D.W. ALLEY & Associates aquatic biology

2008 Juvenile Steelhead Densities in the San Lorenzo, Soquel, Aptos and Corralitos Watersheds, Santa Cruz County, California, With Trend Analysis of the San Lorenzo and Soquel Watersheds, 1997-2008

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REPORT SUMMARY

Scope of Work

In fall 2008, 4 Santa Cruz County watersheds were sampled for juvenile steelhead with the purpose of comparing habitat quality and juvenile densities with past results. Refer to maps in **Appendix A** that delineate reaches and sampling sites. The mainstem San Lorenzo River and 6 tributaries were sampled with a total of 17 sites. Seventeen half-mile segments were habitat typed to assess habitat conditions and select habitats of average quality to sample. Tributaries included Branciforte, Zayante, Lompico, Bean, Fall and Boulder and Bear creeks. Fall Creek was added at the request of the San Lorenzo Valley Water District. Seven steelhead sites were sampled below anadromy barriers in Soquel Creek and its branches. Eight half-mile segments were habitat typed, including between Girl Scout Falls I and II. NOAA Fisheries discontinued fall sampling between these falls. In the Aptos Creek watershed, 2 sites in Aptos Creek and 2 sites in Valencia Creek were sampled, and the 4 associated half-mile segments were habitat typed. In the Corralitos sub-watershed of the Pajaro River drainage, 4 sites were sampled in Corralitos Creek, 2 sites were sampled in Shingle Mill Gulch and 2 sites were sampled in Browns Valley Creek, along with 8 associated half-mile segments habitat typed.

Steelhead Life History

Most juvenile steelhead spend 1-2 years in freshwater before smolting and migrating to the ocean to reach sexual maturity. In the ocean they spend 1-2 years of rapid growth before returning as adults to their natal streams to spawn. When juveniles reach 75 mm Standard Length (SL) (Size Class II) by fall sampling time (~ 3 ½ inches total length) they are considered large enough to smolt the following late winter and spring. Unpublished, independent research has shown that many returning adult steelhead in some local streams reached smolt size their first growing season (**J. Smith, pers. comm.; E. Freund, pers. comm.**). Smith also found evidence of one-year smolts in 1978 in Uvas Creek after the drought of 1976-77 that had prevented adult access (**Smith and Li 1983**). Therefore, habitat conditions are very important in portions of watersheds that have the highest capacity to grow a percentage of YOY to Size Class II in their first growing season. These portions include the San Lorenzo River Lagoon, Aptos Lagoon, Soquel Lagoon, lower and middle (wet years only) mainstem of the San Lorenzo River and mainstem Soquel Creek. High baseflow in May−September increases the percentage of YOY reaching Size Class II. Enhanced production of Size Class II and III juveniles is necessary to increase adult returns because ocean survival increases exponentially with smolt size.

YOY emerge from the spawning gravels and spread (primarily downstream) throughout the watershed in spring and early summer. Since more adult steelhead spawning tends to occur in the upstream and tributary reaches of the watershed (barring passage difficulties), the highest initial YOY densities tend to be there. Therefore, it is likely that juveniles distribute mostly in a downstream direction where competition is reduced. High streamflows probably increase downstream dispersal, and it may be reduced in drier years. Once habitats have been selected, juveniles remain in the same habitats or in close proximity throughout the summer and fall. They distribute according to the quality of feeding habitat (fastwater with adequate depth) and/ or maintenance habitat (water depth and degree of escape cover as overhanging vegetation, undercut banks, surface turbulence, cracks under boulders and submerged wood). Habitat quality improves when less sand enters the stream (called sedimentation) from soil and streambank erosion because less sand input increases aquatic insect habitat. With less sand, embeddedness of larger cobbles and boulders is reduced to provide more cracks and crevices for insects to use. Less sand and embeddedness also provide better fish habitat with more escape cover for fish to hide under and by increasing water depth around scour objects (more escape cover).

Most Significant Findings in 2008 Compared to 2007

In All Watersheds:

- Larger stormflows came prior to March 1, with a late January peak flow of more than twice the bankfull flow. Large stormflows challenge overwintering juvenile survival but provide access for adult spawning.

- Virtually no stormflows occurred after March 1, allowing redd (nest) retention, good egg survival and good, young YOY survival after emergence from the gravel.

- There was a reduction in fastwater habitat and depth due to low summer stream flows. Loss of fastwater habitat and depth reduce habitat quality by causing less riffle habitat shallower riffles, and slower insect drift rate, resulting in reduced juvenile steelhead growth rate.

- YOY densities increased following a winter with larger stormflows early on and little rain after March 1, leading to low baseflows in May–September and slow YOY growth rate.

- Yearling densities decreased after a winter with stormflow that was more than twice bankfull on the mainstem San Lorenzo at Big Trees and similarly high in other watersheds.

- There was a continuing small proportion of young-of-the-year (YOY) steelhead growing into Size Class II after a spring of relatively low streamflow that slowed growth rate.

In the San Lorenzo River Watershed:

- *In the lower and middle mainstem* (Reaches 1, 2, 4, 6 and 8), there was a reduction in fastwater habitat and depth; this resulted in a significant loss of habitat quality where most juvenile steelhead utilize fastwater habitat to feed on drifting insects.

- *In the lower and middle mainstem* (Reaches 1, 2, 4, 6 and 8), overall habitat quality declined primarily due to shallower (and presumably slower) fastwater habitat caused by channel widening, continued low baseflow and less escape cover in fastwater (**Table 41**).

- *In the lower mainstem* (Reaches 1, 2 and 4) a potential passage impediment became reduced in Reach 2 at the beginning of the Rincon riffle (natural re-arrangement of boulders and reduced gradient).

- *In San Lorenzo tributaries*, of the 12 reaches monitored and compared between 2007 and 2008, 6 reaches were similar in habitat quality (3 in Zayante, 2 in Branciforte and 1 in Bear), 3 reaches had slight decline in habitat quality (2 in Boulder and 1 in Fall (compared to 2000)), 2 reaches had significant decline (2 in Bean) and one reach had slight improvement in habitat quality (Lompico) (**Table 41**). Slight declines were attributed to shallowing of habitat due to reduced streamflow. Scour was evident in pools in some reaches to offset the reduced streamflow. Substrate conditions remained similar in most reaches between years. Significant declines were due to reduced pool escape cover in middle Bean and dewatering in upper Bean Creek.

- YOY densities increased, with them being near or above average at 13 of 17 sites.

- The highest YOY site densities were found in Reaches 13c and 13d of Zayante Creek (highest in the watershed), Reach 17b in Creek middle Boulder and the lower mainstem in Reach 4 near the Henry Cowell Bridge entrance.

- Yearling densities decreased at 8 of 10 tributary sites, indicating poor overwinter survival. This decrease was statistically significant for sites in the San Lorenzo drainage.

- Site densities of important larger juveniles (smolt-sized, Size Class II/III and yearlings) were below average at all sites except one where YOY densities were high in 2007 and over-winter survival was high (upper Zayante #13d) and one where resident rainbow trout may be established (Fall #15).

- In Bean Creek, in the normally productive middle Reach 14b, overall habitat conditions declined with 27% less pool escape cover after human cutting of instream wood.

- Upper Bean Creek Reach 14c was dry by early September, likely causing mortality of hundreds of juvenile steelhead based on previous years' densities. A stranded adult female was observed in this reach prior to dewatering.

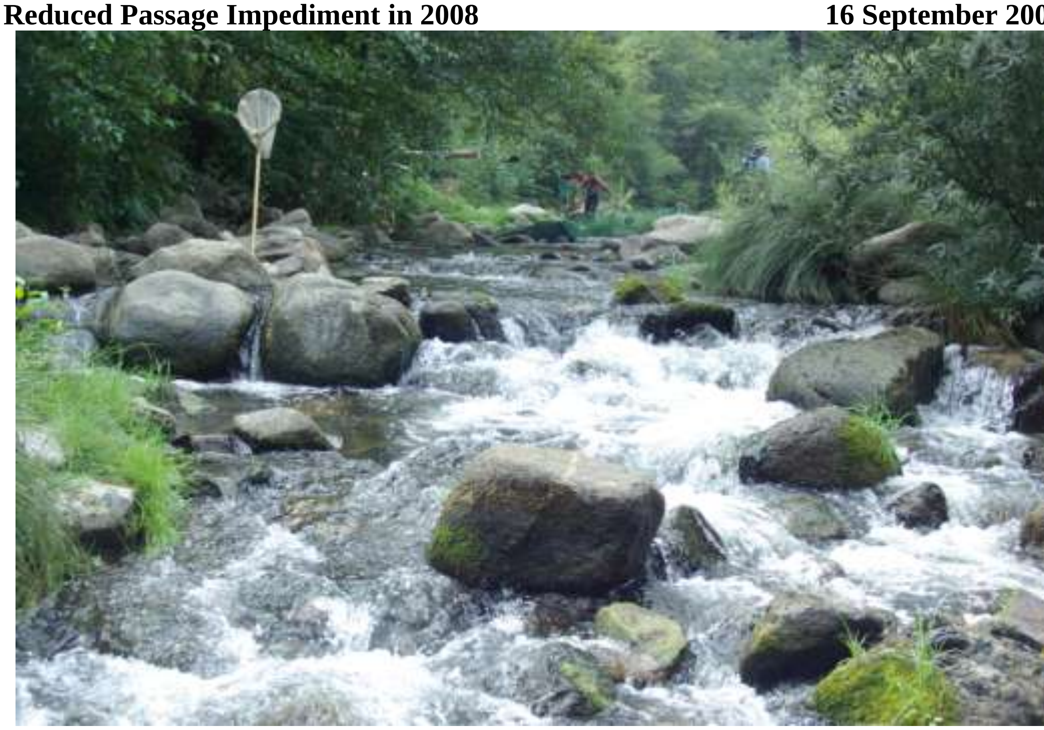
- An adult steelhead passage impediment was discovered on Fall Creek (large, downed redwood spanning the creek).

- In Lompico Creek a log cluster was discovered at a narrow slot created by a flashboard dam remnant with a concrete apron, likely created a partial adult migrational impediment.

Wide and Steep Rincon Riffle in the Lower Mainstem San Lorenzo River, Reach 2, Low-Flow Passage Impediment in 2002 11 June 2002

Wide and Steep Rincon Riffle in the Lower Mainstem San Lorenzo River, Reach 2, Low-Flow Passage Impediment in 2002 11 June 2002

Reduced Gradient Rincon Riffle in the Lower Mainstem San Lorenzo River− Reach 2
Reduced Passage Impediment in 2008 16 September 2008



Close-up of Rincon Riffle in the Lower Mainstem San Lorenzo River 16 September 2008

Large YOY Steelhead from the San Lorenzo River, Rincon Site 2 16 September 2008

<u>In the Soquel Creek Watershed:</u>

- Juvenile coho salmon were captured at the lower East Branch Site 13a, downstream of Mill Pond.

- The dry streambed in the SDSF reach on the upper East Branch expanded from 165 ft in 2007 to 301 ft in 2008, with streamflow at a trickle (estimated 0.01 cfs).

- Dry streambed was reported in the lower East Branch, downstream of the study segment, and baseflow in the West Branch was visually observed in August to be more than twice the baseflow in the East Branch at their confluences.

- *In the 4 mainstem reaches* analyzed, non-streamflow related habitat quality was similar in Reaches 1 and 7, with slightly deeper pools and similar escape cover, while Reaches 3 and 8 had lower habitat quality, with shallower pools, less escape cover, increased fines and increased embeddedness.

- *In the lower East Branch* below Mill Pond, habitat quality improved with deeper pools, similar streambed conditions and more pool escape cover.

- *In the upper East Branch* above Amaya Creek, habitat quality declined with step-run habitat converting to shallow pool habitat, with reduced pool depth and reduced pool escape cover.

- *In West Branch Soquel* below Hester Creek, habitat quality was similar to 2007 (slightly deeper pools but slightly less pool escape cover, shallower runs and similar substrate conditions).

- *In West Branch* Soquel between Girl Scout Falls I and II, habitat quality was similar to 2007 (slightly shallower average pool depth and run depth but similar pool escape cover and substrate conditions).

- Total and YOY densities increased at 6 of 7 sites, and YOY densities were above average at all sites except at the upper East Branch #16 in the SDSF (although YOY density at that site was much improved over 2007, a year with a very mild winter that may have been hindered adult access).

- Yearling densities declined at 6 of 7 sites, except in the lower East Branch where they remained low, indicating poor overwinter survival of yearlings and/or limited recruitment from YOY in 2007.

- Size Class II and III juvenile densities declined at 5 of 7 sites and were similar to 2007 at the other two.

- Size Class II and III densities were below average at 5 of 7 sites and near average at Mainstem Site # 1 and East Branch Site #16, with few YOY reaching Size Class II in the mainstem and lower East Branch due to low baseflow and reduced YOY growth rate.

- Retrieval of NOAA PIT-tagged juveniles included one YOY (age based on size) on 23 September at Site #10 in the mainstem above Moores Gulch and 4 juveniles captured on 24 September at Site #16 in the SDSF above Long Ridge Road crossing (likely 1 YOY and 3 small yearlings based on size).

<u>In the Aptos Creek Watershed:</u>

- Habitat conditions continued to improve in 3 of 4 studied reaches, with the exception of lower Reach 2 in Valencia Creek. The observed reduction in baseflow had shallowed pools, runs and riffles. But this was offset by increased pool escape cover in 3 of 4 reaches.

- YOY densities increased at upper sites in Aptos and Valencia creeks and were lower or similar at lower sites, indicating more spawning effort and success higher in the watershed, with YOY densities above average at all 4 sites.

- Size Class II and III juvenile densities and yearling densities declined at 3 of 4 sites and below average at 3 of 4 sites, the exception being upper Valencia Site #3.

- *In Aptos Creek* the fewer large juveniles may have occurred due to fewer YOY reaching Size Class II at the lower site and reduced overwinter survival of yearlings. At the upper Aptos site there were few YOY in 2007 to be recruited into the yearling age class.

- *In lower Valencia Creek*, major sedimentation was observed in 400 feet of channel below the confluence of the East Branch, downstream of Valencia Road Bridge.

- *In lower Valencia Creek*, poorer overwinter survival of yearlings and low densities of YOY the previous year could help explain fewer larger juveniles.

- *In upper Valencia Creek*, that had once been upstream of two man-made passage barriers, may have maintained a 2008 density of larger juveniles greater than in 2007 and above average because overwinter survival may have been better with the high frequency of instream wood and a resident rainbow component of larger fish that remained in the stream.

In the Corralitos Creek Sub-Watershed:

- Total juvenile densities were close to average at all sites except above average at the lower most Corralitos site and below average at the uppermost Browns Valley site.

- YOY densities increased at 5 sites, were similar at two middle Corralitos sites and were less at the upper Browns Valley site.

- YOY densities were near average at 4 sites, above average at the lowermost Corralitos site and below average at both Browns Valley sites.

- Size Class II and III densities declined at 5 of 8 sites, were similar at 2 sites in lower and middle Corralitos Creek, and increased only at the upper uppermost Corralitos site.

- Size Class II and III densities were below average at all sites, but very close to average at the lowermost Corralitos site and the uppermost Browns Valley site.

- Size Class II and III densities declined because of poorer overwinter survival of yearlings and no YOY reaching Size Class II the first summer, as had occurred in lower Corralitos sites in 2006. Four of the 5 monitoring years have been after mild winters.

- Reach 1 below the diversion dam on Corralitos Creek had higher than usual bypass flows in summer and fall, while the fish ladder was being replaced. This improved rearing habitat conditions by deepening habitat and creating faster water velocities, greater surface turbulence and more insect drift. In addition to flow augmentation, pool escape cover had improved, though fines increased in pools and riffle embeddedness increased.

- Rearing habitat quality declined in the remaining 3 Corralitos reaches with reduced pool depth (step-run converting to shallow pool in the uppermost Reach 7), likely reduced insect drift in all reaches from reduced baseflow, pool escape cover declining with more fines and higher embeddedness in the reach below Rider Creek and non-flow related parameters remaining similar to 2007 in the two upstream reaches.

- Rearing habitat quality in Shingle Mill Gulch was similar between years. Pool depths declined somewhat but pool escape cover increased slightly.

- Rearing habitat quality improved in lower Browns Valley Creek, downstream of Redwood Canyon Creek, due to increased habitat depth despite presumably reduced baseflow, along with increased pool escape cover.

Habitat at sampling sites in the four watersheds was rated, based on smolt-sized (=>75 mm SL) juvenile steelhead density and average smolt size according to the rating scheme developed by

Smith (**1982**). This rating scheme assumed that rearing habitat was usually near saturation with smolt-sized juveniles, at least in tributaries where 2 years are usually required to reach smolt size, and also assumed that spawning rarely limited juvenile steelhead abundance, except at sites with very poor spawning habitat and/or that are dependent upon fry movement from upstream tributaries. These assumptions may not have been met in 2008 in the lower two mainstem reaches of the San Lorenzo River (Reaches 1 and 2), where YOY densities were about average for these reaches but much lower than in Reach 4 below the Zayante Creek confluence. In particular, low stream flows may have reduced YOY movement from tributaries to the mainstem, though YOY densities were much above average below the mouth of Zayante Creek. Streamflows were too low to grow many YOY in the lower and middle mainstem San Lorenzo to smolt size in 2008. Lower Aptos and all Corralitos sites were probably below carrying capacity for larger juveniles for the same reasons of fewer yearling holdovers and slow YOY growth that prevented most of them from reaching Size Class II.

Refer to the next summary table for smolt-sized juvenile densities and ratings. Figures 3, 6, 9 and 12 have been excerpted from the main report to compare 2008 smolt densities to averages calculated from all monitoring years of data.

2008 Sampling Sites Rated by Smolt-Sized Juvenile Density (=>75 mm SL) and Average Smolt Size, with Physical Habitat Change since 2007. (Red denotes rating of poor, very poor or dry.)

Site	Multi-Year Avg. Density (Size Class II and III/100 ft)	2008 Smolt Density (per 100 ft)/ Avg Smolt Size (mm)	2008 Smolt Rating	Numerical Rating (1 to 7)	Physical Habitat Change by Reach Since 2007
Low. San Lorenzo #1	11.4 (n=8)	4.9/ 91 mm	Below Average	***	Negative
Low. San Lorenzo #2	18.5 (n=7)	12.2/ 88 mm	Below Average	***	Negative
Low. San Lorenzo #4	18.2 (n=8)	13.2/ 82 mm	Below Average	***	Negative
Mid. San Lorenzo #6	**4.7 (n=11)**	**2.2/ 82 mm**	**Very Poor**	*	**Negative**
Mid. San Lorenzo #8	**7.2 (n=11)**	**3.6/ 87 mm**	**Very Poor**	*	**Negative**
Up. San Lorenzo #11	**7.2 (n=11)**	**2.8/ 98 mm**	**Poor**	**	**Slight Neg.**
Zayante #13a	10.4 (n=10)	6.3/ 92 mm	Below Average	***	Similar
Zayante #13c	11.9 (n=10)	4.4/ 98 mm	Below Average	***	Similar
Zayante #13d	18.2 (n=10)	22.5/ 89 mm	Good	*****	Similar
Lompico #13e	7.8 (n=3)	6.4/ 89 mm	Below Average	***	Positive
Bean #14b	13.9 (n=11)	4.7/ 117 mm	Fair	****	Negative
Bean #14c	**13.0 (n=9)**	**Dry**	**-**		**Negative**
Fall #15	13.8 (n=6)	15.8/ 107 mm	Good	*****	Slight Negative (Since 2000)
Boulder #17a	12.0 (n=11)	7.2/ 112 mm	Fair	****	Slight Negative
Boulder #17b	**10.3 (n=11)**	**3.8/ 102 mm**	**Poor**	**	**Slight Neg.**
Bear #18a	12.1 (n=11)	5.1/ 105 mm	Fair	****	Similar
Branciforte #21a-1	**2.2 (n=2)**	0.5/ 133 mm	Very Poor	*	**Similar**
Branciforte #21a-2	6.0 (n=8)	5.7/ 105 mm	Fair	****	Similar
Soquel #1	**3.8 (n=11)**	**3.8/ 96 mm**	**Poor**	**	**Slight Neg.**
Soquel #4	10.3 (n=12)	4.9/ 98 mm	Below Average	***	Negative
Soquel #10	**8.9 (n=12)**	**3.1/ 92 mm**	**Poor**	**	**Similar**
Soquel #12	**8.0 (n=11)**	**1.5/ 82 mm**	**Very Poor**	*	**Similar**
E. Branch Soquel #13a	**9.0 (n=12)**	**4.0/ 99 mm**	**Poor**	**	**Positive**
East Branch Soquel #16	9.8 (n=12)	10.0/ 100 mm	Fair	****	Negative
West Branch Soquel #19	**4.0 (n=8)**	**5.7/ 82 mm**	**Poor**	**	**Negative**
West Branch Soquel #21	10.5 (n=7)	-	-		Similar
Aptos #3	11.7 (n=4)	6.0/ 93 mm	Below Average	***	Positive
Aptos #4	9.9 (n=4)	5.5/ 112 mm	Fair	****	Positive
Valencia #2	11.9 (n=4)	11.0/ 92 mm	Fair	****	Similar
Valencia #3	12.7 (n=4)	14.0/ 93 mm	Fair	****	Positive
Corralitos #0	8.9 (n=2)	8.7/ 105 mm	Good	*****	Positive
Corralitos #3	10.5 (n=5)	8.3/ 104 mm	Good	*****	Slight Negative
Corralitos #8	13.8 (n=5)	9.4/ 95 mm	Fair	****	Similar
Corralitos #9	21.9 (n=5)	17.1/ 100 mm	Good	*****	Slight Positive
Shingle Mill #1	13.9 (n=5)	5.6/ 98 mm	Below Average	***	Similar
Shingle Mill #3	**3.7 (n=5)**	**0.7/ 83 mm**	**Very Poor**	*	**Slight Positive**
Browns Valley #1	17.7 (n=5)	11.5/ 102 mm	Fair	****	Positive
Browns Valley #2	14.2 (n=5)	12.6/ 103 mm	Good	*****	Similar

Figure 2. Juvenile Steelhead Site Densities for Young-of-the-Year in the San Lorenzo River in 2008 Compared to the 10-Year Average. (8the year for Mainstem (1), 7th year for Mainstem (2a), 3rd year for Lompico (13e) and 2nd Year for Branciforte (21a-1).

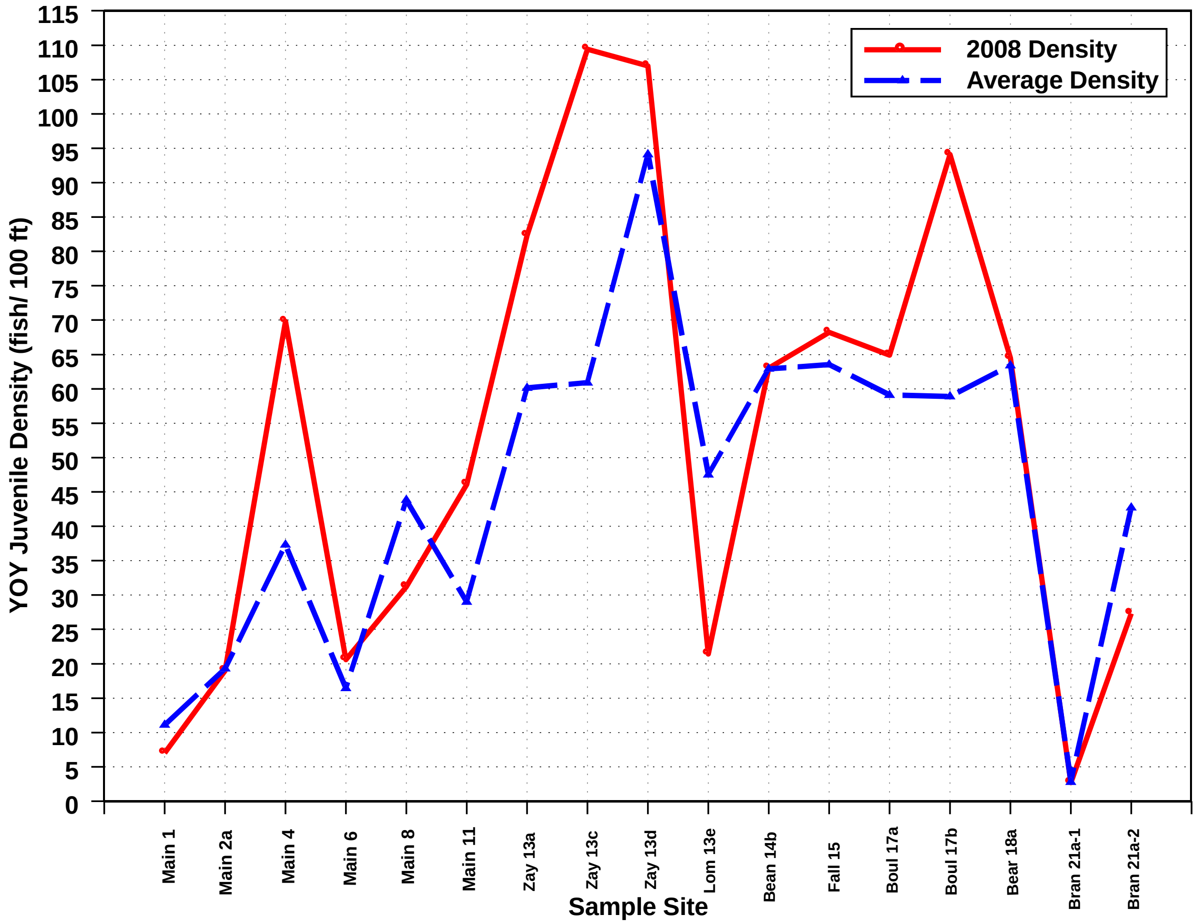


Figure 3. Juvenile Steelhead Site Densities for Size Classes II and III in the San Lorenzo River in 2008 Compared to the 10-Year Average. (8th year for Mainstem (1), 7th year for Mainstem (2a), 3rd Year for Lompico (13e) and 2nd Year for Branciforte (21a-1).

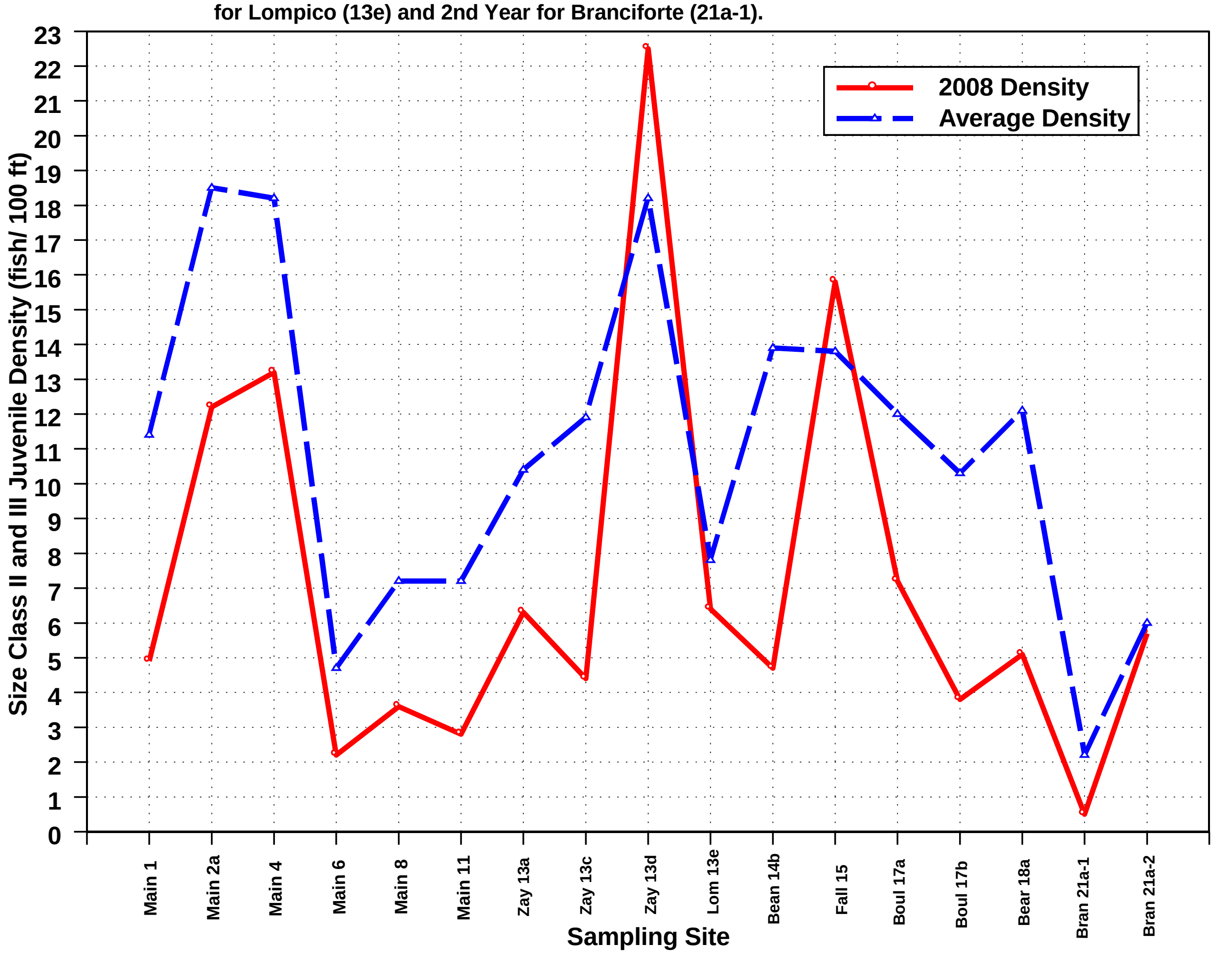


Figure 5. Juvenile Steelhead Site Densities for Young-of-the-Year in Soquel Creek in 2008 Compared to the 12-Year Average (8th Year West Branch (19)).

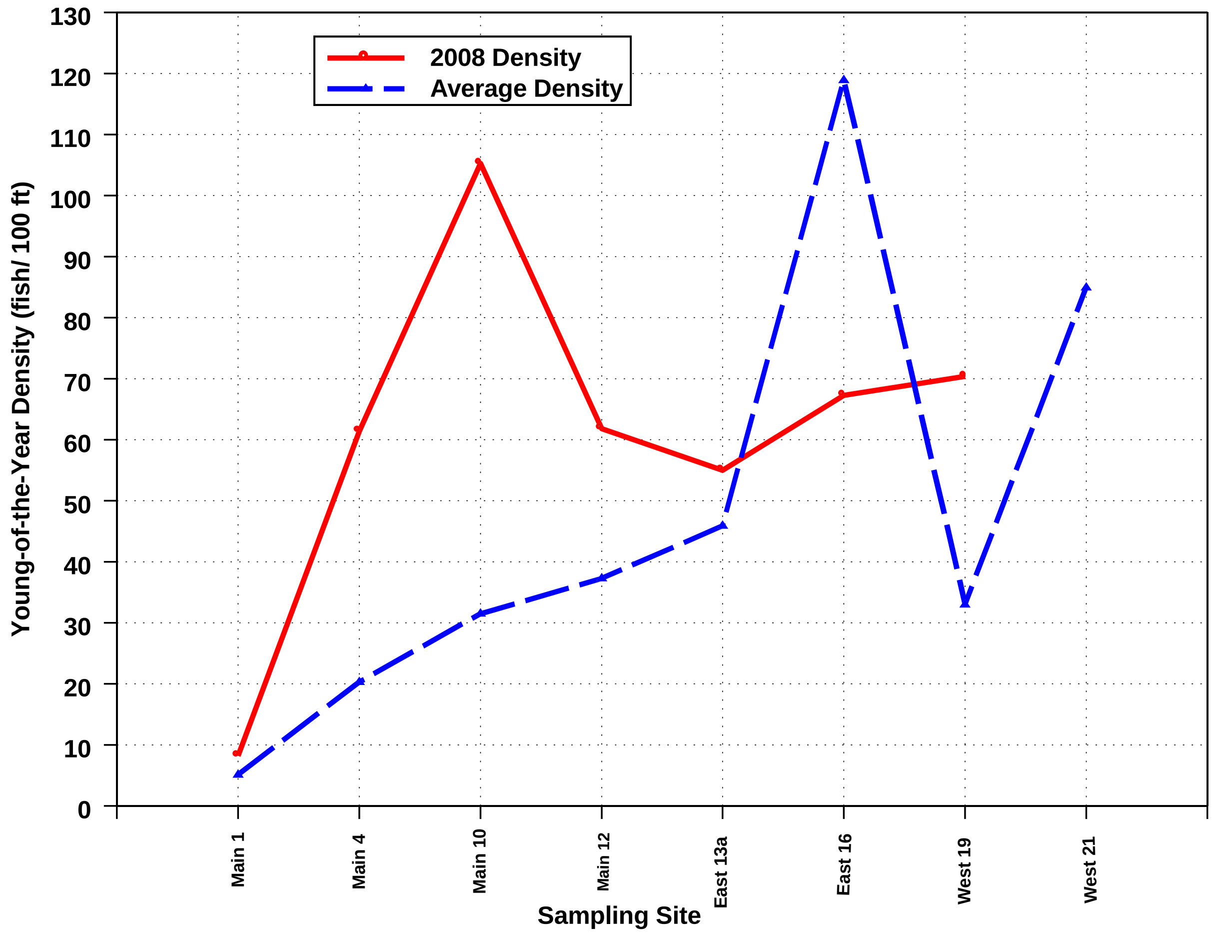


Figure 6. Juvenile Steelhead Site Densities for Size Classes II and III in Soquel Creek in 2008 Compared to the 12-Year Average Density (8th Year West Branch (19)).

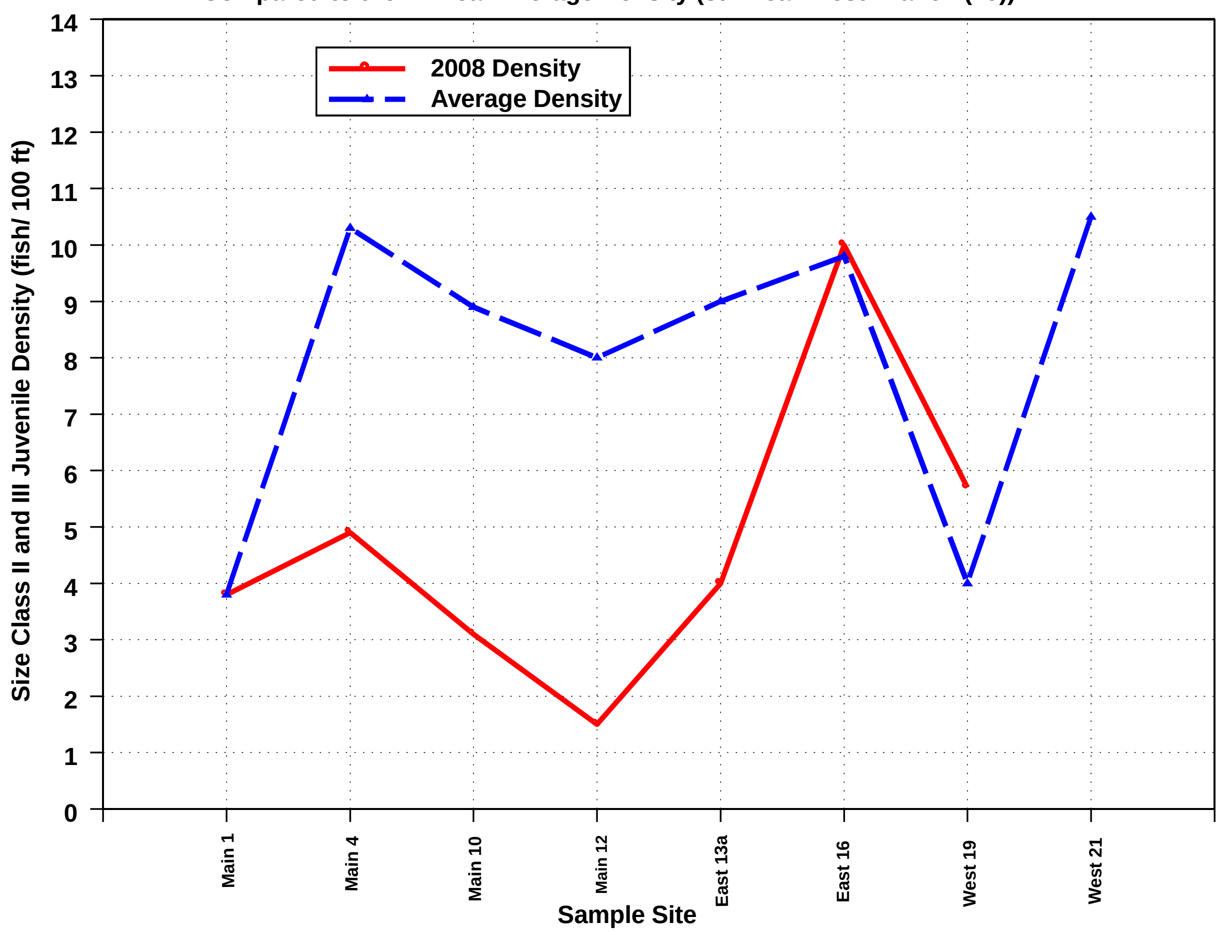


Figure 8. Juvenile Steelhead Site Densities for Young-of-the-Year in Aptos and Valencia Creeks in 2007, 2008 and the Average, Including 1981 and 2006.

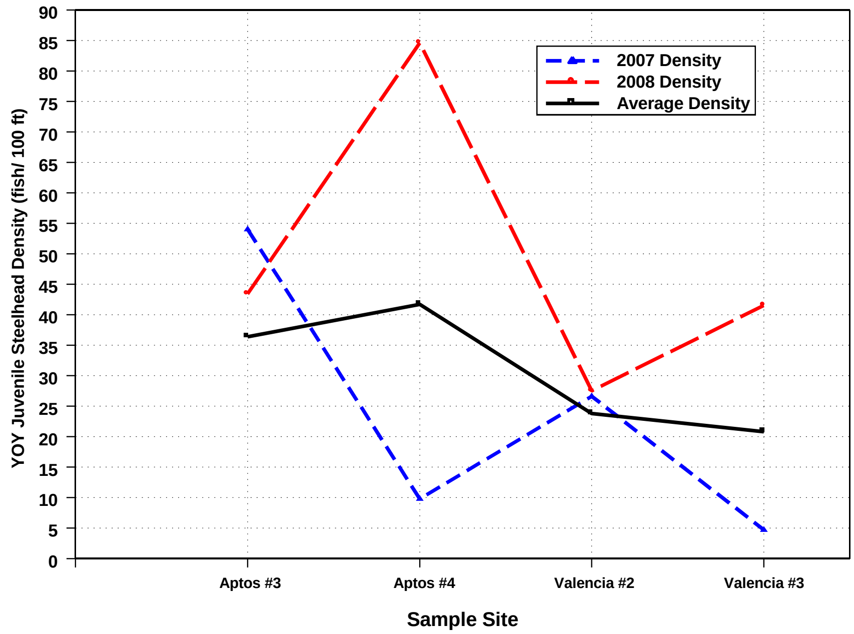


Figure 9. Juvenile Steelhead Densities for Size Classes II and III in Aptos and Valencia Creeks in 2007, 2008 and the Average, Including 1981 and 2006.

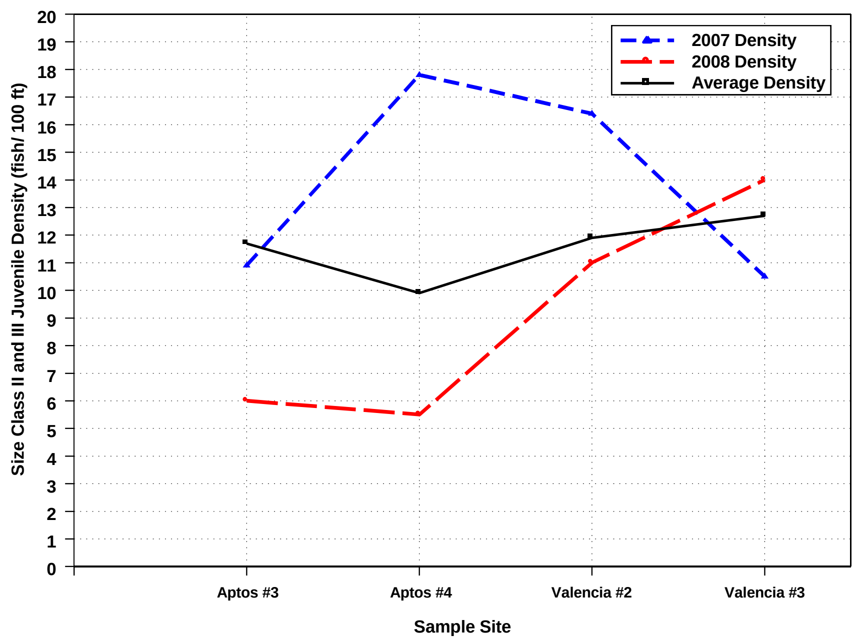


Figure 11. Juvenile Steelhead Densities for Young-of-the-Year in Corralitos, Shingle Mill and Browns Valley Creeks in 2007, 2008 and the Average, Including 1981, 1994 and 2006.

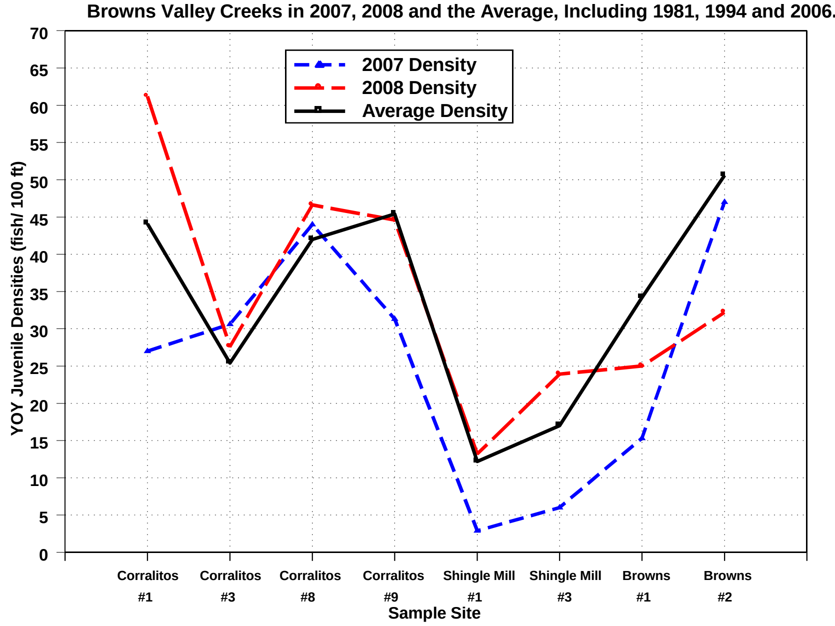
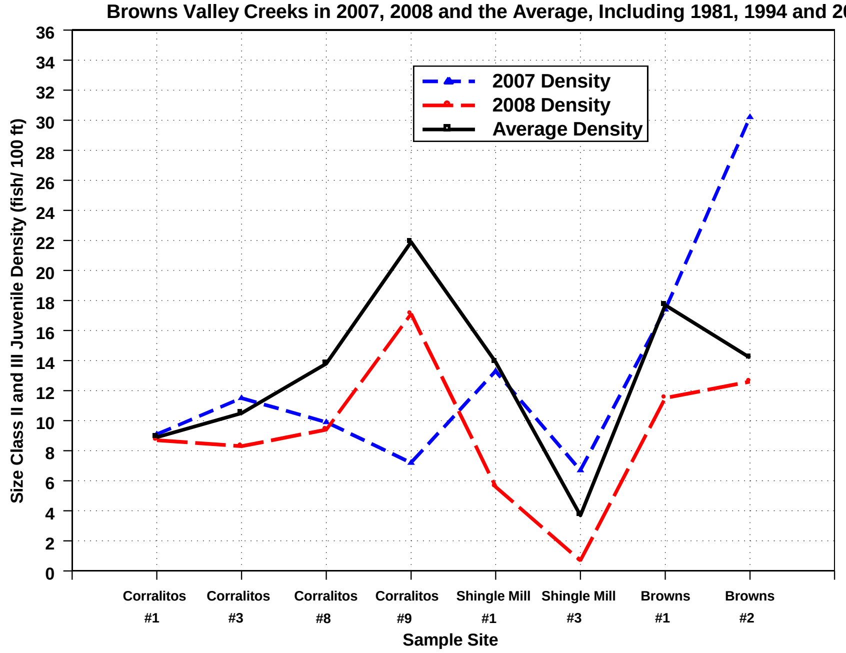


Figure 12. Juvenile Steelhead Densities for Size Classes II and III in Corralitos, Shingle Mill and Browns Valley Creeks in 2007, 2008 and the Average, Including 1981, 1994 and 2006.



Trends of Juvenile Densities and Habitat in the Lower and Middle Mainstem San Lorenzo River

The lower and middle mainstem have become less important in producing juvenile steelhead in both the YOY age class and the Size Class II and III categories from 2000 onward but showed substantial YOY density improvement in 2008 at Site 4 below the Zayante Creek confluence. Total juveniles (most of which were YOY juveniles) increased in 2002 after a winter that had larger storms early in the winter and smaller ones afterwards. 2008 was a similar year with even fewer storms after March 1. The years 1998 and 2006 had similarly wet winters prior to fall sampling. However, 1998 juvenile densities were substantially higher than in 2006. Conditions in 1998 that were better than in 2006 in both the lower and middle mainstem (depicted for Reaches 4 and 8, respectively) included greater depth in fastwater habitat (riffles), higher water velocity (and likely greater insect drift) due to higher streamflow and more escape cover in fastwater habitat in the middle mainstem Reach 8. However, 2006 had better riffle habitat in the lower mainstem Reach 4, such as greater escape cover (more overhanging willows) and less percent fines. In Reach 8 the estimated percent fines in 1998 and 2006 were the same.

Densities of Size Class II and III juvenile in the lower and middle mainstem were higher in the years 1997−1999 than later years, with relatively low densities from 2000 until 2008, with 2007 having the lowest densities measured in the last 12 years (**Figure 17**).

<u>**Lower Mainstem Reach 4.**</u> Rearing habitat conditions in fastwater riffle habitat in Reach 4 in 2008 have improved since 1999 regarding more escape cover (declined since 2007) (**Figure 28**) and reduced percent fines (embeddedness similar (**Alley 2000**)) (**Figure 29**). However, 1999 riffle conditions were better with regard to greater habitat depth compared to 2008, as were all other years deeper than 2008, partially because of the low baseflows in late summer 2008 (**Figure 27**). If baseflows had been the same in 1997 and 2008, habitat conditions in Reach 4 riffles may have been similar between years for percent fines and escape cover, but riffles would have been considerably deeper in valuable pockets of maximum depth in 1997. It appeared that the arrangement and composition of boulders and sediment in riffles shifted during the high stormflow of February 1998 (19,400 cfs at Big Trees gage), resulting in fewer deep pockets.

<u>**Middle Mainstem Reach 8.**</u> Rearing habitat conditions in fastwater habitat in Reach 8 in 2008 have improved since 1999 regarding less percent fines and reduced embeddedness (43% in 1999 (**Alley 2000**) and 30% in 2008) (declined since 2007) (**Table 8 and Figure 32**). However, 1999 riffle conditions were better with regard to more escape cover (**Figure 31**) and greater habitat depth compared to 2008, as were all other years deeper than 2008, primarily because of the low baseflows in late summer 2008 (**Figure 30**). If baseflows had been the same in 1997 and 2008, habitat conditions in Reach 8 riffles may have been similar between years with regard to percent fines and embeddedness, but in 1997 the riffles would have been deeper with important deeper maximum depth pockets, as was the case in Reach 4 riffles. 1997 riffles also had much more escape cover.

Figure 13. Plot of Annual Total Juvenile Densities at San Lorenzo Mainstem Sites, 1997-2008.

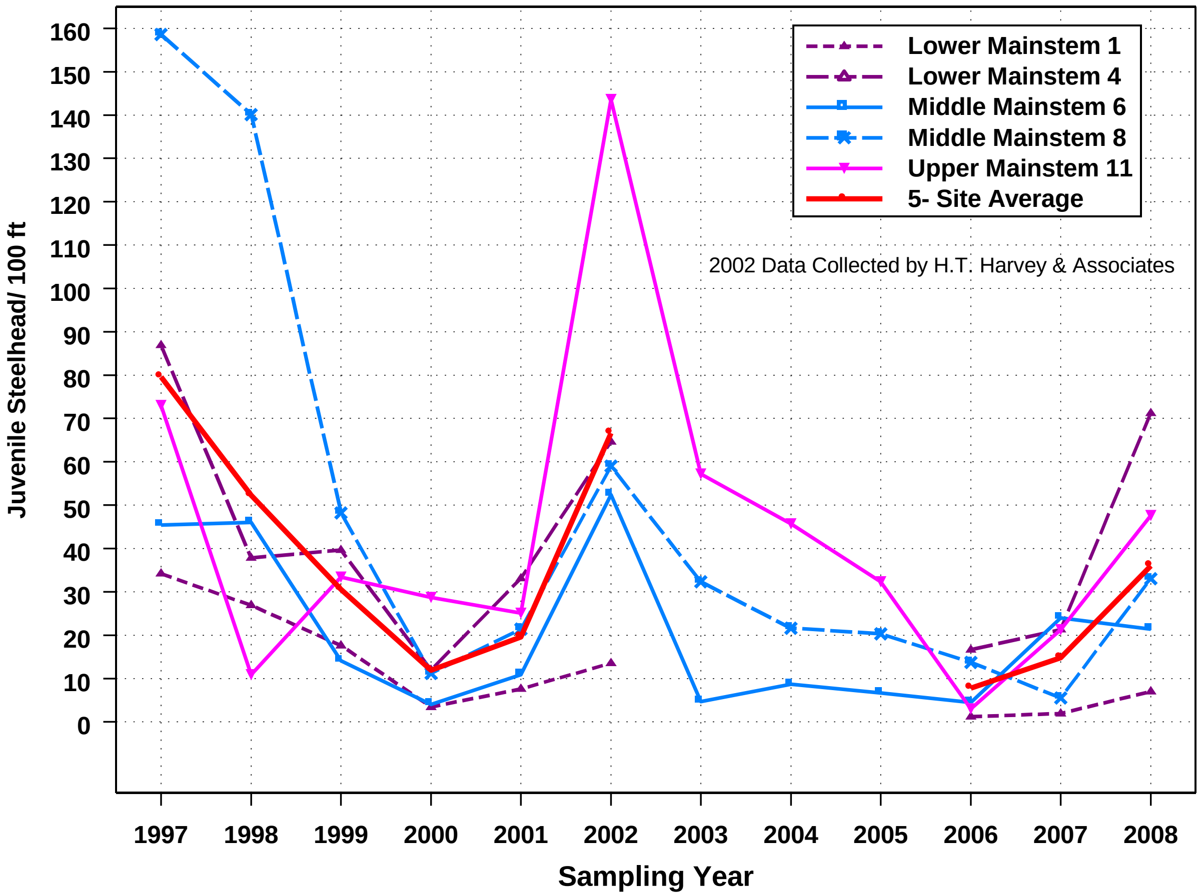


Figure 15. Plot of Annual YOY Juvenile Densities at San Lorenzo Mainstem Sites, 1997-2008.

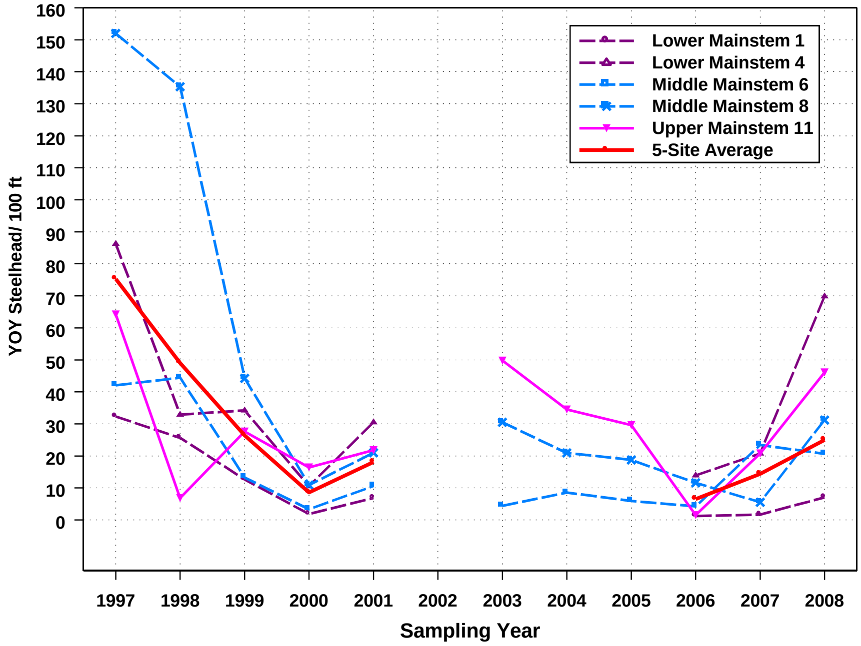
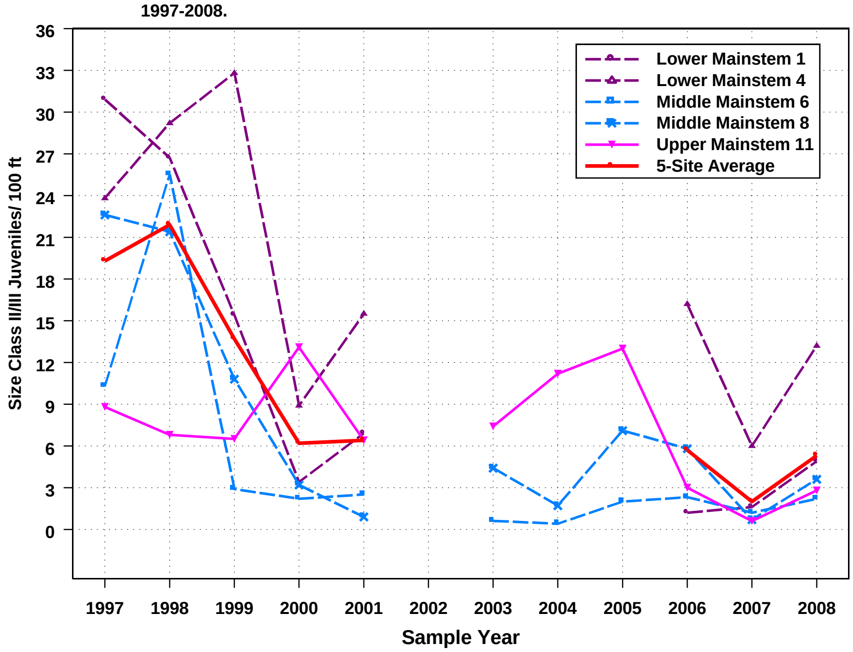


Figure 17. Scatter Plot of Annual Size Class II/ III Juvenile Densities at San Lorenzo Mainstem Sites, 1997-2008.



Recommendations. In order for adult returns to increase substantially, the mainstem will need to again support at least the densities of Size Class II and III juveniles that were present in 1997−99, though 1998 and 1999 were wet years when a higher proportion of YOY reached larger size classes. Habitat quality will need to improve substantially in the lower and middle mainstem to increase adult returns. Retention of more large, instream wood in the lower and middle mainstem will promote scour to deepen pools, create patches of coarser spawning gravel and provide escape cover for juvenile steelhead rearing and overwinter survival. Better retention of winter storm runoff in Scotts Valley and Felton will reduce stormflow flashiness that increases streambank erosion and sedimentation leading to poor spawning and rearing conditions in the mainstem. Better retention of storm runoff will also increase winter recharge of aquifers to increase spring and summer baseflow, which will increase YOY steelhead growth into Size Classes II and III in the lower mainstem.

Trend Analysis of Juvenile Densities and Habitat for San Lorenzo Tributaries

For tributary sites and the upper mainstem (above the Boulder Creek confluence as represented by Reach 11), there was a general decline in total densities from 1997 to 2000, with a general increase from 2000 to 2003, followed by a general decline from 2003 to 2007 and a rebound in 2008 (**Figures 13 and 14**). The extremely high juvenile density measured in 2002 at Site 11 by HTH (**2003**) seemed highly unusual, considering our 14 other years of sampling experience with Reach 11 in the upper mainstem. In 2007 and 2008, total densities bounced back up in Zayante Creek. In 2008, total densities at wetted sites in Bean and Bear creeks also rebounded. Reach 14c went dry in Bean Creek. Since most juveniles were YOY, their densities followed the same trend (**Figures 15 and 16**).

Tributary densities of Size Class II and III (smolt size) showed no general trend, though as a group they were relatively low in 2007−2008 (**Figures 17 and 18**). Years that had overall low tributary site densities of larger juveniles were 2001, 2004, 2007 and 2008, all of which had relatively low averaged mean monthly streamflow for May−September over the last 12 years and below the median daily flow for the years of record (**Figures 25, 58, 62, 65 and 66**). After wetter winters, densities of larger juveniles generally increased, as occurred in 1998, 1999, 2003, 2005 and 2006. Densities were similar between 1997 and 1998 but generally increased in 1999 to a 12-year high, particularly in Zayante, upper Boulder and Bear creeks. In 1999, the winter had only 1 peak flow that was near bankfull in early February and continued to rain through April for a relatively wet winter but without creating bankfull flow intensity (**Figure 56**). Spring and summer baseflow in 1999 was above the median (**Figure 25**). Then in 2000 there was a general decline in tributary densities except in Bear Creek, despite the above median baseflow. The year 2001 showed mixed changes in densities of larger juveniles, with some sites increasing in density and others declining. Comparable data for the San Lorenzo system for 2002 are unavailable. However, if trends were similar to Soquel Creek in that year (**Figures 23 and 24**), densities of larger juveniles were likely similar to 2001 in San Lorenzo tributaries. Densities of these larger juveniles declined at all sites under consideration in the drier years of 2007 and 2008 except for upper Zayante Creek #13d, which increased in 2008 to the highest in the watershed.

In analyzing habitat change in an important eastern tributary reach, it was noted that rearing habitat conditions had declined in Zayante Reach 13d from 1997 to 2007 and 2008, judging by the shallowest pool depths in the 12-year period in 2007 (**Figure 33**) (where annual differences in fall baseflow have limited effect on pool depth) and the relatively low pool escape cover in 2007 and 2008 for the reach (**Figure 34a**). The percent fines went back up in step-runs to 30% in 2008 after being at a 12-year low in 2007 of 13% (**Figure 35**).

In analyzing habitat change in an important western tributary reach, it was noted that overall rearing habitat quality in Boulder Reach 17a has declined from 1997 to 2008 due to reach-wide pool filling (**Figure 36**) and reduced pool escape cover (**Figure 37a**), although a positive change was reduced fines in step-runs/ runs (**Figure 38**).

Figure 14. Plot of Annual Total Juvenile Densities at San Lorenzo Tributary Sites, 1997-2008.

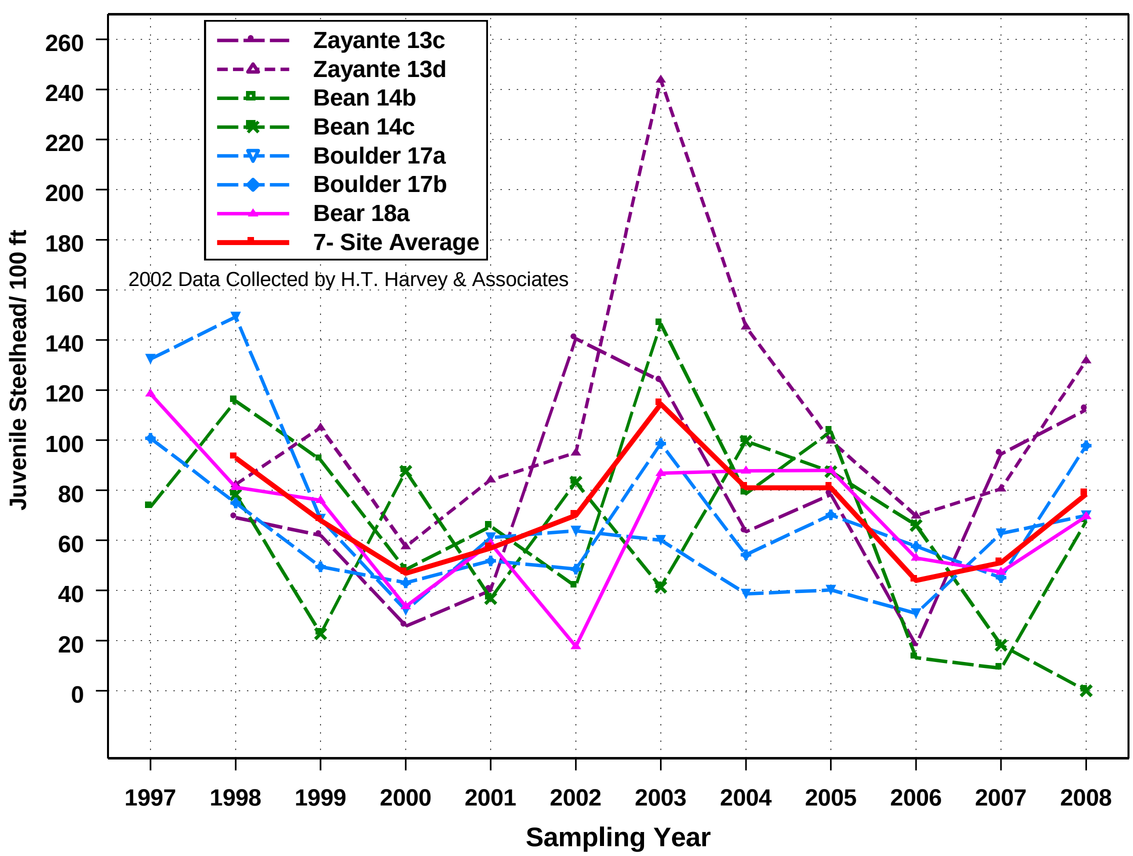


Figure 16. Plot of Annual YOY Juvenile Densities at San Lorenzo Tributary Sites, 1997-2008.

