

State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

**CHINOOK SALMON MONITORING IN
CLEAR, ANTELOPE, MILL AND DEER CREEKS FOR 2006**

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

By

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August 2007



**Your purchase of fishing equipment
and motor boat fuel supports boating
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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. 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.

Precipitation in the upper Sacramento Valley in 2006 was 183% of normal. In addition, late spring rains in May and June insured that stream conditions for Chinook migration holding and spawning were optimal. Spatial separation between spring and fall runs was maintained in both Mill and Deer Creeks in 2006.

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 spring-run Chinook salmon (SRCS) abundance. Seventy spring-run Chinook were counted in August 2006. A temporary picket weir was installed at Reading Bar to spatially separate SRCS from fall-run Chinook salmon (FRCS) spawners.

Fall Run

Ten weekly FRCS spawner surveys of lower Clear Creek were made during 9 October 2006 through 11 December 2006 in the 6.7 km (4.2 mi) reach downstream of the former McCormick-Saeltzer Dam site. 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.

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 8,422 fish** (Table 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 contact:

The Office of Human Resources
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Table 1. FRCS carcass mark-and-recovery data used to estimate the 2006 spawner population in Clear Creek from the former McCormick-Saeltzer Dam site to 6.4 km downstream, using the modified Schaefer equation.

Recovery Period (j)	Number of marked carcasses recovered from marking period (i):									Total Marked Carcasses recovered (Rj)	Total Carcasses observed (Cj) ¹	Population Estimate (N) ²
	1	2	3	4	5	6	7	8	9			
16 Oct	5									5	264	856
23 Oct	2	32								34	573	1,293
30 Oct	2	31	66							99	1,174	1,494
6 Nov	1	2	12	132						147	1,172	1,688
13 Nov			3	19	83					105	897	1,424
20 Nov				5	24	55				84	653	799
27 Nov				3	5	9	54			71	447	488
4 Dec				1		8	11	67		87	282	258
11 Dec					1	3	12	10	19	45	128	122
Recovery R(i)	10	65	81	160	113	75	77	77	19			
Marked M(i)	26	98	147	242	197	135	113	118	66			
										Total Estimate		8,422

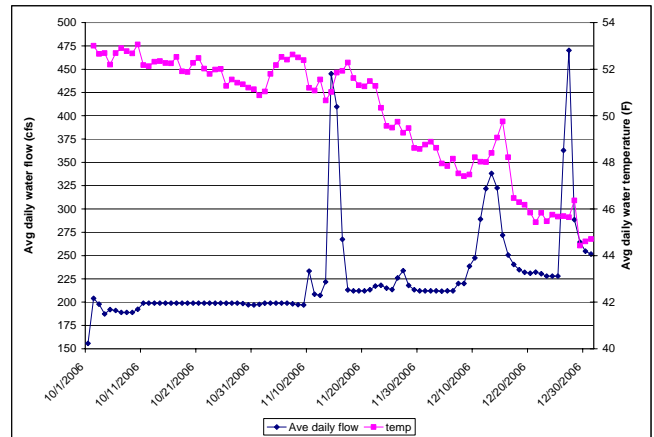
¹ Includes salmon carcasses which were marked and marked carcasses that were recovered

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 4,923 carcasses, the FRCS spawner population in Clear Creek consisted of 37% male adults (fork length [FL] \geq 61 cm [24 in]), 65% female adults and 2% grilse (FL < 61 cm). The seasonal average of pre-spawning mortality of female salmon in Clear Creek was < 1%.

Carcass recovery conditions in Clear Creek remained stable in 2006. Recapture rates of marked carcasses ranged from 29% to 68% with a seasonal average of 59%. During the surveys the average daily flows ranged between 182 cfs and 445 cfs. A peak flow of 758 the week of October 6 did not reduce tag recovery efficiency, (Figure 1).

Figure 1. Average daily flow and temperature in Clear Creek during FRCS spawning in 2006.



Thirteen coded-wire-tags (CWT's), representing 4 tag codes, were recovered during the surveys. All CWT recoveries in Clear Creek originated from Feather River Hatchery (FRH) and Merced River Fish Facility (MRFF) releases, (Appendix, Table 2).

Physical Habitat Conditions

Average daily water flow and temperatures in lower Clear Creek are recorded real-time at the United States Geological Survey's (USGS), IGO stage (www.cdec.water.ca.gov). October flows averaged 197 cfs, and for the duration of fall spawning ranged between 156 cfs and 470 cfs, (Figure 1). Average daily water temperatures within fall-run Chinook spawning habitat ranged from 53.1 °F in early October to 47.4 °F in early December (Figure 1). These temperatures 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 with this flow and temperature regime. (Clear Creek temperatures for water year 2006-2007 are preliminary and have not been finalized.)

Population Trends

Clear Creek FRCS counts have been sporadically recorded since 1947, (Appendix, Table 1). 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 9,000 FRCS.

Antelope Creek

Spring Run

On July 25, 2006, Antelope Creek, Tehama County, was snorkel surveyed to count holding adult SRCS. **A total of 102 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 2 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 2. 2006 SRCS holding and spawning distribution in Antelope Creek in 2006.

