LOWER MOKELUMNE RIVER
Fall-run Chinook Salmon Escapement Report
October 2007 through January 2008

April 2008

Michelle L. Workman
Edward T. Rible
Jason L. Shillam
East Bay Municipal Utility District, 1 Winemasters Way, Lodi, CA 95240

Key words: lower Mokelumne River, fall-run Chinook salmon, escapement, carcass survey

---

Abstract

A mark-recapture carcass survey was conducted from October 2007 through January 2008 to estimate the fall-run Chinook salmon population in the lower Mokelumne River. The estimate based on 135 tagged wild carcasses and 400 injected hatchery carcasses was 470 in-river spawners (+/- 72). The Mokelumne River Fish Hatchery's (MRFH) count of hatchery spawners was 1,051. Total Mokelumne River escapement was estimated at 1,521 (+/- 72). The river spawning population was composed of 98% adults and 2% grilse. The grilse component was 100% female. The adult component, as well as total escapement (adult and grilse), was 42% male and 58% female. Ninety-seven percent of females were completely spawned out, while 1.5% were completely unspawned and 1.5% were partially spawned out. Most carcasses were observed upstream of the Highway 88 bridge and were decayed on initial observation.

Introduction

East Bay Municipal Utility District (EBMUD) has been monitoring adult fall-run Chinook salmon, *Oncorhynchus tshawytscha*, escapement in the lower Mokelumne River (LMR) using video monitoring and trapping at the Woodbridge Irrigation District (WID) Dam at Rkm 64 since fall 1990. The reconstruction of WID's dam, fish ladders and fish screening facilities on the lower Mokelumne River indicated that video monitoring may not be feasible during all construction and operation phases so an alternative method of salmonid escapement estimation would be needed. Carcass estimates were deemed an appropriate surrogate for video monitoring based on two years of comparative data (Workman 2004, 2005). In 2007/08 the lower Mokelumne River fall-run Chinook salmon escapement was estimated by conducting carcass surveys for in-river escapement and adding the salmon trapped at the Mokelumne River Fish Hatchery (MRFH) for a total Mokelumne River fall-run Chinook salmon escapement.

Objectives

The objectives of this report are to:

1) Provide an escapement estimate for fall-run Chinook salmon for the lower Mokelumne River for 2007/08.

2) Summarize sex and age composition, timing, spatial distribution, prespawn mortality rates, and the coded wire tagged (CWT) component of the river spawning portion of the 2007/08 fall-run Chinook salmon population on the lower Mokelumne River.

Methods

Survey Methods

Carcass surveys were conducted twice weekly from the fourth week in October 2007 through the first week of January 2008. Each week, three people surveyed from the base of Camanche Dam to approximately two and one half river miles upstream of Elliott Road. This distance encompasses three sections of river designated as Reaches 6a, 6b, and 5 (Figure 1). One day was sufficient to cover the entire survey area each week. Split channels were surveyed with one person walking one channel and two surveyors in the boat drifting the other channel looking for carcasses. The river channel and banks were scanned for carcasses.

A fish guidance fence, installed on October 1st each year to block fish access to the powerhouse afterbay of Camanche Dam, marked the beginning of the survey area. The crew walked out on the fence to scan for carcasses above and below. Any carcasses encountered above the fence were marked and released below the fence. The remainder of the river was surveyed from boat or by foot. Surveys were conducted by drifting in the boat until a carcass was encountered. All observed carcasses were collected with a gaff, and then observed for condition (decayed, fresh, skeleton), sex, fork length, and the presence of any clip, tag or mark. Females were checked for spawning condition (completely spawned out, partially spawned out, or unspawned).

Carcasses were given a condition classification of “fresh” (F), “decayed” (D), or “skeleton” (S). Fish with clear eyes and blood remaining in the gills were recorded as fresh, while fish with cloudy eyes and no blood in the gills were designated as decayed. Only fresh or decayed carcasses were tagged. Skeletons were fish that were in an advanced state of decay (i.e. covered entirely or nearly entirely with fungus, falling apart, lacking substantial flesh on the bones) (Marston et al 2002). Skeletons were enumerated, jaws were removed, and the entire skeleton was placed outside of the survey area, so as not to be counted again in subsequent weeks. The jaws were removed in case scavengers brought the carcass back into the survey area. Any carcass without a lower jaw was not counted during surveys. Skeletons were not part of the calculated estimate since they were unavailable for recapture, they were simply counted as an addition of one fish to the estimate. Fresh and decayed carcasses were tagged with a uniquely numbered jaw tag applied to the lower jaw, and colored flagging to denote the week of survey, and then returned into the river where they were initially captured. Each carcass encountered

was assessed for the presence of a numbered jaw tag from previous surveys. If a previously tagged carcass was recaptured, the jaw tag number was recorded and the carcass was released back to the water for subsequent recapture. Recaptured fish were not removed from the sample population as in other Central Valley carcass surveys (Seesholtz et al 2004, Marston et al 2002, Snider et al 1999). The Jolly-Dickson full model allows for multiple recaptures, so all fish were available for multiple recapture during the survey period (Appendix A).

Beginning the first week of November continuing through the third week in December, 20 fresh hatchery carcasses marked with carcass tags were distributed throughout the reach above HWY 88 and 20 were distributed below HWY 88. These 400 hatchery carcasses were used to increase sample size for statistical analysis. A Jolly-Dickson open population mark recapture model, was used to develop an in river spawner estimate using the POPAN 5 statistical package (Arnason et al. 1998).

Length, Sex and Age Determination

Length of carcasses was estimated to the nearest 5 cm using a measuring board with 1 cm increments. Sex was determined by secondary sexual characteristics visible on the carcass such as presence or absence of a developed kype, size of adipose fin, or as in severely decayed carcasses, internal anatomy was used. Carcasses were classified as adults (males $\geq$ 70 cm and females $\geq$68 cm), or grilse (males $\leq$ 69.5 cm and females $\leq$ 67.5 cm) based on length frequencies of known age coded wire tag returns to the Mokelumne River Fish Hatchery (Smith and Workman 2006).

