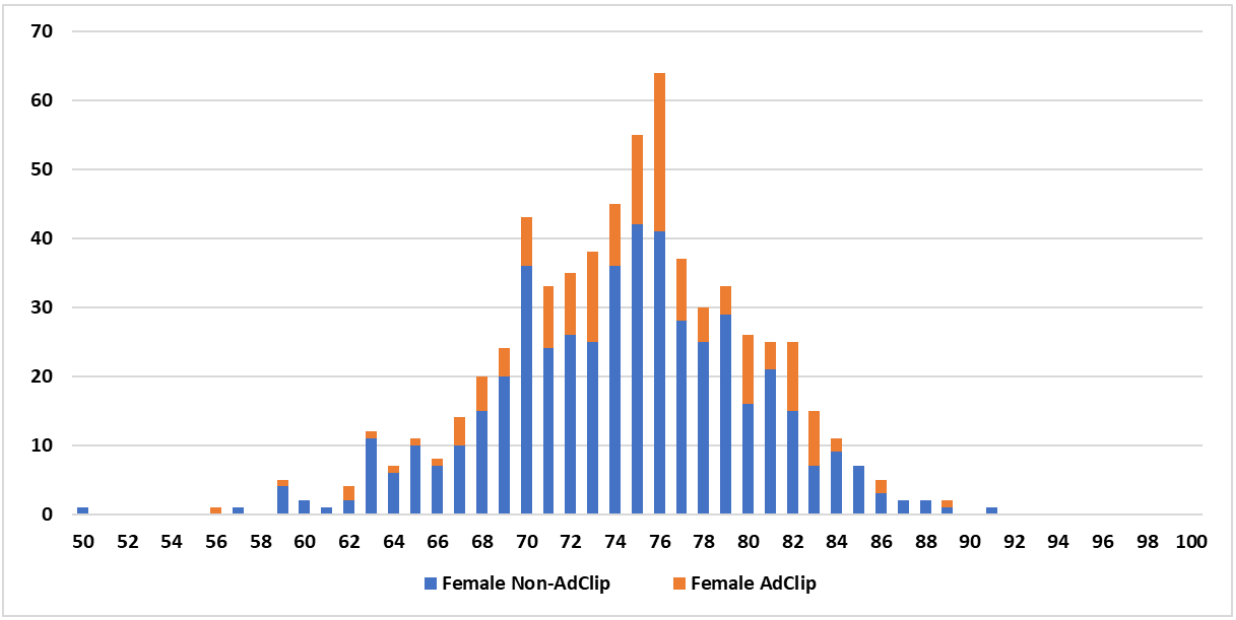


FIGURE 11: FEMALE FORK LENGTH HISTOGRAM

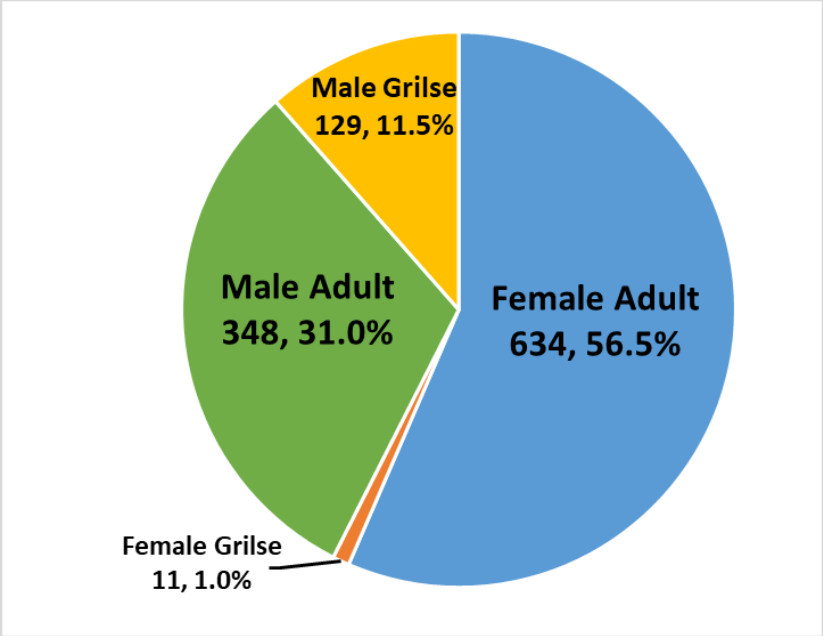


FIGURE 13: SEX AND GRILSE COMPOSITION

Scale Age Analysis

In 2022, all 1,122 tagged fish had scale samples collected from them in the field. These were returned to the CDFW La Grange office to be cleaned, mounted on a microscope slide, and aged using a microfiche reader. Two full sets of age reads were completed by separate trained employees, with a third reader being used as a tie breaker if the first two readers recorded different ages for a given fish. All scales were analyzed blindly, meaning that mounted scales did not contain sex or length information to prevent bias during age determination. Data collected for each fish included the number of annuli, number of freshwater circuli, number of first year circuli, and number of edge circuli.

Of the 1,122 scale samples that were collected in 2022, 1,117 scales were able to be processed and have an age determined using the above methods. Samples that were unable to be analyzed were due to the scales being too deteriorated to accurately estimate an age (4) or the sample was lost (1). For males, 12 fish (2.5%) classified as grilse using the fork-length breakpoint estimate were classified as adults using the scale age data. For females, 10 fish (1.6%) classified as adults using the fork-length breakpoint estimate were classified as grilse using the scale age data. Additional results and analysis will be contained in a separate 2022 age report.

CWT Analysis

There were 265 adipose fin clipped fish handled during the 2022 survey. The upper portion of the head was removed, individually bagged with a tag containing information about the fish and brought back to the La Grange office for temporary storage. Heads were then transported to the Central Valley

Tissue Archive for processing. Of the 265 heads collected, CWT's were successfully retrieved and read from 257 fish. Table 6 shows the hatchery location, brood year, and release site for all 257 fish that successfully had the CWT retrieved. Table 7 shows the CWT composition by year for all carcasses handled during the escapement surveys. The percentage of catch is listed in each box with the actual number of fish tagged inside the parenthesis. Figure 14 shows brood year percentage, figure 15 shows hatchery composition, and figure 16 shows male and female composition for CWT and non-adipose clipped fish for 2022.

Hatchery	Release Location	Brood Year			Total
		2018	2019	2020	
Feather River Hatchery	Fort Baker - Minor Pt	0	0	1	**1**
	Mare Island Net Pen	0	3	0	**3**
Merced River Hatchery	San Joaquin River - Sherman Island Net Pen	0	1	3	**4**
Mokelumne River Hatchery	Fort Baker - Minor Pt	0	58	5	**63**
	Half Moon Bay - John PR Net	0	17	2	**19**
	Monterey - Major Pt	0	0	3	**3**
	San Joaquin River - Sherman Island Net Pen	3	123	14	**140**
	Santa Cruz Harbor	0	10	2	**12**
Nimbus Hatchery	Mare Island Net Pen	1	6	4	**11**
	Wickland Oil Net Pen	0	0	1	**1**
UNKNOWN	**TAG NOT FOUND/LOST**				**8**
	Grand Total	**4**	**218**	**35**	**265**