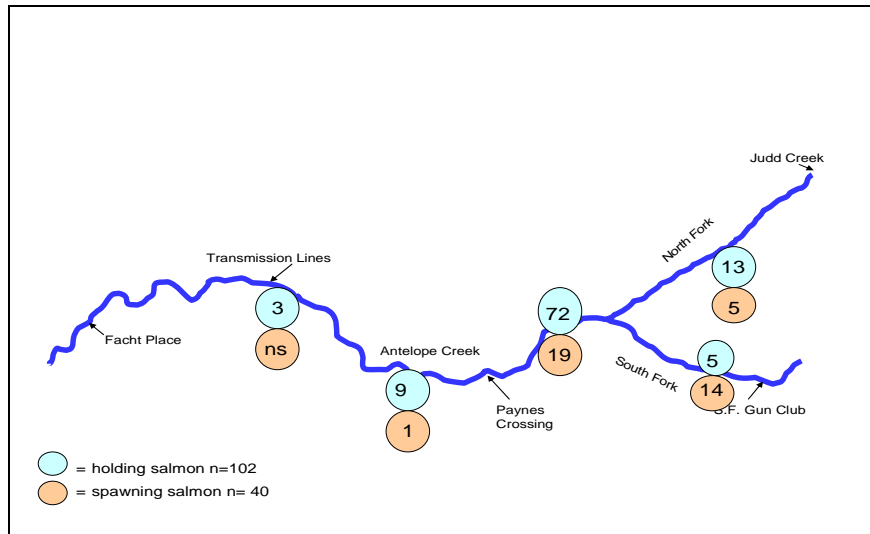


Table 2. Adult SRCS holding and redd counts in Antelope Creek in 2006.

Section	Holding Salmon		Spawning Salmon	
	# of salmon	% of total	# of redds	% of total
North Fork	13	13	5	13
South Fork	5	5	14	36
Main Stem to Paynes	72	70	19	48
Paynes to Canyon Mouth	9	9	1	3
Canyon Mouth to Facht Place	3	3	ns ¹	
Totals	102	100%	40	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. These same holding pools were snorkeled in 2006, but no salmon were observed. Initially, the reach upstream of Judd Creek to the Middle Fork was scheduled to be added to the annual survey for the first time in 2006, but Lassen National Forest (LNF) law enforcement personnel advised against this, due to a marijuana surveillance investigation. This reach should be included in future years when salmon are observed holding near Judd Creek.

Spawning Distribution

One spawning survey was completed over the period 28-29 September covering the same reaches as the holding survey, except the north fork upstream of Judd creek and the main stem downstream of canyon mouth was omitted. A total of 40 redds, 16 carcasses and 40 live salmon was observed, (Figure 2 and Table 2). Spawning may not have been completed as evidenced by the number of live fish observed. (Ideally this survey would occur the first or second week in October, but scheduling conflicts prohibit this.)

Although fall-run Chinook monitoring currently does not occur on Antelope Creek, on 8 November three Chinook were observed attempting to ascend the road crossing at Paynes

Place (Fischer) campground. The following week 10 salmon were observed in the pool below this road crossing. On November 20th, a FRCS spawning survey was made between the north and south fork confluences downstream to Paynes crossing. Four fresh redds and one fresh carcass was observed. It is not known whether fall-run Chinook ascended past the confluences. In 2006, there appears to have been temporal isolation but limited spatial isolation between the spring and fall runs of Chinook in Antelope Creek. The Department is currently looking at alternatives to improve fish passage at the Paynes Place road crossing. Since the majority of SRCS habitat and cold water refugia is upstream of this crossing, providing a long-term solution for fish passage will be critical in maintaining access to viable spring-run habitat in Antelope Creek.

Physical Habitat Conditions

In 2005, there were concerns that water temperatures in spring Chinook holding areas may have limited adult survival. Consequently, in the spring of 2006, additional water temperature monitors were deployed and instream flows were measured in each of the forks and the main stem.

Water flows in Antelope Creek were measured weekly from 17 May thru 26 September, 2006 using a Marsh McBirney FlowMate Model 2000 flow meter. Monitoring stations were set up on the main stem at Paynes Crossing, and on the north and south forks, near each forks confluence with the main stem. Flows in the main stem ranged from a maximum of 372 cubic feet per second (cfs) in early May to a minimum of 43 cfs by late September. Eighty-two percent of holding SRCS and 51% of spawning SRCS occurred in the main stem (Figure 3 and Table 2). Flows in the south fork ranged from 204 cfs to 25 cfs during this time period. Five percent of holding SRCS and 36% of spawning SRCS occurred in the south fork. The north fork had the lowest flows, ranging from 164 cfs to 19 cfs. Thirteen percent of SRCS held and spawned in the north fork.

