CALIFORNIA DEPARTMENT OF FISH AND GAME
Habitat Conservation Division
Native Anadromous Fish and Watershed Branch
Stream Evaluation Program

Upper Sacramento River
Late-Fall-Run Chinook Salmon Escapement Survey
January–April 2001

by

Bill Snider
Bob Reavis
and
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Stream Evaluation Program
Technical Report No. 01-5
November 2001

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2/ Stream Evaluation Program Technical Report 01-5.

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SUMMARY

A late-fall-run chinook salmon *Oncorhynchus tshawytscha* escapement survey was conducted in the upper Sacramento River during the winter and spring period of 2001 to acquire data on spawner abundance, age of population, pre-spawning mortality, and temporal and spatial distribution of spawning. This was the 4th year a late-fall-run escapement survey was conducted as part of a multi-year investigation by the Department of Fish and Game (DFG) to determine salmon habitat requirements in the Sacramento River system.

Late-fall-run spawning occurs from winter through early spring, during a period when survey conditions can be affected by high flows and reduced water clarity. Suitable survey conditions may last from only a few days to several months. The late-fall-run survey initiated in January 1996 (the 1995–1996 season) was terminated early due to high flows. No survey was attempted during the 1996–1997 season due high flows and extremely poor visibility. Surveys were conducted during 1997–1998, 1998–1999, 1999–2000, and 2000–2001. Survey conditions during 2001 were excellent (relatively low stable flows and favorable water clarity) during the first 7 weeks of the survey (when the peak of spawning occurs) and good for the remainder of the survey. The 2001 survey was hampered less by high flows or poor water clarity than any of the other surveys conducted since 1995–1996.

Weekly surveys were conducted from 3 January through 26 April 2001. The surveys covered a 16.5-mile long section of the Sacramento River between Anderson-Cottonwood Irrigation District (ACID) Dam, at river mile (RM) 298.5, and Anderson River Park (RM 282.0). ACID Dam is located 3.5 miles downstream of Keswick Dam, the upstream limit to salmon migration. Flows ranged from 3,300 cubic feet per second (cfs), during weeks 6 through 9 (8–28 February), to 6,900 cfs in week 17 (23–25 April). Water visibility ranged from 6 ft during week 8, (20–22 February), to 17 ft during week 1, (3–5 January). Water temperature ranged from 46 °F in week 7, (13–15 February), to 53 °F in weeks 1, 2, 12, 13, and 16.

We observed 4,694 late-fall-run carcasses (619 fresh and 4,075 decayed). We measured (length) and sexed 533 fresh carcasses. Based on the fresh carcass measurements, 47% of the spawner population were male adults (>2-years old), 49% were female adults, 3% were male grilse (2-years old), and 1% were female grilse. Examination of 255 fresh female carcasses for egg retention showed that 253 (99%) had completely spawned, and 2 (1%) were unspawned.

A total spawner escapement of 13,148 (543 grilse and 12,605 adults) was estimated using the Petersen formula; 11,536 (476 grilse and 11,060 adults) using the Schaefer formula; and 7,250 (6,951 adults and 299 grilse) using the Jolly-Seber formula.

INTRODUCTION

The California Department of Fish and Game's (DFG) Stream Evaluation Program (STEP) conducted an intensive late-fall-run chinook salmon *Oncorhynchus tshawytscha* spawner escapement survey on the upper Sacramento River during the winter-spring period of 2001 to estimate spawner abundance and distribution. This survey was carried out to develop information necessary to fulfill the mandates of Section 3406(b)(1)(B) of the Central Valley Project Improvement Act (CVPIA), PL 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 DFG have signed a "Cooperative Agreement" by which the FWS will fund 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 spawner populations 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 to be identified. 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 routinely 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 subsequent recapture. This protocol was initially used in the Central Valley in 1973 to estimate spawner escapement in the Yuba River (Taylor 1974).

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 and late-fall-run populations) (Snider et al. 2000). A modification of the Schaefer model has been used in Central Valley tributary streams since 1973, when it was first used to estimate escapement in the Yuba River.

Based on Law's (1994) analysis, the Schaefer and Petersen models will overestimate escapement when carcass "survival" (carry-over from week-to-week) and “catch” 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 spawner escapement given the "survival" encountered in Central Valley stream surveys. The Jolly-Seber model was first used to estimate escapement in the Central Valley in 1988. It is more accurate when model assumptions are met and recovery rates are ≥10% (Boydstun 1994, Law 1994). Still, there has been considerable disagreement about model use among fishery managers responsible for estimating spawner escapement for California streams. They have believed that population estimates obtained by the Jolly-Seber model are too low (F. Fisher, California Department of Fish and Game, personal communication and F. Meyer, California Department of Fish and Game, personal communication). 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.

This is the 4th year a carcass tag-and-recapture survey was conducted in the upper Sacramento River to estimate late-fall-run escapement. A late-fall-run spawner escapement survey was first attempted in 1995-96, but was severely hampered by high flows. Extremely high flow conditions prevented a late-fall-run survey in 1996-97. Complete surveys were carried out in 1997-98, 1998-99, and 1999-2000 (Snider et al. 1998, Snider et al. 1999, and Snider et al. 2000).

METHODS

The 2001 late-fall-run salmon spawner escapement survey was conducted from 3 January through 25 April 2001. The 16.5-mile stream segment from ACID Dam (RM 298.5) downstream to Anderson River Park (RM 282) was divided into three reaches (Fig.1 and Table 1). Each reach was surveyed once per week.

Table 1. Location of reaches surveyed during the upper Sacramento River late-fall-run chinook salmon escapement survey, January –April 2001.

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 (10.0)

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 week

tagged) to the jaw using a hog ring. Carcasses that were not tagged 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 the numbers tagged, chopped, and 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, and egg retention for females. Females were classified as spent if few eggs were remaining, as "partially spent" if a substantial number of 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 (CWT). Those carcasses with adipose-fin clips were collected in order to recover the information contained on the CWT.

During 2001, tagged carcasses were recovered throughout the survey enabling use of the more accurate Schaefer and Jolly-Seber models. An escapement estimate was also calculated using the Petersen formula to allow comparisons with previous years when results didn't allow calculations with the other models due to lack of tag recoveries.

The formulas used to derive the escapement estimates (E) are as follows:

1. Petersen formula (3.7) as described by Ricker (1975):

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

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

2. Schaefer model (as described by Taylor 1974): $E = N_{ij} = R_{ij}(T_iC_j/R_iR_j)-T_i$

where:

N_{ij} = Population size in tagging period *i* recovery period *j*,
R_{ij} = number of carcasses tagged in the *i*th tagging period and recaptured in the *j*th recovery period,
T_i = number of carcasses tagged in the *i*th tagging period,
C_j = number of carcasses recovered and examined in the *j*th recovery period,
R_i = total recaptures of carcasses tagged in the *i*th tagging period, and
R_j = total recaptures of tagged carcasses in the *j*th recovery period.

This model differs from the original in that the number of tags applied after the first week is subtracted from the population estimate to account for sampling with replacement. Schaefer's original model was based on sampling without replacement, while in salmon survey conditions sampling occurs with replacement.

3. Jolly-Seber model (as described by Boydstun 1994): $E = N_1 + D_1 + D_2... + D_j$

where:

N_1 = Number of carcasses in the population in period 1, the first period of spawning and dying, and

D_i = number of carcasses that joined the population between periods *i* and *i*+1, with j as the last survey period.

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 4,694 carcasses was observed (Table 2). Flows were much more stable than during the previous survey years (Table 2, Fig. 2). Mean[1/] flow ranged from 3,300 cfs during weeks 6 through 9 (8–28 February 2001) to 6,900 cfs during week 17 (23 –25 April). Mean temperature ranged from 47 ˚F during week 9 (26–28 February) to 53 ˚F during weeks 1, 2, 12, 13, and 16 (Table 2, Fig. 2). Mean water visibility (Secchi depth) ranged from 6 ft in week 8 (20–22 February) to 17 ft during the week 1 (Table 2, Fig. 2). Stable flows and good visibility provided excellent survey conditions during the first 7 weeks, which encompassed the peak of spawning, and good conditions for the remainder of the season.

Temporal Distribution

Spawning was concentrated during the early part of the survey and generally declined as the season progressed. Most carcasses were observed during January (68.6%, n = 3,218) (Table 2 and Fig. 3). In February, 20.0% (n = 939) were observed, 8.3% (n = 392) were observed in March, and 3.1% (n = 145) in April.

Spatial Distribution

The majority of carcasses were observed in Reach 1 (59.1%, n = 2,775); 29.0% were observed in Reach 2 (n = 1,363), and 11.9% (n = 556) in Reach 3 (Table 3 and Fig. 4). The spatial distribution

1/ Mean of daily measurements for survey period.

may not accurately define spawning distribution since an unknown proportion of carcasses likely drifted downstream.

Size Distribution

Mean size of all measured carcasses was 86.3 cm FL (n = 533) (Table 4). Size ranged from 51 to 111 cm FL. Male salmon size (n = 269) averaged 89.5 cm FL (range: 51–111 cm FL) (Fig. 5). Female salmon size (n = 264) averaged 83.1 cm FL (range: 60–100 cm FL) (Fig. 6). The weekly mean size for males ranged from 79.0 to 110.0 cm FL (Table 4 and Fig. 7). Weekly mean size for females ranged from 63.0 to 91.0 cm FL (Table 4 and Fig. 8).

