TRINITY RIVER FLOW EVALUATION

ANNUAL REPORT - 1988

FISH AND WILDLIFE SERVICE

U.S. DEPARTMENT OF THE INTERIOR

ANNUAL REPORT

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1988

U.S. Fish and Wildlife Service
Division of Ecological Services
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P.O. Box 174
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PREFACE

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

Through this undertaking, we hope to gain a better understanding of the dynamic forces which influence and control the destiny of the 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 indigenous fishery resources.

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

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PERSONNEL AND ACKNOWLEDGEMENTS

The following persons contributed to this report:

Mike Aceituno, Project Leader:
Water Temperature Monitoring, Program Planning and Coordination.

Randy Brown, fishery biologist:
Spring Chinook Holding Requirements, Side-channel Salmonid Populations.

Andy Hamilton, fishery biologist:
IFIM Model, Side-channel Habitat, Juvenile Salmonid Populations, Invertebrate Studies.

Mark Hampton, fishery biologist:
Winter Habitat Use, Spawning Distribution, Juvenile Salmonid Growth.

Robyn Roberts, clerk-typist:
Data entry, graphics, word-processing.

Bill Somer, fishery biologist:
Fry Emergence and Migration. Invertebrate field collection, identification, data entry, and initial study planning.

Rick Macedo, now with the California Department of Fish and Game, did the initial work on side-channel populations and fry emergence. Phil North of the USFWS Sacramento Ecological Services Field Office helped process invertebrate samples.

Jim Carson, Assistant Field Supervisor at the Ecological Services Field Office in Sacramento, provided editorial assistance.

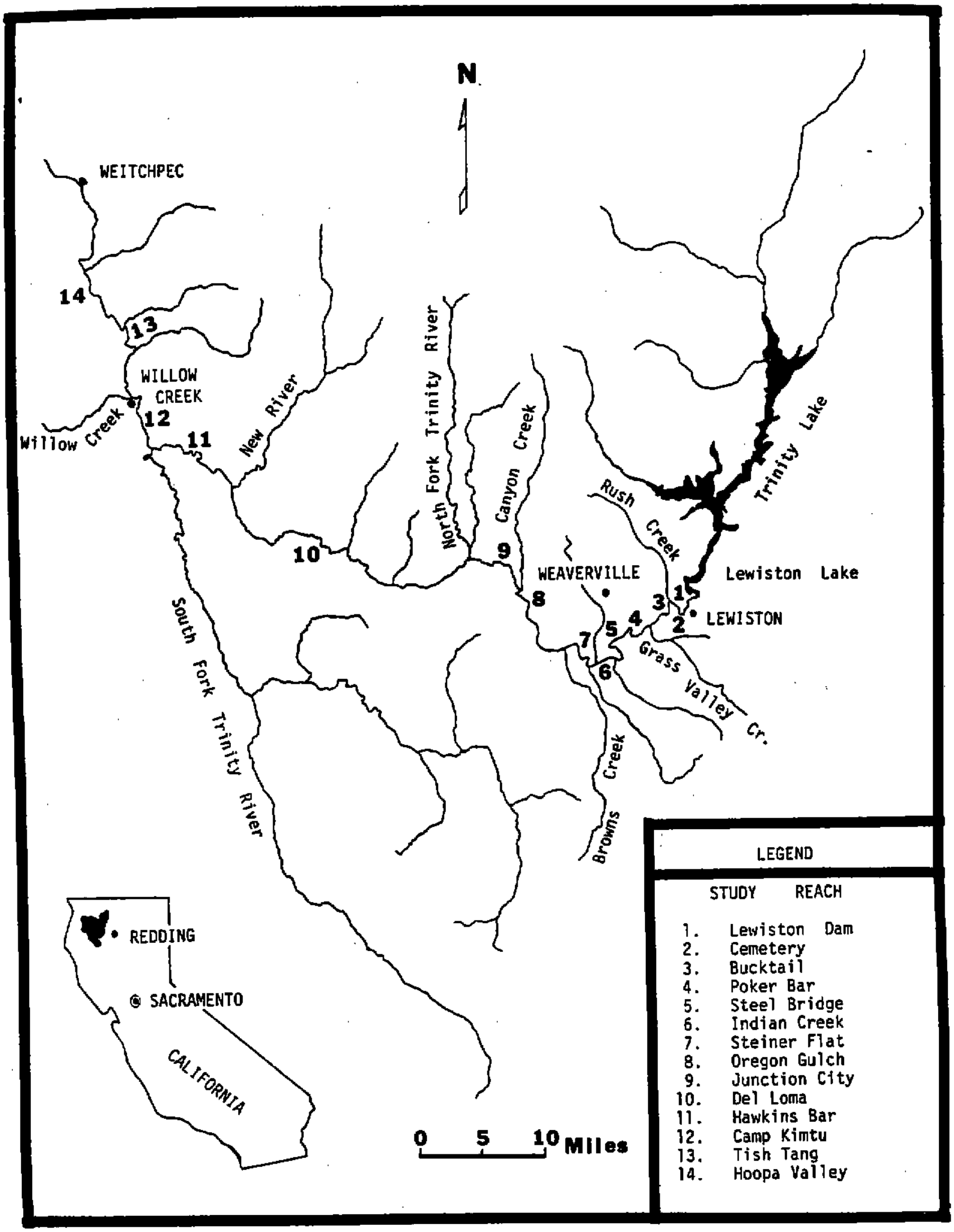

Figure 1. Trinity River Basin with Study Site Locations.

TRINITY RIVER FLOW EVALUATION STUDY
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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 agreemement 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 implememted; 5) in dry-years, releases will be 220,000 acre-feet and in critically dry years 140,000 acre-feet; 6) dry and critically dry years will be based on forecasted Shasta Reservoir inflow; and, 7) at the end of the 12-year study the Service is to report to the Secretary, describing the effectiveness of the improved flows and any other habitat rehabilitation measures (e.g. those contained in the Trinity River Basin Fish and Wildlife Management Program) in restoring fish populations and habitat below Lewiston Dam.

As directed by the Secretary the Fish and Wildlife Service completed a Plan of Study for the Trinity River Flow Evaluation in December 1983. Subsequently, Department of Interior funding was provided through the Bureau of Reclamation and field work initiating the 12-year evaluation program began in January 1985 (Fiscal Year 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 Developmemt.

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

TASK 3. Determination of Habitat Availibility and Needs.

Objective: A. To determine the amout 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 mangagement options and needs.

The following sections summarize project activities primarily between September 1987 and October 1988. The final section on program Planning and Coordination describes the focus of study efforts planned for 1989.

II. HABITAT AVAILABILITY AND NEEDS

1. FURTHER CONSIDERATION OF FLOW MODEL DATA

Introduction

This year we further analyzed our IFIM flow model data from 1986 field work in order to present a clearer picture of the effects of flow on available habitat, given the present channel morphology, and to follow up on a few of its many implications.

The results include first the following overview of the current total available Weighted Usable Area, a measure of fish habitat based in this case on water velocity, depth, and substrate, in a modification of the three river segments we used to organize our study at its inception. Secondly, we investigated the potential detrimental effects that high spring Lewiston releases, up to 3500 cfs, might have through creating off-channel pools that would strand rearing fish. Finally, we looked at the relationship between higher flows and rearing habitat at the Hoopa Valley site, which seems to retain some of the morphological characteristics of the pre-project upper Trinity River, and provides some indication of the appropriate way to proceed in rehabilitating the river's habitat.

Habitat by River Segment

Figures 1 through 5 show rearing and spawning habitat of our target species and life stages in three river segments. These segments are the upper river between the New Bridge in Lewiston and Weaver Creek, the middle river between Weaver Creek and the North Fork, and the lower river between the North Fork and Hoopa Valley. The upper segment includes our Cemetery, Bucktail, Poker Bar, and Steelbridge study sites. The middle river includes our Steiner Flat, Oregon Gulch, and Junction City sites. The lower river includes our Del Loma, Hawkins Bar, Tish-Tang, and Hoopa Valley sites. Our target species are chinook salmon and steelhead trout, along with coho salmon, which are a species of lesser import to the Trinity, and which exhibit habitat needs that would be answered by the provision of habitat for the other two species.

To prepare these data, the PHABSIM output, which is expressed as square feet of Weighted Usable Area per 1000 feet of river, was multiplied by the number of thousands of feet in the river reach represented by each of our study sites. The resulting habitat values were then summed over each river segment.

We used the same fish habitat utilization curves that were used in 1987 (Hampton, 1987, Appendix A). These curves reflect the fact that chinook, coho and steelhead fry live in slow to very slow water, and that their preferences change at varying rates as they grow. Once they have reached juvenile size, about two inches, coho maintain a preference for slow water, chinook move to somewhat faster water, and steelhead select yet faster currents. The fastest current in which we find significant numbers of young steelhead is 4.0 feet per second, which can be waded with little trouble at knee-high depth. We used no substrate criteria, since we have not found that rearing Trinity river salmonids require any special substrate or cover types during the spring and summer, except where large rocks and woody debris may create limited areas of low velocity immediately downstream.

Our spawning habitat curves show that spawning salmonids require moving water, peaking at between 1.0 and 2.0 feet per seconds, and clean gravel of an appropriate size.

Upper River The resulting habitat curves shown in Figures 1 through 5 are smoother than the collection of individual curves for each site presented in our 1987 annual report. They show a smaller variation in habitat with changes in flow, and permit a clearer comparison of the relationships between fry and juvenile habitat availability for the various salmonids.

The reduction in variation in rearing habitat in the upper segment (Figure 1) is caused mostly by a spreading of the effects of side-channel inundation at Cemetery and Bucktail over the entire upper river, which tends to maintain total fry and juvenile habitat at a consistent level as flows increase. Total available habitat still drops with increasing flows, because of the steep-sided configuration of the river channel, which forces added water to flow faster.

The rearing curves show that the river provides more juvenile habitat than spawning habitat at all flows. The least amount of habitat is available for coho fry, which select water of zero velocity and avoid velocities above 1.0 foot per second. The most is available to steelhead juveniles, which prefer velocities between 1.0 and 2.0 feet per second.

Coho and steelhead spawning habitat in the upper river is seen in Figure 2 to be relatively insignificant. The lack of steelhead spawning habitat is probably caused by an absence of clean gravel in the appropriate sizes. The apparent lack of coho spawning habitat may be an artifact of our curve-development procedures, which require field observations of spawning fish to define habitat-use curves. During use data collection most of the coho in the mainstem Trinity spawned in the reach directly below Lewiston Dam, where gravel is cleaner than it is in the rest of the upper segment. The

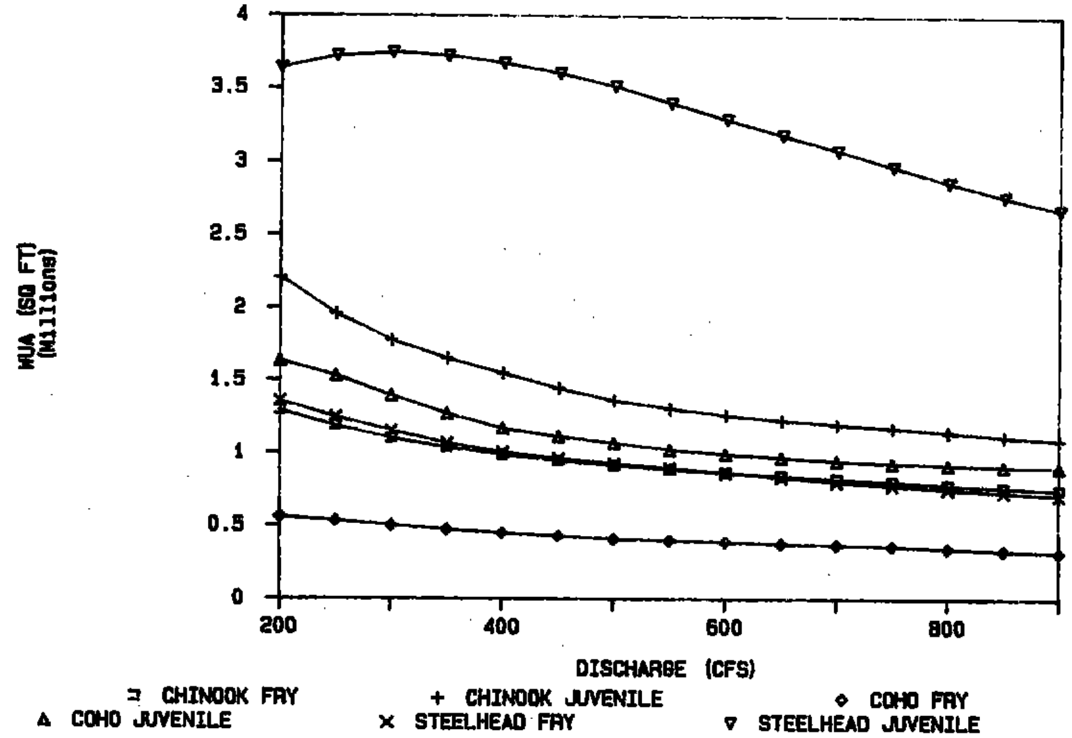

Figure 1. Weighted Usable Area for Fry and Juveniles, Lewiston to Douglas City.

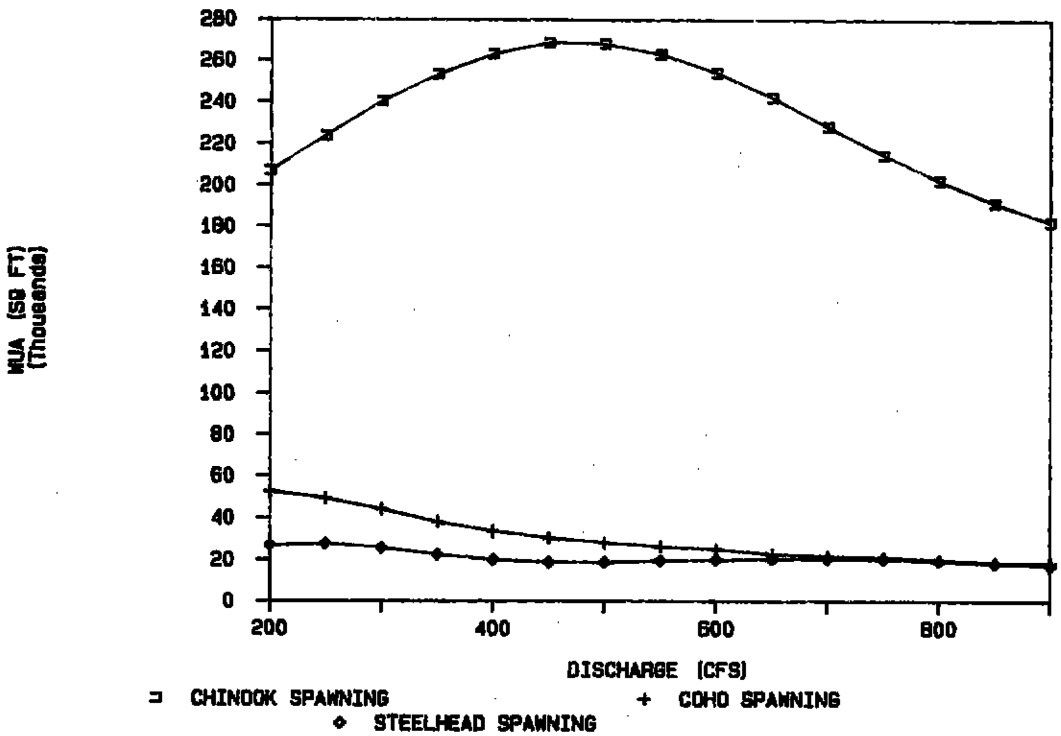

Figure 2. Weighted Usable Area for Spawning, Lewiston to Douglas City.

resulting curves, applied to the sandy bottom below Lewiston, show little available habitat for coho spawning.

Upper-reach spawning habitat for chinook salmon peaks at about 425 cfs, when an estimated 265,000 square feet of spawning habitat are available above Douglas City. This drops to about 240,000 square feet at the currently scheduled spawning release of 300 cfs.

Middle and Lower River Habitat trends in the middle river segment, from Weaver Creek to the North Fork, are similar to those in the upper river. Once again the habitat curves are smoother and clearer. Figure 3 indicates that increasing river flow depresses rearing habitat somewhat, and that there is more habitat for juveniles than for fry. Figure 4 shows substantially more habitat for spawning chinook than for coho or steelhead.

For the lower river segment, from the North Fork to Hoopa Valley, we simulated only chinook and steelhead rearing habitat, and we increased the range of flows simulated from 900 to 3500 cfs. The habitat curves for fry (Figure 5) generally descend until about 900 cfs, and then begin to increase slightly, mostly because the segment includes Hoopa Valley, where increased flows result in an increased area of slow-water habitat (see below). Chinook fry and juvenile habitat drops steadily from peaks near the low end of simulated flows. At flows above about 2000 cfs, the curves at all sites other than Hoopa begin to take radical turns, indicating that the habitat simulation, which is based on field data taken at much lower flows, is no longer a trustworthy reflection of reality.

Relationship to Fish We have found by measuring chinook redds that they take up an average of about 50 square feet. Adding room for separation between redds, 100 square feet is another reasonable estimate for the amount of spawning area required for a pair of chinook. Based on these high and low estimates, in the reach between Lewiston and Douglas City, there is habitat for from 2,700 to 5,400 spawning pairs. In the reach between Weaver Creek and the North Fork, about 5,500 to 11,000 pairs should be able to spawn, for a total between Lewiston and the North Fork of 8,200 to 16,400 pairs.

We as yet have incomplete information on area needs of rearing salmonid fry and juveniles. The highest density of juvenile salmonids we have seen was 1.06 chinook fry per square foot in March at the upper electrofishing site at the Moose side-channel in Lewiston (Section III.4). Peak Weighted Usable Area for chinook fry between Lewiston and Weaver Creek is 1,294,548 square feet, which would provide habitat for about 1.4 million fry. There are an additional maximum 770,861 square feet of chinook fry Weighted Usable

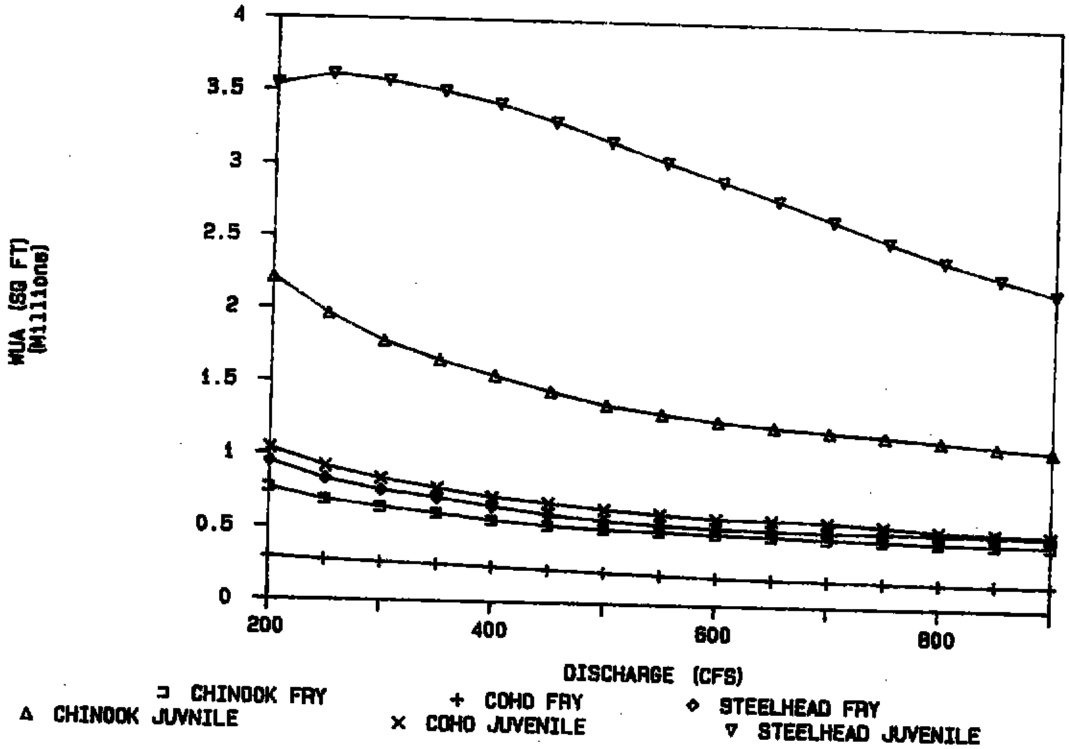

Figure 3. Weighted Usable Area for Fry and Juveniles, Douglas City to North Fork.

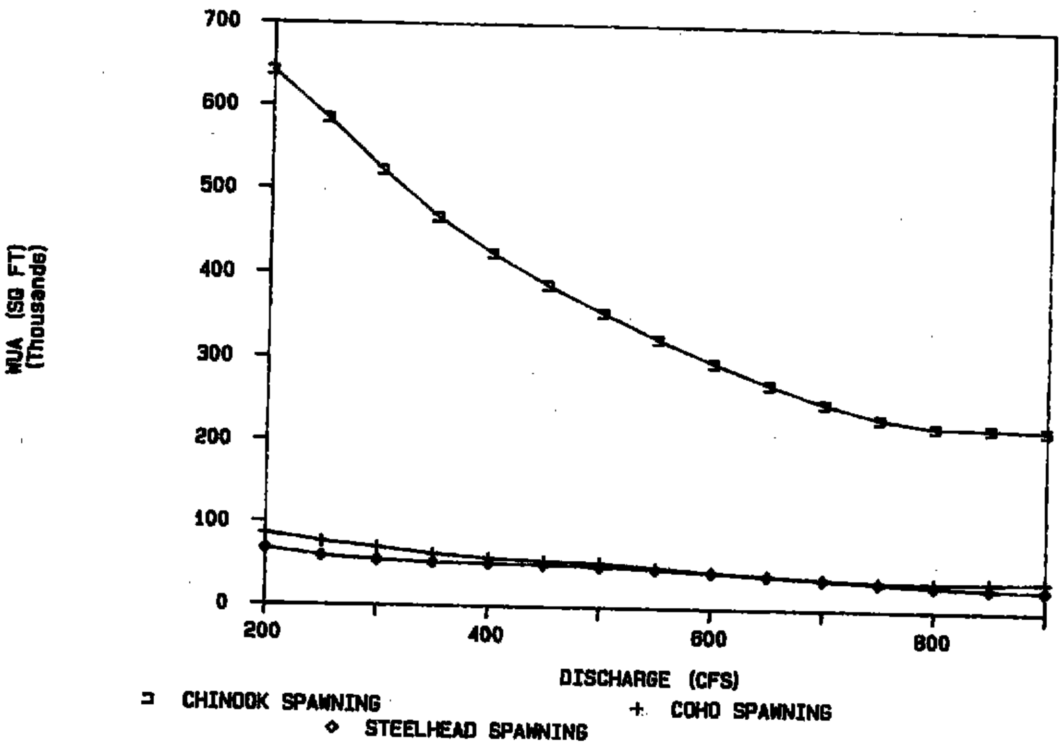

Figure 4. Weighted Usable Area for Spawning, Douglas City to North Fork.

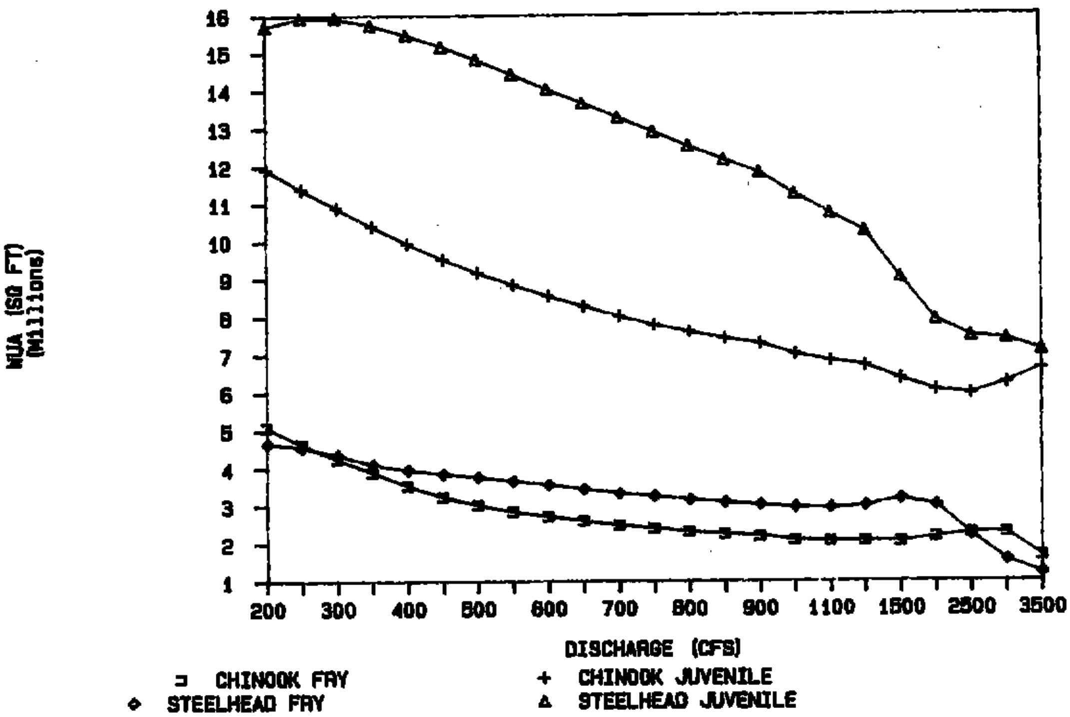

Figure 5. Weighted Usable Area for Fry and Juveniles, North Fork to Hoopa Valley.

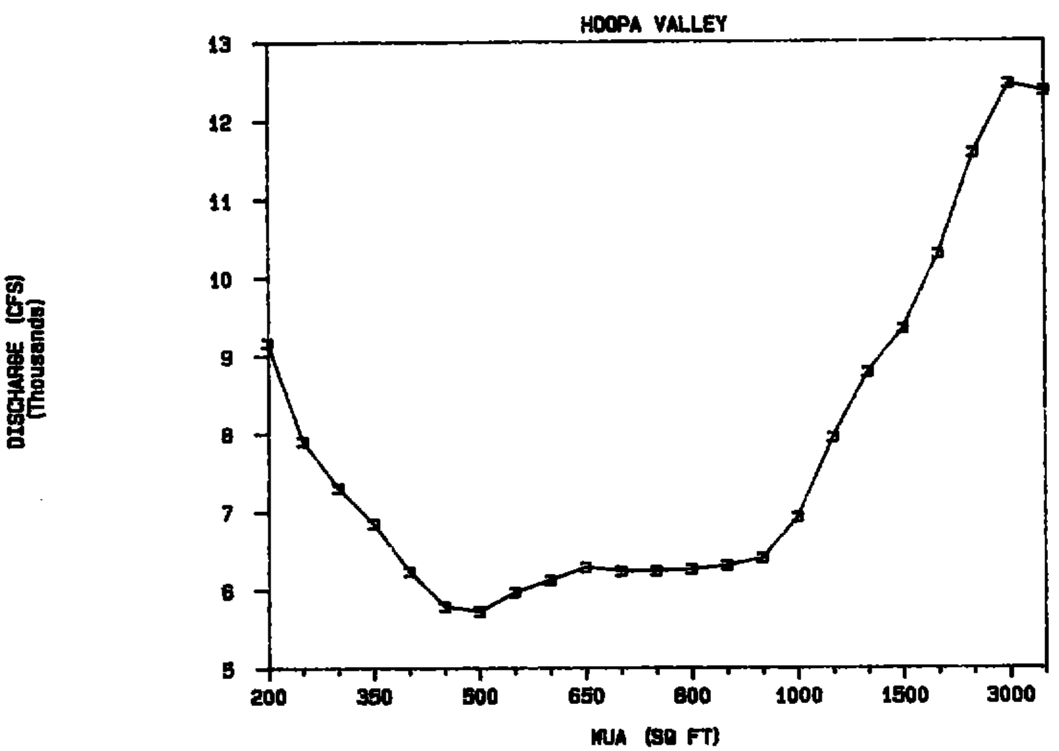

Figure 6. Weighted Usable Area for Chinook Salmon Fry at Hoopa Valley IFIM Site.

Area between Weaver Creek and the North Fork, which at the maximum observed density would provide habitat for 817,113 fry. A total of approximately 2.2 million resident fry could be supported between Lewiston and the North Fork. According to our simulations, in the river between the North Fork and Hoopa Valley there could be a maximum of 5,098,305 square feet of chinook fry habitat, although here it is possible that actual habitat could be reduced or eliminated if temperatures are not suitable for salmonids.

The total chinook fry Weighted Usable Area between Lewiston and Hoopa Valley, without consideration of temperature, is 7,163,714 square feet. At our highest observed densities, this could support approximately 7.6 million chinook fry.

We do not have good electrofishing information on what might be considered maximum chinook juvenile densities, because only the side-channels are amenable to electrofishing, and most chinook evidently leave the side-channels by the time they have reached the 50 mm in length that we define as juvenile size. Generally, from our snorkel population observations (Section III.2), it may be assumed that we see juvenile densities at most an order of magnitude below fry densities. Lister and Genoe (1970) found maximum juvenile chinook densities of about 4.5 per square meter, or 0.42 per square foot, in the Big Qualicum River in British Columbia, and with some license this may be taken as an upper density for juvenile chinook. According to our PHABSIM output, there is a maximum of 2,925,700 square feet of juvenile chinook habitat in the upper segment, 2,212,253 square feet in the middle river, and about 12,000,000 square feet from the North Fork to Hoopa Valley. Thus the river, at 0.42 juveniles per square foot of suitable habitat, could support about 1.2 million fish in the upper segment, about 1.0 million in the middle segment, and if temperature is not a factor about 5.0 million in the lower segment, for a total of 7.2 million.

Table 1 shows these relationships between habitat and the life-stages of chinook it might support.

Table 1. Estimated Maximum Trinity River Chinook Salmon Populations for Various Life Stages Supportable with Maximum Habitat Available.

Segment	Fry	Juvenile	Spawning Pairs
Lewiston to Douglas City	1,372,220	1,228,794	5,400
Douglas City to North Fork	817,113	929,146	11,000

North Fork to Hoopa Valley	5,404,203	5,040,000	--
Total	7,593,536	7,197,940	16,400

Assuming that naturally-produced chinook juveniles can out-compete the millions of hatchery fish that are released each year at Lewiston, and that the density values for fry and juveniles are reasonable, it appears that there is adequate juvenile habitat to accommodate the fry that can successfully rear within the river.

It further appears that there is adequate spawning habitat to produce the numbers of fry that the river can be expected to support. Female chinook at the Trinity River Fish Hatchery produce about 2,800 eggs each, and hatchery egg-to-fry survival is about 84 percent. If naturally-spawning fish produce as many eggs, and have a 50 percent egg-to-fry mortality, then 5,400 pairs spawning above Douglas City, adequately spaced in the available spawning area, could fully seed the entire river.

Effects of High Flow on the Formation of Isolated Pools

Occasional high releases from Lewiston Dam to help wash accumulated sediments from the mainstem Trinity River, prevent the encroachment of riparian vegetation on the river channel, and maintain the channel in its natural shape, have been consistently recommended by various organizations concerned with the management of the Trinity River since the river was first controlled by the Trinity River Project (e.g. VTN, 1979, Section II-28).

Major objections to such flushing flows on the Trinity have been:

1) high water is to be avoided because it can cause property damage to persons who have built in the flood-plain,

2) excessive amounts of water are required to flush sediments, causing lost benefits in power generation and water supply to the Central Valley Project, and

3) water at some indeterminate level above 800 cfs will overtop a berm that has developed along the river and create numerous isolated pools that will strand and kill fish.

In order to evaluate the third of these objections, we undertook a review of our IFIM data to determine if it supports the idea that a flushing flow will create significant stranding areas.

Current Conditions Sediment is entrained and transported at high water velocities, and deposited at lower velocities. When a river overtops its banks it may fill a wide flood channel with water high in suspended fines, which may subsequently be deposited along the channel in a natural levee or berm, possibly creating isolated channels or backwaters on the flood-plain. Where vegetation has encroached along the river bank, it may slow flood-waters so that they deposit sediments adjacent to the low-flow channel while the river is still in flood, increasing the height of the berm.

Such berms are evident along the Trinity River in some areas. They are most evident between the California Department of Fish & Game counting weir above Junction City, at river mile 86, and Cooper's Bar at river mile 75. In this section, many of the inside bends of the main channel are bordered by berms covered with a thick growth of willow, alder, and blackberry. The berms tail off to the height of the natural bank-full edges of the river at their upper and lower ends, where the occasional flood-water that forms them enters and leaves the flood channel behind them. They are generally interspersed with low sections where the inland gravel or cobble bars slope gently to the river. Many of these low points have been further lowered by fishermen, who have cut foot-trails and boat-launching access from dirt roads behind the berm.

The river below the North Fork has no berms. The steep canyon walls and the unregulated flows prevent their formation. Above the Department of Fish & Game weir their are a few discernable berms. Isolated berms have developed on some of the gravel bars between the end of Steiner Flat road and the BLM Steiner Flat campground upstream. Between Indian Creek and Limekiln Gulch there are a few areas where an irregular, low sandy berm is present. There is a broken berm of soil and sand on the left bank of the river above Bucktail hole, and there are indications that a berm may be forming on parts of the left bank between Rush Creek and Lewiston.

IFIM Data We have established 126 transects across the river from Lewiston Dam to Hoopa valley, and have developed stage-discharge relationships at these transects based on Lewiston releases between 300 and 800 cfs.

The stage-discharge relationships permit the estimation of the river's water surface elevation at various flows. Transect profile data permits us to predict where the water level will be in relation to the river bank at these flows.

Since we established them to measure discharges up to about 1000 cfs, and because extending them further would have served no purpose within IFIM, most of our transects begin and end on the bank-full edge of the river, inside any berms. As a result, flow that keeps within our transect end-pins can be considered to remain within the channel.

To determine the effects of a 3,500 cfs release, we simulated this flow in IFIM hydraulic computer programs, and examined results for the creation of any fish-stranding pools beyond the berm.

<u>Results</u> Our two sites within the area of definable berms are at Oregon Gulch and Junction City Campground.

At Junction City Campground, a simulated flow of 3,500 cfs backed water up into the side-channel on the right bank of the river, overtopping our riverbank pin by 2.8 feet. This was well below the height of the berm, but it is possible that the discharge could cause flow in the side-channel on the Highway 299 side of the berm. However, on several occasions during the past three years we have seen the channel watered behind the berm at flows up to about 10,000 cfs, and have seen no subsequent formation of isolated pools.

At Oregon Gulch, the berm is more well-defined than at Junction City. Our simulation of a 3,500 cfs flow showed no approach by flood waters to the berm top, or even overtopping of our pins along the berm, which are set close to the bottom of its higher terrace. There would be no stranding of fish with a 3,500 cfs flow at Oregon Gulch.

At our Steiner Flat site there is a discernable berm and potential flood channel along the right bank between transects 1 and 4. The 3,500 cfs water surface elevation does not come near to overtopping the berm in this area. We have seen the channel behind the berm flowing during flood stages. It drains back into the main river at the location of our transect 4 without forming noticeable isolated pools.

Further upstream at our Steelbridge site the right bank between transects 6 and 10 is benched and fairly level, and could form a side-channel at high flows. The 3,500 water surface elevations is higher than our pins, though whether it is high enough to encroach widely on the benched area is unknown. The bench is irregular, composed of recently-deposited decomposed granite sediments, and thickly covered with blackberries, alders, and willows. It is difficult to predict if any stranding would occur there. There is no record of any biological survey of the area during flood recession, and we do not know whether isolated pools would form there. In the river reach between Steelbridge and Limekiln Gulch the right bank generally has the same configuration, and several minor side-channels form there during higher flows, including our Limekiln Gulch study side-channel (Section II.2).

Along portions of our Poker Bar study site there is a sandy berm on the right bank, but the 3,500 cfs flow does not overtop it. Formation of isolated off-channel pools is not probable at Poker Bar.

At our Bucktail site some of the transect end-pins along the left bank would be overtopped by a 3,500 cfs flow. These areas would drain without forming significant isolated pools, and significant stranding would not occur.

At our Cemetery site there is some elevation of the bank adjacent to the river, but no real berm. A 3,500 cfs flow would spill over into low brushy areas above a small side-channel on the right bank above the chute in the area of transect 5 and 6. This would be a natural upstream extension of the existing side-channel, and would drain without creating significant isolated pools.

At the upper section of the Cemetery site a 3,500 cfs flow would overtop some of our pins on both sides of the river. This section consists of a defined river channel, a smaller but well-defined side-channel, and a broad area of broken, shallow, brushy side-channel between them. The central channel is increasingly inundated from flows over about 350 cfs, and provides the best extended area of salmonid fry rearing habitat on the Trinity River. Isolated pools form here every spring as the water recedes, and this is the only area where we saw stranding after the floods that subsided in March, 1986. Formation of isolated pools will occur here at any flow above about 350 cfs. Since most young-of-the-year salmonids leave side-channels before mid-May, there is insignificant stranding in years when water remains high until the last week of that month.

In conclusion, there is no physical evidence suggesting that a spring release of 3,500 cfs from Lewiston Dam would have any measurable detrimental effect on rearing salmonids. It is probable that water higher than the regulated flows that have been normal over the past decades would form some isolated pools that would strand fish if fish were present in the main river. It does not appear from our data, however, that the effect would go beyond the range that could be expected in a natural, unregulated system, or that it would seriously affect fish production in the Trinity River.

Hoopa Valley Flow/Habitat Relationships

As noted in our 1987 annual report, the river at Hoopa Valley is a series of meanders with wide, gently-sloping point bars where increases in flow create increased areas of slow water that provide ideal rearing velocities.

Figure 6 shows the chinook fry Weighted Usable Area response to flows from 200 to 3500 cfs at our Hoopa Valley site. Weighted Usable Area in this case measures availability of suitable velocities and depths, and actual habitat in the Hoopa area may be limited by temperature or other factors. At 500 cfs there is an increase in Weighted Usable Area with increasing flows, and the rate of increase rises dramatically at 950 cfs. The reason is to be found in the shape of the river cross-sections at Hoopa, which are shown in Figure 7.

Habitat for salmonid rearing at our Hoopa Valley site increases at an increasing rate with higher flows as water encroaches on a wide gravel bar that is evident at the right in transects 2 through 4, and somewhat less evident in transect 5 and 6. At this site, the river takes a broad turn to the right, toward a shallow slope that can be seen by motorists on the Highway 96 bridge. On such a bar, the water is slowed both by the friction of shallow flow over a rough substrate, and by the vector of flow past the obtruding point, which leaves a kind of velocity shadow on the bar's downstream edge. This velocity shadow creates ideal habitat for rearing salmonids, which can school at the shear zone between slow and fast water, and feed on the drift that the main current brings past their protected area of relatively still water.

Through inspection of aerial photographs, personal memory of pre-dam conditions, field observation of existing morphology, and discussion with persons familiar with the pre-dam Trinity River, it seems evident that similar gravel point bars existed in the river from Douglas City to Lewiston prior to flow control. Since that time the river, under its controlled flow regime, has channelized, developing steep banks with a broad, canal-like expanse of fast water between them. This new channel shape has reduced the habitat available for rearing salmonids, and may have skewed the flow-habitat relationship so that more water, up to bankful depth, results in less rearing habitat, although the needs of fish for variations in flows for downstream transport, invertebrate production, temperature control, and definition of river morphology may still be the same.

<u>Management Implications</u> Our evidence that point bars are necessary on the Trinity River consists of personal recollections of pre-dam conditions, unverifiable statements in various documents that high returns of fish existed then, our flow-model evidence at Hoopa Valley, suppositions about the relationship between high flows and river morphology, empirical knowledge of the salmonid production capability of other rivers such as the Sacramento, and our recent observations on the habitat preferences of Trinity River salmonids and on existing Trinity River habitat. All of these bits of information seem to point to the idea that reshaping the river channel and maintaining that shape with sustained high flows during at least part of the year are

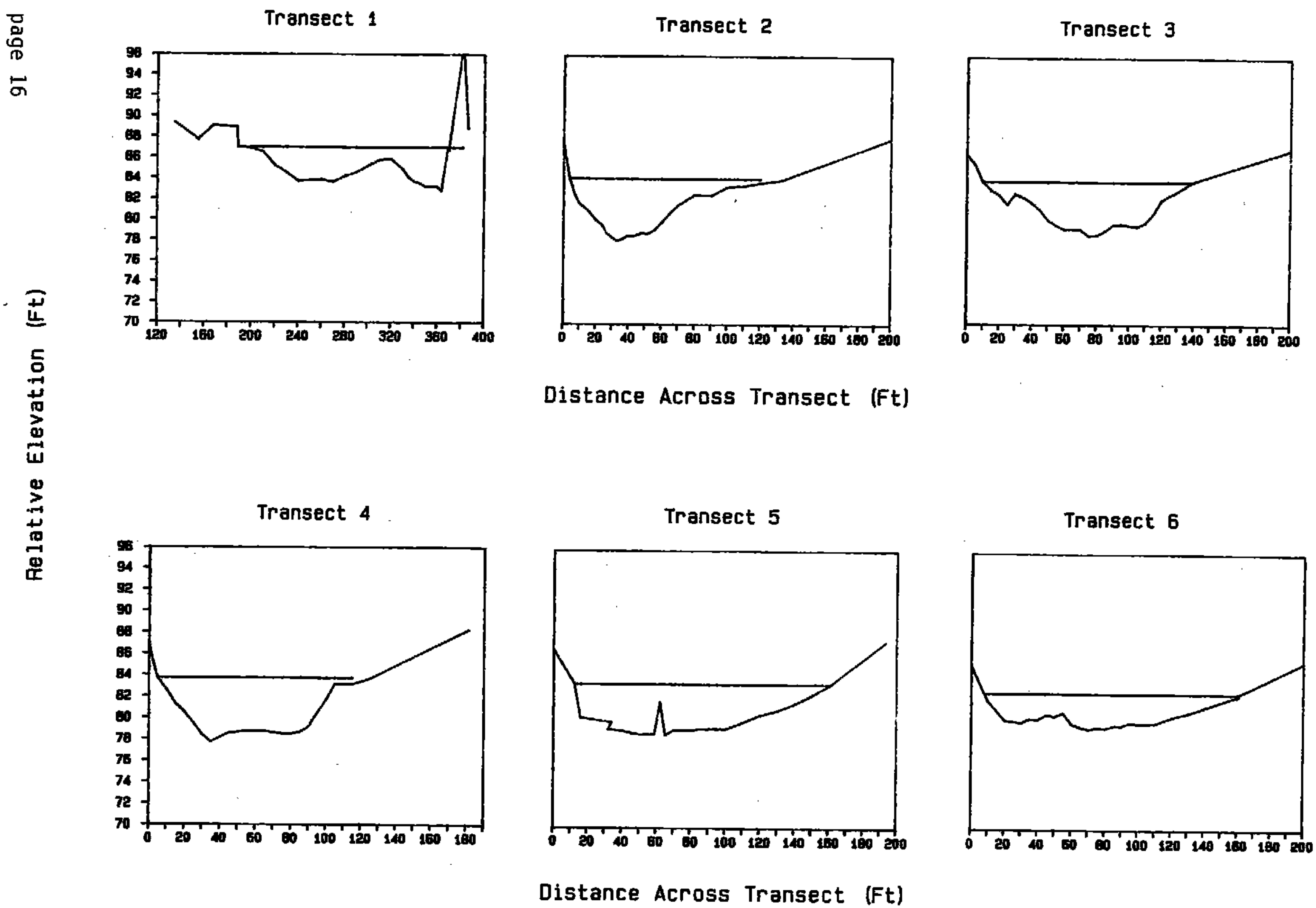

Figure 7. Transect Profiles at Hoopa Valley IFIM Site.

necessary actions if the Trinity River is to be rehabilitated as a natural system.

Fredericksen, Kamine and Associates (1980) faced the same scientific or informational limitations when they stated, with no supporting evidence other than qualitative observation by fisheries biologists, that increasing the flows in the Trinity would not increase habitat unless the channel were widened, which presumably meant the re-creation by heavy equipment of a point bar configuration. Fredericksen, Kamine and Associates seem to have discounted this strategy as infeasible.

The arguments against reshaping portions of the river channel are that it would be costly and that it would reduce the riparian habitat, which is the almost continuous thicket of willow, alders, blackberry brambles, and a few other plant species which has grown up over the old overflow plain of the Trinity River from Lewiston to the North Fork since discharge was controlled.

The dollar costs for reshaping a river bank can be fairly easily calculated. Environmental costs are less easy to quantify. Riparian habitat in California has been much reduced by farming, residential development, and flood control, and the thickets that have grown up along the Trinity River may be considered replacement for some of this lost habitat. Recreating salmonid rearing habitat in the river would destroy some of the post-dam riparian, and might require the provision of compensatory habitat elsewhere.

Reshaping the river, like the provision of flushing flows, is an old idea that has taken a less prominent position than projects of more immediate concern such as the improvement of the Trinity River Fish Hatchery, construction of sedimentation control facilities on Grass Valley Creek, manipulation of steelhead cover and spawning habitat on National Forest lands, and required state stock monitoring in the main-stem and its tributaries. Our data on existing habitat-flow relationships at Hoopa Valley, along with our observations in the upper river, indicate that the provision of fish habitat by mechanical manipulations of the channel should be reconsidered.

2. SIDE CHANNEL HABITAT AVAILABILITY

Introduction

This year we applied Instream Flow Incremental Methodology procedures (Bovee, 1978) to four side channels between Lewiston and Indian Creek to determine how much salmonid habitat was available in the side channels at various river flows. Our purpose was to refine the picture of available habitat in the river, and to discover the relationship existing side channel habitat has with habitat available in the main river.

Sites and Methods

Locations Four side channels were selected as appropriate for IFIM habitat simulation, as follows.

Moose: This 1100-foot man-made side-channel is behind the Moose Lodge, just upstream from the Old Bridge in Lewiston at river mile 110. This year we collected fish population and habitat-use data at the side-channel, as reported in Sections II.3 and III.4. The channel provides a variety of pool, run, and riffle habitat, and is heavily used by spawning, rearing, and over-wintering salmonids. We made measurements at five cross-sections to model habitat responses to changes in side-channel flow.

Salt Flat # 2: This is a narrow natural channel measuring 115 feet from its entrance to the head of a beaver pond at its lower end. It is lined with thick riparian vegetation, and contains about 75 percent riffle habitat, with the rest made up of small pools and pocket water. We used four transects to model conditions. We reported on river flow required to maintain this side-channel in our 1987 annual report, and monitored its salmonid populations this year (Section III.4).

Limekiln Gulch: This channel is at river mile 100.7, just below Limekiln Gulch, between Poker Bar and Steelbridge. We established three transects on the upper 200 feet of the channel, two in the riffles that make up most of this section, and one at the head of the pool that makes up the 700-foot lower section. This side-channel was described in our 1987 annual report on flow requirements.

Indian Creek: This is an 840-foot channel upstream from the Indian Creek Lodge off Highway 299. We modeled its upper 500 feet with five transects representing a fairly even spread of pool, run, and riffle habitat types. The lower 340-foot section is a sluggish low-gradient area that cannot be effectively modeled. This side-channel was also a site for our 1987 flow requirement studies, and for this year's winter habitat and population studies.

Additional sites at Salt Flat, Poker Bar, and Bucktail studied in 1987 were not used in this year's IFIM. The Salt Flat #1 channel has an inadequate amount of the flowing water necessary for hydraulic modeling, and at Poker Bar this year water was backed up the entire length of the side-channel by a beaver dam. Habitat available in the Bucktail channel is modeled in our full-river IFIM studies, as is additional side-channel habitat at the Cemetery site in Lewiston.

Field Measurement and Data Analysis We measured water surface elevations and transect profiles with a spirit level and leveling rod from bench-marks set at an assumed 100 foot elevation. We measured velocities with Price-AA or Marsh-McBirney flow meters, and depths with wading rods. Substrate characterizations followed the modified Brusven index described in our 1987 annual report.

We measured side-channel transect water surface elevations and velocities at a Lewiston Dam release of 600 cfs, and took additional water surface elevation and side-channel discharge measurements at one to three lower river flows (Table 1).

Table 1. Trinity River and Side Channel Discharges Used for IFIM Analysis. Moose and Salt River Flows from USGS Lewiston Gauge, Limekiln and Indian River Flows from Limekiln Gauge.

Site		River Flow	Side-channel Flow
Moose	flow 1:	609 cfs	61 cfs
	flow 2:	487 cfs	43 cfs
	flow 3:	304 cfs	17 cfs
Salt	flow 1:	610 cfs	8.2 cfs
	flow 2:	487 cfs	3.5 cfs
	flow 3:	411 cfs	1.6 cfs
	flow 4:	304 cfs	0.1 cfs
Limekiln	flow 1:	670 cfs	9.2 cfs
	flow 2:	312 cfs	0.1 cfs
Indian	flow 1:	656 cfs	26.0 cfs
	flow 2:	527 cfs	18.7 cfs
	flow 3:	316 cfs	7.7 cfs

In order to relate estimated side-channel habitat to a variety of possible Lewiston releases, we regressed side-channel flows against measured river discharges. The best-fit relations were linear for the Moose and Indian side-channels ($R2 = 0.999$ for both). The best fit for Salt #2 was a power equation ($R2 = 0.995$). For Limekiln the two measured points defined a straight-line estimate. Equations were as follows:

Moose : Side-channel Q = 0.144 x River Q - 26.9

Salt #2 : Side-channel Q = 9 EE -15 x River Q ** 5.4

Limekiln: Side-channel Q = 0.025 x River Q - 7.7

Indian : Side-channel Q = 0.053 x River Q - 8.7

We used these relationships as a basis for the flows modeled in each side-channel, which corresponded to river flows from 200 to 900 cfs.

Data was processed through USFWS PHABSIM micro-computer programs, which project velocities and depths at varying flows and translate these conditions to an estimate of habitat based on models of each factor's suitability for various species and life-stages of fish. We employed the same suitability criteria used in our ongoing main-river modeling (Section II.1 and USFWS, 1987).

Our use criteria curves show that the most important habitat factor for juvenile salmon is velocity, with fry selecting very slow to still water, and juveniles, which are over about two inches long, selecting somewhat faster water. Generally coho salmon select the slowest water, chinook may live in somewhat swifter conditions, and steelhead use yet higher velocities. At velocities of two feet per second, salmon fry and juvenile use is low or non-existent, and use by steelhead juveniles drops swiftly.

