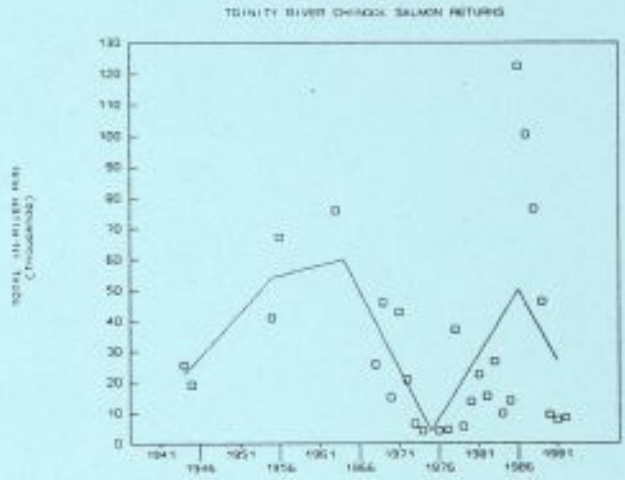
TRINITY RIVER FLOW EVALUATION ANNUAL REPORT - 1991



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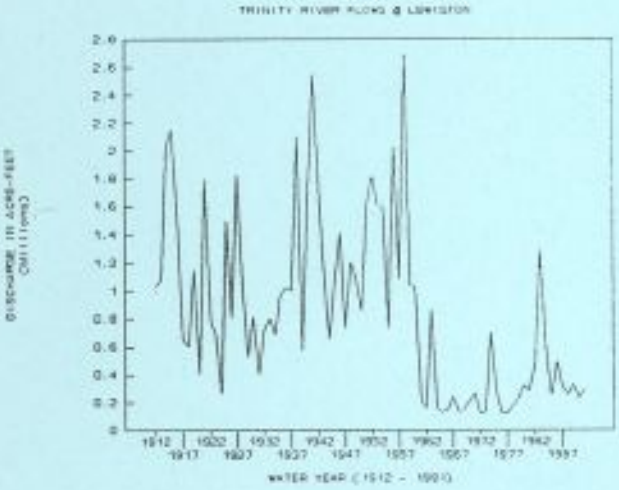

FISH AND WILDLIFE SERVICE

U.S. DEPARTMENT OF THE INTERIOR

ANNUAL REPORT

TRINITY RIVER FLOW EVALUATION

1991

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PREFACE

The following report is the seventh 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 began operations 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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Spawning distribution, temperature monitoring, juvenile steelhead area requirements.

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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 1991 were as follows:

Activities in the Mainstem

Although the winter of 1990-91 was dry, late-season rains resulted in the possibility for a four-day 3000 cfs channel-maintenance and downstream-migration flow during the week following Memorial Day. During this release, Flow Evaluation personnel aided in a cooperative study with the University of California and the Johns Hopkins university to evaluated the mechanics of sand transport at higher flows. Results of this study are to be submitted in 1993, after two years of additional field measurements.

During the 3000 cfs release, field methods for PHABSIM data-collection at high flows were evaluated. It was determined a high-flow study was feasible, and a longer-term 3000 cfs release is planned in 1993 for habitat evaluation.

Flow Evaluation personnel also assisted in development of a US Fish and Wildlife Service National Ecology Research Center fish population model to be used in relating PHABSIM habitat studies with fish population responses.

1991 Side-channel Evaluations

In 1991 we quantified available rearing habitat in the Steiner Flat II and Svensson side-channels and evaluated the effects of cobble placement and channel restoration activities in the Bucktail sidechannel. Mechanical manipulation of the Bucktail side-channel significantly increased the wetted surface area and increased the amount of weighted usable area for rearing chinook salmon by more than 300 percent. Placement of cobble mounds and wing deflectors in the faster riffle habitats improved rearing conditions by creating slow water areas where juvenile trout and salmon could feed more effectively. Cobble piles and wing deflectors also improved winter habitat conditions for juvenile steelhead trout.

When the Trinity River is flowing at 300 cfs, the Steiner Flat II side-channel flows at about five cfs. Under these low flow conditions the side-channel provides only minimal amounts of rearing habitat. Summer daily water temperatures fluctuate by as much as nine degrees fahrenheit. Maximum 1991 water temperatures in the side-channel often exceeded the daily maximum water temperatures in the Trinity River by six degrees fahrenheit. To improve habitat conditions in the side-channel we recommend that the channel be redesigned so that base flows do not drop below 20 cfs. The available slope should also be redistributed throughout the side-channel to increase habitat diversity.

The Svensson side-channel created an additional 6,000 square feet of fry chinook salmon Wighted Usable Area (WUA) and 21,000 square feet of juvenile chinook salmon WUA. The side-channel has undergone two high flows without any changes to the inlet. High flows have

begun to improve the existing the habitat conditions through scour of cobble substrates. Habitat could be improved by increasing habitat diversity by distributing the available slope in the lower half of the side-channel into the upper sections.

Comparison of WUA and Observed Densities of Juvenile Chinook Salmon

We compared measured WUA in microhabitat cells with densities of juvenile chinook salmon across mesohabitat transects in the upper Trinity River. At the microhabitat level, there was a significant relationship between WUA and observed densities of juvenile chinook salmon in 1989 (R^2=0.89) and 1991 (R^2=0.72). However, when WUA and observed fish densities were examined by individual mesohabitat types, no significant relationship between WUA and densities of juvenile chinook salmon could be detected. Factors that complicate attempts to describe the relationship between WUA and fish densities include: microhabitat isolation, the effect of water velocity shear zones on habitat quality, and the adverse effect of large homogenous areas of slack water.

Juvenile Steelhead Area Requirements

Juvenile steelhead area requirements were investigated by direct observation. Preliminary results indicated steelhead from 45 to 94 mm on the average required 24.1 square feet, and fish from 95 to 150 mm required 41.3 square feet.

Thermal Stratification of Pools

During early July three large pools within 15.5 miles of Lewiston dam were examined for thermal stratification. No thermal stratification occurred at a release of 450 cfs from Lewiston Dam.

Chinook Spawning Distribution Survey

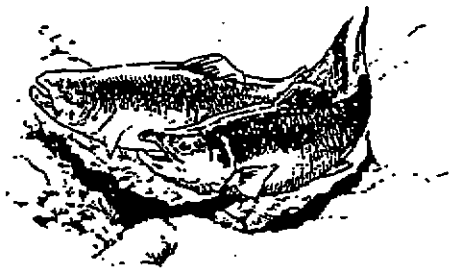
A total of 961 redds were observed in the mainstem Trinity River for the 78.5 miles surveyed. Nearly 80 percent of the redds were located between New Bridge in Lewiston to the confluence of the North Fork Trinity River, and the remaining 20 percent were between the North Fork Trinity River and Tish Tang-a-Tang Creek.

Water Temperature Monitoring

As part of an ongoing effort, water temperatures of the Trinity River were monitored at six locations from Lewiston dam to Weitchpec Falls.

Juvenile Chinook Rearing Populations

Direct observation of juvenile chinook rearing populations continued at four sites from Lewiston to Junction City. Rearing chinook showed a pattern similar to previous years, with highest numbers observed in the upper river, and a general increase in fish densities downriver as the season progressed. Overall counts were the lowest since the 1986 rearing season.



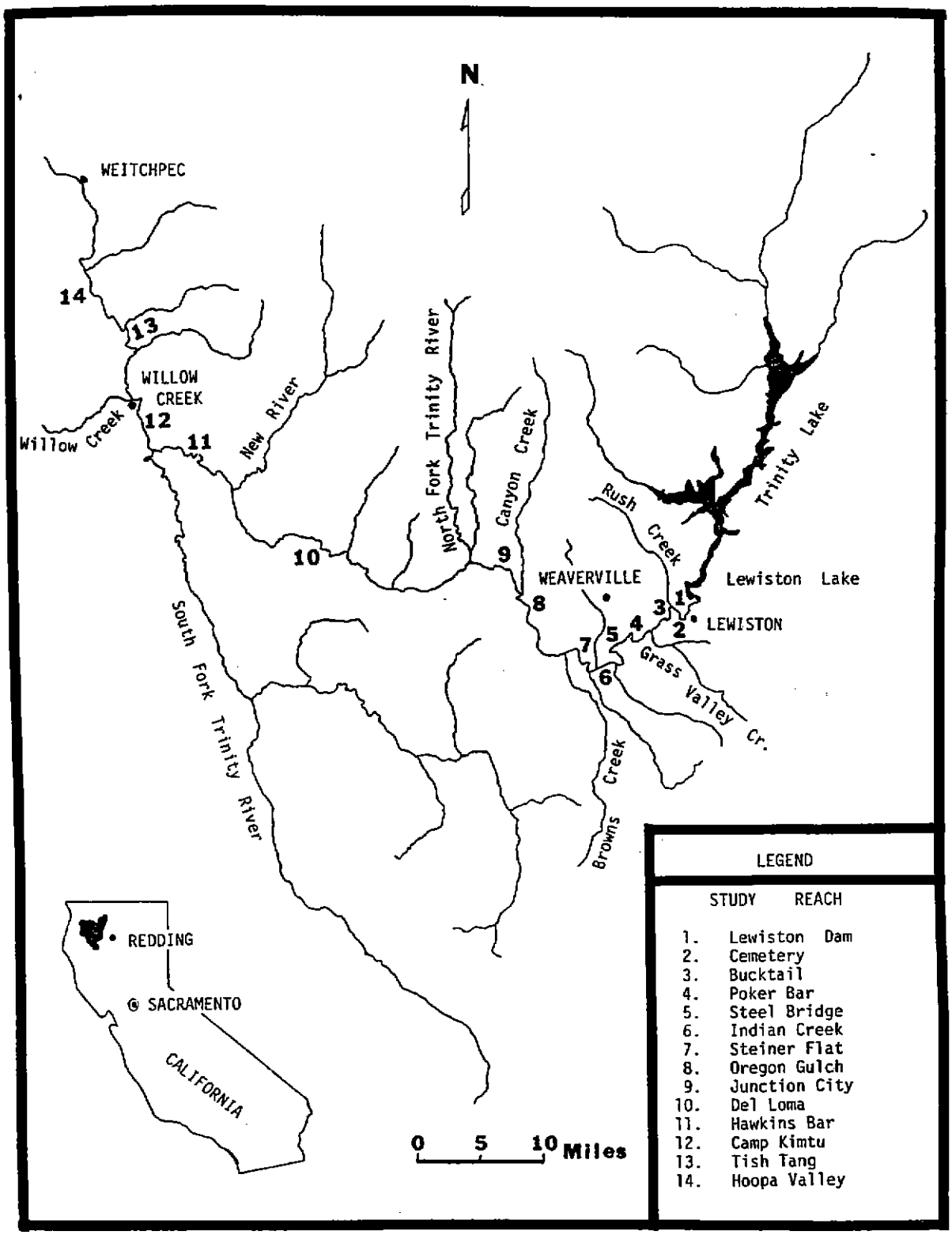


Figure 1. Trinity River Basin with Study Site Locations.

TRINITY RIVER FLOW EVALUATION
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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 in restoring fish populations and habitat below Lewiston Dam.

In May, 1991 the Secretary of Interior issued an amendment to this agreement, providing 340,000 acre-feet to the Trinity River in dry or wetter years, and in critically dry years "if at all possible."

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, substrate, 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 1990 and the end of 1991. The final section on program Planning and Coordination describes the focus of study efforts planned for 1992.

II. HABITAT AVAILABILITY AND NEEDS

ACTIVITIES IN THE MAINSTEM

In the winter of 1990-91 precipitation in the upper Trinity River watershed was minimal, and the availability of water for fishery releases was questionable until early in the spring. By late May, 1991, it was determined that approximately 290,000 acre-feet would be available under then-existing fishery flow provisions. Most of this water volume over that necessary for a base fishery flow was used for a 3,000 cfs release from May 28 through June 3. This high flow was expected to help maintain mainstem salmonid habitat by mobilizing gravel and increasing transport of accumulated sediments through the system. In addition, the high flow was timed to coincide with downstream migration of naturally-rearing chinook salmon, and with the release and emigration of chinook fingerlings from the Trinity River Hatchery.

Sand Transport Study

During the 3,000 cfs release, first-year field studies for our three-year investigation of sand transport mechanics below Grass Valley Creek were carried out. This study is a cooperative investigation between the Trinity River Flow Evaluation, the Johns Hopkins University, and the University of California, intended to combine recent research in sand-transport mechanics with high-flow field measurements to develop an estimate of habitat improvement provided by a range of feasible Lewiston flushing-flow releases.

Sand-transport study field work in 1991 included the installation of scour chains and marked-substrate MacNeil samples, codification of pre- and post-flow substrate materials, pre- and post-flow mapping of pools and profiling of river transects, and intensive measurement of three-dimensional flow patterns and bed-load movement during peak releases. Similar work is to be undertaken in 1992 and 1993, with results to be presented at the end of 1993.

Salmonid Habitat Studies

Since 3,000 cfs at Lewiston is representative of pre-project spring flow conditions, it is necessary to directly measure habitat at all up-river Instream Flow Incremental Methodology study sites before the termination of the Flow Evaluation. The short duration of the 1991 releases did not permit this, but evaluation of potential field methods was carried out. Results show that although habitat measurement at 3000 cfs is difficult, full evaluation will be possible during a high release lasting at least fifteen working days. Such a flow is consistent with use of fishery water for optimization of salmonid habitat and life-history requirements, and we expect to pattern 1993 spring releases to permit the required field investigations.

As flows dropped following the 3,000 cfs release, we surveyed the river from Lewiston to the North Fork for stranding of juvenile salmonids. No significant stranding was observed.

National Ecology Research Center Model

A developing adjunct to the Trinity River Flow Evaluation is the US Fish and Wildlife Service National Ecology Research Center (NERC) fish population model for the Trinity River. This model, an attempt to relate PHABSIM Weighted Usable Area (WUA) estimates with fish population responses, is under development based on field data from the Trinity River and the Gunnison River in Colorado. In 1991 we worked closely with NERC personnel, providing direct mainstem WUA measurements at a variety of flows, codifying and presenting habitat-

mapping data developed for mainstem habitat estimates, and coordinating efforts to relate population model results with Trinity River population observations. These efforts will continue through the remainder of the Flow Evaluation.

HABITAT AVAILABILITY IN CONSTRUCTED SIDE-CHANNELS

INTRODUCTION

The Trinity River Restoration Program has funded construction of ten side-channels along the Trinity River upstream of Junction City (Figure 1). Of the ten side-channels, the flow evaluation team has completed habitat evaluations on five: Cemetery, Rush Creek, Salt Flat, Bucktail, and Steiner Flat side-channels (USFWS, 1989; USFWS, 1990). During 1990 the Trinity River Restoration Program funded the construction of three new side-channels at Poker Bar, Steiner Flat, and on the Svensson property upstream of Junction City. In the spring and summer of 1991 we collected flow related habitat data for the Steiner Flat II and Svensson side-channels.

In our 1989 Annual Report we provided some recommendations to improve existing habitat in Cemetery, Bucktail, and Rush Creek side-channels. Specifically, we recommended the channelized sections of each side-channel be modified to increase hydraulic diversity and provide habitat at higher flows. Suggested modifications included construction of meanders, pool-riffle sequences, wing deflectors, and bank feathering. We also recommended placement of cobbles in selected areas to increase habitat for invertebrates, fry salmonids, and over-wintering juvenile steelhead trout. Following these guidelines the Trinity River Restoration Program manipulated habitat in the Cemetery and Bucktail side-channels in 1989. In 1990 we completed an evaluation of the habitat manipulation work in the Cemetery side-channel and found large increases in rearing habitat had been gained as a result of channel manipulation (USFWS, 1990).

In the summer of 1989, the Trinity River Restoration Program used heavy equipment to modify Bucktail side-channel. The channel was widened and the elevation of benches along the right edge of the channel were lowered so that they would become inundated under Trinity River base flow conditions (300 cfs). The Left bank of the channel was also feathered to increase habitat at higher flows. After the heavy equipment had finished excavating the channel, convict crews from the Trinity River Conservation Camp placed cobbles and small boulders in the channel to create velocity shelters and cover areas for rearing salmonids. The convict crews constructed cobble weirs, wing deflectors, and cobble mounds in various locations throughout the channel.

The goals of this report are: 1) to evaluate the habitat changes that have occurred in the Bucktail side-channel as a result of channel alterations conducted in 1989, and 2) to quantify the salmonid habitat flow relationship for the newly constructed Steiner Flat II and Svensson side-channels.

METHODS

In order to evaluate mechanically induced habitat changes in the Bucktail side-channel, we compared measured physical habitat on three transects before and after habitat manipulations were completed. To estimate weighted usable area (WUA) for rearing chinook salmon we multiplied measured transect data, depths and velocities, by habitat use criteria for fry and juvenile chinook salmon. This procedure eliminated the need to use hydraulic models and allowed for an accurate comparison of empirical data.

Salmonid habitat estimates for Steiner Flat II and Svensson side-channels were conducted using the U.S. Fish & Wildlife Service's Instream Flow Incremental Methodology (IFIM).

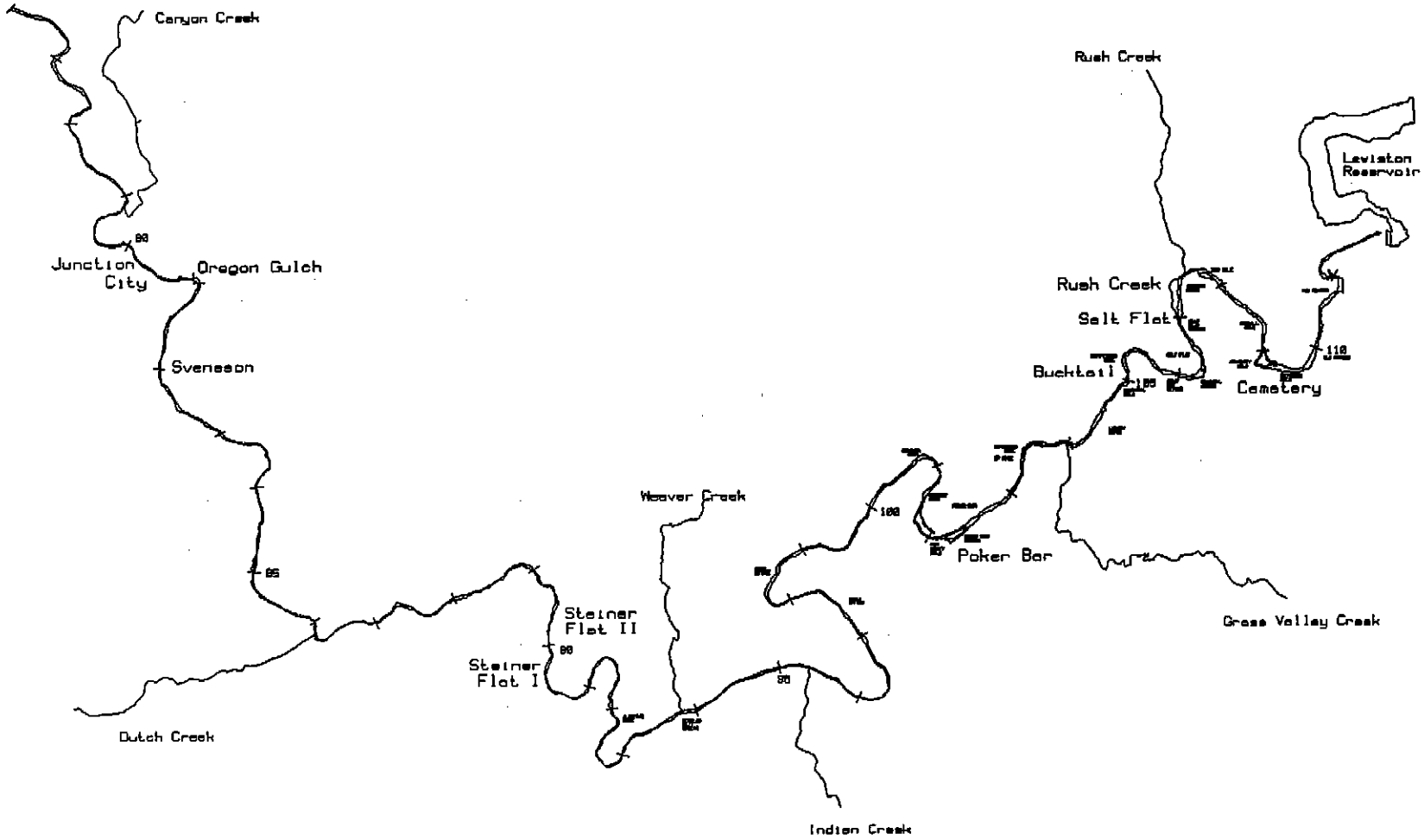


Figure 1. Location of artificial side-channels along the Trinity River, California, 1991.

Field data collection and computer simulations followed procedures recommended by the U.S. Fish & Wildlife Service's National Ecology Research Center (Bovee and Milhous, 1978; Bovee, 1982; Milhous et al., 1989). Water surface elevations and transect profiles were measured with a spirit level and leveling rod from established benchmarks. Mean column water velocities and depths were measured with a Price AA current meter and wading rod. Side-channel hydraulics were simulated using the IFG-4 computer model. Chinook salmon rearing habitat was estimated through the Physical Habitat Simulation System's HABTAT program, using habitat preference criteria developed by Hampton (1988).