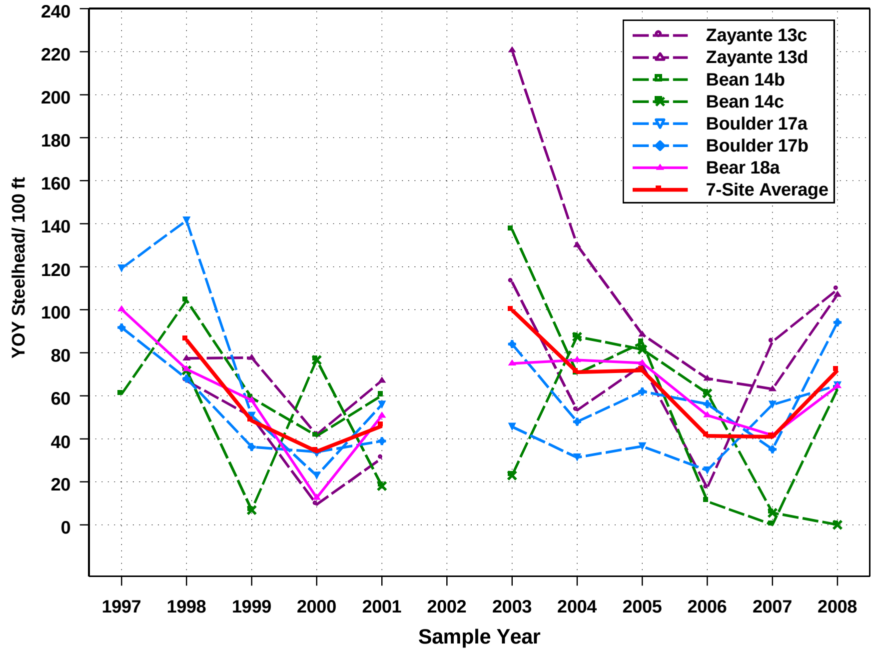
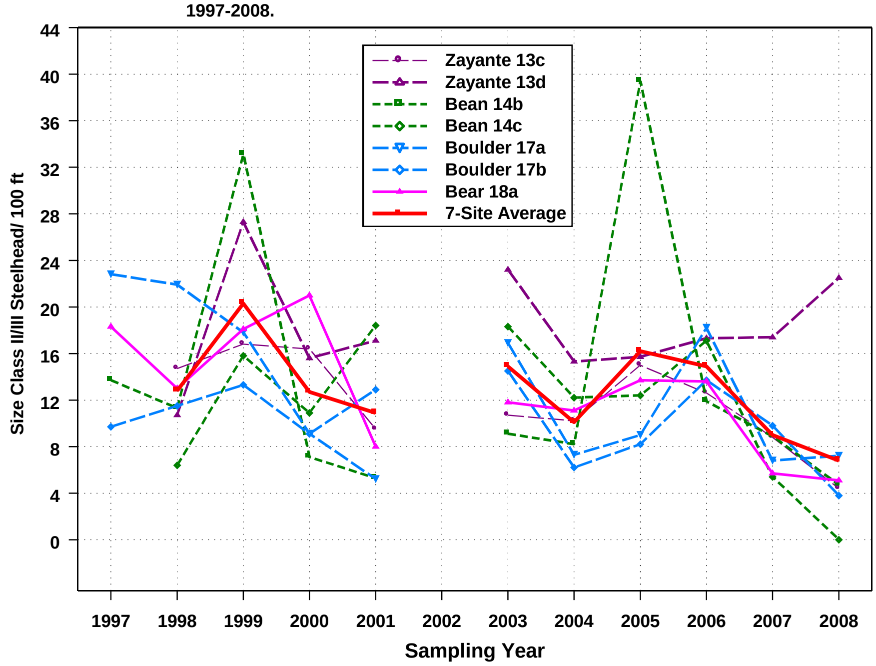


Figure 18. Plot of Annual Size Class II/ III Juvenile Densities at San Lorenzo Tributary Sites, 1997-2008.



Trend Analysis of Juvenile Densities and Habitat for Mainstem Soquel Creek

At the 4 mainstem sites tracked for the past 12 years, annual trends in total and YOY juvenile densities paralleled each other, for the most part (**Figures 19 and 21**). Relatively higher YOY and total densities occurred in 1997, 2002, 2004, 2007 and 2008. Because the juvenile population in the mainstem is largely YOY, spawning effort, spawning success and survival of recently emerged YOY largely dictate total juvenile densities in these reaches. In drier years with milder winter stormflows (or mostly early stormflows and few late stormflows) and reduced baseflow, total and YOY juvenile steelhead densities were relatively higher in the Soquel Creek mainstem than in wetter years (**Tables 19, 21 and 26**). The years of highest YOY and total juvenile density corresponded to years with the lowest averaged mean monthly streamflow (May–September), indicating that drier years or at least years with few late winter and spring storms (**Figure 26**). These are also typically the years when the lagoon population of juveniles is the greatest (**Alley 2009**). This inverse relationship may be explained by reasoning that during milder winters, adult spawners probably have poorer access to the upper watershed's East and West Branches, having more shallow riffles and other impediments to pass. Thus, they expend more spawning effort in the mainstem. Also, in drier years, survival of eggs and emerging YOY may be increased without substantial late stormflows to scour or smother redds and wash away YOY. Our spawning gravel study (**Alley 2003c**), which involved streambed coring and particle size analysis, indicated that spawning gravel conditions in the mainstem were reasonably good in 2002, a year that was likely without large bankfull stormflows that would move considerable sediment. The exception to this inverse relationship was 2001, when YOY and total juvenile densities were relatively low despite the mild winter (except for the uppermost mainstem site with densities all increasing from 2000 to 2001).

The density pattern of larger Size Class II and III juveniles in relation to baseflow is more complex than for YOY in the Soquel mainstem. In wetter years, there may be less spawning effort and spawning success in the mainstem until late in the spawning season. However, the above median daily baseflow results in faster water velocity, increased insect drift and deeper feeding stations in fastwater habitat, at least in the spring. All of these factors promoted faster growth rate, leading to a higher proportion of YOY reaching Size Class II their first year and higher densities of larger juveniles.

There can be wet years with associated high baseflow, relatively low YOY densities, yet relatively high Size Class II densities. The wet years of 1998 and 2005 are in this category (**Figures 23 and 26**). However, 2006 was very wet but did not generate high Size Class II and III densities. This was likely because YOY densities were so low in the mainstem (many large storms occurred in April and May to destroy mainstem steelhead redds, and spawning access to the upper watershed was good even in late spring), that faster growth rate could not make up for the fewer YOY juveniles in the mainstem (**Figure 78**).

The other year having especially high densities of larger juveniles in the mainstem was 1997, which had large storms before 1 February to boost the baseflow and virtually nothing after that. Very stable conditions for spawning and YOY emergence were created. That year had high YOY densities, and a high proportion reached Size Class II, presumably because spawning effort and success were likely high in early February. This would allow early emergence and early spring growth despite the lower baseflow later on.

Since 1997, rearing habitat quality in the lower mainstem (as indicated by Reach 1) has improved with regard to increased average maximum pool depth and has declined with regard to reduced escape cover (**Figures 39 and 40a**). During the instream wood survey in 2002, this reach was noted for its lack of large wood (**Alley 2003c**). However, riffle conditions for aquatic insects and steelhead food supply have improved regarding less embeddedness (**Figure 41**). In the lower mainstem, densities of larger juveniles were not well associated with rearing habitat conditions. Spring and summer baseflow and associated growth rate of YOY appeared to overshadow non-flow related habitat conditions to determine densities of larger juveniles. This was partly a result of extremely low yearling densities in the mainstem. After the two winters with the lowest peak flows since sampling began, 1994 (900 cfs) and 2007 (614 cfs), slightly higher densities of yearlings were detected at some mainstem sites compared to other years. This may indicate that if more overwintering shelter was present (in the form of large instream wood), survival of yearlings might increase in the mainstem of Soquel Creek (**Alley 1995a; 2008**).

In the upper mainstem (upstream of the Moores Gulch confluence in Reach 7), densities of larger juveniles (Size Class II and III) (**Figure 23**) were not associated with reach-wide changes in pool depth or escape cover, except for escape cover in 1997. However, fluctuations in larger juveniles were consistent with fluctuations in pool escape cover at sampling sites (except 2004), but the amplitude of fluctuations was not consistent (**Figure 43b**). Spring and summer baseflow and associated growth rate of YOY appeared to overshadow non-flow related habitat conditions to determine densities of larger juveniles. This was partly a result of low yearling densities in the mainstem.

Habitat conditions in Reach 7 (between the Moores Gulch confluence and the Purling Brook ford) were analyzed since 1997. Overall rearing habitat quality declined since 1997 in the upper mainstem (as indicated by Reach 7) regarding pools filling with sediment and less escape cover (**Figures 42 and 43a**), though maximum pool depth increased slightly in 2008, and escape cover has steadily improved from the low point of 1999. During the instream wood survey in 2002, this reach was noted for its lack of large wood (**Alley 2003c**).

Figure 19. Plot of Annual Total Juvenile Densities at Mainstem Soquel Creek Sites, 1997-2008.

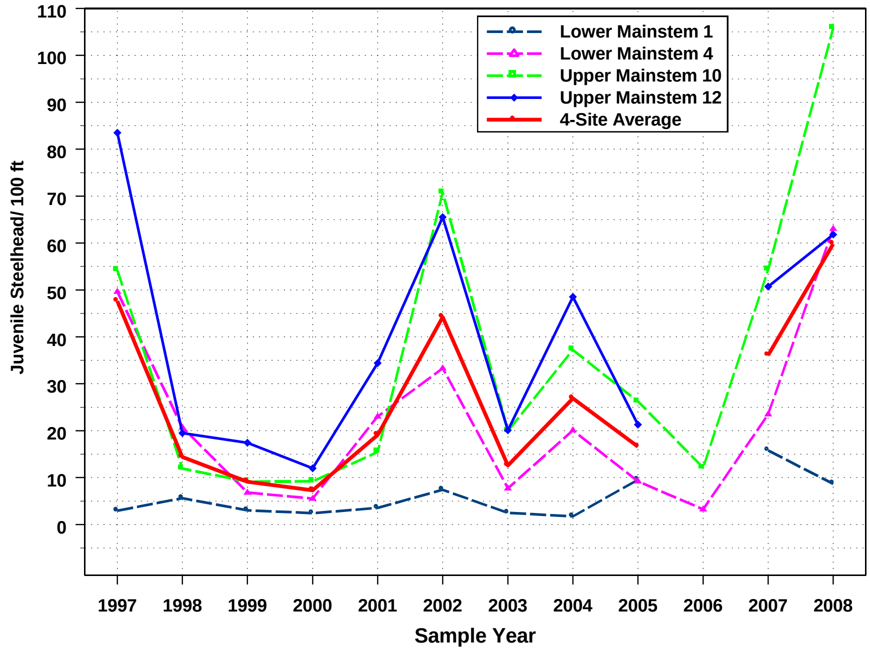
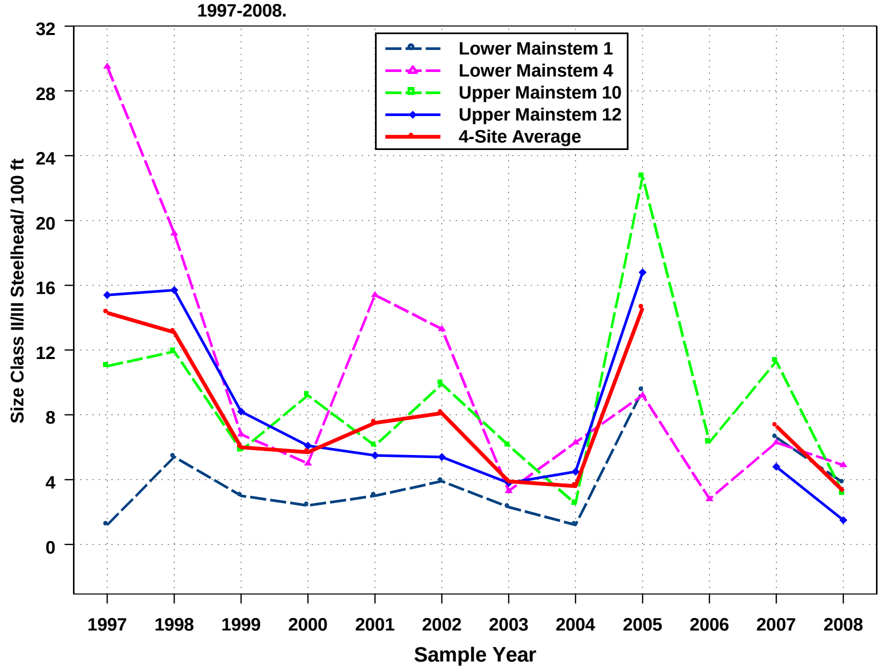


Figure 23. Plot of Annual Size Class II/ III Juvenile Densities at Soquel Mainstem Sites, 1997-2008.



Trend Analysis of Juvenile Densities and Habitat for East Branch Soquel

In East Branch Soquel Creek, total and YOY densities annually fluctuated in a dissimilar fashion in lower East Branch (Site 13a in Reach 9a) and upper East Branch (Site 16 in Reach 12a), except they increased at both locations from 2001 to 2002 and decreased at both locations in 2006 (**Figures 20 and 22**). After reaching a 12-year high in 2004, total and YOY densities in the lower East Branch declined in 2005 and then again in 2006 to almost zero but rebounded in 2007 and 2008. Higher YOY densities in drier years in the lower East Branch may have resulted from 1) greater spawning effort there than in the upper East Branch in wetter years, 2) more spawning success and 3) higher survival of YOY after emergence. In wetter years, more adult steelhead likely continued further up the East Branch into the Soquel Demonstration State Forest (SDSF). Though 2008 was a very dry year in the SDSF, it had larger storms early on than 2007 to provide better spawning access than 2007, with corresponding higher YOY density. With the streambed instability of the lower East Branch, redd (nest) scour or burial in sediment may have been more common in winters with higher stormflows. During the instream wood inventory in 2002 (**Alley 2003c**), this reach was identified as one with small quantities of large instream wood. If the incidence of large instream wood were to increase substantially, rearing habitat quality and improved over-wintering steelhead survival in intermediate to wetter years may play more important roles in increasing Size Class II and III densities.

Overall rearing habitat quality declined in the lower East Branch Reach 9a from 1997 to 2008, primarily with regard to fastwater habitat important to YOY juveniles and aquatic insects. Other factors related to the turbidity and thin silt layer on the substrate observed at the sampling site in 2006 and 2007 (downstream of the Mill Pond outfall) may also indicate reduced habitat quality. Turbidity and the fine silt layer seemed more localized in 2008.

In Reach 9a, since the same pools were sampled for steelhead in 1997–1999 and for 2000–2004, and sampled pools in 2000 were chosen to represent average habitat conditions for depth and escape cover for the habitat typed reach in 2000, then graphing of pool escape cover at sampled pools since 1997 may reflect general trends in escape cover.

At sampling Site 13a, annual densities of Size Class II and III juveniles (**Figure 24**) were not associated with changes in pool escape cover at sampling sites except in 2008 (**Figure 46b**). Insufficient years of data were available for reach-wide changes in pool depth, escape cover or percent fines in run and step-run habitat to make comparisons with trends in juvenile densities (**Figures 45, 46a and 47**). In 2005–2007, juvenile densities did not change as these habitat parameters changed. In 2008, increased densities of larger juveniles were positively associated with increased maximum pool depth and higher escape cover at the interrupted, incomplete sample site. (Capture of coho salmon at the first pool in 2008 prevented sampling of a second pool with less escape cover.) Average embeddedness in riffles and runs at sampling sites generally increased through the years as densities declined in 1997–2000 (**Figure 48**). But densities were not associated with changes in embeddedness in 2001–2005. The relatively high density of larger juveniles in 1997 was consistent with the highest escape cover in sampled pool habitat (provided by instream wood) and the lowest embeddedness in sampled riffle and run habitat in 12 years.

The typical disconnect between Size Class II and III densities in the lower East Branch and non-streamflow related rearing habitat conditions indicated that rearing habitat quality within the observed range in the last 12 years may have been overshadowed by poor over-winter survival of yearlings in years that were not wet enough to grow many YOY to Size Class II the following spring and summer. Over-winter survival did not appear good in any year. Existing escape cover for rearing habitat was apparently insufficient to provide overwintering habitat. During the instream wood inventory in 2002, this reach was identified as one with small quantities of large instream wood (**Alley 2003c**). Retention of more instream wood would enhance overwintering survival of yearlings and rearing habitat. The effect of non-streamflow related rearing habitat conditions was also overshadowed by the added potential for growth of some YOY to Size Class II in intermediate to wet years. The years with highest densities of Size Class II and III juveniles in the lower East Branch occurred in 1998 and 2005 (**Figure 24**), two relatively wet years (Figures 70 and 77) with moderate YOY densities (**Figure 22**). Higher growth rate during these high spring-baseflow years allowed a higher proportion of YOY to reach Size Class II, leading to higher densities of larger juveniles.

In the upper East Branch at Site 16 in the SDSF, densities of Size Class II and III increased during 1997–1999, with a steady decline to less than one-fifth the 1999 density by 2004. Then the density increased to its highest in 12 years in the dry year of 2007 (**Figure 24**). The relatively high density of Size Class II and III juveniles (20/ 100 ft) was likely due to at least moderate numbers of YOY in 2006 and good over-winter survival of yearlings during a mild winter. However, the yearling density declined substantially in 2008 to reduce the density of larger juveniles. This was partially due to low recruitment of YOY from 2007 (**Figure 22**) and likely a bankfull event during the 2007/2008 winter that may have flushed some yearlings downstream.

The three highest Size Class II and III densities in the upper East Branch did not correspond to any hydrologic category. They were 1998 (very wet year), 1999 (intermediate rainfall year with relatively mild peak flow) and 2007 (very dry year). Both 1998 and 1999 had sufficient spring baseflows to grow some YOY into Size Class II. The dry year likely had very good over-winter survival of yearlings, although rearing conditions worsened. In addition, adult access may have been hampered in the very mild 2006/2007 winter, resulting in lower YOY production and reduced competition for food to benefit yearlings. Retrieval of PIT-tagged juveniles has indicated very limited movement of tagged individuals from their original locations.

In the Upper East Branch habitat conditions in Reach 12a (between Amaya Creek confluence to the gradient increase and the beginning of bedrock pools) were analyzed primarily since 2000.

Data indicated that habitat quality in 2008 was similar to conditions in 2000, after flow-related conversion of step-run habitat to shallow pool habitat was taken into account in the dry years of 2007 and 2008 (**Figure 49**). However, pool rearing habitat quality increased in years between (greater pool depth in 2006; much greater pool escape cover in 2004 and higher amounts of pool escape cover in all years between 2000 and 2008 (**Figures 50a and 50b**)).

Since sampled pools in 2000 were chosen to represent average habitat conditions for depth and escape cover for the reach in 2000 and were sampled repeatedly for fish for 5 years, graphing of pool escape cover at the same sampled pools for 2000–2004 may reflect general trends in escape cover for the reach. These results indicated that pool escape cover increased from 2000 to 2002, declined in 2003 and increased to an 8-year high in 2004 (**Figure 50b**). Then it declined reach-wide during the last three years down to slightly less than the 2000 level. Reach-wide percent fines in important step-run habitat declined less than 10% since 2000, not indicating a real change (**Figure 51**). Percent fines at sampled step-runs were similar between 2000 and 2008, as well (**Figure 52**).

At Site 16, annual densities of Size Class II and III juveniles were not associated with changes in pool escape cover at sampling sites (**Figure 50b**). In fact, densities were the lowest in 2004 when pool escape cover at sampling sites was the highest. Densities increased from 2004 to 2007 despite a decline in pool escape cover at sampling sites. Insufficient years of data were available for reach-wide changes in pool depth and escape cover or in percent fines in run and step-run habitat for comparison to trends in juvenile densities (**Figures 49, 50a and 51**). Densities of Size Class II and III juveniles were not positively associated with changes in these habitat parameters but, in fact, increased despite reach-wide decline in pool escape cover for 2005–2007. However, the decline in these smolt-sized fish in 2008 coincided with decreased pool depth and escape cover (**Figures 49, 50a and 50b**). But it also coincided with low YOY densities in 2007 for low recruitment as yearlings. The density decline in 2000–2004 was associated with relatively high percent embeddedness in riffles and step-runs at sampling sites except for the less embeddedness in 2003 (**Figure 52**). Densities increased in 2005 with less embeddedness.

The apparent disconnect between rearing habitat conditions and Size Class II and III densities at Site 16 indicated that rearing habitat quality within the observed range of the last 12 years was overshadowed by 1) poor overwinter survival of yearlings in years that were not wet enough to grow many YOY to Size Class II, 2) the potential for growth of some YOY to Size Class II in only intermediate to wet years and 3) high overwinter survival of yearlings in dry years. If the incidence of large instream wood were to increase substantially, rearing habitat quality and improved over-winter survival in intermediate to wetter years may play more important roles in increasing Size Class II and III densities. More large instream wood would create more pool habitat, which is the primary habitat for larger juveniles in a reach with a shortage of pools and dominated by step-runs.

Figure 20. Plot of Annual Total Juvenile Densities at East Branch Soquel Creek Sites, 1997-2008.

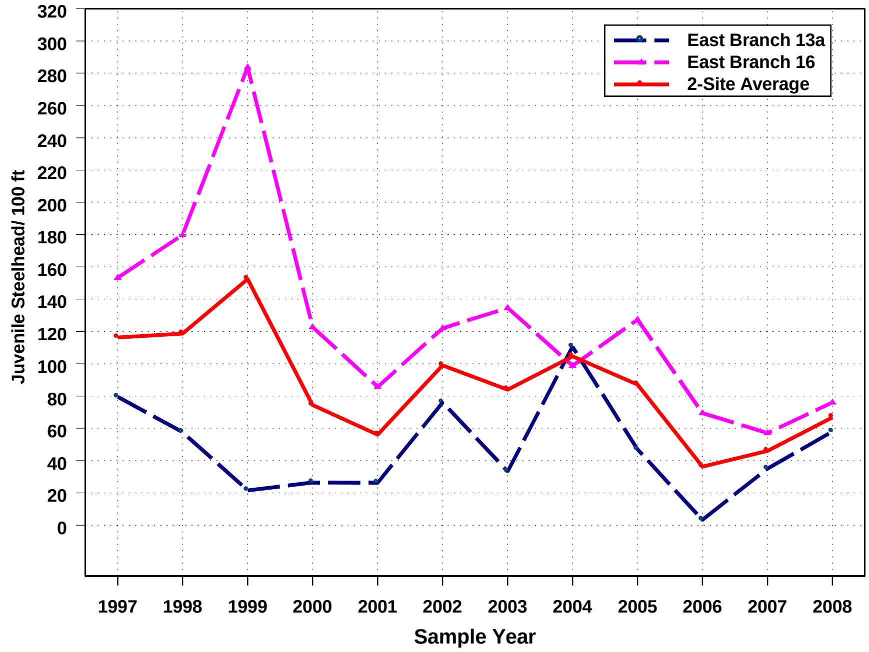


Figure 22. Plot of Annual YOY Densities at East Branch Soquel Creek Sites, 1997-2008.

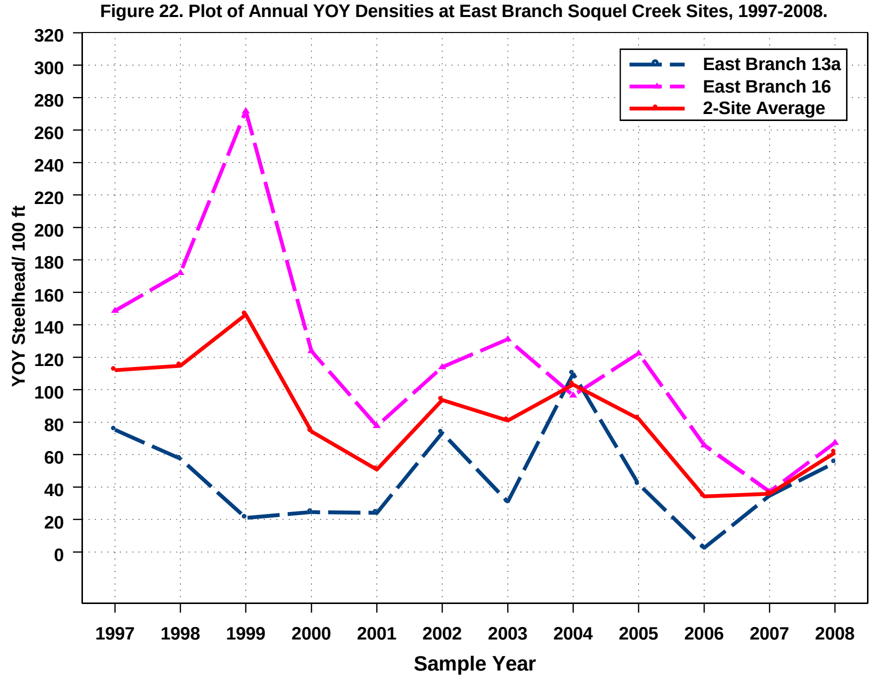
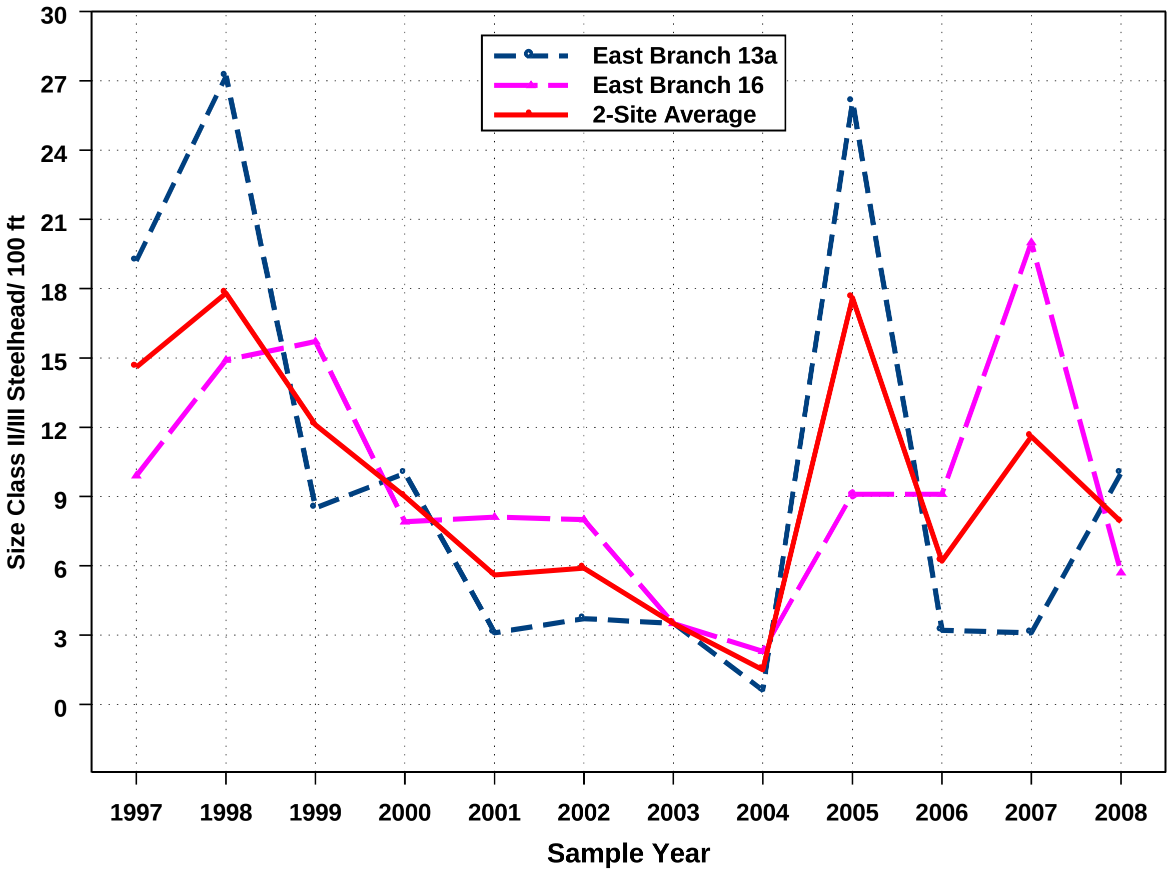


Figure 24. Plot of Annual Size Class II/ III Juvenile Densities at East Branch Soquel Creek Sites, 1997-2008.



SCOPE OF WORK

In fall 2008, 4 Santa Cruz County watersheds were evaluated for habitat quality and sampled for juvenile steelhead to compare with past results. Refer to maps in **Appendix A** that delineate reaches and sampling sites. The mainstem San Lorenzo River and 6 tributaries were sampled with a total of 17 sites. Seventeen half-mile segments were habitat typed to assess habitat conditions and select habitats of average quality to sample. Tributaries included Branciforte, Zayante, Lompico, Bean, Fall and Boulder and Bear creeks. Fall Creek was added at the request of the San Lorenzo Valley Water District. Seven steelhead sites were sampled below anadromy barriers in Soquel Creek and its branches. Eight half-mile segments were habitat typed, including between Girl Scout Falls I and II. NOAA Fisheries discontinued fall sampling between the falls. In the Aptos Creek watershed, 2 sites in Aptos Creek and 2 sites in Valencia Creek were sampled, and the 4 associated half-mile segments were habitat typed. In the Corralitos sub-watershed of the Pajaro River drainage, 4 sites were sampled in Corralitos Creek, 2 sites were sampled in Shingle Mill Gulch and 2 sites were sampled in Browns Valley Creek, along with 8 associated half-mile segments habitat typed.

Annual monitoring of juvenile steelhead began in 1994 in the San Lorenzo and 1997 in Soquel Creek. The Corralitos sub-watershed was previously sampled in 1981, 1994, 2006 and 2007. Aptos Creek was previously sampled in 1981, 2006 and 2007.

For annual comparisons, fish were divided into two age classes and three size classes. Age classes were young-of-the-year (YOY) and yearlings and older. The size classes were Size Class I (<75 mm Standard Length (SL)), Size Class II (between 75 and 150 mm SL) and Size Class III (>=150 mm SL). Juveniles in Size Classes II and III were considered to be "smolt-sized," based on scale analysis of out-migrating smolts by Smith (**2005**), because most fish of that size would grow sufficiently in the following spring to smolt. Fish below that size very rarely smolt the following spring.

INTRODUCTION

I-1. Steelhead and Coho Salmon Ecology

Migration. Adult steelhead in small coastal streams tend to migrate upstream from the ocean through an open sandbar 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 optimal stormflow conditions. We located partial migrational barriers in the San Lorenzo River Gorge caused by a wide riffle that developed below a bend in 1998 (Rincon riffle) and a large boulder field discovered in 1992 that created a falls (above Four Rock). Both of these impediments were probably passable at flows above approximately 50-70 cubic feet per second (cfs) as they were observed in 2002. A split channel had developed at the Rincon riffle by 2002 and in 2007 there existed a steep cascade where the channels rejoined, making adult steelhead passage up the main channel difficult. In 2008, the steep cascade was gone, offering much easier fish passage up the main channel. The boulder field at Four Rock was partially modified in 2008, though we have not examined the results. In most years these are not passage problems. However, in drought years and years when storms are delayed, they can be serious barriers to steelhead and especially coho salmon spawning migration. In the West Branch of Soquel Creek, there are Girl Scout Falls I and II that impede adult passage. Based on juvenile sampling, it appears that adult steelhead pass Girl Scout Falls I in most years but seldom pass Girl Scout Falls II.

Coho salmon often have more severe migrational problems because their migration period, November through early February, is often prior to the stormflows needed to pass shallow riffles, boulder falls and partial logjam barriers. Access 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. In recent years until 2008, the rainfall pattern has generally brought early winter storms to allow for good coho access to the San Lorenzo system, though only a small number of apparent strays have been detected at the Felton fish ladder and trap.

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 early June. In streams with lagoons, young-of-the-year and yearling 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 sandbar closure of the stream mouth or lagoon are additional factors that adversely affect downstream migration. However, for most local streams, downstream migration is not a major problem except under drought conditions.

Spawning. 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) and with good flows of clean water moving over and through them. Flow of oxygenated water through the redd (nest) to the fertilized eggs is restricted by increased fine materials from sedimentation and cementing of the gravels with fine materials. Flushing of metabolic wastes is also hindered. These restrictions reduce hatching success. In many local streams, steelhead appear to successfully utilize spawning substrates with high percentages of coarse sand, which probably reduces hatching success. Steelhead spawning success may be limited by scour from winter storms in some Santa Cruz County streams. Steelhead that spawn earlier in the winter are more likely to have their redds washed out or buried by the greater number of winter and spring storms that will follow. However, unless hatching success has been severely reduced, survival of eggs and alevins is usually sufficient to saturate the limited available rearing habitat in most small coastal streams and San Lorenzo tributaries. However, in the mainstem San Lorenzo River downstream of the Boulder Creek confluence, spawning success in the river may be an important limiting factor. The production of young-of-the-year (YOY) fish is related to spawning success, which is a function of the quality of spawning conditions, the pattern of storm events and ease of spawning access to upper reaches of tributaries, where spawning conditions are generally better.

Rearing Habitat. In the mainstem San Lorenzo River, downstream of the Boulder Creek confluence, many steelhead require only one summer of residence before reaching smolt size. This is also the case in the Soquel Creek mainstem and lagoon. Except in streams with high summer flow volumes (greater than about 0.2 to 0.4 cubic feet per second (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 and the mainstem upstream of the Boulder Creek confluence. This is also the case for most juveniles in the East and West Branches of Soquel Creek, as well as in the Aptos watershed (except its lagoon) and the Corralitos sub-watershed except in wetter years such as 2006. Juvenile steelhead are generally identified as YOY (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 (including over-wintering survival) during either of the two years of residence. Nearly all coho salmon, however, smolt after one year under most conditions, despite their smaller size.

Growth of YOY steelhead and coho salmon appears to be regulated by available insect food (determined by substrate conditions in fastwater habitat and insect drift rate), although escape cover (hiding areas, provided by undercut banks, large rocks which are not buried or "embedded" in finer substrate, surface turbulence, etc.) and water depth in pools, runs and riffles are also important in regulating juvenile numbers, especially for larger fish. Densities of yearling and smolt-sized steelhead in small streams, the upper San Lorenzo (upstream of the Boulder Creek confluence) and San Lorenzo tributaries, are usually regulated by water depth and the amount of escape cover during low-flow periods of the year (July−October) and by over-winter survival in deep and or complex pools. In most small coastal streams, availability of this "maintenance habitat" provided by depth and cover appears to determine the number of smolts produced (**Alley 2006a; 2006b; 2007; Smith 1982**). 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" (provided mostly in spring and early summer) determine the size of these smolts. It was determined that in portions of a watershed that are capable of growing YOY juvenile steelhead to smolt size their first growing season (Size Class II =>75 mm Standard Length in fall), the density of YOY that obtain this size was positively associated with the mean monthly streamflow for May–September (**Alley et al. 2004**). Furthermore, it has been shown that the density of slower growing YOY in tributaries was positively associated with the annual minimum annual streamflow (**Alley et al. 2004**). 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 increase during the period of March through June. Larger steelhead then may smolt as yearlings. For steelhead that stay a second summer, mid to late summer growth is very slight in many tributaries (or even negative in terms of weight) as flow reductions eliminate fast-water feeding areas and reduce insect production. A short growth period may occur in fall and early winter after leaf-drop of riparian trees, after increased streamflow from early storms, and before water temperatures decline below about 48ºF 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 San Lorenzo River) is very important, since ocean survival to adulthood increases exponentially with smolt size.

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. YOY and small yearling steelhead that have moved down from tributaries can grow very fast in this habitat if streamflows are high and sustained throughout the summer. The shallow riffle habitat in the upper mainstem is used almost exclusively by small YOY, although most YOY are in pools. In the warm mainstem Soquel Creek, downstream of Moores Gulch, juvenile steelhead utilize primarily heads of pools in all but the highest flow years, with some YOY using shallower runs and riffles. Upstream of Moores Gulch in summer on the mainstem and in the two Branches (East and West), juvenile steelhead use primarily pool habitat where cover is available and deeper step-runs. Riffles are used by primarily YOY and more so in the upper mainstem than the branches where they become more shallow.

Pools and step-runs are the primary habitat for steelhead in summer in San Lorenzo tributaries, the upper San Lorenzo River above the Boulder Creek confluence, the Aptos watershed and the Corralitos sub-watershed 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 (as overhead cover) and habitat depth, all factors that increase steelhead densities and growth rates. Where found together, young steelhead use pools and faster water in riffles and runs/step-runs, while coho salmon use primarily pools, being poorer swimmers.

Juvenile steelhead captured during fall sampling included a smaller size class of juveniles less than (<) 75 mm (3 inches) Standard Length (SL); these fish would almost always 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 a majority will likely out-migrate the following spring and because fish smaller than this very rarely smolt the following spring. Smolt size was based on scale analysis of out-migrant smolts captured in 1987-89 in the lower San Lorenzo River. This size class in fall may include fast growing YOY steelhead inhabiting the mainstems of the San Lorenzo River and Soquel Creek, lower reaches of larger San Lorenzo tributaries, and lower reaches of Corralitos and Aptos creeks. It also includes slower growing yearlings and older fish inhabiting all watershed reaches.

A basic assumption in relating juvenile densities to habitat conditions where they are captured is that juveniles do not move substantially from where they are captured during the growing season. This assumption is reasonable because at sites in close proximity, such as adjacent larger mainstem and smaller tributary sites, there are consistent differences in fish size, such as juveniles that are consistently larger in the mainstem sites where streamflow is greater and there is more food (**D. Alley pers. observation)**. In other cases, there are differences in fish size between sunny productive habitats and shady habitats where food is scarce. This indicates a lack of movement between sites. In addition, Davis (**1995**), during a study of growth rates in various habitat types, marked juvenile steelhead in June in Waddell Creek and recaptured the same fish in September in the same (or immediately adjacent) habitats where they had been marked. Evidence is lacking that would indicate ecologically significant juvenile movement upstream during the dry season, and the concern that summer flashboard dams without ladders may impede upstream movements of juvenile salmonids appears unfounded. Shapovalov and Taft (**1954**), after 9 consecutive years of fish trapping on Waddell Creek, detected very limited upstream juvenile steelhead movements; most of the relatively limited movement was in the winter.

Overwintering Habitat. Shelter for fish against high winter flows is provided by deeper pools, undercut banks, side channels, large unembedded rocks and large wood clusters. Over-wintering survival is usually a major limiting factor, since yearling fish are usually less than 10-20% as abundant as YOY. Extreme floods (i.e. 1982 and 1998) may make overwintering habitat the most critical for steelhead production. In the majority of years when bankfull or greater stormflows occur, these refuges are critical, and it is unknown how much refuge is needed. The remaining coho streams, such as Gazos, Waddell and Scott creeks, have considerably more instream wood than others (**Leicester 2005**).

I-2. Project Purpose and General Study Approach

The 2008 fall fish sampling and habitat evaluation included comparison of 2008 juvenile steelhead densities at sampling sites and rearing habitat conditions with those in 1997–2001 and 2003–2007 for the San Lorenzo River and 7 tributaries and in 1997−2007 for the Soquel Creek mainstem and branches. Fall steelhead densities and habitat conditions in 2008 in the Corralitos Creek watershed were compared to those in 1981, 1994 and 2006−2007. Fall 2008 steelhead densities and habitat conditions in the Aptos Creek watershed were compared to those in 1981 and 2006−2007. Habitat conditions were assessed primarily from measured streamflow, escape cover, water depth and visual estimates of streambed composition and embeddedness.

METHODS

M-1. Choice of Reaches and Vicinity of Sites to be Sampled

In 2008, fish densities at average habitat quality sampling sites in previously determined reaches were compared to past fish densities. The scope since 2006 has not included estimation of fish population sizes for reaches or extrapolation to adult indices.

The mainstem San Lorenzo was divided into 13 reaches, based on past survey work (**Table 1a; Appendix A map, 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 map, Figure 2**). In past work for the San Lorenzo Valley Water District, Zayante and Bean creeks were surveyed and divided into reaches. Previous work for the Scotts Valley Water District required survey of Carbonera Creek and reach determination, although it has not been sampled since 2001. Considerations for reach boundaries in Lompico Creek were similar to those for other tributaries, including summer baseflows, past road impacts and bridge crossings, water diversion impacts and extent of perennial channel. The half-mile segment surveyed and sampled in Lompico Creek was mostly in the lowermost Reach 13e and included some of Reach 13f with two bridge crossings.

In each tributary and the upper mainstem of the San Lorenzo, the uppermost extent of steelhead use was approximated in past years to make watershed population estimates. For the upper San Lorenzo River, topographic maps were used with attention to change in gradient and tributary confluences to designate reach boundaries (**Table 1b; Appendix A map, Figure 2**). The uppermost reach boundaries for Bean and Bear creeks were based on a steep gradient change seen on the topographic map, indicative of passage problems. The Deer Creek confluence was used on Bear Creek, although steelhead access continues somewhat further. Known barriers were upper reach boundaries in Carbonera, Fall, Newell, Boulder and Kings creeks. The extent of perennial stream channel in most years was used for setting boundaries on Branciforte, Zayante and Lompico creeks. Steelhead estimates in Zayante Creek stopped at the Mt. Charlie Gulch confluence in past years, although steelhead habitat exists above in Zayante Creek and Mt. Charlie Gulch in many years. Steelhead habitat in the Zayante tributary, Lompico Creek, was first sampled in 2006.

In 2008, sampled tributaries of the San Lorenzo included Zayante, Lompico, Bean, Fall, Boulder, lower Bear and lower Branciforte creeks. Newell Creek was dropped in 2007 because the City of Santa Cruz collected habitat and fish density data on Newell Creek independent of our effort. The City of Santa Cruz did not fund sampling in Newell Creek in 2008. The San Lorenzo Valley Water District funded the resumption of sampling and habitat typing in Fall Creek, which had not been monitored since 2001. The historic reach in Fall Creek was studied. Refer to **Table 1c, Appendix**

A, Figure 2 and page 2 for a list of sampling sites and locations in 2008. Half-mile segments in the vicinity of sampling sites were habitat typed to select sampling sites with average habitat conditions. Steelhead inhabit other tributaries, and in the past, 9 major tributaries were sampled. 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, Mountain Charlie Gulch in the upper Zayante Creek drainage, Love Creek, Clear Creek, Two Bar Creek, Logan Creek tributary to Kings Creek and Jamison Creek (a Boulder Creek tributary). Other creeks likely to provide limited steelhead access and perennial habitat in some years for relatively low densities of steelhead include Glen Canyon and Granite creeks in the Branciforte system; Powder Mill Creek, Gold Gulch (lower mainstem San Lorenzo tributaries); and Ruins and Mackenzie creeks (2 small Bean Creek tributaries). This list is not exhaustive for steelhead. Resident rainbow trout undoubtedly exist upstream of steelhead migrational barriers in some creeks and especially upper Boulder Creek above the bedrock chute near the Boulder Creek Country Club.

In Soquel Creek, reach boundaries downstream of the East and West Branch confluence were determined from our habitat typing and stream survey work in September 1997. For reaches on the East and West branches, boundaries were based on observations made while hiking to sampling sites, observations made during previous survey work, and reach designations made by Dettman during earlier work (**Dettman and Kelley 1984**). Changes in habitat characteristics that necessitated reach boundary designation often occurred when stream gradient changed. Stream gradient is often associated with changes in habitat type proportions, pool depth, substrate size distribution and channel type. Other important factors separating reaches are a change in tree canopy closure or significant tributary confluences that increase summer baseflow and/or may be locations of sediment input from tributaries in the winter.

The 7.1 miles of Soquel Creek (excluding the lagoon) downstream of the East and West Branches were divided into 8 reaches (**Table 2a; Appendix A of watershed maps**). The lagoon was designated Reach 0. The 7 miles of the East Branch channel between the West Branch confluence and Ashbury Gulch were divided into 4 reaches. The upstream limit of steelhead in this analysis was considered Ashbury Gulch due to the presence of a bedrock falls and several boulder drops constituting Ashbury Falls immediately downstream. These impediments likely prevent adult access to areas above the falls in most years. Furthermore, the salmonid size distribution of previous years at Site 18 above Ashbury Falls (delineated in **Table 2b**) indicated that a higher proportion of larger resident rainbow trout was present in the population upstream of Reach 12b. The West Branch had 2 reliable steelhead reaches (13 and 14a). The upper West Branch reach was shortened in 2000 when a bedrock chute (Girl Scout Falls I) was observed upstream of Olson Road (formerly Olsen Road) near the Girl Scout camp. This chute is likely impassable during many stormflows. Therefore, juvenile steelhead population estimates for previous years were reduced to exclude potential juvenile production above this passage impediment. Sampling in 2003 and 2005 indicated that steelhead likely passed Girl Scout Falls I but not Girl Scout Falls II. Sampling in 2004 indicated that some steelhead might have passed Girl Scout Falls II, although young-of-the-year production above Girl Scout Falls II was approximately half what it was downstream. Sampling in 2005 and 2006 indicated that adult steelhead did not pass Girl Scout Falls II. After 2006, the sampling site upstream of Girl Scout Falls II was dropped from the scope.

In 2002, the upper West Branch was surveyed. Significant impediments to salmonid migration were found and used as reach boundaries. Reach 14b was designated between Girl Scout Falls I and Girl Scout Falls II. Reach 14c was designated between Girl Scout Falls II and Tucker Road (formerly Tilly's Ford). Reach 14d was designated between Tucker Road and Laurel Mills Dam.

In 2008, all captured fish in Soquel Creek were scanned for PIT tags to detect any previously tagged individuals at NOAA Fisheries sites. Soquel Creek sites included 4 mainstem sites with one in Reach 1 (Site 1) upstream of the lagoon (downstream of Bates Creek), one in the lower mainstem below Moores Gulch in Reach 3 (Site 4), one in the upper mainstem in Reach 7 (Site 10) and one in the upper mainstem in Reach 8 (Site 12) (**Table 2b**). Half-mile segments encompassing these sites were habitat typed to determine sampling sites with average habitat quality, except 0.8 miles were habitat typed in Reach 1. Sampling sites were chosen to represent the lower East Branch Reach 9 (Site 13a) and the upper East Branch Reach 12a (Site 16) (**Table 2b**) in the upper Soquel Creek watershed where most of the spawning usually occurs. On the West Branch, one sampling site was chosen downstream of Girl Scout Falls I and Hester Creek in Reach 13 (Site 19). The reach between Girl Scout Falls I and II was habitat typed (Reach 14b) to compare habitat conditions with 2007. Landowner objection in 2006 prevented surveying and sampling of Reach 14a in the future.

In the Aptos Creek watershed, 2 sites were sampled in Aptos Creek, representing the low-gradient Reach 2 above the Valencia Creek confluence and the higher gradient Reach 3 in Nisene Marks State Park (**Appendix A map**). Two sites on Valencia Creek were sampled in the vicinity of historical sites previously sampled in 1981 (**Table 3**). Reach 2 was above passage impediments near Highway 1 where a new fish ladder was constructed. Reach 3 was above the passage impediment that has been retrofitted at the Valencia Road culvert crossing. Half-mile segments in the vicinity of historical sampling sites were habitat typed so that pools with average habitat quality could be chosen for sampling, along with adjacent fastwater habitat. Site numbers were consistent with 1981 numbering.

In the Corralitos Creek sub-watershed of the Pajaro River Watershed, sampling sites were chosen based on historical sampling locations (**Smith 1982; Alley 1995a**) and historical reach designations determined in 1994 (**Alley 1995a**). Reach delineations were based on previous stream survey work of streambed conditions, streamflow and habitat proportions by Alley of the extent of steelhead distribution in sub-watershed in 1981 and past knowledge of streamflow and sediment inputs from tributaries by Smith and Alley during drought and flood (**Table 4a; Appendix A**). Half-mile segments were habitat typed in the vicinity of the historical sampling sites to identify pools with average habitat quality and their adjacent fastwater habitat to sample. Site numbers were kept consistent with the original 1981 designations to prevent confusion.

In Corralitos Creek, 4 reaches were chosen: Reach 1 downstream of the water diversion dam (Site 0), Reach 3 downstream of Rider Creek as streamflow steadily increased toward the diversion dam (Site 3), Reach 6 upstream of Rider Creek (a historical sediment source) and the Eureka Canyon Road crossing at RM 2.95 (box culvert baffled in 2008) that is a partial passage impediment (Site 8) and Reach 7 upstream of Eureka Gulch, a historical sediment source (Site 9) (**Tables 4a and 4b; Appendix A map**).

In Shingle Mill Gulch, Reach 1 was chosen below the partial passage impediment at the second road crossing (Site 1) and Reach 3 above the second and third road crossings and the steep Reach 2. Reach 3 is a lower gradient, low flow reach downstream of Grizzly Flat (Site 3) (**Tables 4a and 4b; Appendix A map**).

In Browns Valley Creek, Sites 1 and 2 were chosen to represent the 2 reaches previously delineated there (**Tables 4a and 4b; Appendix A map**). The diversion dam demarcated the reach boundaries because of its potential effect on surface flow and a change in channel type. Other valuable steelhead habitat exists in Ramsey Gulch and Gamecock Canyon Creek (**Smith 1982**).

M-2. Classification of Habitat Types and Measurement of Habitat Conditions

In each watershed, ½-mile stream segments were habitat-typed using a modified CDFG Level IV habitat inventory method; with fish sampling sites chosen within each segment based on average habitat conditions. See sampling methods for more details. Habitat types were classified according to the categories outlined in the California Salmonid Stream Habitat Restoration Manual (**Flosi et al. 1998**). 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 to obtain more detailed, biologically relevant information.

M-3. Measurement of Habitat Conditions

During habitat typing in 2008, as in past years, visual estimates of substrate composition and embeddedness were made. The observer looked at the habitat and made mental estimates based on what he saw with his trained eye. Therefore, these estimates are somewhat subjective, with consistency between data collectors requiring calibration from one to the other. An assumption is that the same data collector will be consistent in visual estimates. If more than one data collector contributed to the same study, the original observer trained the others to be consistent ("calibrated") on visual estimates. Changes in visual estimates of substrate abundance or embeddedness of about 10% or more between sites and years probably represent real changes in habitat quality. The previous years' data was not reviewed prior to data collection so as not to bias current data.

Fine Sediment. Fine sediment was visually estimated as particles smaller than approximately 0.08 inches. In the Santa Cruz Mountains, there is little gradual gradation in particle size between sand and larger substrate, making visual estimates of fines relatively easy. There is generally a shortage of gravel-sized substrate. The comparability of these visual estimates to data collection via pebble counts would depend on the skill of the visual estimator and the skill of the pebble count collectors. Untrained volunteers tend to select larger substrate to pick up and measure during pebble counts, resulting in an overestimate of particle size composition of the streambed. The accuracy of pebble counts is also dependent on sample size. Neither the pebble count nor the visual estimate will provide data for substrate below the streambed surface. The McNeil Sampler may be used for core samples, and results from this method may not comparable to the other methods. The substrate that may be sampled with core sampling is restricted by the diameter of the sampler. Both the pebble count method and the core sampling method are too labor intensive for habitat typing. We do not believe more in-depth estimates than those taken for percent fines during habitat typing are necessary for purposes of this fishery study. It is best to have annual consistency in data collecting personnel during habitat typing, however.

Embeddedness. Embeddedness was visually estimated as the percent that cobbles and boulders larger than 150 mm (6 inches) in diameter were buried in finer substrate. Previous to 1999, the cobble range included substrate larger than 100 mm (4 inches). The change in cobble size likely had little effect on embeddedness estimates. The reason the cobble size was increased to 150 mm was because substrate smaller than that probably offered little benefit for fish escape cover, and embeddedness of smaller substrate was not a good indicator of habitat quality for fish.

Cobbles and boulders larger than approximately 150 mm in diameter provided good, heterogeneous habitat for aquatic insects in riffles and runs and some fish cover if embedded less than 25%. Cobbles and boulders larger than 225 mm provided the best potential fish cover if embedded less than 25%.

Tree Canopy Closure. Tree canopy closure was measured with a densiometer. Included in the tree canopy closure measurement were trees growing on slopes considerable distance from the stream. 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 and with stream orientation. 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 mainstem San Lorenzo River (Reaches 10-12) and tributaries because water temperatures are well within the tolerance range of juvenile steelhead and coho salmon. If reaches with low summer baseflow become unshaded, water temperature rapidly increases. Limited openings (10-15%) in the canopy provide some sunlight during the day for algal growth and visual feeding by fish. 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 30-75% range. There is an inverse relationship between tree canopy and insect production in riffles, which allows faster steelhead growth in larger, mainstem reaches, especially downstream of the Zayante Creek confluence, having deeper, fast-water feeding areas, despite the elevated temperatures and steelhead metabolic rate (and associated food requirements.) In addition, very dense shading reduces visibility of drifting insect prey and reduces fish feeding efficiency. 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.

Escape Cover− Sampling Sites. The escape cover index for each habitat type within sampled sites was quantitatively determined in the same manner in 1994-2001 and in 2003-2008. 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 some escape cover when 2 feet deep and good escape cover when it is 3 feet deep (1 meter) or greater. Escape cover was measured as the ratio of the linear distance under submerged objects and undercut banks within the habitat type that fish at least 75 mm (3 inches) Standard Length (SL) could hide under, divided by the length of the habitat type. The summer escape cover (as unembedded cobbles, undercut banks and instream wood) also provides overwintering habitat in the tributaries. This allowed annual comparisons for the habitats at historical sites.

Escape Cover− Habitat Typing Method by Reach. Reach averages in 1997−2000, 2003, 2005−2008 for escape cover by habitat type were determined from habitat typed segments. Reach cover indices were determined for habitat types in reach segments for purposes of annual comparisons. The escape cover index for each habitat type in a half-mile segment was measured as the ratio of linear feet of cover under submerged objects that Size Class II and III juveniles could hide under for all of that habitat type in the segment divided by total feet of stream channel as that habitat type in the reach segment. Objects of cover included unembedded boulders, submerged woody debris, undercut banks, bubble curtains 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. Steelhead habitat is illustrated in the following drawings.

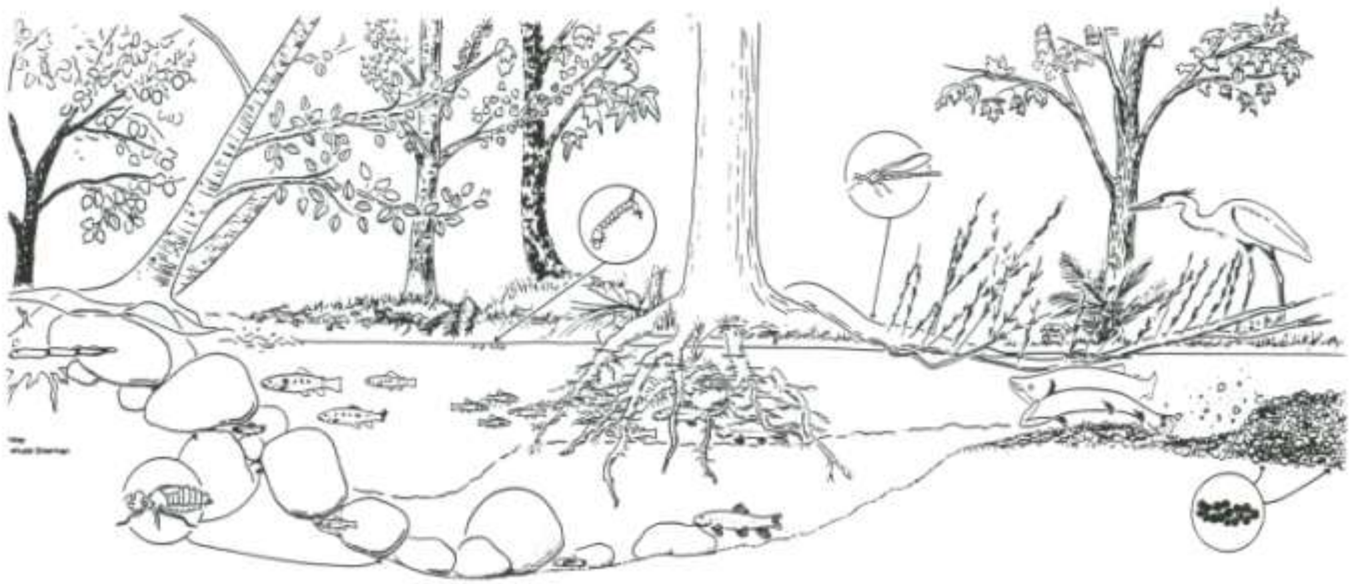


Illustration of pool habitat (stream flowing from left to right) showing escape cover under boulders and undercut bank with tree roots. Juvenile steelhead are feeding at the head of the pool. (Female steelhead covering her redd of eggs after spawning at the tail of the pool.)

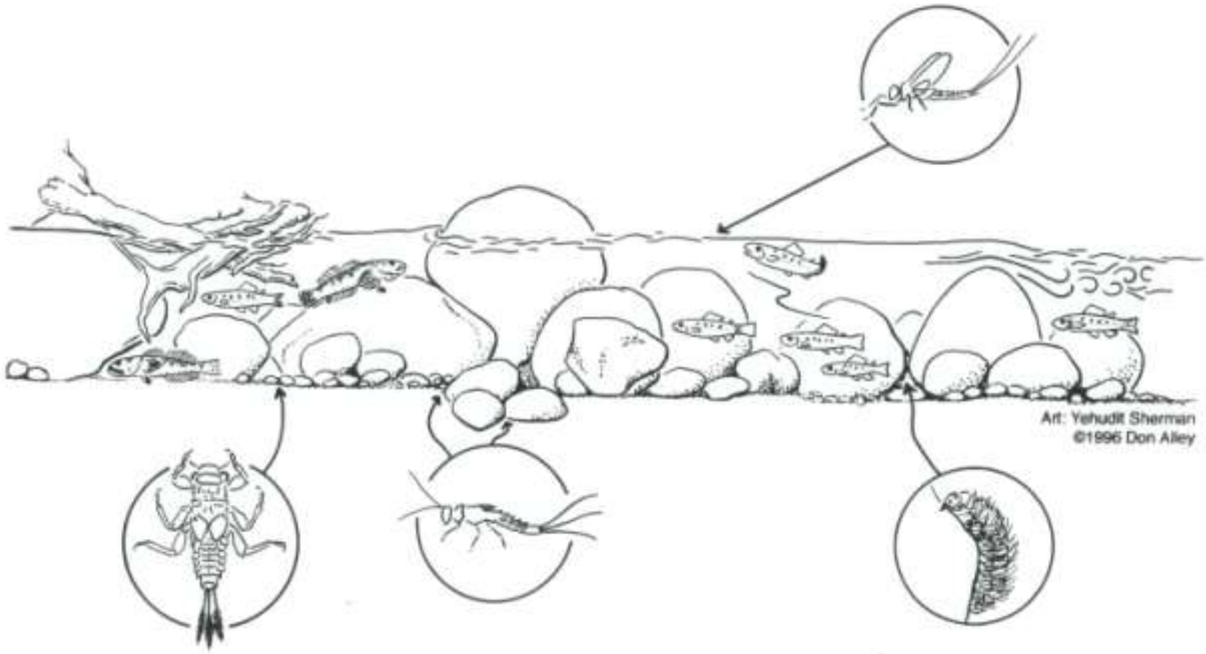


Illustration of riffle habitat (stream flowing from left to right) showing escape cover under rootwad and boulders. (Juvenile steelhead are holding feeding positions, facing upstream.)

<u>Water Depth, Channel Length and Width.</u> Water depth is important because deeper habitat is utilized more heavily by steelhead, especially by larger fish. Deeper pools are 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. Soundings throughout the habitat type were made to estimate mean and maximum depth. Annual comparisons of habitat depth were possible because measurements were taken in the fall of each year. Minimum depth was determined approximately one foot from the stream margin in earlier years. Stream length was measured with a hip chain. Width in each year was measured with the graduated dip net except in wider habitats of the mainstem. In wider habitats (greater than approximately 20 feet), a range finder was used to measure width.

Streamflow. For 1995 and 1998 onward, the Marsh McBirney Model 2000 flowmeter was more extensively used at most sampling sites. Streamflow measurement was beyond the project scope and budget in 2006−2008. Even so, streamflow was measured in 2006 at historical sites in the San Lorenzo watershed in fall before any fall storms, as in past years. Mean column velocity was measured at 20 or more verticals at each cross-section. After 2006, streamflow measurements made by Santa Cruz County staff were used for annual comparisons.

M-4. Choice of Specific Habitats to be Sampled Within Reaches

Based on the habitat typing conducted in each reach prior to fish sampling, representative habitat units were selected with average habitat quality values in terms of water depth and escape cover to determine fish densities by habitat type. In mainstem reaches of the lower and middle San Lorenzo River (Sites 1, 2, 4, 6 and 8), riffles and runs that were close to the average width and depth for the reach were sampled by electrofishing. Pools in these reaches were divided into long pools (greater than 200 feet long) and short pools (less than 200 feet) and at least one pool of each size class was either snorkel censused or electrofished. The exception was Reach 1, which had only one pool less than 200 ft long, which was not censused. Only a long pool was censused in Reach 1 (which historically consisted of a long pool and a short pool). In these mainstem reaches, most fish were in the fastwater habitat of riffles, runs and the heads of pools and fish were not using most of the pool habitat. Some of the pools are hundreds of feet long with very few juveniles, except for those at the heads of pools.

For all other reaches in this study, in the upper San Lorenzo River above the Boulder Creek confluence, all San Lorenzo tributaries and in the Aptos and Corralitos watersheds, the location of representative pools with average habitat quality in terms of water depth and escape cover determined the pool habitat to be sampled. Pools were deemed representative if they had escape cover ratios and water depths similar to the average values for all pools in the half-mile segment that was habitat typed within the reach. Therefore, pools that were much deeper or much shallower than average or had much less or much more escape cover than average were not sampled. Once the pools were chosen for electrofishing, adjacent riffles, step-runs, runs and glides were sampled, as well. In these smaller channel situations, these latter habitat types showed great similarity to most other habitats of the same type. Namely, all riffles had similar depth and escape cover; all runs had similar depth and escape cover; all step-runs had similar depth and escape cover; and all glides had similar depth and escape cover.

Sampled units may change from year to year since habitat conditions change, and locations of individual habitat units may shift depending on winter storm conditions. Our assumption is that fish sampling of mean habitat quality will reflect representative habitat for the reach and provide average fish densities for the reach. The assumption is that there is a correlation between fish density and habitat quality in that better habitat has more fish. Past modeling has indicated that increased densities of smolt-sized juveniles are positively associated with greater water depth and escape cover in small, low summer flow streams (**Smith 1984**). Site densities were determined by calculating the number of juveniles present in each sampled habitat from electrofishing and/or snorkel censusing and adding those to numbers of juveniles from other habitats. The total number of fish was divided by the total lineal feet sampled at the site.

M-5. Consistency of Data Collection Techniques in 1994-2001 and 2003-2008

Habitat conditions were measured at the monitoring sites in 2008 consistent with methods used in 1981 and 1994-2001 and 2003−2007 in the San Lorenzo River and Soquel Creek watersheds. Donald Alley, the principal investigator and data collector in 1994−2001 and 2003−2007, had also collected the fish and habitat data at approximately half or more of the sites in the 1981 study for the County Water Master Plan that included the 4 watersheds in the current study, except for Aptos Creek (**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 smolt-sized (=>75 mm SL) and larger steelhead was consistent through the years, although the escape cover index in 1981 was based upon linear cover per habitat perimeter and later escape cover indices were based on linear cover per habitat length. In 2006−2008, Chad Steiner habitat typed 4 reaches in the Aptos Watershed, 2 reaches in Branciforte Creek, 2 reaches in Browns Valley Creek and 2 reaches in Shingle Mill Creek, after working with Alley since 2001. During electrofishing from 1996 onward, block nets were used to partition off habitats at all electrofishing sites. This prevented steelhead escapement. A multiple-pass method was used in each habitat with at least three passes.

