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BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Turlock Irrigation District	)	
	)	
and	)	Project No. 2299
	)	
Modesto Irrigation District	)	

2007 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2007-1

2007 Spawning Survey Report (Draft)

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INTRODUCTION

The San Joaquin fall-run Chinook salmon is currently a species of concern under the Federal and State Endangered Species Acts. Population levels in the Tuolumne River have declined in the latter half of the 20th century from a high of approximately 130,000 returning adults in 1944 (Fry 1961) to a low of 77 in 1991 (Neillands et al. 1993). Population levels increased to 17,873 in 2000 (Vasques 2001) indicating a slight recovery period, and are once again declining with estimates of 724 in 2005 (Blakeman 2006) and just 625 in 2006 (Blakeman 2007), with this years estimate continuing this trend. The decline of the species is believed to be caused by many factors. In general, reduction of spawning and rearing habitat and stream flow management practices are thought to be the major factors limiting overall population numbers. Numerous additional factors including but not limited to predation, streambed alteration, water diversion, gravel mining, land use practices, and ocean angler harvest contribute to a web of complex population dynamics which effect population numbers within the habitat currently available to Tuolumne River Chinook salmon.

The California Department of Fish and Game (CDFG) has reported salmon population estimates on the Tuolumne River since 1940 (Fry 1961). The Schaefer mark recapture escapement estimation model (Schaefer 1951) has been utilized since 1971. The 2007 escapement survey uses the adjusted Peterson method. Beginning in 1992, CDFG escapement surveys have been utilized as part of the New Don Pedro FERC Project No. 2299 license monitoring program and annual reporting.

The primary objectives of the Tuolumne River escapement survey are to:

- Estimate the escapement of fall run Chinook salmon on the Tuolumne River.
- Collect fork length and sex data.
- Collect scale and otolith samples with which to conduct age determination analysis and subsequent cohort analysis.
- Collect and analyze coded wire tag data from adipose fin clipped fish.
- Evaluate the distribution of salmon redds through the study area.

STUDY AREA

Approximately 26.5 river miles were surveyed during the Tuolumne River escapement survey in 2007 (Figure 1). The survey area was divided into 4 sections with Section 1 being the upstream most reach. Section 1, also referred to as the primary spawning reach, extends from riffle A1 at river mile 52.0 near La Grange Dam downstream to Basso Bridge at river mile 47.5. Section 2 extends from Basso Bridge down to the Turlock Lake State Recreation Area (TLSRA) at river mile 41.9. Section 3 covers the area between TLSRA and riffle S1 at river mile 34. Section 4 extends downstream to Fox Grove (river mile 26). Figure 1 also includes a section 5, which was not surveyed, that extends downstream of Fox Grove to RM 24.1.

All riffles in the study area have been identified and mapped using a Trimble GPS unit and the GIS computer program ArcView. Each riffle has been systematically re-named upstream to downstream using sequential letter/number designations for river mile and riffle number, respectively. For example, the first riffle surveyed below La Grange Dam in the first river mile (51) is named A1. The riffle immediately below La Grange Dam (riffle A1) is surveyed by foot and only redd and live fish counts are made. This numbering system is a departure from the historical riffle numbering system. However, the new riffle identification system is more conducive to editing and tracking riffles as river morphology changes. Changes in riffle locations which may occur during high flow periods will affect riffle names only within that river mile. There were no changes in riffle names from 2006 to 2007 (Table 1).

METHODS

Population Estimation

CDFG has used the Schaefer (1951) model to estimated escapement since 1971. In 2007 capture, mark and recapture numbers were too low to use the Schaefer (1951) model to estimate escapement. The 2007 estimate was calculated using the adjusted Peterson method.

Adjusted Peterson equation:

$$N = \frac{(M+1)(C+1)}{(R+1)}$$

Where:

N= population estimate,
M= number of carcasses marked,
C= catch (all skeletons and tagged fish),
R= number of recaptures

The adjusted Peterson method utilizes marked, subsequently recovered carcasses and skeletons to estimate the escapement population. The CDFG began the survey on 2 October 2007 (Week 1) and concluded on 28 December 2007 (Week 13). Carcasses were tagged for the first 11 weeks. The last two weeks were recovery weeks only, live and redd counts were made. Two fish were tagged in the last week but were not used in the analysis. These last two tagged fish were only used for sample collections (scales and otoliths).

All carcasses encountered were handled during weekly drift boat surveys of the study area. Carcasses were gaffed as the sampling crew drifted past and held in the boat until the end of the riffle and adjacent downstream pool. Subsequent to drifting the riffle and downstream pool the riverbanks were walked to collect carcasses that could not be seen or collected from the drift boat. 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 criteria used was at least one clear eye (Figure 2). Decayed fish had cloudy eyes. Skeletons were carcasses judged to be in an advanced state of decay and unlikely to have the same probability of recapture as fresh or decayed specimens (Figure 3 and 4).