Table 3 shows the number of days at select Antelope Creek elevations, where water temperatures exceeded levels for normal egg development and adult survival. Salmon holding in the north fork were observed holding in areas where water temperatures should not have reduced egg or adult survival. In the south fork, water temperatures exceeded egg viability thresholds on 3 days, but didn't exceeded adult mortality thresholds. On the main stem 70% of SRCS were holding in areas where the water temperature exceeded optimum levels for egg survival on 13 days, but remained below adult mortality levels. The only location where water temperatures may have caused pre-spawn mortality in adult salmon was below canyon mouth, where 3 salmon were observed during the late July holding survey. Figure 4 shows the average daily water temperatures at select elevations in SRCS habitat in Antelope Creek. A total of 40 SRCS redds were counted and 102 SRCS were observed over-summering in Antelope Creek, which represents a redd to fish ratio of 1: 2.5. In 2005, with warmer temperatures and lower flows, the redd to fish ratio was 1:3.7 which suggests lower survival of adult fish.

Figure 3. Weekly flow in Antelope Creek SRCS holding and spawning habitat in 2006.

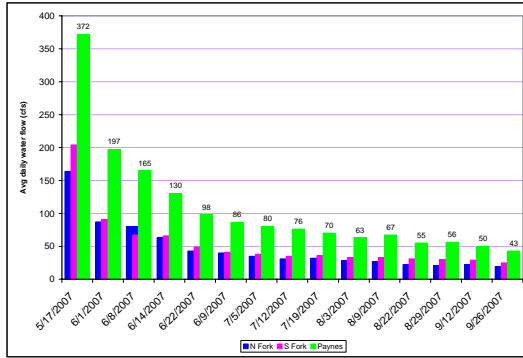


Figure 4. Average daily water temperature in Antelope Creek SRCS habitat in 2006.

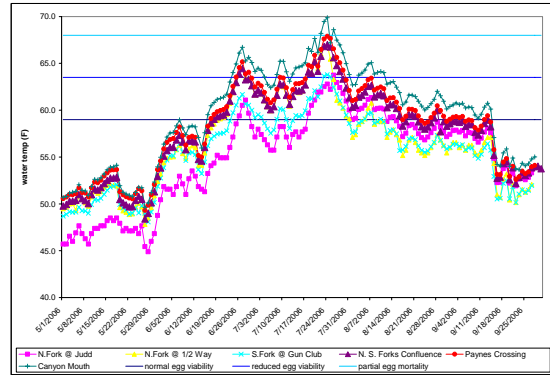


Table 3. Temperature exceedence in Antelope Creek SRCS Habitat in 2007.

Location	Elevation (ft)	Number of Days Mean Daily Temperature Exceeds:		
		≥59.0°F normal egg viability	≥63.5°F reduced egg viability	≥68.0°F partial mortality
North Fork @ Judd Ck	1870	31	1	0
North Fork @ 1/2 Way	1600	45	10	0
South Fork @ Gun Club	1600	35	3	0
N and S Confluence	1400	65	13	0
Paynes Crossing	1300	78	18	0
Canyon Mouth	1120	91	43	4

Population Trends

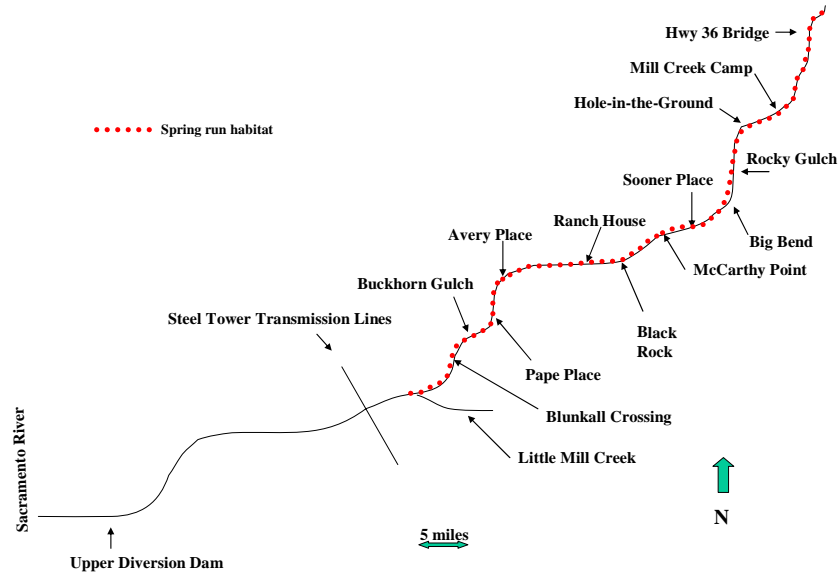
For the past 18 years the Department has been monitoring the SRCS population in Antelope Creek using snorkel observation techniques. The 2006 count of 102 is the second highest number observed since snorkel counts began in 1989. During this period, counts have ranged from 0 to 154 salmon (Appendix, Table 1). 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 6th and 13th October SRCS spawning redds in Mill Creek were counted to estimate the spawning population. Based on these redd counts, **an estimated 1,002 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 5.).

