TRINITY RIVER FLOW EVALUATION

ANNUAL REPORT - 1990

FISH AND WILDLIFE SERVICE

U. S. DEPARTMENT OF THE INTERIOR

ANNUAL REPORT

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1990

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PREFACE

The following report is the sixth annual report prepared as part of the Trinity River Flow Evaluation, a 12-Year effort which began in October, 1984. The U.S. Fish and Wildlife Service has been directed to conduct the evaluation as part of the January 1981 decision by the Secretary of the Interior to increase Trinity River releases at Lewiston Dam from the 120,000 acre-foot per year level which had been in effect since the Trinity River Division of the California Central Valley project was completed in 1960.

Through this undertaking, we hope to gain a better understanding of the biological forces which influence and control Trinity River salmon and steelhead. At the completion of the evaluation period the Service will provide a report to the Secretary. The report will summarize the knowledge gained through the evaluation period and recommend an appropriate course of action for future management of Trinity River flows. Through this effort the Secretary can then fulfill his responsibilities for the preservation and propagation of the Trinity River's fishery resources.

To those who are interested, comments and information regarding this program and the habitat resources of the Trinity are welcomed. Written comments or information can be submitted to:

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PERSONNEL AND ACKNOWLEDGEMENTS

The following persons contributed to this report:

Mike Aceituno, Project Leader:
Program Planning and Coordination.

Andy Hamilton, fish and wildlife biologist:
Mainstem habitat, Steelhead Winter Habitat, Juvenile Salmonid Populations.

Mark Hampton, fish and wildlife biologist:
Side-channel habitat studies, Pool Evaluation.

Larry Hanson, fishery biologist:
Spawning Distribution, Temperature Monitoring.

Field assistance was provided by Rick Williams of the Sacramento USFWS Field Office and by Gwyn Hampton.

CONTENTS

SUMMARY

The Trinity River Flow Evaluation, a study designed to monitor fishery habitat in the Trinity River and report to the Secretary of the Interior in 1996 on the effectiveness of the Secretary's 1981 decision to increase releases from Trinity and Lewiston dams, has completed its fifth year. Various activities undertaken in 1990 were as follows:

Mainstem Habitat Availability

Mainstem habitat estimates were made at IFIM study sites between Lewiston and Steiner Flat during a Lewiston release of 150 cfs. Above Douglas City, weighted usable area for rearing salmonids increased with decreasing flows as shown in previous studies. At Steiner Flat, weighted usable area decreased from 300 to 150 cfs. Available habitat for rearing salmonids was slightly lower than predicted by hydraulic modeling downward from higher flows.

Mainstem Habitat for Juvenile Steelhead

An evaluation of steelhead winter weighted usable area provided by existing conditions and after sand removal showed potential habitat increases ranging from 300 to 2000 percent at five upper-river IFIM study sites. Evaluation of known steelhead densities associated with winter and summer habitat indicated that lack of winter habitat for steelhead is a major bottleneck limiting steelhead populations.

1990 Side-channel Evaluations

1990 side-channel evaluations were designed to quantify physical habitat for rearing salmonids in two side-channels, describe the relationship between weighted useable area and fish populations between habitat types, and evaluate the accuracy of habitat estimates within habitat types.

The Trinity River Restoration Program created feathered banks, meanders, and cobble/boulder wing deflectors in the Cemetery side-channel to improve salmonid rearing habitat. These changes increased weighted useable area for fry and juvenile chinook salmon 5.3 and 3.6 times. Steelhead trout and coho salmon habitat also increased, with steelhead over-wintering habitat increasing 11.7 times. Habitat could still be improved by placing cobbles in side-channels.

Analysis of the Salt Flat side-channel, constructed in 1989, showed that it provided 4,574 ft^2 and 14,823 ft^2 of weighted usable area for fry and juvenile chinook salmon.

In the Cemetery and Salt Flat side-channels fish populations estimates collected and analyzed by the Trinity River Restoration Program were compared to weighted usable area estimates for each habitat type sampled. Regression analysis showed a relationship between fry and juvenile chinook salmon and available habitat.

Evaluation of Dredged Pools

In the summer of 1989 the Trinity River Restoration Program excavated four pools in the upper river, one upstream of Cemetery Pool, Cemetery Pool, Bucktail Pool, and Society Pool at Poker Bar. With the exception of Bucktail Pool, the majority of sediments removed were silt, sand, and small gravel. A total of 21,986 cubic yards of material were removed over two years. The Soil Conservation Service estimates that Grass Valley Creek contributes an average annual sediment load of 177,000 cubic yards. The completion of Buckhorn Debris Dam should reduce this sediment load by 27% or 47,790 cubic yards. An additional 85,000 cubic yards of sediment can be captured by the Hamilton and Wellock sediment ponds. This leaves a potential sediment load of 44,210 cubic yards of sediment to enter the Trinity River. Pool dredging removed approximately 25% of the average annual sediment contributions from Grass Valley Creek.

In order to reduce the level of disturbance that pool excavation imposes on holding spring chinook salmon we recommend that future dredging activities occur earlier in the summer in late June and July.

Water Temperature Monitoring

Water temperature monitoring for use in calibrating estimates of available salmonid habitat continued in 1990 at six sites from Lewiston to Hoopa Valley. From mid-July through the chinook salmon spawning season, temperatures were within generally-accepted criteria for holding and spawning spring and fall-run chinook.

Chinook Salmon Spawning Distribution

Spawning surveys from Lewiston to Tish Tang in 1990 showed patterns similar to previous years, with a majority of redds observed above the North Fork, but continued substantial spawning from the North Fork down.

Juvenile Populations

Late-winter and spring snorkeling surveys at Lewiston, Steelbridge, Steiner Flat, Junction City, and Hayden Flat revealed juvenile chinook rearing populations similar to past years of fairly high adult escapement. Fish numbers were highest at the up-river sites early in the season and decreased from March to May, while numbers at lower sites increased. Rearing densities at all sites were approximately equal by mid-May.

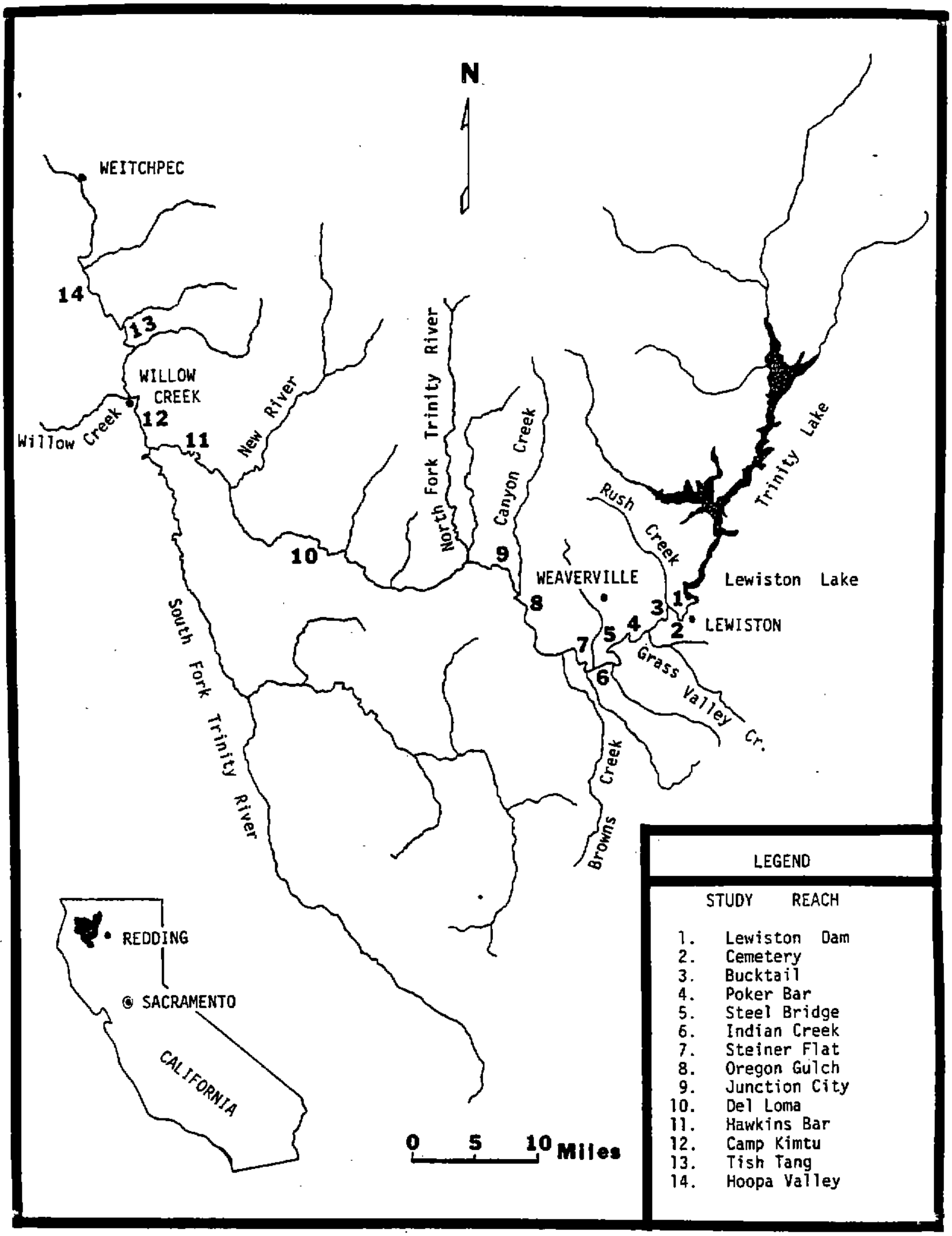

Figure 1. Trinity River Basin with Study Site Locations.

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I. INTRODUCTION

The Trinity River watershed drains approximately 2,965 square miles of Trinity and Humboldt Counties in northwestern California (Figure 1).

The Trinity River Division of California's Central Valley Project, operated by the U.S. Bureau of Reclamation, is the only major water development project in the basin and serves to export water from the Trinity River to the Central Valley of California. The keystones to this project are Lewiston Dam (at river mile 110) and Trinity Dam just upstream. The former represents the upstream limits of anadromous salmonid migration in the basin. As mitigation for upstream losses the Trinity River hatchery was constructed at the base of Lewiston Dam. In addition, minimum downstream flows were to be provided to maintain fish resources. These efforts, however, were not sufficient to sustain fish populations. Both salmon and steelhead trout populations declined, in some stocks as much as 90 percent of former levels.

In December of 1980 the Fish and Wildlife Service and the Bureau of Reclamation reached an agreement to increase releases to the Trinity River below Lewiston Dam to aid in the rehabilitation of the anadromous fishery resources. The agreement was approved by the Secretary of Interior in January 1981. The basic points of the agreement are: 1) the Bureau of Reclamation will maintain releases at Lewiston Dam of up to 340,000 acre-feet annually in normal water years; 2) the Fish and Wildlife Service will conduct a 12-year study to evaluate the effectiveness of the increased flows; 3) the Bureau of Reclamation will maintain an interim release of 287,000 acre-feet annually in normal years until such time as the Service prepares a detailed plan of study; 4) releases will be incrementally increased to 340,000 acre-feet as habitat and watershed restoration measures are implemented; 5) in dry-years, releases will be 220,000 acre-feet and in critically dry years 140,000 acre-feet; 6) dry and critically dry years will be based on forecasted Shasta Reservoir inflow; and, 7) at the end of the 12-year study the Service is to report to the Secretary, describing the effectiveness of the improved flows and any other habitat rehabilitation measures (e.g. those contained in the Trinity River Basin Fish and Wildlife Management Program) in restoring fish populations and habitat below Lewiston Dam.

As directed by the Secretary the Fish and Wildlife Service completed a Plan of Study for the Trinity River Flow Evaluation in December 1983. Subsequently, Department of Interior funding was provided through the Bureau of Reclamation and field work initiating the 12-year evaluation program began in January 1985. The study focuses on the mainstem Trinity River from Lewiston Dam to its confluence with the Klamath River at Weitchpec. Its goal is to monitor the rehabilitation of fishery habitat in the Trinity River below Lewiston Dam. The intent of the study is that: 1) it be conducted by utilizing current scientific methodologies; 2) it be flexible to meet changing fishery resource conditions; 3) it be closely coordinated with other studies and resource management agencies; and 4) it be reported on, by providing timely data analysis at regular intervals and at the conclusion of the study. Under the current schedule, field studies will be completed in 1995, with a final report to the Secretary by September 30, 1996.

The general study plan consists of six major tasks. These tasks and their objectives are:

TASK 1. Annual Study Plan Review and Modification.

Objective: To assure that the study plan reflects current findings and data.

TASK 2. Habitat Preference Criteria Development.

Objective: To develop habitat preference criteria quantifying depths, velocities, substrates, and cover requirements for chinook and coho salmon and steelhead trout spawning, incubation, rearing, holding, and migration. Other factors, such as water quality and temperature will be considered under TASK 3.

TASK 3. Determination of Habitat Availability and Needs.

Objective: A. To determine the amount of salmon and steelhead trout habitat available in the Trinity River downstream of Lewiston Dam under various flow conditions and levels of habitat rehabilitation or through other resource management actions (e.g. the Trinity River Basin Fish and Wildlife Management Program);

B. To determine the amount of habitat required for each freshwater lifestage of salmon and steelhead trout, to sustain those portions of the fish populations in the Trinity Basin that were historically dependent on the Trinity River downstream of Lewiston Dam.

TASK 4. Determination of Fish Population Characteristics and Life History Relationships.

Objective: A. To determine the relative levels of successful use by fish populations of available habitat in the Trinity River downstream of Lewiston Dam, including spawning success and the subsequent survival and growth of juveniles.

B. To determine which habitat factors may be limiting the restoration of fish populations.

TASK 5. Study Coordination.

Objective: To develop and maintain coordination with other study and resource management agencies in the Trinity River Basin to maximize effective use of available information (and to avoid duplication of effort).

TASK 6. Reports (Progress, Findings, and Recommendations)

Objective: A. To report on the analysis of information developed from field investigations (TASKS 2, 3, and 4) and on relevant information from other studies which have a bearing on the levels of fishery resource rehabilitation achieved in the Trinity River between Lewiston and Weitchpec.

B. To develop recommendations to the Secretary and to other resource management agencies concerning future management options and needs.

The following sections summarize project activities primarily between September 1989 and the end of 1990. The final section on program Planning and Coordination describes the focus of study efforts planned for 1991.

II. HABITAT AVAILABILITY AND NEEDS

1990 MAIN-STEM HABITAT MEASUREMENTS

In 1990 we planned to measure habitat provided by a Lewiston release of 3000 cfs. Relatively dry conditions, however, led to the adoption of a critical dry-year flow regime, with 120,000 acre-feet available and flows dropped to 150 cfs in early June. Late spring rains allowed reversion to a dry-year regime, but the increase was not enough to provide a 3,000 cfs study flow.

To accommodate the critical dry-year water availability, Lewiston releases were dropped to 150 cfs by June 7 and remained at this level until June 15, by which time it had been determined that inflow to Shasta Lake were adequate for a dry-year schedule. We took advantage of the low flows to measure microhabitat provided by 150 cfs at five sites in the upper river, to be used as a check on low-flow habitat estimates provided by the PHABSIM model.

Methods

We re-established transects used since 1985 at our study sites at Cemetery, Bucktail, Poker Bar, Steelbridge, and Steiner Flat, and carried out microhabitat measurements following US Fish and Wildlife Service Instream Flow Group procedures (USFWS 1986). Data were collected on depths, water velocity, substrate characteristics, and cover at least twenty points on each transect.

To determine weighted usable area (WUA), we calculated the suitable area available by applying Trinity River preference criteria (Hampton 1988, appendix E) to the actual depths and velocities measured, rather than using a hydraulic simulation.

To determine the total habitat availability between Lewiston and Douglas City, WUA estimated at each transect was multiplied by the distance of the river most closely represented by the transect, as described in Section II.2 of our 1989 annual report. A similar procedure was used to estimate representative habitat within the Steiner Flat site.

The habitat relationships presented below include similar direct calculation of available habitat at Lewiston releases of 350, 450, 800, and 2000 cfs, as described in our 1989 report.

Results

Figures 1 through 4 show WUA estimates based on our five measured flows between Lewiston and Douglas City. Figures 5 and 6 show estimates at the Steiner Flat site, which is representative of the additional eight miles of river to Dutch Creek. Figures 1 through four are equivalent to those presented in our 1989 report, with the addition of direct data for the 150 cfs flow.

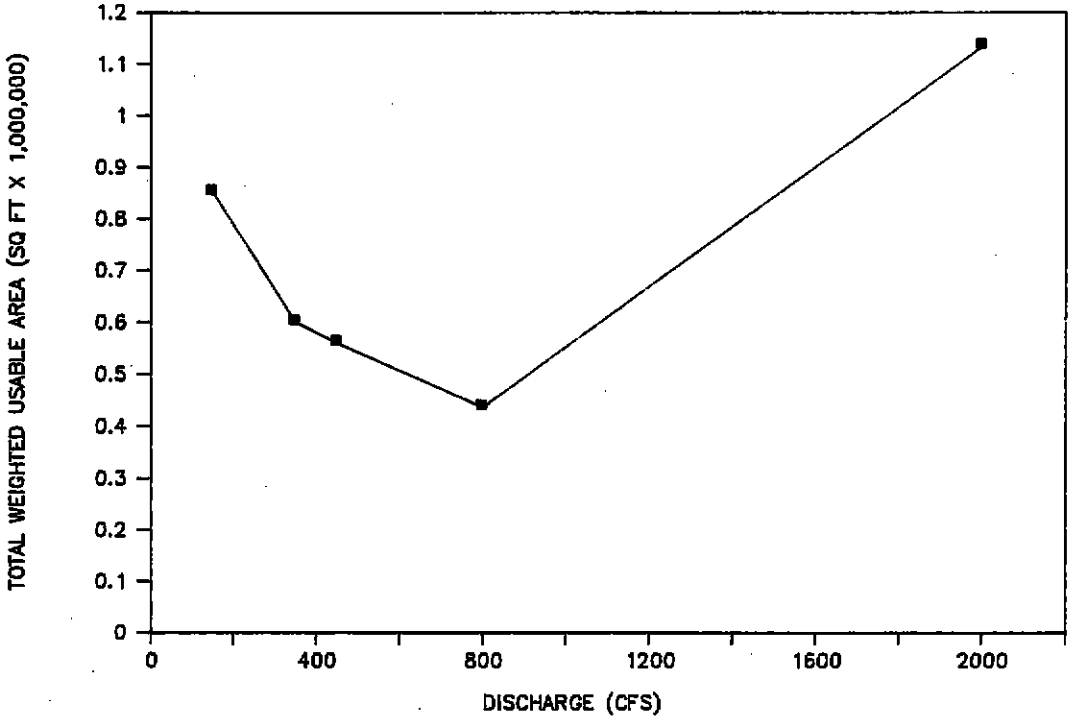


Figure 1. Weighted usable area for chinook fry as a function of discharge between Lewiston and Douglas City in the Trinity River.

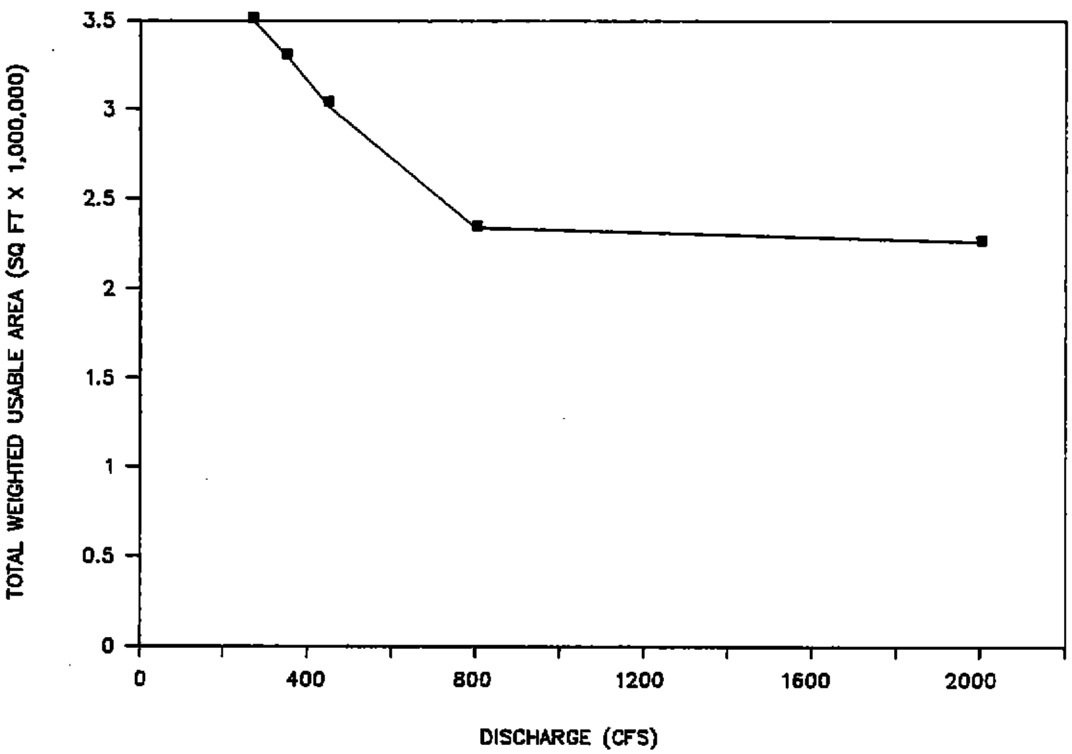


Figure 2. Weighted usable area for chinook juveniles as a function of discharge between Lewiston and Douglas City in the Trinity River.

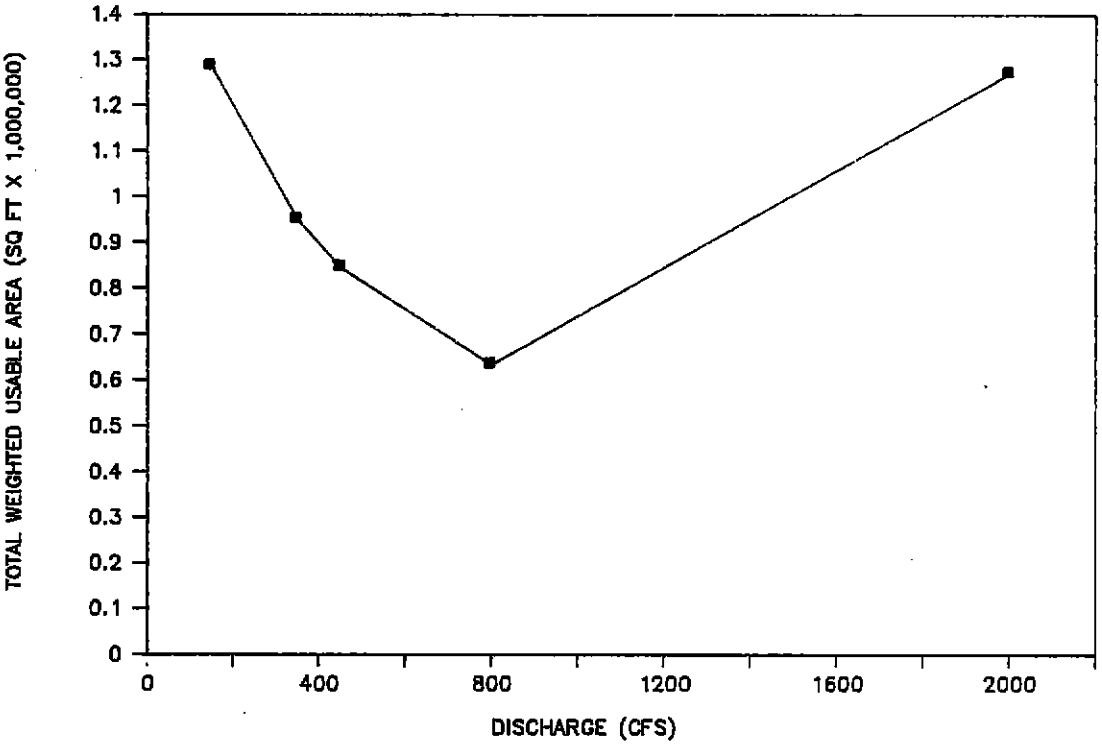


Figure 3. Weighted usable area for steelhead fry as a function of discharge between Lewiston and Douglas City in the Trinity River.

