SALMON RIVER HABITAT ENHANCEMENT

ANNUAL REPORT 1990

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PREFACE

This project, No. 83-359, was funded by the Bonneville Power Administration (BPA) under Contract No. DE-A179-84BP1483. The annual report contains three individual subproject sections detailing tribal fisheries work completed during the summer and fall of 1990. Subproject I contains summaries of evaluation/monitoring efforts associated with the Bear Valley Creek, Idaho enhancement project. Subproject II contains an evaluation of the Yankee Fork of the Salmon River habitat enhancement project. Subproject III concerns the East Fork of the Salmon River, Idaho.

SUBPROJECT I

Bear Valley Creek

Post Construction Evaluation

ABSTRACT

Bear Valley Creek

Fine sediments from an inactive dredge mine in the headwaters of Bear Valley Creek (BVC) contributed to degradation of spawning and rearing habitat of spring chinook salmon (Oncorhynchus tshawvtscha) and steelhead trout (O. mvkiss) in a 55-km section of stream. Major construction efforts targeted at decreasing recruitment of fine sediments in the mined area were completed in the fall of 1988. In 1989 a completed revegetation program finalized enhancement efforts in the mined area. Biological monitoring for evaluation of project efficacy continued throughout the length of BVC in 1990. We monitored physical habitat features only in the mined area and strata directly above and below this area. We also continued an evaluation of floodplain revegetation work in the reclaimed section of stream.

Direct fisheries benefits have been slow to accrue in the reconstructed section of stream. Much of this is the result of recent drought years combined with downstream passage induced mortalities in the Snake and Columbia rivers. This has resulted in little to no adult salmon escapement into upper BVC. However, in 1989 following a year where we counted 12 chinook salmon redds in the reclaimed section of stream we documented extensive rearing by juvenile salmon throughout the summer. This suggests that construction efforts have had a positive effect on salmon production, the full potential of which will not be fully realized until out-of-basin limiting factors are improved.

In 1990 the greatest chinook salmon densities were observed in the middle portion in July of BVC and in the headwaters in September. Mean chinook salmon densities in stratum 3 were 3.6 and 0.6 fish/100m^2 in July and September,. respectively. This corresponds to the area that recently has been used by adults for spawning during low escapement years. In stratum 7, the section of stream directly above the mined area, we noted a mean September chinook salmon density of 2.3 fish/100m^2. Main channel salmon densities in this stratum were low in July when most fish were probably using slough habitat in this vicinity.

The greatest benefit of the project to the stream's physical character has occurred in the composition of subsurface fine sediments. In the mined area subsurface fines have significantly decreased from 35.6% in 1987 to 28.7% in 1990. Sediment levels have been similar among years since 1987 and probably will not decrease much more until a spring runoff with extensive flushing flows is experienced. Sediment levels in the stratum below the mined area have also decreased from 45.4% in 1987 to 35.1% in 1990. Surface embeddedness values for the mined area and stratum 5 directly downstream were similar at 44.2% and 46.5%, respectively. These embeddedness values were significantly less than the undisturbed upstream stratum (stratum 7) where embeddedness was estimated at 38%.

Recovery of floodplain vegetation, measured as percent plant cover, has shown little improvement from 1989 to 1990 in plots seeded in three different years (1986-1988). In 1990 total plant cover **was the same in 1986 and 1987 seeded plots at 27.1% and was much less in the 1988 seeded plot at 12.8%.**

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INTRODUCTION

Bear Valley Creek (BVC), a major tributary of the Middle Fork of the Salmon River, is a spawning and rearing stream for wild stocks of spring chinook salmon (Oncorhvnchus tshawvtscha) and steelhead trout (O. mvkiss). Redd counts that exceeded one thousand per year in the mid-1950's have decreased to less that 50 per year in the early 1980's (Schwartzberg and Roger 1986). Fish passage problems with downstream migrating juveniles and upstream migrating adults, ocean and river harvest, and regional habitat degradation due to adverse land use practices are the principal causes that have led to a declining salmon population in the Salmon River subbasin.

Dredge mining (mid- and late-1950's) in Bear Valley, near the BVC headwaters, left the stream meandering and downcutting through 2.3 km of unconsolidated mine spoils. An estimated 500,000 cubic meters of fine material were gradually deposited into the stream over a thirty-year period as a result of this floodplain disturbance. The increased sediment loading into Bear Valley Creek severely degraded the aquatic habitat throughout its entire length. Spawning riffles were covered with layers of fine materials while rearing pools filled with sand.

Enhancement efforts were targeted at abating future sediment recruitment from the mined area. The goal of this project was to stabilize sediment sources and reduce sediment input from those stream reaches within the mined area contributing the most sediment into Bear Valley Creek, and to restore the floodplain alongside these reaches. It was estimated that 90% of the sediment problem occurred within four stream reaches (J. M. Montgomery 1985).

Construction activity began in September of 1985 and was completed in early summer of 1989. In the intervening years, implementation and construction occurred during the summer and fall of 1986 through 1988. Construction was finished in October of 1988. The revegetation effort began in 1987 and was completed in early summer of 1989.

The Shoshone-Bnnock Tribes monitoring and evaluation of the project has been ongoing since baseline data collection was first collected in summer and fall of 1984. The monitoring and evaluation program was established to assess post-treatment effects of enhancement activities on the fish community and physical habitat. Future monitoring/evaluation programs will continue to evaluate the effectiveness of the Bear Valley Creek Enhancement Project using our baseline information. As newly acquired and acceptable methods of monitoring and evaluating fisheries habitat becomes available, these will be used to meet the needs of this project.

STUDY AREA

Bear Valley Creek located in Valley County, Idaho, flows northwest for 54.5 km to its confluence with Marsh Creek to from the Middle Fork of the Salmon River (Figure 1). The stream was sub-divided into seven sampling strata based on physiographic features (Konopacky et al. 1986). BVC is generally a low to medium gradient system (0.2% and 1.5% in strata 5 and 7, respectively)

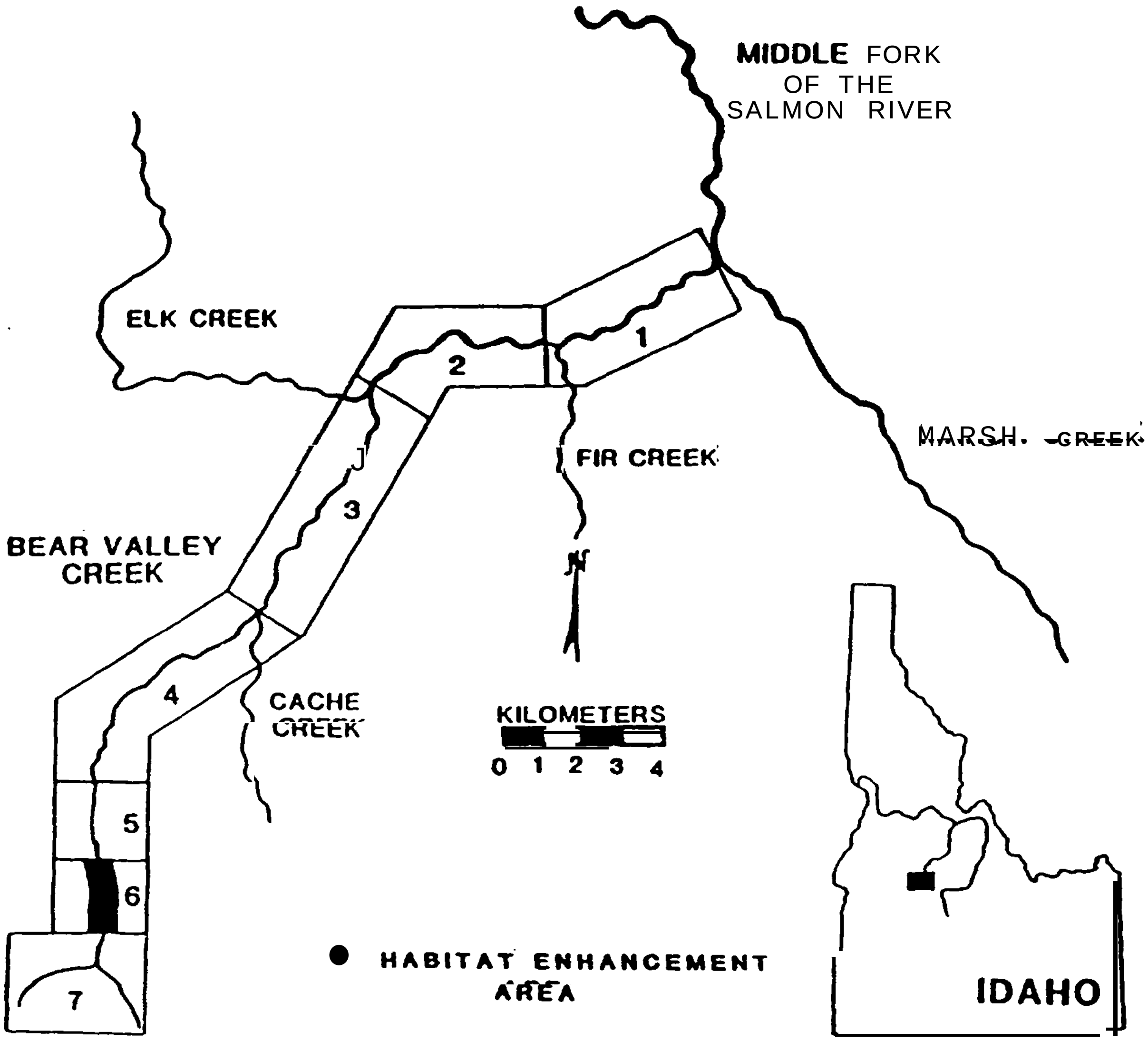

Figure 1. Bear Valley Creek, Idaho, study area and strata location.

that meanders through sub-alpine meadows and lodgepole pine (Pinus contorta) forests in a granitic batholith. Alluvial deposits of highly erosive sandy soils typify the region. All land in the Bear Valley Creek drainage is under federal ownership as part of the Boise National Forest. Current uses in Bear Valley include system-wide livestock grazing and recreation.

METHODS

Stream Habitat

The biological and physical variables measured in 1990 are presented in Table 1. The monitoring of physical variables in Bear Valley Creek was confined to strata 5, 6, and 7 in August of 1989 (Rowe et al. 1990) and repeated in August of 1990 for comparative purposes. Enhancement efforts were concentrated in stratum 6 (Figure 1), the reclaimed stream reach, and any measurable physical response should first be detected in this stratum and immediately downstream in stratum 5. Stratum 7 is located above the reclaimed stream reach and was not affected by the mining operation. As such stratum 7 serves as a control for analytical and comparative purposes when viewing change over time within a stratum and between strata.

Past monitoring of physical variables was conducted throughout the length of Bear Valley Creek in 1984 and 1985 (Konopacky et al. 1986) and in 1987 and 1988 (Richards and Cernera 1988; Richards et al. 1989). This baseline data, collected during the early years of the project from the lower strata of BVC, serves as a benchmark to measure any future changes in these strata.

Table 1. Physical and biological variables measured in strata 5, 6, and 7 of Bear Valley Creek, Idaho, 1990.

Physical	Biological
Pool Area	Fish
Pool Width	Species Composition
Maximum Pool Depth	Relative Abundance
Average Pool Depth	Densities
Pool Bank Angle	Chinook Salmon Abundance
Riparian Cover	Chinook Salmon Redd Counts
Absolute (cm)	
Percent of Stream Width	Floodplain
Riffle Area	Percent Vegetation Cover
Riffle Substrate Composition	Species Composition
Core Analysis	
Cobble Embeddedness	

Statistical comparisons of physical variables were made among strata and years using two-way analysis of variance (2-way ANOVA) and within a stratum among years using l-way ANOVA. All tests were run in the software statistical analysis package STATGRAPHICS, version 2.6. Variables were measured in one riffle-pool complex at seven systematically determined sites in strata 5 and 7, and at 11 sites in stratum 6. Riffle-pool sites and strata delineation were the same as those utilized in 1987 (Richards and Cernera 1988). Surface area and mean width of pools, maximum pool depth, and riparian and undercut bank cover were measured using methods outlined in Richards and Cernera (1988). Average pool depths and stream bank angle measurements were taken in all sites of strata 5, 6, and 7 in August of 1990. Biologists equipped with a 30-meter Lietz measuring tape and a meter stick measured depths to the nearest centimeter at three depths (1/4, 1/2, and 3/4 of the stream width) per transect across each pool. Average depths were calculated by summing the depths and dividing by four to account for the zero water depth at the stream's edge. Stream channel-bank angle (degree) measurements were taken on both sides of each transect. Measurements were taken using a clinometer. and a measuring rod. An undercut angle was determined directly from the clinometer placed on top of the rod as it formed the angle determined by the protruding edge of the bank to the midpoint of the undercut on the transect. If banks were not undercut, then angles were determined by placing the clinometer on the top of the measuring rod that is aligned parallel to the streambank along the transect. The clinometer reading was then subtracted from 180° to get the bank angle. Average bank angles were calculated from these measurements taken in each pool-riffle site.

Substrate

McNeil core samples were taken in August of 1990. In previous years, 1987-1989, we collected two core samples in the pool tail at each site of strata 5, 6, and 7. In an attempt to reduce sampling variability, three core samples were taken at each site of strata 5 and 6, and two cores per site in stratum 7 in 1990. Coring methods followed procedures described in Richards and Cernera (1988). Statistical analysis was performed on combined percentages (arcsine transformed) of fine particles (150 um and 850 urn). Comparisons of fine sediments were made between strata 5, 6, and 7 for 1990 and within a stratum among years (1987-1990) using ANOVA.

In 1990, we initiated the "Hoop Method" (Burns and Edwards 1985) for measuring cobble embeddedness. The hoop method measures surface substrate embeddedness. Three 60-cm stainless steel hoop samples were randomly located in pool tails where McNeil core samples were taken. All samples were taken during base flow in August and water depth never exceeded 45 cm. Within each hoop the degree of embeddedness of all rocks between 4.5 and 30 cm was measured. Substrate particles less than 6.35 mm (0.25 in.) were the criteria used to classify embedding materials. Three measurements were taken on each embedded rock. Depth of embeddedness (De) and total depth (Dt) were measured to the nearest mm perpendicular to the plane of embeddedness. The maximum length of each rock (Dm) was also measured. Rocks not embedded, those lying freely on the surface, were measured for Dm only with the De being zero. To calculate the percent embeddedness for each sample the sum of De is divided by the sum of Dt and multiplied by 100. If more than ten percent of the hoop was all fine particles (<6.35 mm) without any rocks showing, we used a weighted embeddedness value. Without weighting the value for fine particles, the hoop method underestimates embeddedness. The weighted value was calculated using the equation:

$$\%\ \text{weighted embeddedness} = \frac{(\%\ \text{fines} \times 100) + (\%\ \text{embeddedness} \times 100)}{100}$$

For analytical purposes the embeddedness data were arcsine transformed and compared among strata using one-way ANOVA.

In addition to surface embeddedness percentages derived from our hoop samples, we also calculated the amount of vertically exposed rock for each hoop. This calculation was expressed as the sum in meters of Dt-De for the entire hoop- area (Skille and King 1989) divided by the area of our hoop ($0.47 m^2$). The resulting quotient gave us the "Interstitial Space Index" (ISI) (Kramer 1989). The IS1 (m/m^2) is an indicator of the amount of interstitial space available for living organisms.

Fish Densities

Fish densities were assessed in all strata of Bear Valley Creek during the first week of both July and September. Flow conditions during this period were optimal for discerning pool-riffle habitat and for fish observation. Observations were conducted by divers equipped with snorkel and mask following techniques outlined in Platts et al. (1983). All pre-established sites, which were representative of the habitat found in each of the seven strata, were snorkeled and inventoried. Individual fish species were noted and enumerated. All observations were conducted between 1100-1500 hours when visibility was greatest. Abundance of age 0+ chinook salmon by strata was estimated utilizing mean and variance values derived from snorkel surveys using techniques outlined in Mendenhall et al. (1979). Individual species densities were compared between sessions and among strata using two-way ANOVA; an alpha level of 0.05 was used for the significance criterion. When a main effect term was significant, Tukey's multiple range test was applied to discern where the difference occurred.

Redd counts were conducted in late August and early September by ground survey. Biologists, equipped with polarized lenses for increased observer efficiency, walked the entire length of BVC (except stratum 1) and surveyed for redd abundance and distribution.

Floodplain Monitoring

Vegetative monitoring, begun in 1989 to establish the contribution to floodplain cover from seedings and natural recruitment, was continued in 1990. Three distinct sample units were defined by seeding year-1986, 1987, and 1988. Six 100-foot transects were set parallel to the stream channel in each sample unit. Sampling consisted of identifying plants to genus and measuring, to the nearest tenth of a foot, the amount of basal diameter cover directly on the transect. From these measurements we calculated percent cover contributed by each genus, total percent vegetative cover, and species composition for each transect and each sample unit. Total percent cover values were arcsine transformed and statistical comparisons were made among sample units and between sample year using one-way ANOVA.

RESULTS AND DISCUSSION

Stream Habitat

There has been little change in physical habitat in Bear Valley Creek in the last four years based on the variables we measured. Only percent pool cover was significantly different among years (Table 2 and 3). Physical habitat variables among strata were significantly different.

It was suggested in our report last year that strata delineation was based on measurable physical differences in stream habitat. The significant differences found among strata for all physical habitat parameters monitored among years confirms this (Table 3). Our decision to make comparisons of physical variables within a stratum to detect change over time was based on this information.

Pool depths were more similar in strata 6 and 7 than in stratum 5. There was no significant difference in maximum pool depths in strata 6 or 7 between 1989 and 1990. In 1990, for example, maximum pool depths in stratum 6 averaged 47.5 cm and

Table 2. Mean and standard error (parentheses) for physical variables monitored in 1987-90 for strata 5, 6, and 7 of Bear Valley Creek.

VARIABLE	STRATUM	Year 1987	1988	1989	1990
Pool area (m^2)	5	133.5 (17.8)	106.3 (23.6)	123.3 (19.1)	141.1 (22.8)
	6	119.6 (19.6)	57.7 (11.8)	76.9 (12.7)	83.0 (14.9)
	7	43.3 (16.3)	31.8 (13.8)	46.2 (18.5)	32.9 (10.6)
Riffle area (m^2)	5	27.7 (6.6)	25.5 (4.7)	26.1 (6.3)	*
	6	126.8 (33.6)	122.2 (37.9)	99.3 (33.3)	*
	7	8.7 (2.2)	9.9 (2.9)	15.6 (4.3)	*
Pool width (m)	5	5.4 (0.3)	5.1 (0.3)	5.7 (0.2)	5.1 (3.1)
	6	5.2 (0.3)	5.3 (0.3)	5.6 (0.3)	4.7 (0.3)
	7	2.9 (0.5)	2.6 (0.5)	2.7 (0.5)	2.5 (6.4)
Pool cover (cm)	5	41.5 (5.5)	35.4 (6.1)	55.2 (8.7)	33.4 (4.0)
	6	24.8 (8.3)	28.8 (9.7)	39.8 (12.8)	14.8 (3.9)
	7	72.9 (9.4)	88.5 (15.6)	70.6 (12.8)	41.5 (7.4)
Pool cover (%)	5	9.0 (1.2)	7.1 (1.3)	9.9 (1.7)	6.5 (0.8)
	6	6.0 (2.3)	6.0 (2.3)	7.3 (2.7)	3.1 (0.7)
	7	37.1 (7.7)	40.6 (11.5)	35.8 (9.7)	19.6 (4.1)
Pool depth maximum (cm)	5	82.0 (6.7)	79.0 (7.9)	106.7 (6.9)	116.6 (4.2)
	6	46.0 (8.6)	46.3 (10.3)	47.9 (9.6)	47.5 (7.4)
	7	48.0 (9.2)	54.4 (9.6)	44.9 (6.5)	41.3 (8.5)
Pool depth average (cm)	5	*	*	*	56.1 (3.2)
	6	*	*	*	22.8 (3.2)
	7	*	*	*	30.6 (6.7)
Bank angle average (deg.)	5	*	*	*	112.7 (5.3)
	6	*	*	*	146.5 (4.9)
	7	*	*	*	[illegible] 5.2)

* = not sampled

Table 3. Two-way analysis of variance (ANOVA) comparing physical variables among years (1987-1990) and strata (5, 6, and 7), Bear Valley Creek, 1990. Independent variables were strata and year; the dependent variable was each physical habitat measure. The alpha level was set at 0.05 and a significant difference is noted by an asterisk.

VARIABLE	SOURCE	DF	F VALUE
Pool area (m^2)	Year	6	1.15
	Stratum	2	33.45 *
	Year * Stratum	12	0.31
Riffle area (m^2)[1]	Year	5	0.43
	Stratum	2	35.06 *
	Year * Stratum	10	0.75
Pool width (m)	Year	6	1.02
	Stratum	2	112.64 *
	Year * Stratum	12	0.55
Pool cover (%)	Year	6	2.28 *
	Stratum	2	93.90 *
	Year * Stratum	12	1.44
Pool max. depth (cm)	Year	6	1.62
	Stratum	2	104.56 *
	Year * Stratum	12	1.18

[1] = Riffle data was not collected in 1990.

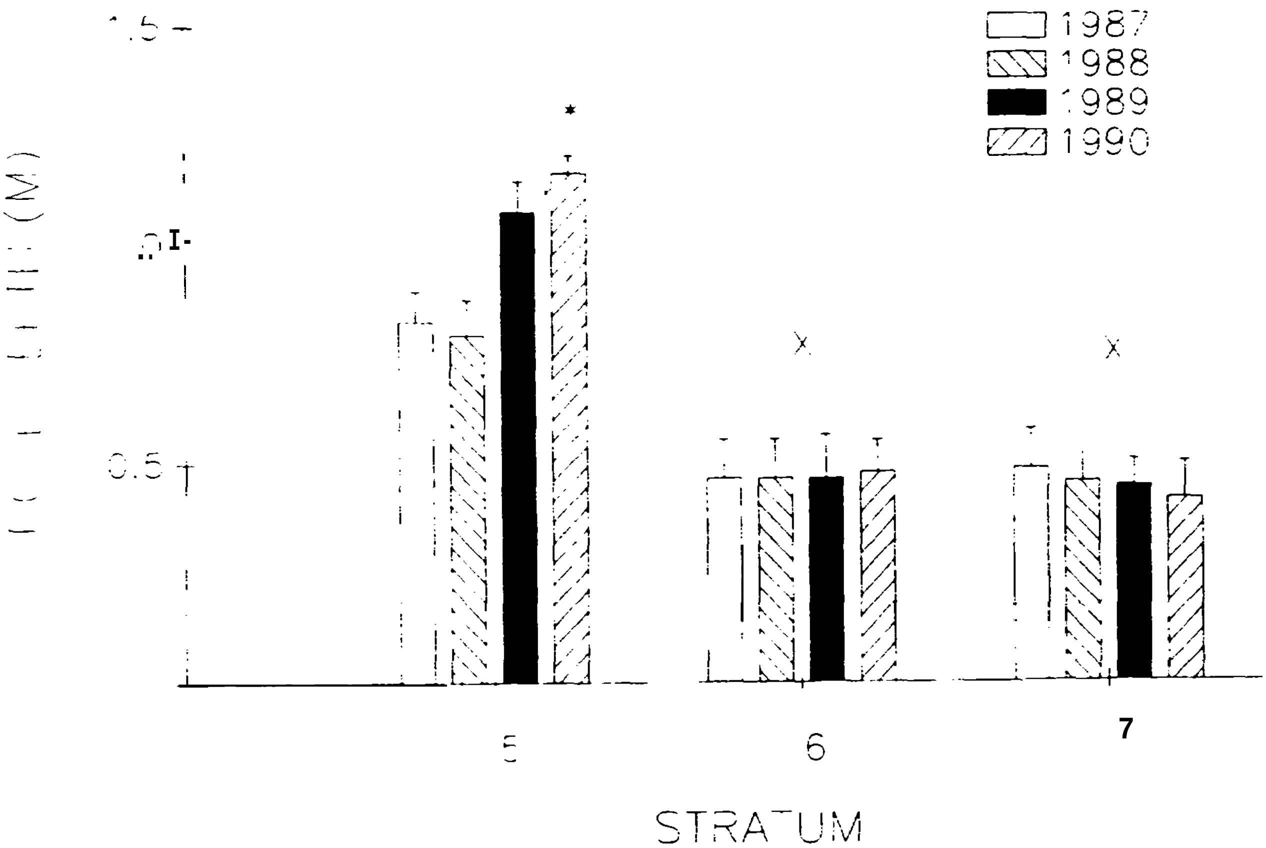

Figure 2. Mean maximum pool depths among years (1987-1990) and strata (n=7 for strata 5 and 7, and n=11 for strata 6) in Bear Valley Creek. A common letter indicates no significant (P>0.05) difference betweenmeans with that letter. An asterisk indicates a significant (P≤0.05) difference between means within a stratum. Error bars represent 95% confidence intervals of the mean.

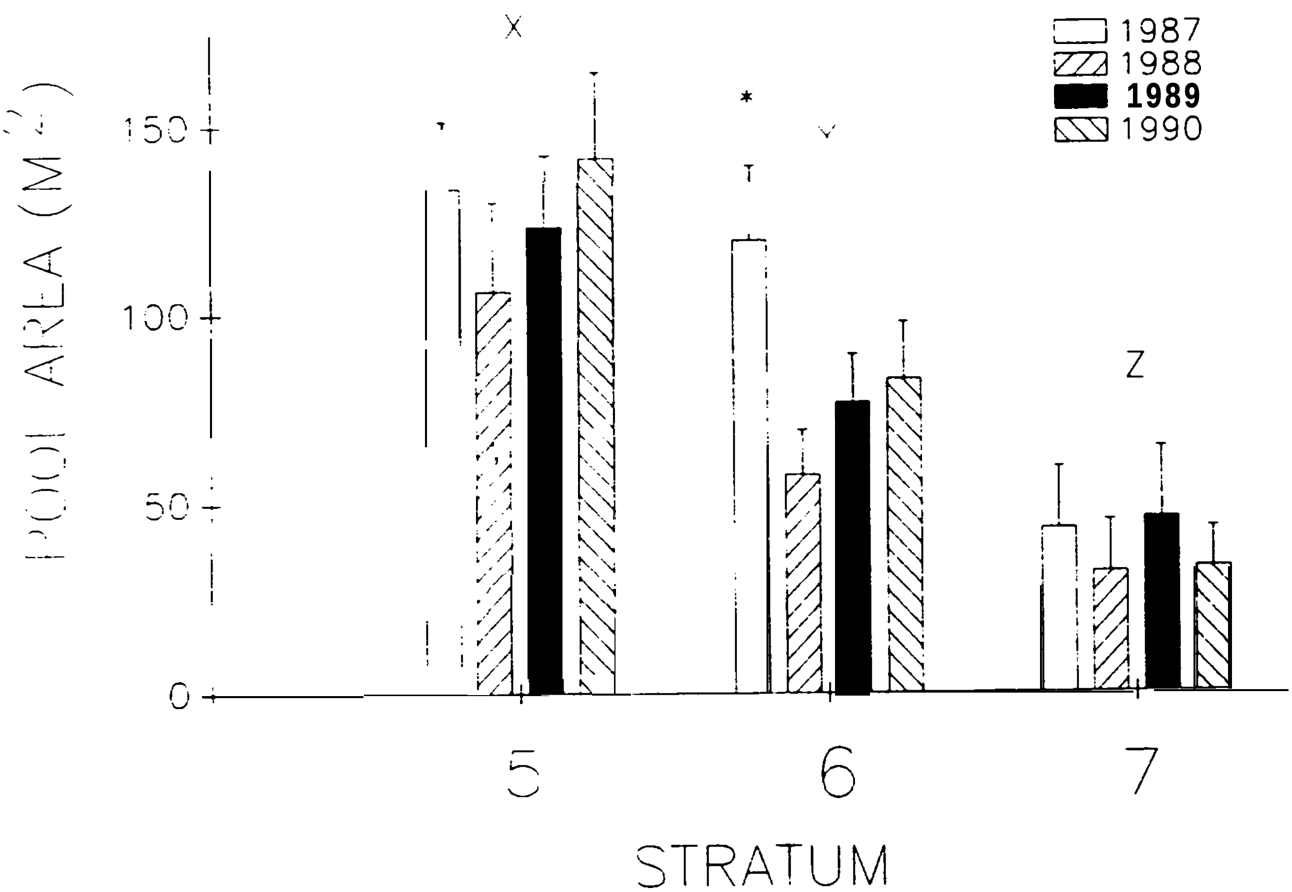

Figure 3. **Mean pool areas among years (1987-1990) and strata (n=7 for strata 5 and 7 and n=11 for stratum 6) in Bear Valley Creek. A common letter indicates no significant (P>0.05) difference between means with that letter. An asterisk indicates a significant (P<0.05) difference between means within a stratum. Error bars represent 95% confidence intervals of the mean.**

41.3 cm in stratum 7. Maximum pool depths in stratum 5, however, were significantly different among years increasing from 79 cm in 1988 to 116.6 cm in 1990 (Table 2, Figure 2). Average pool depth, a measure taken in 1990, was also similar in strata 6 (22.8 cm) and 7 (30.6 cm) compared to stratum 5 (56.1 cm) (Table 2).

Pool areas were significantly different between strata (Table 3) but, in general, were not significantly different within a stratum among years. Greatest pool area was found in stratum 5 and the lowest amount of pool area was in stratum 7. No significant change in pool area has occurred in strata 5 or 7 in the four years of sampling. Only in stratum 6 did we note a significant change in pool area from 1987 to 1990. Pre-construction pool areas in the project area averaged 119.6 m^2 in 1987 (Table 3). These areas dropped significantly to 57.7 m^2 in 1988. Since 1988 there is a trend towards increasing pool area in both stratum 5 and 6 (Figure 3).

Pool cover, both absolute and as a percent, decreased in all three strata between 1989 and 1990 (Figure 4). The fact that this decrease was observed in all three strata leads us to believe that it was drought related and possibly caused by a lowering of the water table.

Pool cover percentages were far less in strata 5 (6.5%) and 6 (3.1%) compared to stratum 7 (19.6%) in 1990. Stratum 7 has narrower pool widths (Table 2) and is well forested. Pools in both strata 5 and 6 are in open meadow vegetation communities with greater widths which renders the riparian area less effective as a cover component.

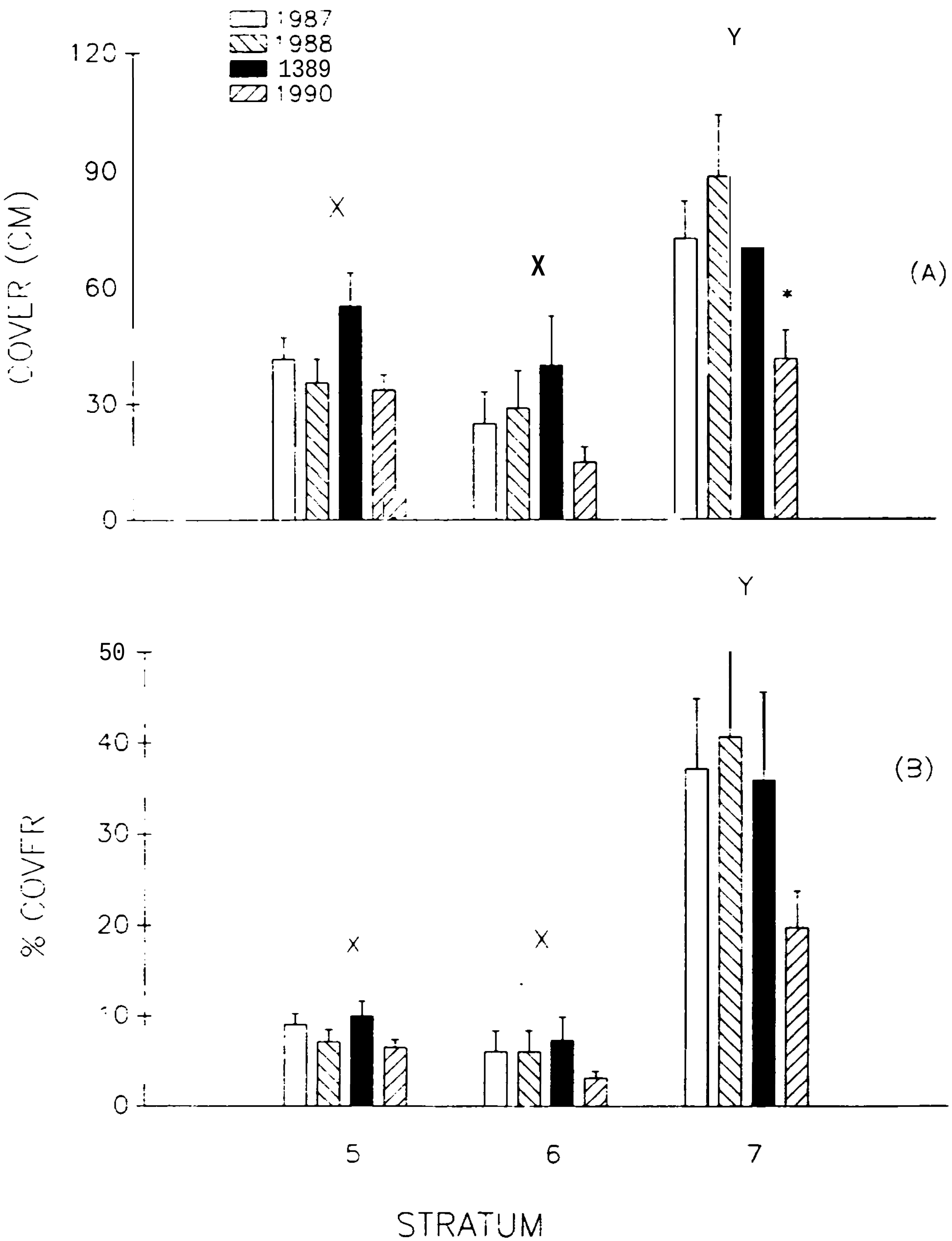

Figure 4. Absolute (A) and mean percent (B) pool cover found in strata 5 **(n=7)**, 6 **(n=11)**, and 7 **(n=7)** among years **(1987-1990)**, Bear Valley Creek. A common letter indicates no significant **(P>0.05)** difference between strata with that letter. An asterisk indicates a significant **(P≤0.05)** difference from other means within a stratum. Error bars represent 95% confidence intervals of the mean.

