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State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

JUVENILE SPRING-RUN CHINOOK SALMON EMERGENCE, REARING AND OUTMIGRATION PATTERNS IN DEER AND MILL CREEKS, TEHAMA COUNTY, FOR THE 1997 BROOD YEAR

SPORT FISH RESTORATION ANNUAL PROGRESS REPORT

by

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INTRODUCTION

This annual brood year (BY) report investigates to life-history of spring-run chinook salmon, (*Oncorhynchus tshawytscha*), in Mill and Deer creeks for the 1997 BY. This includes monitoring the holding and spawning distribution of adult spring-run chinook returning in 1997, and monitoring the 1997 BY juvenile salmon life-history characteristics of emergence timing, relative growth and timing of outmigration.

Water flow during adult and juvenile spring-run chinook salmon migration times and water temperatures during adult salmon immigration, holding and spawning, and egg development and juvenile salmon rearing were also monitored.

This 97 BY report is the fifth Juvenile Spring-Run Chinook Salmon Emergence, Rearing and Outmigrant Report for Mill and Deer Creeks. This research is funded through the Federal Sport Fish Restoration Act for the purpose of investigating spring-run chinook salmon life-history in Mill and Deer creeks.

Procedures

Adult holding and spawning distribution was documented by surveying the known holding and spawning habitat in each creek. Holding distribution surveys are made by underwater snorkel counts prior to the onset of spawning. Spawning surveys are made near the end of spawning season and carcasses, live salmon and redds are recorded. Tissues were collected from carcasses for genetic analysis. Areas, where a high concentration of spawning is known to occur, are surveyed weekly at the onset of predicted fry emergence to determine relative growth of salmon fry and to predict the occurrence of fry or yearling outmigration.

Spring-run fry in habitat not used by fall-run are monitored weekly for presence or absence of salmon fry. Samples of the fry are made to measure size and condition, and tissue samples are taken for genetic analysis. In the fall and early winter months, traps are fished in the lower section of these streams near their confluence with the Sacramento River to monitor outmigration of salmon on a real-time basis. These data are used in predicting the occurrence of spring-run in the Sacramento-San Joaquin Delta.

1997 Adult Population Counts and Spawning Surveys in Mill and Deer Creeks.

During a flood event in January 1997, Clough Dam on Mill Creek was breeched by flood waters. Clough Dam which was traditionally used to count adult spring-run salmon migrants was destroyed in the flood. With Clough Dam gone and unimpaired adult fish passage in lower Mill Creek, alternative methods of estimating adult spring-run populations were investigated in 1997. Snorkel surveys, redd distribution surveys and carcass counts were made to determine the most feasible method of estimating adult salmon populations that could be duplicated each year in Mill Creek. The area surveyed included the spring-run chinook salmon holding and spawning habitat, extending approximately from the Lassen National Park Boundary, downstream to the confluence of Little Mill Creek (Figure 1). After completing the survey season, snorkel counts and carcass counts were discounted as reliable means of counting adult salmon due to turbidity and the scarcity of carcasses, respectively. Using redd counts, on an estimated 200 adult spring-run spawned in Mill Creek in 1999 (Attachment 1).

In Deer Creek, an total of 466 spring-run salmon were counted in 1997. This count was derived from a snorkel survey of the adult spring-run holding habitat from Upper Deer Creek Falls downstream to Iron Mountain Creek (Figure 2 and Attachment 2). The Lassen National Forest fisheries crew followed-up with a spawning census survey in the fall of 1997 and counted 275 redds. This is the first spring-run spawning distribution survey ever recorded for Deer Creek (Attachment 3).

FIGURE 1. Spring-run chinook salmon survey reaches in Mill Creek.

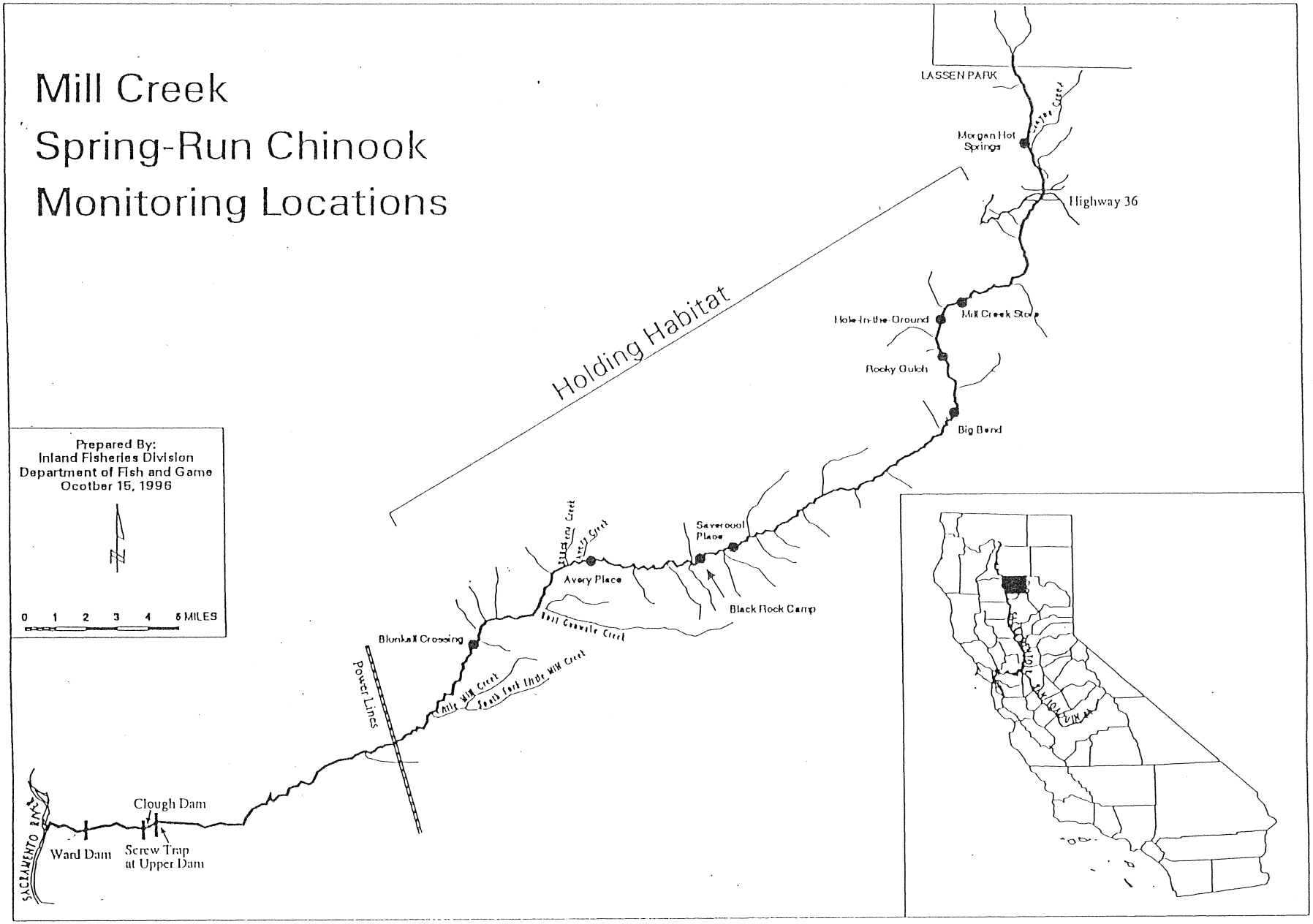
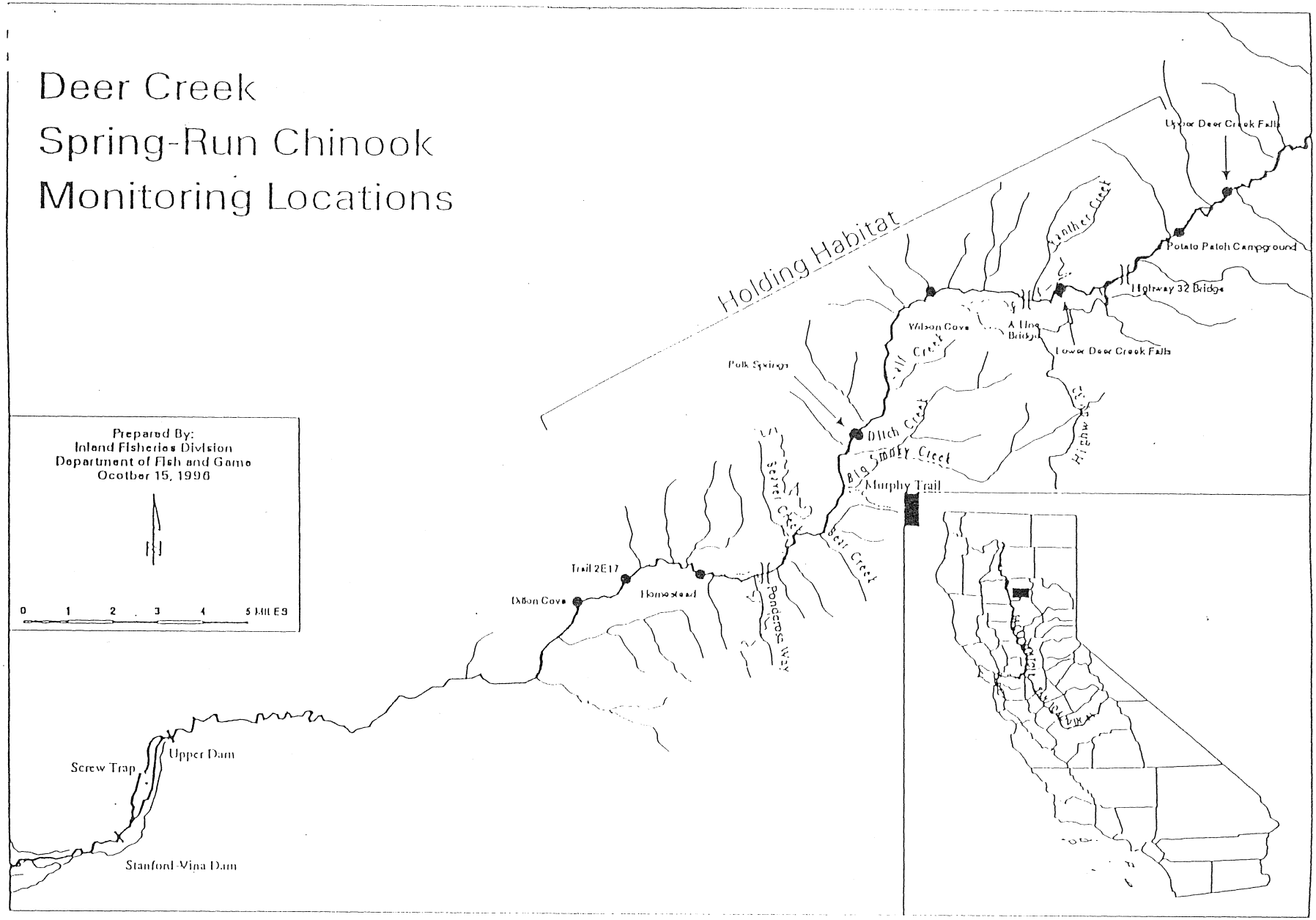


FIGURE 2. Deer Creek spring-run chinook salmon monitoring locations.



Sex and Age Structure of the Population

All 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, the Mill and Deer creeks' data was combined. A total of 97 carcasses were encountered ranging in size from 45 cm FL to 95 cm FL (Figure 3). Trapping records at Red Bluff Diversion Dam indicate a cut-off length between adults and grilse salmon of 61 cm FL. Using this criteria, 19% of the spring-run were grilse and 81% were adults, 3 years old and older . Seventy percent of the carcasses were female and 30% were male. Due to the low sample size and the tendency for male salmon to swim away from the spawning areas before dying, this data set may not reflect the actual age and sex composition of the population. Tissue samples for genetic analysis were collected on fresh carcasses and sent to the Department's Salmon Stock Tissue Collection Project. A total of three tissue samples was collected on Mill Creek and 47 samples on Deer Creek.

Population Trend and Cohort Replacement Rate

For Mill Creek, the estimated 200 adults returning to spawn in 1997, represents a cohort replacement rate (CRR) of 0.3, when compared with the 723 spawners in 1994. Typically a CRR of less than 1.0 means the cohort abundance is decreasing (Table 1). (In calculating CRR's, it must be assumed all spawners return as 3-year old fish, there is a 1:1 sex ratio, and there is no variation in these factors between BY's.) Indeed, a population of 200 spring-run represents a significant decline from counts of 3,500 fish in the 1940's. In the 1990's, counts have ranged from a low of 61 in 1993 to a high of 844 in 1990 (Figure 4).

For Deer Creek, the count of 466 adult spring-run in 1997 represents a CRR of 1.0, when compared with 485 adults counted in 1994. A CRR of 1.0 represents a population that is self-sustaining in a constant environment. The adult population returning from the 1994 BY in 1997, replaced itself but the cohort abundance did not increase (Table 2). A returning population of less than 500 adult spring-run represents a significant decline from counts of up to 4,000 salmon in the 1940's. More recently in the 1990's, counts have ranged from a low of 209 salmon in 1992 to a high of 1,295 salmon in 1995 (Figure 5).

Conditions for Adult Spring-Run Chinook Salmon Migration

In order to assess whether adequate water flows and water temperatures are available in Mill and Deer creeks for adult salmon migrants upstream and downstream of water diversion points, real-time monitoring of these conditions is necessary from March through early July.

FIGURE 3. Length frequency distribution of spring-run chinook salmon carcasses in Mill and Deer Creeks, 1997.