Length-frequency distributions were used to define general size criteria to distinguish grilse (2-year-old salmon) and adults (>2-year-old salmon) for each sex (Table 5 and Fig. 5 and 6). Both male (n = 19) and female (n = 3) grilse were defined as salmon ≤67 cm FL. Male grilse (n = 19) averaged 63.2 cm FL (range: 51–67 cm FL, SD = 4.4); male adults (n = 250) averaged 88.6 cm FL (range: 68–111 cm FL, SD = 10.8). Female grilse (n = 3) averaged 62.3 cm FL (range: 60–64 cm FL, SD = 2.1); and, female adults (n = 261) averaged 81.9 FL (range: 68–100 cm FL, SD = 6.5).

Grilse comprised 4.1% (n = 22) of the 533 measured carcasses (Table 6). All grilse but one were sampled during the first 8 weeks of the survey (Fig. 9). The one exception was sampled during the last survey week. Grilse comprised less than 7% of the weekly fresh carcass sample except during the last week when one grilse and only two adults were sampled.

Sex Composition

Males comprised 48.9% (n = 250) and females comprised 51.1% (n = 261) of the fresh adult carcasses examined (Table 7). Males also comprised 86% (n=19) and females comprised 14% (n=3) of the fresh grilse examined. Males (n = 269) and females (n = 264) each comprised about 50% of all fresh carcasses (n = 533).

The female to male ratio for adult spawners was nearly even (261:250) (Table 7 and Fig.10). The female to male ratio for grilse was 3:19. Males comprised all of the grilse sampled during 6 of the 9 weeks when grilse were present in the fresh carcass sample (Fig.11).

Spawning Success

A total of 255 female carcasses was examined for egg retention (Table 8); 99.2% (n = 253) had completely spawned, none were partially spawned, and 0.8% (n = 2) had not spawned.

Table 2. General survey information for the upper Sacramento River late-fall-run chinook salmon escapement survey, January – April 2001.

Week	Survey dates	Flows (cfs)[1/]	Secchi depth (ft)[2/]	Water temperature (^{O}F)[2/]	Carcass count[3/]		
					Fresh	Decayed	Total
1	Jan 3–5	4,400	17	53	153	858	1,011
2	Jan 8–10	4,000	11	53	113	494	607
3	Jan 16–18	4,000	15	52	76	566	642
4	Jan 22–24	4,000	15	50	65	447	512
5	Jan 29–31	3,500	14	49	41	405	446
6	Feb 8–10	3,300	16	48	44	379	423
7	Feb 13–15	3,300	15	46	37	233	270
8	Feb 20–22	3,300	6	48	19	102	121
9	Feb 26–28	3,300	8	47	9	116	125
10	Mar 5–7	3,400	8	49	12	127	139
11	Mar 12–14	6,100	8	51	11	79	90
12	Mar 19–21	4,600	13	53	13	96	109
13	Mar 26–28	4,200	11	53	11	43	54
14	Apr 2–4	5,400	16	51	4	34	38
15	Apr 9–11	6,100	16	52	4	47	51
16	Apr 16–18	6,100	15	53	3	26	29
17	Apr 23–25	6,900	14	52	4	23	27
				Totals	619	4,075	4,694

1/ Mean flow during days sampled as measured at Keswick Dam by U.S. Geological Survey.

2/ Mean of daily measurements taken by survey crews.

3/ Includes both adults and grilse.

Table 3. Distribution of carcasses (adults and grilse) observed during the upper Sacramento River late-fall-run chinook salmon escapement survey, January –April 2001.

Week	Reach 1		Reach 2		Reach 3	
	M[1/]	C[2/]	M	C	M	C
1	513	97	216	49	121	15
2	267	119	106	42	45	28
3	177	179	116	83	44	43
4	140	178	78	89	15	12
5	140	146	50	51	30	29
6	126	160	32	40	39	26
7	74	60	40	65	17	14
8	40	26	26	23	3	3
9	30	39	27	22	4	3
10	38	36	17	24	14	10
11	24	12	24	22	4	4
12	35	16	22	26	4	6
13	19	14	9	3	3	6
14	7	11	5	10	4	1
15	8	15	9	13	4	2
16	0	14	0	13	0	2
17	0	15	0	11	0	1
Total	1,638	1,137	777	586	351	205

1/ Number of carcasses tagged.

2/ Number of untagged carcasses chopped.

Table 4. Size and sex statistics for fresh carcasses measured during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, January-April 2001.

	All salmon			Male salmon			Female salmon		
		Length (FL in cm)			Length (FL in cm)			Length (FL in cm)	
Week	Number measured	Mean	Range	Number measured	Mean	Range	Number measured	Mean	Range
1	110	81.4	51–103	53	82.7	51–103	57	80.1	69–98
2	84	85.4	60–111	44	88.5	60–111	40	82.0	68–100
3	72	83.2	64–106	39	84.4	64–106	33	81.7	71–95
4	65	86.8	64–106	43	89.2	64–106	22	82.2	70–94
5	44	82.5	64–105	20	84.5	64–105	24	81.2	64–96
6	42	83.9	52–108	20	86.3	52–108	22	81.6	69–93
7	40	83.7	60–107	16	87.2	65–107	24	80.8	60–92
8	18	84.7	62–108	9	85.8	52–108	9	83.7	78–90
9	8	82.9	68–91	2	79.0	68–90	6	84.2	73–91
10	12	90.0	79–106	6	89.8	79–106	6	90.2	84–98
11	11	94.9	82–105	7	97.1	82–106	4	91.0	85–98
12	13	90.1	70–104	6	99.8	94–104	7	81.7	70–90
13	0	-	-	0	-	-	0	-	-
14	4	88.5	82–94	1	94.0	-	3	86.7	82–92
15	4	89.2	86–92	0	-	-	4	89.3	86–96
16	3	96.3	88–110	1	110.0	-	2	89.5	88–91
17	3	78.0	63–94	2	85.5	77–94	1	63.0	-
Total	533	84.4	51–111	269	86.8	51–111	264	81.9	60–100

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, January – April 2001.

	Female		Male	
	Grilse	Adults	Grilse	Adults
Number	3	261	19	250
Mean FL (cm)	62.3	81.9	63.2	88.6
Range FL (cm)	60–64	68–100	51–67	68–111
S D	2.1	6.5	4.4	10.8

Table 6. Age composition (grilse and adult) of carcasses measured during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, January – April 2001.

	Adults		Grilse[1/]	
Week	Number	Percent	Number	Percent
1	104	95	6	5
2	81	96	3	4
3	68	94	4	6
4	63	97	2	3
5	42	95	2	5
6	41	98	1	2
7	38	95	2	5
8	17	94	1	6
9	8	100	0	0
10	12	100	0	0
11	11	100	0	0
12	13	100	0	0
13	0	-	0	-
14	4	100	0	0
15	4	100	0	0
16	3	100	0	0
17	2	67	1	33
Total(mean)	511	(96)	22	(4)

1/ Based on length-frequency distributions, grilse are defined as ≤67 cm FL.

Table 7. Sex composition of grilse and adults carcasses measured during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, January – April 2001.

	Adults				Grilse[1/]			
	Male		Female		Male		Female	
Week	Number	%	Number	%	Number	%	Number	%
1	47	45.2	57	54.8	6	100.0	0	0
2	41	51.0	40	49.0	3	100.0	0	0
3	35	51.5	33	48.5	4	100.0	0	0
4	41	65.1	22	34.9	2	100.0	0	0
5	19	45.2	23	54.8	1	50.0	1	50.0
6	19	46.3	22	53.7	1	100.0	0	0
7	15	39.5	23	60.5	1	50.0	1	50.0
8	8	47.1	9	52.9	1	100.0	0	0
9	2	25.0	6	75.0	0	-	0	-
10	6	50.0	6	50.0	0	-	0	-
11	7	63.6	4	36.4	0	-	0	-
12	6	46.1	7	-	0	-	0	-
13	0	-	0	-	0	-	0	-
14	1	25.0	3	75.0	0	-	0	-
15	0	-	4	100.0	0	-	0	-
16	1	33.3	2	66.7	0	-	0	-
17	2	100.0	0	0	0	0	1	100.0
Total (mean)	250	(48.9)	261	(51)	19	(87.5)	3	(14)

1/ Based on length-frequency distributions, grilse are defined as ≤67 cm FL.

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, January–April 2001.

Week	No. females measured	No. females checked for egg retention	Number spawned (%)	Number partially spawned (%)	Number unspawned (%)
1	57	52	51(98.1)	0(0)	1(1.9)
2	40	39	38(97.4)	0(0)	1(2.6)
3	33	32	32(100.0)	0(0)	0(0)
4	22	22	22(100.0)	0(0)	0(0)
5	24	23	23(100.0)	0(0)	0(0)
6	22	21	21(100.0)	0(0)	0(0)
7	24	24	24(100.0)	0(0)	0(0)
8	9	9	9(100.0)	0(0)	0(0)
9	6	6	6(100.0)	0(0)	0(0)
10	6	6	6(100.0)	0(0)	0(0)
11	4	4	4(100.0)	0(0)	0(0)
12	7	7	7(100.0)	0(0)	0(0)
13	0	0	-	-	-
14	3	3	3(100.0)	0(0)	0(0)
15	4	4	4(100.0)	0(0)	0(0)
16	2	2	2(100.0)	0(0)	0(0)
17	1	1	1(100.0)	0(0)	0(0)
Total (mean)	264	255	253(99.7)	0(0)	2(0.3)

Population Estimates

A total of 4,573 adult carcasses (not including recaptures) was observed. Of these, 560 fresh carcasses were tagged and 212 (37.9%) were later recovered. Applying the Petersen formula to these data yielded an escapement estimate of 12,605 adults (Table 9). The adult estimate was then divided by the portion of adults in the population, based on fresh carcass data, yielding a total population estimate of 13,148 salmon (12,605 adults and 543 grilse).