Coded Wire Tag Recoveries

All fish were checked for an adipose fin clip. If clipped, the fish was assessed with a Northwest Marine Technologies (NMT) handheld wand detector for the presence of a CWT. If no tag was detected the fish was left intact and tagged as usual. If a CWT was detected, the upper portion of the head was taken and data recorded on the head tag following the protocol supplied by the California Department of Fish and Game (CDFG) Ocean Salmon Project. By leaving the lower jaw the fish was still available for the mark-recapture portion of the survey and was tagged with a jaw tag for carcass sampling.

Spawning Condition

Egg retention rates were assessed for female carcasses. Fish were classified as exhibiting completely unspawned (all or nearly all eggs retained), partially spawned ($\geq$50% of eggs intact), or spawned out (few to no eggs retained).

Biological Sampling

The Mokelumne River was a collection site for the Ocean Salmon Project of California Department of Fish and Game. Scales were collected from a small percentage of fish

encountered in the river and in the hatchery following a scale collection protocol provided by CDFG (Duran 2005). All scale samples collected were deposited with the Ocean Salmon Project of CDFG at the end of the survey season. No otolith or tissue samples were collected for the 2007 carcass survey period.

Environmental Variables

EBMUD collects and records flow and temperature information at permanent stations along the river. These data were used to analyze temporal patterns of spawning and subsequent recruitment to the carcass survey. Carcass locations were mapped in the river and entered into ArcGIS to facilitate analysis of spatial patterns of carcass collection.

Data Analysis

Temporal distribution of population attributes was represented graphically by number and percent for each survey week including sex and age composition, length frequency distribution, egg retention, and spatial distribution. A generalized Jolly-Dickson full model (Schwarz et al 1993; Schwarz and Arnason 1996) mark recapture model was used to develop an escapement estimate utilizing the data collected in the field. This model allows for injections of hatchery fish, used to increase sample size, and enumeration of loss on captures (skeletons), and also facilitates an estimate of precision (95% confidence interval) based on the variance of recapture probabilities from week to week. Unlike other commonly used mark-recapture estimators which are closed population models, namely the Peterson and Schaeffer methods, the Jolly-Dickson full model is an open population model and allows for losses and additions to the population between sample periods and is therefore a more robust tool to estimate population size than the Peterson and Schaeffer methods. The POPAN 5 statistical software (http://www.cs.umanitoba.ca/~popan/) was used to analyze the data.

Results

The 2007/08 river escapement estimate for the lower Mokelumne River was 470 (+/- 72). This number is based on 135 tagged wild carcasses and 400 injected hatchery carcasses, of which there were 48 wild carcass recaptures, 233 hatchery injection recaptures and an additional 67 skeletons (Appendix A). When added to the final count of fish entering and staying in the hatchery (1,051), the final total escapement for fall run Chinook salmon on the lower Mokelumne River for 2007 was 1,521 (+/- 72).

Length, Sex and Age Composition

The 2007 run was composed of 98% adults and 2% grilse. The grilse sex composition 100% females. The sex composition of adults, as well as total escapement (adult and grilse), was 42% males and 58% females (Figure 2). The first eight weeks of the run were composed of all adult fish. As in previous years the weekly numbers were dominated by adult females (Workman 2006) (Table 1, Figure 3). Grilse made up a very small portion of the run in any given week (Figure 3). Measured adult females ranged in size from 70-89 cm ($\overline{X}$ =79.8), female grilse ranged in size from 60-67 cm ($\overline{X}$ =64.3). Males in the adult size range were 75-105 cm

($\bar{X}$ =92.2) and no male grilse were observed (Table1). The greatest contribution to the population by a single sex and size class was adult females in the 80-85 cm size range at 24% of total (Figure 4). Peaks of size distribution of males and females show the most abundant size class of males is about 10 cm larger than the most abundant size class of females (Figure 4).

Also, when compared by survey week, the largest average size for males was observed in week 4 and females during week 5. This is the same pattern that was seen in the 2006/07 season when in 2005/06 the largest fish were observed during the first week of the survey (Workman 2006, 2007) (Table 1).

Table 1. Length distribution of measured, tagged carcasses, listed by sex, observed on the lower Mokelumne River, October 2007 through January 2008.

	Females			Males			All		
Week	Number	Mean	Range	Number	Mean	Range	Number	Mean	Range
1	2	78	76-80	0			2	78	76-80
2	3	76.3	75-79	1	79	79	4	77	75-79
3	7	77.9	70-83	2	87	84-90	9	79.9	70-90
4	4	80	75-83	6	97.5	83-105	10	90.5	75-105
5	1	83	83	2	92.8	89-96.5	3	89.5	83-95.6
6	12	80.2	75-86	7	89.9	84-100	19	83.8	75-100
7	6	83.1	77-86.4	6	88.3	75-102	12	85.7	75-102
8	7	81.6	75-89	5	97	90-105	12	88	75-105
9	8	81.8	75-86	8	94.2	85-105	16	88	75-105
10	5	74.4	60-86	5	90.8	80-105	10	82.6	60-105
11	3	77.8	74-85	4	92.6	85-96	7	86.3	74-96
12	9	77.7	66-83	6	90.3	84-95	15	82.7	66-95
13	9	81.7	75-89	3	97.5	87.5-103	12	85.6	75-103
14	2	84	81-87	2	87.5	85-90	4	85.8	81-90
Total	78	79.8	60-89	57	92.2	75-105	135	85	60-105

There were very few coded-wire tag recoveries at the MRFH in 2007/08. Only three adult cwt fish were collected, all were 3 year olds. Of the 3 cwt recoveries, 2 were females and one was a male. Only one CWT was recovered in the river last year, so no age structure can be assessed for river fish based on CWT returns.

Coded Wire Tag Recoveries

We observed 1 fish that appeared to have adipose fin clips. This fish had a positive detection for a CWT. The head was collected for this carcass and sent to the Santa Rosa head lab of CDFG for tag reading and determination of age and origin of fish. No data has been received from this head to date. In the 2006/07 season CWT recoveries included one Feather River fall run Chinook brood year 2003 released in San Pablo Bay, and one Mokelumne origin hatchery fall

run Chinook brood year 2002 released at the hatchery (CDFG Santa Rosa office DRAFT findings).