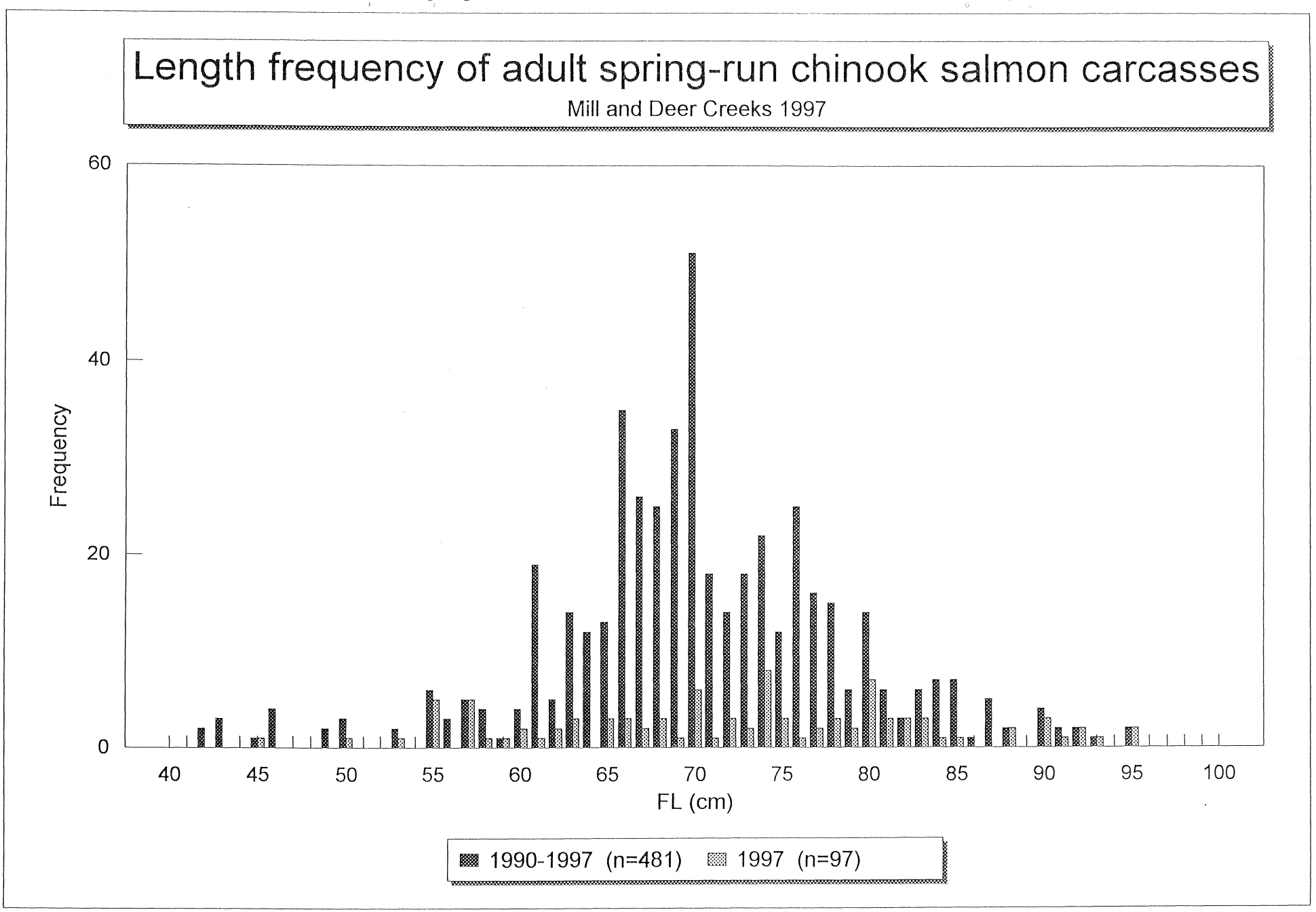


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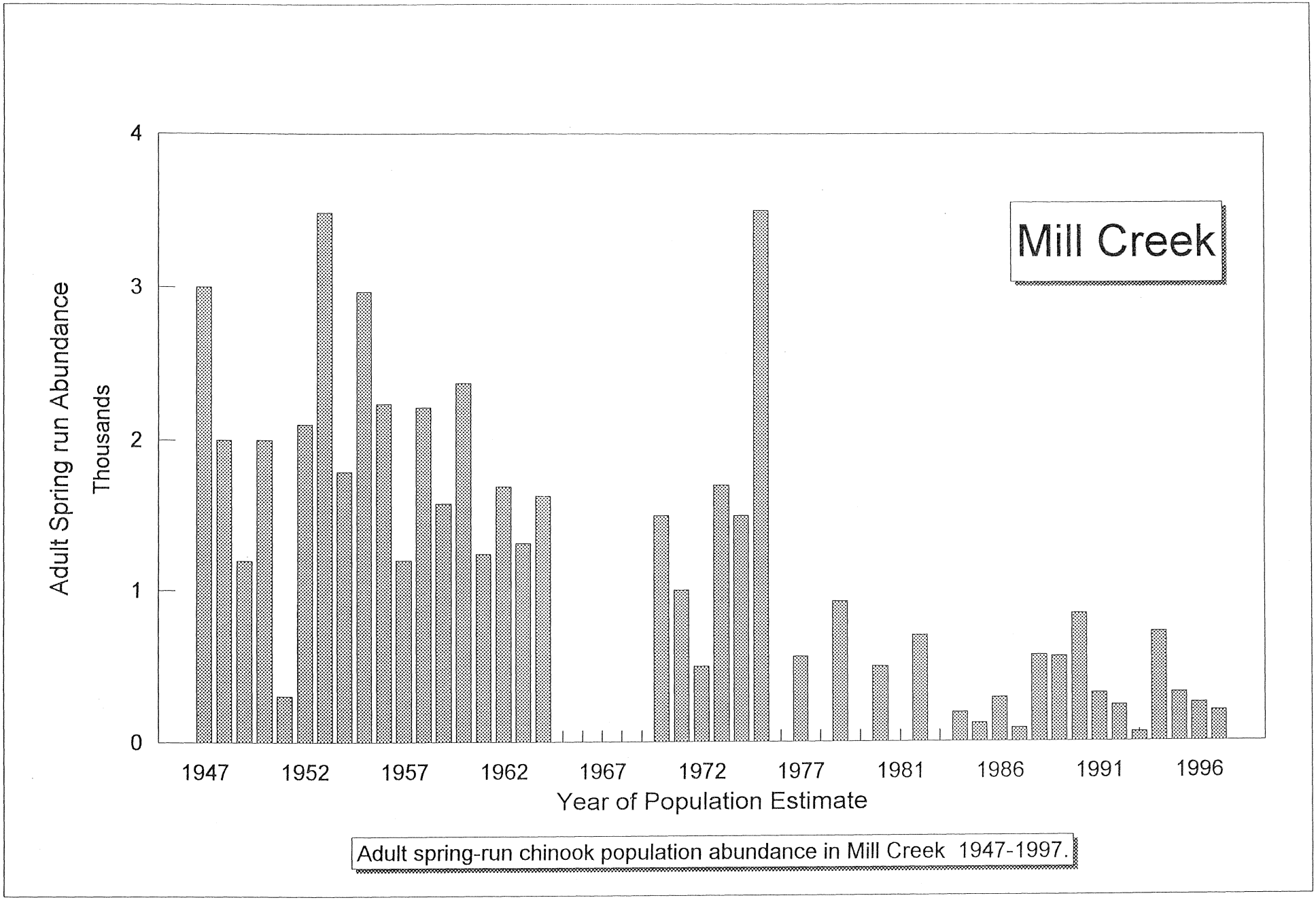
TABLE 1. Mill Creek spring-run chinook salmon cohort replacement rate.

Cohort	Brood Year	Cohort Replacement Rate
1	1957	1203 ÷ 1789 = 0.7
2	1958	2212 ÷ 2967 = 0.7
3	1959	1580 ÷ 2233 = 0.7
1	1960	2368 ÷ 1203 = 2.0
2	1961	1245 ÷ 2212 = 0.6
3	1962	1692 ÷ 1580 = 1.1
1	1963	1315 ÷ 2368 = 0.6
2	1964	1628 ÷ 1245 = 1.3
3	1990	844 ÷ 89 = 9.5
1	1991	319 ÷ 572 = 0.6
2	1992	237 ÷ 563 = 0.4
3	1993	61 ÷ 844 = 0.1
1	1994	723 ÷ 319 = 2.3
2	1995	320 ÷ 237 = 1.4
3	1996	252 ÷ 61 = 4.1

Source: DFG, 1998.

FIGURE 4. Adult spring-run chinook salmon population abundance in Mill Creek.



Adult spring-run chinook population abundance in Mill Creek 1947-1997.

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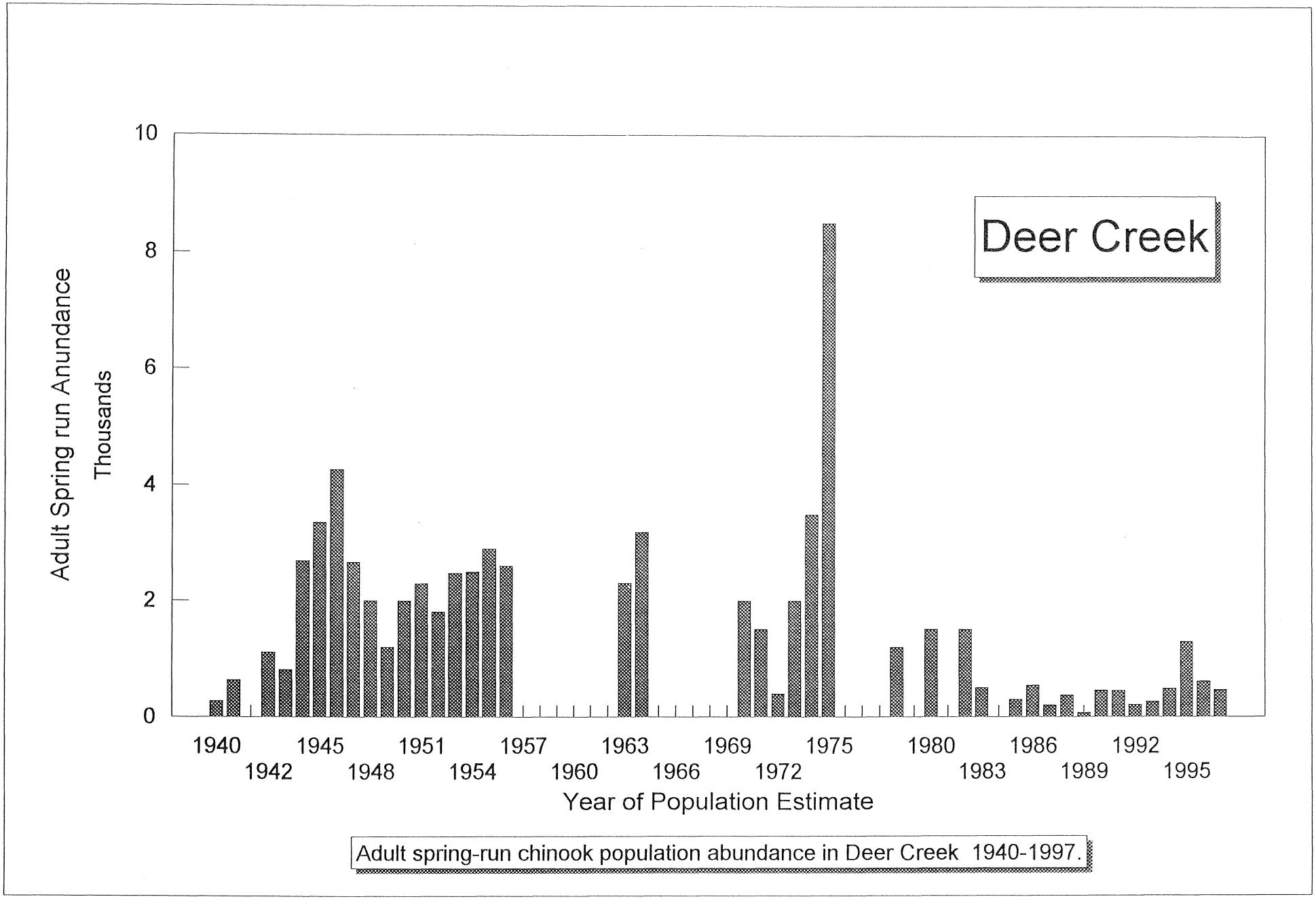
TABLE 2. Deer Creek chinook salmon cohort replacement rate.

Cohort	Brood Year	Cohort Replacement Rate
1	1990	458 ÷ 200 = 2.3
2	1991	448 ÷ 371 = 1.2
3	1992	209 ÷ 77 = 2.7
1	1993	259 ÷ 458 = 0.6
2	1994	485 ÷ 448 = 1.1
3	1995	1295 ÷ 209 = 6.2
1	1996	614 ÷ 259 = 2.4
2	1997	466 ÷ 485 = 1.0

Source: DFG, 1998

FIGURE 5. Adult spring-run chinook salmon population abundance in Deer Creek.



Adult spring-run chinook population abundance in Deer Creek 1940-1997.

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In Mill Creek, hourly flow readings were recorded at the United States Geological Survey (USGS) gauge located upstream of the Upper Diversion Dam. Water temperatures were recorded near the USGS gauge and near the mouth of Mill Creek (Figure 6). Since the flow readings were recorded upstream of all water diversion points, no conclusions can be made concerning attraction flows for migrating adult salmon. (In January 1999, a flow gauge will be installed downstream from the lower most point of diversion.) In the absence of flow records at the mouth of Mill Creek, it is unknown if flow was a limiting factor in allowing adult passage to upstream holding habitat.

The preferred temperature range for spring-run salmon upstream migration is considered to be 38° F to 56° F (Bell,1991 in DFG, 1998). During the peak periods of salmon migration (approximately May 15-June 10), average daily water temperatures at the mouth of Mill Creek ranged from a minimum of 60.3° F to a maximum of 68.7° F. Water temperatures upstream of diversion points averaged up to 66° F during the peak migration periods. It is not known, at this time, what effect these water temperatures may have had on immigrating adult salmon. Although, if one assumes water temperature upstream of diversion points have not significantly changed since the 1940's when 3,000-4,000 spring-run chinook salmon were returning to Mill Creek, then temperatures warmer than the preferred high of 38°F to 56°F may be thermally tolerable for short periods of migration.

In Deer Creek, hourly flow readings were recorded at the USGS gauge located upstream of the Deer Creek Irrigation District Dam. Again since the flow readings were recorded upstream of the upper most diversion point, no conclusions can be made concerning attraction flows for migrating adult salmon. (In October 1997, a flow gauge will be installed downstream from the lower most point of diversion.) In the absence of low records at the mouth of Deer Creek, it is unknown if flow was a limiting factor in allowing adult passage to upstream holding habitat.

Water temperatures were recorded at the Deer Creek Irrigation District Dam, the Highway 99 Bridge and at the mouth of Deer Creek (Figure 7). During the peak periods of salmon migration (approximately May 15-June 10), average daily water temperatures at Highway 99 Bridge ranged from a minimum of 66° F to a maximum of 73.5° F. Water temperatures upstream of diversion points averaged up to 69° F during this peak migration period. It is unknown what effect temperature above the preferred range may have had on migrating adult salmon. Although, as in Mill Creek, if salmon were historically migrating into Deer Creek with similar temperatures conditions, then salmon may be tolerant to warmer temperatures for brief migration periods.

FIGURE 6. Water temperatures and flows in Mill Creek during adult spring-run chinook salmon migration.

