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BUTTE CREEK SPRING-RUN CHINOOK SALMON, *ONCORHYNCHUS TSHAWYTSCHA*, JUVENILE OUTMIGRATION AND LIFE HISTORY 1995-1998

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ABSTRACT

This report covers juvenile chinook salmon, *Oncorhynchus tshawytscha*, monitoring in Butte Creek from October, 1995 until July, 1998. Fish were trapped in Butte Creek at sites near Chico, California (Butte County) and Sutter Bypass/Lower Butte Creek, West Borrow (Sutter County).

For the 1995/1996 sampling year, 119,788 juvenile chinook salmon were captured at the Chico site and 52,284 at the Sutter Bypass site. Of the 119,788 captured near Chico, 14,452 were coded-wire tagged. Fifty-nine of the tagged salmon were recaptured at the Sutter Bypass site trap.

For the 1996/1997 sampling period, 1,922 juvenile chinook salmon were captured at the Chico site and 111 at the Sutter Bypass site. Of the 1,922 captured near Chico, 449 were coded-wire tagged. None of the tagged salmon was recaptured.

For the 1997/1998 sampling period, 10,583 juvenile chinook salmon were captured at the Chico site and 15,480 at the Sutter Bypass site. Of the 10,583 captured near Chico, 3,408 were coded-wire tagged. Five of the tagged salmon were recaptured at the Sutter Bypass site trap.

Yearling salmon were captured at the uppermost trapping site near Chico in October. Young-of-the-year were captured as early as mid-November. Virtually all juvenile salmon had left the Sutter Bypass by mid-May.

Adult escapement of Butte Creek spring-run chinook salmon was determined by snorkel survey. Escapement estimates for 1995, 1996, and 1997 were 7,480, 1,400, and 635 fish, respectively. All

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escapements were higher than the average escapement of 461 fish from 1967 to 1994.

INTRODUCTION

Spring-run chinook salmon (SRCS), *Oncorhynchus tshawytscha*, are listed as threatened under the California Endangered Species Act. Butte Creek is one of only three streams that form a basis for population trends of SRCS in the Central Valley of California. Nearby Mill and Deer creeks are the other two streams. The Butte Creek SRCS escapement for the years 1967 to 1994 averaged 461 fish and ranged from 10 fish in 1979 to 2,384 fish in 1989 (California Department of Fish and Game [CDFG], 1998). The adult escapement is used to indicate population trends for Butte Creek SRCS. The recovery status of SRCS is determined, in part, by escapement trend. The adult escapement was estimated for 1995 through 1997.

In general, SRCS in Butte Creek display the following life history pattern. Fish enter fresh water starting in February, ending in June. They enter Butte Creek from late February through June. SRCS are sexually immature when they enter fresh water. They hold in deep pools during the summer. Their gonads mature during the summer holding period and spawning begins in late September when stream temperatures cool. Emergence occurs as early as late November, but emergence time is a function of water temperature. From observation and inference, most SRCS emigrate from Butte Creek as fry (young-of-the-year [YOY]) but some emigrate as yearlings. Yearlings are juvenile SRCS that remain in the stream, oversummer, and emigrate in the fall, usually in October after enough rain has fallen to provide transport. The disposition of these fish, after they exit the spawning area, is loosely defined. SRCS leave upper Butte Creek either through Butte Slough Outfall or through Sutter Bypass to the Sacramento River through the Delta before they enter saltwater.

To better define the juvenile life history of Butte Creek SRCS, this study 1) monitored outmigration timing and relative abundance of age 0+ juvenile SRCS within Butte Creek, including Sutter Bypass, and as they entered the mainstem Sacramento River, 2) documented the outmigration of yearling SRCS, and 3) documented growth of juvenile SRCS in the Butte Creek system, including the Sutter Bypass, through coded-wire tagging of juvenile salmon at Parrott-Phalen Diversion Dam (PPDD) and Adams Dam. Through the efforts of other researchers, coded-wire tagged Butte Creek SRCS juveniles will be tracked as they emigrate downstream through the mainstem Sacramento River and the Delta. Tagged salmon will also be recovered in the ocean fishery to determine how and where Butte Creek SRCS contribute to the ocean harvest.

Butte Creek Watershed and Hydrology

The Butte Creek watershed is approximately 390 km^2 and is located in the northeast portion of Butte County. The headwaters of Butte Creek are in Lassen National Forest. Butte Creek enters the mainstem Sacramento River at two locations, the Butte Slough outfall gates and the downstream end of the Sutter Bypass near the confluence of the Feather River with the Sacramento River (Figure 1). When flows are greater than 21,000 ft^3 per second (cfs) at Wilkins Slough in the Sacramento River, part of the Sacramento River flows into lower Butte Creek and the Sutter Bypass through the Tisdale

Weir. Moulton and Colusa weirs are upstream of Tisdale Weir and are staged to spill when the flow at Ord Bend reaches 45,000 cfs and 65,000 cfs, respectively (Paul Ward, CDFG, pers. comm.). The capacity of the Sacramento River channel downstream of the Tisdale Weir at Wilkins Slough is 30,000 cfs. These weirs have a combined capacity to pass 133,000 cfs into the Sutter Bypass (Dept. of the Army, 1975). When water is bypassed, outmigrating salmonids from upstream of the Sutter Bypass mix with SRCS from Butte Creek.

MATERIALS AND METHODS

Trapping Sites

Fish were trapped at three locations along Butte Creek (Figure 1). The PPDD is the uppermost site. The site is immediately downstream of the SRCS holding and spawning area and upstream of where fall-run chinook salmon spawn, although on occasion some fall-run chinook salmon spawn above PPDD. Adams Dam is approximately 11 km downstream of PPDD, both sites are near Chico, California. The Sutter Bypass West Borrow Weir 1 is adjacent to the Sutter National Wildlife Refuge approximately 98 km downstream of PPDD near Yuba City, California. Each site was sampled with a 2.4 m (8 ft) rotary screw trap with a live box 1.2 m x 1.2 m x 0.9 m (4 ft x 4 ft x 3 ft) manufactured by EG Solutions (Eugene, Oregon). In addition to the screw trap at PPDD, the diversion canal had an off-stream fish screen outfitted with a trap box 1.2 m x 0.9 m x 2.1 m (4 ft x 3 ft x 7 ft) used to trap fish. Steel cable 0.6 cm (1/4 in.) in diameter connected the screw trap to the dam or another upstream stationary object. Placement was adjusted regularly based on water flow; typically with higher flows the trap was moved away from the dam allowing safer operation and access. All traps were fished 24 h a day, seven days a week, except during extraordinarily high water flows or during periods of excessive debris.

Processing Captured Fish

All fish were netted from the live-boxes and immediately placed into a shallow tub of fresh river water. Juvenile chinook salmon were sorted from other species and transferred swiftly with small aquarium nets into buckets equipped with portable aerators to be transported to shore for processing. The first 10 of each non-salmon fish species were measured to the nearest mm fork length (FL) and released. The remainder were counted and released. Other species captured were recorded (Appendices D and E).

A sub-sample of 50 salmon juveniles was placed into a bucket containing a weak, standardized solution of tricaine methanesulfonate (MS-222) and anaesthetized (6.3 g of MS-222 powder are dissolved in 1 liter of fresh distilled water to create a stock solution, which is then used at a dilution of 8-9 ml stock solution/1 liter of fresh river water). Upon immobilization, the juveniles were individually placed onto a wetted plexiglass measuring board and measured to the nearest mm FL. Thirty of this group were then

transferred to a wetted container on an Ohaus electronic scale and weighed to the nearest 0.01 g. All salmon caught in the Sutter Bypass trap were examined for an adipose fin clip. Salmon with a clipped adipose fin were sacrificed and preserved for future coded-wire tag (CWT) recovery and decoding. Each fish was individually bagged and given a tag having a unique numeric code identifying the date of capture, fork length and capture location. Unclipped fish were poured into a bucket of fresh aerated river water for recovery. After full recovery, all unmarked salmon were released downstream of the trap.

Juvenile chinook salmon were tagged adjacent to the PPDD trapping site. A sample of the salmon (up to 5,000) caught each day was put into a net holding pen (1.2 m^3,(4 ft^3) with 0.32 cm, (1/8 in.) mesh) near the diversion trap for future tagging. Holding time ranged from 2-10 d, depending on processing time and the number of fish being caught at any one time.

Fish were tagged using a Northwest Marine Technology Tag Injector Model MKII and Model MKII Quality Control Device (QCD). Injectors were fitted with a 1,200 fish/lb head mold and injected half-length (0.5 mm) binary coded-wire tags. Fish were anaesthetized in MS-222, adipose fin clipped, then tagged in the rostrum and placed through the QCD. All but a group of 100 tagged fish were recovered in fresh water and released. The remaining fish were held for 24 hours and re-run through the QCD to obtain a 24-hour tag shedding rate and then released. Yearling salmon and late-fall juveniles were not included in the sample tagged, except in 1996 when a group of 20 yearlings was tagged. Tag codes were changed periodically through the outmigration period.

Juvenile Outmigration

Yearling SRCS are determined by examining length-frequency distributions of salmon trapped at PPDD or Adams Dam. These fish are the only salmon that emigrate in the fall before fish from the newly spawned brood year emerge. When both year classes are in the stream, the yearlings appear much larger than YOY.

Outmigration of YOY SRCS is described by examining catches of salmon trapped at PPDD, Adams Dam and from tagged fish recovered in the Sutter Bypass.

Growth

Information from tagged salmon recoveries at the Sutter Bypass site was used to determine how long juvenile salmon remained in the system and to make a preliminary estimate of growth expressed in millimeters per day. The mean FL was calculated for each tag group. Because the release of a tag code covered a varying number of days, the median release date was used for calculating mean growth. Growth was determined by subtracting the mean release size from the individual capture size. Growth rate was calculated by dividing the difference between mean size at release ($FL_{Release}$) and size at recovery ($FL_{Recovery}$) by the difference in the number of days (d) between median release date and

recovery date ($FL_{Recovery}$-$FL_{Release}$/$d_{Recovery-Release}$).

Relative Abundance

Relative abundance will be measured by comparing catches at PPDD for the 1995, 1996, and 1997 brood years.