All fresh and decayed carcasses were given a unique number by attaching a numbered aluminum tag to the lower jaw. These newly tagged carcasses were redistributed to river current near the lower end of the riffle for recovery in subsequent weeks. For tag recoveries, the unique tag number and riffle location was noted and the carcass was chopped and returned to the river. All skeletons were enumerated and chopped to avoid double counting and returned to the river.

Weekly Fish Distribution and Redd Counts

Weekly live fish observation and redd counts were conducted during the survey (Table 2, Figure 5). These counts are conducted for each riffle and pool using the riffle identification system noted earlier. Counts are made using tally counters as field crews drifted through riffles and pools. For consistency the same observer was used each week to make live fish and redd counts.

Individual Fish Data Collection

Fork length (to the nearest 1 centimeter), sex and condition (fresh or decayed) data were recorded for all tagged carcasses. Carcasses that were too decayed were counted and recorded as skeletons. Scale and otolith samples were collected to determine the size and age composition of annual spawning runs. Coded wire tags (CWTs) are collected from marked (adipose fin clipped) carcasses to monitor hatchery production and as part of long term survival evaluation of marked outmigrating smolts. This also allows for determining the incidence of straying from other river systems. CWT specimens are also used to validate scale and otolith age determination work. Scale and otolith samples were collected from both wild and CWT carcasses and are catalogued at the CDFG La Grange Field Office. CWTs samples are collected via removal of the head minus the lower jaw. Otolith samples were collected by dissecting the head of tagged fish. Analysis of otoliths and CWTs from these heads is conducted after the spawning season. All fish samples are catalogued by the fish's unique jaw tag number, which allows the samples to be tracked to the specific data and riffle number where collected.

RESULTS

Population Estimate

Based on the adjusted Peterson model the 2007 escapement estimate was **211 salmon**. The Adjusted Peterson model utilizes the number of recoveries of tagged carcasses, the total number of tagged fish, and the total number of carcasses handled to generate an escapement estimate (Table 3). Overall tag recovery rate was 42.9%. Week 13 live fish count was added to the Adjusted Peterson to account for them not being available for capture.

Weekly Counts

Both live fish and redd counts slowly increased through week 8 then steadily declined through the end of the survey (Table 2, Figure 5). Carcass counts slowly increased through week 9 then decreased through the end of the survey.

Spawning Distribution

The maximum redd count represents counts made when external factors like visibility and turbidity were at optimum conditions. The maximum redd counts for each riffle over the course of the season is listed in Table 4. During the 2007 survey the maximum redd count in any one riffle was 99, 28, 29, and 5 for sections 1 through 4 respectively (Figure 6). The results of total weekly redd counts indicate that the majority (greater than 61%) of spawning activity is concentrated in the riffles of Section 1 (Figure 7). Sections 1 and 3 combined saw nearly 78% of redds in 2007.

Population Composition

There were no CWT fish encountered during the 2007 Tuolumne River escapement survey. Females made up 37.8 % of spawning salmon. Fork length frequencies were combined from the entire San

Joaquin basin to determine the breakpoint between adult and grilse. The breakpoint was determined to be 66cm for all fish. Length frequencies of all fish tagged on the Tuolumne River are presented in Figure 8.

Sample Collection

Scale and otolith samples were collected from all tagged fish. Distribution of samples taken is presented in Table 5. Scale and otolith samples will be utilized in the CDFG age determination program and for subsequent cohort analysis of San Joaquin River Basin Chinook salmon populations. This data will also be essential for population models being developed as well as ongoing cohort analysis of factors affecting the populations.

Egg Production Estimate

An estimate of egg production by the 2007 fall run Chinook salmon is done using the relationship of fork length to fecundity. The relationship was developed using 48 San Joaquin fall run Chinook females ranging from fork length 62.5 to 94.0 cm (Loudermilk et al. 1990). The estimated egg production was calculated for tagged females (n=14, average FL=81.5) and expanded to the entire estimated female population. Females (all natural) made up 37.8% of the 2007 estimate and produced approximately 540,342 eggs.

Tuolumne River Flows

Tuolumne River daily average flows at the La Grange gauge ranged from approximately 109 to 188 cfs during the 2007 spawning season (Figure 9). No attraction flows were delivered to help attract fish into the Tuolumne River in 2007.

Tuolumne River Temperature

Temperatures in the upper reaches of the Tuolumne River ranged from 8.3 – 14.4 ^{o}C. Temperatures were recorded using onset temperature monitors throughout the spawning season (Figure 10).

