EVALUATION OF SIDE CHANNELS FOR INCREASING REARING HABITAT OF JUVENILE SALMONIDS, TRINITY RIVER, CALIFORNIA

by

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ABSTRACT

This study monitored two side channels in the upper Trinity River near Lewiston, California to determine the extent of their use by juvenile salmonids from December 1985 to May 1987. Objectives were: 1) to compare species compositions between two side channels (upper and lower) and Trinity River, 2) to compare the size of salmonids in side channels and Trinity River over time, 3) to determine salmonid densities and biomass in side channels, 4) to determine length of salmonid residency in side channels, and 5) to investigate salmonid behavior in relation to stream discharge and temperature in both side channels and Trinity River.

Four species of salmonids were captured by electroshocking: chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), steelhead (*O. mykiss*) and brown trout (*Salmo trutta*). Except in winter, chinook appeared to have a preference for side channels. Coho preferred side channels during all seasons and steelhead preferred side channels during winter. Brown trout preferred side channels during winter.

Juvenile steelhead in the lower side channel were significantly larger. In general, salmonids were comparable

in size to those reported elsewhere. Fish biomass varied by station which indicated a heterogeneity in habitat.

Chinook densities peaked in both side channels during April 1987. Coho densities peaked during May 1986 in the upper side channel and during November 1986 in the lower side channel. Densities of 0+ steelhead peaked during May 1987 in the upper side channel. Densities of 1+ steelhead peaked during March 1987 in the upper side channel. Densities for 0+ and 1+ brown trout followed the same patterns exhibited by steelhead trout.

With the exception of 0+ brown trout, the upper channel had the longest residency period for each salmonid group. The maximum residency period for each fish group was: five months for chinook, six months for coho, four month for 0+ steelhead, seven months for 1+ steelhead, four months for 0+ brown trout, and six months for 1+ brown trout. Minimum residency periods ranged from less than one month to two months.

Lewiston Dam discharges ranged from 8.5 to 169.9 m^3/s during the course of this investigation. Water temperatures in side channels were warmer during winter and colder during summer than the main stem. Side channels were extensively used by juvenile salmonids, apparently to their benefit.

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I owe a great deal of gratitude to members of my Graduate Committee for their direction and enduring patience. They are Dr. Roger Barnhart, Leader of the California Cooperative Fishery Research Unit, and Drs. Terry Roelofs and Robert VanKirk, both on staff at Humboldt State University's College of Natural Resources.

Numerous students from Humboldt State University volunteered their time and energy during long days of arduous field work. Space limits me from identifying each volunteer, however I recognize that without their assistance this project would have not been possible. Family members Dave, Chris, Jake, and Deana also assisted during field work.

My mother, Marie Macedo, provided both financial and spiritual support during my tenure at Humboldt State. My wife, Suzanna Macedo, gave unceasingly during the one and one-half years of field work and provided critical assistance during preparation of the thesis.

Finally, I wish to dedicate this thesis to the late Richard Macedo senior, my father and the person responsible for taking me to my first river and introducing me to a wondrous and intricate world.

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INTRODUCTION

The Trinity River was a major producer of chinook salmon (Oncorhynchus tshawytscha) (chinook), coho salmon (O. kisutch) (coho) and steelhead (O. mykiss) (Gibbs 1956; LaFaunce 1965; Smith 1970; U.S. Fish and Wildlife Service 1985). Physical alterations to the Trinity River watershed have diminished salmonid resources in the system (Gibbs 1956; LaFaunce 1965; Murray 1968; Smith 1970; Woodhull 1970; Meacham 1973). The Trinity River Division of California's Central Valley Project, operated by the U.S. Bureau of Reclamation, exports water from the Trinity River to the Central Valley of California. Since 1974, 85-90 percent of Trinity River run-off has been impounded by two dams (Trinity and Lewiston) and diverted out of the basin. Reduced river flows combined with substantial logging throughout the watershed have resulted in confinement and siltation of the stream channel (California Department of Fish and Game 1970).

Prior to construction of Lewiston Dam, chinook used 95 km of river habitat above the dam and both coho and steelhead used 175 km of up-river habitat (Woodhull 1970). Woodhull reported that salmonid spawners consisted of approximately 12,000 chinook, 10,000 steelhead and an unknown number of coho. In order to mitigate losses of spawning and rearing habitat, the Trinity River Fish Hatchery was built in 1972. The hatchery is responsible for spawning and rearing chinook, coho and steelhead which are released into the Trinity River (Murray 1968).

Mitigation projects downstream of Lewiston Dam have included mechanical tilling of the streambed, dredging, construction of sediment retention basins on Grass Valley Creek, and construction of artificial spawning riffles (U.S. Bureau of Reclamation 1952; U.S. Fish and Wildlife Service and California Department of Fish and Game 1956; California Department of Fish and Game 1970; Rogers 1970; Buck 1988). Recent efforts have also been directed at side channel development along the Trinity River (U.S. Fish and Wildlife Service 1990).

In addition to the above projects, the U.S. Fish and Wildlife Service and the U.S. Bureau of Reclamation agreed to increase water releases into the Trinity River below Lewiston Dam to help rehabilitate the salmonid fishery. This agreement was finalized following a January 1981 decision by the Secretary of the Interior. To evaluate changes resulting from increased flows, several operative tasks were developed. Task 4 provided direction toward analyzing fish population characteristics and life history relationships of Trinity River salmonids (U.S. Fish and

Wildlife Service 1985). My study was designed to address certain objectives of Task 4.

Fishery biologists have agreed that in order to maintain viable stocks of salmon and steelhead, sufficient escapement of juveniles must be allowed from freshwater habitats. Concern over declining salmon and steelhead runs has prompted fishery biologists to study the problem from many aspects. One approach is to analyze the quality and quantity of juvenile rearing habitat within riverine environments (Shapovalov and Taft 1954; Chapman 1965; Lister and Genoe 1970; Bjornn 1971; Bustard and Narver 1975a; Peterson 1982; Platts et al. 1983; and Hankin 1984).

Riverine environments are complex ecosystems (Minshall et al. 1985) and can be divided into subunits such as riffles, pools, runs and off channel or side channel habitats. A side channel separates from the main stem river at an upstream point and eventually returns to the main stem at a downstream point. Side channel habitats have received cursory attention by some investigators studying juvenile salmonids (Maciolek and Needham 1952; Ruggles 1966; Mundie 1974; Bustard and Narver 1975b; Mundie 1980; Mundie and Traber 1983b; Tschaplinkski and Hartman 1983; Brusven et al. 1986; House and Boehne 1986; Swales et al. 1986; Hartman and Brown 1987; Hillman et al. 1987; Moore and Gregory 1988; Taylor 1988; Reeves et al. 1989; Nielsen 1990). Other researchers have specifically focused on side channels and other off-channel habitats during their investigations (Hamilton and Buell 1976; Kerr et al. 1980; Everest and Sedell 1983; Mundie and Traber 1983a; Bachen 1984; Doyle 1984; Everest et al. 1984; Brown 1985; U.S. Fish and Wildlife Service 1988, 1990).

The Trinity River has several side channels which may be important to juvenile salmonids. The purpose of this study was to monitor two side channels in the upper Trinity River to determine the extent of their use by juvenile salmonids. The study objectives were:

1) Compare species compositions in two side channels and the Trinity River.

2) Compare the size of juvenile salmonids in side channels and Trinity River over time.

3) Determine salmonid densities and biomass in side channels by season.

4) Determine length of salmonid residency in side channels.

5) Investigate salmonid behavior in relation to stream discharge and temperature in both side channels and Trinity River.

STUDY SITE

The Trinity River is the largest tributary in the Klamath River system. The Trinity River watershed is approximately 7,679 km^2 in size and spans both Trinity and Humboldt Counties. Originating on the western slopes of the Trinity mountains, the Trinity River flows 278 km south and west through Trinity County, then north to its confluence with the Klamath River in Humboldt County. The upstream limit for anadromous salmon and steelhead is at Lewiston Dam (river km 177). Major tributaries include Rush Creek, Grass Valley Creek, Browns Creek, Canyon Creek, North Fork, New River, South Fork, and Willow Creek (Figure 1).

The Trinity River basin is characterized by warm summers and cool, humid winters. Eighty percent of annual precipitation occurs between November and March (Knott 1974). Average annual precipitation in the upper Trinity basin varies from 100 cm at Lewiston to 200 cm at higher elevations (U.S. Bureau of Reclamation 1952). Mean monthly temperature at Weaverville ranges from 3°C in January to 22°C in July (Knott 1974).

The Trinity River watershed supports a mixed coniferous forest including Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), digger pine (*P. sabiniana*), sugar pine (*P. lambertiana*), Oregon oak

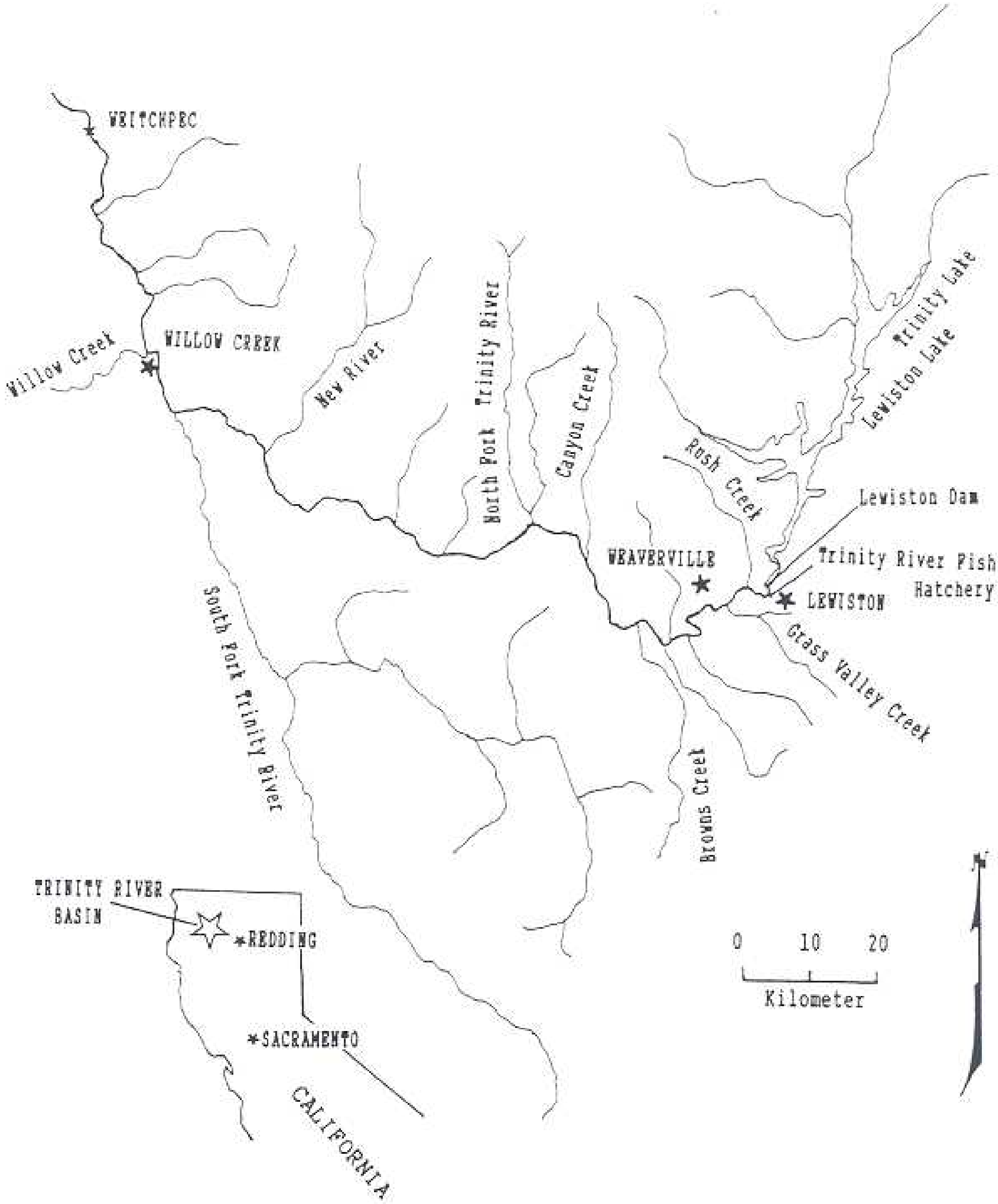


Figure 1. Trinity River Basin, California.

(Quercus garryana) and California black oak (Q. kelloggii). The Trinity River maintains a well-defined riparian corridor consisting of willow (Salix sp.), alder (Alnus sp.), Oregon ash (Fraxinus latifolia), and bigleaf maple (Acer marcrophyllum). Fish species utilizing the Trinity river include chinook salmon, coho salmon, steelhead, brown trout (Salmo trutta), speckled dace (Rhinichthys osculus), Klamath smallscale sucker (Catostomus rimiculus), threespine stickleback (Gasterosteus aculeatus), white sturgeon (Acipenser transmontanus), green sturgeon (A. medirostris), sculpin (Cottus sp.), and Pacific lamprey (Lampetra tridentata) (Moyle 1976).

Two side channels (upper and lower) and two Trinity River sites (Trinity #1 and Trinity #2) were studied for this investigation. All of these sites are downstream of Lewiston Dam (river km 177) and in the vicinity of Lewiston, California (Figure 2).

The upper side channel was 366 m long and was at river km 174.5. When Lewiston Dam was discharging at 8.5 m^3/s (300 cfs), flow in the upper channel was 0.3 m^3/s (10.6 cfs) and mean channel width was 10.0 m with a range of 7.1 to 12.9 m. This side channel was constructed in the early 1980's to optimize flow over an adjacent artificial spawning riffle and to provide habitat for rearing salmonids (pers. comm., E. Miller, 1985, California Department of Fish and Game, Redding, CA 96001). The bottom and banks of this

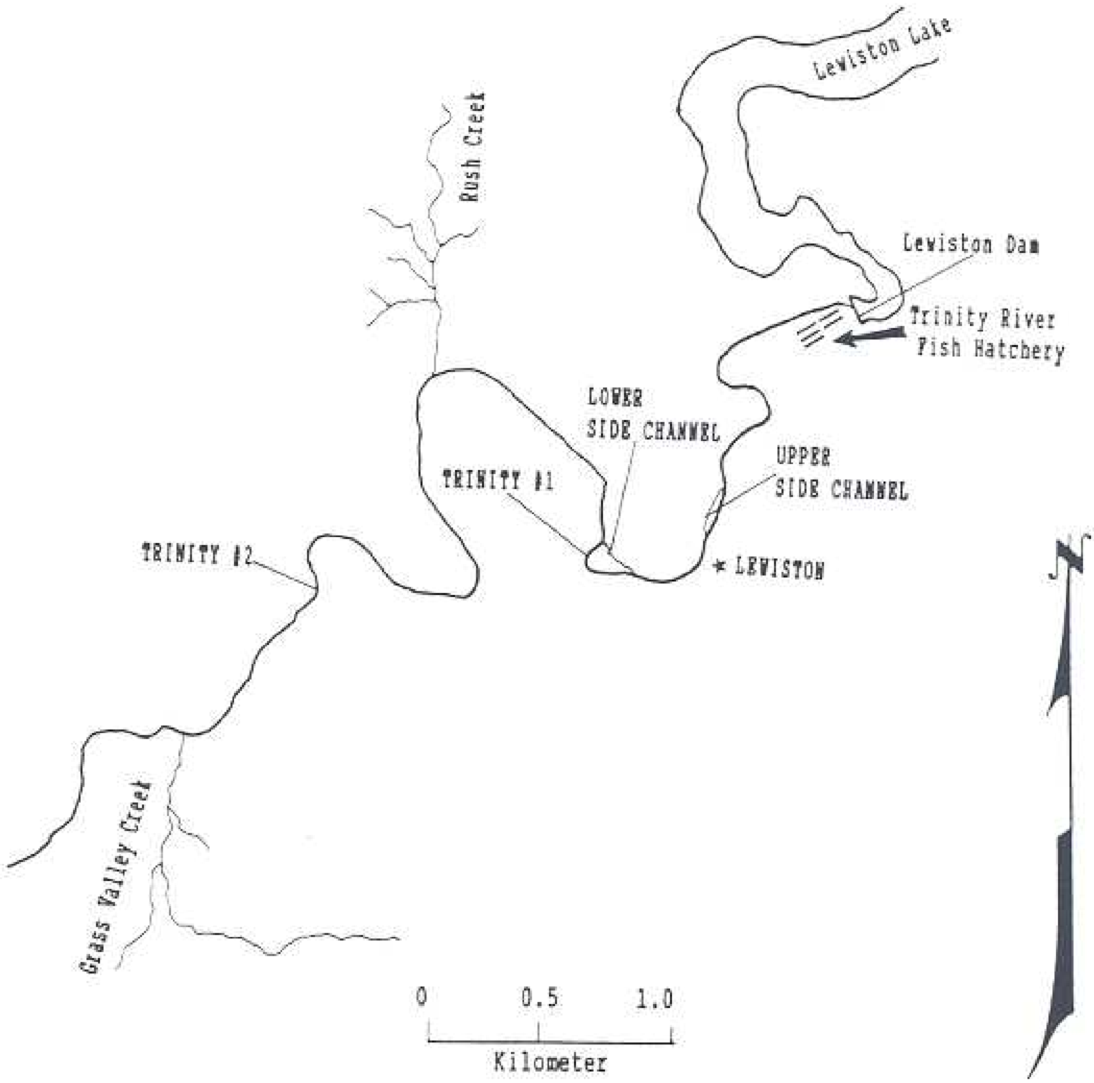


Figure 2. Location of Side Channel and River Survey Sites, Trinity River, California.

channel were lined with sediment-free cobble. Riparian growth was sparse at downstream reaches and dense at the upstream end.

The lower side channel was 444 m long and was at river km 173. During a Lewiston Dam discharge of 8.5 m^3/s, flow in the lower channel was 0.9 m^3/s (31.5 cfs) and mean channel width was 9.6 m with a range of 8.6 to 11.1 m. This channel was probably constructed as a result of gold mining activity and later modified to improve the water supply to a now abandoned saw mill. Most of the channel was heavily bordered with riparian growth and many sections were too deep for electroshocking. Beaver (Castor canadensis) used this channel during my investigation. This channel has since been modified by the Trinity River Restoration Program for purposes of improving salmonid rearing habitat (U.S. Fish and Wildlife Service 1990). The lower side channel is visible on the Lewiston, Calif. Quadrangle; 7.5 minute (topographic) U.S. Geological Service map; (NW 1/4 of S.19, R.8W., T.33N.).

Two sites were sampled on main stem Trinity River. The upstream-most site, Trinity #1, was near the lower side channel at river km 173. This site included a riffle near what is known as the Cemetery Pool. Total surface area for Trinity #1 was 627.1 m^2.

Trinity #2 was 2.5 km downstream of Trinity #2 at river km 170.5. This site consisted of two separate riffle areas. Total surface area for both riffles equaled 2,043.8 m^2. Both Trinity #1 and #2 were used by U.S. Fish and Wildlife Service personnel for monitoring juvenile salmonid growth. They were identified as the Cemetery and Bucktail sites (U.S. Fish and Wildlife Service 1986, 1987, 1988 and 1989).

MATERIALS AND METHODS

The upper side channel was surveyed on a monthly or bi-monthly basis during December 1985-January 1986 and during May 1986-May 1987. Surveys at this site were not conducted during February-April 1986 due to flooding. The lower side channel was surveyed on a monthly or bi-monthly basis during June 1986-May 1987. While surveys of both side channels were usually conducted every month, bi-monthly surveys were made during June-July 1986 and during January-February 1987 due to inclement weather and scheduling conflicts. With the exception of August 1986, sites on the upper Trinity River were surveyed on a monthly basis during June 1986-May 1987.

Two stations on the main stem Trinity River were selected for their adequate representation of shallow water habitats along the Trinity River. The upstream station was known as Trinity #1 and the downstream station was known as Trinity #2. Access and suitability for backpack electroshocking were also considered in the selection of Trinity River stations. Trinity #1 and #2 were usually treated as separate stations and fishery data collected at these stations were used to represent the main stem Trinity River. Data from Trinity #1 and #2 were pooled for temperature monitoring.

Side channel reaches suitable for backpack electroshocking were divided into 15.2 m stations. The upper side channel contained 17 stations and the lower side channel had 7 stations. Depending on daylight hours and time needed to measure all fish in a survey station, two to four randomly selected side channel stations were surveyed each month.

Juvenile salmonids were captured using a battery-powered DC backpack electroshocker (Smith-Root Model 11-A or Coffelt Model BP-4). Electroshocking passes were conducted in an upstream direction. The person operating the electroshocker was flanked by one to three netters. Electroshocking voltage, sampling effort and the number of netters was kept constant for each station. One pass was made at the two Trinity River stations and two to four passes were made at side channel stations. In order to be consistent with data collected from the Trinity River, only first pass data were used from side channels for comparative analyses. Prior to electroshocking side channels, block nets were set at upstream and downstream station boundaries to prevent immigration and/or emigration of fish. Block nets were not used on the main stem Trinity River. Captured fish were held in live cages (Buynak and Mohr 1980) or water-filled buckets and anesthetized with MS-222/Finquel (Tricane Methane Sulfonate) prior to handling.

Length-frequency histograms were plotted each month in order to separate young-of-the-year (0+) from older (1+) juvenile steelhead and brown trout. This method is described by Jearld (1983) as the "Peterson method" and has been used on other studies to separate age classes of juvenile salmonids (Burns 1971). Chinook and coho salmon were not separated into age classes. The resulting six fish groups (chinook, coho, 0+ steelhead, 1+ steelhead, 0+ brown trout and 1+ brown trout) were my focus during this study.

Species Composition

Fish data were analyzed to determine; 1) if a given species demonstrated a preference for the upper side channel, the lower side channel, or the main stem Trinity River and 2) if preference for a given habitat changed with season. I defined preference as a statistically significant difference in species composition among selected habitats. Seasons were designated by winter (December, January and February), spring (March, April and May), summer (June, July and August), and fall (September, October and November). Seasonal data were pooled for those months that were surveyed more than one year. Statistical analyses were performed using the Statistical Analysis System (SAS) for personal computers (SAS Institute Inc., Cary, North Carolina). The SAS procedures "FREQ" and "GLM" were used.

To address the first question of whether species exhibit general preferences among selected habitats, fish totals were tabulated into two-way contingency tables where fish were categorized by species and habitat. Contingency tables and Chi-square test of homogeneity of proportions were performed. From cell counts in the contingency table, corresponding percentages of species for each habitat were calculated. These percentages reflected the relative counts of each species with respect to the other species in that habitat. The contingency table analysis was performed on the overall table summed over all seasons. This procedure tested for overall habitat preference, regardless of season, with the hypothesis being that species composition among the three habitats was similar. This was the hypothesis of homogeneity of proportions. A higher than expected percentage under the assumption of no difference could be interpreted as a preference for a given habitat ($p < 0.05$).

To address the second question regarding the influence of seasonality on species ratios among the three habitats, contingency table analyses were performed by season. Analysis of Variance (ANOVA) and Scheffe's method for multiple comparisons were also completed. The count by species was converted to square root of count to induce more similar variances, since equality of variances was an assumption in the ANOVA. Another assumption in this analysis was the independence of species counts. A three-factor ANOVA with interaction was performed where the outcome variable was the square root of fish count, and the factors were species, habitat, and season. Results from this analysis indicated which effects were important ($p < 0.01$). In addition, for each species, a two-factor ANOVA with interactions was performed where the factors were habitat and season. Multiple comparisons using Scheffe's method of statistically significant effects were also completed. Analysis of Variance and Scheffe's method have been used on projects with comparable objectives (Bain et al. 1985; Nielsen 1990).

Length and Biomass

For length and biomass analyses, steelhead and brown trout were not divided into age classes. Fork lengths were measured to the nearest millimeter (mm). Fish volumes were measured to the nearest milliliter (ml) using a graduated cylinder. Volumetric displacement was used as an indirect measure of weight (Leitritz and Lewis 1976; Anderson and Gutreuter 1983). For salmonids, one ml of displaced water is equal to one gram of fish flesh (Brown 1988).

Analyses were performed to determine; 1) if a mean fork length of a given species differed among the three habitats and 2) if seasonality affected differences in mean fork lengths among habitats. Only first pass data from side channels were used in comparison with data obtained from the main stem Trinity River. Seasonal designation for this analysis was identical to that used in species composition analyses. Seasonal data were pooled for those months that were surveyed more that one year.

To address the first question of whether differences existed between fork lengths of fishes using different habitats, ANOVA was performed with fork length as the outcome variable. ANOVA was performed by using mean fork length data without modifications which resulted in an unweighted ANOVA. Weighted ANOVA was also performed by multiplying fork length data by the size of the sample from which the mean was calculated. Mean square errors for weighted and unweighted ANOVA were compared to determine which analysis would best analyze fork length data among the three habitats. Mean square error is a measure of unexplained or residual variability. The ANOVA with the highest mean square error was considered more conservative and was the method chosen for fork length comparisons.

Contingency tables and Chi-square test of homogeneity of proportions were conducted using procedures outlined in the Species Composition section. Two-factor ANOVA was performed by comparing species fork lengths to habitat, with the hypothesis being that species fork lengths among the three habitats were similar ($p > 0.0001$).

To address the second question regarding the influence of seasonality on species fork lengths among the three habitats, contingency table analysis was performed by season. Analysis of Variance and Scheffe's method for multiple comparisons were also completed to determine effects of species fork lengths by habitat and species fork lengths by habitat and by season. Equality of variances and independence of observations were assumed for this analysis.

Growth of juvenile salmonids utilizing side channels was illustrated by graphing mean monthly fork length and biomass data. Growth was not monitored in the main stem Trinity River.

Biomass was expressed as a ratio of total fish weight to surface area and was reported in kilograms (kg) per hectare (ha). Biomass estimates were graphed using data obtained from fish density estimates, average fish weight and surface area measurements of side channel stations. I used the following formula, described by Hillman et al. (1987), to calculate fish biomass:

$$\text{Biomass (kg/ha)} = (\hat{A})*(\overline{W})/(L)*(\overline{w})$$

$\hat{A}$ = estimated population size (# fish)

$\overline{W}$ = mean fish weight (kg)

L = length of survey station (m)

$\overline{w}$ = mean width of survey station (m)

Area measurements of side channel stations $[(L)*(\overline{w})]$ were converted from m^2 to ha and were regularly amended to account for varying conditions associated with fluctuations in side channel discharge.

Fish Density

Population estimates were made for the six salmonid groups occupying the upper and lower side channels. Fish populations were not estimated for the main stem Trinity River. Standard backpack electroshocking techniques involving multiple-step, removal-depletion methods were used to collect fish population data (Platts et al. 1983). Two to four electroshocking passes were made through each station based on criteria developed by Price and Adams (1982). The maximum weighted likelihood estimation formula described by Carle and Strub (1978) was used to derive fish population estimates.

Salmonid densities were expressed as a ratio of population estimate to surface area and was reported in fish/m^2. Fish density estimates were calculated by station and by month. As was the case for biomass estimates, area measurements of side channel stations were regularly amended to account for variations in channel width associated with varying discharge rates.

Fish density estimates and 95 percent confidence intervals were graphed by side channel station and by month. Mean monthly density estimates were also graphed along with observed 95 percent confidence intervals. Population estimates, 95 percent confidence intervals, catch probabilities, and standard errors were calculated for salmonids at all side channel stations and listed in appendixes. In cases where initial electroshocking passes had less fish than in subsequent passes, density estimates could not be calculated. In these cases, fish totals were summed over all passes and expressed as total fish captured during electroshocking.

Records for hatchery-reared fish that were released at the Trinity River Hatchery site were obtained from California Department of Fish and Game personnel. Trinity River Hatchery personnel fin clipped a portion of hatchery-reared fish prior to releasing them. All fish collected in side channels were examined for fin clips. Graphs were drawn to show percentages of fin clipped chinook, coho, and steelhead trout occurring in side channels.

Fish Residency

From December 17, 1985-February 7, 1987, seven electroshocking campaigns were conducted at the upper and lower side channels for purposes of capturing and marking juvenile salmonids. These were completed in addition to regular monthly sampling. One or two backpack electroshockers were used to capture fish. Electroshocking and marking were conducted concurrently by separate crews until the length of each side channel was covered. The objective was to capture and mark as many juvenile salmonids as possible in one day. Marked fish were tallied by species. Fish captured in the main stem Trinity River were not marked.

Dorsal, anal, and upper and lower lobes of the caudal fin were alternately marked using a Panjet needleless injector (Wright Dental Group, Kingsway West, Dundee, Scotland) and alcian blue 8GX dye. Marks were alternated to prevent duplicating the fin mark used on the previous marking campaign. Methods used to apply dye to fins were similar to that described by Hart and Pitcher (1969), Young (1987), and Nielsen (1990). A successful mark involved angling the injector so that dye could penetrate the integument and travel alongside a fin ray. Following marking, fish were placed in a live cage and monitored prior to being released. Delayed mortality of marked fish following release was not monitored.

A group of Trinity River fish consisting of four chinook, two coho, four steelhead, and four brown trout were captured from the Trinity River, marked and transferred to a 114 liter aquarium. Dorsal, anal, and upper and lower lobes of the caudal fin were alternately marked using the Panjet needleless injector and alcian blue 8GX dye. These fish were used to determine retention rates of fin marks.

Marked fish were used to determine the length of time juvenile salmonids resided in side channels (Weinstein and O'Neil 1986). Monthly electroshocking was scheduled so that a side channel was surveyed the day following a marking campaign. Marked fish captured during monthly sampling were recorded by species and by fin mark. The ratio of marked to unmarked fish observed on the day following marking was used as a baseline to monitor fish residency in side channels.

In order to quantify fish residency in side channels, I developed the Duration Index (DI). The DI was a comparison of the initial percentage of marked fish following a marking campaign to the observed percentage of marked fish over time. Duration Indices result from a fraction, with the denominator being the percentage of marked fish first noted after a marking campaign and the numerator being the percentage of marked fish observed during a given month. Percentages of marked fish were derived by comparing total number of marked fish to total number of fish captured during electroshocking. The numerator and denominator were equal for the first month following marking and were assigned a value of 1. Following is the formula used to calculate DI:

$$\text{Duration Index} = \frac{\%\ \text{Marked}_i}{\%\ \text{Marked}_o}$$

$\%\ \text{Marked}_i$ = percentage of marked fish observed for a given month

$\%\ \text{Marked}_o$ = percentage of marked fish observed the day following a marking campaign

Duration indices were graphed by species, month and side channel. A gradual descent in the DI line indicated a tendency for a species to persist in that side channel. Conversely, a steep descent in a DI line indicated hastened movement of a species out of that side channel. The length of time salmonids resided in side channels could be used as an indicator of habitat suitability.

Stream Discharge and Temperature

Stream discharge for the upper and lower side channels was measured using either a Price AA current meter or a Marsh/McBirney Portable (Model 201) current meter. A 1.2 m or a 1.8 m top-adjusting rod was used in association with either current meter. The technique and formula used for obtaining discharge were described by Buchanan and Somers (1969). Trinity River flow was assumed to be equal to discharge rates from Lewiston Dam. Records of Lewiston Dam releases were obtained from California Department of Fish and Game personnel at Trinity River Hatchery.

Water temperatures of side channels and Trinity River were measured prior to surveying each station using a hand held thermometer. Temperatures were generally measured between 0800 and 1700 hours.

RESULTS

Species Composition

Species compositions were different for the three habitats despite seasonality (Appendix A). For example, chinook comprised 45 percent of fish in the upper channel, 72 percent in the lower channel, and 30 percent in the Trinity River. The statistically significant Chi-square test ($p < 0.05$) indicated that species compositions were different for the three habitats and that habitat preference did exist.

Preferences for given habitats remained statistically significant when seasonality was incorporated into the analyses (Appendix B). Except during winter, juvenile chinook preferred side channels over the main stem. Coho preferred side channels over the main stem during all seasons. Except during winter, steelhead and brown trout preferred the main stem. Table 1 summarizes information contained in Appendixes A and B.

Results from ANOVA on the square root of the count indicated that the most pertinent effects were:

Species/Habitat interaction ($p = 0.0001$)

Species/Habitat/Season interaction ($p = 0.01$)

The statistically significant species/habitat interaction indicated that at least one species preferred certain

Table 1. Habitat With the Highest Relative Species Percentages or "Preference" as Determined by Contingency Tables and Chi-Square Analyses ($p < 0.05$), Trinity River, California and Side Channels, 1985-1987.

	Season				
Species	Winter	Spring	Summer	Fall	Overall
Chinook	Trinity[a]	Lower[b]	Lower	Lower	Lower
Coho	Lower	Upper[c]	Upper	Lower	Upper
Steelhead	Upper	Trinity	Trinity	Trinity	Trinity
Brown Trout	Upper	Trinity	Trinity	Trinity	Trinity

[a]Trinity River
[b]Lower Channel
[c]Upper Channel

habitats ($p < 0.0001$). The statistically significant three-way interaction of species/habitat/season interaction indicated that habitat preference for at least one species might change with season ($p < 0.01$).

Square root counts from ANOVA revealed discernable patterns (Table 2). Results in Table 2 are similar to those in Table 1, with the exception of coho and steelhead.

Two-factor and three-factor ANOVA with interaction was completed for each species separately in order to examine further the habitat preference (p) by species (Table 3). Results for the main effect of habitat indicated that at least one habitat had a statistically higher square root count than another for coho, steelhead and brown trout ($p < 0.0001$). In contrast, chinook counts in the three habitats were similar ($p > 0.0001$).

Coho was the only species to exhibit a statistically significant habitat/season interaction ($p < 0.01$). Figure 3 shows which habitats were preferred by coho; lower channel for winter, upper channel for spring, upper channel for summer, and upper channel for fall. These results agreed with those in Table 2.

Scheffe's multiple comparisons for chinook indicated no significant habitat preference ($p > 0.05$). For coho, results indicated that the upper channel had statistically higher average square-root counts than both the lower channel and Trinity River ($p < 0.05$). Both steelhead and

Table 2. Habitat with the Highest Average Square-Root Count or Preference as Determined by ANOVA ($p < 0.0001$), Trinity River, California and Side Channels, 1985-1987.

	Season			
Species	Winter	Spring	Summer	Fall
Chinook	Trinity[a]	Lower[b]	Lower	Lower
Coho	Lower	Upper[c]	Upper	Upper
Steelhead	Upper	Upper	Trinity	Trinity
Brown Trout	Upper	Trinity	Trinity	Trinity

[a]Trinity River
[b]Lower Channel
[c]Upper Channel

Table 3. P Values of Species Composition Data as Determined by Two-Factor ANOVA, Trinity River, California and Side Channels, 1985-1987.