There was a significant difference observed among strata for stream channel bank angles in 1990. Strata 5 and 7 had similar values of 112.7 and 93.0 respectively compared to strata 6 at 146.5 (Table 2). Most stream banks in stratum 6 slope down to the waters edge and are not undercut. Bank development is expected to increase with time as riparian vegetation increases and stabilizes the stream channel.

There has been little change in physical habitat in Bear Valley Creek in the last four years based on the variables we measured. The region has experienced several consecutive years of drought and with a normal water year we would expect to see more pronounced changes in stream habitat in the project area.

Substrate Analysis

There has been relatively little change in substrate particle size distribution from McNeil core samples taken in strata 5, 6, and 7 between 1989 and 1990 (Figure 5). A significant difference was found in stratum 7 with an increase in the percentage of fine particles (<4.75 mm) observed between 1989 and 1990 (Figure 6, Table 4). The percentage of fine sediments has increased to 25.3% from 19.6% and can be attributed to sampling error or an annual fluctuation in fine sediment recruitment and accumulation. Percent of fine sediment in stratum 6 remained stable between 1989 and 1990 at 28.7% and 29.5%, respectively. This trend also was observed in stratum 5 with fine particle percentages about the same from 1989 (37.7%) to 1990 (35.1%).

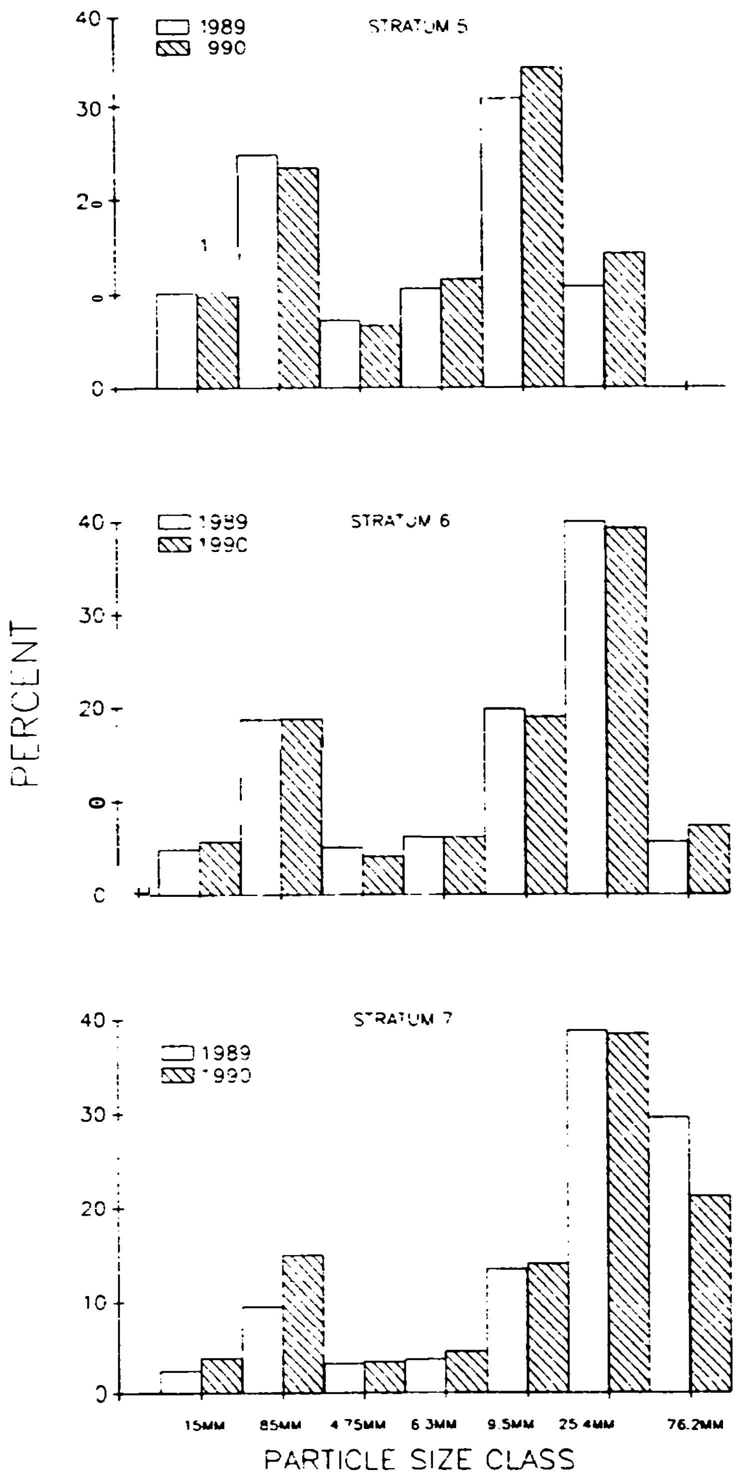

Figure 5. Core substrate particles size distributions for strata 5 (n=7), 6 (n=11), and 7 (n=7), of Bear Valley Creek in 1989 and 1990.

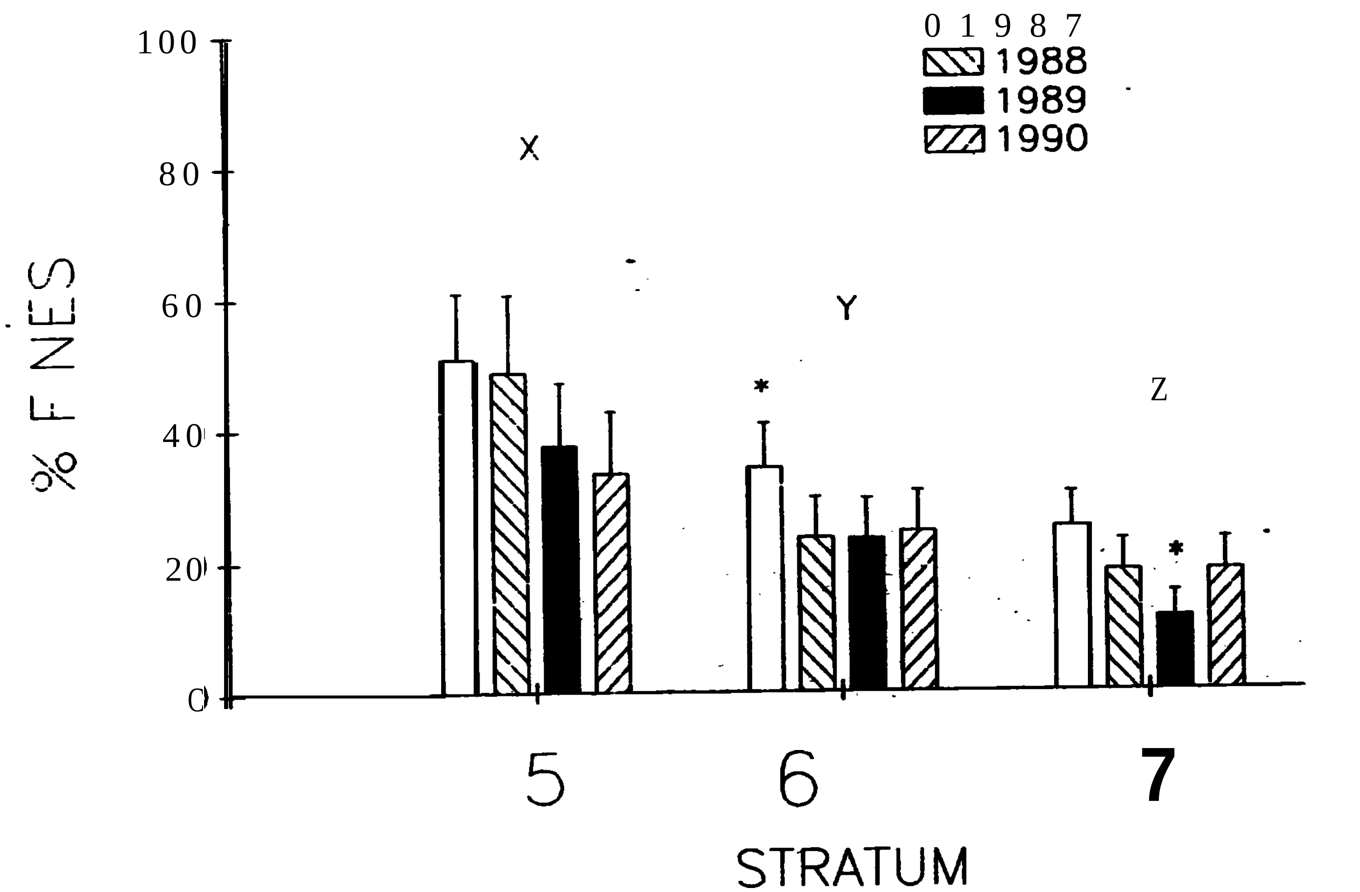

Figure 6. Percent fine sediment (0.15 mm and 0.85 mm size classes combined) found in core samples taken in strata 5 (n=7), 6 (n=11) and 7 (n=7) of Bear Valley Creek from 1987-1990. A common letter indicates no difference (P>0.05) between means with that letter. An asterisk indicates a significant difference from other means within a stratum. Error bars represent 95% confidence intervals of the mean.

Table 4. Summary of one-way analysis of variance (AWOVA) using arcsine transformed values of percent fines (0.15 and 0.85 mm size classes combined) in core samples for strata 5, 6, and 7 of Bear Valley Creek. The years 1987-1990 were the non-metric independent variables. An asterisk denotes significant difference among years at an alpha level of 0.05.

VARIABLE	SOURCE	D.F	MEAN SQUARE	F-RATIO
Stratum S	Between	2	166.95	2.63
	Within	16	63.53	
Stratum 6	Between	2	119.40	3.41 •
	Within	30	34.98	
Stratum 7	Between	2	123.73	9.15 *
	Within	18	13.52	

Table 5. Wean and standard deviation (parentheses) for maximum cobble diameter (cm) and cobble numbers per hoop sampled in strata 5, 6, and 7 in Bear Valley -Creek, 1990. Interstitial space index (m/m^2) and standard deviation (parentheses) for the three strata are also presented.

STRATUM	n	MEAN COBBLE DIAMETER	COBBLE NO. /SAMPLE	I S 1
5	21	4.86 (0.94)	35.71 (15.69)'	1.07 (0.14)
6	29	6.33 (1.92)	59.96 (19.37)	2.45 (0.20)
7	17	8.38 (3.58)	48.52 '(12.50)	2.92 (0.25)

A much greater decrease in fine sediments was noted in both strata 5 and 6 between 1987 and 1989 immediately after completion of construction in 1988 and elimination of the area as an above normal source of sediment. This decrease was significant for stratum 6 values (Figure 6). Levels of fine particles in stratum 6 were estimated at 35.6% in 1987. By 1989 levels dropped to 20.7%. A large decrease also occurred in stratum 5 with levels of fine particles estimated at 45.4% in.1987 dropping to 35.1% in 1990; this decrease, however, was not significant (P=0.07). Any further decreases in the percentages of fine particles in strata S and 6 may well depend on whether the region receives normal snowpack and spring conditions that will effectively contribute to channel altering flows.

We observed a significant (P<0.05) difference among strata for percent cobble embeddedness in 1990. Stratum 6, the project area, and stratum S directly downstream had similar embeddedness values of 44.2% and 46-5%, respectively. Stratum 7, which was undisturbed by the mining activity, had a lower embeddedness value of 38,0%.

The Interstitial Space Index (ISI) for stratum 5 differed significantly from strata 6 and 7 (Table 5). Pool tails in strata 6 and 7 had greater amounts of cobble between 4.5 and 30 cm than did pool tails in stratum 5 andboth strata had larger mean cobble diameters than did stratum 5. Consequently, the ISI's for both strata 6 and 7 were larger indicating that more interstitial space in the substrate was available for the biota.

Kramer (1989), in stream sediment studies using the hoop method, found that as percent of cobble embeddedness increases, ISI generally decreases. This is consistent with our data where we found a negative correlation (r^2=0.35, $P<0.05$) between the two measures.

We have seen much greater changes in sediment levels in the substrate than changes in stream habitat. Analysis of 1990 wring data indicate fine sediments decreased in stratum 6 from 1987 levels. Levels of fine particles have also decreased in stratum S since 1987 but percentages still remain higher than those in stratum 6. Bear Valley Creek meanders considerably through stratum S and an enormous quantity of fine sand has accumulated in most of the pools. Consequently, percentages of fine sediments and surface embeddedness estimates are higher than stratum 6.

Floodplain Evaluation

Recent years of below normal snowpack have resulted in below average spring flows. Concurrent with these reduced flows has been a lowering of the water table. As floodplain vegetation is highly dependent on the water table for moisture any lowering of the water table will affect plant growth. In addition lower spring flows result in less accumulation of silt and organic matter on the floodplain which add fertility and- improve the moisture storing potential of the soils. Currently, the reconstructed floodplain is essentially composed of coarse grantic material.

Our data seem to indicate that better moisture and soil conditions may be necessary for,additional increases in cover values on the floodplain. From our 1990 sampling,- total-percent cover from the plot seeded in 1988 remains significantly lower than

1986 or 1987 plots (Table 6). Whereas total percent cover in the 1987 plot was 26.5% after two years of growth, for a similar amount of time the total percent cover was only 12.8% for the 1988 plot. The total percent cover for the 1987 plot was virtually unchanged between 1989 and 1990. while in the.1986 plot, the total percent cover decreased slightly for the same time period.

All three plots were seeded with a wet-seed mixture, primarily' grasses, and this vegetation type comprised the majority of the relative percent cover on the floodplain. Graminoids represented 96.5% of the relative cover in the 1986 plot, 95.1% in the 1987 plot and 98.5% in the 1988 plot. We do not expect this trend to change much over time.

Physical Habitat Summary

In the two years following completion of construction activities in Bear Valley Greek there have been some notable changes. Sediment recruitment and deposition into the stream from pre-construction mine spoils has been virtually eliminated. Attempts at establishing a riparian plant community on the reconstructed floodplain have met with some success: Vegetative cover on the floodplain from seedings and willow'plantings has gradually increased with time. Measurable changes since reclamation in other physical stream habitat components have been small.

Table 6. Relative percent cover by plant type and mean percent and standard error (parentheses) of the total cover for sections of stratum 6 seeded during 1986, 1987, and 1988. and sampled in 1989 (n=19) and 1990 (n=18) in Bear Valley Creek.

	YEAR SAMPLED					
	1989			1990		
	Year Seeded			Year Seeded		
Species	1986	1987	1988	1986	1987	1988
Achillea millefolium	0.5	2.5		0.1	1.1	
Agrostis spp.				0.1	0.05	
Agropyron spp.	20.3	0.8	22.6	3.1	1.3	26.5
Arabis drummondii		0.7	3.2		0.5	1.0
Bromus inermis		2.4	10.1			0.8
Bromus tectorum			3.4			
Carex aquatilis	0.3			0.7		
Circium spp.	0.1					
Dactylis glomerata		5.2	5.7	22.6	10.6	12.5
Descarania spp.	0.5	0.9	3.6			
Frageria virginiana		0.1				
Festuca spp.				0.1	12.7	7.7
Lupinus spp.				0.05		
Muhlenbergia spp.	0.1					
Penstemon globosus	0.4	1.5				0.3
Phleum pratensis	5.5	11.1	38.2	13.4	19.6	43.0
Pinus contorta				0.25		
Poa pratensis	64.1	73.9	12.9	57.2	50.9	8.0
Salix scrouleriana	8.2		0.4	0.5	0.25	
Trifolium hybridum		0.9			3.0	0.2
% Total Cover	34.6 (6.5)	26.5 (4.6)	8.4 (3.3)	27.1 (1.43)	27.1 (3.93)	12.8 (1.15)

Fish Evaluation

Densities

We found significant differences in densities of various salmonids among strata and between sessions during-1990, There was a significant difference ($P<0.05$) in densities of age-O+ chinook salmon and age-O+ and older whitefish (Prosopium williamsoni) among strata (Table 7). Densities of age-O+ steelhead trout and age-O+ and older whitefish differed significantly ($P<0.05$) between sessions and there was an interaction effect between stratum and session for age-O+ steelhead trout and age-O+ whitefish.

Mean total fish densities were low in 1990. The densities (0.1-3.0 fish/100m^2) during session- 1 were similar to' what we observed during session 1 in 1989 (0.1-3.4 fish/100m^2). Total fish densities were relatively unchanged (O-1-3.3 fish/100m^2) during session 2 in 1990. The highest total fish densities wue observed in the upper two strata (6 and 7) during both sessions (Table 8).

Age. 0+ Chinook Salmon

Chinook salmon distribution was contagious throughout the length of Rear Valley Creek. There was a significant difference in age-O+ chinook salmon densities among strata but not between Sampling periods (Table 7). In early July, we found the highest mean of age-O+ chinook salmon density in stratum 3 (3.6 fish/100m^2) (Figure 7). High densities of age-O+ chinook salmon had been observed in stratum 3 in 1988 (Richards et al. 1989) and in 1990 (Rowe et al. 1990). This section of Bear Valley Creek offers good

Table 7. Two-way analysis of variance 'for fish densities by species comparing densities among strata and between sessions (July and September), Bear Valley Creek, 1990. An asterisk next to a probability value denotes significance at the $P<0.05$ level.

SPECIES BY AGE CLASS	SOURCE	DF	F VALUE	PROBABILITY
[illegible] Chinook	Stratum	6	2.7	0.01 •
	Session	1	0.8	0.37
	Stratum • Session	6	3.0	0.01 •
Age-O+ Steelhead	Stratum	6	1.8	0.09
	Session	1	6.7	0.01 •
	Stratum * Session	6	2.3	[illegible] •
Age-O+ Whitefish	Stratum	6	3.0	0.01 •
	Session.	1	7.6	0.00 *
	Stratum • Session	6	3.6'	0.00 *
Age-l+ Whitefish	Stratum	6	6.4	[illegible] •
	Session	1	7.0	0.01 •
	Stratum • Session	6	1.7	0.13

Table 8. Mean total fish densities (fish/100m^2) by session and strata.

STRATUM	CHS YOY	STH YOY	STH A&B	WHF YOY	WHF J W	WHF AD	BKT ALL	OTH SPP	TOTALS
	Density by Species								
	Session 1 (July)								
1	0.5	0.3	1.6	0.0	0.1	0.8	0.5	0.2	0.5
2	0.1	0.0	0.0	1.2	0.0	2.7	2.9	0.1	0.8
3	3.6	0.0	0.2	1.8	0.0	0.0	0.8	0.4	0.8
4	1.0	0.0	0.0	0.5	0.0	0.0	0.6	0.0	0.2
5	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.1
6	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1
7	0.1	0.0	0.1	0.0	0.0	0.0	1.6	13.3	3.0
	Session 2 (September)								
1	0.0	0.0	0.0	0.0	0.1	3.1	0.0	0.1	0.4
2	0.0	0.7	0.0	0.0	0.0	7.3	0.0	0.3	1.0
3	0.4	2.5	0.1	0.0	0.0	3.4	0.1	0.0	0.8
4	0.6	0.2	0.1	0.0	0.0	0.6	1.1	0.0	0.3
5	0.0	0.0	0.0	0.2	0.6	0.0	0.1	0.1	0.1
6	0.3	0.6	1.2	18.0	0.0	0.0	6.1	0.2	3.3
7	2.3	0.3	2.8	9.6	0.0	0.0	1.7	5.3	2.7

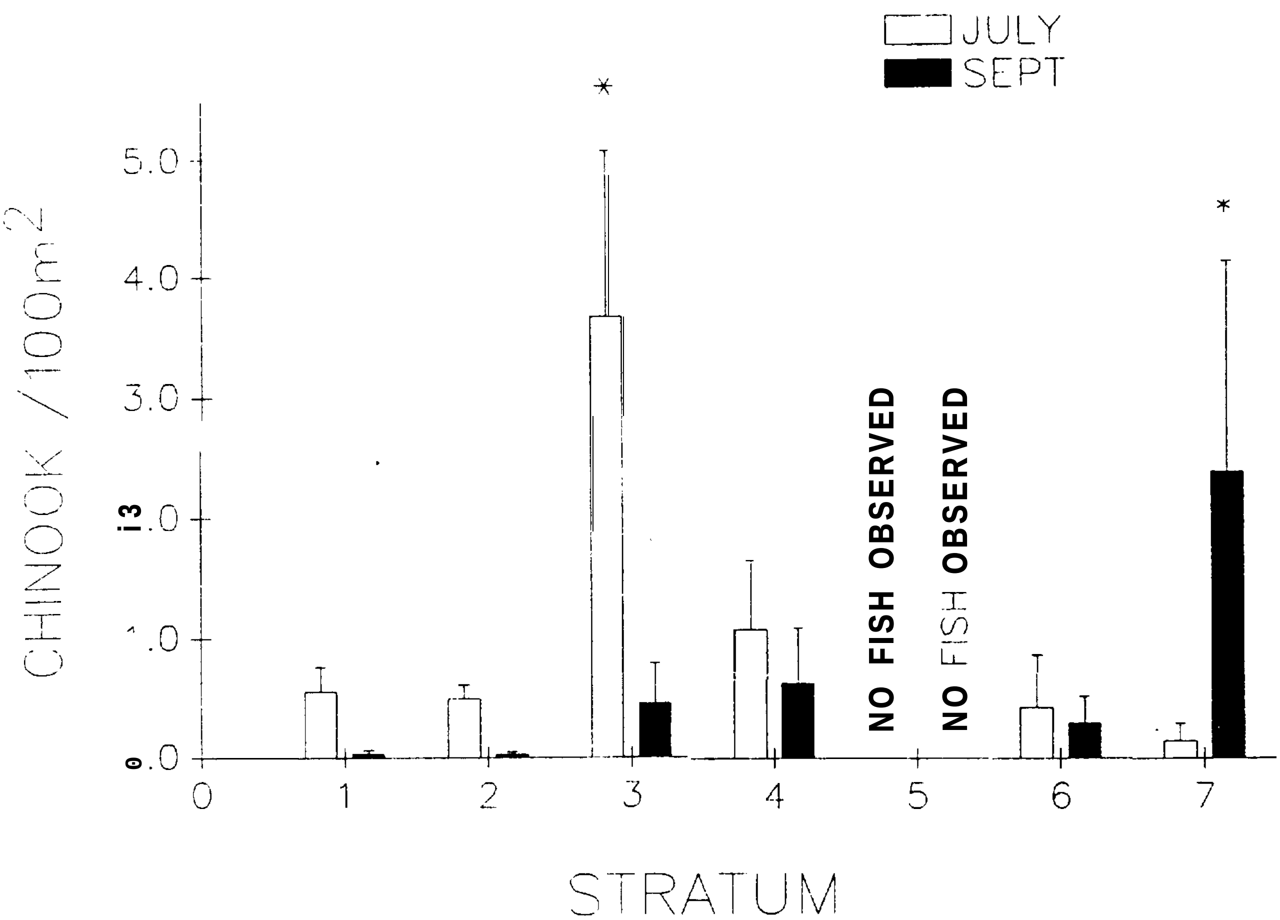

Figure 7. Density of age 0+ chinook salmon among strata (n=11 for stratum 6 and n=7 for all other strata) for July and September sampling sessions, Bear Valley Creek, 1990. An asterisk indicates a significant difference (P<0.05) from all other means within a session without the asterisk. Error bars represent 95% confidence intervals of the mean.

spawning and rearing habitat and salmon redds have been concentrated here in five of the past six years.

During the second sampling period, in early September, we observed the highest density of age-O+ chinook salmon in stratum 7. The density was 2.3 fish/100m^2, an increase from 0.1 fish/100m^2 sampled in July. We counted one redd in the lower section of stratum 7 in 1989 and the fish we observed were in the vicinity of this redd. There are a number of sloughs located in upper stratum 6 and lower stratum 7 that have good rearing habitat. The importance of these sloughs as late spring, early summer rearing areas was documented last year (Rowe et al. 1990). We believe that age-0+ chinook salmon are using these sloughs during the high flow runoff period, and eventually moving out into the main stream channel as conditions improve later in the summer. This may have contributed to the increased density observed in stratum 7 during the early September sampling period..

An integral part of our monitoring program is to assess how the improvement in stream habitat conditions, due to the enhancement project, benefits chinook salmon. Our physical stream habitat monitoring and substrate analysis indicate that conditions have improved but there has been minimal spawning in the project area or in adjacent strata to effectively quantify any benefits. In the two years, 1989 and 1990, following completion of the BVC enhancement project, only one salmon redd has been, counted in strata 5, 6, and 7. Previously, in 1988, as the BVC enhancement project neared completion, we counted 12 redds within the project area and 27 redds downstream in stratum 5. Estimates of age-O+

chinook salmon densities the following summer (1989) in stratum 5 were 23.3 fish/100m^2; in stratum 6, 76.9 fish/100m^2; and in stratum 7, 117.8 fish/100m^2. These densities indicate the potential the project area and adjacent strata provide for juvenile salmon production.

Age 0+ Steelhead Trout

We found a significant difference (P<0.05) in age-O+ steelhead trout density between sessions with a significant (P<0.05) interaction between stratum and session also noted (Table 7). During July no age-O+ steelhead trout were observed in strata 2 through 7. -Densities in stratum 1 were extremely low at 0.4 fish/100m^2. By early September fish were distributed throughout Bear Valley Creek but densities remained low ranging from 0.2 to 2.5 fish/100m^2 (Figure 8). In general, during periods of higher flows, age 0+ steelhead trout are associated- with any available cover and are much more difficult to observe and enumerate. Fish observed during the early September sampling period may well have been overlooked in July.

Whitefish

Densities and distribution patterns for age-O+ whitefish were similar to previous years (Rowe et al. 1990; Richards et al. 1989). There was a significant (P<0.05) difference in densities of age-O+ whitefish between sampling periods when strata were combined (Table 7). Significant (P<0.05) differences were also found among strata within a sampling period (Figure 9). Densities of age-O+ whitefish

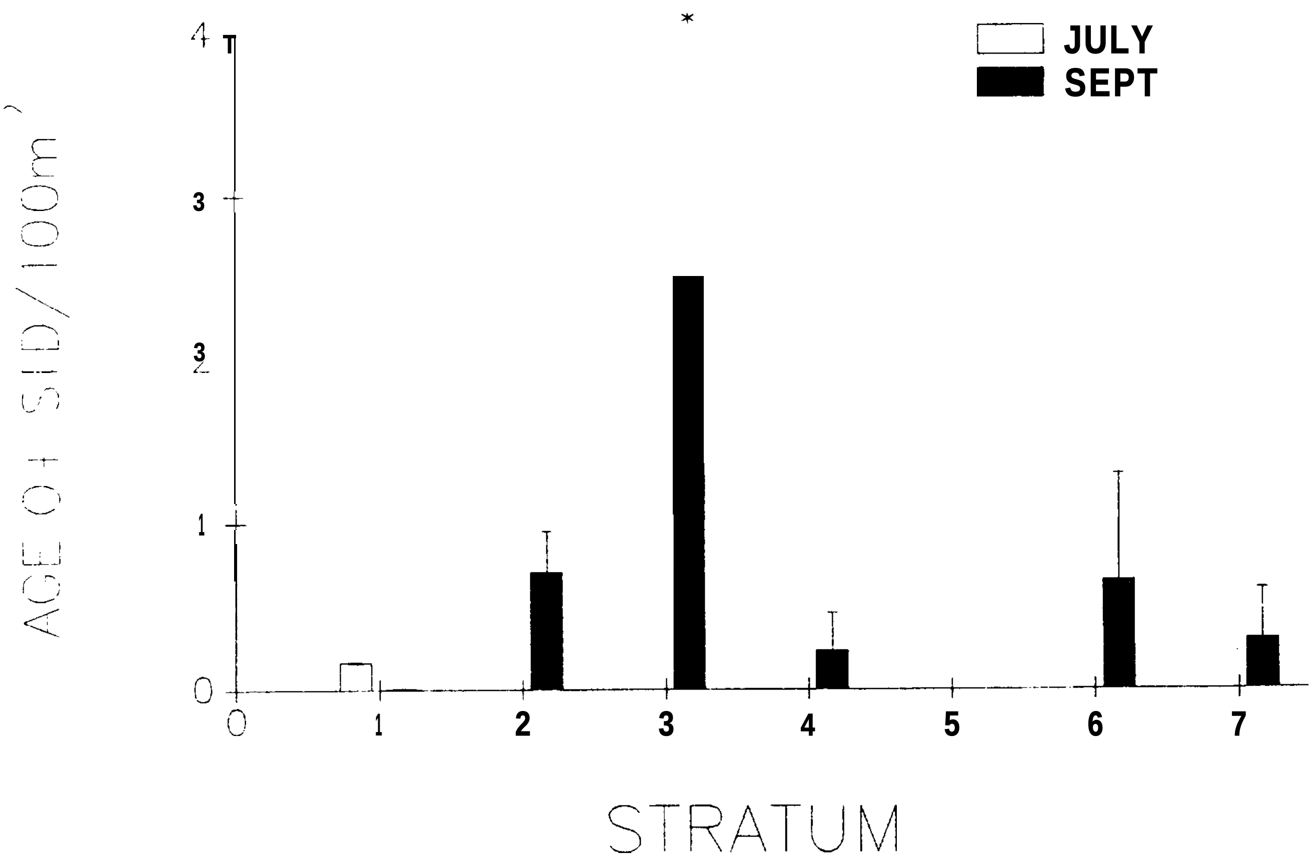

Figure 8. Density of age 0+ steelhead trout among strata (n=11 for stratum 6 and n=7 for all other strata) between July and September, Bear Valley Creek, 1990. Where bar graphs are absent for a sampling session no fish were observed. Error bars represent 95% confidence intervals o-f the mean.

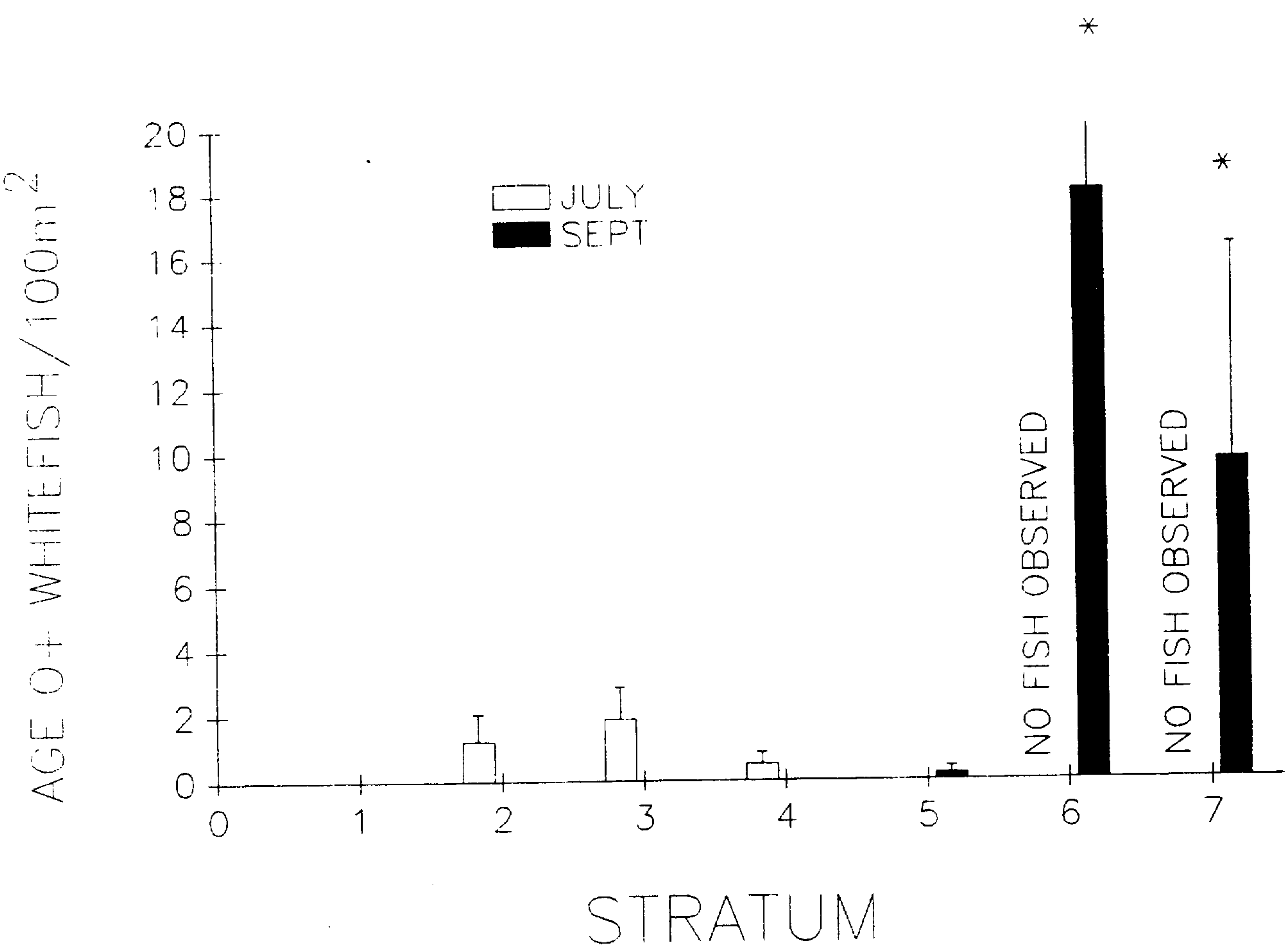

Figure 9. Density of age 0+ whitefish among strata (n=11 for stratum 6 and n=7 for all other strata) between July and September, Bear Valley Creek, 1990. Where bar graphs are absent for a sampling session no fish were observed. Error bars represent 95% confidence intervals of the mean.

were low (range 0.5 to 1.8 fish/100m^2) in July and concentrated in the lower strata (2, 3, and 4). During our September sampling period higher densities were observed, 9.6 and 18.7 fish/100m^2 in strata 6 and 7, respectively (Figure 9). No fish were observed in the lower four strata at this time.