Results and Discussion

Side-channel Morphology Figures 1 through 4 show transect profiles at each of the sites. Straight lines across each profile show the water surface elevations we measured at the flows shown in Table 1.

Most of the profiles at Salt #2, Limekiln, and Indian show relatively steep sides, indicating that these side-channels, like the main river, are somewhat channelized by the managed flow regime of the Trinity. Where steeply defined banks predominate, higher flows may be expected to do little to increase slow-water habitat once a threshold flow is reached, since the increased water is confined and velocities must increase.

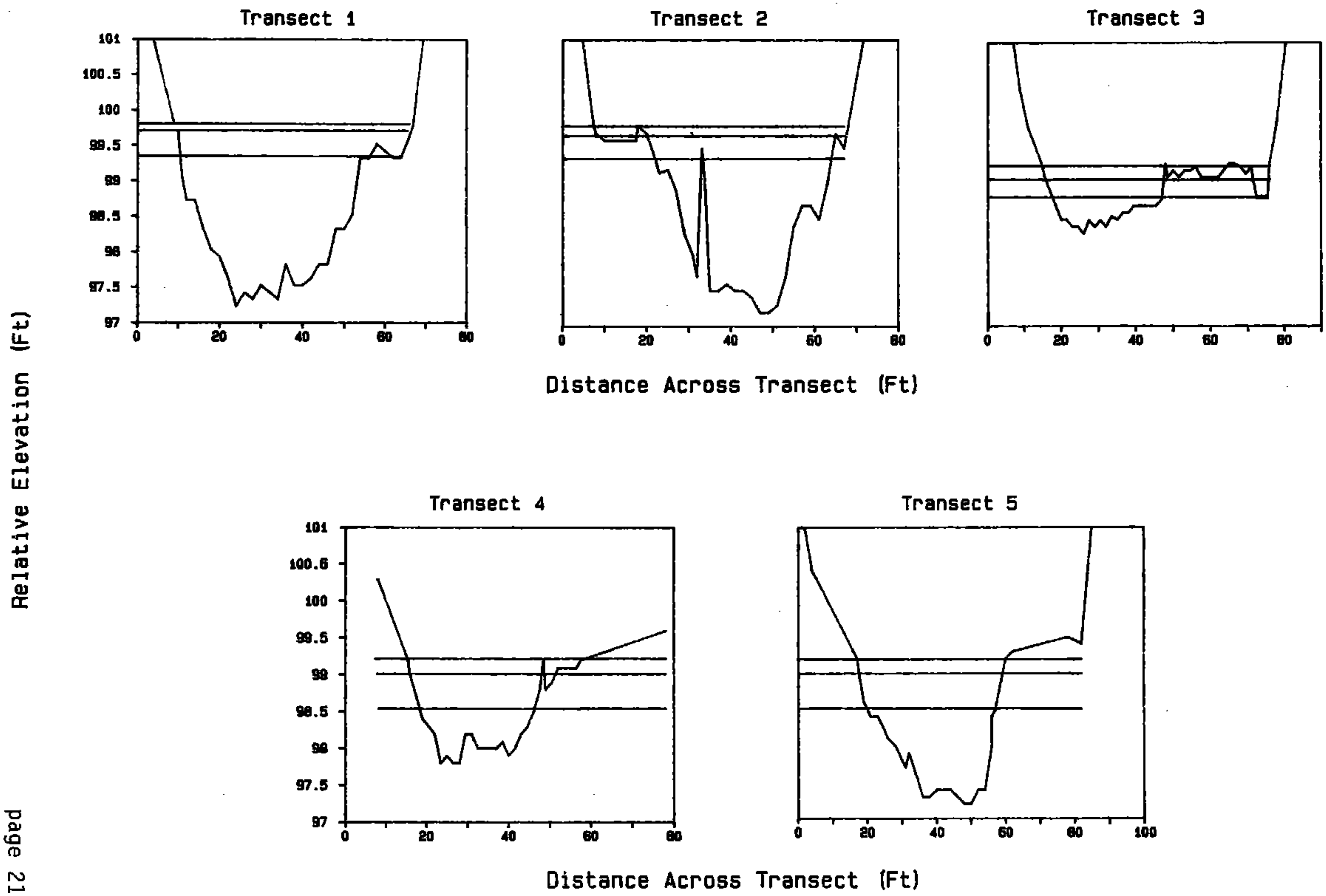

Figure 1. Transect Profiles at Moose Side-channel IFIM Site.

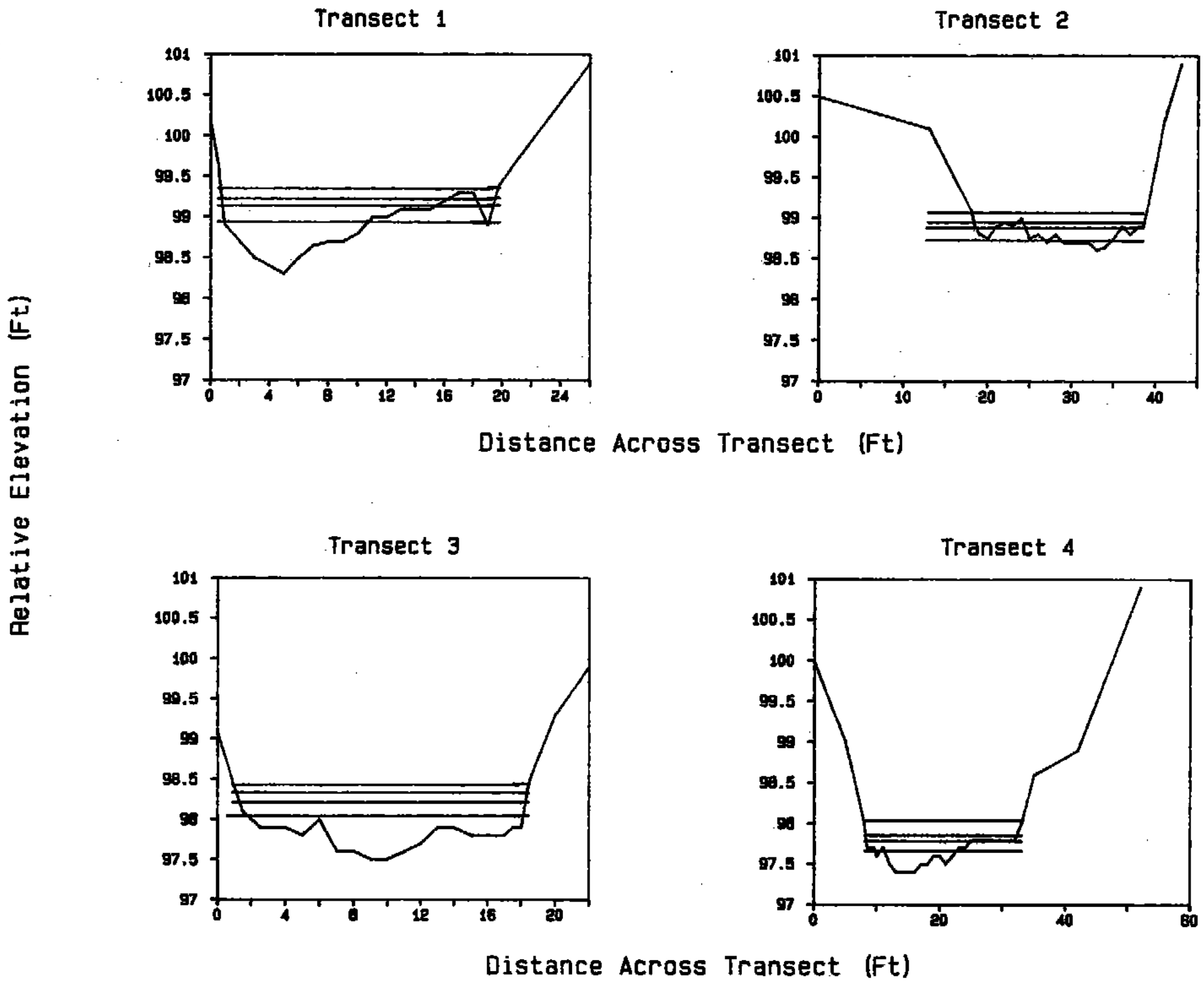

Figure 2. Transect Profiles at Salt Flat #2 Side-channel IFIM Site.

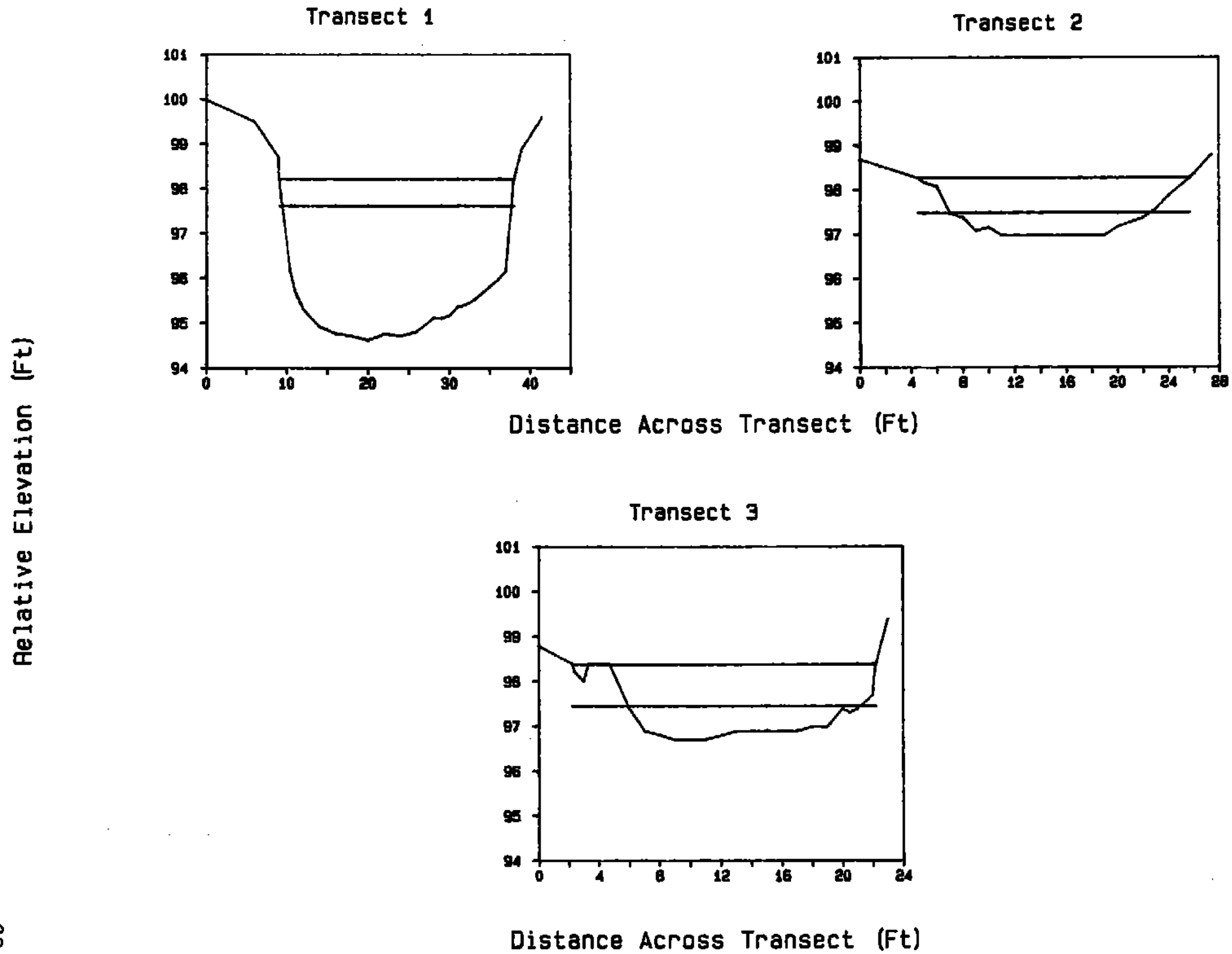

Figure 3. Transect Profiles at Lime Kiln Gulch Side-channel IFIM Site.

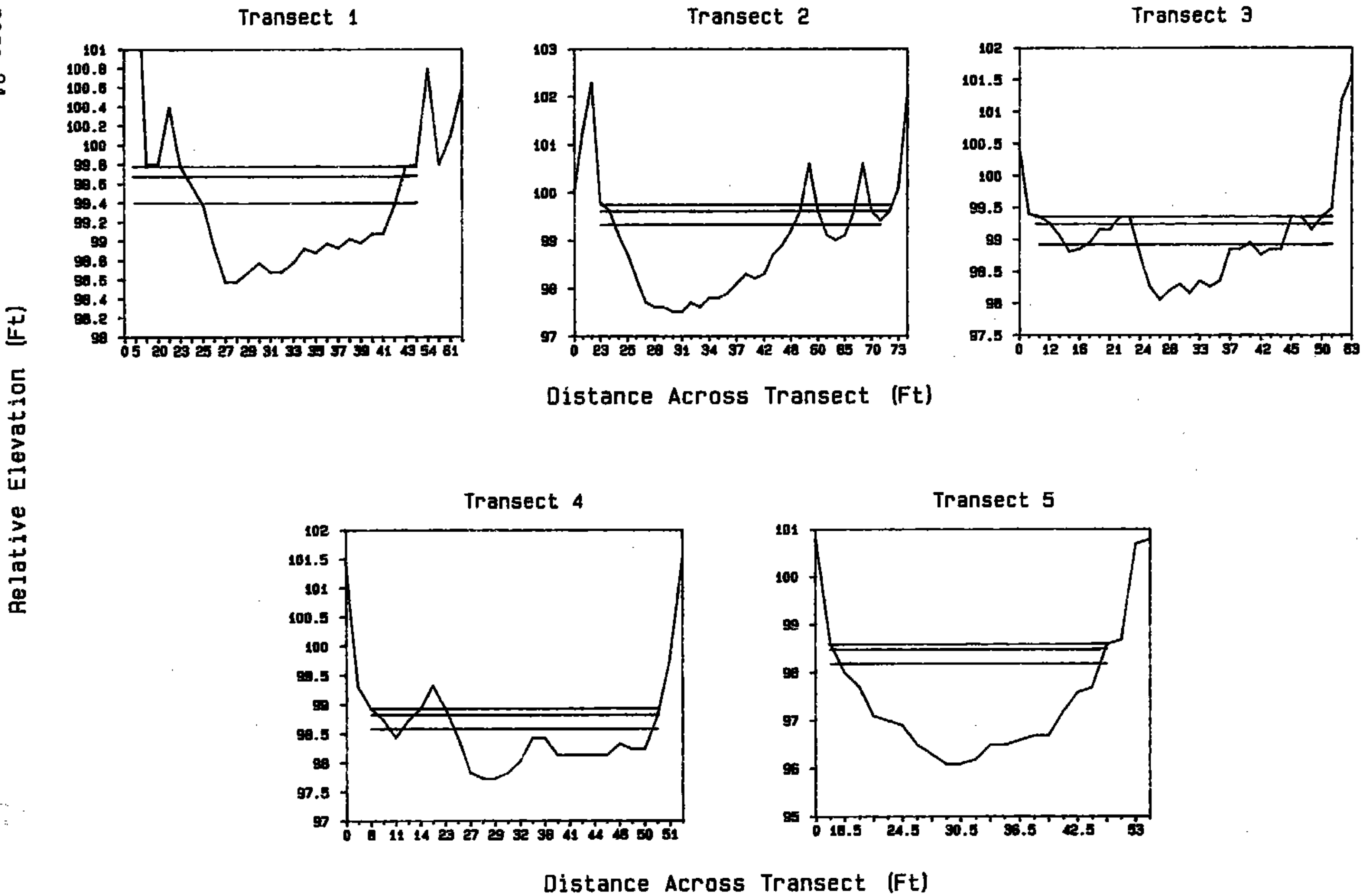

Figure 4. Transect Profiles at Indian Creek Side-channel IFIM Site.

The Moose side-channel profiles show a steeply sloping channel up to about the elevation of the 500 cfs river flow, and then a benched area that is progressively inundated at higher discharge. Flooding this bench would increase slow-water habitat, with the increasing velocities caused by higher discharge tending to localize in the defined main channel.

There is a degree of benching shown in the Indian Creek side-channel profiles. These benches are actually a series of low-gradient, low-volume channels running through grass and brush riparian tangles off the defined side-channel.

<u>Estimated Habitat</u> The PHABSIM Weighted Usable Area per 1000 feet of side-channel over projected river flows is shown in Figures 5 through 8. Weighted Usable Area, a square-foot measurement of usable habitat, is shown for each side-channel and for the average of main-stem river conditions between Lewiston and Douglas City, the river segment where our study side-channels are located.

Figure 5 shows relationships for chinook salmon fry, which select water velocities ranging from zero to about one foot per second. The habitat available in 1000 feet of side-channel at Moose, Limekiln, and Indian Creek is close to the average amount available in the main river. The narrower Salt #2 side-channel provides substantially less habitat.

The trend of the Limekiln and Indian Creek curves follows that of the main river, with increasing side-channel flow providing slightly diminishing overall fry habitat. The Salt #2 curve shows increasing habitat to about 425 cfs in the river, then decreasing habitat, a phenomenon which may be the result of our measuring an extremely low flow in the side-channel. This provides an input of real data to the PHABSIM model at the low flow end, and probably improves the Salt #2 habitat simulation.

The habitat-flow relationship at Moose Lodge shows decreasing chinook fry habitat up to about the point where water begins to inundate the relatively gently-sloping bench areas adjacent to the defined channel, then increasing fry habitat as the benches provide new slow-water areas. This increase tapers off toward the higher simulated flows, presumably because the entire stream begins to speed up.

Chinook juvenile habitat response to flow is relatively flat in all side-channels after an initial increase in habitat to the 350 to 550 cfs range (Figure 6). Evidently the increasing velocities are either maintained within the acceptable limits for chinook juveniles, or developing medium-velocity water at the edges compensates for faster midstream velocities. The habitat provided at Salt #2 drops at lower river flows than does the habitat in the other side-

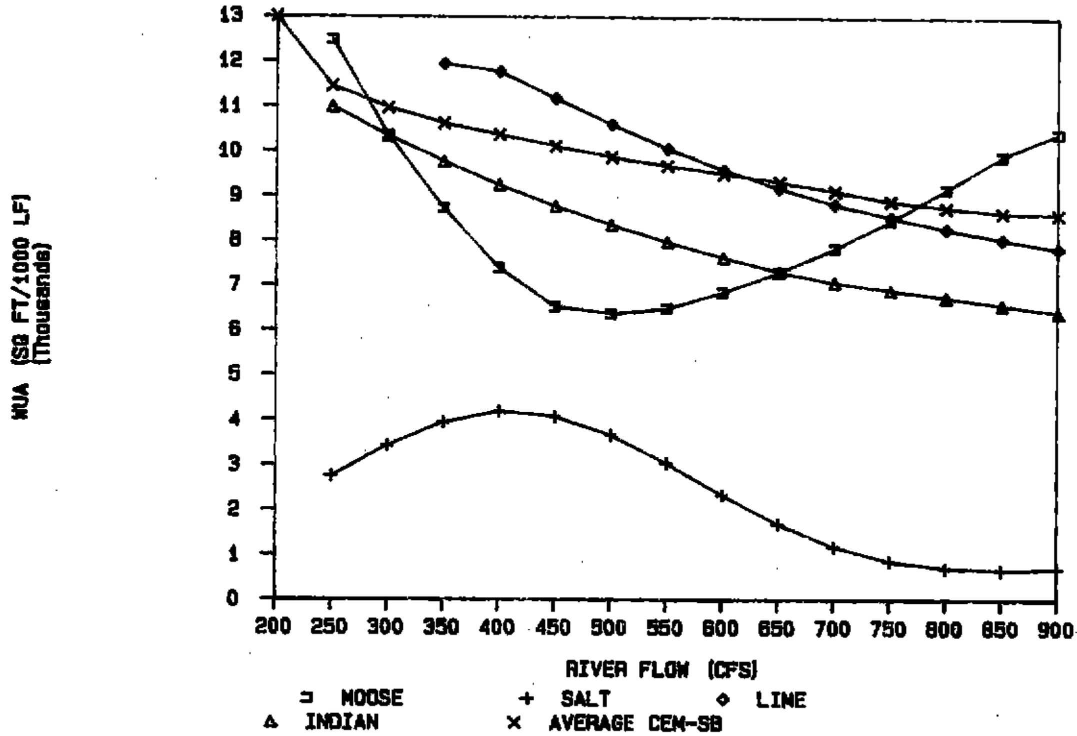

Figure 5. Weighted Usable Area for Chinook Salmon Fry in Side-channels.

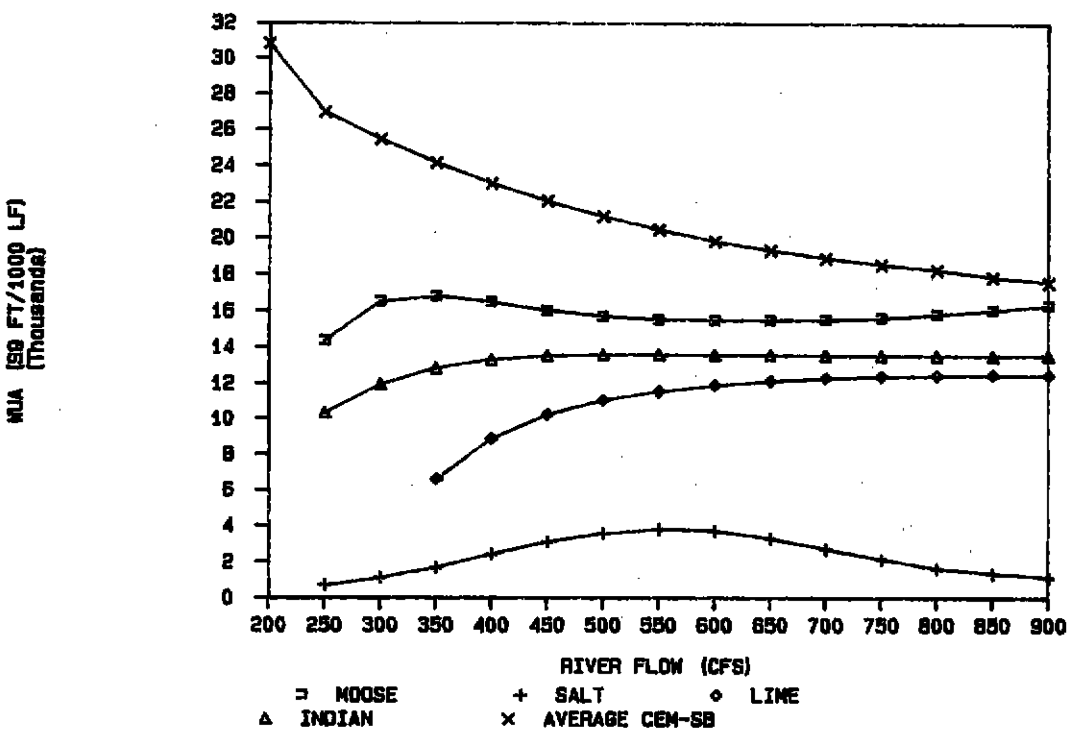

Figure 6. Weighted Usable Area for Chinook Salmon Juveniles in Side-channels.

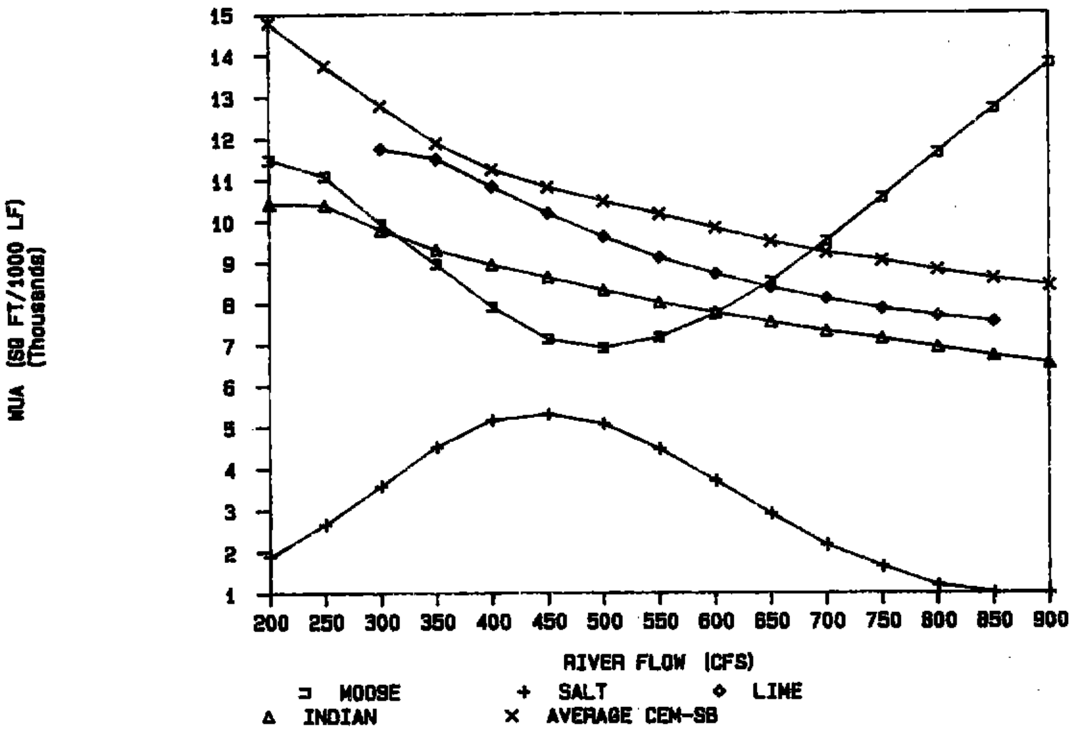

Figure 7. Weighted Usable Area for Steelhead Trout Fry in Side-channels.

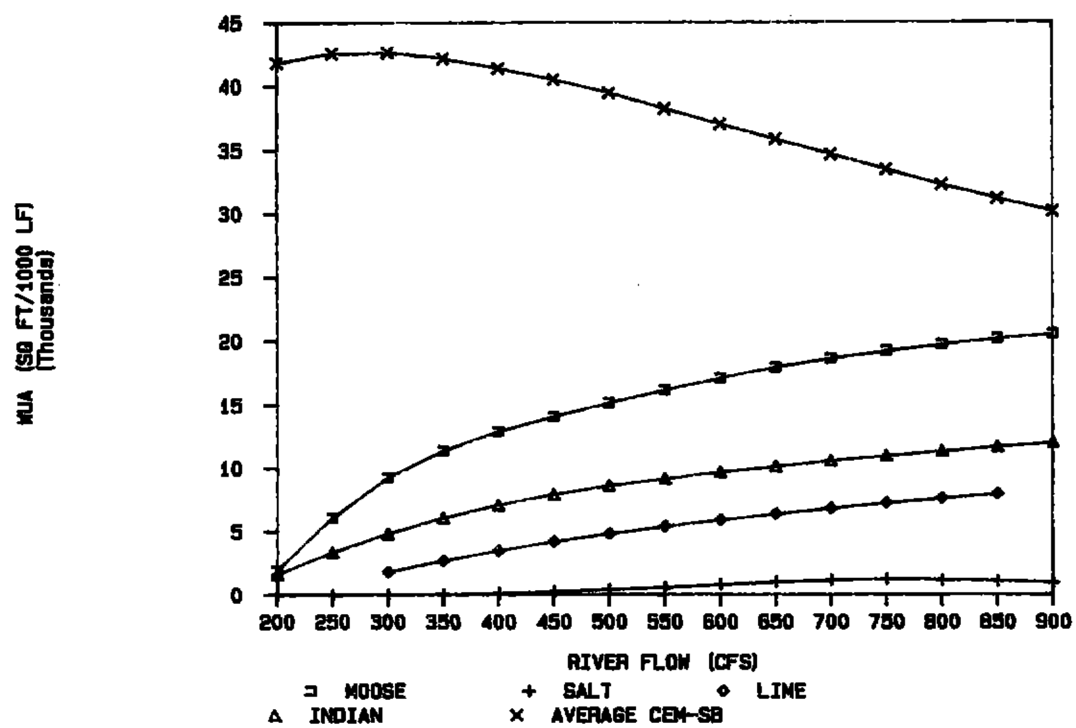

Figure 8. Weighted Usable Area for Steelhead Trout Juveniles in Side-channels.

channels, probably because of the parabolic relationship between river flow and Salt #2 side-channel flow. This relationship causes more rapidly increasing flow in the side-channel, and more rapidly increasing velocities, with increased river flow.

Steelhead fry habitat-flow relationships in the side-channels are almost indistinguishable from those of chinook fry habitat, since velocity suitability curves are similar for both types of fish (Figure 7).

Steelhead juveniles select optimum velocities of about 1.3 feet per second, but continue to occupy habitat where velocities are as high as 4.0 feet per second. Their habitat increases gradually throughout the range of flows simulated at the Moose, Limekiln, and Indian Creek side-channels (Figure 8). At Salt #2 there is a slight drop at higher flows, and insignificant habitat provided throughout. Average steelhead juvenile habitat in the main river is much greater than that provided in the side-channels at lower flows, but the side-channel and main river habitat curves approach one another at higher flows. This is probably caused by the side-channel velocities increasing toward the fish's optimum, while river velocities increase past the fish's limit of tolerance.

<u>Relative Habitat Provided by Side-channels</u> Side channel habitat adds to the habitat in the adjacent main river, in some cases almost doubling it, as can be seen with the chinook fry curves in Figure 5. The side-channels we modeled provide a 72 to 102 percent increase in chinook fry habitat on a per linear foot basis at various flows between 350 to 900 cfs.

Table 2. Comparison of Chinook Fry Weighted Usable Area/1000 linear feet in Four Side-channels and in the Main Trinity River between Lewiston and Douglas City at Various River Flows.

River cfs	Chinook Fry WUA (sq ft/1000 lf)		
	River	4 Side-channels	Percent
350	11554	9199	80%
400	10988	8323	76%
450	10539	7643	73%
500	10197	7345	72%
550	9908	7204	73%
600	9647	7207	75%
650	9416	7273	77%
700	9185	7427	81%
750	8972	7668	85%
800	8724	7963	91%

850	8509	8286	97%
900	8363	8498	102%
Averages	9667	7836	82%

This habitat requires much less flow than main river habitat, as seen in Table 3, which shows the Weighted Usable Area for chinook salmon fry as a ratio of the cubic feet per second necessary to produce it in the main river and in the four side channels.

Table 3. Chinook Fry Weighted Usable Area as a Ratio of Flow in Four Side-channels and in the Main Trinity River Between Lewiston and Douglas City

	Main River	Moose	Salt	Limekiln	Indian
			(sq ft / cfs)		
River CFS					
350	30	372	8985	11487	997
400	26	241	4669	5141	746
450	22	172	2416	3168	585
500	20	141	1230	2223	472
550	18	124	613	1673	393
600	16	115	295	1323	332
650	14	109	139	1082	286
700	13	106	66	908	250
750	12	104	33	779	224
800	11	104	19	677	202
850	10	104	13	598	182
900	10	101	10	533	166
Average	17	150	1541	2466	403

<u>Weighted Usable Area and Fish Populations</u> We undertook fish population sampling this year in the Moose, Salt #2, and Indian Creek side-channels (Section III.4), and it was possible to use the resulting population estimates to test the IFIM habitat simulation.

Generally we assume that fish habitat estimation is meaningful because it corresponds to potential long-term fish populations; optimizing habitat in the Trinity River will provide one of the necessary conditions for its long-term ecological health.

To test whether populations do correspond to available habitat, we compared chinook and steelhead fry Weighted Usable Area in the three side-channels with estimated fish

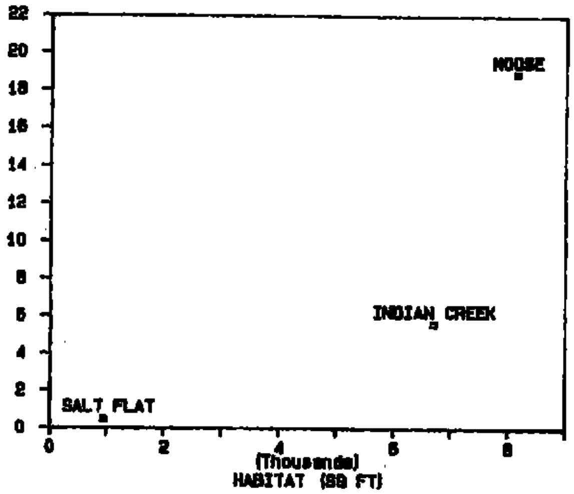

Figure 9. March 1988 Chinook Fry Density and Weighted Usable Area in Side-channels.

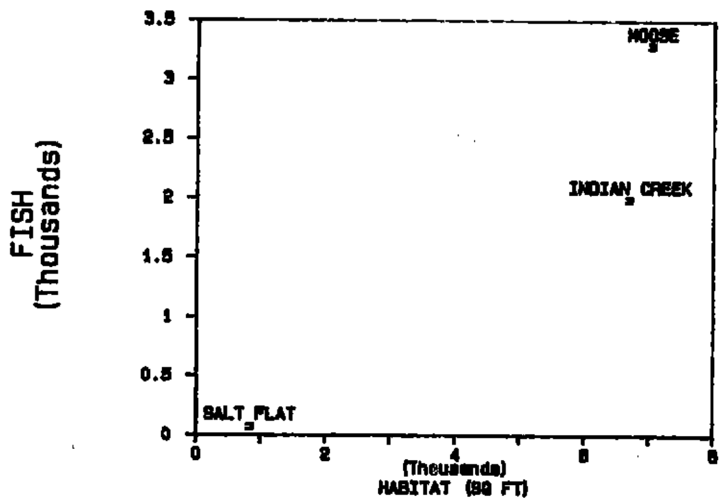

Figure 10. April 1988 Chinook Fry Density and Weighted Usable Area in Side-channels.

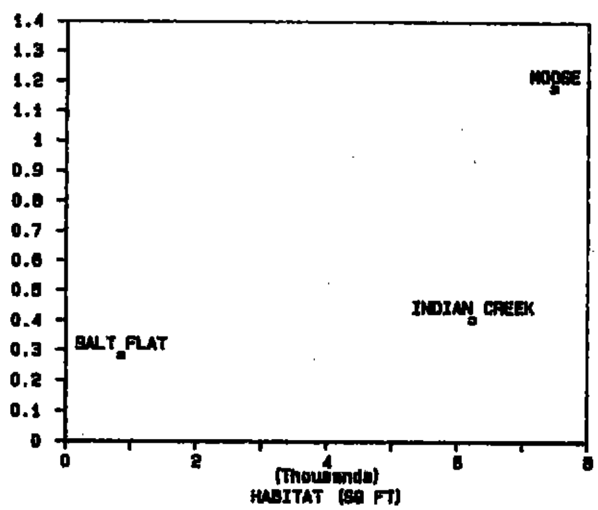

Figure 11. May 1988 Steelhead Trout Fry and Density and Weighted Usable Area in Side-channels.

populations for the sampling periods when these life-stages were most numerous. Figure 9 shows chinook fry population/habitat comparisons for the March samples, Figure 10 shows chinook fry comparisons for the April samples, and Figure 11 shows comparisons for the samples of steelhead fry in May.

In each case, there is an increase in fish populations with increasing available habitat. The ratio of fish to available habitat is lower at Indian Creek than would be expected if the relationship between fish and habitat were linear; this may be explained by the fact that the Indian Creek side channel is 14 miles below the Moose channel and 11 miles below Salt Flat #2. Near this site, in-river spawning is much less than it is near the upper side-channels, especially the Moose channel, which is adjacent to an area of intensive, superimposed chinook spawning, and last fall had intensive chinook spawning within it. In the fall of 1987 there was also intensive spawning just upstream from the Salt Flat #2 side-channel. The difference in localized spawning could result in a lower fry recruitment in the Indian Creek side-channel, depressing the population/habitat ratio relative to the upper sites.

Design of Artificial Side-channels Our results indicate that the best design for a man-made side-channel would include gently sloping banks that produce optimum fry and juvenile habitat at a variety of flows. Side-channels with steep banks tend to lose habitat as flows increase, and may provide significant usable habitat only within a narrow range of flows.

This factor is especially important if side-channels are designed to provide habitat at the current normal-year minimum Lewiston discharge of 300 cfs. Higher natural flows from tributaries and spills from Lewiston are common during the rearing season, and higher dam releases may well be required for channel maintenance, sediment flushing, rearing in an improved main channel and in natural side-channels, and as an aid to downstream migration.

3. WINTER HABITAT USE

Introduction

Steelhead trout (Salmo gairdneri) and coho salmon (Oncorhynchus kisutch) juveniles rear in freshwater for one or more years before migrating to the ocean. During the spring and summer growing seasons Trinity River steelhead trout juveniles occupy run, riffle, and riffle-pool transition type habitats, while coho salmon juveniles are typically found along stream margins, in side-channels, or backwater pools, where slow water and abundant cover are present (U.S. Fish & Wildlife Service, 1987). During the fall and winter months, when water temperatures begin to drop below 48 - 50 degrees Fahrenheit, juvenile salmon and trout in the Trinity River shift their habitat selection to sheltered areas containing abundant cover. Seasonal changes in habitat selection by juvenile salmonids is well documented in the literature (Bjornn, 1971; Bustard and Narver,1975a,b; Cunjak and Power, 1986; Everest and Chapman, 1972; Hartman, 1965; Heifetz et al., 1986; Peterson, 1982a,b; Swales et al., 1986; Tschaplinski and Hartman, 1983). In Idaho streams Bjornn (1971) found that fall seasonal movements of nonsmolt trout and salmon correlated best with the amount of cover provided by large rubble substrate. In Ontario, Canada, Cunjak and Power (1986) found that during the winter both brook and brown trout exhibited a strong preference for positions beneath cover in slow water. Swales et al. (1985) found side channels and off channel ponds to be the preferred overwintering habitats of juvenile coho salmon, while steelhead trout juveniles took shelter in rock crevices or beneath large substrate material. Bustard and Narver (1975a) found that pools formed by upturned tree roots and logs were important wintering areas for coho salmon and age 1+ steelhead trout, while rubble was the principal source of cover for age 0 steelhead trout. Heifetz et al. (1986) also found that most wintering coho salmon, dolly varden trout, and steelhead trout occupied deep pools with cover (i.e., upturned tree roots, accumulations of logs, and cobble substrate). Immigration of juvenile salmon and trout from main stream habitats into side channels, sloughs, off channel ponds, and tributary streams in search of suitable winter habitat has been shown to occur by Tschaplinski and Hartman (1983) and Peterson (1982b).

The goal of this study was to obtain a better understanding of the habitat requirements of overwintering juvenile salmonids in the Trinity River. This information is important to the continued efforts of the Flow Evaluation and to the Trinity River Management Program and their goal to restore the anadromous fishery of the Trinity River to historical levels.

Study Area

Five study sites were selected, each of which contain different microhabitats that would be available to juvenile salmonids during the winter season. Two sites are located in side-channels, while the remaining three sites are contained within the main river channel.

The Moose Lodge side-channel is located behind the Moose Lodge in Lewiston along the northwest bank of the river. The channel is approximately 1200 feet long and may be broken down into an upper and lower section, with each representing a different habitat type.

The upper section is approximately 400 feet in length and is composed of two channels with the majority of the flow passing through the right channel looking downstream. This channel may be described as a long, slow run. Water velocities are slow, less than 1.0 cubic feet per second, and total depths throughout the majority of the channel rarely exceed 2.0 feet. The substrate is composed of cobbles highly embedded in clay and silt. There are a few pockets of clean gravel and cobble available but they are limited in volume. The riparian community consists of grasses, willows, and alders. Instream cover is limited to occasional down logs, cobble pockets, emergent and submergent aquatic plants, and overhanging vegetation.

The lower channel is approximately 700 feet in length with a discharge of 17 cubic feet per second when the river discharge equals 300 cfs. A small pool is present at the beginning of this section where the two channels from the upper section merge. The remainder of the channel is composed of three run-riffle sequences, with the lower riffle joining the main river. This entire section contains cobble and large gravel substrates. Several boulders are also present throughout this reach which provide some instream cover. Cover is also provided by large mats of submergent aquatic vegetation which are scattered along the channel. Riparion vegetation is abundant along the left bank, however, along the right bank the riparian is generally offset from the edge and is limited in developement to small willows, with the exception of two large alders.

The second side-channel selected is located at river mile 96, and is referred to as Indian Creek side-channel in this report. The channel is located along the left bank of the Trinity River and is approximately 900 feet long. Discharge through the channel was less than 8 cubic feet per second during the study period. The upper 200 feet of the channel is composed of one small pool at the inlet to the channel followed by a short section of shallow riffles and runs. A small area of braided channel is also present in this section. The substrate here is composed of small gravel and sand, however, some cobbles are present in the upper pool.

Below this upper area, the channel forms a slow deep run or pool. The substrate changes to sand and then silt proceeding downstream. The depths range from about 1.0 to 4.0 feet. The channel begins to braid considerably in the lower reaches as pool habitat turns to riffle. The substrate in the lower reaches of the channel is similiar to that already described for the upper segment, being composed of small gravel and sand. Both banks of the channel contain mature riparian communities. This rich riparian community provides large volumes of woody debris to the channel, which is the dominant instream cover type available. Other sources of cover are provided by emergent and submergent aquatic plants, cut banks, and overhanging vegetation.

The three main river study sites were located in a run and riffle sequence above sawmill pool near the Cemetery in Lewiston and in a backwater located at the upstream end of Poker Bar. The run and riffle habitats both contain substrates largely composed of cobbles ranging from 3 to 12 inches that are less than 20 % embedded in fines. Bedrock outcroppings are located at various locations in both habitats as well. Boulders provide some instream cover across the entire width of the riffle while overhanging vegetation and instream organic debris provide some cover along the stream edges. Cover items are not as available within the run habitat, but some organic debris is present along the left bank. Water velocities in the run mostly range between 0.5 to 2.0 feet/second, while depths are generally less than 3.0 feet. Water velocities in the riffle are slightly higher and depths shallower. The velocity diversity in the riffle is considerably higher than the velocities present in the run, as would be expected.

The backwater at Poker Bar is located on the right bank at the upstream limit of subdivision development. The backwater is a shallow slack water area approximately 150 feet long by 50 feet wide. The substrate may be described as heavily silted cobble. Cover is provided by a few small willows both instream and along the bank. There are also some large areas of aquatic moss which provide some cover. Water depths are less than 1.0 feet over the majority of the area and water velocities are zero or very slow.

Methods

Fish population estimates were conducted by multiple pass depletion using a backpack electrofisher. In side channel and backwater habitat types the upper and lower boundries of each site were blocked with 3/16 inch mesh seines to prevent fish movement into or out of the area while sampling. In the Moose Lodge side channel three sites each 50 feet in length were selected. One site was located in the upper right channel, while the other two sites were located in the lower channel. The Indian Creek side channel was divided into nine one hundred foot sections. Two of the nine sections were selected by judgement, one to represent the slow run pool habitat and one to represent the riffle habitat. The Poker Bar backwater was simply split in half providing two 75 foot sections, one of which was selected by coin toss.

In the main river riffle and run habitat types, discrete areas were blocked off by anchoring nets and bag seines with a combination of ropes, rebar and fence posts. The upstream entrance to the area was not sealed. It was assumed that fish movement was minimal because of the cold water and therefore movement out of or into the sample site would not occur. Direct observations conducted by us have verified the absence of any fish up in the water column during this time of year. The area was then electrofished, starting at the open upstream end, proceeding downstream toward the bag in the seine. Four sites were randomly selected within the riffle and three sites within the run.

Fish depletion data was analyzed with the use of a maximum weighted likelihood (MWL) microcomputer program written by Conner (1987). References used in the writing of this program, as cited by Conner (1987), include Carle and Strub (1978) and Zippin (1958).

Habitat use data were collected at all study sites with the use of a backpack electroshocker. At each site fish were shocked in an upstream direction, one person operated the electroshocker while a second person netted stunned fish. A numbered float with a weight attached was used to mark capture locations. When exact focal point locations of sampled fish couldn't be determined no data was collected for that observation. Once all of the floats were deployed we discontinued electroshocking and went back to collect microhabitat information for each float marking a capture location.

The data collected included total depth (feet), mean column velocity (feet/second), substrate, and cover. Substrates were described as fines (< 4mm), gravel (4 - 75mm), cobble (75 - 300mm), boulder (300mm +), or bedrock. Substrate values were recorded as dominant, subdominant, and percent embedded in fines. The dominant substrate was defined as the largest abundant partical size present. The cover types recorded include cobble, boulder, brush, logs, undercut bank, overhanging vegetation, and aquatic vegetation.

Habitat utilization criteria were developed through the use of frequency analysis as described by Bovee (1986), Bovee and Cochnauer (1977), and Slauson (1988). Total depth and mean column velocity frequency intervals were determined by Sturges Rule (Cheslak and Garcia, 1988).

In order to increase both the sample size and validity of the habitat use criteria developed, microhabitat data collected during the winters of 1985 and 1986 for habitat preference criteria development (Hampton, 1988) were included here. This data was collected using the same methods within the Instream Flow Incremental Methodology study areas in the upper Trinity River.

Results

Fish population and microhabitat use data were collected from December 15 through February 11. Water temperatures ranged from 42 to 48 degrees Fahrenheit during the sampling period.

Steelhead Trout. Steelhead trout juveniles captured in the Moose Lodge side-channel ranged in fork length from 54 to 193mm with an average of 93.8 mm. The highest densities of juvenile steelhead were found in the lower section of the Moose Lodge side-channel (1.21 fish per square meter), followed by Cemetery riffle and run habitats which had densities of 0.32 and 0.22 fish per square meter respectively (Figure 1). Steelhead trout densities were highest in those microhabitats which contained cobble and boulder substrates. Indian Creek side-channel, which contains primarily silt substrates and large amounts of woody debris, only yielded 0.07 fish per square meter. In the upper Moose Lodge side-channel, where the substrates are primarily composed of cobbles embedded in clay, only 0.05 fish per square meter were found. No juvenile steelhead were found in the backwater habitat of Poker Bar, which contained large quantities of sand and highly silted cobble substrates.

Habitat use criteria (category II) for overwintering juvenile steelhead are presented in Figure 2. Microhabitats selected by wintering steelhead juveniles contained slow water velocities with clean cobble substrates. Focal points where nearly always located underneath cobbles or boulders.

Brown Trout. Brown trout juveniles captured in the Moose Lodge side-channel ranged in fork length from 63 to 205 mm with an average fork length of 89.5 mm. Habitat densities of juvenile brown trout ranged from 0.10 fish per square meter in the lower Moose Lodge side-channel to 0.01 fish per square meter in the backwater at Poker Bar (Figure 3). Densities of juvenile brown trout were consistently lower than densities of juvenile steelhead at all sites except Poker Bar, where no steelhead were sampled, and at upper Moose Lodge side-channel, where the densities where equal.

Juvenile brown trout, much like juvenile steelhead, were found holding in intersticial areas between cobbles or under boulders (Figure 4). Mean column velocities selected by wintering juvenile brown trout were slightly slower than the velocities selected by juvenile steelhead with a velocity of 0.3 ft/sec being most utilized.

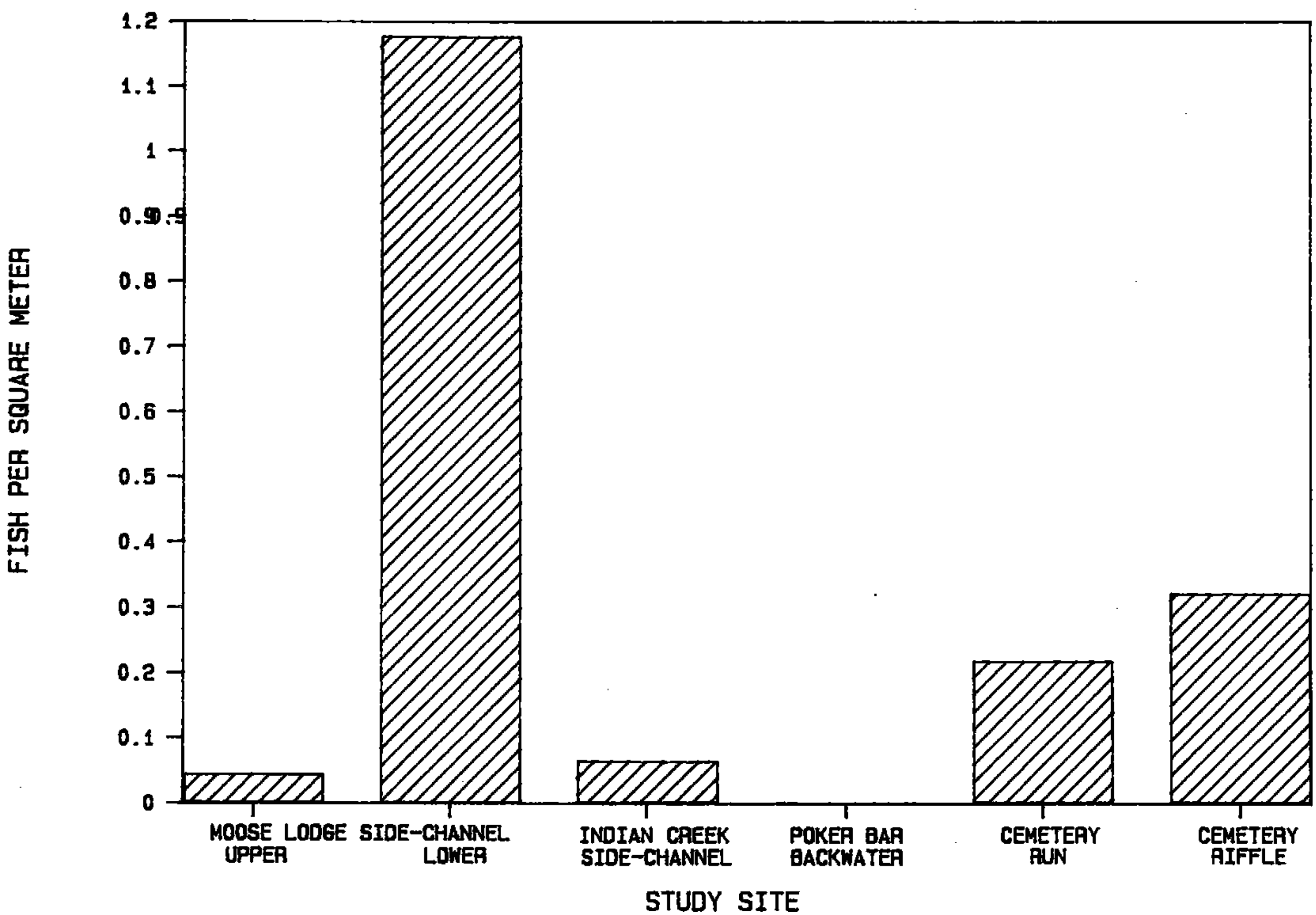

Figure 1. Densities of juvenile steelhead trout collected in five study sites located in the upper Trinity River, California 1988.

