PROGRESS REPORT

Evaluation of Artificially Constructed Side Channels as Habitat for Salmonids in the Trinity River, Northern California

1991 - 1993

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ABSTRACT

Seven artificially constructed side channels along the Trinity River were sampled using electrofishing two to four times per year from 1991 through summer, 1993. Populations of juvenile chinook and coho salmon, brown trout and steelhead were estimated for selected habitat types or for the entire side channel if all habitat types present were sampled. Chinook and coho salmon densities were highest in the spring and early summer; as expected, very few salmon were captured during fall or winter sampling.

Steelhead densities were greatest in late spring and summer, and fall in some side channels; steelhead densities were low during the winter, indicating a need for additional overwintering habitat for these fish. Brown trout densities were highest in spring, but brown trout were usually captured year round. Overwintering use by brown trout was extensive in some side channels.

Habitat types such as low gradient riffles and riffle runs, where microhabitat was most diverse, were used most extensively by all species. Swiftwater areas with large cobble substrates and run areas that had suitable cover for juveniles, such as large woody debris, were also utilized more than those areas without such cover.

Side channels were also monitored to determine spawning by chinook salmon. Twelve of 18 channels surveyed had redds; one new channel that was built in July of 1993 had several redds in areas where suitably sized gravel was placed during construction.

Water temperatures were monitored in two side channels during

the summer of 1993 to determine if they affected the temperature in the mainstem Trinity. Temperatures did increase during daylight hours in the side channels, but there were no substantial temperature effects to the mainstem river. The highest one day average increase in mainstem temperature was 0.033° F.

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INTRODUCTION

The Trinity River is one of several rivers in the Pacific Northwest that have experienced a drastic decline in the number of Pacific salmon (*Oncorhynchus spp.*) and steelhead (*Oncorhynchus mykiss*) in recent history. Both human influences, and natural factors in conjunction with human effects, have contributed to these declines. One key factor in the declines of salmon and steelhead has been the Trinity River Division of the Central Valley Project (Trinity and Lewiston dams). With the construction of these dams, and the subsequent exports of large volumes of water from the Trinity River basin to the Sacramento River, the morphology of the Trinity River between Lewiston, California and the North Fork Trinity has been drastically altered (Frederiksen and Kamine, 1980; Evans, 1979). These morphological changes include establishment of higher than normal amounts of riparian vegetation on unnatural sand berms that have developed along the banks of the Trinity River. These berms have formed as a result of a lack of high flows in the river that would normally flush much of the fine sediment out of the river. These berms have greatly reduced the width of the river which has resulted in a loss of slow water habitat that is essential for various stages of rearing anadromous salmonids (Hampton, 1988; Allen and Hassler, 1986).

In October of 1984 Public Law 98-541 was passed by the United States Congress providing the means to begin a 10 year fish and wildlife restoration program in the Trinity River Basin.

One of the major goals of the program is to restore *natural* salmon and steelhead production below Lewiston Dam (TRBFWMP, 1982). One of the objectives developed under this goal was to evaluate the effectiveness of restoration and maintenance efforts in the mainstem.

In 1984, the U.S. Fish and Wildlife Service Trinity River Flow Evaluation (TRFE) was initiated to evaluate increased flows and rehabilitation measures to restore salmonid habitat in the Trinity River below Lewiston Dam. Study reaches were established between Lewiston Dam and Hoopa Valley to collect fish habitat preference and habitat availability data. Initial data indicated that both fry and juvenile salmonid habitat was limited in the upper river and that as stream flow increases up to approximately 22.6 cms (800 cfs), the amount of fry and juvenile salmonid rearing habitat decreased in the mainstem and increased in natural side channel areas. Salmonid population studies indicated that side channels supported chinook and coho salmon fry at equal or greater densities than in main-channel habitats. These studies also indicated that optimal over-wintering habitat for juvenile steelhead was provided in the off-channel areas where suitable substrates were available (USFWS, 1987; USFWS, 1988).

In 1988, the Trinity River Restoration Program (TRRP) began designing and building artificial side channels to provide habitat for rearing juvenile salmonids. Four channels were constructed in 1988 and two additional channels in 1989. In

1989, TRRP began evaluating these artificial side channels to determine habitat use by different lifestages of juvenile salmonids (Krakker, 1990). In 1990, TRRP continued with evaluations of three channels constructed as part of the restoration program and one constructed in 1981 by CDF&G (Krakker, 1991).

As of October 1993, there had been a total of 18 side channels constructed along the upper Trinity River (Figure 1). This report continues the side channel evaluations and is a compilation of results from data collected from 1991 through summer, 1993. There were three objectives for the 1991 - 1993 sampling period:

1) Determine the seasonal use of side channels by juvenile salmonids,
2) Evaluate the relationship between available habitat and salmonid densities, and
3) Identify and evaluate technical problems associated with achieving each of the above objectives.

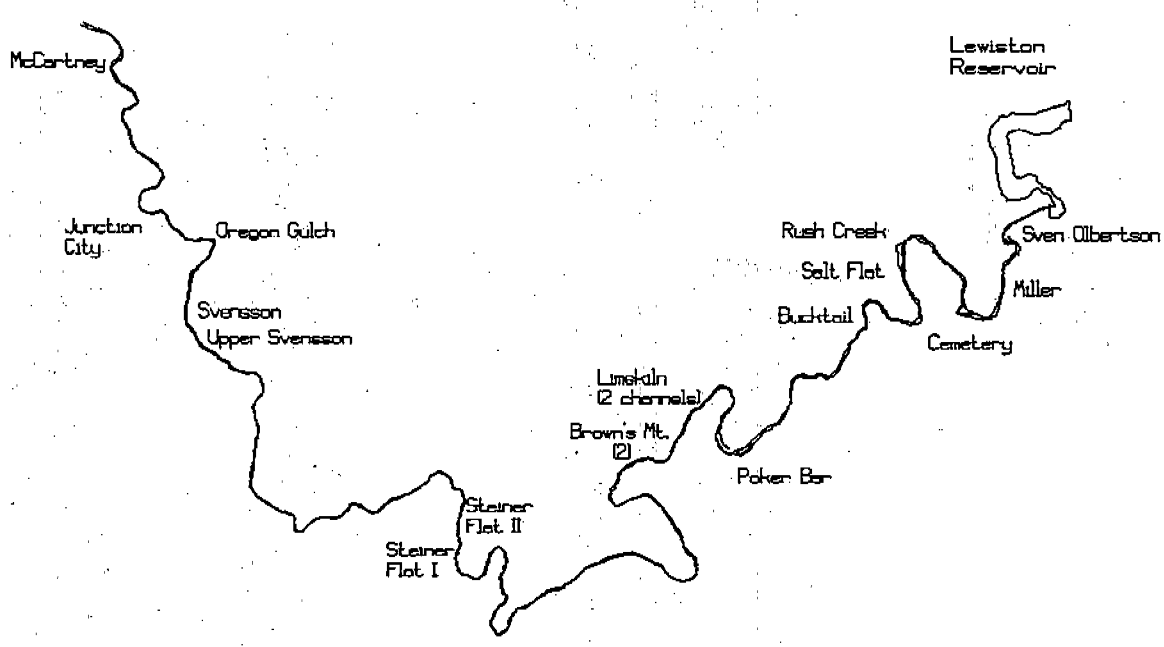

Figure 1. Locations of constructed side channels along the Trinity River, Northern California, 1993.

STUDY SITES

From 1991 through 1993, seven different side channels were sampled to determine use by juvenile salmonids; however, five was the highest number of channels sampled in any single year.

Miller side channel was constructed in 1981 by the California Department of Fish and Game (CDFG). Located at mi 110.6 (km 177), this side channel was 1,100ft (335m) long and was comprised of two major habitat types; run and riffle run. The run was 700ft (213m) long with slow moving water. The riffle run was 400ft (122m) long with short sections of swiftly flowing water over cobble substrates interspersed with areas of slow moving run type water.

Salt Flat side channel was constructed in the summer of 1989 at mi 107 (km 172); it was 1,636ft (498m) long and consisted of eight major habitat types during our sampling. We sampled up to five habitat types in Salt Flat side channel; wooded run, run, high gradient riffle, low gradient riffle and riffle backwater. The wooded run (WDRN) was a run through an area with heavy riparian vegetation and some woody debris in the channel. The run habitat was wider and deeper with slower water velocities than the wooded run and there was limited suitable substrate or vegetation available as cover. The high gradient riffle (HGR) had fast flowing, broken surface water with large cobble substrates. The low gradient riffle (LGR) was slower than the HGR with smaller substrates. The riffle backwater (RBW) flowed through a bend in the channel; the riffle was on the outside of the channel and the inside of the bend made up the slower, backwater area.

