UPSTREAM MIGRATION AND SPAWNING OF FALL RUN CHINOOK SALMON IN THE MOKELUMNE RIVER, 1995, WITH NOTES ON STEELHEAD SPAWNING, WINTER 1996

by

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EXECUTIVE SUMMARY

- The 1995 chinook fall run began 2-3 weeks earlier than in previous years and was underway by September 1 when monitoring began. Peaks occurred in late September to early November, and declined through the first part of December.

- A total of 5,417 fall run chinook salmon (168% of the historical average of 3,218) were counted passing Woodbridge Dam in 1995 by video monitoring, trapping, and rescue from the riprap below Woodbridge Dam. Of the 5,417 salmon, 46% of these salmon were adult females, 39% were adult males, 2% were grilse females, and 13% were grilse males.

- A total of 3,323 fall run chinook salmon (53% females) entered the Mokelumne River Fish Installation in 1995, with 2,094 able to spawn in the river. The average size of adult salmon was 6 cm greater than any previously surveyed run.

- There were 888 total fall run chinook salmon redds recorded in the Lower Mokelumne River in 1995 between Camanche Dam and Elliott Road. The highest weekly redd count was 147 on November 14, the same week as the 1994 peak spawning, but earlier than 1992 & 1993 weeks. The last redd was recorded on January 17, 1996.

- Measured depth, flow-velocity, substrate, and redd area were within known ranges of preference regardless of stream flow. The slightly larger mean redd size (+4 sq/ft) corresponds with the larger average adult salmon size.

- More than half of the spawning in all reaches was associated with berms. There was no correlation found between percent of redds on berms and streamflow between 160 cfs and 400 cfs.

- Large woody debris (LWD) remains an important component of spawning habitat in the Mokelumne River. As in 1994, the percentage of 1995 LWD associated redds increased in a downstream direction. In 1994 LWD association was greatest at 1.6-2.0 ft, while in 1995 it was greatest at depths of 0.6 ft to 1.0 ft.

- Enhancement gravel placed in the Mokelumne River Day Use Area by EBMUD has been used increasingly each year by chinook salmon and steelhead for spawning, though full use does not occur until the second year following enhancement. Gravel enhancement at Alder Island was deeply scoured by flood flows during spring 1995.

- River water temperatures during spawning were higher than in any year since 1990.

- A total of 256 redds were constructed in the Mokelumne River Day Use Area and were subject to wading from anglers after fishing season re-opened on January 1, 1996.

- There were 120 redds (13.5 %) that were total superimpositions on egg-pockets of existing redds. Superimposition in enhancement gravel areas ranged from 67% to 77%.

- Steelhead were observed migrating past Woodbridge Dam at the start of video monitoring in September. Steelhead were not observed spawning until December. The most steelhead redds seen were constructed in mid-January. The steelhead redd survey was terminated on January 28, 1996 when a large increase in Camanche flows made further study impossible.

INTRODUCTION

The East Bay Municipal Utility District (EBMUD) annually monitors the fall spawning run of chinook salmon (*Oncorhynchus tschawytscha*) in the Lower Mokelumne River. This survey is conducted concurrently with video monitoring and/or trapping of migrating fall run salmon downstream of the spawning reach at Woodbridge Dam (Figure 1). Video monitoring in 1995 was conducted by Natural Resources Scientists (NRS) of Red Bluff, California. The video monitoring and trapping gives an empirical count of the migrating salmon (escapement) and is used to anticipate a minimum level of effort needed during the spawning survey upstream. This report reviews the preliminary 1995 migration data from NRS and presents the results of the EBMUD 1995 spawning surveys.

The Mokelumne River Fish Installation (MRFI) is an EBMUD facility located at the base of Camanche Dam and operated by the California Department of Fish and Game (CDFG). Each year CDFG spawns salmon and steelhead (*O. mykiss*) entering the hatchery, obtaining a count of spawned fall run chinook salmon and steelhead and numbers of eggs taken from each species. These hatchery data were examined to compare hatchery and natural spawning for 1995.

