D.W. ALLEY & Associates aquatic biology

Comparisons of Juvenile Steelhead Densities, Population Estimates and Habitat Conditions for the San Lorenzo River, Santa Cruz County, California, 1995-99; with an Index of Adult Returns

Prepared for
City of Santa Cruz Water Department,
Santa Cruz County Environmental Planning
and the
San Lorenzo Valley Water District

by
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REPORT SUMMARY

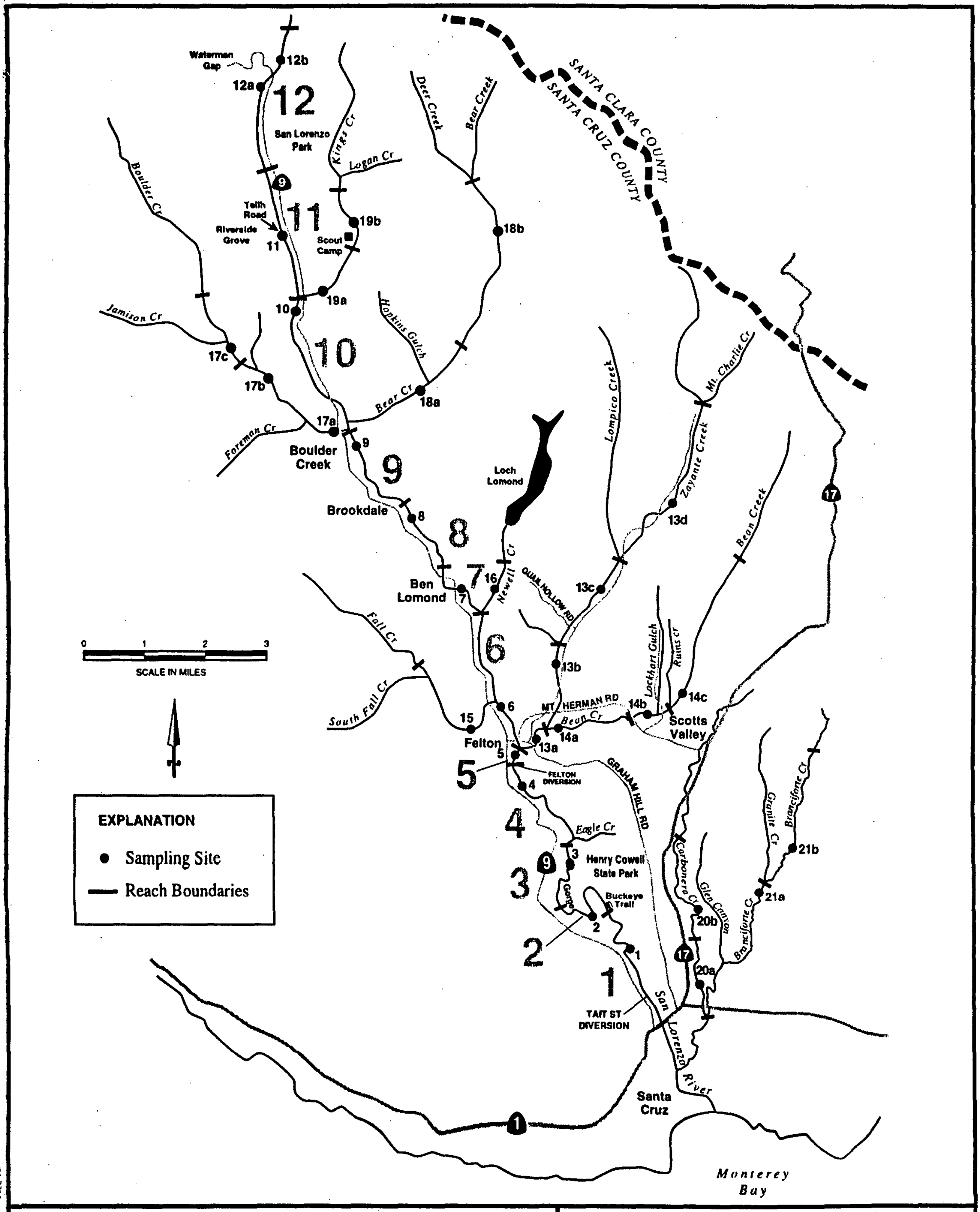
Approach to Estimating Juvenile Steelhead Population Size

Juvenile steelhead were sampled and habitat was evaluated in the San Lorenzo River drainage to compare 1999 fish densities with those in 1995-98 in this major steelhead-producing system flowing into the northern Monterey Bay (**Page 2 and Appendix A; Figure 1**). The intent was also to detect any coho salmon juveniles. Juvenile steelhead densities and production in 12 mainstem reaches (25 channel miles) were estimated from densities at 13 mainstem sites with habitat proportions determined by habitat-typing (**Tables 1a and 1c**). Juvenile steelhead densities and production were also determined in the 9 major tributaries (33 channel miles) by the sampling of 20 tributary sites in habitat-typed reaches (**Appendix A; Figure 2; Tables 1b and 1c**).

Approach to Obtaining an Index of Adult Returns Expected from Juvenile Production

The predicted index of returning adults from juvenile production was determined for mainstem reaches and tributaries. This index indicated the trend in adult steelhead populations resulting from natural smolt production. The index was based on a model developed for differential survival rate of juvenile age/size classes returning as adults to Waddell Creek during the period, 1933-42 (**Shapovalov and Taft 1954**). Steelhead survival rate to spawning adults increased exponentially with increasing size of steelhead smolts (**J. Smith, personal communication**). The model emphasized the increased survival rate expected for larger size classes of juvenile steelhead. Dave Dettman (**Kelley and Dettman 1987**) developed the model based on the Waddell Creek relationship of average size of each age class as smolts and survival to returning adult.

The model required estimated juvenile steelhead production by size class in the fall of the year. The size classes were divided according to year class sizes typically found in Waddell Creek, based on Dr. Jerry Smith's experience. Young-of-the-year



APPENDIX A, FIGURE 2 Reach & Site Designations in the San Lorenzo River Drainage
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fish were up to 75 mm Standard Length. Yearlings were from 75 mm to 150 mm Standard Length. Steelhead were included in the 2+ age class if larger than 150 mm Standard Length.

To make a more realistic estimate of returning adults from juveniles present, the estimates derived from the Dettman model were reduced by 50%, based on an estimate of returning adult steelhead to Waddell Creek in 1991-92 (**Smith 1992**).

Mainstem's Juvenile Numbers and Habitat Conditions

<u>**Overall Trends.**</u> Mainstem production of young-of-the-year juveniles (Y-O-Y's) was much reduced in 1999 (34,300) compared to 1998 (52,500) and 1997 (81,300) (**Table 48; Figures 24a-b**). Yearling numbers were increased in 1999 (7,300) compared to 1998 (5,500) and less than 1997 (8,400) (**Figures 25a-b**). The high proportion of yearlings maintained the mainstem production of larger juveniles => 75 mm SL in 1999 (24,100) to near levels in 1998 (26,600) and 1997 (24,800), despite the fewer Y-O-Y's in 1999 (**Table 49; Figures 23a-b**). The estimated total juvenile production in the mainstem was less in 1999 (41,700) than 1998 (57,800) or 1997 (88,000).

Closer evaluation of the three sub-units of the mainstem (the lower, middle and upper), indicated that 1999 Y-O-Y production and numbers of larger juveniles were similar to 1998 except for precipitous declines in the middle River. A more detailed explanation will follow.

<u>**Lower River.**</u> Young-of-the-year numbers were similar in 1998 (15,700) and 1999 (15,000). These numbers were both lower compared to 1997 (22,500). The number of smaller juveniles <75 mm SL less in 1999 (1,700) than 1998 (2,100) due to the fewer Y-O-Y's present. There were many more small juveniles in the lower River in 1997 (9,000), presumably because of more spawning, more escape cover, and the slower growth rate then, with reduced streamflow. Yearling production was nearly double in 1999 (2,100) over 1998 (1,100). Number of larger juveniles in the => 75 mm SL range was similar in 1997 (14,400), 1998 (14,700) and

1999 (15,900). This indicated that the carrying capacity for the valuable larger juveniles remained in the 14,000-16,000 range over the three years.

Juvenile densities in mainstem pools of the lower and middle River were much reduced in 1999, presumably due to the reduced streamflow compared to 1998 and less fastwater habitat at the heads of pools. Riffles and runs were heavily used in all reaches except for Reach 2. The decline in Reach 2 cannot be easily explained by examining habitat changes. It is likely that spawning effort and/or success was reduced in Reach 2 in 1999. Another possibility was that Reach 2 suffered angling pressure in summer of 1999.

Refer to the following table for a summary of habitat changes in mainstem reaches. Generally, habitat conditions worsened in the lower River, with pool and run escape cover declining in 4 of 5 reaches and riffle escape cover declining in 3 of 4 measured reaches. Although maximum pool depth increased or remained similar in 4 of 5 reaches and average pool depth was more or similar in 3 of 5 reaches, maximum riffle depth declined in all 5 reaches and average run depth declined in 3 of 5 reaches. Riffle and run embeddedness worsened in 3 of 5 reaches.

Habitat Changes from 1998 to 1999 in the San Lorenzo River Mainstem.

	Lower River					Middle River				Upper River		
Habitat Parameter	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8	R-9	R-10	R-11	R-12
Pool Escape Cover	- *	-	-	-	+ **	-	-	-	-	+	+	-
Riffle Escape Cover	+	no data	-	-	-	sim***	sim	-	+	+	-	-
Run Escape Cover	-	-	-	-	+	-	-	+	-	-	-	+
Max. pool Depth	+	sim	+	+	-	-	+	-	-	+	-	-
Avg. pool Depth	-	same	+	+	-	-	+	-	-	+	-	-
Max. Riffle Depth	-	-	-	-	-	-	+	-	-	+	-	same
Avg. Run/Stp-rn Depth	-	+	+	-	-	-	-	-	-	-	-	+
% Sand-pools	same	same	-	-	+	+	sim	sim	+	+	+	sim
% Sand-riffles	sim	same	+	sim	no data	-	sim	same	sim	same	sim	same
% Sand-stp-rn/ run	+	sim	sim	same	same	sim	-	sim	same	+	same	sim
Embeddedness-riffle/runs	-	-	+	+	-	-	-	-	-	-	-	-
Embeddedness-pools	-	same	same	sim	no data	-	same	-	-	-	-	-

* (-) denotes condition worsened.

** (+) denotes condition improved.

*** "sim" denotes similar values.

Middle River. The middle River was much less productive in 1999 than 1998 in terms of Y-O-Y's and larger juvenile size classes. Y-O-Y production was estimated at 12,600 in 1999 compared to 31,000 in 1998 and 33,000 in 1997. The number of yearlings were more similar in 1999 (1,800) and 1998 (2,100), but 1997 had many more (3,600). The number of yearlings was greater in Reaches 6 (upper Felton) and 7 (Ben Lomond) in 1999, but less in Reaches 8 and 9 (in the vicinity of the towns, Brookdale and Boulder Creek) compared to past years. In 1999, numbers of larger juveniles (=> 75 mm SL) were half (4,300) what they were in 1998 (8,500) and also less than in 1997 (7,000). The greatest reduction occurred in Reaches 8 and 9.

The reduced juvenile numbers in Reaches 8 and 9 in 1999 were likely due in part to reduced spawning and reduced egg survival. Besides that, rearing habitat quality deteriorated from reduced streamflow. Less fastwater habitat and additional sediment contributed to reduced habitat depth. Average pool depth, maximum pool depth and maximum riffle depth declined in 3 of 4 reaches. Average run depth declined in all 4 reaches. Pool escape cover declined in all 4 reaches, as did escape cover in runs in 3 of 4 reaches. Riffle cover declined in one reach, was similar in two reaches and improved in one reach. Pool embeddedness worsened in 3 of 4 reaches, and riffle and run embeddedness worsened in all 4 reaches. There was substantially less riffle habitat in all middle River reaches in 1999, which was habitat where juvenile densities were highest. Run habitat decreased in Reaches 8 and 9 (Figure 54).

Upper River. Y-O-Y production above the Boulder Creek confluence increased in 1999 (6,800) over 1998 (5,800), but was well below the 1997 level (25,800). The 1999 improvement came from Reach 11 production, with Y-O-Y production reduced in Reaches 10 and 12. An illegal dam was discovered in Reach 12, which may have restricted adult access to Waterman Gap for spawning. The number of yearlings in the upper River increased in 1999 (3,400) over 1998 (2,200) and was similar to 1997 (3,400). Production of larger juveniles (=> 75 mm SL) was somewhat greater in 1999 (3,900) than 1998 (3,500) and 1997 (3,400). Similar numbers of larger juveniles in 1998 and 1999, despite fewer yearlings in

1998, resulted from faster Y-O-Y growth rates in 1998 associated with higher streamflow. Reach 12 in Waterman Gap produced many more larger juveniles in 1999 than 1998.

Higher production of larger juveniles in 1999 probably resulted from slower Y-O-Y growth rates over the past spring that caused more to stay as yearlings, compared to 1998. It was less a result of improved habitat in 1999. In 1999, the upper River had not recovered from the pulse of sediment entering the mainstem in 1998. Reach 10, downstream of the Kings Creek confluence, remained heavily sediment-laden from inputs of sediment from Kings Creek in 1998. Hill slopes continued to erode downslope of Highway 9 in Reach 12 in 1999. Percent sand remained similar to 1998 in all three reaches, with slight improvement in pools and runs. Embeddedness worsened in all three reaches for all habitats. In general, escape cover in pools increased only slightly in Reaches 10 and 11 and declined in Reach 12 in 1999. Reach 12 had much more cover per foot of pool than Reaches 10 and 11, which were characterized by long, mostly barren pools. Sampled pools in Reaches 10 and 12 had more cover in 1997. In 1999, average and maximum pool depth continued to decline in Reaches 11 and 12 compared to 1998. Pool depth was greater in 1997 in Reaches 10 and 11 compared to later years.

Comparison of Annual Juvenile Production Between Tributaries

Zayante Creek was the most productive in 1999 for Y-O-Y's, yearlings and larger juvenile size classes. With 17% of the assessed steelhead tributary channel miles, Zayante Creek produced 29% of the tributary Y-O-Y's, 24% of the tributary yearlings and 26% of the larger juveniles in tributaries in 1999. Bear Creek was second. Bean Creek was third in production of yearlings and larger size classes, but had much reduced Y-O-Y production in 1999 compared to 1998 (2/3 reduction).

Branciforte Creek produced more Y-O-Y's than Bean Creek in 1999. Boulder Creek produced nearly as many Y-O-Y's as Bean and produced similar numbers of yearlings and larger juveniles as Branciforte Creek. Despite the relatively short extent of steelhead habitat in Fall Creek (1/2 that in Boulder Creek and 1/3 that in Bean Creek), Y-O-Y production was greater than in Boulder Creek and nearly as high as in Bean Creek. Kings Creek was the least productive in terms of yearlings and larger juveniles and was next to last in Y-O-Y production, despite its having more steelhead channel miles than Boulder, Carbonera, Fall and Newell creeks. Newell Creek had the lowest Y-O-Y production in 1999 tributaries with only a mile of steelhead habitat, it producing approximately 1/4 as many Y-O-Y's as in 1998.

All sampled tributaries except Zayante Creek, followed the trend of lower Y-O-Y production and many more yearlings holding over in 1999 compared to 1998. Growth rate of Y-O-Y's was much less in 1999 tributaries, with none reaching Size Class 2 (=> 75 mm SL) except in Zayante Creek in 1999. In 1998, more than half of the Size Class 2 juveniles in tributaries were Y-O-Y's. Zayante Creek was the only tributary that produced more Y-O-Y's in 1999 than 1998. Six of the nine sampled tributaries (Zayante, Bean, Fall, Newell, Boulder and Bear) produced more large juveniles (=> 75 mm SL) in 1999 than 1998 because of the high yearling numbers. Exceptions were Branciforte, Carbonera and Kings creeks. These creeks had more yearlings in 1999, but fewer large juveniles than 1998 because in 1998, many Y-O-Y's grew into the larger size class while none did in 1999.

Tributary Habitat Conditions- General Trends

Refer to the following summary table for habitat trends. Habitat quality generally deteriorated in all tributaries except Bear, Zayante and Newell creeks. Bear Creek greatly improved. Escape cover increased in Zayante Creek. Newell Creek showed little habitat change, though the reach-wide cover estimate was incomparable between years. Pool escape cover decreased in 7 of 9 tributaries and increased in Zayante and Bear creeks. Sampled pools were more embedded in 7 of 9 tributaries. It improved in Newell and was unchanged in Kings Creek. Embeddedness worsened in sampled riffles and runs in 6 of 9 tributaries, with improvement at one site each in Branciforte and Bear creeks.

Habitat Changes from 1998 to 1999 in Tributaries of the San Lorenzo River.

Habitat Parameter	Branciforte	Carbonera	Zayante	Bean	Fall	Newell	Boulder	Bear	Kings
Pool Escape Cover	- *	-	+ **	-	-	-	-	+	-
Max. pool depth	+/-	-/+ ***	-	+	+	+	-	+/-	same/-
Avg. pool depth	+/same	-/+	-	same	-	-	-	+/same	-
Run/Stp-rn depth	+	+/-	-	-	-	-	-	-	-
% Sand-pools	-	-	-	+	+	+	-	+	-
% Sand-riffles	-	no data	+/-	-/+	-	+	-	+	-
% Sand-stp-rn/ run	-	-	-	+	same	+	-	+	-/+
Embeddedness-riffle/runs	-/+	-	-	-	-	same	-	+/-	-
Embeddedness-pools	-	-	-	-	-	+	-	-	same

* (-) denotes condition worsened.

** (+) denotes condition improved.

*** (-/+) denotes conditioned worsened in lower Reach and improved in upper Reach.

Summary of Juvenile Steelhead Totals and Habitat Conditions by Tributary

Branciforte Creek. Branciforte Creek had fewer Y-O-Y's in 1999 (9,500) than in 1998 (14,800) and more yearlings in 1999 (3,100) versus 1998 (1,900) (**Table 48; Figures 24a-b; Figures 25a-b**). With more rapid growth rate of Y-O-Y's during the high flow 1998 year, there were actually more larger juveniles (=> 75 mm SL) in 1998 (3,300) (**Table 49; Figures 23a-b**) than in 1999 (3,100).

Habitat conditions generally worsened in 1999. Parameters that worsened in both reaches included pool escape cover, percent sand in all habitat types, and pool embeddedness. Escape cover by reach in pools declined by nearly 50% in the upper reach, which would correspond to the fewer large juveniles in the Creek in 1999. Averaged maximum pool depth and average pool depth improved in the lower reach, and embeddedness in riffles and runs worsened in the lower reach and improved in the upper reach. The cover index at sampled runs/step-runs declined at both sampling sites. The overhanging willows and woody debris had diminished.

Carbonera Creek. Y-O-Y steelhead production in Carbonera Creek declined in 1999 (4,900) compared to 1998 (6,900), while yearlings increased in 1999 (1,500) over 1998 (550) (**Table 48; Figures 24a-b; Figures 25a-b**). As in Branciforte, production of valuable, larger juveniles (=> 75 mm SL) was actually higher in 1998 (2,500) than 1999 (1,600), despite the fewer yearlings in 1998 (**Table 49; Figures 23a-b**). The growth rate of Y-O-Y's was impressive in 1998 with the higher streamflow compared to 1999.

Although more large juveniles used Carbonera Creek in 1999, habitat quality worsened. Habitat parameters that worsened in both reaches included pool escape cover, percent sand in pools, runs and step-runs, and embeddedness in all habitat types. The average percent sand in pool habitat of the upper reach increased from 30% in 1998 to 70%. Pool depth (both average and maximum) declined in the lower reach and improved in the upper reach.

Zayante Creek. Unlike the mainstem River and other tributaries, Zayante Creek had higher Y-O-Y steelhead production in 1999

(22,000) than in 1998 (19,800). It had 4 times the production of yearlings in 1999 (6,700) compared to 1998 (1,700) (**Table 48; Figures 24a-b; Figures 25a-b**). Yearling densities were substantially higher in 1999 in all reaches and 6 times more dense in upper Reach 13d. Densities of larger juvenile Size Classes 2 and 3 were greater in all four Zayante reaches in 1999 (7,500), compared to 1998 (3,800) (**Table 49; Figures 23a-b**). The disparity between years was less so than for yearlings. The high Y-O-Y growth rate in 1998 boosted production of larger juveniles.

The higher number of yearlings and larger juveniles present in 1999 compared to 1998 was probably largely due to the abnormally low proportion of 1997 Y-O-Y's that stayed over another year in 1998 before smolting. Many Y-O-Y fish of 1997 likely either were flushed out with high 1998 storm events or grew sufficiently in spring of 1998 to leave prior to censusing in 1998. In 1999, with less streamflow, Y-O-Y's from 1998 stayed another spring and summer as yearlings and were censused in fall, 1999.

The primary habitat improvement in Zayante Creek in 1999 was more escape cover, which was consistent with much higher densities of larger juvenile steelhead compared to 1998. Pool escape cover increased in Reaches 13b-d, especially where overhanging willows and dogwood increased. Pool cover declined in Reach 13a with reduced woody debris. The proportion of pool habitat increased in all reaches. Riffle cover increased in Reaches 13a and 13d. Cover in run/step-run habitat improved in Reaches 13b and 13d.

Habitat parameters that worsened included increased sedimentation in Zayante Creek as indicated from higher percent sand in pools and runs in 1999. Water depth declined in pools (average and maximum), runs and step-runs. Riffle embeddedness increased at Sites 13a and 13b. There was much more percent sand in riffles of Reaches 13b and 13c. Substrate embeddedness worsened in all habitat types.

Bean Creek. Y-O-Y steelhead production was considerably reduced in 1999 (6,100) compared to 1998 (17,900) (**Table 48; Figures 24a-b; Figures 25a-b**). Disparities were most apparent in the upper Reach 14c, where streamflows were most reduced. However, as in

Zayante Creek, yearling numbers were much greater in 1999 (4,200) versus 1998 (1,500). Y-O-Y's produced in 1997 probably smolted early and left in spring, 1998, with the high spring flows allowing more rapid growth than in spring 1999. Y-O-Y's produced in spring, 1998, benefited from a summer of high streamflow for improved growth that allowed early smolting of the larger ones in spring, 1999. However, there was a wide range of Y-O-Y sizes in Fall, 1998, causing a substantial proportion of them to apparently hold over as yearlings in 1999. With so many yearlings in 1999, the production of larger juveniles (=> 75 mm SL) (4,200) was greater than in 1998 (1,600) (**Table 49; Figures 23a-b**). The high density of yearlings may have also suppressed Y-O-Y densities in 1999. The proportion of pools increased substantially in Reach 14a in 1999 (31 to 51%), and densities of Y-O-Y's and yearlings were higher there than in riffles or runs. Riffles increased as runs decreased in proportion, and Y-O-Y's were more abundant in riffles.

Habitat conditions primarily worsened in Bean Creek in 1999, including pool escape cover, run and step-run depth and embeddedness in all habitat types. Escape cover was much reduced in Reaches 14a-b. At the traditional sampling site in Reach 14b, pool escape cover was at a three-year low. The upper reach (14c) had better substrate conditions in 1999 than 1998, but the habitat-typed segment was further upstream in 1999 and above many erosion sites. There were 33 erosion sites between the 1998 sampling site in Reach 14c and the 1999 sampling site upstream. Our survey of streambank erosion in Bean Creek in 1999 detected 9 erosion sites (569 feet) in Reach 14a, 7 erosion sites (391 feet) in Reach 14b, and 40 erosion sites (2,567 feet) in Reach 14c.

Habitat improvement occurred for maximum water depth in pools and percent sand in pools, runs and step-runs and upstream riffles. Average pool depth remained constant.

Fall Creek. Y-O-Y steelhead production in Fall Creek in 1999 (5,800) was nearly identical to 1998 (5,800), with nearly three times the number of yearlings, 1,400 versus 500 (**Table 48; Figures 24a-b; Figures 25a-b**). However, 1999 growth rates were less, with no Y-O-Y's reaching the larger juvenile size classes.

In 1998, 500 Y-O-Y's grew into the larger size class, making the 1998 estimate of Size Class 2 and 3 juveniles 1,000 compared to the 1,400 in 1999 (**Table 49; Figures 23a-b**). There were more larger fish and more steelhead in Fall Creek in 1999.

Regarding habitat, overall streambed conditions deteriorated and average habitat depth declined in Fall Creek in 1999. Parameters that worsened included pool escape cover, average pool depth, depth in runs and step-runs, percent sand in riffles and embeddedness in all habitat types. Percent sand worsened in pools. Average pool depth by reach declined from 1.3 to 1.1, while average maximum pool depth increased slightly from 1.8 to 1.9 feet. Escape cover in the sampled pools declined considerably. The proportions of pools and runs increased in 1999, and juvenile densities were greater in these habitat types compared to riffle habitat, which decreased substantially in 1999. Maximum pool depth increased slightly.

Newell Creek. Newell Creek's composition of juvenile steelhead age/size classes was consistent with most tributaries, having reduced Y-O-Y production in 1999 (1,000) compared to 1998 (3,600) (**Table 48; Figures 24a-b; Figures 25a-b**). Yearling production was much higher in 1999 (1,300) versus 1998 (400). There were much fewer fish in the Creek in 1999 (2,100 versus 4,000 in 1998), but more large juveniles => 75 mm SL were predicted (1,100) than in 1998 (700) due to more yearlings (**Table 49; Figures 23a-b**).

Newell Creek habitat did not change much from 1998 conditions. Riffle substrate remained at the same embeddedness, with only a 5% increase in percent sand. Percent sand in runs was unchanged. Embeddedness in pools declined 5% while percent sand increased only 5%. Newell Creek typically had deep pools, but average pool depth by reach declined, while average maximum depth increased. Most large juveniles inhabited pools in 1999.

Boulder Creek. Being consistent with most other tributaries, Boulder Creek production declined in Y-O-Y steelhead from 1998 (13,400) to 1999 (5,800) and increased in yearlings from 1,300 in 1998 to 3,100 in 1999 (**Table 48; Figures 24a-b; Figures 25a-b**). The largest drop in Y-O-Y's occurred in lower Reach 17a, where densities went from 143 Y-O-Y's per 100 feet in 1998 to 45 Y-O-Y's per 100 feet. But the yearlings increased from 7 to 15 fish per 100 feet in 17a. Reach 17c had the largest increase in yearlings from 7 to 19 fish per 100 feet in 1999. The annual difference in number of larger juveniles was reduced because high growth rates in 1998 associated with high baseflows allowed Y-O-Y's to enter the larger size class. In 1999 only yearlings (3,100) were => 75 mm SL, while in 1998 there were 2,200 larger juveniles, meaning that 900 Y-O-Y's entered the larger size (Table 49; Figures 23a-b).

In general, habitat value in lower Boulder Creek deteriorated in 1999. The percent sand in riffles increased in Reaches 17a-b. The percent sand in runs/step-runs increased in Reaches 17a and 17c, with an improvement in 17b. The percent sand increased in 17a pools from 45 to 60%, with improvement in upper reaches. The escape cover in sampled riffles of Reaches 17a and 17b declined substantially with the added sand. The reach index of cover declined in both reaches, as well. The escape cover in all sampled pools in Boulder Creek declined in 1999, representing a steady 4-year decline at Sites 17a and 17b since 1996. The reach-wide escape cover index for pools in Reach 17a went from the best tributary rating in 1998 to an abysmal level in 1999. Pool escape cover declined in Reach 17c also, but pool cover increased in middle Reach 17b. Average and maximum pool depth declined in Reach 17b. Though the escape cover in the sampled run/step-run habitat in 17a improved in 1999, the reach escape cover index declined by more than half. Escape cover in run/step-run habitat in the upper two reaches improved, particularly in 17c.

Despite overall habitat deterioration, small habitat improvements included slightly increased average pool depth in Reach 17a, though pools were already adequately deep. Average maximum depth increased notably in Reach 17a from 3 to 3.5 feet and in Reach 17c from 2.7 to 4.2 feet (different segment surveyed in 1999). The proportion of pools declined in Reach 17a, while run/step-run habitat increased. This was an improvement because more Y-O-Y's and yearlings used run/step-runs in 1999 more than pool habitat.

Bear Creek. Bear Creek had similar Y-O-Y production of steelhead in 1999 (16,700) to 1998 (18,100) (**Table 48; Figures 24a-b; Figures 25a-b**). The yearling production in 1999 (5,500) was much greater than in 1998 (1,200), resulting in many more large juveniles (=> 75 mm SL) in 1999 (5,500) versus 1998 (2,250) (**Table 49; Figures 23a-b**). More juveniles were present in 1999 than 1998. Improvement in juvenile production resulted from higher numbers in Reach 18b, where 60% of the Y-O-Y's and 56% of the yearlings were produced.

Unlike most tributaries, habitat conditions improved in Bear Creek in 1999. Major streambank erosion had occurred just downstream of the Bear Creek Country Club in 1998, and some sediment apparently moved out and into the mainstem by 1999. Embeddedness in riffle/step-run habitat at sampling sites improved at the lower Site 18a and increased slightly at upper Site 18b. Reach averages for percent sand in riffles decreased from both Reaches 18a and 18b. Percent sand in run/step-run habitat by reach also declined in Reach 18b from 50 to 25%. Maximum pool depth increased in the lower reach (3 to 3.6 feet), despite reduced streamflow, and declined in the upper reach (3.2 to 2.9 feet). Average depth improved in the lower reach and remained constant in the upper reach. The cover index for riffle habitat in Reach 18b improved, and there was a slight improvement in step-run habitat. The escape cover index for sampled pools increased at both sampling sites in 1999 and for pool habitat reach-wide in the upper reach.

An exception to this rosy picture of improvement in 1999 was increased percent sand in pools of the lower reach from 75 to 90%. Percent sand in pools remained at 70% in the upper reach.

Kings Creek. Kings Creek steelhead followed the pattern of most tributaries with reduced Y-O-Y production in 1999 (2,700) than 1998 (3,300), with more yearlings holding over in 1999 (1,200) than 1998 (300) (**Table 48; Figures 24a-b; Figures 25a-b**). However, the production of larger juveniles (=> 75 mm SL) was less in 1999 (1,200) than 1998 (1,700) because no Y-O-Y's grew into the larger size class in 1999 and 1,400 did in 1998 with the higher streamflow (**Table 49; Figures 23a-b**).

The pre-existing poor habitat conditions had worsened in 1999. Percent sand in important step-run habitat increased in Reach 19b from 25 to 35%. The percent sand in pool habitat increased significantly in Reach 19a from 50 to 85% and in Reach 19b from 65 to 95%. Correspondingly, average pool depth in Reach 19a decreased from 1.5 to 0.8 feet (indicating considerable pool filling) in 1999 and decreased from 1.3 to 1.1 (less dramatic) in Reach 19b. Average maximum pool depth remained constant in Reach 19a at a relatively shallow 1.5 feet and declined 0.1 foot in the upper Reach 19b. The reach escape cover index for riffle habitat in 19b declined substantially in 1999. The cover in the sampled step-run declined slightly at Site 19b in 1999, but the reach index for run/step-run habitat declined substantially in Reach 19b. The reach's escape cover index for pools also declined.

Conclusions

If coho salmon spawned in the San Lorenzo River system in winter, 1998-1999, they were too few in number to produce juveniles at detectable levels with our 33-site sampling regime.

The sharp decline in Y-O-Y numbers in the middle River and most tributaries in 1999, may indicate a decline in adult returns in 1998-99 compared to recent years. Other factors leading to reduced Y-O-Y's were probably reduced survival of Y-O-Y's resulting from less fastwater feeding habitat and shallower conditions resulting from less streamflow in 1999. However, mainstem Y-O-Y numbers were much greater in 1997 than 1999, even though baseflows were less (Figures 55-56). The difference between the two years was that in 1999, much less escape cover existed in most mainstem reaches, and substantially more sand was present in mainstem riffles and runs/step-runs. Embeddedness in riffles and runs was greater in most mainstem and tributary reaches compared to 1998, leading to less escape cover and insect productivity. Escape cover was reduced in most tributary reaches in 1999, providing another reason for fewer Y-O-Y's. However, in the two tributaries that had more escape cover in 1999, Zayante and Bear creeks, there were 3.9 and 3.5 times the number of yearlings, respectively, compared to 1998. All tributaries had at least a predicted doubling of yearlings in 1999 except for

Branciforte Creek. Slower growth rates over the 1998-99 winter and spring of 1999 caused more Y-O-Y's to stay another growing season rather than smolt in spring 1999. This was contrary to what had occurred the previous spring of 1998 with higher streamflow and growth rates. Many more Y-O-Y's smolted after just one growing season in 1998.

In 1999, the mainstem contributed fewer juveniles to the total population (all size classes) and a smaller proportion of larger juveniles than in 1998. In 1999 the 9 tributaries (58% of the nearly 60 channel miles of evaluated steelhead habitat) produced 68% of the Y-O-Y steelhead (66% in 1998) and 79% of the yearlings (63% in 1998.) (Table 48). The following table shows trends in estimated number of juvenile steelhead by age class.

Estimated Number of Juvenile Steelhead by AGE-CLASS in the San Lorenzo River Mainstem From Highway 1 to Above Waterman Gap in Fall of 1996-99, with 1998-99 Tributary Estimates Included.

YEAR	# OF YOUNG-OF-THE-YEAR STEELHEAD	# OF YEARLING STEELHEAD	TOTAL NUMBER OF JUVENILES
1996 Main-stem	62,000*	9,500*	71,500*
1997 "	81,500	8,500	89,500
1998 "	52,500	5,500	58,000
1999 "	34,500	7,500	41,500
1998 Tribs.	103,500	9,500	113,000
1999 Tribs.	74,500	28,000	102,500
1998 TOTAL	156,000	15,000	171,000
1999 TOTAL	109,000	35,000	144,000

* Estimates were rounded to the nearest 500.

The tributaries produced 81% of the Size Class 1 juveniles (75% in 1998) and 54% of the Size Class 2-3 juveniles (40% in 1998) (Table 49). The following table shows trends in estimated number of juvenile steelhead by size class.

Estimated Number of Juvenile Steelhead by SIZE-CLASS in the San Lorenzo River Mainstem From Highway 1 to Above Waterman Gap in Fall of 1981, 1994-99, with 1998-99 Tributary Estimates Included.

YEAR	# OF SIZE-CLASS 1 STEELHEAD (< 75 mm SL)	# OF SIZE-CLASSES 2 & 3 STEELHEAD (=> 75 mm SL)	TOTAL NUMBER OF JUVENILES
1981 Main-stem	37,000*	31,500	69,000
1994 "	24,500	23,000	45,000
1995 "	37,000	38,000	75,000
1996 "	40,000	32,500	72,500
1997 "	63,000	25,000	88,000
1998 "	31,000	26,000	58,000
1999 "	17,500	24,000	41,500
1998 Tribs.	91,500	19,000	111,000
1999 Tribs.	73,500	28,500	102,000
1998 TOTAL	123,000	45,500	168,500
1999 TOTAL	91,000	53,000	144,000

* Estimates were rounded to the nearest 500.

Tables 56 and 57 and Figures 28a-b and 29 summarize the index of adult spawners expected from the mainstem juveniles through 1999, with predictions from tributary juveniles in 1998-99. The following table summarizes annual indices of adult returns.

Comparison of Index of Adult Steelhead Returns to the San Lorenzo River in 1981 and 1994-99, With Indices from the Nine Tributaries in 1998-99. (Graphically represented in Figure 29).

SAMPLE YEAR		NUMBER OF FIRST TIME SPAWNERS FROM 12 REACHES	TOTAL NUMBER OF RETURNING ADULTS FROM 12 REACHES
1981	Mainstem	1,250	1,500
1994	"	900	1,100
1995	"	1,500	1,800
1996	"	1,300	1,500
1997	"	1,100	1,300
1998	"	1,100	1,300
1998	Tribs.	1,000	1,200
1998	Mainstem + Tribs.	2,100	2,500
1999	Mainstem	950	1,150
1999	Tribs.	1,300	1,500
1999	Mainstem + Tribs.	2,250	2,650

The index of adults did not decline substantially in 1999, despite the nearly 30% decline in Y-O-Y's. This was because the model incorporated size-dependent survival rates on juvenile production. This assigned more value to larger juveniles in producing adults. The 16% increase in larger juveniles from 1998 to 1999 offset much of the 26% decline in Size Class 1 juveniles. The mainstem contributed about 43% of the 2,650 predicted adult steelhead returns in 1999, although it was inhabited by only 29% of the juveniles (Figure 28b). In 1998, the mainstem contributed about 52% of the 2,450 predicted adult steelhead returns, while it was inhabited by 34% of juveniles (Figure 28a).

The adult index from mainstem juveniles declined over the period of 1995-99. The number of adults predicted from 1999 mainstem juveniles declined 10% from 1998, resulting from a 40+% reduction in Size Class 1 juveniles and an 8% decline in Size Class 2-3 juveniles, despite a 33% increase in mainstem yearlings (**Tables 50 and 56**). There was a 35% reduction in Y-O-Y juveniles in the 1999 mainstem and a 28% reduction in tributaries compared to 1998 (**Table 48**). Tributaries had a 20% reduction in Size Class 1 juveniles but a 50% increase in Size Classes 2 and 3 to boost the total index of adult returns. The much higher tributary production of larger juveniles resulted from a 197% increase in yearlings holding over in tributaries in 1999 compared to 1998.

INTRODUCTION

Regulatory Context

Both coho salmon (Oncorhynchus kisutch) and steelhead (Oncorhynchus mykiss) inhabiting the San Lorenzo River have become protected as Threatened species under the Endangered Species Act (ESA). The Threatened listing means that coho salmon and steelhead in the ESU will likely become endangered in the foreseeable future without improved conditions. Additionally, coho salmon have been listed by the State of California as an Endangered species, south of San Francisco Bay. The San Lorenzo coho salmon population (remnant) is included in one of two federal Evolutionarily Significant Units (ESUs) in California under the ESA, it being the Central California Coast ESU. This coho salmon ESU extends from Punta Gorda in the north to the San Lorenzo River in the south. The San Lorenzo steelhead population is included in one of four ESUs with Threatened status, it being in the Central California Coast ESU. The ESU for steelhead populations includes streams from the Russian River in the north to (but not including) the Pajaro River in the south.

As part of the ESA, critical habitat is designated for Threatened species, defining areas in which federally permitted projects will require Section 7 consultation with the National Marine Fisheries Service to determine conditions of the permit. A Habitat Conservation Plan (HCP) may eventually be required for the San Lorenzo River watershed to allow incidental take of coho salmon and steelhead. Independent water districts, cities (because of their public works and water supply activities), and Santa Cruz County will likely be required to join in this process. A recovery plan is being developed by the state to increase the coho salmon population size to a level at which the species may be de-listed. A similar plan may be developed for steelhead. The present fish monitoring effort is supported by the City of Santa Cruz, Santa Cruz County and the San Lorenzo Valley Water District to obtain scientific information regarding the existing status of coho salmon and steelhead populations and habitat conditions. These data will be used to set population goals for de-listing and to guide habitat restoration.

Steelhead and Coho Salmon Ecology

<u>**Migration**</u>. Adult steelhead in small coastal streams tend to migrate upstream from the ocean after several prolonged storms; the migration seldom begins earlier than December and may extend into May if late spring storms develop. Many of the earliest migrants tend to be smaller than those entering the stream later in the season. Adult fish may be blocked in their upstream migration by barriers such as bedrock falls, wide and shallow riffles and occasionally log-jams. Man-made objects, such as culverts, bridge abutments and dams are often significant barriers. Some barriers may completely block upstream migration, but many barriers in coastal streams are passable at higher streamflows. If the barrier is not absolute, some adult steelhead are usually able to pass in most years, since they can time their upstream movements to match peak flow conditions. In 1992 we located a partial migrational barrier in the San Lorenzo River Gorge caused by a large boulder field, which is probably passable at flows above 100-125 cubic feet per second. In most years it is not a problem. However, in drought years and years when storms are delayed in coming, it can be a serious barrier to steelhead and particularly coho (silver) salmon spawning migration. In 1998 and 1999, a difficult passage riffle was observed in the upper portion of Reach 2 in the Rincon area. A split channel was developing, causing difficult passage conditions for adults at flows less than 40-50 cfs.

Coho salmon often have severe migrational problems, because their migration period, November through February, is often prior to the peak flows needed to pass shallow riffles, boulder falls and partial logjam barriers. Access at the rivermouth is also a greater problem for coho salmon, because they die at maturity and cannot wait in the ocean an extra year if access is poor due to failure of sandbar breaching during drought or delayed stormflow.

Smolts (young steelhead and coho salmon which have physiologically transformed in preparation for ocean life) in local coastal streams tend to migrate downstream to the lagoon and ocean in March through June. In streams with lagoons, young-of-the-year fish may spend several months in this highly productive lagoon habitat and grow rapidly. In some small coastal streams, downstream migration can occasionally be blocked or restricted by low flows due primarily to heavy streambed percolation or early season stream diversions. Flashboard dams or closure of the stream mouth or lagoon by sandbars are additional factors which adversely affect downstream migration. However, for most local streams, downstream migration is not a major problem except under extreme drought conditions.

<u>Spawning</u>. Steelhead and coho salmon require spawning sites with gravels (from 1/4" to 3 1/2" diameter) having a minimum of fine material (sand and silt) mixed with them and with good flows of clean water moving over and through them. Increases in fine materials from sedimentation, or cementing of the gravels with fine materials, restrict water and oxygen flow through the redd (nest) to the fertilized eggs. These restrictions reduce hatching success. In many local streams, steelhead appear to successfully utilize substrates for spawning with high percentages of coarse sand which probably reduce hatching success. Steelhead that spawn earlier in the winter than others, are much more likely to have their redds washed out or buried by winter storms. Steelhead spawning success may be limited by scour from winter storms in some Santa Cruz County streams. Unless hatching success has been severely reduced, however, survival of eggs and larvae is usually sufficient to saturate the limited available rearing habitat in most small coastal streams and San Lorenzo tributaries. This may not be the case in the mainstem San Lorenzo River downstream of the Boulder Creek confluence. The production of young-of-the-year fish is related to spawning success, which is a function of the quality of spawning conditions and ease of spawning access to upper reaches of tributaries, where spawning conditions are generally better.

<u>Rearing Habitat</u>. In the mainstem San Lorenzo River downstream of the Boulder Creek confluence, many steelhead require only one summer of residence before reaching smolt size. Except in streams with high summer flow volumes (greater than .2 to .4 cfs per foot of stream width), steelhead require two summers of residence before reaching smolt size. This is the case for most

juveniles inhabiting tributaries of the San Lorenzo River. Juvenile steelhead are generally identified as young-of-the-year (first year) and yearlings (second year). The slow growth and often two-year residence time of most local juvenile steelhead indicate that the year class can be adversely affected by low streamflows or other problems during either of the two years of residence. Coho salmon, however, smolt after one year, despite their small size.

Growth of young-of-the-year steelhead and coho salmon appears to be regulated by available insect food, although cover (hiding areas, provided by undercut banks, large rocks which are not buried or "embedded" in finer substrate, surface turbulence etc.) and pool and riffle depth are also important in regulating juvenile numbers, especially for larger fish. During summer in the mainstem San Lorenzo River downstream of the Boulder Creek confluence, steelhead use primarily fast-water habitat where insect drift is the greatest. This habitat is found in deeper riffles, heads of pools and faster runs. Pool habitat and step-run habitat are the primary habitat for steelhead in summer in San Lorenzo tributaries and the upper San Lorenzo River above the Boulder Creek confluence because riffles and runs are very shallow, offering limited escape cover. Primary feeding habitat is at the heads of pools and in deeper pocket water of step-runs. The deeper the pools, the more value they have. Higher streamflow enhances food availability, surface turbulence and habitat depth, all factors in increasing steelhead densities and growth rates. Where they occur together, young steelhead use pools and faster water in riffles and runs/ step-runs, while coho salmon use primarily pools.

Densities of yearling steelhead are usually regulated by water depth and the amount of escape cover that exists during low-flow periods of the year (July-October). In most small coastal streams, availability of this "maintenance habitat" provided by depth and cover appears to determine the number of smolts produced by the smaller streams and tributaries. The abundance of food (aquatic insects and terrestrial insects that fall into the stream) and fast-water feeding positions for capture of drifting insects in "growth habitat" determines the size of these smolts. Aquatic insect production is maximized in unshaded, high gradient riffles dominated by relatively unembedded substrate larger than about 4 inches in diameter.

Yearling steelhead growth usually shows a large incremental increase during the period of March through June. Larger steelhead then smolt. But for those steelhead which stay a second summer, summer growth is very slight (or even negative in terms of weight) as flow reductions eliminate fast-water feeding areas and reduce insect production. A growth period may also occur in fall and early winter after leaf-drop of riparian trees, after increased streamflow from early storms, and before water temperatures decline to less than about 48 degrees Fahrenheit or water clarity becomes too turbid for feeding. The "growth habitat" provided by higher flows in spring and fall (or in summer for the mainstem River with higher flows) is very important, since ocean survival and rate of return as spawning adults increases exponentially with the smolt size.

Of the two size-class categories of juvenile steelhead captured during fall sampling, the smaller size class was those juveniles less than (<) 75 mm (3 inches) Standard Length (SL) because those would likely require another growing season before smolting. The larger size class included juveniles 75 mm SL or greater (=>) and constituted fish that are called "smolt size" because they will out-migrate the following spring. This size class may include fast growing young-of-the-year steelhead inhabiting the mainstem River or lower reaches of larger tributaries and yearlings and older fish inhabiting tributaries and the mainstem River.

<u>Overwintering Habitat</u>. Deeper pools, undercut banks, side channels, and especially large, unembedded rocks provide shelter for fish against the high winter flows. In some years, such as 1982, extreme floods may make overwintering habitat the critical factor in steelhead production. In most years, however, if the pools have sufficient larger boulders, large woody debris or undercut banks to provide summer rearing habitat, then these elements are sufficient to protect juvenile steelhead and coho salmon against winter flows.

Project Purpose and General Study Approach

The intent of the fall, 1999 fish sampling and habitat evaluation was to compare 1999 production of juvenile steelhead and rearing habitat conditions with those in 1981 and 1994-98 in the San Lorenzo River, a major river drainage flowing into the northern Monterey Bay. Steelhead density at each of 13 mainstem sampling sites and habitat proportions obtained from habitat typing were used to estimate juvenile production in 12 reaches of the River. Sampling also included 20 tributary sites representing 20 reaches of 9 tributaries of the San Lorenzo River. Densities determined by habitat type were combined with habitat proportion data by reach to estimate juvenile steelhead production in the mainstem River and its major tributaries. An estimate of an index of adults returning to the system was extrapolated from mainstem and tributary juvenile steelhead production by use of a model based on survival rates of three juvenile size classes.

Habitat conditions were assessed from estimates of streamflow, escape cover, channel width, water depth, streambed substrate composition, substrate embeddedness and tree canopy.

METHODOLOGY

FISH POPULATION MONITORING- METHODS

Study Area

The mainstem was divided into 12 reaches, based on past survey work (**Table 1a; Appendix A, Figure 2**). Much of the San Lorenzo River was surveyed during a past water development feasibility study in which general geomorphic differences were observed (**Alley 1993**). This work involved survey and determination of reach boundaries in the mainstem and certain tributaries, including Kings and Newell creeks (**Tables 1a-b; Appendix A, Figure 2**). In past work for the San Lorenzo Valley Water District, Zayante and Bean creeks were surveyed and divided into reaches (**Table 1b; Appendix A, Figure 2**). Previous work for the Scotts Valley Water District required survey of Carbonera Creek and determination of reaches (**Table 1b; Appendix A, Figure 2**).

In each drainage, the uppermost extent of steelhead was estimated. For the upper San Lorenzo River, Bear and Boulder creeks, topographic maps were used with attention to change in gradient and tributary confluences to designate reach boundaries (**Table 1b; Appendix A, Figure 2**). The uppermost reach boundaries for Bean and Bear creeks were based on a steep gradient change seen on the topographic map, indicative to passage problems. Known barriers set the upper reach boundaries in Carbonera, Fall, Newell, Boulder and Kings creeks. The extent of perennial stream channel in most years was the basis for setting boundaries on Branciforte and Zayante creeks.

In 1999, habitats in the mainstem were in the vicinity of habitats used in 1998, and in some cases were the same habitats. Habitats were chosen for being representative. More pool habitat was censused by underwater observation in the mainstem River in 1999. Most pools were too deep to electrofish in Reaches 1-9, downstream of the Boulder Creek confluence. More shallow pools were electrofished in Reaches 1, 6 and 7, along with snorkel-censusing.

Branciforte, Carbonera, Zayante, Bean, Fall, Newell, Boulder and Kings creeks were the major tributaries sampled in the San Lorenzo River drainage. Refer to **Table 1c, Appendix A; Figure 2 and page 2** for a list sampling sites and locations. Steelhead inhabit other tributaries, but these are the important ones that provide a conservative estimate of juvenile population size and annual trends in juvenile numbers and habitat changes. Other tributaries known to contain steelhead from past sampling and observation include (from lower to upper watershed) Eagle Creek in Henry Cowell State Park, Lockhart Gulch, Lompico Creek, Mountain Charlie Gulch in the upper Zayante Creek drainage, Love Creek, Clear Creek, Two Bar Creek and Jamison Creek. Other creeks likely to provide steelhead access and perennial habitat include Glen Canyon and Granite creeks in the Branciforte system, Powder Mill Creek, Gold Gulch and two small tributaries to Bean Creek- Ruins and Mackenzie creeks. This list is not exhaustive for steelhead. Resident rainbow trout undoubtedly exist upstream of steelhead migrational barriers in some creeks.

Sampling sites were representative of their reaches in regard to depth, length and escape cover. In previously sampled reaches, 1999 sampling sites were chosen in the vicinity of previous sites. In some cases, the same habitats were sampled in 1999 as in 1998. After habitat-typing was completed in 1999, different electrofishing sites were chosen than in 1998 within mainstem Reach 6, mainstem Reach 10, mainstem Reach 12 (#12b) at Waterman Gap, Reach 1 of Newell Creek (#16), Reach 2 of Boulder (#17b) and Branciforte creeks (#21b), Reach 3 of Bean Creek (#14c) and Reach 4 of Zayante Creek (#13d).

In 1998 and 1999, more stream channel was censused at Sites 1-3 and 6-9 than in 1997, primarily due to the necessity to visually census pool habitat that was too deep for electrofishing. All habitat that could be effectively electrofished was censused by electrofishing. However, the pool that had been electrofished at Site 1 (Reach 1-Paradise Park) in 1997 had to be snorkeled in 1998 due to increased depth. A more shallow pool was also electrofished at Site 1. At Site 2 (Reach 2-Rincon), the pool that had been electrofished in 1997 had deepened in 1998 and had to be snorkeled in following years.

Table 1a. Defined Reaches on the Mainstem San Lorenzo River. (Refer to Appendix A for map designations.)

Reach #	Reach Boundaries	Reach Length (ft)
1	Highway 1 to Buckeye Trail Crossing CM1.92 - CM4.73	14,837
2	Buckeye Trail Crossing to the Upper End of the Wide Channel Representation on the Felton USGS Quad Map CM4.73 - CM6.42	8,923
3	From Beginning of Narrow Channel Representation in the Gorge to the Beginning of the Gorge (below the Eagle Creek Confluence) CM6.42 - CM7.50	5,702
4	From the Beginning of the Gorge to Felton Diversion Dam CM7.50 - CM9.12	8,554
5	Felton Diversion Dam to Zayante Creek Confluence CM9.12 - CM9.50	2,026
6	Zayante Creek Confluence to Newell Creek Confluence CM9.50 - CM12.88	17,846
7	Newell Creek Confluence to Bend North of Ben Lomond CM12.88 - CM14.54	8,765
8	Bend North of Ben Lomond to Clear Creek Confluence in Brookdale CM14.54 - CM16.27	9,138
9	Clear Creek Confluence to Boulder Creek Confluence CM16.27 - CM18.38	11,137
10	Boulder Creek Confluence to Kings Creek Confluence CM18.38 - CM20.88	13,200
11	Kings Creek Confluence to San Lorenzo Park Bridge Crossing CM20.88 - CM24.23	17,688
12	San Lorenzo Park Bridge to Gradient Change, North of Waterman Gap CM24.23 - CM26.73	13,200
	TOTAL	**131,016 (24.8 miles)**

Table 1b. Defined Reaches For Sampled Tributaries of the San Lorenzo River. (Appendix A provides map designations.)

Creek-Reach #	Reach Boundaries (Downstream to Upstream)	Reach Length (ft)
Zayante 13a	San Lorenzo River Confluence to Bean Creek Confluence CM0.0-CM0.61	3,221
13b	Bean Creek Confluence to Tributary Transporting Sediment from Santa Cruz Aggregate CM0.61-CM2.44	9,662
13c	Santa Cruz Aggregate Tributary to Lompico Creek Confluence CM2.44-CM3.09	3,432
13d	Lompico Creek Confluence to Mt. Charlie Creek Confluence CM3.09-CM5.72	13,886
Bean 14a	Zayante Creek Confluence to Mt. Hermon Road Overpass CM0.0-CM1.27	6,706
14b	Mt. Hermon Road Overpass to Ruins Creek Confluence CM1.27-CM2.15	4,646
14c	Ruins Creek Confluence to Gradient Change Above the Second Glenwood Road Crossing CM2.15-CM5.45 (with 0.33 miles dewatered)	17,424
Fall 15	San Lorenzo River Confluence to Boulder Falls CM0.0-CM1.58	8,342
Newell 16	San Lorenzo River Confluence to Bedrock Falls CM0.0-CM1.04	5,491
Boulder 17a	San Lorenzo River Confluence to Foreman Creek Confluence CM0.0-CM0.85	4,488
17b	Foreman Creek Confluence to Narrowing of Gorge Adjacent Forest Springs CM0.85-CM2.0	6,072
17c	Narrow Gorge to Bedrock Chute At Kings Highway Junction with Big Basin Way CM2.0-CM3.46	7,709

Table 1b. (cont'd) **Defined Reaches For Sampled Tributaries of the San Lorenzo River. (Appendix A provides map designations.)**

Bear 18a	San Lorenzo River Confluence to Unnamed Tributary at Narrowing of the Canyon Above Bear Creek Country Club CM0.0-CM2.42	12,778
18b	Narrowing of the Canyon to the Deer Creek Confluence CM2.42-CM4.69	11,986
Kings 19a	San Lorenzo River Confluence to Unnamed Tributary at Fragmented Dam Abutment CM0.0-CM2.04	10,771
19b	Fragmented Dam to Bedrock-Boulder Cascade CM2.04-CM3.73	8,923
Carbonera 20a	Branciforte Creek Confluence to Old Road Crossing and Gradient Increase CM0.0-CM1.38	7,293
20b	Old Road Crossing to Moose Lodge Falls CM1.38-CM3.39	10,635
Branciforte 21a	Carbonera Creek Confluence to Granite Creek Confluence CM1.12-CM3.04	10,138
21b	Granite Creek Confluence to Tie Gulch Confluence CM3.04-CM5.73	14,203
	TOTAL	**177,806 (33.7 miles)**

Table 1c. **Sampling Sites Used to Estimate Densities of Steelhead by Reach on the Mainstem San Lorenzo River and Tributaries in 1999.**

Reach #	Sampling Site # -Channel Mile	Location of Sampling Sites
		SAN LORENZO MAINSTEM SITES
1	1 -CM3.8	Paradise Park
2	2 -CM5.7	Lower Gorge at Rincon Trail Access
3	3 -CM7.4	Upper End of the Gorge
4	4 -CM8.9	Downstream of the Park Entrance Bridge
5	5 -CM9.3	Downstream of Zayante Creek Confluence
6	6 -CM10.4	Below Fall Creek Confluence
7	7 -CM13.8	Lower Highway 9 Crossing in Ben Lomond
8	8 -CM15.9	Upstream of the Larkspur Road (Brookdale)
9	9 -CM18.0	Downstream of Boulder Creek Confluence
10	10 -CM20.7	Below Kings Creek Confluence
11	11 -CM22.3	Downstream of Teilh Road, Riverside Grove
12	12a-CM24.7	Downstream of Waterman Gap and Highway 9
	12b-CM25.4	Waterman Gap Upstream of Highway 9
		TRIBUTARY SITES
13a	13a-CM0.3	Zayante Creek Upstream of Conference Drive Bridge
13b	13b-CM1.6	Zayante Creek Above First Zayante Rd Xing
13c	13c-CM2.8	Zayante Creek downstream of Zayante School Road Intersection with E. Zayante Road
13d	13d-CM4.1	Zayante Creek upstream of Third Bridge Crossing of E. Zayante Road After Lompico Creek Confluence
14a	14a-CM0.1	Bean Creek Upstream of Zayante Creek Confluence
14b	14b-CM1.8	Bean Creek Below Lockhart Gulch Road

Table 1c. (Cont'd) **Sampling Sites Used to Estimate Densities of Steelhead by Reach on the Mainstem San Lorenzo River and Tributaries, 1998.**

TRIBUTARY SITES (cont'd)

Reach #	Sampling Site # -Channel Mile	Location of Sampling Sites
14c	14c-CM4.5	Bean Creek 1/3-mile Above Mackenzie Creek Confluence and Below Golpher Gulch Rd.
15	15 -CM0.8	Fall Creek, Above and Below Wooden Bridge
16	16 -CM0.5	Newell Creek, Upstream of Glen Arbor Road Bridge
17a	17a-CM0.2	Boulder Creek Just Upstream of Highway 9
17b	17b-CM1.6	Boulder Creek Below Bracken Brae Creek Confluence
17c	17c-CM2.6	Boulder Creek, Downstream of Jamison Creek
18a	18a-CM1.5	Bear Creek, Downstream of Hopkins Gulch
18b	18b-CM4.2	Bear Creek, Downstream of Bear Creek Road Bridge and Deer Creek Confluence
19a	19a-CM0.8	Kings Creek, Upstream of First Kings Creek Road Bridge
19b	19b-CM2.5	Kings Creek, 0.2 miles Above Boy Scout Camp and upstream of Second Kings Creek Road Bridge
20a	20a-CM0.7	Carbonera Creek, Upstream of Health Services Complex
20b	20b-CM1.9	Downstream of Buelah Park Trail
21a	21a-CM2.8	Branciforte Creek, Downstream of Granite Creek Confluence
21b	21b-CM4.6	Upstream of Granite Creek Confluence and Happy Valley School

In 1999, four additional representative pools were snorkeled and censused. At Site 3 (Reach 3-Upper Gorge) in 1998 and 1999, three representative pools were snorkel-censused. The streamchannel had changed course at Site 4 (Reach 4-below Henry Cowell Bridge) in 1998, and a large sycamore had fallen into the channel to scour a new pool. This newly formed pool was electrofished in 1998 but had to be snorkel-censused in 1999. Site 5 (Reach 5-below Zayante Creek) was added in 1998 and continued in 1999. At Site 6 (Reach 6-near Fall Creek), one of the two pools that was electrofished in 1997 had to be snorkeled in 1998 and 1999 due to increased depth. At Site 7 (Reach 7-Ben Lomond) only the 1997 riffle habitat was sampled again in 1998. The pools chosen for electrofishing and visual censusing were different from past years and more representative. The same habitats were censused in 1999. At Site 8 (Reach 8-Brookdale), the pool that had been electrofished in 1997 was too deep in 1998 and 1999, and a deeper, longer, more representative pool was visually censused instead. At Site 9 (Reach 9-below Boulder Creek), the pool that had been electrofished in 1997 had become combined with a longer pool and was too deep to electrofish in 1998 and 1999. Two pools were snorkel-censused downstream in 1999.

Consistency of Data Collection Techniques in 1994-99

There was consistency in methods used to assess habitat parameters at the monitoring sites between 1981 and 1994-99. Donald Alley, the principal investigator and data collector in 1994-99, had also collected the fish and habitat data at 9 of the 18 San Lorenzo River sites and 5 of the 8 tributary sites in the 1981 study during the data collection for the County Water Master Plan (Smith 1982). His qualitative estimates of embeddedness, streambed composition and habitat types were calibrated to be consistent with those of Dr. Smith, the primary investigator for the 1981 sampling program. Mr. Alley's method of measuring escape cover for yearling-sized and larger steelhead was consistent through the years. However, escape cover was measured by an additional biologist in 6 tributary reaches in 1999. His observations were insufficiently calibrated to Alley's to be included in the habitat analysis. This affected annual comparisons of lower Branciforte, lower Carbonera, Newell, Fall, lower Kings and lower Bear creeks. Regarding electrofishing, in 1995 a block net was used at the lower end of each habitat at only Site 2 in the Gorge. In 1994-95, block nets were not used for the sake of consistency with 1981 techniques. In 1996-99, block nets were used to partition off habitats at all sites. This prevented steelhead escapement during electrofishing. A multiple pass method was used in each habitat with at least three passes.

In 1998 and 1999, underwater visual (snorkel) censusing was incorporated with electrofishing so that pool habitat in the mainstem River, which had been electrofished in past years, could still be censused in 1998-99 even though it was too deep for backpack electrofishing. Snorkel censusing was also used to obtain density estimates in deeper pools previously unsampled at Sites 2, 3, 7, 8 and 9, in an effort to increase the accuracy of production estimates. A more realistic juvenile production estimate and predictions of adult returns was made with snorkel-censusing of pool habitat in the mainstem River.

Juvenile Steelhead Densities at Sampling Sites - Methods

Electrofishing was used to determine densities according to two juvenile age classes and three size classes in all stream reaches in 1997 and most stream reaches in 1998 and 1999, including those upstream of Boulder Creek in the mainstem and all tributary reaches. For 7 mainstem reaches included in **Table 2**, underwater censusing of deeper pools was incorporated into density estimates with electrofishing data from more shallow habitats.

Estimation of juvenile steelhead densities by site was based on either the 2- (**Knable 1978**) or 3-pass depletion method of capture by electrofishing in 1994-95 and the 3-pass method in 1996-99. Block nets were used at all sites in 1996-99. The 13 mainstem sites electrofished in 1999 averaged 221 feet per site, totaling 2,873 linear feet sampled. This consisted of 2.2% of the estimated, mainstem steelhead habitat. Eighteen deep pools were censused by underwater observation, totaling 5,569 linear feet and consisting of 4.3% of the estimated mainstem habitat (**Table 2**. Therefore, a combined 6.5% of the mainstem was censused.

Snorkeling was used to visually census juvenile steelhead by underwater observation in pool habitat in the lower and middle, mainstem River (Reaches 1-4; 6-9). This method was used in deeper pools and their associated glides that could not be electrofished. Fish densities determined by snorkeling were used to represent deep pool habitat and their associated glides.

In larger rivers of northern California, density estimates from electrofishing are commonly combined with those determined by underwater observation in habitats too deep for electrofishing. Ideally, underwater censusing would be calibrated to electrofishing data in habitat where capture approached 100%. Calibration was originally attempted by Hankin and Reeves for small trout streams (1988). Their intent was to substitute snorkel censusing for electrofishing. However, attempts at calibration of the two methods of censusing in large, deep pools of the mainstem San Lorenzo River was judged impractical, beyond the scope of the study and probably would be inadequate.

In our judgment based on experience with electrofishing from a boat, the deep pools where visual censusing was used could not be effectively electrofished in most reaches. There would be no assurance that counts obtained by electrofishing would be more accurate than visual counts. Even with crews of 10 people or more and motor-powered rafts equipped with special electrofishing devices, electrofishing would probably not be more than 80 percent successful in capturing all of the steelhead in pools that were hundreds of feet long and 50-100 feet wide. Factors to consider in such a calibration attempt were the difficulty of hauling rafts or barges into sampling sites, the danger of operating electrofishing devices on small flotation devices and the excessive cost of labor and equipment necessary to sample deep pools in the San Lorenzo River by electrofishing. Electrofishing from the streambank would have been futile with pool widths of 30 to 100 feet and maximum water depths commonly 8 feet or greater. In conclusion, underwater snorkeling was the only practical way to census pool habitat in the lower and middle San Lorenzo River in 1998, and it yielded realistic density estimates in deeper pool habitat. The principle investigator in this study was a pioneer in underwater snorkel censusing of the 1970's, having developed the original methodology. He has more than 2,000 hours of experience in underwater observations and censusing of Sierran stream fishes, including juvenile steelhead/rainbow trout and chinook salmon.

Two divers were used in snorkel censusing. In wide pools, divers divided the channel longitudinally into counting lanes, combining their totals after traversing the habitat in an upstream direction. Divers would warn each other of juveniles being displaced into the other's counting lane to prevent double-counting. For juveniles near the boundaries of adjacent counting lanes, divers would verbally agree to who would include them in their tallies. In narrower pools, divers would alternate passes through the pool to obtain replicates to be averaged. In most pools, three replicate passes were accomplished per pool. The average number of steelhead observed per pass in each age and size category became the density estimate. Visual censusing of deeper pools occurred after electrofishing of the sites. The relative proportions of steelhead in the three Size Classes obtained from electrofishing were considered in dividing visually censused steelhead into size and age classes. In Reaches 1-7, most juveniles were greater than 75 mm SL, and yearlings were considerably larger than Y-O-Y fish. Therefore, it was relatively easy to separate fish into size and age classes. In Reaches 8 and 9, more juveniles were approximately 75 mm SL, leading to a small error for some individuals in deciding size class division between Classes 1 and 2. However, there was no difficulty in distinguishing age classes.

Visual censusing in pools offered realistic density estimates of steelhead in deeper mainstem pools in 1998 and 1999. Very few steelhead used these pools in 1999. It was the only practical way to inventory such pools, which were mostly bedrock- or boulder-scoured and having limited escape cover. Visibility was 15 feet or more, making the streambed and counting lanes observable.

Steelhead numbers were visually censused for two size classes of pools. They were short pools less than approximately 200 feet in length and those more than approximately 200 feet. Juvenile densities of censused pools were extrapolated to other pools in their respective size categories. Steelhead were censused by size and age class, as in electrofishing. The number of steelhead for each size/age class counted per underwater pass of the habitat was averaged to estimate density for each pool and glide censused in this manner. However, in 1999 the steelhead densities in some pools were so low that on some passes the one or two juvenile steelhead present were not seen on every pass. In these cases, the highest number per pass was used to estimate density.

Table 2. Number of Pools and Associated Glides Censused in Linear Feet per Reach by Underwater Snorkeling Versus Electrofishing in the Mainstem River, 1999.

Reach #	# of Pools Snorkeled	Linear Feet Snorkeled	# of Pools Electrofished	Linear Feet Electrofished
Lower River				
1	2	445	1	114
2	5	1,436	0	0
3	3	347	0	0
4	2	556	0	0
5	0	0	0	0
Middle River				
6	2	1,067	1	110
7	1	928	1	175
8	1	322	0	0
9	2	468	0	0
Upper River				
10	0	0	1	252
11	0	0	2	188
12	0	0	4	162
Total	18	5,569	10	1,001

The same 9 tributaries were sampled in 1999 as in 1998. The tributaries were Branciforte, Carbonera, Zayante, Bean, Fall, Newell, Boulder, Bear and Kings. The sampling effort included 20 tributary sites with one site per reach in stream channel likely to be inhabited by steelhead in most years. The 20 sites averaged 212 feet per site, totaling 4,239 feet and 2.4% of the 33.3 miles of estimated habitat in the nine tributaries.

Age and Size Class Divisions

With electrofishing data, the young-of-the-year age class was separated from the yearling and older age class in each habitat, based on the site specific break in the length-frequency distribution (histogram) of fish lengths lumped into 5 mm groupings. Density estimates of age classes in each habitat type were determined by the standard depletion model used with multiple pass capture data.

Depletion estimates of juvenile steelhead density were also applied separately to two size categories in each habitat type at each site for all years of data. The numbers of fish in Size Classes 1 and the combined Classes 2 and 3 were recorded for each pass. The size class boundary between Size Classes 1 and 2 was 75 mm SL (3 inches) because fish smaller than this would probably spend another spring, summer and fall in the stream before smolting and entering the ocean the following winter and spring. Fish larger than 75 mm SL would probably migrate downstream and smolt during spring to enter the ocean. The depletion method estimated the number of fish in the habitat type in two categories; those less than (<) 75 mm SL (3 inches) (Class 1) and those equal to or greater than, (=>) 75 mm SL (Classes 2 and 3).

Next, the number of => 75 mm SL sized steelhead (Class 2) was estimated separately from the => 150 mm SL sized fish (Class 3) in each habitat type sampled. The proportion of each size class was determined in the fish captured. These proportions of fish captured were multiplied by the estimate of fish density for all fish greater than 75 mm SL to obtain estimates of numbers of Class 2 and Class 3 steelhead. These larger size classes were entered separately into the Dettman population model (Kelley and Dettman 1987) to predict returning adults.

In the lower mainstem San Lorenzo River, many young-of-the-year steelhead reached the Size Class 2 in just one growing season, as did some in tributaries during 1995-99. Sampling site densities were compared for the last four years by size class and age class. At each sampling site, habitat types were sampled separately and fish numbers were combined and divided by the stream length of the site for annual comparisons. Size Classes 2 and 3 were combined for annual comparisons.

Juvenile Densities Determined by Reach in the Mainstem San Lorenzo River and Tributaries- Methods

For comparison in 1995-96, it was assumed that sampled habitat types were representative of habitat found in the defined reaches and were in the same proportions at the site as existed in the reach. In 1997-99, habitats were chosen as representative, based on their depth and amount of escape cover, compared to segment averages derived from habitat-typing.

The sampling design for 1996 and before was intended to assess trends in juvenile steelhead numbers by comparing monitoring site densities to previous years. This was done by sampling the same locations and habitat types originally sampled in 1981. Steelhead densities at each sampling site were extrapolated to reach numbers in the mainstem San Lorenzo River. The sampled habitat length was divided into the reach length. This quotient was then multiplied by the numbers of juveniles of each size class present in the sample site to obtain reach totals.

In the past, the simplifying assumption was that the proportion of habitat types sampled at sites was consistent with habitat proportions in the reach. This was not completely accurate. In 1997-99, accuracy of measuring juvenile steelhead production was increased at the expense of making close comparisons with previous years' sampling results. In 1998 and 1999, accuracy was increased by adding a sampling site in Reach 5.

In 1997-99, habitat-typing in the mainstem River improved our estimate of habitat proportions by reach for more accurate fish population estimates. Approximately 1/2 mile or more of stream was habitat-typed in the vicinity of each sampling site on the mainstem River. In 1998 and 1999, tributaries were divided into reaches with 1/2-mile segments surveyed in each so that representative habitats were sampled within each 1/2-mile segment, based on depth and escape cover considerations.

The proportion of habitat types within each 1/2-mile segments represented habitat proportions for the entire reach. Fish densities by size class and age class determined in each electrofished and visually censused (in 1998-99) habitat type were multiplied by the number of feet of that habitat type estimated for the reach. Then the number of fish estimated in each habitat type was added to those in other habitat types for reach totals. In Reach 6 in 1997, long quiet glides without cover or water velocity sufficient for steelhead feeding were present at the tails of pools. Therefore, steelhead were assumed to be absent in this habitat type, which made up an estimated 21.6% of the reach. In 1998 and 1999, the long glides associated with pools in Reach 6 were included as long pool habitat, and steelhead densities determined in long pools in Reach 7 were used for this similar habitat in Reach 6 in 1998. In 1999, a long pool in Reach 6 was snorkel-censused.

So that 1997-99 juvenile densities by reach and mainstem production could be compared to 1996 results, 1997 habitat proportions were applied to 1996 densities in habitat types sampled in each reach. Thus, a revised estimate of 1996 juvenile production was obtained in the mainstem River.

In 1998 and 1999, habitat-typing in 9 tributaries allowed estimation of tributary steelhead densities by reach. Reach densities were extrapolated from steelhead densities by habitat type at representative sampling sites, coupled with habitat proportions within reaches.

Density of Returning Adult Steelhead Resulting from Natural Production of Juveniles - Methods

For purposes of comparison between 1995-99, the predicted index of the number of returning adults was determined for the mainstem River from estimates of juvenile densities. This would indicate the trend in adult steelhead populations resulting from natural smolt production. The predicted number of adults returning from tributary juvenile production was also determined in 1998 and 1999, allowing comparisons of the indices in tributaries and overall for tributaries and the mainstem. Steelhead survival in the ocean also affects returning numbers and will be discussed later. Production of adults from hatchery plantings was not accurately available and excluded in estimating the adult index.

The index of predicted adult returns was based on survival rate of different juvenile age/size classes returning as adults to Waddell Creek during the period, 1933-42 (**Shapovalov and Taft 1954**). It was found that steelhead survival rate to spawning adults increased exponentially with increasing size of steelhead smolts (**J. Smith, personal communication**). Dave Dettman (**Kelley and Dettman 1987**) developed a model based on the Waddell Creek relationship of average size of each age class as smolts and survival to returning adult. He estimated survival of juveniles from a reasonable estimate of densities in Waddell Creek in the fall to the down-migrant smolt stage for the different age classes. The Waddell Creek relationship was:

$$\text{Fraction of Survival} = (0.067)e^{(0.025)(\text{Fork length of smolt})}$$

The Dettman model required an estimate of juvenile steelhead densities by age class in the fall of the year. The size classes were divided according to year class sizes typically found in Waddell Creek, based on Dr. Jerry Smith's experience. Young-of-the-year fish were up to 75 mm Standard Length. Yearlings were from 75 mm to 150 mm Standard Length. Steelhead were included in the 2+ age class if larger than 150 mm Standard Length. Fork Length equals 1.1 times the Standard Length.

Number of juvenile steelhead by age/size class per foot of each habitat type in each reach was inputted to the Dettman model to predict number of returning adults, using the Waddell Creek rate of return in the 1933-42 period. Returning adults consisted of two categories. One was first time spawners. The other was the total number of returning adults expected with a 20% repeat spawning rate. The model emphasized the increased survival rate expected for larger size classes of juvenile steelhead.

To make a more realistic estimate of returning adults from juveniles present, the estimates derived from the Dettman model were reduced by 50%, based on an estimate of returning adult steelhead to Waddell Creek in 1991-92 (Smith 1992). Smith estimated that roughly 248 adults returned to spawn, based on his trapping of up-migrating adult steelhead, tagging, sampling upstream of the trap for recaptures, and trapping down migrants for recaptures. This estimate was approximately half of the average return of 432 adults during the Shapovalov and Taft study (1933-42) (1954). An assumption was that the reduction in returns in 1992 resulted from reduced ocean survival. Another underlying assumption in the 50% reduction factor was that rearing habitat in Waddell Creek is currently capable of producing 1930's levels of juvenile smolts over the long term. This was judged likely by Dr. Smith (personal communication).

Smith noted that adults returning to Waddell Creek in 1991-92 came from juvenile production in 1989-91, at the end of a five-year drought. Further, additional streamflow reduction and habitat degradation came from summer water diversion that did not exist in the 1930's. Therefore, juvenile production leading to adults in 1991-92 was probably much less than the average juvenile production in the 1930's. Therefore, the average return estimate of 432 adults in the 1930's may be higher than expected from juveniles produced in drought years of the 1930's. Limited supporting evidence is that the first recorded water year on the San Lorenzo River (record beginning in 1937) that produced similar acre-feet of streamflow as the drought years of 1987-92 was water year 1938-39. The adult return checked through the upstream trap on Waddell Creek in 1941-42 from primarily juveniles produced in the 1938-39 water year was 377 adults.

The range of estimates of adult returns during the earlier study was 373-539 adults. A less conservative reduction factor in terms of preventing an overestimate of adult returns, but perhaps more realistic one, may be 0.33 (1 - 248/373) or 33% instead of 50%, using the ratio of Smith's estimated adult return divided by the lowest estimated adult return during the 1932-42 period. However, 0.33 may be too small a reduction factor because during drought in 1989-90, there was surface water diversion to reduce juvenile production that was absent during drought in the 1930's.

The model provides an annual adult index for comparison, regardless of whether the reduction factor should be 50% or 33% or something else. It is important to note that our annually applied model uses the same constant survival rates of juveniles to adults, and our correction factor is also constant. However, in reality there are annual fluctuations in ocean survival that are impossible to account for. In addition, sea lions and harbor seals congregate at the mouth of the San Lorenzo River which may increase the mortality of steelhead adults entering the River compared to Waddell Creek, particularly in drier years.

The aforementioned method of estimating returning adult steelhead was more practical than trying to capture down-migrant smolts. Estimates of adult numbers from smolt numbers captured by down-migrant smolt trapping would be prohibitively expensive and inefficient because down-migrant smolt trapping would require nightly trapping activities over a period of at least two months in the spring. Smolt trapping would be very inefficient during stormflows when down-migration would increase. Unless a very permanent trapping facility was constructed, the fish trap would be very ineffective during storm events. Down-migrant adult trapping to estimate numbers of kelts returning to the ocean after spawning would not accurately indicate numbers of adult spawners because many adults do not survive to down-migrate after spawning. Trapping of down-migrant adults would require the same expensive, intensive effort required for down-migrant smolt trapping, with the associated ineffectiveness during stormflows. An added negative aspect would be potentially high fish mortality unless the trap was emptied through the night, every night.

In recent years, the Monterey Bay Salmon and Trout Project has operated a trap for spawning adults at the inflatable Felton Diversion Dam, in cooperation with the City of Santa Cruz. Adults that use the fish ladder may be trapped there. In drier winters without major storm events and high baseflows, the trap may capture a major portion of the adults passing that point. However, the City is required to deflate the dam every few days. In wetter years and during major flood flows the trap is less effective because the adults bypass the fish ladder. An index of adult returns could be estimated from trapping data, based on the number of days the trap was operated and the number of days of likely upstream migration for each year. The assumption would be that trapping rate on the days that the trap was operational was similar to the migration rate on days that the trap was not working. This may be only partially accurate.

HABITAT ASSESSMENT- METHODS

Classification of Habitat Types and Measurement of Habitat Characteristics

Approximately 1/2-mile or more of stream was surveyed and habitat-typed in the vicinity of each sampling site on the mainstem River and tributaries. The proportion of habitat types in the surveyed sections was used to extrapolate to the habitat proportions for the entire reach. Habitat comparisons were made between 1997, 1998 and 1999 in mainstem reaches at electrofished sites and in 1/2-mile, habitat-typed segments within reaches. Tributary results were compared between 1998 and 1999. A total of 43,757 feet (8.3 miles) were habitat-typed in August and September, 1999, in the same 13 reach-segments examined in 1998. In 1999, an additional segment was added between the Water Street Bridge where the lagoon ended and the Tait Street Diversion structure on the mainstem. Some 7,842 feet of habitat was found in this 1-mile segment having considerable split-channels.

A total of 55,409 feet (10.5 miles) were habitat-typed in 21 reach-segments of tributaries to assess habitat conditions. An additional segment was added on Branciforte Creek between the Carbonera and Glen Canyon creek confluences, thus, dividing the former Reach 21a into two reaches. Tributaries were divided into reaches with approximately 1/2-mile segments habitat-typed in each. Tributary sampling sites were compared between years where the same or similar habitats were sampled. Then conditions in tributary reaches were compared between 1998 and 1999.

Habitat types were classified according to the categories outlined in the California Salmonid Stream Habitat Restoration Manual (Flosi and Reynolds 1998). A modified CDFG Level III habitat inventory method was used. Some habitat characteristics were estimated according to the manual's guidelines, including length, width, mean depth, maximum depth, shelter rating and tree canopy (tributaries only in 1998). More data were collected for escape cover than required by the manual, however.

Measurement of Habitat Parameters - Methods

Substrate composition and embeddedness were qualitatively estimated in each habitat type at each fish sampling site in 1994-97 and in each habitat type of surveyed reach segments in 1997. In 1998 and 1999, only percent fines (sand and silt) was estimated in habitat types. In 1999, embeddedness was estimated as the percent that cobbles and boulders larger than 150 mm (6 inches) in diameter were buried in finer substrate. Data collection was not biased by review of previous years' data before the latest data collection. Cobbles and boulders larger than approximately 150 mm in diameter provided good, heterogeneous habitat for aquatic insects in riffles and runs if embedded less than 25%. Cobbles and boulders larger than 225 mm provided potential fish cover if embedded less than 25%.

Quantitative estimates of tree canopy closure were made in 1994-98, using a densiometer, but not in 1999 because riparian canopy was deemed similar to the previous year. No major storm flows had eliminated riparian vegetation over the winter. Included in the tree canopy closure measurement in past years were trees growing on slopes considerable distance from the stream. The tree canopy estimates were based on the canopy closure provided by the trees on the day of the measurements, which was probably between 5 and 15% lower than summer conditions because leaf drop had begun by the time of fall sampling. The difference between October conditions and summer conditions depended on the percent of the tree canopy that was deciduous versus evergreen. The percent deciduous value was based on visual estimates of the relative proportion of deciduous canopy closure provided to the stream channel. Tree canopy closure directly determines the amount of solar radiation that reaches the stream on any date of the year, but the relationship changes as the sun angle changes through the seasons. Our measure of canopy closure estimated the percent of blue sky blocked by the vegetative canopy and was not affected by the sun angle.