Spawning Condition

Of 71 female carcasses sampled, 1.5% were unspawned, 1.5% retained ≥ 50% of their eggs (partially spawned), and 97% were spawned out. Figure 5 shows the distribution of spawning condition throughout the survey.

Spatial Distribution of Carcasses

Carcass abundance in Reach 6a was much greater than in Reaches 6b and 5 (Table 2). Seventy percent of all tagged carcasses and 76 percent of all skeletons were observed in Reach 6a.

More carcasses were observed in Reach 6b than 5 (Table 2). Female carcasses were more abundant than male carcasses in Reach 6a and in Reach 6b. In Reach 5 males outnumbered females (Table 2). Reaches 6a and 6b contain most of the available spawning habitat in the lower Mokelumne River and males may move farther from spawning habitat before dying than females which stay to guard their nests.

Table 2. Spatial distribution of male and female tagged carcasses and skeletons observed on the lower Mokelumne River, October 2007 - January 2008

	Reach 6a (Fish Guidance Fence to Hwy 88)			Reach 6b (Hwy 88-Mackville Rd.)			Reach 5 (Mackville Rd. to Elliot Rd.)		
Week	Female	Male	Skeletons	Female	Male	Skeletons	Female	Male	Skeletons
1	1	0	0	1	0	1	0	0	0
2	2	0	2	0	0	0	1	1	0
3	5	1	2	0	0	0	2	1	0
4	3	4	0	0	1	0	1	1	0
5	1	1	0	0	0	0	0	1	0
6	10	4	4	2	1	0	0	2	1
7	5	5	4	1	1	2	0	0	0
8	5	4	4	1	1	3	1	0	1
9	4	5	4	2	2	0	2	1	1
10	3	4	8	2	1	1	0	0	0
11	3	2	4	0	2	3	0	0	0
12	7	4	12	2	0	2	0	2	0
13	6	2	5	3	1	0	0	0	0
14	2	2	2	0	0	0	0	0	1
Totals	57	38	51	14	10	12	7	9	4

For all reaches, the majority of tagged fish were decayed, with very few fresh carcasses observed overall. 53 fish were tagged fresh, and the balance, 82 were tagged as decayed carcasses. Abundance of skeletons is also greater in the last nine weeks of the survey than in weeks one through five (Table 3).

Environmental Variables

Weekly average water temperature for the survey period ranged from 11.0^{o} C to 14.9^{o} C. Temperatures throughout the survey never surpassed 15^{o}C. For the last five weeks the temperatures were 13^{o} C or less (Table 3).

Releases from Camanche Dam were constant throughout the survey period at approximately 235 cfs (Table 3). Similar to last year without flood releases we were able to monitor into the first week in January.

Table 4. Weekly Carcass Abundance and related flow and temperature on the lower Mokelumne River. October 2007 - January 2008.

Week	Dates	Fresh	Decayed	Skeletons	Total	Average Flow (cfs)	Average Temperature (˚c)
1*	Oct. 24-Nov. 10	2	0	1	3	228	14.5
2	Nov. 11-Nov. 13	2	2	2	6	225	14.5
3	Nov. 14-Nov.17	6	3	2	11	222	14.9
4	Nov. 18-Nov. 20	6	4	0	10	223	14.5
5	Nov. 21-Nov. 24	2	1	0	3	235	14.3
6	Nov. 25-Nov. 27	6	13	5	24	237	14.3
7	Nov. 28-Dec. 1	2	10	6	18	241	14.3
8	Dec. 2-Dec. 4	5	7	8	20	243	14.1
9	Dec. 5-Dec. 8	5	11	5	21	241	13.6
10	Dec. 9-Dec. 11	7	3	9	19	236	13.0
11	Dec. 12-Dec. 15	1	6	7	14	235	12.5
12	Dec. 16-Dec. 18	4	11	14	29	242	12.7
13	Dec. 19-Dec. 22	5	7	5	17	243	12.1
14*	Dec. 23-Jan. 5	0	4	3	7	245	11.0
	Totals	53	82	67	202		

* Weeks combined due to small sample sizes

Acknowledgements

We would like to thank the field crew of Charles Hunter and Matt Saldate for their hard work and commitment to obtaining accurate survey data and keeping equipment functioning properly through the field season. Thanks to all EBMUD Lodi Fisheries and Wildlife staff for their contributions.

Literature Cited

Arnason, A.N., C.J. Schwarz, and G. Boyer. 1998. POPAN-5: A data maintenance and analysis system for mark-recapture data. Scientific Report, Department of Computer Science, University of Manitoba, Winnipeg.

Duran, J. 2005. Central Valley Chinook Salmon Scale Collection Protocol. California Department of Fish and Game. Ocean Salmon Project. 3pp.

Marston, D, T. Heyne, and S. Baumgartner. 2002. Stanislaus River fall Chinook salmon escapement survey, 2001. SFRA Annual Report, Project 26, Job 2. California Department of Fish and Game. 9pp.

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

Schwarz, C.J. and A.N. Arnason. 1996. A general methodology for the analysis of capture-recapture experiments in open populations. Biometrics. 52:860-873.

Seesholtz, A., B. Cavallo, J. Kindopp, and R. Kurth. 2005. 2004 Feather River Salmon Spawning Escapement Survey Summary. California Dept. of Water Resources. Division of Environmental Services. 5pp.

Smith, J.R. and M.L. Workman. 2006. Lower Mokelumne River Fall-run Chinook Salmon Size at Age. East Bay Municipal Utility District. 9pp.

