State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

SPRING-RUN CHINOOK SALMON (*ONCORYHNCHUS TSHAWTSCHA*) LIFE HISTORY INVESTIGATIONS IN MILL AND DEER CREEKS, TEHAMA COUNTY FOR THE 1999 BROOD YEAR

SPORT FISH RESTORATION ACT ANNUAL PROGRESS REPORT

by

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INTRODUCTION

This annual brood year (BY) report investigates the life-history characteristics of spring-run Chinook salmon (SRCS), (*Oncorhynchus tshawtscha*), in Mill and Deer Creeks, Tehama County, California for adult fish returning in 1999. These investigations include: holding and spawning distribution of adult SRCS returning in 1999, juvenile SRCS rearing studies in 1999 and 2000, and yearling SRCS emigration in 2000 and 2001. Included in these investigations are the physical parameters of water flow and temperature during critical periods of SRCS life history.

SRCS once occupied the headwaters of most major river systems in California's Central Valley. Most of this former spring-run habitat has been eliminated by water development and dams that prevent adult salmon access to head water areas (CDFG, 1998). Present day range and distribution of spring-run salmon is restricted to a few tributaries in the Sacramento River System. Due to declining population levels, loss of historical habitat and concerns over hybridization with fall run in the Sacramento and Feather Rivers, tributary SRCS were listed as threatened under CESA and FESA in 1998. Self-sustaining populations of SRCS still persist in Mill, Deer, and Butte Creeks. Even prior to water development, habitat conditions in these remnant streams may have been marginal when compared to habitat conditions historically occurring in the headwaters of the San Joaquin, Little Sacramento, McCloud, and Pit rivers. The purpose of this research is to define life history characteristics and to monitor stream conditions for all life stages of SRCS and to identify factors within each watershed which may be limiting survival. This information will ultimately be used in determining recovery criteria and developing a recovery plan for delisting of SRCS.

This research is funded through the Federal Sport Fish Restoration Act. This 99BY report is the seventh annual brood year Report for Mill and Deer Creeks. [1]

[1] This program received financial assistance through the Federal Aid in Sport Fish Restoration Act. The U.S. Department of the Interior prohibits discrimination on the basis of race, color, national origin, age, sex, or disability. If you believe you have been discriminated against in any program, activity, or facility, or if you desire further information, please write to:

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METHODS

Adult SRCS Holding and Spawning Surveys

Adult SRCS holding distribution surveys are made using underwater snorkel counts. Snorkel surveys are made in August, prior to the onset of spawning. Each creek is divided into reaches ranging in 2 to 4 miles in length. A minimum of 2 divers snorkel each reach in a downstream direction and record the maximum number of salmon observed in each habitat type. Pools, riffles and glides deep enough for a diver to float downstream are surveyed. Correction factors are not applied to the counts to determine a population estimate. Rather, these counts are standardized to serve as an index of population size. This standardization involves: conducting the surveys during the same time period annually, using the same reach boundaries, and using personnel experienced with each creek.

Spawning distribution surveys are made by walking the creek and enumerating redds, carcasses and live salmon. Redds are identified by walking in the creek or observing from a helicopter. Two observers walk downstream on opposite banks and look for recently moved, clean gravel with a discernable redd configuration. Practice redds were not included in the total redd count. Spawning surveys are made in September and October. Salmon carcasses are counted, sexed and measured. Tissue samples are collected from fresh carcasses and archived for genetic analysis.

Juvenile SRCS Rearing Surveys

Areas in each creek accessible by vehicle are sampled weekly at the onset of predicted fry emergence to determine the range of emergence timing and relative growth of salmon fry. These surveys extend from December through September. (No surveys are made in October and November due to scheduling conflicts with fall run Chinook monitoring). A backpack electro-shocking unit and a 10' x 4' x ¼" beach seine is used to capture fish. A maximum of 50 fish are measured to the nearest millimeter fork length (mmfl) and weighed to the nearest 0.1 gram (gm). Weights are not taken on fish under 50mmfl.

SRCS Outmigrant Surveys

Timing of outmigration and relative size of salmon outmigrants is monitored using 5' rotary screw traps. These traps are located downstream of SRCS rearing areas near each creeks confluence with the Sacramento River. The traps are fished from October through June or until elevated water temperatures become lethal for fish trapped and held in the live cars. Each trap is operated 7 days a week, 24 hours per day and checked daily. Traps are fished at minimum flows sufficient to rotate the traps cone at least 3 revolutions per minute and maximum flows of 800cfs. (Flows over 800 cfs make the trap unsafe for personnel to access and also compromise the structural integrity of the trap.)

All yearlings captured are measured to the nearest mmfl and weighed to the nearest 0.1 gm. The first 50 YOY salmon are measured and the remaining salmon are enumerated. Salmon under 50mmfl are not weighed. All fish are released downstream of the trap after sampling.

Water Temperature Monitoring

Water temperature records were collected by the Department of Water Resources (DWR), Northern District Office Water Quality Branch through 1999. Beginning in 2000 the temperature monitoring for Mill and Deer Creeks was transferred to the Department. Onset Temperature Recorders are used to collect hourly data. For reporting purposes, the data is later summarized into average daily minimum, maximums and means. In Mill Creek, recorders are installed at: the mouth, flow gage MCH, USGS gage MLM, confluence of Little Mill Creek, confluence of Rancheria Creek, Black Rock, Sooner Place, Hole-in-the-Ground Camp, and Hwy 36 Bridge. In Deer Creek recorders are installed at: flow gage DVD, USGS flow gage DCV, Trail 2E17, Ponderosa Way, Murphy Trail, Wilson Cove, A-Line Bridge, and Upper Falls.

Water Flow Monitoring

Water flow records are taken from DWR's California Data Exchange Centers (CDEC) web site: www.cdec.water.ca.gov. (The data from CDEC is preliminary and subject to change.) Flows are recorded hourly and summarized into average daily flows for the purposes of this report. Flows are recorded upstream and downstream of irrigation diversions.

All locations referenced in this report are shown in Appendix, Figure 1 (Mill Creek) and Appendix, Figure 2 (Deer Creek).

RESULTS AND DISCUSSION

Conditions for Adult SRCS Migration

Mill Creek

In Mill Creek, available attraction flows for adult migrants are measured at CDEC's MCH gage, located downstream of the lowermost irrigation diversion, near Mill Creeks confluence with the Sacramento River. Adult SRCS migration timing data comes from a counting station operated at the Clough Dam site from 1953 thru 1964 (Van Woert, 1964). Eighty percent of adult SRCS migrated past the counting station between the 6 May and 23 June. Appendix, Figure 3 shows the post-diversion average daily flows in Mill Creek in relation to the migration timing of adult SRCS in Mill Creek. In 1999, post-diversion flows in Mill Creek during the May and June time period ranged from 558 to 200cfs. Minimum flows during the entire period of SRCS migration was 62 cfs post-diversion and 197 cfs pre-diversion. Although minimum flow requirements for adult salmon migration have yet to be established on Mill Creek, an IFIM Modeling of critical riffles in lower Mill Creek recommended passage flows of 157cfs without critical riffle modification (Alley, 1996). However, fisheries personnel have observed Chinook salmon successfully entering and migrating up Mill Creek at flows of 50 cfs. Regardless of which migration flow criterion is used, flow does not appear to have limited adult SRCS migration into Mill Creek in the spring of 1999.

The average daily water temperatures, post-diversions, during the peak periods of adult SRCS migration in Mill Creek ranged between 52°F and 69°F, (Appendix, Figure 4). For adult Chinook salmon in the Sacramento River, the maximum temperature for successful upstream migration appears to be < 65°F (Boles, 1988). The upstream migration of adult Chinook salmon from the Delta to the San Joaquin River has been prevented by water temperatures > 70°F. Upstream migration was resumed when water

temperatures cooled to 65°F (Hallock et al, 1970). After 21 June, water temperatures remained above 65°F and exceeded 70°F by 29 June in the post-diversion reach. SRCS may be locally adapted to brief periods of elevated water temperatures in order to reach their natal holding and spawning areas. In addition, salmon migrate during periods of the day when temperatures are lower than the average daily calculation. In the Lower Klamath River system water temperatures as high as 76°F apparently have no effect on upstream migration of adult salmon (Dunhan, 1968). Suffice it to say, continued monitoring of flows and water temperatures during periods of adult salmon migration into Mill Creek will facilitate the formation of minimum flow requirements and temperature tolerance limits for successful adult SRCS migration.