Adult Escapement

Each year's adult count was determined by snorkel survey. The entire known spring-run salmon holding habitat was surveyed. The holding habitat is from Quartz Bowl 1 km downstream of the Centerville Head Dam downstream to PPDD, which is approximately 16.9 km or 10.5 miles. Surveys were conducted each August, while SRCS adults were holding in pools. Three to five experienced personnel swam abreast downstream through pools counting adult salmon. At the end of the pool, each person would state their figure and whether it was a count or an estimate. If there was a greater than 20% discrepancy between the counts, the pool would be surveyed again until greater precision was obtained. If there was less than 20% discrepancy, all counts were recorded with the lowest values and highest values for all pools summed for reporting a minimum and maximum range of total escapement. Counts were used for most pools, but estimates were used when the number of salmon in a pool precluded an actual count. The sum of the maximum count or estimate was used as an escapement estimate. The same individuals conducted the week-long survey.

RESULTS

1995-1996 Trapping Season

Fish capture for the 1995-1996 sampling year began 28 November 1995 at the PPDD site, when the diversion screen trap was installed. The screw trap was installed on 1 December 1995. Both traps were fished (when stream flow permitted) until April 29, 1996, when the screw trap was removed due to a high volume of debris at the trapping site. An eddy had formed during high flows which gathered debris and directed it into the entrance of the trap. The diversion screen trap was fished until 8 July 1996. A total of 119,788 juvenile chinook salmon was captured in both traps — 38,149 in the diversion screen trap and 81,639 in the screw trap (Tables 1-3). Of the total captured, 14,452 were tagged and released (Table 4). Since the diversion screen trap is located off-stream in the diversion canal, the trapping data indicate conclusively the benefit of the PPDD fish screen; any fish captured in the trap would have been lost into the canal if there was no fish screen.

FIGURE 1. Butte Creek watershed indicating trapping sites.

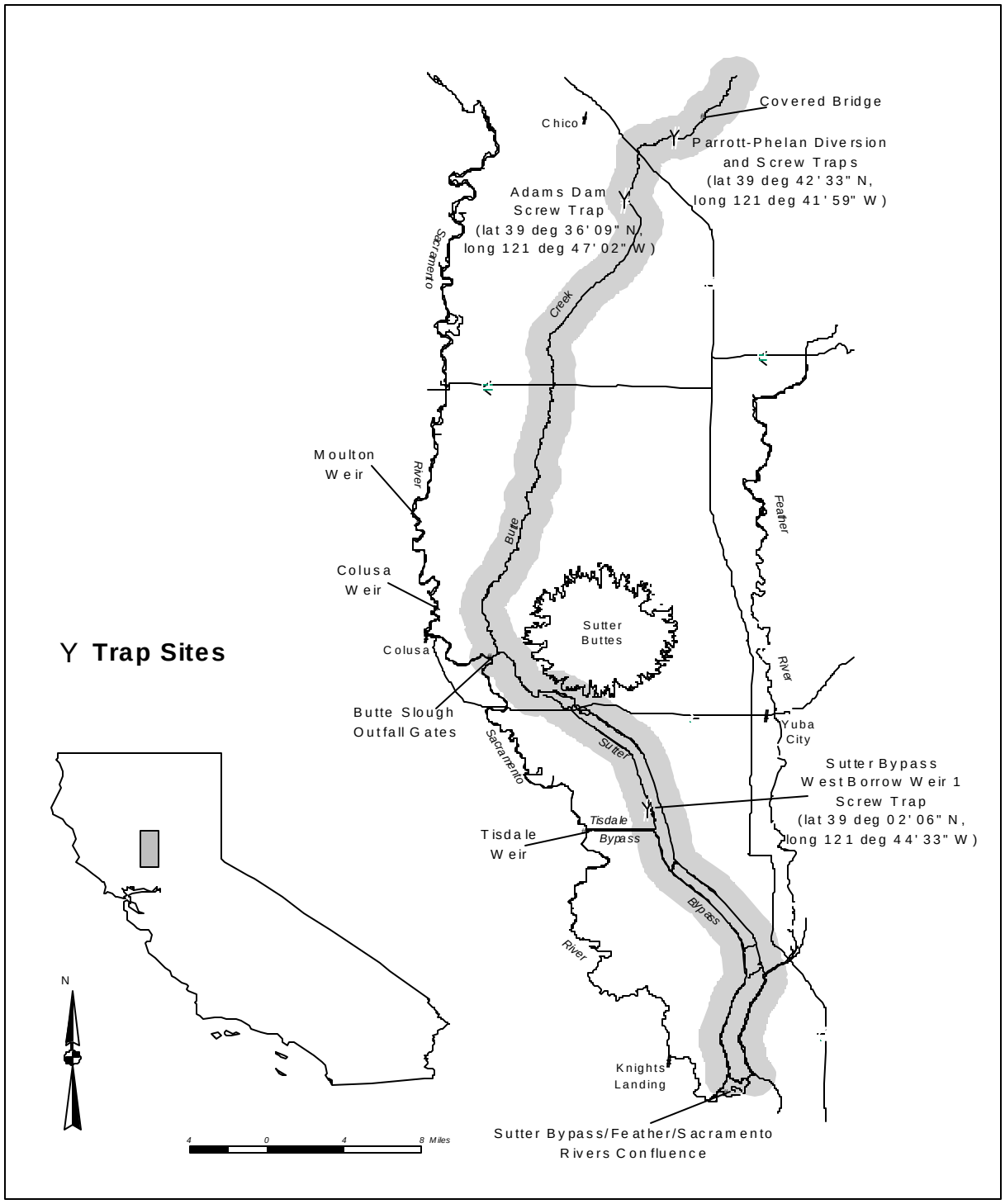

TABLE 1. Bi-weekly catch summary of spring-run chinook salmon fishing the screen trap at Parrott-Phelan Diversion Dam from 28 November 1995 to 8 July 1996; yearling captures are excluded.

Trapping period		Mean FL (mm)	Standard deviation	Range FL (mm)		Total no. captured	No. trapping days
11/28/95	11/30/95	35	1.4	33	39	47	2
12/1/95	12/15/95	35	1.3	30	39	2,247	12
12/16/95	12/31/95	35	1.2	32	41	4,238	13
1/1/96	1/15/96	36	1.6	30	53	19,536	15
1/16/96	1/31/96	36	2.7	34	61	10,366	5
2/1/96	2/15/96	37	2.8	31	51	964	9
2/16/96	2/29/96	41	8.8	32	79	201	6
3/1/96	3/15/96	51	6.5	40	63	12	9
3/16/96	3/31/96	56	10.9	42	90	20	14
4/1/96	4/15/96	61	6.0	52	75	29	12
4/16/96	4/30/96	75	8.8	56	92	60	11
5/1/96	5/15/96	86	10.2	50	116	247	12
5/16/96	5/31/96	75	15.6	50	107	26	12
6/1/96	6/15/96	72	11.6	55	103	32	15
6/16/96	6/30/96	74	4.7	67	85	18	15
7/1/96	7/8/96	81	-	81	81	1	8
					Total:	38,044	170

TABLE 2. Bi-weekly catch summary of spring-run chinook salmon fishing the screw trap at Parrott-Phelan Diversion Dam from 1 December 1995 to 29 April 1996; yearling captures are excluded.

Trapping period		Mean FL (mm)	Standard deviation	Range FL (mm)		Total no. captured	No. trapping days
12/1/95	12/15/95	35	1.1	31	38	3,742	12
12/16/95	12/31/95	35	1.7	26	51	6,518	10
1/1/96	1/15/96	36	2.3	32	53	44,937	15
1/16/96	1/31/96	36	1.3	32	43	18,420	8
2/1/96	2/15/96	36	4.1	33	60	7,583	3
2/16/96	2/29/96	36	4.5	31	60	74	3
3/1/96	3/15/96	63	9.9	56	70	2	1
3/16/96	3/31/96	59	13.3	40	91	49	16

4/1/96	4/15/96	76	10.5	52	101	92	15
4/16/96	4/29/96	81	11.6	57	113	53	14
					Total:	81,470	97

TABLE 3. Bi-weekly catch summary of spring-run chinook salmon combining the effort of the screen trap and the screw trap at Parrott-Phelan Diversion Dam from 28 November 1995 to 8 July 1996; yearling captures are excluded.

Trapping period		Mean FL (mm)	Standard deviation	Range FL (mm)		Total no. captured	No. trapping days
11/28/95	11/30/95	35	1.4	33	39	47	2
12/1/95	12/15/95	35	1.2	30	39	5,989	12
12/16/95	12/31/95	35	1.5	26	51	10,756	13
1/1/96	1/15/96	36	2.0	30	53	64,473	15
1/16/96	1/31/96	36	1.8	32	61	28,786	10
2/1/96	2/15/96	37	3.3	31	60	8,547	9
2/16/96	2/29/96	40	8.1	31	79	275	6
3/1/96	3/15/96	53	7.8	40	70	14	9
3/16/96	3/31/96	58	12.7	40	91	69	16
4/1/96	4/15/96	73	11.5	52	101	121	15
4/16/96	4/30/96	77	10.5	56	113	113	14
5/1/96	5/15/96	86	10.2	50	116	247	12
5/16/96	5/31/96	75	15.6	50	107	26	12
6/1/96	6/15/96	72	11.6	55	103	32	15
6/16/96	6/30/96	74	4.7	67	85	18	15
7/1/96	7/8/96	81	-	-	-	1	8
					Total:	119,514	183

TABLE 4. Summary of coded-wire tagged spring-run chinook salmon released at Parrott-Phelan Diversion Dam from 4 January 1996 to 5 June 1996.

Tag code	Release date range		Mean FL (mm)	Range FL (mm)		Total no. released
B6-12-01	1/4/96	1/25/96	36	30	53	6,598
B6-12-02	1/25/96	3/16/96	37	31	79	7,393
B6-12-03	3/22/96	4/7/96	65	41	95	85
B6-12-04	4/8/96	4/29/96	76	52	113	165
B6-12-05	5/4/96	6/5/96	84	50	116	211

Approximately 93,000 (78 %) juvenile SRCS (Table 3) of the entire salmon catch occurred during January 1996. Trapping had to be suspended for various periods of time (Tables 1 and 2) because of high flows (Appendix A, Figure 1).