Species	Habitat	Habitat/Season
Chinook	0.054	0.3
Coho	0.0003	0.003
Steelhead	0.0003	0.3
Brown Trout	0.0001	0.5

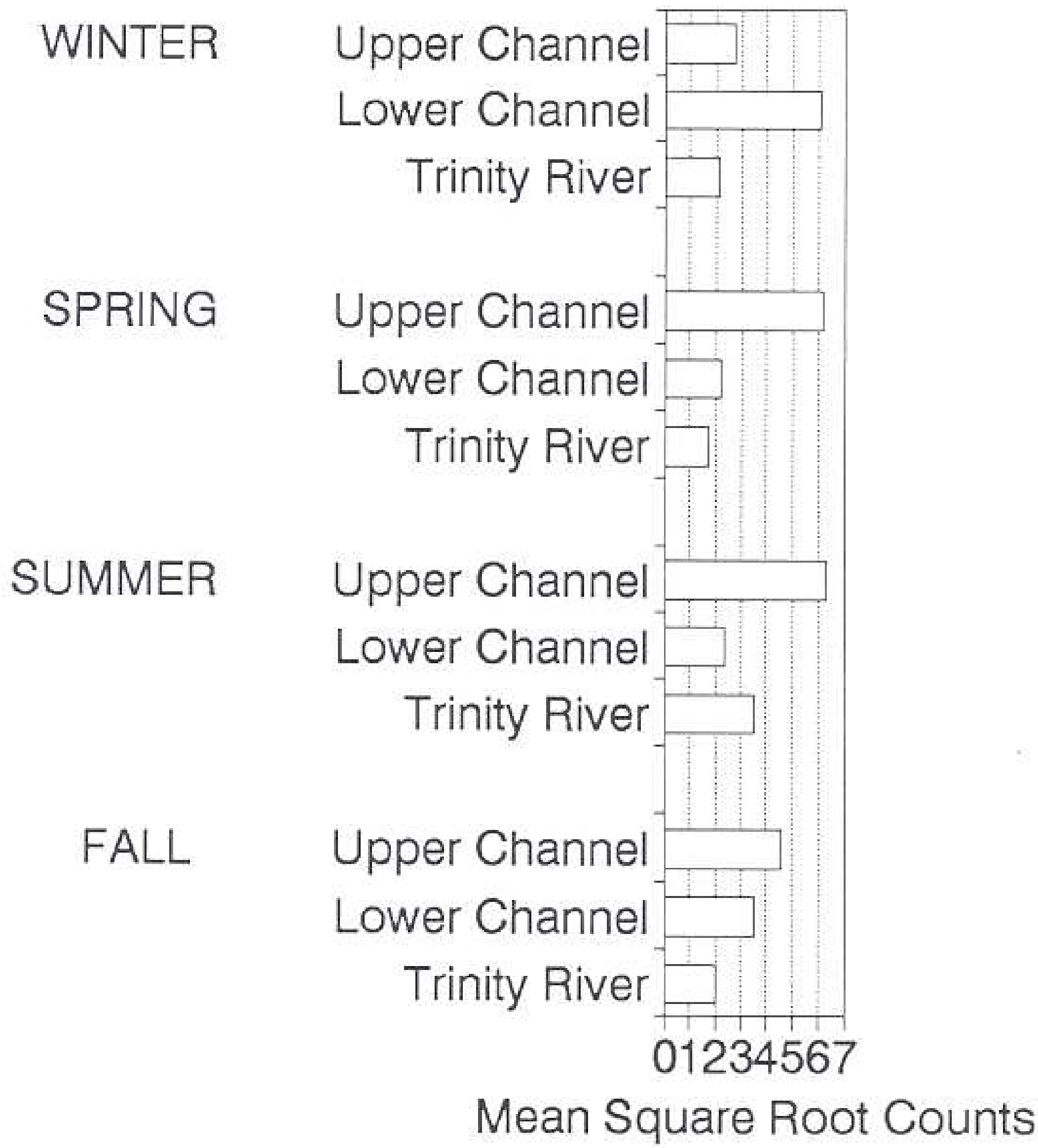


Figure 3. Mean Square-Root Counts by Habitat and by Season for Juvenile Coho Salmon, Trinity River, California and Side Channels, 1985-1987.

brown trout occurred in significantly greater numbers in the Trinity River and in the upper side channel ($p < 0.05$).

Appendix C illustrates results from ANOVA analysis by graphing mean square-root counts by species and by habitats. Results from multiple comparisons are summarized in Table 4. With the exception of chinook, results from ANOVA and contingency table analyses were similar. For steelhead and brown trout, the preference for Trinity River main stem habitat remained constant over both analyses, however the upper channel was also shown as important by ANOVA.

Length and Biomass

Length comparisons were made for fishes occupying side channels and the Trinity River to determine if a given habitat maintained different sized fishes. Seasonality was also considered in the analyses. Based on a higher mean square-root error value, unweighted ANOVA was selected for fork length comparisons.

The species/habitat interaction was statistically significant ($p < 0.0001$), which implied that at least one species had a longer fork length in a particular habitat. The species/habitat/season interaction was usually not significant, which indicated that seasonality did not influence fish length in the study sites. In order to further examine the species/habitat interaction, each species was analyzed separately (unweighted two-factor

Table 4. Summary of Overall Salmonid Habitat Preferences as Determined by Scheffe's Multiple Comparison Analyses ($p < 0.05$), Trinity River, California and Side Channels, 1985-1987.

Species	Habitat Preference
Chinook	None
Coho	Upper Channel
Steelhead	Trinity River, Upper Channel
Brown Trout	Trinity River, Upper Channel

ANOVA) (Table 5). When considering the main effect of habitat, only steelhead were significantly larger ($p < 0.0001$). When considering the main effect of season, only chinook were significantly larger ($p < 0.0001$). The significant difference on chinook length may have been due to growth over time and/or incursions of hatchery-produced chinook. Results of a Scheffe's multiple comparison analysis for steelhead indicated that fish in the lower channel had the larger average fork length ($p < 0.05$) (Table 6).

Figures 4-6 plot mean monthly fork lengths of juvenile salmonids for the three habitats. Growth of juvenile salmonids followed expected patterns in the upper and lower side channels and the Trinity River. Fish releases from the Trinity River Hatchery may have affected average fork length data but the effects are not apparent in the graphs.

From December 1985 through May 1987, mean biomass at the upper side channel was 9.1 kg/ha for chinook, 10.9 kg/ha for coho, 5.7 kg/ha for 0+ steelhead, 9.9 kg/ha for 1+ steelhead, 6.3 kg/ha for 0+ brown trout, and 8.4 kg/ha for 1+ brown trout. From June/July 1986 through May 1987, mean biomass at the lower side channel was 28.9 kg/ha for chinook, 16.8 kg/ha for coho, 1.2 kg/ha for 0+ steelhead, 15.2 kg/ha for 1+ steelhead, 1.7 kg/ha for 0+ brown trout,

Table 5. P Values and Mean Square Errors From Two-Factor ANOVA of Fork Length Data, Trinity River, California and Side Channels, 1985-1987.

Species	Habitat	Season	Habitat/Season	Mean Square Error
Chinook	0.3	0.0001	0.8	243
Coho	0.6	0.5	0.4	321
Steelhead	0.0001	0.7	0.7	676
Brown Trout	0.2	0.2	0.9	506

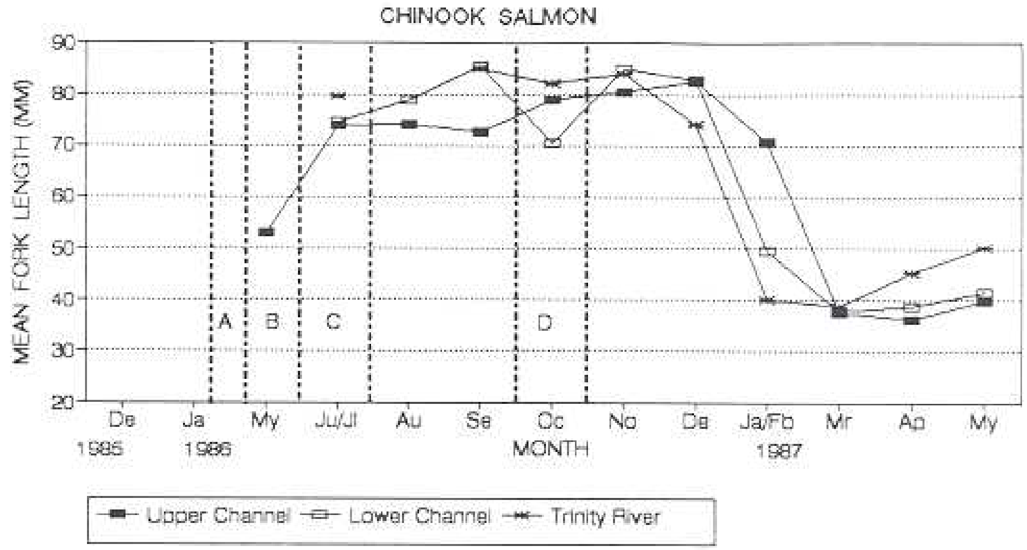
Table 6. Results of Scheffe's Test for Multiple Comparison for Steelhead Average Fork Length Data, Trinity River, California and Side Channels, 1985-1987.

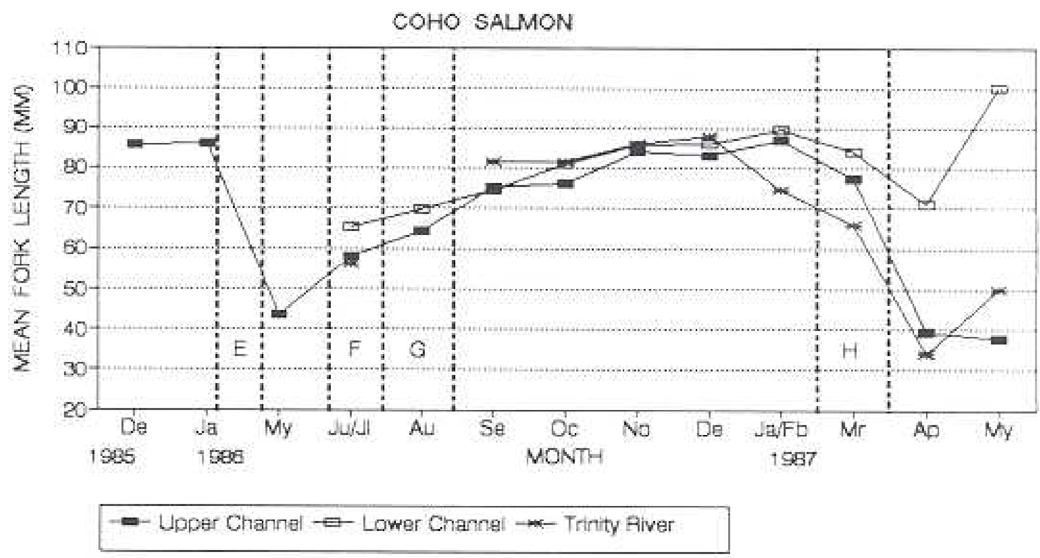
Habitat Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
Lower/Upper Chan.	7.213	26.007	44.801	**
Lower Chan./Trinity	14.738	34.853	54.967	**
Upper/Lower Chan.	-44.801	-26.007	-7.213	**
Upper Chan./Trinity	-9.428	8.846	27.120	
Trinity/Lower Chan.	-54.967	-34.83	-14.738	**
Trinity/Upper Chan.	-27.120	-8.846	9.428	

Comparisons significant at 0.05 are indicated by '**'

Alpha = 0.05 Confidence = 0.95 df = 66 MSE = 675.8143

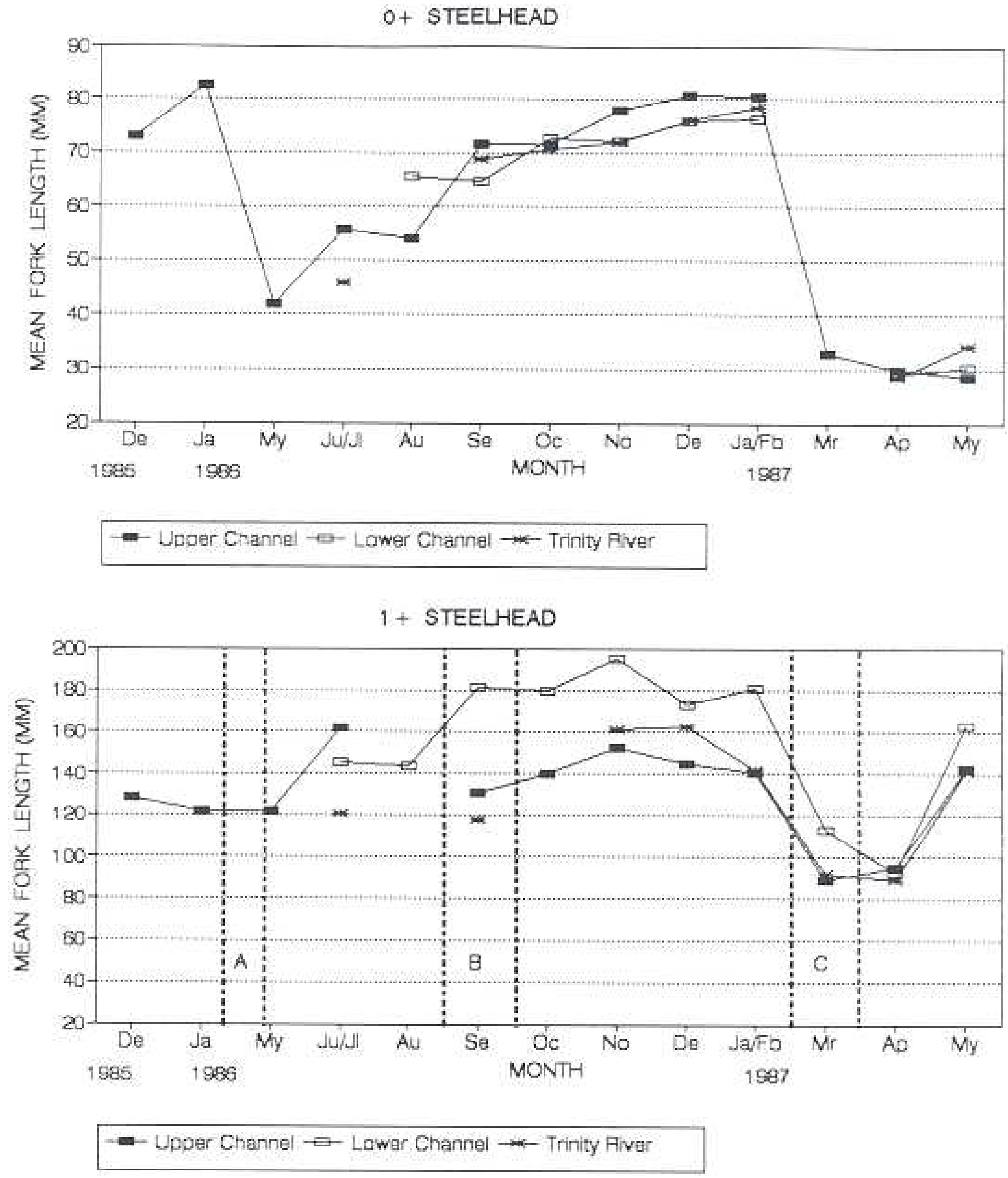
Critical Value of F = 3.13592





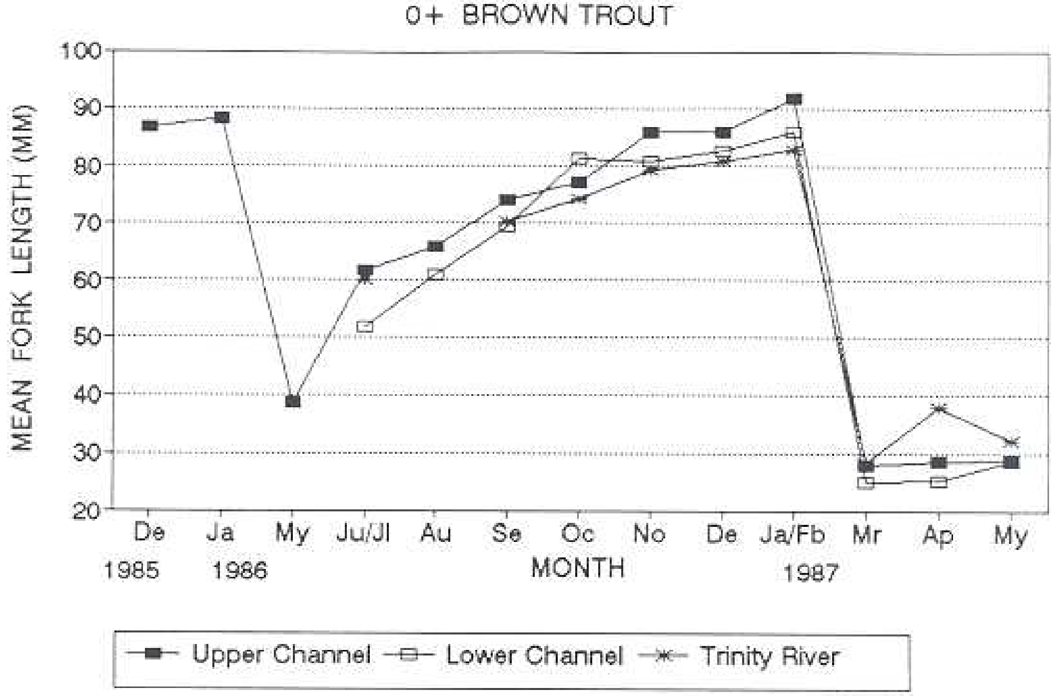
A - 156,090 Chinook; Released Over Several Days During February 1986.
B - 879,510 Chinook; Released Over Several Days During May 1986.
C - 3,974,575 Chinook; Released Over Several Days During June 1986.
D - 1,511,300 Chinook; Released Over Several Days During October 1986.
E - 562,713 Coho; Released Over Several Days During March 1986.
F - 157,500 Coho; Released On July 30, 1986.
G - 182,435 Coho; Released Over Several Days During August 1986.
H - 568,803 Coho; Released Over Several Days During March 1987.

Figure 4. Mean Fork Lengths for Chinook and Coho Salmon In the Upper and Lower Side Channels and Trinity River, California, 1985-1987. Characters "A" Through "H" Represent Numbers and Dates of Fish Released at the Trinity River Fish Hatchery.



A - 17,755 1+ Steelhead; Released Over Several Days During March 1986.
B - 317,576 1+ Steelhead; Released Over Several Days In April 1986.
C - 31,683 1+ Steelhead; Released On May 20, 1986.
D - 29,140 1+ Steelhead; Released On September 22, 1986.
E - 291,880 1+ Steelhead; Released Over Several Days During March 1987.
F - 215,723 1+ Steelhead; Released Over Several Days During April 1987.

Figure 5. Mean Fork Lengths for 0+ and 1+ Steelhead In the Upper and Lower Side Channels and Trinity River, California, 1985-1987. Characters "A" Through "F" Represent Numbers and Dates of Fish Released at the Trinity River Fish Hatchery.



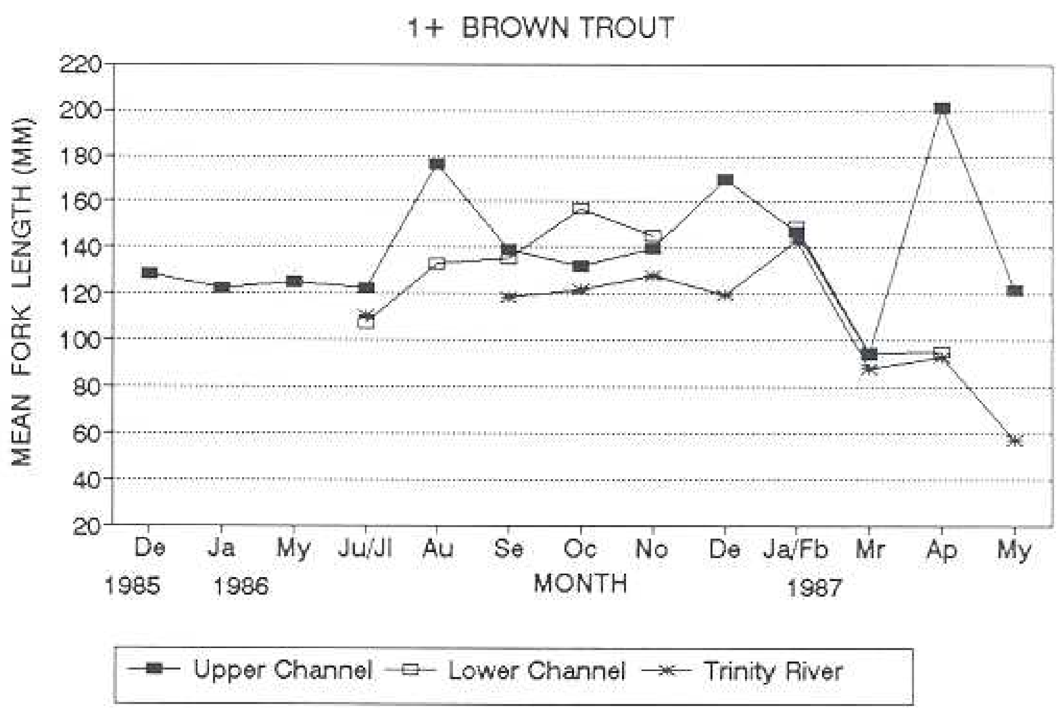


Figure 6. Mean Fork Lengths for 0+ and 1+ Brown Trout In the Upper and Lower Side Channels and Trinity River, California, 1985-1987.

and 2.8 kg/ha for 1+ brown trout. Table 7 summarizes maximum, minimum, and averaged mean biomass estimates.

Figures 7-12 are graphs of mean monthly biomass estimates and observed ranges (95% C.I.) for salmonids in upper and lower side channels. In the upper side channel, biomass for each salmonid group decreased in December 1986. Peak biomass for both age classes of steelhead and brown trout in the upper side channel occurred in January 1986 and again in January/February 1987. A corresponding peak was noted in the lower side channel during January/February 1987. Biomass estimates and 95% C.I.'s for each fish group by month and by survey station are graphed in Appendix D.

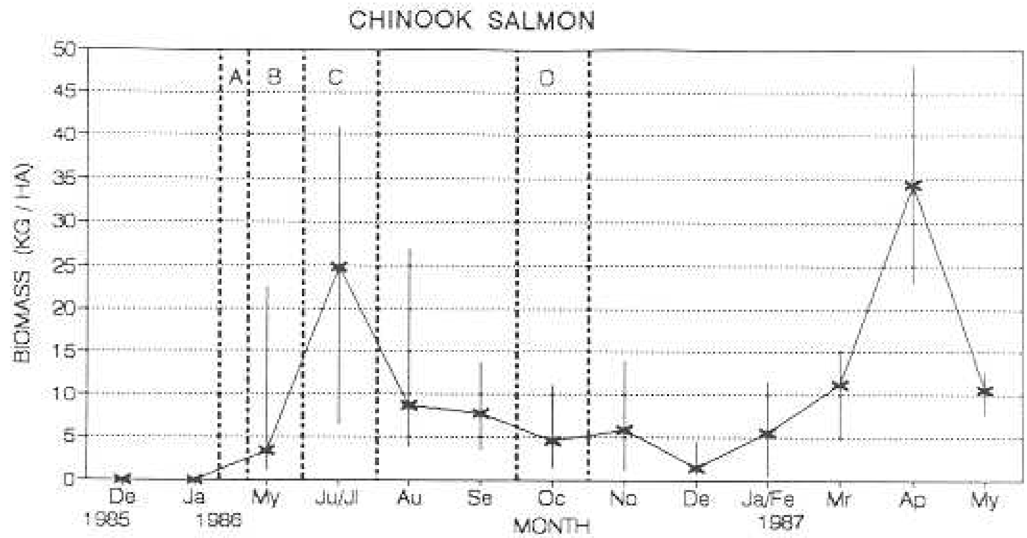
Fish Density

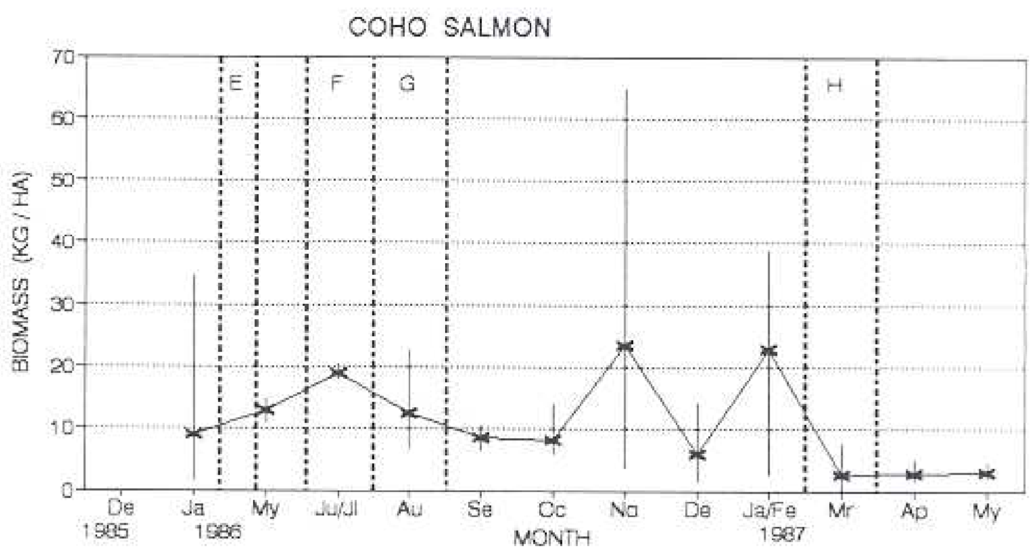
From December 1985 through May 1987, mean density at the upper side channel was 0.88 fish/m^2 for chinook, 0.34 fish/m^2 for coho, 0.15 fish/m^2 for 0+ steelhead, 0.04 fish/m^2 for 1+ steelhead, 0.10 fish/m^2 for 0+ brown trout, and 0.04 fish/m^2 1+ brown trout. From June/July 1986 through May 1987, mean density at the lower side channel was 1.00 fish/m^2 for chinook, 0.22 fish/m^2 for coho, 0.02 fish/m^2 for 0+ steelhead, 0.04 fish/m^2 for 1+ steelhead, 0.03 fish/m^2 for 0+ brown trout, and 0.01 fish/m^2 for 1+ brown trout. Table 8 summarizes maximum, minimum, and averaged mean density estimates for each fish group in the upper and lower side channels.

Table 7. Maximum ($Biomass_{max}$), Minimum ($Biomass_{min}$), and Averaged ($Biomass_{ave}$) Mean Biomass Estimates (kg/ha) for Salmonids Utilizing the Upper and Lower Side Channels, Trinity River, California, 1985-1987.

Species	$Biomass_{max}$	$Biomass_{min}$	$Biomass_{ave}$
UPPER SIDE CHANNEL			
Chinook	34.4[a]	0.0[bc]	9.1
Coho	23.7[d]	2.5[e]	10.9
0+ Steelhead	17.1[f]	0.0[e]	5.7
1+ Steelhead	23.4[g]	0.0[h]	9.9
0+ Brown Trout	32.4[c]	0.1[e]	6.3
1+ Brown Trout	18.1[c]	0.6[i]	8.4
LOWER SIDE CHANNEL			
Chinook	100.3[i]	2.7[f]	28.9
Coho	71.8[d]	1.1[e]	16.8
0+ Steelhead	5.3[f]	0.0[ej]	1.2
1+ Steelhead	85.5[k]	1.3[d]	15.2
0+ Brown Trout	4.8[f]	0.1[aeg]	1.7
1+ Brown Trout	9.2[l]	0.0[mg]	2.8

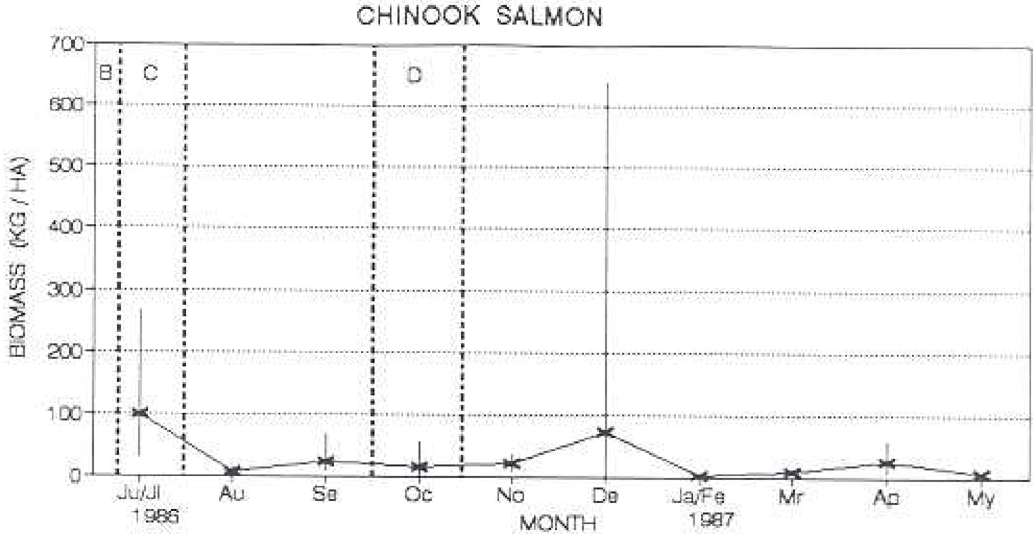
[a]April 1987
[b]December 1985
[c]January 1986
[d]November 1986
[e]March 1987
[f]January/February 1987
[g]May 1987
[h]August 1986
[i]April 1987
[j]June/July 1986
[k]October 1986
[l]September 1986
[m]December 1986

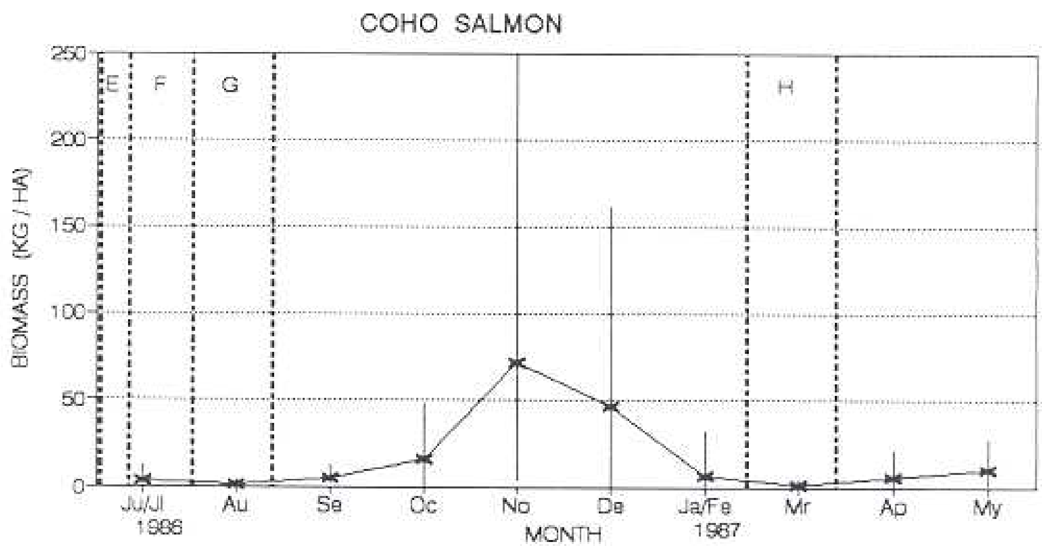




A - 156,090 Chinook; Released Over Several Days During February 1986.
B - 879,510 Chinook; Released Over Several Days During May 1986.
C - 3,974,575 Chinook; Released Over Several Days During June 1986.
D - 1,511,300 Chinook; Released Over Several Days During October 1986.
E - 562,713 Coho; Released Over Several Days During March 1986.
F - 157,500 Coho; Released On July 30, 1986.
G - 182,435 Coho; Released Over Several Days During August 1986.
H - 568,803 Coho; Released Over Several Days During March 1987.

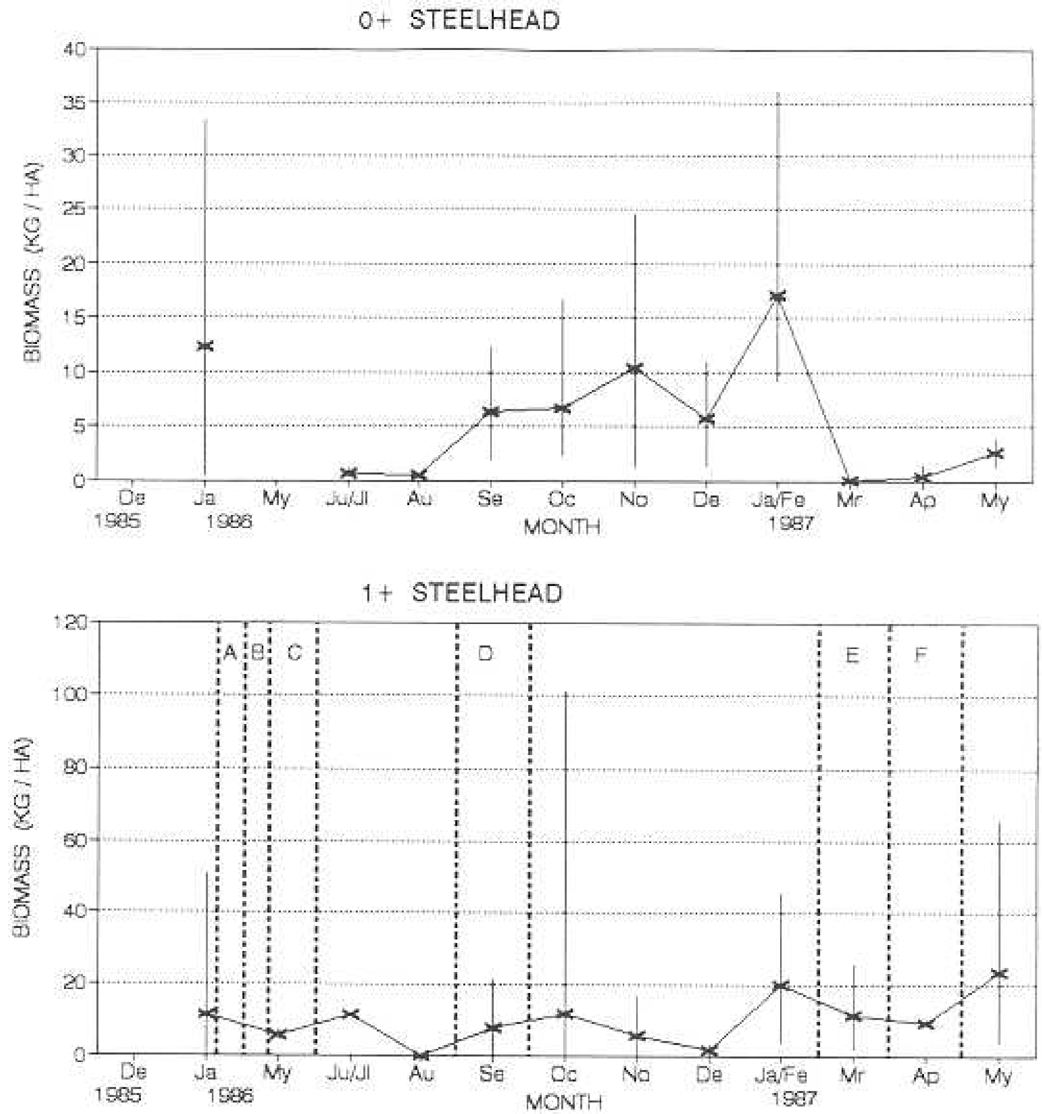
Figure 7. Mean Monthly Biomass Estimates and Observed Ranges (95% C.I.; Vertical Lines) for Juvenile Chinook and Coho Salmon Utilizing the Upper Side Channel, Trinity River, California, 1985-1987. Characters "A" Through "H" Represent Numbers and Dates of Fish Released at the Trinity River Fish Hatchery.