Deer Creek

In Deer Creek, attraction flows for adult SRCS migrants are measured at CDEC's DVD gage, located downstream of Stanford-Vina dam, the lowermost diversion. The average migration timing of SRCS has not been determined for Deer Creek spring run. Mill Creek migration timing will be assumed for the purposes of discussing migration flow; although, there is a limited amount of antidotal evidence that migration may occur earlier than in Mill Creek. In the spring of 1999, pre-diversion flows in Deer Creek ranged from 609 to 195 cfs. Post-diversion flows ranged from 208 to 122 cfs. Minimum flow at the end of June was 176 cfs pre-diversion and 98 cfs post-diversion. Minimum flow requirements for adult salmon migration have not been established on Deer Creek. If salmon in Deer Creek are able to migrate at minimum flows of 50 cfs as observed in Mill Creek, flow does not appear to have limited migration into Deer Creek this season. Appendix, Figure 5 shows the pre-diversion and post-diversion average daily flow during estimated SRCS peak migration timing into Deer Creek.

The post-diversion average daily water temperatures during the estimated peak periods of adult SRCS migration in Deer Creek ranged between 55°F and 75°F (Appendix, Figure 6). Between 25 May and 1 June and after 10 June, average daily water temperatures exceeded 65°F and may have created a thermal barrier to upstream migration of adult salmon. Post-diversion average daily water temperatures exceeded 70°F after 14 June. Although, as with Mill Creek, maximum SRCS adult temperature tolerances relative to acclimation temperatures, duration of exposure, and daily migration timing need to be studied further for each stream.

1999 Adult SRCS Population Counts and Spawning Surveys in Mill and Deer Creeks

Mill Creek

An estimated 560 spring-run Chinook salmon spawned in Mill Creek in 1999. This estimate was made by enumerating salmon redds within the spawning habitat of spring-run Chinook salmon and expanding the redd counts to a population estimate. Mill Creek remained too turbid this year to count salmon using snorkel methodology.

Mill Creek was surveyed from the Hwy-36 Bridge crossing downstream to the Power lines Crossing (Appendix, Figure1). The reach of creek from the Hwy 36 Bridge crossing to Pape Place was separated into 11 sections, and each section was walked at least once from 21 September to 8 November. The reach of Mill Creek from Black Rock downstream to the Power lines was flown by helicopter and redds counted from the air. Redd counts from Black Rock to Pape Place were made by both ground survey and helicopter to obtain a correction factor for helicopter-only counts. October's survey efforts were restricted by the Gun II wildfire in the Mill Creek and Antelope Creek canyons. Ground surveys were canceled from 28 September through 7 October, and air

surveys could not resume until 18 October. Within the Mill Creek watershed, the fire burned from approximately Sooner Place downstream to the steel tower power lines and crossed the creek from the north rim at several locations A total of 60,000 acres was burned. What impact this event will have on the anadromous fish habitat in Mill Creek is unknown at this time. Lassen National Forest (LNF) is implementing a Fisheries Monitoring Plan and Burned Area Rehabilitation Plan to evaluate and address fisheries impacts.

A total of 17 live salmon, 14 carcasses and 280 redds was observed (Table 1). In order to expand the redd counts to a population estimate, it was assumed each female constructs one redd and there is a 1:1 male to female sex ratio in the population:

280 redds x 1 female/redd x 2 = 560 salmon.[2]

Ten fin-clip tissue samples were collected and sent to the Departments Central Valley Salmon Stock Tissue Collection Project archives.

This year's estimated population of 560 spring-run salmon compares with a previous 10 year average of 394 salmon. Adult spring-run Chinook counts in Mill Creek date back to the late 1940's. An average of 1,900 SRCS spawned in Mill Creek annually from 1947 -1964, (Appendix, Figure 8). Since counts of spring run in Mill and Deer Creeks have been made using inconsistent methodologies over the last 60 years, numbers may not be comparable between year classes.

It was previously thought that the 100 year flood event of January 1997 may have destroyed a significant proportion of the incubating eggs from the 1996 BY. Electro fishing surveys prior to the flood found no emergence of the 1996 BY fry, YOY were not detected during electro fishing surveys in the spring of 1997, and outmigrant trapping in the fall of 1997 did not capture yearling SRCS. Temperature monitors in place at Big Bend and Black Rock at the time of spawning were destroyed in the flood; therefore calculations cannot be made to estimate the developmental stage of the eggs when the flood occurred. Since the 3-year old proportion of that year class returning this year is an increase from the 1996 population of 253, it suggests that there was production from that year class.

[2] Redd surveys and snorkel counts of holding salmon in Deer Creek in 1997, 1998 and 1999 have yielded ratios of 1.7, 2.4 and 1.1, respectively. (These ratios may be low due to snorkel surveys underestimating actual numbers of salmon.) Surveys of redds and holding salmon will continue in Deer Creek to better refine this redd to salmon estimate in the future. For the 1999 Mill Creek estimate, a multiplier of 2 will be used to remain consistent with the 1997 and 1998 estimates.

TABLE 1. SRCS spawning distribution in Mill Creek in 1999.

Section	Total redds	% redds
Above Hwy 36	ns	
Hwy 36 to Mill Creek Camp	0	0
Mill Creek Camp to Hole-in-the-Ground	1	0
Hole-in-the-Ground to Rocky Gulch	3	1
Rocky Gulch to Big Bend	11	4
Big Bend to Sooner Place	6	2
Sooner Place to McCarthy Peak	22	8
McCarthy Peak to Black Rock	75	27
Black Rock to Ranch House	58	21
Ranch House to Avery Place	52	19
Avery Place to Pape Place		
Pape Place to Bear Canyon [1/]	12	4
Bear Canyon to Blunkall Crossing [1/]	23	8
Blunkall Crossing to Little Mill Creek [1/]	17	6
Little Mill Creek to power lines [1/]	0	0
Total redds	**280**	**100**
Population Estimate	**560**	

[1/] Estimated redds from a ground:aerial redd survey ratio.

Deer Creek

On 10 and 12 of August, Deer Creek was snorkel surveyed to count holding adult SRCS. The survey reaches extended from Upper Deer Creek Falls downstream to Dillon Cove, a distance of approximately 24 miles (Appendix, Figure 2). A total of 1,591 spring-run Chinook salmon was observed (Table 2). Grilse and adult sized salmon were not counted separately due to the abundance of salmon holding in pools and the difficulty associated with separating size classes while snorkeling. This year's survey was terminated at Dillon Cove due to the scarcity of salmon holding in the lowermost reach, and elevated water temperature. Snorkel surveys of the entire known holding habitat have been completed since 1992. During this seven year period, counts have ranged from a high of 1,879 fish in 1998 to a low of 209 fish in 1992. Observations made at fish ladders during the 1940-1964 time period counted an average of 2,200 SRCS annually (Appendix, Figure 9).

Between 13 and 19, October LNF fisheries crews completed SRCS spawning distribution surveys on Deer Creek. Although spawning activities may occur before and after the survey, this time period is chosen since it's after the peak of spawning but before earlier redds become difficult to identify. A total of 1,495 complete redds, 81 practice redds, 220 carcasses and 100 live salmon were counted (Table 2). Seventy-two percent of salmon holding and 66% of salmon spawning occurred between Lower Falls and Beaver Creek.