DISCUSSION

Population Estimate

The Adjusted Peterson method was used due to very low numbers of retuning adults. Stream flow dynamics affects the likelihood of collecting carcasses in that it effects both how carcasses are distributed in the system and the effectiveness in recovering carcasses by field crews. During the low flow conditions in 2007 it is likely that most if not all carcasses were found by field crews. The banks of riffles were walked in an effort to collect all carcasses that could not be seen or collected during the initial float through the riffle and subsequent pool. The Tuolumne River escapement estimate for 2007 of 211 salmon is the lowest since the 1994 estimate of 513 returning adults.

Weekly Counts

Live fish, redd and carcass counts as illustrated in Figure 5 shows a typical bell curve shape with counts gradually increasing, peaking near mid-spawning season and gradually decreasing when most fish are done spawning. Live fish counts peaked in week 8 with the peak in carcass counts occurring one week later.

Spawning Distribution

Redd counts are affected by time of day, visibility, sunlight, wind rippling the water surface, redd superimposition, and other physical factors as well as the natural variability between observers. The same observer was used each week during the Tuolumne escapement survey to minimize any bias which may occur when using different observers. Furthermore, redd counts are conducted with a single pass as opposed to an intensive systematic approach which is beyond the scope of current funding. The 2007 survey required just two days per week to cover the entire spawning reach. The majority of spawning occurred within the first section. With so few fish returning to spawn there likely was very little (if any) redd superimposition occurring.

Population Composition

There were no CWT fish encountered during the Tuolumne escapement survey in 2007. Skeletons were not checked for adipose fin clips due to their advanced state of decomposition. Females made up 37.8 % of spawning salmon. Grilse composition was entirely made up of males, with 5 (21.7 % of male fish) seen on the Tuolumne, and only 10 seen for entire San Joaquin basin.

Sample Collection

Scales and otolith samples were collected from all fish. Scale and otolith samples were taken over the entire survey and collected throughout the entire survey area (Table 5). Distribution throughout entire spawning reach is intended to best represent the spawning population over time, space and origin. Both otolith and scale samples were collected in the field and are stored at the La Grange field office.

Tuolumne River Flows

Low dissolved oxygen (DO) levels in the San Joaquin River are believed to be a barrier for fall-run salmon migrating up the San Joaquin stem to spawn in the Merced, Tuolumne and Stanislaus Rivers. A fall pulse flow regime was developed to lower river temperatures and elevate dissolved oxygen levels in the San Joaquin River in order to attract salmon and prevent straying. The 2007 escapement season saw low flows and no pulse flow from the Tuolumne River. Spawning activity was delayed until later in the spawning season likely due to the lack of a pulse flow from the Tuolumne River. Redds were not observed until week 4 and peak redd counts were delayed until week 9. With the low flows throughout the entire spawning season survival of the few outmigrating juveniles and smolts will likely suffer as well only compounding the population decline problems.

Tuolumne River Temperatures

Temperatures in the Tuolumne River remained below the thermal limit for successful egg incubation of 13.3 ^{o}C (Myrick and Cech 1998) throughout most of the spawning reach and season. The thermograph placed in riffle K1 remained above the maximum thermal limit (MTL) throughout most all of October, falling below 13.3^{o}C on about 2 November (Figure 11). The thermograph placed at riffle D2 remained below the MTL for the entire spawning season except during the first week of October. As has been seen nearly every year, spawning activity and live count increases very closely relate to the temperature dropping below the 13.3^{o}C which in 2007 occurred in week 6 (5-11 November 2007).

Table 1. Tuolumne River riffle identification cross-reference, 2006 to 2005.

Section 1		Section 2		Section 3		Section 4	
New ID	Old ID	New ID	Old ID	New ID	Old ID	New ID	Old ID
A1	A1	F1	F1	K1	K1	S1	S1
A2	A2	F2	F2	K2	K2	S2	S2
A3	A3	F3	F3	K3	K3	S3	S3
A4	A4	G1	G1	L1	L1	S4	S4
B1	B1	G2	G2	L2	L2	T1	T1
B2	B2	G3	G3	L3	L3	T2	T2
B3	B3	G4	G4	L4	L4	T3	T3
B4	B4	G5	G5	M1	M1	T4	T4
C1	C1	G6	G6	M2	M2	T5	T5
C2	C2	H1	H1	N1	N1	U1	U1
C3	C3	H2	H2	N2	N2	U2	U2
D1	D1	H3	H3	N3	N3	U3	U3
D2	D2	H4	H4	N4	N4	V1	V1
D3	D3	H5	H5	O1	O1	V2	V2
D4	D4	H6	H6	O2	O2	V3	V3
D5	D5	H7	H7	O3	O3	V4	V4
D6	D6	I1	I1	O4	O4	W1	W1
E1	E1	I2	I2	O5	O5	W2	W2
		I3	I3	O6	O6	W3	W3
		I4	I4	O7	O7		
		J1	J1	O8	O8		
		J2	J2	P1	P1		
		J3	J3	P2	P2		
		J4	J4	P3	P3		
		J5	J5	P4	P4		
		J6	J6	P5	P5		
		J7	J7	Q1	Q1		
		J8	J8	Q2	Q2		
				Q3	Q3		
				R1	R1		
				R2	R2		
				R3	R3		

Table 2. Maximum weekly counts of live fish, redds, and skeletons.