Habitat determinations for each side-channel were made in coordination with Trinity River Restoration Program staff. Habitat types were delineated based on the similarity of physical channel characteristics, depth, velocity, width, and cover. After habitat types were selected, Trinity River Restoration Program staff randomly selected fish population sampling sites within each habitat type. IFIM transects were then selected within each fish population sampling site. In habitat types that contain diverse velocity profiles, such as riffles, more than one transect was selected in order to improve the precision of our habitat measurements.

STUDY SITES

Bucktail Side-Channel

The Bucktail side-channel is located at river mile 105, just upstream of Browns Mountain Road Bridge. The side-channel is approximately 541 feet long with an overall bed slope of 0.38 percent. Prior to habitat manipulation, the side-channel was composed of two low-gradient riffles separated by a pool. In our 1989 evaluation we divided the side-channel into three sections. The upper and lower sections were described as low-gradient riffles with cobble and gravel substrate embedded in approximately 50 percent sand. The middle section contained a pool and large backwater. One transect was selected in each section to estimate the total salmonid habitat available in the side-channel. To evaluate habitat changes that resulted from mechanical manipulation of the channel, we collected a second set of hydraulic data on the same transects that were used in 1989.

Steiner Flat II Side-Channel

The Steiner Flat II side-channel was constructed by the Bureau of Land Management with funding from the Trinity River Restoration Program and was completed in the summer of 1990. The side-channel is located on the bar downstream of Steiner Flat I side-channel (RM 89). The side-channel is 2,611 feet long with a bed slope of 0.13 percent. The side-channel contains three major habitat types, run, moderate-gradient riffle, and low-gradient riffle. The run habitat was further broken down into secondary types to better represent specific channel characteristics or mesohabitat types. The secondary run mesohabitat types are standard run, wide run, narrow run, and split channel run. Run habitat types comprise 88 percent of the side-channel. In order to estimate available salmonid habitat in the side-channel, one transect was placed in each of the four run mesohabitat types. In order to increase the accuracy of our WUA estimates in the riffle habitats, we selected four transects to represent these areas.

Svensson Side-Channel

The Svensson side-channel was constructed by the Trinity River Restoration Program in January of 1991. The side-channel is located upstream of Junction City on the Svensson property, at river mile 82. The side-channel is 1709 feet long and is comprised of moderate-gradient riffles, low-gradient riffles, and runs. One transect was selectively placed in each habitat type in a location that was believed to best represent hydraulic characteristics of that habitat type.

RESULTS AND DISCUSSION

Bucktail Side-Channel

Mechanical manipulation of the Bucktail side-channel increased wetted surface area in riffle habitat sections by over 50 percent and increased surface area in the pool/backwater section by over 100 percent (Figure 2). Increased wetted area and reduced water velocities increased the amount of WUA for rearing chinook salmon by more than 300 percent (Figure 3). A snorkel survey on July 2, 1991 verified extensive use of the side-channel by fry and juvenile salmonids. Side-channel flow during our survey was approximately 28 cfs. During the survey we observed numerous juvenile steelhead and brown trout focalized within and behind the various cobble structures. Fry steelhead trout were abundant along slow edge-water habitat in the upper and lower sections of the channel. Although the majority of juvenile chinook salmon migrate downstream before July, some salmon were observed feeding along shear zones and backwaters that were created by wing defectors and cobble piles.

The cobble weir at the upper end of the channel has reduced the discharge into the side-channel in relationship to flows in the mainstem. Prior to construction of the cobble weir, Trinity River flows of 300 cfs contributed 26 cfs to the Bucktail side-channel. Under current conditions only 4 cfs enters the side-channel. Even though fry and juvenile chinook salmon prefer slow water microhabitats, the quality of those microhabitats is greatly enhanced when they are located in close proximity to high velocity areas. Under 4 cfs flows the side-channel contains almost no habitat diversity and provides only limited value to rearing salmon and trout. In order to improve rearing habitat in the side-channel, we recommend the upper most cobble weirs be dismantled and the cobbles be distributed along the bottom of the channel. Removal of the upper weir will lower the elevation of the hydraulic control in the side-channel allowing more water to enter. Higher flows will increase the amount of habitat diversity and improve rearing conditions.

Steiner Flat II Side-Channel

Six discharges were measured in the Steiner Flat II side-channel between February and October of 1991. Measured discharges equaled 5, 7, 9, 18, 24, and 271 cubic feet per second. In order to predict daily side-channel flows a regression was calculated between Trinity River flows near Junction City and side-channel flow (Table 1). Trinity River flows were obtained from a stage-discharge relationship at the U.S. Fish & Wildlife Service's rotary fish trapping site at river mile 82.

Total chinook salmon WUA is presented in Figure 4. Fry chinook salmon WUA decreases with increasing flow. Juvenile chinook salmon WUA increases with flow until 25 cfs is reached at which time WUA for juvenile chinook salmon peaks. Between flows of 25 cfs and 100 cfs, juvenile chinook salmon WUA gradually declines. At flows above 100 cfs juvenile chinook salmon WUA remains stable. Chinook salmon spawning WUA peaks at approximately 50 cfs.

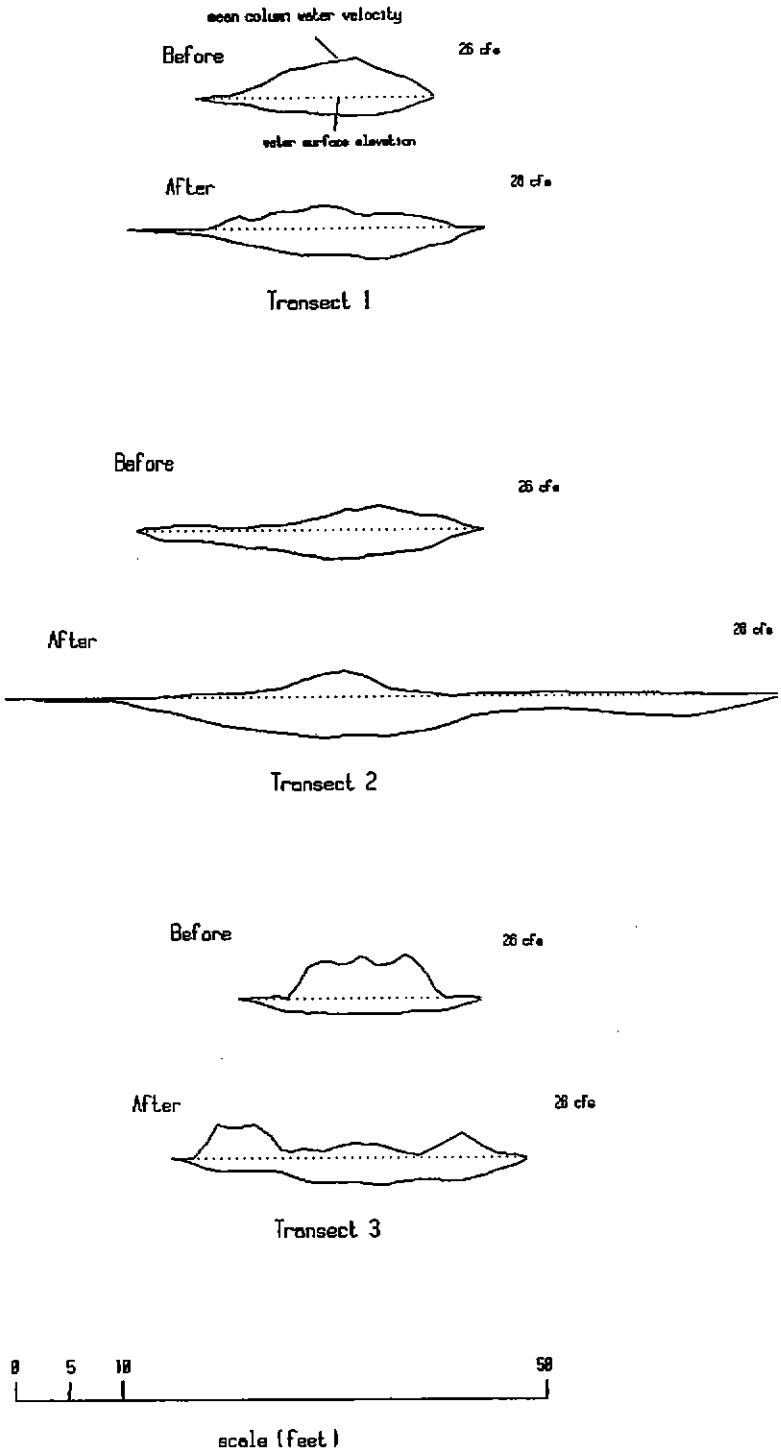


Figure 2. Depth and velocity profiles for three transects in the Bucktail Side-channel before and after mechanical manipulation of the channel's morphology.

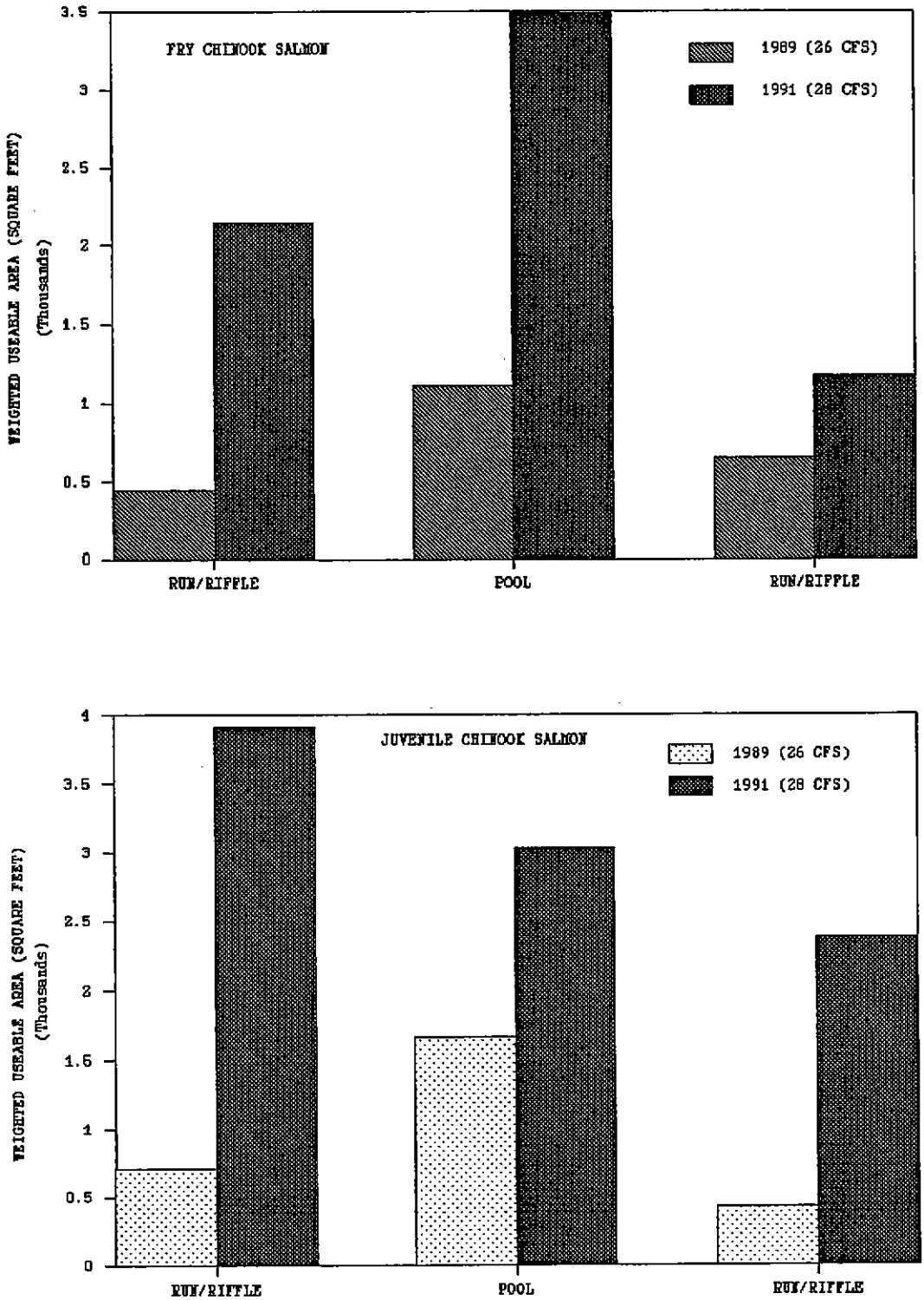


Figure 3. Total weighted usable area for fry and juvenile chinook salmon available in the Bucktail Side-channel before and after habitat manipulation conducted in 1989.

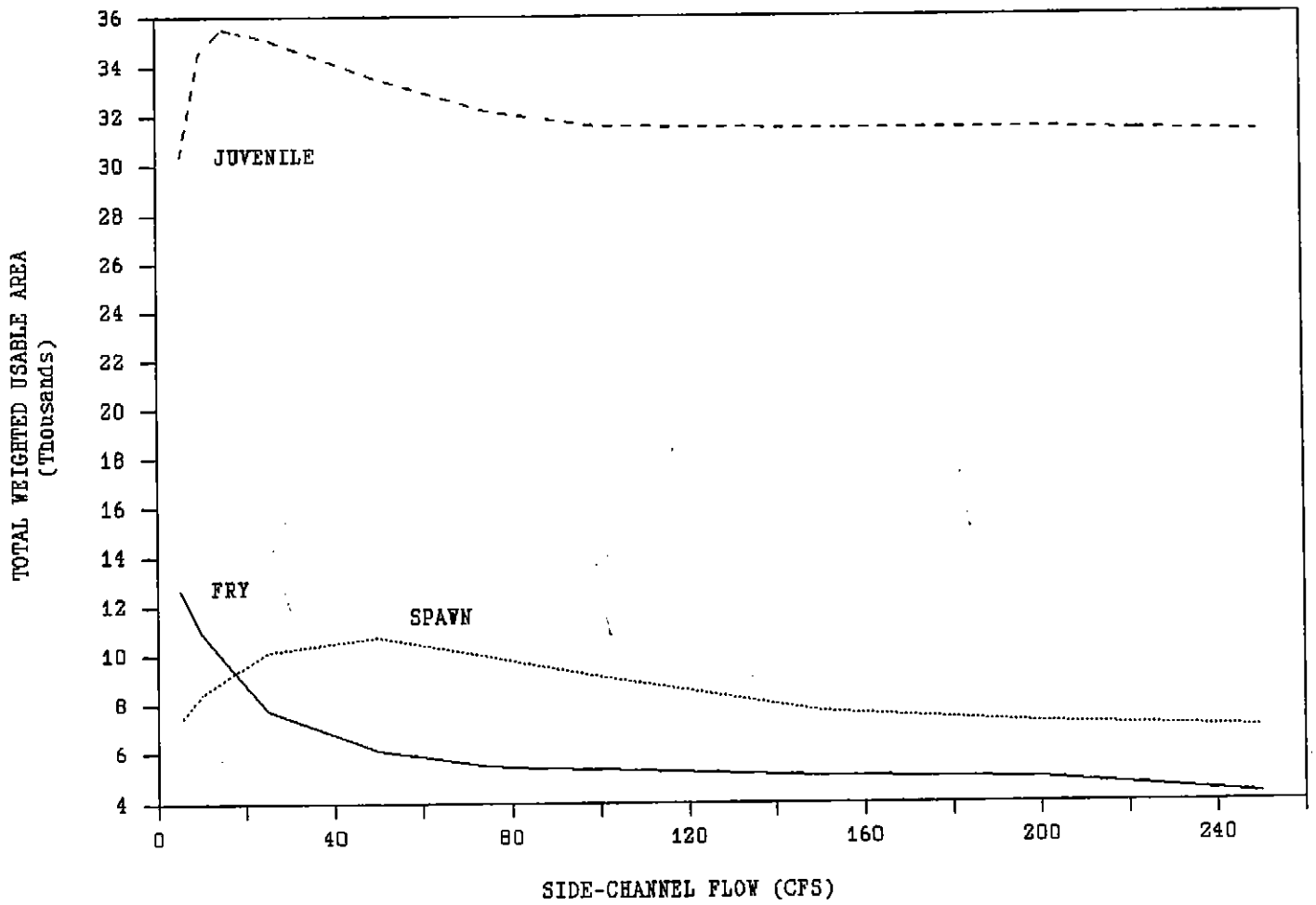


Figure 4. Chinook salmon habitat (WUA) versus flow relationship for the Steiner Flat II Side-channel, 1991.

Table 1. Trinity River flow (cfs) and predicted flow (cfs) for the Steiner Flat II side-channel.

Trinity River	Side-channel	Trinity River	Side-channel
150	1.3	500	11.9
200	2.2	750	24.7
250	3.3	1000	41.7
300	4.6	1500	87.2
350	6.2	2000	147.1
400	7.9	2500	220.9
450	9.7	3000	307.8

Where: $\text{Log}(SQ) = -3.219487 + 1.64893(\text{Log}(RQ))$
SQ = Side-Channel Flow
RQ = Trinity River Flow

Since fry chinook salmon prefer zero water velocities, it is not surprising to discover that fry WUA predictions are greatest at stage of zero flow. Under these conditions the entire channel would contain a series of ponds located upstream of hydraulic controls. Such conditions do not create viable habitat for fry chinook salmon even though WUA predictions indicate otherwise. The reason is that WUA calculations consider only depth, velocity, and substrate or cover. Other variables such as food production, water quality, adjacent habitat, and temperature are not directly used in the calculation of WUA, but have a major effect on habitat quality. In our investigations we have found that adjacent microhabitat can have a significant influence on habitat capacity for fry and juvenile chinook salmon (USFWS 1989). Mesohabitats that contain some velocity diversity such as backwaters, pocket waters, and velocity shear zones consistently support higher densities of fry and juvenile chinook salmon. Long slow-velocity habitats do not contain the longitudinal or cross sectional velocity diversity that is required to create optimum rearing habitat.

During high flows, eddies and backwaters form downstream of cobble islands and peninsulas creating good quality rearing habitat in the split channel and wide run mesohabitats. Rearing habitat also improves in the low gradient riffle mesohabitat as feathered edges become inundated creating shear zone and eddy microhabitats (Figure 5).

In its present condition, the Steiner Flat II side-channel contributes only minimal amounts of salmonid rearing habitat. The current design allows only 5 cfs into the channel during Trinity River base flows of 300 cfs. Visual surveys of the channel in August saw only two juvenile brown trout using the side-channel. We did see several schools of sucker fry holding in the warm edge water areas in the run mesohabitats.

Higher discharges are needed if the cobble islands and split channel areas are to become effective habitat features by creating velocity shear zones. Higher flows are also necessary to improve rearing, spawning and invertebrate habitats in the low-gradient riffle mesohabitats that are located in the lower half of the side-channel. To improve rearing habitat we suggest that the side-channel be modified so that a minimum of 20 cfs flows through the channel during Trinity River base flows of 300 cfs. This may be accomplished by lowering the elevation of

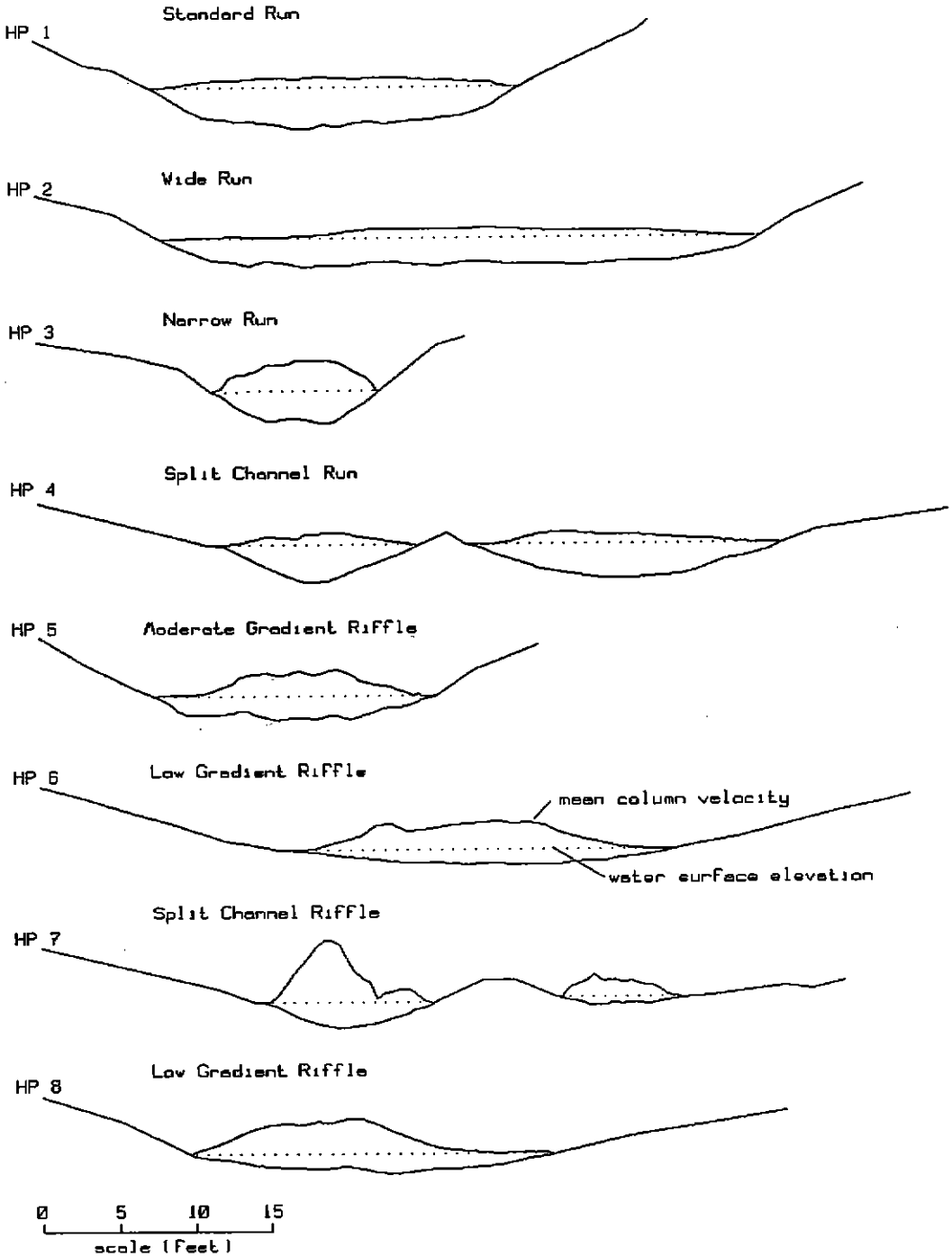


Figure 5. Transect profiles in the Steiner Flat II Side-channel showing water depth and mean column velocity during flows equal to 26 cfs.

the existing hydraulic control in the upper half of the side-channel. Figure 6 is a map of the longitudinal thalweg profile which shows the current location of all the hydraulic controls in the side-channel. The hydraulic control that currently regulates flow into the side-channel is located approximately 570 feet below the mouth of the side-channel. If flows are to be increased into the side-channel, bed elevations along this control will have to be lowered with heavy equipment. We further recommend that the longitudinal slope of the side-channel be redesigned to improve the distribution of mesohabitats along the side-channel to create some longitudinal diversity. All of the riffle habitats are currently located at the bottom of the side-channel. The side-channel should be redesigned so that riffle habitats are distributed in short sections through out the side-channel. This would result in a better distribution of high quality rearing micro-habitats, food production areas, and spawning areas in the side-channel.