TABLE 2. SRCS holding and spawning distribution in Deer Creek for 1999

Section	# Holding	% Holding	Redds	% Redds
Upper Falls to Potato Patch	114	7	126	8
Potato Patch to Red Bridge	91	6	100	7
Red Bridge to Lower Falls	28	2	72	5
Lower Falls to A-Line	241	15	96	6
A-Line to Wilson Cove	167	10	396	26
Wilson Cove to Polk Springs	158	10	188	13
Polk Springs to Murphy Trail	247	16	150	10
Murphy Trail to Beaver Creek	350	22	161	11
Beaver Creek to Ponderosa	39	2	6	<1
Ponderosa to Trail 2E17	106	7	100	7
Trail 2E17 to Dillon Cove	50	3	103	7
Totals	1,591	100	1,495	100

Sex and Age Structure of the Population

All salmon carcasses encountered during spawning surveys in Mill and Deer Creeks were sexed and measured to the nearest centimeter fork length (cm, FL). To increase the sample size, Mill and Deer Creek data are combined. (This is assuming that the Mill and Deer Creek populations have similar age structures.) A total of 141 carcasses were measured ranging in size from 42 cm FL to 96 cm FL (Appendix, Figure 7). An unknown percentage of SRCS exhibit a yearling life-history strategy, and these fish may return at a different age and size than spring run emigrating as fry. In the absence of CWT, otolith or scale aging data, classifying age structure using length data is only speculative. For the purposes of this report, no attempt will be made to determine age structure using this limited length frequency data set. Preliminary data from CWT studies on Butte creek are showing returns of 2, 3, 4 and 5 year old fish. One age 2 return was 46 cm fl. Age 3 CWT returns ranged from 56 cm fl to 88 cm fl. Age 4 returns ranged from 83 cm fl to 92 cm fl.

Conditions of Adult SRCS Holding and Spawning

Immature adult SRCS hold at elevations > 1200 feet in Mill and Deer creeks from the time of spring migration until the onset of fall spawning, approximately May through September. Temperature records in the holding and spawning habitat are presented here for the purpose of documenting the actual temperature regimes experienced by wild salmon. According to Hinz (1959), the survival of adult fish can be reduced when holding in water temperatures warmer than 59°F. Additionally, prolonged exposure of female salmon to water temperatures between 60°F and 62°F may reduce egg viability up to 30%. Chronic exposure to water temperatures in excess of 68°F can be lethal. Appendix, Figures 10 and 11, show average daily mean water temperatures within SRCS holding habitat for Mill and Deer creeks, respectively. The maximum average daily water temperature threshold for normal egg viability is shown as 59°F. Table 3 shows the number of days in each creek the average daily water temperature exceeded the preferred temperature range for maturing salmon.

Table 3. Average Daily Water Temperature Exceedence in Mill and Deer Creeks during Spring Run Chinook Salmon Holding Periods.

Creek	Location	Elevation	Time Period	Number Days Equal or Exceeding		
				59°F	62°F	68°F l
				stress	egg loss	lethal
Mill	Hwy 36	4800'	5/01/99-9/15/99	9	0	0
	Black rock	2100'	5/01/99-9/15/99	37	4	0
Deer	Upper Falls	3600'	5/01/99-9/15/99	2	0	0
	A-Line	3000'	5/01/99-9/15/99	25	3	0
	Ponderosa	1700'	5/01/99-9/15/99	82	69	8

In Mill Creek, locations monitored had between 9 and 37 days where water temperatures may have caused physiological stress to holding salmon. Note that water temperatures were not monitored below 2100 ft elevation, and although the holding distribution of salmon was not surveyed in 1999, SRCS have been known to hold down to 1000 ft in some years.

In Deer Creek, elevations between 3600 ft and 1700 ft were monitored for water temperatures. Ninety percent of salmon held at elevations above 1700 ft in 1999 (Table 2). Spring run were observed holding as low as 1200 ft. In the areas monitored, temperatures exceeded physiological stress levels between 2 and 82 days. At Ponderosa Way, levels exceeded potentially lethal levels for 8 days.

Very little information exists on the effects of prolonged elevated water temperatures in maturing Chinook salmon outside of a controlled hatchery environment. Water temperature data is presented in this report to document the real-time temperatures regimes these salmon are holding in. What effect these water temperatures have on the survival and viability of adult SRCS holding in Mill and Deer Creek is only speculative at this time.

Current literature suggests that the upper temperature tolerance for spawning adult salmon, without destroying egg viability, is 57°F (Reiser and Bjorn, 1979). When water temperatures exceed 57.5°F, up to 80% salmon egg and fry losses can occur (Healey, 1977). In Mill Creek the average daily water temperatures remained below the 57°F threshold at Hwy 36 on 20 September, and after 25 September at Black Rock. Sixty-seven percent of spawning activity occurred between McCarty Peak and Pape Place ((2500' – 1500' elevation). Spawning surveys were completed on 21 and 23 September and 10, 12 and 13 of October. Turbidity ranged between 7 and 13 ntu's and flows at the MLM gage averaged 89 cfs during the spawning surveys. In Deer Creek, temperatures remained below the threshold after 25 August at Upper Falls and after 31 August at A-Line. Sixty percent of the spawning activity occurred between A-Line Bridge and Beaver Creek (3000'-1700' elevation). Spawning surveys were completed between 13 and 19 of October. Flows averaged 122 cfs at the DCV gage at the time of the spawning surveys. In 1999, weekly surveys of indexed areas to determine the onset, peak and termination of spawning were not made, and therefore It is unknown whether spawning activities began prior to water temperatures decreasing to below the threshold level.

Egg Incubation, Hatching and Fry Emergence

Average daily water temperature records are used to estimate the length of time from spawning for the eggs to hatch and fry to emerge from the gravels. To predict an estimated time of fry emergence, daily temperature units (DTU's) are calculated from the water temperature records on each creek. A DTU is defined as the average daily water temperature (measured in ° Fahrenheit) minus 32. From the time of fertilization, an average cumulative total of 1,550 DTU's is required for the egg to hatch and the fry to emerge (Armor, 1991 in CDFG, 1998). The time between the onset and termination of spawning (generally late August through the end of October) can last up to eight weeks. This can lead to significant variability in timing of fry emergence. Weekly surveys to determine the onset and termination of spawning were not made in 1999. For the purposes of calculating earliest emergence dates, onset of spawning is arbitrarily estimated at 7 days after the average daily water temperature drops below 57°F. The latest expected emergence of fry is not estimated in this report.

In Mill Creek, water temperature records are available at Hwy-36 (the upper limit of spawning) and at Black Rock (mid-way in the spawning habitat). The earliest expected emergence is calculated as 30 January, 2002 in the Hwy 36 spawning reach, and 10 January, 2002 in the Black Rock spawning reach (Tables 4 and 5). Although no spawning was observed near Hwy 36 (Table 1), this illustrates the point that fish may spawn earlier at higher elevations, but actually emerge later due to the slower accumulation of daily temperature units. Biweekly electrofishing surveys to detect 99BY fry emergence began 7 January 2000 at Black Rock. Two SRCS emergent fry, 33 and 38 mmFL, were captured (Appendix, Figure 14). Emergent sized fry continued to be captured at Black Rock thru May 15. (The only other access point for electrofishing is Hole-in-the-Ground Camp, which is typically snowed-in thru spring.)

In Deer Creek, water temperature records are available at Upper Falls and A-Line Bridge. Twenty-six percent of spawning activity occurred in this reach. The earliest expected emergence is calculated as 21 December in the Upper Falls spawning reach, and 1 December in the A-Line spawning reach (Tables 6 and 7). No surveys to detect early emergence were conducted in December 1999. Biweekly electrofishing surveys began on 6 January at A-Line and Ponderosa Way. Six SRCS emergent sized fry ranging between 35 and 37 mmfl were captured, (Appendix, Figure 16.) Emergent sized fry continued to be captured thru May 15. This apparent "continual emergence" observed in both Mill and Deer Creeks may be attributed to the range in spawning times, resulting in a constant recruitment of smaller fish into the sampling site, or reduced growth of weaker fish.

Table 4. Estimated time of fry emergence based on daily temperature units recorded in Mill Creek at Hwy 36 Bridge, (4800' elevation).