Week	Maximum Counts		
	Live	Redds	Skeletons
1	0	0	0
2	0	0	0
3	0	0	0
4	3	1	0
5	7	2	0
6	20	10	1
7	31	16	1
8	34	22	2
9	17	25	9
10	8	21	3
11	9	9	1
12	5	3	3
13	5	3	2
Total	**139**	**112**	**22**

Table 3. Weekly total counts.

Week	Tagged	Recovered	Carcasses[1]
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
6	2	0	4
7	8	0	13
8	10	4	14
9	6	3	21
10	6	3	15
11	3	3	8
12	0	1	7
13	2	1	5
Total	**37**	**15**	**87**

[1]Carcasses includes all tagged carcasses and skeletons but does not include recoveries.

Table 4. Maximum redd count for each riffle over the course of the escapement survey by section.

Section 1		Section 2		Section 3		Section 4	
Riffle	Maximum Redd Count	Riffle	Maximum Redd Count	Riffle	Maximum Redd Count	Riffle	Maximum Redd Count
A1	4	F1	4	K1	0	S1	0
A2	2	F2	1	K2	5	S2	0
A3	2	F3	3	K3	1	S3	0
A4	0	G1	2	L1	3	S4	2
B1	25	G2	1	L2	0	T1	0
B2	16	G3	3	L3	0	T2	2
B3	2	G4	3	L4	0	T3	0
B4	3	G5	1	M1	0	T4	0
C1	5	G6	1	M2	1	T5	0
C2	16	H1	3	N1	2	U1	0
C3	13	H2	0	N2	5	U2	0
D1	3	H3	0	N3	0	U3	0
D2	9	H4	2	N4	4	V1	0
D3	1	H5	0	O1	0	V2	0
D4	4	H6	1	O2	0	V3	0
D5	2	H7	6	O3	0	V4	0
D6	2	I1	0	O4	0	W1	0
E1	3	I2	1	O5	0	W2	0
		I3	1	O6	1	W3	0
		I4	0	O7	0		
		J1	0	O8	6		
		J2	0	P1	0		
		J3	0	P2	0		
		J4	0	P3	1		
		J5	5	P4	1		
		J6	1	P5	0		
		J7	3	Q1	2		
		J8	2	Q2	2		
				Q3	0		
				R1	0		
				R2	0		
				R3	0		
Sub Total	112		44		34		4
Total	194						

Table 5. Distribution of scale and otolith samples collected by section and week for all fish.

Week	Section				Weekly Totals
	1	2	3	4	
1	0	0	0	0	**0**
2	0	0	0	0	**0**
3	0	0	0	0	**0**
4	0	0	0	0	**0**
5	0	0	0	0	**0**
6	2	0	0	0	**2**
7	8	0	0	0	**8**
8	9	1	0	0	**10**
9	5	1	0	0	**6**
10	4	0	1	1	**6**
11	2	1	0	0	**3**
12	0	0	0	0	**0**
13	1	0	1	0	**2**
Total	**31**	**3**	**2**	**1**	**37**