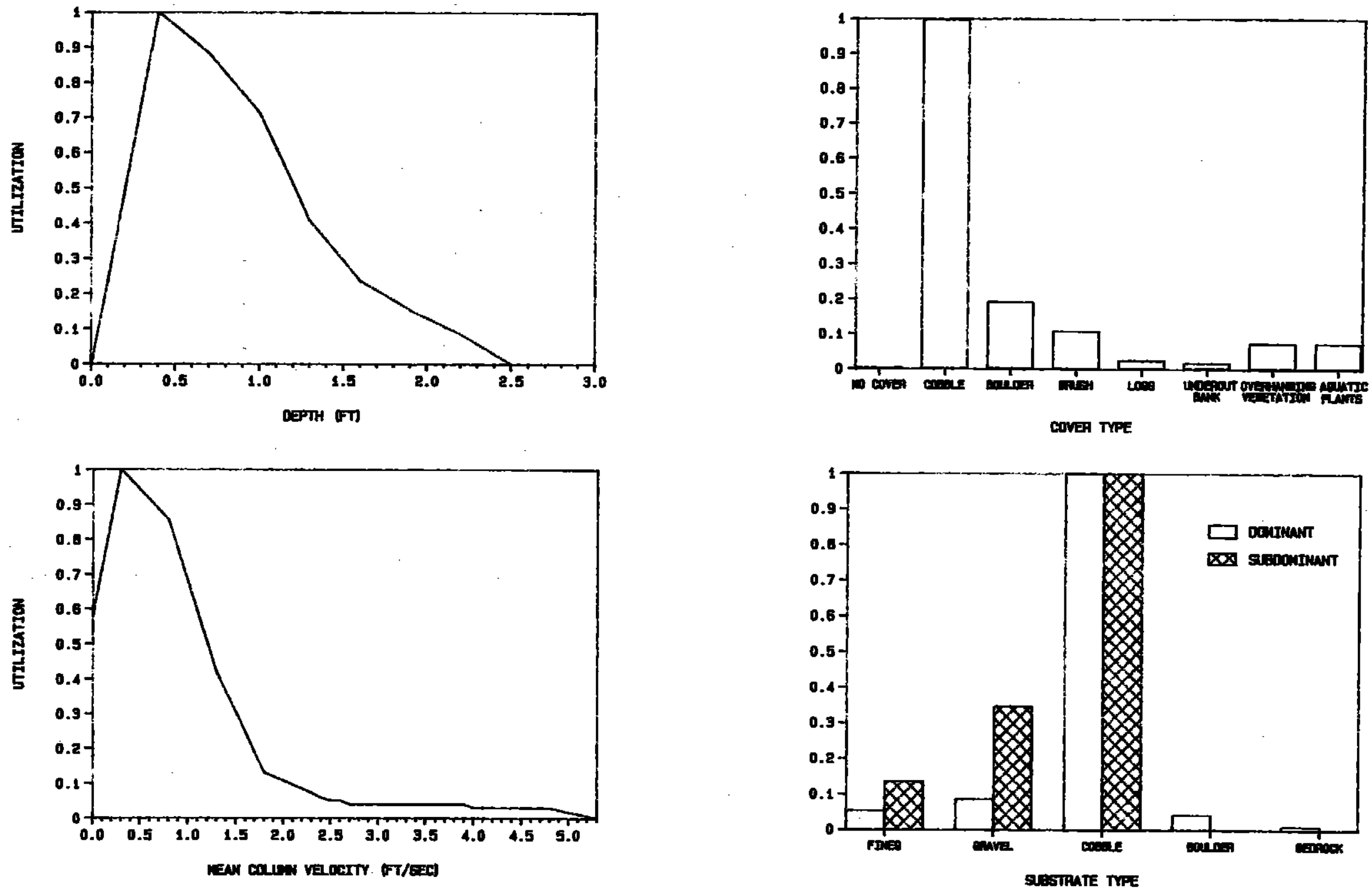

Figure 2. Habitat use by overwintering juvenile steelhead trout in the upper Trinity River, California 1988.

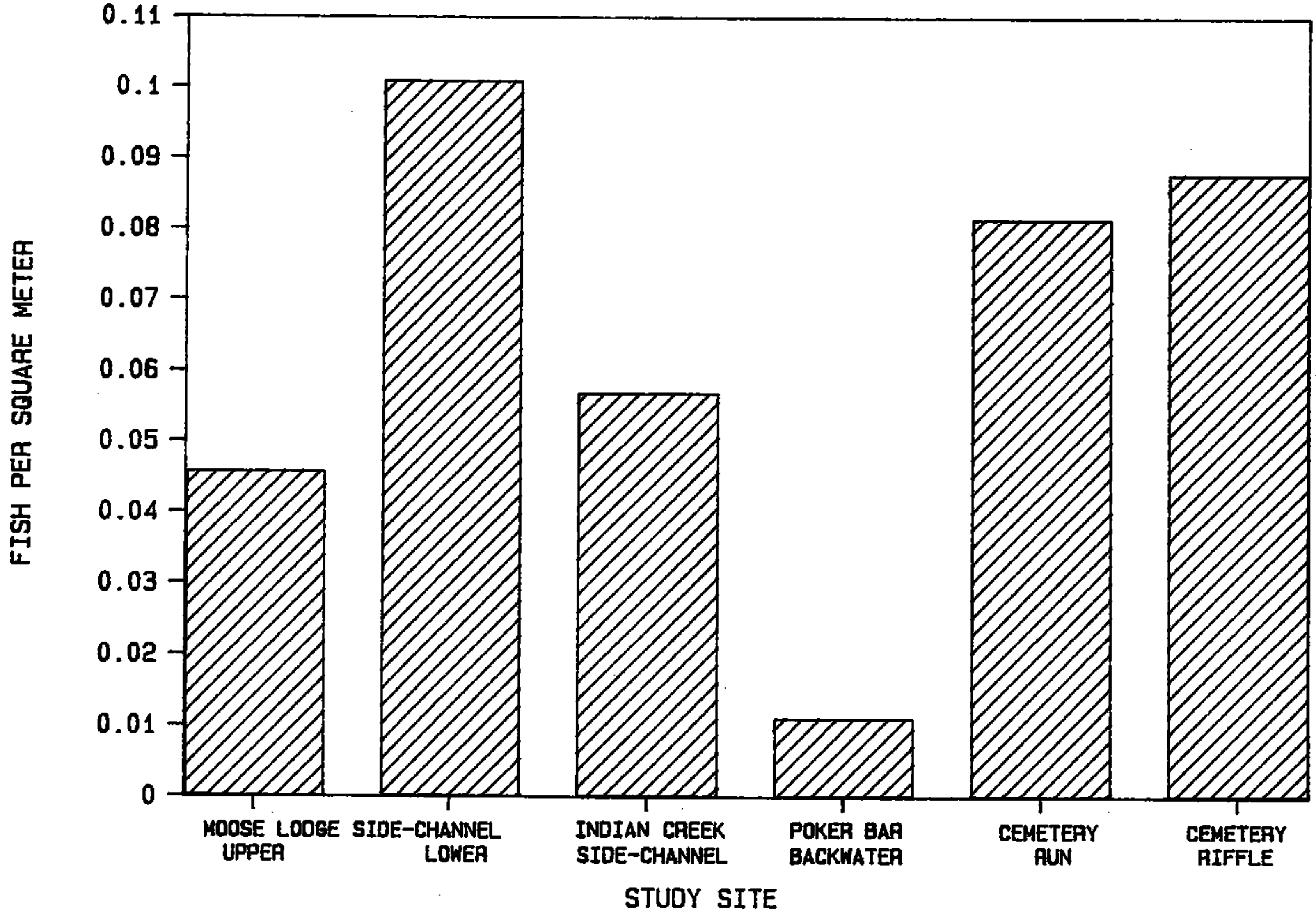

Figure 3. Densities of juvenile brown trout collected in six study sites located in the upper Trinity River, California 1988.

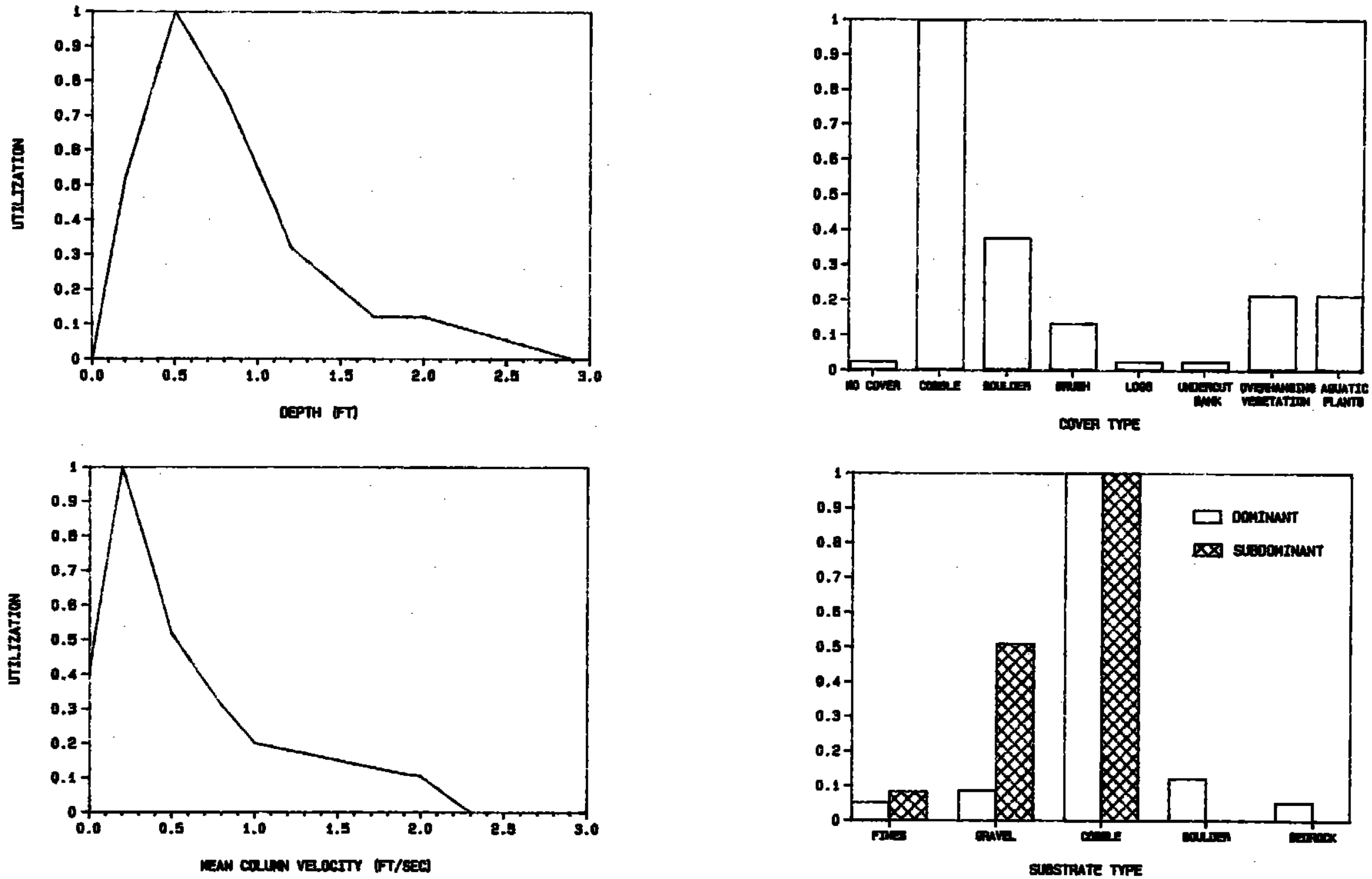

Figure 4. Habitat use by overwintering juvenile brown trout in the upper Trinity River, California 1988.

Coho Salmon. Coho salmon juveniles captured in the Moose Lodge side-channel ranged in fork length from 65 to 100 mm, with an average of 85 mm. Juvenile coho salmon were only captured in three study sites, lower Moose Lodge side-channel, Indian Creek side-channel and at Poker Bar backwater (Figure 5). The highest densities of juvenile coho salmon were observed in the lower section of the Moose Lodge side-channel. Although the highest densities for all species were found in this section, the microhabitats selected by coho salmon were quite different from those selected by juvenile steelhead and brown trout.

Coho salmon juveniles tended to select areas in still water with aquatic vegetation or woody debris as the main cover type (Figure 6). Juvenile coho were rarely observed holding underneath cobbles as was common behavior for juvenile steelhead and brown trout. In the backwater at Poker Bar all of the coho salmon captured were holding underneath one willow. This aggregative behavior was also observed while sampling mats of aquatic vegetation located in the Moose Lodge side-channel. Use of large woody debris by juvenile coho salmon would have probably been greater had this type of cover been available in greater quantities within the study sites or Trinity River in general.

Chinook Salmon. The large run of adult chinook salmon that entered the Trinity River during the spring and fall of 1987 produced millions of fry all along the Trinity River during the spring of 1988. Although most of these young emigrated from the system by early summer, some did remain in the Trinity River over the summer. Most of these late rearing chinook probably migrated downstream in the fall after lower river temperatures dropped. During our winter sampling we captured a total of 52 juvenile chinook salmon, some of which may have been of hatchery origin. In the Moose Lodge side-channel juvenile chinook salmon ranged in fork length from 65 to 99 mm, with an average of 78 mm.

Habitat utilization criteria were not developed for overwintering juvenile chinook salmon for two reasons: 1) not enough microhabitat observations were collected to accurately construct use criteria, and 2) overwintering behavior by juvenile chinook salmon is rare, and in this case there was no certainty as to the origin (wild or hatchery) of the juvenile chinook salmon captured.

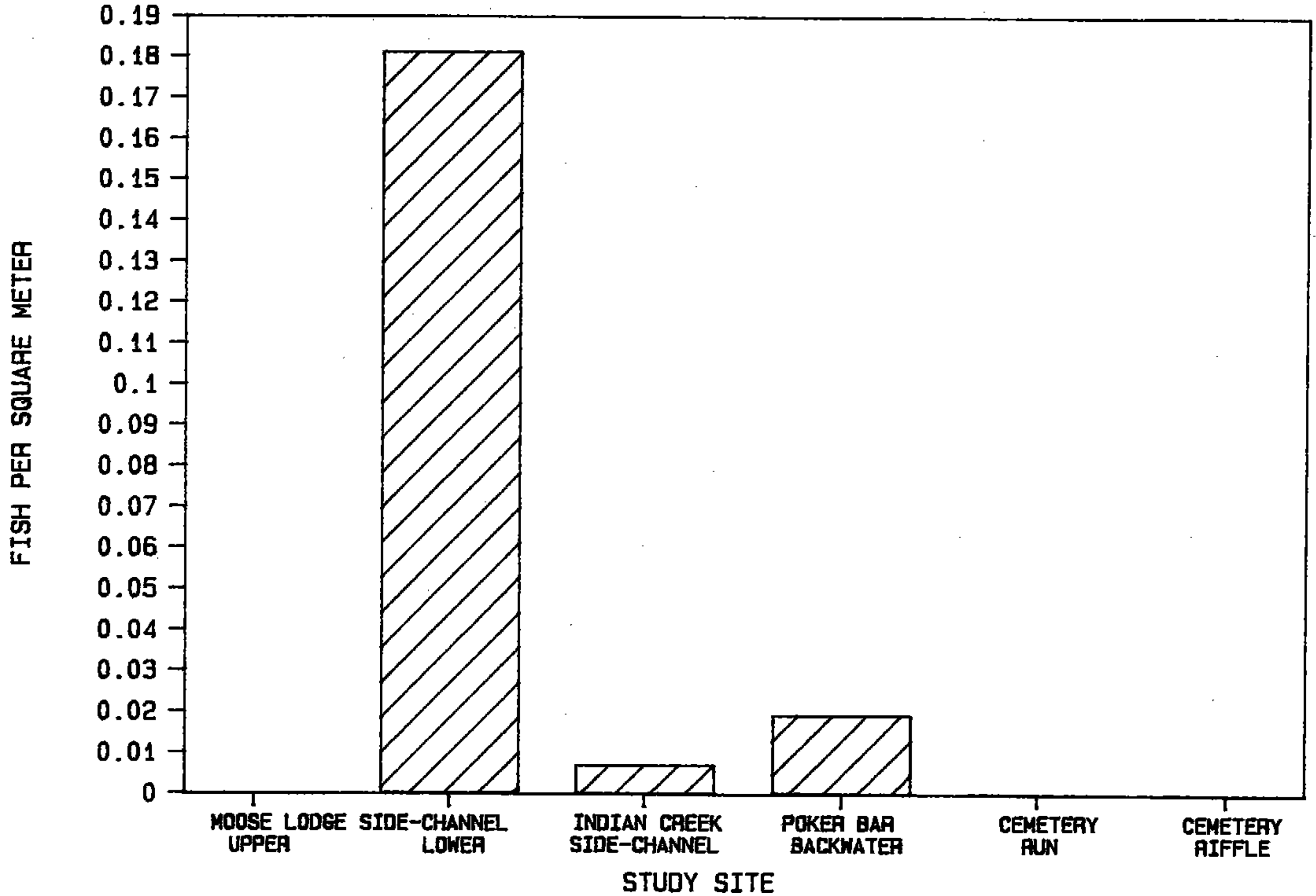

Figure 5. Densities of juvenile coho salmon collected in three study sites located in the upper Trinity River, California 1988.

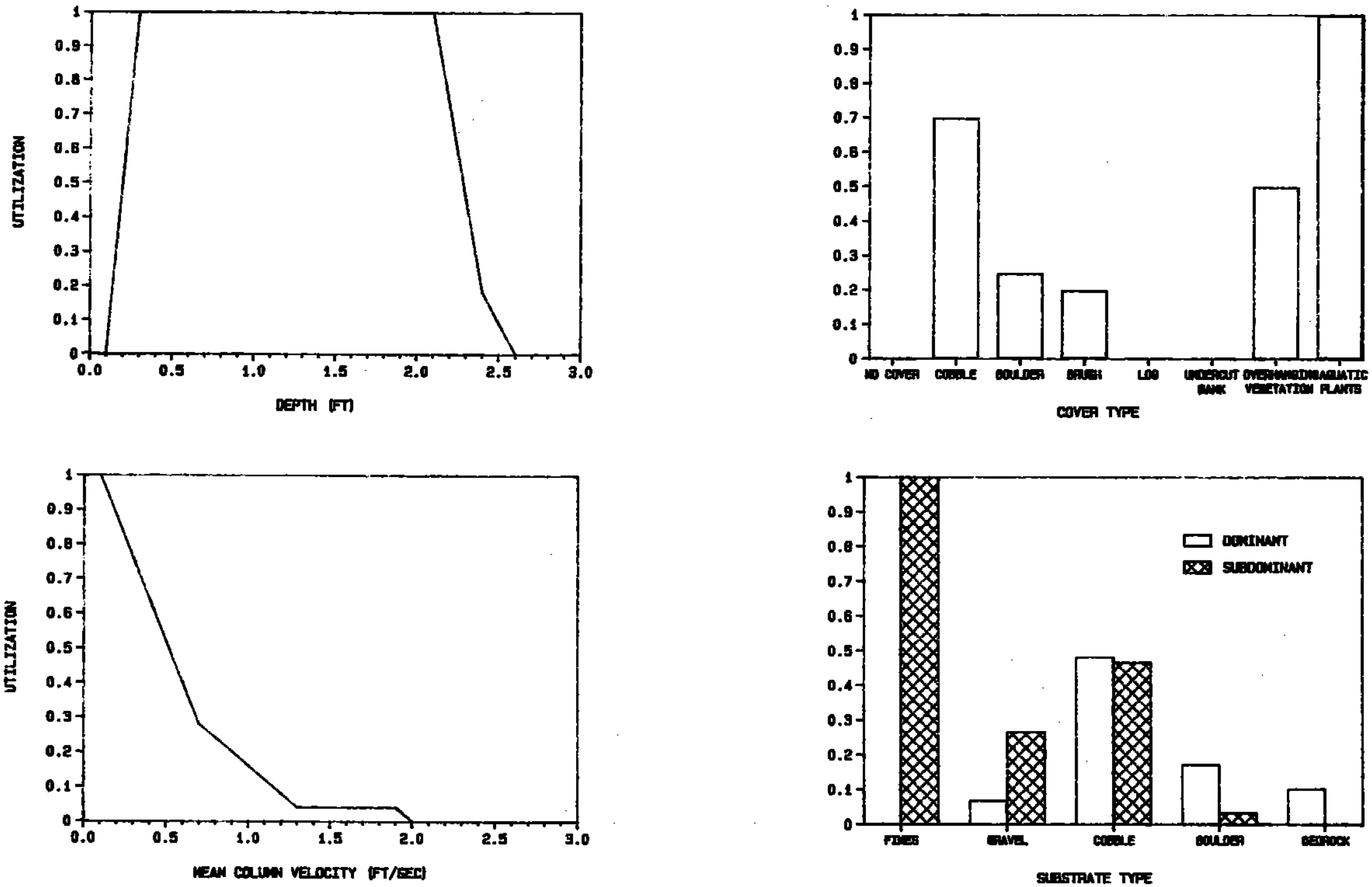

Figure 6. Habitat use by overwintering juvenile coho salmon in the upper Trinity River, California 1988.

DISCUSSION

The Moose Lodge side-channel, with cobble substrates and slow water velocities overwintered nearly four times more juvenile steelhead per habitat area than any of the other habitats sampled. The habitat use criteria developed for juvenile steelhead trout also show a strong preference for cobbles and slow water velocities as important variables in their selection of winter habitat.

Our findings, that steelhead fry and juveniles utilize cobble substrates extensively as refuge while overwintering, agree with those of Bjornn (1971), Bustard and Narver (1975a), Hartman (1965), and Swales et al. (1985). The intersticial spaces underneath and between cobbles provide young steelhead with refuge points in which to hold when environmental conditions are severe. Mason (1976) states that during periods of low temperature, salmonids have lower metabolism, reduced food requirements, and less swimming ability; thus, their survival depends more on areas of shelter and rest, than on food. By hiding in cobble substrates juvenile steelhead may avoid predation from surface feeding birds and mammals at a time when there swimming ability is reduced because of lower metabolic rates.

Coho salmon juveniles were only captured in the side-channel and backwater habitats. Although more coho were captured in the Moose Lodge side-channel than in either of the other two sites where coho where found, we think the reason for this was more of a function of coho salmon spawning distribution rather than habitat selection on the part of the juveniles. Since more coho salmon spawned in the upper river, near or within the Moose Lodge side-channel, more juveniles were present there than in the lower river sites near Poker Bar and Indian Creek, where few adult coho salmon spawn. This is in part borne out by the fact that even though cobbles are the dominant cover type available in the Moose Lodge side-channel, juvenile coho preferred to shelter inside clumps of aquatic vegetation or in woody debris. Coho salmon juveniles were rarely pulled from cobble substrates while electroshocking. This difference in cover type selection between juvenile coho salmon and steelhead trout was also observed by Hartman (1965) and Bustard and Narver (1975a). They state that steelhead fry and coho fry seek out different cover types in the winter, with coho associated with logs, roots, and bank cover areas and steelhead associated with rubble areas.

The habitat use criteria describing total depths used by all species may not be entirely appropriate. Since the microhabitat data collection was conducted with the use of a backpack electroshocker, the resulting depth criteria may be a better description of wading depth than actual fish preferences for those depths as discribed by the use criteria. This was an inherent problem with the sampling procedure that could not be avoided.

Historically, the Trinity River experienced many periods of high flows or freshets, which are still common in the tributary streams. High flows may still occasionally occur in the main stem Trinity River below Lewiston and Trinity Dams, as was evident during the February flood of 1986. These high flood flows undoubtedly cause mortalities to overwintering salmonids through displacement downstream or by crushing them under moving bedload. In the spring of 1986, immediatly after the flood in February, we noticed several juvenile steelhead in the lower Trinity River that had been injured, probably from being caught between moving cobbles and sand during the high water. Therefore, it seems evident that cobbles alone do not provide sufficient wintering habitat for juvenile steelhead.

Wintering habitat must also provide areas that are sheltered from high velocities that may cause scouring of bedload material. side-channels, backwaters, and deep pools may all provide velocity shelters required by overwintering steelhead. Pools, however, are probably not optimum overwintering habitats in the Trinity River because of the large amounts of sand that are deposited within them as flows drop. Deposition of new sand within these pools could trap the young steelhead hiding under existing cobbles should they fail to move. Natural pools are also formed and reformed by scour during peak flows which would definitely have adverse effects on juvenile steelhead holding within them. side-channels are less affected by high flows, since they are generally located across the inside bends of the river where velocities are reduced during high flows. side-channels are also bordered by healthy riparian systems which reduce velocities when flood flows do occur.

The quantity and quality of suitable winter habitat within the Trinity River is extremely low. The same habitat problems that have reduced salmon and trout spawning and summer rearing habitat in the river have also nearly eliminated crucial overwintering habitat for juvenile steelhead and brown trout and coho salmon. Excessive sedimentation of substrates by granitic sand has eliminated the intersticial areas required by young trout seeking refuge from high flow and predation during the winter months. Channelization of the mainstem Trinity River above the North Fork Trinity River has reduced surface area and increased velocities due to the changed morphology of the channel. Currently, when high flows do occur a greater percentage of the water is forced to remain within the channel rather than spread out across bars or through secondary channels as would have happened historically. This phenomenon has probably reduced the amount of slow velocity habitats that existed before constuction of the Trinity River Division.

It is important that future restoration efforts within the

Trinity River consider the value of overwintering habitat when considering projects directed toward increasing production of juvenile steelhead trout and coho salmon. Without such consideration, increases in production in other areas of habitat work, such as improving spawning habitat, could all be for naught should the limiting factor on smolt production turn out to be winter habitat survival (Hall and Baker, 1982).

Additional information, which is important the effective management and habitat restoration for these species,is the knowledge of survival rates for each year class over the winter season. This type of information may verify the importance of winter habitat as a factor contributing toward over all steelhead trout and coho salmon smolt production.

4. SPRING CHINOOK HOLDING HABITAT

Introduction

Historic accounts suggest that spring-run chinook salmon were once the most numerous race of salmon in the Klamath River system during the mid-1800's, but by the beginning of the 20th century fall-run chinook were dominant (Snyder 1931). Since construction of the Trinity River Project and Trinity Hatchery, the number of spring chinook returning to the upper-Trinity River has increased substantially (Bedell 1970-1987, Murray 1959-1968), with record returns in the past two years (J. Krakker pers. comm.). Since the majority of these fish reach the upper river in June and July and do not spawn until mid-September they must find suitable habitat in which to hold during this period. Past (TRBFWTF 1977), and future (TRTFTCC 1988), habitat restoration efforts have targeted improvement of holding habitat for adult salmon as a concern since many once deep holding pools in the river have reportedly been filled by decomposed granitic sands. We undertook this study to describe and quantify spring chinook salmon holding habitats in the mainstem upstream of the North Fork as a guide for future restoration efforts and to further define the habitat needs for anadromous salmonids in the Trinity River system.

Methods

Pool Counts. Numbers of holding adult spring chinook salmon were counted at selected pools in the upper-Trinity River between May 24 and August 17. Pools chosen for repeated sampling included New Bridge located at river mile 111, Cemetery at river mile 109, Bucktail at river mile 105, and Steelbridge at river mile 98.5. Fish aggregated at other pools or deep runs were counted at various times during the summer while gathering habitat use information.

Fish were counted by direct observation. Snorkeling or SCUBA diving were the primary methods. On a few occasions fish were counted at the New Bridge and Old Bridge pools from atop the bridge spans. The observer used polarized sun glasses to reduce glare off the water and improve visibility of fish. Bridge top observations at the New Bridge pool were used to complement counts made while diving.

Fish counting using SCUBA was always conducted by at least two divers. Using SCUBA, fish counts were conducted with divers starting at the downstream end of a pool and slowly swimming upstream along the bottom. Divers were assigned individual counting lanes of a width based upon the size and shape of the pool, clarity of the water, and number of divers present. Generally, each diver tried to keep within sight of the others while moving together upstream. Counts using snorkel gear were conducted by swimming downstream through a pool, viewing fish from the surface or by swimming at mid-column depth. Snorkel counts were usually conducted by a single diver followed by a support raft, although multiple divers were sometimes used. Fish counts by divers using SCUBA and swimming in counting lanes were summed together to produce a total pool count. Counts by multiple snorkelers swimming one at a time through a pool were compared and the numbers of fish counted were averaged. When a lone observer counted fish, a second pass through the pool was usually conducted to verify the initial count.

Repetitive counts of fish in the pools found that counts were often quite precise. However, the accuracy of counts was unknown. Most counts for aggregations of fish numbering less than 50 were probably very accurate, with accuracy declining as numbers increased. Accuracy of counts was influenced by pool size and shape and water visibility. For example, a large number of fish in a relatively confined area, such as the Bucktail pool, could be more accurately counted than a much lower number of fish in a broader expanse of water such as the Hog Hole located at the Rush Creek fishing access (river mile 108).

Pool Characterization. Surface area and depth contours at the New Bridge, Cemetery, and Bucktail pools were mapped for a release of 300 cfs from Lewiston Dam. A theodolite and electronic distance meter were used following standard surveying techniques. Pool maps were drawn with a CADD computer program. Pool surface area for selected depth contours were determined on the maps with a compensating polar planimeter to the nearest 100 square feet. Water velocities at selected locations in the Bucktail and Cemetery pools were measured with a mechanical gurley meter. Fish distributions within each pool were characterized based upon observations while diving and viewing the pools from elevated vantage points.

Habitat Use. We collected data on holding salmon habitat use between June 7 and August 16. The upper Trinity River from the old weir site just above the New Bridge pool downriver to Steelbridge pool was surveyed. We did not include the one mile of river from the old weir up to Lewiston Dam and Fish Hatchery presuming that the proximity to the terminus of migration might bias habitat use. The river below Steelbridge was not surveyed due to lack of time. However, based on our observations within the surveyed reach and those by Department of Fish and Game personnel downriver (J. Krakker pers. comm.), most spring salmon were holding upriver of Steelbridge during the period surveyed.

Data collection methods generally followed those previously used on the Trinity River by the Fish and Wildlife Service (Hampton 1988). Fish were located and observed while snorkeling in a downriver direction with the observer assisted by a data recorder in a raft. Data were gathered only for fish greater than 55 cm total length. The Department of Fish and Game uses the 55 cm length criteria at its counting weirs on the Trinity River to differentiate between adults and grilse (J. Krakker pers. comm.). In the time available we were able to survey approximately one-half of the riffle, run, and small area-shallow pool habitats (less than ten feet in depth) within the study reach. An adequate survey of large area, deep pool habitats was not accomplished during this effort and those data were excluded from the habitat use analysis. Instead of the three digit codes used by Hampton (1988) to identify cover and substrate types for each observation, this study only identified the dominant cover and substrate types used by each fish. In addition to the seven cover types used by Hampton (1988), surface turbulence was included as an eighth type. Hampton's report (1988) should be consulted regarding cover and substrate type descriptions and other data collection details.

Each fish observed was recorded as an individual observation, rather than lumping observations for aggregations of fish. This approach was selected because of the relatively limited number of fish available for observation and because we felt it would best represent habitat selection by holding salmon.

The physical condition of each fish observed was ranked on a scale of 0 to 3 where:

0 = very good condition; no obvious scars or lesions.

1 = good condition; limited fungal growth observed, no debilitating injuries or disease conditions noted.

2 = fair condition; obvious injuries and/or moderate growths of fungus on head and along back. Visual impairment in at least one eye possible from spread of fungus.

3 = poor condition; Heavy growth of fungus on body, fish blind in one or both eyes, likely near death.

Data Analysis. Habitat use curves were constructed from frequency histograms of the collected data. Frequency interval bin size for each continuous variable was selected using Sturges' Rule (Cheslak and Garcia 1987), and compared with the raw data to ensure that the resulting frequency histogram was representative of the pre-manipulated data. For the continuous variables of depth and velocity, habitat use curves were constructed by determining the midpoint of each frequency interval, normalizing the frequency of each interval to the interval with the most observations (see Bovee 1986), and drawing the curve by connecting the normalized interval midpoints. For the discrete variables of cover and substrate, the frequency histograms were normalized as before, but curves were not constructed. The curves for continuous variables were truncated at their extremes so that they represent the actual interval of habitat use observed.

To evaluate the effect of fish condition on habitat use, curves and histograms were constructed separately for good-condition fish, rankings 0 and 1, and poor-condition fish, rankings 2 and 3. The frequency interval bin sizes for continuous habitat variables were constructed using the good-condition fish only, and subsequently applied to poor-condition fish to facilitate the comparison of habitat use between condition types.

Results

Pool Counts. Few adult spring chinook were found during late May and early June (Tables 1 and 2). Most fish were seen in upriver pools such as Bucktail, New Bridge, and Hog Hole; however, Cemetery pool did not have many fish. By the next survey in July, a large number of fish had entered the upper river and numbers holding in the New Bridge and Old Bridge pools had increased dramatically. These increases were not reflected in counts at pools further downriver. By August, large numbers of fish were holding in Bucktail and SP pools, but the numbers in the New Bridge pool appeared to have decreased. Other pools surveyed in the upper river in August also had large aggregations of fish (Table 2). The largest aggregation observed in the upper river during the year was at the Ponderosa pool where an estimated 800 fish were seen. In contrast to the pools at Bucktail and New Bridge, Steelbridge and Cemetery pools never contained many fish during the holding surveys.

We first observed spawning by spring chinook in the upper river on September 14, and presumably many fish holding in pools had begun to move to spawning areas by this date. A cursory observation of the New Bridge pool on September 19 found that all but a few fish had vacated the pool.

Pool Characterization. The pools at New Bridge and Bucktail are deeper and much larger than Cemetery pool (Figures 1 through 3). The deepest pool was Bucktail with a maximum depth of 22 feet. New Bridge was intermediate at 15 feet, and Cemetery the shallowest at 12 feet. Pool area measurements showed that New Bridge and Bucktail pools had nearly three times the area that Cemetery pool did for depths equal to or greater than three feet, and at least 24 times the area for depths greater than or equal to 12 feet (Table 3).

Water velocity measurements were collected at various locations in Bucktail and Cemetery pools (Figures 2 & 3). Velocities at Bucktail were arbitrarily collected at four feet off the bottom since most fish there occurred between three and 10 feet off the bottom. Velocities at Cemetery

Table 1. Numbers of Holding Adult Spring Chinook Salmon Counted at Index Pools in the Trinity River Below Lewiston Dam, Lewiston, California, Between May 25 and September 19, 1988.

Pool	Date Sampled	Number	Method	Count Accuracy
NEW BRIDGE	May 24	12	SCUBA	very good
	June 6	15	SCUBA	very good
	July 12	600	SCUBA	fair
	July 22	600	surface observation	fair
	Aug. 12	300	surface observation	fair
	Aug. 17	300	snorkel	fair
	Sep. 19	40	surface observation	fair
CEMETERY	June 6	0	SCUBA	very good
	July 13	2	snorkel	very good
	July 26	5	snorkel	very good
	Aug. 17	5	snorkel	very good
BUCKTAIL	May 25	11	SCUBA	very good
	June 8	20	SCUBA	very good
	July 14	30	SCUBA	very good
	Aug. 11	150	snorkel	good
	Aug. 17	150	snorkel	good
STEELBRIDGE	May 25	3	SCUBA	very good
	June 8	3	SCUBA	very good
	July 14	7	snorkel	very good
	Aug. 9	0	snorkel	very good

Table 2. Numbers of Holding Adult Spring Chinook Salmon Counted at Various Pools in the Trinity River Below Lewiston Dam, Lewiston, California, Between May 26 and August 16, 1988.

Name	Date	Location	Number	Method	Count Accuracy
J & M	5/26	RM 77	1	SCUBA	very good
Salmon	5/26	RM 72	2	SCUBA	good
Hog	6/9	RM 108	25	SCUBA	poor
SP	6/9	RM 103.5	3	SCUBA	very good
Steiner Flat	7/8	RM 92	3	snorkel	very good
Hayden Flat	7/11	RM 55.5	2	SCUBA	good
Old Bridge	7/22	RM 110	300	surface observ.	fair
Old Weir	7/27	RM 111	150	snorkel	fair
Poker Bar Road	8/9	RM 101.5	200+	snorkel	fair
Limekiln Gulch	8/9	RM 101	50	snorkel	good
Driskell	8/15	RM 106	60	snorkel	good
Wellock	8/16	RM 104	100	snorkel	good
SP	8/16	RM 103.5	200	snorkel	good
Ponderosa	8/16	RM 103.5	800	snorkel	fair

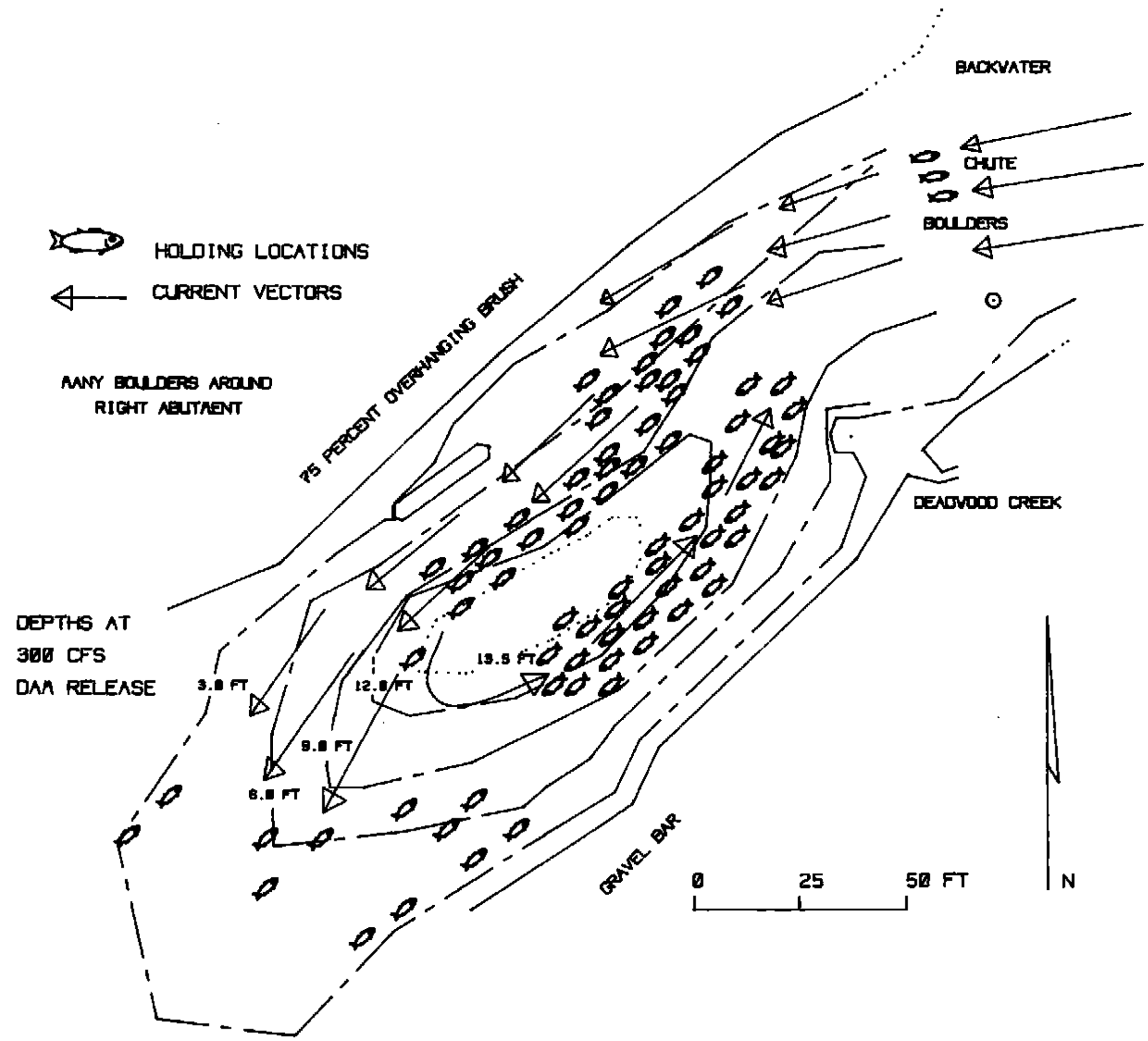

Figure 1. Scale map of New Bridge pool, river mile 111, Trinity River, Trinity County, California, with depth contours, current vectors, and adult spring chinook aggregation locations.

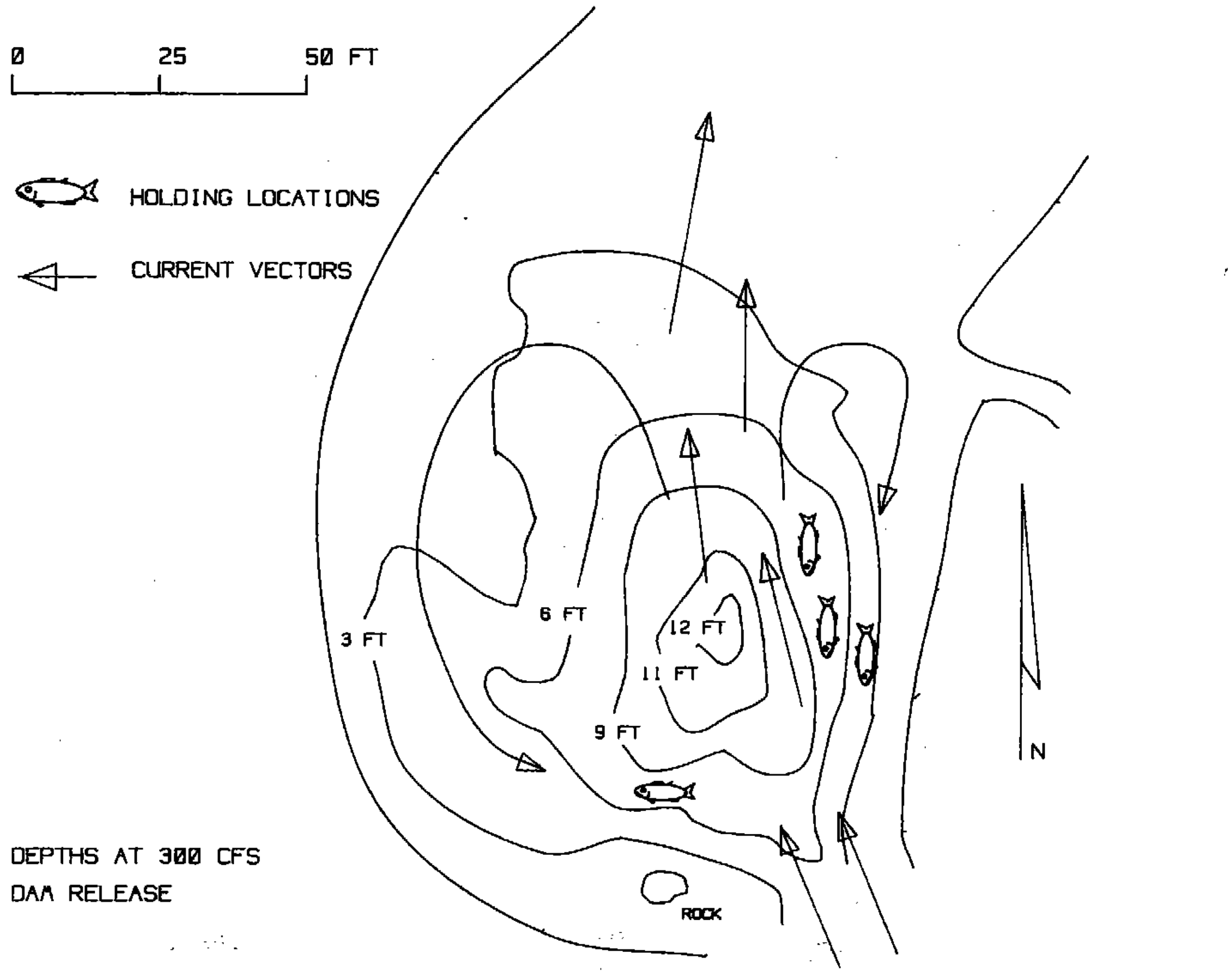

Figure 2. Scale map of Cemetery pool, river mile 109, Trinity River, Trinity County, California, with depth contours, velocity vectors, and adult spring chinook aggregation locations.

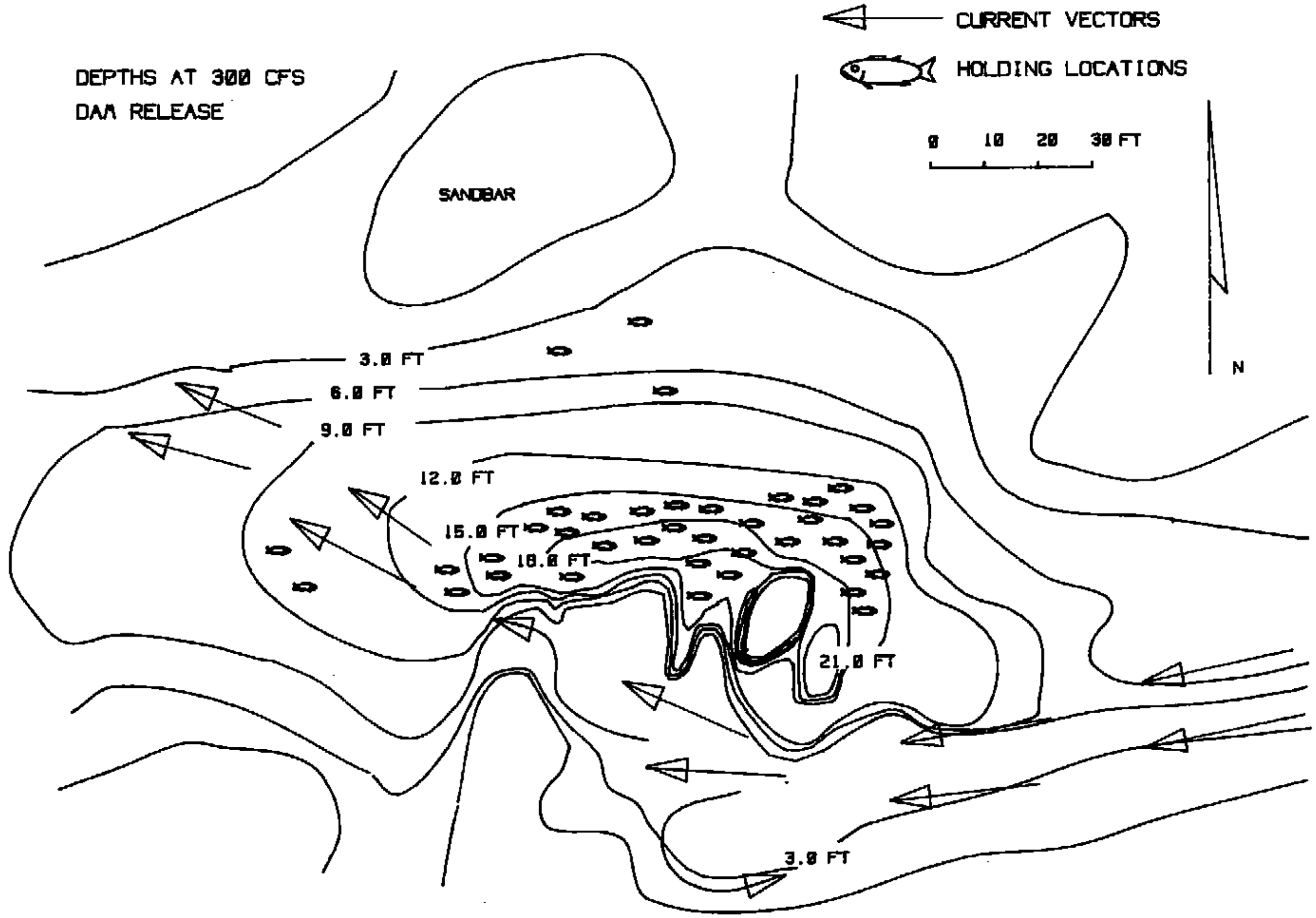

Figure 3. Scale map of Bucktail pool, river mile 105, Trinity River, Trinity County, California, with depth contours, velocity vectors, and adult spring chinook aggregation locations.

Table 3. Surface Area Versus Depth at Selected Index Pools in the Trinity River Below Lewiston Dam, Lewiston, California, Summer 1988.

Pool	Depth		
	3 feet	6 feet	12 feet
New Bridge	17700[a]	10600	2400
Cemetery	6400	2900	100
Bucktail	16300	9200	3700

[a] square feet

pool were collected at two feet off the bottom. Velocities measured at Bucktail ranged between 0.2 and 0.9 feet per second while velocities at Cemetery ranged between 0.3 and 1.7 feet per second. The velocity at the deepest location in Bucktail pool was 0.2 feet per second while the deepest spot in Cemetery pool had a measured velocity of 1.7 feet per second.

In Bucktail and New Bridge pools, most good-condition fish congregated in the deepest areas of the pools, apparently seeking out low water velocities and diffused sunlight (Figures 1 & 3). At the Bucktail pool, few fish could be seen from a vantage point approximately 10 feet above the pool, even though a subsequent observation dive found 150 fish there. The fish were concentrated below ten feet in depth beyond the range of visibility from the surface. Even though the fish were obviously disturbed by the presence of divers in the pool they stayed within the deepest portion concentrating at the upriver end farthest from the divers and then swimming past the divers to the downriver end as the divers came within sight. This behavior was observed in numerous pools in which the deepest pool area was in a narrowed channel, and it facilitated the counting of fish as they streamed past the divers. The preference of good-condition fish for shade was very obvious at the New Bridge pool when a dive there at midday found the majority of an estimated 600 fish schooled tightly underneath the shadow cast by the bridge. In contrast, poor-condition fish at the pools were usually located at the margins or tail-outs in shallow, low velocity water. Poor-condition fish were also not as disturbed by the presence of divers, unless physically handled, and were often found exposed to direct sunlight.