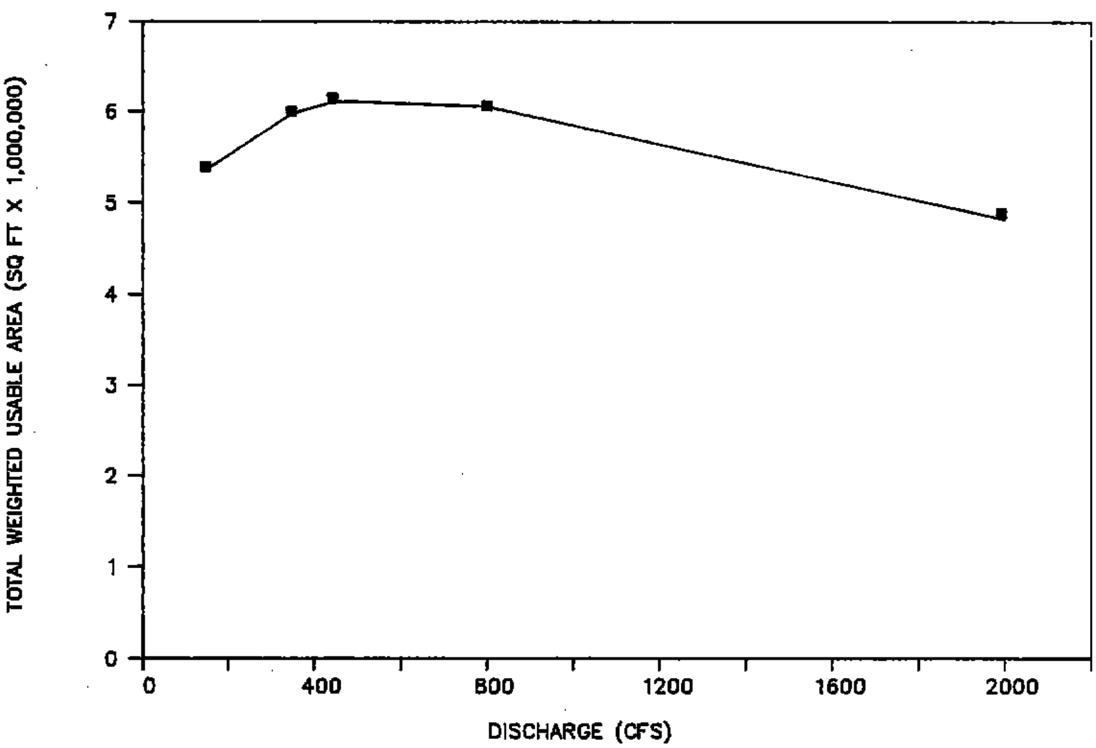


Figure 4. Weighted usable area for steelhead juveniles as a function of discharge between Lewiston and Douglas City on the Trinity River.

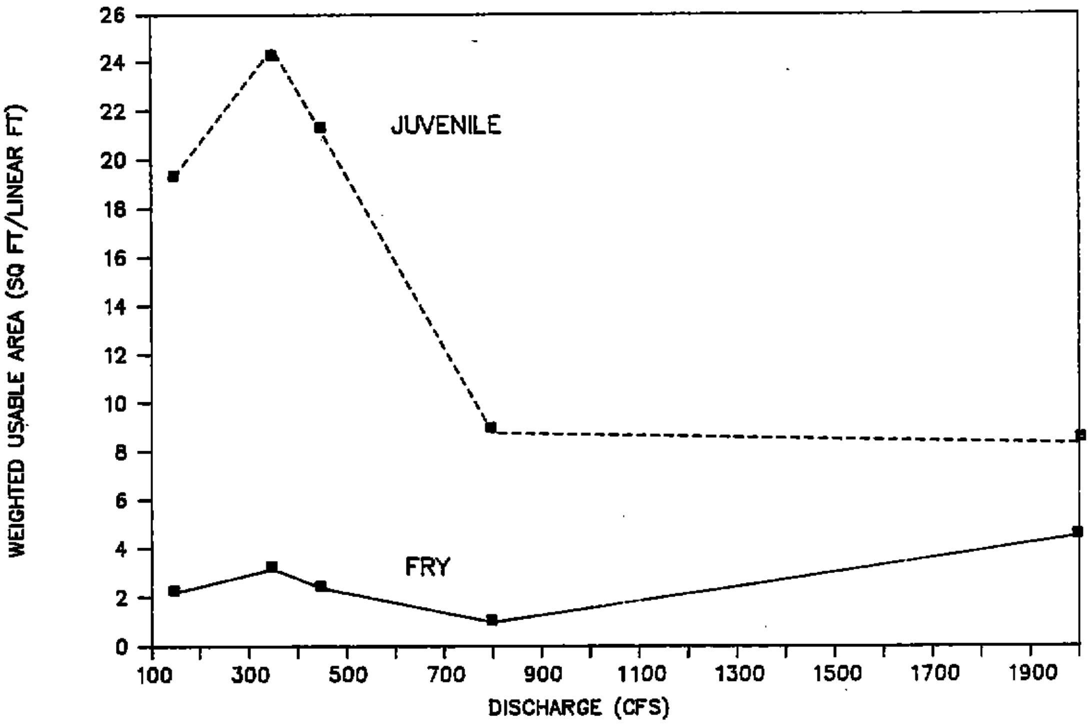


Figure 5. Weighted usable area for chinook fry and juveniles as a function of discharge in the Steiner Flat reach of the Trinity River.

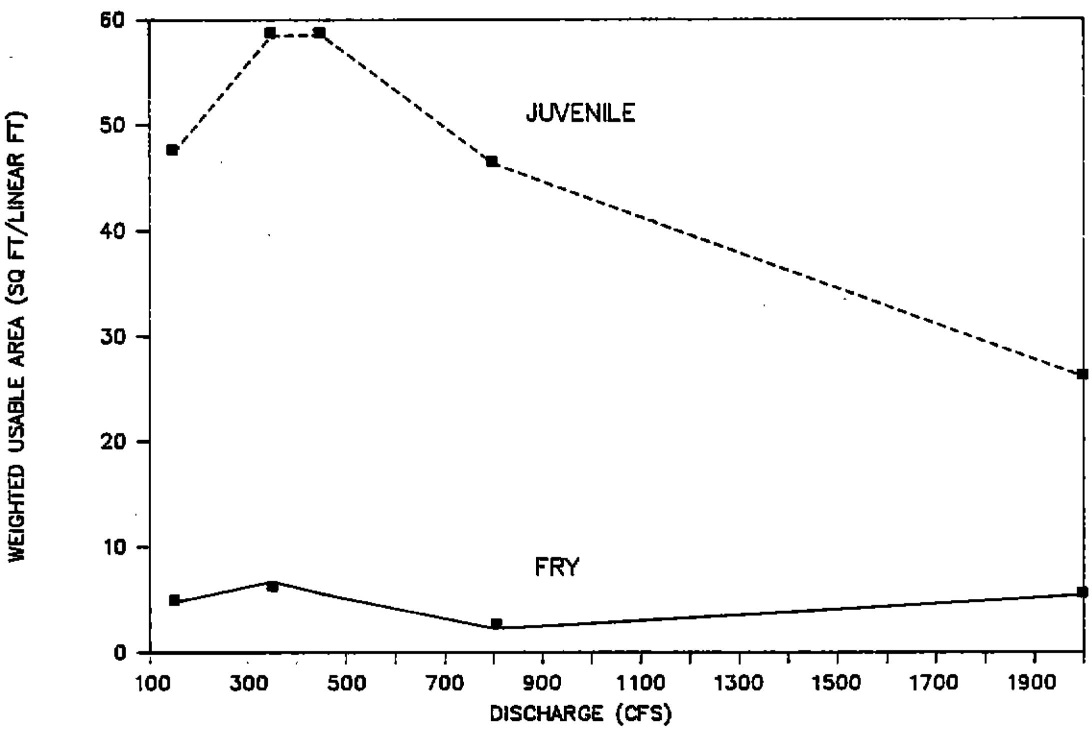


Figure 6. Weighted usable area for steelhead fry and juveniles as a function of discharge in the Steiner Flat reach of the Trinity River.

The addition of 150 cfs measurements for the four upper-river sites accentuates the bi-modal pattern for fry life-stages, with available slow-water WUA increasing with decreasing flows. The patterns for juvenile life-stages also extend in a consistent pattern, juvenile chinook WUA continuing to increase with decreasing flows and juvenile steelhead WUA continuing to decrease with decreasing flows.

At the Steiner Flat site WUA for all life-stages decreases between the measured 350 and 150 cfs flows.

Discussion

The measurement at low flow in the upper river provided no surprises, since the PHABSIM hydraulic programs gave similar results when measured conditions were projected downward.

The major difference between measured WUA and low-flow WUA that we have estimated by hydraulic modeling is that generally the direct measurements show more WUA than is estimated by modeling. This is probably because most of the best fish habitat is in slower water at the edges of the river. The IFG-4 hydraulic model seems to tend to overestimate lower-flow edge velocities unless adjustments are made to account for shifting the high-friction area at the river's edge.

The decrease in WUA for all life-stages at Steiner Flat seems to be the result of a substantial decrease in surface area at gently-sloping backwater margins, coupled with insubstantial increases in slow water with reduced flow through much of this relatively steep and predominantly narrow reach.

WINTER STEELHEAD HABITAT AVAILABILITY

During field-work in the winter of 1985-86, we noted that once the water temperature dropped below about 48 degrees Fahrenheit steelhead juveniles retreat to spaces between cobbles on the river-bottom, and are not seen swimming in the day-time. Subsequent winter electrofishing revealed dense populations of steelhead in side-channels and mainstem areas where the substrate was composed of clean cobbles with little sand. Since these conditions are extremely rare in the Trinity River, we concluded that availability of winter habitat may be an important factor limiting steelhead production.

In 1986 and 1987 we conducted studies of habitat for over-wintering salmonids, and in our 1988 annual report we presented winter habitat use curves for steelhead and brown trout, and coho salmon. For steelhead, by far the most important criterion for habitat utilization is the presence of cobbles from six to twelve inches in diameter free of sand or silt.

This report section presents results of applying the steelhead winter use curves to upper-river conditions.

Methods

To analyze the available habitat provided by the upper Trinity for over-wintering steelhead, we used the microhabitat data collected from 1985 to 1990 in our IFIM studies (Section II.1). Weighted usable area (WUA) was calculated at our five upper-river sites: Cemetery, Bucktail, Poker Bar, Steelbridge, and Steiner Flat.

In addition to calculating steelhead winter WUA based on existing conditions, including depth, velocity, and substrate, we calculated it based on depth, velocity, and substrate without the embeddedness component. To achieve this we simply prepared a utilization curve with the effects of embeddedness removed. This gives an estimate of habitat gains that would be realized if the decomposed granite sand that has accumulated in cobble substrates were removed.

Results

Figure 1 shows the winter WUA at 350 cfs at our five upper sites for existing conditions and with sand removed. It also shows existing WUA for free-swimming juvenile chinook.

A comparison between existing overwinter habitat and potential increases with clean substrate shows that winter WUA would increase in the Cemetery reach by about 750 percent, Bucktail by 820 percent, Poker Bar and Steelbridge by about 2000 percent each, and Steiner Flat by about 300 percent.

Figure 2 shows the same WUA normalized by rough estimates of the densities of steelhead that each type of habitat might support. Existing and potential winter WUA is multiplied by 0.1124 fish/ft^2 (1.21/m^2), based on densities at clean-cobble sites we studied in 1987 (USFWS 1988, page 36). Available rearing WUA is multiplied by 0.0357 fish/ft^2, based on a radius of three feet,

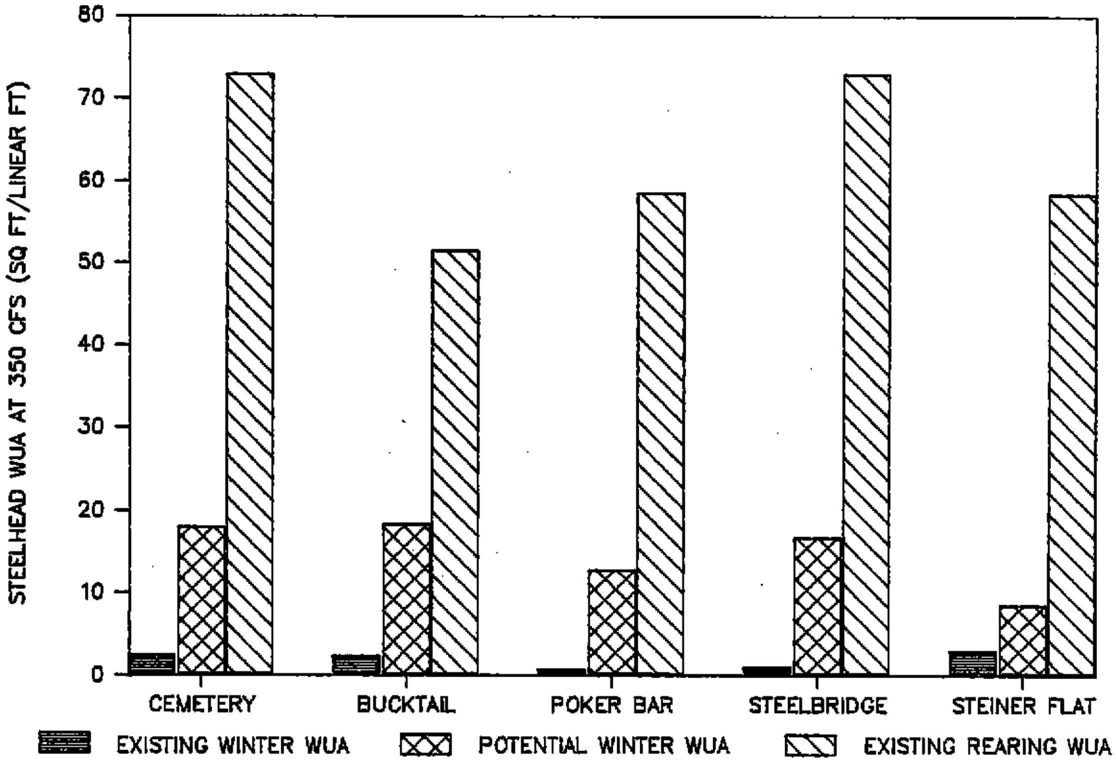


Figure 1. Weighted usable area for existing steelhead overwintering habitat, overwintering habitat with all sand removed, and existing spring–through–fall steelhead rearing habitat at five study sites in the Trinity River, 1990.

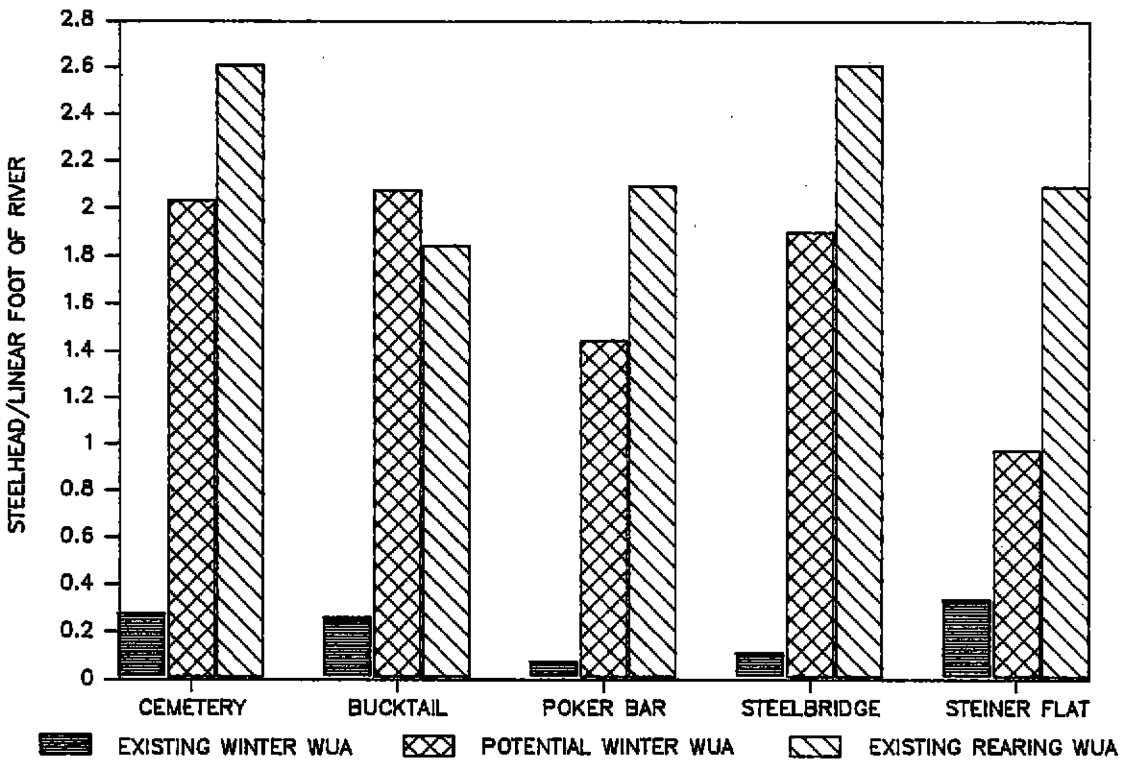


Figure 2. Estimated juvenile steelhead per linear foot of river permitted by existing and potential winter habitat and by existing rearing habitat. Based on 0.1124 fish/sq. ft. of winter WUA and 0.0357 fish/sq. ft. of rearing WUA.

equivalent to the maximum distance traveled by most fish from feeding stations during our adjacent-velocity habitat studies (USWFS 1989, page 75).

If the estimated densities are roughly correct, the presence of interstitial sand in upper-river cobble substrates is clearly limiting overall habitat for juvenile steelhead. The numbers of juveniles that could be accommodated by existing spring-through-fall conditions cannot be supported over the winter.

Discussion

In the past, in-river projects for sand removal have generally been justified on the basis of improved spawning conditions and provision of resting pools for adult fish, though neither habitat type appears to be in critically short supply. Evaluation of winter habitat availability, however, indicates that the major direct benefit of sand reduction would be in improving steelhead winter survival.

Although pool dredging will have a secondary effect by removing stored sand that could later cover down-river cobbles, a more immediate improvement in the fishery would be realized by directly cleaning sand from cobbles, perhaps by suction dredging appropriate substrates and returning cleaned rocks to the river.

As recommended in Sections II.3 and II.4 of this report, dredged cobbles should be replaced after any pool-dredging operation, and clean cobbles should be placed or replaced in any constructed side-channel.

Provision of high flows to scour substrates and remove sand may be the most effective means of improving steelhead winter habitat. We are currently funding a cooperative agreement with the University of California and the Johns Hopkins University to determine the sand-transport effects of higher Lewiston releases in the upper river. An element of this study, which is scheduled for completion in 1993, is an analysis of the extent to which higher flows are capable of removing sand from cobble substrates.

HABITAT AVAILABILITY IN CONSTRUCTED SIDE-CHANNELS

INTRODUCTION

During 1989 we evaluated salmonid rearing habitat in four side-channels using the Instream Flow Incremental Methodology (USFWS 1989). The construction of these side-channels, by the Trinity River Restoration Program (TRRP) and Bureau of Land Management, created 10,461 ft^2 and 37,514 ft^2 of weighted usable area (WUA) for fry and juvenile chinook salmon respectively. Although rearing habitat along the upper Trinity River was increased by construction of these side-channels, some habitat types within them provided very little additional habitat. For example, channelized habitat sections in the Cemetery and Rush Creek side-channels created far less rearing habitat then was believed possible. The narrow trapezoidal channel morphology in these sections confined available rearing habitat to the extreme edges.

To increase rearing habitat in these channelized sections we recommended the following: 1) Create meanders in the channel to decrease the longitudinal slope and increase channel length. 2) Feather back the steep banks of the channel to a gradual slope. 3) Place cobbles and boulders throughout the channel to increase over-wintering habitat for juvenile steelhead trout. In faster velocity areas construction of cobble and boulder clusters and wing deflectors would also create slow backwater and pocket water microhabitats where young salmonids can feed more efficiently. These habitat improvement measures will improve salmonid rearing habitat by reducing water velocities, increasing wetted surface areas, and increasing habitat diversity.

Based on these recommendations, the Trinity River Restoration Program modified channelized sections of the Cemetery side-channel. Through a coordinated effort with the Trinity River Restoration Program we are evaluating the effectiveness of these habitat manipulations. As a result, a second IFIM study was conducted in the Cemetery side-channel in the spring of 1990. Concurrently, Trinity River Restoration Program staff continued to monitor fry and juvenile salmonid populations within the channel.

In the late summer of 1989 the Trinity River Restoration Program constructed a new side-channel at river mile 107 along the left bank at Salt Flat Road. Design of this side-channel included several different habitat types creating a large degree of diversity. Since construction of this side-channel incorporated many of the lessons learned from constructing the earlier pilot side-channels, we decided to conduct a more intensive habitat and fish use investigation. Our goals were to: 1) Develop a WUA habitat flow relationship, 2) Establish a relationship between habitat WUA and fry and juvenile chinook salmon standing crops in each habitat type, and 3) Test the accuracy of IFIM habitat estimates in two available habitat types.

STUDY SITES

Cemetery Side-Channel

In our 1989 side-channel evaluation habitat types within the Cemetery side-channel were described as run, riffle, and channelized. Five IFIM transects were established to represent available rearing habitat, two in the run, one in the riffle, and two in the channelized habitat. Habitat modifications in 1989 replaced the channelized habitat with two new habitat types described as feathered bar and pocket backwater. In the Spring of 1990 we established six new IFIM transects in order to evaluate the habitat manipulations that were made in the channelized section and measure any gradual habitat changes that may have occurred in the run and riffle habitats during high flows.

Transects one, two and three were randomly established in the run and riffle habitats located in the upper half of the side-channel. Transects four, five and six were placed in the feathered bar and pocket backwater habitats that were created where the channelized habitat formerly existed. Transect four was placed across a feathered bar and transects five and six were placed below cobble wing deflectors across pocket backwater habitat. The WUA habitat predictions from these transects would then be compared to the habitat predictions for Cemetery side-channel in our 1989 evaluation.