From 1998 onward, underwater visual (snorkel) censusing was incorporated with electrofishing so that pool habitat in the mainstem San Lorenzo River, which had been electrofished in past years, could be effectively censused despite it being too deep in 1998 (a high-flow year) for backpack electrofishing. Snorkel censusing was also used to obtain density estimates in deeper pools previously unsampled prior to 1998 at Sites 2, 3, 7, 8 and 9, in an effort to increase the accuracy of production estimates. A better juvenile production estimate and predictions of adult returns were made with snorkel-censusing of pool habitat in the mainstem San Lorenzo River for 1998–2005. In 2006−2008, deeper pools were snorkel-censused at Sites 1, 2, 4 and 8 in the lower and middle mainstem to determine site densities only. All other watersheds were sampled by electrofishing.

The City of Santa Cruz funded a separate San Lorenzo watershed sampling effort in 2002. Their data were not included in this report because their methods were inconsistent with ours except in graphs of total juvenile density at some sites. For our review of their findings, please refer to our 2003 censusing report (**Alley 2004**).

Table 1a. Defined Reaches in the Mainstem San Lorenzo River.

(Refer to Appendix A for map designations. Surveyed reaches indicated by asterisk)

Reach #	Reach Boundaries	Reach Length (ft)
0	Water Street to Tait Street Diversion CM0.92 – CM1.92	5,277
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	136,293 (25.8 miles)

Table 1b. Defined Reaches in Major Tributaries of the San Lorenzo River.

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 Trib. Draining from S.Cruz Aggregate Quarry 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 Gulch Confluence CM3.09-CM5.72	13,886
Lompico 13e*	Lompico Creekmouth to 1st Culvert Crossing CM0.0-CM0.5	4,265
Lompico 13f	1st Culvert Crossing to Carol Road Bridge CM0.5-CM1.77	5,077
Lompico 13g	Carol Road Bridge to Mill Creek Confluence CM1.77-CM2.35	3,046
Lompico 13h	Mill Creek Confluence to End of Perennial Channel CM2.35-CM3.73	7,311
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	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

Creek-Reach #	Reach Boundaries (Downstream to Upstream)	Reach Length (ft)
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 Former Fragmented Dam Abutment Location CM0.0-CM2.04	10,771
19b	Tributary 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. Fish Sampling Sites in the San Lorenzo Watershed.
(2008 Sites Indicated by Asterisk.)

Reach #	Sampling Site # -Channel Mile	MAINSTEM SITES Location of Sampling Sites
0	0a –CM1.6	Above Water Street Bridge
0	0b –CM2.3	Above Highway 1 Bridge
1	*1 -CM3.8	Paradise Park
2	*2 –CM6.0	Lower Gorge in Rincon Reach, Downstream of Old Dam Site
3	3 -CM7.4	Upper End of the Gorge
4	*4 -CM8.9	Downstream of the Cowell Park Entrance Bridge
5	5 -CM9.3	Downstream of Zayante Creek Confluence
6	*6 -CM10.4	Below Fall Creek Confluence
7	7 -CM13.8	Above 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	Upstream of Teilh Road, Riverside Grove
12	12a -CM24.7	Downstream of Waterman Gap and Highway 9
	12b -CM25.2	Waterman Gap Upstream of Highway 9

Table 1c. Fish Sampling Sites in the San Lorenzo Watershed, with 2008 Sites indicated by Asterisk (continued).

Reach #	Sampling Site # -Channel Mile	TRIBUTARY SITES Location of Sampling Sites
13a	*13a-CM0.3	Zayante Creek Upstream of Conference Drive Bridge
13b	13b-CM1.6	Zayante Creek Above First Zayante Rd crossing
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 East Zayante Road After Lompico Creek Confluence
13e	*13e-CM0.4	Lompico Creek upstream of the fish ladder and downstream of first bridge crossing.
14a	14a-CM0.1	Bean Creek Upstream of Zayante Creek Confluence
14b	*14b-CM1.8	Bean Creek Below Lockhart Gulch Road
14c	14c-CM4.7	Bean Creek 1/2-mile Above Mackenzie Creek Confluence and Below Golpher Gulch Rd.
15	*15 -CM0.8	Fall Creek, 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, Just Upstream 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 the Second Kings Creek Road Bridge
20a	20a-CM0.7	Carbonera Creek, Upstream of Health Services Complex
20b	20b-CM1.9	Carbonera Creek, Downstream of Buelah Park Trail
21a	*21a1-CM1.5	Branciforte Creek, Upstream of the Highway 1 Overpass
21a	*21a2-CM2.8	Branciforte Ck, Downstream of Granite Creek Confluence
21b	21b-CM4.6	Branciforte Ck, Upstream of Granite Crk Confl. and Happy Valley School

Table 2a. Defined Reaches on Soquel Creek.

(Refer to Appendix A for map designations. Surveyed reaches indicated by asterisk.)

Reach #	Reach Boundaries (Downstream to Upstream)	Reach Length (ft)
0	Soquel Creek Lagoon	3,168
1*	Upper Lagoon's Extent to Soquel Avenue CM0.6 - CM1.41	4,449
2	Soquel Avenue to First Bend Upstream CM1.41 - CM1.77	2,045
3*	First Bend Above Soquel Avenue to Above the Bend Closest to Cherryvale Avenue CM1.77 - CM2.70	4,827
4	Above the Bend Adj. Cherryvale Ave to Bend at End of Cherryvale Ave CM2.70 – CM3.54	4,720
5	Above Proposed Diversion Site to Sharp Bend Above Conference Center CM3.54 - CM4.06	3,041
6	Sharp Bend Above Conference Center to the Moores Gulch Confluence CM4.06-CM5.34	6,640
7*	Moores Gulch Confluence to Above the Purling Brook Road Crossing CM5.34 - CM6.41	5,569
8*	Above Purling Brook Road Crossing to West Branch Confluence CM6.41 - CM7.34	5,123
	Subtotal	39,582 (7.5 miles)
9a*	West Branch Confluence to Mill Pond Diversion CM7.34 - CM9.28	10,243
9b	Mill Pond Diversion to Hinckley Creek Confluence CM9.28 - CM9.55	1,425
10	Hinckley Creek Confluence to Soquel Creek Water District Weir CM9.55 - CM10.66	5,856
11	Soquel Creek Water District Weir to Amaya Creek Confluence CM10.66 - CM11.79	5,932
12a*	Amaya Creek Confluence to Gradient Increase CM11.79 – 12.56	4,062
12b	Gradient Increase to Ashbury Gulch Confluence CM12.56 - CM14.38	9,647
	SUBTOTAL	76,747 (14.5 miles)

Table 2a. Defined Reaches on Soquel Creek (continued).

Reach #	Reach Boundaries (Downstream to Upstream)	Reach Length (ft)
13*	West Branch Confluence to Hester Creek Confluence on West Branch CM0.0 - CM0.98	5,173
14a	Hester Creek Confluence to Girl Scout Falls I CM0.98- CM2.26	6,742
	SUBTOTAL	88,662 (16.8 miles)
14b*	Girl Scout Falls I to Girl Scout Falls II CM2.26 – CM2.89	3,311
14c	Girl Scout Falls II to Tucker Road (Tilly's Ford) CM2.89 – CM4.07	6,216
14d	Tucker Road (Tilly's Ford) to Laurel Mill Dam- 1,465 ft Below Confluence of Laurel and Burns Creeks on West Branch CM4.07 - CM6.56	13,123
	TOTAL	111,312 (21.1 miles)

Table 2b. Locations of Sampling Sites by Reach on Soquel Creek.
(An asterisk indicates sampling in 2008.)

Reach #	Site # -Channel Mile	Location of Sampling Sites
1	*1 -CM1.4	Above Grange Hall
2	2 -CM1.6	Near the USGS Gaging Station
3	3 -CM2.1	Above Bates Creek Confluence
3	*4 -CM2.7	Upper Reach 3, Adjacent Cherryvale Ave Flower Fields
4	5 -CM2.9	Near Beach Shack (Corrugated sheet metal)
4	6 -CM3.4	Above Proposed Diversion Site
5	7 -CM3.9	Upstream to Proposed Reservoir Site, End of Cherryvale
6	8 -CM4.2	Adjacent to Rivervale Drive Access
6	9 -CM4.8	Below Moores Gulch Confluence, Adjacent Mountain School
7	*10 -CM5.5	Above Moores Gulch Confluence and Allred Bridge
7	11 -CM5.9	Below Purling Brook Road Ford
8	*12 -CM7.0	Above Soquel Creek Road Bridge
9a	*13a-CM8.9	Below Mill Pond
9b	13b-CM9.2	Below Hinckley Creek Confluence
10	14 -CM9.7	Above Hinckley Creek Confluence
11	15 -CM10.8	Above Soquel Creek Water District Weir
12a	*16 -CM12.3	Above Amaya Creek Confluence
12b	17 -CM13.0	Above Fern Gulch Confluence
	18 -CM15.2	Above Ashbury Gulch Confluence One Mile
13	*19 -CM0.2	West Branch below Hester Creek Confluence
14a	20 -CM2.0	West Branch Near End of Olson Road
14b	21 -CM2.4	Above Girl Scout Falls I (Added in 2002)
14c	22 -CM3.0	Above Girl Scout Falls II (Added in 2002)

Table 3. Locations of Sampling Sites by Reach in the Aptos Watershed.
(An asterisk indicates sampling in 2006−2008.)

Reach #	Site # -Channel Mile	Location of Sampling Sites
Aptos Creek		
1	1 -CM0.4	Below Mouth of Valencia Creek
2	2 -CM0.5	Just Upstream of Valencia Creek Confluence
2	*3 -CM0.9	Above Railroad Crossing in County Park near Center
3	*4 -CM2.9	In Nisene Marks State Park, 0.3 miles above First Bridge Crossing
Valencia Creek		
1	1 -CM0.9	0.9 miles Up from the Mouth
2	*2 -CM2.85	0.15 miles (840 ft) Below Valencia Road Crossing
3	*3 -CM3.26	0.26 miles (1,400 ft) Above Valencia Road Crossing

Table 4a. Defined Reaches in the Corralitos Sub-Watershed.
(Refer to Appendix A for map designations. Reaches surveyed indicated by asterisk.)

Reach #	Reach Boundaries (Downstream to Upstream)	Reach Length (ft)
Corralitos Creek		
1*	Browns Creek Confluence to 0.25 miles Below Diversion Dam CM0.00 – CM10.25	4,171
2	0.25 miles below Diversion Dam to Diversion Dam CM10.25.6 - CM10.5	1,320
3*	Diversion Dam to Rider Creek Confluence CM10.5 – CM11.77	6,706
4	Rider Creek Confluence to Box Culvert Crossing above Rider Creek Confluence CM11.77 – CM12.87	3,643
5	First Bridge Crossing Above Rider Creek to Clipper Gulch Confluence CM12.46 – CM12.87 CM2.70 - CM3.54	2,165
6*	Clipper Gulch Confluence to Eureka Gulch Confluence CM12.87 – CM13.33	2,429
7*	Eureka Gulch Confluence to Shingle Mill Gulch Confluence CM13.33 –CM13.98	3,432
Shingle Mill Gulch		
1*	From Corralitos Creek Confluence to Second Eureka Canyon Road Crossing on Shingle Mill Gulch CM0.0 – CM0.35	1,848
2	From 2nd Eureka Canyon Road Crossing of Shingle Gulch to 3rd Road Crossing CM0.35 – CM0.62	1,420
3*	3rd Eureka Canyon Road Crossing of Shingle Mill Gulch to Beginning of Steep (Impassable) Gradient on Rattlesnake Gulch CM0.62 –CM1.35	3,858
	Total	30,992 (5.9 miles)
*Browns Valley Creek **		
1*	First Bridge Crossing on Browns Valley Road below the Diversion Dam to the Diversion Dam	1,015
2*	From Diversion Dam to Redwood Canyon Creek Confl.	4,468
	Total	5,483 (1.04 miles)

* More steelhead habitat exists above Reach 2 in Browns Valley Creek and in Redwood Canyon Creek, Ramsey Gulch and Gamecock Canyon Creek. Varying amounts of perennial steelhead habitat exists downstream of Reach 1, depending on bypass flows from the diversion dam.

Table 4b. Locations of Sampling Sites by Reach in the Corralitos Sub-Watershed.
(An asterisk indicates sampling in 2008.)

Corralitos Creek

Reach #	Site # -Channel Mile	Location of Sampling Sites
1	*0 –CM10.1	Downstream of Diversion Pipe Crossing
2	1 –CM10.3	Below Diversion Dam to Around the Bend
3	2 –CM10.6	Just Upstream of Diversion Dam
	*3 –CM11.1	0.6 miles Upstream of Diversion Dam (above Colinas Drive)
	4 –CM11.3	Below Rider Creek Confluence below bridge crossing
	5 –CM11.4	Below Rider Creek confluence and upstream of bridge crossing
4	6 –CM11.4	Upstream of Rider Creek Confluence
5	7 –CM12.0	Upstream of First Bridge Crossing above Rider Creek Confluence
6	*8 –CM12.9	Downstream of Eureka Gulch near Clipper Gulch
7	*9 –CM13.6	0.4 miles Above Eureka Gulch Confluence

Shingle Mill Gulch

1	*1 –CM0.3	Below Second Bridge on Shingle Mill Gulch
2	2 –CM0.5	Above Second Bridge on Shingle Mill Gulch
3	* 3 –CM0.9	Above Washed Out Check Dams below Grizzly Flat on Shingle Mill Gulch

Browns Valley Creek

1	*1 –CM1.9	Between First Browns Valley Road Crossing and Diversion Dam Upstream
2	*2 –CM2.7	Above Diversion Dam but Below Redwood Canyon Creek Confluence

M-6. Juvenile Steelhead Densities at Sampling Sites - Methods

Electrofishing was used at sampling sites to determine steelhead densities according to two juvenile age classes and three size classes in all 4 watersheds in 2007. Block nets were used at all sites to separate habitats during electrofishing. A three-pass depletion process was used to estimate fish densities. If there was poor depletion on 3 passes, a fourth pass was performed and the fish captured in 4 passes were assumed to be a total count of fish in the habitat. Electrofishing mortality rate has been approximately 1% or less over the years. Snorkel-censusing was used in deeper pools that could not be electrofished at sites in the mainstem reaches of the San Lorenzo River, downstream of the Boulder Creek confluence. For the middle mainstem reaches included in Table 2, underwater censusing of deeper pools was incorporated into density estimates with electrofishing data from more shallow habitats.

Visual censusing was judged inappropriate in other habitats because it would be inaccurate in fastwater habitat in the mainstem and in 80-90% of the habitat in tributaries. For example, twenty-four of 26 sampled tributary pools had more than 20 fish in 2005. Most tributary sites are well shaded and many pools have substantial escape cover, making it very difficult to count all of the juveniles, much less divide them into size and age classes. Riffles, step-runs, runs and glides are usually too shallow to snorkel in tributaries. Dense shading in most tributaries also reduces snorkeling effectiveness.

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 (**1988**) for small trout streams. 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 inadequate.

Two divers were used in snorkel censusing. Visual censusing of deeper pools occurred prior to electrofishing of sites. 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 relative proportions of steelhead in the three Size Classes obtained from electrofishing were considered in dividing visually censused steelhead into size and age classes. The average number of steelhead observed per pass in each age and size category became the density estimate. In Reaches 1-4, most juveniles were greater than 75 mm SL, and yearlings were considerably larger than YOY fish. Therefore, it was relatively easy to separate fish into size and age classes. In Reaches 6-9, more juveniles are normally around 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.

Steelhead were visually censused for two size classes of pools in the San Lorenzo. There were short pools less than approximately 200 feet in length and those more than approximately 200 feet. Juvenile densities in censused pools were extrapolated to other pools in their respective size categories. Steelhead were censused by size and age class, as in electrofishing. If less than 20 juveniles were observed in a pool, the maximum number observed on a pass was the estimate. When 20 or more fish were observed, the average of the three passes was the best estimate.

Visual censusing offered realistic density estimates of steelhead in deeper mainstem pools. It was the only practical way to inventory such pools, which were mostly bedrock- or boulder- scoured and had limited escape cover. Visibility was 15 feet or more, making the streambed and counting lanes observable. Very few steelhead used these pools in 1999-2001 and 2003-2008, compared to 1998 when mainstem baseflow was considerably higher (minimum of 30 cubic feet per second at the Big Trees Gage compared to approximately 20 cfs or less in later years).

M-7. Age and Size Class Divisions

With electrofishing data, the young-of-the-year (YOY) 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 combined into 5 mm groupings. Also, scale analysis was utilized for fish captured at lower mainstem sites in the San Lorenzo River and Soquel Creek. Density estimates of age classes in each habitat type were determined by the standard depletion model used with multiple pass capture data. Densities were expressed in fish per 100 feet of channel. Density estimates were measured in the lowest baseflow period of the year when juvenile salmonids remain in specific habitats without up or downstream movement. Density is typically provided per channel length by convention and convenience. Channel length may be accurately measured quickly. If the density measure is consistent from year to year, valid comparisons can be made.

Depletion estimates of juvenile steelhead density were applied separately to two size categories in each habitat at each site. The number of fish in Size Class 1 and combined Classes 2 and 3 were recorded for each pass. The size class boundary between Size Classes 1 and 2 was 75 mm Standard Length (SL) (3 inches) because smaller fish would almost always spend another growing season in freshwater before smolting and entering the ocean the following spring. Although some fish larger than 75 mm SL stayed a second year in the stream, the majority of fish captured during fall sampling that were larger than 75 mm SL were found to smolt the very next spring to enter the ocean. These assumptions are based on scale analysis, back-calculated annuli and standard length determinations by Smith of steelhead smolts captured in spring of 1987 and 1989 (**Smith unpublished**). He found that 97% of a random sample (n=248) of yearling smolts in spring were 76 mm SL or longer after their first growing season. In addition, about 75% of smolts that were 75 mm SL or larger at their first annulus (n=319) smolted as yearlings. All 2-year old smolts from a random sample (n=156) were larger than 75 mm SL after 2 growing seasons prior to smolting. Also, 95% of these 2-year olds were at least 60 mm SL after their first growing season, indicating that few YOY less than 60 mm SL after their first growing season survived to smolt.

The depletion method estimated the number of fish in each sampled habitat in two size categories; those less than (<) 75 mm SL (Class 1) and those equal to or greater than (=>) 75 mm SL (Classes 2 and 3). Then, the number of juveniles => 75 mm SL (Class 2) was estimated separately from the juveniles => 150 mm SL (Class 3). This was done by multiplying the proportion of each size class (Class 2 and 3 separately) in the group of captured fish by the estimate of fish density for all fish => 75 mm SL. A density estimate for each habitat type at each site was then determined for each size class. Densities in each habitat type were added together and divided by the total length of that habitat type at the sampling site to obtain a density estimate by habitat type.

The depletion method was also used to estimate the number of fish in each sampled habitat based on 2 age classes: young-of-the-year (YOY) and yearling and older (1+) age classes. Age classes in the mainstem San Lorenzo and mainstem Soquel Creek were determined by scale analysis of a spectrum of fish sizes in 2007. A total of 28 larger San Lorenzo juvenile steelhead and 10 larger Soquel Creek juveniles were aged by scale analysis, along with 20 juveniles from Soquel Lagoon. These limited results showed that the majority of fish => 75 mm SL in the mainstems and lagoon were YOY, but also included yearlings that moved into the mainstem after slow tributary growth in their first year. These data provided information for age class division for both watersheds. Scale analysis, along with past experience of growth rates, and breaks in fish length histograms were used to discern age classes at other sampling sites. Density estimates determined by size class and age class were not the same when YOY reached Size Class II by fall.

In 2008, the lower mainstem of the San Lorenzo River and Soquel Creek, some YOY steelhead reached Size Class 2 size in one growing season, as did a few in the middle mainstem San Lorenzo and upper mainstem of Soquel Creek. In this monitoring report, sampling site densities were compared for 11 years in the San Lorenzo system by size and age (1997−2001 and 2003−2008) and for 12 years in Soquel Creek (1997−2008). At each sampling site, habitat types were sampled separately, with density estimates calculated for each habitat. Then these density estimates were combined and divided by the stream length of the entire site for annual site density comparisons.

RESULTS

R-1. Capture and Mortality Statistics

For this study overall in 2008, 4,246 juvenile steelhead were captured by electrofishing among all sites, with 31 mortalities (0.73% mortality rate). A total of 98 juvenile and 1 adult steelhead were visually censused at mainstem sites. All but one of the lost steelhead were small YOY fish less than 65 mm SL. Six mainstem sites and 11 tributary sites were sampled in the San Lorenzo watershed in 2008, with a total of 2,069 juvenile steelhead captured and 17 mortalities (0.82%). A total of 1,037 juvenile steelhead were captured at 7 sites in the Soquel watershed in 2008 with 7 mortalities (0.68%). A total of six juvenile coho salmon were captured in East Branch Soquel (Reach 9a) with no mortalities. A total of 527 juveniles steelhead were captured in the Aptos Watershed at 4 sites with 2 mortalities (0.38%). A total of 613 juveniles were captured in the Corralitos watershed at 8 sites with 5 mortalities (0.82%).

R-2. Habitat Change in the San Lorenzo River Mainstem and Tributaries, 2007 to 2008

Refer to **Appendix A** for maps of reach locations. A summary table of habitat change for all reaches is provided in **Table 41**. Overall habitat quality declined in the lower and middle mainstem (Reaches 1, 2, 4, 6 and 8) primarily due to shallower (and presumably slower) fastwater habitat caused by channel widening and reduced escape cover in either riffles or runs in each reach (**Tables 5b, 6, 9 and 10**). Riffle habitat also became more embedded in Reaches 4 and 8 (**Table 8**). Pools had more fines in Reaches 1 and 2 (**Table 7**). Riffles had less escape cover in Reaches 1 (slightly more in runs), 4 (slightly more in runs) and 8 (also less in runs) (**Tables 9 and 10**). Runs also had less escape cover in Reach 2. Pool escape cover was less important because most steelhead were in fastwater in the lower and middle mainstem. However, it increased slightly in Reaches 1, 4 and 6 and declined slightly in Reaches 2 and 8 (**Table 11**). Pool depth increased in all but Reach 6, on average, in the lower and middle mainstem, indicating some scouring. In the upper mainstem reach that was monitored, Reach 11 near Teihl Road, slight habitat decline was detected with slight shallowing of pool depth, higher embeddedness in pools and runs, and more percent fines in pools.

In San Lorenzo River tributaries, of the 12 reaches monitored and compared between 2007 and 2008, 6 reaches were similar in habitat quality (3 in Zayante, 2 in Branciforte and 1 in Bear), 3 reaches had slight decline in habitat quality (2 in Boulder and 1 in Fall (compared to 2000)), 2 reaches had significant decline (2 in Bean) and one reach had slight improvement in habitat quality (Lompico). Slight declines were attributed to shallowing of habitat due to reduced streamflow. Scour was evident in pools in some reaches to offset the reduced streamflow. Substrate conditions remained similar in most reaches between years. Significant declines were due to reduced pool escape cover in middle Bean and dewatering in upper Bean Creek.

In Zayante Creek, habitat conditions were similar between years with deepening in pool depth in Reach 13a despite less streamflow (indicating scour of fines) and slight shallowing in fastwater habitat due to reduced streamflow. Embeddedness increased in Reach 13c pools and runs in both Reaches 13a and 13c. Escape cover in pools (**Table 12**) and percent fines remained similar in all three monitored reaches.

In Lompico Creek, habitat conditions improved slightly in 2008 with deeper mean and maximum pool depth, on average, and slightly more pool escape cover (**Table 12**). Embeddedness and percent fines remained similar. Of course, riffles and runs were shallower due to reduced streamflow.

In Bean Creek, in the normally productive middle Reach 14b, overall habitat conditions declined with 27% less pool escape cover after human cutting of instream wood, and mean pool and run depth decreased slightly. However, substrate improved in runs with less fines and reduced embeddedness. Upper Reach 14c had only a few isolated puddles by late September 2008, eliminating all fish habitat. Based on August 2008 habitat typing before the reach became nearly completely dewatered, substrate conditions were similar to 2007, and pools were slightly more scoured.

In Boulder Creek, habitat quality declined slightly in Reaches 17a and 17b due to general shallowing of pool and run/step-run habitat resulting from reduced streamflow and slightly reduced escape cover in these habitats, too, except for slightly more escape cover in Reach 17b pools. Percent fines and embeddedness were similar between years.

Bear Creek habitat quality was similar between years, with similar pool escape cover, embeddedness and percent fines. Some sediment scour was detected in pools with greater maximum pool depth, but average pool depth was slightly shallower.

Habitat conditions were similar in the two lower Branciforte reaches between years, although there was some evidence of slight scour and deepening in pools in the lowermost reach, and reduced embeddedness in runs there. Percent fines were less in runs in both monitored reaches. Pool escape cover was similar between years, with slightly more in the upper reach in 2008.

R-3. Habitat Change in Soquel Creek and Its Branches, 2007 to 2008

Refer to **Appendix A** for maps of reach locations. A summary table of habitat change for all reaches is provided in **Table 41**. For **lower mainstem** Reaches 1 and 3 below Moores Gulch, Reach 1 had similar habitat quality (slightly deeper pools but slightly less pool escape cover) and Reach 3 had lower habitat quality (shallower pools and less pool escape cover; less riffle habitat for insect production) (**Tables 14−17**). For **upper mainstem** Reaches 7 and 8 below the Branch confluences, Reach 7 had similar habitat quality (slightly deeper maximum pool depths and similar substrate and pool escape cover; less riffle habitat for insect production) and Reach 8 had lower habitat quality (shallower pools and fastwater habitat, increased fines in pools and runs, increased embeddedness in runs, but similar pool escape cover). In the **lower East Branch**, Reach 9 below Hinckley Creek and Mill Pond had higher habitat quality (slightly lower average pool depth but slightly deeper maximum pool depth, similar substrate conditions and more pool escape cover). **Upper East Branch** Reach 12a in the SDSF had reduced habitat quality (shallower pools and fastwater habitat and less pool escape cover, with more stream channel dewatered (346 ft in 2008 vs. 165 ft in 2007); considerable riffle and step-run habitat lost to shallow pool habitat). On the **lower West Branch**, Reach 13 had similar habitat quality (slightly deeper maximum pool depth, slightly shallower runs, similar substrate conditions and slightly less pool escape cover) and **middle West Branch** Reach 14b between Girl Scout Falls I and II had similar habitat quality (slightly shallower average pool depth, shallower run habitat, similar substrate conditions and similar pool escape cover).

R-4. Habitat Change in Aptos and Valencia Creeks, 2007 to 2008

Refer to **Appendix A** for maps of reach locations. A summary table of habitat change for all reaches is provided in **Table 41**. The January 1982 storm caused severe streambank erosion and landsliding throughout the Santa Cruz Mountains, and streams have been recovering since. The 1997-98 winter also brought significant stormflow and sedimentation into other watersheds by 1999, such as the San Lorenzo River (**Alley 2000**). From 2007 to 2008 habitat conditions continued to improve in 3 of 4 studied reaches in the Aptos Creek watershed, with the exception of the lower Reach 2 in Valencia Creek (**Table 41**). The reduced baseflow in 2008 (**Table 5b**) caused somewhat shallower pools, riffles and runs and reduced fastwater habitat, but pool escape cover was increased in the 3 of 4 reaches, offsetting the shallower habitat (**Tables 5c and 18**). Substrate conditions were generally similar between years in all habitat types, though percent fines and embeddedness worsened in the upper Valencia Creek Reach 3 (**Tables 18−20**). Habitat quality worsened only in lower Valencia Creek Reach 2 because habitat conditions shallowed without any increase in pool escape cover.

R-5. Habitat Change in Corralitos, Shingle Mill and Browns Valley Creeks, 2007 to 2008

Refer to **Appendix A** for maps of reach locations. A summary table of habitat change for all reaches is provided in **Table 41**. Reach 1 below the Corralitos diversion dam experienced higher streamflow than the previous year without the diversion being active. As a result, habitat conditions were improved in 2008 with deeper habitat conditions, faster water velocities and more pool escape cover (**Table 18**). More percent fines and higher embeddedness were detected in most habitat types in this reach (**Tables 19−20**). However, the change was 10% or greater and assumed beyond potential inaccuracy due to visual estimates in only pool percent fines and run/step-run embeddedness.

Reach 3 on Corralitos Creek below Rider Creek had reduced habitat quality due to reduced pool depth probably beyond effects of reduced streamflow, reduced run depth, reduced pool escape cover, with general substrate decline from increased fines in pools and riffles and increased embeddedness in riffles and runs.

Reach 6 above the box culvert and below Eureka Gulch had slightly reduced habitat quality resulting from slightly shallower pool and riffle habitat (presumably due to reduced baseflow) and more fines in pools. All other habitat parameters were similar between years. The proportion of fastwater habitat was not lost (**Table 5c**).

Habitat quality in Reach 7 above Eureka Gulch was reduced because of the presumably lower baseflow in 2008. More valuable step-run habitat in 2007 became shallow pool habitat in 2008, with shallower pool and step-run habitat. Step-run habitat with some escape cover and water velocity for insect habitat and insect drift would be better habitat than shallow, stagnant pool habitat. The proportion of pool habitat went from 35% in 2007 to 52% in 2008. Pool escape cover increased slightly and step-run escape cover was similar in 2008. Substrate conditions were similar between years.

In Shingle Mill Gulch, baseflow was very low both years. In Reach 1, all habitat parameters were similar (**Tables 18-20**), but as in Reach 7 in Corralitos Creek, substantial step-run habitat was lost to shallow pool habitat, indicating a reduced habitat quality. In Reach 3, habitat quality was similar between years. Pool habitat was slightly shallower, but pool escape cover was slightly higher in 2008. All other habitat parameters were similar between years, and habitat proportions remained similar.

Habitat quality improved in Reach 1 below Redwood Canyon creek on Browns Valley Creek due to increased pool, riffle and run depth, despite presumably reduced baseflow, and increased pool escape cover (**Tables 18-20**). About 5% of run/step-run habitat was lost to pool habitat. Habitat quality in Reach 2 above Redwood Canyon Creek was similar between years, with slight shallowing in maximum pool depth and run/step-run depth. All other habitat parameters were similar, with 4% of run/step-run habitat lost to pool habitat. This contributed to the shallower pool conditions along with presumably reduced baseflow.

Table 5a. Fall STREAMFLOW (cubic feet/ sec) Measured by Flowmeter at SAN LORENZO Sampling Sites Before Fall Storms, 1995-2001 and 2003-2006 by D.W. ALLEY & Associates.

Site # - Location	1995	1996	1998	1999	2000	2001	2003	2004	2005	2006
1- SLR/ Paradise Pk	22.9	25.5	34.3	26.2	21.7	19.6				26.2
2- SLR/Rincon				24.0	21.1	17.2				
3-SLR Gorge	23.3	20.5								
4-SLR/Henry Cowell	18.7		32.7	23.3	21.8	15.5				24.1
5- SLR/Below Zayante			31.9							
6- SLR/ Below Fall	14.6		23.4	12.8	11.6	9.4	10.6	8.8	18.9	14.3
7- SLR/ Ben Lomond	5.8				5.4	3.7	5.4	3.7	8.1	
8- SLR/Below Clear Ck	4.2		10.3	4.9	4.2	3.1	4.2	2.7	7.1	6.4
9- SLR/Below Boulder Ck	4.6		7.2	3.5		3.0	3.7	2.1	5.8	
10- SLR/Below Kings Ck				3.0	1.1	1.3	0.6	0.52	1.4	
11- SLR/ Teihl Rd			1.7	0.8	0.8	0.4	0.9	0.63	1.5	
12a- SLR/Lower Waterman G			1.0	0.7						
13a- Zayante below Bean			8.5	6.3	5.2	4.7	5.4	5.1	7.4	7.8*
13b- Zayante above Bean			3.9	2.9	2.8	1.9	2.1	1.7	3.2	2.8
14b- Bean below Lockhart G	1.5		1.1	1.1	1.0	1.1	1.1	0.77	1.0	1.1
15- Fall	2.0		3.4	2.2	1.7	1.7				
16- Newell	1.6				0.51					
17a- Boulder	2.0		2.2		1.1	1.0	1.25	0.9	1.6	1.7
18a- Bear				0.45	0.61	0.34	0.6	0.51	0.90	1.1
19a- Lower Kings			1.1	0.11	0.17	0.02				
20a- Lower Carbonera	0.33	0.36								
21a-2- Branciforte			0.80							

*Streamflow in lower Zayante Creek done 3 weeks earlier than usual and before other locations.

Table 5b. Fall/Late Summer STREAMFLOW (cubic feet/ sec) Measured by Santa Cruz County Staff in 2006 − 2008 and Obtained from Stream Gages.

Location	2006	2007	2008
SLR at Sycamore Grove	34.8	14.6	14.2
SLR at Big Trees	26	11	12
SLR above Love Cr	13.14	5.42 After*	3.8
SLR below Boulder Cr	7.49	2.87 After	3.1
SLR @ Two Bar Cr	1.81	0.78	0.39
Zayante @ SLR	6.51	3.80	–
Zayante below Lompico Cr	1.21	0.96	0.41
Bean at Mt. Hermon	2.6	1.9	2.1
Bean Below Lockhart Gulch	1.37	0.72	0.79
Newell Cr @ Rancho Rio	1.18	1.16	1.11
Boulder Cr @ SLR	2.09	0.84	1.04
Bear Cr @ SLR	1.87	0.37	0.27
Soquel Cr at USGS Gage	7.1**	1.3**	0.65**
Soquel Cr @ Bates Cr	5.73	-	1.08
W. Branch Soquel @ S.J. Olive Springs	2.17 (1.6 cfs in 2000)	1.75 After	–
W. Branch above Hester Creek (Soquel Creek Water District Weir/ Brook Kraeger - preliminary)	1.48 (15 Sep)	1.04 (15 Sep)	–
E. Branch Soquel @ 152 Olive Springs Rd.	-	1.01 After	–
E. Branch below Amaya and above Olive Springs Quarry (Soquel Creek Water District Weir/ Brook Kraeger-preliminary)	1.53 (15 Sep)	0.43 (15 Sep)	–
Aptos Cr @ Valencia Cr	2.48	1.21 After	0.77
Valencia Cr @ Aptos Cr			0.007
Corralitos Cr below Browns Valley Road Bridge	15.94 (May)	0.49 (May)	dry
Corralitos Cr @ Rider Cr	3.35	2.50 After	1.44
Browns Cr @ 621 Browns Valley Rd	0.96	0.30 After	0.32

* After 2 early October storms that increased baseflow.
** Estimated from USGS Hydrographs.

Table 5c. Habitat Proportions in Habitat-Typed Reaches of the San Lorenzo, Soquel, Aptos and Corralitos Watersheds in 2007 and 2008.

Reach	2008 Pool Habitat Feet/ Percent / # Habitats	2007 Pool Habitat Feet/ Percent / # Habitats	2008 Riffle Habitat Feet/ Percent / # Habitats/ Riffle Width (ft)	2007 Riffle Habitat Feet/ Percent / # Habitats/ Riffle Width (ft)	2008 Run/Step-run Habitat Feet/ Percent / # Habitats/ Width (ft)	2007 Run/ Step-run Habitat Feet/ Percent / #Habitats/ Width (ft)
Low. San Lorenzo #1	1948/63%/ 6	1653/61%/ 5	501/ 16%/ 8/ 26 ft	533/ 20%/ 8/ 21 ft	634/ 21%/ 6/ 38 ft	527/ 19%/ 6/ 29 ft
Low. San Lorenzo #2	2321/70%/ 10	2371/68%/ 12	572/ 17%/ 12/ 26 ft	873/ 25%/ 10/ 25 ft	400/ 12%/ 6/ 24.5 ft	232/ 7%/ 4/ 34 ft
Low. San Lorenzo #4	3227/77%/ 11	3347/82%/ 7	494/ 12%/ 10/ 29 ft	480/ 12%/ 8/ 24.5 ft	460/ 11%/ 8/ 30 ft	269/ 7%/ 3/ 26 ft
Mid. San Lorenzo #6	3280/75%/ 13	3456/75%/ 12	523/ 12%/ 10/ 29 ft	592/ 13%/ 11/ 17 ft	596/ 15%/ 8/ 29 ft	569/ 12%/ 8/ 15 ft
Mid. San Lorenzo #8	3459/85%/ 14	3481/83%/ 16	169/ 4%/ 5/ 20 ft	224/ 5%/ 8/ 16.5 ft	438/ 11%/ 9/ 15 ft	487/ 12%/ 8/ 14 ft
Up. San Lorenzo #11	2205/68%/ 21	2310/70%/ 21	253/ 8%/ 11	235/ 7%/ 12	775/ 24%/ 11	775/ 23%/ 16
Zayante #13a	1740/64%/ 13	1669/61%/ 15	530/ 20%/ 12	546/ 20%/ 14	443/ 16%/ 7	523/ 19%/ 7
Zayante #13c	2108/74%/ 22	2371/83%/ 23	235/ 8%/ 10	292/ 10%/ 14	505/ 18%/ 10	195/ 7%/ 7
Zayante #13d	1850/72%/ 36	1857/71%/ 36	120/ 5%/ 8	120/ 5%/ 9	240/ 9%/ 7	651/ 25%/ 22
Lompico #13e	1557/51%/ 37	1667/62%/ 39	304/ 10%/ 10	432/ 16%/ 26	1198/ 39%/ 28	600/ 22%/ 21
Bean #14b	2049/70%/ 29	1719/61%/ 25	506/ 17%/ 19	529/ 19%/ 19	352/ 12%/ 11	580/ 21%/ 11
Bean #14c	909/ 78%/ 20	662/ 71%/ 30	104/ 9% 7	19 21%/ 26	157/ 13%/ 5	68/ 7%/ 5
Fall #15	528/ 17%/ 26	-	2098/ 68%/ 30	-	472/ 15%/ 16	-
Boulder #17a	1514/ 55%/ 22	1369 52%/ 19	260/ 10%/ 12	40 15%/ 16	963/ 35%/ 17	873/ 33%/ 17
Boulder #17b	1554/ 66%/ 25	1345 63%/ 20	127/ 5%/ 6	28 13%/ 10	682/ 37%/ 13	514/ 24%/ 7
Bear #18a	2393/ 73%/ 22	2395 70%/ 23	213/ 6%/ 7	30 9%/ 12	374/ 11%/ 6	709/ 21%/ 17

Reach	2008 Pool Habitat Feet/ Percent / # Habitats	2007 Pool Habitat Feet/ Percent / # Habitats	2008 Riffle Habitat Feet/ Percent / # Habitats	2007 Riffle Habitat Feet/ Percent / # Habitats	2008 Run/Step-run Habitat Feet/ Percent / # Habitats	2007 Run/ Step-run Habitat Feet/ Percent / #Habitats
Branciforte #21a-1	2380/ 85%/ 20	2279 83%/ 21	290/ 10%/ 13	318/ 12%/ 19	125/ 5%/ 5	158/ 6%/ 10
Branciforte #21a-2	2079/ 75% 27	1998/ 3%/ 28	256/ 9%/ 20	268/ 10%/ 18	453/ 16%/ 14	472/ 17%/ 18
Soquel #1	3293/ 76%/ 15	3380/80%/ 16	392/ 9%/ 10	445/ 10%/ 12	648/ 15%/ 9	411/ 10%/ 9
Soquel #3a	2308/ 68%/ 18	1618/64%/ 11	320/ 9%/ 14	409/ 16%/ 10	769/ 23%/ 10	499/ 20%/ 10
Soquel #7	2569/ 67%/ 21	2104/62%/ 20	393/ 10%/ 12	446/ 13%/ 14	899/ 23%/ 14	832/ 25%/ 11
Soquel #8	2122/ 72%/ 16	1514/63%/ 11	391/ 13%/ 11	381/ 16%/ 9	440/ 15%/ 7	495/ 21%/ 5
E. Branch Soquel #9a	1653/ 54%/ 18	1732/56%/ 18	328/ 11%/ 14	338/ 11%/ 12	1105/ 36%/ 17	1018/ 33%/ 14
E. Branch Soquel #12a	1728/ 74%/ 30	1126/45%/ 25	18/ 1% 1	122/ 5%/ 9	583/ 25%/ 16	1238/ 50%/ 18
W Branch Soquel #13	1833/ 67%/ 16	1833/67%/ 16	446/ 16%/ 16	371/ 14%/ 14	468/ 17%/ 12	517/ 19%/ 10
W. Branch Soquel #14b	2214/ 69%/ 31	2218/71%/ 33	333/ 10%/ 17	313/ 10%/ 14	662/ 21%/ 15	604/ 19%/ 17
Aptos #2	2085/ 77% 21	1911/70%/ 21	526/ 20%/ 20	443/ 16%/ 19	90/ 3%/ 3	379/ 14%/ 9
Aptos #3	1911/ 66%/ 23	1744/61%/ 23	762/ 26%/ 21	730/ 26%/ 22	226/ 8%/ 9	367/ 13%/ 12
Valencia #2	638/ 23%/ 15	608/ 21%/ 19	710/ 25%/ 25	759/ 26%/ 31	1438/ 52% 18	1508/ 52%/ 25
Valencia #3	1954/ 73% 43	1797/69%/ 43	484/ 18%/ 38	507/ 19%/ 32	239/ 9%/ 11	314/ 12%/ 11
Corralitos #1	1478/ 54%/ 21	1520/56%/ 22	734/ 27%/ 24	241/ 9%/ 11	532/ 19%/ 12	938/ 35%/ 13
Corralitos #3	1392/ 53%/ 23	1417/54%/ 18	685/ 26%/ 22	477/ 18%/ 18	571/ 22%/ 13	709/ 27%/ 11
Corralitos #5/6	1532/ 51%/ 28	1479/51%/ 26	323/ 11%/ 13	322/ 11%/ 14	1121/ 38%/ 19	1126/ 38%/ 16
Corralitos #7	1406/ 52% 45	983/ 35%/ 27	74/ 3%/ 6	77/ 3%/ 4	1226/ 45%/ 27	1780/ 63%/ 23

Reach	2008 Pool Habitat Feet/ Percent / # Habitats	2007 Pool Habitat Feet/ Percent / # Habitats	2008 Riffle Habitat Feet/ Percent / # Habitats	2007 Riffle Habitat Feet/ Percent / # Habitats	2008 Run/Step-run Habitat Feet/ Percent / # Habitats	2007 Run/ Step-run Habitat Feet/ Percent / #Habitats
Shingle Mill #1	950/ 45%/ 50	719/ 35%/ 39	344/ 16%/ 31	264/ 13%/ 15	789/ 38%/ 26	1098/ 53%/ 27
Shingle Mill #3	1681/ 63%/ 63	1591/61%/ 61	663/ 26%/ 46	686/ 26%/ 41	306/ 11%/ 16	338/ 13%/ 16
Browns Valley #1	1537/ 56%/ 32	1321/51%/ 30	504/ 19%/ 20	513/ 20%/ 20	683/ 25%/ 19	757/ 29%/ 16
Browns Valley #2	1633/ 60%/ 43	1479/56%/ 43	646/ 24%/ 31	641/ 24%/ 29	426/ 16% 19	530/ 20%/ 18

Table 6. Averaged Mean and Maximum WATER DEPTH (ft) of Habitat in SAN LORENZO Reaches Since 2003.

Reach	Pool 2003	Pool 2005	Pool 2006	Pool 2007	Pool 2008	Riffle 2003	Riffle 2005	Riffle 2006	Riffle 2007	Riffle 20008	Run/ Step-Run 2003	Run / Step Run 2005	Run / Step Run 2006	Run / Step Run 2007	Run / Step Run 2008
1- L. Main			2.5/ 4.4	1.8/ 3.0	**1.85 / 3.4**			1.1/ 1.5	0.8/ 1.2	**0.7/ 1.2**			2.4/ 3.1	1.0/ 1.5	**0.9/ 1.35**
2- L. Main	3.0/ 5.2 (2000			2.5/ 4.1	**2.6/ 5.1**	1.2/ 2.0 (2000			0.9/ 1.4	**0.8/ 1.3**	1.7/ 2.4 (2000			1.4/ 2.2	**1.3/ 1.9**
3- L. Main															
4- L. Main			2.6/ 4.4	1.9/ 3.8	**2.0/ 3.6**			0.9/ 1.5	0.7/ 1.2	**0.5/ 1.0**			1.6/ 2.2	1.4/ 2.1	**0.9/ 1.5**
5- L. Main															
6- M. Main	1.9/ 3.5	1.9/ 3.4	2.2/ 4.3	1.7/ 3.4	**1.6/ 3.1**	0.6/ 0.9	0.9/ 1.4	0.8/ 1.3	0.6/ 1.0	**0.55/ 0.9**	1.2/ 1.9	1.1/ 2.1	1.3/ 1.85	0.9/ 1.3	**0.8/ 1.1**
7- M. Main	1.8/ 3.7	2.0/ 3.5				0.6/ 1.0	0.7/ 1.1				0.9/ 1.4	1.1/ 1.4			
8- M. Main	2.5/ 5.2	2.6/ 5.8	2.7/ 5.5	2.3/ 4.3	**2.3/ 4.7**	0.6/ 1.0	1.0/ 1.5	1.1/ 1.6	0.6/ 1.0	**0.45/ 0.7**	1.0/ 1.4	1.3/ 2.1	1.3/ 2.25	0.8/ 1.2	**0.8/ 1.2**
9- M. Main	1.7/ 3.0	1.9/ 3.5				0.6/ 1.1	0.7/ 1.1				0.8/ 1.2	1.0/ 1.4			
10- U. Main	1.4/ 2.9	1.4/ 2.8				0.3/ 0.5	0.4/ 0.7				0.5/ 0.9	0.7/ 1.0			
11- U. Main		1.1/ 2.0	1.1/ 2.1	1.0/ 1.9	**0.9/ 1.8**		0.4/ 0.7	0.5/ 0.8	0.2/ 0.4	**0.25/ 0.5**		0.5/ 1.0	0.6/ 1.1	0.4/ 0.6	**0.4/ 0.7**
12b- U. Main		1.3/ 2.2					0.3/ 0.6					0.5/ 0.8			
Zayante 13a	1.1/ 2.1	1.5/ 2.5	1.6/ 2.6	1.4/ 2.2	**1.5/ 2.5**	0.7/ 1.1	0.6/ 0.9	0.6/ 0.9	0.5/ 0.8	**0.4/ 0.8**	0.7/ 1.2	0.8/ 1.1	0.85/ 1.2	0.6/ 1.0	**0.6/ 0.9**
Zayante 13b	1.5/ 2.4	1.7/ 2.9				0.5/ 0.7	0.5/ 0.9				0.8/ 1.1	0.7/ 1.2			
Zayante 13c	1.2/ 2.2	1.35 / 2.4		1.2/ 2.2	**1.2/ 2.2**	0.4/ 0.7	0.5/ 0.8		0.2/ 0.5	**0.2/ 0.6**	0.5/ 1.0	0.7/ 1.0		0.5/ 0.9	**0.4/ 0.8**
Zayante 13d	1.1/ 1.7	1.1/ 2.1	1.35 / 2.1	1.0/ 1.5	**1.0/ 1.55**	0.4/ 0.6	0.5/ 0.7	0.45/ 0.8	0.3/ 0.5	**0.2/ 0.5**	0.8/ 1.3	0.8/ 1.4	0.9/ 1.4	0.6/ 1.0	**0.5/ 0.9**
Lompico 13e			1.1/ 1.8	0.8/ 1.5	**1.0/ 1.7**			0.3/ 0.6	0.15 /0.4	**0.1/ 0.3**			0.45/ 0.8	0.35/ 0.65	**0.3/ 0.5**
Bean 14a	0.8/ 1.6	1.0/ 1.9				0.4/ 0.7	0.4/ 0.7				0.6/ 1.2	0.7/ 1.1			
Bean 14b	0.9/ 1.5	1.0/ 1.9		1.1/ 1.8	**1.0/ 1.8**	0.3/ 0.6	0.3/ 0.5		0.2/ 0.4	**0.2/ 0.4**	0.6/ 0.9	0.6/ 0.8		0.4/ 0.8	**0.4/ 0.65**
Bean 14c	1.0/ 1.7	1.0/ 1.7	1.0/ 1.8	0.8/ 1.5	**0.9/ 1.7**	0.1/ 0.3	0.1/ 0.3	0.2/ 0.3	0.03 /0.1	**0.03/ 0.1**	0.25/ 0.4	0.2/ 0.5	0.35/ 0.5	0.1/ 0.2	**0.06/ 0.1**

Reach	Pool 2003	Pool 2005	Pool 2006	Pool 2007	Pool 2008	Riffle 2003	Riffle 2005	Riffle 2006	Riffle 2007	Riffle 2008	Run/ Step-Run 2003	Run/ Step Run 2005	Run/ Step Run 2006	Run/ Step Run 2007	Run/ Step Run 2008
Fall 15	1.0/ 1.8 (2000				**0.9/ 1.4**	0.2/ 0.5 (2000				**0.4/ 0.8**	0.4/ 0.6 (2000				**0.6/ 0.9**
Newell 16			1.6/ 2.8					0.3/ 0.5					0.6/ 0.9		
Boulder 17a		1.8/ 2.9	2.0/ 3.1	1.7/ 2.7	**1.6/ 2.6**		0.5/ 0.9	0.6/ 1.0	0.4/ 0.7	**0.4/ 0.7**		0.7/ 1.2	0.9/ 1.4	0.6/ 1.0	**0.6/ 0.95**
Boulder 17b		1.7/ 2.8	1.7/ 2.8	1.6/ 2.7	**1.5/ 2.7**		0.4/ 1.0	0.6/ 1.0	0.4/ 0.75	**0.3/ 0.6**		0.7/ 1.2	0.8/ 1.4	0.6/ 1.1	**0.55/ 0.95**
Boulder 17c		1.9/ 2.9					0.4/ 0.8					0.9/ 1.5			
Bear 18a	2.0/ 3.4	2.0/ 3.4	2.0/ 3.35	1.4/ 2.4	**1.3/ 2.55**	0.4/ 0.7	0.4/ 0.7	0.6/ 0.9	0.2/ 0.4	**0.2/ 0.4**	0.6/ 0.9	0.7/ 1.1	0.8/ 1.25	0.4/ 0.7	**0.35/ 0.7**
Bear 18b															
Branciforte 21a-1				1.2/ 2.2	**1.35 / 2.3**				0.15 /0.3	**0.2/ 0.3**				0.3/ 0.5	**0.3/ 0.6**
Branciforte 21a-2			1.1/ 1.9	1.0/ 1.7	**0.9/ 1.7**			0.3/ 0.5	0.2/ 0.4	**0.2/ 0.35**			0.5/ 1.0	0.4/ 0.7	**0.45/ 0.65**
Branciforte 21b		1.1/ 1.7					0.4/ 0.7					0.3/ 0.6			

Table 7. Average PERCENT FINE SEDIMENT* IN SAN LORENZO Reaches River Since 2003.

Reach	Pool 2003	Pool 2005	Pool 2006	Pool 2007	Pool 2008	Riffle 2003	Riffle 2005	Riffle 2006	Riffle 2007	Riffle 2008	Run/ Step Run 2003	Run/ Step Run 2005	Run/ Step Run 2006	Run/ Step Run 2007	Run/ Step Run 2008
1			80	65	**77**			20	15	**20**			40	46	**46**
2	70 (2000			42	**54**	25 (2000			10	**13**	50 (2000			26	**23**
4			75	46	**47**			20	13	**10**			50	42	**37**
6	70	70	75	61	**68**	25	20	25	17	**12**	35	40	38	18	**23**
7	70	70				25	20				50	40			
8	55	65	60	41	**47**	25	20	20	7	**6**	40	25	25	11	**16**
9	70	60				25	15				30	30			
10	60	70				20	15				25	35			
11	55	35	40	32	**52**	40	15	25	10	**9**	45	25	15	24	**14**
12b	50	35				35	35				40	10			
Zayante 13a	85	65	65	59	**62**	40	25	35	22	**19**	70	50	40	36	**31**
Zayante 13b	65	65				30	30				45	30			
Zayante 13c	50	45		45	**47**	25	10		9	**12**	30	20		27	**34**
Zayante 13d	40	40	50	38	**44**	25	25	15	13	**13**	25	25	40	21	**29**
Lompico 13e			50	49	**54**			20	15	**20**			30	24	**29**
Bean 14a	80	70				40	25				70	35			
Bean 14b	85	80		67	**66**	45	15		18	**9**	80	45		58	**34**
Bean 14c	70	60	65	42	**37**	25	5	15	6	**6**	40	30	40	28	**10**
Newell 16			25					5					20		
Fall 15	74 (2000				**64**	50 (2000				**30**	63 (2000				**48**
Boulder 17a		30	35	31	**27**		20	5	12	**9**		15	20	17	**13**
Boulder 17b		30	35	31	**32**		5	10	5	**5**		15	15	12	**14**
Boulder 17c		25					5					5			
Bear 18a	55	50	60	41	**46**	15	15	15	7	**11**	25	20	25	13	**13**
Bear 18b															
Brancifo rte 21a-1				65	**62**				7	**10**				30	**16**
Brancifo rte 21a-2			75	50	**42**			40	12	**8**			55	35	**21**
Brancifo rte 21b		55					15					65			

* Fine sediment was visually estimated as particles less than approximately 2 mm (0.08 inches).

Table 8. Average EMBEDDEDNESS IN SAN LORENZO Reaches Since 2003.

Reach	Pool 2003	Pool 2005	Pool 2006	Pool 2007	Pool 2008	Riffle 2003	Riffle 2005	Riffle \2006	Riffle 2007	Riffle 2008	Run/ Step Run 2003	Run/ Step Run 2005	Run/ Step Run 2006	Run/ Step Run 2007	Run/ Step Run 2008
1			59	50	**52**			31	23	**26**			49	48	**48**
2				26	**38**	30* (2000			13	**18**	30* (2000)			23	**25**
3															
4			64	43	**45**			37	19	**33**			47	37	**42**
5															
6	52	49	56	45	**51**	27	31	31	18	**21**	38	46	41	34	**39**
7	53	54				34	27				49	40			
8	49	53	56	40	**46**	32	25	28	18	**30**	44	29	35	28	**26**
9	52	39				32	25				40	31			
10	38	39				32	27				32	34			
11		58	48	34	**47**		30	33	22	**30**		45	27	31	**43**
12b		58					27					45			
Zayante 13a	44	45	54	44	**51**	33	29	23	25	**30**	41	44	50	36	**47**
Zayante 13b	44	46				36	25				43	39			
Zayante 13c	48	48		36	**49**	29	25		19	**28**	33	38		31	**44**
Zayante 13d	41	47	51	55	**49**	35	48	37	30	**33**	33	43	42	39	**37**
Lompico 13e			55	52	**47**			42	16	**19**			46	37	**32**
Bean 14a	46	45				32	21				49	37			
Bean 14b	35	41		45	**44**	35	20		22	**14**	41	29		36	**22**
Bean 14c	49	50	62	39	**42**	19	27	36	8	**15**	43	46	52	25	**29**
Newell 16			36					12					33		
Fall 15	47 (2000				**48**					**25**	44 (2000)				**40**
Boulder 17a		34	48	37	**37**		24	29	18	**21**		30	33	27	**31**
Boulder 17b		36	43	33	**35**		14	24	22	**17**		29	34	33	**34**
Boulder 17c		31					18					13			
Bear 18a	48	42	54	33	**48**	28	22	35	28	**34**	47	30	41	36	**43**
Brancifo rte 21a-1				60	**58**				31	**24**				55	**41**
Brancifo rte 21a-2			68	62	**46**			41	30	**28**			59	36	**33**
Brancifo rte 21b		41					28					32			

* Were from sampling sites and not reaches.

Table 9. Reach-wide ESCAPE COVER Index (Habitat Typing Method*) in RIFFLE HABITAT in MAINSTEM Reaches of the SAN LORENZO, Based on Habitat Typed Segments.

Reach	1998	1999	2000	2003	2005	2006	2007	2008
1	0.187	0.244	0.084	-	-	0.270	0.257	0.200
2	-	0.503	0.260	-	-		0.228	0.287
3	0.250	0.216	0.257	-	-			
4	0.125	0.078	0.109	-	-	0.183	0.354	0.141
5	0.032	0.001	0.222	-	-			
6	**0.099**	**0.093**	**0.042**	**0.027**	**0.152**	**0.101**	**0.072**	**0.082**
7	**0.148**	**0.146**	**0.050**	**0.130**	**0.187**			
8	**0.335**	**0.173**	**0.124**	**0.080**	**0.320**	**0.241**	**0.123**	**0.036**
9	**0.038**	**0.080**	**0.043**	**0.066**	**0.161**			
10	0.011	0.039	0.012	0.018	0.040			
11	0.025	0.020	0.017	-	0.056	0.014	0.005	0.010
12	0.086	0.022	0.036	-	0.044			

*Habitat Typing Method = linear feet of escape cover divided by habitat typed channel length as riffle habitat.

Table 10. Reach-wide ESCAPE COVER Index (Habitat Typing Method*) in RUN HABITAT in MAINSTEM Reaches of the SAN LORENZO, Based on Habitat Typed Segments.

Reach	1998	1999	2000	2003	2005	2006	2007	2008
1	0.273	0.130	0.064	-	-	0.131	0.120	0.151
2	0.228	0.136	0.100	-	-		0.282	0.226
3	0.186	0.113	0.144	-	-			
4	0.234	0.159	0.091	-	-	0.125	0.204	0.221
5	0.071	0.249	0.261	-	-			
6	**0.145**	**0.107**	**0.044**	**0.068**	**0.098**	**0.101**	**0.049**	**0.044**
7	**0.038**	**0.030**	**0.023**	**0.165**	**0.074**			
8	**0.129**	**0.152**	**0.131**	**0.154**	**0.164**	**0.103**	**0.168**	**0.087**
9	**0.138**	**0.051**	**0.036**	**0.046**	**0.098**			
10	0.072	0.041	0.081	0.062	0.057			
11	0.026	0.016	0.022	-	0.021	0.0084	0.0068	0.014
12	0.031	0.069	0.126	-	0.048			

*Habitat Typing Method = linear feet of escape cover divided by habitat typed channel length as run habitat.

Table 11. ESCAPE COVER Index (Habitat Typing Method*) in POOL HABITAT in MAINSTEM Reaches of the SAN LORENZO, Based on Habitat Typed Segments.

Reach	2003	2005	2006	2007	2008
1	-	-	0.271	0.186	0.205
2	-	-		0.076	0.058
3	-	-			
4	-	-	0.203	0.275	0.290
5	-	-			
6	**0.077**	**0.077**	**0.044**	**0.083**	**0.088**
7	**0.134**	**0.105**			
8	**0.026**	**0.027**	**0.039**	**0.057**	**0.030**
9	**0.037**	**0.070**			
10	0.054	0.051			
11	0.054 (2000)	0.059	0.031	0.034	0.035
12	-	0.178			

*Habitat Typing Method = linear feet of escape cover divided by habitat typed channel length as pool habitat.

Table 12. ESCAPE COVER Index (Habitat Typing Method*) for POOL HABITAT in TRIBUTARY Reaches of the SAN LORENZO.

Reach	1998	1999	2000	2003	2005	2006	2007	2008
Zayante 13a	0.320	0.069	0.056	0.169	0.081	0.074	0.071	**0.086**
Zayante 13b	0.150	0.093	0.072	0.130	0.087			
Zayante 13c	0.114	0.110	0.095	0.110	0.109		0.102	**0.099**
Zayante 13d	0.145	0.191	0.132	0.237	0.269	0.126	0.117	**0.118**
Lompico 13e						0.089	0.082	**0.095**
Bean 14a	0.248	0.143	0.186	0.124	0.155			
Bean 14b	0.378	0.280	0.205	0.288	0.212		0.231	**0.171**
Bean 14c	0.259	0.093	0.100	0.142	0.141	0.131	0.142	**0.131**
Fall 15	0.380		0.330					**0.375**
Newell 16	0.285		0.325			0.120		
Boulder 17a	0.131	0.051	0.061	-	0.108	0.064	0.076	**0.058**
Boulder 17b	0.129	0.141	0.164	-	0.232	0.100	0.140	**0.155**
Boulder 17c	0.250	0.072	0.057	-	0.143			
Bear 18a	0.069	-	0.103	0.119	0.114	0.074	0.088	**0.087**
Branciforte 21a-1							0.140	**0.136**
Branciforte 21a-2						0.121	0.134	**0.151**
Branciforte 21b	0.147	0.083	0.102	-	0.189			

*Habitat Typing Method = linear feet of escape cover divided by habitat typed channel length as pool habitat.

Table 13. ESCAPE COVER Index (Habitat Typing Method*) for RUN/STEP-RUN HABITAT in TRIBUTARY Reaches of the SAN LORENZO.

Reach	1998	1999	2000	2003	2005	2006	2007	2008
Zayante 13a	0.127	0.059	0.059	0.065	0.031	0.038	0.027	**0.009**
Zayante 13b	0.060	0.127	0.087	0.152	0.103			
Zayante 13c	0.116	0.095	0.070	0.016	0.070		0.051	**0.074**
Zayante 13d	0.050	0.098	0.143	0.223	0.297	0.071	0.101	**0.130**
Lompico 13e						0.001	0.042	**0.020**
Bean 14a	0.060	0.058	0.092	0.051	0.086			
Bean 14b	0.045	0.048	0.041	0.107	0.050		0.138	**0.141**
Bean 14c	-	0.018	0.023	0.015	0.012	0.009	0.0	**0.0**
Newell 16	0.072		0.129			0.020		
Fall 15								**0.110**
Boulder 17a	0.188	0.093	0.170	-	0.135	0.169	0.138	**0.113**
Boulder 17b	0.116	0.156	0.137	-	0.194	0.102	0.114	**0.105**
Boulder 17c	0.019	0.122	0.107	-	0.114			
Bear 18a	0.073	-	0.177	0.063	0.088	0.063	0.027	**0.030**
Branciforte 21a-1							0.087	**0.040**
Branciforte 21a-2						0.028	0.045	**0.037**
Branciforte 21b	0.138	0.014	0.087	-	0.133			

*Habitat Typing Method = linear feet of escape cover divided by habitat typed channel length as run habitat.

Table 14. Averaged Mean and Maximum WATER DEPTH (ft) of Habitat in SQOUEL CREEK Reaches Since 2003 with Pool Depths Since 2000.