An estimate of 11,060 adults was calculated using the Schaefer formula (Tables 10 and 11) and the fresh carcass tag-recapture data. The adult estimate was divided by the proportion of adults to calculate a total escapement estimate of 11,536 late-fall-run spawners (estimate includes 476 grilse).

An estimate of 6,951 adults was calculated using the Jolly-Seber formula (Table 12). Both fresh and decayed carcass data results were used to calculate this estimate(2,697 fresh and decayed carcasses were tagged and 1,144 (42.4%) were later recovered). This estimate was divided by the portion of adults to yield a total escapement estimate of 7,250 late-fall-run spawners (includes 299 grilse). .

The population estimates for salmon spawning in the upper Sacramento River from ACID Dam (RM 298.5) to Anderson River Park (RM 282.0) are as follows:

	Petersen formula	Schaefer model	Jolly-Seber modal
Total estimate	13,148	12,536	7,250
Adult estimate	12,605	11,060	6,951
Grilse estimate	543	476	299

The estimated 2001 late-fall-run chinook salmon escapement of 13,148 (using Petersen formula) is less than the 1967–1992 average of 14,159 for the section of stream from Keswick Dam to Red Bluff Diversion Dam (RBDD)[2/] (Table 13 and Fig.12). The 2001 estimate is the highest estimate made since carcasses surveys were started 1996.

Coded-wire-tag Recovery Data

Nine fresh carcasses observed during the survey were marked with adipose-fin clips. Eight of the marked fish possessed coded-wire tags (Table 12). All tag groups were reared at Coleman National Fish Hatchery and tagged by the USFWS. All tag groups were released at the hatchery except, 05-23-22 and 05-50-61, which were released at Port Chicago.

2/ The annual estimates made from 1967 through 1992 were based on RBDD ladder counts. Changes in operation of RBDD eliminated the opportunity to count late-fall run since 1992.

Table 9. Summary of tagging and recapture of fresh adult carcasses observed during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, January–April 2001.

Week	Date	Number observed[1/]	Number tagged	Number recovered (Original tagging period)
1	Jan 3–5	990	146	–
2	Jan 8–10	586	105	41(1)
3	Jan 16–18	625	61	22(2), 11(1)
4	Jan 22–24	502	59	9(3), 8(2), 9(1)
5	Jan 29–31	434	34	15(4), 4(3), 5(2), 6(1)
6	Feb 7–9	409	40	6(5), 6(4), 1(3), 1(2), 1(1)
7	Feb 13–15	260	34	14(6), 4(5), 2(4), 2(4)
8	Feb 20–22	113	17	6(7), 1(6), 1(4)
9	Feb 26–28	124	9	8(8), 1(7), 2(6)
10	Mar 5–7	138	12	1(9), 2(8), 3(7)
11	Mar 12–14	89	11	1(8)
12	Mar 19–21	107	13	4(11), 1(10)
13	Mar 26–29	54	11	2(12), 1(11), 1(10)
14	Apr 2–4	38	4	1(13), 1(12)
15	Apr 9–11	49	4	2(14), 1(13), 2(10)
16	Apr 19–21	29	0	2(15)
17	Apr 23–25	26	0	1(14)
Totals		4,573	560	212

1/ Number does not include recoveries.

Table 10. Summary of tagging and recapture of both fresh and decayed adult carcasses observed during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, January–April 2001.

Week	Date	Number observed[1/]	Number tagged	Number recovered (Original tagging period)
1	Jan 3–5	990	830	–
2	Jan 8–10	586	416	327(1)
3	Jan 16–18	625	329	95(2), 74(1)
4	Jan 22–24	502	228	71(3), 38(2), 45(1)
5	Jan 29–31	434	211	79(4), 30(3), 13(2), 13(1)
6	Feb 7–9	409	189	57(5), 19(4), 16(3), 6(2), 1(1)
7	Feb 13–15	260	122	45(6), 15(5), 6(4), 4(4)
8	Feb 20–22	113	64	14(7), 8(6), 8(5), 2(4)
9	Feb 26–28	124	60	18(8), 4(7), 7(6), 2(5)
10	Mar 5–7	138	68	11(9), 10(8), 10(7), 3(6)
11	Mar 12–14	89	52	7(10), 1(9), 2(8), 1(7), 1(6)
12	Mar 19–21	107	60	13(11), 8(10), 3(9), 3(8)
13	Mar 26–29	54	31	11(12), 2(11), 6(10)
14	Apr 2–4	38	16	7(13), 5(12), 3(11)
15	Apr 9–11	49	21	4(14), 3(13), 3(12), 2(10)
16	Apr 19–21	29	0	4(15), 1(12)
17	Apr 23–25	26	0	2(14), 1(13)
Totals		4,573	2,697	1,144

1/ Number does not include recoveries.

Table 11. Summary of late-fall-run chinook salmon escapement estimates (adults and grilse) for the Sacramento River (Keswick Dam to RBDD) from 1956 through 2001. (Data provided by Frank Fisher, DFG, Red Bluff).

Year	Total	Year	Total
1967	37,208	1985	7,660
1968	34,733	1986	6,710
1969	37,178	1987	14,443
1970	19,190	1988	10,683
1971	14,323	1989	9,875
1972	31,553	1990	6,921
1973	22,204	1991	6,531
1974	6,445	1992	10,371
1975	16,663	1993	no est.
1976	15,280	1994	no est.
1977	9,090	1995	no est.
1978	8,880	1996	no est.
1979	8,740	1997	no est.
1980	7,747	1998	9,717[1/]
1981	1,597	1999	8,683[1/]
1982	1,141	2000	8,552[1/]
1983	13,274	2001	13,148[1/]
1984	5,907		

1/ Estimates based on carcass counts; all other estimates based on RBDD ladder counts.

Table 12. Summary of coded-wire tags recovered from carcasses observed during the 2001 late-fall-run chinook salmon spawner escapement survey.

Tag #	Brood year	Release date	Release location	Date recovered	Sex	Length (cm)	River mile recovered
05-42-37	96	1/9/97	CNFH	1/3/01	F	87	296.5
05-23-19	98	1/4/99	CNFH	1/4/01	M	51	294
05-23-18	98	1/4/99	CNFH	1/5/01	M	85	289
05-23-22	98	12/22/99	Port Chicago	1/22/01	M	84	298
05-50-61	97	12/29/97	Port Chicago	1/22/01	F	86	298
No tag	-	-	-	1/23/01	F	86	295
05-23-22	98	12/22/99	Port Chicago	1/30/01	F	69	295
05-41-27	96	1/16/97	CNFH	2/8/01	F	82	296.5
05-41-26	96	1/16/97	CNFH	3/5/01	M	91	-

CONCLUSIONS AND RECOMMENDATIONS

1. Flows were relatively stable and water clarity was good ($\geq$ 6 ft) throughout the survey. This was the first year that surveys were unhampered by high flow or poor water clarity and may provide the best insight into the temporal distribution of late-run-run spawning season. With the peak number of carcasses observed being in the first survey week, future surveys should start earlier.

2. The stable flows and good water clarity provided good study conditions and resulted in high tag-recovery rates. The recovery rate for all tagged carcasses (fresh and decayed) was 42%. For fresh tagged carcasses it was 38%. Usually the recovery rate for fresh carcasses is slightly higher than for combined fresh and decayed.

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APPENDIX

Appendix Table 1. Comparison of results from the 1998 through 2000 upper Sacramento River late-fall-run spawner survey.

Parameter	1998 survey	1999 survey	2000 survey	2001 survey
Survey dates	29 Dec 1997–1 May 1998	28 Dec1998–28 Apr 1999	27 Dec 1999–25 Apr 2000	3 January–25 April 2001
No. of total carcasses	847	2,206	2,554	4,694
No. of fresh carcasses	182	450	365	619
No. of decayed carcasses	665	1,756	2,189	4,075
Tag recovery rate	9.2%	28.4%	32.8%	38% (fresh)
Estimated population	9,717 (Petersen model)	8,614 (Petersen model)	8,552 (Petersen model)	13,148 (Petersen model)
Adult estimate	8,648	7,467	6,493	12,605
Grilse estimate	1,069	1,216	2,059	543
Adult female estimate	49%	56%	49%	49%
Adult male estimate	40%	30%	27%	47%
Grilse female estimate	7%	9%	4%	1%
Grilse male estimate	4%	5%	20%	3%
Female:male ratio adults	1.2:1	1.9:1	1.8:1	1:1
Size criterion (male)	Adult >70cm FL	Adult >71 cm FL	Adult >70 cm FL	Adult > 67cm FL
Size criterion (female)	Adult >70cm FL	Adult >71 cm FL	Adult >70 cm FL	Adult > 67cm FL
Spawning success (%)	93%	93%	97%	99%
Spatial distribution (Reach 1,2,3)	62%, 19%, 19%	46%, 32%, 22%	60%,28%,12%	59%, 29%, 12%
Temporal distribution (Jan, Feb, Mar, Apr)	97%, 2%, 0.3%, 0.7%	57%, 22%, 16%, 5%	83%,13%,2%,2%	69%, 20%, 8%, 3%
Flow range	4,200–52,800 cfs	5,500–29,800 cfs	4,000–41,700 cfs	3,300–6,900 cfs
Temperature range	47–54 ^{o}F	47–52 ^{o}F	48–53 ^{o}F	46–53 ^{o}F
Visibility range	4–12 ft	5–10 ft	5–15 ft	6-17 ft

