

1996 Progress Report

Anadromous Salmonid Escapement and Downstream Migration Studies in Prairie Creek, California, 1995-1996

By

Dr. Terry Roelofs
and Bernard Klatte

Humboldt State University

Arcata, California

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ABSTRACT

Humboldt State University and Pacific Coast Fish, Wildlife and Wetlands Restoration Association, under a Memorandum of Agreement with the California Department of Transportation Compliance Plan under Regional Water Quality Control Board Order 90-8, monitored the migration of adult and juvenile salmonids in Prairie Creek, an old-growth coastal stream, located in northern California. Anadromous salmonids entering and spawning in Prairie Creek were examined over a 3-month period starting in December of 1995 and ending in February of 1996. A total of 221 live fish were captured using a weir and fish trap placed 6 miles above the creek mouth. Species composition, numbers, size of fish, run timing, and sex ratios were recorded. Spawning and carcass surveys were conducted over the study period. A total of 288 individual chinook and coho salmon redds was measured within the Redwood National Park 7 mile index reach (Streelow Creek to Good Creek). Coded wire tags were recovered from chinook salmon carcass during spawning surveys. Juvenile migrating salmonids were captured using an EG Solution rotary screw trap placed 5 miles above the creek mouth. This trap was operated from 13 March 1996 to 10 July 1996. Total captures to date included 26,333 chinook young of the year (YOY); 25,492 coho YOY; 2,117 coho yearlings; 207 trout YOY; 997 trout yearlings; and 613 coastal cutthroat trout. Weekly trapping efficiencies were conducted with juvenile chinook. The rotary screw trap total mortality rate calculated over the trapping period was less than 1 %.

INTRODUCTION

Prairie Creek is a tributary to Redwood Creek in Humboldt County, California. It is an important spawning and rearing area for anadromous salmonids, specifically chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), steelhead trout (*O. mykiss*), and coastal cutthroat trout (*O. clarki clarki*). The recent decline in numbers of anadromous species has increased the potential for these species to become listed in California under both federal and state endangered species laws. In October 1989, a storm event generated numerous mud flows from a highway construction alignment project within the Prairie Creek Basin (Welsh and Olliver 1992). Several hundred tons of sediment eroded from the project and were deposited into the Prairie Creek Basin. In anticipation of damage to fish and other aquatic resources, the California Department of Transportation (Caltrans) proposed monitoring to study the impacts and persistence of this fine sediment (Myers et al. 1994). Caltrans also contracted the Pacific Coast Fish, Wildlife and Wetlands Restoration Association (PCFWWRA) to rear and release salmonids in Prairie Creek in 1990. Efforts to supplement the salmon populations using streamside incubation and rearing facilities ended in 1995 (PCFWWRA 1995). Currently, natural spawning success and rearing within the Prairie Creek Basin is being evaluated. Here we present the results of the 1995-1996 field study of the anadromous salmonids of Prairie Creek.

Objectives

In this study we proposed to quantify the impacts of a human-caused sedimentation event on salmonids in a coastal old-growth redwood forest. Our objectives were as follows:

- Determine the species composition of the anadromous fish runs,
- estimate the anadromous salmon escapements,
- determine run-timing for salmon,
- determine the age and size of salmon,
- describe sex ratios,
- document locations and success of spawning activities, and
- estimate the juvenile salmonid outmigration.

STUDY AREA

The Prairie Creek Basin lies within the Coast Redwood Belt of the Humid Transition Life Zone near the town of Orick, Humboldt County, California (Figure 1). Prairie Creek, tributary to Redwood Creek, is 14 miles long and drains an area of 30 mi². The altitude ranges from sea level to 1000 ft and the rainfall of the area averages about 50 inches annually (Briggs 1953). The Prairie Creek channel originates at JSGS Fern Canyon, CA quadrangle T12N R1E section 10, and flows south along U.S. Highway 101 through private agriculture and old-growth forests in Prairie Creek Redwoods State Park and Redwood National Park (RNP). The stream enters Redwood Creek 3.5 miles from the Pacific Ocean at USGS Orick, CA quadrangle T1 IN R1E section 34. The study was conducted between the confluence of Streelow Creek and Good Creek, within the RNP 7 mile index reach (Figure 2).

METHODS and MATERIALS

Upstream Migration

A weir and fish trap were placed in Prairie Creek 250 feet above the confluence of Streelow Creek to catch upstream migrating salmon. The trap was operated from 9 December to 29 December 1995. A 10-12 year storm event occurred on 29-30 December 1995 which devastated the trapping site (R. Klein pers. comm.). The weir and trap were relocated upstream to Elk Prairie Campground, campsite 65, and were operated between 2 January 1996 and 11 February 1996. The weir spanned the entire width of the creek with the trap located in the thalweg.

The trap was 3.5 ft. wide by 4.5 ft. long by 3.5 ft. high, constructed of marine plywood flooring with sides and top formed by a combination of chicken wire and wood. Steel weir panels used were 3.5 ft high by 6 ft. long and placed end to end in a 'V' configuration leading upstream, directing fish into the trap (CDFG 1992). The trap was operated and monitored 24 hours per day, 7 days per week except when flows prevented safe operation or were too low for adult migration. Each salmon captured was identified to species, sexed, and measured to the nearest cm fork length (FL). A scale sample was taken from the left side slightly above the lateral line and posterior to the insertion of the dorsal fin. All fish were tagged with non-reward blue spaghetti tags and released upstream in a side-eddy.

Spawning and Carcass Surveys

Spawning and salmon carcass surveys were conducted within the RNP 7 mile index reach in order to identify and measure salmonid redds and recover tagged and untagged fish. Two person crews surveyed the creek on a weekly basis, unless poor visibility or high stream discharge prevented surveying. All new redds were measured (width and length), recorded, and marked with pink surveyors flagging. All live fish sighted were identified by sex and species if possible. Scales were removed from all untagged carcasses recovered.