Some good-condition fish were also found within high velocity chutes, most often those located at the head of pools such as at New Bridge. Chutes occupied by fish had surface turbulence and entrained bubbles in the water column which apparently provided cover. The chutes also were deep enough and had substrates of a sufficient coarseness that near bottom velocities were far less than those at the surface. Fish using these areas were always near or on the bottom and appeared to be using little energy to maintain their position.

On the night of July 15/16, SCUBA dives were conducted at the New Bridge and Bucktail pools between 10:00 pm and 12:30 am. We were interested in determining how adult holding behavior might change after dark and if so, whether it would facilitate the counting of fish. We had hoped to find the salmon resting on the bottom of the pools or at least swimming less actively, as have been reported for salmon (Neave 1943), and other diurnally active fish species (e.g. Hobson 1971). We knew from previous diving experience that dive lights also tend to confuse the fish at night causing them to hold their position, at least momentarily. During our dives we found some fish lying on the bottom of the pools as we had hoped, but the majority of fish were swimming about the pool obviously spooked by our presence and confused by the bright dive lights. About 30 fish were estimated to be in the Bucktail pool during that dive, and counting conditions were worse than during the daytime.

A few days prior to our night dive at the the New Bridge pool we had estimated that approximately 600 fish were holding there. However, we were not prepared for or expecting the mayhem that occurred during the dive. Apparently our presence in the pool started a chain reaction of adult salmon swimming haphazardly throughout the pool and striking objects and divers alike. As such the dive became more hazardous than expected. The dive lights provided visibility only for a distance of three to five feet, and throughout the dive adult salmon swam unpredictably through our limited field of vision, some coming straight at our faces or bodies so that we had to continually ward off fish with our hands. The fish were swimming in all directions, so it soon became unnerving as unseen fish repeatedly struck us from behind. This behavior made any sort of count impossible.

The few fish seen at Cemetery pool during our dives were usually of poor-condition and located in shallow water near the margins (Figure 2). The Cemetery pool has the highest velocity water passing through the center of the pool at its deepest point, therefore the pool provides little in the way of deep, low-velocity habitat. Some shading is provided by riparian canopy and the steep hill to the west.

Habitat Use. Holding habitat use was measured for 148 good-condition and 157 poor-condition adult spring chinook salmon. Comparison of total depths used by adult fish found that 56 percent of the good-condition fish were found in water deeper than 4 feet while 67 percent of the poor-condition fish were in water less than 4 feet deep (Figure 4). The use curve of total depth for good-condition fish peaked near five feet while that for poor-condition fish peaked lower at less than three feet. The range of total depths used were similar for fish of either condition ranging from 0.4 to 10 feet.

Nose depth curves for good- and poor-condition fish were almost identical with poor-condition fish occurring farther off the bottom slightly more often (Figure 5). However, a few good-condition fish were found at depths of six feet off the bottom. Most nose depth observations ranged between 0.3 and 4 feet, and both use curves peaked at the same point slightly below a nose depth of 1 foot.

The use curves for mean column velocities both peaked at the same point near 0.5 feet per second for fish of either condition and most fish observed generally used the same velocities with similar frequency (Figure 6). However, good-condition fish used a much wider range of velocities with some observations over four feet per second while poor-condition observations did not exceed three feet per second. Fish of either condition used zero velocity water at the opposite extreme.

The frequency of nose velocities measured for good-condition fish peaked slightly above 0.5 feet per second, higher than poor-condition fish which peaked somewhat below 0.5 feet per second (Figure 7). Nose velocities for good-condition fish also ranged somewhat further than those for poor-condition fish, slightly exceeding three feet per second, while all poor-condition fish were found at nose velocities less than three feet per second (Figure 7). Fish of both conditions used nose velocities down to zero.

Perhaps the most dramatic difference in habitat use between the two groups of fish was for cover. Eighty-seven percent of good-condition fish used some form of cover while only 50 percent of the poor-condition fish did (Figure 8). For good- and poor-condition fish alike, surface turbulence was the cover type most often chosen with submerged woody debris and overhanging vegetation following in frequency of use.

Good- and poor-condition fish were both found over cobble substrates most often (Figure 9). In relation to good-condition fish, a relatively large number of poor-condition fish also were found over other substrate types, with fine substrates used more often than the others.

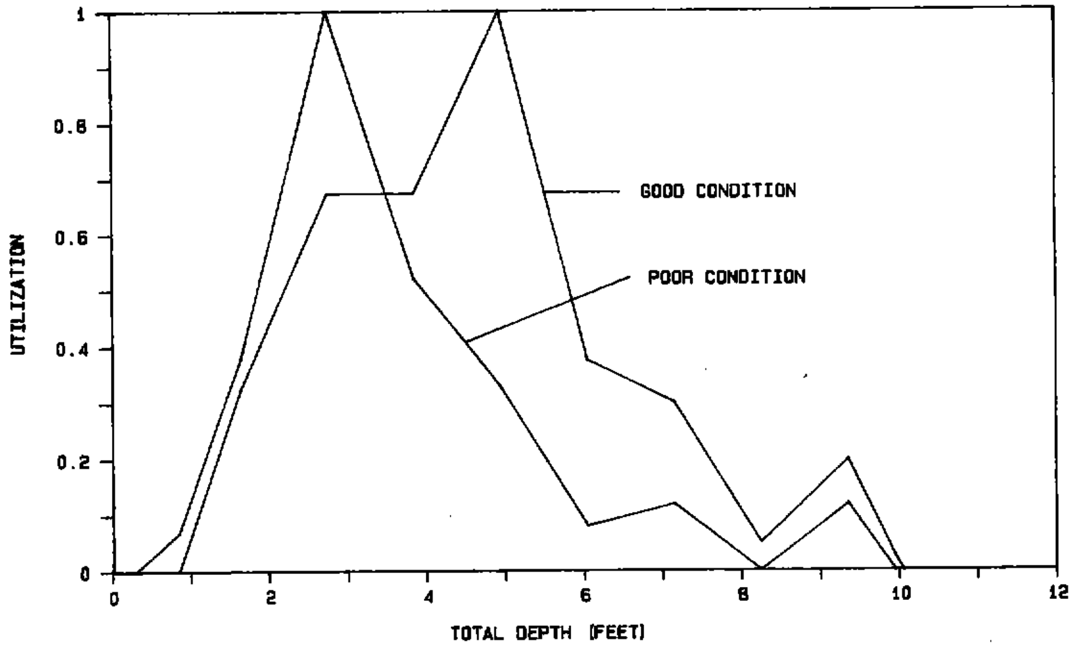

Figure 4. Total depth habitat use curve of holding adult spring-run chinook salmon for depths less than ten feet in the upper Trinity River, Trinity County, California (See Methods regarding definition of good- and poor-condition fish).

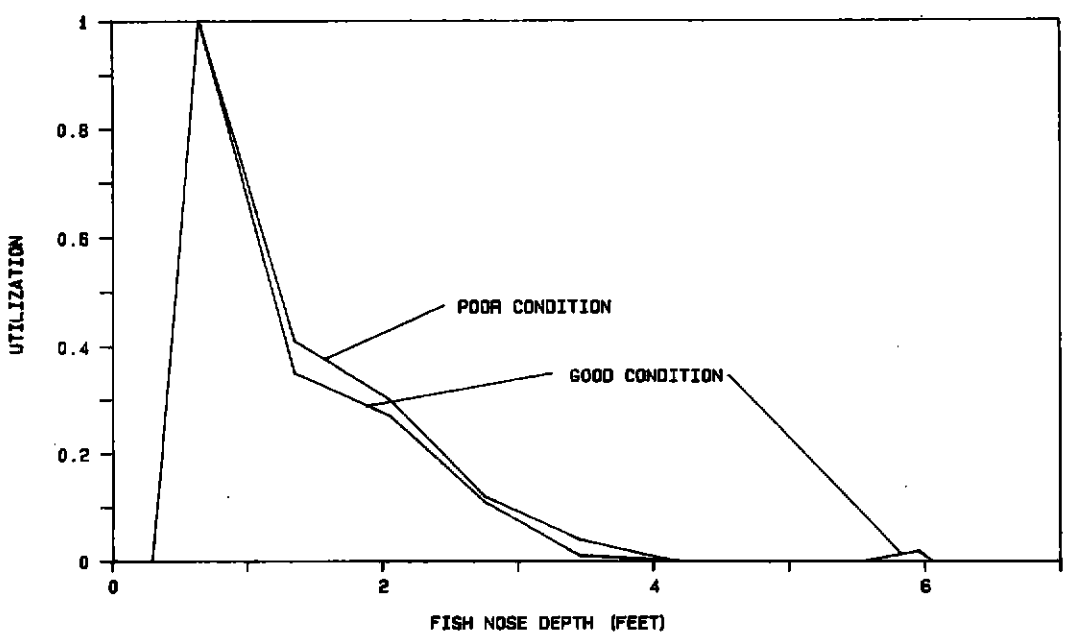

Figure 5. Fish nose depth habitat use curve of holding adult spring-run chinook salmon for depths less than ten feet in the upper Trinity River, Trinity County, California (See Methods regarding definition of good- and poor-condition fish).

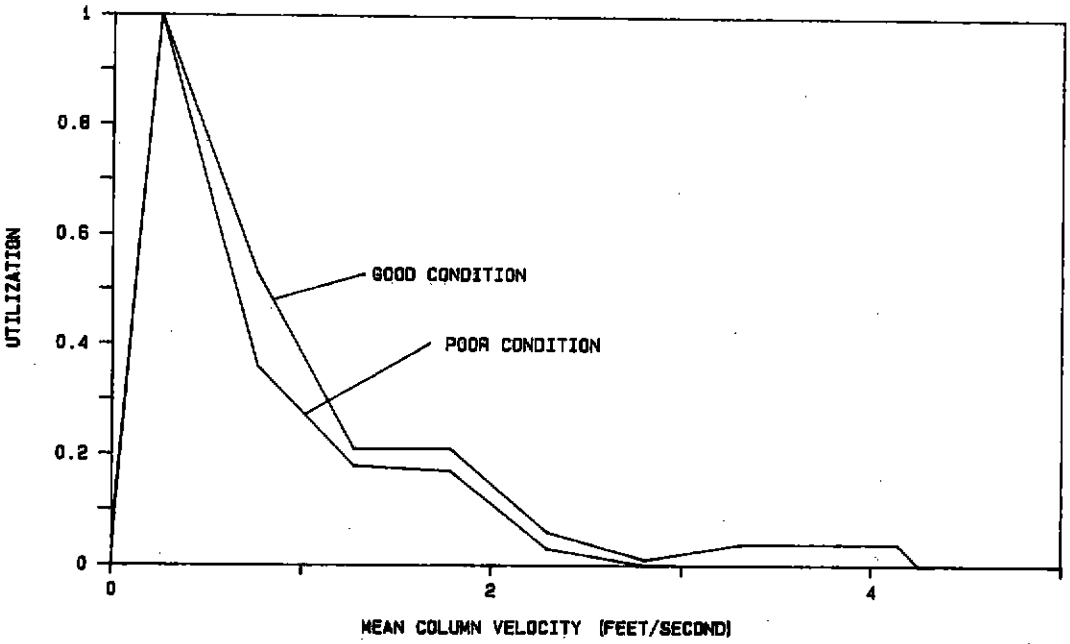

Figure 6. Mean column velocity habitat use curve of holding adult spring-run chinook salmon for depths less than ten feet in the upper Trinity River, Trinity County, California (See Methods regarding definition of good- and poor-condition fish).

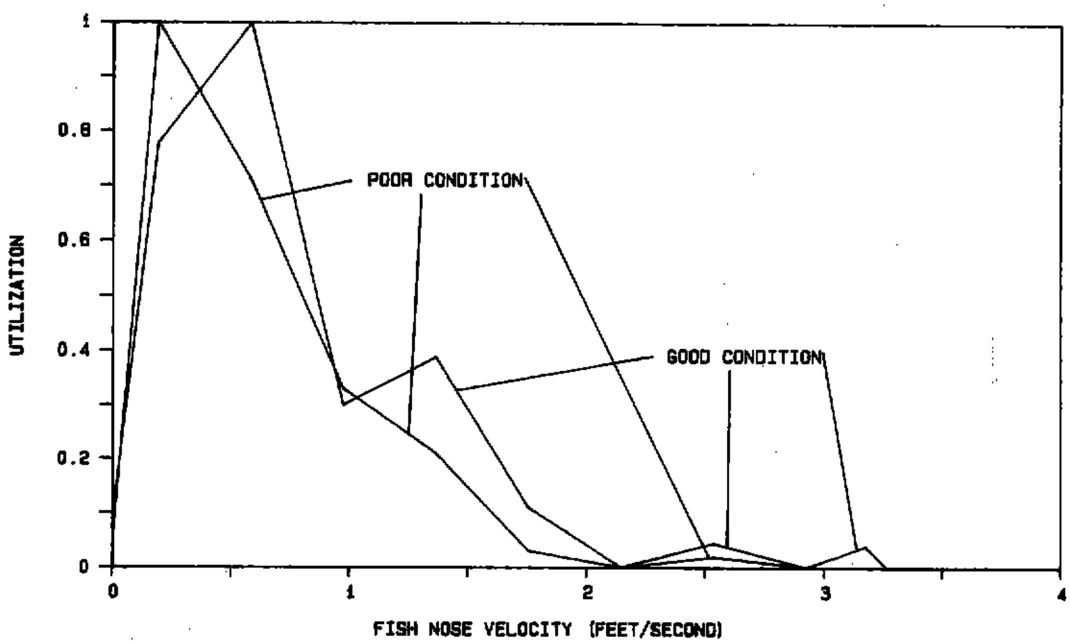

Figure 7. Fish nose velocity habitat use curve of holding adult spring-run chinook salmon for depths less than ten feet in the upper Trinity River, Trinity County, California (See Methods regarding definition of good- and poor-condition fish).

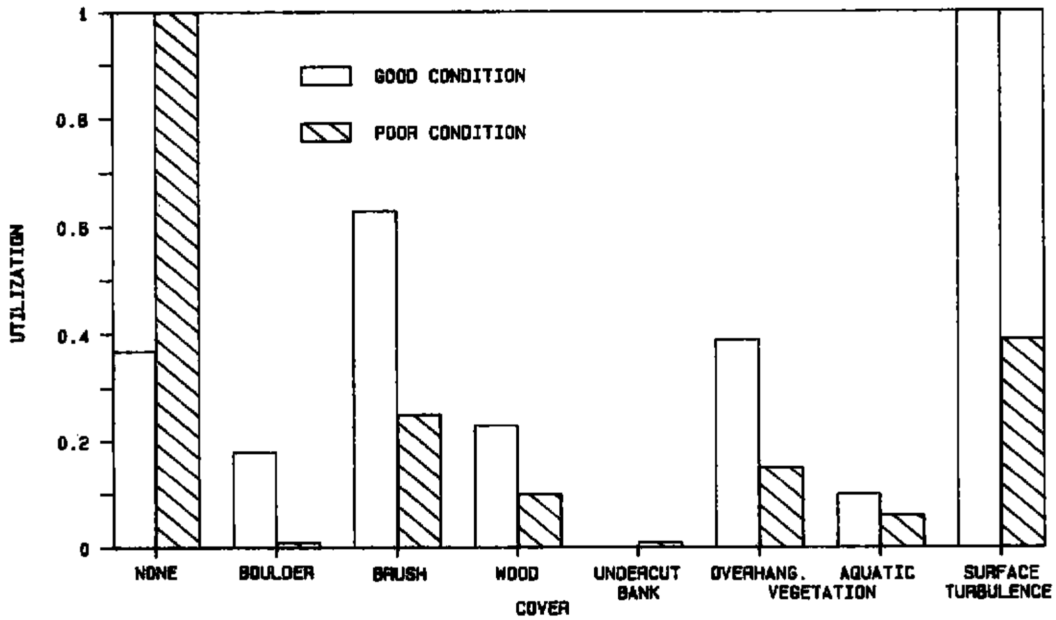

Figure 8. Resting and hiding cover habitat use curve of holding adult spring-run chinook salmon for depths less than ten feet in the upper Trinity River, Trinity County, California (See Methods regarding definition of good- and poor-condition fish).

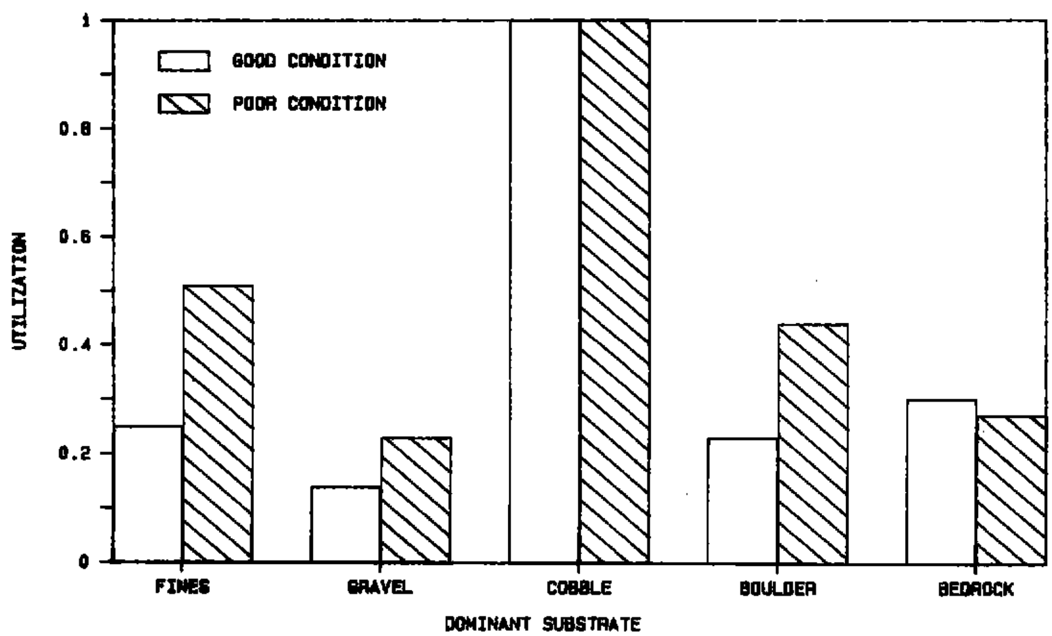

Figure 9. Dominant substrate habitat use curve of holding adult spring-run chinook salmon for depths less than ten feet in the upper Trinity River, Trinity County, California (See Methods regarding definition of good- and poor-condition fish).

Discussion

Preliminary estimates by the Department of Fish and Game placed the number of adult spring chinook returning to the upper Trinity River above their Junction City weir site in 1988 at near 75,000, with over 15,000 of those fish taken at Trinity Hatchery (J. Bedell pers. comm.). This would be the largest number of spring-run chinook returning to the river since counts were begun in the late 1970's, and the greatest return to the hatchery since its construction. As such, this was an excellent year to examine habitat use by holding adults since most habitats along the preference gradient should have been in use.

During our early counts in late May we observed only a few spring chinook in the upper river (Tables 1 and 2). Beginning the week of June 11 the Department of Fish and Game reported large numbers of spring chinook passing through their Junction City weir at river mile 85. The peak number of spring-run chinook counted at the weir occurred the following week with nearly 1500 fish seen over a four-day period. Of all fish counted at the weir between May 28 and September 9, 90 percent had passed upriver by July 22 (J. Krakker pers. comm.).

Prior to construction of Trinity Dam, Moffett and Smith (1950) reported that there were distinct spring, summer, and fall runs of chinook salmon in the Trinity River. The spring-run fish migrated past Lewiston during June and July and the summer-run during August and September. Spring fish were described as "very deliberate in their migratory habits", traveling quickly to their upriver destination, while summer fish were called "slow and cautious in their migratory habits." These investigators also stated that the summer fish migration appeared to be influenced by temperature and further speculated that the summer run might really be spring-run fish that had held downriver until forced to migrate upriver by high summer water temperatures. Hubbell (1973) reported that more recent data indicated the existence of only spring and fall runs.

The peak of the spring chinook run at Junction City occurred shortly after a marked increase in downriver water temperatures (section II.5). The daily mean water temperature recorded at Lewiston never exceeded 55.6 degrees Fahrenheit (13.1 degrees Celsius) during the period of this study, while mean daily water temperatures at Steelbridge, Idaho Bar (RM 73), Cedar Flat (RM 47.5), and Willow Creek (RM 23) reached peaks of 63.3 degrees Fahrenheit (17.4 degrees Celsius), 68.7 degrees Fahrenheit (20.4 degrees Celsius), 74.4 degrees Fahrenheit (23.6 degrees Celsius), and 78.4 degrees Fahrenheit (25.8 degrees Celsius), respectively (section II.5). Temperatures greater than 60 degrees Fahrenheit are considered suboptimal for migrating and holding spring chinook (Bell 1986; Raleigh 1986), and such temperatures may decrease the viability of eggs and increase the incidence of disease (Burrows 1960), which may increase pre-spawning mortality (Cramer and McPherson 1983). River temperatures during the holding period appeared to influence the distribution of spring chinook salmon since no large aggregations of fish were seen downriver of Limekiln Gulch at river mile 101. However, fish would also be expected to concentrate near the dam since the majority of the run are likely hatchery-produced progeny.

Not surprisingly, our counts and observations found most spring chinook concentrated in the deep, slow water areas of the upper river (Tables 1 and 2). Use of deep pools for holding or resting has been previously reported for spring chinook salmon and summer steelhead trout in the Trinity (Freese 1982; Hubbell 1973; Moffett and Smith 1950) as well as for anadromous salmon and trout in other rivers (Wampler 1986; Dunn 1981; Burck et al. 1980; Keenleyside 1962; Ellis 1962). Generally, the sites most used in the upper Trinity have large areas of deep water and slow mean column water velocities. The index and characterization pools provide examples of high and low use pools (Table 3, Figures 1 through 3). Although not mapped, the Steelbridge pool was similar to the Cemetery pool with respect to size and velocity distribution, with a relatively small area deeper than ten feet, and higher relative velocities through the pool. Fish use of the Steelbridge pool was likely also affected by the summer water temperatures at that location.

Other studies have reported that adult salmon may be active at night (Ellis 1962; Neave 1943). However, Neave (1943) reported that the salmon were generally not disturbed by lights used to observe their movements and behavior, although the lights were shone into the water from above the surface. Ellis (1962) observed fish underwater at night with lights but does not report their reaction. Based on our experience this summer it is unlikely that we will attempt any future night dives to count holding adult salmon, especially in pools with large aggregations of fish. Not only were the divers at a greater risk of injury during the dive at the New Bridge Pool, but the salmon were subject to injury as well, which could significantly affect their survival to spawning given the apparent high incidence of physical impairment by fungal growth on these fish.

Habitat Use. What appeared to be obvious differences in habitat use and behavior prompted the designation of fish conditions and the separation of good- and poor-condition fish for habitat use curve development. A carcass survey of the upper mainstem Trinity in 1987 found an extremely high 48 percent pre-spawning mortality for spring chinook females (J.M. Stempel pers. comm.). We believe it very likely that a majority of the poor-condition fish we observed did not survive to spawn, and as such will not contribute to the gene pool, and therefore should not be considered in the development of habitat criteria curves.

The criteria curves and frequencies developed for this study (Figures 4 through 9), misrepresent the true habitat use of spring chinook salmon in the upper Trinity River because of the failure to include the deep pools and runs most used by these fish. To emphasize this point, consider that 145 good-condition spring salmon were found holding in shallow water areas in the 12.5 mile reach between the New Bridge in Lewiston and Steelbridge. The person collecting use data covered approximately half of the river, working downriver from one bank to the other. Assuming then that half of the salmon holding in shallow water were seen, we might guess that a total of around 300 fish were holding in the river between the New Bridge and Steelbridge; about half the number found in the New Bridge pool alone. The selective use of pools is emphasized even further when the size of the 1988 run is taken into consideration.

Upon reviewing the habitat use curves and histograms for good-condition fish presented in this study in light of all our habitat observations, it seems likely that more comprehensive sampling would change the use criteria for the Trinity River as follows:

Total Depth - Peak of use would be expected to shift to the right, with depths ten feet and more showing the greatest use. (The deepest area found so far in the upper river is the 30-foot-deep pool at the base of Trinity Dam.)

Fish Nose Depth - Peak would also shift to the right since most fish in the pools are swimming at least several feet off the bottom.

Mean Column Velocity - Change uncertain, but peak would probably broaden with most use occurring at less than 1 foot per second.

Fish Nose Velocity - Change probably similar to mean column velocity with most use below 1 foot per second.

Cover - In deep pools, depth itself would likely be the most used form of cover, greatly exceeding all other types.

Substrate - Change uncertain, however substrate use might shift to left if deep pools tend to have smaller substrates than shallower river reaches.

Deep pools were not sampled during this initial year of study because of difficulties encountered in assigning a single depth, velocity, or measure of any variable to a large school of adult salmon milling over a relatively large area. We do, however, intend to continue our study of spring salmon holding habitat in 1989, concentrating exclusively on the deeper pools. We intend to deal with the pool sampling problem by describing pools in which aggregations of fish occur and then weighting the importance of pool characteristics by the density of fish found there. We also intend to place greater emphasis on the investigation of shade as an important cover feature (see Wampler 1986), and to attempt to describe the relationship of pool area and shape with fish density.

Need For Holding Habitat Improvement and Expansion.

The high pre-spawning mortality last year again raised the questions: 1) was the holding capacity of the upper river for spring chinook exceeded?, and if so; 2) could that capacity be expanded by increasing the size or number of holding pools? Trinity River spring chinook apparently have a history in recent years of high pre-spawning mortality (Hubbell et al. 1984; Bedell 1970), which has been compared to a similar situation in the Rogue River of Oregon (Cramer and McPherson 1983). The Rogue River fish are apparently greatly affected by high temperatures, which is not a serious problem in the upper Trinity. If the Trinity mortalities are the result of some pathogen, which seems to be the case for the Rogue River fish, then perhaps by providing more dispersed holding pools, the transmittal of that pathogen between fish could be diminished. However, even with more holding pools, the fish are still somewhat confined by temperature to the mainstem upriver of Limekiln Gulch (give or take some depending on the weather in a given year). Also, the fish tend to concentrate in the reach just below the dam and hatchery anyway.

Further, we must ask whether more holding habitat is really neccessary for spring chinook since the large runs of the past two years: 1) were greatly underharvested, and 2) far exceeded the capacity of the hatchery and the available spawning habitat in the river (see FWS 1987; section II.1 this report).

5. WATER TEMPERATURE MONITORING

Introduction

During the fall of 1987 and throughout the summer of 1988 water temperatures continued to be monitored in the mainstem of the Trinity River. Water temperature monitoring is being done to enhance the record and to provide a data base for planned modeling of the Trinity River system.

Sites and Methods

Three semi-permanent monitoring sites were used during the October 1987 through September 1988 period. Locations are downstream from Lewiston Dam (river mile 111.4), off Steel Bridge Road (river mile 97.5), and at Idaho Bar approximately 1 river mile upstream of the confluence of the North Fork Trinity River (river mile 73). Shorter-term water temperature monitoring was also conducted at Cedar Flat (river mile 39) and near Willow Creek (river mile 16). The latter set of temperature data was provided courtesy of the U.S. Fish and Wildlife Service, Fishery Assistance Office in Arcata, California.

The distrubution of the water temperature monitoring sites on the Trinity River is shown in Figure 1. Along with location descriptor, Table 1, below, lists the river mile location, distance from Lewiston Dam, type of recorder deployed, recording interval, and period of record for each site.

Table 1. Water temperature recorders deployed in the Trinity River between October 1987 and September 1988.

Location	River Mile	Dist. from Lewiston Dam (miles)	Type of Recorder	Recording Interval	Recording Period
Lewiston	111.4	0.5	Datapod	daily	July 1987 - present
Steel Bridge Rd.	97.5	14.4	Datapod	daily	July 1987 - present
Idaho Bar	73.0	38.9	Datapod	daily	July 1987 - present
Cedar Flat	39.0	72.9	Datapod	daily	June 9 - Sept. 1[illegible]
Near Willow Ck.	16.0	95.9	TempMentor	2 hrs.	April 26 - present

Except for the Willow Creek monitoring site the temperature recorders used are Omnidata Datapod Model DP-112 temperature/voltage recorders. The units are installed with Omnidata Application Engineering Special # 1013 software to record temperatures to the nearest 0.1 degree Celsius in a

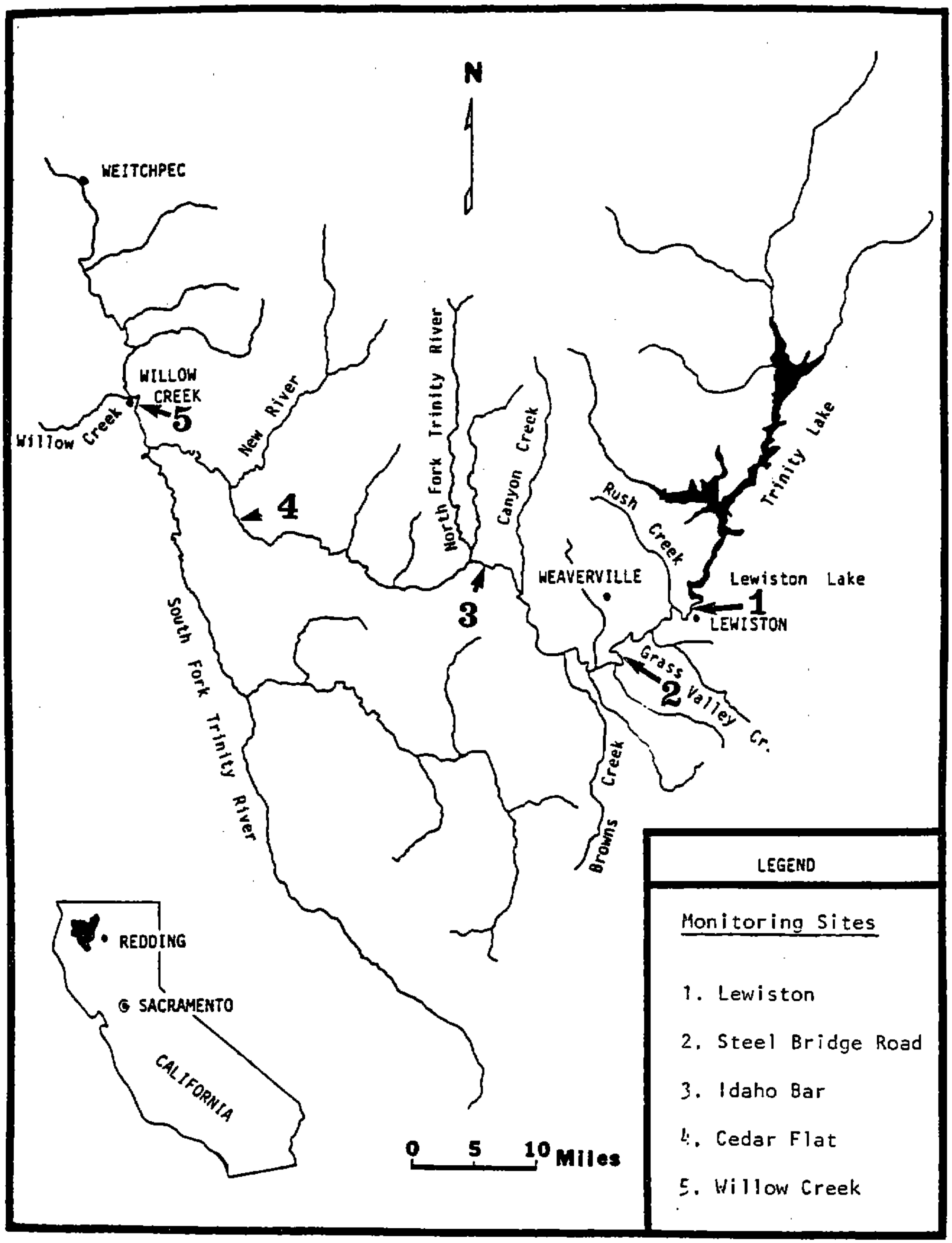

Figure 1. Distribution of water temperature monitoring sites on the Trinity River from October 1987 through September 1988.

range from 5.0 degrees to 30.0 degrees. These units are also programmed to record average daily water temperatures along with the daily minimum and maximum.

Generally, the recording temperature range of the Datapods was sufficient for water temperatures observed in the Trinity except for several short periods during the months of December, January, and February when water temperatures dipped below 5.0 degrees Celsius. On these occasions temperatures were recorded as 5.0 degrees.

Data recorded by the Datapods is stored on a nonvolatile storage medium called a data storage module (DSM) which can be removed and replaced without an interruption in the data record. The nonvolatile storage modules provide the capability of storing data even in the event of power loss, flooding, or other mishap. Stored data is transferred to computer files using an Omnidata Datapod Model 217 DSM Reader.

At the Willow Creek monitoring site a Ryan Instruments TempMentor temperature recording unit was used. This unit has a range of -32 degrees to 70 degrees Celsius with a resolution of 0.1 degrees. The recording interval used was 2 hours which is the maximum interval for the unit. Stored data was transferred to computer files using a RS232C connector interfacing with a desk top computer. Daily averages at this site were then calculated by averaging the 12 temperature records for each recording day.

For deployment on site all temperature recorders were sealed in a water-resistant housing, placed in armored cases, and submerged at depths which kept them immersed over the range of river flows observed during the monitoring period. For security each unit was chained to trees or other immovable objects, or in the case of the TempMentor placed in an artificially constructed "boulder" and placed in the river. Each unit was serviced at intervals of approximately 30 days. For the Datapods this consisted of removing the "full" data storage module and replacing with an "empty" one to continue the data record. To recover data from the TempMentor the unit was retrieved from the monitoring site and taken back to the office. Once data was recovered the unit was returned to the monitoring site.

Results

Mean daily water temperatures recorded for the three semi-permanent monitoring sites, Lewiston, Steel Bridge Road, and Idaho Bar, are presented in Figure 2. Mean daily water temperatures recorded at the Cedar Flat site and near Willow Creek are presented in Figure 3, along with the Idaho Bar data for comparison. All temperature data gathered on the Trinity for the period of October 1987 through September 1988 are provided in Appendix C.

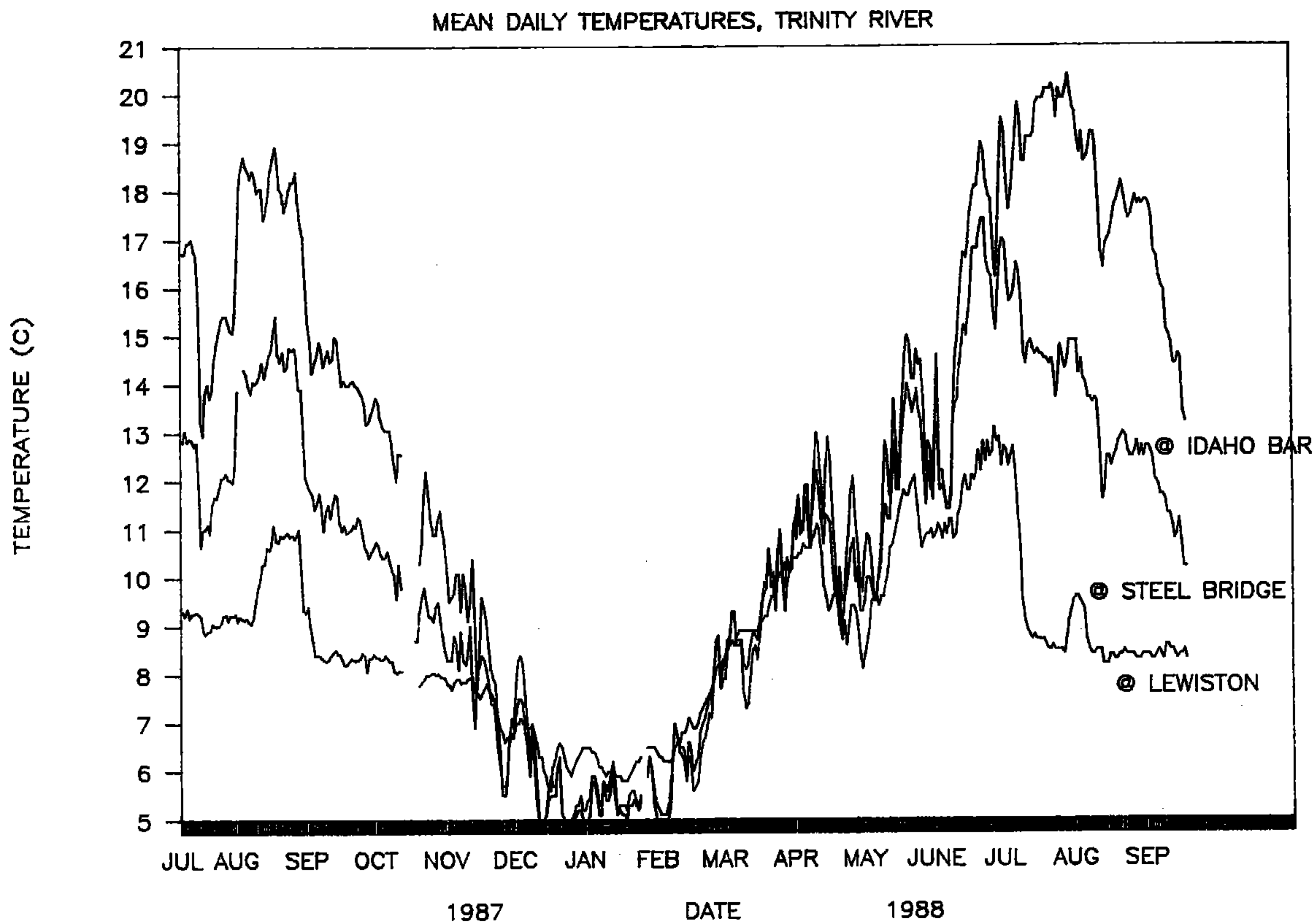

Figure 2. Mean daily water temperatures at the Lewiston, Steelbridge Road, and Idaho Bar monitoring sites on the Trinity River between July 1987 and September 1988.

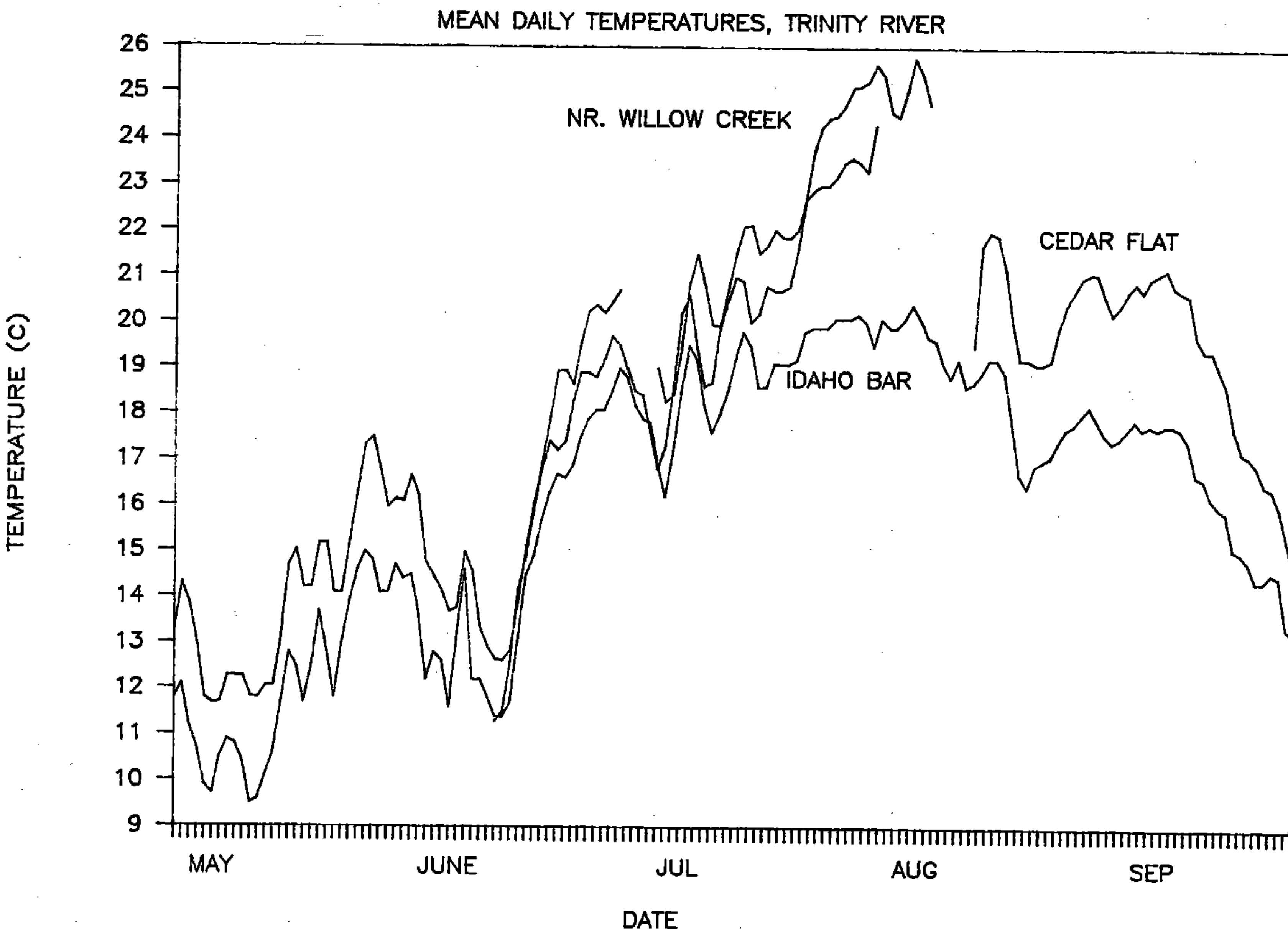

Figure 3. Mean daily water temperatures recorded at the Idaho Bar, Cedar Flat, and Willow Creek monitoring sites on the Trinity River during 1988.

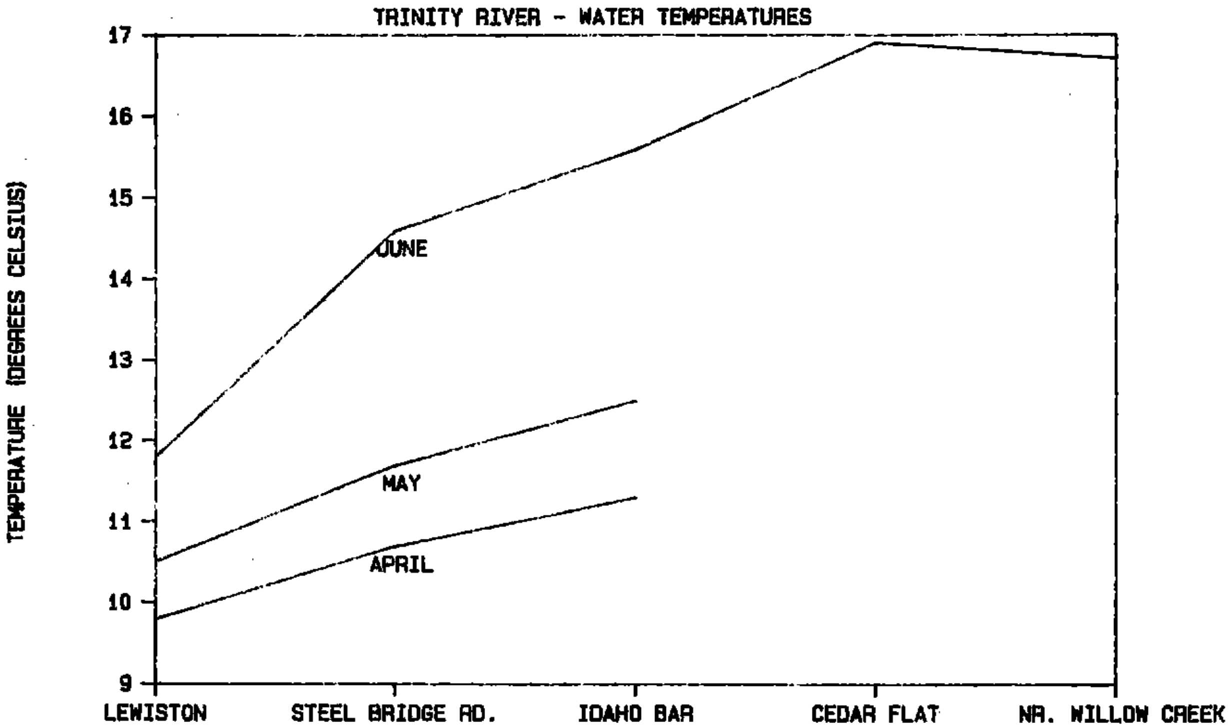

Figure 4a. Water temperature profile for the Trinity River between Lewiston Dam (river mile 111.9) and Idaho Bar (river mile 73.0) during the months of April, May, and June 1988.

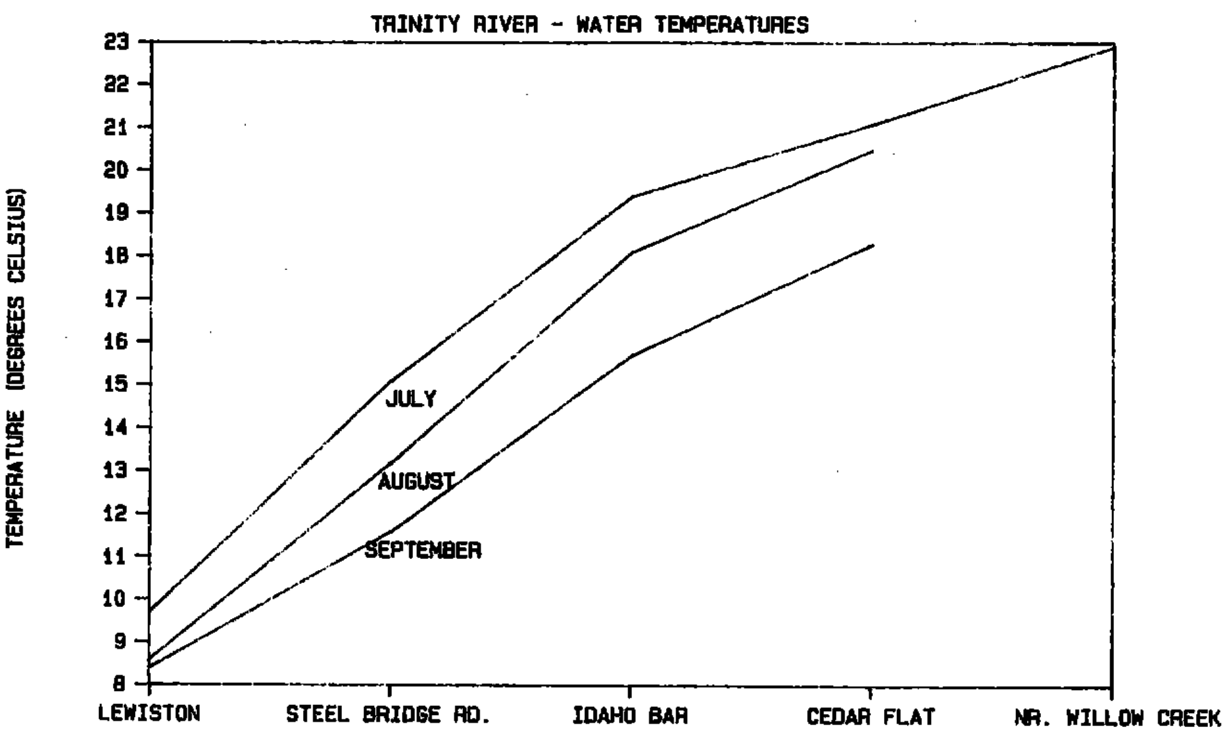

Figure 4b. Water temperature profile for the Trinity River between Lewiston Dam (river mile 111.9) and Idaho Bar (river mile 73.0) during the months of July, August, and September 1988.

Mean daily water temperatures, at least between Lewiston Dam and the confluence of the North Fork Trinity River, generally increased downstream during the summer months (June through September) and decreased downstream during the winter months (December through March). Temperatures at the Lewiston site remained fairly constant, relative to the downstream sites, and seemed to be influenced more by the location of the release from Lewiston Dam (e.g., surface release or mid-level release). At the Steel Bridge road site and downstream river water temperatures begin to respond to changes in ambient air temperature.

Instream water temperature profiles for the Trinity River below Lewiston Dam are illustrated in Figure 4A for the spring months of April, May and June, and in Figure 4B for the summer months of July, August and September.

Discussion

The water temperature monitoring data presented in this report provides some insight into the seasonal effects on water temperatures and the importance of the release from Lewiston Dam. The data clearly reflects trends associated with ambient air temperature (Figure 5). The Significance of ambient air temperature, especially at lower release levels (e.g., 300 cubic feet per second), is quite evident. Ambient air temperature alone, however, is not the only factor influencing Trinity River water temperatures.

The degree to which river releases from Lewiston Dam affected downstream water tempeatures are somewhat obscure during the 1987-1988 water year. Since the highest releases during this water year were scheduled during the spring months and held constant (at 300 cubic feet per second) through the summer the importance of the river release is not evident. Going back to the summer of 1987, however, helps to clarify the issue. Figure 6 is an illustration of the observed Trinity River daily mean water temperatures from July through September 1987 along with the river release from Lewiston Dam and ambient air temperatures observed at Lewiston. While the overall effect of river releases on river water temperatures depends on the stream reach, location (e.g., surface or mid-level) and volume of release, it is nonetheless evident that at higher release levels, daily mean water temperatures are substantially reduced. Although the true effects of Trinity River releases from Lewiston Dam may be somewhat obscured by day-to-day variations in ambient air temperature along with other meterological conditions (i.e. cloudiness, humidity, etc.), the importance of these releases can not be overlooked.

In addition to controlling summertime water temperatures, it also appears that Trinity River releases from Lewiston Dam during the winter months may require close consideration

(Figure 5). During the winter months water temperatures immediately downstream of Lewiston Dam are actually warmer than historic water temperatures. Under these conditions incubation time is reduced causing fry salmon to emerge from the gravels earlier than in predam conditions. Whether this change is beneficial or detrimental to overall survival of rearing fry salmon has yet to be determined. To this point our concern has not focused on the importance of winter water temperatures on the survival of eggs and juveniles spawned naturally in the Trinity River below Lewiston. Future study will consider this situation.