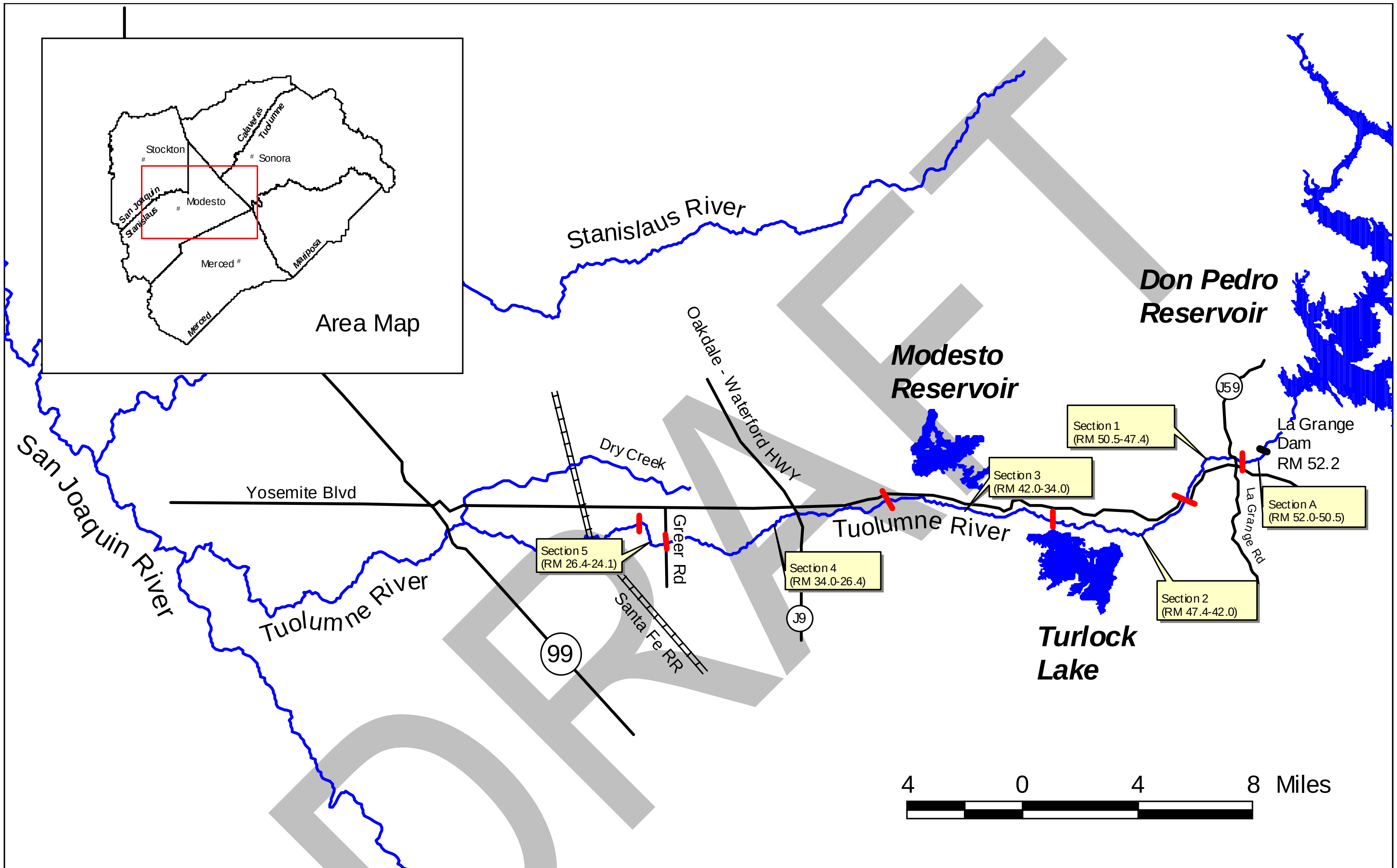

Figure 1. Salmon survey study areas, lower Tuolumne River.

California Department of Fish & Game

Prepared by: Gerald Hatler 01/18/2000

Figure 2. Fresh carcass indicated by clear eye.

Figure 3. Fungus covered skeleton.

Figure 4. Two skeletons showing varied degrees of decomposition and a fresh carcass.

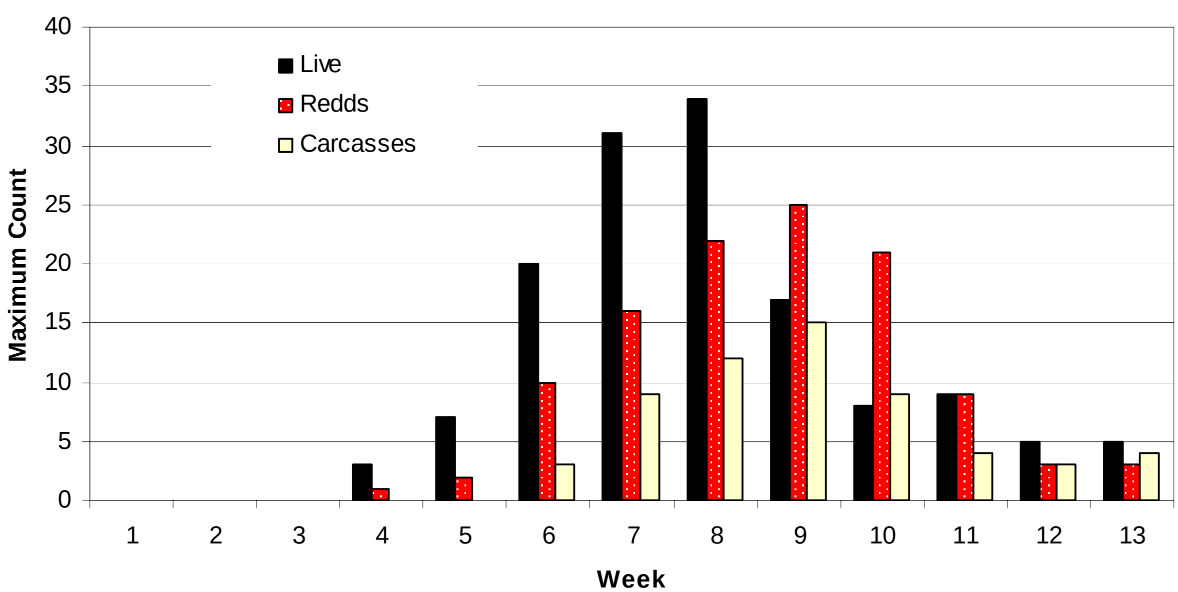

Figure 5. Live fish and redd maximum weekly counts and total carcass weekly counts. Carcasses include all tagged carcasses and skeletons.