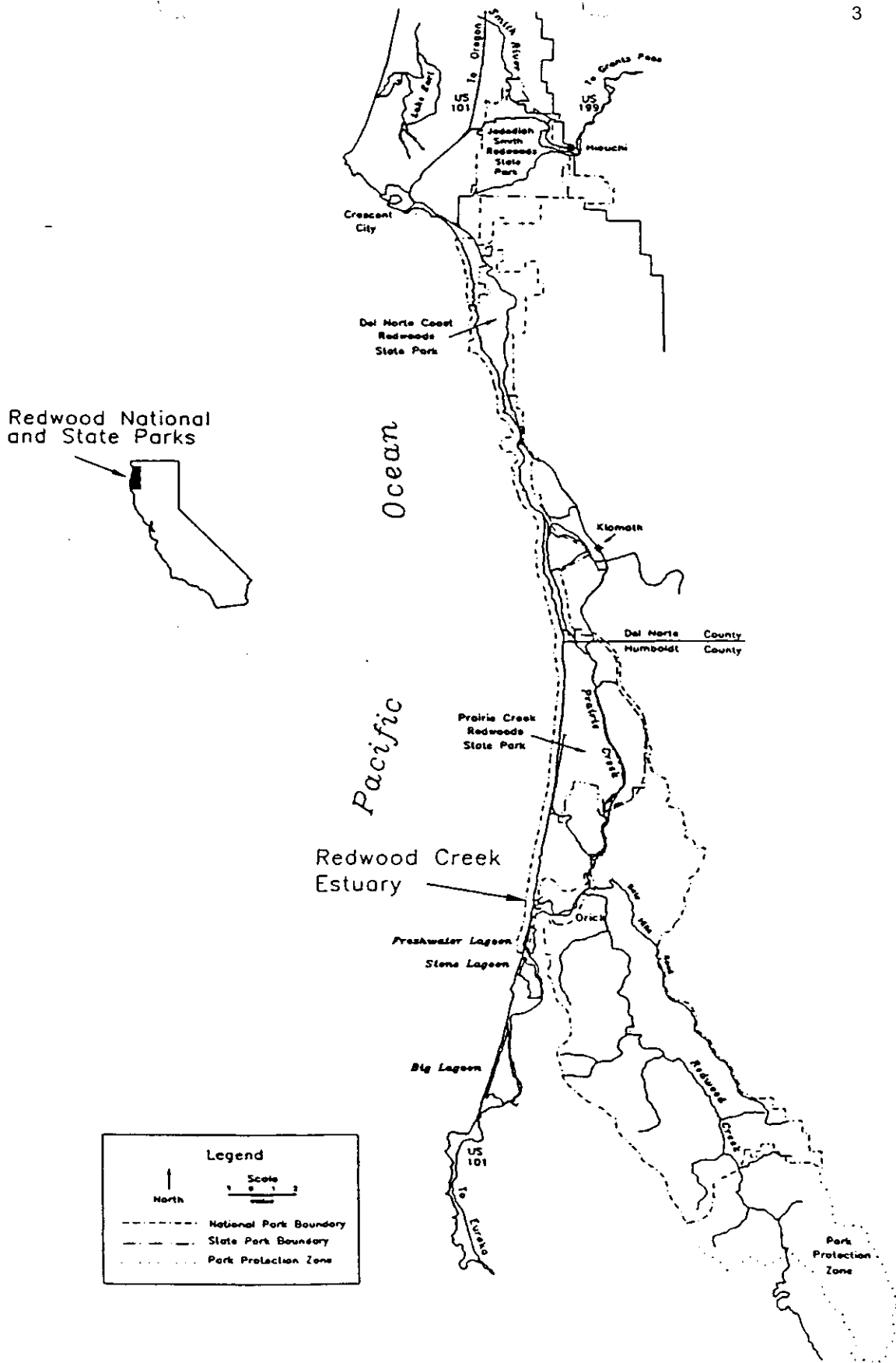


Figure 1. Location map of Prairie Creek, Redwood National and State Park, Humboldt County, California.