Finally, the next step in this Trinity River water temperature monitoring effort is to apply known data (water temperature, meterological, and hydrological) to the U.S. Fish and Wildife Service's instream temperature model (SNTEMP). This model provides an analytical framework to isolate the effect of alternate release flows on river water temperatures under a variety of conditions.

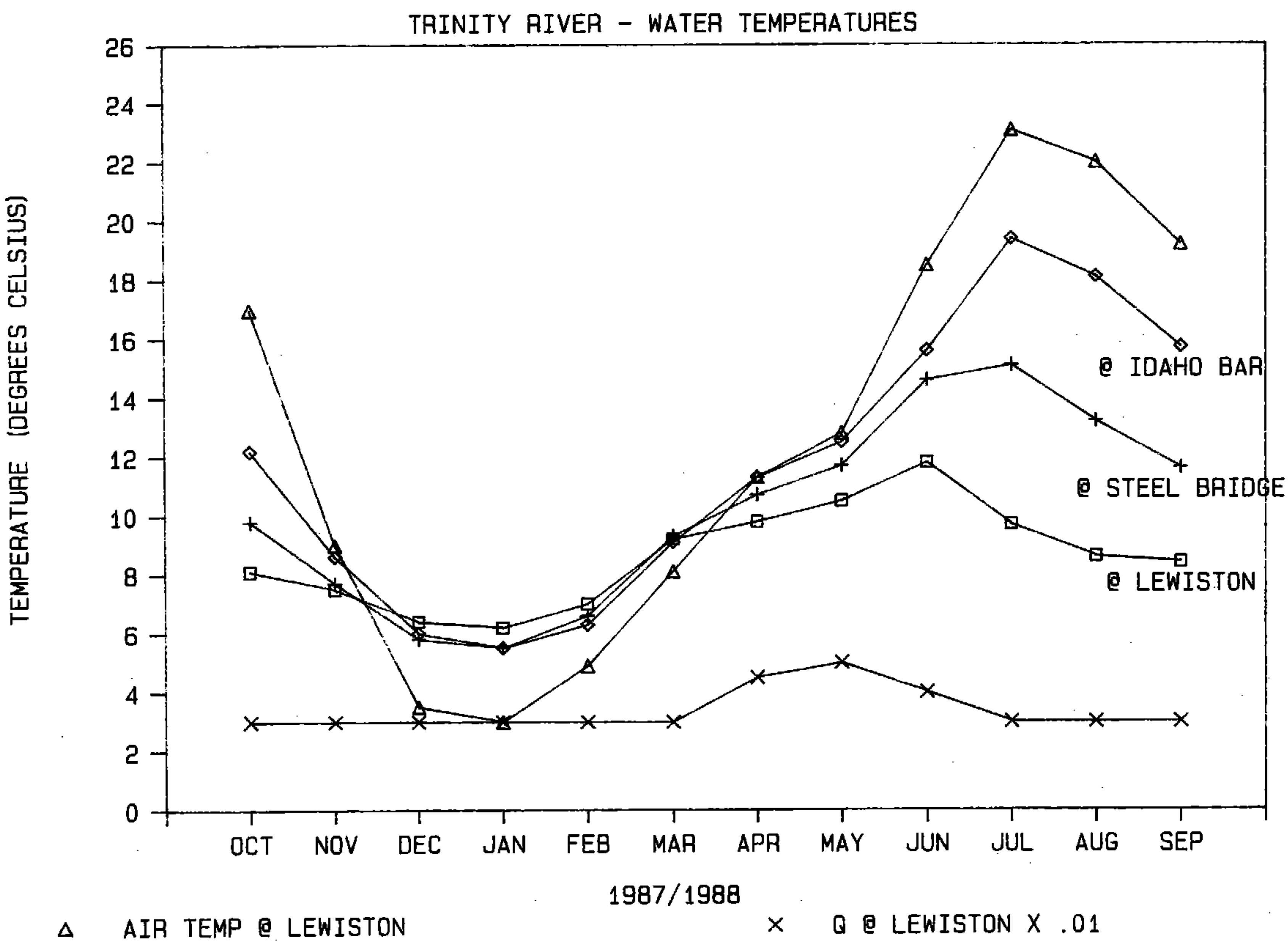

Figure 5. A comparison of Trinity River water temperatures at three monitoring sites with ambient air temperatures recorded at Lewiston and the river release from Lewiston Dam for the period of October 1987 through September 1988.

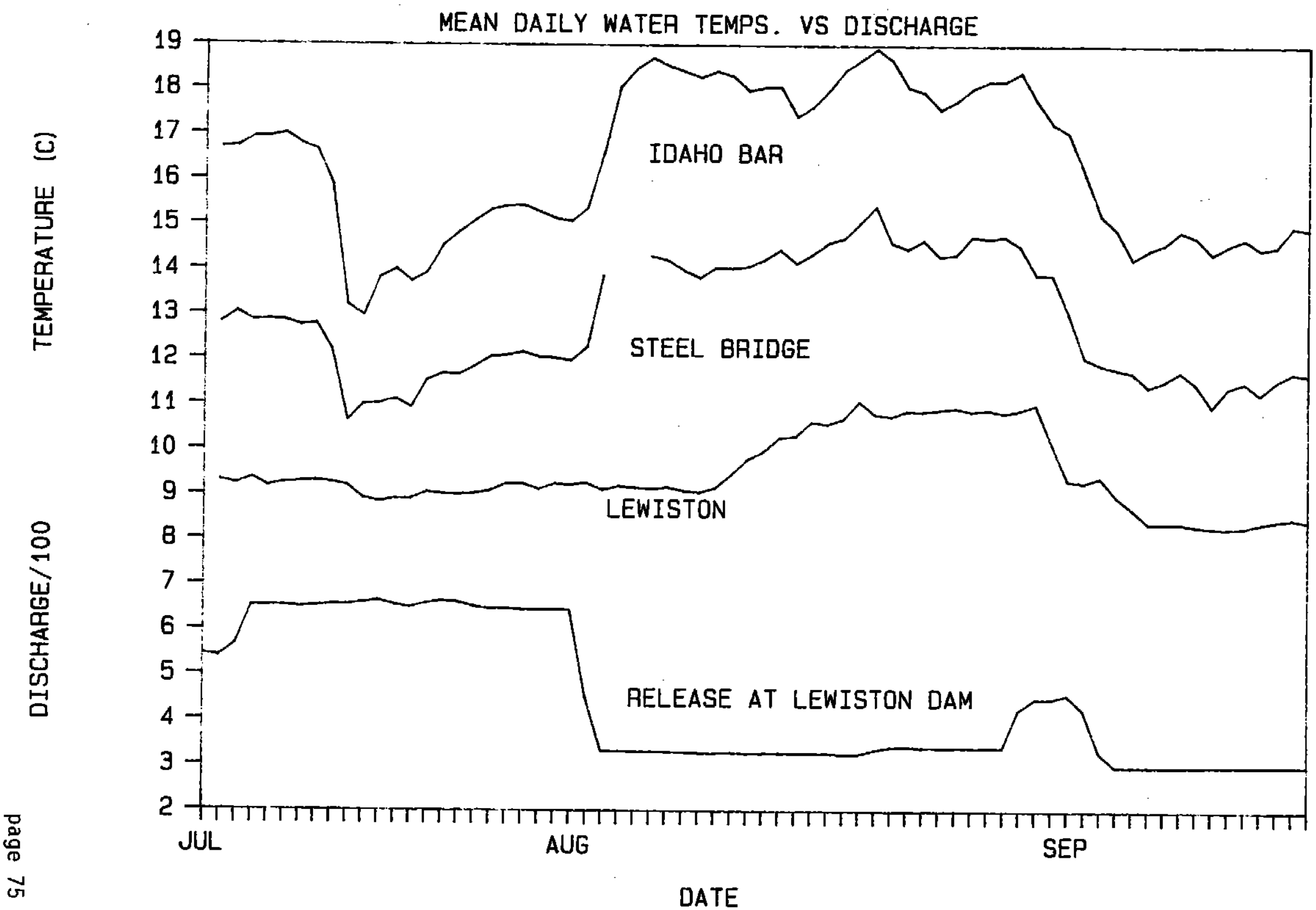

Figure 6. A comparison of mean daily water temperatures in the Trinity River with instream releases from Lewiston Dam during the period of July 8 through September 15, 1987.

III. FISH POPULATION CHARACTERISTICS AND LIFE HISTORY RELATIONSHIPS

1. CHINOOK SALMON SPAWNING DISTRIBUTION

Introduction

In the fall and winter of 1987 we continued our effort to describe chinook salmon spawning habitat within the mainstem Trinity River. Knowledge of chinook salmon spawning habitat is necessary in order to evaluate yearly changes of spawning habitat throughout the Trinity River as they occur. The information is also helpful to us in directing our efforts toward studies of juvenile chinook salmon the following spring.

Methods and Results

Spawning surveys were conducted from a raft during float trips down various sections of the Trinity River from September through November 1987. The entire river between Lewiston Dam and Cedar Flat was surveyed. High flows and turbidity prevented us from surveying the lower river areas below the New River Gorge. Chinook salmon spawning redds were recorded on aereal photos during each float trip. Occasionally sections were snorkeled in order to locate salmon redds that could not be seen from the raft.

Table 1 presents a summary of the float reaches and number of redds that were observed on each trip.

Table 1. Chinook salmon spawning survey results for the Trinity River in the fall of 1987.

DATE	REACH	REDDS
SEPT 17	NEW BRIDGE TO BUCKTAIL	95
SEPT 24	BUCKTAIL TO POKER BAR	34
OCT 1	POKER BAR TO STEELBRIDGE	132
OCT 8	STEELBRIDGE TO STEINER FLAT	78
NOV 5	STEINER FLAT TO EVANS BAR	114
NOV 12	EVANS BAR TO J&M SPORTING GOODS	49
NOV 17	J&M SPORTING GOODS TO NORTH FORK	47
NOV 18	NORTH FORK TO BIG FLAT (TURBID)	3
Turbid water conditions may have prevented effective survey of some redds located in deep runs within this reach.		
NOV 23	BIG FLAT TO FRENCH BAR	348
NOV 30	FRENCH BAR TO CEDAR FLAT	132
TOTAL		1032

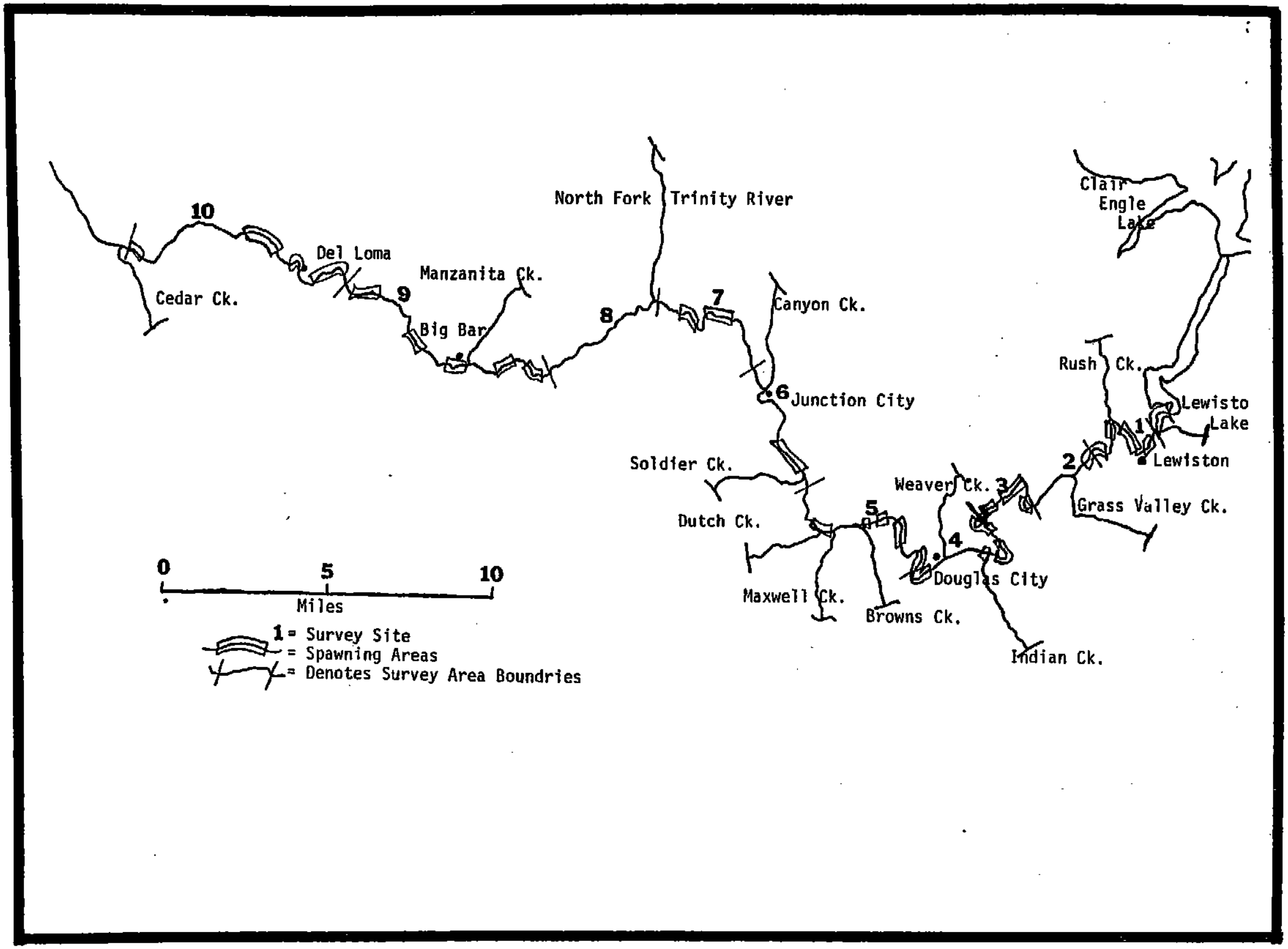

Figure 1. Spawning areas used by chinook salmon in the Trinity River, California during the fall of 1987.

Major chinook salmon spawning locations on the Trinity River above Cedar Flat are displayed in Figure 1.

Discussion

The California Department of Fish and Game estimated that 82,678 adult chinook salmon spawned in the Trinity River above Willow Creek including the South Fork Trinity during 1987 (CDF&G, 1988). The U.S. Fish & Wildlife Sevice estimated from carcass surveys during 1987 that 45,815 adult chinook salmon spawned in the mainstream Trinity River above the North Fork Trinity River confluence (USFWS 1988). The chinook salmon run of 1987 was slightly smaller than the run in 1986, which was estimated to be 113,007 fish (CDF&G, 1988).

In 1987 we observed a fairly large increase in chinook salmon spawning activity in the Trinity River below the North Fork. Due to dry weather conditions tributary inflow below Lewiston Dam was low. With reduced tributary flow the lower river water levels were below normal. This low flow slowed the migration of many adult salmon causing an increase in spawning use of lower river habitats. This probably helped to reduce the amount of superimposition of redds in the upper river, and undoubtedly increased the use of available rearing habitat in the lower river the following spring.

In the upper river chinook salmon generally used the same spawning areas as they had used in the previous year with one noticeable exception. In 1988 fewer chinook salmon spawned in the area below Grass Valley Creek then in 1987.

The greatest shift in spawning distribution occurred in the lower river. Large increases in habitat use by spawning chinook salmon were observed between Hell Hole, upstream of Big Flat, and Schneiders Bar. The largest concentrations of spawners within this area were observed below Sailor Bar Creek, above the Big Bar Bridge, upstream of French Bar, below French Creek, and across Canadian Bar. This increase in spawning use of lower river habitats may be a key to overall increases in chinook salmon smolt production in future years.

2. JUVENILE POPULATIONS

Methods

In 1988, we continued to monitor mainstem Trinity River juvenile salmon populations by underwater observations at the Cemetery, Steelbridge, Steiner Flat, and Junction City sites, and at the Hayden Flat campground.

Our method, as in previous years, was to ascend a 200-foot rope up the river edge at selected locations at each of the four upper sites (USFWS, 1987). At Hayden Flat we surveyed a 473-foot section of the river bank by crawling or swimming up the cobbled river bottom, which provides adequate handholds to allow upstream movement.

From mid-winter through late February water temperatures below about 45 degrees Farenheit caused yearling salmonids to remain hidden in the substrate, and the only visible fish were a few schools of sticklebacks. Chinook swim-up fry emerged from the gravel in significant numbers by about mid-February, and we made surveys between the 13th and 19th of each ensuing month through August. Water visibility was consistently good through this period, ranging from about ten to twenty feet.

Figures 1 through 4 show chinook fry and juvenile numbers for each site in 1986, 1987, and 1988. Figure 5 shows the 1987 and 1988 chinook counts at Hayden Flat, and Figure 6 shows chinook at the four upper sites combined. Figures 7 and 8 show comparative 1988 chinook and coho salmon counts at our upper two sites. All fish numbers are reported as individuals per linear foot of the river's edge.

Results

Chinook Figures 1 through 5 show that this year juvenile chinook left the upper sites earlier than they did in 1988, and that they persisted somewhat longer in the lower river.

Initial fry populations seem to have been higher than they were in 1987 at the Cemetery site, but they dropped to numbers comparable to the previous year by mid-April. This may be because we caught a peak emergence period in 1988 that occurred before or between our counts in 1987, or it could be explained by a higher initial fry population as indicated by our Steelbridge migrant trapping results (Section III.3).

At Steelbridge and Steiner Flat, April and May juvenile

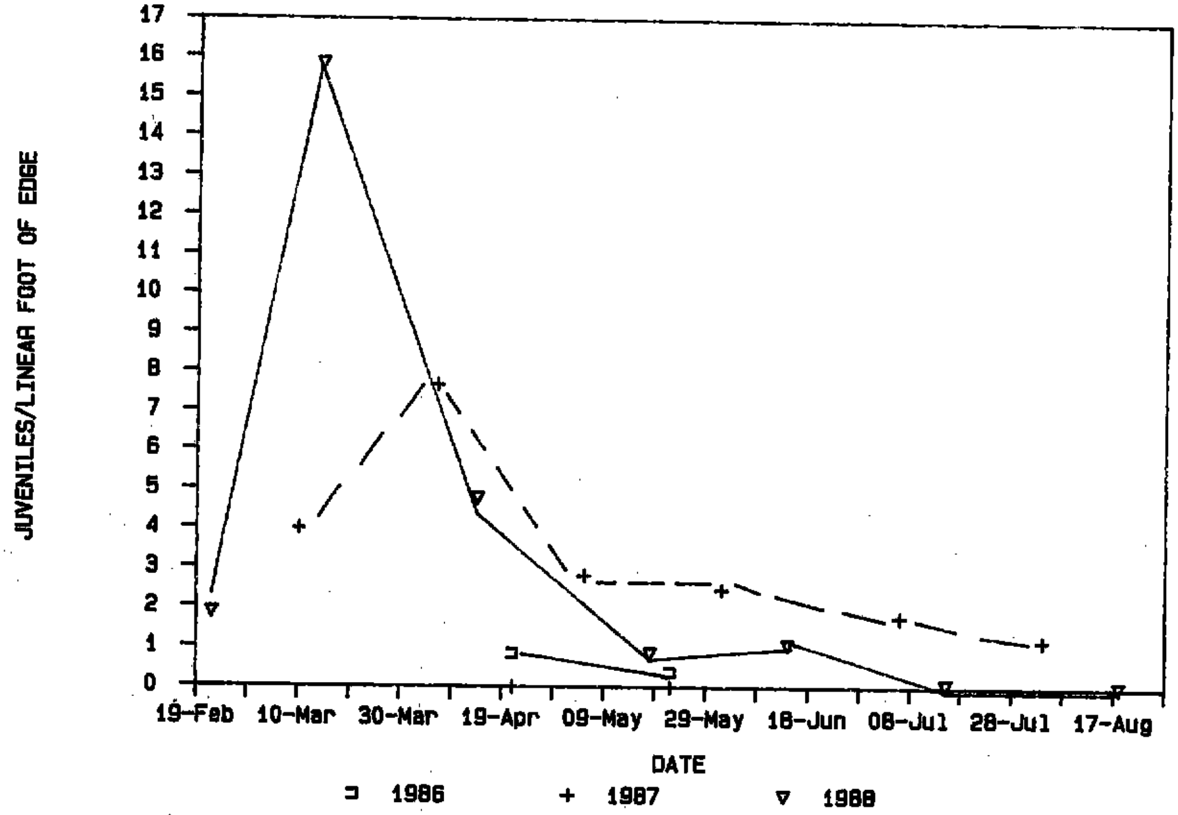

Figure 1. Rearing Chinook Densities at Cemetery Reach, 1986-1988.

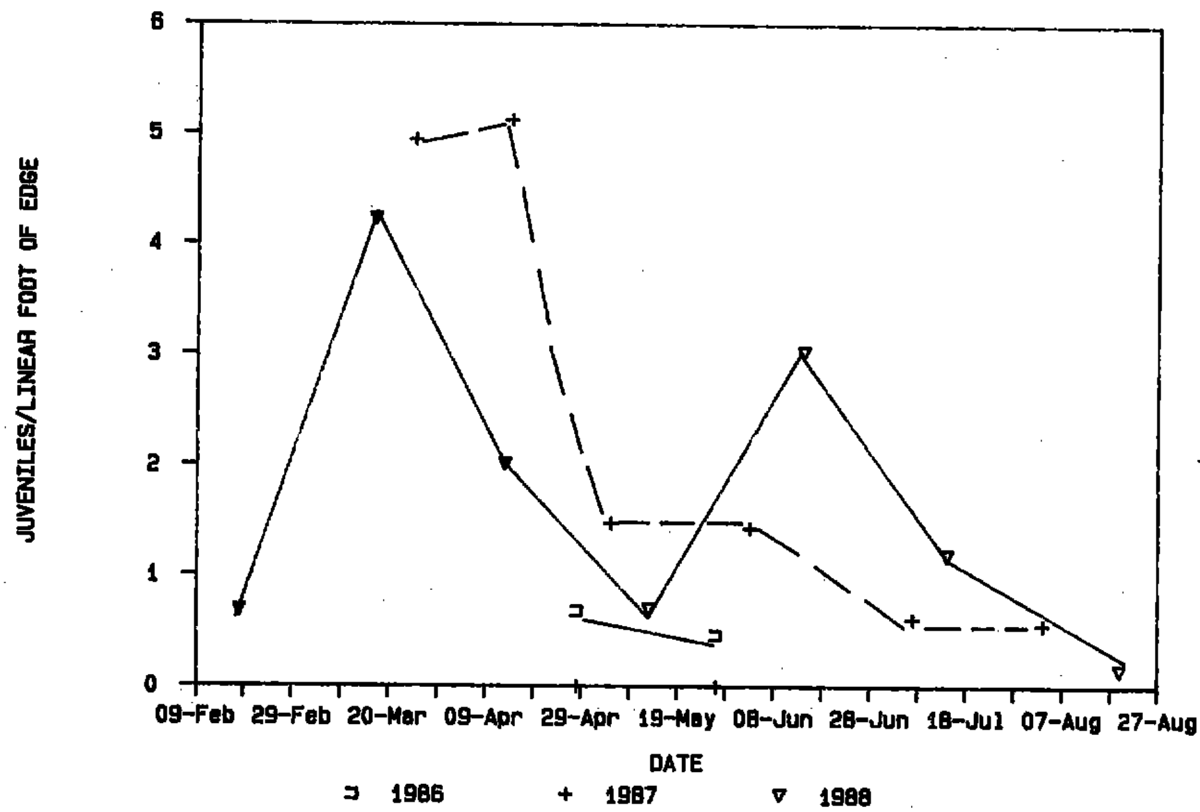

Figure 2. Rearing Chinook Densities at Steelbridge Reach, 1986-1988.

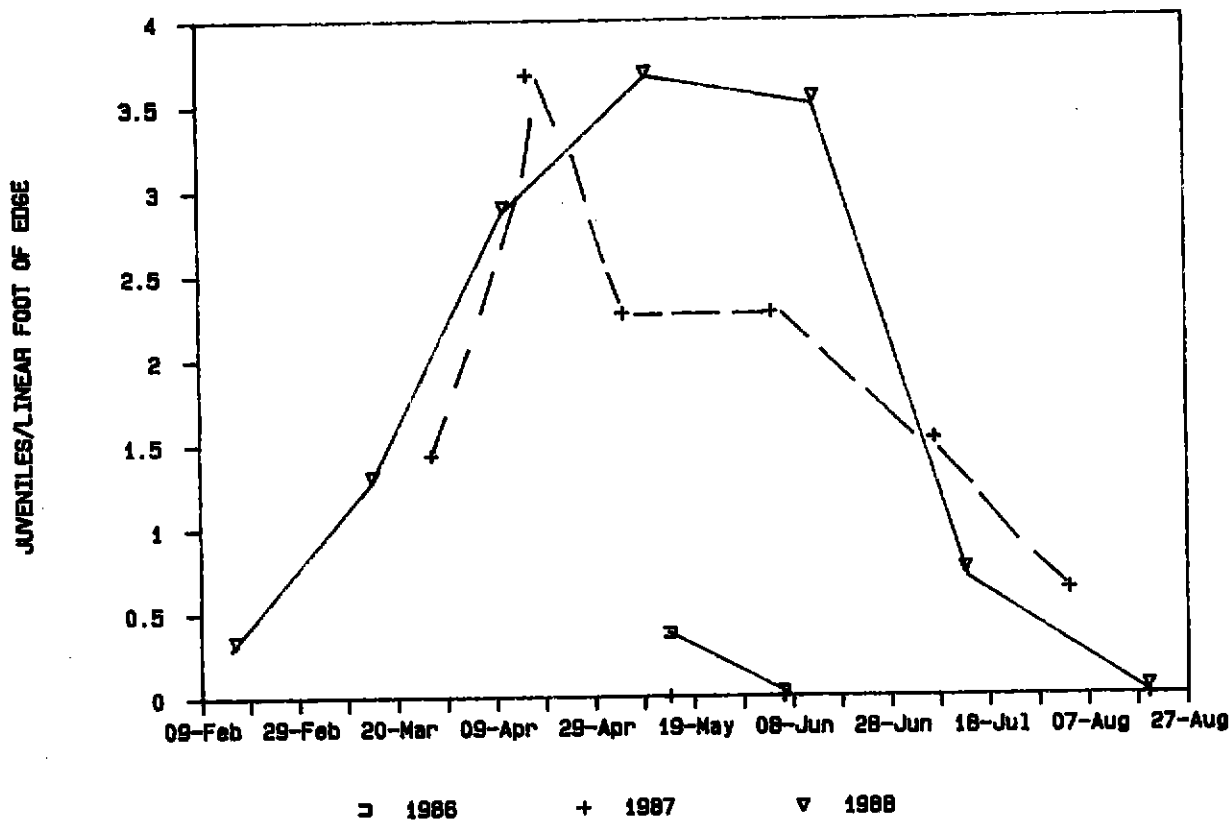

Figure 3. Rearing Chinook Densities at Steiner Flat Reach, 1986-1988.

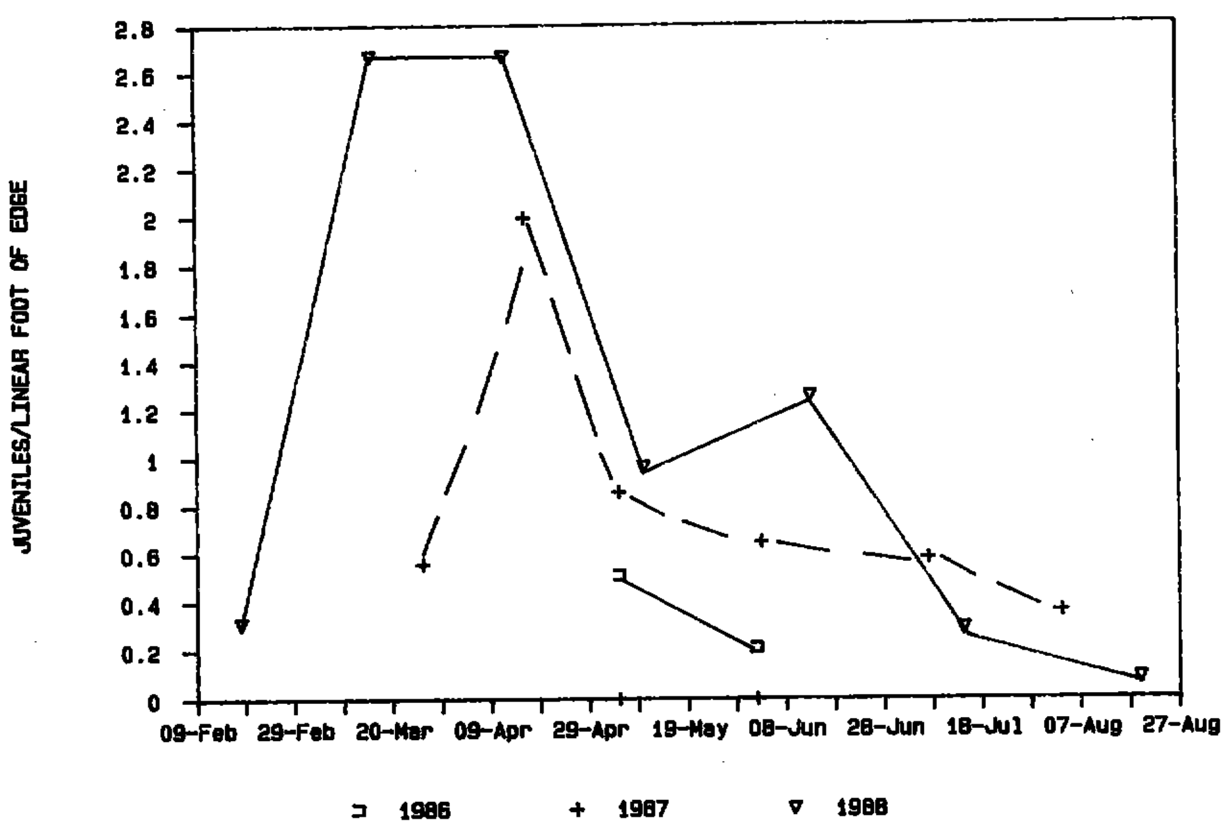

Figure 4. Rearing Chinook Densities at Junction City Reach, 1986-1988.

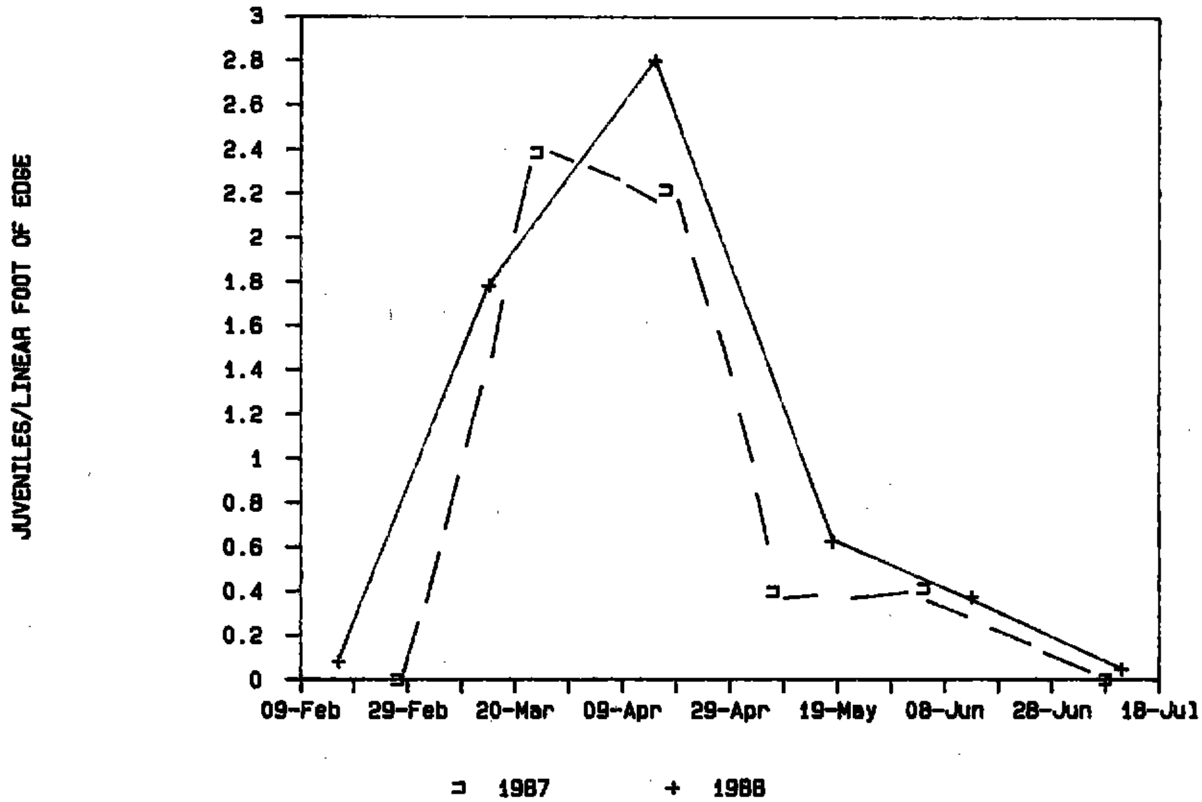

Figure 5. Rearing Chinook Densities at Junction City Reach, 1986-1988.

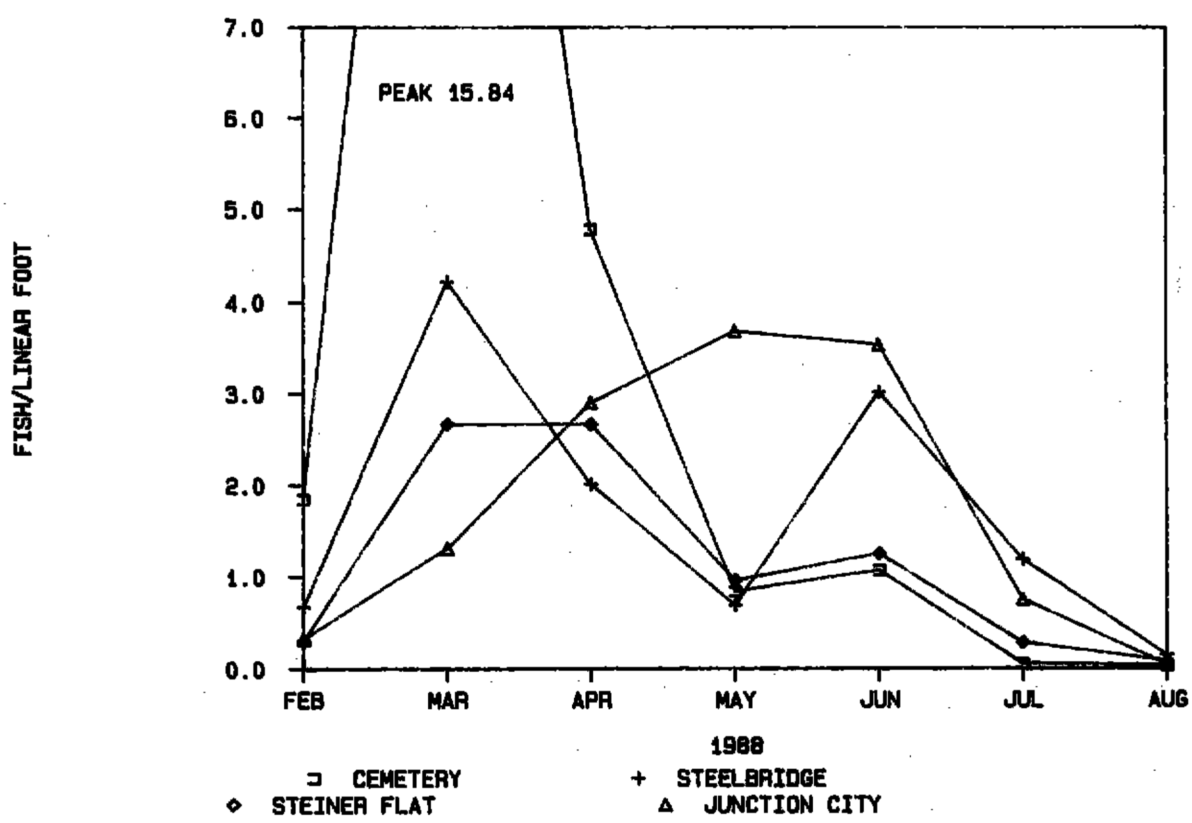

Figure 6. Rearing Chinook Densities at Upper-river Sites, 1988.

counts were comparable in both years. In the mid-june 1988 survey substantially more fish were seen at Steelbridge, Steiner Flat, and Junction City, probably because 4.9 million chinook juveniles were released from Lewiston-area rearing ponds in two batches in Late May and early June.

The releases were made at the Ambrose ponds, several miles below our Cemetery site, and at the Sawmill ponds which drain into the bottom end of the Cemetery site. There is a slight increase in the Cemetery count between mid-May and mid-June, probably because a few hatchery fish were counted. In 1987, releases upstream at the Trinity River Fish Hatchery were consistent through the spring, which may explain the slightly higher counts at the Cemetery site that year.

The counts at Hayden Flat again this year showed heavy use of the Hayden Flat edge habitat by rearing chinook. Numerous chinook had spawned in the area the preceding fall (Section III.1). The Hayden Flat young were of all sizes throughout the spring, from evidently newly-emerged 35 to 40 millimeter fish to juveniles of about 70 millimeters. In addition, in mid-April we saw a relatively dense population of young chinook across the broad cobble bar adjacent to our edge sampling site.

In 1988, as in 1987, spring chinook fry and juvenile counts at all our sites were substantially higher than they were in 1986.

<u>Coho</u> In 1987 there were insignificant numbers of rearing coho in the mainstem Trinity. In 1988, the coho run was much stronger, and at our upper site mid-spring coho rearing numbers were comparable to chinook numbers.

Figures 7 and 8 show chinook and coho populations at the two sites where coho were found in substantial numbers, Cemetery and Steelbridge. The first few coho emerged by March 15, about a month later than the chinook. By April 15, they were close to chinook numbers at the Cemetery site, and through the rest of the spring and on into mid-July they far outnumbered the few chinook remaining.

There was an increase in coho counts at Cemetery from May through mid-July. These may have been fish moving upstream to seek lower water temperatures, or possibly fish moving downstream from Deadwood Creek. In early September, a cursory survey of Deadwood Creek showed dense populations of young-of-the-year coho.

There was a precipitous drop in coho numbers at the cemetery site between mid-July and mid-August, from estimated total numbers of 2,233 to an estimated 422. Of the coho we counted in August, seven percent had misshapen backbones toward the tail, indicating that the population may have been affected

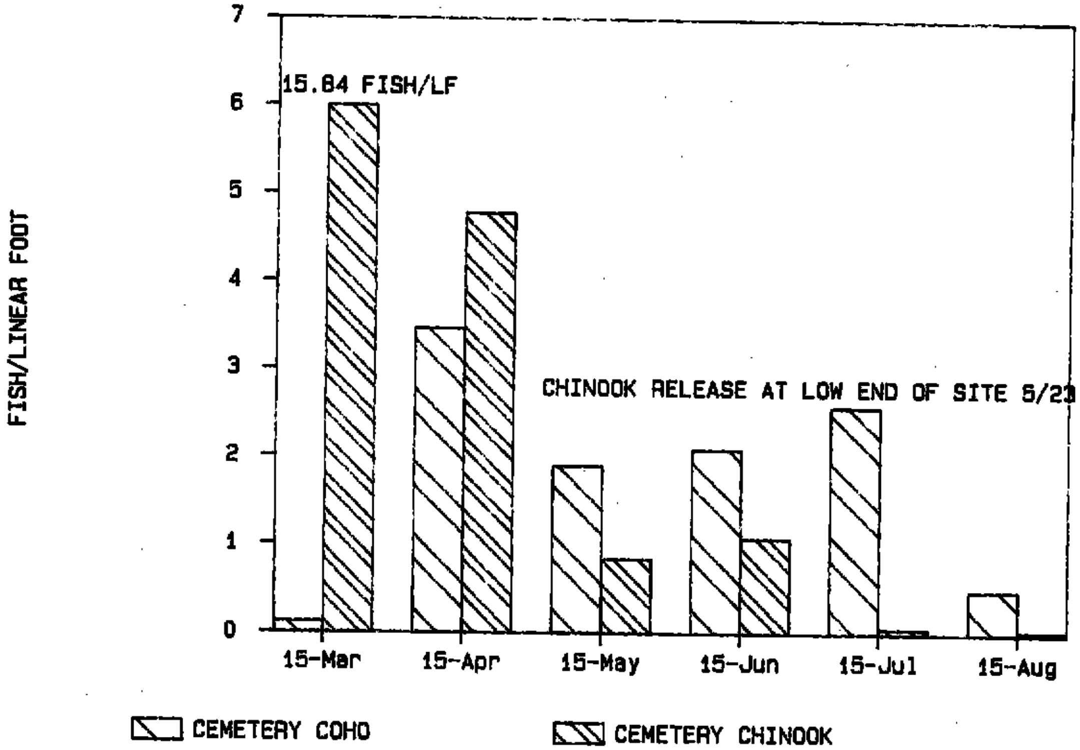

Figure 7. Rearing Coho and Chinook Densities at Cemetery Reach, 1988.

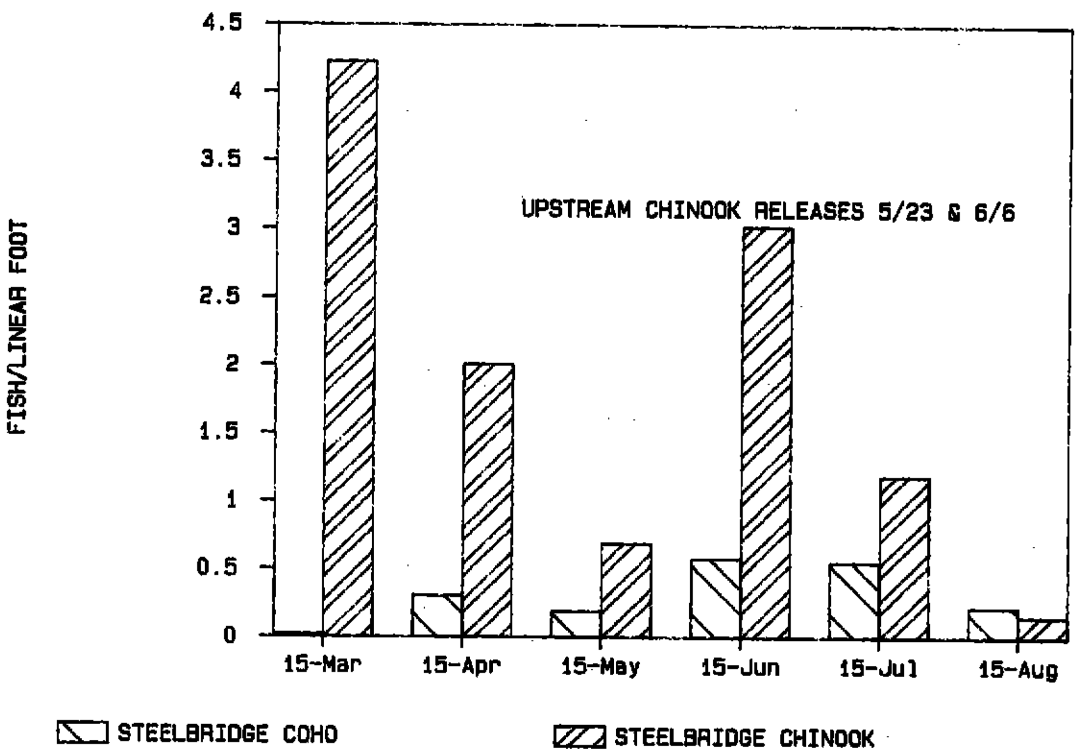

Figure 8. Rearing Coho and Chinook Densities at Steelbridge Reach, 1988.

by disease, deleterious water quality, or some unknown major stress.

It is possible that the presence of dense coho fry populations in the upper river stimulated the apparent earlier downstream movement of young chinook in 1988. Although Cemetery and Steelbridge site coho and chinook seem to occupy many of the same habitat areas with no antagonistic behavior, the coho do take up space that would otherwise be available to chinook.

<u>Sticklebacks</u> Although we made no attempt to count them, from February until mid-June three-spine sticklebacks appeared to be as numerous as any fish species at the Cemetery site. There were insignificant numbers of them at Steelbridge, and they were rare at other sites. The Sticklebacks in the upper river were interspersed with the salmonids, swimming with schools of chinook and coho fry and juveniles.

3. FRY EMERGENCE AND SURVIVAL

Introduction

Production and emergence timing of chinook salmon from Trinity River redds is poorly understood. This information is important for the Trinity River Flow Study to determine habitat needs for spawning, and assist in decisions of water release schedules.

The fecundity of chinook salmon has been described (Allen and Hassler, 1986; Healey and Heard, 1984; Moyle, 1986), as has mortality of the eggs (Wales and Coots, 1954; Gangmark and Bakkala, 1960; Briggs, 1953). Various researchers have described the behavior of fry prior to, and during emergence (Allen and Hassler, 1986; Dill, 1964; Godin, 1981; Fast et al, 1981; Bams, 1969; Rich, 1920).

We sought to estimate production and duration of chinook salmon fry emerging from isolated redds, and to monitor timing of downstream migrants.

Methods

Emergence Traps . Two redds,each with a spawning pair of spring chinook salmon, were located in the Moose and Cemetery side channels. Both redds were enclosed on October 13, 1987 by wood-frame plastic screens (mesh diameter 3mm) set flush with the gravel, having an average distance of 5 feet from the redd. It was believed that this arrangement would minimize loss from intergravel movement of fry. Inclined plane migrant traps were placed at the downstream side of redd enclosures to trap and enumerate fish. Fish in emergence traps were counted and forklength measured three times weekly, at which time the screens were cleaned of debris. Emergence trapping was concluded on March 21, 1988.

Stickleback Experiment. To test trap efficiency we planted 120 stickleback into each of the emergence traps on February 2, 1988, eight stickleback were captured in the Moose emergence trap, for a 6 percent recovery and 14 stickleback were captured in the Cemetery trap, for a 12 percent recovery.

Downstream Migrant Trap. A 3-foot wide (1/8 inch mesh) fyke net, which fed into a 2-by-3 foot box trap on a gravel bar in the Steelbridge Road area, trap was set February 12, 1988, and removed March 16, 1988. The trap was checked at 2- to 3-day intervals during this period. The trap was washed out by an increase of river discharge from 300 to 450 cfs on March 2, 1988, and was repositioned.

Results

A total of 747 and 197 spring chinook fry were trapped in the Cemetery and Moose emergence traps, respectively. Chinook fry emergence timing is shown for the Cemetery and Moose traps in Figures 1 and 2. Chinook salmon emerging from the redds sampled showed no clear trends in size with time (Figures 3 and 4).

The chinook salmon catch from the Steelbridge migrant trap totaled 3617. Timing of chinook migrants peaked Feb. 16, 1988 (Figure 5). Coho salmon migrants appeared March 7, 1988, and peaked March 14, 1988 (Figure 6), although a substantial catch was made prior to trap removal. Stickleback counts generally peaked with chinook salmon and lamprey ammocetes showed similar periodicity, although with different peaks (Figure 7).

Discussion

The average number of eggs per female for 1987-run chinook at the Trinity River Hatchery was 2800 (Gary Ramsden, CDFG, 1988, pers. comm.). The hatchery reported 84 percent survival to fry for these eggs, or 2352 fry per female. Assuming 2800 eggs were deposited in the Cemetery and Moose redd enclosures, survival rates were 27 percent, and 7 percent, respectively.

The stickleback release showed that fish could escape through the enclosures, although stickleback recoveries were probably lower than would be expected for the less mature (and wary) chinook fry. Incidental catches of coho and brown trout fry occurred frequently in the Moose enclosure, demonstrating that fish could move in as well as out of that enclosure.

The 27 percent capture of fry at the Cemetery trap may be a minimum estimate of survival, because fish could escape the trap directly, or submerge into the gravel and emerge outside the enclosure. This minimum estimate is low when compared with other studies. We found 70 percent survival (with a range of 0 to 100 percent) of eggs to the eyed stage in a survey of Trinity River redds during winter 1986 (U.S. Fish and Wildlife Service, 1986). In ideal conditions, chinook egg mortality may be as low as 10 percent (Briggs, 1953). However, in adverse conditions mortality may reach 95 percent (Wales and Coots, 1954; Gangmark and Bakkala, 1960).

Trends over time in mean size of emergence may have been masked by low sample size for early and late fish, or by random measurement error: or, perhaps fish emerge at roughly the same size. Emergence size was similar to values reported by Rich (1920) of 35 to 40 mm length.

Catches of chinook salmon fry in the Steelbridge downstream migrant trap were much higher than last year (U.S. Fish and Wildlife Service, 1987). This was primarily a result of the large pulse of fish captured in mid-February 1988. A similar pulse was observed in 1987, of approximately 1/5 the magnitude. A second, smaller pulse of fish was caught in late March both years. These pulses in number of chinook fry during mid-February and late March probably represent downstream migration of the spring and fall run stocks, respectively. This differentiation of stocks is further substantiated by comparing timing between emergence and downstream migrant traps. Peak emergence in the Cemetery trap occurred during the interval (February 12 - 29, 1988) of highest downstream migration observed in the Steelbridge trap.

The screen enclosures proved useful in determining duration and timing of chinook fry in redds, but were of limited value in estimating production. A minimum estimate of 27 percent survival is proposed, which may be low because of trap avoidance and escape. A good estimate of redd production will require: 1) isolating the redd from superimposition, 2) isolating the redd from intergravel movement of fry from other redds, 3) confining fish within the redd without substantially altering intergravel waterflow, and 4) an escape-proof trap.