The Sutter Bypass sampling began 16 January 1996 in the Sutter Bypass at Weir 1, West Borrow. The Bypass was flooded and water was slack for most of the time period between trap installation and 15 March 1996, so trapping was not possible for much of the time. As the flood waters began to recede in mid-March, salmon captures increased significantly. From 16 March 1996 to 31 March 1996, the trap was fished only during the day to avoid fish mortality, therefore the reported 22,793 total salmon captured is deceptively low; a significantly larger number would have been caught if the trap had fished 24 h/d. The first CWT recapture was on 21 March 1996, the last on 19 May 1996 (Table 6). One fish with tag code B6-12-04 was recovered at 96 mm FL. Two fish were recovered with tag code B6-12-05 at 95 mm FL and 87 mm FL. Of 61 CWT recaptures from the Sutter Trap, 59 were Butte Creek SRCS and two were from Coleman National Fish Hatchery (CNFH) (one fall-run and one winter-run chinook salmon).

TABLE 5. Bi-weekly catch summary of juvenile chinook salmon fishing a screw trap in the Sutter Bypass at West Borrow Weir 1 from 16 January 1996 to 8 July 1996. Fish captured at this location can not be identified as spring-run chinook salmon because of the mixing of juvenile salmon of other races from the Sacramento River.

Trapping period		Mean FL (mm)	Standard deviation	Range FL (mm)		Total no. captured	No. trapping days
1/16/96	1/31/96	42	12.1	32	98	92	4
2/1/96	2/15/96	50	19.9	30	171	1,545	13
2/16/96	2/29/96	50	15.5	32	128	142	9
3/1/96	3/15/96	76	22.0	32	133	926	15
3/16/96	3/31/96*	90	13.6	36	134	22,793	13
4/1/96	4/15/96	87	10.6	36	125	14,407	15
4/16/96	4/30/96	91	9.6	62	124	7,669	15
5/1/96	5/15/96	87	8.6	55	127	4,143	15
5/16/96	5/31/96	86	8.7	57	116	555	14
6/1/96	6/15/96	86	9.9	76	104	9	15
6/16/96	6/30/96	103	28.3	84	145	4	15
7/1/96	7/8/96	-	-	-	-	0	8
					Total:	52,285	151

* Trap fished only during daylight hours.

TABLE 6. Recaptures of spring-run chinook salmon bearing coded-wire tags in the Sutter Bypass West Borrow Weir 1. All fish were tagged at Parrott-Phelan Diversion Dam. All fish were from the 1995 brood year.

Tag code B6-12-01

Recovery date	Recovery FL (mm)	d at large	mm/d
3/21/96	96	67	0.90
3/21/96	91	67	0.82
3/22/96	80	68	0.65
3/22/96	85	68	0.72
3/23/96	88	69	0.75
3/29/96	85	75	0.65
3/29/96	73	75	0.49
3/29/96	73	75	0.49
4/7/96	95	84	0.70
4/7/96	98	84	0.74
4/9/96	91	86	0.64
4/9/96	90	86	0.63
4/9/96	93	86	0.66
4/9/96	91	86	0.64
4/10/96	90	87	0.62
4/11/96	97	88	0.69
4/11/96	84	88	0.55
4/11/96	79	88	0.49
4/12/96	87	89	0.57
4/13/96	80	90	0.49
4/14/96	89	91	0.58
4/15/96	87	92	0.55
4/15/96	85	92	0.53
4/16/96	78	93	0.45
4/18/96	108	95	0.76
4/18/96	92	95	0.59
4/18/96	105	95	0.73

TABLE 6 (continued). Recaptures of spring-run chinook salmon bearing coded-wire tags in the Sutter Bypass West Borrow Weir 1. All fish were tagged at Parrott-Phelan Diversion Dam. All fish were from the 1995 brood year.

Tag code B6-12-02

Recovery date	Recovery FL (mm)	d at large	mm /d
3/29/96	67	37	0.81
3/29/96	68	37	0.84
4/1/96	77	40	1.00
4/6/96	83	45	1.02
4/7/96	89	46	1.13
4/9/96	89	48	1.08
4/9/96	78	48	0.85
4/9/96	86	48	1.02
4/10/96	83	49	0.94
4/10/96	84	49	0.96
4/10/96	80	49	0.88
4/10/96	69	49	0.65
4/11/96	83	50	0.92
4/11/96	89	50	1.04
4/12/96	92	51	1.08
4/14/96	82	53	0.85
4/14/96	76	53	0.74
4/15/96	85	54	0.89
4/15/96	90	54	0.98
4/16/96	90	55	0.96
4/16/96	85	55	0.87
4/16/96	87	55	0.91
4/18/96	95	57	1.02
4/21/96	105	60	1.13
4/22/96	79	61	0.69
4/27/96	92	66	0.83
4/29/96	78	68	0.60
4/29/96	90	68	0.78
5/19/96	113	88	0.86

TABLE 7. Recaptures of spring-run chinook salmon bearing coded-wire tags from Sherwood Harbor (Sacramento, California), Chipps Island (near Pittsburg, California), and Walnut Grove, California. All fish were tagged at Parrott-Phelan Diversion Dam. All fish were from the 1995 brood year.

Tag code	Recovery date	Recovery FL (mm)	mm/d	Recapture location	d at large
B6-12-01	4/2/96	91	0.47	Sherwood H.	79
B6-12-02	4/3/96	77	0.95	Walnut Gr.	42
B6-12-02	4/8/96	78	0.87	Walnut Gr.	47
B6-12-02	4/9/96	77	0.83	Walnut Gr.	48
B6-12-02	5/8/96	95	0.75	Chipps Is.	77

1996-97 Trapping Season

Fish capture for the 1996-1997 sampling year began 17 September 1996 at the PPDD site, when the diversion trap was installed. The screw trap was installed on 20 September 1996. Both traps were fished until 28 December 1996 when both traps were pulled due to very high flow. A total of 1,860 SRCS fry was captured.

On 1 January 1997, flow in Butte Creek reached a record 26,600 cfs (Appendix A, Figure 2). Significant damage was done to the diversion structure and to the fish ladder. The creek moved from the channel during the night of 1 January and left the diversion structure, fish ladder and both fish traps hundreds of meters from the old channel.

On 17 January 1997 a screw trap was installed at Adams Dam and was fished until 26 June 1997. Neither PPDD trapping sites could be utilized until the following sampling year when the creek was moved back to its original channel. A total of 32 juvenile salmon was captured; none was tagged.

TABLE 8. Bi-weekly catch summary of spring-run chinook salmon fishing the screen trap at Parrott-Phelan Diversion Dam from 17 September 1996 to 31 December 1996; yearling captures are excluded.

Trapping period		Mean FL (mm)	Standard deviation	Range FL (mm)		Total no. captured	No. trapping days
9/17/96	9/30/96	-	-	-	-	0	13
10/1/96	10/15/96	-	-	-	-	0	15
10/16/96	10/31/96	-	-	-	-	0	16
11/1/96	11/15/96	-	-	-	-	0	15
11/16/96	11/30/96	32	1.3	30	34	16	15
12/1/96	12/15/96	35	2.1	29	41	694	10
12/16/96	12/31/96	35	1.6	28	39	391	12
					Total:	1,101	96

TABLE 9. Bi-weekly catch summary of spring-run chinook salmon fishing the screw trap at Parrott-Phelan Diversion Dam from 20 September 1996 to 31 December 1996; yearling captures are excluded.

Trapping period		Mean FL (mm)	Standard deviation	Range FL (mm)		Total no. captured	No. trapping days
9/20/96	9/30/96	-	-	-	-	0	10
10/1/96	10/15/96	-	-	-	-	0	15
10/16/96	10/31/96	-	-	-	-	0	15
11/1/96	11/15/96	-	-	-	-	0	15
11/16/96	11/30/96	32	1.8	29	37	32	15
12/1/96	12/15/96	34	1.4	31	38	278	8
12/16/96	12/31/96	35	1.6	25	40	449	7
					Total:	759	85

TABLE 10. Bi-weekly catch summary of spring-run chinook salmon fishing the screw trap at Adams Dam from 16 January 1997 to 26 June 1997; yearling captures are excluded.

Trapping period		Mean FL (mm)	Standard deviation	Range FL (mm)		Total no. captured	No. trapping days
1/16/97	1/31/97	37	-	37	37	1	6
2/1/97	2/15/97	-	-	-	-	0	12
2/16/97	2/28/97	-	-	-	-	0	13
3/1/97	3/15/97	-	-	-	-	0	14
3/16/97	3/31/97	-	-	-	-	0	13
4/1/97	4/15/97	92	7.9	74	101	9	15
4/16/97	4/30/97	82	9.7	67	108	22	12
5/1/97	5/15/97	-	-	-	-	0	15
5/16/97	5/31/97	-	-	-	-	0	16
6/1/97	6/15/97	-	-	-	-	0	15
6/16/97	6/26/97	-	-	-	-	0	11
					Total:	32	142

Sampling began on 20 March 1997 at Weir 1 in the Sutter Bypass. Sampling was suspended on 24 March after only 4 days because several winter-run sized salmon[2]/ had been captured. A winter-run chinook salmon take permit application had been submitted to National Marine Fisheries Service but had not yet been approved. Of the 111 salmon captured, none was marked.

TABLE 11. Bi-weekly catch summary of spring-run chinook salmon combining the effort of the screen trap and the screw trap at Parrott-Phelan Diversion Dam and Adams Dam from 17 September 1996 to 26 June 1997; yearling captures are excluded.

Trapping period		Mean FL (mm)	Standard deviation	Range FL (mm)		Total no. captured	No. trapping days
9/17/96	9/30/96	-	-	-	-	0	13
10/1/96	10/15/96	-	-	-	-	0	15
10/16/96	10/31/96	-	-	-	-	0	16
11/1/96	11/15/96	-	-	-	-	0	15
11/16/96	11/30/96	32	1.6	29	37	48	15
12/1/96	12/15/96	35	1.9	29	41	972	11
12/16/96	12/31/96	35	1.6	25	40	840	12
1/1/97	1/15/97	-	-	-	-	-	0
1/16/97	1/31/97	37	-	-	-	1	6
2/1/97	2/15/97	-	-	-	-	0	12
2/16/97	2/28/97	-	-	-	-	0	13
3/1/97	3/15/97	-	-	-	-	0	14
3/16/97	3/31/97	-	-	-	-	0	13
4/1/97	4/15/97	92	7.9	74	101	9	15
4/16/97	4/30/97	82	9.7	67	108	22	12
5/1/97	5/15/97	-	-	-	-	0	15
5/16/97	5/31/97	-	-	-	-	0	16
6/1/97	6/15/97	-	-	-	-	0	15
6/16/97	6/26/97	-	-	-	-	0	11
					Total:	1,892	239

TABLE 12. Summary of coded-wire tagged spring-run chinook salmon released at Parrott-Phelan Diversion Dam from 12 October 1996 to 21 December 1996.