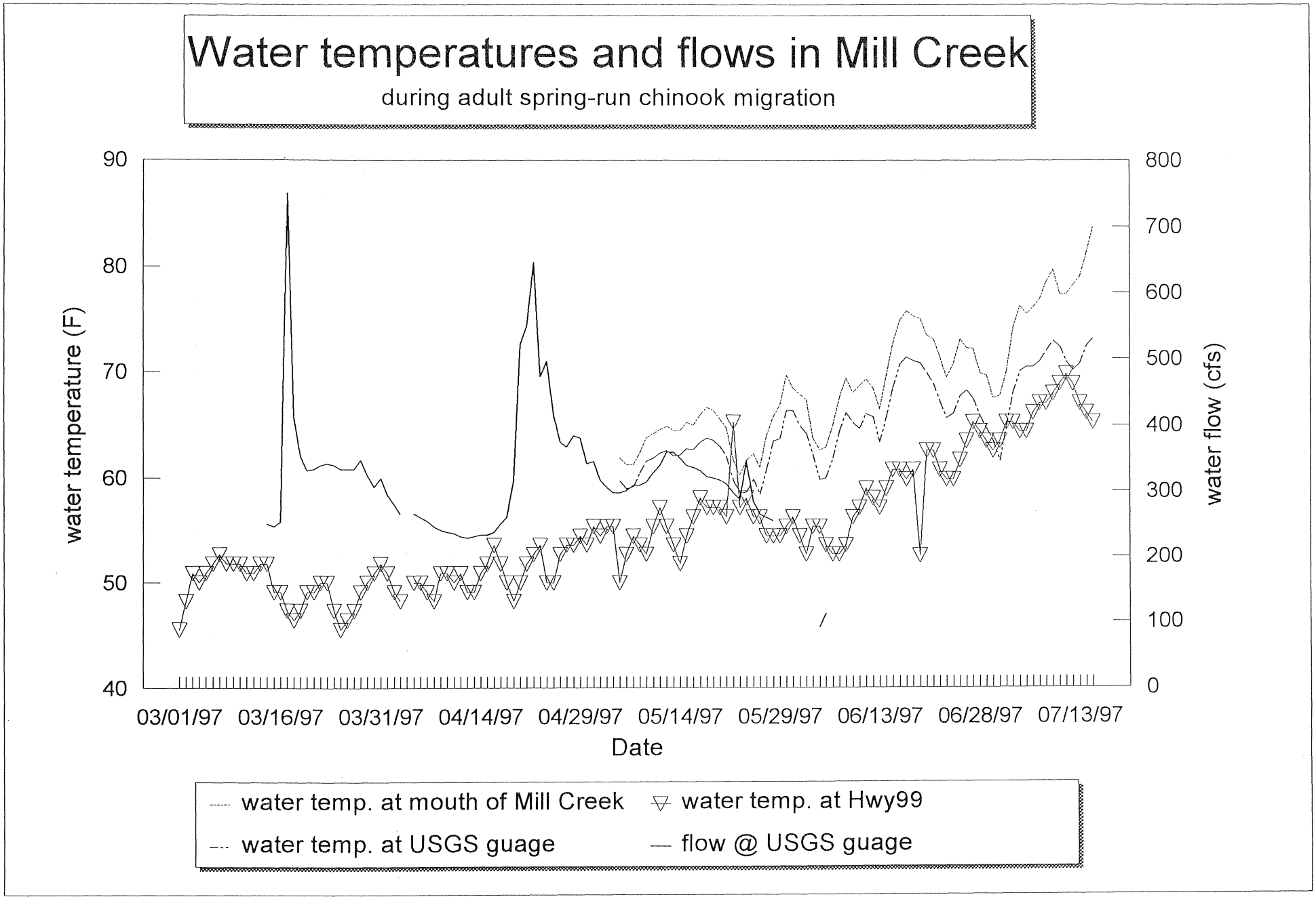

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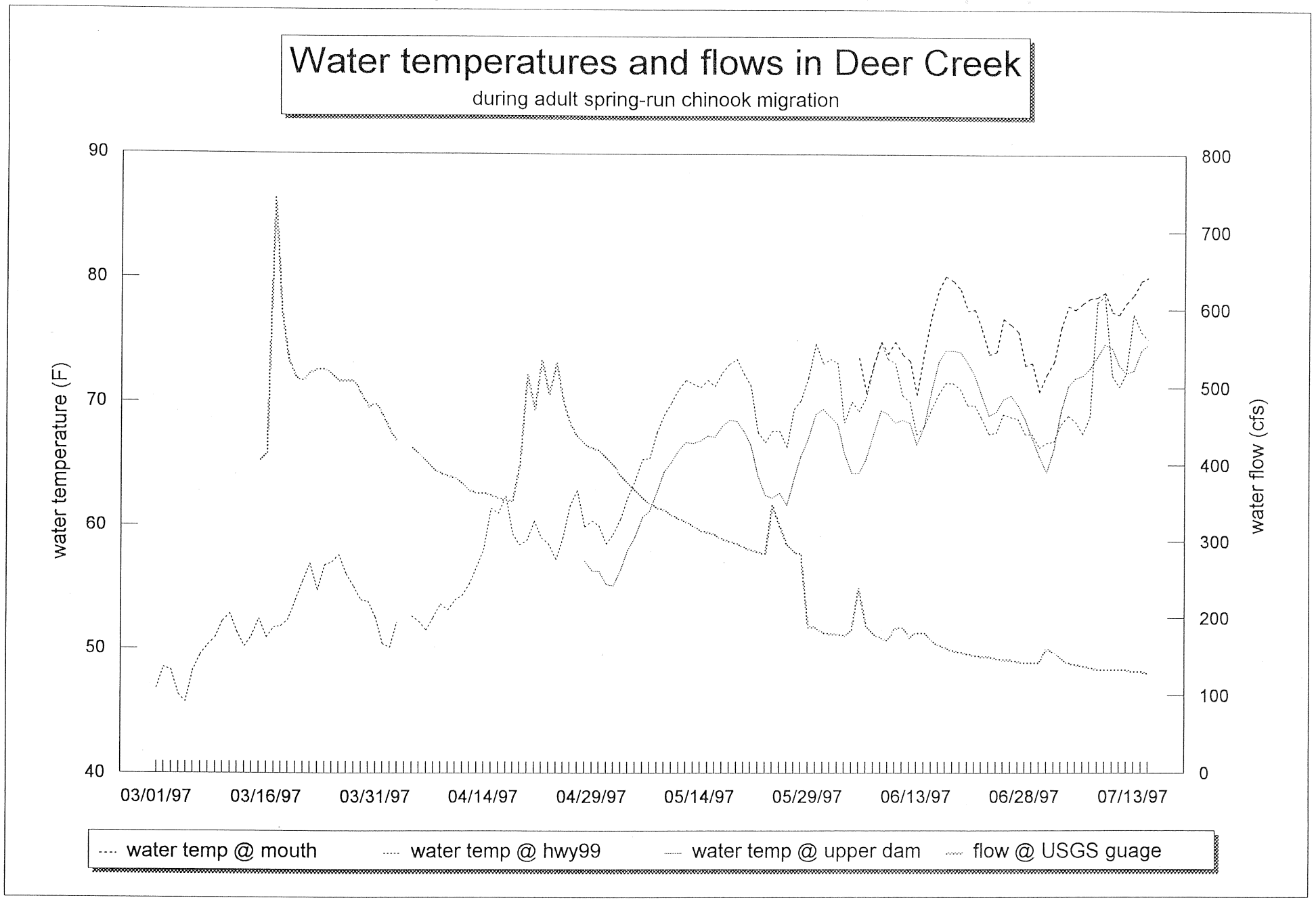
FIGURE 7. Water temperatures and flows in Deer Creek during adult spring-run chinook salmon migration.



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Conditions for Holding and Spawning

Immature adult spring-run chinook salmon hold in the headwaters of Mill and Deer creeks from the time of spring migration until the onset of fall spawning - approximately May through September. In Mill Creek, salmon hold and spawn from approximately the Lassen National Park boundary downstream to the Little Mill Creek confluence (Figure 1). In Deer Creek, adult spring-run chinook salmon hold and spawn from the Upper Deer Creek Falls downstream to below Dillon Cove (Figure 2). Temperature records in the holding and spawning habitat in each creek are presented here for the purpose of documenting the real-time temperatures that spring-run are holding and spawning in. The recorded upper limit of the optimal water temperature range for adults holding while eggs are maturing is 59°F to 60°F (Hinz, 1959 in DFG, 1998). Sustained water temperatures above 80.6°F are lethal for holding adult salmon (Cramer and Hammack, 1952 in DFG, 1998). The upper temperature tolerance for spawning adult salmon without destroying egg viability is 57°F (Reiser and Bjorn, 1979 in DFG, 1998). With these temperature limits in mind, Figures 8 and 9 give the water temperatures during adult holding periods in Mill and Deer creeks, respectively. Figures 10 and 11 give the water temperatures during spawning periods in Mill and Creek creeks, respectively.

This year spawning survey efforts were redirected to document the distribution of spawning redds within each creek, therefore, weekly surveys of indexed areas to determine the onset, peak and termination of spawning were not made.

Egg Incubation, Hatching and Fry Emergence

Beginning in 1997, all water quality data for Mill and Deer creeks (including monitoring water temperatures) are being collected by the Department of Water Resources, Northern District. These daily water temperature records are used not only to document adult migrating, holding and spawning temperatures, but also to estimate the length of time it will take from spawning for the eggs to hatch and fry to emerge from the gravels.

In Mill Creek, water temperature records from Hole-in-the-Ground, Black Rock and below the Little Mill Creek confluence were used for emergence timing studies. In Deer Creek, water temperature records from A-line Bridge crossing, Ponderosa Way, and Apperson Cow Camp were used to estimate the time of emergence.

To calculate an estimated time of fry emergence, daily temperature units (DTU) were calculated from the water temperature records on each creek. A DTU is defined as the average daily water temperature (in Fahrenheit) minus 32. From the time of egg fertilization, a cumulative total of 1,550 DTU's is required for the egg to hatch and the fry to emerge (Armor, 1991 in DFG, 1998). Based on these criteria, the calculated earliest emergence in Mill Creek at Black Rock was 24 February 1998 (Table 3); and near the Little Mill Creek confluence 23

FIGURE 8. Water temperatures in Mill Creek during adult spring-run chinook salmon holding periods.

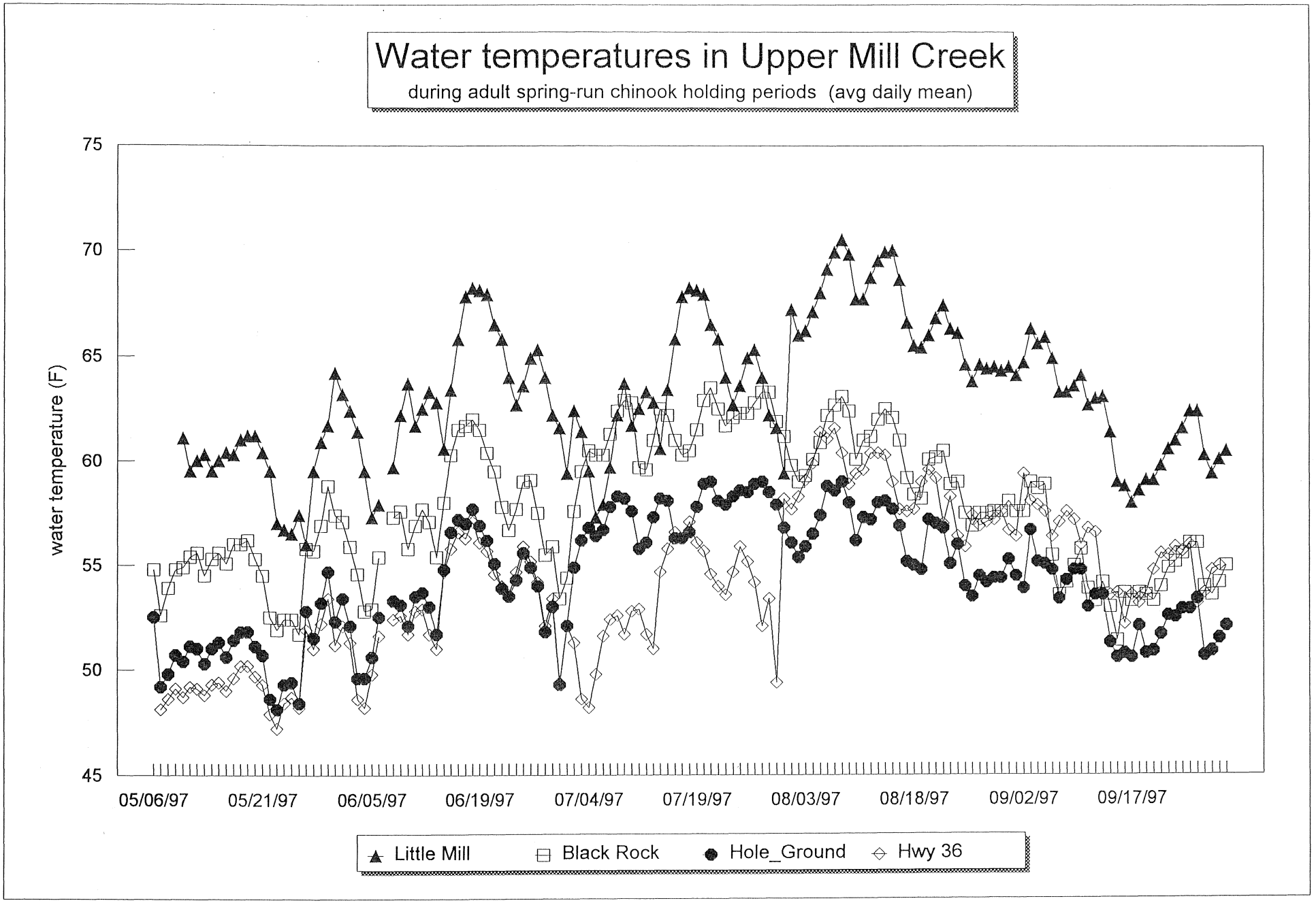

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FIGURE 9. Water temperatures in Deer Creek during adult spring-run chinook salmon holding periods.

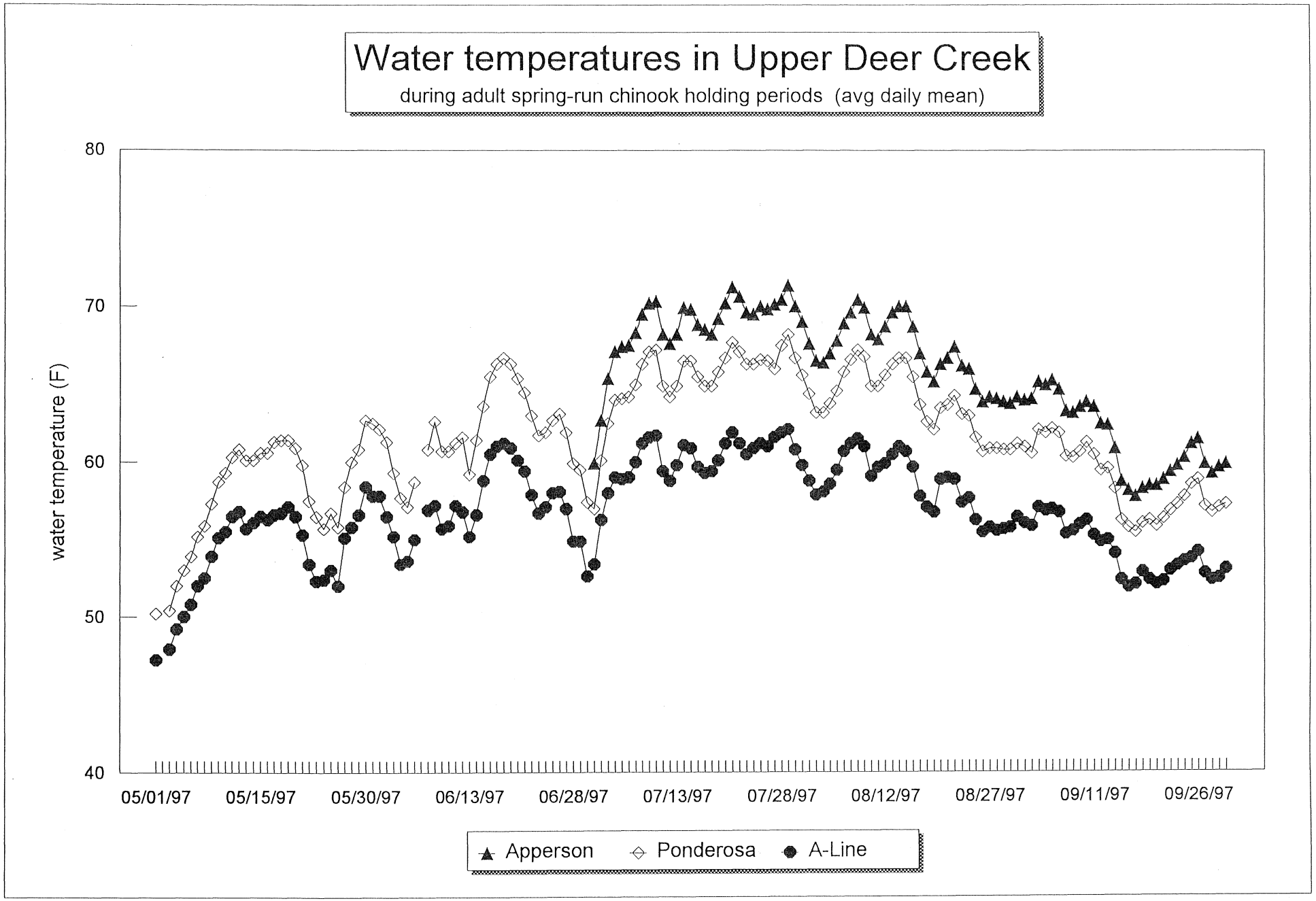

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FIGURE 10. Water temperatures in Mill Creek during spring-run chinook salmon holding periods.