Salt Flat Side-Channel

The Salt Flat side-channel has a total length of 1620 feet. In coordination with the Trinity River Restoration Program we identified eight habitat types. They are: 1) Wooded Run, 2) Pool, 3) Run, 4) High Gradient Riffle, 5) Riffle/Backwater, 6) Backwater, 7) Low Gradient Riffle, and 8) Pond. IFIM transects were placed in six of the habitat types excluding the backwater and pond habitat types, because zero water velocities dominated these two habitats reducing the effectiveness of IFIM as an evaluation tool. Each IFIM transect was randomly placed within Trinity River Restoration Program fish sampling sites, which were also randomly selected, for each habitat type evaluated.

In the run and low gradient riffle habitats we conducted a more intensive IFIM analysis. In each of these habitats ten IFIM transects were randomly selected. This was done to compare habitat WUA predictions among transects and to check the reliability of WUA predictions in two habitat types. The run and riffle habitats were selected because they exemplified different depth and velocity profiles. The run habitat contains monotypic depth and velocity patterns across the profile, while the riffle habitat contains a great deal of variation in depths and velocities across the profile.

METHODS

Salmonid habitat estimates were made for the Cemetery and Salt Flat side-channels using the U.S. Fish & Wildlife Service's, Instream Flow Incremental Methodology (IFIM). Field data collection and computer simulations followed the procedures recommended by the U.S. Fish & Wildlife Service's, Aquatic Systems Branch of the National Ecology Research Center (Bovee, 1982; Bovee and Milhous, 1978; Milhous, Wegner, and Waddle, 1984; Trihey and Wegner, 1981).

Water surface elevations and transect profiles were measured with a spirit level and leveling rod from established benchmarks with an assumed elevation of 100.00 feet. Mean column water velocities and total depths were measured with a Price AA current meter, USGS current meter digitizers, and wading rod.

Hydraulic flow data was collected during Lewiston Dam releases of 600, 300, and 150 cfs. Side-channel discharges during these river flows equaled 24, 10, and 6 cfs in the Cemetery side-channel and 26, 12, and 6 cfs in the Salt Flat side-channel respectively. Because of the critical dry water year designation, later revised to dry, we were not able to collect hydraulic flow data at higher flows as was done in 1989. Therefore, the habitat predictions and comparisons presented in this report are limited to side-channel flows between 1 and 44 cfs. In order to compare habitat predictions, before and after habitat manipulation in the Cemetery side-channel, we used the same IFIM program options and side-channel discharges that were used in 1989.

Substrate and cover were described visually using the same techniques and codes as last years side-channel evaluation (USFWS 1989).

RESULTS AND DISCUSSION

Cemetery Side-Channel

Total side-channel WUA for fry and juvenile chinook and coho salmon and steelhead trout are presented in Figure 1. Transect profiles and WUA estimates per thousand linear feet for each species are presented in Figures 2 through 7.

WUA increased for all species and lifestages in 1990 following habitat manipulation work (Table 1). The largest habitat increase occurred for overwintering steelhead trout. Two habitat alterations, slower water velocities and improved cobble substrates, are responsible for the eleven-fold increase in this habitat. Although several cobbles were manually placed within

Table 1. Total Weighted Usable Area and the ratio of habitat gain for each species and lifestage in the Cemetery Side-channel before (1989) and after (1990) habitat manipulation work. Side-channel flow equals 24 cfs.

Species/Lifestage	1989	1990	Habitat Gain Ratio
Chinook Salmon			
Fry	451	2404	5.332
Juvenile	3123	11243	3.600
Coho Salmon			
Fry	114	595	5.196
Juvenile	293	1183	4.033
Steelhead Trout			
Fry	1420	6412	4.513
Juvenile	5869	11722	1.997
Over-Wintering	346	4065	11.748

the side-channel, winter habitat could still be improved dramatically by increasing the amount of cobble substrates to a depth of at least 12 inches. This would also benefit fry and juvenile chinook salmon by increasing cover

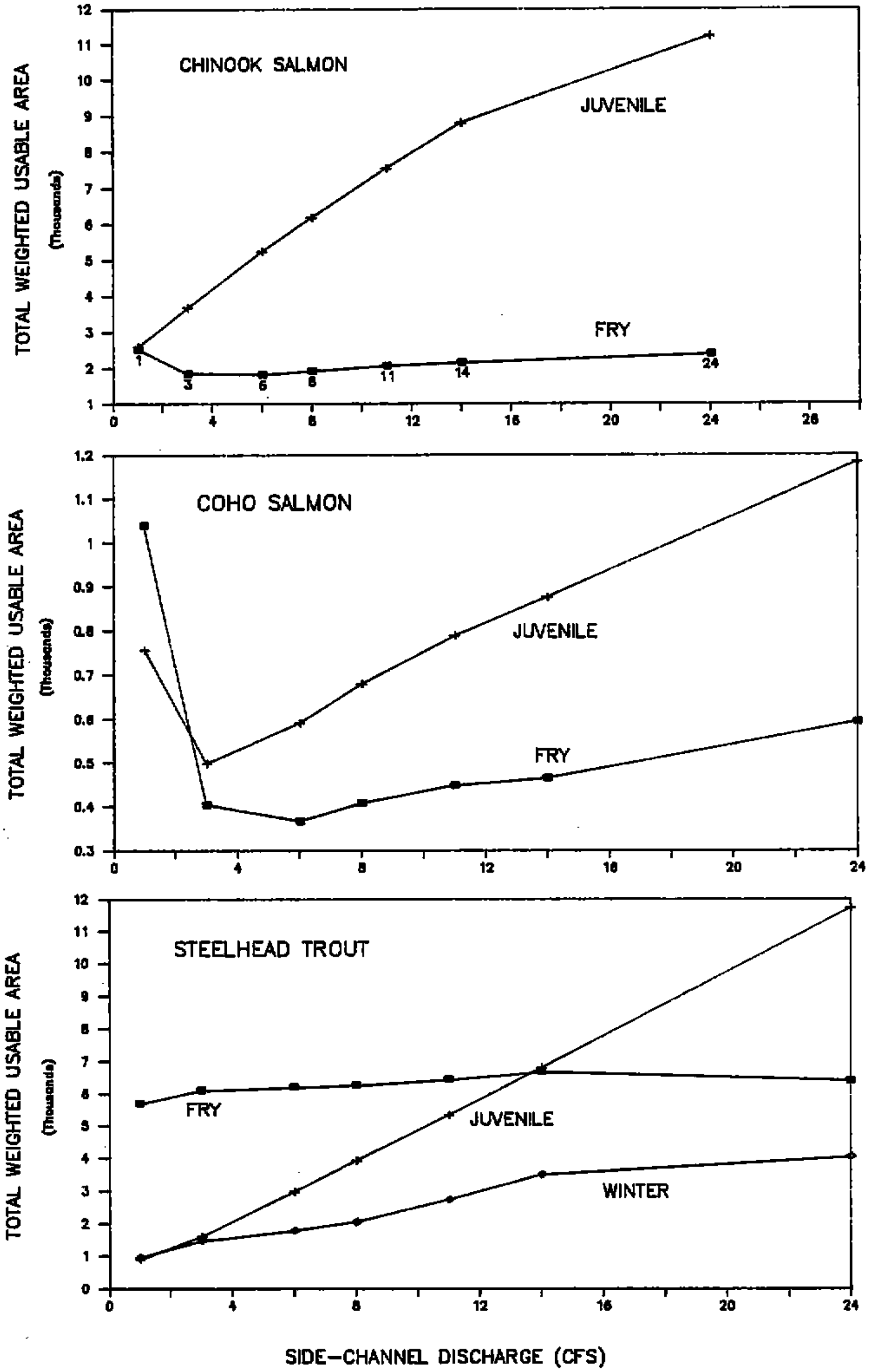


Figure 1. Total Weighted Usable Area for each species and lifestage in the Cemetery Side-Channel after habitat manipulations were completed.

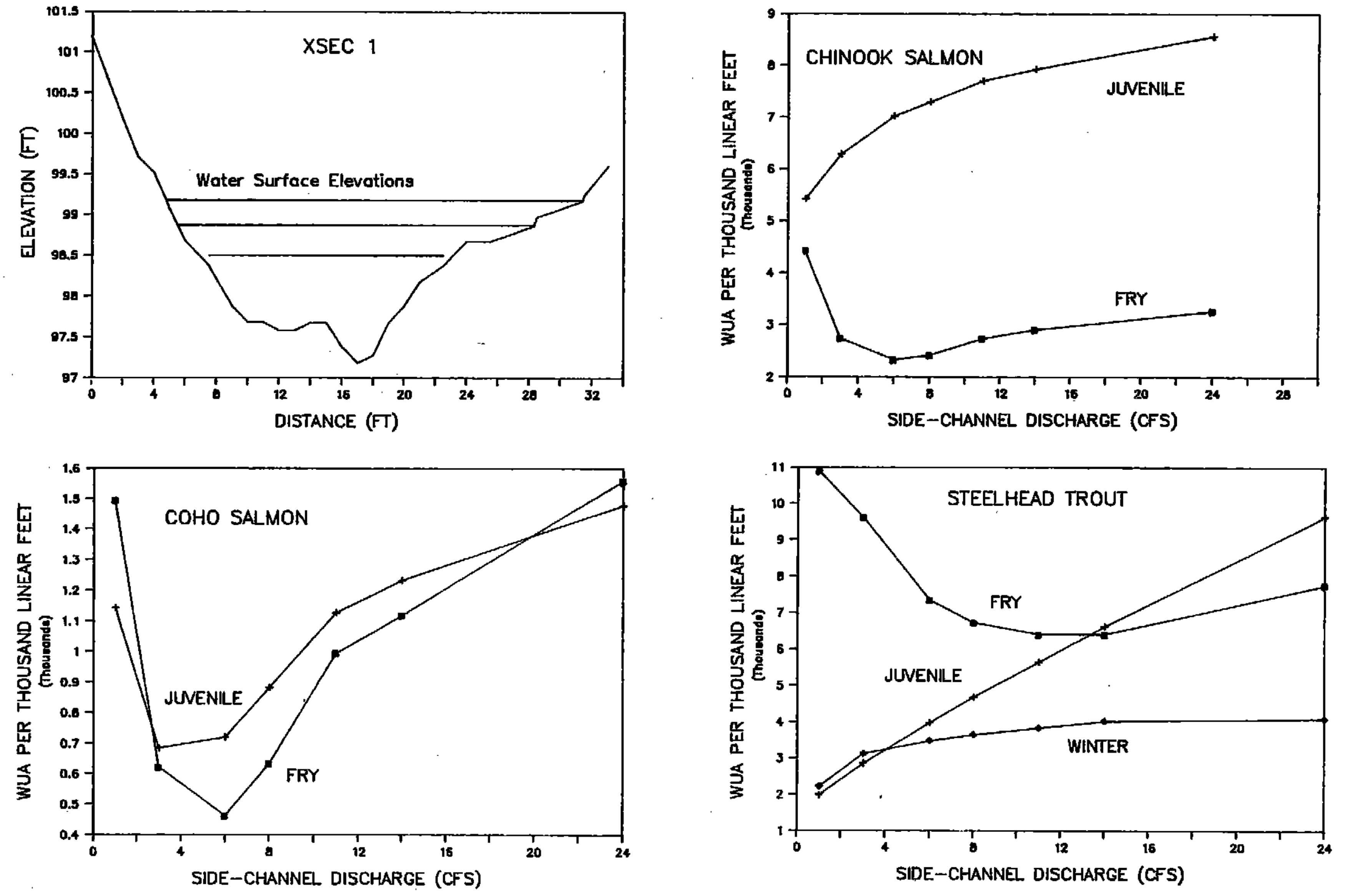


Figure 2. Cemetery side—channel transect 1 profile and WUA for fry and juvenile salmonids.

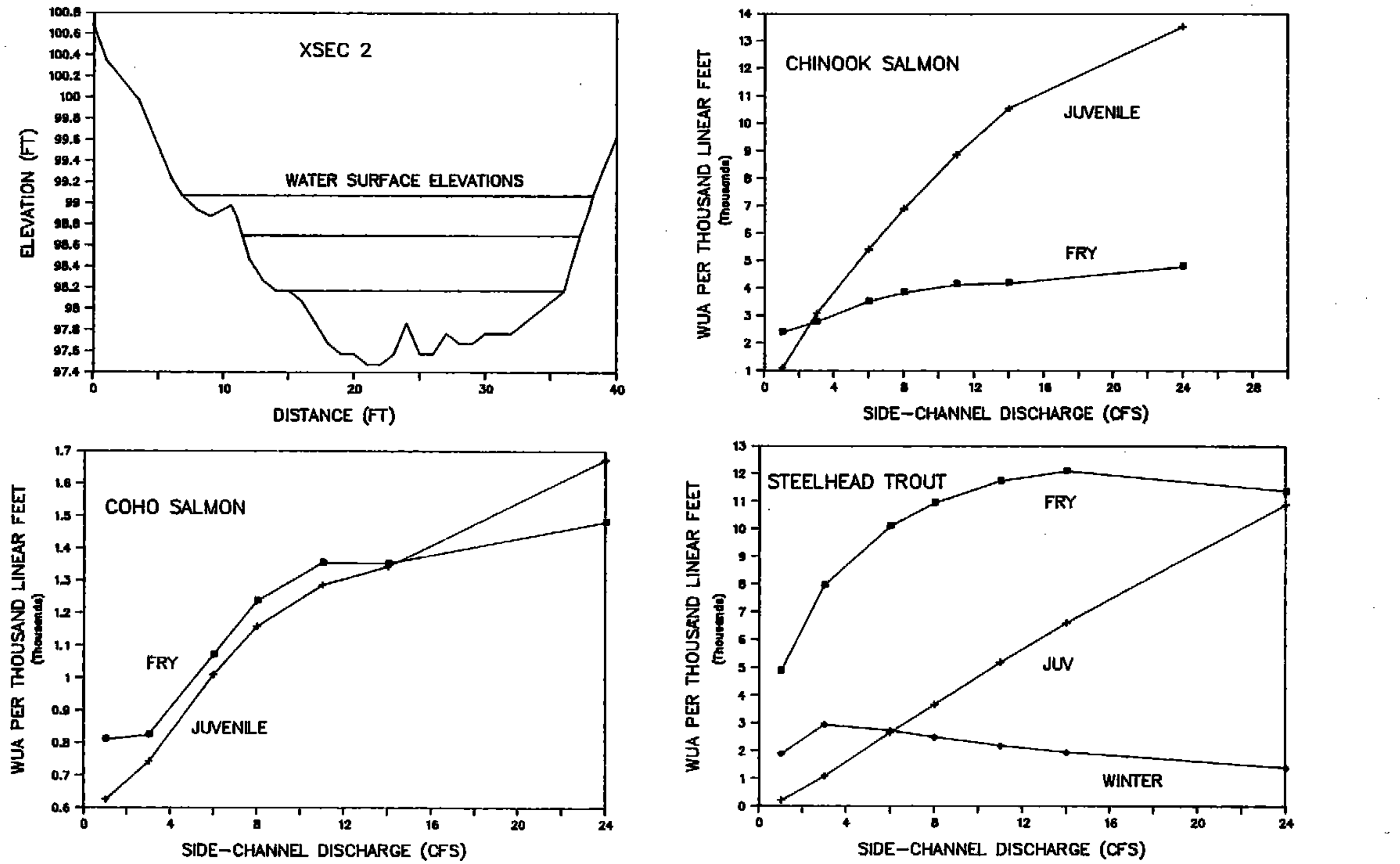


Figure 3. Cemetery side-channel transect 2 profile and WUA for fry and juvenile salmonids.

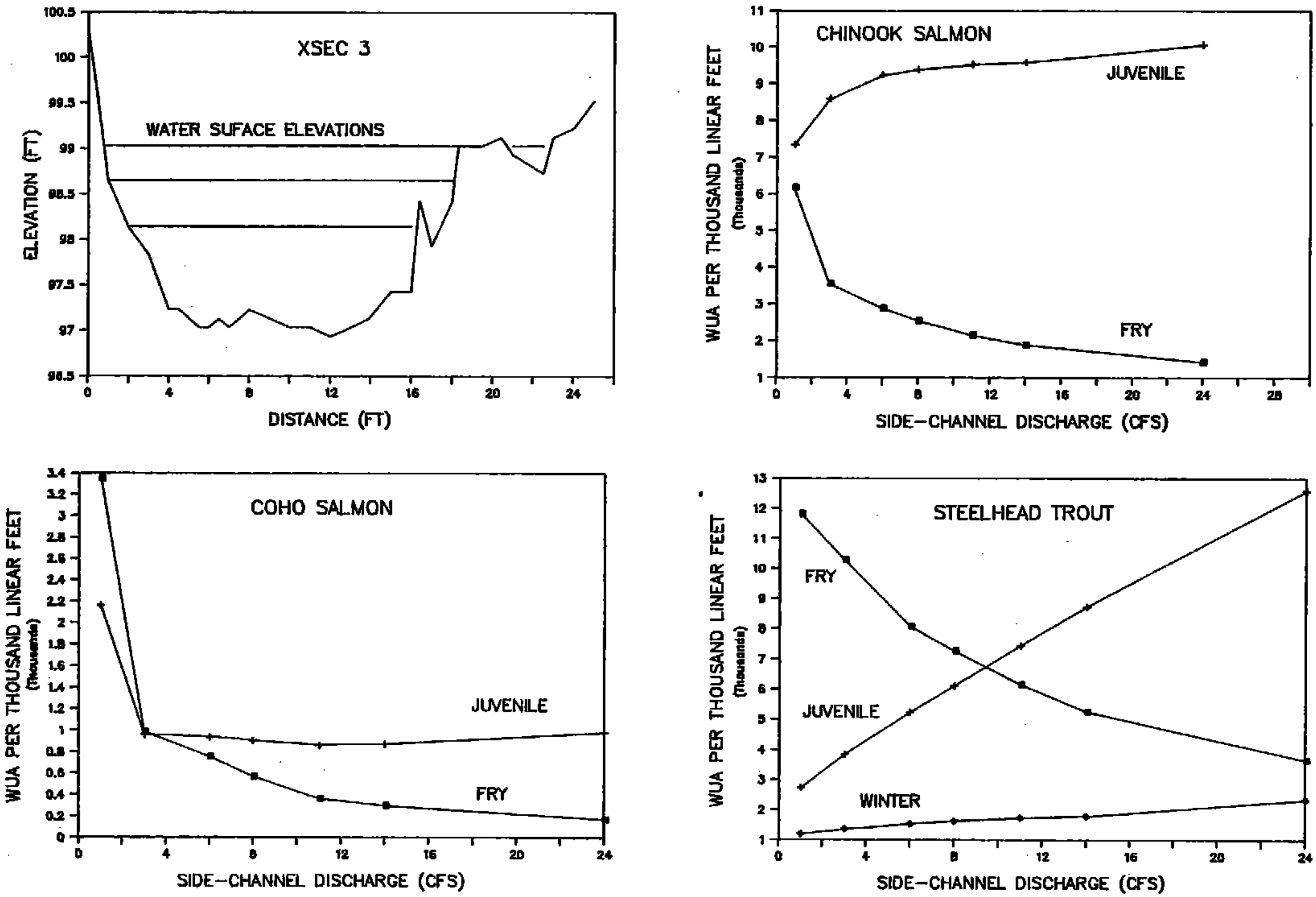


Figure 4. Cemetery side–channel transect 3 profile and WUA for fry and juvenile salmonids.

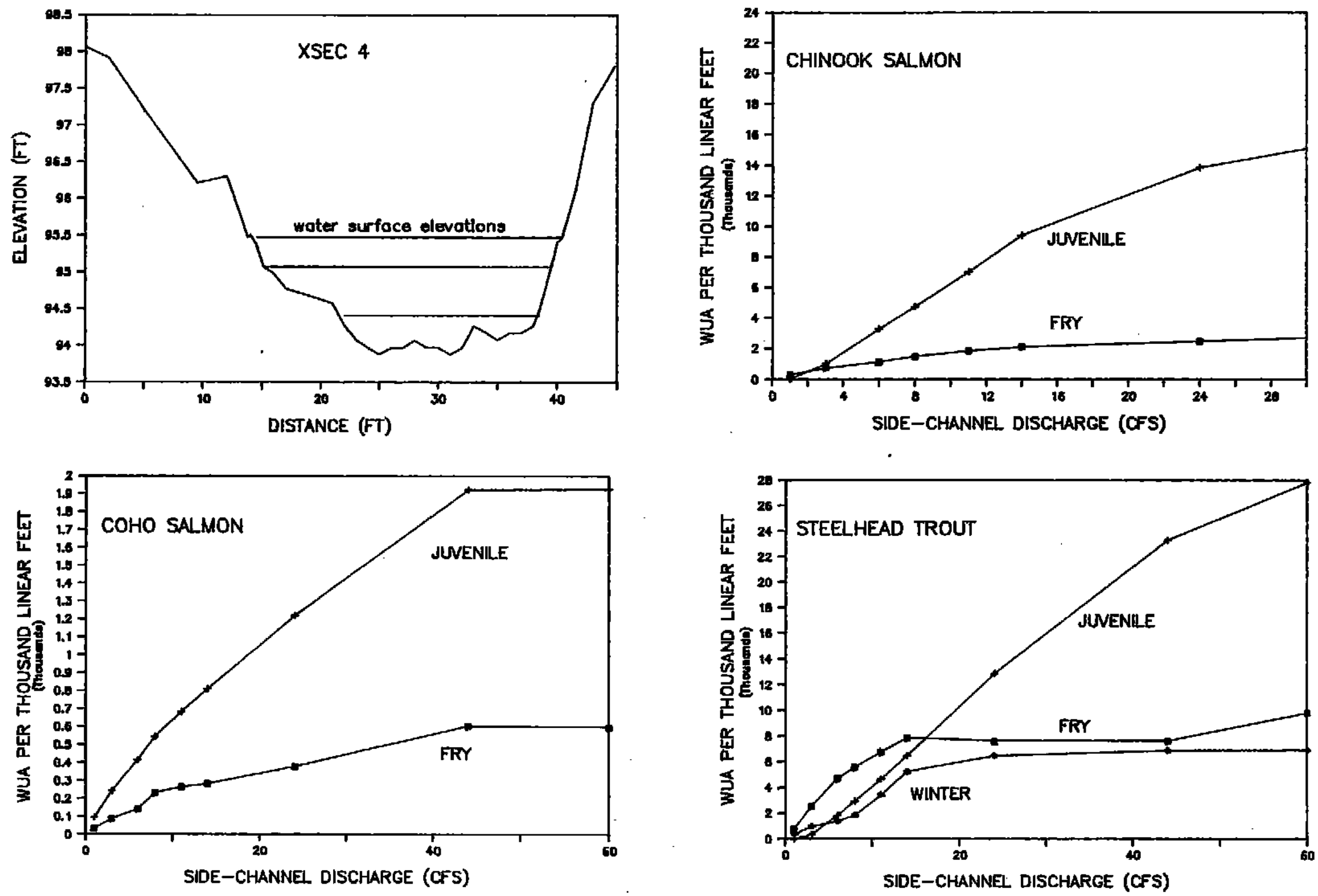


Figure 5. Cemetery side-channel transect 4 profile and WUA for fry and juvenile salmonids.