Poker Bar side channel was constructed in 1991, at mi 102.5 (km 164). This channel was a naturally occurring high flow channel which was modified to allow water to flow into the channel during lower discharges in the river. It was 1,390ft (424m) long and consisted of one continuous run habitat type.

Steiner Flat I side channel was constructed in 1988 by the Bureau of Land Management (BLM) and is located at mi 90.3 (km 145); it is 2,250ft (625m) long. When we sampled the channel it was comprised of four major habitat types; high gradient riffle, low gradient riffle, shallow run and deep run. The riffle types were similar to those described in Salt Flat. The deep run (DPRN) had slow moving water with depths over two feet; substrates consisted mostly of finer materials. The shallow run (SHRN) had more swiftly flowing water than the deep run with shallower depths.

Steiner Flat II side channel was constructed in the summer of 1990 at mi 90 (km 144); it was 2,611ft (796m) long. There were three major habitat types described by TRFE personnel; they were run, moderate gradient riffle and low gradient riffle. To better represent specific mesohabitat types, the run was further broken down into run, wide run (WIRN), narrow run (NARN) and split channel run (SPRN) (USFWS 1991). We sampled five of the habitat types present in this side channel; run, split run, narrow run, wide run, and low gradient riffle.

Svensson side channel was constructed in January of 1991 at mi 82 (km 131); it was 1,709ft (521m) long. Svensson side channel consisted of three types of habitat; run, low gradient riffle and high gradient riffle. All three types were sampled.

Oregon Gulch side channel was constructed in the summer of 1991 by BLM at mi 80.7 (km 129); it was 2,300ft (701m) long. In Oregon Gulch side channel we sampled low and high gradient riffles and run habitat types.

In the spring of 1993, four index channels were established for future consistent annual monitoring in an effort to determine long term trends in usage by salmonids. The four index channels selected were Miller, Salt Flat, Steiner Flat 1 and Svensson. These channels were selected based on location (to sample representative channels located from the upper to the lower bounds of the mainstem restoration program) and if they had been sampled in the past in order to make comparisons over several years.

After 1993, newly constructed channels will also be sampled at least once annually to quantify habitat. Population estimates will also be made in some selected new side channels and in existing side channels where habitat improvements are made.

METHODS

Habitat and Population Measurements

Mesohabitat types in the side channels were determined in coordination with Trinity River Flow Evaluation (TRFE) personnel. Quantities of fry and juvenile salmonid habitat were determined in side channels at various times by TRFE personnel using the Instream Flow Incremental Methodology (IFIM) (USFWS, 1989). When habitat sampling was concurrent with population sampling, the habitat quantifications were used to evaluate relationships between fish use and amount of habitat available.

Equal-effort multiple pass depletion electrofishing was used to sample fish populations during all three years (Seber & Lecren,1967; Zippen, 1958). In areas where electrofishing was not possible (i.e. deep pools, very high velocity areas), direct observation with mask and snorkel was utilized. Captured salmonids were counted and measured to the nearest millimeter (fork length). When large numbers of fish were captured, the first 50 randomly selected fish of each species were measured. Steelhead, coho salmon and brown trout were categorized as young of year (yoy) or 1+ based on length frequencies. Chinook salmon were categorized as fry (less than 50 mm) or juvenile (greater than 50 mm). Population estimates in each sample site were generated using a fisheries population and statistical computer program (Van Deventer and Platts, 1983). Numbers of fish from specific sample sites were then extrapolated to estimate populations for the entire habitat type in the channel and totaled for population estimates of the entire channel. In some channels, population sampling was not conducted in all habitat types. In those channels, estimates could only be extrapolated for the specific habitat types sampled and not for the entire channel.

Spawning

Adult salmonids also use several of the side channels for spawning. In the fall of 1993, TRRP personnel walked the entire length of 18 side channels to look for chinook salmon redds or redd building activity. Personnel from CDFG also looked in the side channels when performing spawning surveys on the mainstem. Any redds found were marked by placing a colored rock near the redd to identify it as counted during future surveys.

Temperature Monitoring

In 1993, we began extensive monitoring of water temperatures at two of our index side channels to determine if the channels had any significant effect on mainstem Trinity River water temperatures. Miller and Svensson side channels were monitored with Temp Mentor temperature monitors from early July through September 3.

Temperatures were recorded once every hour in three locations:

1. at or near the inlet of the channel,
2. at the outlet of the channel, and
3. in the mainstem Trinity River *upstream* of the channel outlet.

To measure temperature effects, the flows through the side channel and in the river were first determined. Temperature effects in the mainstem below the outlet of the side channel were then calculated by using the following mixing equation:

$$T_m = (T_{sc}Q_{sc} + T_rQ_r)/(Q_{sc} + Q_r)$$

where,

T_m = mean temperature in the river after mixing,

T_{sc} = temperature of the side channel near the outlet,

Q_{sc} = discharge in the side channel,

T_r = temperature in the river before mixing with the side channel,

Q_r = discharge in the river between the inlet and the outlet of the channel.

RESULTS

Habitat Use - 1991

There were four separate sample periods in 1991; late January to early February, April, June and November. Salt Flat, Poker Bar and Svensson side channels were sampled during all four of the sample periods. Steiner Flat II was sampled in April, June, and November. Fork lengths of fish were taken during April, June and November so estimates of numbers per year class or size class were not made for January.

Salt Flat Side Channel

Chinook salmon were captured during January, April and June. Coho salmon and brown trout were captured during all four sample periods. Steelhead were captured during April and June (Table 1).

Table 1 Population estimates of salmonids in all sampled habitat types, Salt Flat side channel, 1991 (chinook reported as fry and juveniles).

DATE	(size)	CHINOOK	COHO	STEELHEAD	BROWN
JANUARY		30	23	0	146
APRIL	0+ (fry)	513	721	38	581
	1+ (juveniles)	63	169	0	327
JUNE	0+ (fry)	24	0	25	349
	1+ (juveniles)	24	27	4	58
NOVEMBER	0+ (fry)	0	20	0	260
	1+ (juveniles)	0	12	0	19

Chinook salmon utilized all five habitat types sampled during the April sampling period; the riffle backwater had the highest density of chinook at 0.9 fish/ft. Brown trout were found in all five types throughout the year. The riffle backwater and the low gradient riffle had the highest brown trout densities during April and June, respectively. Steelhead were found in the run, and low and high gradient riffle types during April, and in the wooded run, run and low gradient riffle in June. Densities of steelhead never exceeded 0.06 fish/ft in any habitat type. Coho occupied the run and high gradient riffle during January and all five types during April and June. Highest densities of coho were 1.4 fish/ft in the low gradient riffle during April (Figure 2).

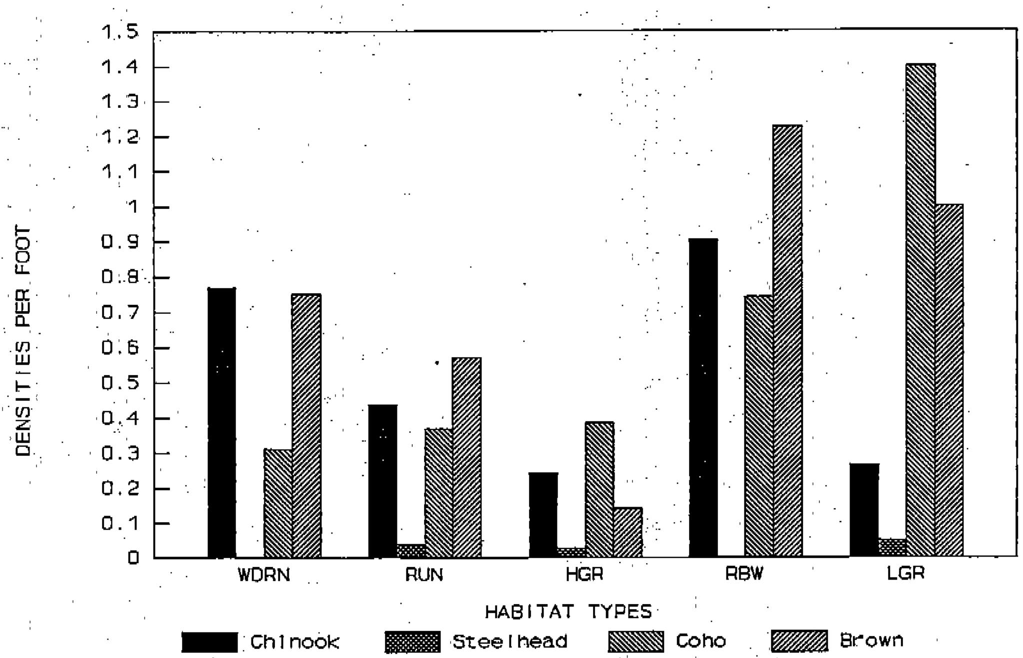

Figure 2. Densities of salmonids in sampled habitat types, Salt Flat side channel, April 25, 1991.