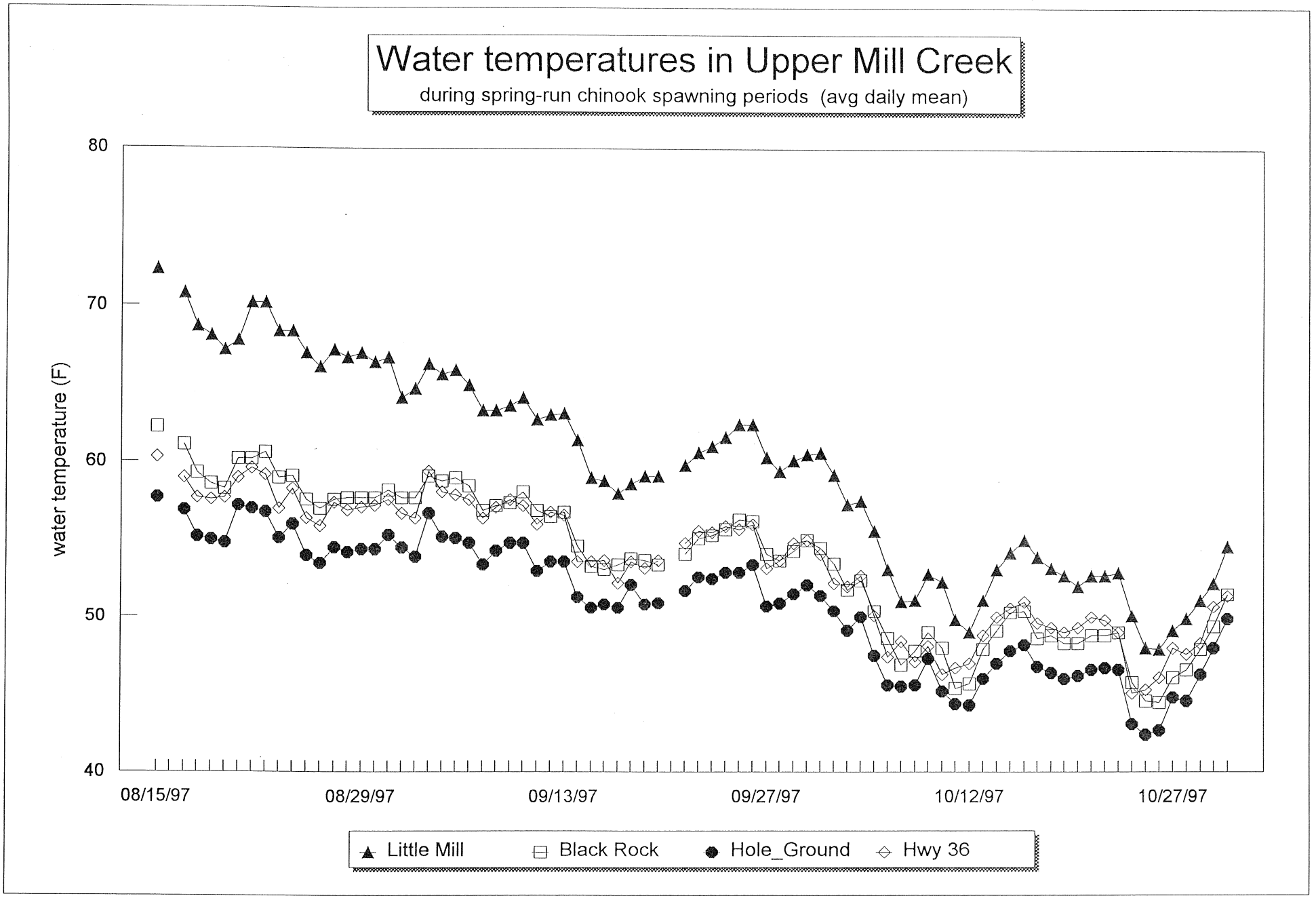

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FIGURE 11. Water temperatures in Mill Creek during spring-run chinook salmon holding periods.

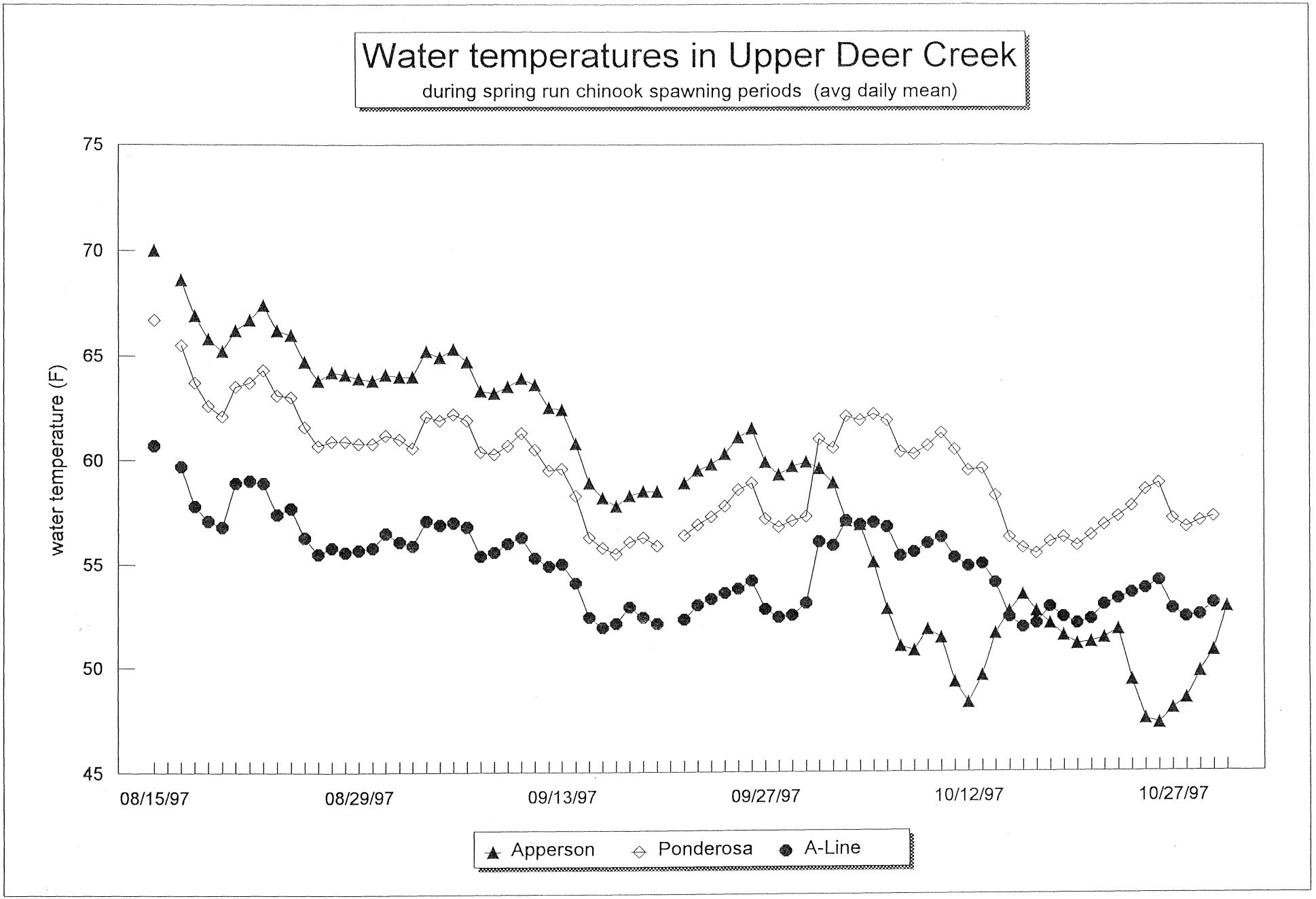

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Table 3 Mean daily water temperatures in Mill Creek at Black Rock.
Estimated time of egg hatching and fry emergence is based on Octoer 15 peak of spawning, and calculated from daily temperature units (DTU).

Oct 97				Nov 97				Dec 97				Jan 98				Feb 98				Mar 98			
DAY	mean	DTU	cum DTU	DAY	mean	DTU	cum DTU	DAY	mean	DTU	cum DTU	DAY	mean	DTU	cum DTU	DAY	mean	DTU	cumDTU	DAY	mean	DTU	cumDTU
1	42.7			1	50.1	18.1	274.8	1	42.7	10.7	685.9	1	42.4	10.4	948.5	1	42.9	10.9	1269.8	1	43.8	11.8	1561
2	41.4			2	49.0	17	291.8	2	41.5	9.5	695.4	2	42.0	10	958.5	2	43.1	11.1	1280.9	2	44.4	12.4	1573.4
3	41.4			3	48.5	16.5	308.3	3	41.4	9.4	704.8	3	42.4	10.4	968.9	3	43.3	11.3	1292.2	3	43.2	11.2	1584.6
4	44.0			4	48.4	16.4	324.7	4	44.0	12	716.8	4	40.7	8.7	977.6	4	42.9	10.9	1303.1	4	40.8	8.8	1593.4
5	43.7			5	47.7	15.7	340.4	5	43.7	11.7	728.5	5	39.4	7.4	985	5	42.7	10.7	1313.8	5	40.1	8.1	1601.5
6	44.1			6	48.2	16.2	356.6	6	44.0	12	740.5	6	38.0	6	991	6	42.6	10.6	1324.4	6	39.7	7.7	1609.2
7	44.2			7	48.9	16.9	373.5	7	44.2	12.2	752.7	7	39.3	7.3	998.3	7	42.5	10.5	1334.9	7	39.6	7.6	1616.8
8	40.8			8	45.7	13.7	387.2	8	40.9	8.9	761.6	8	41.0	9	1007.3	8	43	11	1345.9	8	41.7	9.7	1626.5
9	39.4			9	45.9	13.9	401.1	9	39.4	7.4	769	9	42.3	10.3	1017.6	9	42.4	10.4	1356.3	9	42.3	10.3	1636.8
10	39.2			10	46.5	14.5	415.6	10	39.2	7.2	776.2	10	43.0	11	1028.6	10	42	10	1366.3	10	42.9	10.9	1647.7
11	39.5			11	46.9	14.9	430.5	11	39.5	7.5	783.7	11	43.1	11.1	1039.7	11	42.4	10.4	1376.7	11	44.7	12.7	1660.4
12	39.4			12	45.3	13.3	443.8	12	39.5	7.5	791.2	12	43.3	11.3	1051	12	42.9	10.9	1387.6	12	44.4	12.4	1672.8
13	40.2			13	45.2	13.2	457	13	40.2	8.2	799.4	13	42.6	10.6	1061.6	13	43.5	11.5	1399.1	13	44.8	12.8	1685.6
14	40.6			14	44.3	12.3	469.3	14	40.7	8.7	808.1	14	42.2	10.2	1071.8	14	42.8	10.8	1409.9	14	44.5	12.5	1698.1
15	41.1	9.1	9.1	15	43.8	11.8	481.1	15	41.1	9.1	817.2	15	43.1	11.1	1082.9	15	42.2	10.2	1420.1	15	45.8	13.8	1711.9
16	42.6	10.6	19.7	16	44.5	12.5	493.6	16	42.8	10.8	828	16	44.0	12	1094.9	16	41.4	9.4	1429.5	16	46	14	1725.9
17	48.6	16.6	36.3	17	45.0	13	506.6	17	43.3	11.3	839.3	17	43.5	11.5	1106.4	17	41.7	9.7	1439.2	17	44.1	12.1	1738
18	48.8	16.8	53.1	18	44.0	12	518.6	18	41.3	9.3	848.6	18	43.5	11.5	1117.9	18	43.1	11.1	1450.3	18	43.6	11.6	1749.6
19	48.3	16.3	69.4	19	45.0	13	531.6	19	38.8	6.8	855.4	19	42.2	10.2	1128.1	19	41.6	9.6	1459.9	19	44.5	12.5	1762.1
20	48.3	16.3	85.7	20	44.3	12.3	543.9	20	39.4	7.4	862.8	20	41.7	9.7	1137.8	20	40.7	8.7	1468.6	20	45.6	13.6	1775.7
21	48.8	16.8	102.5	21	44.4	12.4	556.3	21	38.7	6.7	869.5	21	41.2	9.2	1147	21	40.7	8.7	1477.3	21	44.8	12.8	1788.5
22	48.8	16.8	119.3	22	45.2	13.2	569.5	22	36.5	4.5	874	22	42.5	10.5	1157.5	22	41.5	9.5	1486.8	22	44.2	12.2	1800.7
23	49.0	17	136.3	23	47.0	15	584.5	23	36.8	4.8	878.8	23	42.6	10.6	1168.1	23	41.7	9.7	1496.5	23	43.9	11.9	1812.6
24	45.8	13.8	150.1	24	47.3	15.3	599.8	24	37.2	5.2	884	24	43.2	11.2	1179.3	24	41.6	9.6	1506.1	24	44.1	12.1	1824.7
25	44.6	12.6	162.7	25	45.7	13.7	613.5	25	36.7	4.7	888.7	25	42.7	10.7	1190	25	41.5	9.5	1515.6	25	44	12	1836.7
26	44.5	12.5	175.2	26	45.5	13.5	627	26	37.0	5	893.7	26	43.6	11.6	1201.6	26	42.4	10.4	1526	26	43.9	11.9	1848.6
27	46.1	14.1	189.3	27	45.2	13.2	640.2	27	37.4	5.4	899.1	27	43.8	11.8	1213.4	27	43.1	11.1	1537.1	27	42.5	10.5	1859.1
28	46.6	14.6	203.9	28	43.4	11.4	651.6	28	39.8	7.8	906.9	28	43.6	11.6	1225	28	44.1	12.1	1549.2	28	41.3	9.3	1868.4
29	47.9	15.9	219.8	29	43.4	11.4	663	29	42.5	10.5	917.4	29	44	12	1237	29				29	41.8	9.8	1878.2
30	49.4	17.4	237.2	30	44.2	12.2	675.2	30	42.3	10.3	927.7	30	43	11	1248	30				30	42.2	10.2	1888.4
31	51.5	19.5	256.7	31				31	42.4	10.4	938.1	31	42.9	10.9	1258.9	31				31	42.3	10.3	1898.7

January 1999 (Table 4). The temperature recorder at Hole-in-the-Ground Camp malfunctioned on 26 March but only 1,319 DTU's had accumulated from the estimated time of spawning (Table 5).

The time lapse between the onset and termination of spawning (late August through the end of October) is approximately eight weeks. This can lead to a great deal of variability in the onset and termination of fry emergence. In Mill Creek, the calculated earliest emergence of fry was 27 January in the Little Mill Creek area; 1 March in the Black Rock area, and after 26 March at Hole-in-the-Ground. Weekly sampling for newly emerged fry began in late January. The first fry was observed in the Black Rock area on 21 January measuring 33 mm FL. The first group of fry (>20 fish) was captured on 12 February and ranged in size from 32 to 46 mm FL. Fry in the 30 to 40 mm FL size range continued to be sampled through late May 1998 at Black Rock (Figure 12). (Due to limited winter access, surveys were not made in the Little Mill Creek or Hole-in-the-Ground areas.)

The actual and calculated dates of fry emergence are compared in Table 6. In Deer Creek, the calculated earliest emergence of fry was 13 January at Apperson Cow Camp (Table 7), 26 January at Ponderosa Way (Table 8) and 7 March at A-line Bridge (Table 9). The first fry was observed on 30 December at A-line and 23 January 1999 at Ponderosa Way. Each of the fry measured 33 mm FL. The first group of fry (>20 fish) was captured on 4 March at A-line Bridge and ranged in size from 31 to 34 mm FL. Fry in the 30 to 40 mm FL size range continued to be sampled through late May 1999 (Figure 13).

TABLE 6. Actual and calculated emergence of fry in Mill and Deer creeks from the estimated peak of spawning, based on temperature units. a/

	Mill Creek			Deer Creek		
	Hole-in-the-Ground	Black Rock	Little Mill	A-line	Ponderosa Way	Apperson
1st Observed Emergence	No survey-snow	Jan. 21, 1998	No survey	Dec. 30, 1997	Jan. 23, 1998	No survey
1st Group Emergence (>20 fry)	No survey-snow	Feb. 17, 1998	No survey	Mar. 4, 1998	No survey	No survey
Calculated Emergence	After Mar. 26, 1998	Mar. 1, 1998	Jan. 27, 1998	Mar. 7,1998	Jan. 26, 1998	Jan. 13, 1998

a/ Due to sampling intensity and duration of time between onset and termination of spawning, this data may not reflect the earliest dates of observed and calculated emergence.

