CALIFORNIA DEPARTMENT OF FISH AND GAME
ENVIRONMENTAL SERVICES DIVISION
Stream Evaluation Program

Upper Sacramento River
Late-Fall-Run Chinook Salmon Escapement Survey
December 1997 - May 1998

by

Bill Snider
Bob Reavis
and
Scott Hill

Stream Evaluation Program
Technical Report No. 98-4
July 1998

CALIFORNIA DEPARTMENT OF FISH AND GAME
ENVIRONMENTAL SERVICES DIVISION
Stream Evaluation Program

Upper Sacramento River
Late-Fall-Run Chinook Salmon Escapement Survey
December 1997 - May 1998 [1/,2/]

by

Bill Snider
Bob Reavis
and
Scott Hill

July 1998

1/ This work was supported by funding provided by U.S. Fish and Wildlife, Service Central Valley Anadromous Fish Restoration Program as part of a cooperative agreement with the California Department of fish and Game pursuant to the Central Valley Project Improvement Act (PL. 102-575).

2/ Stream Evaluation Technical Report No. 98-4.

SUMMARY

A late-fall-run chinook salmon *Oncorhynchus tshawytscha* escapement survey was conducted in the upper Sacramento River during winter and spring 1997 - 1998 to acquire data on spawner abundance, age and sex composition of the spawner population, pre-spawning mortality and temporal and spatial distribution of spawning. The 1997-1998 survey is a part of a multi-year investigation by the DFG to determine salmon habitat requirements in the Sacramento River system. This was the second year we conducted a late-fall-run carcass survey on the upper Sacramento River. During the first survey, initiated in January 1996, high flows and extremely poor visibility forced suspension of the survey in late January. Poor survey conditions are typical during the late-fall-run spawning period. The duration of suitable survey conditions can range from less than a few days to several months.

Weekly surveys were conducted from 29 December 1997 through 1 May 1998. The surveys covered a 16.5-mile section of the Sacramento River located between Anderson-Cottonwood Irrigation District dam (ACID), at river mile (RM) 298.5, and Anderson River Park (RM 282.0). ACID dam is 3.5 miles downstream of Keswick Dam the upstream limit to salmon migration. Mean flow ranged from 4,200 cubic feet per second (cfs) during survey periods 1 and 2 (29 December 1997 through 7 January 1998), to 52,800 cfs in survey period 7 (9 - 10 February 1998). Mean water clarity ranged from 2 feet during survey periods 8 through 10 (19 February through 3 March 1998) and during survey period 13 (25 - 26 March 1998), to 12 feet during survey period 4 (20 - 22 January 1998). Mean water temperatures ranged from 47^{o} F in survey period 13 (25 - 26 March) to 54^{o} F in survey period 18 (30 April - 1 May 1998).

We examined 847 late-fall-run carcasses (182 fresh and 665 decayed), and measured (length) and sexed 179 fresh carcasses. Forty percent of the spawner population were male adults (>2-years old), 49% were female adults, 7% were male grilse (2-years old), and 4% were female grilse. We examined 91 fresh female carcasses for egg retention. Of these, 85 (93%) had completely spawned; 1 (1%) still contained a substantial number of eggs; and 5 (6%) were unspawned.

The number of carcasses observed was adversely affected by water clarity (Secchi disk readings ranged from only 2 to 4 feet during 12 weeks of the survey) and high flows (weekly averages were greater than 30,000 cfs or greater during 6 weeks of the survey). Peak carcass recovery occurred during the second survey period (5 - 7 January) when clarity was 11 ft..

The total spawner escapement of 9,717 (1,069 grilse and 8,648 adults) was estimated using the Peterson formula. The Peterson formula was used because there were no recoveries from 10 of the 17 tag groups released. The Schaefer and Jolley-Seber models are more credible but require that there be recoveries from most all of the tag groups released.

INTRODUCTION

The California Department of Fish and Game's (DFG) Stream Evaluation Program (STEP) conducted an intensive late-fall-run chinook salmon *Oncorhynchus tshawytscha* escapement survey on the upper Sacramento River during the winter-spring period of 1997-98 to estimate spawner abundance and distribution. This survey was carried out to fulfill the mandates of Section 3406(b)(1)(B) of the Central Valley Project Improvement Act (CVPIA), P.L. 102-575, which requires the Secretary of the Interior to determine instream flow needs for all Central Valley Project controlled streams and rivers. Flow-need recommendations are to be provided to the Secretary by the U. S. Fish and Wildlife Service (FWS) after consultation with the DFG. In response to this Act, the FWS and the DFG have signed a "Cooperative Agreement" by which the FWS will fund the DFG to conduct studies to determine flow needs of salmonids in the upper Sacramento River.

The primary charge of STEP - to improve understanding of the relationships between anadromous salmonids and habitat in the upper Sacramento River - requires reliable estimates of the spawner population to help distinguish habitat versus population influences on temporal and spatial spawning distribution (Snider and McEwan 1992, Snider *et al*. 1993, Snider and Vyverberg 1995). Changes in spawning activity related to changes in flow and temperature need to be distinguished from changes due to population size. Spawning density, redd superimposition, habitat use, and other parameters can be affected by both changes in habitat conditions (flow dependent) and spawner population size. A reliable population estimate developed concurrently with redd surveys allows this distinction. An intensive spawning escapement survey also provides additional baseline information on egg retention (pre-spawning mortality), age and sex composition, and behavior relative to habitat conditions and population size.

Carcass tag-and-recapture surveys have been regularly used to estimate fall-run chinook salmon spawner escapements in Central Valley tributary streams (e.g., American, Yuba, and Feather rivers). During these surveys, carcasses are tagged and released into running water for later recapture. This protocol was initially used in the Central Valley in 1973 to estimate the Yuba River escapement (Taylor 1974). This is the second year a carcass tag-and-recapture survey was conducted in the upper Sacramento River to estimate late-fall-run escapement. A late-fall-run carcass survey attempted in 1996, but was severely hampered by high flows.

Three models have been used by the DFG to estimate escapement based on carcass tag-and-recovery data: Petersen (Ricker 1975), Schaefer (1951) and Jolly-Seber (Seber 1982). The Petersen model is the simplest but least accurate (Law 1994). It has been used primarily when data are insufficient to allow calculation with the other models. It is occasionally used to calculate estimates for small spawner populations (e.g., recent upper Sacramento River winter-run populations). A modification of the Schaefer model has been used in "larger" Central Valley tributary streams since 1973 when it was first used to estimate the Yuba River escapement. The

Schaefer and Jolly-Seber models have been used during the last 3 seasons to estimate fall-run

salmon escapement for the upper Sacramento River (Snider *et. al.* 1997 and Snider *et. al.* 1996)

Based on Law's (1994) analysis, the Schaefer model will overestimate escapement when carcass "survival" (carry-over from week-to-week) and recovery rates are equivalent to those typically observed in Central Valley tributaries. Similarly, based on Law's (1994) analysis, the Jolly-Seber model will slightly underestimate Central Valley spawner escapement. This model was first used to estimate escapement in the Central Valley in 1988. The Jolly-Seber model is more accurate when model assumptions are met and recovery rates are $\geq$10% (Boydstun 1994, Law 1994). Still, there is considerable disagreement about model use among fisheries managers responsible for estimating spawner escapement for California streams. They believe that population estimates obtained by the Jolly-Seber model are too low (Fisher and Meyer, pers. comm.)[1]. Law (1994) states that both models could produce low estimates if the basic assumption of equal mixing of tagged carcasses with all carcasses is violated, resulting in the recaptured carcasses constituting a different subpopulation.

METHODS

The 1998 late-fall-run salmon spawner escapement surveys were conducted from 29 December 1997 through 1 May 1998. The 16.5-mile-long stream segment from ACID dam (RM 298.5) downstream to Anderson River Park (RM 282; Figure 1) was divided into three reaches (Table 1). Each reach was surveyed once per week.

Table 1. Location of survey reaches during the upper Sacramento River late fall-run chinook salmon escapement survey, December 1997 - May 1998.

Reach	Location	River mile (length in miles)
1	ACID Dam to Cypress St. Bridge	298.5 - 295.0 (3.5)
2	Cypress St. Bridge to Bonnyview Bridge	295.0 - 292.0 (3.0)
3	Bonnyview Bridge to Anderson River Park	292.0 - 282.0 (8.0)

Surveys were primarily conducted using one boat with two observers per boat. The observers attempted to locate and collect carcasses as the boat traversed the river between the channel margins. Collected carcasses were checked for completeness (i.e., with the head intact) and previous tags. Complete, untagged carcasses were usually tagged by attaching a colored ribbon (to indicate survey period tagged) to the jaw using a hog ring. Carcasses that were not tagged

1 Personal communication with Frank Fisher (DFG-Inland Fisheries Division, Red Bluff) and Fred Meyer (DFG Region 2, Sacramento (retired)).

were chopped in half. Chopped carcasses included: i) those previously tagged, ii) those on shore in a "leathery condition"; and, iii) those in the lower end of Reach 3 (the most downstream reach) that would likely wash out of the survey area and never be recovered. Tagged carcasses were released into running water for recapture. Data collected to estimate population size included number tagged, number chopped, and number recovered.

All carcasses were examined for eye clarity and gill color to determine freshness. Carcasses were considered fresh if either eye was clear or gills were pink. Data collected from a subsample of the fresh carcasses included gender, fork length (FL) in centimeters, reach of the stream that each carcass was observed, and egg retention for females. Females were classified as spent if few eggs were remaining; as partially spent if a substantial amount of the eggs remained; and unspent if the ovaries appeared nearly full of eggs. Carcasses were also examined for adipose-fin marks indicating presence of a coded-wire tag.