Poker Bar Side Channel

The habitat at Poker bar side channel consisted of one continuous deep run. No habitat transects were set at this channel to determine amount of weighted usable area so no evaluation could be made comparing available habitat with fish use. Chinook salmon were captured in February, April and June; densities were 0.01, 0.19 and 0.03 fish/ft, respectively. Coho salmon were captured in November; the density was 0.01 fish/ft. Steelhead were captured in January, April and June at 0.01, 0.01 and 0.02 fish/ft, respectively. Brown trout were captured in April and November at 0.05 and 0.03 fish/ft, respectively (Table 2).

Table 2 Population estimates of salmonids captured in Poker Bar side channel, 1991 (chinook reported as fry and juveniles).

DATE (size)		CHINOOK	COHO	STEELHEAD	BROWN
February		14	0	14	0
April	0+ (fry)	85	0	14	70
	1+ (juveniles)	180	0	0	0
June	0+ (fry)	0	0	28	0
	1+ (juveniles)	42	0	0	0
November	0+ (fry)	0	14	0	42
	1+ (juveniles)	0	0	0	0

Steiner Flat II Side Channel

Chinook salmon were captured in January, April, and June; April captures were highest for the year. Coho salmon were captured during all four sample periods. Steelhead were captured in January and brown trout were captured during all four sample periods (Table 3).

Table 3 Population estimates of salmonids in all sampled habitat types, Steiner Flat II side channel, 1991 (chinook reported as fry and juveniles).

DATE		CHINOOK	COHO	STEELHEAD	BROWN
JANUARY		18	129	9	21
APRIL	0+ (fry)	195	0	0	5
	1+ (juvenile)	258	21	0	41
JUNE	0+ (fry)	0	68	0	26
	1+ (juvenile)	23	14	0	0
NOVEMBER	0+ (fry)	0	9	0	189
	1+ (juvenile)	0	18	0	0

The highest density in April for chinook salmon was in the low gradient riffle with 0.36 fish/ft. According to IFIM measurements made by the USFWS TRFE office, the total amount of fry and juvenile chinook WUA in the low gradient riffle was the second highest of all habitat types. The split channel run and run types had 0.22 and 0.19 chinook/ft; these were the second and third highest densities, respectively, during April (Figure 3). The split channel run, however, had the lowest amount of fry and juvenile chinook WUA (USFWS 1991).

Coho salmon densities were highest in the run type with 0.14 fish/ft in January and 0.20 fish/ft in the narrow run in June. Brown trout densities were highest in the run type with 0.21 fish/ft in November.

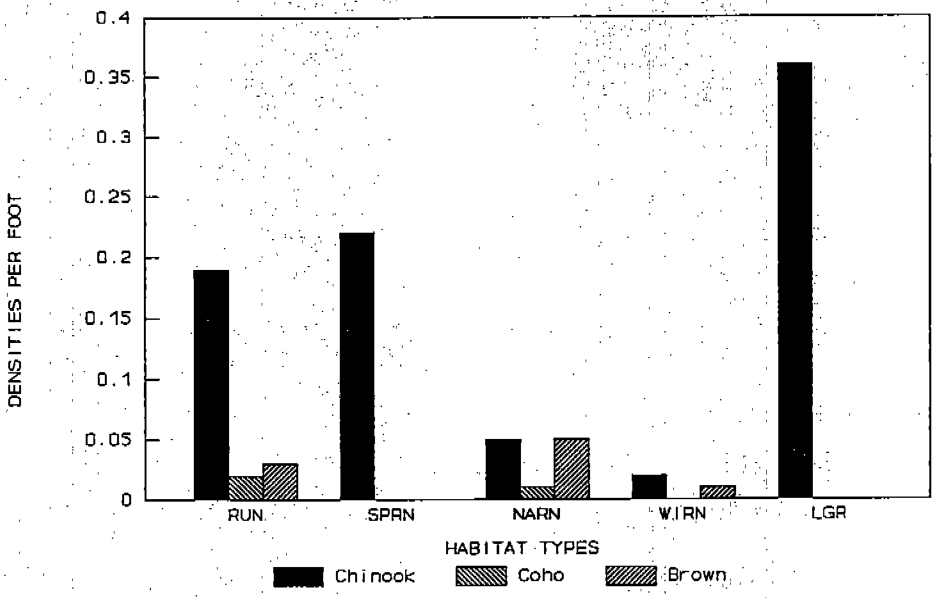

Figure 3. Densities of salmonids in sampled habitat types, Steiner Flat II side channel, April 9, 1991.

Svensson Side Channel

Chinook salmon were captured in April, June and November. Coho salmon were captured in during all four sample periods. Steelhead were captured only in April, and brown trout were not captured during any sampling period in this side channel (Table 4).

Table 4 Population estimates of salmonids in Svensson side channel, 1991 (chinook reported as fry and juveniles).

DATE		CHINOOK	COHO	STEELHEAD	BROWN
JANUARY		0	9	0	0
APRIL	0+ (fry)	1453	0	32	0
	1+ (juvenile)	161	28	0	0
JUNE	0+ (fry)	0	35	0	0
	1+ (juvenile)	17	0	0	0
NOVEMBER	0+ (fry)	0	0	0	0
	1+ (juvenile)	9	7	0	0

Habitat in Svensson side channel was determined by the USFWS TRFE office in 1991. They found that total fry and juvenile chinook habitat was highest at discharges around five cfs and decreased with increasing flows in all habitats except the high gradient riffle. In this habitat type, WUA began to increase again at flows over 100 cfs (USFWS, 1991). The approximate discharge during April sampling was 55 cfs. The low gradient riffle was used most extensively by both fry and juvenile chinook (1.55 and 0.17 fish/ft respectively) during this time and the high gradient riffle was the second most used habitat by chinook salmon fry and juveniles (0.58 and 0.06 fish/ft respectively) (Figure 4).

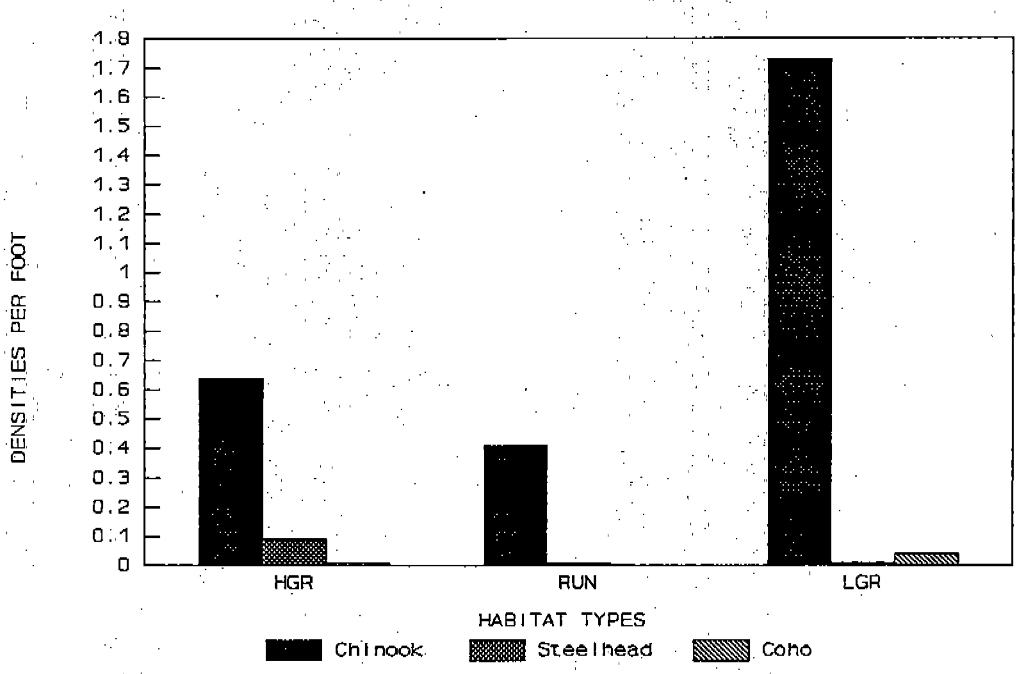

Figure 4. Densities of salmonids in Svensson side channel, April 16, 1991.