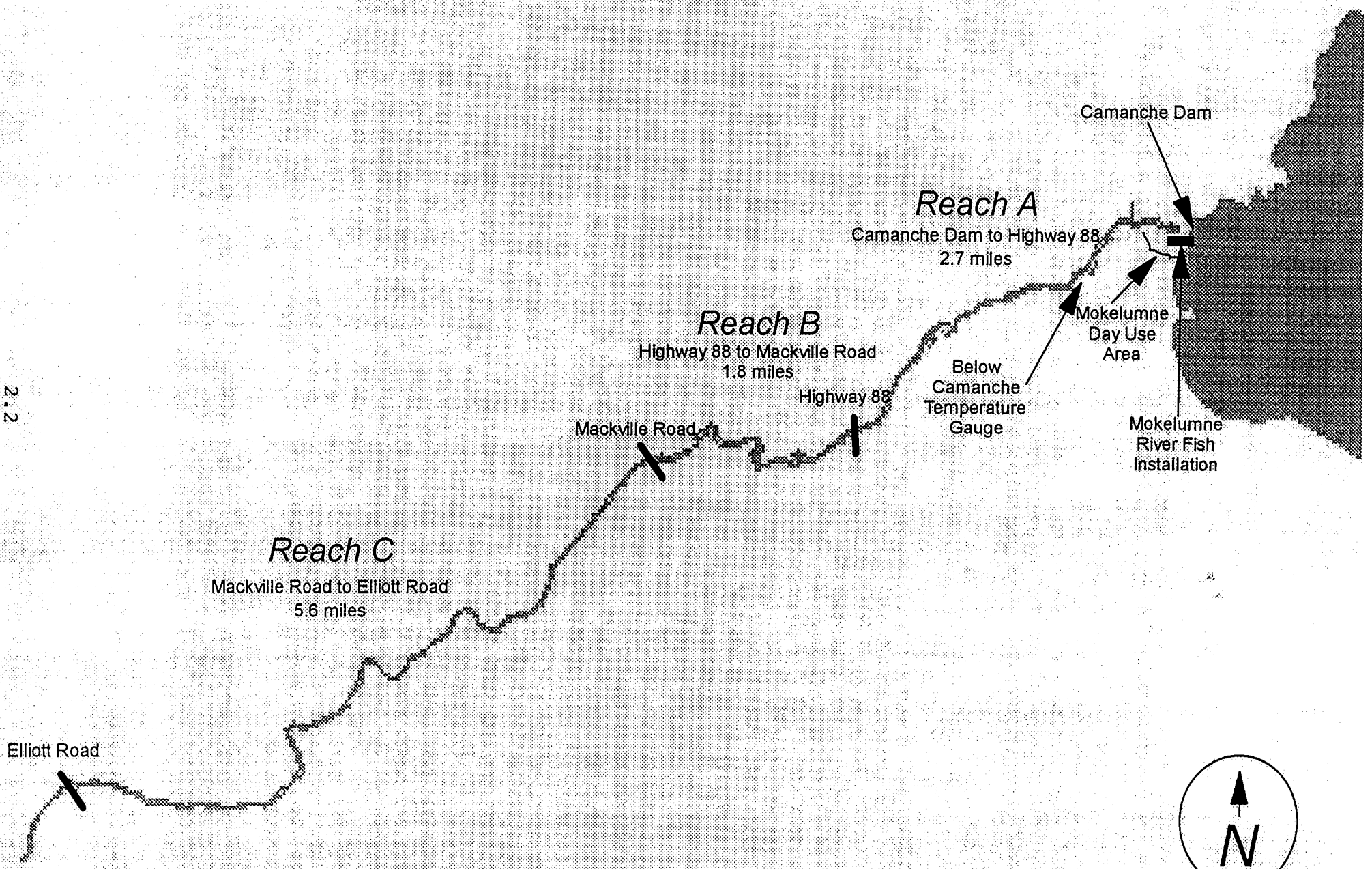


Figure 1. Lower Mokelumne River Spawning Reaches

OBJECTIVES

The principal objective of this 1995 survey was to determine the number of chinook salmon naturally spawning in the Lower Mokelumne River. Other objectives were to determine rates of spawning superimposition, to map the location of redds, and to determine preferences of spawning salmon for a variety of parameters including habitat type, stream velocity, stream depth, dominant substrate, cover, association of redds with berms, and association of spawning with large woody debris (LWD). General condition of the river as described by streamflow, water clarity and river water temperature was also recorded.

METHODS

Spawning areas were accessed on foot near the fish barrier fence in the Mokelumne River Day Use Area (MDUA) and by canoe in areas downstream to Elliott Road (total spawning reach = 10 miles). Based on video monitoring started at Woodbridge Dam on September 1, a preliminary survey was performed on October 5, 1995. New redds were easily distinguishable by the presence of lighter colored gravel that has been newly exposed from redd building activity. Since this newly exposed gravel quickly darkens as it becomes coated with algae (periphyton), and as this darkening process is variable depending on riparian shading, stream velocity, redd depth, and substrate size, weekly surveys give the best opportunity of distinguishing new redds from older ones. Regular weekly surveys for redds were conducted from October 11, 1995 through January 17, 1996. Riffles and bermed areas where redds were numerous were surveyed by wading around the previously marked and the newly constructed nests.