Table 4. Mean daily water temperatures in Mill Creek at Little Mill Creek confluence.
Estimated time of egg hatching and fry emergence is based on Octoer 15 peak of spawning, and calculated from daily temperature units (DTU).

Oct 97				Nov 97				Dec 97				Jan 97				Feb 97				Mar 97			
DAY	mean	DTU	cum DTU	DAY	mean	DTU	cum DTU	DAY	mean	DTU	cum DTU	DAY	mean	DTU	cumDTU	DAY	mean	DTU	cumDTU	DAY	mean	DTU	cumDTU
1	60.6			1	54.4	22.4	360.6	1	47.4	15.4	869	1	44.4	12.4	1205	1	46.2	14.2	1634.7	1	47.2	15.2	2012.4
2	59.2			2	53.4	21.4	382	2	45.3	13.3	882.3	2	45.7	13.7	1218.7	2	46.2	14.2	1648.9	2	48.1	16.1	2028.5
3	57.3			3	52.4	20.4	402.4	3	44.0	12	894.3	3	45.6	13.6	1232.3	3	47.5	15.5	1664.4	3	47.3	15.3	2043.8
4	57.5			4	52.2	20.2	422.6	4	46.1	14.1	908.4	4	45.3	13.3	1245.6	4	45.9	13.9	1678.3	4	43.9	11.9	2055.7
5	55.6			5	51.5	19.5	442.1	5	46.8	14.8	923.2	5	44.7	12.7	1258.3	5	44.2	12.2	1270.5	5	45.7	13.7	1692	5	43.1	11.1	2066.8
6	53.1			6	51.3	19.3	461.4	6	47.7	15.7	938.9	6	44.2	12.2	1270.5	6	43.6	11.6	1282.1	6	46.2	14.2	1706.2	6	42	10	2076.8
7	51.0			7	52.4	20.4	481.8	7	48.7	16.7	955.6	7	43.6	11.6	1293.7	7	43.6	11.6	1293.7	7	45.6	13.6	1719.8	7	42	10	2086.8
8	51.1			8	49.5	17.5	499.3	8	45.6	13.6	969.2	8	43.6	11.6	1293.7	8	44	12	1305.7	8	45.8	13.8	1733.6	8	43.7	11.7	2098.5
9	52.8			9	48.5	16.5	515.8	9	43.0	11	980.2	9	44	12	1305.7	9	44.9	12.9	1318.6	9	45.1	13.1	1746.7	9	45.1	13.1	2111.6
10	52.3			10	49.2	17.2	533	10	41.7	9.7	989.9	10	44.9	12.9	1318.6	10	46.1	14.1	1332.7	10	45	13	1759.7	10	45.9	13.9	2125.5
11	49.8			11	49.9	17.9	550.9	11	42.3	10.3	1000.2	11	46.1	14.1	1332.7	11	47.4	15.4	1348.1	11	45.1	13.1	1772.8	11	48.3	16.3	2141.8
12	49.0			12	48.7	16.7	567.6	12	41.8	9.8	1010	12	47.4	15.4	1348.1	12	45.3	13.3	1361.4	12	46	14	1786.8	12	48.7	16.7	2158.5
13	51.1			13	48.1	16.1	583.7	13	42.3	10.3	1020.3	13	45.3	13.3	1361.4	13	45.5	13.5	1374.9	13	46.5	14.5	1801.3	13	48.9	16.9	2175.4
14	53.1			14	47.6	15.6	599.3	14	43.9	11.9	1032.2	14	45.5	13.5	1374.9	14	46.5	14.5	1389.4	14	46.8	14.8	1816.1	14	48.3	16.3	2191.7
15	54.2	22.2	22.2	15	46.8	14.8	614.1	15	44.0	12	1044.2	15	46.5	14.5	1389.4	15	47.2	15.2	1404.6	15	45	13	1829.1	15	49.8	17.8	2209.5
16	55.0	23	45.2	16	47.7	15.7	629.8	16	45.6	13.6	1057.8	16	47.2	15.2	1404.6	16	48.1	16.1	1420.7	16	44	12	1841.1	16	50.9	18.9	2228.4
17	53.9	21.9	67.1	17	48.7	16.7	646.5	17	46.3	14.3	1072.1	17	48.1	16.1	1420.7	17	47.3	15.3	1436	17	44.2	12.2	1853.3	17	48.6	16.6	2245
18	53.2	21.2	88.3	18	46.8	14.8	661.3	18	45.1	13.1	1085.2	18	47.3	15.3	1436	18	47.1	15.1	1451.1	18	45.4	13.4	1866.7	18	47.4	15.4	2260.4
19	52.7	20.7	109	19	48.3	16.3	677.6	19	41.3	9.3	1094.5	19	47.1	15.1	1451.1	19	45.2	13.2	1464.3	19	45.7	13.7	1880.4	19	47.6	15.6	2276
20	52.0	20	129	20	46.7	14.7	692.3	20	41.0	9	1103.5	20	45.2	13.2	1464.3	20	45.6	13.6	1477.9	20	43.6	11.6	1892	20	49.5	17.5	2293.5
21	52.7	20.7	149.7	21	47.1	15.1	707.4	21	41.0	9	1112.5	21	45.6	13.6	1477.9	21	45.3	13.3	1491.2	21	44.3	12.3	1904.3	21	48.8	16.8	2310.3
22	52.7	20.7	170.4	22	47.6	15.6	723	22	38.3	6.3	1118.8	22	45.3	13.3	1491.2	22	45.5	13.5	1504.7	22	44.5	12.5	1916.8	22	49.2	17.2	2327.5
23	52.9	20.9	191.3	23	46.7	14.7	737.7	23	37.8	5.8	1124.6	23	45.5	13.5	1504.7	23	45.6	13.6	1518.3	23	45	13	1929.8	23	47.2	15.2	2342.7
24	50.1	18.1	209.4	24	50.3	18.3	756	24	38.0	6	1130.6	24	45.6	13.6	1518.3	24	45.8	13.8	1532.1	24	44.3	12.3	1942.1	24	46	14	2356.7
25	48.0	16	225.4	25	48.6	16.6	772.6	25	37.3	5.3	1135.9	25	45.8	13.8	1532.1	25	46.7	14.7	1546.8	25	44.4	12.4	1954.5	25	47.1	15.1	2371.8
26	47.9	15.9	241.3	26	49.8	17.8	790.4	26	37.8	5.8	1141.7	26	46.7	14.7	1546.8	27	47.5	15.5	1562.3	26	45.2	13.2	1967.7	26	46.8	14.8	2386.6
27	49.1	17.1	258.4	27	49.2	17.2	807.6	27	37.8	5.8	1147.5	28	46.9	14.9	1577.2	28	46.9	14.9	1577.2	27	46.2	14.2	1981.9	27	46.2	14.2	2400.8
28	49.9	17.9	276.3	28	47.4	15.4	823	28	39.5	7.5	1155	29	47.8	15.8	1593	28	47.3	15.3	1997.2	28	44.1	12.1	2412.9
29	51.1	19.1	295.4	29	45.7	13.7	836.7	29	43.6	11.6	1166.6	30	46.1	14.1	1607.1	29				29	44.4	12.4	2425.3
30	52.2	20.2	315.6	30	48.9	16.9	853.6	30	44.9	12.9	1179.5	31	45.4	13.4	1620.5	30				30	44.8	12.8	2438.1
31	54.6	22.6	338.2	31				31	45.1	13.1	1192.6					31				31	45.3	13.3	2451.4

Table 5. Mean daily water temperatures in Mill Creek at Hole-in-the-Ground.
Estimated time of egg hatching and fry emergence is based on Octoer 15 peak of spawning, and calculated from daily temperature units (DTU).

Oct 97				Nov 97				Dec 97				Jan 98				Feb 98				Mar 98			
DAY	mean	DTU	cum DTU	DAY	mean	DTU	cum DTU	DAY	mean	DTU	cum DTU	DAY	mean	DTU	cumDTU	DAY	mean	DTU	cumDTU	DAY	mean	DTU	cumDTU
1	51.4			1	47.0	15	254.1	1	40.0	8	591.3	1	38.9	6.9	769.3	1	38.2	6.2	961.3	1	40.5	8.5	1122.7
2	50.4			2	46.1	14.1	268.2	2	39.1	7.1	598.4	2	36.5	4.5	773.8	2	37.5	5.5	966.8	2	40.6	8.6	1131.3
3	49.1			3	46.1	14.1	282.3	3	39.7	7.7	606.1	3	37.4	5.4	779.2	3	37	5	971.8	3	40	8	1139.3
4	50.0			4	46.1	14.1	296.4	4	42.1	10.1	616.2	4	34.4	2.4	781.6	4	38	6	977.8	4	37.9	5.9	1145.2
5	47.5			5	45.4	13.4	309.8	5	40.8	8.8	625	5	35.9	3.9	785.5	5	36.6	4.6	982.4	5	36.9	4.9	1150.1
6	45.6			6	46.0	14	323.8	6	41.4	9.4	634.4	6	33.8	1.8	787.3	6	36.1	4.1	986.5	6	37.7	5.7	1155.8
7	45.5			7	47.2	15.2	339	7	39.1	7.1	641.5	7	37.6	5.6	792.9	7	36.2	4.2	990.7	7	36.8	4.8	1160.6
8	45.6			8	43.1	11.1	350.1	8	37.7	5.7	647.2	8	39.2	7.2	800.1	8	37.4	5.4	996.1	8	40	8	1168.6
9	47.3			9	43.6	11.6	361.7	9	36.4	4.4	651.6	9	40	8	808.1	9	37.9	5.9	1002	9	39.8	7.8	1176.4
10	45.2			10	44.2	12.2	373.9	10	36.4	4.4	656	10	39.7	7.7	815.8	10	36.8	4.8	1006.8	10	40.1	8.1	1184.5
11	44.4			11	45.1	13.1	387	11	36.8	4.8	660.8	11	38.4	6.4	822.2	11	38.5	6.5	1013.3	11	41.5	9.5	1194
12	44.3			12	44.1	12.1	399.1	12	36.8	4.8	665.6	12	37.1	5.1	827.3	12	38.1	6.1	1019.4	12	40.9	8.9	1202.9
13	46.0			13	42.3	10.3	409.4	13	37.9	5.9	671.5	13	38.2	6.2	833.5	13	39.8	7.8	1027.2	13	40.7	8.7	1211.6
14	47.0			14	41.2	9.2	418.6	14	35.3	3.3	674.8	14	36.8	4.8	838.3	14	37.1	5.1	1032.3	14	41.2	9.2	1220.8
15	47.8	15.8	15.8	15	41.2	9.2	427.8	15	38.6	6.6	681.4	15	37.9	5.9	844.2	15	38.7	6.7	1039	15	41.7	9.7	1230.5
16	48.2	16.2	32	16	40.9	8.9	436.7	16	40.0	8	689.4	16	38.9	6.9	851.1	16	36.9	4.9	1043.9	16	41.5	9.5	1240
17	46.8	14.8	46.8	17	42.4	10.4	447.1	17	40.3	8.3	697.7	17	38.1	6.1	857.2	17	38.5	6.5	1050.4	17	40.5	8.5	1248.5
18	46.4	14.4	61.2	18	41.5	9.5	456.6	18	38.3	6.3	704	18	38	6	863.2	18	40.2	8.2	1058.6	18	40.4	8.4	1256.9
19	46.0	14	75.2	19	41.6	9.6	466.2	19	35.8	3.8	707.8	19	37.9	5.9	869.1	19	35.2	3.2	1061.8	19	41.2	9.2	1266.1
20	46.2	14.2	89.4	20	42.2	10.2	476.4	20	37.1	5.1	712.9	20	38.8	6.8	875.9	20	37.6	5.6	1067.4	20	41.6	9.6	1275.7
21	46.6	14.6	104	21	42.4	10.4	486.8	21	36.3	4.3	717.2	21	38	6	881.9	21	33.4	1.4	1068.8	21	40.5	8.5	1284.2
22	46.7	14.7	118.7	22	42.9	10.9	497.7	22	34.2	2.2	719.4	22	39.3	7.3	889.2	22	37.4	5.4	1074.2	22	37.9	5.9	1290.1
23	46.6	14.6	133.3	23	44.6	12.6	510.3	23	34.8	2.8	722.2	23	39.3	7.3	896.5	23	36.5	4.5	1078.7	23	38.4	6.4	1296.5
24	43.1	11.1	144.4	24	44.1	12.1	522.4	24	35.7	3.7	725.9	24	40.2	8.2	904.7	24	38.2	6.2	1084.9	24	38.7	6.7	1303.2
25	42.4	10.4	154.8	25	43.6	11.6	534	25	34.5	2.5	728.4	25	39.6	7.6	912.3	25	37.4	5.4	1090.3	25	39.7	7.7	1310.9
26	42.7	10.7	165.5	26	41.8	9.8	543.8	26	34.7	2.7	731.1	26	38.3	6.3	918.6	26	38.7	6.7	1097	26	39.9	7.9	1318.8
27	44.8	12.8	178.3	27	43.3	11.3	555.1	27	35.9	3.9	735	27	39.6	7.6	926.2	27	40.4	8.4	1105.4	27	optic shuttle failure		
28	44.6	12.6	190.9	28	41.6	9.6	564.7	28	37.9	5.9	740.9	28	39.8	6.8	934	28	40.8	8.8	1114.2	28			
29	46.3	14.3	205.2	29	41.3	9.3	574	29	39.0	7	747.9	29	38.8	6.8	940.8	29				29			
30	48.0	16	221.2	30	41.3	9.3	583.3	30	38.8	6.8	754.7	30	39.4	7.4	948.2	30				30			
31	49.9	17.9	239.1	31				31	39.7	7.7	762.4	31	38.9	6.9	955.1	31				31			

Figure 12. Length frequency distribution (mmFL) of spring-run chinook salmon rearing in Mill Creek, December 1997 - January 1999. Sample size = 507 fish.

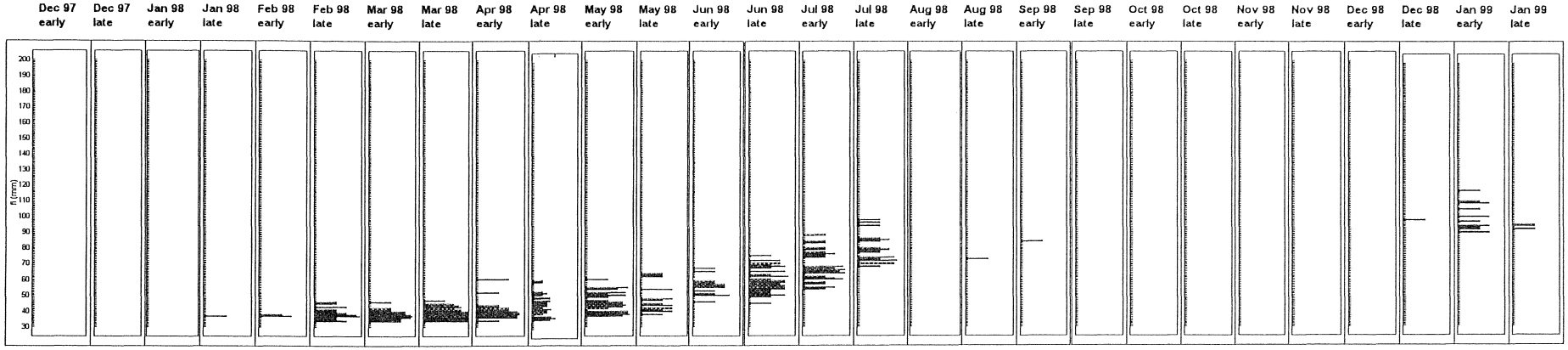


Table 7. Mean daily water temperatures in Deer Creek at Apperson Cow Camp.
Estimated time of egg hatching and fry emergence is based on an estimated peak time of spawning of October 1 , and calculated from daily temperature units (DTU).