Our objective was to estimate the late-fall-run salmon natural escapement in the upper Sacramento River, preferably using the more accepted Schaefer or Jolly-Seber models. since there were no recoveries from 10 of the 17 released tag groups, these models could not be used. We instead used the Peterson model.

Flow measurements for each survey day were obtained from the Keswick gauge operated by the U.S. Geological Survey. Water temperature (grab sample) and water visibility (Secchi depth) were measured daily by the survey crew.

RESULTS AND DISCUSSION

A total of 847 carcasses was observed (Table 2). Mean flow ranged from 4,200 cubic feet per second (cfs) during the first and second survey periods (29 December 1997 - 7 January 1998) to 52,800 cfs during survey period 7 (9 - 10 February); flow was greater than 20,000 cfs during half of the periods surveyed (Table 2, Figure 2). Mean temperature ranged from 47° F during survey period 13 (25 - 56 March 1998) to 54° F during survey period 18 (30 April - 1 May 1998) (Table 2, Figure 2). Water clarity (Secchi depth) ranged from 2 ft in survey period 13 to 12 ft in survey period 4, and averaged 4 ft or less in 12 of the 18 survey periods surveyed (Table 2, Figure 2).

Temporal Distribution

Most (58%) of the 847 carcasses observed during the survey were seen during the first 2 survey periods (Table 2 and Figure 3). After the second period, poor survey conditions (high flows and reduced water clarity) caused by heavy rains, likely resulted in fewer carcasses being counted.

Table 2. General survey information for the upper Sacramento River late-fall-run chinook salmon escapement survey, December 1997 - May 1998.

Survey period	Survey dates	Flows (cfs)[1/]	Secchi depth (ft)[2/]	Water temperature (^{O}F)[2/]	Carcass count[3/]	
					Fresh	Decayed
1	Dec 29 - 31 (1997)	4,200	10	51	60	160
2	Jan 5 - 7	4,200	8	48	61	211
3	Jan 12 - 14	5,100	6	48	25	66
4	Jan 20 - 22	29,500	12	50	7	38
5	Jan 26 - 28	31,000	11	49	6	14
6	Feb 2 - 5	29,400	3	48	3	85
7	Feb 9 - 10	52,800	3	48	2	6
8	Feb 19 - 20	30,000	2	48	5	26
9	Feb 23 - 24	36,200	2	48	1	5
10	Mar 2 - 3	38,700	2	48	0	1
11	Mar 11 - 12	11,600	3	48	1	13
12	Mar 18 - 20	8,900	4	49	1	3
13	Mar 25 - 26	44,000	2	47	1	0
14	Apr 2	23,800	4	48	1	5
15	Apr 7 - 9	6,800	4	49	0	9
16	Apr 15 - 17	6,000	4	49	2	11
17	Apr 23 - 24	10,000	5	51	0	1
18	Apr 30 - May 1	10,900	4	54	5	11
				Totals	182	665

1/ Mean flow during days sampled as measured at Keswick Dam by U.S. Bureau of Reclamation.
2/ Mean of daily measurements taken by survey crews.
3/ Includes both adults and grilse.

Spatial Distribution

The distribution of the total carcasses observed per reach was 62% in Reach 1, 19% in Reach 2, and 19% in Reach 3 (Table 3 and Figure 4).

Size Distribution

A total of 179 carcasses was measured (Table 4). Mean size was 84.0 cm FL. Size ranged from 42 to 112 cm FL. Male salmon (n = 84) averaged 86.0 cm FL (range: 42 - 112 cm FL) (Figure 5). Female salmon (n = 95) averaged 82.2 cm FL (range: 50 - 100 cm FL) (Figure 6). The weekly mean size for males ranged from 71.0 to 96.0 cm FL (Figure 7). Weekly mean size for females ranged from 72.0 to 89.0 cm FL (Table 4 and Figure 8).

Length-frequency distributions were used to define a general size criterion distinguishing grilse (2-year-old salmon) and adults (>2-year-old salmon) for each sex (Figures 5 and 6). Both male (n=12) and female (n=8) grilse were defined as salmon $\leq$ 70 cm FL (Table 5). Male grilse averaged 59.6 cm FL (range: 42 - 70 cm FL, SD=9.3); male adults (n=72) averaged 90.4 cm FL (range: 71 - 112 cm FL, SD=9.7). Female grilse averaged 64.4 cm FL (range: 50 - 70 cm FL, SD=7.0); female adults (n=87) averaged 83.8 FL (range: 71 - 100 cm FL, SD=6.7).

Grilse comprised 11% (20) of the 179 measured carcasses (Table 6). The greatest numbers of grilse (13) were observed in the first 2 survey periods (29 December 1997 - 7 January 1998) (Figure 9). Adults comprised 89% (159) of the carcasses measured. The greatest number of adults (108) was also observed during survey periods 1 and 2.

Sex Composition

Males comprised 45% (n = 72) of the fresh adult carcasses examined and females comprised 55% (n=87)(Table 7). Males comprised 60% (n=12) and females comprised 40% (n=8) of the fresh grilse observed. Females comprised 53% (n=95) and males comprised 47% (n=84) of all fresh carcasses measured.

The female to male ratio for adult spawners was nearly 1.2:1 (87:72) (Table 7 and Figure 10). Females made up at least half of the adult population throughout the survey period. Male grilse were only observed during the first 3 survey periods while female grilse observations were scattered throughout the survey (Figure 11).

Table 3. Distribution of carcass (adults and grilse) observed during the upper Sacramento River late-fall-run chinook salmon escapement survey, September - December 1997.

Survey period	Reach 1		Reach 2		Reach 3	
	M[1/]	C[2/]	M	C	M	C
1	131	1	45	1	42	0
2	132	32	33	15	49	11
3	38	8	28	8	6	3
4	37	5	1	0	2	0
5	7	1	7	2	2	2
6	43	26	0	2	10	7
7	1	0	0	0	5	2
8	19	4	6	2	0	0
9	5	0	0	1	0	0
10	0	0	0	0	0	1
11	5	1	0	1	4	3
12	3	0	1	0	0	0
13	1	0	0	0	0	0
14	2	1	0	3	0	0
15	3	2	2	1	1	0
16	5	1	2	0	3	2
17	1	0	0	0	0	0
18	0	6	0	4	0	6
Total	433	88	125	40	124	37

1/ Number of carcasses tagged.
2/ Number of untagged carcasses chopped.

Table 4. Size and sex statistics for fresh late-fall-run chinook salmon carcasses measured during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

	All salmon			Male salmon			Female salmon		
		Length (FL in cm)			Length (FL in cm)			Length (FL in cm)	
Survey period	Number measured	Mean	Range	Number measured	Mean	Range	Number measured	Mean	Range
1	60	83.6	42-112	36	85.9	42-112	24	84.3	69-100
2	61	82.1	47-111	31	86.2	47-111	30	80.6	69-96
3	22	83.6	60-95	11	85.4	68-94	11	82.3	60-95
4	7	80.7	69-93	0	-	-	7	80.7	69-93
5	7	85.3	79-91	1	91.0	-	6	85.6	79-87
6	3	81.3	67-89	0	-	-	3	81.3	67-89
7	2	91.0	87-95	1	95.0	-	1	87.0	-
8	5	81.6	50-100	2	96.0	92-100	3	72.0	50-85
9	1	87.0	-	0	-	-	1	87.0	-
10	0	-	-	0	-	-	0	-	-
11	1	87.0	-	0	-	-	1	87.0	-
12	1	91.0	-	0	-	-	1	91.0	-
13	1	87.0	-	0	-	-	1	87.0	-
14	1	87.0	-	0	-	-	1	87.0	-
15	0	-	-	0	-	-	0	-	-
16	2	80.0	-	1	71.0	-	1	89.0	-
17	0	-	-	0	-	-	0	-	-
18	5	78.2	61-91	1	73.0	-	4	79.5	61-91
Total (mean)	179	(84.0)	42-112	84	(86.0)	42-112	95	(82.2)	50-100

Table 5. Summary of adult and grilse sizes and numbers by sex for carcasses measured during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

	Female		Male	
	Grilse	Adults	Grilse	Adults
Number	8	87	12	72
Mean FL (cm)	64.4	83.8	59.6	90.4
Range FL (cm)	50-70	71-100	42-70	71-112
S D	7.0	6.7	9.3	9.7

Table 6. Age composition (grilse and adult) of carcasses measured during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

	Adults		Grilse	
Survey period	Number	Percent	Number	Percent
1	52	87	8	13
2	56	92	5	8
3	19	86	3	14
4	6	86	1	14
5	7	100	0	0
6	2	67	1	33
7	2	100	0	0
8	4	80	1	20
9	1	100	0	0
10	0	-	0	-
11	1	100	0	0
12	1	100	0	0
13	1	100	0	0
14	1	100	0	0
15	0	-	0	-
16	2	100	0	0
17	0	-	0	-
18	4	80	1	20
Total(mean)	159	(89)	20	(11)

Table 7. Sex composition of late-fall-run chinook salmon grilse and adults carcasses measured during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

Survey period	Adults				Grilse*			
	Male		Female		Male		Female	
	Number	%	Number	%	Number	%	Number	%
1	29	51	23	49	7	88	1	12
2	27	48	29	52	4	80	1	20
3	10	53	9	47	1	33	2	67
4	0	0	6	100	0	0	1	100
5	1	14	6	86	0	-	0	-
6	0	0	2	100	0	0	1	100
7	1	50	1	50	0	-	0	-
8	2	50	2	50	0	0	1	100
9	0	0	1	100	0	-	0	-
10	0	-	0	-	0	-	0	-
11	0	0	1	100	0	-	0	-
12	0	0	1	100	0	-	0	-
13	0	0	1	100	0	-	0	-
14	0	0	1	100	0	-	0	-
15	0	-	0	-	0	-	0	-
16	1	50	1	50	0	-	0	-
17	0	-	0	-	0	-	0	-
18	1	25	3	75	0	0	1	100
Total (mean)	72	(45)	87	(55)	12	(60)	8	(40)

C Based on length-frequency distributions grilse are defined as $\leq$ 70 cm FL.