To determine if spawning took place below Elliott Road, the area downstream of the normal spawning reach was surveyed on two occasions during the spawning season. Other areas downstream known to have contained salmon redds in the past were also surveyed. In 1993, salmon built two redds in the river on the downstream edge of Highway 99 in crushed gravel that had been dumped into the river following road work. Redds have been observed in the past near Woodbridge Dam (CDFG 1991; Hartwell 1995a). The Highway 99 site was surveyed twice during the course of the season, while the NRS video monitoring field crew was queried about possible redds near Woodbridge Dam. Finally, the Woodbridge site was surveyed near the end of the season by the EBMUD crew.

Preliminary escapement data from video monitoring at Woodbridge Dam suggested that the 1995 run would be larger than the historical average. The run was also earlier than usual. As the

number of migrating salmon continued to increase, subsampling was started after redd number 30 and continued throughout the survey. Subsample frequency was based on the variability of data taken in previous years, and on the projected run size. Qualitative data, taken at every redd, included habitat type, cover, redd type, redd level of development, fish activity (including sex and estimated length), superimposition, berm presence, redd association with LWD, and redd location in the river.

On "full data" redds additional information was recorded. Stream and nose velocities were measured with a Marsh McBurney Model 2000 flowmeter and stream depth in front of the redd depression was recorded. Habitat types were classified according to a modified Bisson (1981) system; dominant substrates were rated on a modified Wentworth Scale (Bovee and Milhous 1978). The sex of fish observed at the redd was noted and, where possible, fish length was estimated. Redds were classified from descriptions of chinook nests given by Burner (1951):

O = redd with typical oval shape
L = redd usually made in fast water, w/ tailspill minimal or flattened by hydraulic influence
S = redd without discernable tailspill
P = redd constructed across front of berm perpendicular to flow

The level of redd development was recorded as follows:

1 = definite depression but no discernable area of deposition (egg-pocket)
2 = some discernable area of deposition
3 = egg deposition well underway (from observation of female and/or size of redd
4 = deposition completed, female may be wandering in front of redd, continuing to dig without adding to egg-pocket; or redd appears completed and female not present

Small undeveloped "test" redds were not counted.

Water temperature in the redd was measured with a hand-held thermometer graduated in increments of one degree Celsius, and the distance from the edge of the egg-pocket to the nearest shoreline was measured with a Ranging, Inc. range-finder. Methodology for redd area measurement is not universal (Burner 1951, Briggs 1953, Vronskiy 1972). In this study, redd width was measured just upstream of the crown of the tailspill and also across the redd at the front of the egg-pocket. To compute the redd area, these two widths were averaged and then multiplied by the length of the redd as measured from the upstream extent of

digging to the crown of the tailspill. Tailspill area behind the crown is subject to hydraulic distortion and was not measured. Presence of redd depressions was noted and depression diameters were measured.

Because of the need for the incubating chinook salmon eggs to receive intergravel flow (Shapovalov and Taft 1954; Vronskiy 1972; Nielsen and Banford 1983; Vronskii & Leman 1991), it was noted if the redd was located on a berm. Proximity of the redd to LWD such as logs and rootwads was also noted. When necessary for clarification, a sketch of the redd was made and dimensions were added as measured. The redd was marked on a 1" = 46' scale map developed from 10 X enlargements of 1 X 4800 aerial photos taken in February 1994 at a Camanche release of 202 cfs.

All occurrences of superimposition were recorded and rated as follows:

Level A = tailspill of one redd superimposed on tailspill of second redd.
Level B = tailspill of one redd superimposed on egg-pocket of second redd.
Level C = egg-pocket of one redd superimposed on egg-pocket of second redd (i.e. first egg-pocket excavated to build second redd). Percent level of egg-pocket superimposition is estimated (plus or minus 25%).
Level D = egg-pocket of one redd superimposed on egg-pockets of two or more redds (multiple superimposition).

Percentage of riverine habitat types (Bisson et at. 1981) were determined for the entire spawning reach (Camanche Dam to Elliott Road) from the 1" = 46' scale aerial photos and ground-truthed as required (Hartwell 1995a).