FIGURES

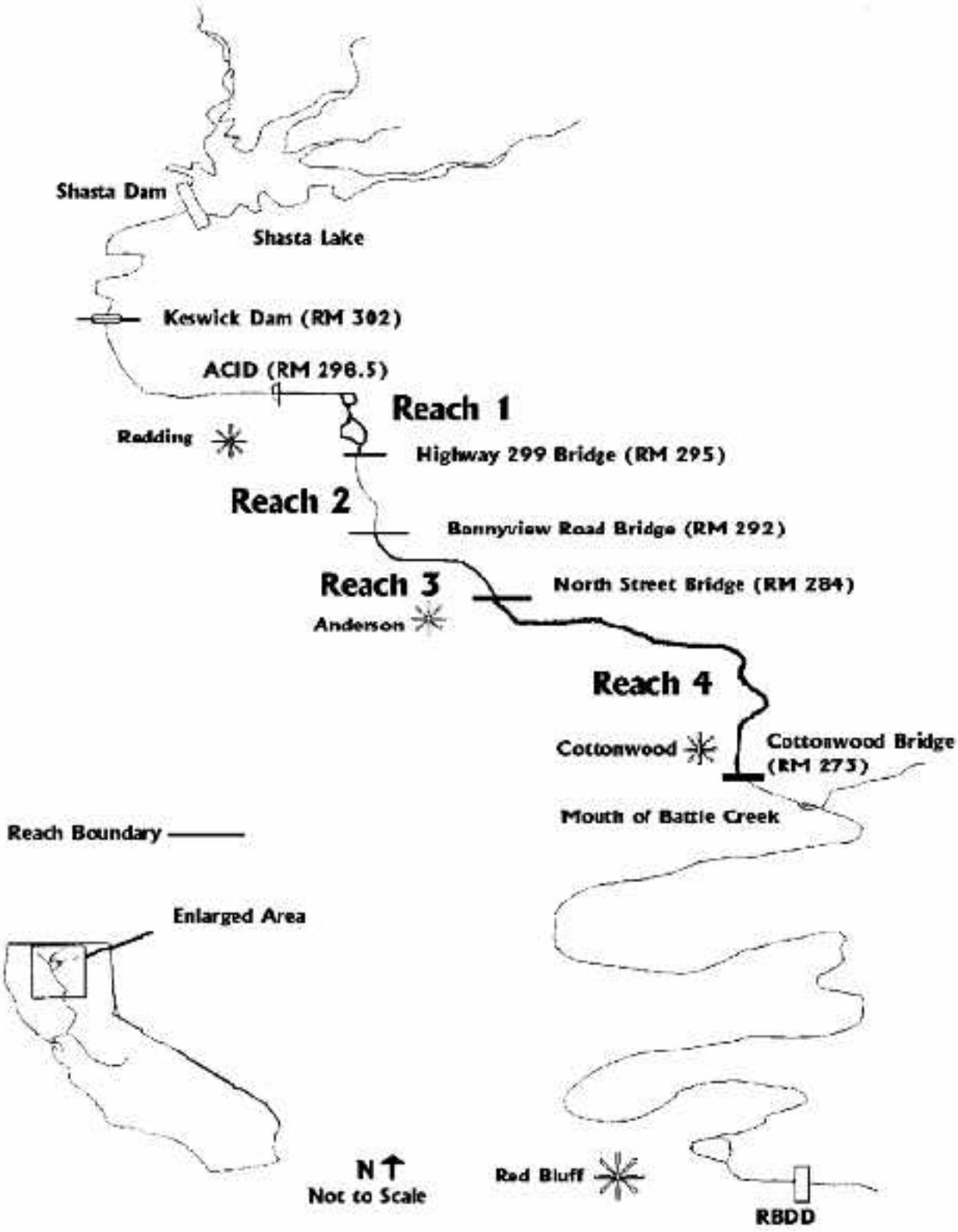

Figure 1. Upper Sacramento RIver late-fall-run Chinook salmon spawner escapement survey location, including reach designations, January - March 2001.

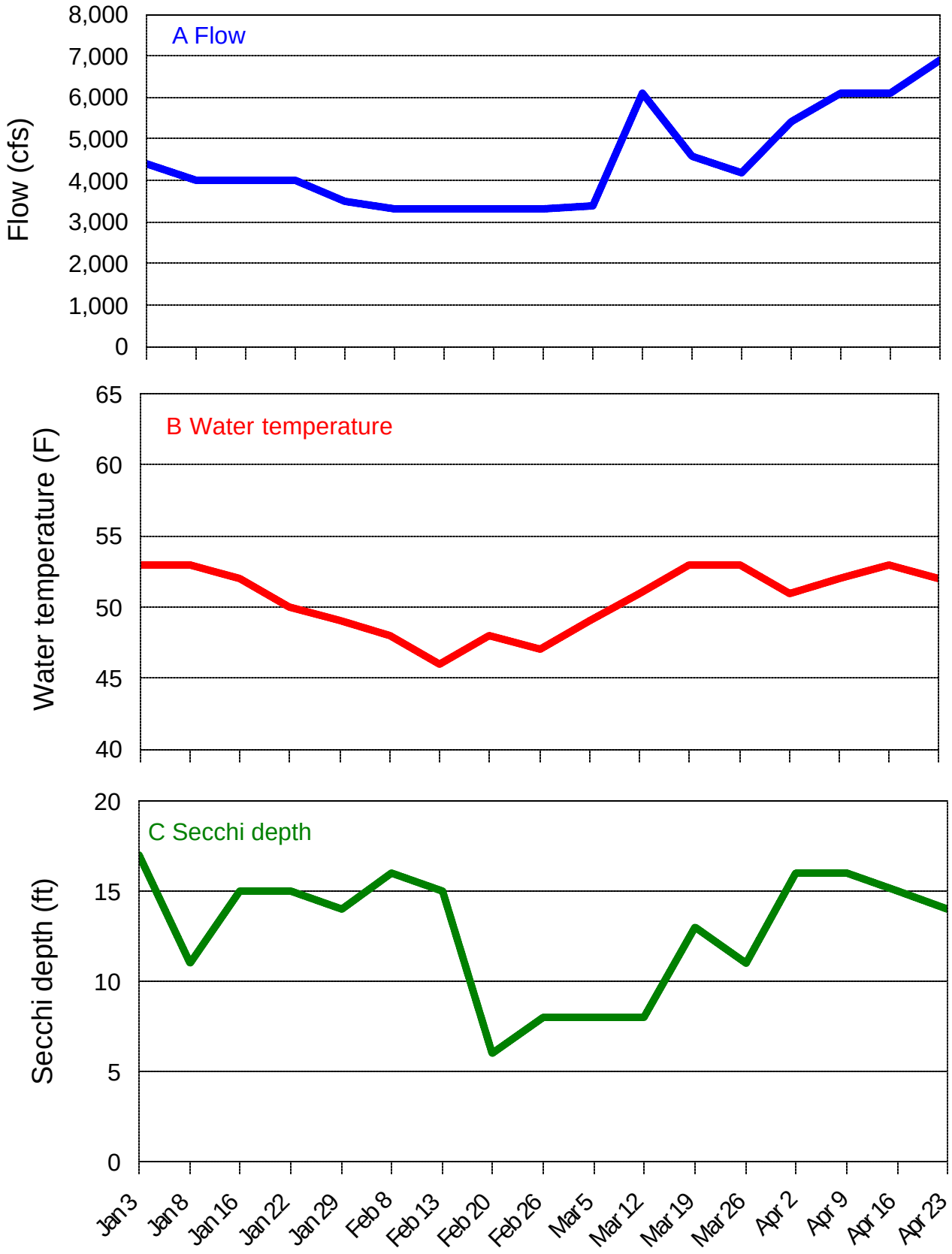

Figure 2. Mean daily flow (A) measured at Keswick Dam, water temperature (B) and secchi depth (C) during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, January - April 2001.