Reach	Pool 2000	Pool 2003	Pool 2005	Pool 2006	Pool 2007	Pool 2008	Riffle 2003	Riffle 2005	Riffle 2006	Riffle 2007	Riffle 2008	Run/ Step Run 2003	Run/ Step Run 2005	Run/ Step Run 2006	Run/ Step Run 2007	Run/ Step Run 2008
1	1.3/ 2.5	1.4/ 2.7	1.1/ 2.8		1.2/ 2.7	**1.2/ 2.8**	-/ 0.5	-/ 0.7		0.3/ 0.4	**0.2/ 0.4***	-/ 0.7	-/ 0.8		0.4/ 0.5	**0.3/ 0.5**
2	1.0/ 1.9	1.0/ 1.6	1.0/ 1.7				-/ 0.5	-/ 0.6				-/ 0.7	-/ 1.1			
3	1.3/ 2.4	1.35/ 2.5	1.3/ 2.3	1.4/ 2.5 *	1.4/ 2.3 *	**1.2/ 2.3 ***	-/ 0.5	-/ 0.7	0.5/ 0.8 *	0.3/ 0.5 *	**0.2/ 0.4 ***		-/ 1.0	0.7/ 1.0 *	0.4/ 0.6 *	**0.3/ 0.6 ***
4	1.3/ 2.3	1.2/ 2.6	1.1/ 2.6				-/ 0.6	-/ 0.8				-/ 0.7	-/ 0.9			
5	1.3/ 2.2	1.2/ 2.2	1.2/ 2.3				-/ 0.5	-/ 0.7				-/ 0.8	-/ 0.9			
6	1.3/ 2.4	1.45/ 2.5	1.25 / 2.2				-/ 0.6	-/ 0.7				-/ 0.8	-/ 0.9			
7	1.4/ 2.4	1.6/ 2.9	1.2/ 2.2	1.3 / 2.3 *	1.2/ 2.1 *	**1.2/ 2.2 ***	-/ 0.7	-/ 0.8	0.5/ 0.8 *	0.3/ 0.6 *	**0.3/ 0.5 ***	-/ 0.9	-/ 0.9	0.8/ 1.2 *	0.3/ 0.6 *	**0.4/ 0.7 ***
8	1.5/ 2.7	1.6/ 2.9	1.4/ 2.7		1.5/ 2.9 *	**1.4/ 2.5 ***	-/ 0.6	-/ 0.8		0.4/ 0.6 *	**0.2/ 0.4 ***	-/ 0.9	-/ 0.9		0.5/ 0.9 *	**0.4/ 0.7 ***
9	1.4/ 2.3		1.3/ 2.1	1.5 / 2.5	1.3/ 2.2	**1.2/ 2.3**		-/ 0.6	0.4/ 0.6	0.2/ 0.4	**0.2/ 0.4**		-/ 0.9	0.6/ 1.0	0.4/ 0.6	**0.4/ 0.6**
10	1.5/ 2.4															
11	1.9/ 3.3															
12a	1.1/ 1.6		1.1/ 1.7	1.3 / 2.05	0.8/ 1.4	**0.6/ 1.1**		-/ 0.6	0.45 / 0.8	0.1/ 0.2	**0.02 /0.1**		-/ 1.1 (S. run)	0.7/ 1.2	0.3/ 0.7	**0.2/ 0.5**
12b	1.3/ 2.0		1.1/ 1.6					-/ 0.5					-/ 1.0 (S. Run)			
13	1.3/ 2.7				1.1/ 2.2 *	**1.1/ 2.3 ***				0.3/ 0.5 *	**0.3/ 0.5 ***				0.5/ 0.8 *	**0.4/ 0.7 ***
14a	1.3/ 2.4		1.0/ 1.8	1.4 / 2.4				-/ 0.5	0.5/ 0.8				-/ 0.7	0.6/ 1.0		

14b		1.5/ 2.6 2002		1.6/ 2.9	1.4/ 2.4	**1.3/ 2.4**			0.4/ 0.6	0.2/ 0.4	**0.2/ 0.4**			0.7/ 1.0	0.5/ 0.8	**0.4/ 0.7**
14c		1.4/ 2.4 2002														

*Partial, ½-mile segments habitat typed in 2006–2008. Previously, the entire reach was habitat typed.

Table 15. Average PERCENT FINE SEDIMENT in Habitat-typed Reaches in SOQUEL CREEK Since 2003 with Pool Sediment Since 2000.

Reach	Pool 2000	Pool 2003	Pool 2005	Pool 2006	Pool 2007	Pool 2008	Riffle 2003	Riffle 2005	Riffle 2006	Riffle 2007	Riffle 2008	Run/ Step Run 2003	Run/ Step Run 2005	Run/ Step Run 2006	Run/ Step Run 2007	Run/ Step Run 2008
1	81	73	84		59	**64**	21	25		18	**13**	45	36		29	**16**
2	71	69	80				20	24				47	34			
3	77	70	75	62 *	55 *	**57 ***	25	17	14 *	17 *	**15***	34	43	29 *	29 *	**20***
4	69	72	61					21					29			
5	72	66	69					21					27			
6	68	59	63					14					26			
7	80	66	69	69 *	52 *	**59 ***		17	21 *	20 *	**23***		35	33 *	25*	**25***
8	70	59	64		46 *	**56 ***		16		14 *	**15***		24		25 *	**64***
9	65		56	62	47	**49**	13	17	12	13	**10**		25	30	24	**26**
10	63															
11	56															
12a	48		33	40	29	**34**		9	12	6	**10**		15 (S.run)	21 (S.run)	20 (S.run)	**21 (S.run)**
12b	49		36					5					18			
13	73				64 *	**75 ***				26 *	**18***				29 *	**26***
14a	71		55	66				15	14				31 (run)	28 (run)		
14b				51	40	**55**			15	9	**10**			35 (run)	26 (run)	**20 (run)**
14c																

*Partial, ½-mile segments habitat typed in 2006–2007. Previously, the entire reach was habitat typed.

Table 16. Average EMBEDDEDNESS in Pool and Fastwater (Riffle and Run) Habitat of SOQUEL CREEK Reaches Since 2003 with Pool Embeddedness Since 2000.

Reach	Pool 2000	Pool 2003	Pool 2005	Pool 2006	Pool 2007	Pool 2008	Riffle 2003	Riffle 2005	Riffle 2006	Riffle 2007	Riffle 2008	Run/ Step Run 2003	Run/ Step Run 2005	Run/ Step Run 2006	Run/ Step Run 2007	Run/ Step Run 2008
1	47	55	57		48	**35**	33	25		22	**18**	55	35		29	**29**
2	55	60	56				39	34				69	46			
3	57	59	58	55*	40*	**39**	30	27	27*	17*	**22***	46	42	46*	28*	**33***
4	55	58	61				40	31				54	48			
5	51	52	55				36	27				48	42			
6	52	50	53				31	28				43	40			
7	49	53	53	56*	42*	**44**	33	30	25*	25*	**23**	43	43	39*	35*	**39***
8	53	49	60		44*	**43**	38	29		25*	**17**	46	45		35*	**48***
9	56		59	54	47	**44**		34	26	18	**22**		45	50	37*	**47***
10	51															
11	54															
12a	55		53	53	55	**54**		29	30	41	**45**		37 (S.run)	38 (S.run)	47	**39**
12b	51		59					30					47			
13	55				50*	**42***				26*	**23***				39*	**29***
14a	50		58	57				47	18				59(run)	34(run)		
14b		55 2002		57	47	**44**	33 2002		32	17	**19**	47(run) 2002		46(run)	25	**27**
14c		61 2002					30 2002					45 2002				

*Partial, ½-mile segments habitat typed in 2006–2007. Previously, the entire reach was habitat typed.

Table 17. ESCAPE COVER Index (Habitat Typing Method*) in Pool Habitat in SOQUEL CREEK, Based on Habitat Typed Segments.

Reach	Pool 2000	Pool 2003	Pool 2005	Pool 2006	Pool 2007	Pool 2008
1	0.091	0.103	0.107		0.147	**0.134**
2	0.086	0.055	0.106			
3	0.085	0.092	0.141	0.178 * **	0.177 **	**0.131 ****
4	0.041	0.071	0.086			
5	0.061	0.023	0.075			
6	0.082	0.102	0.099			
7	0.089	0.101	0.129	0.141 **	0.164 **	**0.170 ****
8	0.047	0.036	0.060		0.070 **	**0.071 ****
9	0.146		0.101	0.086	0.117	**0.147**
10	0.100					
11	0.068					
12a	0.113		0.222	0.175	0.121	**0.097**
12b	0.129		0.158			
13	0.077				0.081 **	**0.069 ****
14a	0.064			0.048		
14b		0.051 (2002)		**0.058**	0.076	**0.080**
14c		0.068 (2002)				

* Habitat Typing Method = linear feet of escape cover divided by reach length as pool habitat.
** Partial, ½-mile segments habitat typed in 2006–2007. Previously, the entire reach was habitat typed.

Table 18. Average POOL HABITAT CONDITIONS and Escape Cover Indices for Reaches in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS VALLEY Creeks in 2006–2008 (and at Sampling Sites only in Aptos/ Valencia in 1981 and in Corralitos/ Browns in 1981 and 1994).

Reach #/ Sampling Site #	Mean Depth/ Maximum Depth			Escape Cover*			Embeddedness					Percent Fines				
	2006	2007	2008	2006	2007	2008	1981	1994	2006	2007	2008	1981	1994	2006	2007	2008
Aptos #2/#3- in County Park	1.4/3.0	1.1/2.3	1.1/2.1	0.123	0.133	0.172	35		82	49	47	75		85	76	60
Aptos #3/#4- Above Steel Bridge Xing (Nisene Marks)	1.3/2.4	1.2/2.2	1.1/2.2	0.059	0.102	0.132	35		80	59	57	65		78	62	63
Valencia #2/#2- Below Valencia Road Xing	0.7/1.2	0.8/1.4	0.6/1.3	0.115	0.148	0.131	35		88	70	45	85		93	98	88
Valencia #3/#3- Above Valencia Road Xing	1.0/1.7	0.9/1.6	0.7/1.4	0.119	0.154	0.210	55		82	56	55	70		83	78	79
Corralitos #1/#0- Below Dam		1.25/1.95	1.3/2.0		0.106	0.152	65	40		35	44	45	40		37	50
Corralitos #3/#3- Above Colinas Drive	1.5/2.6	1.3/2.3	1.1/2.0	0.138	0.191	0.172	60	45	52	41	46	45	35	47	38	50
Corralitos #6/#8- Below Eureka Gulch	1.3/2.2	1.1/1.9	1.0/1.8	0.061	0.084	0.090	54	50	54	42	45	35	20	45	35	48
Corralitos #7/#9- Above Eureka Gulch	1.2/1.8	1.0/1.6	0.9/1.5	0.160	0.185	0.171	56	60	47	37	40	35	15	33	30	29
Shingle Mill #1/#1- Below 2nd Road Xing	1.15/1.8	0.8/1.3	0.8/1.3	0.180	0.198	0.214	42	45	71	58	58	23	8	49	33	26
Shingle Mill #3/#3- Above 3rd Road Xing	1.15/1.8	0.9/1.4	0.8/1.3	0.190	0.196	0.223	60		71	62	62			55	38	34
Browns Valley #1/#2- Below Dam	1.4/2.4	1.1/1.8	1.2/1.9	0.051	0.127	0.156	58	37	71	60	56	38	47	61	40	35
Browns Valley #2/#2- Above Dam	1.45/2.35	1.0/1.7	1.0/1.6	0.120	0.161	0.155	73	47	69	59	56	47	37	53	36	32

* Habitat typing method = total feet of linear pool cover divided by total habitat typed channel length as pool habitat.

Table 19. Average RIFFLE HABITAT CONDITIONS for Reaches in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS VALLEY Creeks in 2006–2008 (and at Sampling Sites only in Aptos/Valencia in 1981 and Corralitos/ Browns in 1981 and 1994).

Reach #/ Sampling Site #	Mean Depth/ Maximum Depth			Escape Cover*			Embeddedness					Percent Fines				
	2006	2007	2008	2006	2007	2008	1981	1994	2006	2007	08	1981	1994	2006	2007	2008
Aptos #2/#3- in County Park	0.4/ 0.7	0.3/ 0.6	0.2/ 0.4	0.007	0.061	0.027	50		48	21	23	68 riffle & run		26	14	11
Aptos #3/#4- Above Steel Bridge Xing (Nisene Marks)	0.5/ 0.8	0.3/ 0.7	0.4 / 0.7	0.004	0.026	0.075	40		47	34	32	30 riffle & run		25	16	16
Valencia #2/#2- Below Valencia Road Xing	0.3/ 0.4	0.2/ 0.4	0.2 / 0.4	0.003	0.022	0.010	15		54	29	36	48 riffle & run		50	36	47
Valencia #3/#3- Above Valencia Road Xing	0.3/ 0.5	0.2/ 0.4	0.15 / 0.3	0.004	0.010	0.052	30		56	15	18	30 riffle & run		33	17	11
Corra- litos #1/#0- Below Dam		0.3/ 0.5	0.5 / 0.7		0.033	0.046	60	30		17	26	20	20		10	17
Corra- litos #3/#3- Above Colinas Drive	0.5/ 0.9	0.4/ 0.6	0.4 / 0.6	0.028	0.080	0.066	53	30	26	12	23	35	10	18	7	17
Corra- litos #6/#8- Below Eureka Gulch	0.4/ 0.7	0.3/ 0.5	0.2 / 0.5	0.021	0.034	0.015	50	50	28	22	27	25	5	14	12	19
Corra- litos #7/#9- Above Eureka Gulch	0.5/ 0.8	0.3/ 0.5	0.25/ 0.6	0.041	0.0	0.061	60	30	33	23	29	35	7	7	8	8

Shingle Mill #1/#1- Below 2nd Road Xing	0.25/ 0.5	0.1/ 0.3	0.1 / 0.3	0.0 22	0.0 29	0.037	45	40	19	30	26	10	0	31	3	2
Shingle Mill #3/#3- Above 3rd Road Xing	0.2/ 0.3	0.1/ 0.2	0.1 / 0.2	0.0 20	0	0	20		25	30	25			5	4	3
Browns Valley #1/#2- Below Dam	0.4/ 0.7	0.2/ 0.4	0.3 / 0.5	0	0.0 17	0.026	60	45	36	36	26	20	10	15	9	10
Browns Valley #2/#2- Above Dam	0.3/ 0.6	0.2/ 0.4	0.2 / 0.4	0	0.0 05	0.007	35		40	33	35			15	13	12

* Habitat typing method = total feet of linear riffle cover divided by total habitat typed channel length as riffle habitat.

Table 20. Average RUN or STEP-RUN (More Commonly Used by Fish) HABITAT CONDITIONS for Reaches in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS VALLEY Creeks in 2006–2008 (and at Sampling Sites only in Aptos/Valencia in 1981 and Corralitos/ Browns in 1981 and 1994).

Reach #/ Sampling Site #	Mean Depth/ Maximum Depth			Escape Cover*			Embeddedness					Percent Fines				
	2006	2007	2008	2006	2007	2008	1981	1994	2006	2007	2008	1981	1994	2006	2007	2008
Aptos #2/#3- in County Park	0.75/1.4 run	0.4/0.8 run	0.4/0.6 run	0.030	0.023	0.067	40		66	32	38	68 riffle & run		53	52	47
Aptos #3/#4- Above Steel Bridge Xing (Nisene Marks)	0.7/1.0 run	0.55/0.95 run	0.5/0.8 run	0.014	0.007	0.138			61	44	47	30 riffle & run		39	25	28
Valencia #2/#2- Below Valencia Road Xing	0.3/0.6 run	0.3/0.6 run	0.25/0.55 run	0.018	0.025	0.015			77	-	35	48 riffle & run		90	98	96
Valencia #3/#3- Above Valencia Road Xing	0.4/0.7 run	0.4/0.6 run	0.4/0.5	0.008	0.031	0.078			59	29	44	30 riffle & run		48	33	50
Corra-litos #1/#1- Below Dam		0.45/0.8 both	0.6/0.8 run		0.035	0.055				25	43				25	27
Corra-litos #3/#3- Above Colinas Drive	0.75/1.1 run	0.6/0.9 run	0.5/0.8 run	0.017	0.052	0.052	60	40	43	16	34	90	60	25	19	20
Corra-litos #6/#8- Below Eureka Gulch	0.6/0.95 step-run	0.4/0.9 step-run	0.4/0.9 step-run	0.010	0.046	0.044	60	50	48	27	32	49	5	21	16	21

Corralitos #7/#9- Above Eureka Gulch	0.8 / 1.3 step-run	0.5 / 1.0 step-run	0.4 / 0.8 step-run	0.063	0.055	0.051			34	40	34			16	18	22
Shingle Mill #1/#1- Below 2nd Road Xing	0.6 / 1.2 step-run	0.4 / 0.8 step-run	0.4 / 0.8 step-run	0.013	0.034	0.037	45	30	48	35	41	18	5	19	5	6
Shingle Mill #3/#3- Above 3rd Road Xing	0.4 / 0.8 step-run	0.3 / 0.6 step-run	0.3 / 0.6	0.023	0.060	0.079			45	38	40			18	14	14
Browns Valley #1/#1- Below Dam	0.6 / 1.05 step-run	0.4 / 0.6 run	0.4 / 0.65 run	0.015	0.038	0.056	70	35	58	42	41	35	10	36	15	18
Browns Valley #2/#2- Above Dam	0.6 / 1.05 step-run	0.4 / 0.65 run	0.4 / 0.6 both	0.015	0.066	0.067			58	39	37			32	19	14

* Habitat typing method = total feet of linear run and step-run cover divided by total habitat typed channel length as run and step-run habitat.

JUVENILE STEELHEAD DENSITY COMPARISONS

R-6. Comparison of 2008 Steelhead Densities in the San Lorenzo Drainage with Those Since 1997

All figures presented within the text may be found in color in the FIGURES section (page 221) after the REFERENCES AND COMMUNICATIONS.).In the mainstem San Lorenzo River, total juvenile steelhead densities were generally higher in 2008 than 2007 (5 of 6 sites) (**Figure 1; Table 21**). This was due to higher young-of-the-year (YOY) densities in 2008 than 2007 (5 of 6 sites) (**Figure 2; Table 22**). Three of six sites had above average total densities with 8−11 years of data. Higher total densities were due to higher young-of-the-year (YOY) densities in 2008 (5 of 6 sites) and above average YOY densities at three of six sites (**Figure 2; Table 22**). At half the mainstem sites, yearling densities declined slightly from 2007 to 2008 (**Tables 22 and 23**). But yearling densities have been consistently low in the mainstem, downstream of the Boulder Creek confluence, from 1998 onward. Higher YOY densities in 2008 resulted in higher densities of small, Size Class I juveniles (<75 mm SL) (**Table 24**). However, due to a proportion of the more plentiful YOY reaching Size Class II (75 mm SL), densities of Size Class II and III juveniles also increased at all 6 mainstem sites compared to 2007 (**Figure 3; Table 25**). Even so, densities of these important larger juveniles (soon to smolt) were below average in 2008 at all sites due to slower growth rates of YOY and lower yearling densities. Middle and upper mainstem Sites 6, 8 and 11 were rated “poor” in terms of Size Class II and III densities, with Site 1 rated “Below Average” and Sites 2 and 4 rated only “Fair” (**Table 41**).

Site densities in the mainstem below the Boulder Creek confluence have been low from 1999 onward (compared to the 1997 and 1998 juvenile densities that were much higher) for spawning and YOY production (**Table 22**). 1997 was unusual in that considerable rain occurred prior to 1 March with little afterwards, resulting in very stable spawning conditions after March 1 and baseflows near the average median flow. 1998 was a very wet year with so much baseflow that steelhead were in high densities at the heads of pools and even further back in pools where water velocity was still high, unlike other years when they primarily rear in runs and riffles. The one exception to low steelhead densities in the mainstem after 1998 was the rebound in YOY densities in 2008 in Reach 4 in Henry Cowell Park (**Table 22**). Unfortunately, in 2008, a smaller proportion of YOY reached smolt size at that site than if streamflow had been higher in May−September (**Figure 25; Appendix C**). YOY recruitment into the mainstem from tributaries has apparently been minimal from 1999 onward, except for possibly at Site 4 in 2008.

It was the winter of 1999 when substantial sediment entered the middle mainstem from erosion in upstream tributaries that occurred from the 1998 high peak-flow event (19,400 cfs at Big Trees), followed by the 1999 water year that had a relatively low peak flow (3,200 cfs at Big Trees) that apparently could not transport the sediment out of the system. Despite the fact that substrate conditions have improved in riffles and runs in terms of reduced fine sediment and embeddedness since then, substrate in glides where spawning occurs apparently has not, and spawning habitat in the mainstem remains poor in quality and primarily sand and fine gravel.

Figure 1. Total Juvenile Steelhead Site Densities in the San Lorenzo River in 2008 Compared to the 10-Year Average Density. (8th year for Mainstem (1), 7th year for Mainstem (2a), 3rd year for Lompico (13e) and 2nd Year for Branciforte (21a-1)).

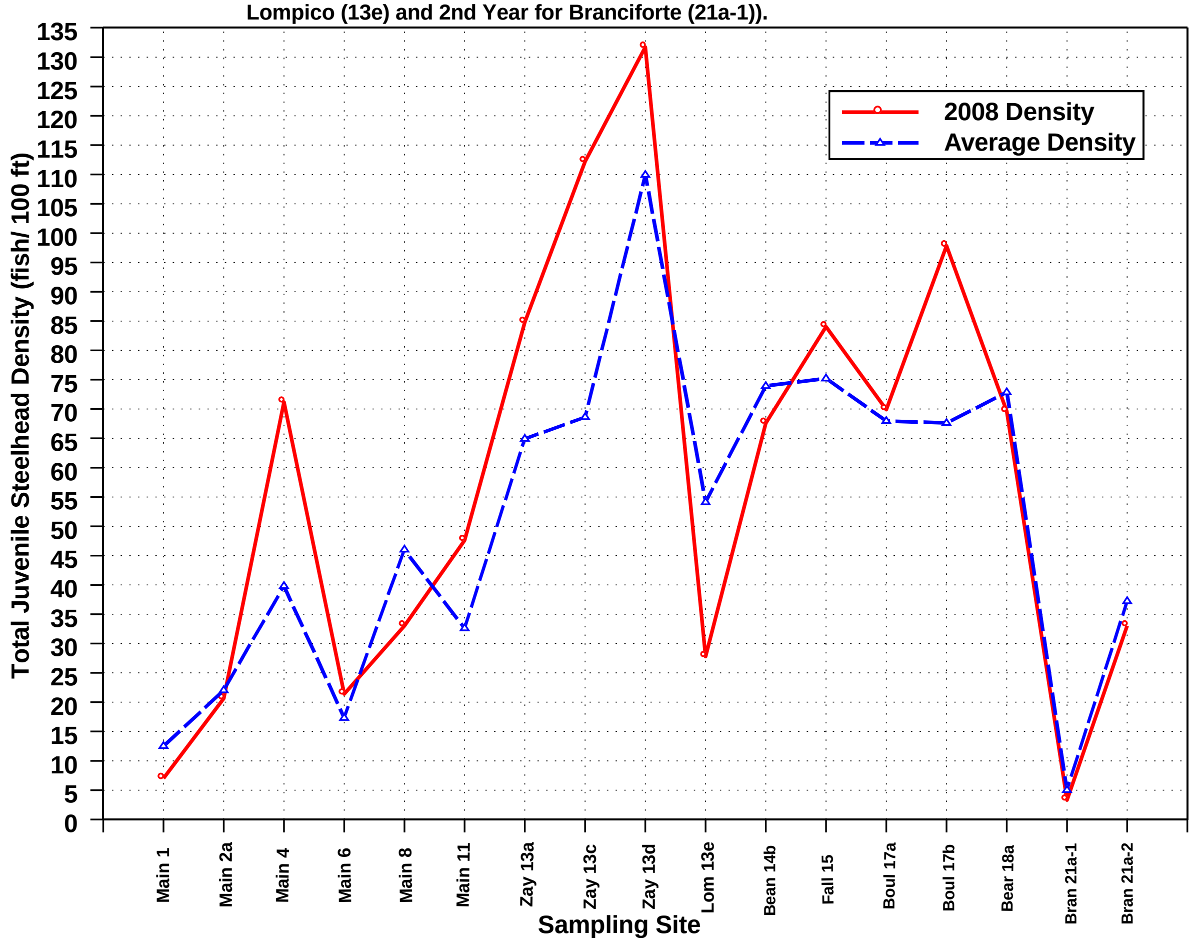


Table 21. Density of Juvenile Steelhead for ALL SIZES at MAINSTEM SAN LORENZO RIVER Monitoring Sites in 1997-2001 and 2003-2008.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	Avg.
0a				5.4								
0b				4.3	5.2							4.8
1	34.2*	26.9	17.6	3.4	7.6				1.2	1.9	7.0	12.5
2a	74.9	21.4	4.6	3.9	13.5					14.8	20.6	22.0
2b				24.8	15.4							20.1
3	83.9	73.5	29.0	33.0	36.0							51.1
4	86.9	37.8	39.6	12.0	33.1				16.6	21.3	71.2	39.8
5		133.8	46.2	4.5	23.6							52.0
6	45.4	46.0	14.1	4.0	10.9	4.7	8.7	6.7	4.5	24.0	21.4	17.3
7	149.3	21.7	11.8	7.6	15.5	29.4	38.9	11.0				35.7
8	158.6	140.1	48.2	11.2	21.4	32.3	21.6	20.3	13.7	5.5	33.0	46.0
9	126.8	77.3	27.6	12.0	29.6	17.4	10.9	17.1				39.8
10	69.1	17.9	10.9	18.4	19.7	51.9	44.6	21.9				31.8
11	73.0	10.9	33.4	28.7	5.1	57.2	45.7	32.3	3.0	21.3	47.6	32.6
12a	56.8	30.8	21.1	39.9	49.8							39.7
12b		32.2	25.9	43.5	30.4	51.9	48.4	98.2				47.2

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

Figure 2. Juvenile Steelhead Site Densities for Young-of-the-Year in the San Lorenzo River in 2008 Compared to the 10-Year Average. (8the year for Mainstem (1), 7th year for Mainstem (2a), 3rd year for Lompico (13e) and 2nd Year for Branciforte (21a-1).

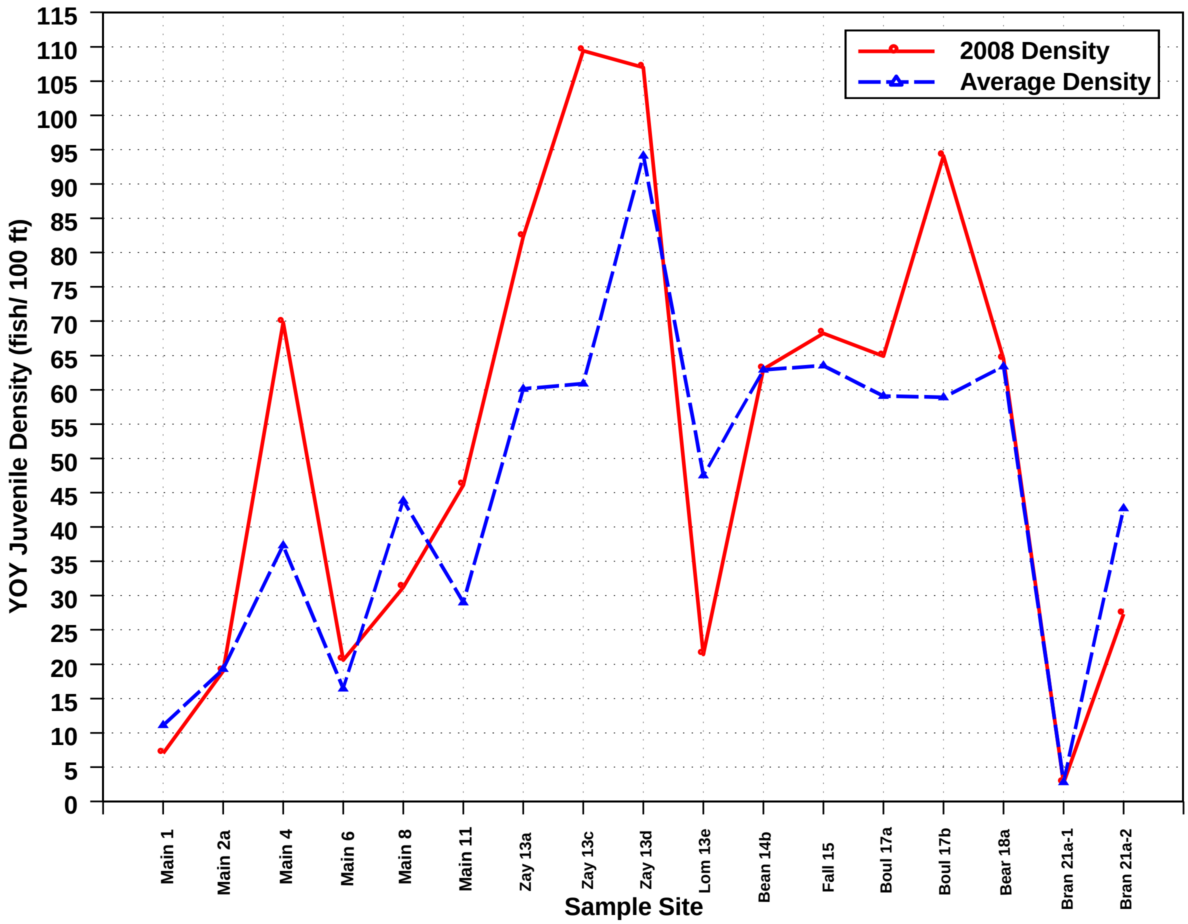


Table 22. Density of Juvenile Steelhead for the YOUNG-OF-THE-YEAR Age Class at MAINSTEM SAN LORENZO RIVER Monitoring Sites in 1997-2001 and 2003-2008.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	Avg.
0a				2.2								
0b				3.3	2.3							2.8
1	32.3*	25.6	12.6	1.8	6.8				1.2	1.6	7.0	11.1
2a	66.3	19.2	3.2	2.7	11.0					13.7	19.0	19.3
2b				21.2	12.1							16.7
3	84.3	68.2	24.7	29.4	29.6							47.2
4	86.2	32.9	34.2	10.5	30.5				13.9	20.7	69.8	37.3
5		132.4	38.5	3.5	22.8							49.3
6	42.0	44.4	13.2	3.3	10.6	4.4	8.5	5.9	4.2	23.4	20.6	16.4
7	143.5	19.8	5.7	3.6	12.0	9.7	38.0	11.2				32.9
8	152.0	135.3	44.2	10.9	21.0	30.5	20.9	18.7	11.6	5.5	31.2	43.8
9	119.9	69.7	23.4	11.0	28.9	17.6	10.0	15.4				37.0
10	65.8	11.7	6.5	13.4	5.9	45.1	40.5	18.4				27.2
11	64.2	6.8	27.6	16.4	21.8	49.8	34.5	29.6	1.5	20.8	46.1	29.0
12a	50.9	27.9	5.4	34.4	37.3							31.2
12b		24.2	14.3	37.9	15.8	44.4	39.3	89.1				37.9

*Density in Number of Juveniles per 100 feet of Stream.

Table 23. Density of Juvenile Steelhead for YEARLINGS AND OLDER at MAINSTEM SAN LORENZO RIVER Monitoring Sites in 1997-2001 and 2003-2008.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	Avg.
0a				2.2								
0b				1.0	2.9							2.0
1	1.6*	1.4	2.9	1.9	0.5				0	0.3	0	1.1
2a	7.9	1.5	0.9	1.2	1.5					0.9	0.4	2.0
2b				2.4	2.0							2.2
3	5.2	5.3	3.9	4.4	6.6							5.1
4	7.6	4.7	2.2	1.2	0.5				2.4	0.2	0.3	2.4
5		2.9	5.4	1.0	0.8							2.5
6	4.6	2.2	0.8	0.7	0.5	0.3	0.2	0.8	0.3	0.7	0.03	1.0
7	6.0	2.5	6.3	4.8	3.6	0.4	0.3	3.0				3.0
8	5.4	4.2	4.1	0.3	0.4	2.0	2.6	2.4	1.6	0	2.0	2.3
9	4.3	8.1	2.5	1.0	0.6	0.8	1.9	2.5				2.5
10	3.3	6.4	4.6	5.5	4.1	6.8	2.7	4.7				4.7
11	8.8	3.9	6.5	11.2	4.7	7.4	3.0	7.1	1.5	0.6	1.1	5.1
12a	5.9	3.2	15.7	5.5	12.9							8.6
12b		6.8	12.6	5.5	14.3	7.5	9.1	9.3				9.3

*Density in Number of Juveniles per 100 feet of Stream.

Table 24. Density of Juvenile Steelhead for SIZE CLASS I (<75 mm SL) at MAINSTEM SAN LORENZO RIVER Monitoring Sites in 1997-2001 and 2003-2008.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	Avg.
0a				0								
0b				0	0							0
1	3.3*	0.2	2.2	0	0.7				0	0.3	2.1	1.1
2a	7.9	1.3	0.4	0.2	2.5					3.7	8.4	3.5
2b				1.2	6.7							4.0
3	47.7	9.4	3.7	5.9	18.1							17.0
4	63.0	8.6	6.8	3.1	17.6				0.5	15.4	58.1	21.6
5		19.1	5.2	0	8.1							8.1
6	35.1	20.5	11.2	1.8	8.4	4.1	8.3	4.7	2.2	22.8	19.2	12.6
7	126.7	11.7	2.9	1.5	8.6	23.6	35.0	4.9				26.9
8	138.6	118.7	37.4	8.0	20.5	27.9	19.9	13.2	7.9	4.8	29.4	38.8
9	102.2	57.5	18.5	6.2	28.4	15.4	9.6	12.2				31.3
10	65.8	9.6	4.4	10.1	12.2	45.1	39.8	17.6				25.6
11	64.2	4.1	26.9	15.6	18.7	49.8	34.5	19.3	0	20.8	44.9	27.2
12a	50.9	26.2	5.4	34.4	40.3							31.4
12b		19.5	4.1	37.0	17.4	44.4	39.3	87.6				35.6

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

Figure 3. Juvenile Steelhead Site Densities for Size Classes II and III in the San Lorenzo River in 2008 Compared to the 10-Year Average. (8th year for Mainstem (1), 7th year for Mainstem (2a), 3rd Year for Lompico (13e) and 2nd Year for Branciforte (21a-1).

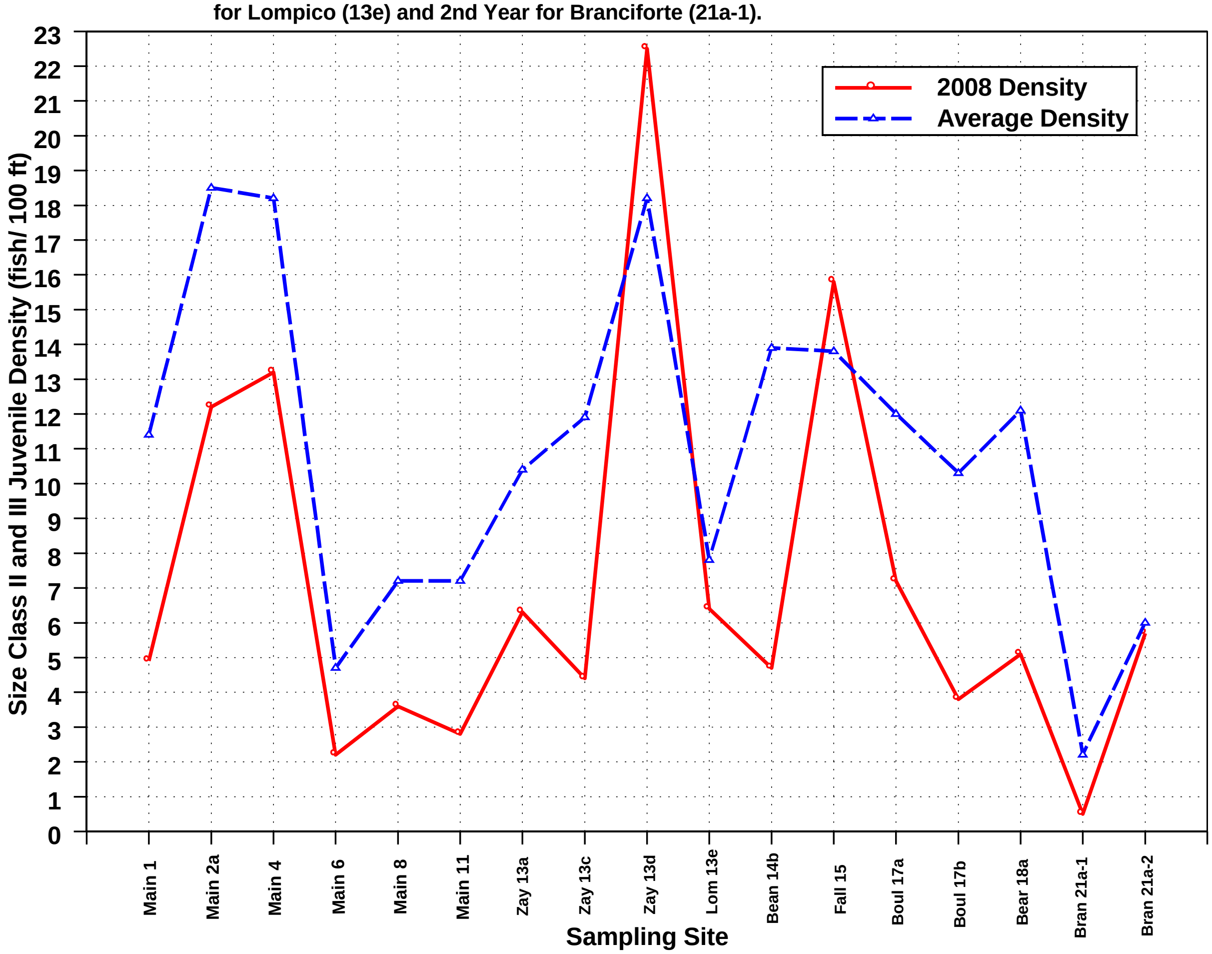
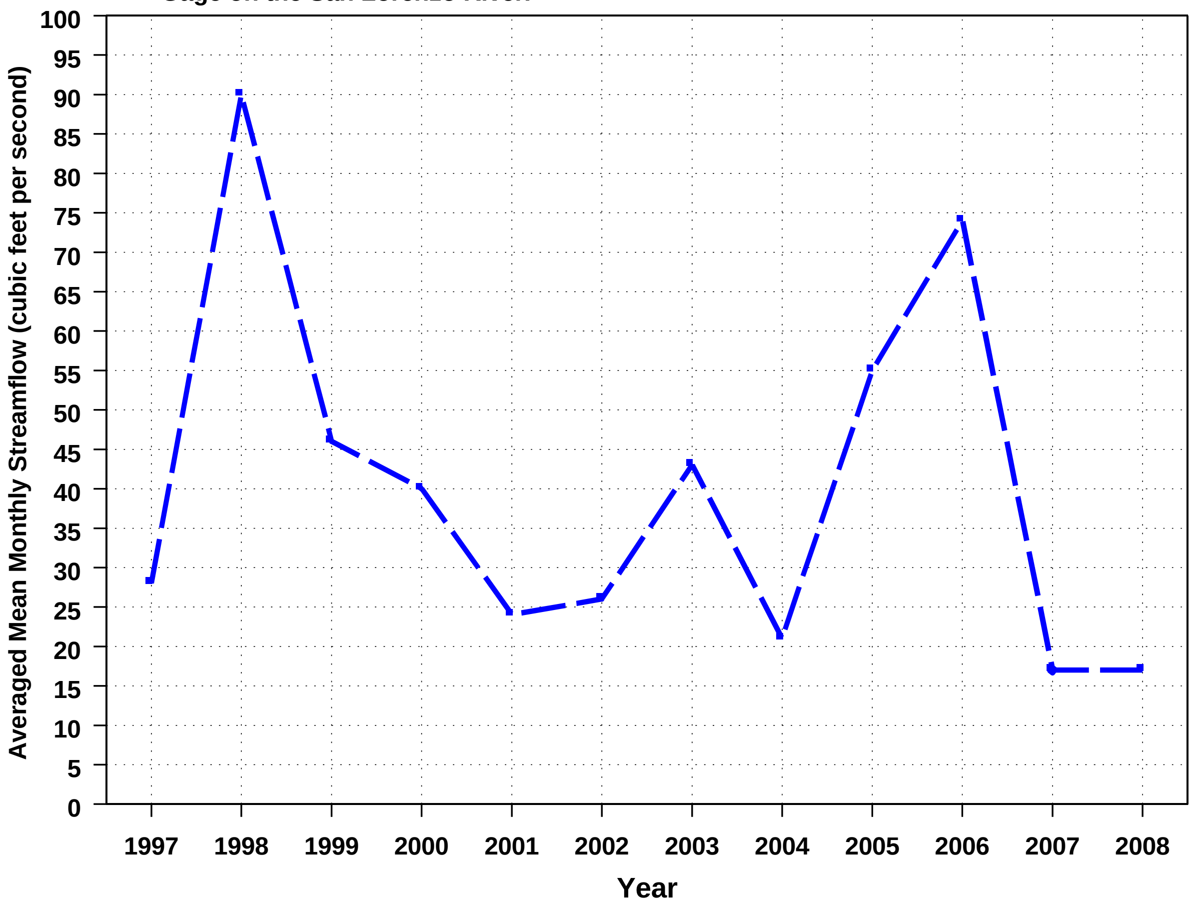


Table 25. Density of Juvenile Steelhead for SIZE CLASS II/ III (=>75 mm SL) at MAINSTEM SAN LORENZO RIVER Monitoring Sites in 1997-2001 and 2003-2008.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	Avg.
0a				5.4								
0b				4.3	5.2							4.8
1	30.9*	26.7	15.4	3.4	6.9				1.2	1.6	4.9	11.4
2a	67.0	20.1	4.2	3.7	11.0					11.1	12.2	18.5
2b				23.6	8.7							16.2
3	36.2	64.1	25.3	27.1	17.9							34.1
4	23.8	29.2	32.8	8.9	15.5				16.2	6.0	13.2	18.2
5		114.7	41.0	4.5	15.5							43.9
6	10.3	25.5	2.9	2.2	2.5	0.6	0.4	2.0	2.3	1.2	2.2	4.7
7	22.6	10.0	8.9	6.1	6.9	5.8	3.9	6.1				8.8
8	20.0	21.4	10.8	3.2	0.9	4.4	1.7	7.1	5.8	0.7	3.6	7.2
9	24.6	19.8	9.1	5.8	1.2	2.0	1.3	4.9				8.6
10	3.3	8.3	6.5	8.3	7.5	6.8	4.8	4.3				6.2
11	8.8	6.8	6.5	13.1	6.4	7.4	11.2	13.0	3.0	0.6	2.8	7.2
12a	5.9	4.6	15.7	5.5	9.5							8.2
12b		12.7	21.8	6.5	13.0	7.5	9.1	10.6				11.6

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

Figure 25. Averaged Mean Monthly Streamflow for May–September, 1997–2008 at the Big Trees Gage on the San Lorenzo River.



In the mainstem below Boulder Creek (middle and lower mainstem), site densities of the important Size Class II and III juveniles were very similar between 2007 and 2008 except at Site 4, where they had doubled due to a tripling of YOY densities and a portion of them reaching Size Class II (**Tables 22 and 25**).

In tributaries of the San Lorenzo River, total juvenile steelhead densities were generally higher in 2008 than 2007 (7 of 10 sites) due to higher YOY densities (7 of 10 sites) (**Figures 1 and 2; Tables 26 and 27**). Five of ten tributary sites had above average total densities in 2008 (10−11 years of data at most sites). Most tributary sites had lower yearling densities in 2008 compared to 2007 (8 of 10 sites) (statistically significant (**Table 42**), and a majority of them had lower Size Class II juvenile densities (6 of 10 sites) (**Figure 3; Tables 28 and 29**). Only one of ten sites had above average densities of these important larger juveniles in 2008 (soon to smolt) due to the low densities of yearlings. Of the 11 wetted sites sampled in tributaries, Size Class II (smolt) densities were generally low, with one rated “Very Poor,” one rated “Poor,” seven rated “Below Average,” one rated “Fair,” and one rated “Good” (Site 13d in upper Zayante Creek) (**Tables 40 and 41**). Site 13d had the highest density of yearlings and Size Class II juveniles in the watershed in 2008.

The upper Bean Creek Site 14c was completely dry in 2008. By early September, the only wetted channel in the ½-segment usually habitat typed had consisted of only two shallow, isolated puddles that had been the deepest pools in the segment before dewatering occurred. The dewatering included stream channel upstream of the segment an unknown distance and downstream of the segment to near the Ruins Creek confluence.

The reduced 2008 yearling densities (which were Size Class II and III) compared to 2007 at some tributary sites (Zayante 13c and Lompico 13e) may have resulted from reduced overwinter survival of yearlings caused by the much-above-bankfull, high peak flow on 25 January 2008 (7,570 cfs at the San Lorenzo River gage at Big Trees with bankfull estimated for 1.3 year recurrence interval at 2,800 cfs and for 1.5 year recurrence interval at 4,300 cfs (**Alley 1999a**)) (**Figure 66**). The peak flow in 2007 was only 1,210 cfs at the Big Trees Gage, allowing good overwinter survival during a very mild winter (**Figure 65**).

Reduced rearing habitat in tributaries in 2008 was not a good explanation for reduced densities of larger juveniles because that was mostly not the case. Reduced water velocity and presumably reduced insect drift due to reduced baseflow likely slowed growth rates of yearling fish but probably did not reduce their densities. When starvation becomes a factor, it is typically the YOY that are most impacted. Six of eleven wetted tributary reaches had similar rearing habitat quality between 2007 and 2008, one had positive change, and three reaches showed only slightly negative change. Only Reach 14b in middle Bean Creek showed clearly negative change due to reduced escape cover in pools (**Table 12**).

At other tributary sites (Bean 14b, Boulder 17b and Bear 18a), lower yearling densities (which were Size Class II and III) in 2008 compared to 2007 and/or below average densities may also have resulted from lower YOY densities the previous year 2007 compared to 2006 for recruitment and/or below average YOY in 2007. At Site 13e in Lompico Creek, the lower YOY density in 2008 compared to 2007 could not be conclusively explained. Adult access at the fish ladder and immediately above was likely better in 2008 than 2007 because of higher winter stormflows in 2008. Spawning success should have been better in 2008 than 2007. Rearing habitat in pools of Lompico Creek was of similar quality in both years, with escape cover similar and pool depth slightly deeper in 2008, on average. The only deterioration that was detected was slightly more percent fines in all habitats. Some of the deepest pools had been filled in more with sediment in 2008. There was a log jam across the entire channel width, downstream of the sampling site. The wood was hung up on the old dam abutment that constricted the channel width where the streambanks were near vertical. This wood cluster, in concert with the concrete apron below, may have prevented adult passage from March 1 onward without stormflows. But it was not expected to be a significant fish passage impediment at envisioned winter stormflows that occurred prior to March 1.

Figure 1. Total Juvenile Steelhead Site Densities in the San Lorenzo River in 2008 Compared to the 10-Year Average Density. (8th year for Mainstem (1), 7th year for Mainstem (2a), 3rd year for Lompico (13e) and 2nd Year for Branciforte (21a-1)).

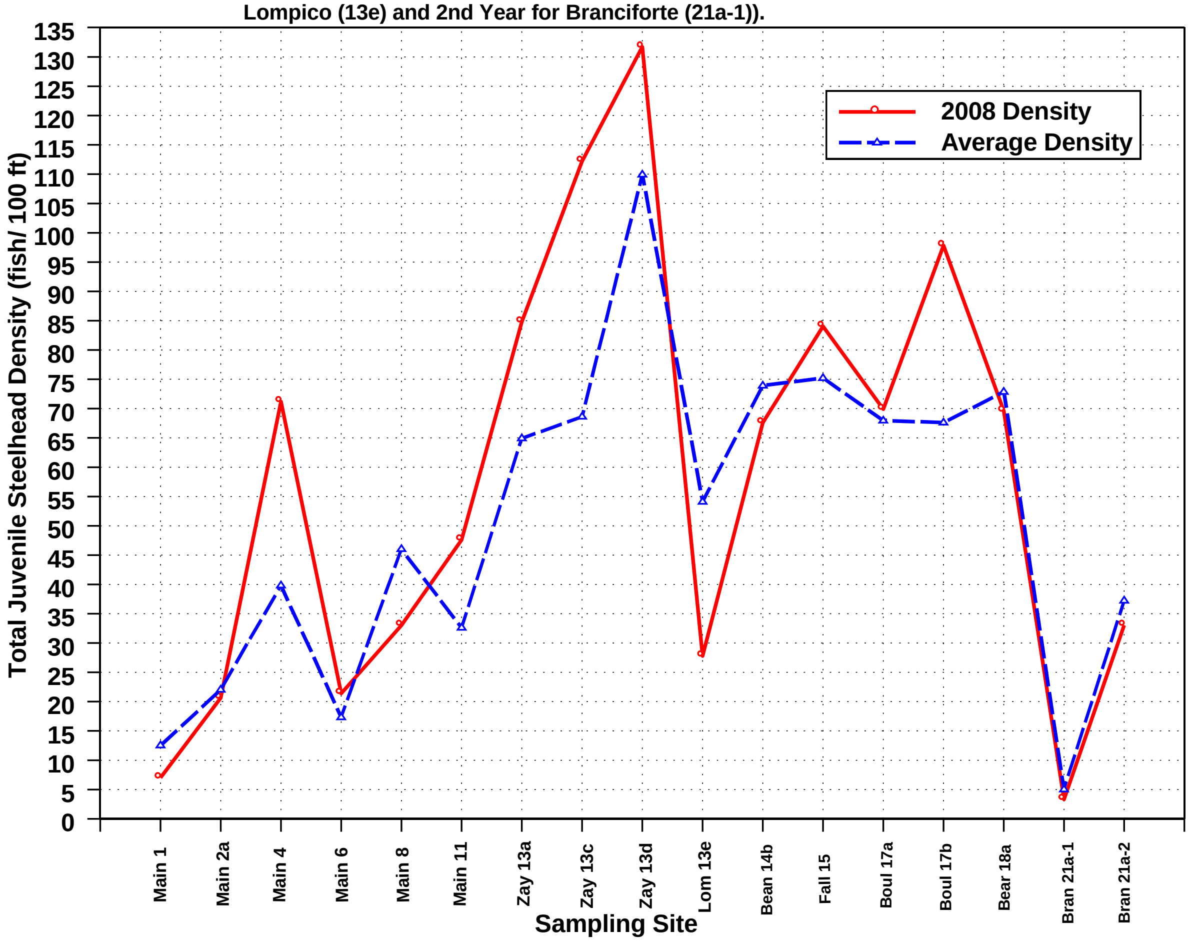


Figure 2. Juvenile Steelhead Site Densities for Young-of-the-Year in the San Lorenzo River in 2008 Compared to the 10-Year Average. (8the year for Mainstem (1), 7th year for Mainstem (2a), 3rd year for Lompico (13e) and 2nd Year for Branciforte (21a-1).

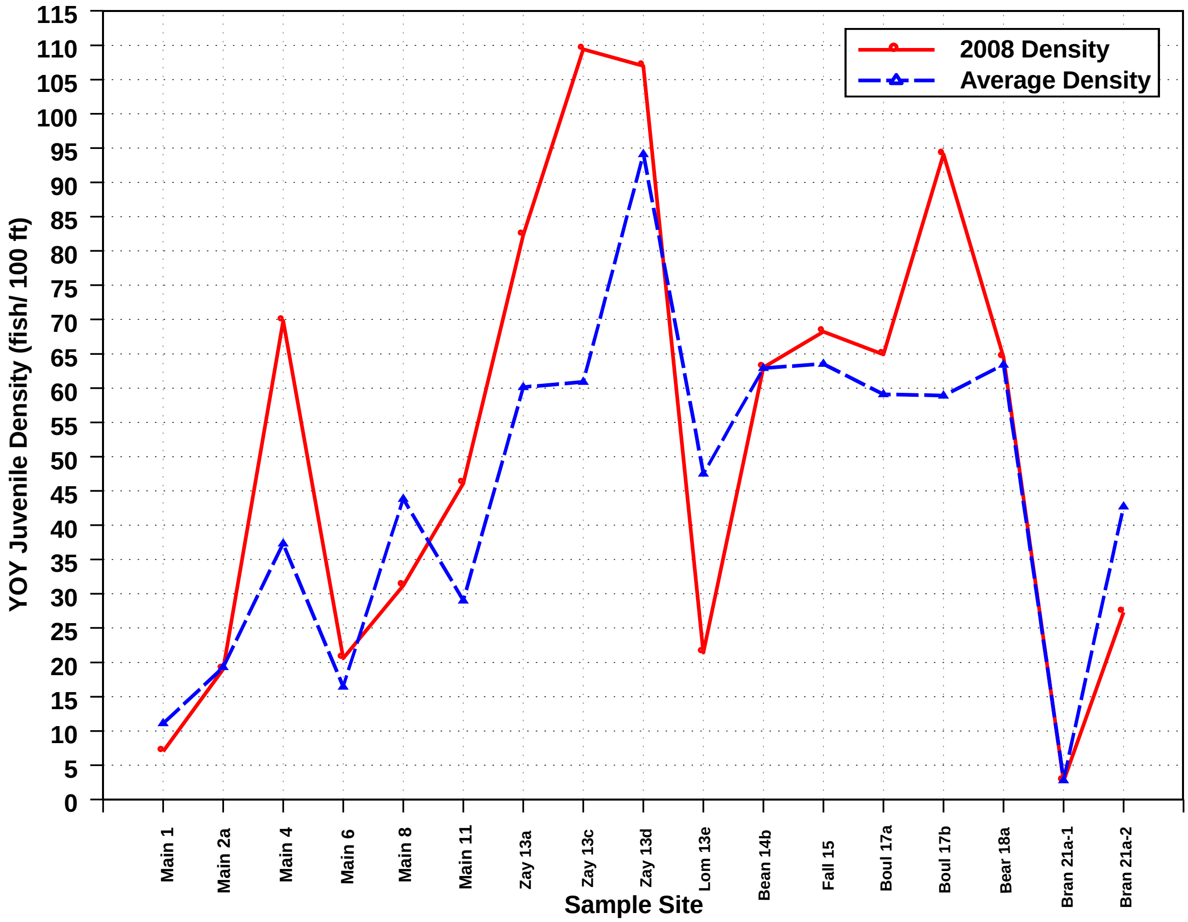


Figure 65. The 2007 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.

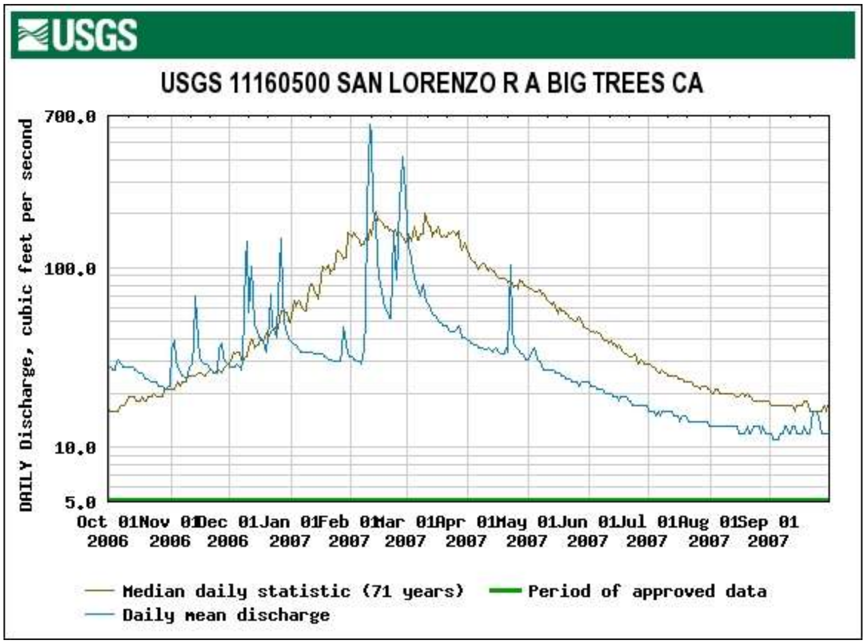


Figure 66. The 2008 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.

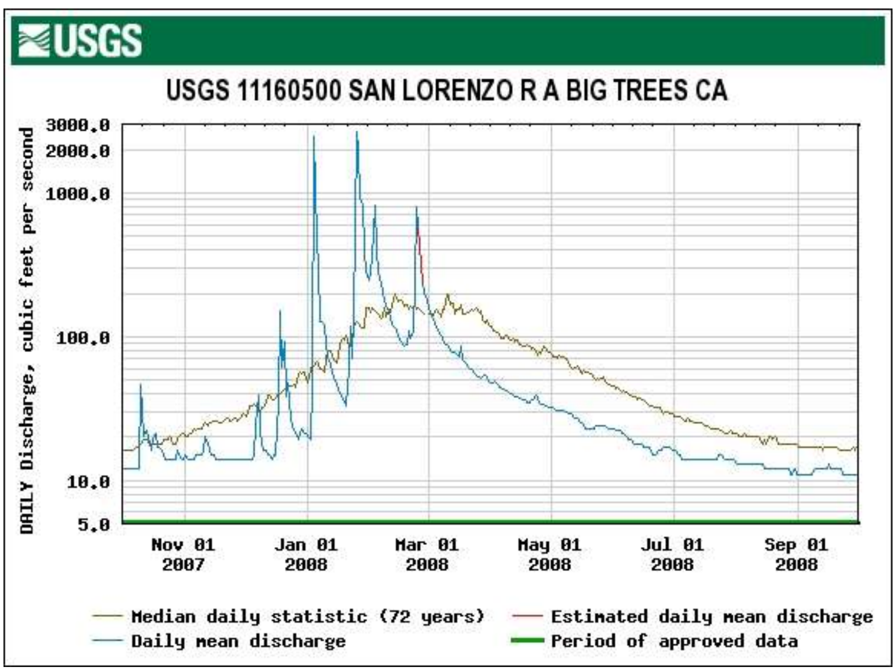


Table 26. TOTAL DENSITY of Juvenile Steelhead at SAN LORENZO TRIBUTARY Monitoring Sites in 1997-2001 and 2003-2008.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	Avg.
Zayante 13a		83.0	104.0	46.6	54.8	68.3	69.9	53.6	17.0	66.9	84.8	64.9
Zayante 13b	74.9*	50.7	74.9	24.9	38.0	70.0	65.1	53.3				56.5
Zayante 13c		69.0	61.9	25.8	40.0	123.6	63.4	78.2	18.0	94.4	112.2	68.6
Zayante 13d		82.2	105.0	57.5	84.1	243.8	145.3	99.7	69.8	80.5	131.7	109.9
Lompico 13e									26.2	108.3	27.8	54.1
Bean 14a		44.2	45.9	17.0	38.0	50.9	31.9	54.0				45.4
Bean 14b	73.0	115.6	92.1	48.3	65.5	146.4	78.5	103.5	13.1	8.9	67.6	73.9
Bean 14c		78.2	22.7	87.5	36.8	41.3	99.6	87.4	66.0	18.2	Dry	59.7
Fall 15	84.5	82.7	85.0	55.0	59.8						84.0	75.2
Newell 16	94.9	76.3	40.5	28.8	40.3				26.0			51.1
Boulder 17a	134.2	149.2	68.5	32.0	61.1	60.0	38.6	40.1	30.7	62.7	69.9	67.9
Boulder 17b	100.7	74.9	49.5	43.0	51.8	98.6	54.2	70.2	57.6	45.1	97.8	67.6
Boulder 17c		42.8	33.9	36.0	39.4	75.8	81.5	67.4				53.9
Bear 18a	118.5	81.2	76.0	33.6	58.8	86.8	87.7	87.9	52.9	47.3	69.6	72.8
Bear 18b		69.5	116.1	67.6	63.5							79.2
Kings 19a		10.8	0.5	8.4	7.6							6.8
Kings 19b	52.7	22.9	44.9	37.5	41.6							39.9
Carbonera 20a	13.4	21.0	18.9	9.7	19.6							16.5
Carbonera 20b		53.4	51.7	45.2	45.2							48.9
Branciforte 21a-1										6.6	3.3	5.0
Branciforte 21a-2	70.0	60.2	47.1	65.2	45.2				29.5	49.1	33.0	37.2
Branciforte 21b		67.8	57.6	59.6	57.5			20.4				52.1

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

Table 27. Density of Juvenile Steelhead for YOUNG-OF-THE-YEAR Fish (and Size Class I Juveniles in Most Years) at SAN LORENZO TRIBUTARY Monitoring Sites in 1997-2001 and 2003-2008.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	Avg.
Zayante 13a		80.0	96.4	29.0	52.9	64.4	68.3	50.1	14.6	62.1	82.3	60.1
Zayante 13b	64.9*	43.5	60.6	7.7	31.2	60.4	58.7	48.1				46.9
Zayante 13c		66.9	50.2	9.4	30.9	112.9	53.2	74.2	17.1	85.1	109.4	60.9
Zayante 13d		77.4	77.7	41.9	67.0	220.6	130.0	88.5	68.0	63.1	107.0	94.1
Lompico 13e									24.2	96.9	21.4	47.5
Bean 14a		43.4	42.0	11.1	36.0	46.4	30.0	50.9				37.1
Bean 14b	60.7	104.3	59.0	41.3	60.2	137.3	70.3	84.7	10.9	0	63.0	62.9
Bean 14c		71.8	6.9	76.6	18.1	23.0	87.4	81.5	61.1	5.6	Dry	48.5
Fall 15	79.6	74.8	68.1	45.1	45.4						68.2	63.5
Newell 16	77.1	67.6	17.7	19.9	35.6				20.1			43.6
Boulder 17a	119.2	141.5	50.7	22.9	55.9	45.6	31.3	36.5	25.3	55.9	64.9	59.1
Boulder 17b	91.8	68.0	36.2	33.9	38.9	84.1	48.0	62.0	56.1	35.1	94.1	58.9
Boulder 17c		37.6	15.3	27.5	30.7	64.0	69.7	61.3				43.7
Bear 18a	100.2	72.4	57.9	12.6	50.8	75.0	76.6	75.2	51.0	41.7	64.5	63.4
Bear 18b		66.6	89.2	58.3	48.1							65.6
Kings 19a		9.8	0	6.6	6.0							5.6
Kings 19b	48.2	20.8	32.1	31.5	28.5							32.2
Carbonera 20a	9.1	17.2	13.2	5.6	16.5							12.3
Carbonera 20b		50.9	40.3	29.7	33.4							38.6
Branciforte 21a-1										2.8	2.7	2.8
Branciforte 21a-2	64.6	54.1	35.5	47.2	34.2				30.6	47.6	27.3	42.7
Branciforte 21b		60.1	44.2	45.8	49.4			9.1				41.7

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

Table 28. Density of Juvenile Steelhead for YEARLING and OLDER Fish at SAN LORENZO TRIBUTARY Monitoring Sites in 1997-2001 and 2003-2008.