Placement of cobble substrate and large woody debris in selected areas of the side-channel would improve rearing and over-wintering habitat for juvenile salmonids. Currently the side-channel lacks any significant amount of cover.

We monitored water temperatures in the side-channel and mainstem Trinity River for approximately two weeks in August and September in order to document water temperatures in the side-channel under low flow conditions (Figure 7). We found that daily mean water temperatures in the side-channel were approximately two degrees higher than the mainstem, and daily maximum water temperatures were sometimes as much as six degrees warmer than the mainstem. As a result of low flows, daily side-channel temperatures fluctuated much more than main river temperatures. Reiser and Bjornn (1979) state the preferred temperature range for juvenile chinook salmon and steelhead trout exists between 45 and 58 degrees Fahrenheit. The upper lethal limit for chinook salmon juveniles is 77.4°F and for steelhead trout juveniles is 75.4°F. During our monitoring, water temperatures in the side-channel did not exceed the lethal limits for either chinook salmon or steelhead trout juveniles. The lack of use of the side-channel by juvenile salmonids in the summer is probably more closely related to poor habitat conditions resulting from low flows rather then water temperatures. By increasing flows into the side-channel, not only will habitat improve, but daily water temperature fluctuations will be moderated.

Svensson Side-Channel

We measured habitat data in the Svensson side-channel during flows of 37, 48, 126, and 285 cubic feet per second. The flow relationship between the main stem Trinity River and Svensson side-channel was calculated by using a log regression equation (Table 2).

Total chinook salmon habitat estimates for the Svensson side-channel are presented in Figure 8. Fry and juvenile chinook salmon WUA decrease with increasing flow in all habitats except the moderate gradient riffle, where WUA begins to increase at flows over 100 cfs. Spawning chinook salmon WUA is greatest for flows between 40 and 80 cfs in the run and low-gradient riffle mesohabitats. We observed chinook salmon spawning in the run mesohabitat during October.

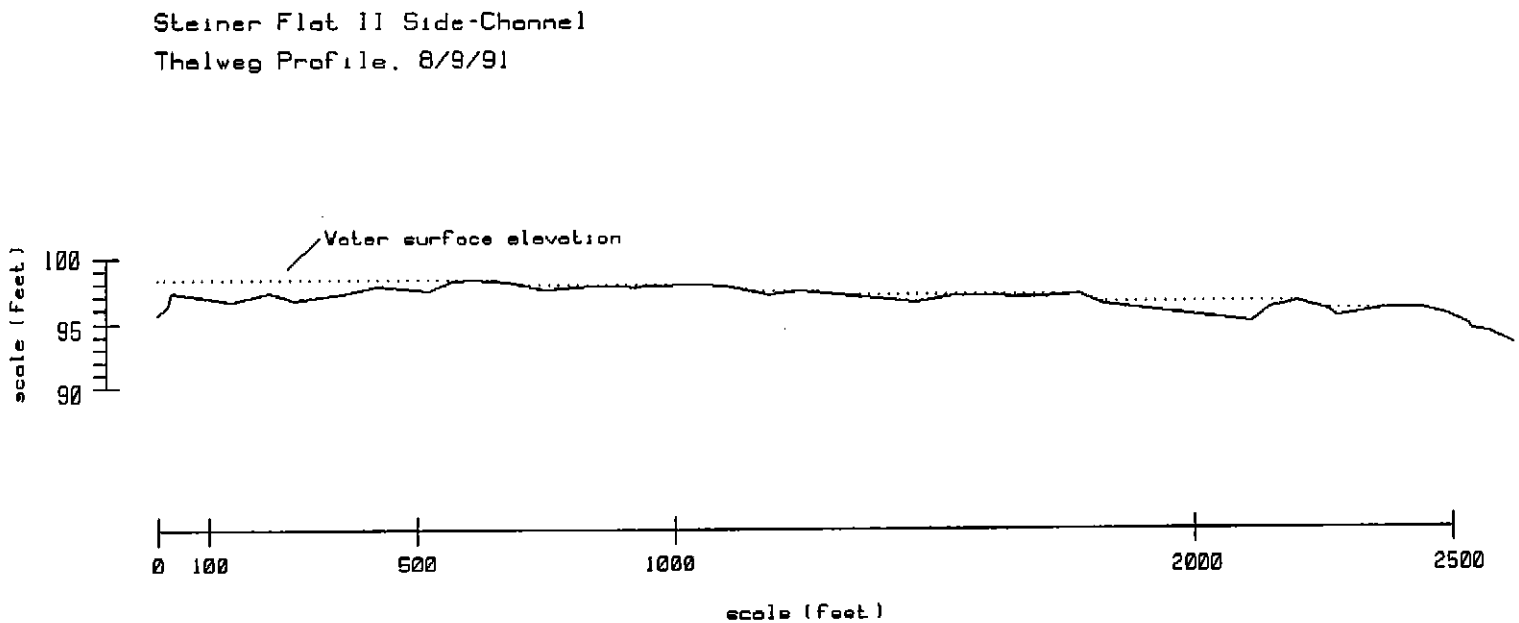


Figure 6. Longitudinal thalweg profile and predicted water surface elevation at zero flow in the Steiner Flat II side-channel, 1991.

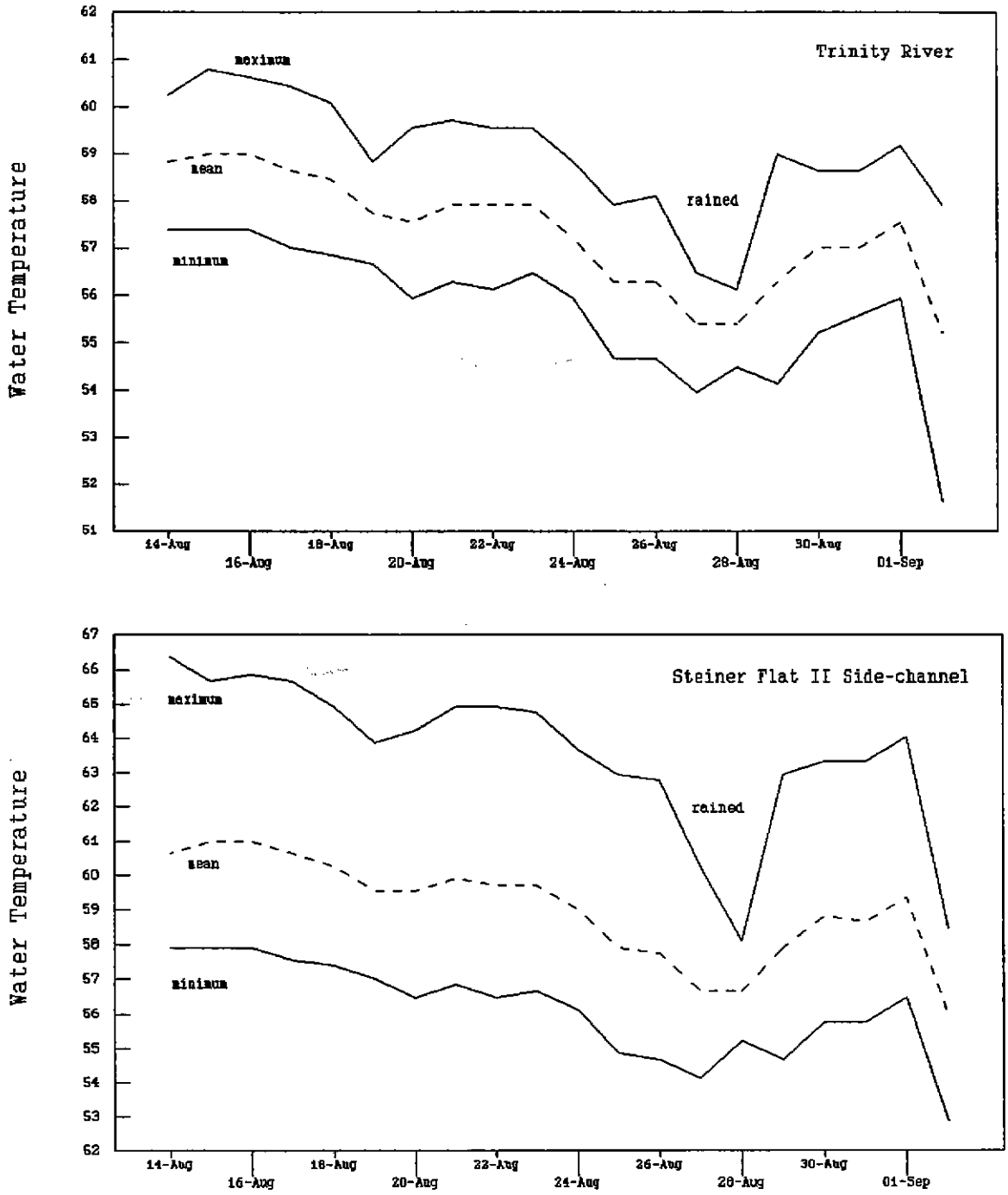


Figure 7. Daily water temperatures in the Trinity River and Steiner Flat II Side-channel measured in the summer of 1991.

Table 2. Trinity River flow (cfs) and predicted Svensson side-channel flow (cfs) as estimated by a log regression equation.

Trinity River	Side-channel	Trinity River	Side-channel
150	1.6	400	19.0
200	3.3	450	25.6
250	5.8	500	33.4
300	9.1	750	93.3
350	13.5	1000	193.5

Where: $\log(SQ) = -5.31704 + 2.53457(\log(RQ))$
SQ = Side-channel flow
RQ = Trinity River flow

The side-channel has been exposed to high flows on two occasions since its construction in January of 1991. In May 1990, 3,000 cfs flows were released below Lewiston Dam. Flows in the Svensson side-channel during this release were 285 cfs. Flows in this range did not cause any major changes in the side-channel's bed morphology. Some sand was scoured from high velocity thalweg areas and redeposited in backwaters and slow moving edge water areas. We recommend placement of cobbles in areas of the side-channel where sand deposition did not occur at higher flows. Cobble placement will improve invertebrate production and create additional rearing habitat for salmon and over-wintering habitat for juvenile steelhead. Cobbles should not be placed in the side-channel above the upstream hydraulic control where they might reduce flows entering the side-channel.

Habitat in the side-channel could be improved by increasing the number and diversity of mesohabitats longitudinally along the side-channel. Currently, the side-channel contains two major blocks of homogeneous mesohabitats (Figure 9). The upper channel contains run mesohabitat with an occasional hydraulic control forming short riffle break points. The lower half of the side-channel is comprised of a low gradient riffle. Construction of additional riffles in the upper section and pools or runs in the lower section would result in a greater amount of longitudinal diversity resulting in higher quality rearing habitat. The lower riffle provides little rearing habitat for fry and juvenile chinook salmon because there is a lack of roughness elements in the channel to create slow water velocity microhabitats. Placement of large woody debris, boulders, or cobble clusters would improve rearing habitat in this section.

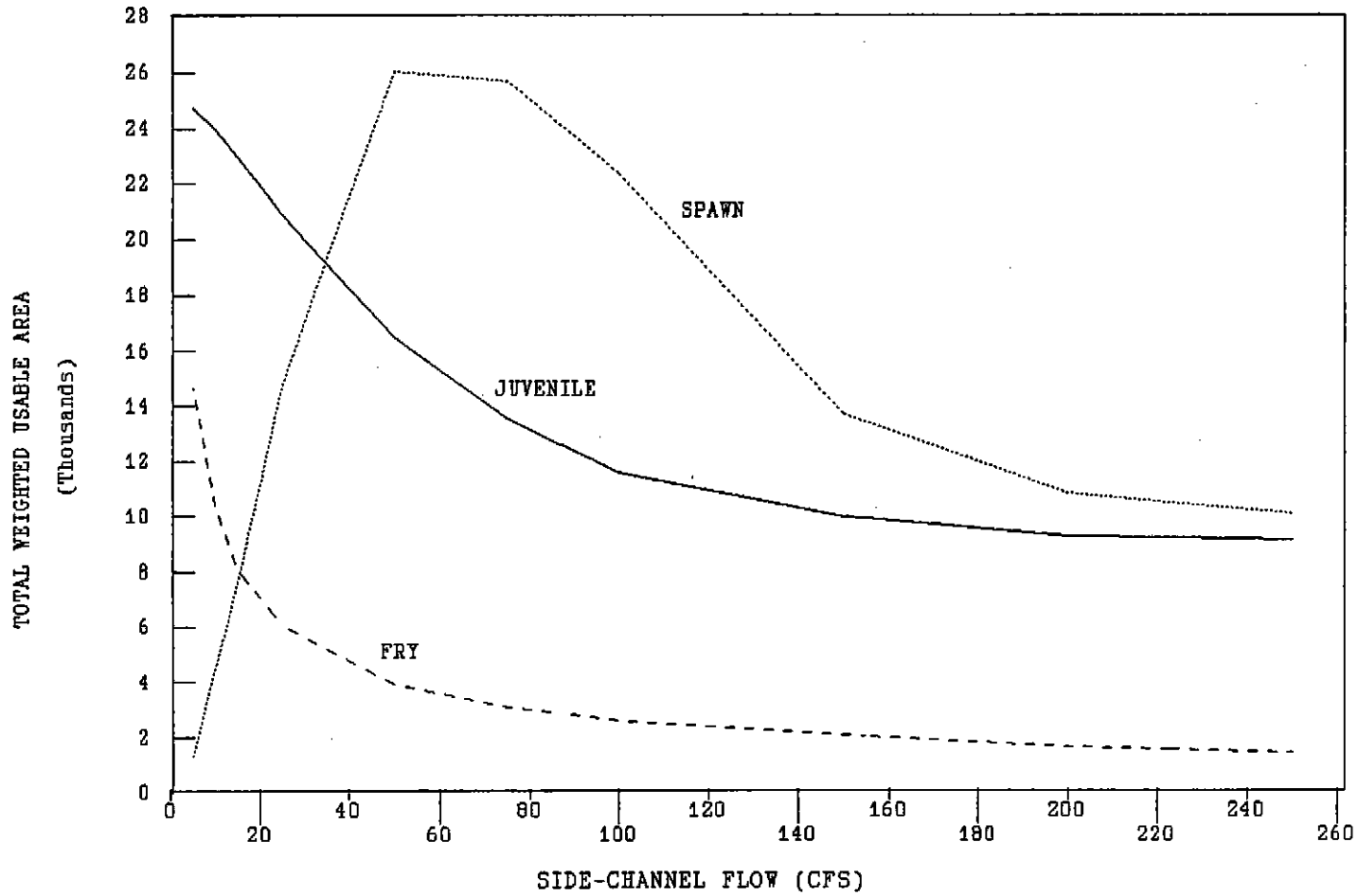


Figure 8. Weighted usable area versus flow relationship for chinook salmon in the Svensson Side-channel, 1991.

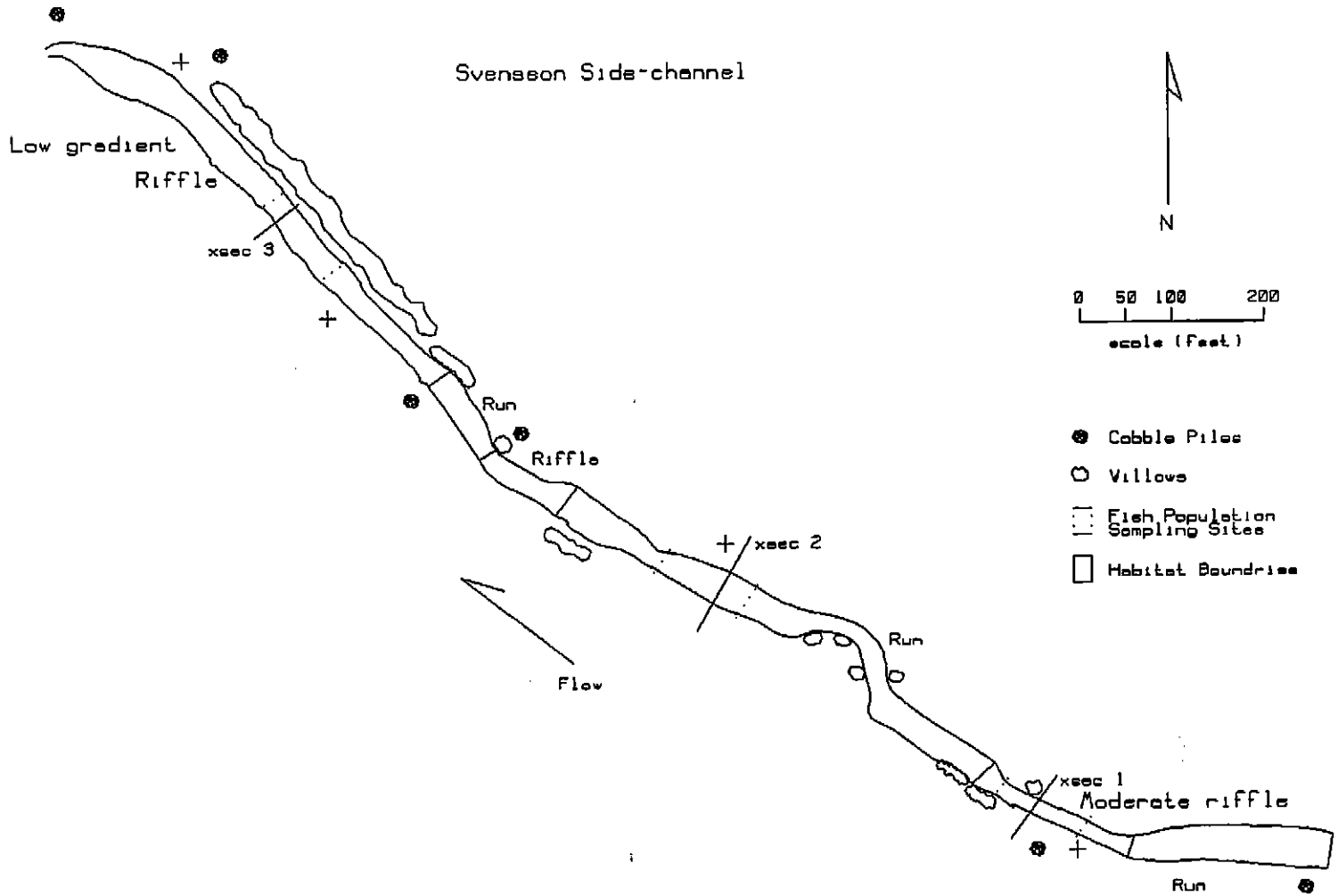


Figure 9. Map of the Svensson side-channel on the Trinity River at river mile 82. 1991.

COMPARISON OF WUA AND DENSITIES OF JUVENILE CHINOOK SALMON

INTRODUCTION

The Trinity River Flow Evaluation uses the Instream Flow Incremental Methodology (IFIM) to evaluate the effects of flow and habitat restoration activities on anadromous salmonid habitat. The IFIM can be thought of as a collection of computer models and analytical procedures designed to predict changes in fish habitat due to increments of flow change (Bovee 1982). As part of the IFIM, the Physical Habitat Simulation system (PHABSIM) links macrohabitat measurements, or predictions, in terms of channel structure and discharge, with a species microhabitat suitability, described in terms of depth, velocity, and a channel index such as cover or substrate, to estimate the total habitat or weighted usable area (WUA) available for a species life stage. A basic assumption of the IFIM is that by optimizing the quantity and quality of available microhabitat (WUA), a beneficial response in fishery populations will result.

