LOWER MOKELUMNE RIVER
Fall-run Chinook Salmon Escapement Report
October 2006 through January 2007

September 2007

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

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

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Abstract

A mark-recapture carcass survey was conducted from October 2006 through January 2007 to estimate the fall-run Chinook salmon population in the lower Mokelumne River. The estimate based on 459 tagged carcasses was 1,732 in-river spawners (+/- 378). The Mokelumne River Fish Hatchery's (MRFH) count of hatchery spawners was 4,139. Total Mokelumne River escapement was estimated at 5,871 (+/- 378). The river spawning population was composed of 90% adults and 10% grilse. The grilse component was 56% male and 44% female. The adult component, as well as total escapement (adult and grilse), was 45% male and 55% female. Eighty-three percent of females were completely spawned out, while 13% were completely unspawned and 4% 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 2006/07 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 2006/07

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 2006/07 fall-run Chinook salmon population on the lower Mokelumne River.

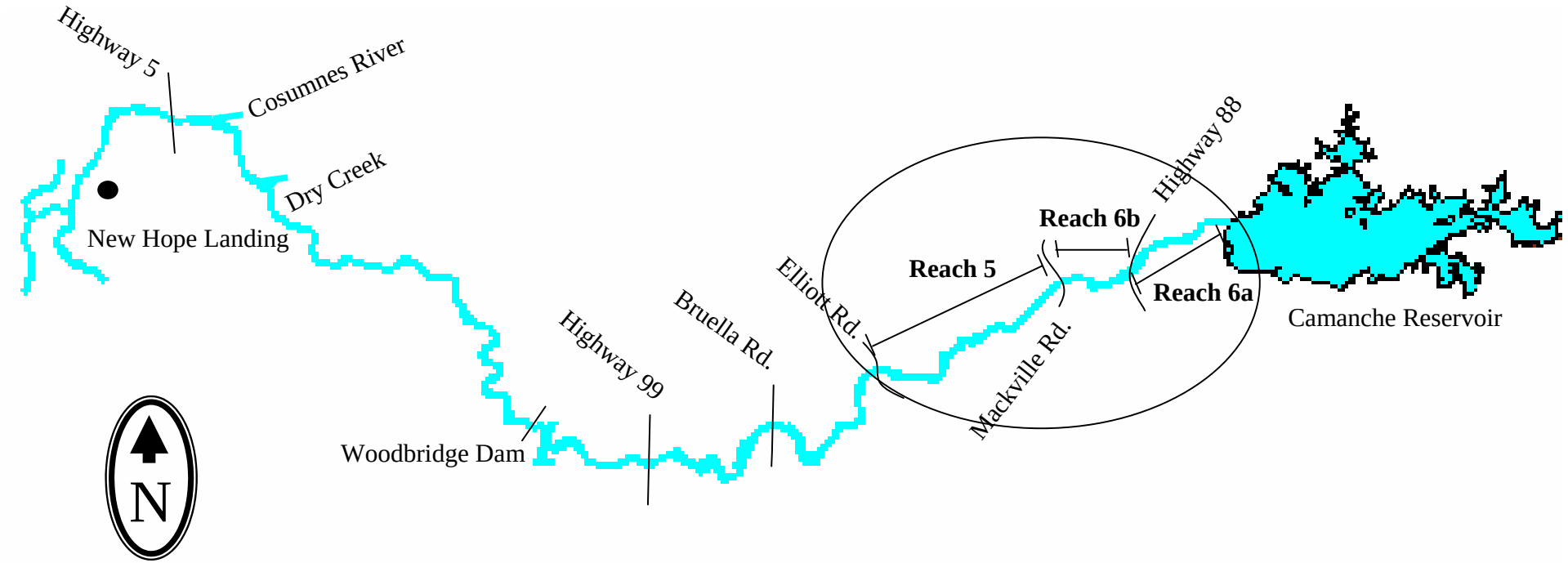
Methods

Survey Methods

Carcass surveys were conducted weekly from the first week in October 2006 through mid January of 2007. Each week, two to three people surveyed from the base of Camanche Dam to Elliott Road. This distance encompasses three sections of river designated as Reaches 6a, 6b, and 5 (Figure 1). One to two days 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



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 Elliott Road	59-53 (6 miles)

Figure 1. Reach designations for carcass surveys on the lower Mokelumne River, California. October 2006 – January 2007

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).