Figure 5. 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 used to enumerate redds from the air. A ground to aerial-to-ground survey ratio is determined by comparing combined air and ground surveys to air only surveys.

A total of 167 live salmon, 44 carcasses and 501 redds was observed (Table 4). 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:

$$501 \text{ redds} \times 1 \text{ female/redd} \times 2 = 1,002 \text{ salmon}^2$$

² Ratio's of redds to holding SRCS in Deer Creek from 1997 to 2006 have ranged from 1.1 to 2.5 with a 10-year average of 2.0. For Mill Creek estimates from 1997 thru current, multiplier of 2 has been used.

Table 4. Spawning distribution of Mill Creek SRCS in 2006.

Survey Reach	# of Redds Counted	% of Total
Above Hwy 36	19	4
Hwy 36 to Little Hole-in-Ground	28	6
Little Hole-in-Ground to Hole-in-Ground	18	3
Hole-in-Ground to Ishi Trailhead	28	6
Ishi Trailhead to Big Bend	21	4
Big Bend to Canyon Camp	21	4
No survey from Canyon Camp to Sooner		
Sooner Place to McCarthy	72	14
McCarthy to Savercool	80	16
Savercool to Black Rock	25	5
Black Rock to Ranch House	46	9
Ranch House to Avery	38	8
Avery to Pape	34	7
Pape to Buckhorn	37	7
Buckhorn to Transmission Lines ¹	34	7
Total Redds	501	100
Population Estimate (redds x 2)	1,002	

¹ Helicopter Survey

Population Trends

Counts of SRCS in Mill Creek were first recorded in the late 1940's using a trapping and counting station at a diversion dam fish ladder. Up to 3,500 adult SRCS were counted annually. An average of 2,000 SRCS was counted during the 12 years of trap operation, (Appendix, Table 1). Ladder counts were again used from 1984 until 1996 with an average of 350 SRCS counted annually. Since 1997, redd counts have been used to estimate the spawning population. The average spawning population during these last 10 years has been 900 fish.

In 2006, the United States Fish and Wildlife Service funded a pilot study to evaluate two different acoustic technologies to estimate SRCS escapement in Mill Creek. Since the removal of Clough dam and the original counting station, various alternate methods of assessing real-time adult escapement into Mill Creek have been explored. Local stakeholders and biologists were concerned about technologies that might cause harassment or delay to adult salmon, such as a trapping station or passage weir, and the inherent turbidity from spring run-off in most years precludes direct observation. Consequently, a biosonics split-beam system and dual frequency identification sonar (DIDSON) system were evaluated in Mill Creek in the spring of 2006 (Johnson, et al, 2006). These technologies do not delay migration or require handling of fish. The DIDSON counts totaled 1,447 fish from 8 March through 23 June whereas split-beam counts totaled 458 from 5 May through 15 July. Results from this pilot study demonstrate that acoustic technologies, especially DIDSON, may potentially be useful in determining run timing and salmon escapement in creeks with high spring run-off and turbidity.

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 $\leq 65^\circ\text{F}$ (Boles, 1988). (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

Conditions for upstream migration of SRCS in 2006 were optimal. Average daily pre-diversion water temperatures remained below the 65°F threshold thru 8 July and post-diversion water temperatures thru the 22 June. Post-diversion water flow remained above 350 cfs thru June. Figure 6 shows average daily water flow and temperature at both pre- and post water diversion points in Mill Creek for the April thru June migration period.

Water temperature recorders placed in SRCS holding and spawning areas are used to document temperature regimes wild salmon are subjected to, and to document thermal conditions used by holding 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 7 shows the average daily water temperatures within the SRCS holding habitat in Mill, and Table 5 shows the number of days at each elevation that water temperatures exceeded upper tolerance limits for normal egg development and adult survival. The highest water temperatures that may have reduced egg viability occurred between the Rancheria Creek and Little Mill monitoring stations. Twenty-one percent of the SRCS population spawned in this reach.

Figure 6. Average daily water flow and temperature during adult SRCS migration into Mill Creek in 2006.

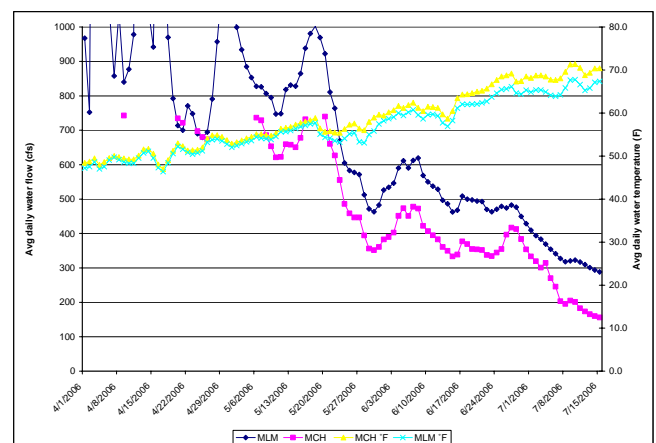


Figure 7. Average daily flow and water temperature during SRCS holding and spawning in Mill Creek.