In a survey concerning instream flow issues, one of the most commonly reported needs for instream flow research included testing of the relationship between flow, habitat, and fish production (Reiser et al. 1989). Intuitively, it seems logical that those microhabitats where a species lifestage is most frequently observed, those most suitable, would also support the greatest densities of that species lifestage. However, verification of the relationship between WUA and fish standing crop has proven to be a difficult task (Scott and Shirvell 1987; Conder and Annear 1987; Orth and Maughan 1982; Wolff et al. 1990). Factors that may complicate the verification of the relationship between WUA and fish biomass include interspecies competition, predation, food availability, harvest, and short duration habitat limiting events such as flood flows or stream dewatering (Orth 1987).

In California, there has been considerable effort on the part of various investigators to develop salmonid population models (Hagar et al. 1988, EA Engineering, Science, and Technology, Incorporated 1991, and Cheslak and Jacobson 1990). In 1990, the National Ecology Research Center initiated efforts to develop a population model that will link existing habitat and stream temperature models to predict production of chinook salmon presmolts from the upper Trinity River. The development of a population response model on the Trinity River will improve our ability to conduct limiting factor analysis, evaluate habitat restoration projects, and generate more effective flow recommendations to optimize fishery populations.

Calibration and verification of any IFIM based population model for anadromous salmonids will require that the relationship between WUA and standing crop be described for each freshwater lifestage. For the last three years the Trinity River Flow Evaluation has been attempting to describe habitat-fish density relationships for early life stages of anadromous salmonids. In our side channel evaluations we described relationships linking mesohabitat quality with fry and juvenile chinook salmon standing crop (USFWS 1990). In 1989 we concentrated our efforts on trying to describe the relationship between the predicted composite suitability index for individual habitat cells and use of habitat cells by juvenile chinook salmon (USFWS 1989). When the National Ecology Research Center selected the Trinity River as one of two sites to develop an IFIM based population model, we concentrated our efforts in the spring of 1991 on further describing the relationship between habitat availability and habitat use of juvenile chinook salmon.

METHODS

Fifteen transects were sampled within four study sites along the upper Trinity River at Cemetery (RM 109), Bucktail (RM 105), Poker Bar (RM 102) and Steel Bridge (RM 99). Field data was

collected following the procedures recommended by the U.S. Fish & Wildlife Service (Bovee and Milhous, 1978). Distance to vertical sampling locations were measured with a tape from established iron head pins. Total depths were measured with a top setting wading rod and mean column velocities were measured with a Price AA current meter.

Computation of Weighted Usable Area

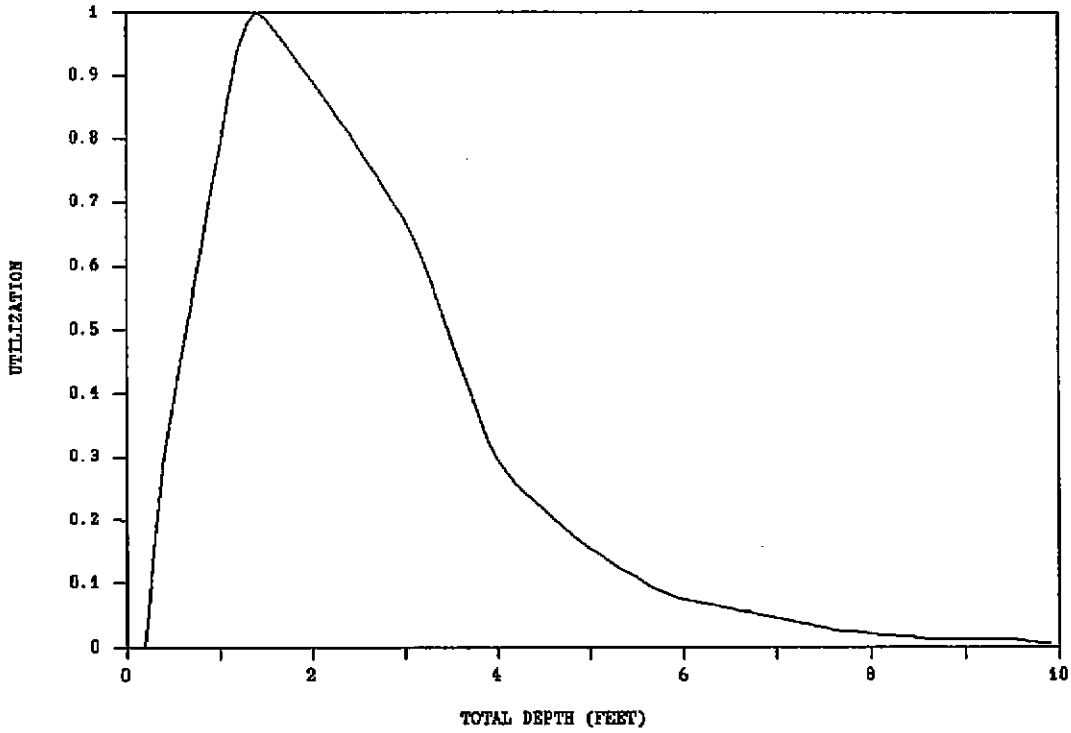
Because of stable flow conditions, hydraulic models were not used to simulate depth and velocity values across each transect. To calculate WUA, we multiplied actual field data by habitat use criteria. This was done using procedures similar to the PHABSIM system. The total depth and mean column velocity for each habitat cell was calculated by averaging the measured depth and mean column velocity of adjacent verticals. The composite suitability index for each cell was then calculated by multiplying the habitat cell depth and mean column velocity by habitat use criteria. The habitat utilization criteria used to calculate the composite suitability index were developed by Hampton (1988) using direct observation on the Trinity River (Figure 1). Only depth and mean column velocity criteria were used in the calculation of the composite suitability index. No channel index values (substrate or cover) were used. Cell Weighted Usable Areas were then determined by multiplying the Composite Suitability Index by the cell area. The total WUA for each mesohabitat equaled the sum of the cell WUAs across the transect.

So that we could visually inspect the entire microhabitat cell during underwater observations, all cells were limited to 6 feet in length. Cells ranged in area between 12 and 42 square feet. The corners of each habitat cell were marked with numbered white cobbles so that they could be easily located and identified by underwater observers.

Direct Observation Techniques

Across each transect, juvenile chinook salmon use was determined by snorkel divers. Each day, prior to sampling, ropes were strung across each transect approximately three to four feet above the water surface. After allowing the ropes to rest undisturbed for a minimum of 30 minutes, one diver would cautiously approach the line from downstream and attach a pulley and hand line. The diver would then use the hand line to suspend downstream from the transect to observe fish within habitat cells (Figure 2). The divers controlled movement across the transect by slowly angling their bodies against the current. The number of juvenile chinook salmon in each cell was then counted and recorded on an underwater slate. Each transect within the study site was sampled once by each diver each sampling day. In 1991 all sampling was conducted after 12:00 noon to coincide with peak activity levels of juvenile chinook salmon and insure full use of all available microhabitats (USFWS 1989).

Observations of fish use were made between 6 April and 19 April of 1989 and between 1 May and 23 May of 1991. In 1989, we sampled five transects at the Cemetery study site on eleven occasions for a total of 55 transect counts. In 1991, we sampled four transects at Cemetery study site, four transects at Bucktail study site, three transects at Poker Bar study site, and four transects at Steel Bridge study site. With the exception of the Cemetery study site, all transects were sampled on four occasions for a total of 54 transect counts.



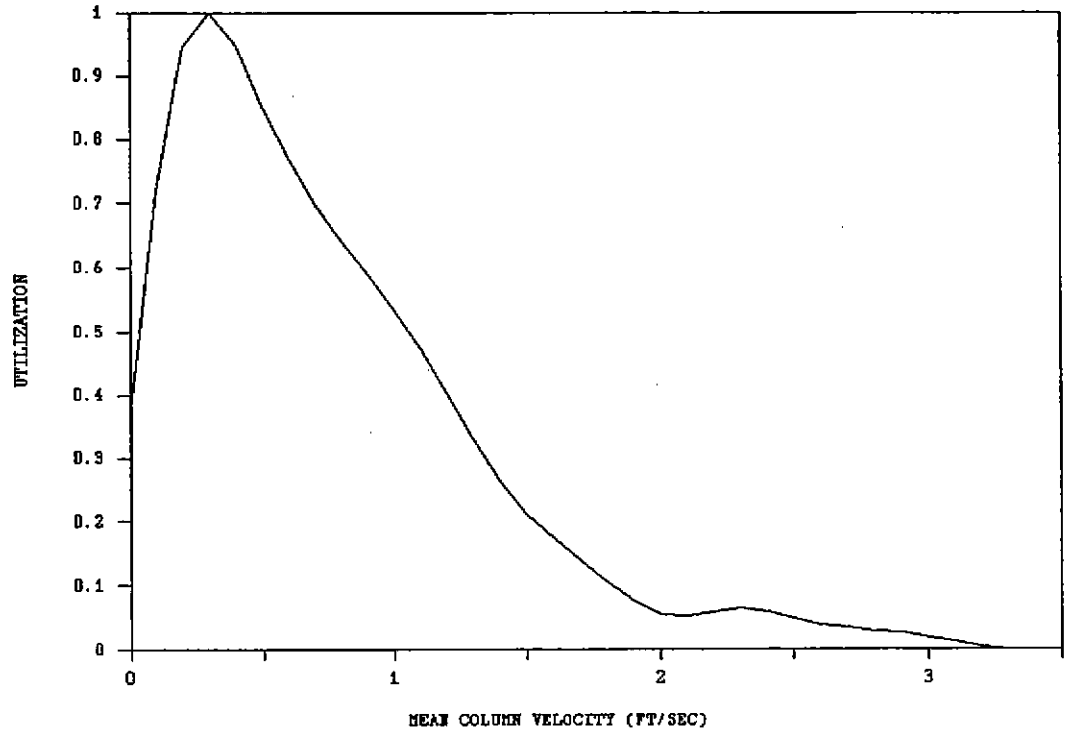


Figure 1. Habitat use criteria for juvenile chinook salmon in the Trinity River.

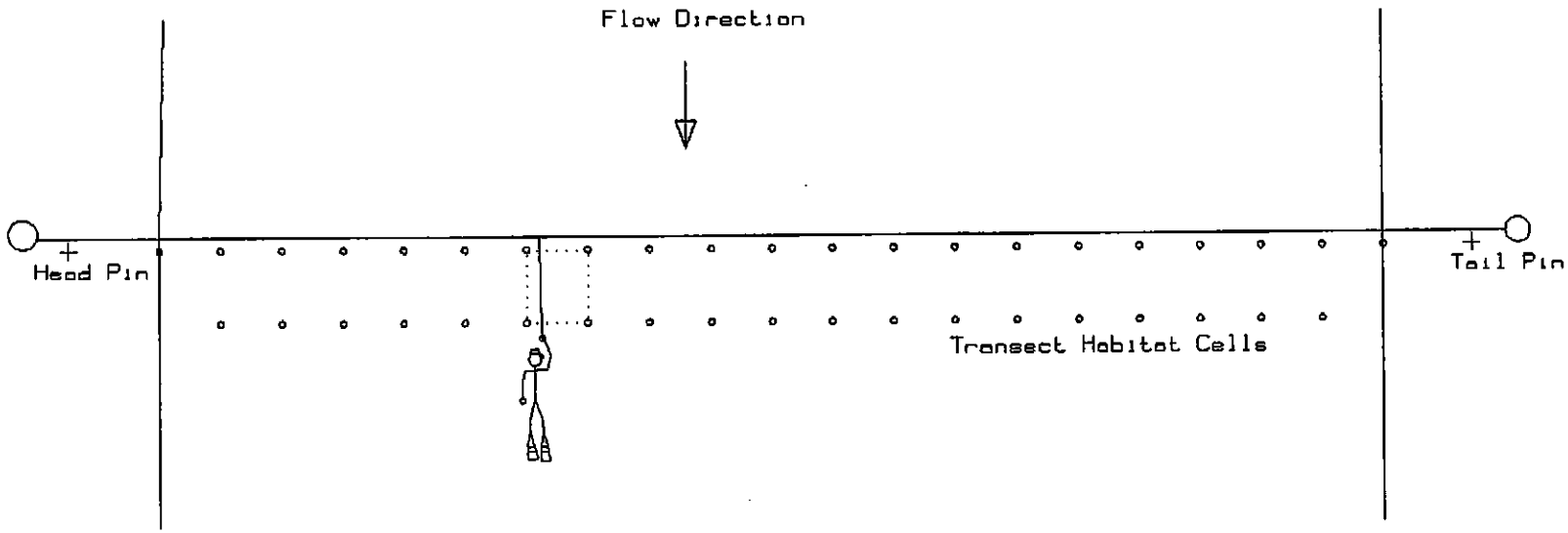


Figure 2. Top view of 'Tinkerbell' line transect sampling method used to conduct observations of juvenile chinook salmon habitat use across IFIM transects in the upper Trinity River.

Microhabitat Data Analysis

Observed densities of juvenile chinook salmon were paired with their respective microhabitat cell. All habitat cells were then sorted based on the amount of weighted usable area calculated for each cell. Sturges' Rule (Sturges 1926) was then used to determine the optimum interval size to place calculated cell weighted useable areas. Mean densities of juvenile chinook salmon and 95% confidence intervals were determined for each interval. To determine if cell WUA had an influence on fish density, a regression analysis was conducted between mean fish density and cell weighted usable area.

In order to compare our finding in 1991 with data collected in 1989, the 1989 data were analyzed using the methods described here. Data collection procedures were the same in both years.

RESULTS

Diver Precision

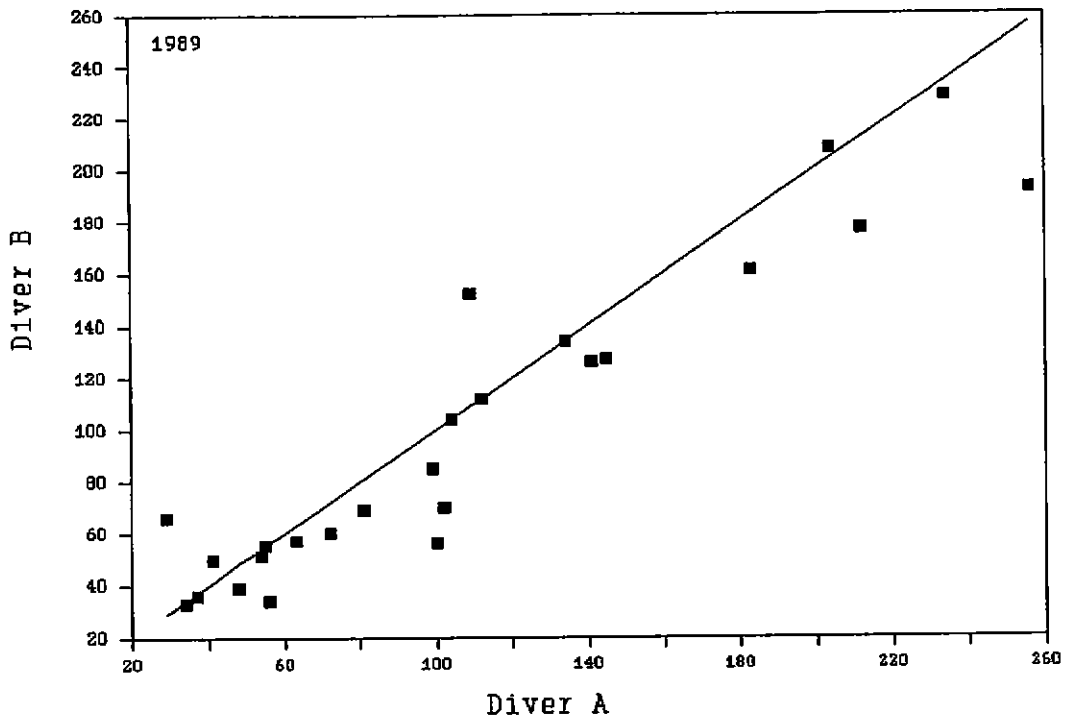
Juvenile chinook salmon proved to be an ideal candidate for this type of validation study because they were relatively abundant and were rarely frightened or disturbed by snorkel divers. When fish were disturbed, we found that in most cases, if the diver remained motionless, juvenile chinook redistributed themselves across habitat cells and resumed normal feeding behavior within one or two minutes.

A comparison of diver transect counts for 1989 and 1991 are presented in Figure 3. Figure 3 includes a line of equality identifying the value where both Diver A and Diver B counts are equal. We found significant correlation between divers in both 1989 ($r=0.94$) and 1991 ($r=0.95$). Snorkel counts could not be calibrated with other sample methods, such as seining or electro-fishing, because the river is too large to sample effectively with these methods. Differences in counts between divers are probably real, since fish were free to move in and out of habitat cells as they chose.

Microhabitat Use

Figure 4 shows the relationship between WUA in habitat cells and the average density of juvenile chinook salmon observed per habitat cell in 1989 and 1991. Linear regression analysis of habitat cell WUA versus mean fish density for 1989 ($R^2=0.89$) and 1991 ($R^2=0.72$) describe a relationship between microhabitat quality, as described by depth and velocity use criteria, and numbers of juvenile chinook salmon. Based on these relationships, approximately 0.103 and 0.019 juvenile chinook salmon per square foot of WUA were present in 1989 and 1991, respectively. The density of juvenile chinook salmon per square foot of WUA in 1991 was 82 percent less than in 1989. In high quality microhabitat cells, those cells where WUA and surface area were nearly equal, the density of juvenile chinook salmon in 1989 was 0.501 fish per square foot of WUA, and in 1991 it was 0.215 fish per square foot of WUA, a decrease of 57 percent.

Three transects at the Cemetery study site, a run (C1), riffle (C2), and pool (C9), were sampled in both 1989 and 1991. A comparison between mesohabitat transects sampled in the Cemetery study site in 1989 and 1991 found that the average number of juvenile chinook salmon was 53 percent less in 1991 than in 1989 (Figure 5). In both years the run mesohabitat (C1) supported the greatest number of fish per square foot of WUA. Approximately 0.96 fish per square foot of WUA in 1989 and 0.52 fish per square foot of WUA in 1991.



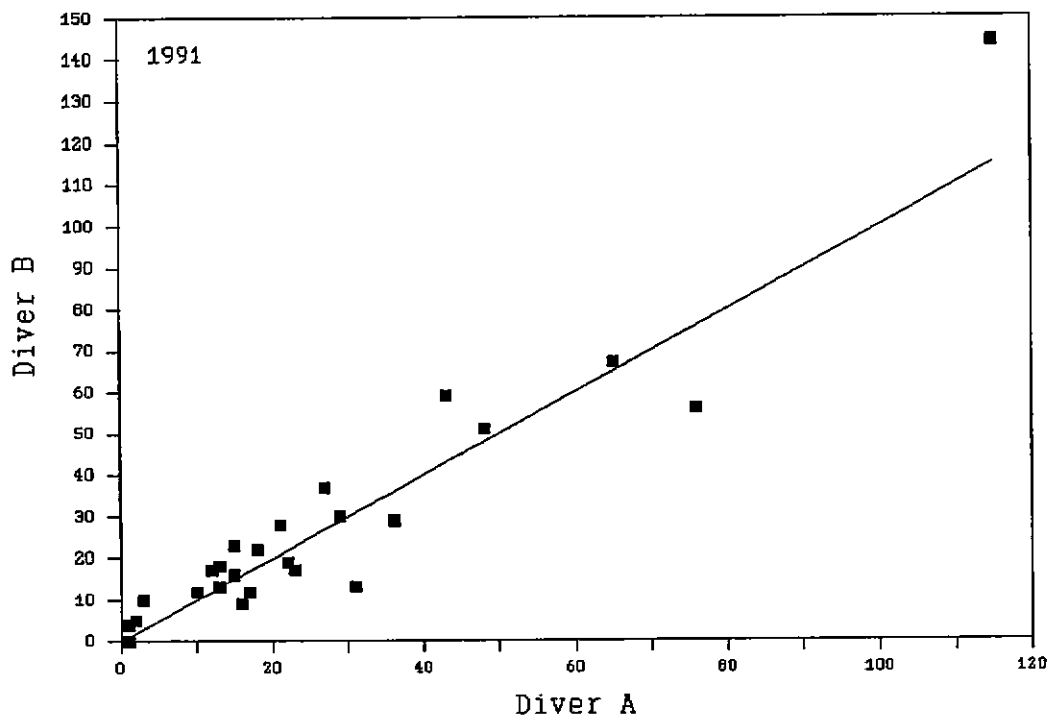
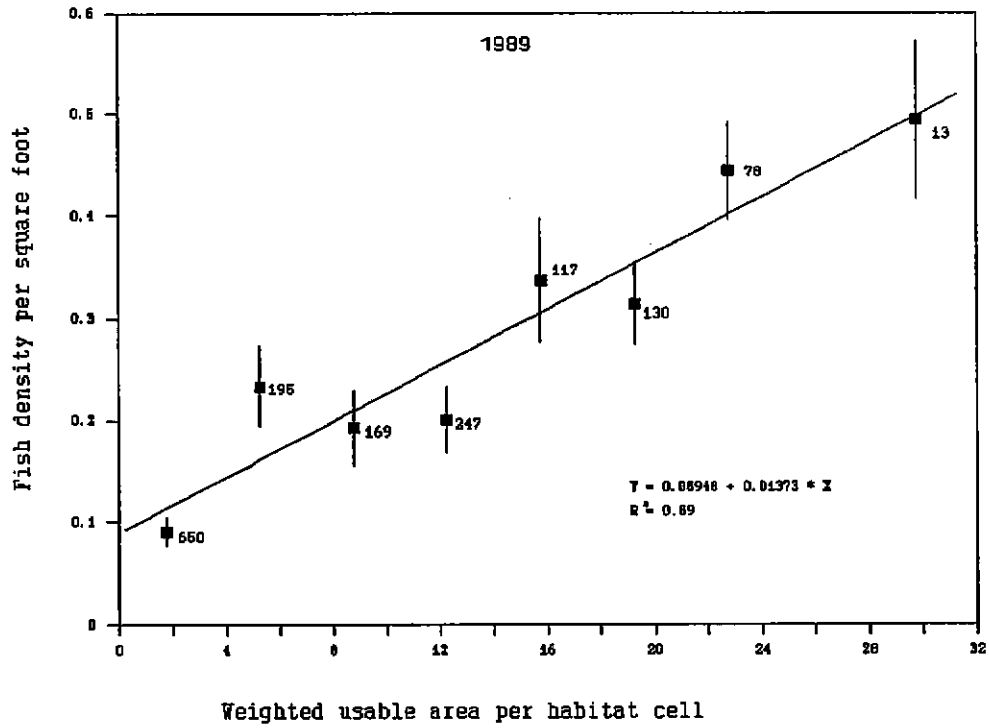


Figure 3. Comparison between snorkel diver mesohabitat transect counts of juvenile chinook salmon in the Trinity River during 1989 and 1991.