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).

Hatchery Returned Fish

Last year the MRFH initiated a program to return unripe, live fish to the river to encourage river spawning and reduce the need for disposing of fish and/or gametes which were above production goals for the hatchery. At each spawning event hatchery staff designated a portion of the fish that were not ready to be spawned and these fish were tagged with a disc or floy tag or pelvic fin clip and released alive back into the river. These fish were not included in the hatchery escapement total, but were included in the river escapement total.

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 2006 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.

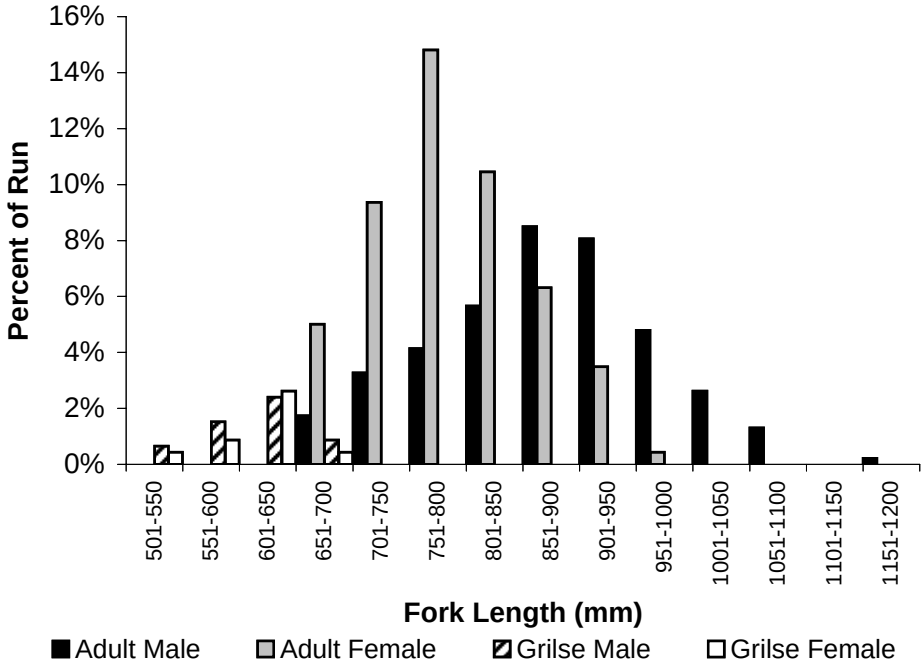
Results

The 2006/07 river escapement estimate for the lower Mokelumne River was 1,732 (+/-378). This number is based on 459 tagged carcasses, of which there were 139 recaptures and an additional 109 skeletons (Appendix A). When added to the final count of fish entering and staying in the hatchery (4,139), the final total escapement for fall run Chinook salmon on the lower Mokelumne River for 2006 was 5,871 (+/- 378).

Length, Sex and Age Composition

The 2006 run was composed of 90% adults and 10% grilse. The grilse sex composition was 56% males and 44% females. The sex composition of adults, as well as total escapement (adult and grilse), was 45% males and 55% females (Figure 2). The first two weeks of the run were composed of all adult fish. The weekly numbers of males and females were about the same as opposed to last year when most weeks 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 68-100 cm ($\overline{X}$ =80.4), female grilse ranged in size from 55-67 cm ($\overline{X}$ =63.2). Males in the adult size range were 70-117.5 cm ($\overline{X}$ =89.7) and male



	Female		Male	
	Adult	**Grilse**	**Adult**	**Grilse**
Number	229	22	183	25
Mean FL	80.4	63.2	89.7	62.1
Range FL	68 - 100	55 - 67	70 - 117.5	51 - 69