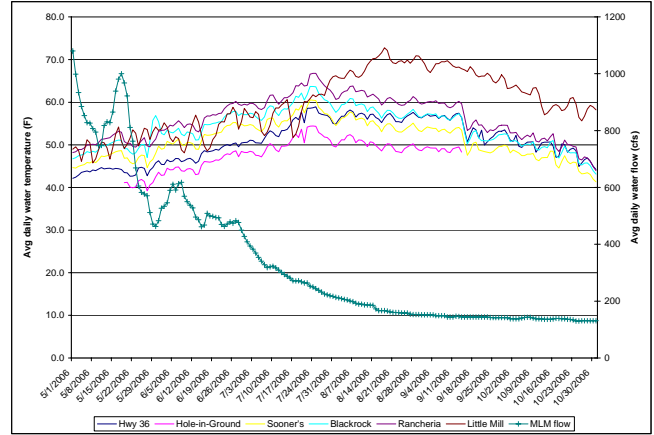


Table 5. Temperature Exceedence in Mill Creek SRCS habitat in 2006.

Location	Elevation (ft)	Number of Days Mean Daily Temperature Exceeds:		
		≥59.0°F normal egg viability	≥63.5°F reduced egg viability	≥68.0°F partial mortality
To Brokenshire	4800	0	0	0
To Hole-in-Ground	4200	0	0	0
To Sooner Place	2800	5	0	0
To Black Rock	2100	26	3	0
To Rancheria Trail	1600	77	13	0
To Little Mill	1000	91	45	5

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 counts by direct observation impractical. The most consistent data available is a trapping station at the Clough dam that operated from 1954 thru 1963. During this 10 year period, SRCS counts ranged from 1,203 to 3,485 (Appendix, Table 1). Since the removal of Clough dam in 1997, redd counts have been used to estimate returning SRCS. In these 10 years, estimates of SRCS have ranged from 202 to 1,594, and have been above 998 salmon since 2002.

Fall Run

Six weekly spawner surveys were made between 26 October and 7 December covering a 8 mile reach between the canyon mouth (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.

Using fresh carcass mark-and-recovery data with a modified Schaefer model (Hoopaugh, 1978), **the minimum FRCS spawner escapement into Mill Creek was estimated to be 1,403 salmon** (Table 6). Recapture rates of marked carcasses ranged from 41% to 58%

and averaged 51%. No survey periods were missed. Recovery rates were normal even on weeks with poor visibility.

Table 6. FRCS carcass mark-and-recovery data used to estimate the 2006 spawner population in Mill Creek from the canyon mouth downstream 8 miles to the confluence with the Sacramento River, using the modified Schaefer equation.

Recovery Period (j)	Number of marked carcasses recovered from marking period (i):				Total Marked Carcasses recovered (Rj)	Total Carcasses observed (Cj) ¹	Population Estimate (N) ²
	1	2	3	4			
9 Nov	25				25	216	618
6 Nov	11	14			25	158	310
21 Nov	3	4	17		24	122	214
30 Nov	4	5	10	11	30	162	172
7 Dec	2	6	2	4	14	89	89
Recovery R(i)	45	29	29	15			
Marked M(i)	83	62	50	37			
					Total Estimate		1,403

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 45% male adults (FL ≥ 61 cm [24 in]), 51% female adults and 4% grilse (FL < 61 cm), based on an examination of 748 carcasses. Less than 1 % of the female carcasses encountered were pre-spawned mortalities.

Three CWT's representing 3 tag codes were recovered during the carcass surveys. CWT recoveries were from CNFH and Merced River Hatchery releases.

Spawning Distribution

This is the first year that weekly surveys were completed upstream of the upper diversion dam throughout the entire spawning period. Redds were GPS'ed to document spawning distribution. Since each waypoint may represent more than one redd, this data should only be used for purposes of identifying active spawning and relative distribution of spawning locations. Sixty-two percent of fall-run Chinook spawning occurred between the upper diversion dam and the canyon, 31% occurred between Ward dam and the upper dam, and 7% of spawning occurred between the confluence and Ward dam, (Figure 8). One survey was completed from a site called Ten Mile downstream to the canyon mouth, a distance of 3.5 miles. Only 4 redds were observed in this uppermost reach. There is a velocity chute at the canyon entrance which may have been an impediment to FRCS in 2006, therefore restricting spawning to the valley floor, (Figure 9). Due to the above average flows in the fall of 2006, this chute may have aided in maintaining spatial separation between the spring and fall runs.

Figure 8. Spawning distribution of Mill Creek FRCS in 2006. Note: each point may represent multiple redds; GPS coverage may limit accuracy of redd locations.