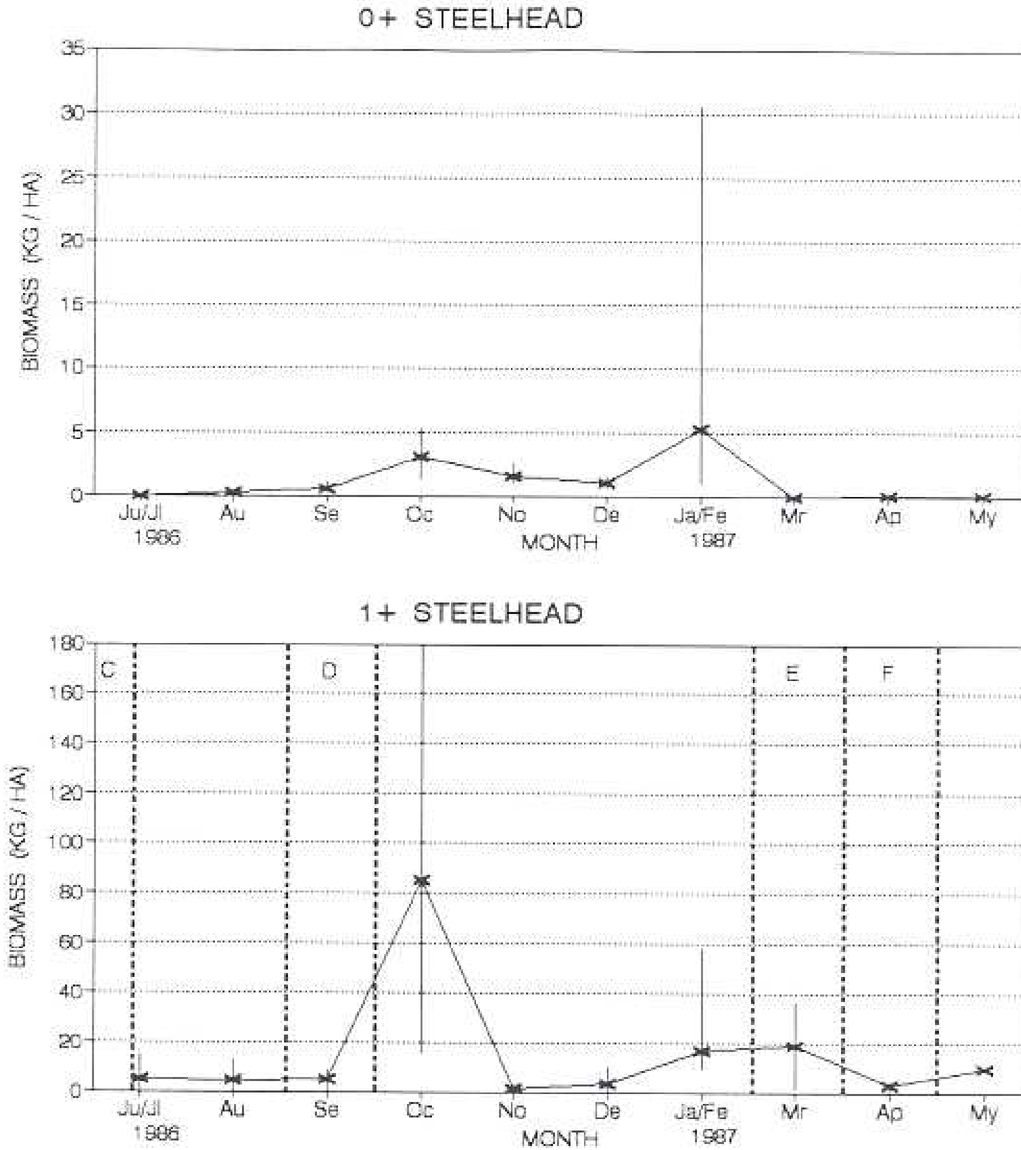
B - 879,510 Chinook; Released Over Several Days During May 1986.
C - 3,974,575 Chinook; Released Over Several Days During June 1986.
D - 1,511,300 Chinook; Released Over Several Days During October 1986.
E - 562,713 Coho; Released Over Several Days During March 1986.
F - 157,500 Coho; Released On July 30, 1986.
G - 182,435 Coho; Released Over Several Days During August 1986.
H - 568,803 Coho; Released Over Several Days During March 1987.

Figure 8. Mean Monthly Biomass Estimates and Observed Ranges (95% C.I.; Vertical Lines) for Juvenile Chinook and Coho Salmon Utilizing the Lower Side Channel, Trinity River, California, 1985-1987. Characters "B" Through "H" Represent Numbers and Dates of Fish Released at the Trinity River Fish Hatchery.



A - 17,755 1+ Steelhead; Released Over Several Days During March 1986.
B - 317,576 1+ Steelhead; Released Over Several Days In April 1986.
C - 31,683 1+ Steelhead; Released On May 20, 1986.
D - 29,140 1+ Steelhead; Released On September 22, 1986.
E - 291,880 1+ Steelhead; Released Over Several Days During March 1987.
F - 215,723 1+ Steelhead; Released Over Several Days During April 1987.

Figure 9. Mean Monthly Biomass Estimates and Observed Ranges (95% C.I.; Vertical Lines) for 0+ and 1+ Steelhead Utilizing the Upper Side Channel, Trinity River, California, 1985-1987. Characters "A" Through "F" Represent Numbers and Dates of Fish Released at the Trinity River Fish Hatchery.



C - 31,683 1+ Steelhead; Released On May 20, 1986.
D - 29,140 1+ Steelhead; Released On September 22, 1986.
E - 291,880 1+ Steelhead; Released Over Several Days During March 1987.
F - 215,723 1+ Steelhead; Released Over Several Days During April 1987.

Figure 10. Mean Monthly Biomass Estimates and Observed Ranges (95% C.I.; Vertical Lines) for 0+ and 1+ Steelhead Utilizing the Lower Side Channel, Trinity River, California, 1985-1987. Characters "C" Through "F" Represent Numbers and Dates of Fish Released at the Trinity River Fish Hatchery.

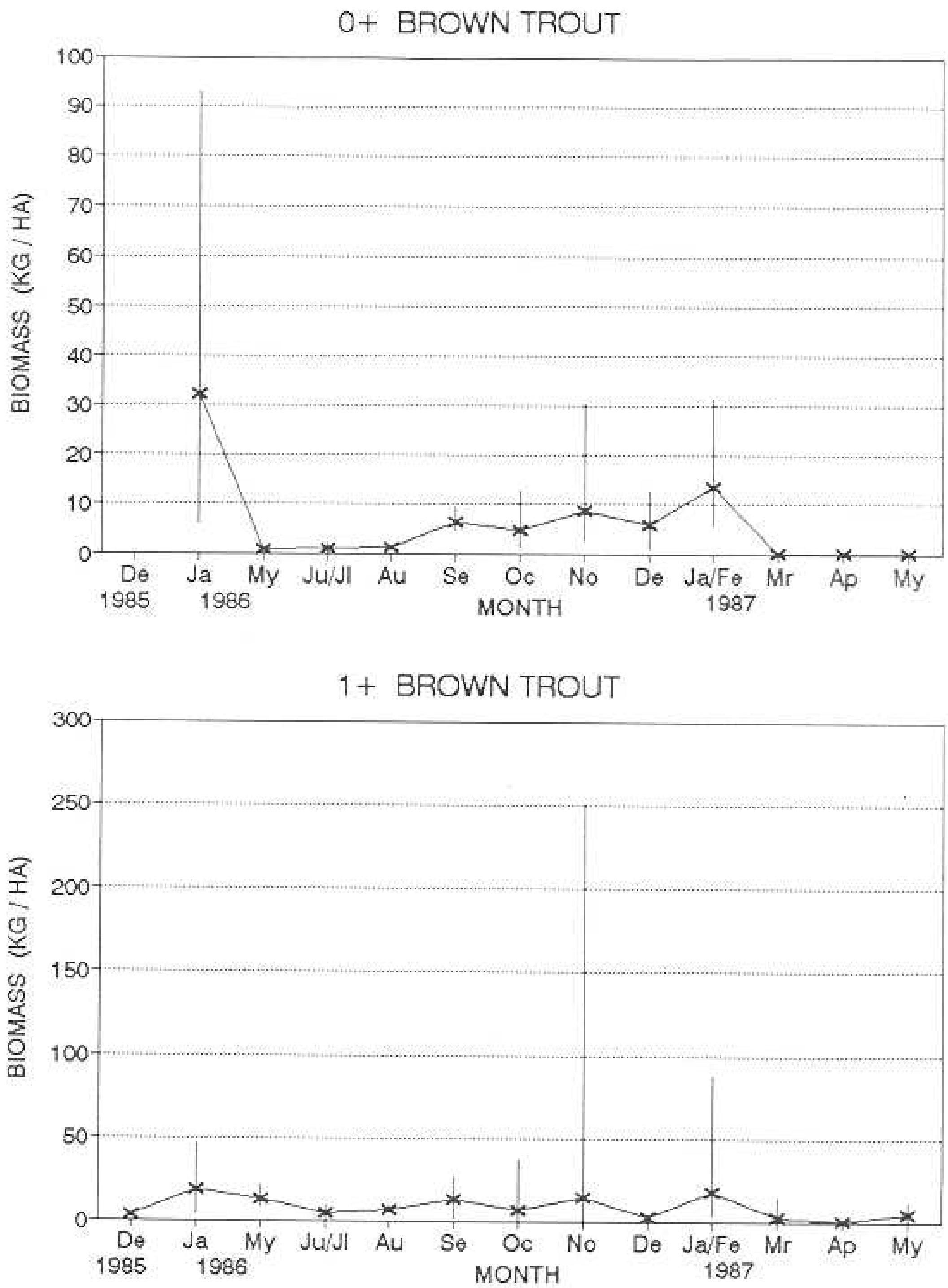


Figure 11. Mean Monthly Biomass Estimates and Observed Ranges (95% C.I.; Vertical Lines) for 0+ and 1+ Brown Trout Utilizing the Upper Side Channel, Trinity River, California, 1985-1987.

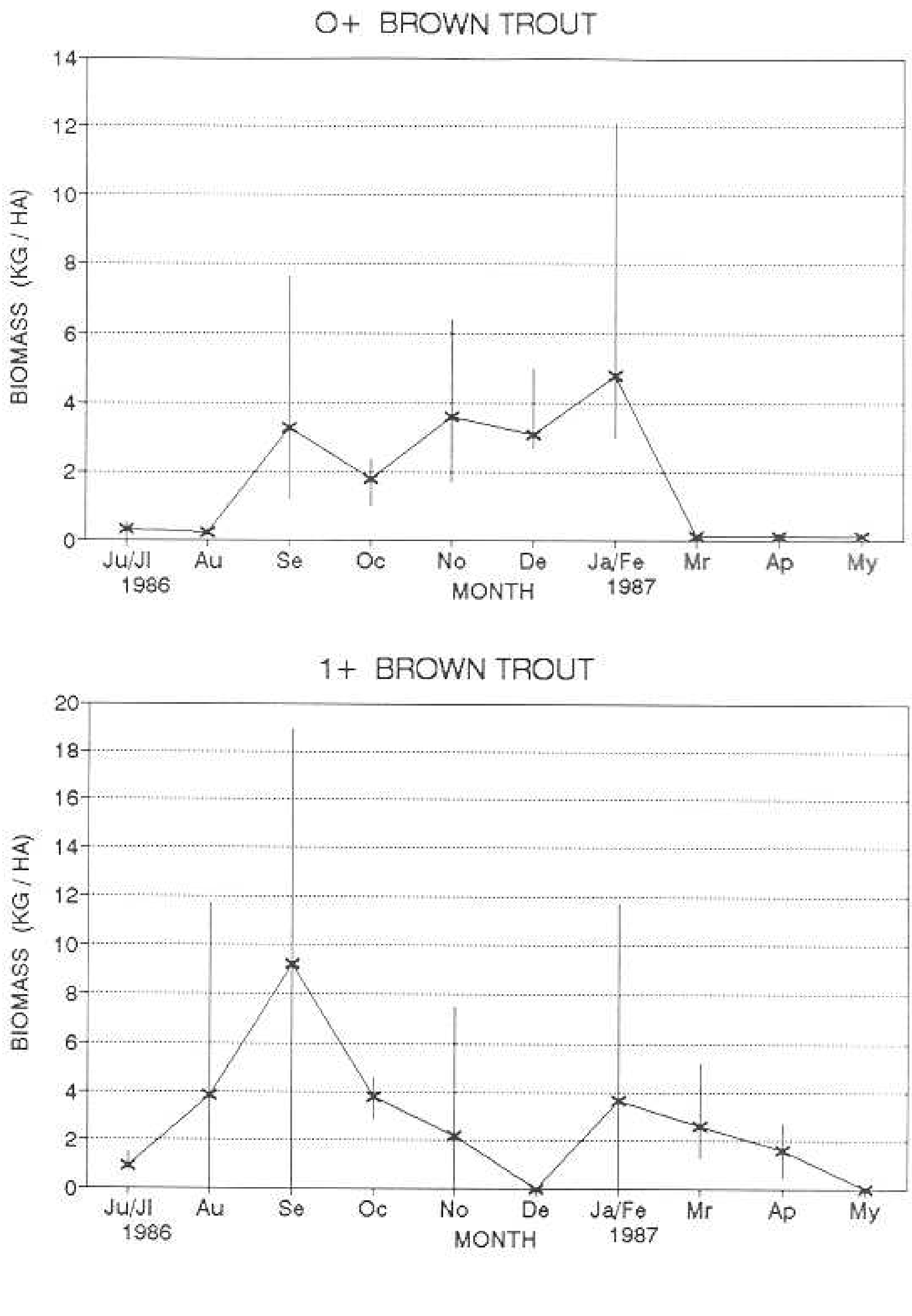


Figure 12. Mean Monthly Biomass Estimates and Observed Ranges (95% C.I.; Vertical Lines) for 0+ and 1+ Brown Trout Utilizing the Lower Side Channel, Trinity River, California, 1985-1987.

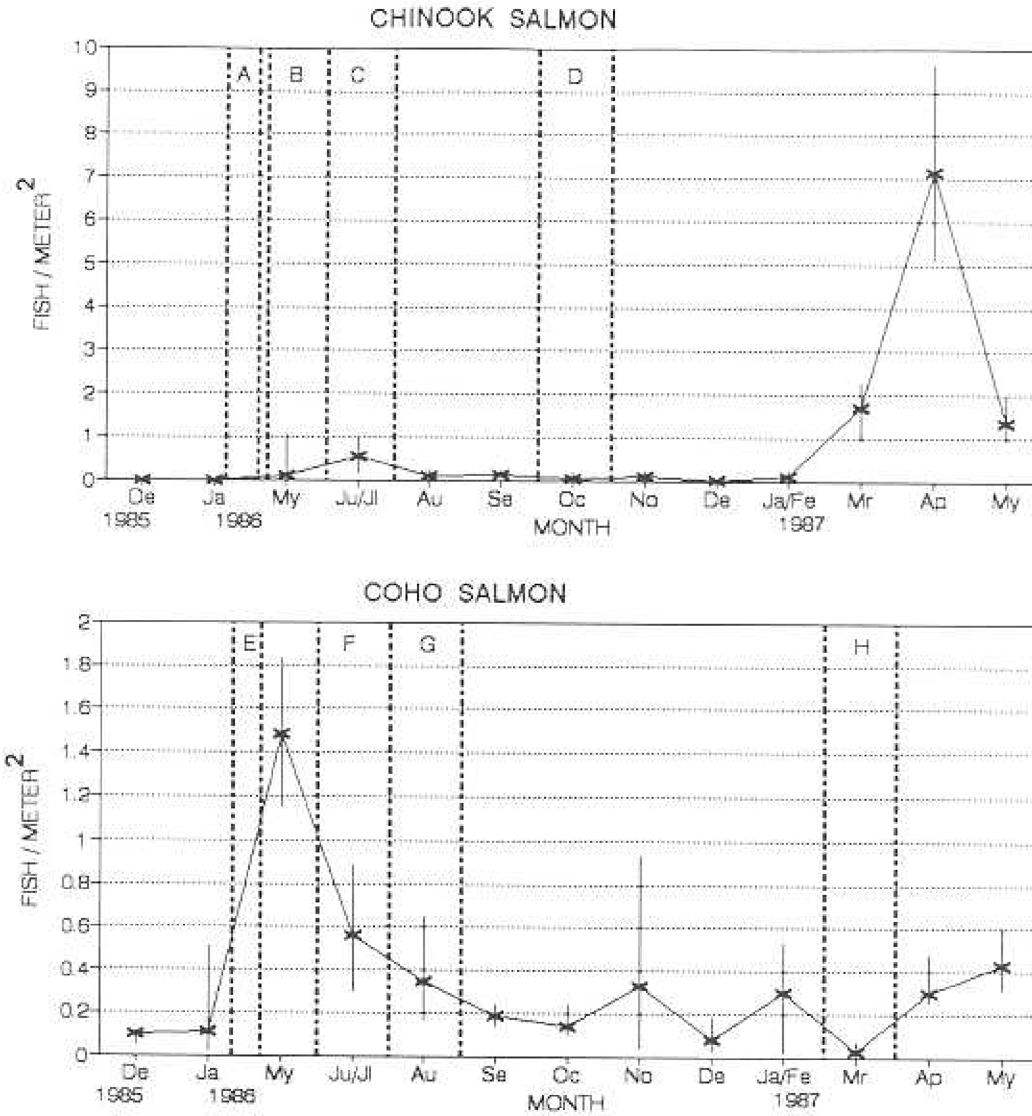
Table 8. Maximum ($Density_{max}$), Minimum ($Density_{min}$), and Averaged ($Density_{ave}$) Mean Density Estimates ($fish/m^2$) for Salmonids Utilizing Upper and Lower Side Channels, Trinity River, California, 1985-1987.

Species	$Density_{max}$	$Density_{min}$	$Density_{ave}$
UPPER SIDE CHANNEL			
Chinook	7.16[a]	0.00[bc]	0.88
Coho	1.48[d]	0.03[e]	0.34
0+ Steelhead	0.76[f]	0.01[de]	0.15
1+ Steelhead	0.11[e]	0.00[g]	0.04
0+ Brown Trout	0.32[c]	0.01[e]	0.10
1+ Brown Trout	0.07[cd]	0.01[agh]	0.04
LOWER SIDE CHANNEL			
Chinook	3.81[a]	0.10[g]	1.00
Coho	0.88[i]	0.02[e]	0.22
0+ Steelhead	0.08[j]	0.00[ek]	0.02
1+ Steelhead	0.13[l]	0.01[ghim]	0.04
0+ Brown Trout	0.08[m]	0.01[aegk]	0.03
1+ Brown Trout	0.03[m]	0.00[fh]	0.01

[a]April 1987
[b]December 1985
[c]January 1986
[d]May 1986
[e]March 1987
[f]May 1987
[g]August 1986
[h]December 1986
[i]November 1986
[j]January/February 1987
[k]June/July 1986
[l]October 1986
[m]September 1986

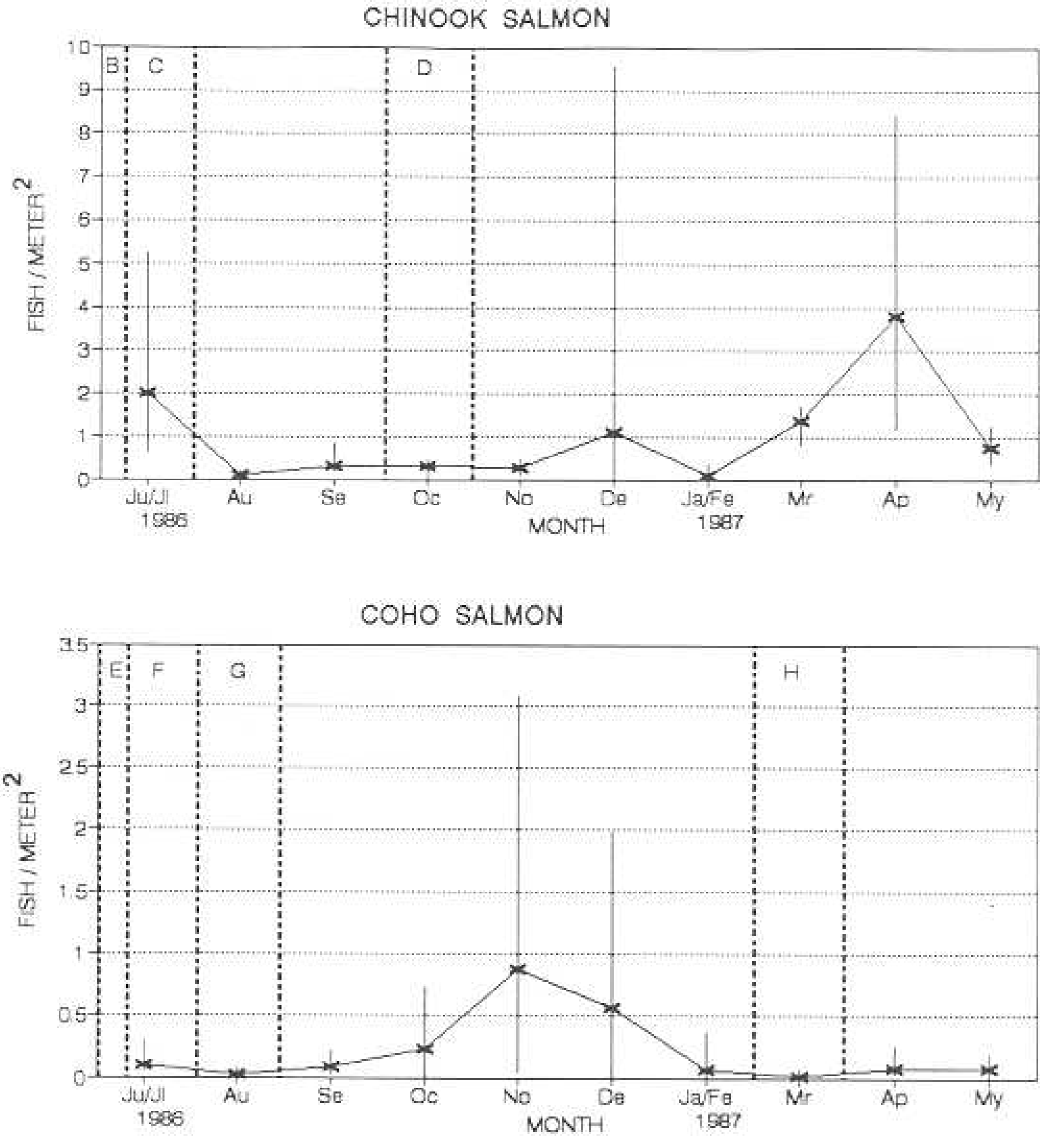
Figures 13-18 graph mean monthly population densities and 95 percent confidence intervals for juvenile salmonids utilizing upper and lower side channels. Chinook densities peaked in both side channels during April 1987. Coho densities peaked during May 1986 in the upper side channel and during November 1986 in the lower side channel. Peak densities for 0+ and 1+ steelhead in the upper side channel occurred during May and March 1987 respectively. Peak monthly fish densities for both age classes of brown trout in the upper side channel occurred during January 1986 and again during January/February 1987. Fish density trends for steelhead and brown trout were not as detectable in the lower side channel. Appendix E summarizes population estimates and confidence statistics for each fish group by month and by survey station.

Densities of chinook, coho, and steelhead were a product of both natural production and fish releases from Trinity River Hatchery. This hatchery does not culture brown trout, consequently brown trout densities were a result of natural reproduction. Appendix F summarizes fish released from Trinity River Hatchery during my study. Figures 19 and 20 chart percentages of fin clipped (hatchery) salmonids captured each month along with the time and number of fin clipped fish released from Trinity River Hatchery.



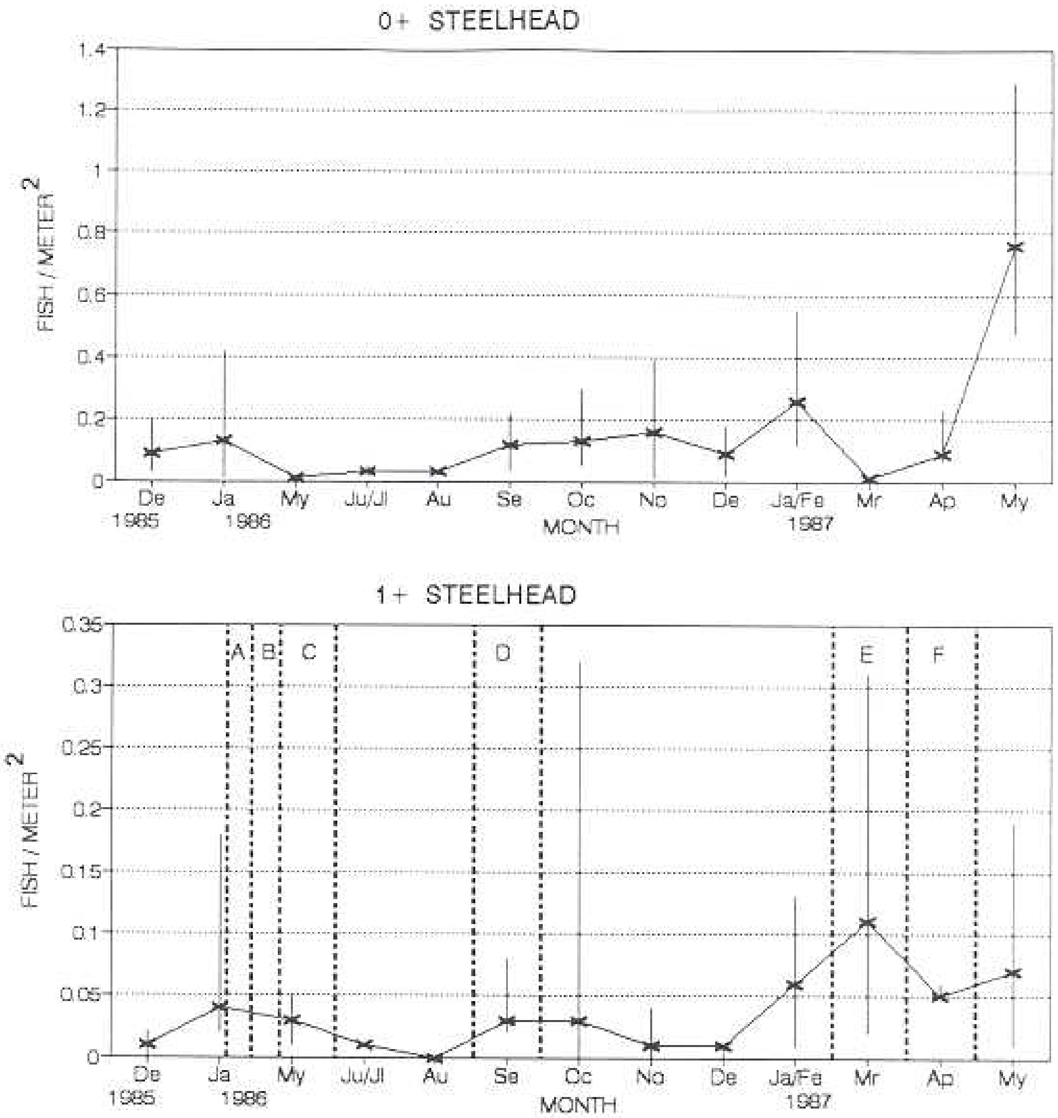
A - 156,090 Chinook; Released Over Several Days During February 1986.
B - 879,510 Chinook; Released Over Several Days During May 1986.
C - 3,974,575 Chinook; Released Over Several Days During June 1986.
D - 1,511,300 Chinook; Released Over Several Days During October 1986.
E - 562,713 Coho; Released Over Several Days During March 1986.
F - 157,500 Coho; Released On July 30, 1986.
G - 182,435 Coho; Released Over Several Days During August 1986.
H - 568,803 Coho; Released Over Several Days During March 1987.

Figure 13. Mean Monthly Population Densities and Observed Ranges (95% C.I.; Vertical Lines) for Juvenile Chinook and Coho Salmon Utilizing the Upper Side Channel, Trinity River, California, 1985-1987. Characters "A" Through "H" Represent Numbers and Dates of Fish Released at the Trinity River Fish Hatchery.



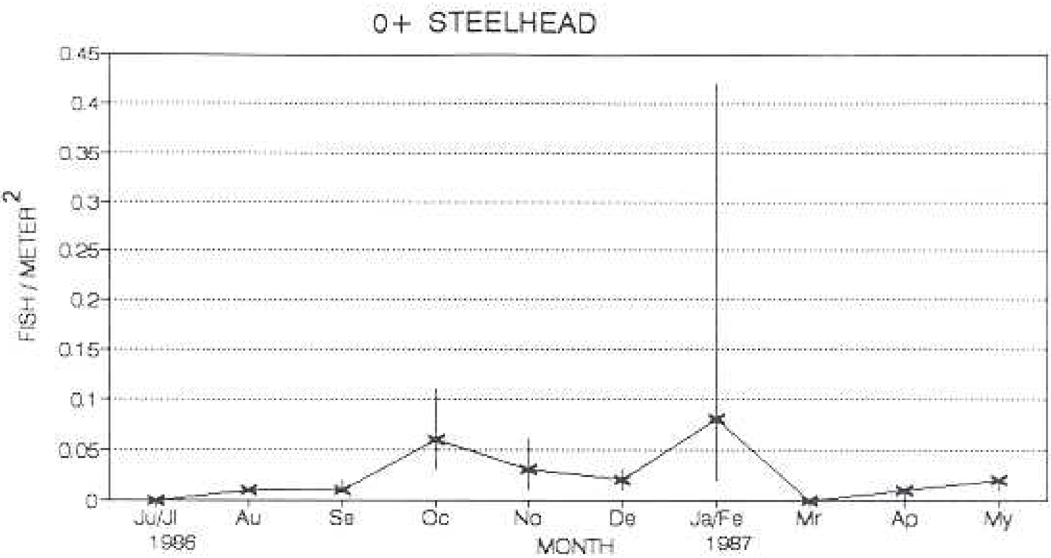
B - 879,510 Chinook; Released Over Several Days During May 1986.
C - 3,974,575 Chinook; Released Over Several Days During June 1986.
D - 1,511,300 Chinook; Released Over Several Days During October 1986.
E - 562,713 Coho; Released Over Several Days During March 1986.
F - 157,500 Coho; Released On July 30, 1986.
G - 182,435 Coho; Released Over Several Days During August 1986.
H - 568,803 Coho; Released Over Several Days During March 1987.

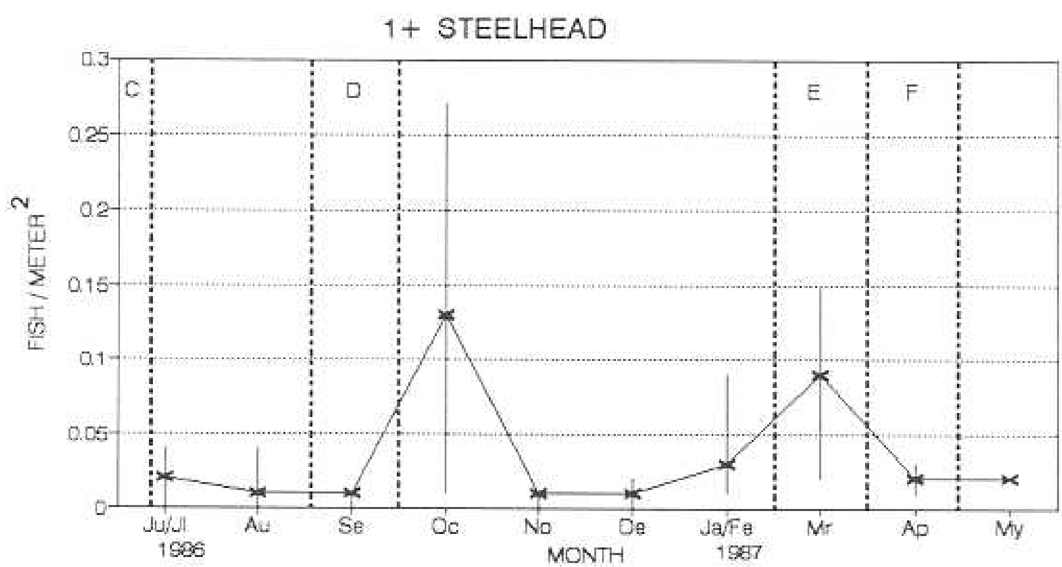
Figure 14. Mean Monthly Population Densities and Observed Ranges (95% C.I.; Vertical Lines) for Juvenile Chinook and Coho Salmon Utilizing the Lower Side Channel, Trinity River, California, 1985-1987. Characters "B" Through "H" Represent Numbers and Dates of Fish Released at the Trinity River Fish Hatchery.



A - 17,755 1+ Steelhead; Released Over Several Days During March 1986.
B - 317,576 1+ Steelhead; Released Over Several Days In April 1986.
C - 31,683 1+ Steelhead; Released On May 20, 1986.
D - 29,140 1+ Steelhead; Released On September 22, 1986.
E - 291,880 1+ Steelhead; Released Over Several Days During March 1987.
F - 215,723 1+ Steelhead; Released Over Several Days During April 1987.