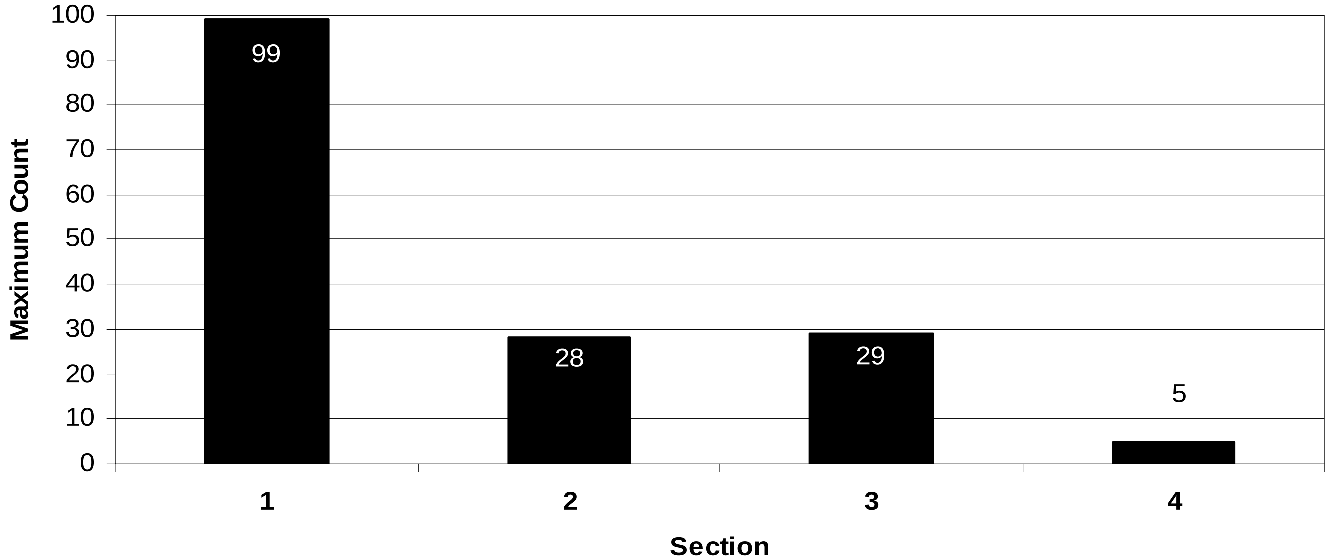

Figure 6. Maximum number of redds counted per section.