TABLE 6: CWT HATCHERY, RELEASE LOCATION, AND BROOD YEAR

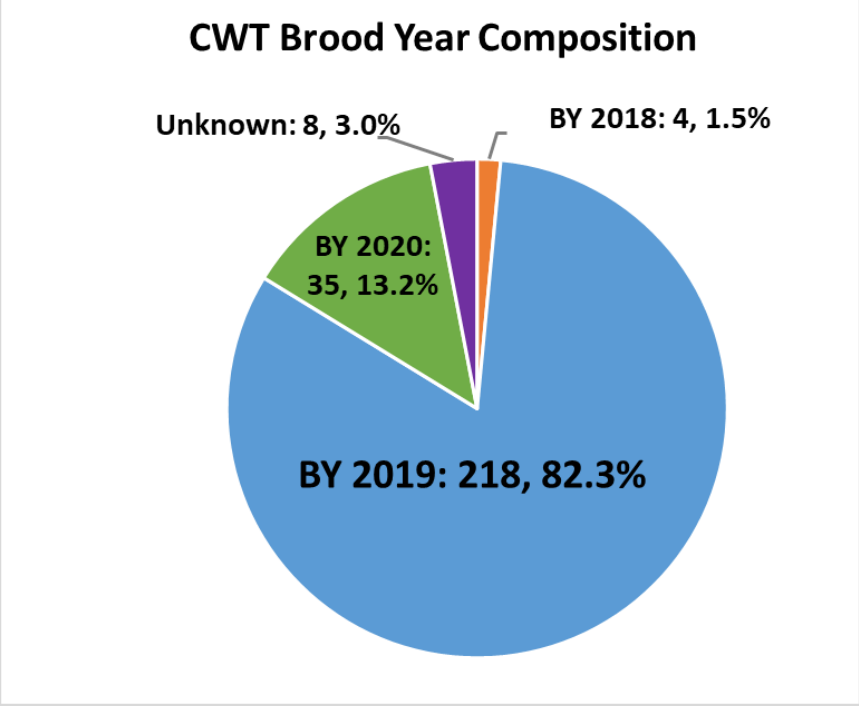


FIGURE 14: CWT BROOD YEAR, COUNT, AND PERCENTAGE

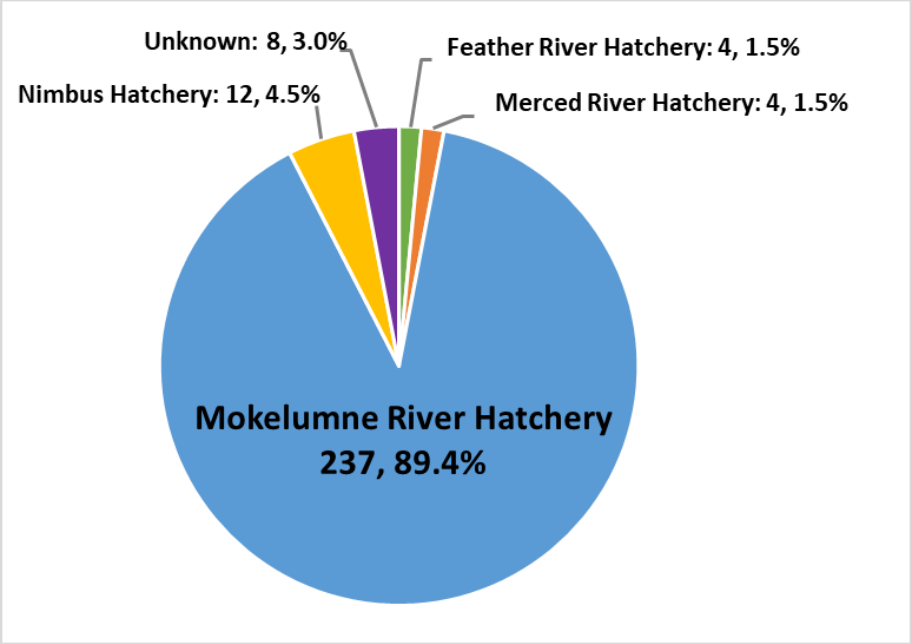


FIGURE 15: CWT HATCHERY, COUNT, AND PERCENTAGE

Year	Adipose Fin Clipped (CWT)		Non-Adipose Fin Clipped	
	% Female	% Male	% Female	% Male
2002	6.9 (132)	3.7 (71)	53.0 (1012)	36.4 (695)
2003	7.3 (141)	4.4 (85)	52.1 (1002)	36.1 (694)
2004	4.5 (50)	3.2 (35)	55.5 (616)	36.8 (408)
2005	2.2 (10)	1.8 (8)	65.6 (295)	30.4 (137)
2006	2.0 (5)	68.8 (174)	1.6 (4)	27.7 (70)
2007	0 (0)	0 (0)	37.5 (9)	62.5 (15)
2008	1.9 (2)	1.9 (2)	60.2 (65)	36.1 (39)
2009	7.6 (7)	3.3 (3)	37.0 (34)	52.2 (48)
2010	9.8 (15)	14.4 (22)	35.3 (54)	40.5 (62)
2011	31.0 (153)	30.8 (152)	20.7 (102)	17.4 (86)
2012	50.4 (400)	22.1 (175)	14.1 (112)	13.4 (106)
2013	17.0 (145)	10.0 (82)	46.0 (386)	27.0 (233)
2014	8.5 (37)	9.2 (40)	44.9 (196)	37.5 (164)
2015	11.8 (94)	8.7 (69)	40.7 (323)	38.8 (308)
2016	9.7 (74)	9.7 (74)	43.8 (334)	36.8 (281)
2017	16.4 (60)	13.2 (48)	38.9 (142)	31.5 (115)
2018	16.5 (94)	7.2 (41)	50.3 (287)	26.0 (148)
2019	16.1 (30)	2.7 (5)	41.2 (77)	40.0 (74)
2020	11.7 (19)	8.6 (14)	52.5 (85)	27.2 (44)
2021	7.6 (64)	17.1 (144)	25.7 (216)	49.5 (416)
2022	14.2 (159)	9.4 (106)	43.3 (486)	33.1 (371)

TABLE 7: CWT COMPOSITION BY YEAR

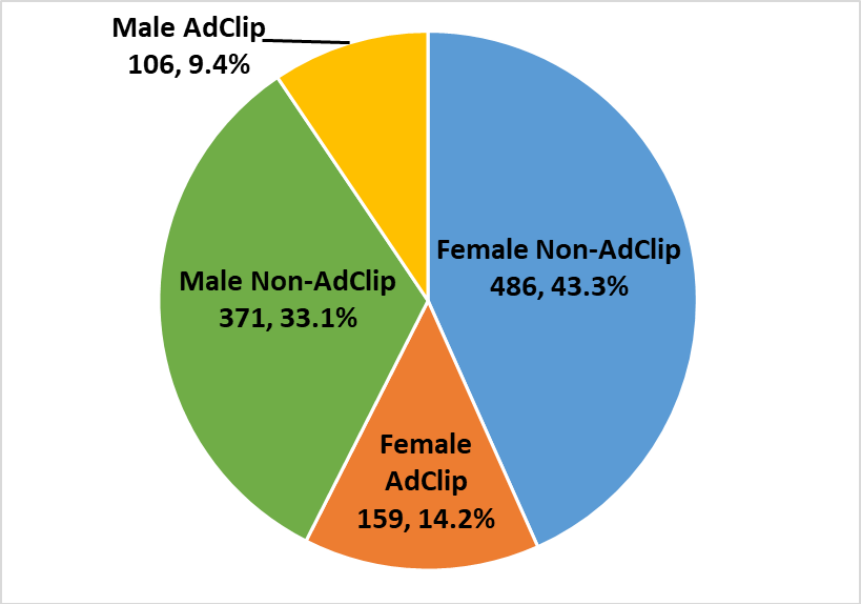


FIGURE 16: SEX AND AD-CLIP COMPOSITION

Egg Production Estimate

An estimate for the number of eggs produced by the 2022 fall run chinook salmon was generated using a standard regression equation ((158.45 * average fork length cm – 6138.91) * CJS female estimate) = number of eggs. This fork length-fecundity relationship was determined for 48 San Joaquin fall-run Chinook salmon females ranging from 62.5 to 94.0 cm fork length (Loudermilk et al. 1990). In the 2022 Stanislaus River escapement survey, the number of eggs was calculated for the expanded non-adipose fin-clipped female fish population based on the CJS estimate. 486 non-adipose fin clipped female carcasses were collected in 2022, with an average fork length of 74.3cm and an estimated egg production of 5,626 eggs per fish. Expanding this using the CJS estimate of 1,579 non-adipose clipped females, the egg production regression equation yields a total of 8,885,310 eggs. The number of eggs produced from adipose fin clipped females was calculated using the same equation. 159 adipose fin clipped female carcasses were collected in 2022, with an average fork length of 75.0cm and an estimated egg production of 5,752 eggs per fish. Expanding this using the CJS estimate of 517 adipose fin clipped females, the egg production regression equation yields a total of 2,971,843 eggs. Combined, these result in a total estimate of 11,857,153 eggs for 2022.