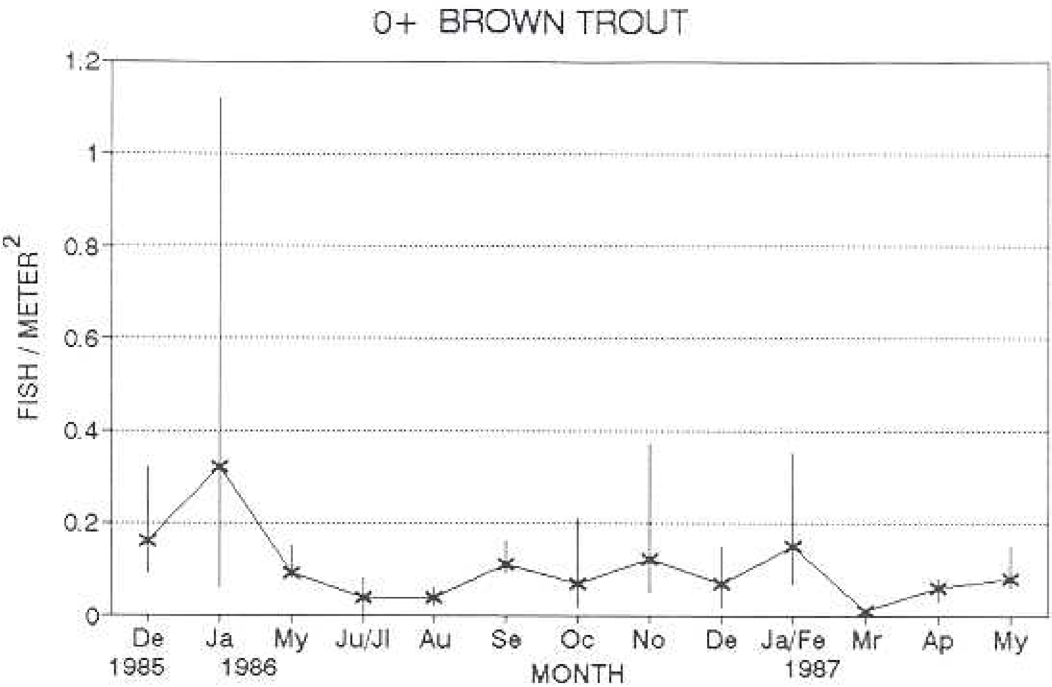
Figure 15. Mean Monthly Population Densities and Observed Ranges (95% C.I.; Vertical Lines) for 0+ and 1+ Steelhead Utilizing the Upper Side Channel, Trinity River, California, 1985-1987. Characters "A" Through "F" Represent Numbers and Dates of Fish Released at the Trinity River Fish Hatchery.





C - 31,683 1+ Steelhead; Released On May 20, 1986.
D - 29,140 1+ Steelhead; Released On September 22, 1986.
E - 291,880 1+ Steelhead; Released Over Several Days During March 1987.
F - 215,723 1+ Steelhead; Released Over Several Days During April 1987.

Figure 16. Mean Monthly Population Densities and Observed Ranges (95% C.I.; Vertical Lines) for 0+ and 1+ Steelhead Utilizing the Lower Side Channel, Trinity River, California, 1985-1987. Characters "C" Through "F" Represent Numbers and Dates of Fish Released at the Trinity River Fish Hatchery.



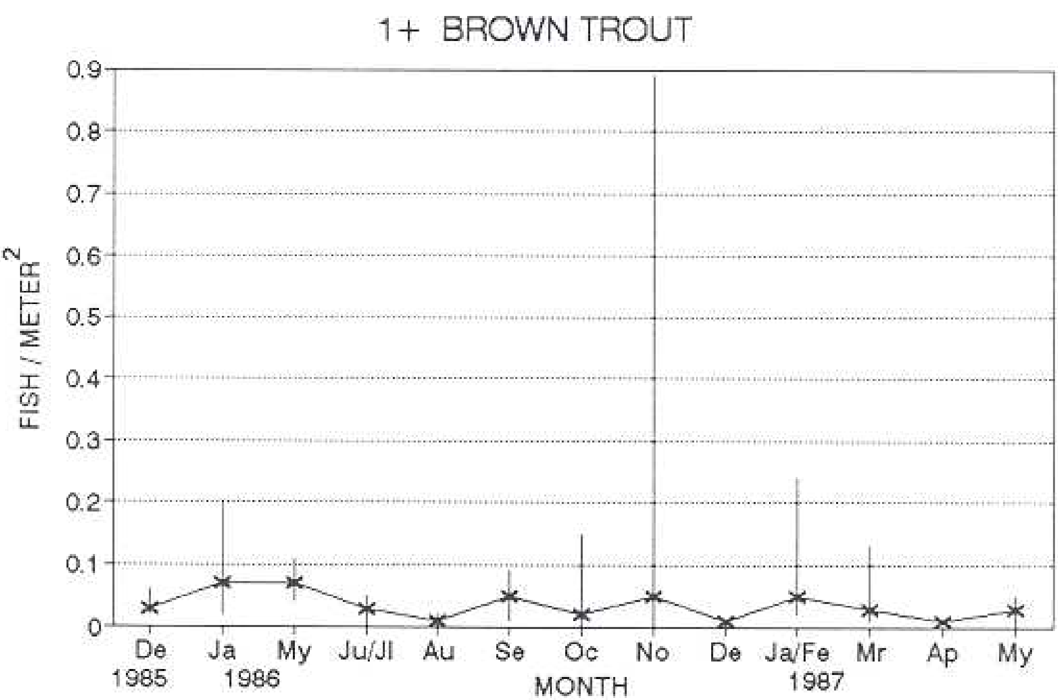


Figure 17. Mean Monthly Population Densities and Observed Ranges (95% C.I.; Vertical Lines) for 0+ and 1+ Brown Trout Utilizing the Upper Side Channel, Trinity River, California, 1985-1987.

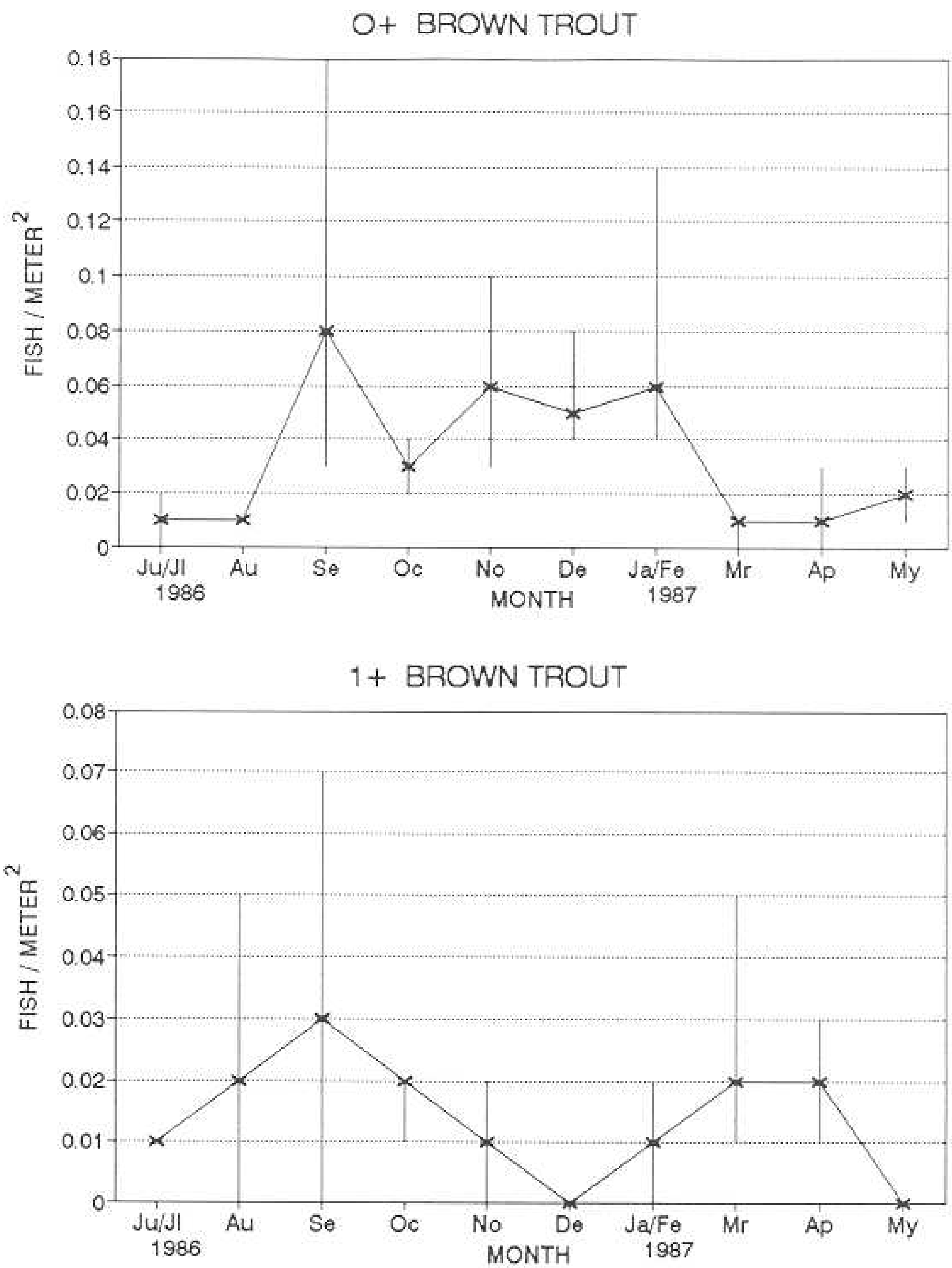
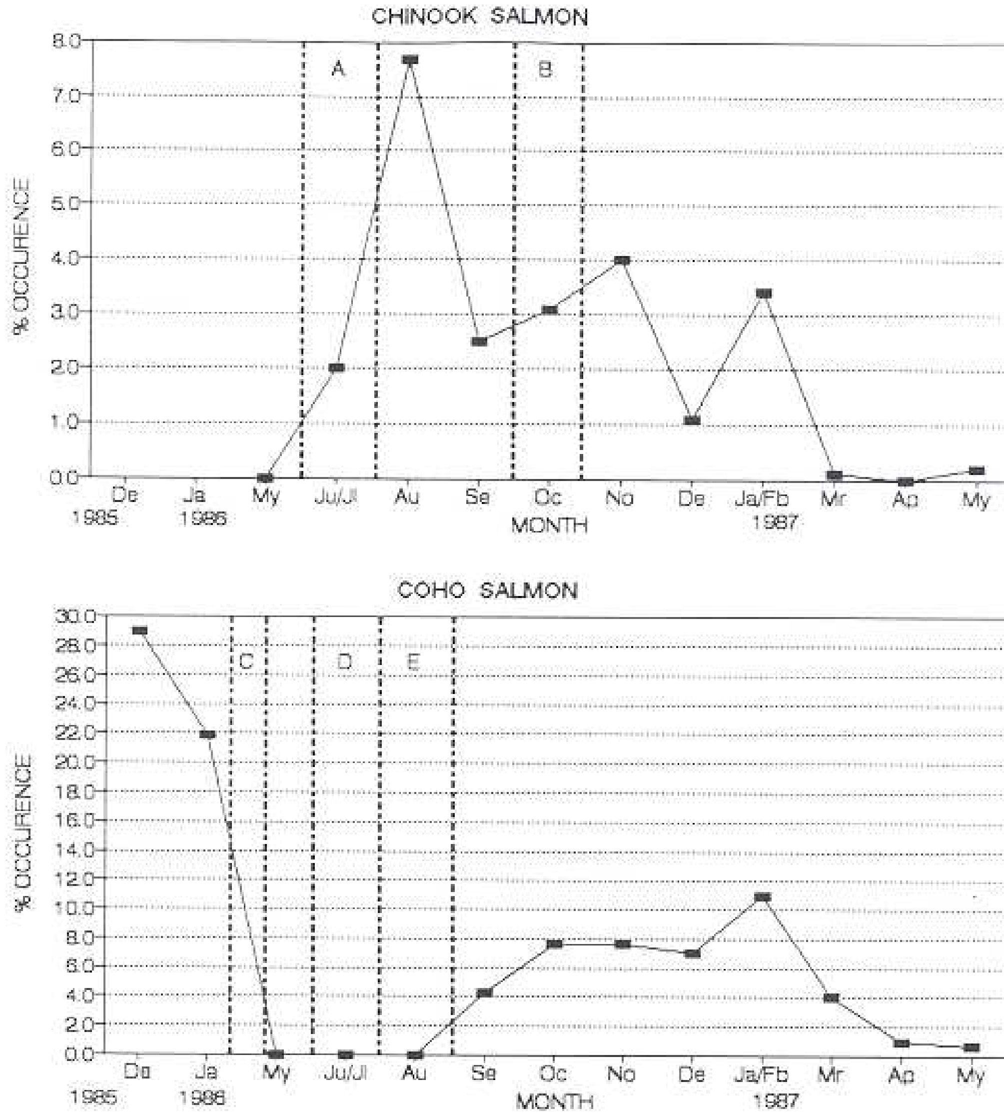
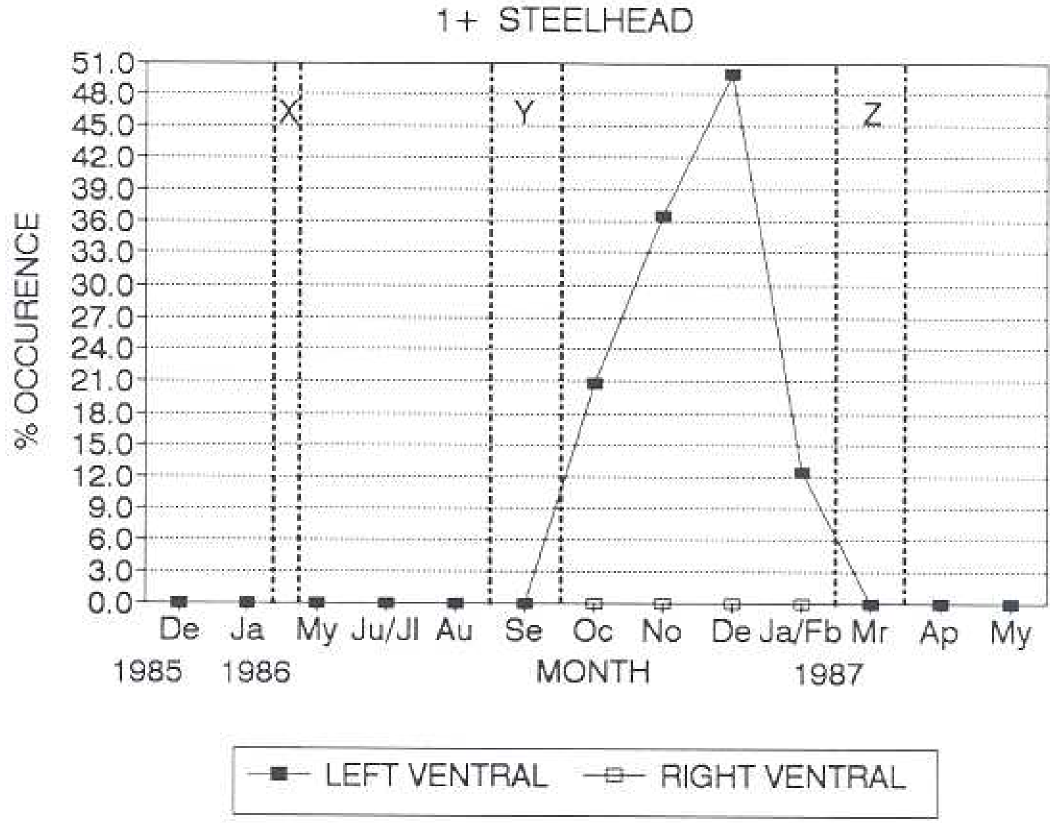


Figure 18. Mean Monthly Population Densities and Observed Ranges (95% C.I.; Vertical Lines) for 0+ and 1+ Brown Trout Utilizing the Lower Side Channel, Trinity River, California, 1985-1987.



A - 3,974,575 Chinook (10.3% Adipose Clip); Released Over Several Days During June 1986.
B - 1,511,300 Chinook (16.2% Adipose Clip); Released Over Several Days During October 1986.
C - 562,713 Coho (8.4% Adipose Clip); Released Over Several Days During March 1986.
D - 157,500 Coho (53.0% Adipose Clip); Released On July 30, 1986.
E - 182,435 Coho (6.4% Adipose Clip); Released Over Several Days During August 1986.

Figure 19. Percentage of Fin-Clipped (Adipose Clip) Chinook and Coho Salmon Observed in the Upper and Lower Side Channels, Trinity River, California, 1985-1987. Characters "A" Through "E" Represent Numbers and Percentages of Clipped Chinook Released at the Trinity River Fish Hatchery.



X - 17,755 1+ Steelhead (100% Right Ventral Clip); Released Over Several Days During March 1986.

Y - 29,140 1+ Steelhead (100% Left Ventral Clip); Released On September 22, 1986.

Z - 291,880 1+ Steelhead (9.6% Right Ventral Clip); Released Over Several Days During March 1987.

Figure 20. Percentage of Fin-Clipped (Right and Left Ventral) 1+ Steelhead Observed in the Upper and Lower Side Channels, Trinity River, California, 1985-1987. Characters "X" Through "Z" Represent Numbers and Percentages of Clipped 1+ Steelhead Released at the Trinity River Fish Hatchery.

Fish Residency

Marked fish were used to obtain information on fish residency periods in side channels. I conducted four marking campaigns in the upper channel and three in the lower channel (Table 9).

Changes in the ratio of marked to unmarked fish were monitored over time. Figures 21-26 plot monthly Duration Indices for chinook, coho and both age classes of steelhead and brown trout utilizing side channels. These figures show that fish residency in side channels was longer during the fall and winter than during the spring and summer. The residency period of salmonids in side channels ranged from less than one month to seven months. Salmonid residency was longer in the upper channel than in the lower channel (Table 10). Appendix G provides additional information on fish residency in side channels. Fish movement from one side channel to the other was not observed.

Several fish were captured from the Trinity River, marked using the Panjet inoculator, and transferred into a 114 liter aquarium to determine mark retention. Water temperatures in the aquarium ranged from 14.4 to 25.6°C. One fish (chinook) died nine days after marking and others followed at irregular intervals. The longest lived fish in the control group, a steelhead, survived 12 months. This steelhead and all other marked fish reared in the aquarium

Table 9. Dates, Number and Fin Location for Fishes Marked Using a Panjet Needleless Injector at the Upper and Lower Side Channels, Trinity River, California, 1985-1987.

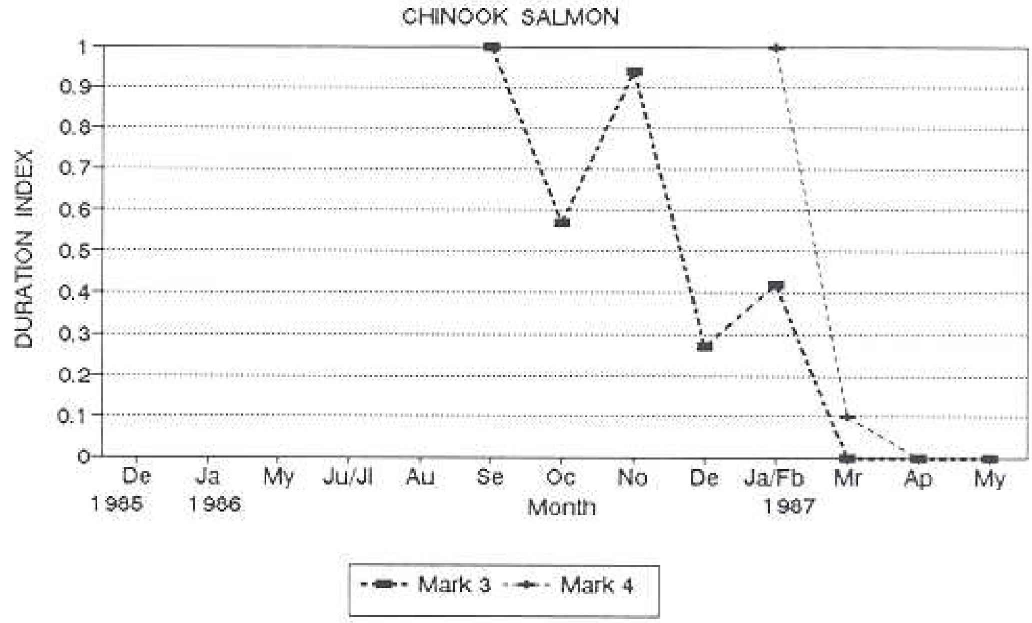
UPPER SIDE CHANNEL

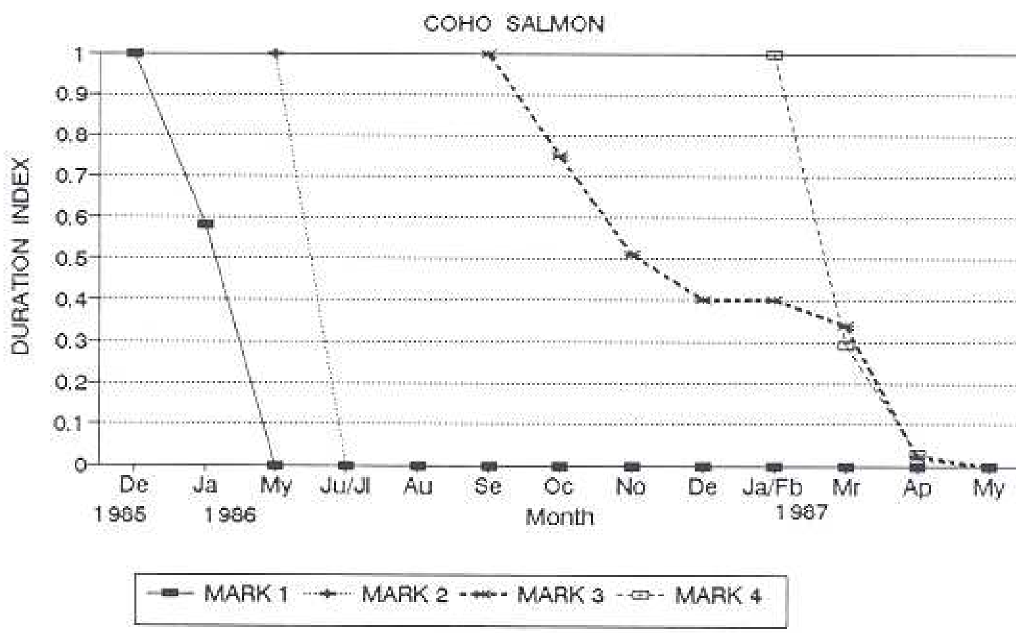
	Mark #1 [a]12/17/85 [b]Lower Caudal Fin	Mark #2 5/24/86 Anal Fin	Mark #3 9/27/86 Lower Caudal Fin	Mark #4 1/31/87 Dorsal Fin
Chinook	0	76	178	63
Coho	156	507	319	185
Steelhead	131	66	185	109
Brown Trout	322	109	106	80
Total	609	758	788	437

LOWER SIDE CHANNEL

	Mark #5 6/23/86 Lower Caudal Fin	Mark #6 9/13/86 Upper Caudal Fin	Mark #7 2/7/87 Dorsal Fin
Chinook	87	116	42
Coho	196	130	37
Steelhead	18	22	35
Brown Trout	34	75	35
Total	335	343	149

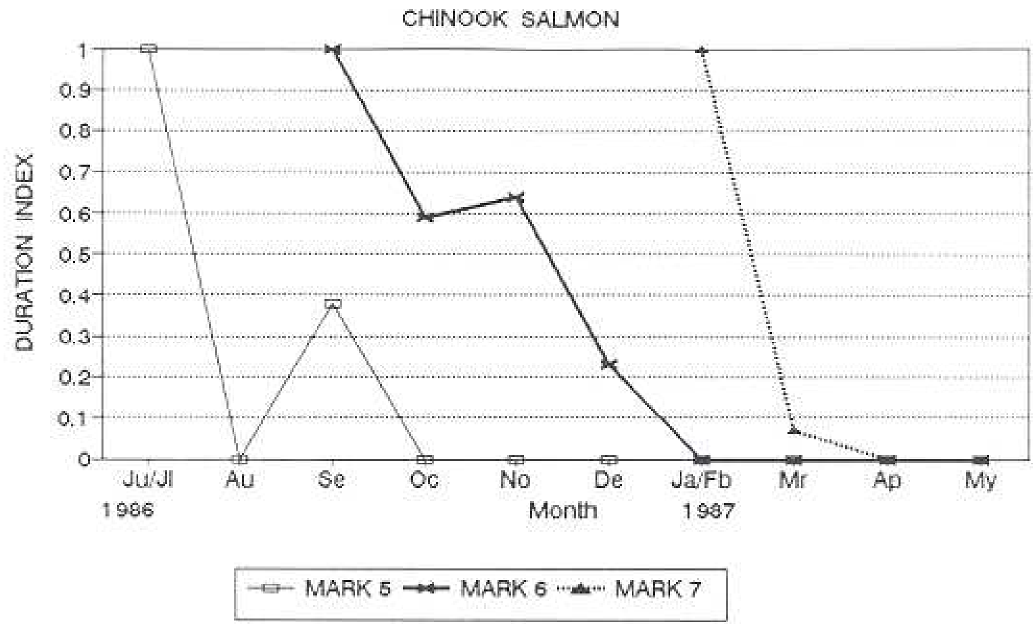
[a]Date of Mark
[b]Location of Fin Mark

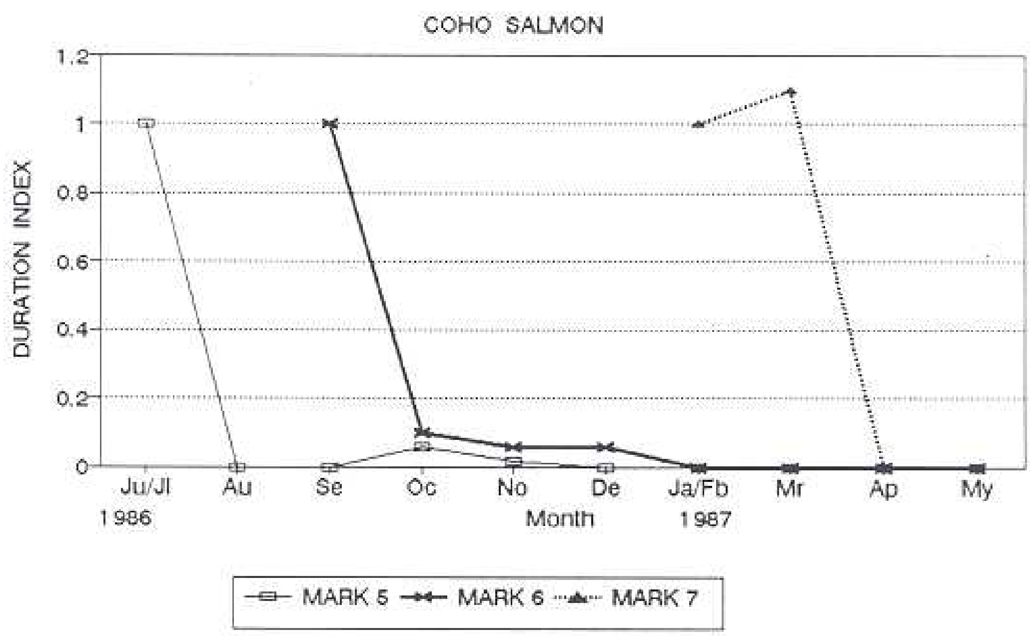




Mark 1 - December 17, 1985
Mark 2 - May 24, 1986
Mark 3 - September 27, 1986
Mark 4 - January 31, 1987

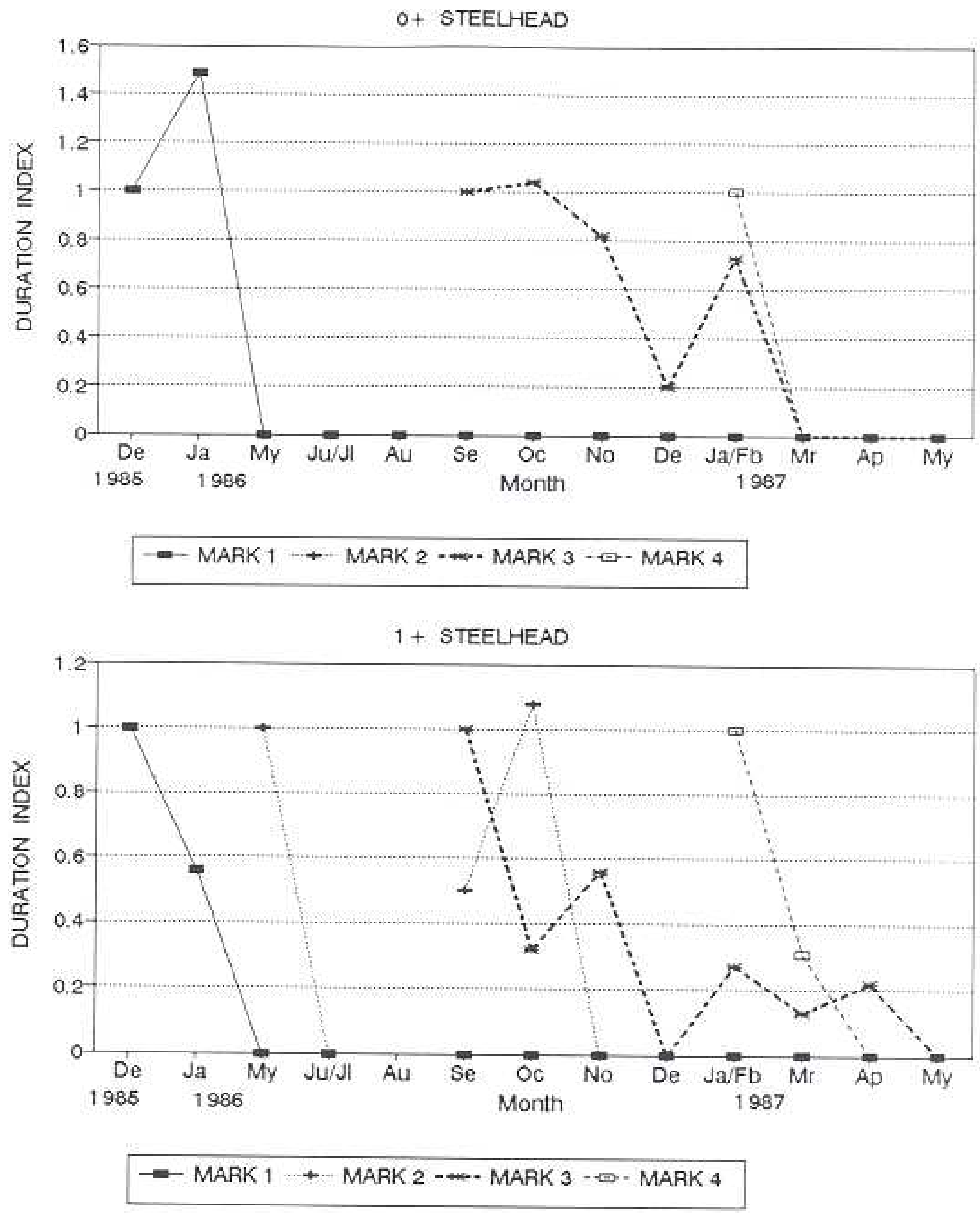
Figure 21. Duration Indices for Chinook and Coho Salmon Utilizing the Upper Side Channel, Trinity River, California, 1985-1987.





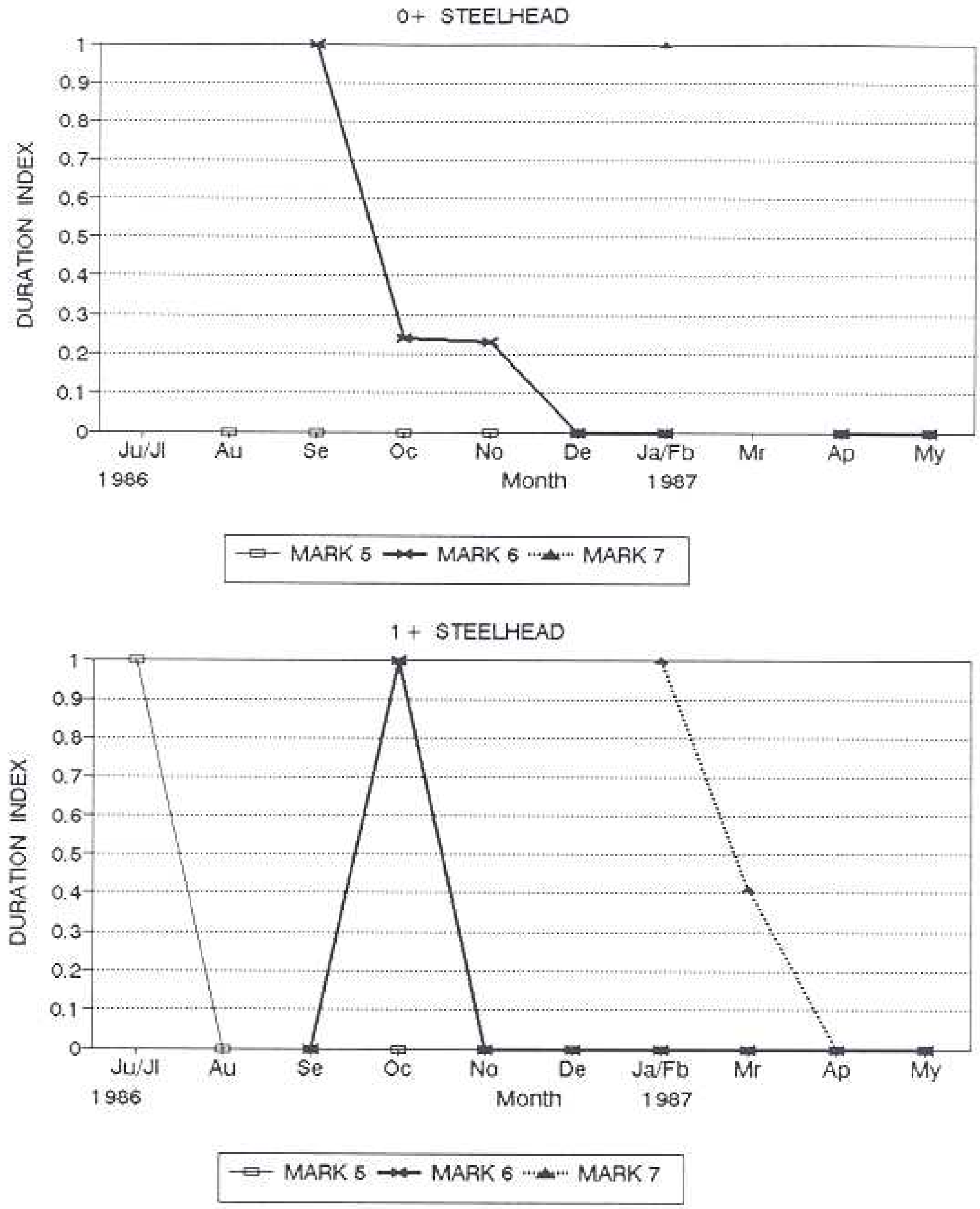
Mark 5 - June 23, 1986
Mark 6 - September 13, 1986
Mark 7 - February 7, 1987

Figure 22. Duration Indices for Chinook and Coho Salmon Utilizing the Lower Side Channel, Trinity River, California, 1985-1987.