Spawning Success

Ninety-one females were examined for egg retention (Table 8). Ninety-three percent (85) had completely spawned, 1% (1) had only partially spawned, and 6% (5) had not spawned. At least 75% of the females checked per survey period had completely spawned.

Coded-wire-tag Recovery Data

Two of the observed carcasses contained coded-wire tags. Both were from tag-code group # 05-36-20 indicating they were 1994 brood year late-fall run chinook salmon released from Coleman National Fish Hatchery. One carcass was a 89.0 cm FL male that was recovered on 12 January 1998, and the other was a 77.0 cm FL female that was recovered on 7 January 1998.

Population Estimates

Carcasses were recovered from only 5 of the 16 tag groups precluding use of either the Schaefer or Jolly-Seber models. As such, both fresh and decayed adult carcasses data were combined to calculate an escapement estimate using the Peterson model. The adult escapement estimate of 8,648 adults was calculated using the following adjusted Petersen formula (3.7) as described by Ricker (1975)[2]: The adult estimate was then divided by 0.89 (portion of adults as determined from fresh carcass subsample) yielding a total population estimate of 9,717 (8,648 adult and 1,069 grilse). It should be noted that Law (1994) concluded the Petersen model consistently and substantially overestimated the total population compared to either the Schaefer or Jolly-Seber models.

The 1998 escapement of 9,717 is less than the 1967 - 1992 average of 14,159 for the section of stream from Keswick Dam to Red Bluff Diversion Dam (RBDD) (Table 12 and Figure 12). These estimates for the 1967 through 1992 period were based on RBDD ladder counts. Changes in operation of RBDD has eliminated the opportunity to count late-fall run since 1993.

2

$$N' \frac{(M\%1)(C\%1)}{(R\%1)}$$

Where, N = estimated spawning population for survey period,
M = number of carcasses marked during survey,
C = total number of carcasses examined during survey, and
R = number of marked carcasses recovered during survey.

Table 8. Summary of spawning completion (egg retention) determined from fresh female salmon carcasses measured during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

Survey period	No. females measured	No. females checked for egg retention	Number spawned (%)	Number partially spawned (%)	Number unspawned (%)
1	24	23	20(87)	1(4)	2(9)
2	30	28	27(96)	0(0)	1(4)
3	11	11	10(91)	0(0)	1(9)
4	7	7	7(100)	0(0)	0(0)
5	6	6	6(100)	0(0)	0(0)
6	3	3	3(100)	0(0)	0(0)
7	1	1	1(100)	0(0)	0(0)
8	3	2	2(100)	0(0)	0(0)
9	1	1	1(100)	0(0)	0(0)
10	0	0	-	-	-
11	1	1	1(100)	0(0)	0(0)
12	1	1	1(100)	0(0)	0(0)
13	1	1	1(100)	0(0)	0(0)
14	1	1	1(100)	0(0)	0(0)
15	0	0	-	-	-
16	1	1	1(100)	0(0)	0(0)
17	0	0	-	-	-
18	4	4	3(75)	0(0)	1(25)
Total (mean)	95	91	85(93)	1(1)	5(6)

Table 9. Summary of tagging and recapture of salmon carcasses (fresh and decayed) observed during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

Survey period	Date	Number observed		Number tagged		Number recovered (Original tagging period)
		Adults	Grilse	Adults	Grilse	
1	Dec 30-31	200	20	199	19	-
2	Jan 5-7	256	16	204	10	38*(1)
3	Jan 12-14	83	8	64	8	15(2), 3(1)
4	Jan 20-22	44	1	39	1	1(2)
5	Jan 26-28	19	2	15	1	1(4)
6	Feb 2-5	83	5	49	4	1(5), 1(4), 1(3)
7	Feb 9-10	8	0	6	0	0
8	Feb 19-20	30	1	24	1	0
9	Feb 23-24	6	0	5	0	2(8)
10	Mar 2-3	1	0	0	0	0
11	Mar 11-12	13	1	8	1	0
12	Mar 18-20	4	0	4	0	0
13	Mar 25-26	1	0	1	0	0
14	Apr 2	5	1	2	0	0
15	Apr 7-9	9	0	6	0	0
16	Apr 15-17	13	0	10	0	0
17	Apr 23-24	1	0	1	0	0
18	Apr 30 -May 1	14	2	0	0	0
Totals		790	57	637	45	63

* Includes one grilse

Table 10. Summary of tagging and recapture of late-fall-run chinook salmon carcasses (fresh) observed during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

Survey period	Date	Number observed*		Number tagged**		Number recovered (Original tagging period)
		Adults	Grilse	Adults	Grilse	
1	Dec 30-31	200	20	53	6	-
2	Jan 5-7	256	16	49	2	8+(1)
3	Jan 12-14	83	8	20	2	2(2)
4	Jan 20-22	44	1	6	0	0
5	Jan 26-28	19	2	13	0	0
6	Feb 2-5	83	5	3	0	1(5)
7	Feb 9-10	8	0	2	0	0
8	Feb 19-20	30	1	4	1	0
9	Feb 23-24	6	0	1	0	0
10	Mar 2-3	1	0	0	0	0
11	Mar 11-12	13	1	1	0	0
12	Mar 18-20	4	0	1	0	0
13	Mar 25-26	1	0	0	0	0
14	Apr 2	5	1	1	0	0
15	Apr 7-9	9	0	0	0	0
16	Apr 15-17	13	0	2	0	0
17	Apr 23-24	1	0	0	0	0
18	Apr 30 -May 1	14	2	0	0	0
Totals		790	57	156	11	11

* Includes total carcasses observed.
** Includes only tagged fresh carcasses.
\+ Includes one grilse.

Table 11. Annual late-fall-run chinook salmon escapement estimates (adults and grilse) for upper Sacramento River from Keswick Dam to RBDD, 1956 - 1998. (Data provided by Frank Fisher, DFG, Red Bluff).

Year	Total	Year	Total
1967	37,208	1983	13,274
1968	34,733	1984	5,907
1969	37,178	1985	7,660
1970	19,190	1986	6,710
1971	14,323	1987	14,443
1972	31,553	1988	10,683
1973	22,204	1989	9,875
1974	6,445	1990	6,921
1975	16,663	1991	6,531
1976	15,280	1992	10,371
1977	9,090	1993	no est.
1978	8,880	1994	no est.
1979	8,740	1995	no est.
1980	7,747	1996	no est.
1981	1,597	1997	no est.
1982	1,141	1998	9,717*

* Based on carcass counts.

CONCLUSIONS AND RECOMMENDATIONS

1. Flows in excess of 30,000 cfs and water clarity 3 ft or less greatly hampered carcass recovery. As a result, the temporal distribution (Table 2) may not accurately reflect the temporal spawning distribution of this race. The February carcass counts would have likely been considerable greater under more optimal recovery conditions.

2. There may have been several peaks in spawning activity during the January to May period that would likely have been observed under more stable flow and better water clarity conditions.

3. Surveys should be continued assuming conditions for survey could improve (e.g., during a dry year) to more precisely determine: (i) the length of the period this run spawns; (ii) if there is one clearly defined period this ran spawns or are there a series of peaks; (iii) the appropriateness of categorizing salmon spawning during the January through May period as late-fall run.

ACKNOWLEDGEMENTS

The California Department of Fish and Game recognizes the efforts of Chris Cox, Jon Ferguson, John Galos, Jeffrey Jahn, James Lyons, Warren Nichols, Mike Spiker, and Jonathan Sutliff. Their efforts in the collection of field data are greatly appreciated. The data collection was funded by the FWS as a part of a cooperative agreement with the DFG as authorized by the CVPIA (P.L. 102-575).

LITERATURE CITED

Boydstun, L.B. 1994. Evaluation of the Schaefer and Jolly-Seber methods for the fall-run chinook salmon, *Oncorhynchus tshawytscha,* spawning run into Bogus Creek, Upper Klamath River, Calif. Fish & Game 80(1):1-13.

Law, P.M.W. 1994. A simulation study of salmon carcass survey by capture-recapture method. Calif. Fish & Game 80(1):14-28.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Canada Dep of Environ., Fish. And Mar. Serv. Bull.191. 382 p.

Schaefer, M.B. 1951. Estimation of the size of animal population by marking experiments. USF&WS Bull. 52:189-203.

Seber, G.A.F. 1982. The estimation of animal abundance and related parameters. 2nd. MacMillan, New York, N.Y. 654 p.

Snider, B. and D. McEwan. 1992. Chinook salmon and steelhead trout redd survey: Lower American River, 1991 - 1992, Final report. Calif. Dept. Fish & Game, Envir. Serv. Div., Stream Flow and Habitat Evaluation Program.