Tag code	Release date range		Mean FL (mm)	Range FL (mm)		Total no. released
06-01-12-01-11	12/8/96	12/18/96	35	29	39	429
06-01-08-05-05*	10/12/96	12/21/96	114	92	144	20

*Yearlings; all others sub-yearlings

[2]/ F. Fisher. 1992. Chinook salmon, *Oncorhynchus tshawytscha*, growth and occurrence in the Sacramento-San Joaquin river system. CDFG, Inland Fisheries Division, Red Bluff, California. manuscript, 42 p.

TABLE 13. Bi-weekly catch summary of juvenile chinook salmon fishing the screw trap in Sutter Bypass at West Borrow Weir 1 from 21 March 1997 to 24 March. Fish captured here can not be identified as spring-run chinook salmon because of the mixing of juvenile salmon of other races from the Sacramento River.

Trapping period		Mean FL (mm)	Standard deviation	Range FL (mm)		Total no. captured	No. trapping days
3/21/97	3/24/97	81	10.8	57	110	111	4
					Total:	111	4

1997-98 Trapping Season

Sampling for the 1997-1998 sampling began 6 October 1997 at the PPDD site, when the diversion screen trap was installed. The screw trap was installed on 20 October 1997. Both traps were fished until 11 January 1998 when a large storm clogged the ladder with debris and blocked flow to the screw trap. The ladder obstruction was cleared and trapping resumed 5 March 1998. A total of 8,808 juvenile SRCS was captured (Tables 14 through 17). Of that total, 3,408 were coded-wire tagged (Table 18).

TABLE 14. Bi-weekly catch summary of spring-run chinook salmon fishing the screen trap at Parrott-Phelan Diversion Dam from 6 October 1997 to 23 July 1998; yearling captures are excluded.

Trapping period		Mean FL (mm)	Standard deviation	Range FL (mm)		Total no. captured	No. trapping days
10/6/97	10/15/97	-	-	-	-	0	9
10/16/97	10/31/97	-	-	-	-	0	16
11/1/97	11/15/97	-	-	-	-	0	15
11/16/97	11/30/97	31	2.2	28	34	10	12
12/1/97	12/15/97	34	1.9	28	37	74	15
12/16/97	12/31/97	35	1.2	30	37	76	15
1/1/98	1/15/98	35	1.6	31	40	1,865	9
1/16/98	1/31/98	35	1.8	30	45	206	15
2/1/98	2/15/98	34	1.2	33	36	12	9
2/16/98	2/28/98	39	-	-	-	1	13
3/1/98	3/15/98	-	-	-	-	0	15
3/16/98	3/31/98	-	-	-	-	0	13
4/1/98	4/15/98	-	-	-	-	0	14
4/16/98	4/30/98	90	3.5	87	92	2	15
5/1/98	5/15/98	67	10.6	54	83	8	14
5/16/98	5/31/98	72	10.5	52	91	35	13
6/1/98	6/15/98	80	4.2	75	83	4	15
6/16/98	6/30/98	83	3.5	78	86	4	15
7/1/98	7/15/98	-	-	-	-	0	15
7/16/98	7/23/98	-	-	-	-	0	8
					Total:	2,297	265

TABLE 15. Bi-weekly catch summary of spring-run chinook salmon fishing the screw trap at Parrott-Phelan Diversion Dam from 20 October 1997 to 23 July 1998; yearling captures are excluded.

Trapping period		Mean FL (mm)	Standard deviation	Range FL (mm)		Total no. captured	No. trapping days
10/20/97	10/31/97	-	-	-	-	0	11
11/1/97	11/15/97	-	-	-	-	0	15
11/16/97	11/30/97	31	1.6	29	33	6	12
12/1/97	12/15/97	34	1.7	31	38	74	15
12/16/97	12/31/97	35	1.0	31	38	251	16
1/1/98	1/15/98	36	1.6	31	39	5,171	8
1/16/98	1/31/98	-	-	-	-	-	0
2/1/98	2/15/98	-	-	-	-	-	0
2/16/98	2/28/98	-	-	-	-	-	0
3/1/98	3/15/98	53	7.4	43	61	123	7
3/16/98	3/31/98	69	11.2	50	86	71	12
4/1/98	4/15/98	73	16.4	49	101	7	14
4/16/98	4/30/98	60	12.8	46	85	25	15
5/1/98	5/15/98	67	11.0	44	99	94	14
5/16/98	5/31/98	75	8.8	52	98	140	13
6/1/98	6/15/98	83	11.0	65	125	22	10
6/16/98	6/30/98	86	8.7	72	113	20	15
7/1/98	7/15/98	108	24.7	90	125	2	15
7/16/98	7/23/98	149	n/a	149	149	1	8
					Total:	6,007	200

TABLE 16. Bi-weekly catch summary of spring-run chinook salmon fishing the screw trap at Adams Dam from 2 March 1998 to 9 May 1998; yearling captures are excluded.

Trapping period		Mean FL (mm)	Standard deviation	Range FL (mm)		Total no. captured	No. trapping days
3/2/98	3/15/98	59	7.2	47	71	432	13
3/16/98	3/31/98	71	14.5	45	86	351	8
4/1/98	4/15/98	72	13.2	49	97	20	12
4/16/98	4/30/98	68	12.4	45	95	62	9
5/1/98	5/9/98	75	11.1	49	124	122	4
					Total:	987	46

The screw trap was installed at the Sutter Bypass site on 15 April 1998 and was fished until 17 July 1998. A total of 15,480 juvenile chinook salmon was captured (Table 17). Of that total, 41 were tagged. Of the 41 CWT recoveries, 36 were released from CNFH (Appendix C) and 5 were released at PPDD or Adams Dam (Table 20).

TABLE 17. Bi-weekly catch summary of spring-run chinook salmon combining the effort of the screen trap and the screw traps at Parrott-Phelan Diversion Dam and Adams Dam from 6 October 1997 to 23 July 1998; yearling captures are excluded.

Trapping period		Mean FL (mm)	Standard deviation	Range FL (mm)		Total no. captured	No. trapping days
10/6/97	10/15/97	-	-	-	-	0	9
10/16/97	10/31/97	-	-	-	-	0	16
11/1/97	11/15/97	-	-	-	-	0	15
11/16/97	11/30/97	31	1.9	28	34	16	12
12/1/97	12/15/97	34	1.8	28	38	148	15
12/16/97	12/31/97	35	1.1	30	38	327	16
1/1/98	1/15/98	36	1.6	31	40	7,036	10
1/16/98	1/31/98	37	4.2	30	58	443	15
2/1/98	2/15/98	34	1.2	33	36	12	9
2/16/98	2/28/98	54	8.0	39	69	23	13
3/1/98	3/15/98	57	7.5	43	71	555	15
3/16/98	3/31/98	70	12.7	45	86	422	14
4/1/98	4/15/98	72	13.8	49	101	27	15
4/16/98	4/30/98	66	13.3	45	95	89	15
5/1/98	5/15/98	71	11.6	44	124	224	14
5/16/98	5/31/98	75	9.2	52	98	175	14
6/1/98	6/15/98	83	10.5	65	125	26	15
6/16/98	6/30/98	86	8.1	72	113	24	15
7/1/98	7/15/98	108	24.7	90	125	2	15
7/16/98	7/23/98	149	-	-	-	1	8
					Total:	9,550	270

TABLE 18. Summary of coded-wire tagged spring-run chinook salmon released at Parrott-Phelan Diversion Dam and Adams Dam from 14 January 1998 to 3 April 1998.

Tag code	Release date range		Capture and release location	Mean FL (mm)	Range FL (mm)		Total no. released
06-01-12-01-13	1/14/98	1/25/98	Parrott-Phelan Dam	35	31	42	1,794
06-01-12-01-14	1/30/98	1/30/98	Parrott-Phelan Dam	36	34	37	267
06-01-12-01-15	2/26/98	3/9/98	Parrott-Phelan Dam	60	59	61	98
06-01-12-02-01	3/9/98	3/17/98	Adams Dam	59	47	71	1,018
06-01-12-02-05	3/12/98	3/17/98	Parrott-Phelan Dam	69	56	82	110
06-01-12-02-06	3/26/98	4/3/98	Parrott-Phelan Dam	66	50	76	98
06-01-12-02-02	3/26/98	4/3/98	Adams Dam	72	45	84	23

TABLE 19. Bi-weekly catch summary of juvenile chinook salmon captured fishing the screw trap in Sutter Bypass at West Borrow Weir 1 from 16 April 1998 to 17 July 1998. Fish captured here can not be identified as spring-run chinook salmon because of the mixing of juvenile salmon of other races from the Sacramento River.

Trapping period		Mean FL (mm)	Standard deviation	Range FL (mm)		Total no. captured	No. trapping days
4/16/98	4/30/98	89	10.2	43	130	10,568	15
5/1/98	5/15/98	90	11.3	51	130	3,090	15
5/16/98	5/31/98	89	11.0	56	131	1,261	15
6/1/98	6/15/98	86	12.1	37	126	457	15
6/16/98	6/30/98	87	7.0	66	104	102	15
7/1/98	7/15/98	95	12.7	86	104	2	15
7/16/98	7/17/98	-	-	-	--	0	2
					Total:	15,480	92

TABLE 20. Recaptures of spring-run chinook salmon bearing coded-wire tags. All fish were tagged at either Parrott-Phelan Diversion Dam or Adams Dam; all fish were recaptured at Sutter Bypass West Borrow Weir 1. All fish were from the 1997 brood year.

Tag code	Recovery date	Recovery FL (mm)	Growth rate (mm/d)	d at large
06-01-12-01-15	5/24/98	84	0.30	81
06-01-12-02-01	5/21/98	81	0.32	69
06-01-12-02-05	4/24/98	74	0.13	40
06-01-12-02-05	5/22/98	75	0.09	68

06-01-12-02-05	5/24/98	80	0.16	70

Juvenile Outmigration

Both YOY and yearling juvenile SRCS outmigration patterns were documented based on length of juvenile salmon captured at PPDD and by juvenile salmon observed during the summer adult escapement snorkel surveys. The majority of Butte Creek SRCS begin outmigrating as fry during high flows starting in mid-November. Some YOY remain in Butte Creek above PPDD and rear until later in the spring or early summer, then begin outmigrating. Yearling SRCS outmigrate as early as October. The length-frequency distributions in Appendix B are an indicator of timing and not an indicator of abundance. During the peak of outmigration, YOY fish number in the thousands. Later in the spring, YOY outmigration number in the hundreds.