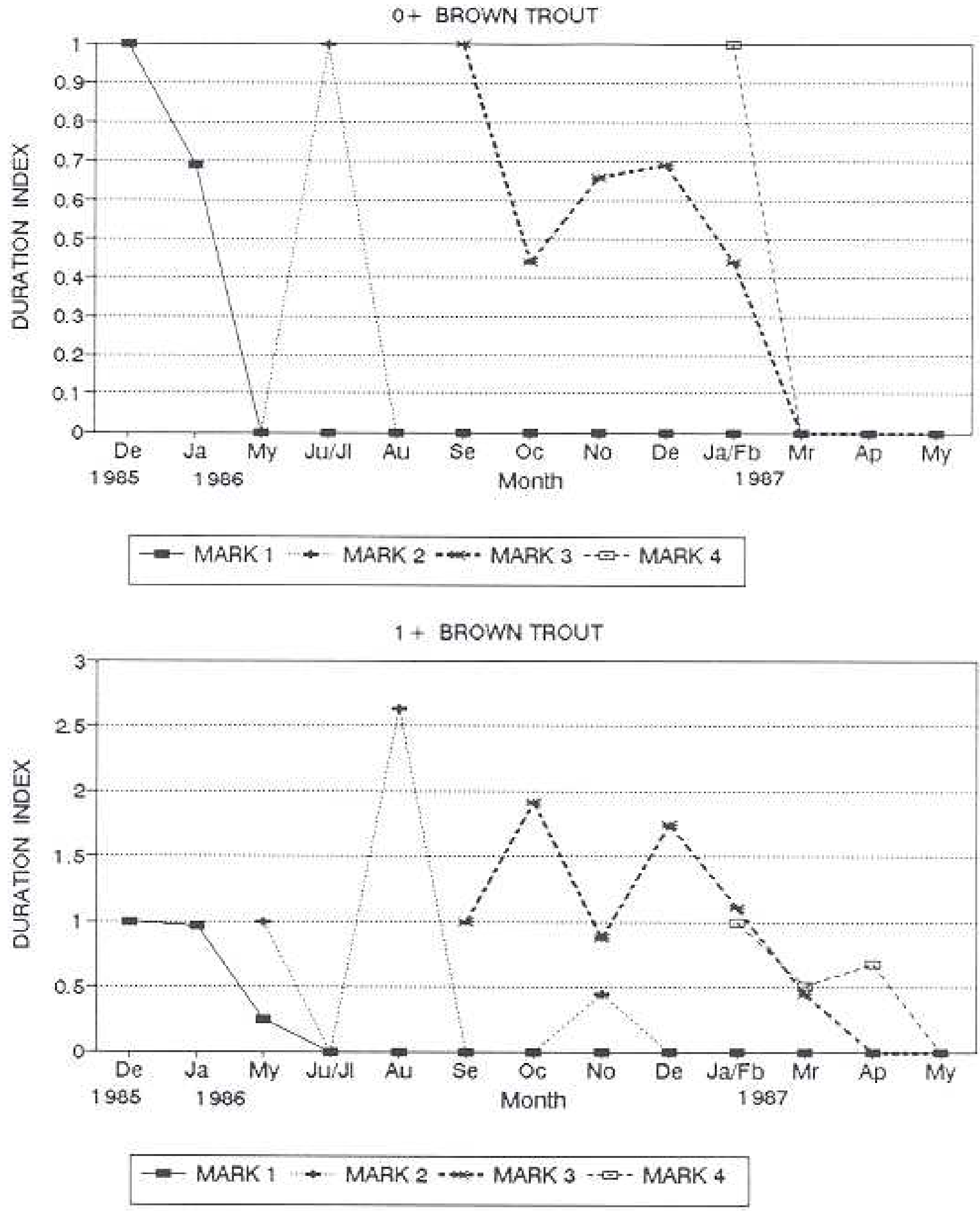
Mark 1 - December 17, 1985
Mark 2 - May 24, 1986
Mark 3 - September 27, 1986
Mark 4 - January 31, 1987

Figure 23. Duration Indices for 0+ and 1+ Steelhead Utilizing the Upper Side Channel, Trinity River, California, 1985-1987.



Mark 5 - June 23, 1986
Mark 6 - September 13, 1986
Mark 7 - February 7, 1987

Figure 24. Duration Indices for 0+ and 1+ Steelhead Utilizing the Lower Side Channel, Trinity River, California, 1985-1987.



Mark 1 - December 17, 1985
Mark 2 - May 24, 1986
Mark 3 - September 27, 1986
Mark 4 - January 31, 1987

Figure 25. Duration Indices for 0+ and 1+ Brown Trout Utilizing the Upper Side Channel, Trinity River, California, 1985-1987.

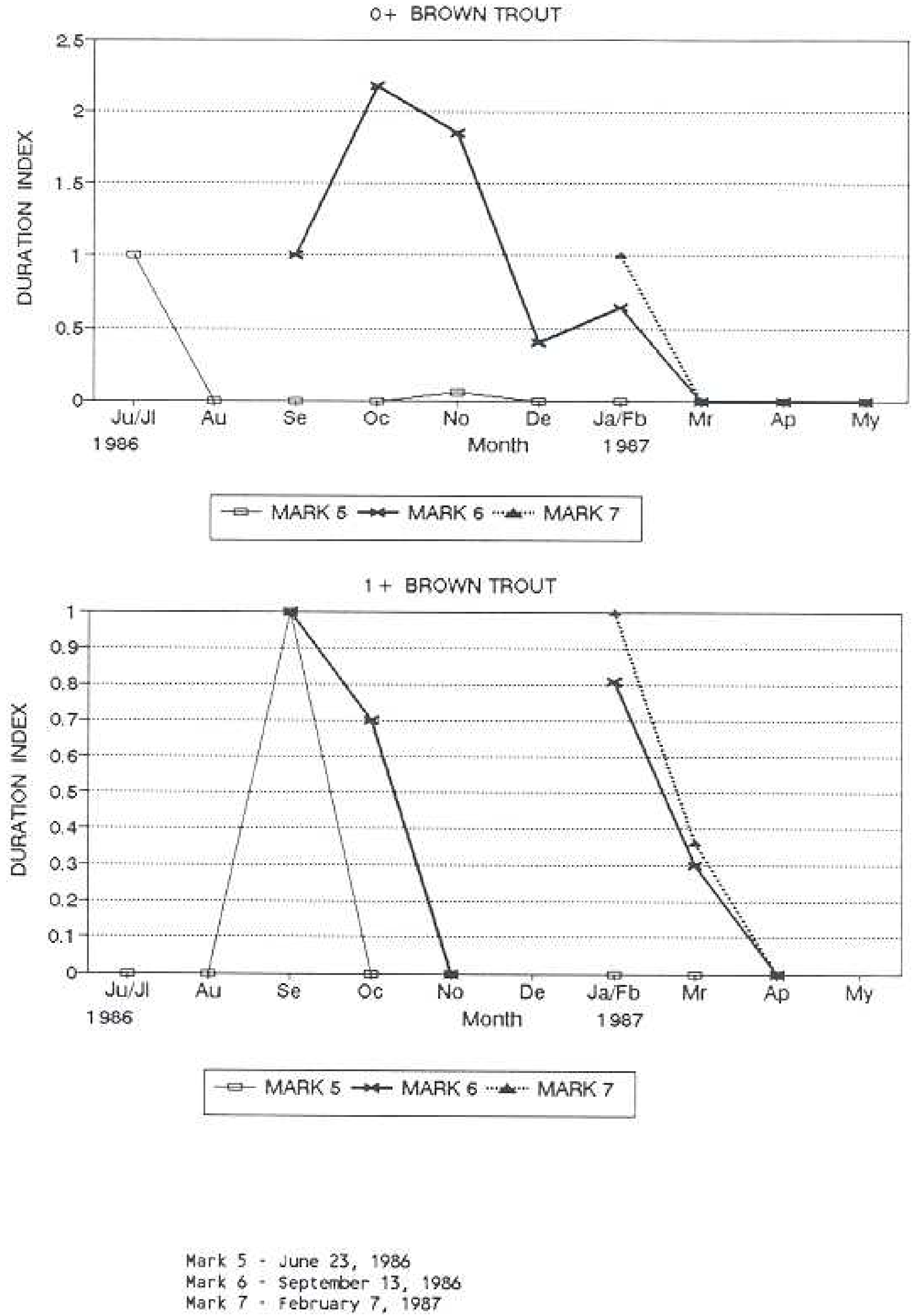


Figure 26. Duration Indices for 0+ and 1+ Brown Trout Utilizing the Lower Side Channel, Trinity River, California, 1985-1987.

Table 10. Maximum and Minimum Number of Months that Fishes Resided in the Upper and Lower Side Channels, Trinity River, California, 1985-1987.

	UPPER SIDE CHANNEL		LOWER SIDE CHANNEL	
	Maximum	Minimum	Maximum	Minimum
Chinook	5	1	3	1
Coho	6	<1	3	<1
0+ Steelhead	4	<1	2	<1
1+ Steelhead	7	1	1	<1
0+ Brown Trout	4	<1	4	<1
1+ Brown Trout	6	2	1	1

retained visible marks up to the time of their demise. High water temperatures and over-crowding contributed to fish mortalities in the aquarium.

Stream Discharge and Temperature

Stream discharges at all sites was influenced by releases from Lewiston Dam. Releases from Lewiston Dam ranged from 8.5 m^3/s to 169.9 m^3/s. During normal years, high releases from Lewiston Dam averaged 22.7 m^3/s. Flooding during Spring 1986 resulted in unusually high releases from Trinity and Lewiston Dams.

Stream discharges in the upper channel ranged from 0.3 m^3/s to 10.3 m^3/s. Stream discharges in the lower channel ranged from 0.9 m^3/s to 10.8 m^3/s. Minimum stream discharge in side channels was measured during a Dam release of 8.5 m^3/s and maximum side channel discharge was measured during a Dam release of 70.8 m^3/s (Figure 27). Stream discharges were not measured during the 169.9 m^3/s release from Lewiston Dam.

Surface area of survey stations was affected by stream discharge. Surface area of stations in the upper channel ranged from a mean of 151.7 m^2 to a mean of 165.5 m^2. Surface area of survey stations in the lower channel ranged from a mean of 146.3 m^2 to a mean 172.3 m^2.

Despite warm air temperatures during summer months, cold water releases from Lewiston Dam maintained low summer

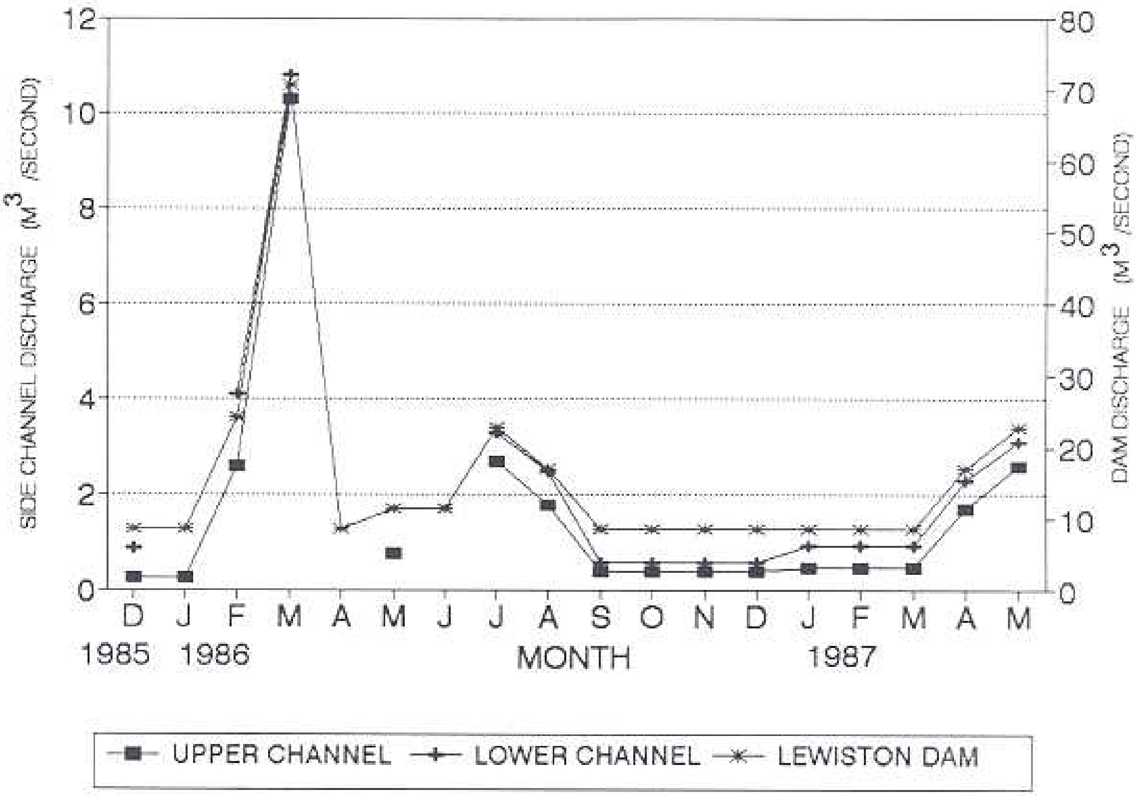


Figure 27. Monthly Discharge Rates for the Upper and Lower Side Channels and Lewiston Dam, Trinity River, California, 1985-1987.

water temperatures. Water temperatures in the upper side channel ranged from 7.5 to 13.3°C with a mean of 9.7°C (Figure 28, Appendix H). Water temperatures in the lower side channel ranged from 7.5 to 13.1°C with a mean of 10.0°C. Trinity River temperatures ranged from 6.4 to 13.9°C with a mean of 10.4°C.

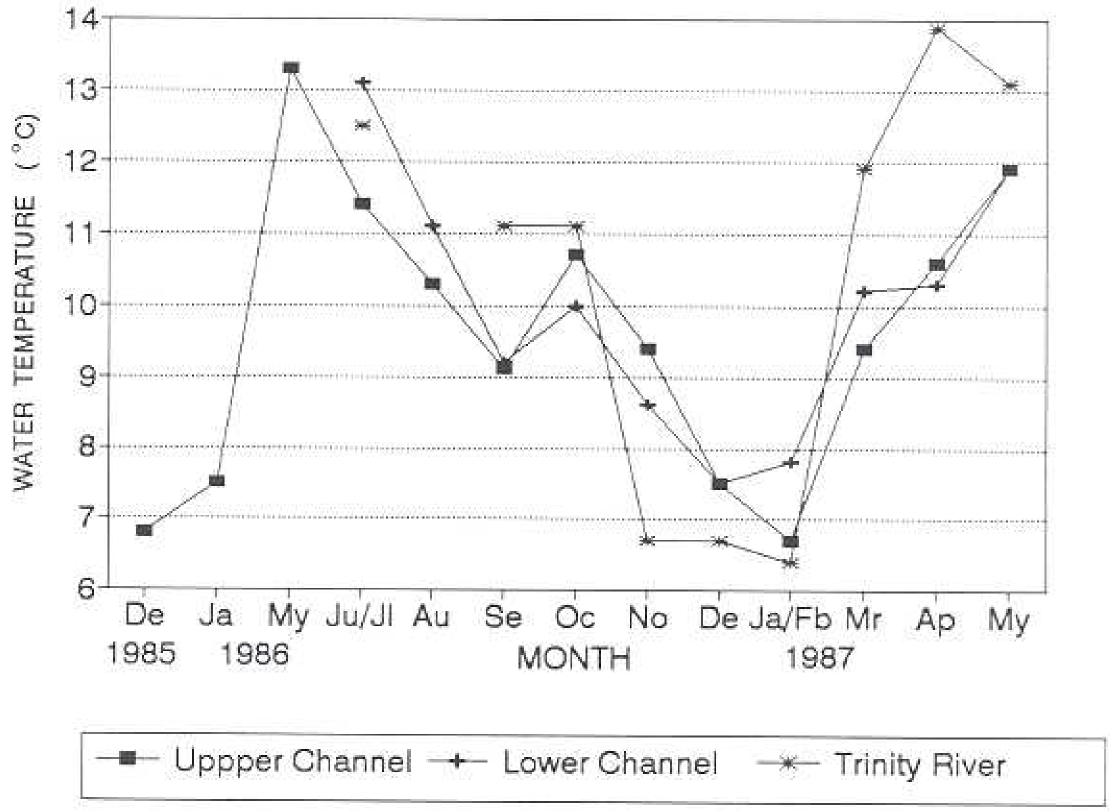


Figure 28. Monthly Water Temperatures for the Upper and Lower Side Channels and Trinity River, California, 1985-1987.

DISCUSSION

Species Composition

Species compositions differed among the three habitats studied and an overall habitat preference did exist for coho, steelhead, and brown trout, even when seasonality was factored in the analyses. Except for winter, chinook showed a preference for side channels (Chi-square, $p < 0.05$; ANOVA, $p < 0.0001$). Coho preferred side channels during all seasons (Chi-square, $p < 0.05$; ANOVA, $p < 0.0001$). Coho preferred the lower channel during winter and the upper channel during spring, summer and fall (ANOVA, $p < 0.01$). Steelhead preferred side channels during winter (Chi-square, $p < 0.05$) or during winter and spring (ANOVA, $p < 0.0001$). Brown trout preferred side channels during winter (Chi-square, $p < 0.05$; ANOVA, $p < 0.0001$).

Contrary to results from Chi-square and ANOVA analyses, chinook showed no statistically significant preference for any habitat following the Scheffe's test ($p > 0.05$). Coho preferred the upper channel ($p < 0.05$), steelhead preferred the upper channel and Trinity River ($p < 0.05$), and brown trout preferred the upper channel and Trinity River ($p < 0.05$).

Except for chinook, all analyses pertaining to species preference had similar results. Discrepancies among different analyses for chinook can be attributed to differing sensitivities of each test. Contingency table analysis (Chi-square) is more sensitive to relative count data. Analysis of variance is more sensitive to actual count data (Sokal and Rohlf 1969).

My findings suggest juvenile chinook utilized Trinity River side channels to some degree. Use of side channels by juvenile chinook is mentioned by other investigators (Hamilton and Buell 1976; Doyle 1984; Brusven et al. 1986; Swales et al. 1986; Hillman et al. 1987; U.S. Fish and Wildlife Service 1988; U.S. Fish and Wildlife Service 1990). Everest and Sedell (1983) and Everest et al. (1984) reported juvenile chinook absent in side channels, however Hamilton and Buell (1976) found conspicuously high numbers of both chinook and coho in side channels of the Campbell River in British Columbia. U.S. Fish and Wildlife Service (1988) reported that Trinity River side channels provided a 72 to 102 percent increase in chinook fry habitat when stream discharge in the Trinity River was 9.9 to 25.5 m^3/s. A new side channel created along the Trinity River at Salt Flat (river km 172) in 1989 increased weighted usable area for chinook fry by 425 m^2 and chinook juveniles by 1,377 m^2 (U.S. Fish and Wildlife Service 1990). This report also noted that modifications to the lower side channel increased weighted usable area for chinook fry 5.3 times and chinook juveniles 3.6 times.

Although creation and modification of existing side channels should increase available habitat for juvenile salmon, other variables that influence use of these habitats must be considered. Interspecific competition may limit the use of side channels by some species. Lister and Genoe (1970) documented that coho and chinook had similar habitat requirements but direct competition was avoided by spatial segregation. Stein et al. (1972) reported that chinook populations in Sixes River, Oregon may be adversely affected by increases in coho numbers during the fall.

All analyses indicated an overwhelming preference by coho for side channel habitats. Use of side channels by juvenile coho is well documented (Ruggles 1966; Bustard and Narver 1975a; Bustard and Narver 1975b; Hamilton and Buell 1976; Kerr et al. 1980; Mundie 1980; Everest and Sedell 1983; Mundie and Traber 1983a; Mundie and Traber 1983b; Tschaplinkski and Hartman 1983; Bachen 1984; Doyle 1984; Everest et al. 1984; House and Boehne 1986; Swales et al. 1986; Hartman and Brown 1987; Taylor 1988; U.S. Fish and Wildlife Service 1988; Reeves et al. 1989; Nielsen 1990; U.S. Fish and Wildlife Service 1990). Doyle (1984) reported that coho were the primary benefiting species following side channel enhancement projects in Puget Sound stream systems. Habitat modifications increased rearing habitat by 30 to 75 percent and doubled high quality spawning habitat. In another case, coho use increased by 300 percent following enlargement of a side channel (Everest and Sedell 1983). Modifications to Trinity River's lower channel by U.S. Fish and Wildlife Service increased weighted usable area (WUA) 5.1 times for coho fry and 4.0 times for coho juveniles (U.S. Fish and Wildlife Service 1990). This study also found that development of a new side channel at Salt Flat increased WUA by 204.6 m^2 for coho fry and 306.6 m^2 for coho juveniles.

Coho showed a significant preference for the lower channel during winter and the upper channel during spring, summer and fall. The lower channel was 18 percent longer and had a higher discharge rate than the upper channel. Many sites at the lower channel could not be surveyed due to deep pools. These pools may have been preferred habitat for coho during winter. Several studies documented the importance of low velocity, deep pool habitats for over-wintering coho (Hartman 1965; Lister and Genoe 1970; Peterson 1982; Everest and Sedell 1983; Heifetz et al. 1986). Other studies specifically mentioned side channels as over-wintering habitat for juvenile coho (Bustard and Narver 1975a; Bustard and Narver 1975b; Kerr et al. 1980; Mundie and Traber 1983a; Tschaplinkski and Hartman 1983; Swales et al. 1986; Reeves et al. 1989). Martin et al. (1986) found that winter mortality of coho ranged from 60 to 83 percent in Washington streams. The preference by over-wintering coho for the lower channel suggested that this channel had optimum habitat that supported coho and minimized mortality.

The preference by coho for the upper channel during the spring, summer and fall suggested that this channel maintained optimal habitat during the growing season. Swales et al. (1986) reported that juvenile salmonids preferred British Columbia side channels over main stem habitats, particularly coho. Swales et al. (1986) reported that this attraction to side channels may be related to low water velocity, abundant cover, higher water temperatures, lack of predators, and abundant food supply. Mundie (1980) stated that the main river provides side channel habitats with flow and drifting invertebrates. Mundie (1974) reported that side channel sites should be designed to maintain riffle habitats in order to optimize invertebrate production. The upper channel more closely paralleled the main stem and may have received a greater influx of invertebrate drift. The upper channel also appeared to have a greater riffle to pool ratio. These two factors may have combined to give greater invertebrate production and, as such, made the upper channel more desirable for coho during the growing season.

All my analyses concurred that steelhead preferred side channels during winter. Steelhead also preferred side channels during the spring. Use of side channels by juvenile steelhead has also been documented (Bustard and

Narver 1975a; Doyle 1984; Everest and Sedell 1983; Mundie and Traber 1983a; Everest et al. 1984; House and Boehne 1986; Swales et al. 1986; Hartman and Brown 1987; U.S. Fish and Wildlife Service 1988; Nielsen 1990; U.S. Fish and Wildlife Service 1990). In addition, Maciolek and Needham (1952) documented side channel use by resident rainbow trout.

Everest and Sedell (1983) reported that the most preferred habitat for 0+ steelhead was side channels; steelhead (0+) comprised 64 percent of the salmonid population in side channels. They also reported that increases in coho numbers following side channel enhancement may have occurred to the detriment of 0+ steelhead populations. Since juvenile coho were larger and more aggressive than 0+ steelhead, competition for space may have acted to reduced 0+ steelhead numbers. Modifications to lower side channel (Trinity River) by the U.S. Fish and Wildlife Service increased weighted usable area 4.5 times for steelhead fry, 2.0 times for steelhead juveniles, and 11.7 times for over-wintering steelhead (U.S. Fish and Wildlife Service 1990). This study also reported that development of a new side channel at Salt Flat increased WUA by 706.4 m^2 for steelhead fry, 1112.6 m^2 for steelhead juveniles, and 106.7 m^2 for over-wintering steelhead.

A few studies have documented the importance of low velocity habitats for over-wintering steelhead (Hartman

1965; Everest and Sedell 1983; Heifetz et al. 1986). Everest and Sedell (1983) and U.S. Fish and Wildlife Service (1990) reported that over-wintering juvenile steelhead used side channels. My findings suggested that side channels maintained vital over-winter habitat for steelhead. The prevalence of low-velocity habitat in side channels is probably a key factor in winter steelhead use. Hartman (1965) found no significant habitat segregation between over-wintering coho and steelhead. Apparently, territoriality and other competitive-driven interactions were outweighed by the necessity for low-velocity sites during winter high flow periods. The reduced metabolism of fishes rearing in cold water habitats may also reduce competitive interactions, thereby allowing temporary sympatry.

My results also indicated that steelhead preferred side channels during spring (ANOVA). A preference for side channels during the spring may have been related to the fact that many newly emergent steelhead had not developed to the extent that they could venture out into the faster velocities of the Trinity River. As steelhead grew and developed a greater ability to use faster water velocities, main stem habitats could be exploited. This was confirmed by both analyses as steelhead showed a preference for main stem habitats during the summer and fall. Multiple comparison analysis indicated that steelhead showed an overall preference for both the upper side channel and the Trinity River. This was probably related to the fact that steelhead preferred side channels during the winter-spring and Trinity River during the summer-fall.

All my analyses concurred that brown trout preferred side channels during the winter and Trinity River during the spring, summer and fall. I was unable to find references pertaining to side channel use by brown trout. Similarly, information on brown trout interactions with anadromous salmonids is limited. Hartman (1963) reported that brown trout show seasonal behavioral differences and become less active during low water temperatures. My results indicated that juvenile brown trout behave in a manner similar to juvenile steelhead.

Studies which monitor species composition in a habitat over time should consider specific habitat requirements and intraspecific/interspecific competition. These factors probably affect species composition. Many studies concurred that juvenile salmonids prefer slow water habitats during certain developmental stages (Lister and Genoe 1970; Bjornn 1971; Everest and Chapman 1972; Taylor 1988; U.S. Fish and Wildlife Service 1988; Murray and Rosenau 1989). Seasonality may also affect habitat selection (Hartman 1965; Bustard and Narver 1975a; Kerr et al. 1980; Peterson 1982; Heifetz et al. 1986; Taylor 1988). Competition among juvenile salmonids may also affect species composition (Hartman 1965; Lister and Genoe 1970; Stein et al. 1972; Dill 1978; Ejike and Schreck 1980; Mundie and Traber 1983a). Side channels appear to maintain a contingency of habitat variables that are preferred by juvenile salmonid populations.

Length and Biomass

Steelhead was the only species that showed a significant difference in fork length related to habitat ($p < 0.0001$). Steelhead in the lower channel had the longest average fork length ($p < 0.05$). Juvenile steelhead length did not differ significantly between the upper channel and the Trinity River.

Several deep pools in the lower side channel may have provided habitat for larger steelhead. Barnhart (1986) reported that steelhead in their first year of life tend to inhabit riffles, but older juveniles tend to inhabit pools or deeper runs. I would have expected the Trinity River to also support larger juvenile steelhead. In the main stem Trinity River adjacent to my survey stations, there were several deep pools and run habitats. During electroshocking, larger fish may have retreated to these deeper habitats prior to becoming immobilized. Deeper areas in both the Trinity River and side channels were not surveyed due to sampling limitations. Although deep pools also existed at the lower channel, block nets may have prevented some larger fish from escaping prior to electroshocking.

Larger juvenile steelhead may have been drawn to the lower channel by the presence of large numbers of younger salmonids and other forage. Moyle (1976) reported that rainbow trout begin feeding on fish at 300 to 350 mm total length. Other investigators reported that newly emerged fry are sometimes preyed upon by older juvenile steelhead (Shapovalov and Taft 1954; Chapman 1966; Barnhart 1986). Perhaps an optimal combination of food availability and water depth encouraged use of the lower side channel by larger juvenile steelhead.

As expected, growth of all species was most rapid during the spring and summer and static during late fall and winter (Figures 4-6). Mean fork length values decreased significantly during the spring when emergent fry entered the population. Peak emergence of chinook and coho fry were approximately one month apart with chinook emergence peaking in March and coho emergence peaking in April (Figures 4-6). Older 1+ steelhead and brown trout did not show as clear a growth pattern. This may have been attributed to larger fish leaving side channels for deeper main stem habitats, which opened up territories for smaller individuals.

Figure 5 tends to support the finding that larger steelhead preferred the lower side channel over the upper side channel and Trinity River. While the graph for 0+

steelhead indicates fish were slightly smaller in the lower side channel, the graph for 1+ steelhead clearly shows that the lower channel maintained larger fish over time.

Fish releases from Trinity River Hatchery had no obvious affect on average fork length data. Hatchery fish were relatively close in size to wild fish when released.

Fish fork length data were generally comparable to those from other investigations (Lister and Genoe 1970; Young 1987; U.S. Fish and Wildlife Service 1988; Murray and Rosenau 1989), although I recorded larger mean fork lengths for coho than Lister and Genoe (1970) during April and May. The mean fork length for chinook was below 90 mm for all habitats. Presumably, most chinook left the upper Trinity River and began their downstream migration prior to attaining this size. Young (1987) reported that juvenile chinook entering the ocean at the Mattole River, California estuary averaged 107 mm. Fork length data for chinook measured in 1988 at the upper channel by U.S. Fish and Wildlife personnel (U.S. Fish and Wildlife Service 1988) were comparable to my 1987 findings.

In addition to providing supplemental habitat for fish populations, side channels may increase total fish biomass of a stream system (Mundie and Traber 1983a). Moore and Gregory (1988) observed an increase in biomass with increases in lateral habitat. Side channels are a form of lateral habitat. Increases in lateral habitat may be beneficial, especially in channelized streams (Hampton 1988; U.S. Fish and Wildlife Service 1988).

There were no obvious trends in biomass common to all species and age classes except for a common reduction in December 1986. This reduction may have been related to a drop in average body weight, fish density or a combination of both. Peak biomass for both age classes of steelhead and brown trout occurred during January/February 1986 and again in 1987 in both side channels. Graphs in Appendix D show wide variations in biomass estimates among survey stations.

Chinook mean biomass reached a high of 100.3 kg/ha at the lower channel during June/July 1986. Another peak of 73.8 kg/ha was observed at the lower channel during December 1986. Over the course of this survey, the upper channel had an average biomass of 9.1 kg/ha while average biomass at the lower channel was 28.9 kg/ha. Young (1987) measured average chinook biomass at 20 kg/ha in the Mattole River, California estuary. Everest and Sedell (1983) measured chinook biomass in various habitat types in Fish Creek, Oregon and found that chinook biomass ranged from 0.0 kg/ha in a side channel and a beaver pond to 1.9 kg/ha in a pool habitat. In 1984, biomass for chinook ranged from 0.0 kg/ha in an alcove, riffle and a side channel to 0.4 kg/ha in a pool (Everest et al. 1984). Chinook biomass in Trinity River side channels was high relative to the Mattole River and Fish Creek.

Coho mean biomass reached a high of 71.8 kg/ha at the lower side channel and 23.7 kg/ha at the upper channel during November 1986. Mean coho biomass was 10.9 kg/ha at the upper channel and 16.8 kg/ha at the lower channel. Burns (1971) surveyed North Fork Caspar Creek, California and measured coho biomass at 1.8 kg/ha in June 1987, 1.5 kg/ha in October 1987, 1.3 kg/ha in June 1968, 1.9 kg/ha in October 1968, 6.1 kg/ha in June 1969, and 8.1 in October 1969. These values were well below my findings for Trinity River side channels during the same months. Biomass values were comparable to my estimates during June/July and October 1986 (Figures 7 and 8). Estimates of coho biomass in Godwood Creek, California by Burns (1971) during July 1967, 1968 and 1969 were also less than my estimates for the same period. However, coho biomass at Godwood Creek during August 1967, 1968, and 1969 exceeded coho biomass in both side channels during August 1986. The highest coho biomass for Godwood Creek was 23.8 kg/ha in August 1968. Coho biomass at a side channel of Fish Creek, Oregon varied during September 1982, 1983 and 1984 (Everest and Sedell 1983; Everest et al. 1884). Coho biomass was measured at 12 kg/ha in September 1982, 17 kg/ha in September 1983 and 31.2 kg/ha in September 1984. In September 1986, coho biomass estimates at Trinity River side channels were 8.6 kg/ha and 5.1 kg/ha at the upper and lower side channels, respectively.

Mundie and Traber (1983a) reported that side channels of the Big Qualicum River in British Columbia sometimes contained ten times greater salmonid biomass than the main stem. For coho, biomass in a side channel was 128 kg/ha while only 20 kg/ha in the main stem. Chapman (1965) noted coho biomass declined steadily in Oregon streams from 19 to 28 kg/ha in April, shortly after emergence, to approximately 2 to 3 kg/ha in December and January. In February, biomass increased to 5 to 6 kg/ha, just prior to emigration. My findings showed an increase in coho biomass at the upper channel during the January/ February 1987 period, however other trends were not as apparent.

Biomass for 0+ steelhead in a Fish Creek, Oregon side channel was 27 kg/ha in September 1982, 17 kg/ha in September 1983 and 14 kg/ha in September 1984 (Everest and Sedell 1983; Everest et al. 1984). In September 1986, 0+ steelhead biomass in Trinity River side channels were 6.4 kg/ha at the upper and 0.5 kg/ha at the lower side channel, which was well below Fish Creek values.

Burns (1971) reported 0+ steelhead biomass at Godwood Creek during July 1967, 1968 and 1969 ranged from 1.2 to 1.4 kg/ha. Trinity River biomass for 0+ steelhead was 0.7 kg/ha at the upper channel and 0.0 kg/ha at the lower channel during June/July 1986. Burns (1971) also measured 0+ steelhead biomass at South Fork Yager Creek during August 1967, 1968 and 1969 and in North Fork Caspar

Creek during June and October 1967, 1968 and 1969. Biomass ranged from 10.2 to 18.4 kg/ha at South Fork Yager Creek during the month of August. Trinity River biomass for 0+ steelhead was 0.5 kg/ha at the upper channel and 0.2 kg/ha at the lower channel during August 1986. Biomass ranged from 5.7 to 9.7 kg/ha at North Fork Caspar Creek during June and 7.0 to 10.3 kg/ha during the month of October (Burns 1971). Biomass for 0+ steelhead in Trinity River side channels was consistently below that for other side channel and stream systems in Oregon and California.

Biomass for 1+ steelhead was 25 kg/ha in September 1982, 15 kg/ha in September 1983 and 22 kg/ha in September 1984 in a Fish Creek, Oregon side channel (Everest and Sedell 1983; Everest et al. 1984). In September 1986, 1+ steelhead biomass estimates at Trinity River side channels were 7.7 kg/ha at the upper and 5.0 at the lower side channel which were well below that for Fish Creek.