Pre-Spawn Mortality

Any female fish that was tagged and met the criteria noted in the methods section was checked to see if it was an unspawned or partially spawned mortality. In 2022, few females met these criteria; only four fish (0.006%) had enough eggs present to be classified as unspawned, and four (0.006%) other fish had enough eggs present to be classified as partially spawned. In 2022, one male (0.002%) met the criteria and released enough milt during processing to be considered a partially spawned mortality.

However, male fish were not always intentionally squeezed to check for milt, so the number of partially spawned males is likely higher than observed.

Stanislaus River Flows and Temperature

Stanislaus River flows and temperature related to live salmon and redd observations for the period of October 3, 2022, through January 15, 2023, are shown in Figure 17. Daily average river flow and temperature data was taken from the California Data Exchange Center (CDEC) website using the Orange Blossom Bridge (OBB) station. The thermal limit for incubation of 13.3°C was taken from the 2009 NMFS Biological Opinion. Not shown in figure 19; average flows at OBB peaked at 4,275 cfs on 1/1/23 and again at 2,320 cfs on 1/9/23.

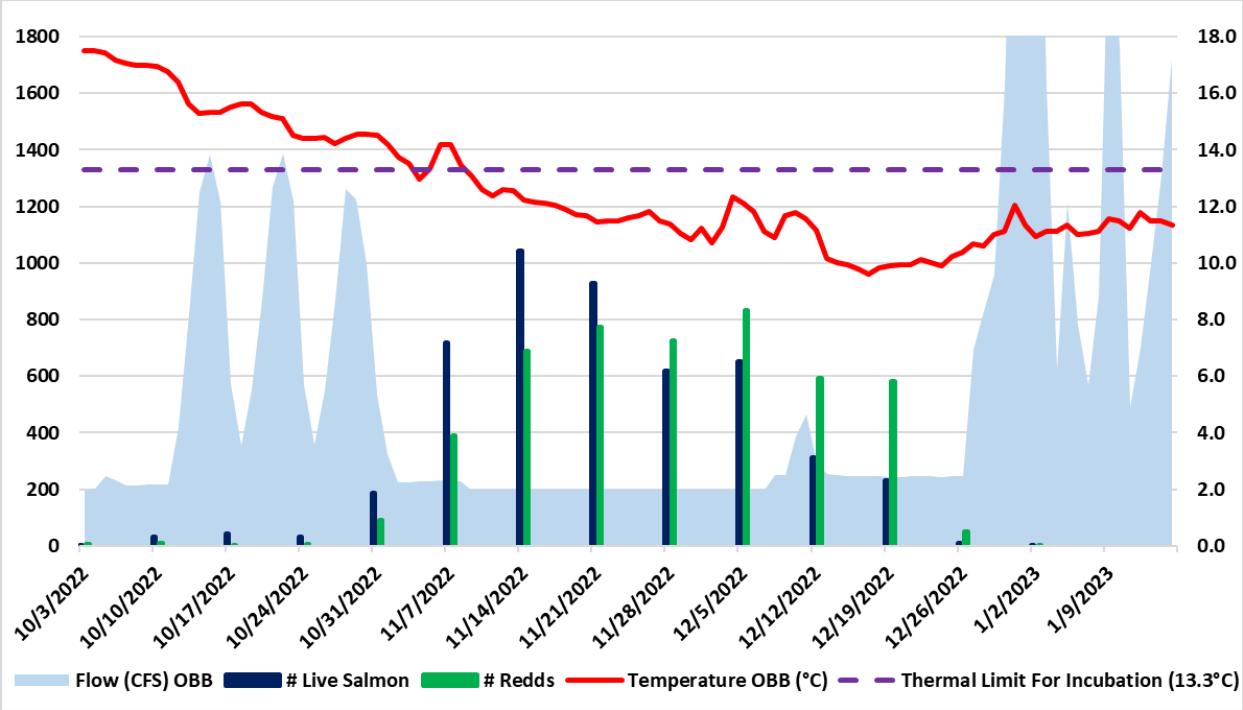


FIGURE 17: WEEKLY LIVE FISH AND REDD COUNTS WITH FLOW AND TEMPERATURE

Trout

Two dead rainbow trout were collected during the 2022 escapement survey. All fish had an adipose fin and successfully had scales, otoliths, and fin clips collected. One fish was male, and one was female. The carcasses also had a heart tissue sample collected at the CDFW La Grange office for further DNA analysis.

Discussion

Escapement Estimate

The 2022 Stanislaus River escapement CJS estimate was 3,646 fish. This was a decrease from 2021 (4,301 fish), but still higher than the 2017-2020 estimates. However, this number may be a conservative estimate due to certain conditions encountered during the survey period. The ability of the crew to effectively count redds, live fish, and collect carcasses was greatly reduced during the fall pulse flow (weeks 3-5) and December/January rain events (weeks 13-15), due to decreased water clarity and drifting faster downstream. During this time, it is likely that counts could be lower than would normally be expected.

Live, Redd, and Carcass Counts

Live, redd and carcass counts are strongly affected by water clarity, available sunlight, wind or rain disturbing the water surface, redd superimposition (when a salmon digs a new redd on top of an old redd), and other factors such as the natural variability between observers. During the fall pulse flow (weeks 3-5) and December/January rain events (weeks 13-15), the turbidity increased and so the ability of the crew to perform accurate counts was reduced. Furthermore, redd counts are conducted with a single pass as opposed to an intensive systematic approach, and so during weeks of high flow counts are likely lower than what might have been expected. River mile 55 is unable to be surveyed due to a lack of access. Section 1 live, redd, and carcass counts are likely to be higher than reported because they are surveyed by foot and many areas are inaccessible.

Fork Length and Sex Distribution

Traditionally, the female distribution is likely a better representation of the population because carcass surveys can be biased towards capturing more female carcasses than male carcasses. This occurs because females typically defend their redd after spawning, and so they die near their redd and wash downstream into slow moving water, while males continue to move around after spawning and will often die in pools with heavy vegetation or along the river margins; making them harder to find (Murdoch, 2010).

In 2022 more female carcasses (57.5%) were captured than male. Based on fork lengths, about a quarter of the male carcasses recovered (27.0%) were deemed to be grilse while very few of the female carcasses (1.7%) were determined to be grilse. Males made up 42.5% of the tagged carcasses, which would indicate that there were likely more males in the 2022 run that were either not captured or were found as skeletons and chopped without being processed.

CWT Analysis

In 2022, 23.6% of the tagged fish had an adipose fin clip indicating the presence of a CWT in the snout of the fish. The majority of the CWT's came from Mokelumne River Hatchery (89.4%), followed by Nimbus Hatchery (4.5%), Merced River Hatchery (1.5%), and Feather River Hatchery (1.5%). The remaining fish were of unknown origin (3.0%) since no tag was found, or the tag was lost, during processing. All CWT fish that had a tag read were from brood years 2018 (1.5%), 2019 (82.3%), and 2020 (13.2%). This is consistent with the scale aging data as these would represent fish that are between two and four years old. It is difficult to say exactly what proportion of the run was produced at hatcheries because hatcheries have only been marking a portion of their fish before releasing them.

Egg Production Estimate

An estimated 11,857,153 eggs were produced during the 2022 run on the Stanislaus River. Water temperatures at Orange Blossom gradually decreased during weeks 1-6 (starting at 17.5°C during week 1 and decreasing to 12.9°C by week 6), before finally holding below 13°C in week 7 for the rest of the survey. Since temperatures were below the thermal limit for incubation (13.3°C) during the peak spawning times, there was not as much concern for egg survival as in some previous drought years.

Pre-Spawn Mortality

Nine females were marked as unspawned (4) or partial spawn (4) mortalities. This is likely a low estimate because some fish may not be obviously full of, or releasing, eggs but still have many eggs present after death. One male was marked as a partial spawn mortality. This is also likely a low estimate because it is difficult to determine if a male has died before spawning since they exhibit fewer external signs of being an unspawned mortality and may not be intentionally squeezed to check for milt during processing. Crews are unable to collect carcasses from two river miles in section one, and so it is possible that some additional unspawned fish could have been missed in that area.