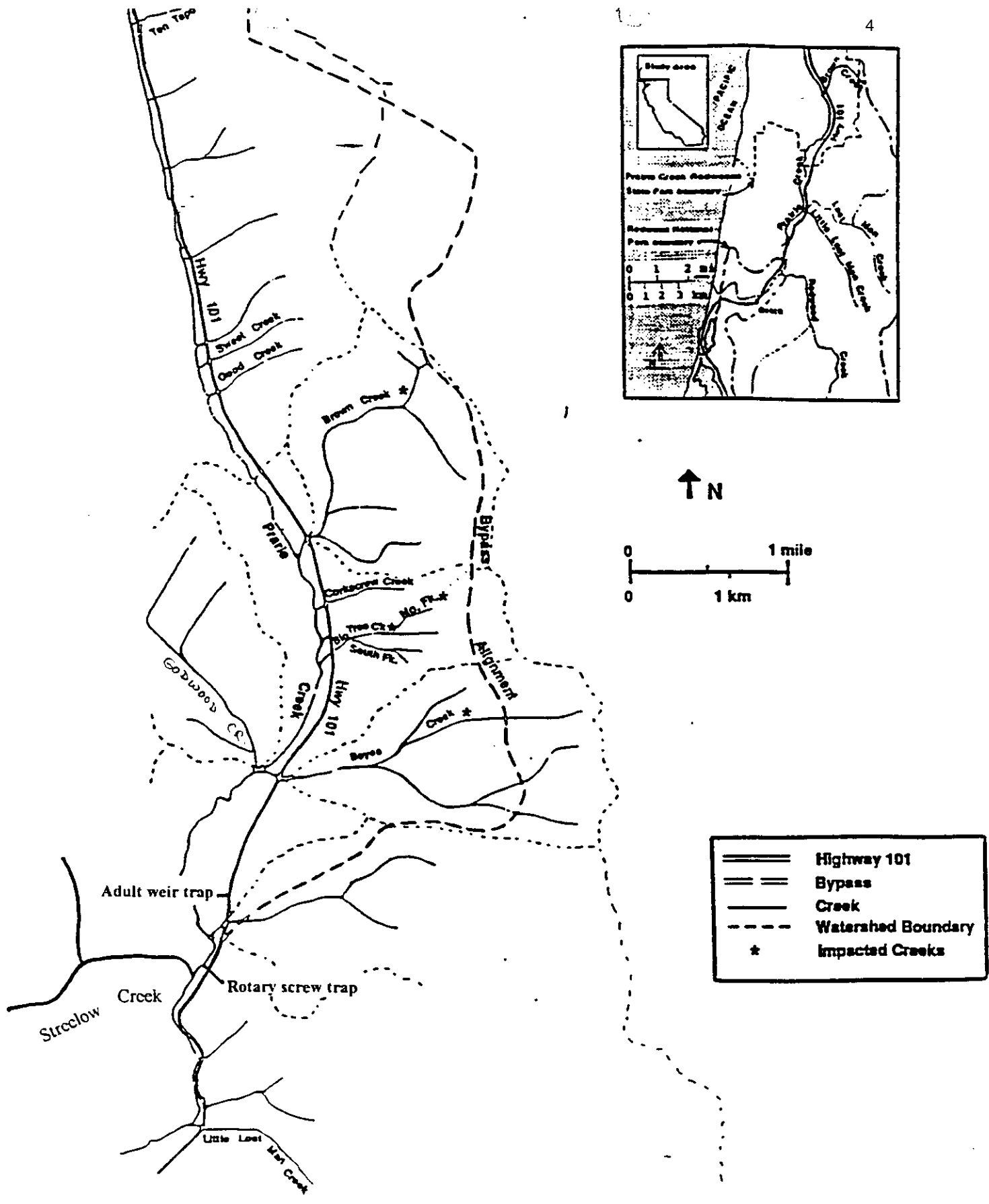


Figure 2. Location map of study site showing trap locations and impacted creeks in Prairie Creek Basin. Redwood National and State Parks. Humboldt County, California (Welsh and Olliver 1992).

Heads from adipose fin clipped carcasses were taken to obtain coded-wire tags and sent to the California Department of Fish and Game (CDFG) in Arcata, California for analysis.

Downstream Migration

A United States Fish and Wildlife Service (USFWS) 5-foot EG Solution rotary screw trap was used for the assessment of emigrating juvenile salmonids and other species of Prairie Creek (Figure 3). The rotary screw trap was comprised of a 5-foot diameter cone with a spiral vein supported by foam filled aluminum pontoons. The trap was placed 500 feet above the confluence of Streeflow Creek (Figure 2) and fished at a depth of 2.5 feet throughout the trapping period. As water pushes the spiral vein the cone spins, entrapping emigrating fish and forcing them into the live holding box located at the rear of the trap (Shaw and Jackson 1994). The trap was operated 24 hours per day, 7 days per week, from 13 March to 10 July 1996. The live holding box was checked daily and a simple random sample (SRS) of size $n=30$ fish was taken for chinook young-of-the-year (YOY) salmon. Fork length and weight were recorded for each individual. Also, samples of size $n=30$ were taken for all other age and species offish present. All remaining fish were identified and counted. The separation of age was based on fork length and appearance. Fish were anesthetized with Tricaine methanesulfonate (MS-222) to facilitate handling. Each fish was measured to the nearest millimeter and weighed to the nearest 0.10 gram.

Trap efficiencies were conducted weekly, when possible, to estimate the numbers of chinook juveniles emigrating from above the trapping site in Prairie Creek. This estimate does not take into account the level of production downstream from the trap or those fish remaining in the basin beyond the trapping season. Juvenile chinook salmon were marked weekly with a Bismark Brown Y biological stain solution. The numbers marked varied due to the fluctuations in downstream migration. At least 200 or more fish were used for the efficiency tests. Bismark Brown Y (2 grams) was dissolved in 30 gallons of water and the juvenile chinook were held in this solution for 30 minutes. A compressed air tank, regulator, and air stones were used to aerate the solution (Shaw and Jackson 1994). Marked fish were transported upstream from the rotary screw trap 0.3 miles and released in a deep pool containing large woody debris for refuge. A control group of 25 marked and 25 unmarked fish was held instream in a 2.5 ft. by 4 ft. by 3 ft. live car to determine marking mortality and the duration of the stain mark. The marked chinook retained an orange coloration for 3-4 days. Recaptures were recorded and weekly estimates of outmigrant chinook were calculated using the equations of Shaw and Jackson (1994) in Table 1.

Table 1. Equations used to estimate the number of emigrating juvenile salmonids each week in Prairie Creek during 1996 (Shaw and Jackson 1994).

1. $\% MM = \% CM - \% CUM$, where
%MM = percent marked mortalities
%CM = percent control marked mortalities
%CUM = percent control unmarked mortalities

 2. $TMRS = \%MM \times MR$, where
TMRS = total marked released survival
%MM = percent marked mortalities
MR = marked released

 3. $TE = MR/TMRS$, where
TE = trap efficiency
TMRS = total marked released survival
MR = marked released

 4. $EWC = 1/TE \times (TWC)$, where
EWC = expanded weekly catch
TE = trap efficiency
TWC = total weekly catch
-

Trapping Mortality

Percent trapping mortality was calculated for all salmonids captured over the entire trapping period. An artificial refugia was created with rocks, mop heads and a small root was placed in the live box to minimize predation.

Summer Fish Survey

Juvenile chinook salmon surveys were conducted in Prairie Creek by two teams of divers between the confluence of Streetlow Creek and Godwood Creek on 8 July 1996. Visual observations were made by divers starting downstream and moving upstream in each habitat unit. Divers recorded all juvenile chinook present after reaching the upstream end of each habitat unit selected. Only those units which contained depth over 1 foot were selected. No coho estimates were made during these dives.

Water Temperature and Stream Discharge

Water temperature and stream discharge data were measured at the United States Geological Survey (USGS) stream gaging station, located at the Wolf Creek Bridge in the Redwood National Park. RNP staff biologists provided this information for the study period.

Temperatures were recorded every 40 seconds by a HOBOTEMP™ temperature monitor placed inside a protective sleeve in Prairie Creek. Discharge (Q) was calculated using a calibration curve generated by RNP from water stage heights recorded at the USGS gaging station.