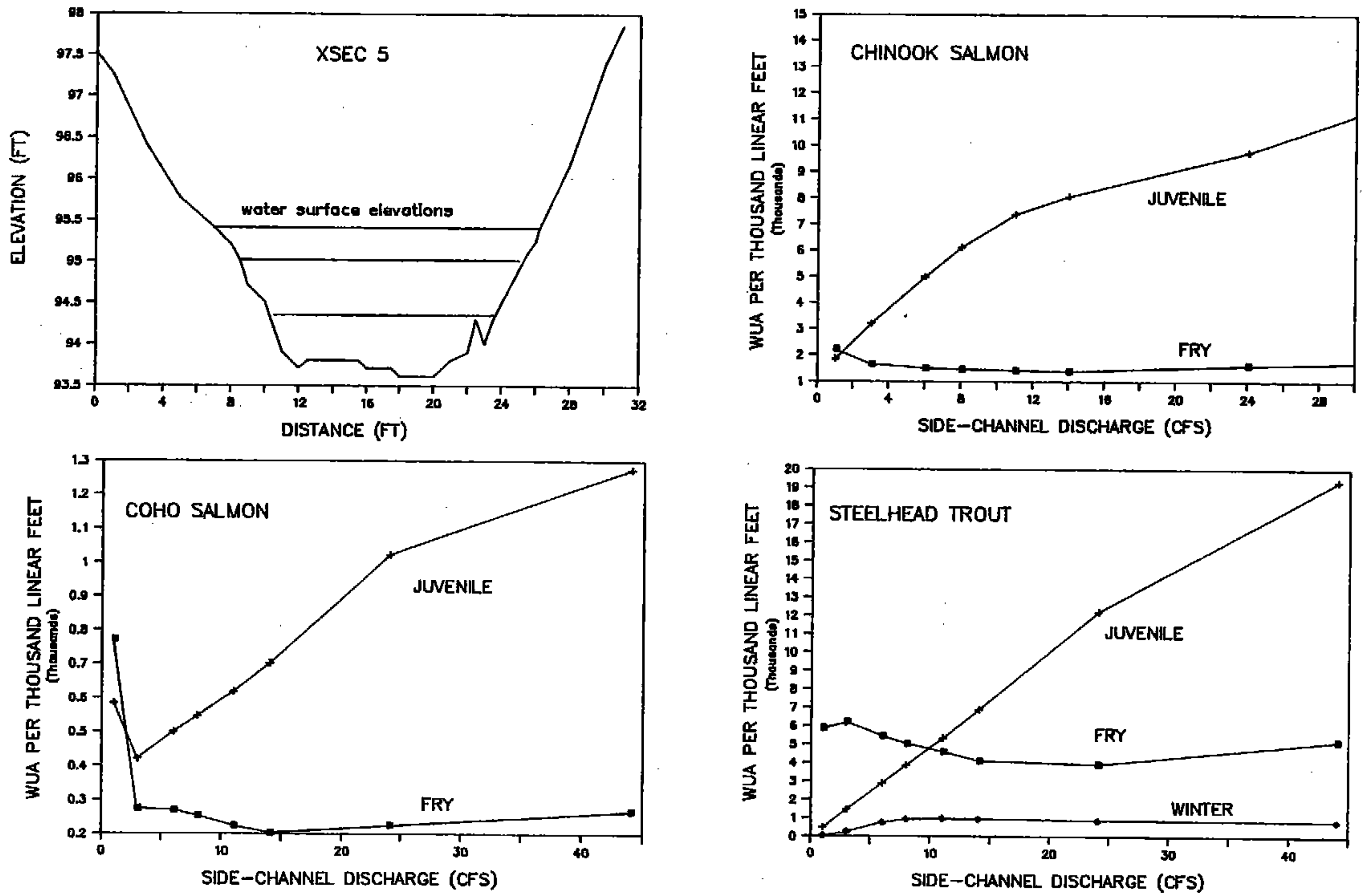


Figure 6. Cemetery side-channel transect 5 profile and WUA for fry and juvenile salmonids.

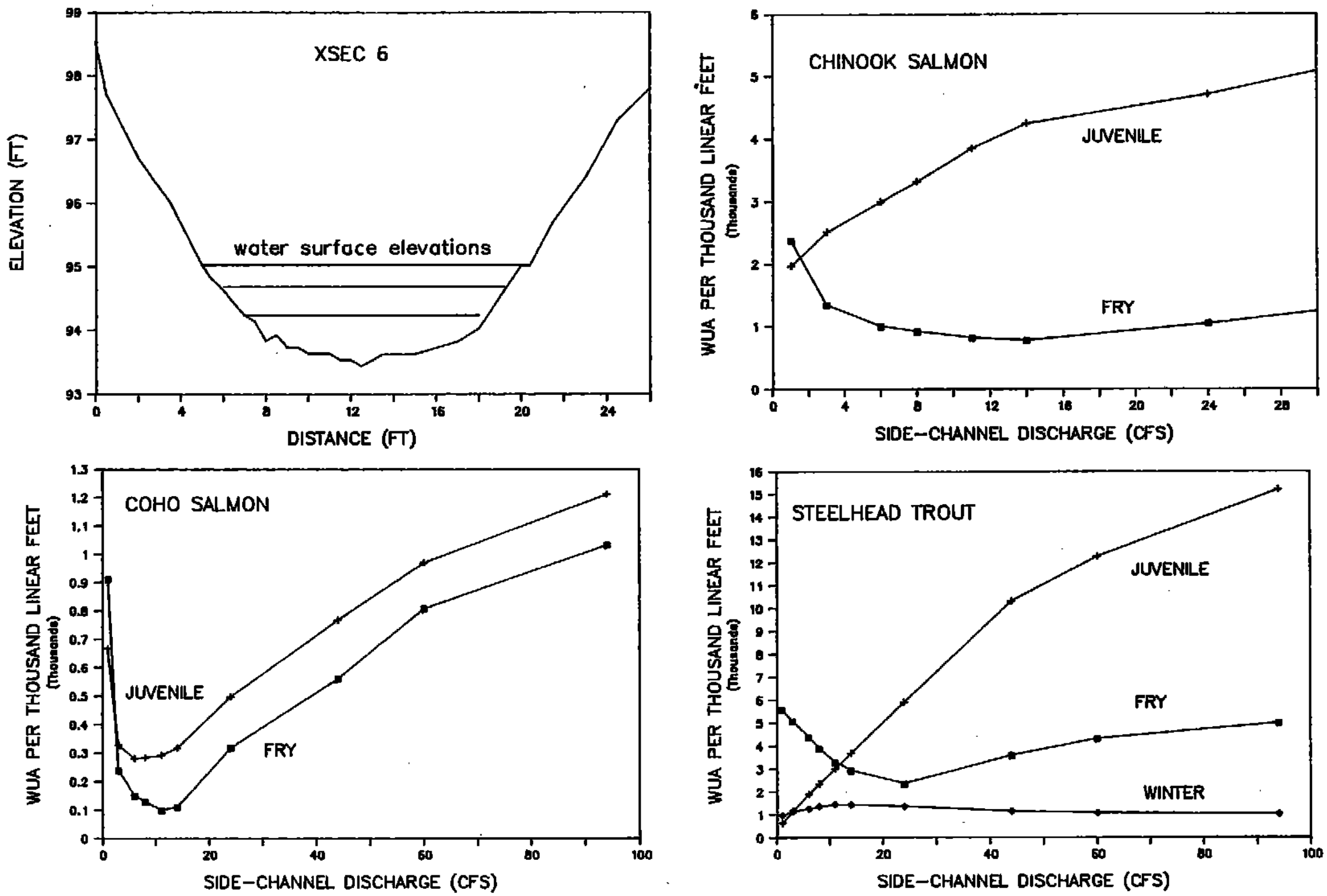


Figure 7. Cemetery side–channel transect 6 profile and WUA for fry and juvenile salmonids.

and bottom surface area for invertebrate production. During the construction phase for future side-channels we recommend use of a front loader and sieve to screen out cobble substrates for immediate placement in the channel.

The habitat modifications made in the channelized section of the side-channel account for the majority of the increased habitat observed in 1990 over 1989. Before the habitat alterations in the channelized section were completed, fry and juvenile chinook salmon habitat decreased with flow. However, since completion of the habitat manipulations fry and juvenile chinook salmon habitat increases with flow and provides substantial increases in total habitat (Figure 8). The feathered bar habitat, represented by transect 4, provides the greatest amount of rearing habitat for chinook salmon per thousand linear feet of side-channel. Construction of the feathered bar in the channelized section effectively doubled the channel width, dramatically increasing available surface area. These channel alterations also created slow water microhabitats more suitable for rearing chinook salmon. Because of the gradual bank slope, characteristic to the feathered bar, additional slow water microhabitats are created as side-channel flows increase thus increasing total available habitat.

Figures 9 and 10 compare fry and juvenile chinook salmon habitat estimates between channelized habitat in 1989 and feathered bar habitat in 1990. As is depicted in Figure 9, before habitat alterations were made in the channel fry chinook salmon habitat was limited to a narrow strip of slow water located along the side-channels edge. Construction of the feathered bar in the same channel created fry habitat across the entire channel width by slowing water velocities and greatly increasing available wetted area. Juvenile chinook salmon habitat responded in much the same way as fry habitat for like reasons.

Fish Population Estimates And Weighted Usable Area

As was done in 1989, the Trinity River Restoration Program again conducted salmonid population sampling within the run, riffle, and pocket backwater habitat reaches that were modeled using IFIM. The goal of this coordinated effort was to develop a relationship between WUA and fish density.

Fish population estimates were made by Trinity River Restoration Program biological staff. Data was gathered on a seasonal basis using multiple pass depletion methods with a backpack electrofisher in isolated habitat sample sites. Fish depletion data was analyzed using an unpublished microcomputer program written by Conner (1987). The program is based on a maximum weighted likelihood estimator as presented by Carle and Strub (1978) and Zippin (1958). Sample site population estimates were then extrapolated based on the total habitat length represented by each sample site.

Population estimates provided by the Trinity River Restoration Program staff are based on year class rather than forklength. This caused some problems because during habitat preference data collection, lifestages were separated by forklength, with fish less than or equal to 50 mm considered fry and fish greater 50 mm categorized as juveniles. To resolve this, Trinity River Restoration staff took subsamples each sample day to obtain forklength data for each species. By using the proportion of fry and juveniles captured in

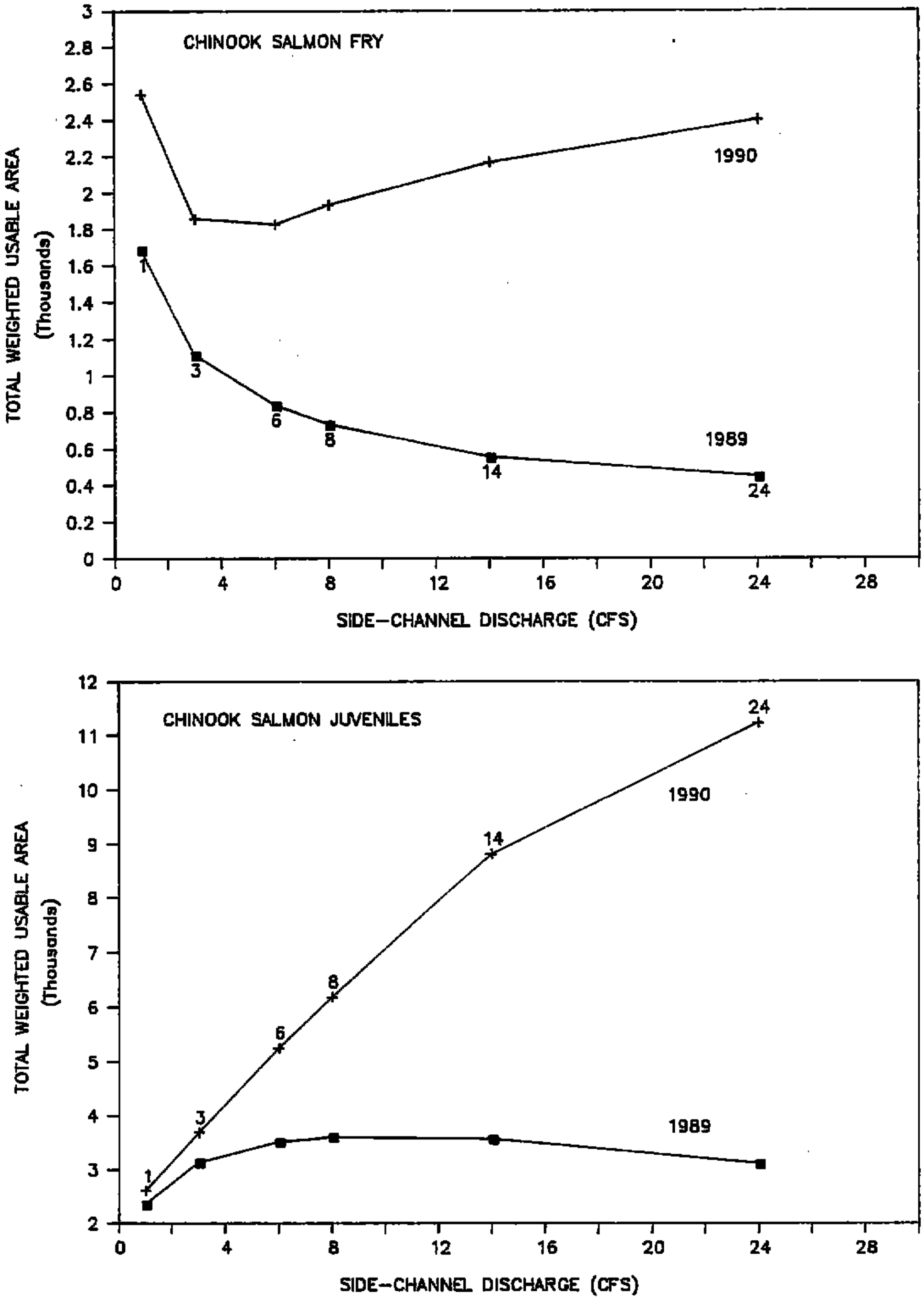
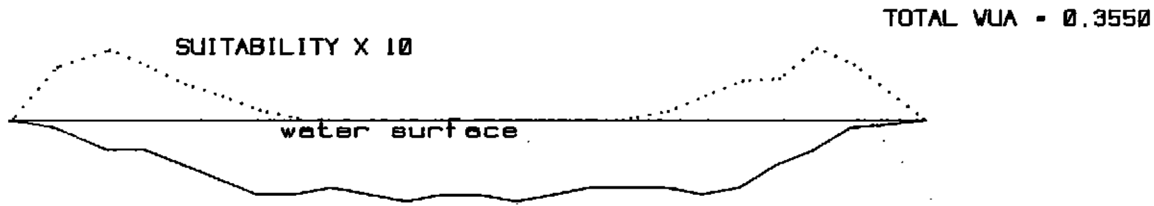
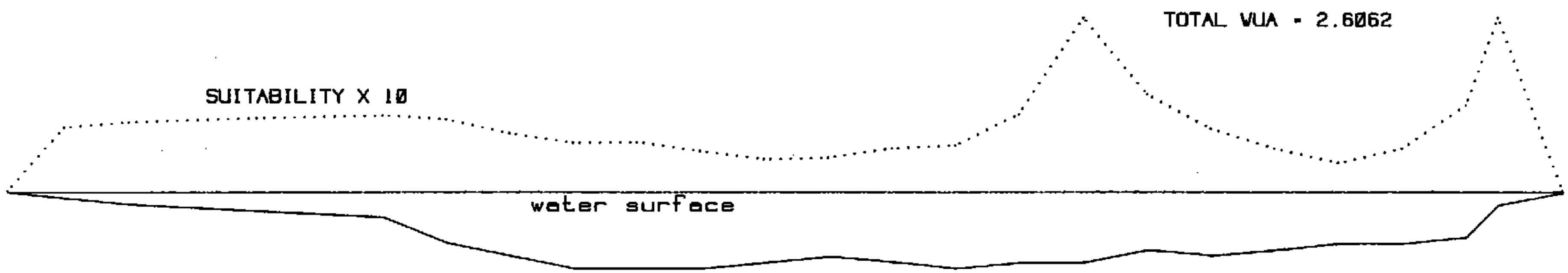


Figure 8. Total side-channel WUA before (1989) and after (1990) habitat manipulations.

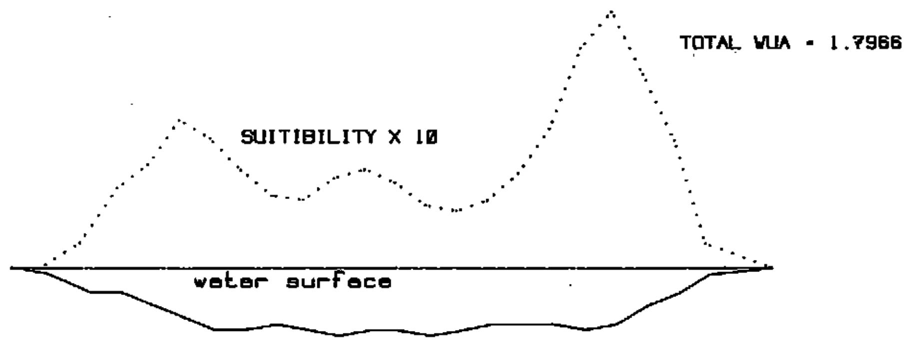


Profile of the channelized habitat and cell habitat suitability in 1989.

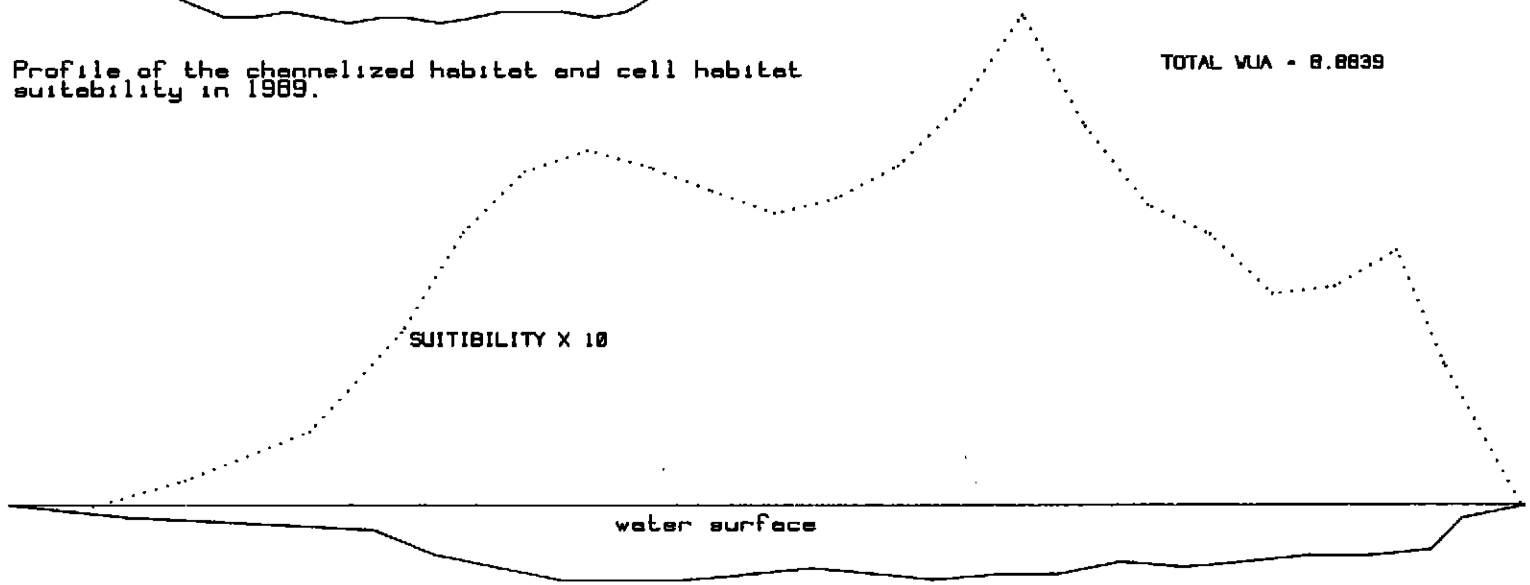


Profile of the feathered bank habitat and cell habitat suitability in 1990.

Figure 9. Comparison of fry chinook salmon habitat in the channelized habitat and feathered bank habitat created by habitat manipulation in the cemetery side-channel. Side-channel discharge equals 24 cfs.

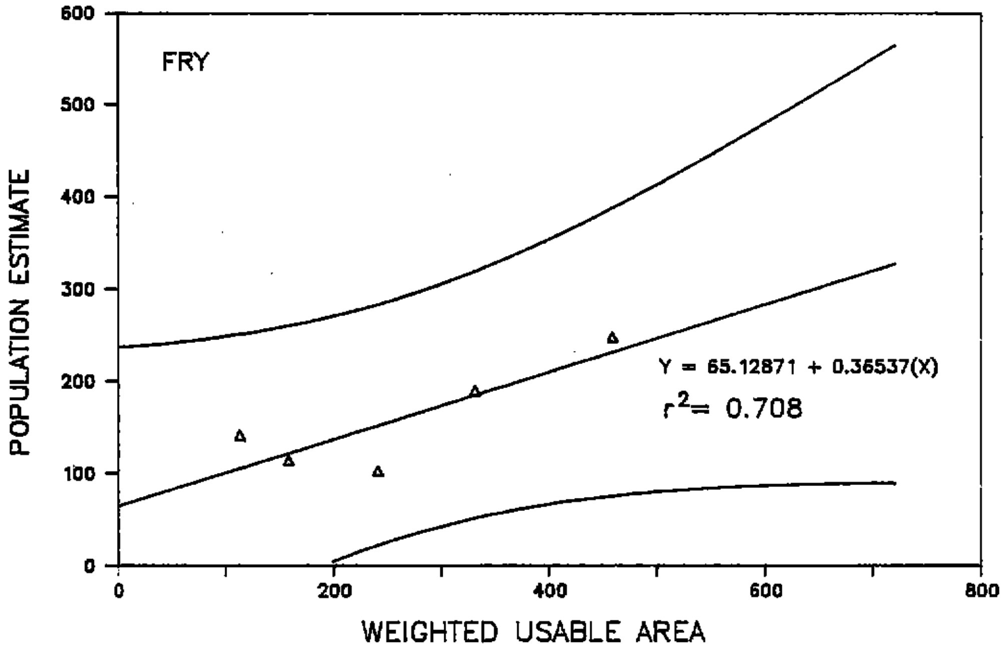


Profile of the channelized habitat and cell habitat suitability in 1989.



Profile of the feathered bank habitat and cell habitat suitability in 1990.

Figure 10. Comparison of juvenile chinook salmon habitat in the channelized habitat and feathered bank habitat created through physical habitat manipulation in the cemetery side-channel. Side-channel discharge equals 24 cfs.