Greater tree canopy inhibits warming of the water and is critically important in small tributaries. Increased water temperature increases the metabolic rate and food requirements of steelhead. Tree canopy in the range of 75-90% is optimal in the upper River (Reaches 10-12) and tributaries, where low summer baseflow allows rapid water temperature increases if shade is insufficient. In the San Lorenzo River system, it is important that the tributaries remain well shaded so that tributary inflows to the mainstem are sufficiently cool to prevent excessively high water temperatures in the lower mainstem River (Reaches 1-5), where tree canopy is often in the 50-75% range. There is an inverse relationship between tree canopy and insect production in riffles, which allows faster steelhead growth in larger, mainstem reaches of the San Lorenzo River having deeper, fast-water feeding areas, despite the elevated temperatures and steelhead metabolic rate (and associated food requirements.) However, as fast-water feeding areas diminish in smaller stream channels with less streamflow further up the watershed, high water temperatures may increase steelhead food demands beyond the benefits of greater food production in habitat lacking in fast-water feeding areas. Here is where shade canopy must increase to maintain cooler water temperature and lowered metabolic rate and food requirements of juvenile steelhead.

The escape cover index for each habitat type within sampled sites was quantitatively determined in the same manner in 1994-98. The importance of escape cover is that the more there is in a habitat, the higher the production of steelhead, particularly for steelhead => 75 mm SL. Water depth itself provides good escape cover when it is 3 feet deep (1 meter) or greater.

At sampling sites, escape cover was measured as the ratio of the linear distance under submerged objects within the habitat type that fish at least 75 mm (3 inches) Standard Length (SL) could hide under, divided by the perimeter distance of the habitat type. Reach averages for escape cover were determined from habitat-typed segments. For reach segments, escape cover was calculated differently than had been done at sampling sites. Cover in reach segments was determined as linear feet of cover under submerged objects per foot of stream channel for each habitat type. Objects of cover included unembedded boulders, submerged woody debris, undercut banks and overhanging tree branches and vines that entered the water. Man-made objects, such as boulder rip-rap, concrete debris and plywood also provided cover. Escape cover constituted areas where fish could be completely hidden from view. This was not a measure of the less effective overhead cover that may be caused by surface turbulence or vegetation hanging over the water but not touching.

Water depth was important because deeper habitat was more utilized by steelhead. Deeper pools were associated with scour objects that often provided escape cover. Mean depth and maximum depth were determined with a dip net handle, graduated in half-foot increments for the first foot and foot increments for the remainder of the handle. Soundings throughout the habitat type were made to estimate mean and maximum depth. Minimum depth was determined approximately one foot from the stream margin in earlier years. Stream length in 1994-99 was measured with a hip chain. Width in each year, and length in 1981, were measured with the graduated dip net.

In 1994-97 in the tributary sites and mainstem sites above Boulder Creek, streamflow was estimated visually by measuring the stream cross-sectional area in portions of uniform velocity and estimating the channel velocity for the uniform portions of the cross-sections. For visual estimates, the channel velocity was estimated at several locations across the stream channel by measuring the speed of floating objects and multiplying that quantity by 0.6. The flow volume of all the portions of the cross-section were then added to obtain a streamflow estimate. Estimates were likely within +/- 10-20% of actual streamflow, based on experience. To prevent sampling bias, streamflow was estimated before earlier years' estimates were examined.

In 1998 and 1999, the Marsh McBirney Model 2000 flowmeter was more extensively used at most mainstem sites and many tributary sites. Mean column velocity was measured at 20 verticals or more at each cross-section. When streamflow was compared between years with only visual approximations and 1998 and 1999 streamflows measured by flowmeter, comparisons should be thought of as more qualitative than quantitative, and as only approximate.

RESULTS

HABITAT ASSESSMENT FOR MAINSTEM REACHES

Proportion of Habitat Types and Habitat Characteristics

Habitat proportions in mainstem reaches for 1998 and 1999 are graphed in **Figures 43b-c**. Tables 1a-c of reach and site descriptions are repeated on pages 141-145 before the Figures. The proportion of pool habitat increased in all reaches in 1999 except for Reaches 2 and 10-12. However, Reaches 10 and 12 included different surveyed segments between the years, making that the likely reason they differed from the general trend. The highest proportion of pool habitat in 1999 was in Reaches 7-10, ranging from more than 70% to more than 80%. Reaches 2, 3, 6, 11 and 12 were in the 50-60% pool range. Reaches 1, 4 and 5 ranged from near 30 to more than 45%. Riffle habitat, the most valuable feeding habitat and resulting cause of good feeding at the heads of pools, ranged between 5 and 25% in mainstem reaches in 1999, with the highest being in Reaches 2 and 3 (**Figure 43c**). The lower River (Reaches 1-4) had the highest occurrence of deep riffles that could support high fish densities, as did Reaches 6, 7, 8 and 9. Riffles in other reaches were too shallow and/or swift to support many juveniles. Reaches 4, 5 and 6 had relatively high proportions of slow runs and glides between 35 and 65%, with limited habitat value.

Results of survey work and habitat-typing are summarized for each mainstem reach in **Tables 3a-15**. Reach 0 above the lagoon was mostly long run habitat (54.7%) in 1999, with 24% long pool habitat primarily woody debris scoured, 12.7% relatively short riffle habitat and 8.6% long glide (**Table 3a**). Average pool depth was shallow at less than 1.5 feet, with runs rather deep with average depth of 0.8 feet and maximum depth of 1.6 feet. Riffles were relatively shallow and averaged 0.4 feet. Habitat width was mostly narrower than upstream Reaches 1 and 2, with narrower split channels.

Table 3a. Mainstem San Lorenzo River in Reach 0; Summary of Habitat Types and Habitat Characteristics, 1999, Located Between Water Street Bridge and Tait Street Diversion.

Habitat Type	Units Measured # 1999	Total Length ft 1999	Average Length ft 1999	Average Width ft 1999	Average Depth ft 1999	Average Maximum Depth 1999	% of Surveyed Portion 1999
PLP	1	193	193	63	1.3	5.4	2.5
LSR	2	589	295	28	1.2	2.3	7.5
LSL	4	1096	274	39	1.4	3.3	14.0
RUN	16	4291	268	23	0.8	1.6	54.7
GLD	3	676	225	35	0.6	1.2	8.6
LGR	15	997	67	19	0.4	0.9	12.7

Total Units Surveyed- 41

Total Length Surveyed- 7,842 ft. (Numerous split channels)

plunge pool (PLP), corner pool (CRP), lateral scour rootwad pool (LSR), glide (GLD), low gradient riffle (LGR).

Table 3b. Mainstem San Lorenzo River in Reach 1; Summary of Habitat Types and Habitat Characteristics, 1998 and 1999, Located in the Vicinity of Paradise Park.

Habitat Type	Units Measured # 1999	'98	Total Length ft 1999	'98	Average Length ft 1999	'98	Average Width ft 1999	'98	Average Depth ft 1999	'98	Average Maximum Depth 1999	'98	% of Surveyed Portion 1999	'98
MCP	0	1	0	85	0	85	0	60	0	2.0	0	2.6	0	2.4
LSR	1	3	100	698	100	233	22	57	1.9	2.3	2.9	3.0	12.6	19.3
LSBk	2	1	341	163	171	163	23	40	3.0	3.0	5.6	6.0	9.6	4.5
LSBo	1	1	109	117	109	117	57	50	2.1	2.7	3.2	3.6	3.1	3.2
CRP	1	0	336	0	336	0	45	0	2.1	0	3.1	0	9.5	0
Run&GLD	13	11	1337	1633	103	148	59	51	1.3	1.5	1.8	2.1	37.7	45.3
LGR	11	7	874	911	79	130	21	30	0.9	1.3	1.4	1.9	24.7	25.3

Total Units Surveyed- 30/ 20

Total Length Surveyed- 3,542/ 3,607 ft.

mid-channel pool (MCP), corner pool (CRP), lateral scour rootwad pool (LSR), lateral scour bedrock pool (LSBK), lateral scour boulder pool (LSBo), glide (GLD), low gradient riffle (LGR).

Table 4. Mainstem San Lorenzo River in Reach 2; Summary of Habitat Types and Habitat Characteristics, 1998 and 1999, Located in Lower San Lorenzo River Gorge Along the Rincon Trail.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth		% of Surveyed Portion	
	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98
MCP	1	1	235	229	235	229	40	53	2.8	2.5	4.0	4.5	6.8	6.9
LSBk	4	5	1307	1348	327	270	53	59	2.9	2.8	6.0	5.9	37.7	40.8
LSBo	1	1	120	140	120	140	45	50	3.0	2.8	5.0	5.0	3.4	4.2
LSL	1	0	82	0	82	0	25	0	2.2	0	3.5	0	2.4	0
Run&GLD	9	6	786	457	87	76	37	57	2.0	1.9	3.1	3.0	22.6	13.8
LGR	5	5	836	997	167	199	41	50	1.3	1.3	2.0	2.1	24.1	30.2
HGR	2	2	105	129	53	65	40	35	1.0	1.2	1.8	2.2	3.0	3.9

Total Units Surveyed- 23/ 20
Total Length Surveyed- 3,471/ 3,300 ft.

mid-channel pool (MCP), lateral scour bedrock pool (LSBK), lateral scour boulder pool (LSBo), lateral scour woody debris pool (LSL), glide (GLD), low gradient riffle (LGR), high gradient riffle (HGR).

Table 5. Mainstem San Lorenzo River in Reach 3; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, Located in Upper San Lorenzo River Gorge, Downstream of Eagle Creek.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth		% of Surveyed Portion	
	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98
LSBK	17	15	2012	1774	118	118	29	39	3.2	2.9	5.6	5.1+	49.5	46.9
RUN	11	8	1020	861	93	108	30	41	2.1	2.0	3.4	2.9	25.1	22.8
LGR	14	12	1030	1146	74	96	27	29	1.7	2.0	2.7	3.0	25.4	30.3

Total Units Surveyed- 42/ 35
Total Length Surveyed- 4,062/ 3,781 ft.

lateral scour bedrock pool (LSBK), low gradient riffle (LGR).

Table 6. Mainstem San Lorenzo River in Reach 4; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, Located in Upper Henry Cowell Park and Downstream of the Felton Diversion Dam.

Habitat Type	Units Measured # 1999	'98	Total Length ft 1999	'98	Average Length ft 1999	'98	Average Width ft 1999	'98	Average Depth ft 1999	'98	Average Maximum Depth 1999	'98	% of Surveyed Portion 1999	'98
LSR	2	3	422	531	211	177	40	44	2.6	2.7	5.0	4.7	10.1	12.7
LSL	3	2	1102	172	367	86	42	24	2.4	1.9	3.9	3.9	26.4	4.3
CRP	1	1	304	119	304	119	55	35	1.5	2.2	4.2	3.2	7.3	2.8
LSBk	1	0	128	0	128	0	70	0	2.5	0	4.0	0	3.1	0
RUN	9	9	1532	2326	170	258	39	43	1.5	1.7	2.4	2.7	36.7	55.6
LGR	7	7	689	789	98	113	30	35	0.7	1.1	1.2	1.7	16.5	18.8

Total Units Surveyed- 23/ 22

Total Length Surveyed- 4,177/ 4,185 ft.

lateral scour rootwad pool (LSR), lateral scour woody debris pool (LSL), corner pool (CRP), lateral scour bedrock pool (LSBk), low gradient riffle (LGR), step-run (SRN)

Table 7. Mainstem San Lorenzo River in Reach 5; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, Located Between the Zayante Creek Confluence and Felton Diversion Dam.

Habitat Type	Units Measured # 1999	'98	Total Length ft 1999	'98	Average Length ft 1999	'98	Average Width ft 1999	'98	Average Depth ft 1999	'98	Average Maximum Depth 1999	'98	% of Surveyed Portion 1999	'98
DPL	1	1	186	521	165	521	80	75	1.0	2.2	2.9	5.0	9.9	26.3
LSL	2	1	205	93	103	93	35	44	1.8	3.5	3.6	5.5	10.9	4.7
LSBk	1	0	89	0	89	0	45	0	2.2	0	4.0	0	4.7	0
LSR	1	0	75	0	75	0	16	0	1.7	0	2.9	0	4.0	
RUN	6	6	1243	984	207	164	32	38	1.1	1.8	2.4	2.5	66.0	49.7
GLD	0	1	0	286	0	286	0	58	0	1.6	0	2.0	0	14.5
LGR	2	2	84	94	42	47	22	64	0.8	0.7	1.2	1.5	4.5	4.8

Total Units Surveyed- 11

Total Length Surveyed- 1,978 ft.

dammed pool (DPL), lateral scour woody debris pool (LSL), lateral scour bedrock pool (LSBk), lateral scour rootwad pool (LSR), glide (GLD), low gradient riffle (LGR),

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Table 8. Mainstem San Lorenzo River in Reach 6; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, Located Between Zayante and Newell Creek Confluences.

Habitat Type	Units Measured # 1999	'98	Total Length ft 1999	'98	Average Length ft 1999	'98	Average Width ft 1999	'98	Average Depth ft 1999	'98	Average Maximum Depth 1999	'98	% of Surveyed Portion 1999	'98
LSBk	3	6	1353	1797	451	300	27	40	2.6	2.1	4.4	4.2	28.6	37.2
DPL	2	2	349	200	179	100	28	30	1.7	1.8	2.4	2.7	7.4	4.1
LSL	4	0	428	0	107	0	24	0	2.1	0	3.6	0	9.0	0
LSR	1	0	234	0	234	0	23	0	2.4	0	5.0	0	4.9	0
GLD	0	2	0	208	0	104	0	45	0	1.0	0	1.6	0	4.3
RUN	11	8	1722	1212	157	152	24	36	1.3	1.4	2.1	2.0	36.4	25.1
LGR	8	7	645	1033	81	148	15	24	0.7	1.0	1.0	2.0	13.6	21.4

Total Units Surveyed- 29/ 20

Total Length Surveyed- 4,731/ 4,831 ft.

mid-channel pool (MCP), dammed pool (DPL), lateral scour bedrock pool (LSBK), lateral scour woody debris pool (LSL), lateral scour rootwad pool (LSR), glide (GLD), low gradient riffle (LGR).

Table 9. Mainstem San Lorenzo River in Reach 7; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, Located Between Newell Creek Confluence and the Bend Above Ben Lomond.

Habitat Type	Units Measured # 1999	'98	Total Length ft 1999	'98	Average Length ft 1999	'98	Average Width ft 1999	'98	Average Depth ft 1999	'98	Average Maximum Depth 1999	'98	% of Surveyed Portion 1999	'98
LSBk	8	7	1354	1201	169	172	31	46	2.4	2.2	2.7	3.8	34.6	31.2
LSR	0	2	0	256	0	128	0	35	0	1.8	0	3.2	0	6.7
MCP	2	2	1213	1185	607	593	58	65	1.7	1.6	3.6	3.7	31.0	30.8
CRP	1	1	300	270	300	270	55	80	3.7	3.5	7.0	7.0	7.7	6.8
RUN	3	3	230	212	77	74	22	29	0.7	0.9	1.1	1.1	5.9	5.5
LGR	7	12	485	723	69	60	18	46	0.8	0.7	1.4	1.0	12.4	18.8

Total Units Surveyed- 21/ 27

Total Length Surveyed- 3,908/ 3,847 ft.

mid-channel pool (MCP), lateral scour bedrock pool (LSBk), lateral scour rootwad pool (LSR), low gradient riffle (LGR).

Table 10. Mainstem San Lorenzo River in Reach 8; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, Located Between the Bend Above Ben Lomond and the Clear Creek Confluence in Brookdale.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth		% of Surveyed Portion	
	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98
LSBk	9	9	2506	2213	330	246	36	58	2.8	3.1	5.0	5.5	62.1	69.2
DPL-LSBK	1	0	796	0	796	0	35	0	2.4	0	5.0	0	19.7	0
RUN	3	5	219	306	73	61	24	32	1.4	1.6	2.1	1.9	5.4	9.6
HGR-LGR	9	8	516	677	57	85	19	25	0.9	1.2	1.2	1.7	12.8	21.2

Total Units Surveyed- 22/ 22
Total Length Surveyed- 4,037/ 3,196 ft.

mid-channel pool (MCP), lateral scour bedrock pool (LSBk), lateral scour root pool (LSR), high gradient riffle (HGR), low gradient riffle (LGR).

Table 11. Mainstem San Lorenzo River in Reach 9; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, Located Between the Clear Creek and Boulder Creek Confluences.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth		% of Surveyed Portion	
	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98
LSBk	5	3	1847	1131	369	377	31	43	2.6	2.2	4.7	4.8	66.6	46.2
LSBo	2	0	126	0	63	0	23	0	1.0	0	1.6	0	4.5	0
LSR	0	1	0	315	0	315	0	52	0	2.2	0	4.0	0	12.9
LSL	1	0	45	0	45	0	25	0	0.9	0	1.6	0	1.6	0
RUN	4	4	354	418	89	105	18	32	1.0	1.1	1.7	1.9	12.8	17.1
HGR-LGR	8	5	400	583	50	117	19	21	0.7	0.8	1.1	1.4	14.4	23.8

Total Units Surveyed- 18/ 13
Total Length Surveyed- 2,772/ 2,447 ft.

lateral scour boulder pool (LSBo), lateral scour bedrock pool (LSBk), lateral scour rootwad pool (LSR), lateral scour woody debris pool (LSL), high gradient riffle (HGR), low gradient riffle (LGR).

Table 12. Mainstem San Lorenzo River in Reach 10; Summary of Habitat Types and Habitat Characteristics in 1999* and 1998, Located Between the Boulder Creek and Kings Creek Confluences.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth		% of Surveyed Portion	
	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98
LSBk	10	5	2245	1481	225	296	21	24	1.4	1.3	3.3	2.7	75.1	65.7
CRP	0	2	0	470	0	235	0	24	0	1.2	0	2.2	0	20.9
LSR	1	0	55	0	55	0	13	0	0.4	0	0.7	0	1.8	0
LSBo	1	0	61	0	61	0	25	0	1.3	0	2.1	0	2.0	0
RUN	4	3	194	170	49	57	14	14	0.8	1.0	1.4	1.5	6.5	7.6
LGR	12	4	434	133	36	33	18	18	0.5	0.5	0.9	0.8	14.5	5.9

Total Units Surveyed- 28/ 14
Total Length Surveyed- 2,989/ 2,254 ft.

lateral scour rootwad pool (LSR), corner pool (CRP), lateral scour bedrock pool (LSBk), lateral scour boulder pool (LSBo), low gradient riffle (LGR).

* In 1999, 574 feet of stream was omitted due to a rock dam backing up habitat. Therefore, more downstream habitat was surveyed in 1999 than 1998, making comparisons difficult.

Table 13. Mainstem San Lorenzo River in Reach 11; Summary of Habitat Types and Habitat Characteristics in 1999 and 1998, Located Between the Kings Creek Confluence and a Point of Increased Gradient Above Riverside Grove.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth		% of Surveyed Portion	
	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98
LSBk	15	7	1508	775	101	111	14	20	1.0	1.2	1.8	2.2	43.8	27.9
CRP	2	2	251	440	47	235	15	20	1.0	1.4	2.2	2.8	7.3	15.8
LSBo	1	2	34	75	34	38	19	14	0.8	1.2	1.2	1.5	1.0	2.7
LSR	0	1	0	42	0	42	0	18	0	1.2	0	1.8	0	1.5
LSL	1	0	36	0	36	0	10	0	1.0	0	1.8	0	1.0	
RUN	13	10	966	1020	74	102	13	16	0.5	0.6	1.0	1.2	28.1	36.7
LGR	16	7	642	430	40	61	10	15	0.4	0.6	0.7	0.9	18.7	15.5

Total Units Surveyed- 48/ 29
Total Length Surveyed- 3,437/ 2,782 ft.

lateral scour rootwad pool (LSR), corner pool (CRP), lateral scour bedrock pool (LSBk), lateral scour boulder pool (LSBo), low gradient riffle (LGR),

Table 14. Mainstem San Lorenzo River in Lower Reach 12a; Summary of Habitat Types and Habitat Characteristics in 1999 and 1998, From Above Riverside Grove to the Highway 9 Overpass at Waterman Gap.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth		% of Surveyed Portion	
	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98
LSBk	18	12	1034	800	57	67	13	16	1.3	1.4	1.9	2.5	36.8	24.3
LSBo	5	5	170	172	34	34	12	15	1.2	1.1	1.9	1.7	6.0	5.2
LSR	3	4	199	256	66	64	15	15	0.6	1.5	1.1	2.7	7.1	7.8
LSL	0	1	0	54	0	54	0	28	0	2.2	0	3.8	0	1.6
CRP	1	1	47	55	47	55	15	24	0.8	1.6	1.5	3.1	1.7	1.7
STP	0	1	0	98	0	98	0	15	0	1.3	0	2.2	0	3.0
RUN	5	10	240	723	48	72	14	15	0.6	0.8	1.2	1.4	8.5	22.0
SRN	9	5	318	224	35	56	9	14	1.0	0.7	1.6	1.3	11.3	6.8
LGR	19	21	515	910	27	43	10	14	0.4	0.4	0.8	0.8	18.3	27.6

Total Units Surveyed- 60/ 60

Total Length Surveyed- 2,812/ 3,292 ft.

lateral scour rootwad pool (LSR), corner pool (CRP), lateral scour bedrock pool (LSBK), lateral scour boulder pool (LSBo), lateral scour woody debris pool (LSL), step-pool (STP), step-run (SRN), low gradient riffle (LGR),

Table 15. Mainstem San Lorenzo River in Upper Reach 12b; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999*, From the Highway 9 Overpass at Waterman Gap to the Gradient Change Further Upstream.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth		% of Surveyed Portion	
	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98
LSBk	6	6	524	485	87	81	13	14	1.4	1.3	3.3	2.7	27.1	31.8
LSBo	4	4	161	209	40	52	13	16	1.4	0.9	2.0	1.5	8.3	5.9
LSR	2	6	67	304	34	51	13	15	1.5	1.4	2.4	2.3	3.5	2.4
LSL	4	2	259	193	65	97	15	14	1.4	1.6	2.1	3.0	13.4	2.1
CRP-LSBk	1	4	72	292	72	73	14	15	2.6	1.5	5.0	2.6	3.7	1.6
DPL	1	0	38	0	38	0	13	9	1.0	0	1.4	0	2.0	0
STP	0	1	0	43	0	43	0	16	0	1.0	0	1.3	0	4.2
RUN	6	6	192	212	32	35	11	16	0.8	0.7	1.3	0.9	9.9	26.4
SRN	5	0	249	0	50	0	10	0	0.8	0	1.3	0	12.9	0
LGR-HGR	15	24	412	1077	28	45	12	14	0.7	0.6	1.0	1.0	21.3	20.1

Total Units Surveyed- 44/ 53
Total Length Surveyed- 1,937/ 2,815

lateral scour bedrock pool (LSBk), lateral scour boulder pool (LSBo), lateral scour rootwad pool (LSR), lateral scour woody debris pool (LSL), corner pool (CRP), step pool (STP), low gradient riffle (LGR), high gradient riffle (HGR).

* In 1999, upstream of the stream ford was surveyed instead of downstream.

Reach 1 in Paradise Park was predominantly deep run habitat (45.3% in 1998; 37.7% in 1999), with 35.4% pool habitat in 1998 and 34.8% in 1999 (**Table 3b**). There were 6 pools formed in 1998 compared to 5 in 1999 in the same surveyed segment. There was an island in the reach in 1999, creating a split channel. The heads of pools were important for feeding while the deeper portions were important for cover. Riffle habitat remained similarly abundant- 25.3% in 1998 and 24.7% in 1999.

Reach 2 in the lower San Lorenzo Gorge was predominantly pool habitat (50.3% in 1999 and 51.9% in 1998) and deep, very productive riffles (27.1% in 1999; 34.1% in 1998) (**Table 4**). There was more run habitat in 1999, with 22.6% compared to 13.8% the previous year. In this warm habitat, heads of pools, riffles and to a lesser extent, runs, were important feeding locations.

The high gradient Reach 3 in the upper Gorge shifted slightly from riffle habitat to more pool and run habitat in 1999 (Table 5). Step-run habitat became run habitat with the reduced streamflow in 1999. Pools were bedrock scour (49.5% in 1999; 46.9% in 1998), runs and step-runs (25.1% in 1999; 22.8% in 1998) and riffles (25.4% in 1999; 30.3% in 1998), with most fish using riffles and runs in 1999.

The lower gradient Reach 4 in upper Henry Cowell Park was mostly pool habitat in 1999 (46.9%), with a shift from run habitat (36.7%) to pool habitat in 1999 (Table 6). It had more pools (46.9% in 1999; 19.8% in 1998), less riffles (16.5% in 1999; 18.8% in 1998) and less runs (36.7% in 1999; 55.6% in 1998), all associated with reduced streamflow in 1999.

As in 1998, Reach 5 in 1999 was dominated by long, wide, slow runs (66%). The dammed pool formed by the base of the Felton Diversion Dam was shorter in 1999, with a wider variety of pools in 1999 (29.5%) (Table 7). For the most part, habitat depth was substantially shallower and habitat width was narrower.

Reach 6 between Zayante Creek and Newell Creek confluences had a shift from riffles (21.4% in 1998; 13.6% in 1999) and glides (4.3% in 1998 and none in 1999) to more run (25.1% in 1998; 36.4% in 1999) and pool habitat (41.3% in 1998 ; 49.9% in 1999) (Table 8). There were 4 pools scoured by large woody debris in 1999, which were absent in 1998. Habitats were narrower in 1999, but bedrock pools were deeper in 1999. Riffles were substantially shallower and shorter in 1999, with runs similar in both years for depth and length. There were more habitats in 1999.

Reach 7 between the Newell Creek confluence and the bend beyond Ben Lomond was dominated by long pools (73.3% in 1999; 75.5% in 1998) (Table 9). Riffle habitat and the number of riffles decreased in 1999 (7 at 12.4% in 1999; 12 at 18.8% in 1998), providing less of the most productive habitat under reduced baseflow conditions. Riffles were slightly deeper in 1999, but much narrower. The proportion of runs was similar in the two years (5.9% in 1999 and 5.5% in 1998).

Reach 8, between the bend above Ben Lomond and the Clear Creek confluence in Brookdale, had the deepest bedrock pools in the mainstem River. Adult coho salmon carcasses were commonly observed during spawning in Reaches 8 and 9 prior to the 1976-77 drought. In 1999, the dammed pool that had been absent in 1998 was in place. The proportion of pool habitat increased substantially compared to 1998 (81.8% in 1999; 69.2% in 1998). Run habitat decreased (5.4% in 1999; 9.6% in 1998) as did riffle habitat (12.8% in 1999; 21.4% in 1998) (**Table 10**). Reach 9 between the Clear and Boulder Creek confluences also had more pool habitat (72.7% in 1999; 59.1% in 1998) (**Table 11**). While the proportion of pool and run habitat increased, riffle habitat decreased (14.4 in 1999; 23.8% in 1998).

The low-gradient Reach 10 between Boulder and Kings creek confluences was primarily bedrock pool habitat (78.9% in 1999 86.6% in 1998) (**Table 12**). Riffle habitat increased in 1999, unlike most downstream reaches. This was partially due to changes in the segment surveyed in 1999. People had built a cobble dam in the 1998 segment which backed up water for 574 feet upstream. This portion was excluded in the habitat-typed segment in 1999.

In 1999, the low gradient Reach 11 had slightly increased pool habitat (53.1% in 1997; 47.9% in 1998) and increased riffle habitat and number in this bedrock-controlled reach (**Table 13**). The riffles were shorter and shallower.

Lower Reach 12a, downstream of Highway 9 was higher gradient than Reaches 10 and 11, with more riffle habitat and the appearance of step-runs not seen elsewhere in the mainstem. In 1999, the proportion of pool habitat increased (51.6% in 1999; 43.6% in 1998) as riffle and run habitat was lost (**Table 14**). The number of pools increased slightly from 24 to 27 in 1999 and the step-pool was lost. Run habitat was converted (22% in 1998; 8.5% in 1999) to step-run (6.8% in 1998; 11.3% in 1999) and pool. Habitat lengths decreased in 5 of 7 habitat types from 1998 to 1999, especially for bedrock pools, runs, step-runs and riffles. This perhaps resulted from reduced winter and summer flows in 1999 because the drier 1997 also had shorter habitats.

Upper Reach 12b differed from lower Reach 12a, with the disappearance of step-runs in 12b and increased pool habitat (58%), and pool length (**Table** 15). The proportion of riffle habitat increased slightly in upper Reach 12b (21.3% compared to 18.3% in Reach 12a). The surveyed segment in 1999 was upstream of that surveyed in 1998 and included the part of the reach containing log weirs for pool enhancement. The 1999 segment had more pool habitat than the 1998 segment, 58% compared to 43.8%, respectively. Pool depth was greater in most cases in the 1999 segment, as well.

Riffle Habitat, Channel Width and Erosion

The proportion of riffle habitat in 1999 decreased from 22.5% in 1998 to 18% (15% decline in stream length) for the stream length habitat-typed in the mainstem River (**Figure** 54). This occurred despite a 6% increase in stream length that was habitat-typed in 1999. However, the number of riffles increased from 92 in 1998 to 118 in 1999, a 28% increase in 1999.

Bank-full stream channels widen when excessive sediment must be transported, leading to more streambank erosion and potential channel braiding. Channel widening and streambank erosion had been substantial in Reach 4 in 1998, washing old-growth sycamores into the channel downstream of the Henry Cowell Bridge. An island developed in Reach 1 and the island in Reach 4 continued. The critical passage riffle at the upper end of Reach 2 was especially wide and nearly braided in 1999. Land-sliding and streambank erosion continued to be significant in 1999 in Reach 11 below Teilh Road and in lower Reach 12a, down-slope of previous road repairs on Highway 9. The average riffle width and average width in most other habitat types decreased by reach in 1999 in all mainstem reaches except Reach 10 (remained unchanged in riffles and runs and narrowed in pools), compared to 1998 (**Tables** 3b-14). This was attributable to reduced baseflow in 1999 (**Figures** 55, 59-60).

Escape Cover

__Lower River.__ An important habitat parameter affecting juvenile survival was escape cover, and it was averaged for each mainstem reach. Downstream of the Zayante Creek confluence (lower San Lorenzo), riffle cover increased from Reach 5 downstream through 2, with Reach 1 having substantial cover, as well (**Figure 34b**). Riffle cover decreased from 1998 to 1999 in 3 of the 4 lower river reaches that could be compared. Run habitat had more cover than riffles in the lower River Reaches 4 and 5 in 1999, with the highest amount in the mainstem River being in Reaches 1-4, 6 and 8 (**Figure 36b**). Run cover decreased in 1999 in all lower river reaches except Reach 5. Pool cover was excellent in Reaches 1 and 5 in 1999, with the presence of large woody debris and overhanging vegetation, and at low levels in Reaches 2 and 3 (**Figure 38b**). As with runs and riffles, pools in 1999 had less cover than in 1998 except in Reach 5. Overhanging willows were extensive in Reach 5.

__Middle River.__ In the middle San Lorenzo, riffle cover was low in Reach 9 below the Boulder Creek confluence, but increased in the Brookdale Reach 8 and steadily declined downstream (**Figure 34b**). There was nearly twice the escape cover in Reach 8 riffles in 1998 compared to 1999. Cover in riffles of other mid-River reaches were similar between the years. Run cover in the middle River was at intermediate levels in Reaches 6 and 8. Run cover declined in all mid-River reaches except Reach 8 (**Figure 36b**). Pool cover in the middle River was intermediate in Reach 7 in 1999, but declined in all reaches compared to 1998 (**Figure 38b**).

__Upper River.__ In the upper San Lorenzo (upstream of the Boulder Creek confluence) riffle cover was very low in all three reaches, 10-12, with a slight increase in Reach 10 over 1998 (**Figure 34b**). Run cover in the upper River declined in 1999 in Reaches 10 and 11 from already low 1998 levels (**Figure 36b**). It increased in the Waterman Gap's runs (Reach 12). Pool cover was consistently low in Reaches 10 and 11, as was the case in 1998, but increased decidedly in the Waterman Gap Reach 12a-b as it had in 1998. A dam was present at the downstream end of Reach 12a, consisting of sediment, visquine and logs. It had trapped considerable sediment behind and was a potential passage barrier. It was constructed in a bedrock section which prevented a jump pool from forming.

Substrate Composition

The overall change in substrate composition in the mainstem River from 1998 to 1999 was an improvement of less fine sediment in pools of reaches of the middle and upper river, except for Reach 8, which stayed the same (**Table 16**). In the lower River, the percent fine sediment in pools stayed the same or worsened in Reaches 1-4, and improved in Reach 5 pools.

Regarding riffles, the reach average for percent fines remained the same in Reach 2, but improved in other reaches. In the middle River, riffles worsened in Reach 6, improved in Reach 7, remained the same in Reach 8 and worsened in Reach 9. In the upper River, riffles remained the same or improved with less fine sediment.

Regarding fine sediment in runs of the lower River, solid improvement occurred in Reaches 1 and 3. In the middle River, sediment increased in runs of 3 out of 4 reaches, with no change in Reach 9. In the upper River, the runs improved with less sediment in Reaches 10 and 12, with no change in Reach 11. The following reaches had two of three habitat-types improve from 1998 to 1999; 1, 3, 7, 10 and 12. Only Reach 6 had worse conditions in two of three habitat categories.

Water Depth

In the lower River, average pool depth by reach remained similar to 1998 in reaches 1 and 2, increased in Reaches 3 and 4 compared to 1998 and declined substantially in Reach 5 (**Figure 41**). Averaged maximum pool depth followed the same trend except it also increased in Reach 1 in 1999 (**Figure 43a**). Average riffle depth by reach declined in Reaches 1, 2 and 4, remaining the same in Reach 3 and deeper in Reach 5, though sample size was small in Reach 5 (**Figure 47**). The important averaged maximum riffle depth declined in all 5 lower River reaches, indicating negative impacts of sedimentation and reduced streamflow (**Figure 48**). The deeper pockets of riffles offer valuable habitat. Average depth by reach in runs declined in Reaches 1, 4 and 5, with increases in Reaches 2 and 3 (**Tables 3b-7**) in the lower River.

In the middle River, average pool depth by reach declined in 1999 in Reaches 6, 8 and 9 while increasing in Reach 7. Averaged maximum pool depth, average riffle depth and averaged maximum riffle depth followed the same trend, with substantial changes. Average depth by reach in runs declined in all 4 reaches of the middle River in 1999 (**Tables 8-11**).

In the upper River, average pool depth and averaged maximum pool depth increased in Reach 10, but declined in Reaches 11 and 12 in 1999. Average riffle depth remained unchanged in Reaches 10 and 12, while decreasing in Reach 11. Averaged maximum riffle depth increased in Reach 10 and remained unchanged in Reaches 11 and 12. Average run depths by reach declined in Reaches 10, 11 and 12, but step-runs deepened in Reach 12 (**Tables 12-14**).

Table 16. Streambed Sedimentation Expressed as Percent Fine Sediment by Habitat type in Mainstem Reach Segments, 1997-99.

Habitat Type
(Percent Sand and Silt- Visually Estimated)

Reach	Pool			Riffle			Run/Step-run		
#	1997	1998	1999	1997	1998	1999	1997	1998	1999
0			90%			25%			90%
1	75%	80%	80%	10%	25%	20%	35%	55%	40%
2	70	75	75	10	30	30	20	40	45
3	70	75	85	35	45	35	70	60	55
4	35	70	85	5	30	25	25	65	65
5	-*	100	90	-	-	25	-	75	75
6	70	80	70	10	25	40	35	50	55
7	45	70	65	5	25	20	15	30	40
8	30	70	70	0	20	20	10	35	40
9	55	80	60	10	15	20	20	35	35
10	35	85	75	1	20	20	20	60	50
11	30	75	65	2	25	20	20	35	35
12	40	60	55	5	15	15	15	35	30

* Indicates no data.

HABITAT ASSESSMENT FOR TRIBUTARY REACHES

Proportion of Habitat Types and Habitat Characteristics

Reach of tributaries were habitat-typed for the first time in 1998, and it was repeated in 1999. Within each sub-basin, habitat proportions and characteristics were affected by gradient, levels of winter stormflow and sediment load. Most tributary reaches (16 of 20 in 1998 and 1999) had a high proportion of pool habitat between 50 and 80 percent of the habitat length (**Tables 17-36; Figure 45c-d**). In 1999, reaches with less than 50 percent were lower Zayante (13a), Fall (15), lower Boulder (17b) and upper Branciforte (21b) creeks. Tables 1a-c of reach and site descriptions are repeated on pages 141-145 before the Figures. Overall, the trend in tributaries was for increased pool habitat in 1999 compared to 1998. Fall Creek had the lowest proportion of pools and the highest proportion of riffles. Productive step-runs were common in upper reaches of Zayante (13d), Bear (18b), Kings (19b), Carbonera (20b) and Branciforte (21b). Lower Zayante (13a) had the highest proportion of run habitat, more than 35%. Fall Creek had the lowest proportion of pools and the highest as riffles (nearly 50%). This was down from 1998, however, when riffle habitat was 75% under higher baseflow conditions. Riffle habitat shifted to run habitat in Fall Creek in 1999.

Changes in Habitat Conditions- General Trends

Habitat quality generally deteriorated in all tributaries except Bear, Zayante and Newell creeks. Bear Creek greatly improved. Escape cover increased in Zayante Creek. Newell Creek showed little habitat change, though the reach-wide cover estimate was incomparable between years. Pool escape cover decreased in 7 of 9 tributaries and increased in Zayante and Bear creeks. Sampled pools were more embedded in 7 of 9 tributaries. It improved in Newell and was unchanged in Kings Creek. Embeddedness worsened in sampled riffles and runs in 6 of 9 tributaries, with improvement at one site each in Branciforte and Bear creeks.

Substrate Composition

Sand and silt were the dominant substrate in tributary pools, with only the middle reach in Boulder Creek having less than 50% fines in 1999(**Table 37; Figure 33b**). Percent fines were consistently 60% or greater in Zayante, Bean, Bear, Kings and Carbonera creeks for pools. Comparing pools in 1998 and 1999, the notable increased percent fines occurred in lower reaches of Boulder, Bear, Kings and Carbonera creeks and upper reaches of Kings and Carbonera creeks.

Riffles averaged 30% fines or more in all reaches of Zayante and two of three in Bean Creeks in 1999 (**Figure 31c**). The greatest increase in percent fines was in middle reaches of Zayante Creek. Five percent increases were registered in Fall, lower and middle Boulder, upper Kings and lower Branciforte creeks. Riffle improvements occurred in Newell, lower Bear and upper Branciforte creeks. Percent fines increased in runs/step-runs in 1999 in lower Zayante, Boulder and Branciforte creeks and in upper Boulder, Kings, Carbonera and Branciforte creeks (**Figure 31d**). Less fines in runs/step-runs were noted in all Bean Creek reaches, Newell, upper Bear and lower Kings creeks. However, the upper Bean Creek segment was upstream of many slides in 1999.

Escape Cover

Regarding escape cover in tributary riffles, runs and step-runs, the reaches that had relatively more cover than other tributaries were three of four middle reaches of Zayante Creek and all reaches in Boulder Creek (**Figures 35b and 37b**). Pool habitat had the most escape cover in many tributary reaches, and was where juvenile densities were the greatest. In most reaches with comparable data, average pool escape cover declined in 1999 (**Figure 39b**). This occurred in three of four Zayante reaches, all three Bean Creek reaches, two of three Boulder Creek reaches (especially the lower reach), and upper reaches of Kings, Carbonera and Branciforte creeks. Improvement occurred in upper Zayante, middle Boulder (slight) and upper Bear creek pools.

Lower Zayante Creek (13a), below the Bean Creek confluence, typically has the highest streamflow of all tributary reaches (**Figures** 55-56). The increased pool habitat in 1999 and shallower habitats likely resulted from reduced streamflow and added sedimentation in pools and runs (**Tables 17 and 37**).

The Zayante reach (**13b**) between the Bean Creek confluence and the tributary confluence leading from Santa Cruz Aggregate, had shallower pools and riffles in 1999 (**Table** 18). The number of pools increased and the proportion of riffles decreased as runs increased slightly. The percent fines increased in pools and especially riffles (**Table** 37). The delta of sediment at the mouth of the Santa Cruz Aggregate tributary was smaller in 1999.

Table 17. Zayante Creek in Reach 13a; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999 from the San Lorenzo River Confluence to the Bean Creek Confluence.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth		% of Surveyed Portion	
	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98
POOL	10	8	988	724	99	91	23	24	1.6	1.7	2.5	2.8	39.0	30.9
RUN	8	5	917	1,000	115	200	24	29	1.1	1.5	1.7	1.5	36.2	42.7
RIFFLE	12	8	631	617	53	77	22	28	0.7	0.7	1.1	1.1	24.9	26.3

Total Units Surveyed- 30/ 21

Total Length Surveyed- 2,536/ 2,341 ft.

Table 18. Zayante Creek in Reach 13b; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From the Bean Creek Confluence the Santa Cruz Aggregate Tributary.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth		% of Surveyed Portion	
	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98
POOL	20	16	2,823	2,229	141	139	17	21	1.4	1.6	2.6	2.7	80.0	79.2
RUN	7	3	260	133	37	44	16	18	0.8	0.7	1.2	1.4	7.4	4.7
RIFFLE	17	16	444	453	26	28	15	22	0.7	0.6	1.0	0.9	12.6	16.1

Total Units Surveyed- 44/ 35

Total Length Surveyed- 3,527/ 2,815 ft.

Table 19. Zayante Creek in Reach 13c; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From the Santa Cruz Aggregate Tributary to Lompico Creek.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth		% of Surveyed Portion	
	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98
POOL	19	16	2,334	1,827	130	114	16	18	1.4	1.6	2.5	2.6	71.6	66.7
RUN	8	8	495	529	62		13	14	0.7	0.7	1.0	1.3	15.2	19.3
STEP-RUN	1	2	16	197	16	99	10	15	1.1	0.8	1.5	1.6	0.5	7.2
RIFFLE	12	5	417	188	35	38	13	14	0.6	0.6	1.0	1.2	12.8	6.9

Total Units Surveyed- 40/ 31

Total Length Surveyed- 3,262/ 2,741 ft.

Table 20. Zayante Creek in Reach 13d; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From the Lompico Creek Confluence to Mountain Charlie Gulch.

Habitat Type	Units Measured # 1999	'98	Total Length ft 1999	'98	Average Length ft 1999	'98	Average Width ft 1999	'98	Average Depth ft 1999	'98	Average Maximum Depth 1999	'98	% of Surveyed Portion 1999	'98
POOL	22	16	1,327	1,287	60	80	14	20	1.4	1.4	2.1	2.4	52.5	49.6
RUN	4	1	102	41	26	41	13	22	0.8	0.8	1.0	1.2	4.0	1.6
STEP-RUN	16	12	1,030	1,034	64	86	14	19	0.9	1.0	1.5	1.8	40.7	39.8
RIFFLE	3	5	70	233	23	47	10	14	0.4	0.5	0.8	0.8	2.8	9.0

Total Units Surveyed- 45/ 34

Total Length Surveyed- 2,529/ 2,595 ft.

Table 21. Bean Creek in Reach 14a; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From the Zayante Creek Confluence to Mt. Hermon Road Bypass and Reduced Gradient.

Habitat Type	Units Measured # 1999	'98	Total Length ft 1999	'98	Average Length ft 1999	'98	Average Width ft 1999	'98	Average Depth ft 1999	'98	Average Maximum Depth 1999	'98	% of Surveyed Portion 1999	'98
POOL	19	11	1,223	671	64	61	15	15	1.3	1.4	2.2	2.1	50.8	32.0
RUN	8	10	484	947	61	95	15	12	0.6	0.6	1.0	1.2	20.1	45.1
RIFFLE	13	9	701	480	54	53	14	14	0.5	0.5	0.9	0.9	29.1	22.9

Total Units Surveyed- 40/ 30

Total Length Surveyed- 2,408/ 2,098 ft.

Table 22. Bean Creek in Reach 14b; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From the Mt. Hermon Road Bypass to the Ruins Creek Confluence.

Habitat Type	Units Measured # 1999	'98	Total Length ft 1999	'98	Average Length ft 1999	'98	Average Width ft 1999	'98	Average Depth ft 1999	'98	Average Maximum Depth 1999	'98	% of Surveyed Portion 1999	'98
POOL	35	24	2,094	1,249	60	54	12	11	1.1	1.1	1.9	1.8	65.6	58.9
RUN	15	6	389	247	26	41	11	12	0.4	0.5	0.7	0.8	12.2	11.7
RIFFLE	29	22	710	624	25	28	9	11	0.3	0.3	0.5	0.6	22.2	29.4

Total Units Surveyed- 79/ 52

Total Length Surveyed- 3,193/ 2,120 ft.

Table 23. Bean Creek in Reach 14c; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999*, From the Ruins Creek Confluence to the Redwood Camp and Gradient Increase.

Habitat Type	Units Measured # 1999	'98	Total Length ft 1999	'98	Average Length ft 1999	'98	Average Width ft 1999	'98	Average Depth ft 1999	'98	Average Maximum Depth 1999	'98	% of Surveyed Portion 1999	'98
POOL	29	18	1,356	912	47	51	10	10	0.9	0.9	1.7	1.5	57.6	60.0
RUN	16	2	616	74	39	37	6	-	0.5	-	0.7	-	26.2	4.9
RIFFLE	18	14	383	533	21	38	6	-	0.2	-	0.5	-	16.3	35.1

Total Units Surveyed- 63/ 34

Total Length Surveyed- 2,355, 1,519 ft.

*In 1999 the habitat-typed segment was further upstream than in 1998.

Table 24. Fall Creek in Reach 15; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From the San Lorenzo River Confluence to the Boulder-Bedrock Falls.

Habitat Type	Units Measured # 1999	'98	Total Length ft 1999	'98	Average Length ft 1999	'98	Average Width ft 1999	'98	Average Depth ft 1999	'98	Average Maximum Depth 1999	'98	% of Surveyed Portion 1999	'98
POOL	20	20	700	519	35	26	12	12	1.1	1.3	1.9	1.8	26.8	18.0
RUN	18	2	613	59	34	30	11	13	1.0	1.0	1.3	1.4	23.5	2.0
STEP-RUN	0	2	0	97	0	49	0	12	0	0.9	0	1.4	0	3.3
RIFFLE	28	19	1,300	2,216	46	117	10	12	0.6	0.7	1.1	1.2	49.8	76.7

Total Units Surveyed- 66/ 43

Total Length Surveyed- 2,613/ 2,891 ft.

Table 25. Newell Creek in Reach 16; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From the San Lorenzo River Confluence to the Bedrock Falls.

Habitat Type	Units Measured # 1999	'98	Total Length ft 1999	'98	Average Length ft 1999	'98	Average Width ft 1999	'98	Average Depth ft 1999	'98	Average Maximum Depth 1999	'98	% of Surveyed Portion 1999	'98
POOL	17	13	1,421	1,283	84	99	15	17	1.5	1.7	2.8	2.6	55.0	54.3
RUN	7	8	475	551	68	69	15	15	0.9	0.7	1.2	1.0	18.4	23.3
RIFFLE	17	12	687	528	40	44	14	18	0.5	0.8	0.7	1.1	26.6	22.4

Total Units Surveyed- 41/ 33

Total Length Surveyed- 2,583/ 2,362 ft.

Table 26. Boulder Creek in Reach 17a; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From the San Lorenzo River Confluence to the Foreman Creek Confluence.

Habitat Type	Units Measured # 1999	'98	Total Length ft 1999	'98	Average Length ft 1999	'98	Average Width ft 1999	'98	Average Depth ft 1999	'98	Average Maximum Depth 1999	'98	% of Surveyed Portion 1999	1998
POOL	14	19	1,302	1,505	93	79	17	23	2.3	2.1	3.5	3.0	45.1	51.7
RUN	7	7	561	380	80	54	19	26	0.7	0.8	1.3	1.2	19.4	13.1
STEP-RN	2	0	138	0	69	0	16	0	0.9	0	1.4	0	4.8	0
RIFFLE	19	20	884	1,023	47	51	17	18	0.7	0.5	1.1	1.2	30.6	35.2

Total Units Surveyed: 42/ 46

Total Length Surveyed- 2,885/ 2,908 ft.

Table 27. Boulder Creek in Reach 17b; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From the Foreman Creek Confluence to the Narrowing of the Canyon.

Habitat Type	Units Measured # 1999	'98	Total Length ft 1999	'98	Average Length ft 1999	'98	Average Width ft 1999	'98	Average Depth ft 1999	'98	Average Maximum Depth 1999	'98	% of Surveyed Portion 1999	1998
POOL	19	22	1,230	1,685	65	77	16	22	1.8	2.0	2.9	3.1	60.6	63.0
RUN	1	2	45	54	45	27	18	13	1.2	0.8	2.0	1.2	2.2	2.0
STEP-RN	2	5	191	472	96	94	15	16	0.8	0.8	1.5	1.1	9.4	17.7
RIFFLE	14	14	564	462	40	33	12	15	0.6	0.6	1.3	1.2	27.8	17.3

Total Units Surveyed- 36/ 43

Total Length Surveyed- 2,030/ 2,673 ft.

Table 28. Boulder Creek in Reach 17c; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999*, From Narrowing of Canyon to Bedrock Cascade Adjacent the Kings Highway Junction with Big Basin Way.

Habitat Type	Units Measured # 1999	'98	Total Length ft 1999	'98	Average Length ft 1999	'98	Average Width ft 1999	'98	Average Depth ft 1999	'98	Average Maximum Depth 1999	'98	% of Surveyed Portion 1999	'98
POOL	11	9	1,115	589	101	65	15	16	2.7	1.8	4.2	2.7	63.4	71.5
RUN	3	0	90	0	30	0	13	0	0.9	0	1.5	0	5.1	0
STEP-RN	1	2	50	107	50	54	23	20	0.9	1.0	1.1	1.8	2.8	13.0
RIFFLE	13	6	505	128	39	21	11	-	0.6	-	1.0	-	28.7	15.5

Total Units Surveyed- 28/ 17

Total Length Surveyed- 1,760/ 824 ft. *Surveyed different segment in 1999.

Table 29. Bear Creek in Reach 18a; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From the San Lorenzo River to the Point of Increased Gradient and Unnamed Tributary Confluence.

Habitat Type	Units Measured # 1999	Units Measured # '98	Total Length ft 1999	Total Length ft 1998	Average Length ft 1999	Average Length ft '98	Average Width ft 1999	Average Width ft '98	Average Depth ft 1999	Average Depth ft '98	Average Maximum Depth 1999	Average Maximum Depth '98	% of Surveyed Portion 1999	% of Surveyed Portion 1998
POOL	16	15	1,889	2,097	118	140	20	23	1.9	1.8	3.6	3.0	63.7	64.4
RUN	6	8	275	497	46	30	14	17	0.7	0.8	1.5	1.2	9.3	15.3
RIFFLE	12	13	804	662	67	51	11	16	0.7	0.5	1.1	0.8	27.1	20.3

Total Units Surveyed- 34/ 36
Total Length Surveyed- 2,967/ 3,256 ft.

Table 30. Bear Creek in Reach 18b; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From the Gradient Increase to the Deer Creek Confluence.

Habitat Type	Units Measured # 1999	Units Measured # '98	Total Length ft 1999	Total Length ft '98	Average Length ft 1999	Average Length ft '98	Average Width ft 1999	Average Width ft '98	Average Depth ft 1999	Average Depth ft '98	Average Maximum Depth 1999	Average Maximum Depth '98	% of Surveyed Portion 1999	% of Surveyed Portion 1998
POOL	23	19	1,862	1,619	81	85	16	21	1.8	1.8	2.9	3.2	59.6	58.0
RUN	4	4	194	377	49	94	12	14	0.6	0.9	1.2	1.2	6.2	13.5
STEP-RN	11	9	706	577	64	64	15	16	0.7	0.8	1.3	1.6	22.6	20.7
RIFFLE	16	8	362	217	23	27	13	-	0.4	-	0.7	-	11.6	7.8

Total Units Surveyed- 54/ 40
Total Length Surveyed- 3,124/ 2,790 ft.

Table 31. Kings Creek in Reach 19a; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From the San Lorenzo River to the Southern, Unnamed Tributary at the Old Dam Remnants.

Habitat Type	Units Measured # 1999	Units Measured # '98	Total Length ft 1999	Total Length ft '98	Average Length ft 1999	Average Length ft '98	Average Width ft 1999	Average Width ft '98	Average Depth ft 1999	Average Depth ft '98	Average Maximum Depth 1999	Average Maximum Depth '98	% of Surveyed Portion 1999	% of Surveyed Portion 1998
POOL	25	20	1,856	1,403	74	70	13	14	0.8	1.0	1.5	1.5	64.9	52.8
RUN	8	13	627	677	78	52	10	13	0.5	0.7	0.8	0.9	21.9	25.5
RIFFLE	13	11	377	576	29	52	12	11	0.3	0.4	0.6	0.7	13.2	21.7

Total Units Surveyed- 46/ 43
Total Length Surveyed- 2,860/ 2,656 ft.

Table 32. Kings Creek in Reach 19b; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From the the Southern, Unnamed Tributary at the Old Dam Remnants to the Boulder Falls.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth		% of Surveyed Portion	
	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	1998
POOL	17	17	1,375	1,594	81	94	13	14	1.1	1.3	2.2	2.3	53.0	61.2
STEP-RN	10	12	752	938	75	78	12	13	0.7	0.7	1.2	1.3	29.0	36.0
RUN	7	0	281	0	40	0	16	0	0.7	0	1.3	0	10.8	0
RIFFLE	8	4	185	71	23	18	11	12	0.5	0.5	0.9	0.8	7.1	2.7

Total Units Surveyed- 42/ 33

Total Length Surveyed- 2,593/ 2,603 ft.

Table 33. Carbonera Creek in Reach 20a; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From Branciforte Creek Confluence to the Old Road Crossing and Gradient Increase.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth		% of Surveyed Portion	
	1999	1998	1999	1998	1999	'98	1999	'98	1999	'98	1999	'98	1999	1998
POOL	22	14	1,653	1,308	75	93	13	-	1.0	1.2	2.1	2.3	64.9	56.1
RUN	13	10	540	619	42	62	7	-	0.4	0.3	0.6	0.4	21.2	26.5
RIFFLE	21	12	354	406	17	34	7	-	0.3	0.25	0.4	0.4	13.9	17.4

Total Units Surveyed- 56/ 36

Total Length Surveyed- 2,547/ 2,333 ft.

Table 34. Carbonera Creek in Reach 20b; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From the Gradient Increase to Moose Lodge Falls.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth		% of Surveyed Portion	
	1999	'98	1999	1998	1999	'98	1999	'98	1999	'98	1999	'98	1999	1998
POOL	23	30	1,319	1,879	57	63	14	17	1.4	1.3	2.3	2.2	50.5	56.8
RUN	10	3	353	153	35	51	10	-	0.5	-	0.7	-	13.5	4.6
STEP-RN	14	24	784	1,265	56	53	14	15	0.6	0.7	1.0	1.2	30.0	38.2
RIFFLE	9	1	156	11	17	11	9	-	0.4	-	0.6	-	6.0	0.3

Total Units Surveyed- 56/ 58

Total Length Surveyed- 2,612/ 3,308 ft.

Table 35a. Branciforte Creek in Reach 21a-1; Summary of Habitat Types and Habitat Characteristics in 1999, From the Carbonera Creek Confluence to the Glen Canyon Creek Confluence.

Habitat Type	Units Measured # 1999	Total Length ft 1999	Average Length ft 1999	Average Width ft 1999	Average Depth ft 1999	Average Maximum Depth 1999	% of Surveyed Portion 1999
POOL	22	2,226	101	13	0.8	1.8	84.6
RUN	8	267	33	8	0.4	0.8	10.1
RIFFLE	13	139	11	6	0.3	0.5	5.3

Total Units Surveyed- 43
Total Length Surveyed- 2,632 ft.

Table 35b. Branciforte Creek in Reach 21a-2; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999, From the Glen Canyon Creek Confluence to the Granite Creek Confluence.

Habitat Type	Units Measured # 1999	Units Measured # '98	Total Length ft 1999	Total Length ft '98	Average Length ft 1999	Average Length ft '98	Average Width ft 1999	Average Width ft '98	Average Depth ft 1999	Average Depth ft '98	Average Maximum Depth 1999	Average Maximum Depth '98	% of Surveyed Portion 1999	% of Surveyed Portion 1998
POOL	28	22	1,608	1,724	57	78	19	14	1.1	1.0	1.9	1.8	67.9	62.6
RUN	12	8	470	425	39	53	9	9	0.5	0.5	0.8	0.8	19.8	15.4
RIFFLE	12	20	291	557	24	28	9	11	0.4	0.5	0.6	0.8	12.3	20.2
GLIDE	0	1	0	50	0	50	0	12	0	0.5	0	0.8	0	1.8

Total Units Surveyed- 52/ 51
Total Length Surveyed- 2,369/ 2,756 ft.

Table 36. Branciforte Creek in Reach 21b; Summary of Habitat Types and Habitat Characteristics in 1998 and 1999*, From the Granite Creek Confluence to the Tie Gulch Confluence.

Habitat Type	Units Measured #		Total Length ft		Average Length ft		Average Width ft		Average Depth ft		Average Maximum Depth		% of Surveyed Portion	
	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	'98	1999	1998
POOL	16	19	949	1,454	59	77	13	15	1.2	1.2	2.1	2.3	46.9	52.6
RUN	6	3	220	139	37	46	10	11	0.8	0.5	1.1	0.8	10.9	5.0
RIFFLE	8	7	386	326	48	47	11	12	0.4	0.4	0.7	0.7	19.1	11.8
STEP-RN	7	7	469	752	67	107	10	14	0.7	0.6	1.0	1.2	23.2	27.2
Glide	0	1	0	92	0	92	0	12	0	0.5	0	1.2	0	3.3

Total Units Surveyed- 37/ 37

Total Length Surveyed- 2,024/ 2,763 ft.

* In 1999, a segment less affected by rock walls and dams was surveyed downstream of the 1998 segment.

Table 37. Streambed Sedimentation Expressed as Average Percent Fine Sediment by Habitat Type in Tributary Reaches, 1998 and 1999.

		Habitat Type (Percent Sand and Silt Averaged by Reach- Visually Estimated)					
Reach #		Pool		Riffle		Run/Step-run	
		1998	1999	1998	1999	1998	1999
Zayante	13a	70%*	70%	35%	30%	50%	65%
	13b	70	75	10	40	40	55
	13c	65	75	25	50	45	40
	13d	65	70	50	45	35	45
Bean	14a	80	75	45	45	75	65
	14b	70	70	10	15	70	30
	14c**	75	70	50	30	60	40
Fall	15	55	50	35	40	55	55
Newell	16	55	35	20	10	20	10
Boulder	17a	45	60	20	30	25	35
	17b	45	50	20	30	45	30
	17c***	60	75	-****	20	20	35
Bear	18a	75	60	20	15	10	10
	18b	70	55	30	20	50	35
Kings	19a	50	50	20	20	35	25
	19b	65	75	15	20	25	35
Carbo-nera	20a	-	75	-	20	-	40
	20b	30	60	-	20	30	45
Branci-forte	21a-1	-	45	-	20	-	35
	21a-2	50	55	20	25	25	35
	21b**	65	65	30	40	40	45

* Average Percent Rounded to the Nearest 5%.
** Surveyed Segment in 1999 was further upstream than in 1998.
*** Surveyed Segment in 1999 was further downstream than in 1998.
****No data.

Zayante Reach 13c below Lompico Creek had more pools and pool habitat that was shallower in 1999 (**Table 19**). Average depths of runs and riffles were unchanged, with maximum depths decreasing. The number and total length of riffles increased in 1999. Limited step-run habitat declined in depth. Percent fines increased in pools and riffles, but declined in runs (**Table 37; Figures 31c-d, 33b**).

In upper Zayante Creek (**13d**), pools and step-runs were more numerous in 1999 with slightly higher proportions (**Table 20**). Average depth in step-runs and riffles were 0.1 feet shallower in 1999 while in pools and runs they were the same as 1998. Average maximum depths were shallower in all habitats except riffles, indicating some sedimentation. Percent fines increased in pools and runs/step-runs in 1999. Habitat width was substantially less in 1999 (**Table 37**).

In lower Bean Creek (**14a**) there were more numerous and considerably higher proportions of pools and riffles in 1999, though the segment was longer in 1999 (**Table 21**). Habitat water depths were very similar between years, with the greatest difference being 0.2 feet less maximum depth for runs in 1999. Percent fines were less in pools and runs in 1999 (**Table 37; Figures 31c-d, 33b**).

The usually most productive reach in Bean Creek (**14b**) had a higher proportion of pools and an almost equal decrease in riffle proportion in 1999 (**Table 22**). Pools and riffles had identical average depths between 1998 and 1999. In 1999, pools averaged deeper maximum depth with slightly greater depths. Percent fines were estimated the same between years in pools, higher in runs and substantially less in riffles in 1999 (**Table 37; Figures 31c-d, 33b**).

The surveyed segment representing upper Bean Creek (**14c**) in 1999 was higher in the watershed than in 1998. In 1999, pools had the same average depth and greater average maximum depth (**Table 23**). Pool proportions were similar between years, with a much higher proportion of runs and lower proportion of riffles. All habitat types had lower percent fines higher in the watershed in 1999

(**Table 37; Figures 31c-d, 33b**). There were numerous bank failures between the two segments surveyed in Reach 14c between the years.

In Fall Creek (15) in 1999, average depths of pools and riffles were shallower, but pools averaged greater maximum depth (**Table 24**). Proportions of pools and runs increased in 1999, and riffles decreased. Riffles were more numerous, being separated by runs. Percent fines were similar between 1998 and 1999, with slight improvement in pools and slight worsening in riffles (**Table 37; Figures 31c-d, 33b**).

In Newell Creek (16) in 1999, average depths decreased in pools and riffles (**Table 25**). But average maximum depth increased in pools and riffles. Sedimentation was less in all habitat types in 1999 with less percent fines (**Table 37; Figures 31c-d, 33b**).

In lower Boulder Creek (17a), pools were deeper on average and maximally in 1999 (**Table 26**). Riffles were also deeper on average and were more common. The proportion of runs increased while that of pools and riffles declined. Percent fines increased significantly in all habitat types. Pool and run widths were much less in 1999 (**Table 37; Figures 31c-d, 33b**).

In the middle reach of Boulder Creek (17b), pools were more shallow in 1999, while other habitat types had greater average maximum depths (**Table 27**). Percent fines were greater in pools and riffles, but much less in runs/step-runs (**Table 37; Figures 31c-d, 33b**). Pools were much narrower in 1999.

In upper Reach 17c in Boulder Creek, the surveyed segment was moved downstream in 1999. Pools were much deeper and longer in the 1999 segment (**Table 28**). Percent fines were higher in pools and riffles in the 1999 segment (**Table 37; Figures 31c-d, 33b**).

Habitat depth improved in lower Bear Creek Reach 18a in 1999 with deep pools, and deeper riffles, despite reduced streamflows (**Table 29**). The proportion of riffles increased while the run proportion decreased in 1999. There were less percent fines in pools and riffles also (**Table 37; Figures 31c-d, 33b**).

In upper Bear Creek Reach 18b, average pool depth remained the same in 1999 while maximum depth declined (**Table 30**). Runs and step-runs were shallower in 1999. Habitat proportions did not change much in 1999, with slightly less common runs and more common riffles. Percent fines decreased substantially in all habitat types in 1999 (**Table 37; Figures 31c-d, 33b**).

Habitat depth declined in lower Reach 19a of Kings Creek probably due to reduced streamflow in 1999 (**Table 31**). The proportion of pools increased while the proportion of runs and riffles declined. Percent fines remained the same, except in runs where it decreased in 1999 (**Table 37; Figures 31c-d, 33b**).

Habitat depth declined in upper Reach 19b of Kings Creek probably due again to reduced streamflow (**Table 32**). Unlike most other reaches, the proportion of pools declined, as did the proportion of step-runs. Runs appeared in 1999, and the riffle proportion increased. The percent fines increased in all habitat types (**Table 37; Figures 31c-d, 33b**).

In lower Carbonera Creek (20a), the proportion of pools increased in 1999 while runs and riffles were lower in proportion (**Table 33**). Pools were shallower in 1999, concomitant with reduced streamflow. Runs were deeper while riffles had similar depths between years. Pools and riffles were much more numerous in 1999.

In upper Carbonera Creek (20b), the number and proportion of pools and step-runs declined while the proportion of runs and riffles increased in 1999 (**Table 34**). Average and maximum depth increased in pools despite the reduced streamflow in 1999. Runs and step-runs shallowed as would be expected. Pools and runs had significantly more fines, with a substantial landslide present in the surveyed segment (**Table 37; Figures 31c-d, 33b**).

The additional reach segment that was surveyed in lower Branciforte Creek (21a-1) had a much higher proportion of pool habitat and lower proportions of riffles and runs compared to the next segment upstream in Reach 21a-2 (**Tables 35a-b**). The average pool depth was less in the lower segment.

Regarding characteristics of the segment in Reach 21a-2 for 1998 and 1999, average and maximum pool depth increased slightly while riffle depth declined slightly (**Table 35b**). Proportions of pool and run habitat increased at the expense of riffle habitat. Percent fines increased in all habitat types (**Table 37; Figures 31c-d, 33b**).

In upper Branciforte Creek (**21b**), different segments were surveyed between the years, with the 1999 segment located downstream where no flashboard dam structures were present. In the downstream segment in 1999, there was a lower proportion of pools and step-runs and a higher proportion of runs and riffles (**Table 36**). Depth in pools, riffles and step-runs were similar between years, with average maximum depth declining in 1999. Runs were deeper in 1999. Percent fines increased in riffles and runs/step-runs, with pool fines remaining the same (**Table 37; Figures 31c-d, 33b**).

At comparable sampling sites in tributaries, average pool depth increased at 3 of 9 sites and decreased at 4 of 9 sites from 1998 to 1999 (**Figure 44a**). It increased in the lower two sites of Bean Creek and the lower site on Carbonera Creek. Average pool depth decreased at the lower site on Zayante Creek, lower and upper sites on Boulder Creek, and at the lower Branciforte Creek site. The average depth remained the same at sites in upper Bear and upper Kings creeks. Maximum pool depth declined at 6 of 9 comparable sites, those being in Zayante, Bean, Boulder, Bear and Kings creeks (**Figure 45a**), and increased in lower Bean, Carbonera and Branciforte creeks.

In comparing average depth between tributary reaches, Boulder Creek had the deepest pools, averaging 2.3 feet in Reach 17a and 2.7 feet in Reach 17c (**Tables 17-36; Figure 45b**). Bear Creek had the next deepest pools, averaging 1.9 and 1.8 feet in the two reaches. In comparing 1998 to 1999, average pool depth decreased in 10 of 20 tributary reaches, remained the same in 5 reaches and increased in 5 of 20 reaches. Average pool depth decreased in most of Zayante, lower Bean, Fall, Newell, middle Boulder, Kings, and lower Carbonera creeks. The greatest decrease was in lower Kings Creek where it went from 1.5 to 0.8 feet.

In comparing maximum depth between tributary reaches, they were best in Boulder and Bear Creeks, followed by Newell and Zayante creeks (**Tables 17-36; Figure 45b**). Maximum pool depth increased the most in identical segments of lower Boulder Creek (3 to 3.5 feet) and lower Bear Creek (3 to 3.6 feet). Upper Boulder Creek had the deepest average maximum depth after the segment was moved upstream in 1999 (4.2 feet). Pools in Bear and Boulder creeks have potential as coho rearing habitat, if more woody debris was present in bedrock-scoured pools. Zayante Creek had deep, large pools that could be used by coho if reintroduced, but had a shortage of woody debris that would provide sufficient cover in its many bedrock pools. More woody debris would increase pool use by juvenile steelhead, as well.

Site and Reach Densities of Steelhead <75 mm Standard Length and the Young-of-the-Year Age Class

Appendix B contains capture data from electrofishing. **Table 38 and Figures 1 and 3** summarize site densities by size-class in the mainstem River. **Table 39 and Figures 5 and 7** summarize site densities of age classes for the mainstem River. **Tables 40-43 with Figures 9a-b, 10, 11 and 12a-b** summarize reach densities for Size Class 1 and the Y-O-Y age class in the mainstem. <u>Tables 1a-c of reach and site descriptions are repeated on pages 141-145 before the Figures.</u>

Site densities in 1999 for steelhead <75 mm SL (Size Class 1) were lower than in 1998 at 6 of 7 comparable mainstem sites (**Table 38; Figure** 3) due to fewer young-of-the-year (Y-O-Y) fish (**Table 39; Figure** 7). In 1999, reach densities of Size Class 1 juveniles in the mainstem were relatively low at less than 25 fish per 100 feet for all reaches except 6 where there were 32 fish per 100 feet (**Table 40; Figure** 9a). There were less than 10 Size Class 1 fish per 100 feet in all mainstem reaches except middle Reaches 6, 8 and 9 and upper Reach 11. In the middle Reaches 7-9, Size Class 1 fish were decidedly fewer because of generally lower densities of Y-O-Y juveniles in 1999 (**Table 41**). All reaches had lower Size Class 1 densities compared to 1997. For 1999 reach densities of Y-O-Y fish, Reaches 3-6 had the highest between 38-56 fish per 100 feet, with Reaches 1, 8, 9 and 11 intermediate at 20-34 Y-O-Y's per 100 feet (**Table 41; Figure** 12a). Reaches 2 and 7 had between 10 and 20 Y-O-Y's per 100 feet, with Reaches 10 and 12 at less than 10 Y-O-Y's per 100 feet. Only Reaches 1, 4-6 and 11 had higher Y-O-Y densities in 1999.

Overall reach densities of Size Class 1 fish declined in 1999 in the lower and middle River and increased in the upper River (**Table** 42). Densities were less than half that of 1998. Overall reach densities of Y-O-Y fish declined in 1999 in the middle and upper River, and increased in the lower River (**Table 43**).

Table 38. Density of Juvenile Steelhead by SIZE-CLASS at Mainstem Monitoring Sites in the San Lorenzo River Drainage in 1995-99. Sites were sampled in one or more different habitats in 1997-99 compared to previous years. Underwater visual censusing of deeper pools with less steelhead use began in 1998.

Sample Site*	1995 Densities**			1996 Densities			1997 Densities			1998 Densities			1999 Densities		
	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes
1	0	63.7	63.7	0	29.5	29.5	3.3	30.9	34.2	0.2	26.7	26.9	2.2	15.4	17.6
2	-***	-	-	-	-	-	7.9	67.0	74.9	1.3	20.1	21.4	0.4	4.2	4.6
3	22.8	55.9	78.7	33.3	77.2	110.5	47.7	36.2	83.9	9.4	64.1	73.5	3.7	25.3	29.0
4	13.3	31.9	45.2	20.0	45.9	65.9	63.0	23.8	86.9	8.6	29.2	37.8	6.8	32.8	39.6
5	-	-	-	-	-	-	-	-	-	19.1	114.7	133.8	5.2	41.0	46.2
6	28.6	18.8	47.4	24.6	13.6	38.2	35.1	10.3	45.4	20.5	25.5	46.0	11.2	2.9	14.1
7	73.5	85.7	159.2	74.2	41.9	116.1	126.7	22.6	149.3	11.7	10.0	21.7	2.9	8.9	11.8
8	84.4	37.0	121.4	113.0	46.0	159.0	138.6	20.0	158.6	118.7	21.4	140.1	37.4	10.8	48.2
9	30.7	22.7	53.4	61.7	13.0	74.7	102.2	24.6	126.8	57.5	19.8	77.3	18.5	9.1	27.6
10	18.2	7.1	25.3	32.8	8.8	41.6	65.8	3.3	69.1	9.6	8.3	17.9	4.4	6.5	10.9
11	35.5	5.0	40.5	44.7	14.0	58.7	64.2	8.8	73.0	4.1	6.8	10.9	26.9	6.5	33.4
12a	31.2	2.6	33.8	21.3	5.0	26.3	50.9	5.9	56.8	26.2	4.6	30.8	5.4	15.7	21.1
12b	-	-	-	-	-	-	-	-	-	19.5	12.7	32.2	4.1	21.8	25.9

* Refer to Table 1c for Site description and Appendix A - Figure 2 for Site Locations.
** Density in number of fish per 100 feet of stream.
*** Indicates no data.

Table 39. Density of Juvenile Steelhead by Age Class at Monitoring Sites in the Mainstem San Lorenzo River in 1997-99.

Sampling Site *		Densities**					
		Y-O-Y's			Yearlings and 2+		
		1997	1998	1999	1997	1998	1999
SLR- Paradise Park	#1	32.3	25.6	12.6	1.6	1.4	2.9
SLR- Rincon	#2	66.3	19.2	3.2	7.9	1.5	0.9
SLR- Upper Gorge	#3	84.3	68.2	24.7	5.2	5.3	3.9
SLR- Below Felton	#4	86.2	32.9	34.2	7.6	4.7	2.2
SLR- Below Zayante	#5	-	132.4	38.5	-	2.9	5.4
SLR- Below Fall Cr.	#6	42.0	44.4	13.2	4.6	2.2	0.8
SLR- Ben Lomond	#7	143.5	19.8	5.7	6.0	2.5	6.3
SLR- Below Clear Cr	#8	152.0	135.3	44.2	5.4	4.2	4.1
SLR- Below Boulder Cr	#9	119.9	69.7	23.4	14.3	8.1	2.5
SLR- Below Kings Cr	#10	65.8	11.7	6.5	3.3	6.4	4.6
SLR- Below Teilh Rd	#11	64.2	6.8	27.6	8.8	3.9	6.5
SLR- Below Highway 9 (Waterman Gap)	#12a	50.9	27.9	5.4	5.9	3.2	15.7
SLR- Above Highway 9 (Waterman Gap)	#12b	-	24.2	14.3	-	6.8	12.6

Table 40. Estimated DENSITY of Juvenile Steelhead by SIZE-CLASS and REACH in the San Lorenzo River Mainstem in 1996-99, using 1997 Habitat Proportions for 1996 and 1997, and using 1998 and 1999 Habitat Proportions for Those Years' Estimates, Respectively.

	Density in Number of Juveniles per 100 feet of Stream Reach											
Reach*	1996			1997			1998			1999		
	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes
1	0	20.0	20.0	3.6	34.2	37.8	0.4	25.2	25.6	0.4	41.0	41.4
2	30.8	69.6	100.4	5.1	65.8	70.9	7.4	61.3	68.7	1.0	19.3	20.3
3	28.8	63.4	92.2	47.7	34.1	81.8	8.6	48.3	56.8	6.5	45.0	51.5
4	16.3	47.3	63.6	51.1	15.4	66.4	8.7	21.8	30.5	12.4	55.4	67.8
5	20.2	50.5	70.3	43.0	9.9	52.9	6.6	41.6	48.2	5.5	37.8	43.3
6	15.5	10.8	26.3	16.4	5.1	21.6	8.1	6.9	15.0	32.0	6.8	38.8
7	44.5	42.5	87.0	67.2	12.5	79.8	22.3	16.4	38.7	7.2	14.9	22.1
8	64.7	23.6	88.3	89.1	20.0	109.0	111.6	22.6	134.3	21.6	9.3	30.9
9	57.3	14.6	71.9	103.7	28.1	131.8	90.6	23.9	114.5	16.6	8.2	24.8
10	29.4	15.1	44.5	53.0	5.5	58.5	7.2	7.0	14.2	4.5	1.4	5.9
11	46.9	14.3	61.2	66.5	9.2	75.7	3.7	7.0	10.7	26.0	5.9	31.9
12	21.2	4.9	26.1	53.3	7.9	61.2	24.3	7.6	31.9	4.6	18.2	22.8

* Reach designations specified in Table 1a and mapped in Appendix A; Figure 2.

Table 41. Estimated DENSITY of Juvenile Steelhead by AGE-CLASS and REACH in the San Lorenzo River MAINSTEM in 1996-99, using 1997 Habitat Proportions for 1996 and 1997 and 1998 and 1999 Habitat Proportions for 1998 and 1999 Estimates, respectively.

Reach*	Density in Number of Juveniles per 100 feet of Stream Reach											
	1996			1997			1998			1999		
	Y-O-Y	Year-lings	Both Sizes	Y-O-Y	Year-lings	Both Sizes	Y-O-Y	Year-lings	Both Sizes	Y-O-Y	Year-lings	Both Sizes
1	15.2	4.7	19.9	35.1	1.2	36.3	24.3	1.2	25.5	34.1	7.1	41.2
2	98.9	1.5	100.4	61.1	5.6	66.7	66.0	5.0	71.0	16.3	2.9	19.2
3	90.8	1.4	92.2	82.1	4.9	87.0	50.9	3.9	54.8	44.2	6.5	50.7
4&5	60.9	2.8	63.6	67.8	4.4	72.2	31.4	2.7	34.0	55.9	6.0	61.9
6	21.3	2.3	23.6	19.9	2.5	22.4	23.7	1.3	25.0	37.7	1.5	39.2
7	66.7	15.6	82.2	78.1	6.2	84.3	34.9	5.2	40.2	12.3	10.1	22.4
8	81.9	4.3	86.2	99.5	8.4	108.0	129.3	5.1	134.4	26.3	4.7	31.0
9	65.4	6.8	72.2	121.3	16.3	137.6	107.4	8.8	116.2	21.0	2.3	23.3
10	29.4	15.1	44.5	53.0	5.5	58.5	7.4	7.0	14.4	6.3	5.1	11.4
11	46.9	14.3	61.2	66.5	9.2	75.7	6.6	4.0	10.6	26.8	5.5	32.3
12	21.2	4.9	26.1	53.3	7.9	61.2	27.4	4.6	32.0	9.2	13.2	22.4

* Reach designations specified in Table 1a and mapped in Appendix A; Figure 2.

Table 42. Annual Comparisons of Estimated OVERALL DENSITY* of Juvenile Steelhead Produced by SIZE-CLASS in REACHES of the Mainstem San Lorenzo River, 1996-99.

Mainstem Reaches	1996 <75mm	1996 =>75mm	1996 Both Sizes	1997 <75mm	1997 =>75mm	1997 Both Sizes	1998 <75mm	1998 =>75mm	1998 Both Sizes	1999 <75mm	1999 =>75mm	1999 Both Sizes
1-5 Lower SLR (7.6 miles)	15.5	44.6	60.1	22.3	36.0	58.3	5.2	36.6	41.8	4.2	39.7	43.9
6-9 Middle SLR (8.9 miles)	40.4	20.1	60.5	60.8	14.9	75.7	51.7	18.1	69.8	21.7	9.2	30.9
10-12 Upper SLR (8.3 miles)	34.0	11.7	45.7	58.5	7.7	66.2	10.9	7.9	18.8	13.1	9.6	22.7

* Density in fish per 100 feet of stream.

Table 43. Annual Comparisons of Estimated OVERALL DENSITY* of Juvenile Steelhead Produced by AGE-CLASS in REACHES of the MAINSTEM San Lorenzo River, 1996-99.

Mainstem Reaches	1996 Y-O-Y	1996 Year-lings	1996 Both Sizes	1997 Y-O-Y	1997 Year-lings	1997 Both Sizes	1998 Y-O-Y	1998 Year-lings	1998 Both Sizes	1999 Y-O-Y	1999 Year-lings	1999 Both Sizes
1-5 Lower SLR (7.6 miles)	56.7	3.0	59.7	56.2	3.6	59.8	39.2	2.8	42.0	39.2	5.5	44.7
6-9 Middle SLR (8.9 miles)	52.0	6.2	58.3	70.4	7.6	78.0	66.3	4.5	70.8	26.8	3.9	30.7
10-12 Upper SLR (8.3 miles)	34.0	11.7	45.7	58.5	7.7	66.2	10.9	7.9	18.8	15.4	7.7	23.1

*Density in fish per 100 feet of stream.

Site and Reach Density of Larger Juvenile Steelhead, =>75 mm Standard Length and the Yearling and Older Age Classes

Site densities of juvenile steelhead =>75 mm SL (Size Classes 2 and 3) were higher in 1999 than in 1998 at only Sites 4, 12a and 12b, while yearling density was more at Sites 1, 5, 7, 11, 12a and 12b (**Tables 38 and 39; Figures** 4 and 8).

In 1999, the highest reach densities of Size Classes 2 and 3 juveniles in the mainstem were again in the lower River (Reaches 1-5), though the range was wide from 19-55 per 100 feet (**Table 40; Figure 13a**). They were highest in Reaches 1, 3 and 4, which also had the highest densities of yearlings in the mainstem after Reaches 7 and 12 (**Table 41; Figure 13c**). Reaches 1, 4 and 12 had sizable increases in reach densities of larger fish in 1999 compared to 1998. Reach 2 had a substantial reduction in larger size classes in 1999, declining from 61 in 1998 to 19 fish/ 100 feet. Eight of 12 mainstem reaches had lower densities of Size Classes 2 and 3.

In 1999, the overall density of these larger fish was greater in the lower (39.7 fish per 100 feet) and upper River (9.6 fish per 100 feet) compared to 1998, though it dropped off substantially in the middle River (9.2 fish per 100 feet) (**Table 42**). For overall density of yearling fish, the lower River increased in 1999 (5.5 fish per 100 feet), but it declined slightly in the middle (3.9 fish per 100 feet) and upper (7.7 fish per 100 feet) River (**Table 43**). As in 1998, the highest yearling density was in the upper River in 1999.

Total Density of Juvenile Steelhead at Mainstem Sites and Reaches of the San Lorenzo River Drainage.