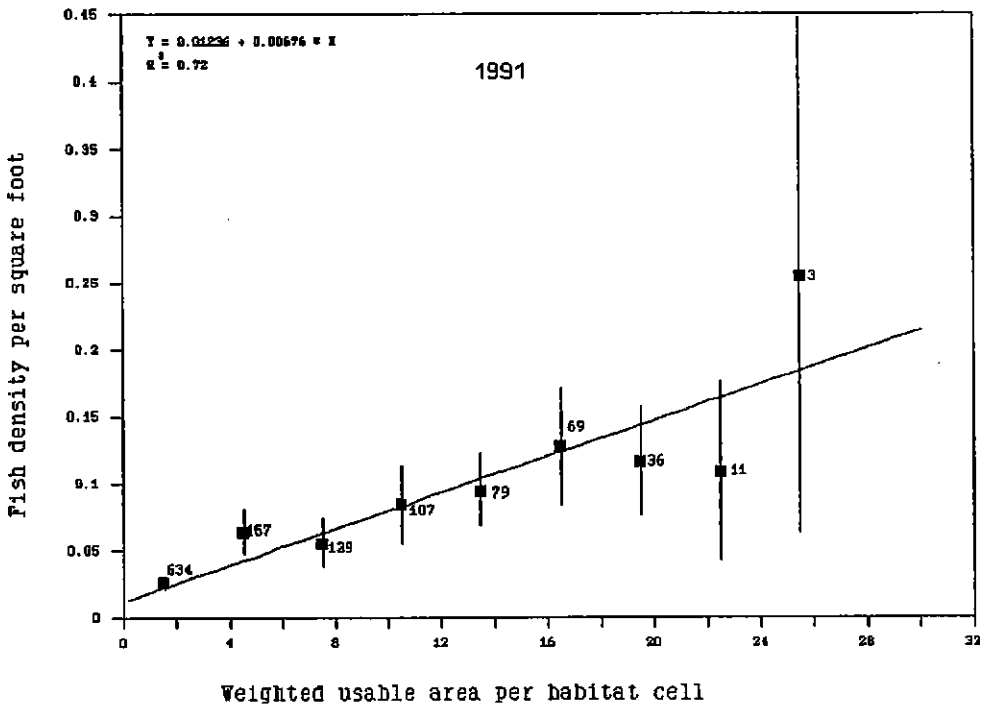


Figure 4. Mean density of juvenile chinook salmon versus weighted usable area in microhabitat cells in the upper Trinity River in 1989 and 1991.

Figure 5. Average number of juvenile chinook salmon observed across three mesohabitat transects in the Cemetery study site in 1989 and 1991.

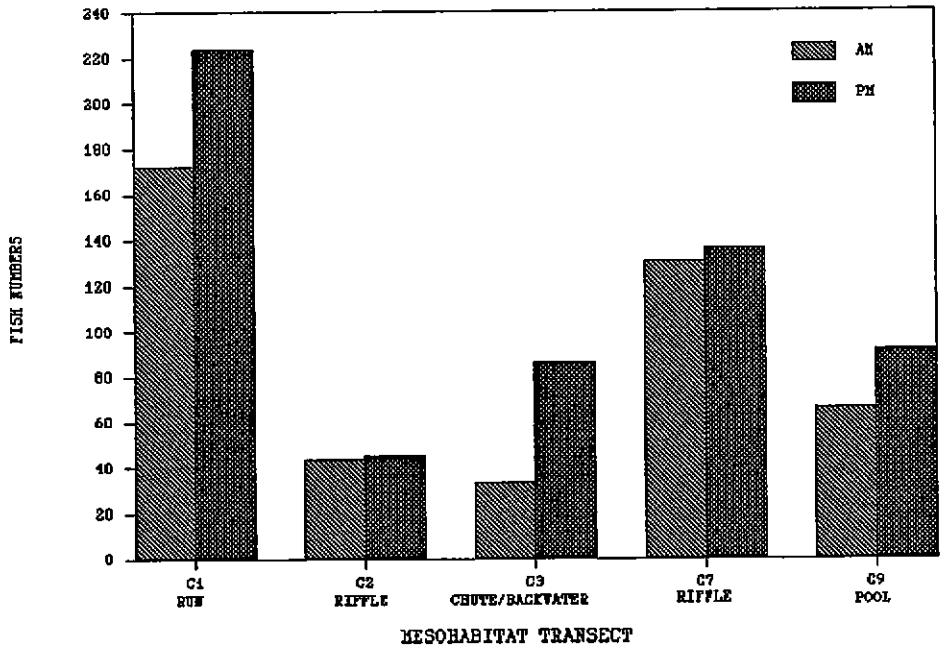


Figure 6. Average number of juvenile chinook salmon counted across five mesohabitat transects in the morning and afternoon of April 12, 1989.

The California Department of Fish and Game (Zuspan, pers. comm.) estimates that 83,945 spring and fall run chinook salmon spawned naturally in the Trinity River above Willow Creek in 1988, while only 10,562 are estimated to have spawned in the same area in 1990. The reduced number of spawners in 1990 resulted in fewer juvenile chinook salmon in 1991 versus 1989.

Daily Habitat Shifts

On 12 April 1989, we conducted transect counts in the morning starting at 9:30 AM and then repeated transect counts starting at 1:30 PM. Our results showed a shift in the distribution and density of juvenile chinook salmon between the two sampling efforts in run, backwater, and pool mesohabitats (Figure 6). In the afternoon juvenile chinook salmon distribution and densities had increased toward thalweg areas of faster and deeper water (Figure 7). It appears that daily habitat shifts occur gradually throughout the daylight hours and complete habitat saturation probably does not happen until late in the afternoon. Future studies to develop habitat suitability criteria for rearing salmon should direct effort toward afternoon hours to collect data under full habitat saturation conditions.

Mesohabitat Use

A summary of fish use, WUA, and numbers of fish per square foot of WUA for each transect sampled in 1991 is presented in Figure 8. The greatest numbers of juvenile chinook salmon were found in Cemetery 1 (115 fish), Bucktail 2 (66 fish), Poker Bar 3 (40.75 fish), and Steel Bridge 5 (33.25 fish), run mesohabitat types. The lowest number of juvenile chinook salmon observed was 1.5 fish in the run mesohabitat at Poker Bar 1. The remaining transects contained an average of fewer than 27 fish each. We found that the number fish per square foot of WUA across the various transects averaged 0.225 ($\pm$0.087 95% Confidence Intervals) and ranged from 0.015 to 0.562 fish per square foot of WUA. Since WUA is based on microhabitat suitability, in theory, the number of fish per unit of WUA should be equal for all mesohabitat types. The results presented here indicate that there may be variation in the number of fish per WUA for different microhabitat cells and mesohabitat types.

Close examination of the distribution of microhabitats within each mesohabitat transect may provide a better understanding of the relationships between microhabitat, mesohabitat, and fish use. This may help explain the variation in fish numbers per WUA observed in this study. Figures 9 through 12 show a graphic representation of total depths, water velocities, WUA, and fish numbers across each transect sampled in 1991. All figures are drawn to scale. Total depths are presented in feet and mean column water velocity in feet per second. Weighted usable area is shown as the total square feet of WUA per cell and fish numbers are presented as the average number of juvenile chinook salmon observed per cell.

Cemetery Study Site

In the Cemetery study site four transects were selected in three mesohabitat types, one in a run, two in riffle/pocket-waters, and one in a pool. Transect profiles, WUA, and number of fish observed for the Cemetery study site are shown in Figure 9. Transect C1 is located across a run mesohabitat. Water velocity and depth gradually increase toward the thalweg where the total depth peaks at 3.3 feet with a mean column velocity of 2.4 feet per second. Boulders and a small log provide cover along the left bank. A small log and some sparse aquatic vegetation provide minimal cover along the right bank. Cobble substrate embedded between 30 and 90 percent in sand are present across most of the transect. Fish numbers corresponded well with measured WUA across the transect with one exception. The cell containing the greatest amount of WUA was located along the right side of the transect; the number of fish observed in that habitat cell was lower than in adjacent habitat cells located in slightly faster water toward the

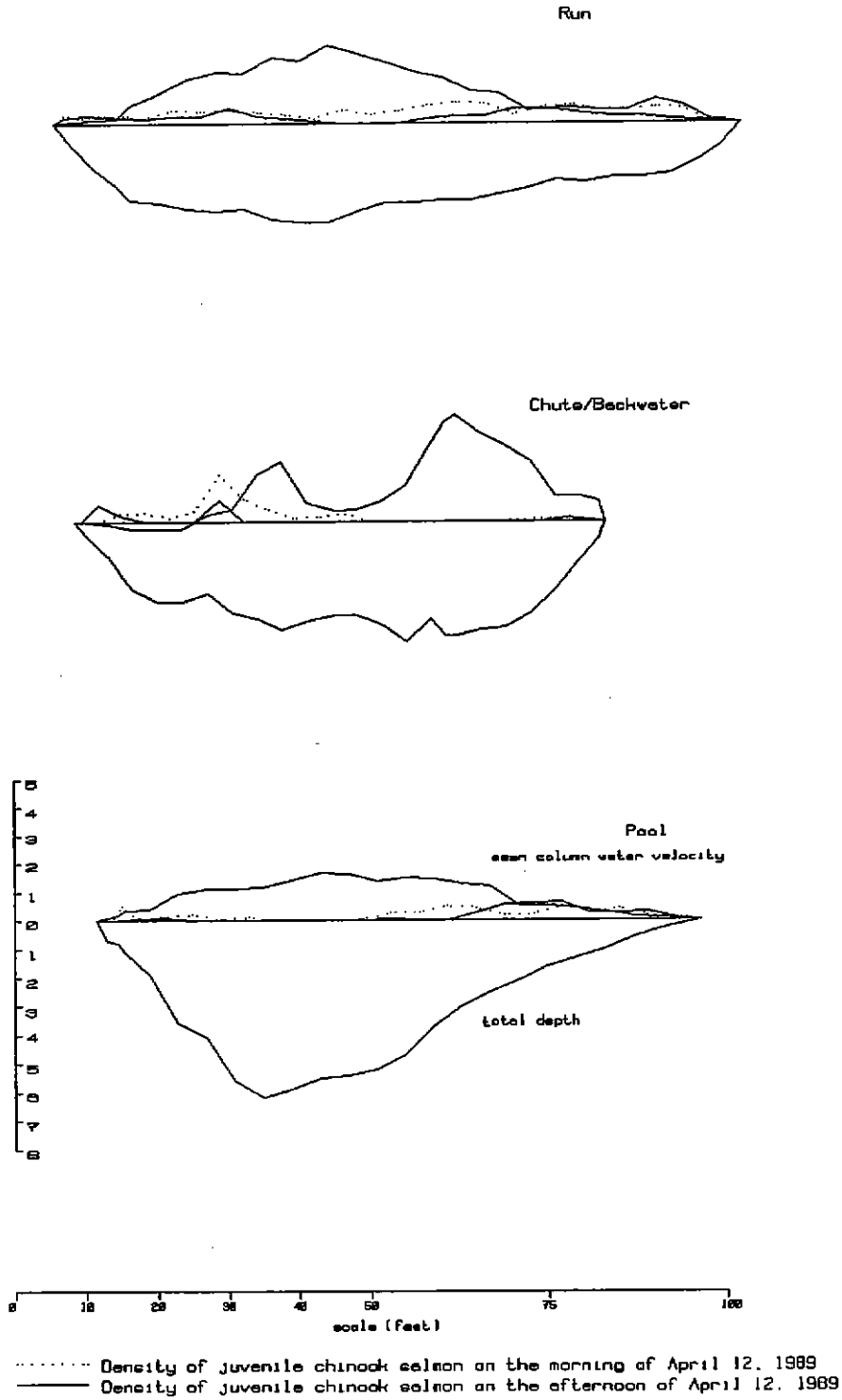


Figure 7. Comparison of juvenile chinook salmon densities (fish/feet^2) along three mesohabitat transects in the Cemetery study site in morning and afternoon of April 12, 1989.

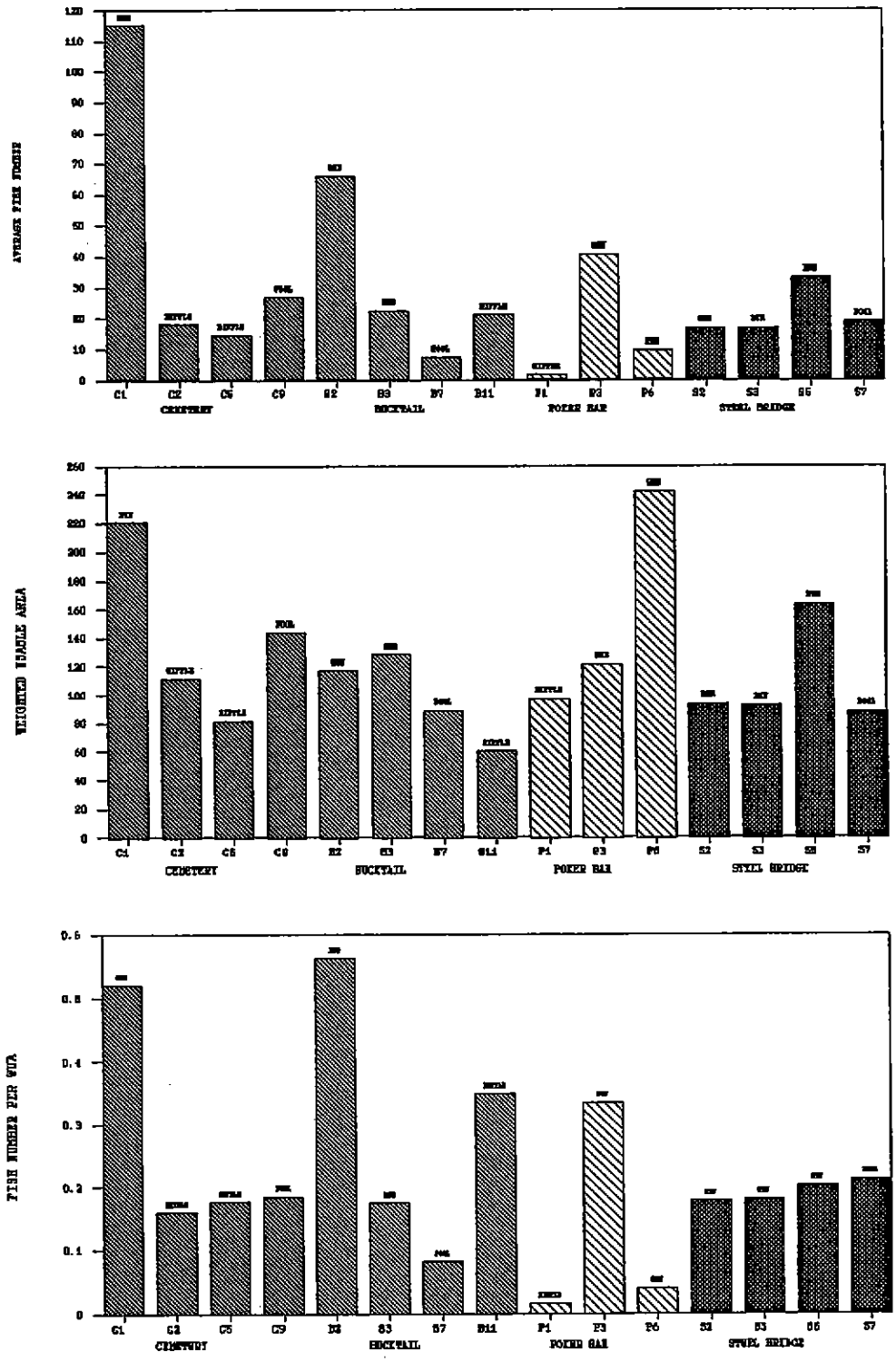


Figure 8. Mean number of juvenile chinook salmon, weighted usable area, and average number of juvenile chinook salmon per weighted usable area for each mesohabitat transect sampled in the Trinity River in 1991.

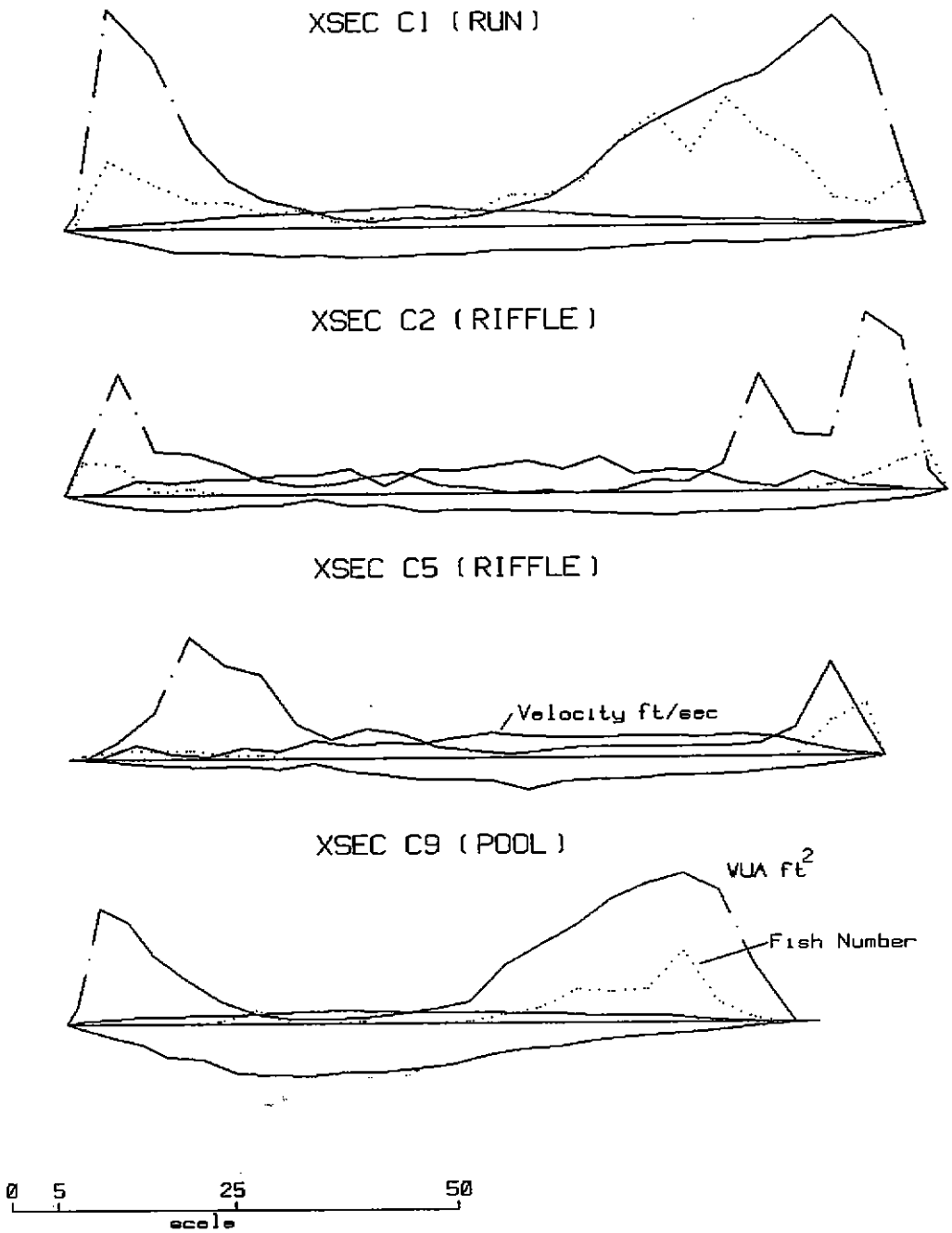


Figure 9. Transect profiles for the Cemetery study site showing total depths, mean column water velocities, water surface elevations, WUA, and the average number of juvenile chinook salmon observed in 1991.

thalweg. The habitat cells where the greatest number of fish were observed contained cobble substrate 80 percent embedded in sand. The closest cover was over 13 feet away along the right edge. Schools of juvenile chinook salmon were distributed throughout the water column in the cells along each bank. As water velocities increased with increased distance from the banks, juvenile chinook salmon moved closer to the river bottom, using cobble substrate as velocity shelters. When mean column water velocities began to exceed 1.0 feet per second, the numbers of juvenile chinook salmon that were able to use those habitat cells dropped dramatically as the bottom velocities became too swift. Large juvenile chinook salmon ($\pm$100 mm) were able to use those habitat cells where mean column velocities exceeded 1.0 feet per second.