	Sep-99		CUM		Oct-99		CUM		Nov-99		CUM		Dec-99		CUM		Jan-00		CUM
Day	mean	TU	TU		mean	TU	TU		mean	TU	TU		mean	TU	TU		mean	TU	TU
1	53.0				53.5	21.5	83.4		49.0	17.0	656.0		42.2	10.2	1057.5		38.9	6.9	1336.8
2	53.8				53.4	21.4	104.8		48.6	16.6	672.6		41.4	9.4	1066.9		37.8	5.8	1342.6
3	54.4				53.6	21.6	126.4		48.5	16.5	689.1		39.2	7.2	1074.1		41.2	9.2	1351.8
4	54.9				52.9	20.9	147.3		49.1	17.1	706.2		40.5	8.5	1082.6		41.1	9.1	1360.9
5	55.8				51.4	19.4	166.7		49.4	17.4	723.6		41.8	9.8	1092.4		39.2	7.2	1368.1
6	56.4				50.3	18.3	185.0		48.0	16.0	739.6		42.9	10.9	1103.3		39.8	7.8	1375.9
7	56.9				51.4	19.4	204.4		46.6	14.6	754.2		40.3	8.3	1111.6		41.8	9.8	1385.7
8	56.8				53.1	21.1	225.5		44.7	12.7	766.9		38.6	6.6	1118.2		42.2	10.2	1395.9
9	56.6				53.0	21.0	246.5		45.7	13.7	780.6		38.3	6.3	1124.5		41.9	9.9	1405.8
10	57.5				52.9	20.9	267.4		45.2	13.2	793.8		38.0	6.0	1130.5		42.2	10.2	1416.0
11	57.1				52.8	20.8	288.2		47.8	15.8	809.6		41.1	9.1	1139.6		39.0	7.0	1423.0
12	56.3				52.1	20.1	308.3		48.0	16.0	825.6		42.4	10.4	1150.0		40.6	8.6	1431.6
13	56.3				51.3	19.3	327.6		47.4	15.4	841.0		40.3	8.3	1158.3		40.7	8.7	1440.3
14	56.9				52.4	20.4	348.0		48.5	16.5	857.5		39.6	7.6	1165.9		42.5	10.5	1450.8
15	56.3				49.4	17.4	365.4		48.3	16.3	873.8		41.6	9.6	1175.5		41.7	9.7	1460.5
16	56.4				47.4	15.4	380.8		45.2	13.2	887.0		41.7	9.7	1185.2		38.2	6.2	1466.7
17	55.8				48.7	16.7	397.5		44.2	12.2	899.2		42.3	10.3	1195.5		40.6	8.6	1475.3
18	55.2				49.6	17.6	415.1		44.0	12.0	911.2		42.4	10.4	1205.9		*	8.5	1483.8
19	57.2				50.5	18.5	433.6		41.4	9.4	920.6		42.8	10.8	1216.7			8.5	1492.3
20	56.7				50.9	18.9	452.5		43.8	11.8	932.4		42.5	10.5	1227.2			8.5	1500.8
21	57.0				51.0	19.0	471.5		41.9	9.9	942.3		41.8	9.8	1237.0			8.5	1509.3
22	56.0				50.4	18.4	489.9		40.9	8.9	951.2		41.4	9.4	1246.4			8.5	1517.8
23	56.8				49.7	17.7	507.6		42.1	10.1	961.3		41.6	9.6	1256.0			8.5	1526.3
24	56.7				49.0	17.0	524.6		43.2	11.2	972.5		41.6	9.6	1265.6			8.5	1534.8
25	56.7				48.6	16.6	541.2		44.5	12.5	985.0		41.6	9.6	1275.2			8.5	1543.3
26	55.2				48.0	16.0	557.2		44.7	12.7	997.7		41.4	9.4	1284.6			8.5	1551.8
27	52.9				49.4	17.4	574.6		46.5	14.5	1012.2		41.5	9.5	1294.1	*thermograph stopped recording			
28	52.0	20.0	20.0		47.4	15.4	590.0		45.9	13.9	1026.1		41.4	9.4	1303.5	used 7 day daily average DTU			
29	52.6	20.6	40.6		47.2	15.2	605.2		45.1	13.1	1039.2		41.2	9.2	1312.7				
30	53.3	21.3	61.9		48.7	16.7	621.9		40.1	8.1	1047.3		40.9	8.9	1321.6				
31					49.1	17.1	639.0						40.3	8.3	1329.9				

Table 5. Estimated time of fry emergence based on daily temperature units recorded in Mill Creek at Black Rock (2100' elevation).

	Oct-99		CUM		Nov-99		CUM		Dec-99		CUM		Jan-00		CUM
Day	mean	TU	TU		mean	TU	TU		mean	TU	TU		mean	TU	TU
1	53.3	21.3	21.3		49.1	17.1	586.8		49.1	17.1	1029.6		40.5	8.5	1463.8
2	53.2	21.2	42.5		48.6	16.6	603.4		48.6	16.6	1046.2		39.3	7.3	1471.1
3	53.1	21.1	63.6		48.1	16.1	619.5		48.1	16.1	1062.3		40.5	8.5	1479.6
4	53	21.0	84.6		48.3	16.3	635.8		48.3	16.3	1078.6		42.2	10.2	1489.8
5	52.1	20.1	104.7		48.9	16.9	652.7		48.9	16.9	1095.5		40.9	8.9	1498.7
6	51.9	19.9	124.6		48.2	16.2	668.9		48.2	16.2	1111.7		40.7	8.7	1507.4
7	51.1	19.1	143.7		47.5	15.5	684.4		47.5	15.5	1127.2		42.3	10.3	1517.7
8	52.6	20.6	164.3		47.8	15.8	700.2		47.8	15.8	1143.0		42.4	10.4	1528.1
9	52.6	20.6	184.9		46.8	14.8	715.0		46.8	14.8	1157.8		42.9	10.9	1539.0
10	52.7	20.7	205.6		47.5	15.5	730.5		47.5	15.5	1173.3		45	13	**1552.0**
11	52.8	20.8	226.4		49.4	17.4	747.9		49.4	17.4	1190.7		44.3	12.3	1564.3
12	52.1	20.1	246.5		49.2	17.2	765.1		49.2	17.2	1207.9		42.5	10.5	1574.8
13	51.3	19.3	265.8		48.1	16.1	781.2		48.1	16.1	1224.0		43.6	11.6	1586.4
14	51.7	19.7	285.5		48.7	16.7	797.9		48.7	16.7	1240.7		45.5	13.5	1599.9
15	50.5	18.5	304.0		50.4	18.4	816.3		50.4	18.4	1259.1		46.2	14.2	1614.1
16	47.7	15.7	319.7		48.9	16.9	833.2		48.9	16.9	1276.0		44.1	12.1	1626.2
17	47.6	15.6	335.3		46.3	14.3	847.5		46.3	14.3	1290.3		43.1	11.1	1637.3
18	48.2	16.2	351.5		45	13.0	860.5		45	13	1303.3		45	13	1650.3
19	48.7	16.7	368.2		45.1	13.1	873.6		45.1	13.1	1316.4		46.1	14.1	1664.4
20	49.2	17.2	385.4		46.3	14.3	887.9		46.3	14.3	1330.7		45.7	13.7	1678.1
21	49.6	17.6	403.0		44.4	12.4	900.3		44.4	12.4	1343.1		44.2	12.2	1690.3
22	49.7	17.7	420.7		41.5	9.5	909.8		41.5	9.5	1352.6		43.8	11.8	1702.1
23	49.2	17.2	437.9		41.6	9.6	919.4		41.6	9.6	1362.2		44.9	12.9	1715.0
24	48.3	16.3	454.2		42.4	10.4	929.8		42.4	10.4	1372.6		44.1	12.1	1727.1
25	47.5	15.5	469.7		43.6	11.6	941.4		43.6	11.6	1384.2		45.1	13.1	1740.2
26	47.9	15.9	485.6		44.9	12.9	954.3		44.9	12.9	1397.1		44.3	12.3	1752.5
27	50.2	18.2	503.8		47	15.0	969.3		47	15	1412.1		43.3	11.3	1763.8
28	50.6	18.6	522.4		46.6	14.6	983.9		46.6	14.6	1426.7		42	10	1773.8
29	47.3	15.3	537.7		46.7	14.7	998.6		46.7	14.7	1441.4		42.2	10.2	1784.0
30	48	16.0	553.7		45.9	13.9	1012.5		45.9	13.9	1455.3		42.8	10.8	1794.8
31	48	16.0	569.7										42.6	10.6	1805.4

Table 6. Estimated time of fry emergence based on daily temperature units recorded in Deer Creek at Upper Falls (3600' elevation)..