Sample Site	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	Avg.
Zayante 13a		3.0	7.6	17.7	1.9	3.9	1.6	3.5	3.2	4.9	2.1	5.0
Zayante 13b	10.0*	7.2	14.3	17.2	6.8	9.6	6.4	5.2				13.2
Zayante 13c		2.1	11.7	16.4	9.1	10.7	10.2	4.0	1.0	8.8	2.9	7.7
Zayante 13d		4.7	27.3	15.6	17.1	23.2	15.3	11.2	1.7	17.4	24.0	15.7
Lompico 13e									1.9	11.3	6.4	6.5
Bean 14a		0.8	3.9	5.9	2.0	4.5	1.9	3.1				4.6
Bean 14b	12.3	11.3	33.1	7.0	5.3	9.1	8.2	18.8	2.0	8.9	3.7	10.9
Bean 14c		6.4	15.8	10.9	18.7	18.3	12.2	5.9	4.1	5.4	Dry	10.8
Fall 15	4.9	7.9	16.9	9.9	14.4						15.8	11.6
Newell 16	17.8	8.7	22.8	8.9	4.7				5.4			11.4
Boulder 17a	15.0	7.7	17.8	9.1	5.2	14.4	7.3	3.6	5.9	6.8	5.8	9.0
Boulder 17b	8.9	6.9	13.3	9.1	12.9	14.5	6.2	8.2	1.1	9.8	3.8	8.6
Boulder 17c		5.2	18.6	8.5	8.7	11.8	11.8	6.1				10.4
Bear 18a	18.3	7.8	18.1	21.0	8.0	11.8	11.1	12.7	1.6	5.7	5.1	11.0
Bear 18b		2.9	26.9	9.3	15.4							13.6
Kings 19a		1.0	0.5	1.8	1.6							1.2
Kings 19b	4.5	2.1	12.8	6.0	13.1							7.7
Carbonera 20a	4.3	3.8	5.7	4.1	3.1							4.2
Carbonera 20b		2.5	11.4	15.5	11.8							10.3
Branciforte 21a-1										3.9	0.5	2.2
Branciforte 21a-2	5.4	6.1	11.6	18.0	11.0				0	1.5	5.7	7.4
Branciforte 21b		7.6	13.4	11.1	8.1			11.3				12.7

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

Figure 3. Juvenile Steelhead Site Densities for Size Classes II and III in the San Lorenzo River in 2008 Compared to the 10-Year Average. (8th year for Mainstem (1), 7th year for Mainstem (2a), 3rd Year for Lompico (13e) and 2nd Year for Branciforte (21a-1).

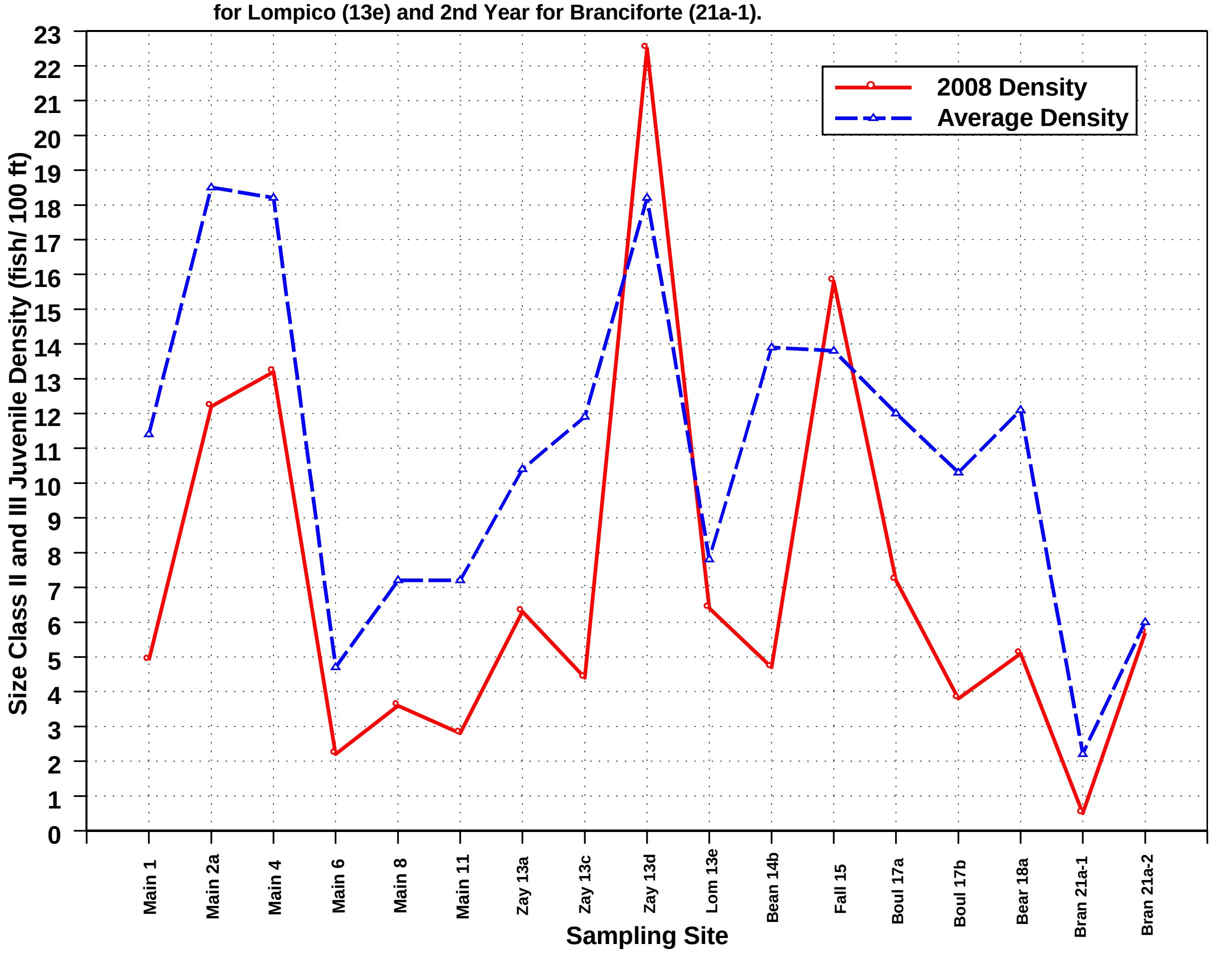


Table 29. Density of Juvenile Steelhead for SIZE CLASS II/III (=>75 mm SL) Fish at SAN LORENZO TRIBUTARY Monitoring Sites in 1998-2001 and 2003-2008.

Sample Site	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	Avg.
Zayante 13a	12.3*	13.5	17.7	1.9	3.9	1.6	31.4	11.7	4.9	6.3	10.4
Zayante 13b	14.9	19.9	17.2	7.1	9.6	6.4	17.3				13.2
Zayante 13c	14.7	16.8	16.4	9.5	10.7	10.2	15.0	12.6	8.8	4.4	11.9
Zayante 13d	10.7	27.3	15.6	17.1	23.2	5.3	15.7	17.3	17.4	22.5	18.2
Lompico 13e								5.7	11.3	6.4	7.8
Bean 14a	2.1	3.9	5.9	2.0	4.5	1.9	12.0				4.6
Bean 14b	11.3	33.1	7.1	5.3	9.1	8.2	39.4	11.9	8.9	4.7	13.9
Bean 14c	6.4	15.8	10.9	18.4	18.3	12.2	12.4	17.1	5.4	Dry	13.0
Fall 15	13.3	16.9	9.9	13.0						15.8	13.8
Newell 16	14.9	22.8	8.9	4.7				16.2			13.5
Boulder 17a	21.9	17.8	9.1	5.2	16.9	7.3	9.0	18.2	6.8	7.2	12.0
Boulder 17b	11.5	13.3	9.1	12.9	14.5	6.2	8.2	13.7	9.8	3.8	10.3
Boulder 17c	5.2	18.6	8.5	8.7	11.8	11.8	8.4				10.4
Bear 18a	13.0	18.1	21.0	8.0	11.8	11.1	13.7	13.6	5.7	5.1	12.1
Bear 18b	6.2	26.9	9.3	13.2							13.9
Kings 19a	6.2	0.5	1.8	1.6							2.5
Kings 19b	6.2	12.8	6.0	10.0							8.8
Carbonera 20a	11.5	5.7	4.1	3.1							6.1
Carbonera 20b	11.4	11.4	15.5	11.8							12.5
Branciforte 21a-1									3.9	0.5	2.2
Branciforte 21a-2	8.5	11.6	18.0	10.8				10.8	1.5	5.7	6.0
Branciforte 21b	14.8	13.4	11.1	8.1			16.0				12.7

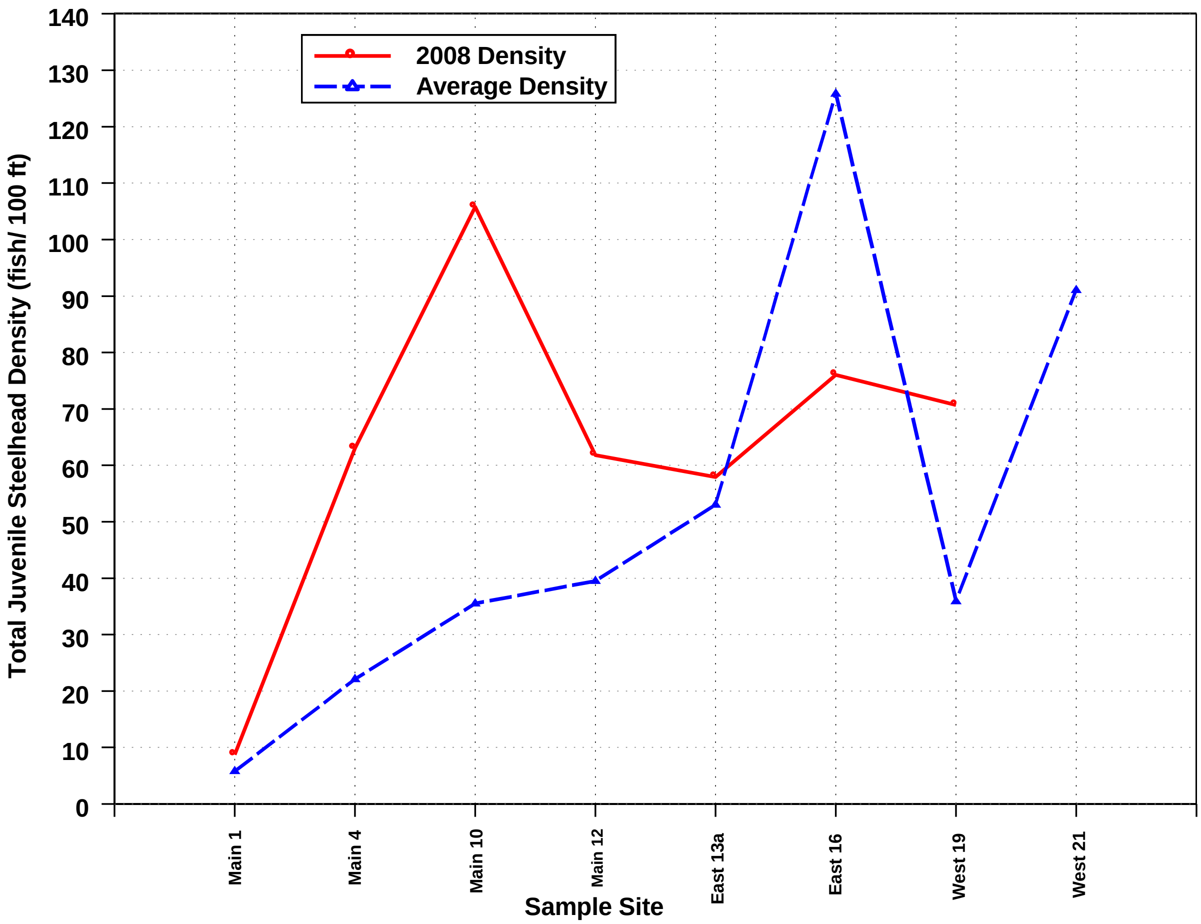
* Density in number of fish per 100 feet of stream.

R-7. Comparison of 2008 Steelhead Densities in Soquel Creek with Those Since 1997

In Soquel Creek in 2008, total juvenile steelhead densities were generally higher than in 2007 (6 of 7 sites) (**Figure 4; Table 30**). Total densities were above average at four of seven sites in 2008, with 8−12 years of data. This was due to higher YOY densities in 2008 compared to 2007 (the same 6 of 7 sites) and above average at 6 of 7 sites (**Figure 5; Table 31**). Yearling densities were generally lower in 2008 compared to 2007 (6 of 7 sites), below average at 4 of 6 sites and typically low throughout the watershed (**Table 32**). Densities of small Size Class I juveniles were generally higher in 2008 (6 of 7 sites) due to the high densities of YOY and slow growth rates (**Table 33**). Densities of Size Class II and III juveniles were generally less in 2008 than 2007 (5 of 7 sites) due to slower YOY growth rates in the upper two mainstem sites (**Appendix C and Alley 2008**) that allowed a smaller proportion of YOY to reach Size Class II their first growing season and fewer yearlings throughout most of the watershed (**Figure 6; Table 34**). Densities of these important larger juveniles that would soon smolt were above average at only two of seven sites in 2008. Of the 7 sampling sites rated according to Size Class II and II (smolt) densities, one was rated “Very Poor,” three rated “Poor,” two rated “Below Average” and only one rated “Fair” (Site 16 in the East Branch in the SDSF) (**Tables 40 and 41**).

Adult Yellow-legged frog- Mainstem Soquel Creek Adjacent to Flower Fields, Site 4, 21 September 2008

Figure 4. Total Juvenile Steelhead Site Densities in Soquel Creek in 2008 Compared to the 12-Year Average. (8th year West Branch (#19).



California Roach in Mainstem San Lorenzo River at Henry Cowell Site 4 15 September 2008

Immature Pacific Lamprey in Mainstem San Lorenzo River at Henry Cowell Site 4 15 September 2008

Table 30. TOTAL Juvenile Steelhead SITE DENSITIES (fish/ 100 ft) at Monitoring Sites in SOQUEL CREEK in 1997–2008.
(Resident rainbow trout likely present at Sites 18 and 22).

Sample Site	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Avg
1- Near GrangeHall	2.9	5.6	3.0	2.4	3.5	7.4	2.5	1.7	9.5	-	15.8	8.7	5.8
2- Adj. USGS Gage	4.5	9.4	1.2	5.9	7.7	-	4.1	3.5	4.2	-	-	-	5.1
3- Above Bates Ck	13.2	50.6	7.6	2.2	8.4	14.8	-	-	7.9	-	-	-	15.0
4- Adj. Flower Fld	49.6	20.7	6.8	5.5	23.0	33.3	7.7	20.1	9.2	3.2	23.5	63.0	22.1
5-Adj. Beach Shk	50.3	20.6	8.1	9.2	28.0	-	-	-	-	-	-	-	23.2
6- End of Cherryvale	24.7	9.4	2.6	5.3	5.7	47.69	15.9	13.1	16.1	-	-	-	15.6
7- Adj. Orchard	96.6	14.0	5.6	2.0	27.5	-	-	-	-	-	-	-	29.1
8- Below Rivervale	21.0	10.7	4.1	4.9	12.4	59.2	-	-	-	-	-	-	18.7
9- Adj. Mt. School	61.6	18.4	5.1	7.9	20.7	94.8	26.2	45.8	26.8	-	-	-	28.2
10- Above Allred	54.2	11.9	9.1	9.2	15.5	70.7	19.9	37.2	26.2	12.1	54.3	105.8	35.5
11- Below Purling Br	81.9	13.1	10.5	13.1	31.6	-	-	-	-	-	-	-	30.0
12- Near Soquel Ck Bridge	83.5	19.5	17.4	12.0	34.4	65.5	20.1	48.5	21.3	-	50.7	61.8	39.5
13a- Below Mill Pond	79.4	57.6	21.5	22.8	26.2	142.0	33.3	110.5	46.9	3.2	35.0	57.9	53.0
13b- Below Hinckley	-	-	17.0	24.4	47.3	110.6	-	-	-	-	-	-	49.8
14- Above Hinckley	49.6	47.7	23.6	18.5	37.7	107.6	86.0	78.0	39.5	-	-	-	54.2
15- Below Amaya Ck	137.9	79.9	55.4	39.0	38.3	91.6	-	-	-	-	-	-	73.7
16- Above Amaya Ck*	153.2	179.7	283.5	122.6	85.7	121.9	134.6	98.7	127.3	69.4	57.0	76.0	125.8
17- Above Fern Glch*	138.3	104.2	170.9	93.8	96.3	129.5	102.4	117.2	157.3	-	-	-	123.4
18- Above Ashbury G*	44.1	24.5	53.0	-	-	-	-	-	-	-	-	-	40.5
19- Below Hester Ck	62.3	21.7	32.1	27.6	37.8	-	-	-	-	8.3	26.5	70.7	30.9
20- Above Hester Ck	-	28.2	36.9	37.7	28.3	52.1	49.1	87.2	50.2	22.9		-	43.6
21- Above GS Falls I	-	-	-	-	-	119.0	112.9	99.4	102.0	44.2**	68.3**	-	91.0
22- Abv GS Falls II	-	-	-	-	-	65.5	27.5	58.1	5.5	8.6	-	-	33.1

* Raw data obtained from the Soquel Demonstration State Forest, 1997–1999.
** Raw Data obtained from NOAA Fisheries in 2006 and 2007.

Figure 5. Juvenile Steelhead Site Densities for Young-of-the-Year in Soquel Creek in 2008 Compared to the 12-Year Average (8th Year West Branch (#19)).

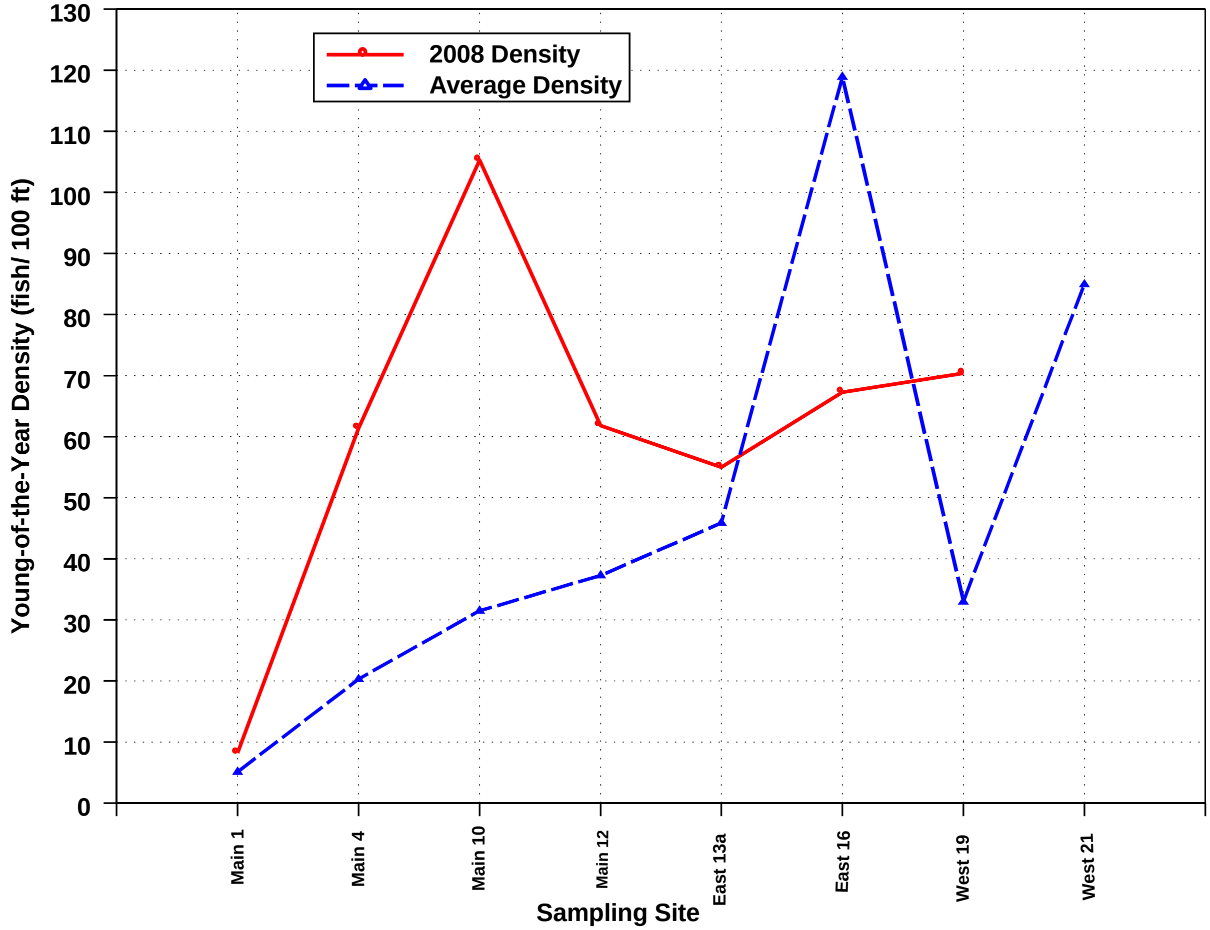


Table 31. SITE DENSITIES (fish/ 100 ft) of Juvenile Steelhead by YOUNG-OF-THE-YEAR AGE CLASS at Monitoring Sites in SOQUEL CREEK in 1997–2008.

(Resident rainbow trout likely present at Sites 18 and 22).

Sample Site	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Avg
1- Near GrangeHall	6.1	4.3	1.0	0.9	2.8	6.7	1.7	1.2	8.6	-	14.6	8.0	5.1
2- Adj. USGS Gage	4.1	8.3	0.4	5.3	6.3	-	4.9	3.5	2.6	-	-	-	4.4
3- Above Bates Ck	11.7	48.0	5.6	2.0	8.2	14.1	-	-	6.7	-	-	-	13.8
4- Adj. Flower Fld	45.7	18.2	6.2	3.5	19.9	28.8	7.1	19.4	8.7	2.4	22.2	61.4	20.3
5-Adj. Beach Shk	54.0	19.2	5.8	7.6	27.2	-	-	-	-	-	-	-	22.8
6- End of Cherryvale	21.1	8.3	2.4	4.4	5.1	46.4	15.8	12.8	12.9	-	-	-	14.4
7- Adj. Orchard	94.0	13.6	5.2	1.6	26.4	-	-	-	-	-	-	-	28.2
8- Below Rivervale	18.9	9.9	3.9	1.7	11.4	57.2	-	-	-	-	-	-	17.2
9- Adj. Mt. School	53.4	16.0	4.5	4.9	18.8	92.5	22.7	43.6	22.2	-	-	-	31.0
10- Above Allred	52.2	10.8	7.8	7.9	12.9	68.8	17.2	36.3	22.3	11.8	51.9	105.3	31.5
11- Below Purling Br	78.3	12.4	9.5	10.2	31.7	-	-	-	-	-	-	-	28.4
12- Near Soquel Ck Bridge	79.8	18.7	14.4	11.2	33.1	65.1	19.7	48.6	9.3	-	49.2	61.5	37.3
13a- Below Mill Pond	75.3	57.4	20.9	24.5	24.0	73.4	30.9	109.9	41.7	2.5	34.6	55.0	45.9
13b- Below Hinckley	-	-	16.2	22.0	45.9	109.5	-	-	-	-	-	-	48.4
14- Above Hinckley	46.9	46.6	24.7	14.6	37.2	104.6	83.7	76.8	36.7	-	-	-	52.4
15- Below Amaya Ck	139.0	76.9	49.6	35.8	35.4	87.1	-	-	-	-	-	-	70.6
16- Above Amaya Ck*	148.6	171.9	271.6	123.8	77.6	113.9	131.1	96.4	122.4	65.8	37.1	67.3	118.9
17- Above Fern Glch*	131.9	101.3	159.4	84.7	8.1	112.4	4.4	10.1	147.9	-	-	-	113.4
18- Above Ashbury G*	29.4	24.8	33.3	-	-	-	-	-	-	-	-	-	29.2
19- Below Hester Ck	60.6	5.7	30.8	27.0	36.6	-	-	-	-	8.3	24.9	70.4	33.0
20- Above Hester Ck	-	30.6	36.3	34.3	26.2	49.2	45.3	84.9	49.4	21.5	-	-	41.9
21- Above GS Falls I	-	-	-	-	-	107.2	104.0	93.7	98.7	42.7**	63.2**	-	84.9
22- Abv GS Falls II	-	-	-	-	-	56.2	24.7	53.2	1.0	6.1	-	-	28.2

* Raw data obtained from the Soquel Demonstration State Forest, 1997–1999.
** Raw data obtained from NOAA Fisheries in 2006 and 2007.

Table 32. SITE DENSITIES (fish/ 100 ft) of Juvenile Steelhead by YEARLING AND OLDER AGE CLASS at Monitoring Sites in SOQUEL CREEK in 1997–2008.
(Resident rainbow trout likely present at Sites 18 and 22).

Sample Site	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Avg.
1- Near GrangeHall	1.2	1.5	1.0	1.9	0.7	0.6	0.9	0.5	1.0	-	1.0	0.7	1.0
2- Adj. USGS Gage	0.6	1.2	0.4	0.5	1.4	-	0	0	1.3	-	-	-	0.7
3- Above Bates Ck	2.5	2.6	2.0	0.5	0.2	0.5	-	-	1.3	-	-	-	1.4
4- Adj. Flower Fld	2.2	1.5	0.9	2.0	0.7	2.6	0.6	0.7	0.6	0.7	2.2	1.6	1.3
5-Adj. Beach Shk	2.8	1.4	2.0	1.6	0.5	-	-	-	-	-	-	-	1.7
6- End of Cherryvale	3.2	1.7	0.7	1.0	0.5	1.3	0	0.3	3.1	-	-	-	1.3
7- Adj. Orchard	2.2	0.5	0.4	0.4	1.1	-	-	-	-	-	-	-	0.9
8- Below Rivervale	1.0	0.9	0.7	3.1	1.4	1.6	-	-	-	-	-	-	1.5
9- Adj. Mt. School	3.4	1.7	1.3	4.7	1.7	2.6	3.6	2.3	4.5	-	-	-	2.9
10- Above Allred	1.3	1.1	1.3	1.1	0.9	1.8	3.0	0.2	2.9	0.4	4.3	0.4	1.3
11- Below Purling Br	2.7	0.6	2.2	4.1	0.3	-	-	-	-	-	-	-	2.0
12- Near Soquel Ck Bridge	3.6	0.5	2.0	1.1	0.9	0.3	0.5	0	1.9	-	1.5	0.3	1.1
13a- Below Mill Pond	7.1	0	1.1	2.9	2.1	2.6	2.1	0.6	5.3	0.7	0.7	2.9	2.3
13b- Below Hinckley	-	-	1.1	4.7	1.4	2.0	-	-	-	-	-	-	2.3
14- Above Hinckley	2.6	1.0	1.6	4.8	1.9	2.9	1.4	0.6	2.8	-	-	-	2.2
15- Below Amaya Ck	0	2.5	6.7	4.0	2.9	4.3	-	-	-	-	-	-	3.4
16- Above Amaya Ck*	3.6	5.4	11.6	2.8	8.1	8.0	3.5	2.3	4.4	3.5	20.0	11.0	7.0
17- Above Fern Gch*	5.7	3.1	11.5	6.9	18.2	17.0	7.8	7.1	9.6	-	-	-	9.7
18- Above Ashbury G*	13.8	9.6	19.8	-	-	-	-	-	-	-	-	-	14.4
19- Below Hester Ck	1.2	0.4	1.6	1.2	1.2	-	-	-	-	0.3	1.6	0.4	1.0
20- Above Hester Ck	-	0.3	0.3	3.0	2.1	2.9	3.8	2.3	1.0	0.6	-	-	1.8
21- Above GS Falls I	-	-	-	-	-	11.9	8.8	5.3	2.1	1.2**	5.1**	-	5.7
22- Abv GS Falls II	-	-	-	-	-	9.3	2.8	4.9	4.5	2.5	-	-	4.8

* Raw data obtained from the Soquel Demonstration State Forest, 1997–1999.
** Raw Data obtained from NOAA Fisheries in 2006 and 2007.

Table 33. SITE DENSITIES (fish/ 100 ft) of Juvenile Steelhead by SIZE CLASS I at Monitoring Sites in SOQUEL CREEK in 1997–2008.
(Resident rainbow trout likely present at Sites 18 and 22).

Sample Site	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Avg.
1- Near GrangeHall	1.7	0.2	0	0	0.5	3.5	0.3	0.5	0	-	9.2	4.9	1.9
2- Adj. USGS Gage	0.9	0.2	0	0	2.2	3.5	1.7	1.9	0	-	-	-	0.9
3- Above Bates Ck	1.8	0	0	0.9	4.0	10.4	-	-	0	-	-	-	2.4
4- Adj. Flower Fld	20.1	1.5	0	0.5	7.6	20.0	4.4	13.8	0	0.4	17.2	58.1	11.9
5-Adj. Beach Shk	38.2	0	0.3	1.1	21.6	-	-	-	-	-	-	-	12.2
6- End of Cherryvale	14.3	0	0	0	2.8	42.9	13.7	12.5	0.4	-	-	-	9.6
7- Adj. Orchard	71.6	1.0	1.6	0.4	21.5	-	-	-	-	-	-	-	19.2
8- Below Rivervale	11.7	0.2	1.0	0.2	6.3	49.6	-	-	-	-	-	-	11.5
9- Adj. Mt. School	36.7	1.1	0.4	0.5	6.6	79.7	12.7	27.1	2.1	-	-	-	18.5
10- Above Allred	43.2	0	3.3	0	9.4	60.8	13.8	34.7	3.5	5.8	43.0	102.7	26.6
11- Below Purling Br	60.5	0.9	4.1	2.8	29.1	-	-	-	-	-	-	-	19.5
12- Near Soquel Ck Bridge	68.1	3.8	9.2	5.9	28.9	60.1	16.3	44.0	4.5	-	45.9	60.4	31.6
13a- Below Mill Pond	60.2	30.4	13.0	16.4	23.1	138.3	29.8	109.9	20.8	0	31.8	53.9	44.0
13b- Below Hinckley	-	-	3.2	15.8	43.9	105.1	-	-	-	-	-	-	42.0
14- Above Hinckley	27.4	26.9	11.8	3.5	24.3	101.7	78.9	76.1	17.8	-	-	-	40.9
15- Below Amaya Ck	130.4	64.1	38.2	30.5	35.4	84.9	-	-	-	-	-	-	63.9
16- Above Amaya Ck*	143.3	164.8	267.8	114.7	77.6	113.9	131.1	96.4	118.2	60.3	37.1	66.0	116.0
17- Above Fern Glch*	130.3	90.1	151.7	82.4	78.1	112.4	94.4	110.1	130.9	-	-	-	108.9
18- Above Ashbury G*	29.2	20.6	33.2	-	-	-	-	-	-	-	-	-	27.7
19- Below Hester Ck	60.1	20.4	23.4	24.5	36.6	-	-	-	-	3.6	21.7	65.0	31.9
20- Above Hester Ck	-	20.6	33.2	32.4	26.2	49.2	45.3	84.9	47.3	17.1	-	-	39.6
21- Above GS Falls I	-	-	-	-	-	107.2	103.1	91.8	90.0	30.1**	61.3**	-	80.6
22- Abv GS Falls II	-	-	-	-	-	56.2	24.7	50.9	0.3	3.9	-	-	27.2

*** Raw data obtained from the Soquel Demonstration State Forest, 1997–1999.**
**** Raw data obtained from NOAA Fisheries in 2006 and 2007.**

Coho Salmon juveniles, East Branch Soquel Creek, Site 13a 25 September 2008

Sacramento Sucker's Ventral Mouth in Soquel Creek Site 1 near Nob Hill 22 September 2008

Adult Sacramento Sucker Soquel Creek Site 1 near Nob Hill 22 September 2008

Figure 6. Juvenile Steelhead Site Densities for Size Classes II and III in Soquel Creek in 2008 Compared to the 12-Year Average Density (8th Year West Branch (#19)).

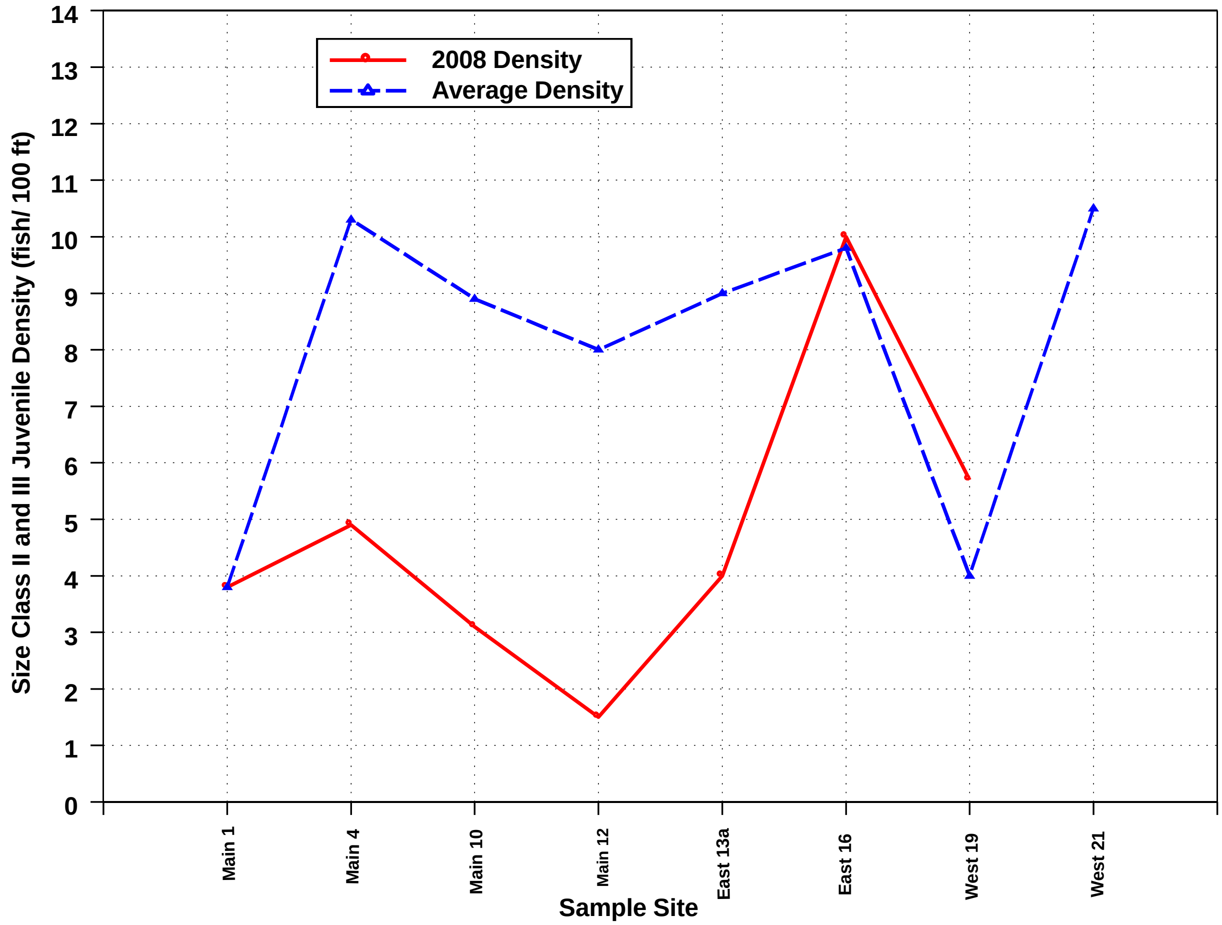


Table 34. SITE DENSITIES (fish/ 100 ft) of Juvenile Steelhead by SIZE CLASS II/III at Monitoring Sites in SOQUEL CREEK in 1997–2008.
(Resident rainbow trout likely present at Sites 18 and 22).

Sample Site	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Avg
1- Near GrangeHall	1.2	5.4	3.0	2.4	3.0	3.9	2.3	1.2	9.5	-	6.6	3.8	3.8
2- Adj. USGS Gage	3.6	9.4	0.8	5.9	5.5	-	2.4	1.6	4.2	-	-	-	4.2
3- Above Bates Ck	11.4	50.6	7.6	1.3	4.4	4.4	-	-	7.9	-	-	-	12.5
4- Adj. Flower Fld	29.5	19.2	6.8	5.0	15.4	13.3	3.3	6.3	9.2	2.8	6.3	4.9	10.3
5-Adj. Beach Shk	18.1	20.6	7.8	8.1	6.4	-	-	-	-	-	-	-	12.2
6- End of Cherryvale	10.4	9.4	2.6	5.3	2.9	4.7	2.2	0.6	15.7	-	-	-	6.0
7- Adj. Orchard	25.0	13.0	4.0	1.6	6.0	-	-	-	-	-	-	-	9.9
8- Below Rivervale	9.3	10.5	3.1	4.7	6.1	9.6	-	-	-	-	-	-	7.2
9- Adj. Mt. School	24.9	17.3	4.7	7.4	14.1	15.1	13.5	18.7	24.7	-	-	-	15.6
10- Above Allred	11.0	11.9	5.8	9.2	6.1	9.9	6.1	2.5	22.7	6.3	11.3	3.1	8.9
11- Below Purling Br	21.4	12.2	6.4	10.3	2.5	-	-	-	-	-	-	-	10.6
12- Near Soquel Ck Bridge	15.4	15.7	8.2	6.1	5.5	5.4	3.8	4.5	16.8	-	4.8	1.5	8.0
13a- Below Mill Pond	19.2	27.2	8.5	6.4	3.1	3.7	3.5	0.6	26.1	3.2	3.1	4.0	9.0
13b- Below Hinckley	-	-	13.8	8.6	3.4	5.5	-	-	-	-	-	-	7.8
14- Above Hinckley	22.2	20.8	11.8	15.0	13.4	5.9	7.1	1.9	21.7	-	-	-	13.3
15- Below Amaya Ck	7.5	15.8	17.2	8.5	2.9	6.7	-	-	-	-	-	-	9.8
16- Above Amaya Ck*	9.9	14.9	15.7	7.9	8.1	8.0	3.5	2.3	9.1	9.1	20.0	10.0	9.8
17- Above Fern Glch*	8.0	14.1	19.2	11.4	18.2	17.1	8.0	7.1	26.4	-	-	-	14.4
18- Above Ashbury G*	14.9	3.9	19.8	-	-	-	-	-	-	-	-	-	12.9
19- Below Hester Ck	2.2	1.3	8.7	3.1	1.2	-	-	-	-	4.7	4.8	5.7	4.0
20- Above Hester Ck	-	7.6	3.7	5.3	2.1	2.9	3.8	2.3	2.9	5.8	-	-	4.0
21- Above GS Falls I	-	-	-	-	-	11.8	9.8	7.6	12.0	14.1**	7.5**	-	10.5
22- Above GS Falls II	-	-	-	-	-	9.3	2.8	7.2	5.2	4.7	-	-	5.8

* Raw data obtained from the Soquel Demonstration State Forest, 1997–1999.
**Raw data obtained from NOAA Fisheries in 2006 and 2007.

Figure 79. The 2007 Daily Mean and Median Flow at the USGS Gage on Soquel Creek at Soquel.

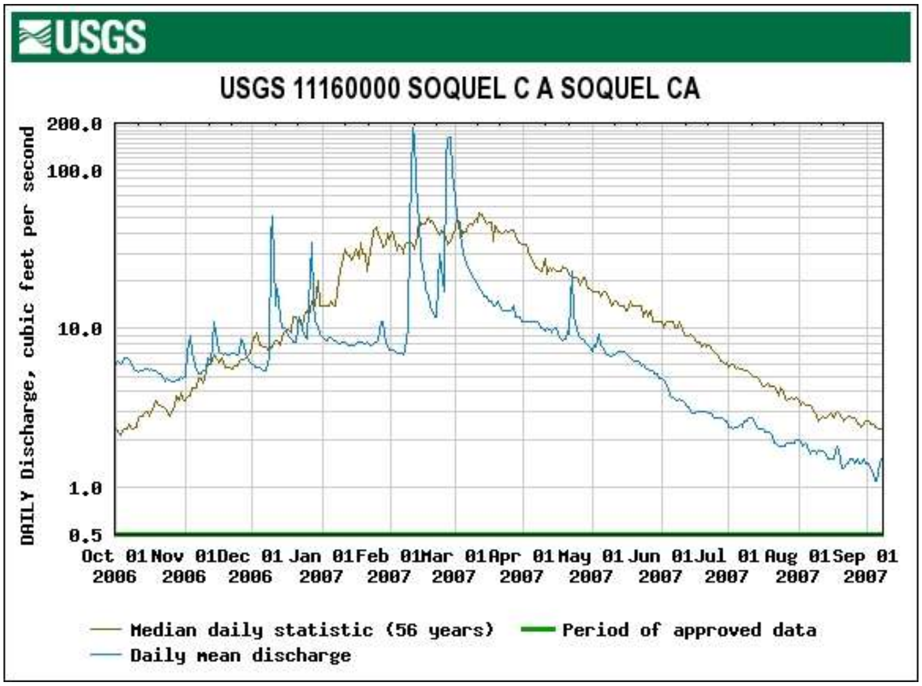
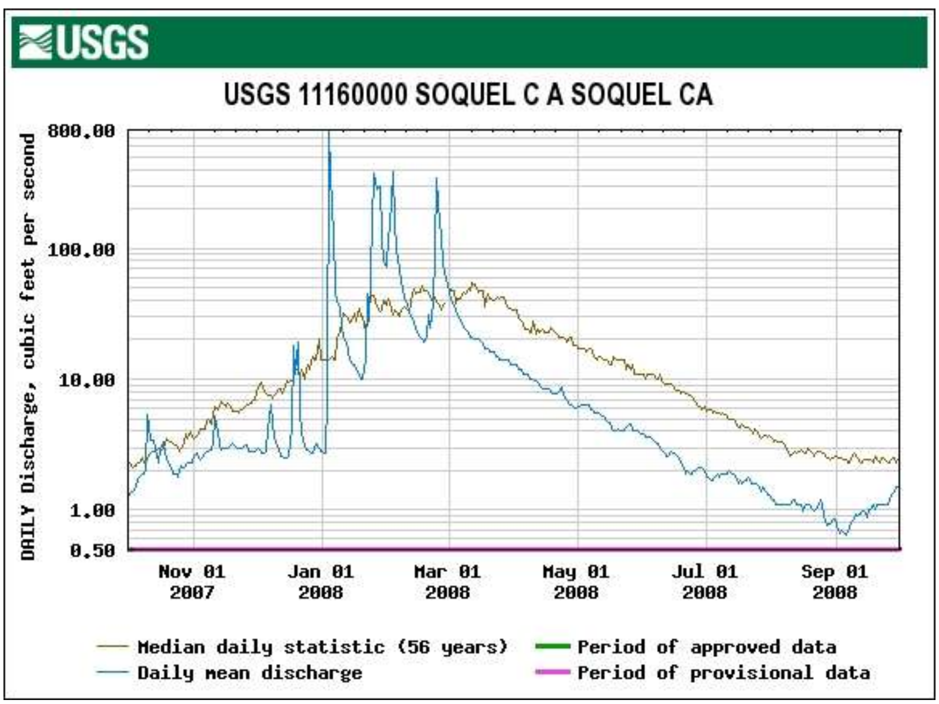


Figure 80. The 2008 Daily Mean and Median Flow at the USGS Gage on Soquel Creek at Soquel.



R-8. Comparison of 2008 Steelhead Densities in Aptos and Valencia Creeks with Those in 1981, 1994 and 2006–2008.

In the Aptos Creek watershed, total juvenile steelhead densities in 2008 were higher in the upper two sites (one in Aptos Creek and one in Valencia Creek) and lower in the two lower sites compared to 2007 (**Figure 7; Table 35**). Total densities were above average at all four sites, with a limited four years of data. YOY densities were generally higher in 2008 (3 of 4 sites), and yearling densities were generally lower (3 of 4 sites) (**Figure 8; Tables 36 and 37**). Densities of smaller juveniles (Size Class I < 75 mm SL) were higher in 2008 at 3 of 4 sites due to the higher YOY densities and slow growth rates (**Table 38**). Densities of larger juveniles (Size Classes II and III => 75 mm SL) were generally less in 2008 (3 of 4 sites) due to lower yearling densities (**Figure 9; Table 39**). Densities of these important larger juveniles that would smolt soon were below average at three of four sites. Of the four sampling sites rated by densities of Size Class II and III juveniles (smolt-sized), the two sites in Aptos Creek were rated "Below Average," and the two sites in Valencia Creek were rated "Fair" (**Tables 40 and 41**).

The higher yearling densities in Valencia Creek than Aptos Creek was inconsistent with habitat quality. Aptos Creek had deeper pools, more streamflow and better substrate conditions in 2008. The only higher habitat rating for Valencia Creek was the segment-wide escape cover rating for its upper reach above Valencia Road Bridge compared to those in Aptos Creek (**Table 18**). The higher Valencia Creek yearling densities in 2008 were also incongruous with the consistently lower densities of YOY for recruitment into the yearling age class in Valencia Creek in 2006−2008 (**Table 36**).

Coastrange sculpin in Mainstem San Lorenzo River in the Rincon Reach, Site 2
16 September 2008

Figure 7. Total Juvenile Steelhead Site Densities in Aptos and Valencia Creeks in 2007, 2008 and 4-Year Average, Including 1981 and 2006.

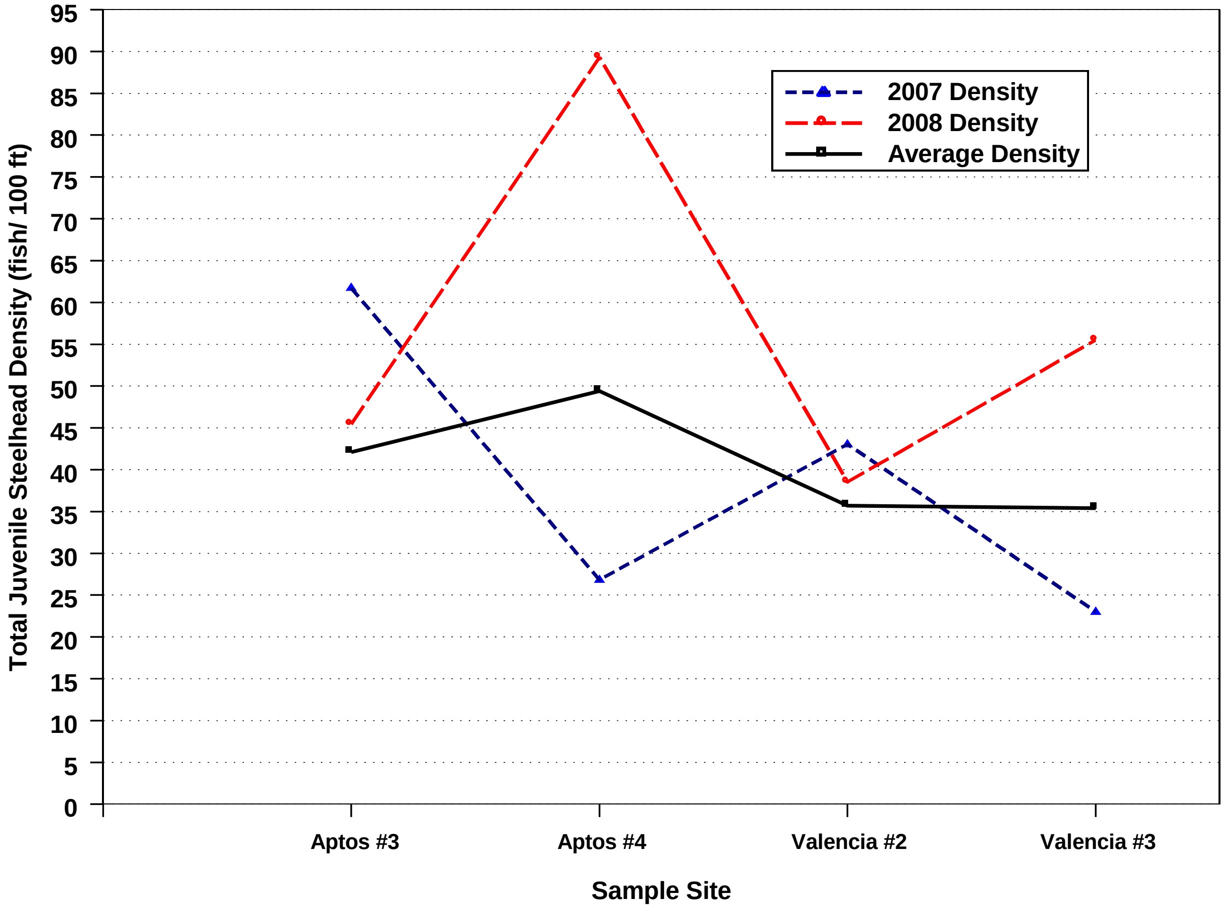


Table 35. TOTAL DENSITY of Juvenile Steelhead at Monitoring Sites in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS VALLEY Creeks, 1981, 1994 and 2006–2008.

Sample Site	1981	1994	2006	2007	2008	Avg.
Aptos #3- in County Park	35.2*	–	26.2	61.7	45.4	42.1
Aptos #4- above steel Bridge Xing (Nisene Marks)	43.0	–	38.6	26.8	89.3	49.4
Valencia #2- below Valencia Road Crossing	33.1	–	28.3	43.0	38.5	35.7
Valencia #3- Above Valencia Road Crossing	29.8	–	33.4	23.0	55.5	35.4
Corralitos #0- Below Dam				36.2	69.9	53.1
Corralitos #3- Above Colinas Drive	39.1	18.6	35.5	42.1	35.9	34.2
Corralitos #8- Below Eureka Gulch	81.9	28.6	49.0	52.9	55.9	53.7
Corralitos #9- Above Eureka Gulch	86.1	29.9	87.1	38.5	61.7	60.7
Shingle Mill #1- Below 2nd Road Crossing	24.5	30.0	33.9	16.2	18.8	24.7
Shingle Mill #3- Above 2nd Road Crossing	32.6	–	22.9	12.7	24.5	23.2
Browns Valley #1- Below Dam	54.3	22.5	101.6	35.4	36.5	50.1
Browns Valley #2- Above Dam	71.6	18.5	99.5	79.0	44.8	62.7

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

Figure 8. Juvenile Steelhead Site Densities for Young-of-the-Year in Aptos and Valencia Creeks in 2007, 2008 and the Average, Including 1981 and 2006.

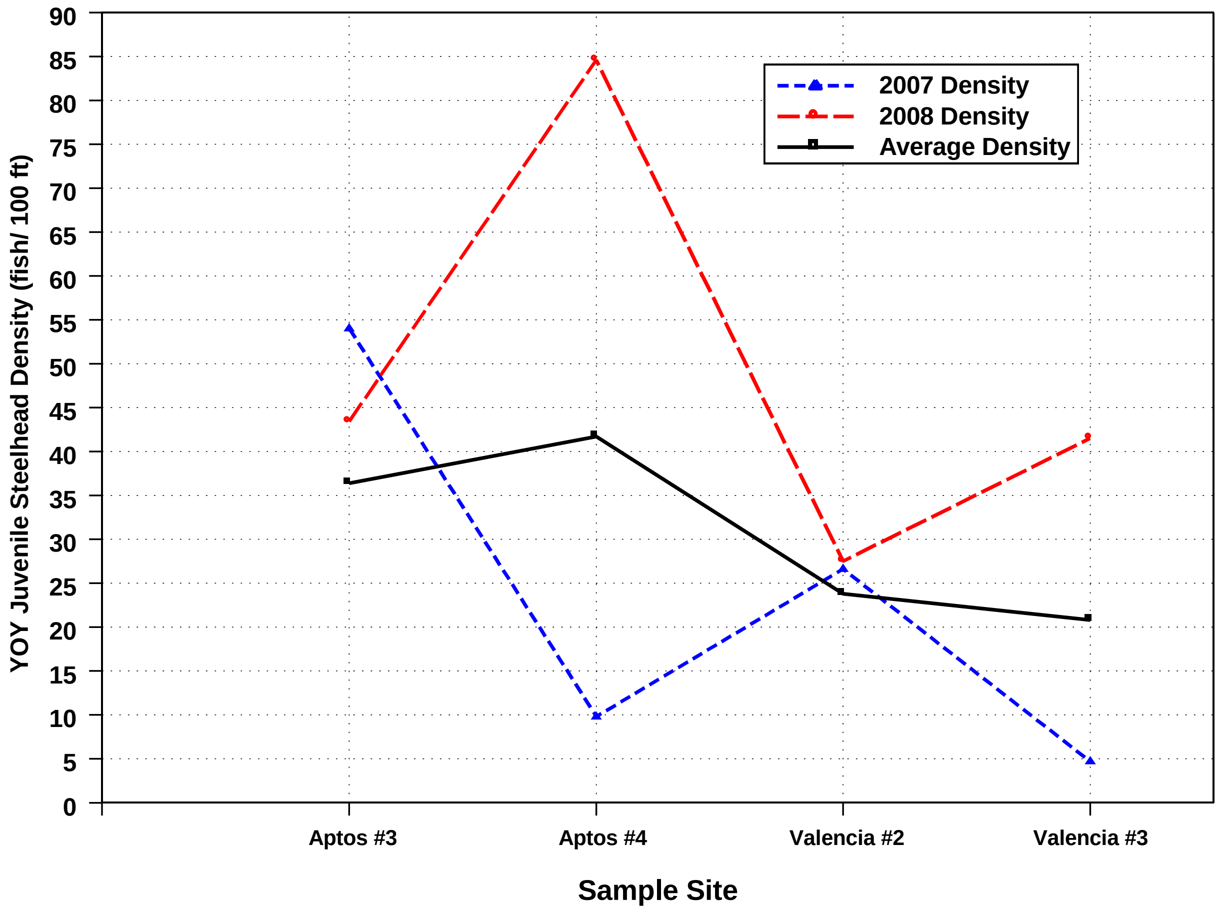


Table 36. Density of Juvenile Steelhead for YOUNG-OF-THE-YEAR Fish at Monitoring Sites in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS VALLEY Creeks, 1981, 1994, 2006–2008.

Sample Site	1981	1994	2006	2007	2008	Avg.
Aptos #3- in County Park	24.4*	–	23.7	54.0	43.4	36.4
Aptos #4- above steel Bridge Xing (Nisene Marks)	37.1	–	35.2	9.8	84.6	41.7
Valencia #2- below Valencia Road Crossing	16.6	–	24.5	26.6	27.5	23.8
Valencia #3- Above Valencia Road Crossing	16.6	–	20.5	4.7	41.5	20.8
Corralitos #0 Below Dam				27.0	61.2	44.1
Corralitos #3- Above Colinas Drive	33.9	10.2	24.6	30.6	27.6	25.4
Corralitos #8- Below Eureka Gulch	59.7	14.3	45.0	44.0	46.6	42.0
Corralitos #9- Above Eureka Gulch	55.8	16.7	78.4	31.3	44.6	45.4
Shingle Mill #1- Below 2nd Road Crossing	14.3	5.7	25.1	2.9	13.2	12.2
Shingle Mill #3- Above 2nd Road Crossing	18.6	–	19.5	6.0	23.9	17.0
Browns Valley #1- Below Dam	26.9	7.0	96.6	15.3	25.0	34.2
Browns Valley #2- Above Dam	66.1	12.8	94.7	47.0	32.2	50.6

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

Table 37. Density of Juvenile Steelhead for YEARLING AND OLDER Fish at Monitoring Sites in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS VALLEY Creeks, 1981, 1994 and 2006–2008.

Sample Site	1981	1994	2006	2007	2008	Avg.
Aptos #3- in County Park	10.8*	–	3.1	7.6	2.3	6.0
Aptos #4- above steel Bridge Xing (Nisene Marks)	5.9	–	3.0	17.1	4.9	4.6
Valencia #2- below Valencia Road Crossing	16.5	–	3.8	16.4	11.0	11.9
Valencia #3- Above Valencia Road Crossing	13.2	–	12.9	11.5	14.0	12.9
Corralitos #0 Below Dam				9.1	8.7	8.9
Corralitos #3- Above Colinas Dr.	5.2	8.4	10.8	11.5	8.3	8.9
Corralitos #8- Below Eureka Gulch	22.2	14.3	4.0	9.0	9.4	11.8
Corralitos #9- Above Eureka Gulch	30.3	13.2	9.5	7.2	17.1	15.5
Shingle Mill #1- Below 2nd Road Crossing	10.2	24.3	9.0	13.3	5.6	12.5
Shingle Mill #3- Above 2nd Road Crossing	14.0	–	3.4	6.7	0.7	6.7
Browns Valley #1- Below Dam	27.4	15.5	4.3	19.6	11.5	15.7
Browns Valley #2- Above Dam	5.5	7.7	2.8	32.0	12.6	12.1

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

Table 38. Density of Juvenile Steelhead for SIZE CLASS I Fish (<75 mm SL) at Monitoring Sites in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS VALLEY Creeks, 1981, 1994, 2006–2008.

Sample Site	1981	1994	2006	2007	2008	Avg.
Aptos #3- in County Park	24.4*	–	7.2	50.8	39.4	30.5
Aptos #4- above steel Bridge Xing (Nisene Marks)	37.1	–	28.5	9.0	83.8	39.6
Valencia #2- below Valencia Road Crossing	16.6	–	24.5	26.6	27.5	23.8
Valencia #3- Above Valencia Road Crossing	16.6	–	20.5	5.7	41.5	21.1
Corralitos #0 Below Dam				27.0	61.2	44.1
Corralitos #3- Above Colinas Drive	33.9	10.2	16.2	30.6	27.6	19.9
Corralitos #8- Below Eureka Gulch	59.7	14.3	35.8	43.0	46.6	39.9
Corralitos #9- Above Eureka Gulch	55.8	16.7	45.5	31.3	44.6	38.8
Shingle Mill #1- Below 2nd Road Crossing	14.3	5.7	17.7	2.9	13.2	10.8
Shingle Mill #3- Above 2nd Road Crossing	32.4	–	19.5	6.0	23.9	20.5
Browns Valley #1- Below Dam	26.9	7.0	84.6	18.1	25.0	32.4
Browns Valley #2- Above Dam	66.1	12.8	82.6	48.8	32.2	48.5

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

Figure 9. Juvenile Steelhead Densities for Size Classes II and III in Aptos and Valencia Creeks in 2007, 2008 and the Average, Including 1981 and 2006.

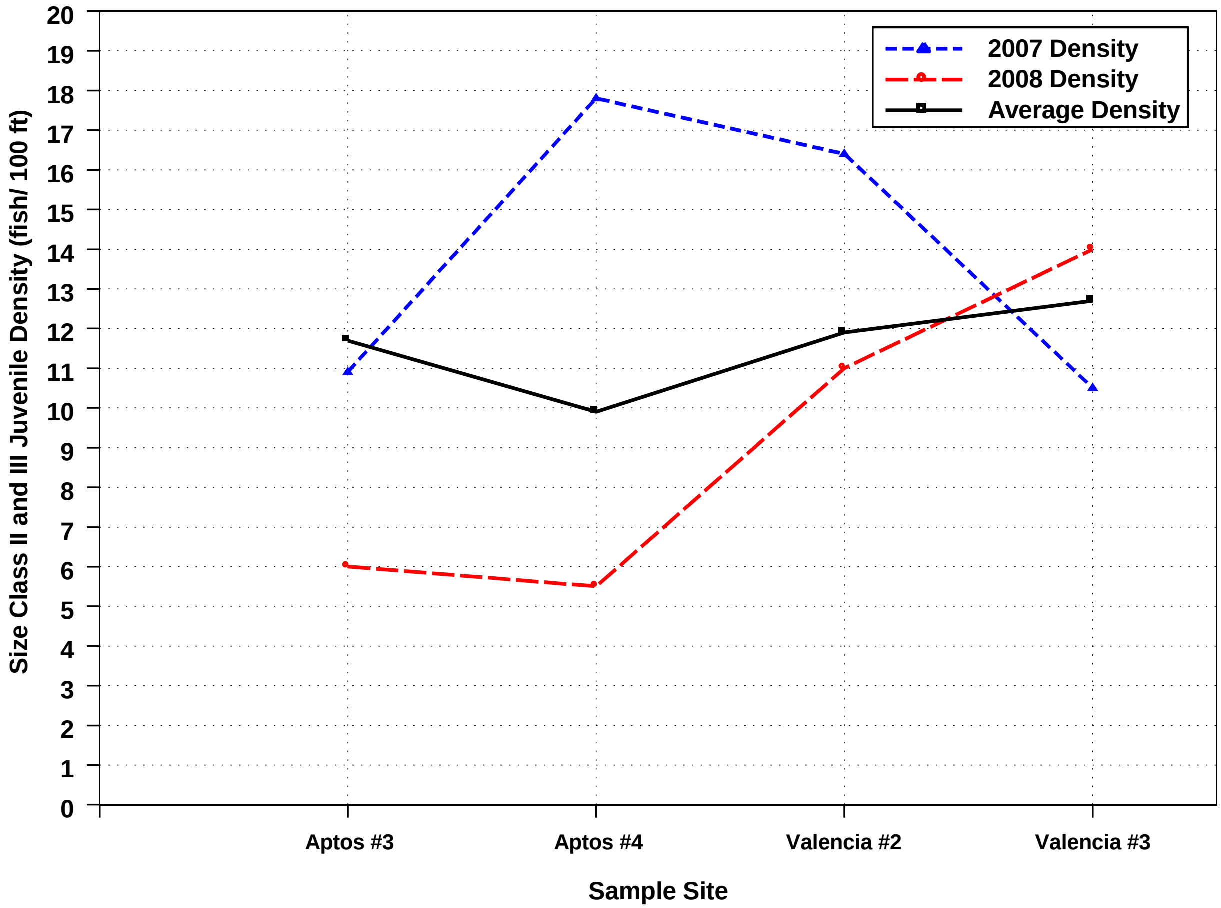


Table 39. Density of Juvenile Steelhead for SIZE CLASS II/III Fish (=>75 mm SL) at Monitoring Sites in APTOS, VALENCIA, CORRALITOS, SHINGLE MILL and BROWNS VALLEY Creeks, 1981, 1994 and 2006–2008.

Sample Site	1981	1994	2006	2007	2008	Avg.
Aptos #3- in County Park	10.8*	–	19.0	10.9	6.0	11.7
Aptos #4- above steel Bridge Xing (Nisene Marks)	5.9	–	10.1	17.8	5.5	9.9
Valencia #2- below Valencia Road Xing	16.5	–	3.8	16.4	11.0	11.9
Valencia #3- Above Valencia Road Xing	13.2	–	12.9	10.5	14.0	12.7
Corralitos #0 Below Dam				9.1	8.7	8.9
Corralitos #3- Above Colinas Dr.	5.2	8.4	19.3	11.5	8.3	10.5
Corralitos #8- Below Eureka Gulch	22.2	14.3	13.2	9.9	9.4	13.8
Corralitos #9- Above Eureka Gulch	30.3	13.2	41.6	7.2	17.1	21.9
Shingle Mill #1- Below 2nd Road Xing	10.2	24.3	16.2	13.3	5.6	13.9
Shingle Mill #3- Above 2nd Road Xing and check dams	4.0	–	3.4	6.7	0.7	3.7
Browns Valley #1- Below Dam	27.4	15.5	17.0	17.4	11.5	17.7
Browns Valley #2- Above Dam	5.5	5.7	16.9	30.2	12.6	14.2

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

R-9. Comparison of 2008 Steelhead Densities in Corralitos, Browns Valley and Shingle Mill with those in 1981, 1994 and 2006–2007 and Density Comparisons Above and Below the Corralitos Diversion Dam

In the Corralitos Creek watershed, total juvenile steelhead densities were generally higher in 2008 than 2007 (6 of 8 sites) (**Figure 10; Table 35**). Total densities in 2008 were above average at five of eight sites, but only slightly above average at four of them, with five years of data. The higher total densities resulted from generally higher YOY densities (6 of 8 sites) (**Figure 11; Table 36**). 2008 YOY densities were above average at 5 of 7 sites but close to average at 4 of 7 sites. There were higher densities of smaller Size Class I juveniles in 2008 than 2007 (6 of 8 sites) because of the higher YOY densities (**Table 38**). Yearling densities were generally lower in 2008 (6 of 8 sites), as were densities of Size Class II and III juveniles (7 of 8 sites) (**Figure 12; Tables 37 and 39**). Densities of these important larger juveniles that would smolt soon were below average at all sites, with them near average at one site. Of the 8 sampling sites rated according to Size Class II and III (smolt) densities, 1 was rated "Very Poor" in upper Shingle Mill Gulch; the other Shingle Mill site was rated "Below Average;" 5 were rated "Fair" in Browns Valley and Corralitos creeks; and 1 was rated "Good" in upper Corralitos Creek below Shingle Mill Gulch (**Tables 40 and 41**).