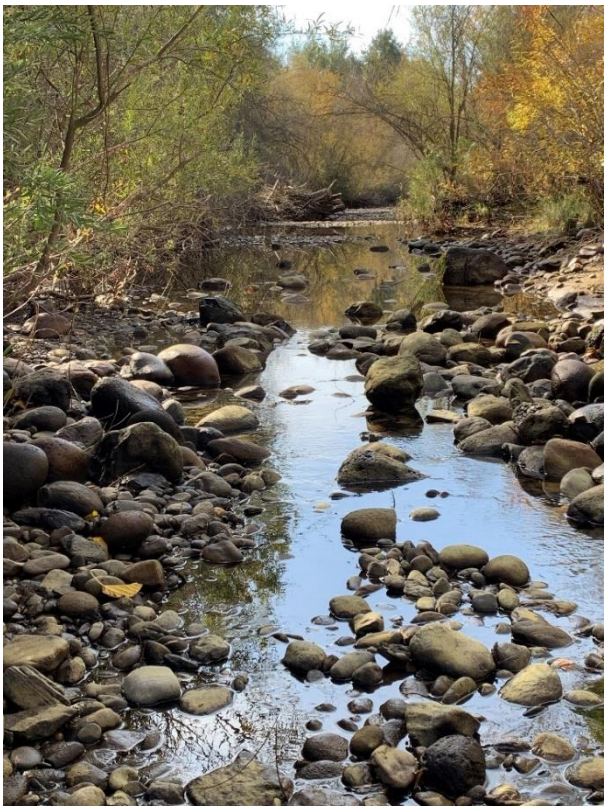
Stanislaus River Flows and Temperature

Stanislaus River water temperatures gradually decreased throughout October before reaching ideal spawning temperatures during the second week of November. High flows can affect water clarity as well as decrease the amount of time it takes to drift through a riffle; making it harder to see live fish, redds, and carcasses. This was not much of a problem in 2022 until the end of December and January, as flows remained around 200 cfs following the fall pulse flow for the peak of the spawning season. The Honolulu Bar side channel (riffle K1S) was not surveyed for most of November and December due to it being dry and disconnected.

Stranding and Redd Dewatering

The Honolulu Bar side channel is a restoration project that was completed in 2012 to provide salmonid spawning and rearing habitat. However, in the years since then, the river and side channel

morphology have changed to the point where the side channel now has the potential to strand fish and dewater redds following the transition from high to base flows. The side channel was once again disconnected in 2022, both before the fall pulse flows, and again afterwards as the river transitioned back to base flow conditions (200 cfs). However, unlike in 2021, adult stranding was not observed in the Honolulu Bar side channel in 2022. Below are images of what the side channel can look like as it disconnects at lower flows.



References

Bergman, J. M., R. M. Nielson, and A. Low. 2011. Central Valley in-river Chinook salmon escapement monitoring plan. Final Contract Product. No. P0685618. California Department of Fish and Game. Sacramento, CA.

Giudice, D. 2016. 2016 Stanislaus River Fall Chinook Salmon Escapement Survey.

"GrandTab 2022.07.20, California Central Valley Chinook Population Database Report." California Department of Fish and Wildlife, 21 June 2023.

Heyne, T. 2000. Annual Performance Report, Federal Aid In Sport Fish Restoration Act. Inland and Anadramous Sport Fish Management and Research. Fish Population Management. Project 26. Job 2. 16pp.

Law, P. M. W. 1994. Simulation study of salmon carcass survey capture-recapture methods. *Calif. Fish and Game* 80(1): 14-28.

Louie, Stephen & Henery, Rene & Rosenfield, Jonathan & Shelton, John & Zimmerman, Julie & Gutierrez, Monica & Ellrott, Brian & Wikert, John & Howard, Jeanette & Heyne, Tim & Weber-Stover, Alison. (2019). Conservation Planning Foundation for Restoring Chinook Salmon (Oncorhynchus Tshawytscha) and O. mykiss in the Stanislaus River.

Loudermilk, W., Neilands, W., Fjelstad, M., Chadwick, C., and Shiba, S. 1990. 1989 Annual Performance Report. Inland and Anadramous Sport Fish Management and Research. Project F-51-R-1. Job 2. 7pp.

Murdoch, A. R., Pearsons, T. N. and Maitland, T. W. (2010), Estimating the Spawning Escapement of Hatchery- and Natural-Origin Spring Chinook Salmon Using Redd and Carcass Data. North American Journal of Fisheries Management, 30: 361-375. doi:10.1577/M09-071.1

NMFS 2009. 2009 NMFS Final Biological and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project (pp. 1-844, Rep.). Long Beach, CA: NMFS Southwest Region.

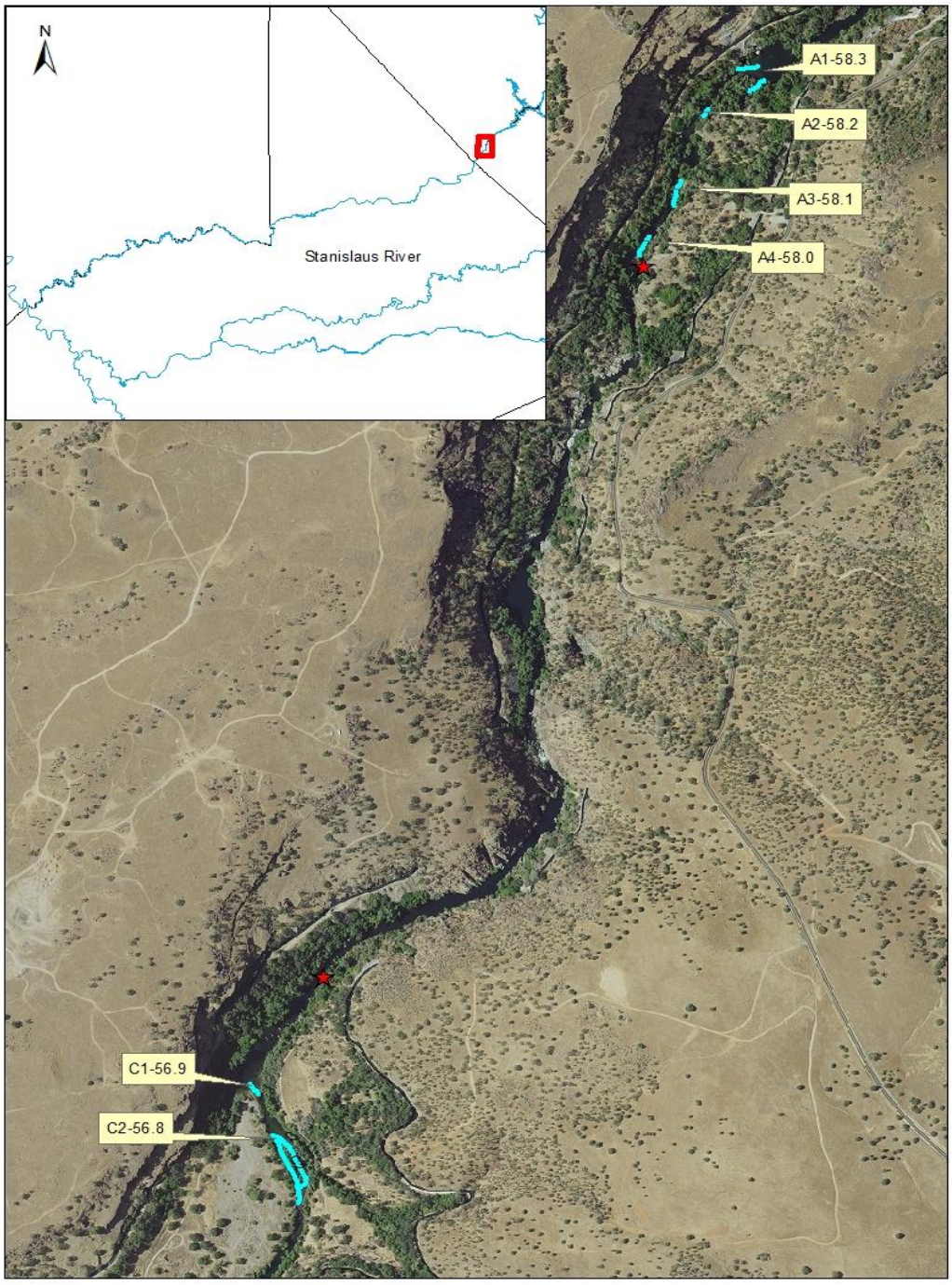
NMFS. "Species of Concern: Chinook Salmon Central Valley Fall/Late-Fall Run ESU." NOAA National Marine Fisheries Service, 16 June 2009.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. *Dept. of the Env. Fisheries and Marine Service, Bull.,* 191, 382 pp.