Snider, B., B. Reavis and L. Hanson. 1997. Upper Sacramento River fall-run chinook salmon escapement survey, September - December 1995. Final report. Calif. Dept. Fish & Game, Envir. Serv. Div., Stream Flow and Habitat Evaluation Program.

Snider B., B. Reavis, and S. Hill. 1998. 1996 Upper Sacramento River fall-run chinook salmon Escapement survey, September - December 1996. Calif. Dept. Fish & Game, Envir. Serv. Div., Stream Habitat Evaluation Program.

Snider, B., K. Urquhart, D. McEwan, and M. Munos. 1993. Chinook salmon redd survey, lower American River, Fall 1992. Calif. Dept. Fish & Game, Envir. Serv. Div., Stream Flow & Habitat Evaluation Program.

Snider, B. And K. Vyverberg. 1995. Chinook salmon redd survey, lower American River, Fall, 1993. Calif. Dept. Fish & Game, Envir. Serv. Div., Stream Flow & Habitat Evaluation Program.

FIGURES

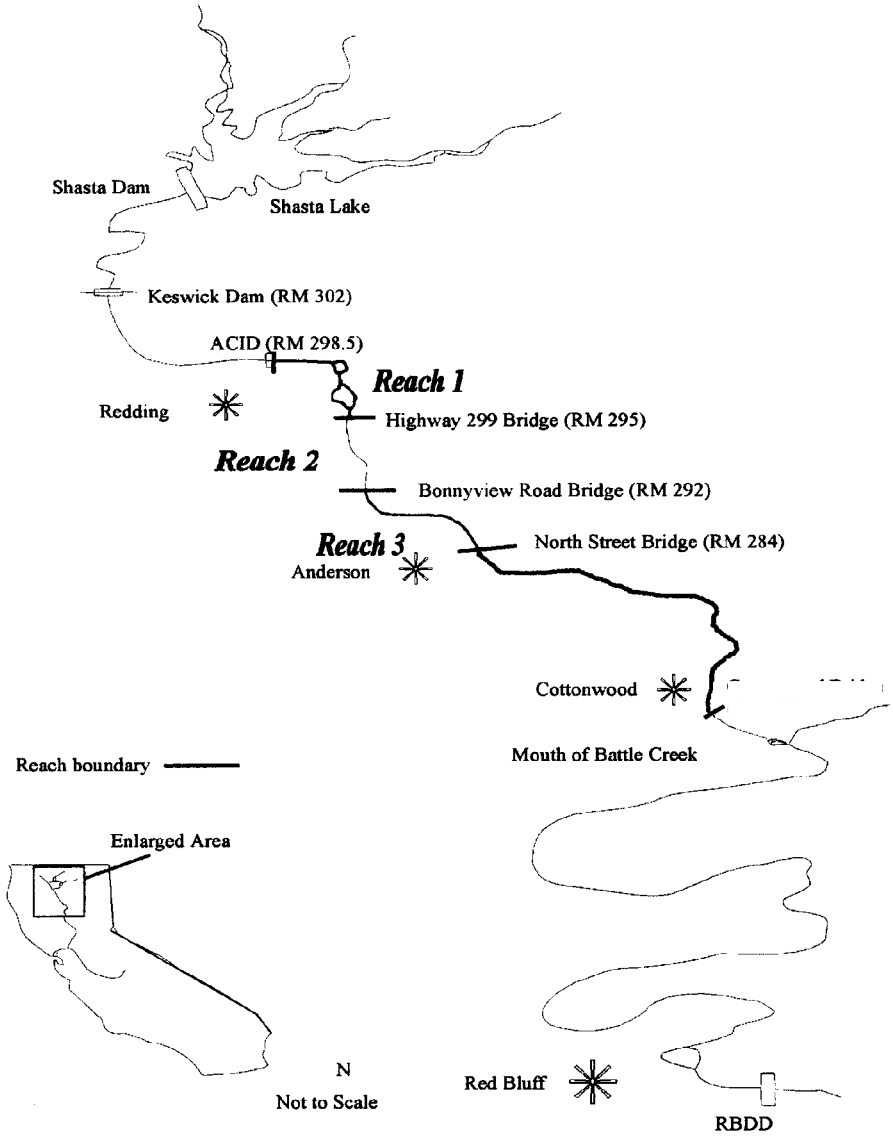

Figure 1. Location of sampling reaches in the upper Sacramento River late- fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

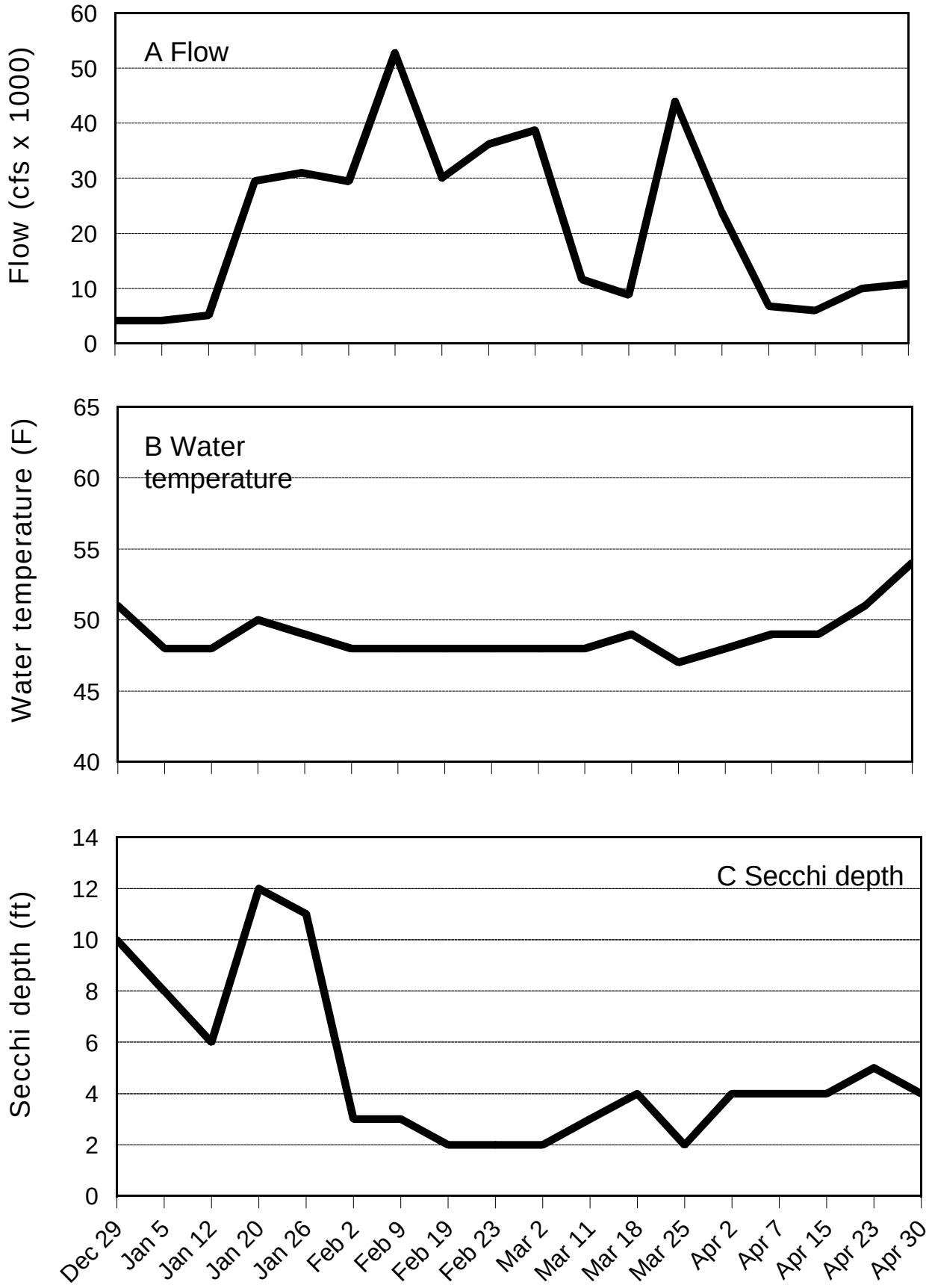

Figure 2. Mean daily flow (A) measured at Keswick Dam, water temperature (B) and secchi depth (C) during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