California Rough-Skinned Newts in Shingle Mill Gulch (Corralitos sub-watershed), Site 3, 2 October 2008

Figure 10. Total Juvenile Steelhead Site Densities in Corralitos, Shingle Mill and Browns Valley Creeks in 2007, 2008 and the Average, Including 1981, 1994 and 2006.

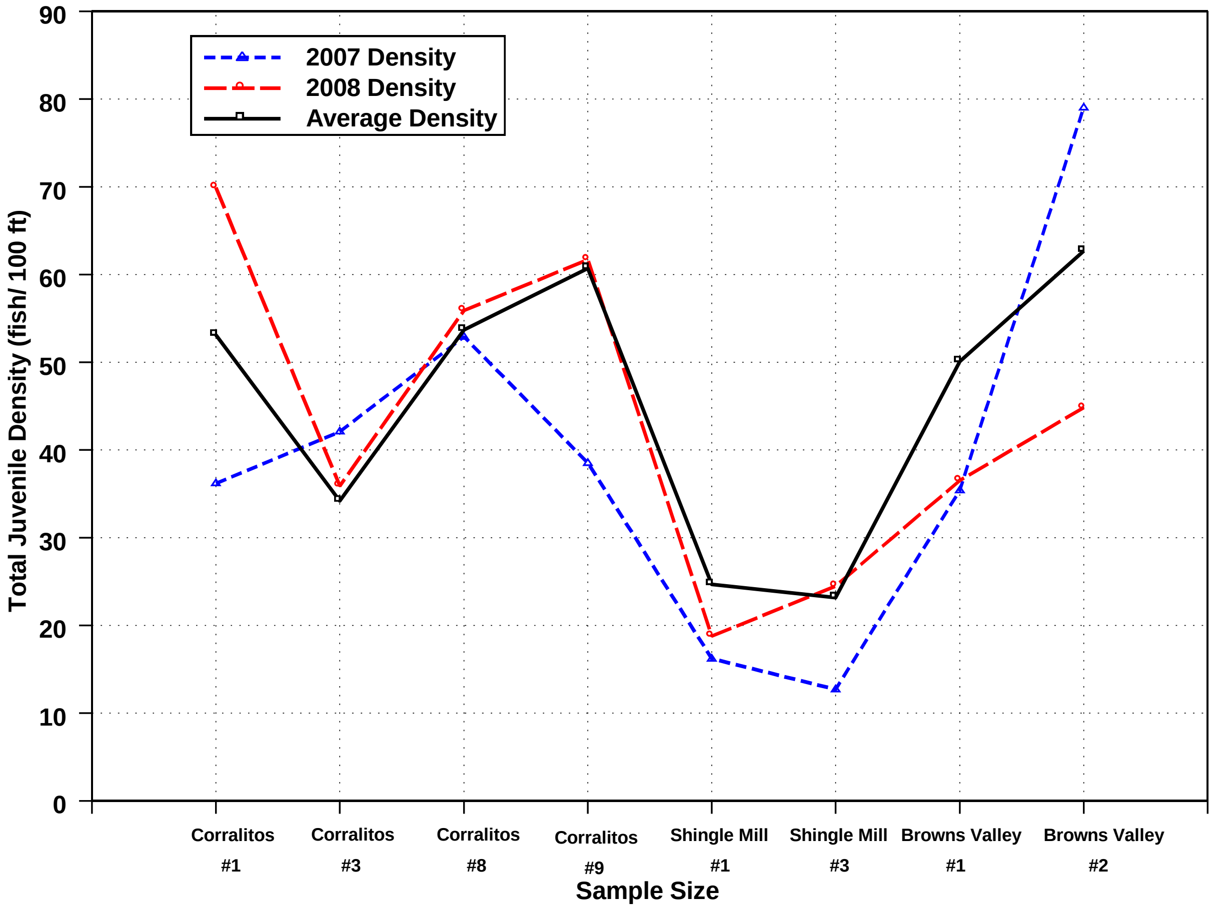


Figure 11. Juvenile Steelhead Densities for Young-of-the-Year in Corralitos, Shingle Mill and Browns Valley Creeks in 2007, 2008 and the Average, Including 1981, 1994 and 2006.

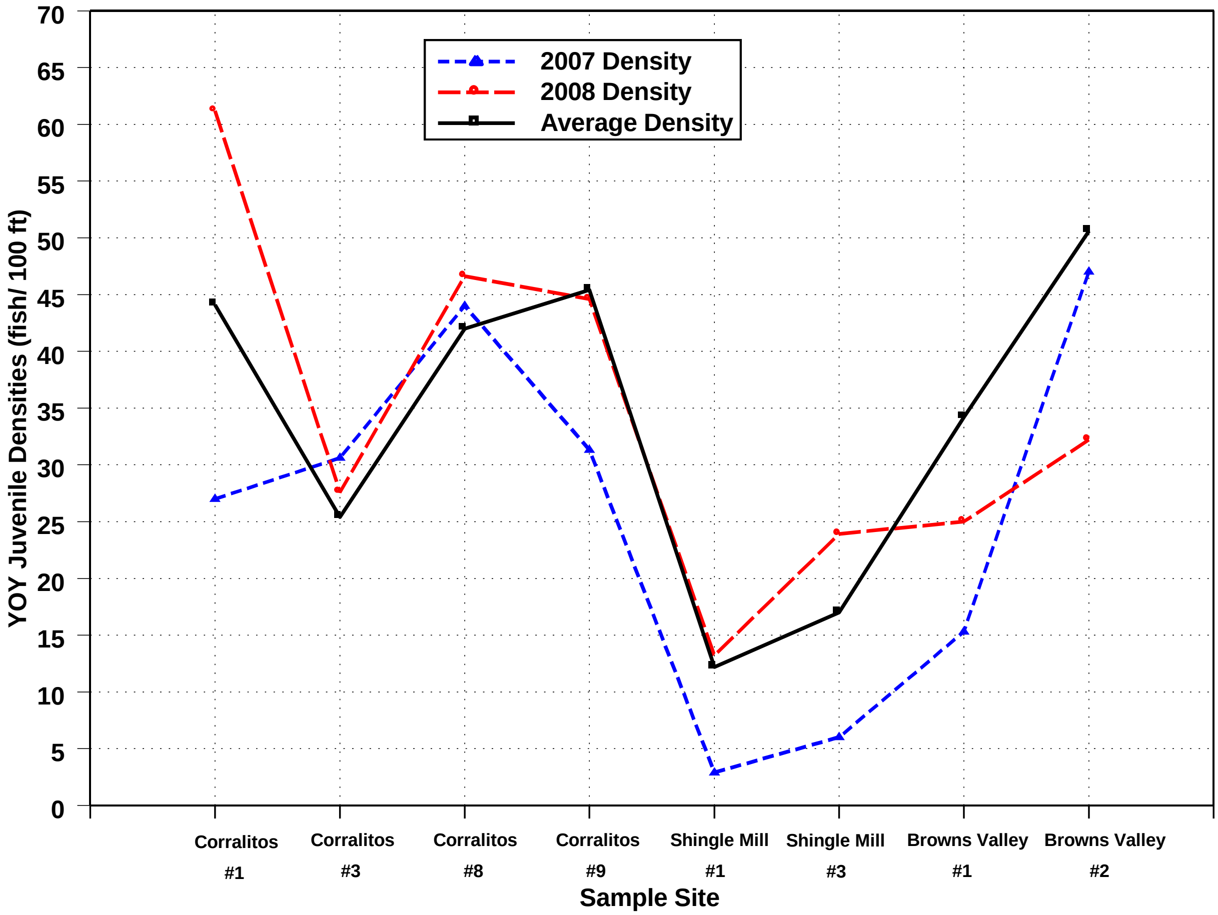


Figure 12. Juvenile Steelhead Densities for Size Classes II and III in Corralitos, Shingle Mill and Browns Valley Creeks in 2007, 2008 and the Average, Including 1981, 1994 and 2006.

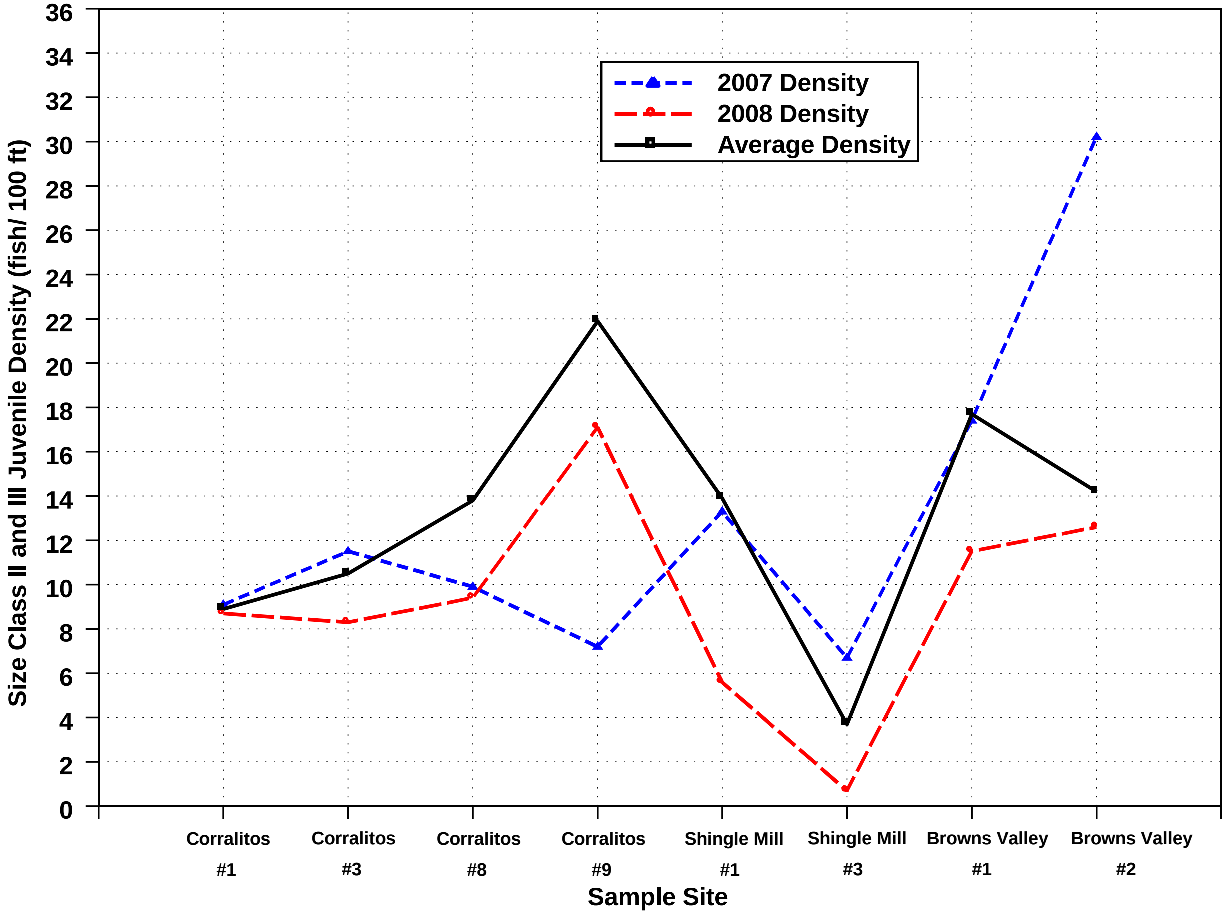


Figure 84. The 2007 Daily Mean and Median Flow at the USGS Gage on Corralitos Creek at Freedom. (USGS website would not provide a logarithmic scale of discharge).

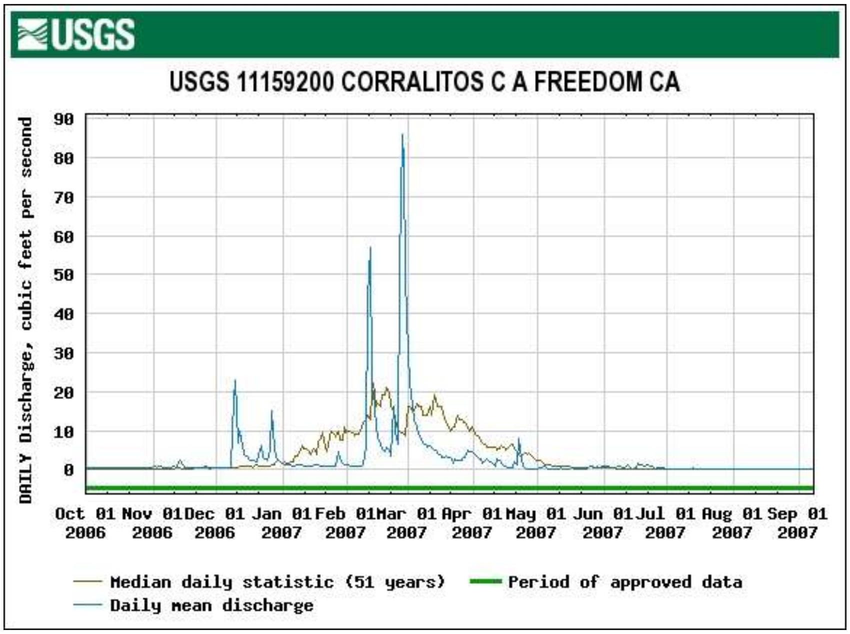
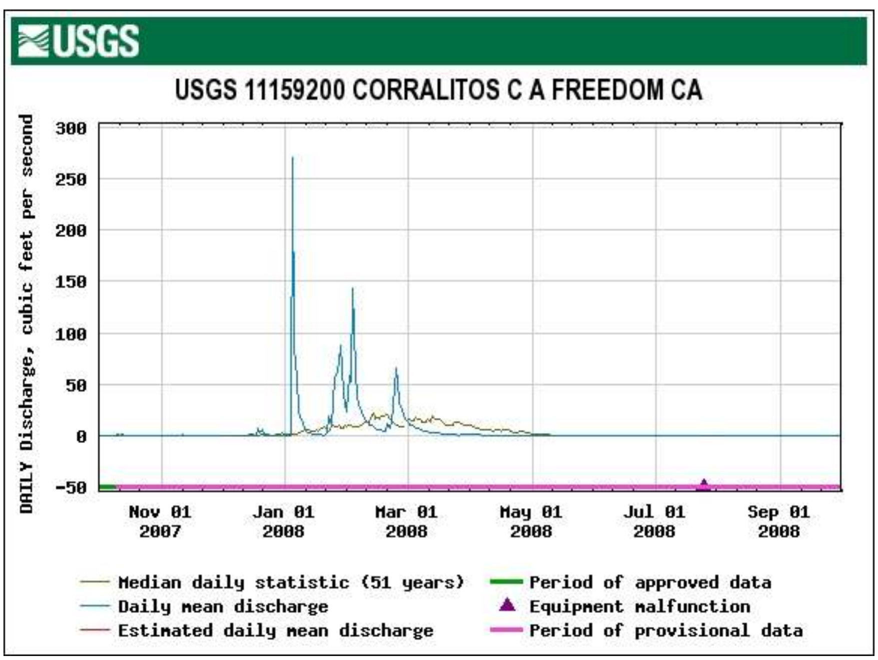


Figure 85. The 2008 Daily Mean and Median Flow at the USGS Gage on Corralitos Creek at Freedom. (USGS website would not provide a logarithmic scale of discharge).



Adult California Giant Salamander, Corralitos Creek near Clipper Gulch, Site 8   1 October 2008

Adult California Giant Salamander, Corralitos Creek near Clipper Gulch, Site 8   1 October 2008

Immature, Aquatic California Giant Salamander, Upper San Lorenzo River Mainstem near Teihl Road, Site 11
11 September 2008

R-10. Rating of Smolt Rearing Habitat in 2008, Based on Site Densities of Smolt-Sized Fish

Smolt habitat was rated at sampling sites, based on smolt-sized (=>75 mm SL) fish density according to the rating scheme developed by Smith (**1982**) (**Tables 40 and 41**). In this scheme, the average standard length for smolt-sized fish was calculated for each site. If the average was less than 89 mm SL, then the density rating according to density alone was reduced one level. If the average was more than 102 mm SL, then the rating was increased one level. (Note: the rating scale was applied to all sites, and lower San Lorenzo sites were rated very good and excellent in 1981.) This scheme assumed that rearing habitat was usually near saturation with smolt-sized juveniles, at least at tributary sites, and that spawning rarely limited juvenile steelhead abundance.

Table 40. Rating of Steelhead Rearing Habitat For Small, Central Coastal Streams.*
(From Smith 1982.)

Very Poor - less than 2 smolt-sized** fish per 100 feet of stream.			
Poor - from 2 to 4	"	"	"
Below Average - 4 to 8	"	"	"
Fair - 8 to 16	"	"	"
Good - 16 to 32	"	"	"
Very Good - 32 to 64	"	"	"
Excellent - 64 or more	"	"	"

* Drainages sampled included the Pajaro, Soquel and San Lorenzo systems, as well as other smaller Santa Cruz County coastal streams. Nine drainages were sampled at over 106 sites.

** Smolt-sized fish were at least 3 inches (75 mm) Standard Length at fall sampling and would be large enough to smolt the following spring.

Table 41. 2008 Sampling Sites Rated by Smolt-Sized Juvenile Density (=>75 mm SL) and Average Smolt Size in Standard Length, with Physical Habitat Change Since 2007.

Site	2008 Smolt Density (per 100 ft)/ Avg Smolt Size (mm)	2008 Smolt Rating	2007 Smolt Density (per 100 ft)/ Avg Smolt Size (mm)	2007 Smolt Rating	Physical Habitat Change by Reach Since 2007
Low. San Lorenzo #1	4.9/ 91 mm	Below Average	1.6/ 119 mm	Poor	Negative
Low. San Lorenzo #2	12.2/ 88 mm	Below Average	11.1/ 101 mm	Fair	Negative
Low. San Lorenzo #4	13.2/ 82 mm	Below Average	5.2/ 88 mm	Poor	Negative
Mid. San Lorenzo #6	2.2/ 82 mm	Very Poor	1.2/ 86 mm	Very Poor	Negative
Mid. San Lorenzo #8	3.6/ 87 mm	Very Poor	0.7/ 82 mm	Very Poor	Negative
Up. San Lorenzo #11	2.8/ 98 mm	Poor	0.6/ 81 mm	Very Poor	Slight Negative
Zayante #13a	6.3/ 92 mm	Below Average	4.9/ 92 mm	Below Average	Similar
Zayante #13c	4.4/ 98 mm	Below Average	8.8/ 101 mm	Fair	Similar
Zayante #13d	22.5/ 89 mm	Good	17.4/ 100 mm	Good	Similar
Lompico #13e	6.4/ 89 mm	Below Average	11.3/ 98 mm	Fair	Positive
Bean #14b	4.7/ 117 mm	Fair	8.9/ 117 mm	Good	Negative
Bean #14c	Dry	-	5.4/ 105 mm	Fair	Negative
Fall #15	15.8/ 107 mm	Good	9.9/ 95 mm (2000)	Fair (2000)	Slight Negative (Since 2000)
Boulder #17a	7.2/ 112 mm	Fair	6.8/ 115 mm	Fair	Slight Negative
Boulder #17b	3.8/ 102 mm	Poor	9.8/ 98 mm	Fair	Slight Negative
Bear #18a	5.1/ 105 mm	Fair	5.7/ 102 mm	Below Average	Similar
Branciforte #21a-1	0.5/ 133 mm	Very Poor	3.9/ 127 mm	Below Average	Similar
Branciforte #21a-2	5.7/ 105 mm	Fair	1.5/ 120 mm	Poor	Similar
Soquel #1	3.8/ 96 mm	Poor	6.6/ 88 mm	Below Average	Slight Negative
Soquel #4	4.9/ 98 mm	Below Average	6.3/ 105 mm	Fair	Negative
Soquel #10	3.1/ 92 mm	Poor	11.3/ 101 mm	Fair	Similar
Soquel #12	1.5/ 82 mm	Very Poor	4.8/ 104 mm	Fair	Similar
East Branch Soquel #13a	4.0/ 99 mm	Poor	3.1/ 80 mm	Very Poor	Positive
East Branch Soquel #16	10.0/ 100 mm	Fair	20.0/ 96 mm	Good	Negative
West Branch Soquel #19	5.7/ 82 mm	Poor	4.8/ 90 mm	Below Average	Negative
West Branch Soquel #21	-	-	7.5/ 94 mm	Below Average	Similar
Aptos #3	6.0/ 93 mm	Below Average	10.9/ 109 mm	Good	Positive
Aptos #4	5.5/ 112 mm	Fair	17.8/ 112 mm	Very Good	Positive
Valencia #2	11.0/ 92 mm	Fair	16.4/ 91 mm	Good	Similar
Valencia #3	14.0/ 93 mm	Fair	10.5/ 98 mm	Fair	Positive
Corralitos #0	8.7/ 105 mm	Good	9.1/ 109 mm	Good	Positive
Corralitos #3	8.3/ 104 mm	Good	11.5/ 124 mm	Good	Slight Negative
Corralitos #8	9.4/ 95 mm	Fair	9.9/ 111 mm	Good	Similar
Corralitos #9	17.1/ 100 mm	Good	7.2/ 111 mm	Fair	Slight Positive
Shingle Mill #1	5.6/ 98 mm	Below Average	13.3/ 117 mm	Good	Similar
Shingle Mill #3	0.7/ 83 mm	Very Poor	6.7/ 93 mm	Below Average	Slight Positive
Browns Valley #1	11.5/ 102 mm	Fair	17.4/ 92 mm	Good	Positive
Browns Valley #2	12.6/ 103 mm	Good	30.2/ 90 mm	Good	Similar

For 2008, the breakdown of ratings for the 37 sampling sites was the following;

1 (2.7%) = Dry
5 (13.5%) = "**Very Poor**"
6 (16.2%) = "**Poor**"
9 (24.3%) = "**Below Average**"
10 (27%) = "**Fai**r"
6 (16.2%) = "**Good**"

Therefore, 57% (21 of 37) of the sites were rated less than fair in 2008 compared to 38% in 2007. Sites that fell into the less than fair categories in 2008 included all 6 mainstem San Lorenzo sites, lower and middle Zayante, Lompico, middle Boulder, lowermost Branciforte, all 4 mainstem Soquel sites, lower East and West Branch Soquel, lower Aptos and both Shingle Mill sites.

R-11. Statistical Analysis of Annual Difference in Juvenile Steelhead Densities

The trend in fish densities between 2007 and 2008 was analyzed by using a paired t-test (**Snedecor and Cochran 1967; Sokal and Rohlf 1995; Elzinga et al. 2001**). Comparisons were made for total density, age class densities and size class densities (AC1, AC2, SC1, SC2). The paired t-test is among the most powerful of statistical tests, where the difference in mean density (labeled "mean difference" in the analysis) is tested. This test was possible because the data were taken at the same sites between years when consistent with average habitat conditions between years, as opposed to re-randomizing each year. The null hypothesis for the test was that among all sites, the site-by-site difference between years 2007 and 2008 was zero. The non-random nature of the initial choice of sites was necessary for practical reasons and does not violate the statistical assumptions of the test; the change in density is a randomly applied effect (i.e. non-predictable based on knowledge of the initial sites) that does not likely correlate with the initial choice of sites. So, the mean difference is a non-biased sample.

The null hypothesis was that the difference in mean density was zero. Results from 2008 were compared to 2007, such that a positive difference indicated that the densities in 2008 were larger than in 2007 on average. A p-value of 0.05 meant that there was only a 5% probability that the difference between densities was zero and a 95% probability that it was not zero. A 2-tailed test was used, meaning that an increase or a decrease was tested for. The confidence limits tell us the limits of where the true mean difference was. The 95% confidence interval indicated that there was a 95% probability that the true mean difference was between these limits. If these limits included zero, then it could not be ruled out that there was no difference between 2007 and 2008 densities. The 95% confidence limits are standard and a p-value of < 0.05 is considered significant.

Despite only 13 comparable sites in the San Lorenzo drainage, the decline in yearling site densities was statistically significant (**Table 42**). With only 1 site repeatedly sampled in both years, steelhead densities at Soquel Creek sites could not be statistically compared. With only 1 site repeatedly sampled in the Aptos watershed, steelhead densities at Aptos/Valencia creek sites could not be statistically compared. No statistically significant changes were detected in the Corralitos watershed with a small sample size of five (**Table 43**).

Table 42. Paired T-test for the Trend in Steelhead Site Densities by Size Class and Age Class at All Repeated Sites In the San Lorenzo Watershed (2008 to 2007; n=13).

Statistic	s.c. 1	s.c. 2	a.c. 1	a.c. 2	All Sizes
Mean difference	16.20	-0.05	17.75	-1.92	16.01
Df	12	12	12	12	12
Std Error	9.46	1.07	9.61	0.75	9.66
t Stat	1.71	-0.04	1.85	-2.56	1.66
P-value (2-tail)	0.1126	0.992	0.090	0.0248	0.1235
95% CL (lower)	-5.04	- 2.37	-3.20	-3.56	-5.04
95% CL (upper)	37.06	2.28	38.71	-0.29	37.06

Table 43. Paired T-test for the Trend in Steelhead Site Densities by Size Class and Age Class at All Repeated Sites In the Corralitos Creek Watershed (2008 to 2007; n=5).

Statistic	s.c. 1	s.c. 2	a.c. 1	a.c. 2	All Sizes
Mean difference	1.76	-6.64	-29.30	-7.26	-4.90
Df	4	4	4	4	4
Std Error	5.70	2.92	15.47	3.35	7.87
t Stat	0.31	-2.27	-1.89	-2.17	-0.62
P-value (2-tail)	0.7730	0.0854	0.1311	0.0963	0.5671
95% CL (lower)	-14.07	-14.75	-72.24	-16.57	-26.74
95% CL (upper)	17.59	1.47	13.64	2.05	16.94

R-12. Adult Trapping Results at the Felton Dam's Fish Ladder and 2008 Planting Records

The trap at the City of Santa Cruz Felton Diversion dam was operated by Terry Umstead (aquaculture teacher), San Lorenzo Valley High School students and other volunteers for 10 days during the winters of 2006-2007 and 2007-2008. It was used from the afternoon of 5 February 2008 through the morning of 15 February 2008 during a rainy period (**Table 46; Figure 26)**. A total of 78 adult steelhead =>14 inches Fork Length were captured; 20 (26%) were hatchery clipped. In 2007 during a similar period (15−21 February), a total of 53 adult steelhead =>18 inches Fork Length were captured; 17 (32%) were hatchery clipped. No coho salmon were captured in 2007 or 2008, likely due to the late trapping period. More adults were trapped in 2006, with 247 adult steelhead and 2 coho salmon captured in 2 months in 2006 from mid January to late March. But trapping was over much shorter periods in 2007 and 2008. The 2006 total was less than the 371 adult steelhead and 18 adult coho captured in 2005 over a longer time period, but trapping began and ended later in the 2006 season than in 2005 and began after several storm events in 2006. Since in all years the trap has operated for only a small portion of the adult migration period, no comparisons among years can be used to estimate actual adult abundance or trends.

Based on the planting log from the Monterey Bay Salmon and Trout Native Anadromous Fish Hatchery, in April 2008 an estimated 31,759 juvenile smolts (3,490 lbs.) were planted at each of the following locations:

San Lorenzo River at Henry Cowell Bridge in Felton (9,100 smolts; 2 April 2008)
San Lorenzo River below fish ladder at Felton Inflatable Dam (9,100 smolts; 3 April 2008)
San Lorenzo River at Paradise Park (9,009 smolts; 4 April 2008)
Zayante Creek at Graham Hill Road Bridge in Felton (4,550 smolts; 2 April 2008)

Aquatic Garter Snake in East Branch Soquel Creek, Site 13a 5 September 2008

Table 46. Adult Steelhead Trapping Data from the San Lorenzo River With Adult Return Estimates.

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	Near Boulder Ck (2)
1941-42	Dec 24 - Apr 11	827	Near Boulder Ck (2)
1942-43	Dec 26 - Apr 22	624	Near Boulder Ck (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 (estimate)	Alley Estimate from 1994 Mainstem Juveniles only
1997-98		1,784 (estimate)	Alley Estimate from 1995 Mainstem Juveniles only
1998-99		1,541 (estimate)	Alley Revised Estimate from 1996 Mainstem Juveniles only
1999-2000	17 Jan- 10 Apr	532 (above Felton)	Monterey Bay Salmon & Trout Project
1999-2000		1,300 (estimate)	Alley Index from 1997 Mainstem Juveniles only
2000-01	12 Feb- 20 Mar	538 (above Felton)	Monterey Bay Salmon & Trout Project
2000-01		2,500 (estimate)	Alley Index from 1998 Juveniles in Mainstem and 9 Tributaries
2001-02		2,650 (estimate)	Alley Index from 1999 Juveniles in Mainstem and 9 Tributaries
2002-03		1,650 (estimate)	Alley Index from 2000 Juveniles in Mainstem and 9 Tributaries
2003-04		1,600 (estimate)	Alley Index from 2001 Juveniles in Mainstem and 9 Tributaries
2003-04	28 Jan- 12 Mar	1,007 Steelhead 14 Coho	SLV High School-Felton Diversion Dam
2004-05	12 Dec 29 Jan	371 Steelhead 18 Coho	SLV High School-Felton Diversion Dam
2005-06	17 Jan- 24 Mar	247 Steelhead 2 Coho	SLV High School-Felton Diversion Dam
2006-07	15 Feb- 21 Feb	54 Steelhead	SLV High School-Felton Diversion Dam
2006-07	05 Feb- 15 Feb	78 Steelhead	SLV High School-Felton Diversion Dam

(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, 1995.

DISCUSSION OF 2008 RESULTS

D-1. Causal Factors for Above Average 2008 Size Class II/ III (Smolt-Sized) Steelhead Density in Reach 4 of the Lower Mainstem San Lorenzo

There may have been more recruitment of YOY into Reach 4 from the lower Zayante sub-watershed in 2008. YOY densities at Zayante Site 13a were much higher in 2008 than in 2007, as they were at Site 4 in the mainstem (**Table 27**). YOY densities were above average at both sites (**Figure 2**). A portion of the YOY juveniles in Reach 4 were able to reach Size Class II by fall sampling, thus increasing the Size Class II density in 2008.

Decline in rearing habitat quality was apparently insufficient to affect juvenile densities, although YOY growth rates were less in 2008 with continued low baseflow as occurred in 2007 (**Figure 25, Appendix C and Alley 2008**). The proportion of riffle habitat declined in 4 of 5 reaches of the middle and lower mainstem from 2007 to 2008 by fall, with riffle being converted to more run habitat with less habitat value due to slower water velocity and insect drift rate (**Table 5c**). In 2007 there were 2,702 feet of riffle in the 5 habitat typed segments compared to only 2,259 feet in 2008. Riffle depth declined in all reaches from 2007 to 2008 (**Table 6**) due to increased channel widening in riffles in 2008 (**Table 5c**) with similar baseflow (**Table 5b**), resulting in slower water velocity in riffles at all sites and likely reduced insect drift rate later in the dry season. Smaller YOY size may have also occurred in 2008 due to later successful spawning in the mainstem due to bankfull stormflow occurring as late as February, which may have scoured or buried redds previously constructed (**Figure 66**). In 2007, there were no bankfull stormflows the entire winter (**Figure 65**).

D-2. Causal Factors for Reduced 2008 Yearling and Size Class II and III Densities in Soquel Creek

A partial explanation for reduced yearling densities in 2008 compared to 2007, along with reduced densities of Size Class II and III juveniles is that some of the yearlings may have been flushed or encouraged out of the Soquel Creek system in 2008 that would have remained during the mild winter of 2007. Though the peak stormflow for water year 2008 was not yet available at the USGS website, comparison of hydrographs between 2007 and 2008 indicated that 2008 had larger storm flows (**Figures 79 and 80**). It is likely to assume that because the peak flow on the San Lorenzo in 2008 was nearly double bankfull, the peak flow on Soquel Creek was similar. Rearing habitat quality was likely not an important factor for the general decline in Size Class II and III juvenile densities, with four of eight reaches showing similar or more positive conditions in 2008. Only 3 of 8 reaches had more than slightly negative change in 2008.

The halving of yearling and smolt-sized juvenile densities in 2008 compared to 2007 at Site 16 in the SDSF on the East Branch was partially explained by approximately half the density of YOY in 2007 compared to 2006 to be recruited as yearlings in the succeeding year. In addition, reduced densities of larger fish was partially explained by rearing habitat deterioration in pools and step-runs in Reach 12a of the SDSF due to reduced streamflow that converted faster water step-runs into stagnant, shallow pools. Visually estimated streamflow was only 0.01 cfs on 29 August 2008 (a trickle) in Reach 12a, and 301 feet of dry streambed existed downstream of the Long Ridge crossing compared to 165 feet of dry streambed in 2007, another dry year. Averaged mean and maximum pool depth and step-run depth were much less in 2008 than 2007 (**Table 14**), along with reduced pool escape cover (**Table 17**).

D-3. Causal Factors for Differences in Yearling and Size Class II and III Densities between Aptos and Valencia Creek in 2008 and the Reduction in Larger Juveniles at Most Sites

The most plausible explanation for higher densities of yearlings and older fish (Size Class II and III) in Valencia Creek than Aptos Creek, despite the better rearing habitat in Aptos is that a resident rainbow trout population developed in Valencia before passage barriers were removed, which persists with steelhead that have recently had access. Fish scale analysis of two larger fish captured in Valencia Creek in 2006 indicated that they were both two-year olds (Standard Lengths of 132 and 154 mm). These resident rainbows would not smolt and emigrate as quickly as steelhead, if at all. Perhaps a greater proportion of the Size Class II and III fish in Valencia Creek were resident rainbows compared to Aptos Creek and would serve to inflate the larger size classes and typical "yearling and older" age class.

Retention of two-year old fish and yearlings in Valencia Creek may also have been due to their much slower growth rate than in Aptos Creek, which would also delay yearling steelhead from smolting. Additionally, with the faster growth rate of steelhead in Aptos Creek, a proportion of YOY from 2007 had reached the common threshold (=> than 75 mm SL) to smolt in spring 2008 while none of the Valencia YOY had. Another factor may have been the likelihood that Aptos Creek had larger winter peak flows, well above bankfull, based on gaging at Big Trees on the San Lorenzo and the hydrographs of streamflow for the San Lorenzo River and Soquel Creek (**Figures 66 and 80**), to possibly flush/encourage more young yearlings (Size Class II fish) out to the Bay in late January than occurred in Valencia Creek. It would be beneficial to have stream gages in Aptos and Valencia creeks to track annual streamflow.

The greater prominence of instream wood in Valencia Creek may have been another factor contributing to retention of more overwintering yearlings there and higher densities of larger fish in fall, compared to Aptos Creek. More instream wood may have offered to overwintering yearlings and older fish more shelter from the currents of high stormflows. Habitat typing data from half-mile segments in 2008 indicated that in lower Aptos Reach 2, only 1 of 21 pools (5%) was scoured primarily by instream wood, while the segment in upper Aptos Reach 3 had 7 of 23 pools (30%) primarily scoured by instream wood. The ½-mile segment in lower Valencia Creek Reach 2 had 11 of 15 pools (73%) primarily scoured by instream wood, while the segment in upper Valencia Reach 3 had 16 of 43 pools (37%) primarily scoured by instream wood. So, Valencia Creek had 27 instream wood-scoured pools (indicating 27 instream wood clusters), while Aptos Creek had only eight in a mile of stream.

D-4. Causal Factors for Differences in Size Class II/III Juvenile Densities between 2007 and 2008 in the Corralitos Creek Watershed

The generally lower densities of larger Size Class II and III juveniles in 2008 than 2007 may have been due to reduced overwinter survival of yearlings in 2008 after a peak winter stormflow likely much greater than bankfull in January, based on the peak flow at the Big Trees gage on the San Lorenzo River. The 2007 winter had been very mild by comparison, likely increasing overwinter survival of yearlings (**Figures 84 and 85**). The below average densities of these larger juveniles at all sites may have also been due to reduced habitat quality for yearlings in terms of pool and step-run depth resulting from reduced baseflow in 2008, although pool escape cover was similar between 2007 and 2008 and was generally greater than in 2006 (**Table 18**). Smolt densities were close to average at 4 of 8 sites, thus indicating that 2008 densities were not substantially less than average. It is important to note that four of the five fish-monitored years were relatively dry, and in the one wet year, 2006, Size Class II and III juveniles were much higher primarily due to a high proportion of YOY reaching smolt size their first growing season in Corralitos Creek, which did not happen in 2007 or 2008.

D-5. Annual Trend in Young-of-the-Year and Yearling Steelhead Densities in Our Four Sampled Watersheds Compared to Trends in Other Local Coastal Streams

YOY steelhead densities in 2008 continued to be low in Scott and Waddell creeks (**Smith 2008**). This was inconsistent with higher YOY densities at a majority of sites in the San Lorenzo, Soquel and Corralitos watersheds. In Scott Creek, average YOY steelhead site densities were even lower in 2008 (20 fish/ 100 ft) than 2007 (49 fish/ 100 ft), and the lowest ever detected. Smith attributed low YOY densities in Scott Creek to perhaps narrow windows of access, and the possibility that many adults may have spawned prior the large stormflow in late January 2008 in sandy lower reaches and had their redds destroyed. He also stated that very low baseflows in summer may have caused low YOY numbers. In Waddell Creek average YOY steelhead site densities were low in 2008 (23 fish/ 100 ft) but not as low as in 2007 (13 fish/ 100 ft). Gazos Creek was not sampled.

YOY densities in Scott and Waddell creeks in 2008 were generally less than in the mainstem San Lorenzo, San Lorenzo tributaries, Soquel, Aptos, Valencia and Corralitos creeks, but similar to densities in Shingle Mill and Browns Valley creeks.

Average 1+/2+ density in Scott Creek in 2008 (8 fish/ 100 ft) was near average and similarly low to 2007 (10 fish/ 100 ft), but yearlings were small (**Smith 2008**). Average 1+/2+ density in Waddell Creek were the lowest ever at 1 fish/ 100 ft compared to 2 fish/ 100 ft in 2007. In these creeks, these were likely the only fish reaching Size Class II. So, Size Class II and III densities in

Scott Creek were similar to densities at sites in the mainstem and tributary sites of the San Lorenzo River in 2008, except higher densities of Sites 2, 4, 13d and 15. Scott Creek densities were similar to densities in the mainstem Soquel and Branches. Scott Creek densities were similar to densities in Corralitos Creek and Shingle Mill Gulch but less than in Aptos, Valencia and Browns Valley creeks in 2008.

Size Class II abundance at sites in Waddell Creek in 2008 was less than in all sites sampled in our four watersheds, except for lower Branciforte Site #21a-1, upper Soquel mainstem Site #12 and upper Shingle Mill Site #3.

D-6. Data Gaps

Annual monitoring of steelhead needs to continue through the next drought period and beyond to assess the extent of population recovery. For 2003-2005, only the middle and upper mainstem of the San Lorenzo and 5 tributaries were sampled (except for 1 site in upper Branciforte in 2005), and sampling in several tributaries or portions of them was discontinued. By 2007, only 3 sites were re-established in the lower River below the Zayante Creek confluence, as well as two in lower Branciforte Creek. More fish and habitat monitoring must occur in the lower mainstem, including the flood control channel and lagoon/estuary, in order to assess success of management and collect data pertinent to the conjunctive water use program.

The Newell Creek sampling site and study reach have not been monitored by D.W. ALLEY & Associates since 2001. They should be re-established to minimize data gaps and to collect data pertinent to the conjunctive water use program in a way consistent with other fish data collection in the watershed. The Fall Creek study reach and sampling site were re-established in 2008 after the San Lorenzo Valley Water District absorbed the Felton water supply system.

Only 1 mainstem site is sampled upstream of the Boulder Creek confluence. Therefore, there are data gaps for the upper San Lorenzo mainstem in the more pristine Waterman Gap. Data are no longer collected in Carbonera Creek, though it is increasingly impacted by increased urbanization of Scotts Valley. This is an important data gap. Only one sampling site remains on Bear Creek, leaving much of the upper portion of a major tributary data-less. This is an important data gap. More fish sampling must occur in upper Zayante Creek and Mt. Charlie Gulch adjacent to Santa Cruz City watershed lands to assess success of management efforts.

With the change in County management guidelines for large instream wood, incidence of large instream wood should be annually monitored. The wood survey completed in 2002 on Soquel Creek (**Alley 2003c**) could be repeated periodically for comparison purposes.

In 2006, annual estimation of juvenile steelhead population size and calculation of adult indices from juvenile population size ceased for the first time since 1994. This is a significant loss in monitoring information when trends in overall juvenile populations can no longer be assessed.

While determination of site densities is very valuable, the relative contributions of different reaches and tributaries to juvenile total population size is lost when only site densities are reported, rather than the total density of the reaches that the sites represent. In particular, the relative importance of mainstem reaches compared to tributaries in production of large juveniles is lost when only site densities are considered. Calculation of an *index of adult returns* is the most meaningful way to compare the value of annual juvenile population numbers because it weights the juveniles according to size categories and size-dependent survival rates. Although the index may not accurately predict actual adult numbers, it reflects *relative* adult production between reaches and between years.

There is a shortage of streamflow data on the San Lorenzo River mainstem and tributaries. More stream gages should be established and maintained in the watershed to better correlate streamflow with habitat conditions and fish densities and to detect insufficient streamflow. Mainstem locations for additional gages would include Waterman Gap, above and below the Boulder Creek confluence on the mainstem. Tributaries that need better gaging include Zayante Creek (above and below the Bean Creek confluence), Bean Creek (below Lockhart Gulch and just below the Mackenzie Creek confluence), Fall Creek above the water diversion and Boulder Creek (near the mouth).

There is no stream gage in the Aptos watershed. It would be beneficial to have stream gages on lower Valencia Creek and Aptos Creek near the lagoon. Any future management of Aptos Lagoon would benefit from continuous streamflow data in relation to sandbar manipulation. It is a valuable tool on Soquel Creek with the USGS gage in Soquel Village. The only stream gage data for the Corralitos watershed is at Freedom. This is below the City of Watsonville diversions and is in a percolating reach that is dry in summer. It would be beneficial to install stream gages at the diversion dams on Browns Valley and Corralitos Creeks. Then the streamflow above and below the diversions could be monitored.

If stream gaging proves prohibitively expensive, streamflow should be annually measured in mid-May and mid-September at the proposed gage locations in the San Lorenzo watershed, as well as in the mainstem at Paradise Park, at the Henry Cowell Park bridge, downstream of the Fall Creek confluence (under Graham Hill Road bridge), downstream of the Clear Creek confluence (near Larkspur Bridge), downstream of the Boulder Creek confluence (along Erwin Way), and in the upper valley near the Mountain Store (downstream of Kings Creek) and at the Teihl Road bridge. Streamflow should also be measured in Bear Creek below Hopkins Gulch and in Newell Creek (Glen Arbor Road bridge).

We are aware that County staff measure streamflow each year but noted that many former sites have been removed or are measured only occasionally. It would be beneficial if more streamflow sites could be added to the Soquel, Aptos and Corralitos watersheds and if sites in the San Lorenzo watershed could be visited more regularly in the fall before early storms.

In Soquel Creek, streamflow should ideally be measured in mid-May and mid-September on the mainstem below Highway 1, near the Soquel Village USGS gage, adjacent at the Mountain School and at the Soquel Creek Road Bridge. In East Branch Soquel, streamflow should be measured just upstream of the West Branch confluence, just downstream of Mill Pond and in the SDSF at the Long Ridge Road crossing. In the West Branch Soquel, streamflow should be measured just upstream of the East Branch confluence.

In Aptos Creek, streamflow should ideally be measured in mid-May and mid-September just upstream of the lagoon, adjacent to the County Park and upstream of the metal bridge. On Valencia Creek, streamflow should be measured between the fish ladder and Valencia Road crossing.

In Corralitos Creek, streamflow should ideally be measured in mid-May and mid-September downstream of the Watsonville diversion, upstream of the Watsonville diversion, downstream of the Rider Creek confluence, downstream of the Eureka Gulch confluence and upstream of the Eureka Gulch confluence. In Browns Valley Creek, streamflow should be measured downstream of the Watsonville diversion and upstream of the Watsonville diversion.

Recent data gaps in the heavily impacted mainstem of Soquel Creek have occurred. In 2008, only 2.5 miles of mainstem was habitat typed, when all 7.2 miles were habitat typed in the past to assess habitat quality. Sampling in Soquel creek was increased from 6 to 7 sites in 2007, though in earlier years there were 21 sites annually sampled. On the plus side, fish sampling and habitat monitoring in the Aptos and Corralitos watersheds were renewed.

TRENDS IN JUVENILE STEELHEAD DENSITY AND HABITAT CONDITIONS IN THE SAN LORENZO RIVER, 1997-2008

Trend in Juvenile Densities in the Lower and Middle Mainstem San Lorenzo River

The lower San Lorenzo mainstem (downstream of the Zayante Creek confluence) and middle mainstem (between the Boulder and Zayante Creek confluences) have become less productive for juvenile steelhead in both the YOY age class and the Size Class II and III categories from 1999 onward, based on our data (**Figures 13, 15 and 17**). No data were available from the HTH report (**2003**) regarding YOY or Size Class II and III densities. Total juveniles increased in 2002 after a winter that had larger storms early in the winter and smaller ones afterwards, as they also did in 2008 to a lesser degree. But juvenile densities were less in years between these. Density comparisons in 2002 with other years are weakened because different methods were employed in 2002 by H.T. Harvey & Associates (HTH) (**2003**) to choose sampling sites. We saw the same increased densities in the adjacent Soquel Creek in 2002 to strengthen the comparison. The years 1998 and 2006 had similarly wet winters prior to fall sampling. However, the mainstem had substantially higher juvenile densities in 1998 than 2006. Habitat conditions in 1998 that were better than in 2006 in both the lower and middle mainstem (depicted for Reaches 4 (lower mainstem) and 8 (middle mainstem), respectively) included greater depth in fastwater habitat (riffles) (**Figures 27 and 30**), higher water velocity due to higher streamflow (**Figure 25**) (and likely greater insect drift) and more escape cover in fastwater habitat in the middle mainstem Reach 8 (**Figure 31**). However, certain riffle habitat parameters were better in 2006 in the lower mainstem Reach 4, such as greater escape cover (more overhanging willows) (**Figure 28**) and less percent fines (**Figure 29**). In Reach 8 the estimated percent fines in riffles in 1998 and 2006 were the same (**Figure 32**).

Densities of Size Class II and III juvenile in the lower and middle mainstem were higher in the years 1997−1999 than later years, with relatively low densities from 2000 until 2008, with 2007 having the lowest densities measured in the last 12 years (**Figure 17**). The lower and middle mainstem have become less important in producing larger juveniles in recent years. In order for adult returns to increase substantially, the mainstem will need to again support at least the densities of Size Class II and III juveniles that were present in 1997−99.

Rearing habitat conditions in fastwater riffle habitat in Reach 4 in 2008 have improved since 1999 regarding more escape cover (declined since 2007) (**Figure 28**) and reduced percent fines (embeddedness similar (**Alley 2000**)) (**Figure 29**). However, 1999 riffle conditions were better with regard to greater habitat depth compared to 2008, as were all other years deeper than 2008, partially because of the low baseflows in late summer 2008 (**Figure 27**). If baseflows had been the same in 1997 and 2008, habitat conditions in Reach 4 riffles may have been similar between years for percent fines and escape cover, but riffles would have been considerably deeper in valuable pockets of maximum depth in 1997. It appeared that the arrangement and composition of boulders and sediment in riffles shifted during the high stormflow of February 1998 (19,400 cfs at Big Trees gage), resulting in fewer deep pockets.

Rearing habitat conditions in fastwater habitat in Reach 8 (middle mainstem) in 2008 have improved since 1999 regarding less percent fines and reduced embeddedness (43% in 1999 (**Alley 2000**) and 30% in 2008) (declined since 2007) (**Table 8 and Figure 32**). However, 1999 riffle conditions were better with regard to more escape cover (**Figure 31**) and greater habitat depth compared to 2008, as were all other years deeper than 2008, primarily because of the low baseflows in late summer 2008 (**Figure 30**). If baseflows had been the same in 1997 and 2008, habitat conditions in Reach 8 riffles may have been similar between years with regard to percent fines and embeddedness, but in 1997 the riffles would have been deeper with important deeper maximum depth pockets, as was the case in Reach 4 riffles. 1997 riffles also had much more escape cover.

The upper mainstem site in this analysis is upstream of major tributaries (Branciforte, Zayante, Fall, Newell, Boulder and Bear creeks) and may be categorized with tributary sites because few of its YOY grow into Size Class II their first growing season.

Ecological Considerations for the Lower and Middle Mainstem

The density and size of juvenile steelhead in the lower and middle mainstem San Lorenzo River is dependent upon a number of factors; 1) number of spawning adults, 2) spawning effort in these segments after large, sediment moving, redd scouring storms are over for the wet season, 3) spawning success (survival rate from egg to emerging fry), 4) the number of juveniles that enter the lower and middle mainstem from tributaries, 5) survival of emerging YOY in spring and 6) the rearing habitat quality primarily in fastwater habitat (riffles, runs and heads of pools) in the spring and summer (higher baseflow increases juvenile growth rate and size of YOY). The lower and middle mainstem are inhabited by primarily fast growing YOY with much fewer yearlings. In relatively drier winter/springs, more spawning effort occurs in the lower and middle mainstem and less in the tributaries due to more limited access to the upper watershed reaches. In the last 12 years, 1997, 2001, 2002 2004, 2007 and 2008 were relatively dry, based on averaged mean monthly streamflow (May–September) (**Figure 25**). Spawning success is likely greater in drier years in the lower and middle mainstem because fewer storms are likely to destroy spawning redds after spawning. However, shallow water depth in spawning glides may make it more difficult for adults to spawn, and water percolates more slowly through the gravels to buried eggs in drier years to provide adequate oxygen and remove metabolic wastes, which may reduce egg and sac-fry survival rates. Years in which most of the larger winter storms occur early in the winter, and they are of sufficient number to maintain a high but steady decline in the hydrograph through the late winter and spring with the help of smaller stormflows, will have maximum spawning success later in the spawning season and maximum juvenile survival after emergence in the lower and middle mainstem. The years of 1997, 2002 and 2008 were examples of this hydrologic pattern (**Figures 54, 59 and 66**). The year 2007 had few late winter storms but also had few early winter storms, as well, it being the driest of the last 12 years (**Figure 65**).

In wetter years, more spawning effort occurs in the upper reaches of the watershed, namely in the upper mainstem and the tributaries. Relative wet years included 1997, 1998, 1999, 2000, 2005 and 2006 (**Figures 25, 54-57 and 63-64**). Spawning success and survival of emerging YOY may be reduced in the lower and middle mainstem in these years due to later storms that destroy redds and wash away emerging YOY (except in 1997 when stormflow nearly ceased after 1 March). There may be fewer of the large yearlings in those mainstem segments because either growth rate may have been substantial in early spring to encourage yearlings to smolt. Large storms may also reduce overwinter survival of yearlings, as well. However, after wetter winters, the baseflow will be higher, and growth rate of YOY in the lower and middle mainstem will be substantial. The density of Size Class II and III juveniles may be relatively higher in the fall following the high baseflow spring and summer due to a higher proportion of YOY reaching this smolt size their first summer, as reflected in their densities in 1997−1999 (**Figure 17**).

Habitat quality will need to improve substantially in the lower and middle mainstem to increase adult returns. Retention of more large, instream wood will promote scour to deepen pools, create patches of coarser spawning gravel and provide escape cover for juvenile steelhead rearing and overwinter survival. Better retention of winter storm runoff in Scotts Valley and Felton will reduce stormflow flashiness that increases streambank erosion and sedimentation leading to poorer spawning and rearing conditions. Better retention of storm runoff will also increase winter recharge of aquifers to increase spring and summer baseflow, which will increase YOY steelhead growth into Size Classes II and III in the lower mainstem.

Figure 25. Averaged Mean Monthly Streamflow for May–September, 1997–2008 at the Big Trees Gage on the San Lorenzo River.

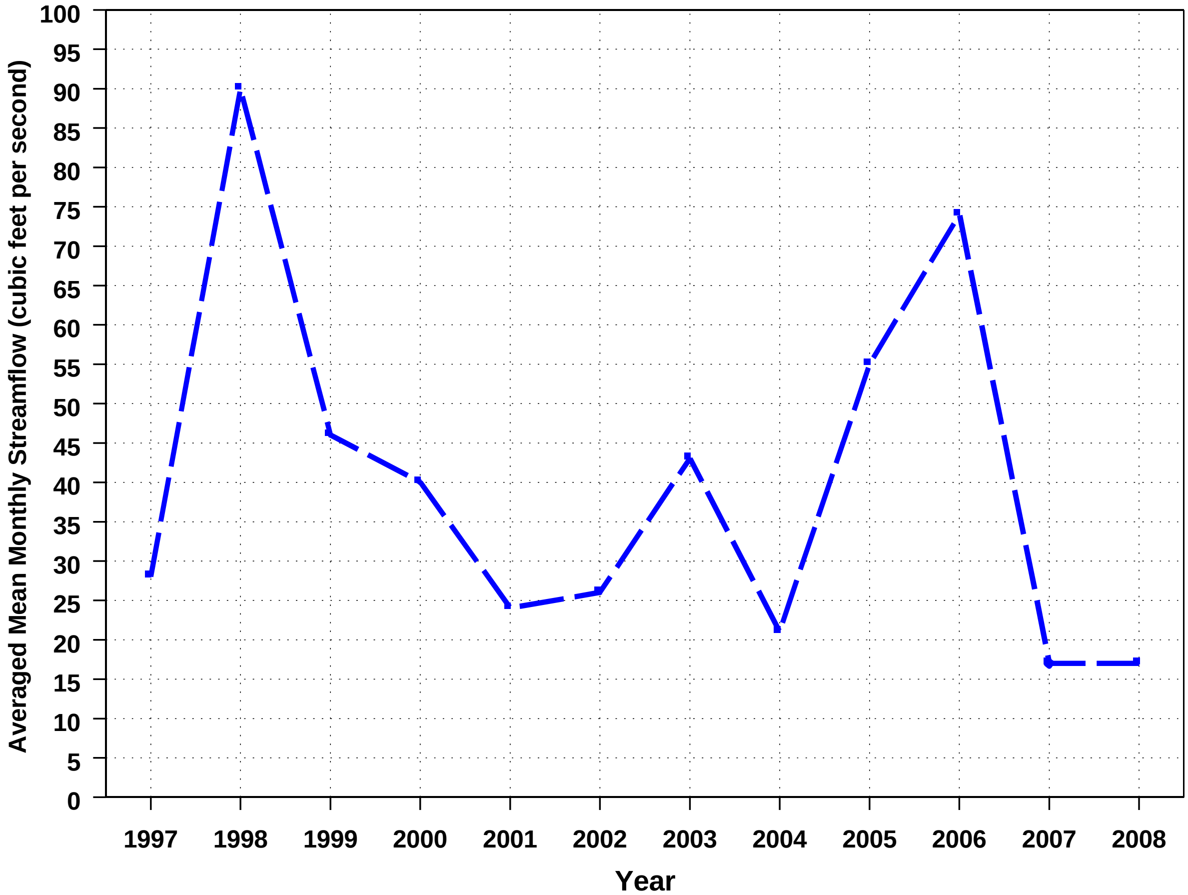


Figure 13. Plot of Annual Total Juvenile Densities at San Lorenzo Mainstem Sites, 1997-2008.

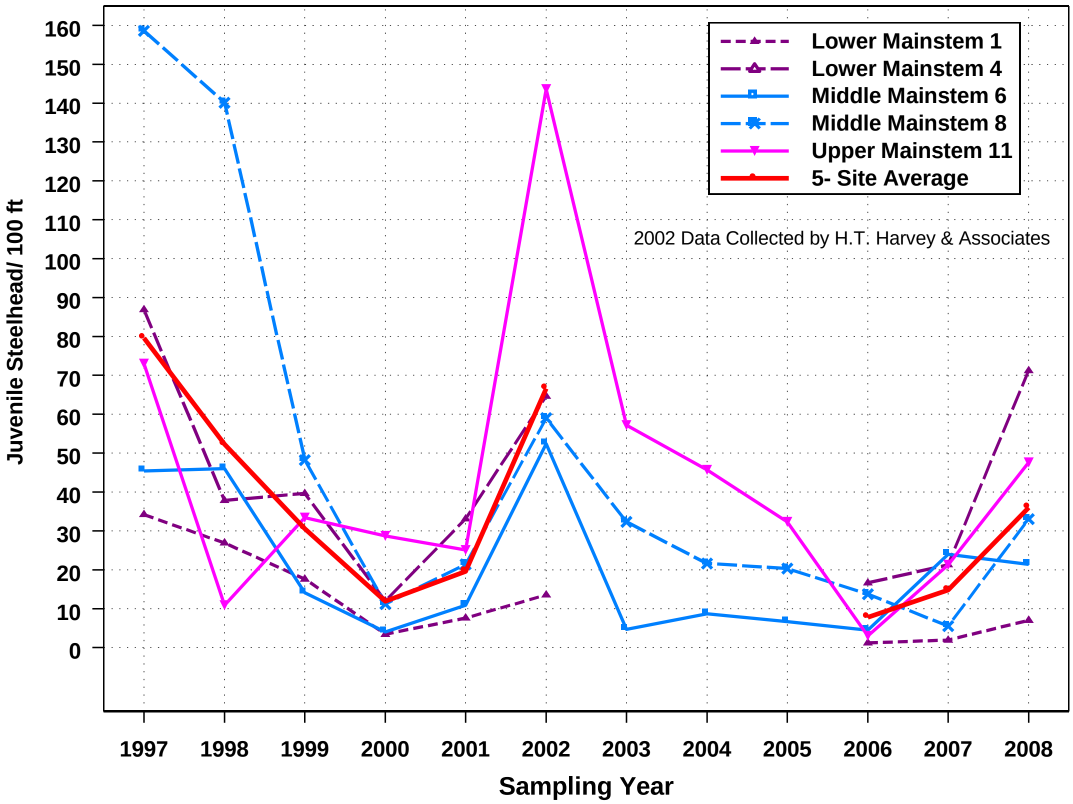


Figure 15. Plot of Annual YOY Juvenile Densities at San Lorenzo Mainstem Sites, 1997-2008.

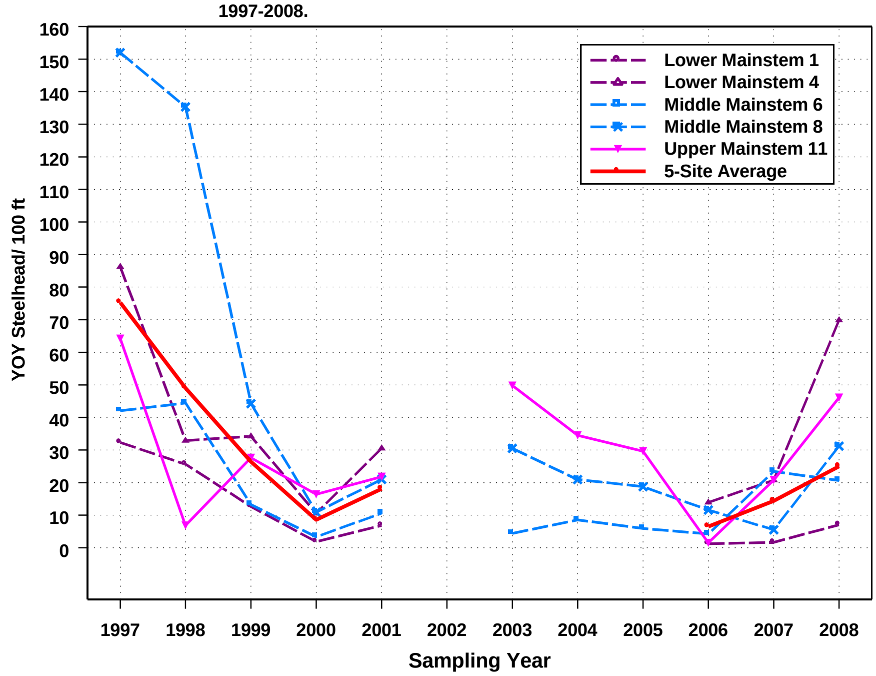


Figure 17. Scatter Plot of Annual Size Class II/ III Juvenile Densities at San Lorenzo Mainstem Sites, 1997-2008.

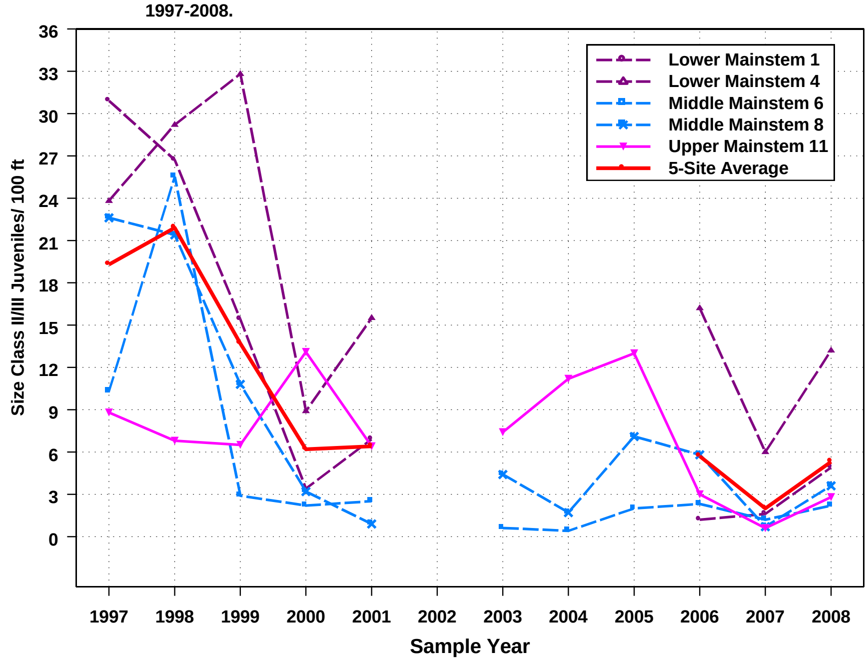


Figure 27. Averaged Maximum and Mean Riffle Depth in Reach 4 of the Lower Mainstem San Lorenzo River, 1997-2002 and 2006-2008.