In 1999, site densities of juveniles varied widely in the mainstem River. Downstream of the Zayante Creek Confluence (Sites 1-5), the highest density was in the riffle-run habitat sampled in Reach 5 as it was in 1998 (**Table 38; Figure 1**). But abundance there was less than half that of 1998, with larger juveniles at 41 fish per 100 feet and total density at 46 fish per 100 feet. The Reach 4 site had an total density of nearly 40 fish per 100 feet. The high-gradient, Reach 3 site had a total density in the 25-30 fish per 100 feet range. Site 1 had 15-20 fish per 100 feet, and Site 2 had less than 5 fish per 100 feet. In the middle River (Sites 6-9), Sites 8 and 9 were most productive, as they were in 1998. But 1999 densities were less than half those in 1998, with densities of 48 and 28 total juveniles per 100 feet, respectively (**Table 38; Figure 1**). Reaches 6 and 7 had much reduced total site densities of 14.1 and 11.8 fish per 100 feet.

In 1999 in the upper River (Sites 10-12b), Site 10 had the lowest total density in the mainstem (10.9 fish per 100 feet). Reach 11 improved in 1999 (33.4 fish per 100 feet) compared to 1998, but densities were still lower than earlier years (**Table 38**).

When habitat proportions were factored in to determine reach densities of combined size classes, Reaches 3 and 4 were the highest at 52 and 68 fish per 100 feet, while Reaches 8 and 9 were highest in 1998 (**Table 40; Figure 14a**). In 1999 five reaches (1, 5, 6, 8 and 11) were in the 30-45 fish 100 feet range. The remaining reaches (2, 7, 9, 10, and 12) were in the range of 6 to 23 fish per 100 feet). With the exception of Reaches 3 and 12, these sediment-laden, low-gradient reaches had mostly long (more than 200 feet), slow-velocity pools that were largely absent of juveniles. In 1999, pools were largely unused in Reach 3, as well. In Reach 12, water temperature was less, pools were short with fastwater habitat in close proximity at the head and adequate escape cover. Therefore, pools in Reach 12 had more steelhead than pools elsewhere in the mainstem.

Estimate of Juvenile Steelhead Numbers by Reach- San Lorenzo River Mainstem

In 1997-99, stream survey work and habitat-typing in each mainstem reach allowed for better choices of representative habitat to sample where necessary. It also improved our estimate of habitat proportions in each reach to obtain more accurate fish population estimates. In addition, sampling sites were added to

Reach 2 in 1997 and to Reaches 5 and upper 12 in 1998-99. These three additional sites increased the accuracy density estimates for those reaches. In 1998 and 1999, long, deep pools were snorkel-censused in the lower 8 reaches to improve accuracy further. Comparisons in juvenile production in mainstem reaches were best made between 1998 and 1999 because the sampling methods were most similar.

Size Class 1. In 1999, the number of Size Class 1 fish produced in each mainstem Reach was much less than in 1998 except for Reaches 4, 6 and 11 (**Table 41; Figure 9b**). These reductions were due to fewer Y-O-Y's in the 1999 year class (**Table 46**). The mainstem estimate of Size Class 1 fish in 1999 was **17,600** compared to **31,200** in 1998 (**Table 49 and 50**). This was a 43.6% decrease. Numbers accumulated by reach up the mainstem were tabulated and graphed (**Table 45; Figure 15**). Of the mainstem Size Class 1 fish, 9.5% were produced in the lower River (6.7% in 1998), 57.7% were produced in the middle River (77.8% in 1998) and 32.8% were produced in the upper River (15.5% in 1998) (**Table 49**). For the entire censused watershed the lower River produced 2% of the Size Class 1 juveniles (2% in 1998), the middle River produced 11% (20% in 1998) and the upper River produced 6% (4% in 1998) (**Figures 22a-b**).

Size Classes 2 and 3. Reach numbers of Size Class 2 and 3 juveniles followed the same relative pattern between years as reach densities of that size category. However, reach length was a factor in the numbers of juveniles produced per reach. Reaches 1, 3, 4, and 12 were the largest contributors (**Table 44; Figure 13b**). Large increases in production of these larger juveniles from 1998 to 1999 occurred in Reaches 1, 4 and 12, with large declines in Reaches 2, 8 and 9. The mainstem estimate of Size Classes 2-3 fish in 1999 was **24,000** compared to **26,500** in 1998 (**Table 49**). This was an 10% decrease. Numbers accumulated by Reach up the mainstem were tabulated and graphed (**Table 44; Figure 17**). Approximately 66% of the mainstem Size Class 2-3 juveniles were produced in the lower River (55.1% in 1998), 17.9% were produced in the middle River (31.8% in 1998) and 16.1% were produced in the upper River (13.1% in 1998) (**Table 49**).

For the entire censused watershed, the lower River produced 30% of the Size Class 2-3 juveniles (32% in 1998), the middle River produced 8% (19% in 1998) and the upper River produced 7% (8% in 1998) (**Figures 23a-b**).

In 1999, 42.3% of mainstem juveniles were Size Class 1 and 57.7% were Size Classes 2 and 3 (**Figure 26d**). In 1998, 53.9% of mainstem juveniles were in Size Class 1 and 46.1% were in Size Classes 2 and 3 (**Figure 26e**). In 1997, 71.9% were Size Class 1 and 28.1% were Size Classes 2 and 3 in the mainstem (**Figure 26f**).

Young-of-the-Year Age Class. In 1999, Y-O-Y production in mainstem reaches declined in all but Reaches 1 and 4, 6 and 11 (**Table 46; Figure 12b**). Substantial declines occurred in Reaches 2, 7-9 and 12. Reach 10 had still not recovered from the 1997-98 stormflows.

The mainstem estimate for Y-O-Y fish in 1999 was 34,300 compared to 52,500 in 1998 (**Table 47**). This was a 35% decrease in mainstem Y-O-Y production in 1999. Numbers accumulated by Reach up the mainstem were tabulated and graphed (**Table 47; Figure 16**). The lower River produced 43.6% of the mainstem Y-O-Y's (29.9% in 1998), the middle River produced approximately 36.6% of the Y-O-Y fish (59.1% in 1998) and the upper River produced 19.8% (10.9% in 1998) (**Table 48**). For the entire censused watershed, the lower River produced 14% of the Y-O-Y's (10% in 1998), the middle River produced 12% (20% in 1998) and the upper River produced 6% (4% in 1998) (**Figures 24a-b**).

Yearlings and Older Age Classes. The number of yearlings and older juveniles produced by reach in the mainstem followed the same relative pattern between years as reach densities of that age category. However, reach length was a factor in the numbers of juveniles produced per reach. Reaches 1 and 12 had the most yearlings in 1999 and the greatest increases over 1998, with increases also in Reaches 3, 4, 6, 7 and 11, making increases in 7 of 12 mainstem reaches (**Table 46; Figure 13d**). The mainstem estimate of yearling fish in 1999 was 7,300 compared to 5,500 in 1998 (**Table 47**). This was a 33% decrease. Numbers accumulated by reach up the mainstem were tabulated and graphed (**Table 47;**

Figure 18). Of the mainstem yearlings, approximately 29% inhabited the lower River (20% in 1998), 25% inhabited the middle River (39% in 1998) and 46% were in the upper River 41% in 1998) (**Table 48**). In 1999, 17.5% of the mainstem juveniles were yearlings, compared to 9.4% in 1998 and 1997 (**Figures 26a-c**). For the entire censused watershed, the lower River produced 6% of the yearlings in 1999 (8% in 1998), the middle River produced 5% (14% in 1998) and the upper River produced 10% (15% in 1998) (**Figures 25a-b**).

Table 44. Estimated NUMBER of Juvenile Steelhead by SIZE-CLASS and REACH in the San Lorenzo River Mainstem i using 1997 Habitat Proportions for 1996 and 1997 and using 1998 and 1999 Habitat Proportions for T Years' Estimates, Respectively.

Reach*	1996			1997			1998			1999		
	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes
1	0	2,972	2,972	537	5,072	5,609	63	3,735	3,798	55	6,088	6,143
2	2,752	6,208	8,960	454	5,871	6,325	658	5,468	6,126	88	1,722	1,810
3	1,644	3,613	5,257	2,720	1,942	4,662	488	2,753	3,241	369	2,566	2,935
4	1,398	4,044	5,442	4,367	1,317	5,684	745	1,868	2,613	1,057	4,743	5,800
5	410	1,014	1,424	872	200	1,072	134	842	976	112	765	877
6	2,762	1,929	4,691	2,934	915	3,849	1,451	1,227	2,678	5,716	1,223	6,939
7	3,903	3,723	7,626	5,893	1,096	6,989	1,958	1,436	3,394	632	1,309	1,941
8	5,915	2,152	8,067	8,139	1,824	9,963	10,200	2,068	12,268	1,978	852	2,830
9	6,383	1,621	8,004	11,549	3,132	14,681	10,091	2,659	12,750	1,849	915	2,764
10	3,886	1,993	5,879	6,991	729	7,720	951	930	1,881	592	790	1,382
11	8,299	2,524	10,823	11,756	1,633	13,389	662	1,246	1,908	4,596	1,042	5,638
12	2,799	645	3,444	7,031	1,046	8,077	3,213	997	4,210	602	2,402	3,004
TOTALS:	39,741	31,491	71,232	63,243	24,577	88,020	31,165	26,629	57,794	17,646	24,417	42,063

* Reach designations specified in Table 1a and mapped in Appendix A; Figure 2.

Table 45. Estimated NUMBER of Juvenile Steelhead in the Mainstem San Lorenzo River, ACCUMULATED by Reach in 1996-99, in SIZE CLASSES using Habitat Proportions Determined by Habitat-Typing.

Reach*	1996			1997			1998			1999		
	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes
1	0	2,972	2,972	537	5,072	5,609	63	3,735	3,798	55	6,088	6,143
2	2,752	9,180	11,932	991	10,943	11,934	721	9,203	9,924	143	7,810	7,953
3	4,396	12,793	17,189	3,711	12,885	16,596	1,209	11,956	13,165	512	10,376	10,888
4	5,794	16,904	22,698	8,078	14,202	22,280	1,954	13,824	15,778	1,569	15,119	16,688
5	6,204	17,918	24,122	8,950	14,402	23,352	2,088	14,666	16,754	1,681	15,884	17,565
6	8,966	19,847	28,813	11,884	15,317	27,201	4,093	16,984	21,077	7,397	17,107	24,504
7	12,869	23,570	36,439	17,777	16,413	34,190	6,051	18,420	24,471	8,029	18,416	26,445
8	18,784	25,722	44,506	25,916	18,237	44,153	16,251	20,488	36,739	10,007	19,268	29,275
9	25,167	27,343	52,510	37,465	21,369	58,834	26,342	23,147	49,489	11,856	20,183	32,039
10	29,053	29,336	58,389	44,456	22,098	66,554	27,293	24,328	51,621	12,448	20,973	33,421
11	37,352	31,860	69,212	56,212	23,731	79,943	27,955	25,574	53,529	17,044	22,015	39,059
12	40,151	32,505	72,656	63,243	24,777	88,020	31,168	26,630	57,798	17,646	24,417	42,063

* Reach designations specified in Table 1a and mapped in Appendix A; Figure 2.

Table 46. Estimated NUMBER of Juvenile Steelhead by AGE-CLASS and Reach in the San Lorenzo River Mainstem in 1996-99, using 1997 Habitat Proportions for 1996 and 1997 and Using 1998 and 1999 Habitat Proportions for Those Years' Estimates.

Reach*	1996			1997			1998			1999		
	Y-O-Y	Year-lings	Both Sizes	Y-O-Y	Year-lings	Both Sizes	Y-O-Y	Year-lings	Both Sizes	Y-O-Y	Year-lings	Both Sizes
1	2,251	701	2,952	5,201	181	5,382	3,604	175	3,779	5,060	1,056	6,116
2	8,824	137	8,961	5,455	499	5,954	5,888	443	6,331	1,456	258	1,714
3	5,176	82	5,258	4,679	280	4,959	2,905	220	3,125	2,521	373	2,894
4&5	6,440	291	6,731	7,170	469	7,639	3,319	283	3,602	5,917	401	6,318
6	3,795	408	4,203	3,558	440	3,998	4,230	224	4,454	6,733	259	6,992
7	5,842	1,366	7,208	6,847	543	7,390	3,062	460	3,522	1,074	885	1,959
8	7,484	392	7,876	9,093	772	9,865	11,818	465	12,283	2,406	428	2,834
9	7,286	760	8,046	13,512	1,816	15,328	11,964	977	12,941	2,339	255	2,594
10	3,886	1,993	5,879	6,991	729	7,720	976	927	1,903	836	675	1,511
11	8,299	2,524	10,823	11,756	1,633	13,389	1,165	708	1,873	4,739	967	5,706
12	2,799	645	3,444	7,031	1,046	8,077	3,612	612	4,224	1,219	1,736	2,955

* Reach designations specified in Table 1a and mapped in Appendix A; Figure 2.

Table 47. Estimated NUMBER of Juvenile Steelhead in the Mainstem San Lorenzo River, ACCUMULATED by Reach in 1996-99 in AGE CLASSES, using Habitat Proportions Determined by Habitat-Typing.

Reach*	1996		1997		1998		1999	
	Y-O-Y	Year-lings	Y-O-Y	Year-lings	Y-O-Y	Year-lings	Y-O-Y	Year-lings
1	2,251	701	5,201	181	3,604	175	5,060	1,056
2	11,075	838	10,656	680	9,492	618	6,516	1,314
3	16,251	920	15,335	960	12,397	838	9,037	1,687
4&5	22,691	1,211	22,505	1,429	15,716	1,121	14,954	2,088
6	26,486	1,619	26,063	1,869	19,946	1,345	21,687	2,347
7	32,328	2,985	32,910	2,412	23,008	1,805	22,761	3,232
8	39,812	3,377	42,003	3,184	34,826	2,270	25,167	3,660
9	47,098	4,137	55,515	5,000	46,790	3,247	27,506	3,915
10	50,984	6,130	62,506	5,729	47,766	4,174	28,342	4,590
11	59,283	8,654	74,262	7,362	48,931	4,882	33,081	5,557
12	62,082	9,299	81,293	8,408	52,543	5,494	34,300	7,293

* Reach designations specified in Table 1a and mapped in Appendix A; Figure 2.

Table 48. Annual Comparisons of Estimated NUMBER of Juvenile Steelhead Produced by AGE-CLASS in REACHES of the Mainstem San Lorenzo River (1996-99), with 1998-99 Tributary Production Included.

Mainstem Reaches* & Tribs.	1996 Y-O-Y	1996 Yearlings	1996 Both Ages	1997 Y-O-Y	1997 Yearlings	1997 Both Ages	1998 Y-O-Y	1998 Yearlings	1998 Both Ages	1999 Y-O-Y	1999 Yearlings	1999 Both Ages
1-5 Lower SLR (7.6 miles)	22,691	1,211	23,902	22,505	1,429	23,934	15,716	1,121	16,837	14,954	2.088	17,042
6-9 Middle SLR (8.9 miles)	24,407	2,926	27,333	33,010	3,571	36,581	31,074	2,126	33,200	12,552	1,827	14,379
10-12 Upper SLR (8.3 miles)	14,984	5,162	20,146	25,778	3,408	29,186	5,753	2,247	8,000	6,794	3,378	10,172
1-12	62,082	9,299	71,381	81,293	8,408	89,701	52,543	5,494	58,037	34,300	7,293	41,593
1-2 Branciforte Creek (4.6 miles)							14,754	1,888	16,642	9,532	3,149	12,681
1-2 Carbonera Creek (3.4 miles)							6,876	565	7,441	4,939	1,536	6,475
Branciforte Creek Sub-Basin							21,630	2,453	24,083	14,471	4,685	19,156
1-4 Zayante Creek (5.7 miles)							19,819	1,707	21,526	21,966	6,665	28,631
1-3 Bean Creek (5.4 miles)							17,884	1,457	19,341	6,146	4,157	10,303
Zayante Creek Sub-Basin (without Lompico Cr.) (11.1 miles)							37,703	3,165	40,868	28,142	10,822	38,964
1 Fall Creek (1.6 miles)							5,804	535	6,339	5,801	1,420	7,221
1 Newell Creek (1.0 miles)							3,636	410	4,046	971	1,274	2,245
1-3 Boulder Creek (3.5 miles)							13,428	1,290	14,718	5,790	3,066	8,856
1-2 Bear Creek (4.7 miles)							18,080	1,227	19,307	16,655	5,462	22,117
1-2 Kings Creek (3.7 miles)							3,296	325	3,621	2,705	1,211	3,916
Smaller Tributaries, Combined (Fall, Newell, Boulder Bear and Kings)							44,244	3,786	48,030	31,922	12,433	44,355
TRIBUTARY SUBTOTAL							103,577	9,404	112,981	74,535	27,940	102,475
MAINSTEM AND TRIBUTARY TOTAL							156,120	14,898	171,018	108,835	35,233	144,068

* Reach designations specified in Tables 1a-b and mapped in Appendix A; Figure 2.

Table 49. Annual Comparisons of Estimated NUMBER of Juvenile Steelhead Produced by SIZE-CLASS in REACHES of the Mainstem San Lorenzo River (1996-99), with 1998-99 Tributary Production Included. Reach designations mapped in Appendix A; Figure 2.

Mainstem Reaches & Tribs.	1996 <75mm	1996 =>75mm	1996 Both Sizes	1997 <75mm	1997 =>75mm	1997 Both Sizes	1998 <75mm	1998 =>75mm	1998 Both Sizes	1999 <75mm	1999 =>75mm	1999 Both Sizes
1-5 Lower SLR (7.6 miles)	6,204	17,918	24,122	8,950	14,402	23,352	2,088	14,666	16,754	1,682	15,884	17,565
6-9 Middle SLR (8.9 miles)	18,963	9,425	28,388	28,515	6,967	35,482	24,254	8,481	32,735	10,175	4,299	14,474
10-12 Upper SLR (8.3 miles)	14,984	5,162	20,146	25,778	3,408	29,186	4,826	3,483	8,309	5,790	3,872	9,662
1-12	40,151	32,505	72,656	63,243	24,777	88,020	31,168	26,630	57,798	17,647	24,055	41,702
1-2 Branciforte Creek- Above Carbonera Confl. (4.6 miles)							13,335	3,286	16,621	9,532	3,149	12,681
1-2 Carbonera Creek- to Moose Lodge Falls (3.4 miles)							5,002	2,472	7,474	4,898	1,578	6,476
Branciforte Sub-Basin (8.0 miles)							18,337	5,758	24,095	14,390	4,727	19,117
1-4 Zayante Creek- to Mt. Charlie Confl. (5.7 miles)							17,880	3,792	21,672	21,103	7,526	28,629
1-3 Bean Creek- to Second Glenwood Rd Crossing (5.4 miles)							17,757	1,577	19,334	6,146	4,157	10,303
Zayante Creek Sub-Basin (without Lompico Cr.) (11.1 miles)							35,637	5,369	41,006	27,249	11,683	38,932
1 Fall Creek- to Boulder Falls (1.6 miles)							5,291	1,032	6,323	5,801	1,420	7,221
1 Newell Creek- to Bedrock Falls (1.0 miles)							3,245	727	3,972	971	1,131	2,102
1-3 Boulder Creek- to Bedrock Chute at Kings Highway (3.5 miles)							10,033	2,248	12,281	5,790	3,066	8,856
1-2 Bear Creek- to Deer Creek Confl. (4.7 miles)							17,182	2,245	19,427	16,655	5,462	22,117
1-2 Kings Creek- to Bedrock Cascade (3.7 miles)							1,966	1,730	3,696	2,705	1,211	3,916
Smaller Tributaries Combined (Fall, Newell, Boulder Bear and Kings)							37,717	7,982	45,699	31,922	12,290	44,212
TRIBUTARY SUBTOTAL							91,691	19,109	110,800	73,561	28,700	102,261
MAINSTEM AND TRIBUTARY TOTAL							122,859	45,739	168,598	91,208	52,755	143,963

The total number of juveniles produced in the mainstem followed the same relative pattern between years as reach densities of all size classes combined. However, reach length was a factor in the numbers of juveniles produced per reach. Reaches 1, 4 and 6 contributed the the most mainstem juveniles (**Table 44; Figure 14b**). The mainstem estimate of juveniles in 1999 was **41,700** compared to **57,800** in 1998 (**Tables 44, 49 and 50**). This was a 28% reduction. Numbers accumulated by Reach up the mainstem were tabulated and graphed (**Tables 45 and 47; Figure 18**).

The 1999 population estimate of the young-of-the-year (Y-O-Y) age class in the mainstem River was **34,300** (**Table 47**) compared to **17,600** Size Class 1 juveniles (**Table 45**). The difference was **16,700**, which were the **49%** of the Y-O-Y's that grew into Size Class 2. The 1998 estimate of the Y-O-Y age class was **52,500** (**Table 54**) compared to **31,200** Size Class 1 juveniles (**Table 49**). The difference was **21,300**, which were the **41%** of the Y-O-Y's that grew into Size Class 2. Therefore, an estimated **4,600** fewer Y-O-Y steelhead grew into the larger size class in 1999, but a slightly higher proportion (49% compared to 41% of the Y-O-Y age class). There may have been reduced competition between the less numerous Y-O-Y steelhead in 1999.

In 1999, 82.5% of the mainstem juveniles were Y-O-Y's and 17.5% were yearlings and older. In 1998, 90.5% were Y-O-Y's and 9.5% were yearlings and older. In 1997, 90.6% were Y-O-Y's and 9.4% were yearlings and older.

Table 50. Estimated Number of Juvenile Steelhead by SIZE-CLASS in the San Lorenzo River Mainstem From Highway 1 to Above Waterman Gap in Fall of 1981, 1994-99, with 1998-99 Tributary Estimates Included.

YEAR	# OF SIZE-CLASS 1 STEELHEAD (< 75 mm SL)	# OF SIZE-CLASSES 2 & 3 STEELHEAD (=> 75 mm SL)	TOTAL NUMBER OF JUVENILES
1981 Main-stem	37,000*	31,500	69,000
1994 "	24,500	23,000	45,000
1995 "	37,000	38,000	75,000
1996 "	40,000	32,500	72,500
1997 "	63,000	25,000	88,000
1998 "	31,000	26,000	58,000
1999 "	17,500	24,000	41,500
1998 Tribs.	91,500	19,000	111,000
1999 Tribs.	73,500	28,500	102,000
1998 TOTAL	123,000	45,500	168,500
1999 TOTAL	91,000	53,000	144,000

* Estimates were rounded to the nearest 500. In the years prior to 1997, estimates were generated from sampling site densities extrapolated to reach densities. In 1997, the estimates were generated from habitat-type densities extrapolated to reach densities after habitat proportioning was determined during survey work. A revised 1996 estimate was generated, using 1997 habitat proportions. In 1998 and 1999, habitat proportions were re-determined and incorporated into estimates. Estimates are approximations.

FISH POPULATION MONITORING- TRIBUTARIES

Overall Summary

Zayante Creek was the most productive tributary in 1999 in terms of Y-O-Y's, yearlings and larger size classes. With 17% of the steelhead tributary channel miles assessed, Zayante Creek produced 29% of the tributary Y-O-Y's, 24% of the tributary yearlings and 26% of the larger juveniles in tributaries in 1999. Bear Creek was second. Bean Creek was third in importance for yearlings and larger size classes, but had much reduced Y-O-Y production in 1999 compared to 1998 (2/3 reduction). Branciforte Creek produced more Y-O-Y's than Bean Creek in 1999. Boulder Creek produced nearly as many Y-O-Y's as Bean and produced similar numbers of yearlings and larger juveniles as Branciforte Creek. Despite the relatively short extent of steelhead habitat in Fall Creek, Y-O-Y production was greater than in Boulder Creek and nearly as high as in Bean Creek. Kings Creek was the least productive in terms of yearlings and larger juveniles and was next to last in Y-O-Y production, despite its having more steelhead channel miles than Boulder, Carbonera, Fall and Newell creeks. Newell Creek had the lowest Y-O-Y production in 1999 tributaries, producing approximately 1/4 as many as in 1998.

Site and Reach Densities of Steelhead <75 mm Standard Length and the Young-of-the-Year Age Class- Tributaries

Table 51 and Figures 2 and 3 summarize site densities of size classes for tributaries. <u>Tables 1a-c of reach and site descriptions are repeated on pages 141-145 before the Figures.</u> **Table 52 and Figures 6 and 7** summarize site densities of age classes. **Table 53** provides average site densities for tributary sites. **Figures 20a-d and 21a-c** summarize reach densities for size classes and age classes.

Out of the 20 tributary sites in 1999, 15 of 20 declined in Y-O-Y and Size Class 1 fish compared to 1998. For Zayante Creek (17a-d), site densities of Size Class 1 and Y-O-Y fish in 1999 were greater than in 1998 at 3 of 4 sites (**Tables 51 and 52;**

Figures 3 and 7). Other notable increases occurred at sites in upper Bear (18b) and upper Kings (19b). In Bean Creek (14a-c), juvenile densities were down in all three sites, with larger reductions in Sites 14b-c. Regarding other tributary sites in 1999, Size Class 1 and Y-O-Y fish densities were reduced considerably (more than 20%) from 1998 in Newell Creek (16), all three reaches of Boulder Creek (17a-c) and lower Branciforte Creek (21a). In Boulder Creek, Y-O-Y densities were down more than 50% at Sites 17a and 17c and more than 40% in Reach 17b. Reductions of 15-30% were noted in lower Bear (18a) and lower Carbonera (20a) creeks, and no Y-O-Y's were found in lower Kings Creek (19a). Sites in Fall Creek (15) and upper Carbonera (20b) remained similar for Size Class 1 fish, but both had a lower density of Y-O-Y's in 1999 (**Tables 51 and 52**).

Table 51. Density of Juvenile Steelhead by SIZE-CLASS at Tributary Monitoring Sites in the San Lorenzo River Drainage in 1995-99. Sites were sampled in one or more different habitats in 1997 and 1998 compared to previous years.

Sample Site*	1995 Densities**			1996 Densities			1997 Densities			1998 Densities			1999 Densities		
	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes	<75mm	=>75mm	Both Sizes
13a	50.6	16.9	67.5	67.8	6.8	74.6				70.4	12.3	82.7	90.3	13.5	103.8
13b							63.5	11.7	75.2	37.8	14.9	52.7	55.2	19.9	75.1
13c										56.9	14.7	71.6	44.3	16.8	61.1
13d										71.0	10.7	81.7	77.7	27.3	105.0
14a										42.0	2.1	44.1	42.0	3.9	45.9
14b	87.3	9.9	97.2	41.8	9.1	50.9	59.6	13.7	73.3	104.3	11.3	115.6	59.0	33.1	92.1
14c										71.8	6.4	78.2	7.0	15.8	22.8
15	22.2	15.2	37.4	39.7	11.4	51.1	43.7	12.2	55.9	69.1	13.3	82.4	68.1	16.9	85.0
16	4.8	15.2	20.0	48.8	42.9	91.7	105.3	13.0	118.3	59.8	14.9	74.7	17.7	22.8	40.5
17a	117.3	25.0	142.3	52.1	17.7	69.8	109.6	22.8	132.4	127.4	21.9	149.3	50.7	17.8	68.5
17b							91.0	9.7	100.7	64.7	11.5	76.2	36.2	13.1	49.3
17c	27.2	7.1	34.3	30.6	14.7	45.3				37.6	5.2	42.8	15.3	18.6	33.9
18a	45.2	12.1	57.3	50.4	12.3	62.7	100.2	18.3	118.5	67.4	13.0	80.4	57.9	18.1	76.0
18b										64.1	6.2	70.3	89.2	26.9	116.1
19a										4.8	6.2	11.0	0.0	0.5	0.5
19b	60.1	14.1	74.2	44.9	9.6	54.5	48.2	4.5	52.7	13.6	9.7	23.3	32.1	12.8	50.9
20a	21.9	14.1	36.0	10.9	2.7	13.6	9.1	4.3	13.4	9.4	11.5	20.9	12.6	5.7	18.3
20b	10.2	13.4	23.6	18.7	10.3	29.0				39.6	11.4	51.0	40.3	11.4	51.7
21a							64.6	5.4	70.0	51.1	8.5	59.6	35.5	11.6	47.1
21b										53.3	14.8	68.1	44.2	13.4	57.6

* Refer to Table 1c for Site descriptions and Appendix A - Figure 2 for Site locations. Zayante (13a-d), Bean (14a-c), Fall (15), Newell (16), Boulder (17a-c), Bear (18a-b), Kings (19a-b), Carbonera (20a-b), Branciforte (21a-b).

** Density in number of fish per 100 feet of stream.

Table 52. DENSITY of Juvenile Steelhead by AGE CLASS at MONITORING SITES in Tributaries of the San Lorenzo River in 1997-99.

Sampling Site *	Site No.	Juvenile Densities** Y-O-Y's 1997	1998	1999	Yearlings and 2+ 1997	1998	1999
Zayante Creek	#13a		80.0	96.4		3.0	7.6
Zayante Creek	#13b	64.9	43.5	60.6	10.0	7.2	14.3
Zayante Creek	#13c		66.9	50.2		2.1	11.7
Zayante Creek	#13d		77.4	77.7		4.7	27.3
Bean Creek	#14a		43.4	42.0		0.8	39.4
Bean Creek	#14b	60.7	104.3	59.0	12.3	11.3	33.1
Bean Creek	#14c		71.8	6.9		6.4	15.8
Fall Creek	#15	79.6	74.8	68.1	4.9	7.9	16.9
Newell Creek	#16	77.1	67.6	17.7	17.8	8.7	22.8
Boulder Creek	#17a	119.2	141.5	50.7	15.0	7.7	17.8
Boulder Creek	#17b	91.8	68.0	36.2	8.9	6.9	13.3
Boulder Creek	#17c		37.6	15.3		5.2	18.6
Bear Creek	#18a	100.2	72.4	57.9	18.3	7.8	18.1
Bear Creek	#18b		66.6	89.2	18.3	2.9	26.9
Kings Creek	#19a		9.8	0		1.0	0.5
Kings Creek	#19b	48.2	20.8	32.1	4.5	2.1	12.8
Carbonera Creek	#20a	9.1	17.2	13.2	4.3	3.8	5.7
Carbonera Creek	#20b		50.9	40.3		2.5	11.4
Branciforte Creek	#21a	64.6	54.1	35.5	5.4	6.1	11.6
Branciforte Creek	#21b		60.1	44.2		7.6	13.4

* Refer to Table 1c for Site description and Appendix A - Figure 2 for Site Locations.

** Density in number of fish per 100 feet of stream.

Table 53. Average Site Density per Creek for Juvenile Steelhead by SIZE-CLASS in Tributaries of the San Lorenzo River in 1998 and 1999.

Average Site Density per Creek- 1998 and 1999*
(Standard Deviation)

Year/ Size Class	Branciforte	Carbonera	Zayante	Bean	Fall	Newell	Boulder	Bear	Kings
1998/ Y-O-Y	57.1 (3.0)	34.1 (16.9)	67.0 (14.4)	73.2 (24.9)	74.8 NA**	67.6 NA	82.4 (43.6)	69.5 (2.9)	15.3 (5.5)
1999/ Y-O-Y	39.1 (4.4)	26.8 (13.6)	71.2 (17.5)	56.9 (11.4)	68.1 NA**	17.7 NA	34.1 (14.5)	73.6 (15.7)	16.1 (16.1)
1998/ Yearlings	6.9 (0.8)	3.2 (0.7)	4.3 (1.9)	6.2 (4.3)	7.9 NA	8.7 NA	6.6 (1.0)	5.4 (2.5)	1.6 (0.6)
1999/ Yearlings	12.5 (0.9)	8.6 (2.9)	15.2 (7.4)	29.4 (10.0)	16.9 NA	22.8 NA	16.6 (2.3)	22.5 (4.4)	6.7 (6.2)

* Density measured as number of steelhead per 100 feet of stream.

** Not applicable because only one site was sampled in the Creek.

In 12 of 20 tributary reaches, reach densities of Size Class 1 fish declined in 1999 (**Table 54**). Reach densities by size class in 1999 were graphed in **Figure 20a**). Six of 9 stream densities declined (**Figure 20c**). Fifteen of 20 reaches had lower Y-O-Y reach densities in 1999 compared to 1998 (**Table 55**). Reach densities and stream densities by age class were graphed in **Figures 21a-b**. The largest declines were in middle and upper Bean Creek (14b-c), Newell Creek (16), all three reaches of Boulder Creek (17a-c) and lower Bear and Kings creeks (18a and 19a).

Reach Densities of Steelhead =>75 mm Standard Length and the Yearling Age Class in Tributaries

In 5 of 20 tributary reaches, reach densities of Size Classes 2 and 3 fish declined in 1999 (**Table 54; Figure 20b**). Three of 9 stream densities declined (**Figure 20d**). Only 2 of 20 reaches had lower yearling and older reach densities in 1999 compared to 1998 (**Table 55 and Figure 21d**). The only reaches that did not have substantial (more than 50%) increases in yearlings were lower Carbonera, lower Branciforte, lower Kings and middle Bean creeks, and middle Bean increased by a third. The increase in Size Classes 2 and 3 were somewhat less substantial because growth rates were greater in 1998, which allowed more Y-O-Y's to grow into the larger size class in 1998 than 1999 (**Figures 20b and 20d**).

Total Density of Juvenile Steelhead in Tributary Reaches of the San Lorenzo River Drainage.

In 13 of 20 tributary reaches, total juvenile density declined in 1999 compared to 1998 (**Table 54**), and 5 of 9 stream densities declined (**Figure 20e**). Zayante, Fall and Bear creeks had stream densities between 80 and 95 juveniles per 100 feet. Streams with intermediate densities of 35-55 juveniles per 100 feet were Branciforte, Carbonera, Bean, Newell and Boulder creeks. Kings Creek had 20 juveniles per 100 feet.

Table 54. Comparisons of Estimated REACH DENSITY of Juvenile Steelhead Produced by SIZE-CLASS in Tributary REACHES of the San Lorenzo River, 1998-99.

Tributary Sub-Basin	1998 <75mm SL	1998 =>75mm SL	1998 Both Sizes	1999 <75mm SL	1999 =>75mm SL	1999 Both Sizes
21a-b Branciforte	53.3	13.5	66.8	39.2	12.9	52.9
21a	56.1	11.9	68.0	21.4	7.6	29.0
21b	51.2	14.7	65.9	51.9	16.8	68.7
20a-b Carbonera	27.9	13.8	41.7	27.3	8.8	36.1
20a	9.2	11.5	20.8	11.5	5.1	16.6
20b	40.7	15.3	56.0	38.1	11.3	49.4
Branciforte Sub-Basin	43.4	13.6	57.0	34.1	11.2	45.3
13a-d Zayante	59.2	12.6	71.8	69.9	24.9	94.8
13a	73.8	12.9	86.7	91.2	13.7	104.9
13b	34.2	15.2	49.4	52.6	24.1	76.7
13c	57.8	12.8	70.6	45.8	19.6	65.4
13d	73.5	10.6	84.1	82.9	29.4	112.3
14a-c Bean	71.7	6.3	78.1	24.8	16.8	41.6
14a	48.7	3.0	51.7	41.3	3.8	45.1
14b	103.7	11.1	114.8	52.8	29.4	82.2
14c	72.1	6.4	78.6	6.9	18.1	25.0
Zayante Sub-Basin (without Lompico Cr.)	64.8	9.8	71.0	49.6	21.3	70.9
15 Fall	63.4	12.4	75.8	69.5	17.0	86.5
16 Newell	59.1	13.2	72.3	17.7	23.2	40.9
17a-c Boulder	54.9	12.3	67.2	31.7	16.8	48.5
17a	127.7	23.5	151.2	46.5	15.5	62.0
17b	64.0	13.0	77.1	43.5	15.0	58.5
17c	38.7	5.2	43.9	19.3	18.9	38.2
18a-b Bear	69.4	9.0	78.4	67.3	22.1	89.4
18a	73.4	12.0	85.4	51.9	18.8	70.7
18b	65.0	6.0	71.0	83.7	25.5	109.2
19a-b Kings	10.0	8.8	18.8	13.7	6.1	19.8
19a	7.0	8.0	15.0	0	0.5	0.5
19b	13.6	9.7	23.3	30.3	12.9	43.2

Table 55. Comparisons of Estimated REACH DENSITY of Juvenile Steelhead Produced by AGE-CLASS in TRIBUTARY REACHES of the San Lorenzo River, 1998-99.

Tributary Sub-Basin	1998 Y-O-Y	1998 Year-lings	1998 Both Ages	1999 Y-O-Y	1999 Year-lings	1999 Both Ages
21a-b Branciforte	60.6	7.8	68.4	39.2	12.9	52.9
21a	60.4	8.4	68.8	21.4	7.6	29.0
21b	60.8	7.3	68.1	51.9	16.8	68.7
20a-b Carbonera	38.4	3.2	41.6	27.3	8.8	36.1
20a	16.6	3.8	20.4	11.5	5.1	16.6
20b	53.0	2.7	55.7	38.1	11.3	49.4
Branciforte Sub-Basin	51.2	5.8	57.0	34.1	11.2	45.3
13a-d Zayante Creek	65.6	5.6	71.3	72.8	22.1	94.9
13a	84.1	3.0	87.0	97.7	7.4	105.1
13b	35.3	7.5	42.8	57.4	19.2	76.6
13c	65.7	1.9	67.6	52.0	13.9	65.9
13d	80.1	5.4	85.5	83.0	29.5	112.5
14a-c Bean Creek	72.2	5.9	78.1	24.8	16.8	41.6
14a	49.0	1.1	50.1	41.3	3.8	45.1
14b	103.7	11.1	114.8	52.8	29.4	82.2
14c	72.1	6.4	78.5	6.9	18.9	25.8
Zayante Sub-Basin (without Lompico Cr.)	68.6	5.8	74.4	51.2	19.7	70.9
15 Fall Creek	69.6	6.4	76.0	69.5	17.0	86.5
16 Newell Creek	66.2	7.5	73.7	17.7	23.2	40.9
17a-c Boulder Creek	73.5	7.1	80.6	31.7	16.8	48.5
17a	143.0	6.9	149.9	46.5	15.5	62.0
17b	66.3	9.5	75.8	43.5	15.0	58.5
17c	40.2	5.4	45.6	19.3	18.9	38.2
18a-b Bear Creek	73.0	5.0	78.0	67.3	22.1	89.4
18a	78.3	7.0	85.3	51.9	18.8	70.7
18b	67.4	2.8	70.2	83.7	25.5	109.2
19a-b Kings Creek	16.7	1.7	18.4	13.7	6.1	19.8
19a	13.3	1.3	14.6	0	0.5	0.5
19b	20.9	2.1	23.0	30.3	12.9	43.2

Long-term Trends in Tributary Site Densities

Our fall sampling in Zayante Creek in 1989 during drought at two sites averaged 29.7 juveniles/ 100 feet (**Gilchrist 1990**). Total juvenile steelhead densities per 100 feet at our badly sedimented lower Zayante site for 1981 and 1994-96 were 40.9, 37.9, 67.5 and 74.6, respectively. It was 75.2 at upstream Site 13b in 1997, 72.2 when averaged for 4 sites in 1998, and 86.3 when averaged in 1999 (**Table 51; Figure 4d**). In 1970, CDFG sampled Bean Creek at several 100-ft long sites in six, 1-mile sections, averaging 530 "trout"/ km (16.2 trout/ 100 ft) and ranging from 237 trout/ km (8.3 trout/ 100 ft) to 744 trout/ km (22.7 trout/ 100 ft) (**Unpublished CDFG data**). CDFG methods were unspecified. Our fall sampling in Bean Creek in 1989 under drought conditions at two sites averaged 36.2 juveniles/ 100 feet (**Gilchrist 1990**). Total densities per 100 feet at our Bean Creek site for 1981 and 1994-97 were 62.5, 24.2, 97.2, 50.7, and 73.3, respectively. It was 79.3 for three sites averaged in 1998 and 53.6 for the three sites averaged in 1999 (**Table 51; Figure 4d**). In 1970, CDFG sampled Fall Creek and estimated 774 trout/km (23.6 trout/ 100 ft) in the lowermost mile, which encompassed our sampling site, and 517 trout/km (15.8 trout/ 100 ft) in the next 1 mile upstream. Total densities per 100 feet at our Fall Creek Site 15 for 1981 and 1994-99 were 35.7, 37.4, 51.1, 55.9, 80.8, 82.5 and 85.0, respectively (**Figure 4d**). These data indicated no decline in juvenile steelhead densities in the three tributaries of the San Lorenzo from 1970 to 1999, steady improvement in Fall Creek, similar site densities in Zayante Creek in 1996-99 and considerable annual fluctuations in Bean Creek.

Estimate of Juvenile Steelhead Numbers by Reaches- San Lorenzo River Tributaries

Comparison Between Tributaries and the Mainstem. In 1999, the 9 sampled tributaries produced an estimated 102,300 juvenile steelhead, which was approximately 71% of the River system's juvenile population of 144,000 (**Table 49 and 50**). In 1998, the 9 sampled tributaries produced an estimated 110,800 juvenile steelhead, which was approximately 65% of the River system's juvenile population 168,600 (**Table 49 and 50**). In comparing 1998 to 1999, the tributary production of juveniles was down 7.7% in 1999. The watershed's juvenile production was down 14.6%.

<u>Young-of-the-Year Age Class.</u> An estimated 74,500 Y-O-Y juveniles were produced in 9 tributaries in 1999, amounting to 68% of the censused watershed total of 108,800 (**Table 48**). The Zayante (including Bean) and Branciforte (including Carbonera) sub-basins produced an estimated 28,100 Y-O-Y fish (26% of the watershed) and 14,500 Y-O-Y fish (13% of the watershed), respectively (**Figure 21f**). The other 5 tributaries, Fall, Newell, Boulder, Bear and Kings, produced an estimated 31,900 Y-O-Y fish (29% of the watershed) (**Figure 24b**). The relative percentages were similar to 1998 for the watershed.

An estimated 103,600 Y-O-Y juveniles were produced in 9 tributaries in 1998, amounting to 66% of the censused watershed total of 156,100 (**Table 48**). The Zayante (including Bean) and Branciforte (including Carbonera) sub-basins produced an estimated 37,700 (24% of the watershed) and 21,600 Y-O-Y fish (14% of the watershed), respectively (**Figure 21e**). The other 5 tributaries, Fall, Newell, Boulder, Bear and Kings, produced an estimated 44,200 Y-O-Y fish (29% of the watershed).

Comparisons between 1998 and 1999 indicate that Y-O-Y production in 1999 was down 28% from 1998 in the 9 tributaries. The Zayante sub-basin was down 25%. The Branciforte sub-basin was down 33%. The other 5 tributaries were down 28%.

<u>Yearling and Older Age Classes.</u> In 1999, the Zayante and Branciforte sub-basins produced an estimated 10,800 (31% of the watershed) and 4,700 yearling and older fish (13% of the watershed), respectively (**Table 48; Figure 25b**). The other 5 tributaries, Fall, Newell, Boulder, Bear and Kings, produced an estimated 12,400 yearlings and older (36% of the watershed), making 27,900 approximated in the tributaries and constituting 79% of the 35,200 yearlings in the San Lorenzo drainage and 27.3% of the juveniles in the tributaries. Yearlings made up 17.5% of the mainstem juveniles in 1999.

In 1998, the Zayante and Branciforte sub-basins had produced an estimated 3,165 (21% of the watershed) and 2,453 yearling and older fish (16% of the watershed), respectively (**Table 48; Figure 25a**). The other 5 tributaries, Fall, Newell, Boulder, Bear and Kings, produced an estimated 3,786 yearlings and older (25% of the watershed), making 9,400 approximated in the tributaries and constituting 63% of the 14,900 yearlings in the San Lorenzo drainage and 8.3% of the juveniles in the tributaries. Yearlings made up 9.5% of the mainstem juveniles in 1998.

Comparisons between 1998 and 1999 indicated that yearling production in tributaries in 1999 increased 197% from 1998. In the Zayante sub-basin, yearling production increased 241% (from 21 to 31% of the watershed). In the Branciforte sub-basin, yearling production increased 88.5% (from 16 to 13% of the watershed). In the other 5 tributaries, yearling production increased 228% (from 25 to 36% of the watershed).

In comparing relative numbers of age classes in tributaries in 1999, 72.7% were Y-O-Y's and 27.3% were yearlings and older (**Table 48; Figure 27a**). In 1998, 91.7% were Y-O-Y's and 8.3% were yearlings and older (**Figure 27b**).

Size Class 1. In tributaries in 1999, 71.9% of juveniles were in Size Class 1 and 28.1% were in Size Classes 2 and 3 (**Figure 27c**). In 1998, 82.8% had been in Size Class 1 and 17.2% were in Size Classes 2 and 3 (**Figure 27d**).

In 1999, the 9 sampled tributaries produced 73,600 Size Class 1 fish, which was approximately 81% of this size group in the censused watershed (**Table 49**). This was four times the number produced in the mainstem. In 1999, the Zayante and Branciforte sub-basins produced an estimated 27,200 (30% of the watershed) and 14,400 Size Class 1 fish (16% of the watershed), respectively (**Figure 22b**). The other 5 tributaries produced 31,900 fish (35% of the watershed). These were similar percentages to those in 1998.

In 1998, the 9 sampled tributaries had produced 91,700 Size Class

1 fish, which was approximately 75% of this size group in the censused watershed (**Table 49**). This was nearly three times the number produced in the mainstem. In 1998, the Zayante and Branciforte sub-basins produced an estimated **35,600** (29% of the watershed) and **18,300** Size Class 1 fish (15% of the watershed), respectively (**Figure 22a**). The other 5 tributaries produced **37,700** fish (31% of the watershed).

In comparing 1998 to 1999, in 1999 the tributary production of Size Class 1 was reduced 19.8%. Production in the Zayante sub-basin was reduced 23.6%. Production in the Branciforte sub-basin was reduced 21.3%. Production in the other 5 tributaries was reduced 15.4%.

<u>Size Classes 2 and 3.</u> In 1999, an estimated **28,700** Size Class 2-3 juveniles were produced in the 9 sampled tributaries, which was approximately 54% of the this size group in censused watershed (**Table 49**). In 1999, the Zayante and Branciforte sub-basins produced an estimated **11,700** (22% of watershed production) and **4,700** Size Class 2-3 fish (9% of production), respectively (**Figure 23b**). The other 5 tributaries produced **12,300** fish (23% of production). The Zayante sub-basin produced a much greater proportion of these large fish than in 1998, while the Branciforte sub-basin and the other 5 tributaries taken as sub-unit produced smaller proportions.

In 1998, an estimated **19,000** Size Class 2-3 juveniles were produced in the 9 sampled tributaries, which was approximately 40% of the this size group in the censused watershed (**Table 49**). In 1998, the Zayante and Branciforte sub-basins produced an estimated **5,400** (12% of watershed production) and **5,800** Size Class 2-3 fish, respectively (13% of production) (**Figure 23a**). The other 5 tributaries produced **8,000** fish (17% of production).

In comparing 1998 to 1999, Size Class 2-3 production increased 46% in 1999. Production increased 117% in the Zayante Creek sub-basin. Production decreased 19% in the Branciforte sub-basin. Production increased 54% in the 5 remaining tributaries.

DISCUSSION

Mainstem's Juvenile Numbers and Habitat Conditions

As a whole, mainstem production of Y-O-Y's was much reduced in 1999 (34,300) compared to 1998 (52,500) and 1997 (81,300). Yearling numbers were increased in 1999 (7,300) compared to 1998 (5,500) and less than 1997 (8,400). The high proportion of yearlings maintained the mainstem production of larger juveniles => 75 mm SL in 1999 (24,100) to near 1998 (26,600) and 1997 levels (24,800), despite the fewer Y-O-Y's in 1999. Closer evaluation of the three sub-units of the mainstem, the lower, middle and upper, indicated that 1999 Y-O-Y production and numbers of larger juveniles were similar to 1998 except for precipitous declines in the middle River. A more detailed examination and explanation will follow.

Lower River. Young-of-the-Year numbers were similar in the lower River in 1998 (15,700) and 1999 (15,000). These numbers were both off compared to 1997 (22,500). Y-O-Y production in Reach 2 was off considerably in 1999, but was made up for in Reaches 1 and 4. Yearlings production was nearly double in 1999 (2,100) over 1998 (1,100) in the lower River. It was up 5 times in Reach 1 in 1999, and was greater than in 1998 except in Reach 2 of the lower River. Numbers of larger juveniles in the => 75 mm SL range were similar in 1997 (14,400), 1998 (14,700) and 1999 (15,900) in the lower River, with smaller juveniles <75 mm SL less in 1999 (1,700) than 1998 (2,100) due to the fewer Y-O-Y's present. This indicated that the carrying capacity for the valuable larger juveniles remained in the 14,000-16,000 range over the three years. There were many more small juveniles in the lower River in 1997 (9,000), presumably because of more spawning there, more escape cover, and the slower growth rate then, with reduced streamflow.

Juvenile densities in pools were much reduced in 1999, presumably due to the reduced streamflow and fastwater habitat at the heads of pools. Riffles and runs were heavily used in all reaches except for Reach 2. The decline in Reach 2 cannot be easily explained by examining habitat changes. It is likely that spawning effort and/or success was off in Reach 2 in 1999. Riffles in Reach 2 had more escape cover, while runs had less in 1999. Riffle embeddedness increased substantially in Reach 2, but it had also in Reach 1, which had many Y-O-Y's. Another possibility was that Reach 2 suffered angling pressure in summer of 1999.

Middle River. The middle River experienced a substantial reduction in Y-O-Y production in 1999 (12,600) compared to 1998 (31,100) and 1997 (33,000). Reach 6 had more Y-O-Y's in 1999, but Reaches 7-9 had less than half the number present in 1997 and 1998. The number of yearlings were more similar in 1999 (1,800) and 1998 (2,100), but 1997 had many more (3,600). The number of yearlings was greater in Reaches 6 and 7 in 1999, but less in Reaches 8 and 9 compared to past years. Numbers of larger juveniles (=> 75 mm SL) were half in 1999 (4,300) what they were in 1998 (8,500) and also less than in 1997 (7,000). The greatest reduction was seen in Reaches 8 and 9.

The severely reduced juvenile numbers in Reaches 8 and 9 in 1999 were likely due in part to reduced spawning and reduced egg survival. Besides that, there was deterioration in habitat quality brought on by reduced streamflow that reduced fastwater feeding areas in heads of pools and much reduced width. Reduced streamflow and added sediment to the middle River contributed to reduced depth in pools, with the reach average depth declining from 3.5 to 2.7 feet (23% decline) in Reach 8 and from 2.2 to 2 feet (9% decline) in Reach 9. Average maximum pool depth by reach declined from 6.2 to 5 feet (19%) decline) in Reach 8 and from 4.6 to 3.6 feet (22% decline) in Reach 9, indicating increased sedimentation. Pools were deeper in 1997 than 1999, despite the reduced streamflow that year. Average reach depth in riffles of Reach 8 declined from 1.2 to 0.7 feet (42% decline) in 1999, and average maximum riffle depth declined from 1.7 to 1.2 feet (29% decline). Average riffle depth at Site 8 in Reach 8 declined from 1.1 feet in 1998 to 0.8 feet (27% decline) in 1999, and the riffle width declined from 30 to 20 feet (33% decline). This riffle was shallower in 1997, but had less sand and significantly more escape cover.

Other indications of poorer habitat in the middle River was that escape cover in riffles was much less in Reach 8 in 1999. Escape cover in runs was much less in Reach 9. For example, the riffle traditionally sampled in Reach 8 had 49 feet of escape cover in 103 feet of stream in 1998 and only 9 feet of cover in 94 feet of stream in 1999. Woody debris was present in 1998 but was absent in 1999. The percent sand in riffles increased in Reach 9 and remained the same in Reach 8. There was more sand in runs of Reach 8, while it remained constant in Reach 9. There was much less fine sediment in 1997. Riffle/run embeddedness increased in Reaches 8 and 9 in 1999. For example, at Site 8 in Reach 8, riffle and run embeddedness increased from 35 and 40%, respectively, in 1998 to 40 and 50% in 1999. There was substantially less riffle habitat in all middle River Reaches 6-9, which was where juvenile densities were the highest. Run habitat decreased in Reaches 8 and 9.

Upper River. The upper River above the Boulder Creek confluence had not recovered from the onslaught of sediment entering the mainstem in 1998. Y-O-Y production above Boulder Creek increased in 1999 (6,800) from 1998 (5,800), but was far below the 1997 level (25,800). The 1999 improvement came from Reach 11 production, with Y-O-Y production reduced in Reaches 10 and 12. An illegal dam was discovered in Reach 12, which may have restricted adult access to Waterman Gap for spawning. The number of yearlings in the upper River increased in 1999 (3,400) over 1998 (2,200) and was similar to 1997 (3,400). In 1999, production in Reach 10 declined and increased in Reaches 11 and especially 12.

Production of larger juveniles (=> 75 mm SL) was somewhat greater in 1999 (3,900) than 1998 (3,500) and 1997 (3,400). The more similar numbers of larger juveniles in 1998 and 1999, despite the fewer yearlings in 1998, resulted from the faster growth rates in 1998 of Y-O-Y fish, with the increased streamflow. Reach 12 produced many more larger juveniles in 1999 than 1998.

Habitat in the upper River did not seem to improve in 1999 to explain higher production of larger juveniles. Riffle/run embeddedness worsened in 1999. Percent sand in riffles declined slightly in Reach 11 (25 to 20%). Percent sand in pools declined in all three Reaches by 5 to 10%. The escape cover in sa pools increased in Reaches 11 and 12, which may explain higher estimates of larger juveniles in those reaches. I general, escape cover in pools increased only slightly i 10 and 11 and declined in Reach 12 in 1999. Reach 12 had more pool cover in its short pools than Reaches 10 and 1 their long pools. In 1997, all upper River riffles at sampled sites had more cover than succeeding years. Sampled pools in Reaches 10 and 12 had more cover in 1997. In 1999, average and maximum pool depth declined in Reaches 11 and 12 by 0.2 and 0.3 feet, respectively. Riffle depth in Reach 11 was 0.2 feet shallower in 1999. Pool depth was greater in 1997 in Reaches 10 and 11 compared to succeeding years.

Branciforte Creek Numbers and Habitat Conditions

Branciforte Creek had fewer Y-O-Y steelhead in 1999 (9,500) than in 1998 (14,800) and more yearlings in 1999 (3,100) versus 1998 (1,900), though the disparity was less than in most other tributaries. Because of the more rapid growth rate during the high flow 1998 year, there were actually fewer larger juveniles (=> 75 mm SL) in 1999 (3,100) than 1998 (3,300), which was unique to the Branciforte sub-watershed in 1999.

Though no significant changes in pool depth were detected in 1999, streambed conditions deteriorated with increased sedimentation in the lower reach and reduced escape cover in the upper reach, where comparisons were possible. Comparisons of escape cover by reach for 21a were unavailable. Percent sand in riffles increased in the lower Reach 21a from 20 to 25%, but declined in 21b from 30 to 20%. The embeddedness in riffles and runs of 21a increased from 38 to 55% in 1999 and declined in 21b from 43 to 37%. Percent sand in run habitat in 21a increased from 25 to 35% and in step-runs in 21b from 40 to 55%, a significant deterioration. The pool embeddedness at sampling Site 17a increased from 65 to 100% (all sand), though the reach percent sand in pools remained constant between 1998 and 1999 at 50%. Percent sand in pools in Reach 17b declined from 65 to 50%. Average pool depth increased slightly in Reach 21a in 1999, but remained constant in 21b. Maximum pool depth increased in 21a and declined in 21b in 1999. The cover index at sampled runs/step-runs declined at both sites, though slightly at 21b. Escape cover by reach declined substantially in step-runs of Reach 21b from 0.4 feet per foot of stream in 1998 to 0.01 foot per foot of stream in 1999. The cover index in sampled pools declined at both sites in 1999, and by more than half at Site 21a. The overhanging willows and woody debris had diminished. Escape cover by reach in pools declined by nearly 50% in Reach 21b, which would correspond to the fewer large juveniles in the Creek in 1999.

Carbonera Creek Numbers and Habitat Conditions

The Y-O-Y steelhead production in Carbonera Creek declined in 1999 (4,900) compared to 1998 (6,900), while yearlings increased in 1999 (1,500) over 1998 (550). The reduced disparity in Y-O-Y's between the years compared to other tributaries, was seen in Carbonera as in Branciforte Creek in 1999. And, as in Branciforte, production of valuable, larger juveniles (=> 75 mm SL) was actually higher in 1998 (2,500) than 1999 (1,600), despite the fewer yearlings in 1998. The growth rate of Y-O-Y's in 1998 with higher baseflow was impressive compared to 1999.

Although more large juveniles used Carbonera Creek in 1999, habitat quality worsened. The embeddedness in riffle and run/step-run habitat at sampling sites worsened from 38 to 50% at Site 20a and from 35 to 40% at Site 20b. The percent sand in run/step-run habitat in Reach 20b increased from 30 to 55%. The percent sand in the lowermost, sampled pool at Site 20b in 1999 was 70% compared to 50% in 1998. The average percent sand in pool habitat of Reach 20b increased from 30% in 1998 to 70% in 1999. Accordingly, percent embeddedness in pools sampled at both Carbonera sites worsened in 1999 from 40 to 60% at 20a and 50 to 65% at 20b. The average depth in pools declined 0.1 foot in the lower reach, as would be expected. For the important escape cover index, it declined substantially in the traditionally sampled step-run at Site 20b. The cover index in pools at both sampling sites declined in 1999, as did the reach index for pools in 20b. A cover comparison between years was unavailable for Reach 20a.

Zayante Creek Numbers and Habitat Conditions

Unlike the mainstem River and other tributaries, Zayante Creek had higher Y-O-Y steelhead production in 1999 (22,000) than in 1998 (19,800). It had 4 times the production of yearlings in 1999 (6,700) compared to 1998 (1,700). Y-O-Y densities were greater in 3 of 4 Zayante reaches, excepting Reach 13c. Yearling densities were substantially higher in 1999 in all reaches and 6 times more dense in Reach 13d. Densities of larger juvenile Size Classes 2 and 3 were greater in all four Zayante reaches in 1999 (7,500), especially the upper Reach 13d, compared to 1998 (3,800). The disparity between years was less so than for yearlings. The high growth rates of Y-O-Y's in 1998 boosted that year's production of larger juveniles.

The much greater number of yearlings and larger juveniles present in 1999 than 1998 was probably largely due to abnormally low proportion of 1997 Y-O-Y's that needed to stay over another year before smolting. A high number of Y-O-Y fish of 1997 likely either got flushed out with high 1998 storm events or grew sufficiently in spring of 1998 to leave prior to censusing in 1998. In 1999, with less streamflow, Y-O-Y's from 1998 stayed another spring and summer as yearlings and were censused in fall, 1999.

There was not substantial habitat improvement in Zayante Creek in 1999 to warrant the much higher densities of larger juvenile steelhead. Escape cover did improve, however, which provided more habitat for larger juveniles. Improvements included more escape cover in pools sampled in Reaches 13b-d. Pool cover improved by reach in Reaches 13b-d, especially 13b, which had considerable overhanging willows. Pool cover declined in Reach 13a. The proportion of pool habitat increased in all reaches. Riffle cover increased in Reaches 13a and 13d, and riffle habitat was important in 13a. Cover in run/step-run habitat improved in Reaches 13b and 13d, though the step-run sampled in 13d in 1999 had less cover than the one in 1998.

Evidence of increased sedimentation in Zayante Creek came from higher percent sand in runs in Reaches 13a, 13b and 13d in 1999. Riffle embeddedness was increased at Sites 13a and 13b. There was much more percent sand in riffles of Reaches 13b and 13c. Pools were shallower in the lower three reaches (13a-c) and remained constant in the fourth. Percent sand in pools was similar between 1998 and 1999. Average maximum pool depth was reduced in all four Zayante reaches. Some of this reduction may have been due to reduced streamflow in 1999.

Bean Creek Numbers and Habitat Conditions

Y-O-Y steelhead production was considerably reduced in 1999 (6,100) compared to 1998 (17,900). Disparities were most apparent in the upper Reach 14c, where streamflows were most reduced. However, as in Zayante Creek, yearling numbers were much greater in 1999 (4,200) versus 1998 (1,500) in all three reaches. Y-O-Y's produced in 1997 probably smolted early and left in Spring, 1998, with the high spring flows allowing more rapid growth than in Spring 1999. Y-O-Y's produced in Spring, 1998, benefited from a summer of high streamflow for improved growth that would allow early smolting of the larger ones in Spring, 1999. However, there was a wide range of Y-O-Y sizes in Fall, 1998, causing a substantial proportion of them to apparently hold over as yearlings in 1999. With the high number of yearlings in 1999, the production of larger juveniles (=> 75 mm SL) (4,200) was greater than in 1998 (1,600). The high density of yearlings may have also suppressed Y-O-Y densities in 1999. In the lower baseflow year of 1997, there were more Y-O-Y's and fewer yearlings at the middle Site 14b, compared to 1999.

Habitat conditions worsened in Bean Creek in 1999. Escape cover was much reduced in Reaches 14a-b. At the traditional sampling site in Reach 14b, pool escape cover was at an three-year low. Riffle embeddedness increased in all three reaches, as well. The upper reach (14c) had better substrate conditions in 1999 than 1998, but the habitat-typed segment was further upstream in 1999. Our survey of streambank erosion in Bean Creek, 1999, detected 9 erosion sites (569 feet) in Reach 14a, 7 erosion sites (391 feet) in Reach 14b, and 40 erosion sites (2,567 feet) in Reach 14c.

There were 33 erosion sites between the 1998 sampling site in Reach 14c and the 1999 sampling site upstream. Percent sand in riffles was similar in the lower two reaches between the years, but much less in the new segment surveyed in Reach 14c in 1999. Run habitat had less percent sand in all three reaches in 1999. Pools in the lower two reaches had the same percent sand, with less in pools of the more upstream segment of Reach 14c in 1999.

Average pool depth by reach declined 0.1 foot in Reach 14a and remained constant in the upper two reaches. Average maximum pool depth remained constant in the lower reach and deepened 0.1 foot in Reach 14b, despite the reduced 1999 baseflow. This was an improvement, but escape cover was a more important variable in this shallow stream, and it declined. Sampled pools at Site 14b had the deepest average depth in three years, but maximum depth was the least in 3 years. The proportion of pools increased substantially in Reach 14a in 1999 (31 to 51%), and densities of Y-O-Y's and yearlings were higher there than in riffles. Riffles increased as runs decreased in proportion, and Y-O-Y's were more abundant in riffles. The proportion of pools increased in Reach 14b (59 to 66%), and Y-O-Y's and yearlings were much more abundant there than in other habitats. The proportion of pools in Reach 14c were similar between the years.

Fall Creek and Habitat Conditions.

Y-O-Y steelhead production in Fall Creek in 1999 (5,800) was nearly identical to 1998 (5800), with nearly three times the number of yearlings, 1,400 versus 500. However, in 1999 the growth rate was less, with no Y-O-Y's reaching the larger juvenile size classes. In 1998, 500 Y-O-Y's grew into the larger size class, making the 1998 estimate of Size Class 2 and 3 juveniles 1,000 compared to the 1,400 in 1999. So there were more fish and more larger fish in Fall Creek in 1999.

With respect to habitat conditions in Fall Creek, substrate conditions deteriorated and habitat depth declined. Riffle and run embeddedness was substantially worse in 1999, increasing from 35 to 48%. Pool embeddedness worsened from 40 to 55 %. The percent sand increased form 35 to 40% in 1999, while in runs it remained constant at 55%. Percent sand in pools increased from 50 to 65%. Though substrate conditions degraded in 1999, escape cover in sampled riffle improved substantially. Average pool depth by reach declined from 1.3 to 1.1 feet while average maximum pool depth increased from 1.8 to 1.9 feet. These changes were not substantial. Aspects of habitat that would increase juvenile densities included increased cover in the sampled riffle at the sample site in 1999. The cover index in the sampled run improved slightly. But the escape cover in the sampled pools declined considerably. Reach comparisons for escape cover were unavailable. The proportions of pools and runs increased in 1999, and juvenile densities were greater in these habitat types compared to riffle habitat, which declined substantially in 1999.

Newell Creek Numbers and Habitat Conditions

Newell Creek's composition of juvenile steelhead age/size classes was consistent with most tributaries, having reduced Y-O-Y production in 1999 (1,000) compared to 1998 (3,600). Yearling production was much higher in 1999 (1,300) versus 1998 (400). Though fewer fish inhabited the Creek in 1999 (2,100 versus 4,000 in 1998), there were more large juveniles => 75 mm SL predicted in 1999 (1,100) than in 1998 (700) due to the many yearlings.

Newell Creek habitat did not change much from 1998 conditions. Riffle substrate remained at the same embeddedness in 1999 as in 1998, with a 5% increase in percent sand. Percent sand in runs was unchanged. Embeddedness in pools declined 5%. Percent sand in pools increased 5%. Average pool depth by reach declined from 1.7 to 1.5 feet, but average maximum depth increased from 2.6 to 2.8 feet. Cover comparisons were unavailable except that the sampled pool in 1999 had slightly more escape cover than sampled pool in 1998. The proportion of pools declined slightly and the proportion of runs increased slightly in 1999. Most large juveniles inhabited the pools in 1999.

Boulder Creek Numbers and Habitat Conditions

Boulder Creek had the typical decline in Y-O-Y steelhead seen in most other tributaries from 1998 (13,400) to 1999 (5,800), with the typical increase in yearlings from 1,300 in 1998 to 3,100 in 1999. The largest drop in Y-O-Y's occurred in lower Reach 17a, where densities went from 143 Y-O-Y's per 100 feet to 45 Y-O-Y's per 100 feet. But the yearlings increased from 7 to 15 fish per 100 feet in 17a. Reach 17c had the largest increase in yearlings from 7 to 19 fish per 100 feet in 1999. The disparity between years in larger juveniles was less because of the high growth rates in 1998 associated with high baseflows. In 1999 only the yearlings (3,100) were => 75 mm SL, while in 1998 there were 2,200 larger juveniles, meaning that 900 Y-O-Y's grew into the larger size in 1998.

The habitat value in lower Boulder Creek deteriorated in 1999. The percent sand in riffles increased from 25 to 30% in Reaches 17a-b. The percent sand in runs/step-runs increased in Reaches 17a from 25 to 35% and in 17c from 20 to 35%, with an improvement in 17b where it declined from 45 to 30% in 1999. The percent sand increased in 17a pools from 45 to 60%, with improvement in upper reaches. The escape cover in sampled riffles of Reaches 17a and 17b declined substantially with the added sand. The reach index of cover declined in both reaches, as well. Though the escape cover in the sampled run/step-run habitat in 17a improved in 1999, the reach escape cover index declined by more than half. Escape cover in run/step-run habitat in the upper two reaches improved, particularly in 17c. The escape cover in all sampled pools in Boulder Creek declined in 1999, representing a steady 4 year decline at Sites 17a and 17b since 1996. The reach-wide escape cover index for pools in Reach 17a went from the best tributary rating of 1.1 feet of cover per foot of stream to an abysmal 0.05 feet of cover per foot of stream in 1999. Reach cover in pools of 17c also declined, but cover increased in the middle Reach 17b.

Improvement in Boulder Creek habitat included slightly increased average pool depth in Reach 17a, though pools were already adequately deep. It declined in Reach 17b and at traditionally sampled Sites 17a and 17c. Maximum depth at Sites 17a and 17c also declined in 1999. Average maximum depth increased notably in Reach 17a from 3 to 3.5 feet and in Reach 17c from 2.7 to 4.2 feet (different segment surveyed in 1999). It declined slightly in Reach 17b. The proportion of pools declined in Reach 17a, while run/step-run habitat increased from 13.1 to 24.2%. This was an improvement because more Y-O-Y's and yearlings used run/step-run habitat in 1999 than pool habitat in Reach 17a.

Bear Creek Numbers and Habitat Conditions

Bear Creek had more similar Y-O-Y production of steelhead in 1999 (16,700) to 1998 (18,100) than was observed in other tributaries except Zayante Creek. The yearling production in 1999 (5,500) was much greater than in 1998 (1,200), resulting in many more large juveniles (=> 75 mm SL) in 1999 (5,500) versus 1998 (2,250). More juveniles were present in 1999 than 1998. Improvement in juvenile production resulted from higher numbers in the upper reach, where 60% of the Y-O-Y's and 56% of the yearlings were produced.

Habitat conditions improved in Bear Creek in 1999. Major streambank erosion had occurred just downstream of the Boulder Creek Country Club in 1998, and some sediment appeared to have moved out by 1999 into the mainstem. Embeddedness in riffle/step-run habitat at sampling sites improved at the lower Site 18a from 43 to 38% and increased slightly at Site 18b. Reach averages for percent sand in riffles decreased from 20 to 15% in Reach 18a and from 30 to 20% in Reach 18b in 1999. Percent sand in run/step-run habitat by reach also declined in Reach 18b from 50 to 25% and remained unchanged in Reach 18a at 10%. An exception to this rosy picture of improvement was increased percent sand in pools of Reach 18a from 75 to 90% and increased embeddedness in the sampled pool at Site 18a from 50 to 65% in 1999. Percent sand in pools remained constant in Reach 18b at 70%. Average pool depth increased a 0.1 foot in Reach 18a, despite reduced streamflow, and remained constant in Reach 18b. Average maximum depth improved from 3 to 3.6 feet in Reach 18a in 1999, but declined 0.3 feet in Reach 18b. The cover index for riffle habitat in Reach 18b improved in 1999, as it did slightly for step-run habitat. The escape cover index for pools increased at both sampling sites and for overall pool habitat in Reach 18b. Cover comparisons for Reach 18a were unavailable between years.

Kings Creek Numbers and Habitat Conditions

Kings Creek steelhead followed the pattern of most tributaries with reduced Y-O-Y production in 1999 (2,700) than 1998 (3,300), with more yearlings holding over in 1999 (1,200) than 1998 (300). However, the production of larger juveniles (=> 75 mm SL) was less in 1999 (1,200) than 1998 (1,700) because no Y-O-Y's grew into the larger size class in 1999 and 1,400 did in 1998 with the higher streamflow.

The already poor habitat conditions present in 1998 had worsened in 1999, restricting the survival of yearlings in 1999. At the sampling Site 19b in 1999, riffle/step-run embeddedness increased slightly from 38 to 40%. Percent sand in riffle habitat increased in Reach 19b from 15 to 20%. Percent sand in step-run habitat increased in Reach 19b from 25 to 35%. The percent sand in pool habitat increased significantly in Reach 19a from 50 to 85% and in Reach 19b from 65 to 95%. Correspondingly, average pool depth in Reach 19a decreased from 1.5 to 0.8 feet (indicating considerable pool filling) in 1999 and decreased from 1.3 to 1.1 (less dramatic) in Reach 19b. Average maximum pool depth remained constant in Reach 19a at a relatively shallow 1.5 feet and declined 0.1 foot in the upper Reach 19b. The reach escape cover index for riffle habitat in 19b declined from 0.18 feet per foot in 1998 to 0.07 feet per foot in 1999. The cover in the sampled step-run declined slightly at Site 19b in 1999, but the reach index for run/step-run habitat declined from 0.16 to 0.04 in Reach 19b in 1999. Though the pool escape cover at sampling Site 19b increased slightly in 1999, the reach's escape cover index for pools declined somewhat in 1999.

Assumptions Associated with Determining the Adult Index

The estimated number of returning adults from the Dettman model was probably high before the 50% reduction was factored in. We have no data to indicate the actual survival rates of smolts to adulthood or the percent of repeat spawners. But for comparison purposes, the model provided insight, assuming the return rate has not changed significantly from 1981 to 1999. This assumption appeared reasonable until 1999, based on return rates over the years at the Mad River hatchery for marked adult steelhead returns (**Table 58**). Data from 20 years of marking hatchery-planted yearlings in the Mad River and enumerating returning marked adults indicated no overall trend in return rate, though there were annual fluctuations. The return rates in the early 1970's were about the same as in the late 1980's. However, the sharp decline in Y-O-Y numbers in portions of the mainstem and in most tributaries in 1999, without substantial habitat deterioration, may indicate an atypical drop in adult returns.

Smith detected much reduced steelhead Y-O-Y densities in Scott and Waddell creeks in 1999 (**Smith 1999**). However, In Scott Creek they were similar to 1997 levels when streamflow was similar. He also attributed low densities to suppression by coho salmon competition. Coho competition was used to explain the decline in Waddell Creek, where he noted that combined densities of steelhead and coho juveniles were similar between 1998 and 1999 at some sampling sites.

Survival of steelhead eggs was probably higher in 1999 than in 1996-1998. This is because fewer bankfull events occurred in 1999 that may have scoured steelhead redds. Poorer egg survival may have occurred in 1998 in some reaches compared to other recent years due to scouring and/or smothering of nests with sediment during the much higher peak stormflows of 1997-98 (**Figures 57-60**). Bankfull discharge is typically considered to reoccur every 1.5 years (recurrence interval). Bankfull discharge is the minimum flow thought to have channel forming capabilities, and may be the approximate flow when spawning beds begin to wash away or become smothered with sediment.

For the San Lorenzo River, the flood flow with a recurrence interval of 1.5 years at the Felton Big Trees Gage is 4,300 cfs, based on the flood flow frequency analysis using the Gumbell

Extreme Value Method for 60 years of data from 1937 through 1996. A flood frequency analysis done on the Russian River at three locations concluded that the estimated flood frequency corresponding to bankfull discharge was different for each site; 1.3, 1.7 and 2 years (**Williams and Associates 1997**). On the San Lorenzo River the flood flow of 2,800 cfs had a 1.3 recurrence interval, may be within the range of the estimated bankfull event.

In the 1999 water year, only one storm event produced a bankfull event capable of scouring steelhead redds at potentially a significant level (**Figure 60**). It occurred in early February. On the other hand, in 1998 there were at least 4 bankfull events occurring in January and February (**Figure 59**). In 1997 there were 4 bankfull events in December and January (**Figure 58**). In 1996 there were 5 bankfull events between mid-January and mid-March.

Historical data available on trapping of adult steelhead on the San Lorenzo River have been summarized (**Table 59**) for comparison with our estimates of adult returns. Numbers are not directly comparable because egg-taking stations were on the mainstem in Brookdale and Boulder Creek above several tributaries in the 1930's and 1940's (**Appendix A**) and we do not know the duration of trapping each year. Some spawners went up these tributaries or spawned in the mainstem below the egg-taking stations in the past. The largest downstream tributary, Zayante Creek, has been estimated to contain 18% of the salmon and steelhead habitat in the San Lorenzo Drainage (**Ricker and Butler 1979**) and coincidentally constituted 19% of the channel miles assumed to be inhabited by steelhead in this study (**Table 57**). The Zayante Creek sub-basin will produce an estimated 22.6% of the adult returns from 1999 juveniles (**Table 57**).

The trap at the Felton Diversion Dam is below the Zayante Creek confluence (**Appendix A**), but upstream of the Gorge. Some adults spawn in the Gorge and Paradise Park, with juveniles contributing to 25% of the adult returns from 1999 juveniles (676 adults). The Branciforte sub-watershed would contribute to another 9.6% of the adult returns from 1999 juveniles (257 adults). The Felton trap was inoperative during stormflows that forced the dam to

Table 59. Historical Adult Steelhead Trapping Data from the San Lorenzo River With Recent Estimates of Adult Returns.

Trapping Year	Trapping Period	Number of Adults	Location
1934-35	?	973	Below Brookdale (1)
1938-39	?	412	Below Brookdale (1)
1939-40	?	1,081	Below Brookdale (1)
1940-41	?	671	Boulder Creek (2)
1941-42	Dec 24 - Apr 11	827	Boulder Creek (2)
1942-43	Dec 26 - Apr 22	624	Boulder Creek (3)
1976-77	Jan-Apr	1,614	Felton Diversion (4)
1977-78	Nov 21 - Feb 5	3,000 (Estimate)	Felton Diversion (4)
1978-79	Jan-Apr	625 (After drought)	Felton Diversion (4)
1979-80	Jan-Apr ?	496 (After drought)	Felton Diversion (4)
1982-83		1,506	Alley Estimate from 1981 Mainstem Juveniles only
1994-95	6 Jan-21 Mar (48 of 105 days-Jan-15 Apr)	311 (After drought)	Felton Diversion (5) Monterey Bay Salmon & Trout Project
1996-97		1,076	Alley Estimate from 1994 Mainstem Juveniles only
1997-98		1,784	Alley Estimate from 1995 Mainstem Juveniles only
1998-99		1,541	Alley Revised Estimate from 1996 Mainstem Juveniles only
1999-2000	17 Jan-10 Apr	532 (above Felton)	Felton Diversion (5)
1999-2000		1,308	Alley Estimate from 1997 Mainstem Juveniles only
2000-01		2,468	Alley Estimate from 1998 Mainstem and 9 Tributary's Juveniles
2001-02		2,669	Alley Estimate from 1999 Mainstem and 9 Tributary's Juveniles

(1) Field Correspondence from Document # 527, 1945, Div. Fish and Game.
(2) Field Correspondence from Document #523, 1942, Div. Fish and Game.
(3) Inter-office Correspondence, 1943, Div. Fish and Game.
(4) Kelley and Dettman (1981).
(5) Dave Strieg, Big Creek Hatchery Manager, pers. comm. 1995.

CONCLUSIONS

The sharp decline in Y-O-Y numbers in the middle River and most tributaries in 1999, may indicate a decline in adult returns in 1998-99 compared to recent years. Other factors leading to reduced Y-O-Y's were probably reduced survival of Y-O-Y's resulting from less fastwater feeding habitat and shallower conditions resulting from less streamflow in 1999. However, mainstem Y-O-Y numbers were much greater in 1997 than 1999, even though baseflows were less (Figures 55-56). The difference between the two years was that in 1999, much less escape cover existed in most mainstem reaches, and substantially more sand was present in mainstem riffles and runs/step-runs. Embeddedness in riffles and runs was greater in most mainstem and tributary reaches compared to 1998, leading to less escape cover and insect productivity.

Sampling results in 1999 indicated that production of young-of-the-year steelhead declined in the Rincon reach (2) of the lower mainstem, in the Ben Lomond to Boulder Creek reaches (7-9) of the middle River and much of the upper mainstem except in Reach 11 from the Kings Creek confluence to Forest Grove. This was likely due to fewer spawners, reduced habitat associated with more fine sediment, less escape cover and more competition from the much higher number of yearlings present in the mainstem in 1999. Large and small woody debris that provided cover in 1998 was reduced in Reach 1 of Paradise Park, in Reach 4 of upper Henry Cowell Park, in Reach 5 below the Zayante Creek confluence and in in Reach 6 near the Fall Creek confluence.

Escape cover was reduced in most tributary reaches in 1999, providing another reason for fewer Y-O-Y's. However, in the two tributaries that had more escape cover in 1999, Zayante and Bear creeks, there were 3.9 and 3.5 times the number of yearlings, respectively, compared to 1998. All tributaries had at least a predicted doubling of yearlings in 1999 except for Branciforte Creek. Slower growth rates over the 1998-99 winter and spring of 1999 caused more Y-O-Y's to stay another growing season rather than smolt in spring 1999, contrary to what had occurred the previous spring of 1998 with higher streamflow and growth rates.

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Table 1a. Defined Reaches on the Mainstem San Lorenzo River. (Refer to Appendix A for map designations.)

Reach #	Reach Boundaries	Reach Length (ft)
1	Highway 1 to Buckeye Trail Crossing CM1.92 - CM4.73	14,837
2	Buckeye Trail Crossing to the Upper End of the Wide Channel Representation on the Felton USGS Quad Map CM4.73 - CM6.42	8,923
3	From Beginning of Narrow Channel Representation in the Gorge to the Beginning of the Gorge (below the Eagle Creek Confluence) CM6.42 - CM7.50	5,702
4	From the Beginning of the Gorge to Felton Diversion Dam CM7.50 - CM9.12	8,554
5	Felton Diversion Dam to Zayante Creek Confluence CM9.12 - CM9.50	2,026
6	Zayante Creek Confluence to Newell Creek Confluence CM9.50 - CM12.88	17,846
7	Newell Creek Confluence to Bend North of Ben Lomond CM12.88 - CM14.54	8,765
8	Bend North of Ben Lomond to Clear Creek Confluence in Brookdale CM14.54 - CM16.27	9,138
9	Clear Creek Confluence to Boulder Creek Confluence CM16.27 - CM18.38	11,137
10	Boulder Creek Confluence to Kings Creek Confluence CM18.38 - CM20.88	13,200
11	Kings Creek Confluence to San Lorenzo Park Bridge Crossing CM20.88 - CM24.23	17,688
12	San Lorenzo Park Bridge to Gradient Change, North of Waterman Gap CM24.23 - CM26.73	13,200
	TOTAL	131,016 (24.8 miles)

Table 1b. Defined Reaches For Sampled Tributaries of the San Lorenzo River. (Appendix A provides map designations.)