Burns (1971) reported that 1+ steelhead biomass at Godwood Creek, California during July 1967, 1968 and 1969 ranged from 3.7 to 4.3 kg/ha. Trinity River 1+ steelhead biomass was 11.4 kg/ha at the upper channel and 5.0 kg/ha at the lower channel during June/July 1986. Biomass of 1+ steelhead ranged from 18.3 to 23.8 kg/ha at South Fork Yager Creek during the month of August (Burns 1971). Trinity River biomass for 1+ steelhead was 0.0 kg/ha at the upper channel and 4.3 kg/ha at the lower channel during August

1986. Biomass ranged from 1.3 to 4.1 kg/ha at North Fork Caspar Creek during June and from 4.3 to 5.8 kg/ha during October (Burns 1971). Biomass for 1+ steelhead in Trinity River side channels was above that reported for North Fork Caspar Creek during June and well above that reported during October. Biomass for 1+ steelhead during October 1986 was 11.7 kg/ha in the upper side channel and 85.5 kg/ha in the lower side channel. Biomass for 1+ steelhead in Trinity River side channels exhibited wide fluctuations during the periods June/July, August and October 1986.

Biomass estimates for 0+ and 1+ brown trout in Trinity River side channels appeared to follow patterns exhibited by steelhead trout. Because all studies I located were of brown trout populations which did not interact with anadromous salmonids, comparative biomass information was unavailable.

Brown trout in the Trinity River competed with salmon and steelhead. The impacts of brown trout competition on chinook, coho and steelhead must be considered. I suspect that brown trout reduced potential biomass of salmon and steelhead in Trinity River side channels. Due to similarities in juvenile habitat preferences, steelhead were probably most affected by brown trout.

Fish Density

Density estimates were not made for fish in the main stem Trinity River. Investigators have found that collecting population data in large rivers is a difficult task (Cleary and Greenbank 1954).

Chinook densities peaked in both side channels during April 1987. For the period December 1985 through May 1987, mean chinook density was 0.88 fish/m^2 at the upper side channel. For the period June/July 1986 through May 1987, mean chinook density was 1.00 fish/m^2 at the lower side channel. Murray and Rosenau (1989) monitored juvenile chinook densities in non-natal tributaries of the Fraser River, British Columbia and noted that maximum densities ranged from 0.06 to 0.68 fish/m^2.

During January and March, 1985, juvenile chinook densities at two side channels along the Nicola River, British Columbia were measured at 0.31 and 0.02 fish/m2 (Swales et al. 1986). I estimated chinook densities at the upper side channel at 0.00 and 0.12 fish/m^2 during January 1986 and January/February 1987. Chinook densities at the lower side channel were measured at 0.11 fish/m^2 during January/February 1987. My findings were comparable to those of Swales et al. (1986).

Everest and Sedell (1983) and Everest et al. (1984) measured chinook densities from a side channel along Fish Creek, Oregon during September 1983 and 1984. During both years, no chinook were found in this side channel although chinook did use some main channel habitats. During September 1986, I calculated chinook densities of 0.14 and 0.32 from the upper and lower side channel. Hamilton and Buell (1976) noted very large numbers of chinook fry in a side channel off of the Columbia River, British Columbia. They reported that side channels were heavily utilized by chinook and coho fry and were frequented by chinook downstream migrants. U.S. Fish and Wildlife Service (1988) calculated chinook densities at 0.10 fish/m^2 at the upper side channel during March 1988. This was well below the chinook density of 1.71 fish/m^2 I measured in 1987.

Coho densities peaked during May 1986 in the upper side channel and during November 1986 in the lower side channel. For the period December 1985 through May 1987, mean coho density was 0.34 fish/m^2 at the upper side channel. For the period June/July 1986 through May 1987, mean coho density was 0.22 fish/m^2 at the lower side channel. Mundie and Traber (1983a) calculated an average coho density of 0.85 fish/m^2 from a side channel of the Big Qualicum River, British Columbia. During January and March, 1985, juvenile coho densities at two side channels along the Nicola River, British Columbia were measured at 1.80 and 1.50 fish/m^2 (Swales et al. 1986). They found that side channels maintained higher densities of coho than any other habitat. Coho densities at my upper side channel were measured at 0.11 and 0.30 fish/m^2 during January 1986 and January/February 1987. Coho densities at the lower side channel were measured at 0.07 fish/m^2 during January/February 1987. These densities were notably less than those reported by Swales et al. (1986).

Everest et al. (1984) found that coho preferred side channels and Hamilton and Buell (1976) noted very high numbers of coho in side channels along Campbell River, British Columbia. Everest and Sedell (1983) and Everest et al. (1984) measured coho densities from a side channel along Fish Creek Oregon during September 1982, 1983 and 1984. Coho densities were 0.20 fish/m^2 in 1982, 0.60 in 1983 and 0.96 in 1984. During September 1986, I calculated coho densities of 0.19 and 0.09 from the upper and lower side channel. Overall, coho densities at Trinity River side channels were below that noted at Fish Creek, Oregon.

Crone (1968) reported that coho juveniles decreased from 3.25 fish/m^2 in July to 0.92 fish/m^2 in August 1964 in an Alaskan stream, a 71.7 percent decline in fish density. Nielsen (1990) reported that coho density ranged from 1.3 fish/m^2 in June to 1.1 fish/m^2 in August at Huckleberry Creek, Washington, a 15.4 percent decline. In Trinity River side channels, coho density at the upper channel decreased from 0.56 fish/m^2 in June/July to 0.35 fish/m^2 in August for a decline of 37.5 percent. Coho at the lower channel decreased from 0.10 fish/m^2 in June/July to 0.03 fish/m^2 in August for a decline of 70.0 percent.

Burns (1971) measured juvenile coho densities of 0.37 fish/m^2 during July 1967, 0.31 fish/m^2 during July 1968 and 0.10 fish/m^2 during July 1969 in Godwood Creek, California. These densities were less than my estimates at the upper side channel and greater or equal to what I found in the lower channel during June/July 1986. Burns (1971) also measured coho densities at Caspar Creek, California during June and October 1967-1969. During the June/July period, the upper side channel at Trinity River maintained twice the average coho density of Caspar Creek while coho density at the lower side channel was less than one-half of that observed in Caspar Creek. Coho densities at Caspar Creek during the October period were comparable to my findings at both upper and lower side channels. Trinity River side channels have the potential to support coho in densities commensurate with other stream systems in the Pacific Northwest.

Densities of 0+ steelhead peaked during May 1987 in the upper side channel. For the period December 1985 through May 1987, mean 0+ steelhead density was 0.15 fish/m^2 at the upper side channel. For the period June/July 1986 through May 1987, mean 0+ steelhead density was 0.02 fish/m^2 at the lower side channel. Everest and Sedell (1983) and Everest et al. (1984) reported 0+ steelhead densities at a

Fish Creek, Oregon side channel during September 1982-1984. Densities at this side channel were 1.10 fish/m^2 in 1982, 0.60 fish/m^2 in 1983 and 0.55 fish/m^2 in 1984. These values were well above my September 1986 findings of 0.12 fish/m^2 at the upper channel and 0.01 fish/m^2 at the lower channel. Everest et al. (1984) found that 0+ steelhead dominated side channels in terms of populations densities.

Burns (1971) measured 0+ steelhead densities of 0.14 fish/m^2 during July 1967, 0.11 fish/m^2 during July 1968 and 0.07 fish/m^2 during July 1969 in Godwood Creek, California. These densities were higher than my mine for both upper and lower side channels during June/July 1986. Burns (1971) also measured 0+ steelhead densities at South Fork Yager Creek, California during August 1967-1969 and at Caspar Creek, California during June and October 1967-1969. In all cases, 0+ steelhead densities at both upper and lower side channels were well below that reported for South Fork Yager and Caspar Creeks.

Densities of 1+ steelhead peaked during March 1987 in the upper side channel. For the period December 1985 through May 1987, mean 1+ steelhead density was 0.04 fish/m^2 at the upper side channel. For the period June/July 1986 through May 1987, mean 1+ steelhead density was 0.04 fish/m^2 at the lower side channel. Everest and Sedell (1983) and Everest et al. (1984) reported 1+ steelhead densities at the Fish Creek side channel during September 1982-1984.

Densities at this side channel were 0.10 fish/m^2 in 1982, 0.10 fish/m^2 in 1983 and 0.14 fish/m^2 in 1984. These densities were well above my September 1986 values of 0.03 fish/m^2 at the upper channel and 0.01 fish/m^2 at the lower channel.

A side channel of the Big Qualicum River, British Columbia produced 0.66 fish/m^2 for 1+ steelhead (Mundie and Traber 1983a). In terms of unit area, this side channel contained 31 times more 1+ steelhead than the main stem. Densities of 1+ steelhead at the Big Qualicum side channel were well above any 1+ steelhead densities I measured.

Burns (1971) measured 1+ steelhead densities of 0.04 fish/m^2 during July 1967, 0.03 fish/m^2 during July 1968 and 0.02 fish/m^2 during July 1969 in Godwood Creek, California. These densities were comparable to my findings at both upper and lower side channels during June/July 1986. Burns (1971) also measured 1+ steelhead densities at South Fork Yager Creek and Caspar Creek. While 1+ steelhead densities at both upper and lower side channels were comparable with findings from Caspar Creek, South Fork Yager Creek had notably higher densities of 1+ steelhead during the August period.

As was noted for biomass, density estimates for 0+ and 1+ brown trout in Trinity River side channels appeared to follow patterns exhibited by steelhead. Studies by the U.S. Fish and Wildlife Service (1988) at Trinity River side channels measured brown trout densities of 0.10 fish/m^2 during December 15 through February 11, 1988.

Salmonid densities and biomass may not be directly comparable with other studies because brown trout may cause unique interactions between cohabiting salmonids. Brown trout probably reduced potential densities of salmon and steelhead in Trinity River side channels.

During the course of my investigation, the Trinity River Fish Hatchery produced and released chinook, coho and 1+ steelhead trout. The U.S. Fish and Wildlife Service (1988) noted that it is unclear how hatchery fish affect salmonid populations in side channels. My findings suggested that hatchery fish notably influenced populations in side channels for certain species during certain periods. Figures 13-16 indicated that fish densities increased following some hatchery fish releases. This was particularly evident for 1+ steelhead during the fall (Figures 15 and 16). I expected fall fish densities to remain static or to decline slightly (Figures 15 and 16). Although not as apparent, chinook densities increased following hatchery releases during June/July 1986 (Figures 13 and 14).

Figures 19 and 20 plot percentages of fin-clipped (hatchery) fish in side channels together with periods of hatchery releases. Maximum clip-ratios were 7.7 percent for chinook during August 1986, 28.9 percent for coho during

December 1985 and 50.0 percent for 1+ steelhead during December 1986. Actual percentages of hatchery fish in side channels were higher because only a fraction of total hatchery fish were clipped. In summary, salmonid populations in side channels were notably affected by hatchery released fish.

Fish Residency

The quality of a given habitat for rearing salmonids may be judged on the basis of average fish size and weight or population density of fishes using that habitat. Larger fish or greater densities are an indication of a superior habitat. Length of residency may also be used as an indicator of habitat value. Prolonged residency period would be an indicator of superior habitat. Conversely, limited residency would indicate that a habitat was deficient and could not sustain the requirements of a fish species.

Habitat suitability is not the only factor which controls fish residency. Anadromous salmonid smolts will eventually leave rearing habitats for estuarine environments regardless of habitat quality. Over-population and inter/intraspecific competition are also factors controlling fish residency. Some investigators report hatchery fish adversely affect residency of wild populations (Moyle 1976; Fenderson and Carpenter 1971). Interactions between hatchery and wild fish in the Trinity River probably affected fish residency.

Prolonged freshwater residency by anadromous salmonids may have adaptive advantages. Despite the fact that extended residency in streams and rivers may add to increases in freshwater mortality, ensuing smolts would be larger and, therefore better apt to survive in marine environments. This strategy may have adaptive significance (Drucker 1972). Stream systems having limited rearing habitat may force fish into marine environments prematurely. Survival is low among juveniles forced into marine environments at an early age (Mason 1975).

Optimal winter habitat is one of the more limited resources for juvenile salmon and steelhead (Kerr et al. 1980; Mundie and Traber 1983a; Tschaplinkski and Hartman 1983; Martin et al. 1986; Swales et al. 1986). During winter, most juvenile salmonids prefer habitat with slow water velocities and ample in-stream cover. Large cobble, logs, and aquatic vegetation are used by salmonids for refuge during winter months (Hartman 1963; Hartman 1965; Edmundson et al. 1968; Chapman and Bjornn 1969; Bustard and Narver 1975b; Gardiner and Geddes 1980; Kerr et al. 1980; Everest et al. 1984). Hiding is thought to have an adaptive value (Hillman et al. 1987). Optimal hiding habitat may prolong fish residency in a given habitat. While assessing habitat quality in side channels was beyond the scope of my study, results from my residency studies indicated that side channels contained adequate habitat, especially during fall and winter. Electroshocking in side channels during the fall and winter revealed that salmonids were often hiding under cobble and within aquatic vegetation. These findings were similar to the above-mentioned investigations.

In order to quantify residency time in side channels, I developed the Duration Index (DI) and graphed the results (Figures 21-26). I expected graphs to show sequential declines in DI during months following the initial marking campaign. In most cases, this was the outcome. In some instances, however, DI on the month following marking was higher than that recorded the day after marking. I believe that electroshocking and/or marking may have caused behavioral changes in fishes which made them less susceptible to recapture the day after being handled. Electroshocking and its effect on behavior and catchability is documented in the literature (Cross and Stott 1975; Leitritz and Lewis 1976; Schreck et al. 1976; Mundie and Traber 1983b; Mesa and Schreck 1989; Nielsen 1990). While most studies observed some changes in behavior and catchability, Bohlin and Sundstrom (1977) found no affects on future catchability. Most investigators acknowledged that the effects of electroshocking on catchability diminish after 24 hours. Some of my efforts to recapture fish occurred only 15 to 20 hours after capture.

In some cases, DI was higher two and three months following the initial DI. I have no explanation for this anomaly other than certain survey stations may have maintained higher percentages of marked fish than other stations. Since I randomly selected survey stations each month, it is possible that stations having high percentages of marked fish may have not been selected until two or three months following a marking campaign.

Maximum chinook residency following marking was five months in the upper channel and three months in the lower channel. Minimum residency was one month for both side channels. Hillman et al. (1987) used marked fish to monitor chinook movements in an Idaho stream and found that a side channel had the highest percentage of marked fish and the longest chinook residency. Substrate appeared to be one of the most important variables controlling use of a habitat by juvenile chinook. Edmundson et al. (1968) reported that over-wintering chinook remained under rock rubble and were rarely seen in the water column. This was comparable to my observations, especially in the upper side channel where the bottom and banks were lined with cobble. Bjornn (1971) found that substrate size and population density were the two most important variables affecting chinook migration. Fish began moving to other locations when population densities increased competition. I believe that movement out of Trinity River side channels during spring and summer may have been partially related to increased population densities. In addition, as chinook fry matured, they were able to utilize faster water and may have moved out of side channels to exploit additional food sources. The gradual movement of juvenile chinook into areas of faster velocities has been reported elsewhere (Everest and Chapman 1972; Kerr et al. 1980).

The maximum coho residency period was six months in the upper channel and three months in the lower channel. Minimum residency was less than one month for both side channels. Figures 21 and 22 show DI rates for coho in the upper and lower side channel. Precipitous declines in DI graphs indicated very short residency times for coho during spring and summer. Tschaplinkski and Hartman (1983) studied Carnation Creek, British Columbia and found coho moved into side channels and other low-velocity areas following their displacement by freshets. Coho re-entered the main stem in spring prior to out-migrating to the ocean. This is pattern similar to coho rearing in the Trinity River. This pattern has been documented for other streams inhabited by coho (Shapovalov and Taft 1954; Drucker 1972; Bustard and Narver 1975a; Bustard and Narver 1975b; Mason 1975; Dill 1978; Kerr et al. 1980; Peterson 1982; Reeves et al. 1989).

Unlike chinook, coho rear at least one year in freshwater prior to migrating to the ocean. In order to sustain a viable coho population, a stream or river must have abundant slow water habitat such as back-water pools or side channels. Coho typically over-seed spawning grounds and fry often move to find usable habitat (Mason 1975). Movement of coho away from natal areas may be related to inter- or intraspecific competition (Dill 1978) and movements may be either upstream or downstream (Ruggles 1966).

During winter, coho prefer clean, silt-free cobble (Bustard and Narver 1975b). These characteristics existed in sections of the lower side channel and throughout most of the upper side channel. Separation between coho and steelhead is least pronounced during winter months as both species seek cobble and low-velocity areas (Hartman 1965). Martin et al. (1986) found that winter mortality of coho ranged from 62 to 83 percent. Large organic debris helped reduce winter mortality.

Although investigations of fish mortality were beyond the scope of my study, DI graphs showed that recapture of marked fish was highest during fall and winter. Apparently, winter mortality was not extremely high during the 1986/87 winter because considerable numbers of marked coho were recovered from both side channels during this period. Assuming little immigration and emigration during the fall and winter periods, DI graphs could be used as indicators of mortality. My residency results not only reflected differences in residency but mortality as well.

Use of data for this purpose is subject to many obstacles and is only mentioned here for discussion.

The maximum 0+ steelhead residency period was four months in the upper channel and two months in the lower channel. Minimum residency for 0+ steelhead was less than one month for both side channels. Maximum residency for 1+ steelhead was seven months in the upper channel and one month in the lower channel. Minimum residency for 1+ steelhead in the upper and lower channel was one month and less than one month respectively. Figures 23 and 24 show DI rates for 0+ and 1+ steelhead in upper and lower side channels.

Kerr et al. (1980) reported that 0+ steelhead preferred shallow, low-velocity habitats. In winter, 0+ steelhead hid under boulders while 1+ steelhead used low-velocity pools with in-stream debris. Bustard and Narver (1975a) noted that steelhead moved into small tributaries during fall and early winter and Chapman and Bjornn (1969) observed winter hiding behavior in juvenile steelhead. During electroshocking, I found both 0+ and 1+ steelhead in interstices of rocks during winter. The electroshocker actually "pulled" fish out of rocks and into the water column where they could be netted. This observation was noted for all age classes of juvenile salmonids during winter months. Investigators have reported that habitat separation between steelhead and coho is least pronounced during winter (Hartman 1965). I found that this characterization existed for all Trinity River salmonids during winter months.

With the exception of 1+ steelhead at the upper side channel, steelhead movements accelerated during spring and summer. Maher and Larkin (1954) found that 60 percent of young steelhead began out-migration to marine environments during spring months at age two. Thirty-five percent made the journey at age three.

The seven-month residency period for 1+ steelhead at the upper side channel was the longest time measured during this investigation. Only one fish was recovered on the seventh month. Edmundson et al. (1968) found that steelhead may spend a year or more in one "home area" and move less than six meters per day during summer. This static nature may have some adaptive value. Since fish density may affect movements of juvenile steelhead, hatchery releases may have caused premature movement of fish out of side channels.

The maximum 0+ brown trout residency period was four months in both upper and lower side channels. The minimum residency period for 0+ brown trout was less than one month at both channels. The maximum residency period for 1+ brown trout was six months in the upper channel and one month in the lower channel. Minimum residency period for 1+ brown trout was two months and one month in the upper and lower side channels respectively. Figures 25 and 26 show DI rates for 0+ and 1+ brown trout in upper and lower side channels.

The six-month residency period for 1+ brown trout at the upper side channel equaled that of coho. The two-month minimum residency period for 1+ brown trout was the highest measured during this study. Apparently, 1+ brown trout preferred the upper side channel and were reluctant to leave. Moyle (1976) reported that non-reproducing, juvenile brown trout 250 mm or less in length are often sedentary, moving less than several meters from one location. Brown trout larger than 250 mm are more mobile. Heacox (1974) reported that male brown trout become sexually active by the end of the second year and females by the third year. He also found that mortality from fry to fingerling stages approaches 90 percent. Age, mortality, and sexual maturity were all factors that influenced brown trout residency in Trinity River side channels.

Retention rates for salmonids marked using a Panjet injector were sufficient for use in monitoring fish residency in Trinity River side channels. Although some marks may have been overlooked because of mark absorption and fading, I believe that most marks were readily identifiable in the field. Hart and Pitcher (1969) reported that retention rates of Panjet marks ranged from three to fourteen months for non-salmonid fishes. In order to measure mark retention for salmonid species, I marked a group of Trinity River fish consisting of chinook and coho salmon, steelhead and brown trout. The longest-lived fish, a steelhead, survived in an aquarium for 12 months and still retained a visible mark. All fish retained visible marks up to the time of their demise.

Stream Discharge and Temperature

High precipitation during Spring 1986 initiated unusually high discharges from Lewiston Dam. At one point, Dam releases reached 169.9 m^3/s. This is approximately 7.5 times greater than normal peak discharge. The effect of flooding on juvenile salmonids was unknown, however some displacement of fish from side channels and river habitat was likely.

Trinity River discharge was not measured, however flows at main stem stations were near or equal to discharge rates from Lewiston Dam during the dry season. Figure 27 showed that side channel discharges were approximately 5-10 percent of main stem discharge during most months. Mundie and Traber (1983a) found juvenile salmonids used side channels with discharges averaging only 2.6 percent of the main stem.

Side channels usually have lower average flow velocities than main stem channels. Due to channel confinement resulting from riparian encroachment, slow water habitats in the upper Trinity River are limited (Hampton

1988). Low velocity habitats are important to young-of-the-year and older juvenile salmonids (Bustard and Narver 1975a; Kerr et al. 1980; Mundie and Traber 1983a; Tschaplinkski and Hartman 1983; Taylor 1988; U.S. Fish and Wildlife Service 1988). Studies by the U. S. Fish and Wildlife Service (1988) on the Trinity River found that habitat for fry and juvenile salmonids becomes non-existent when stream velocities reach or exceed 0.6 m/s (2 feet/second). These studies concluded that velocity was the most important factor affecting juvenile salmonid distribution in the Trinity River. Tschaplinkski and Hartman (1983) noted that coho left main stem sites on Carnation Creek, British Columbia to seek side channels and other low velocity habitats during freshets. They further reported that all microhabitats occupied by juvenile coho were characterized by water velocities of less than 0.3 m/s. The low velocity habitats provided by side channels were probably a key factor in their use by juvenile salmonids in the upper Trinity River.

My Trinity River stations had higher mean water temperatures than the side channel stations. Mean water temperature in the Trinity River was 10.4°C while mean temperatures at the upper and lower side channels were 9.7 and 10.0°C, respectively. Trinity River stations also had the widest temperature ranges. Trinity River temperatures exceeded side channel temperatures during summer and early fall periods and dropped below side channel temperatures during late fall and winter months (Figure 28). Lower side channel temperatures during spring, summer and early fall can be attributed to heavy riparian cover and the screening of solar radiation. Higher winter temperatures in side channels can be attributed to greater surface area to volume ratios and increased solar effect. Deciduous riparian vegetation enabled solar radiation to reach the water surface during winter months after leaf drop had occurred.

Temperature and discharge, either individually or collectively, may initiate changes in habitat selection by juvenile salmonids (Bustard and Narver 1975a; Kerr et al. 1980; Tschaplinkski and Hartman 1983; Taylor 1988). Taylor (1988) reported that juvenile chinook and coho in laboratory channels increased their use of cover and low velocity areas during periods of low water temperatures. He concluded that water temperature and, to some extent, increases in water velocity, may be important stimuli for microhabitat shifts during the fall-winter transition. Swales et al. (1986) studied British Columbia streams and found higher densities of juvenile salmonids in side channels and off-channel ponds where winter water temperatures were usually several degrees warmer than main channel habitats. Hamilton and Buell (1976) found that water temperatures in side channels were 2-8°C warmer than in main stem habitats. Bustard and Narver (1975a) observed movements by coho and steelhead into smaller tributary streams during periods of low temperatures where they hid among vegetation and cobbles. Bustard and Narver (1975a) postulated that this temperature-related behavior had adaptive value. Hiding during winter periods decreased contact with predators and prevented displacement during high winter flows. Snorkeling surveys conducted in Fish and Wash Creeks, Oregon found fish absent from the water column when water temperatures were 2.8-3.0°C (Everest et al. 1984). Fish were found hiding in substrate consisting of large cobble. Gardiner and Geddes (1980) reported that young salmon sought shelter in the streambed at low temperature and emerged when temperatures reached 6-7°C. Fish remained near the substrate until temperatures reached 10-11°C when they entered the water column.

Trinity River side channels were comparable to other side channel habitats in terms of stream velocity and temperature. Behavior of Trinity River salmonids in response to discharge and temperature were also comparable to that of other populations reported in the literature.

Side channels appear to maintain a contingency of habitat variables that are preferred by juvenile salmonid populations. Reports by U.S. Fish and Wildlife Service on Trinity River side channels concurred with my findings that they were important to juvenile salmonids (U.S. Fish and Wildlife Service 1988; U.S. Fish and Wildlife Service 1990). Subsequently, side channel development is being used as a tool for increasing rearing habitat for salmonids on the upper Trinity River. Additional work is needed to determine which habitat variables in side channels most benefit juvenile salmonids. Once these variables are identified, side channels can be designed to specifically meet the requirements of juvenile salmonids rearing in the upper Trinity River.

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APPENDIX A. Contingency Table for All Species Summed Over the Entire Survey Period, Trinity River, California, 1985-1987.

	Chinook	Coho	Steelhead	Brown Trout	Total
Upper Channel	[a]1444 [b]1594.9 [c]-150.9 [d]45.37	862 652.52 209.48 27.08	479 487.57 -8.571 15.05	398 448.02 -50.02 12.50	3138
Lower Channel	1259 874.86 384.14 72.11	287 357.93 -70.93 16.44	101 267.45 -166.5 5.78	99 245.76 -146.8 5.67	1746
Trinity River	362 595.26 -233.3 30.47	105 243.54 -138.5 8.84	357 181.98 175.02 30.05	364 167.22 196.78 30.64	1188
Total	3065	1254	937	861	6117

[a]Observed Frequency
[b]Expected Frequency
[c]Deviation
[d]Row Percentage

Statistics For Table of Habitat By Species

Statistic	DF	Value	Probability
Chi-Square	6	1031.353	0.000
Likelihood Ratio Chi-Square	6	1005.445	0.000
Mantel-Haentzel Chi-Square	1	127.847	0.000
Phi Coefficient		0.411	
Contingency Coefficient		0.380	
Cramer's V		0.290	

Sample Size = 6117

APPENDIX B. Contingency Table for All Species Summed Over the Winter Period, Trinity River, California, 1985-1987.

	Chinook	Coho	Steelhead	Brown Trout	Total
Upper Channel	[a]5 [b]53.198 [c]-48.2 [d]1.21	87 98.496 -11.5 21.01	125 106.92 18.076 30.19	197 155.38 41.618 47.58	414
Lower Channel	15 15.291 -0.291 12.61	84 28.312 55.688 70.59	8 30.734 -22.73 6.72	12 44.663 -32.66 10.08	119
Trinity River	81 32.51 48.49 32.02	16 60.192 -44.19 6.32	70 65.342 4.6578 27.67	86 94.955 -8.955 33.99	253
Total	101	187	203	295	786

[a]Observed Frequency
[b]Expected Frequency
[c]Deviation
[d]Row Percentage

Statistics For Table of Habitat By Species

Statistic	DF	Value	Probability
Chi-Square	6	315.405	0.000
Likelihood Ratio Chi-Square	6	314.458	0.000
Mantel-Haentzel Chi-Square	1	63.167	0.000
Phi Coefficient		0.633	
Contingency Coefficient		0.535	
Cramer's V		0.448	

Sample Size = 786

APPENDIX B. Contingency table for All Species Summed Over the Spring Period, Trinity River, California, 1985-1987 (continued).

	Chinook	Coho	Steelhead	Brown Trout	Total
Upper Channel	[a]1237 [b]1369.7 [c]-132 [d]65.94	385 240.726 144.28 20.52	181 161.61 19.393 9.65	73 103.97 -30.97 3.89	1876
Lower Channel	941 738.88 202.12 92.98	28 129.85 -101.9 2.77	30 87.178 -57.178 2.96	13 56.087 -43.09 1.28	1012
Trinity River	246 315.41 -69.41 56.94	13 55.431 -42.43 3.01	75 37.214 37.786 17.36	98 23.942 74.058 22.69	432
Total	2424	426	286	184	3320

[a]Observed Frequency
[b]Expected Frequency
[c]Deviation
[d]Row Percentage

Statistics For Table of Habitat By Species

Statistic	DF	Value	Probability
Chi-Square	6	631.871	0.000
Likelihood Ratio Chi-Square	6	587.387	0.000
Mantel-Haentzel Chi-Square	1	21.387	0.000
Phi Coefficient		0.436	
Contingency Coefficient		0.400	
Cramer's V		0.308	

Sample Size = 3320

APPENDIX B. Contingency Table for All Species Summed Over the Summer Period, Trinity River, California, 1985-1987 (continued).

	Chinook	Coho	Steelhead	Brown Trout	Total
Upper Channel	[a]96 [b]124.27 [c]-28.27 [d]32.32	165 99 66 55.56	11 38.523 -27.52 3.70	25 35.209 -10.21 8.42	297
Lower Channel	184 97.49 86.51 78.97	24 77.667 -53.67 10.30	10 30.222 -20.22 4.29	15 27.622 -12.62 6.44	233
Trinity River	20 78.243 -58.24 10.70	50 62.333 -12.33 26.74	72 24.255 47.745 38.50	45 22.169 22.831 24.06	187
Total	300	239	93	85	717

[a]Observed Frequency
[b]Expected Frequency
[c]Deviation
[d]Row Percentage

Statistics For Table of Habitat By Species

Statistic	DF	Value	Probability
Chi-Square	6	369.495	0.000
Likelihood Ratio Chi-Square	6	355.052	0.000
Mantel-Haentzel Chi-Square	1	61.538	0.000
Phi Coefficient		0.718	
Contingency Coefficient		0.583	
Cramer's V		0.508	

Sample Size = 717

APPENDIX B. Contingency Table for All Species Summed Over the Fall Period, Trinity River, California, 1985-1987 (continued).

	Chinook	Coho	Steelhead	Brown Trout	Total
Upper Channel	[a]106 [b]110.54 [c]-4.541 [d]17.79	225 185.16 39.844 37.75	162 163.51 -1.509 27.18	103 136.79 -33.79 17.28	596
Lower Channel	119 70.85 48.15 31.15	151 118.67 32.326 39.53	53 104.8 -51.82 13.87	59 87.677 -28.68 15.45	382
Trinity River	15 58.609 -43.61 4.75	26 98.17 -72.17 8.23	140 86.692 53.308 44.30	135 72.529 62.471 42.72	316
Total	240	402	355	297	1294

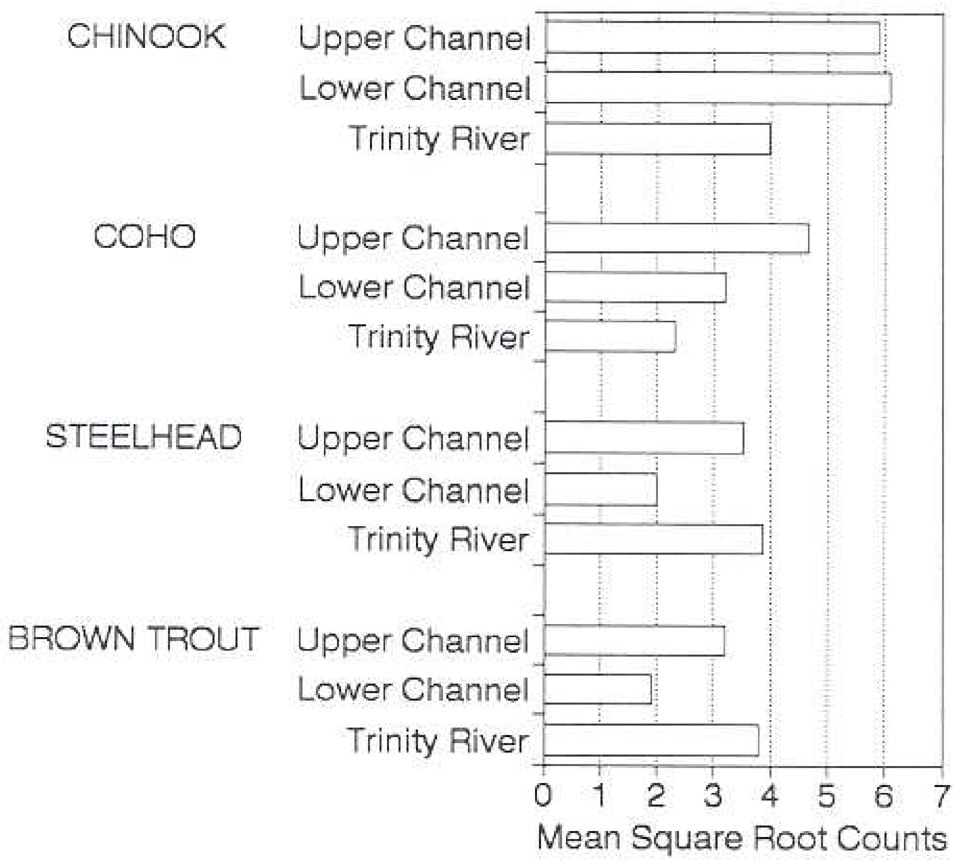
[a]Observed Frequency
[b]Expected Frequency
[c]Deviation
[d]Row Percentage

Statistics For Table of Habitat By Species

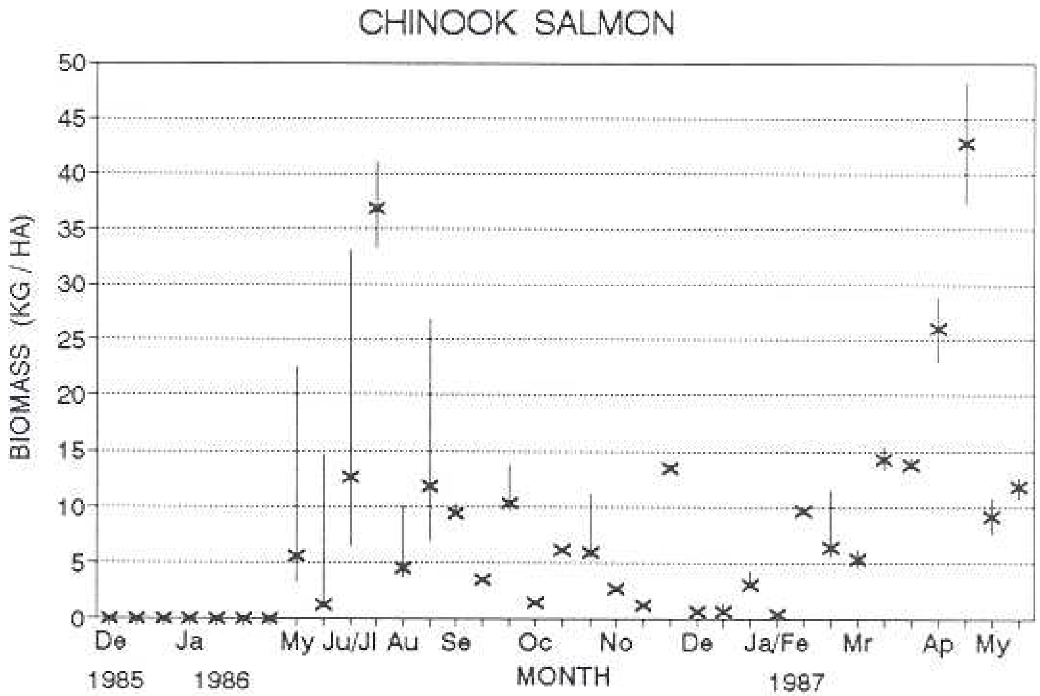
Statistic	DF	Value	Probability
Chi-Square	6	265.726	0.000
Likelihood Ratio Chi-Square	6	286.492	0.000
Mantel-Haentzel Chi-Square	1	89.336	0.000
Phi Coefficient		0.453	
Contingency Coefficient		0.413	
Cramer's V		0.320	

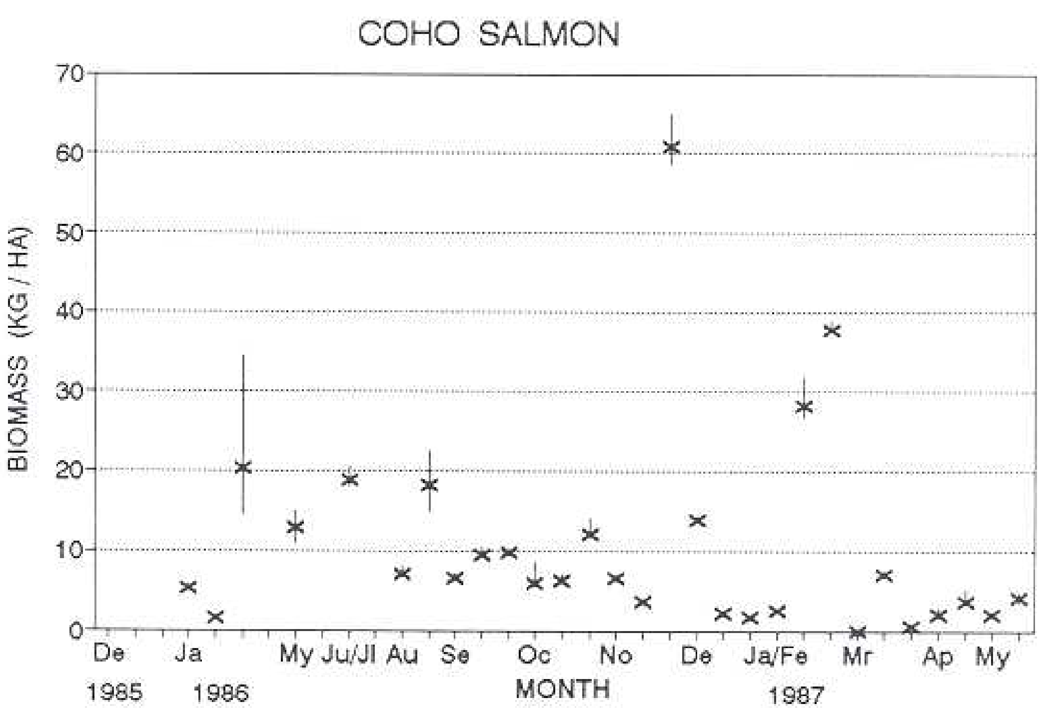
Sample Size = 1294

APPENDIX C. Mean Square-Root Counts by Species and by Habitat for Juvenile Salmonids, Trinity River, California and Side Channels, 1985-1987.