Both transects C2 and C5 are located across riffle-pocket water mesohabitat types. Mean column water velocities range between 0.0 and 4.0 feet per second. However, instantaneous water velocities undoubtedly exceed 5.0 feet per second in many habitat cells. Across transect C2 only four habitat cells contained more than 10 square feet of WUA. Juvenile chinook salmon were never observed in one of these cells located along the right side of the transect. The habitat cells located on each side of this cell contained water velocities in excess of 2.0 feet per second. These high water velocities created a barrier that prevented movement of juvenile chinook salmon from slow edge water habitats into this suitable habitat cell. In diverse habitats, high water velocities or shear velocity zones may have a negative effect on WUA-fish density relationships by isolating suitable habitat areas.

Transect C9 is located across the lower end of a bedrock-formed pool. Mean column water velocities ranged from 0.0 to 1.5 feet per second and total depth peaked at 5.9 feet. The left edge of the transect is formed by bedrock outcroppings. Cobble and gravel substrate, embedded between 40 and 90 percent in sand, are present throughout the thalweg and right side of the transect. Across the entire transect, juvenile chinook salmon were closely associated with the river bottom. Numbers of juvenile salmon and WUA show a good relationship along the right side of the transect. Fish numbers decreased when mean column water velocities began to exceed 1.0 feet per second, similar to our finding across transect C1. In 1991, no fish were ever observed in the cells that contain suitable microhabitat along the left bank. However, in 1989 when population levels were much higher, we did observe regular use of these habitat cells. Upstream from these cells the thalweg deflects off of a bedrock outcropping forming an eddy upstream. The current deflects away from the left bank downstream along the right side of these habitat cells. The physical characteristics upstream and adjacent to the area may prevent many juvenile chinook salmon from coming in contact with these suitable habitat cells. In 1989, when large numbers of juvenile chinook were present in the river, the probability of juvenile chinook salmon seeding these isolated microhabitats was undoubtedly greater, thus accounting for their presence in 1989. Large numbers of juvenile chinook salmon are commonly observed using the eddy upstream on the other side of the high velocity zone that deflects off of the bedrock bank.

Bucktail Study Site

At Bucktail, four transects were sampled, two in a run, one in a pool, and one in a spawning riffle (Figure 10). Transect B2 represents a run mesohabitat. Maximum mean column water velocities were 2.5 feet per second and the maximum depth measured was 3.9 feet. Small woody debris provided an excellent source of cover along both river banks. Some cover is also provided by small boulders and cobbles embedded less than 40 percent in sand. Fish numbers corresponded well with measured WUA across this transect. As was true for the Cemetery study site, the largest number of juvenile chinook salmon observed across the transect were not directly associated with cover. All fish observed along the left half of the transect were close to the river bottom using small velocity shelters located between cobble substrate. Larger juveniles were able to use microhabitats near the thalweg where mean column water velocities

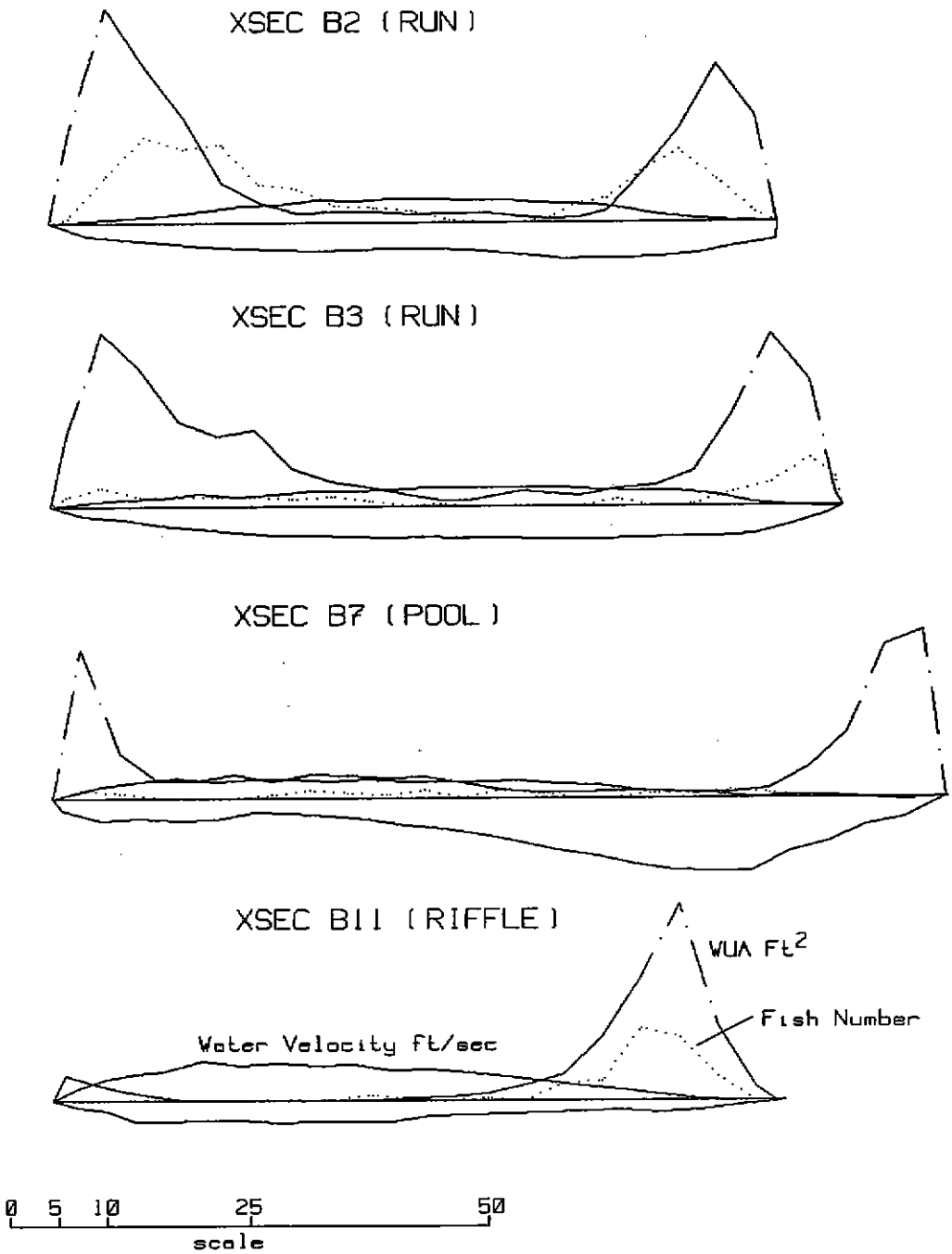


Figure 10. Transect profiles for the Bucktail study site showing total depths, mean column water velocities, water surface elevations, WUA, and the average number of juvenile chinook salmon observed in 1991.

approached 2.5 feet per second. These larger juveniles held in the velocity shelters behind large cobbles. Along the right edge of the transect juvenile chinook salmon distributed throughout the water column adjacent to and in submerged woody cover. The mean column water velocity in these habitat cells was less than 0.4 feet per second.

Transect B3 is located 205 feet downstream from transect B2 in the same run mesohabitat and has similar microhabitat conditions. Transect B3 does not contain woody cover along either edge and water velocities across the transect are slightly slower and the overall average depth greater. Mean column water velocities across the thalweg ranged from 1.6 to 2.0 feet per second. Submerged aquatic vegetation provides some cover along the right bank. Although fish were present in those cells that contain suitable microhabitat, the number of fish observed per cell was far less than the number of fish found using transect B2. One possible explanation for the differences in fish use between these two similar transects might lie in their relative location to other mesohabitat types. Transect B2 is closer to a riffle upstream; whereas transect B3 is located closer to a long, deep, slow pool downstream. Hatchery steelhead were also observed across transect B3 on more occasions than across transect B2. This may have had some impact on juvenile chinook salmon use of the microhabitat along transect B3.

Transect B7 is located in a slow pool just downstream from very turbulent water. The left bank is formed by a cobble-gravel bar that experienced severe agrading in 1986. The bar slopes downward to a total depth of 7.8 feet. Large bedrock ledges and boulders make up the right bank. This transect supported an average of only 7.25 juvenile chinook salmon, the second lowest number of fish per mesohabitat observed. Although only 7 fish used the transect, they were all large juveniles, exceeding 100 mm in length. Two habitat cells located along the right edge of the transect contained approximately 33 square feet of WUA, yet juvenile chinook salmon were never observed in those cells. Mean column water velocities across 22 feet along the right side of the transect never exceeded 0.2 feet per second. Mean column water velocities exceeding 0.5 feet per second were more than 20 feet away from the two habitat cells that contained most of the WUA on the transect.

The fact that these two habitat cells were located in a large area of slow water resulted in a negative effect on overall habitat quality, even though WUA was high. Without the benefit of higher water velocities nearby to deliver food, the actual quality of slow water microhabitats for juvenile chinook salmon was greatly reduced. This transect provides an excellent example of the influence that adjacent physical conditions can have on the use of otherwise suitable microhabitat cells by juvenile chinook salmon. It also provides an example of the possible errors that can occur within PHABSIM by over-estimating WUA for a species lifestage. This is possible because although juvenile chinook salmon prefer slow water within a certain range of depths, they were not found in all microhabitat areas of the river where those water velocities and depths were present.

Transect B11 is located across a salmon and steelhead spawning riffle. Proceeding from left to right across the transect, water velocities and depths increased to over 4.0 feet per second and 2.3 feet deep within the first 12 feet. From this point in the thalweg, water velocities and depths gradually decrease along a gravel bar forming the right bank. In total numbers of fish observed this transect supported an average of 21 juvenile chinook salmon. This transect exhibited the best relationship between WUA and observed fish use. Slow water microhabitat located along the right edge of the transect, near increasing water velocities, created ideal microhabitat for rearing juvenile chinook salmon.

Poker Bar Study Site

Poker Bar is located downstream from the confluence of Grass Valley Creek. As a result, the substrate throughout the Poker Bar site contain excessive amounts of decomposed granitic sand. The increased sediment load has degraded the quality of food-producing areas, over-wintering habitat, and spawning habitat. Our sampling at the Poker Bar study site included one broad riffle, and two run habitat types (Figure 11).

Transect P1 is located across a wide shallow riffle. Chinook salmon spawn along the right edge. Substrate across the transect are composed of cobble and gravel highly embedded in sand. Small quantities of woody cover were present along the left water's edge. An average of only 1.5 juvenile chinook salmon was observed across this transect, the lowest number of fish observed for any transect. With the exception of the edges, mean column velocities across the transect exceeded 1.5 feet per second. Fast water combined with highly embedded substrate resulted in poor habitat. Highly embedded substrate reduced bed roughness and reduced the number of velocity shelters that could otherwise be used by feeding juvenile chinook salmon.

Transect P3 is located across a deep run mesohabitat with cobble substrate, the majority of which are embedded in more than 80 percent sand. Depths ranged from 3.0 to 4.8 feet. Along the left side of the transect, mean column water velocities ranged from 1.2 to 2.2 feet per second. Mean column velocities along the right side of the transect were much slower, ranging from 0.0 to 0.5 feet per second. The greatest amount of WUA (>10 ft^2) was located in four habitat cells with slow to zero water velocities along the right side of the transect. The greatest numbers of juvenile chinook salmon were located along both edges of the river, and in two habitat cells located near the thalweg, where water velocities start to increase. Along the left edge, chinook salmon juveniles were also associated near a shear velocity zone. Along the right water's edge, we observed some juvenile chinook salmon using woody debris cover in still water. The habitat cells containing the greatest amount of WUA contained only a few chinook salmon. The lack of higher velocity areas near these habitat cells reduced their value to juvenile chinook salmon.

Transect P6 is located across a monotypic run mesohabitat. Depths ranged between 1.6 and 2.6 feet and mean column velocities gradually increased from 0.0 feet per second along each edge to 1.4 feet per second in the thalweg. The substrate were composed of sand or gravel completely embedded in sand. Small woody debris and aquatic vegetation provide some excellent cover for juvenile chinook salmon along the left edge of the transect. Compared to the other transects sampled, this transect contained the greatest amount of WUA, yet ranked twelfth out of fifteen transects for the number of fish supported, with an average of 9.5 juvenile chinook salmon. Environmental factors that contribute to the lack of fish use across this transect that were not included in the calculation of WUA include lack of velocity diversity, lack of any bed roughness elements to create velocity shelters, and excessive sedimentation.

Steel Bridge Study Site

At Steel Bridge study site we sampled four transects (Figure 12). Two transects, S2 and S3, are located across run mesohabitats. With the exception of a few bedrock outcropping along the left side of transect S2, large cobbles, embedded between 30 and 60 percent in sand, dominate the thalweg profiles of both transects. Both transects also share similar depth profiles, but mean column velocities across transect S3 were approximately 0.5 feet per second slower than transect S2. Slower water velocities across transect S3 resulted in slightly higher WUA estimates across the thalweg than for transect S2. However, the total amount of WUA provided by each transect was nearly equal. Transect S2 contains 93.9 square feet of WUA and transect

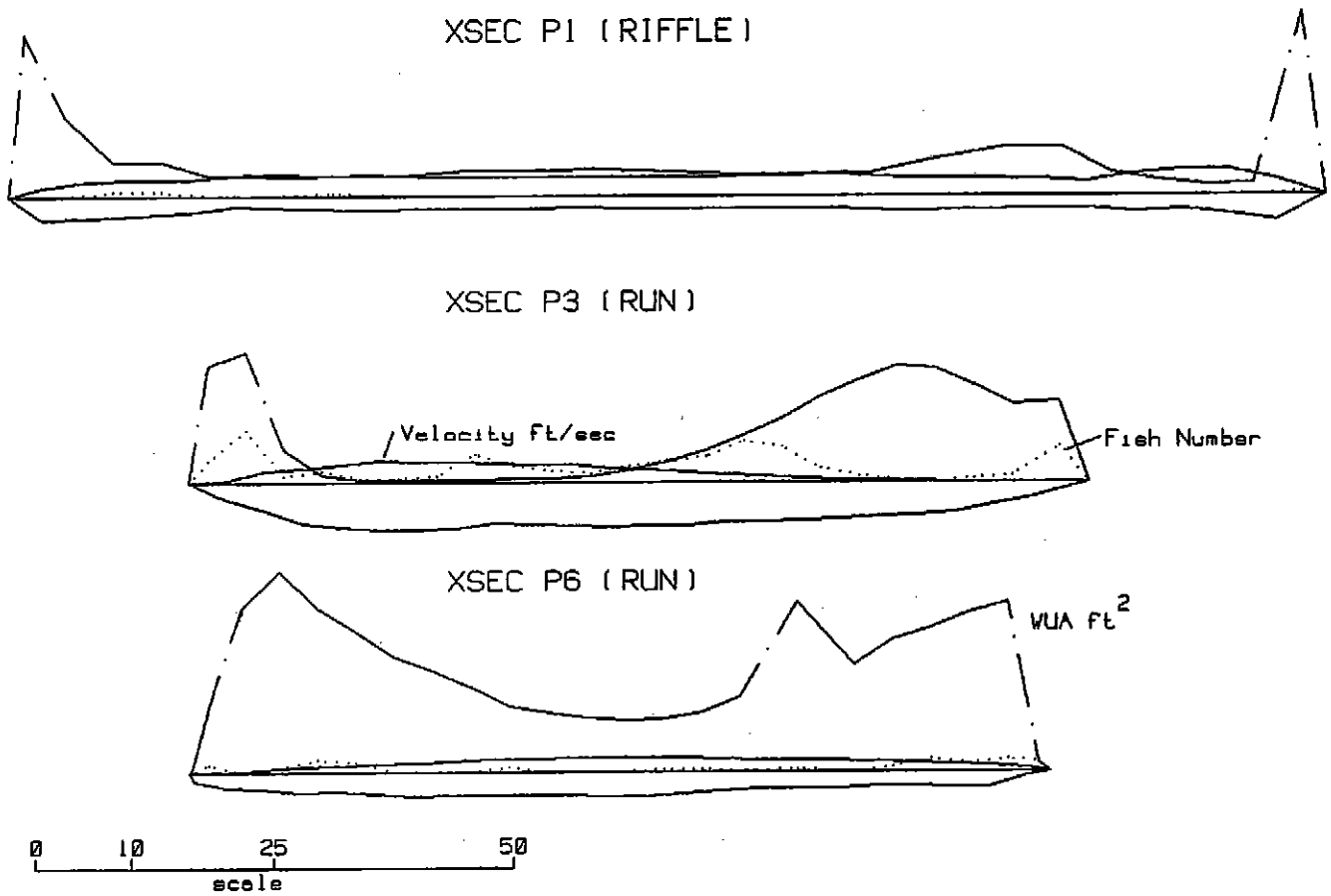


Figure 11. Transect profiles showing total depth, mean column water velocity, water surface, WUA, and number of juvenile chinook salmon observed at the Poker Bar study site, Trinity River, CA, 1991.

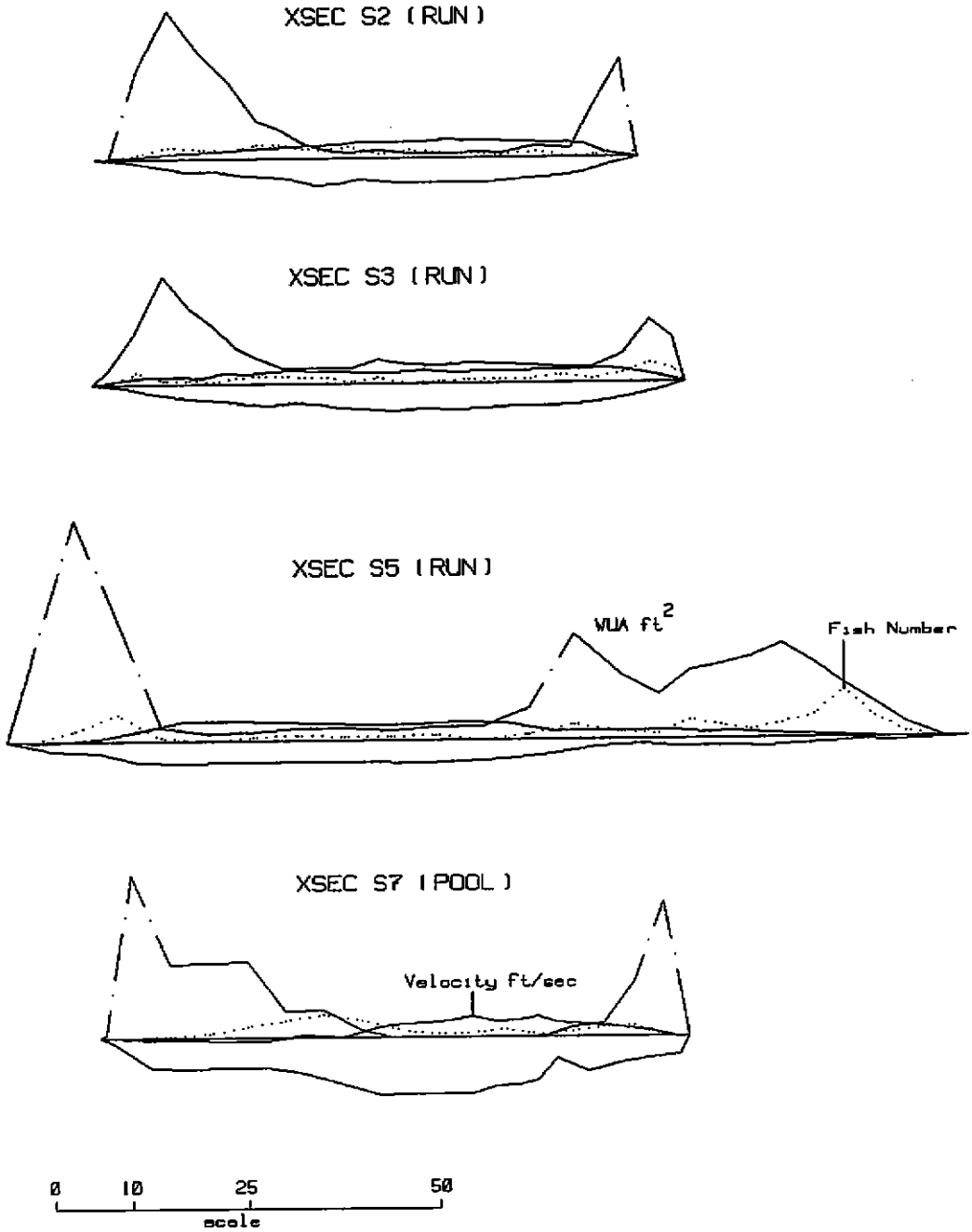


Figure 12. Transect profiles for the Steel Bridge study site showing total depths, mean column water velocities, water surface elevations, WUA, and the average number of juvenile chinook salmon observed in 1991.

S3 contains 92.9 square feet of WUA. An average of 16.75 juvenile chinook salmon were supported by each transect, ranking them tenth in numbers of fish. The proportionate distribution of fish numbers across these two transects did not resemble the distribution of WUA across the transects. In general, however, more juvenile chinook were found in habitat cells that contained the greatest amount of WUA. Larger juveniles (> 100 mm) were distributed in cells containing higher water velocities across the thalweg between large cobble substrate.

