State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

CHINOOK SALMON POPULATION AND PHYSICAL HABITAT MONITORING IN CLEAR, ANTELOPE, MILL AND DEER CREEKS FOR 2007

SACRAMENTO RIVER SALMON AND STEELHEAD ASSESSMENT PROJECT
SPORT FISH RESTORATION ANNUAL PROGRESS REPORT

By

Colleen Harvey Arrison
Associate Fishery Biologist
Northern Region
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Summary

Monitoring of Chinook salmon escapement in the Upper Sacramento tributaries is an important part of the California Department of Fish and Game's efforts in managing Central Valley Chinook stocks. Chinook populations in Clear, Antelope, Mill and Deer Creeks, located in Shasta and Tehama Counties, have been monitored since the 1950's. Currently, these creeks are surveyed annually for spring-run and fall-run Chinook escapements. Small numbers of late-fall Chinook may also spawn in these tributaries, but the status of these populations is unknown. Water flow and temperature are also monitored to evaluate conditions that may either enhance or adversely affect salmon survival.

The Sacramento Valley experienced a dry water year in 2007. Run-off for the 2007 water year was 55% of average. The lack of precipitation and run-off April thru June may have influenced migration patterns of spring Chinook salmon. A rain event in mid-October improved stream conditions for fall Chinook.

Water flow and temperature data obtained from United States Geological Survey (USGS) and Department of Water Resource (DWR) gages is finalized and certified through 9/30/07. Data reported after 10/1/07 is draft and subject to revision.

The estimated cost to complete these surveys in 2007 was $60,700. This includes Technician labor, contractor overhead, supplies and transportation costs. This figure does not include DFG's administrative costs. This research is funded through the Federal Sport Fish Restoration Act and the CALFED Ecosystem Restoration Program. [1]

Clear Creek

Spring Run

The U.S. Fish and Wildlife Service (USFWS), Northern Central Valley Fisheries Resource Office (NCVFRO) conducts snorkel surveys in August as an annual index of adult spring-run Chinook salmon (SRCS) abundance. A total of 194 spring-run Chinook were counted in August 2007. A temporary picket weir was installed at Reading Bar to spatially separate SRCS from fall-run Chinook salmon (FRCS) spawners. Reports on USFWS monitoring efforts on Clear Creek can be found at: www.fws.gov/redbluff/cvpia.html.

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[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 contact:

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4040 N. Fairfax Drive, Room 300
Arlington, VA 22203

Fall Run

Ten weekly FRCS spawner surveys of lower Clear Creek were made during 10 October 2007 through 17 December 2007 in the 6.7 km (4.2 mi) reach downstream of the former McCormick-Saeltzer Dam site, (Figure 1). Salmon carcasses were marked by attaching colored tags to the jaw with a hog-ring and placing the fish back into running water for recovery during subsequent surveys.

Figure 1. Map of SRCS and FRCS habitat in Clear Creek.

Using fresh carcass mark-and-recovery data with a modified Schaefer model (Hoopaugh, 1978 and Schaefer, 1951)), **the spawner population in Clear Creek was estimated to be 4,129 fish** (Table 1).

Table 1. 2007 FRCS escapement estimate in Clear Creek using the modified Schaefer equation.

Recovery Period	Number of marked carcasses recovered from marking period (i):									Total Marked Carcasses recovered	Total Carcasses observed	Population Estimate
(j)	1	2	3	4	5	6	7	8	9	(Rj)	(Cj) [1]	(N) [2]
15 Oct	32									32	312	628
22 Oct	9	40								49	519	944
29 Oct	1	18	78							97	883	1,094
5 Nov	1	7	25	75						108	623	629
13 Nov			3	18	34					55	276	366
19 Nov			1	4	12	13				30	138	147
23 Nov			5	4	2	6	9			24	102	103
3 Dec					4	4	3	8		19	96	120
10 Dec							0	3	4	7	43	97
17 Dec							4	2	5	11	53	0
Recovery R(i)	43	65	110	101	52	23	16	13	9	Total Estimate		4,129
Marked M(i)	64	109	155	139	94	41	29	28	22			

[1] Includes salmon carcasses which were marked and marked carcasses that were recovered

[2] Adjusted estimate reflects the modified Schaefer equation (Hoopaugh, 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate.

Based on examination of 2,638 carcasses, the FRCS spawner population in Clear Creek consisted of 35% male adults (fork length [FL] ≥ 61 cm [24 in]), 64% female adults and 1% grilse (FL < 61 cm). The seasonal average pre-spawning mortality of female salmon in Clear Creek was < 1%. Recapture rates of marked carcasses ranged from 41% to 73% with a seasonal average of 63%.

Scale samples were collected and analyzed from 491 carcasses as part of a Central Valley Salmon Aging Program administered by DFG's Marine Region. The age composition for Clear Creek fall Chinook in 2007 was 3% age 2 fish, 21% age 3, 74% age 4 and 2% age 5.

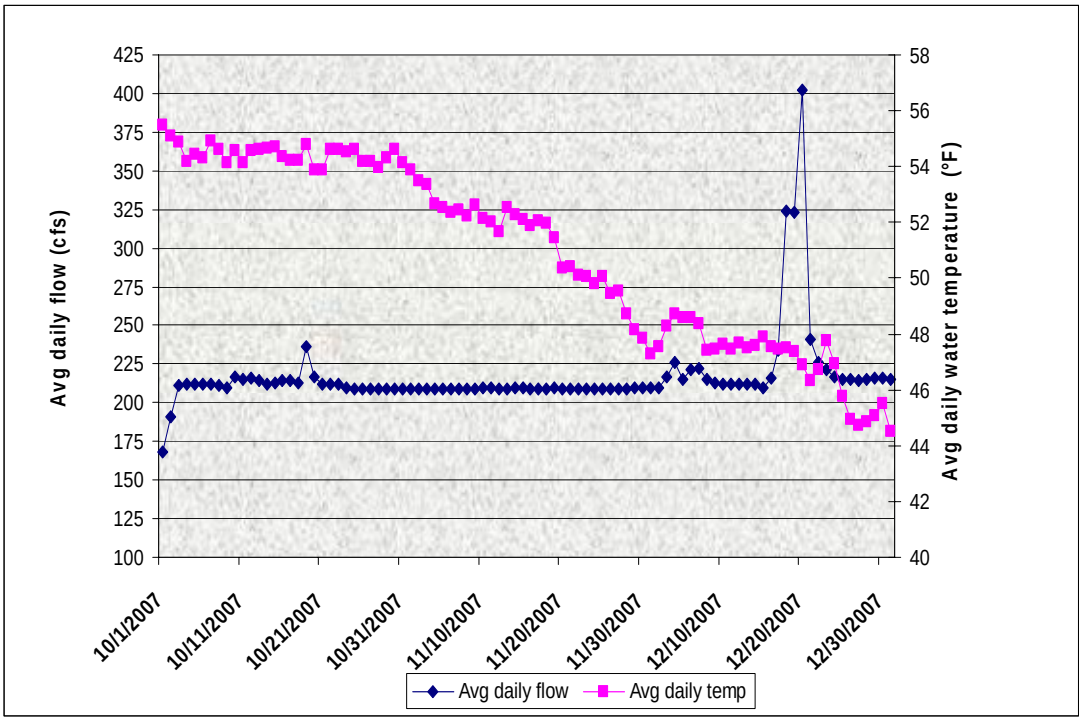
Fourteen coded-wire-tags (CWT's), representing 10 tag codes, were recovered during the surveys. All CWT recoveries in Clear Creek originated from Coleman National Fish Hatchery (CNFH), Feather River Hatchery (FRH) and Merced River Fish Facility (MRFF) releases, (Appendix, Table 1).

The cost of implementing a weekly tag-recapture FRCS carcass survey in Clear Creek for 2007 was $12,500.

Physical Habitat Conditions

Average daily water flow and temperatures in lower Clear Creek are recorded real-time at the USGS, IGO stage (www.cdec.water.ca.gov). During the October thru December surveys the average daily flows ranged between 168 cfs and 402 cfs, (Figure 2). Flows remained stable for the duration of the spawning surveys and did not negatively influence carcass recovery rates. Average daily water temperatures during the FRCS spawning period ranged between 55.5 °F and 44.5 °F, which are within the preferred temperature range of 42 ˚F to 57 ˚F for Chinook salmon spawning (Bjornn and Reiser, 1991). There was no evidence of adult Chinook stranding or pre-spawning mortalities in Clear Creek FRCS with this flow and temperature regime.

Figure 2. Water temperature and flow in Clear Creek FRCS habitat for 2007.



Population Trends

Clear Creek FRCS counts have been sporadically recorded since 1947, (Appendix, Table 2). Since various and inconsistent methodologies have been used to count salmon, historical salmon data in Clear Creek is not comparable to recent data. Beginning in 1988, comparable survey methods have been applied, using weekly mark-recapture surveys and standardized survey reaches. Since 1988, populations have ranged from 600 in 1992 to 16,071 in 2001. The average for the previous 10 years is 9,354 FRCS.

Antelope Creek

Spring Run

On 10 July, 2007, Antelope Creek, Tehama County, was snorkel surveyed to count holding adult SRCS. **A total of 26 adult salmon was observed.** Sixteen miles of stream was surveyed including: the North Fork from 0.8 miles upstream of Judd Creek's confluence to the South Fork confluence, the South Fork from the South Antelope Gun Club to the North Fork confluence, and the main stem from the North and South Fork confluence to Facht Place, (Figure 3 and Table 2). This snorkel survey is a cooperative effort between the Department, Pacific States Marine Fisheries Commission (PSMFC), Lassen National Forest (LNF), Sierra Pacific Industries (SPI) and National Marine Fisheries Service (NMFS). The survey is completed in one day to minimize harassment to holding salmon and salmon movement between surveys.

Figure 3. Map of SRCS holding and spawning distribution in Antelope Creek for 2007.