General data collected included streamflow as determined by Camanche release, secchi disk (water clarity) measurements, dissolved oxygen, and stream temperature. Water temperature was obtained from below Camanche Dam from a Campbell Thermistor located at the site of the former USGS Mokelumne River stream gauge (gauge #11323500). Data was collected at fifteen minute intervals from this site from September 1, 1995 through January 31, 1996. Water temperature at Mackville Road was obtained from a remote-access Campbell temperature station maintained at the site. During redd surveys below the fish fence in the MDUA and below Mackville Road near Stillman-McGee Park, Secchi disk depth (water clarity) was measured, and dissolved oxygen measurements were taken with a YSI model 55 handheld meter.

RESULTS

UPSTREAM MIGRATION

Woodbridge Irrigation District (WID) withdrew the flash boards from the WID Diversion Dam the mornings of November 1 & 2, 1995. The boards were pulled in two stages, producing morning pulse-flows that peaked at 1:00PM on Nov 1 at 978 cfs (J. Burgess pers. comm.). The average flows for November 1 and 2 were 503 cfs and 456 cfs, respectively (EBMUD Water Operations 1995). Except for some residual bank storage, Lake Lodi (2,200 acre-ft.) was drained by the afternoon of November 2.

Upstream migrating chinook salmon and steelhead were monitored by NRS at the fish ladder on the south side of the WID Diversion Dam. Counts of migrating salmon were obtained from video monitoring or trapping as described in the EBMUD scope of work for 1995 (EBMUD 1995) and by NRS (Marine 1995). Passage of migrating salmon and steelhead was video-monitored from overhead in the high-stage ladder (Figure 2) until Lake Lodi was lowered. Salmon lengths could be determined from comparison with a white background marked with lines 10 cms apart. Sex could not be accurately determined for overhead monitored salmon in the high-stage ladder.

Video-monitoring using a camera with a fisheye lens was done in the low-stage ladder once Lake Lodi had drained. Sex could be determined in the low-stage ladder; however, distortion from the fisheye lens prevented accurate length measurements. During turbid periods when video-monitoring was ineffective, migrating fish were trapped in the fishways and released above the dam.

Trapping was conducted to create length estimates for salmon counted by video. About one percent of the migrating salmon, attracted to the dam by water flowing through riprap at the base, were captured in nets and moved upstream.

CHINOOK SALMON ESCAPEMENT IN THE MOKELUMNE RIVER (1940-1995)[1]

1940-1995 average = 3,218 salmon

1995 percent of 1940-1995 average = 168%

[1]EBMUD 1996b.

The 1995 salmon escapement count on the Mokelumne River at Woodbridge Dam began on September 1 and lasted until December 31 (122 days) (Figure 3A). During this time 5,417 salmon were counted by trapping and by video monitoring. Adjusted 1995 totals of adults and grilse (by sex ratios determined from the low-stage fishway) are: 2,106 adult males (39%), 2,495 adult females (46.0%), 687 male grilse (13%), 128 female grilse (2%),