Habitat Use - 1992

There were three sampling periods during 1992: May, July, and late October to early November. Salt Flat, Poker Bar, Svensson, and Oregon Gulch side channels were sampled during all three periods; Miller side channel was sampled during May and late October.

Salt Flat Side Channel

The wooded run, run, high gradient riffle, and riffle backwater habitat types were sampled at Salt Flat during May and July; we added the low gradient riffle to our sampling again in November. Chinook salmon were captured during May and July. No chinook were sampled during November. Coho salmon, steelhead and brown trout were sampled during all three sample periods (Table 5).

Table 5 Population estimates of salmonids in all sampled habitat types, Salt Flat side channel, 1992 (chinook reported as fry and juveniles).

DATE		CHINOOK	COHO	STEELHEAD	BROWN
MAY	0+ (fry)	34	52	304	110
	1+ (juvenile)	38	0	13	38
JULY	0+ (fry)	0	0	60	209
	1+ (juvenile)	6	0	0	23
NOVEMBER	0+ (fry)	0	3	73	143
	1+ (juvenile)	0	0	3	12

In May, the two habitat types with the highest numbers (and densities) of chinook salmon were the high gradient riffle with

0.20 fish/ft and the wooded run with 0.10 fish/ft. The other two types sampled, the run and riffle backwater, had 0.01 and 0.03 fish/ft respectively. Chinook were found in the high gradient riffle during July at 0.03 fish/ft; This habitat use was much different than in 1990 and 1991 when the run and riffle backwater types were two of the most utilized types and the high gradient riffle was not as highly used. Chinook were not captured in November.

Numbers of coho salmon during May were the same in the high gradient riffle as chinook numbers with 0.20 fish/ft. Coho used the riffle backwater more extensively than chinook though, with 0.16 fish/ft in that habitat. Steelhead and brown trout were found in all habitat types during all sample periods (Figure 5).

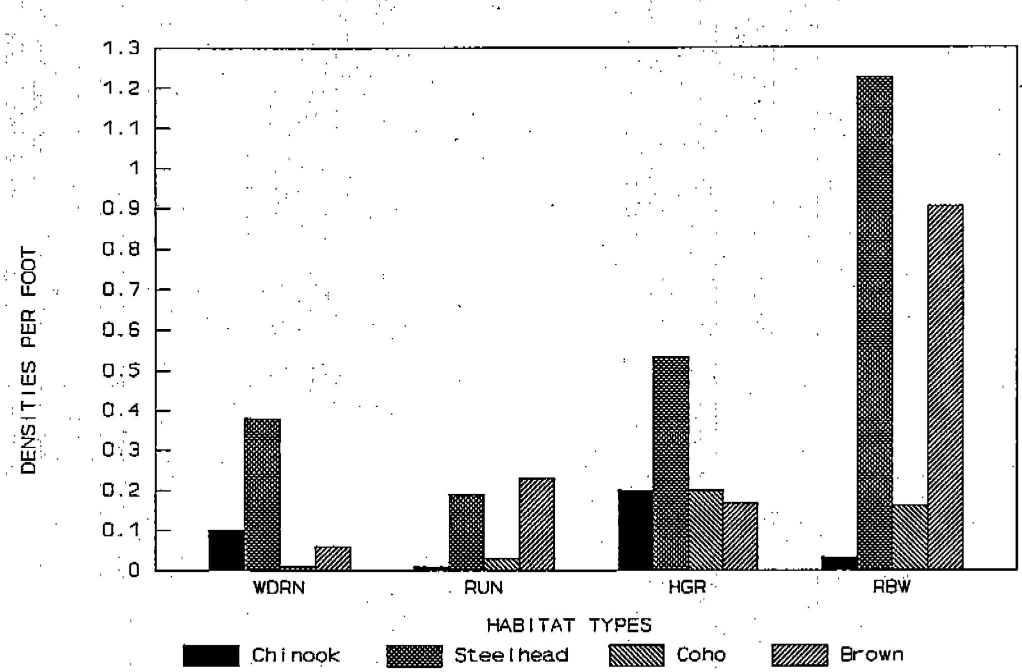

Figure 5. Densities of salmonids in sampled habitats, Salt Flat side channel, May 7, 1992.

During all three sample periods, steelhead used the high gradient riffle and riffle backwater most extensively. For brown trout, the most utilized habitats were the riffle backwater and the run during May and the riffle backwater and high gradient riffle during July and November.

Poker Bar Side Channel

Poker Bar side channel was sampled during May, July and October. Chinook salmon were found in Poker Bar side channel during the May sample period only. Coho salmon were also found only during May; all coho were 0+. Steelhead were sampled during all three periods and brown trout were sampled during May and July (Table 6).

Table 6 Population estimates of salmonids Poker Bar side channel, 1992 (chinook reported as fry and juveniles).

DATE		CHINOOK	COHO	STEELHEAD	BROWN
MAY	0+ (fry)	125	42	56	194
	1+ (juvenile)	180	0	0	15
JULY	0+ (fry)	0	0	42	191
	1+ (juvenile)	0	0	0	31
NOVEMBER	0+ (fry)	0	0	14	0
	1+ (juvenile)	0	0	0	0

The density of chinook fry and juveniles was 0.22 fish/ft in May. Highest densities for steelhead and coho were 0.04 and 0.03, respectively, during May. Brown trout densities were highest of all species with 0.15 fish/ft in May and 0.16 fish/ft in July.

Miller Side Channel

Chinook and coho salmon were captured during May only. Steelhead and brown trout were captured during both sample periods (Table 7).

Table 7 Population estimates of salmonids in Miller side channel, 1992 (chinook reported as fry and juveniles).

DATE		CHINOOK	COHO	STEELHEAD	BROWN
MAY	0+ (fry)	14	25	141	77
	1+ (juvenile)	42	0	5	18
OCTOBER	0+ (fry)	0	3	128	47
	1+ (juvenile)	0	0	0	6

Habitat at Miller side channel was quantified by lengths of each mesohabitat and not by amounts of WUA in each type. All chinook salmon fry and juveniles captured in May were found in the riffle/run habitat (Figure 6). Coho salmon were captured in both types; all coho were 0+ fish. Steelhead were found in both habitat types but used the riffle/run much more than the run. Brown trout were found in both types at near equal densities in May but used the riffle/run more extensively in October.

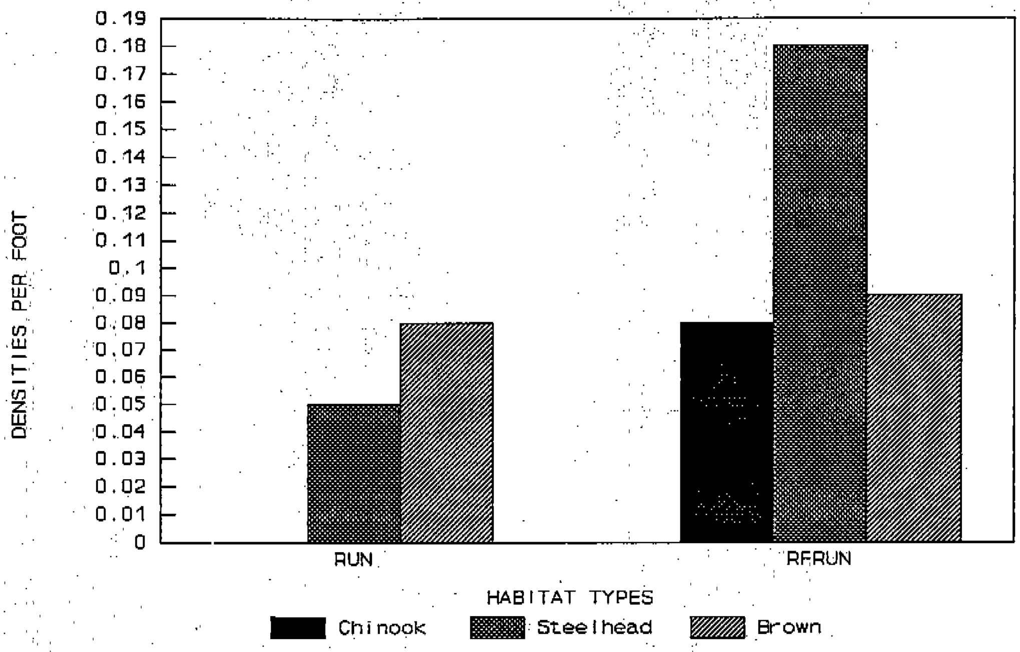

Figure 6. Densities of salmonids in Miller side channel, May 12, 1992.