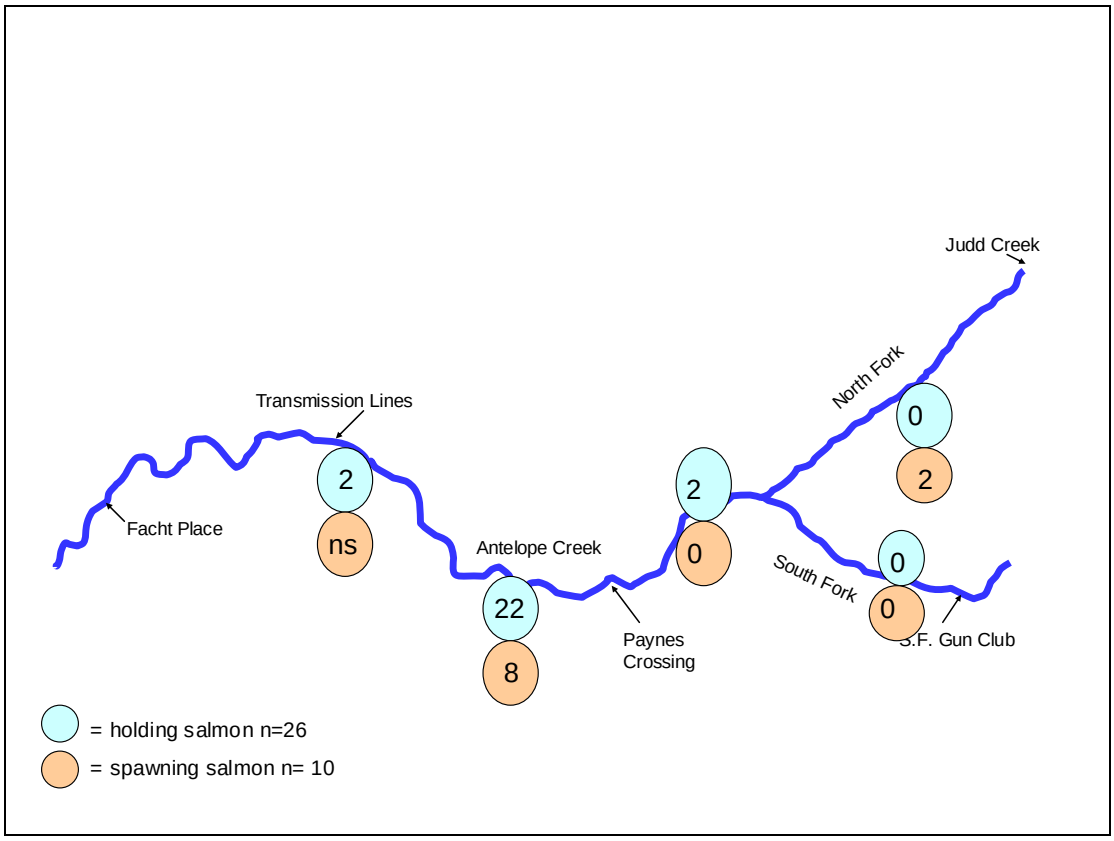


Table 2. Adult SRCS holding and redd counts in Antelope Creek for 2007.

Section	Holding Salmon		Spawning Salmon	
	# of salmon	% of total	# of redds	% of total
North Fork	0	0	2	20
South Fork	0	0	0	
Main Stem to Paynes	2	8	0	
Paynes to Canyon Mouth	22	84	8	80
Canyon Mouth to Facht Place	2	8	ns	
Totals	**26**	100%	**10**	100%

[1] ns = no survey

In 2005, 4 salmon were observed holding in pools within 300 yards upstream of the "boulder cascades" near the Judd Creek confluence, an area not normally surveyed. The reach upstream of Judd Creek to the Middle Fork was scheduled to be added to the survey in 2007 but law enforcement agencies advised against this, due to a surveillance investigation. This reach should be included in future years when salmon are observed holding near Judd Creek and when it is safe to access this area.

Spawning Distribution

One spawning survey was completed on 4 October covering the same reaches as the holding survey, except omitting the north fork upstream of Judd creek and the main stem downstream of canyon mouth. A total of 10 redds, 0 carcasses and 3 live salmon was observed, (Table 2).

The total cost of completing SRCS holding and spawning surveys on Antelope Creek in 2007 was $6,400. (Labor costs of LNF Technicians were assumed similar to DFG contract labor for calculation purposes.)

Physical Habitat Conditions

Overall, water temperatures in Antelope Creek in 2007 were warmer than in 2006. Figure 4 shows the average daily water temperatures at select elevations in SRCS habitat in Antelope Creek. Table 3 shows water temperature exceedence in SRCS habitat in 2006 (a high water year) and 2007 (a low water year). Temperature exceedence represents the number of days at select elevations where water temperatures exceeded levels for normal egg development and adult survival.

Figure 4. Water temperature and flow in Antelope Creek SRCS habitat in 2007.

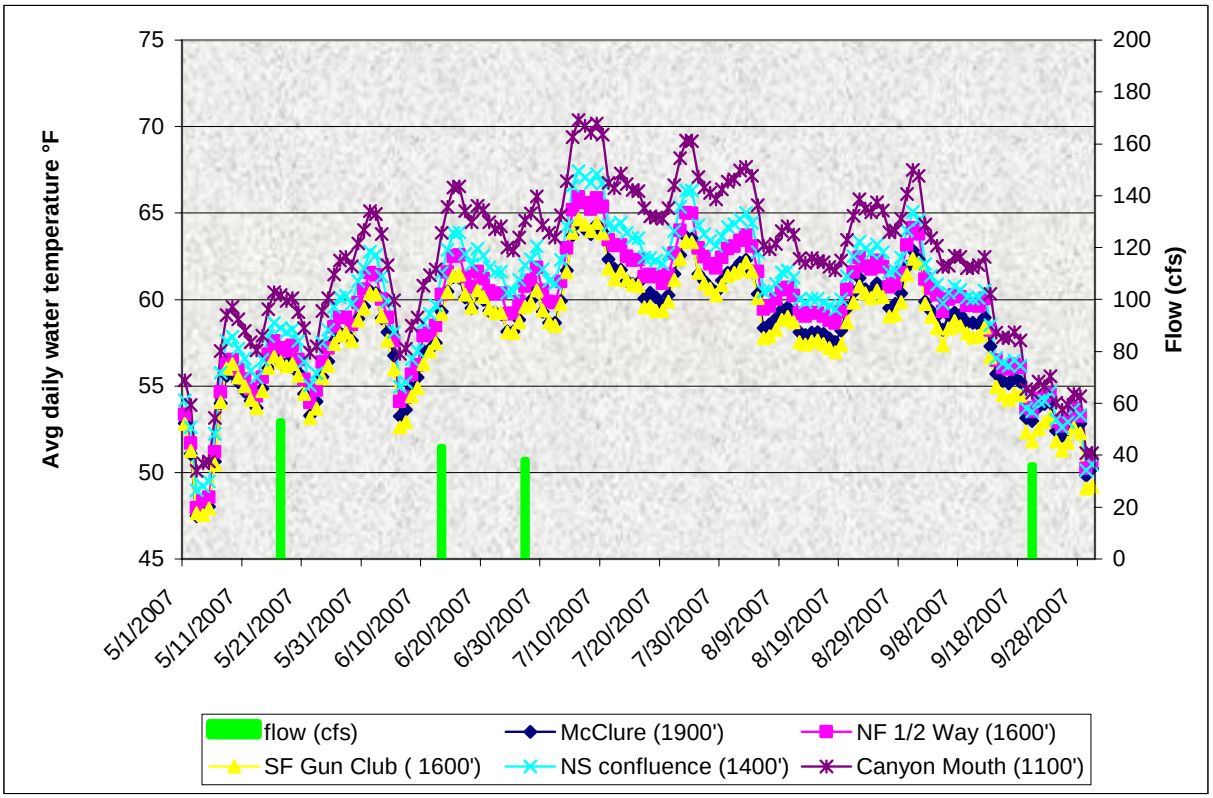


Table 3. Water temperature exceedence and SRCS occurrence in Antelope Creek, May thru September, 2006 and 2007.

Location	Elevation (ft)	% holding/ % spawning salmon 2007	Number of Days Mean Daily Temperature Exceeds:					
			≥59.0˚F normal egg viability		≥63.5˚F reduced egg viability		≥68.0˚F partial mortality	
			2006	2007	2006	2007	2006	2007
Below North Fork @ Judd Ck	1870	0 / 10	31	74	1	8	0	0
Below North Fork @ ½ Way	1600	0 / 10	45	95	10	12	0	0
Below South Fork @ Gun Club	1600	0 / 0	35	68	3	6	0	0
Below N and S Confluence	1400	8 / 0	65	104	13	30	0	0
Below Paynes Crossing	1300	84 / 80	78	no data	18	no data	0	no data
Below Canyon Mouth	1120	8 / ns	91	117	43	73	4	9

All holding salmon occurred in areas where temperatures may have reduced egg or salmon survival. Temperatures below Paynes crossing may have been lethal in 2007, although the redd to fish ratio in 2007 was similar to 2006: 1:2.6 verses 1:2.5.

Water flows in Antelope Creek at Paynes Crossing were measured four times between 17 May and 20 September, 2007 using a Marsh McBirney FlowMate Model 2000 flow meter. Flows ranged between 53 cfs in May to 36 cfs in September, (Figure 4).

Paynes Crossing

In 2007, the majority of holding and spawning SRCS occurred downstream of Paynes Crossing (Figures 3 and 5). Fish passage conditions at the crossing may have impeded upstream migration, leaving salmon to hold and spawn in habitat marginally suitable for successful survival.