Creek-Reach #	Reach Boundaries (Downstream to Upstream)	Reach Length (ft)
Zayante 13a	San Lorenzo River Confluence to Bean Creek Confluence CM0.0-CM0.61	3,221
13b	Bean Creek Confluence to Tributary Transporting Sediment from Santa Cruz Aggregate CM0.61-CM2.44	9,662
13c	Santa Cruz Aggregate Tributary to Lompico Creek Confluence CM2.44-CM3.09	3,432
13d	Lompico Creek Confluence to Mt. Charlie Creek Confluence CM3.09-CM5.72	13,886
Bean 14a	Zayante Creek Confluence to Mt. Hermon Road Overpass CM0.0-CM1.27	6,706
14b	Mt. Hermon Road Overpass to Ruins Creek Confluence CM1.27-CM2.15	4,646
14c	Ruins Creek Confluence to Gradient Change Above the Second Glenwood Road Crossing CM2.15-CM5.45 (with 0.33 miles dewatered)	17,424
Fall 15	San Lorenzo River Confluence to Boulder Falls CM0.0-CM1.58	8,342
Newell 16	San Lorenzo River Confluence to Bedrock Falls CM0.0-CM1.04	5,491
Boulder 17a	San Lorenzo River Confluence to Foreman Creek Confluence CM0.0-CM0.85	4,488
17b	Foreman Creek Confluence to Narrowing of Gorge Adjacent Forest Springs CM0.85-CM2.0	6,072
17c	Narrow Gorge to Bedrock Chute At Kings Highway Junction with Big Basin Way CM2.0-CM3.46	7,709

Table 1b. (cont'd) **Defined Reaches For Sampled Tributaries of the San Lorenzo River. (Appendix A provides map designations.)**

Bear 18a	San Lorenzo River Confluence to Unnamed Tributary at Narrowing of the Canyon Above Bear Creek Country Club CM0.0-CM2.42	12,778
18b	Narrowing of the Canyon to the Deer Creek Confluence CM2.42-CM4.69	11,986
Kings 19a	San Lorenzo River Confluence to Unnamed Tributary at Fragmented Dam Abutment CM0.0-CM2.04	10,771
19b	Fragmented Dam to Bedrock-Boulder Cascade CM2.04-CM3.73	8,923
Carbonera 20a	Branciforte Creek Confluence to Old Road Crossing and Gradient Increase CM0.0-CM1.38	7,293
20b	Old Road Crossing to Moose Lodge Falls CM1.38-CM3.39	10,635
Branciforte 21a	Carbonera Creek Confluence to Granite Creek Confluence CM1.12-CM3.04	10,138
21b	Granite Creek Confluence to Tie Gulch Confluence CM3.04-CM5.73	14,203
	TOTAL	**177,806 (33.7 miles)**

Table 1c. Sampling Sites Used to Estimate Densities of Steelhead by Reach on the Mainstem San Lorenzo River and Tributaries in 1999.

Reach #	Sampling Site # -Channel Mile	Location of Sampling Sites
		SAN LORENZO MAINSTEM SITES
1	1 -CM3.8	Paradise Park
2	2 -CM5.7	Lower Gorge at Rincon Trail Access
3	3 -CM7.4	Upper End of the Gorge
4	4 -CM8.9	Downstream of the Park Entrance Bridge
5	5 -CM9.3	Downstream of Zayante Creek Confluence
6	6 -CM10.4	Below Fall Creek Confluence
7	7 -CM13.8	Lower Highway 9 Crossing in Ben Lomond
8	8 -CM15.9	Upstream of the Larkspur Road (Brookdale)
9	9 -CM18.0	Downstream of Boulder Creek Confluence
10	10 -CM20.7	Below Kings Creek Confluence
11	11 -CM22.3	Downstream of Teilh Road, Riverside Grove
12	12a-CM24.7	Downstream of Waterman Gap and Highway 9
	12b-CM25.4	Waterman Gap Upstream of Highway 9
		TRIBUTARY SITES
13a	13a-CM0.3	Zayante Creek Upstream of Conference Drive Bridge
13b	13b-CM1.6	Zayante Creek Above First Zayante Rd Xing
13c	13c-CM2.8	Zayante Creek downstream of Zayante School Road Intersection with E. Zayante Road
13d	13d-CM4.1	Zayante Creek upstream of Third Bridge Crossing of E. Zayante Road After Lompico Creek Confluence
14a	14a-CM0.1	Bean Creek Upstream of Zayante Creek Confluence
14b	14b-CM1.8	Bean Creek Below Lockhart Gulch Road

Table 1c. (Cont'd) Sampling Sites Used to Estimate Densities of Steelhead by Reach on the Mainstem San Lorenzo River and Tributaries, 1998.

TRIBUTARY SITES (cont'd)

Reach #	Sampling Site # -Channel Mile	Location of Sampling Sites
14c	14c-CM4.5	Bean Creek 1/3-mile Above Mackenzie Creek Confluence and Below Golpher Gulch Rd.
15	15 -CM0.8	Fall Creek, Above and Below Wooden Bridge
16	16 -CM0.5	Newell Creek, Upstream of Glen Arbor Road Bridge
17a	17a-CM0.2	Boulder Creek Just Upstream of Highway 9
17b	17b-CM1.6	Boulder Creek Below Bracken Brae Creek Confluence
17c	17c-CM2.6	Boulder Creek, Downstream of Jamison Creek
18a	18a-CM1.5	Bear Creek, Downstream of Hopkins Gulch
18b	18b-CM4.2	Bear Creek, Downstream of Bear Creek Road Bridge and Deer Creek Confluence
19a	19a-CM0.8	Kings Creek, Upstream of First Kings Creek Road Bridge
19b	19b-CM2.5	Kings Creek, 0.2 miles Above Boy Scout Camp and upstream of Second Kings Creek Road Bridge
20a	20a-CM0.7	Carbonera Creek, Upstream of Health Services Complex
20b	20b-CM1.9	Downstream of Buelah Park Trail
21a	21a-CM2.8	Branciforte Creek, Downstream of Granite Creek Confluence
21b	21b-CM4.6	Upstream of Granite Creek Confluence and Happy Valley School

FIGURES

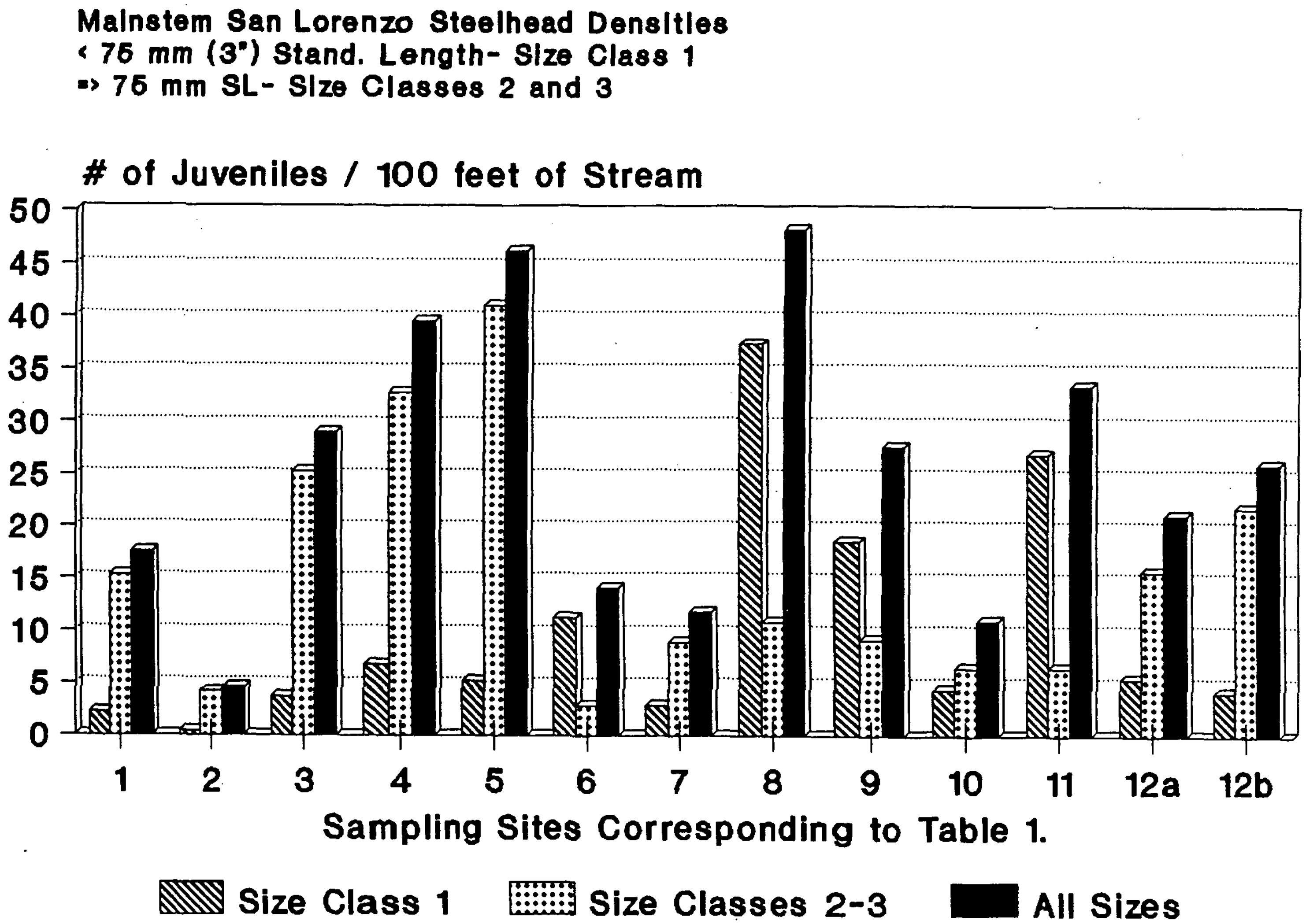


Figure 1. Steelhead Site Density of Juvenile Size Classes at Mainstem San Lorenzo River Sites, 1999.

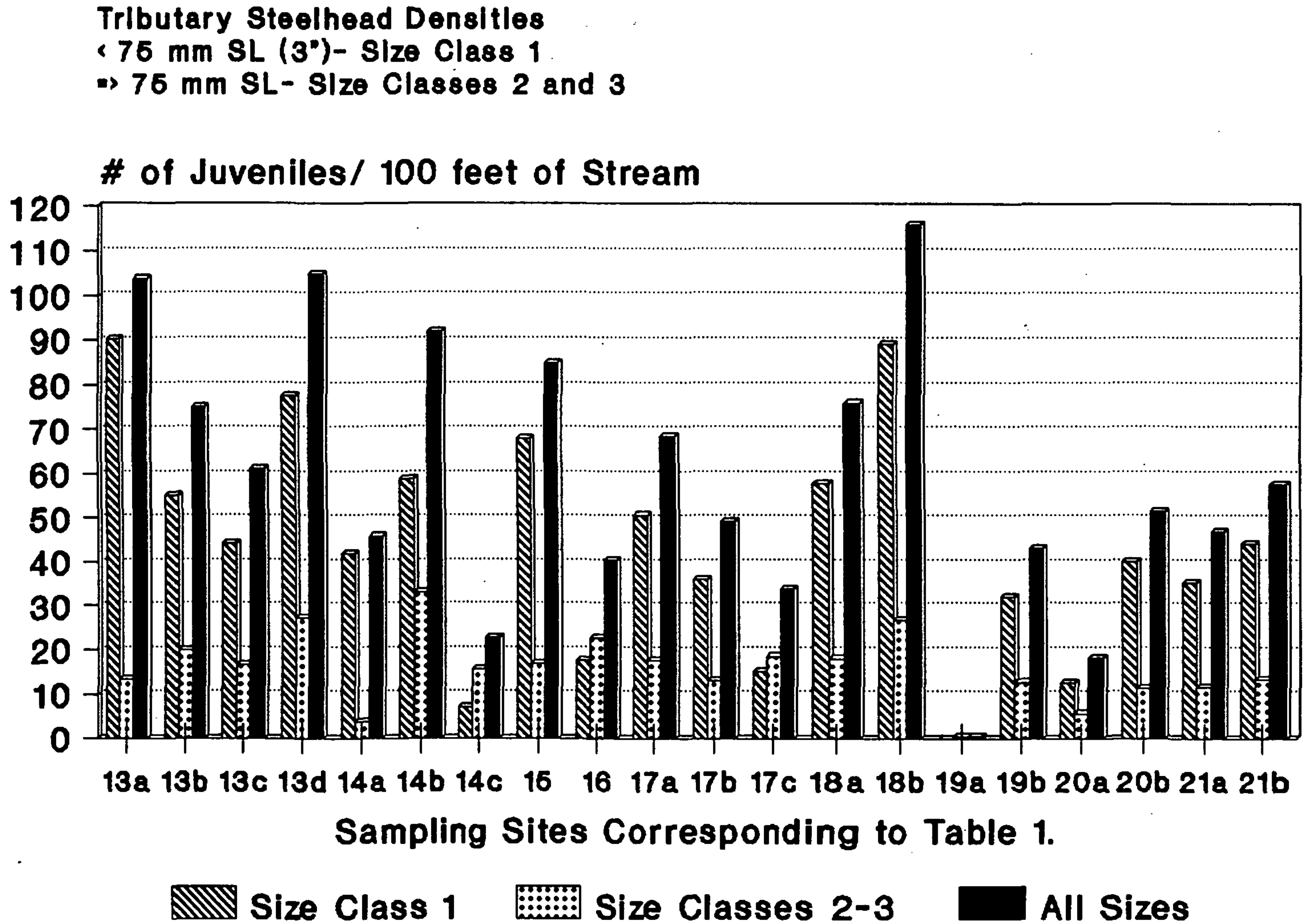


Figure 2. Steelhead Site Density of Juvenile Size Classes; Tributary Sites, 1999.

Density of Size Class One at Comparable Mainstem and Tributary Sites, 1996-99. Pools in Sites 1-9 Snorkeled in 1998-99.

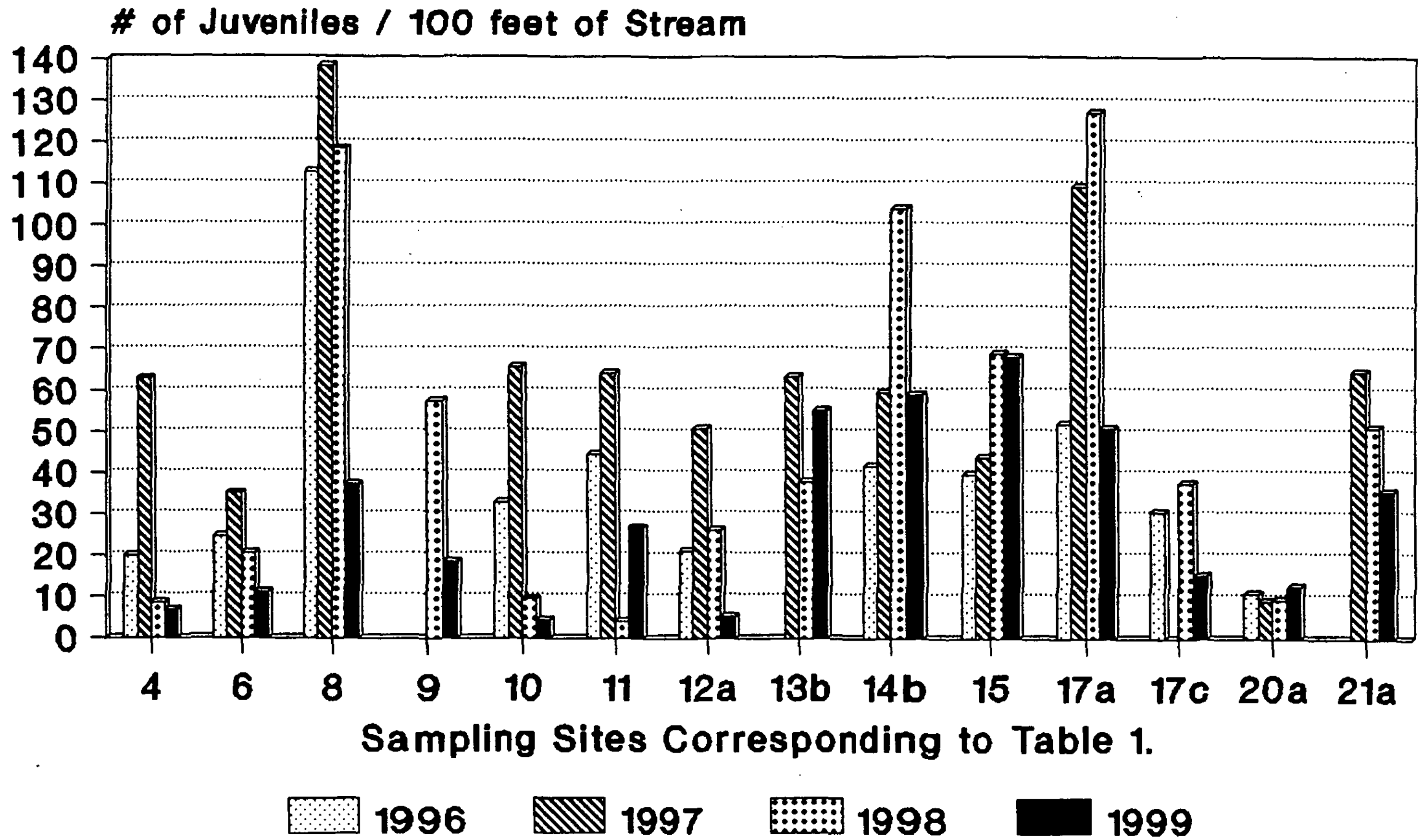


Figure 3. Juvenile Steelhead Densities at Comparable Mainstem and Tributary Sites; Size Class 1, 1996-99.

Density of Size Class 2-3 at Comparable Mainstem and Tributary Sites, 1996-99. Pools in Sites 1-9 Snorkeled in 1998-99.

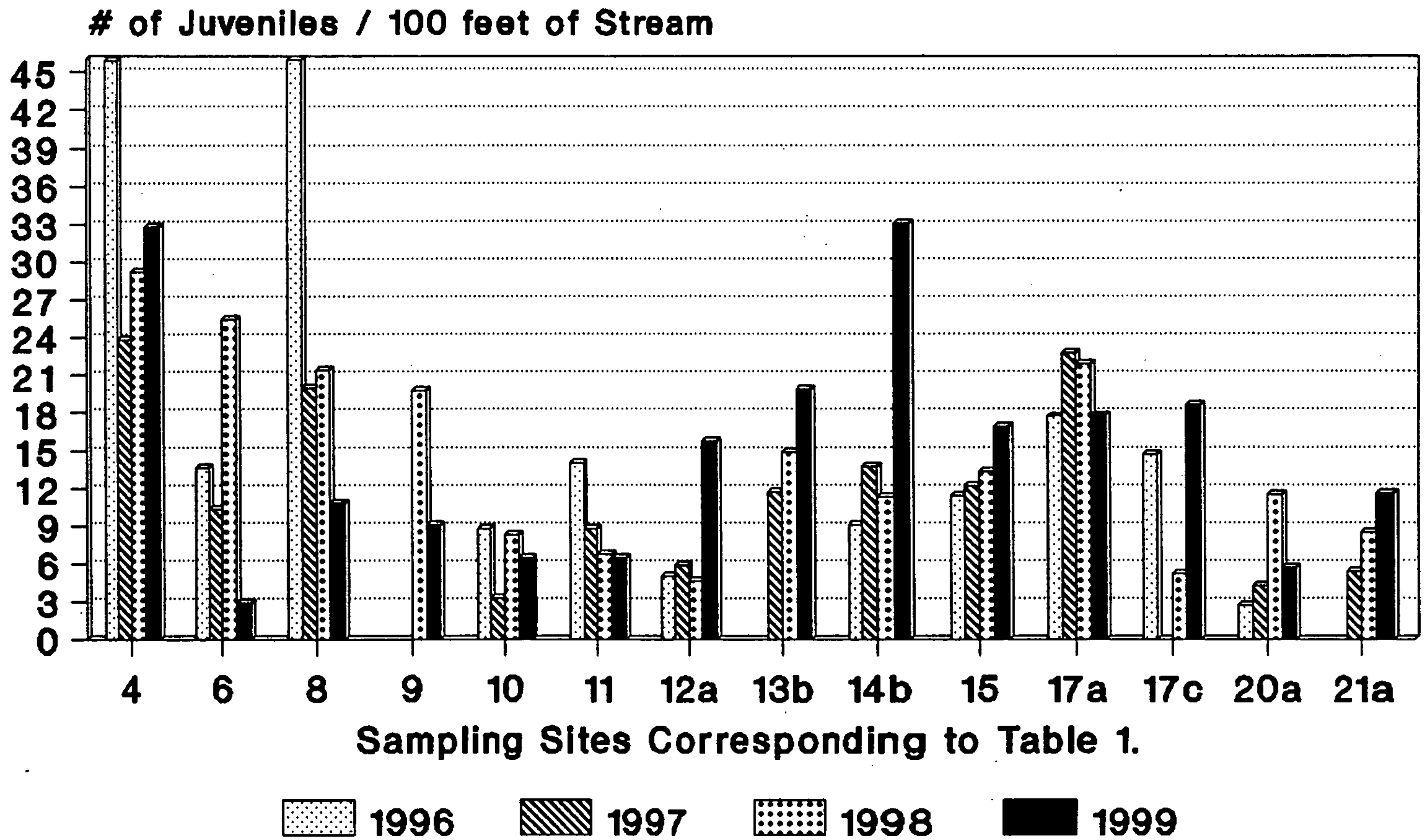


Figure 4a. Juvenile Steelhead Densities at Comparable Mainstem and Tributary Sites; Size Classes 2-3, 1996-99.

Lower San Lorenzo Steelhead Densities
All Juvenile Size Classes, Combined
Paradise Park to Boulder Cr. Confluence.

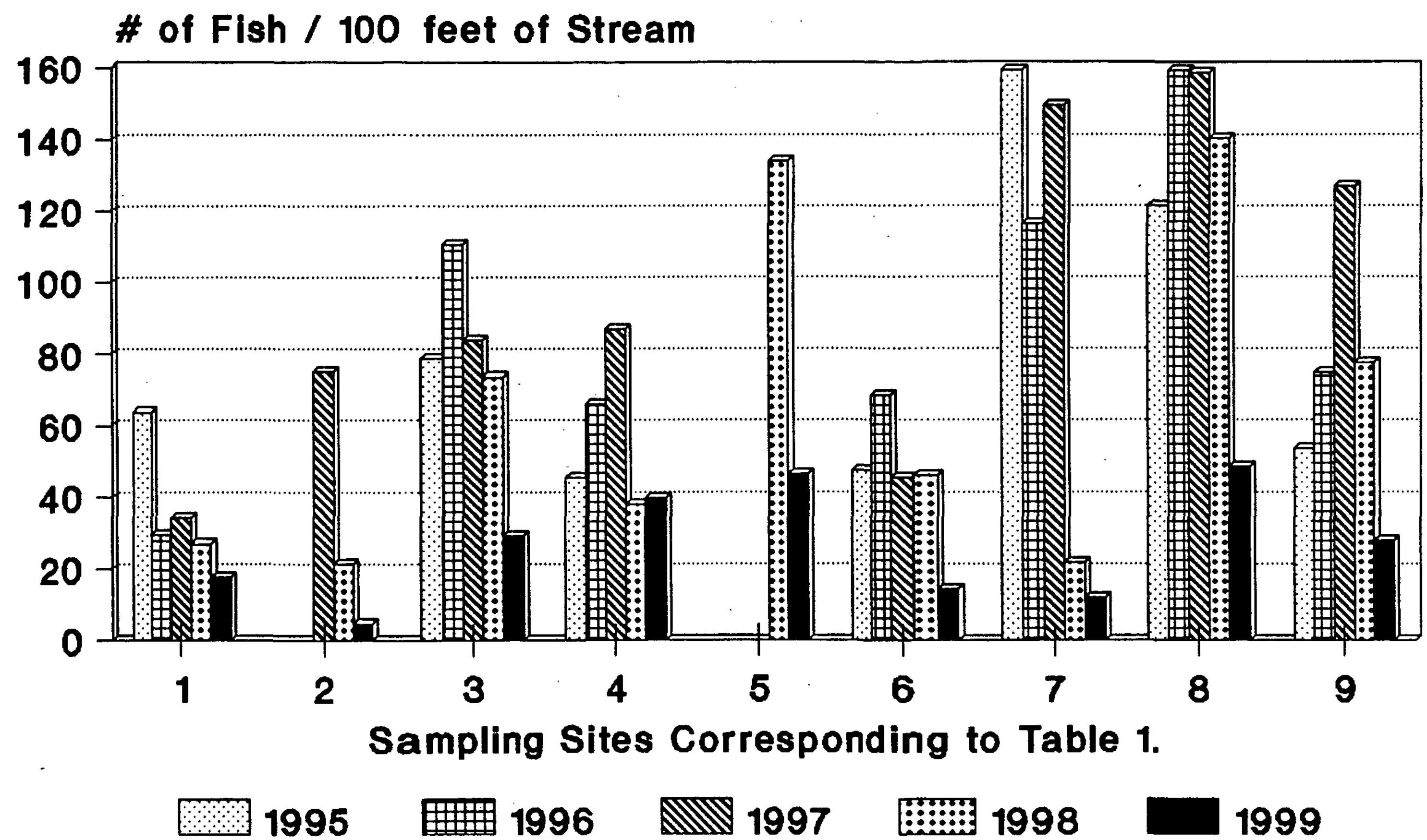


Figure 4b. Density of Juvenile Steelhead Combining All Size Classes; Lower and Middle River Sampling Sites, 1995-99.

Upper San Lorenzo and Tributary Sites
All Juvenile Size Classes, Combined

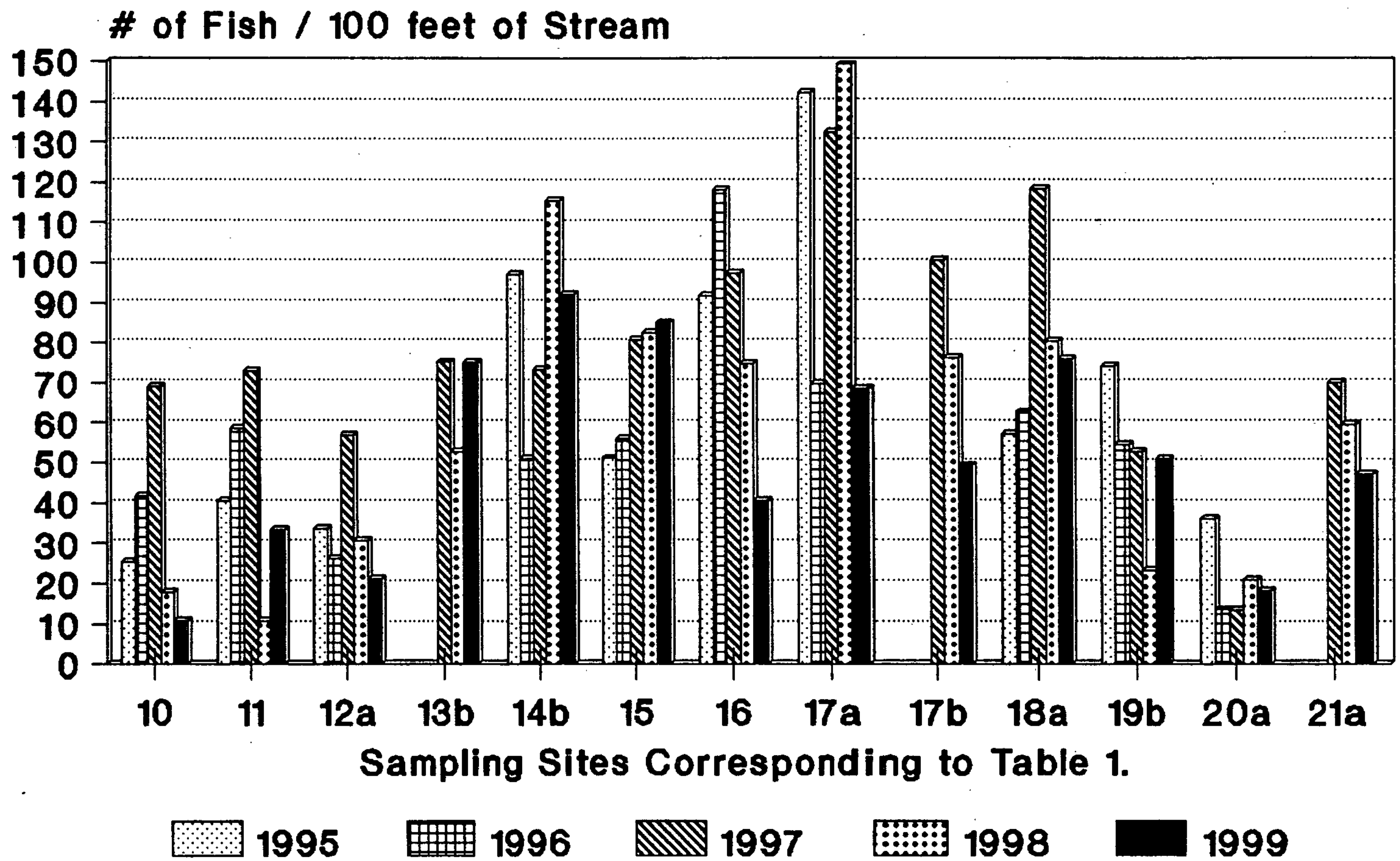


Figure 4c. Density of Juvenile Steelhead Combining All Size Classes; Upper Main-stem and Tributary Sites, 1995-99.

Tributary Steelhead Densities.
All Juvenile Size Classes, Combined.
Average Site Densities per Tributary.

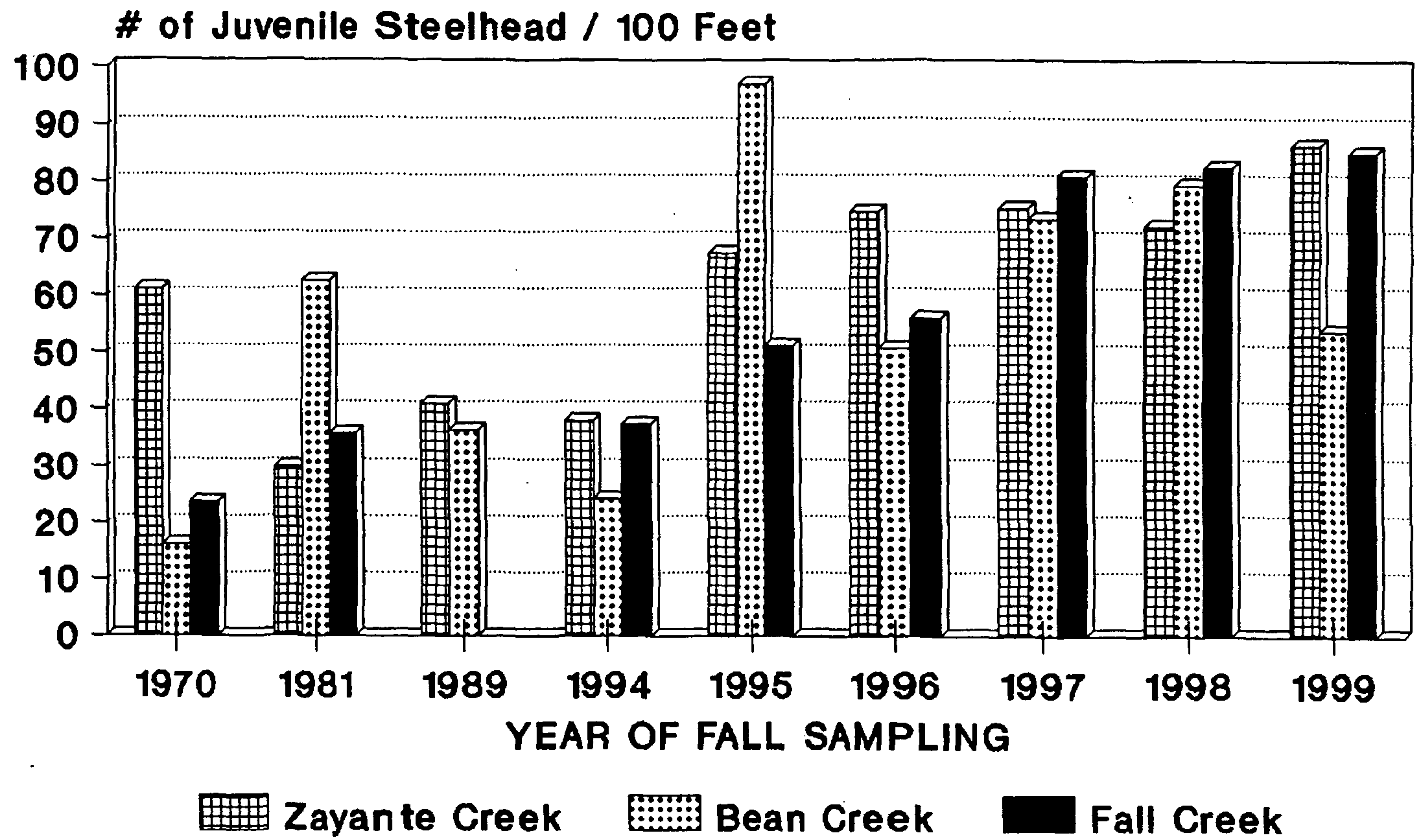


Figure 4d. Trend in Average Juvenile Steelhead Site Density for Tributaries; Zayante, Bean and Fall Creeks, 1970-99.

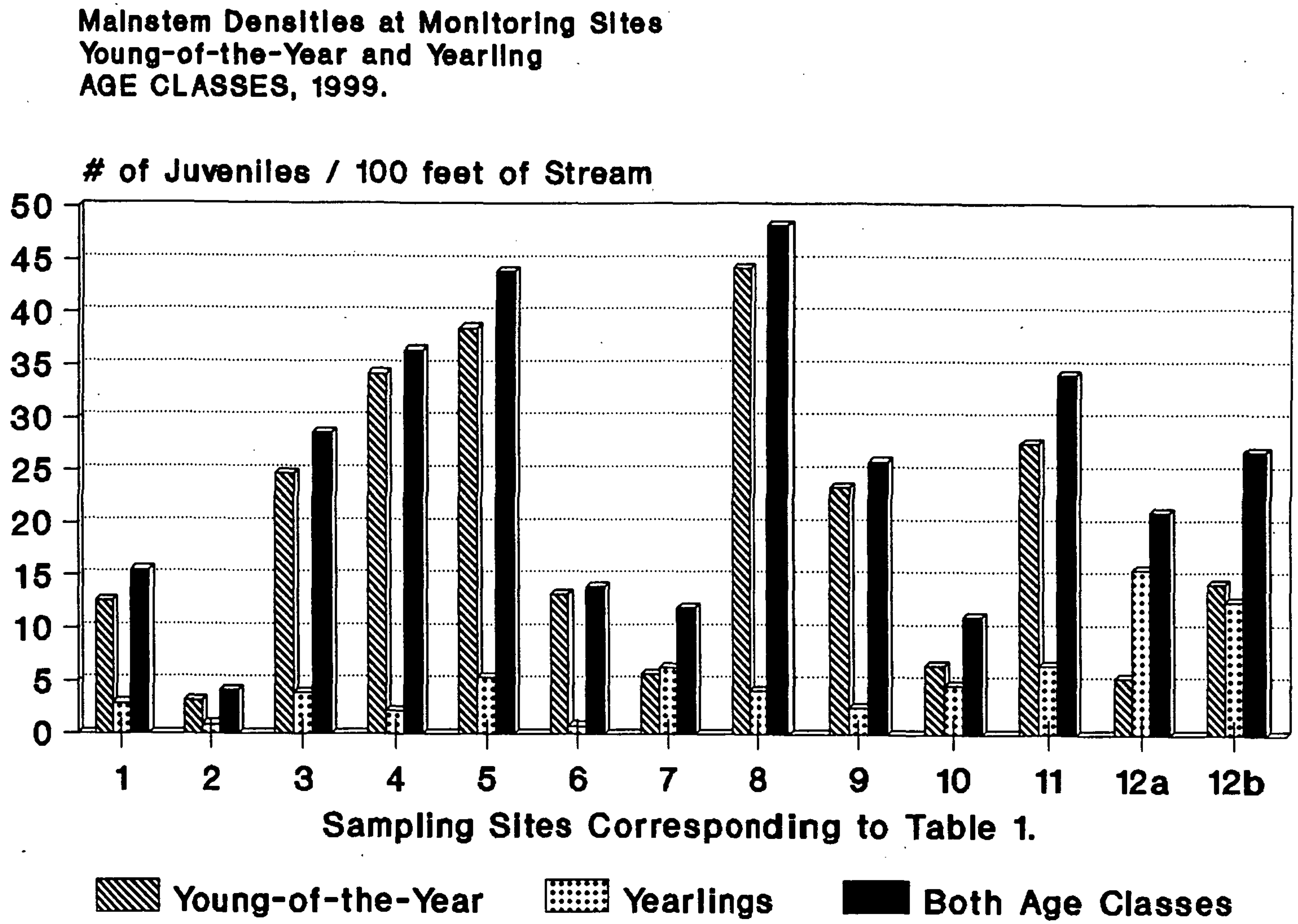


Figure 5. Steelhead Density of Young-of-the-Year and Yearling AGE CLASSES; Mainstem Monitoring Sites, 1999.

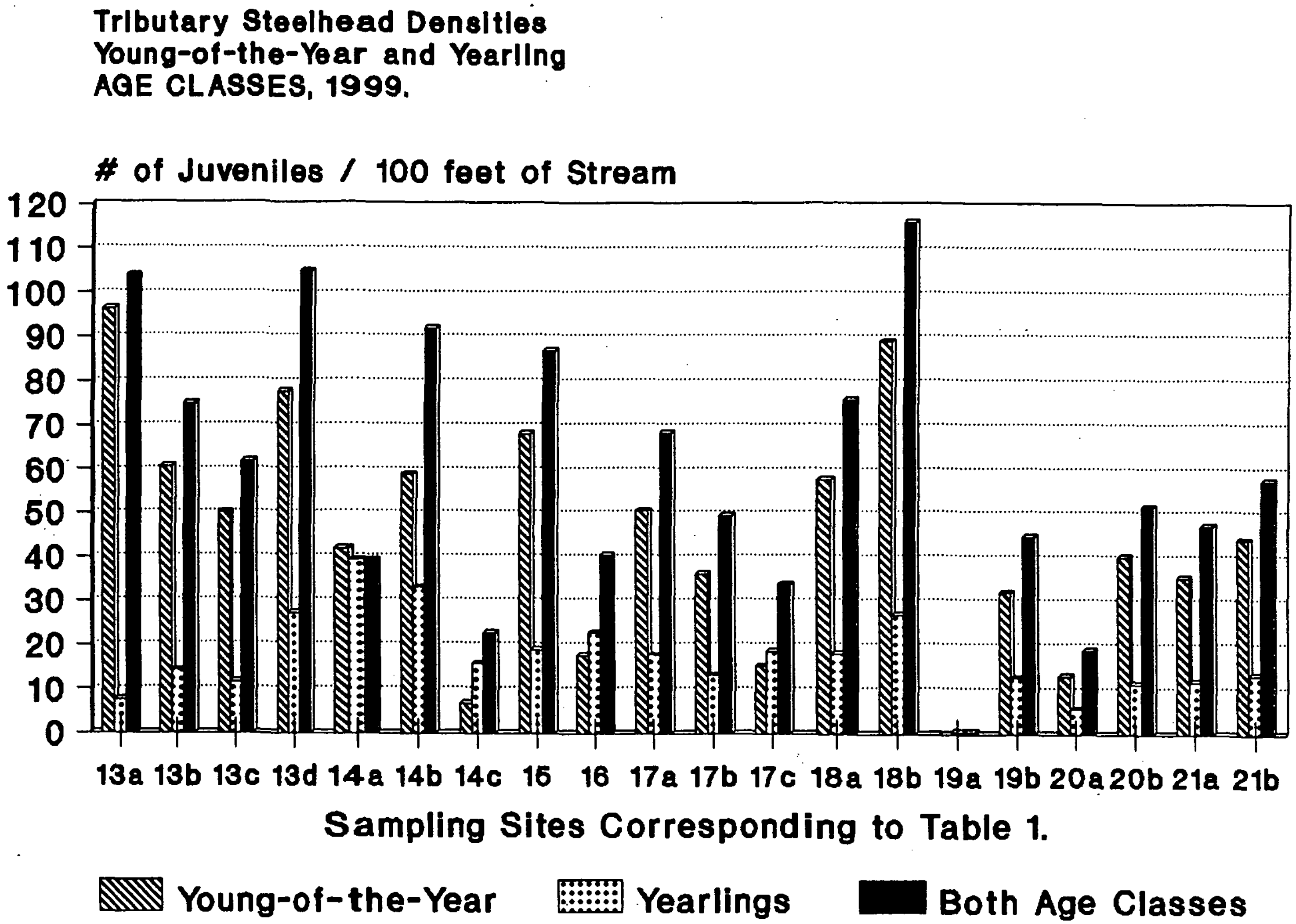


Figure 6. Steelhead Density of Young-of-the-Year and Yearling AGE CLASSES; San Lorenzo Tributary Sites, 1999.

Y-O-Y AGE CLASS at Comparable Mainstem and Tributary Sites, 1997-99. Mainstem Pools (Sites 1-9) Snorkeled in 1998-99.

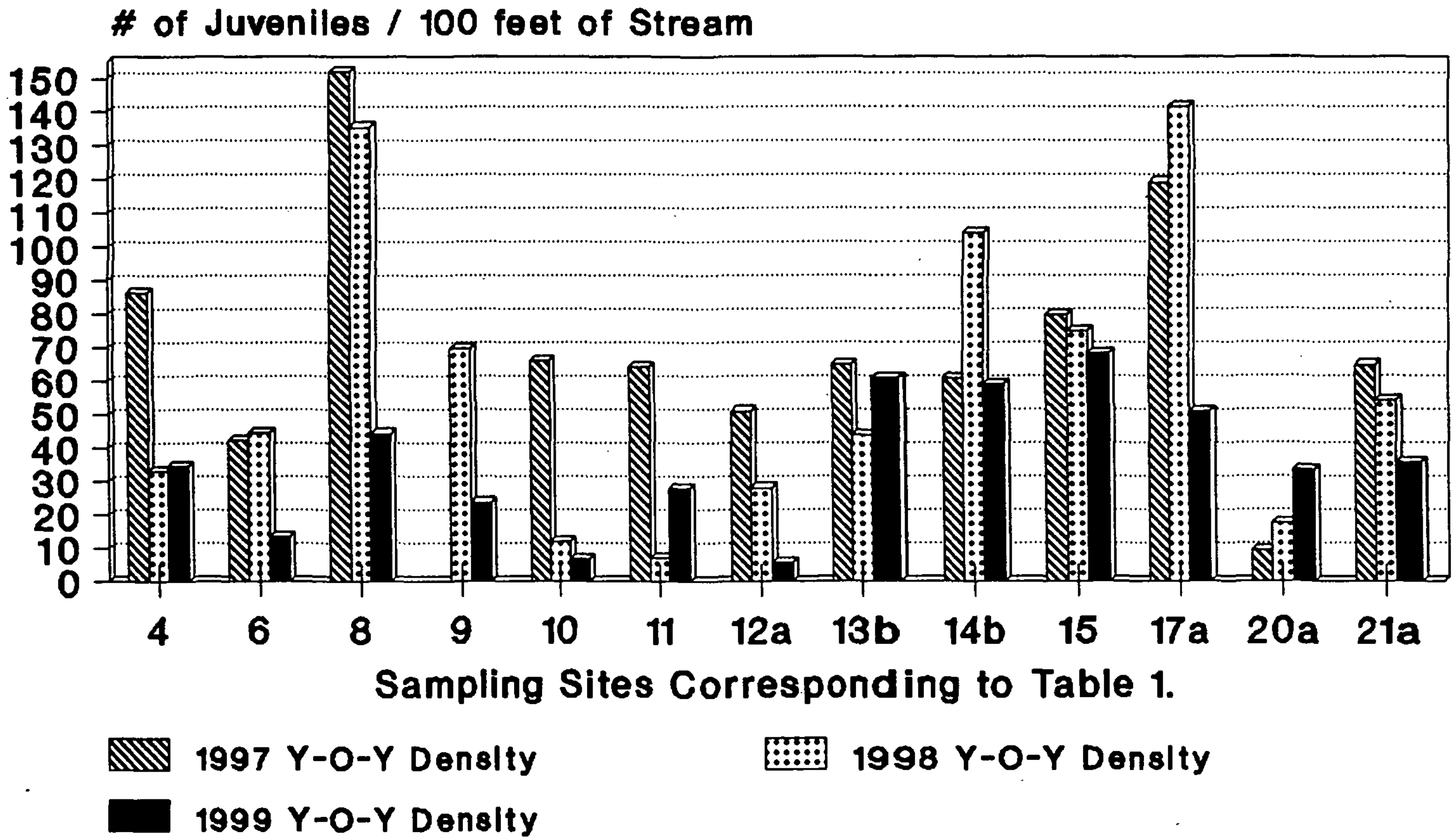


Figure 7. Steelhead Densities at Comparable Mainstem and Tributary Sites; Young-of-the-Year AGE CLASS, 1997-99.

Yearling AGE CLASS at Comparable
Mainstem & Tributary Sites, 1997-99.
Pools (Sites 1-9) Snorkeled in 1998-99.

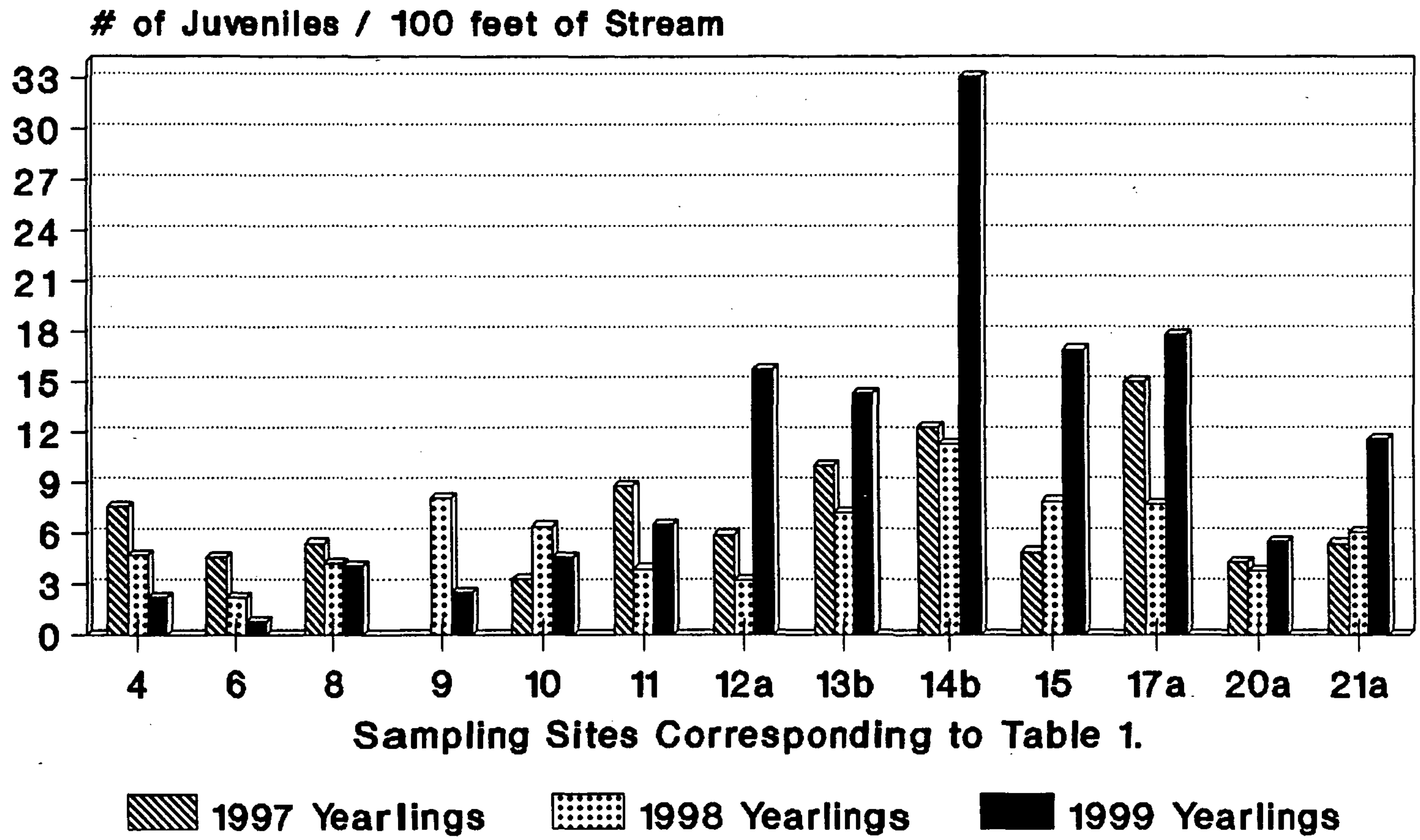


Figure 8. Steelhead Densities at Compar-
ble Mainstem and Tributary Sites;
Yearling Age Class, 1997-99.

REACH DENSITIES in 1996-99 Based on Fish Density per Habitat Type and Habitat Proportions Within Reaches.

Size Class 1 Fish per 100 feet of Reach

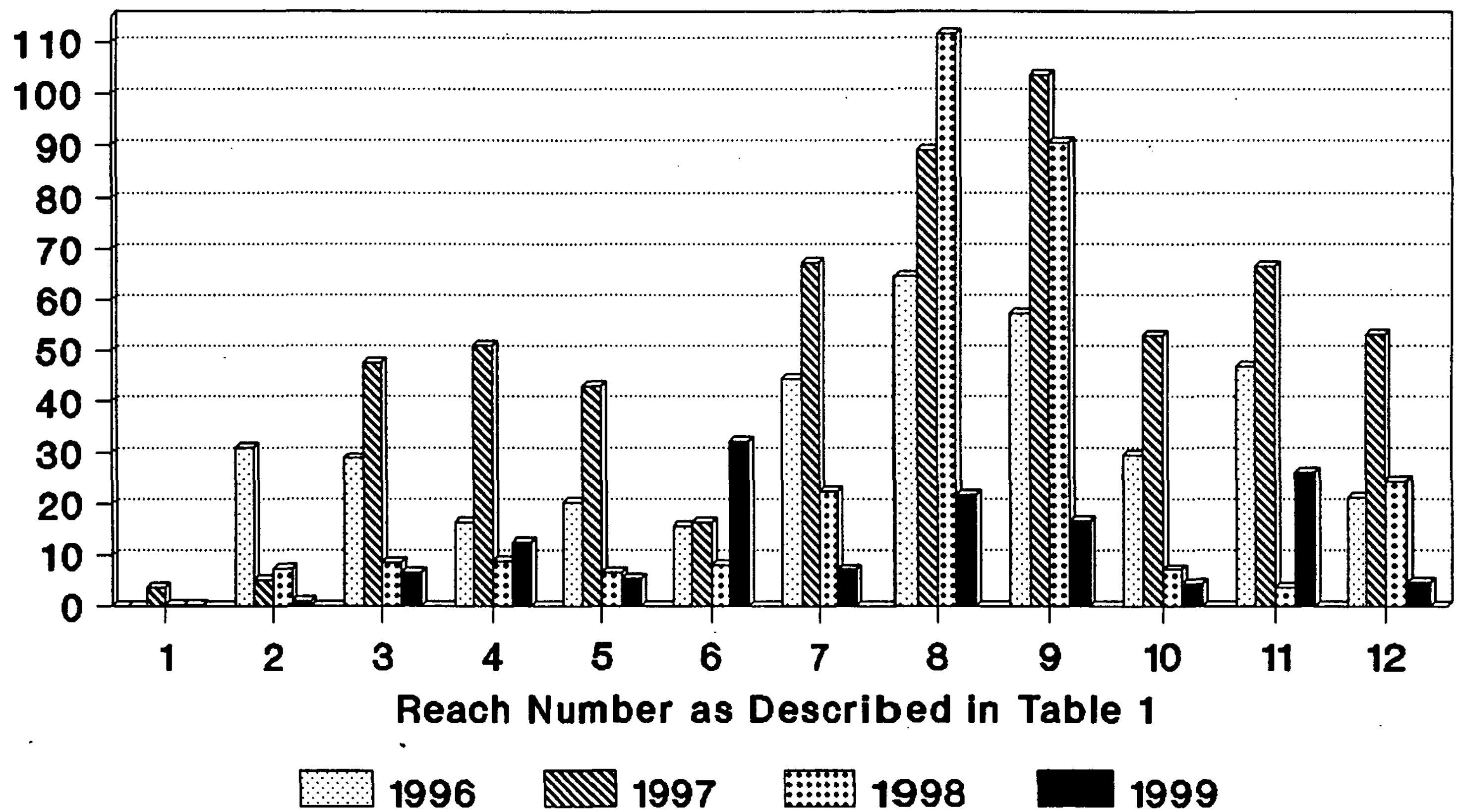


Figure 9a. DENSITIES of Juvenile Steelhead <75 mm Standard Length BY REACH in the Mainstem San Lorenzo River; 1996-99.

Reach Estimates In 1996-99 Based on
Fish Density per Habitat Type and
Habitat Proportions Within Reaches.

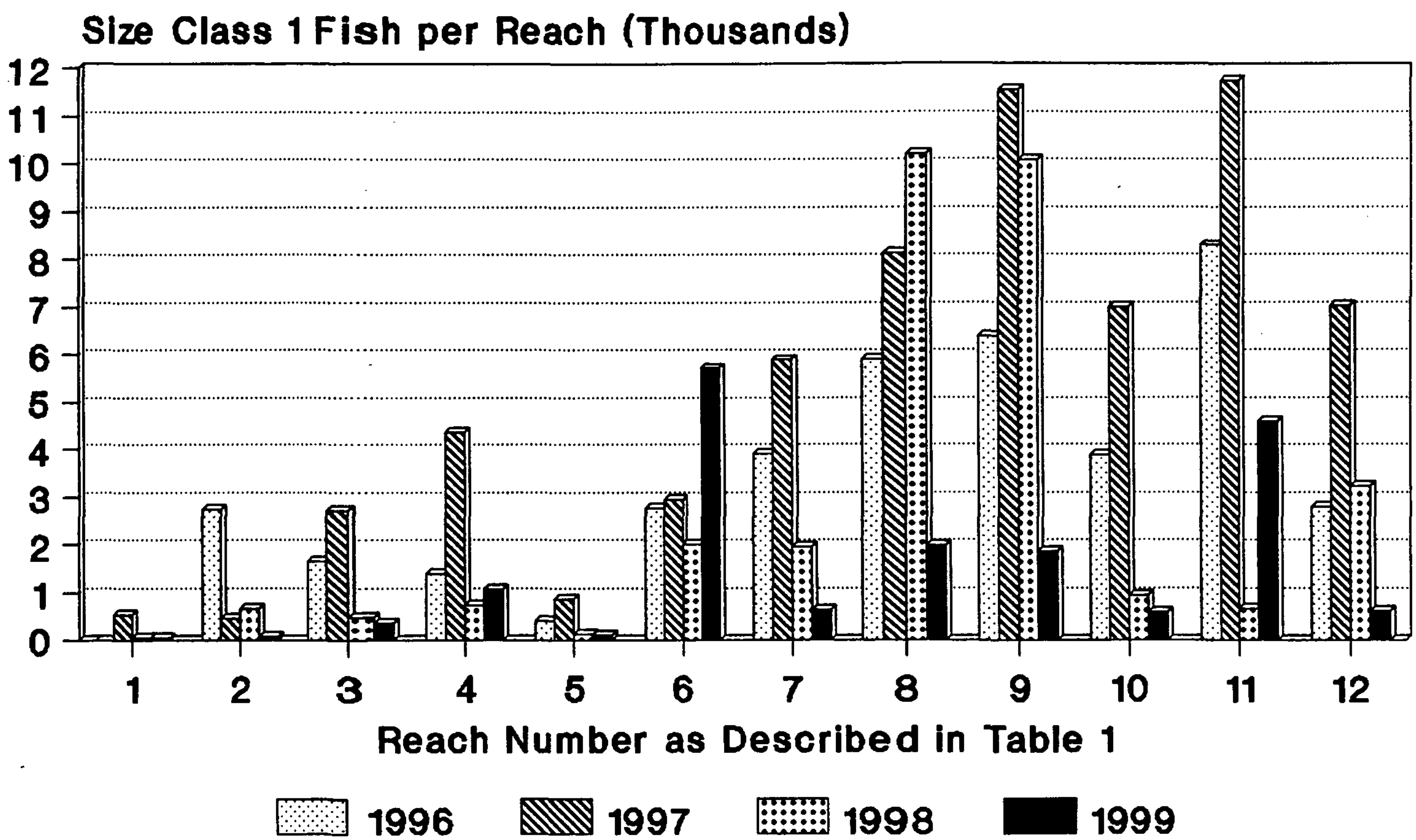


Figure 9b. NUMBERS of Juvenile Steelhead
<75 mm Standard Length by Reach in the
Mainstem San Lorenzo River; 1996-99.

Reach Estimates of Y-O-Y's Based on Steelhead Densities by Habitat and Habitat Proportions in 1999.

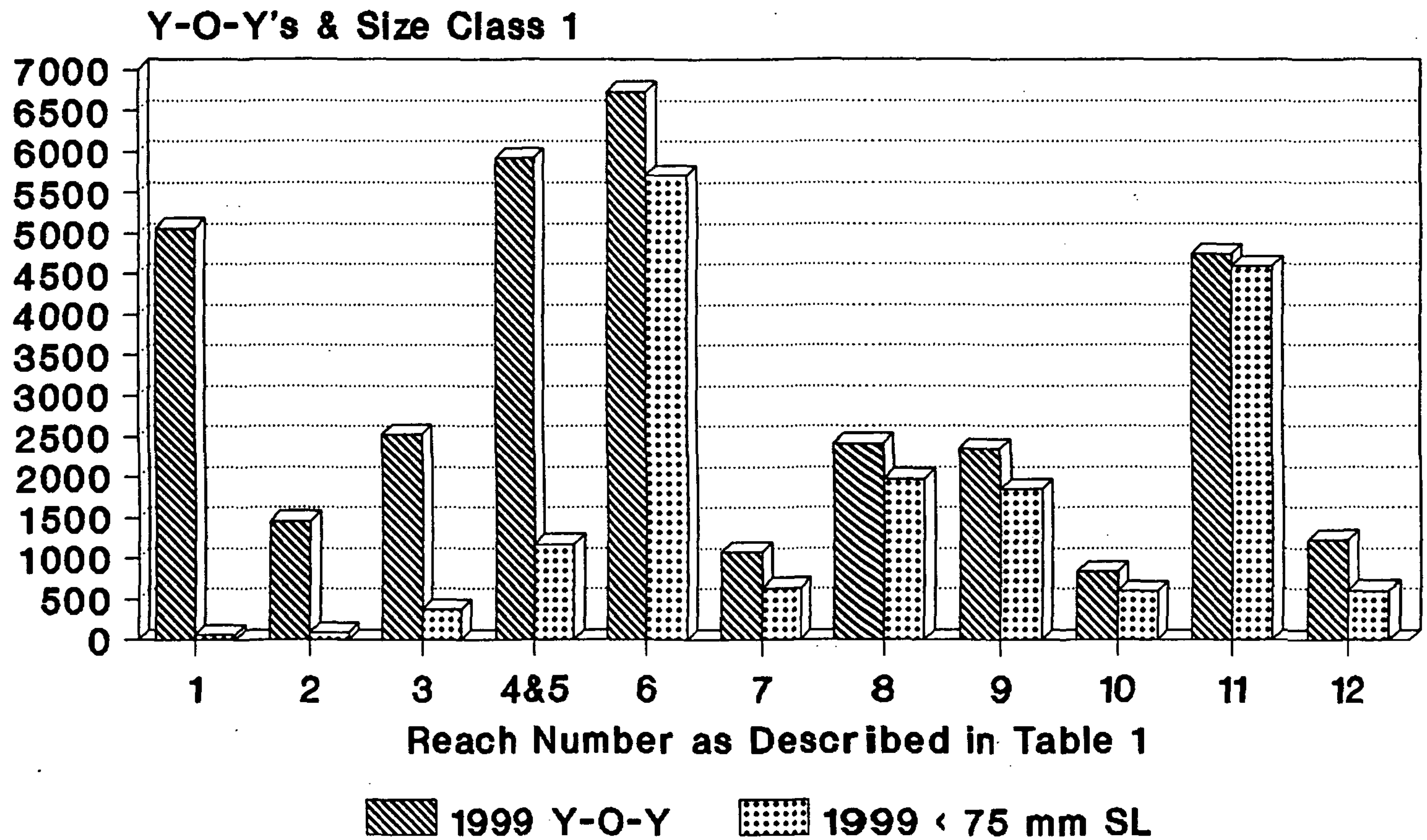


Figure 10. NUMBER of Juvenile Steelhead by Reach as Young-of-the-Year and <75mm Standard Length; Mainstem Reaches, 1999.

Reach Estimates of Y-O-Y's/Size Class 1
Based on Steelhead Densities by Habitat
Type and Habitat Proportions in 1998.

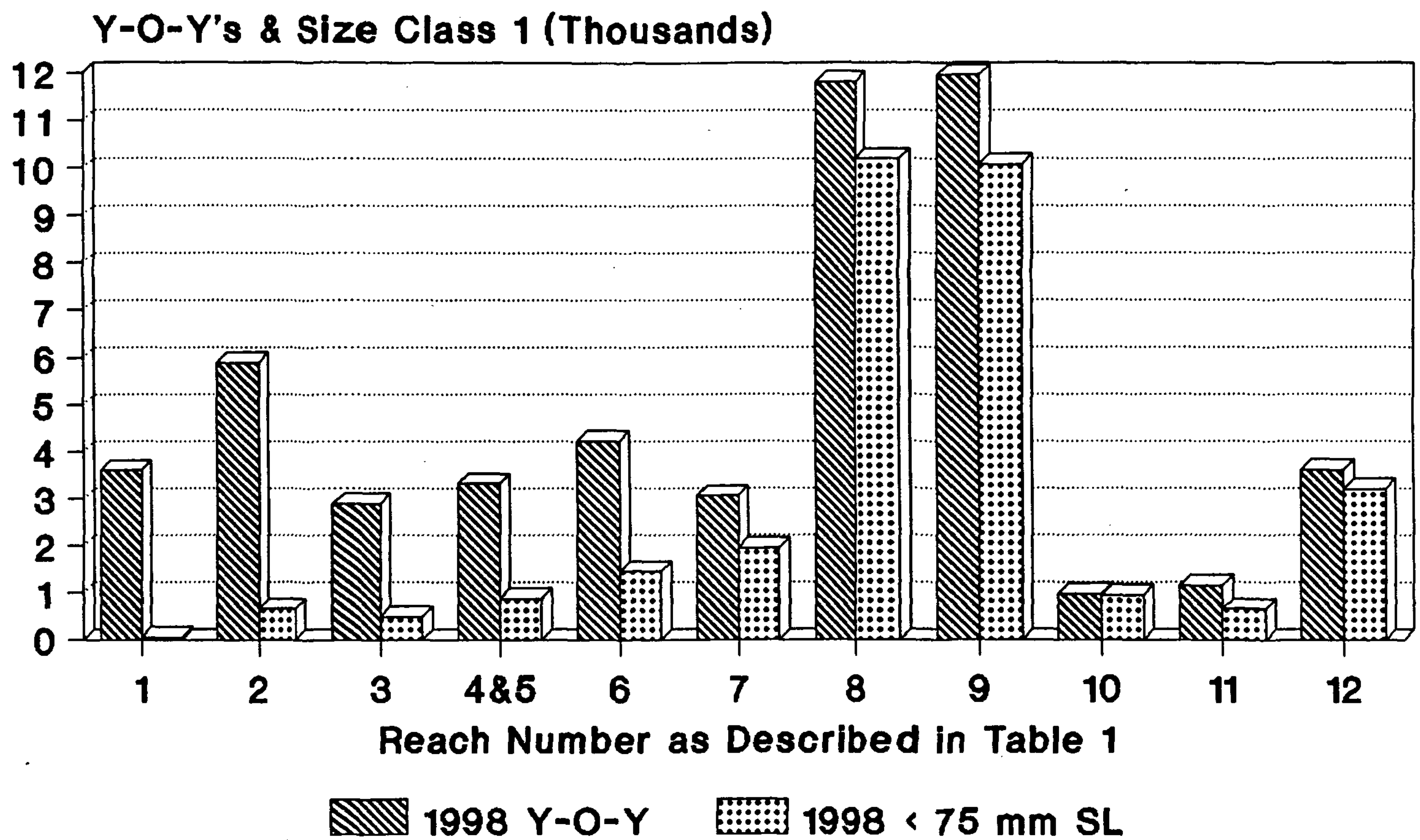


Figure 11. Numbers of Juvenile Steelhead by Reach as Young-of-the-Year and <75 mm Standard Length; Mainstem Reaches, 1998.

Reach DENSITIES in 1996-99 Based on Steelhead Densities by Habitat and Habitat Proportions in 1997-99.

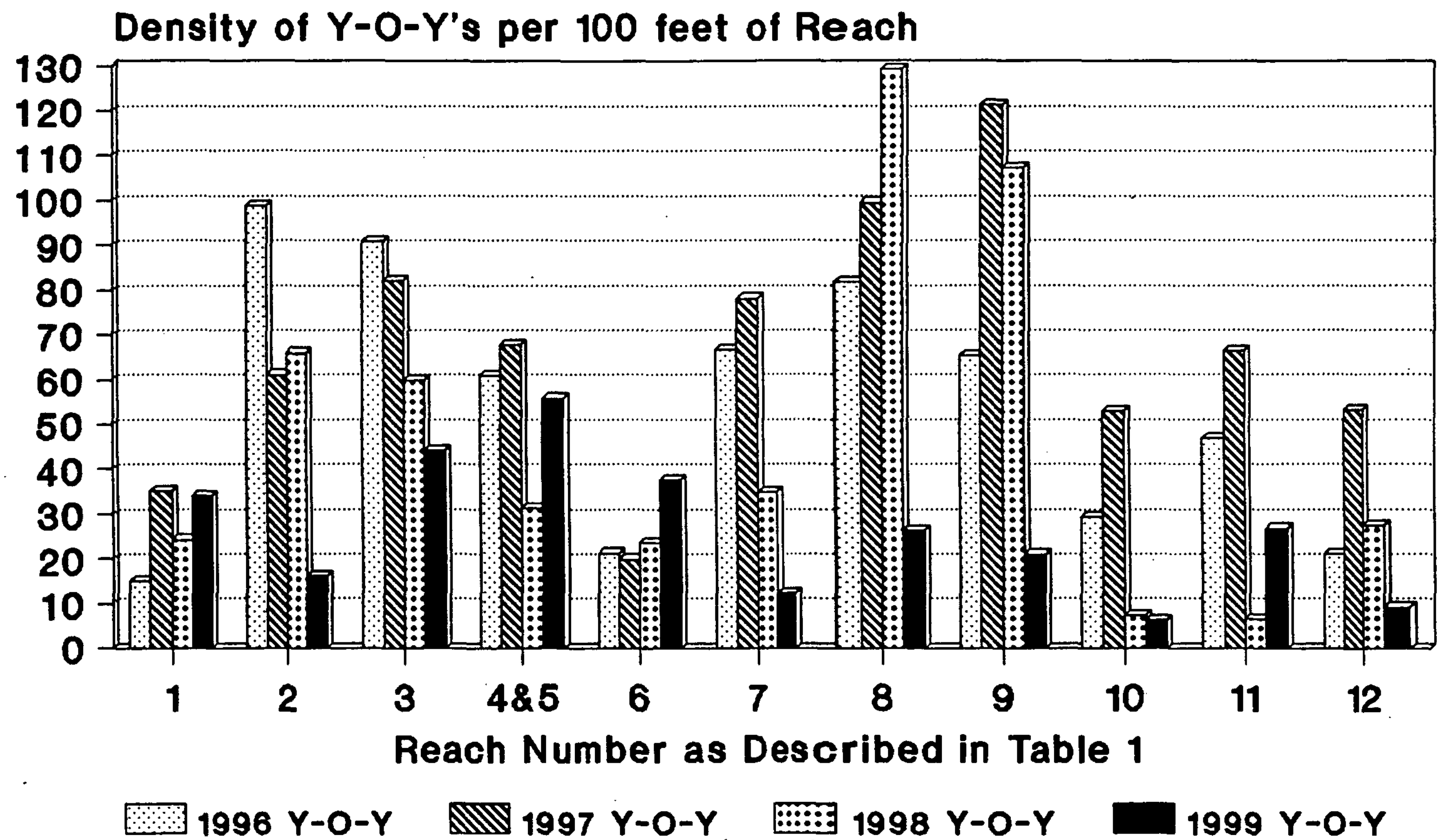


Figure 12a. REACH DENSITY of Juvenile Steelhead as YOUNG-OF-THE-YEAR in Mainstem San Lorenzo Reaches, 1996-99.

Reach Estimates in 1997-99 Based on Steelhead Densities by Habitat and Habitat Proportions in 1997-99.

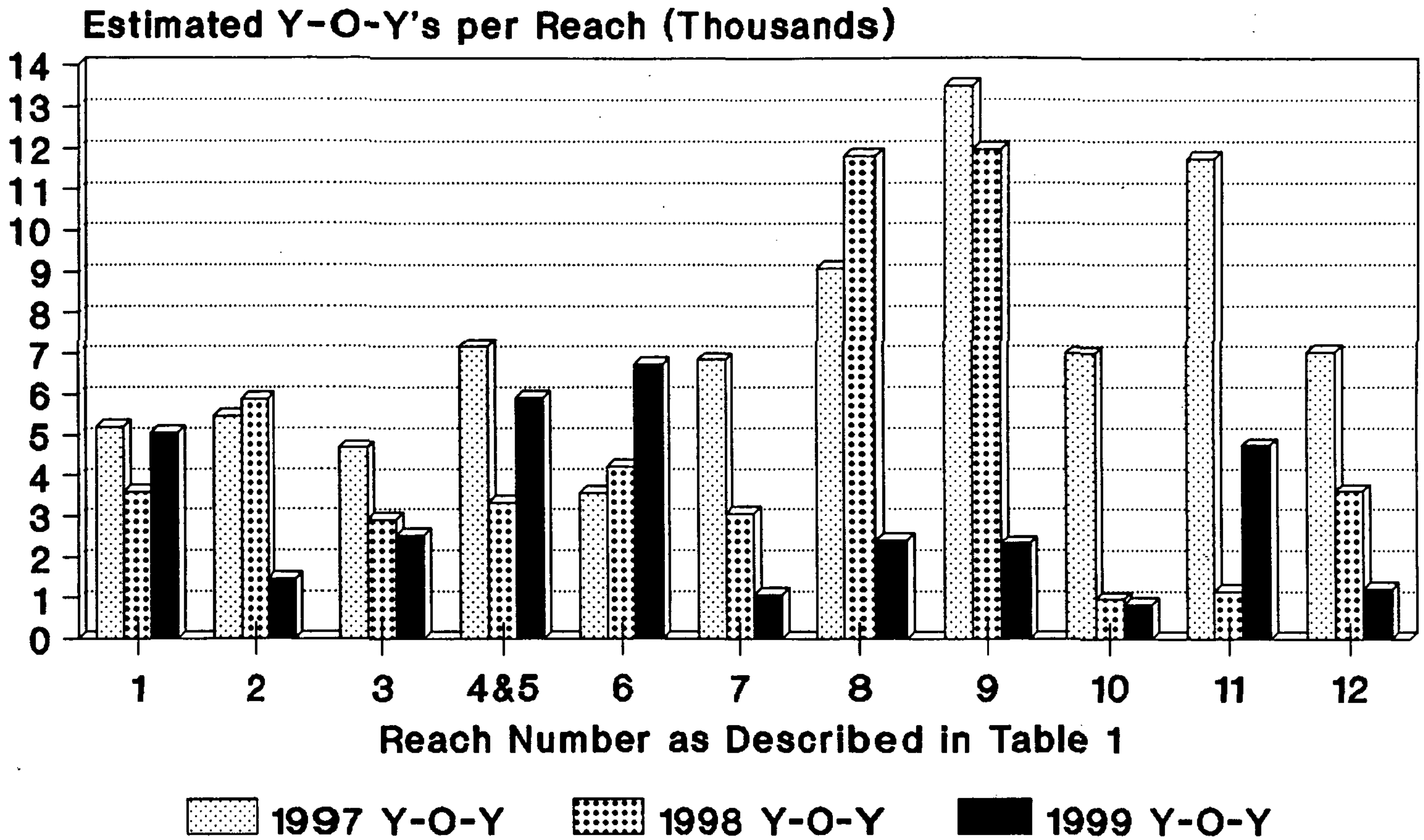


Figure 12b. NUMBER of Juvenile Steelhead by Reach as Young-of-the-Year in Mainstem San Lorenzo Reaches, 1997-99.

Reach DENSITIES Based on Fish Habitat Densities and Habitat Proportions. Mainstem Pools Snorkeled in 1998-99.

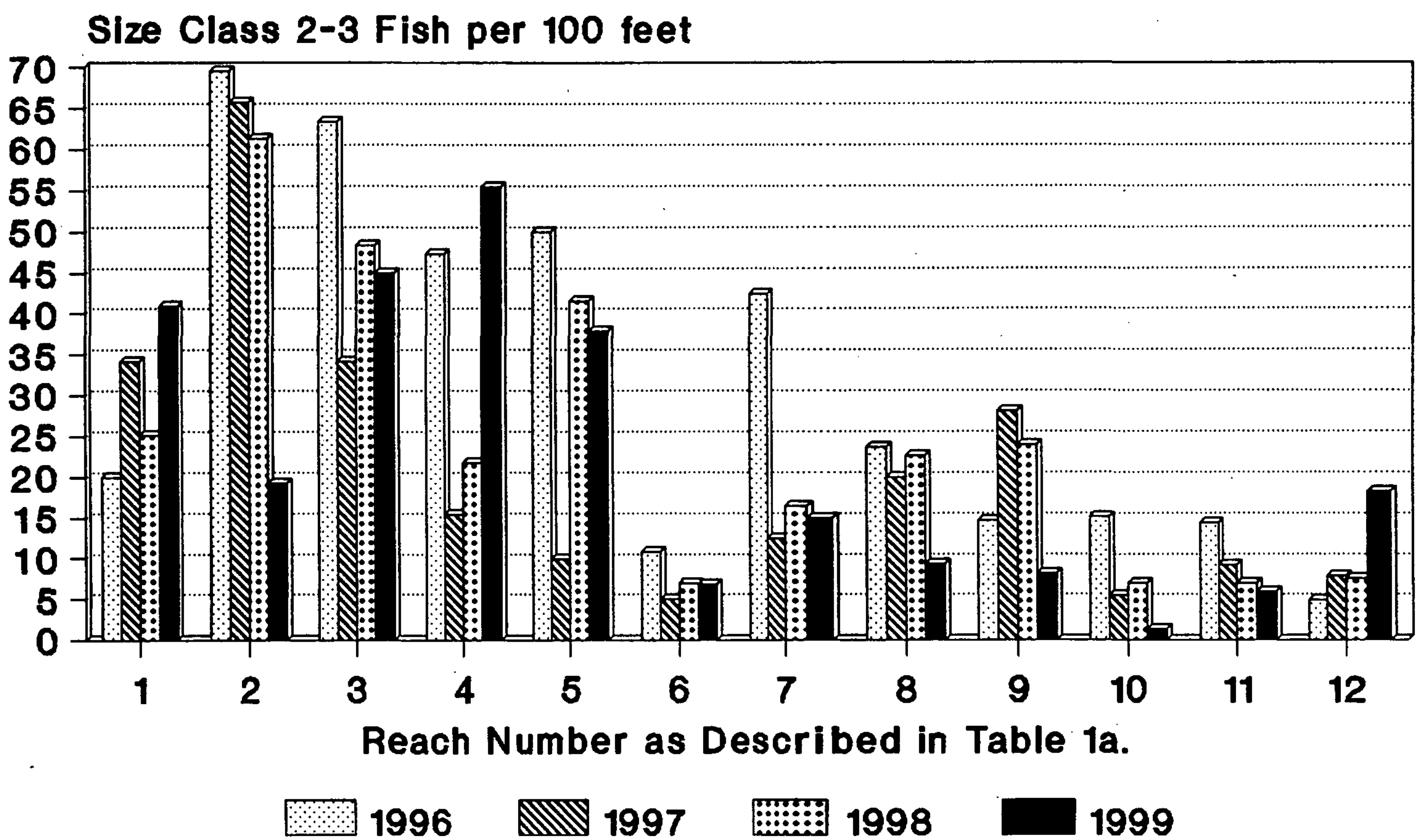


Figure 13a. DENSITY of Juvenile Steelhead =>75 mm Standard Length BY REACH in the Mainstem San Lorenzo River; 1996-99.

Reach Estimates Based on Habitats' Fish Densities and Habitat Proportions.
Pools in Sites 1-9 Snorkeled in 1998-99.

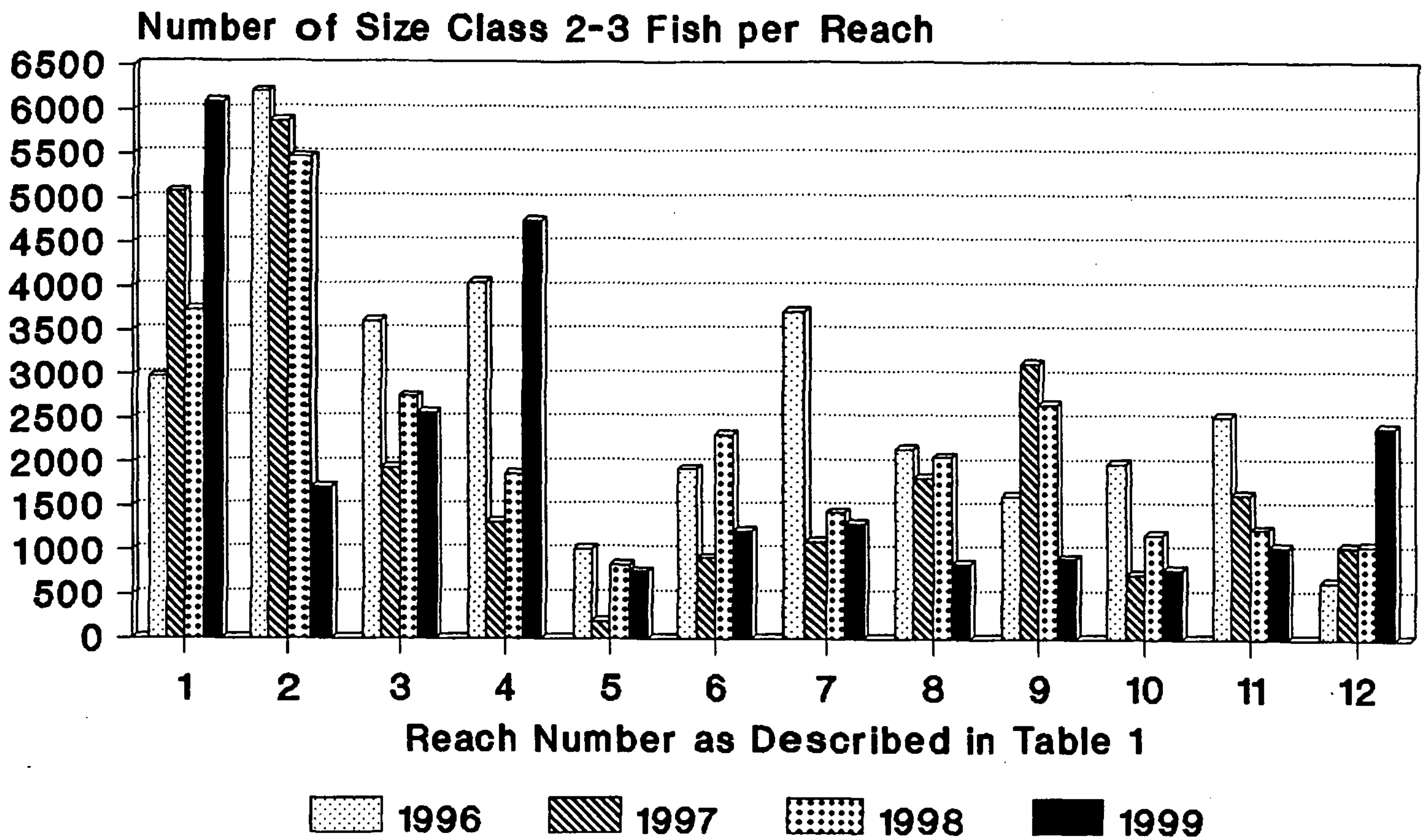


Figure 13b. NUMBER of Juvenile Steelhead =>75 mm Standard Length BY REACH in the MAINSTEM San Lorenzo River; 1996-99.

REACH DENSITY in 1996-99 Based on
Steelhead Densities by Habitat and
Habitat Proportions in 1997-99.