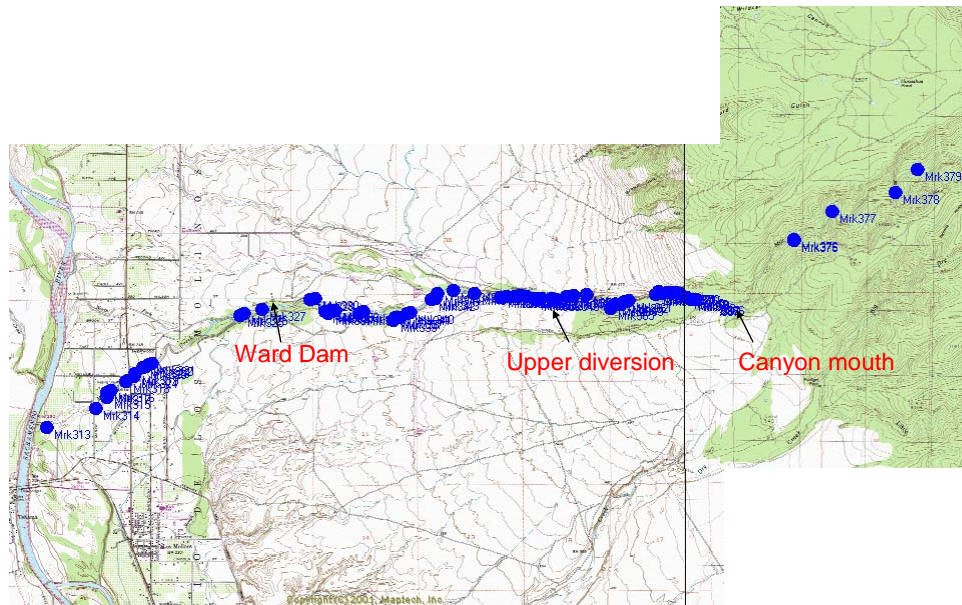


Figure 9. Mill Creek velocity chute at the upper end of FRCS spawning in 2006, (186 cfs on 11/16/2006).

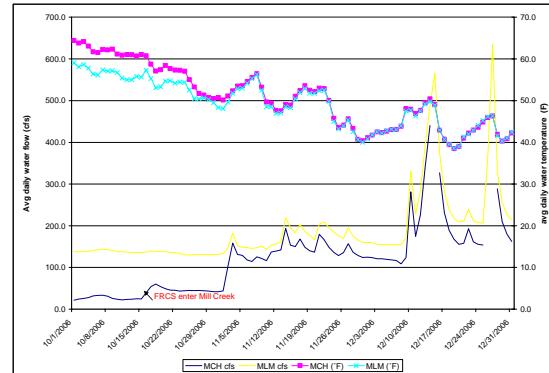


Physical Habitat Conditions

On 16 October Los Molinos Mutual Water Company (LMMWC) bypassed an additional 30 cfs of flow into Mill Creek, increasing the average daily post-diversion flow to 54 cfs. Within 12 hours of this initial ramping-up of flows, salmon were observed ascending the lower (Ward) diversion dam. Attraction flows averaged 46 cfs for the remainder of October, and after 2 November remained above 100 cfs, (Figure 10). Average daily water temperatures remained suitable for successful spawning and egg incubation after

22 October, (Figure 10). (Note: flow and temperature data for water year 2007, starting in October, are preliminary and subject to revision.) There was no evidence of fish stranding or pre-spawning mortalities of FRCS in Mill Creek with this flow and temperature regime.

Figure 10. Average daily water flow and temperature Mill Creek during FRCS spawning in 2006.



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 1). Due to inconsistent methodologies and questionable data accuracy, it's unrealistic to compare population trends between these years. Years 2002 thru 2006 represent the most comprehensive data set, where the known spawning habitat was surveyed during the peak weeks of FRCS spawning. During these past 5 years, populations have ranged from 1,182 to 2,611 salmon, and averaged 2,000 salmon.

Deer Creek

Spring Run

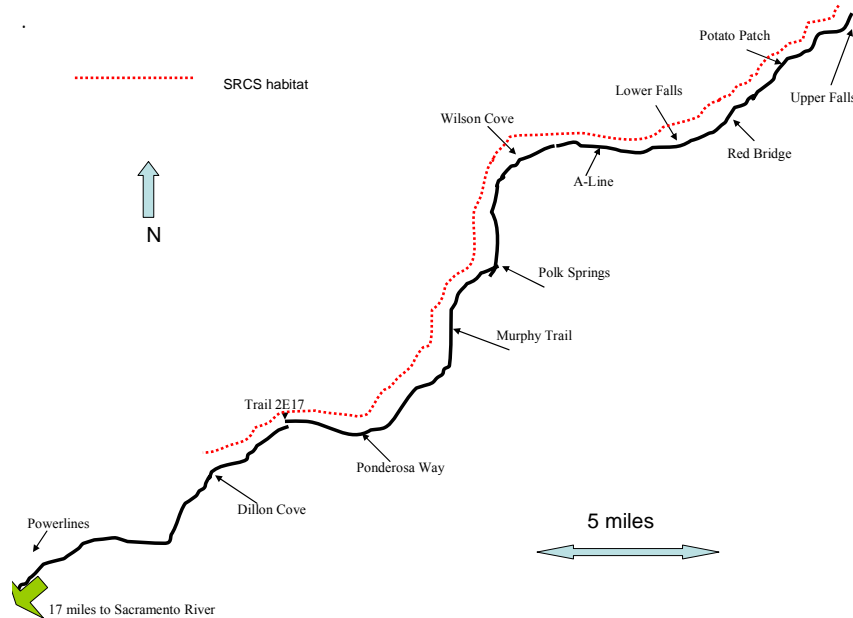
On 8 August, Deer Creek was snorkel surveyed to count holding adult SRCS. **A total of 2,432 SRCS was observed**, Table 7. Twenty-four miles of stream was surveyed from the Upper Deer Creek Falls downstream to within 2 miles of Dillon Cove (Figure 3). This encompasses the known holding habitat of adult SRCS in Deer Creek.