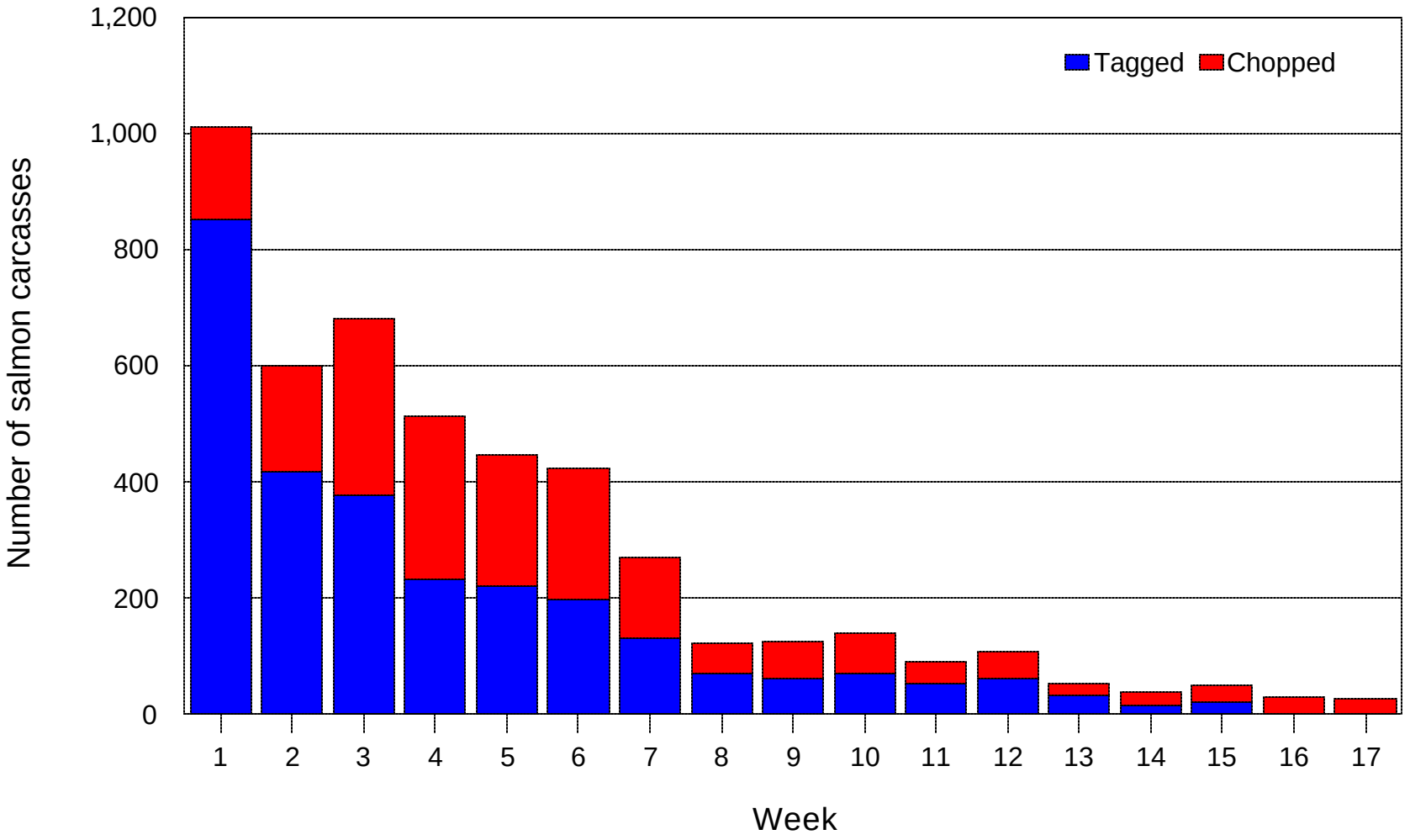

Figure 3. Weekly distribution of both fresh and decayed carcasses observed during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, January - April 2001.

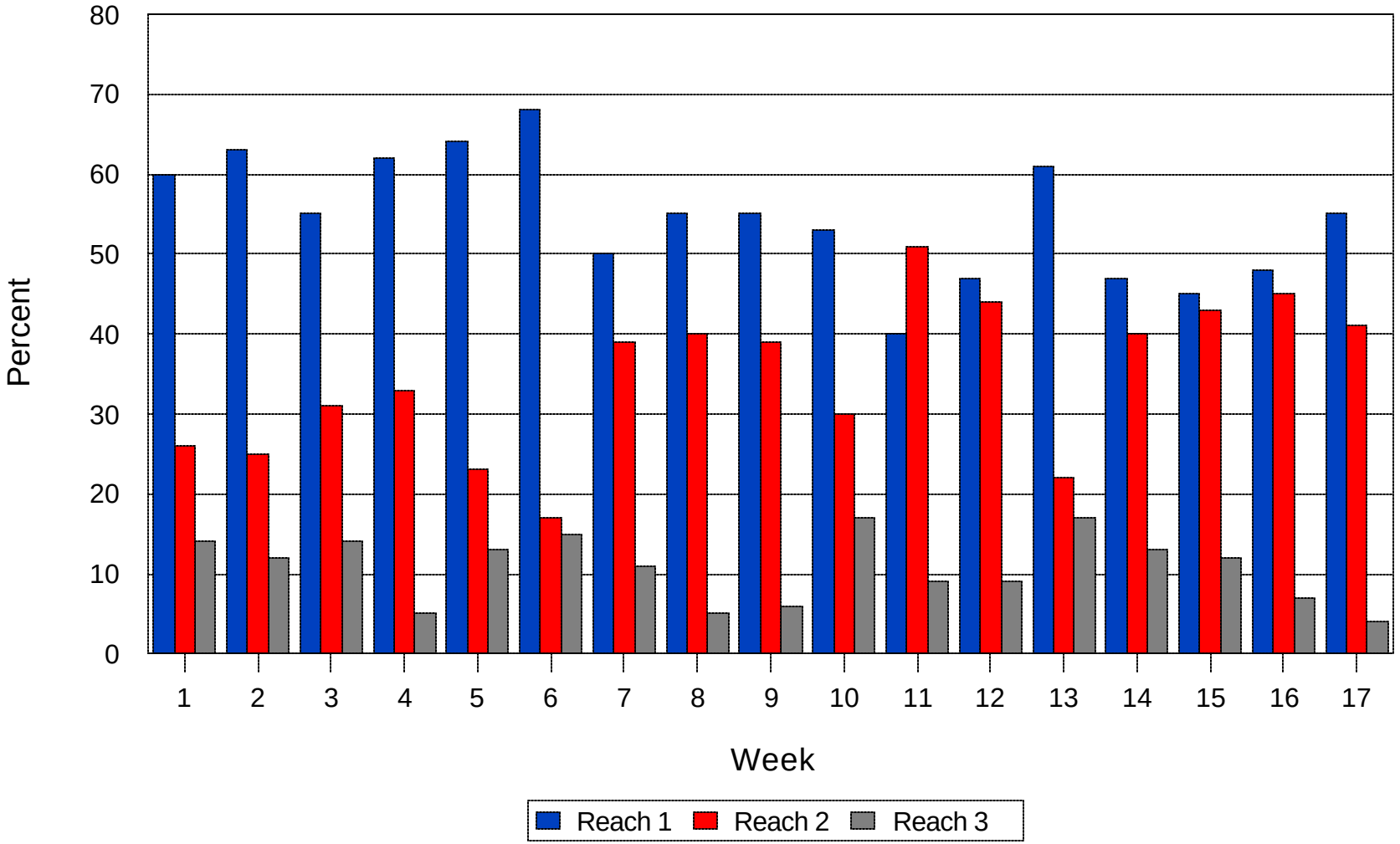

Figure 4. Weekly distribution (%) by reach of both fresh and decayed carcasses observed during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, January - April 2001.

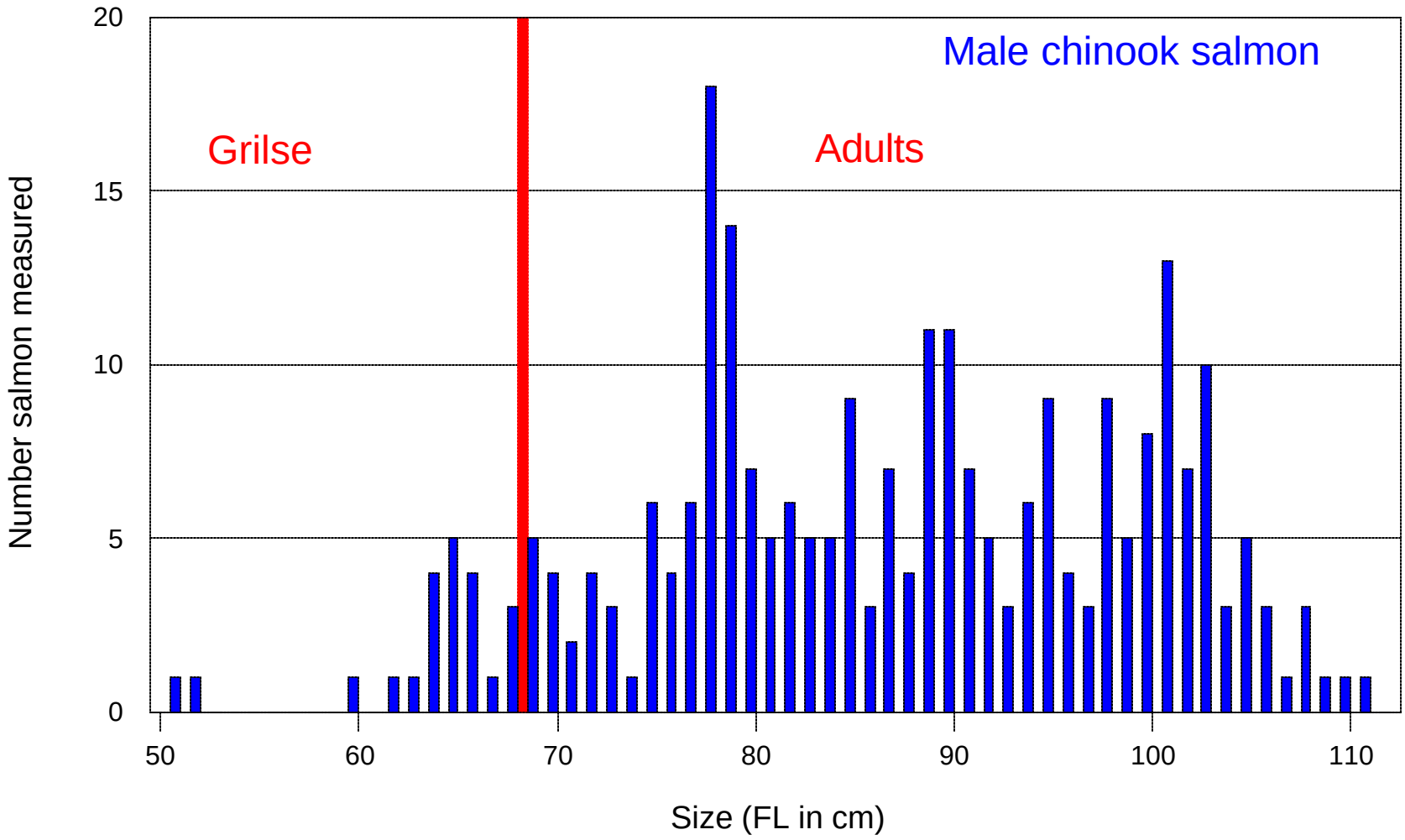

Figure 5. Size (FL in cm) distribution of male carcasses measured during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, January - April 2001.