For the nine year period between 1998 and 2006, an average of 72% of holding SRCS occurred upstream of this crossing. In 2007, only 8% of salmon (2 out of 26) ascended the road crossing (Table 4). Additionally, in years 2005 and 2006, an average of 90% of the SRCS spawned upstream of the crossing, while in 2007 only 20% of salmon spawned above the crossing (Table 4). The Paynes Crossing in Antelope Creek occurs at only 1300 ft elevation. Salmon holding and spawning below this elevation, especially in low water years, are exposed to conditions that may reduce adult survival and egg viability.

Table 4. Holding and spawning distribution of SRCS in Antelope Creek from 1998 thru 2007.

Section	1998	1999	2000	2001	2002	2003	2004	2005		2006		2007	
								salmon	redds	salmon	redds	salmon	redds
North Fork upstream Judd to South Fork	9	5	0	1	0	6	0	18	0	13	5	0	2
South Fork Gun Club to North Fork	9	3	1	1	0	0	0	0	6	5	14	0	0
Main Stem Confluences to Paynes	77	19	2	4	31	29	3	53	12	72	19	2	0
Paynes to Canyon Mouth	23	6	1	1	1	7	0	10	4	9	1	22	8
Canyon Mouth to Power Lines	25	5	4	1	8	4	0	1	ns	3	ns	1	ns
Power Lines to Facht Place	11	2	1	0	6	0	0	0	ns	0	ns	1	ns
Facht Place to Grapevine Ck	0	0	0	0	0	0	0	0	ns	ns	ns	ns	ns
Totals	**154**	**40**	**9**	**8**	**46**	**46**	**3**	**82**	**22**	**102**	**39**	**26**	**10**

Figure 5. Antelope Creek at Paynes Crossing in September 2007 at 38 cfs.

A long term solution needs to be developed at this site which may take several years to implement. In the interim, an emergency modification to the metal grate crossing should be made to improve SRCS passage prior to the 2008 migration season.

Population Trends

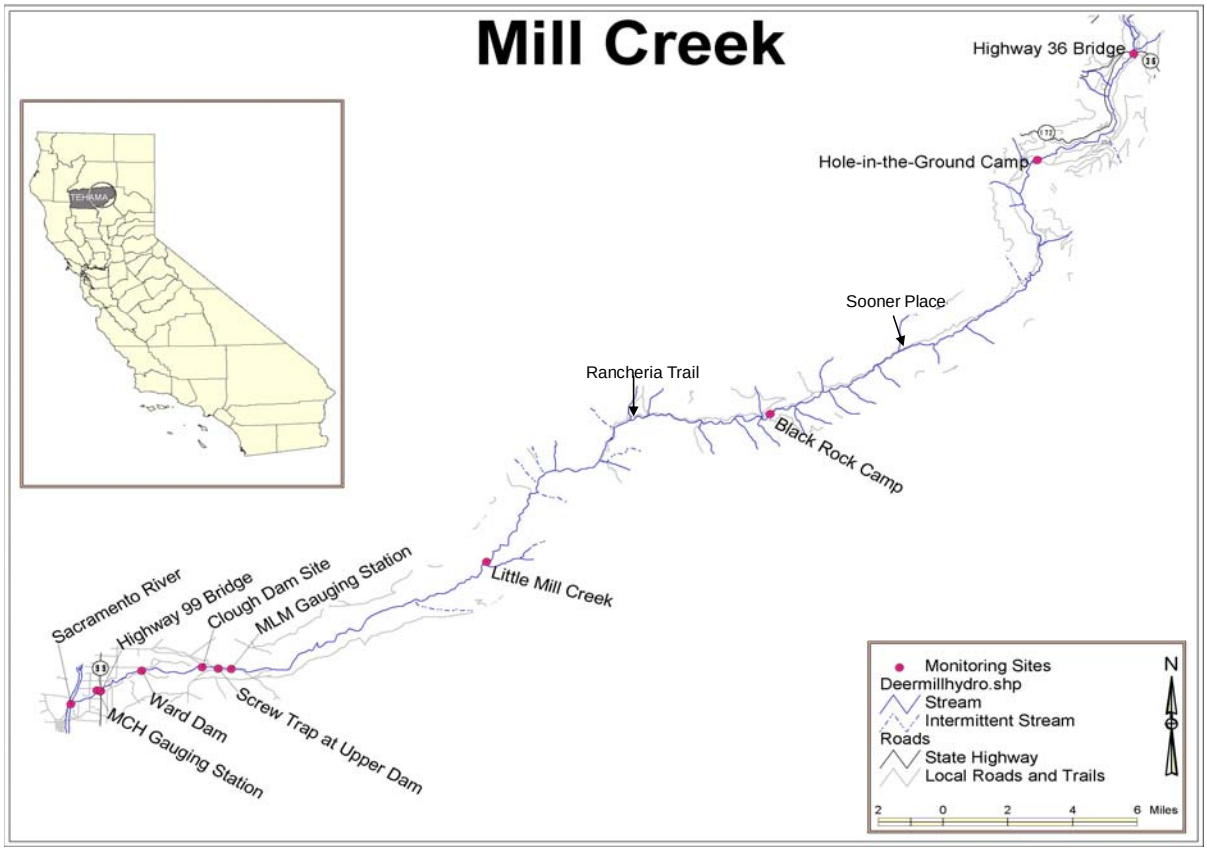
For the past 19 years the Department has been monitoring the SRCS population in Antelope Creek using snorkel observation techniques. During this period, counts have ranged from 0 to 154 salmon (Appendix, Table 2). The Department has limited historical records of SRCS occurrence in Antelope Creek dating back to the 1950's. In 1953 and 1956, 127 and 253 SRCS respectively, were seined below the Cone Kimball Diversion Dam. (The Cone-Kimball dam was removed in the 1960's.) No records exist to infer historical population levels, or holding and spawning distributions.

Mill Creek

Spring Run

Between the 1st and 12th of October, SRCS spawning redds in Mill Creek were counted to estimate the spawning population. Based on these redd counts, **an estimated 920 SRCS spawned in Mill Creek in 2006.** Forty-one miles of spring run spawning habitat was surveyed beginning upstream of the Highway 36 Bridge downstream to the Steel Tower Transmission Lines (Figure 6.).

Figure 6. Map of SRCS holding and spawning habitat in Mill Creek.



To complete these surveys, the creek is subdivided into 14 reaches and a team of 2 people walk each reach and enumerate complete redds. Higher elevation spawning areas are surveyed first, and surveys progress in a downstream manner. In the most remote area of Mill Creek, a helicopter is typically used to enumerate redds from the air. A ratio of aerial to ground redds is determined by comparing combined air and ground surveys to air only surveys. In 2007, requests to schedule the helicopter survey in early October were repeatedly denied by the flight company. A rain event on 15 October increased turbidity and made aerial viewing worthless. Any redds occurring downstream of Buckhorn Gulch were not counted in 2007.

A total of 123 live salmon, 19 carcasses and 460 redds was observed (Table 5). In order to expand redd counts to a population estimate, we assume that each female constructs one redd and there is a 1:1 male to female sex ratio in the population, or, stated differently, each redd represents 2 salmon:

460 redds x 1 female/redd x 2 = 920 salmon [2]

[2] Ratio's of redds to holding SRCS in Deer Creek from 1997 thru 2007 have ranged from 1.1 to 2.5 with an 11-year average of 2.0. For Mill Creek estimates from 1997 thru current, multiplier of 2 has been used.

Table 5. Mill Creek SRCS spawning distribution and population estimate for 2007.

Survey Reach	# of Redds Counted	% of Total
Above Hwy 36	3	1
Hwy 36 to Little Hole-in-Ground	17	4
Little Hole-in-Ground to Hole-in-Ground	14	3
Hole-in-Ground to Ishi Trailhead	18	4
Ishi Trailhead to Big Bend	11	2
Big Bend to Canyon Camp	29	6
Canyon Camp to Sooner	70	15
Sooner Place to McCarthy	78	17
McCarthy to Savercool	38	8
Savercool to Black Rock	35	8
Black Rock to Ranch House	65	14
Ranch House to Avery	23	5
Avery to Pape	51	11
Pape to Buckhorn	8	2
Buckhorn to Transmission Lines [1]	ns [1]	
Total Redds	460	100%
Population Estimate (redds x 2)	920	

[1] Helicopter Survey not made in 2007

The cost of completing one pass redd surveys on Mill Creek in 2007 was $8,200.

In addition to the spawning surveys completed in the fall of 2007, a video fish counting station operated on Mill Creek from 6 March through 18 June 2007. An estimated 1,060 SRCS were counted entering Mill Creek during this time period, (Killam et.al., 2008).

Physical Habitat Conditions

An instream flow objective to transport adult salmon from the Sacramento River is currently being investigated as part the Mill Creek Watershed Conservancies, Lower Mill Creek Water Management Study. The goal of the anadromous fish monitoring component of this project is to determine the following:

- Minimum stream discharge for unimpaired fish passage over critical riffles
- Effectiveness of pulse flows in triggering fish migration
- Relationship between water temperature and duration of salmon migration.

By monitoring annual spring water flow and temperature conditions in SRCS tributaries, biologists can develop flow and temperature criteria for successful upstream migration of salmon. The maximum water temperature threshold for successful upstream migration of salmon in the Sacramento River system appears to be ≤ 65 ˚F (Boles, 1988). (Although, there is evidence of adult salmon migrating in water temperatures above this threshold; consequently, temperature threshold criteria warrant further study and refinement.) When average daily water temperatures upstream of water diversion points consistently exceed this threshold, it can be inferred that upstream migration is completed for the season. By developing annual spring hydrographs thermal graphs, we can determine if flow or thermal conditions limited salmon migration into a tributary.

Due to the dry conditions in 2007, flow and water temperatures in Mill Creek during SRCS immigration were marginal for fish migration. Between 1 April and 18 June, average daily post-diversion attraction flow ranged from 160 cfs to 60 cfs. Average daily post-diversion water temperatures remained above 65°F after 6 May. Pre-diversion water temperatures remained above 65°F after 9 June, (Figure 7). Flow bypasses were discontinued after 18 June due to the high water temperatures and the absence of adult or juvenile salmonids.