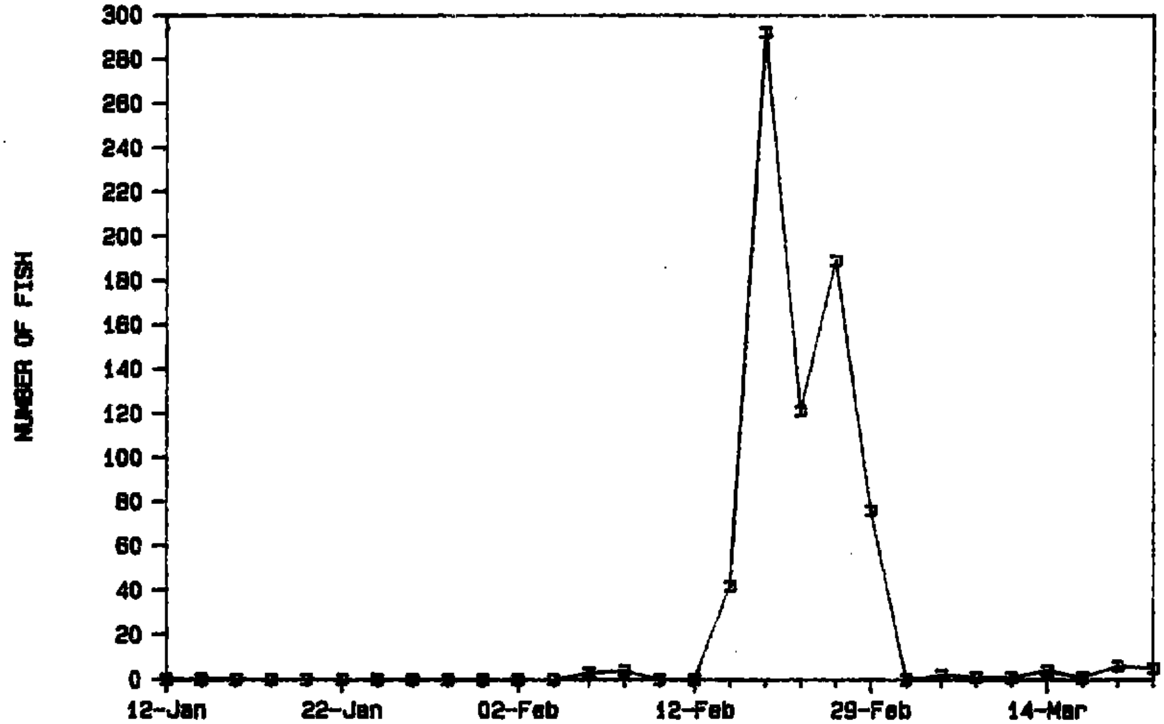

Figure 1. Number of chinook salmon fry emerging by date in the Cemetery side-channel redd enclosure.

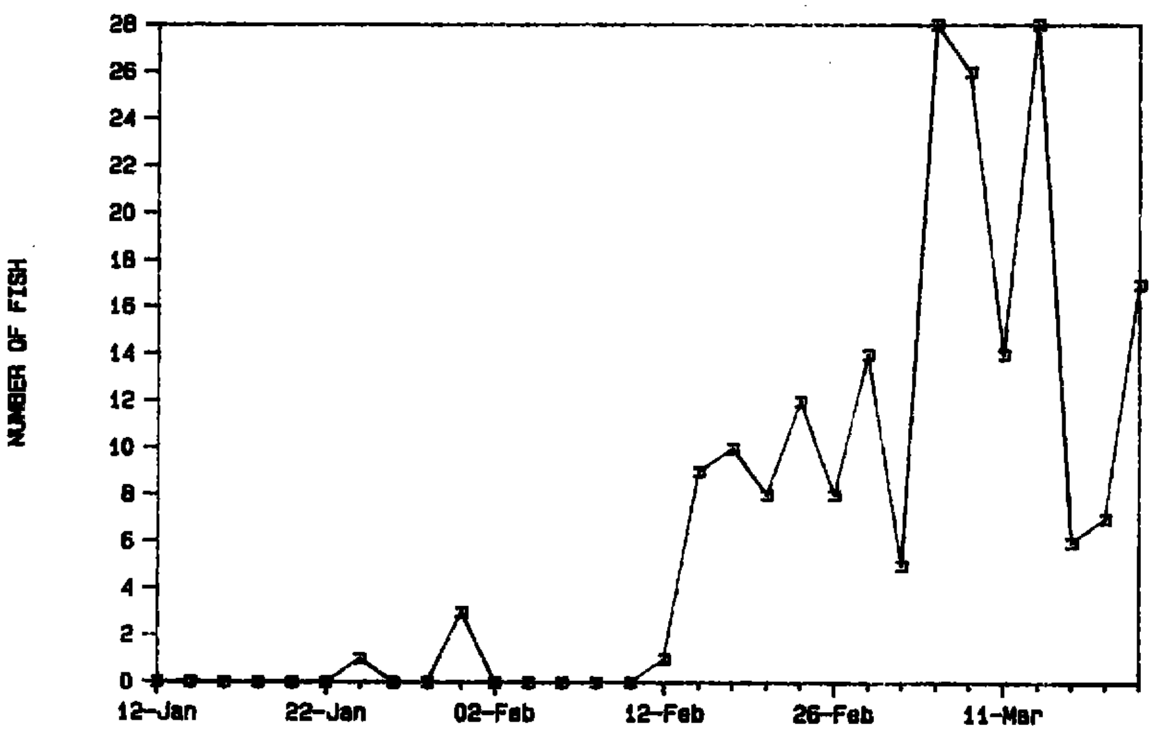

Figure 2. Number of chinook salmon fry emerging by date in the Moose side-channel redd enclosure.

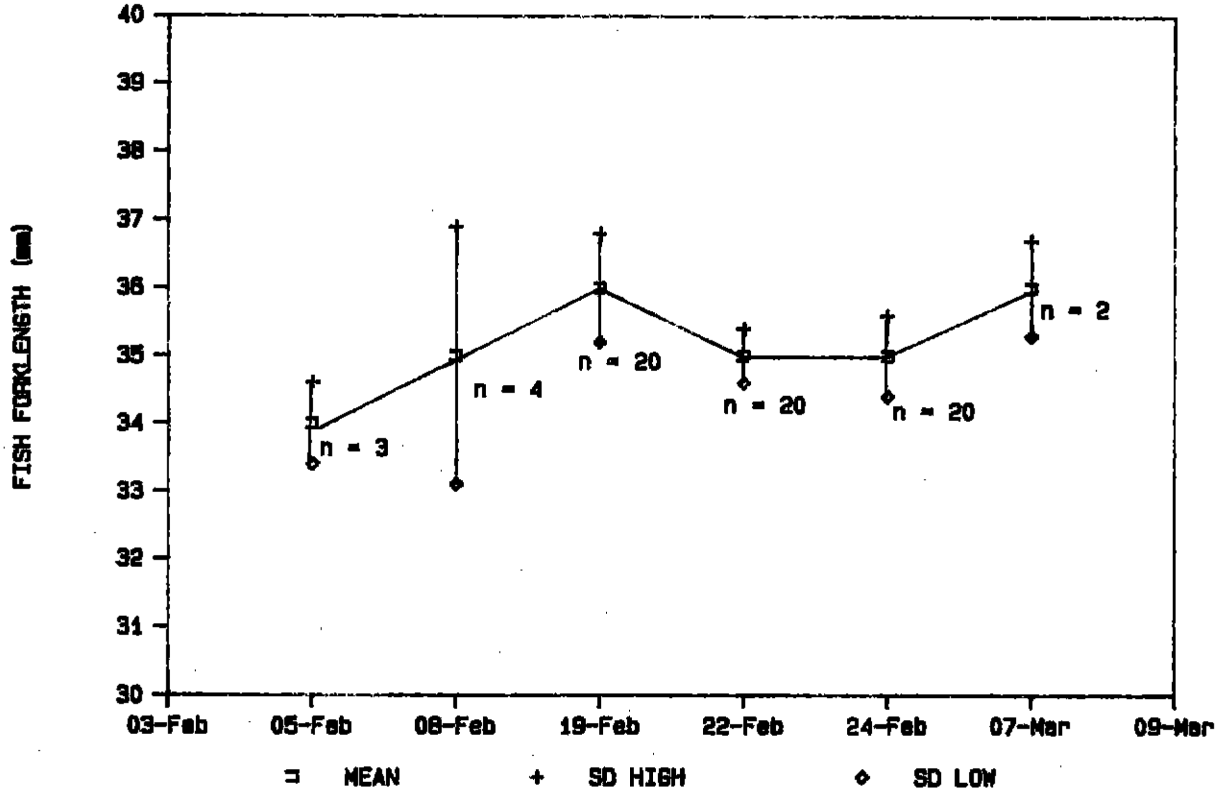

Figure 3. Mean forklength and standard deviation by date for emergent chinook salmon trapped in the Cemetery side-channel redd enclosures.

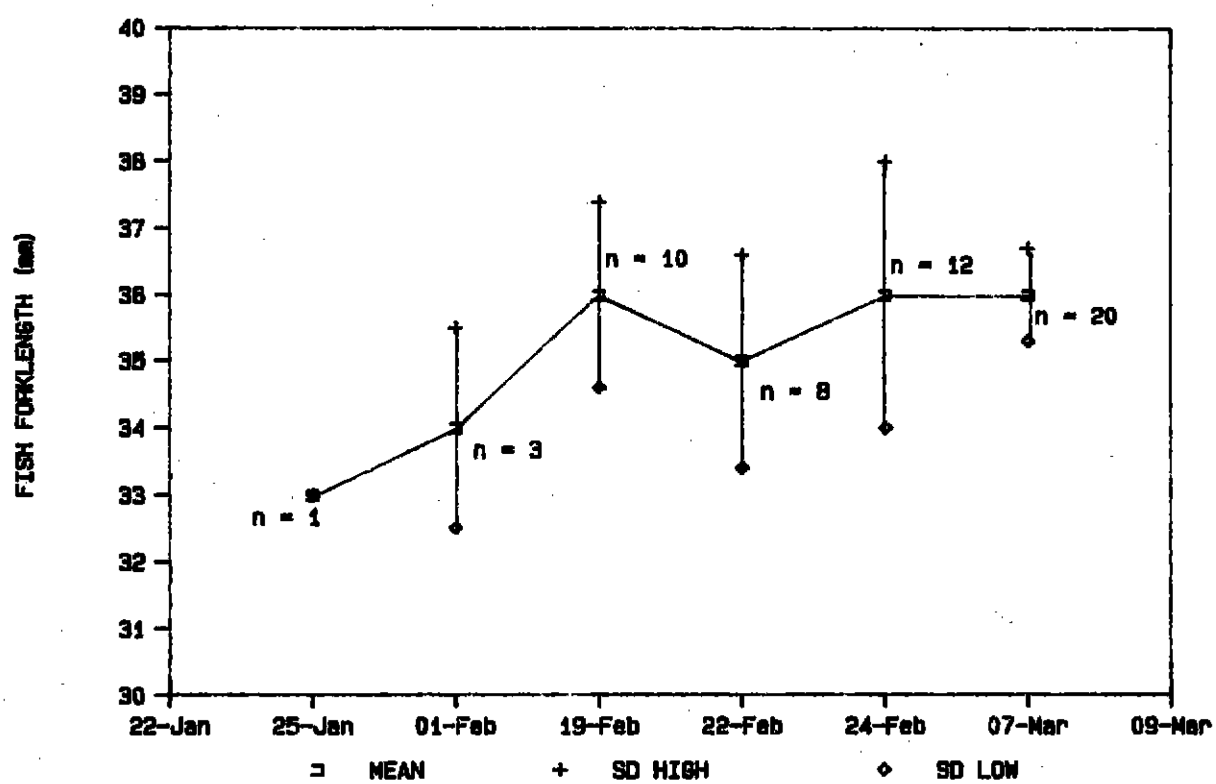

Figure 4. Mean forklength and standard deviation by date for emergent chinook salmon trapped in the Moose side-channel redd enclosure.

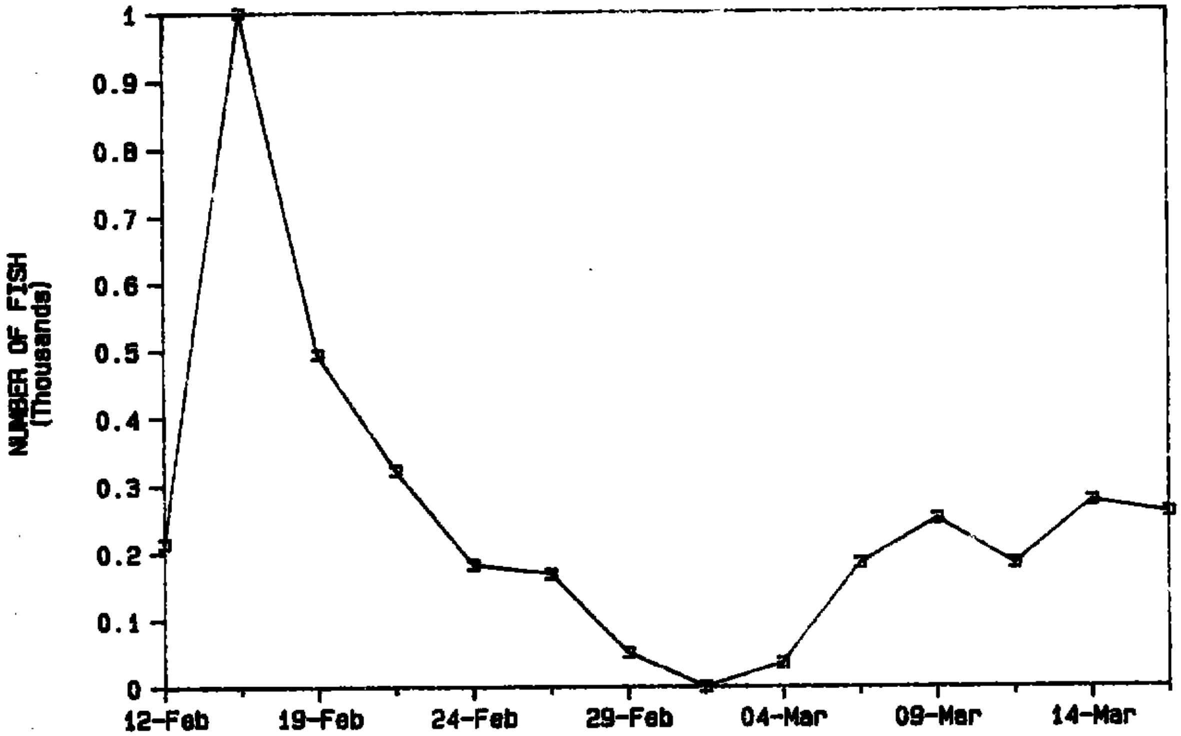

Figure 5. Number of chinook salmon fry caught by date in the Steelbridge downstream migrant trap.

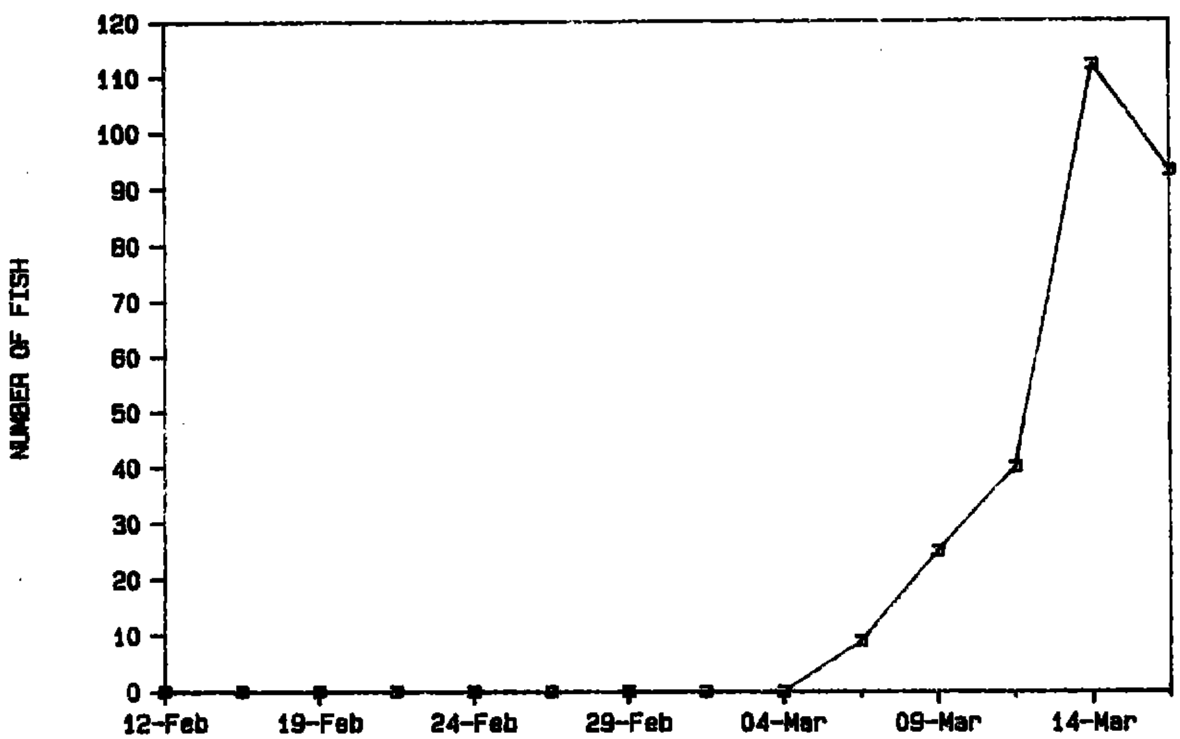

Figure 6. Number of coho salmon fry caught by date in the Steelbridge downstream migrant trap.

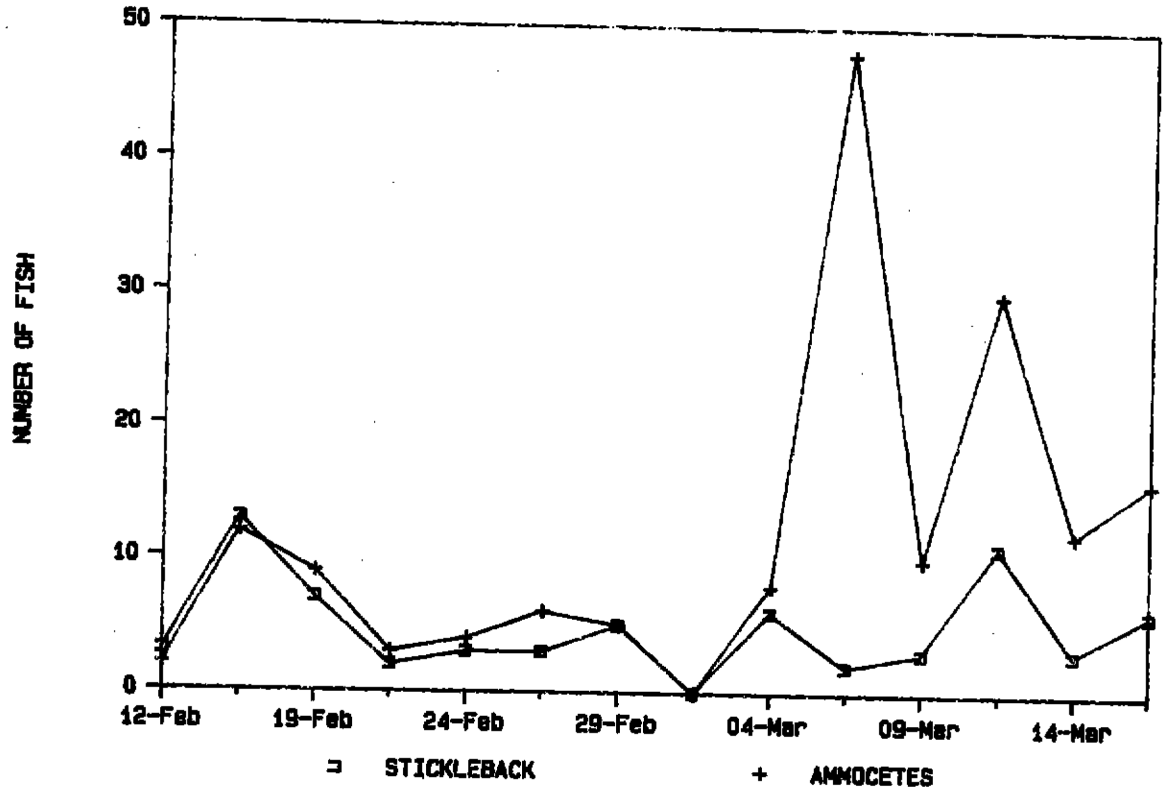

Figure 7. Number of stickleback and lamprey ammocetes caught by date in the Steelbridge downstream migrant trap.

4. SIDE-CHANNEL SALMONID POPULATIONS

Introduction

Off-channel habitats adjacent to the mainstem of larger rivers and streams have been recognized as important rearing areas for fry and juvenile anadromous salmonids (Mundie 1974; Bustard and Narver 1975; Hamilton and Buell 1976; Sedell et al. 1982; Hartman and Brown 1987). As a result, artificially constructed off-channel areas have gained favor as a means of increasing rearing habitats in anadromous salmonid habitat rehabilitation or enhancement projects (Mundie and Mounce 1978; Doyle 1984; Everest et al. 1985). In their report to the Bureau of Reclamation, VTN Environmental Sciences (1979) recommended the construction of side-channels as one means of increasing the rearing capacity of the Trinity River for fry and juvenile salmonids. In the early-1980's the California Department of Fish and Game constructed the Moose Lodge side-channel just upstream of the Old Bridge in Lewiston. Although, this side-channel was primarily developed to improve velocities for spawning at an adjacent artificial riffle, it also incorporated features, such as a cobble substrate, to provide salmonid rearing habitat (E. Miller, CDFG, pers. comm.). This past year the Trinity River Management Program funded the construction of three side-channels and the Bureau of Land Management constructed another.

Because of our interest in side-channels as rearing habitat we have previously investigated the relationship between mainstem Trinity River discharge and the discharge and surface area in several existing side-channels (FWS 1987). We have also supported studies by the California Cooperative Fish Research Unit at Humboldt State University on side-channel invertebrate and salmonid populations. In this years report we continue our study of side-channels by describing salmonid populations in selected side-channels beginning in winter and following through spring and early summer.

Methods

Six sites in three side-channels were chosen for sampling salmonid population densities. Three sites were located in the Moose Lodge side-channel at river mile 110. One site in the Salt Flat Bridge #2 side-channel at river mile 107, and two sites in the Indian Creek side-channel at river mile 96. Sample sites in the Moose Lodge channel were all 50 feet in length and were selected by simple random sampling of all possible sites within the channel excluding the smaller eastern fork in the upper channel. For the Indian Creek side-channel, two 100-foot sites were chosen based upon our ability to access and effectively sample the sites, as well as how representative they were of habitat in the side-channel. The single 50-foot site at Salt Flat Bridge was chosen following the same selection procedure as for Indian Creek. The Moose Lodge and Indian Creek sample sites were considered to be representative of habitats found throughout each of those side-channels and therefore populations estimated at each site were extrapolated for the entire side-channel. The sample site at Salt Flat Bridge was only considered to be representative of the upper half of that side-channel, a long continuous riffle. As such, population estimates were expanded to cover only this area. Detailed habitat descriptions of the side-channels are provided in section II.3 of this report and last year's annual report (FWS 1987).

Moose Lodge and Indian Creek side-channels were each sampled five times between mid-December 1987 and early July 1988. The sample site at Salt Flat Bridge #2 was added after the study began and was sampled four times between March and June of 1988. The sample period was chosen to concentrate on the use of side-channels by fry chinook salmon although all salmonid species were examined.

Salmonid populations were sampled at each site following an equal-effort catch-removal method (Youngs and Robson 1978). Each end of a sample site was blocked with either a 3/16 or 1/8 inch mesh net. Fish were stunned with a Smith-Root Model 11-A backpack electroshocker and captured with a dip net. We attempted to maintain a constant effort between successive passes at a site by using the same voltage and frequency settings throughout and fishing for approximately the same length of time on each pass. At the end of each sample pass captured fish were identified and counted.

Fork lengths were measured to the nearest millimeter and fish were identified as either young-of-the-year, meaning the 1988 year class, or yearling and older, meaning 1987 and earlier age classes, based on size. Obviously, any 1987 year class salmonids captured in December are not yet a year old, but this nomenclature was chosen so that as time progressed, the age classes were viewed distinctly, rather than lumping all age classes as juveniles as they exceeded the 50 mm fork length that usually serves as the break between the fry and juvenile life stages.

Number of sampling passes at each site varied between two and four depending on the number of fish captured in subsequent passes and the amount of time involved. Our general guideline was to sample until a subsequent pass captured no more than half of the number of fish captured in the preceding pass. However, low capture efficiencies sometimes made this guideline infeasible for smaller fish. Salmonid numbers at each sample site were estimated for each species using the Maximum Weighted Likelihood estimator of Carle and Strub (1978). Standard errors of the statistic and 95 percent confidence intervals were determined using the variance formulae of Zippin (1956). All estimator calculations were conducted with the aid of an unpublished interactive micro-computer program written by Conner (1987). Sample site estimates of population size and associated confidence intervals for the estimate were extrapolated for an entire side-channel, or representative section thereof, by using multistage procedures described by Hankin (1984). As noted above, sample sites at Moose Lodge and Indian Creek were considered representative of all habitats in each side-channel and fish numbers were extrapolated for the entire area of each side-channel. Estimated numbers for the Salt Flat Bridge side-channel were extrapolated only for the upstream riffle area of that side-channel.

Fish densities in each side-channel were calculated by dividing the estimated number of fish of each species by the wetted surface area of side-channel.

Results

All four species of salmonids known to occur in the Trinity River (chinook and coho salmon, and brown and steelhead trout) were found in the side-channels during at least some period of this study (Tables 1-4).

Since the fry of these species did not begin emerging until late winter or spring, only yearling and older salmonids, hereafter referred to as yearlings, were present in the Moose Lodge and Indian Creek side-channels during the initial sampling in December (Tables 1-4). December also proved to be the month when the highest number of yearling fish of all species were present in those side-channels. With the next sampling in March, numbers of yearling fish at Moose and Indian Creek declined (Tables 1-4). After March, yearling salmon of either species were rarely found, although yearling coho seemed to prefer the Moose channel, and by June, no yearling salmon were collected (Tables 1 and 2). Yearling trout, although they had declined from winter numbers, maintained fairly constant populations through the spring and early summer in all side-channels (Tables 3 and 4). Steelhead and coho yearlings were more numerous than browns and chinook at the Moose side-channel, but there was no clear difference between species at the other channels.

The March sampling found chinook young-of-the-year at their highest numbers of the study in all side-channels (Table 1). Coho young-of-the-year were found at the upriver Moose and Salt Flat channels, but not at Indian Creek (Table 2). Small numbers of brown trout young-of-the-year were also found at all side-channels during March (Table 4). By April, chinook young-of-the-year numbers in all side-channels were in a decline that would continue through June (Table 1). Coho young-of-the-year numbers peaked at Moose Lodge and Indian Creek during April and declined steadily thereafter. In

Table 1. Estimated Number of Young-Of-The-Year and Yearling Chinook Salmon Residing in Three Side-channels of the Trinity River During Five Sample Periods Between December 1987 and July 1988.

	Total Number Estimated Per Sample Period				
Side-channel	12/15-17/87	3/9-15/88	4/21-28/88	5/17-23/88	6/16-7/5/88
YOUNG-OF-THE-YEAR					
Moose Lodge	0	18882 (28248-9517)[a]	3312 (7700-209)	751 (1360-143)	130 (-c)
Salt Flat Bridge #2	-b	501 (559-443)	61 (79-44)	21 (30-12)	51 (62-40)
Indian Creek	0	5640 (5998-5290)	1995 (2236-1754)	2820 (4390-1249)	421 (547-295)
YEARLING					
Moose Lodge	190 (269-112)	20 (29-12)	0	0	0
Salt Flat Bridge #2	-b	2 (2-2)	0	8 (8-8)	0
Indian Creek	76 (90-62)	5 (5-5)	0	35 (35-35)	0

a 95 percent confidence interval about the population estimate
b site not sampled
c confidence could not be calculated

Table 2. Estimated Number of Young-Of-The-Year and Yearling Coho Salmon Residing in Three Side-channels of the Trinity River During Five Sample Periods Between December 1987 and July 1988.

Side-channel	Total Number Estimated Per Sample Period				
	12/15-17/87	3/9-15/88	4/21-28/88	5/17-23/88	6/16-7/5/88
YOUNG-OF-THE-YEAR					
Moose Lodge	0	1841 (2373-1309)[a]	10884 (12307-9461)	5770 (6359-5181)	3847 (4646-3048)
Salt Flat Bridge #2	-[b]	30 (37-22)	101 (116-87)	120 (139-102)	238 (254-221)
Indian Creek	0	0	796 (974-618)	571 (662-480)	360 (399-321)
YEARLING					
Moose Lodge	419 (743-94)	68 (130-10)	54 (69-39)	14 (42-2)	0
Salt Flat Bridge #2	-[b]	4 (13-2)	2 (2-2)	8 (8-8)	0
Indian Creek	20 (21-19)	5 (5-5)	0	5 (5-5)	0

a 95 percent confidence interval about the population estimate
b site not sampled

Table 3. Estimated Number of Young-Of-The-Year and Yearling and Older Steelhead/Rainbow Trout Residing in Three Side-channels of the Trinity River During Five Sample Periods Between December 1987 and July 1988.

	Total Number Estimated Per Sample Period				
Side-channel	12/15-17/87	3/9-15/88	4/21-28/88	5/17-23/88	6/16-7/5/88
YOUNG-OF-THE-YEAR					
Moose Lodge	0	0	1270 (1539-1000)[a]	1184 (1559-809)	996 (1245-746)
Salt Flat Bridge #2	-b	0	95 (143-47)	283 (502-64)	112 (162-63)
Indian Creek	0	0	149 (-c)	406 (536-275)	158 (176-140)
YEARLING AND OLDER					
Moose Lodge	2486 (5319-335)	982 (1745-219)	952 (2275-109)	304 (-c)	1553 (4707-200)
Salt Flat Bridge #2	-b	93 (102-84)	49 (65-32)	44 (63-25)	19 (19-19)
Indian Creek	98 (102-94)	11 (12-10)	17 (18-16)	11 (11-11)	31 (33-29)

a 95 percent confidence interval about the population estimate
b site not sampled
c confidence interval could not be calculated

Table 4. Estimated Number of Young-Of-The-Year and Yearling and Older Brown Trout Residing in Three Side-channels of the Trinity River During Five Sample Periods Between December 1987 and July 1988.

	Total Number Estimated Per Sample Period				
Side-channel	12/15-17/87	3/9-15/88	4/21-28/88	5/17-23/88	6/16-7/5/88
YOUNG-OF-THE-YEAR					
Moose Lodge	0	38 (62-13) [a]	97 (-c)	109 (135-83)	237 (-c)
Salt Flat Bridge #2	-b	30 (84-11)	101 (129-74)	30 (-c)	32 (-c)
Indian Creek	0	3 (3-3)	63 (-c)	52 (75-29)	95 (-c)
YEARLING AND OLDER					
Moose Lodge	264 (384-145)	190 (240-141)	257 (615-32)	101 (-c)	169 (369-24)
Salt Flat Bridge #2	-b	13 (16-9)	6 (7-6)	17 (-c)	6 (6-6)
Indian Creek	114 (120-108)	20 (27-13)	22 (24-20)	13 (15-11)	29 (-c)

a 95 percent confidence interval about the population estimate
b site not sampled
c confidence interval could not be calculated

contrast, the numbers of coho young-of-the-year at Salt Flat gradually increased until the final sampling. Steelhead young-of-the-year appeared for the first time during the April sampling in all side-channels, and their numbers stayed relatively constant through June. Numbers of brown trout young-of-the-year in the side-channels during April increased over March estimates and for the remainder of the study also stayed at relatively constant levels. Total numbers of salmon young-of-the-year were by far greatest at the Moose channel with Indian Creek at intermediate levels and Salt Flat much lower (Tables 1 and 2). Trout young-of-the-year numbers were also greatest at Moose Lodge but the difference for these species between Indian Creek and Salt Flat were negligible.

Examination of fish densities (Tables 5 and 6) revealed that the Moose Lodge generally supported the highest densities of salmon young-of-the-year and yearlings, while the Salt Flat Bridge channel had the highest densities of trout young-of-the-year and yearlings. As noted before, young-of-the-year salmonids were difficult to stun and capture because of their size, therefore, the population estimates and resulting densities should be viewed with caution in comparisons between sites. Fish densities also do not reflect the confidence intervals calculated with the population estimates for each species and site.

Size data collected during this study are analyzed and discussed in section III.5 of this report.

Discussion

Most naturally spawned chinook in the Trinity River migrate to the ocean within a few months of emergence, with a smaller number rearing over summer and leaving in the fall, or even the following spring (Moffett and Smith 1950; Healey 1973; FWS 1987). Coho salmon and steelhead trout in California streams commonly spend at least one year rearing in freshwater with some steelhead remaining longer (Shapovalov and Taft 1954).

The few chinook that rear in the upper Trinity river until the following spring have been presumed by others to be the progeny of spring-run salmon since a full year of stream residence is commonly reported for spring-run juveniles from populations at higher latitudes (Frederiksen, Kamine and Assoc. 1980). But, this longer residence time is considered uncommon for populations of California chinook salmon (Moyle 1976; Raleigh et al. 1986). Based on our observations of chinook in the mainstem during the summer and fall, we believe it is more likely that the larger chinook juveniles which migrate in the spring after spending the previous summer through winter in the upper river are either late-emerging progeny of naturally spawned fall-run adults or

Table 5. Estimated Densities (Number Per Square Meter) of Young-Of-The-Year Salmon and Trout Residing in Three Side-channels of the Trinity River During Five Sample Periods Between December 1987 and July 1988.

Species	Side-channel	12/15-17/87	3/9-15/88	4/21-28/88	5/17-23/88	6/16-7/5/88
chinook salmon	Moose Lodge	0.00	5.94	1.04	0.24	0.04
	Salt Flat Br.	-	2.82	0.30	0.10	0.29
	Indian Creek	0.00	2.86	1.01	1.43	0.21
coho salmon	Moose Lodge	0.00	0.58	3.42	1.81	1.21
	Salt Flat Br.	-	0.17	0.49	0.58	1.34
	Indian Creek	0.00	0.00	0.40	0.29	0.18
stlhed./ rainbow trout	Moose Lodge	0.00	0.00	0.40	0.37	0.31
	Salt Flat Br.	-	0.00	0.46	1.37	0.63
	Indian Creek	0.00	0.00	0.08	0.21	0.08
brown trout	Moose Lodge	0.00	0.01	0.03	0.03	0.07
	Salt Flat Br.	-	0.17	0.49	0.14	0.18
	Indian Creek	0.00	0.00	0.03	0.03	0.05

Table 6. Estimated Densities (Number Per Square Meter) of Yearling and Older Salmon and Trout Residing in Three Side-channels of the Trinity River During Five Sample Periods Between December 1987 and July 1988.

Species	Side-channel	12/15-17/87	3/9-15/88	4/21-28/88	5/17-23/88	6/16-7/5/88
chinook salmon	Moose Lodge	0.06	0.01	0.00	0.00	0.00
	Salt Flat Br.	–	0.01	0.00	0.04	0.00
	Indian Creek	0.04	0.00	0.00	0.02	0.00
coho salmon	Moose Lodge	0.13	0.02	0.02	0.00	0.00
	Salt Flat Br.	–	0.02	0.01	0.04	0.00
	Indian Creek	0.01	0.00	0.00	0.00	0.00
stlhed./ rainbow trout	Moose Lodge	0.78	0.31	0.30	0.10	0.49
	Salt Flat Br.	–	0.53	0.24	0.22	0.11
	Indian Creek	0.05	0.01	0.01	0.01	0.02
brown trout	Moose Lodge	0.08	0.06	0.08	0.03	0.05
	Salt Flat Br.	–	0.07	0.03	0.08	0.04
	Indian Creek	0.06	0.01	0.01	0.01	0.01

hatchery-spawned fall-run progeny which failed to leave after release in the previous year.

The higher numbers of yearling and older salmonids found in the side-channels during December is attributed to their importance as winter rearing habitat (see for example Edmundson et al. 1968; Bjornn 1971; Bustard and Narver 1975; and Hillman et al. 1987). Use and availability of winter habitats in the upper Trinity River is explored in greater detail in section II.3 of this report.

Population declines of yearling and older salmonids between December and March (Tables 1-4), presumably occurred because these fish left to continue rearing in the main river or to migrate downstream (Moffett and Smith 1950, Healey 1973). As might be expected this emigration eventually includes all members of the salmon populations but is not nearly so complete for the trout because of the extended residence time of steelhead juveniles, and brown trout in the Trinity River are supposedly not anadromous, although the occurrence of anadromous brown trout in the Trinity is a topic of continual speculation. Yearling pre-smolt steelhead and resident brown trout are also known to maintain generally permanent stations within a stream depending on whether the station meets the fish's metabolic and life stage needs (see Edmundson et al. 1968, Bachman 1984). Along with changes due to fish growth and emigration due to smoltification, changes in side-channel discharge also affect the availability and distribution of habitat in the side-channels (see section II.2), and no doubt also contribute to changes in side-channel densities.

Young-of-the-year chinook salmon were first captured in the Moose side-channel in late January of 1988 and by mid-February emergence was well underway (see section III.3). Aggregations of chinook young-of-the-year were first seen in the main channel in February, and densities at upriver sites peaked in March, dramatically so at the Cemetery site (section III.2). Comparison of the Cemetery main-channel and Moose side-channel sites found that side-channel populations of chinook young-of-the-year started out at generally similar or maybe even slightly higher densities than their main-channel counterparts in March, but by June the main-channel densities appeared greater (Table 7). This trend is likely the result of fish emigrating from the side-channels to the main river, and also seems to be reflected in the disparities of mean fish length between the side- and main-channels as larger juveniles leave the former for the latter.

Coho salmon young-of-the-year were first sighted in the mainstem (section III.2) and side-channels in March and they appeared to reach and maintain much higher densities in the side-channels than the corresponding main-channel sites until June (Table 7). Densities of coho young-of-the-year at the downstream Indian Creek side-channel and Steelbridge main-

Table 7. Comparison of Chinook and Coho Young-of-the-Year Densities Between Side-channel and Main-Channel Trinity River Sample Sites, March Through June, 1988.

Sample Site	March	April	May	June
CHINOOK				
Moose Lodge SC[a]	17.16	3.01	0.68	0.12
Cemetery MC[b]	15.84	4.78	0.84	1.07
Indian Creek SC	7.05	2.49	3.52	0.53
Steelbridge MC	4.23	2.01	0.69	3.02
COHO				
Moose Lodge SC	1.67	9.89	5.24	3.50
Cemetery MC	0.13	3.47	1.89	2.09
Indian Creek SC	0	1.00	0.71	0.45
Steelbridge MC	0.02	0.31	0.19	0.58

[a] SC = side-channel site; densities in number of fish per lineal foot of side-channel.

[b] MC = main-channel; densities in number of fish per lineal foot of main-channel edge

channel sites showed lower overall densities, as well as a delay in peak densities, from March to April, versus the upper river sites. Spawning surveys (section III.1) and limited observations in the tributaries this past year (unpublished data), found that coho spawning was concentrated in tributaries and upriver of Rush Creek, at river mile 107.5, in the mainstem. As such, differences in total density and the delay in peak density at Steelbridge and Indian Creek apparently resulted from adult coho spawning distribution. In addition, cooler water temperatures in the upper river during the summer also likely induce coho to remain upriver. Reductions in side-channel coho populations as the spring progresses are likely due to the emigration of individuals as a result of population pressures as fish grow and food and space demands increase (Chapman 1962; Hartman 1965).

Growth study results showed that both chinook and coho young-of-the-year generally also grew at the same rate in the side-channels as the main river during March and April (section III.5). We attributed the greater deviation in size between young-of-the-year salmon between the two habitats beginning in May to the emigration of larger, earlier emerging fish from the side-channels (section III.5).

In comparison to the salmon, small spawning populations generally resulted in much lower densities of young-of-the-year steelhead and brown trout in the side-channels (Table 6). Based on our unpublished observations, brown trout populations are concentrated in the upper river, and as was the case for coho salmon, the distribution of brown trout spawning was likely the reason why brown trout young-of-the-year appeared a month earlier in the upriver side-channels. The higher densities of young-of-the-year brown trout at the Salt Flat side-channel throughout the period of study is presumably related to habitat preference factors (Table 5). Steelhead young-of-the-year also displayed greater densities in the Salt Flat side-channel (Table 5). As noted for coho salmon, changes in the numbers of steelhead and brown trout after emergence was well underway were presumably population responses to density as fish died, migrated, and grew, and feeding hierarchies were established (McFadden 1969, Allen 1969), and habitat availability changed with changes in discharge and temperature.

To what extent fish released from Trinity Hatchery or other artificial rearing facilities may contribute to the populations found in the side-channels is unclear. Examination of release dates, locations, species, and size at release suggests that artificially reared yearling chinook and coho salmon did not contribute to side-channel populations (Appendix B). However, chinook fry released from the hatchery or escaping from the off-site rearing ponds (see FWS 1987), and steelhead released at fork lengths less than about six inches (150 mm) (Taylor 1977), likely did occur in the side-channels to some unknown degree. We have captured yearling and older steelhead with what appeared to be signs of fin erosion, as well as fin clips, during the course of our studies in the side-channels.

The results of this limited study suggest that under the existing conditions side-channels will support densities of chinook and coho fry equal to or greater than the main-channel at a much greater efficiency since the side-channels require far less water to do so. Therefore, side-channels are an effective means of supplementing main-channel rearing habitats. Further, they provide winter rearing habitat, which is deficient in the main river, and is of great importance to salmonids with prolonged freshwater life stages such as coho salmon and steelhead trout (section II.3).

5. JUVENILE SALMONID GROWTH

Introduction

In 1988, growth sampling of juvenile salmonids was continued throughout the Trinity River. Information on the growth of juvenile salmonids provides further knowledge of population health, habitat conditions, and life history patterns, all of which contribute importantly to the findings of the Flow Evaluation. Growth sampling of juvenile salmonids began in January of 1986 and is expected to continue into the future years of the study.

Study sites

We continued to use the same nine study sites that were sampled in 1987, A description of which is given in our 1987 Annual Report (U.S. Fish & Wildlife Service, 1987). In 1988 we also sampled three side-channel habitats in order to compare growth in these areas with main river habitat areas. Sampling was done in coordination with the side-channel and winter habitat requirement study. The Moose Lodge, Salt Flat, and Indian Creek side-channels were sampled during December 1987 and March and April 1988. These three study areas are described in sections II.2 and II.4 of this report.

Methods

At each study site fish were collected with a Smith - Root DC backpack electroshocker. Sampling was always conducted in an upstream direction in riffle or run microhabitats within each study site. One person operated the electroshocker, while a second person followed behind to capture shocked fish with a dip net. Once captured, fish were anesthetized with MS-222 (Tricaine Methanesulfonate), measured for fork length (mm), and weighed (grams). No data was collected on clipped fish or any other fish believed to be of hatchery origin. Approximately five fish of each species and age class were sacrificed for stomach analysis on a seasonal basis. Fish stomachs were only taken at Cemetery, Bucktail, Steelbridge, Steiner Flat , Del Loma , and Tish Tang. All other fish were returned to the river unharmed. The results of the stomach analysis will be presented in a future report.

Data Analysis

Age class determinations for juvenile steelhead were made from length frequency histogram analysis. Instantaneous growth rates in length (Bagenal, 1978) were calculated for steelhead on a seasonal basis for each age class as follows:

$$G = \frac{\log_e \bar{L}_2 - \log_e \bar{L}_1}{\Delta T}$$

where: G = Instantaneous rate of length increase

$\bar{L}_1$ = Initial mean fork length for year class

$\bar{L}_2$ = Final mean fork length for year class

ΔT = The change in time in years

Results

Since growth sampling began in January of 1986 a total of 10,646 juvenile trout and salmon have been collected through July of 1988. A breakdown of the total numbers of each species collected is presented in Table 1.

Table 1. Total number of juveniles, by species and sample year, captured in growth sampling efforts from January 1986 to July 1988, Trinity River, California.

	Sample Year		
Species	1986	1987	1988
Chinook Salmon	892	1201	1328
Coho Salmon	320	111	407
Steelhead Trout	1293	2030	1717
Brown Trout	443	515	389
Total	2948	3857	3841

In the fall of 1987 the Trinity River again hosted a large run of adult chinook salmon. Approximately 89,000 adult chinook salmon were estimated to have spawned naturally within the Basin. The vast majority of these adult spawners could not ascend upper river tributary streams because of low flows and were forced to spawn in the mainstem. The low water year also increased the spawner distribution to many lower river habitats that had not been used by spawning salmon in recent years. The increase in distribution was caused by barriers that became more difficult to pass due to reduced flow. Examples include Burnt Ranch Falls, Gray's Falls, and Hell Hole, to name a few.

The 1988 year class of chinook salmon emerged from the gravels in January and exhibited growth rates comparable to the 1986 year class (Figure 1). Growth of juvenile chinook salmon in 1988 improved greatly over the rather slow growth that was apparent for the 1987 year class. Average fork lengths of juvenile chinook salmon sampled in the side-channels during March, April, and May are compared with average fork lengths of juvenile chinook salmon sampled in the mainstem in Figure 2.

Coho salmon fry began emerging from the gravels in March, two months later than the chinook salmon fry. Coho salmon juveniles were captured as far downstream as Del Loma, however, the majority of juvenile coho were still found in the upper river above Douglas City. The average fork lengths of juvenile coho salmon captured at Steelbridge, Bucktail, and Cemetery in 1988 are presented in Figure 3. Growth of juvenile coho salmon through July of 1988 is compared to the growth of the 1986 and 1987 year classes in Figure 4. Growth in the side-channels is compared with growth in the main river in Figure 5.

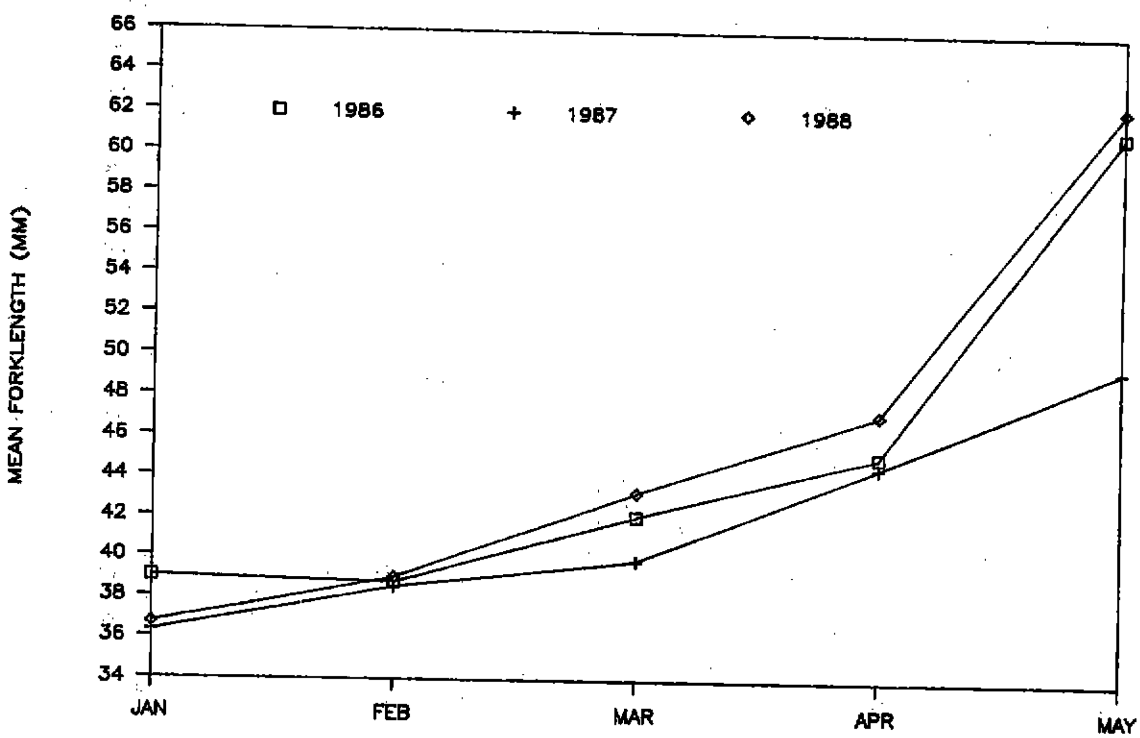

Figure 1. Comparison of mean fork lengths of juvenile chinook salmon, between 1986, 1987, and 1988 in the Trinity River, California.

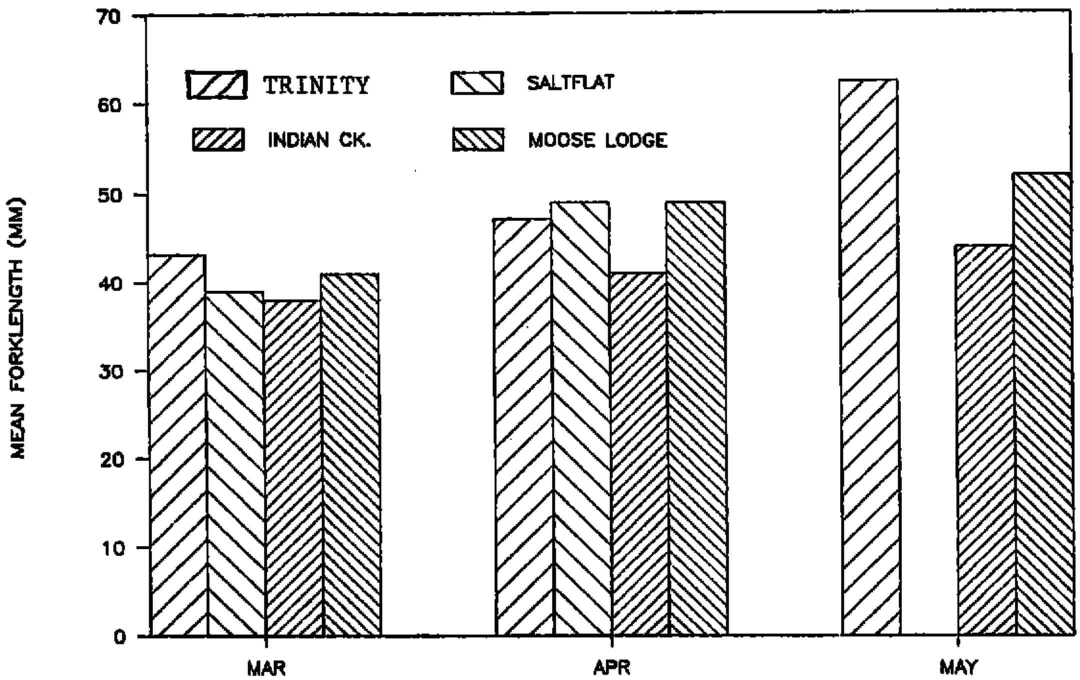

Figure 2. Mean fork lengths of juvenile chinook salmon sampled in Trinity River and three side-channel habitats during the spring of 1988, Trinity River, CA.