Figure 2. Length, sex and age composition by FL of fall-run chinook salmon on the lower Mokelumne River, October 2006-January 2007

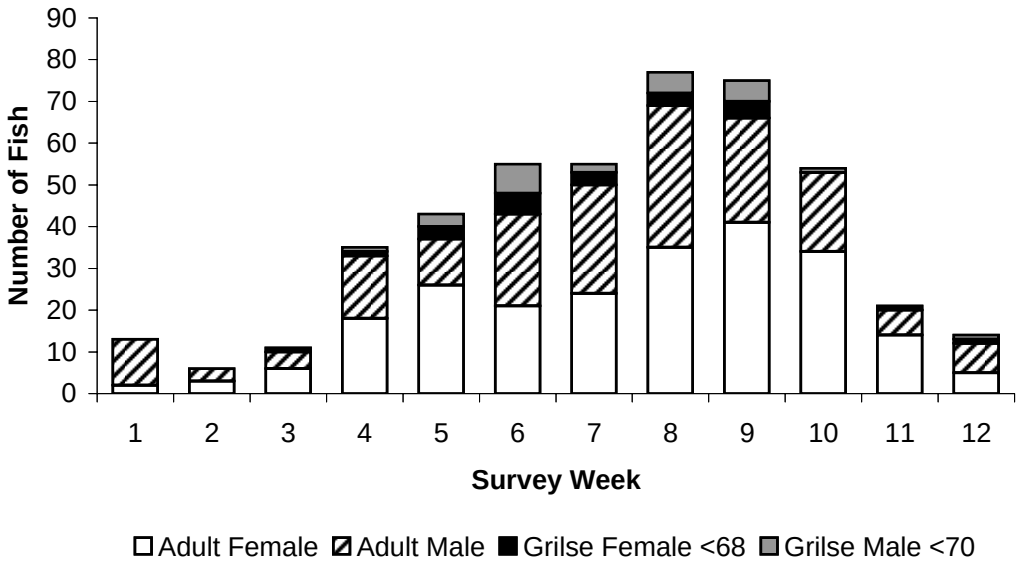


Figure 3. Sex and age composition by survey week of fall run chinook salmon on the lower Mokelumne River, October 2006 -January 2007.

grilse were 51-69 ($\overline{X}$ =62.1) (Table1). The greatest contribution to the population by a single sex and size class was adult females in the 75-80 cm size range at 14% of total (Figure 4). Peaks of size distribution of males and females show the most abundant size class of males is about 15 cm larger than the most abundant size class of females (Figure 4).

Also, when compared by survey week, the largest average size for males and females was observed during week 10 as opposed to week one last year (Workman 2006) (Table 1).

Table 1. Length distribution of measured, tagged carcasses, listed by sex, observed on the lower Mokelumne River, October 2006 through January 2007.

	Females			Males			All		
Week	Number	Mean	Range	Number	Mean	Range	Number	Mean	Range
1	2	75	70-80	11	90.2	80-98	13	87.8	70-98
2	3	80	78-82	3	83.3	75-95	6	81.6	75-95
3	7	77.5	65-85	4	86	80-92	11	80.6	65-92
4	19	78.8	67-90	16	92.2	65-110	35	84.9	65-110
5	29	78.9	64-91	14	83.6	59-110	43	80.4	59-110
6	26	77.1	60-92	29	82.9	51-105	55	80.1	51-105
7	27	78.7	55-95	28	85	65-106	55	81.9	55-106
8	38	81.1	60-100	39	87.5	57-110	77	84.3	57-110
9	45	76.7	60-90	30	83.6	55-110	75	79.5	55-110
10	34	82.4	69-95	20	89.3	52.5-117.5	54	85	52.5-117.5
11	15	77.9	55-90	6	88.7	75-102.5	21	81	55-102.5
12	6	73.8	65-85	8	88.3	67-110	14	82.1	65-110
Total	251	78.9	55-100	208	86.3	51-117.5	459	82.3	51-117.5

Coded-wire tag recoveries at the MRFH in 2006/07 showed age composition of females as 17% 2-year olds, 24% 3-year olds and 59% 4-year olds (n=29). Male proportions in the MRFH were 67% 2-year olds, 9% 3-year olds and 22% 4-year olds, 2% 5-year olds (n=45). CWT returns in the river for 2005 showed age composition of females as 22.2% 2-year olds, 77.8% 3-year olds, and no 4-year olds (n=18). Only three CWT's were recovered in the river last year, so no age structure can be assessed for river fish based on CWT returns (Table 2).