Due to concerns with low, warm water inhibiting SRCS migration into Mill Creek in 2007, DFG requested LMMWC to release a 3 day pulse flow back into Mill Creek to enhance fish passage. It was decided between DFG and LMMWC that when base flows reached approximately 50 cfs and water temperatures increased above 70°F a pulse flow would be scheduled. Within the first 14 days in June, attraction flows for SRCS declined from 103 cfs to 52 cfs. Concurrently, water temperatures at Mill Creek's confluence increased to 72°F. A three-day pulse was scheduled between 15 and 18 June, 2007, increasing attraction flows into Mill Creek to between 109 and 114 cfs and decreasing water temperatures by 1°F. A total of 390 acre-feet of water was generated to benefit migrating salmon. Although the increased attraction flow improved passage conditions for adult SRCS no salmon were observed migrating during this time. The run may have entered Mill Creek earlier as a result of the drier conditions.

Base flows in Mill Creek within SRCS holding and spawning habitat (measured at the MLM gage) ranged from 318 cfs in early May to 90 cfs by the time of spawning, (Figure 8). The average base flows during the same time periods for the previous 79 years of record are 446 cfs and 107 cfs, respectively.

Water temperature recorders placed in SRCS holding and spawning areas are used to document temperature regimes encountered by wild salmon. Optic StowAway® temperature recorders are located in six locations, ranging from 4800ft elevation to 1000ft elevation. As mentioned previously in Antelope creek, prolonged temperatures in excess of 60˚F may reduce adult and egg survival. Figure 8 shows the average daily water temperatures within the SRCS holding habitat in Mill Creek, and Table 6 shows the number of days at each elevation that water temperatures exceeded upper tolerance limits for normal egg development and adult salmon survival for both 2007 and 2006.

Mill Creek water temperatures were higher in 2007 than 2006. In 2007, temperature exceedence occurred at elevations below 2800 ft. In 2006, water temperatures remained at levels supporting normal egg viability above 2100 ft elevation.

The highest water temperatures that may have reduced egg viability occurred downstream of Sooner Place (2800 ft. elevation). Water temperatures exceeded 63.5 °F between 13 and 99 days during SRCS holding periods. Although holding distributions are not available, 51% of spawning SRCS occurred downstream of Sooner Place. Water temperatures exceeded 68 °F between 10 and 42 days downstream of Blackrock (2100 ft elevation). Eighteen percent of SRCS spawned in this area. In 2007, elevated water

temperatures in SRCS holding and spawning areas may have affected an unknown proportion of egg viability in up to 51% of the population.

Figure 7. Water temperature and flow during adult SRCS migration into Mill Creek in 2007.

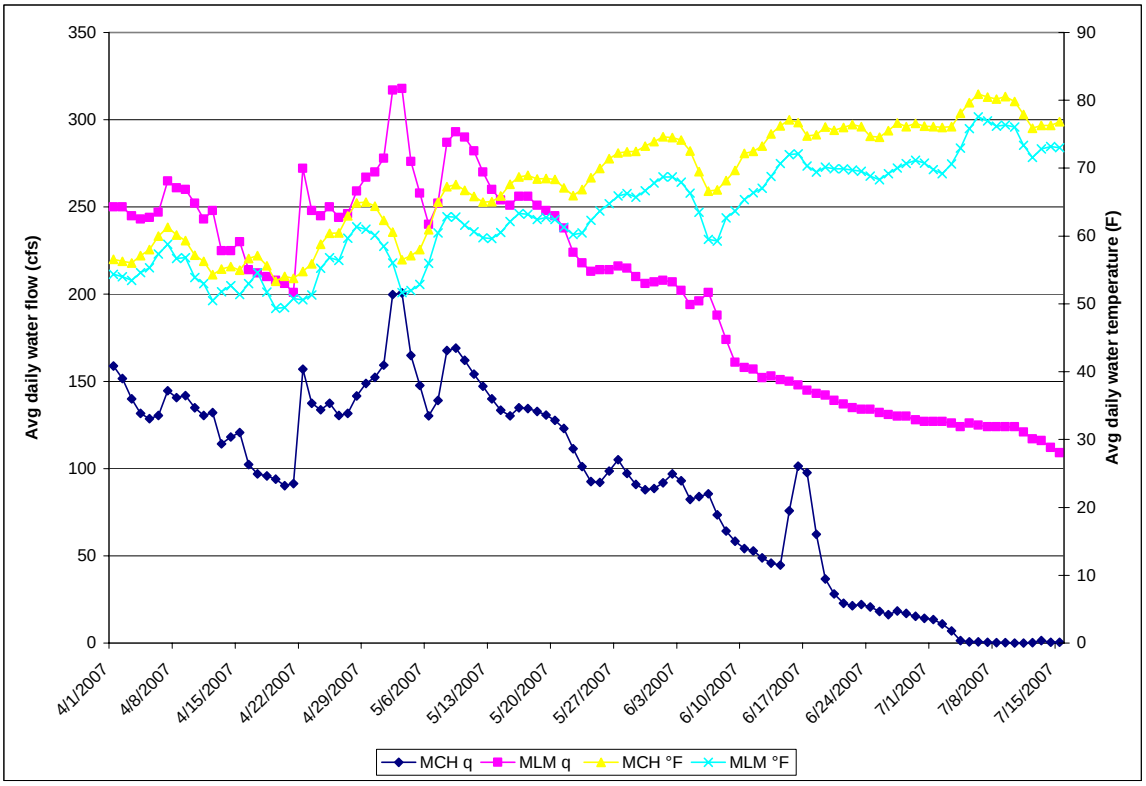


Figure 8. Water temperature and flow during SRCS holding and spawning in Mill Creek for 2007.

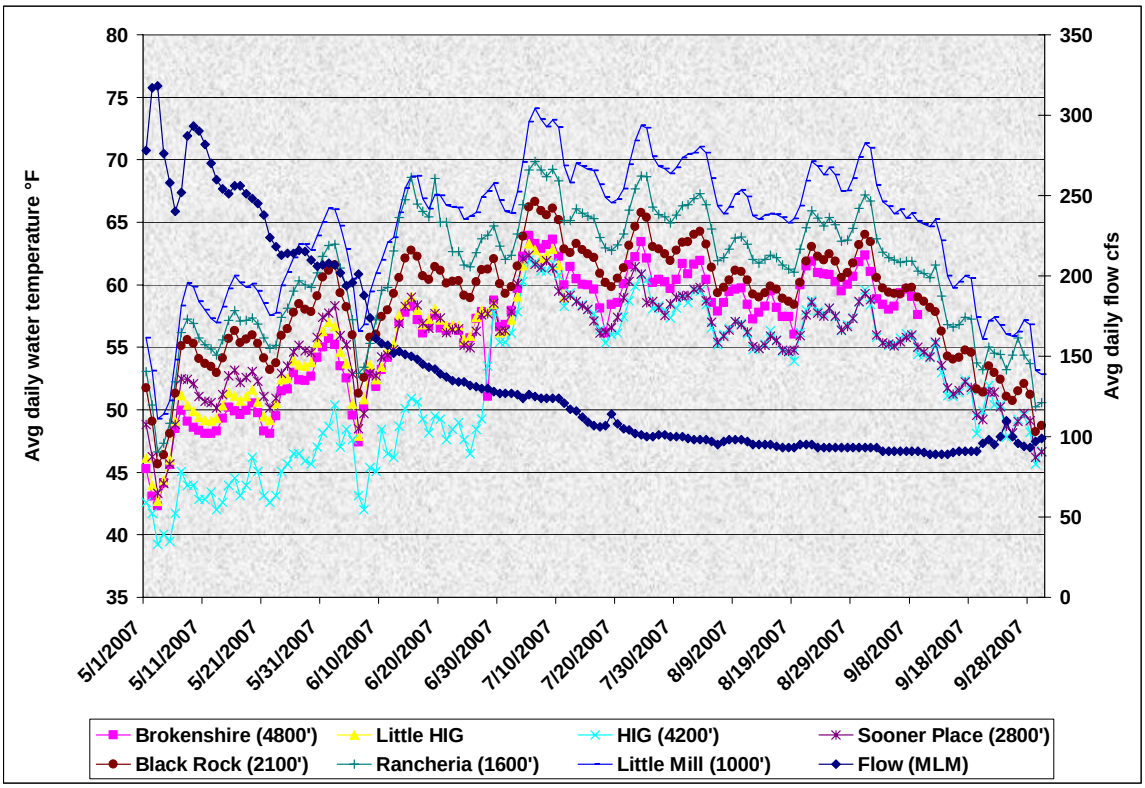


Table 6. Water Temperature Exceedence and spawning distribution in Mill Creek SRCS habitat May thru September, 2006 and 2007.

Location	Elevation (ft)	% Spawning Salmon 2007	Number of Days Mean Daily Temperature Exceeds:					
			≥59.0˚F normal egg viability		≥63.5˚F reduced egg viability		≥68.0˚F partial mortality	
			2006	2007	2006	2007	2006	2007
To Brokenshire	4800	1	0	na	0	na	0	na
To Hole-in-Ground	4200	7	0	14	0	0	0	0
To Sooner Place	2800	27	5	19	0	0	0	0
To Black Rock	2100	33	26	91	3	13	0	0
To Rancheria Trail	1600	16	77	160	13	57	0	10
To Little Mill	1000	2	91	124	45	99	5	42

Population Trends

Mill Creek SRCS populations have been monitored since the late 1940's. Various counting methods have been employed, including: carcass and redd counts, electronic counters and fish traps. The natural turbidity of Mill Creek makes annual counts by direct observation impractical. The most consistent data available is a trapping station at the Clough dam that operated from 1954 thru 1963, (Van Woert,1964). During this 10 year period, SRCS counts ranged from 1,203 to 3,485 (Appendix, Table 2). Since the removal of Clough dam in 1997, redd counts have been used to estimate returning SRCS.