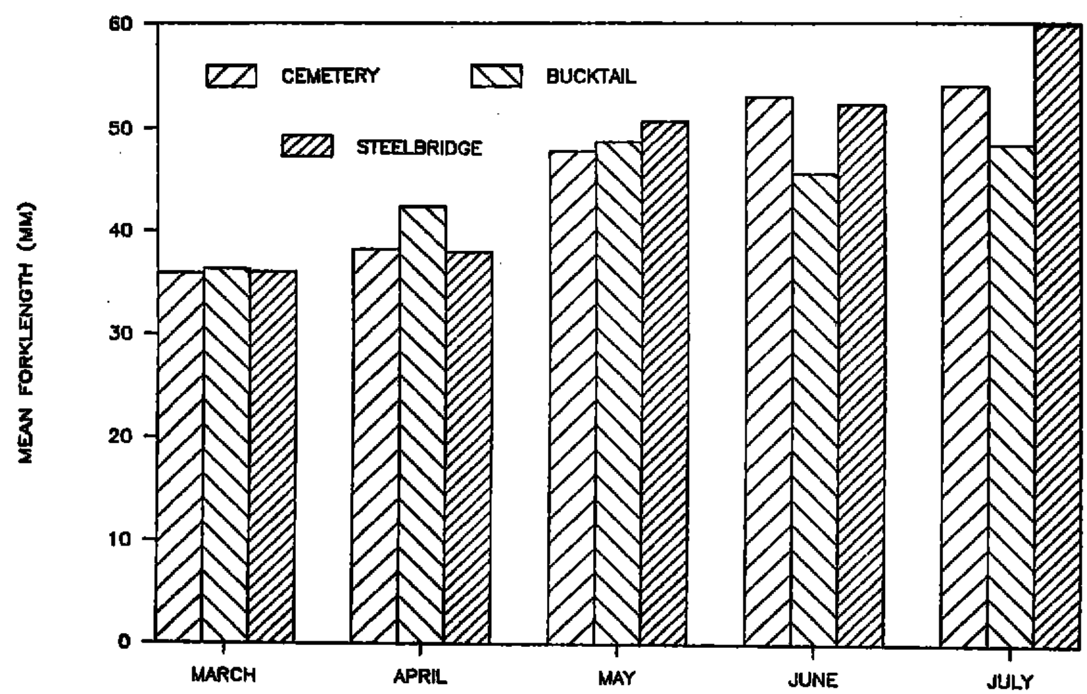

Figure 3. Mean fork lengths of juvenile coho salmon captured at Steelbridge, Bucktail, and Cemetery study sites during the spring of 1988, Trinity River, CA.

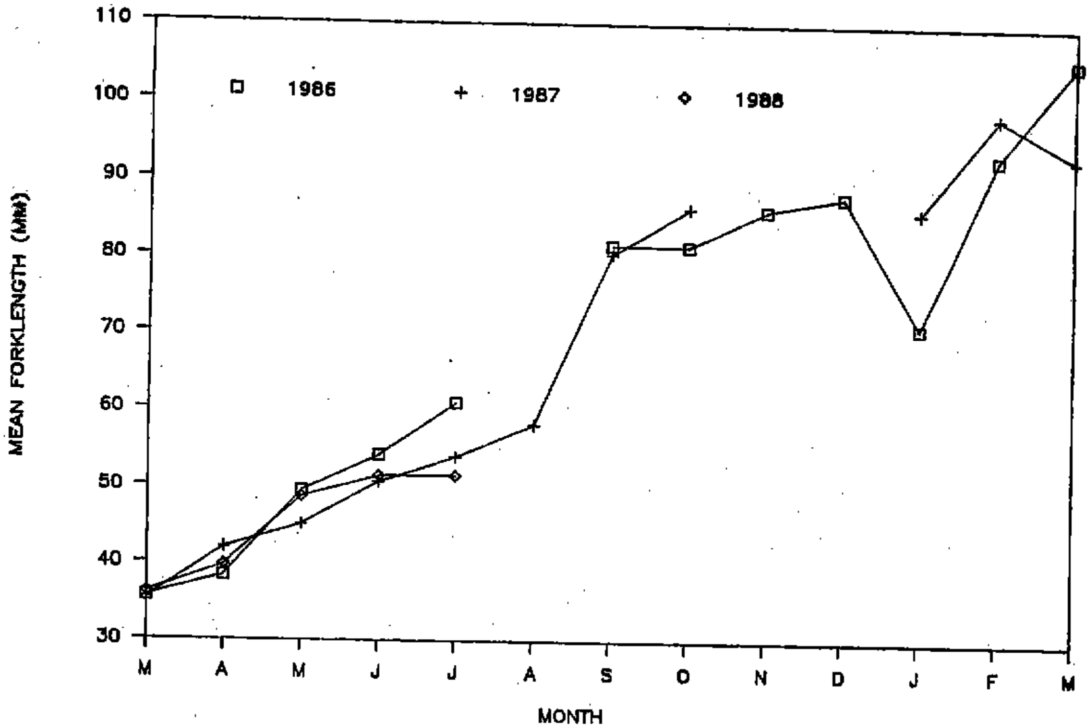

Figure 4. Growth comparison between the 1986, 1987, and 1988 year classes of coho salmon in the upper Trinity River, CA.

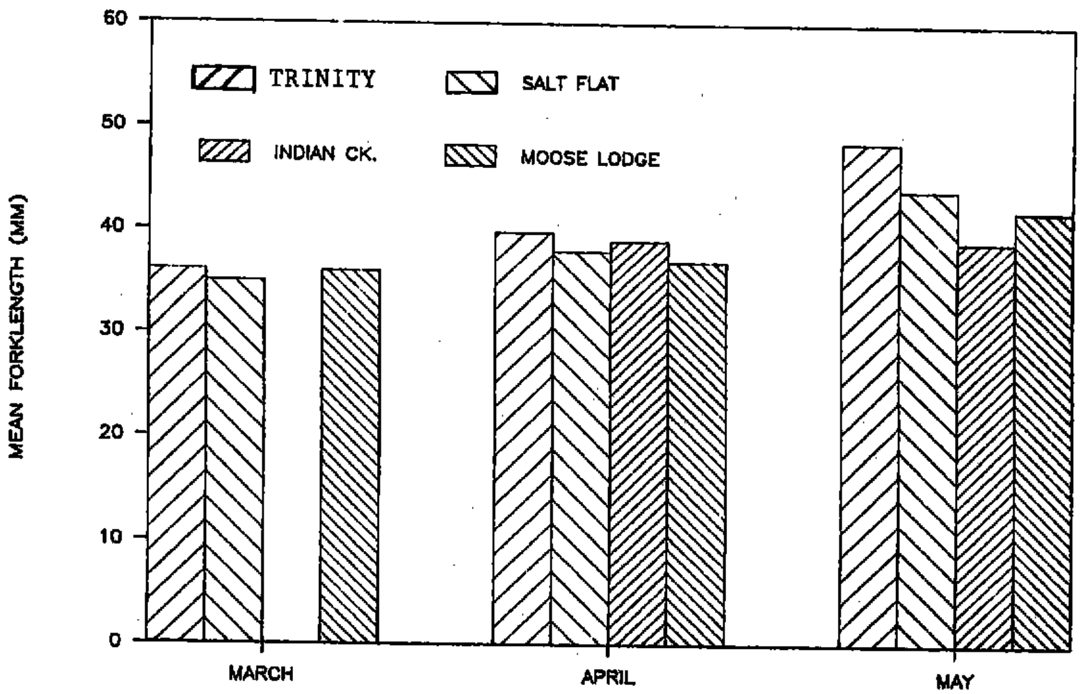

Figure 5. Mean fork lengths of juvenile coho salmon sampled in Trinity River and three side-channel habitats during the spring of 1988, Trinity River, CA.

Juvenile steelhead trout are found throughout the entire river. Fry steelhead trout first appeared in April at all study sites. Growth of juvenile steelhead was analyzed on a seasonal basis which included the months of April, July, October, and January. Figure 6 presents mean fork lengths over time for the last four year classes.

Instantaneous growth rates for the same four year classes are presented in Figure 7. Analysis of steelhead trout fork lengths sampled in three side-channels during December and April yielded no significant differences when compared with average fork lengths of steelhead trout sampled in the main river study sites.

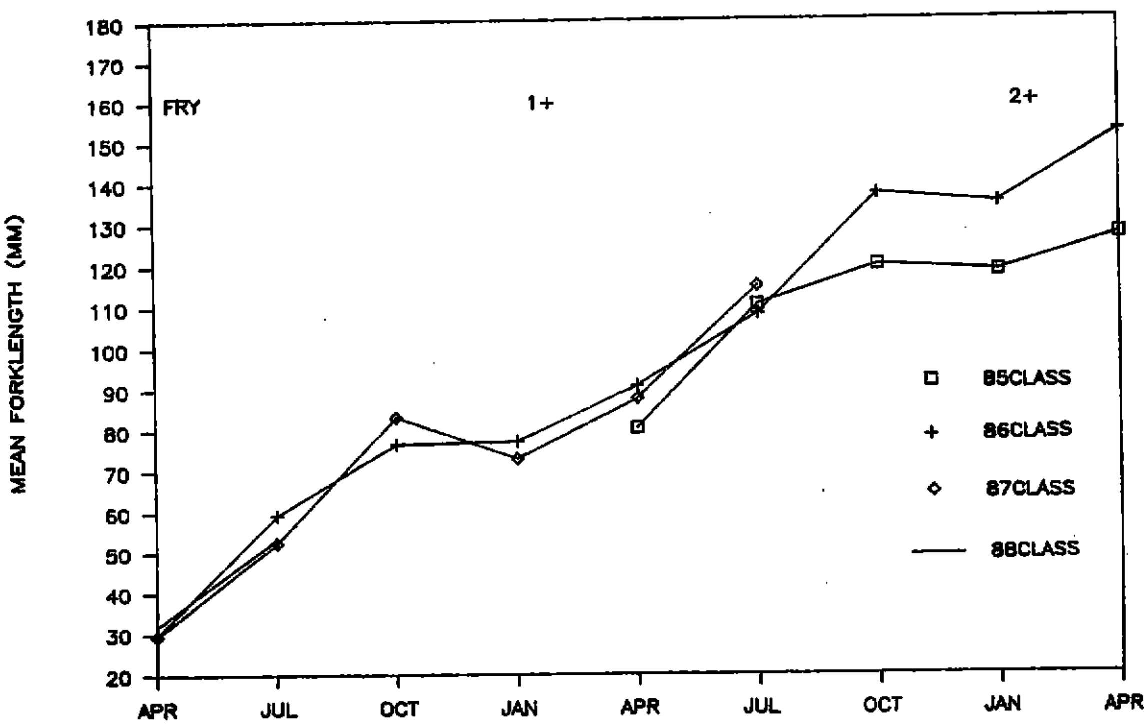

Figure 6. Growth comparison between the 1985, 1986, 1987, and 1988 year classes of juvenile steelhead trout captured throughout the Trinity River, CA.

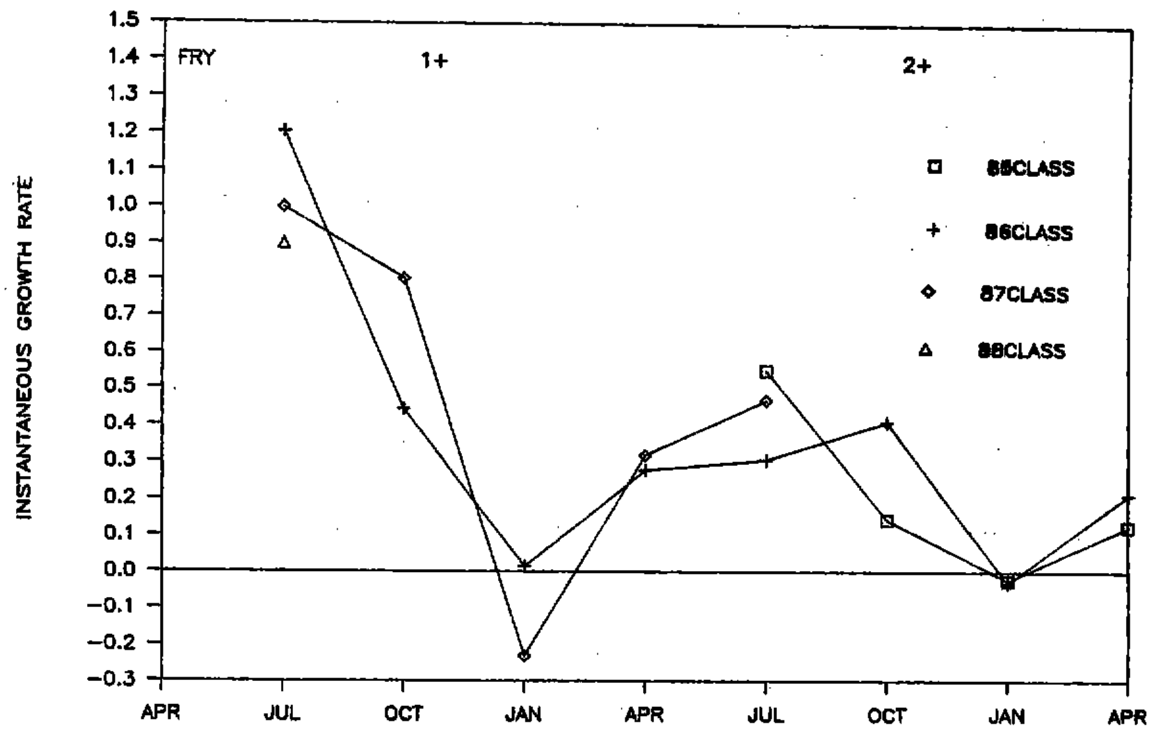

Figure 7. Seasonal instantaneous growth rates for the 1985, 1986, 1987, and 1988 year classes of juvenile steelhead trout in the Trinity River, CA.

Discussion

Chinook salmon. In 1988 fry and juvenile chinook salmon grew at rates equivalent to the 1986 year class. Fork lengths of the 1987 year class of juvenile chinook salmon were found to be significantly less than either the fork lengths of the 1986 or 1988 year classes in May and June. Population densities of the 1987 and 1988 year classes were much greater than the 1986 year class. The 1988 year class was comparable to the 1987 year class, and when combined with the large number of fry and juvenile coho salmon that were present in 1988, far more fry salmon were using the available habitat in 1988 than in 1987. The slow growth observed in 1987 for chinook salmon was attributed to two possible factors: 1) temperature differences that might have occurred between 1986 and 1987, and 2) the possibility that carrying capacity for fry and juvenile salmon might have been exceeded. There did not appear to be any substantial differences in water temperature between the 1986 and 1987 year classes.

Temperatures in the river at Lewiston during the spring rearing seasons of 1986 and 1987 were generally between 48 to 50 degrees Fahrenheit. This fact further emphasized carrying capacity as a factor for slower growth rates for the 1987 year class. In 1988, however, the water temperatures observed at Lewiston ranged from a low of 47 degrees in March to a high of 54 degrees in May. As biologists are aware, carrying capacities in natural systems fluctuate with changing physical characteristics. It would seem logical that the increased temperatures observed in the spring of 1988 acted to increase rearing capacity for juvenile chinook salmon in the Trinity River. There are other other possibilities (food supply, predation, and survival) not studied that may also have contributed to the growth differences observed over the past three years.

The side-channel data indicate that these areas provide important habitats for fry rearing. The fact that larger chinook salmon juveniles were found in the main river in May rather than in side-channels indicate that as chinook salmon grow larger they tend to utilize faster and deeper water than is available in the side-channels. Larger chinook juveniles are also leaving these side-channel habitats during May and June in order to begin their migration downstream.

Coho salmon. A strong run of adult coho salmon spawned in the Trinity River during the late fall and winter of 1987, yielding a large number of juveniles during the spring of 1988. Since coho salmon spawn later than chinook salmon, many of the tributary streams had higher flows, and as a result coho salmon managed to spawn in many of the upper river tributaries that had not been accessible to chinook salmon. Coho salmon fry emerge from the gravels beginning in March and apparently rear for one year before migrating. From our experience on the river we have never observed any large numbers of juvenile coho salmon surviving the winter season within the river. Capture rates during the fall and winter months have always been very low compared to earlier in the year. When juvenile coho are captured late in the year we also have difficulty differentiating between wild and hatchery strains. Juvenile coho salmon that do survive the winter season migrate downstream the following spring around March.

Growth of juvenile coho salmon in 1988 was similar to the growth observed for the 1986 and 1987 year classes through the end of May, however, in June and July the 1988 year class appears to be slowing in comparison. Water temperatures in the upper Trinity River dropped from 56 to below 50 degrees F at the end of June. This may be one factor for the apparent slow down in growth observed in July of 1988. Conclusions as to the final growth of juvenile coho cannot be drawn at this time without fall and winter samples.

In the side-channels the same trend that was observed for chinook salmon was observed for coho. Larger juvenile coho salmon were captured in the main river than in the side-channels when sampled in May. During earlier months the growth rates between the two habitats were nearly equal. It appears that either the growth rates of coho in the main river and side-channels is different or that larger coho left the side-channels as their habitat selection shifted.

Steelhead trout. The number of adult steelhead that spawned in the winter of 1988 was about equal to the 1987 spawning run. Steelhead trout fry began emerging in April throughout the river. When the last four year classes, 1985, 1986, 1987, and 1988, are compared no significant differences in growth are noticeable (95% Confidence Intervals) Growth of juvenile steelhead follows a seasonal pattern with rapid growth in the spring and summer, slower growth in the fall, and practically no growth in the winter months. The 1987 year class actually exhibits negative instantaneous growth for the winter months. Obviously, the average fork length for the sample of steelhead collected during January was less causing a negative instantaneous growth rate. This could have resulted if larger individuals within the year class chose to migrated downstream, or to overwinter in habitats outside of the study sites.

6. INVERTEBRATE STUDIES

Introduction

In April, July, and October of 1986 and in January 1987 we collected bottom samples of aquatic invertebrates at five riffles between Lewiston and Del Loma with the intent of determining diversity, standing biomass, and possibly production of fish foods.

Methods and Sites

We took five 1.07 square-foot bottom samples at each site each season, and sorted and keyed invertebrates to the lowest practicable taxonomic level. Invertebrate biomass was determined by measuring the width and length of each animal and calculating the volume of a cylinder based on these measurements. A detailed description of these methods may be found in our 1987 annual report.

Cemetery Site The Cemetery sampling riffle is just above Cemetery Hole, at about river mile 109, three miles below Lewiston Dam and the Trinity River Fish Hatchery. The dominant rock size on the riffle ranges from three to nine inches in diameter, and gravel and cobble is embedded from 10 to 30 percent in sand. Hoadley Gulch, about a half-mile upstream, is a source of decomposed granite, but the riffle is relatively clean because of swift water velocities. Currents sampled ranged from about 0.5 to 4 feet per second mean column velocity, and depths from 0.5 to 1.5 feet.

The Cemetery site is distinctive because it is the first site below Lewiston Dam, so invertebrate colonization by downstream drift is limited. The lakes above the dams also affect the kinds of foods available for invertebrates, by discharging fine particulate organic matter such as phytoplankton, and at times microscopic zooplankton, to the river. The Trinity River Fish Hatchery, just below the dam, is a source of organic nutrients, including fine particulate organic matter which is a food source for filter-feeding invertebrates.

The river is lined with willows and alders from near Lewiston Dam, and decomposing leaves and other terrestrial organic debris are present in the Cemetery reach. There is generally a heavy growth of rooted aquatic plants and periphyton, which tends to increase through the summer and die back in winter, and rocks are usually covered with a slippery coating of algae.

Bucktail Site The Bucktail site is the riffle above the Brown's Mountain Road bridge. Dominant substrate is generally six to nine-inch rock, 20 percent embedded in fine material. Bucktail is above Grass Valley Creek, the greatest source of decomposed granite, and is relatively clean. Sample area velocities range from 0.8 to 4.6 feet per second, and depths range from 0.5 to 1.5 feet.

There is less algal growth in the Bucktail area than at the cemetery site, and rooted aquatic plants are restricted to a few backwaters.

Steelbridge Site The Steelbridge sampling area is the right riffle below an island at the lower end of the BLM campground. The dominant substrate is generally six to twelve-inch cobbles, embedded from 30 to 50 percent in decomposed granite sand. Grass Valley Creek is five miles above the site. Sample velocities range from 1.0 to 3.2 feet per second, and depths from 0.8 to 1.9 feet.

The site was chosen to represent the sandy conditions below Grass Valley Creek, and the rocks here are embedded in fines to a higher degree than in any of the other sites.

Steiner Flat Site The Steiner Flat sampling area is the riffle below the BLM campground on Steiner Flat Road, accessible from the area of dredger tailings at river mile 92, about 20 miles below Lewiston Dam. Dominant substrate is six to nine-inch rock embedded from 10 to 30 percent in fines, mostly decomposed granite. Sample velocities ranged from about 0.2 to 3.8 feet per second, and depths from 0.5 to 1.5 feet.

Although the reach is affected by sedimentation, there is generally less sand present than at the Steelbridge site, and it may be considered a zone of limited recovery from the highly sedimented conditions upstream.

Del Loma Site The Del Loma sampling riffle is at river mile 56, in a reach where hydrologic effects of the Trinity River dams are often overshadowed by uncontrolled runoff from the North Fork and other upstream tributaries. The dominant substrate is six to twelve-inch rock, embedded 20 to 30 percent in fines. Sample velocities ranged from about 1.0 to 3.0 feet per second, and depths from 0.7 to 1.5 feet.

The river from the North Fork to Del Loma, approximately 18 miles, is sparsely vegetated along its banks compared to the reaches above the North Fork, and there is a corresponding reduction in coarse organic matter such as leaves and woody debris. Sampling this reach in the summer, we notice a seasonal increase in turbidity, possibly indicating an increase in in-river production of floating algae, although some turbidity is caused by gold dredges operating below the North Fork. Because the site is below major undammed tributaries, its hydrology is changeable, and its invertebrate populations will be more exposed to catastrophic drift than at any of the upper sites.

Analytical Approach

Stream invertebrates in general have a clumped or contagious spatial distribution (Elliot, 1971), and ours were no exception. Figure 1 shows the relationship between sampling variance and mean sample biomass for the 20 sets of five samples we collected. Sample variance increases with mean biomass, indicating a negative binomial or other skewed distribution.

Parametric statistics require the assumption of a normal distribution, which can be approximated in a contagious distribution by transforming counts with an appropriate mathematical formula. To calculate standard error and to compare sample means we used the transformation defined by a power equation describing the best fit between logarithms of means and of variances, as shown in Figure 1 (Ibid.). Other statistical operations we used in examining the data were non-parametric tests, which are generally suitable for small samples of non-normal distributions.

We identified approximately 200 separate kinds of insects in our samples, many of them present in very small numbers. To order analysis, we selected six taxonomic groupings for emphasis, based on their high incidence in salmonid diets as found in our fish feeding studies (USFWS, 1987.) These groups were the Chironomidae or midges; the Simuliidae or black flies; two kinds of mayflies, Baetis and Ephemerella; the hydropsychid caddis flies; and the perlodid stoneflies. These six groups were the most consistently-used fish-foods during the period of invertebrate sampling. On the average, they made up 53 percent of the sample biomass (Table I).

Table 1. Biomass in Average Milligrams/Sample, Biomass of Major Fish-food Groups, and Percent Fish-food in Invertebrate Samples at Five Trinity River Sites, 1986-1987.

	April	July	October	January
Cemetery				
Sample biomass	121	698	1188	649
Fishfood biomass	52	448	605	183
Percent	43%	64%	51%	28%
Bucktail				
Sample biomass	455	173	1037	572
Fishfood biomass	157	57	448	291
Percent	34%	33%	43%	51%
Steelbridge				

Sample biomass	84	110	547	321
Fishfood biomass	27	21	177	136
Percent	32%	19%	32%	42%
Steiner Flat				
Sample biomass	117	299	860	1378
Fishfood biomass	38	70	315	873
Percent	33%	23%	37%	63%
Del Loma				
Sample biomass	41	100	289	675
Fishfood biomass	11	52	43	257
Percent	28%	52%	15%	38%

Results

Total Biomass Average sample biomass, with range of biomass among the five samples and standard error calculated on transformed counts is shown for each of the five sites in Figures 2 through 6. Figure 7 shows the mean sample biomass at all the sample sites.

To test the significance of differences in mean biomass, we ran completely randomized analyses of variance (ANOVA1, Northwest Analytical Statpak) on differences between transformed seasonal biomass means at each sample site (Table 2), and on differences between transformed sample site means for each of four seasons (Table 3).

To determine which of the site or seasonal differences contributed to the significance of the ANOVA, we ran Newman-Keuls multiple-range comparison tests on each of the sets of ANOVA data. The results are also included in Tables 2 and 3, which show all differences between means which are significant above the 95 percent confidence level (reported significance = 0.05). Difference between any means not shown in the Newman-Keuls listings are not statistically significant.

Table 2. Significant Differences Between Seasonal Invertebrate Biomass Means at Five Trinity River Sample Sites, April 1986 to January 1987.

CEMETERY   ANOVA significance level = 0.0000

Newman-Keuls Range Test:	significance
April-January	0.01
April-July	0.01
April-October	0.01

	July-October	0.05
BUCKTAIL	ANOVA significance level =	0.0038
	Newman-Keuls Range Test:	significance
	July-October	0.01
	April-October	0.05
STEELBRIDGE	ANOVA significance level =	0.0000
	Newman-Keuls Range Test:	significance
	April-January	0.01
	April-October	0.01
	July-January	0.01
	July-October	0.01
STEINER FLAT	ANOVA significance level =	0.0018
	Newman-Keuls Range Test:	significance
	April-October	0.01
	April-January	0.01
	July-October	0.05
DEL LOMA	ANOVA significance level =	0.0000
	Newman-Keuls Range Test:	significance
	April-July	0.05
	April-October	0.01
	April-January	0.01
	July-October	0.05
	July-January	0.01

Table 3. Significant Differences Between Invertebrate Biomass Means at Five Trinity River Sample Sites for Four Seasons, April 1986 to January 1987.

APRIL	ANOVA significance level =	0.0043
	Newman-Keuls Range Test:	significance
	Del Loma-Bucktail	0.01
	Steelbridge-Bucktail	0.05
	Steiner Flat-Bucktail	0.05
	Cemetery-Bucktail	0.05
JULY	ANOVA significance level =	0.0002
	Newman-Keuls Range Test:	significance
	Del Loma-Cemetery	0.01
	Steelbridge-Cemetery	0.01
	Bucktail-Cemetery	0.01
	Steiner Flat-Cemetery	0.01
OCTOBER	ANOVA significance level =	0.0000
	Newman-Keuls Range Test:	significance
	Del Loma-Steelbridge	0.05

	Del Loma-Steiner Flat	0.01
	Del Loma-Bucktail	0.01
	Del Loma-Cemetery	0.01
	Steelbridge-Steiner Flat	0.05
	Steelbridge-Bucktail	0.05
	Steelbridge-Cemetery	0.01
JANUARY	ANOVA significance level =	0.3307
	No significant differences	

Seasonal Differences As can be seen in Figure 6, invertebrate biomass tended to increase over time. This was most evident at Del Loma and Steiner Flat, the two lowest sites. At Cemetery and Steelbridge there were drops in mean biomass for January, and Bucktail was irregular throughout the year.

The Newman-Keuls test of means over the seasons (Table 2) shows that there were no statistically significant differences between sample biomass in January and October at any site. This is the result of the large variability between samples at all sites in January, as seen in Table 3, where differences between the widely-spread means for January show no statistical difference. We also tested January mean differences with the non-parametric Kruskal-Wallis single-factor analysis of variance by ranks, which showed a significance level of 0.4229, as compared to 0.3307 for the ANOVA.

Newman-Keuls significant differences at Cemetery (Figure 2) were between April and all other sample months, July and all months but January, and October and all months but January.

Significant differences at Bucktail (Figure 3) were between July and October and April and October. The sample variance in April was very high, because one sample had almost four times the biomass of the next highest sample. This sample had high numbers of oligochaetes (earthworms), large stoneflies, the large mayfly *Ephemerella grandis*, and the caddisfly *Hydropsyche*. Without this outlying sample, the mean for April would have been 226.89 milligrams, compared to the 219.79 milligram July mean. The actual difference between April and July was not statistically significant.

Significant differences at Steelbridge (Figure 4) were between April and October, April and January, July and January, and July and October. There was no significant difference between April and July or between October and January.

At Steiner Flat, significant differences were found between April and October, April and January, and July and October. The increases between April and July and October and January

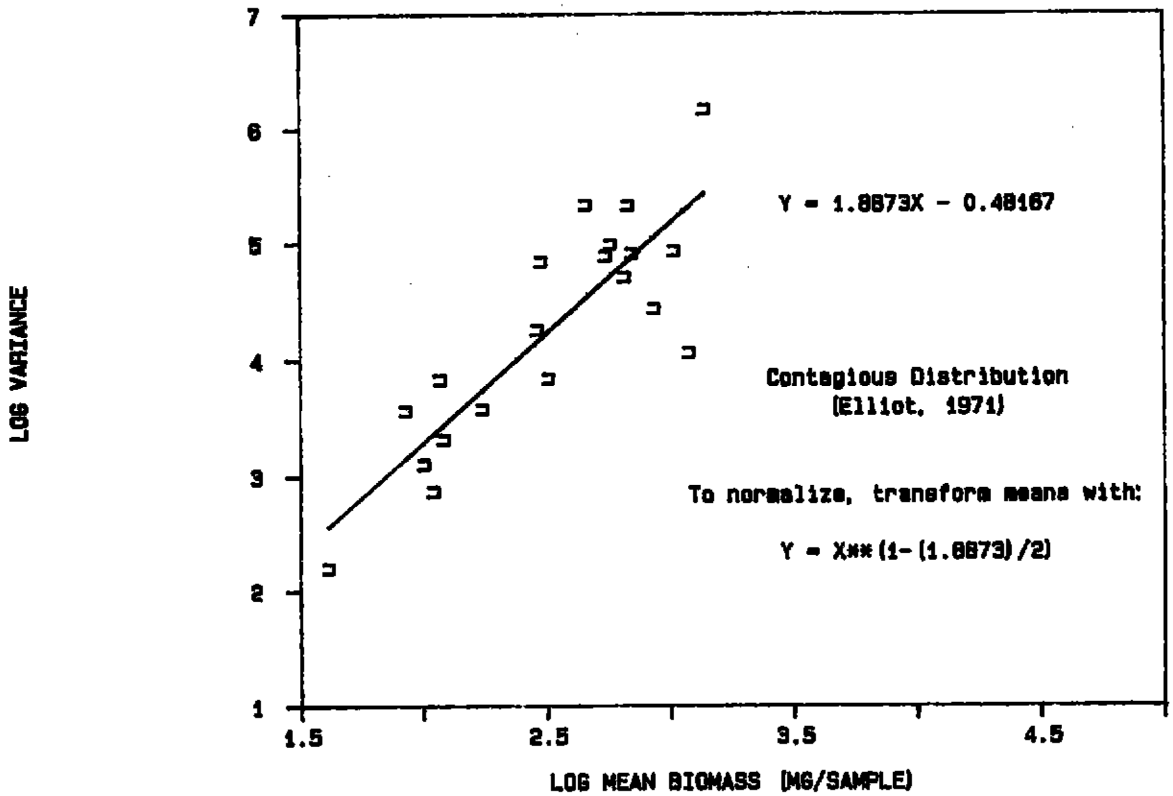

Figure 1. Least-squares Plot for Logarithms of Invertebrate Sample Means and Variances.

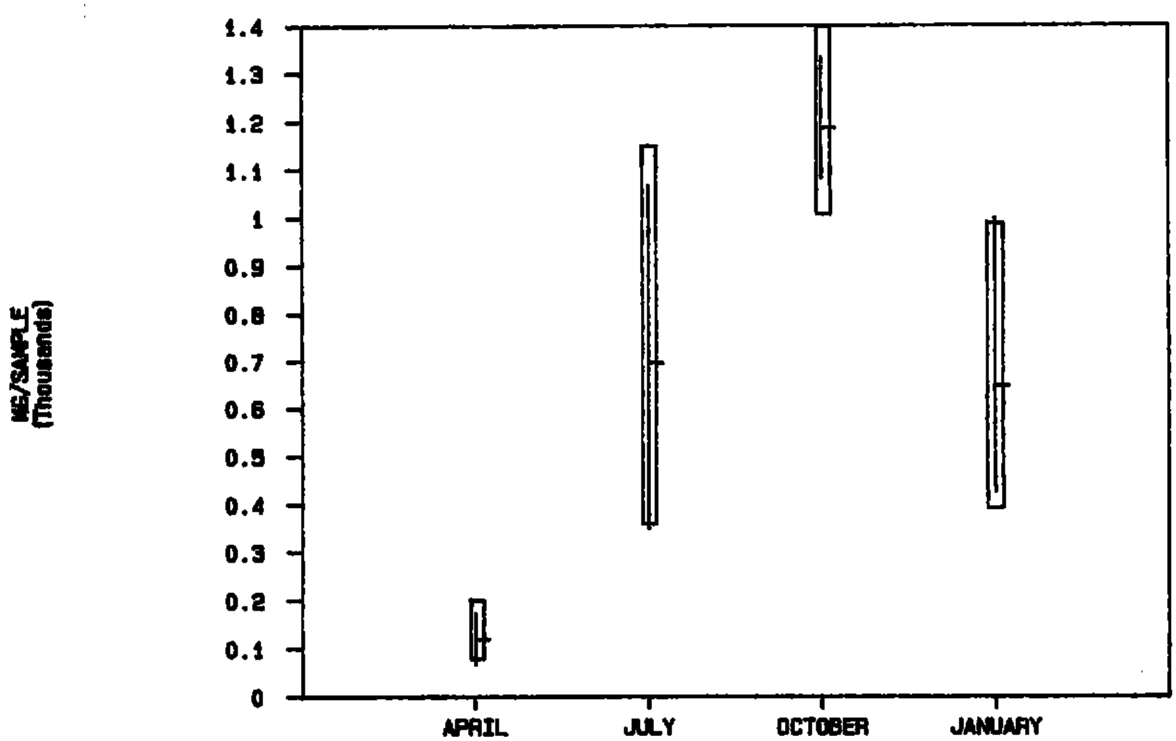

Figure 2. Invertebrate Sample Biomass Means at Cemetery. Line Shows Range and Box Shows Standard Error.

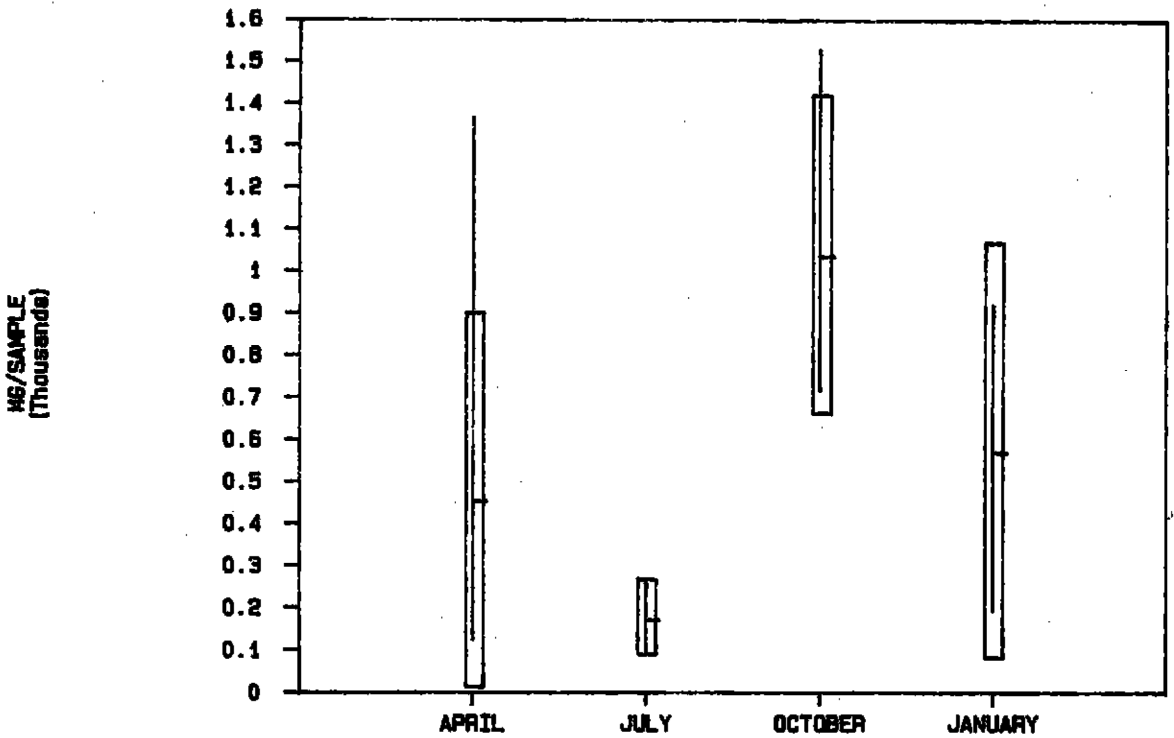

Figure 3. Invertebrate Sample Biomass Means at Bucktail. Line Shows Range and Box Shows Standard Error.

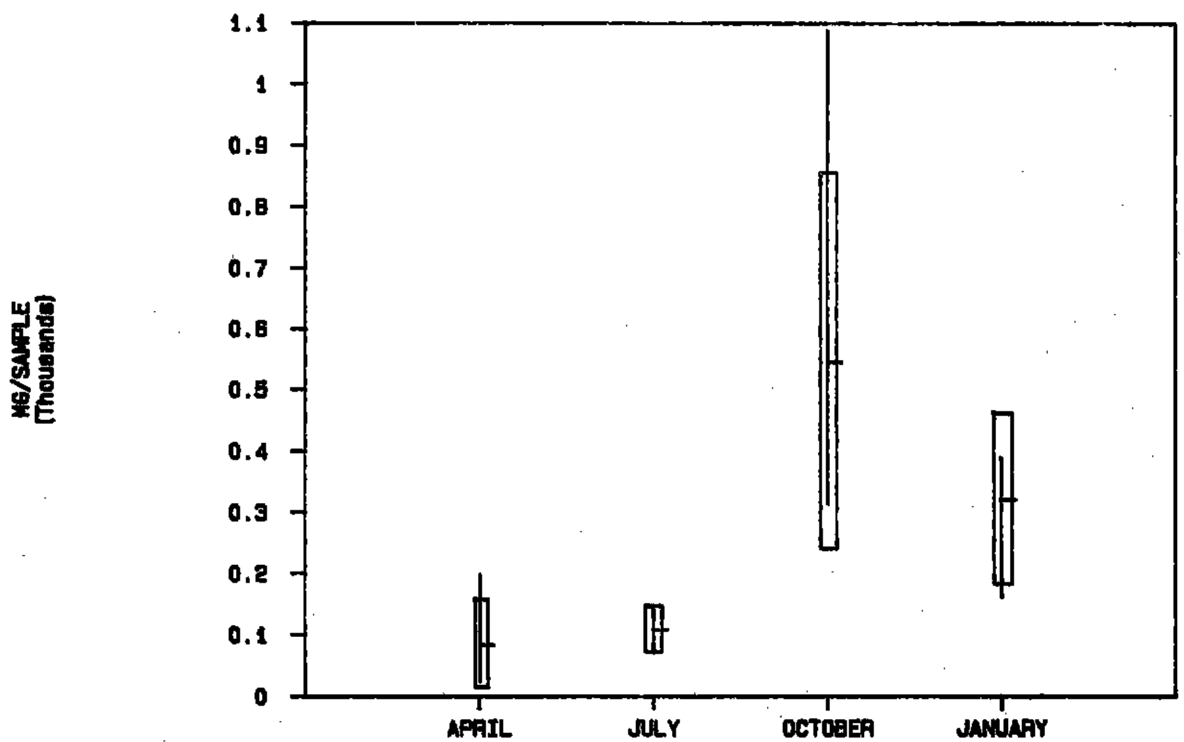

Figure 4. Invertebrate Sample Biomass Means at Steelbridge. Line Shows Range and Box Shows Standard Error.

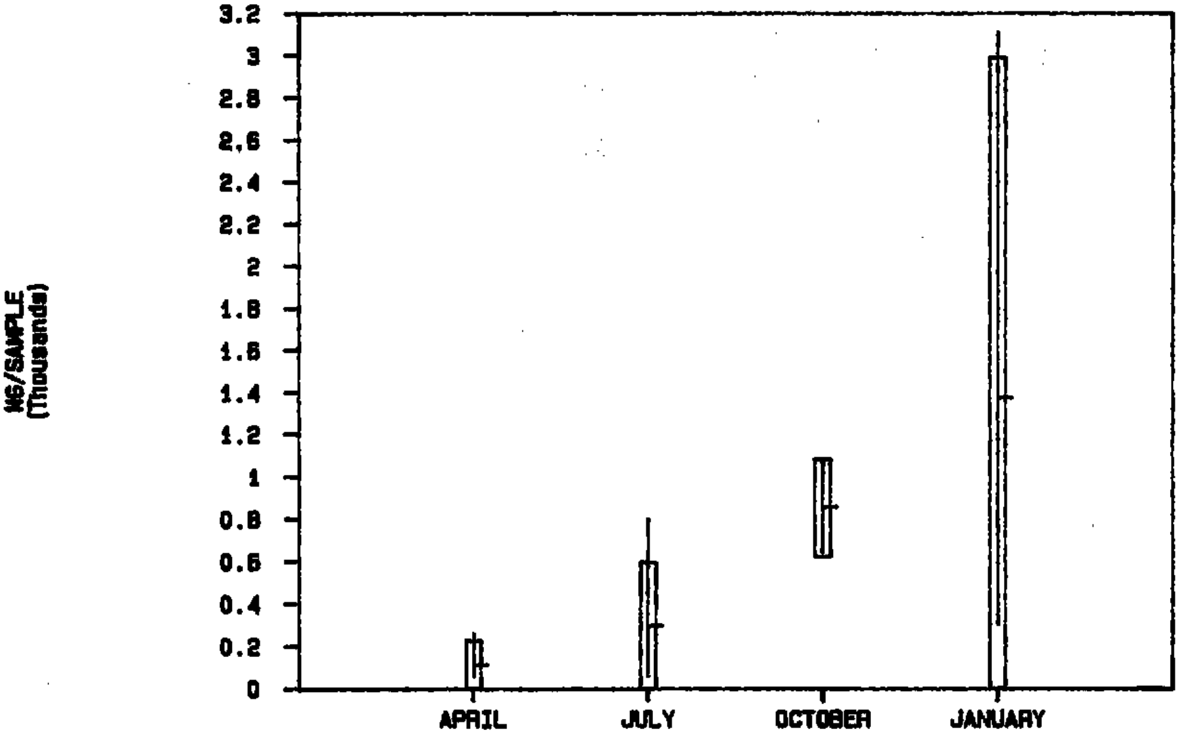

Figure 5. Invertebrate Sample Biomass Means at Steine Flat. Line Shows Range and Box Shows Standard Error.

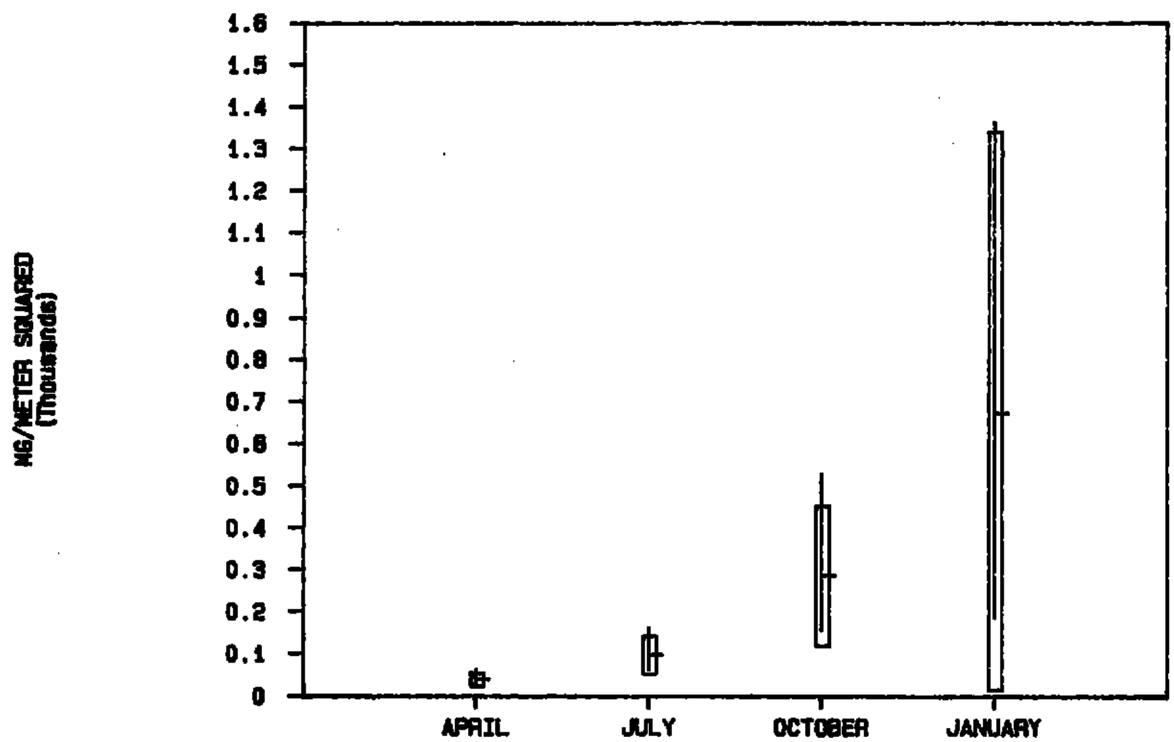

Figure 6. Invertebrate Sample Biomass Means at Del Loma. Line Shows Range and Box Shows Standard Error.

are not significant to the 95 percent level, although a clear trend in increase over the year is evident from Figure 5.

At Del Loma (Figure 6), all differences in means were significant except the one between October and January. Again this is statistically significant, and the figure shows a clear increase in biomass from spring into winter.

Site Differences Table 3 shows Newman-Keuls range test differences between sites for each sampling season. Overall differences are significant for each season but January, when the sample variances were too high to find statistical differences despite the wide variation in sample means.

In the April samples, the mean biomass at Bucktail was significantly higher than all other sites, and the other four sites were similar to one another. The high biomass at Bucktail is attributable largely to a single sample among five as described above.

In July, the biomass at Cemetery was significantly higher than at the other sites, which showed no significant difference among themselves.

In the October samples, the low mean biomass at Del Loma was significantly different from all others, and the higher biomass at Steelbridge was significantly different from all others. Cemetery, Bucktail, and Steiner Flat biomass means were not significantly different.

In January, there were no statistically significant differences among sample sites, although as Figure 6 shows, there were wide differences in sample means. Sample variances were high, partly because much of the biomass was composed of a relatively few large invertebrates. This tended to magnify the effects of invertebrate spatial dispersion.

Differences in Diversity Figure 8 shows the average Shannon-Weaver diversity index, calculated on the basis of logarithms to the base 2 (USFWS, 1987, page 93) for each of the five sample sites over four seasons. This diversity index shows the evenness of the mixture of different kinds of invertebrates in a sample. If a population has high numbers of one species and low numbers of a few other species, it will have a low diversity. An example would be a pure stand of Douglas-fir with no brush understory. A population where total numbers are spread evenly among many species will have a higher relative diversity, for example a mature deciduous forest with many kinds of trees and a varied understory. These diversities are based on numbers of invertebrates in each taxonomic classification, and are unaffected by differences in biomass.

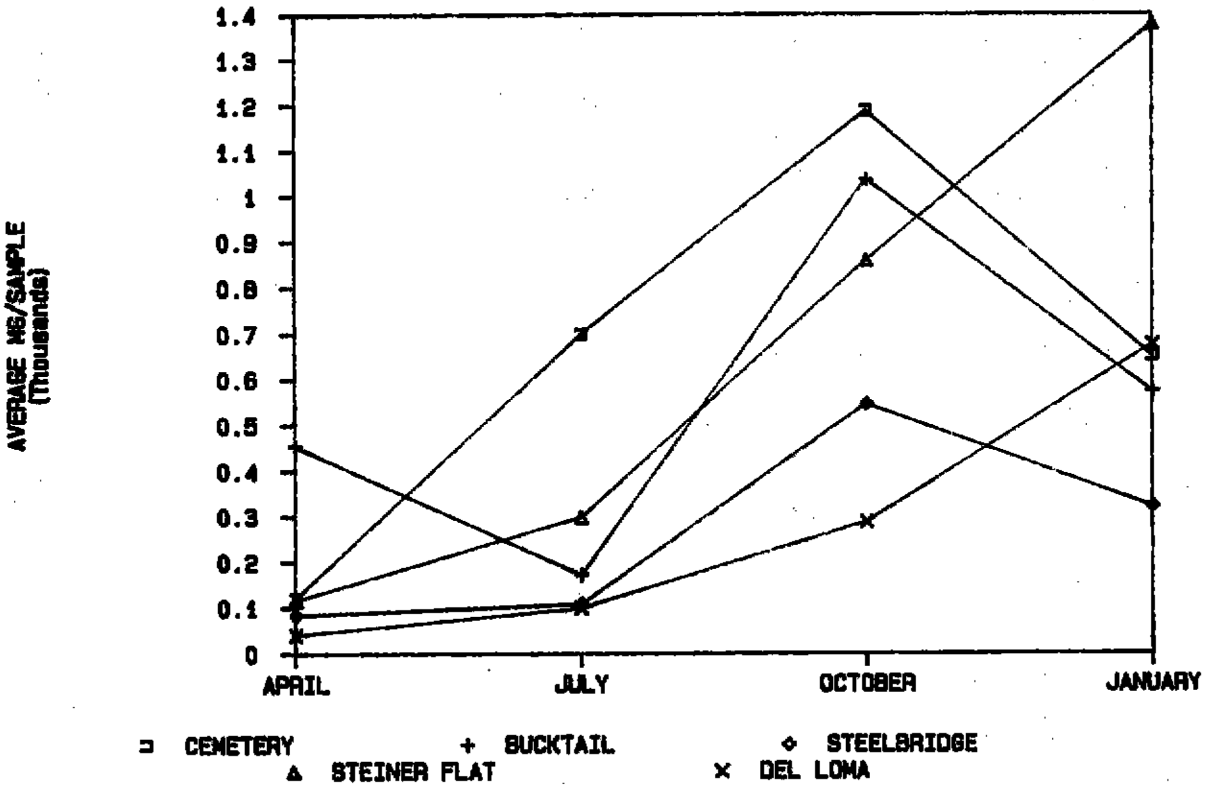

Figure 7. Invertebrate Sample Biomass Means at Five Trinity River Sites, 1986-1987.