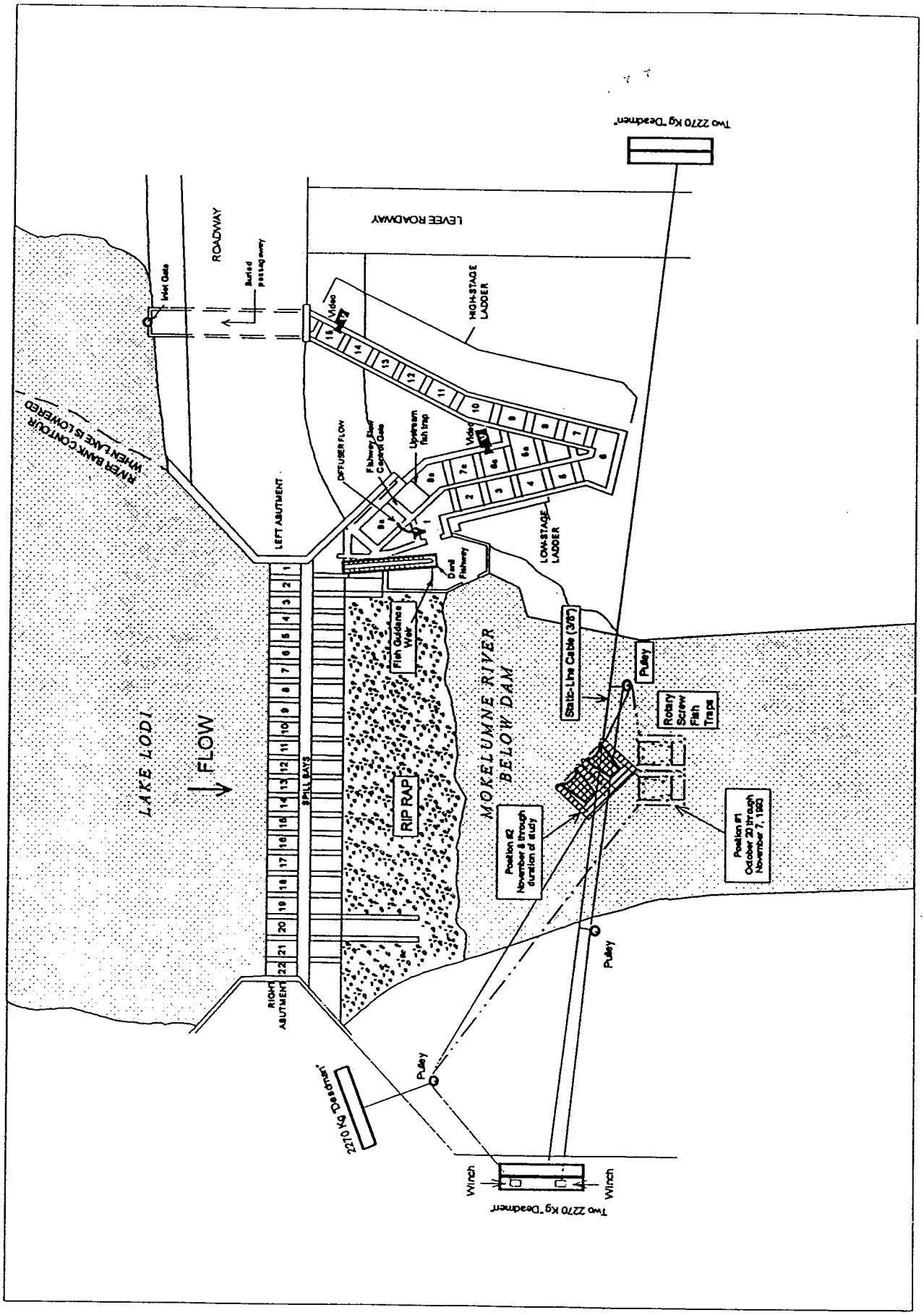
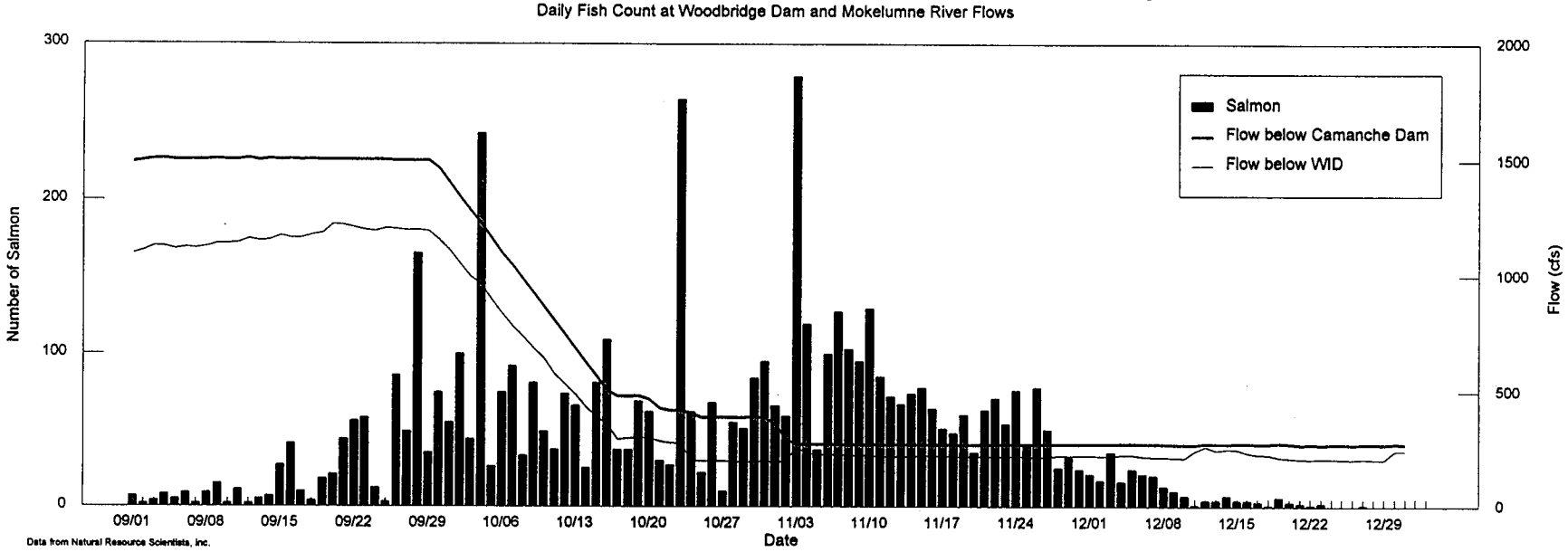