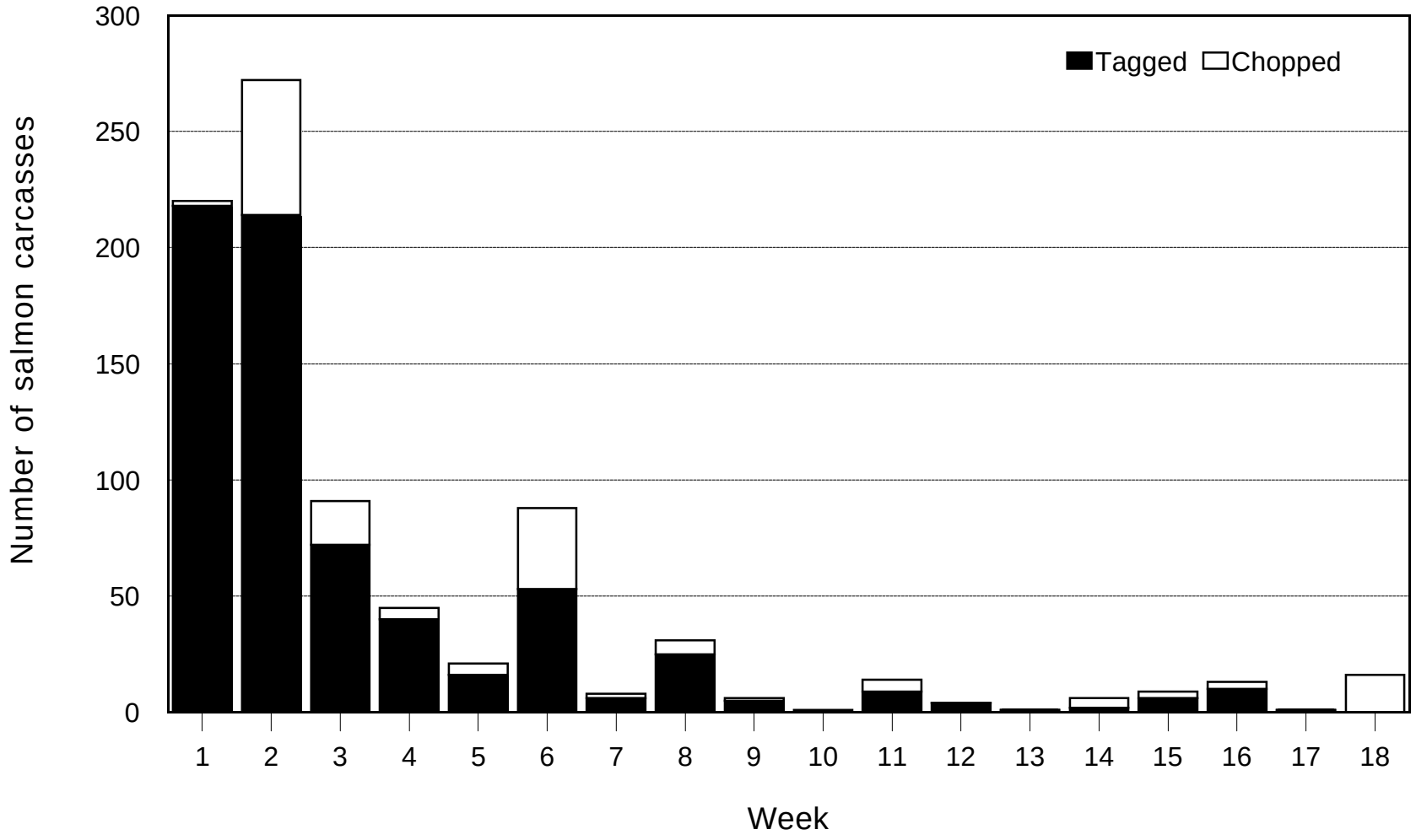

Figure 3. Weekly distribution of both fresh and decayed carcasses observed during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

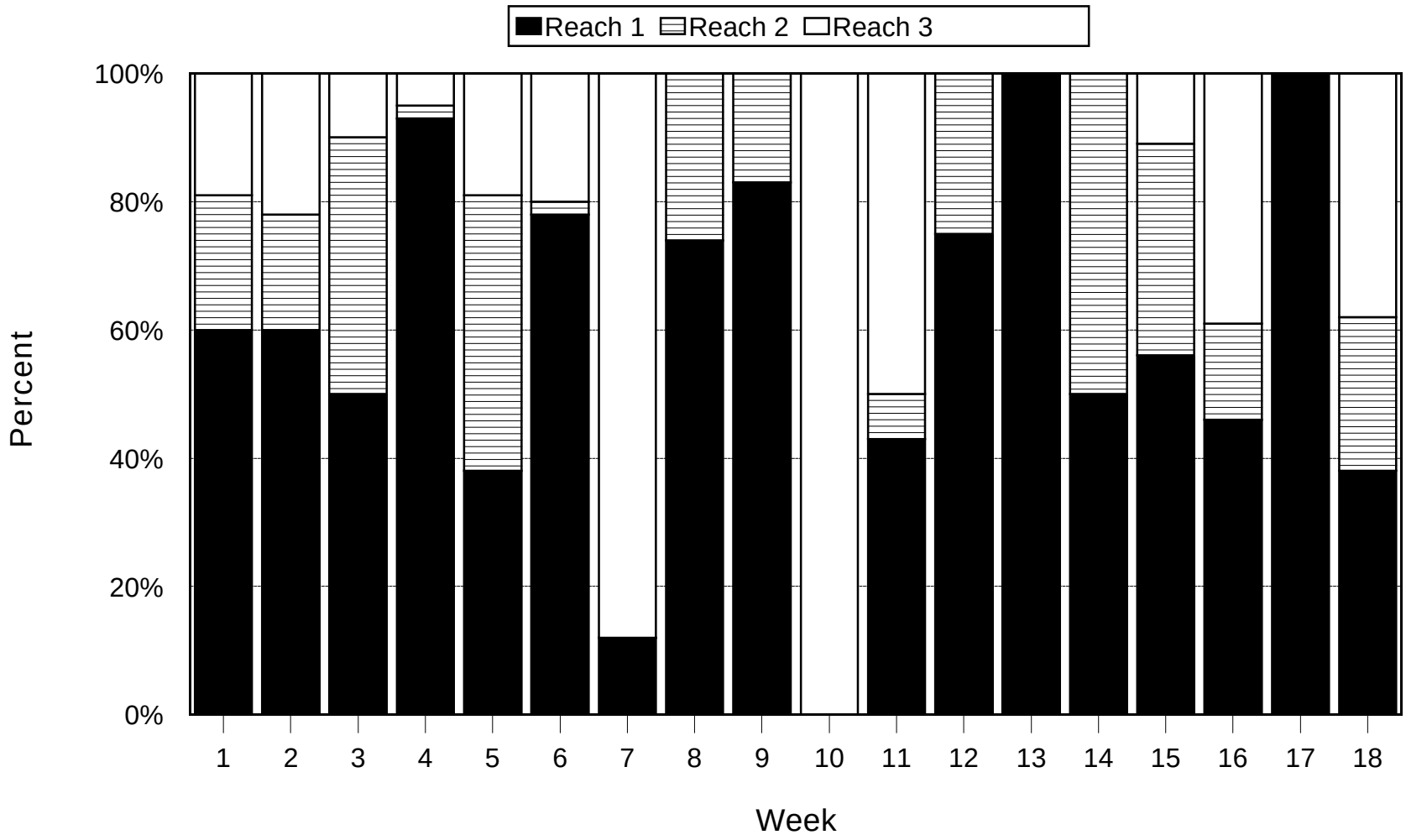

Figure 4. Weekly distribution (%) by reach of both fresh and decayed carcasses observed during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

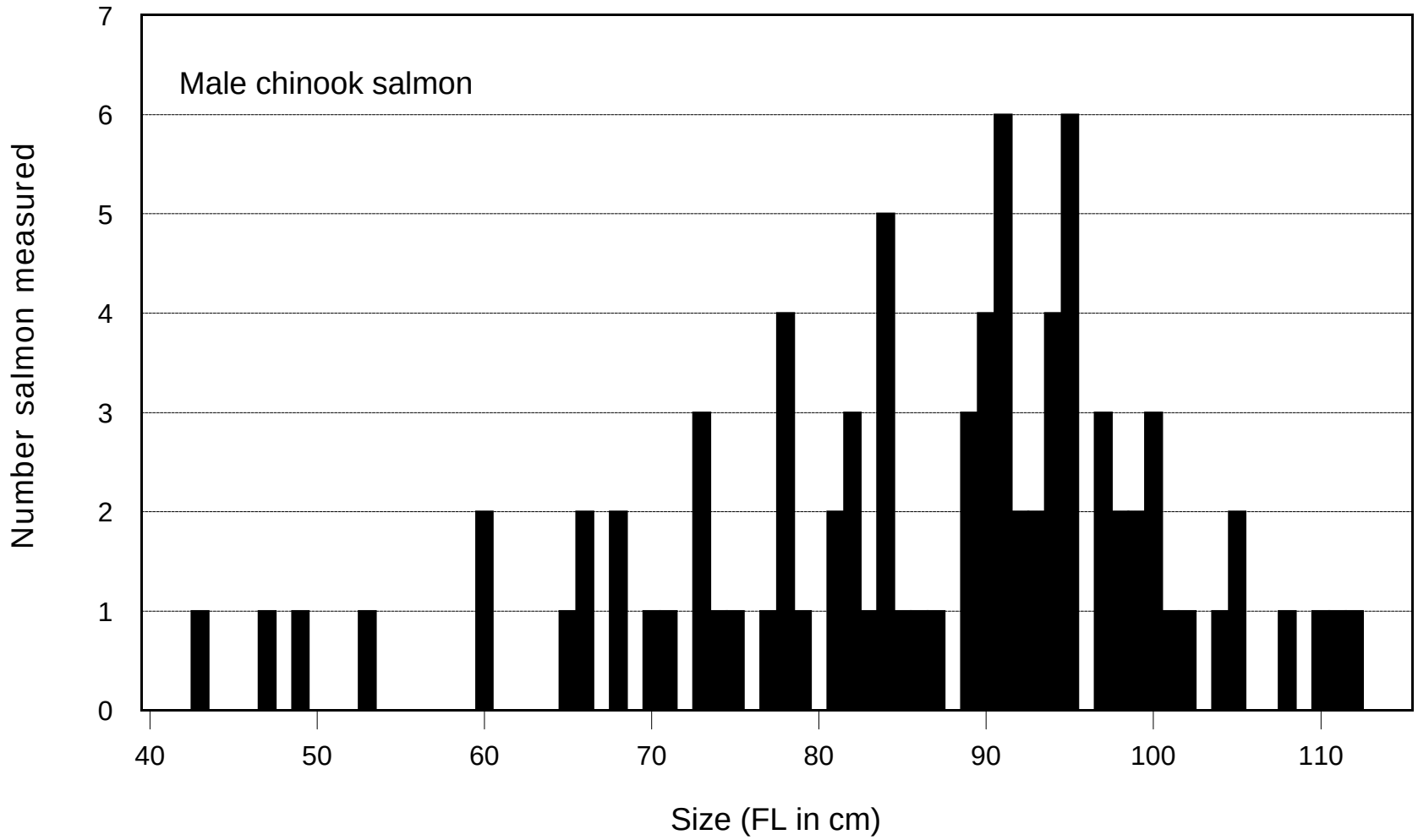

Figure 5. Size (FL in cm) distribution of male chinook salmon carcasses measured during the upper Sacramento River late-fall-run spawner escapement survey, December 1997 - May 1998.