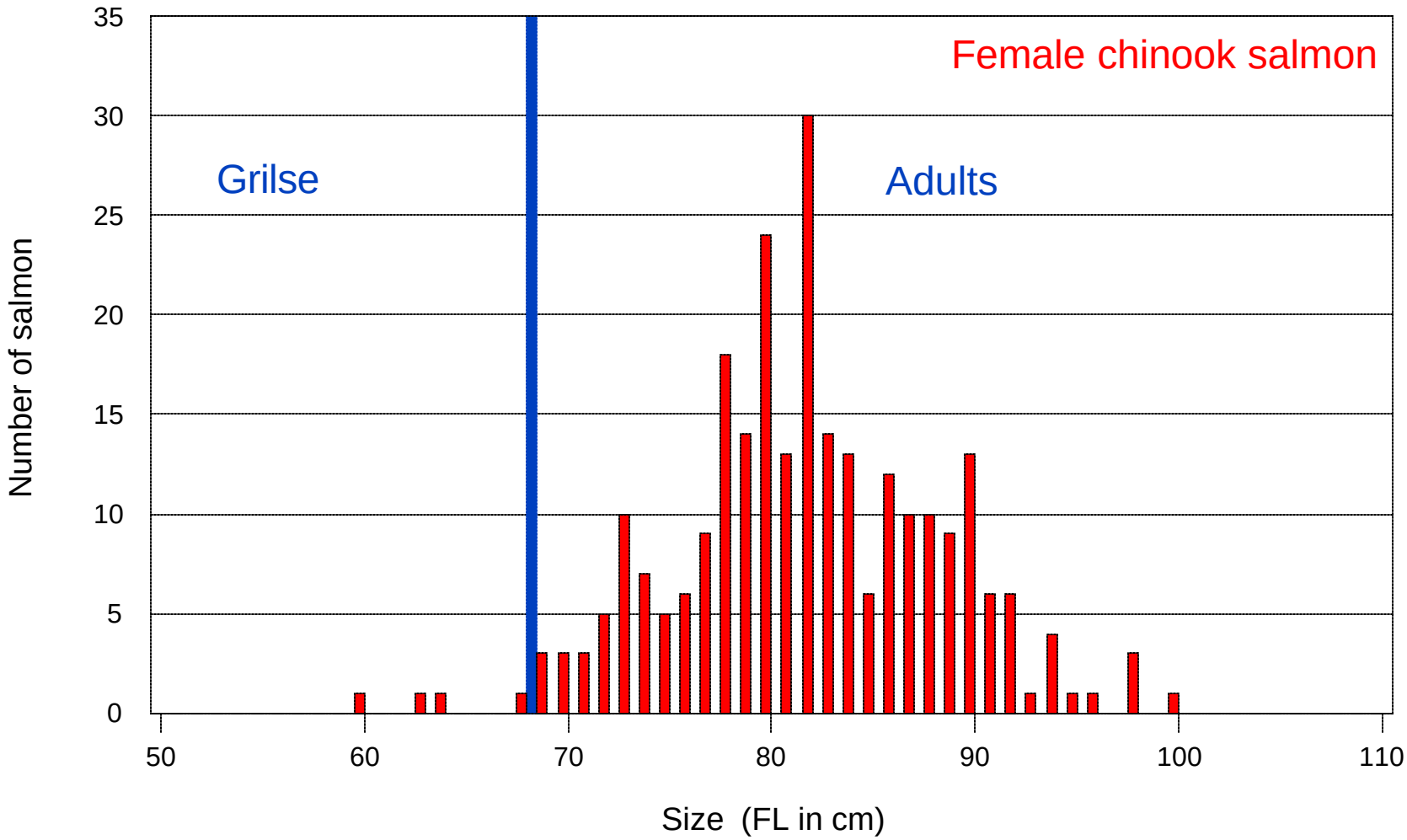

Figure 6. Size (FL in cm) distribution of female carcasses measured during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, January - April 2001.

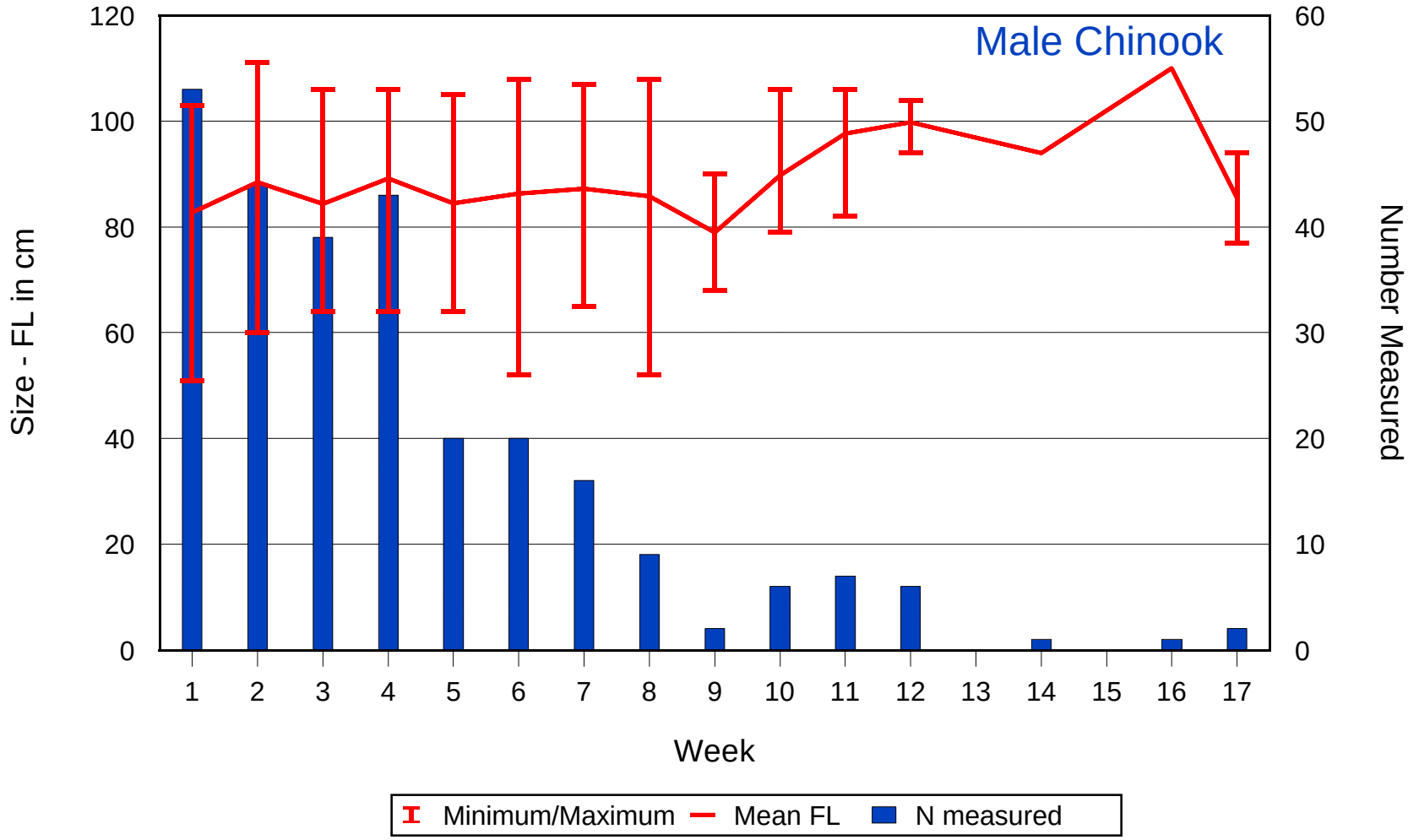

Figure 7. Mean size, size range, and number of male chinook salmon measured weekly during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, January - April 2001.