	Aug-99		CUM		Sep-99		CUM		Oct-99		CUM		Nov-99		CUM		Dec-99		CUM
Day	**mean**	**TU**	**TU**		**mean**	**TU**	**TU**		**mean**	**TU**	**TU**		**mean**	**TU**	**TU**		**mean**	**TU**	**TU**
1	56.2				50.0	18.0	57.5		49.5	17.5	653.0		44.8	12.8	1102.6		38.9	6.9	1422.4
2	56.3				50.4	18.4	75.5		49.5	17.5	670.5		44.2	12.2	1114.8		40.0	8.0	1430.4
3	56.3				50.9	18.9	93.9		49.7	17.7	688.2		44.1	12.1	1126.9		38.1	6.1	1436.5
4	56.9				51.1	19.1	112.8		49.1	17.1	705.3		44.3	12.3	1139.2		38.0	6.0	1442.5
5	55.8				51.5	19.5	131.9		48.5	16.5	721.8		44.6	12.6	1151.8		38.6	6.6	1449.0
6	54.1				52.2	20.2	151.4		48.7	16.7	738.5		44.1	12.1	1163.9		39.9	7.9	1456.9
7	53.5				52.6	20.6	171.6		47.5	15.5	754.0		44.0	12.0	1175.9		39.4	7.4	1464.3
8	53.9				52.8	20.8	192.2		48.4	16.4	770.4		44.0	12.0	1187.9		37.3	5.3	1469.6
9	54.7				52.6	20.6	213.0		48.5	16.5	786.9		43.3	11.3	1199.2		37.9	5.9	1475.5
10	54.9				53.0	21.0	233.6		48.4	16.4	803.3		43.9	11.9	1211.1		36.6	4.6	1480.1
11	55.8				53.0	21.0	254.6		48.4	16.4	819.7		45.7	13.7	1224.8		37.6	5.6	1485.7
12	55.5				52.2	20.2	275.6		47.6	15.6	835.3		45.0	13.0	1237.8		39.0	7.0	1492.7
13	54.2				52.8	20.8	295.8		46.8	14.8	850.1		44.1	12.1	1249.9		38.6	6.6	1499.4
14	53.4				53.0	21.0	316.6		47.4	15.4	865.5		44.2	12.2	1262.1		37.8	5.8	1505.1
15	53.4				52.3	20.3	337.6		46.9	14.9	880.4		46.2	14.2	1276.3		38.4	6.4	1511.6
16	54.3				52.2	20.2	357.9		44.9	12.9	893.3		44.4	12.4	1288.7		38.3	6.3	1517.8
17	54.3				52.0	20.0	378.1		44.8	12.8	906.1		41.0	9.0	1297.7		38.7	6.7	1524.6
18	54.1				51.0	19.0	398.1		44.7	12.7	918.8		41.5	9.5	1307.2		39.1	7.1	1531.6
19	53.6				52.9	20.9	417.1		45.1	13.1	931.9		41.3	9.3	1316.5		39.9	7.9	1539.6
20	53.8				53.1	21.1	438.0		45.4	13.4	945.3		42.0	10.0	1326.5		40.6	8.6	1548.2
21	54.5				53.3	21.3	459.1		45.6	13.6	958.9		40.7	8.7	1335.2		39.8	7.8	**1556.0**
22	56.1				52.7	20.7	480.4		45.6	13.6	972.5		38.7	6.7	1341.9		39.3	7.3	1563.3
23	57.2				53.2	21.2	501.1		45.2	13.2	985.7		39.0	7.0	1348.9		38.9	6.9	1570.2
24	56.0				53.0	21.0	522.3		44.6	12.6	998.3		39.3	7.3	1356.2		38.8	6.8	1577.0
25	55.6				52.4	20.4	543.3		44.1	12.1	1010.4		40.1	8.1	1364.3		39.3	7.3	1584.3
26	55.2				51.6	19.6	563.7		44.6	12.6	1023.0		41.3	9.3	1373.6		38.7	6.7	1591.0
27	55.3				50.2	18.2	583.3		46.4	14.4	1037.4		43.1	11.1	1384.7		38.8	6.8	1597.8
28	55.5				49.1	17.1	601.5		47.0	15.0	1052.4		42.5	10.5	1395.2		38.2	6.2	1604.0
29	55.0				48.9	16.9	618.6		44.3	12.3	1064.7		43.0	11.0	1406.2		37.7	5.7	1609.8
30	52.8	20.8	20.8		49.4	17.4	635.5		44.7	12.7	1077.4		41.3	9.3	1415.5		37.5	5.5	1615.2
31	50.7	18.7	39.5						44.4	12.4	1089.8						37.3	5.3	1620.5

Table 7. Estimated time of fry emergence based on daily temperature units recorded in Deer Creek at A-Line Bridge (3000' elevation)..