Fry Emergence

Spawning and carcass surveys helped identify redds with actively spawning salmon. From these redds, 5 were selected for a survival to emergence study (HSU senior thesis project by Michael Sparkman). Five emergent fry traps used in Prairie Creek by Coey (1990, 1991) were placed over the selected redds 10-30 days before expected emergence (17 April 1996). Each trap frame was 8 ft long by 4 ft wide, constructed from 0.5 in. diameter steel rebar and covered with 0.165 in. polyethylene netting. Each trap was anchored to the streambed using hooked rebar stakes. Streambed material was removed around the margin of the trap frame to a depth of approximately 8-15 in. to place the net apron. The apron was buried in place with gravel/cobbles to prevent lateral migration of fry beyond the trap perimeter. The placement, maintenance, and operation of the traps was in accordance with the methods of Olson (1996), and Coey (1994). Traps were inspected and maintained every two days until emergence occurred, then monitored daily. All captured fry were anesthetized with Tricaine methanesulfonate (MS-222) to facilitate handling. Each fish was measured to the nearest millimeter and released downstream upon recovery. Each trap was fished until 10 'zero catch' days were recorded after the expected emergence date.

Permeability

Early in July, standpipe inflow measurements were taken in the egg pocket and tailspill of each trapped redd, 10 ft. adjacent to each redd, and in 5 untrapped control redds. The criteria for selecting the control redds were that each redd must have positive identification of spawning fish from previous spawning surveys and the same habitat type and water depths as trapped redds. Also, each control redd must be excavated by the salmon within 10 days of the trapped redds excavation date. The substrate depth selected for permeability measurements corresponded to Briggs (1953) average depth of egg deposition in redds of chinook (12 in.) and coho (8 in.) salmon. Three measurements were taken and averaged at each specific location and the time for evacuating the water within the pipe for each measurement was held constant. A graph of permeability (cm/hr) versus standpipe inflow rate (ml/sec) was used to convert inflow rate to permeability. The permeability rate was then standardized to a stream temperature of 10°C using the equation $K_{10} = XK_T$, where K_T is the permeability value and X is the viscosity correction factor for water temperature (Barnard and McBain 1994). Survival to emergence was estimated using Chapman's (1988) survival index for chinook salmon.

Upstream Migration

Fall-run chinook were captured the same day that the weir trap was in place, 9 December 1995. The number of fish trapped increased through the month and into January 1996 (Figure 3). A total of 106 fish, 30 females (28%) and 76 males (62% male) were caught. Average fork length for chinook females was 89 cm and 75 cm for males. A total of 115 coho salmon were trapped, 66 females (60%) and 49 males (40%) (Figure 3). Average fork length for both female and male coho salmon was 67 cm.

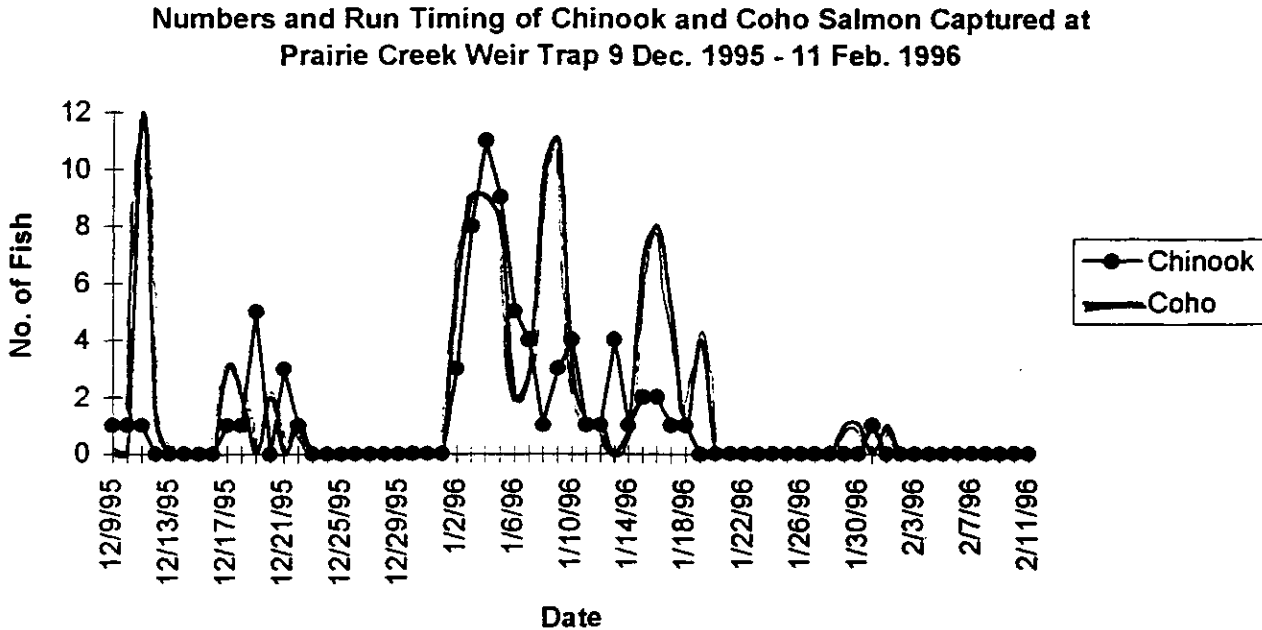


Figure 3. Adult salmon captured in Prairie Creek weir trap.

Spawning and Carcass Surveys

Spawning surveys

Measured redds that were greater or equal to 1:5 m long by 1.0 m wide were considered to be excavated by a coho or chinook salmon in Prairie Creek (Briggs, 1953; Bjornn and Reiser, 1991; M. Farro, pers. comm. 1996). A total of 149 redds was measured during the month of December 1995. Of these 149 redds, 54 had adult fish present at the time of the survey. Chinook salmon account for 85 % (46 fish) of these fish and coho salmon contributed 15 % (8 fish). Applying these percentages to the 149 redds measured gives 127 chinook redds and 22 coho redds.

A total of 71 new salmonid redds were measured during the month of January 1996. Of these 71 redds, 30 had adult fish present at the time of the survey. Chinook salmon accounted for 60 % (18 fish) of these fish and coho salmon contributed 40 % (12 fish). Applying these percentages to the 71 redds measured gives 43 chinook redds and 28 coho redds.