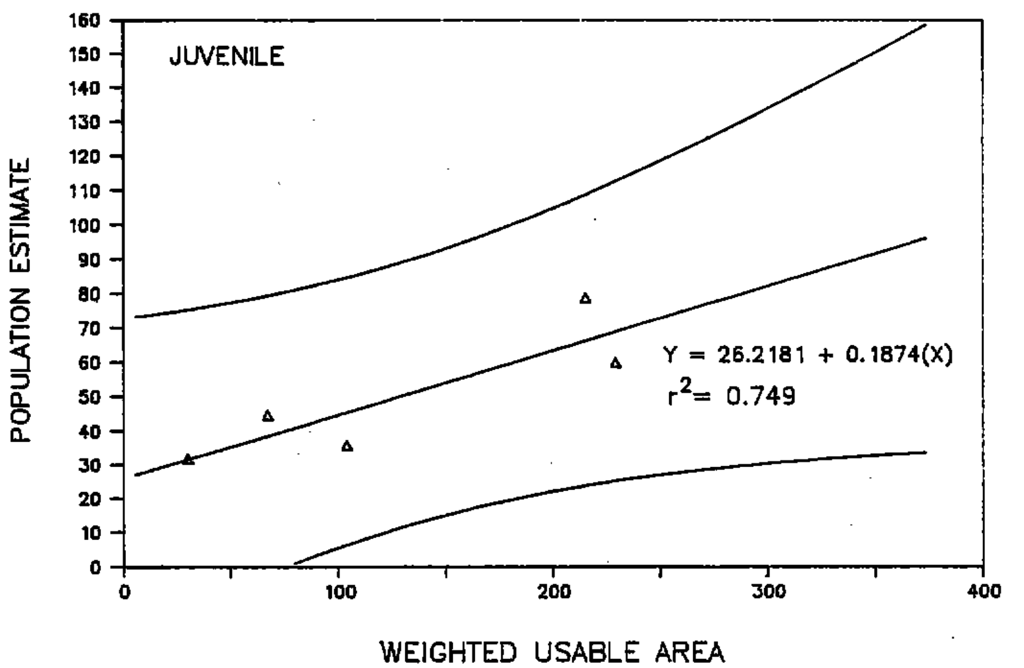


Figure 11. Regression analysis of chinook salmon WUA versus population estimates per habitat type in the cemetery side-channel.

each subsample as a correction factor for each total population estimate, we were able to estimate fry and juvenile populations. This assumed that fry and juvenile chinook salmon respond to each habitat type in the same proportion as the habitat type in which the subsample was taken. Estimated fry and juvenile chinook salmon populations for each habitat were then compared to WUA estimates for each habitat type (Table 2). A linear regression analysis between WUA and population estimates for both fry and juvenile chinook salmon is presented in Figure 11.

Table 2. Weighted Usable Area, estimated fry and juvenile chinook salmon population estimates, and Fish per WUA, for each habitat type sampled in the Cemetery Side-Channel, 1990.

Habitat Type	Fry Chinook WUA	Fry Chinook Pop.	Fry Ft.	Fry WUA	Juv. Chinook WUA	Juv. Chinook Pop.	Juv Ft.	Juv WUA
Slow Run	458	249	1.49	.54	215	79	0.47	.36
Riffle	241	103	1.78	.42	30	32	0.55	1.06
Run	331	191	1.23	.57	229	60	0.39	.26
Slow Wing Deflectors	158	115	1.03	.72	104	36	0.32	.34
Fast Wing Deflectors	113	143	1.04	1.26	67	45	0.33	.67

Habitat modifications to the Cemetery side-channel greatly improved rearing habitat for all salmonid species. Habitat modifications greatly improved rearing habitat with in the Cemetery side-channel. Compared to the habitat provided by high flows of 2,000 cfs in the mainstem Trinity River, however, the availability of habitat in the improved Cemetery side-channel is insignificant. In our estimation attempts to improve fry chinook salmon habitat under 300 cfs river flows to comparable levels provided by 2000 cfs river flows, through side-channel construction would require approximately 49 miles or 243 improved cemetery side-channels would be need to be constructed along the upper Trinity River.

Salt Flat Side-Channel

Total side-channel WUA for fry and juvenile chinook and coho salmon and steelhead trout are presented in Figure 12. Transect profiles and WUA estimates per thousand linear feet for each species and lifestage are presented in Figures 13 through 19. Construction of the Salt Flat side-channel created an additional 4574 ft^2 and 14823 ft^2 of WUA for fry and juvenile chinook salmon, 2202 ft^2 and 3300 ft^2 of WUA for fry and juvenile coho salmon, and 7604 ft^2, 11976 ft^2, and 1149 ft^2 of WUA for fry, juvenile and overwintering steelhead trout during a side-channel discharge of 12 cfs.

Table 3 compares habitat type population estimates to habitat WUA estimates during side-channel flows of 11 cfs. Calculated fish densities (fish/linear feet and fish/WUA) for each habitat type sampled are also presented in Table 3. Population estimates were not conducted for the backwater, pool, and pond habitats and the IFIM was not conducted in the backwater and pond habitats. Therefore, comparisons between population use and WUA for these three habitat

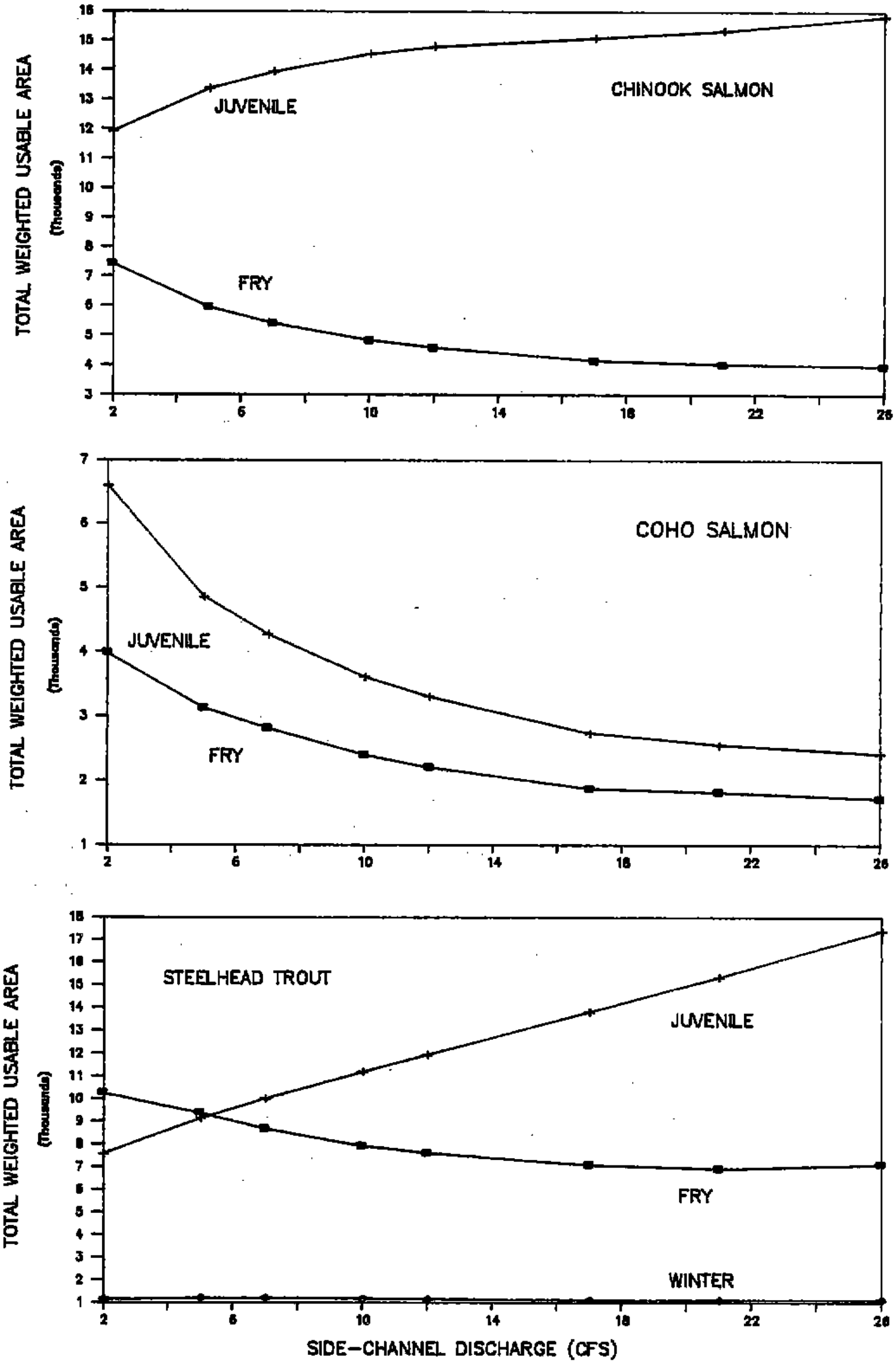


Figure 12. Total Weighted Usable Area for each species and lifestage in the Salt Flat Side-Channel.

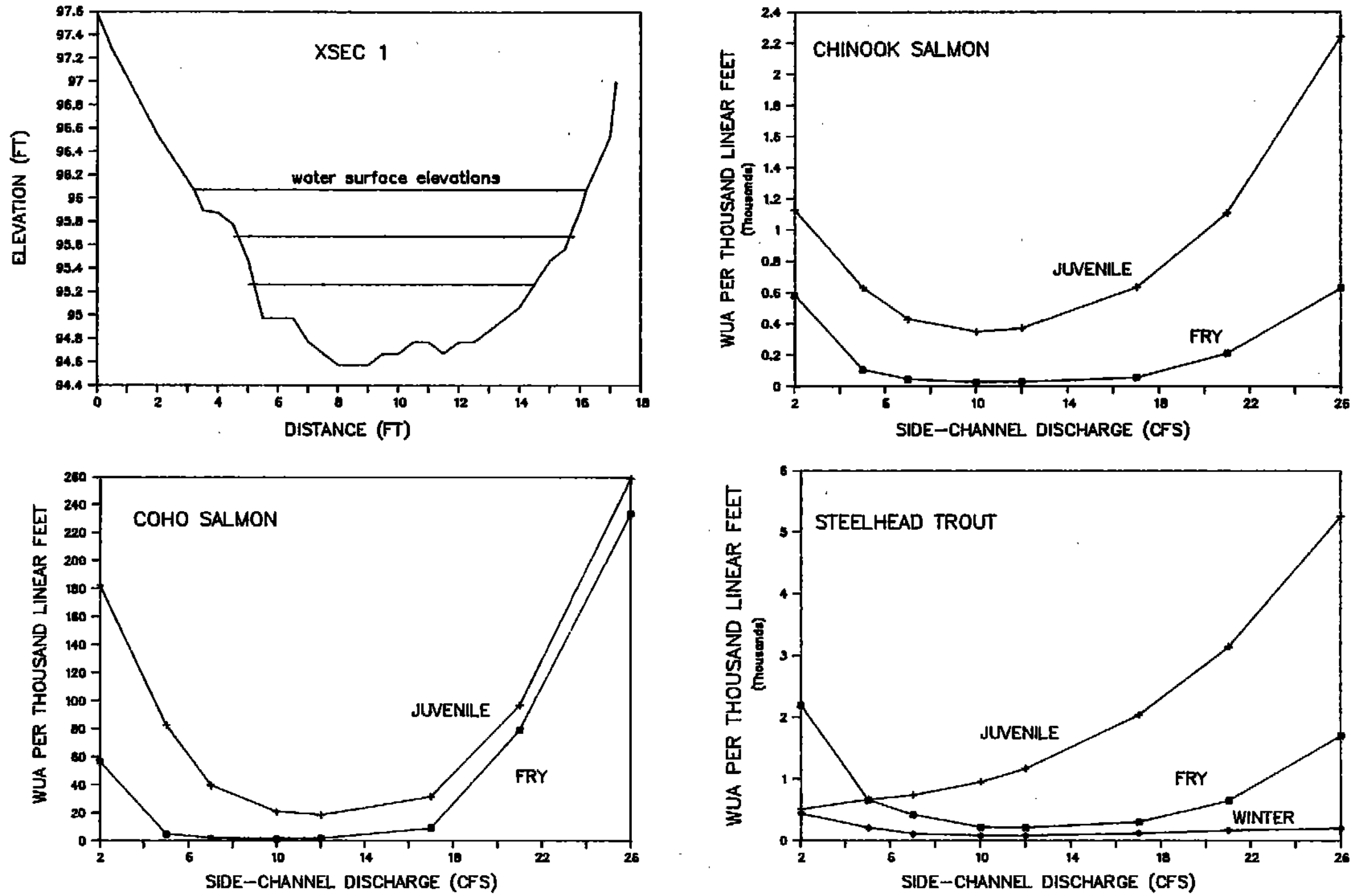


Figure 13. Salt Flat side-channel transect 1 (wooded run) profile and WUA for fry and juvenile salmonids.

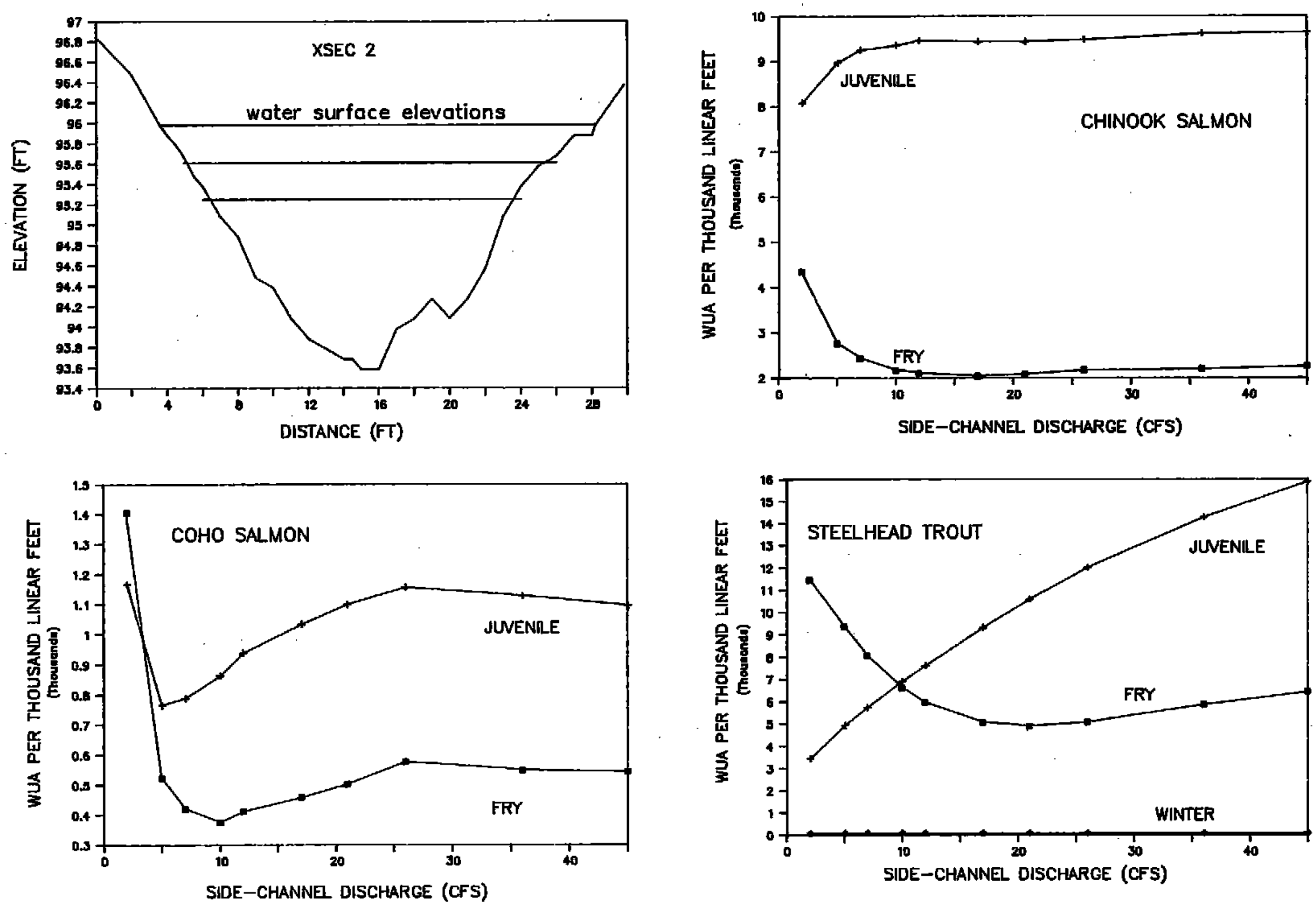


Figure 14. Salt Flat side-channel transect 2 (run) profile and WUA for fry juvenile salmonids.

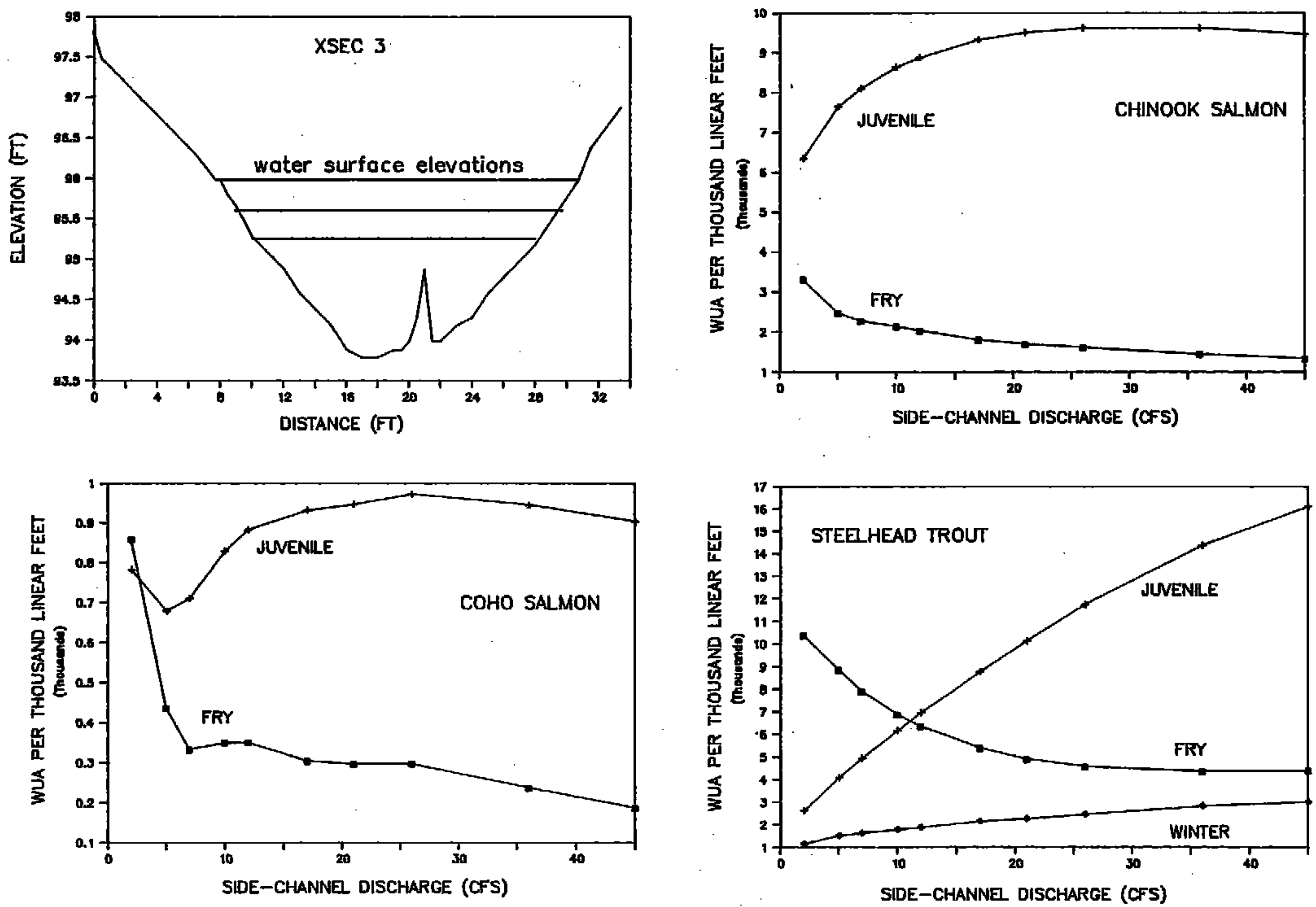


Figure 15. Salt Flat side-channel transect 3 (run) profile and WUA for fry and juvenile salmonids.

that are monotypic or contain very little diversity, reliable habitat estimates can be developed from one habitat transect.

Table 4. Total fry and juvenile chinook salmon WUA per linear foot of side-channel per transect in run and low gradient riffle habitat types located in the Salt Flat side-channel. Side-channel discharge = 12 cfs.

RUN HABITAT XSEC	WUA/Linear ft. FRY	JUVENILE	RIFFLE XSEC	WUA/Linear ft. FRY	JUVENILE
G-1	1.896	8.591	R-1	3.219	10.501
G-2	2.266	10.239	R-2	1.681	6.464
G-3	2.054	9.794	R-3	6.289	8.860
G-4	1.941	9.295	R-4	0.823	1.785
G-5	1.831	8.524	R-5	0.607	1.765
G-6	1.795	8.598	R-6	1.037	1.894
G-7	2.205	10.468	R-7	1.425	2.460
G-8	2.471	11.052	R-8	1.258	3.453
G-9	2.108	9.472	R-9	0.677	3.592
G-10	2.026	8.895	R-10	5.167	11.207
Mean	2.059	9.493		2.218	5.198
95% Confidence Limits					
lower	1.909	8.863		0.779	2.514
upper	2.210	10.123		6.289	7.883
Standard Deviation (s)	0.2107	0.8806		2.0116	3.7523
Variance (s^2)	0.0444	0.7755		4.0466	14.0796

Fry and juvenile chinook salmon WUA estimates exhibited a large degree of variation within the low gradient riffle habitat sampled. WUA estimates ranged between 0.607 and 6.289 WUA/linear feet for fry chinook and between 1.765 and 11.207 WUA/linear feet for juvenile chinook salmon. This variation in habitat estimates between riffle transects can be explained through examination of the physical characteristics of the habitat from which the hydraulic data was collected.

Water velocities across riffle habitats tend to be highly diverse and distributed in a patchy or random network. The presence of small islands, boulders, and cobble clusters create valuable microhabitats for rearing salmonids in the form of backwaters, shear zones, and pocket water. The water velocity habitat preference criteria that have been developed for rearing chinook salmon in the Trinity River have a steep slope that rapidly decreases the suitability factor as water velocities increase. Because of this fact, small changes in water velocity across transects can result in large differences in predicted WUA. Habitat transects that, during random placement, missed these slower velocity microhabitats resulted in significantly less WUA. It is evident that one transect alone, cannot accurately simulate WUA in habitat types containing diverse velocity profiles. This is particularly true when the target species lifestage for which you are estimating habitat WUA prefer a narrow range of water velocities and depths.