	Sep-99		CUM		Oct-99		CUM		Nov-99		CUM		Dec-99		CUM		Jan-00		CUM
Day	mean	TU	TU		mean	TU	TU		mean	TU	TU		mean	TU	TU		mean	TU	TU
1	52.0	20.0	20.0		51.8	19.8	692.0		46.5	14.5	1196.6		41.3	9.3	**1557.0**		37.8	5.8	1786.9
2	52.3	20.3	40.3		51.7	19.7	711.7		46.1	14.1	1210.7		41.2	9.2	1566.2		36.8	4.8	1791.7
3	53.0	21.0	61.3		51.9	19.9	731.6		45.6	13.6	1224.3		38.9	6.9	1573.1		38.0	6.0	1797.7
4	53.5	21.5	82.8		51.4	19.4	751.0		45.7	13.7	1238.0		38.4	6.4	1579.5		39.1	7.1	1804.8
5	54.0	22.0	104.8		50.6	18.6	769.6		46.0	14.0	1252.0		39.0	7.0	1586.5		38.3	6.3	1811.1
6	54.6	22.6	127.4		50.5	18.5	788.1		45.6	13.6	1265.6		40.4	8.4	1594.9		38.1	6.1	1817.2
7	55.1	23.1	150.5		49.5	17.5	805.6		45.3	13.3	1278.9		40.6	8.6	1603.5		39.5	7.5	1824.7
8	55.4	23.4	173.9		50.4	18.4	824.0		45.7	13.7	1292.6		38.0	6.0	1609.5		39.6	7.6	1832.3
9	55.1	23.1	197.0		50.5	18.5	842.5		44.6	12.6	1305.2		38.5	6.5	1616.0		40.0	8.0	1840.3
10	55.9	23.9	220.9		50.5	18.5	861.0		45.2	13.2	1318.4		37.3	5.3	1621.3		42.0	10.0	1850.3
11	55.9	23.9	244.8		50.5	18.5	879.5		46.9	14.9	1333.3		38.0	6.0	1627.3		41.0	9.0	1859.3
12	55.0	23.0	267.8		49.8	17.8	897.3		46.7	14.7	1348.0		39.7	7.7	1635.0		38.9	6.9	1866.2
13	55.5	23.5	291.3		48.9	16.9	914.2		45.7	13.7	1361.7		39.7	7.7	1642.7		40.3	8.3	1874.5
14	55.7	23.7	315.0		49.2	17.2	931.4		45.9	13.9	1375.6		38.2	6.2	1648.9		42.2	10.2	1884.7
15	55.1	23.1	338.1		48.7	16.7	948.1		47.5	15.5	1391.1		38.8	6.8	1655.7		42.9	10.9	1895.6
16	54.9	22.9	361.0		46.4	14.4	962.5		46.3	14.3	1405.4		38.8	6.8	1662.5		40.7	8.7	1904.3
17	54.8	22.8	383.8		45.9	13.9	976.4		43.1	11.1	1416.5		39.7	7.7	1670.2		39.8	7.8	1912.1
18	53.8	21.8	405.6		46.3	14.3	990.7		42.5	10.5	1427.0		39.9	7.9	1678.1		41.5	9.5	1921.6
19	55.1	23.1	428.7		46.8	14.8	1005.5		42.6	10.6	1437.6		40.9	8.9	1687.0		42.2	10.2	1931.8
20	56.0	24.0	452.7		47.1	15.1	1020.6		43.6	11.6	1449.2		42.1	10.1	1697.1		42.7	10.7	1942.5
21	56.0	24.0	476.7		47.3	15.3	1035.9		41.9	9.9	1459.1		41.3	9.3	1706.4		40.5	8.5	1951.0
22	55.5	23.5	500.2		47.3	15.3	1051.2		39.6	7.6	1466.7		40.5	8.5	1714.9		40.1	8.1	1959.1
23	55.7	23.7	523.9		46.9	14.9	1066.1		39.4	7.4	1474.1		40.1	8.1	1723.0		41.3	9.3	1968.4
24	55.6	23.6	547.5		46.2	14.2	1080.3		39.9	7.9	1482.0		39.9	7.9	1730.9		40.6	8.6	1977.0
25	55.2	23.2	570.7		45.4	13.4	1093.7		40.7	8.7	1490.7		40.3	8.3	1739.2		41.4	9.4	1986.4
26	54.3	22.3	593.0		45.9	13.9	1107.6		41.9	9.9	1500.6		40.0	8.0	1747.2		40.8	8.8	1995.2
27	52.8	20.8	613.8		47.8	15.8	1123.4		44.0	12.0	1512.6		39.9	7.9	1755.1		39.8	7.8	2003.0
28	51.3	19.3	633.1		48.7	16.7	1140.1		43.6	11.6	1524.2		39.3	7.3	1762.4		38.6	6.6	2009.6
29	51.3	19.3	652.4		46.0	14.0	1154.1		44.1	12.1	1536.3		38.6	6.6	1769.0		38.6	6.6	2016.2
30	51.8	19.8	672.2		46.2	14.2	1168.3		43.4	11.4	1547.7		38.2	6.2	1775.2		39.3	7.3	2023.5
31					45.8	13.8	1182.1						37.9	5.9	1781.1		39.6	7.6	2031.1

SRCS Juvenile Rearing and Growth

Growth rates are not calculated for SRCS juveniles rearing in these creeks. In order to calculate a growth rate, sufficient numbers would need to be tagged with unique marks and consistently recaptured throughout the rearing period. This was attempted in 1996. All juveniles sampled during biweekly surveys in Mill and Deer Creeks were Coded-Wire-Tagged (CWT'ed). A total of 157 SRCS was CWT'ed in Mill Creek, and a total of 782 were tagged in Deer Creek. None of these tagged fish were recaptured on subsequent juvenile or adult surveys. In general, too few fish are captured at current sampling stations within the Sacramento-San-Joaquin systems and ocean fisheries to get recoveries on a small sample of tagged fish. Calculated growth rates for Chinook salmon rearing in the Upper Sacramento River averaged 0.33 mm/day and ranged from 0.26 to 0.40 mm/day, (Kjelson et.al., 1982). Growth rates for Chinook salmon from two different brood years in Butte Creek were calculated at 0.77 mm/d (range 0.45 to 1.02 mm/d) and 0.2 mm/d (range 0.09 to 0.32 mm/d) respectively, (Hill, 1999). Juvenile salmon rearing in the Sacramento River and SRCS in Butte Creek are incubating and rearing at different elevations and water temperatures than Mill and Deer Creek fish which may influence growth rates.

In Mill Creek, a total of 655 rearing 99BY SRCS were sampled from January 2000 thru January 2001. Fish ranged in size from 33 mmfl to 101 mmfl (Table 8). In Deer Creek, a total of 818 rearing SRCS were sampled during the same time period, ranging in size from 34 mmfl to 116 mmfl. Combining Mill and Deer Creek rearing data, fish emerged around 33 mmfl and grew to at least 116 mmfl over a 13 month period. Once fish reached approximately 50 mmfl in both creeks they appeared to either migrate out of the sample reaches or effectively escape the sampling gear (Appendix, Figures 15 and 17). Due to the size selectivity associated with electrofishing and seining, the actual maximum obtained growth may be larger than the observed maximum growth. From this data we cannot predict what proportion of the 1999BY emigrated as fry or reared over summer and emigrated as yearlings. Also, distribution of rearing juveniles in each watershed thru time has not been researched.

Table 8. Bimonthly electrofishing catch summary of spring-run chinook salmon rearing in Mill Creek at Hole-in-the-Ground and Black Rock from January 2000 through January 2001. Only 1999BY fish are reported.

Capture Period	Mean (mmFL)	Standard Deviation	Range (mmFL)		Total Number Captured
01/01/00-01/15/00	36	1.8	33	39	12
01/16/00-01/31/00	38	1.9	32	42	62
02/01/00-02/15/00	39	2.0	35	42	56
02/16/00-02/28/00	38	2.0	33	42	23
03/01/00-03/15/00	40	2.2	36	44	29
03/16/00-03/31/00	38	3.2	49	34	122
04/01/00-04/15/00	38	3.3	35	55	83
04/16/00-04/30/00	44	5.1	38	60	57
05/01/00-05/15/00	48	7.4	35	68	51
05/16/00-05/31/00					no survey
06/01/00-06/15/00					0
06/16/00-06/30/00					0
07/01/00-07/15/00	70	4.8	65	79	9
07/16/00-07/31/00	71	7.2	52	84	20
08/01/00-08/15/00	82	4.7	74	88	15
08/16/00-08/31/00	85	5.1	73	96	63
09/01/00-09/15/00	87	4.3	79	97	35
09/16/00-09/30/00	90	5.8	83	101	16
10/01/00-10/15/00					0
10/16/00-10/31/00					no survey
11/01/00-11/15/00					no survey
11/16/00-11/30/00					no survey
12/01/00-12/15/00					no survey
12/16/00-12/31/00					0
01/01/01-01/15/01					0
01/16/01-01/31/01	89	12.7	80	98	2

Table 9. Bimonthly electrofishing catch summary of spring-run chinook salmon rearing in Deer Creek at A-Line Bridge and Ponderosa Way from January 2000 through January 2001. Only 1999BY fish are reported.

Capture Period	Mean (mmFL)	Standard Deviation	Range (mmFL)		Total Number Captured
01/01/00-01/15/00	36	1.1	34	37	10
01/16/00-01/31/00	36	1.4	34	39	29
02/01/00-02/15/00	37	1.6	34	41	73
02/16/00-02/28/00	35	1.2	34	36	3
03/01/00-03/15/00	39	2.4	35	44	42
03/16/00-03/31/00	37	2.6	31	45	189
04/01/00-04/15/00	37	1.5	34	42	152
04/16/00-04/30/00	38	2.5	33	45	60
05/01/00-05/15/00	39	3.1	34	48	43
05/16/00-05/31/00					0
06/01/00-06/15/00	51	3.5	47	55	4
06/16/00-06/30/00					0
07/01/00-07/15/00	62	6.1	54	80	22
07/16/00-07/31/00	65	6.8	52	75	11
08/01/00-08/15/00	116	0	116	116	1
08/16/00-08/31/00	75	5.6	55	88	73
09/01/00-09/15/00	80	8.8	59	109	76
09/16/00-09/30/00	83	9	67	102	21
10/01/00-10/15/00					no survey
10/16/00-10/31/00					no survey
11/01/00-11/15/00					no survey
11/16/00-11/30/00					no survey
12/01/00-12/15/00					0
12/16/00-12/31/00					0
01/01/01-01/15/01	86	5.6	79	92	9

SRCS Fry and Yearling Emigration

Rotary screw traps (RST) were used to sample fry and yearling Chinook salmon outmigration in each creek. The purpose of this sampling is to determine the relative size at outmigration and the timing of outmigration. Abundance estimates of SRCS emigrants are not made due to difficulties of obtaining trap efficiency estimates during peak emigration periods (i.e., high flow events, debris, trap removal, and run separation). Also, recaptures of the small numbers of wild fish captured in each trap is improbable. In 2000 rotary screw trap monitoring was expanded to include to months of February through June to include spring- and fall-run fry Chinook outmigration. Traps are removed when water temperatures become lethal for fish captured in the traps' live car.