Oct 97				Nov 97				Dec 97				Jan 98			
Day	mean	DTU	cum DTU	Day	mean	DTU	cum DTU	Day	mean	DTU	cum DTU	Day	mean	DTU	cum DTU
1	59.6	27.6	27.6	1	52.7	20.7	635.7	1	45.6	13.6	1118.6	1	43.8	11.8	1417.6
2	58.9	26.9	54.5	2	52.1	20.1	655.8	2	43.3	11.3	1129.9	2	45.2	13.2	1430.8
3	57.1	25.1	79.6	3	51.5	19.5	675.3	3	42.7	10.7	1140.6	3	45.3	13.3	1444.1
4	56.9	24.9	104.5	4	51.0	19	694.3	4	44.6	12.6	1153.2	4	44.0	12	1456.1
5	55.2	23.2	127.7	5	50.3	18.3	712.6	5	45.1	13.1	1166.3	5	41.4	9.4	1465.5
6	52.8	20.8	148.5	6	50.3	18.3	730.9	6	46.2	14.2	1180.5	6	39.9	7.9	1473.4
7	51.0	19	167.5	7	50.9	18.9	749.8	7	47.1	15.1	1195.6	7	41.1	9.1	1482.5
8	50.8	18.8	186.3	8	48.6	16.6	766.4	8	44.9	12.9	1208.5	8	41.7	9.7	1492.2
9	51.9	19.9	206.2	9	48.0	16	782.4	9	41.7	9.7	1218.2	9	43.5	11.5	1503.7
10	51.4	19.4	225.6	10	48.5	16.5	798.9	10	40.2	8.2	1226.4	10	44.9	12.9	1516.6
11	49.3	17.3	242.9	11	49.1	17.1	816	11	40.7	8.7	1235.1	11	45.4	13.4	1530
12	48.3	16.3	259.2	12	47.9	15.9	831.9	12	40.6	8.6	1243.7	12	45.5	13.5	1543.5
13	49.7	17.7	276.9	13	47.3	15.3	847.2	13	40.7	8.7	1252.4	13	43.8	11.8	1555.3
14	51.6	19.6	296.5	14	47.3	15.3	862.5	14	42.2	10.2	1262.6	14	44.4	12.4	1567.7
15	52.7	20.7	317.2	15	46.2	14.2	876.7	15	43.7	11.7	1274.3	15	45.5	13.5	1581.2
16	53.5	21.5	338.7	16	47.2	15.2	891.9	16	44.9	12.9	1287.2	16	46.4	14.4	1595.6
17	52.7	20.7	359.4	17	47.8	15.8	907.7	17	45.5	13.5	1300.7	17	46.1	14.1	1609.7
18	52.1	20.1	379.5	18	46.5	14.5	922.2	18	43.9	11.9	1312.6	18	45.7	13.7	1623.4
19	51.5	19.5	399	19	47.6	15.6	937.8	19	40.5	8.5	1321.1	19	43.9	11.9	1635.3
20	51.1	19.1	418.1	20	46.3	14.3	952.1	20	40.4	8.4	1329.5	20	43.3	11.3	1646.6
21	51.3	19.3	437.4	21	46.4	14.4	966.5	21	39.7	7.7	1337.2	21	42.5	10.5	1657.1
22	51.4	19.4	456.8	22	46.7	14.7	981.2	22	37.9	5.9	1343.1	22	43.7	11.7	1668.8
23	51.8	19.8	476.6	23	48.5	16.5	997.7	23	37.3	5.3	1348.4	23	44.0	12	1680.8
24	49.4	17.4	494	24	49.2	17.2	1014.9	24	36.9	4.9	1353.3	24	44.8	12.8	1693.6
25	47.6	15.6	509.6	25	47.9	15.9	1030.8	25	36.6	4.6	1357.9	25	44.2	12.2	1705.8
26	47.3	15.3	524.9	26	48.9	16.9	1047.7	26	36.6	4.6	1362.5	26	46.0	14	1719.8
27	48.0	16	540.9	27	47.6	15.6	1063.3	27	36.7	4.7	1367.2	27	46.3	14.3	1734.1
28	48.5	16.5	557.4	28	45.9	13.9	1077.2	28	38.2	6.2	1373.4	28	45.5	13.5	1747.6
29	49.9	17.9	575.3	29	44.6	12.6	1089.8	29	41.3	9.3	1382.7	29	46.7	14.7	1762.3
30	50.8	18.8	594.1	30	47.2	15.2	1105	30	43.2	11.2	1393.9	30	45.0	13	1775.3
31	52.9	20.9	615	31				31	43.9	11.9	1405.8	31	44.5	12.5	1787.8

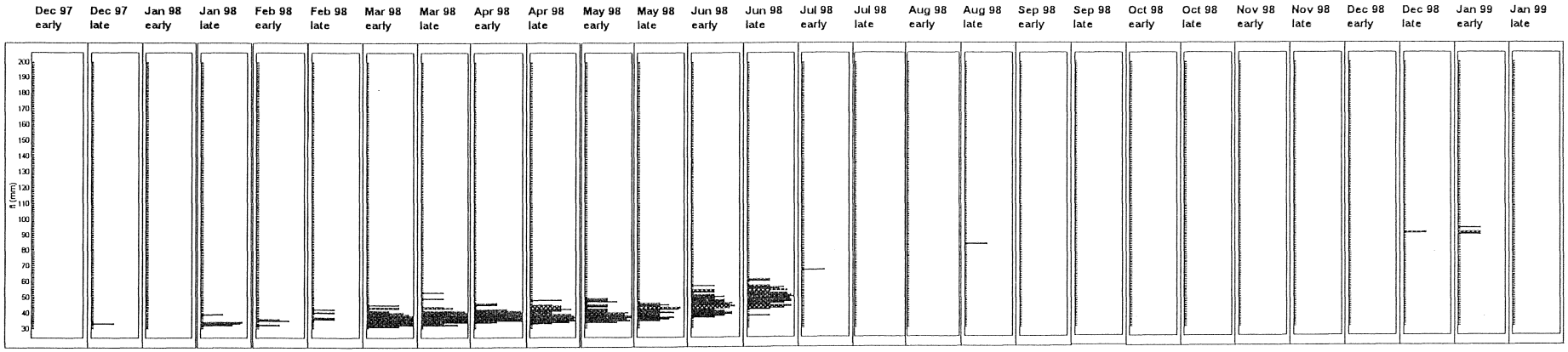
Table 8. Mean daily water temperatures in Deer Creek at Ponderosa Way .
Estimated time of egg hatching and fry emergence is based on an estimated peak time of spawning of October 1, and calculated from daily temperature units (DTU).

Oct 97				Nov 97				Dec 97				Jan 98				Feb 98				Mar 98			
Day	mean	DTU	cum DTU	Day	mean	DTU	cum DTU	Day	mean	DTU	cum DTU	Day	mean	DTU	cum DTU	Day	mean	DTU	cum DTU	Day	mean	DTU	cum DTU
1	57.0	25	25	1	51.2	19.2	577.4	1	44.2	12.2	1017.9	1	42.7	10.7	1290.9	1	44.2	12.2	1633.6	1	45.0	13	1965.9
2	56.5	24.5	49.5	2	50.4	18.4	595.8	2	42.2	10.2	1028.1	2	43.9	11.9	1302.8	2	44.7	12.7	1646.3	2	45.9	13.9	1979.8
3	54.7	22.7	72.2	3	49.7	17.7	613.5	3	41.7	9.7	1037.8	3	43.8	11.8	1314.6	3	45.3	13.3	1659.6	3	44.7	12.7	1992.5
4	54.5	22.5	94.7	4	49.3	17.3	630.8	4	43.7	11.7	1049.5	4	42.4	10.4	1325	4	44.2	12.2	1671.8	4	41.8	9.8	2002.3
5	52.9	20.9	115.6	5	48.7	16.7	647.5	5	44.1	12.1	1061.6	5	40.0	8	1333	5	44.3	12.3	1684.1	5	41.0	9	2011.3
6	50.8	18.8	134.4	6	48.4	16.4	663.9	6	44.9	12.9	1074.5	6	38.8	6.8	1339.8	6	44.7	12.7	1696.8	6	40.5	8.5	2019.8
7	49.1	17.1	151.5	7	49.3	17.3	681.2	7	45.6	13.6	1088.1	7	39.9	7.9	1347.7	7	44.3	12.3	1709.1	7	40.4	8.4	2028.2
8	48.9	16.9	168.4	8	47.1	15.1	696.3	8	43.2	11.2	1099.3	8	40.7	8.7	1356.4	8	44.6	12.6	1721.7	8	42.3	10.3	2038.5
9	50.3	18.3	186.7	9	46.8	14.8	711.1	9	40.5	8.5	1107.8	9	42.3	10.3	1366.7	9	43.7	11.7	1733.4	9	42.9	10.9	2049.4
10	49.4	17.4	204.1	10	47.4	15.4	726.5	10	39.4	7.4	1115.2	10	43.5	11.5	1378.2	10	43.4	11.4	1744.8	10	43.6	11.6	2061
11	47.4	15.4	219.5	11	47.8	15.8	742.3	11	39.8	7.8	1123	11	43.9	11.9	1390.1	11	43.6	11.6	1756.4	11	45.7	13.7	2074.7
12	46.5	14.5	234	12	46.5	14.5	756.8	12	39.6	7.6	1130.6	12	43.8	11.8	1401.9	12	44.0	12	1768.4	12	45.6	13.6	2088.3
13	48.3	16.3	250.3	13	46.0	14	770.8	13	39.9	7.9	1138.5	13	42.6	10.6	1412.5	13	44.8	12.8	1781.2	13	46.1	14.1	2102.4
14	50.1	18.1	268.4	14	46.0	14	784.8	14	41.4	9.4	1147.9	14	43.0	11	1423.5	14	44.5	12.5	1793.7	14	45.6	13.6	2116
15	51.0	19	287.4	15	44.7	12.7	797.5	15	42.4	10.4	1158.3	15	44.2	12.2	1435.7	15	43.4	11.4	1805.1	15	45.9	13.9	2129.9
16	51.5	19.5	306.9	16	45.8	13.8	811.3	16	43.7	11.7	1170	16	45.0	13	1448.7	16	42.4	10.4	1815.5	16	47.6	15.6	2145.5
17	50.7	18.7	325.6	17	46.4	14.4	825.7	17	44.4	12.4	1182.4	17	44.5	12.5	1461.2	17	42.9	10.9	1826.4	17	45.5	13.5	2159
18	50.0	18	343.6	18	45.1	13.1	838.8	18	42.5	10.5	1192.9	18	44.1	12.1	1473.3	18	43.9	11.9	1838.3	18	44.9	12.9	2171.9
19	49.5	17.5	361.1	19	46.3	14.3	853.1	19	39.5	7.5	1200.4	19	42.7	10.7	1484	19	43.6	11.6	1849.9	19	45.2	13.2	2185.1
20	49.1	17.1	378.2	20	45.3	13.3	866.4	20	39.3	7.3	1207.7	20	42.3	10.3	1494.3	20	42.4	10.4	1860.3	20	46.7	14.7	2199.8
21	49.6	17.6	395.8	21	45.1	13.1	879.5	21	39.0	7	1214.7	21	41.6	9.6	1503.9	21	42.6	10.6	1870.9	21	46.0	14	2213.8
22	49.7	17.7	413.5	22	45.6	13.6	893.1	22	37.2	5.2	1219.9	22	42.7	10.7	1514.6	22	43.6	11.6	1882.5	22	44.9	12.9	2226.7
23	50.0	18	431.5	23	47.2	15.2	908.3	23	36.6	4.6	1224.5	23	42.9	10.9	1525.5	23	43.4	11.4	1893.9	23	44.2	12.2	2238.9
24	47.8	15.8	447.3	24	47.9	15.9	924.2	24	36.6	4.6	1229.1	24	43.5	11.5	1537	24	43.1	11.1	1905	24	43.9	11.9	2250.8
25	46.2	14.2	461.5	25	46.7	14.7	938.9	25	36.3	4.3	1233.4	25	43.0	11	1548	25	42.9	10.9	1915.9	25	44.4	12.4	2263.2
26	45.9	13.9	475.4	26	47.1	15.1	954	26	36.5	4.5	1237.9	26	44.4	12.4	1560.4	26	43.4	11.4	1927.3	26	44.0	12	2275.2
27	46.5	14.5	489.9	27	46.1	14.1	968.1	27	36.6	4.6	1242.5	27	44.8	12.8	1573.2	27	44.3	12.3	1939.6	27	43.6	11.6	2286.8
28	47.0	15	504.9	28	44.4	12.4	980.5	28	38.3	6.3	1248.8	28	44.2	12.2	1585.4	28	45.3	13.3	1952.9	28	41.7	9.7	2296.5
29	48.3	16.3	521.2	29	43.6	11.6	992.1	29	41.8	9.8	1258.6	29	45.0	13	1598.4	29				29	42.2	10.2	2306.7
30	49.6	17.6	538.8	30	45.6	13.6	1005.7	30	42.8	10.8	1269.4	30	43.6	11.6	1610	30				30	42.9	10.9	2317.6
31	51.4	19.4	558.2	31			1005.7	31	42.8	10.8	1280.2	31	43.4	11.4	1621.4	31				31	43.6	11.6	2329.2

Table 9. Mean daily water temperatures in Deer Creek at A-Line Bridge.
Estimated time of egg hatching and fry emergence is based on an estimated peak time of spawning of October 1, and calculated from daily temperature units (DTU).