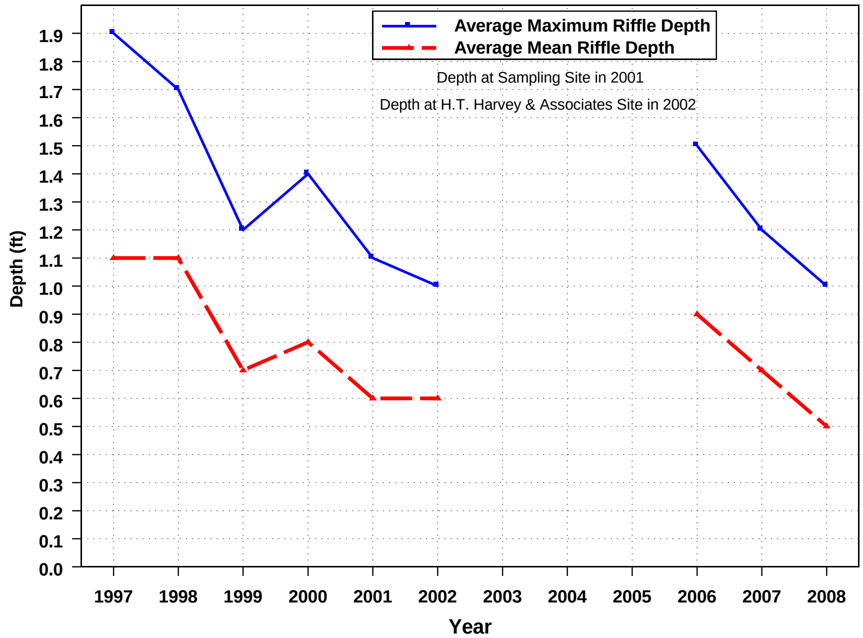


Figure 30. Averaged Maximum and Mean Riffle Depth in Reach 8 of the Middle Mainstem San Lorenzo River, 1997-2008.

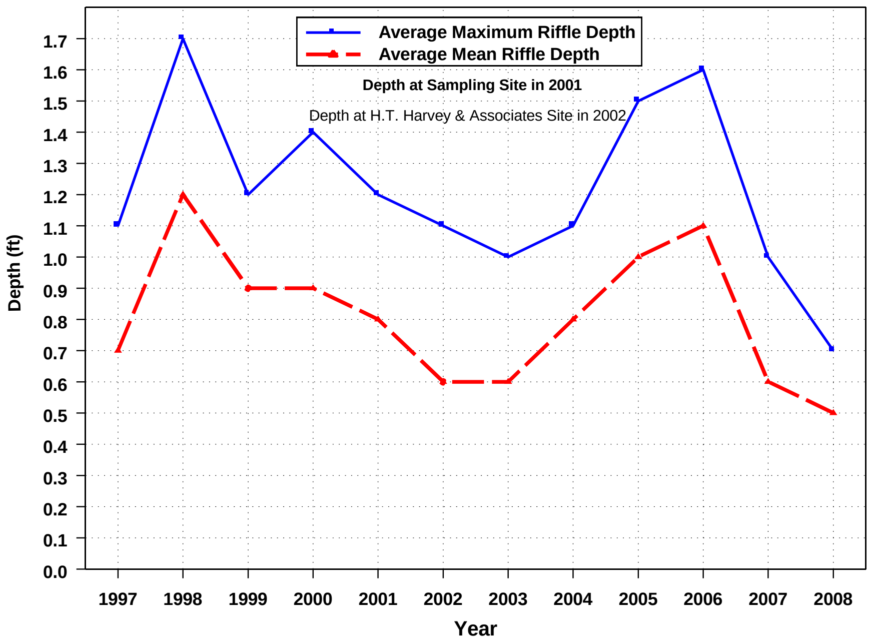


Figure 28. Escape Cover Index for Riffle Habitat in Reach 4 of the Lower Mainstem San Lorenzo River, 1998-2000 and 2006-2008.

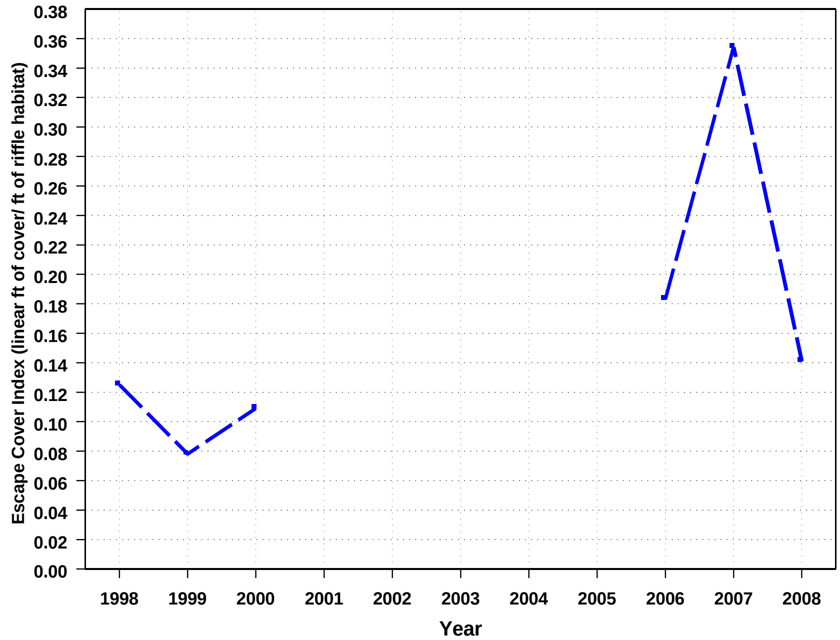


Figure 31. Escape Cover Index for Riffle Habitat in Reach 8 of the Middle Mainstem San Lorenzo River, 1998-2000, 2003 and 2005-2008.

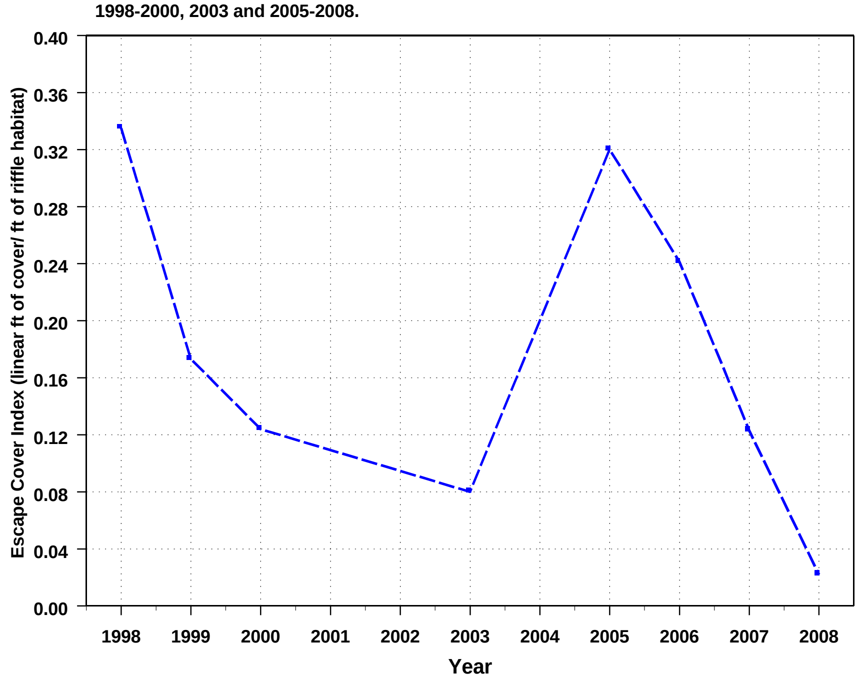
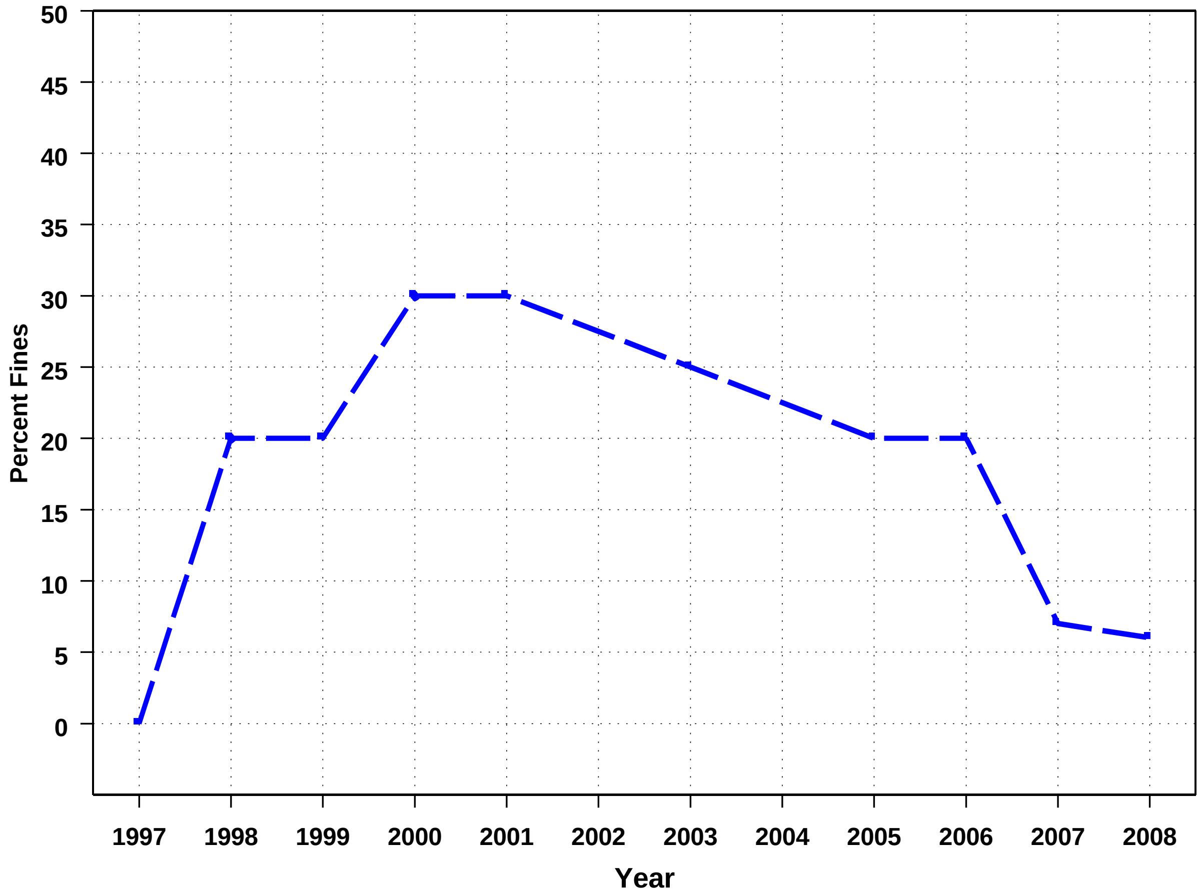


Figure 32. Averaged Percent Fines in Riffle Habitat in Reach 8 of the Middle Mainstem San Lorenzo River, 1997-2001, 2003 and 2005-2008.



Trends in Juvenile Densities in San Lorenzo River Tributaries and the Upper Mainstem

Looking for overall trends in juvenile densities for all of the tributaries combined is difficult. Each tributary drains a sub-watershed with its own climate, geology, gradient, habitat proportions, residential density and human activities (logging, bridge building, paving and water extraction). Adult spawning access and habitat conditions do not necessarily fluctuate annually in parallel between sub-watersheds. Some sub-watersheds are accessible in most years while others are difficult to pass in drier winters. Some sub-watersheds are more stable regarding sedimentation while others are more erosive. Some have high annual variability in baseflow while others are stable.

Most of the juvenile population in tributaries consists of YOY juveniles. YOY densities at tributary sites are influenced by several factors; 1) number of adults returning to the respective tributaries, 2) spawning effort, 3) spawning success, 4) survival of emerging YOY in late winter and spring and 5) rearing habitat quality in primarily pools. Spawning conditions are better in the tributaries than the mainstem, but late stormflows may be very successful in destroying many spawning redds because of the high percent fines in spawning glides in nearly all tributary spawning sites. Water velocities from late stormflows may also wash newly emerged YOY away with high mortality in the face of little instream wood to provide velocity shelter.

For tributary sites and the upper mainstem, there was a general decline in total densities from 1997 to 2000, with a general increase from 2000 to 2003, followed by a general decline from 2003 to 2007 and a rebound in 2008 (**Figures 13 and 14**).

For tributary sites and the upper mainstem (above the Boulder Creek confluence as represented by Reach 11), there was a general decline in total densities from 1997 to 2000, with a general increase from 2000 to 2003, followed by a general decline from 2003 to 2007 and a rebound in 2008 (**Figures 13 and 14**). The extremely high juvenile density measured in 2002 at Site 11 by HTH (**2003**) seemed highly unusual, considering our 14 other years of sampling experience with Reach 11 in the upper mainstem. In 2007 and 2008, total densities bounced back up in Zayante Creek. In 2008, total densities at wetted sites in Bean and Bear creeks rebounded. Reach 14c went dry in Bean Creek.

Since most juveniles were YOY, their densities followed the same trend (**Figures 15 and 16**). No data were available from the HTH report (**2003**) regarding YOY or Size Class II and III densities. Although there were no YOY data available in 2002, we can guess that YOY densities followed the same trend as total densities. YOY densities fluctuated greatly through the years at certain sites. YOY density at Site 14c in upper Bean Creek fluctuated the most. This reach is greatly impacted by well pumping. During the 2003–2008 period, Site 14b in middle Bean Creek surprisingly had no YOY in 2007, presumably because a long segment of the creek upstream of the site was dry and prevented YOY recruitment. YOY density at Site 13c on Zayante Creek annually fluctuated up and down, and Site 13d on Zayante Creek declined significantly in 2007, with its 2007 density the second lowest in 12 years. However, it rebounded in 2008. The 2007 sampling site in Reach 13d had been upstream of a major landslide that had created a steep boulder cluster in the channel during the winter of 2005−2006. This boulder cluster may have been a passage impediment in 2007 that resulted in reduced spawning and juvenile recruitment upstream. This possible impediment became modified in 2008.

Figure 14. Plot of Annual Total Juvenile Densities at San Lorenzo Tributary Sites, 1997-2008.

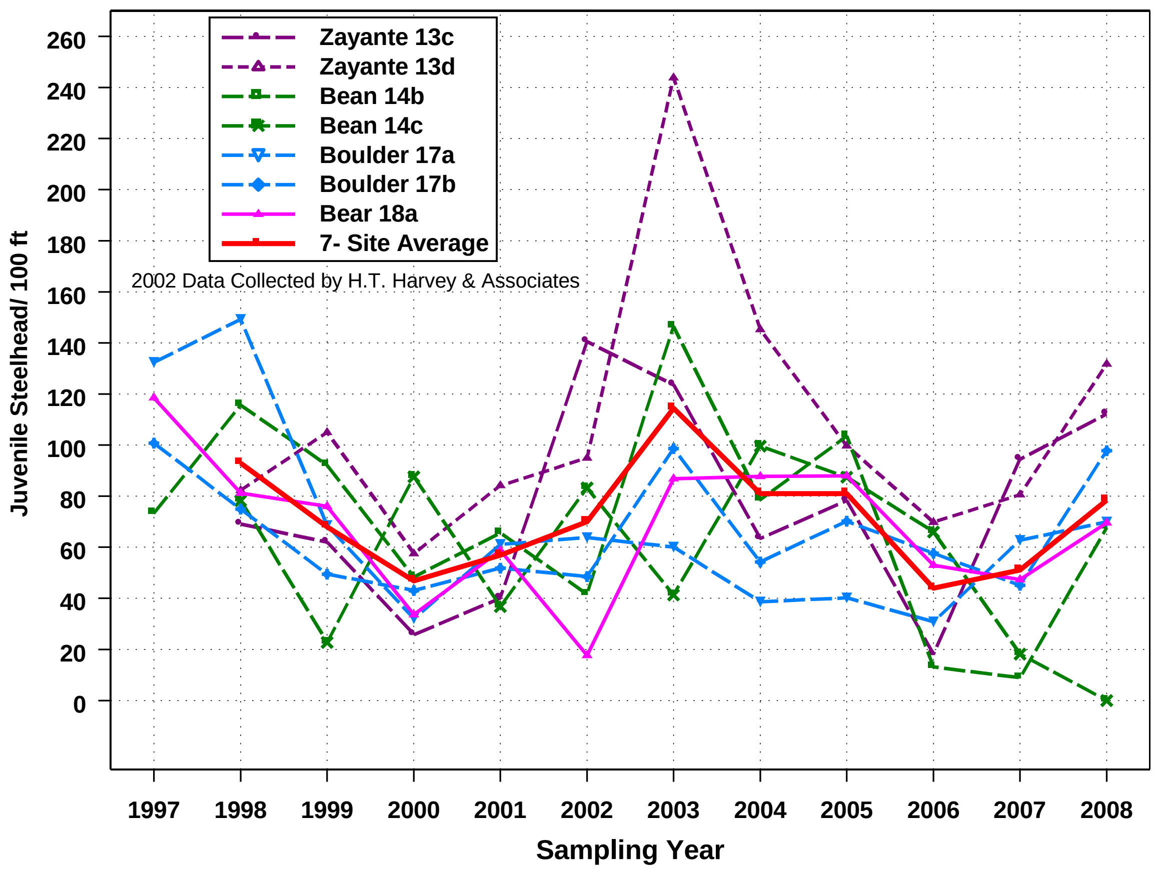
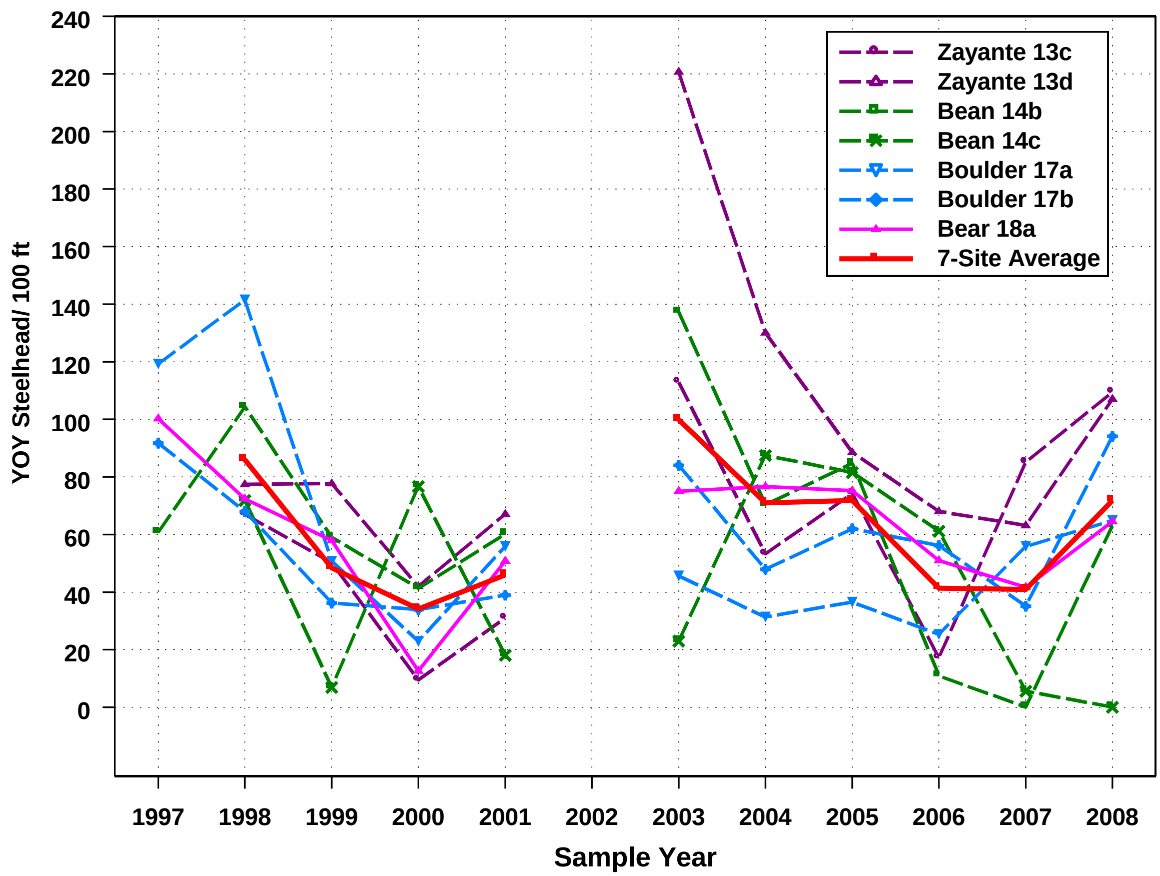


Figure 16. Plot of Annual YOY Juvenile Densities at San Lorenzo Tributary Sites, 1997-2008.



YOY densities in San Lorenzo tributaries may be relatively higher in years like 1997 and 2002 because of no large, late storms but smaller late storms sufficient to promote spawning through the winter and spring. YOY densities may also be higher in wet years, such as 1998, which had high winter flows for good spawning access and high baseflows later on for good rearing habitat, with no large stormflows occurring between March and June but still adequate spawning flows for late spawners. 1999 had relatively large stormflows in April and May that may have reduced YOY survival. The year 2000 had multiple large stormflows from January through early March, making egg survival likely difficult, followed by rapid decline in baseflow with no storms except for a short one in late April. In addition, it was hypothesized that there were reduced adult returns in 2000 associated with the El Niño storm pattern and associated ocean conditions. There was likely high mortality of smolts in winter of 1997-1998 due to large flood flows. The El Niño period began in summer 1997 and persisted through spring and summer of 1998. Warm water, low macronutrient levels and low chlorophyll and primary production along the continental shelf characterized the event. Poor smolt survival in the ocean may have resulted from high competition for food under warm water conditions, contributing to low adult returns in 2000.

The drier to moderate rainfall years of 2001–2004 and 2008 likely allowed for relatively higher egg and young YOY survival, with enough small storms to allow adult access to tributaries and the largest storms occurring in early winter. Years 2004, 2005 and 2008 produced similar YOY densities as 1999 with very different hydrographs (**Figures 61, 62 and 66**). The years 2004 and 2008 had no significant storms after early March and below average baseflows after that. The year 2005 had periodic stormflows throughout March, April and early May, with above average baseflows through the summer. YOY densities declined in 2006 with periodic stormflows through mid-May as in 2005, but the storms were of larger dimension and lasted longer in 2006, thus likely leading to poor egg and young YOY survival (**Figure 64**). The year 2007 had only very small storms in January that would have provided limited access to tributaries and only two moderate stormflows in March that would have provided access and flows conducive to spawning in tributaries, likely limiting spawning effort in the tributaries (**Figure 65**). Egg survival was likely good but competition for food associated with low baseflow in April−May likely reduced YOY survival in 2007.

Figure 61. The 2004 Daily Average Discharge and Median Daily Flow on Record for the USGS Gage On the San Lorenzo River at Big Trees.

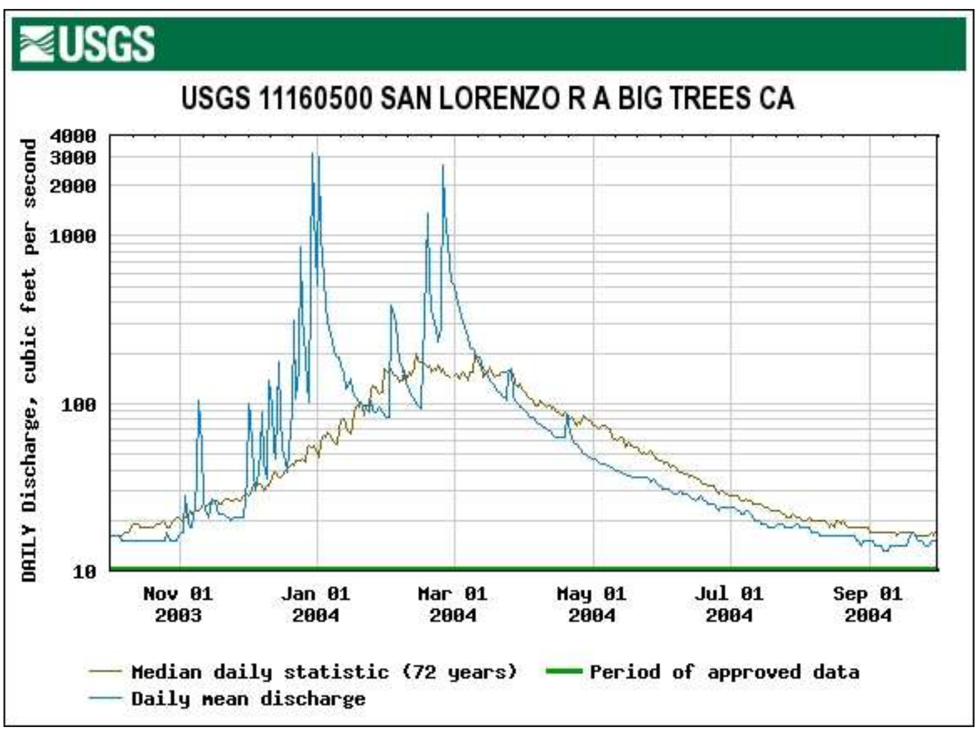


Figure 62. The 2005 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.

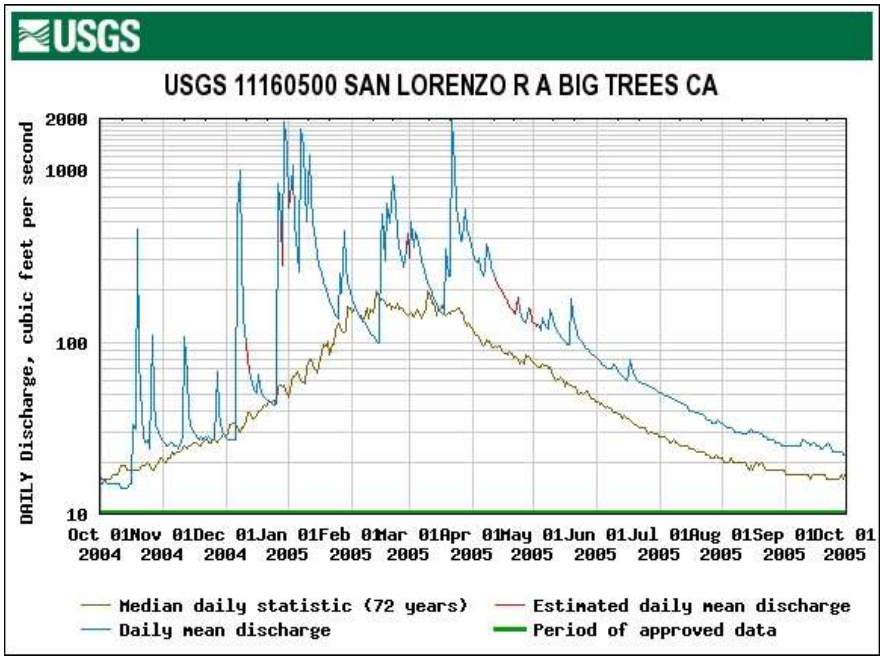


Figure 64. The 2006 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.

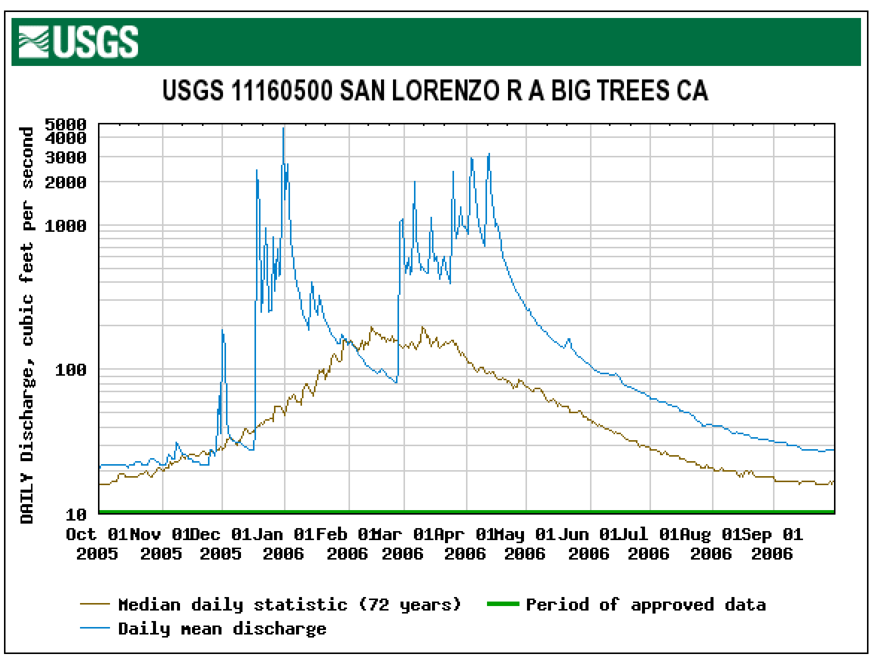


Figure 65. The 2007 Daily Average Discharge and Median Daily Flow on Record for the USGS Gage On the San Lorenzo River at Big Trees.

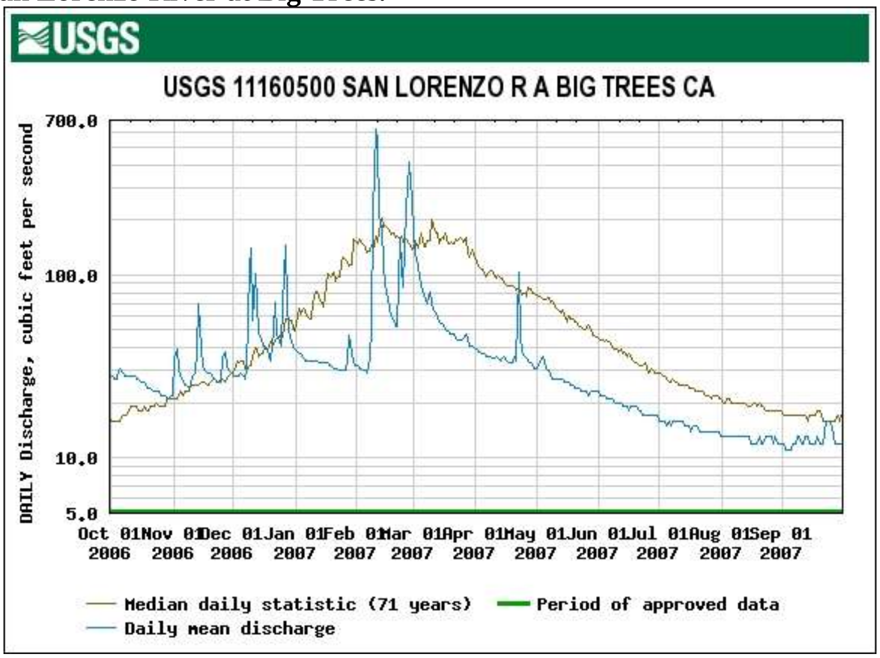
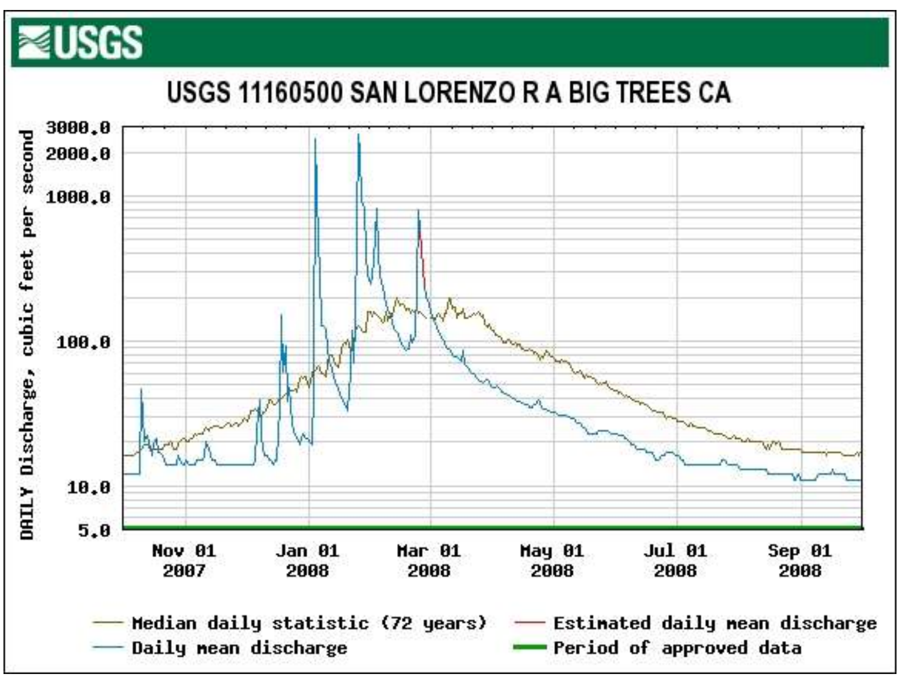


Figure 66. The 2008 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.



Tributary densities of larger Size Class II and III juveniles (almost entirely yearlings) in fall are determined mainly by 1) over-wintering survival the previous winter, 2) growth rate in spring that may allow early smolting of yearlings their first spring and 3) rearing habitat quality through the summer.

Tributary densities of Size Class II and III (smolt size) showed no general trend, though as a group they were relatively low in 2007−2008 (**Figures 17 and 18**). Years that had overall low tributary site densities of larger juveniles were 2001, 2004, 2007 and 2008, all of which had relatively low averaged mean monthly streamflow for May−September over the last 12 years and below the median daily flow for the years of record (**Figures 25, 58, 62, 65 and 66**). After wetter winters, densities of larger juveniles generally increased, as occurred in 1998, 1999, 2003, 2005 and 2006. Densities were similar between 1997 and 1998 but generally increased in 1999 to a 12-year high, particularly in Zayante, upper Boulder and Bear creeks. In 1999, the winter had only 1 peak flow that was near bankfull in early February and continued to rain through April for a relatively wet winter but without creating bankfull flow intensity (**Figure 56**). Spring and summer baseflow in 1999 was above the median (**Figure 25**). Then in 2000 there was a general decline in tributary densities except in Bear Creek, despite the above median baseflow. The year 2001 showed mixed changes in densities of larger juveniles, with some sites increasing in density and others declining. Comparable data for the San Lorenzo system in 2002 were unavailable. However, if trends were similar to Soquel Creek in that year (**Figures 23 and 24**), densities of larger juveniles were likely similar to 2001 in San Lorenzo tributaries. Densities of these larger juveniles declined at all sites under consideration in the drier years of 2007 and 2008 except for upper Zayante Creek #13d, which increased in 2008 to the highest in the watershed.

Figure 18. Plot of Annual Size Class II/ III Juvenile Densities at San Lorenzo Tributary Sites, 1997-2008.

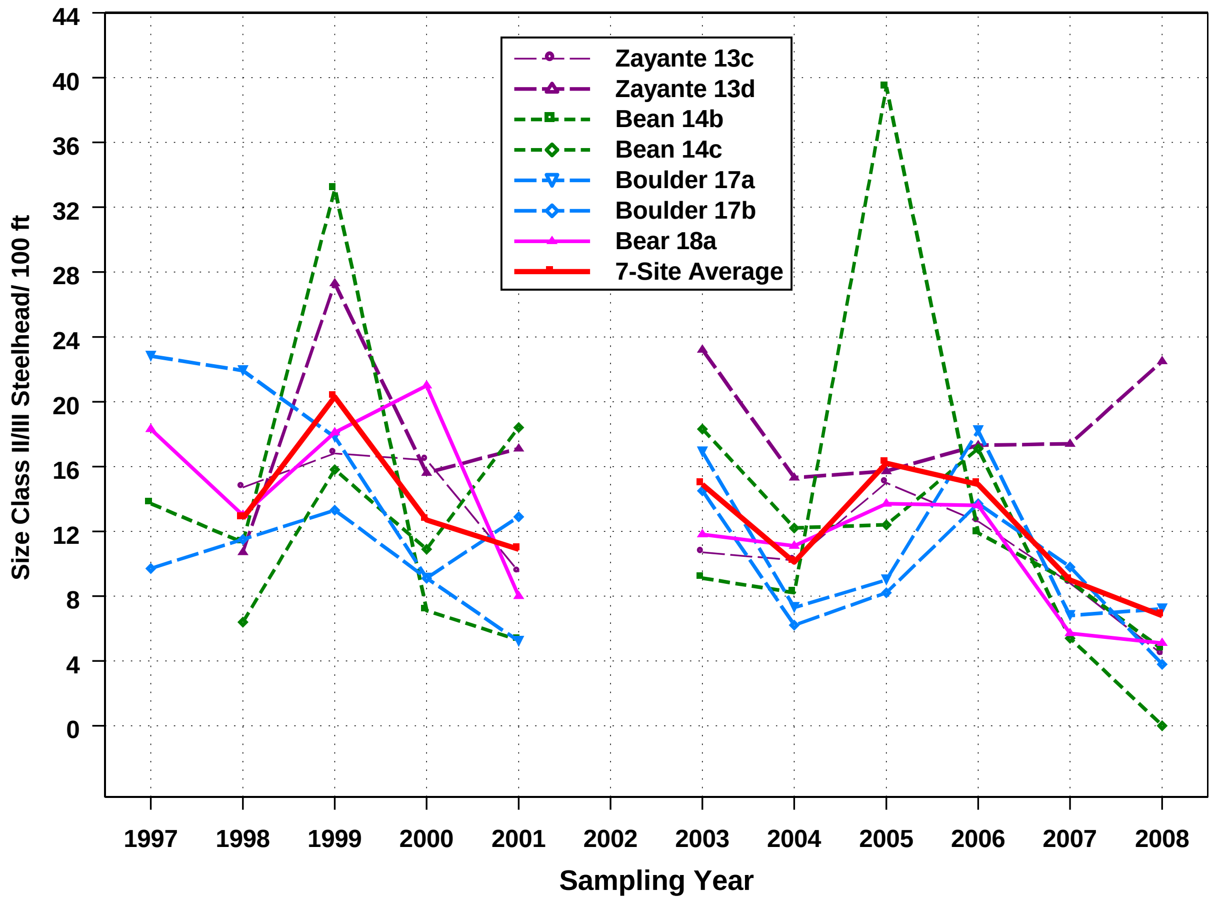


Figure 23. Plot of Annual Size Class II/ III Juvenile Densities at Soquel Mainstem Sites, 1997-2008.

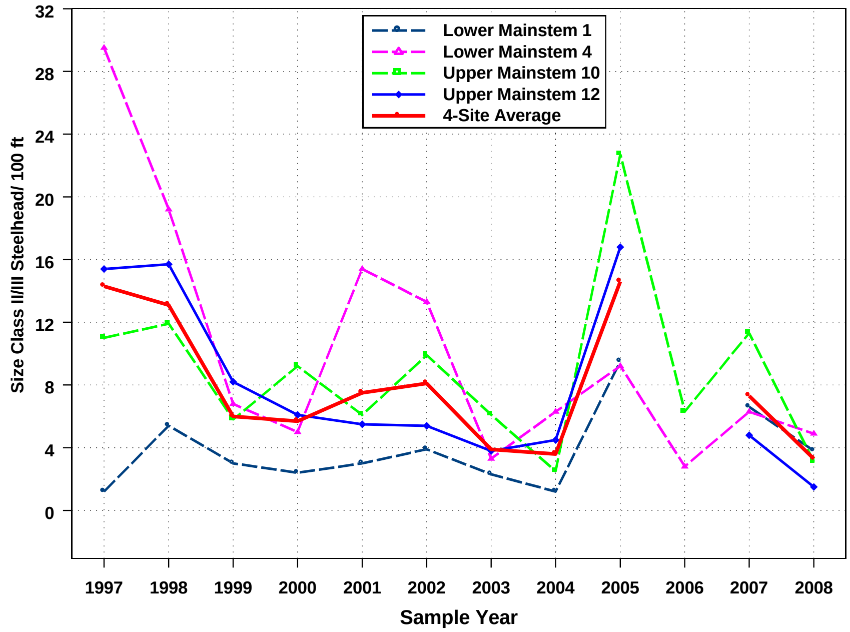
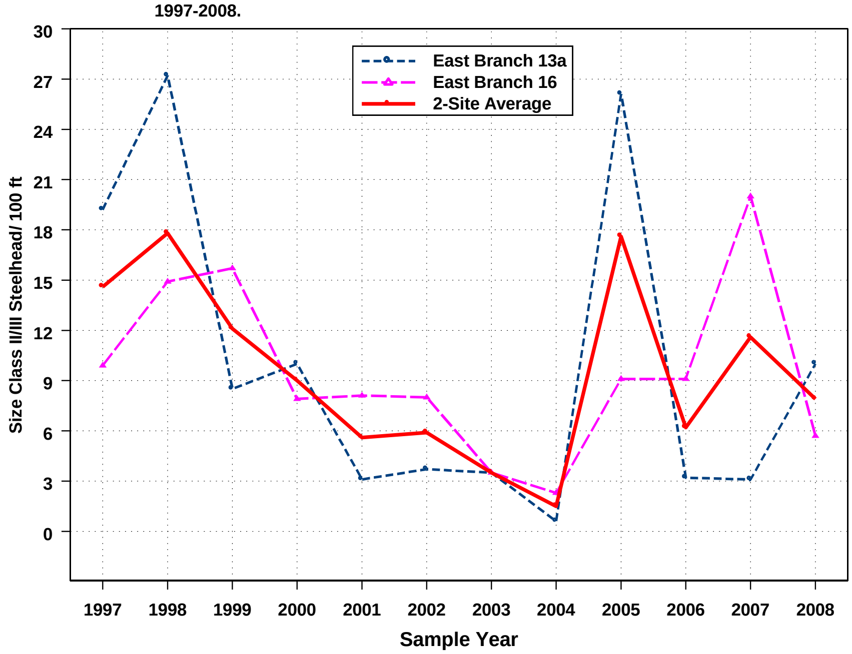


Figure 24. Plot of Annual Size Class II/ III Juvenile Densities at East Branch Soquel Creek Sites, 1997-2008.



The highest overall Size Class II and III densities at most tributary sites occurred in 1999, which was a relatively wet year without stormflows that continued through April with only one possibly reaching bankfull streamflow (2,800– 4,300 cfs at Big Trees; (**Alley 1999a**) in early February at 3,200 cfs. The averaged mean monthly streamflow for May−September was intermediate for the last 12 years (**Figure 25**). 1999 had a much above median daily baseflow for May−September (**Figure 56**). Years that had overall low tributary site densities of larger juveniles were 2001, 2004, 2007 and 2008, all of which had relatively low averaged mean monthly streamflow for May through September in the last 12 years and below the median daily flow for the years of record (**Figures 25, 58, 62, 65 and 66**). When one takes a less detailed look at the changes in densities of larger juveniles at tributary sites, there has been little overall change except in 2007 and 2008, when they mostly declined substantially. If adult returns are to substantially improve, densities of these larger, soon to smolt, juveniles must greatly increase from much improved tributary habitat quality.

Figure 56. The 1999 Daily Average Discharge for the USGS Gage On the San Lorenzo River at Big Trees.

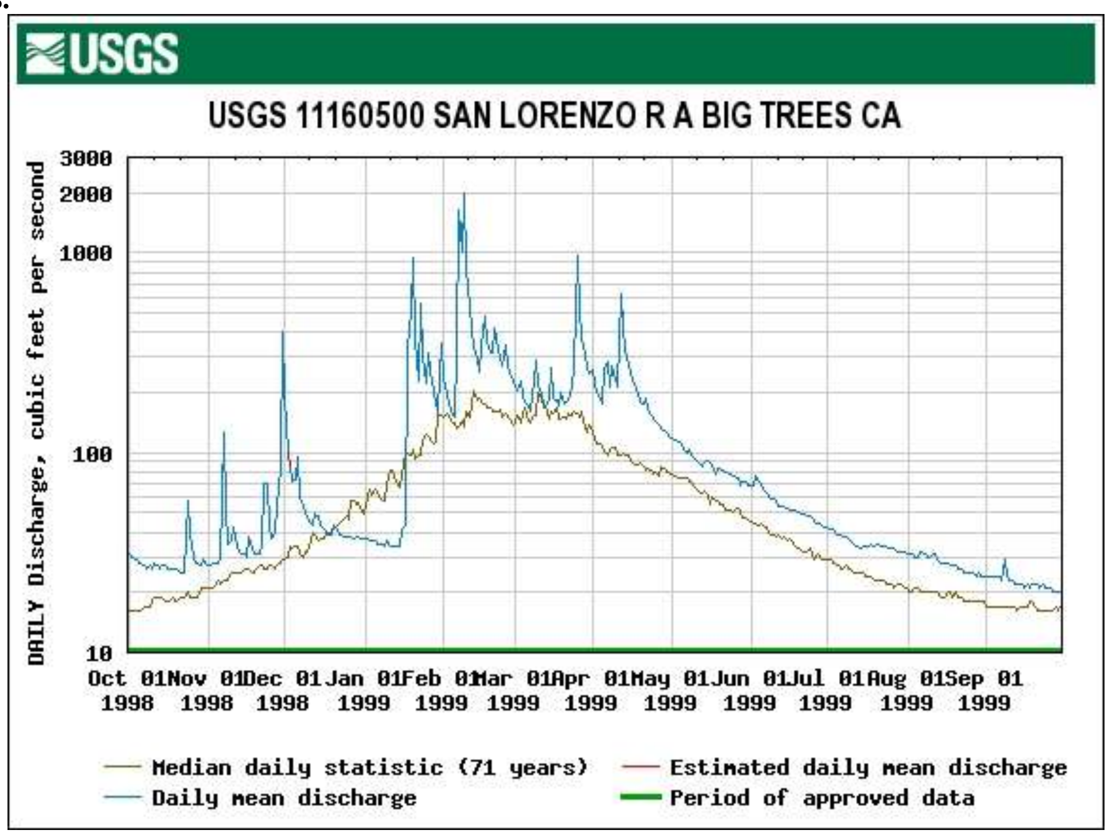
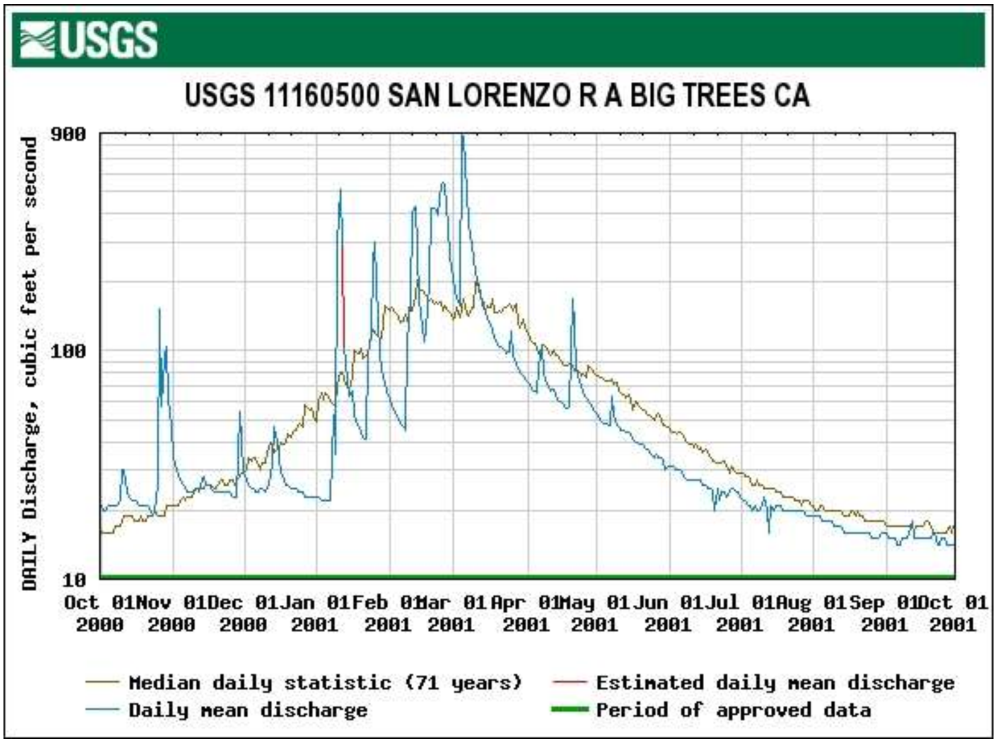


Figure 58. The 2001 Daily Average Discharge for the USGS Gage On the San Lorenzo River at Big Trees.



Annual trends in Size Class II and III densities at the upper Zayante Site 13d did not correlate well with changes in reach-wide pool depth for the years of available data. However, no reach data were available for drier years of 2001, 2002 or 2004 (**Figure 33**). Changes in densities in upper Zayante Creek was associated with changes in sampling site escape cover in pools until 2006 and 2007, when densities were stable at 2005 levels despite reduced escape cover (**Figures 18 and 34b**). They may have remained constant because of higher baseflow in 2006 and higher over-winter survival in 2007 after a mild winter. Densities increased as escape cover increased at Site 13d in 2008. Changes in densities also coincided well with changes in reach-wide escape cover in 1998–2000 and 2003 (**Figure 34a**). However, somewhat higher reach-wide escape cover in 2005 did not correspond to high Size Class II and III fish density in that year, presumably because escape cover at sampled pools remained similar between 2004 and 2005. The decline in step-run percent fines was only positively associated with increased densities from 2001 to 2003, but pool escape cover was also relatively high in 2003 to encourage higher fish densities (**Figure 35**).

In analyzing habitat change in an important eastern tributary reach, it was noted that rearing habitat conditions had declined in Zayante Reach 13d from 1997 to 2007 and 2008, judging by the shallowest pool depths in the 12-year period in 2007 (**Figure 33**) (where annual differences in fall baseflow have limited effect on pool depth) and the relatively low pool escape cover in 2007 and 2008 for the reach (**Figure 34a**). The percent fines went back up in step-runs to 30% in 2008 after being at a 12-year low in 2007 of 13% (**Figure 35**).

Figure 33. Averaged Maximum and Mean Pool Depth in Reach 13d of Zayante Creek, 1998-2000, 2003 and 2005-2008.

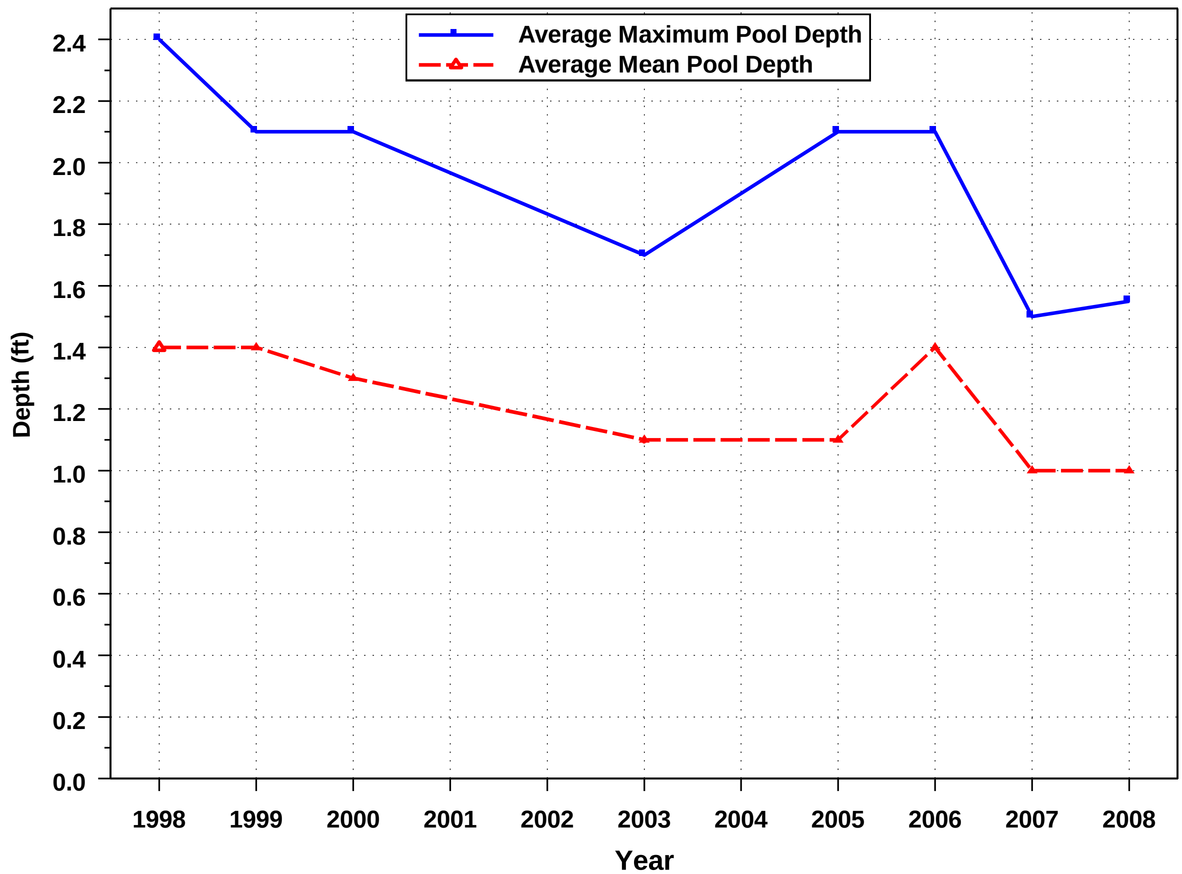


Figure 34a. Escape Cover Index for Pool Habitat in Reach 13d of Zayante Creek, 1998-2000, 2003 and 2005-2008.

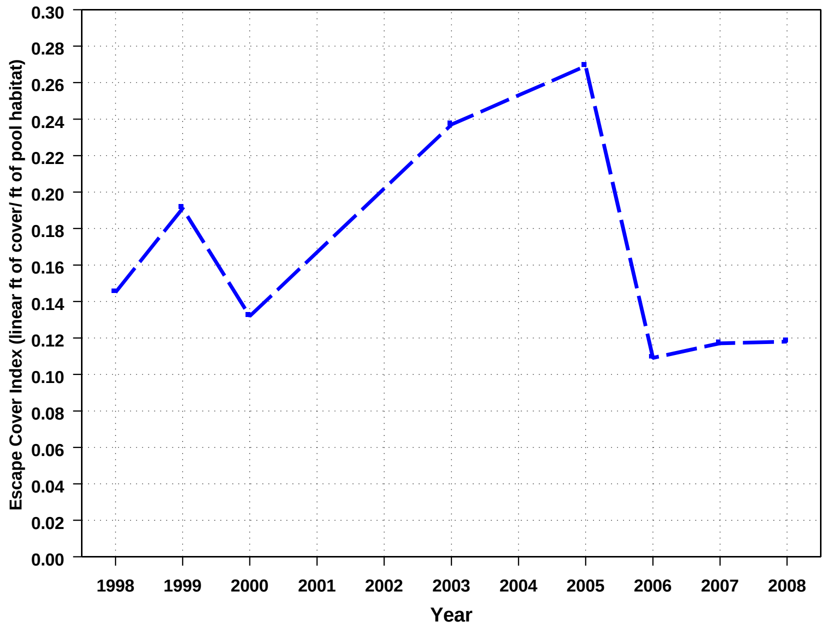


Figure 34b. Escape Cover Index for Pool Habitat at Site 13d in Zayante Creek, 1998-2001 and 2003-2008.

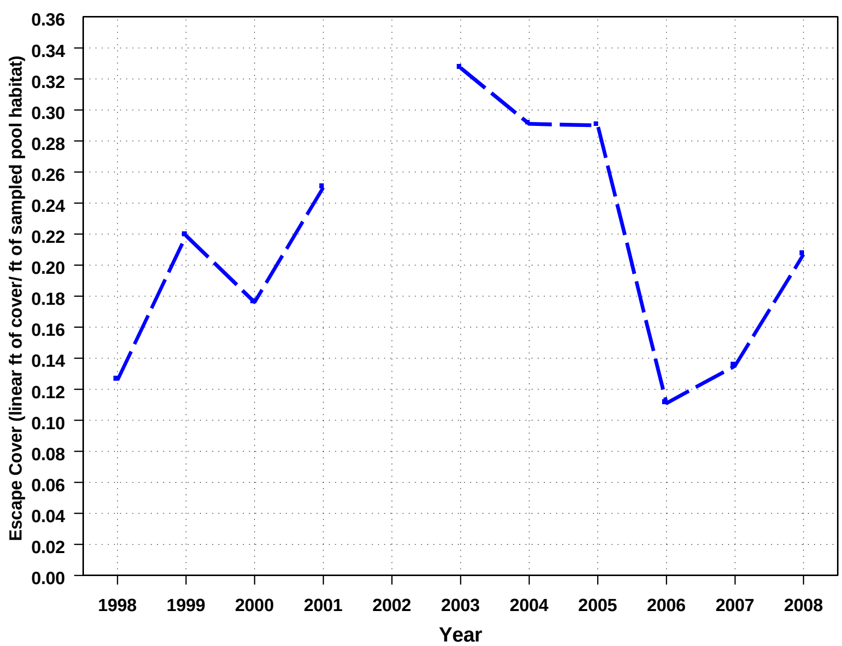
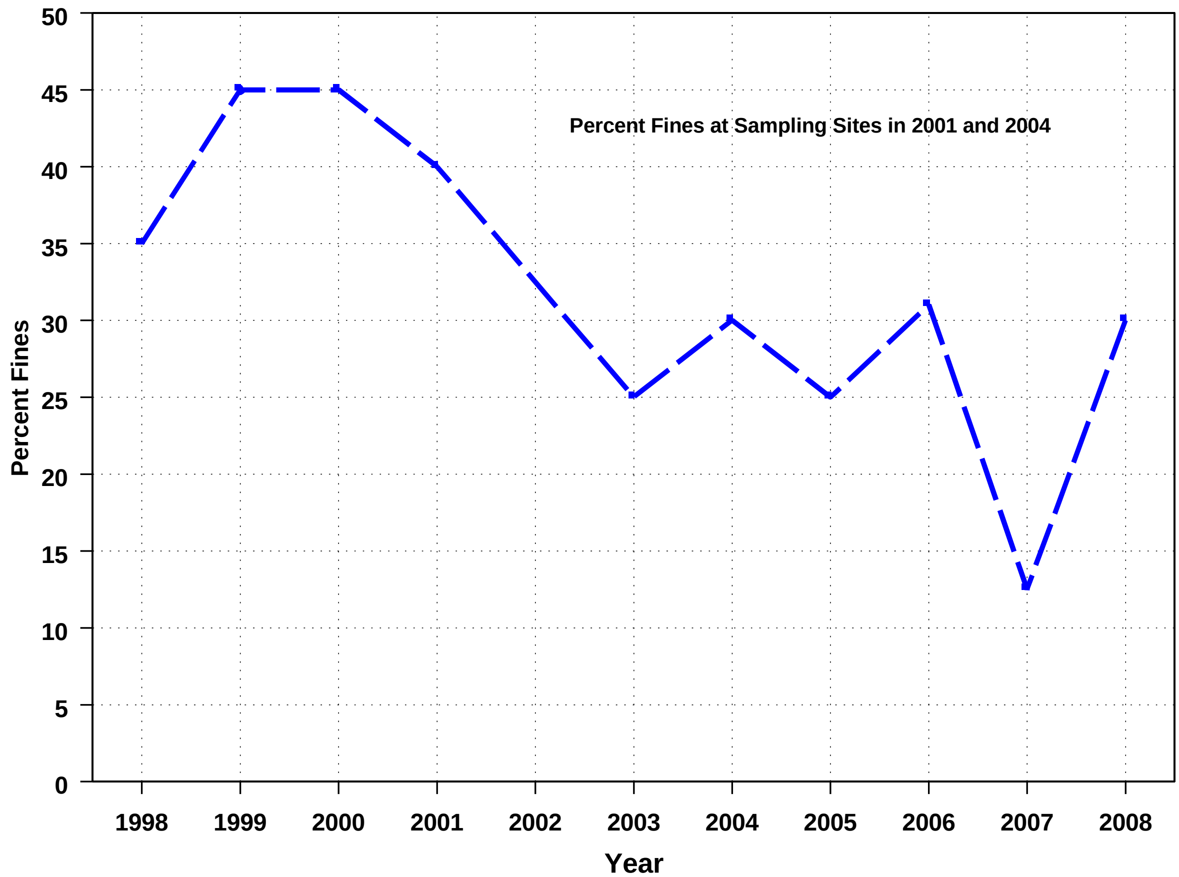


Figure 35. Averaged Percent Fines in Step-Run Habitat in Reach 13d of Zayante Creek, 1998-2001, 2003-2008.



In analyzing habitat change in an important western tributary reach, it was noted that overall rearing habitat quality in Boulder Reach 17a has declined from 1997 to 2008 due to reach-wide pool filling (**Figure 36**) and reduced pool escape cover (**Figure 37a**), although a positive change was reduced fines in step-runs/ runs (**Figure 38**).

For the lower Boulder Creek Site 17a, annual changes in density of Size Class II and III juveniles were associated with reach-wide changes in pool depth for the years of data (1998–2000 and 2005–2008) (**Figures 18 and 36**). Changes in smolt density were not associated with changes in escape cover in sampled pools or with reach-wide changes in pool escape cover (**Figures 37a-b**). The poor correlation may result from no consideration of step-run escape cover and depth in a reach where step-runs are a large proportion of the habitat and deep enough to be inhabited by larger juveniles. Also, except for 1997 and 2007, the annual differences in pool escape cover were small in sampled pools that generally lacked much escape cover. Therefore, other factors may have played larger roles in determining densities. The 2007 density was much less than the 2006 density, despite increased pool escape cover in 2007. However, large yearlings from the previous wet year may have smolted and out-migrated in spring 2007 prior to fall sampling, leading to small fall yearling densities. Densities were sometimes positively associated with increases in percent fines in step-runs, though percent fines did not increase a substantial amount except from 1998 to 1999 (**Figure 38**). This is the opposite of what was expected because increased percent fines indicates a decline in habitat quality. Apparently the negative effect of increased percent fines measured in 1999 and 2006 were overcome by relatively high streamflow and water velocity, greater water depth in step-runs and better feeding stations in step-runs and the heads of pools.

Figure 18. Plot of Annual Size Class II/ III Juvenile Densities at San Lorenzo Tributary Sites, 1997-2008.