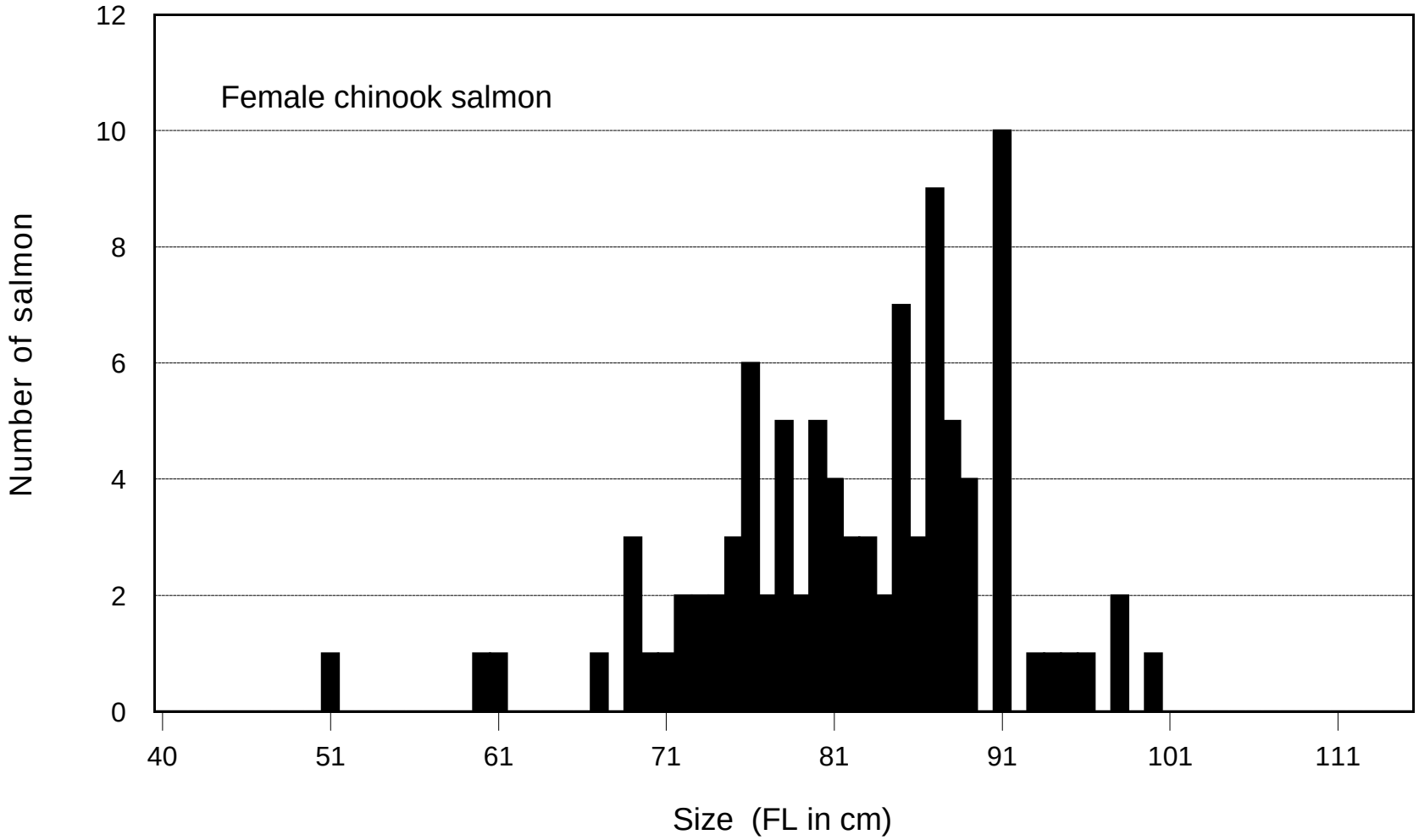

Figure 6. Size (FL in cm) distribution of female chinook salmon carcasses measured during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

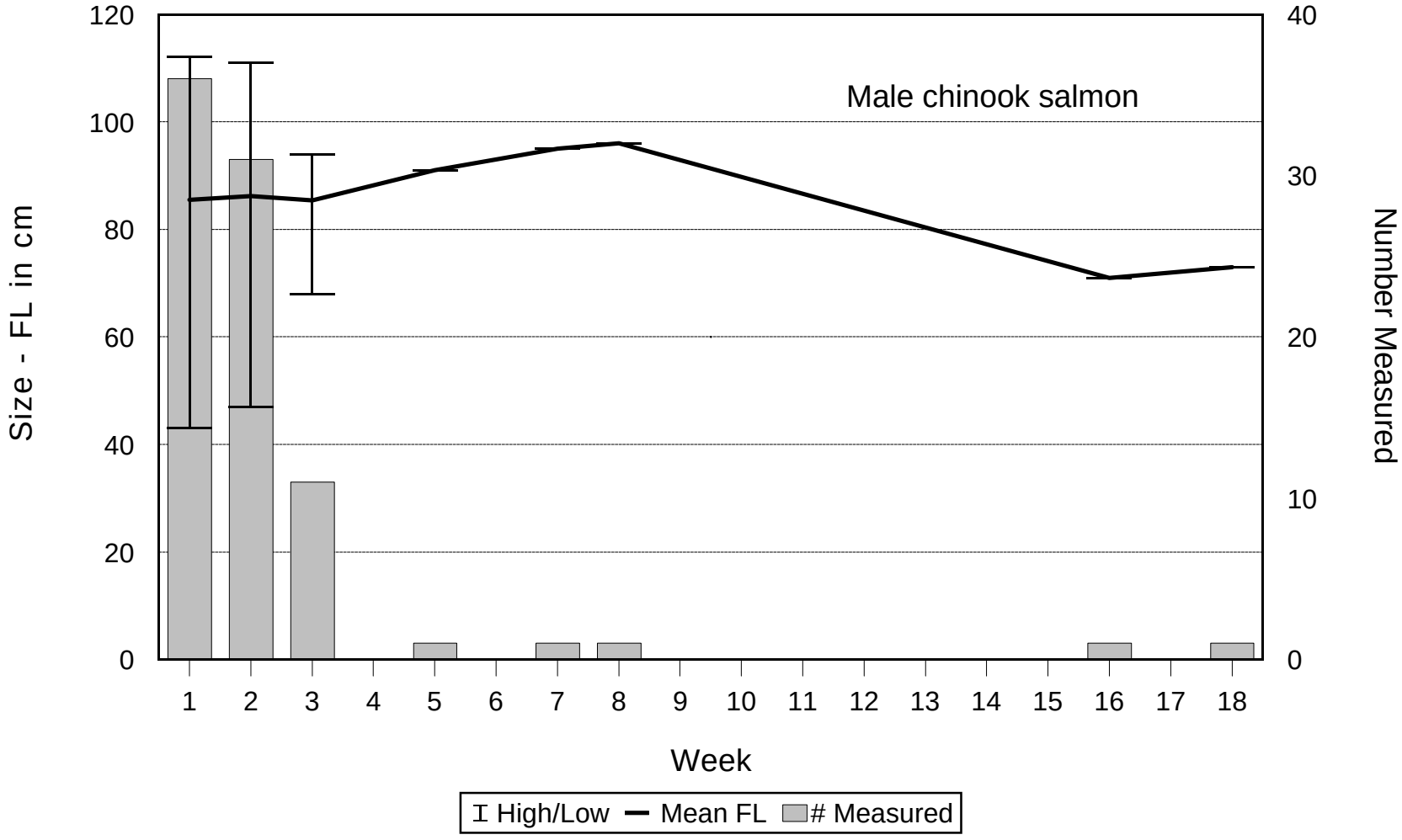

Figure 7. Mean size, size range, and number of male chinook salmon measured weekly during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