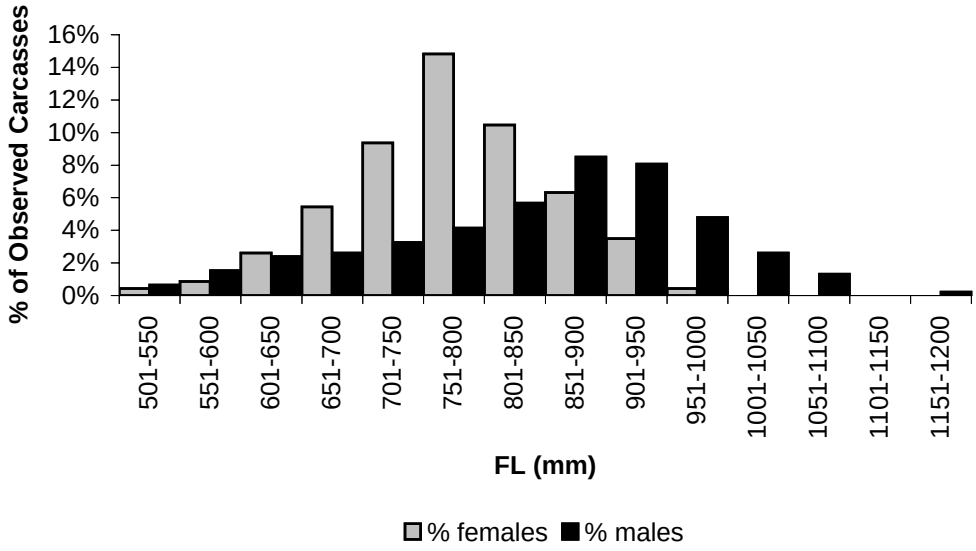


Figure 4. Length frequency distribution of male and female chinook salmon carcasses observed on the lower Mokelumne River, October 2006-January 2007.

Table 2. Percent age composition based on coded wire tag returns to the Mokelumne River Fish Hatchery and in-river populations.

		2005		2006	
Origin	**Age**	**Male**	**Female**	**Male**	**Female**
		n=102	n=159	n=45	n=29
Hatchery	**2**	3	1.3	67	17
	3	79.4	89.3	9	24
	4	17.6	9.4	22	59
	5	0	0	2	0
		n=22	n=18		
In-River	**2**	4.5	22.2		
	3	59.1	77.8		
	4	36.4	0		
	5		0		

* sample size of 3 in 2006 in-river population too small to compare

Coded Wire Tag Recoveries

We observed 4 fish that appeared to have adipose fin clips. Three of these fish had a positive detection for a CWT. Heads were collected for these 3 carcasses and were sent to the Santa Rosa head lab of CDFG for tag reading and determination of age and origin of fish. 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).

Hatchery returned fish

In 2005/06 the MRFH tagged and released 2,452 fall-run Chinook back to the river. In 2006/07 because of the smaller run size, the hatchery returned only 149 ripe females to the river. These fish were not detected in the carcass survey.

Spawning Condition

Of 229 female carcasses sampled, 14% were unspawned, 3% retained $\geq$50% of their eggs (partially spawned), and 83% 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 3). Eighty-eight percent of all tagged carcasses and 85 percent of all skeletons were observed in Reach 6a.