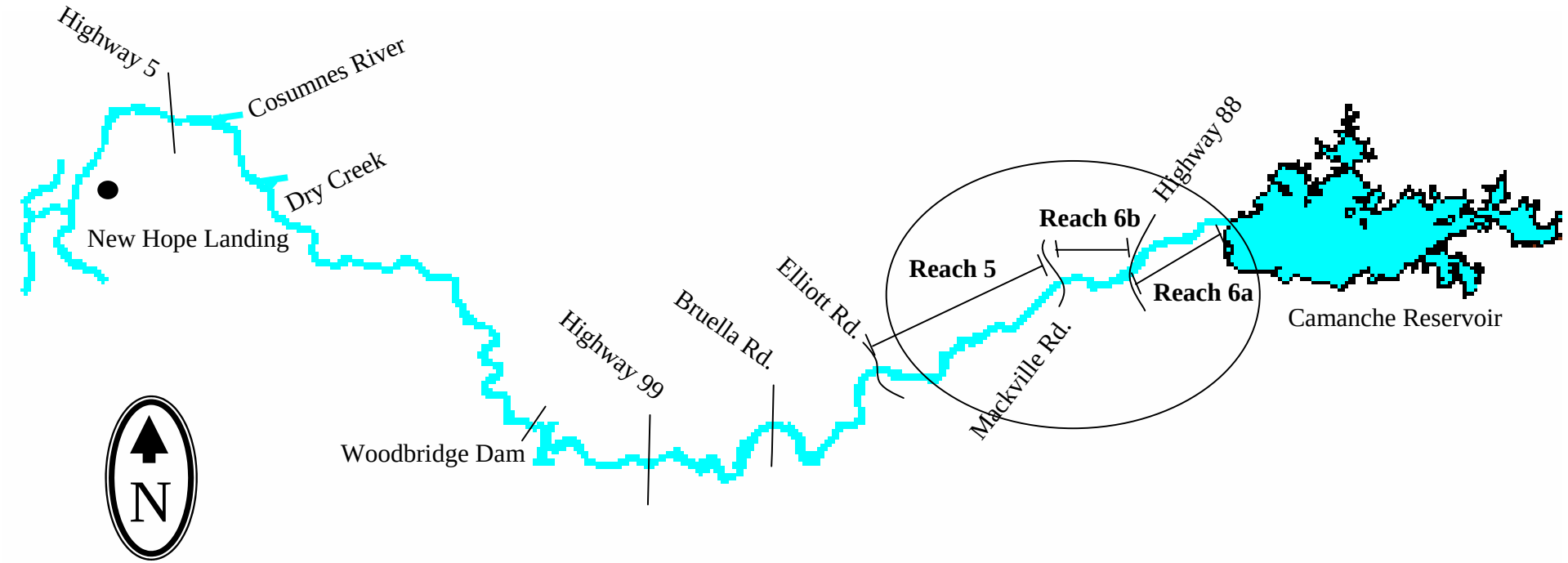
Snider, B., B. Reavis, and S. Hill. 1999. Upper Sacramento River Fall-Run Chinook Salmon Escapement Survey September-December 1998. California Department of Fish and Game Habitat Conservation Division. Stream Evaluation Program. Technical Report No. 99-2. 21pp + figures.

Workman, M.L. 2004. Lower Mokelumne River Upstream Fish Migration Monitoring conducted at Woodbridge Irrigation District Dam August 2003 through July 2004. Unpublished EBMUD report. Lodi, CA 23pp + Appendix.

Workman, M.L. 2005. Lower Mokelumne River Upstream Fish Migration Monitoring conducted at Woodbridge Irrigation District Dam August 2004 through July 2005. Unpublished EBMUD report. Lodi, CA 1pp + Appendix.

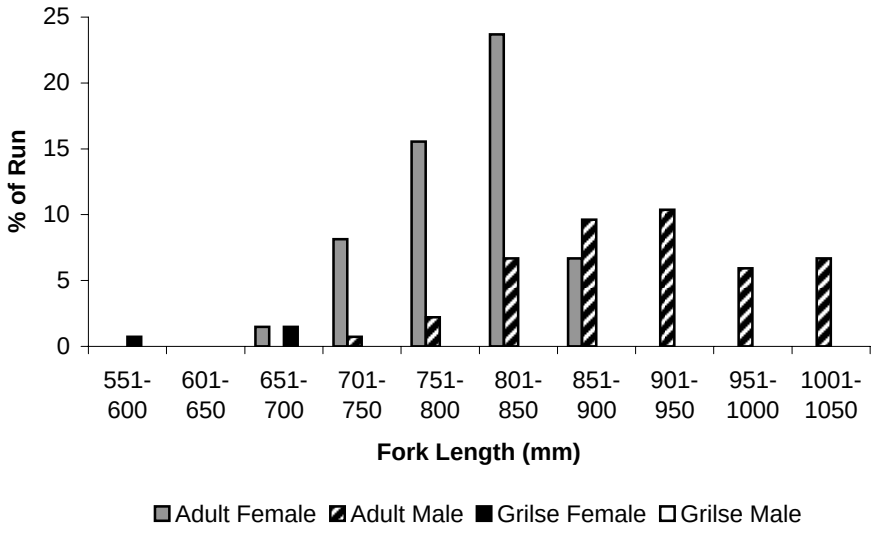
Workman, M.L. 2006. Lower Mokelumne River Fall-run Chinook Salmon Escapement Report October 2005 through January 2006 Unpublished EBMUD report. Lodi, CA 17 pp + Appendix.

Workman, M.L. 2007. Lower Mokelumne River Fall-run Chinook Salmon Escapement Report October 2006 through January 2007. Unpublished EBMUD report. Lodi, CA 14 pp + Appendix.



Reach	Location	River Mile (distance in miles)
6a	Fish Guidance Fence at Camanche Dam to Hwy 88	64-61 (3 miles)
6b	Hwy 88 to Mackville Road	61-59 (2 miles)
5	Mackville Road to above Elliott Road	59-54 (5 miles)

Figure 1. Reach designations for carcass surveys on the lower Mokelumne River, California. October 2007 – January 2008



	Female		Male	
	Adult	Grilse	Adult	Grilse
Number	75	3	57	0
Mean FL	80.4	64.3	92.2	
Range FL	68 - 89	60 - 67	75 - 105	

Figure 2. Length, sex and age composition by FL of fall-run chinook salmon on the lower Mokelumne River, October 2007 - January 2008.