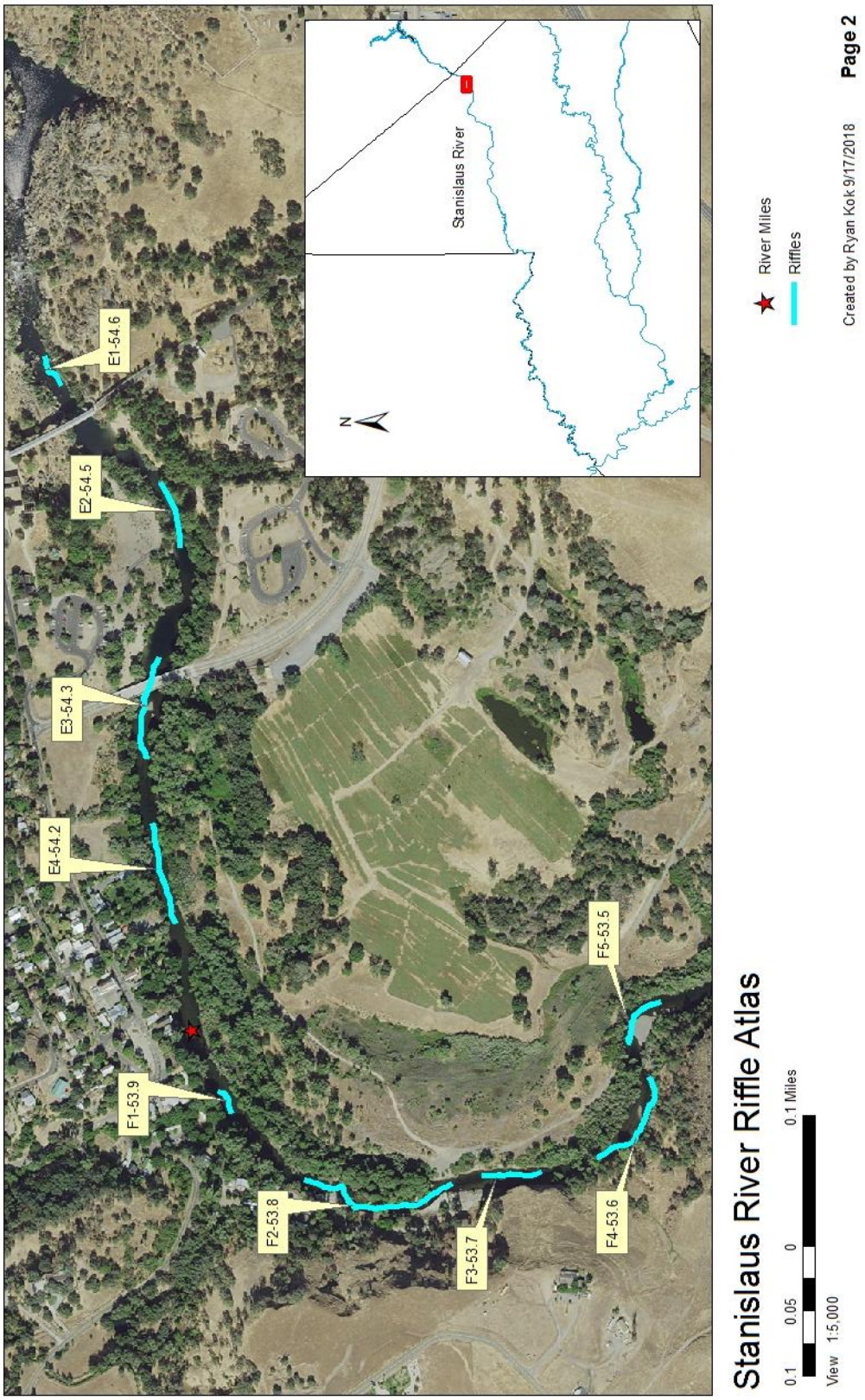
Schwarz, C.J., R.E. Bailey, J.R. Irvine, and F.C. Dalziel. 1993. Estimating salmon spawning escapement using capture-recapture methods. Can. J. Aquat. Sci. 50: 1181-1197.