Oct 97				Nov 97				Dec 97				Jan 98				Feb 98				Mar 98			
Day	mean	DTU	cum DTU	Day	mean	DTU	cum DTU	Day	mean	DTU	cum DTU	Day	mean	DTU	cum DTU	Day	mean	DTU	cum DTU	Day	mean	DTU	cum DTU
1	53.0	21	21	1	48.2	16.2	481.7	1	41.2	9.2	846.8	1	40.5	8.5	1055.4	1	40.8	8.8	1276.3	1	42.0	10	1512.1
2	52.4	20.4	41.4	2	47.0	15	496.7	2	40.1	8.1	854.9	2	40.2	8.2	1063.6	2	40.7	8.7	1285	2	42.5	10.5	1522.6
3	50.4	18.4	59.8	3	46.5	14.5	511.2	3	40.0	8	862.9	3	40.1	8.1	1071.7	3	40.8	8.8	1293.8	3	41.6	9.6	1532.2
4	50.7	18.7	78.5	4	46.3	14.3	525.5	4	41.9	9.9	872.8	4	37.8	5.8	1077.5	4	40.8	8.8	1302.6	4	39.3	7.3	1539.5
5	49.2	17.2	95.7	5	45.7	13.7	539.2	5	41.9	9.9	882.7	5	37.1	5.1	1082.6	5	40.8	8.8	1311.4	5	38.6	6.6	1546.1
6	47.4	15.4	111.1	6	45.7	13.7	552.9	6	42.3	10.3	893	6	36.3	4.3	1086.9	6	40.6	8.6	1320	6	38.1	6.1	1552.2
7	46.1	14.1	125.2	7	46.6	14.6	567.5	7	42.1	10.1	903.1	7	37.4	5.4	1092.3	7	40.3	8.3	1328.3	7	38.2	6.2	1558.4
8	46.6	14.6	139.8	8	44.7	12.7	580.2	8	39.2	7.2	910.3	8	38.9	6.9	1099.2	8	40.8	8.8	1337.1	8	40.1	8.1	1566.5
9	47.5	15.5	155.3	9	44.6	12.6	592.8	9	37.7	5.7	916	9	40.1	8.1	1107.3	9	40.4	8.4	1345.5	9	40.6	8.6	1575.1
10	46.6	14.6	169.9	10	45.3	13.3	606.1	10	37.4	5.4	921.4	10	40.7	8.7	1116	10	39.9	7.9	1353.4	10	41.0	9	1584.1
11	44.4	12.4	182.3	11	45.7	13.7	619.8	11	37.6	5.6	927	11	40.5	8.5	1124.5	11	40.4	8.4	1361.8	11	42.5	10.5	1594.6
12	44.3	12.3	194.6	12	44.1	12.1	631.9	12	37.5	5.5	932.5	12	39.8	7.8	1132.3	12	40.9	8.9	1370.7	12	42.4	10.4	1605
13	46.0	14	208.6	13	44.0	12	643.9	13	38.0	6	938.5	13	39.7	7.7	1140	13	41.6	9.6	1380.3	13	42.8	10.8	1615.8
14	47.0	15	223.6	14	43.5	11.5	655.4	14	38.8	6.8	945.3	14	39.6	7.6	1147.6	14	40.6	8.6	1388.9	14	42.4	10.4	1626.2
15	47.9	15.9	239.5	15	42.8	10.8	666.2	15	39.5	7.5	952.8	15	40.8	8.8	1156.4	15	40.2	8.2	1397.1	15	43.5	11.5	1637.7
16	48.2	16.2	255.7	16	43.0	11	677.2	16	41.0	9	961.8	16	41.5	9.5	1165.9	16	39.7	7.7	1404.8	16	43.9	11.9	1649.6
17	47.2	15.2	270.9	17	43.8	11.8	689	17	41.6	9.6	971.4	17	40.8	8.8	1174.7	17	40.0	8	1412.8	17	42.1	10.1	1659.7
18	46.7	14.7	285.6	18	43.0	11	700	18	39.2	7.2	978.6	18	40.2	8.2	1182.9	18	41.2	9.2	1422	18	41.9	9.9	1669.6
19	46.2	14.2	299.8	19	43.6	11.6	711.6	19	36.9	4.9	983.5	19	39.4	7.4	1190.3	19	40.4	8.4	1430.4	19	42.5	10.5	1680.1
20	46.3	14.3	314.1	20	43.1	11.1	722.7	20	37.4	5.4	988.9	20	39.6	7.6	1197.9	20	39.1	7.1	1437.5	20	43.4	11.4	1691.5
21	46.7	14.7	328.8	21	42.9	10.9	733.6	21	37.2	5.2	994.1	21	39.3	7.3	1205.2	21	38.5	6.5	1444	21	42.8	10.8	1702.3
22	46.8	14.8	343.6	22	43.5	11.5	745.1	22	35.3	3.3	997.4	22	39.9	7.9	1213.1	22	39.7	7.7	1451.7	22	41.2	9.2	1711.5
23	47.1	15.1	358.7	23	45.1	13.1	758.2	23	35.2	3.2	1000.6	23	40.6	8.6	1221.7	23	39.5	7.5	1459.2	23	41.0	9	1720.5
24	45.0	13	371.7	24	45.6	13.6	771.8	24	35.9	3.9	1004.5	24	40.9	8.9	1230.6	24	39.5	7.5	1466.7	24	41.1	9.1	1729.6
25	43.6	11.6	383.3	25	44.2	12.2	784	25	35.4	3.4	1007.9	25	40.7	8.7	1239.3	25	39.5	7.5	1474.2	25	41.4	9.4	1739
26	43.3	11.3	394.6	26	43.7	11.7	795.7	26	35.7	3.7	1011.6	26	41.3	9.3	1248.6	26	40.3	8.3	1482.5	26	41.4	9.4	1748.4
27	44.3	12.3	406.9	27	43.4	11.4	807.1	27	36.2	4.2	1015.8	27	41.5	9.5	1258.1	27	41.4	9.4	1491.9	27	40.3	8.3	1756.7
28	44.7	12.7	419.6	28	42.1	10.1	817.2	28	38.2	6.2	1022	28	41.4	9.4	1267.5	28	42.2	10.2	1502.1	28	39.2	7.2	1763.9
29	45.9	13.9	433.5	29	41.9	9.9	827.1	29	40.2	8.2	1030.2	29	41.3	9.3	1276.8	29				29	40.1	8.1	1772
30	47.0	15	448.5	30	42.5	10.5	837.6	30	40.2	8.2	1038.4	30	40.7	8.7	1285.5	30				30	40.8	8.8	1780.8
31	49.0	17	465.5	31				31	40.5	8.5	1046.9	31	40.8	8.8	1294.3	31				31	41.0	9	1789.8

Figure 13. Length frequency distribution (mmFL) of spring-run chinook salmon rearing in Deer Creek, December 1997 - January 1999. Sample size = 770 fish.



Juvenile Rearing

In Mill Creek, 507 juvenile spring-run salmon were sampled from January 1998 through January 1999. No sampling occurred during the September through December 1998 time period. Sub-yearling spring-run salmon up to 98 mm FL were sampled in the summer of 1998 (Figure 12).

In Deer Creek, 770 juvenile spring-run salmon were sampled from December 1997 through January 1999. No sampling occurred during the September through December 1998 time period. Sub-yearling spring-run salmon up to 82 mm FL were sampled in the summer of 1998 (Figure 13). Techniques used to sample juvenile spring-run (electroshocking and seining) are biased towards sampling the smaller salmon occurring in shallow pools and edge water habitat. The larger juveniles in the riffle habitat or deeper pool habitat are not being effectively sampled. A total of 72 survey trips was made to both Mill and Deer creeks and less than 1,300 spring-run 97 BY juveniles were sampled. This is too small of a sample to coded-wire tag for river/delta rearing and outmigrant studies. Due to the small sample size of juveniles inherent with low adult population numbers and the limitations of juvenile sampling in these inaccessible canyons, coded-wire tagging of spring-run in Mill and Deer creeks may not be a practical method for monitoring juvenile spring-run salmon movement in the Sacramento River and Delta. Coded-wire tagging of spring-run juveniles in Mill and Deer creeks should continue to be delayed until sufficient numbers can be tagged (≥50,000 juveniles) for subsequent river and delta recaptures.

Tissue samples were collected on juvenile spring-run in each creek for genetic analysis. A total of 162 samples was collected on each creek and sent to the Department's Salmon Stock Tissue Collection Project.

Fry and Yearling Emigration

Rotary screw traps were placed in Mill and Deer creeks near each creek's confluence with the Sacramento River. The purpose of this trapping was to sample outmigrant yearling spring-run and record size at emigration and timing of emigration. In both Mill and Deer creeks, these traps are placed in fall-run chinook spawning habitat. Since fall-run and spring-run fry emerge during similar time periods, if a portion of the 97 BY were emigrating as fry, we would be unable to distinguish them between emigrating 97 BY fall-run fry in the trap samples. Also, since each trap is located upstream of dams and fish ladders that are considered obstacles to immigrating non-natal rearing fry from the Sacramento River, all chinook salmon captured in the traps are considered natal rearing fry or yearlings.

The rotary screw trap in Mill Creek was fished from December 1997 through January 1998 and late October 1998 through January 1999. A total of 46, 1997 BY spring/fall fry and 13,

1997 BY spring-run yearlings were during these time periods (Table 10 and Figure 14). Fry ranged in size from 31 to 39 mm FL and yearlings ranged in size from 98 to 122 mm FL. The first 1998 BY spring/fall fry was captured on 23 November 1998.

The Deer Creek rotary screw trap was fished from December 1997 through January 1998 and late October 1998 through January 1999. A total of 231, 1997 BY spring/fall fry and 338, 1997 BY spring-run yearlings were trapped during these time periods (Table 11 and Figure 15). Fry ranged in size from 31 to 42 mm FL and yearlings ranged in size from 62 to 128 mm FL. The first 1998 BY spring/fall fry was captured on 25 November 1998.

Due to the designation of Sacramento River spring-run salmon as a candidate species under California Endangered Species Act in 1997, the Department of Fish and Game and CALFED agencies established a Spring-Run Chinook Salmon Protection Plan (Spring-run Plan). The CALFED Bay-Delta Program is a cooperative effort by 15 state, federal agencies with regulatory and management responsibilities in the San Francisco Bay-Sacramento-San Joaquin River Bay-Delta ecosystem to develop a long-term plan to restore ecosystem health and improve water management for beneficial uses of the Bay-Delta ecosystem). This Spring-run Plan established monitoring of both salmon emigration and environmental parameters (flow, turbidity), and set operational responses if salmon detection indicated spring-run may be entering the Delta. The Spring-run Plan depends on identifying the time when juvenile spring-run are likely entering the Delta and taking action to avoid or minimize the effects of the State Water Project and Central Valley Project facilities operations on juvenile salmon survival through the Delta. Real-time monitoring of yearling spring-run chinook salmon emigration in Mill and Deer creeks is now being used to provide data in evaluating the distribution and movement of spring-run salmon through the river and estuary. Spring-run chinook salmon protection actions are triggered once yearling spring-run are detected in Mill, Deer and Butte creeks.

Recommendations

Real-time monitoring of adult migration, water temperatures and attraction flows in Mill and Deer creeks is needed for coordination between instream flows for fish and irrigation demands during periods of adult migration. The real-time monitoring of yearling spring-run chinook emigration should continue in order to provide data in evaluating salmon distribution and movement through the Sacramento River and Sacramento-San Joaquin estuary. Emigration monitoring should be expanded to include the months of February through June when spring- and fall-run fry are migrating from each creek. Sacramento-San Joaquin flow standards and water project facilities operational criteria should be evaluated for these spring periods of fry outmigration.

Table 10. Rotary Screw Trap Real-time Monitoring in Mill Creek to Determine Timing of 97BY Spring run Yearling Outmigration

Date	Status	Flow	Turbidity	Yearling 1/ CHN	Fry 2/ CHN	RBT	SQ	HH	SCP	LP	RH	SASU
10/26/98	set	149										
10/27/98	check	---	>120 cm	0	0							
10/28/98	check	---	>126 cm	0	0			2				1
10/29/98	check	144	>109 cm	0	0				1			
10/30/98	check	141	>120 cm	0	0							
10/31/98	check	134	>116 cm	0	0							1
11/01/98	check	134	>116 cm	0	0							
11/02/98	check	129	>120 cm	0	0							
11/03/98	check	131	>117 cm	0	0							
11/04/98	check	131	>117 cm	0	0							
11/05/98	check	131	>120 cm	0	0							
11/06/98	check	129	>120 cm	0	0							
11/07/98	check	157	>120 cm	0	0							
11/08/98	check	180	86 cm	0	0							
11/09/98	check	159	94 cm	0	0			5				1
11/10/98	check	149	>120 cm	0	0			1				
11/11/98	check	162	96 cm	0	0							
11/12/98	check	162	>120 cm	0	0		1	5				1
11/13/98	not check	149	---									
11/14/98	check	149	>120 cm	0	0							
11/15/98	check	146	>120 cm	0	0							
11/16/98	check	152	>120 cm	0	0							
11/17/98	check	167	>116 cm	0	0							1
11/18/98	check	190	97 cm	0	0							
11/19/98	check	157	>120 cm	0	0							
11/20/98	check	149	>117 cm	0	0							
11/21/98	check	147	>120 cm	0	0							1
11/22/98	check	473	24 cm	0	0							6
11/23/98	check	276	54 cm	0	1	1			6	6		
11/24/98	check	665	19 cm	0	0							
11/25/98	check	349	65 cm	0	0			1		4		4
11/26/98	check	258	97 cm	0	0							
11/27/98	check	563	52 cm	0	0	3				1		
11/28/98	check	387	70 cm	0	0	1						1
11/29/98	check	306	>116 cm	0	0							
11/30/98	check	798	42 cm	0	0	2	4					1
12/01/98	pullrd	1341	50.5 ntu	0	0							
12/02/98	out	1113	---									
12/03/98	out	1113	---									
12/04/98	out	875	---									
12/05/98	out	535	---									
12/06/98	out	443	---									
12/07/98	out	375	---									
12/08/98	out	340	---									
12/09/98	out	---	---									
12/10/98	set	276	---									
12/11/98	check	261	2.71 ntu	0	0			1				
12/12/98	check	246	2.71 ntu	0	0							
12/13/98	check	240	2.54 ntu	0	0							
12/14/98	check	532	6.81 ntu	0	0				1			
12/15/98	check	318	2.98 ntu	0	0							
12/16/98	check	276	2.26 ntu	0	3							
12/17/98	check	258	2.23 ntu	0	0							
12/18/98	check	249	2.24 ntu	0	0							
12/19/98	check	240	2.62 ntu	0	0			1				
12/20/98	check	221	2.71 ntu	0	0							2
12/21/98	check	206	20.3 ntu	1	1							
12/22/98	check	229	2.63 ntu	0	0							
12/23/98	check	215	1.85 ntu	0	0							
12/24/98	check	215	1.81 ntu	0	1	1						
12/25/98	not check	209	---									
12/26/98	check	209	1.71 ntu	0	0	2						
12/27/98	check	207	1.21 ntu	0	0							
12/28/98	check	204	1.34 ntu	0	0							
12/29/98	check	201	1.47 ntu	0	0							
12/30/98	check	198	1.58 ntu	0	1							
12/31/98	check	198	1.02 ntu	1	0							
01/01/99	not check	201	---									
01/02/99	check	193	1.07 ntu	0	0							
01/03/99	check	193	1.93 ntu	0	0							
01/04/99	check	190	1.20 ntu	0	0							
01/05/99	check	187	0.98 ntu	1	2							
01/06/98	check	187	0.83 ntu	0	2							
01/07/99	check	187	1.07 ntu	0	1							
01/08/99	check	185	1.24 ntu	1	7							
01/09/99	check	182	1.27 ntu	0	0							
01/10/99	check	182	0.92 ntu	1	0	1			1			
01/11/99	check	182	1.12 ntu	0	32							
01/12/99	check	182	1.54 ntu	0	20				2			
01/13/99	check	182	1.02 ntu	0	21							
01/14/99	check	175	1.27 ntu	0	19							
01/15/99	check	182	0.97 ntu	0	28							
01/16/99	check	270	7.84 ntu	0	191							
01/17/99	check	276	6.97 ntu	0	201							
01/18/99	check	836	39.1 ntu	0	256							
01/19/99	check	508	4.33 ntu	1	251							
01/20/99	check	542	10.8 ntu	0	71	1				3		
01/21/99	check	640	19.0 ntu	0	40				1	1		
01/22/99	check	480	5.96 ntu	0	29	1						
01/23/99	check	1417	74.3 ntu	2	0							
01/24/99	check	810	68.4 ntu	1	5				1			
01/25/99	check	621	10.5 ntu	3	10					2		
01/26/99	check	507	9.16 ntu	0	6							
01/27/99	check	436	5.40 ntu	0	1							
01/28/99	check	381	---	0	3							
01/29/99	check	346	7.48 ntu	0	11							
01/30/99	check	325	4.20 ntu	1	4							
01/31/99	check	312	7.10 ntu	0	0							
			TOTALS	13	1218	13	5	16	13	17	0	20

1/ 97 Brood Year
2/ 98 Brood Year

97byadlt.wk4

Figure 14. Length frequency distribution (mmFL) of 1997BY spring-run and fall-run chinook salmon emigration from Mill Creek, December 1997 - January 1999. N = 59 fish.