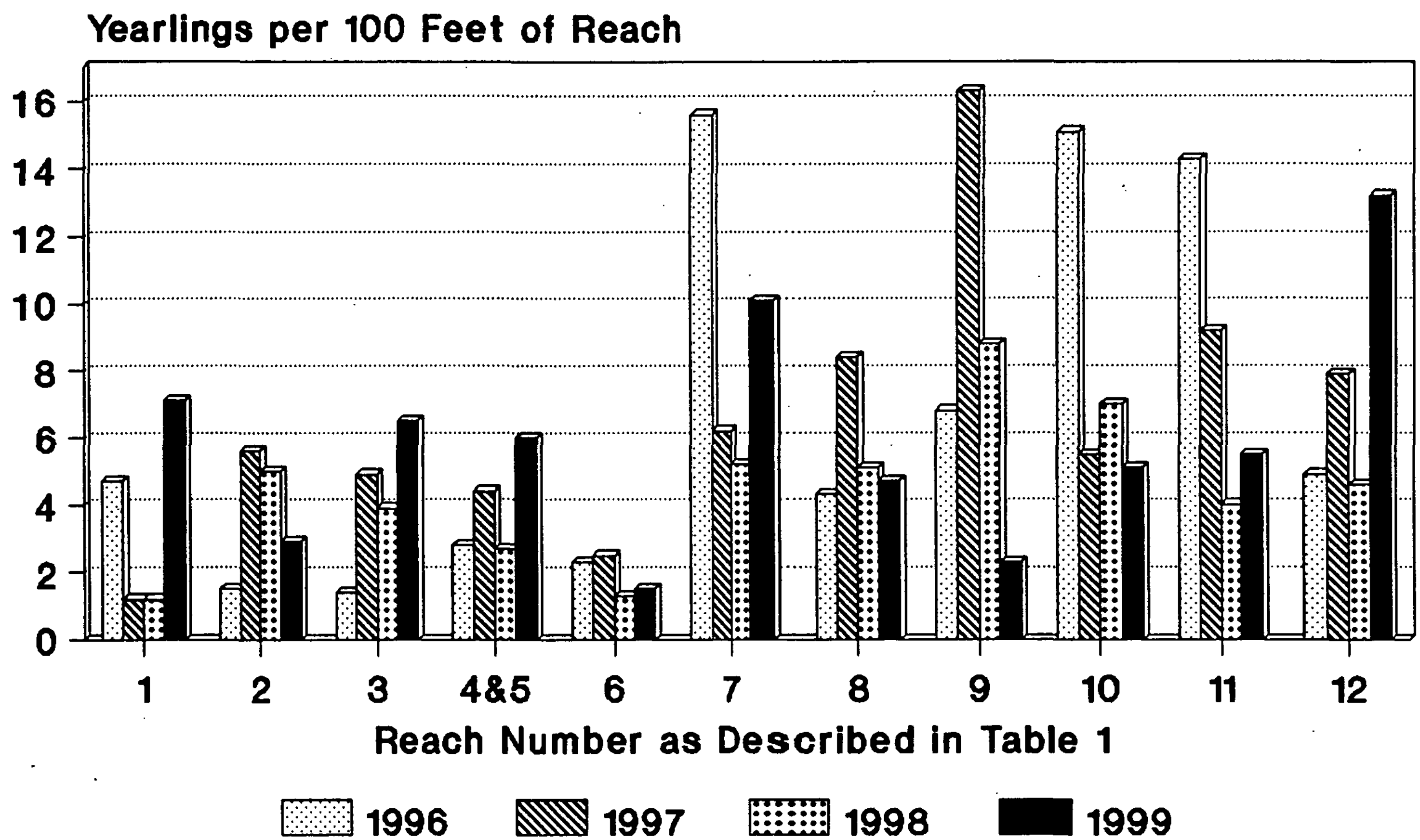


Figure 13c. DENSITY of Juvenile Steel-
head BY REACH as YEARLINGS in Mainstem
San Lorenzo Reaches; 1996-99.

REACH NUMBERS In 1997-99 Based on Steelhead Densities by Habitat and Habitat Proportions.

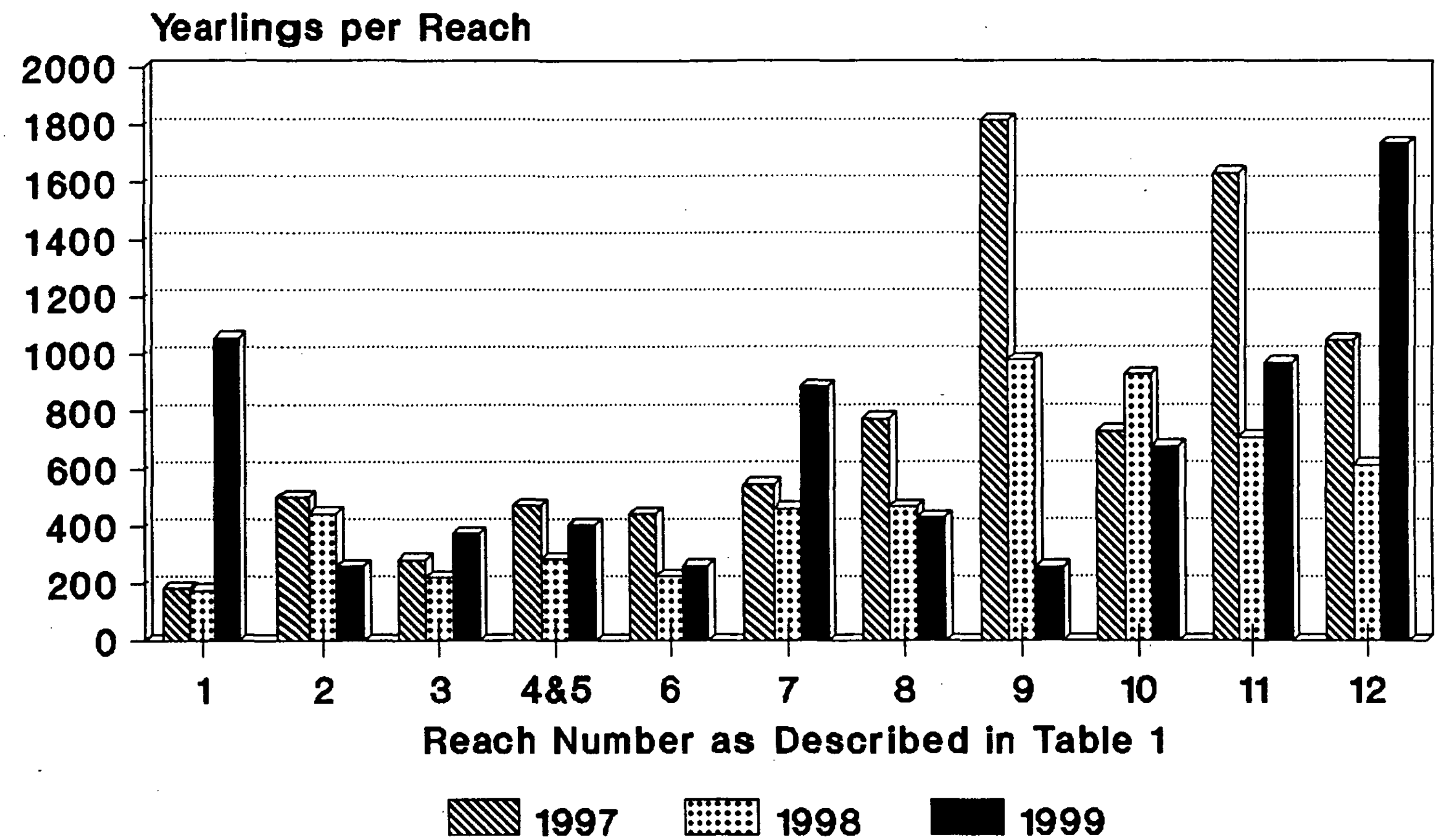


Figure 13d. NUMBER of Juvenile Steelhead BY REACH as YEARLINGS In Mainstem San Lorenzo Reaches; 1997-99.

REACH DENSITIES in 1996-99 Based on Fish Density per Habitat Type and Habitat Proportions Within Reaches.

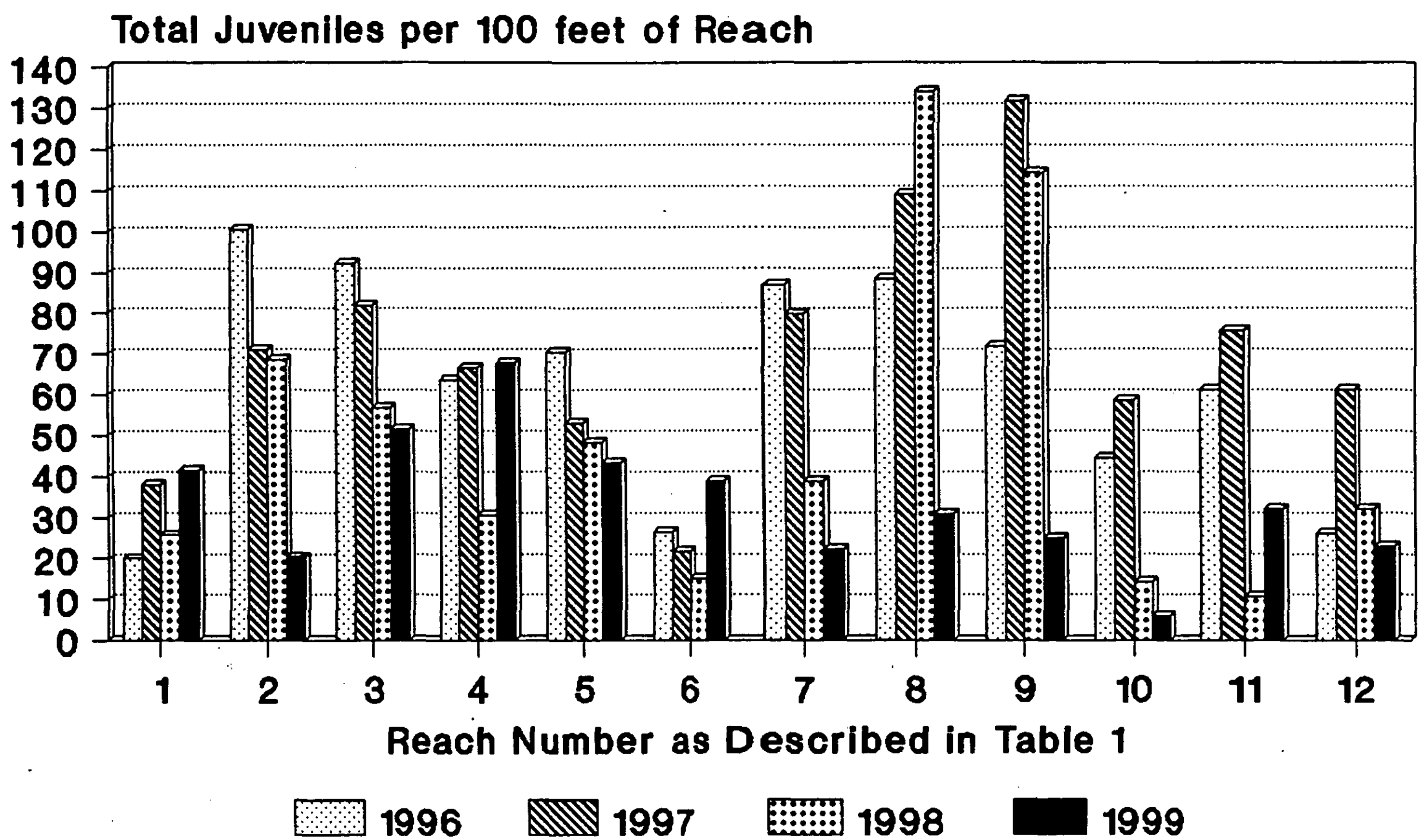


Figure 14a. TOTAL DENSITY of Juvenile Steelhead BY REACH in the Mainstem San Lorenzo River; 1996-99.

Reach Estimates Based on Habitat Fish
Densities and Habitat Proportions
In 1996-99.

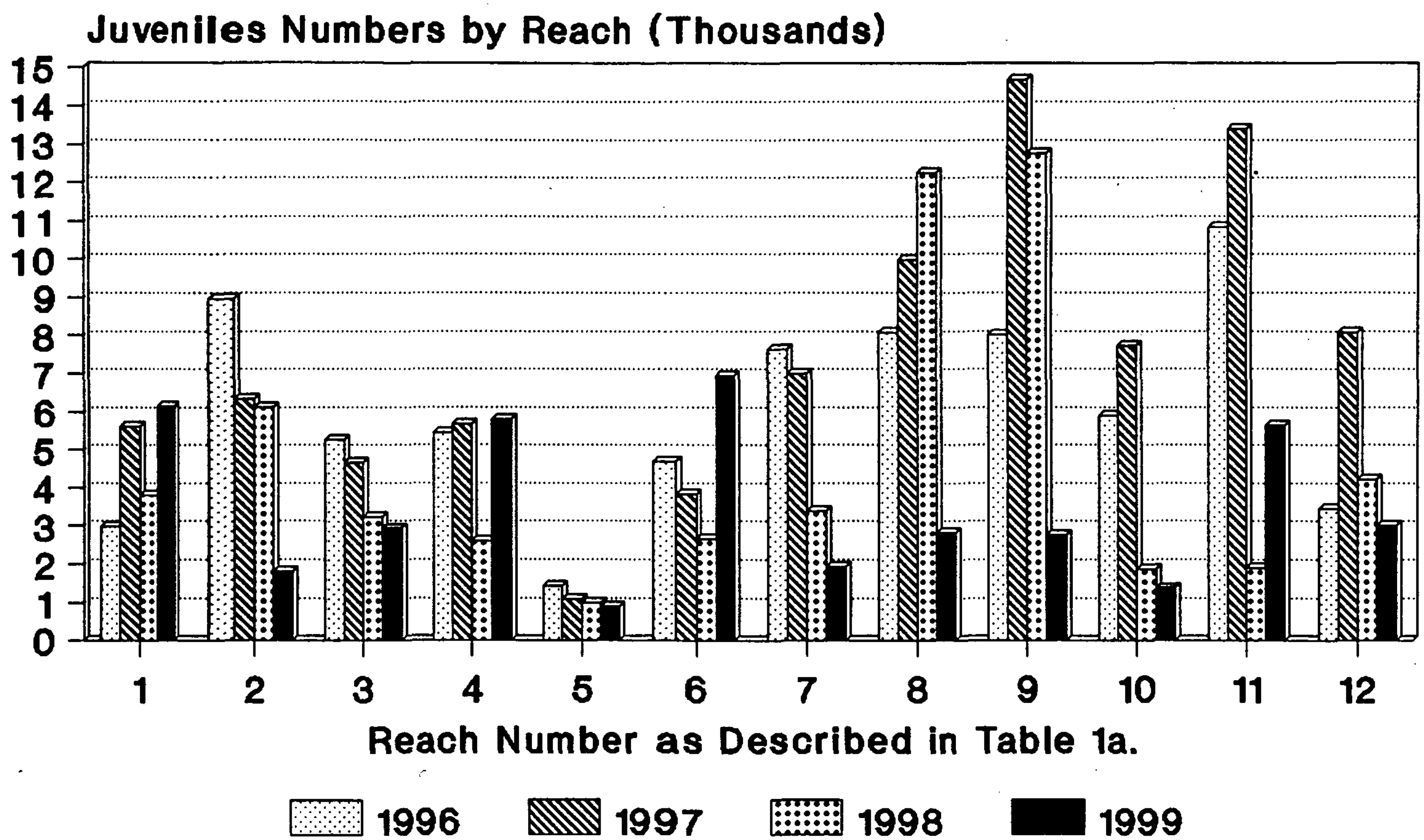


Figure 14b. Total Number of Juvenile
Steelhead by Reach in the San Lorenzo
River Mainstem; 1996-99.

Reach Estimates Based on Densities by Habitat Type. Habitat Proportions Determined by 1997-99 Surveys.

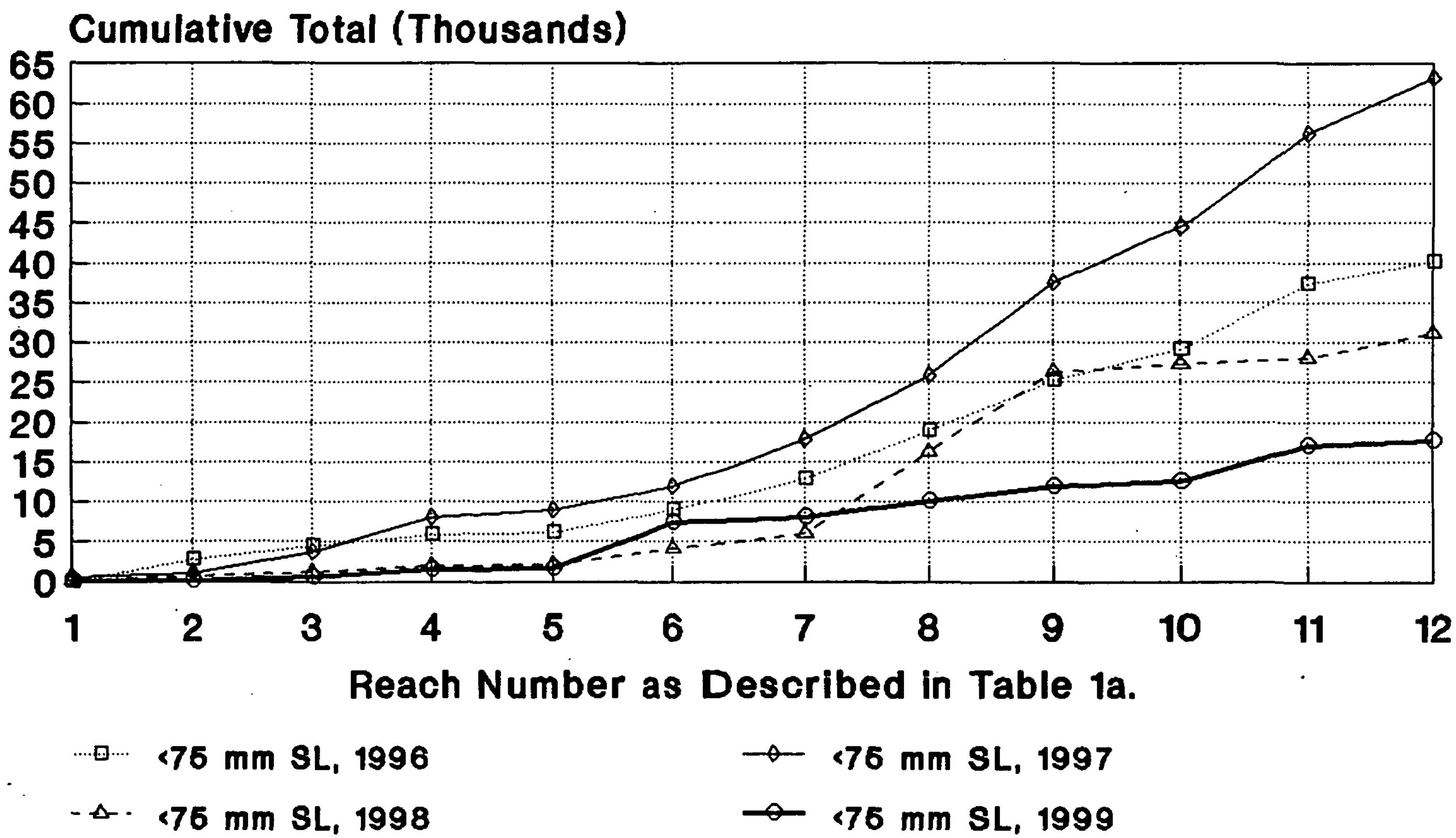


Figure 15. NUMBER of Juvenile Steelhead <75 mm SL ACCUMULATED BY REACH in the MAINSTEM San Lorenzo River, 1996-99.

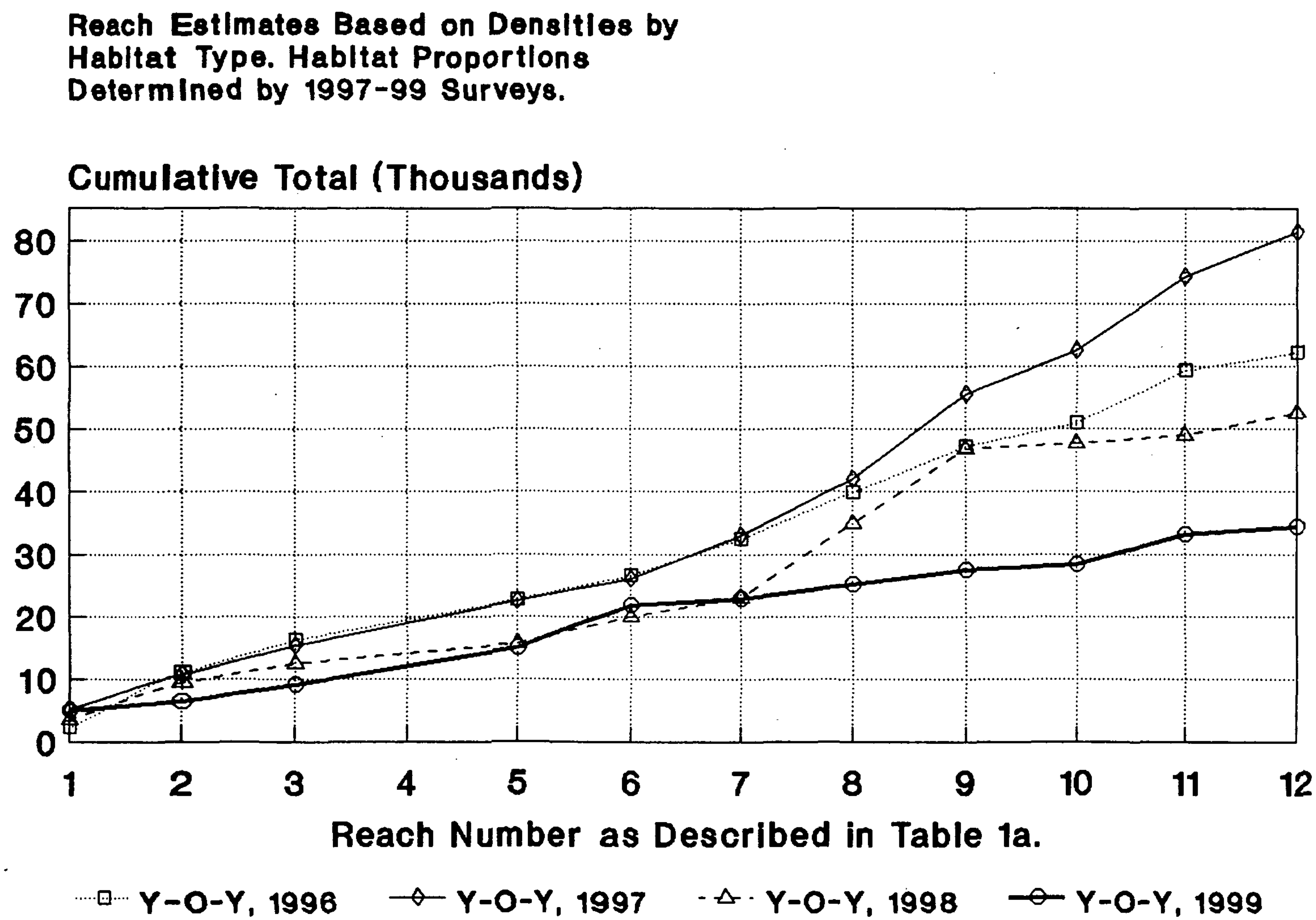


Figure 16. Number of YOUNG-OF-THE-YEAR Steelhead ACCUMULATED BY REACH in the MAINSTEM San Lorenzo River, 1996-99.

Reach Estimates Based on Habitat Type Densities. Habitat Proportions Determined by 1997-99 Habitat-Typing.

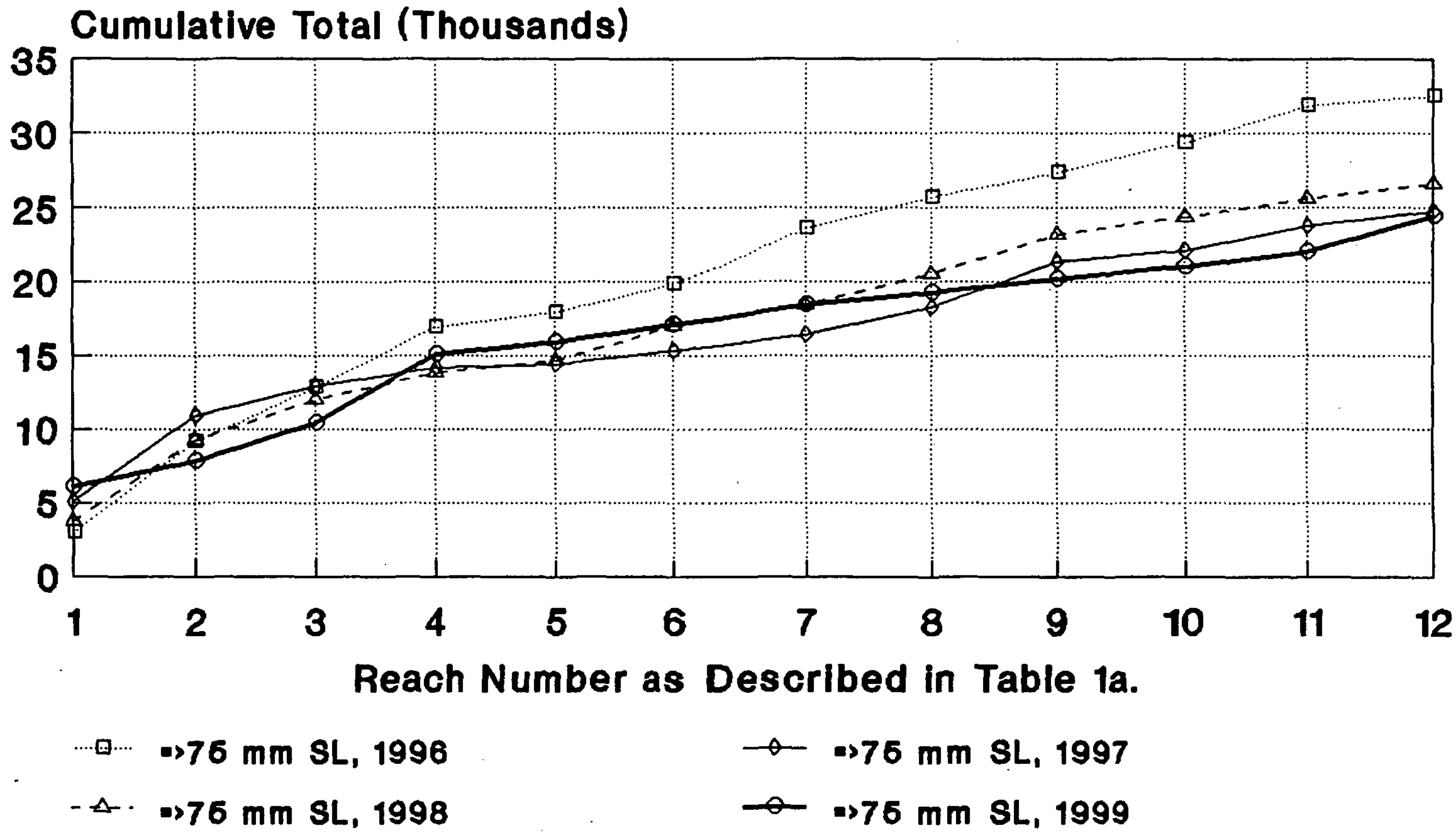


Figure 17. NUMBER of Juvenile Steelhead ≥75 mm SL ACCUMULATED BY REACH in the San Lorenzo River Mainstem, 1996-99.

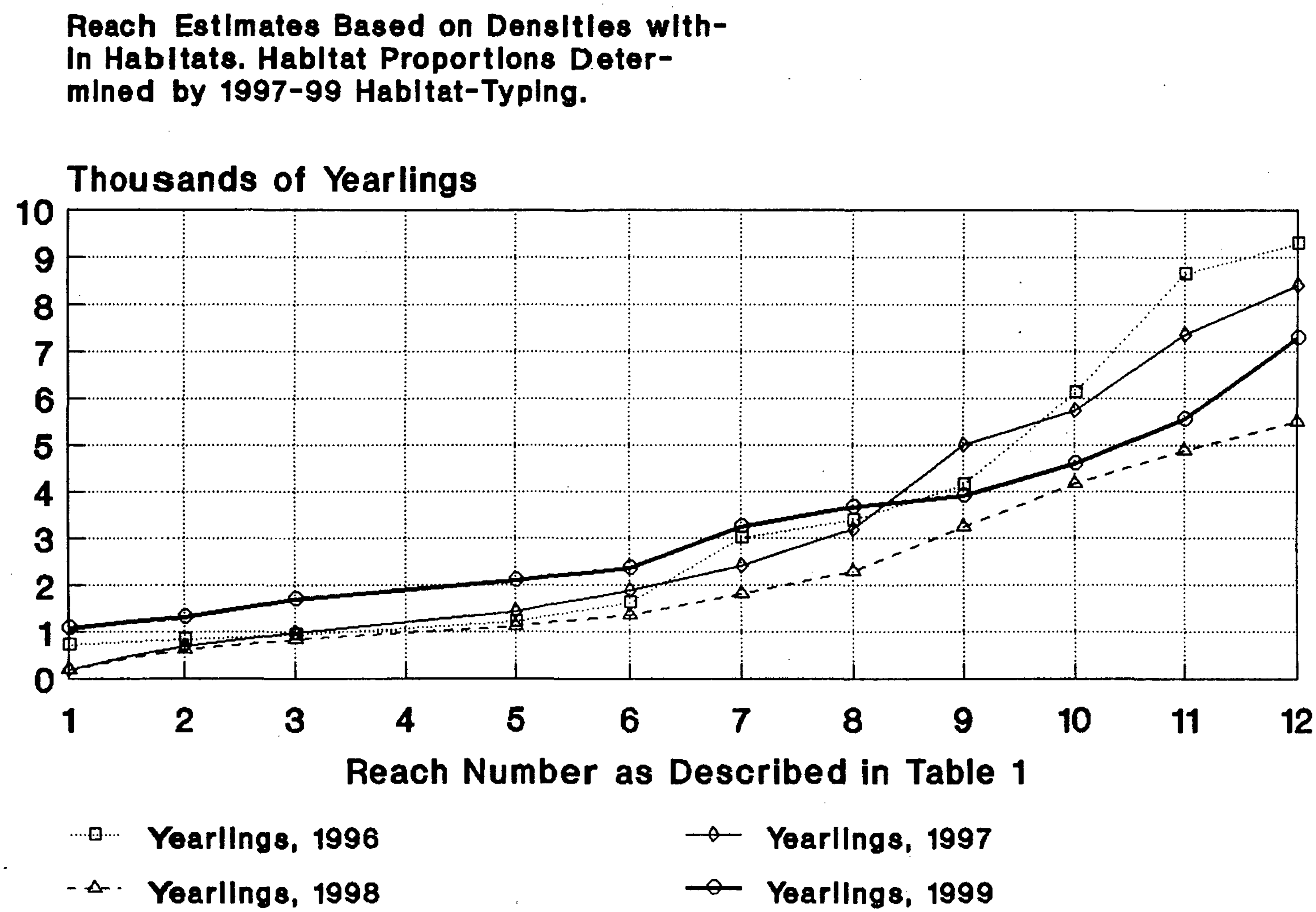


Figure 18. Number of Juvenile Steelhead Yearlings Accumulated by Reach in the San Lorenzo River Mainstem, 1996-99.

**Reach Estimates Based on Habitat Type.
Densities and Proportions Determined in
1997-99 Habitat-Typing Surveys.**

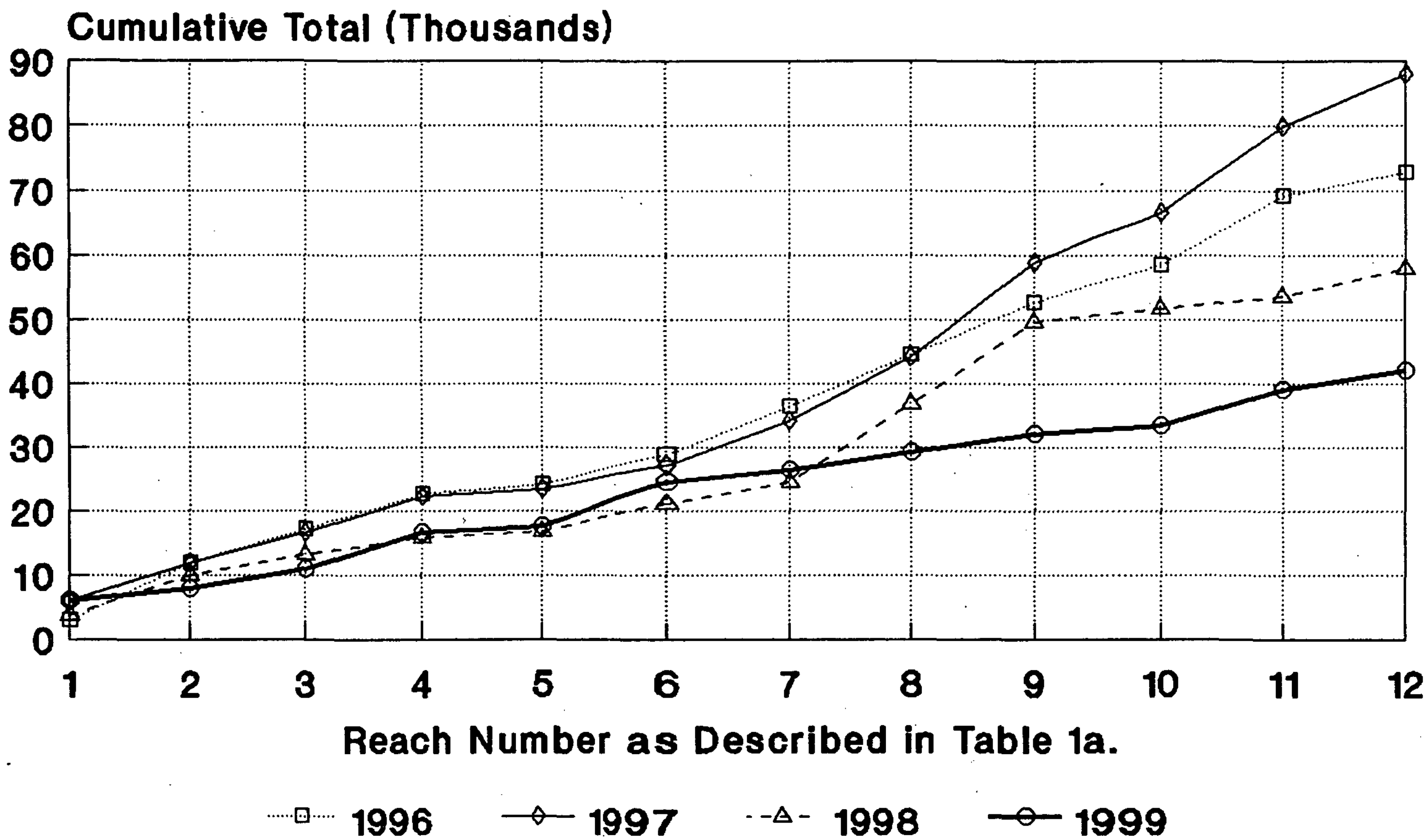


**Figure 19. NUMBER of Juvenile Steelhead
in the MAINSTEM San Lorenzo, ACCUMULATED
by Reach in 1996-99; ALL SIZES Combined.**

Tribulary REACH Densities
< 75 mm SL (3")- Size Class 1
=> 75 mm SL- Size Classes 2 and 3

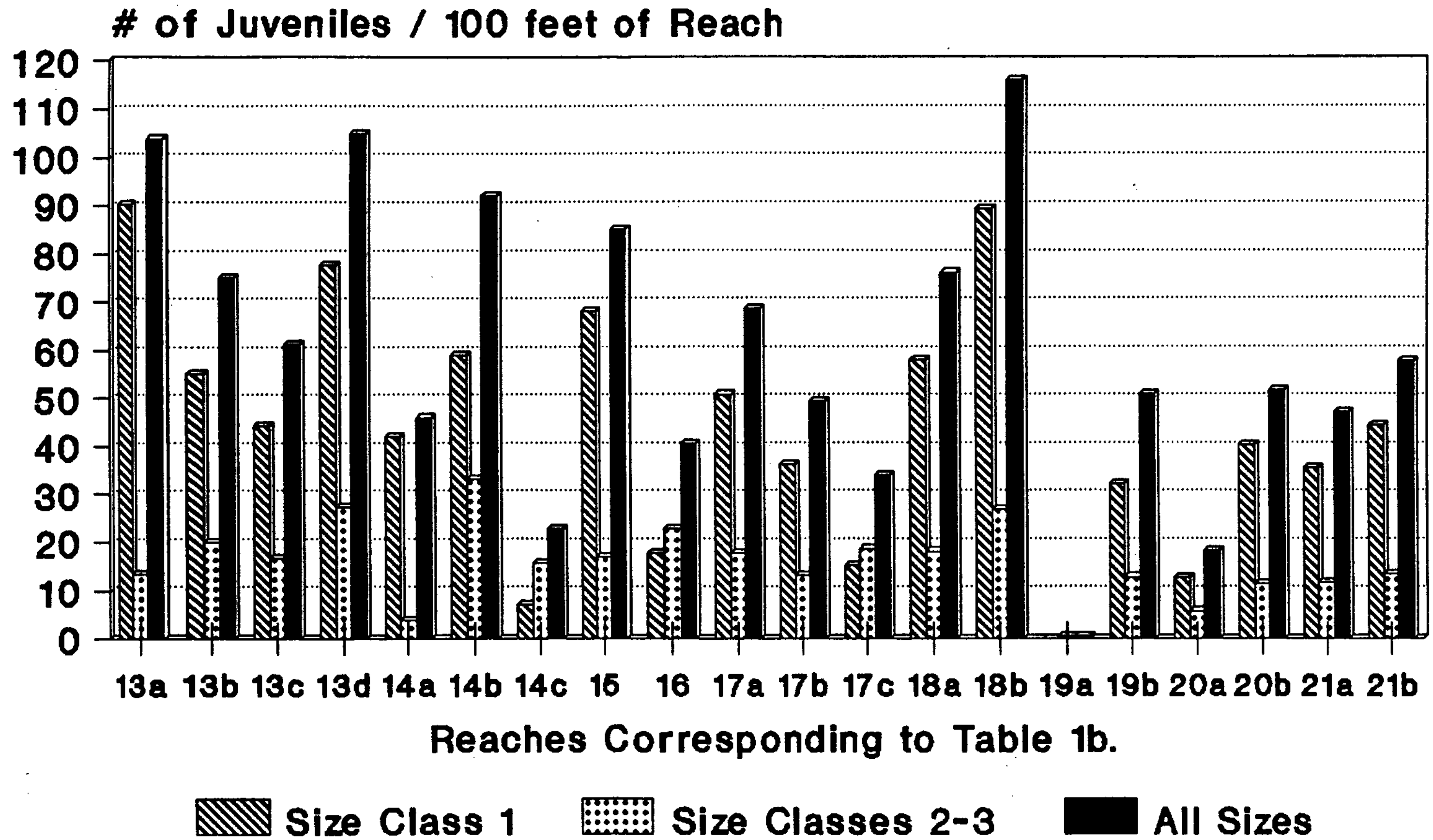


Figure 20a. Steelhead REACH Density by Juvenile SIZE Class; TRIBUTARY REACHES, 1999.

Tribütary REACH Densities
=> 75 mm SL- Size Classes 2 and 3

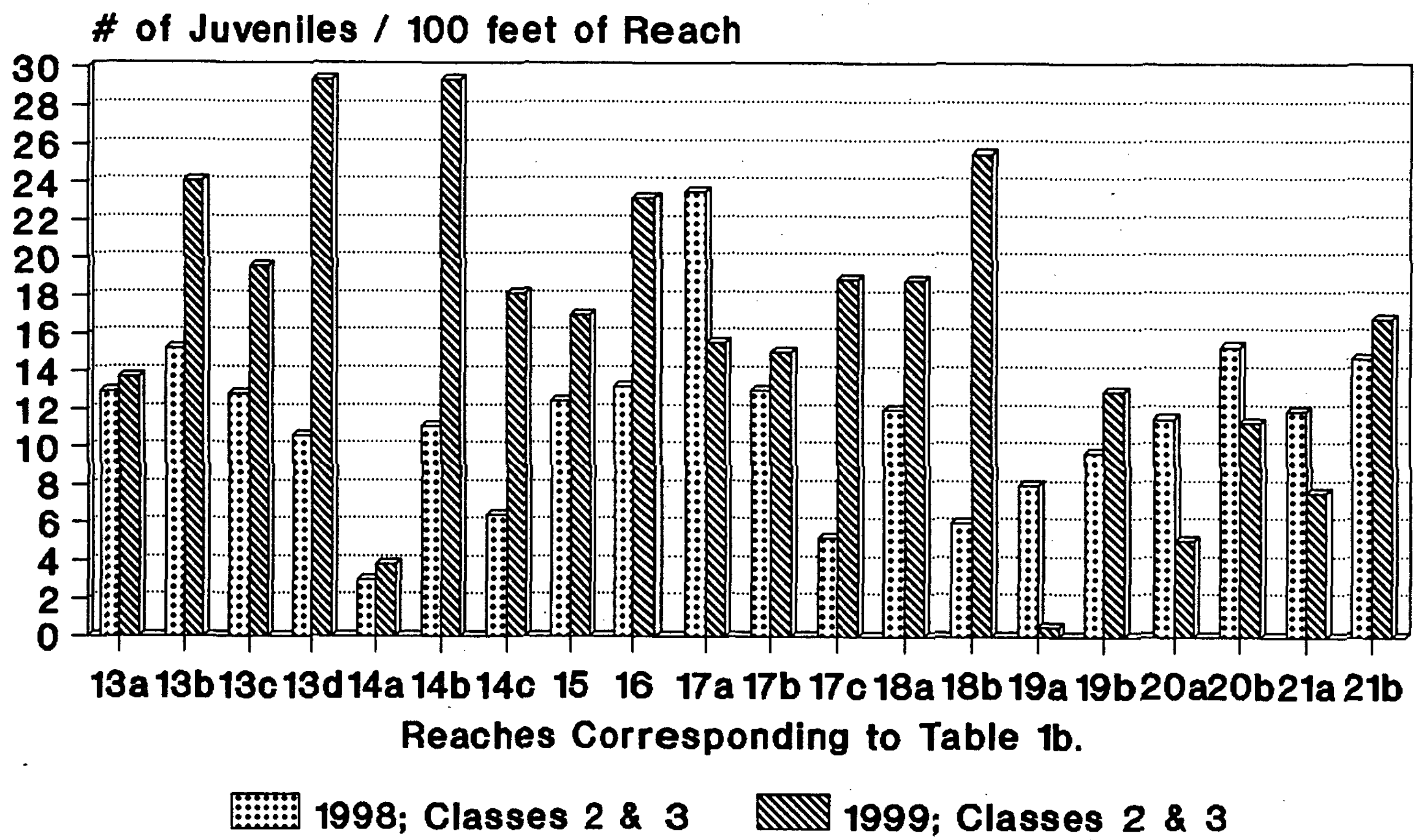


Figure 20b. Steelhead REACH Density of Juvenile SIZE Classes 2 and 3; Tributary REACHES, 1998 and 1999.

Estimates of Juvenile Density by Size
Based on Fish Densities by Habitat
and Habitat Proportions in 1998-99.

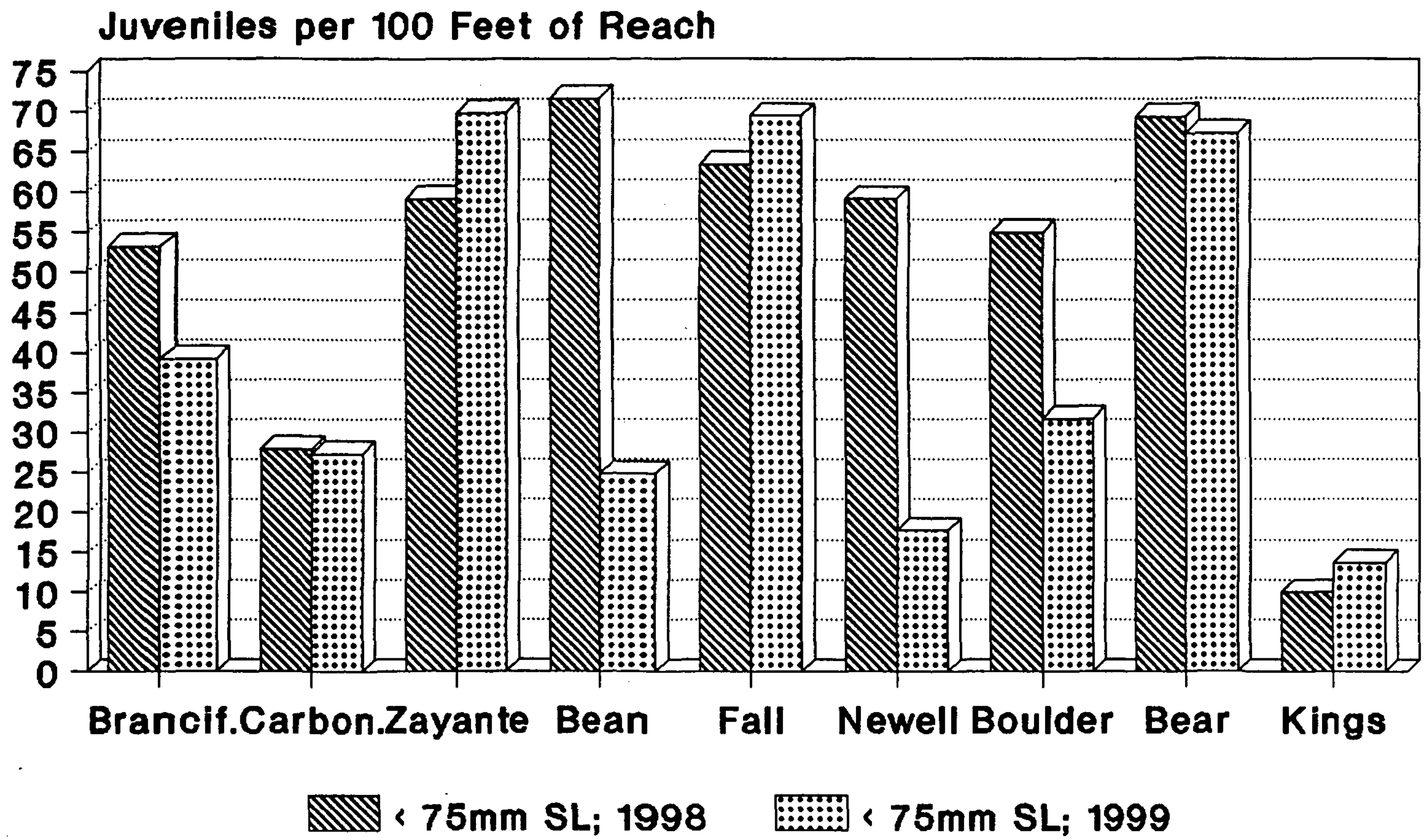


Figure 20c. STREAM DENSITY of Size
Class 1 Juvenile Steelhead by Tributary,
1998 and 1999.

Estimates of Juvenile Density by Size
Based on Fish Densities by Habitat
and Habitat Proportions in 1998-99.

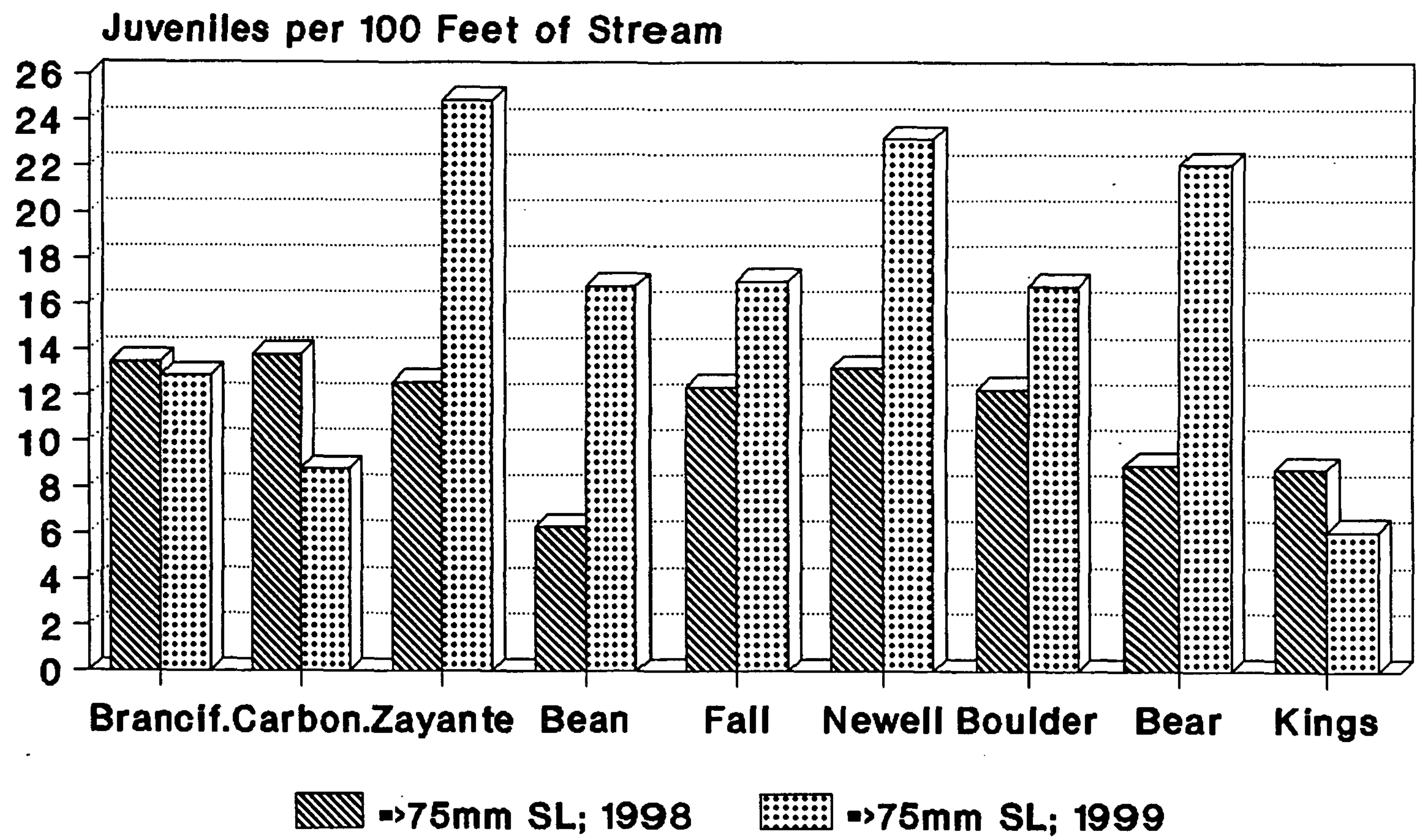


Figure 20d. STREAM DENSITY of Size
Classes 2 and 3 Juvenile Steelhead by
Tributary, 1998 and 1999.

Estimates of Total Juvenile Density
Based on Fish Densities by Habitat
and Habitat Proportions in 1998-99.

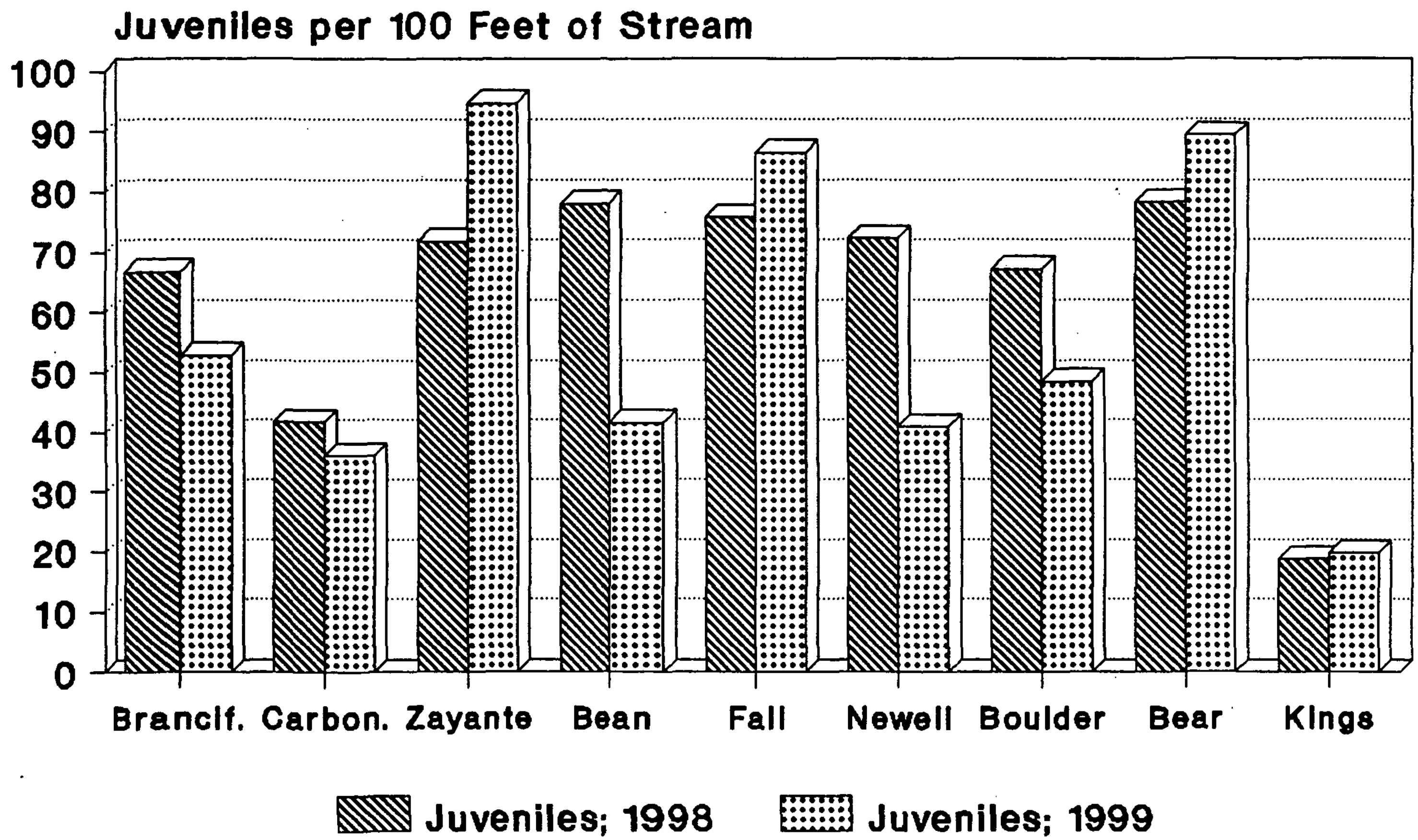


Figure 20e. STREAM DENSITY of All
Juvenile Steelhead by Tributary,
1998 and 1999.

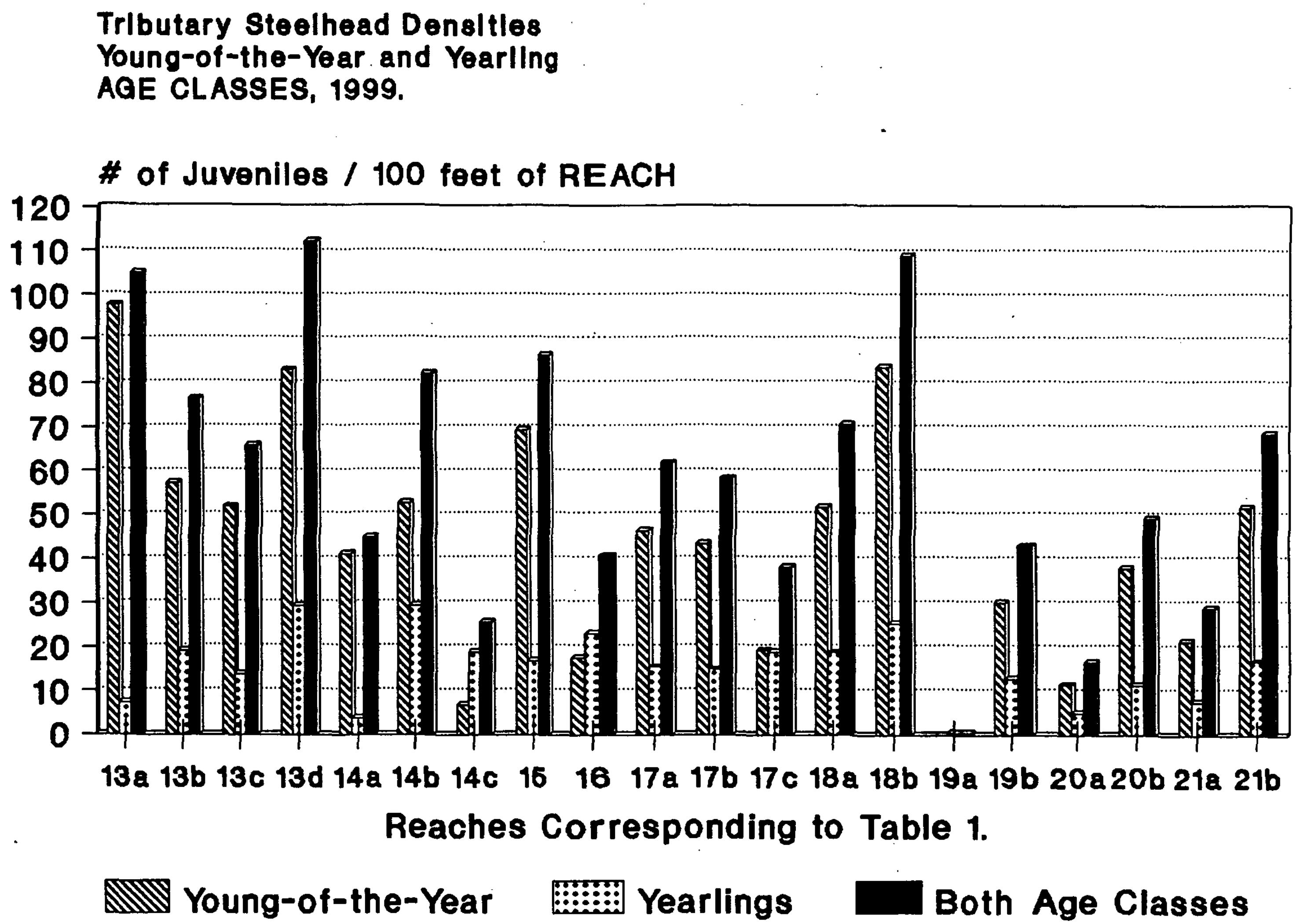


Figure 21a. REACH Density of Young-of-the-Year and Yearling AGE CLASSES; San Lorenzo TRIBUTARY REACHES, 1999.

Stream DENSITIES by AGE CLASSES
Based on Fish Densities by Habitat
and Habitat Proportions in 1999.

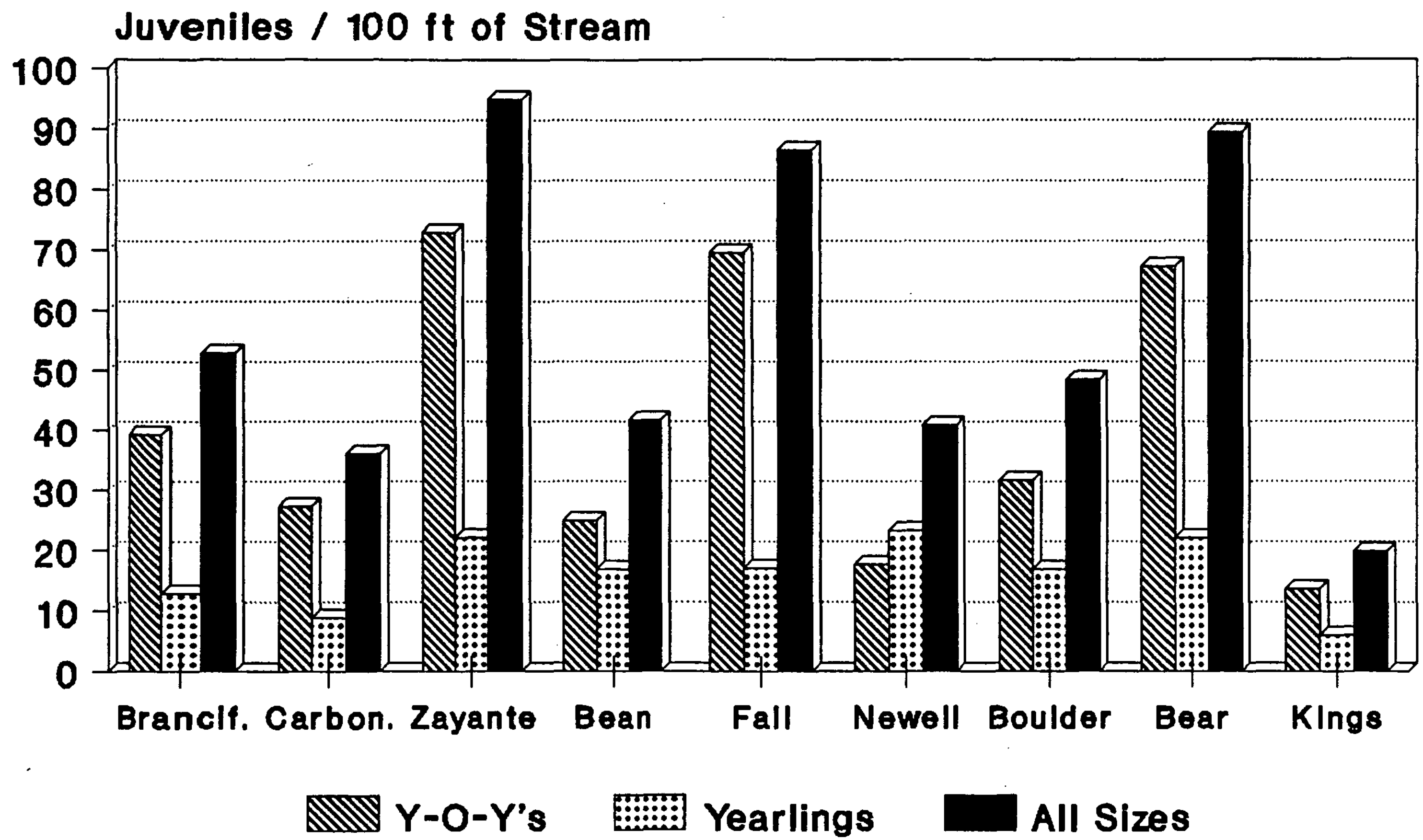


Figure 21b. OVERALL STREAM DENSITY of Juvenile Steelhead by Tributary for AGE Classes, 1999.

Tributary Steelhead Densities
Y-O-Y AGE CLASS, 1998 and 1999.

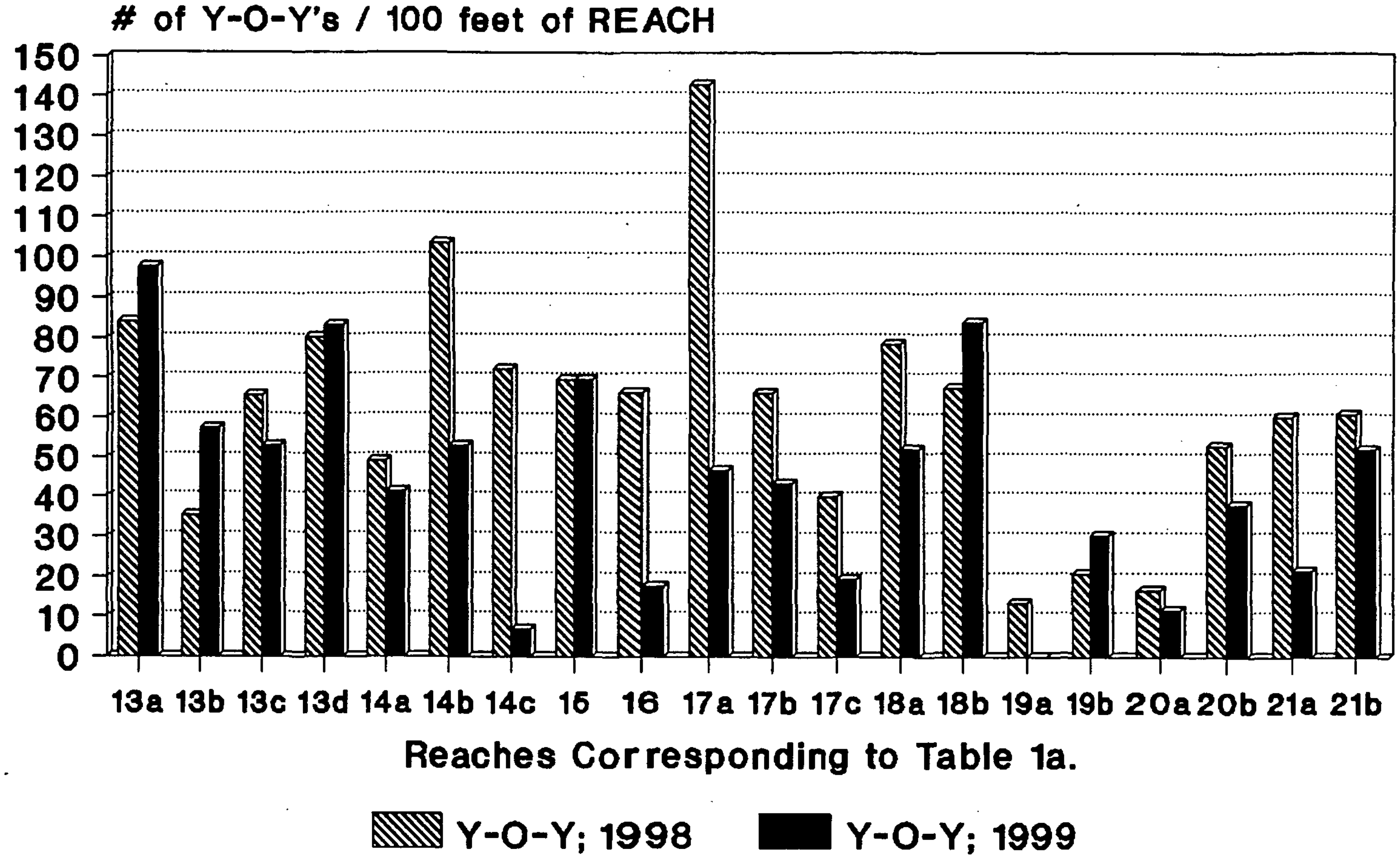


Figure 21c. Steelhead REACH Density of the Young-of-the-Year Age Class in San Lorenzo Tributaries, 1998 and 1999.

Tributary Steelhead Densities
Yearling AGE CLASS, 1998-99.

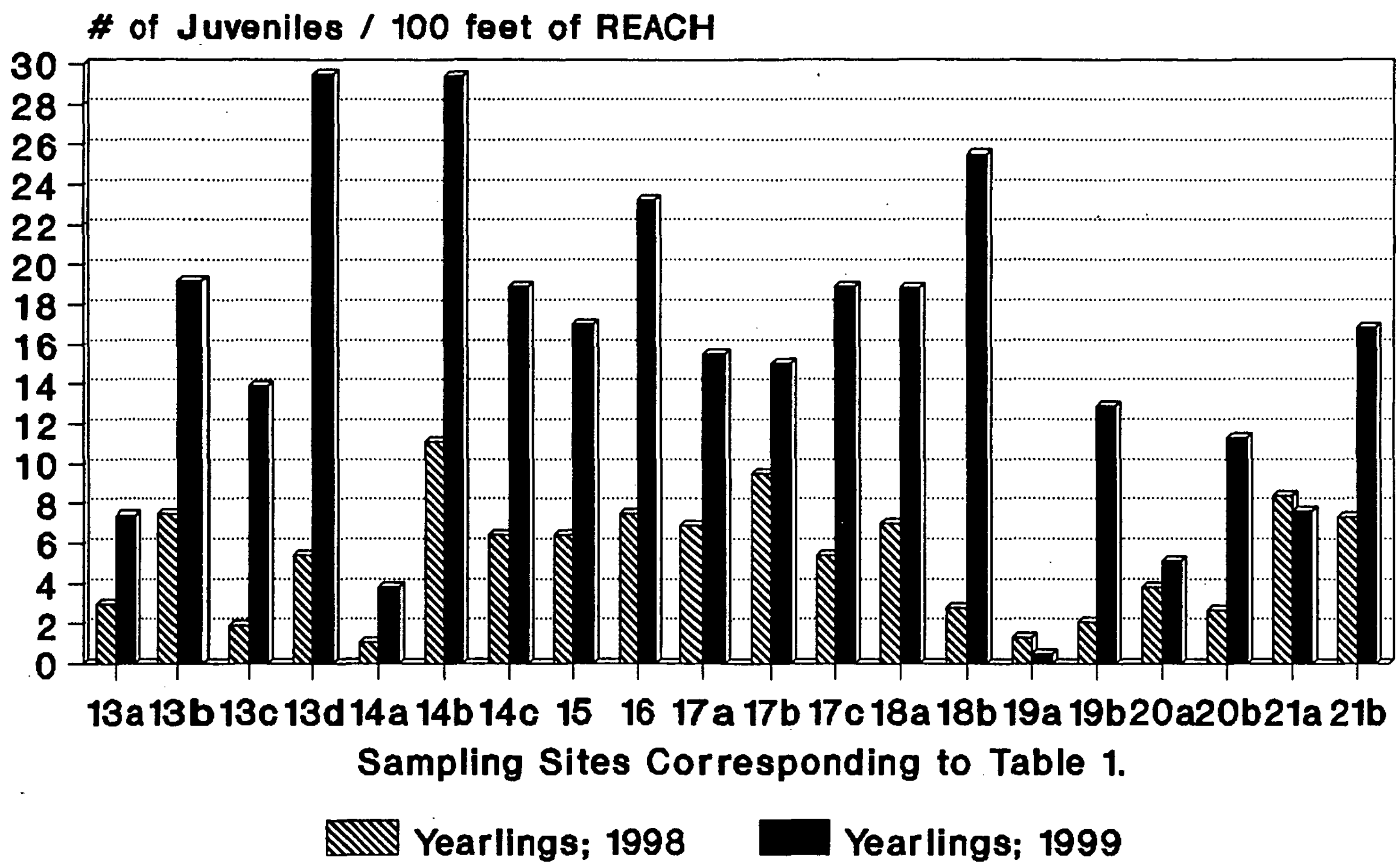


Figure 21d. Steelhead Density of the Yearling AGE CLASS; San Lorenzo Tributary REACHES, 1998 and 1999.

Stream Estimates of AGE CLASSES
Based on Fish Densities by Habitat
and Habitat Proportions in 1998.

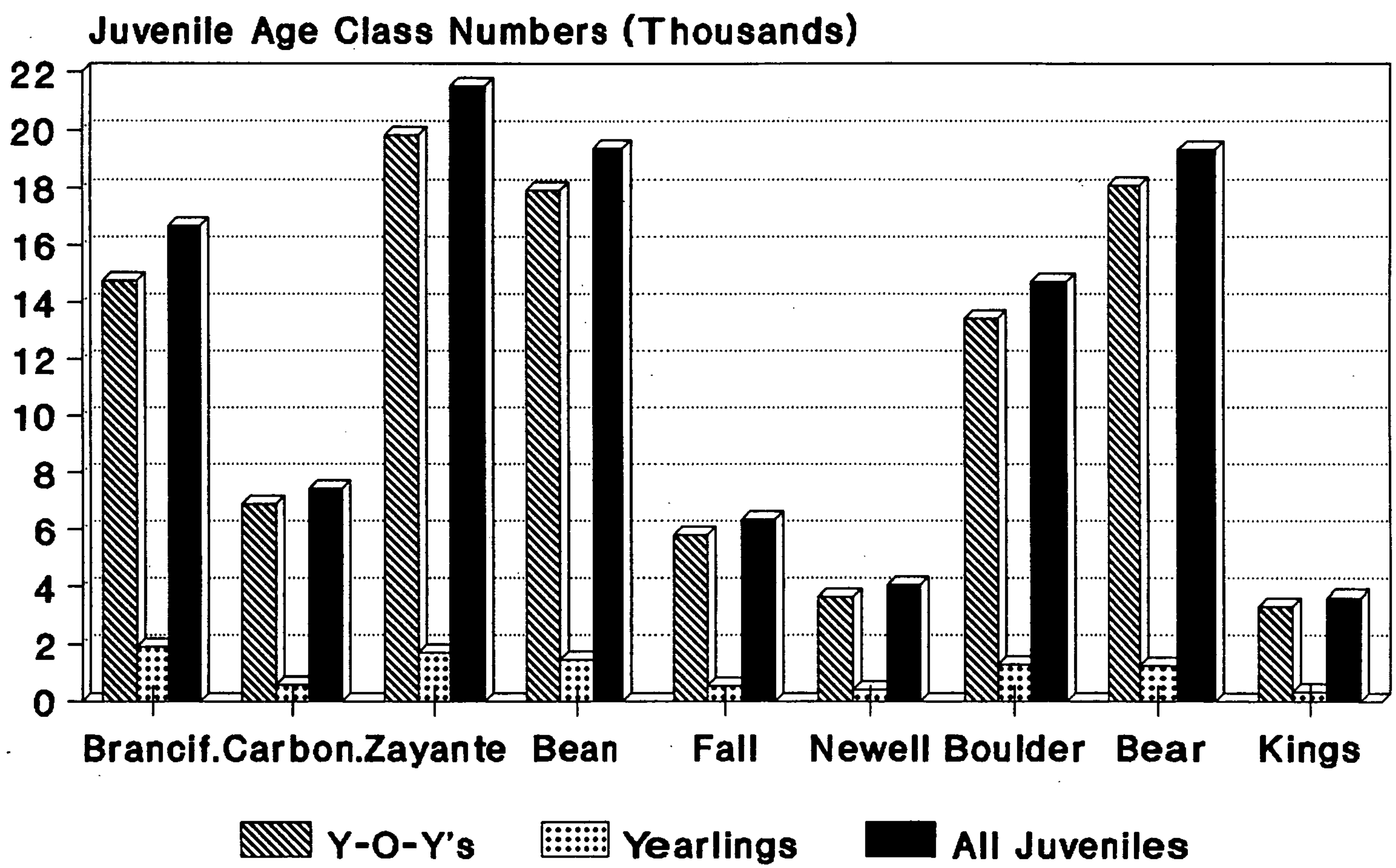


Figure 21e. NUMBER of Juvenile Steel-
head by Tributary for AGE CLASSES, 1998.

Stream Estimates of AGE CLASSES
Based on Fish Densities by Habitat
and Habitat Proportions in 1999.

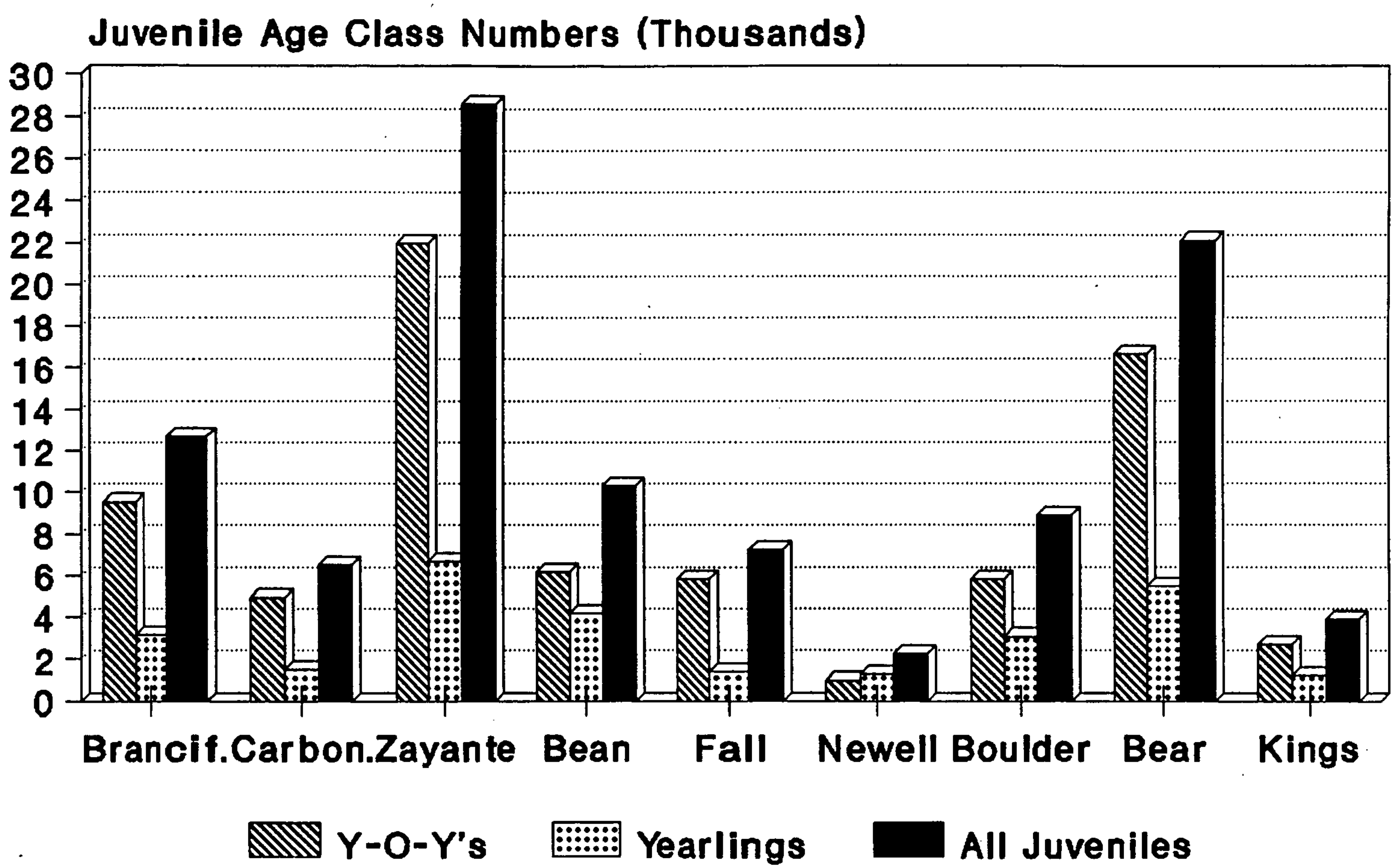
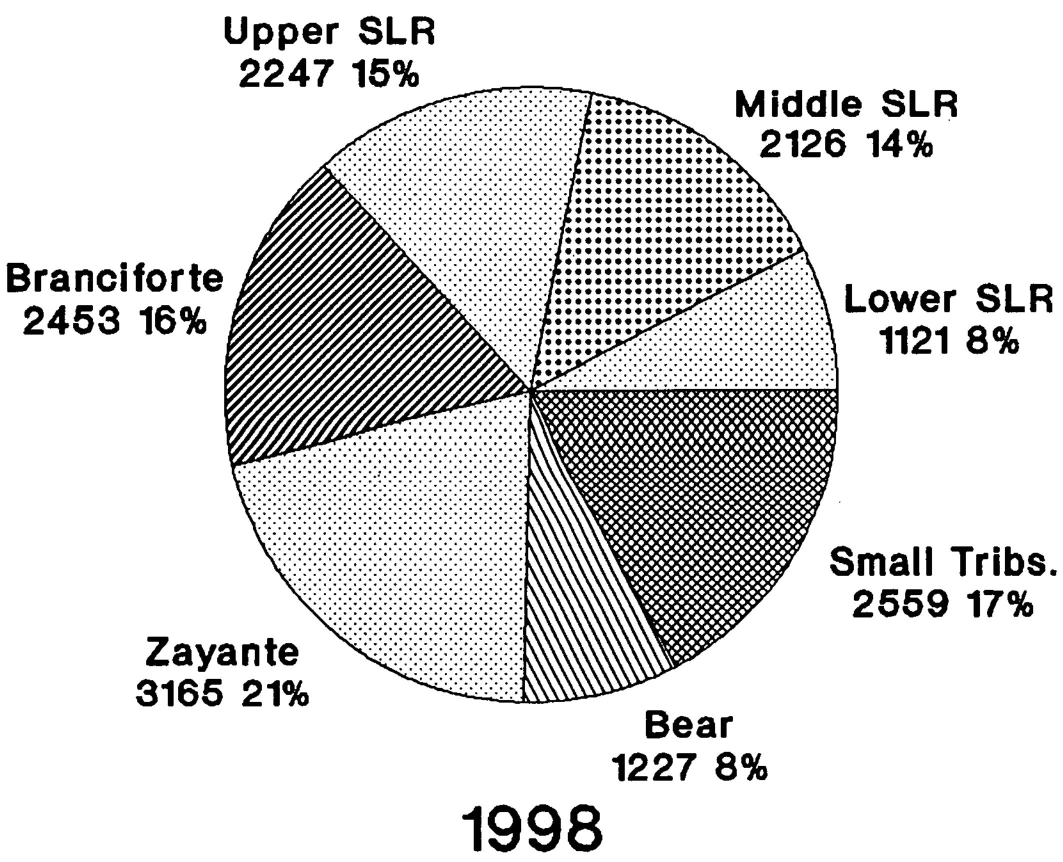


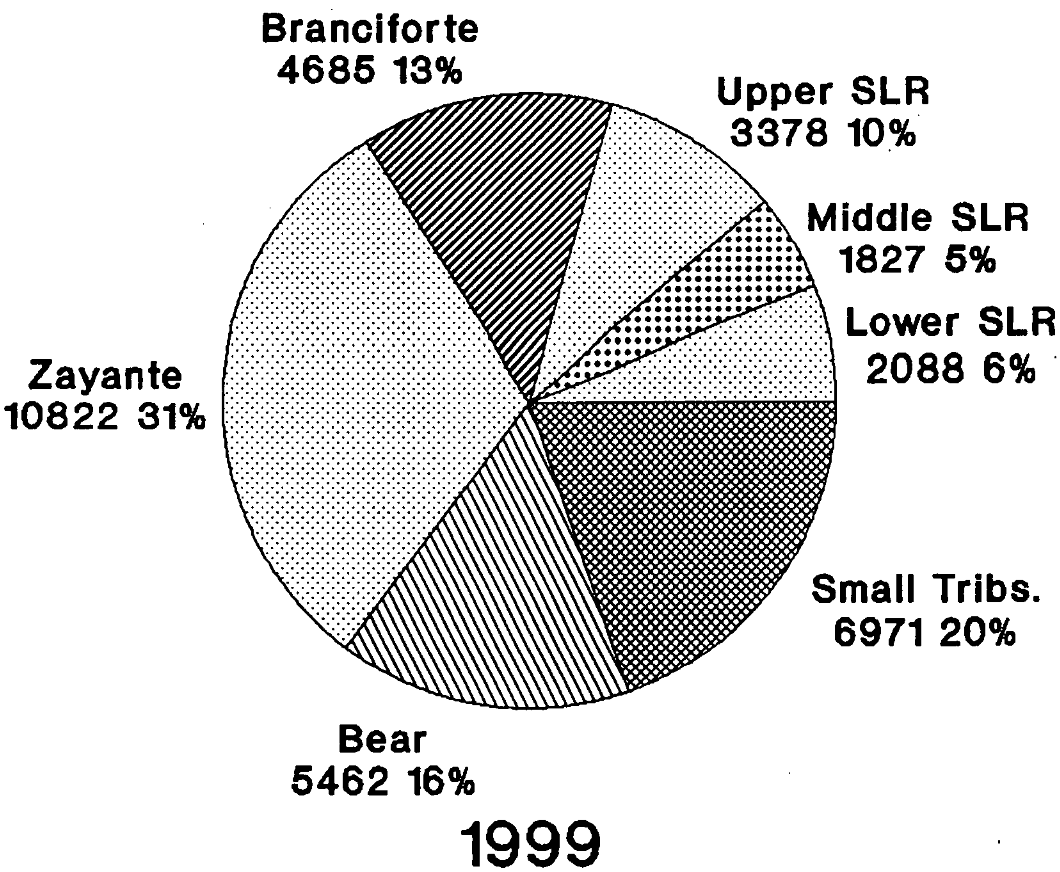
Figure 21f. NUMBER of Juvenile Steel-
head by Tributary for AGE CLASSES, 1999.