Appendix 1: Stanislaus River Riffle Maps

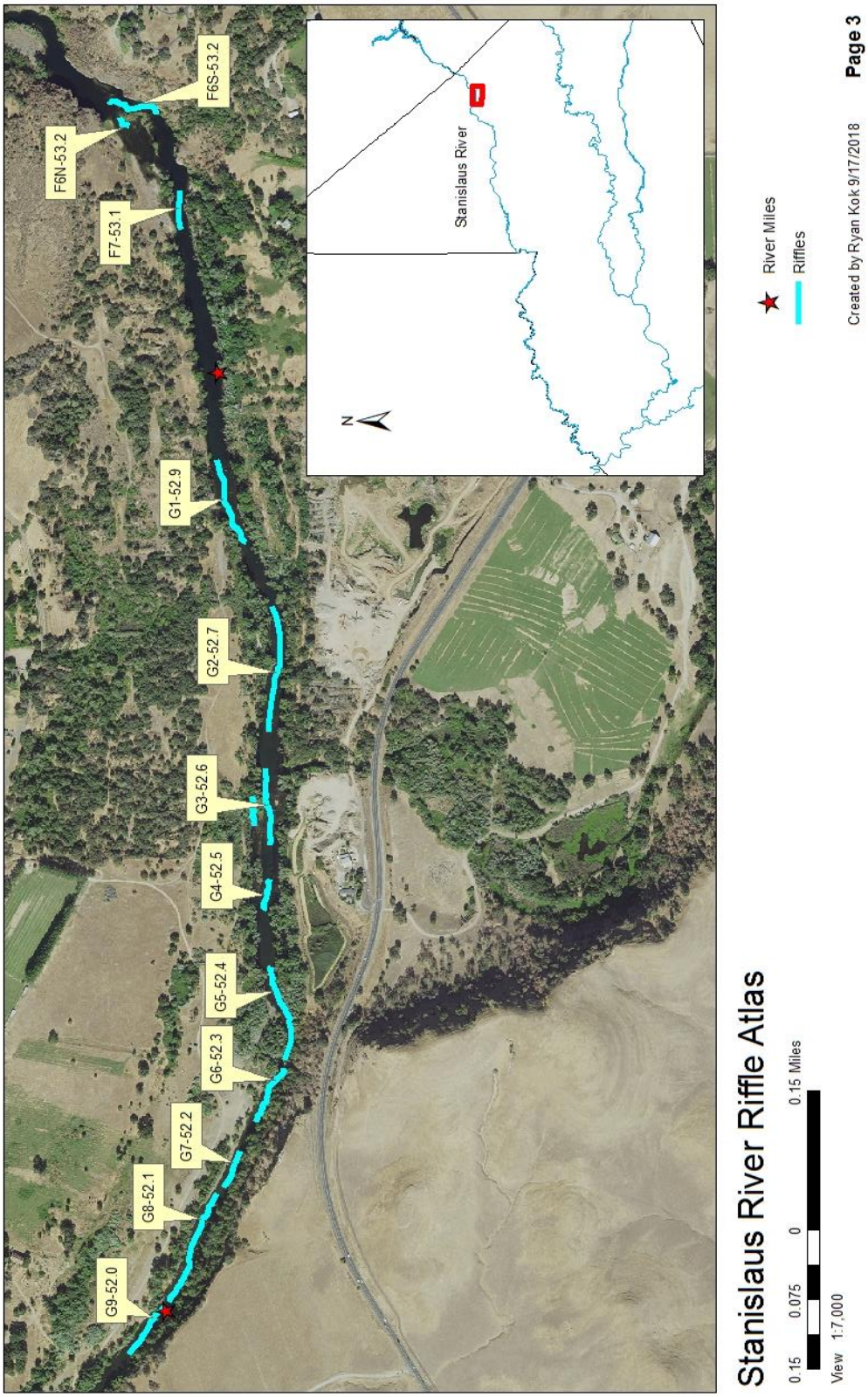
Map 1: Section 1, Riffles A1-C2



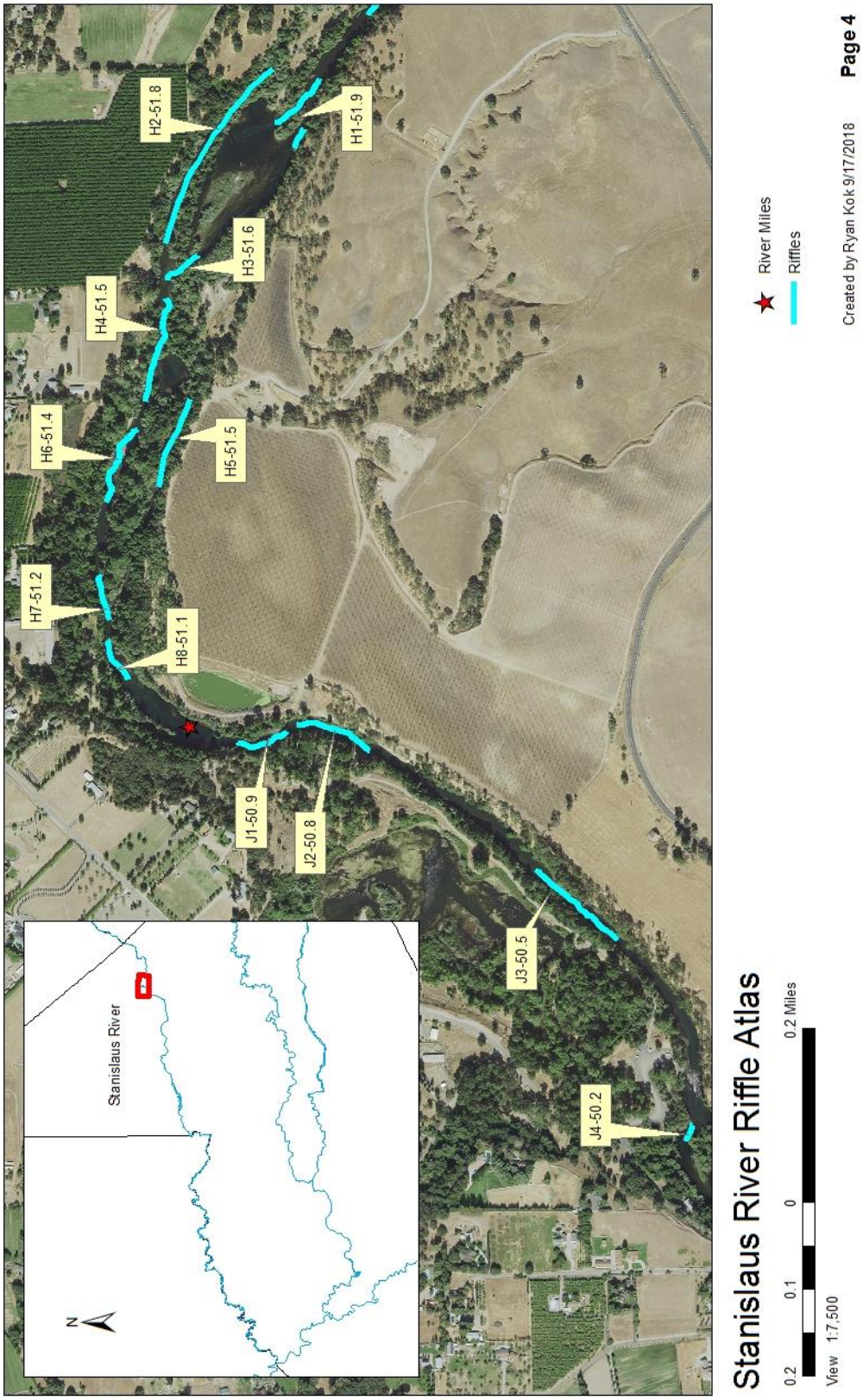
Map 2: Section 2, Riffles E1-F5



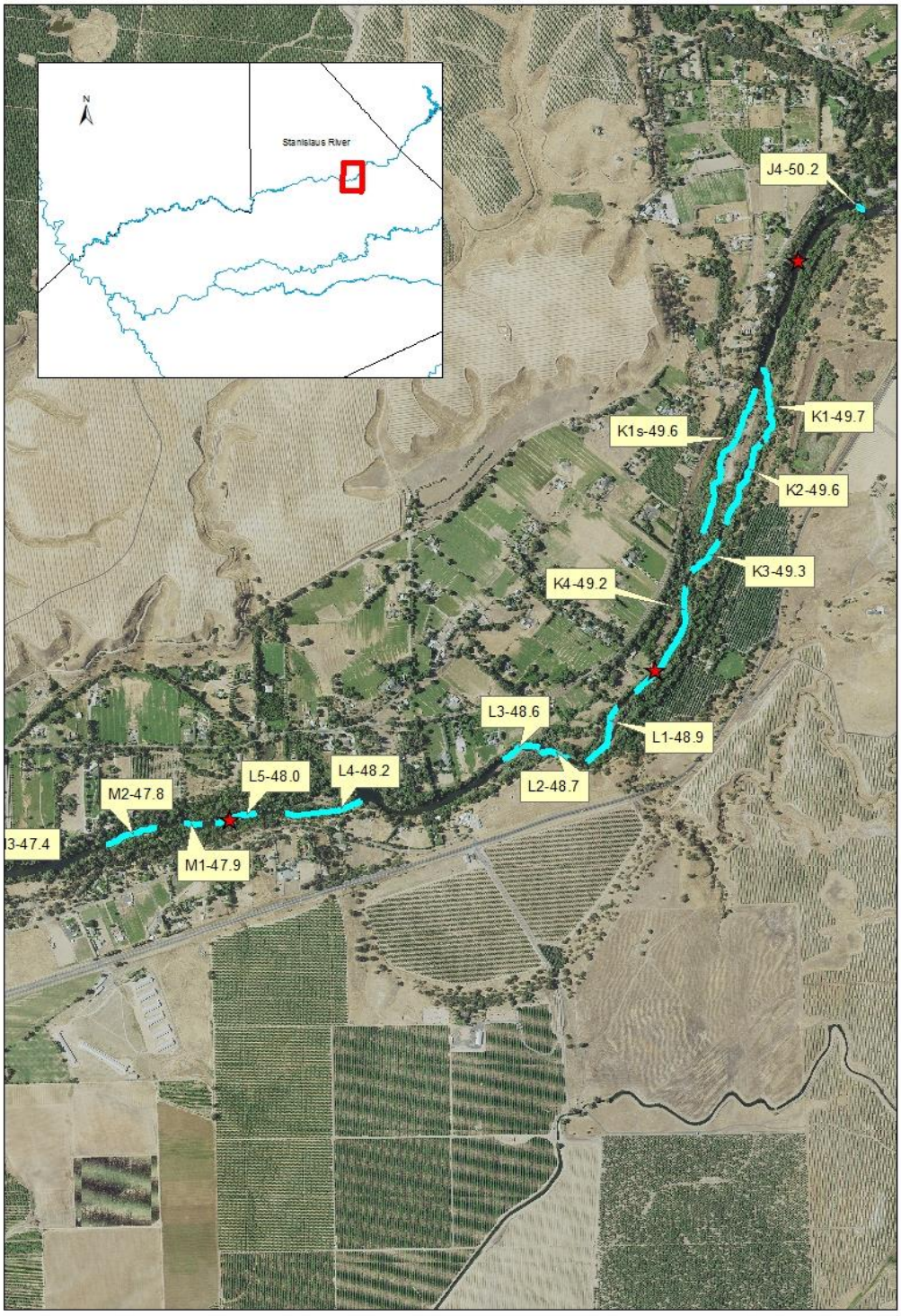
Map 3: Section 2, Riffles F6-G9



Map 4: Section 2, Riffles H1-J3