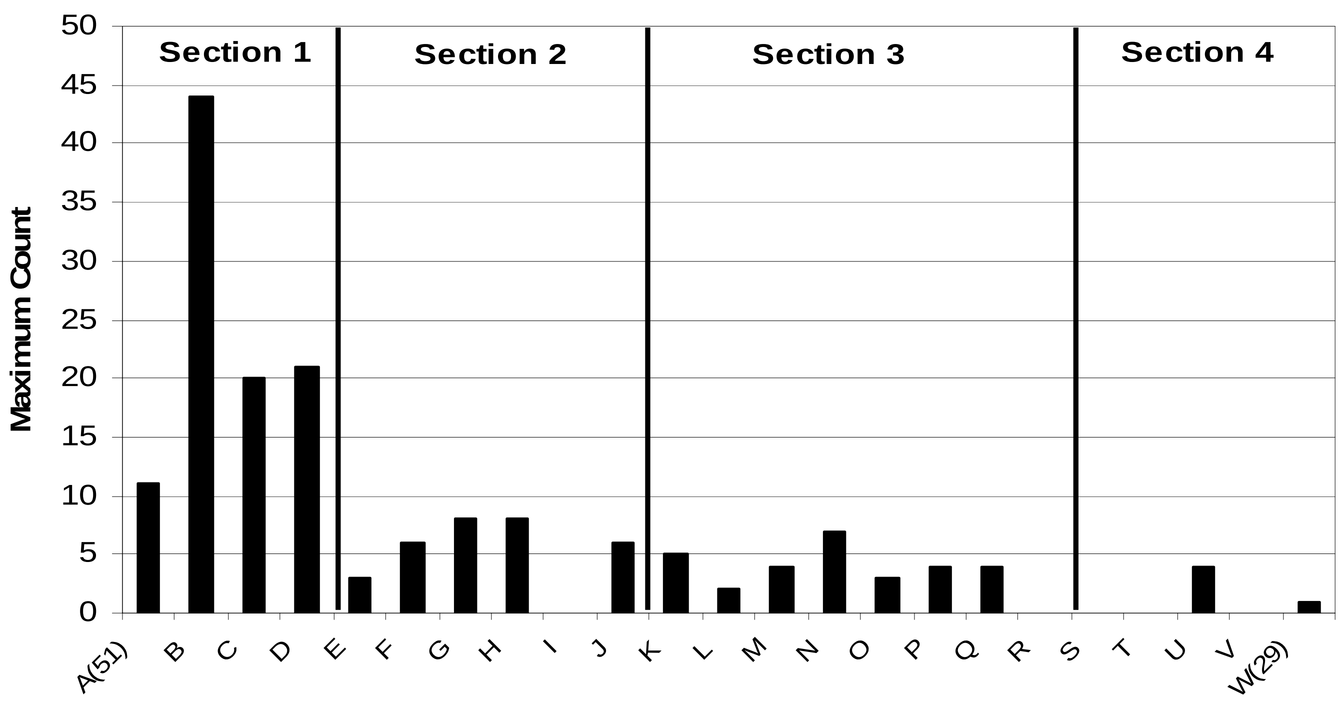

Figure 7. Maximum redds observed by riffle and section. Each letter represents one river mile. Actual river miles are in parenthesis.

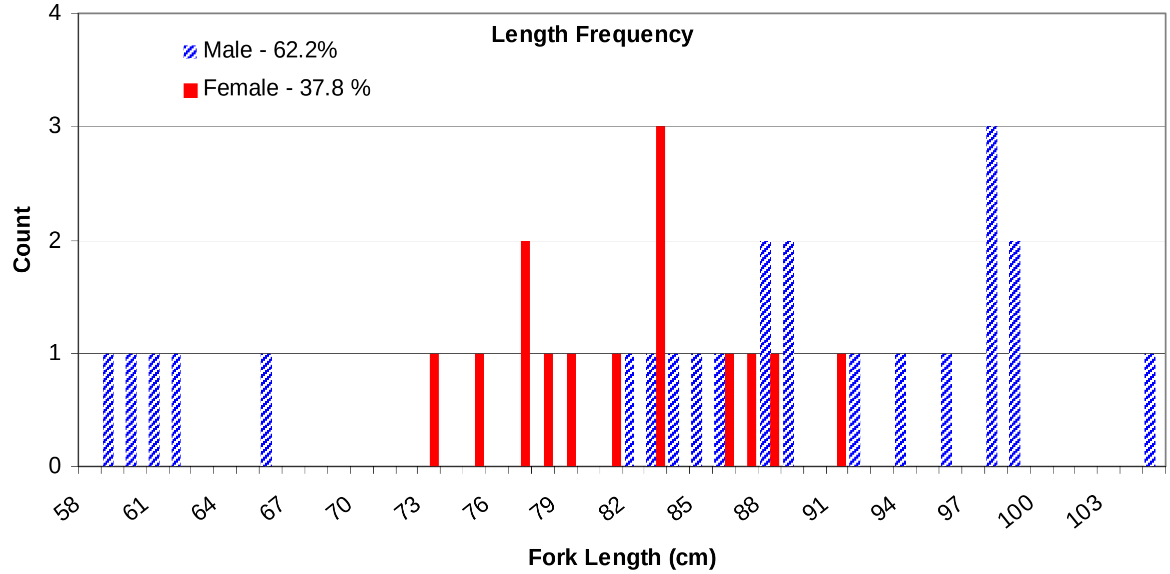

Figure 8. Length frequency histogram of female and male Chinook.