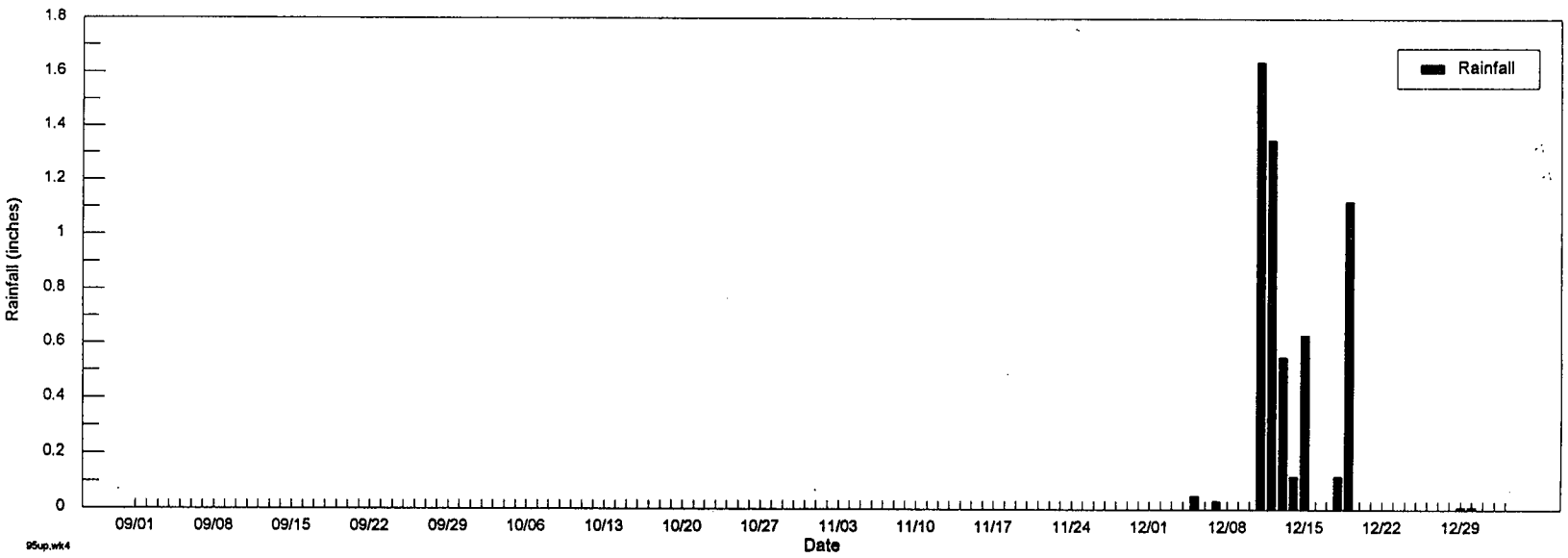
Figure 2. Plan view of Woodbridge Dam showing video monitoring sites and locations of upstream migrant fish trap and downstream migrant rotary screw traps. (NRS 1994)

Figure 3. 1995 Mokelumne River Fall Run Chinook Salmon Migration

A.



B.



and 1 fish of undetermined sex or size (K. Marine pers. comm). Historical average fall run chinook escapement on the Mokelumne River, based on data obtained from 1940 through 1995 is 3,218 fish (DFG 1991; Biosystems 1992; Marine 1993; Marine 1994; Marine 1995). Escapement in 1995 was 168% of this historical average.

The first adult salmon was caught by an angler in the MDUA prior to August 15 (Steve Boyd 1995a) and the first salmon were observed in the hatchery on August 21 (CDFG 1995a). Seven salmon of unknown sex were monitored by video in the upper-stage ladder on the first day of monitoring (September 1). Numbers of salmon migrating past Woodbridge increased irregularly with a first migration peak (165 fish) on September 28. Migration peaks of 242, 264, and 279 salmon were recorded on October 4, October 23, and November 3 respectively (Figure 3A).