In these 11 years, estimates of SRCS have ranged from 202 to 1,594, and have been above 900 salmon since 2002.

Fall Run

Six weekly spawner surveys were made between 31 October and 13 December covering an 8 mile reach between the canyon mouth (2.5 miles upstream of Los Molinos Mutual's Upper Diversion Dam) and the confluence with the Sacramento River. Salmon carcasses were marked by attaching colored tags to the jaw with a hog ring and replacing the carcass back into running water for recovery during subsequent surveys. In addition a redd survey from the canyon mouth to 3 miles upstream was completed to determine the extent of spawning upstream from the weekly surveyed section.

Using fresh carcass mark-and-recovery data with a modified Schaefer model (Hoopaugh, 1978), **the FRCS spawner escapement into Mill Creek was estimated to be 796 salmon** (Table 7). Recapture rates of marked carcasses ranged from 15% to 83% and averaged 50%. One survey period was missed due to high flows.

Table 7. 2007 FRCS escapement estimate in Mill Creek using the modified Schaefer equation.

Recovery Period	Number of marked carcasses recovered from marking period (i):					Total Marked Carcasses recovered	Total Carcasses observed	Population Estimate
(j)	1	2	3	4	5	(Rj)	(Cj) [1]	(N) [2]
14 Nov	23					23	169	382
20 Nov	11	23				34	104	104
29 Nov	4	6	5			15	103	99
6 Dec		No survey				0	0	0
13 Dec		1	2		7	10	55	212
Recovery R(i)	38	30	7	0	7	Total Estimate		796
Marked M(i)	63	36	18	0	47			

[1] Includes salmon carcasses which were marked and marked carcasses that were recovered

[2] Adjusted estimate reflects the modified Schaefer equation (Hoopaugh, 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate.

The composition of natural spawning FRCS in Mill Creek was 43% male adults (FL ≥ 61 cm [24 in], 55% female adults and 2% grilse (FL < 61 cm), based on an examination of 396 carcasses. None of the female carcasses encountered were pre-spawned mortalities.

No CWT's were recovered during fall carcass surveys in Mill Creek in 2007.

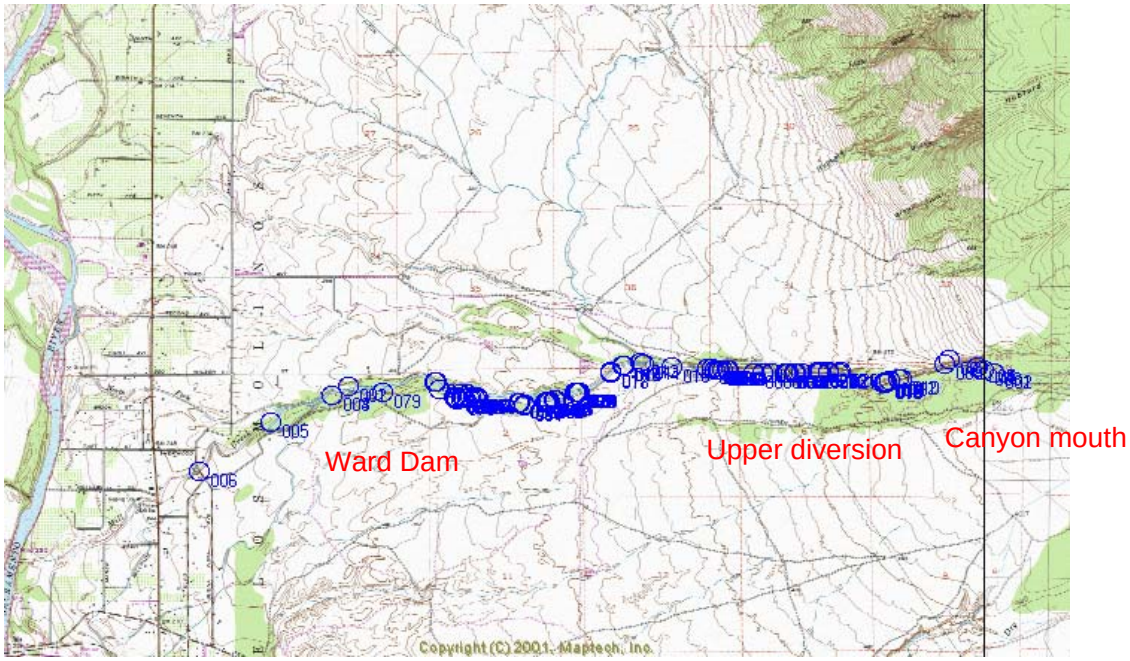
The cost of completing weekly tag-recapture spawning surveys on Mill Creek in 2007 was $11,900.

Spawning Distribution

On the 7 and 8 of November, redds were GPS'ed to document spawning distribution. Since each waypoint may represent more than one redd and additional redds were constructed after this data was collected, this data should only be used for purposes of identifying active spawning and relative distribution of spawning locations. Thirty-nine percent of fall Chinook spawning occurred between the canyon mouth and LMMWC's

Upper Dam, 49% occurred between the Upper Dam and Ward Dam, and 11% of spawning occurred between Ward Dam and the confluence (Figure 9). The weekly tag-recapture surveys occurred in areas having 99% of the FRCS spawning activity.

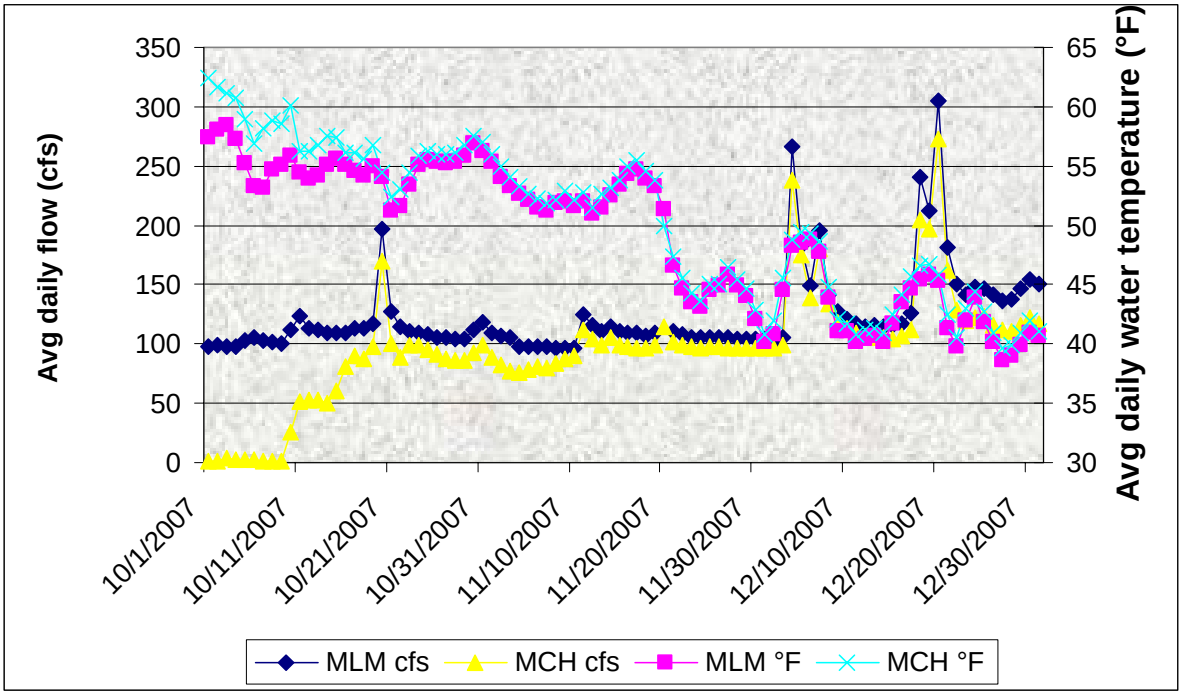
Figure 9. Spawning distribution of Mill Creek FRCS in 2007.



Physical Habitat Conditions

The release of bypassed irrigation water back into Mill Creek in the fall is coordinated between DFG and Los Molinos Mutual Water Company (LMMWC). DFG typically waits to call on water until average daily water temperatures fall below 57.5°F to insure successful spawning. LMMWC began increasing post-diversion flows on 10 October. By 16 October post-diversion flows remained above 80 cfs for the duration of FRCS spawning. On 15 October live salmon and redds were observed in lower Mill Creek. Average daily water temperatures remained suitable for successful spawning and egg incubation after 11 October, (Figure 10). There was no evidence of fish stranding or pre-spawning mortalities of FRCS in Mill Creek with this flow and temperature regime.

Figure 10. Water temperature and flow in Mill Creek FRCS habitat for 2007.



Population Trends

FRCS population counts in Mill Creek have been made since the early 1950's. Estimates have ranged from 150 to 16,000 spawners, (Appendix, Table 2). Due to inconsistent methodologies and questionable data accuracy, it's unrealistic to compare population trends between these years. Years 2002 thru 2007 represent the most comprehensive data set, where the known spawning habitat was surveyed during the peak weeks of FRCS spawning. During these past 6 years, populations have ranged from 796 to 2,611 salmon, and averaged 1,800 salmon.

Deer Creek

Spring Run

On 24 July, Deer Creek was snorkel surveyed to count holding adult SRCS. **A total of 644 SRCS was observed, (**Table 8). Twenty-four miles of stream was surveyed from the Upper Deer Creek Falls downstream to within 2 miles of Dillon Cove (Figure 11). This encompasses the known holding habitat of adult SRCS in Deer Creek.

