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BEFORE THE
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Project No. 2299

2007 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2007-1

2007 Spawning Survey Report (Draft)

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2007 Tuolumne River Fall Chinook Salmon Escapement Survey

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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 estimate 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 ºC. 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 °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°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°C which in 2007 occurred in week 6 (5-11 November 2007).
Table 1. Tuolumne River riffle identification cross-reference, 2006 to 2005.

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

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<tr>
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Table 3. Weekly total counts.

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¹Carcasses includes all tagged carcasses and skeletons but does not include recoveries.
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<td><strong>Riffle</strong></td>
<td><strong>Maximum Redd Count</strong></td>
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<td><strong>Total</strong></td>
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Table 5. Distribution of scale and otolith samples collected by section and week for all fish.

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<th>Weekly Totals</th>
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<tr>
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Figure 1. Salmon survey study areas, lower Tuolumne River.
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 reds 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.
References