The density of adult (age-l+ or older) whitefish differed between sampling periods when strata were combined and among strata within a sampling period (Table 7). Strata 1, 2, and 3 had significantly higher densities than all other strata for both sampling periods. Densities were highest in these lower three strata during the September sampling period (Figure 10). This distribution pattern of adult whitefish, with none observed in the upper three strata, has been well documented (Rowe et al. 1990; Richards et al. 1989). This pattern appears to be habitat related as the stream becomes much wider with deeper and larger pools in the lower three strata.

Relative Abundance, Population Estimates, Egg to Parr Survival

Relative abundance of all salmonid species varied greatly according to strata and session. In July the relative composition of all species in the upper strata (5, 6, and 7) of Bear Valley Creek was dominated by "other" species mostly brook trout (Salvelinus fontinalis) and bull trout (S. confluentus) (Figure 11). Age-O+ chinook salmon represented a large proportion of species composition in strata 3 and 4, at 49% and 563, respectively. The lower two strata were comprised of whitefish, steelhead trout, cutthroat trout (Oncorhvnchus clarki) and chinook

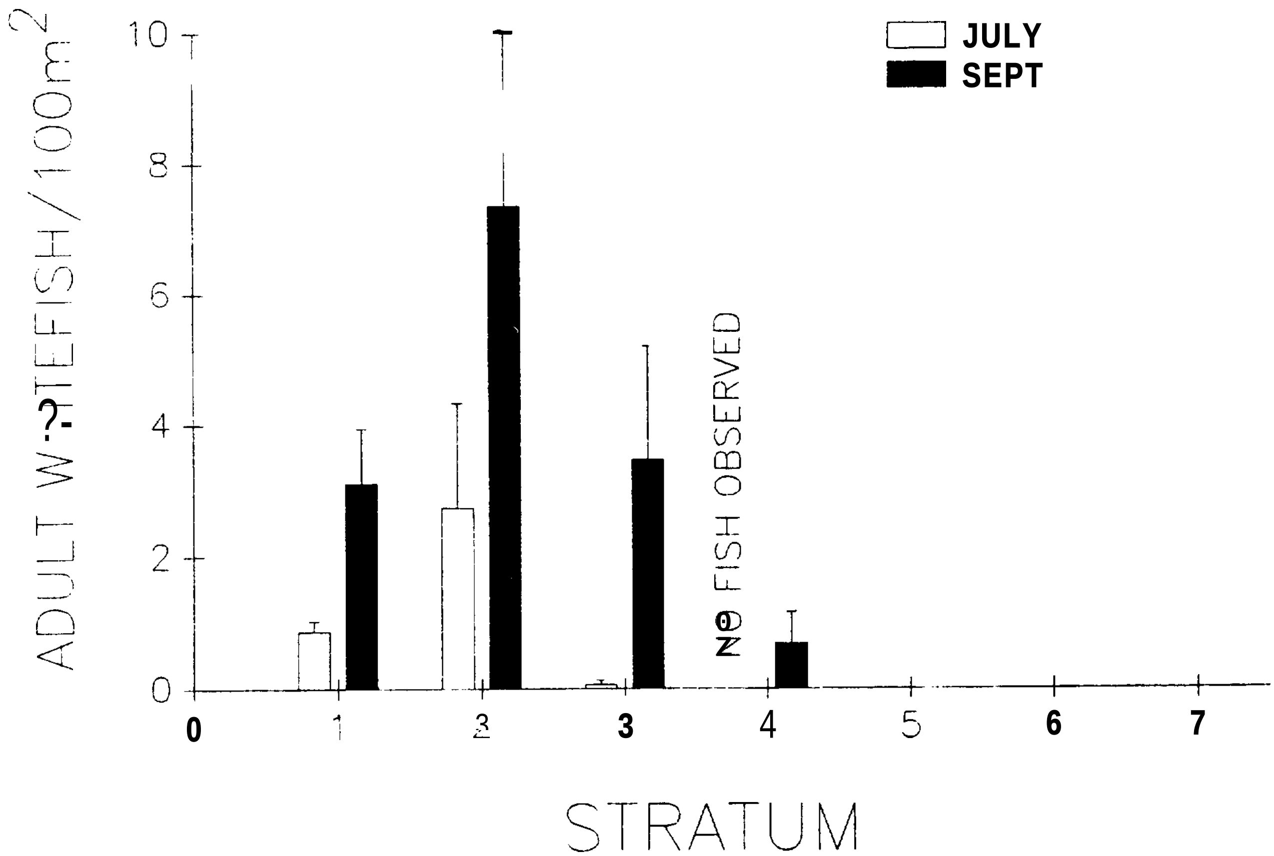

Figure 10. Density of adult whitefish among strata (n=11 for stratum 6, and n=7 for all other strata) between July and September, Bear Valley Creek, 1990. Where bar graphs are absent for a sampling session no fish were observed. Error bars represent 95% confidence intervals of the mean.

salmon in varying proportions. In early September whitefish were ubiquitous, accounting for the greatest proportion of all species in every stratum with the exception of stratum 4 (Figure 11). The relative abundance of age-O+ chinook salmon dropped considerably in strata 3 and 4 but a notable increase was observed in stratum 7 in September. A similar increase was documented in 1988 and 1989 (Richards et al. 1989; Rowe et al. 1990).

Our July estimate of 2,129 fish age-O+ chinook salmon represents a 85 to 90% reduction in numbers in contrast to estimates in July of 1988 and June of 1989 (Richards et al. 1989; Rowe et al. 1990). However, redd counts in 1987 and 1988 were greater at 72 and 234 redds, respectively. Almost all (16) of the 17 redds we counted in 1989 were located in strata 2 and 3 corresponding to the majority of the salmon population that was observed in the lower part of the system (Figure 12).

In early September we observed very few chinook salmon. Most fish were still concentrated in strata 3 and 4 with a notable increase in stratum 7. The population estimate was 568 a 27% reduction from July.

Egg to parr survival was marginally higher in 1990 compared to 1989. Assuming 6,121 eggs (Howell et al. 1985) were deposited in each of the redds counted in 1989, egg to July parr survival was 2.3%. This was slightly better than egg to parr survival for June of 1989 at 1.5% (Rowe et al. 1990).

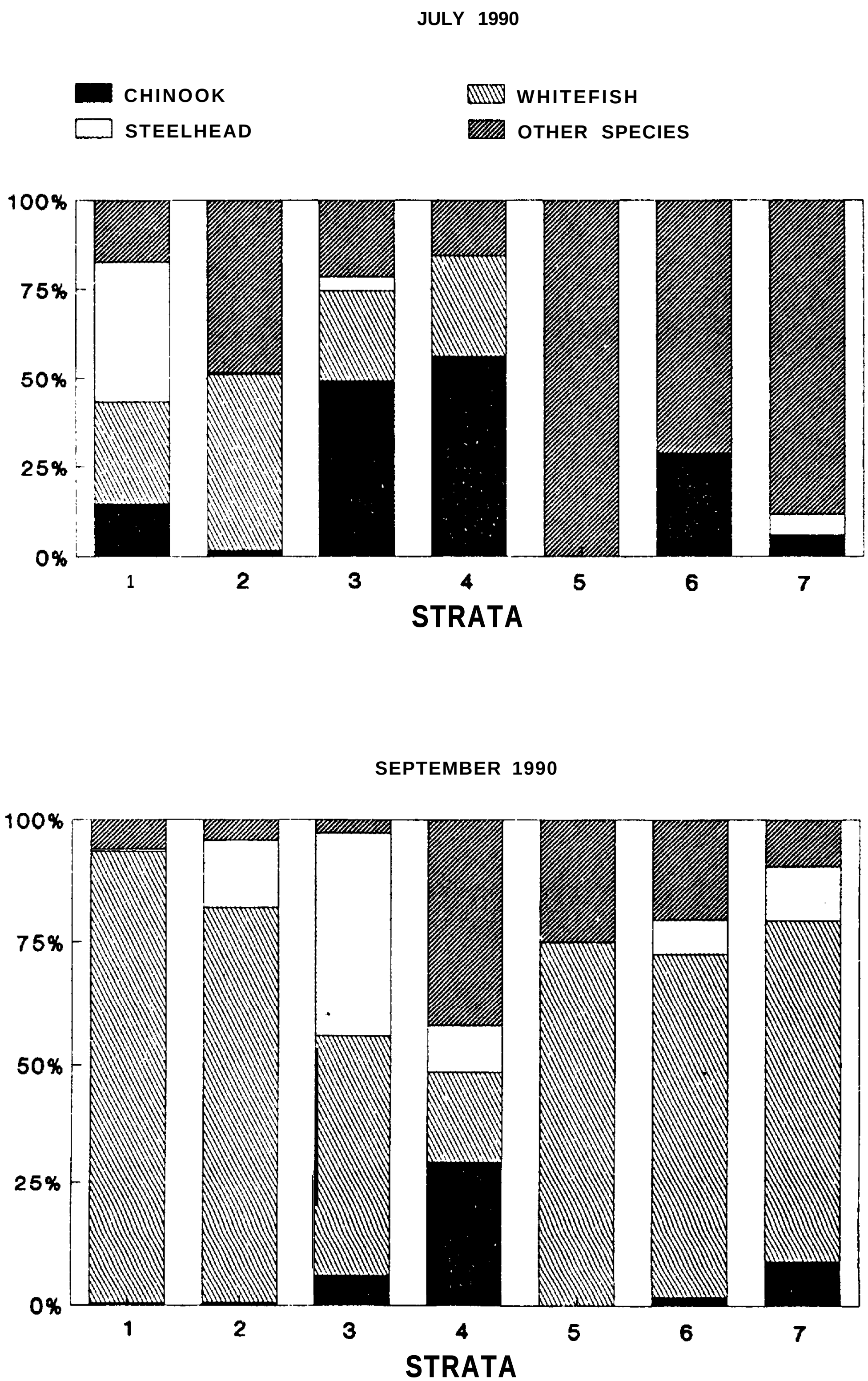

Figure 11. Relative abundance of fish species by strata in July and September, Bear Valley Creek, 1990. Other species includes brook trout, bull trout and cutthroat trout.

Salmon Redd Count

Redd counts were conducted on 30-31 August. A total of 45 redds were counted for the entire length of Bear Valley Creek excluding stratum 1. Similar to 1989, redds were concentrated in strata 2 and 3 (Table 9). The lack of redds in the uppermost strata may be due to low spawner escapement and good spawning habitat found in the lower four strata. Chinook salmon redds have consistently been concentrated in strata 2 and 3 'in years (e.g., 1985 to 1987) when numbers of spawners were depressed.

Fisheries Summary 1990

Total mean fish densities in Bear Valley Creek continue to remain low. Chinook salmon densities were concentrated in strata 2 and 3, the area of greatest redd activity in 1989, during the July and early September sampling periods. Chinook salmon density in stratum 7 was higher during September than that observed in July and it is believed that late spring, early summer utilization of slough habitat may have contributed to this observation. Population estimates of chinook salmon in BVC for both sampling periods were extremely low. Egg to parr survival in 1990 was similar to 1989 at 2.3 and 1.5%, respectively. Redds were concentrated in strata 2 and 3, similar to what has been observed in previous years when escapement has been low.

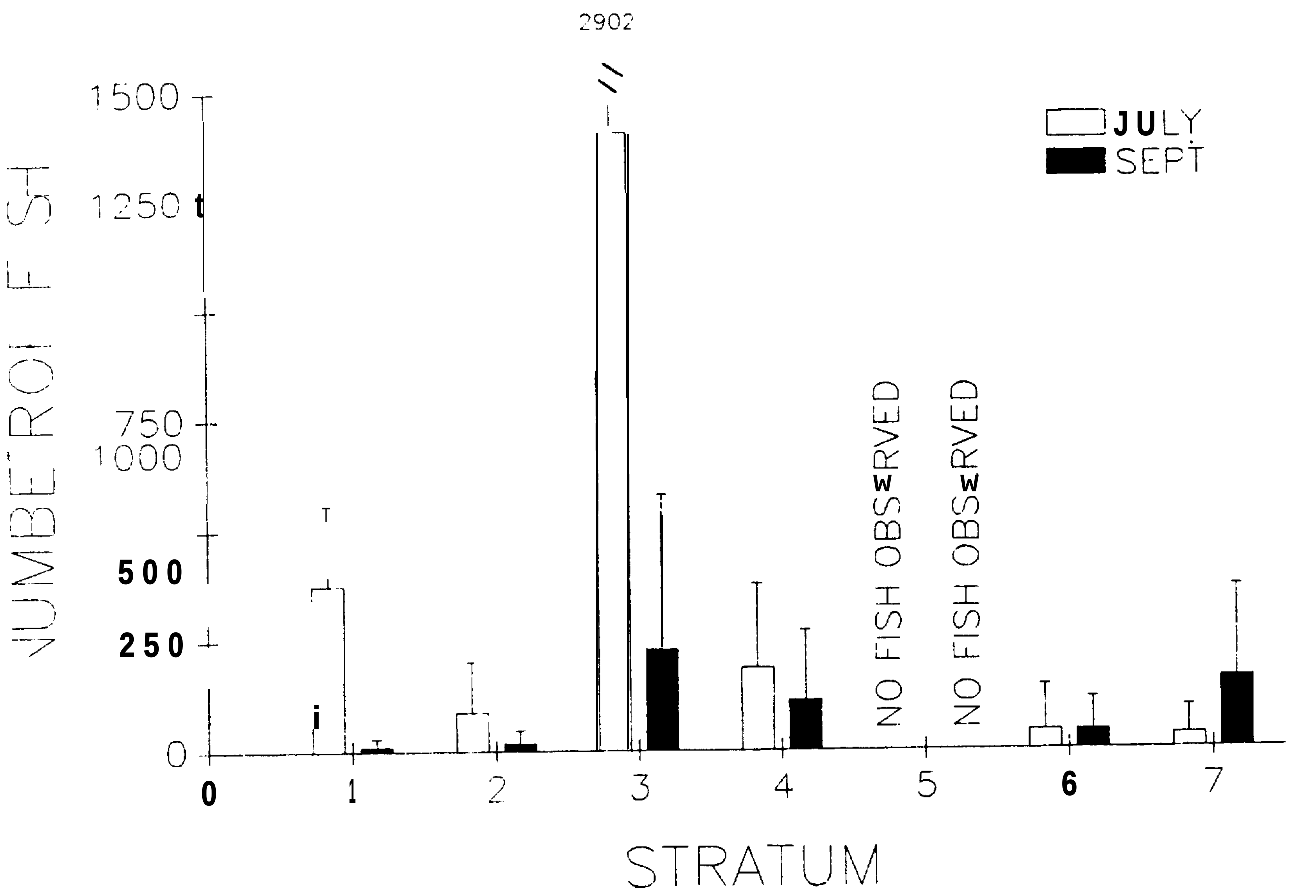

Figure 12. Total abundance of age 0+ chinook salmon in July and September by strata, Bear Valley Creek, 1990. Error bars represent 95% confidence intervals of the mean.

Table 9. Distribution and number of redds found in Bear Valley Creek for 1985-1990.

	REDDS COUNTED					
STRATUM	* 1985	1986	1987	1988	1989	1990
1	3	0	NC	NC	NC	NC
2	40	23	27	92	7	16
3	38	4	22	74	9	26
4	1	1	19	29	0	1
5	2	0	4	27	0	0
6	1	0	0	12	0	0
7	0	0	0	0	1	0
TOTAL	85	28	72	234	17	43

NC = Not Counted
* = Aerial Survey

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SUBPROJECT II

Yankee Fork of the Salmon River

Stream and Pond Evaluation

ABSTRACT

Yankee Fork of the Salmon River

Extensive dredge mining degraded spawning and rearing habitat for chinook salmon (Oncorhvnchus tshawvtscha) and steelhead trout (O. mvkiss) in the Yankee Fork drainage of the Salmon River. Four series of off-channel dredge/settling ponds incorporated into the Yankee Fork provided effective rearing habitat for hatchery-outplanted and naturally-produced juvenile chinook salmon and steelhead trout. Two of the four pond series (PS 1 and 3) were outplanted on 20 July with spring chinook salmon at about 600 fish/100m^2; PS 2 and 4 were left to be seeded by naturally-produced salmon. Total chinook salmon densities for September in the stocked pond series were 117 and 64 fish/100m^2 in PS 1 and 3, respectively. These densities were much greater than those observed in stocked series in 1989. Much of this difference is attributed to releasing fish after peak spring/summer runoff and inhibiting post-release emigration. Late summer densities in supplemented series were much greater than salmon densities in the two most productive sections of the Yankee Fork proper, where we estimated September densities of 4.0 and 9.0 fish/100m^2. In the two supplemented pond series feasibility objectives stated a chinook salmon smolt production capacity of 13,600 fish. By September we estimated that these two series had maintained salmon production for 59% of this goal. September chinook salmon densities in the unsupplemented series were greatest in PS 4 at 2.0 fish/100m^2. Even though this density was low compared to the supplemented series, it

was still considerably greater than the mean density (0.1 fish/100m^2) of salmon in the degraded habitat of the adjacent river sites. We estimated that PS 4 sustained numbers of naturally-produced chinook salmon equivalent to what was produced in 1.9 km of the mainstem influenced by dredge activities (strata 2 and 3). This differs considerably from 1989 where PS 4 maintained numbers of chinook salmon equivalent to that produced in 3.9 km of the same stretch of river. Most likely a result of the low amount of spawning observed in the West Fork in 1989.

Open water habitat with cover maintained the greatest chinook salmon densities throughout the summer. Use of channel habitat became more important in September as water temperatures decreased. Age-O steelhead were most abundant in pond bank habitat and channel habitat.

Peaks of chinook salmon movement into and out of pond series habitat coincided with high early summer flow and low water temperatures in the fall. Steelhead moved into and out of off-channel habitats throughout the summer. In the fall we observed most age-0 steelhead moving upstream from the main Yankee Fork into pond channel habitat.

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INTRODUCTION

off-channel habitat use by juvenile coho salmon (Oncorhvnchus kisutch) during the fall and winter freshet season in coastal watersheds is well documented (Bustard and Narver 1975, Cedarholm and Scarlett 1981, Peterson 1982). Recently, spring and summer use of off-channel ponds by coho salmon in interior streams has been documented (Bustard 1986, Swales and Levings 1989). Few studies have investigated the importance of off-channel habitats to the rearing ecology of juvenile salmon in interior systems.

Flow regimes differ considerably between coastal and interior systems. For interior streams the timing of movement by fish into pond habitat generally coincides with the spring and early summer high flow period. These habitat types have also been shown to provide productive rearing habitat throughout the summer. This has partially been attributed to favorable water temperatures and an abundant invertebrate fauna (Swales and Levings 1989).

A paucity of information related to chinook salmon (O. tshawvtscha) use of off-channel rearing ponds exists. However, data from Swales and Levings (1989) indicate that chinook salmon will use these habitats. Hard (1986) found that hatchery-outplanted chinook salmon fry in two small southeastern Alaska lakes grew rapidly and survived well to the smolt stage. It is likely that off-channel pond habitat can improve juvenile salmon production when suitable main channel rearing habitats are limited.

Several miles of stream habitat in the lower Yankee Fork of the Salmon River have been drastically altered by dredge mining for gold since the late 1800's (Richards et al. 1989). As a result of the mining main channel rearing habitat in the Yankee Fork was determined to be limiting to anadromous fish production (Bechtel National, Inc. 1987). This loss of critical rearing habitat, in combination with other out-of-basin factors, has contributed to the present depressed state of chinook salmon in the Yankee Fork drainage.

To partially remediate for lost anadromous fish production, the Bonneville Power Administration (BPA) funded enhancement measures targeted at increasing rearing capacity in the Yankee Fork. Many isolated off-channel settling ponds exist in the Yankee Fork floodplain as remnants of dredge mining. Four series of these off-channel ponds were interconnected to each other, as well as connected to the Yankee Fork mainstem, via excavation of channels and construction of flow regulating structures (Figure 2). This increased rearing area is expected to produce an additional 24,000 chinook salmon smolts (Bechtel National, Inc. 1987). Construction on the ponds was initiated in September 1987 and completed in the fall of 1988.

Since 1988, the Shoshone-Bannock Tribes in cooperation with the Idaho Department of Fish and Game have outplanted spring chinook salmon fry in at least two of the four developed pond series. We have varied stocking protocols from year to year (e.g., time of release and stocking density) have varied from year to year to evaluate optimal stocking procedures and seeding levels.

The objectives of our 1990 program were: 1) to estimate total chinook salmon and steelhead abundance in two supplemented pond series and in two pond series seeded by natural production; 2) to compare fish densities in constructed off-channel habitats to fish densities in Yankee Fork main channel sites; 3) to describe summer/fall habitat use by salmon and steelhead in the off-channel pond series; 4) to evaluate growth and condition of fish in both off-river pond and channel habitat and in mainstem river sites; 5) to quantify movement patterns of chinook and steelhead into and out of off-river habitats; and 6) to continue a quantitative assessment of the benthic and planktonic invertebrate community within the same off-river habitat types used to quantify fish use patterns.

STUDY AREA

The Yankee Fork of the Salmon River, located on the Challis National Forest in Custer County, Idaho, is a major tributary of the upper Salmon River. The Yankee Fork is a *medium-gradient system which flows through narrow canyons and moderately wide valleys of lodgepole pine (Pinus contorta) forests. Investigations were conducted on the mainstem Yankee Fork from its confluence with the Salmon River upstream to McKay Creek (including four off-channel pond series located in the lower reaches of Yankee Fork); on the West Fork of Yankee Fork from its confluence with Yankee Fork upstream to Cabin Creek; and on Jordan Creek from its confluence with Yankee Fork upstream approximately 7 km (Figure 1).

The 9.6 kilometer dredge-mined section of the Yankee Fork is characterized by a relatively wide, straight channel dominated by boulder and cobble substrates with over 30 ponds of varying size, shape, and depth that are remnants of the dredging operation.

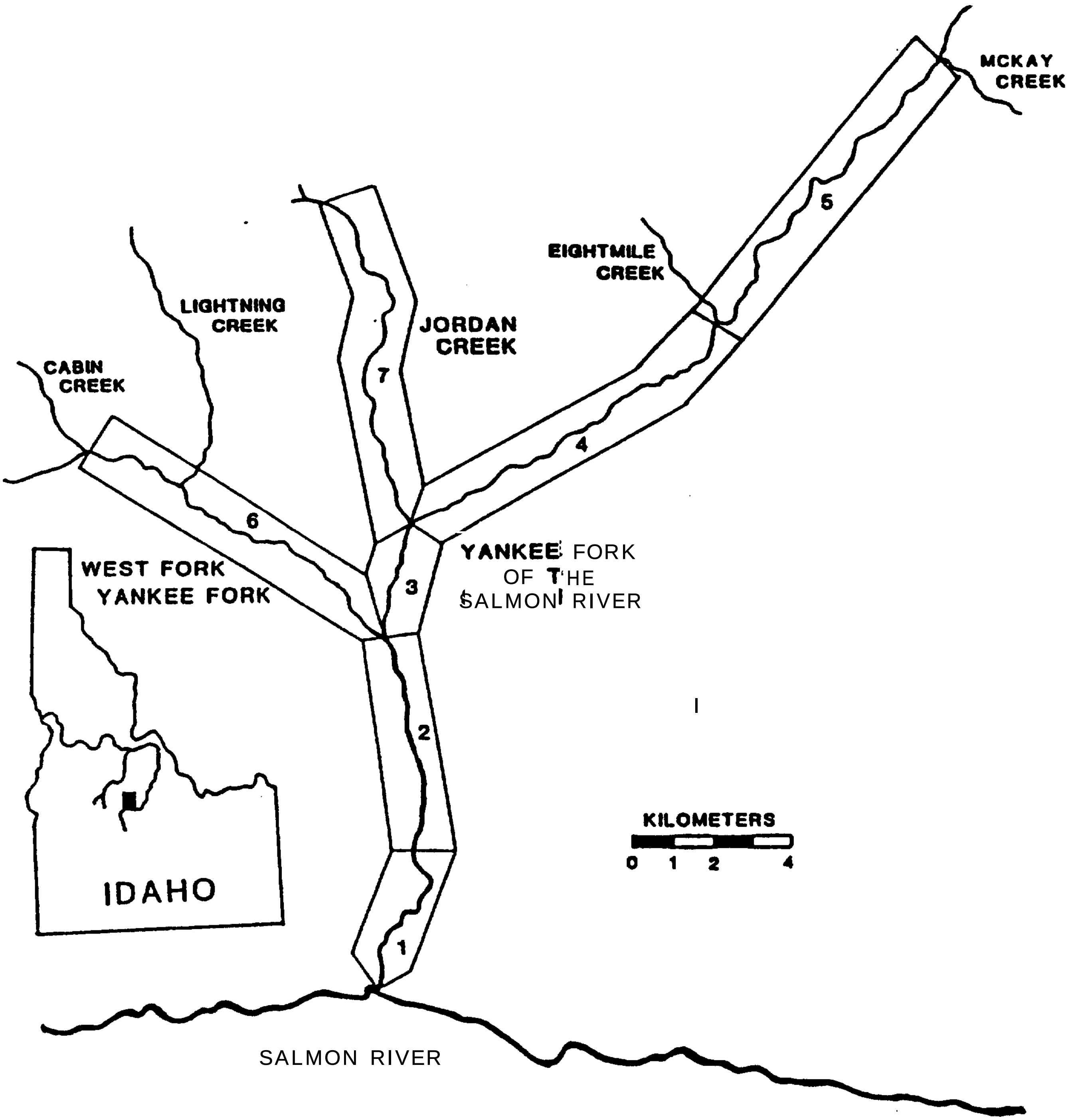


Figure 1. Yankee Fork drainage of the Salmon River, Idaho, study area and strata location.

Channels were developed between ponds within four distinct pond series from 1987 to 1988 (Figure 2). Each of the four pond series were then connected to the Yankee Fork mainstem. Flow controls (check structures) were constructed within the channels between some ponds to permit surface flow regulation.

METHODS

Area totals for individual ponds within a pond series were determined from 1:24,000 air photos. Each pond was traced from the photos and areas calculated using planimetry. Within each pond, specific 'habitat types were identified and enumerated by area. Habitat types classified were: 1) bank cover, 2) bank no-cover, 3) open deep no-cover, 4) open deep cover, 5) open shallow no-cover, 6) **open** shallow cover, and 7) channel. We designated **water depths** less than a meter as shallow pond habitat. Plant and algal masses, root wads, and bottom substrates in compositions large enough to provide hiding or escape cover for young-of-the-year fish were designated as cover components.

We used two to four transects per pond (depending on pond size) to estimate habitat availability. A meter tape was used to span the pond at selected transects. At each meter a diver equipped with a measuring stick would identify the dominant habitat type present and the water depth. From these measures the quantity of each habitat type by individual pond was calculated by proportional extrapolation. The quantity of channel habitat present within a pond series was estimated by habitat unit (i.e.,

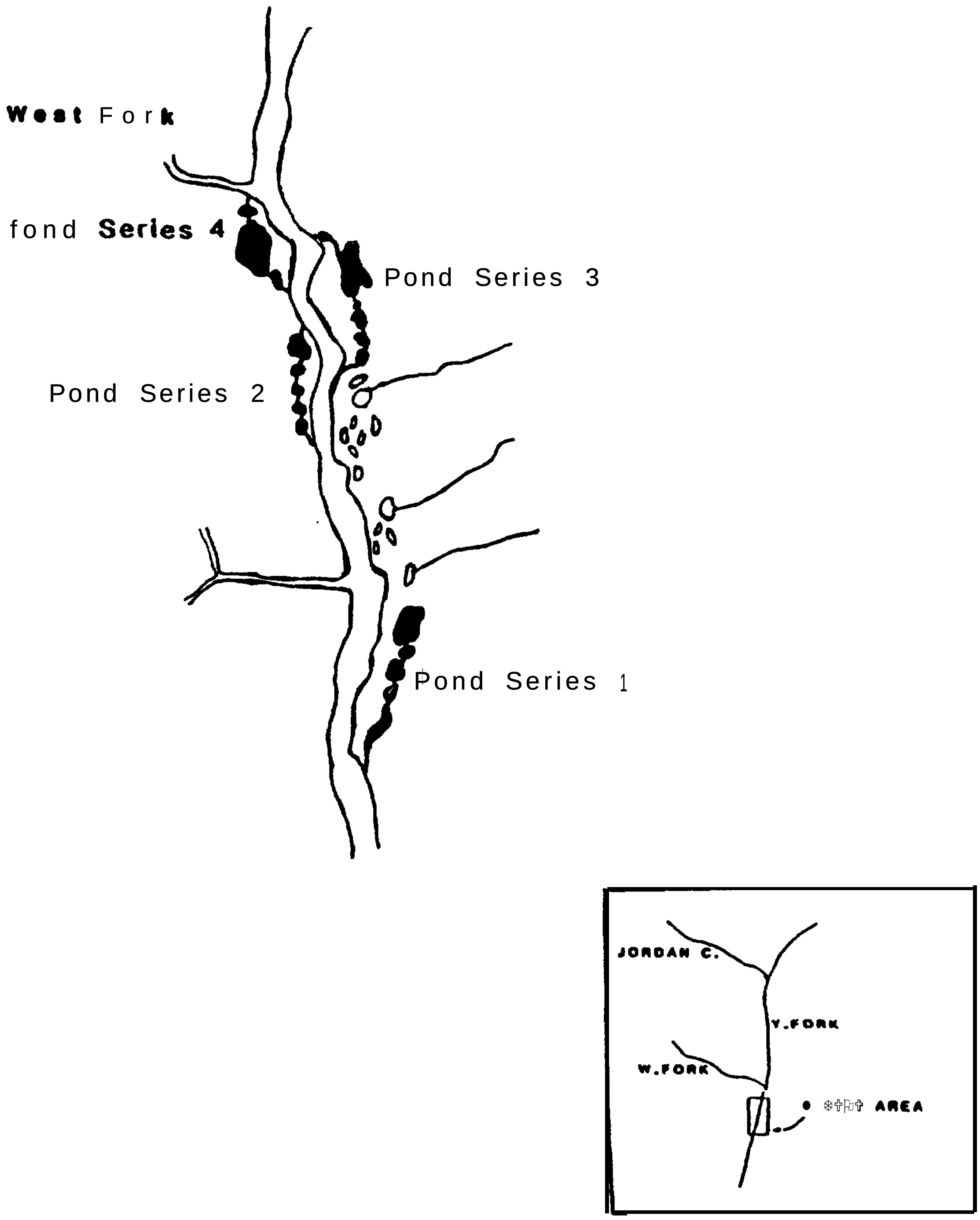


Figure 2. Pond series locations, Yankee Fork of the Salmon River.

pool and riffle) using measured average widths and paced lengths. Habitat availability was determined in June.

Water temperatures in three to four ponds of each series and two adjacent river locations were recorded weekly from 25 May to 25 October using Taylor "max-min" thermometers. For each pond series a weekly average water temperature was generated from the mean of the weekly maximum and minimum temperatures. Degree days by week were calculated by multiplying the weekly degree average by seven. This allowed us to estimate degree day accumulation by pond series and for the adjacent river habitat.

In addition to degree day estimates we used two Ryan (Model J) thermographs to continuously monitor water temperature. One thermograph was placed in shallow pond habitat (0.5 m) and one in deep pond habitat (2.0 m). Temperatures in both habitats were monitored from 8 May to 5 August and in just the deep water habitat from 10 September to 1 November. Temperatures (degrees Celsius) were summarized as the mean of the daily maximum and minimum temperatures. Other water quality features that we monitored were dissolved oxygen and conductivity using portable YSI field meters.

On 20 July we outplanted 25,000 spring chinook salmon (Rapid River stock) juveniles into each pond series 1 and 3. This outplanting yielded initial total densities of 5.4 and 6.1 fish/m^2 in pond series 1 and 3, respectively. Fish were stocked in the upper most pond of series 1 and 3. Downstream movement of outplanted fish was inhibited for one week by blocking off surface flow at check structures located on the lower end of each pond.

Pond series 2 and 4 were left to be used by naturally-produced salmon.

To investigate emigration patterns of hatchery-outplanted fish, we used a custom made fry trap located at the lower end of pond series 1. This trap was monitored from 25 July through 31 October. We also used two of these traps, located at the upper-and-lower most check structures in pond series 4, to acquire fish movement patterns into and out of a non-supplemented pond series. These traps were monitored from 17 May to 1 September. 'In pond series 2 we placed two emigrant/immigrant fry traps at the upper- and lower-most channels of the series. These traps were in place from 16 July through 31 October. All traps were monitored during the work week generally from Tuesday through Friday. Selected traps (PS 1 and 4) were checked in the morning and evenings. All emigrants and immigrants were measured (total length) to the nearest mm. To get a estimate of total numbers of chinook salmon emigrating from pond series 1, we extrapolated fish numbers for unsampled days. The number of emigrants three days before and three days after the unsampled days were averaged. This average number was assigned to each of the unsampled days within the six day range.

Fish densities by habitat were estimated once a month from June through September in the supplemented pond series and in June through August in unsupplemented pond series. Density estimates for mainstem habitats were made during June and September at pre-established strata and sites following procedures outlined in Rowe et al. (1990).

In pond habitat fish were enumerated by divers equipped with snorkel and mask. When pond widths were narrow enough to allow underwater observation to both banks from the pond's center, one diver would approach from the downstream end of the pond and slowly work upstream, noting the presence of fish and the habitat type occupied. In wider pond segments, two divers would enter the downstream end of the pond and move upstream in parallel lanes. Each observer only counted fish in his lane. Lane width was dictated by underwater visibility. In large sections of pond where two divers could not adequately cover all the habitat the divers would cross on a transect. Two transects were counted in larger ponds. Given the estimated visibility, the width of the observation transect was estimated. Fish numbers were then extrapolated for the rest of the unsnorkeled habitat.