A total of 2,944 salmon were observed by video ascending the high-stage fishway and recorded from September 1 to the morning of November 1; 2,417 salmon were recorded on video or trapped while using the low-stage fishway from November 1 through December 31. An additional 56 salmon were rescued from the rip-rap at the base of Woodbridge Dam by DFG and placed in the pool downstream where they were able to find the fishway (K. Marine 1996).

Chinook Returns to Mokelumne River Fish Installation

A total of 61.1% of the fish (3,323) passing Woodbridge returned to the Mokelumne River Fish Installation (Table 1), leaving 2,094 potentially naturally spawning chinook salmon in the river. An estimated 14 of these salmon (expanded for total catch and effort) were harvested by anglers in the MDUA before the end of fishing season on October 15, 1995 (Workman 1995a). Fishing gear that is commonly used by poachers (large weighted treble-hooks, etc.) was found in several areas along the river, suggesting that an unknown portion of the fish not entering the hatchery were taken illegally from the river.

The MRFI spawned 1,260 adult female salmon and took a total of 4,886,641 eggs (average of 3,878 eggs per female) (Table 1A). A total of 1118 adult male salmon and 945 grilse salmon returned to the hatchery (CDFG 1996a).

In 1994, 54% of the salmon passing woodbridge and 53% of the salmon returning to the hatchery were adult females (CDFG 1995b) Table 1B. In 1995 56% of the salmon passing Woodbridge, but only 38% of the fish entering the hatchery, were females. The reason for the disparity between the percentage of known females and hatchery females observed in 1995 is not known. There is a good correlation between the total hatchery return and escapement as recorded at Woodbridge Dam (Figure 4).

TABLE 1A. MOKELUMNE RIVER FISH INSTALLATION

Chinook Salmon Return and Egg Take

	1993	1994	1995
Adult Females:	794	582	1,260
Adult Males:	748	584	1,118
Grisle:	622	752	945
Total Returns:	2,164	1,918	3,323
Egg Take:	2,951,595	2,626,000	4,886,641

Fish totals from draft DFG annual report for 1993-94 and 1994-95, and DFG Staff for 1995-96.

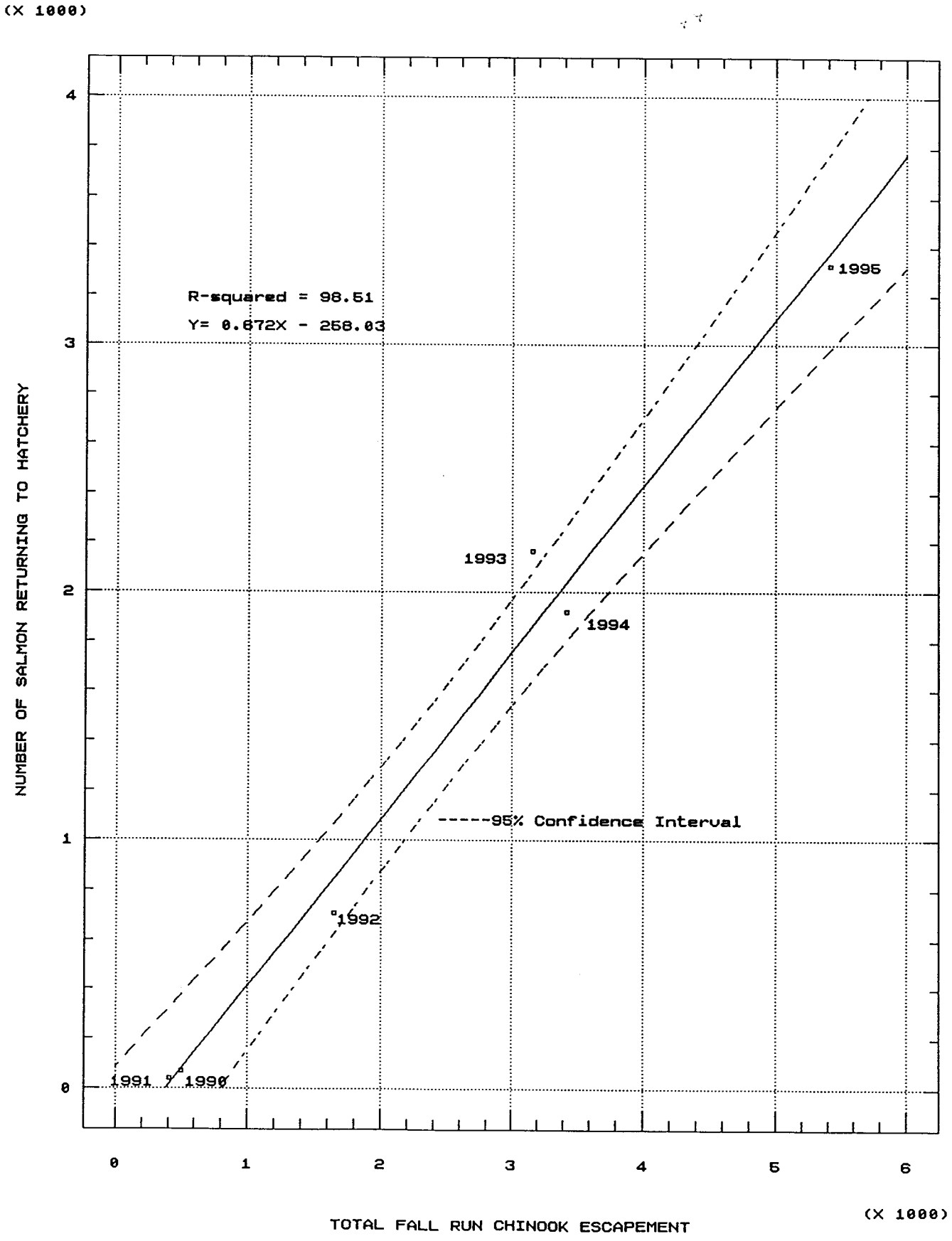
eggtake.wk4 (\mrffprod\95escp3.wk4)