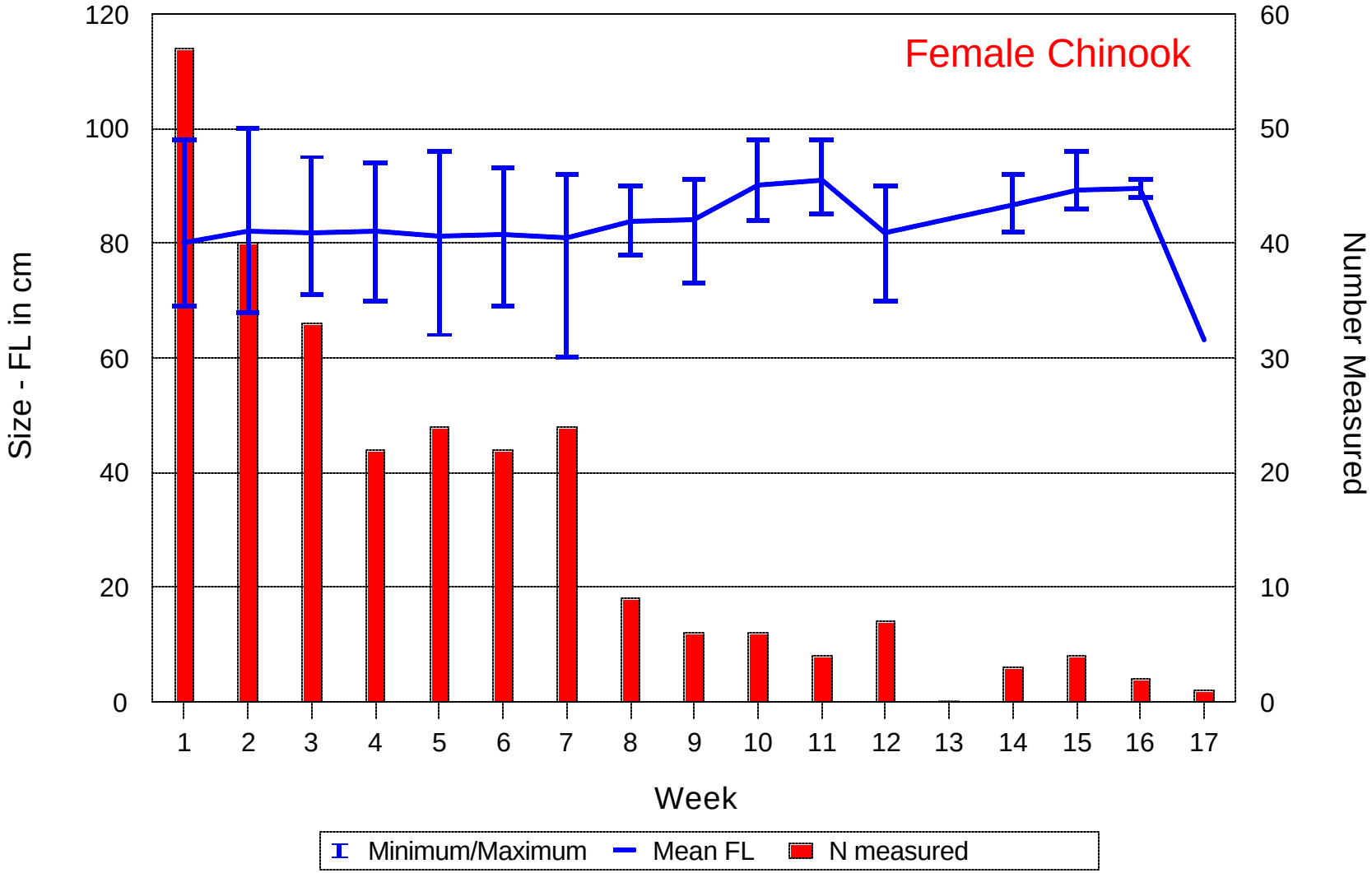

Figure 8. Mean size, size range, and number of female chinook salmon measured weekly during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, January - April 2001.

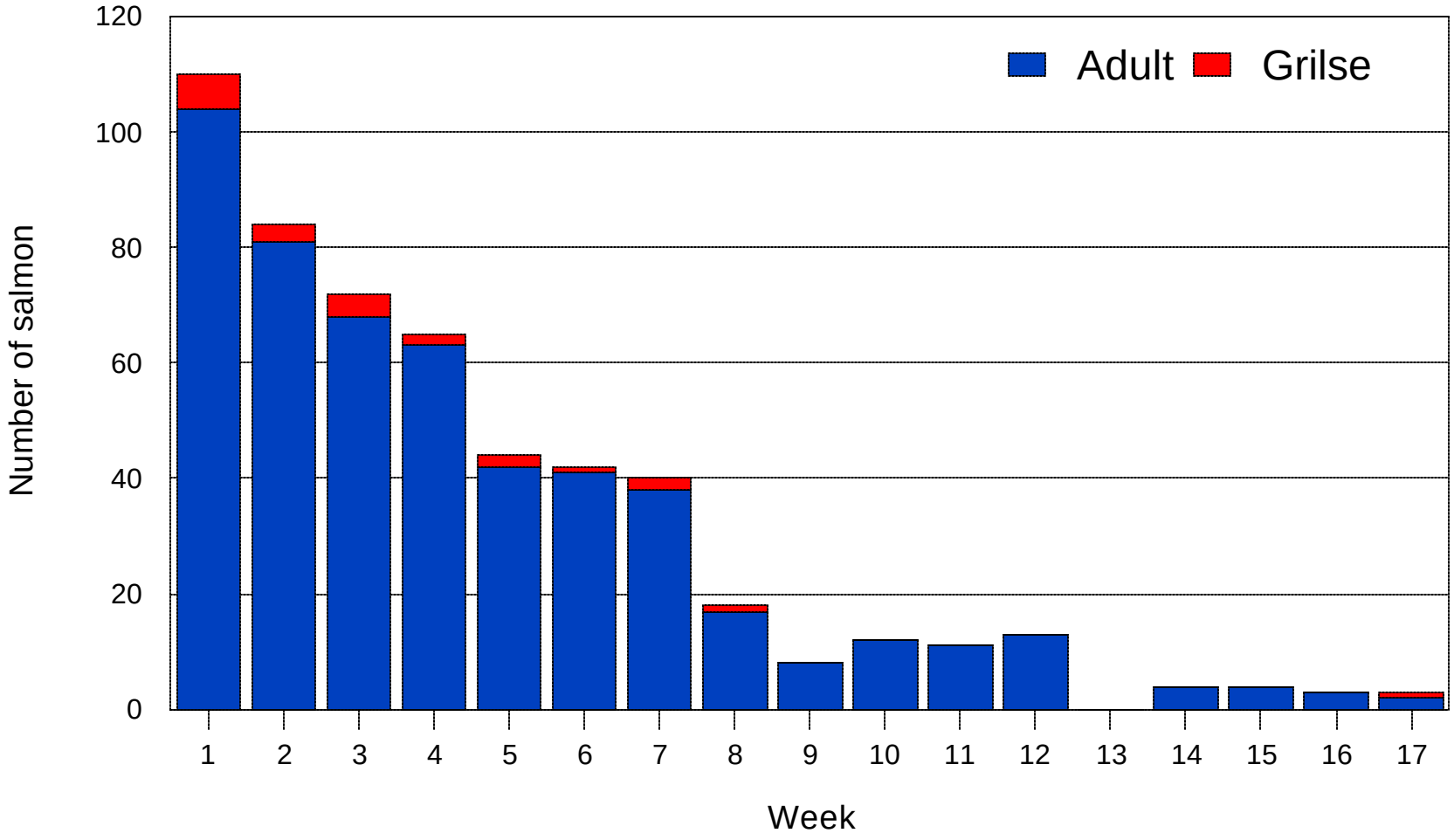

Figure 9. Age compostion of chinook salmon measured during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, January - April 2001.