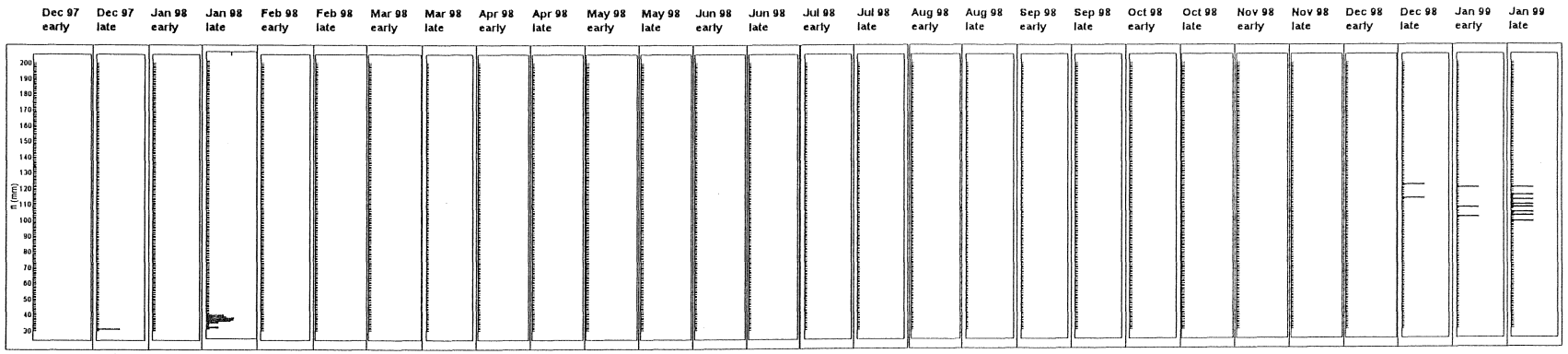


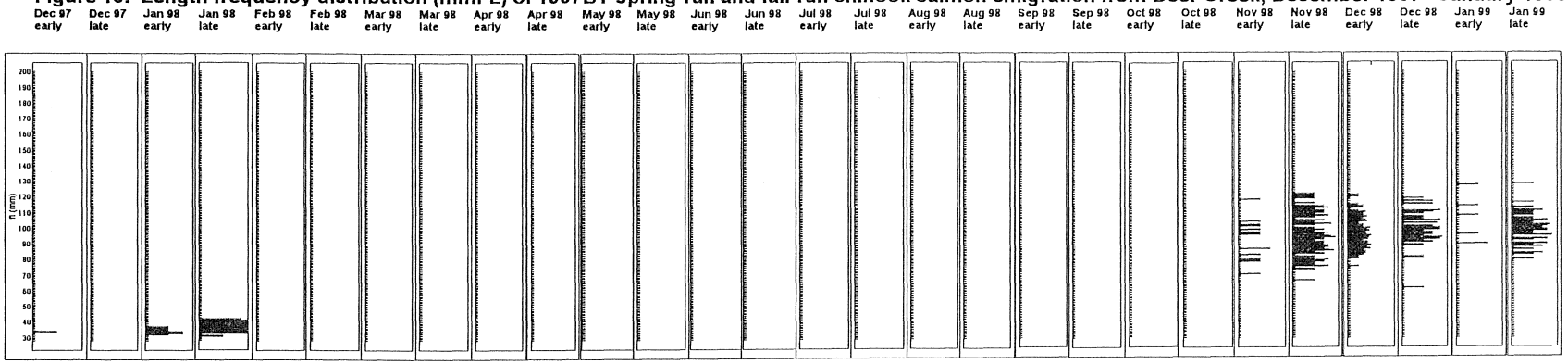
TABLE 11. Rotary Screw Trap Real-time Monitoring in Deer Creek to Determine Timing of 97BY Spring-Run Yearling Outmigration

Date	Status	Flow	Turbidity	Yearling 2/ CHN	Fry 3/ CHN	RBT	SQ	HH	SCP	LP	RH	SASU
10/26/89	set	138										
10/27/98	check	BRT 1/	>110 cm	0	0							
10/28/98	check	BRT 1/	>126 cm	0	0							
10/29/98	check	129	---	0	0							
10/30/98	check	127	>120 cm	0	0			1				
10/31/98	check	124	>96 cm	0	0							
11/01/98	check	129	>105 cm	0	0							
11/02/98	check	131	>120 cm	0	0			1	1			
11/03/98	check	126	>120 cm	0	0			1				
11/04/98	check	127	>120 cm	0	0			3				
11/05/98	check	127	>120 cm	0	0				1			
11/06/98	check	129	>120 cm	0	0			1				
11/07/98	check	158	>116 cm	0	0			1				
11/08/98	check	214	>120 cm	0	0	4	2	20		1		
11/09/98	check	165	>120 cm	5	0		1	14				1
11/10/98	check	143	>120 cm	0	0			5				
11/11/98	check	163	>120 cm	1	0		4	1				
11/12/98	check	163	>116 cm	1	0			1	2			
11/13/98	not check	138	---									
11/14/98	check	136	>120 cm	4	0	1		1				
11/15/98	check	134	>120 cm	2	0	1		3				
11/16/98	check	141	>120 cm	0	0		6	1	1			
11/17/98	check	168	>120 cm	1	0	3		9		2	2	
11/18/98	check	223	>120 cm	5	0	2		9	1	2	1	1
11/19/98	check	160	>116 cm	3	0			3	1	1		
11/20/98	check	143	>117 cm	3	0		1		9	2		
11/21/98	check	136	>117 cm	1	0			2				
11/22/98	check	566	46 cm	6	0			24	3	8		
11/23/98	check	312	74 cm	26	0	2		39	2	24		3
11/24/98	check	757	39 cm	1	0							
11/25/98	check	358	>108 cm	10	3	5	2	27	8	93		4
11/26/98	check	256	>120 cm	8	0	8		5	2	20	1	
11/27/98	check	193	>113 cm	3	0	3		3	5	2		
11/28/98	check	370	>116 cm	4	0	8	4	1		4		
11/29/98	check	316	>116 cm	3	0	5		2		3		
11/30/98	check	850	66 cm	13	0	5	1	1	2	1		2
12/01/98	damaged	1568	14.3 ntu	0	0							
12/01/98	out	745	---									
12/02/98	out	942	10.32 ntu									
12/03/98	set	942	20.4 ntu									
12/04/98	check	1003	7.56 ntu	0	0	1	1	8		16		5
12/05/98	check	626	4.32 ntu	7	2	3	4	2		3		3
12/06/98	check	513	2.35 ntu	4	0	2		2		2		1
12/07/98	check	423	2.09 ntu	15	1	1	2	7		7		4
12/08/98	check	366	7.88 ntu	10	0			4		1		2
12/09/98	check	335	1.20 ntu	10	1	1	1			2		
12/10/98	check	298	1.04 ntu	10	7			1		4		
12/11/98	check	276	0.81 ntu	8	5	1		1		3		
12/12/98	check	266	1.21 ntu	12	3	1	1	1		2		
12/13/98	check	259	1.12 ntu	8	0	1				1		
12/14/98	check	483	3.22 ntu	12	62	2	1	9	3	9		
12/15/98	check	327	1.31 ntu	30	19	2		1		10		
12/16/98	check	290	1.13 ntu	10	7	1			3	2		
11/17/98	check	280	0.98 ntu	9	17				1			
12/18/98	check	266	0.72 ntu	12	3				1			
12/19/98	check	252	0.71 ntu	7	4							
12/20/98	check	242	0.68 ntu	8	9				2	1		
12/21/98	check	229	0.60 ntu	2	14				1	1		
12/22/98	check	232	0.82 ntu	1	3					1		
12/23/98	check	217	0.46 ntu	0	1							
12/24/98	check	>200	1.17 ntu	0	0							
12/25/98	not check	208										
12/26/98	check	205	0.80 ntu	0	6							
12/27/98	check	205	0.72 ntu	0	0							
12/28/98	check	199	0.51 ntu	2	3							
12/29/98	check	196	0.82 ntu	0	4		2					
12/30/98	check	190	0.52 ntu	3	2							
12/31/98	check	189	0.39 ntu	0	0							
01/01/99	not check	193	---									
01/02/99	check	---	0.54 ntu	3	1			1	1	1		
01/03/99	check	---	0.72 ntu	0	0			1		1		
01/04/99	check	---	0.40 ntu	2	2							
01/05/99	check	---	0.32 ntu	1	7							
01/06/99	check	---	1.11 ntu	0	3							
01/07/99	check	163	0.50 ntu	0	6							
01/08/99	check	160	0.38 ntu	0	55							
01/09/99	check	158	0.82 ntu	0	15							
01/10/99	check	155	0.78 ntu	0	20							
01/11/99	check	155	0.44 ntu	0	28							
01/12/99	check	155	0.37 ntu	0	31							
01/13/99	check	153	0.49 ntu	0	34							
01/14/99	check	153	0.40 ntu	0	13							
01/15/99	check	160	0.32 ntu	0	29							
01/16/99	check	219	1.48 ntu	1	261							
01/17/99	check	249	1.69 ntu	0	517							
01/18/99	check	458	6.32 ntu	0	678					1		
01/19/99	check	473	3.71 ntu	2	1501				1	4		
01/20/99	check	703	3.84 ntu	14	1344							
01/21/99	check	857	10.4 ntu	3	360							
01/22/99	check	576	3.47 ntu	6	551	2			1	9		
01/23/99	check	1714	28.5 ntu	0	59							
01/24/99	check	982	7.01 ntu	2	23							
01/25/99	check	769	4.04 ntu	15	320	2	2			2		
01/26/99	check	632	3.73 ntu	5	247					1		
01/27/99	check	533	3.14 ntu	1	250	2		1	1	1		
01/28/99	check	468	1.48 ntu	1	168	1				1		
01/29/99	check	418	1.74 ntu	0	141		1					
01/30/99	check	388	1.60 ntu	2	11							
01/31/99	check	370	1.52 ntu	0	0							
			TOTALS	338	6851	70	36	209	53	249	4	26

1/ BRT = below rating table
2/ 97 Brood Year
3/ 98 Brood Year

97byadlt.wk4

Figure 15. Length frequency distribution (mmFL) of 1997BY spring-run and fall-run chinook salmon emigration from Deer Creek, December 1997 - January 1999. N = 569 fish.



Literature Cited

California Department of Fish and Game. 1998. Report to Fish and Game Commission: A Status Review of the Spring-run Chinook Salmon, (*Oncorhynchus tshawytscha)*, is the Sacramento Candidate Species Report 98-01.

ATTACHMENT 1.

Files November 17, 1997

Mill Creek Adult Spring-Run Chinook Salmon Survey Results and Population Estimate for 1997.

On 1 January 1997 Clough Dam on Mill Creek was breeched by flood waters. Adult salmon migrating past Clough Dam no longer can be counted as they pass through the fish ladder. With unimpaired adult fish passage in lower Mill Creek, alternative methods of estimating adult spring-run chinook salmon populations were investigated this year. Snorkel surveys, redd distribution surveys and carcass counts were made August through October 1997 to determine the most feasible method that could be duplicated each year in Mill Creek.

From 11 August through 11 September 1997, Mill Creek was snorkel surveyed to count adult spring-run chinook salmon. This survey extended from 2.5 miles downstream of the Lassen National Park Boundary to the confluence of Rancheria Creek, a distance of approximately 31 miles. The survey routes were separated into 2 to 4 mile reaches with two to three snorkelers per reach. A four-mile reach from Rocky Gulch to Sooner Creek was not surveyed. Rain storms in late August caused the water to be too turbid to complete this section of Mill Creek prior to the onset of spawning. A total of 21 spring-run chinook salmon was observed (Table 1).

From 2 October through 8 October, a spawning distribution survey was made along the same reaches (including the Rocky Gulch to Sooner Place reach, which was not snorkeled). A total of 35 redds, four carcasses and 19 live salmon was observed (Table 1). Since spawning activity was not over yet (as evidenced by four live salmon not observed on redds), another spawning distribution survey was made by Lassen National Forest Fisheries personnel on 29 October (Table 1). A total of 100 redds, nine carcasses and one live salmon was observed.

TABLE 1. 1997 Spring-Run Salmon Survey in Mill Creek.

Section	Snorkel Survey Aug. 11 - Sept. 11	Carcass Survey Oct. 2 - Oct. 8			Carcass Survey Oct. 29		
		Redds	Carcass	Live	Redds	Carcass	Live
Above Hwy-36	0	not surveyed			0	0	0
Camp Tehama	0	0	0	0	1	0	0
Little Hole-in-the-Ground to Hole-in-the-Ground	0	4	0	1	7	0	0
Hole-in-the-Ground to Rocky Gulch	0	1	1	0	0	0	0
Rocky Gulch to Big Bend	8	6	0	3	7	0	0
Big Bend to Sooner Place	not surveyed	4	1	2	53	7	0
Sooner Place to Savercool	11	12	0	8	19	0	0
Savercool to Black Rock	0	1	0	1	1	1	0
Black Rock to Avery Place	2	7	2	4	12	1	1
Total	21	35	4	19	100	9	1

Snorkel Results

Using underwater observations, 21 adult spring-run salmon were counted in Mill Creek. It is not known, what percentage of the actual population count this represents. Visibility was poor due to the natural turbidity in Mill Creek. The turbidity in Mill Creek will make snorkeling observations impossible in most years. Snorkeling should be discounted as a reliable method of determining adult spring run population size in Mill Creek.

Carcass Results

Only thirteen adult spring-run carcasses were observed in the two complete spawning distribution surveys on Mill Creek. A tag and recapture survey on carcasses cannot be made on such a low number of carcasses. Therefore, carcass surveys should be discounted for making population estimates.

Redd Count Results

A total of 100 redds were counted within the spring-run salmon spawning habitat of Mill Creek. This count was made at the end of the spawning season, and since only one live salmon was observed it is assumed this count represents the maximum number of redds constructed. Two methods can be used in estimating a population estimate from this redd count. One method is to determine the redd to an adult count ratio of spring-run salmon in Deer Creek and multiply

it by the redd count in Mill Creek to determine the Mill Creek adult count. In Deer Creek a total of 275 redds was observed in a spawning census survey on 15 October 1999 (Table 2).

Calculation: 466 salmon/275 redds = 1.7 salmon/redd.
Mill Creek estimate = 100 redds x 1.7 salmon/redd = 170 salmon.

Another method is to determine the number of females per redd, and to determine the number of female salmon and then multiply the result by the male to female sex ratio:

100 redds x 1 female/redd x 2 = 200 salmon.

Therefore, using redd counts to indicate relative population size, between 170 and 200 spring-run salmon spawned in Mill Creek in 1997. Since spawning surveys are not done annually in Deer Creek, the later method of estimating spawners, yielding 200 salmon, will be used to estimate spawners in Mill Creek.

To determine relative grilse composition, the ratio of grilse to adults observed in Deer Creek snorkel surveys can be applied to Mill Creek. In Deer Cree, 47 of the 466 (10%) spring-run salmon observed were grilse. This gives an estimate of between 17 and 20 grilse salmon in Mill Creek.

I would like to acknowledge the assistance of the Lassen National Forest fish survey crew. Without their participation neither the Deer Creek spawning distribution survey nor the last Mill Creek spawner distribution survey would have been made and the Department would be unable to make a population estimate on Mill Creek spring-run salmon for 1997.

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Associate Biologist (Marine/Fisheries

ATTACHMENT 3. Spring-run chinook salmon spawning distribution in Deer Creek, 1997.

Date: 15 October 1997

Reach	Redds	Practice redds	Carcasses	Salmon on redds	Salmon act on redds
Upper Falls to Potato Patch	63	1	9	3	4
Potato Patch to Red Bridge	30	5	5	2	0
Red Bridge to Lower Falls	14	1	2	0	0
Lower Falls to A-line	94	5	6	9	3
A-line to Wilson Cove	7	1	7	1	2
Wilson Cove to Polk Springs	1	0	2	0	0
Polk Springs to Murphy Trail	26	0	2	1	0
Murphy Trail to Beaver Creek	40	15	10	3	4
Beaver Creek to Ponderosa Way	0	0	0	0	0
Ponderosa Way to Homestead	0	0	0	0	0
Homestead to Trail 2E17	0	0	0	0	0
Total	275	28	43	19	13

Surveys conducted by Lassen National Forest.