TABLE 1B. 1990-1995 Fall Run Chinook Salmon Escapement & MRFI Returns

Year	Date WID Dam Removed	% Adults	% Females (adults)	% Grilse	WID Dam Returns		Total MRFI Returns	
1990	Oct 15	69	35	31	497		681	1
1991	Nov 2	85	37	15	410		41	1
1992	Oct 26	43	30	57	1645	3	710	2
1993	Nov 2	72	29	28	3157		2164	4
1994	Oct 20	80	54	20	3421		1918	5
1995	Nov 2	85	56	15	5417	6	3323	7

[1] CDFG Annual Report for 1990 and 1991a
[2] CDFG 1993
[3] Run began in mid to late August. Enumeration did not begin until October 14.
[4] CDFG 1994
[5] CDFG 1995
[6] NRS 1996 Preliminary Data
[7] CDFG 1996a Preliminary Central Valley Escapement Report

FIGURE 4. REGRESSION OF CHINOOK RETURN TO HATCHERY ON ESCAPEMENT



As in past years, the percentage of the fish entering the hatchery that were grilse (28%) (Table 1B) was greater than the percentage of grilse in the river (15%). The determination of whether a salmon that has entered the MRFI is a grilse is conservatively done by sight estimation by hatchery personnel, and salmon close to the lower size limit for adults may be classified grilse.

Since the MRFI does not sex grilse, it is not possible to determine an accurate number of female grilse present in the hatchery return. [The policy of the California State Fish Hatcheries is to not utilize gametes from female grilse salmon to supply fertilized eggs for their fry programs, so grilse females returning to the MRFI (126 fish) were discarded (M. Cochran 1996)].

The MRFI records show a higher number of grilse (+126) than the empirical count derived at Woodbridge Dam in 1995 by NRS. This discrepancy between grilse counts prevents a calculation of the total in-river potential spawning females (female adults and estimated female grilse).

Each year from 1993 through 1995 NRS measures five environmental parameters at Woodbridge Dam in association with the salmon migration: streamflow, barometric pressure, rainfall, water temperature, and turbidity. They found no correlation between these parameters and salmon migration in 1995. In 1992 and 1993 the data suggested a weak correlation between rainfall and migration (Marine 1993; Vogel 1994); however, this correlation was not statistically established. Radio telemetry of migrating adult salmon performed by NRS below Woodbridge Dam suggests that fish passage may increase during crepuscular periods and on cloudy days. This increase in fish passage during periods of low light could account for a perceived association between storm events and migration (Marine 1996).

A greater percentage of salmon are consistently recorded migrating past Woodbridge Dam during the daylight hours than at night. Diurnal migration past Woodbridge Dam in 1995 (3640 salmon = 68%) was higher than in 1994 (1938 fish = 61%) and 1993 (59%) but similar to 1992 (69%).

Escapement in the Mokelumne River has increased from 410 fish in 1991 to 5417 in 1995 (Table 1B). As a consequence of the larger runs, the number of adult females returning to spawn in the river has also increased. There has been a decline in the percent of grilse salmon in the past four years from 57% in 1992 to 15% in 1995 as escapement has increased, though there is no statistical negative correlation between escapement and percentage of grilse salmon.