Svensson Side Channel

Svensson side channel was sampled three times during 1992. In May we sampled all three habitat types found in the channel: high gradient riffle, low gradient riffle and run. In July and October we sampled just the two riffle types. Chinook and coho salmon and brown trout were found during the May sampling period. Steelhead were found during all three sample periods (Table 8).

Table 8 Population estimates of salmonids in Svensson side channel, 1992 (chinook reported as fry and juveniles).

DATE		CHINOOK	COHO	STEELHEAD	BROWN
MAY	0+ (fry)	46	243	8	0
	1+ (juvenile)	32	0	8	4
JULY	0+ (fry)	0	0	10	0
	1+ (juvenile)	0	0	0	0
OCTOBER	0+ (fry)	0	0	34	0
	1+ (juvenile)	0	0	5	0

Amount of WUA for this side channel was not quantified during 1992. In May, chinook salmon used primarily high gradient riffle habitat. There was some use of the low gradient riffle and the run habitat. Coho densities were highest in the low gradient riffle and there was some limited use of the high gradient riffle and run types. Steelhead densities were 0.02 fish/ft both in the low and high gradient riffle types. Brown trout were sampled in the high gradient riffle in May (Figure 7).

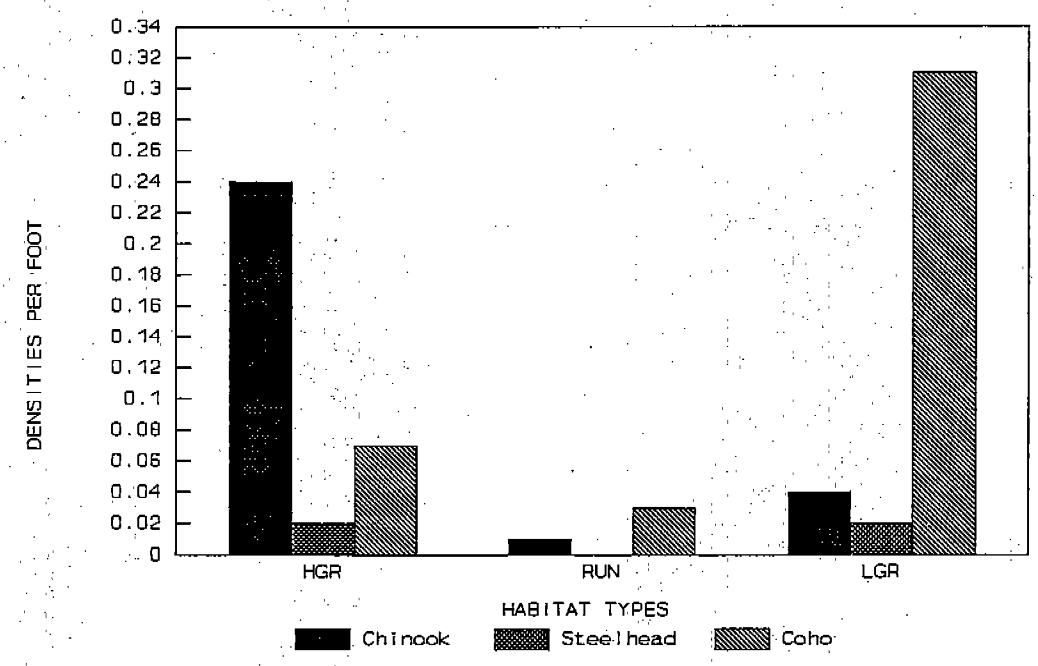

Figure 7 Densities of salmonids in Svensson side channel, May 5, 1992.

Oregon Gulch Side Channel

Chinook and coho salmon were found during the May sampling period. Steelhead were found during all three sample periods, and brown trout were found during October (Table 9).

Table 9 Population estimates of salmonids in Oregon Gulch side channel, 1992 (chinook reported as fry and juveniles).

DATE		CHINOOK	COHO	STEELHEAD	BROWN
MAY	0+ (fry)	21	10	30	0
	1+ (juvenile)	48	0	0	0
JULY	0+ (fry)	0	0	59	0
	1+ (juvenile)	0	0	0	0
OCTOBER	0+ (fry)	0	0	6	4
	1+ (juvenile)	0	0	0	0

Chinook densities were highest in the low gradient riffle; the high gradient riffle and run types actually had higher total numbers of chinook than the low gradient riffle but densities were lower. Coho were found in the low gradient riffle type in May. Steelhead were found in the run and high gradient riffle during May (Figure 8).

For steelhead, the high gradient riffle was used most extensively during July with 0.12 fish/ft, and both riffle types had equal densities of steelhead in October (0.01 fish/ft). Brown trout were found in the high gradient riffle at 0.01 fish/ft in October.

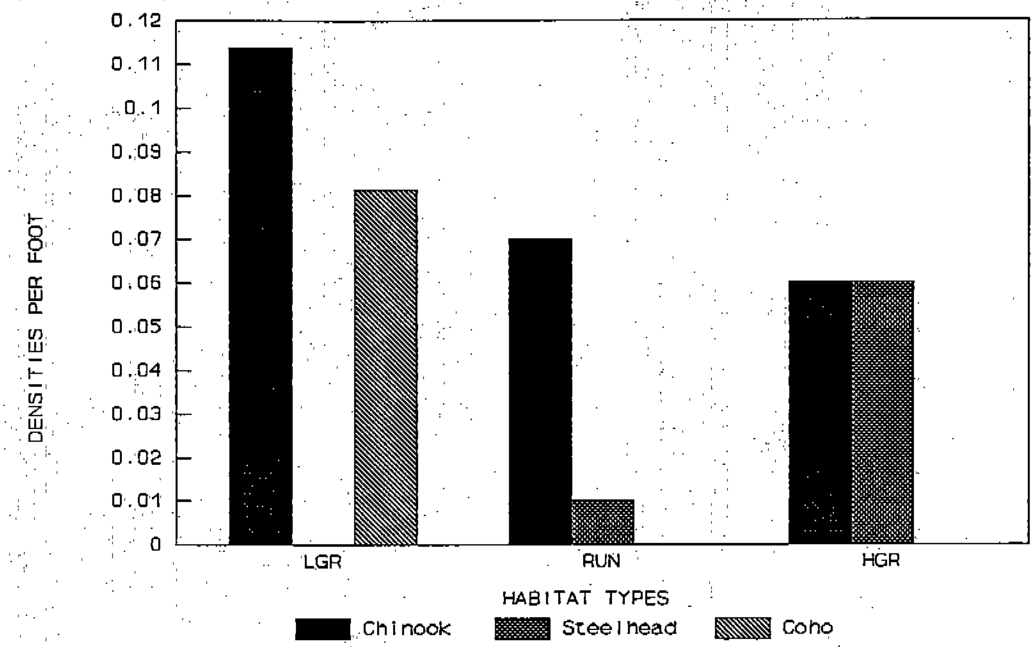

Figure 8. Densities of salmonids in sampled habitats at Oregon Gulch side channel, May 14, 1992.

Habitat Use - 1993

In 1993, due to winter storms that kept river flows at high levels, we were not able to sample side channels until March. We also changed the late autumn sampling to early winter and set future sampling schedules for winter (January), spring (late March) and summer (early July) for more consistent timing of sampling. There were four channels sampled this year; Miller, Salt Flat, Steiner Flat 1 and Svensson.

Salt Flat Side Channel

Five habitat types were sampled at Salt Flat in early April and July during this season. A low gradient riffle and an adjacent high gradient riffle that were sampled in 1991 were combined into one continuous riffle. We also sampled the wooded run, run, high gradient riffle and riffle backwater units that were sampled in 1992 and 1991. Chinook and coho salmon were found in all five habitat units during April sampling. Steelhead were found in the wooded run and riffle backwater in April. Steelhead and brown trout were found in all units during July (Table 10).

Table 10 Population estimates of salmonids in sampled habitats of Salt Flat side channel, 1993 (chinook reported as fry and juveniles).