The screw traps in each creek are placed within fall-run Chinook salmon (FRCS) spawning habitat. No spawning surveys were made for FRCS in either creek in 1999, therefore, it is not known if fall run spawned upstream of the trap sites. Although FRCS spawn later in the season than spring run, FRCS fry emergence and emigration timing may be similar to SRCS due to warmer water temperatures during egg incubation in fall run spawning areas. Therefore, Chinook fry captured in the rotary screw trap are not identified to run. All yearling-sized Chinook salmon captured in the traps are assumed to be SRCS.

In Mill Creek the RST was fished from 18 October 1999 through the 20 June 2000. Trapping resumed on 4 October 2000 and continued until 1 June 2001. A total of 1734, 1999 BY SRCS and FRCS fry, and 429, 1999 BY SRCS yearlings were captured during these time periods (Table 10 and Appendix, Figures 18 and 19). The first 1999 BY fry outmigrant was captured on 28 December, 1999. Fry continued to be caught in the trap through 23 June, 2000. Fry ranged in size from 32 to 104 mmFL. The first 1999 BY yearling outmigrant was captured on 11 October, 2000. Yearlings continued to be captured through 30 April, 2001. Yearlings ranged in size from 76 to 158 mmFL. Migration of 1999 BY SRCS occurred over a 16 month period.

In the spring of 2000, water flow conditions for fry outmigration were above normal. In Mill Creek 89% of fry outmigrated between Jan 20 and March 11. Flows during this time period were above 286 cfs with two peak periods above 2300 cfs, (Appendix, Figure 20). During the same time period, turbidity ranged from 6.2 to 43 ntu's, (Appendix, Figure 21). The fall of 2000 was dry with little increase in flow or turbidity until mid-January. Sixty-one percent of 99 BY yearlings migrated in 2000 and 2001 in these low flow conditions.

In Deer Creek the RST was fished from 15 October, 1999 through the 30 June, 2000. Trapping resumed 6 October, 2000 and continued until 18 May, 2001. A total of 5089, 1999 BY SRCS and FRCS fry, and 742, 1999 BY SRCS yearlings were captured during these time periods, (Table 11 and Appendix, Figures 22 and 23). The first 1999 BY fry outmigrant was captured on 2 December, 1999. Fry continued to be caught in the trap through 30 June, 2000. Fry ranged in size from 31 to 94 mmFL. The first 1999 BY SRCS yearling outmigrant was captured on 11 October, 2000. Yearlings continued to be captured through 4 May, 2001. Yearlings ranged in size from 58 to 135 mmFL. Migration of 1999 BY SRCS occurred over a 17 month time period.

Table 10. Size statistics and bimonthly catch of spring-run and fall-run CS fry and SRCS yearlings captured in the Mill Creek rotary screw trap. Only 1999 BY salmon are reported

Capture Period	Mean (mmFL)	Standard Deviation	Range (mmFL)		Total Number Captured
12/16/99-12/31/99	37	0.7	37	38	2
01/01/00-01/15/00	37	1.7	32	45	239
01/16/00-01/31/00	38	1.4	34	45	659
02/01/00-02/15/00	39	2.2	32	51	437
02/16/00-02/28/00	41	5.5	33	59	79
03/01/00-03/15/00	39	5.5	35	67	94
03/16/00-03/31/00	39	4.6	36	63	49
04/01/00-04/15/00	40	9.9	34	70	10
04/16/00-04/30/00	80	6.4	75	84	2
05/01/00-05/15/00	79	13.4	53	99	34
05/16/00-05/31/00	82	8.2	54	104	117
06/01/00-06/15/00	83	12.2	54	95	9
06/16/00-06/30/00	82	5.8	78	89	3
07/01/00-07/15/00		no trapping July 2000 - September 2000			
07/16/00-07/31/00					
08/01/00-08/15/00					
08/16/00-08/31/00					
09/01/00-09/15/00					
09/16/00-09/30/00					
10/01/00-10/15/00	109	16.6	91	158	15
10/16/00-10/31/00	101	12.4	82	134	43
11/01/00-11/15/00	101	10.8	84	120	12
11/16/00-11/30/00	100	11.6	76	136	50
12/01/00-12/15/00	100	11.7	86	125	18
12/16/00-12/31/00	101	10.4	87	137	30
01/01/01-01/15/01	103	8.7	86	129	93
01/16/01-01/31/01	101	7.3	86	120	64
02/01/01-02/15/01	101	10.3	87	128	17
02/16/01-02/28/01	107	8.8	98	116	4
03/01/01-03/15/01	108	9.3	96	120	5
03/16/01-03/31/01	112	8.6	95	126	32
04/01/01-04/15/01	118	12.7	105	134	6
04/16/01-04/30/01	120	8.2	100	134	40

Table 11. Size statistics and bimonthly catch of spring-run and fall-run CS fry and SRCS yearlings captured in the Deer Creek rotary screw trap. Only 1999 BY salmon are reported

Capture Period	Mean (mmFL)	Standard Deviation	Range (mmFL)		Total Number Captured
12/01/99-12/15/99	38	0.0	38	38	1
12/16/99-12/31/99	37	1.0	36	39	20
01/01/00-01/15/00	37	1.2	35	40	62
01/16/00-01/31/00	37	0.9	34	52	875
02/01/00-02/15/00	39	2.7	32	52	834
02/16/00-02/28/00	40	5.1	33	58	63
03/01/00-03/15/00	40	5.5	31	63	1191
03/16/00-03/31/00	45	9.4	34	73	872
04/01/00-04/15/00	46	12.2	32	80	594
04/16/00-04/30/00	52	14.4	33	89	261
05/01/00-05/15/00	56	10.9	32	94	189
05/16/00-05/31/00	61	8.7	43	82	100
06/01/00-06/15/00	69	11.0	44	83	19
06/16/00-06/30/00	70	6.4	63	80	8
07/01/00-07/15/00		no trapping July 2000 - September 2000			
07/16/00-07/31/00					
08/01/00-08/15/00					
08/16/00-08/31/00					
09/01/00-09/15/00					
09/16/00-09/30/00					
10/01/00-10/15/00	108	11.4	79	135	30
10/16/00-10/31/00	83	12.2	58	133	99
11/01/00-11/15/00	88	11.5	68	120	38
11/16/00-11/30/00	90	12.0	64	130	131
12/01/00-12/15/00	96	8.8	66	120	182
12/16/00-12/31/00	90	8.4	73	112	44
01/01/01-01/15/01	91	9.0	71	115	92
01/16/01-01/31/01	90	10.0	70	116	70
02/01/01-02/15/01	91	12.7	75	112	6
02/16/01-02/28/01	85	4.1	77	93	11
03/01/01-03/15/01	93	5.6	81	102	13
03/16/01-03/31/01	98	11.7	80	110	7
04/01/01-04/15/01	102	9.2	88	120	13
04/16/01-04/30/01	98	3.3	93	102	5
05/01/01-05/15/01	118	0.0	118	118	1

In Deer Creek, 92% of the fry outmigration occurred between January 19 and April 24. Flows during this time period remained above 335 cfs with 2 periods above 3300 cfs, (Appendix, Figure 24). In May 2000, the turbidity meter was replaced in Deer Creek. Average turbidity readings instantly dropped from 6 to <1 ntu's. Therefore, turbidity readings prior to May will be disregarded, (Appendix, Figure 25). The yearling outmigration period in fall 2000 and spring 2001 experienced lower than normal precipitation. Eighty-three percent of the yearlings outmigrated prior to increases in flow in mid-January.