Transect S5 is located just downstream of a mid-channel island. A major spawning riffle is located just upstream of the transect in the river channel to the right of the island. A small backwater is located along the left edge below a small bedrock outcropping just upstream. Depths across the thalweg range between 1.5 and 2.9 feet, and mean column water velocities peak at 2.6 feet per second. The right side of the transect is less than 1.0 feet deep with velocities under 0.5 feet per second. Substrate across most of the channel are composed of cobbles and gravel embedded approximately 20 to 40 percent in sand. Cobble substrate across the right side of the transect are embedded up to 90 percent in sand.

Transect S5 ranked third in WUA with 164 ft^2 and ranked fourth in numbers of fish with an average of 33.25 chinook salmon. Observed fish numbers corresponded well with WUA across the transect. Along the left edge of the transect, juvenile chinook salmon were distributed throughout the water column feeding on drift organisms that passed through the shear velocity zone. Small juvenile chinook salmon were distributed across the right side of the transect in shallow water. The larger juveniles (> 100 mm) were distributed across the bottom between large cobbles in faster and deeper water.

Transect S7 is located across a pool. Depths reach up to 7.4 feet and mean column water velocities peak at 2.8 feet per second. A large backwater is present along the left half of the transect. Sand is present along the left side of the transect, cobbles are distributed across the middle the transect, and large boulders are located along the right side. The greatest number of juvenile chinook salmon observed on this transect were dispersed throughout the water column in association with the edge of the shear velocity zone that forms the boundary between the thalweg and eddy. These fish moved in conjunction with the surging lateral movement of the velocity shear zone, feeding on drift organisms throughout the water column.

No juvenile chinook salmon were observed using the cell along the left edge that contained the greatest amount of WUA. This habitat cell provides another example of a situation where the absence of higher velocity microhabitats nearby had a negative impact on the habitat suitability, even though the depths and velocities present within the habitat cell predicted high quality microhabitat.

DISCUSSION

In this investigation we have attempted to describe and validate the relationship between WUA and standing crop of juvenile chinook salmon in the upper Trinity River. In doing so, we have discovered several variables that influence and complicate efforts to quantify this relationship. These factors include microhabitat isolation, effects of velocity shear zones on microhabitat quality, and a lack of habitat diversity. It may be possible to increase the accuracy of habitat predictions for juvenile chinook with the PHABSIM system by using the nose velocity option in conjunction with the HABTAV program. Use of adjacent velocity criteria should improve exaggerated habitat predictions in large areas of slow water and increase habitat quality predictions in areas near shear velocity zones.

Currently, the model seems to underestimate the value of mid-channel areas with cobble substrate where water velocities are greater than 1.0 feet per second. These midchannel

microhabitats have been shown to support large numbers of juvenile chinook salmon. In these habitats larger juveniles disperse along the bottom using small velocity shelters among the cobbles. The use of HABTAV should improve habitat predictions in these areas. An alternative solution might include the development of conditional criteria that incorporates substrate roughness elements or embeddedness values when mean column velocities begin to exceed 1.0 feet per second. We could have used a substrate channel index in the calculation of WUA, but this would not have increased the accuracy of the WUA estimates in this study, since our substrate criteria for juvenile chinook salmon show a high suitability for sand and highly embedded substrate. There is little doubt that these substrate suitability values are more the result of a combination of poor habitat conditions in the Trinity River and the hydraulic characteristics present in microhabitats selected by juvenile chinook salmon, than they are a factor of preference by juvenile chinook salmon for sandy substrate. Therefore, if conditional substrate criteria are to be used in the future they will have to be derived from professional judgement and applied only in specific mesohabitat types.

The fact that fish densities in high quality habitat cells differed between sampling years indicates that preferred microhabitats do not fill to capacity before lesser quality microhabitats are used. In both 1989 and 1991 juvenile chinook salmon distributed themselves throughout the full range of suitable microhabitats in similar proportions even though population levels were much lower in 1991. When high quality microhabitat areas are limited, many fish may not be able to locate those areas. Under these conditions seeding of optimum microhabitats may be a function of random search, time, and population levels.

On the Trinity River each IFIM transect represents a specific mesohabitat type. The river was habitat-mapped based on the physical characteristics of each mesohabitat transect. The WUA predictions for each mesohabitat transect were then extrapolated based on this habitat map to get a total estimate of available habitat for the river. Habitat in the upper river is currently described by fifty five mesohabitat types or transects. In this investigation we have described fish per WUA relationships for fifteen of these transects. In 1991 the number of fish per square foot of WUA per mesohabitat transect ranged from 0.015 to 0.562 with an average of 0.225 fish per square foot of WUA. The variation in numbers of fish per square foot of WUA between transects was high with 95 percent confidence intervals of 0.138 and 0.311. Based on the large variation that was observed in numbers of fish per WUA between mesohabitats it appears that each mesohabitat type within the population model will need an independent fish per WUA value. This greatly increases the amount of field work that will be required since each mesohabitat will need to sampled each year to obtain model input data. This may not be necessary if habitat predictions can be improved through the use of HABTAV or some conditional substrate criteria that results in a substantial reduction in the variation of fish per WUA values between mesohabitat types.

Between Lewiston and Douglas City there are approximately 3,250,000 square feet of WUA for juvenile chinook salmon at a river flow of 300 cfs. In this study we found an average of 0.225 fish per square foot of WUA among the mesohabitats that were sampled. Using these numbers, in 1991 approximately 731,250 ($\pm$ 282,858) juvenile chinook salmon reared in the upper Trinity River. If we assume a one percent survival to escapement, a total of 7,313 naturally produced adults will return to the Trinity River from the 1991 cohort. This is far short of the Trinity River Restoration Programs escapement goal of 68,000 returning natural adult chinook salmon. Unless flows are dramatically increased to mimic historic patterns it seems doubtful that natural populations of chinook salmon will ever recover to their historical levels.

JUVENILE STEELHEAD AREA REQUIREMENTS

Introduction

Determining the densities of fish for a habitat type relative to other habitat types is usually employed to assess fish habitat quality; high quality habitats being the ones with the highest numbers of fish per square unit of area. Often specific habitat types are identified and the number of fish in each habitat type counted. However, because of disproportionate or unequal distributions of fish in these habitat types, conclusions made regarding habitat quality may be biased. In addition, counting fish in entire habitat units often can only be used in streams small enough to effectively sample by direct observation or electro-fishing methods. In larger streams, the problems associated with accurate counting of fish become greater. Often visibility, manpower, and gear type limitations are encountered forcing creative methods to be developed in attempts to relate fish densities to physical habitat.

Area requirements for juvenile steelhead in the mainstem Trinity River have not been determined to date, and so were the focus of this study. This information is needed to identify possible habitat bottlenecks.

Methods

Nine sites from Cemetery to the Del Loma river access site were sampled from June 21 to August 26. Sites were chosen at or near river access sites. Repeated sampling of some sites occurred, but only after a break of ten days or more. Sites that were sampled once included: Cemetery riffle (RM 109), Bucktail riffle and side channel (RM 105), Steiner Flat (RM 92), Oregon Gulch (RM 81), McCartney's Pond (RM 77), Big French Bar (RM 57), and at Del Loma (RM 56). Sites sampled more than once included: Junction City Campground (RM 78 and 77.5) and the confluence with the North Fork (RM 72). Previous snorkel survey data (USFWS 1989) indicated that juvenile steelhead predominately used riffle type habitat, and consequently these areas were the only habitat types sampled. Juveniles were also observed in pool type habitats, but they did not establish well defined territories and so were excluded from analysis.

Underwater observations by persons wearing wetsuit, mask and snorkel during the afternoon (1200 to 1600 hours) were used to obtain area requirements of juvenile steelhead. Divers entered the stream below the sample site and worked their way upstream slowly, not to disturb fish. When two or more undisturbed juvenile steelhead of one size group, either from 45 to 94 mm or 95 to 150 mm, were observed and exhibited either feeding or territorial behavior, an observation was made. In addition, fish total length was measured or estimated to the nearest 10 millimeters using underwater slates, a numbered washer was placed where each fish was observed, and the distance between each washer was measured to the nearest tenth of a foot. Fish that were over 6 feet apart, a distance that divers could effectively see, were excluded from the analysis. It generally required from 1 to 5 minutes to obtain an observation, and no data was collected on fish believed to be of hatchery origin.

Other physical habitat measurements that were collected but not used for this analysis included: substrate type between fish using the Brusven Index (see USFWS 1989, pp 25), cover code (see USFWS 1989, pp 26), and fish nose, mean column velocity, adjacent mean column velocities. Velocity measurements were taken with a Price AA or Marsh/McBirney electronic flow meter.

We assumed that the distance between fish represented the edge of a fish territory, and that the area requirements of fish were circular in shape, with a radius equal to the distance between fish; observations from staff biologists indicate that overlap of territories does occur. Frequency polygons were developed to graphically display the results. Sturges' rule was used to determine grouping intervals (Cheslak and Garcia 1988).

Results and Discussion

These results should be regarded as preliminary because of the small sample size (n = 82).

Comparisons of the frequency polygons in Figure 1 indicate that the area required by juvenile steelhead increased with fish length. The mean area used by fish from 45 to 94 mm was 24.1 square feet and the mode was 13.6 square feet, while fish from 95 to 150 had a mean of 41.3 square feet and a mode of 43.6 square feet. Because all sample sites were predominantly composed of large gravel and cobble, values presented here should only be regarded as representative for riffles with similar substrate types.

Variation about the mean areas were great for both size groups, and is probably related to the small sample size and other factors that affect fish activity. Some of these would include: water temperature, amount of visual isolation, population density, and habitat availability.

Further sampling is planned this upcoming year and refined area requirements for juvenile steelhead will be given in the 1992 annual report. This will also include detailed analyses of physical habitat as they relate to fish area requirements.

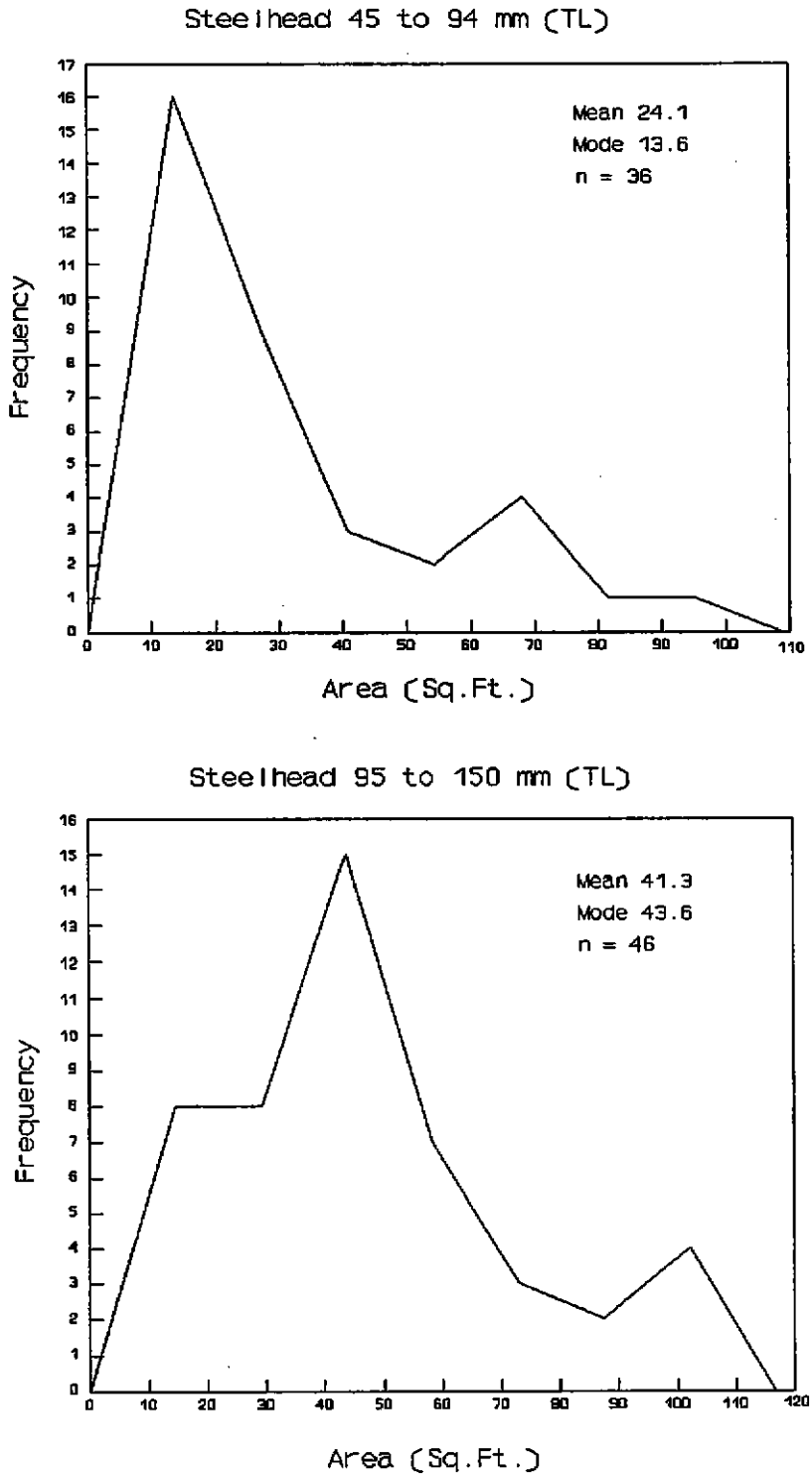


Figure 1. Frequency polygons showing area requirements of two size groups of juvenile steelhead, Trinity River, California, 1991.

WATER TEMPERATURE MONITORING

Introduction

As part of an ongoing effort to apply the U.S. Fish and Wildlife's stream network water temperature model (SNTEMP), we continued to monitor Trinity River water temperatures in 1991. This model is an important element in evaluating the habitat-flow relationship of the Trinity River.

Methods

Water temperatures were monitored at six sites in 1991. These included sites previously established and the addition of one other. Previously established sites included: Lewiston (RM 111), located at the United States Geological Survey gauge where the CDEC (California Data Exchange Center) station is located, Steelbridge (RM 98.5), Douglas City (RM 94), the Elkhorn Lodge (RM 74), and the Burnt Ranch transfer station (RM 46). This year we also monitored temperatures at Weitchpec Falls on the Hoopa Valley Reservation (RM 5).

Either an Omnidata Datapod or Ryan Temp Mentor were used to record temperatures. The Omnidata datapod recorded average, maximum, and minimum daily temperatures by averaging 1440 readings (one reading per minute), while the Ryan Temp Mentors recorded temperatures at hourly intervals. Recording instruments occasionally malfunctioned or were vandalized, resulting in the loss of data.

Results

Lewiston dam release temperatures are controlled by either the turnover rate of the reservoir, which is governed by diversion rates, or by meteorological conditions (Figure 1). When diversions were low, from November to late May, water temperatures increased as a result of increased solar radiation and warm air temperatures. As diversion volumes increased in early June, however, release temperatures decreased and then remained nearly constant until late September even though solar radiation and air temperatures were greatest.

Depending on the time of the year, Trinity River water temperatures either increase or decreased as distance from the dam increased (Figure 2). From March to November water temperatures increased as distance from the dam increases. This trend, however, was inverted from November to March, when water was warmer at upstream sites.

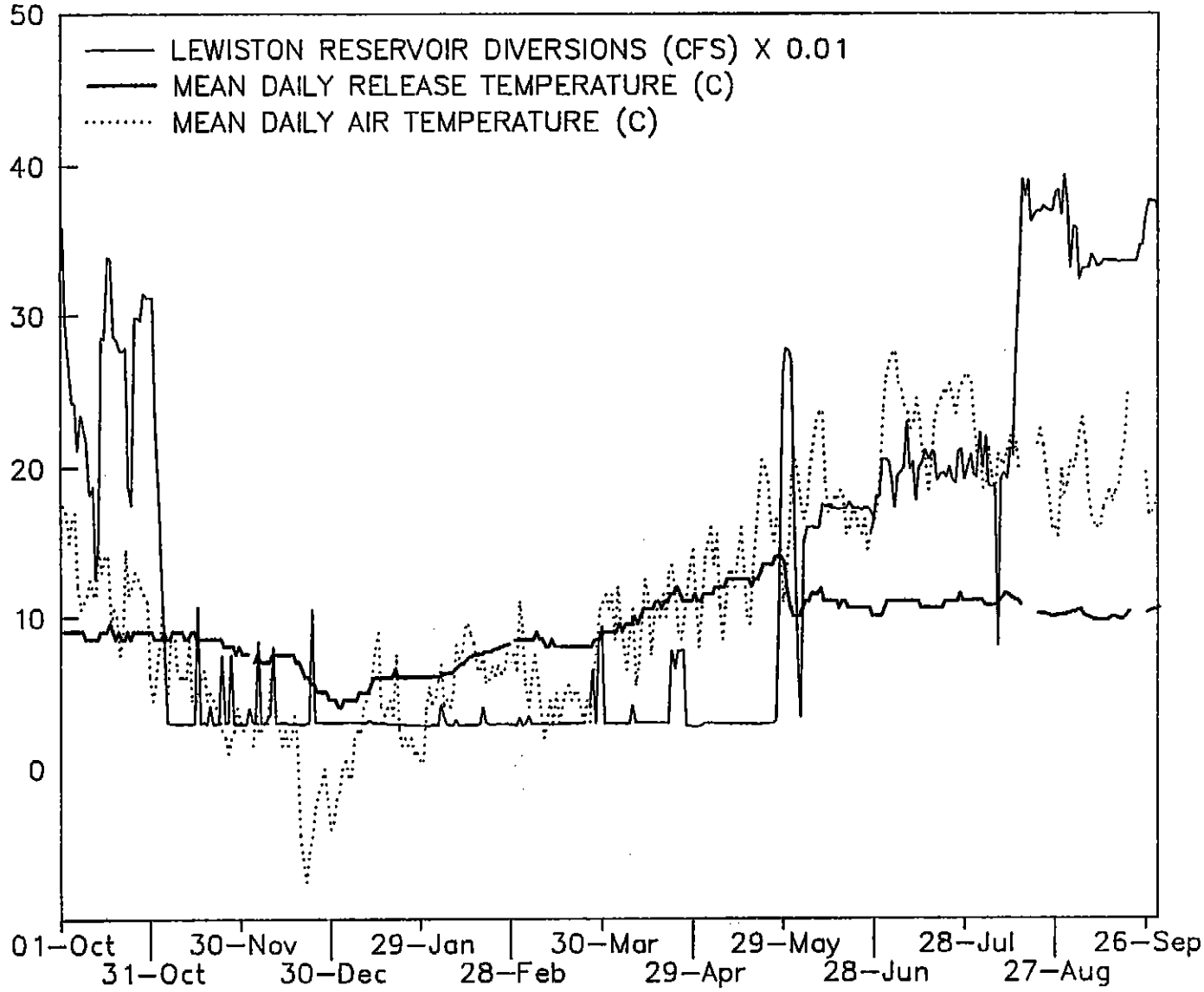


Figure 1. Water temperatures of the Trinity River at Lewiston as related to Lewiston air temperature and diversions from Lewiston Reservoir, WY 1991. Diversions are total diversions including Lewiston dam releases to the Trinity River.

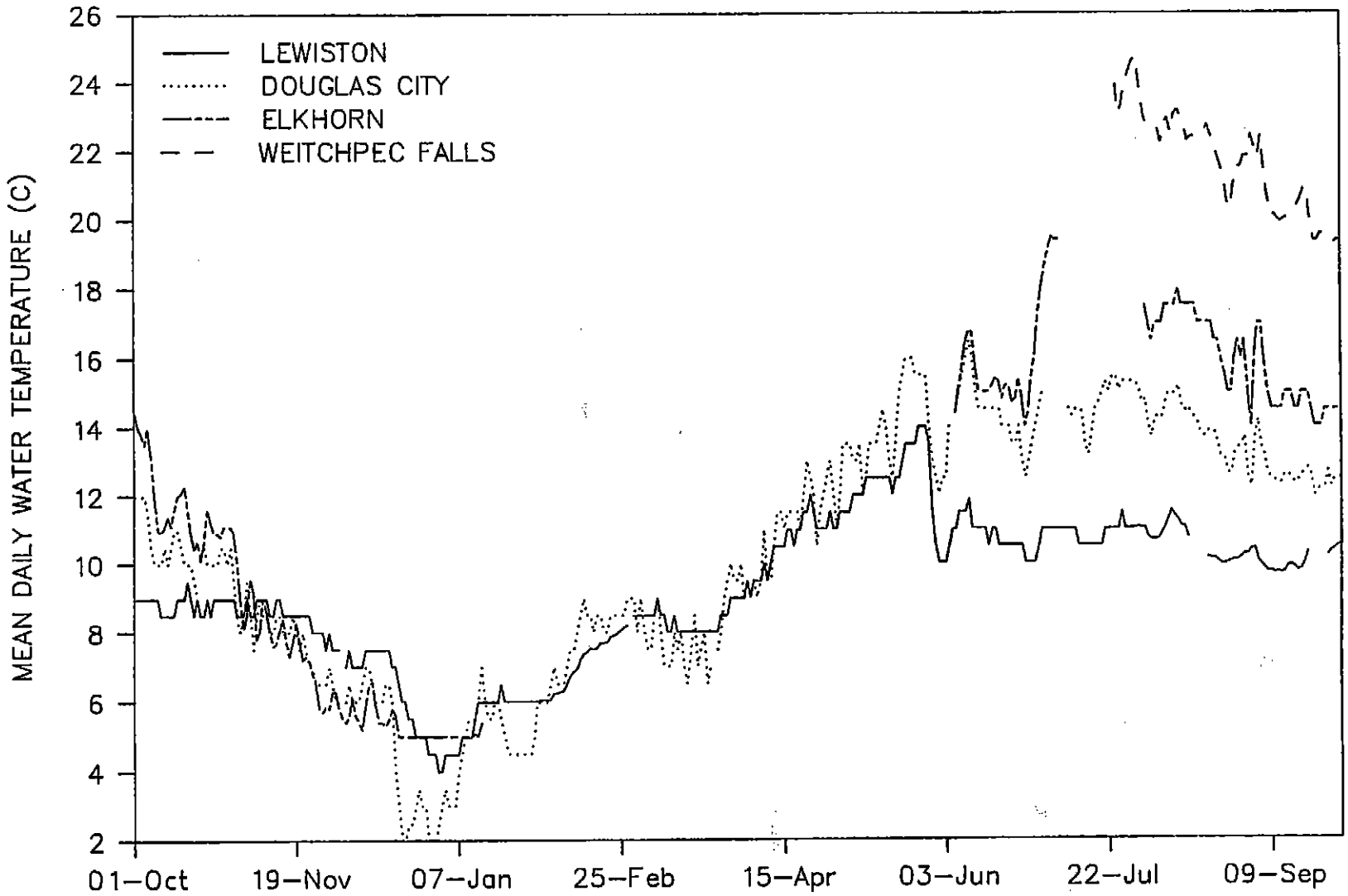


Figure 2. Water temperatures of the Trinity River at four sites, WY 1991.