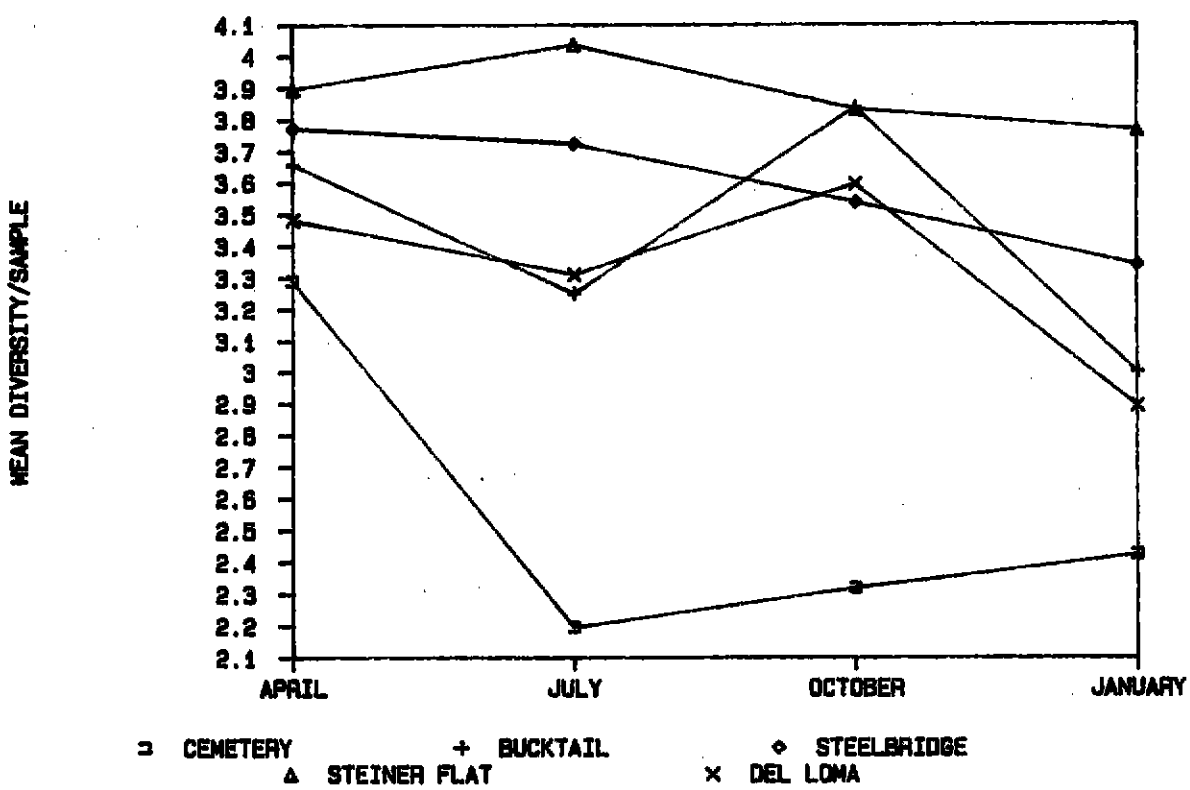

Figure 8. Invertebrate Shannon-Weaver Diversity at Five Trinity River Sites, 1986-1987.

Hydropsychidae The Hydropsychidae are caddis flies that spin silk nets and filter current-borne diatoms, green algae, invertebrates, and organic detritus from the water. Most of ours were in the genus _Hydropsyche_, which spins a net of medium mesh size, and subsists on larger particles than the simuliids. Since the insect builds its net on or among rocks, it depends on a stable substrate.

The hydropsychids are generally univoltine, the larvae growing over a longer season either most chironomids or the simuliids. Thus it will take them longer to colonize an area, since over the seasons fewer adults will be available to fly upstream to oviposit.

In our samples, hydropsychids were most important at downstream sites toward the fall and winter, although relatively high biomass was found at Bucktail for three of the four seasons (Figure 11). There is a general trend of hydropsychid biomass increasing through the year, perhaps reflecting both the year-long growth pattern of these invertebrates and the gradual reestablishment of populations following the February-March floods of 1986.

Baetis This is a genus of mayflies comprised of 41 species indistinguishable in the nymphal stage. In the immature stage, they are small, fusiform insects, subsisting by gathering or scraping detritus and diatoms from rocks. They are fast swimmers, and can colonize new areas as nymphs by swimming upstream.

Baetis is thought to have more than a single generation in a year, and like the simuliids and some chironomids they may do well in disturbed areas through swift recolonization and growth. In our samples they were found in high relative biomass at the Cemetery site in April and July (Figure 12). Their populations were generally highest throughout the river in July. In our fish stomach samples they were important foods for steelhead and brown trout, which may reflect their their adaptation to the fast water frequented by these fish. Like the simuliids, their multivoltinism and fast growth may give them a productive capacity higher than is reflected in their biomass in bottom samples.

Ephemerella This is a genus of ephemerellid mayflies comprised of 28 species. They are generalized clinging insects that crawl among the rocks and subsist by scraping and gathering diatoms and detritus. Although unlike _Baetis_ they are not strong swimmers, they spread their distribution downstream by jumping upward into the water column, and they are frequent in invertebrate drift. Probably because they live among the rocks but drift consistently, they were at times prevalent in the stomachs of all the fish species

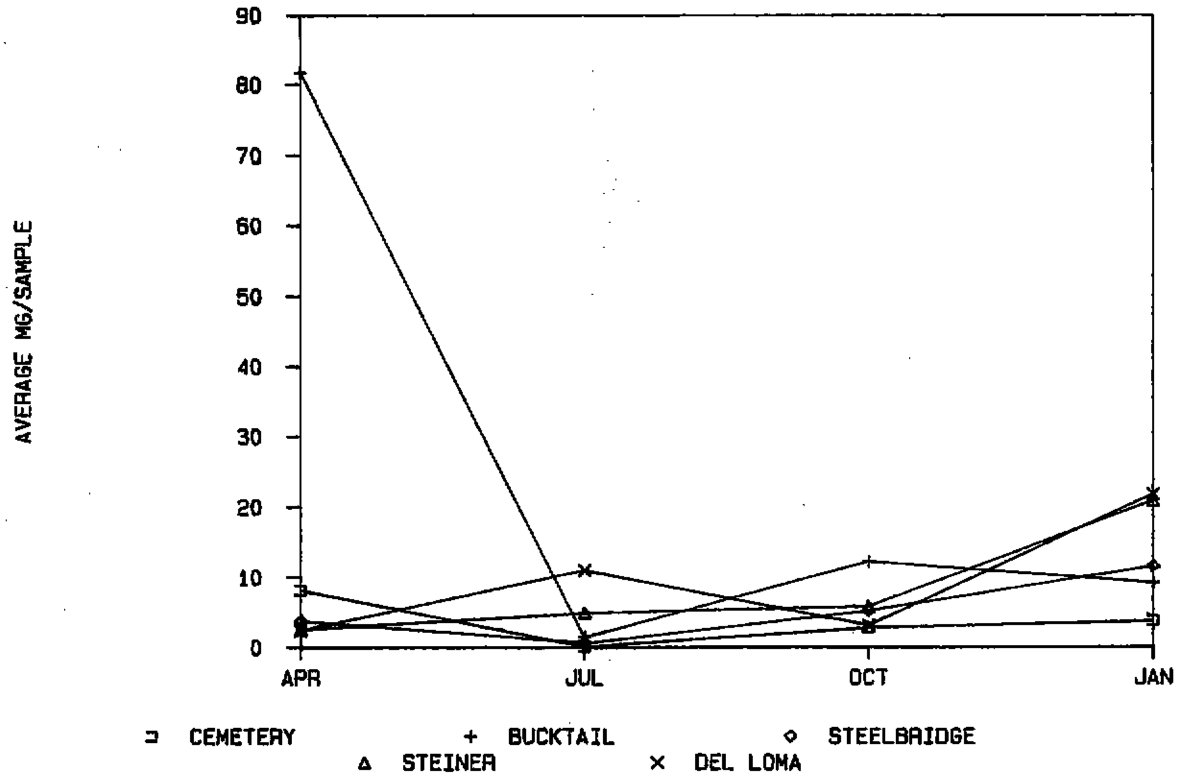

Figure 13. Mean Biomass of Ephemerella at Five Sites, 1986-1987.

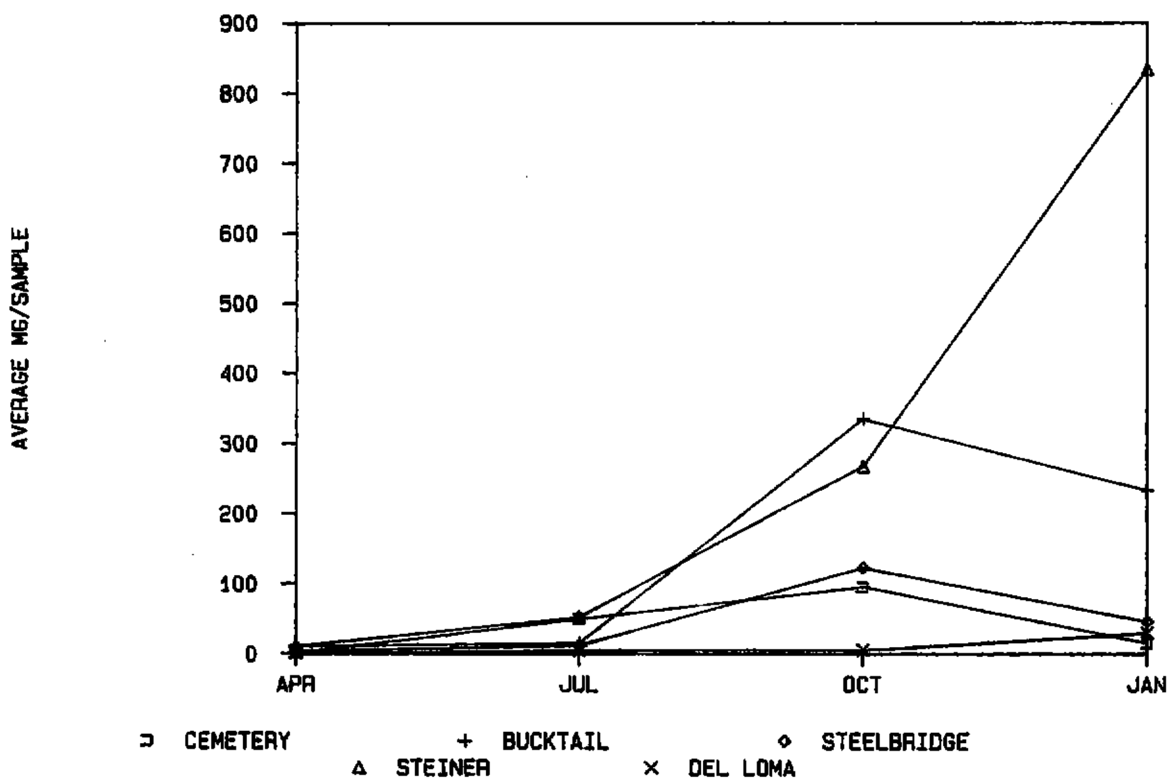

Figure 14. Mean Biomass of Perlodids at Five Sites, 1986-1987.

collected in our 1987 food study.

Figure 13 shows that Ephemerella spp. were found in relatively consistent biomass proportions at all our sites except Cemetery, which was generally lowest; there was an exceptionally large biomass at Bucktail in April, consisting mostly of relatively few individuals of E. grandis, a species which grows to a much larger size than any of our other Trinity River ephemerellid. The low biomass at Cemetery is consistent with a relatively low ability to colonize new upstream areas, and with a need for habitat stability that may exist in Ephemerella. The highest consistent populations were found at Del Loma, our farthest downstream site.

Perlodidae The Perlodidae are a family of predatory stoneflies. They have a single yearly generation, and grow to a relatively large size. The adults are poor fliers, and the nymphs crawl slowly among substrate materials, generally in faster water, so their ability to colonize upstream areas is limited. Like the ephemerellid mayflies, they are found in the drift and in riffle substrates, and they are often important foods for steelhead and brown trout.

In our bottom samples, perlodid biomass generally increased from spring to fall, with a highest biomass at Steiner Flat in January (Figure 14). This would be consistent with the life-cycle of a univoltine species commencing life in the spring and growing through winter. It indicates also that perlodid populations may have been severely affected by the late winter floods of 1986, which moved substrates and washed most of the clinging stoneflies downstream.

Perlodids may reach a relatively large size compared with stream invertebrates such as Baetis, the simuliids, and the Chironomidae, and by October and January they made up the largest proportion of invertebrate biomass at several sites. This large biomass may represent less production than seems apparent, because of the family's univoltine life-cycle and probably relatively slow growth rate.

Discussion

Invertebrates are an extremely important element of the stream biotic community. They represent the trophic step that transforms the energy from instream primary production and heterotrophic consumption of terrestrial organic material into a form available to fish. Without invertebrates in adequate supply, fish populations and growth will be limited, whatever other suitable conditions are present.

The problems with dealing with invertebrates in a management context are that their numbers are astronomical, their range

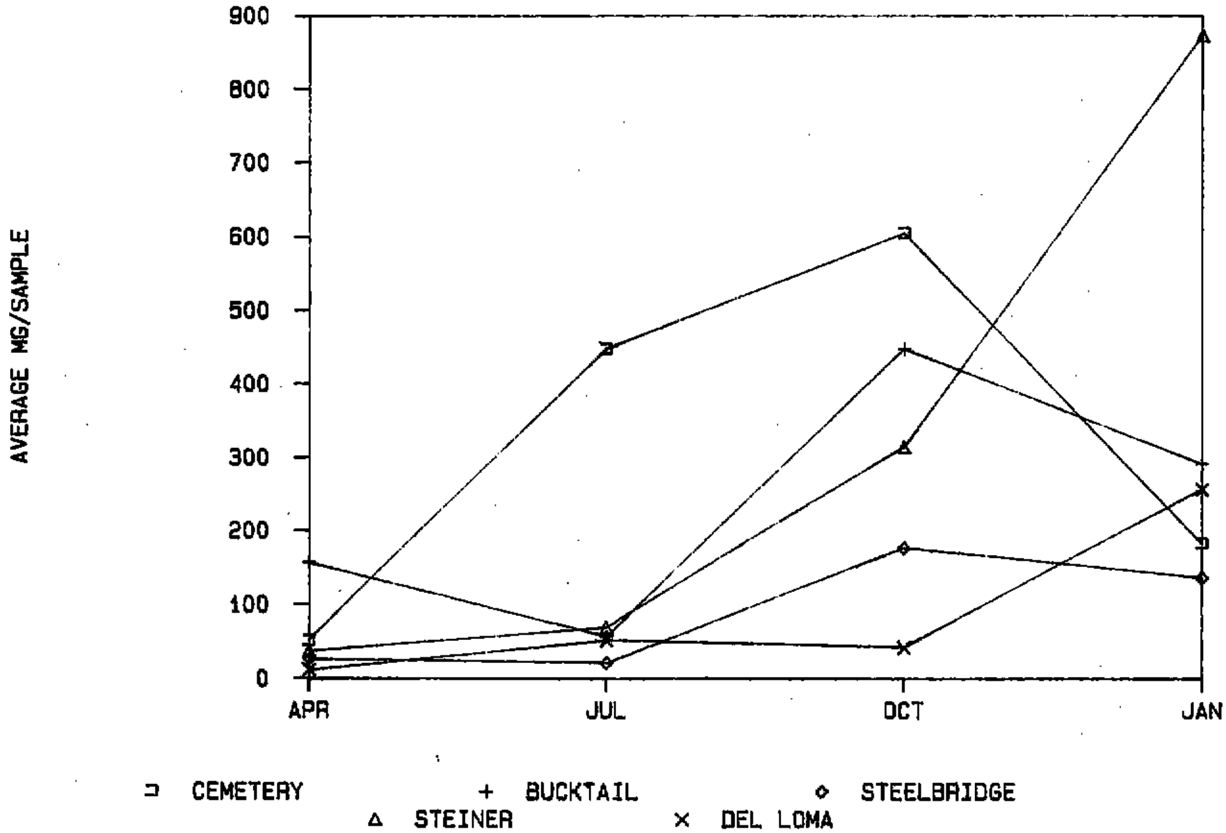

Figure 15. Mean Biomass of Six Important Fish Food Species at Five Sites, 1986-1987.

invertebrate biomass throughout the system, having an evidently greater effect than any influences attributable to distance downstream or changes in sedimentation or water quality.

The major important influence on invertebrate biomass, other than the seasonal trend probably driven by the catastrophic drift associated with flooding, was the decomposed granite at Steelbridge. It depressed invertebrate biomass and production by reducing available living space. Since the accumulation of decomposed granite fines in the Steelbridge area is clearly related to an absence of sustained high flows and the subsequent reduction of sediment transport capacity (Frederickson, Kamine and Assoc. 1980) the one major potential flow manipulation that could improve aquatic invertebrate production would be the provision of flushing flows to clean the riffles.

IV. PROGRAM PLANNING, DIRECTION, AND COORDINATION

Generally, activities associated with the Trinity River Flow Evaluation Program planned for 1989 will contiune to focus on: 1) the analysis of salmon and steelhead habitat available in the mainstem Trinity River at various streamflow regimes; 2) the continued monitoring of salmonid habitat needs and use; and 3) the determination of habitat and population characteristics influenced by streamflows and the degree to which they can be affected by streamflow within the Trinity River. In addition, as mainstem Trinity River habitats are being enhanced or new habitats are being created, such as side-channels to provide additional juvenile rearing habitat, we intend to expand our assessments to these habitats in an attempt to document habitat gains from them.

Determination of Habitat Availability and Needs (TASK 3)

During 1989 we plan to continue to develop an analysis of the amount of salmon and steelhead habitat available in the Trinity River under various flow conditions. Streamflow vs weighted usable area of habitat will again be assessed to complement that done during 1985 and 1986. In an effort to expand our understanding of the available habitat at flow above 800 cubic feet per second we will be looking to include in our 1989 calibration flows a discharge at some level significantly above that (e.g., 3000 cfs). The actual discharge at which calibration data will be gathered will be determined after consultation with the Bureau of Reclamation, California Department of Fish and Game, and the Trinity River Fish and Wildlife Management Program Field Office.

We will continue to monitor mainstem water temperatures at least above the confluence of the North Fork Trinity River. These data will be used as validation points in completing a river network analysis using the Service's Instream Water Temperature Model (SNTEMP). An initial model run will be completed during 1989 and the results will be presented in the 1989 annual report. To the extent possible we will attempt to establish water temperature monitoring points near Cedar Flat and near Willow Creek.

A detailed evaluation of a new side channel constructed along the Trinity River by the Bureau of Land Management will also be done during 1989. We plan to focus on documenting the amount of new habitat created and monitoring changes over time. The utilization of this habitat by juvenile salmonids will be monitored by staff from the Management Program Field Office. Our evaluation will be closely coordinated with ongoing work aimed at determining the importance of side-channel habitats along the Trinity for juvenile salmonid rearing and holding.

It is hoped that eventually these and other macrohabitat data can be combined with microhabitat and hydrologic data in such a manner that an overall stream network habitat analysis for the Trinity River basin can be done.

Fish Population Characteristics and Life History Relationships (TASK 4)

In 1986 we initiated a number of elements aimed at providing insite into fish population and life history relationships of salmon and steelhead within the Trinity River. The initial plan of study (FWS 1983) describes this information as necessary due to our limited knowledge about the total distribution of fish within the Trinity River, their spawning success, and the subsequent survival and growth of salmonid juveniles. Initial efforts have been aimed at obtaining information on: 1) the habitat use and distribution of juvenile salmonids; 2) salmonid egg and fry survival within the mainstem of the Trinity; 3) the timing, duration, and magnitude of juvenile emigration; 4) juvenile salmonid growth within the river; and 5) the overall health and productive capabilities of macroinvertebrate populations of the Trinity. These efforts have continued through 1987 and 1988 and will be continued through 1989.

Efforts will be continued to describe the habitats used and the requirements of juvenile salmonids during the winter months, when water temperatures drop below 50 degrees F. Based on our observations to date we believe that overwintering habitat and its availability may play an important role in determining population levels or the overall carrying capacity of the river. In addition, we plan to expand our efforts and focus on spring habitat requirements as well. We will also evaluate selected holding habitats within the mainstem Trinity in an effort to obtain information on their dynamics and importance to salmonid distribution, especially during the critical summer months when they may be an important habitat type for juvenile and/or adult salmon and steelhead trout.

Efforts aimed at monitoring the growth of juvenile salmon and steelhead within the mainstem Trinity River, especially of "wild" or naturally produced fish will continue through 1989. This work is designed to monitor variations and to build upon dataobtained in 1986, 1987, and 1988. We also plan to continue monitoring food habits of juvenile salmonids, their selectivity, preferred food items and the degree of overlap between different species and lifestages.

Study Coordination (TASK 5)

In 1986 the Trinity River Basin Fish and Wildlife Management Program Field Office initiated efforts to rehabilitate fish and wildlife habitat within the basin, including the mainstem

Trinity River above Grass Valley Creek. The plan of study for the Trinity River Flow Evaluation focuses primarily on evaluating the effects of increased streamflow releases at Lewiston Dam on available anadromous salmoid habitat within the mainstem of the Trinity River. It is recognized, however, that there is a need to monitor changes in available habitat or habitat use brought about by the implementation of the Management Program as well. Such an effort is necessary if it is expected that habitat changes due to increases downstream releases are to be accurately separated from those brought about through implementation of the Management Program. Therefore, we plan to continue our close coordination with the Trinity Management Program Field Office.

Finally, coordination efforts will continue with the Bureau of Reclamation, concerning Trinity River releases, and the California Department of Fish and Game, concerning Trinity River Hatchery operations and other fishery or habitat management efforts planned for 1989.

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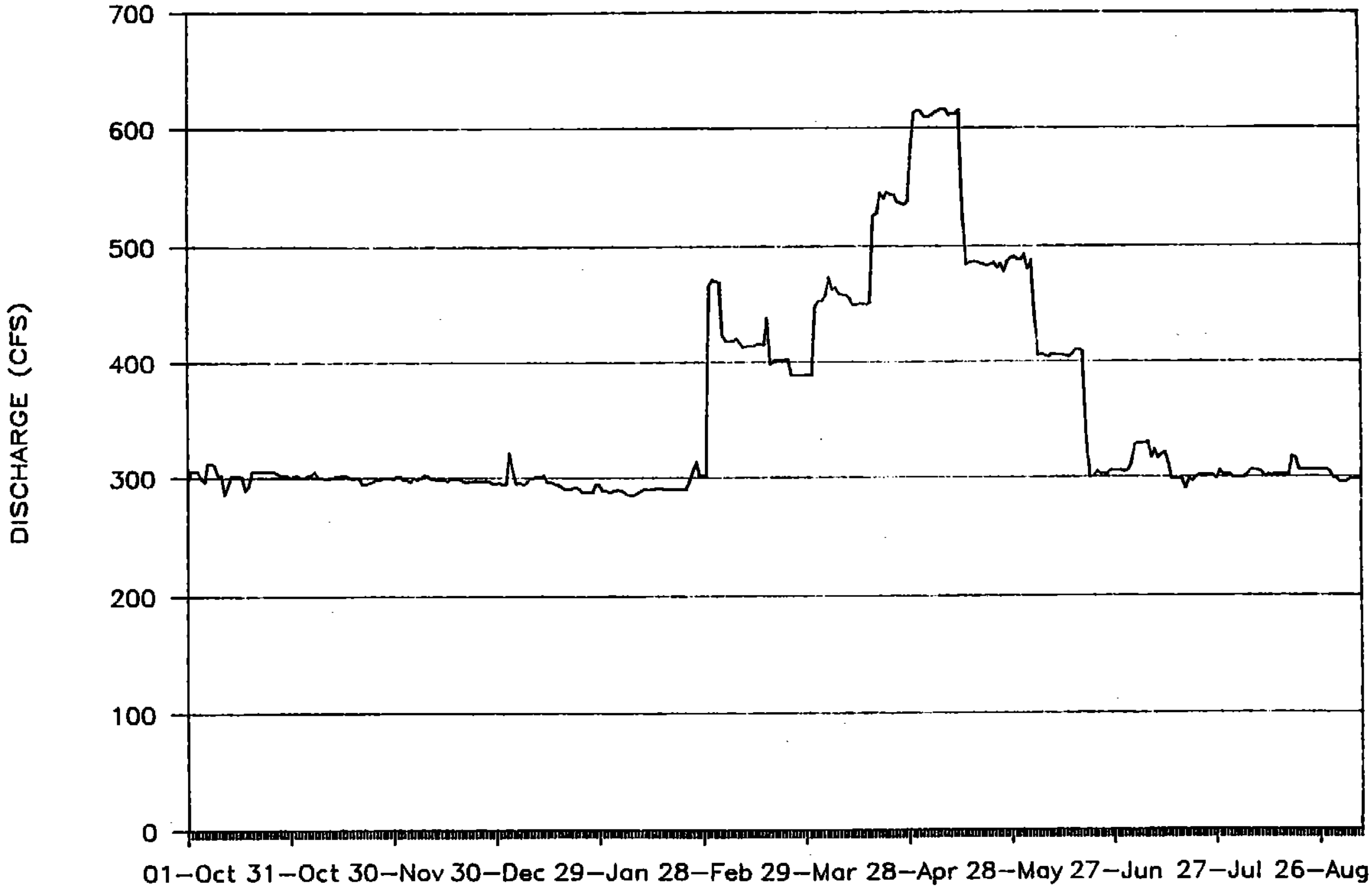
APPENDIX



Mean daily discharge at USGS gauge in Lewiston, 1988 water year.

Table x. Number, Date, Size, and Location of Artificially Reared Salmonid Releases in the Upper Trinity River in 1987 and 1988. Based on Fish Planting Receipts Provided by Trinity River Hatchery, California Department of Fish and Game, Lewiston, California.

Date	Size	Number	Release Site	Race	Marks
1987					
CHINOOK					
May 5	120/lb	567,000	hatchery	spring	no mark
May 7	121/lb	526,350	hatchery	spring	no mark
May 26	85/lb	176,375	hatchery	spring	no mark
May 27	93/lb	313,875	hatchery	spring	no mark
May 28	75/lb	204,920	hatchery	spring	marked
May 28	110/lb	104,500	hatchery	spring	no mark
June 1	85/lb	199,750	hatchery	spring	no mark
June 3	97/lb	356,475	hatchery	fall	no mark
June 5	110/lb	715,000	hatchery	fall	no mark
June 9	95/lb	285,000	hatchery	fall	no mark
June 10	101/lb	631,575	hatchery	fall	no mark
June 11	100/lb	99,000	hatchery	fall	marked
June 12	67/lb	201,670	hatchery	fall	no mark
June 12	118/lb	299,720	hatchery	fall	no mark
June 17	78/lb	107,250	hatchery	fall	marked
June 18	110/lb	363,000	hatchery	fall	no mark
June 19	71/lb	381,625	hatchery	fall	no mark
June 23	74/lb	160,950	hatchery	fall	no mark
COHO					
Mar. 19	8/lb	99,220	hatchery		no mark
Mar. 20	9/lb	77,213	hatchery		no mark
Mar. 23	10/lb	113,000	hatchery		no mark
	17/lb	5,650	hatchery		no mark
Mar. 24	16/lb	184,450	hatchery		no mark
STEELHEAD					
Mar. 13	10/lb	76,500	hatchery		no mark
Mar. 20	3/lb	28,000	hatchery		marked
Mar. 30	9/lb	61,380	hatchery		no mark
Mar. 31	10/lb	126,000	hatchery		no mark
Apr. 1	10/lb	81,585	hatchery		no mark
Apr. 3	10/lb	48,750	hatchery		no mark
Apr. 6	10/lb	85,388	hatchery		no mark

Table x. Number, Date, Size, and Location of Artificially Reared Salmonid Releases in the Upper Trinity River in 1987 and 1988. Based on Fish Planting Receipts Provided by Trinity River Hatchery, California Department of Fish and Game, Lewiston, California. (cont.)

Date	Size	Number	Release Site [a]	Race	Marks
1988					
CHINOOK					
Feb. 17	9/lb	75,004	hatchery	?	no mark
Feb. 22-26	334/lb	13,026	hatchery	spring	no mark
	376/lb	35,720	hatchery	spring	no mark
	460/lb	199,180	hatchery	spring	no mark
Mar. 1	9/lb	26,955	hatchery	spring	no mark
May 23	85/lb	2,359,838	Sawmill Pond	spring	no mark
	85/lb	195,462	Sawmill Pond	spring	marked
June 2	117/lb	2,161,472	Ambrose Pond	fall	no mark
	117/lb	188,733	Ambrose Pond	fall	marked
COHO					
Mar. 8	14/lb	297,256	Sawmill Pond		no mark
	14/lb	50,000	Sawmill Pond		marked
STEELHEAD					
Mar. 8	7/lb	210,000	Sawmill Pond		no mark
	8/lb	210,000	Sawmill Pond		no mark
Apr. 1	9/lb	450,000	Ambrose Pond		no mark

[a] Sawmill and Ambrose ponds are offsite rearing facilities located approximately 3 and 4 miles, respectively, downstream from hatchery, adjacent to Trinity River.

TRINITY RIVER AT LEWISTON, CA

WATER TEMPERATURE (DEG. C), WATER YEAR OCTOBER 1987 TO SEPTEMBER 1988

LOCATION: On left bank approximately 0.3 mi downstream from Lewiston Diversion Dam, and 0.5 mi upstream from USGS Gage at Lewiston(11525500)

PERIOD OF RECORD: July 1987 to present

RECORDER: Omnidata DataPod DP112 (App. Eng. Special # 1013) temperature range 5.0 to 30.0 degrees Celcius to the nearest 0.1 degree. (Note: Temperatures below 5.0 degrees are recorded as 5.0 degrees and temperatures above 30.0 degrees are recorded as 30.0 degrees)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	8.4	7.9	6.8	6.5	6.4	8.1	10.4	8.1	10.8	12.3	9.5	8.4
2	8.4	7.8	7.0	6.5	6.3	8.4	10.4	8.4	10.9	12.7	9.6	8.4
3	8.4	7.8	7.0	6.5	6.3	8.6	10.5	8.7	11.1	12.6	9.6	8.4
4	8.3	7.7	7.1	6.4	6.2	8.6	10.5	9.0	11.0	12.3	9.5	8.3
5	8.3	7.9	7.0	6.4	6.2	8.7	10.7	9.5	10.8	12.5	9.4	8.3
6	8.4	7.9	7.0	6.3	6.2	8.6	10.6	9.6	11.1	12.7	9.3	8.4
7	8.3	7.9	6.9	6.1	6.2	8.8	10.6	9.6	10.9	12.3	8.7	8.5
8	8.3	7.8	6.9	6.1	6.3	8.9	10.6	9.4	11.2	11.3	8.5	8.4
9	8.3	7.9	7.0	6.0	6.5	8.9	10.8	9.6	11.2	10.8	8.4	8.3
10	8.1	7.8	6.8	5.9	6.6	8.9	10.9	9.6	10.8	9.5	8.4	8.6
11	8.0	7.9	6.6	6.0	6.6	8.9	11.1	9.9	10.9	9.1	8.5	8.6
12	8.1	7.9	6.3	6.0	6.8	8.9	11.0	10.1	11.3	8.9	8.5	8.5
13	8.1	7.9	6.3	6.1	6.8	8.9	10.5	10.6	11.5	8.8	8.5	8.5
14	-	7.6	6.0	5.9	6.9	8.9	9.8	10.7	11.9	8.7	8.2	8.4
15	-	7.6	5.9	5.9	7.1	8.9	9.6	10.9	12.1	8.8	8.2	8.3
16	-	7.5	5.6	5.9	7.0	8.9	9.3	11.1	11.8	8.7	8.2	8.4
17	-	7.6	5.6	5.8	6.9	9.1	9.4	11.4	11.8	8.7	8.4	8.4
18	-	7.7	6.1	5.8	6.9	9.1	9.6	11.6	12.1	8.7	8.4	8.5
19	-	7.8	6.3	5.8	7.0	9.2	9.7	11.8	12.0	8.7	8.3	8.3
20	-	7.7	6.5	5.9	7.2	9.2	9.5	11.7	12.2	8.6	8.3	
21	7.8	7.6	6.6	6.0	7.3	9.4	9.0	11.7	12.6	8.5	8.4	
22	7.9	7.5	6.5	6.1	7.4	9.6	8.7	11.9	12.2	8.5	8.4	
23	7.9	7.3	6.3	6.2	7.5	9.6	9.1	12.0	12.8	8.6	8.5	
24	8.0	7.1	6.1	6.2	7.6	9.8	8.6	12.1	12.4	8.5	8.4	
25	8.0	6.9	6.0	6.3	7.7	10.0	9.0	11.5	12.8	8.5	8.4	
26	8.0	6.8	5.9	-	7.9	10.1	9.4	11.0	12.5	8.5	8.4	
27	8.0	6.6	6.1	-	8.1	10.1	9.4	10.6	12.6	8.5	8.4	
28	8.0	6.7	6.2	6.5	8.2	10.3	9.3	10.8	13.1	8.4	8.3	
29	8.0	6.7	6.3	6.5	8.1	10.3	9.0	10.9	12.8	8.7	8.3	
30	7.9	6.7	6.4	6.5		10.1	8.4	10.9	12.9	9.1	8.3	
31	8.0		6.5	6.5		10.4		11.0		9.3	8.4	
MEAN	8.1	7.5	6.4	6.2	7.0	9.2	9.8	10.5	11.8	9.7	8.6	8.4
MAX	8.4	7.9	7.1	6.5	8.2	10.4	11.1	12.1	13.1	12.7	9.6	8.6
MIN	7.8	6.6	5.6	5.8	6.2	8.1	8.4	8.1	10.8	8.4	8.2	8.3

TRINITY RIVER AT IDAHO BAR (NEAR HELENA, CA)

WATER TEMPERATURE (DEG. C), WATER YEAR OCTOBER 1987 TO SEPTEMBER 1988

LOCATION: On right bank 1.0 mi upstream from Highway 299 bridge across the North Fork Trinity River near Helena, California.

PERIOD OF RECORD: July 1987 to present

RECORDER: Omnidata DataPod DP112 (App. Eng. Special # 1013) temperature range 5.0 to 30.0 degrees Celcius to the nearest 0.1 degree. (Note: Temperatures below 5.0 degrees are recorded as 5.0 degrees and temperatures above 30.0 degrees are recorded as 30.0 degrees)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	13.6	10.7	6.9	5.0	5.0	7.9	11.1	9.7	11.6	18.5	20.1	17.7
2	13.7	10.1	7.8	5.0	5.0	7.9	11.3	10.5	13.1	19.5	19.7	17.8
3	13.6	9.5	8.3	5.1	5.0	8.5	11.7	10.9	14.6	19.2	19.6	17.8
4	13.3	9.6	8.4	5.7	5.0	8.7	11.1	10.8	12.2	18.2	19.1	17.7
5	13.1	9.7	8.2	5.8	5.0	9.2	11.0	10.4	12.2	17.6	18.8	17.4
6	13.1	10.1	7.6	5.5	5.0	9.3	11.9	9.5	11.8	18.0	19.2	16.7
7	13.1	10.1	7.0	5.1	5.3	8.6	11.9	9.6	11.4	18.5	18.6	16.6
8	13.1	9.3	6.4	5.1	6.3	8.6	10.7	10.1	11.4	19.2	18.7	16.2
9	12.8	10.1	6.9	5.8	7.0	8.7	11.3	10.6	11.7	19.8	18.9	16.0
10	12.4	9.7	6.7	5.7	6.7	7.6	12.2	11.7	13.1	19.5	19.2	15.9
11	12.0	9.1	5.8	5.6	6.4	7.3	13.0	12.8	14.5	18.6	19.2	15.1
12	12.6	9.5	5.0	5.9	6.3	7.4	12.7	12.5	14.9	18.6	18.9	15.0
13	12.6	10.4	5.0	6.2	6.2	7.9	11.9	11.7	15.7	19.1	17.8	14.8
14	-	9.1	5.0	5.8	5.8	8.5	11.2	12.5	16.3	19.1	16.7	14.4
15	-	7.7	5.1	5.1	6.3	8.6	12.2	13.7	16.7	19.1	16.4	14.4
16	-	8.5	5.6	5.3	6.1	8.3	12.9	12.8	16.6	19.2	16.9	14.6
17	-	9.6	5.9	5.3	5.6	8.8	12.5	11.8	16.9	19.8	17.0	14.5
18	-	9.4	5.7	5.3	5.7	9.4	11.4	13.0	17.5	19.9	17.1	13.4
19	-	9.1	5.7	5.2	5.8	9.9	10.4	13.9	17.9	19.9	17.4	13.2
20	-	8.6	6.1	5.5	6.3	9.9	9.5	14.6	18.1	19.9	17.7	
21	10.3	8.1	6.3	5.6	6.6	10.6	10.2	15.0	18.1	20.1	17.8	
22	10.7	7.9	5.1	5.6	6.7	10.0	9.5	14.8	18.5	20.1	18.0	
23	11.7	7.8	5.0	5.4	6.9	10.1	9.5	14.1	19.0	20.1	18.2	
24	12.2	7.0	5.0	5.2	7.2	9.3	10.5	14.1	18.8	20.2	17.9	
25	11.7	6.4	5.0	5.4	7.1	10.5	11.0	14.7	18.2	20.0	17.6	
26	11.2	5.5	5.0	-	8.0	11.0	11.8	14.4	17.9	19.5	17.4	
27	10.9	5.5	5.0	-	8.7	10.0	12.1	14.5	17.8	20.1	17.5	
28	10.9	5.8	5.1	5.9	8.8	9.3	11.2	13.7	16.9	19.9	17.7	
29	11.2	6.7	5.2	6.3	7.7	9.9	10.7	12.2	16.2	19.9	17.9	
30	11.4	7.1	5.2	6.0		10.1	9.9	12.8	17.2	20.1	17.7	
31	11.0		5.0	5.3		10.2		12.6		20.4	17.8	
MEAN	12.2	8.6	6.0	5.5	6.3	9.1	11.3	12.5	15.6	19.4	18.1	15.7
MAX	13.7	10.7	8.4	6.3	8.8	11.0	13.0	15.0	19.0	20.4	20.1	17.8
MIN	10.3	5.5	5.0	5.0	5.0	7.3	9.5	9.5	11.4	17.6	16.4	13.2

TRINITY RIVER AT STEEL BRIDGE ROAD, CA

WATER TEMPERATURE (DEG. C), WATER YEAR OCTOBER 1987 TO SEPTEMBER 1988

LOCATION: On right bank approximately 11.7 mi downstream from Lewiston Diversion Dam, and 0.5 mi downstream from USGS Gage near Limekiln Gulch(11525500)

PERIOD OF RECORD: July 1987 to present

RECORDER: Omnidata DataPod DP112 (App. Eng. Special # 1013) temperature range 5.0 to 30.0 degrees Celcius to the nearest 0.1 degree. (Note: Temperatures below 5.0 degrees are recorded as 5.0 degrees and temperatures above 30.0 degrees are recorded as 30.0 degrees)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	10.6	8.5	6.7	5.2	5.3	8.3	11.1	9.3	12.2	16.8	14.9	12.5
2	10.8	8.3	7.2	5.4	5.2	8.2	10.8	9.5	13.2	17.0	14.9	12.7
3	10.7	8.3	7.5	5.4	5.1	8.7	11.5	10.0	13.1	16.9	14.9	12.7
4	10.5	8.3	7.5	5.9	5.1	8.8	10.9	10.0	11.8	16.1	14.2	12.6
5	10.4	8.8	7.4	5.9	5.1	9.3	11.0	9.8	11.9	15.7	14.5	12.4
6	10.4	8.6	6.8	5.7	5.3	9.1	11.6	9.5	11.7	15.8	14.1	12.0
7	10.6	8.1	6.5	5.3	5.7	8.7	11.3	9.5	11.5	16.0	14.0	11.9
8	10.3	8.9	5.9	5.3	6.3	8.7	10.6	10.0	11.5	16.5	13.7	11.7
9	10.2	8.3	6.7	5.8	6.9	8.7	11.3	10.3	11.9	16.3	13.7	11.7
10	10.1	8.2	6.2	5.4	6.7	8.2	11.8	11.1	13.3	15.8	13.6	11.6
11	9.6	8.5	5.3	5.4	6.5	8.1	12.2	11.5	13.6	14.6	13.7	11.3
12	10.3	9.0	5.0	5.6	6.5	8.2	11.8	11.2	13.7	14.4	13.6	11.3
13	9.8	7.6	5.0	6.0	6.4	8.6	11.2	11.2	14.4	14.8	12.7	11.1
14	-	6.9	5.0	5.4	6.1	8.9	10.7	12.0	14.8	14.9	11.6	10.8
15	-	8.0	5.1	5.1	6.6	8.8	11.3	12.8	15.2	14.7	11.8	10.9
16	-	8.2	5.4	5.2	6.4	8.7	11.2	11.8	15.0	14.6	12.5	11.2
17	-	8.4	5.5	5.1	6.0	9.1	11.1	12.0	15.4	14.7	12.5	10.8
18	-	8.3	5.5	5.1	6.2	9.5	10.2	12.7	15.8	14.6	12.3	10.2
19	8.7	8.1	5.5	5.0	6.3	9.7	9.6	13.2	16.8	14.6	12.5	10.2
20	8.7	7.8	6.1	5.3	6.8	9.8	9.8	13.6	16.8	14.5	12.6	
21	9.3	7.4	6.1	5.3	7.0	10.4	9.7	14.0	16.8	14.5	12.8	
22	9.6	7.4	5.1	5.4	7.1	9.8	8.8	13.7	17.2	14.4	12.9	
23	9.8	7.1	5.0	5.3	7.3	9.9	9.5	13.4	17.4	14.5	13.0	
24	9.5	6.4	5.0	5.3	7.6	9.6	9.9	13.6	17.4	14.3	12.9	
25	9.2	6.1	5.0	5.5	7.4	10.6	10.2	13.9	16.5	13.7	12.6	
26	9.2	5.7	5.0	-	8.1	10.8	10.6	13.4	16.3	14.1	12.5	
27	9.1	5.7	5.1	-	8.5	10.0	10.8	13.2	16.2	14.8	12.5	
28	9.4	5.9	5.3	6.0	8.8	9.8	9.9	12.3	15.5	14.5	12.6	
29	9.5	6.6	5.3	6.3	7.7	10.4	10.2	11.5	15.1	14.3	12.8	
30	9.1	6.8	5.5	5.9		10.2	9.3	12.4	16.0	14.5	12.5	
31	8.8		5.2	5.6		10.4		11.8		14.9	12.7	
MEAN	9.8	7.7	5.8	5.5	6.6	9.3	10.7	11.7	14.6	15.1	13.2	11.6
MAX	10.8	9.0	7.5	6.3	8.8	10.8	12.2	14.0	17.4	17.0	14.9	12.7
MIN	8.7	5.7	5.0	5.0	5.1	8.1	8.8	9.3	11.5	13.7	11.6	10.2

TRINITY RIVER NEAR CEDAR FLAT, CA

WATER TEMPERATURE (DEG. C), WATER YEAR OCTOBER 1987 TO SEPTEMBER 1988

LOCATION: On right bank 1.0 mi upstream from Highway 299 bridge across the Trinity River at Cedar Flat near Burnt Ranch, California.

PERIOD OF RECORD: June 9 to July 27; August 8 to September 19

RECORDER: Omnidata DataPod DP112 (App. Eng. Special # 1013) temperature range 5.0 to 30.0 degrees Celcius to the nearest 0.1 degree. (Note: Temperatures below 5.0 degrees are recorded as 5.0 degrees and temperatures above 30.0 degrees are recorded as 30.0 degrees)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	-	-	-	-	-	-	-	-	-	17.3	-	21.1
2	-	-	-	-	-	-	-	-	-	18.6	-	21.2
3	-	-	-	-	-	-	-	-	-	20.2	-	20.8
4	-	-	-	-	-	-	-	-	-	20.6	-	20.7
5	-	-	-	-	-	-	-	-	-	19.5	-	20.6
6	-	-	-	-	-	-	-	-	-	18.6	-	19.7
7	-	-	-	-	-	-	-	-	-	18.7	-	19.4
8	-	-	-	-	-	-	-	-	-	19.9	-	19.4
9	-	-	-	-	-	-	-	-	11.3	20.5	21.7	19.0
10	-	-	-	-	-	-	-	-	11.5	21.0	22.0	18.6
11	-	-	-	-	-	-	-	-	12.6	20.9	21.9	17.7
12	-	-	-	-	-	-	-	-	14.2	20.0	21.2	17.2
13	-	-	-	-	-	-	-	-	14.9	20.2	20.0	17.1
14	-	-	-	-	-	-	-	-	15.9	20.8	19.2	16.9
15	-	-	-	-	-	-	-	-	16.8	20.7	19.2	16.5
16	-	-	-	-	-	-	-	-	17.4	20.7	19.1	16.4
17	-	-	-	-	-	-	-	-	17.2	20.8	19.1	16.0
18	-	-	-	-	-	-	-	-	17.4	21.6	19.2	15.3
19	-	-	-	-	-	-	-	-	18.3	22.7	19.9	14.6
20	-	-	-	-	-	-	-	-	18.9	22.9	20.4	
21	-	-	-	-	-	-	-	-	18.9	23.0	20.7	
22	-	-	-	-	-	-	-	-	18.8	23.0	21.0	
23	-	-	-	-	-	-	-	-	19.2	23.2	21.1	
24	-	-	-	-	-	-	-	-	19.7	23.5	21.1	
25	-	-	-	-	-	-	-	-	19.5	23.6	20.6	
26	-	-	-	-	-	-	-	-	19.0	23.5	20.2	
27	-	-	-	-	-	-	-	-	18.5	23.3	20.4	
28	-	-	-	-	-	-	-	-	18.4	-	20.7	
29	-	-	-	-	-	-	-	-	17.6	-	20.9	
30	-	-	-	-	-	-	-	-	16.8	-	20.7	
31	-	-	-	-	-	-	-	-		-	21.0	
MEAN	-	-	-	-	-	-	-	-	16.9	21.1	20.5	18.3
MAX	-	-	-	-	-	-	-	-	19.7	23.6	22.0	21.2
MIN	-	-	-	-	-	-	-	-	11.3	17.3	19.1	14.6

TRINITY RIVER NEAR WILLOW CREEK, CA
WATER TEMPERATURE (DEG. C), WATER YEAR OCTOBER 1987 TO SEPTEMBER 1988

LOCATION: In Trinity River approximately 2 miles downstream of Willow Creek.

PERIOD OF RECORD: April 25, 1988 to present

RECORDER: Ryan Instruments TempMentor in submersible housing. Recording range -32 to +70 Degrees C to the nearest 0.1 degree

REMARKS: Temperature data provided by the Fish and Wildlife Service, Fishery Assistance Office, Arcata, California. Data recorded at 2 hour intervals. Summarized to mean dailys by Ecological Services Office, Sacramento, California.

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	--	--	--	--	11.7	13.7	19.4	25.4	
2	--	--	--	--	--	--	--	11.7	13.8	20.9	24.8	
3	--	--	--	--	--	--	--	12.3	15.0	21.5		
4	--	--	--	--	--	--	--	12.3	14.5	20.8		
5	--	--	--	--	--	--	--	12.3	13.3	20.0		
6	--	--	--	--	--	--	--	11.8	12.9	19.9		
7	--	--	--	--	--	--	--	11.8	12.7	20.7		
8	--	--	--	--	--	--	--	12.1	12.6	21.5		
9	--	--	--	--	--	--	--	12.1	12.9	22.1		
10	--	--	--	--	--	--	--	13.1	14.0	22.1		
11	--	--	--	--	--	--	--	14.7	15.1	21.5		
12	--	--	--	--	--	--	--	15.1	16.0	21.7		
13	--	--	--	--	--	--	--	14.2	16.9	22.0		
14	--	--	--	--	--	--	--	14.2	17.9	21.9		
15	--	--	--	--	--	--	--	15.2	18.9	21.8		
16	--	--	--	--	--	--	--	15.2	19.0	22.0		
17	--	--	--	--	--	--	--	14.1	18.7	22.7		
18	--	--	--	--	--	--	--	14.1	19.6	23.8		
19	--	--	--	--	--	--	--	15.2	20.3	24.3		
20	--	--	--	--	--	--	--	16.3	20.4	24.5		
21	--	--	--	--	--	--	--	17.3	20.2	24.5		
22	--	--	--	--	--	--	--	17.5	20.5	24.8		
23	--	--	--	--	--	--	--	16.8	20.7	25.1		
24	--	--	--	--	--	--	--	16.0	--	25.2		
25	--	--	--	--	--	--	--	16.1	--	25.3		
26	--	--	--	--	--	--	13.3	16.1	--	25.6		
27	--	--	--	--	--	--	14.3	16.7	--	25.4		
28	--	--	--	--	--	--	13.9	16.2	19.0	24.6		
29	--	--	--	--	--	--	13.0	14.8	18.3	24.5		
30	--	--	--	--	--	--	11.8	14.4	18.4	25.1		
31	--	--	--	--	--	--	--	14.1	--	25.8		
MEAN	--	--	--	--	--	--	13.2	14.3	16.7	22.9		
MAX	--	--	--	--	--	--	14.3	17.5	20.7	25.7		
MIN	--	--	--	--	--	--	11.7	11.6	12.6	19.4		