A total of 59 new salmonid redds were measured during the month of February 1996. Of these 71 redds, 7 had adult fish present at the time of the survey. Chinook salmon accounted for 43 % (3 fish) of these fish and coho salmon contributed 57 % (4 fish). Applying these percentages to the 149 redds measured gives 25 chinook redds and 34 coho redds.

Overall, chinook salmon accounted for 70 % (195) of the 279 redds observed in Prairie Creek.

Carcass Survey

Table 2. Carcass recovery results from 56 surveys conducted in Prairie Creek (December 1995-February 1996).

	Chinook salmon		Coho salmon		Unidentified	
	n	ave.ln.	n	ave.ln.	n	ave.ln.
Female	101	86 cm	53	65 cm	-	-
Male	115	86 cm	45	66 cm	-	-
Unknown	-	-	-	-	54	71

*Floy tags recovered from surveys = 27 tags out of 190 tagged fish.

* Adipose fin clipped fish recovered = 24 with an average length of 74 cm (CDFG still reading tags).

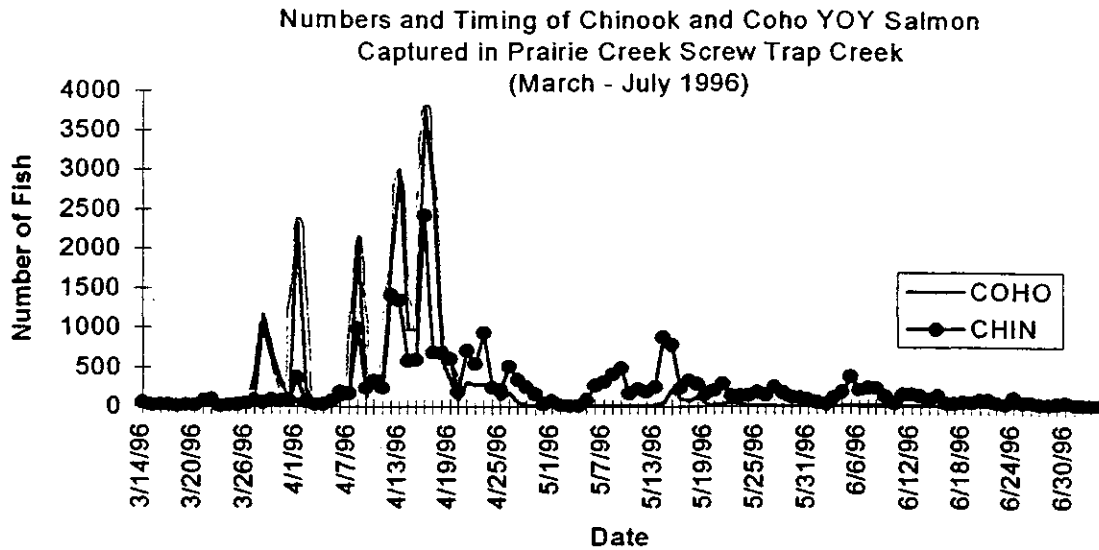
Downstream migration

The rotary screw trap was operated 24-hours per day, between 13 March and 10 July 1996 for a total of 89 days. Chinook age 0+ or YOY constitute the bulk of the catch throughout the sampling period. Other salmonids captured included coho YOY, coho smolts, trout YOY, trout parr, cutthroat trout and steelhead smolts (Table 3). Nongame species captured include sculpin, lampreys, and salamanders.

Table 3. Prairie Creek rotary screw trap salmonid catch summary for 1996.

	Chinook YOY	Coho YOY	Coho Smolt	Trout YOY	Trout Parr	Cutthroat Trout	Trap Mortality
Totals	26,333	25,492	2,117	207	997	613	427*

*=($<1\%$ mortality)

**Figure 4.** Juvenile salmon captured in Prairie Creek rotary screw trap.

The peak of YOY chinook captured occurred on 16 April (2,417) with numbers declining to 4 by July (Figure 4). Juvenile chinook YOY fork length (FL) ranged from 29 mm to 84 mm (Figure 5). Weekly trapping efficiency results conducted for chinook YOY are listed in Table 4. Juvenile chinook age 1+ or yearling smolts, were not captured. It is not known to what extent juvenile chinook remain in Prairie Creek over the winter and leave as yearlings. Length frequency and weight data collected from the 30 fish sample were used to generate a log transformed length-weight relationship (Figure 6). Coho salmon captured in the rotary screw trap consisted of 25,492 YOY (Figure 4) and 2,117 smolts. The peak of capture of 3,770 YOY occurred on 13 April and 158 smolts on 15 May. Coho YOY FL ranged from 32 mm to 63 mm (Figure 7).