Water Temperatures at Emigration

The upper lethal water temperature for emigrating salmon is determined in part by acclimation temperatures. Higher acclimation temperatures produce higher temperature tolerances until an upper lethal threshold is reached. For example, for salmon acclimated at 60°F the upper lethal limit is 70°F, and for salmon acclimated at 70°F the upper lethal limit is 76.8°F, (Orsi, 1971; in Boles, 1988). For the fall 2000 yearling outmigration period in Mill Creek the maximum daily water temperature did not exceed 57.6°F at the trap site. Temperature records have not been updated for the spring 2000 fry and spring 2001 yearling outmigration periods. In Deer Creek, maximum daily water temperatures at the trap site did not exceed 58.2°F during the fall 2000 yearling SRCS emigration period. Maximum daily water temperatures for the spring 2000 fry and spring 2001 yearling outmigration periods did not exceed 67.4°F and 61.4°F, respectively.

Condition Factors at Emigration

A non-lethal method of determining the onset of smoltification in Chinook salmon in the field is to record the condition factor of outmigrants. The condition factor, (K), is a length-weight ratio calculated as: $K = W / L^3$, where W = weight in grams and L = length in millimeters. The metric condition factor (K) is converted to English units by multiplying (K) x 36.12729. This condition factor ratio decreases as a fish loses body fat. Smolts weigh less and exhibit a lower length to weight ratio than do parr (Wedemeyer et. al., 1980). Fry have a higher energy intake and greater tissue growth resulting in greater weight per unit length. This causes the condition factor to increase, (Schreck, et. al., 1990). The average condition factor calculated for optimum health in hatchery Chinook salmon is .0002959, (USFWS).

In Mill Creek the condition factors for outmigrant fry ranged from .00022 to .00050. (Fry < 50 mmFL are not weighted.) Yearlings ranged from .00026 to .00049 (Appendix, Figure 26). In Deer Creek the conditions factors for outmigrant fry ranged from .00014 to .00063. Yearlings ranged from .00027 to .00047, (Appendix, Figure 27). A polynomial trend line for the condition factors for 1999BY outmigrants in both Mill and Deer Creeks show fluctuating condition factors depending on the life-stage of the fish. (The R-squared values for both the Mill and Deer Creek data are not highly significant at $r^2 = 0.26$ and 0.21 respectively.) Fry show an increasing condition factor during winter and spring outmigration. Yearlings show a decreasing trend during fall and winter outmigration, in October – February, but an increasing trend the following spring in March and April (Appendix, Figures 26 and 27).

Length at Date Classification Errors

In the Sacramento –San Joaquin River systems the accepted method to classify juvenile Chinook salmon into their respective runs is based on length at date growth curves. The current length at date growth curves used by many Sacramento River projects were calculated from post-Shasta dam main stem Sacramento River water temperatures and assume that SRCS spawning times are the same as the historical Baird Hatchery SRCS egg-taking records (August and early September), (Fisher, 1992). At the time these growth curves were calculated juvenile outmigration monitoring on Mill and Deer Creek had not begun. In Mill and Deer Creeks, the spawning times are later and egg incubation rates and juvenile growth rates slower than those calculated in the length at date growth curves. Consequently, these calculated growth curves are incorrectly identifying known spring run from Mill and Deer Creeks. Yearling spring-run Chinook are being classified as winter run or late fall run, and young-of-year spring-run Chinook are being classified as fall run, (Appendix, Figure 28).

Management Activities for SRCS in the Sacramento-San Joaquin Delta

A Juvenile Chinook Salmon Protection Decision Process was developed to minimize the impact of State and Federal Water Project operations on SRCS migrating through the Delta. This [Process] is similar to the Spring-run Salmon Protection Plan described in previous annual reports. Information from fish outmigrant monitoring, including Mill and Deer Creeks, is used to make decisions related to the operation of the Delta Cross Channel (DCC) and modification to the State Water Project/Central Valley Project (SWP/CVP) export pumping using CVPIA b(2) water and the CALFED Environmental Water Account (EWA).

Significant movement of yearling SRCS from Mill and Deer Creeks was detected in late-November and December 2000. Chinook salmon of similar size were detected at Knights Landing and Sacramento later in December. Consequently, the DCC gates were closed in late December 2000 to prevent yearling SRCS from migrating through the DCC into the interior Delta, (CDFG, 2001). The DCC gates were reopened in 6 days when monitoring detected little outmigration. Storms in mid-January produced another spike in yearling SRCS in Mill and Deer Creeks. Based on similar sized fish moving into the Delta, the DCC gates were closed from 14 January through 23 January, 2001 and again from 26 January through 31 January. (The DCC gates remain closed from February until 20 May pursuant to the Bay-Delta Water Quality Control Plan.) Several short term adjustments to SWP/CVP exports were made in January and February 2001 to improve survival of SRCS yearlings at the SWP/CVP Diversions. Export reductions were generally between 6000 – 8000 cfs and approximately 5 days in durations (CDFG, 2001).

RECOMMENDATIONS

Real-time monitoring of adult migration, water temperatures and water attraction flows in Mill and Deer Creeks is needed for coordination between instream flows for fish and water management during periods of adult migration. Adult salmon holding and spawning surveys provide information on the status of the population and the distribution within each watershed. Juvenile rearing studies should be expanded to include growth rates throughout the rearing habitat in each creek. The real-time monitoring of yearling spring-run Chinook emigration should continue in order to provide data in evaluating salmon occurrence, distribution and movement through the Sacramento River and Sacramento-San Joaquin estuary.

There are no established minimum flow standards in Mill or Deer creeks to ensure adequate attraction and transport flow and temperature from the Sacramento River upstream past diversions points in the valley floor. Currently there are no systematic surveys scheduled during the months of April thru June to monitor and document migration timing, fish passage, critical riffles, adult stranding or thermal barriers. There is a need to conduct systematic monitoring of these parameters as a basis for establishing real-time minimum flow releases in each creek during the months of April-June.

In future years, scale, otolith and tissue sampling of adult salmon carcasses will be necessary to obtain age and race-specific escapement data. No information is currently available for age-specific models of SRCS. These models are used to estimate ocean abundance and to regulate the ocean fisheries to meet stock rebuilding criteria.

Water temperature monitoring locations need be expanded to duplicate survey reach boundaries. This will better represent the actual temperatures in known holding and spawning areas. Adult SRCS are occurring in water temperatures above the normal temperature tolerance limits reported for Chinook salmon. This includes adult migration temperatures, adult holding temperatures and adult spawning temperatures. We do not know how these temperature exceedences are affecting egg viability. Either temperature is a factor limiting Chinook populations in these remnant watersheds, SRCS are seeking out cold water refugia that temperature monitors are not detecting, or wild SRCS have adapted to tolerate temperatures that are lethal to salmon in controlled lab experiments.

In the Sacramento –San Joaquin River systems the accepted method to classify juvenile Chinook salmon into their respective runs is based on length at date growth curves. The current length at date growth curves used by many Sacramento River projects are incorrectly identifying early spawning fall-run Chinook as spring run and known spring-run fish from Mill and Deer Creek as winter-run, late fall-run or fall-run Chinook. A revised growth curve and length at date criteria needs specific for stream-type tributary SRCS needs to be developed.

The only wild spring-run population within the Central Valley being Coded Wire Tagged (CWT'ed) is Butte Creek. CWT returns are used in monitoring juvenile movement through the Sacramento San-Joaquin Delta, ocean movement and harvest, straying of adults and age structure of the adult population. A pilot CWT study was made in Mill and Deer creeks in 1996, but after extensive sampling effort, less than 1,000 fish were tagged. When either population levels or sampling conditions change,

and a minimum of 50,000 juveniles can be tagged on each creek, this project will resume a CWT'ing program.

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APPENDIX