Some possible solutions that would possibly improve WUA habitat predictions in diverse habitat types include: 1) Further partitioning of diverse habitats into smaller microhabitats that are precisely defined, and 2) Increasing the number of random transects across diverse habitats in order to get an accurate estimate of the average habitat available along with a measure of and dispersion and confidence about the mean. One problem that may exist, with further partitioning of diverse macrohabitats into microhabitat types, is the fact that in many cases identified microhabitats undergo considerable change as flows change.

Another alternative would be to acknowledge the high degree of variation that is likely to occur in these diverse habitats from the outset. This may be a reasonable alternative if the habitat in question receives little use by the target species of concern, and/or the habitat comprises only a small percentage of the total habitat available. Unfortunately in the Salt Flat side-channel neither of these conditions were met. The low gradient riffle habitat comprised 23% percent of total habitat available in the side-channel and contained the highest population of fry chinook salmon compared to the other habitats sampled.

EVALUATION OF EXCAVATED POOLS

INTRODUCTION

Action Item 3 of the Trinity River Basin Fish & Wildlife Management Program identifies the need to rehabilitate and maintain the mainstem Trinity River below Lewiston by rebuilding spawning riffles, dredging holding pools, and cleaning food producing areas. Construction of holding pools would accomplish two objectives, removal of accumulated sediments and increase holding habitat for adult salmonids (USFWS 1983).

Under the Trinity River Management Program the escapement goals for spring chinook salmon are 6,000 natural fish and 3,000 hatchery fish. Over the last three years (1987-1989) escapement of natural spring chinook has equaled 41,513, 53,852, and 23,676 fish. Hatchery returns for the same period equaled 10,839 15,880 and 6,663 fish respectively. During this same period pre-spawning mortality of adult spring chinook seemed abnormally high. From 1987 to 1989 prespawn mortality ranged from 50 to 63.5 percent. These extremely high mortality rates may have been caused by several factors including disease, water temperature, handling stress, or limited habitat quantity.

In our 1988 Annual Report (section II.4) we presented findings on adult spring chinook distributions and habitat use for the upper Trinity River (USFWS 1988). We found that adult spring chinook salmon preferred deep shaded pools, greater than ten feet deep, with water velocities less that 1.0 ft/second. Distribution of adult spring chinook in the upper river seemed to be controlled by water temperature more than flow or physical habitat availability. Spring chinook salmon migration past the Department of Fish & Game's weir at Junction City usually peak as water temperatures begin to exceed 60 degrees fahrenheit. By mid August of 1988 the majority of spring chinook held above Limekiln Gulch where water temperatures remained below 60 degrees. The large holding pools located downstream of Limekiln Gulch were sparsely used by spring chinook salmon.

Prior to construction of the Trinity River Division, Moffet and Smith (1950) reported that spring run chinook salmon migrations past Lewiston in June and July. Their migratory habits were described as deliberate, not hesitating to fight any obstacle encountered. Upon reaching deeper holes in the upper river between Lewiston and Trinity Center, the fish stopped migrating and held in a semi-quiescent state until spawning in early October. The construction of Lewiston Dam eliminated this habitat and forced spring run chinook salmon to hold in areas downstream. The presence of Lewiston Dam may cause spring run chinook salmon to pile up in pools located downstream in densities that are probably above their capacity.

In the summer of 1989 the Trinity River Restoration Program dredged three pools in the upper river, one upriver of Cemetery Pool, Cemetery Pool, and Bucktail Pool. A fourth pool was dredged adjacent to River Road (Poker Bar Pool) at Poker Bar in the summer of 1990. The goal of this investigation is to measure habitat gains.

METHODS

The Cemetery, Bucktail, and Poker Bar Pools were mapped before and after dredging using standard radial traverse and EDM survey methods with a Lietz/Sokkisha total station. Pool depths and river banks were mapped during Trinity River flows of 300 cfs. Pool maps were drawn using Computer Assisted Design (CAD) computer software. The major water velocity vectors were drawn from visual inspection of each pool and then entered on each pool map. Total depth contours were drawn by interpolating lines between actual field data measurements. Depth surface areas were calculated using CAD software.

The Trinity River Restoration Program completed dredging Cemetery Pool ahead of schedule. Since heavy equipment was already on site, this presented the Program with an opportunity to dredge sediment from Upper Cemetery Pool and redirect the main velocity vector away from a slide that was eroding silt into the river along the pools left bank. Because of the limited notice prior to the start of work, we were unable to survey Upper Cemetery Pool before excavation.

RESULTS

Upper Cemetery and Cemetery Pools

Dredging of the Cemetery Pools (Upper Cemetery and Cemetery) removed 5,409.6 Yds^3 of material (Russel Smith pers. comm.). The majority of the material removed was fine granitic sand.

Prior to dredging, the majority of flow entered the pool along the left bank. The water then proceeded into the pool along the left side until the current hit a small point along the eroding bank. The water then deflected toward the center of the pool. A cobble bar at the lower end of the pool, in the center of the channel, caused the current to form two eddies or backwaters. Large amounts of sand were deposited along the right bank. A shallow bar of sand and small gravel formed across the right bank near the upstream end of the pool. This location was often used by fisherman to access the pool. The substrate across the left side of the pool is composed mainly of bedrock and hard clay. The flow leaving the pool was split evenly along the left and right banks divided by the cobble bar in the center.

Dredging removed the entire sand bar located along the right bank to a depth of 8 feet or more. The water velocity thalweg entering the pool was shifted from the left bank to the right bank reducing the force of the water hitting the eroding bank along the left side of the pool under the eddy. Sand and debris has already began to settle out along the right side of the pool. Some of the cobble bar located at the downstream end of the pool was removed. The total surface area and depth of the pool was increased significantly (Figure 1).

Before dredging Cemetery Pool, large amounts of sand were present across of left center of the pool underneath an eddy and across the rear of the pool

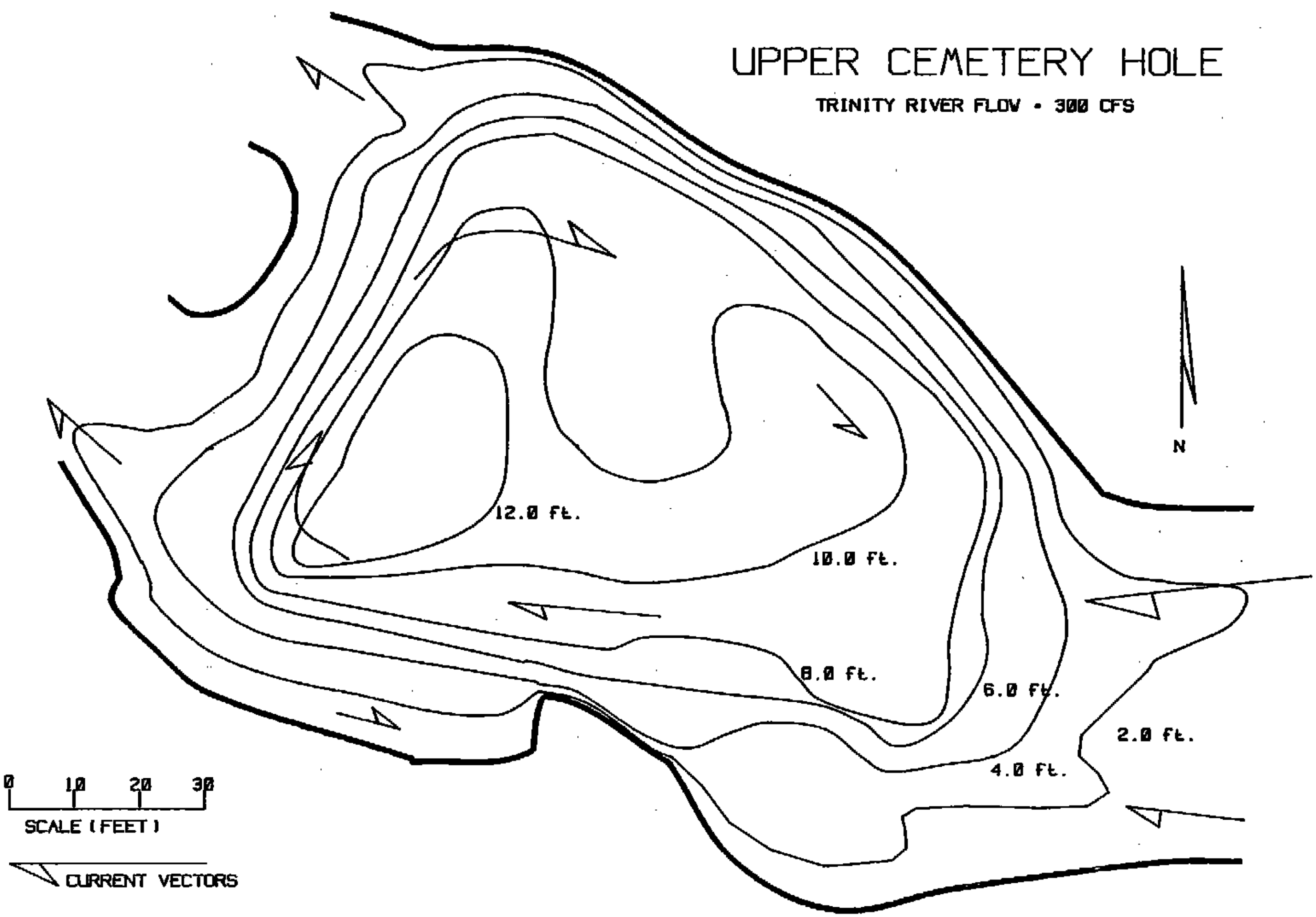


Figure 1. Scale map of Upper Cemetery pool (1989) with depth contours and velocity vectors after being dredged by the Trinity River Restoration Program.

where water velocities slowed before exiting the pool downstream (Figure 2). Dredging removed the majority of material that was located along the left center of the pool, leaving only one small peninsula of sand along the left bank. This small area appeared to be beyond the reach of the equipment. A lot of material was removed from the lower end of the pool greatly increasing the size of the pool downstream (Figure 3). Total surface area of Cemetery Pool increased by 2,124 Ft^2 (Table 1). The surface of water 6 feet deep or more increased by 6,895 Ft^2 and the surface area of water 12 feet deep or more increased by 3,765 Ft^2.

Table 1. Surface area (Ft^2) of total depths greater than or equal to 6 feet, 9 feet, and 12 feet present in Cemetery Pool, Bucktail Pool and Poker Bar Pool before and after dredging.

Pool Location	Total Depth of Pool 6 Ft.	9 Ft.	12 Ft.
Cemetery Pool			
Predredge	2,952 Ft^2	1,288 Ft^2	61 Ft^2
Postdredge	9,848 Ft^2	7,263 Ft^2	3,826 Ft^2
Bucktail Pool			
Predredge	9,369 Ft^2	5,695 Ft^2	3,260 Ft^2
Postdredge	16,420 Ft^2	8,981 Ft^2	1,932 Ft^2
Poker Bar Pool			
Predredge	4,744 Ft^2	0 Ft^2	0 Ft^2
Postdredge	30,778 Ft^2	11,416 Ft^2	0 Ft^2

Bucktail Pool

Bucktail pool is one of most consistently used pools in the upper Trinity River by holding spring chinook salmon. Tall submerged bedrock outcropping and deep water (over 22 feet) combine to provide excellent holding areas for adult salmon protected from high velocities and direct sunlight (Figure 4). The thalweg enters Bucktail Pool along the left bank of the channel. The flow then collides with a large bedrock outcropping along the left bank of the pool causing the flow to form a large eddy in the center of the pool. The upstream boundary of the pool is formed by large cobble and bedrock. Sand was deposited under the large eddy in the upper half of the pool. Sand also was present along the shallow areas along the right bank and a large sand bar was also. The lower half of the pool contained large volumes of cobble that may

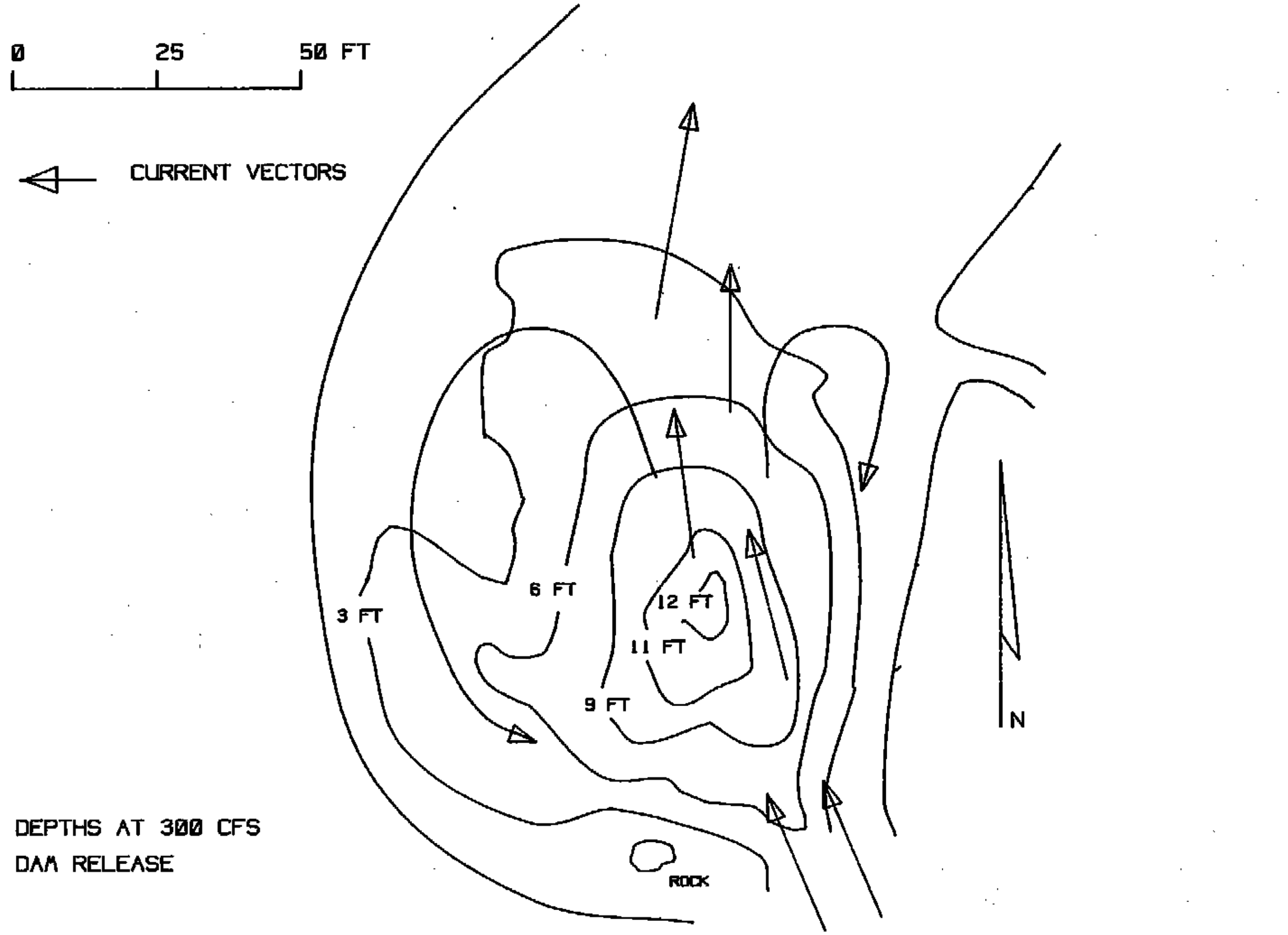


Figure 2. Scale map of Cemetery pool in the summer of 1988 with depth contours and velocity vectors. Pool was dredged by the Trinity River Restoration Program in the summer of 1989.

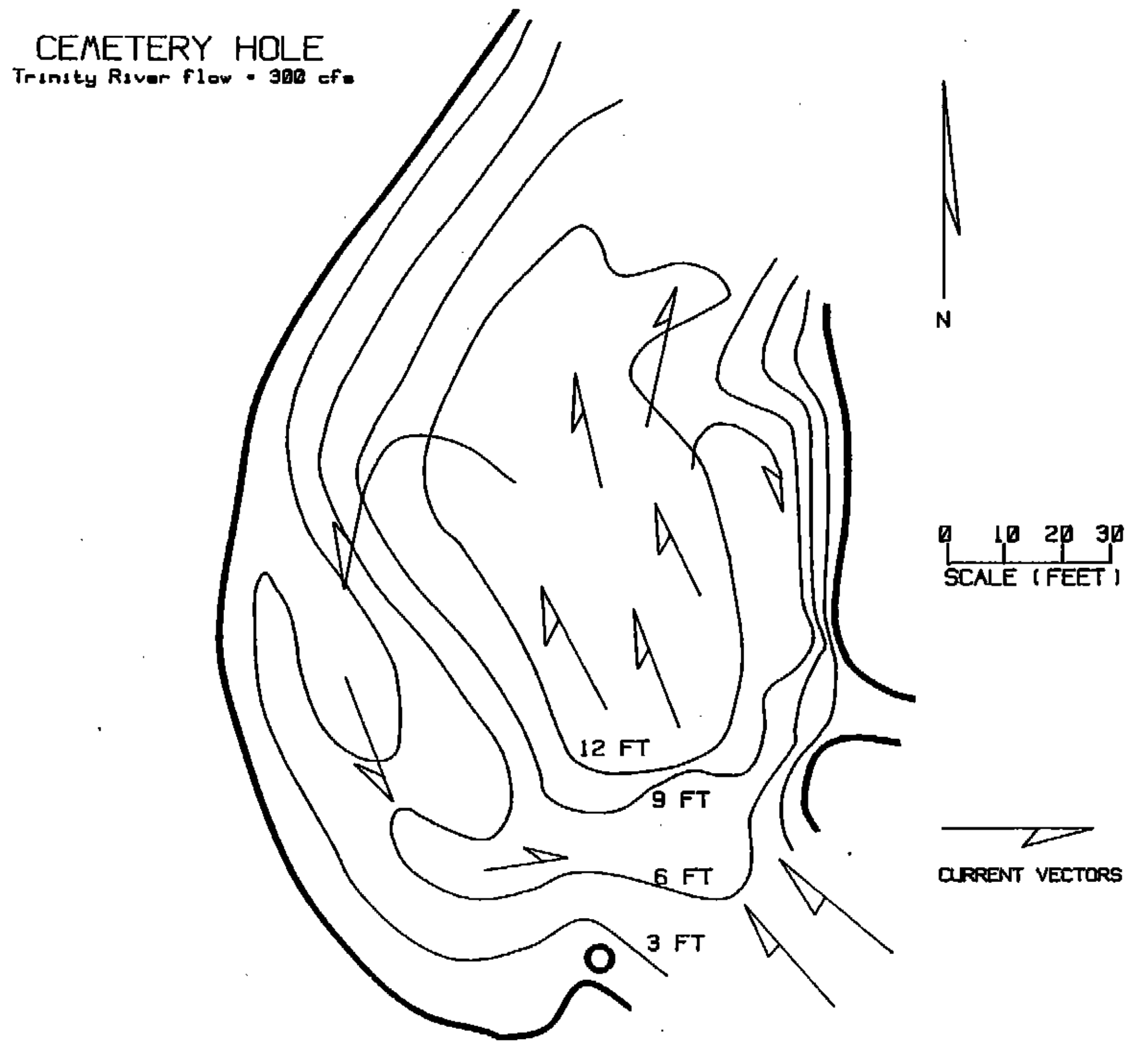


Figure 3. Scale map of Cemetery pool in the summer of 1989 with depth contours and velocity vectors after being dredged by the Trinity River Restoration Program.

have provided some over-wintering habitat for juvenile steelhead trout. A large cobble bar present at the end of the pool forms a split channel.

Approximately 5,800 Yds^3 of material were dredged from the pool, of which an estimated 2,800 Yds^3 were cobble and large gravel. The remaining 3,000 Yds^3 were sand. The cobbles were stockpiled on Bureau of Land Management (BLM) property south of Bucktail Pool and apparently will be used at some future date as a source of spawning gravel. The smaller material was moved to the gravel processing plant located on BLM property upstream (John Elko pers. comm.).

The dredging of Bucktail Pool removed sand and small gravel that was located under the large eddy of the pool (Figure 5). The sand bars located along the right bank were also removed. A large amount of cobble substrate was removed from the lower half of the pool. The upper end of the cobble bar located at the downstream end of the pool was also removed. The left half and deepest sections of the pool did not change. Some sand has settled into the deeper sections in the lower half of the pool decreasing total depths. Based on the depths that were measured, along with our observations of the dredging work, it appears that the maximum depth the equipment can effectively reach is about 10 to 12 feet. Total surface area for water depths greater than 6 and 9 feet increased by 7,051 and 3,286 Ft^2. The total area of deep water habitat greater than 12 feet decreased by 1,328 feet. Higher flow releases may move deposited sand from these areas.

Poker Bar Pool

In the first two years of our study we observed adult chinook salmon holding in the Poker Bar Pool on several occasions while conducting our habitat preference work. In the years following the flood in February of 1986, we noticed that large quantities of sand were filling the pool. We estimated that the total depths in the pool had been reduced from 9 feet to 6 feet. Based on these observations, the pool presented the Trinity River Restoration Program with an ideal opportunity to remove substantial volumes of sand and increase and spring chinook salmon holding habitat.

Water enters the pool from a steep riffle to the south. As flow enters the pool the velocities slow and disperse evenly across the channel. From the air the pool resembles a long deep run approximately 600 feet in length. Through the length of the pool the channel gradually widens and forms a wide run at the downstream end (Figure 6). The run and riffle at the end of the pool were heavily used by spawning chinook salmon in some years prior to 1988. In recent years spawning use of this area has declined. Before dredging the total depth of the pool measured 6.9 feet. Approximately 4,744 Ft^2 of water with a total depth of 6 feet or greater was present.