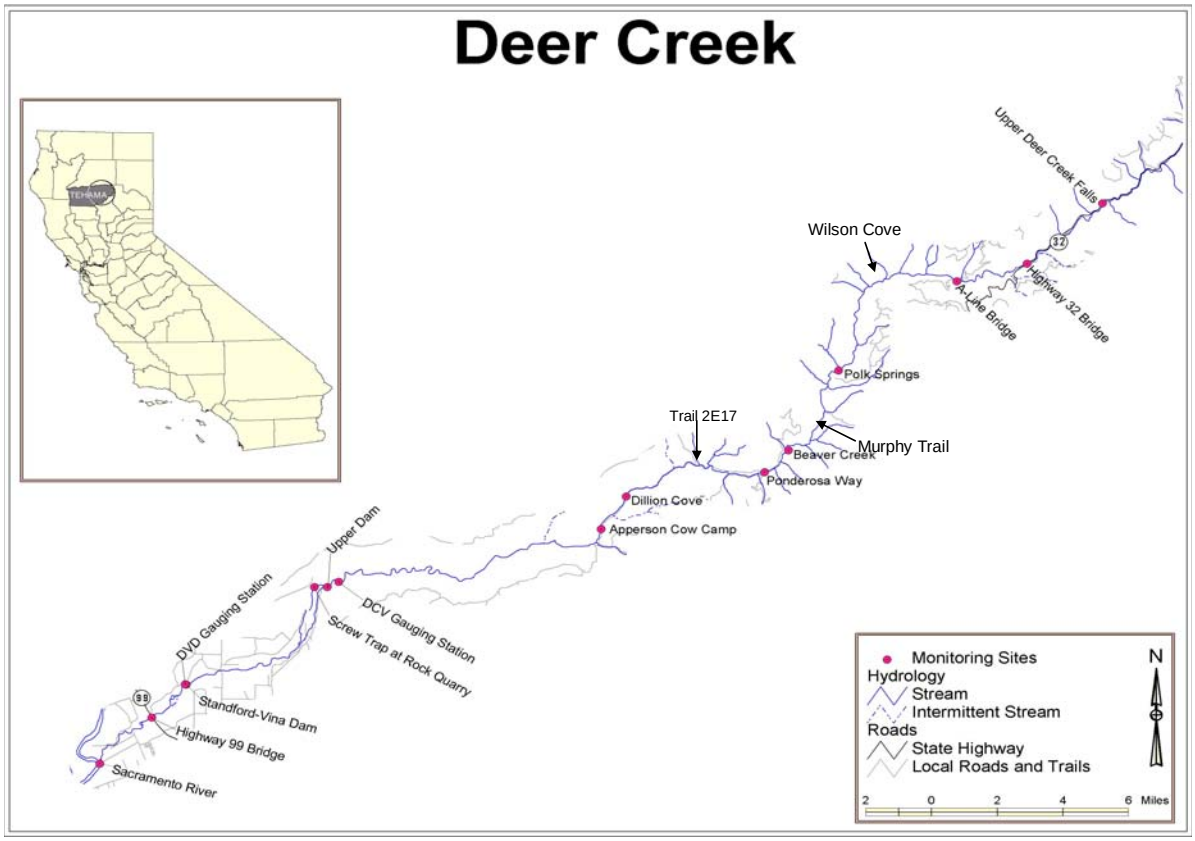
Typically, this annual snorkel survey always occurs the first full week in August. In 2007, it was moved ahead 2 weeks due to concerns with low water and elevated water temperatures. Care was taken by swimmers to minimize harassment to holding salmon.

Table 8. Adult SRCS holding and redd counts in Deer Creek for 2007.

Section	Holding Survey		Spawning Survey	
	# of salmon	% of total	# of redds	% of total
Upper Falls to Potato Patch	7	1	3	1
Potato Patch to Hwy 32	3	<1	0	0
Hwy 32 to Lower Falls	1	<1	0	0
Lower Falls to A-Line	137	22	42	10
A-Line to Wilson Cove	26	4	75	19
Wilson Cove to Polk Springs	66	10	88	22
Polk Springs to Murphy Trail	224	35	63	16
Murphy Trail to Ponderosa Way	53	8	123	30
Ponderosa Way to Trail 2E17	127 [1/]	20	9	2
Trail 2E17 to Dillon Cove			ns	
Totals	**644**	100%	**403**	100%

[1/] Only 4 salmon were observed holding in the lower 1 mile of this reach, therefore it was assumed that no salmon were holding downstream of this point and the survey was terminated at Trail 2E17. No spawning was observed downstream of Trail 2E17 during an aerial redd survey in October.

Figure 11. SRCS holding and spawning habitat in Deer Creek.



Only 1% of the spring-run Chinook population held between Upper Falls and Lower Falls in 2007. Normally, up to 28 % of the population holds in this reach. In 2006, only 3% held upstream of Lower Falls. Attraction flow in the Lower Falls fish ladder has

been declining in recent years. The stream channel upstream of the ladder is slowly degrading, reducing the amount of flow being diverted into the ladder. In addition, the supporting wall of the lowermost weir was lost in the 1997 flood, decreasing the attraction flow for fish. A long-term solution is being explored to increase the functionality of the ladder by providing more flow thru the ladder.

The Lassen National Forest fisheries crew completed the Deer Creek SRCS spawner distribution surveys in 2007. A total of 403 complete redds, 21 practice redds, 18 carcasses and 87 live fish on redds was observed, (Table 8). As with Mill Creek, this spawner survey is a one-time pass scheduled after the peak of spawning activity. The redd to holding fish ratio in 2007 was 1.6, or one redd for every 1.6 fish counted in the snorkel survey. Ratio's of redds to holding SRCS in Deer Creek for the past 11 years have ranged from 1.1 to 2.5 with an average of 2 fish per redd.

In order to determine the extent of SRCS and FRCS isolation in Deer Creek, an aerial flight was completed on 24 October from Ponderosa Way Crossing downstream to the USGS gage. Two SRCS redds were observed at Ponderosa Way (1700 ft elevation). Three FRCS redds were observed at the Transmission Lines (800 ft elevation), located 13 miles downstream. SRCS remained spatially isolated from FRCS in Deer Creek in 2007

The cost of completing SRCS holding and spawning surveys in Deer Creek in 2007 was $11,200.

Physical Habitat Conditions

Adult SRCS migration into Deer Creek in 2007 may have been truncated due to water flow and temperature conditions. Between 1 April and 13 May, post diversion attraction flows ranged from 200 cfs to 60 cfs. Attraction flows dropped below 40 cfs by 15 May and below 20 cfs by 26 May, (Figure 12).

Post-diversion average daily water temperatures remained above 65°F after 7 May. Pre-diversion average daily water temperatures remained above 65°F after 15 May. Consequently, even if Deer Creek were free-flowing, in a low water year elevated water temperatures may inhibit SRCS migration into the creek by mid-May.

In the fall of 2006, FRCS did not migrate upstream of the Deer Creek Irrigation District (DCID) dam. Consequently there was concern for unimpaired passage of SRCS in lower Deer Creek the following spring. Underwater observation surveys using mask and snorkel were conducted weekly in the spring of 2007 to evaluate the passage success of migrating SRCS past dams and critical riffles during receding flows and increasing water temperatures. Between 29 March and 30 May bimonthly surveys were completed on 2 indexed reaches in lower Deer Creek: USGS gage to the Rotary Screw Trap, and Leininger Bridge to Highway 99 Bridge (Figure 11). A total of 326 adult SRCS were observed (51% of the final count), with the highest count occurring the third week in April. Salmon appeared to successfully pass upstream of DCID dam during spring flows in 2007. No salmon were observed in the survey reach downstream of DCID dam after

10 May, (Table 9). Eight salmon were observed holding in the first pool downstream of the Stanford Vina Dam on 30 May. Due to low flows and high water temperatures (20 cfs and 74°), these salmon likely died in lower Deer Creek. These salmon occurrence surveys should be made annually April thru early June. Each indexed section should be snorkeled weekly to assess potential impediments to migration.

Table 9. SRCS occurrence surveys in lower Deer Creek during spring 2007.

Date	DCV cfs/°F	DVD cfs/°F	USGS to DCID	DCID to RST	Bridge to SVD	SVD to Hwy 99	Total SRCS
			# of adult salmon observed				
3/20/07	268 /	151	10	5			15
4/05/07	203 / 56	111 / 58	14	0	3	22	39
4/12/07	220 / 52	112 / 55	15	1	3	2	21
4/19/07	177 / 50	89 / 53	22	2			24
4/23/07	284 / 52	201 / 56			85	46	131
4/26/07	220 / 57	147 / 59	27	5			32
4/30/07	180 / 62	97 / 65	38	4			42
5/10/07	164 / 65	75 / 68	4	1	0	1	6
5/15/07	149 / 65	41 / 69	4	0			4
5/23/07	130 / 64	32 / 67	4	0			4
5/30/07	115 / 70	20 / 74	0	0	0	8	8
							326

Base flow within SRCS holding and spawning habitat (measured at the DCV gage) ranged from 255 cfs in early May to 74 cfs by the time of spawning, (Figure 13). The average base flow during the same time periods for the previous 115 years of record are 395 cfs and 96 cfs, respectively.

Water temperatures are recorded at six locations at elevations ranging from 1,500 ft to 3,200 ft. Two recorders failed representing thermal conditions at 1700 ft elevation and 2000 ft elevation. Water temperatures exceeded 2006 values at all locations recorded, (Table 10). Water temperatures exceeded optimal values for SRCS holding at all locations and may have reduced spawning success in 2007. Water temperatures were below tolerance limits for successful spawning after 2 September upstream of A-Line Bridge. At the lowest elevation of SRCS spawning, temperatures were suitable for successful spawning after 19 September, (Figure 13).

Figure 12. Water temperature and flow during Deer Creek SRCS migration in 2007.