We used three methods to estimate salmon and steelhead abundance in off-river and mainstem habitats. In the ponds most habitat types were completely snorkeled. The total abundance for each of those habitat types was the summation of all fish observed in that habitat. If a habitat type was only partially sampled (e.g., transects across wide open water habitat), our abundance estimate was extrapolated for that habitat type via the technique previously mentioned. Thus, abundance of fish in the ponds was estimated by summing either the total or extrapolated fish counts for each habitat type. In channel habitats within the pond series we enumerated fish by electrofishing. We sampled two representative channel sections per pond series; each section contained at least two pool/riffle sequences. Channel sections were blocked with seines and densities calculated using the Zippin (1958) multiple step (3-pass) depletion method. Total fish abundance for channel habitat within a pond series was calculated using the mean density of the channels multiplied by the number of fish present for the known total channel area. Fish use by cover type in the channels could not accurately be determined by electrofishing. Finally, for main-river habitats, the total abundance of salmon and steelhead in our study strata was estimated from mean and variance density values obtained through snorkel surveys following procedures in Mendenhall et al. (1971).

For statistical analysis, fish density estimates for the seven habitat types were lumped into five habitat groups; pond bank cover and no cover, pond open cover and no cover, and channel habitat. Density means were compared among habitat types, between cover types, and among sessions using analysis of variance (ANOVA). For chinook salmon, statistical comparisons were done separately for outplanted fish (PS 1 and 3) and for naturally-produced fish (PS 2 and 4). Steelhead young-of-the-year comparisons were made only in PS 1. This was the only pond series where we observed appreciable numbers of these individuals using pond habitat; this was probably because we noted one steelhead redd in channel habitat of this series. For all comparisons, mean density values for a given habitat type were derived from pooled density data points from individual ponds within one or more of the series. An individual pond density value for a habitat type was calculated by dividing the estimated fish numbers for that habitat type within the pond by the area of that habitat component for the same pond. For the mainstem Yankee Fork, a one-way ANOVA was used to compare fish densities among strata within a session. We set the alpha level at 0.05 as the criterion for statistical significance. For all significant results we applied Tukey's multiple range test as a post-hoc discriminator of where the differences occurred.

During each pond and mainstem sampling session we attempted to collect a sample of 50 salmon from both channel and pond habitats within a pond series, and from river habitat in each stratum for growth analysis. Fish in channel habitat were captured by electrofishing. In pond habitat we used a seine to capture fish. After fish were captured they were anesthetized with MS-222; their total length was measured to the nearest mm; and their weight, to the nearest 0.1 of a gram, was obtained using an Ohaus digital scale. We rarely observed salmon clustered in pond habitat of the unsupplemented series so we were only able to obtain a small sample of fish from the channels of these series. Further, due to the low level of spawner escapement in the mainstem in 1989 we were only successful at capturing river fish in areas of localized spawning (stratum 4 and 6). We used ANOVA to compare fish lengths among series and between habitat types. We also calculated fish condition in PS 1 and 3 and the West Fork (stratum 6) of the Yankee Fork. We used the isometric growth equation (Everhart and Youngs 1981) to calculate condition; ANOVA was used to compare chinook salmon conditions from both pond series and river habitat.

We counted chinook salmon redds on 4 September in the West Fork and on 13 September in all other Yankee Fork strata. Ground counts were conducted by individuals equipped with polarized glasses. Observers generally walked downstream through a stream segment.

The planktonic and benthic invertebrate community in off-river pond series habitat was sampled from 14 to 18 August. The plankton was sampled using a Wisconsin plankton net (32 cm diameter face opening). Three horizontal tosses (approximately 5 meters) of the plankton net through a specific habitat type constituted a plankton sample. From this we could determine the volume of water column sampled. In habitat with extensive cover one horizontal toss and retrieval of the net was used as a subsample and extrapolated up to compare with full volume samples. We sampled the water column in bank and open water areas with and without vegetative cover. We collected samples from each habitat type in both pond series 3 and 4: these two series have been consistently sampled since 1988. Samples were preserved in 70% ethanol and processed in the lab.

We sampled pond benthos with a Ponar dredge (14.0 cm x 17.0 cm face opening) to a depth of approximately 10 cm. Similar to plankton sampling, we collected 10 dredge samples in representative areas of open and bank habitat with and without cover. Contents of dredge samples were placed in a bucket and large lumps of clay material were broken down into a homogenous slurry. The slurry was then sieved (0.85 mm) to collect most of the debris and benthic organisms from the sample. Samples were preserved in 70% ethanol and processed in the lab.

We also collected 10 benthic channel samples, from both pond series channels and mainstem riffle habitat using a Surber sampler.

The channel substrate was sampled to a depth of approximately 10 cm.

In the laboratory we used a 30 power microscope to identify invertebrate organisms to the lowest possible taxa, generally genus. We used analysis of variance to test the hypotheses that total invertebrate densities were the same among habitat types for plankton and pond benthos samples; among plankton, pond benthos, and channel benthos (all habitat types combined); and among years (all habitat types combined).

RESULTS

Physical Evaluation

Pond series surface area, pond and channel habitat, ranged from about 2500 m^2 (PS 4) to 4600 m^2 (PS 1) (Table 1). Pond series 1 and 3 provided the greatest amount of off-river channel habitat at 1500 and 1600 m^2, respectively; this area accounted for 32% and 39% of the total pond series habitat available. Open-deep habitat with no cover constituted the greatest percentage of pond surface area in all pond series. Detailed information on individual pond depths, elevations,. and water volumes is given in Reiser and Ramey (1987).

All four pond series had a similar pattern of degree day accumulation from June through October (Figure 3). Pond series 1 accumulated the most degree days in June, but throughout the rest of the summer this series accumulated the fewest degree days. This pond series is the only one with a subsurface water source. During

Table 1. Habitat type classification and area measurement of off-river habitat for pond series 1, 2, 3, and 4, Yankee Fork of the Salmon River, June 1990.

HABITAT TYPE	CODE	PS 1 * Area (m')	PS 1 * % of Total	PS 2 Area (m^2)	PS 2 % of Total	PS 3 Area (m^2)	PS 3 % of Total	PS 4 Area (m^2)	PS 4 % of Total
Bank/No Cover	(1)	576	12.5	208	6.3	374	9.0	301	12.1
Bank/Cover	(2)	425	9.2	368	11.1	236	5.7	211	8.5
Open/Deep/No Cover	(3)	1109	24.0	1291	39.1	1007	24.4	1375	55.3
Open/Deep/Cover	(4)	62	1.3	135	4.1	639	15.5	50	2.0
Open/Shallow/No Cover	(5)	888	19.2	150	4.5	174	4.2	106	4.3
Open/Shallow/Cover	(6)	52	1.1	125	3.8	91	2.2	46	1.8
Channel	(7)	1509	32.7	1026	31.1	1613	39.0	399	16.0
Totals		4621 (.76	100.0 acres)	3303 (.56	100.0 acres)	4134 (.62	100.0 acres)	2488 (.52	100.0 acres)

* Mean and maximum water depths (parentheses) for PS 1, 2, 3, and 4 are 1.69m (4.25m), 1.30m (2.25m), 1.16m (2.25m), and 1.49m (2.75m), respectively.

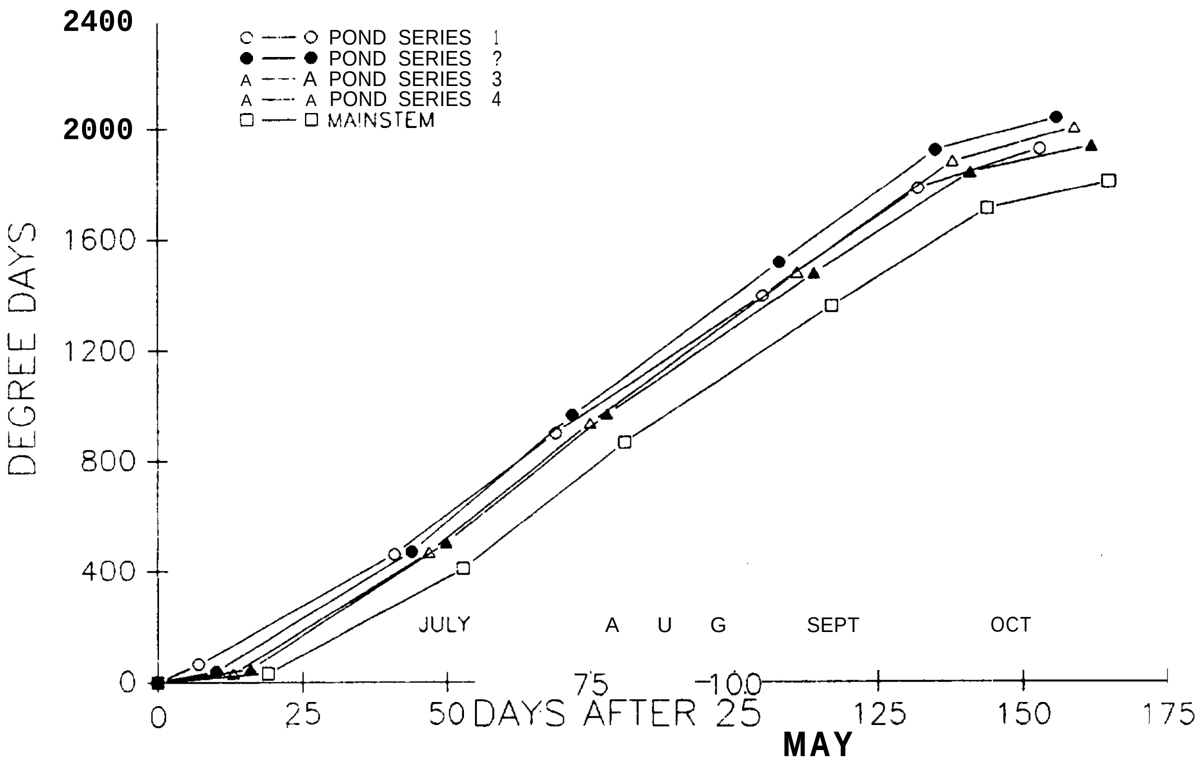


Figure 3. Cumulative degree days in pond series l-4 from 25 May to 25 October, Yankee Fork of the Salmon River, 1990.

the early season subsurface water is warmer than surface snow melt, but then as runoff decreases and air temperature increases, surface water becomes warmer. Pond series 2 accumulated the most degree days throughout the summer and fall (Figure 3). This series has the most individual ponds and apparently (from our observations) has few groundwater sources and thus contribute to the greater degree day accumulation. The minimum and maximum mean daily pond water temperature recorded from our max-mins were 3.5 °C (24 May) and 15.8 °C (16 August), respectively.

Mean daily pond water temperatures (from thermographs) were lower in deep water habitat compared to shallow water habitat (Figure 4). From mid-May to mid-June these water temperatures were more similar. This corresponds to the high flow period (Figure 4) when water mixing was greatest. When the hydrograph was descending (July to August) we found water temperatures in deep habitat to be 1 to 2 °C less than in shallow water. The minimum and maximum thermograph temperatures recorded were 4.0 °C (1 June) and 16.2 °C (6 August).

Dissolved oxygen (D.O.) values remained high in all pond series throughout the summer (Table 2). Values ranged from a high of 9.7 mg/l in August to a low of 6.6 mg/l in the same month. Dissolved oxygen tended to decrease slightly from June though August in each pond series except PS 3. Further, D.O. levels recorded in the off-channel habitats were similar to those levels in the Yankee Fork mainstem.

Conductivity values in the pond series were low (<100 micro mhos) but consistent among pond series (Table 2). Conductivity was

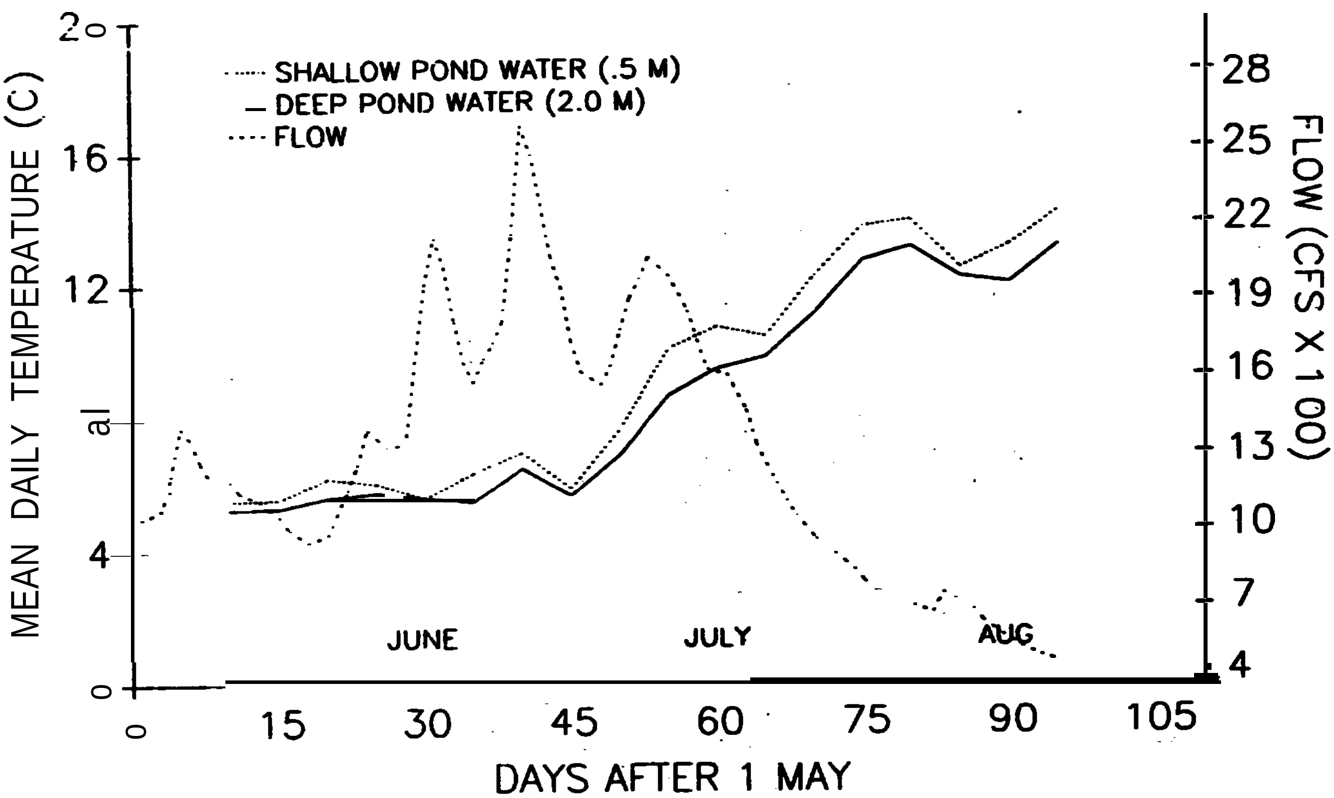


Figure 4. Mean daily water temperature (C) for shallow (.5 m) and deep (2 m) pond habitat. from 10 May to 10 August, and daily flow values for the mainstem Salmon below the Yankee Fork confluence from 1 May to 10 August, 1990

Table 2. Mean and standard deviation (parentheses) for dissolved oxygen (mg/l) and conductivity (umhos) for each -pond series (1 to 4) during June, July, August, and September 1990, Yankee Fork of the Salmon River.

DATE	LOCATION	HABITAT	Dissolved oxygen (mg/l)	conductivity (umhos)
18 June	PS 1	Pond	7.9 (0.2)	57 (6.9)
		Channel	8.1 (0.1)	52 (2.1)
	PS 2	Pond	7.6 (0.5)	47 (1.7)
		Channel	7.9 (0.5)	42 (1.4)
	PS 3	Pond	7.6 (0.5)	51 (1.0)
		Channel	7.5 (0.1)	49 (1.4)
	PS 4	Pond	7.8 (0.3)	45 (0.0)
		Channil	7.7 (0.2)	46 (4.0)
	River		7.8 (0.6)	41 (1.2)
16 July	PS 1	Pond	7.0 (0.5)	69 (1.2)
		Channel	6.6 (0.1)	68 (3.5)
	PS 2	Pond	7.2 (0.1)	63 (1.7)
		Channel	7.1 (0.7)	60 (2.8)
	PS 3	Pdnd	7.3 (0.6)	68 (4.0)
		Channel	7.2 (0.3)	66 (4.9)
	PS 4	Pond	6.7 (6.2)	62 (9.0)
		Channel	6.7 (0.2)	62 (9.3)
	River		7.7 (0.5)	57 (5.8)
29 August	PS 1	Pond	6.6 (0.1)	74 (1.7)
		channel	6.6 (0.1)	72 (0.0)
	PS 2	Pond	7.1 (0.2)	76(14.0)
		Channel	7.0 (0.5)	73 (3.5)
	PS 3	Pond	8.2 (1.0)	85(17.6)
		Channel	9.7 (0.6)	90 (5.0)
	PS 4	Pond	7.7 (0.6)	75 (4.5)
		Channel	7.4 (0.3)	70 (0.7)
	River		7.0 (0.0)	65 (4.2)

Table 2. Continued.

DATE	LOCATION	HABITAT	Dissolved oxygen (mg/l)	Conductivity (umhos)
20 September	PS 1	Pond	7.4 (0.2)	70 (0.0)
		Channel	7.6 (0.0)	70 (0.0)
	PS 2	Pond	8.0 (0.0)	65 (3.0)
		Channel	7.8 (0.4)	63 (0.7)
	PS 3	Pond	8.2 (0.5)	88 (9.3)
		Channel	8.1 (0.5)	80 (7.1)
	PS 4	Pond	7.9 (0.5)	
		Channel	7.9 (0.1)	
	River		8.7 (0-4)	58 (0.0)

lowest in June (range 42-57 umhos) and highest in-Septenber (range 63-88 umhos). This trend was consistently observed from *year* to year. Pond water tended to have lower conductivities than channel habitat, and the mainstem Yankee Fork values were consistently lower than off-river habitats (Table 2). The increase in conductivity throughout the summer may have resulted from decreased flow and turnover rates of water within the pond series.

Biological Evaluation

Fish Movements

In non-supplemented Pond series 4 from may through August, 97% of both immigrant and emigrant chinook had moved by rid-June (Figure 5). This corresponds to when the hydrograph was peaking (Figure 4). After this time chinook salmon movement was minimal. The chinook salmon entering and leaving PS 4 were one year old fish with mean lengths of 88.0 mm'and 92.1mm, respectively. These fish either emerged upstream and'were using this off-channel habitat in a transitory capacity on their way downstream, or they overwintered in this habitat and were out migrating with high flows. Qualitative winter sampling usingminnowtraps confirmed overwinter use of pond series habitat by both chinook and steelhead.

In contrast to chinook salmon, steelheadtendedto move in and out of PS 4 throughout the summer (Figure 5). Steelhead emigrants were all age l+ and older fish (Table 3). Immigrants were both age l+ and older steelhead (Hay to July) and age 0+ fish (July through August). Older steelhead appear to use this habitat in a transitory fashion, both entering and leaving at similar rates,

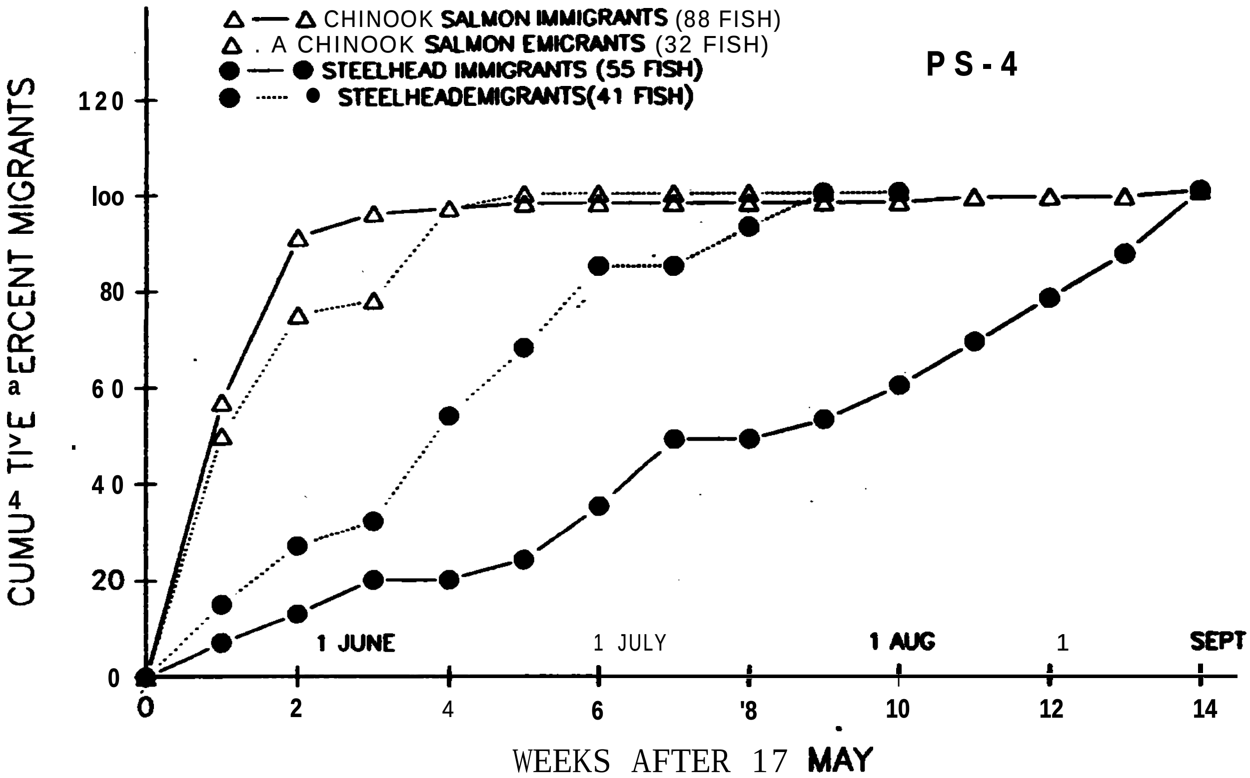


Figure 5. **Summary of weekly fish movements, chinook salmon and steelhead trout (age 0 and 1 + combined) into and out of pond series 4 from 17 May to 1 September.**

Table 3. Summary of mean length and standard deviation of fish migrants (immigrants qnd emigrants) in off-river pond series habitat throughout the summer, 1990, Yankee Fork of the Salmon River.

	SPECIES																	
Pond Series	Ch Immig.			Ch Emig.			St. 1+ Immig.			St 1+ Emig.			at YOY Immig.			St YOY Emig.		
	x	n	SD	x	n	SD	x	n	SD	x	n	SD	x	n	SD	x	n	SD
4	87.4	88	7.2	92.1	32	7.1	103.2	28	15.8	90.9	41	17.4	4S.7	27	4.6		———	
2		WI---a----			------m---		101	5	6.2	98.2	3	2.7	55.2	131	5.5	40.6	23	1.7
1		*		83.4	616	6.8		*		113.0	26	9.1		*		47.8	85	3.8

• Immigrants not monitored x■ thin series.

while young-of-the-year fish were only observed entering'this habitat;

In PS 2, we monitored fish movement into and out of the series at the same trap from an up and down series location. We found that most of the fish movement was from age O+ steelhead moving upstream into channel habitat (Figure 6). Much of this movement occurred from September to October with few corresponding outmigrants; this suggests that these fish will over&inter in the off-river channel habitat. At the upstream trap, few steelhead entered or left PS 2 (Figure 6). We did not observe chinook salmon moving into or out of PS 2 and few older steelhead moved into or out of this habitat (Table 3).

In PS 1, a supplemented series; two emigration peaks of outplanted chinook salmon were observed (Figure 7). The first was right after volitionalmovementwas permitted. The second peak was in the first week of October. This second migrational peak occurred during the same week that mean daily water temperature dropped below 9 °C (Figure 7). This late season emigration peak was also observed for age l+ and older steslhead juveniles: By October 1 we had observed 616 of the outplanted chinook salmon leaving PS 1. Accounting for weekends and down days, we estimated that 273 more fish left this series, making our total estimate of emigrants 889 fish, or 3.6 percent of the fish released in July. We did not trap fish in the other (PS 3) supplemented. series, however, we assume similar patterns of fish movement.

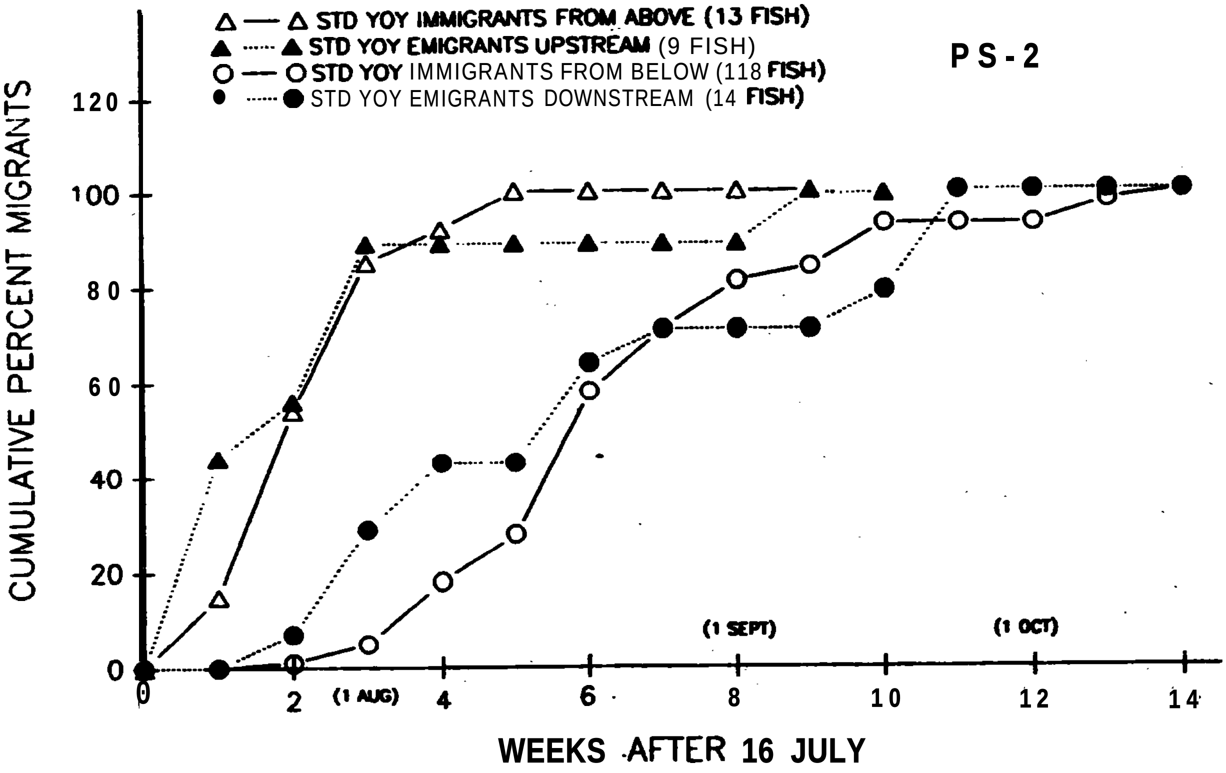


Figure 6. Summary of young-of-the-year steelhead emigrants and **immigrants from both the up and downstream entrances of** pond series 2 from mid-summe through fall.

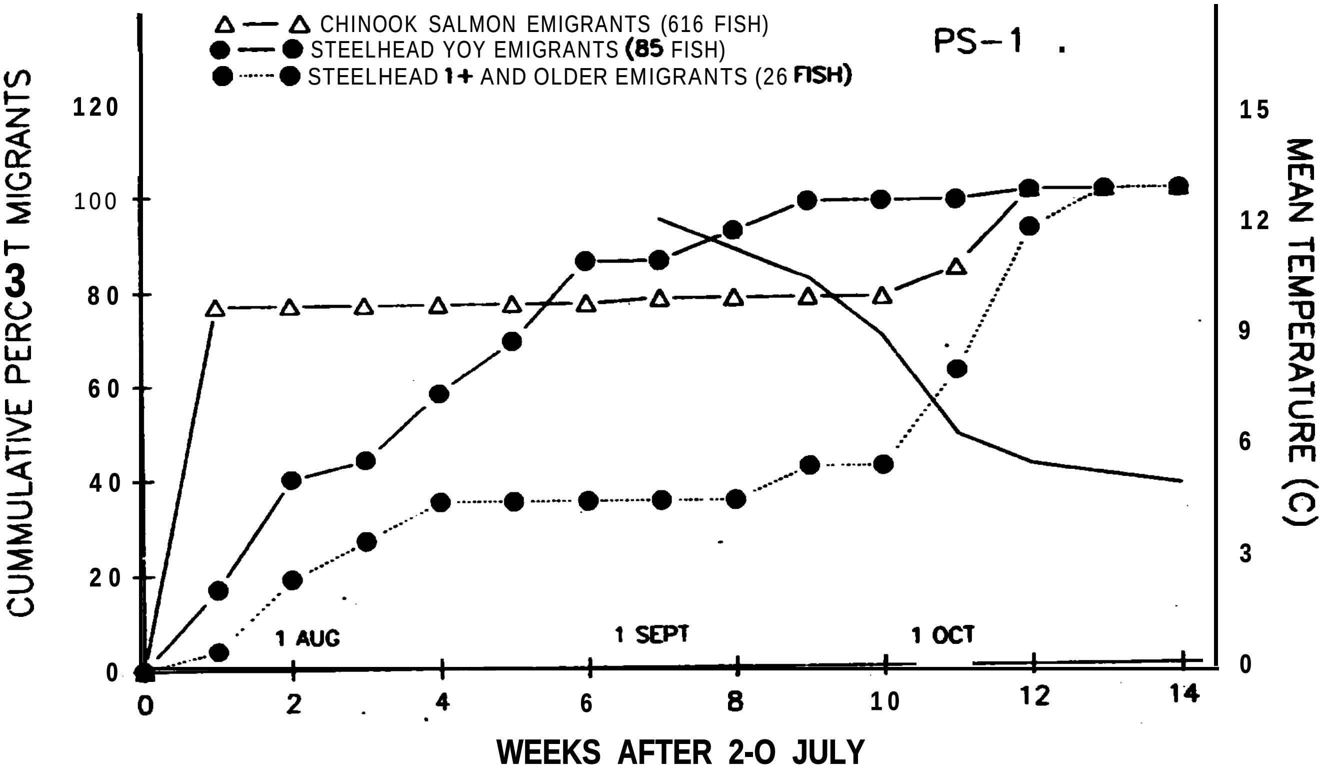


Figure 7. **Summary of chinook salmon and steelhead emigrants from** pond series 1 during **20** July to 20 October; the **mean** daily **water temperature from 1 September** to **20 October** is **superimposed on the fish movement plot.**

Chinook Salmon Densities and Abundance

Chinook salmon densities (all habitat combined) in PS 1 and 3 (supplemented series) did not differ significantly ($P>0.05$) from July through September (Figure 8a). In PS 3 total chinook. densities decreased from 228 fish/100m^2 in July to 64 fish/100m^2 in late September. By comparison chinook salmon densities remained fairly constant from July to September in PS 1, with a range of 96 to 117 fish/100m^2. The high July density of chinook salmon in PS 3 was partially a result of outplanted fish moving up into channel habitat above the upper release pond. Access to this habitat was permitted by high flows due to a summer storm at' the time of release. This allowed fish to move up past a channel check structure. These fish were. unable to leave the series at the upper end because of a culvert. As flow decreased most fish were effectively trapped by a downstream beaver dam. In the week following the storm we made an effort to seine fish out and release them in a downstream pond to let them distribute in a more natural fashion. By summer's end we estimated that 11 percent (2,644 chinook) of the outplanted fish remained in PS 3 and that 22 percent (5,412 chinook) remained in PS 1 (Figure 8a).

We were much more successful this year in preventing immediate post release emigration than in 1989. In 1989 hatchery fish were released during high flows and we had some problem prohibiting immediate downstream migration. The result was a high degree of passive downstream displacement. This year hatchery fish were outplanted at much lower flows, plus we effectively blocked

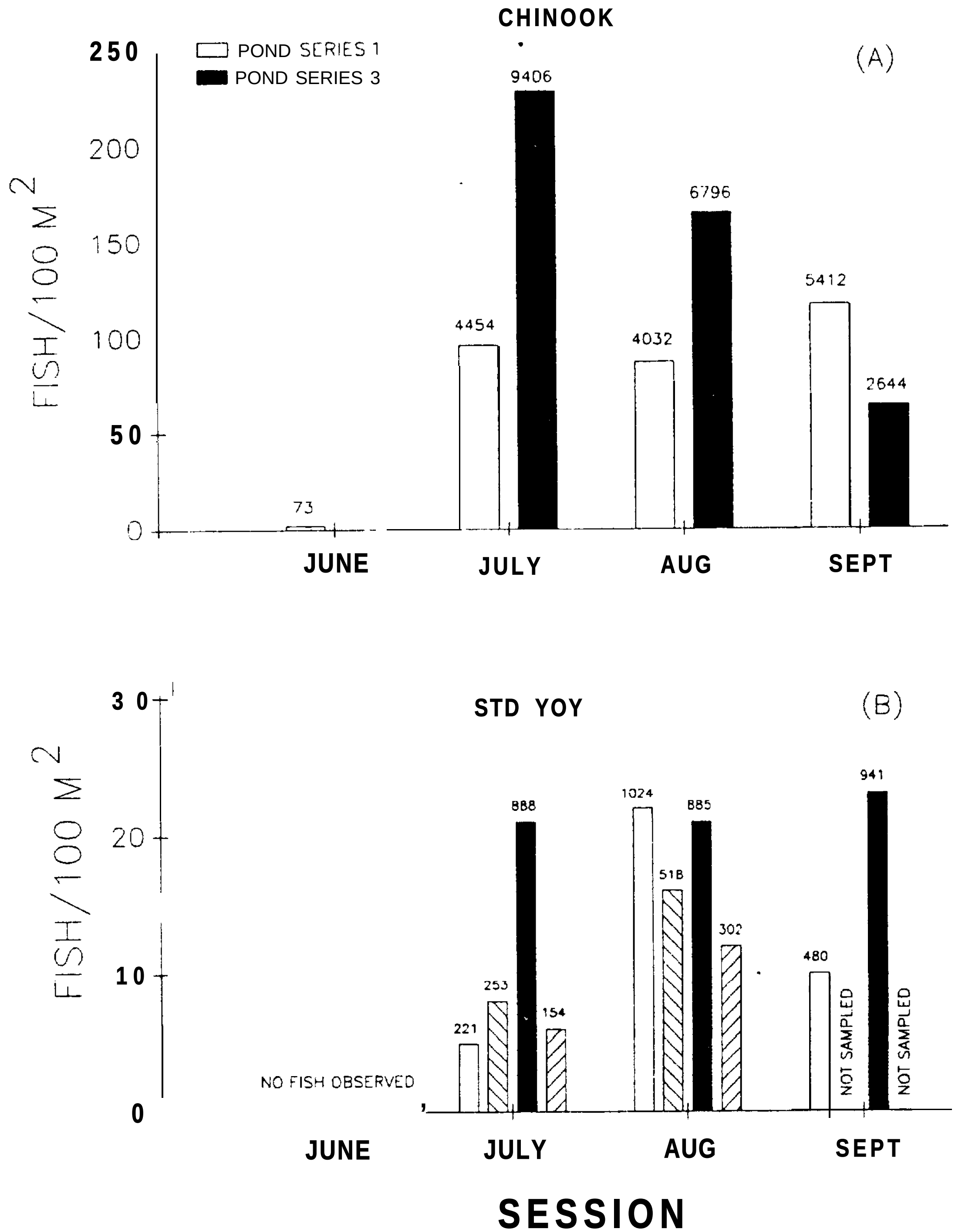


Figure 8. Total densities (no./100m^2) and associated abundance (above density bars) for outplanted chinook (except in June) in pond series 1 and 3, and for steelhead young-of-the-year in all pond series during four snorkel sessions from June through September, 1990

downstream emigration for one week. The result was that the average summer density by pond series was more than twice as high (92 fish/100m^2) as the average density last year (37 fish/100m^2) despite lower stocking rates. However, total outmigration remains high as September abundance estimates indicate an 85% reduction in numbers from initial stocking; similar to the 95% reduction in numbers that we observed in 1989. It should be noted that an unknown, but likely high, percentage of the total abundance reduction observed resulted from predation by avian and river otters (Luttra Eanadensis) predation.