Figure 25a. Production of Yearling Juveniles Proportioned by Sub-Basin in 1998.



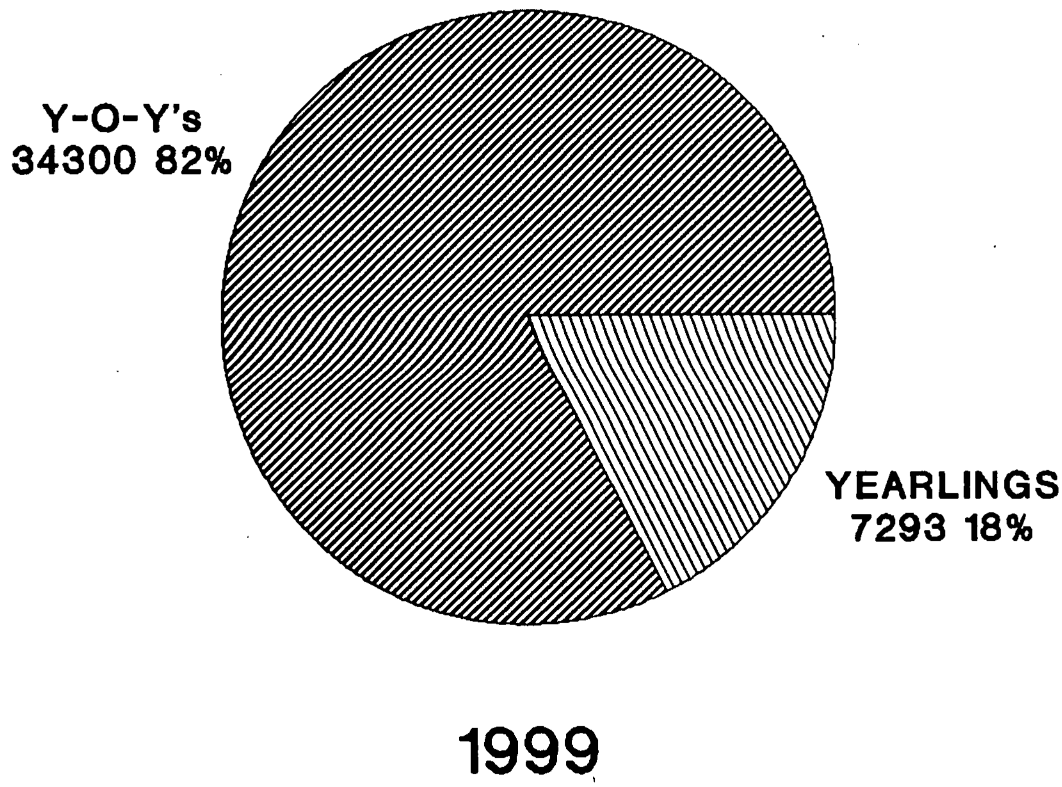
1998 YEARLING AGE-CLASS = 14,898
Lower SLR- Highway 1 to Zayante Creek.
Middle SLR- Zayante to Boulder Cr. Conf.

Figure 25b. Production of Yearling Juveniles Proportioned by Sub-Basin in 1999.



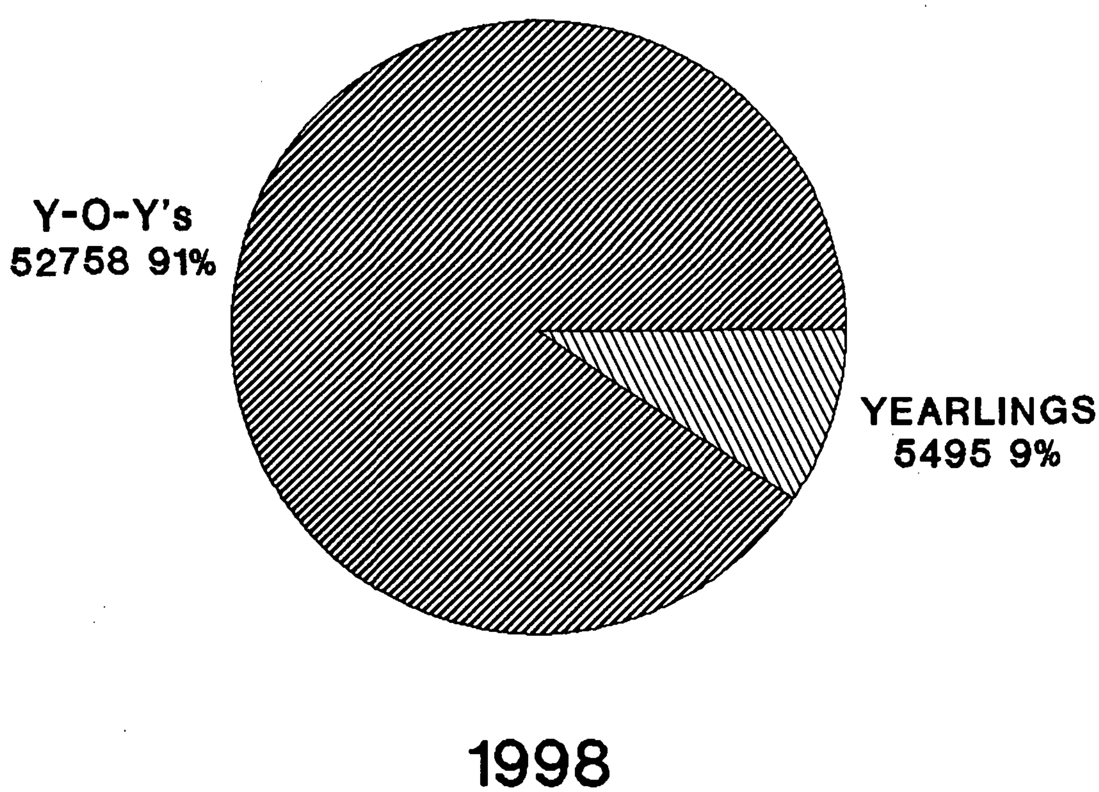
1999 YEARLING AGE-CLASS = 35,233
Lower SLR- Highway 1 to Zayante Creek.
Middle SLR- Zayante to Boulder Cr. Conf.

Figure 26a. The 1999 Mainstem River's Relative Numbers of Young-of-the-Year and Yearling Age Classes of Steelhead.



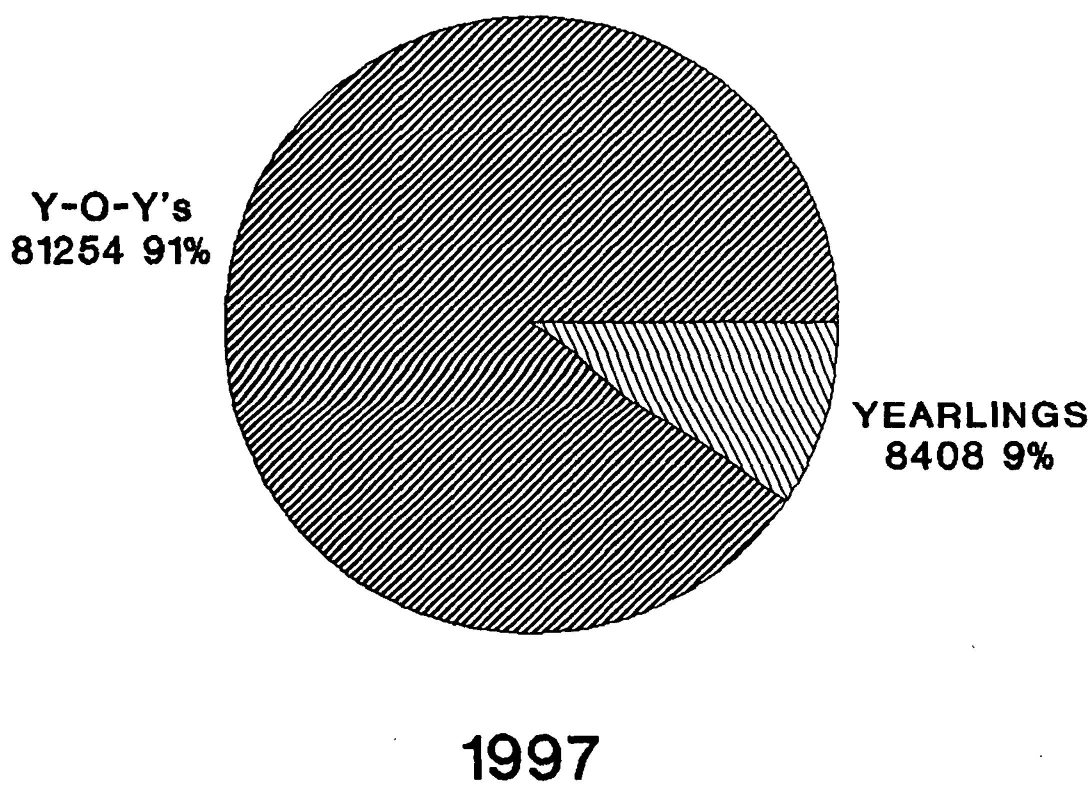
1999 Mainstem Juveniles = 41,593

Figure 26b. The 1998 Mainstem River's Relative Numbers of Young-of-the-Year and Yearling Age Classes of Steelhead.



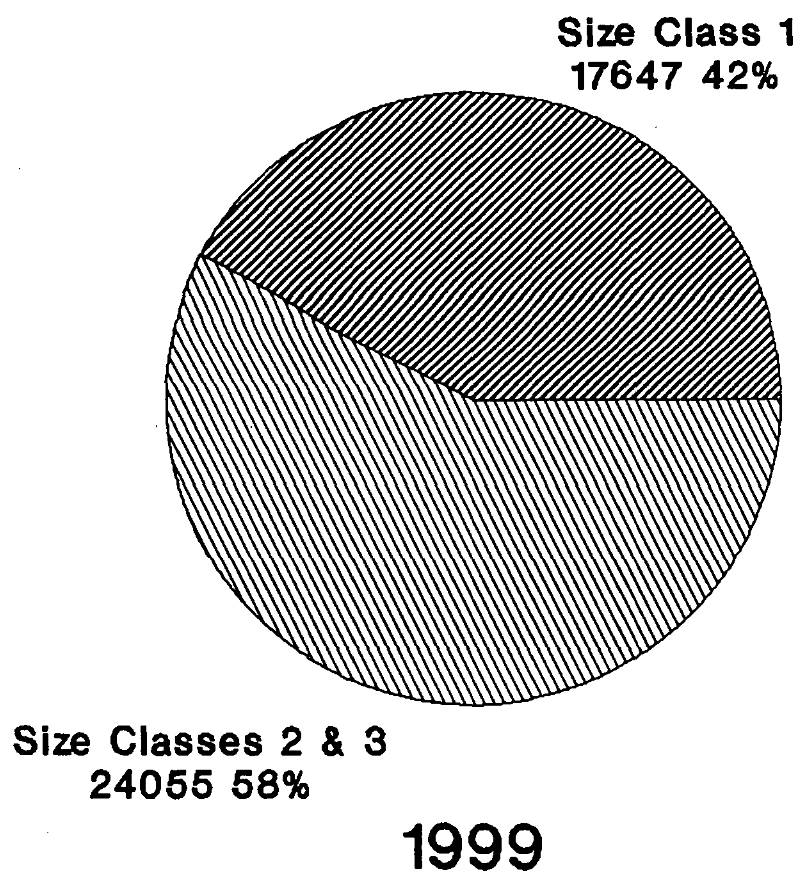
1998 Mainstem Juveniles = 58,253

Figure 26c. The 1997 Mainstem River's Relative Numbers Young-of-the-Year and Yearling Age Classes of Steelhead.



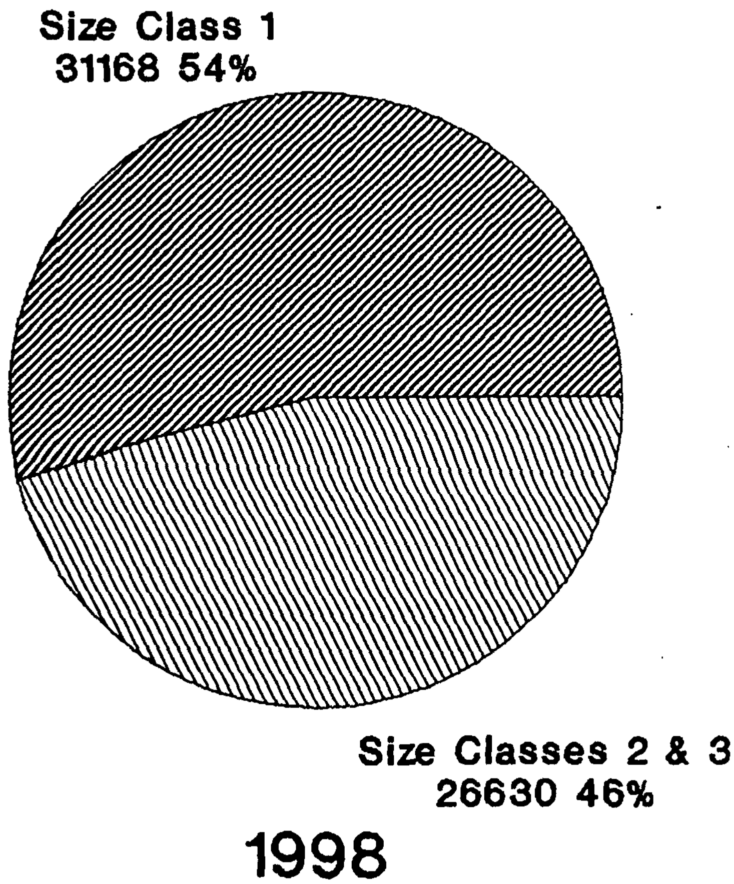
1997 Mainstem Juveniles = 89,662

Figure 26d. The 1999 Mainstem River's Relative Numbers of Size Class 1 Versus Size Class 2 and 3 Juvenile Steelhead.



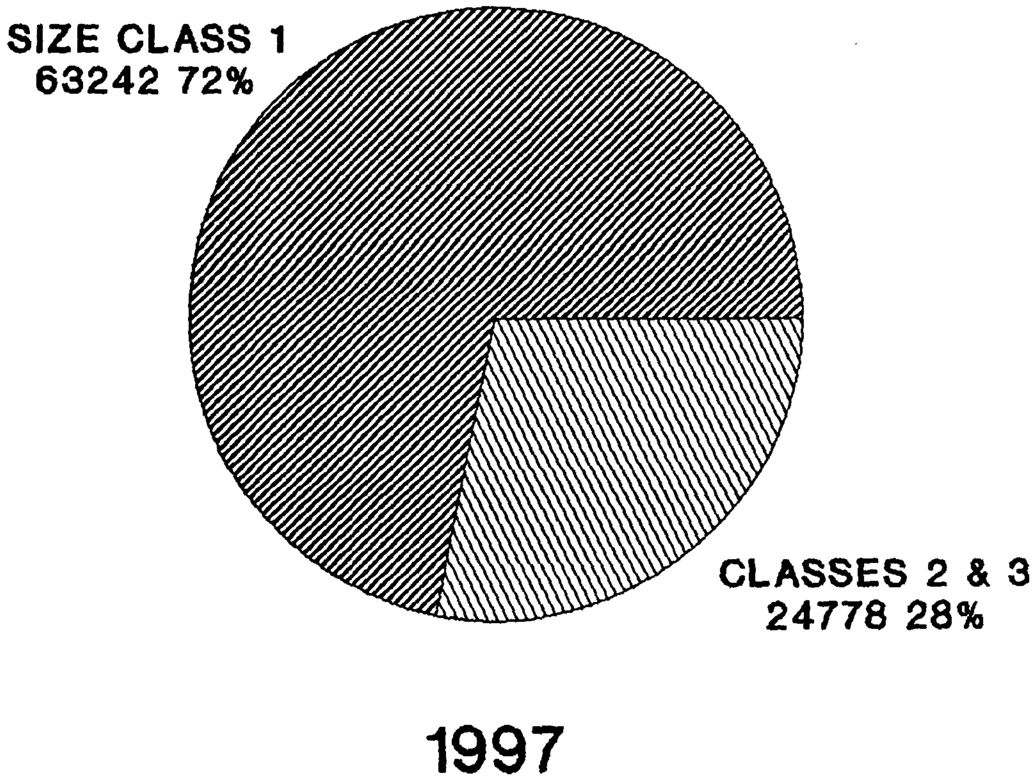
1999 Mainstem Juveniles = 41,702

Figure 26e. The 1998 Mainstem River's Relative Numbers of Size Class 1 Versus Size Class 2 and 3 Juvenile Steelhead.



1998 Mainstem Juveniles = 57,798

Figure 26f. The 1997 Mainstem River's Production of Size Class 1 versus Size 2 and 3 Juvenile Steelhead.



1997 Mainstem Juveniles = 88,020

Trends in Index of Adult Returns-
Mainstem (M) 1981, 1994-99.
Mainstem + Tributaries (T), 1998-99.

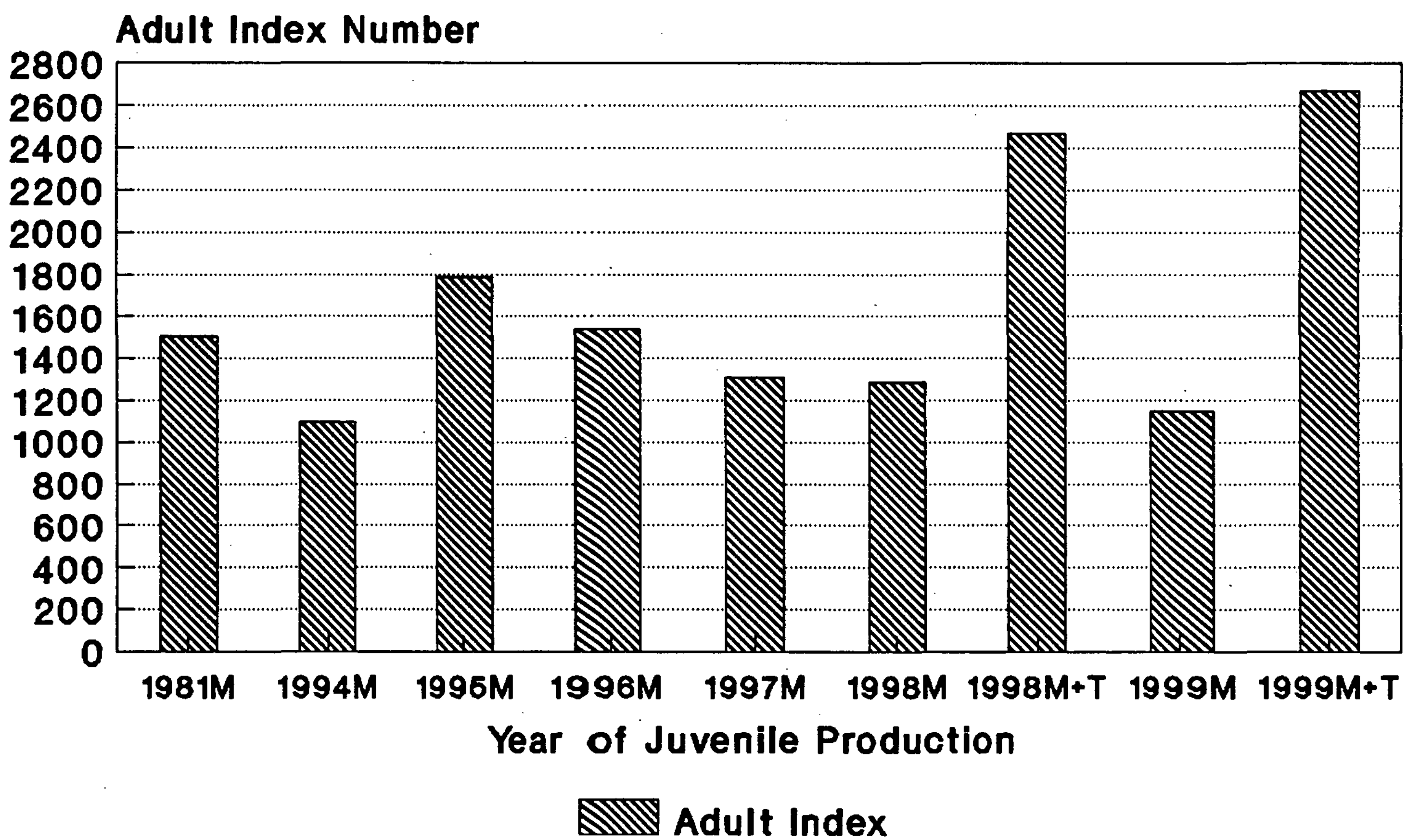


Figure 29. Trends in the Index of Adult Steelhead Returns from Annual Juveniles in the Mainstem and 9 Major Tributaries.

San Lorenzo River Substrate Comparison
Riffle & Run Embeddedness, Averaged
For Cobbles/Boulders as Portion Buried.

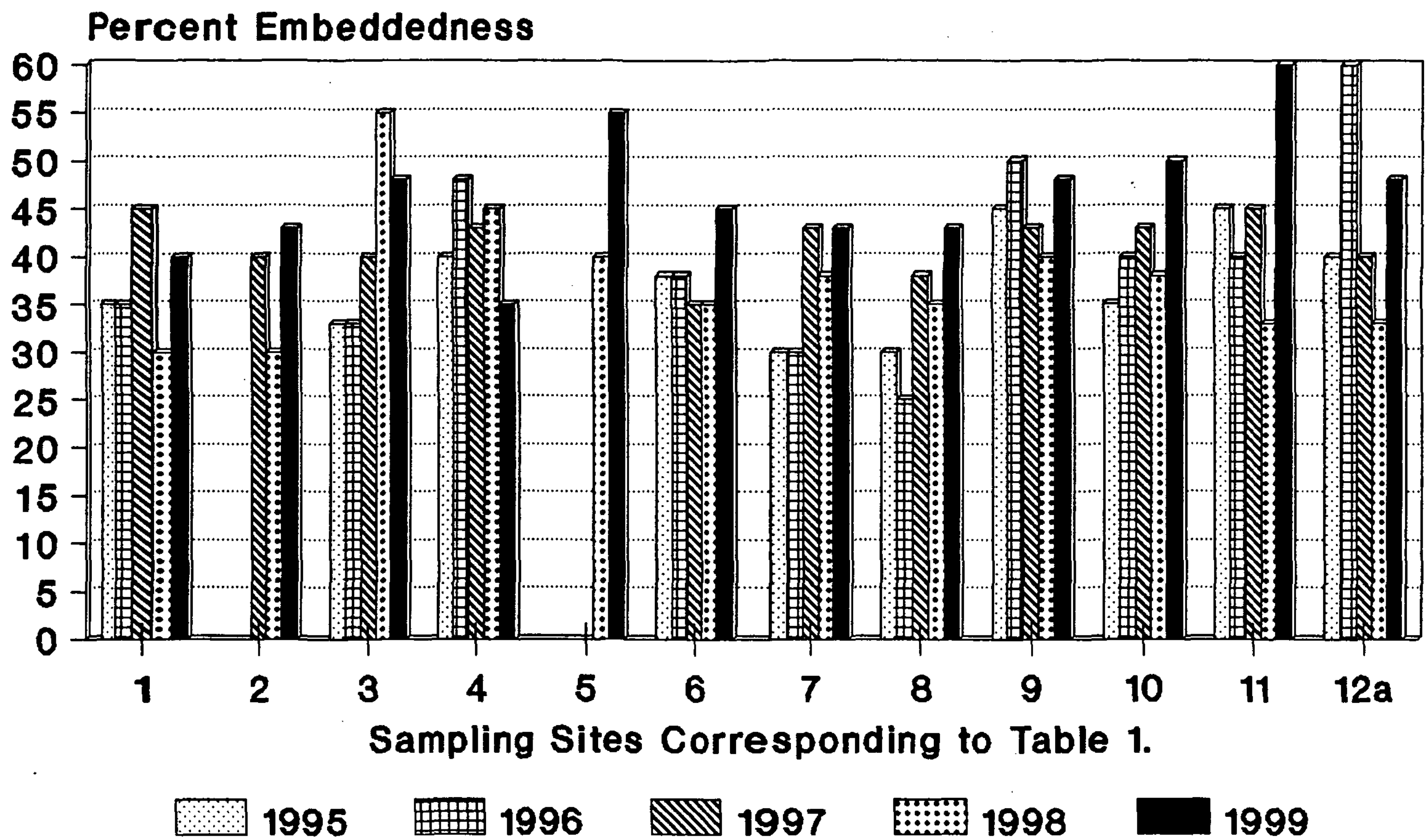


Figure 30a. Average Embeddedness for Riffle and Flat-Water Habitat by Site in the Mainstem San Lorenzo River, 1995-99.

Tributary Substrate Comparison
Riffle & Run Embeddedness, Averaged
For Cobbles/Boulders as Portion Buried.

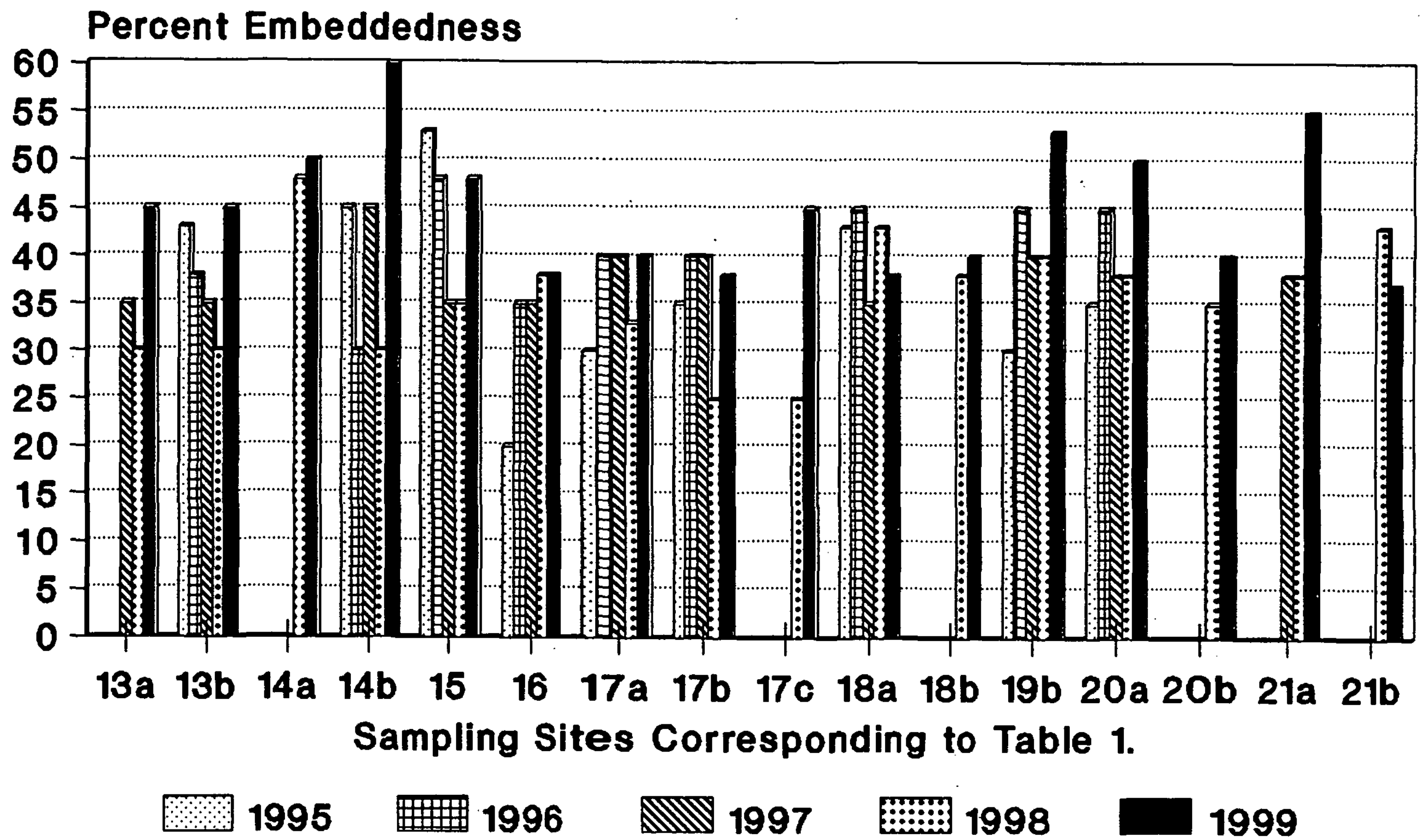


Figure 30b. Average Embeddedness for Riffle and Flat Water Habitat at Tributary Sites in 1995-99.

San Lorenzo River Mainstem Reaches
Streambed Composition- % Fine Sediment
Riffle Habitat by Surveyed Reach Segment

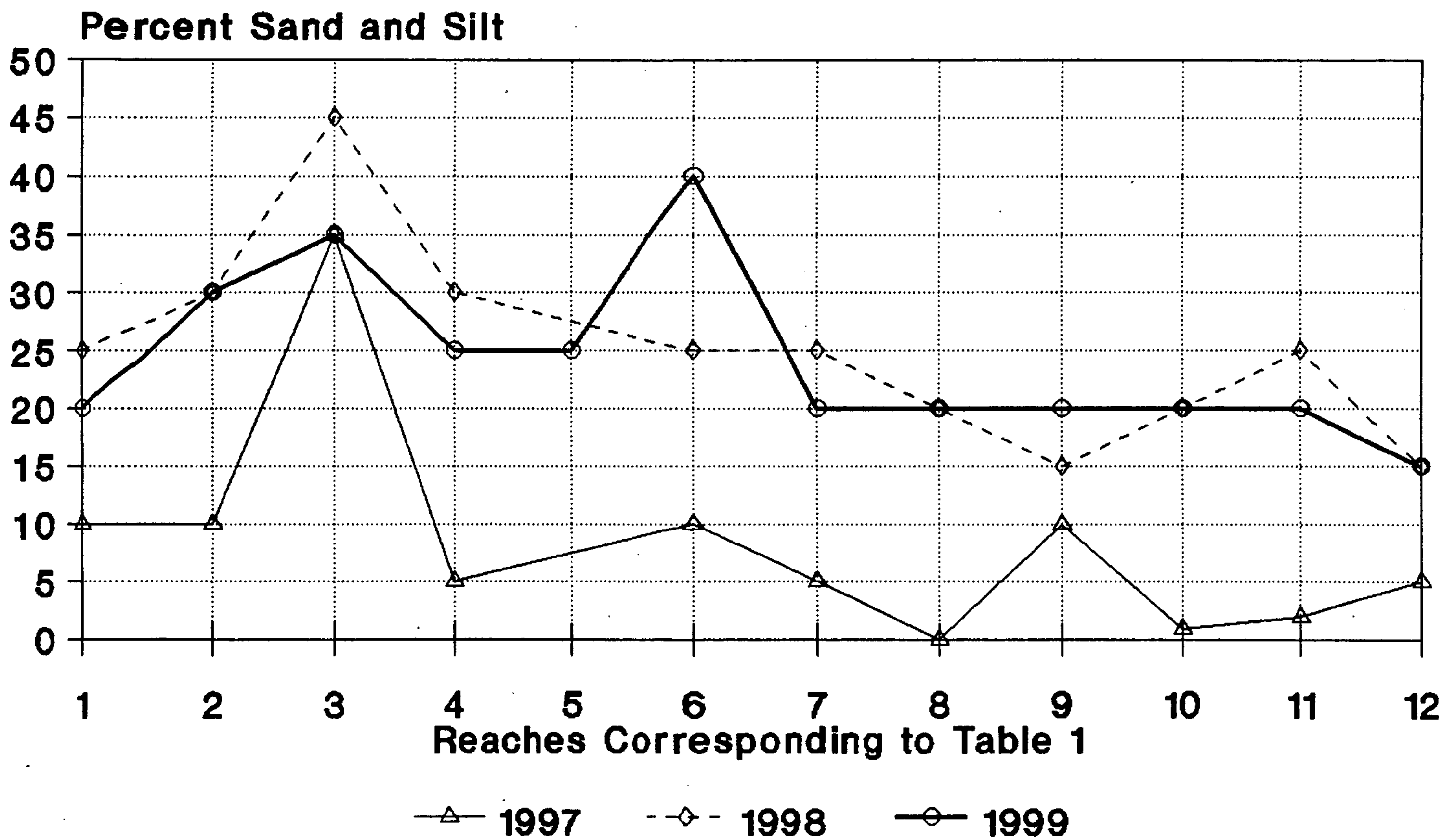


Figure 31a. Streambed Sediment in Riffle Habitat of Mainstem Reaches, Expressed As Average Percent Sand/Silt, 1997-99.

San Lorenzo River Mainstem Reaches
Streambed Composition- % Fine Sediment
Runs & Glides Surveyed in Reach Segments

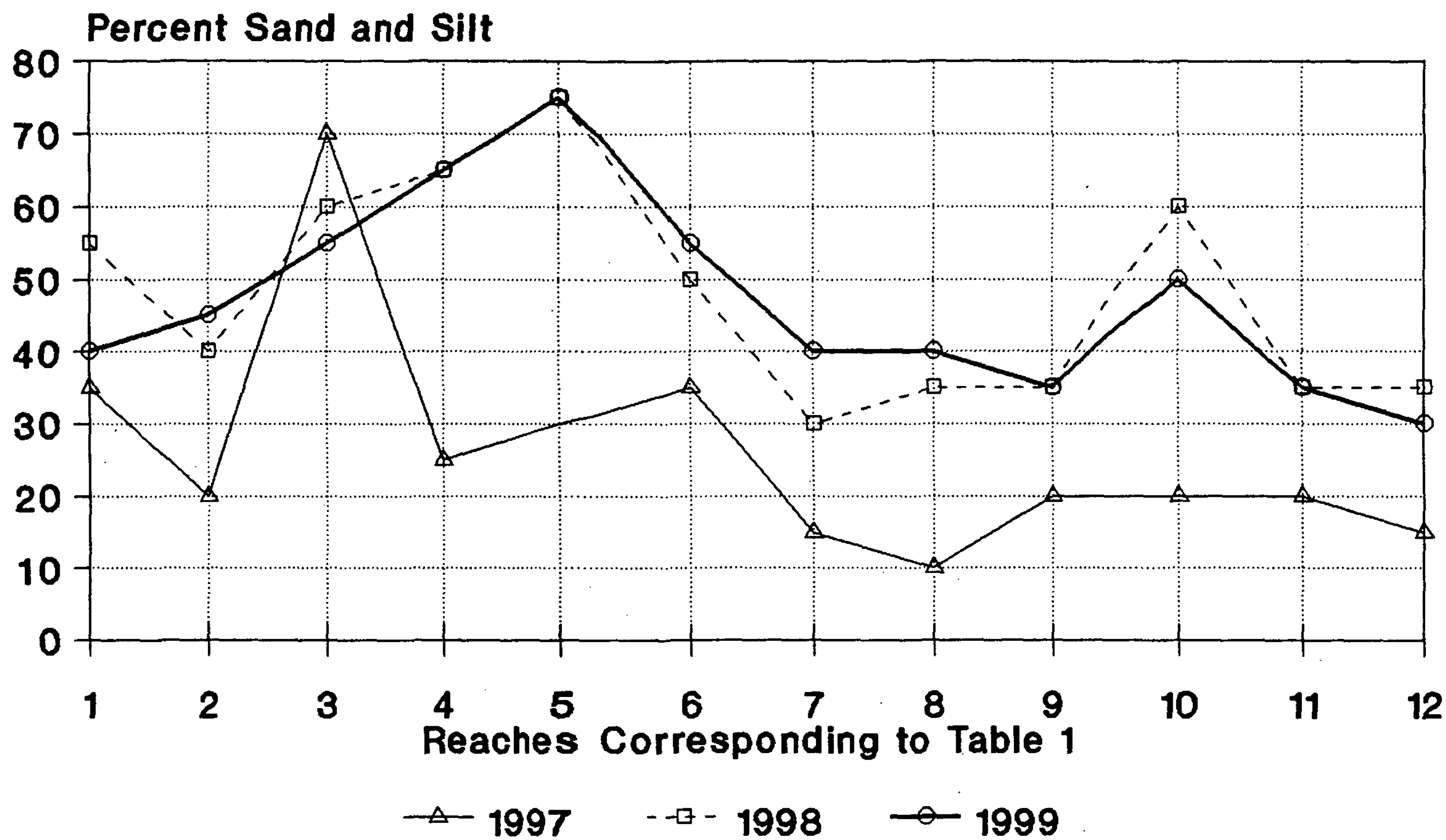


Figure 31b. Streambed Sediment in Run and Glide Habitat of Mainstem Reaches As Average Percent Sand/Silt, 1997-99.

Streambed Composition- % Fine Sediment.
Riffle Habitat in Surveyed Reaches.
***Segment 14c Moved Upstream in 1999.**

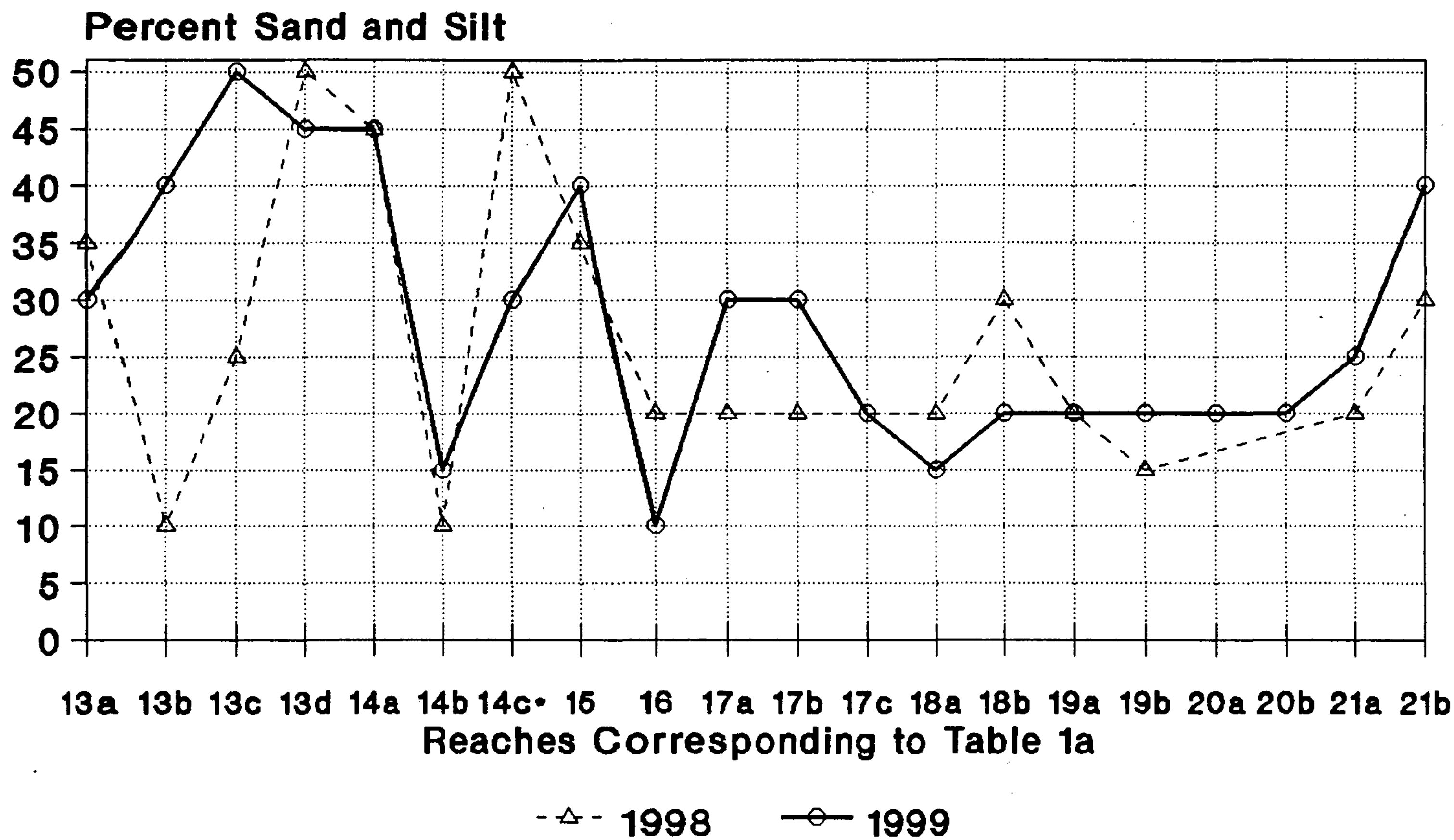


Figure 31c. Streambed Sediment in Riffle Habitat in Tributary Reaches, Expressed As Average Percent Sand/Silt, 1998-99.

Streambed Composition- % Fine Sediment.
Run/Step-runs by Surveyed Reach Segment
Segment 14c Moved Upstream In 1999.

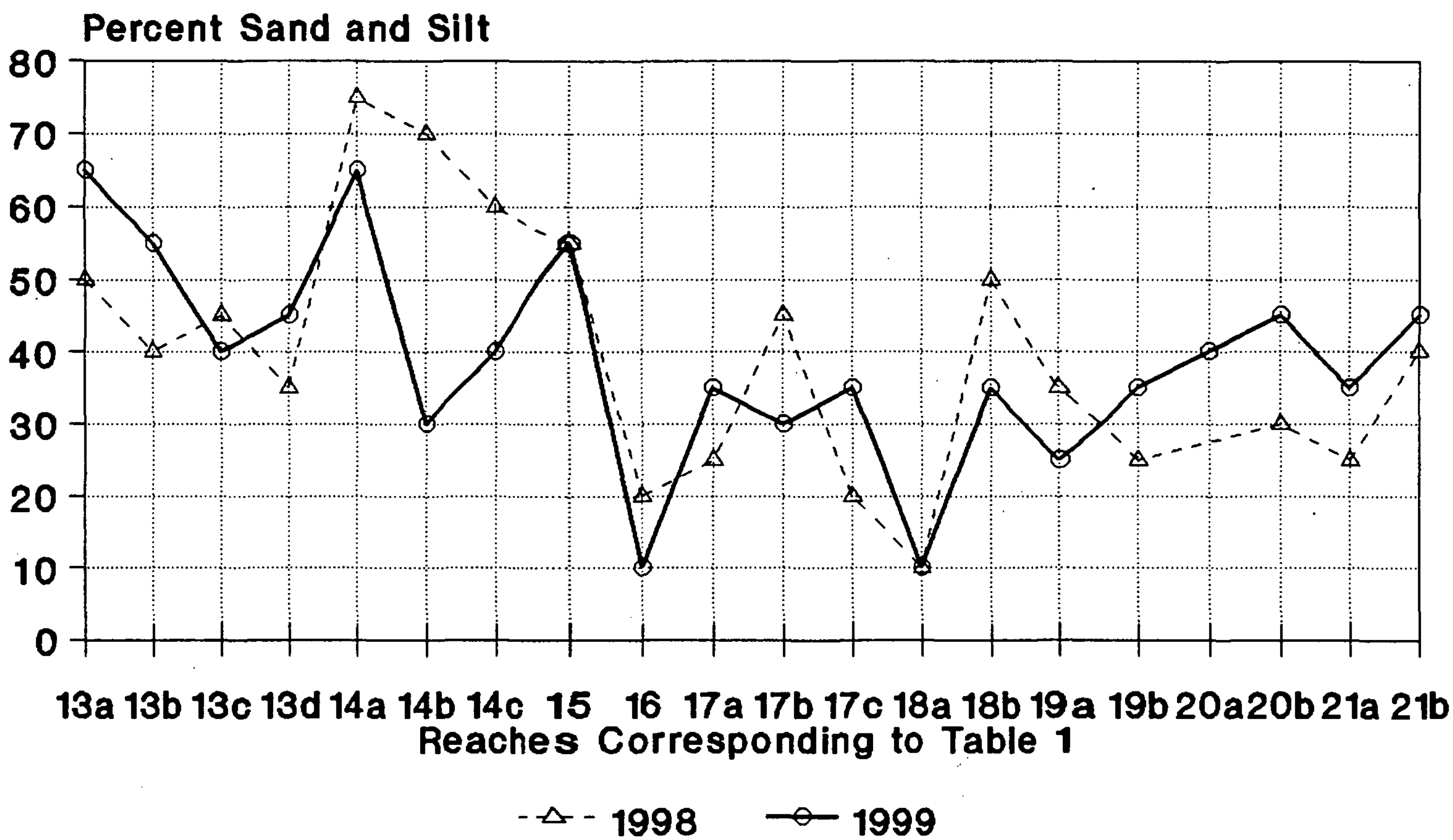


Figure 31d. Streambed Sediment In Run/
Step-run Habitat of Tributary Reaches
As Average Percent Sand/Silt, 1998-99.

San Lorenzo River Substrate Comparison
Pools & Associated Glides, Embeddedness
For Cobbles/Boulders as Portion Buried.

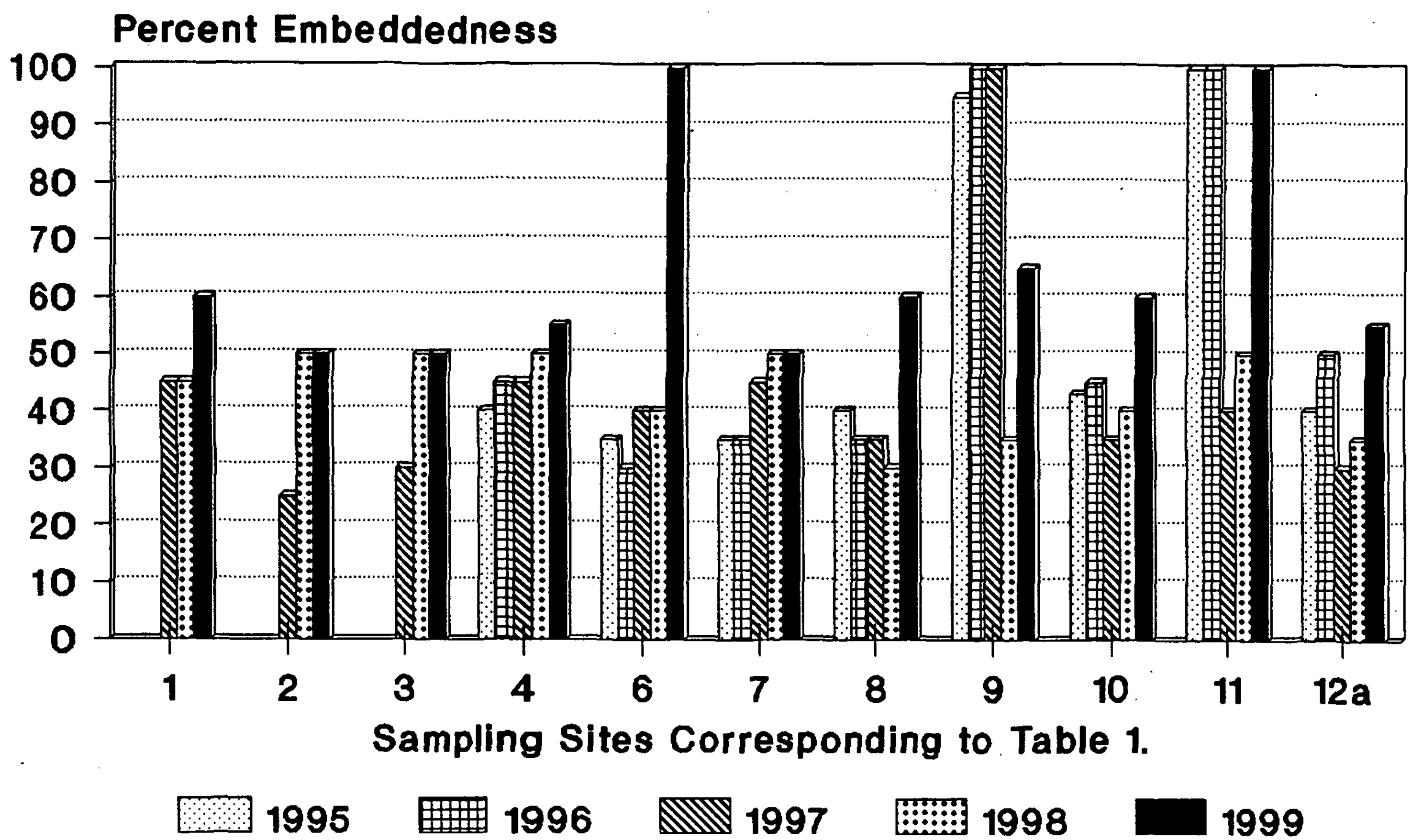


Figure 32a. Average Embeddedness for Pools and Associated Glides at Mainstem River Sites; 1995-99.

Tributary Substrate Comparison
Pools & Associated Glides, Embeddedness
For Cobbles/Boulders as Portion Buried.

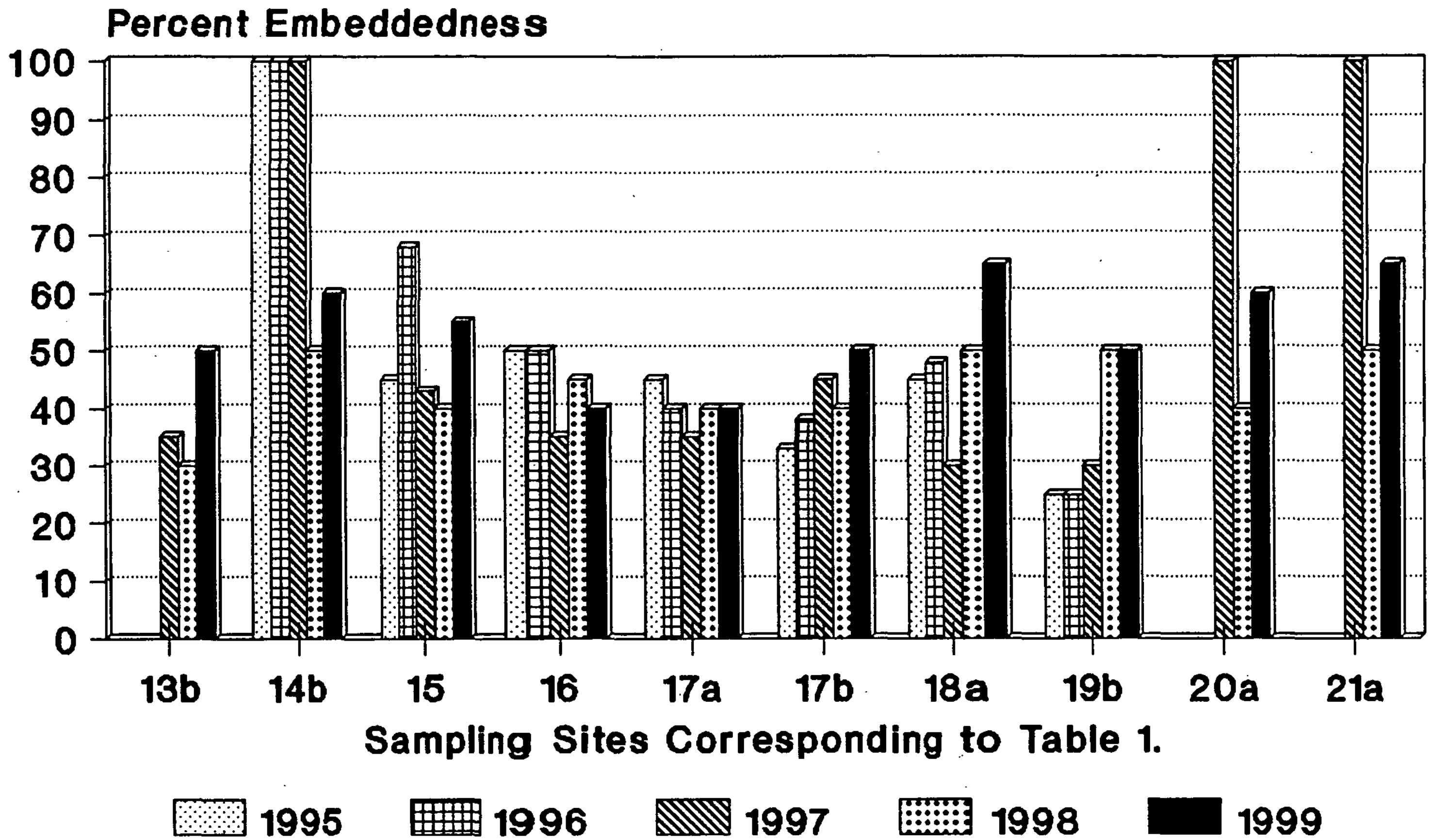


Figure 32b. Average Embeddedness for Pools and Associated Glides At Tributary Sites; 1995-99.

San Lorenzo River Mainstem Reaches
Streambed Composition- % Fine Sediment
Pool Habitat in Surveyed Reach Segments

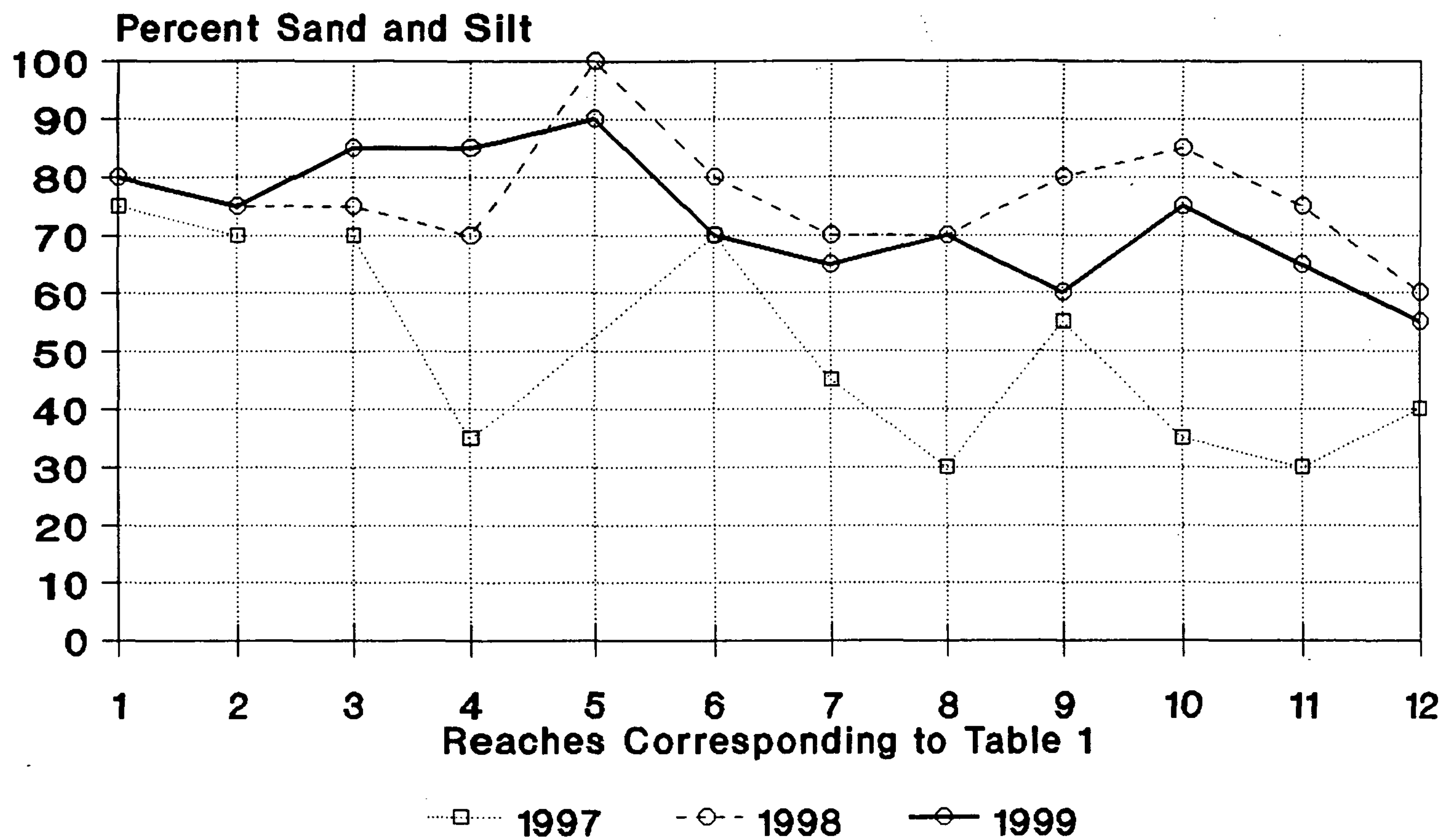


Figure 33a. Streambed Sediment in Pool Habitat of Mainstem Reaches, Expressed As Average Percent Sand/Silt, 1997-99.

Streambed Composition– % Fine Sediment.
Pool Habitat by Surveyed Reach Segment.
Segment 14c Moved Upstream In 1999.

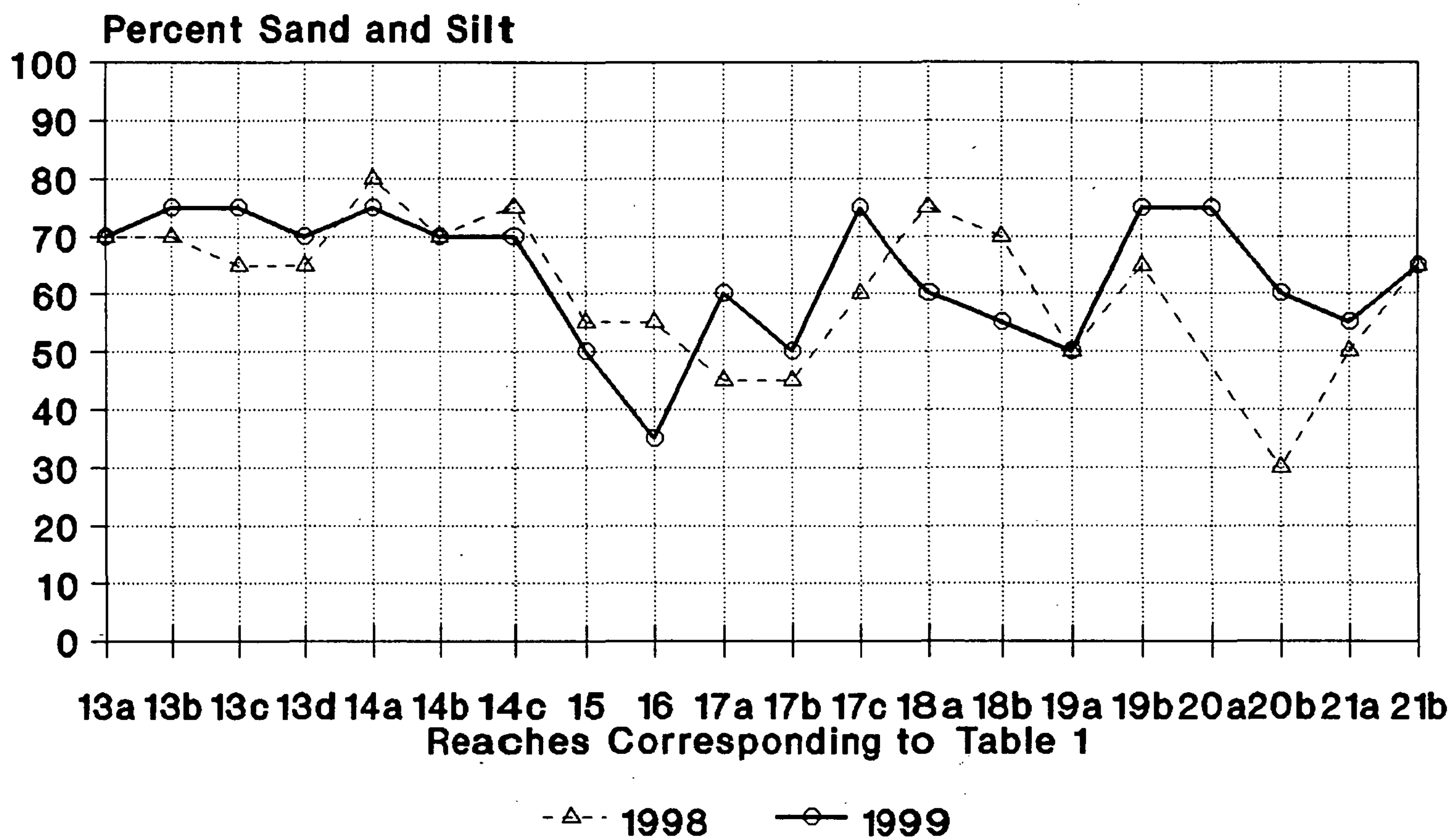


Figure 33b. Streambed Sediment In
Pool Habitat of Tributary Reaches
As Average Percent Sand/Silt, 1998-99.

San Lorenzo River Mainstem Sites
Cover Index; Riffle Habitat, 1995-99.
Ratio; Linear ft. Cover/ Hab. Perimeter

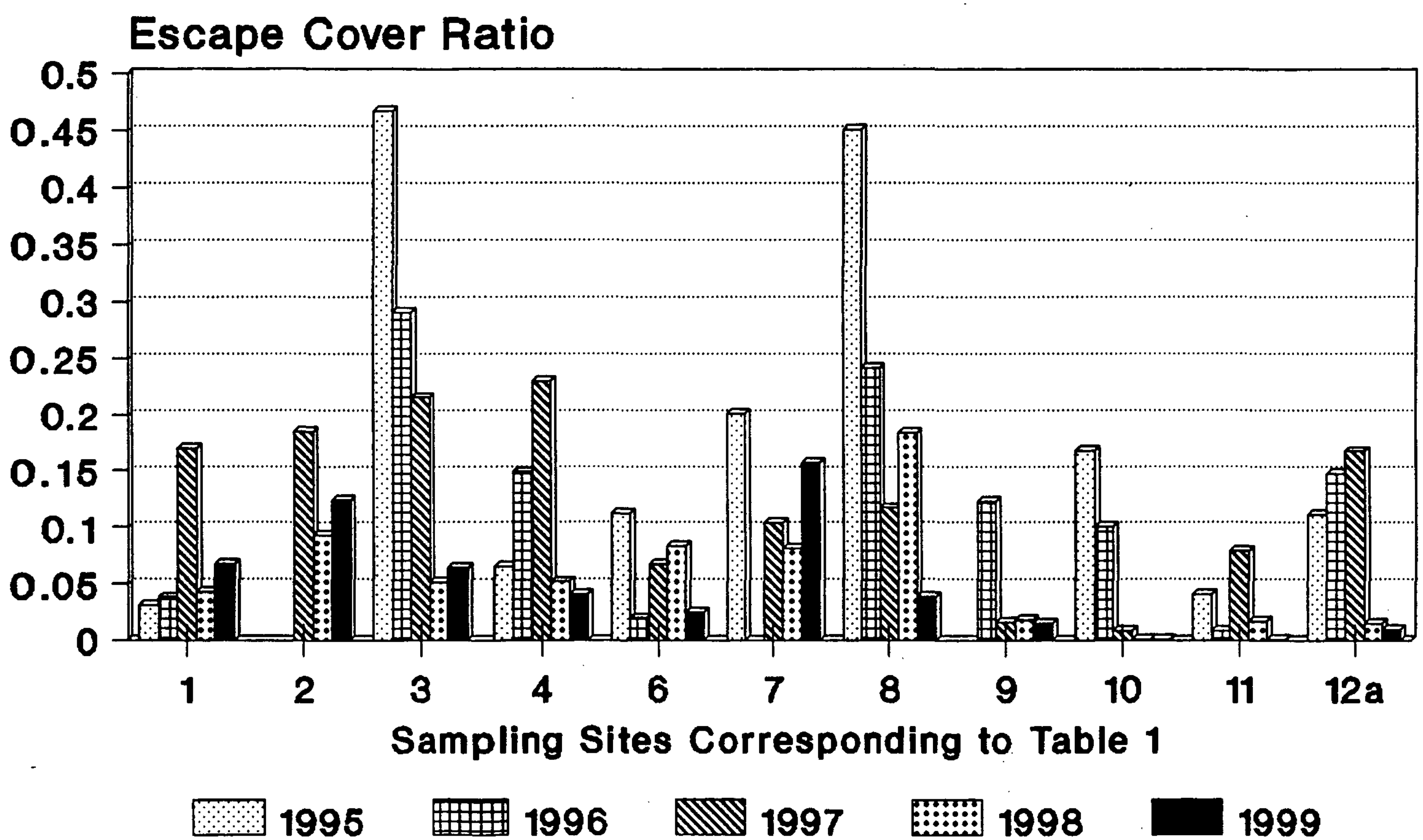


Figure 34a. Cover Index for Riffles at Sampling Sites in the Mainstem San Lorenzo River, 1995-99.

San Lorenzo River Mainstem Reaches
Cover Index; Riffle Habitat, 1998-99.
Ratio; Cover (ft)/ Riffle Length (ft)

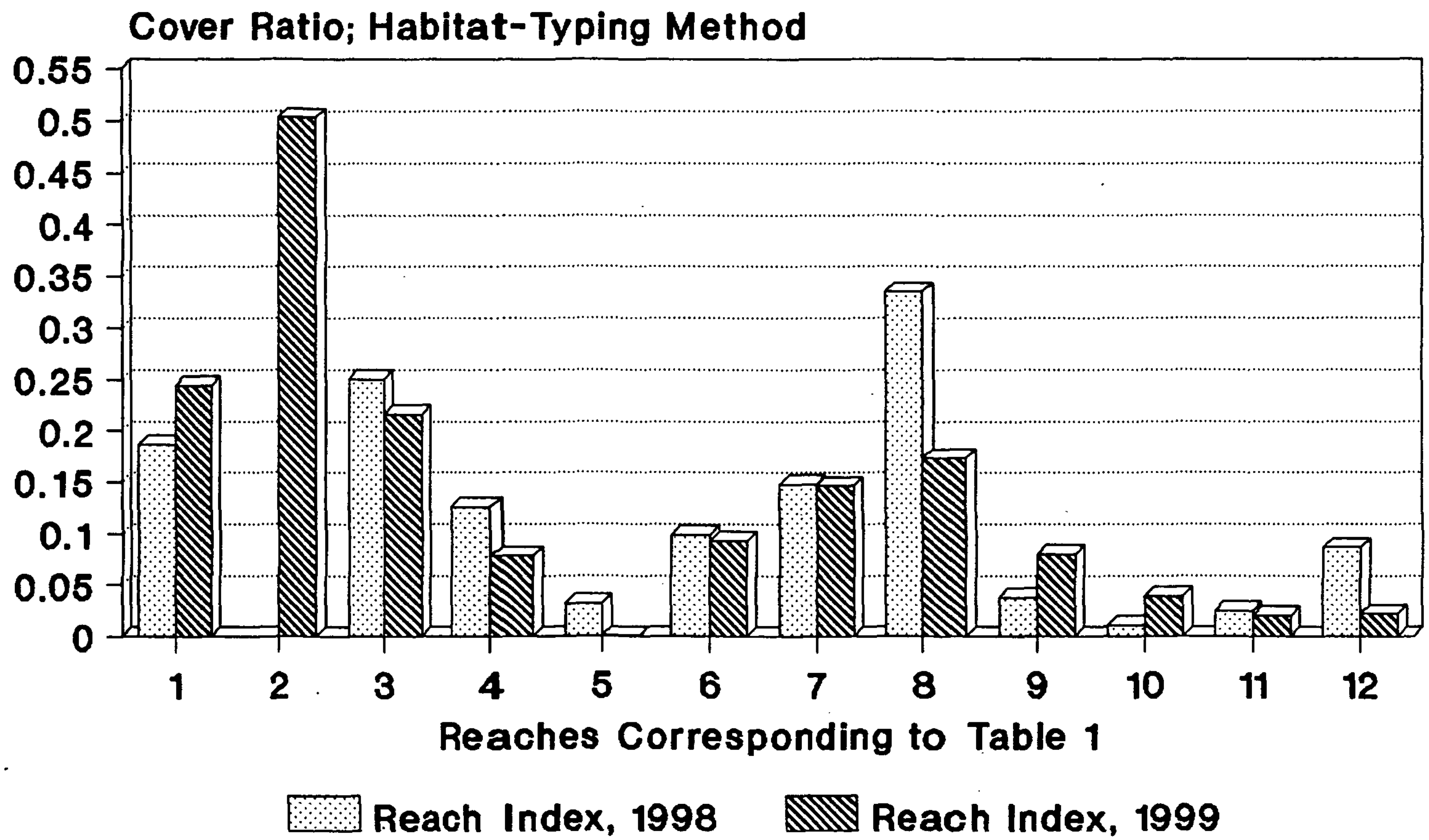


Figure 34b. Escape Cover Index for Riffle Habitat in Mainstem San Lorenzo River Reaches, 1998-99.

San Lorenzo Tributary Sites
Cover Index for Riffle Habitat
Ratio; Linear ft. Cover/ Hab. Perimeter

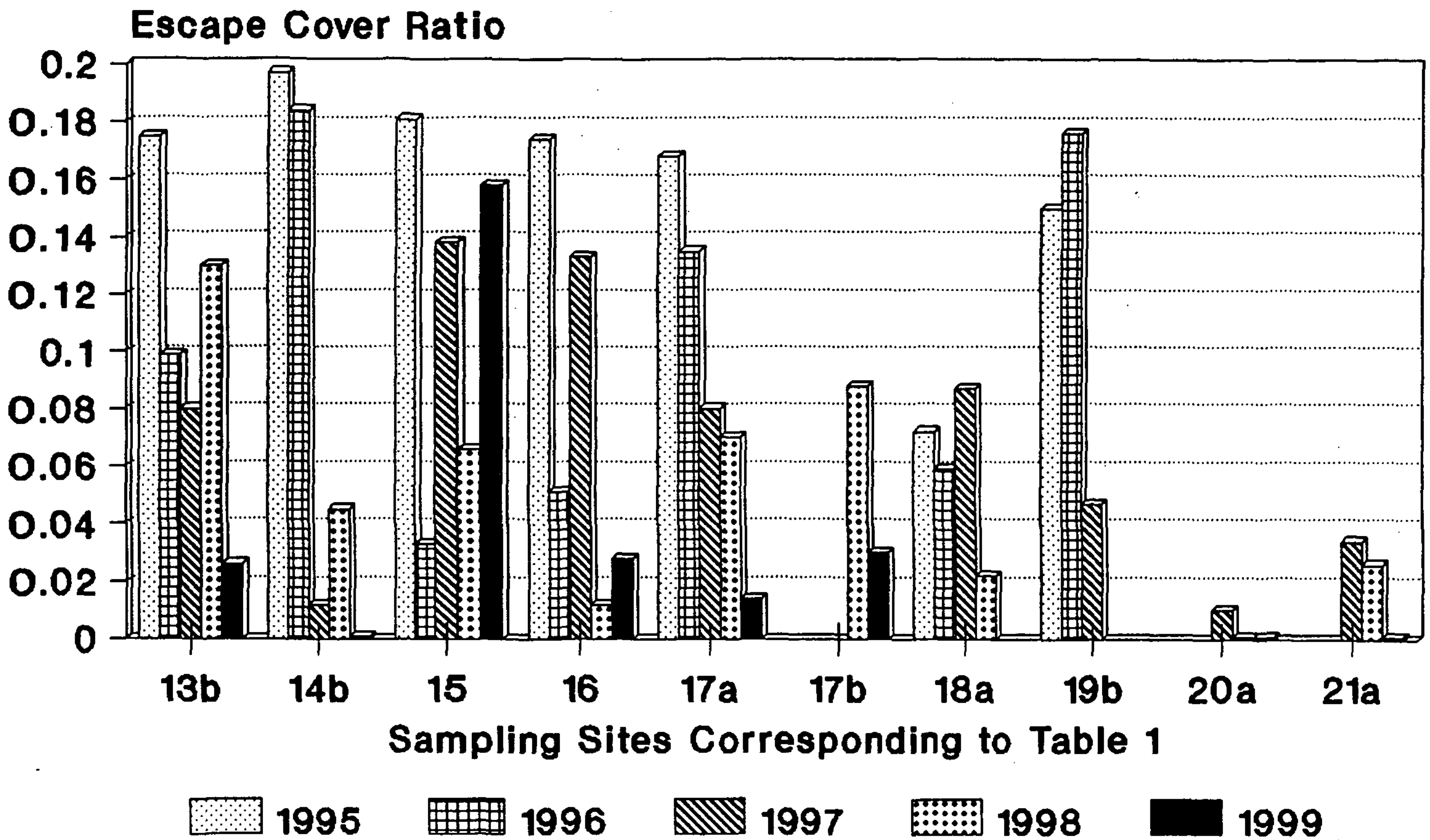


Figure 35a. Cover Index for Riffles at Sampling Sites in San Lorenzo Tributaries, 1995-99.

San Lorenzo Tributary Reaches
Cover Index; Riffle Habitat, 1998-99.
Ratio; Cover (ft)/ Riffle Length (ft)

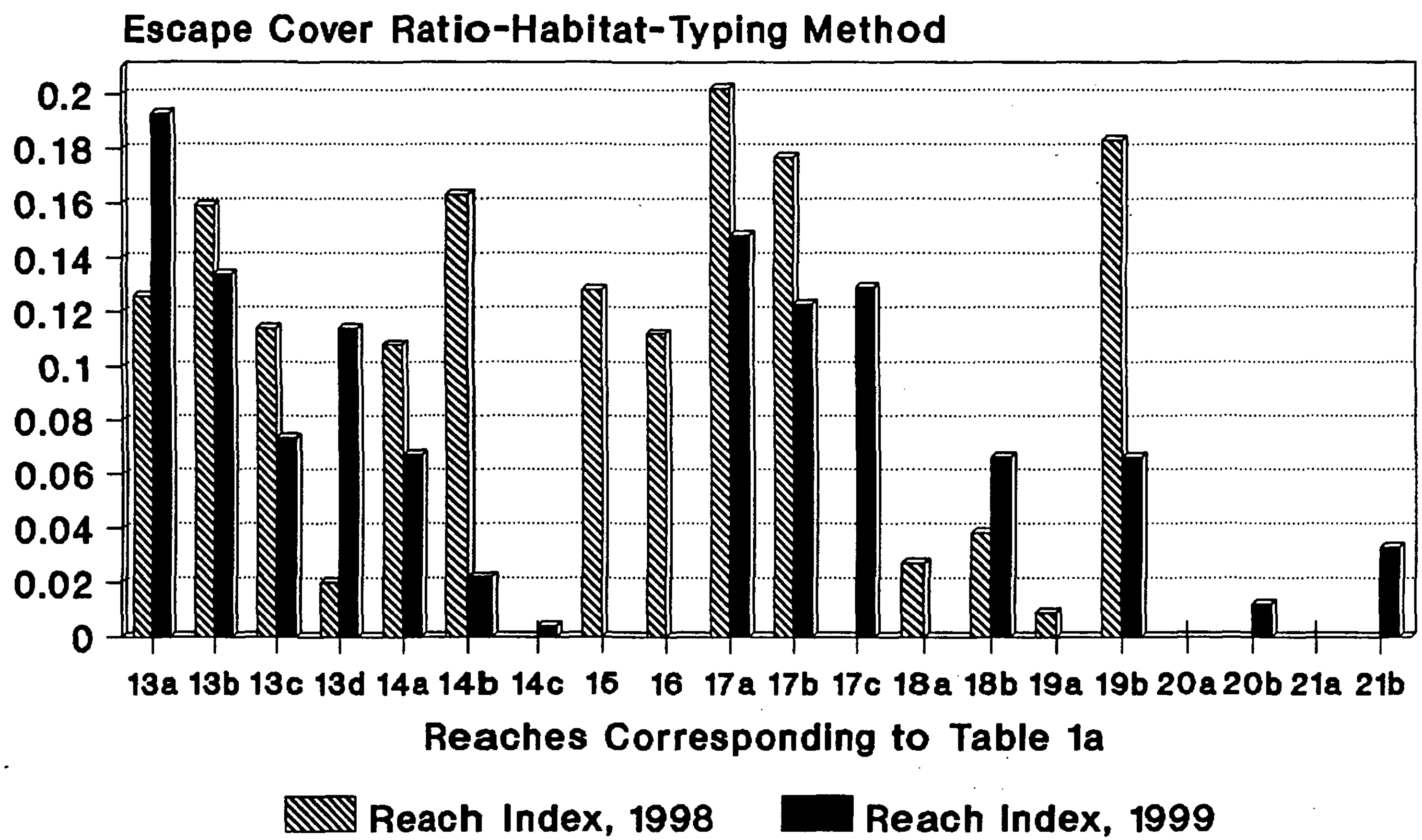


Figure 35b. Cover Index for Riffle Habitat in Tributary Reaches of the San Lorenzo River, 1998-99.

Comparable San Lorenzo Mainstem SITES
Cover Index for Run (Flat-Water) Habitat
Ratio; Linear ft. Cover/ Hab. Perimeter

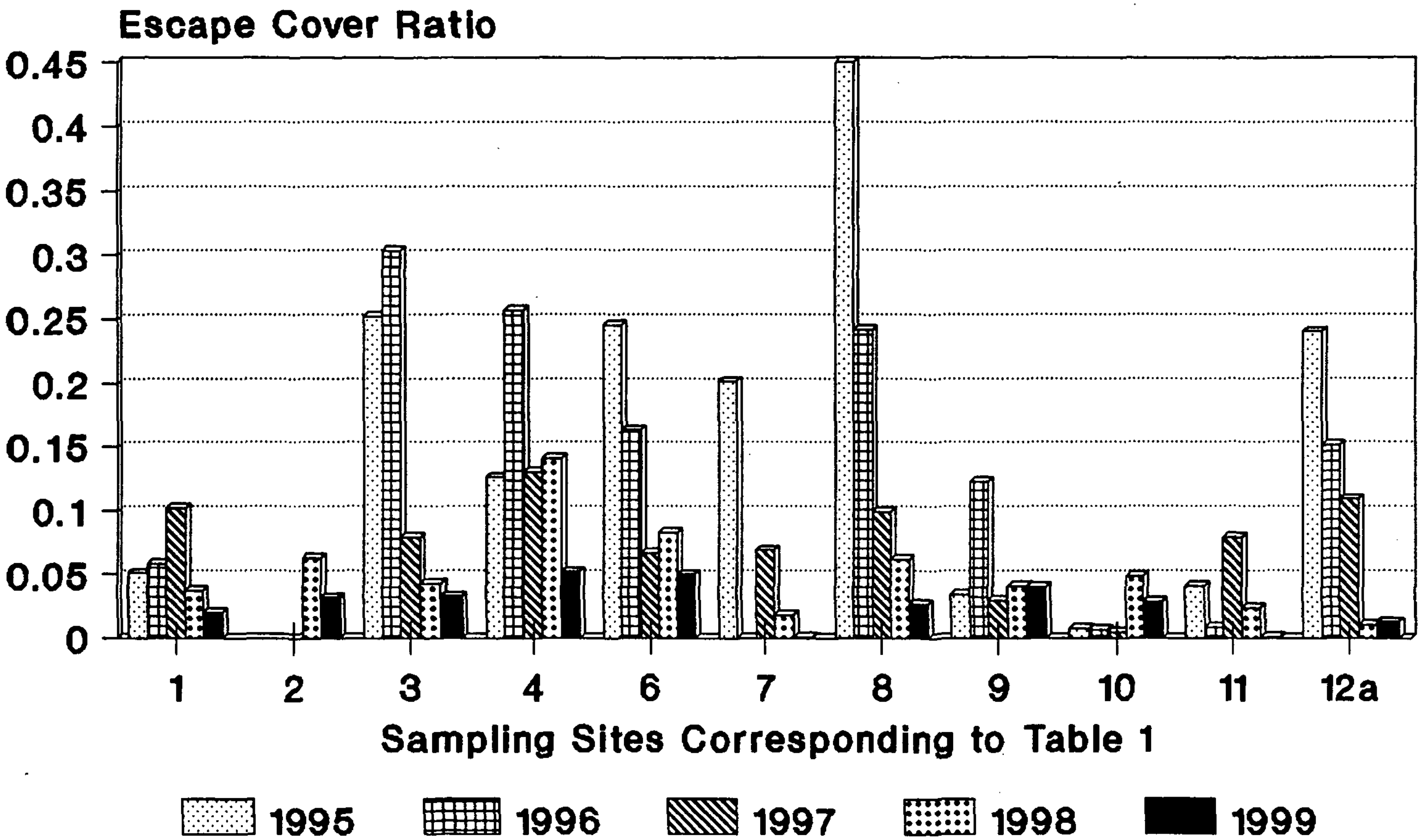


Figure 36a. Cover Index for Run Habitat (Flat-Water) in Mainstem San Lorenzo River Sampling Sites; 1995-99.