THERMAL STRATIFICATION OF POOLS

On July 3, 1991, we measured temperatures in Bucktail pool (RM 105), Stott pool (RM 102), and Steelbridge pool (RM 98.5) to test the theory that they may stratify thermally and provide temperature refuges for holding salmon. These pools were selected because of their large size and depth. During the time of the survey, river flow was 450 cfs, and air temperature ranged from 41.1 to 41.7 C (106 to 107 degrees fahrenheit) at the Lewiston CDEC station, which is about 1/2 mile below Lewiston dam. An Omnidata Datapod that measured water temperatures to the nearest tenth of a degree C was used. To record water temperatures at known depths, the temperature probe was attached to a measuring tape and a dive weight was attached to the end of the tape. Temperature measurements were recorded at the surface and at the bottom at several locations in each pool, including fast and slow velocity areas. An inflatable kayak was used to move about in each pool.

Results from the survey indicated that no vertical thermal stratification occurred. This can be attributed to the thorough mixing of the river at 450 cfs.

III. FISH POPULATION CHARACTERISTICS AND LIFE HISTORY RELATIONSHIPS

CHINOOK SPAWNING DISTRIBUTION

Introduction

As part of an ongoing effort to evaluate the spatial distribution of spawning chinook salmon in the mainstem Trinity River, surveys by the Flow Evaluation Team have continued since 1986. These surveys have shown where fry and juvenile chinook salmon can be found during the following spring, and may provide an index to possible changes in adult salmon habitat use. Presented below is a summary of the 1991 survey.

Methods

Spawning surveys were conducted by two staff biologists from an inflatable raft equipped with a rowing frame. The surveys began in late October and concluded in late November. Polarized sunglasses were worn by the observer. When redds were observed, the number and their location were placed on photocopied aerial photographs. Areas not visible from the raft were waded to insure complete coverage of each river section.

A total of 78.5 miles were surveyed. For reporting purposes, upper and lower river sites refer to river sections above and below the confluence of the North Fork. River sections surveyed included the following:

1. New Bridge (Lewiston, RM 111) to Steel Bridge (RM 99)
2. Steel Bridge to Steiner Flat (RM 92)
3. Steiner Flat to Evans Bar (RM 85)
4. Evans Bar to McCartney's Pond (RM 77)
5. McCartney's Pond to North Fork (RM 72)
6. North Fork to Sailor Bar (RM 67)
7. Sailor Bar to Del Loma (RM 56)
8. Del Loma to Cedar Flat (RM 47.5)
9. Sandy Bar (South Fork RM 1) to Camp Kimtu (RM 26)
10. Camp Kimtu to Tish Tang (RM 17)

Results and Discussion

A total of 998 redds were observed, of which 961 were located in the mainstem Trinity and the remaining 37 were observed from Sandy Bar of the South Fork Trinity to it's confluence with the mainstem. The upper river sections accounted for 80% of observed redds and the remaining 20% were observed in the lower river. A summary of the survey results is given in Table 1.

In the upper river, from New Bridge (RM 110.8) to Sawmill pool (RM 108.7) was the area of greatest spawning activity; 184 redds were observed for this 2 mile section, accounting for 43.5% of redds observed in section 1. Superimposition had also occurred at several locations in this section, including the hatchery rearing pond outflow channel at the Cemetery Site (RM 108.7) where 17 redds were counted. Other areas of considerable spawning activity included: the run above Hog Hole (RM 108.0), below the mouth of Rush Creek (RM 107.6), Salt Flat Bridge riffle (RM 107.0), Gold Bar riffle (RM 106.0), Bucktail riffle (RM 105.1), Louden Ranch riffle (RM 104.8), and the reach from Poker Bar (RM 103.0) to Steel Bridge (RM 98.7). Data from previous surveys also indicated extensive spawner use of these areas. Of surveyed river sections, this section also had the highest number of redds per mile.

Table 1. Observed chinook salmon spawning in the mainstem Trinity River and a one mile section of the South Fork Trinity River, 1991.

DATE	SECTION	MILE	REDDS	REDDS/MI
11-01	New Bridge to Steel Bridge	12	423	35.2
11-05	Steel Bridge to Steiner Flat	7	139	19.8
11-07	Steiner Flat to Evans Bar	7	70	10.0
10-31	Evans Bar to McCartney's Pond	8	103	12.9
11-08	McCartney's Pond to North Fork	5	31	6.2
11-13	North Fork to Sailor Bar	5	1	0.2
11-12	Sailor Bar to Del Loma	11	86	7.8
11-14	Del Loma to Cedar Flat	8.5	38	4.5
11-26	Sandy Bar (South Fork) to Mainstem	1	37	37.0
11-26	South Fork to Camp Kimtu	5	60	12.0
11-19	Camp Kimtu to Tish Tang	9	10	1.1
	TOTALS	78.5	998	2.7 (AVG)

Section 2 had the second highest number of redds per mile, and the majority of the activity occurred from Steel Bridge to the confluence of Indian Creek (RM 94.7). In section 3, the Dutton Creek (RM 89.0) and Evans Bar (RM 84.4) areas accounted for the majority of redds observed, while in Section 4, the Sheridan Creek (RM 81.9) and Oregon Gulch (RM 80.9) areas accounted for the majority. Although section 5 had the fewest redds per mile of stream, redds were concentrated in the riffle and run habitat between Power House Hole (RM 79.6) and the Bigfoot Campground (RM 78.0), where over 50% of the redds in this section were counted.

Although the upper river contained the majority of redds observed, the lower river contributed a substantial number to the total. Section 6 contained the least number of redds of all sections surveyed, which was no doubt a result of the lack of suitable spawning habitat. In section 7, however, the number of redds observed increased and concentrations were observed at Sailor Bar (RM 68.0), Big Flat (RM 66.8), Skunk Point (RM 65.0), Big Bar Bridge riffle (RM 64.0), and between the confluences of Little French creek (RM 59.5) and Big French Creek (RM 58.5). In section 8, 38 redds were observed and, in general, were concentrated at Canadian Bar (RM 56.0) and near the confluence with Don Juan Creek (RM 49.4). In the past both sections 7 and 8 were areas that fish appeared to concentrate in the lower river. Although not part of the mainstem survey, section 9, which is bound on the up-stream end by the Sandy Bar fish weir (RM 1.0), contained a high number of redds per mile, and is therefore worthy of mention. Similar to the situation in section 9, a weir is located in section 10 (Willow Creek weir)(RM 32.0) and the majority of redds observed were located near the weir; 8 above and 23 below, and accounting for over 50% of redds observed in this section. The large number of redds near these weirs may be attributed to the fish weirs acting as barriers and forcing fish to spawn below or it could be that weir placement was in the most suitable habitat in the area. Evidence in support of the latter would include the fact that redds were observed immediately above the Willow Creek weir site. Because of poor viewing conditions, the number of redds counted in section 11 was probably an underestimate. The water was turbid and as a result few redds were observed. However, previous years surveys also indicated few fish using this part of the river.

A total of 12 chinook salmon redds were observed in artificially constructed side-channels. Side-channels with redds and the number they contained, included: Cemetery (2), Salt Flat (1), Steiner I (4), Svennson (1), Oregon Gulch I (2), Oregon Gulch II (2).

Because each river section was only surveyed once, the numbers presented in this report should only be regarded as a relative index of the spatial distribution of spawners and not an index of run size.

JUVENILE CHINOOK 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.

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).

As in past years, chinook fry emerged from the gravel in the upper river by about mid-February. We made counts at Cemetery from starting in mid-February, at Steelbridge starting in mid-March, and at all four sites from mid-April to late may. In the last week of May, Lewiston releases were increased to 3000 cfs, and further observations were not possible.

Results and Discussion

Figure 1 shows chinook fry and juvenile numbers at all sites during the 1991 rearing season. Figures 2 through 5 show counts for each of the four upper from 1986 to 1991. All fish numbers are reported as individuals per linear foot of the river's edge.

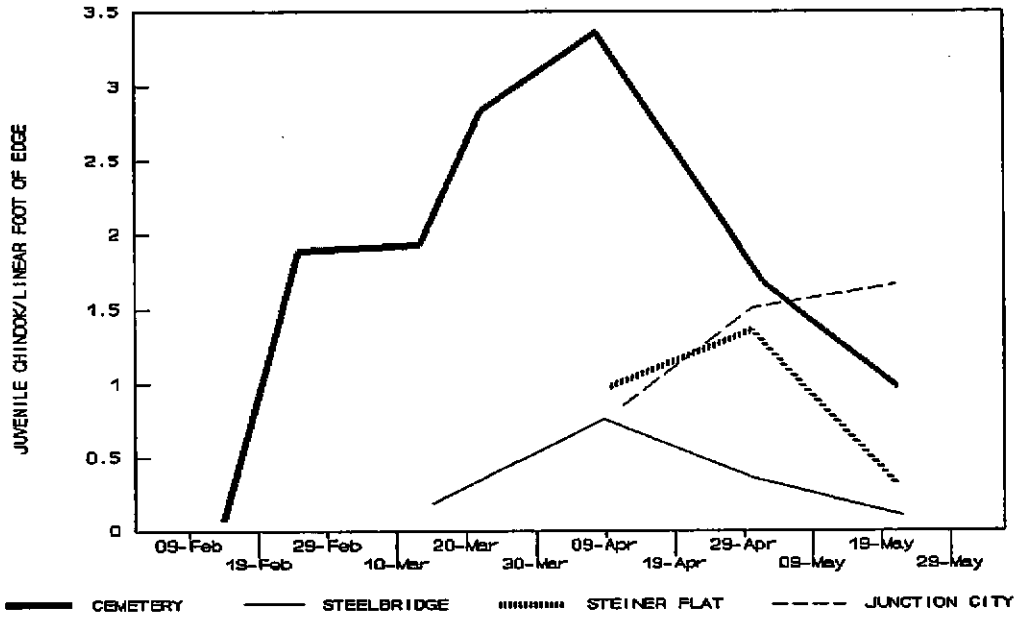


Figure 1 Juvenile chinook salmon population counts at four sites in 1991.

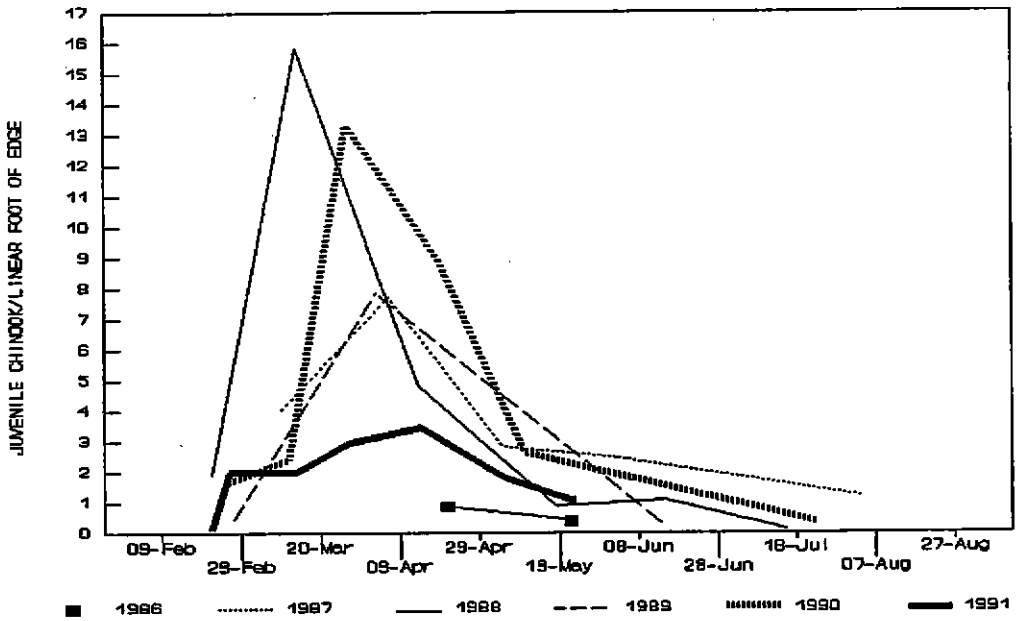


Figure 2 Cemetery site juvenile chinook salmon counts from 1986 through 1991.

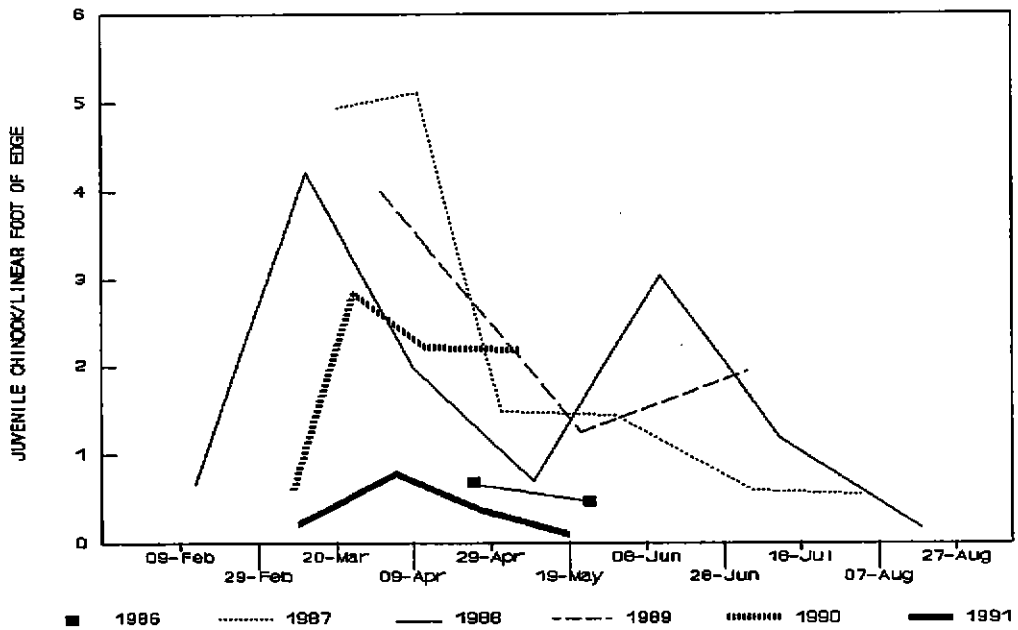


Figure 3 Steelbridge site juvenile chinook counts from 1986 through 1991.

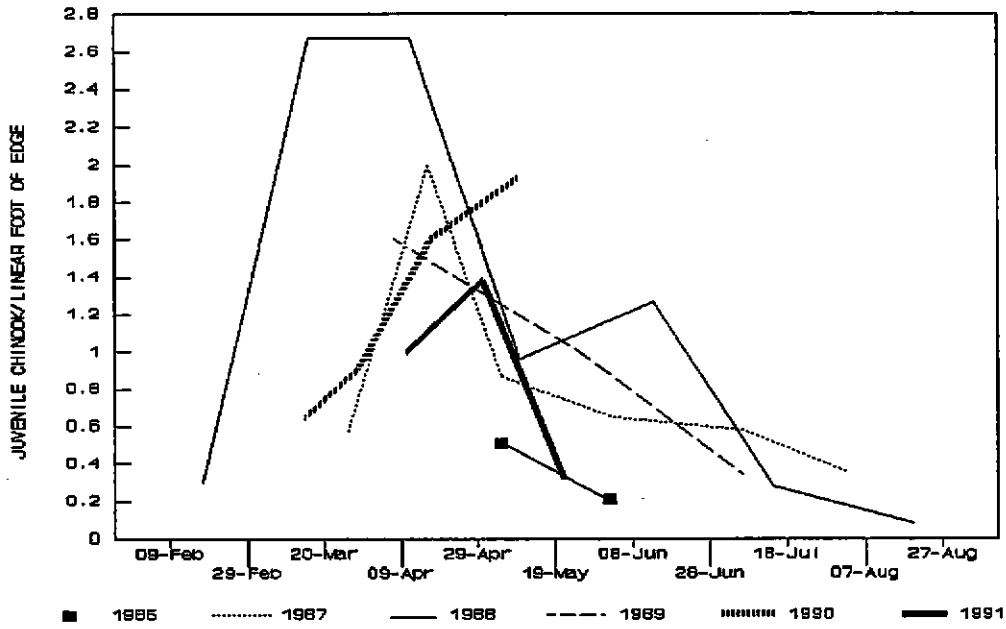


Figure 4 Steiner Flat site juvenile chinook salmon counts from 1986 through 1991.

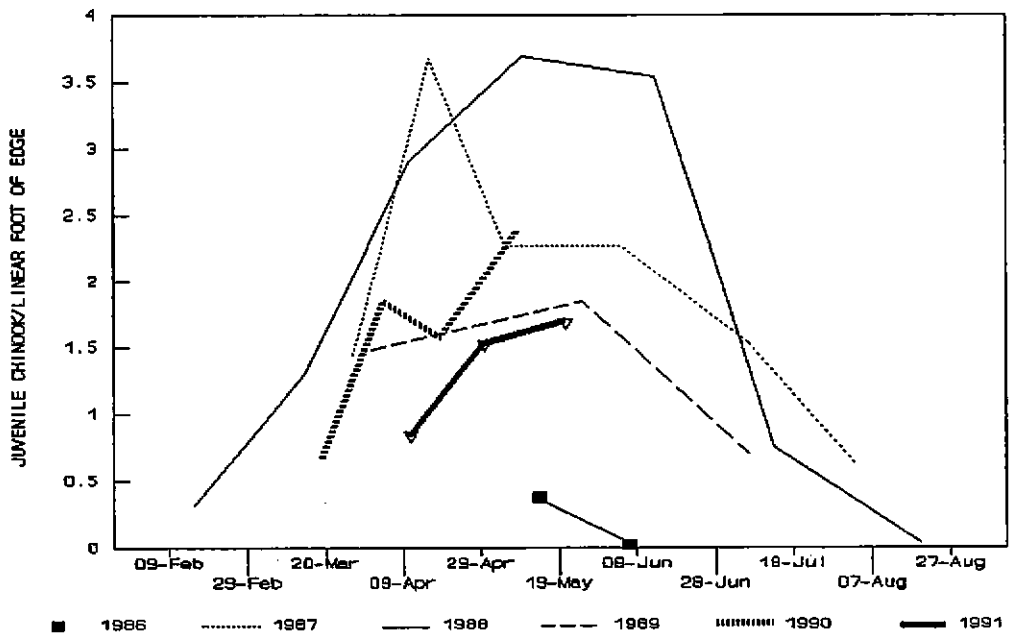


Figure 5 Junction City site juvenile chinook counts from 1986 through 1991.

Overall distribution patterns followed those of previous years, with the greatest numbers of fry rearing in the upper river, as observed at the Cemetery site, and downriver numbers increasing through the season.

Review of counts at specific sites from 1986 through 1991 shows that early-season counts were generally the lowest since 1985, although mid and late-season counts at Steiner Flat and Junction City sites approached those of previous years. The similarity of low counts in 1986 and 1991 is echoed in California Department of Fish and Game run-size estimates. Weir monitoring in the fall of 1985 resulted in an estimate of 9,217 in-river spawners, followed in 1986 by a jump to 92,540 spawners, then a consistent yearly decrease to 30,100 in 1989. In 1990, the best estimate of in-river escapement is 10,562 (Zuspan, pers. comm.), which seems to have resulted in the low numbers of fry observed during the 1991 rearing season.

IV. PROGRAM PLANNING, DIRECTION, AND COORDINATION

Activities of the Trinity River Flow Evaluation in 1992 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 are continuing in 1992. 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

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. Evaluation of fish habitat in constructed side-channels and on feathered river banks 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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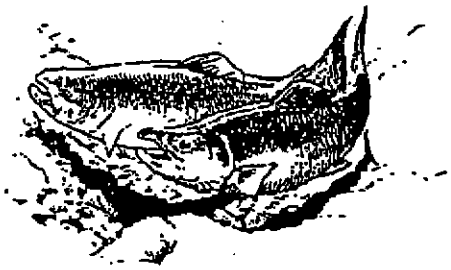
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