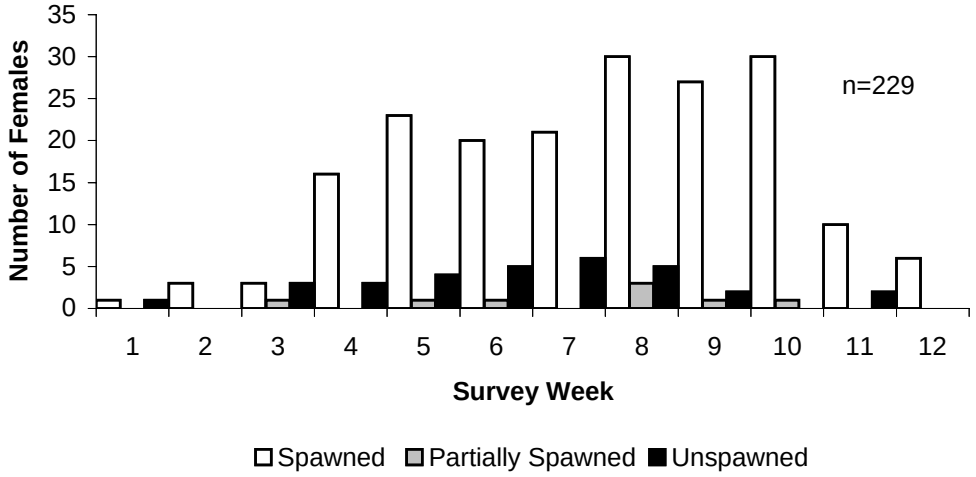


Figure 5. Spawning status of female carcasses, by week, on the lower Mokelumne River. October 2006-January 2007.

More carcasses were observed in Reach 6b than 5 (Table 3). Female carcasses were more abundant than male carcasses in Reach 6a, males were more abundant in Reach 6b and Reach 5 had equal proportions (Table 3). 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 3. Spatial distribution of male and female tagged carcasses and skeletons observed on the lower Mokelumne River, October 2006- January 2007.

	Reach 6a (Fish Guidance Fence to Hwy 88)			Reach 6b (Hwy 88-Mackville Rd.)			Reach 5 (Mackville Rd. to Elliott Rd.)		
Week	Female	Male	Skeletons	Female	Male	Skeletons	Female	Male	Skeletons
1	2	7	1	0	3	0	0	1	0
2	3	2	1	0	0	1	0	1	0
3	7	3	0	0	1	0	0	0	0
4	17	11	11	1	3	0	1	2	0
5	28	12	16	1	2	0	0	0	1
6	25	27	7	1	0	0	0	2	0
7	26	26	11	1	2	2	0	0	1
8	36	32	11	2	6	2	0	1	0
9	39	27	17	2	2	2	4	1	1
10	31	19	6	2	1	1	1	0	0
11	12	4	2	0	1	1	3	1	0
12	4	6	10	1	1	2	1	1	2
Totals	230	176	93	11	22	11	10	10	5

For all reaches, the majority of tagged fish were decayed, with very few fresh carcasses observed overall. 91 fish were tagged fresh, and the balance, 368 were tagged as decayed carcasses. Abundance of skeletons is also greater in the last five weeks of the survey than in weeks one through four (Table 4).

Environmental Variables

Weekly average water temperature for the survey period ranged from 11.0^{o} C to 16.5^{o} C. Temperatures through November were 15^{o}C and above. By the beginning of December temperatures were 14^{o} C or less (Table 4).

Releases from Camanche Dam were constant throughout the survey period at approximately 340 cfs with the exception of the first survey week where the average was over 440 (Table 4). Last year flood flow releases in January precluded monitoring. This year without flood releases we were able to monitor into the second week in January

Table 4. Weekly Carcass Abundance and related flow and temperature on the lower Mokelumne River. October 2006 -January 2007.