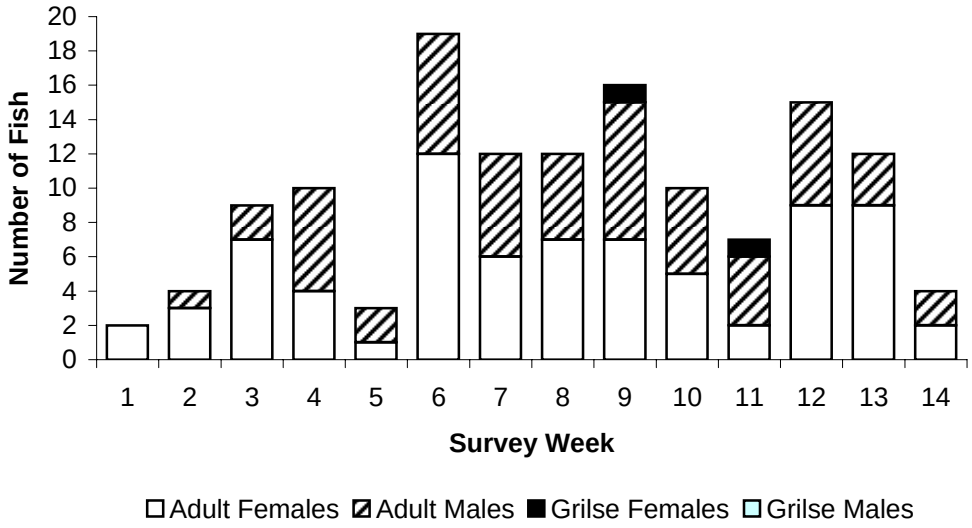


Figure 3. Sex and age composition by survey week of fall run chinook salmon on the lower Mokelumne River, October 2007 - January 2008

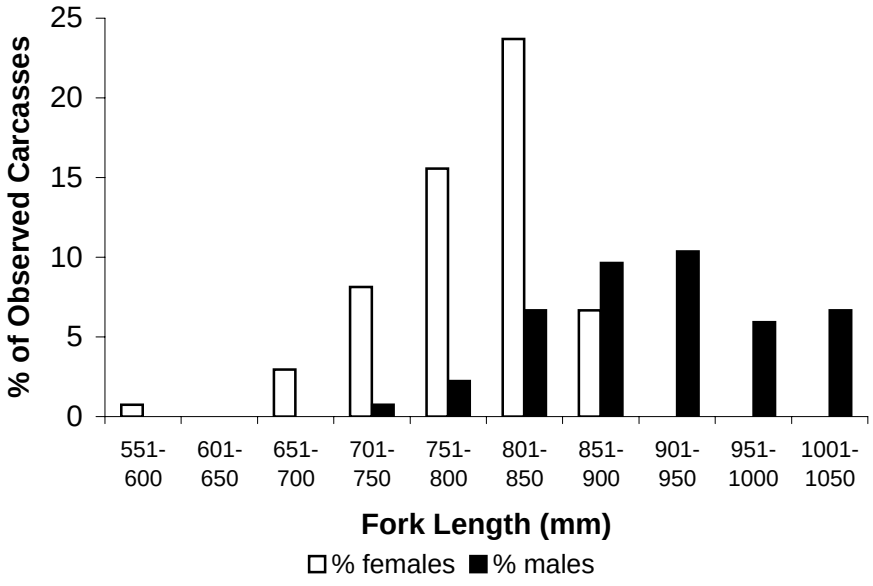


Figure 4. Length frequency distribution of male and female chinook salmon carcasses observed on the lower Mokelumne River, October 2007 - January 2008.

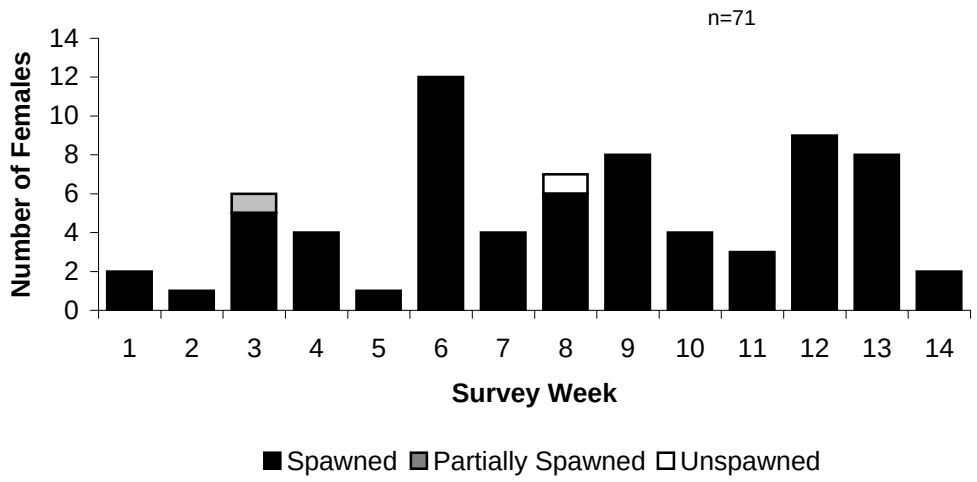


Figure 5. Spawning status of female carcasses, by week, on the lower Mokelumne River. October 2007 - January 2008.