Density and abundance of naturally-produced chinook salmon in non-supplemented series (PS 2 and 4) were very low throughout the summer (Figure 9). In PS 4, which also was not supplemented in 1989, summer density was nearly equal in July and in September at 3 and 2 fish/100m^2, respectively. In 1989, September chinook densities were much greater than those observed this year (1990), 28 and 2 fish/100m^2, respectively. By comparison, September 1989 salmon densities in the West Fork were double those observed this year: 18 versus 9 fish/100m^2, respectively. Thus, the density of naturally-produced chinook salmon in PS 4 appears to be strongly influenced by densities in the West Fork, which in turn are strongly influenced by the previous year's spawner escapement.

Chinook salmon in the mainstem Yankee Fork strata were low throughout the summer (Table 4). We observed the greatest chinook salmon densities in the West Fork of the Yankee Fork (stratum 6) and stratum 4 in September at 9 and 4 fish/100m^2, respectively. These salmon densities were significantly greater ($P<0.01$) than

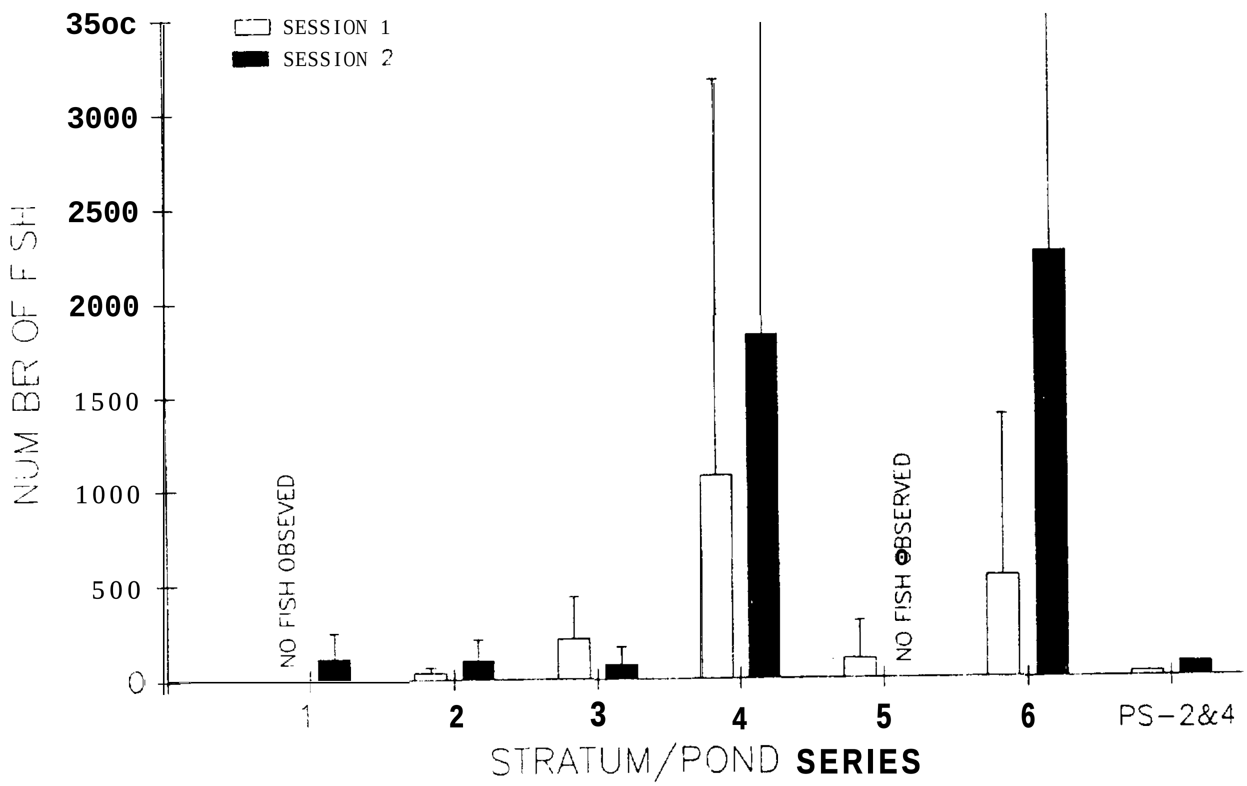


Figure 9. Total estimate of chinook salmon numbers in five mainstem Yankee Fork strata (l-5) and one tributary stratum (6), the West Fork, and two unsupplemented pond series (2 and 4) during June and September snorkel sessions, 1990.

Table 4. Mean total fish densities (fish/100m^2) by session and stratum in the Yankee Fork mainstem, 1990.

STRATUM	Density by Species							TOTALS
	CHS YOY	STH YOY	STH A&B	WHF YOY	WHF J W	WHF AD	OTH SPP	
				Session 1 (June)				
1	0.0	0.0	0.1	0.0	0.0	2.7	0.0	0.4
2	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.1
3	0.4	0.0	0.0	0.0	0.0	1.4	0.0	0.2
4	2.9	0.0	0.0	0.0	0.0	0.1	0.0	0.4
5	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.1
6	2.0	0.0	0.0	0.0	0.0	1.4	0.0	0.5
7	0.0	0.0	0.3	0.0	0.0	0.0	0.9	0.2
				Session 2 (September)				
1	0.4	1.1	1.8	0.0	0.0	3.6	0.0	1.0
2	0.1	1.8	0.0	0.0	0.0	0.0	0.0	0.3
3	0.2	0.2	0.1	0.0	0.0	0.8	0.0	0.2
4	4.0	0.1	0.1	0.0	0.0	0.1	0.1	0.6
5	0.0	0.0	0.1	0.0	0.0	0.0	1.7	0.2
6	9.0	0.4	1.7	0.0	0.0	0.2	0.0	1.6
7	0.0	1.9	2.0	0.0	0.0	0.0	1.7	0.8

salmon densities in other mainstem strata during September. We estimated there to be 4,353 chinook salmon in Yankee Fork strata one to seven in September; 52 percent of these fish were produced in the West Fork (Figure 9).

Steelhead Densities and Abundance

Steelhead young-of-the year (YOY) used pond series habitat from July through September. Total densities of naturally-produced age 0+ steelhead in pond series 1-4 were considerably less than chinook salmon densities in the supplemented pond series (Figure 8, Table 4), but greater than naturally-produced chinook salmon densities. Total densities of age 0+ steelhead ranged from 5 fish/100m^2 in July in PS 1 to 23 fish/100m^2 in September in PS 3 (Figure 8); this corresponds to an estimated abundance of 221 fish and 941 fish in PS 1 an PS 3, respectively. These densities compare favorably to YOY densities observed in mainstem Yankee Fork strata (table 4) where we estimated September densities to range from 0 to 1.8 fish/100m^2 (stratum 2). Emergence of steelhead at the time of our June session had not occurred.

Habitat Selection

We found densities of outplanted chinook salmon to be greatest in the open water habitat in August and September (Figure 10), yet differences were only significant in August (Appendix A). Also, throughout the summer, salmon densities tended to be greater in pond habitat with cover: again, however, differences were only significant ($P<0.05$) in August. At this time (August) chinook

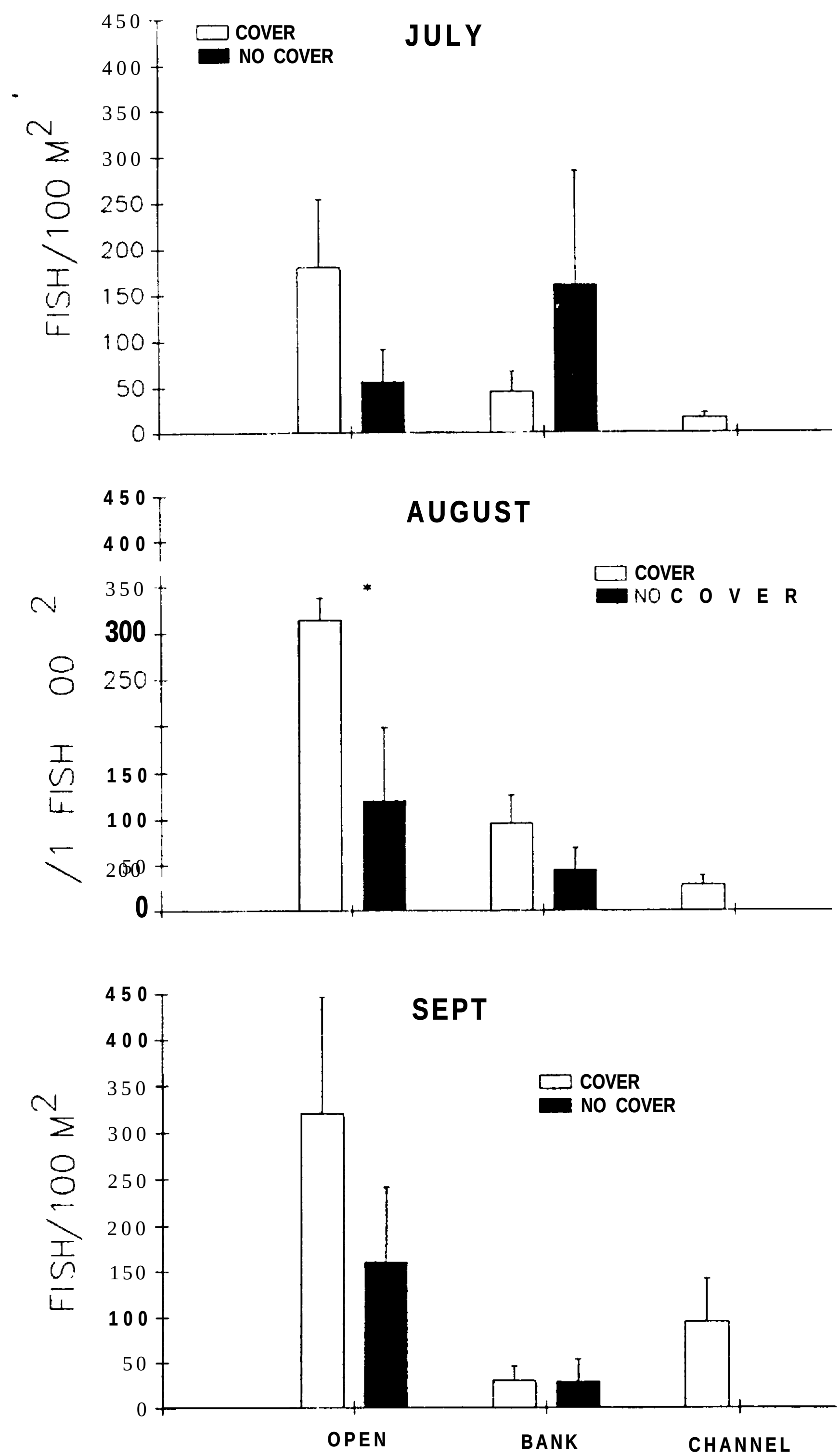


Figure 10. Mean and standard error of chinook salmon densities in supplemented pond series by habitat and cover types during the July-September sampling sessions, Yankee Fork of the Salmon River, 1990. Mean density values are derived from the two-way analysis of variance. An asterisk above a set of values indicates a significant difference from other habitat types.

salmon density was greatest in open habitat with cover (317 fish/100m^2) and lowest in bank no cover habitat (44 fish/100m^2). This difference in densities between habitats became greater in September (Figure 10). Further, the densities in pond series channel habitat increased from July through September, from 16 to 95 fish/100m^2.

In supplemented pond series chinook salmon densities by habitat type were very similar during September between years (1989 and 1990), except in open water habitat (Figure 11). Since we were able to maintain a greater total salmon density throughout the summer in 1990, we found most of this difference to occur in the open water habitat, 238 versus 37 fish/100m^2, in 1990 and 1989, respectively. Since most of the open water habitat was deeper than bank or channel habitat, it makes sense that this habitat could sustain a greater density increase.

In PS 2 and 4, the densities of naturally-produced chinook salmon were not significantly ($P>0.05$) different among habitat types (Figure 12, Appendix A). In July, salmon densities were greatest in open habitat with cover at 11 fish/100m^2. By August naturally-produced densities were greatest in bank habitat, differing from what we observed in ponds with hatchery chinook salmon (Figure 10).

In PS 1, bank and channel habitats maintained the greatest densities of age 0+ steelhead from July through September (Figure 13). Densities were highest in bank cover habitat (46 fish/100m^2) in August, and in channel habitat (41 fish/100m^2) in September. In

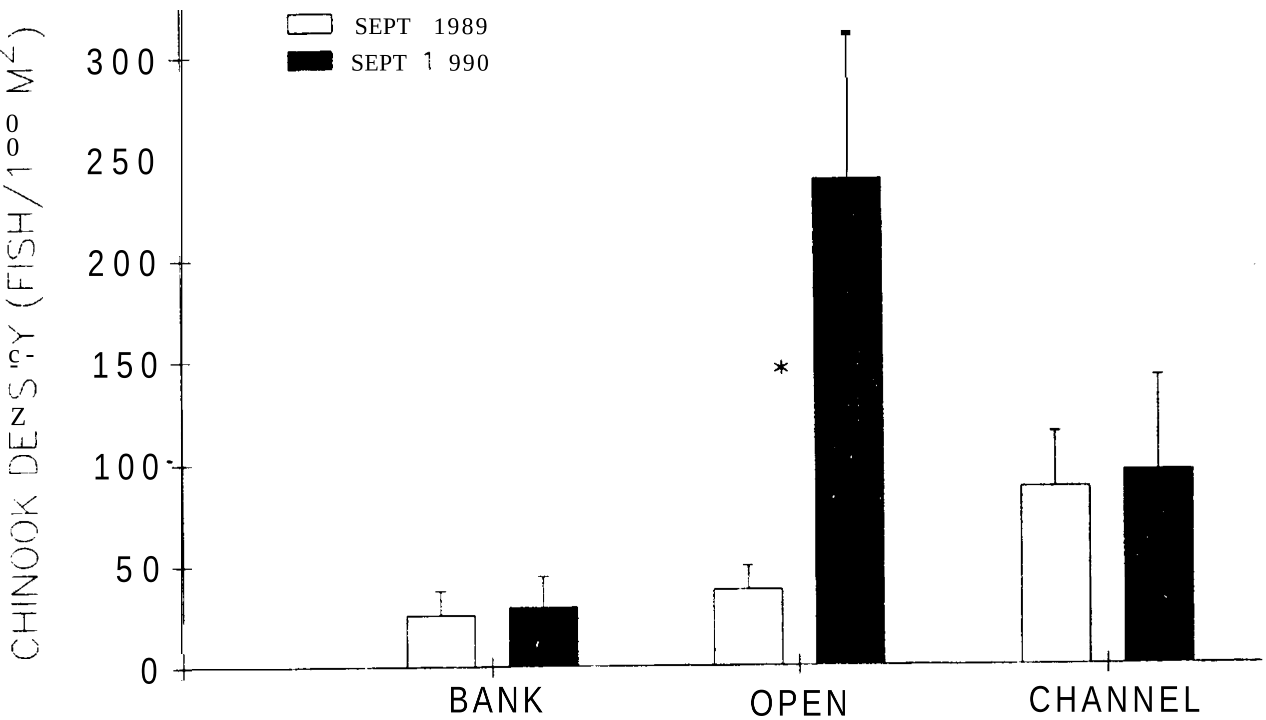


Figure 11. Comparison of mean chinook salmon densities by cover type between years (1989 and 1990) in the Yankee Fork ponds. Only data for pond series that received hatchery-outplanted chinook salmon are presented. An asterisk above means for habitat type indicates a significant difference between means.

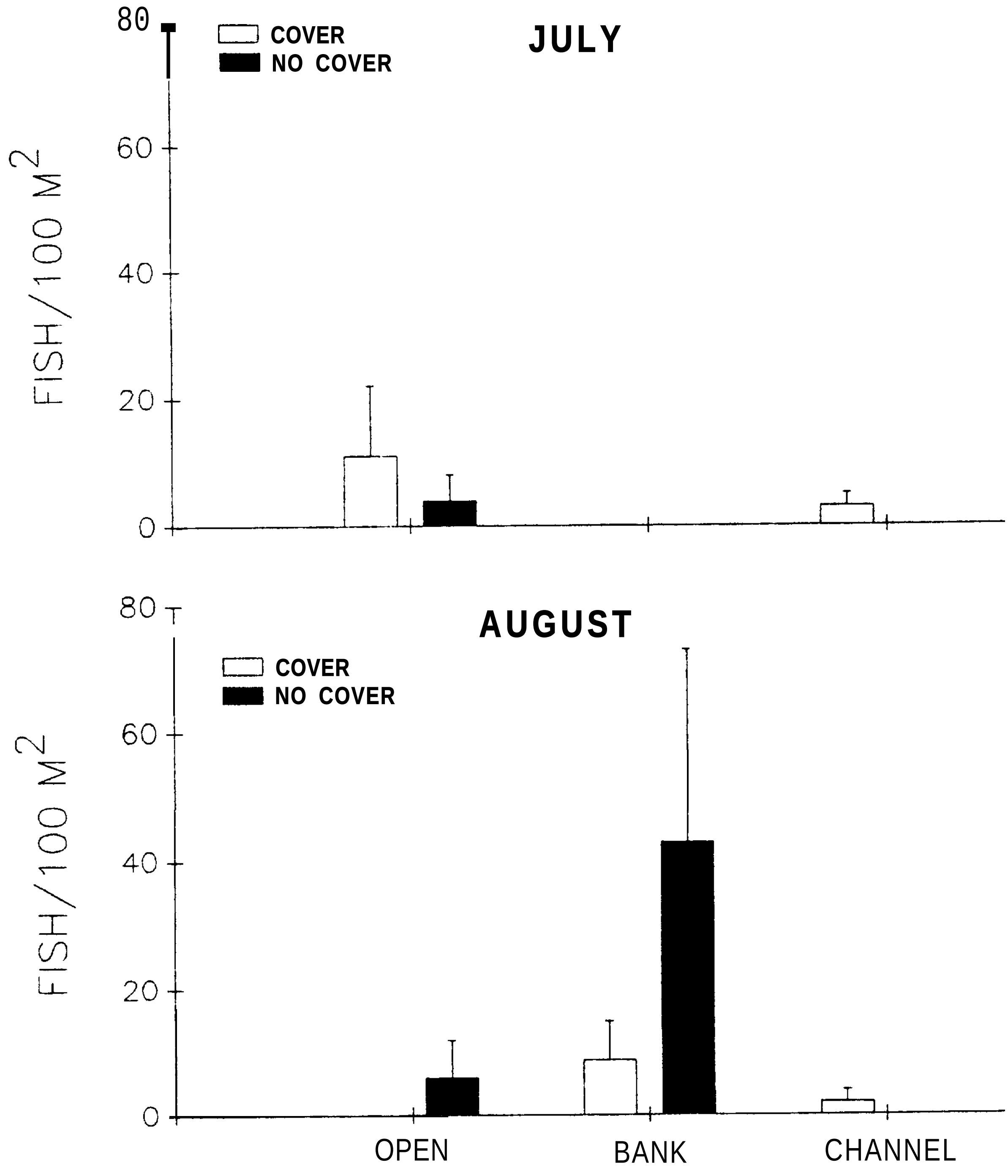


Figure 12. **Mean and standard error of naturally-produced chinook salmon densities (PS 2 and 4) by habitat and cover types during July and August sample sessions, Yankee Fork of the Salmon River, 1990. Density values are derived from the two-way analysis of variance.**

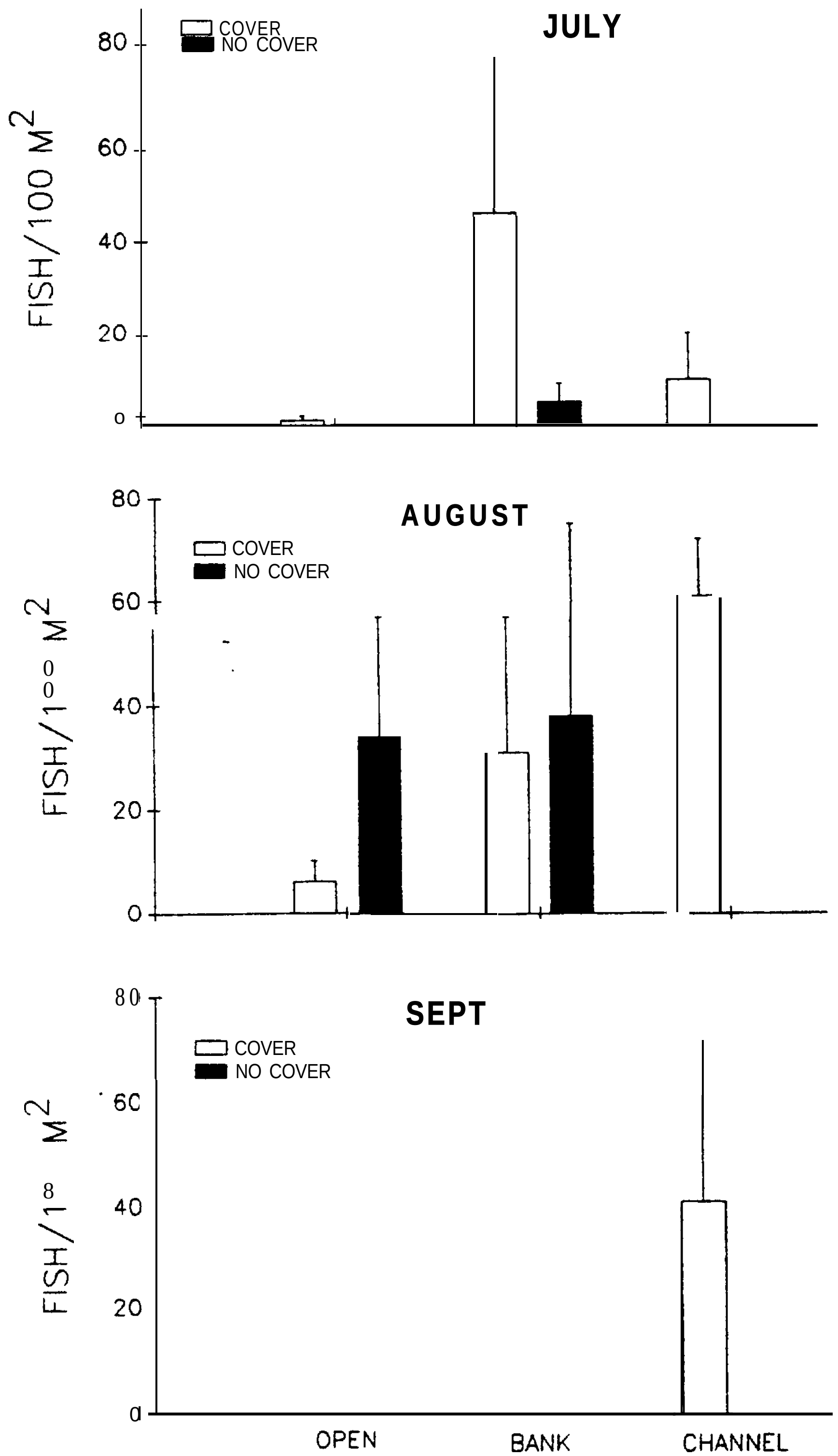


Figure 13. Mean and standard error of age 0+ steelhead in pond series one (PS 1) by habitat and cover types during July-September sample sessions, Yankee Fork of the Salmon River, 1990.

our September session we only observed age 0+ steelhead in the channels (Figure 13).

Mean salmon and steelhead densities using pond series channel habitat varied by species and age class throughout the summer and fall (Figure 14). We observed age 1+ steelhead at the greatest densities in June at 17 fish/100m^2, and age 0+ steelhead at the greatest densities in July and August at 30 and 62 fish/100m^2, respectively. Chinook salmon were most abundant in the channels during September at 78 fish/100m^2.

Trends in habitat use between hatchery-outplanted chinook salmon and naturally-produced fish were similar (Figure 15). Channel habitat was most important during periods with cold water temperatures, June and September. This is supported by a rate of use disproportionate to the amount of this habitat type available (Figure 16). The greatest percentage of habitat use by salmon in July and August occurred in open water habitat. At this time salmon used this habitat at a greater relative proportion compared to the habitat's proportional availability (Figure 16). The use of bank habitat by outplanted salmon decreased throughout the summer (Figure 15).

Chinook Salmon Growth

Hatchery outplanted chinook salmon grew at a slower rate than did naturally-produced salmon sampled in the West Fork of the Yankee Fork (Figure 17). Naturally-produced fish in PS 4 grew at a similar rate to fish in the West Fork. Throughout the summer the mean increase in fish length for PS 1 and 3 was small at 0.062

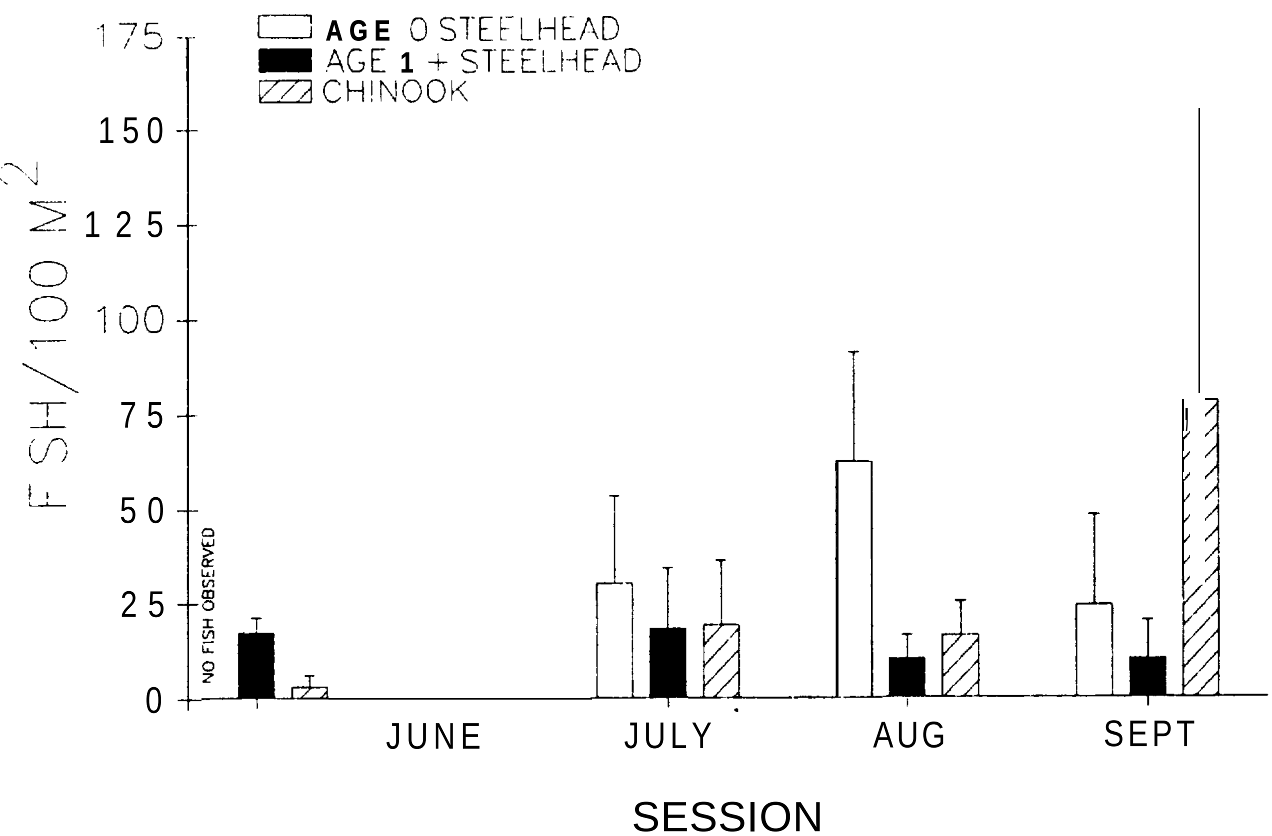
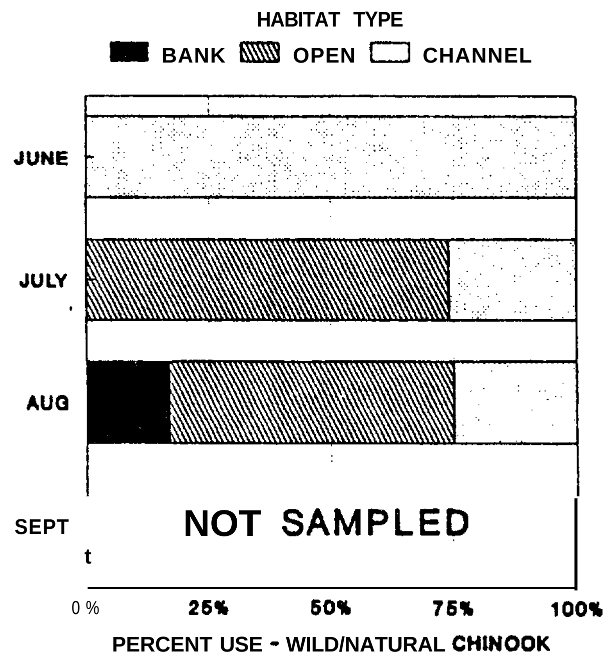


Figure 14. Mean densities of age 0+ and 1+ steelhead and age 0+ chinook salmon observed in channel habitat, all pond series combined, Yankee Fork of the Salmon River, 1990.



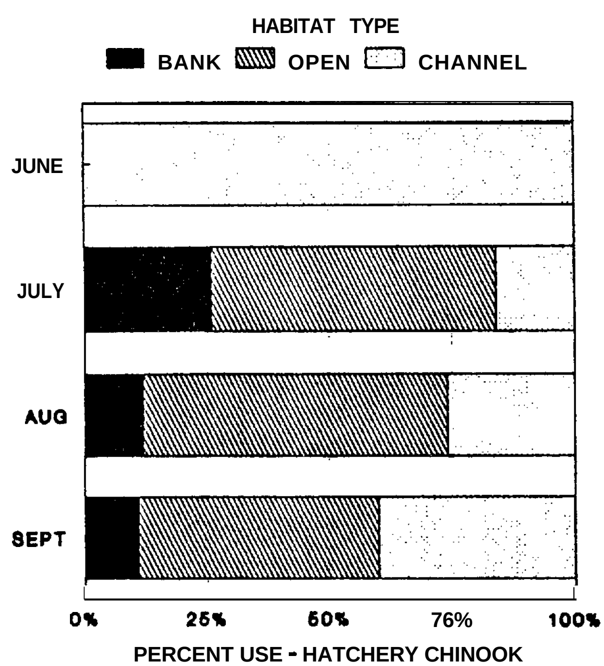


Figure 15. The relative proportion of hatchery-produced chinook salmon using pond series bank, open and channel habitats during June-September snorkel sessions (PS 1 and 3), and the relative proportion of naturally-produced chinook salmon using the same habitats in June-August (PS 2 and 4), Yankee Fork of the Salmon River, 1990.