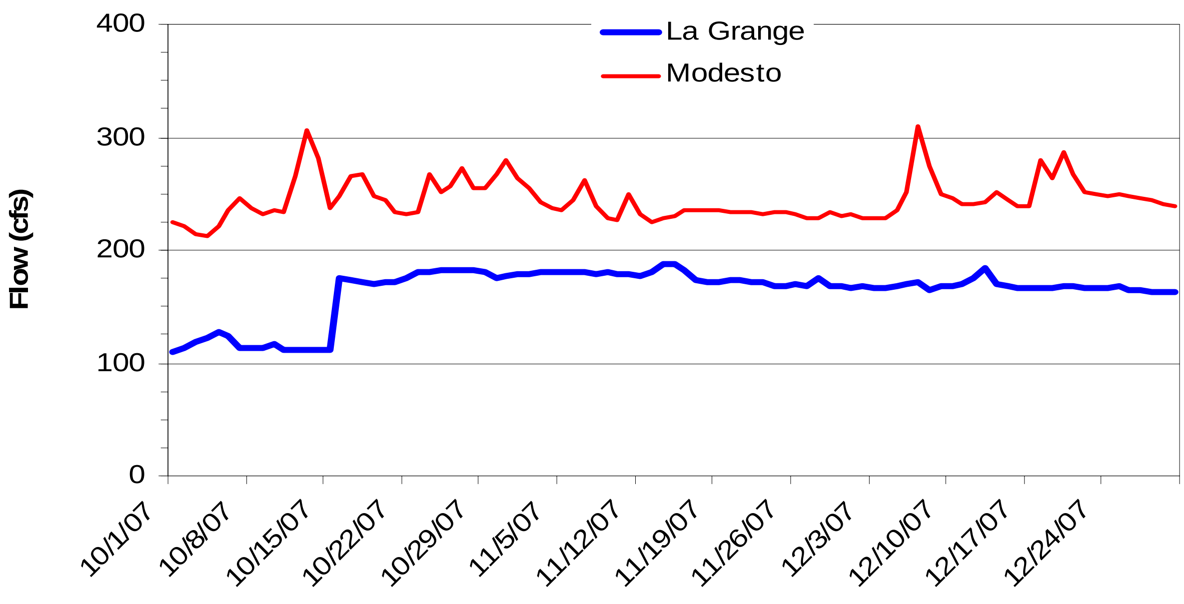

Figure 9. Average daily flow in the Tuolumne River (cubic feet per second) at the Modesto, and La Grange gauges. Preliminary data obtained from California Data Exchange Center (CDEC) website.

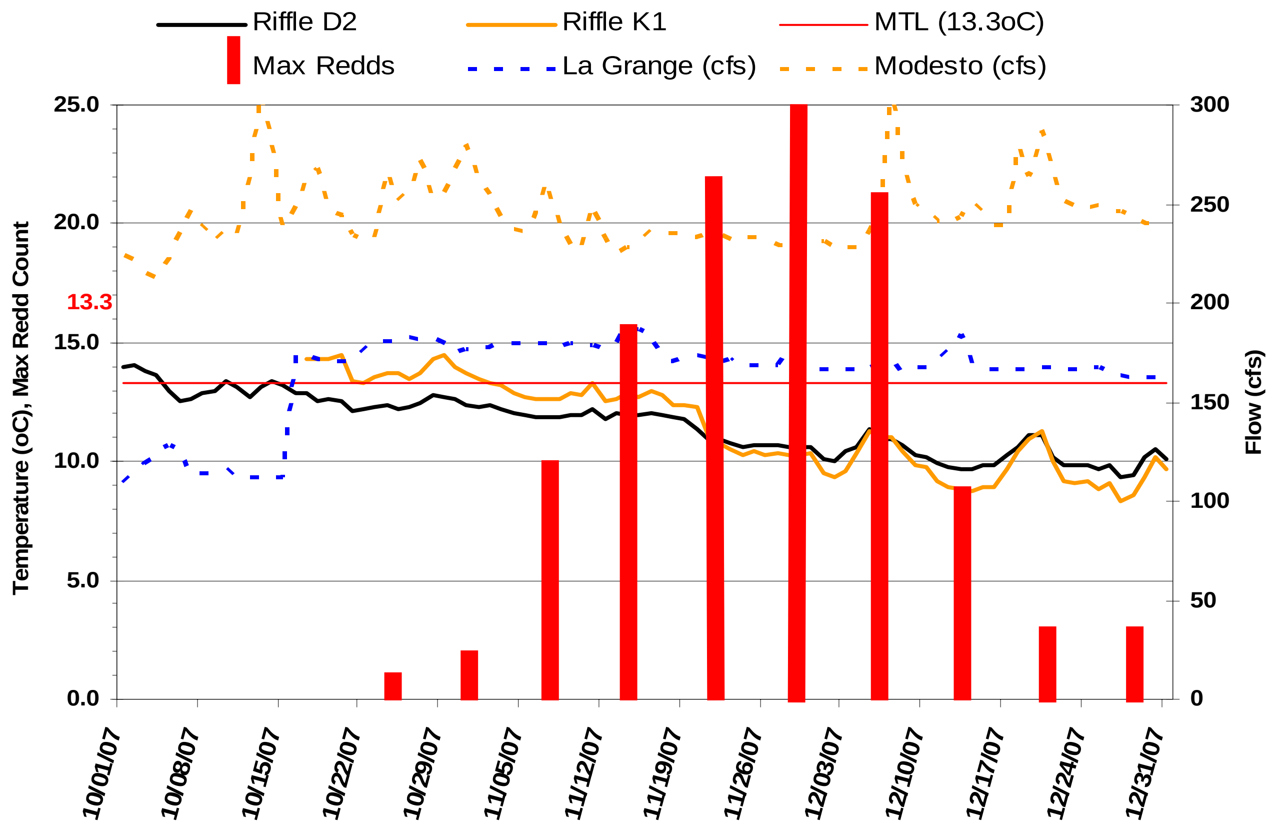

Figure 10. Weekly maximum redd counts for the Tuolumne River escapement survey. Flow (cfs) at La Grange and Modesto gages, temperatures from CDFG monitoring sites and maximum thermal limit.

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