Week	Dates	Fresh	Decayed	Skeletons	Total	Average Flow (cfs)	Average Temperature (°c)
1*	Oct. 3-Oct. 15	3	10	1	14	446	15.7
2	Oct. 16-Oct.22	1	5	2	8	335	15.8
3	Oct. 23- Oct. 29	3	8	0	11	340	15.9
4	Oct. 30- Nov. 5	9	26	11	46	340	16.1
5	Nov. 6-Nov. 12	6	37	17	60	340	16.2
6	Nov. 13-Nov. 19	8	47	7	62	341	16.5
7	Nov. 20-Nov. 26	6	49	14	69	342	16.2
8	Nov. 27-Dec. 3	20	57	13	90	342	15.0
9	Dec. 4-Dec. 10	11	64	20	95	305	14.0
10	Dec. 11-Dec. 17	15	39	7	61	342	13.8
11	Dec. 18-Dec. 24	6	15	3	24	341	12.4
12*	Dec. 25-Jan. 10	3	11	14	20	340	11.0
	Totals	91	368	109	560		

* Weeks combined due to small sample sizes

Acknowledgements

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Appendix A. Tag and recapture matrix for Jolly-Seber methodology using POPAN-5 statistical software for the 2006 fall run chinook salmon estimate on the lower Mokelumne

	Tagged	Skeletons	Recaptures	Never	2	3	4	5	6	7	8	9	10	11	12	Totals*
Week 1	13	1	3		X											
				10												**3(3)**
Week 2	6	2	2				X									**2(2)**
				4												
Week 3	11	0	1				X									
			2					X								**3(3)**
				8												
Week 4	35	11	4					X								
			1										X			
			1					X	X							
			1						X							**7(8)**
				18												
Week 5	43	17	7						X							
			4							X						
			2								X					
				30												**13(13)**
Week 6	55	7	5							X						
			3							X	X					
			1							X			X			**13(9)**
				46												
Week 7	55	14	9								X					
			3									X				
			1								X	X				
			3									X	X			**21(16)**
				39												
Week 8	77	13	13									X				
			4									X	X			
			4										X			
			1											X		
			3												X	
																29(25)
				52												
Week 9	75	20	21										X			
			2										X	X		
			1										X	X	X	
			1										X		X	
			2											X		
			5												X	
																35(30)
				45												
Week 10	54	7	4											X		
			5												X	
				38												**9(9)**
Week 11	21	3	3												X	**3(3)**
Week 12	14	14	0													
Totals	459	109	122	290												**139(122)**

* First number represents total number recaptured, ( ) represent unique codes recaptured. Eg, for totals: 139 total recaptures and 122 unique tag codes represented.

```
This result file generated on 07 Mar 05 at 13:39:49
 from C:\POPAN5\MWEST06.POP




1**********************
 *                    *
 *  CREATE            *
 *  PARAGRAPH #   1   *
 *                    *
 **********************




     *** C R E A T E    S U M M A R Y ***
0    NUMBER OF HISTORIES READ       =            54 EQUALING            568 ANIMALS
     NUMBER OF HISTORIES WRITTEN    =            54 EQUALING            568 ANIMALS
     NUMBER OF HIST. FAILING TCHECK =             0 EQUALING              0 ANIMALS
     NUMBER OF HIST. FAILING ACHECK =             0 EQUALING              0 ANIMALS
     NUMBER OF HISTORIES REORDERED  =             0
     MIN(X(1)) ON HISTORIES WRITTEN =             1
     MAX(X(T)) ON HISTORIES WRITTEN =            12
 POP317W -# HISTORIES READ NOT = NUMBER SPECIFIED IN CREATE -- HEADER ADJUSTED.
 POP319W -DS UNORDERED ON IDENTIFIER -- MODIFY AND ADD CANNOT BE USED .
0    *** E N D   O F   C R E A T E ***
     NEW DATASET STORED IN FILE C:\POPAN5\MWEST06.BIN




     TITLE OF NEW DATASET :            FINAL ESTIMATE
     MIN (X(1)) =          1            BEGIN =          1
     MAX (X(T)) =         12              END =         12
     NUMBER OF HISTORIES ON NEW FILE =                  54
     HISTORIES WERE STORED USING  FORMAT(A8,    A2,2A1,(200A2,200A2,112A2))

     HISTORIES WERE READ USING FREE FORMAT
```

```
1**********************
 *                    *
 *  SELECT            *     FINAL ESTIMATE
 *  PARAGRAPH #   1   *     SELECT ALL
 *                    *
 **********************



0  SELECTED DATASET FILE = C:\POPAN5\MWEST06.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     12     12            54       NO         ORDER & RANGE       NO


  MAP OF NEW NUMBERING FOR SAMPLE TIMES

            OLD NUMBER                                                NEW NUMBER

    I       OX(I)      SDES(I)        ABS. TIMES     WEIGHTS          NX(I)    NEW SDES(I)      ABS. TIMES     WEIGHTS
    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           1
    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           1
    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
```

```
       OLD LSEL (ORIGINAL DATA) =   12

       NEW LSEL (REDUCED DATA)  =   12


  ATTRIBUTE SELECTION CONDITION WAS:
0   AT =ALL



1*********************
 *                   *
 *  UFIT             *     FINAL ESTIMATE
 *  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:
        t  =  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             *     FINAL ESTIMATE
 *  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              *     FINAL ESTIMATE
 *  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	14	0	1	13	0	3	0
2	11	3	2	9	3	2	0
3	11	0	0	11	0	3	2
4	49	3	11	38	3	7	2
5	67	7	17	50	7	14	2
6	71	9	7	64	9	9	7
7	82	13	14	68	13	20	3
8	105	15	13	92	15	26	8
9	119	24	20	99	24	38	10
10	99	38	7	92	38	13	10
11	34	10	3	31	10	4	13
12	45	17	28	17	17	0	0