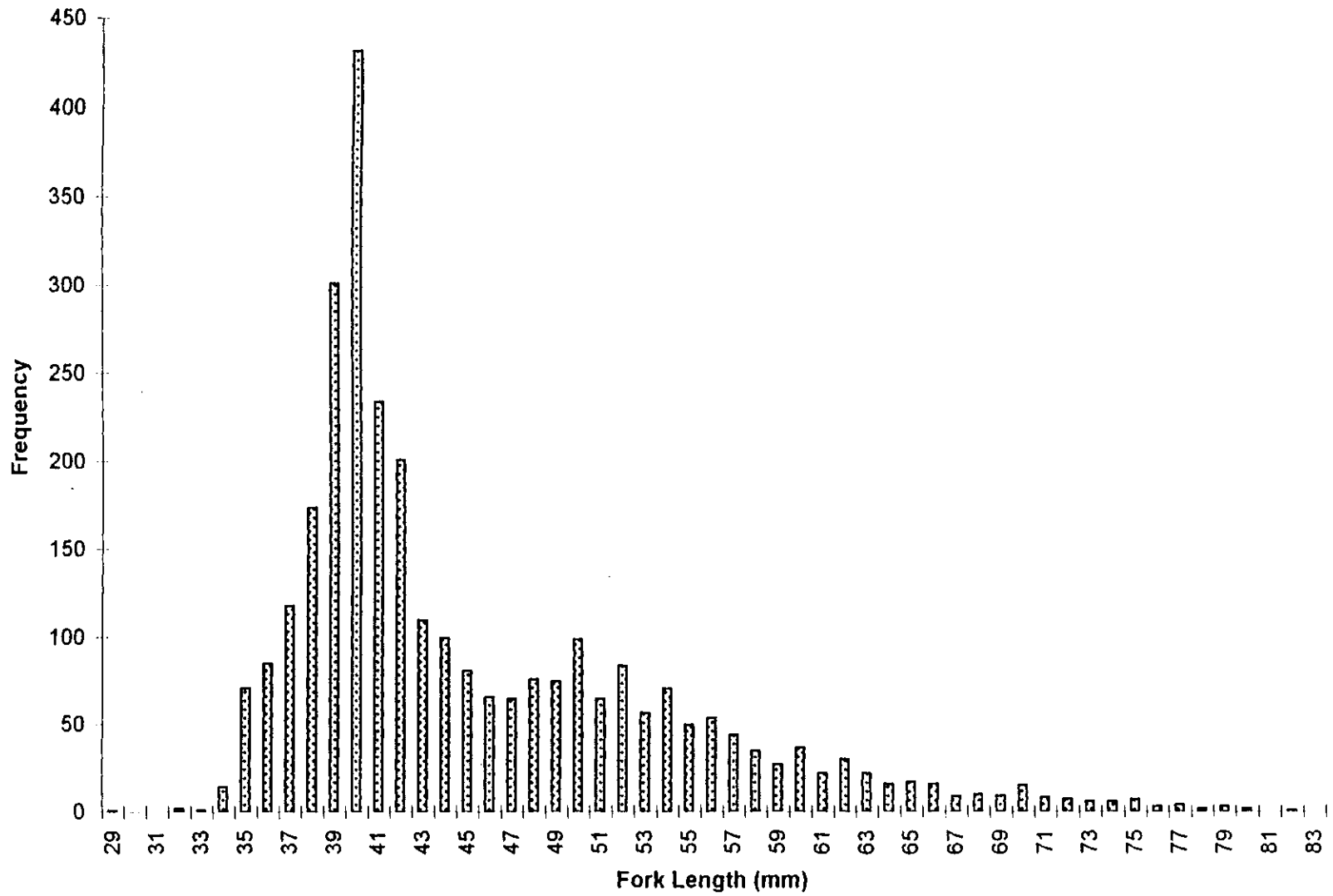


Figure 5. Length frequency histogram for Chinook YOY captured in screw trap, 13 March - 10 July 1996, Prairie Creek, California.

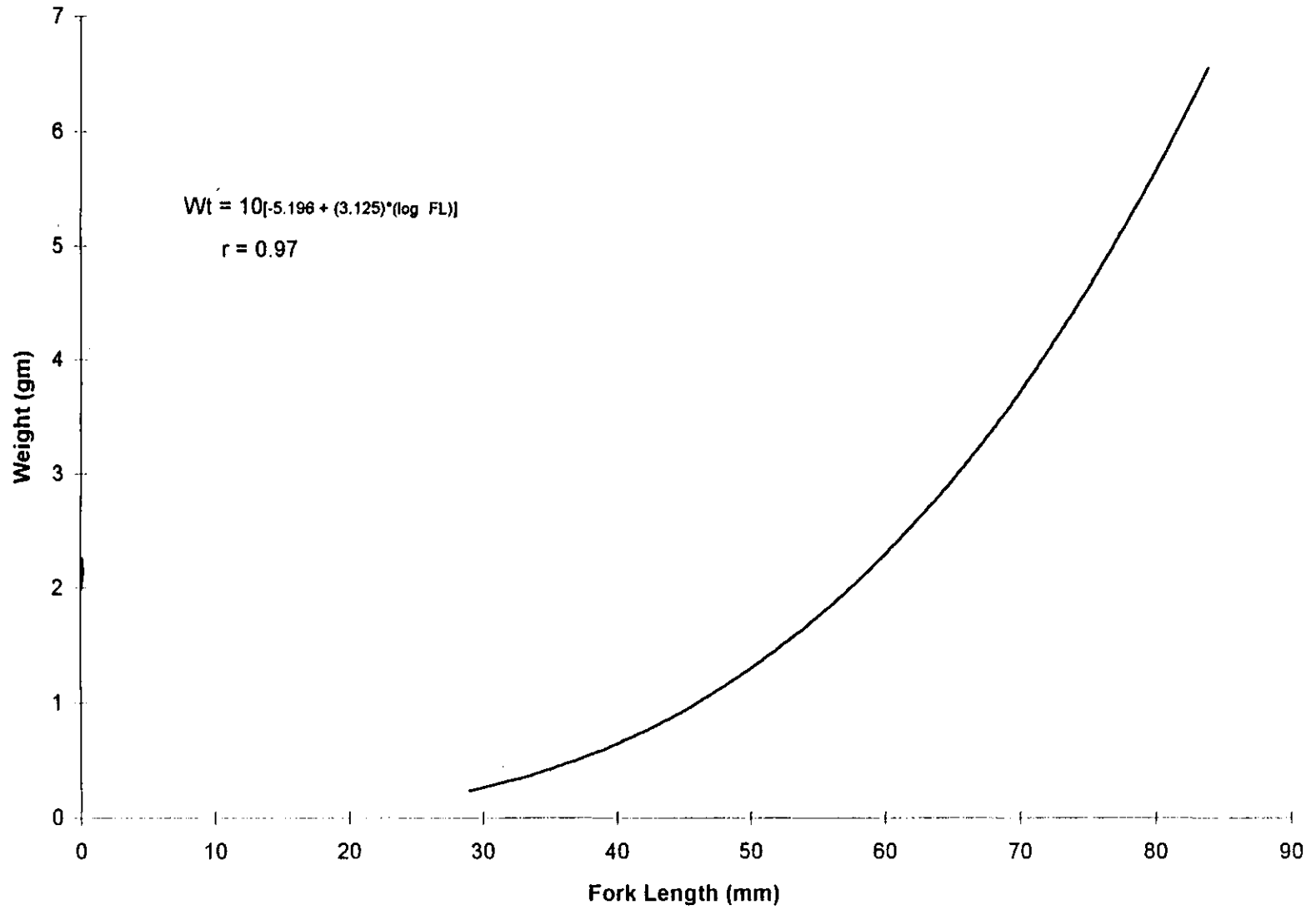


Figure 6. Prairie Creek chinook YOY log transformed length-weight relationship for 1996 trapping season.