DATE		CHINOOK	COHO	STEELHEAD	BROWN
APRIL	0+ (fry)	385	165	0	198
	1+ (juvenile)	43	0	9	49
JULY	0+ (fry)	0	17	71	257
	1+ (juvenile)	27	0	9	36

Chinook used the riffle backwater most extensively followed by the wooded run in April. Chinook were found only in the wooded run in July. Coho densities were highest in the high gradient riffle followed by the wooded run during April. Coho were also found only in the wooded run during July. Steelhead were found in the wooded run and riffle backwater during April. In July, steelhead densities were highest in the wooded run. The other four habitats were all utilized but densities were half that of the wooded run. Brown trout densities were highest in the high gradient riffle followed by the riffle backwater during April (Figure 9).

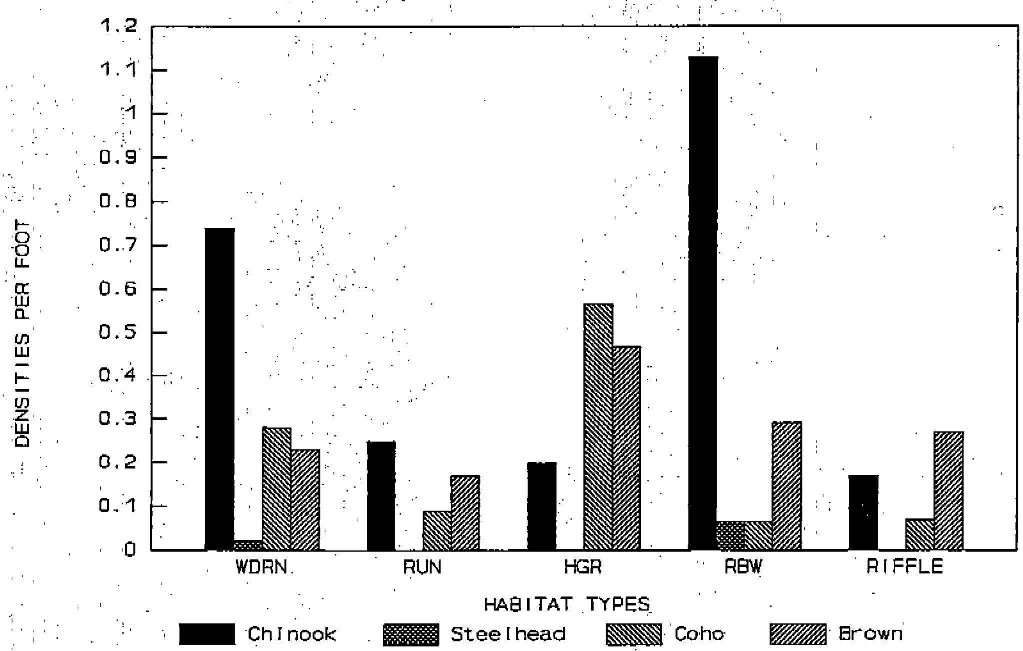

Figure 9. Densities of salmonids in sampled habitat types, Salt Flat side channel, April 6, 1993.

In July, brown trout densities were again highest in the high gradient riffle and riffle backwater, however, the order of use was reversed with the riffle backwater having slightly higher numbers than the high gradient riffle. The third highest use by brown trout during July was in the wooded run.

Steiner Flat 1 Side Channel

This side channel was sampled in early April and mid-July. Chinook and coho salmon and steelhead were captured during April; brown trout were completely absent during April sampling. Steelhead were captured in April and July; one brown trout was captured in July (Table 11).

Table 11 Population estimates of salmonids in sampled habitats of Steiner Flat I side channel, 1993 (chinook reported as fry and juveniles).

DATE		CHINOOK	COHO	STEELHEAD	BROWN
APRIL	0+ (fry)	635	339	0	0
	1+ (juvenile)	0	0	2	0
JULY	0+ (fry)	0	18	12	2
	1+ (juvenile)	5	0	2	0

The highest densities of chinook and coho salmon during April were in the shallow run habitat. The other three types all had similar use by chinook. The second most used type for coho was the low gradient riffle. Steelhead were found only in the high gradient riffle in April (Figure 10).

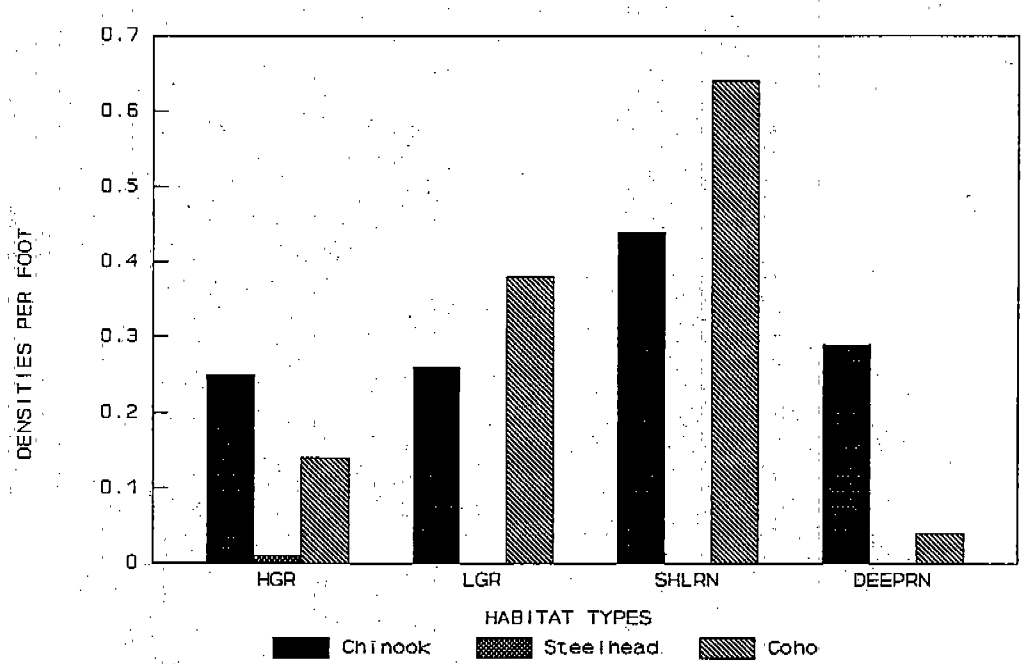

Figure 10. Densities of salmonids in Steiner Flat I side channel, April 5, 1993.

In July, chinook were found in the shallow run. Coho were sampled in the two riffle types and the deep run during July. Steelhead were found in the two riffle types and brown trout were found in the low gradient riffle during July. Numbers of all four of these species were below 0.04 fish/ft during July.

Miller Side Channel

Miller side channel again had two habitat types in 1993; run and riffle/run. Chinook were captured in both types in March but were not found in July. Coho salmon were not found in March but were found in the riffle/run in July. Steelhead were captured during both sample periods in the riffle/run. Brown trout were found during both sample periods in both habitat types (Table 12).

Table 12 · Population estimates of salmonids in Miller side channel, 1993 (chinook reported as fry and juveniles).

DATE		CHINOOK	COHO	STEELHEAD	BROWN
MARCH	0+ (fry)	146	0	0	0
	1+ (juvenile)	0	0	63	64
JULY	0+ (fry)	0	49	231	213
	1+ (juvenile)	0	0	0	9

Estimates of total numbers of fish and densities were higher in the riffle/run habitat than in the run for the three species sampled in March (only coho weren't captured). Chinook densities were over three times higher than in the run (Figure 11).

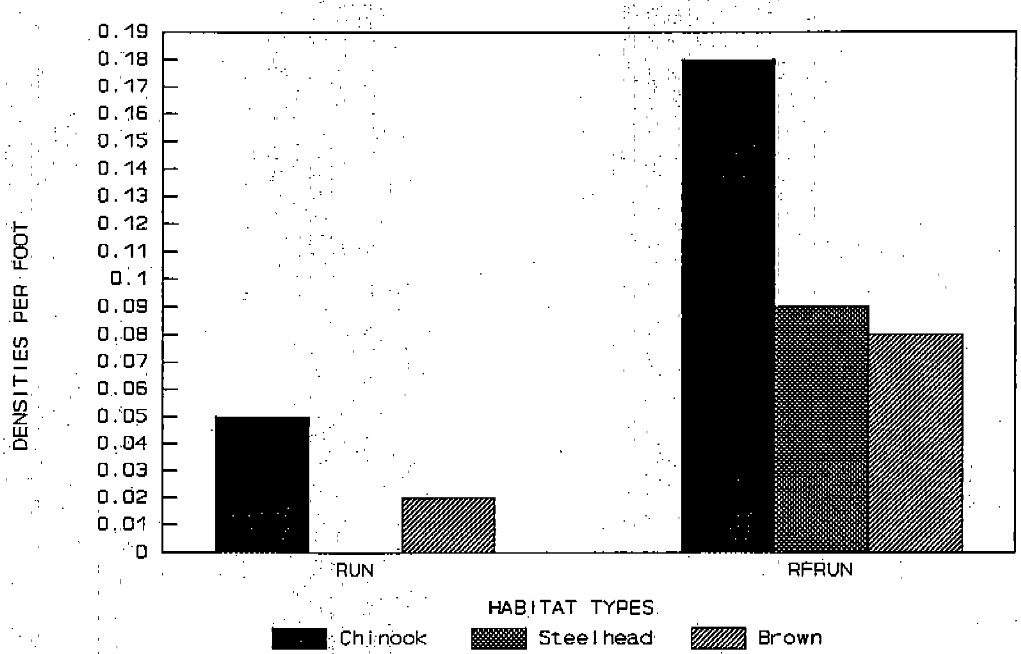

Figure 11. Densities of salmonids in Miller side channel, March 10, 1993.