San Lorenzo River Mainstem Reaches
Cover Index; Run and Glide Habitat.
Ratio; Cover (ft)/ Run-Glide Length (ft)

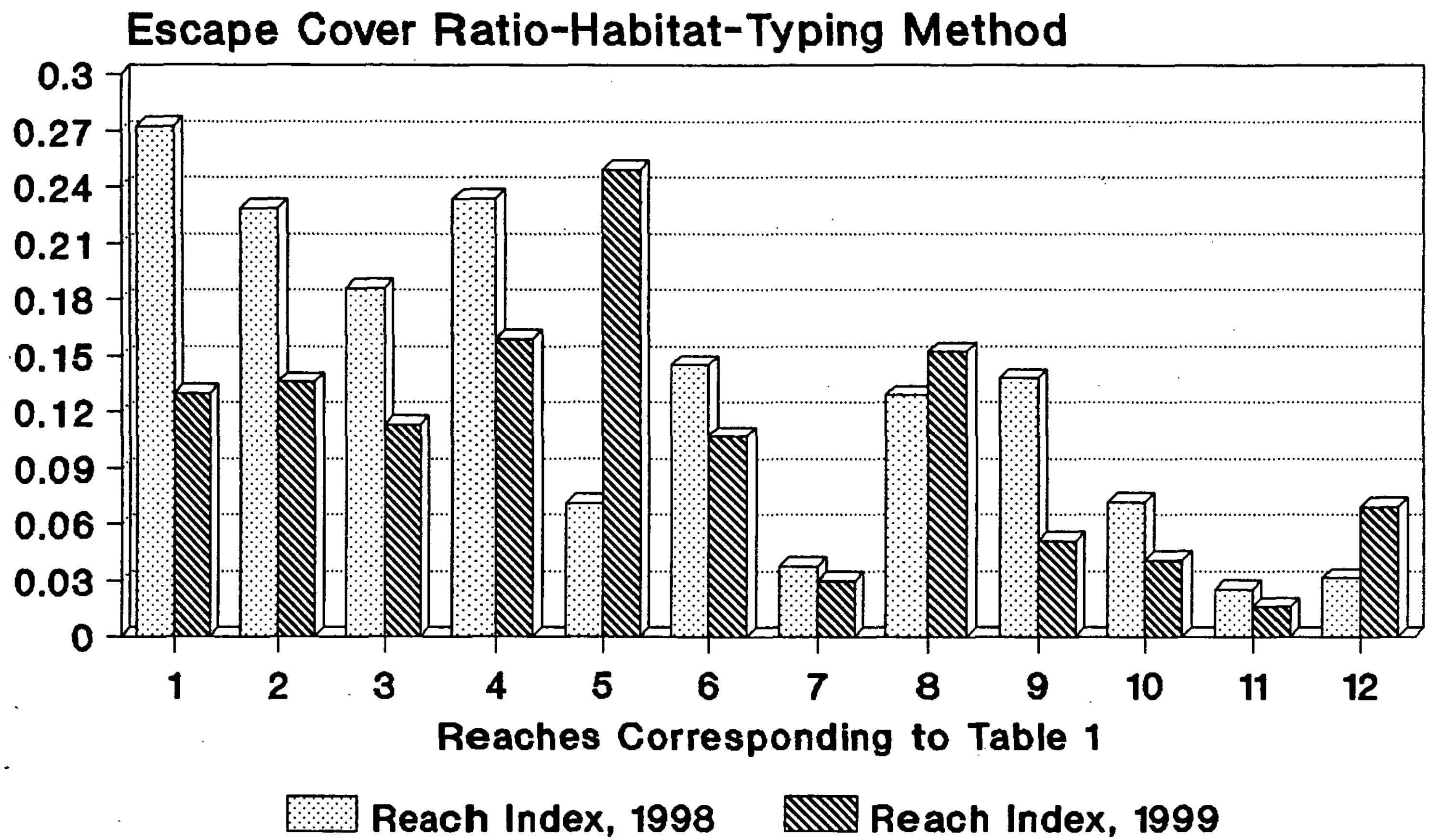


Figure 36b. Cover Index of Run and Glide Habitat in Mainstem San Lorenzo River Reaches, 1998-99.

San Lorenzo River Sampling SITES
Cover Index for Run (Flat-Water) Habitat
Ratio; Lin. Cover (ft)/ Perimeter (ft)

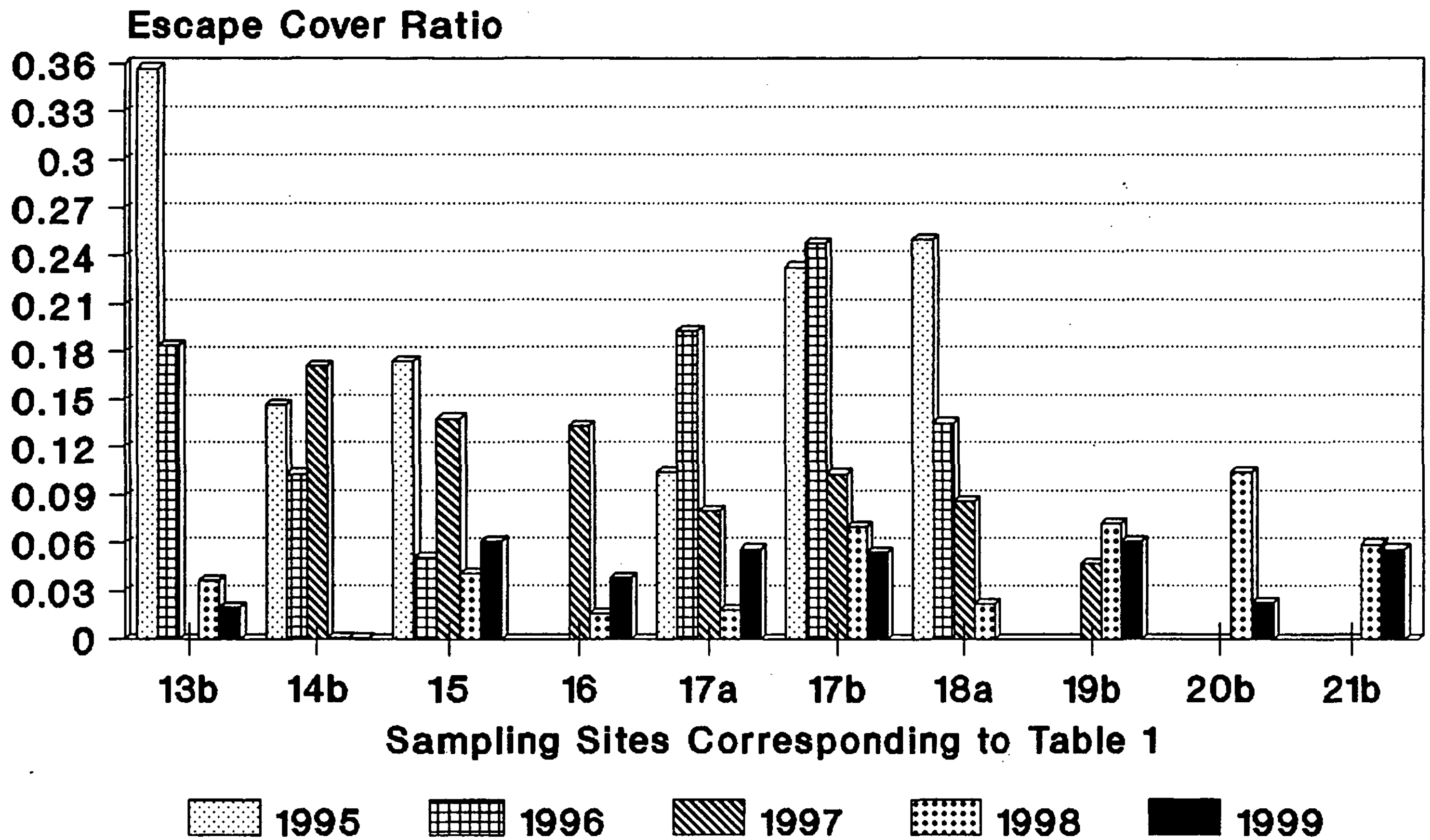


Figure 37a. Cover Index for Run (Flat-Water) and Step-Run Habitat at San Lorenzo Sampling Sites; 1995-99.

San Lorenzo Tributary Reaches
Cover Index; Run/Step-run Habitat.
Ratio; Cover (ft)/ Run Length (ft)

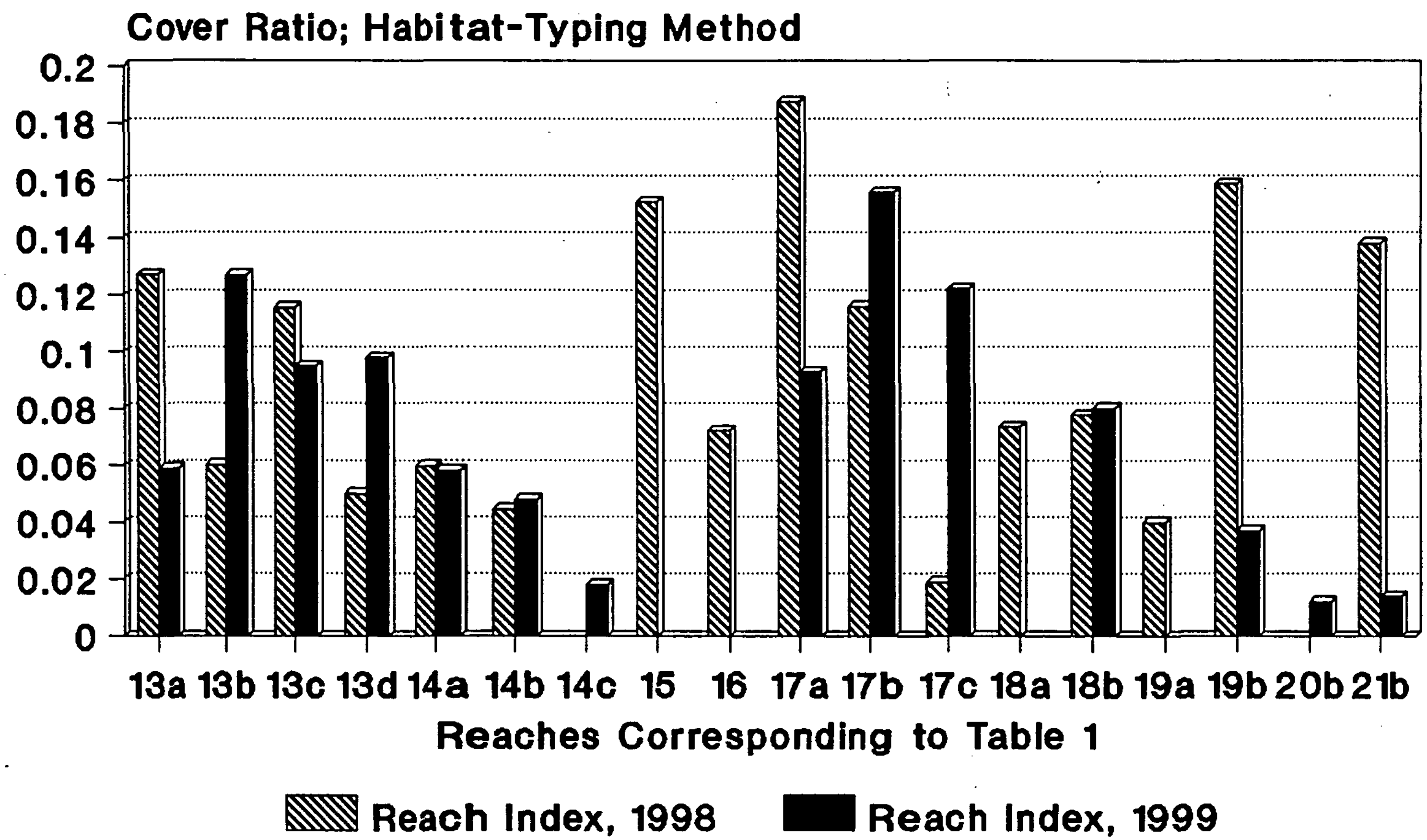


Figure 37b. Cover Index for Run and Step Run Habitat in Tributary Reaches of the San Lorenzo River, 1998-99.

San Lorenzo River Mainstem Sites
Cover Index for Pool Habitat
Ratio; Cover (ft)/ Hab. Perimeter (ft)

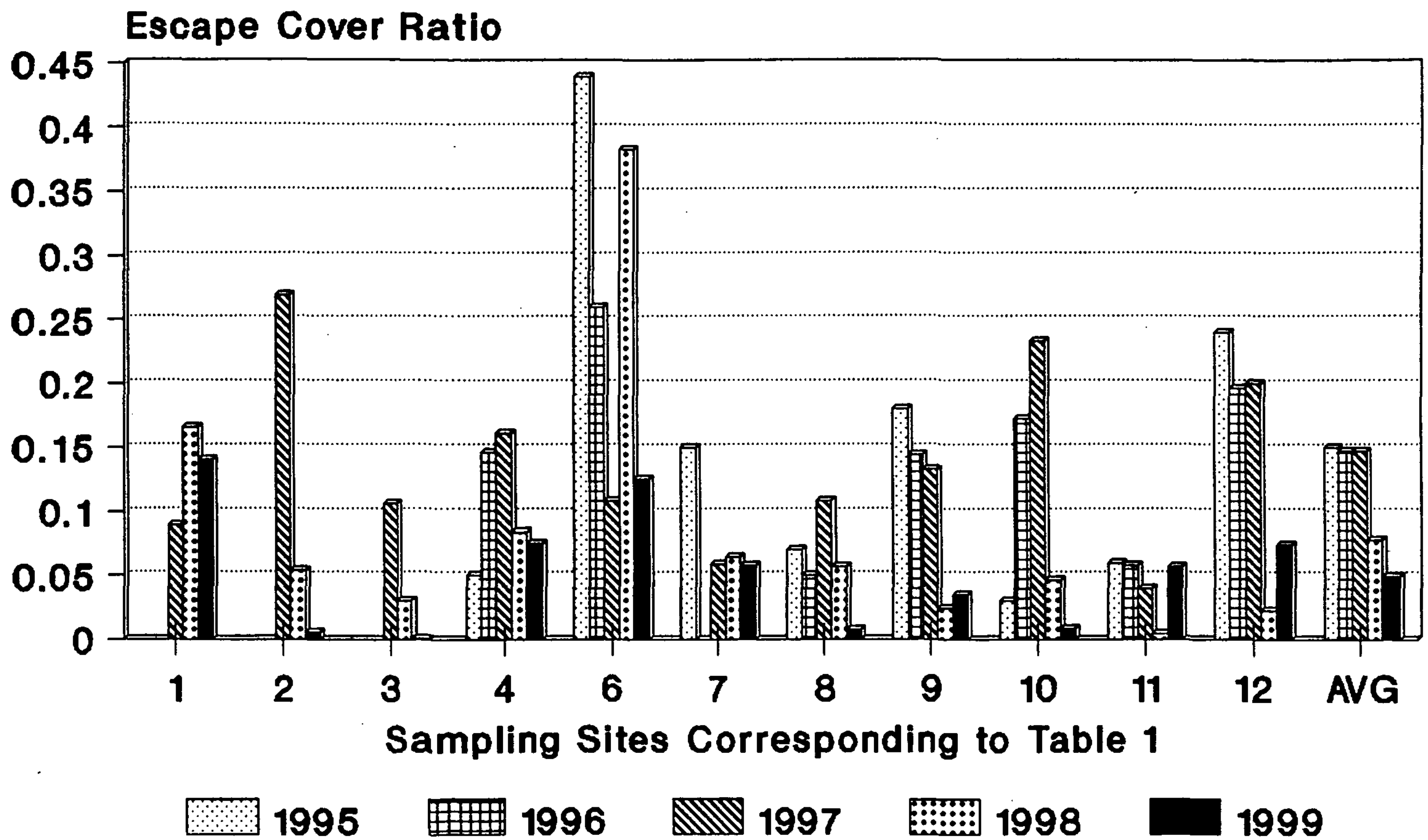


Figure 38a. Cover Index for Pool Habitat at Mainstem San Lorenzo River Sampling Sites, 1995-99.

Mainstem Reach Indices
Cover Index; Pool Habitat, 1998-99.
Ratio; Cover (ft)/ Pool Length (ft)

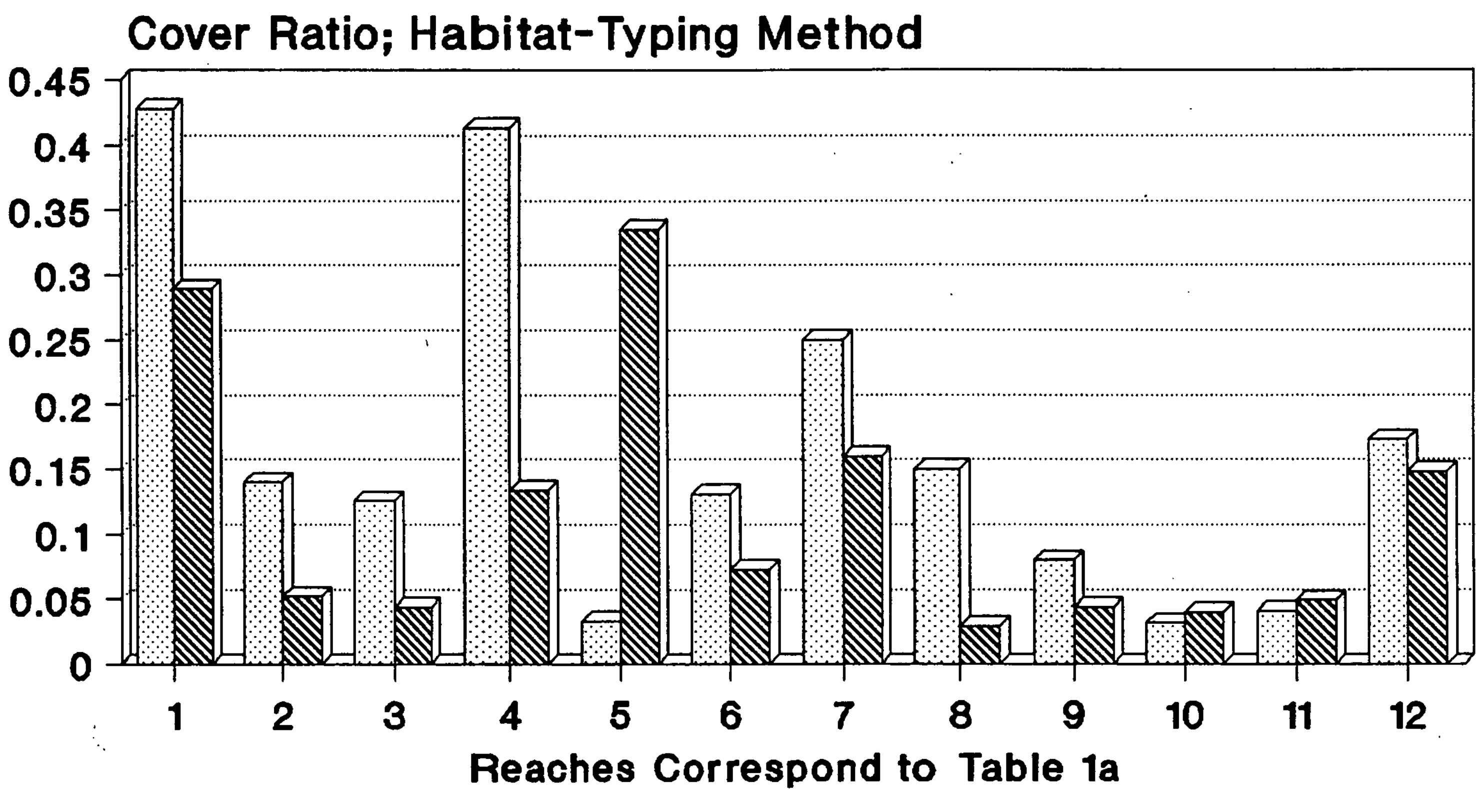


Figure 38b. Cover Index for Pools in Mainstem San Lorenzo River Reaches, 1998-99.

San Lorenzo Tributary Sites
Cover Index for Pool Habitat
Ratio; Cover (Lin. ft)/ Hab. Perimeter

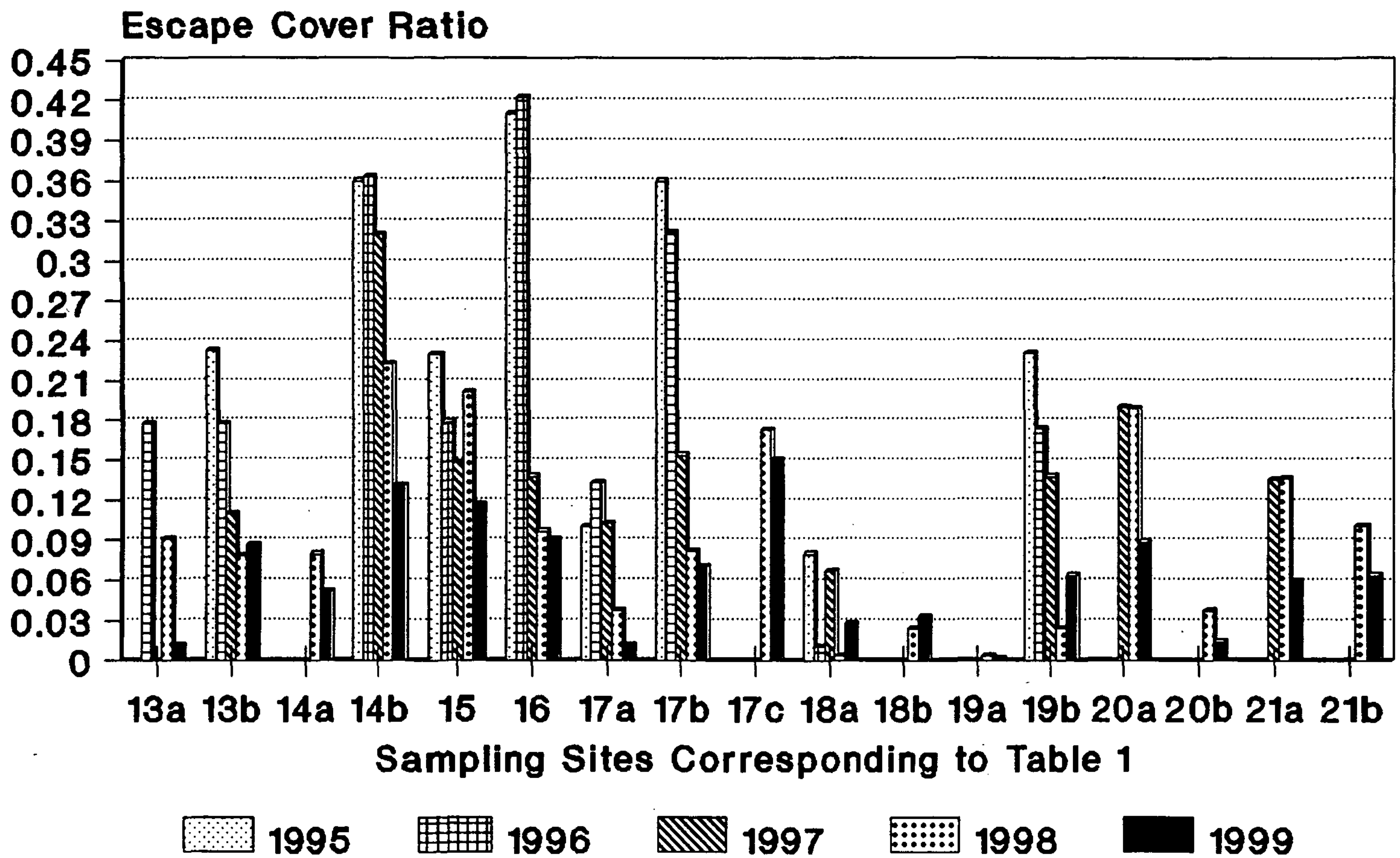


Figure 39a. Cover Index for Pool Habitat
at Comparable Tributary Sites, 1995-99.

Tributary Reach Indices
Cover Index; Pool Habitat, 1998-99.
Ratio; Cover (ft)/ Pool Length (ft)

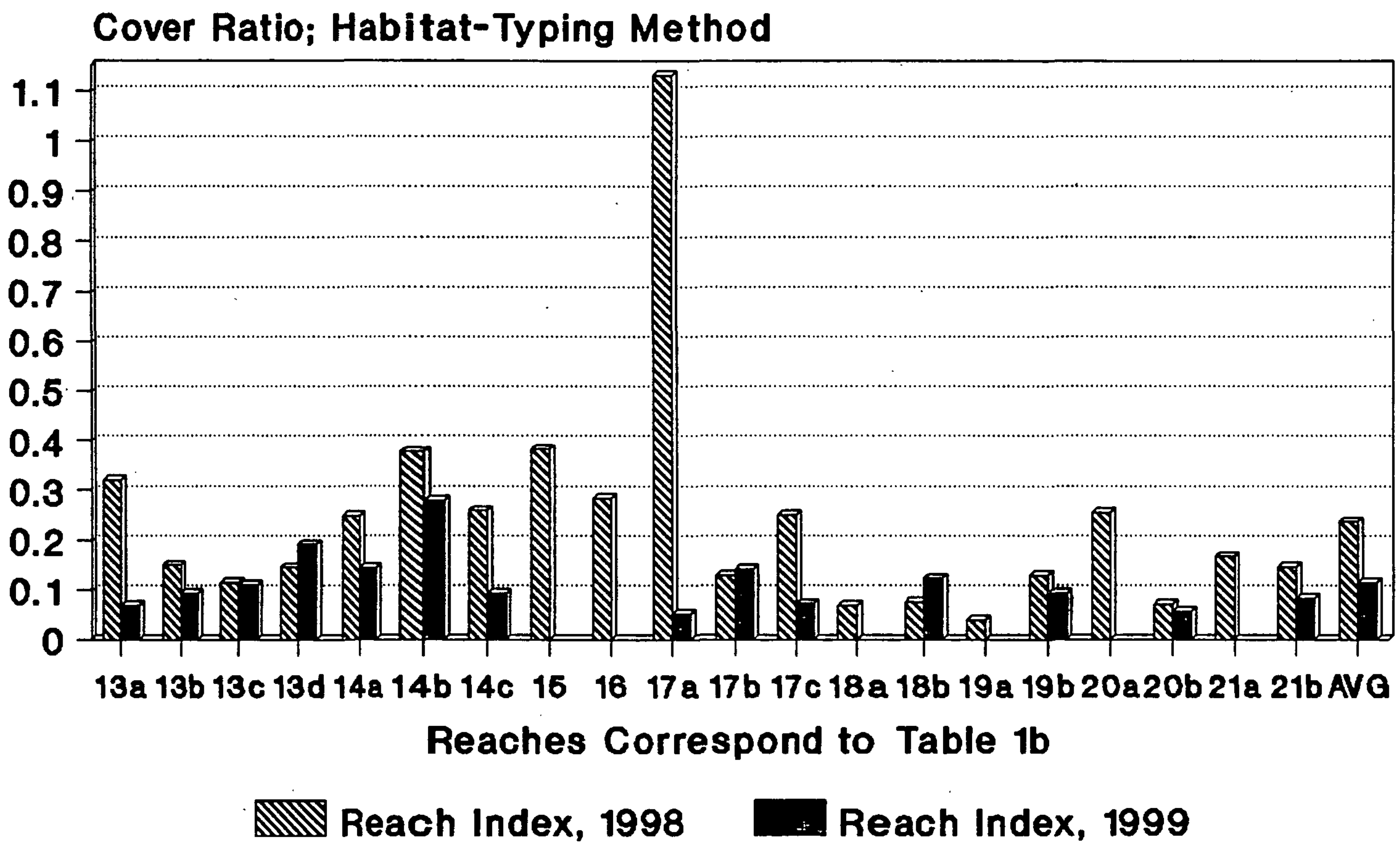


Figure 39b. Cover Index for Pool Habitat in Tributary Reaches of the San Lorenzo River, 1998-99.

San Lorenzo River Mainstem Sites
Average Pool Depth; 1995-99.

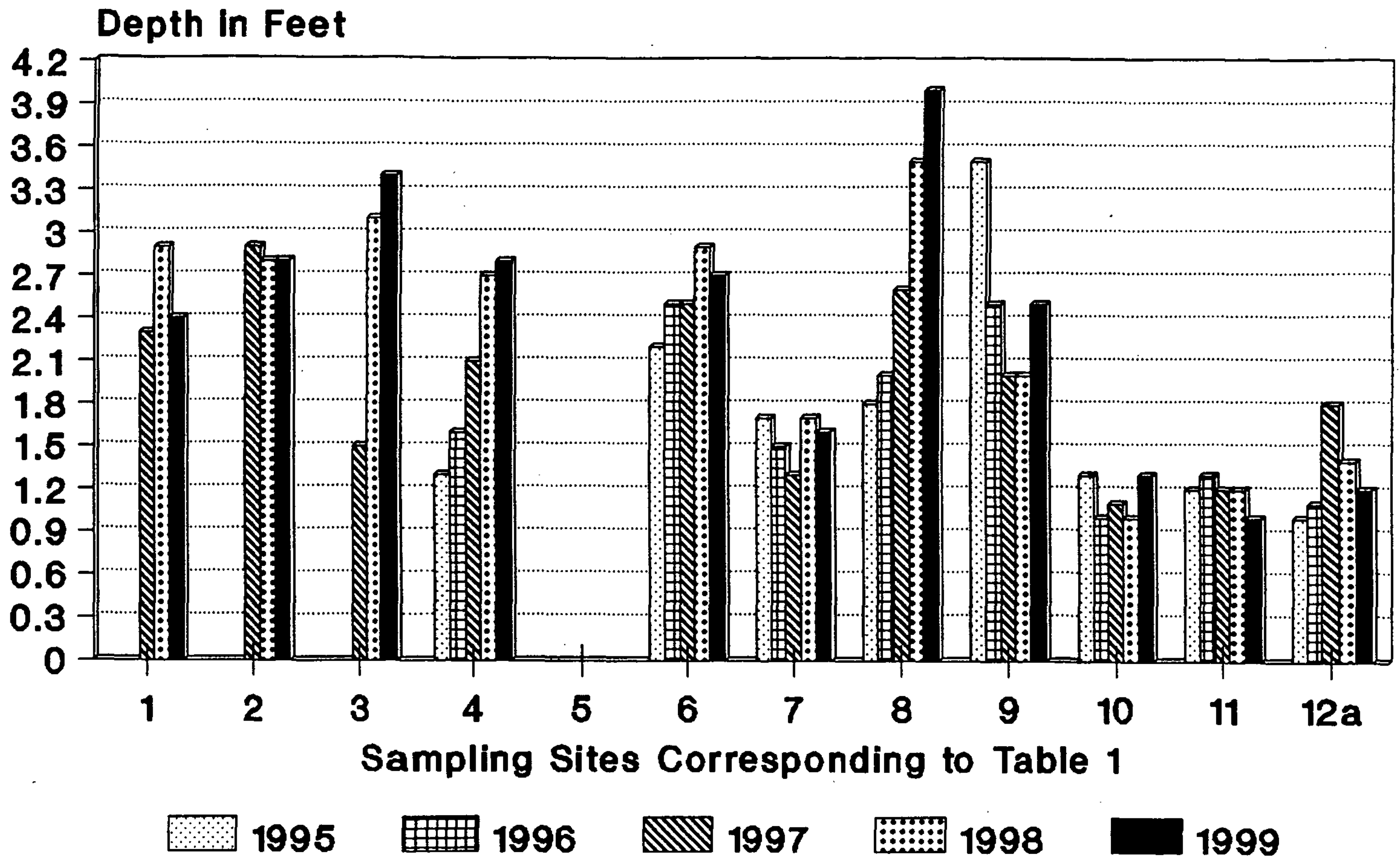


Figure 40. Average Depth in Pools for Mainstem San Lorenzo River Sampling and Snorkeling Sites, 1995-99.

Mainstem San Lorenzo River
Average Pool Depth by Reach, 1997-99.
Based on Habitat Typing Data.

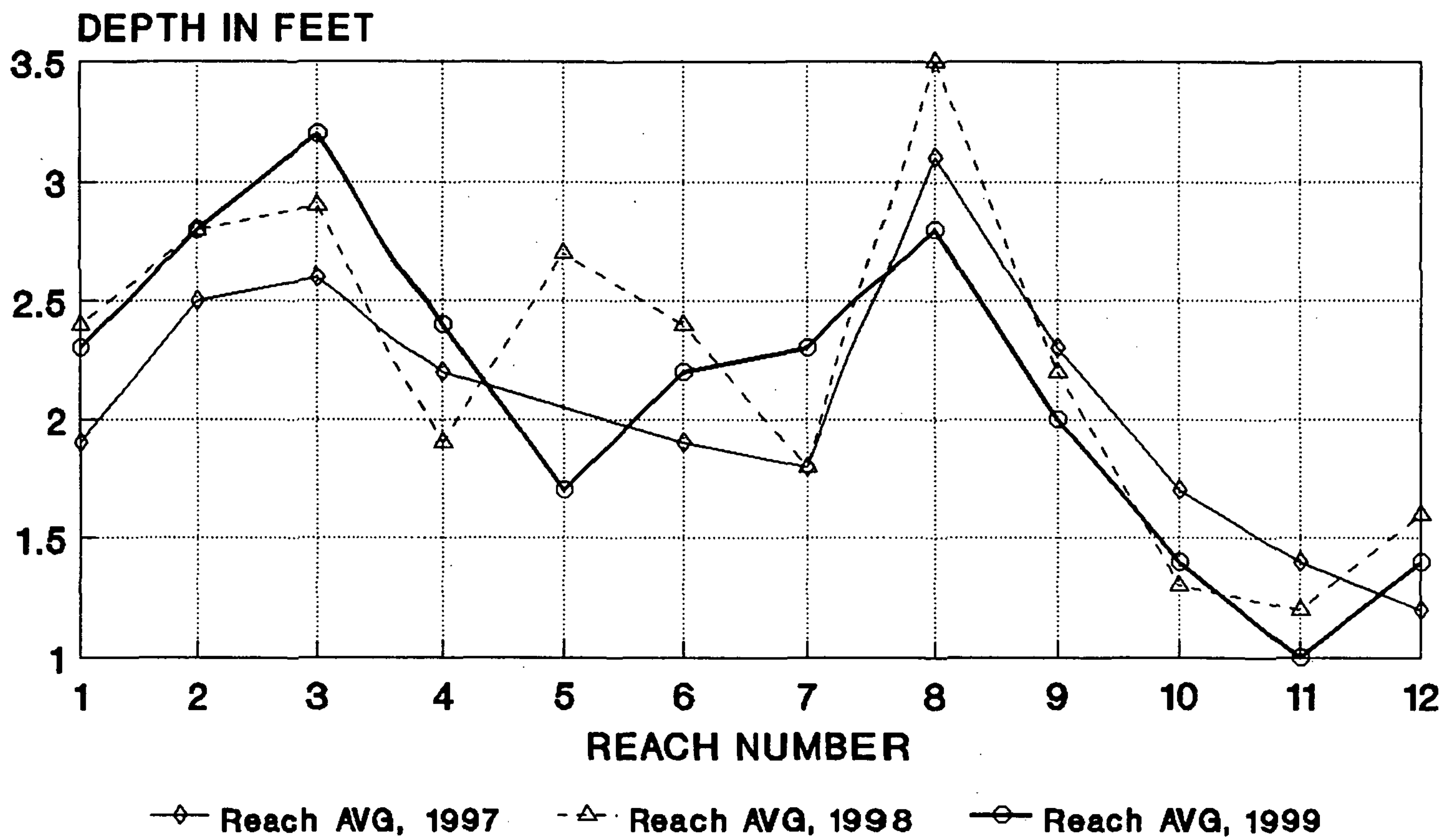


Figure 41. Averaged AVERAGE POOL DEPTH by Reach in the Mainstem San Lorenzo River, Comparing 1997-99.

San Lorenzo Mainstem Sites
Maximum Pool Depth; 1995-99.

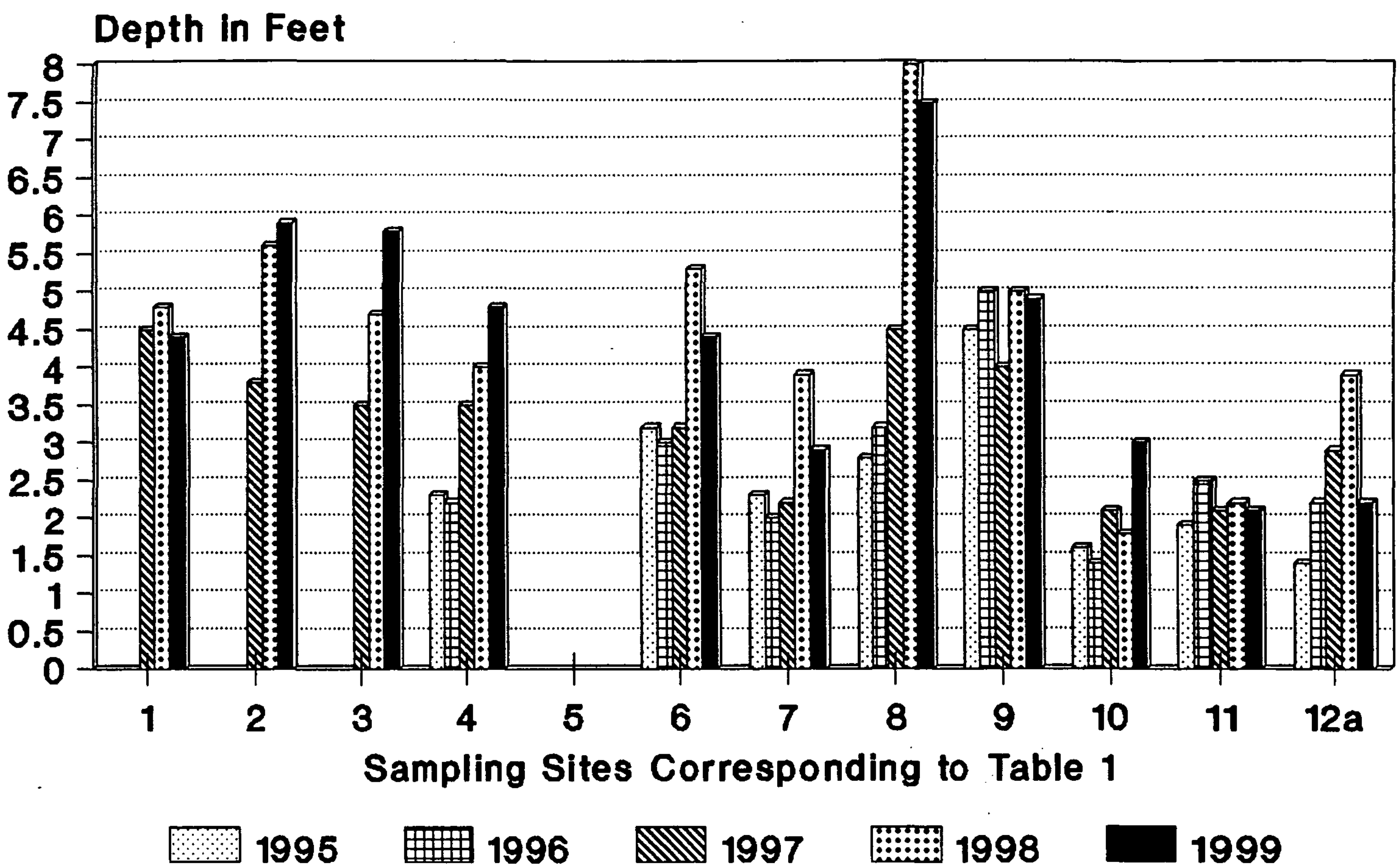


Figure 42. Maximum Depth in Pools for Mainstem San Lorenzo River Sampling Sites, 1995-99.

Mainstem San Lorenzo River- HABITAT
Maximum Pool Depth by Reach, 1997-99.
Reach Averages Based on Habitat Typing.

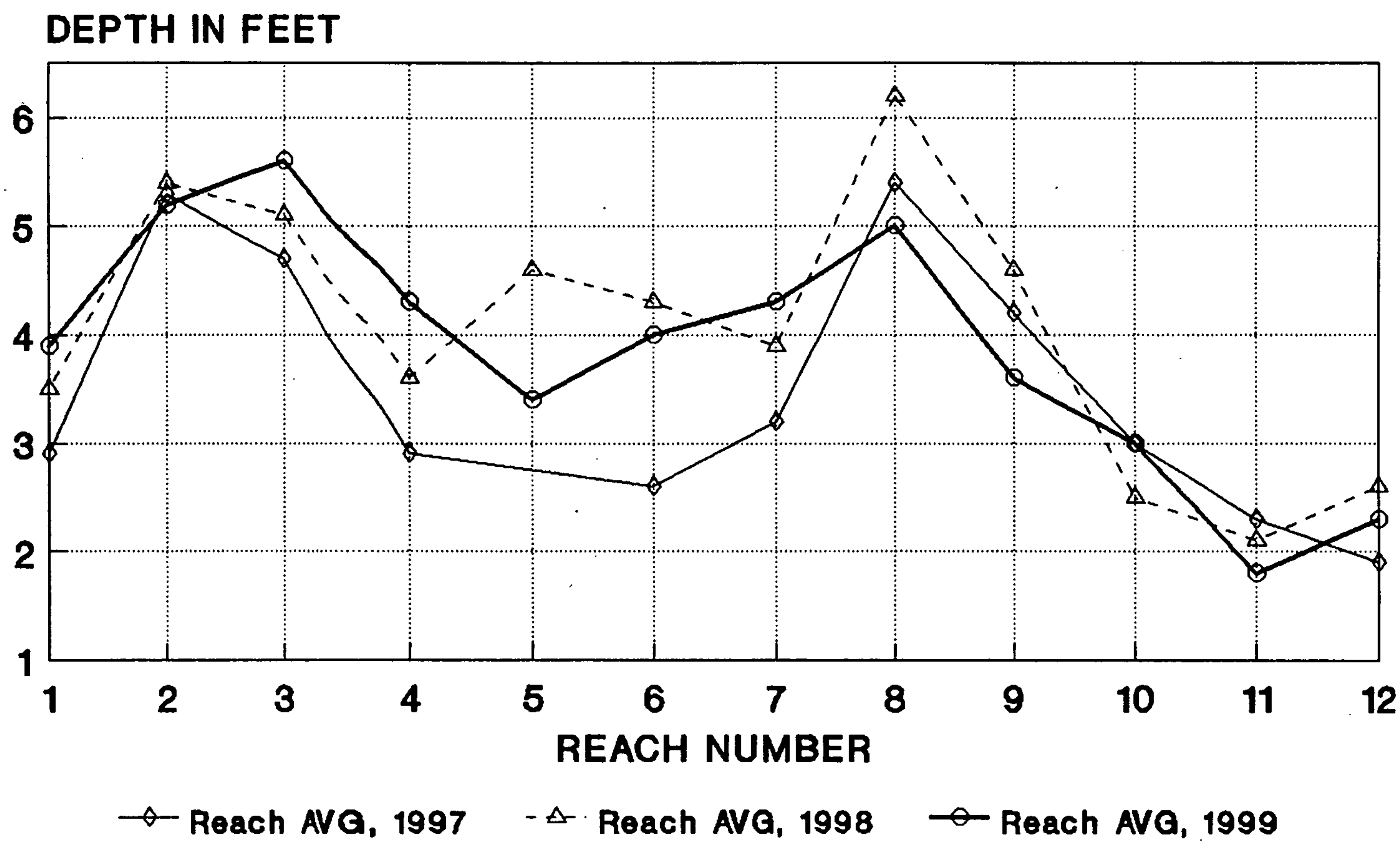


Figure 43a. Averaged MAXIMUM POOL DEPTH by Reach in the Mainstem San Lorenzo River, Comparing 1997-99.

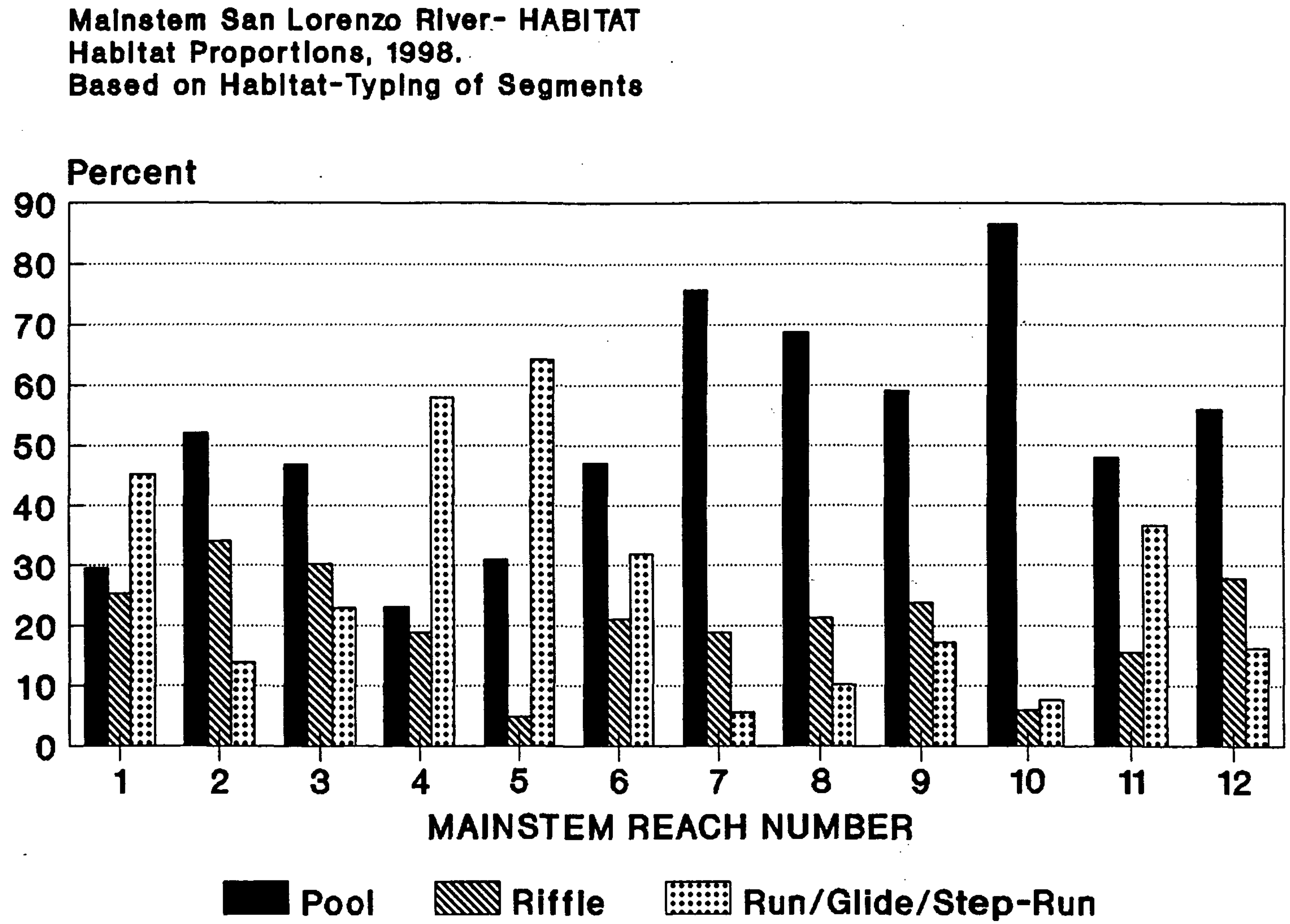


Figure 43b. Habitat Proportions Determined for Reaches in the Mainstem San Lorenzo River, 1998.

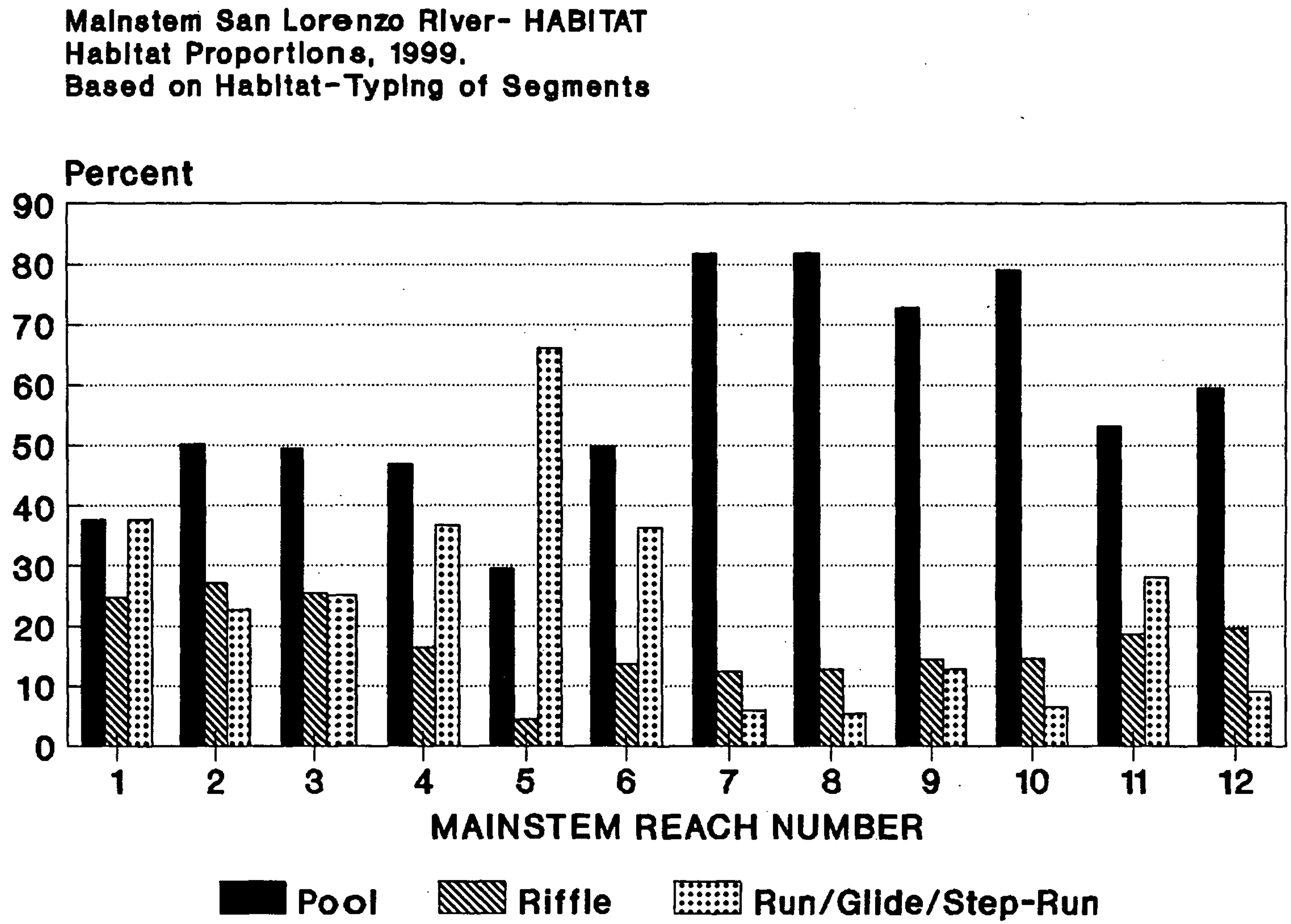


Figure 43c. Habitat Proportions Determined for Reaches in the Mainstem San Lorenzo River, 1999.

Tributary Sampling Sites
Average Pool Depth; 1995-99.

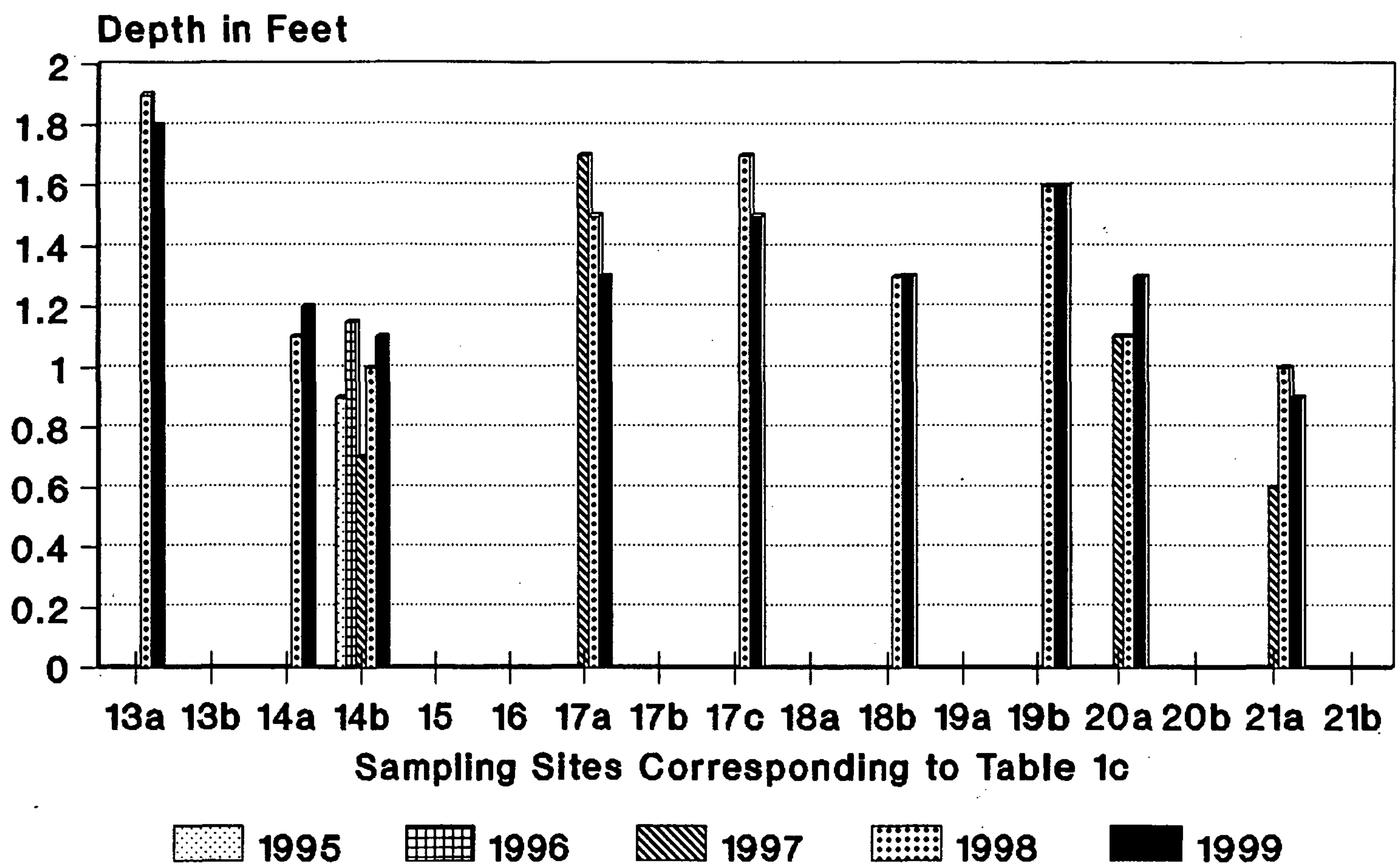


Figure 44a. Average Depth in Pools Sampled at Comparable San Lorenzo Tributary Sites, 1995-99.

San Lorenzo Tributary REACHES
Average Pool Depth; 1998-99.
• Reach 17c More Representative in 1999.

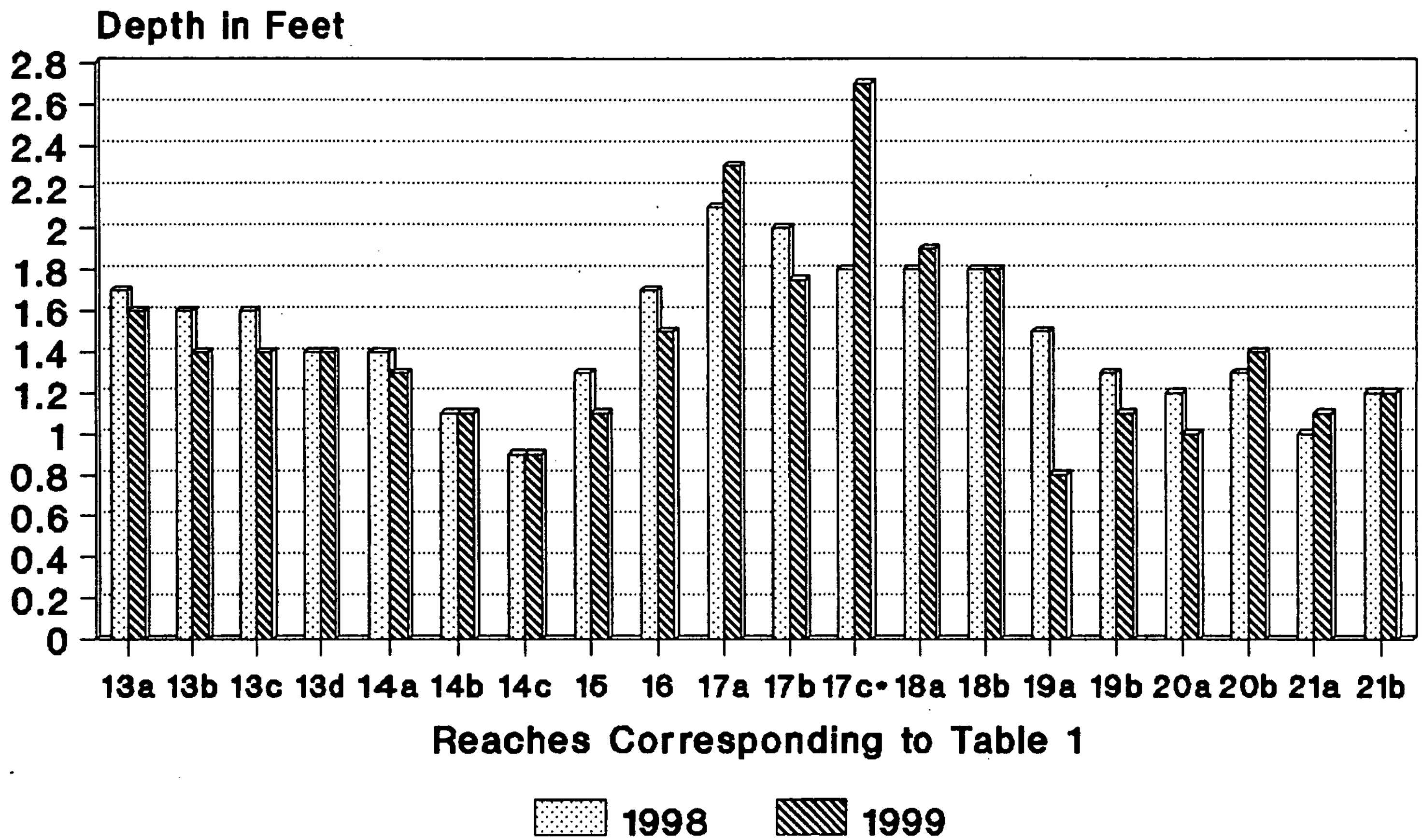


Figure 44b. Averaged AVERAGE POOL DEPTH
In San Lorenzo River Tributary REACHES,
1998-99.

San Lorenzo Tributary Sites
Maximum Pool Depth; 1995-99.

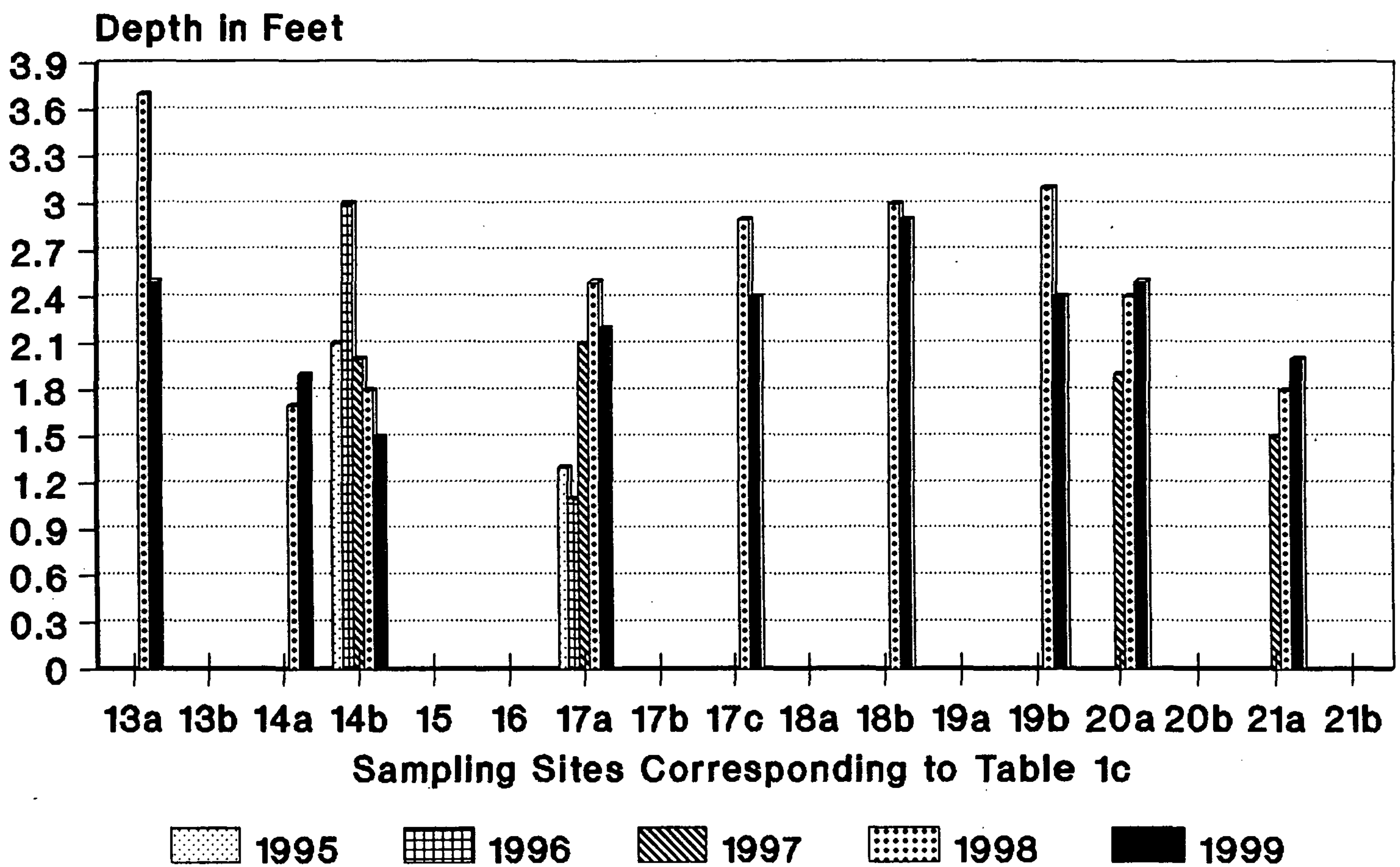


Figure 45a. Maximum Depth in Pools of
Comparable Sampling Sites in San Lorenzo
Tributaries, 1995-99.

San Lorenzo Tributary REACHES
Average Maximum Pool Depth; 1998-99.
• 17c Was More Representative In 1999.

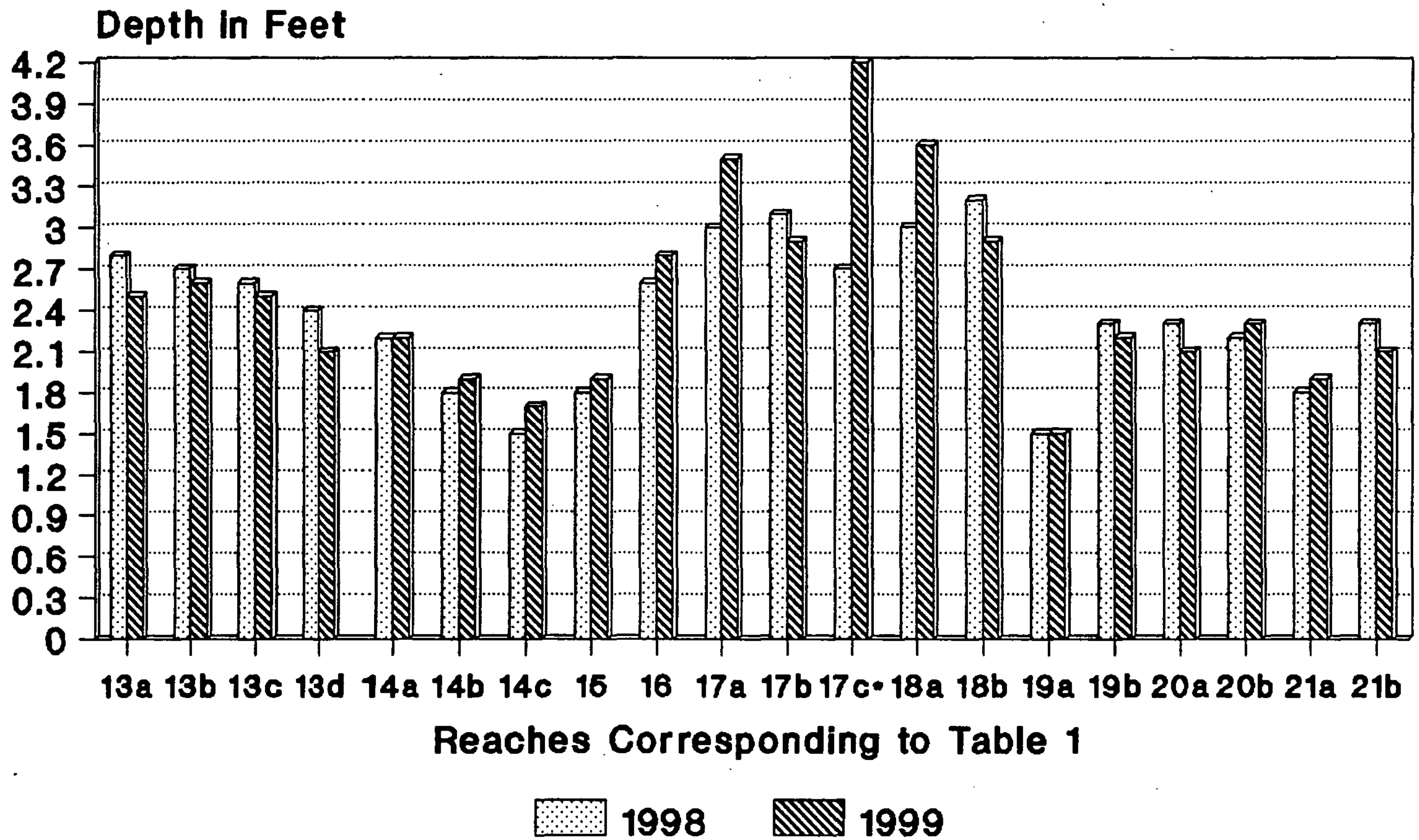


Figure 45b. Average Maximum Depth In Pools of San Lorenzo River Tributary REACHES In 1998-99.

San Lorenzo Tributary REACHES
Habitat Proportions, 1998.
Determined by Habitat-Typing of Segments

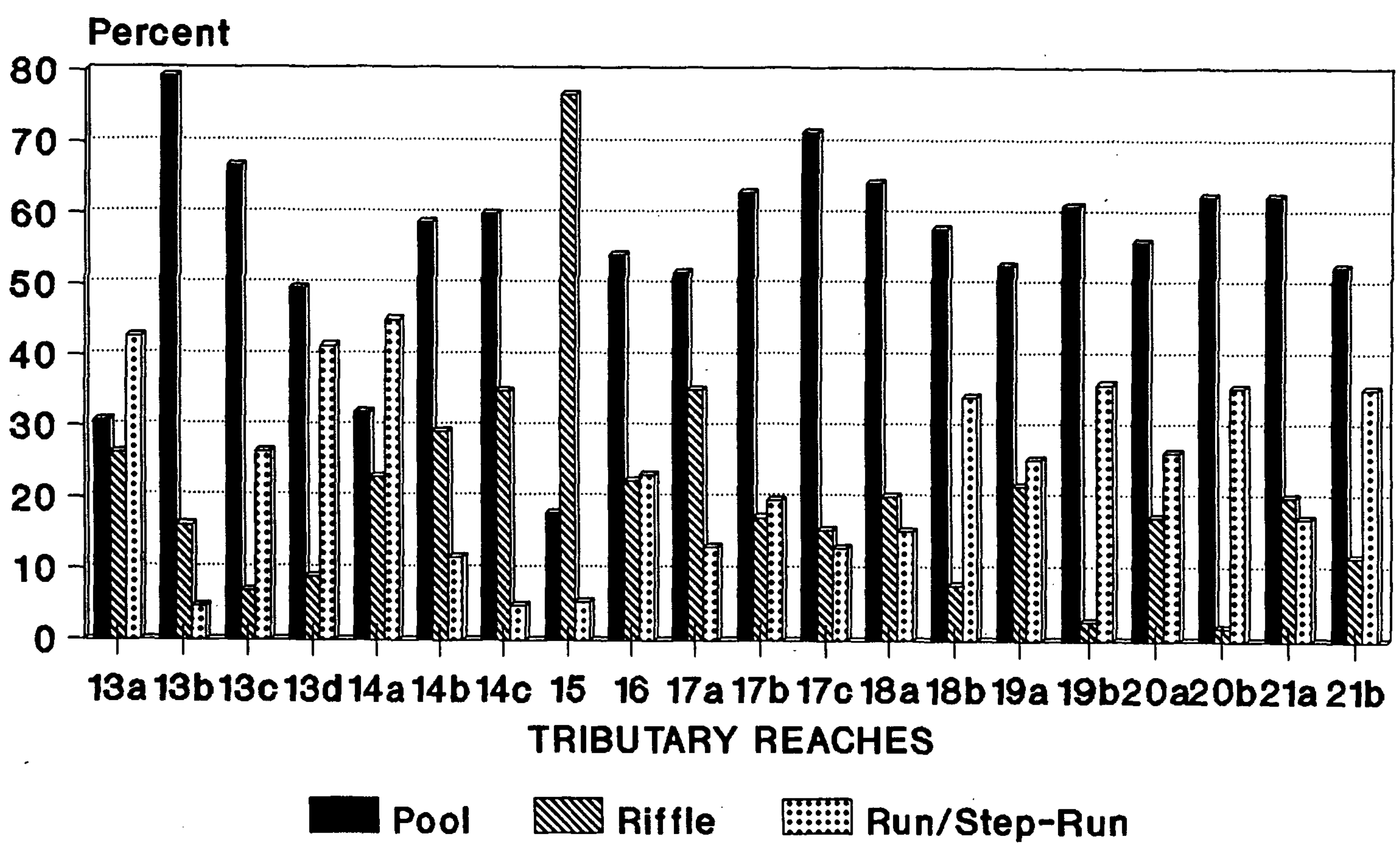


Figure 45c. Habitat Proportions in Tributary Reaches of the San Lorenzo River, 1998.

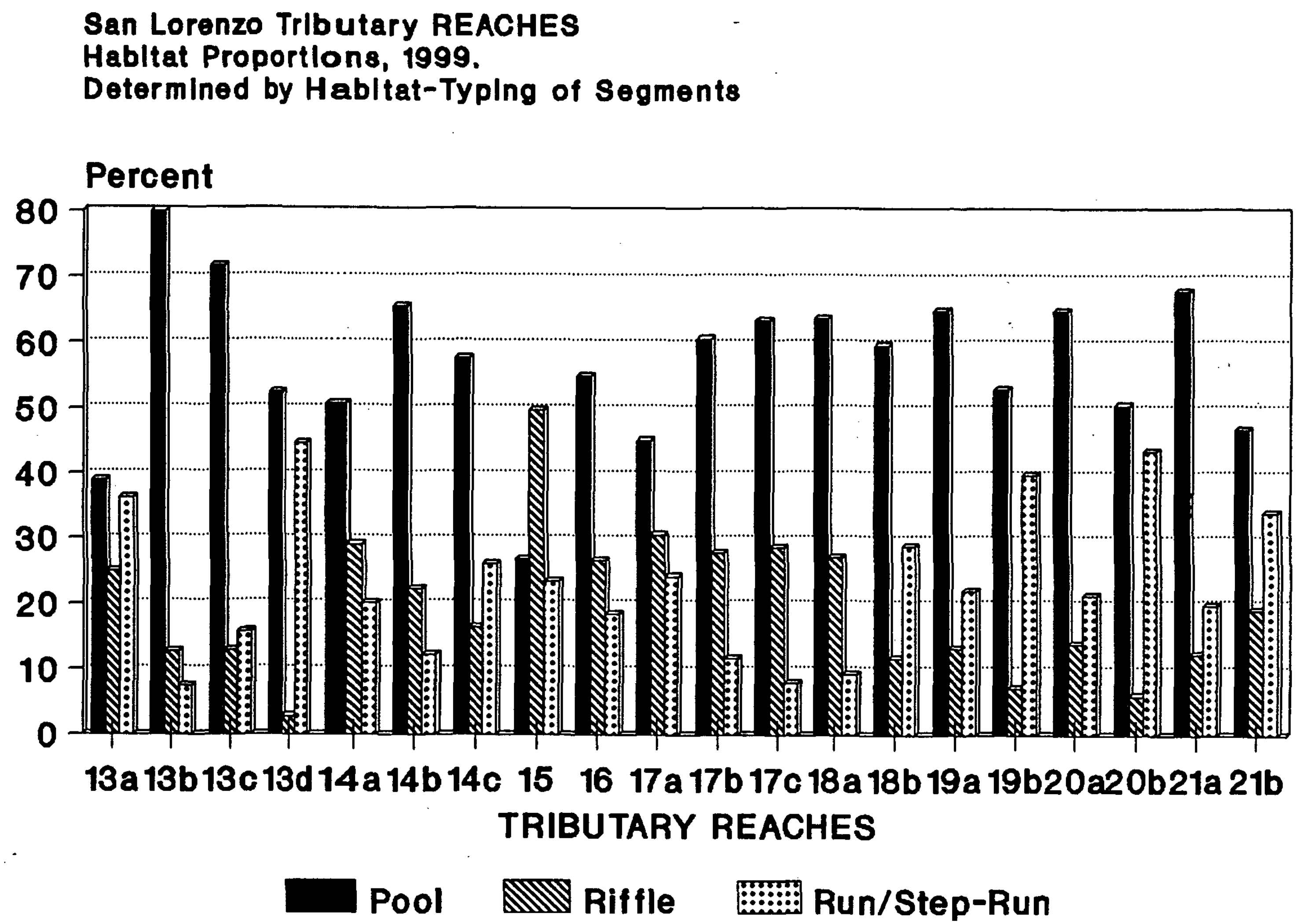


Figure 45d. Habitat Proportions in Tributary Reaches of the San Lorenzo River, 1999.

San Lorenzo Mainstem Sites
Average Riffle Depth; 1995-99.
At Times, Sampled Riffles Varied by Year

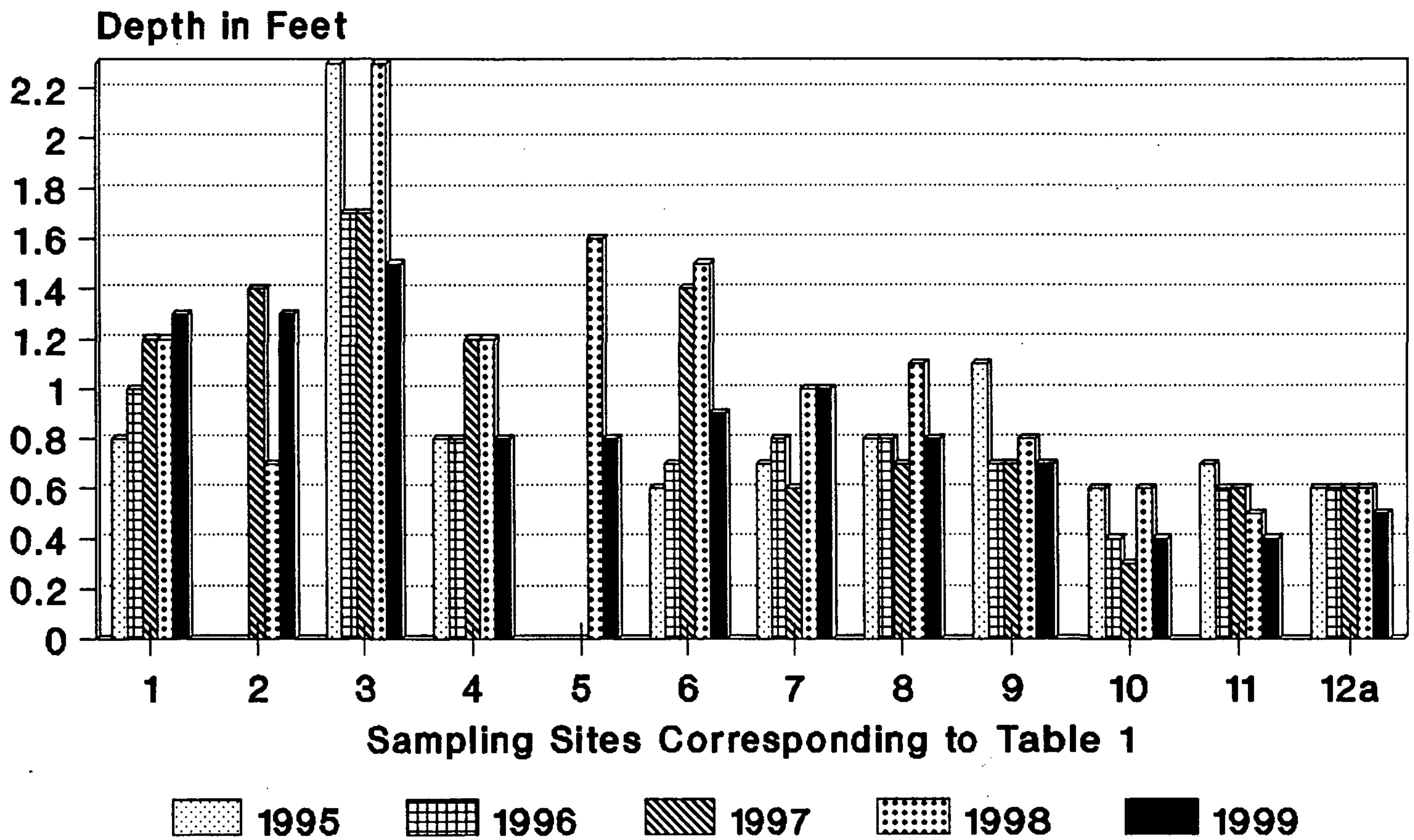


Figure 46. Average Depth in Riffles; Mainstem San Lorenzo River Sampling Sites, 1995-99.

Mainstem San Lorenzo River
Average Riffle Depth by Reach, 1997-99.
Reach Averages Based on Habitat-Typing.