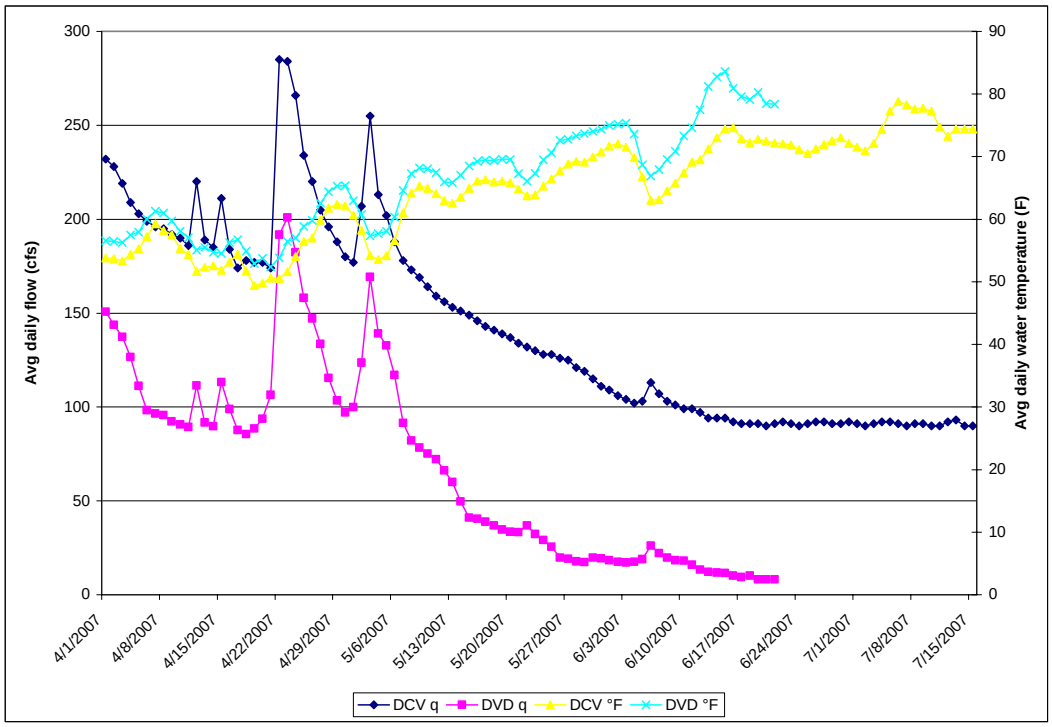


Figure 13. Water temperature and flow during Deer Creek SRCS holding and spawning in 2007.

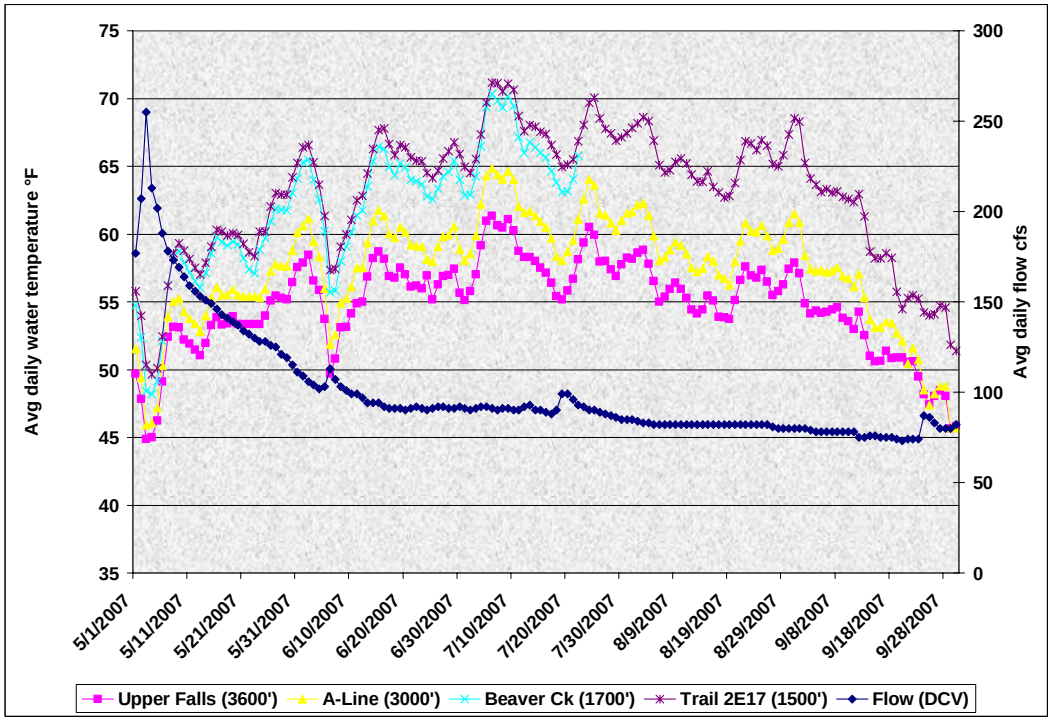


Table 10. Water temperature exceedence and salmon distributions in Deer Creek SRCS habitat May thru September, 2006 and 2007.

Location	Elevation (ft)	% Holding/ % Spawning Salmon 2007	Number of Days Mean Daily Temperature Exceeds:					
			≥59.0˚F normal egg viability		≥63.5˚F reduced egg viability		≥68.0˚F partial mortality	
			2006	2007	2006	2007	2006	2007
At Upper Falls	3600	1 / 1	5	10	0	0	0	0
To A-Line	3000	22 / 10	28	62	0	8	0	0
To Wilson Cove	2700	4 / 19	43	84	3	13	0	0
To Murphy Trail	2000	45 / 38	na	na	na	na	na	na
To Ponderosa Way	1700	8 / 30	90	na	28	na	3	na
To Trail 2E17	1500	20 / 2	99	119	43	86	4	17

Population Trend

During the previous 16 years, SRCS counts in Deer Creek have ranged from 209 to 2,759 salmon (Appendix, Table 2. This year's count of 644 represents a decrease from the 3- and 4-year cohorts, 804 and 2,759 respectively. Between 1940 and 1964, an average of 2,200 SRCS was counted annually using fish ladder counts and carcass surveys. These historical surveys were often expansions of partial weir counts and incomplete carcass surveys and are not comparable to current survey efforts.

Fall Run

Six FRCS spawning surveys were made between 26 October and 30 November encompassing a seven mile reach between the USGS gage, located upstream of Deer Creek Irrigation District's upper diversion dam, and the Highway 99 bridge crossing, (Figure 11). Fresh salmon carcasses were marked by attaching colored tags to the jaw with a hog ring and replacing the carcass back into running water for recovery on subsequent surveys.

Using fresh carcass mark-and-recovery data with a modified Schaefer model (Hoopaugh, 1978), **the FRCS spawner escapement into Deer Creek was estimated to be 508 salmon**, (Table 11). Recapture rates of marked carcasses ranged from 65% to 73% and averaged 69%.

Table 11. 2007 FRCS escapement estimate in Deer Creek using the modified Schaefer equation.

Recovery Period	Number of marked carcasses recovered from marking period (i):			Total Marked Carcasses recovered	Total Carcasses observed	Population Estimate
(j)	1	2	3	(Rj)	(Cj) [1]	(N) [2]
9 Nov	26			26	250	329
16 Nov	13	58		71	149	114
21 Nov	1	7	18	26	51	44
30 Nov		1	4	5	21	21
Recovery R(i)	40	66	22	Total Estimate		508
Marked M(i)	55	102	32			

[1] Includes salmon carcasses which were marked and marked carcasses that were recovered

[2] Adjusted estimate reflects the modified Schaefer equation (Hoopaugh, 1978), where marked carcasses (Mi) from the second marking period on were subtracted from the total estimate.

The composition of natural spawners in Deer Creek was 42% male adults (FL ≥ 61 cm), 58% female adults, and <1% grilse (FL < 61 cm), based on an examination of 391 carcasses. None of the female carcasses encountered were pre-spawned mortalities.

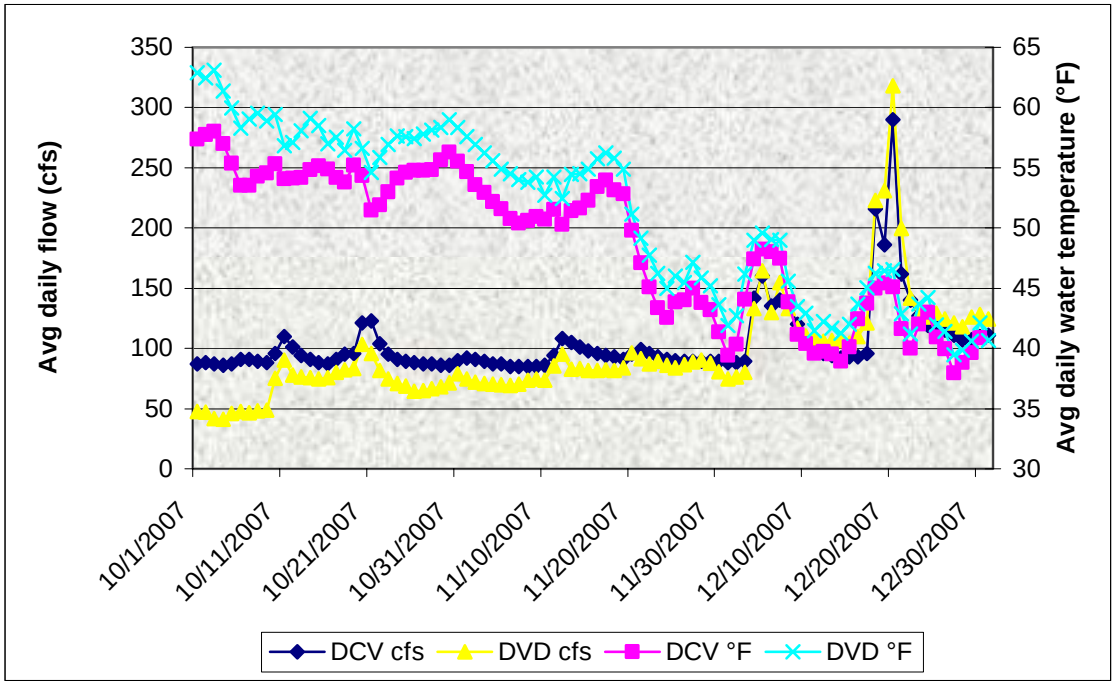
No CWT's were encountered during FRCS carcass surveys in Deer Creek in 2007.