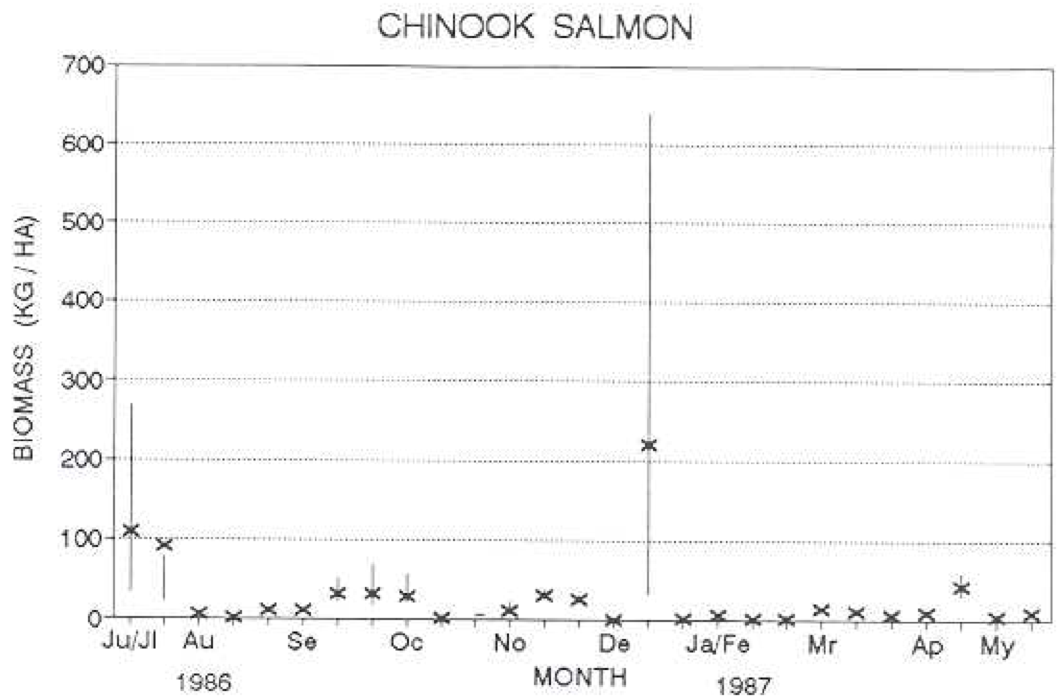


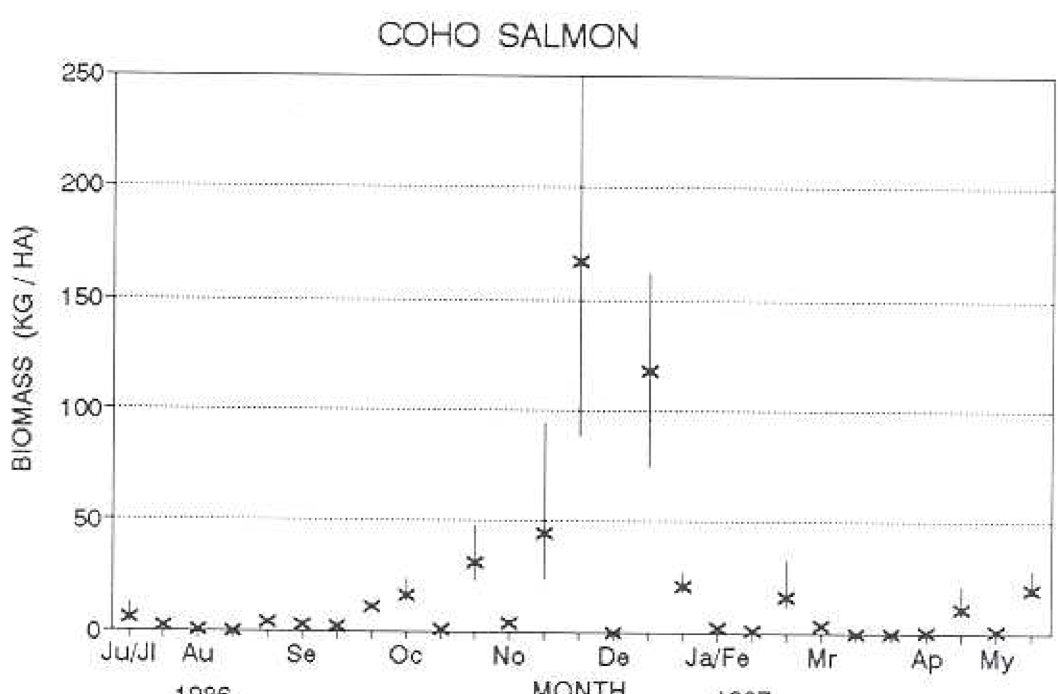
APPENDIX D. Biomass Estimates and 95 Percent Confidence Intervals by Month and by Survey Station for Juvenile Chinook and Coho Salmon Utilizing the Upper Side Channel.





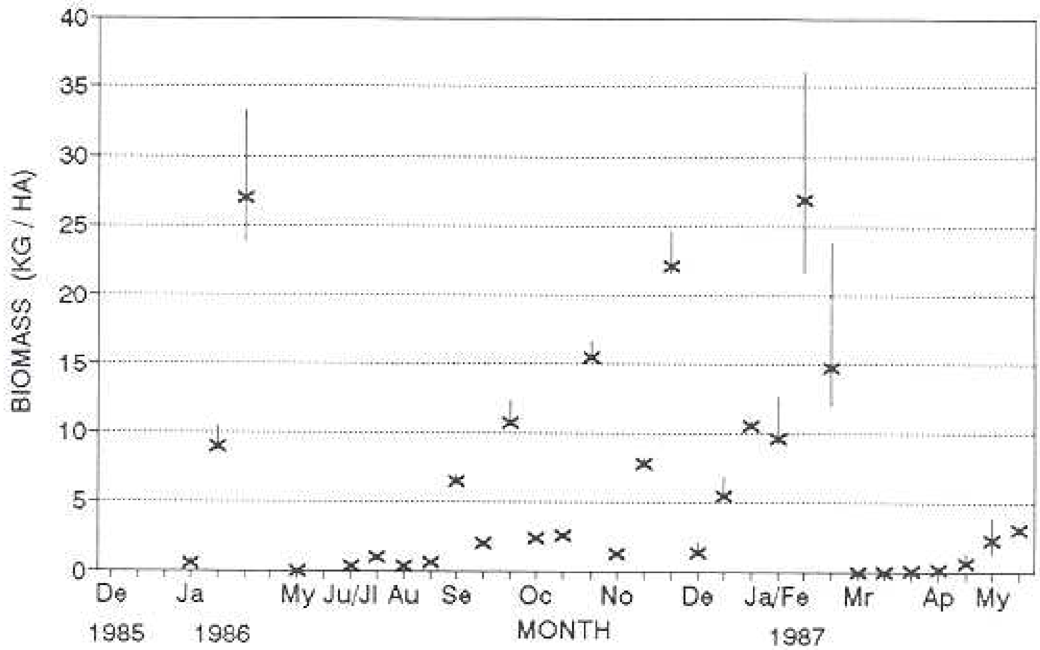
APPENDIX D. Biomass Estimates and 95 Percent Confidence Intervals by Month and by Survey Station for Juvenile Chinook and Coho Salmon Utilizing the Lower Side Channel (continued).



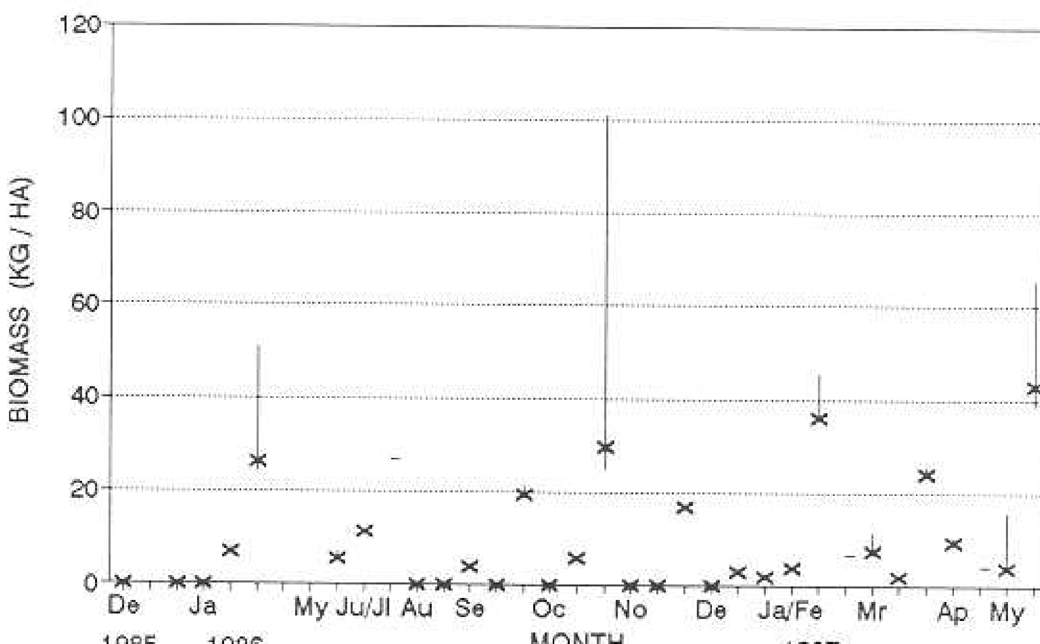


APPENDIX D. Biomass Estimates and 95 Percent Confidence Intervals by Month and by Survey Station for 0+ and 1+ Steelhead Utilizing the Upper Side Channel (continued).

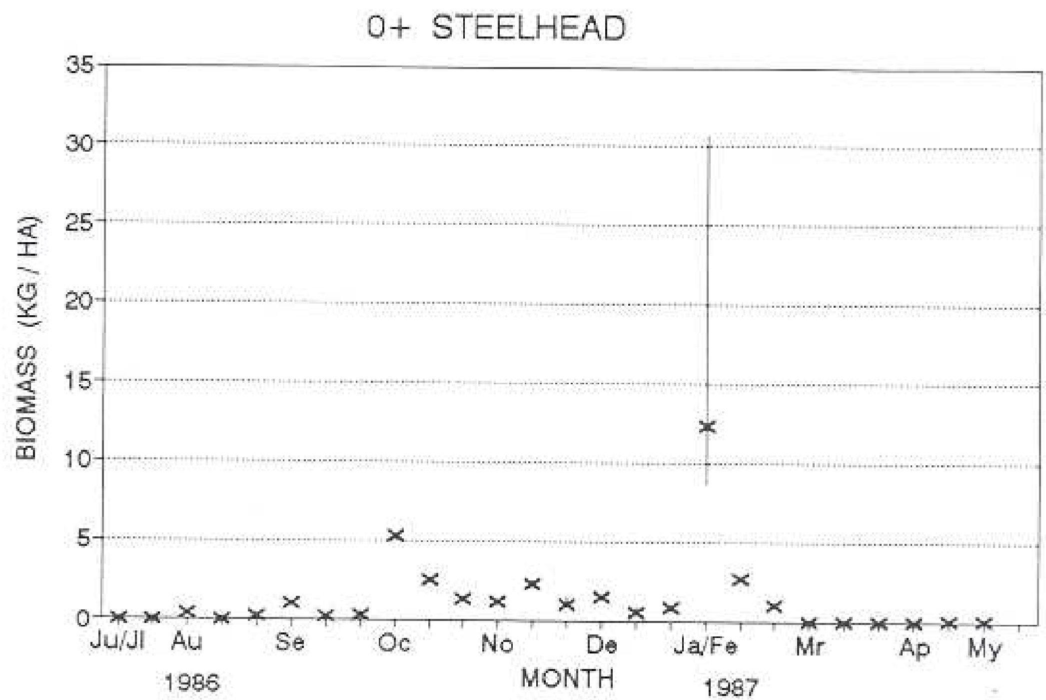
0+ STEELHEAD

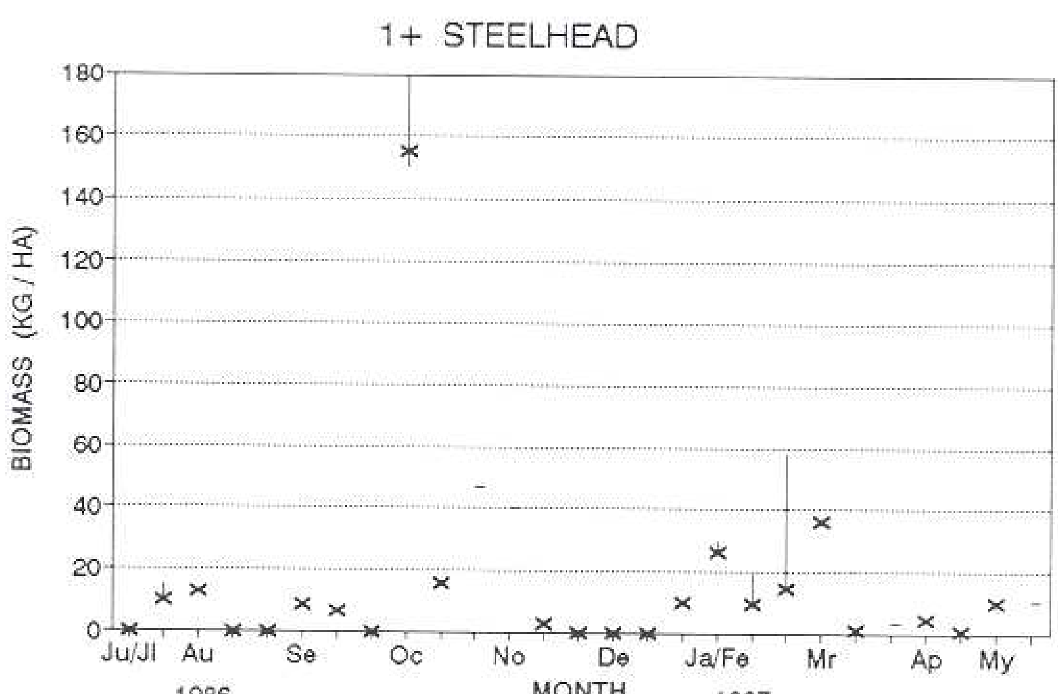


1+ STEELHEAD

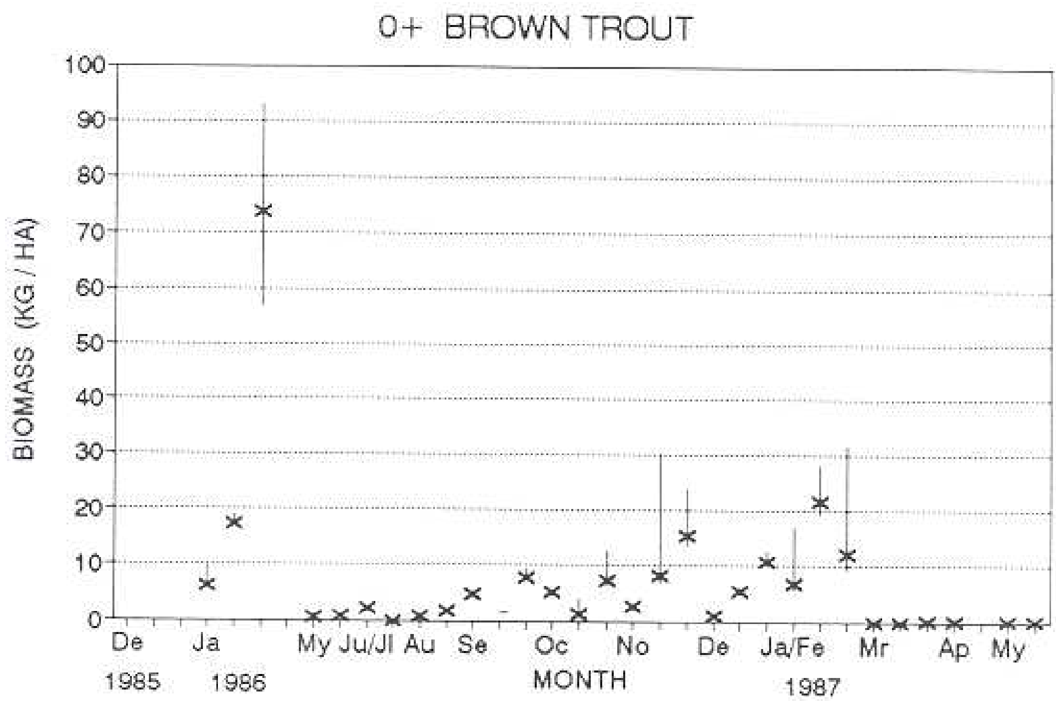


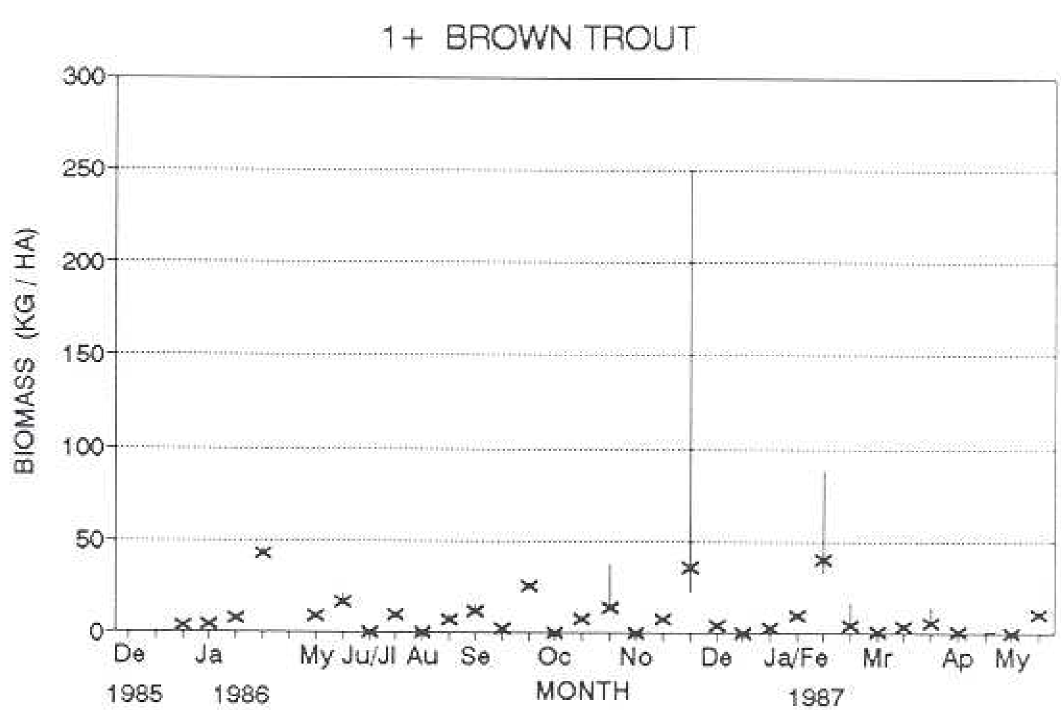
APPENDIX D. Biomass Estimates and 95 Percent Confidence Intervals by Month and by Survey Station for 0+ and 1+ Steelhead Utilizing the Lower Side Channel (continued).



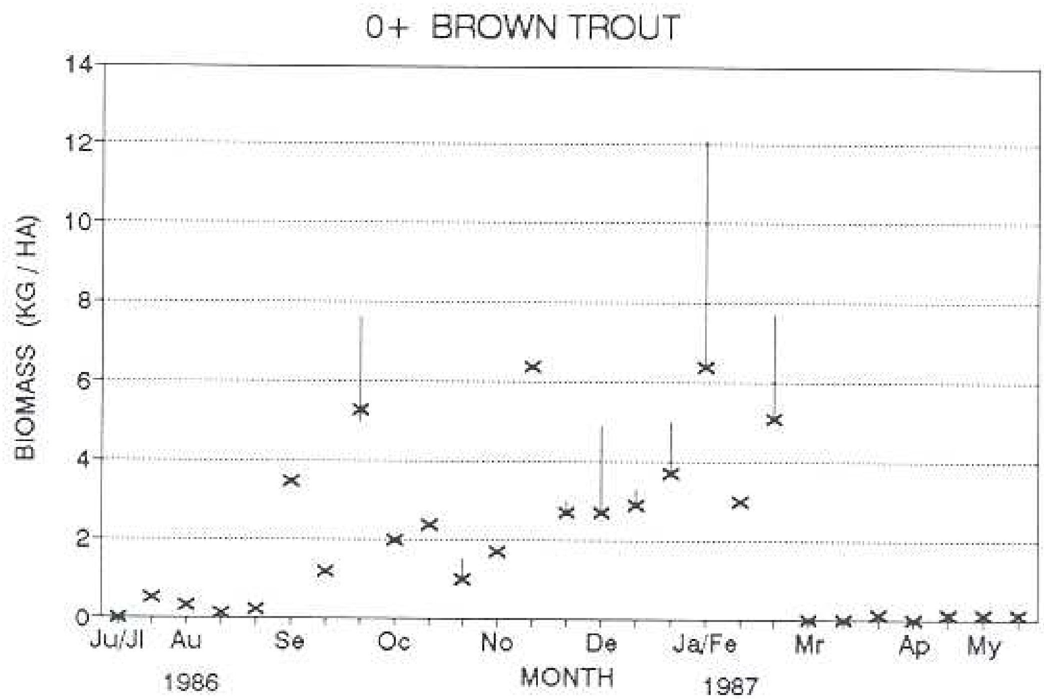


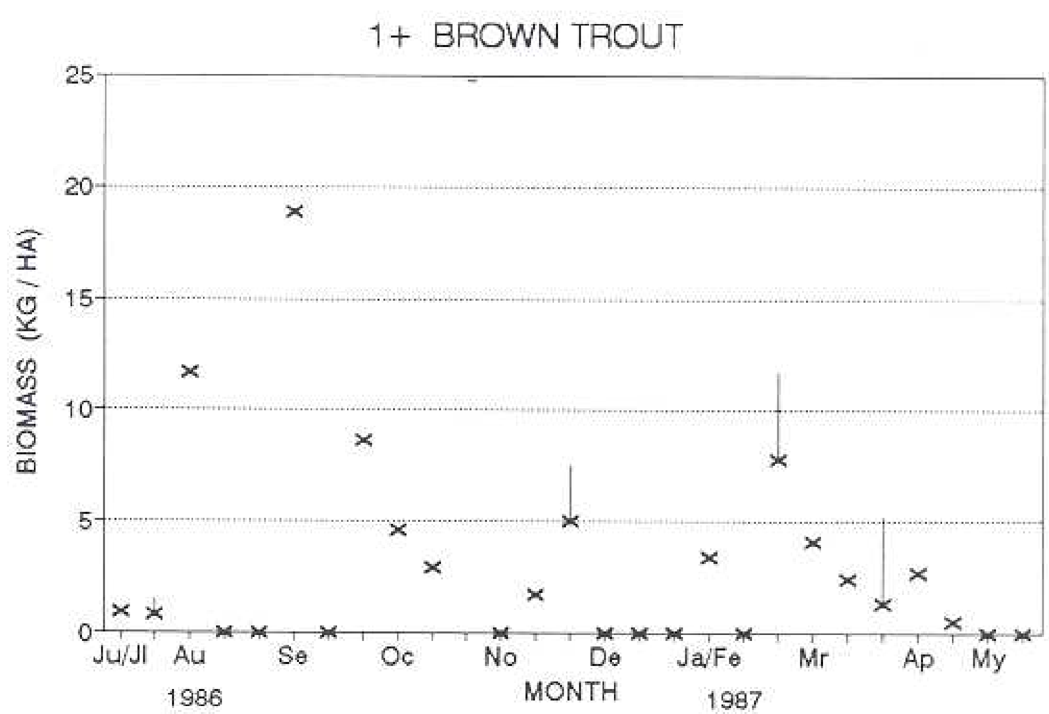
APPENDIX D. Biomass Estimates and 95 Percent Confidence Intervals by Month and by Survey Station for 0+ and 1+ Brown Trout Utilizing the Upper Side Channel (continued).





APPENDIX D. Biomass Estimates and 95 Percent Confidence Intervals by Month and by Survey Station for 0+ and 1+ Brown Trout Utilizing the Lower Side Channel (continued).





APPENDIX E. Fish Population Data, Trinity River, California; December 1985-May 1987. Population Calculations Based on Removal Data and the Maximum Weighted Likelihood Estimation Method Described by Carle and Strub 1978.

Juvenile Chinook Salmon

Upper Side Channel

Date of Capture	Station	No. of Fish	Projected Population	95% Confidence Interval Low	95% Confidence Interval High	Probability of Catch	Standard Error
Dec. 1985	11	0					
"	15	0					
"	17	0					
Jan. 1986	10	0					
"	13	0					
"	16	0					
"	17	0					
May 1986	10	10	17	10	68	0.23	25.93
"	11	12	14	12	166	0.57	77.32
Jun./Jul. 1986	5	24	47	24	122	0.20	38.07
"	7	112	124	112	138	0.54	7.12
Aug. 1986	6	14	17	14	37	0.40	9.97
"	10	25	42	25	95	0.25	27.25
Sep. 1986	8	28	28	28	31	0.74	1.30
"	9	12	12	12	12	1.00	0.00
"	15	26	28	26	37	0.70	4.83
Oct. 1986	5	3	3	3	3	0.75	0.03
"	10	17	17	17	17	0.94	0.03
"	15	12	13	12	30	0.52	8.78
Nov. 1986	4	5	5	5	5	0.83	0.16
"	12	2	2	2	2	1.00	0.00
"	17	28	28	28	29	0.90	0.47
Dec. 1986	10	2	2	2	2	0.67	0.06
"	12	1	1	1	2	0.33	0.72
"	15	8	8	8	9	0.67	0.64
Jan./Feb. 1987	8	9	9	9	9	0.82	0.03
"	16	26	26	26	27	0.76	0.71
"	17	15	17	15	31	0.47	7.05
Mar. 1987	4	120	138	120	157	0.49	9.79
"	9	361	414	383	445	0.49	15.71
"	13	309	323	312	334	0.64	5.85
Apr. 1987	6	817	1152	1020	1284	0.34	67.50
"	14	979	1430	1249	1611	0.44	92.13
May 1987	4	189	239	199	279	0.40	20.62
"	11	163	176	163	189	0.58	6.60

APPENDIX E. Fish Population Data, Trinity River, California; December 1985-May 1987. Population Calculations Based on Removal Data and the Maximum Weighted Likelihood Estimation Method Described by Carle and Strub 1978 (continued).

Juvenile Chinook Salmon

Lower Side Channel

Date of Capture	Station	No. of Fish	Projected Population	95% Confidence Interval Low	High	Probability of Catch	Standard Error
Jun./Jul. 1986	2	88	293	88	715	0.11	215.14
"	3	218	272	232	312	0.41	20.56
Aug. 1986	1	16	16	16	18	0.84	1.11
"	5	1	1	1	1	1.00	0.00
"	6	35	36	35	41	0.66	0.81
Sep. 1986	1	24	25	24	31	0.62	3.08
"	3	39	56	39	93	0.32	19.00
"	4	31	56	31	124	0.23	34.86
Oct. 1986	1	24	34	24	64	0.25	15.38
"	2	1	1	1	1	1.00	0.00
"	7	7	*				
Nov. 1986	3	14	17	14	37	0.40	9.97
"	4	51	57	51	69	0.52	5.90
"	5	51	56	51	66	0.54	5.20
Dec. 1986	2	0					
"	5	80	554	80	1608	0.05	537.57
"	7	3	3	3	6	0.50	1.43
Jan./Feb. 1987	1	35	39	35	49	0.51	5.32
"	6	1	1	1	1	1.00	0.00
"	7	3	3	3	12	0.38	4.39
Mar. 1987	1	226	228	226	232	0.78	2.16
"	2	220	226	220	233	0.69	3.67
"	5	140	145	140	152	0.67	3.60
Apr. 1987	2	181	193	181	205	0.60	6.01
"	5	580	1193	804	1582	0.20	198.27
May 1987	2	66	66	66	68	0.80	1.05
"	5	182	215	188	242	0.46	13.91

*Population estmate cannot be calculated because catch rate among electrofishing passes did not follow an orderly sequence.

APPENDIX E. Fish Population Data, Trinity River, California; December 1985-May 1987. Population Calculations Based on Removal Data and the Maximum Weighted Likelihood Estimation Method Described by Carle and Strub 1978 (continued).

Juvenile Coho Salmon

Upper Side Channel

Date of Capture	Station	No. of Fish	Projected Population	95% Confidence Interval Low	95% Confidence Interval High	Probability of Catch	Standard Error
Dec. 1985	11	17	17	17	18	0.89	0.26
"	15	7	7	7	7	1.00	0.00
"	17	14	14	14	14	0.78	0.18
Jan. 1986	10	11	11	11	12	0.61	0.44
"	13	3	3	3	3	1.00	0.00
"	16	33	46	33	78	0.33	16.25
"	17	7	7	7	9	0.78	0.97
May 1986	10	192	237	201	273	0.42	18.33
"	11	213	255	221	289	0.59	17.59
Jun./Jul. 1986	5	95	100	95	108	0.62	4.12
"	7	52	52	52	52	0.85	0.21
Aug. 1986	6	34	35	34	40	0.64	2.72
"	10	79	96	79	119	0.43	11.58
Sep. 1986	8	26	26	26	29	0.72	1.47
"	9	39	39	39	43	0.87	1.83
"	15	34	34	34	35	0.92	0.35
Oct. 1986	5	12	12	12	17	0.63	2.52
"	10	17	17	17	19	0.85	1.01
"	15	30	31	30	36	0.65	2.59
Nov. 1986	4	12	12	12	12	0.92	0.05
"	12	5	5	5	5	0.83	0.01
"	17	105	109	105	116	0.80	3.78
Dec. 1986	10	31	31	31	32	0.79	0.47
"	12	5	5	5	5	0.83	0.01
"	15	4	4	4	4	0.67	0.18
Jan./Feb. 1987	8	6	6	6	6	1.00	0.00
"	16	52	55	52	62	0.60	3.72
"	17	64	64	64	66	0.80	1.10
Mar. 1987	4	0					
"	9	12	12	12	13	0.75	0.26
"	13	6	6	6	6	0.86	0.01
Apr. 1987	6	55	70	55	95	0.39	12.85
"	14	38	42	38	53	0.68	5.62
May 1987	4	45	46	45	51	0.67	2.44
"	11	79	89	79	103	0.51	7.18

APPENDIX E. Fish Population Data, Trinity River, California; December 1985-May 1987. Population Calculations Based on Removal Data and the Maximum Weighted Likelihood Estimation Method Described by Carle and Strub 1978 (continued).