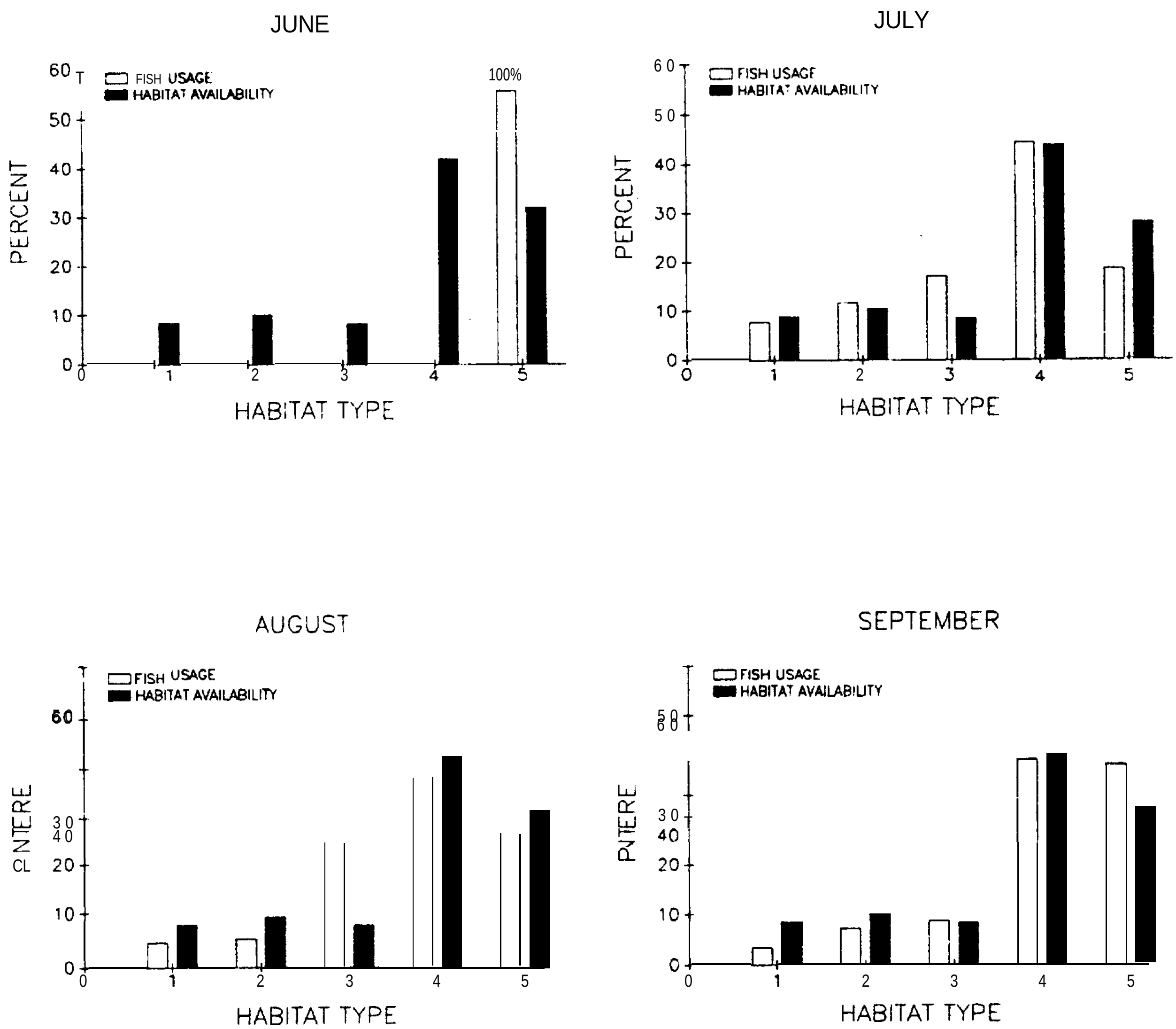


Figure 16. Percent chinook salmon use of five different habitat types (l=bank-cover, 2=bank-no cover, 3=open water-cover, 4=open water-no cover, 5=channel) relative to habitat availability for all pond series from June through September, Yankee Fork of the Salmon River, 1990.

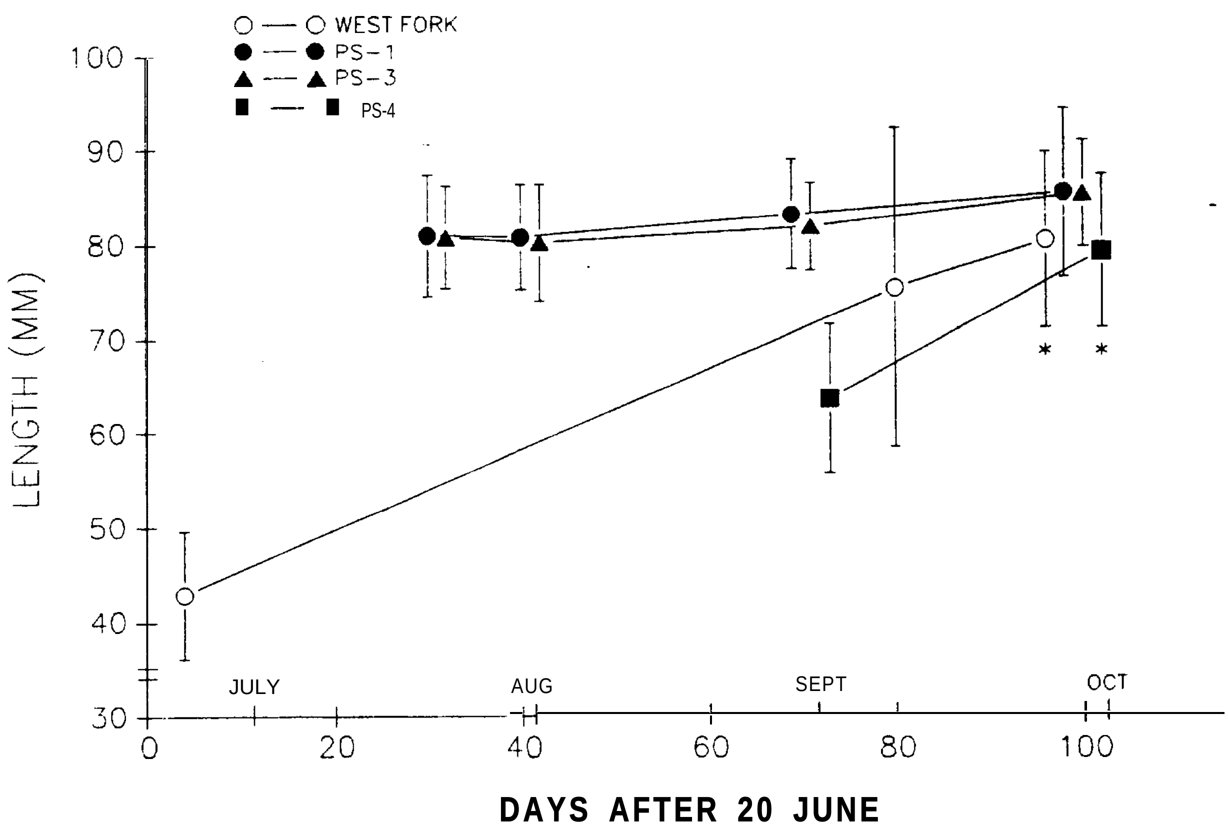


Figure 17. Increase in mean length of chinook salmon in main channel habitat (West Fork) from 25 June to 26 September; in supplemented pond series 1 and 3 from 20 July to 26 September; and in an unsupplemented pond series (PS 4) from 28 August to 26 September. Error bars represent one standard deviation of the mean; an asterisk above a mean indicates a significant difference from means without the asterisk.

mm/day compared to an increase of 0.376 mm/day for naturally-produced fish in the West Fork. Growth rates for fish in the West Fork were similar between this year and 1989, 0.376 mm/day and 0.344 mm/day, respectively. Comparatively, hatchery fish in the ponds grew at a slower rate this year (0.062 mm/day) compared to last year where daily length increases ranged from 0.120 to 0.312 mm/day in three different pond series. Much of this difference is accounted for by the later stocking date at a larger mean fish length this year, such that much of the necessary season's growth had already occurred in the hatchery prior to outplanting. Despite a slower growth rate, hatchery fish were still significantly ($P<0.05$) larger than West Fork fish in late September (Figure 17).

In our two supplemented pond series no distinct trends were observed in mean length increase of fish sampled in channel versus pond habitat. By late August, PS 1 salmon were significantly ($P<0.05$) larger in pond habitat compared to fish in channel habitat (Figure 18). Then, by late September the mean fish length in both habitats was comparable. This was a similar pattern to that observed in 1989. In PS 3 this year, salmon in channel habitat were larger ($P<0.05$) than pond fish in both late August and September.

Chinook Salmon Condition

Mean condition factors for both pond series (1 and 3) and West Fork fish decreased from July through September (Figure 19). Fish conditions in the ponds ranged from 0.95 in July to 0.82 in late September. The mean condition of salmon in PS 1 was greater

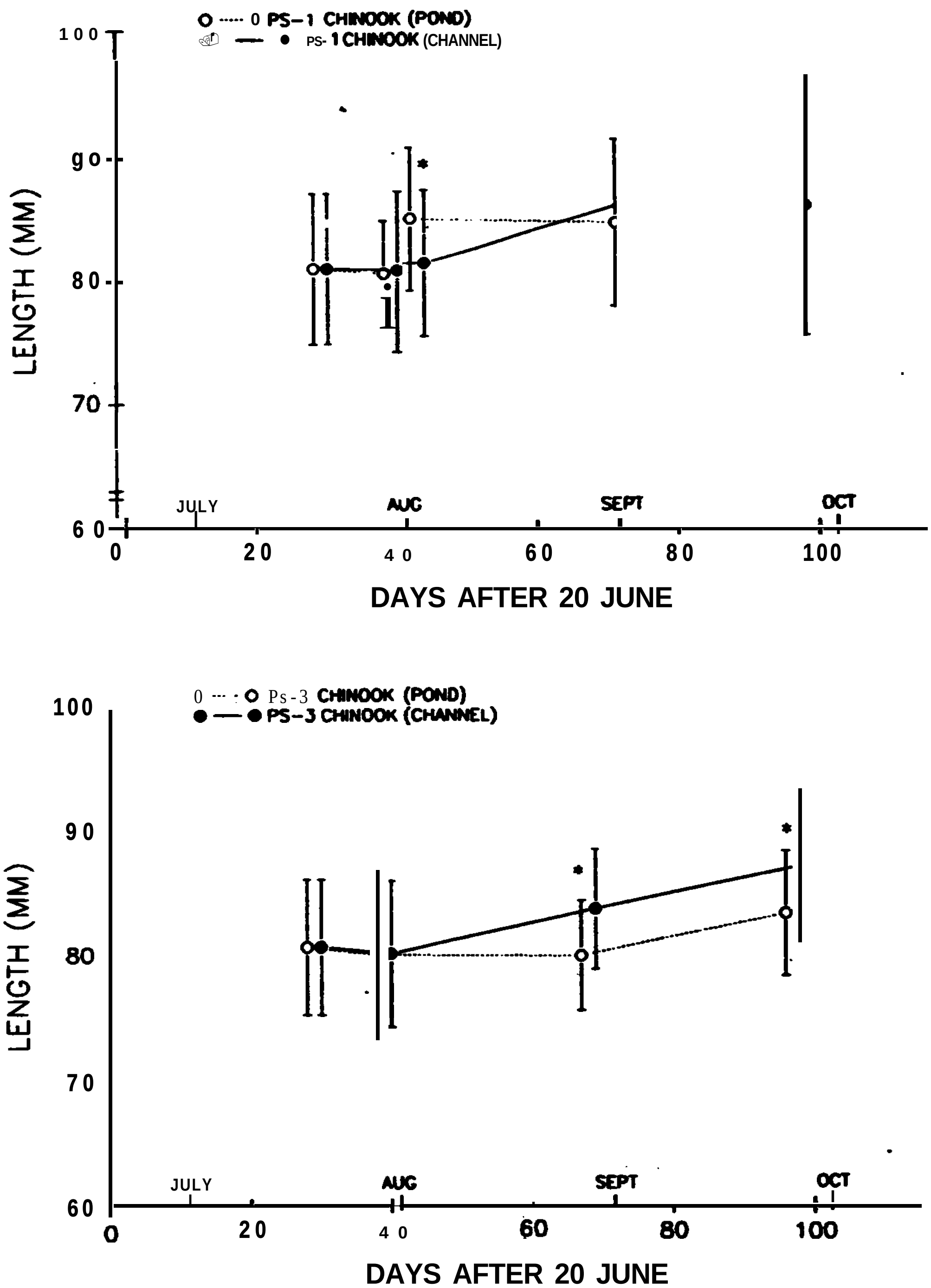


Figure 18. Mean length of chinook salmon- in channel and pond habitat for pond series 1 and 3 from 20 July through 26 September, Yankee Fork of the Salmon River. Error bars represent the standard deviation of the mean; as asterisk indicates a difference between means.

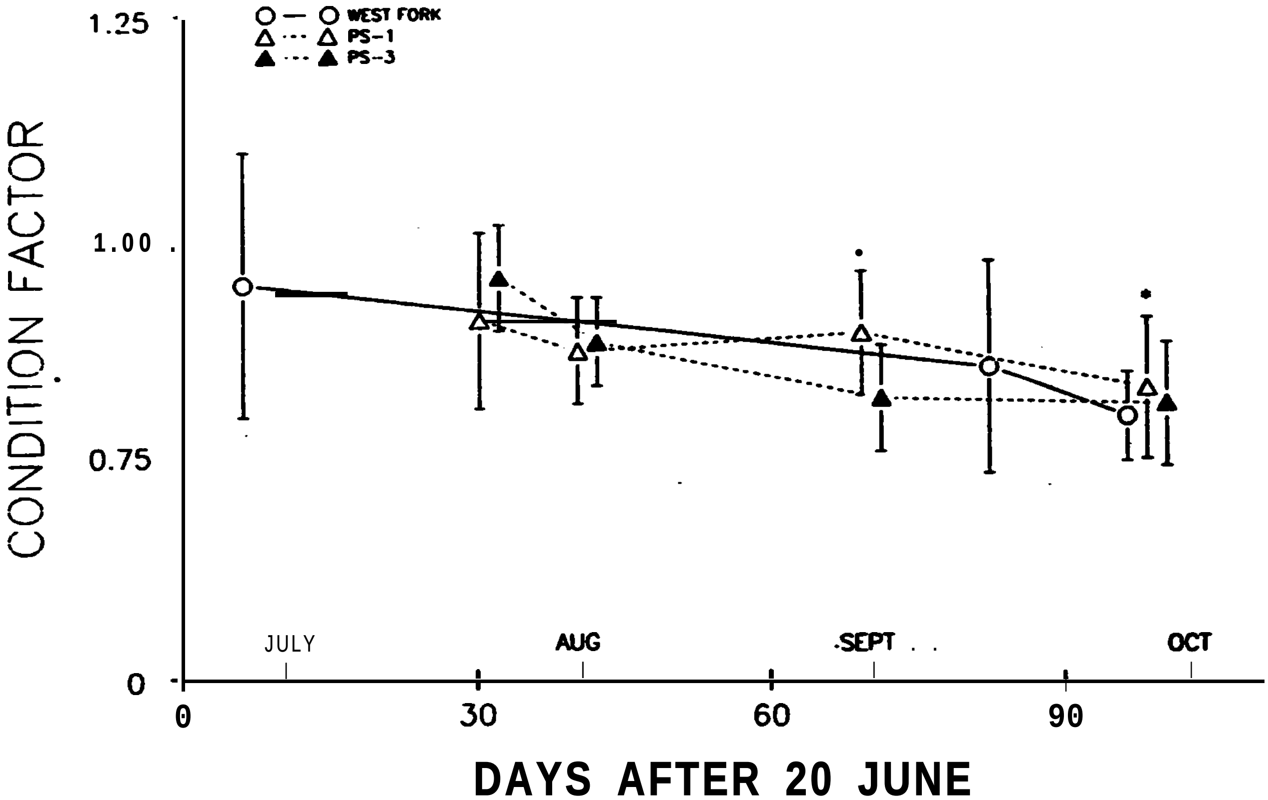


Figure 19. Mean and standard deviations of chinook salmon condition factors throughout the summer for fish stocked into pond series 1 and 3 and naturally-produced fish in the West Fork of the Yankee Fork. As asterisk above a mean indicates a significant difference from other means.

$(P<0.05)$ than fish conditions in PS 3 and the West Fork in September (Figure 19).

Three Year Summary

After three years of chinook salmon supplementation in off-channel pond series, and the evaluation of chinook salmon use in supplemented and unsupplemented series, several patterns have surfaced. If ponds are supplemented during high flows (as in 1988 and 1989), then the post summer parr densities are lower than if the ponds are supplemented after peak flows (Table 5). However, the prevention of post-release immigration can help to reduce immediate density reduction associated with passive downstream movement. In 1990, we were able to maintain greater post summer parr densities from lower initial stocking densities by releasing fish after peak flow and by inhibiting immediate emigration (Table 5). Conditions of salmon rearing in developed off-channel habitats have generally been greater than or equal to fish rearing in quality mainstem habitats. The number of fish using unsupplemented pond series habitat appears to be related to spawning escapement the previous year, especially in the West Fork which is located directly above PS 4. During a good seeding year (1988) the September parr density the following year in PS 4 was greater than the densities in the West Fork (Table 5). Conversely, after a year of low escapement (1989), the end of summer use in PS 4 for 1991 was low relative to densities in the West Fork (Table 5).

Table 5. Sumary of chinook salmon densities, length, and condition factors during three years (1988-1990) of supplementing and sampling in the Yankee Fork ponds. Data are presented for initial stocking densities (where applicable) and end-of-summer pre-emolt densities, mean lengths, and mean conditions. Data are also presented for naturally-spawned chinook salmon in the West Fork of the Yankee Fork.

	1988 *				1989 **				1990 ***			
PS	D.Stocked (no./m2)	Sept. (no./m2)	Sept. $\bar{x}$ length(mm)	Sept. $\bar{x}$ Cond.	D.Stocked (no./m2)	Sept. (no./m2)	Sept. $\bar{x}$ length(mm)	Sept. $\bar{x}$ Cond.	D.Stocked (no./m2)	Sept. (no./m2)	Sept. $\bar{x}$ length(mm)	Sept. $\bar{x}$ Cond.
1					7.50	0.15	90.5 (6.9)	.95	5.41	1.17	85.1 (8.9)	.82
2					9.40	0.39	84.2 (8.6)	.96	n.a.	0.01		
3	8.21	0.46	89.0 (6.1)	.99	13.20	0.60	76.2 (7.7)	.97	6.05	0.64	85.1 (5.6)	.81
4	8.07	0.20	82.0 (10.1)	.94	n.a.	0.28	71.3 (7.3)	.92	n.a.	0.02	80.1 (8.1)	-
West Fork	n.a.	0.08	76.0 (7.6)	1.19	n.a.	0.18	72.6 (7.3)	.89	n.a.	0.09	80.2 (9.3)	.80

n.a. indicates that no chinook salmon were outplanted into that habitat in 1989 and 1990. Pond series 4 was left to be seeded by naturally-produced fish from the West Fork.

* chinook fed fry stocked on 1 June at an average length of 63.3 mm; pond series four was not connected to the river at the upstream end.

** chinook fed fry stocked on 20 May at an average length of 62.1 mm; pond series one has no upstream connection to the river.

*** chinook fed fry stocked on 20 July at an average length of 80.8 mm.

Spawning Ground Survev

Escapement of spring chinook salmon into the Yankee Fork drainage in 1990 was similar to that of 1989, however the distribution of redds differed (Table 6). In 1990, we observed three times as many redds (20) in the West Fork of the Yankee Fork compared to the previous year (6). Therefore we anticipate more use of PS 4 in 1992 by naturally-produced West Fork salmon. Numbers of chinook salmon escaping and spawning in the upper Yankee Fork were much lower in 1990 compared to 1989 (Table 6).

In 1991 we anticipate greater salmon returns to the upper Yankee Fork. In 1987 spring chinook eggs were planted in artificial redds in the upper Yankee Fork, thus these fish should return in 1991 as four-year-olds.

Invertebrate Inventory

In general, pond series 3 and 4, mean invertebrate densities by taxa in the pond benthos and plankton were greatest in habitat with vegetative or algal cover (Appendices C and D). For both pond series combined the mean total invertebrate densities were significantly ($P<0.05$) greater in open and bank habitats with cover (Table 7). Also, the mean total densities of invertebrates was greater ($P<0.05$) in pond and channel benthos (3,280 and 3,408 individuals/$0.1m^3$ respectively) compared to pond plankton (74 individuals/$0.1m^3$) densities.

Invertebrate densities have increased from 1988 to 1990 with the exception of pond benthos densities, which decreased from 1989

Table 6. Distribution of chinook salmon redds found in Yankee Fork of the Salmon River, Idaho from 1988-1990.

STRATUM	REDDS COUNTED * 1985	1986	1987	% OF TOTAL 1988	1989	1990
1	2	0	1	4.4	0	3.4
2	0	0	4	0	0	14.8
3	0	0	0	17.8	0	0
4	4	11	2	8.9	50.0	7.4
5	0	5	0	0	22.7	0
6	31	6	20	68.9	27.3	74.1
7	NS	NS	NS	--	--	--
TOTAL	45	22	27	100%	100%	100%

NS = Not Sampled

Table 7. Mean total invertebrate densities (no./.1m³) by volume and standard errors (parentheses) from pond series 3 and 4 in four different pond habitat types; 1) bank with cover, 2) bank without cover, 3) open cover, 4) open no cover sampled in the benthos and plankton, and in channel habitat, August 1990, Yankee Fork of the Salmon River. An asterisk above a mean indicates a significant difference from all other means from that sample type.

Benthic and Planktonic Invertebrate Density by Sample and Habitat type									
	Benthic				Planktonic				Channel Benthos
PS	1	2	3	4	1	2	3	4	
3	2284.2 (1387) n=10	1200.0 (848) n=10	2007.0 (878) n=10	1403.9 (681) n=10	* 59.0 (45.1) n=10	* 1.07 (0.63) n=10	208.4 (162.3) n=10	1.26 (0.641) n=10	1086.7 (1790) n=8
4	1977.7 (1129) n=10	1452.3 (509) n=10	6179.2 (3318) n=10	2518.0 (3318) n=10	8.23 (10.5) n=10	0.27 (.075) n=10	8.27 (5.55) n=10	0.085 (.000003) n=8	909.9 (1246) n=10
Totals	* 2119.2 (875.8) n=20	1305.9 (506.4) n=20	* 3772.1 (1624.2) n=20	1791.3 (564.7) n=20	* 30.7 (21.82) n=20	0.809 (0.377) n=20	* 105.8 (82.2) n=20	1.13 (0.457) n=18	1005.5 (1071.5) n=18

to 1990 (Figure 20). Mean invertebrate densities in the channels have increased from 1,719 to 3,408 invertebrates/$0.1m^3$ and plankton densities from 11 to 74 invertebrates/$0.1m^3$. Mean plankton density was consistent between 1988 and 1989 (11 invertebrates/$0.1m^3$), but showed a seven-fold increase this year (Figure 20). Some of this extreme increase may be attributed to large numbers of Baetis spp. (Appendix D) that were captured in the plankton net as it was pulled through emergent vegetation in the water column. The plankton samples from this water-column cover type may have been over-represented compared to previous years due to differences in the availability of emergent vegetation.

Ephemeropterans and Dipterans were the most important taxa by number in our sampling. The two taxa constituted 90 and 62% of all taxa by numbers, respectively in channel benthos and pond plankton (Appendices D and E). Dipterans were the second most important group by number in pond benthos; non-insect organisms accounted for 50% of all individuals observed in our pond benthic sampling.

DISCUSSION

Developed off-channel pond series of the Yankee Fork are important rearing areas and have provided rearing benefits to salmonids relative to main channel habitats. Both naturally-produced chinook salmon and steelhead, and hatchery-outplanted chinook salmon were maintained in these habitats at similar or greater densities than main river habitat throughout the summer. Swales and Levings (1989) also found that chinook salmon

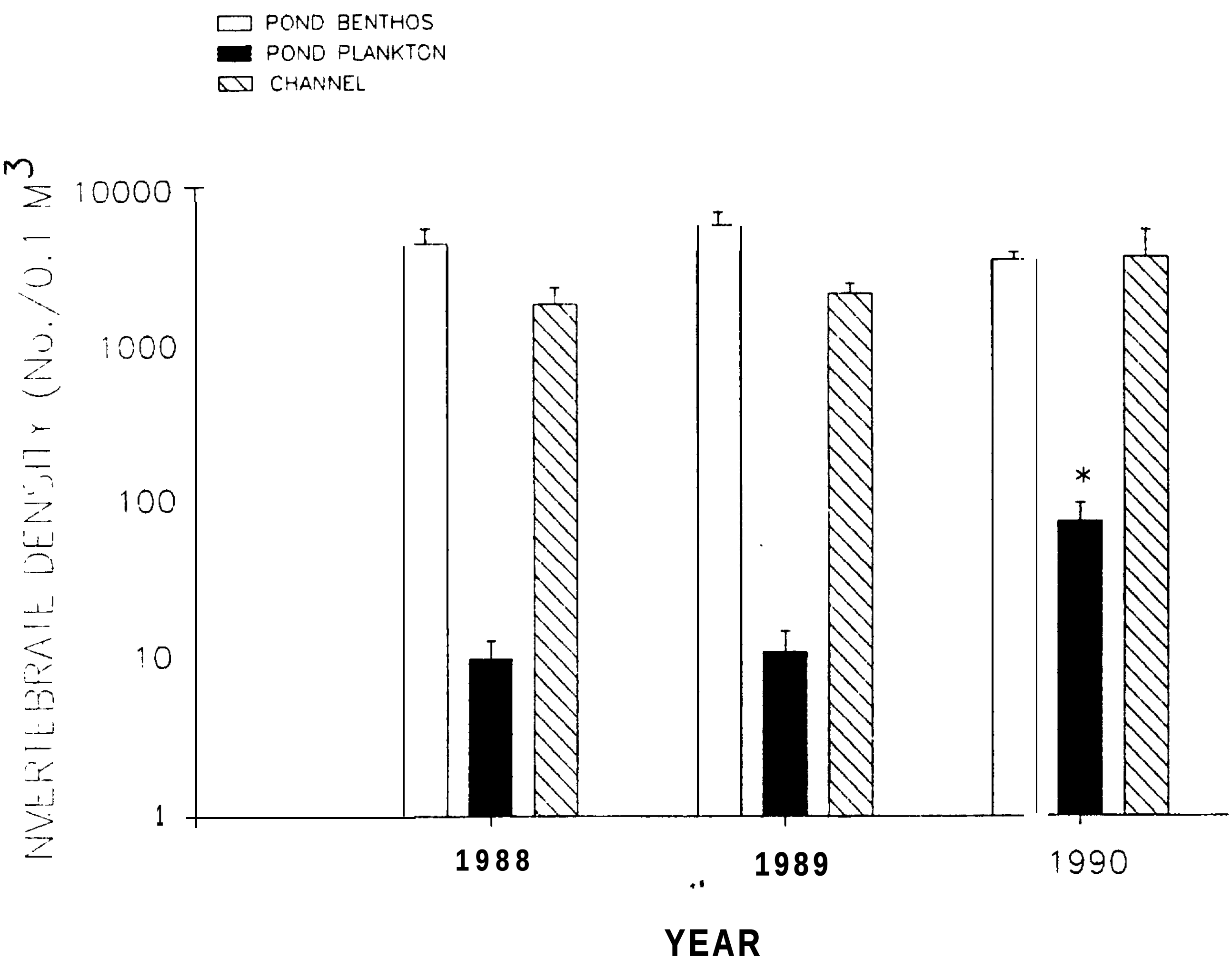


Figure 20. **Mean and standard error of total invertebrate densities from all habitat types combined sampled in the pond benthos, pond plankton and channel benthos for 1988 through 1990. An asterisk indicates a significant difference from other year means for that sample type.**

volitionally used off-channel pond habitat in the Nicola River, British Columbia.

The total densities of outplanted chinook salmon for PS 1 and 3 in September were 117 and 64 fish/100m^2, respectively, accounting for a total of 8,056 pre-smolts. Chinook salmon densities in these ponds were much greater than the highest September chinook salmon density (9 fish/100m^2) observed in the mainstem. Making a parr to smolt comparison, these two pond series maintained production for 59% of their total estimated smolt capacity (BNI 1987). This compares favorably to last year where we were only able to maintain about 24% of smolt production capacity in the ponds by September (Rowe et al. 1990). Even though we are not able to make smolt to smolt comparisons, we feel that these end of the season pre-smolt production estimates are fairly representative of the following year's smolt production. This is supported by the fact that after our late September pond abundance estimates were made we continued to monitor fish outmigration through October. We observed one pulse of outmigration in early October followed by no additional movement. Overwinter mortality is unknown at this time; however we continued to spot sample these habitats through late winter and always observed salmon and steelhead in the ponds.

Naturally-produced chinook salmon used unsupplemented pond series at densities (2 fish/100m^2) greater than the naturally-produced chinook salmon in adjacent river sites (0.1 fish/100m^2). This differs considerably from 1989 where PS 4 maintained a late summer chinook salmon density of 28 fish/100m^2, a production number equivalent to what 3.9 km (57%) of the mine influenced (strata 2 and 3) mainstem produced (Rowe et al. 1990). This year (1990), PS 4 produced chinook salmon numbers equivalent to what was produced in 1.9 km (28%) of the mainstem influenced by dredge activities (strata 2 and 3).

In three years of supplementing the Yankee Fork off-channel ponds, we have found several methods for maximizing use. First, after fish are released, it is best to actively retard downstream volitional emigration for about one week. This facilitates acclimation and prevents rapid density reductions. Further, if fish are released when flows are on the decreasing side of the spring/summer hydrograph, this also facilitates acclimation. However, this entails keeping the fry in the hatchery for a longer period, and the effect of the action on the overall fitness of the outplanted fish is unknown. We have also found that if fish are released in the upper most pond of a series, the fish will effectively distribute themselves among ponds relative to habitat requirements. Finally, following the above protocols we have found that stocking densities of no more than 5-6 fish/m^2 will result in a relatively high rate of use throughout the summer. We would expect that as downriver passage survival is improved, and escapements increase, the off-channel rearing areas will be vital to increasing chinook salmon production in the Yankee Fork drainage.

After two years of tracking the use of naturally-produced chinook salmon in PS 4 (unsupplemented-control), it appears that densities in this series are related to chinook salmon escapement in the West Fork. In 1989, PS 4 was a highly productive rearing area for naturally-produced chinook (Rowe et al. 1990): the previous year (1988) we counted 31 redds in the West Fork. In 1989, we only counted 6 chinook salmon redds in the West Fork and correspondingly documented very minimal salmon use of PS 4 in 1990. This year we counted 20 salmon redds in the West Fork, and we would anticipate greater natural seeding of salmon in PS 4 in 1991 compared to 1990.

Off-channel habitat also sustained good production of steelhead throughout the season. Of the off-river rearing areas, channel habitat was the area most used by steelhead. Pond series densities of naturally-produced age 0+ steelhead ranged from 10 to 23 fish/100m^2 in September compared to a high of 1.8 fish/100m^2 in adjacent river stratum 2. Steelhead YOY production benefit in the ponds, relative to the dredge influenced mainstem (6.8 km) was even greater than that for chinook salmon. Pond series 1 and 3 produced steelhead numbers equivalent to 116 percent of the steelhead production in the adjacent mainstem.

Movements of naturally-produced chinook salmon into and out of pond habitat corresponded with high flows in early summer. These were one year old fish that were using this habitat in a transitory fashion. Little or no movement was observed after the late May early June peak.

Following an emigration pulse during the week after volitional movement was permitted, hatchery outplanted chinook salmon movement patterns were similar to those of natural fish. We observed no emigration from August through September. However, as mean water temperatures dropped below 9 °C, we observed one last emigration pulse of chinook salmon. This emigration pattern, coinciding with decreasing water temperatures, is thought to be a redistribution response by salmon in search of more suitable overwintering habitat (Hillman et al. 1987; Bustard and Narver 1975). During this late fall period we did not fish an immigrant trap at the top of a pond series to see if salmon from upstream were redistributing into this habitat for overwintering.

Channel habitat within the pond series are an important overwintering area for age 0 steelhead. From September through October we found that these fish will immigrate from the mainstem below a pond series up into pond series channel habitat. This upstream movement pattern by young steelhead has been observed by Hillman et al. (1989) in the Wenatchee River, Washington. In contrast, Hillman et al. only observed chinook salmon to move downstream from their natal areas. Since steelhead in headwater systems generally spend more than one year in fresh water, patterns of short distance upstream migration allow the fish to effectively utilize local habitat heterogeneity on a seasonal basis. This also prevents a downstream displacement pattern that is often observed for chinook as they prepare for their ocean migration the following spring.

Habitat selection by outplanted chinook salmon changed from summer to fall with decreasing use of bank habitat and increasing use of channel habitat. Open water habitats maintained high salmon densities throughout the summer. Use of open water habitat may have been temperature related. Our thermograph data show that the open deep (>lm) water areas consistently had cooler mean daily water temperatures than measured bank habitat temperatures. Further, when we made a year to year (1989 to 1990) comparison of habitat use, September densities were nearly equal in bank and channel habitat, but significantly greater in open water habitat. We hypothesize that as we were able to maintain greater densities this year, the greatest amount of exploitable habitat was in the open water. This habitat had a greater three dimensional aspect versus bank and channel habitats which were near full seeding.

Fish consistently keyed into cover in open water, and to a lesser degree in bank habitat. However, the shallow water depth of the bank areas are probably a form of cover and protection from larger fish predators. Further, in the ponds we found the greatest invertebrate (benthic and planktonic) densities in open and bank habitats with cover. Presently the majority of the open water cover in the pond is water column algal mats. Cover composition could most effectively be augmented by large woody complexes which are limited in the ponds. However, when this cover type is present we have documented extensive use by both salmon and steelhead.

When steelhead were observed in the ponds (PS 1), their densities were greatest in bank habitat. This differs from chinook salmon habitat use. We infer that when the two species are sympatric in pond habitat they partition the habitat such that overlap in use is minimized. Habitat partitioning between these species in lotic systems has been well documented (Everest and Chapman 1972; Hillman et al. 1989) but this information is lacking for off-channel lentic environments.

Steelhead were the dominant species by density in the off-river channel habitats in July and August, but by September chinook salmon densities were greatest. Even though we do not have microhabitat data for the species in the pond series channels, qualitative observations from shocking again suggest some degree of resource partitioning in this habitat as well. We generally would capture age 0+ steelhead along shallow channel margins of both pool and riffle units. Most chinook were captured in pools and from mid-channel cover components of the riffle and glide units.