Table 7. Holding and spawning distribution of Deer Creek SRCS in 2006.

Section	Holding Survey		Spawning Survey	
	# of salmon	% of total	# of redds	% of total
Upper Falls to Potato Patch	62	2	11	1
Potato Patch to Hwy 32	15	1	26	2
Hwy 32 to Lower Falls	7	<1	22	2
Lower Falls to A-Line	606	25	127	11
A-Line to Wilson Cove	281	12	351	30
Wilson Cove to Polk Springs	401	16	146	13
Polk Springs to Murphy Trail	456	19	249	22
Murphy Trail to Ponderosa Way	465	19	200	17
Ponderosa Way to Trail 2E17	139 ^{1/}	6	28	2
Trail 2E17 to Dillon Cove	No survey		No survey	
Totals	2,432		1,160	

^{1/} No salmon were observed holding in the lower sections of this reach, therefore it was assumed that no salmon were holding downstream of this point and the survey was terminated at Trail 2E17.

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



Ninety-one percent of the SRCS held between Lower Falls and Ponderosa Way. Normally, up to 28 % of the population holds between the Upper Falls and Lower Falls. In 2006, only 3% of the population held in this reach. Debris and silt accumulation in the lower falls fish ladder, resulting in reduced attraction flow, may have contributed to reduced numbers of adult salmon accessing the upper reaches of Deer Creek. In early August DFG fish habitat crews removed a minor debris accumulation at the entrance to the fish ladder and flushed substrate from the ladder pools. These actions increased water flow thru the weirs creating functional conditions for fish passage. A long-term solution is being explored to increase attraction flow into the fish ladder.

Physical Habitat Conditions

Flow conditions for SRCS migration into Deer Creek in 2006 were optimal and did not appear to limit salmon access into the creek. Average daily post-diversion water flow remained above 95 cfs thru June, (Figure 12). Average daily pre-diversion water temperatures remained below the 65°F threshold until mid-June, and post-diversion water temperatures reached the threshold the first week in June. Water temperatures may have inhibited migration in June if salmon were still actively migrating from the Sacramento River. The range of migration timing of SRCS into Deer Creek has not been documented, although migration is presumed to be earlier than Mill Creek due to earlier snowmelt and run-off.

Base flows within SRCS holding habitat (as measured at the DCV gage), ranged from 1,000 cfs in early May to 130 cfs by the time of spawning, (Figure 13). This is above the average summer base flow of 100 cfs. Water temperatures in Deer Creek are monitored

at six locations at elevations ranging from 1,500 ft to 3,200 ft. Average daily water temperatures below 1,700 ft elevation at Ponderosa Way exceeded values for normal egg viability, (Table 9). Although 28 redds were counted below Ponderosa Way, the spawning success is not known. (The Murphy Trail temperature data is incomplete and prior to mid-August temperatures may have exceeded egg viability limits.) Between 13 and 17 September water temperatures dropped an average of 5°F and remained suitable for late September and October spawning periods.

Figure 12. Average daily water flow and temperature during Deer Creek SRCS migration in 2006,

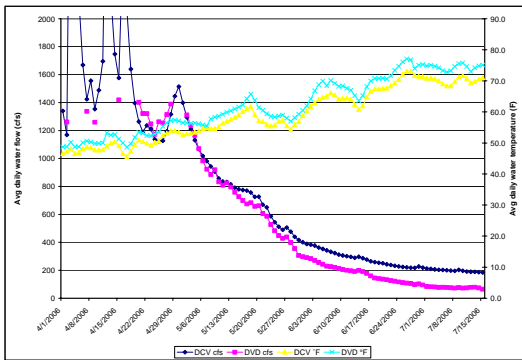


Figure 13. Average daily water flow and temperature during Deer Creek SRCS holding and spawning in 2006

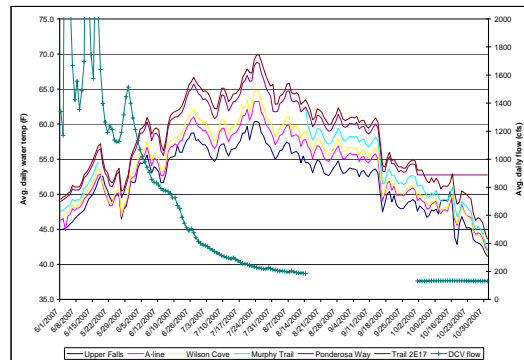


Table 8. Temperature exceedence in Deer Creek SRCS habitat in 2006.