Appendix A. Tag and recapture matrix for Jolly-Seber methodology using POPAN-5 statistical software for the 2007 fall run chinook salmon estimate on the lower Mokelumne

	Injected (Tagged)	Skeletons	Recaptures	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Totals
Week 1	40(2)	1	2	X	X													2
Week 2	40(4)	2	1		X	X	X											
			4		X	X												
			2		X		X											
			10		X													
			1		X				X									
			1		X								X					
			3			X												
			1				X											
			1				X	X	X									
			1							X								
			1					X		X								26
Week 3	40(9)	2	8			X												
			2			X	X											
			2				X											
			1			X				X								
			1			X	X	X	X									
			1			X	X			X								
			1			X					X							
			1				X	X										
			1					X										
			1							X								
			1								X							
			1									X						21
Week 4	40(10)	0	12				X											
			3				X	X										
			2				X		X									
			1				X	X		X								
			1				X			X								
			2					X										
			1					X	X									
			1						X									
			1					X			X							
			1							X	X	X						25
Week 5	40(3)	0	1					X	X	X	X	X						
			8					X										
			1					X			X							
			1							X	X							
			1							X								
			1										X					13
Week 6	(19)	5	2						X									
			1							X	X							
			1								X		X	X				
			1						X						X			5

Appendix A. (cont.) Tag and recapture matrix for Jolly-Seber methodology using POPAN-5 statistical

software for the 2007 fall run chinook salmon estimate on the lower Mokelumne

	Injected (Tagged)	Skeletons	Recaptures*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Totals
Week 7	40(12)	6	7							X								
			7							X	X							
			4								X							
			1							X	X	X						
			1							X	X			X				
			3								X	X						
			1								X	X	X	X				
			1								X	X		X				
			1									X	X					
			2									X						
			1											X				29
Week 8	(12)	8	3								X							3
Week 9	40(16)	5	6									X						
			2									X	X					
			1									X	X	X				
			1									X		X				
			1									X		X	X			
			1										X					
			2											X				14
Week 10	40(10)	9	13										X					
			6											X				
			2										X	X				
			1												X			22
Week 11	40(7)	7	9											X				
			3												X			12
Week 12	(15)	14	4												X			4
Week 13	40(12)	5	5													X		
			1													X	X	
			1														X	7
Week 14	(4)	3	2														X	2
Total	400 (135)	67	185* 233 injections 48 wild															185

```
     HISTORIES WERE READ USING FREE FORMAT
1**********************
 *                     *
 *  SELECT             *     2007PRELIM2
 *  PARAGRAPH #   1    *     SELECT ALL
 *                     *
 **********************



0  SELECTED DATASET FILE = C:\POPAN5\07PRE2.BIN




0  FILE IS STORED UNDER FORMAT(A8,    A2,2A1,(200A2,200A2,112A2))
0  ORIGINAL FILE CREATED USING FREE FORMAT
    IDENTIFIER TYPE   # ATTRIBUTES   BEGIN   END   LSEL   # HISTORIES
ACHECKS DONE   TCHECKS DONE   FILE ORDERED
    ===============   ============   =====   ===   ====   ===========
============
```

```
      GROUPED              0            1     15     15           126       NO
ORDER & RANGE       NO
```

MAP OF NEW NUMBERING FOR SAMPLE TIMES

I	OX(I)	SDES(I)	ABS. TIMES	WEIGHTS	NX(I)	NEW SDES(I)	ABS TIMES	WEIGHTS	NEW NUMBER
1	1		1.0000	1	1	1.0000	1		
2	2		2.0000	1	2	2.0000	1		
3	3		3.0000	1	3	3.0000			
4	4		4.0000	1	4	4.0000	1		
5	5		5.0000	1	5	5.0000	1		
6	6		6.0000	1	6	6.0000	1		
7	7		7.0000	1	7	7.0000	1		
8	8		8.0000	1	8	8.0000			
9	9		9.0000	1	9	9.0000	1		
10	10		10.0000	1	10	10.0000	1		
11	11		11.0000	1	11	11.0000	1		
12	12		12.0000	1	12	12.0000	1		
13	13		13.0000	1	13	13.0000	1		
14	14		14.0000	1	14	14.0000	1		
15	15		15.0000	1	15	15.0000	1		

OLD LSEL (ORIGINAL DATA) = 15

NEW LSEL (REDUCED DATA) = 15

ATTRIBUTE SELECTION CONDITION WAS
0 AT =ALL

```
1**********************
 *                    *
 *  UFIT              *     2007PRELIM2
 *  PARAGRAPH #   1   *     SELECT ALL
 *                    *     ESCAPEMENT ESTIMATE: TOTAL POPULATION
 **********************
```

REPORT ON USER-SPECIFIED CONSTRAINTS
==========

```
  NOTATION:
  =========

        Pt      parameter value at sample time t
        Lt      logit of parameter value at sample time t
       P^t      parameter value at sample time t ADJUSTed for time
                   between sample time t and t+1
       L^t      logit of parameter value at sample time t
                   ADJUSTed for time between sample time t and t+1
  where
                1,..k ( = NLSEL = number of sample times)
         g      1,..n ( = NGROUPS = number of cohort groups)
  and    *      indicates Gross births (P*) or logit Gross births (L*)
  note
      Any group prefix on the above notation (e.g. GgPt) implies
      Group g=1 (e.g. G1Pt) as no cohort groups were specified

  Capture Probability Constraints (CPCONST)
  =========================================

    No constraints specified but AUTOmatic = YES
    POPAN adds the following AUTOmatic constraints
         GgP1  =  1.0       for g=1,...n
         GgPk  =  1.0       for g=1,...n
0   Number of constraints added to model =   2

  Survival Probability Constraints (SPCONST)
  ==========================================

    No constraints specified...none added
0   Number of constraints added to model =   0

  Birth Probability Constraints (BPCONST)
  =======================================
    For ALL models, POPAN adds the following automatic constraints:

         Sum (GgPi)  =  1.0    (sum over i=0    k-1) for each g=1    n

    No additional user constraints specified
0   Number of constraints added to model =   1

  ==========================================
0   Total constraints specified by user  =   3
    (POPAN may add further constraints to fix out-of-range estimates)


 END OF REPORT ON USER-SPECIFIED CONSTRAINTS
 ===========================================



  **** BEGIN CHECKS OF MODELS AND CONSTRAINTS

 ***** GETTING STATISTICS FOR ITERATIVE MODEL FIT
1**********************
 *                    *
 *  UFIT              *     2007PRELIM2
 *  PARAGRAPH #   1   *     SELECT ALL
 *                    *     ESCAPEMENT ESTIMATE: TOTAL POPULATION
 **********************     USER-DEFINED MODEL FIT: ADMISSIBLE MLE'S


0   STATISTICS TABLE DEFINITION
    ===========================

0     NAME          DESCRIPTION (AND DEFINING PHRASE)
+-------------------------------------------------------------------------------
```