Recently emerged fry were trapped at PPDD in the spring, and were assumed to be late-fall-run chinook salmon and are marked on the length-frequency distributions in Appendix B. The line indicating late-fall-run chinook salmon (Appendix B) is an approximate delineation of late-fall-run and spring-run chinook salmon. Neither yearling SRCS nor late-fall fry were tagged, except for the 20 SRCS yearlings tagged in 1996 (Table 12).

Growth

Yearling SRCS grow to 150 mm FL and remain in Butte Creek for 12 months or more before leaving Butte Creek. These fish were captured at PPDD from October through December (Appendix B, Figures 1 and 2).

YOY grow to over 100 mm FL before exiting the system. Fish tagged at PPDD with two tag codes and recovered in the Sutter Bypass from the 1995 brood year provided enough recaptures for a basis to determine mean growth. Fish recovered from tag group B6-12-01 averaged 89 mm FL and ranged from 73 mm FL to 108 mm FL. Fish recovered from tag group B6-12-02 averaged 85 mm FL and ranged from 67 mm FL to 113 mm FL.

Although we calculated a growth rate for these salmon (Tables 6, 7 and 20), it is a general conclusion. Fish were released over a large number of days so the true number of days-at-large before recapture can not be determined. For example, tag group B6-12-01 was released over a range of 22 days and tag group B6-12-02 was released over a range of 52 days. These fish were not of uniform length. The length at tagging for tag group B6-12-01 ranged from 30 mm FL to 53 mm FL and for tag group B6-12-02 ranged from 31mm FL to 79 mm FL. A mean FL was used.

Relative Abundance

We were unable to make an estimate of relative abundance based on catches at PPDD. We were unable to standardize effort on an annual basis.

Adult Escapement

TABLE 21. Estimates of adult spring-run salmon escapement in Butte Creek from snorkel surveys taken annually from 1994 through 1997.

Year	Estimate	Survey dates
1994	474	29 June - 1 July 1994
1995	7,480	24 July - 27 July 1995
1996	1,400	19 August - 23 August 1996
1997	635	18 August - 21 August 1997

DISCUSSION

Anadromous fish monitoring of Butte Creek is difficult because it is a free-flowing stream lacking large dams to buffer or control flows. Butte Creek daily flows for the 1995 through 1998 water years were extremely variable (Appendix A). The PPDD screw trap was destroyed by high flow in February, 1996. On 1 January 1997, Butte Creek flowed at 26,600 cfs, incised a new channel on the far side of the canyon from PPDD, and left the fish traps behind. In addition to these catastrophic flow events, the common high flow events, when the majority of fry may be moving downstream, are generally when trapping must be suspended because of danger to equipment or personnel.

Juvenile Outmigration

The trapping data from PPDD indicate that most SRCS in Butte Creek begin their downstream migration as fry or fingerlings. A portion of Butte Creek SRCS do outmigrate as yearlings. Salmon greater than 80 mm FL captured at PPDD each year in the fall and early winter are outmigrating yearling salmon (Appendix B). Yearling salmon were also seen upstream of PPDD during the summer adult escapement surveys. Yearling salmon may avoid the traps more effectively than YOY SRCS, so it is difficult to quantify the proportion that outmigrate under each scenario.

Butte Creek SRCS outmigration is prolonged and variable and juveniles are present in Butte Creek upstream of PPDD all year, because of yearling holdover. Butte Creek SRCS outmigration began as early as October — demonstrated by a 144 mm yearling salmon captured at PPDD 9 October 1996. The earliest fry were seen in the third week of November and outmigration peaked during a 4- to10-week period between December and April (Tables 3, 11, and 17). Alevin emergence began in late November and extended approximately through mid-January. Juvenile SRCS were trapped at PPDD as late as 19 July and at the Sutter Bypass as late as July 1 (both in 1998).

Recently emerged fry were trapped at PPDD beginning in March or early April (Appendix B). These fish are assumed to be late-fall-run chinook salmon, though no late-fall-run adult salmon have yet been

documented in Butte Creek due to high flow and high turbidity water conditions. We observed late-fall-run salmon adults in nearby Big Chico Creek, where water flow was lower and spawning activity could be documented, and these observations were used to justify the assumption that these spring alevins are late-fall-run chinook salmon.

Sutter Bypass trapping and CWT recaptures suggest that salmon use the Sutter Bypass as a nursery area until it begins to drain in the late winter or spring, at which time the salmon are captured in very large numbers as they exit the West Borrow (Figure 1). While trapping becomes more efficient as the Sutter Bypass drains, the large and rapid increase in capture seems to be due to fish behavior more than simply trapping efficiency. Few fish are captured after mid-May. Any salmon that remain in the Sutter Bypass into the summer months would perish due to high water temperature.

Five 1995/1996 CWT recaptures were from downstream of the Sutter Bypass; four from the mainstem Sacramento River and one from the Delta at Chipps Island (Table 7). The mainstem recaptures were between 2 April and 9 April 1996 and the Delta recapture was on 8 May 1996. These fish ranged in size from 77 mm FL to 95 mm FL. Based on these five recaptures, SRCS leaving the Sutter Bypass may move downstream rapidly and do not have to use the mainstem Sacramento River for further rearing.

Growth

SRCS growth occurs upstream of PPDD (Tables 3, 8, 9, 14, and 15). Outmigrating fry rear downstream of PPDD. Most fish captured at PPDD are less than 40 mm in length, but a portion remain in the spawning area until the spring before beginning to outmigrate. Many of these later-outmigrating fingerlings reach lengths of greater than 100 mm FL. Clearly, the portion of Butte Creek upstream of PPDD is an important component of the nursery habitat.

CWT recaptures from the Sutter screw trap suggest that the Sutter Bypass, when flooded in winter and spring, provides growth opportunity for juvenile salmon. Fish tagged at an average size of 36 mm FL at PPDD were recovered in the Sutter Bypass at an average 89 mm FL. Some of these recovered fish were greater than 100 mm FL. Healey (1991) and Kjelson et al. (1982) reported that 70 mm FL is the approximate size that chinook salmon need to reach before they can enter salt water. Almost all chinook salmon captured at the Sutter Bypass site after 1 March are larger than 70 mm FL (Tables 5, 13, and 19). These salmon that have reared in the Sutter Bypass are large enough to enter saltwater and probably do not use the mainstem Sacramento River or the Delta for substantial rearing, but migrate directly to the ocean. Nursery habitat use, vulnerability to stranding and predation, and overall survival need clearer definition for salmonids that use the Sutter Bypass and the mainstem Sacramento River or Delta.

Kjelson et al. (1982) found fall-run chinook salmon growth rates averaging 0.86 mm/d (range 0.57 to 1.23) in 1980 and 0.53 mm/d (range 0.40 to 0.69) in 1981, for fish that reared in the Delta. They found growth rates averaging 0.33 mm/d (range 0.26 to 0.40) for fish that reared in the upper Sacramento River in 1981. Even though our calculation of grow rate is rough, growth rates for Butte Creek fish are similar to that of Kjelson's (Tables 6 and 20).

Because juvenile salmon from the main stem Sacramento River mix with Butte Creek SRCS, two of the

Sutter Bypass CWT recaptures during 1995/1996 were from CNFH (one late-fall-run and one winter-run chinook salmon, Appendix C). During 1997/1998, of the 41 tags recovered in the Sutter Bypass, five were of Butte Creek origin; the remaining 36 were fall-run chinook released from CNFH (Appendix C).

Using Fisher's length criteria[3/], 49 of 59 Butte Creek SRCS CWT recaptures were identified as SRCS. One was identified as winter-run and nine were identified as fall-run chinook salmon. It is possible, in any of the three sampling years, that a very small proportion of the tagged salmon may have actually been fall-run salmon because of the few fall-run salmon that spawned upstream of PPDD each year.

Relative Abundance

Determination of relative abundance of SRCS outmigration was one of the goals of this study. Relative abundance is determined by comparing the PPDD trapping yields for the three sampling years. However, because of the factors affecting fish trapping at that site, primarily flow events, debris, and operational practices of the PPDD, the abundance cannot be compared except in the most general of terms. Of almost 130,000 SRCS juveniles captured at the PPDD during the three-year period, over 90 % were captured during the 1995-1996 sampling year. While it is reasonable to conclude, based on adult escapement, that more SRCS were produced from the 1995 brood than either of the following two, it is impossible to quantify the magnitude of difference in the three years.

An estimate of absolute abundance of emigrating juvenile SRCS would be very desirable. However, the inability to determine trap efficiency during the peak emigration period (December through April) because of the factors discussed above, makes total abundance resolution impossible.

Adult Escapement

Adult escapement was determined by snorkel survey of the entire summer holding area. The high estimate is used for comparing the three years, because snorkel surveys underestimate actual salmon abundance (Shardlow, et al. 1987). The 1995 adult escapement was estimated at 7,480 adult SRCS. This near-record escapement was probably partly due to high Butte Creek outflow during the winter and spring of 1992/1993, when most of these 1992 brood year juveniles would have been outmigrating. The 1996 and 1997 escapement estimates (1,400 and 635 adults, respectively), while much lower than the 1995 estimate, are still well above average for the 1979 to 1994 period at 461 adult SRCS.

Until recently, spatial separation of spring-run and fall-run spawning habitat has been at, or downstream of, PPDD. However, because of recent fish passage improvements to that and other downstream dams and because of favorable fall flows, some fall-run salmon have ascended PPDD ladder. In fall 1997, particularly, several hundred adult fall-run chinook salmon spawned upstream of PPDD. Superimposition of redds is of concern, as is interbreeding of fall-run and SRCS.

Feather River water is introduced to Butte Creek via the West Branch into DeSabla Reservoir and was introduced, until 1998, from Thermolito Afterbay via Western Canal. There are concerns that Feather

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[3/] Ibid, p 14.