Juvenile Coho Salmon

Lower Side Channel

Date of Capture	Station	No. of Fish	Projected Population	95% Confidence Interval Low	95% Confidence Interval High	Probability of Catch	Standard Error
Jun./Jul. 1986	2	15	19	15	41	0.38	11.37
"	3	7	7	7	7	0.78	0.06
Aug. 1986	1	2	2	2	2	1.00	0.00
"	5	0					
"	6	15	15	15	17	0.71	0.81
Sep. 1986	1	7	7	7	9	0.64	0.86
"	3	4	4	4	4	1.00	0.00
"	4	28	28	28	32	0.70	1.91
Oct. 1986	1	25	29	25	42	0.37	6.54
"	2	2	2	2	2	1.00	0.00
"	7	46	63	46	96	0.35	16.65
Nov. 1986	3	7	7	7	9	0.64	0.86
"	4	41	78	41	165	0.21	44.58
"	5	184	347	184	519	0.22	87.80
Dec. 1986	2	0					
"	5	154	243	154	333	0.28	46.05
"	7	33	37	33	48	0.50	5.63
Jan./Feb. 1987	1	3	3	3	3	1.00	0.00
"	6	2	2	2	2	1.00	0.00
"	7	18	24	18	48	0.27	12.24
Mar. 1987	1	7	7	7	9	0.64	0.86
"	2	0					
"	5	0					
Apr. 1987	2	5	5	5	5	0.83	0.01
"	5	19	25	19	49	0.36	12.39
May 1987	2	2	2	2	3	0.50	0.50
"	5	23	26	23	37	0.49	5.78

APPENDIX E. Fish Population Data, Trinity River, California: December 1985-May 1987. Population Calculations Based on Removal Data and the Maximum Weighted Likelihood Estimation Method Described by Carle and Strub 1978 (continued).

0+ Steelhead

Upper Side Channel

Date of Capture	Station	No. of Fish	Projected Population	95% Confidence Interval Low	95% Confidence Interval High	Probability of Catch	Standard Error
Dec. 1985	11	4	4	4	4	1.00	0.00
"	15	21	22	21	30	0.75	4.31
"	17	10	10	10	10	0.83	0.03
Jan. 1986	10	1	1	1	2	0.33	0.31
"	13	20	20	20	23	0.69	1.78
"	16	46	52	46	64	0.50	6.23
"	17	7	7	7	9	0.78	0.97
May 1986	10	0					
"	11	1	1	1	1	1.00	0.00
Jun./Jul. 1986	5	2	2	2	2	0.67	0.06
"	7	7	7	7	9	0.64	0.86
Aug. 1986	6	3	3	3	3	0.75	0.03
"	10	5	5	5	5	0.71	0.12
Sep. 1986	8	24	24	24	26	0.75	0.58
"	9	6	6	6	6	1.00	0.00
"	15	28	28	28	32	0.85	1.96
Oct. 1986	5	6	6	6	6	0.86	0.01
"	10	8	8	8	8	1.00	0.00
"	15	42	42	42	45	0.75	1.50
Nov. 1986	4	1	1	1	1	1.00	0.00
"	12	17	17	17	18	0.74	0.61
"	17	43	44	43	49	0.81	2.76
Dec. 1986	10	4	4	4	6	0.57	0.81
"	12	12	12	12	15	0.67	1.36
"	15	26	26	26	27	0.76	0.71
Jan./Feb. 1987	8	21	22	21	29	0.60	3.38
"	16	50	62	50	83	0.41	10.94
"	17	25	31	25	50	0.40	9.53
Mar. 1987	4	0					
"	9	0					
"	13	1	1	1	1	1.00	0.00
Apr. 1987	6	13	13	13	17	0.65	2.05
"	14	15	17	15	39	0.63	11.11
May 1987	4	67	110	67	181	0.26	36.39
"	11	116	127	116	140	0.55	6.63

APPENDIX E. Fish Population Data, Trinity River, California; December 1985-May 1987. Population Calculations Based on Removal Data and the Maximum Weighted Likelihood Estimation Method Described by Carle and Strub 1978 (continued).

0+ Steelhead

Lower Side Channel

Date of Capture	Station	No. of Fish	Projected Population	95% Confidence Interval Low	95% Confidence Interval High	Probability of Catch	Standard Error
Jun./Jul. 1986	2	0					
"	3	0					
Aug. 1986	1	1	1	1	1	1.00	0.00
"	5	0					
"	6	2	2	2	2	1.00	0.00
Sep. 1986	1	3	3	3	3	1.00	0.00
"	3	1	1	1	1	1.00	0.00
"	4	2	2	2	3	0.50	0.50
Oct. 1986	1	15	15	15	15	0.68	0.18
"	2	6	6	6	6	0.75	0.08
"	7	4	4	4	4	0.67	0.18
Nov. 1986	3	2	2	2	2	0.67	0.06
"	4	7	7	7	8	0.70	0.27
"	5	4	4	4	6	0.57	0.81
Dec. 1986	2	4	4	4	4	1.00	0.00
"	5	2	2	2	3	0.50	0.50
"	7	2	2	2	2	1.00	0.00
Jan./Feb. 1987	1	16	23	16	57	0.31	17.27
"	6	8	8	8	8	0.89	0.00
"	7	3	3	3	3	0.60	0.06
Mar. 1987	1	0					
"	2	0					
"	5	0					
Apr. 1987	2	0					
"	5	1	1	1	1	0.50	0.13
May 1987	2	3	3	3	3	1.00	0.00
"	5	1	1	1	2	0.33	0.72

APPENDIX E. Fish Population Data, Trinity River, California; December 1985-May 1987. Population Calculations Based on Removal Data and the Maximum Weighted Likelihood Estimation Method Described by Carle and Strub 1978 (continued).

1+ Steelhead

Upper Side Channel

Date of Capture	Station	No. of Fish	Projected Population	95% Confidence Interval Low	95% Confidence Interval High	Probability of Catch	Standard Error
Dec. 1985	11	0					
"	15	3	3	3	3	1.00	0.00
"	17	0					
Jan. 1986	10	0					
"	13	8	8	8	8	0.89	0.00
"	16	13	14	13	27	0.54	6.65
"	17	3	3	3	3	1.00	0.00
May 1986	10	1	1	1	1	1.00	0.00
"	11	6	6	6	8	0.75	1.27
Jun./Jul. 1986	5	1	1	1	1	0.50	0.13
"	7	9	*				
Aug. 1986	6	0					
"	10	0					
Sep. 1986	8	3	3	3	3	1.00	0.00
"	9	0					
"	15	11	11	11	12	0.85	0.49
Oct. 1986	5	0					
"	10	2	2	2	2	1.00	0.00
"	15	11	13	11	48	0.42	17.72
Nov. 1986	4	0					
"	12	0					
"	17	5	5	5	5	0.83	0.16
Dec. 1986	10	0					
"	12	1	1	1	1	1.00	0.00
"	15	1	1	1	1	1.00	0.00
Jan./Feb. 1987	8	2	2	2	2	1.00	0.00
"	16	16	16	16	20	0.67	1.98
"	17	3	*				
Mar. 1987	4	2	2	2	3	0.50	0.50
"	9	3	3	3	3	0.75	0.03
"	13	50	50	50	53	0.76	1.52
Apr. 1987	6	10	10	10	11	0.71	0.39
"	14	9	*				
May 1987	4	2	2	2	8	0.40	3.06
"	11	19	21	19	32	0.50	5.40

*Population estmate cannot be calculated because catch rate among electrofishing passes did not follow an orderly sequence.

APPENDIX E. Fish Population Data, Trinity River, California; December 1985-May 1987. Population Calculations Based on Removal Data and the Maximum Weighted Likelihood Estimation Method Described by Carle and Strub 1978 (continued).

1+ Steelhead

Lower Side Channel

Date of Capture	Station	No. of Fish	Projected Population	95% Confidence Interval Low	95% Confidence Interval High	Probability of Catch	Standard Error
Jun./Jul. 1986	2	0					
"	3	4	4	4	6	0.57	0.81
Aug. 1986	1	6	6	6	6	0.86	0.13
"	5	0					
"	6	0					
Sep. 1986	1	2	2	2	2	1.00	0.00
"	3	1	1	1	1	1.00	0.00
"	4	0					
Oct. 1986	1	31	32	31	37	0.53	2.62
"	2	2	2	2	2	1.00	0.00
"	7	7	*				
Nov. 1986	3	5	*				
"	4	1	1	1	1	0.50	0.13
"	5	0					
Dec. 1986	2	0					
"	5	0					
"	7	2	2	2	2	1.00	0.00
Jan./Feb. 1987	1	7	7	7	8	0.70	0.27
"	6	1	1	1	2	0.33	0.72
"	7	3	3	3	12	0.38	4.39
Mar. 1987	1	20	20	20	20	0.83	0.08
"	2	3	3	3	3	1.00	0.00
"	5	4	*				
Apr. 1987	2	5	5	5	5	0.71	0.12
"	5	2	2	2	2	0.67	0.06
May 1987	2	4	4	4	4	0.80	0.01
"	5	4	*				

*Population estmate cannot be calculated because catch rate among electrofishing passes did not follow an orderly sequence.

APPENDIX E. Fish Population Data, Trinity River, California; December 1985-May 1987. Population Calculations Based on Removal Data and the Maximum Weighted Likelihood Estimation Method Described by Carle and Strub 1978 (continued).

0+ Brown Trout

Upper Side Channel

Date of Capture	Station	No. of Fish	Projected Population	95% Confidence Interval Low	95% Confidence Interval High	Probability of Catch	Standard Error
Dec. 1985	11	15	15	15	17	0.83	1.24
"	15	17	17	17	22	0.81	2.58
"	17	34	35	34	40	0.65	2.57
Jan. 1986	10	10	10	10	16	0.50	3.05
"	13	34	34	34	37	0.72	1.71
"	16	104	135	104	170	0.38	17.97
"	17	17	17	17	19	0.85	1.01
May 1986	10	14	15	14	26	0.52	5.68
"	11	15	15	15	16	0.88	0.32
Jun./Jul. 1986	5	10	10	10	10	0.91	0.00
"	7	0					
Aug. 1986	6	4	4	4	4	0.80	0.01
"	10	11	11	11	11	0.79	0.10
Sep. 1986	8	17	17	17	18	0.74	0.61
"	9	6	*				
"	15	20	20	20	24	0.83	1.92
Oct. 1986	5	9	9	9	9	0.82	0.03
"	10	4	4	4	12	0.67	4.00
"	15	16	18	16	31	0.48	6.42
Nov. 1986	4	6	6	6	6	0.86	0.13
"	12	11	13	11	48	0.42	17.72
"	17	22	25	22	39	0.63	7.79
Dec. 1986	10	3	3	3	3	0.75	0.03
"	12	9	9	9	10	0.69	0.49
"	15	19	19	19	22	0.70	1.39
Jan./Feb. 1987	8	12	14	12	35	0.43	10.61
"	16	33	37	33	48	0.51	5.48
"	17	13	17	13	44	0.35	14.01
Mar. 1987	4	0					
"	9	0					
"	13	2	2	2	2	1.00	0.00
Apr. 1987	6	12	12	12	12	0.80	0.08
"	14	5	5	5	9	0.71	1.86
May 1987	4	9	9	9	15	0.60	3.23
"	11	14	15	14	26	0.54	5.61

*Population estmate cannot be calculated because catch rate among electrofishing passes did not follow an orderly sequence.

APPENDIX E. Fish Population Data, Trinity River, California; December 1985-May 1987. Population Calculations Based on Removal Data and the Maximum Weighted Likelihood Estimation Method Described by Carle and Strub 1978 (continued).

0+ Brown Trout

Lower Side Channel

Date of Capture	Station	No. of Fish	Projected Population	95% Confidence Interval Low	95% Confidence Interval High	Probability of Catch	Standard Error
Jun./Jul. 1986	2	0					
"	3	3	3	3	3	1.00	0.00
Aug. 1986	1	1	1	1	1	1.00	0.00
"	5	1	1	1	1	1.00	0.00
"	6	2	2	2	2	1.00	0.00
Sep. 1986	1	11	11	11	11	0.79	0.10
"	3	4	4	4	4	0.80	0.01
"	4	17	18	17	26	0.57	4.21
Oct. 1986	1	4	4	4	5	0.50	0.47
"	2	5	5	5	5	1.00	0.00
"	7	2	2	2	3	0.50	0.50
Nov. 1986	3	4	4	4	4	0.80	0.01
"	4	14	14	14	14	0.78	0.18
"	5	8	8	8	9	0.67	0.64
Dec. 1986	2	5	5	5	9	0.71	1.86
"	5	7	7	7	8	0.70	0.27
"	7	8	8	8	11	0.62	1.75
Jan./Feb. 1987	1	10	10	10	19	0.59	4.72
"	6	7	7	7	7	0.78	0.06
"	7	8	8	8	12	0.50	2.15
Mar. 1987	1	0					
"	2	0					
"	5	1	1	1	2	0.33	0.72
Apr. 1987	2	0					
"	5	3	3	3	6	0.50	1.43
May 1987	2	2	2	2	2	1.00	0.00
"	5	3	3	3	6	0.50	1.43

APPENDIX E. Fish Population Data, Trinity River, California; December 1985-May 1987. Population Calculations Based on Removal Data and the Maximum Weighted Likelihood Estimation Method Described by Carle and Strub 1978 (continued).

1+ Brown Trout

Upper Side Channel

Date of Capture	Station	No. of Fish	Projected Population	95% Confidence Interval Low	95% Confidence Interval High	Probability of Catch	Standard Error
Dec. 1985	11	8	8	8	10	0.80	0.79
"	15	3	3	3	3	1.00	0.00
"	17	2	2	2	2	1.00	0.00
Jan. 1986	10	3	3	3	3	0.60	0.06
"	13	9	9	9	9	0.75	0.16
"	16	27	27	27	29	0.75	1.00
"	17	1	1	1	1	1.00	0.00
May 1986	10	7	7	7	7	0.78	0.06
"	11	14	14	14	17	0.82	1.40
Jun./Jul. 1986	5	0					
"	7	8	8	8	8	0.73	0.20
Aug. 1986	6	0					
"	10	2	2	2	3	0.50	0.50
Sep. 1986	8	7	7	7	9	0.64	0.86
"	9	1	1	1	1	1.00	0.00
"	15	13	13	13	14	0.87	0.39
Oct. 1986	5	0					
"	10	3	3	3	3	1.00	0.00
"	15	8	8	8	22	0.57	7.09
Nov. 1986	4	0					
"	12	2	2	2	2	1.00	0.00
"	17	10	16	10	111	0.36	48.65
Dec. 1986	10	1	1	1	1	0.50	0.13
"	12	0					
"	15	1	1	1	1	0.50	0.13
Jan./Feb. 1987	8	3	3	3	3	0.75	0.03
"	16	14	17	14	37	0.40	9.97
"	17	2	2	2	8	0.40	3.06
Mar. 1987	4	1	1	1	1	1.00	0.00
"	9	7	7	7	8	0.70	0.27
"	13	8	8	8	22	0.57	7.09
Apr. 1987	6	1	1	1	1	0.50	0.13
"	14	1	*				
May 1987	4	0					
"	11	8	8	8	9	0.67	0.64

*Population estmate cannot be calculated because catch rate among electrofishing passes did not follow an orderly sequence.

APPENDIX E. Fish Population Data, Trinity River, California; December 1985-May 1987. Population Calculations Based on Removal Data and the Maximum Weighted Likelihood Estimation Method Described by Carle and Strub 1978 (continued).

1+ Brown Trout

Lower Side Channel

Date of Capture	Station	No. of Fish	Projected Population	95% Confidence Interval Low	95% Confidence Interval High	Probability of Catch	Standard Error
Jun./Jul. 1986	2	1	1	1	1	1.00	0.00
"	3	1	1	1	2	0.33	0.72
Aug. 1986	1	7	7	7	7	1.00	0.00
"	5	0					
"	6	0					
Sep. 1986	1	9	9	9	9	0.75	0.16
"	3	0					
"	4	4	4	4	4	0.67	0.18
Oct. 1986	1	3	3	3	3	0.75	0.00
"	2	1	1	1	1	0.50	0.13
"	7	4	*				
Nov. 1986	3	0					
"	4	1	1	1	1	1.00	0.00
"	5	2	2	2	3	0.50	0.50
Dec. 1986	2	0					
"	5	0					
"	7	0					
Jan./Feb. 1987	1	2	2	2	2	0.67	0.06
"	6	0					
"	7	2	2	2	3	0.40	0.54
Mar. 1987	1	6	6	6	6	0.86	0.01
"	2	3	3	3	3	0.75	0.03
"	5	2	2	2	8	0.40	3.06
Apr. 1987	2	4	4	4	4	0.67	0.18
"	5	1	1	1	1	0.50	0.13
May 1987	2	0					
"	5	0					

*Population estmate cannot be calculated because catch rate among electrofishing passes did not follow an orderly sequence.

APPENDIX F. Trinity River Hatchery Data for Fish Released at the Hatchery Site, Trinity River, California; October 1985-May 1987.

Juvenile Chinook Salmon

Date Of Release	Number Released	Percent Marked (Adipose Clip)
October 1, 1985	191,400	0
October 2, 1985	188,200	53.8
October 3, 1985	35,200	0
October 4, 1985	159,688	0
October 10, 1985	161,245	62.0
October 11, 1985	119,700	0
February 26, 1986	52,350	0
February 27/28, 1986	103,740	100
May 6, 1986	524,210	0
May 14, 1986	355,300	0
June 2, 1986	335,425	60.3
June 3, 1986	414,950	0
June 4, 1986	241,425	0
June 5, 1986	446,900	0
June 6, 1986	524,400	0
June 9, 1986	303,250	0
June 10, 1986	150,450	0
June 11, 1986	340,425	0
June 13, 1986	114,450	0
June 16, 1986	205,900	100
June 19, 1986	54,250	0
June 24, 1986	588,750	0
June 27, 1986	254,000	0
October 1, 1986	166,650	0
October 2, 1986	168,275	62.9
October 3, 1986	157,935	25.5
October 8, 1986	224,100	0
October 17, 1986	156,000	0
October 21, 1986	31,850	0
October 22, 1986	190,300	0
October 23, 1986	161,040	0
October 24, 1986	98,550	100
October 27, 1986	156,600	0
May 5, 1987	567,000	0
May 7, 1987	526,350	0
May 26, 1987	176,375	0
May 27, 1987	313,875	0
May 28, 1987	309,420	66.2

APPENDIX F. Trinity River Hatchery Data for Fish Released at the Hatchery Site, Trinity River, California; October 1985-March 1987 (continued).

Juvenile Coho Salmon

Date Of Release	Number Released	Percent Marked (Adipose Clip)
October 30, 1985	107,250	100
March 18, 1986	138,038	0
March 19, 1986	98,475	48.2
March 20, 1986	161,200	0
March 27, 1986	165,000	0
July 30, 1986	157,500	53.0
August 1, 1986	176,009	3.0
August 11, 1986	6,426	100
March 19, 1987	99,220	0
March 20, 1987	77,213	0
March 23, 1987	207,920	0
March 24, 1987	184,450	0

APPENDIX F. Trinity River Hatchery Data for Fish Released at the Hatchery Site, Trinity River, California; March 1986-April 1987 (continued).

Juvenile Steelhead

Date Of Release	Number Released	Percent Marked (Right Ventral Clip)	Percent Marked (Left Ventral Clip)
March 12, 1986	17,755	100	0
April 2/3, 1986	137,088	0	0
April 4, 1986	79,688	0	0
April 8, 1986	34,675	0	0
April 9, 1986	59,000	0	0
April 10, 1986	4,450	0	0
April 16, 1986	2,675	0	0
May 20, 1986	31,683	0	0
September 22, 1986	29,140	0	100
March 13, 1987	76,500	0	0
March 20, 1987	28,000	100	0
March 30, 1987	61,380	0	0
March 31, 1987	126,000	0	0
April 1, 1987	81,585	0	0
April 3, 1987	48,750	0	0
April 6, 1987	85,388	0	0

APPENDIX G. Duration of Residency for Fish Using the Upper and Lower Side Channels as Determined by Marking Experiments, Trinity River, California, 1985-1987.

Juvenile Chinook Salmon

UPPER SIDE-CHANNEL

Date of Observation	No. of Fish	Mark #1 (12-17-85) % Marked	Mark #1 Duration Rate (%)*	Mark #2 (5-24-86) % Marked	Mark #2 Duration Rate (%)	Mark #3 (9-27-86) % Marked	Mark #3 Duration Rate (%)	Mark #4 (1-31-87) % Marked	Mark #4 Duration Rate (%)
Dec. 1985	None								
Jan. 1986	None								
May 1986	22	0	0	0	0				
Jun./Jul. 1986	136	0	0	0	0				
Aug. 1986	29	0	0	0	0				
Sep. 1986	66	0	0	0	0	33.3	100		
Oct. 1986	32	0	0	0	0	18.8	56.5		
Nov. 1986	35	0	0	0	0	31.4	94.3		
Dec. 1986	11	0	0	0	0	9.1	27.3		
Jan./Feb. 1987	50	0	0	0	0	14.0	42.0	32.0	100
Mar. 1987	790	0	0	0	0	0	0	0.1	0.7
Apr. 1987	1796	0	0	0	0	0	0	0	0
May 1987	352	0	0	0	0	0	0	0	0

LOWER SIDE-CHANNEL

Date of Observation	No. of Fish	Mark #5 (6-23-86) % Marked	Mark #5 Duration Rate (%)*	Mark #6 (9-13-86) % Marked	Mark #6 Duration Rate (%)	Mark #7 (2-7-87) % Marked	Mark #7 Duration Rate (%)
Jun./Jul. 1986	306	2.9	100				
Aug. 1986	52	0	0				
Sep. 1986	94	1.1	37.9	5.3	100		
Oct. 1986	32	0	0	3.1	58.5		
Nov. 1986	116	0	0	3.4	64.2		
Dec. 1986	83	0	0	1.2	22.6		
Jan./Feb. 1987	39	0	0	0	0	12.8	100
Mar. 1987	586	0	0	0	0	0.9	7.0
Apr. 1987	761	0	0	0	0	0	0
May 1987	248	0	0	0	0	0	0

* Duration Rate shows the percentage of fish that remain in a given side-channel over time. Duration Rate is calculated by dividing the observed "% Marked" number for a given month by the initial "% Marked" number in that column. For example, the Duration Rate of 56.5 for Mark #3 during October, 1986 was calculated by dividing 18.8 by 33.3. To calculate the Duration Index, divide the Duration Rate by 100.

APPENDIX G. Duration of Residency for Fish Using the Upper and Lower Side Channels as Determined by Marking Experiments, Trinity River, California; 1985-1987 (continued).

Juvenile Coho Salmon

UPPER SIDE-CHANNEL

Date of Observation	No. of Fish	Mark #1 (12-17-85) % Marked	Mark #1 Duration Rate (%)	Mark #2 (5-24-86) % Marked	Mark #2 Duration Rate (%)	Mark #3 (9-27-86) % Marked	Mark #3 Duration Rate (%)	Mark #4 (1-31-87) % Marked	Mark #4 Duration Rate (%)
Dec. 1985	38	63.2	100						
Jan. 1986	20	36.4	57.6						
May 1986	405	0	0	0.5	100				
Jun./Jul. 1986	147	0	0	0	0				
Aug. 1986	113	0	0	0	0				
Sep. 1986	99	0	0	0	0	49.5	100		
Oct. 1986	59	0	0	0	0	37.3	75.4		
Nov. 1986	119	0	0	0	0	26.1	52.7		
Dec. 1986	40	0	0	0	0	20.0	40.4		
Jan./Feb. 1987	122	0	0	0	0	19.7	39.8	37.7	100
Mar. 1987	18	0	0	0	0	16.7	33.7	11.1	29.4
Apr. 1987	93	0	0	0	0	1.1	2.2	1.1	2.9
May 1987	124	0	0	0	0	0	0	0	0

LOWER SIDE-CHANNEL

Date of Observation	No. of Fish	Mark #5 (6-23-86) % Marked	Mark #5 Duration Rate (%)	Mark #6 (9-13-86) % Marked	Mark #6 Duration Rate (%)	Mark #7 (2-7-87) % Marked	Mark #7 Duration Rate (%)
Jun./Jul. 1986	22	22.7	100				
Aug. 1986	15	0	0				
Sep. 1986	39	0	0	28.2	100		
Oct. 1986	73	1.4	6.2	2.7	9.6		
Nov. 1986	232	0.4	1.8	1.7	6.0		
Dec. 1986	187	0	0	1.6	5.7		
Jan./Feb. 1987	23	0	0	0	0	13.0	100
Mar. 1987	7	0	0	0	0	14.3	110
Apr. 1987	24	0	0	0	0	0	0
May 1987	25	0	0	0	0	0	0

APPENDIX G. Duration of Residency for Fish Using the Upper and Lower Side Channels as Determined by Marking Experiments, Trinity River, California; 1985-1987 (continued).

0+ Steelhead

UPPER SIDE-CHANNEL

Date of Observation	No. of Fish	Mark #1 (12-17-85)		Mark #2 (5-24-86)		Mark #3 (9-27-86)		Mark #4 (1-31-87)	
		% Marked	Duration Rate (%)	% Marked	Duration Rate (%)	% Marked	Duration Rate (%)	% Marked	Duration Rate (%)
Dec. 1985	35	20.0	100						
Jan. 1986	74	29.7	148.5						
May 1986	1	0	0	0	0				
Jun./Jul. 1986	9	0	0	0	0				
Aug. 1986	8	0	0	0	0				
Sep. 1986	58	0	0	0	0	24.1	100		
Oct. 1986	56	0	0	0	0	25.0	103.7		
Nov. 1986	61	0	0	0	0	19.7	81.7		
Dec. 1986	42	0	0	0	0	4.8	19.9		
Jan./Feb. 1987	96	0	0	0	0	17.7	73.4	18.8	100
Mar. 1987	1	0	0	0	0	0	0	0	0
Apr. 1987	28	0	0	0	0	0	0	0	0
May 1987	183	0	0	0	0	0	0	0	0

LOWER SIDE-CHANNEL

Date of Observation	No. of Fish	Mark #5 (6-23-86)		Mark #6 (9-13-86)		Mark #7 (2-7-87)	
		% Marked	Duration Rate (%)	% Marked	Duration Rate (%)	% Marked	Duration Rate (%)
Jun./Jul. 1986	None						
Aug. 1986	3	0	0				
Sep. 1986	6	0	0	33.3	100		
Oct. 1986	25	0	0	8.0	24.0		
Nov. 1986	13	0	0	7.7	23.1		
Dec. 1986	8	0	0	0	0		
Jan./Feb. 1987	27	0	0	0	0	33.3	100
Mar. 1987	None						
Apr. 1987	1	0	0	0	0	0	0
May 1987	4	0	0	0	0	0	0

APPENDIX G. Duration of Residency for Fish Using the Upper and Lower Side Channels as Determined by Marking Experiments, Trinity River, California; 1985-1987 (continued).

1+ Steelhead

UPPER SIDE-CHANNEL

Date of Observation	No. of Fish	Mark #1 (12-17-85) % Marked	Mark #1 Duration Rate (%)	Mark #2 (5-24-86) % Marked	Mark #2 Duration Rate (%)	Mark #3 (9-27-86) % Marked	Mark #3 Duration Rate (%)	Mark #4 (1-31-87) % Marked	Mark #4 Duration Rate (%)
Dec. 1985	3	66.7	100						
Jan. 1986	24	37.5	56.2						
May 1986	7	0	0	14.3	100				
Jun./Jul. 1986	10	0	0	0	0				
Aug. 1986	None								
Sep. 1986	14	0	0	7.1	49.7	71.4	100		
Oct. 1986	13	0	0	15.4	107.7	23.1	32.4		
Nov. 1986	5	0	0	0	0	40.0	56.0		
Dec. 1986	2	0	0	0	0	0	0		
Jan./Feb. 1987	21	0	0	0	0	19.0	26.6	23.8	100
Mar. 1987	55	0	0	0	0	9.1	12.7	7.3	30.7
Apr. 1987	19	0	0	0	0	15.8	22.1	0	0
May 1987	21	0	0	0	0	0	0	0	0

LOWER SIDE-CHANNEL

Date of Observation	No. of Fish	Mark #5 (6-23-86) % Marked	Mark #5 Duration Rate (%)	Mark #6 (9-13-86) % Marked	Mark #6 Duration Rate (%)	Mark #7 (2-7-87) % Marked	Mark #7 Duration Rate (%)
Jun./Jul. 1986	4	25.0	100				
Aug. 1986	6	0	0				
Sep. 1986	3	0	0	0	0		
Oct. 1986	40	0	0	5.0	100		
Nov. 1986	6	0	0	0	0		
Dec. 1986	2	0	0	0	0		
Jan./Feb. 1987	11	0	0	0	0	27.3	100
Mar. 1987	27	0	0	0	0	11.1	40.7
Apr. 1987	7	0	0	0	0	0	0
May 1987	8	0	0	0	0	0	0

APPENDIX G. Duration of Residency for Fish Using the Upper and Lower Side Channels as Determined by Marking Experiments, Trinity River, California; 1985-1987 (continued).

0+ Brown Trout

UPPER SIDE-CHANNEL

Date of Observation	No. of Fish	Mark #1 (12-17-85) % Marked	Mark #1 Duration Rate (%)	Mark #2 (5-24-86) % Marked	Mark #2 Duration Rate (%)	Mark #3 (9-27-86) % Marked	Mark #3 Duration Rate (%)	Mark #4 (1-31-87) % Marked	Mark #4 Duration Rate (%)
Dec. 1985	66	33.3	100						
Jan. 1986	165	23.0	69.1						
May 1986	29	0	0	0	0				
Jun./Jul. 1986	10	0	0	10.0	100				
Aug. 1986	15	0	0	0	0				
Sep. 1986	43	0	0	0	0	23.3	100		
Oct. 1986	29	0	0	0	0	10.3	44.2		
Nov. 1986	39	0	0	0	0	15.4	66.1		
Dec. 1986	31	0	0	0	0	16.1	69.1		
Jan./Feb. 1987	58	0	0	0	0	10.3	44.2	20.7	100
Mar. 1987	2	0	0	0	0	0	0	0	0
Apr. 1987	17	0	0	0	0	0	0	0	0
May 1987	23	0	0	0	0	0	0	0	0

LOWER SIDE-CHANNEL

Date of Observation	No. of Fish	Mark #5 (6-23-86) % Marked	Mark #5 Duration Rate (%)	Mark #6 (9-13-86) % Marked	Mark #6 Duration Rate (%)	Mark #7 (2-7-87) % Marked	Mark #7 Duration Rate (%)
Jun./Jul. 1986	3	66.7	100				
Aug. 1986	4	0	0				
Sep. 1986	32	0	0	12.5	100		
Oct. 1986	11	0	0	27.3	218.4		
Nov. 1986	26	3.8	5.7	23.1	184.8		
Dec. 1986	20	0	0	5.0	40.0		
Jan./Feb. 1987	25	0	0	8.0	64.0	20.0	100
Mar. 1987	1	0	0	0	0	0	0
Apr. 1987	3	0	0	0	0	0	0
May 1987	5	0	0	0	0	0	0

APPENDIX G. Duration of Residency for Fish Using the Upper and Lower Side Channels as Determined by Marking Experiments, Trinity River, California; 1985-1987 (continued).

1+ Brown Trout

UPPER SIDE-CHANNEL

Date of Observation	No. of Fish	Mark #1 (12-17-85) % Marked	Duration Rate (%)	Mark #2 (5-24-86) % Marked	Duration Rate (%)	Mark #3 (9-27-86) % Marked	Duration Rate (%)	Mark #4 (1-31-87) % Marked	Duration Rate (%)
Dec. 1985	13	38.5	100						
Jan. 1986	40	37.5	97.4						
May 1986	21	9.5	24.7	19.0	100				
Jun./Jul. 1986	8	0	0	0	0				
Aug. 1986	2	0	0	50.0	263.2				
Sep. 1986	21	0	0	0	0	28.6	100		
Oct. 1986	11	0	0	0	0	54.5	190.6		
Nov. 1986	12	0	0	8.3	43.7	25.0	87.4		
Dec. 1986	2	0	0	0	0	50.0	174.8		
Jan./Feb. 1987	19	0	0	0	0	31.6	110.5	36.8	100
Mar. 1987	16	0	0	0	0	12.5	43.7	18.8	51.1
Apr. 1987	4	0	0	0	0	0	0	25.0	67.9
May 1987	8	0	0	0	0	0	0	0	0

LOWER SIDE-CHANNEL

Date of Observation	No. of Fish	Mark #5 (6-23-86) % Marked	Duration Rate (%)	Mark #6 (9-13-86) % Marked	Duration Rate (%)	Mark #7 (2-7-87) % Marked	Duration Rate (%)
Jun./Jul. 1986	2	0	0				
Aug. 1986	7	0	0				
Sep. 1986	13	7.7	100	61.5	100		
Oct. 1986	8	0	0	37.5	70.0		
Nov. 1986	3	0	0	0	0		
Dec. 1986	None						
Jan./Feb. 1987	4	0	0	50.0	81.3	50.0	100
Mar. 1987	11	0	0	18.2	29.6	18.2	36.4
Apr. 1987	5	0	0	0	0	0	0
May 1987	None						

APPENDIX H. Diurnal Air and Water Temperature Data (°C) for Upper and Lower Side Channels and Trinity River, California, 1985-1987.

	UPPER SIDE CHANNEL						LOWER SIDE CHANNEL						TRINITY RIVER		
	Air			Water			Air			Water			Water		
Date	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low
Dec. 1985	2.2	3.9	0.0	6.8	7.2	6.7									
Jan. 1986	8.6	12.2	5.0	7.5	8.3	6.7									
May 1986	28.9	28.9	28.9	13.3	13.3	13.3									
Jun./Jul. 1986	26.7	29.4	23.9	11.4	11.7	10.6	27.5	31.7	23.3	13.1	13.9	12.2	12.5	13.9	11.7
Aug. 1986	28.1	31.7	24.4	10.3	10.6	10.0	27.6	30.0	22.7	11.1	12.2	9.4			
Sep. 1986	13.7	17.2	7.8	9.1	10.6	7.2	14.8	16.1	13.3	9.2	10.0	8.9	11.1	11.1	11.1
Oct. 1986	17.1	18.9	15.0	10.7	11.7	9.4	17.2	20.6	12.8	10.0	10.6	9.4	11.1	11.1	11.1
Nov. 1986	14.6	16.1	12.8	9.4	10.0	8.9	8.3	9.4	7.2	8.6	8.9	8.3	6.7	6.7	6.7
Dec. 1986	6.0	7.2	4.7	7.5	7.8	7.2	6.8	7.8	6.1	7.5	7.8	7.2	6.7	7.2	6.1
Jan./Feb. 1987	7.1	7.2	6.7	6.7	6.7	6.7	12.1	16.1	5.0	7.8	8.3	6.7	6.4	6.7	6.1
Mar. 1987	11.0	14.4	7.2	9.4	10.0	8.9	12.2	14.4	9.4	10.2	11.1	8.9	11.9	12.2	11.7
Apr. 1987	13.1	20.0	6.1	10.6	11.1	10.0	16.9	20.0	13.9	10.3	10.6	10.0	13.9	15.6	12.2
May 1987	17.8	22.8	12.8	11.9	12.2	11.7	16.1	22.2	10.0	11.9	12.8	11.1	13.1	13.9	12.2