Location	Elevation (ft)	Number of Days Mean Daily Temperature Exceeds:		
		≥59.0°F normal egg viability	≥63.5°F reduced egg viability	≥68.0°F partial mortality
Below Upper Falls	3600	5	0	0
Below A-Line	3000	28	0	0
Below Wilson Cove	2700	43	3	0
Below Murphy Trail	2000	No data		
Below Ponderosa Way	1700	90	28	3
Below Trail 2E17	1500	99	43	4

Fall Run

Seven FRCS spawning surveys were made between 20 October and 8 December encompassing the area between the USGS gage, located upstream of Deer Creek Irrigation District’s upper diversion dam, and the Highway 99 bridge crossing. 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 1,905 salmon**, (Table 9). Recapture rates of marked carcasses ranged from 32% to 75% and averaged 63%.

Table 9. FRCS carcass mark-and-recovery data used to estimate the 2006 spawner escapement in Deer Creek from the USGS gage station downstream to the Highway 99 Bridge, using the modified Schaefer equation.

Recovery Period (j)	Number of marked carcasses recovered from marking period (i):						Total Marked Carcasses recovered (Rj)	Total Carcasses observed (Cj) ¹	Population Estimate (N) ²
	1	2	3	4	5	6			
10-13 Nov	16						16	273	532
17 Nov	6	31					37	194	331
22 Nov	3	8	39				50	260	309
27 Nov	3	5	9	54			71	447	397
1 Dec	1	8	5		39		53	210	261
8 Dec		3	4	4	34	18	63	148	76
Recovery R(i)	29	55	57	58	73	18			
Marked M(i)	45	83	76	79	118	56		Total Estimate	1,905
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.									

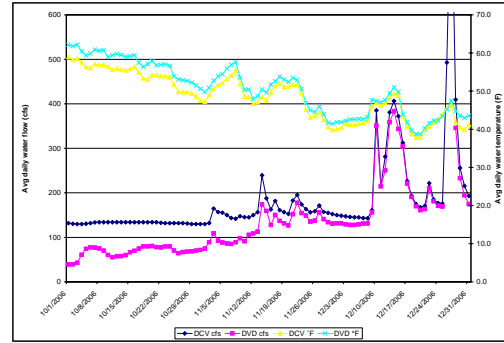
The composition of natural spawners in Deer Creek was 40% male adults (FL \geq 61 cm), 55% female adults, and 5% grilse (FL < 61 cm), based on an examination of 1,275 carcasses. Less than 1% of the female carcasses encountered were pre-spawned mortalities.

One CWT from Feather River Hatchery was recovered in the FRCS survey. No FRCS were observed spawning upstream of DCID's upper diversion dam. Therefore, the weekly spawning surveys encompassed the entire FRCS spawner population on Deer Creek in 2006. SRCS remained spatially isolated from FRCS in Deer Creek this year.

Physical Habitat Conditions

Base flow in Deer Creek was above average during the fall of 2006. Average post-diversion attraction flow in October was 70 cfs. After 11 November, post-diversion flow remained above 100 cfs (Figure 13). Average daily water temperature remained suitable for successful spawning and egg incubation by 17 October. (Note: flow and temperature data for water year 2007, starting in October, are preliminary and subject to revision.) Although it is not known when FRCS first entered Deer Creek in 2006, adult salmon and fresh redds were first observed on 20 October between the upper diversion dam and Highway 99. The week prior to 20 October, average daily post-diversion flows ranged from 58 cfs to 80 cfs. Although minimum attraction and transportation flows for adult salmon in lower Deer Creek have not been determined, this suggests that adult salmon can negotiate critical riffles in lower Deer Creek at these flow levels.

Figure 14. Average daily water flow and temperature during Deer Creek FRCS spawning in 2006.



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. As noted earlier, salmon did not ascend the upper Deer Creek diversion dam in the fall of 2006. Seven percent of spawning occurred between the upper diversion dam and the rotary screw trap site located at the rock quarry. Fifty-three percent of spawning occurred between the rock quarry and Leininger Road Bridge. Forty percent of spawning occurred from the Leininger Road Bridge and Hwy 99 Bridge. Some spawning may have occurred between the 99 bridge and the monastery, but this reach was not surveyed in 2006 (Figure 14).

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Appendices

Appendix Table 1. 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			
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

Year	Fall-run Chinook			Spring-run Chinook		
	Clear	Mill	Deer	Antelope	Mill	Deer
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

Appendix Table 2. Summary of 2006 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
062402	Feather River	San Pablo Bay	03	1		
062794	Feather River	San Pablo Bay	03			1
064580	Merced River	Jersey Point	03	1	1	
0501021514	Coleman	RBDD	03		1	
100000	No CWT found			6	1	
200000	CWT lost			1		
Totals				9	3	1
Carcasses examined for ad-clips				4,913	629	1,242
Fall-run Chinook population estimate				8,422	1,403	1,905