River SRCS adults may stray into Butte Creek: Butte Creek fall-run chinook salmon surveys have recovered three Feather River Hatchery CWT adult salmon, but, as yet, no tagged Feather River-origin SRCS have been found in Butte Creek. However, due to scavenging animals and remote, steep terrain, few SRCS carcasses are examined each year in Butte Creek. Future adult sampling will include expanded adult carcass surveys to recover Butte Creek SRCS that were tagged. This additional effort will help to evaluate straying by Feather River fish into Butte Creek.

ACKNOWLEDGMENTS

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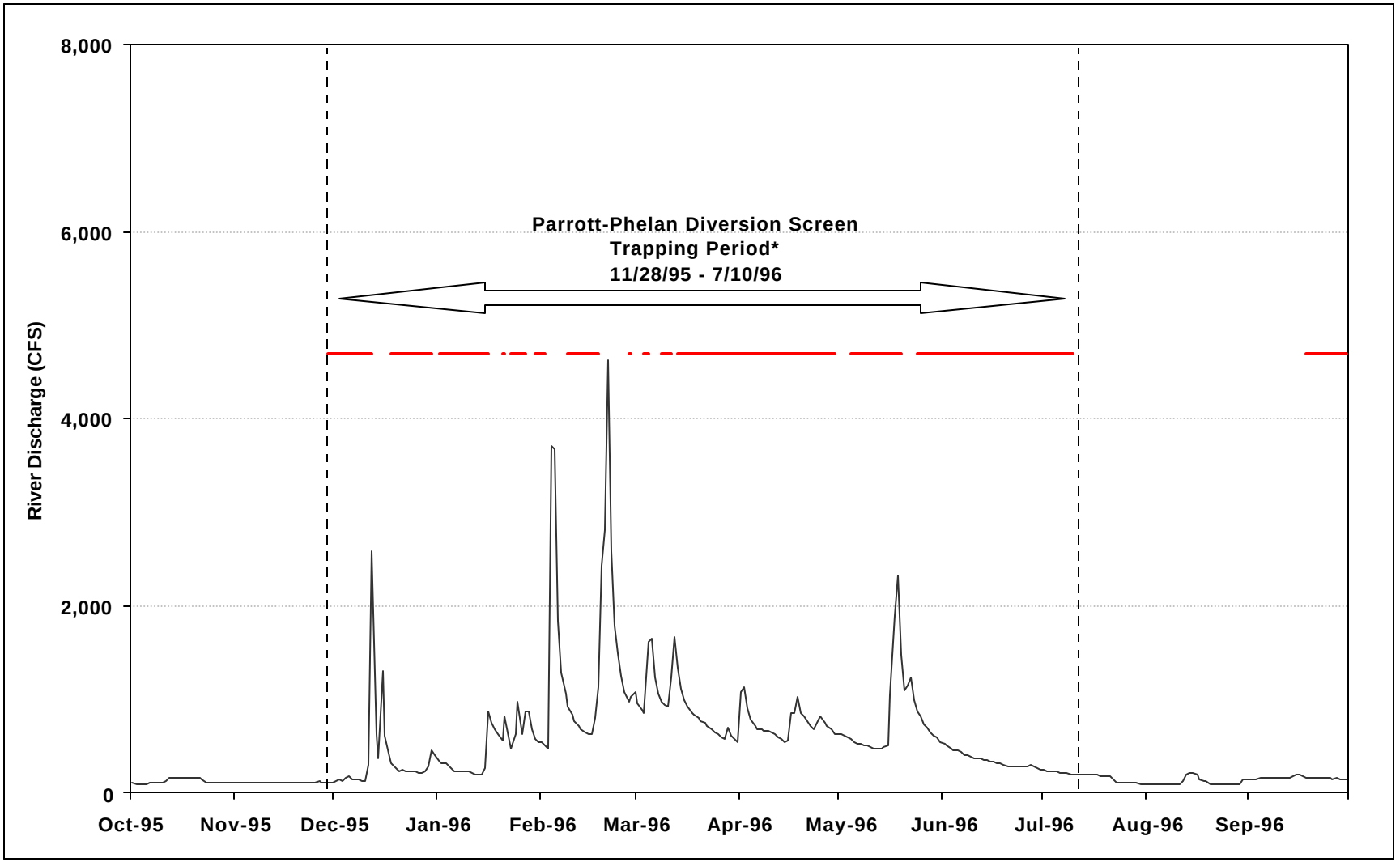
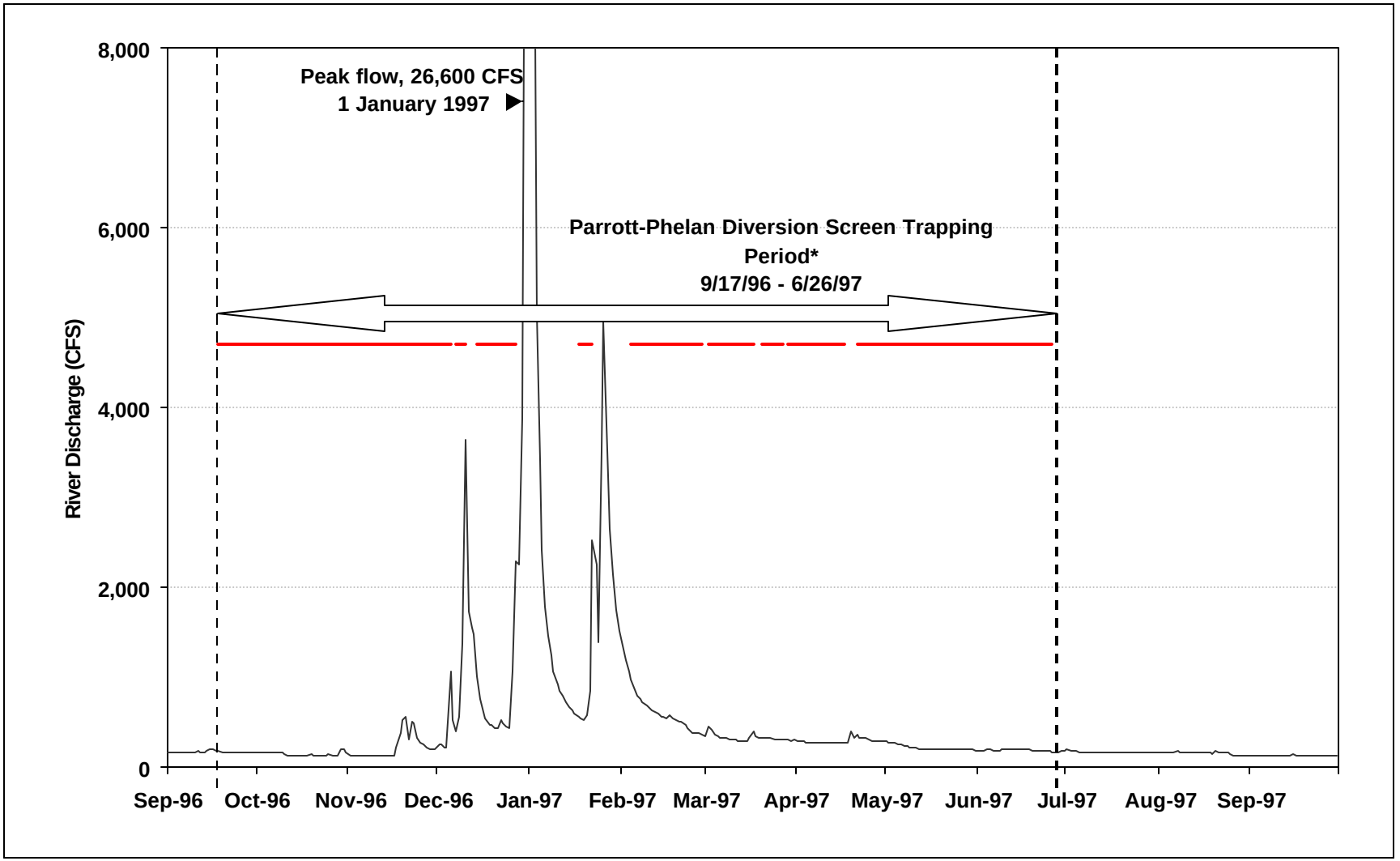
APPENDIX A, FIGURE 1. Butte Creek flow at Parrott-Phelan Diversion Dam, water year 1995-96, with trapping period shown. Flow data provided by U.S. Geological Survey, Butte Creek near Chico, California gage.



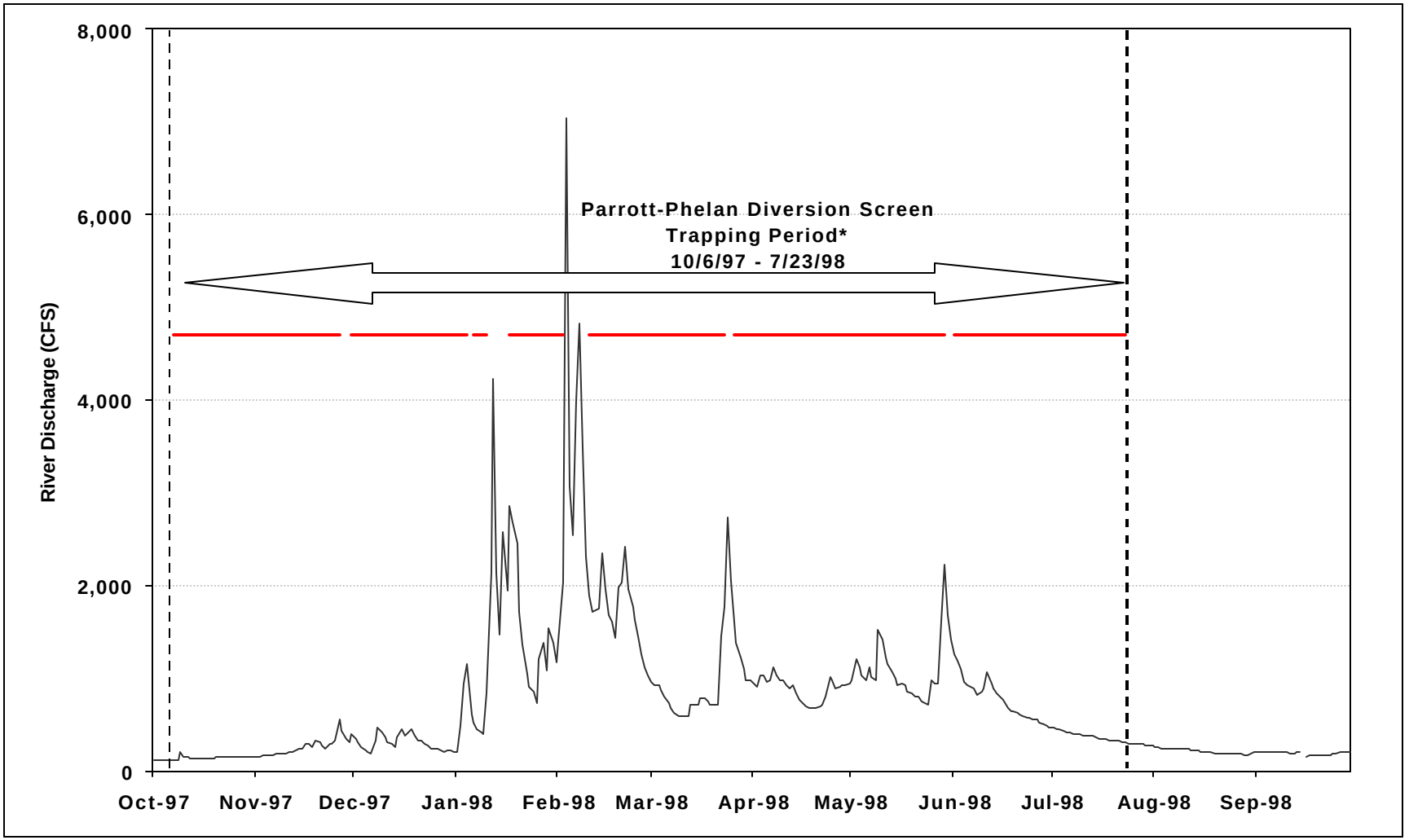
*Breaks in horizontal line indicate periods of time when the trap was not fishing