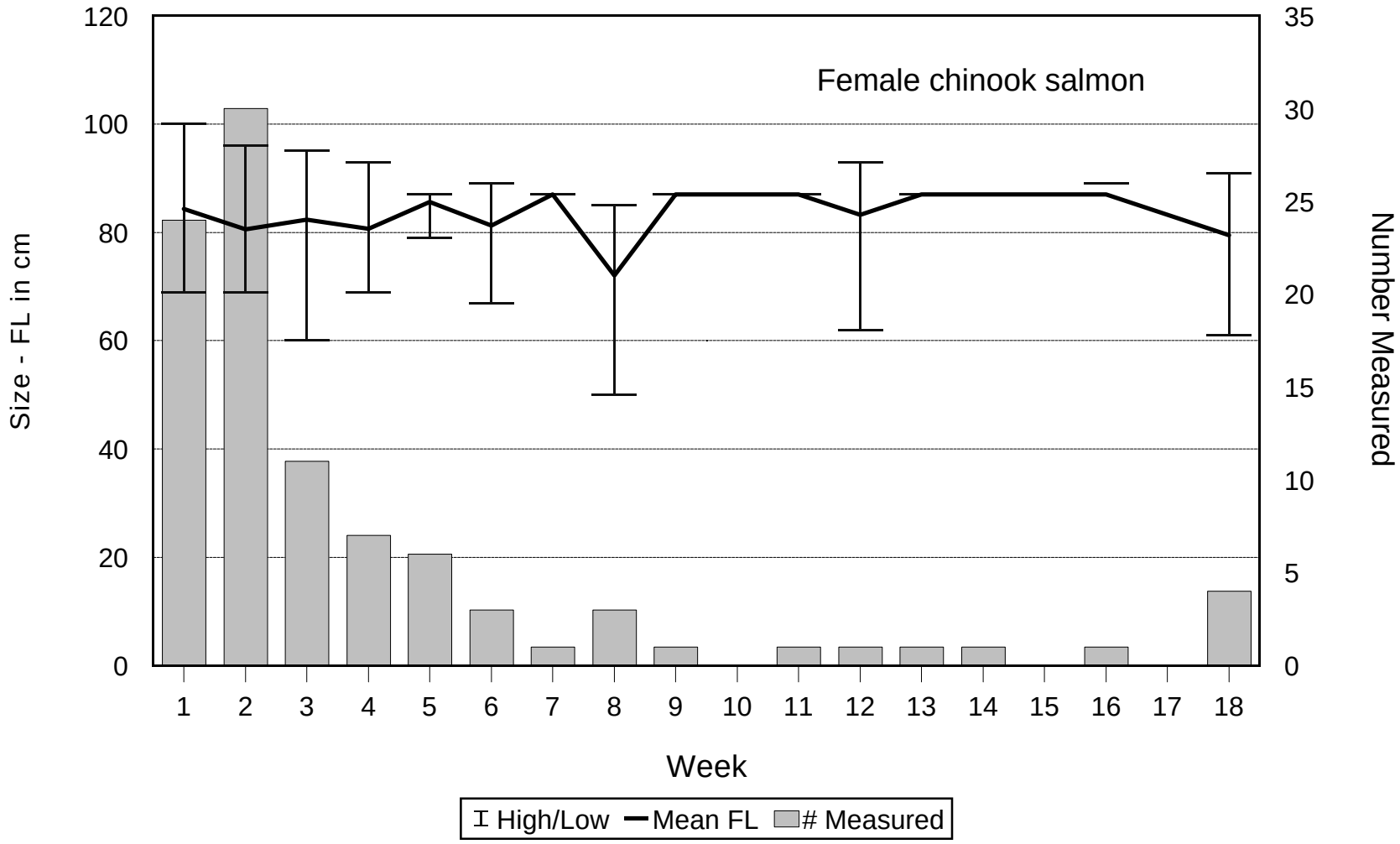

Figure 8. Mean size, size range, and number of female chinook salmon measured weekly during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

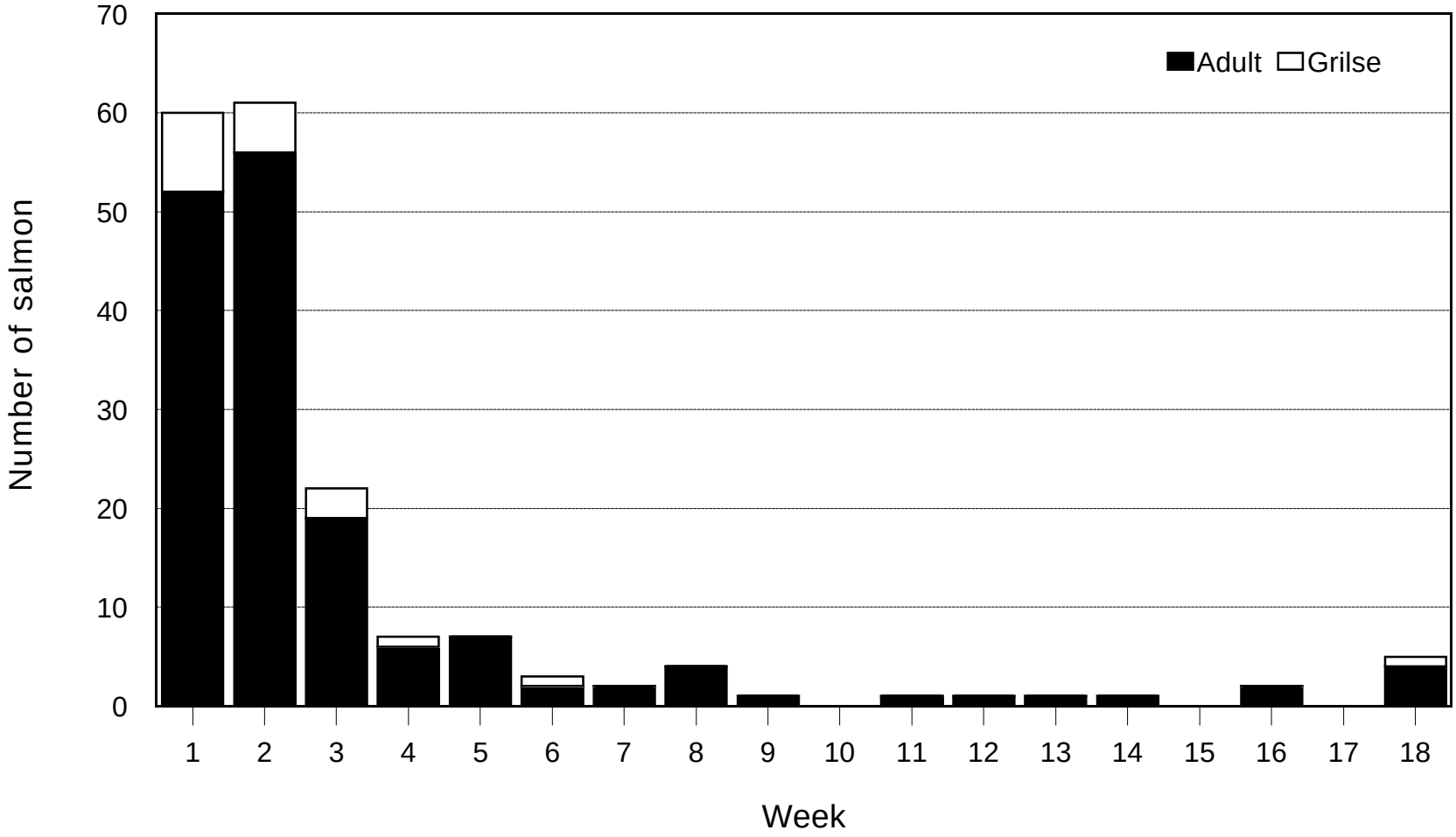

Figure 9. Age compostion of chinook salmon measured during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