The Trinity River Restoration Program dredged 10,776.7 Yds^3 of sediment from the pool (Russel Smith pers. comm.). Surface area of water 6 feet deep or greater increased to 30,778 Ft^2 and approximately 11,416 Ft^2 surface area of water 9 feet deep or greater was created. The pool maximum total depth

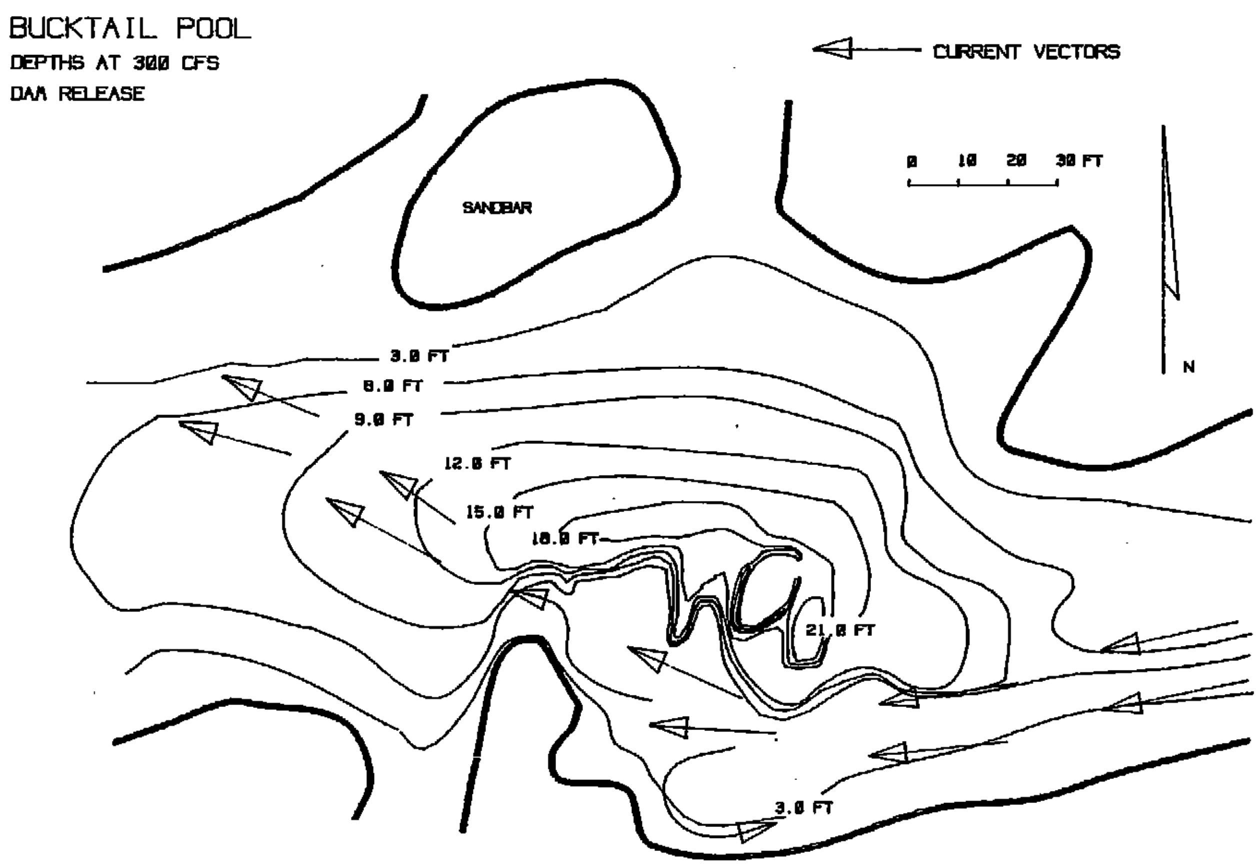


Figure 4. Scale map of Bucktail pool in the summer of 1988 with depth contours and velocity vectors. Pool was dredged by the Trinity River Restoration Program in the summer of 1989.

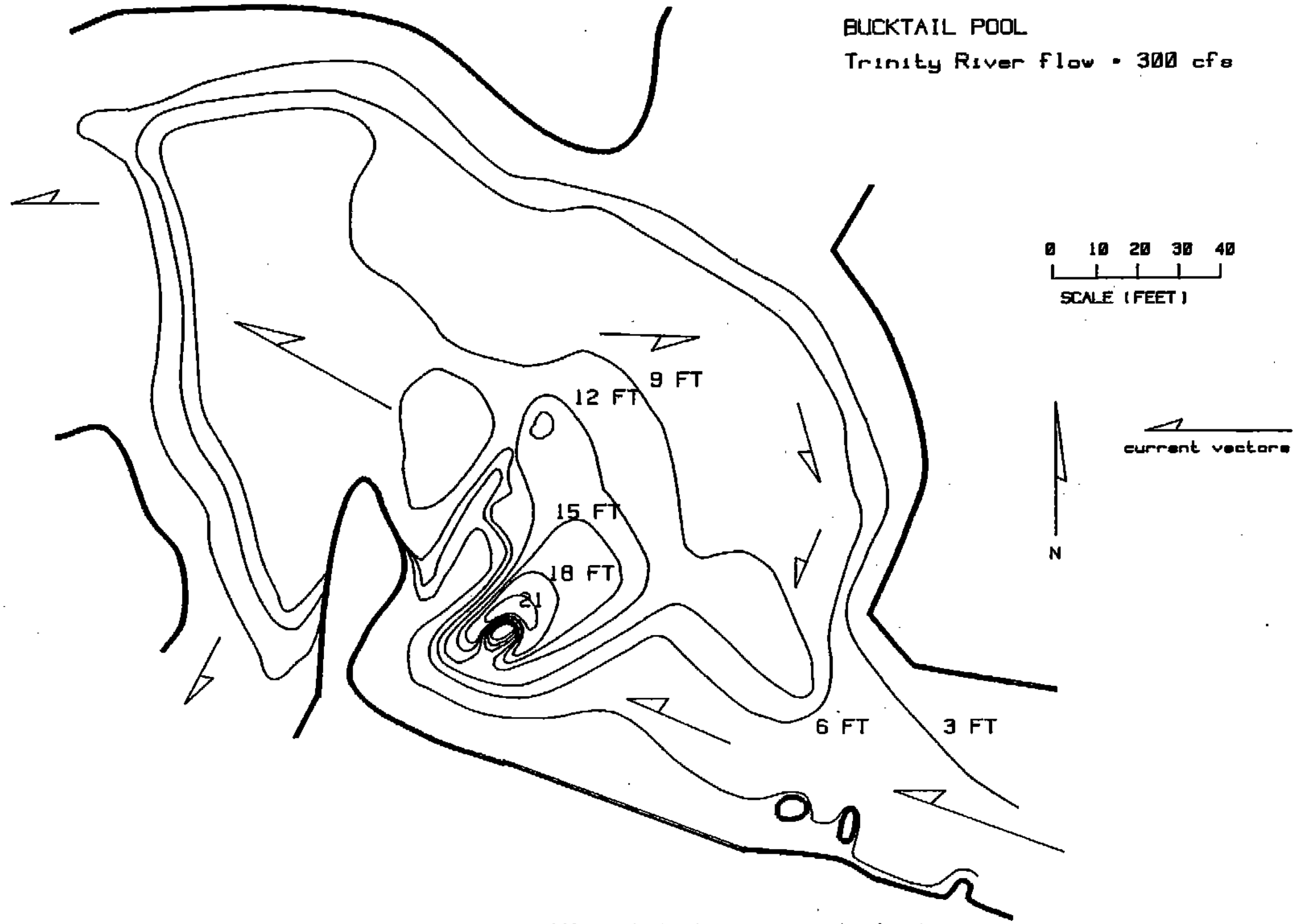


Figure 5. Scale map of Bucktail pool, summer of 1989, with depth contours and velocity vectors, after being dredged by the Trinity River Restoration Program.

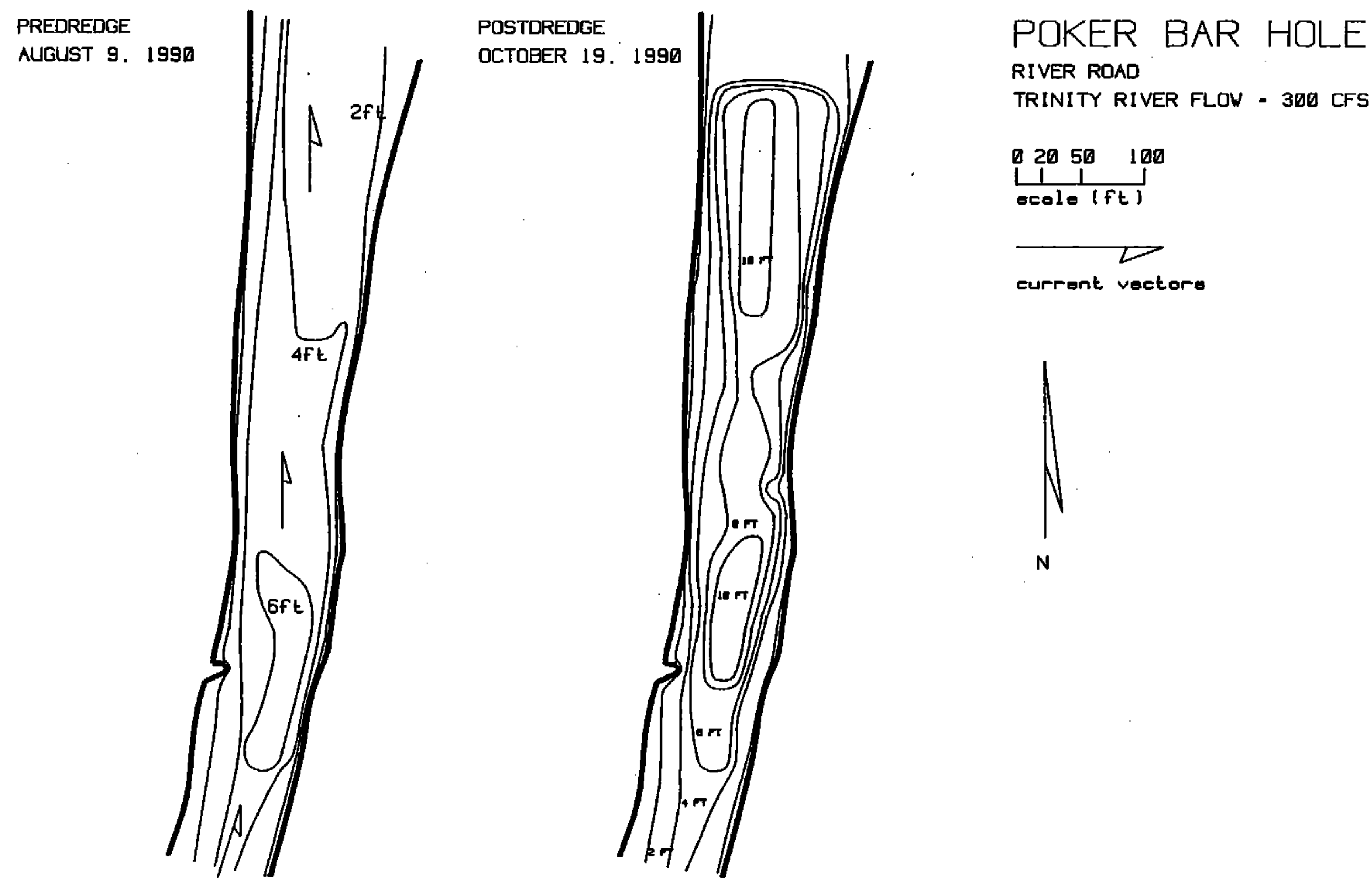


Figure 6. Scale map of Poker Bar Hole before and after dredging in the summer of 1990.

increased from 6.9 feet to 11.5 feet. While conducting the field data survey on October 19, 1990 we observed several adult salmon in the pool. Provided the pool doesn't fill in with sediments over the winter, we plan to verify spring chinook salmon use of the pool during the summer of 1991.

DISCUSSION

The Soil Conservation Service (SCS) estimates that Grass Valley Creek contributes an average annual sediment load of 177,000 yds^3 (Jan Dybdahl pers. comm.). The completion of Buckhorn Dam in 1990 is expected to reduce sediment contributions from Grass Valley Creek by 27% or 47,790 yds^3. The Hamilton and Wellock sediment ponds located near the mouth of Grass Valley Creek have the potential, under ideal conditions, to capture an additional 85,000 yds^3 of sediment (Ed Barnes pers. comm.). The remaining 44,210 yds^3 of sediment enter the Trinity River. A total of 21,986 cubic yards of material were removed from the four pools dredged in 1989 and 1990, enough sediment to cover a football field 10.3 feet deep. With the exception of Bucktail Pool, the majority (about 90%) of substrates removed were sand, silt and small gravel. Removal of 21,986 yds^3 of sediment from the Trinity River over a two year period comprises approximately 50% of the average annual sediment contribution from Grass Valley Creek. Substantial volumes of sediment also enter the Trinity River from other tributaries, such as Hoadly Gulch and Rush Creek, that are not included in these estimates. Use of average annual sedimentation estimates over-simplify the sediment transport process from Grass Valley Creek. In reality, sediment contributions from Grass Valley Creek and other tributaries occur in large volumes during major storms. However, the values used successfully demonstrate the magnitude of the sedimentation problem that is one of the key factors responsible for the decline of the anadromous fishery in the Trinity River.

Nearly half of the material (2,800 Yds^3) removed from Bucktail Pool was composed of substrates ranging from large gravel to large cobble. This material was stock piled adjacent to Bucktail Pool for use in future restoration work. At this time the Department of Water Resources has identified these cobbles for use as spawning material. A lot of the stock piled material appears to be to large for effective use as spawning substrates. A possible second alternative for these larger cobbles could include placement in rearing habitat to improve food production, and cover for fry and juvenile salmonids. Over-wintering habitat for juvenile steelhead trout could also be improved by placement of these cobbles in side-channels.

In our 1988 Annual Report we described the habitat preferences and behavior of holding spring chinook salmon within the upper Trinity River (USFWS 1988). Approximately 53,852 spring chinook salmon entered the Trinity River during the summer of 1988, while we were conducting our observations. This was the highest number of adult spring chinook salmon observed in the Trinity River since construction of the Trinity River Division in the early sixties. The restoration goal for natural spring chinook salmon in the Trinity River is 6,000 fish. If we assume that 53,852 spring chinook salmon saturated available holding habitat in the upper Trinity River, the observations that we made during the summer of 1988 may describe the habitat requirements of adult spring chinook salmon within the upper Trinity River. The best way to describe habitat requirements for holding chinook salmon would be to estimate the density of holding salmon per volume of water greater than 10 feet. For purposes of this report chinook salmon densities are based on surface area of water greater than 9 feet deep in each pool. Future evaluations will consider habitat requirements based on water volume. The average density of spring chinook salmon in the three pools that we have mapped equaled 0.0117 fish/feet^2. Bucktail Pool contained the highest density of spring chinook salmon that we observed at 0.0263 fish/feet^2.

In order to evaluate habitat gains for holding spring chinook salmon created by pool dredging, the surface area of water 9 feet or greater was multiplied by the maximum density of 0.0263 fish/feet^2 that we observed in 1988 (Table 2). Since we don't have predredge area measurements for Upper Cemetery Pool an estimate of the amount of increased habitat could not be made. Dredging of Cemetery Pool, Bucktail Pool, and Poker Bar Pool created habitat for an additional 543 adult spring chinook salmon.

Table 2. An estimate of the number of additional adult spring chinook salmon that may result from increased habitat created by pool dredging based on a maximum density of 0.0263 fish/ft^2.

Pool Location	Area (feet^2) $\geq$ 9 Ft. deep	Number Sp. Chinook	Estimated Increase
<u>Upper Cemetery Pool</u>			
Predredge	?	?	
Postdredge	4,803 Ft^2	126	?
<u>Cemetery Pool</u>			
Predredge	1,288 Ft^2	34	
Postdredge	7,263 Ft^2	191	157
<u>Bucktail Pool</u>			
Predredge	5,695 Ft^2	150	
Postdredge	8,981 Ft^2	236	86
<u>Poker Bar Pool</u>			
Predredge	0 Ft^2	0	
Postdredge	11,416 Ft^2	300	300

In 1989 and 1990 the Restoration Program's pool dredging occurred during low summer flow periods during August and September just before the onset of the spawning season. Pool dredging during this time coincides with the most critical period during the spring chinook holding stage. Since spring chinook salmon do not eat after they enter the river in the spring, they are solely dependant on their fat reserves to sustain themselves throughout the summer until spawning is completed in the fall. While at the same time they are expanding considerable energy levels toward egg maturation. Any disturbances that cause increased stress or force holding salmon to waste energy needlessly also decrease their odds of survival. In order to reduce possible impacts on holding salmon from future dredging activities we recommend the following guidelines:

1) Plan dredging activities in areas where habitat has filled in to the extent that spring chinook salmon have ceased to use the pool (ie. Poker Bar Pool).

2) In pools still being used by holding spring run chinook salmon, dredging activities should be planned earlier in the year, possibly during June, before the majority of fish have entered the upper river.

The removal of fine sediments through construction of holding pools does benefit anadromous salmonids. Holding pools will help reduce the sedimentation rate of spawning and rearing habitats located downstream. Over time reduced sedimentation of these habitats will improve invertebrate production for rearing salmonids and should improve over-wintering habitat for steelhead trout. A reduction in the amount of fine sediments will also increase survival of emerging fry salmon and steelhead trout. Although pool dredging has some benefits it does not address the sedimentation problem of critical run and riffle habitats that have severely impacted spawning and rearing habitat. Flushing flows are probably the only feasible means to clean sediment from these habitats.

WATER TEMPERATURE MONITORING

We maintained six temperature recording sites along the main-stem Trinity River in 1990, from Lewiston to Hoopa Valley. Recorded temperatures are intended for use in calibrating the US Fish and Wildlife Service SNTEMP river temperature model, which will provide a necessary element of our overall evaluation of flow-related habitat conditions in the river.

Temperature recorders were located at the US Geological Survey gaging station in Lewiston (river mile 111), the Douglas City Bridge (river mile 94), near Junction City at Svensson's Bar (river mile 82), just upstream from the North Fork at Idaho Bar (river mile 73.5), at the Burnt Ranch transfer site (river mile 46), and in Hoopa Valley at the US Geological Survey gauging station (river mile 14.4). A seventh recorder was located at the gauging station near the Steelbridge campground (river mile 98), but data at this site were lost because of malfunctions.

Omnidata Datapod Model 112 or 212 temperature recorders were used at all sites. These record maximum, minimum, and mean 24-hour temperatures to the nearest 0.1 degree over a range from 5 to 30 degrees Celsius. The Datapods recorded temperatures on non-volatile data storage modules (DSM), which were changed approximately every 30 days, read into storage files, and compiled in spread-sheets.

Temperatures During Spring Chinook Migration

Temperatures at Lewiston, Douglas City, Junction City, and the North Fork for the critical spring chinook holding and early chinook spawning period from May 15 to October 15 are shown in Figure 1. The various data gaps result from malfunction of underwater housings, equipment malfunction, vandalism, and theft.

Temperatures generally considered acceptable for spring chinook salmon are 60 degrees Fahrenheit (15.6 degrees Celsius) for adult survival and egg development as fish hold over the summer in the upper river, and 56 degrees F (13.3 degrees C) for spawning, which generally begins no earlier than Mid-September.

Figure 1 shows that 1990 water temperatures were suitable for spawning from Lewiston to the North Fork by September 14, and to Douglas City by early August.

Temperatures at Douglas City exceeded 60 degrees during much of June and in early July. Generally these temperatures were caused by high air temperatures and high Lewiston release temperatures caused by relatively low combined release and diversion volumes, which increased residence time in Lewiston Lake.

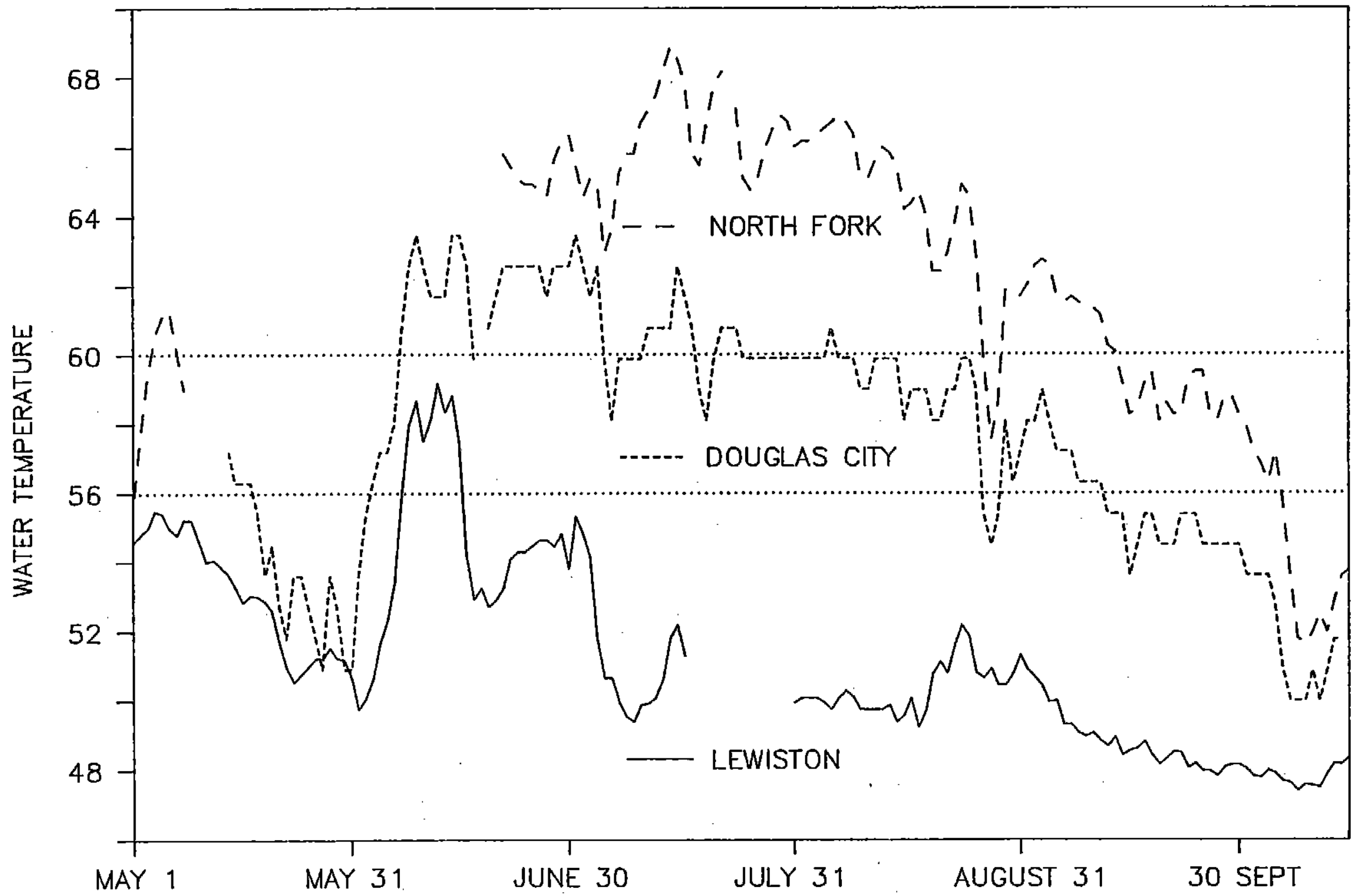


Figure 1. Trinity River water temperatures from May 1 to September 15, 1990 at Lewiston, Douglas City, and above the confluence with the North Fork.

III. FISH POPULATION CHARACTERISTICS AND LIFE-HISTORY RELATIONSHIPS

CHINOOK SPAWNING DISTRIBUTION SURVEY

Introduction

In 1989 and 1990 we continued to conduct chinook salmon spawning surveys in the mainstem Trinity River. The purpose of these surveys is to identify major chinook salmon spawning habitats and to discern changes or trends in habitat use between years as the study progresses. The surveys also provide information regarding areas of the river where we can expect to observe rearing fry and juvenile chinook salmon the following spring.

Methods

Spawning surveys are conducted by two biologists floating various sections of the river in an inflatable raft between October and December of each year. Redd locations were recorded during each float trip on photocopies of aerial photographs. Side-channels and areas of river too shallow to float were waded to assure complete coverage within each reach.