After two years (1989 and 1990), the importance of the pond series channel habitats has been consistent and is critical in maintaining densities of outplanted salmon throughout the summer. Use of these channel habitats is greatest in early summer and fall. Mean September densities of chinook salmon in both years has been around 95 fish/100m^2. These densities are far greater than those observed in our most productive mainstem strata and compare favorably with densities (108 parr/100m^2) seen in Idaho streams that are considered to be in excellent salmon producing condition (Petrosky and Holubetz 1988). Further, since our observed channel densities for chinook salmon in 1989 and 1990 were achieved through different stocking levels and no subsequent emigration constraints, we assume that the channel seeding capacity is in the range of 90-100 fish/100m^2. Other researchers have found greater relative salmon densities in habitats equivalent to these side channels in other systems (House and Boehne 1986; Bilby and Bisson 1987). Side channels have a greater proportion of shoreline habitat to stream surface area, and therefore have a relatively greater structural complexity compared to mainstem habitats.

We found that chinook salmon in supplemented ponds maintained a size advantage over naturally-produced salmon throughout the sampling period. Growth rates and mean lengths of salmon in supplemented series were nearly identical throughout the summer. Even though the growth rate of naturally-produced river fish was greater than that for pond fish, salmon in the ponds were in better condition by late September. This mirrors the pattern observed in 1989 (Rowe et al. 1990).

In conclusion, off-channel dredge ponds and associated channels located in the lower Yankee Fork were a beneficial summer rearing component to both hatchery-outplanted salmon and naturally-produced salmonids. These off-channel habitats are very important in systems such as the Yankee Fork where mainstem rearing areas are limited. It is likely that favorable water temperatures, feeding opportunities, flow regimes, and cover availability all contributed to high pre-smolt rearing densities and good condition factors of fish in these reclaimed dredge habitats.

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Appendix A. Two-way analysis of variance for outplanted (PS 1 and 3) and naturally-produced (PS 2 and 4) chinook salmon densities by habitat type and cover, Yankee Fork of the Salmon River, 1990. An asterisk denotes significance at the 0.05 alpha level.

SESSION	SOURCE	F-RATIO	N	PROBABILITY
		PS 1 and 3		
	Cover	0.84		0.37
1	Habitat Type	0.91	56	0.41
(July)	HT * Cover	1.13		0.33
	Cover	10.00		0.00 *
2	Habitat Type	3.32	67	0.04 *
(Aug.)	HT * Cover	U.67		0.51
	Cover	1.72		0.20
3	Habitat Type	2.83	61	0.07
(Sept.)	HT * Cover	1.72		0.74
		PS 2 and 4		
	Cover	0.27		
1	Habitat Type	0.67	51	
(July)	HT * Cover	0.08		
	Cover	0.71		0.41
2	Habitat Type	0.26	56	0.77
(Aug.)	HT * Cover	0.05		0.95

Appendix B. Two-way analysis of variance for naturally-produced (PS 1) steelhead young-of-year densities by habitat type and cover, Yankee Fork of the Salmon River, 1990. An asterisk denotes significance at the 0.05 alpha level.

SESSION	SOURCE	F-RATIO	N	PROBABILITY
	Cover	1.50		0.24
1	Habitat Type	1.59	24	0.23
(July)	HT * Cover	0.71		0.50
	Cover	u.14		0.72
2	Habitat Type	0.55	29	0.62
(Aug.)	HT * Cover	0.12		0.38
	Cover	0.72		0.41
3	Habitat Type	6.76	29	0.00 *
(Sept.)	HT * Cover	3.62		0.42

Appendix C. Mean and standard deviation of invertebrate densities (number/0.1m²) for Ponar dredge samples taken from different pond habitat in pond series 3 and 4 of the Yankee Fork of the Salmon River, August 1990. Sample size for each habitat type is given in parentheses.

	HABITAT TYPE (POND SERIES 3) - PONAR							
	Open Cover (10)		Open No Cover (10)		Bank Cover (10)		Bank No Cover (10)	
TAXON	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
Hirudinea			16.7	52.8	8.3	26.4		
Oligochaeta	592.1	593.0	867.4	1212.0	750.2	558.8	1105.0	1525.0
Hydracarina	8.3	26.4			41.7	70.9		
Coleoptera								
Dytiscidae								
Agabus spp.					8.3	26.4		
Oreodytes spp.			4.2	13.2	16.7	52.8	12.5	28.2
haliplidae								
Brychius spp.	58.4	56.3	87.6	129.6	25.0	56.3	87.6	91.0
Haliplus spp.	83.4	180.2	41.7	923.2	91.7	133.0	20.9	29.5
Diptera								
Ceratopogonidae								
Chironomidae	633.8	779.0	221.0	230.0	1718.0	4116.0	462.9	1076.0
Scathophagidae			20.9	65.9				
Tabanidae								
Crysops spp.			70.9	114.7	8.3	26.4	79.2	119.0
Tipulidae							12.5	28.2
Tipula spp.								
Ephemeroptera								
Beatidae								
Beatis spp.	8.3	26.4			41.7	81.1	8.3	26.4
Calibeatis spp.	66.7	110.0					4.2	13.2
Leptophlebiidae								
Paraleptophebia spp.	16.7	35.2	216.8	534.0	16.7	35.2	41.7	83.4
Siphlonuridae								
Siphlonurus spp.					8.3	26.4		
Hemiptera								
Corixidae	50.0	131.6	12.5	39.6	125.1	287.0	62.6	198.0
Megaloptera								
Sialis spp.	33.4	58.3	133.4	313.0	16.7	52.8	12.5	39.6
Tricoptera								
Hydroptilidae	8.3	104.0						
Limnephilidae								
Ecclisoniyia spp.	58.4	104.0	58.4	76.6	50.0	131.6	4.2	13.2
Polycentropodidae								
Polycentroplus spp.							12.5	28.2
Gastropoda								
Lymnaidae	717.0	646.0	204.3	362.0	633.8	619.0	70.9	65.3
Planorbidae	50.0	90.0	12.5	39.6	41.7	59.0	4.2	13.2
Pelecypoda								
Sphaeriidae	625.5	699.0	137.6	308.0	5118.7	670.0	141.8	290.0

HABITAT TYPE (POND SERIES 4) - PONAR

TAXON	Open Cover (10) x̄	sd	Open No Cover (10) x̄	sd	Bank Cover (10) x̄	sd	Bank No Cover (10) x̄	sd
hirudinea	805.0	853.0	254.4	295.0	179.3	195.0	191.0	195.0
Oligochaeta	1122.0	1763.0	212.7	307.0	1251.0	1226.0	246.0	370.0
Nematomorpha	4.2	13.2			4.2	13.2		
Hydracarina					66.7	161.0		
Coleoptera								
Dytiscidae								
Agabus spp.					50.0	158.0		
Celina spp.					16.7	53.0		
Oredodytes spp.					41.7	106.0	37.5	63.6
Haliplidae								
Brychius spp.							4.2	13.2
Haliplus spp.					4.2	13.2		
Diptera								
Ceratopogonidae					16.7	53.0		
Chironomidae	3528.0	6758.0	825.7	1433.0	1197.0	1438.0	367.0	631.0
Tabanidae								
Crysops spp.	33.4	58.3	29.2	48.4	179.3	337.u	71.0	71.0
Ephemeroptera								
Beat idae								
Beatis spp.							4.2	13.2
Calibeatis spp.					16.7	53.0		
Leptophlebiidae								
Paraieptophlebia spp.	79.2	15b.0			150.0	275.0	100.1	233.0
Siphlonouridae								
Ameletus spp.	4.2	13.2			54.2	157.0		
Hemiptera								
Corixidae					8.3	26.4		
Xegaioptera								
Sialis spp.			25.0	40.1	166.8	334.0	584.0	116.6
Tricoptera								
Lepidostomidae								
Ecclisomyia spp.	279.4	238.0	25.0	52.8	334.0	533.0	66.7	90.5
Polycentropodidae								
Polycentroplus spp.					37.5	93.1		
Gastropoda								
Lymnaidae	50.0	158.0	8.3	26.4	8.3	26.4	200.2	526.0
Planorbidae					4.2	13.2		
Pelecypoda								
Sphaeriidae	876.0	597.0	633.8	595.0	367.0	373.0	538.0	971.0
Terrestial	16.7	53.0					4.2	13.2

Appendix D. Mean and standard deviation of invertebrate densities (number/0.1m³) for plankton samples taken from different pond habitat in pond series 3-4, Yankee Fork of the Salmon Kiver, August 16, 1990. Sample size for each habitat type is given in parentheses.

	HABITAT TYPE (POND SERIES 3) - PLANKTON							
	Open Cover (10)		Open No Cover (10)		Bank Cover (10)		Bank No Cover (10)	
TAXON	$\bar{x}$	sd	$\bar{x}$	sd	x	sd	x	sd
Oligochaeta	1.84	5.81	.76	2.30				
Hydracarina	13.98	16.10	.03	.08	4.86	6.22	.05	.11
Cladocera								
Daphnia	5.77	5.40	.04	.07	2.16	5.76	.04	.08
Eucopepoda								
Copepoda	22.85	65.10	.06	.03	7.57	8.39	.03	.06
Coloptera								
Dyticidae								
Celina spp.					.03	.08		
Oreodytes spp.	.51	1.10			.64	1.37	.05	.09
Elmidae								
Optioservus spp.			.01	.03				
Haliplidae								
Brychius spp.	4.49	7.25	.01	.03	.13	.22	.03	.06
Haliplus spp.	19.43	29.40	.01	.03	7.61	12.46	.08	.14
Staphylinidae								
Thinobius spp.			.01	.03				
Diptera								
Chironomidae	28.26	34.30	.13	.12	12.15	13.73	.66	1.37
Empididae					.10	.32	0.09	.03
Tabanidae								
Crysops spp.			.01	.03				
Ephemeroptera								
Beatidae								
Beatis spp.	225.20	418.00	.11	.18	68.08	144.70	.20	.29
Calibeatis spp.	.30	.97			.92	2.07		
Leptophlebiidae								
Paraleptophebia					.61	1.38	.01	.03
Siphnlouridae								
Ameletus					1.84	5.81	.01	.03
Siphlonurus	.20	.43			.26	.65		
Hemiptera								
Corixidae	9.28	23.80	.36	.99	16.73	52.90	.01	.03
Hymenoptera					.10	.25		
Bryconidae					.03	.08		
Plecoptera	.20	.65	* .01	.03				
Chloroperlidae spp.							.02	.05

	HABITAT TYPE (POND SERIES 3) - PLANKTON							
	Open cover (10)		Open No Cover (10)		Bank Cover (10)		Bank No Cover (10)	
TAXON	x̄	sd	x̄	sd	x̄	sd	x̄	sd
Tricoptera								
Hydroptilidae spp.	4.90	11.00			.13	.40		
Limnephilidae								
Ecclisomyia spp.	1.53	3.24			6.55	13.58		
Polycentropodidae								
Polycentroplus spp.			.01	.03				
Osteichthyes								
Cottus spp.	.10	.32			.07	.16		
Gastropoda								
Lymnaidae	53.77	86.70	.15	.27	4.05	5.45	.59	.86
Planorbidae	.31	.69			.26	.36	.02	.05
Pelecypoda								
Sphaeriidae	2.96	6.40	.34	.93			.01	.03
Terrestials					.94	1.27	.01	.03

	HABITAT TYPE (POND SERIES 4) - PLANKTON							
	Open Cover (10)		Open No Cover (10)		Bank Cover (10)		Bank No Cover (10)	
TAXON	x	sd	x	sd	x	sd	x	sd
hirudinea	2.23	2.58			.61	.87		
Oligocnaeta	.07	.12						
Nematomorpha					.02	.05		
Hydracarina	1.11	1.02			3.75	7.73		
Cladocera								
Daphnia	.09	.21						
Coleoptera								
Dytiscidae								
Agabus spp.					.02	.05		
Ditiscus spp.	.03	.08						
Oredodytrs spp.	.77	1.23	.01	0.30	.34	.48	.01	.03
Haliplidae								
Haliplus spp.					.39	.57		
Diptera								
Ceratopogonidae					.61	1.71		
Chironomiclae	7.74	9.18	.01	0.27	7.23	20.43	.60	.11
Culicidae	.02	.05			1.34	3.84		
Enpididae					.20	.28		
Ephyridae	.02	.05			.20	.28		
Syrphidae					.02	.05		
Tabanidae								
Crysops spp.	.03	.11			.12	.23		
Ephemeroptera								
Beatidae								
Beatis spp.	.07	.12			.02	.05		
Calibeatis spp.	.19	.59						
Leptophlebiidae								
Paraleptophlebia	.14	.25			1.69	2.38	.02	.05
* Siphnlauridae							.03	.04
Ameletus spp.	.07	.16			1.05	1.19		
Siphlonurus					.02	.05		
hemiptera								
Corixidae	.01	.03			1.00	1.53		
Gerridae								
Trepobate spp.					.02	.05		
Hymnoptera					.82	.78		
Megaloptera								
Sialis spp.	.06	.11			.14	.43		
Tricoptera								
Lepidostomidae								
Lepidostoma spp.					.07	.16		
Limnephilidae								
Ecclisomyia spp.	1.67	1.68			1.27	1.83	.02	.05
Ironquia spp.					.02	.05		
Polycentropodidae								
Polycentroplus spp.					.14	.29	.01	.03

* adult

	HABITAT TYPE (POND SERIES 4) - PLANKTON							
	Open Cover (10)		Open No Cover (10)		Bank Cover (10)		Bank No Cover (10)	
TAXON	x̄	sd	x̄	sd	x̄	sd	x̄	sd
Gastropoda								
Lymnaidae	1.20	1.42			1.50	1.98	.01	.03
Planorbidae					.63	1.03		
Pelecypoda								
Sphaeriidae	1.03	1.33			.71	1.82		
Terrestials	.02	.05			.43	.43	.07	.10

Appendix E. Mean and standard deviation of invertebrate densities (number/0.1m³) for Serber samples taken from channel habitat in pond series 3 and 4, Yankee Fork of the Salmon River, August 1990. Sample size for each series is given in parentheses.

	SEKBER SAMPLES				
	Pond Series 3 (8)		Pond Series 4 (10)		
TAXON	x̄	sd	x	sd	
Hirudinea	1.4	3.8	1.1	3.4	
Oiigochaeta	1.4	3.8			
Hydracarina			3.2	7.3	
Eucopepoda	2.2	7.6			
Coleoptera					
Dyticidae					
Oreodytes spp.			2.2	7.6	
Elmidae					
Heterlimnus spp.	2.7	7.6	4.2	13.4	
Lara spp.	1.4	3.8			
Optioservus spp.	75.6	71.4	105.8	145.0	
tialiplidae	45.9	56.2			
Brychius spp.					
Haliplus spp.	2.7	5.0	41.7	923.2	
Scirt idae					
Cyphon spp.	1.4	3.8			
Collembolla	1.4	3.8			
Diptera					
Ceratopogonidae	18.3	43.7			
Cnironomidae	210.6	276.9	2095.0	2385.6	
Empididae	12.2	22.7	17.3	33.9	
Muscidae	4.1	11.5			
Simul idae	71.5	91.5	9.7	11.9	
Tipulidae			1.1	3.45	pupae
Hexatoma spp.	1.4	3.8			
Tipula spp.	4.1	11.5			
Ephemeroptera					
Baet idae					
Baetis spp.	97.2	167.0	136.1	140.0	
Calibaetis spp.	12.2	17.7	2.2	7.6	
Ephenerellidae					
Drunella spp.			1.1	3.4	
Ephermerella spp.			2.2	7.6	
Serratella spp.	1.4	3.8	8.6	27.3	
Hepteginiidae					
Cinygmula spp.	1.4	3.8	35.6	40.0	
Hhithrogena spp.			5.4	13.7	
Leptophlebiidae					
Paraleptophebia spp.	3653.0	9966.0	47.5	80.7	
Siphnlouridae					
Ameletus spp.	6.8	15.2	8.6	12.3	
Siphlonurus spp.	4.1	11.5	2.2	4.6	

Append ix E. Continued.

TAXON	SERBER SAMPLES Pond Series 3 (8) x̄	sd	Pond Series 4 (10) x̄	sd
Hymenoptera	1.4	3.8		
Megaloptera				
Sialia spp.	2.7	7.6	1.1	3.4
Plecoptera				
Chloroperlidae spp.	54.0	56.3	22.0	33.4
Tricoptera				
Hydroptilidae	7U.2	56.6	2.2	7.6
Lepidostomidae				
Lepidos toma spp.			4.3	9.11
Limnephi 1 idae			7.6	10.3
Ecclisomyia spp.			5.4	13.7
Ironquia spp.			5.4	13.7
Polycentropodidae				
Polycentroplus spp.	45.9	78.7		
Psychomyiidae				
Psychomyia spp.	8.0	15.0		
Gastropoda				
Lymna idae	44.6	70.8	1.1	3.4
Planorbidae	2.7	5.u		
Pe lecypoda				
Sphaeriidae	18.9	21.4		
Terrestial			2.2	4.6

SUBPROJECT III

East Fork of the Salmon River

Pre-Construction Inventory

ABSTRACT

East Fork

The East Fork of the Salmon River drainage is an important spawning and rearing area for spring chinook salmon (*Oncorhvnchus tshawvtscha*) and steelhead' trout (*Oncorhvnchus mvkiss*). Agricultural, grazing, and mining practices in the drainage have degraded available habitat. In the spring of 1988, an interagency task force selected a preferred alternative for the enhancement of anadromous fisheries habitat in the East Fork drainage. The proposed measures include work on Big Boulder and Herd creeks. In Big Boulder Creek plans are to remove an abandoned hydroelectric dam and debris jam, and stabilize a severely eroding channel. In Herd Creek, fencing, revegetation, and bank stabilization are planned. A final environmental assessment has been developed with proposed work scheduled to commence by late summer 1991.

Physical and biological inventories were conducted on Herd and Big Boulder creeks and mainstem East Fork reaches in 1988 and 1989. In 1990, we continued to monitor sediment levels in lower Herd Creek and Big Boulder Creek and conducted a fisheries evaluation throughout the East Fork. Sediment levels from core samples in lower Herd Creek and Big Boulder Creek did not differ significantly between 1990, 22.7% and 11.5% respectively, and previous years. We found no significant ($P < 0.05$) difference in surface sedimentation, as measured by percent embeddedness and the interstitial space index, between sample sites above and below the cutoff channel in Big Boulder Creek.

Densities and abundance of anadromous fish, chinook salmon and steelhead trout, were extremely low due to low adult escapement into the East Fork in 1989. Herd Creek had the highest numbers (both density and abundance) of chinook. and steelhead age 1+ and older. No steelhead young-of-year (YOY) were counted in our July snorkel session, however, large increases in steelhead YOY numbers were seen in September due to outplanting by Idaho Fish and Game just prior to our snorkeling session. No anadromous fish were documented in Big Boulder Creek during either sampling session. We found significant ($P<0.05$) differences in densities of chinook and steelhead (YOY and age 1+ and older) by stratum but saw only differences in steelhead densities by session. Steelhead densities were also significantly ($P<0.05$) different when session vs. stratum was tested.

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INTRODUCTION

The East Fork of the Salmon River, a major tributary of the Salmon River, is a spawning and rearing stream for anadromous salmonids. Wild spring and summer chinook (Oncorhvnchus tshawytscha) redd counts have declined from over 800 in the early 1960's to below 100 in the 1980's (Schwartzberg and Roger 1986). Steelhead trout (O. mvkiss) also use the East Fork system for spawning and rearing. Reductions in spawning escapement can largely be attributed to downstream (Snake and Columbia rivers) hydroelectric facility passage problems, however, this situation has been further exacerbated by habitat degradation throughout the East Fork drainage.

Through Bonneville Power Administration (BPA) funding, baseline habitat and fish inventories were conducted by the Shoshone-Bannock Tribes in Herd Creek during 1985 (Konopacky et al. 1986), and in the East Fork of the Salmon River, including Big Boulder and Herd Creek (Richards and Cernera 1987) in 1986. Physical and biological evaluations of the drainage continued in 1987 and 1988 (Richards and Cernera 1988; Richards et al. 1989). These inventories identified several habitat problems associated with the drainage.

In August1987, the Tribes released a request for proposals to conduct a feasibility study within the drainage and formulate a remediation plan. During the summer of 1987, EA Engineering, Science, and Technology, Inc. of Lafayette, CA (EA) was awarded the contract and began a feasibility study to develop alternatives for anadromous fisheries habitat enhancement in the East Fork drainage.

From late 1987 through 1989, the project evolved to the draft environmental assessment stage. In December 1987, an interagency task force (consisting of representatives of the Tribes, BPA, US Forest Service, Idaho Fish and Game, and Bureau of Land Management) meeting was held to review progress on the project and to make initial decisions on the primary focus of alternative development. The Tribes and EA continued to work on the study throughout the winter.

In the spring of 1988, another interagency task force meeting was held and preferred alternatives were selected. The alternative for Big Boulder Creek focuses on stabilizing a large cut bank, near the Livingston Mill area, removal of a small hydroelectric dam, and modification of a debris jam acting as a passage impediment in the lower reaches of the same stream. On Herd Creek, sedimentation and streambank habitat problems associated with grazing practices will be addressed. Treatment will include localized fencing and revegetation of disturbed riparian areas.

According to the feasibility study (EA 1988) large increases in juvenile production would result from implementation of these actions. Removal of the dam in Big Boulder Creek would open up 2.0 miles of spawning habitat and 4.8 miles of rearing habitat to spring chinook and summer steelhead. In conjunction with stabilization of the cut bank, removal of the dam would result in increased production of 32,832 chinook smolts and 4,818 steelhead smolts if the system were fully seeded by returning adults. In

Herd Creek a conservative estimate of a 30% reduction in embeddedness, due to the proposed remedial activities, would lead to a three-fold increase in chinook smolt production to 93,000 fish and more than a five-fold increase in steelhead to 33,000 smolts in the affected area. A 50% reduction in embeddedness would increase production in the affected area by about 960% for both chinook and steelhead.

The physical and biotic condition of Road Creek was also assessed in 1988. Spawning and rearing habitats were in poor condition and no anadromous fish use was documented (Richards et al. 1989). Due to extensive non-point source contributions to the sediment problem in upstream sections, the Tribes have not identified a specific treatment remedy. However, through cooperation with the Bureau of Land Management, the Tribes will work towards improving fisheries habitat via improved land management practices.

The environmental assessment process is continuing. A draft environmental assessment was completed December 1988 and distributed for public review and comment. A finalized feasibility report and environmental assessment will be completed by summer of 1990.

Since an extensive base of physical habitat data was obtained in 1988, and proposed work has not proceeded, 1989 physical monitoring work was minimal. We did, however, continue sediment monitoring in lower Herd Creek. As in previous years, we also inventoried the fish communities in the East Fork, Herd Creek, and Big Boulder Creek.

STUDY AREA

The East Fork of the Salmon River is located in Custer County, Idaho (Figure 1). Herd Creek and Big Boulder Creek are two major tributaries to the East Fork Salmon River. Other important tributaries to the East Fork include Little Boulder, Wickiup, Germania, Bowery, Road, and West Pass creeks. The East Fork of the Salmon River drainage is a low to medium gradient system which flows through moderately wide valleys of lodgepole pine (Pinus contorta) and Douglas fir (Pseudotsuaa menziesii) forests, improved pasture ranchlands, sagebrush/grass valleys, and narrow canyons. Most of the system is roaded and lies in an area of Challis Volcanics which is characterized by highly erosive sandy and clay-loam soils. Roads parallel almost all of the East Fork, Big Boulder Creek, Herd Creek, and Road Creek. Adjacent lands are managed by the United States Forest Service (Challis National Forest and Sawtooth National Recreation Area), Bureau of Land Management (Salmon District), and private landowners.

Biological monitoring was conducted in the lower 46 km of the mainstem East Fork; in Big Boulder Creek from its confluence with the East Fork upstream to the Livingston Mill (7 km); and in Herd Creek from its East Fork confluence upstream 15.5 km to the East Pass Creek confluence. Physical habitat data collected were core and surface sediment samples in the lower portion of Herd Creek, and the same in Big Boulder Creek up to the Livingston Mill. Above the Livingston Mill only surface sediment samples were collected.

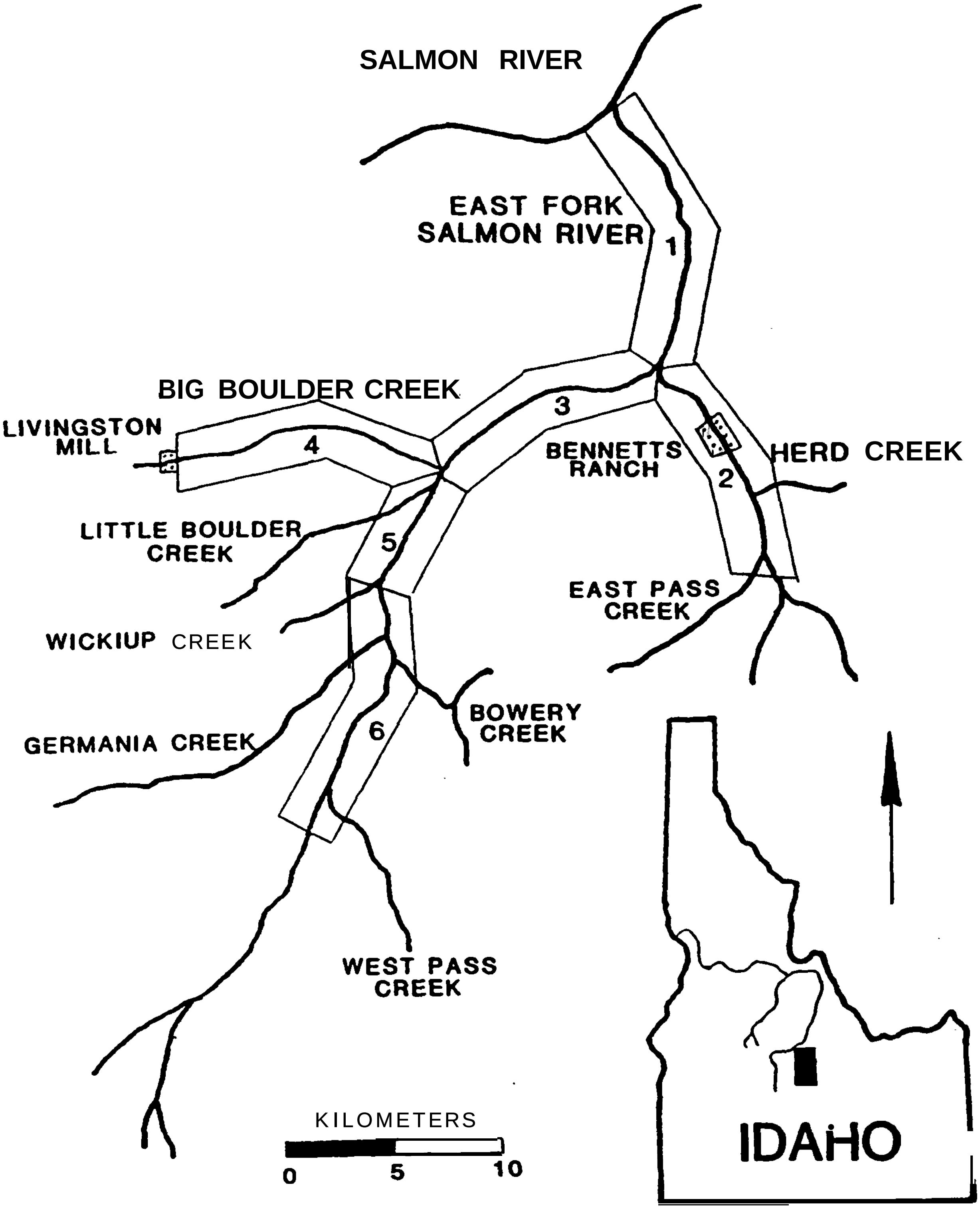


Figure 1. **East** Fork **of the Salmon River, Idaho, study area** and **strata location.**

METHODS

Fish densities were assessed during the first week of July and the third week of September. Observations were conducted by divers equipped with snorkel and mask following techniques outlined in Platts et al. (1983). All observations were conducted between 1100-1500 hours. Observations were conducted at the same site and strata locations as in previous years (Richards and Cernera 1987). As in 1988, stratum 5 was not sampled because of landowner/access difficulties. Abundance estimates of age 0+ chinook salmon and steelhead/rainbow trout were calculated for July and September using mean and variance values obtained from snorkel surveys following techniques outlined in Scheaffer et al. (1979). Analysis of variance (ANOVA) was used to compare fish density means among strata and between sessions. When a main effect term had a significant interaction, Tukey's multiple range test was used to discern where the difference occurred. Significance was determined using an alpha probability of 0.05. Transformation did not substantially improve normality of the data. As Analysis of Variance is robust for data which deviate from the normality assumption, untransformed data was used in the analyses.

Attempts were made to collect age 0+ chinook salmon from available habitats within each stratum by electrofishing during both sessions. However, due to low numbers of fish and poor electrofishing catches, efforts to collect fish for length and weight measurements were abandoned.

As steelhead and rainbow trout are indistinguishable in the juvenile stages, all Oncorhvnchus mvkiss were classified as steelhead. Larger O. mvkiss were considered rainbow trout as steelhead at those lengths would have already migrated.

A ground survey of redd abundance was conducted on Herd Creek on 13 September 1990. Our survey began at the confluence of West Pass Creek with Herd Creek and continued downstream to the confluence with the East Fork of the Salmon River. Due to the large size of the mainstem East Fork, we did'not conduct a ground survey of redds.

McNeil core samples (3/riffle) were taken in both Herd Creek and Big Boulder Creek. Sampling in Herd Creek included one site around Bennetts' ranch and two sites below the ranch. In Big Boulder Creek samples were taken at eight sites within or below the cutoff channel. Core samples were analyzed following procedures outlined in Richards and Cernera (1987). The percent silt (particles less than 4.75 mm) in cores was compared between years using either a two-sample t-test or a one-way ANOVA on arc sin transformed values. An alpha probability of 0.05 was used to detect significance.

In 1990, we initiated the "Hoop Method" (Burns and Edwards 1985) for measuring cobble embeddedness. The hoop method measures surface substrate embeddedness. Three 60-cm stainless steel hoop samples were randomly located in pool tails where McNeil core samples were taken. All samples were taken during base flow in August and water depth never exceeded 45 cm. Within each hoop the degree of embeddedness of all rocks between 4.5 and 30 cm was measured. Substrate particles less than 6.35 mm (0.25 in.) were the criteria used to classify embedding materials. Three measurements were taken on each embedded rock. Depth of embeddedness (De) and total depth (Dt) were measured to the nearest mm perpendicular to the plane of embeddedness. The maximum length of each rock (Dm) was also measured. Rocks not embedded, those lying freely on the surface, were measured for Dm only with the De being zero. To calculate the percent embeddedness for each sample the sum of De is divided by the sum of Dt and multipiied by 100. If more than ten percent of the hoop was all fine particles (< 6.35 mm) without any rocks showing, we used a weighted embeddedness value. Without weighting the value for fine particles, the hoop method underestimates embeddedness. The weighted value was calculated using the equation:

$$\%\ \text{weighted embeddedness} = \frac{(\%\ \text{fines} \times 100) + (\%\ \text{embeddedness} \times 100)}{100}$$

For analytical purposes the embeddedness data were arcsine transformed and compared among strata using one-way ANOVA.

In addition to surface embeddedness percentages derived from our hoop samples, we also calculated the amount of vertically exposed rock for each hoop. This calculation was expressed as the sum in meters of Dt-De for the entire hoop area (Skille and King 1989) divided by the area of our hoop ($0.47 m^2$). The resulting quotient gave us the "Interstitial Space Index" (ISI) (Kramer 1989). The IS1 (m/m*) is an indicator of the amount of interstitial space available for living organisms.

RESULTS AND DISCUSSION

Physical Evaluation

Particle size distribution has shown no change in recent years in either Herd Creek or Big Boulder Creek. Figures 2 and 3 graphically show consistent particle size distribution during our years of sampling. Only the amount of fines (particles smaller than 4.75 mm) were statistically compared between years and we found no significant ($P>0.05$) difference for either drainage (Tables 1 and 2).

We also compared surface sediment from areas above and below the cutoff channel in Big Boulder Creek. Neither embeddedness nor interstitial space index (ISI) were different ($P>0.05$) above or below the cutoff channel (Table 3).

Embeddedness and interstitial space index values indicated greater surface sedimentation problems in Herd Creek than in Big Boulder Creek. Embeddedness averaged 41.7% as compared to less than 35% in Big Boulder Creek. The interstitial space index was 2.51 m/m^2 in Herd Creek as compared to over 3.00 m/m^2 in Big Boulder Creek. However, it should be noted that sampling sites in Herd Creek are C-type channels (Rosgen 1985), as compared to the B-type channels of Big Boulder Creek, and are thus more conducive to sediment deposition.