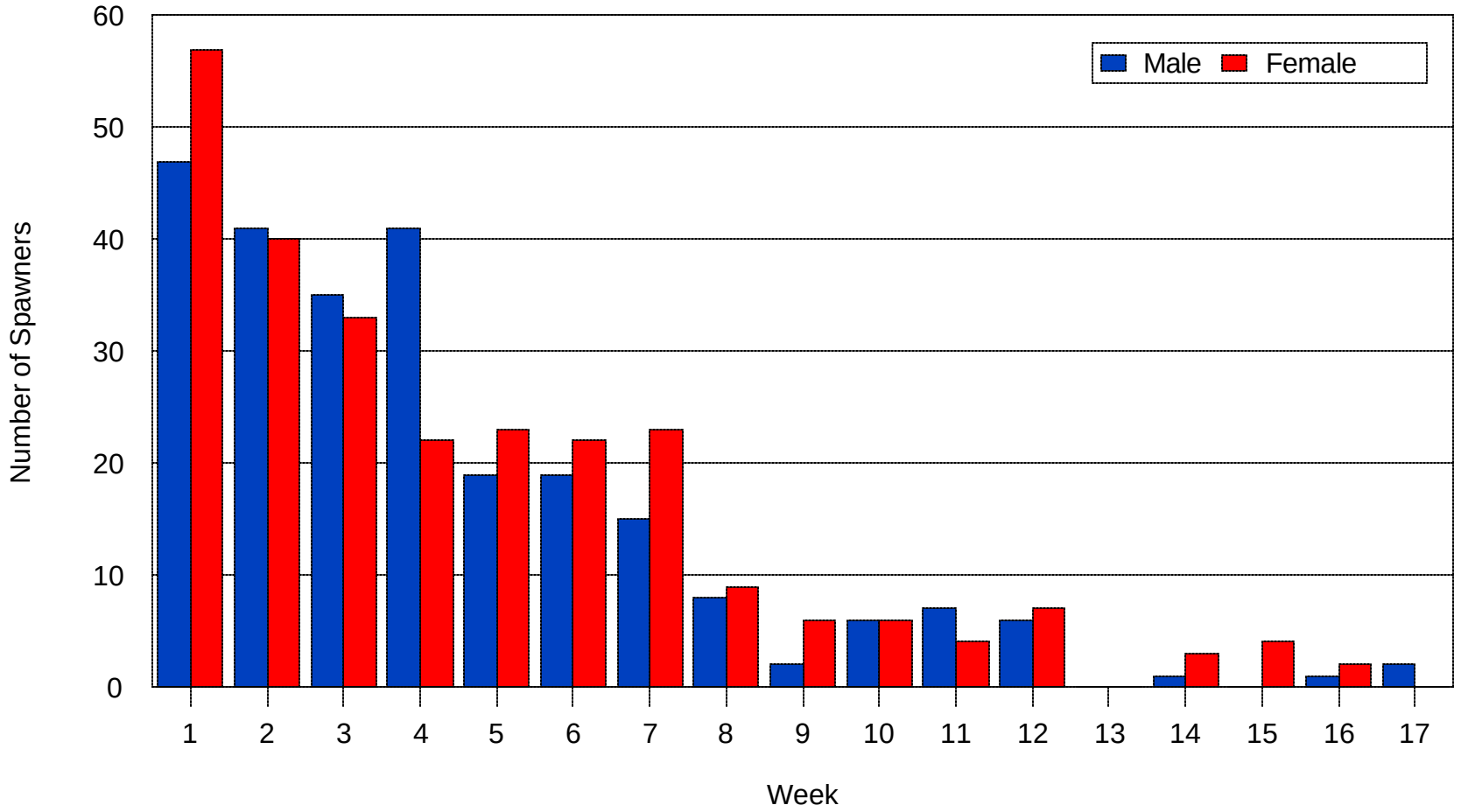

Figure 10. Weekly gender (sex) distribution of adult-sized chinook salmon measured during the upper Sacramento River late-fall-run chinook salmon spawner escapement survey, January - April 2001.

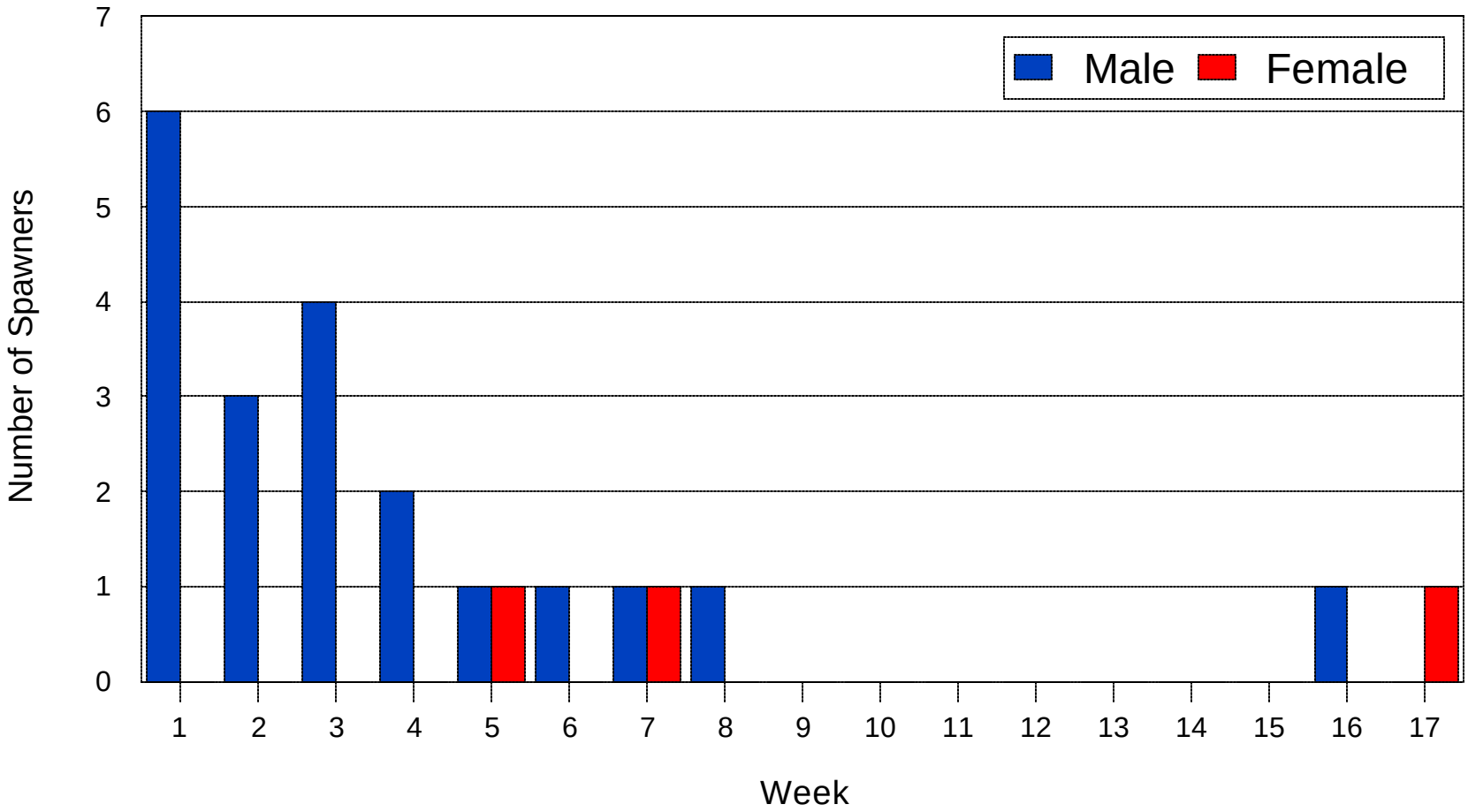

Figure 11. Weekly distribution of the sex of grilse-sized chinook salmon measured during the upper Sacramento River late-fall-run spawner escapement survey, January - April 2001.

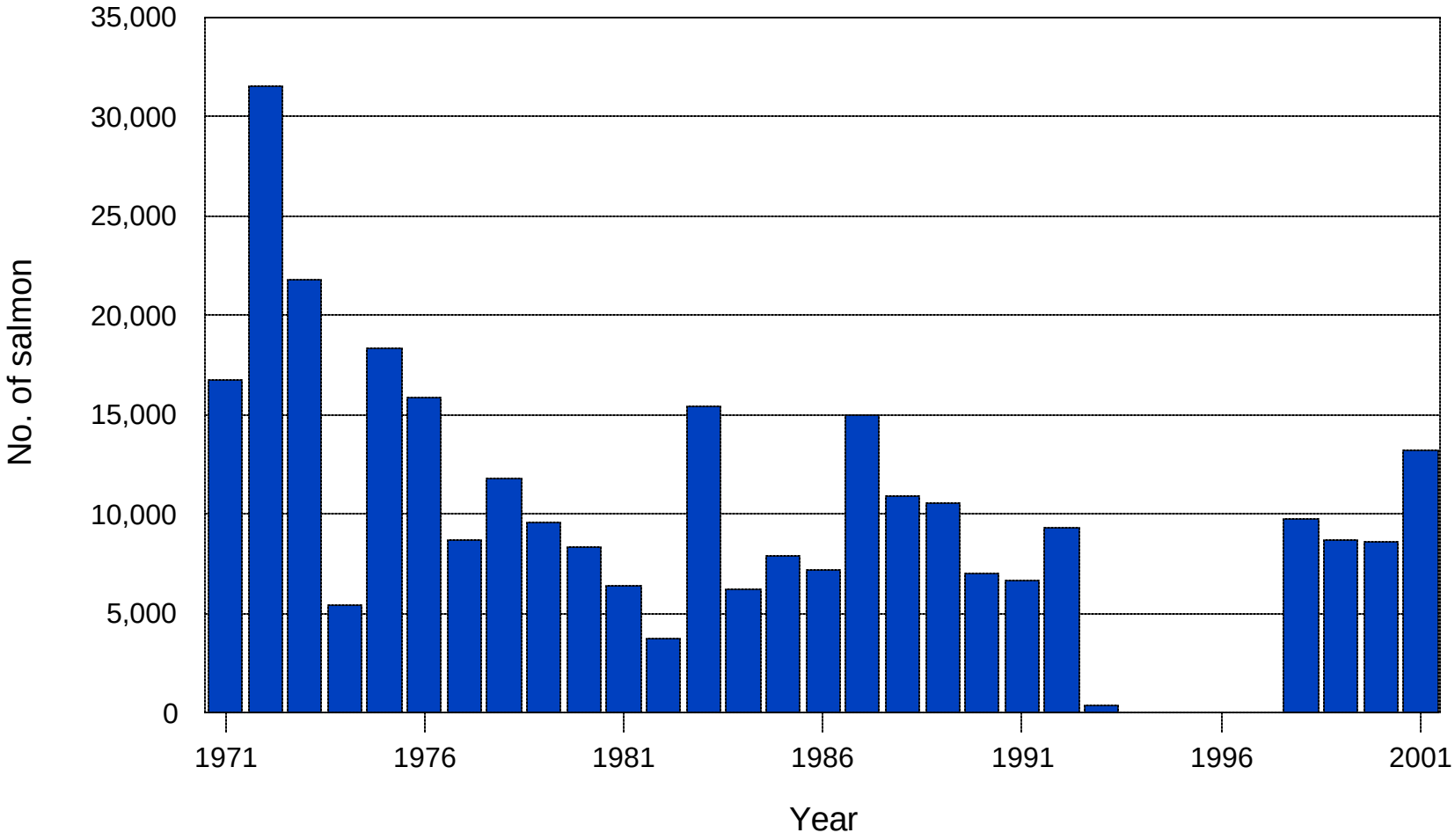

Figure 12. Summary of late-fall-run chinook salmon escapement (adults and grilse) in the mainstem Sacramento River from Keswick Dam downstream to Red Bluff Diversion Dam excluding tributaries (1971 - 2001).