The cost to complete weekly tag-recapture FRCS carcass surveys in Deer Creek in 2007 was $10,400.

Physical Habitat Conditions

Although it is not known when FRCS first entered Deer Creek in 2007, adult salmon and fresh redds were first observed the week of 22 October from Highway 99 bridge upstream 14 miles. The week prior, average daily post-diversion flows ranged from 72 cfs to 87 cfs (Figure 14). Although minimum migration flows for adult salmon in lower Deer Creek have not been determined, adult salmon can access the upper limits of fall Chinook habitat in Deer Creek at these flow levels. Average daily water temperatures were suitable for successful spawning and egg incubation after 4 October in pre-diversion reaches, and after 2 November in post-diversion reaches. Water temperatures may have reduced salmon egg survival during the first two weeks of stream entry.

Figure 14. Water temperature and flow during Deer Creek FRCS spawning in 2007.

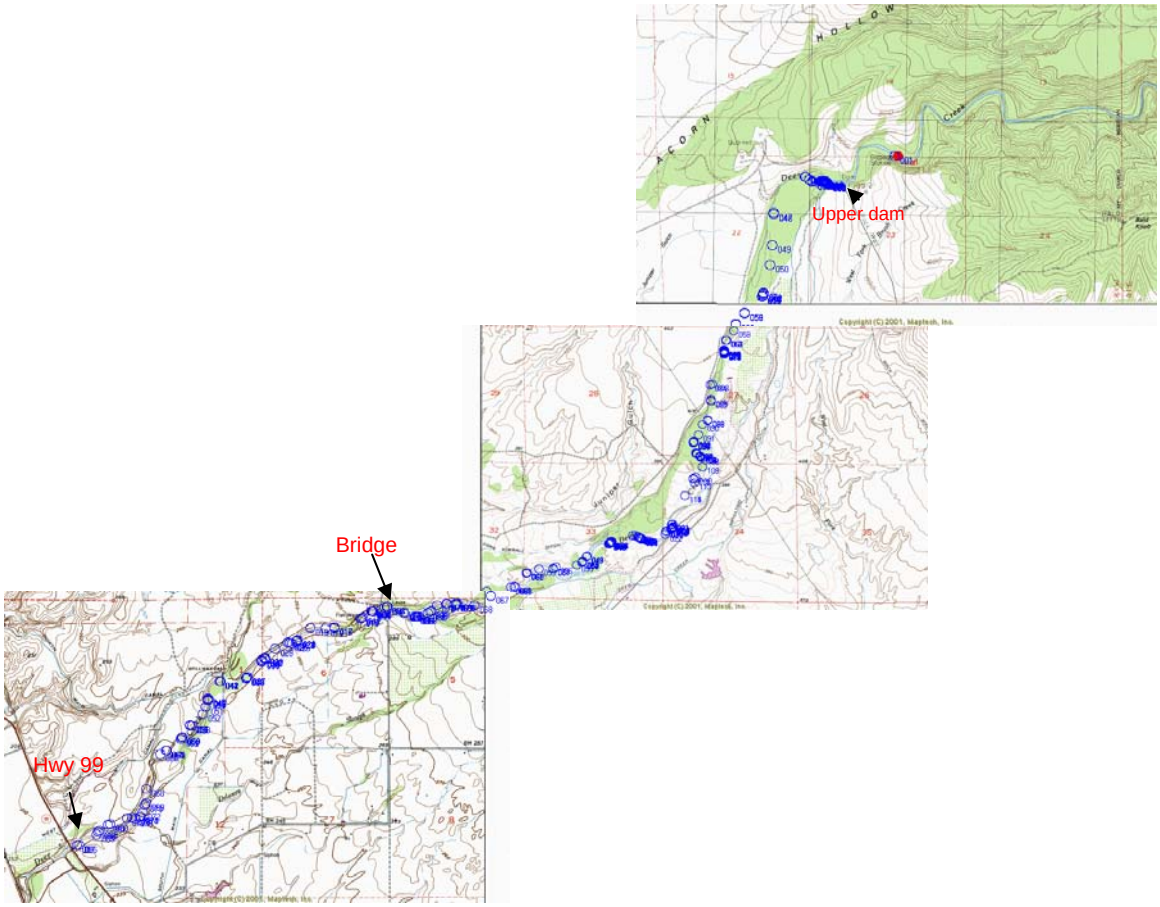


Spawning Distribution

Spawning redds were GPS'ed during the fall carcass surveys to document spawning distribution. Since each waypoint may represent more than one redd, this data should only be used for purposes of identifying areas of active spawning habitat and relative distribution of spawning. A total of 296 redds were counted on 9 November. No spawning occurred from the USGS gage downstream to DCID dam. Seventy-one percent of spawning occurred from DCID dam to Leininger Bridge. Twenty-nine percent of spawning occurred from Leininger Bridge to Highway 99. Some spawning may have occurred downstream of Highway 99, but this reach was not surveyed in 2007, (Figure 15).

The carcass surveys encompassed the majority of the FRCS spawner population, although redds were observed upstream of the weekly surveyed section. On 27 November, spot checks were made at 2 access points between the Transmission Lines and the USGS gage, a distance of 6 miles. Two redds were observed in the areas surveyed, at Hobson Camp and the Transmission Lines. In future years this reach should be surveyed at least once after the peak of FRCS spawning to determine the distribution of spawning and make corrections to the spawner population estimate. Due to limited spawning, remote access and additional labor costs, it's not recommended this section be included in the weekly survey efforts.

Figure 15. Spawning distribution of Deer Creek FRCS in 2007.



Population Trends
Population estimates of FRCS in Deer Creek have been sporadic. Counts date back to the 1950's, but differing survey effort and technique make historical comparisons problematic. In the last 50 years, estimates have ranged from 10 to 2,195, (Appendix, Table 2).

Acknowledgments

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Appendices

Appendix Table 1. Summary of 2007 CWT results for tagged Chinook salmon collected in Upper Sacramento River tributary surveys.

Tag Information				Recovery Location		
CWT code	**Hatchery Origin**	**Release Location**	**Broodyear**	**Clear Creek**	**Mill Creek**	**Deer Creek**
0501030104	CNFH	Below RBDD	03	5		
062447	FRH	Wickland Oil Net Pens	04	1		
062445	FRH	Wickland Oil Net Pens	04	1		
064687	MRFF	Hatfield State Area	04	1		
0501040407	FRH	West Sacramento	03	1		
062799	FRH	Wickland Oil Net Pens	04	1		
0601010308	FRH	Yolo Bypass	04	1		
060101005	FRH	Yolo Bypass	03	1		
0501040109	CNFH	Battle Creek	03	1		
062794	FRH	San Pablo Bay	03	1		
Totals				**14**	**0**	**0**
Carcasses examined for ad-clips				**2638**	**396**	**391**
Fall-run Chinook population estimate				**4,129**	**796**	**508**

Appendix Table 2. Fall- and Spring-run Chinook escapement in select tributaries in the Sacramento River system.

Note: some methodologies and surveys are inconsistent and incomplete.

Year	Fall-run Chinook			Spring-run Chinook		
	Clear	Mill	Deer	Antelope	Mill	Deer
1940						268
1941						635
1942						1,108
1943						812
1944						2,692
1945						3,363
1946						4,271
1947	300				3,000	2,669
1948					2,000	2,000
1949	75				1,200	1,200
1950	700				2,000	2,000
1951	550				300	2,300
1952	1,580	16,000	12,000		2,100	1,800
1953	1,500	10,000	4.000	127	3,485	2,475
1954	3,000	7,000	3,000		1,789	2,500
1955	500	3,000			2,967	2,900
1956	2,650	896	120	253	2,233	2,600
1957	330	5,316	2,195		1,203	
1958	1,600	4,340	1,300		2,212	
1959	775	837	10	40	1,580	
1960	900	940	800		2,368	
1961		1,689			1,245	
1962	5,400	4,384	2,000		1,692	
1963	10,000	1,286	1,249		1,315	2,302
1964	2,500	450	100		1,539	2,874
1965	2,500	150	200			
1966	900	500	100			
1967	370	500	60			
1968	800	750	270			
1969	1,240	1,700	750			

Year	Fall-run Chinook			Spring-run Chinook		
	Clear	Mill	Deer	Antelope	Mill	Deer
1970		690	500		1,500	2,000
1971		980	248		1,000	1,500
1972		631	304		500	400
1973		420	676		1,700	2,000
1974		944	640		1,500	3,500
1975		1,280	328		3,500	8,500
1976	1,013	245	315			
1977	1,362	318	220		460	340
1978	60	300	90		925	1,200
1979		810	780			
1980		320	210		500	1,500
1981	3,133	1,020	820			
1982	785	1,290	480		700	1,500
1983		200	370	59		500
1984	4,000	5,800	680		191	
1985	700	3,840	900		121	301
1986		574	256		291	543
1987		282	64		90	200
1988	4,453	1,487			572	371
1989	2,153	1,565	358	2	563	84
1990	1,011			1	844	496
1991	2,026			0	319	479
1992	600	999		0	237	209
1993	1,246	1,975	72	3	61	259
1994	2,546	1,081	307	0	723	485
1995	9,298			7	320	1,295
1996	5,922			1	253	614
1997	8,569	478	1,203	0	202	466
1998	4,259	546	270	154	424	1,879
1999	8,003			40	560	1,591
2000	6,687			9	544	637
2001	10,865			8	1,100	1,622
2002	16,071	2,611		46	1,594	2,185
2003	9,475	2,426		46	1,426	2,759
2004	6,365	1,182	300	3	998	804
2005	14,824	2,425	946	82	1,150	2,239
2006	8,422	1,403	1,905	102	1,002	2,432
2007	4,129	796	508	26	920	644