In October and November of 1989 we surveyed 63.5 river miles, divided into seven sections between Lewiston and Cedar Flat. The sections surveyed were as follows:

1. New Bridge Lewiston (RM 111) to Bucktail Pool (RM 105)
2. Bucktail Pool to Steel Bridge (RM 99)
3. Steel Bridge to Evans Bar (RM 85)
4. Evans Bar to Cooper's Bar (RM 75)
5. Cooper's Bar to Big Flat (RM 65.5)
6. Big Flat to Del Loma (RM 56)
7. Del Loma to Cedar Flat (RM 47.5)

From October through December of 1990 we surveyed 66 river miles divided into seven reaches as follows:

1. New Bridge at Lewiston (RM 111) to Bucktail Pool (RM 105)
2. Bucktail Pool to Indian Creek (RM 95)
3. Indian Creek to Evans Bar (RM 85)
4. Evans Bar to North Fork Trinity River (RM 72)
5. Big Flat (RM 65.5) to Del Loma (RM 56)
6. Del Loma to Cedar Flat (RM 47.5)
7. Camp Kimtu (RM 26) to Tish Tang (RM 17)

Results and Discussion

A total of 1065 and 669 redds were observed in 1989 and 1990 respectively. Table 1 includes a description of each reach surveyed, date of survey, and number of redds observed within each reach for 1989 and 1990 surveys.

Table 1. Chinook salmon spawning survey results for the main-stem Trinity River in 1989 and 1990.

DATE	SECTION		MILES	REDDS
10-10-89	1	New Bridge to Bucktail Pool	6	183
10-12-89	2	Bucktail Hole to Steel Bridge	6	184
11-08-89	3	Steel Bridge to Evans Bar	14	263
11-13-89	4	Evans Bar to Cooper's Bar	10.5	143
11-15-89	5	Cooper's Bar to Big Flat	9.5	24
11-16-89	6	Big Flat to Del Loma	9	166
11-17-89	7	Del Loma to Cedar Flat	8.5	102
TOTAL			63.5	1065
10-18-90	1	New Bridge to Bucktail Pool	6	116
10-23-90	2	Bucktail Pool to Indian Creek	10	179
11-01-90	3	Indian Creek to Evans Bar	10	72
11-06-90	4	Evans Bar to North Fork	13	114
11-29-90	5	Big Flat to Del Loma	9.5	101
11-28-90	6	Del Loma to Cedar Flat	8.5	80
12-05-90	7	Camp Kimtu to Tish Tang	9	7
TOTAL			66	669

Chinook salmon first begin spawning below Lewiston Dam in mid-September. Spawning then gradually progressed downstream. Spawning below the North Fork Trinity River confluence peaked in November. For the entire river the chinook salmon spawning season lasted mid-September through the end of November.

In 1989 and 1990 the California Department of Fish and Game estimates that approximately 32,785 and 7925 chinook salmon escaped into the Trinity River Basin above Willow Creek, excluding Trinity River Hatchery returns. Since 1986, when 91,088 fall chinook salmon returned to the Trinity River, escapement has been declining steadily. The 1990 fall chinook salmon escapement was the lowest in the last five years. However, we have observed that the distribution of spawning areas used by chinook salmon over the last five years has remained fairly constant.

The upper river, between Lewiston and Evans Bar, continues to support the majority spawning activity. Pre-dam surveys by the California Department of Fish and Game indicate that heavy concentrations of spawning activity occurred in this reach. Gibbs (1955) found that 47% of observed spawning occurred between Lewiston and Canyon Creek. Rogers (1968,1970,1971) found that between 86.4% and 71.5% of spawning was between the North Fork Trinity River confluence and Lewiston. This reflects the importance of this reach for spawning chinook salmon before and after construction of the Trinity River Division. The most heavily used spawning habitats in the upper river are between Lewiston Dam and Sawmill Pool, below the mouth of Rush Creek, Gold Bar riffle, Bucktail riffle, Lowden Ranch riffle, Poker Bar to Steelbridge Road, Reading Bar, Dutton Creek, and between Dutch Creek and Evans Bar. Below Evans Bar we have consistently observed spawning in the lower Chapman Ranch area, Oregon Gulch, Lime Point and Idaho Bar. However, in 1990 for the first time in the last three years we observed no spawning activity in the Lime Point and Oregon Gulch areas.

Though the majority of spawning occurs in the upper river we have observed a substantial amount in the lower river below the North Fork. Major spawning areas that have been consistently used by chinook salmon in the lower river include Big Flat, Big Bar Bridge, French Bar, Canadian Bar, Schneider's Bar, Sandy Bar, and Cedar Flat. In 1990 we also observed spawning at Little Prairie for the first time. The Big Bar Bridge riffle has always been one of the most heavily used spawning riffles in the lower river, but in 1990 use of the lower riffle below the bridge declined substantially. Gold dredging in this area during the summer of 1990 may have decreased the suitability of this habitat resulting in reduced spawner use.

JUVENILE POPULATIONS

In 1990, we continued to monitor mainstem Trinity River juvenile salmon populations by underwater observations at the Cemetery, Steelbridge, Steiner Flat, and Junction City sites, and at the Hayden Flat campground.

Our method, as in previous years, was to ascend a 200-foot rope up the river edge at selected locations: Cemetery (river mile 109), Steelbridge (river mile 99), Steiner Flat (river mile 92), and Junction City Campground (river mile 77). At Hayden Flat (river mile 54) we surveyed a 473-foot section of the river bank by crawling or swimming up the cobbled river bottom.

As in past years, chinook fry emerged from the gravel in significant numbers by about mid-February. We made counts at all five sites in mid-March, April, and early May, and additional counts were made at the Cemetery site in late February and July.

Consistent observation after Mid-May was precluded by hatchery chinook release schedules and the necessity to measure low flow microhabitat resulting from critical dry-year Lewiston releases.

Results and Discussión

Figures 1 through 4 shows chinook fry and juvenile numbers for each of the four upper sites as observed from 1986 to 1990. All fish numbers are reported as individuals per linear foot of the river's edge.

1990 rearing chinook populations were high in the Cemetery reach, approaching the highest numbers observed since 1986. As in past years, population densities decreased from early-season peaks at the Cemetery and Steelbridge sites, and increased from March to May at the Junction City site. The Steiner Flat site also showed increases over the period of observation.

As in previous years, substantially greater numbers of fish were observed at the Cemetery site during the early part of the season. By early May rearing populations had become similar at the four sites, ranging from 1.93 at Steiner Flat to 2.60 at Cemetery.

Numbers of fish per linear foot of edge at Hayden Flat were 0.24 on March 19, 1.69 on April 5, and 1.36 on May 8, indicating a later emergence period and possible immigration of up-river juveniles as the season progresses. Fish numbers observed at this downriver site were comparable to those at Junction City, 23 miles upstream, and Steiner Flat, 38 miles upstream (Figure 5).

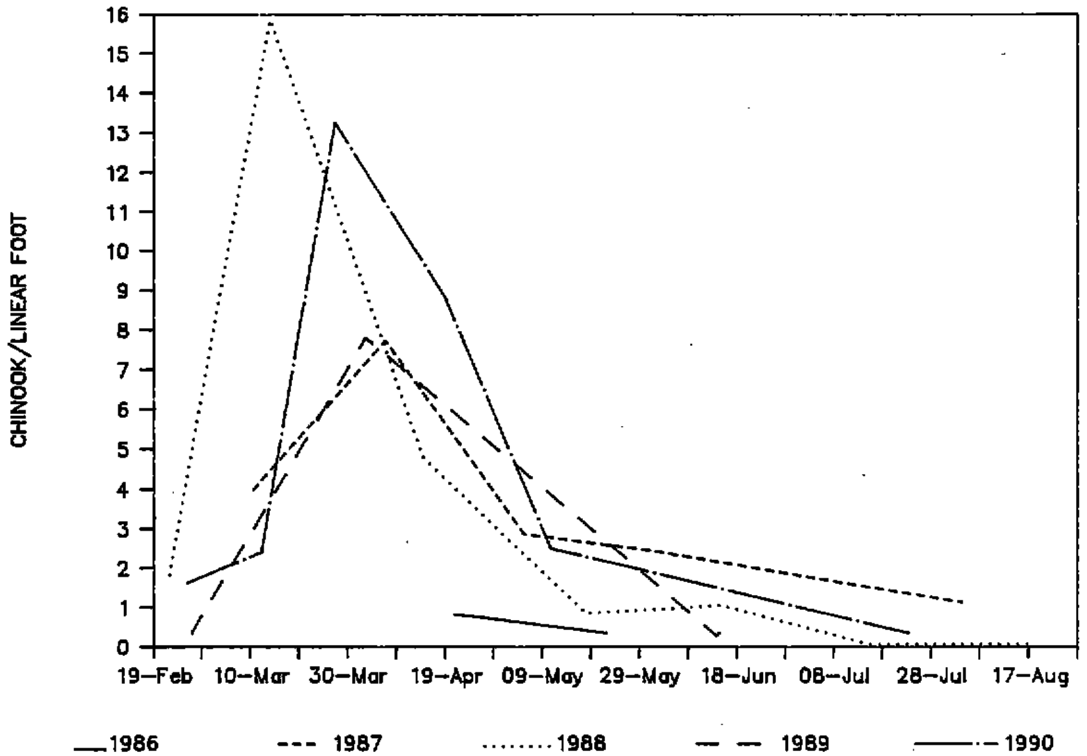


Figure 1. Juvenile chinook population index at Cemetery, 1986 to 1991.

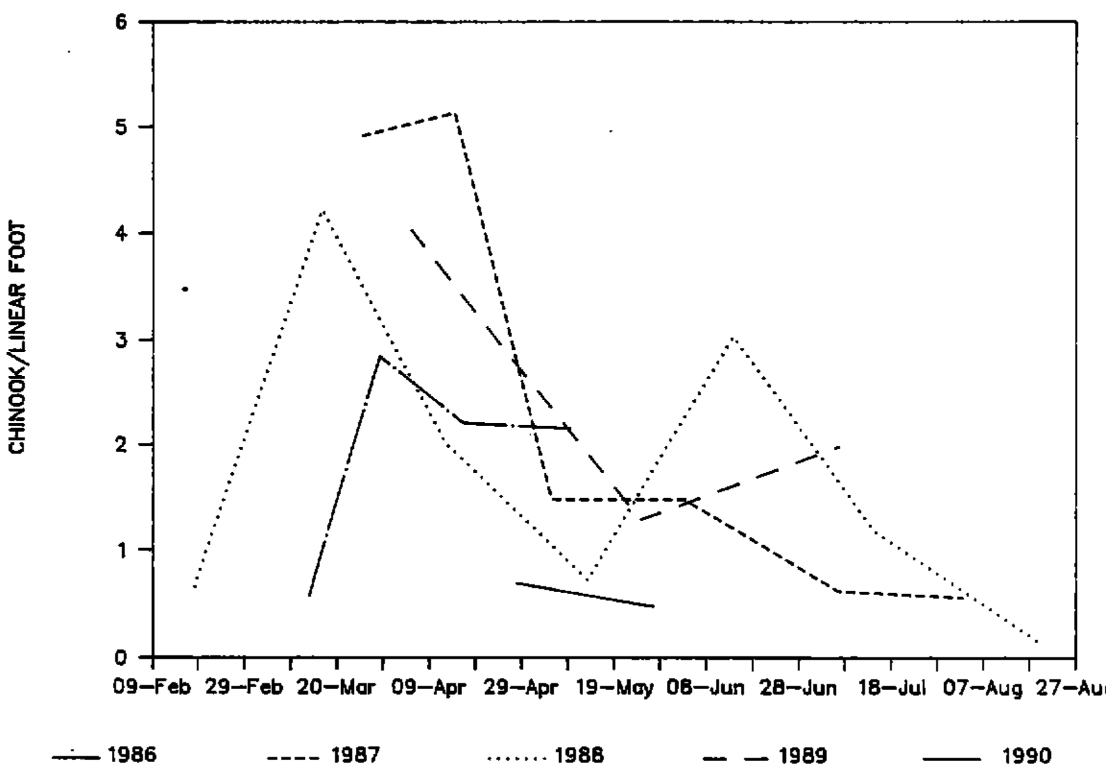


Figure 2. Juvenile chinook population index at Steelbridge, 1986 to 1990.

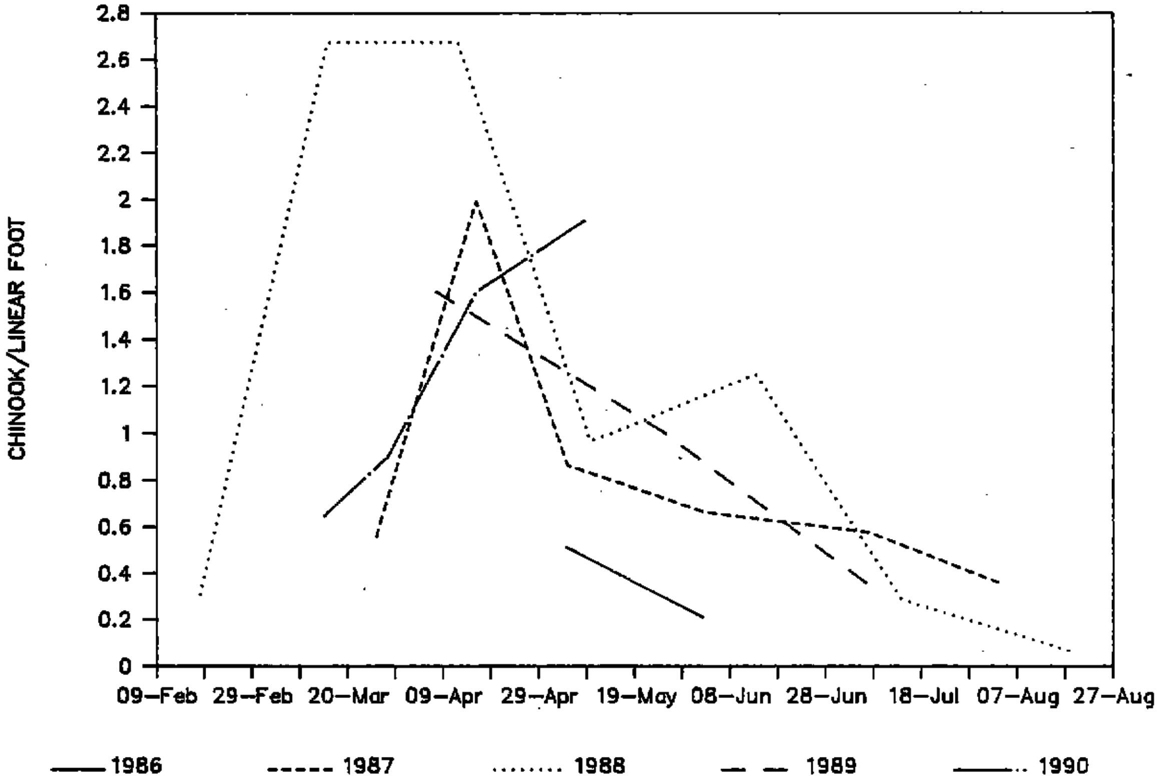


Figure 3. Juvenile chinook population index at Steiner Flat, 1986 to 1990.

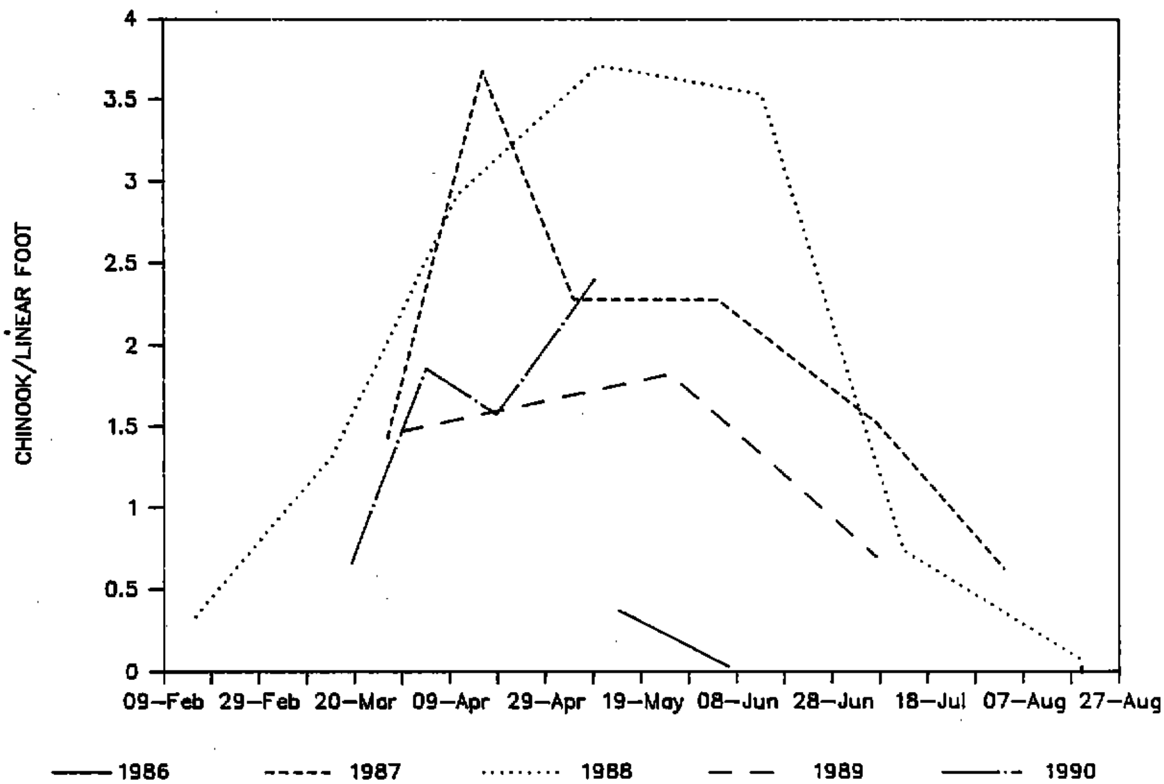


Figure 4. Juvenile chinook population index at Junction City, 1986 to 1990.

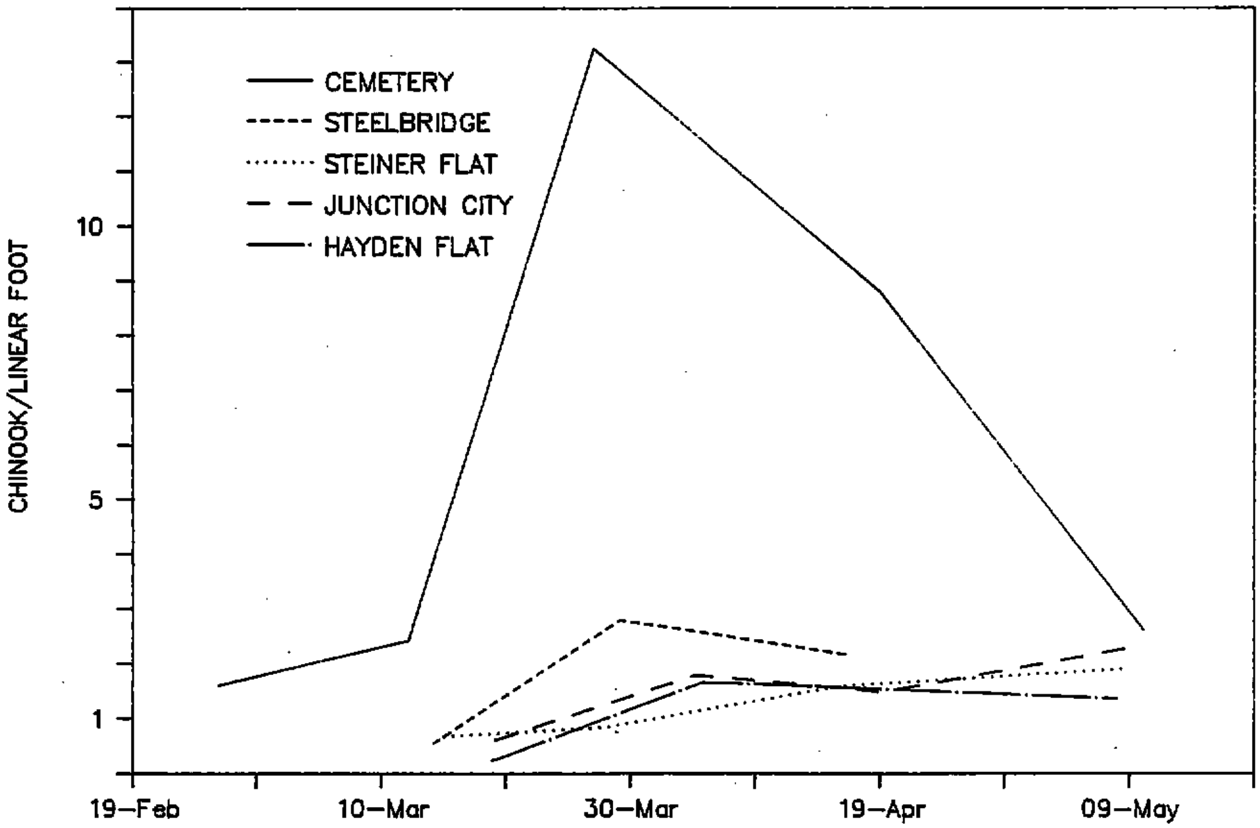


Figure 5. Rearing chinook densities at five Trinity River sites in 1990.

IV. PROGRAM PLANNING, DIRECTION, AND COORDINATION

Activities of the Trinity River Flow Evaluation in 1991 continue to focus on the analysis of salmon and steelhead habitat available in the mainstem Trinity River at various stream flows, monitoring of salmonid habitat needs and use, and monitoring of habitat gains provided by Trinity River Restoration Program projects in the mainstem.

Determination of Habitat Availability and Needs (Task 3)

In 1991 mainstem habitat availability studies were limited by reduced water availability, which did not permit a long-term study flow at the planned 1500 and 3000 cfs. Available water was applied to a short-term spring release of 3000 cfs, allowing intensive study of sand transport and geomorphological changes caused by such a flow. These studies were carried out by a University of California and Johns Hopkins University study team under cooperative agreement with the Flow Evaluation, and by consultants under contract to the restoration program. High-flow habitat estimates were carried out by the Flow Evaluation at three side-channels and at some sites on the main-stem.

Mainstem water temperature modeling and monitoring continue in 1991. Preliminary results from this work, along with micro-habitat estimation through PHABSIM and collection of fish population and habitat use data under Task 4 (below), will be used in cooperative work with the Service's Aquatic Systems Branch of the National Ecology Research Center to develop a fish population model for the mainstem.

Fish Population Characteristics and Life History Relationships (Task 4)

Efforts within this task will continue with 1) juvenile chinook and steelhead habitat area requirement studies, 2) steelhead fry microhabitat use data collection, 3) monitoring of chinook salmon rearing densities and spawning area distribution patterns, and 4) continued evaluation of water temperature requirements for various salmonid life stages.

Study Coordination

Close coordination with the Trinity River Basin Fish and Wildlife Management Program Field Office will continue. The Flow Evaluation will continue to monitor restoration program efforts in the mainstem, with before-and-after mapping of dredged pools and sampling of suction-dredged riffles. Evaluation of fish habitat in constructed side-channels will also continue.

Finally, coordination will continue with the Bureau of Reclamation, the California Department of Fish and Game, the Hoopa Valley Tribe, and Trinity County concerning Trinity River flows, hatchery operations, temperature regulation, restoration projects, and other fishery or habitat management efforts.

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