```
0   # HISTORIES SCANNED USING EFFICIENT  SCAN          =         54 EQUALING         568 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
 POP357W -NO MARKED CAPTURES AT SAMPLE NO.   3      .
```

```
1**********************
 *                    *
 *  UFIT              *     FINAL ESTIMATE
 *  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:  -1328.131
         Number of  restrictions  applied:      7
         Number of  singular values found:      0
     Actual number of restrictions(nr-ns):      7


1**********************
 *                    *
 *  UFIT              *     FINAL ESTIMATE
 *  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 1
'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             *     FINAL ESTIMATE
 *  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	0.2308	0.1169	8.0000	2.8203	14.0000	3.7228
2	1.0000 G	0.0000	0.7443	0.5843	303.0613	187.0947	11.0000	3.3110
3	0.0355	0.0241	0.7800	0.5147	0.0000 L	0.0000	309.7603	189.7442
4	0.2028	0.1578	0.2908	0.1226	68.9275	63.8477	241.6062	185.9775
5	0.4927	0.2058	1.0000 G	0.0000	332.3172	134.7758	135.9879	56.6624
6	0.1573	0.0497	0.2068	0.0614	54.4742	41.9304	451.3051	135.0723
7	0.5603	0.1644	0.5538	0.1412	229.8639	81.6409	146.3385	43.1313
8	0.3464	0.1060	0.4160	0.0824	127.4625	50.6047	303.1538	90.9614
9	0.4795	0.0992	0.8698	0.2283	84.9064	51.0984	248.1776	50.6803
10	0.3494	0.0997	0.6627	0.3317	168.5932	84.7183	283.3725	79.0160
11	0.0967	0.0455	0.1290	0.0602	0.0000 L	0.0000	351.7500	156.1771
12	1.0000 G	0.0000	0.0000 U	0.0000 U	1391.6061	213.2902	45.0000	6.5999

0 ESTIMATE TABLE CONTINUED

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	15.2499	6.1321	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X
2	350.0027	189.6564	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X
3	0.0000	0.0000	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X
4	120.0417	106.0121	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X
5	332.3172	134.7758	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X
6	108.2423	83.5548	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X
7	304.4323	92.2268	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X
8	191.4196	72.2055	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X
9	90.9665	50.1382	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X
10	205.6446	75.5500	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X
11	0.0000	0.0000	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X	0.0000 X
12	1732.3170	193.7950	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