N(I)	SAMPLE SIZE AT TIME I, EXCLUDING INJECTED ANIMALS SEEN AT (I) AND NOT INJECTED AT (I)
M(I)	SIZE OF MARKED SUBSET OF N(I) SEEN AT (I) AND SEEN BEFORE (I)
L(I)	LOSSES ON CAPTURE LOST AT (I)
S(I)	NUMBER RETURNED TO POPULATION (EXCLUDING LOSSES, INCLUDING INJECTIONS) SEEN AT (I) AND NOT LOST AT (I)
SM(I)	NUMBER RETURNED TO THE POPULATION EXCLUDING THOSE FIRST MARKED AT I SEEN BEFORE (I) AND SEEN AT (I) AND NOT LOST AT (I)
R(I)	NUMBER OF RECAPTURES OUT OF S(I) SEEN AT (I) AND SEEN AFTER (I)
Z(I)	NUMBER SEEN BEFORE I, AFTER I, AND NOT AT I SEEN BEFORE (I) AND SEEN AFTER (I) AND NOT SEEN AT (I)

1**********
 * *
 * UFIT * 2007PRELIM2
 * PARAGRAPH # 1 * SELECT ALL
 * * ESCAPEMENT ESTIMATE: TOTAL POPULATION
 ********** USER-DEFINED MODEL FIT: ADMISSIBLE MLE'S

0 STATISTICS TABLE
 ==========

I	N(I)	M(I)	L(I)	S(I)	SM(I)	R(I)	Z(I)
1	3	0	1	42	0	2	0
2	8	2	2	46	2	28	0
3	32	21	2	70	21	30	7
4	33	22	1	72	22	32	15
5	34	31	0	74	31	24	16
6	46	23	4	42	23	13	17
7	29	11	6	63	11	31	19
8	48	28	8	40	28	16	22
9	51	30	5	86	30	28	8
10	44	23	9	75	23	30	13
11	38	24	7	71	24	17	19
12	60	31	14	46	31	5	5
13	27	10	5	62	10	8	0
14	11	6	1	10	6	3	2
15	7	5	2	5	5	0	0

0 # HISTORIES SCANNED USING EFFICIENT SCAN = 126 EQUALING 604 ANIMALS

```
    # HISTORIES REJECTED ON ATTRIBUTES                                  0 EQUALING
0 ANIMALS

    # HISTORIES REJECTED FOR NO CAPTURES IN (BEGIN,END) =               0 EQUALING
0 ANIMALS
0  STATISTICS TABLE NOT SAVED...EXECUTION CONTINUING
1**********************
 *                     *
 *  UFIT               *     2007PRELIM2
 *  PARAGRAPH #   1    *     SELECT ALL
 *                     *     ESCAPEMENT ESTIMATE: TOTAL POPULATION
 **********************     INITIAL ESTIMATES OBTAINED USING: JOLLY-DICKSON
FULL MODEL (BIRTH & DEATH) -- UNADJUSTED ESTIMATES

 *****    ITERATIVE MODEL FIT NOW BEING CALLED    *****
 *****    ITERATIVE FIT CONVERGED SUCCESSFULLY    *****
0        Final conditional log-likelihood:   -560.393
         Number of  restrictions  applied:      6
         Number of  singular values found:      0
     Actual number of restrictions(nr-ns):      6


1**********************
 *                     *
 *  UFIT               *     2007PRELIM2
 *  PARAGRAPH #   1    *     SELECT ALL
 *                     *     ESCAPEMENT ESTIMATE: TOTAL POPULATION
 **********************     INITIAL ESTIMATES OBTAINED USING: JOLLY-DICKSON
FULL MODEL (BIRTH & DEATH) -- UNADJUSTED ESTIMATES


0   ESTIMATE TABLE
    ==============

0   ESTIMATE DEFINITIONS
    ====================

0NAME              DESCRIPTION
+-------------------------------------------------------------------------------
-------------------+

 PH(I)             ESTIMATE OF CAPTURE PROBABILITY AT TIME I

 S(PH(I)           STANDARD ERROR OF ESTIMATE OF CAPTURE PROBABILITY

 PHI(I)            ESTIMATE OF SURVIVAL RATE BETWEEN I,I+1

 S(PHI(I)          STANDARD ERROR OF ESTIMATE OF SURVIVAL RATE

 BH(I)             ESTIMATE OF BIRTHS ENTERING BETWEEN I AND I+1

 S(BH(I)           STANDARD ERROR OF THE ESTIMATE OF BIRTHS

 NH(I)             ESTIMATED POPULATION SIZE AT TIME I

 S(NH(I)!N)        CONDITIONAL STANDARD ERROR OF ESTIMATE OF POPULATION SIZE

 BHG(I)            ESTIMATE OF GROSS BIRTHS BETWEEN I AND I+1

 S(BHG(I)!N)       CONDITIONAL STANDARD ERROR OF ESTIMATE OF GROSS BIRTHS

 C_PC(I)           COEFFICIENTS OF COVARIATE MODEL FOR CAPTURE PROBABILITY

 S(C_PC(I))        STANDARD ERROR OF COEFFICIENTS OF COVARIATE MODEL FOR CAPTURE
PROBABILITY

 C_PHI(I)          COEFFICIENTS OF COVARIATE MODEL FOR SURVIVAL PROBABILITY
```

S(C_PHI(I)) | STANDARD ERROR OF COEFFICIENTS OF COVARIATE MODEL FOR SURVIVAL PROBABILITY

C_PENT(I) COEFFICIENTS OF COVARIATE MODEL FOR ENTRY PROBABILITY

S(C_PENT(I) STANDARD ERROR OF COEFFICIENTS OF COVARIATE MODEL FOR ENTRY PROBABILITY

VALIDITY FLAGS
(LOCATED TO THE IMMEDIATE RIGHT OF ANY ESTIMATE)