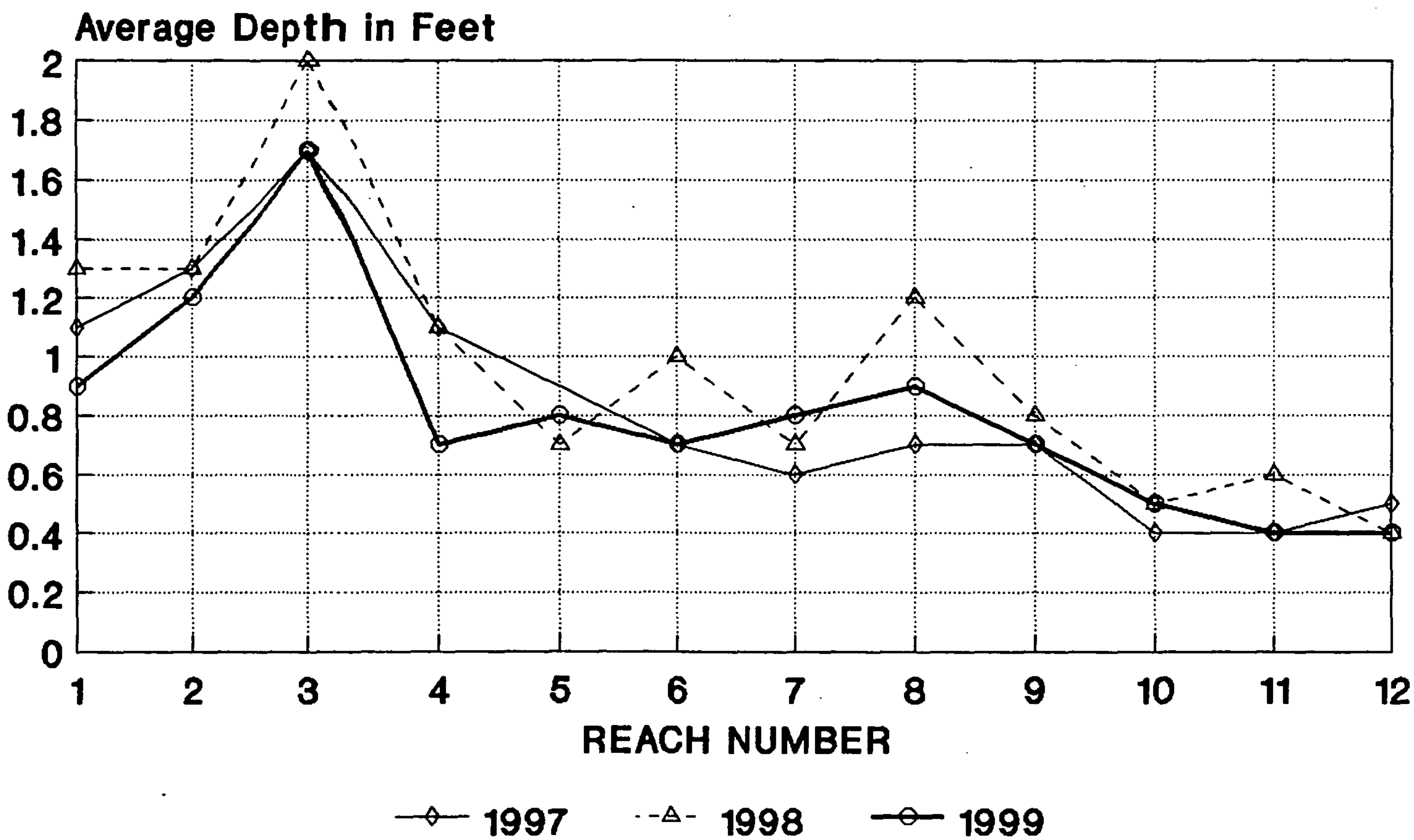


Figure 47. Average Riffle Depth by Reach
In the Mainstem San Lorenzo River,
Comparing 1997-99.

Mainstem San Lorenzo River
Average Maximum Riffle Depth by Reach.
Reach Averages Based on Habitat-Typing.

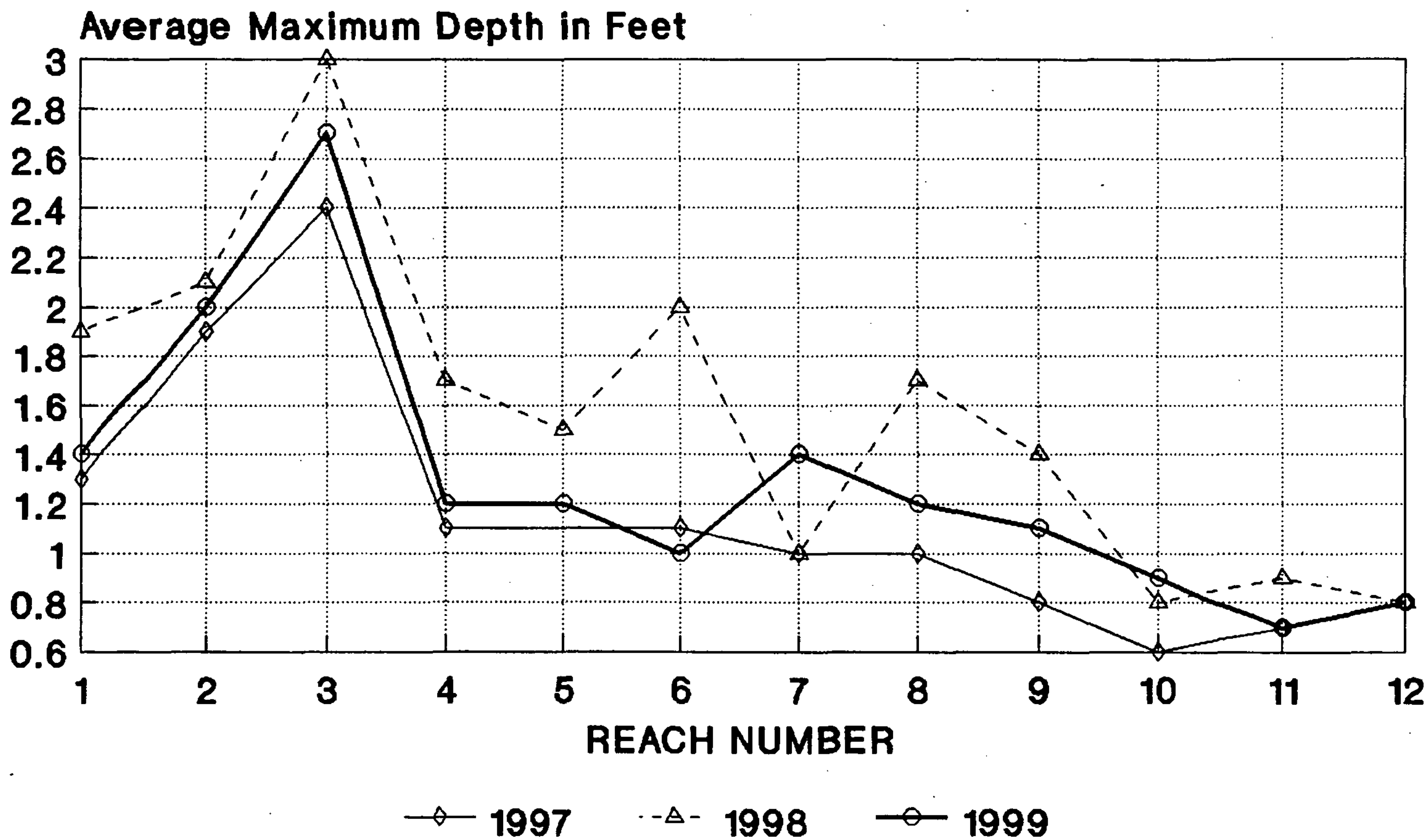


Figure 48. Average Maximum Riffle Depth by Reach in the Mainstem San Lorenzo River, Comparing 1997-99.

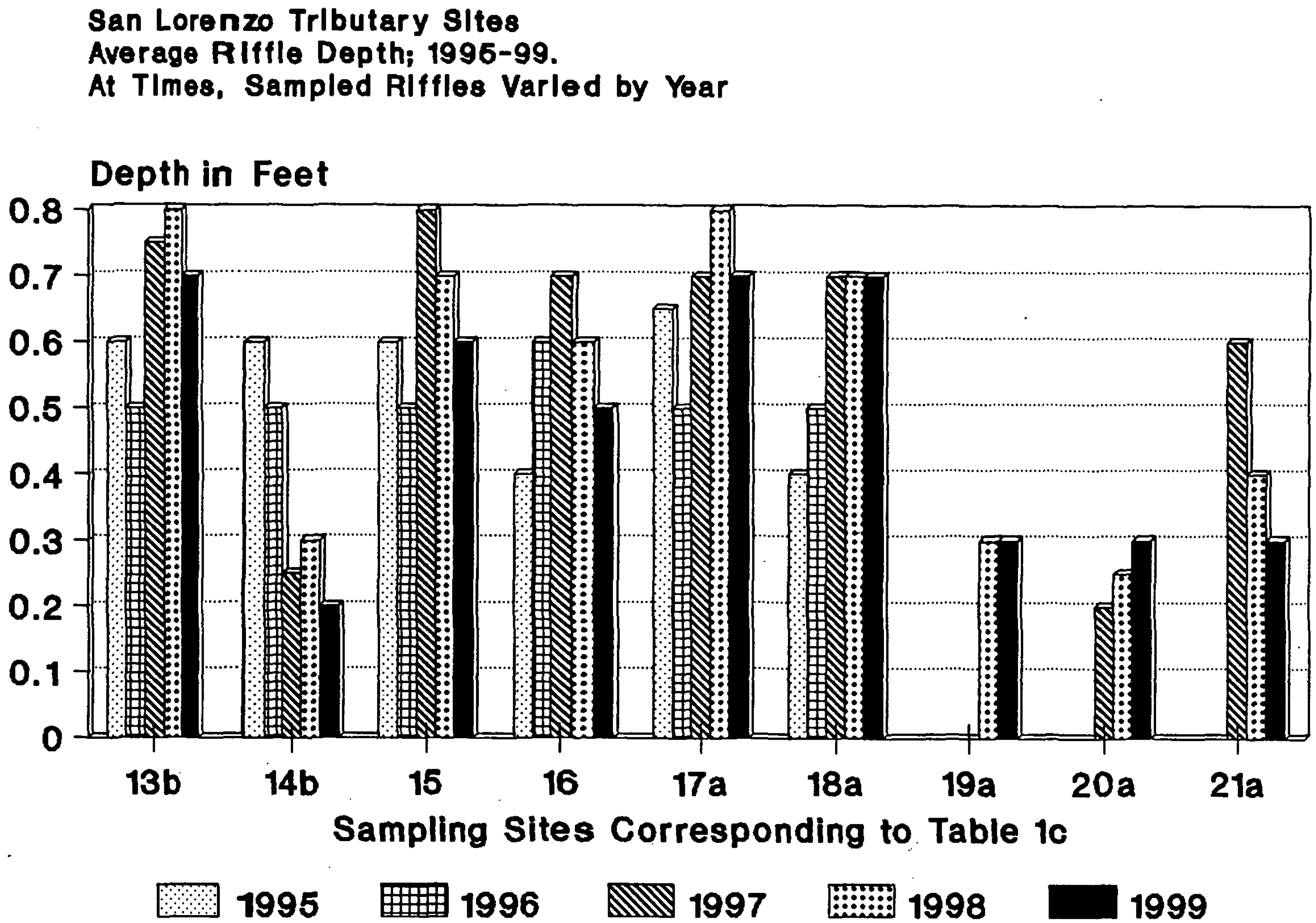


Figure 49. Average Depth in Riffles of Comparable San Lorenzo Tributary Sampling Sites, 1995-99.

Mainstem San Lorenzo River Sites
Average Depth- Flat-Water Runs; 1995-99.
At Times, Sampled Runs Varied by Year.

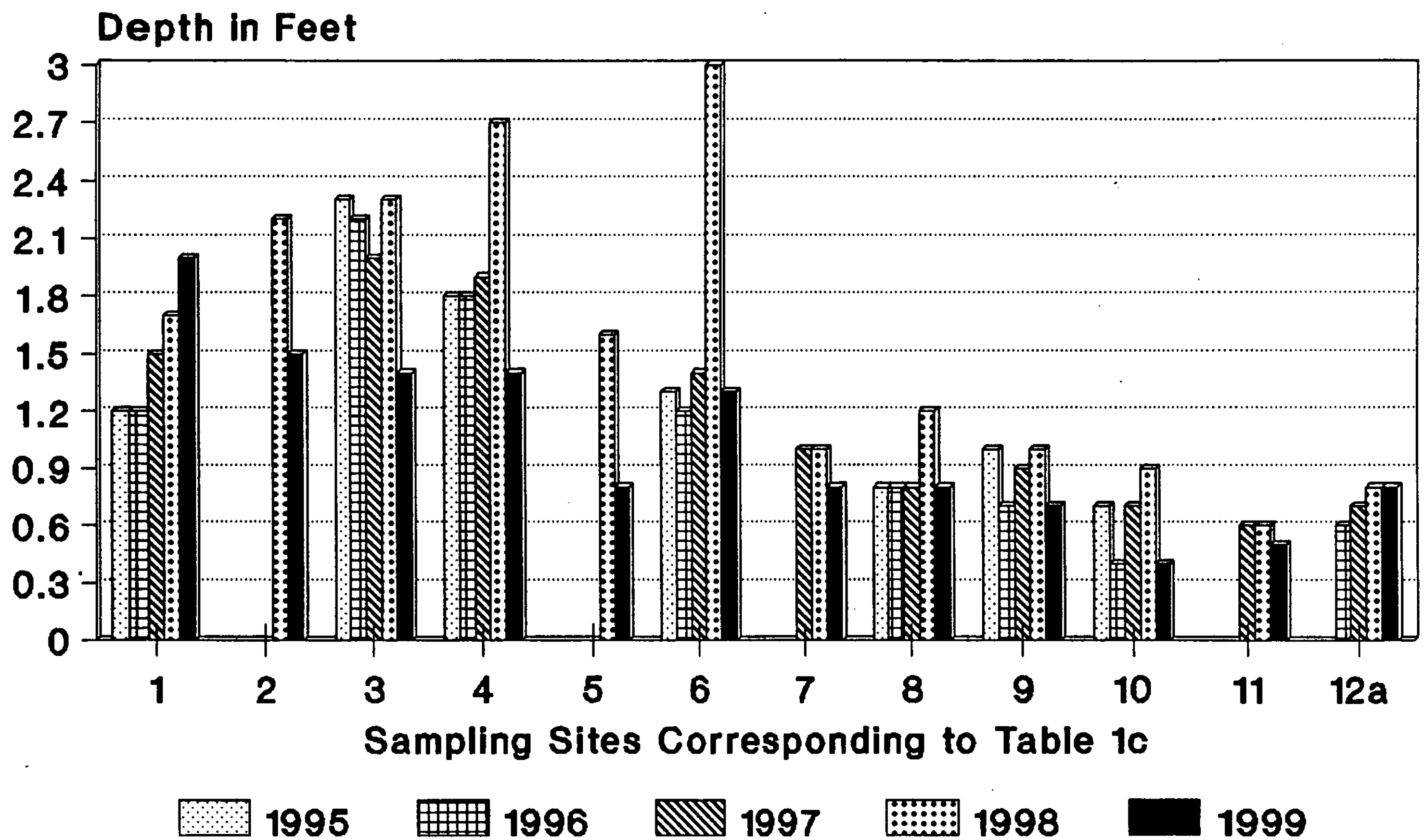


Figure 50. Average Depth in Comparable Flat-Water Runs at Sampling Sites in the Mainstem San Lorenzo River, 1995-99.

San Lorenzo Tributary Sites
Average Depth; Flat-Water Runs, 1995-99.
At Times, Sampled Runs Varied by Year.

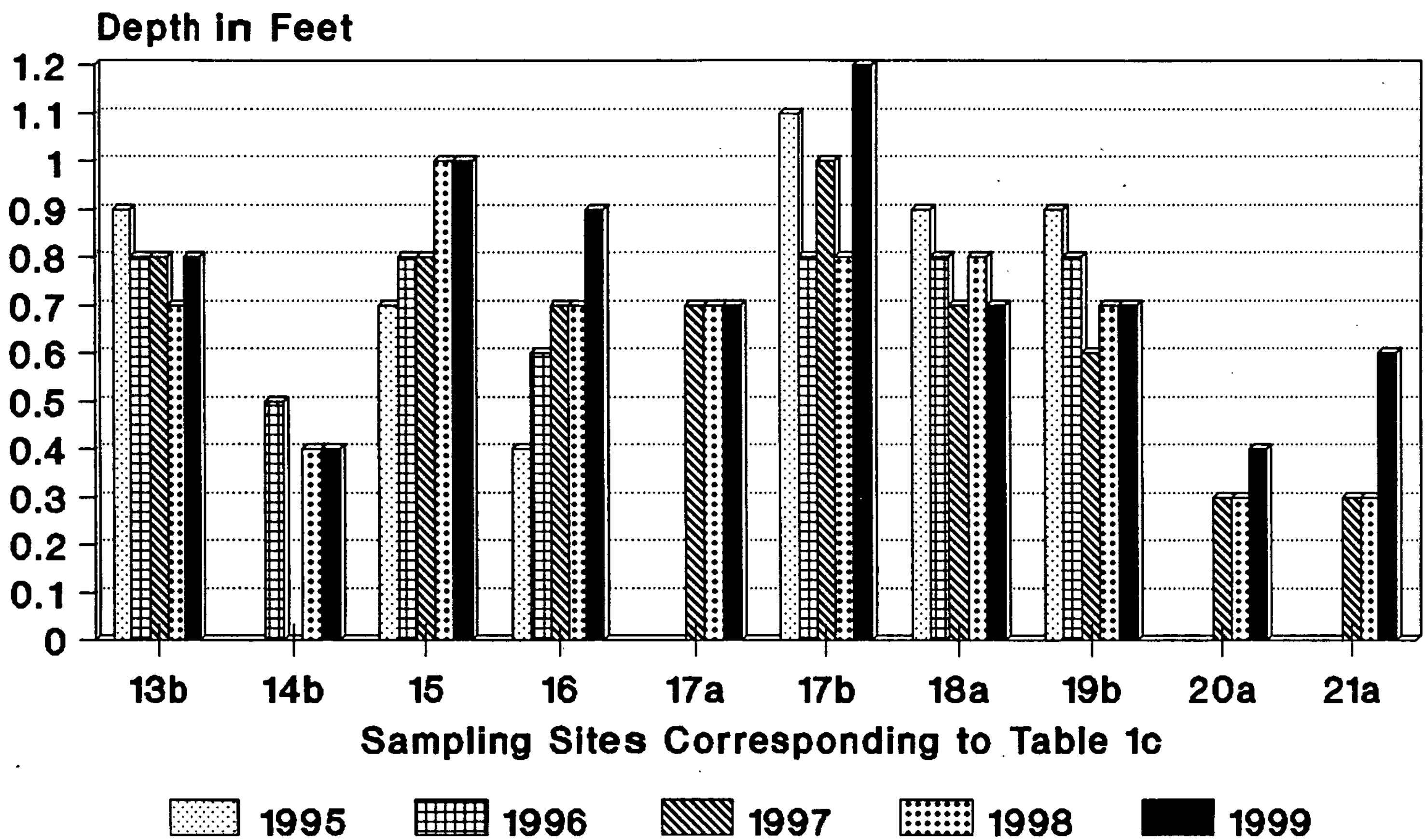


Figure 51. Average Depth in Flat Water Runs at Comparable San Lorenzo River Tributary Sampling Sites, 1995-99.

San Lorenzo River Mainstem Sites
Average Riffle Width; 1995-99.
At Times, Sampled Riffles Varied by Year

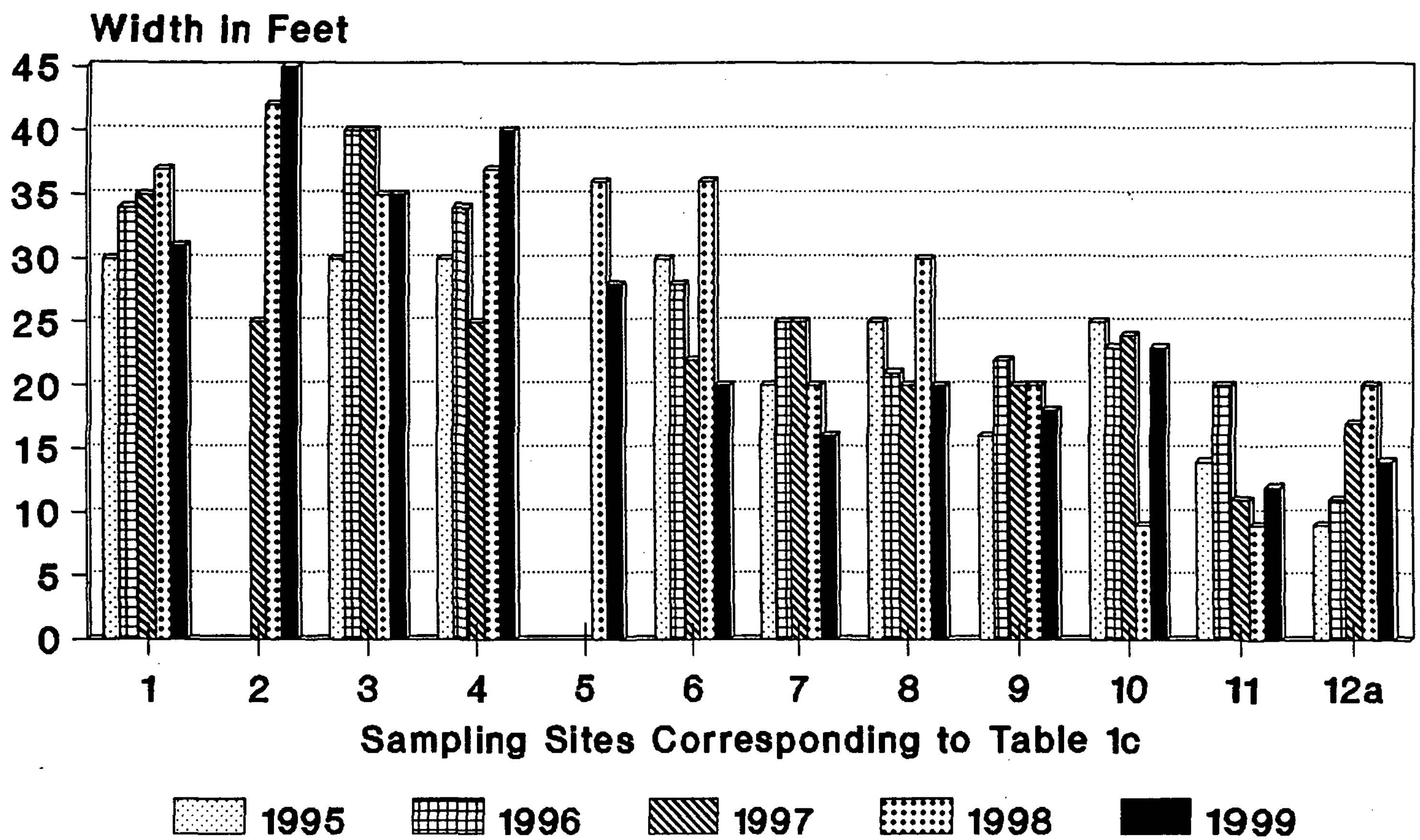


Figure 52. Average Width in Riffles;
San Lorenzo River Mainstem Sampling
Sites, 1995-99.

San Lorenzo Tributary Sites
Average Riffle Width; 1995-99.
At Times, Sampled Riffles Varied by Year

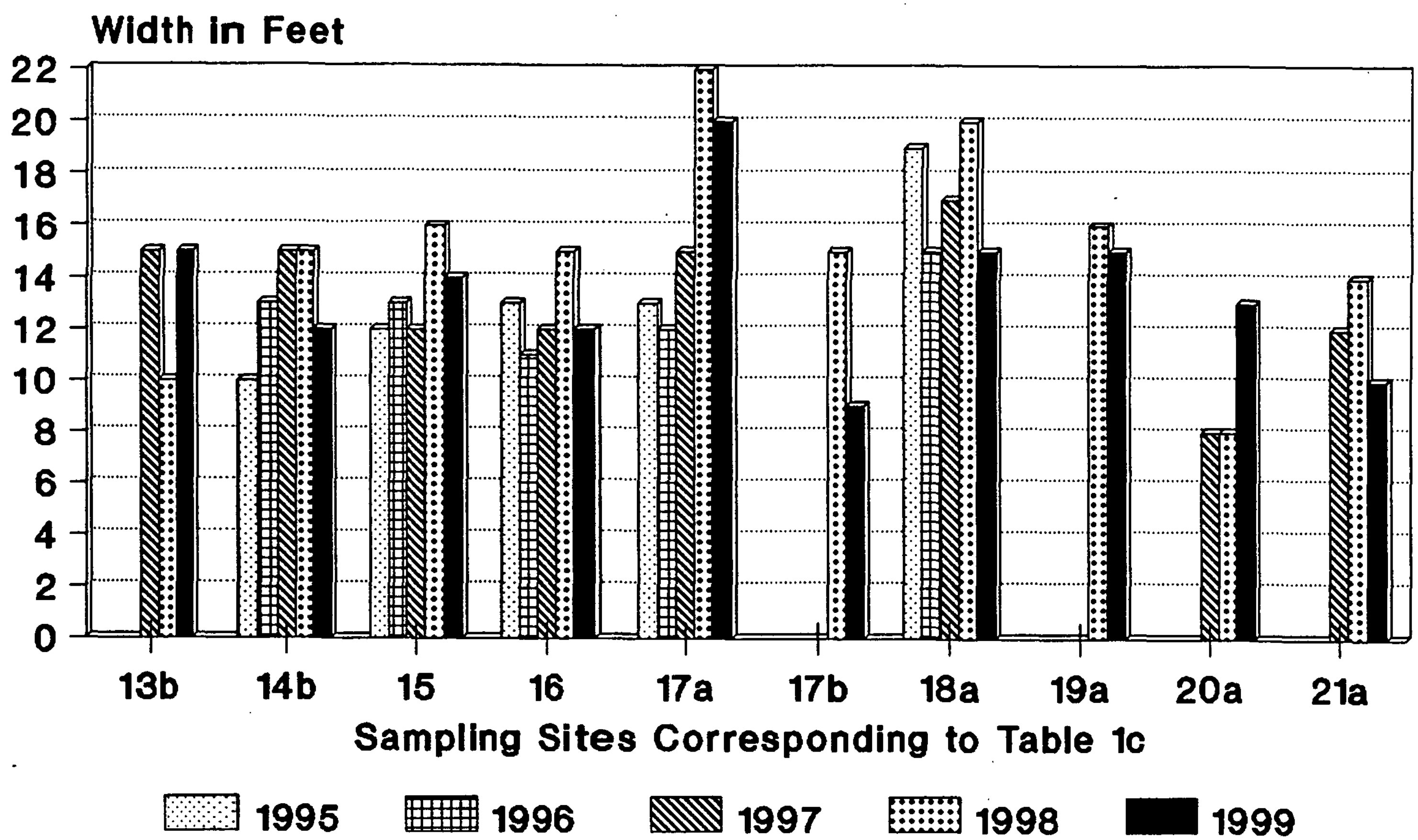


Figure 53. Average Width in Riffles; San Lorenzo River Tributary Sampling Sites, 1995-99.

Riffles: 1997- 5,441'(15.5%) of 35,039';
1998- 8,461'(22.5 %; n=92) of 37,522';
1999- 7,171'(18.0 %; n=118) of 39,938'

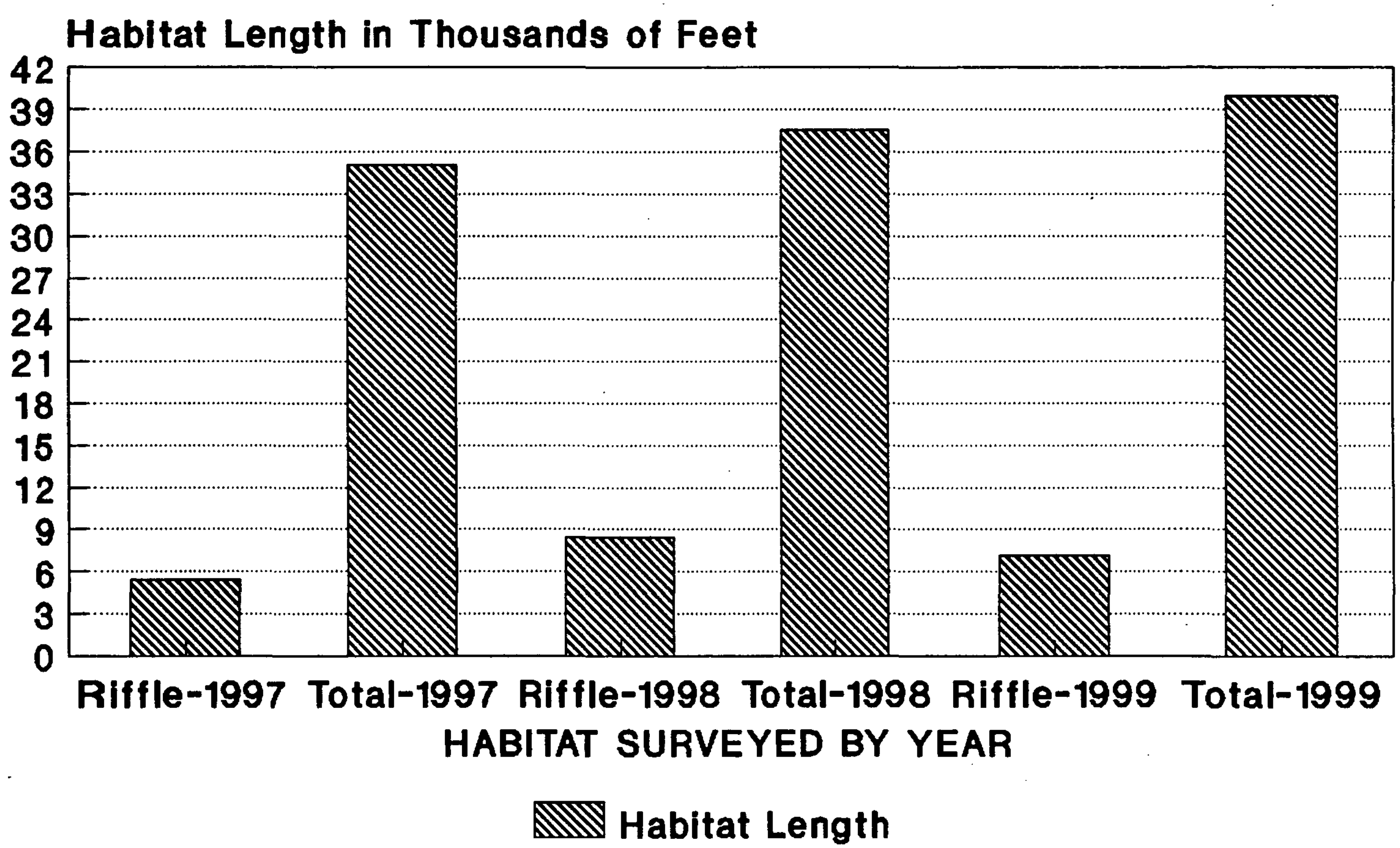


Figure 54. Riffle Length, Habitat-Typed in Identical Reaches of the Mainstem San Lorenzo River, Comparing 1997-99.

Mainstem and Zayante Estimates-Flowmeter
Flowmeter and Visual Estimates- 1995-96.
All Visual-1997; All Flowmeter- 1998-99.

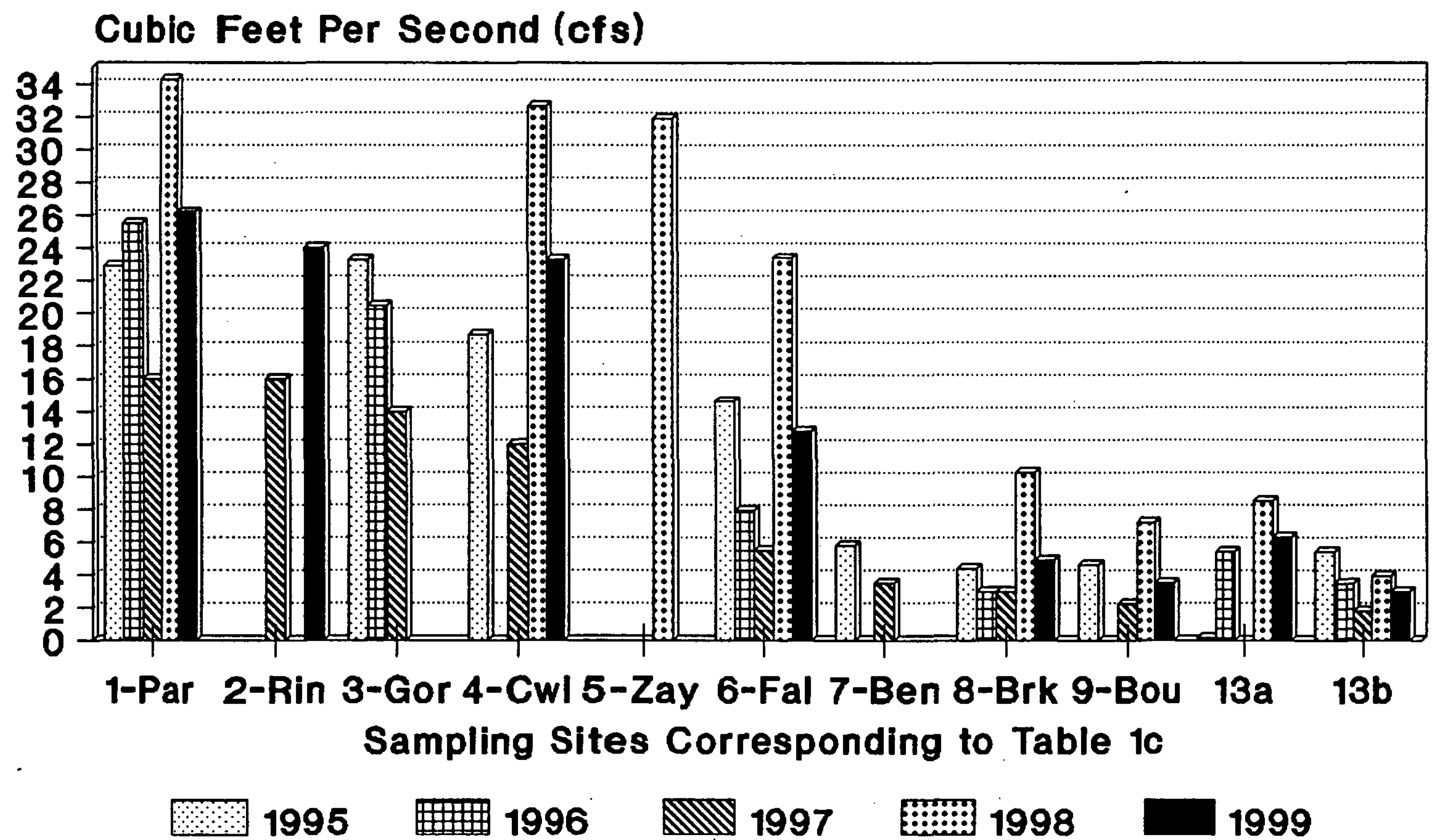


Figure 55. Streamflow at Mainstem Sites, Downstream of the Boulder Creek Confluence, Plus Zayante Creek; 1995-99.

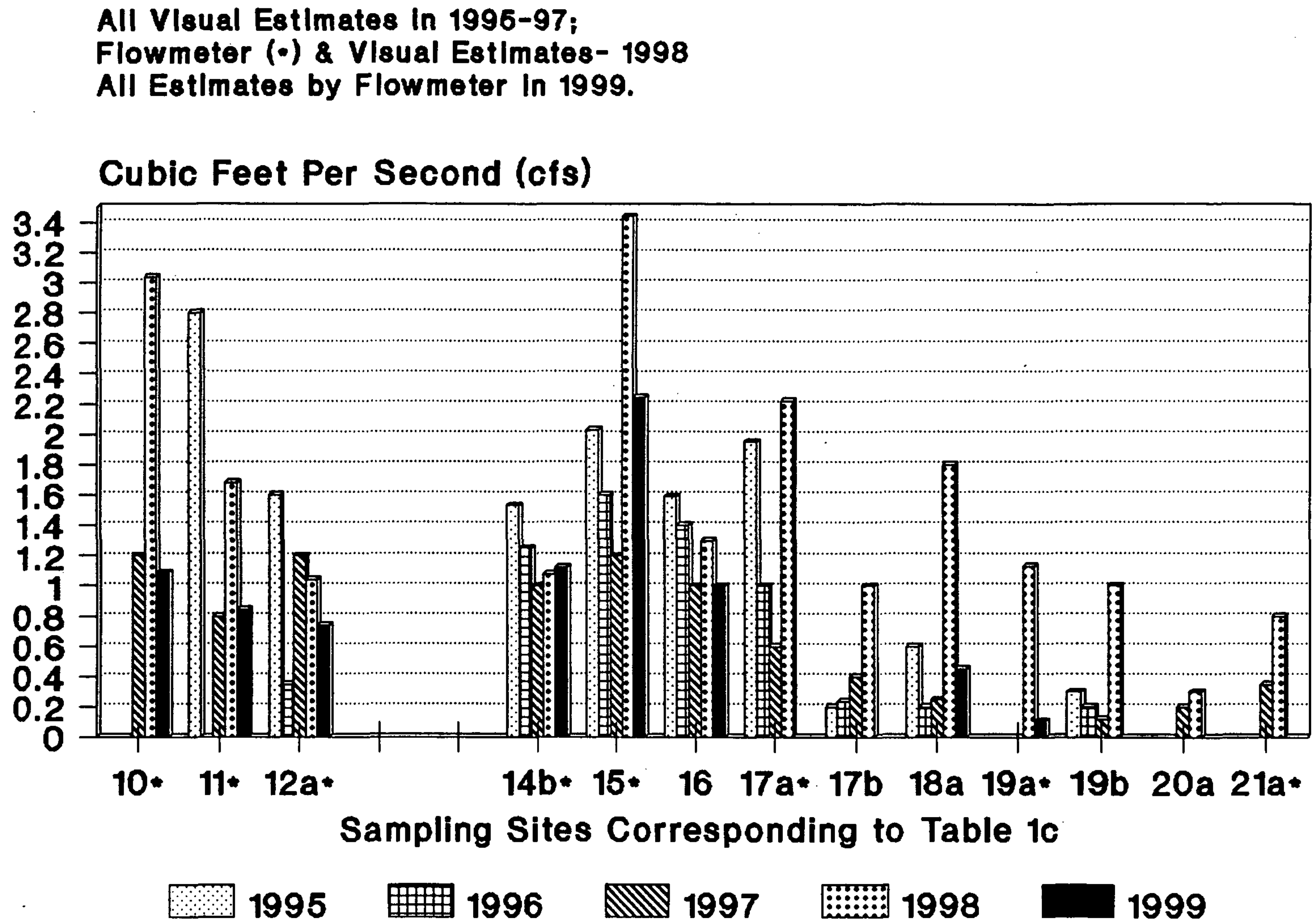


Figure 56. Estimated Streamflow; Upper San Lorenzo River and Small Tributary Sites, Comparing 1995-99.

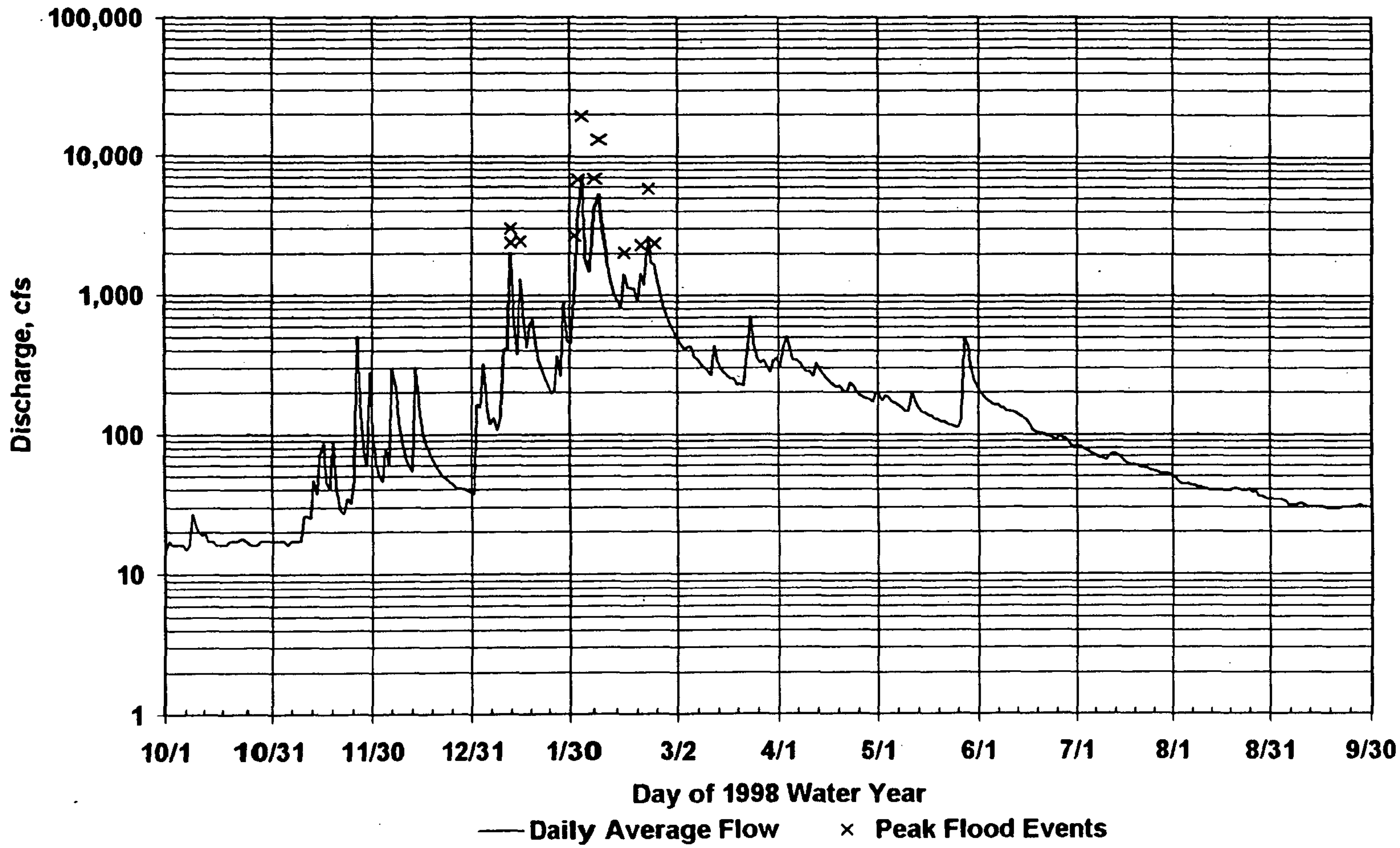


Figure 59. The 1998 daily average discharge and peak flood flows for the USGS gage on the San Lorenzo River at Big Trees.

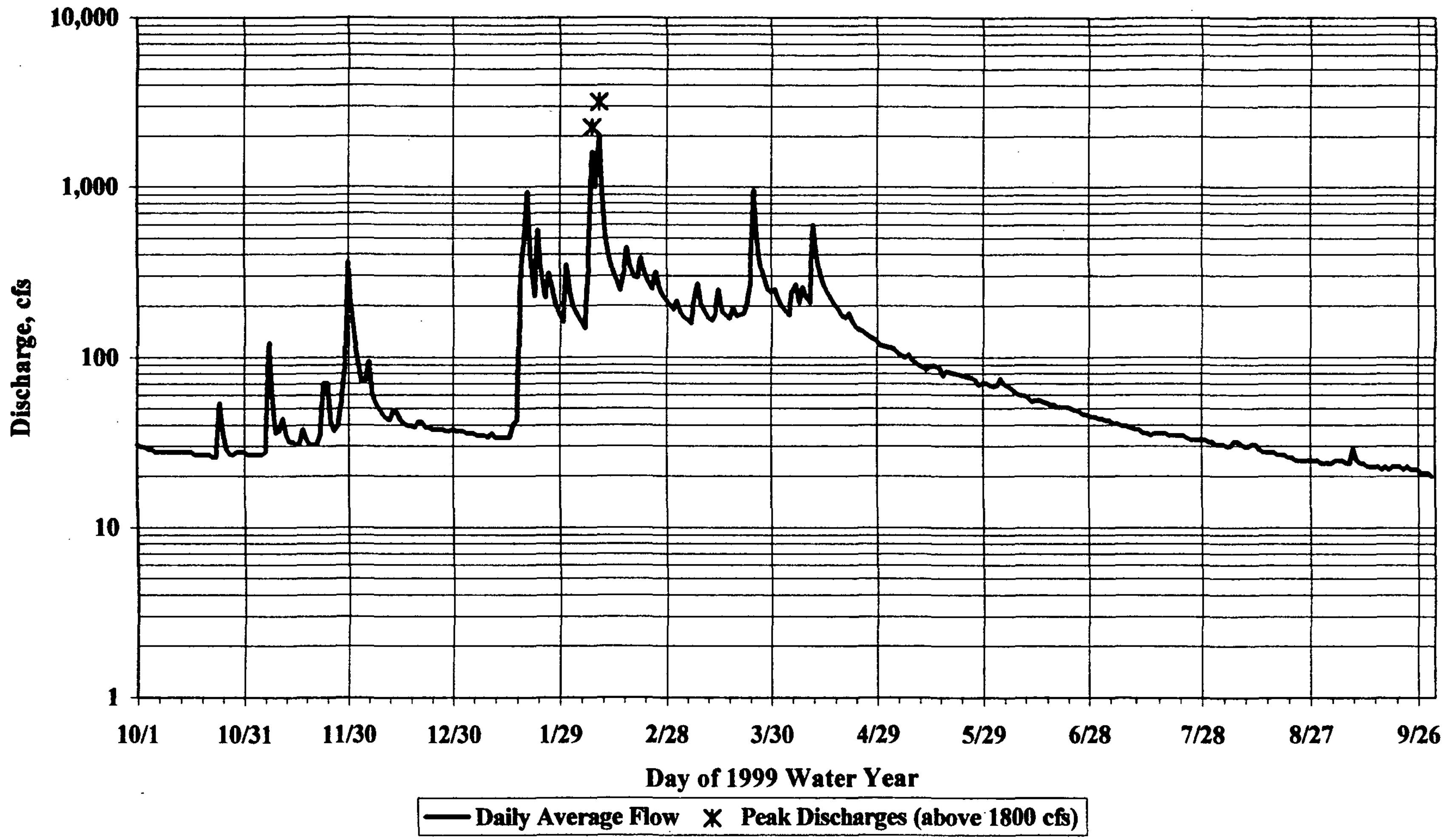
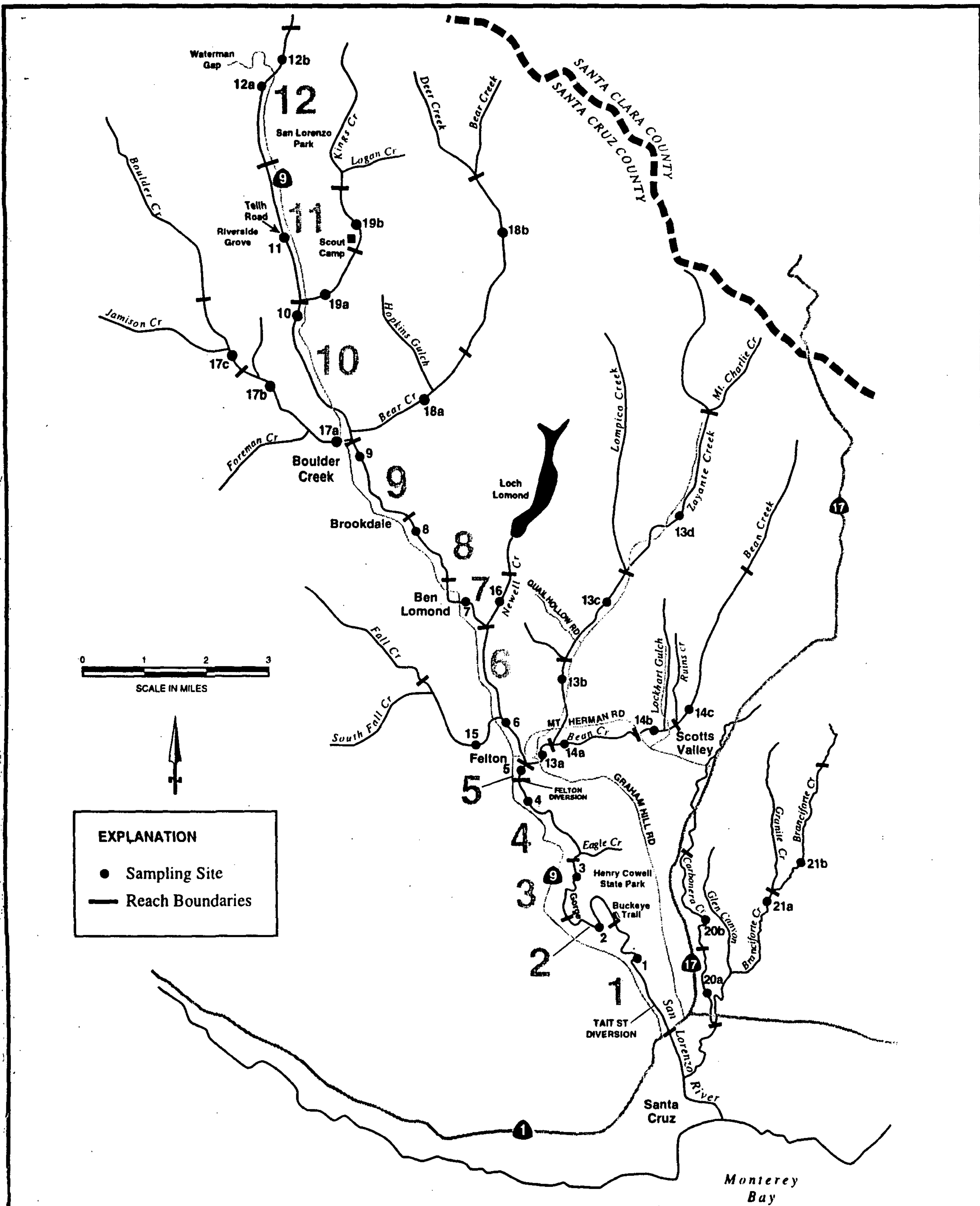


Figure 60: The 1999 daily average discharge and peak flood flows, above 1800 cfs, for the USGS gage on the San Lorenzo River at Big Trees.

APPENDIX A. Maps of the San Lorenzo River Drainage.



APPENDIX A, FIGURE 2 Reach & Site Designations in the San Lorenzo River Drainage
June 2000

D.W. ALLEY & Associates
P.O. Box 200
Brookdale, CA 95007

APPENDIX B. Summary of Catch Data for Sampling Sites.

EXPLANATION OF STEELHEAD/COHO SALMON SAMPLING FORMS

Electrofishing and snorkeling data are presented for each sampling site. All data pertains to steelhead because no coho salmon were captured in 1998. Snorkeled habitat is denoted. Data are presented by successive passes using electrofishing. Fish counts for replicate passes using visual censusing are presented as passes. Population estimates for each electrofished habitat are obtained by the depletion method and regression analysis. Population estimates for habitats that were visually censused are obtained by averaging the totals from each replicate pass.

For each pass, steelhead were divided into age and size class categories. Y-O-Y and 1+ refer to age classes. C-1, C-2 and C-3 refer to Size Classes 1, 2 and 3. For the data presented by pass, C-2 includes Size Classes 2 and 3 combined. Only in the population estimates are these two size classes differentiated.

Site densities at the bottom of the form are obtained by dividing total estimated number of fish in each size/age category by the total length of stream censused.

ORDER OF DATA ORGANIZATION IN THIS APPENDIX

The summary sheets for each sampling site are provided first as steelhead/coho sampling forms. Then the field data sheets for each sampling site are provided. The order of sampling sites corresponds to the numerical order presented in Table 1c of the text on pages 32-33 of the methods section.

Steelhead/Coho Salmon Sampling Form

Date: 14 Sept 99 Stream: San Lorenzo River

Sampled by: Alley, Mori, Allabed, Heady Sampling Site: Paradise Park Site 1

Water Temperatures and Times: 20.8°C @ 1328 hr, 24 Aug 99

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#14 Run 116'	24	0	1	25	12	0	0	12	3	1	1	4	.3715 43.1	.0086 1	.0172 2	.3802 44.1	.0095 1.1
#15 ?iffle 66'	29	0	12	41	12	0	3	15	6	0	1	7	.7742 51.1	0 0	.2455 16.2	.8818 58.2	.1288 8.5
#7 ?ool 114'	2	0	1	3	0	0	0	0	0	0	0	0	.0175 2	0 0	.0088 1	.0263 3	0 0
#10 ?ool ?orkel 336'	4	0	2	6	7	0	2	9	9	0	3	12	7	0	2	9	0
#12 Pool ?orkel 270'	11	1	5	16	10	0	5	15	9	0	4	13	10	1	5	15	0
?gpods 606'													.0281 17	.0017 1	.0116 7	.0396 24	0 0
												TOTALS:	113.2	2	26.2	129.3	9.6

2

Length of Stream Sampled: 902'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.1255 / .0022

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.0290? / 0.1540

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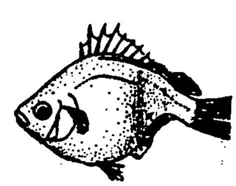

Steelhead/Coho Salmon Sampling Form

Date: 15 September 1999 Stream: San Lorenzo River

Sampled by: Alley, Mori, Allaback, Heady Sampling Site: #6 @ Fall Creek

Water Temperatures and Times: 19.5°C @ 1824hr, 26 Aug 99 above Fall Creek

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#4 Run 99'	29	27	3	5	13	10	0	3	9	9	0	0	.5949 58.9	.5313 52.6	.0303 3	.0808 8	0 0
#5 Riffle 81'	64	46	0	18	15	13	0	2	5	5	0	0	1.0481 84.9	.8086 65.5	0 0	.2469 20	0 0
#6 pool 110'	20	18	3	5	5	5	2	2	6	6	0	0	33.8	32.5	5	6	1
#15 pool 124'	0	0	0	0	1	1	0	0	2	1	2	3	2	1	2	3	0
#17 pool 943'	0	0	1	1	—				—				0 0	0 0	.0011 1	.0011 1	0 0
Short pools 234'													.1530 35.8	.1432 33.5	.0299 7	.0385 9	.0043 1
TOTALS:													179.6	151.6	11	38	1

Length of Stream Sampled: 1357'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.1324 / 0.1117

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.0081 / 0.0287

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Steelhead/Coho Salmon Sampling Form

Date: 16 September 1999 Stream: San Lorenzo River

Sampled by: Alley, Mori, Allabeck, Heady Sampling Site: #7 @ Ben Lomond

Water Temperatures and Times: 66°F @ 1355 hr, 30 Aug 99 (air temp 20.8 °C)

Plot Length	First Pass				Second Pass				Third Pass				Pop. Estimate				
& Habitat	YOY/C-1		1+/C-2		YOY/C-1		1+/C-2		YOY/C-1		1+/C-2		YOY/C-1		1+/C-2/C-3		
#8 Run 57'	10	2	23	31	5	2	4	7	2	2	0	0	.3351 19.1	.1053 6	.4737 27	.5263 30	.1404 8
#7 Riffle 38'	15	11	4	8	2	1	1	2	0	0	0	0	.4474 17	.3158 12	.1316 5	.2632 10	0 0
#6 pool(s) 175'	12	6	22	28	5	3	1	3	3	2	2	3	.1263 22.1	.0754 13.2	.1429 25	.1714 30	.0229 4
#9 pool(L) 928'	10	3	18	25									.0108 10	.0032 3	.0194 18	.0259 24	.0011 1

TOTALS: 68.2 34.2 75 94 13

Length of Stream Sampled: 1198'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.0569 / 0.0285

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.0626 / 0.0893

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Steelhead/Coho Salmon Sampling Form

Date: 16 September 1999 Stream: San Lorenzo River

Sampled by: Alley, Mori, Allsback, Heady Sampling Site: #8 Brookdale, below Clear Creek

Water Temperatures and Times: 19.5°C @ 1533 hr, 27 Aug 99

Plot & Habitat	Length	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#14 Riffle	94'	95	77	12	30	25	21	3	7	6	6	0	0	1.3660 128.4	1.1287 106.1	.1596 15	.3830 36	.0101 1
#13 Run	75'	64	56	3	11	14	12	0	2	5	5	0	0	1.1147 83.6	.98 73.5	.04 3	.1733 13	0 0
#4 pool	322'	6	4	1	3	5	4	2	3	5	5	2	2	.0155 5	.0124 4	.0062 2	.0093 3	0 0

TOTALS: 217 183.6 20 52 1

Length of Stream Sampled: 491'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.4420 / 0.3739

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.0407 / 0.1079

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Steelhead/Coho Salmon Sampling Form

Date: 17 September 1999 Stream: San Lorenzo River

Sampled by: Alley, Mori, Allabeck, Sampling Site: #9 Below Boulder Heady Creek

Water Temperatures and Times: 64°F @ 1450hr, 31 Aug 99 air temp. = 24°C

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#4 Riffle 112'	50	33	1	18	18	13	1	6	9	8	0	1	.7277 81.5	.6313 70.7	.0179 2	.2321 26	0 0
#5 Run 92'	52	38	9	23	14	10	3	7	7	4	1	3	.8109 74.6	.575 52.9	.1467 13.5	.3467 31.9	.0228 2.1
#2 pool 332'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#3 pool 136'	0	0	0	0	0	0	1	1	1	1	1	1	.0074 1	.0074 1	.0074 1	.0074 1	0
pools 468													.0021 1	→ 1	→ 1	→ 1	0
												TOTALS:	157.1	124.6	16.5	58.9	2.1

Length of Stream Sampled: 672'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.2338 / 0.1854

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.0246 / 0.0908

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Steelhead/Coho Salmon Sampling Form

Date: 27 September 1999 Stream: San Lorenzo River

Sampled by: Alley, Allaback, Heady Sampling Site: #10 Below Kings Creek

Water Temperatures and Times: ______

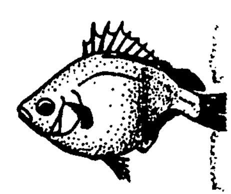
Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#27 pool 252'	7	6	9	10	5	4	1	2	1	1	2	2	.0635 16.0	.0544 13.7	.0492 12.4	.0405 10.2	.0[illegible] 4.1
#26 riffle 34'	2	0	0	2	0	0	0	0	0	0	0	0	.0588 2	0	0	.0588 2	0
#25 Run 70'	1	1	4	4	4	1	0	3	0	0	0	0	.0714 5	.0286 2	.0571 4	.0857 6	.014 1

TOTALS: 23 15.7 16.9 18.2 5.1

Length of Stream Sampled: 356'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.0646 / 0.0441

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.0461 / 0.0654



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Steelhead/Coho Salmon Sampling Form

Date: 24 September 1999 Stream: San Lorenzo River

Sampled by: Alley, Mori, Heady Sampling Site: #11 below Teihl Rd.

Water Temperatures and Times:

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#10 pool 43'	15	15	9	9	10	10	0	0	1	1	1	1	31	31	10.3	9.3	1
#9 run 66'	6	6	0	0	3	2	0	1	2	2	0	0	0.2 13.2	.1712 11.3	0 0	.0152 1	0 0
#8 riffle 41'	5	5	0	0	3	3	0	0	3	3	0	0	.2683 11	.2683 11	0	0	0
#7 pool 145'	17	17	8	8	4	4	1	1	4	4	0	0	26.1	26.1	9	8	1
pools 188'													.3037 57.1	.3037 57.1	.1027 19.3	.0920 17.3	.0106 2

TOTALS: 81.3 79.4 19.3 17.3 2

Length of Stream Sampled: 295'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.2756 / 0.2692

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.0654 / 0.0654

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Steelhead/Coho Salmon Sampling Form

Date: ______________________ Stream: San Lorenzo River

Sampled by: ______________________ Sampling Site: 12a-b

______________________ Waterman Gap - Summary

Water Temperatures and Times: ______________________

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
pools 162'													.1296 21	.0741 12	.1728 28	.2284 37	0 0
step-runs 94'													.1149 10.8	0 0	.1532 14.4	.2479 233	0 0
runs 57'													.0175 1	.0175 1	.0702 4	.0702 4	0 0
riffles 47'													0 0	0 0	.0213 1	.0213 1	0 0
TOTALS:																	

Length of Stream Sampled: ______________________

Young-of-the-Year / Size Class 1 per Foot of Stream: ______________________

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: ______________________

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Steelhead/Coho Salmon Sampling Form

Date: 28 September 1999 Stream: San Lorenzo River

Sampled by: Alley, Mori, Healy Sampling Site: #12a, 12b

Waterman Gap

Water Temperatures and Times: ______

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#40 pool 47'	2	2	8	8	0	0	1	1	0	0	0	0	2	2	9	9	0
#41 steprun 23'	0	0	2	2	0	0	0	0	0	0	0	0	0	0	2	2	0
#44a pool 39'	2	2	8	8	0	0	0	0	0	0	0	0	2	2	8	8	0
#44b run 25'	1	1	4	4	0	0	0	0	0	0	0	0	1	1	4	4	0
#45 riffle 32'/166'	2	2	2	2	2	2	0	0	0	0	1	1	4/9	4/9	3/26	3/26	0
Subtotal													0.0542 →		0.1566 →		
#12 run 32'	0	0	0	0	0	0	0	0	–				0	0	0	0	0
#13a step-run 71'	7	0	9	16	1	0	1	2	2	0	2	3	10.8	0	12.4	21.3	0
13b pool 30'	6	2	6	10	1	1	0	0	0	0	0	0	7	3	6	10	0
#14 riffle 15'	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0
#15 pool 46'/94'	9	4	4	9	1	1	1	1	0	0	0	0	10/27.8	5/8	5/24.4	10/42.3	0/0
Subtotal													0.1433	0.0412	0.1258	0.2180	
TOTALS:													36.8	17	50.4	68.3	0

Length of Stream Sampled: 360'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.1022 / 0.0472

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.1400 / 0.1897

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Steelhead/Coho Salmon Sampling Form

Date: 20 September 1999 **Stream:** Zayante Creek

Sampled by: Alley, Allsback, Hecdy, Peterson **Sampling Site:** #13a Below Bean Creek

Water Temperatures and Times: ____________________

Plot Length & Habitat		First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#12 pool	106'	60	56	8	12	22	21	0	1	11	11	1	1	,9311 98.7	.8868 94	.0877 93	.1226 13	.009 1
#0 riffle	43'	44	40	3	7	4	4	0	0	2	2	0	0	1.1535 49.6	1.0605 45.6	.0698 3	.1628 7	0 0
#18 run	80'	36	33	5	8	20	19	0	1	7	6	0	1	,905 72.4	.8388 67.1	.0625 5	.125 10	0 0
													TOTALS:	220.7	206.7	17.3	30	1

Length of Stream Sampled: 229'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.9638 / 0.9026

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.0755 / 0.1354

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Steelhead/Coho Salmon Sampling Form

Date: 22 September 1999 Stream: Zayante Creek

Sampled by: Alley, Allabeck, Mori Sampling Site: #13b Above Bean Creek

Water Temperatures and Times:

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#9 pool 141'	42	38	27	31	24	23	4	5	3	2	1	2	.5567 78.5	.5170 72.9	.2270 32	.2688 37.9	0 0
#10 Riffle 42'	15	13	0	2	3	3	0	0	0	0	0	0	18	16	0	2	0
#11 Run 58'	35	33	1	3	8	8	0	0	1	1	0	0	.7707 44.7	.7379 42.8	.0172 1	.0517 3	0 0
#13 riffle 25'	18	13	5	10	1	1	0	0	1	1	0	0	20	15	5	10	0
riffles 67'													.5672 38	.4627 31	.0746 5	.1791 12	0 0
TOTALS:													161.2	146.7	38	52.9	0

Length of Stream Sampled: 266'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.6060 / 0.5515

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.1429 / 0.1989

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Steelhead/Coho Salmon Sampling Form

Date: 22 September 1999 Stream: Zayante Creek

Sampled by: Alley, Heady, Mori Sampling site: 13C Above Quail Hollow Rd, Below Lompico Creek

Water Temperatures and Times: ______

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#23 pool 79'	24	19	7	12	11	10	2	3	3	3	1	1	.5228 41.3	.4557 36	.1304 10.3	.2051 16.2	0 0
#25 run 70'	23	20	1	4	8	7	1	2	0	0	0	0	.4429 31	.3857 27	.0286 2	.0857 6	0 0
#17 riffle 25'	13	12	7	6	2	2	1	1	0	0	0	0	.6 15	.56 14	.32 8	.28 7	0 0
TOTALS:													87.3	77	20.3	29.2	0

Length of Stream Sampled: 174'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.5017 / 0.4425

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.1167 / 0.1678

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 22 September 1999 Stream: Zayante Creek

Sampled by: Alley, Mori, Heady Sampling Site: 13d Above Lompico Creek

Water Temperatures and Times:

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#20 step-run 56'	45	45	18	18	13	13	3	3	3	3	1	1	1.1179 62.6	1.1179 62.6	.3929 22	.3929 22	0 0
#21 pool 105'	41	41	14	14	14	14	5	5	5	5	2	2	.5952 62.5	.5952 62.5	.2095 22	.2095 22	0 0

TOTALS: 125.1 125.1 44 44 0

Length of Stream Sampled: 161'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.7770 / 0.7770

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.2733 / 0.2733

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 20 September 1999 Stream: Bean Creek

Sampled by: Alley, Mori, Alleback Sampling Site: 14a Adjacent Mt. Hermon

Water Temperatures and Times: ______

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#8 pool 87'	28	28	3	3	5	5	1	1	5	5	0	0	.4425 38.5	.4425 38.5	.0460 4	.0460 4	0
#9 run 68'	15	15	3	3	6	6	0	0	3	3	0	0	.3074 25.9	.3074 25.9	.0441 3	.0441 3	0
#10 riffle 48'	17	17	1	1	2	2	0	0	2	2	0	0	.4354 20.9	.4354 20.9	.0208 1	.0208 1	0 0

TOTALS: 85.3 85.9 8 8 0

Length of Stream Sampled: 203'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.4202 / 0.4202

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.03941 / 0.03941

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 21 September 1999 Stream: Bean Creek

Sampled by: Alley, Mori, Heady Sampling Site: 14b Below Lockhart Gulch

Water Temperatures and Times:

Plot Length & Habitat		First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#35 pool	45'	38	38	14	14	18	18	1	1	1	1	0	0	1.3867 62.4	1.3867 62.4	.3333 15	.3333 15	0 0
#31&32 pool	109'	25	25	32	32	14	14	11	11	10	10	3	3	.4495 49	.4495 49	.4394 47.9	.4394 47.9	0 0
#37 riffle	25'	6	6	3	3	0	0	0	0	0	0	0	0	.24 6	.24 6	.12 3	.12 3	0 0
#36 run	20'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
pools	154'													.7233 111.4	.7233 111.4	.4084 62.9	.4084 62.9	0

TOTALS: 117.4 117.4 65.9 65.9 0

Length of Stream Sampled: 199'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.5899/0.5899

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.3312/0.3312

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 21 September 1999 Stream: Bean Creek

Sampled by: Alley, Mori, Hady Sampling Site: 14c above Mckenzie Creek

Water Temperatures and Times:

Plot Length & Habitat	First Pass YOY	First Pass C-1	First Pass 1+	First Pass C-2	Second Pass YOY	Second Pass C-1	Second Pass 1+	Second Pass C-2	Third Pass/4th YOY	Third Pass/4th C-1	Third Pass/4th 1+	Third Pass/4th C-2	Pop. Estimate YOY	Pop. Estimate C-1	Pop. Estimate 1+	Pop. Estimate C-2	Pop. Estimate C-3
#49 run 53'	2	2	2	2	2	2	0	0	1	1	0	0	.0943 5	.0943 5	.0377 2	.0377 2	0
#50 pool 29'	0	0	12	12	2	2	3	3	0	0	0	0	2	2	15	15	0
#51 riffle 31'	1	1	0	0	0	0	0	0	0	0	0	0	.0323 1	.0323 1	0	0	0
#52 pool 45'	3	3	3	3	0	0	1	1	0/0	0/0	3/1	3/1	3	3	8	7	1
pools 74'													.0676 5	.0676 5	.3108 23	.2973 22	.0135 1
TOTALS:													11	11	25	24	1

Length of Stream Sampled: 158'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.0696/0.0696

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.1582/0.1582

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 21 September 1999 Stream: Fall Creek

Sampled by: Alley, Mori, Allaback, Heady, Peterson Sampling Site: #15 Below Bridge

Water Temperatures and Times: ____

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass/4th YOY/C-1		Third Pass/4th 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#6 run 38'	22	22	5	5	3	3	1	1	4/0	4/0	0/0	0/0	.7632 29	.7632 29	.1579 6	.1579 6	0
#7 riffle 117'	43	43	12	12	14	14	0	0	7	7	3	3	.5709 66.8	.5709 66.8	.1538 18	.1538 18	0
#8 pool 52'	31	31	10	10	7	7	1	1	6	6	0	0	.8673 45.1	.8673 45.1	.2115 11	.2115 11	0 0

TOTALS: 140.9 140.9 35 35 0

Length of Stream Sampled: 207'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.6807 / 0.6807

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.1691 / 0.1691

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 28 September 1999 Stream: Newell Creek

Sampled by: Alley, Mori, Heady Sampling Site: #16, Above Glen Arbor Road Bridge

Water Temperatures and Times: ______

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#24 Run 31'	3	3	1	1	2	2	0	0	0	0	0	0	.1613 5	.1613 5	.0323 1	.0323 1	0 0
#25 riffle 42'	7	7	4	4	1	1	0	0	0	0	0	0	.1905 8	.1905 8	.0952 4	.0952 4	0 0
#28 pool 85'	9	9	24	24	3	3	4	4	2	2	3	3	.1753 14.9	.1753 14.9	.3647 31	.3176 27	.0471 4
												TOTALS:	27.9	27.9	36	32	4

Length of Stream Sampled: 158'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.1766 / 0.1766

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.2278 / 0.2278

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 17 September 1999 Stream: Boulder Creek

Sampled by: Alley, Mori, Hardy Sampling Site: 17a Above San Lorenzo Confluence + Hwy 9 Bridge

Water Temperatures and Times:

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#4 run 67'	21	21	9	9	12	12	4	4	7	7	1	1	.5970 40	.5970 40	.2254 15.1	.2090 14	.0164 1.1
#5 riffle 54'	15	15	6	6	2	2	2	2	4	4	2	2	.4130 22.3	.4130 22.3	.2093 11.3	.2093 11.3	0
#6 pool 67'	20	20	3	3	6	6	3	3	5	5	1	1	.4940 33.1	.4940 33.1	.1045 7	.1045 7	0 0

TOTALS: 95.4 95.4 33.4 32.3 1.1

Length of Stream Sampled: 188'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.5074/0.5074

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.1777/0.1777

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 27 September 1999 Stream: Boulder Creek

Sampled by: Alley, Heady, Mori Sampling Site: 17b - Above Bracken Brae Bridge

Water Temperatures and Times:

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#16 Step-run 91'	17	17	10	10	6	6	0	0	1	1	0	0	.2758 25.1	.2758 25.1	.1099 10	.0989 9	.0110 1
#20 pool 66'	20	20	6	6	9	9	3	3	4	4	3	3	.55 36.3	.55 36.3	.1818 12	.1667 11	.0152 1
#21 riffle 41'	7	7	4	4	2	2	0	0	1	1	0	0	.2512 10.3	.2512 10.3	.0976 4	.0976 4	0 0
TOTALS:													71.7	71.7	26	24	2

Length of Stream Sampled: 198'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.3621/0.3621

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.1313/ 0.1313

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 27 September 1999 Stream: Boulder Creek

Sampled by: Alley, Mori, Heady Sampling Site: 17C - Below Jamison Creek

Water Temperatures and Times: ______

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#5 (density)													.1304	.1304	.1362	.1217	.0145
pool 69'	6	6	6	6	3	3	2	2	0	0	1	1	9	9	9.4	8.4	1
#7 (density)													.0667	.0667	.1	.1	0
riffle/step-run 30'	2	2	2	2	0	0	0	0	0	0	1	1	2	2	3	3	0
#8 (density)													.2813	.2813	.3719	.3719	0
pool 32'	3	3	10	10	3	3	1	1	3	3	1	1	9	9	11.9	11.9	0
(density)													.1782	.1782	.2406	.2307	.01
pools 101'													18	18	24.3	23.3	1
TOTALS:													20	20	24.3	23.4	1

Length of Stream Sampled: 131'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.1527/0.1527

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.1855/ 0.1855

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 23 September 1999 Stream: Bear Creek

Sampled by: Alley, Mori, Heady, Peterson Sampling Site: 18a - Downstream of Hopkins Gulch

Water Temperatures and Times: ____________________

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#6 riffle 79'	47	47	11	11	7	7	1	1	4	4	1	1	.7304 57.7	.7304 57.7	.1646 13	.1646 13	0 0
#7 run 43'	29	29	2	2	7	7	3	3	2	2	1	1	.8953 38.5	.8953 38.5	.1395 6	.1395 6	0 0
#8 pool 125'	20	20	13	13	13	13	8	8	5	5	1	1	.3736 46.7	.3736 46.7	.2048 25.6	.2048 25.6	0 0
TOTALS:													142.9	142.9	44.6	44.6	0

Length of Stream Sampled: 247'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.5785/ 0.5785

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.1806/0.1806

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 23 September 1999 Stream: Bear Creek

Sampled by: Alley, Mori, Heady, Peterson Sampling Site: 18b Below Bear Creek Road Bridge & Deer Creek

Water Temperatures and Times: 15.5°C @ 1640 hr, 8 September 1999, air temp 22°C overcast & Thunderstorm

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#34													.9286	.9286	.1071	.1071	0
riffle 28'	21	21	3	3	5	5	0	0	0	0	0	0	26	26	3	3	0
#35													1.3141	1.3141	.3578	.3578	0
steprun 64'	51	51	15	15	20	20	5	5	8	8	2	2	84.1	84.1	22.9	22.9	0
#43													.6315	.6315	.2574	.2574	0
pool 108'	44	44	20	20	16	16	6	6	5	5	1	1	68.2	68.2	27.8	27.8	0
TOTALS:													178.3	178.3	53.7	53.7	0

Length of Stream Sampled: 200'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.8915/0.8915

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.2685/0.2685

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 24 September 1999 Stream: Kings Creek

Sampled by: Alley, Mori, Heady, Peterson Sampling Site: 19a - Above First Kings Creek Bridge Xing

Water Temperatures and Times: ______

Plot Length & Habitat		First Pass YOY/C-1		1+/C-2		Second Pass YOY/C-1		1+/C-2		Third Pass YOY/C-1		1+/C-2		Pop. Estimate YOY/C-1		1+/C-2/C-3		
#18 Run	48'	0 →												0	0	0	0	0
#19 pool	119'	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0
#20 riffle	29'	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0
21 pool	91'	0 →												0	0	0	0	0
22a run	86'	0 →												0	0	0	0	0
22b riffle	32'	0 →												0	0	0	0	0
pools	210'													0	0	.0048 1	.0048 1	0
riffles	61'													0	0	.0164 1	.0164 1	0
runs	134'													0	0	0	0	0

TOTALS: 0 0 2 2 0

Length of Stream Sampled: 405'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0/0

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.005/0.005

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 24 September 1999 Stream: Kings Creek

Sampled by: Alley, Mori, Heady Sampling Site: 19b Above Boy Scout Camp

Water Temperatures and Times:

Plot Length & Habitat	First Pass YOY	First Pass C-1	First Pass 1+	First Pass C-2	Second Pass YOY	Second Pass C-1	Second Pass 1+	Second Pass C-2	Third Pass YOY	Third Pass C-1	Third Pass 1+	Third Pass C-2	Pop. Estimate YOY	Pop. Estimate C-1	Pop. Estimate 1+	Pop. Estimate C-2	Pop. Estimate C-3
#21 Step-run 53'	9	9	6	6	3	3	1	1	0	0	0	0	.2264 12	.2264 12	.1321 7	.1321 7	0
#22 run 34'	10	10	1	1	4	4	0	0	1	1	1	1	.4676 15.9	.4676 15.9	.0588 2	.0588 2	0
#23 pool 38'	13	13	5	5	4	4	0	0	1	1	1	1	18.5	18.5	6.7	6.7	0
#24 pool 122'	15	15	15	15	6	6	1	1	6	6	0	0	33	33	16	16	0
pools 160'													.3219 51.5	.3219 51.5	.1419 22.7	.1419 22.7	0 0
TOTALS:													79.4	79.4	31.7	31.7	0

Length of Stream Sampled: 247'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.3214/0.3214

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.1283/0.1283

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 29 September 1999 Stream: Carbonera Creek

Sampled by: Alley, Mori, Heady Sampling Site: 20a Above Health Services Complex

Water Temperatures and Times:

Plot Length & Habitat		First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#29 Run	26'	1	1	0	0	0	0	0	0	0	0	0	0	1 (.0395)	1 (.0385)	0	0	0
#30 pool	65'	6	6	4	4	5	5	1	1	0	0	0	0	11	11	5	5	0
#31 riffle	9'	0 →												0	0	0	0	0
#32 pool	50'	8	7	2	3	1	1	1	1	0	0	0	0	9	8	3	4	0
#33 riffle	9'	0 →												0	0	0	0	0
pools	115'													20 (.1739)	19 (.1652)	8 (.0696)	9 (.0783)	0 (0)
riffles	18'													0	0	0	0	0
TOTALS:														21	20	8	9	0

Length of Stream Sampled: 159'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.1321/0.1258

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.0503/0.0566

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 30 September 1999 Stream: Carbonera Creek

Sampled by: Alley, Mori, Heady Sampling Site: 206 - Adjacent Beulah Park

Water Temperatures and Times:

Plot Length & Habitat	First Pass YOY	C-1	1+	C-2	Second Pass YOY	C-1	1+	C-2	Third Pass YOY	C-1	1+	C-2	Pop. Estimate YOY	C-1	1+	C-2	C-3
#1 pool 70'	9	9	9	9	8	8	3	3	3	3	0	0	20	20	12	12	0
#2 Step-run 117'	31	31	6	6	15	15	1	1	6	6	1	1	.4949 57.9	.4949 57.9	.0598 7	.0598 7	0
#5 pool 49'	9	9	5	5	5	5	2	2	5	5	1	1	19	19	8.6	8.6	0
#6 riffle 7'	1	1	0	0	0	0	0	0	0	0	0	0	.1429 1	.1929 1	0	0	0
pools 119'													.3277 39	.3277 39	.1731 20.6	.1731 206	0 0

TOTALS: 97.9 97.9 27.6 27.6 0

Length of Stream Sampled: 243'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.4029/0.4029

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.1136/0.1136

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 29 September 1999 Stream: Branciforte Creek

Sampled by: Alley, Hardy, Mori Sampling Site: 219 Below Granite Creek

Water Temperatures and Times: ______

Plot Length & Habitat		First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#50 pool	57'	11	11	4	4	4	4	3	3	1	1	1	1	16.8	16.8	10.4	10.4	0		
#51-54 pool	209'	40	40	18	18	17	17	5	5	16	16	5	5	73	73	28	28	0		
#55 riffle	21'	11	11	1	1	3	3	0	0	2	2	0	0	.7857 16.5	.7857 16.5	.0476 1	.0476 1	0 0		
#56 run	60'	11	11	1	1	6	6	0	0	0	0	0	0	.2833 17	.2833 17	.0167 1	.0167 1	0		
pools	266'													.3376 89.8	.3376 89.8	.1444 38.4	.1444 38.4	0 0		
TOTALS:														123.3	123.3	40.4	40.4	0		

Length of Stream Sampled: 347'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.3553/0.3553

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.1164/0.1164

D.W. ALLEY & Associates

Steelhead/Coho Salmon Sampling Form

Date: 29 September 1999 Stream: Branciforte Creek

Sampled by: Alley, Heady, Mori Sampling Site: 2Ib Above Granite Creek

Water Temperatures and Times: ____________________

Plot Length & Habitat	First Pass YOY/C-1		First Pass 1+/C-2		Second Pass YOY/C-1		Second Pass 1+/C-2		Third Pass YOY/C-1		Third Pass 1+/C-2		Pop. Estimate YOY/C-1		Pop. Estimate 1+/C-2/C-3		
#26 pool 85'	21	21	10	10	12	12	4	4	0	0	1	1	.3882 / 33	.3882 / 33	.1871 / 15.9	.1871 / 15.9	0 / 0
#27 riffle 27'	3	3	2	2	3	3	0	0	0	0	0	0	.2222 / 6	.2222 / 6	.0741 / 2	.0741 / 2	0
#28 run 32'	22	22	1	1	4	4	2	2	2	2	0	0	.875 / 28	.875 / 28	.0938 / 3	.0938 / 3	0 / 0
#30 ~~step~~ run 65'	16	16	7	7	6	6	0	0	2	2	0	0	.3892 / 25.3	.3892 / 25.3	.1077 / 7	.1077 / 7	0 / 0

TOTALS: 92.3 92.3 27.9 27.9 0

Length of Stream Sampled: 209'

Young-of-the-Year / Size Class 1 per Foot of Stream: 0.4416/0.4416

Yearlings and 2+ / Size Classes 2 & 3 per Foot of Stream: 0.1335/ 0.1335

D.W. ALLEY & Associates