APPENDIX A, FIGURE 2. Butte Creek flow at Parrott-Phelan Diversion Dam, water year 1996-97, with trapping period shown. Flow data provided by U.S. Geological Survey, Butte Creek near Chico, California gage.



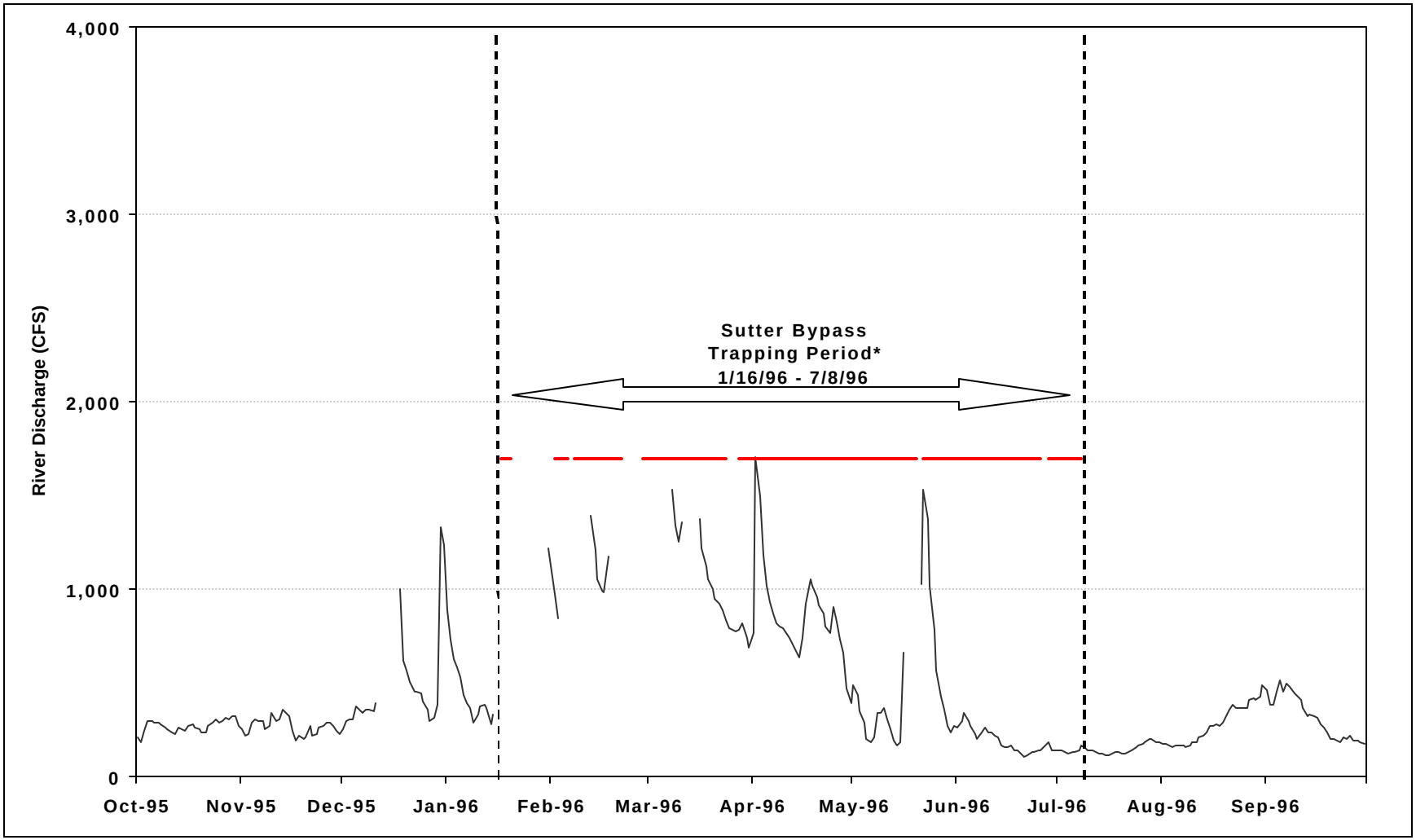
*Breaks in horizontal line indicate periods of time when the trap was not fishing

APPENDIX A, FIGURE 3. Butte Creek flow at Parrott-Phelan Diversion Dam, water year 1997-98, with trapping period shown. Flow data provided by U.S. Geological Survey, Butte Creek near Chico, California gage (preliminary data, subject to revision).



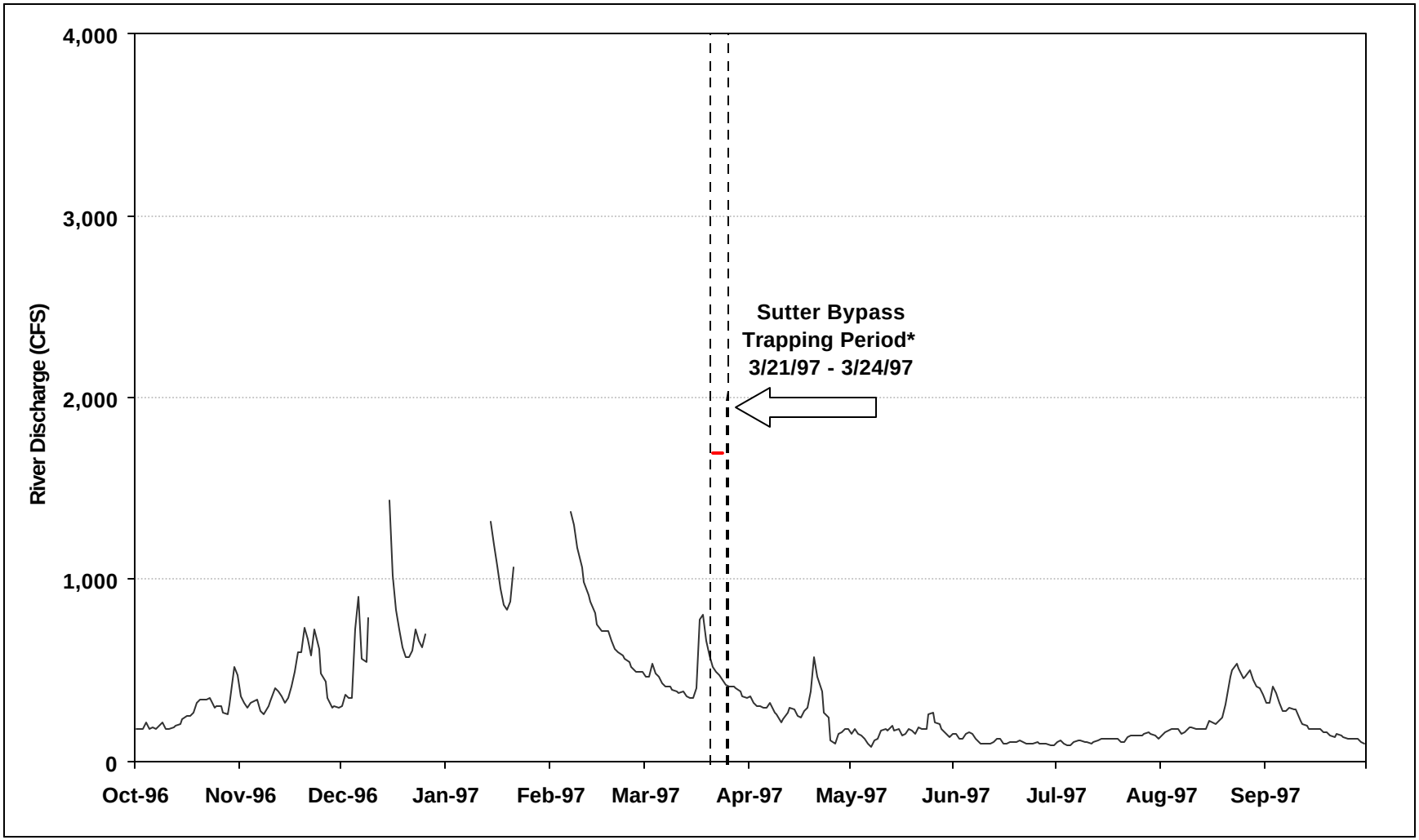
*Breaks in horizontal line indicate periods of time when the trap was not fishing

APPENDIX A, FIGURE 4. Butte Creek flow at Gridley, water year 1995-96, with trapping period shown. Flow data provided by California Department of Water Resources, Butte Creek near Gridley, California gage (preliminary data, subject to revision).