Map 5: Section 3, Riffles J4-M2



Stanislaus River Riffle Atlas

Created by Ryan Kok 9/17/2018

0.25 0.125 0 0.25 Miles

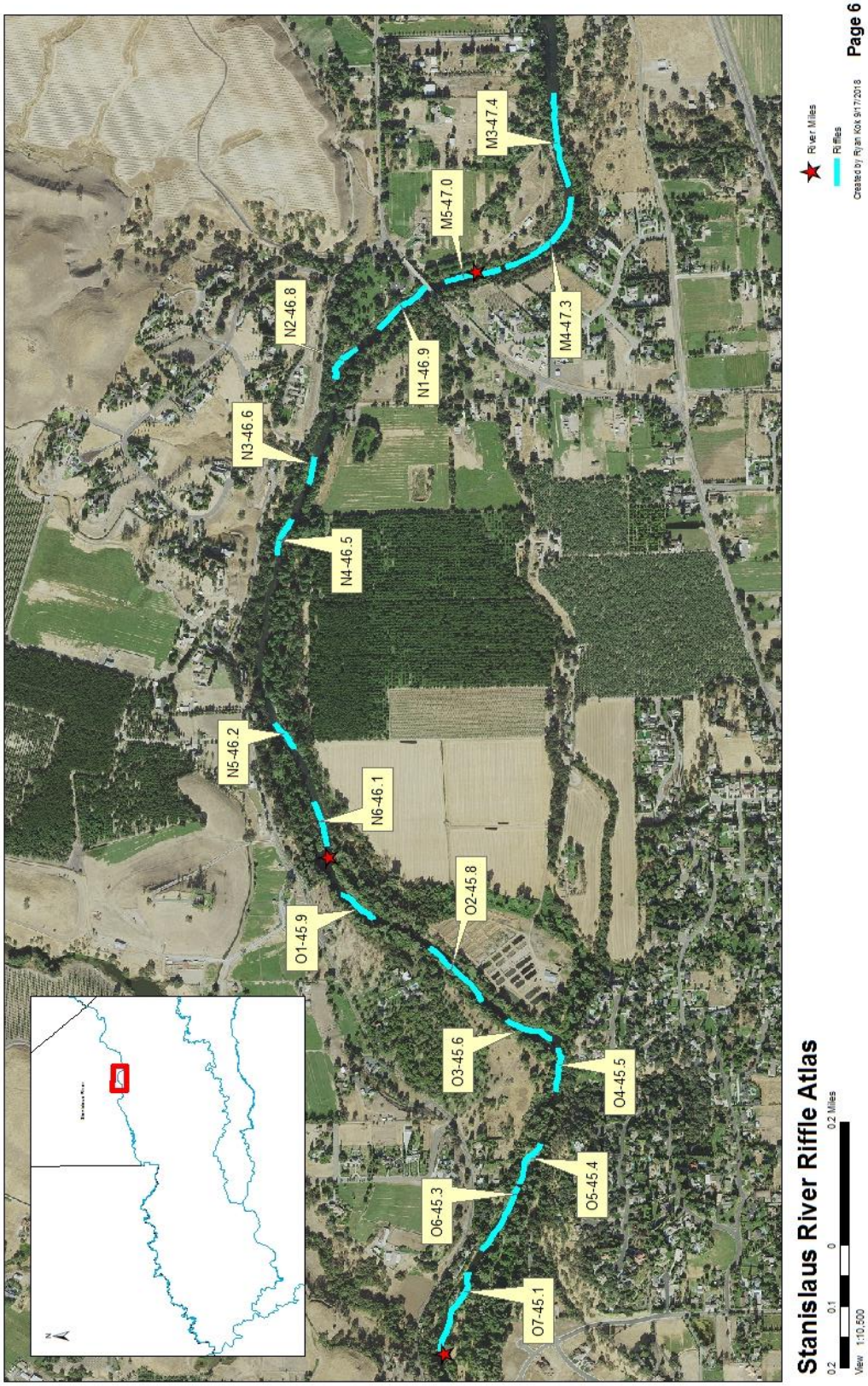
View 1:15,000

River Miles

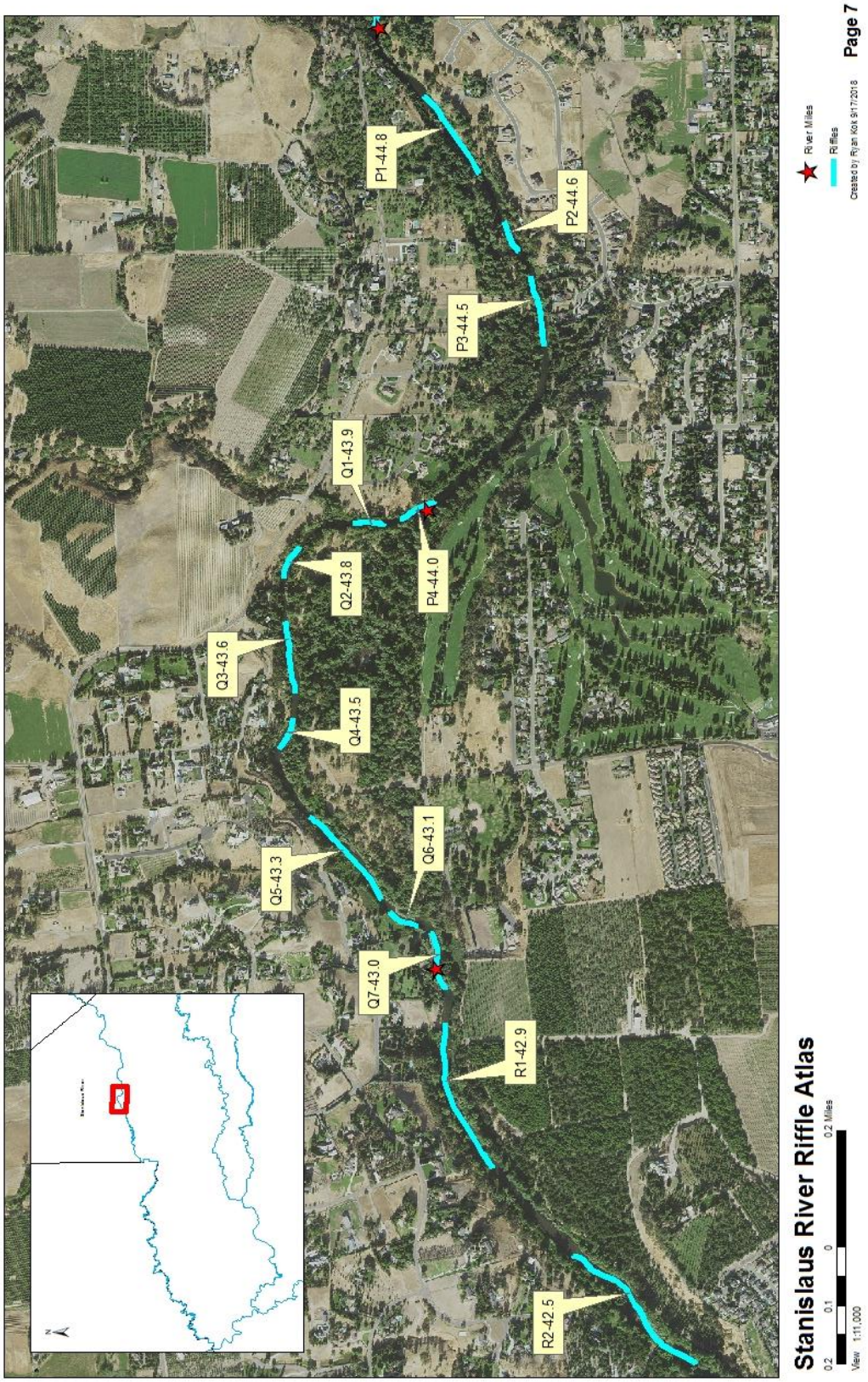
Riffles

Page 5

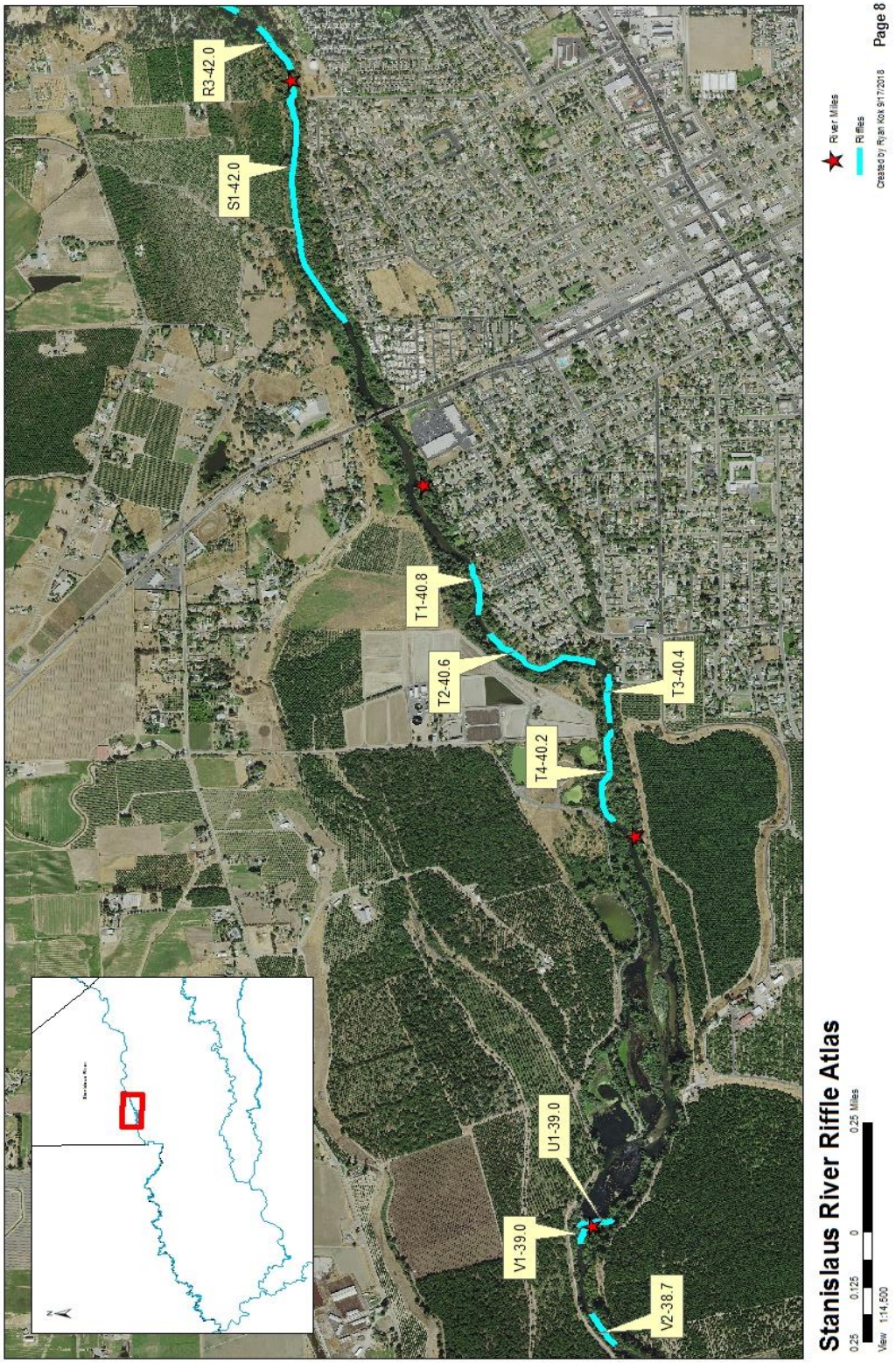
Map 6: Section 3, Riffles M3-O7