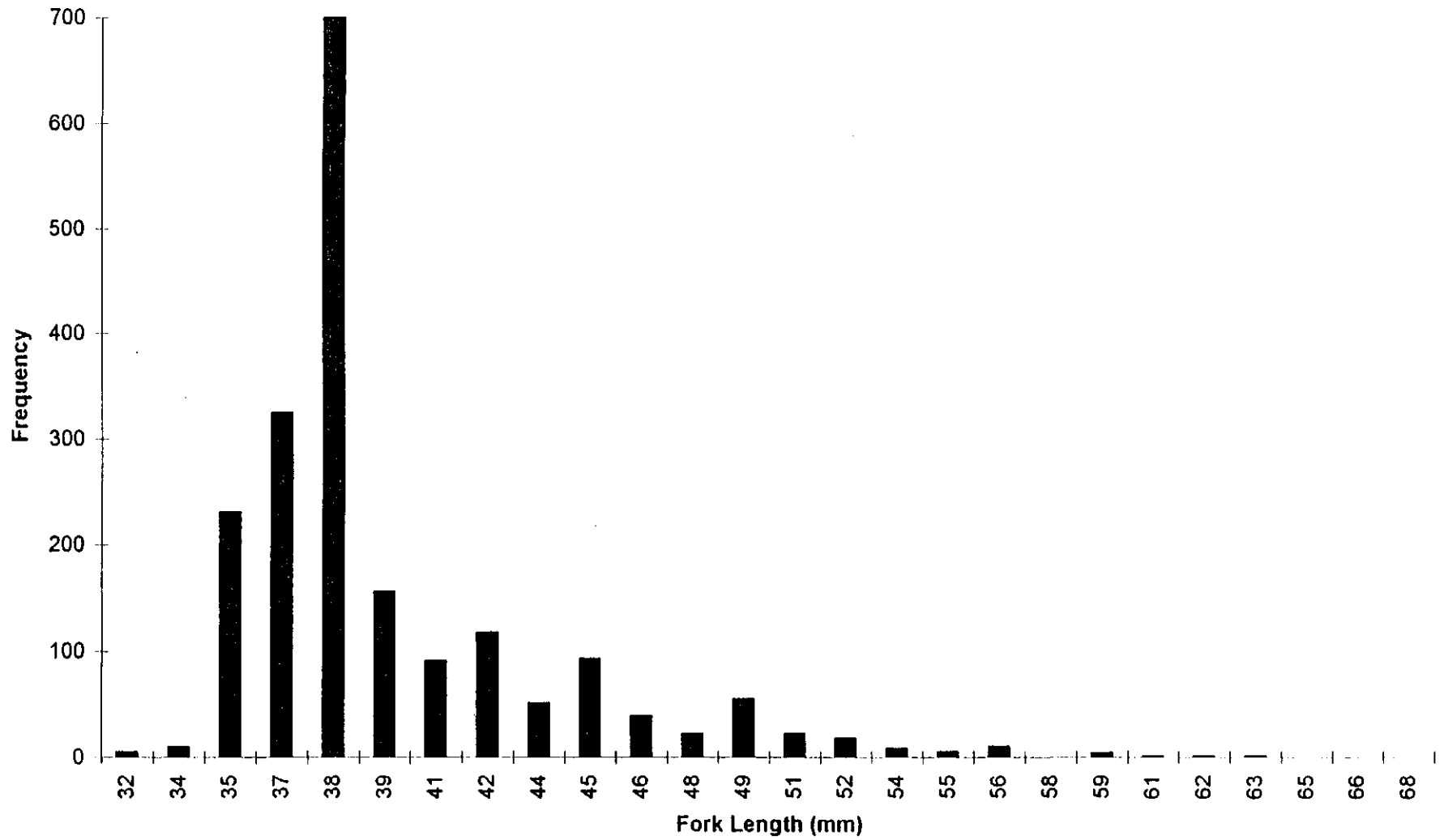


Figure 7. Length frequency histogram for coho YOY captured in screw trap, 13 March -10 July 1196, Prairie Creek, California.

Table 4. Prairie Creek rotary screw trap (weekly) efficiency test results.

Week ending	Chinook YOY Total Catch	No. Marked and released	No. Captured with marks	Trap Efficiency	Expanded Weekly Estimate
16 March 1996	58		-		58+
23 March 1996	266	-	--	-	266+
30 March 1996	388	-	-	-	388+
6 April 1996	803	-	-	-	803+
13 April 1996	4738	-	-	-	4738+
20 April 1996	5757	-	-	-	5757+
27 April 1996	3512	700	0	0%	700
4 May 1996	531	-	-	-	531+
11 May 1996	1961	461	86	18.7%	2412
18 May 1996	2959	250	22	8.8%	3245
25 May 1996	1258	358	206	27.5%	1735
1 June 1996	960	300	213	71%	3310
8 June 1996	1393	300	179	60%	3483
15 June 1996	870	135	73	54.1%	1895
22 June 1996	859	-	-	-	859+
totals	26333				30180

- efficiency test not conducted

Of the 55,759 salmonids captured, a total of 427 (0.76%) mortalities were observed. The highest daily mortality (96 fish) occurred when a live beaver was trapped in the live box and could not escape. The majority of mortalities observed were regurgitated chinook YOY fish from predation in the live box.

Direct Observation Fish Surveys

A total of 190 juvenile chinook were observed in 24 diveable habitat units sampled on 8 July 1996. A juvenile coho salmon estimate will be calculated in October, 1996.

Water Temperature and Stream Discharge

Water temperatures in Prairie Creek follow a relatively constant seasonal pattern (Figure 8). Fluctuations in mean monthly temperatures did not exceed more than 2° to 3° C. The overall mean temperature was 9.2° C.