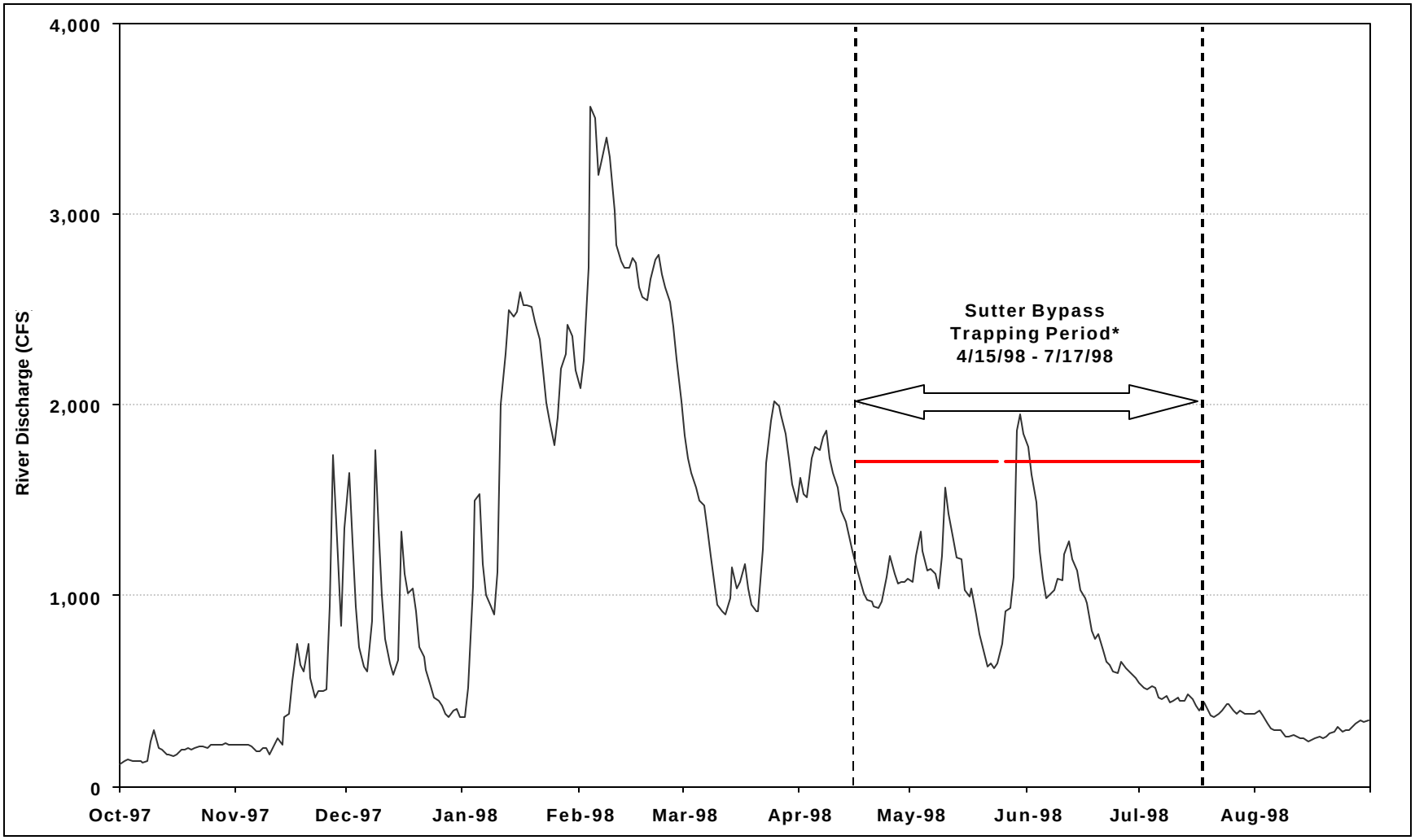
*Breaks in horizontal line indicate periods of time when trap was not fishing

APPENDIX A, FIGURE 5. Butte Creek flow at Gridley, water year 1996-97, with trapping period shown. Flow data provided by California Department of Water Resources, Butte Creek near Gridley, California gage (preliminary data, subject to revision).



*Breaks in horizontal line indicate periods of time when trap was not fishing

APPENDIX A, FIGURE 6. Butte Creek flow at Gridley, water year 1997-98, with trapping period shown. Flow data provided by California Department of Water Resources, Butte Creek near Gridley, California gage (preliminary data, subject to revision).



*Breaks in horizontal line indicate periods of time when trap was not fishing

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APPENDIX C. Recovery of juvenile chinook salmon tagged and released at Coleman National Fish Hatchery. Salmon were recovered in the Sutter Bypass at West Borrow Weir 1. All salmon were fall-run chinook except for one winter-run and one late-fall-run chinook salmon.

Tag code	Recovery date	FL at recovery	Growth rate (mm/d)	Days before recapture
05-01-01-14-09*	3/21/96	102	n/d	91
05-41-19**	3/22/96	134	n/d	72
05-01-02-05-08	4/17/98	90	0.73	44
05-01-02-05-08	4/23/98	85	0.54	50
05-01-02-05-08	4/28/98	83	0.45	55
05-01-02-05-09	4/16/98	81	0.51	43
05-01-02-05-10	4/19/98	86	0.59	44
05-01-02-05-10	4/21/98	70	0.22	46
05-01-02-05-10	4/22/98	75	0.32	47
05-01-02-05-10	4/29/98	95	0.65	54
05-01-02-05-10	4/29/98	91	0.57	54
05-01-02-05-12	4/18/98	76	0.37	43
05-01-02-05-12	4/20/98	84	0.53	45
05-01-02-05-12	4/29/98	96	0.67	54
05-01-02-05-13	4/18/98	80	0.60	45
05-01-02-05-13	4/22/98	88	0.71	49
05-01-02-05-13	4/27/98	94	0.76	54
05-01-02-05-14	4/20/98	75	0.75	20
05-01-02-05-14	4/20/98	85	1.25	20
05-01-02-05-15	4/17/98	83	1.35	17
05-01-02-05-15	4/20/98	72	0.60	20
05-01-02-05-15	4/22/98	84	1.09	22
05-01-02-05-15	4/29/98	83	0.79	29
05-01-02-06-01	4/18/98	76	0.89	18
05-01-02-06-01	4/21/98	78	0.86	21
05-01-02-06-01	5/1/98	87	0.87	31
05-01-02-06-01	5/5/98	93	0.94	35
05-01-02-06-02	4/30/98	90	1.00	30
05-01-02-06-03	4/20/98	75	0.75	20
05-01-02-06-03	4/22/98	78	0.82	22
05-01-02-06-04	4/22/98	77	0.77	22
05-01-02-06-05	5/1/98	88	0.90	31
05-01-02-06-15	6/1/98	85	0.38	40
05-01-02-06-15	6/2/98	92	0.54	41
05-01-02-07-01	6/1/98	92	0.55	40
05-01-02-07-05	6/1/98	80	0.38	39
05-01-02-07-05	6/2/98	82	0.43	40
05-01-02-07-05	6/2/98	86	0.53	40

* Winter-run chinook salmon
**Late-fall-run chinook salmon

APPENDIX D. Parrott-Phelan Diversion Dam species inventory.

Catostomidae
sucker, Sacramento (*Catostomus occidentalis*)

Centrarchidae
bass, largemouth (*Micropterus salmoides*)
bass, smallmouth (*Micropterus dolomieu*)
bluegill (*Lepomis macrochirus*)
sunfish, green (*Lepomis cyanellus*)
sunfish, redear (*Lepomis microlophus*)

Cottidae
sculpin, riffle (*Cottus gulosus*)

Cyprinidae
hardhead (*Mylopharodon conocephalus*)
roach, California (*Hesperoleucus symmetricus*)
shiner, golden (*Notemigonus crysoleucas*)
pikeminnow, Sacramento (*Ptychocheilus grandis*)
dace, speckled (*Rhinichthys osculus*)

Embiotocidae
perch, tule (*Hysterocarpus traski*)

Ictaluridae
bullhead, brown (*Ameiurus nebulosus*)

Petromyzontidae
lamprey, Pacific (*Lampetra tridentata*)

Salmonidae
salmon, chinook (*Oncorhynchus tshawytscha*)
trout, rainbow (*Oncorhynchus mykiss*)
trout, brown (*Salmo trutta*)

APPENDIX E. Sutter Bypass species inventory.

Acipenseridae
sturgeon, white (*Acipenser transmontanus*)

Atherinidae
silverside, inland (*Menidia beryllina*)

Catostomidae
sucker, Sacramento (*Catostomus occidentalis*)

Centrarchidae
bass, largemouth (*Micropterus salmoides*)
bass, smallmouth (*Micropterus dolomieu*)
bluegill (*Lepomis macrochirus*)
crappie, black (*Pomoxis nigromaculatus*)
crappie, white (*Pomoxis annularis*)
pumkinseed (*Lepomis gibbosus*)
sunfish, green (*Lepomis cyanellus*)
sunfish, redear (*Lepomis microlophus*)
warmouth (*Lepomis gulosus)*

Clupeidae
shad, american (*Alosa sapidissima*)
shad, threadfin (*Dorosoma petenense*)

Cottidae
sculpin (*Cottus spp*.)

Cyprinidae
blackfish, Sacramento (*Orthodon microlepidotus*)
carp, common (*Cyprinus carpio*)
goldfish (*Carassius auratus*)
hitch (*Lavinia exilicauda*)
minnow, fathead (*Pimephales promelas*)
shiner, golden (*Notemigonus crysoleucas*)
shiner, red (*Cyprinella lutrensis*)
splittail (*Pogonichthys macrolepidotus*)
pikeminnow, Sacramento (*Ptychocheilus grandis*)

Embiotocidae
perch, tule (*Hysterocarpus traski*)

Ictaluridae
bullhead, black (*Ameiurus melas*)
bullhead, brown (*Ameiurus nebulosus*)
bullhead, yellow (*Ameiurus natalis*)
catfish, channel (*Ictalurus punctatus*)
catfish, white (*Ameiurus catus*)

Osmeridae
wakasagi (*Hypomesus nipponensis*)

Percichthyidae
bass, striped (*Morone saxatilis*)

Percidae
logperch (*Percina caprodes*)

Petromyzontidae
lamprey, Pacific (*Lampetra tridentata*)

Poeciliidae
mosquitofish, western (*Gambusia affinis*)

Salmonidae
salmon, chinook (*Oncorhynchus tshawytscha*)
trout, rainbow (*Oncorhynchus mykiss*)