Biological Evaluation

Total Salmonid Densities and Relative Abundance

As in previous years (Rowe et al. 1989, Richards et al. 1989, Richards and Cernera 1988) Herd Creek continues to support the

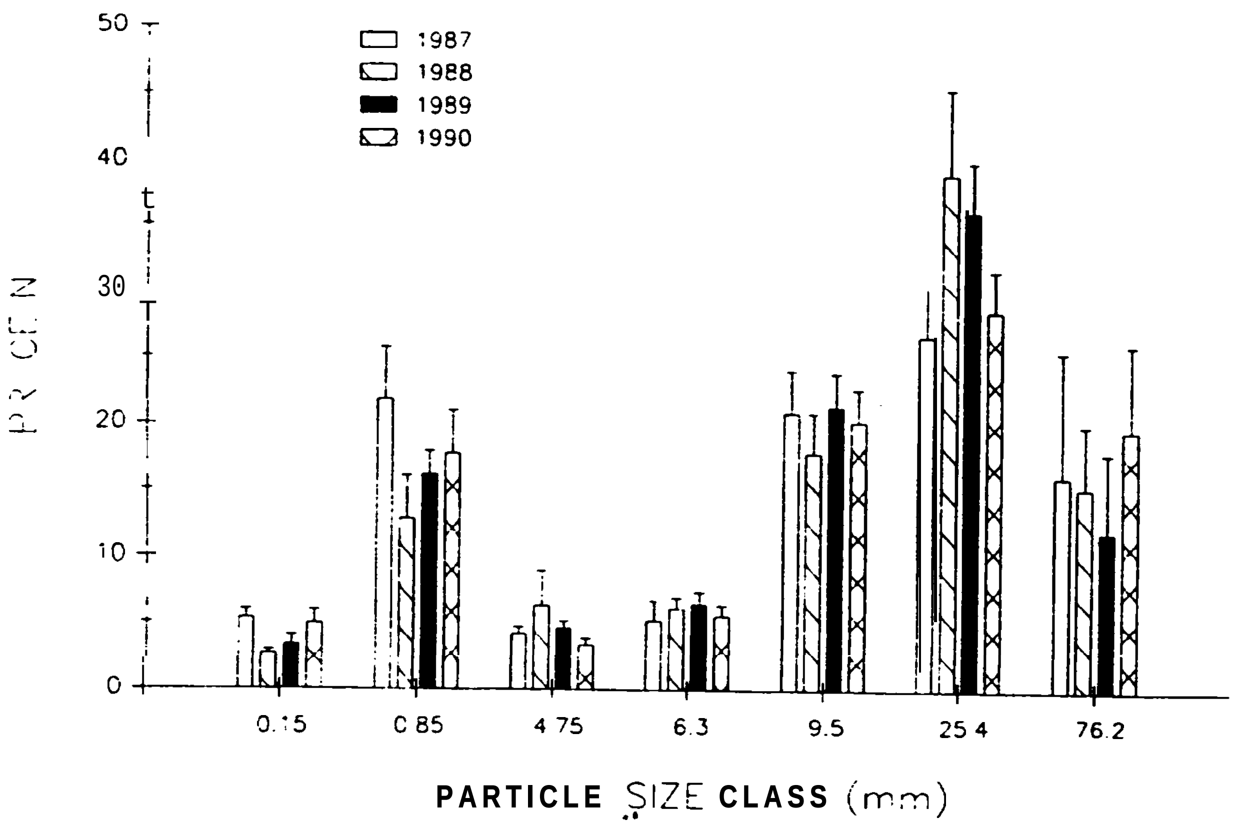


Figure 2. **Comparison of particle size distribution from 1987 to 1990 in lower Herd Creek. Mean values are derived from six core samples in 1987, 1988, and 1989 and nine core samples in 1990. Error bars represent one standard error of the mean.**

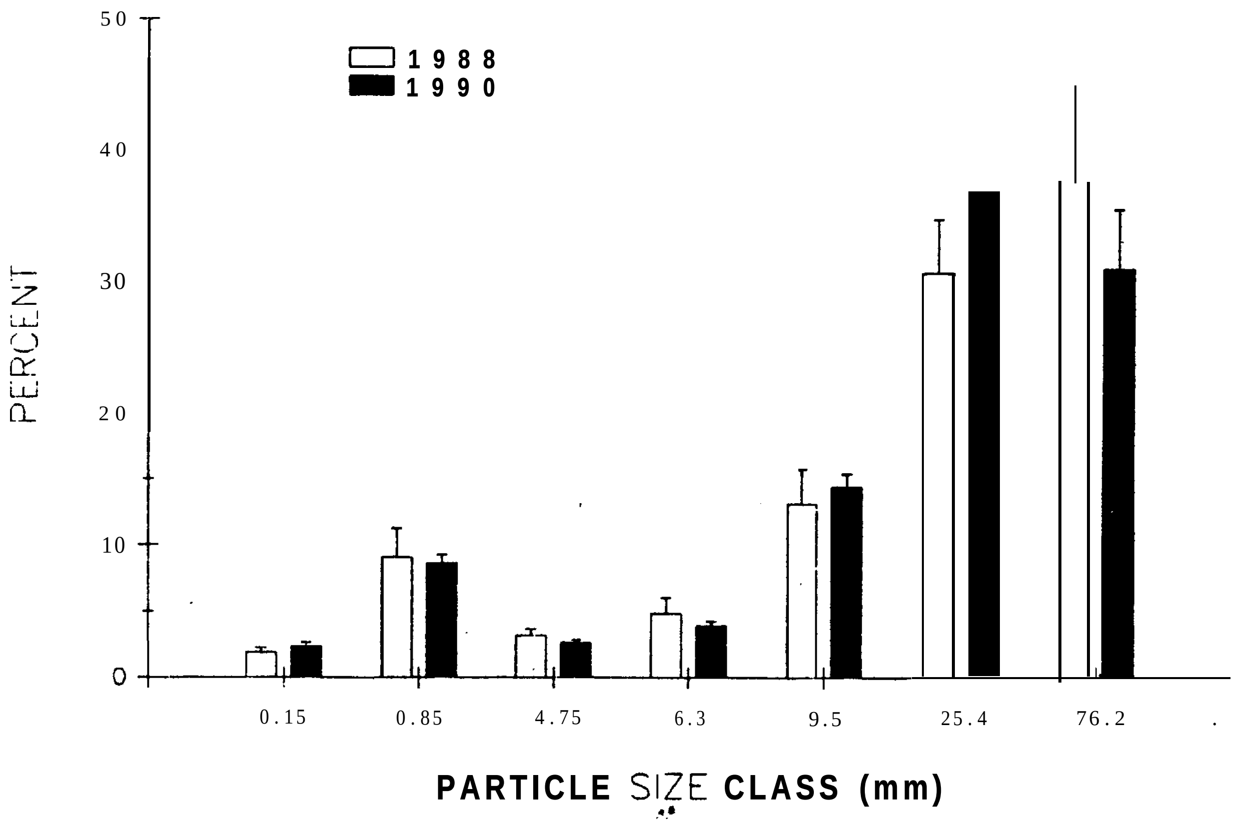


Figure 3. Comparison of particle size distribution from 1988 and 1990 in Big Boulder Creek downstream of the Livingston Mill area. Mean values are derived from eight core samples in 1988 and twelve core samples in 1990. Error bars represent one standard error of the mean.

Table 1. Yearly (1987 to 1990) comparison of fines (particles less than 4.75 mm in size) from core sampling in Herd Creek. Data were transformed using an arcsine transformation. A one-way analysis of variance was used with transformed data to test for significance ($P<0.05$) between years.

		Untransformed	Transformed		
Year	Sample size	Average	Average	Standard Error	Significance Level
1987	6	27.10%	30.99	2.78	
1988	6	15.47%	22.50	2.75	0.29
1989	6	19.49%	26.01	1.69	
1990	9	22.67%	27.33	3.23	

Table 2. Comparison of fines (particles less than 4.75 mm in size) from core sampling in Big Boulder Creek in 1988 and 1990. Data were transformed using an arcsine transformation. A two-sample t-test was used with transformed data to test for significance ($P<0.05$) between years.

		Untransformed	Transformed		
Year	Sample size	Average	Average	Standard Deviation	Significance Level
1988	6	12.37%	19.56	7.57	0.96
1990	21	11.47%	19.66	2.50	

Table 3. Comparison of surface sedimentation in areas above and below the cutoff channel in Big Boulder Creek. A two-sample t-test was used to test for significance ($P<0.05$). Embeddedness values were transformed using the arcsine transformation for testing purposes.

Method	Area	Sample size	Untransformed Avg.	Untransformed Standard Dev.	Transformed Avg.	Transformed Standard Dev.	Signif. Level
Embeddedness	Above	9	33.32%		34.97	8.97	0.763
	Below	21	31.88%		34.09	6.48	
Interstitial Space Index	Above	9	3.04 m/m^2	1.41			0.415
	Below	21	3.61 m/m^2	1.85			

. highest densities of salmonids in our sampling strata (Table 4). In 1990 steelhead young-of-year (YOY) were the exception as high densities of steelhead were noted in strata 6 and 1. These high densities are a result of the steelhead outplanting done by Idaho Fish and Game in mid-September prior to our second snorkeling session. Highest densities of steelhead age 1+ and older and adult bull trout (Salvelinus confluentus) were seen in Herd Creek while cutthroat trout (Oncorhvnchus clarki) adults were most prevalent in Big Boulder Creek in September. Whitefish (Prosooium williamsoni) adults prefer lower East Fork, an area characterized by large pools, as significantly ($P<0.05$) higher densities were seen in that area in both July and September (Tables 4 and 5).

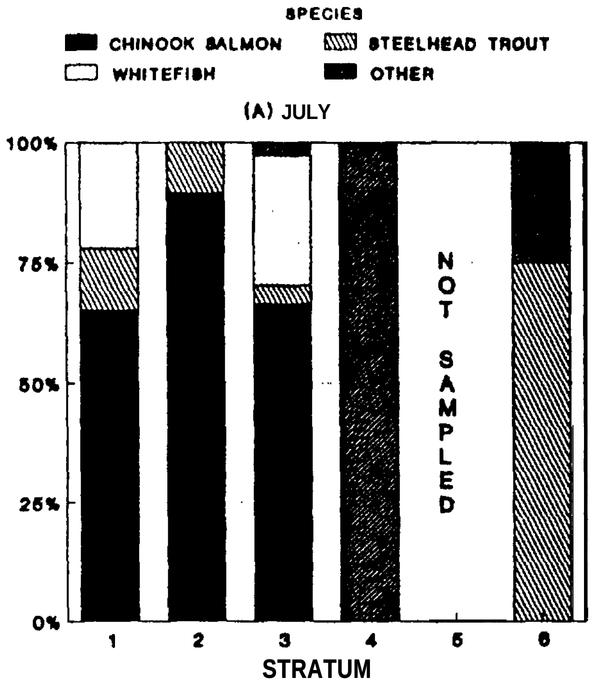
For the most part steelhead (YOY and age 1+ and older) and age-O+ chinook were the dominant species in July and September, respectively, in terms of relative abundance of salmonids (Figure 4). Only Big Boulder Creek (stratum 4) was dominated by a species (cutthroat trout) other than steelhead or chinook. In fact, no anadromous fish were observed in Big Boulder Creek. In addition to the dam, which makes available spawning and rearing habitat above the dam inaccessible, a debris jam just upstream of the mouth of Big Boulder Creek acts as a passage impediment and may possibly be a complete barrier to chinook and steelhead.

Chinook Salmon Densities

We found no significant ($P>0.05$) difference in chinook young-of-year (YOY) densities between sessions but did see a significant ($P<0.05$) difference among strata (Table 5). Densities in Herd Creek for both sessions combined were significantly greater than

Table 4. Mean total salmonid densities (fish/100m²) by session and stratum in the East Fork Salmon River, 1990. Stratum 5 was not sampled in 1990.

	Species						
Stratum	Chinook YOY	Steelhead YOY	Steelhead 1+ and older	Bull trout adult	Cutthroat adult	Whitefish YOY	Whitefish adult
			July				
1	3.78	0	0.78	0	0	0	1.61
2 (Herd Creek)	12.57	0	1.10	0	0	0	0
3	1.64	0	0.21	0.02	0.04	0	0.69
4 (Big Boulder Creek)	0	0	0	0	0	0.29	0
5	NS	NS	NS	NS	NS	NS	NS
6	0	0	0.71	0.03	0.22	0	0
			September				
1	0.61	15.93	0.13	0	0	0	2.31
2 (Herd Creek)	18.26	1.76	6.99	1.19	0	0	0
3	0.57	0.62	0.55	0.01	0	0.01	0.64
4 (Big Boulder Creek)	0	0	0	0	1.07	0	0
5	NS	NS	NS	NS	NS	NS	NS
6	0.35	138.86	2.53	0.44	0.23	0	0.39



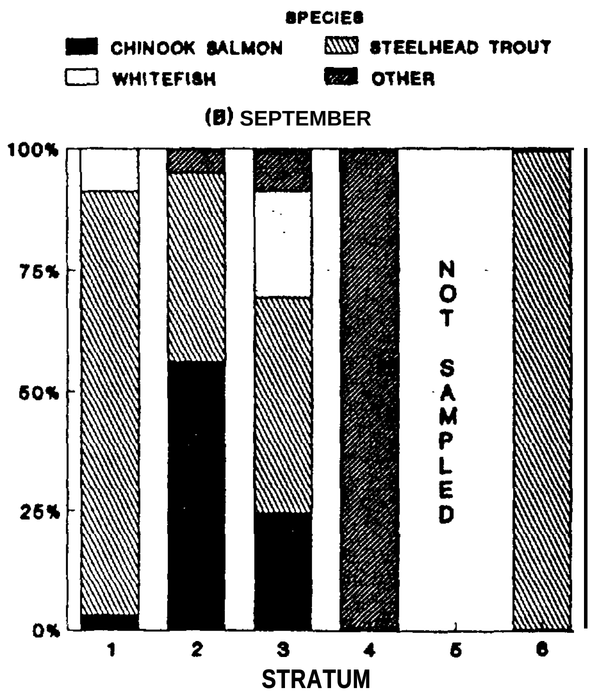


Figure 4. Relative abundance of salmonids by strata in July (A) and September (B) 1990, East Fork Salmon River. Other species include bull trout, cutthroat trout, and rainbow trout.

the other strata sampled (Figure 5). However, these densities of 12.6 chinook/100m^2 in July and 18.3 chinook/100m^2 in September are greatly reduced in comparison to last year when Rowe et al. (1989) counted 129 and 79 chinook/100m^2 pool in June and September, respectively. These low densities are a result of the low number of adults that returned to spawn in Herd Creek in 1989. Low densities of chinook YOY were seen in strata 1 and 3 with few or no chinook noted in strata 4 (Big Boulder Creek) and 6.

Chinook Salmon Abundance and Redd Counts

As with the density estimates, chinook abundance in East Fork in 1990 was extremely low. The estimated number of chinook in strata 1, 2, '3, and 6 was just over 10,000 in July and 8,000 in September (Table 6). This figure is well below the potential production of over 500,000 smolts (Table 6) as estimated during the subbasin planning effort by Kiefer et al. (1990). In July all the chinook were found in the lower end of the drainage with strata 1 and 2 (Herd Creek) supporting the majority of these fish. In September chinook were found throughout the system but Herd Creek supported the bulk of the fish.

These low figures were expected due to low adult escapement in 1989 as measured by redd counts. Figure 6 graphically illustrates this point using Herd Creek as an example. In years when we see large numbers of redds in the fall we subsequently count larger numbers of chinook parr in our snorkel sessions.

Next year, 1991, is expected to be similar to 1990 in terms of chinook numbers in Herd Creek at the very least. On our September

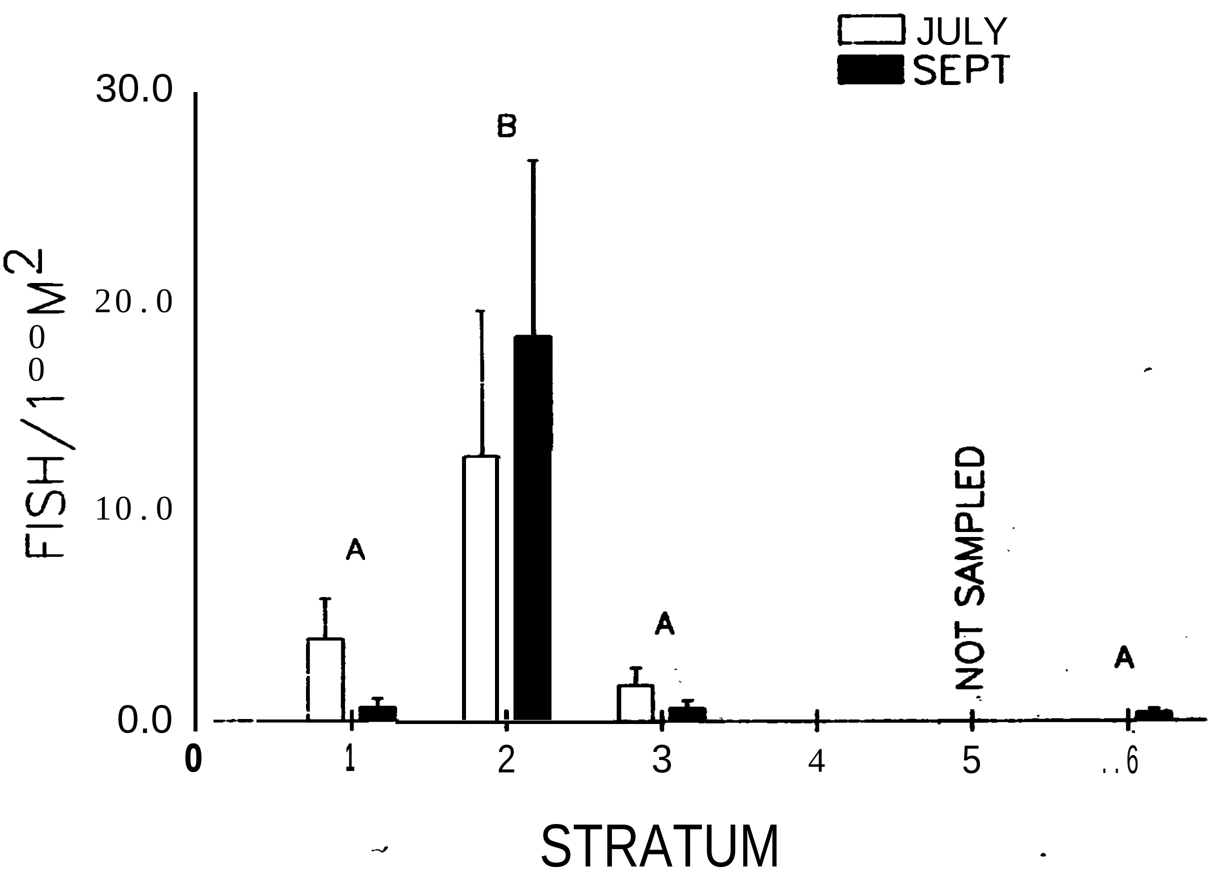


Figure 5. Density of chinook salmon you&of-year by strata (n-6 sites in strata 1, 2, 3, 6, and 11 sites in stratum 4) for July and September 1990, East Fork Salmon River. A common letter above'the bars indicates no significant (P>0.05) difference between strata means with that letter. Error bars represent one standard error of the mean.

Table 6. Estimate of chinook salmon abundance and 95% confidence interval in East Fork Salmon River during July and September 1990. Potential smolt production (PSP) is the total smolt production under current conditions at full seeding as estimated during subbasin planning for the Salmon River (Kiefer et al.1990) and found in the Salmon River subbasin presence/absence files.

	Julv			Se-	
Stratum	Abundance	95% CI	PSP	Abundance	95% CI
1	5,092	3,338	151,806	844	815
2 (Herd Creek)	4,198	4,698	43,919	6,647	6,116
3	901	497	153,751	426	403
4 (Big Boulder Creek)	No chinook		971	No chinook	
S	Not sampled		70,524	Not sampled	
6	0	0	114,518	101	198
Total	10,191	8,573	535,489	8,018	7,532

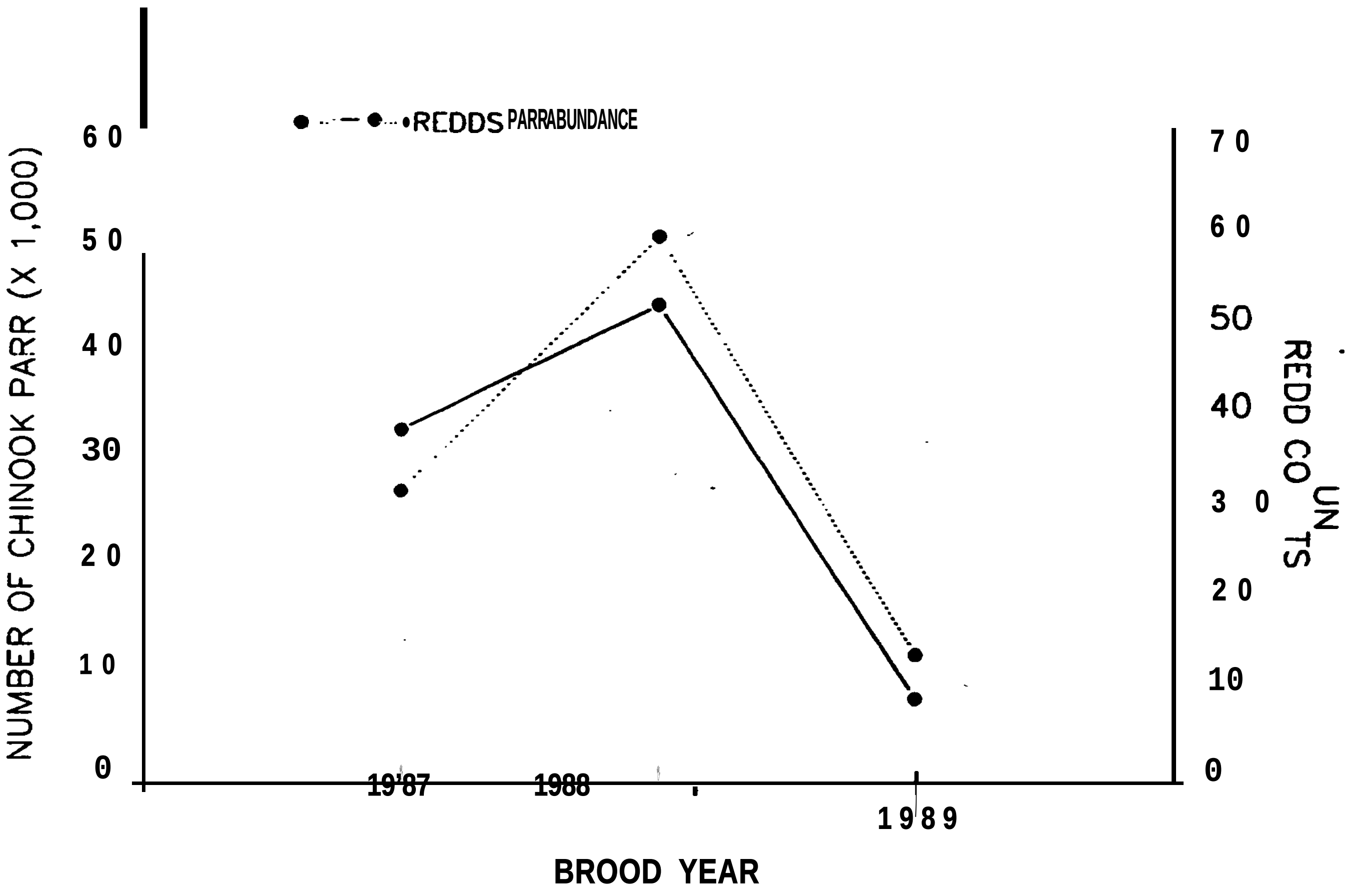


Figure 6. Redd counts and late summer (August or September) abundance estimates for chinook salmon parr in East Fork Salmon River for brood years 1987 to 1989. Data are presented for brood year such that redd counts are from that year and abundance estimates are for the following year when juveniles from those eggs are counted.

walk through on Herd Creek we counted only 13 redds, similar to last year's 14 redds but much lower than the 58 redds seen in 1988 (Table 7). Consistently about-half to slightly more of the redds in Herd Creek have been seen above Bennetts Ranch and 1990 was no exception.

Steelhead Densities and Abundance

Steelhead abundance and densities varied greatly according to time, stratum, and outplanting regime. No young-of-year steelhead *were counted* in July whereas we estimated 101,520 steelhead YOY with densities up to 139 steelhead YOY/100m^2 in strata 1, 2, 3, and 6 (Table 8 and Figure 7). As mentioned earlier, this substantial increase in steelhead YOY numbers was a result of the outplanting by Idaho Fish and Game in rid-September. Host of these fish were contagiously distributed near release sites either in the upper (stratum 6) or lower (stratum 1) end of the East Fork. As a consequence of the outplanting we found significant ($P<0.05$) differences in steelhead YOY by session, stratum, and session vs. stratum (Table 5).

Although densities of steelhead age l+ and older were less polarized than YOY, we still found significant ($P<0.05$) differences in densities by session, Stratum,' and session vs. stratum (Table 4). We counted steelhead in all strata during both sessions except stratum 4 (Big Boulder Creek). Highest densities for both sessions werefound in Herd Creek(stratum2) (Figure8). Both strata 2 and 6 showed considerable increases in density of older steelhead from July to September.

Table 7. Distribution and abundance of redds counted in Herd Creek, East Fork Salmon River from 1988 to 1990.

	Redds Counted					
	1988		1989		1990	
Area	Number	%	Number	%	Number	%
Below Bennetts Ranch	16	27.6	3	21.4	2	15.4
Within Bennetts Ranch	13	22.4	4	28.6	3	23.1
Above Bennetts Ranch	29	50.0	7	50.0	.8	61.5
Total	58	100	14	100	13	100

Table 8. Estimate of steelhead *young-of-year* (YOY) abundance and 95% confidence interval in East Fork Salmon River during July and September 1990. Potential smolt production (PSP) is the total smolt production under current conditions at full seeding as estimated during subbasin planning for the Salmon River (Kiefer et -al. 1990) and found in the Salmon River subbasin presence/absence files.

	July			September	
Stratum	Abundance	95% CI	PSP	Abundance.	95% CI
1	0	0	17,893	22,463	18,017
2 (Herd Creek)	0	0	4,803	641	809
3	0	0	16,960	406	145
4 (Big Boulder Creek)	No steelhead		679	No steelhead	
5	Not sampled		7,835	Not sampled	
6	0	0	12,126	78,010.	66,431
Total	0	0	60,296	101,520	85,402

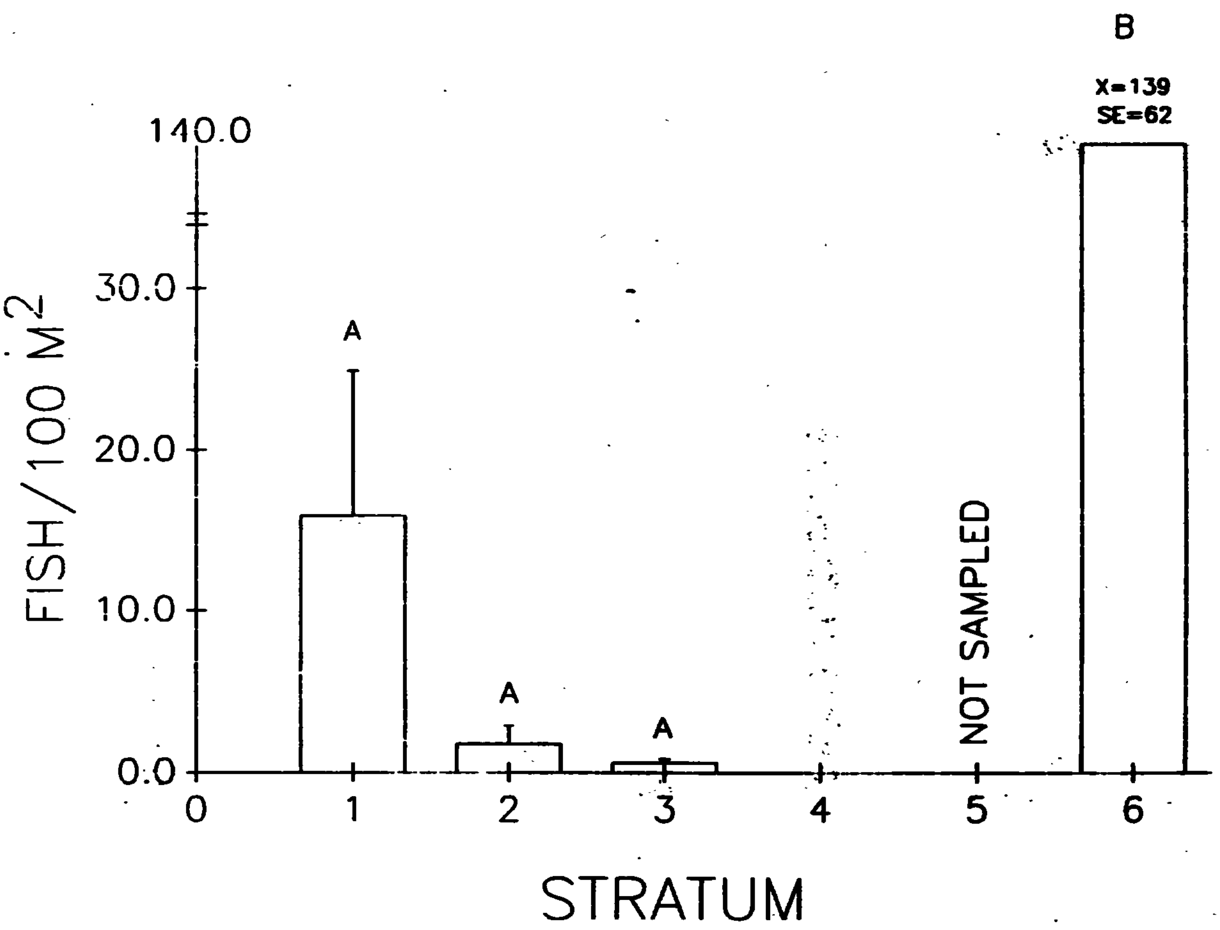


Figure 7. Density of steelhead young-of-year by strata (n=6 sites in strata 1, 2, 3, 6 and 11 sites in stratum 4) for September 1990, East Fork Salmon River. No steelhead young-of-year were counted in July. A common letter above the bars indicates no significant (P>0.05) difference between strata means with that letter. Error bars represent one standard error of the mean.

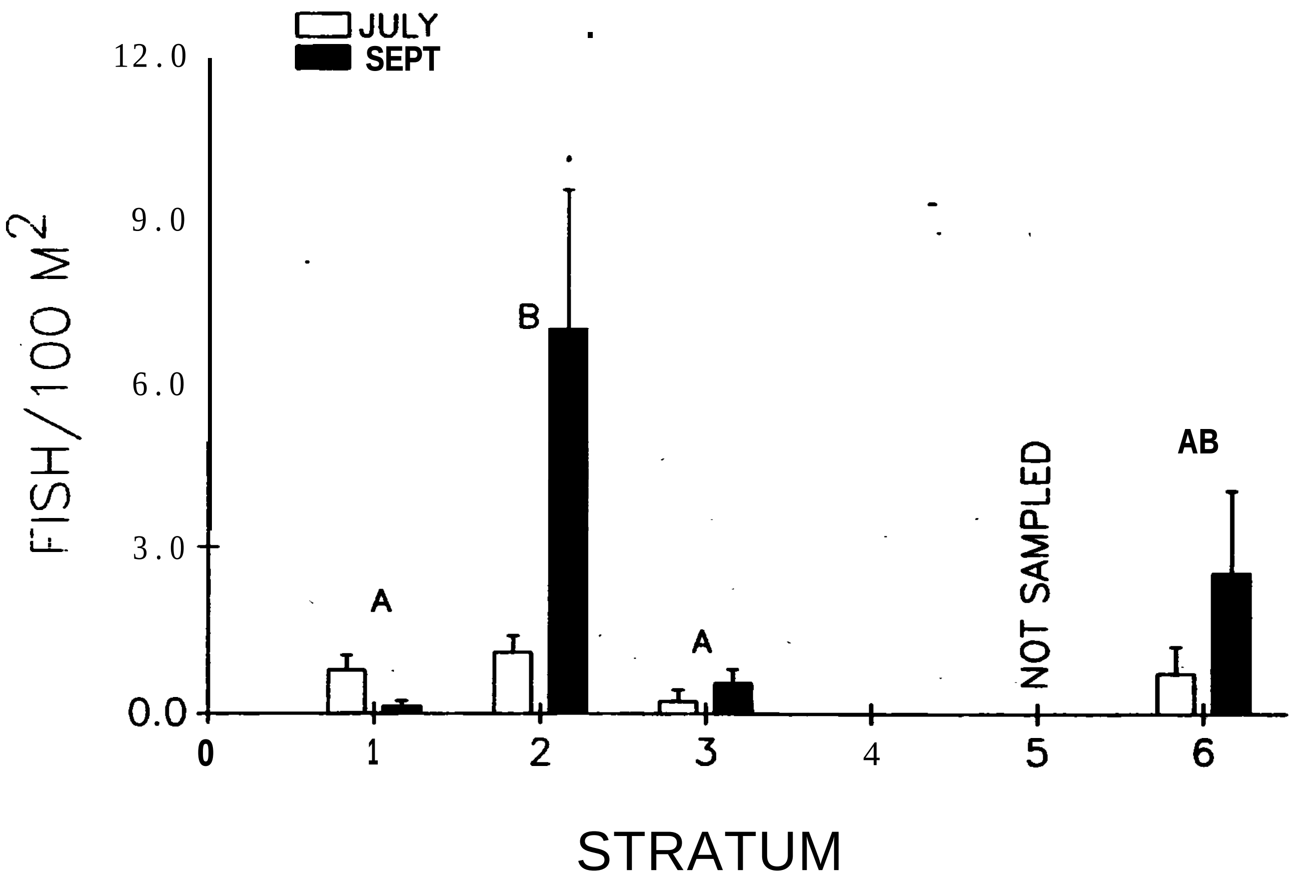


Figure 8. **Density of** steelhead *age* l+ *and oldu by strata (n=6* sites in Strata 1, 2, 3, 6 and 11 site8 in stratum 4) for July and September 1990, **East** Fork Salmon **River**. A **common** letter above the bars indicates no significant **(P>0.05)** difference betveen -strata **means** with that lettu. Error bars represent one standard error of the **mean.**

SUMMARY

We have seen no changes in measured sedimentation parameters in either Big Boulder Creek or Herd Creek. These results are not unexpected as conditions in the last several years have been fairly consistent. With initiation of our proposed projects we expect to see changes within a few years of project completion with proper climatic conditions.

Despite low numbers of anadromous fish due to low adult escapement, Herd Creek continues to, be the most important anadromous fish production area in the East Fork drainage. Any habitat enhancement in Herd Creek serves a dual purpose of protecting the populations of anadrmous fish currently using the stream and improving conditions such that greater production can be realized from those fish. Of the other strata sampled, strata 1 and 6 are the most important. in terms -of anadromous fish production. As in 1988 (Richards et al. 1989) and 1989 (Row et al. 1989) Big Boulder Creek (stratum 4) had no documented use by anadromous fish in 1990. Little anadrowus fish spawning habitat is currently available below the Big Boulder Creek dam. with removal of the dam chinook and steelhead would have access to good spawning areas above the dam.

Physical and biological monitoring in 1991 will be similar to 1990. If we are successful in beginning our proposed project8 this coming year, then our baseline data collection phase will end with this year's field season and the post-construction phase will begin with the collection of 1991 data.

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