In July, coho salmon and steelhead were found in the riffle/run type. Steelhead and brown trout numbers and densities were nearly four times higher than in March in the riffle/run due to the high number of 0+ fish in July that hadn't yet emerged in March. Brown trout densities in the riffle/run were ten times higher (0.3 vs. 0.03 fish/ft) and numbers were nearly 18 times higher (210 vs. 12) than in the run during the same sample period.

Svensson Side Channel

During the winter storms of 1993, Svensson side channel underwent substantial changes due to deposition of gravel that was moved by high flows. A substantial amount of material was deposited at the inlet of the channel, effectively constricting the inlet and reducing flow in the channel to approximately five to ten cfs in late spring. Therefore, this channel was not sampled until early August after modifications were made to the inlet. During modifications to the inlet we also placed three woody debris structures and a cobble wing deflector to increase and improve habitat in this channel. In August, we sampled a high gradient riffle, low gradient riffle and a run type. The high gradient riffle was formed as a result of placement of one of the woody structures. This structure was a log sill placed to divert water towards the right bank in an attempt to scour that side of the channel and possibly create an undercut bank.

Seasonal use of this channel was not determined since the channel was sampled only once during the year. Fish captured during sampling in August were one brown trout and one coho salmon. The coho salmon was captured in the run while the brown trout was captured in the high gradient riffle formed by the log structure (Table 13).

Table 13 Population estimates of salmonids in Svensson side channel, 1993 (chinook reported as fry and juveniles).

DATE	CHINOOK	COHO	STEELHEAD	BROWN
AUGUST 0+ (fry)	0	1	0	0
1+ (juvenile)	0	0	0	1

Temperature Monitoring - 1993

Temperatures in both monitored side channels increased during the July 1 through September 3 sample period. However, effects on the temperature of the mainstem river were extremely low at all times. Both channels underwent some periods when there was a cooling effect to the river, usually late in the evening or early morning. In both side channels, the highest measured instantaneous temperature increase to the river after the side channel water re-entered the river was 0.09°F. These maximum increases occurred on July 6 in Miller and on August 4 in Svensson.

The maximum one day average temperature increase to the river (24 hour period) at Miller side channel was 0.018°F on July 6 and 7. The maximum one day average increase at Svensson side channel was 0.033°F on August 4 and 5 (Table 14).

Table 14. Maximum one day average and instantaneous temperature increases to the Trinity River and instantaneous maximum cooling effects (degrees Fahrenheit) from Miller and Svensson side channels, July 1 through September 3, 1993.

Channel	Max. 1 Day Ave. Increase	Max Instant Increase	Max Instant Cooling
Miller	0.018	0.09	-0.04
Svensson	0.033	0.09	-0.02

DISCUSSION

Densities of fish in side channels as well as habitat use varied substantially during the three years of sampling. It should be noted that early survival and therefore total densities of fry and juvenile salmonids can vary widely from year to year due to natural factors such as river flow and sediment movement prior to and during emergence of fry from spawning gravels. Naturally, the number of fry produced is also influenced by the number of spawning adults in the river during the previous fall. Therefore, it is inappropriate to assume that some side channels may hold lesser or greater numbers of fry and juvenile salmonids between years based solely on the habitat that was available in the side channel.

Results from CDF&G spawning surveys in the Trinity River indicated large variations of adult spawning chinook salmon during the 1990 through 1992 spawning seasons (CDFG, 1993). Salt Flat side channel was sampled during all three years with large differences in the total number of chinook sampled each year. The number of spawning adult chinook salmon in the Trinity River declined and increased in the same years that numbers declined and increased in the side channel. Miller and Svensson side channels were only sampled during two of the years, but declines and increases also occurred in these side channels in relation to numbers of spawning adults (Table 15).

Table 15. Total number of chinook salmon fry and juveniles in three side channels during spring sampling and number of adult spawners in Trinity River during previous fall spawning.

DATE	SALT FLAT	MILLER	SVENSSON	ADULT SPAWNERS
4/25/91	576	*	1614	7682
5/7/92	72	56	78	4867
4/6/93	428	146	*	7139

* Not sampled

Seasonal Use

The most extensive use of these side channels by juvenile chinook salmon was found during our spring sampling periods; fall and winter use was limited. This was expected due to the life history of these fish and their overwhelming tendency towards emigration during late spring and early summer; we captured very few 1+ chinook salmon, and juveniles were rarely found after the month of June. Coho salmon seasonal use was similar to chinook, although we did capture proportionally more 1+ coho.

Steelhead fry usually emerge from redds in the spring much later than salmon and brown trout. Due to this relatively late emergence, in those years when spring sampling occurred in April, very few 0+ steelhead were captured. Steelhead densities, therefore, were usually highest in late spring and early summer. Sampling during January in 1991 revealed very limited use by steelhead in these side channels. During fall sampling in 1991, we did not capture any steelhead in any of the side channels. All side channels sampled during fall of 1992 were used by steelhead; estimated numbers of steelhead in Salt Flat and Svensson side channels were higher in the fall than in summer.

Due to the extended seasonal use by steelhead, it is essential that these side channels have adequate flow throughout low flow periods of late summer and fall. Even though steelhead use was minimal during winter months, overwintering habitat is also crucial in these side channels. If these channels had greater amounts of large cobble, steelhead use, and survival, would likely increase during the winter months.

Brown trout use was most extensive during spring and early summer sampling. Brown trout densities were also relatively high during fall and winter sampling. Many 1+ brown trout were captured throughout the year, indicating successful overwintering by this species in side channels. Most of the larger brown trout we saw were less than 150mm in length, so it appears that these fish move out of the side channels and into the mainstem as they grow.

Habitat Use

Salt Flat Side Channel

In 1990, TRFE personnel determined the amount of weighted usable area (WUA) for chinook in Salt Flat side channel and found that chinook salmon fry and juvenile populations correlated well with WUA estimates for the sampled habitat types. The low gradient riffle and the run were the two most extensively used habitat types by both fry and juvenile chinook. These were also the habitats with the highest amounts of WUA (USFWS, 1990).

Weighted useable area was not determined for Salt Flat side channel in 1991 and amounts of WUA may have changed in various habitat types between years. The riffle backwater was highly used by all species in the three years of sampling in this channel and it was the most utilized type in 1991. This may be due to the microhabitat diversity in this unit. The riffle section of the habitat has large cobble substrates that offer velocity shelter and escape cover for fish as well as some cover from surface turbulence. The high gradient riffle that received the most use was immediately upstream of the riffle backwater and had similar substrates and cover but no slow water area adjacent to it.

The low gradient riffle was not used as extensively by chinook as in 1990 but it was used by all species, again, probably because of the microhabitat diversity. A small island in the middle of the channel and some large cobble provide velocity sheer zones and cover for fish in this unit.

The wooded run had mixed use by fish during the three years possibly due to some changes that took place in this section. Substrate in most of this section consisted of gravel and fine material and did not provide much cover. Woody debris provided excellent cover and velocity shelters in a couple of sections of this channel and was highly utilized by fish. In one section, a portion of the wood washed out in 1992 and was not utilized to the same extent as in 1991. This section has also been highly used by adult spawning salmon, and redd construction has actually affected velocity and the channel bed profile.

The run was used by all salmonid species but not as extensively as in 1990. The slow velocity areas in this habitat may have provided adequate habitat for fry salmonids; however, most of the cover in the run during our sampling was near the banks with almost no cover in the mid-channel area. Without adequate cover and velocity diversity, the actual area available as quality habitat to the fish becomes very limited.