0CHAR MEANING

+---

| ESTIMATE AS CALCULATED IS VALID

'G' ESTIMATE OF A PROPORTION IS > 1 -- ESTIMATE WAS RESET TO

'L' ESTIMATE OF A POSITIVE QTY < 0 -- ESTIMATE WAS RESET TO 0

Z' ESTIMATE NOT FORMED DUE TO 0 IN DENOMINATOR

U' ESTIMATE UNAVAILABLE FOR ESTIMATES NEAR BEGINNING/END OF SAMPLE CHAIN

'R' | NO UNMARKED ANIMALS -- ESTIMATE MAY BE INVALID IF SAMPLE IS 'RECAPTURES ONLY'

'N' | SAMPLE SIZE = 0 -- ESTIMATE SET TO 0 -- OTHERS IN THIS ROW MAY BE INVALID

I' INVALID DUE TO 0 SAMPLE SIZE AT NEXT SAMPLE TIME

'F' GENERAL FAILURE -- E.G. CONVERGENCE FAILURE OR MATRIX INVERSION ERROR

'X' | COEFFICIENT WAS NOT DEFINED BY A COVARIATE CONSTRAINT

1**********

* *
* UFIT * 2007PRELIM2
* PARAGRAPH # 1 * SELECT ALL
* * ESCAPEMENT ESTIMATE: TOTAL POPULATION
********** INITIAL ESTIMATES OBTAINED USING: JOLLY-DICKSON FULL MODEL (BIRTH & DEATH) -- UNADJUSTED ESTIMATES

0 ESTIMATE TABLE
==========

0 I | PH(I) S(PH(I)) | PHI(I) S(PHI(I)) BH(I) S(BH(I)) NH(I) S(NH(I)!N)

1	1.0000 G	0.0000	0.0476	0.0329	6.0000	2.4279	3.0000	1.7244
2	1.0000 G	0.0000	0.8116	0.1266	19.5556	6.9989	8.0000	2.7931
3	0.5625	0.1126	0.6315	0.1063	18.3556	7.2996	56.8889	10.7511
4	0.4216	0.0789	0.7664	0.1439	0.0000 L	0.0000	78.2784	12.5206
5	0.3783	0.0820	0.6318	0.1580	73.7859	26.2778	89.8815	16.8037
6	0.2952	0.0820	0.5119	0.1316	53.0708	31.6645	155.8462	40.0525
7	0.2217	0.0690	0.8168	0.1569	7.6748	27.7412	130.7977	35.9597
8	0.3373	0.0770	0.5744	0.1303				

```
15.6329          12.6007  |    142.2857          29.4506
    9 |       0.5497  |       0.1057  |       0.5019  |       0.0966
42.0406          15.4017          92.7714          17.7686
   10 |       0.4144  |       0.0909  |       0.9614  |       0.2283
31.7600          23.4322          106.1739         21.7213
   11 |       0.2322  |       0.0665  |       0.5121  |       0.2030
48.3262          25.5748          163.6422         41.8012
   12 |       0.4026  |       0.1541  |       0.1087  |       0.0459
12.3226           4.7321          149.0323         55.9735
   13 |       1.0000 G|       0.0000  |       0.2043  |       0.0968
10.5556           7.0524          27.0000           5.0347
   14 |       0.4737  |       0.2365  |       0.3000  |       0.1449
0.3333            2.0993          23.2222          11.3892
   15 |       1.0000 G|       0.0000  |       0.0000 U|       0.0000 U|
342.4138          30.7199             7.0000           2.6244

0    ESTIMATE TABLE CONTINUED
     ========================

0  I   | BHG(I)          | S(BHG(I)!N)   | C_PC(I)          S(C_PC(I)       C_PHI(I)
  S(C_PHI(I))     C_PENT(I)      | S(C_PENT(I))

=====================================================
=============================================
     1 |      19.1805  |       8.5921  |       0.0000 X|       0.0000 X|
0.0000 X|       0.0000 X|       0.0000 X|       0.0000 X|
     2 |      21.6677  |       7.3528  |       0.0000 X|       0.0000 X
0.0000 X|       0.0000 X|       0.0000 X|       0.0000 X|
     3 |      22.8962  |       8.9695  |       0.0000 X|       0.0000 X
0.0000 X|       0.0000 X|       0.0000 X|       0.0000 X|
     4 |       0.0000  |       0.0000  |       0.0000 X|       0.0000 X
0.0000 X|       0.0000 X|       0.0000 X|       0.0000 X|
     5 |      92.0179  |      28.5896  |       0.0000 X|       0.0000 X|
0.0000 X|       0.0000 X|       0.0000 X|       0.0000 X|
     6 |      72.8093  |      42.4306  |       0.0000 X|       0.0000 X|
0.0000 X|       0.0000 X|       0.0000 X|       0.0000 X|
     7 |       8.4774  |      30.5594  |       0.0000 X|       0.0000 X|
0.0000 X|       0.0000 X|       0.0000 X|       0.0000 X|
     8 |      20.3644  |      16.1622  |       0.0000 X|       0.0000 X|
0.0000 X|       0.0000 X|       0.0000 X|       0.0000 X|
     9 |      58.1809  |      20.1211  |       0.0000 X|       0.0000 X|
0.0000 X|       0.0000 X|       0.0000 X|       0.0000 X|
    10 |      32.3889  |      22.8217  |       0.0000 X|       0.0000 X|
0.0000 X|       0.0000 X|       0.0000 X|       0.0000 X|
    11 |      66.2858  |      29.0099  |       0.0000 X|       0.0000 X|
0.0000 X|       0.0000 X|       0.0000 X|       0.0000 X|
    12 |      30.6812  |      12.5277  |       0.0000 X|       0.0000 X|
0.0000 X|       0.0000 X|       0.0000 X|       0.0000 X|
    13 |      21.0682  |      12.5895  |       0.0000 X|       0.0000 X|
0.0000 X|       0.0000 X|       0.0000 X|       0.0000 X|
    14 |       0.5733  |       3.6124  |       0.0000 X|       0.0000 X
0.0000 X|       0.0000 X|       0.0000 X|       0.0000 X|
    15 |     469.5915  |      36.9914  |       0.0000 X|       0.0000 X
0.0000 X|       0.0000 X|       0.0000 X|       0.0000 X|
0 *** ESTIMATE TABLE NOT SAVED...EXECUTION CONTINUING
```