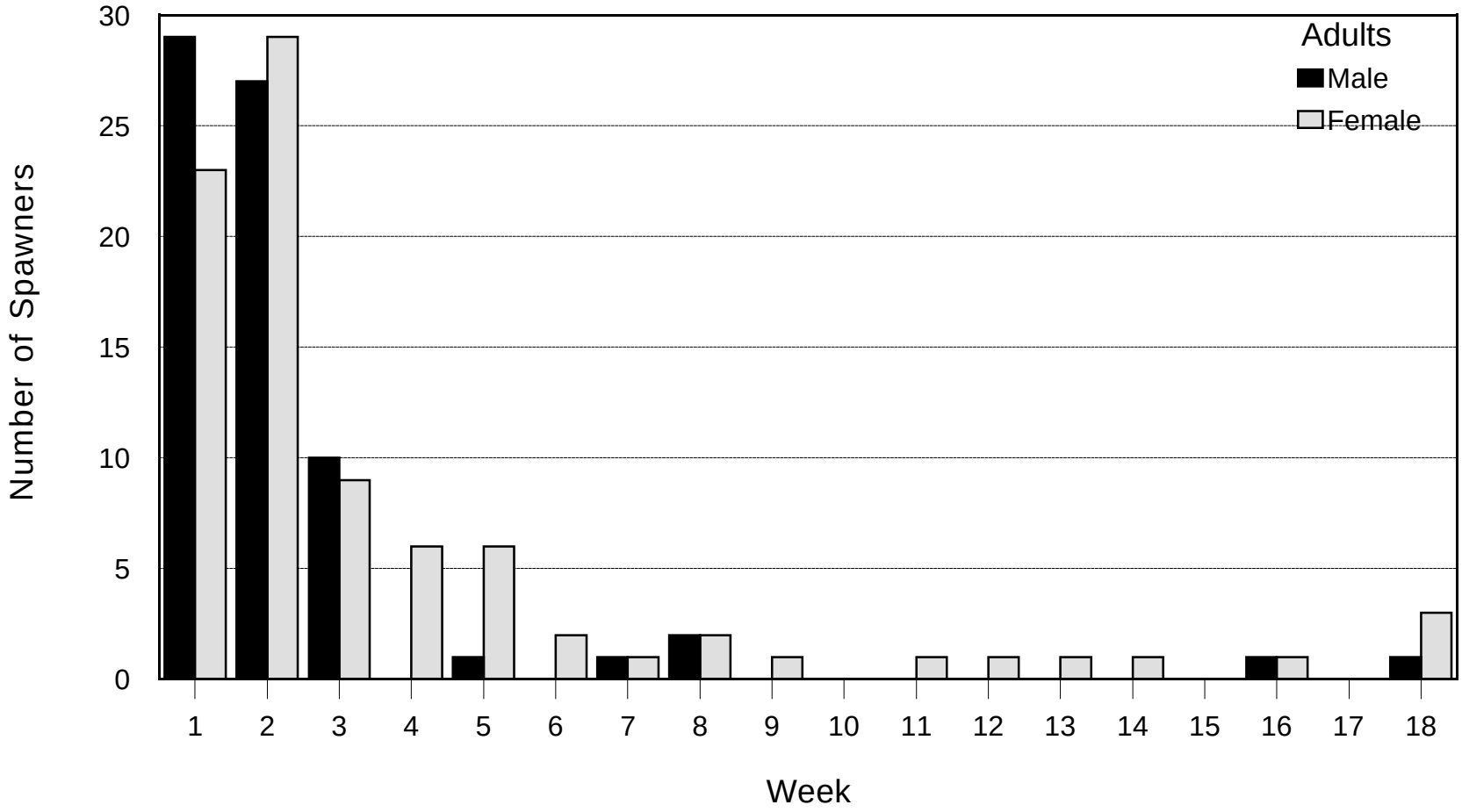

Figure 10. Weekly distribution of the sex of adult-sized chinook salmon measured during the upper Sacramento River late-fall-run chinook salmon escapement survey, December 1997 - May 1998.

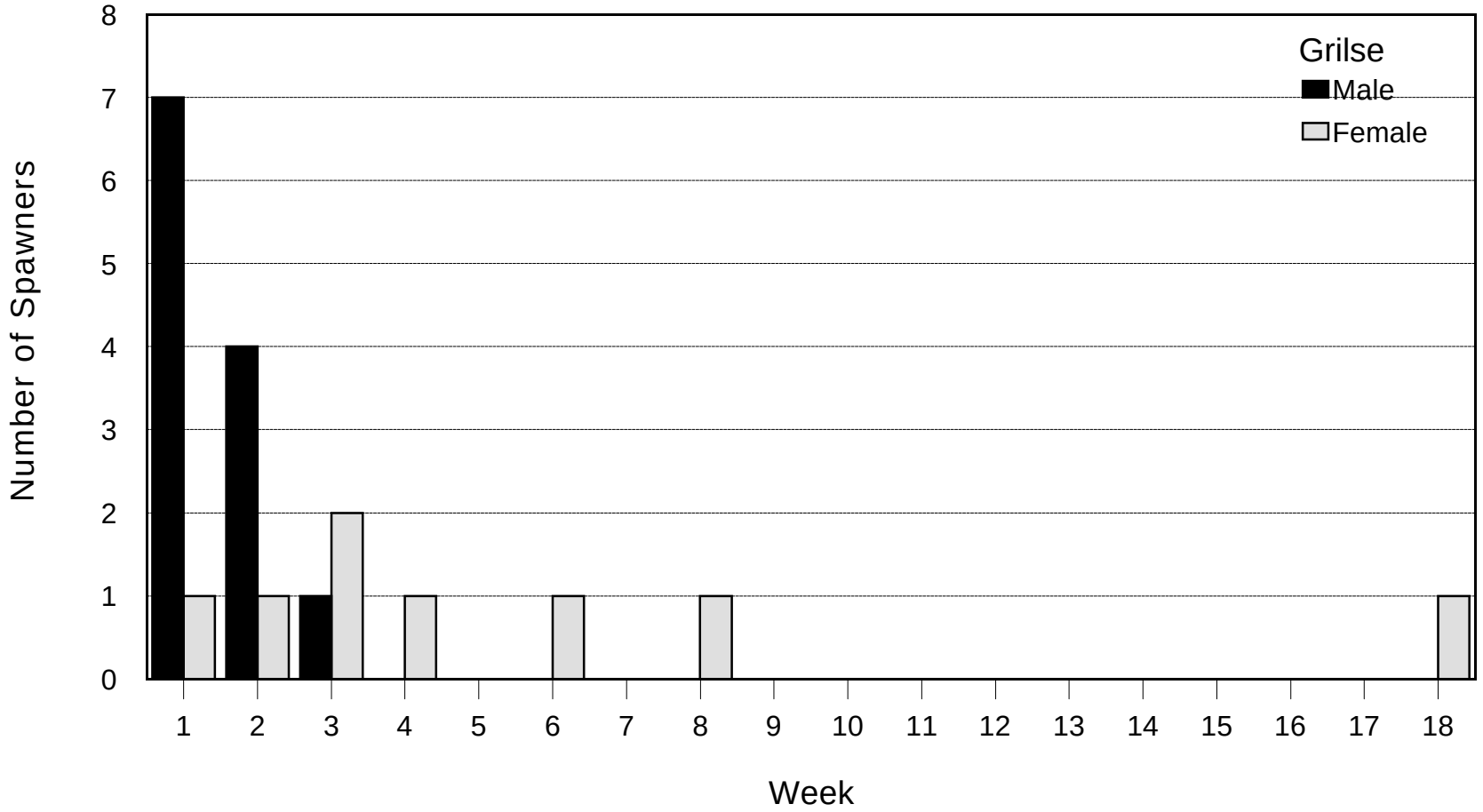

Figure 11. Weekly distribution of the sex of grilse-sized chinook salmon measured during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, December 1997 - May 1998.

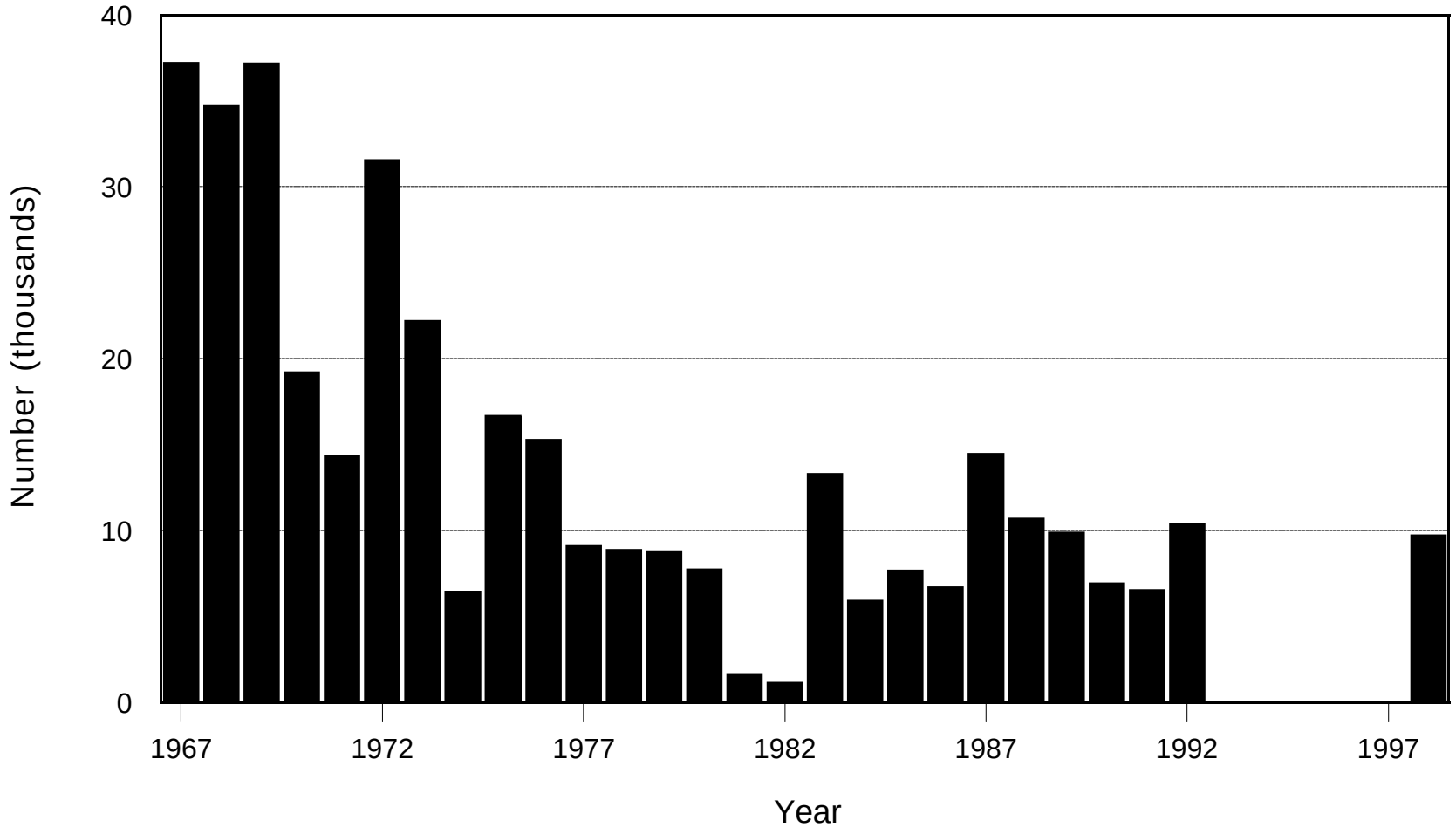

Figure 12. Summary of chinook salmon escapement (adults and grilse) in the mainstem Sacramento River from Keswick Dam downstream to Red Bluff Diversion Dam excluding tributaries (1956 - 1997).