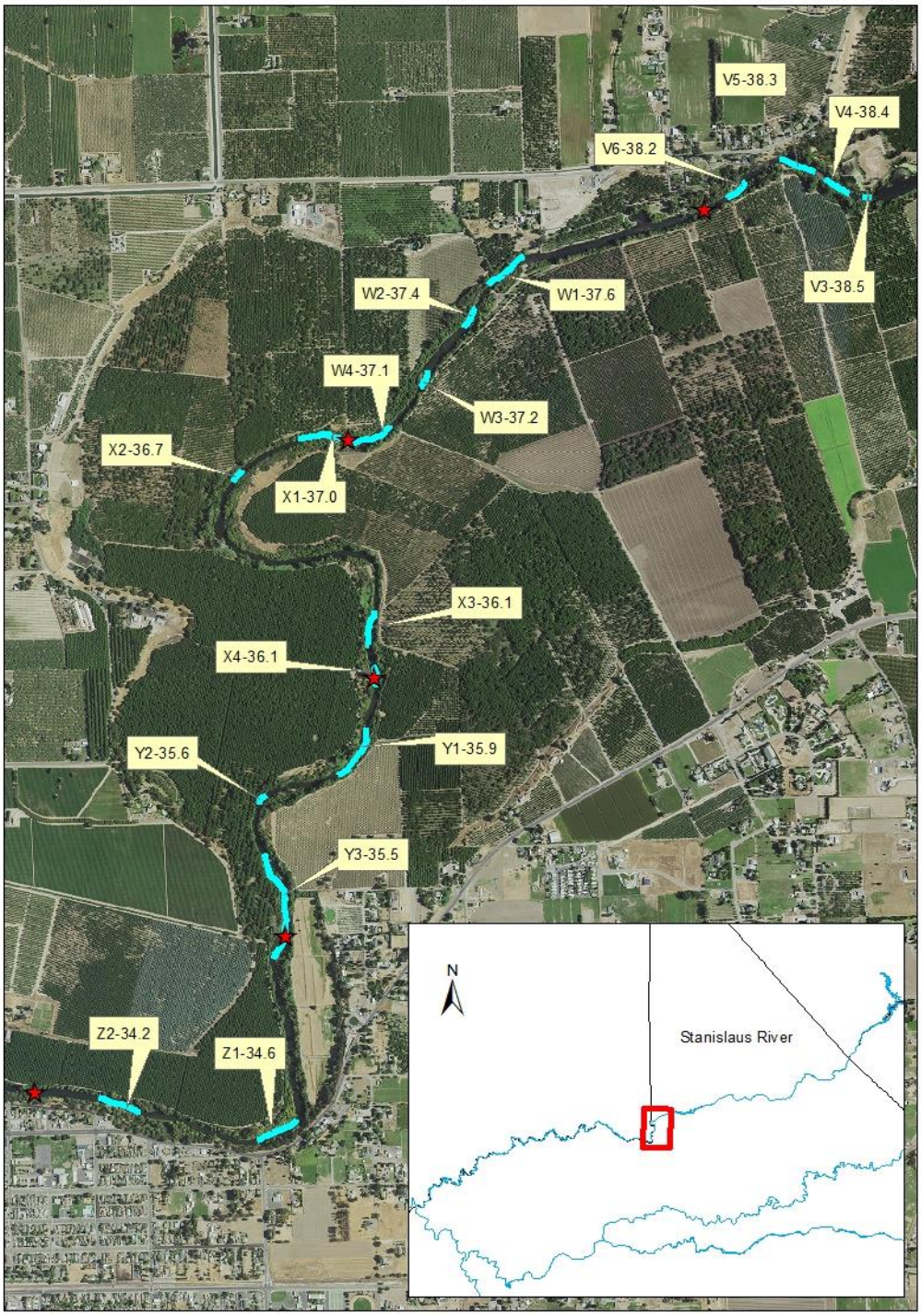
Map 7: Section 3, Riffles P1-R2



Map 8: Section 3, Riffles R3-T4; Section 4, Riffles U1-V2



Map 9: Section 4, Riffles V3-Z2



Stanislaus River Riffle Atlas

River Miles

Riffles

0.45 0.225 0 0.45 Miles

View 1:16,000

Created by Ryan Kok 9/17/2018 **Page 9**