Poker Bar Side Channel

Poker Bar side channel was essentially one long run with limited habitat diversity. The most extensive use of this channel was by chinook salmon fry and juveniles during spring sampling and by brown trout fry in spring and summer of 1992. Densities at other times of the year were extremely low. Much of the cover in this channel was provided by substrate near the banks. Woody debris and large cobble substrates were lacking; this may explain the low densities found during most of our sampling.

Steiner Flat II Side Channel

This side channel consisted entirely of run and low gradient riffle type habitats. There was very limited cover in this channel; cobble substrates were lacking and woody debris was virtually absent in the channel.

The low gradient riffle was most utilized by chinook salmon followed by the split run. The habitat and velocity diversity in these units was likely the reason for the higher densities. The run and narrow run may potentially provide good habitat as they were both used by all three species sampled. However, additional cover will be needed in these types if densities are to increase consistently over time.

<u>Svensson Side Channel</u>

The low gradient riffle was the most extensively used habitat type by chinook salmon fry and juveniles in April of 1991. As in other channels where this type of habitat was highly used, cobble substrates provided cover and velocity shelters and were probably the reason for such high densities during spring sampling. The high gradient riffle was the habitat most used by chinook fry and juveniles in 1992. Densities in this unit, however,were still lower than in 1991. This decrease in density may have been related to numbers of spawning adults and an overall decrease in the numbers of fry produced (see Table 16). Coho salmon densities were highest in the high gradient riffle in 1991, but were higher in the low gradient riffle in 1992.

Steelhead numbers were low and brown trout were not present until 1992; however, this channel was not constructed until January of 1991. These two species generally don't move downstream as juveniles as quickly as chinook and coho salmon do and may take longer to establish populations in new channels. Steelhead numbers did increase slightly in 1992 but habitat and velocity diversity was low. Steelhead numbers would probably increase even more here with increased diversity.

In 1993, three woody debris structures were placed in this channel to provide additional cover and diversity. This channel was only sampled once in 1993 immediately after placing these structures so utilization of these structures by fish can not be fully evaluated at this time.

Miller Side Channel

The riffle/run habitat in this channel was the area where fish were most consistently captured and where more species were found. Cover in this habitat consisted of large cobble substrates, surface turbulence, and some woody debris and bank vegetation. Larger steelhead and brown trout (1+) used this habitat more than the run type. The run had smaller substrates that offered less cover than the riffle run but some sections of this habitat had adequate amounts of woody debris in the channel and overhanging vegetation to provide cover. Densities in this habitat, however, were almost always lower for all species than in the riffle run.

Again, the reason for higher densities in the riffle run was likely due to the microhabitat diversity in this type of habitat. Riffle run habitats generally have stretches of run broken by short riffle sections. The slower sections provide low velocity areas satisfactory for rearing younger fish, and the faster water of the riffle sections produce food and have larger substrates that provide cover.

Oregon Gulch Side Channel

Oregon Gulch side channel was constructed in the summer of 1991 through a large point bar. The channel had some meandering areas that forced the thalweg to shift across the channel creating velocity sheer zones and microhabitat diversity. Cover from large substrate was mostly limited to riffle areas, and woody debris was almost completely absent from the channel.

Chinook and coho salmon densities were highest in the low gradient riffle. According to TRFE measurements of 13 different habitat units, the low gradient riffle had the fourth and fifth highest amounts of WUA for chinook fry and juveniles respectively. This habitat had the highest amounts of coho salmon WUA per linear foot in the entire channel (USFWS unpublished data, 1992).

Steiner Flat I Side Channel

Chinook and coho salmon were captured in all habitat types in this channel; the shallow run had the highest densities for both of these species but chinook were found at just slightly lower densities in the other three habitat types. Steelhead were only present in the high gradient riffle, and brown trout were not captured.

Cover in the form of large substrate was limited mostly to the riffle areas which made up 20% of the channel by length. Woody debris was scarce in this channel, but overhanging vegetation provided substantial cover in the upper 100 to 150 feet of the channel. The shallow run in this channel contained mostly smaller sized substrates such as fines and gravel. There were areas of undercut banks and aquatic vegetation in this habitat that offered good cover and velocity shelters for young fish, and most of the chinook and coho captured in this section were found in those areas. However, larger substrates and woody debris in this habitat would provide substantial amounts of additional cover.

Spawning

Spawning adults also used several of the side channels. In the fall of 1993, TRRP personnel found chinook salmon redds in 12 out of 18 side channels; this included several redds in a new channel that was constructed in the summer of 1993. Spawning also occurred in Svensson side channel immediately adjacent to one of the cover crowns and cobble wing deflector that were placed in the summer of 1993. Survival of fry from redds in side channels that have adequate amounts of habitat should be excellent.

RECOMMENDATIONS

Rearing

Low gradient riffles and similar habitat types such as riffle runs were the most extensively used habitat types in channels where they occurred. The apparent reason for this use was the diversity in these habitats. Substantial velocity shelters and cover in interstitial spaces usually exists in riffle habitats when substrate is of adequate size. In areas where channel meanders create large areas of slow water adjacent to these swift water areas, diversity is even greater. Runs that had woody debris cover or undercut banks were also highly used.

Based on densities of fish and microhabitat use, certain procedures should be used for modifications in side channels and when constructing new channels to increase juvenile salmonid habitat quantity and quality:

1) Construct channels with several meanders to create velocity diversity. Slow water areas adjacent to swift water will be created when meanders are constructed and various forms of habitat will be provided.

2) Place large cobble (at least 6 to 9 inch diameter) and small boulders to provide cover in swift water areas and to improve steelhead overwintering habitat. These substrates should only be placed in areas of adequate flow where sedimentation of fine materials will not occur.

3) Place woody debris structures such as root wads or cover crowns in run areas where cobble placement would not be advantageous due to potential sedimentation.

4) Plant bank vegetation for overhead cover near shore. <u>However, vegetation should be planted *only* on steep banks and not on gradual slopes of side channels since this could lead to bank encroachment.</u>

To fully evaluate the relationship of juvenile salmonid use with available habitat in side channels, and to monitor microhabitat use in areas where woody structures such as root wads or cover crowns are placed, additional efforts are needed in two areas:

1) Determine amounts of usable habitat each time population estimates are conducted during different flows in side channels.

2) Additional direct observations may be desired in the future to help determine the degree to which habitat structures such as root wads and tree crowns are actually used by fish for cover.

Spawning

In large rivers, spawning adult salmonids can and do avoid terrestrial predation at times by spawning away from bank areas. They can also move into mid-channel areas or deep water to escape predators. Most side channels, however, are narrow and shallow, and during observations in the fall of 1993, adults were often seen spawning in areas near sufficient cover such as woody debris or undercut banks. The following are recommendations for improving spawning habitat and possibly the amount of spawning that occurs in side channels:

1) Place additional clean spawning gravel in areas of sufficient velocities and depths. If possible, gravel should be placed near areas where cobble and other cover exists for emerging fry.

2) Place woody structures such as root wads and cover crowns near spawning gravels. Placement of these structures should probably be downstream of spawning gravels so that spawning areas are not affected by flows that may be altered by structures.

Temperature Monitoring

Temperature monitoring in two of the side channels indicated no substantial effects on water temperature to the mainstem river. Temperature monitoring should continue, however, so that conditions can be determined for varying summer and early fall seasons. The four index channels that will be sampled seasonally should be monitored; adequate temperature information should be available from monitoring these four channels as they vary greatly in length and location along the river.

Future Modifications and Evaluations

The Trinity River Fisheries Resource Office (TRFRO) intends to initiate the modifications recommended above during the summer of 1994. In the fall of 1993, measurements for placing cobble, gravel, boulders and woody debris were made for eight previously constructed side channels. Two of the side channels described in this report, Salt Flat and Steiner Flat 1, are scheduled for habitat modifications. As these are two of the index channels that will be monitored annually, information will be acquired on salmonid use in the modified areas over several seasons. Areas in these channels that have had relatively high usage in the past will not be modified.

Additionally, with information collected thus far, comparisons of fish numbers and densities can only be made between channels or between years. Comparisons between fish use in side channels and the mainstem would be beneficial. During

1994 and in future sampling, attempts will be made to compare fish use in side channels with the mainstem. Personnel from the USFWS TRFE office will be snorkeling several areas of the mainstem and personnel from TRFRO will be snorkeling areas along bank feathers that have also been constructed as part of the TRRP. If possible, comparisons of fish use between these areas and side channels will be made.

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