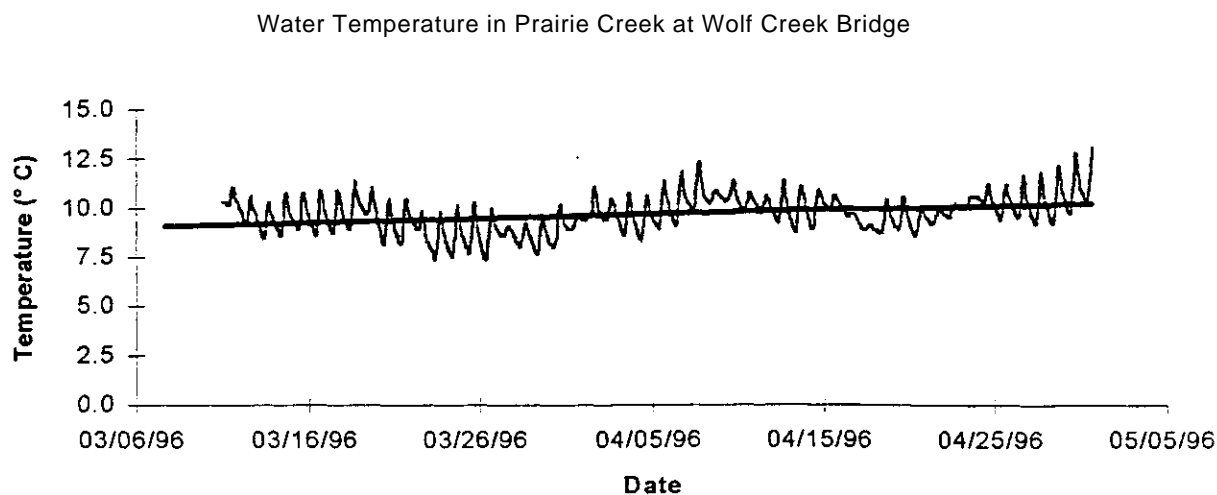


Figure 8. Water temperature in Prairie Creek, March - May 1996.

Stream Discharge - (In preparation).

Fry Emergence and Substrate Permeability

Preliminary studies on the effect of sediments on salmonid fry emergence in Prairie Creek were conducted by Coey (1994). Results from Coey suggests that fine sediments were responsible for causing 100% mortality in 6 of the 10 redds trapped. Sparkman (1996) found 100% mortality in 3 of the 5 redds trapped in 1996 (Table 5). Fry trap 1 captured 223 chinook, trap 2 captured three coho fry, and traps 3, 4, and 5 captured zero fry.

Table 5. Numbers of fry trapped and permeability measurements of 5 trapped redds, 10 ft. adjacent to trapped redds, and 5 control redds in Prairie Creek, California, with survival to emergence percent in relation to gravel permeability (Chapman 1988).

Trap	Fry Trapped (n)	Location measurement taken in Redd	Trapped Redds (cm/hr)	Adjacent to Redds (cm/hr)	Control Redds (cm/hr)	Percent Survival to Emergence based on Permeability Value (Chapman 1988)
1	223	Egg Pocket	10,000	530	470	52%
	-	Tailspill	1,400	-	840	56%
2*	3	Egg Pocket	< 100	1,800	2,400	0%
	-	Tailspill	< 100	-	2,200	0%
3	0	Egg Pocket	140	<100	1,400	0%
	-	Tailspill	250	-	810	0%
4	0	Egg Pocket	1,900	2,700	< 100	21%
	-	Tailspill	290	-	< 100	0%
5	0	Egg Pocket	1,400	110	1,700	19%
	-	Tailspill	2,200	-	1,500	22%

* Trapped redd 2 excavated by coho salmon, all others by chinook salmon.

Note: Permeability's above 10,000 cm/hr result in steelhead emergence survival > 85% (Barnard and McBain 1994).

DISCUSSION

Upstream Migration

Prior to the 1995-1996 adult trapping season, adult salmonids were trapped in Prairie Creek to supplement the salmon populations using streamside incubation and rearing facilities. The weir trap was operated during permissible flows until an adequate number of adults were captured to artificially spawn. Trapping continued, intermittently, to determine the run size and timing until the goal of 100,000 chinook eggs were acquired

Spawning and Carcass surveys

RNP staff conducted annual spawning and carcass surveys in established index reaches of several streams within the park boundaries, including 7 miles on Prairie Creek. Over the past 5 years, RNP's best effort was during the 1992-1993 spawning season where RNP staff measured 167 redds, recovered 87 chinook carcasses, and 18 coho carcasses. No surveys were conducted in Prairie Creek for the 1994-1995 spawning season. The number of carcasses and redds measured during the 1995-1996 season in Prairie Creek has been the highest recorded. It is not known if these numbers are due to increased effort, a strong year class, or a good year for spawning due to higher winter flows.

Downstream Migration

In April 1994, PCFWWRA installed 2 pipe traps to capture downstream migrating juvenile salmonids in Prairie Creek. The traps were monitored daily through 10 July 1994 and every other day to 1 August 1994. The traps were not operated on four days during this period due to high flows. The actual numbers trapped were 3,346 chinook YOY, 123 coho YOY, 421 coho smolts, 391 trout YOY, 81 trout smolt, 48 steelhead smolt and 107 cutthroat trout. Trap efficiencies were determined using a fin clip on chinook YOY and the total number of migrating chinook salmon was estimated to be 13,466. The 1996 downstream migration was monitored using a rotary screw trap. This screw trap was operated from 13 March to 10 July 1996 trapping 26,333 chinook YOY (almost double the 1994 estimated migration).

Fry Emergence and Permeability

Limited inferences can be made from emergence and permeability studies due to the small sample size. Also 3 of 5 trapped redds had no fry emergence. Laboratory studies conducted by McCuddin (1977) reveal a positive correlation between survival and permeability for salmonids ($r = 0.85$ for chinook salmon). The comparison of Chapman's (1988) survival index for chinook salmon with Prairie Creek permeability measurements indicates that fine sediments continue to be a limiting factor for egg incubation and fry emergence in Prairie Creek.

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