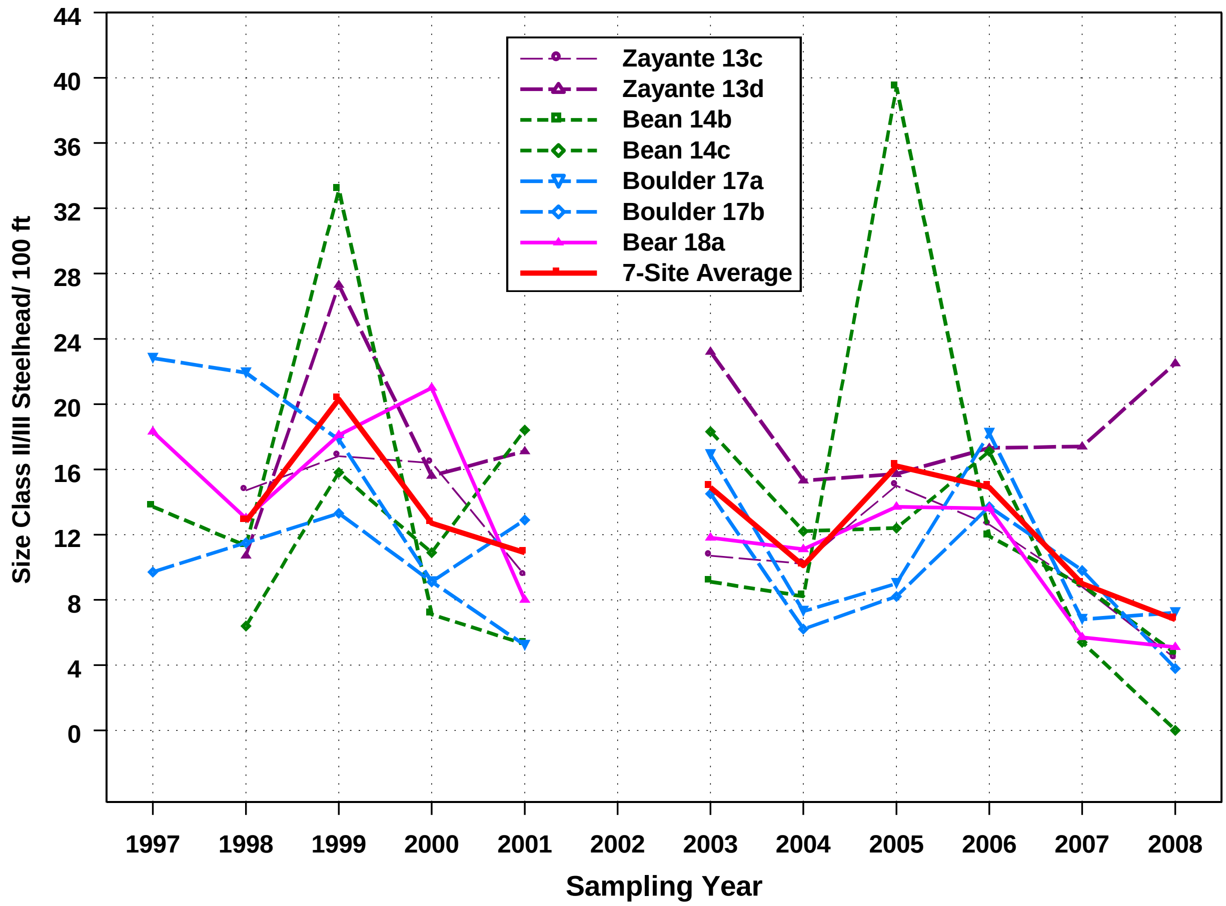


Figure 36. Averaged Maximum and Mean Pool Depth in Reach 17a of Boulder Creek, 1998-2000 and 2005-2008.

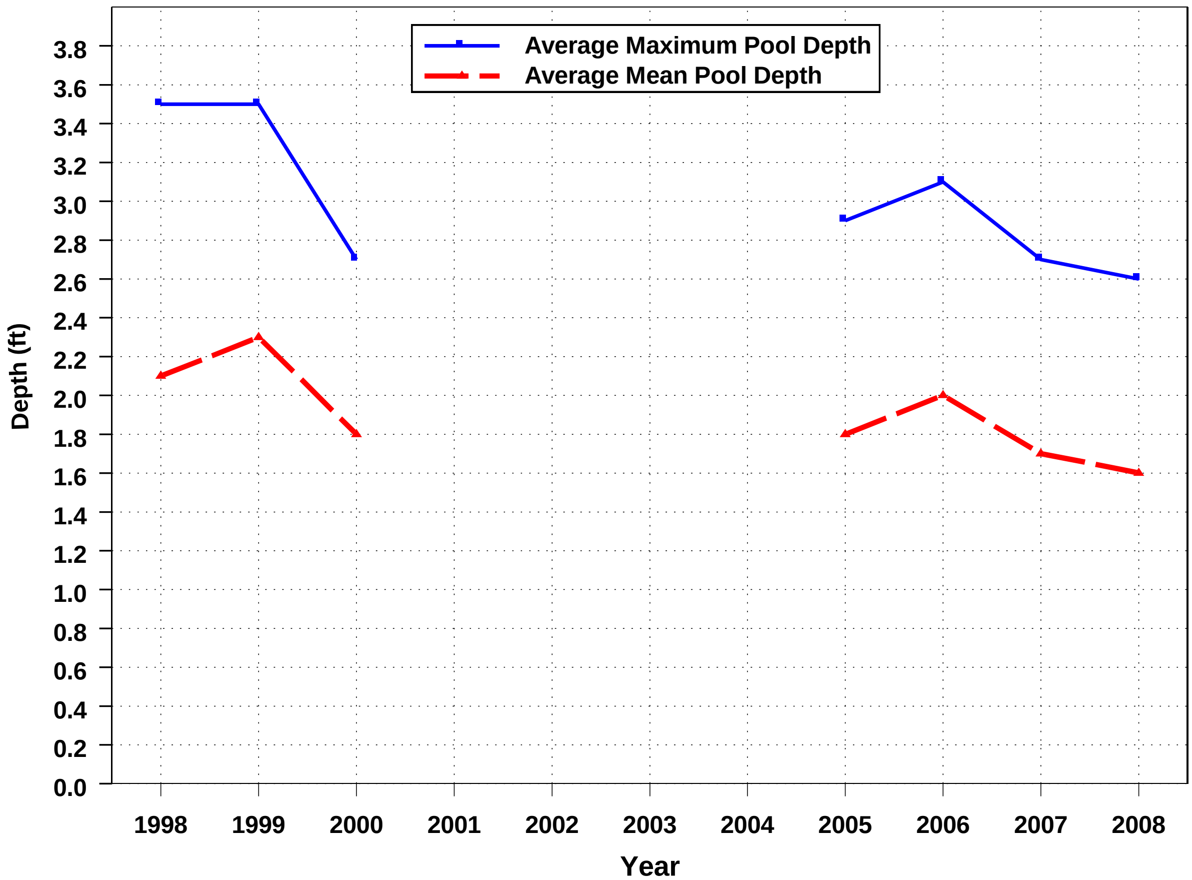


Figure 37a. Escape Cover Index for Pool Habitat in Reach 17a of Boulder Creek, 1998-2000 and 2005-2008.

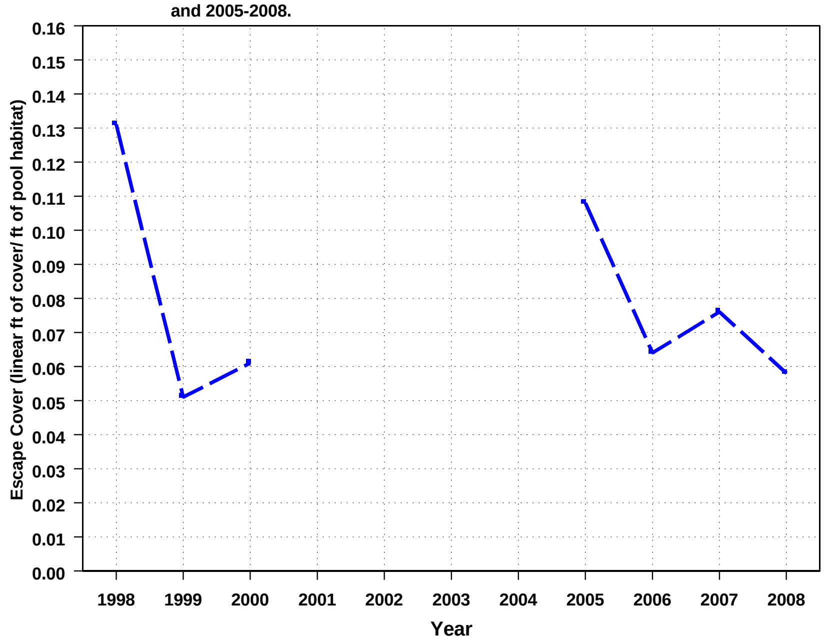


Figure 37b. Escape Cover Index for Pool Habitat at Site 17a in Boulder Creek, 1997-2001 and 2003-2008.

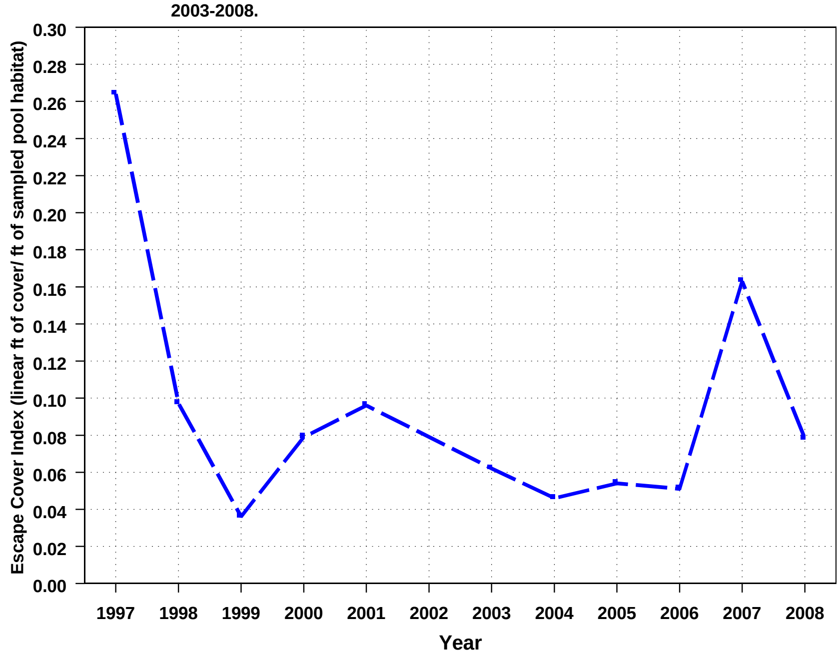
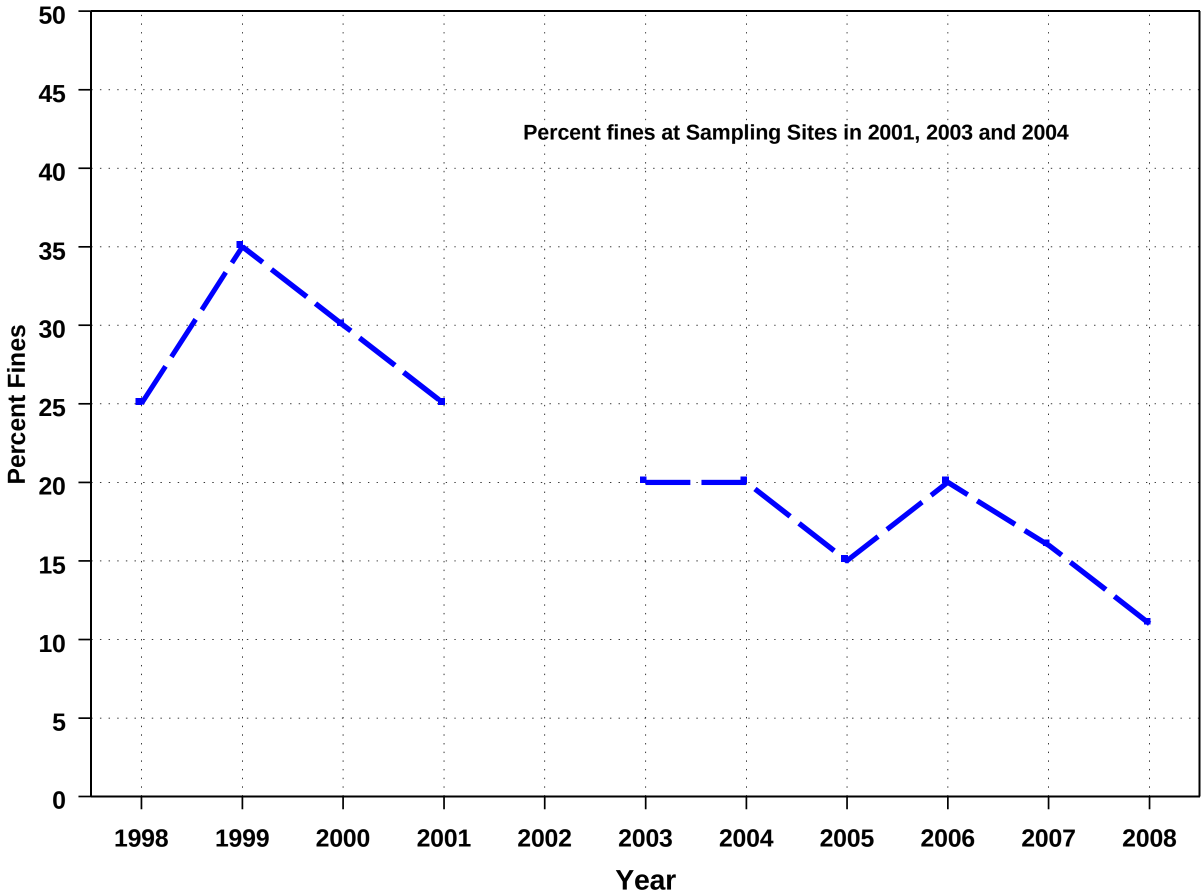


Figure 38. Averaged Percent Fines in Step-Run Habitat in Reach 17a of Boulder Creek, 1998-2001 and 2003-2008.



Habitat Trends in the Lower and Middle Mainstem of the San Lorenzo River

In the lower mainstem (downstream of the Zayante Creek confluence) habitat conditions in Reach 4 (above the gorge and below the Felton water diversion) were analyzed since 1997. Habitat in riffles was focused on in the lower and middle mainstem because warm water temperatures there will increase energy requirements of juvenile steelhead, forcing them to select fastwater habitat where water velocity and insect drift are maximized. Since 1995, the largest peak flows have occurred in 1994/1995, 1997/1998 and 2005/2006 (**Figures 53b, 55 and 65**). The largest stormflows measured at the Big Trees Gage since 1995 were 10 March 1995 (14,200 cfs), 10 December 1997 (11,400 cfs), 3 February 1998 (19,400 cfs), 16 December 2003 (13,200 cfs), 1 January 2004 (11,200 cfs) and 31 December 2005 (13,300 cfs), and all were much above the estimated range of bankfull discharge (2,800−4,300 cfs) (**Alley 1999a**) that would be capable of mobilizing the streambed. These storms (and the onslaught of sediment coming in from the upper watershed and especially the Zayante sub-watershed) brought streambank erosion, bankfull channel widening, channel braiding, large trees entering the channel (subsequently cut up and lost during later stormflows). General channel instability occurred in upper Reach 4 (Henry Cowell Park) of the lower mainstem after the 1997/1998 winter, causing substantial streambank erosion and washing large sycamores into the active channel (**Alley 1999a**).

Water depth in riffles in the late summer/ fall is mainly influenced by 1) baseflow, 2) wetted channel width and 3) the degree of winter filling in between the larger cobbles and boulders with fine sediment/sand (sedimentation) and smaller rocks. Average wetted channel width for habitat typed riffles in Reach 4 in fall 1997–2000 and 2006–2008 was 33, 35, 30 (1999), 39, 39, 25 and 29 feet, respectively. By comparing the averaged mean monthly flow (May through September) at the Big Trees Gage immediately upstream with riffle depth in Reach 4, it was evident that habitat substrate conditions in riffles were likely best in 1997 (deepest riffles despite low baseflows; low percent fines) and 2007 (deeper in 2007 than in 2001 and 2002 despite lower baseflow; low percent fines) (**Figures 25 and 27–29**). Riffle habitat had deteriorated from 2007 to 2008 despite similar baseflow and percent fines. Riffle embeddedness had worsened from 2007 to 2008 (19 to 33%) (**Table 8**), and channel width had increased to make riffle depths shallower in 2008 (**Table 5c**).

Substantial filling of deep riffle pockets was detected in Reach 4 in 1999 (extreme shallowing of maximum depth evident) (**Figure 27**), with improvement observed in 2000. Reduced escape cover in 1999 was consistent with sedimentation that year (**Figure 28**). However, riffle embeddedness at Sample Site 4 was inconsistent with sedimentation in 1999, with riffle embeddedness for 1997–2000 being 40, 45, 30 (1999) and 45%, respectively. Embeddedness improved in 1999 despite apparent filling of pockets. Reach-wide riffle embeddedness for 2006–2007 showed improvement from previous years at 37 and 19%, respectively, but increased back to 33% in 2008. Apparently, the wet winter of 2005/2006 did not cause the erosion and sedimentation that the wetter winter of 1997/1998 had produced. Percent fines were relatively high during the 1998–2001 years. Percent fines were reduced by 2007 and 2008, approaching 1997 levels. The relatively high riffle escape cover in 2007 was created by primarily overhanging willows along the channel margin, root masses and large instream wood and very little from cracks and crevices in the substrate. In 2008, riffle escape cover declined substantially in Reach 4 apparently because the high peak flow in January had removed overhanging vegetation and some instream wood. **In summary, although rearing habitat conditions in Reach 4 riffles in 2008 have improved since 1999 regarding more escape cover and reduced percent fines, 1997 riffle conditions were better with regard to habitat depth, and riffles in 1999 were also deeper and had similar embeddedness compared to 2008. Riffle habitat conditions declined from 2007 to 2008 regarding shallower depth, much less escape cover and higher embeddedness.**

Figure 53b. The 1995 Daily Average Discharge for the USGS Gage On the San Lorenzo River at Big Trees.

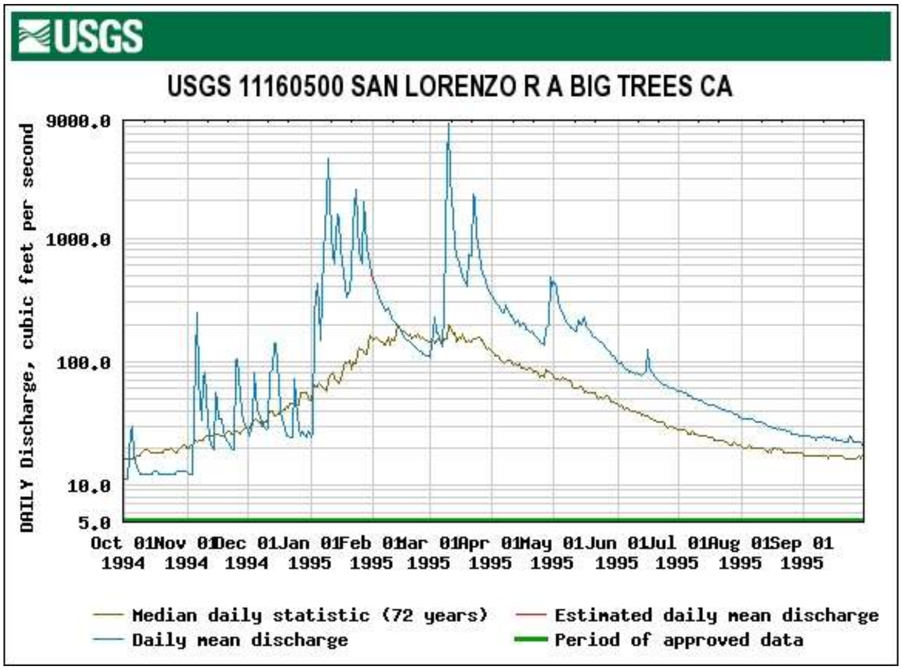


Figure 55. The 1998 Daily Average Discharge for the USGS Gage On the San Lorenzo River at Big Trees.

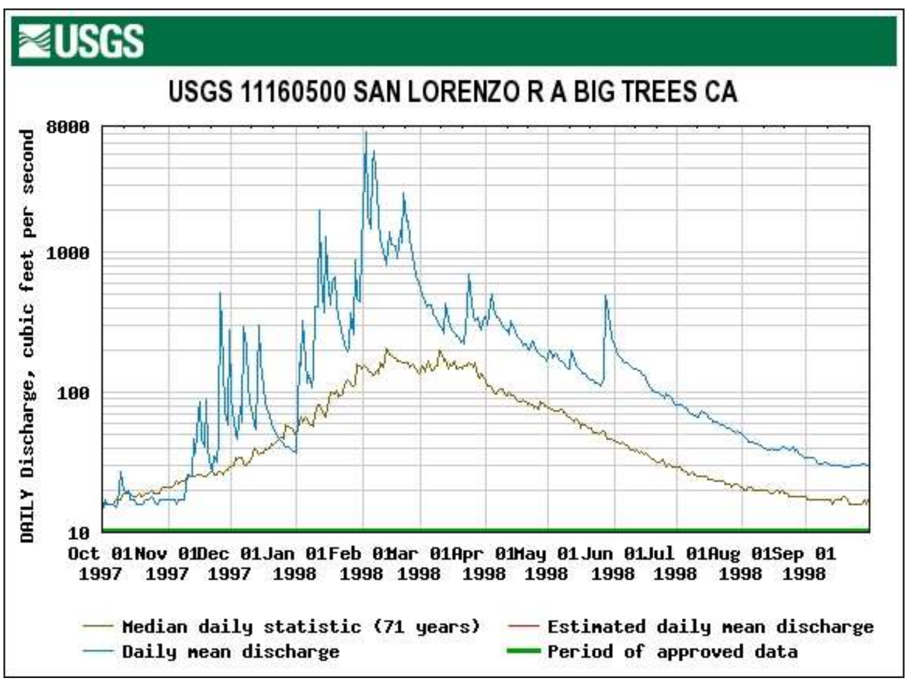


Figure 64. The 2006 Daily Average Discharge for the USGS Gage On the San Lorenzo River at Big Trees.

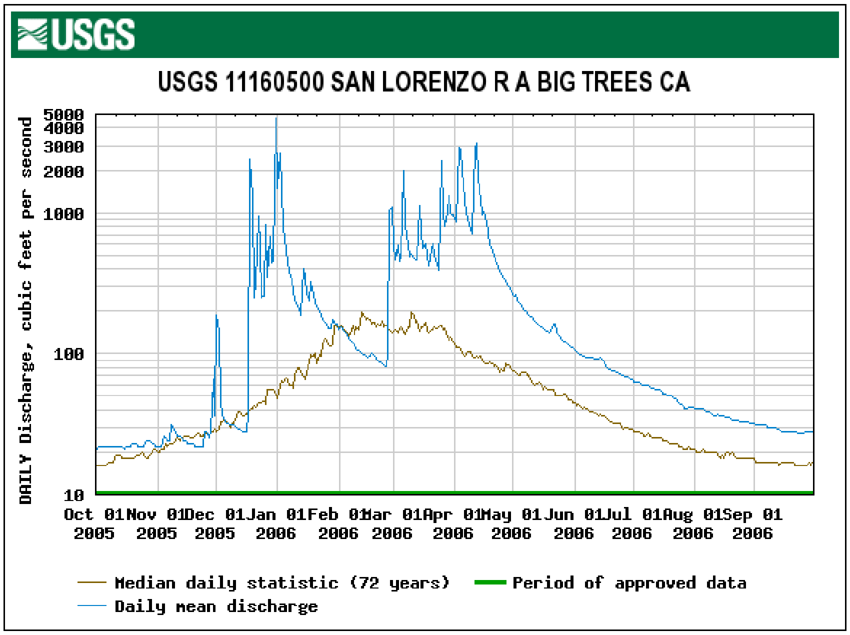


Figure 25. Averaged Mean Monthly Streamflow for May–September, 1997–2008 at the Big Trees Gage on the San Lorenzo River.

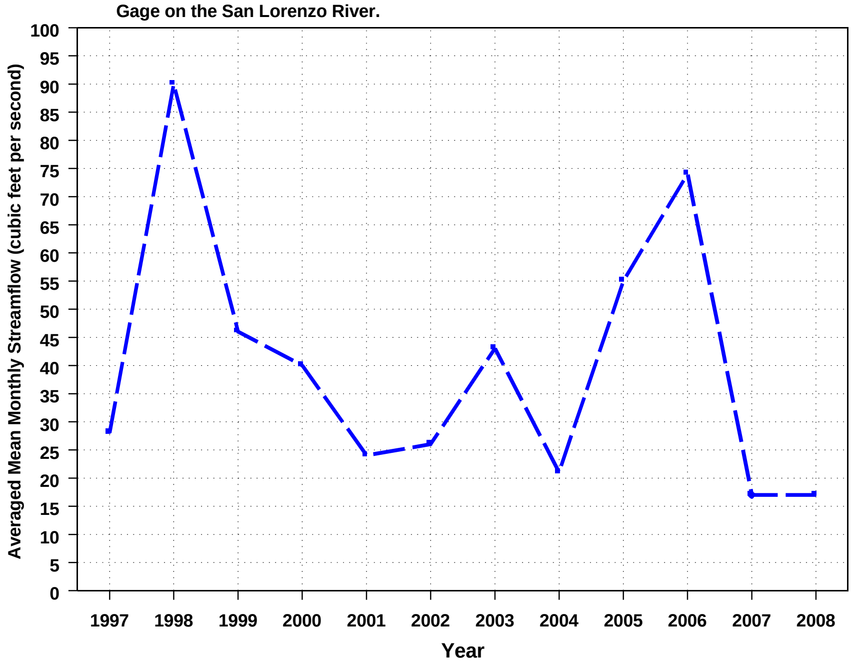


Figure 27. Averaged Maximum and Mean Riffle Depth in Reach 4 of the Lower Mainstem San Lorenzo River, 1997-2002 and 2006-2008.

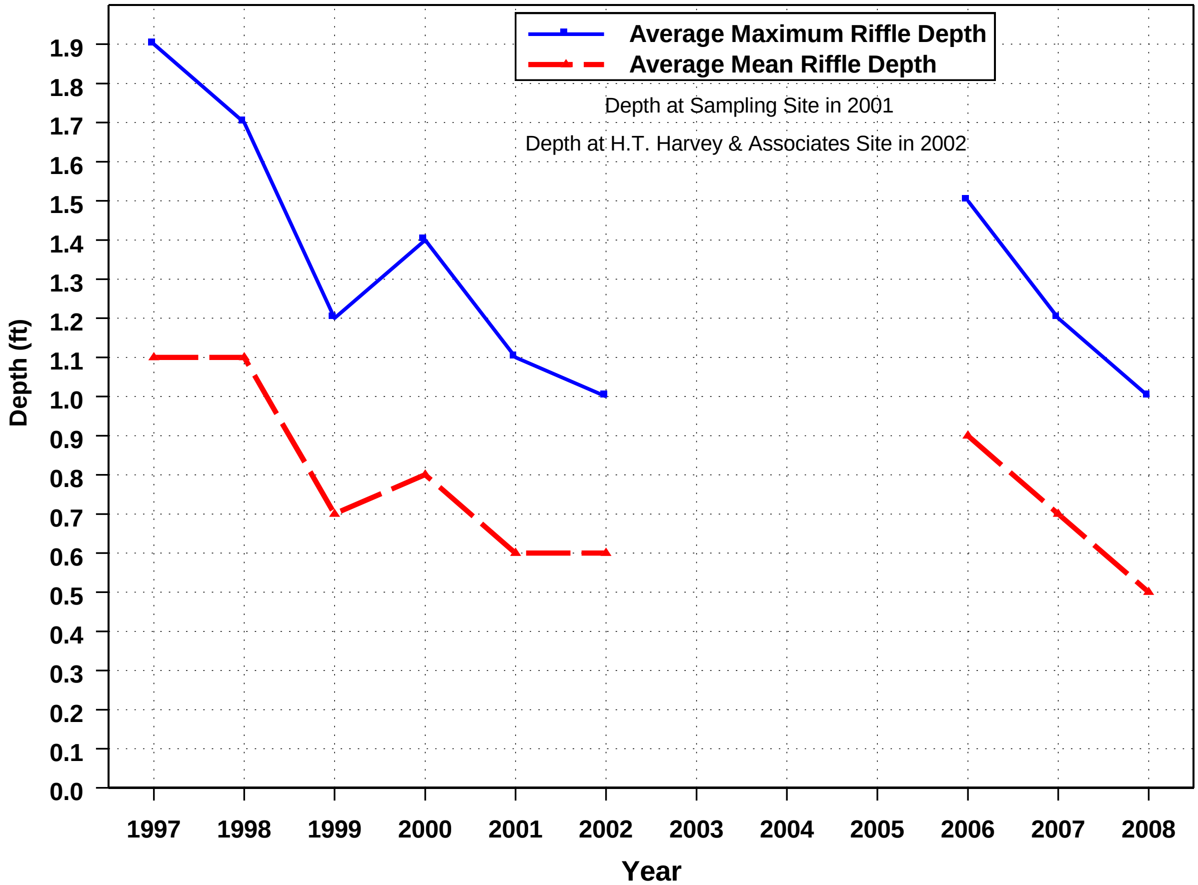


Figure 28. Escape Cover Index for Riffle Habitat in Reach 4 of the Lower Mainstem San Lorenzo River, 1998-2000 and 2006-2008.

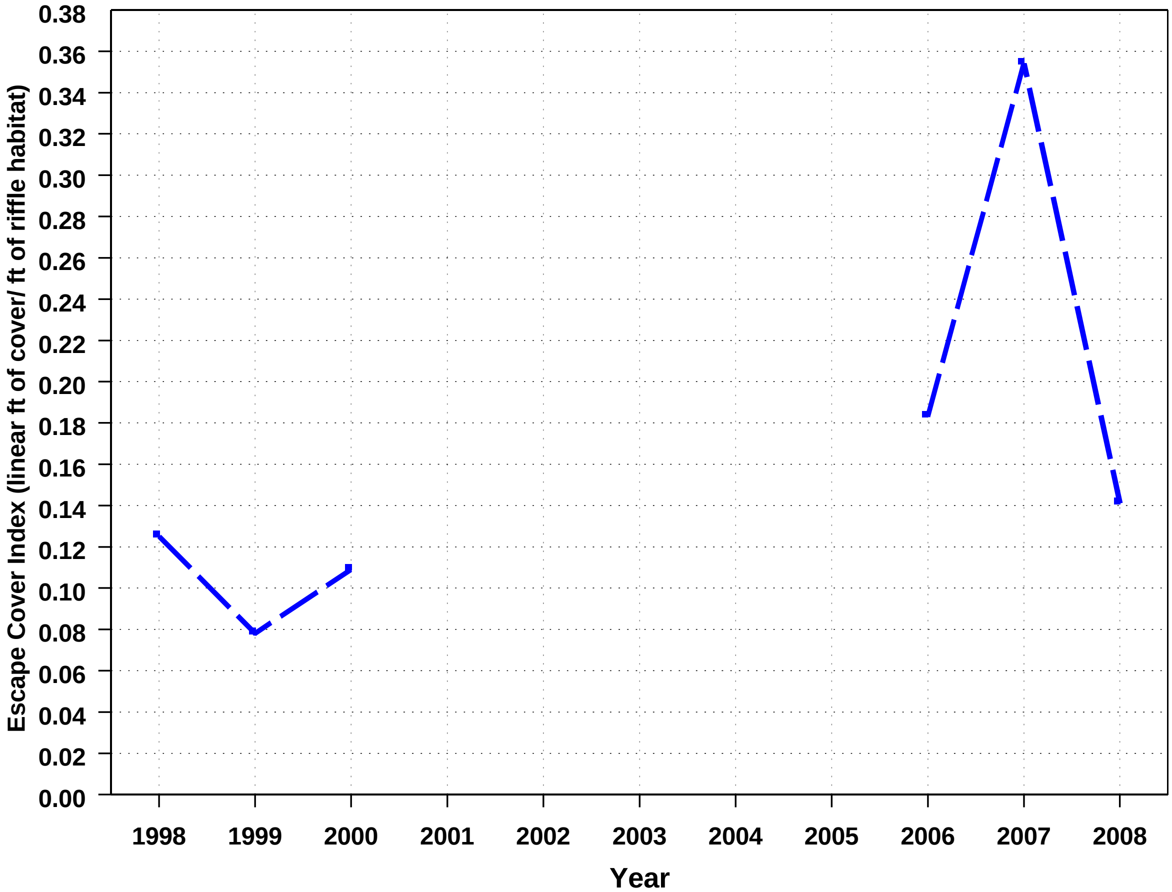
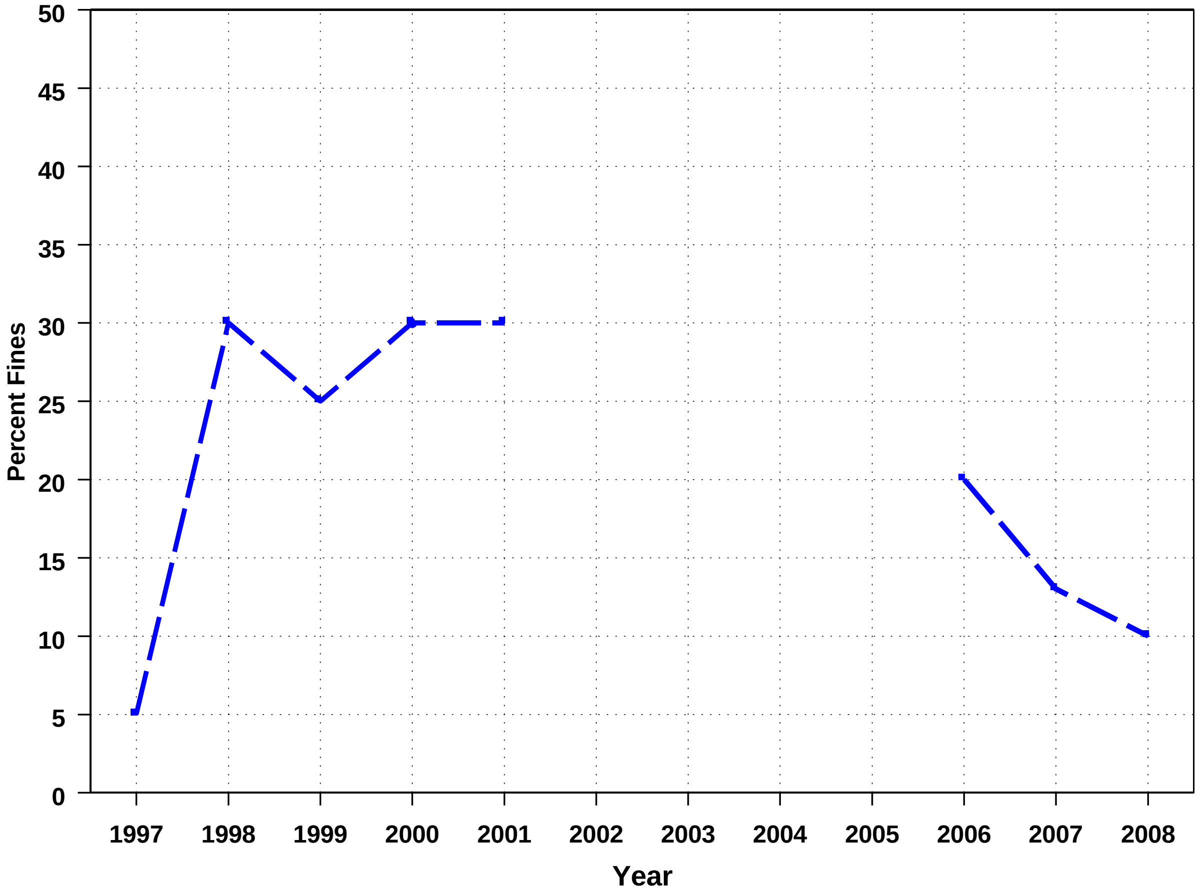


Figure 29. Averaged Percent Fines in Riffle Habitat in Reach 4 of the Lower Mainstem San Lorenzo River, 1997-2001 and 2006-2008.



In the middle mainstem (between the Zayante and Boulder creek confluences) habitat conditions in Reach 8 (from upper Ben Lomond to Brookdale past the Alba Creek confluence and ending at the Clear Creek confluence) were analyzed since 1997. Riffle habitat was focused on because under warm water conditions in the middle mainstem, juvenile steelhead are found primarily in fastwater habitat. Habitat conditions in Reach 8 were best in the wet year of 1998 (highest baseflow, greatest depth, fastest water velocity and most escape cover) (**Figures 30, 31 and 55**). As in Reach 4, we see the dip in riffle depth in 1999, indicating filling by sediment and smaller rocks and gravels, and subsequent improvement in 2000. Changes in riffle depth approximately followed changes in averaged mean monthly streamflow (May-September) except maximum riffle depth continued to decline in 2002 and 2003 despite greater streamflow (**Figure 25**). Riffle filling may have occurred in 2002 and 2003 after relatively high peak flows during winter that were much above bankfull (7,880 cfs in 2002 and 13,200 cfs in 2003). Then improved riffle depth was detected in fall 2004 despite lower baseflow and sizeable preceding winter peak flow (11,200 cfs). Conditions in 2005 and 2006 were also relatively good with high baseflow (**Figure 25**), high riffle depth (**Figure 30**) and relatively high escape cover (**Figure 31**). As in Reach 4, percent fines greatly improved in 2007 and 2008 since 1998 and were approaching the 1997 low (**Figure 32**). Embeddedness in the same sampled riffle in 1997, 2007 and 2008 was 35%, 15% and 30%, respectively, indicating that 2007 had some of the best substrate conditions in 12 years when the low percent fines are also considered. But substrate conditions declined regarding embeddedness in 2008 after the higher peak flow (7,570 cfs). Overall rearing habitat conditions in 2007 were not as good as in 1997 with regard to depth, though percent fines and embeddedness were similar. The deep pockets in riffles that existed in 2007 had filled in 2008. Unfortunately, reach-wide escape cover was not measured in riffles in 1997 for comparisons. However, escape cover in 2008 was much less than in 1998 or 2005, indicating reduced habitat quality in that regard. **If baseflows had been the same in 1997 and 2008, habitat conditions in Reach 8 riffles would have been better in 1997 due to deeper pockets and likely more escape cover in 1997.**

Figure 30. Averaged Maximum and Mean Riffle Depth in Reach 8 of the Middle Mainstem San Lorenzo River, 1997-2008.

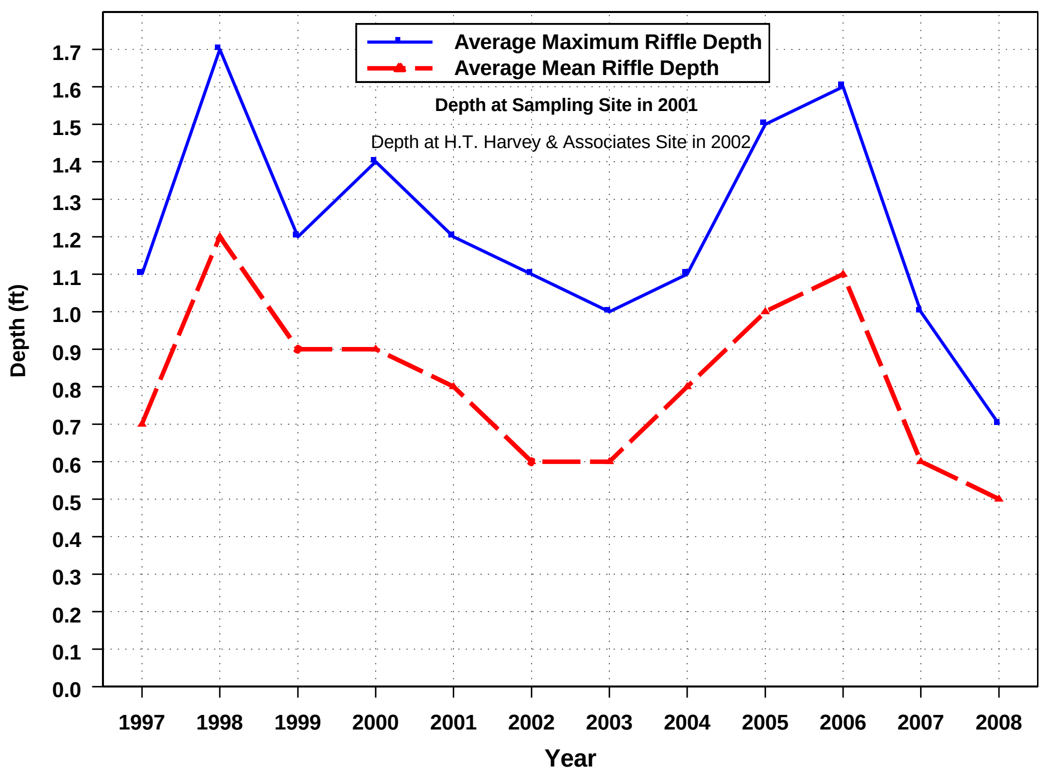


Figure 31. Escape Cover Index for Riffle Habitat in Reach 8 of the Middle Mainstem San Lorenzo River, 1998-2000, 2003 and 2005-2008.

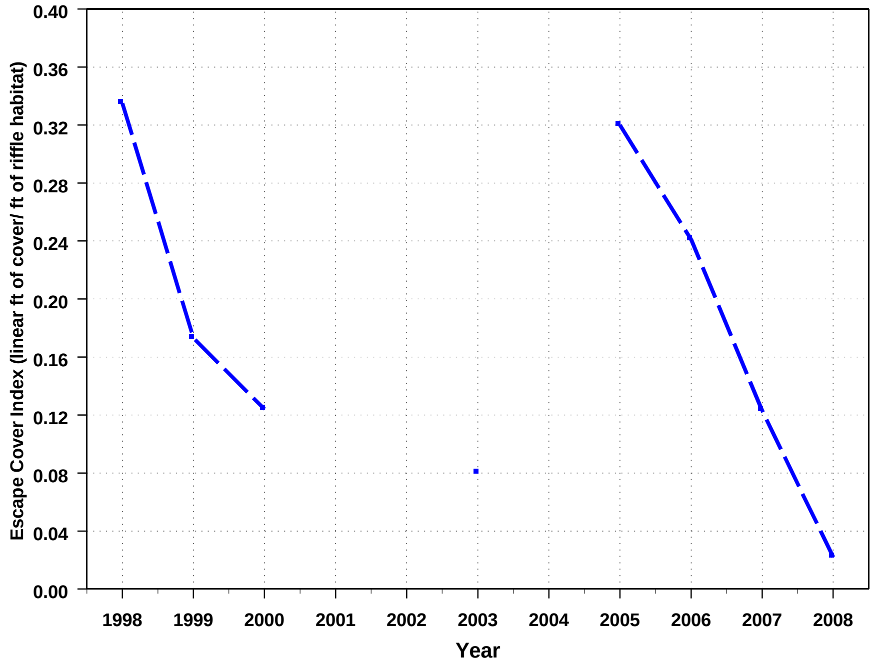
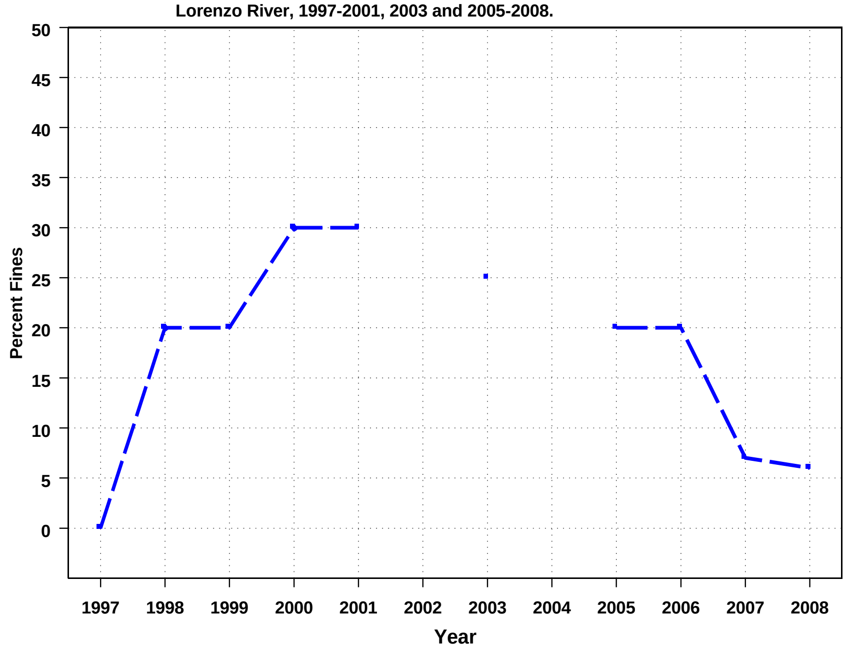


Figure 32. Averaged Percent Fines in Riffle Habitat in Reach 8 of the Middle Mainstem San Lorenzo River, 1997-2001, 2003 and 2005-2008.



Habitat Trends in San Lorenzo Tributaries

In general, in comparing sub-watersheds on the west side of the drainage (largest being Fall and Boulder) with those on the east side, those on the west side are "generally" steeper in gradient, are from granitic origin (rather than shale and sandstone) and generally with larger boulders present in their lower reaches, they flow through deeper and narrower canyons without floodplains, are relatively more shaded and cooler and are impacted by primarily surface water diversions and logging. The sub-watersheds from the east (largest being Branciforte-Carbonera, Zayante-Bean, Newell, Bear and Kings) are generally lower gradient, are mostly from shale and sandstone origin (except Branciforte-Carbonera), have reaches that do not always flow through narrow canyons, are sporadically less shaded by primarily deciduous trees, and they are warmer.

Streamside vegetation plays little role in pool formation in Boulder Creek on the west side but plays an important role in Fall Creek. The flatter sub-watersheds of the eastern tributaries are more impacted than the western tributaries by higher residential and urban density, more human activities (more paved surfaces, quarrying, logging and business- and road-generated chemical pollution) and greater water extraction primarily from wells (except Lompico Creek, which has a surface diversion). The upper mainstem has a mix of substrate influences from western and eastern tributaries but is generally low gradient with short riffles and long pools, except where gradient increases in the upper reaches beginning near Waterman Gap.

In Zayante Creek, the largest eastern sub-watershed of the San Lorenzo system, habitat trends were analyzed in Reach 13d since 1998, when habitat typing of tributary reaches began. This was the uppermost reach under study and downstream of Mountain Charlie Gulch. Pool habitat was focused on for depth and escape cover parameters because in smaller tributary channels, most juvenile steelhead inhabit pools, with important Size Class II and III juveniles restricted to primarily pools and step-runs. In Reach 13d, annual changes in pool depths paralleled annual changes in averaged mean monthly streamflow record at Big Trees gage (May–September) except for additional shallowing from 2000 to 2003, caused by streambed filling despite increased baseflow in 2003 (**Figures 25 and 33**). However, percent fines in step-runs declined substantially through the period to 2007, only to increase substantially in 2008 (**Figure 35**). Percent fines in step-runs in 2007 were at an 11-year low. The important reach-wide pool escape cover showed improvement from 1998 to 2005 but substantial reduction in 2006 and continued low in 2007 and 2008 (**Figure 34a**). (Escape cover and depth in sampled pools mirrored, as much as possible, annual reach-wide changes to sample average habitat conditions but should not be used to detect reach-wide trends (**Figure 34b**).) **Rearing habitat conditions have declined in Zayante Reach 13d from 1998 to 2008, judging by the shallowest mean pool depths in the 12-year period in 2008 (where annual differences in baseflow have limited effect on pool depth) and the relatively low pool escape cover in 2008.**

Figure 25. Averaged Mean Monthly Streamflow for May–September, 1997–2008 at the Big Trees Gage on the San Lorenzo River.

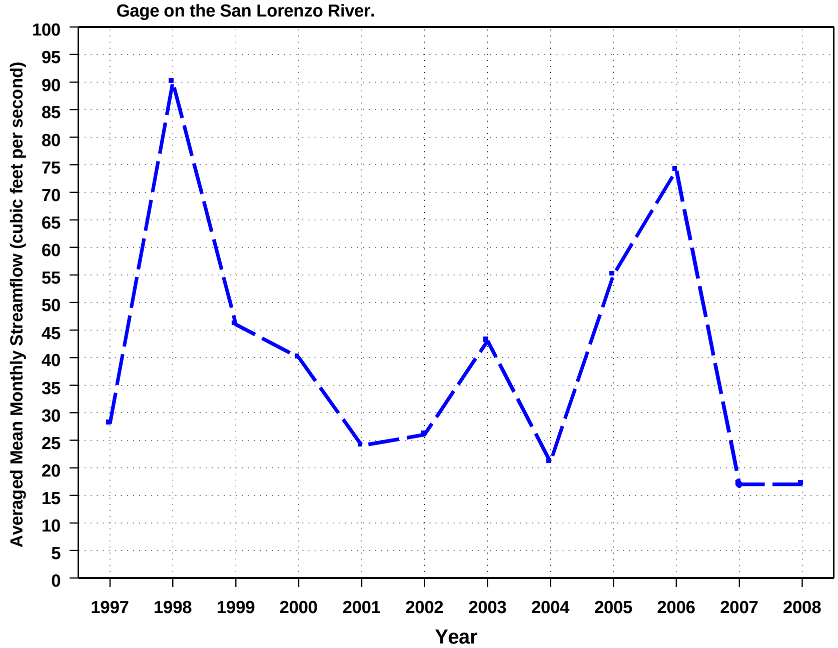


Figure 33. Averaged Maximum and Mean Pool Depth in Reach 13d of Zayante Creek, 1998-2000, 2003 and 2005-2008.

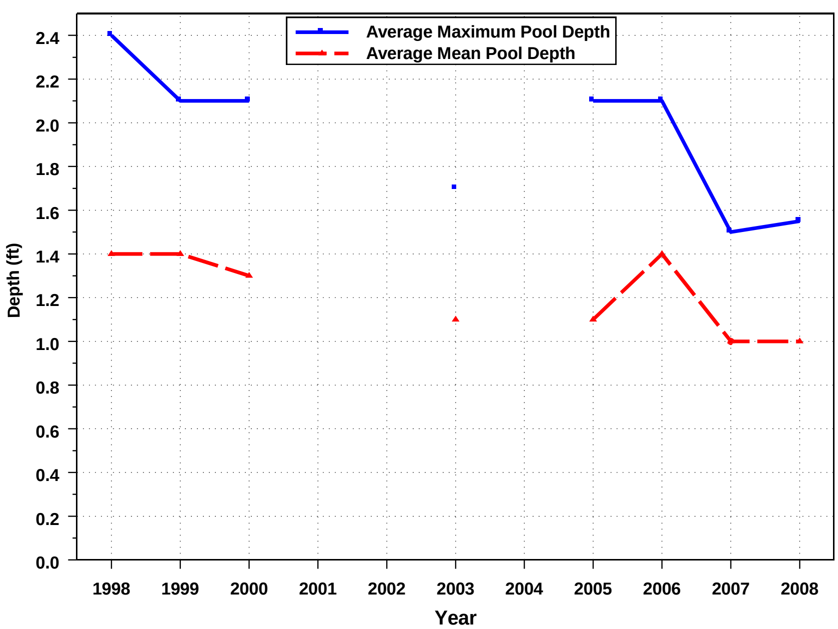


Figure 34a. Escape Cover Index for Pool Habitat in Reach 13d of Zayante Creek, 1998-2000, 2003 and 2005-2008.

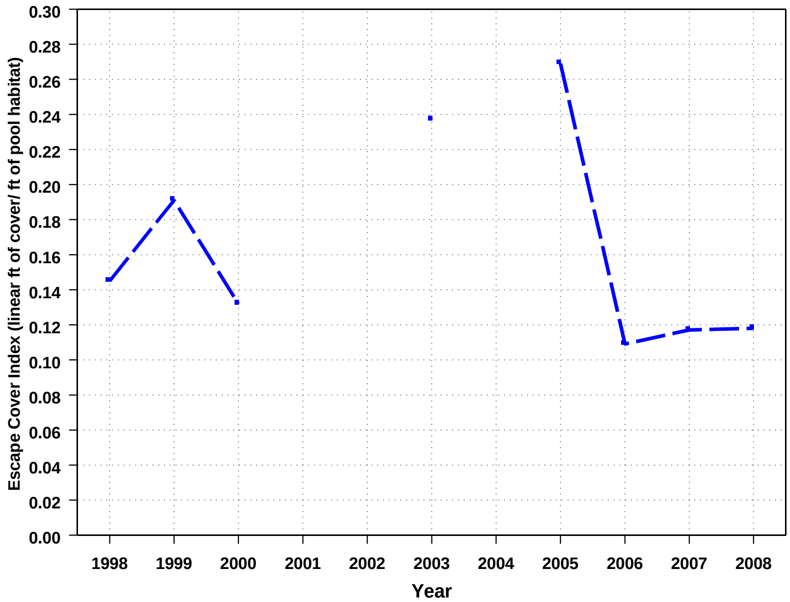


Figure 34b. Escape Cover Index for Pool Habitat at Site 13d in Zayante Creek, 1998-2001 and 2003-2008.

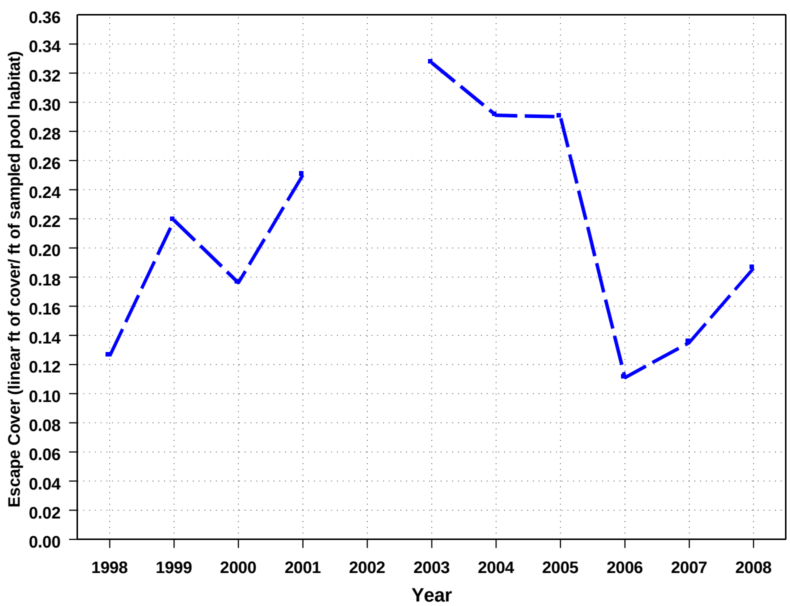
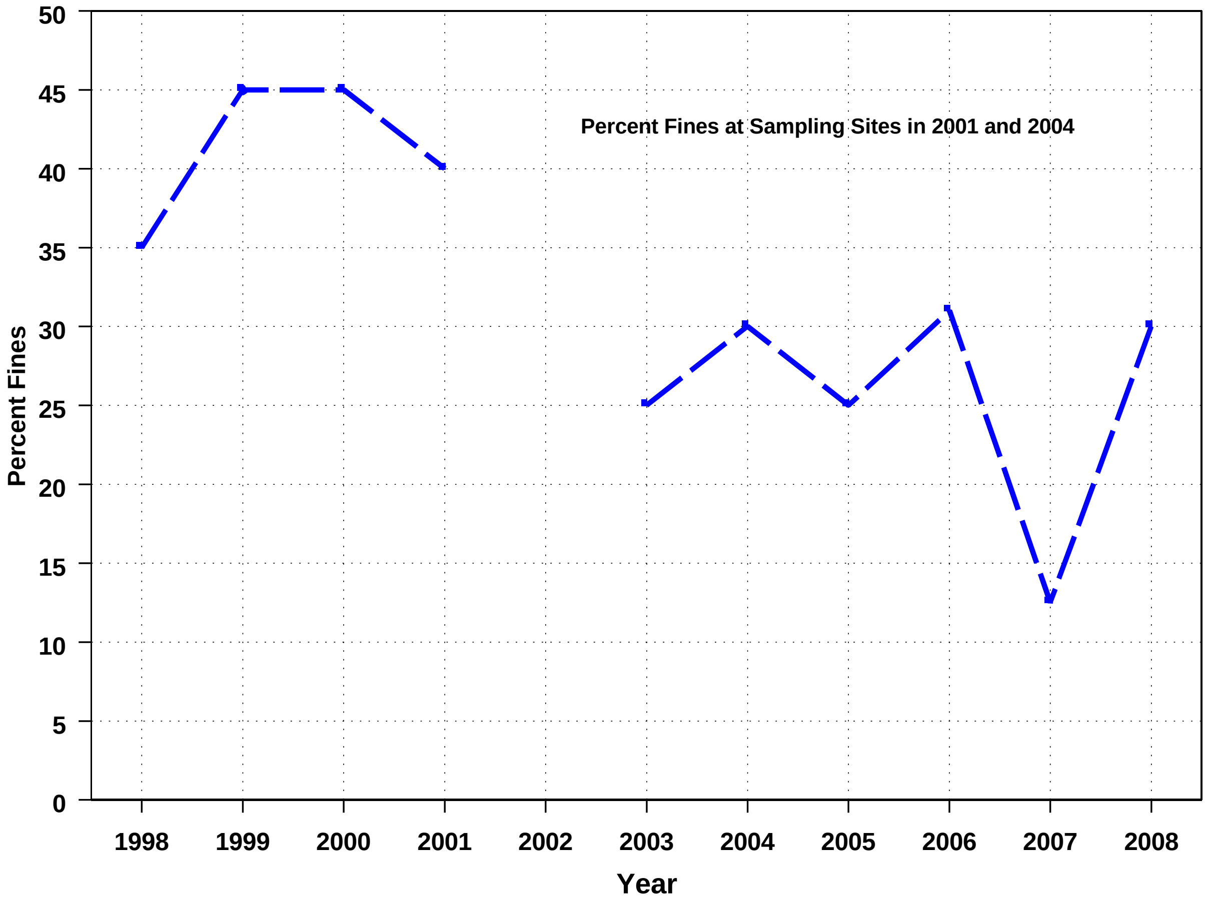


Figure 35. Averaged Percent Fines in Step-Run Habitat in Reach 13d of Zayante Creek, 1998-2001, 2003-2008.



In Boulder Creek, the largest western sub-watershed of the San Lorenzo system, habitat trends were analyzed in Reach 17a since 1998. Annual changes in reach-wide pool depths did not parallel annual changes in averaged mean monthly streamflow record at Big Trees gage (May–September) in 1998–2000 but did in 2005–2008. Pool depth in 1999 remained similar to 1998 and actually improved despite reduced baseflow (**Figures 25 and 36**). Pool depth increased in 2006 and declined in 2007 and 2008, consistent with changes in baseflow. Overall pool filling appeared evident from 1998 to 2008 from reduced pool depths beyond the effects of baseflow differences, especially for maximum pool depth. Reduced pool escape cover, reach-wide, was evident from 1998 to 2008, though it was limited in general (**Figure 37a**). Reach-wide escape cover was highest in 1998, declined considerably in 1999, rebounded in 2005 but declined in

2006 and remained low in 2007 and 2008. High escape cover at the sampled pool habitat in 1997 in the same vicinity of later sampling offered evidence that escape cover was once much higher (**Figure 37b**) than in 2008. Escape cover was generally less in lower Boulder Creek than in Reach 13d in Zayante Creek over the 11-year period. Percent fines in valuable step-run habitat increased from 1998 to 1999 but declined to a low in 2005 and maintained low level in 2007 and 2008 (**Figure 38**). This aspect of rearing habitat improved. Percent fines in Boulder Reach 17a were generally less than in the Zayante Creek Reach 13d, including in 2008 (**Figures 35 and 38**). O**verall rearing habitat quality in Boulder Reach 17a has declined from 1997 to 2008 (as it had in Reach 13d) due to reach-wide pool filling and reduced pool escape cover.**

Figure 36. Averaged Maximum and Mean Pool Depth in Reach 17a of Boulder Creek, 1998-2000 and 2005-2008.

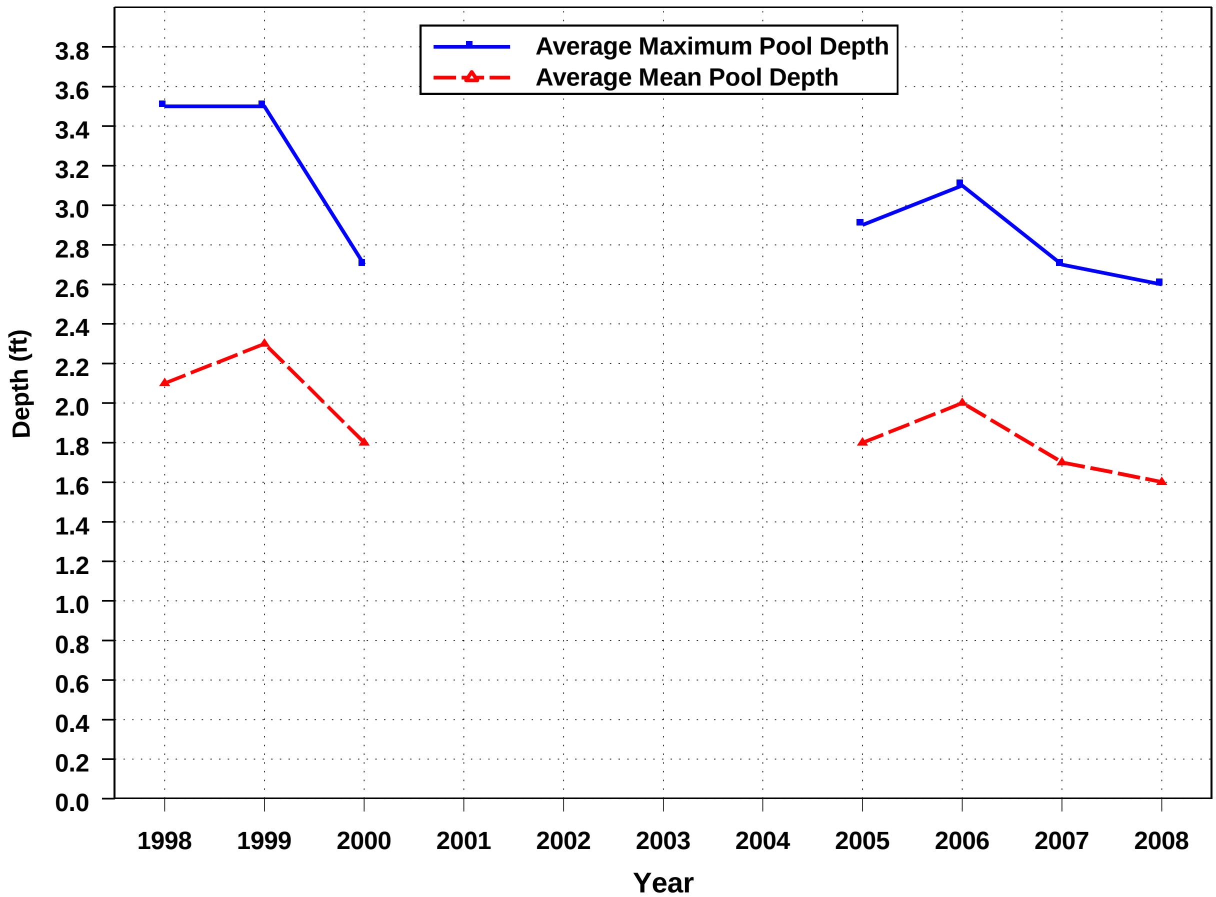


Figure 37a. Escape Cover Index for Pool Habitat in Reach 17a of Boulder Creek, 1998-2000 and 2005-2008.

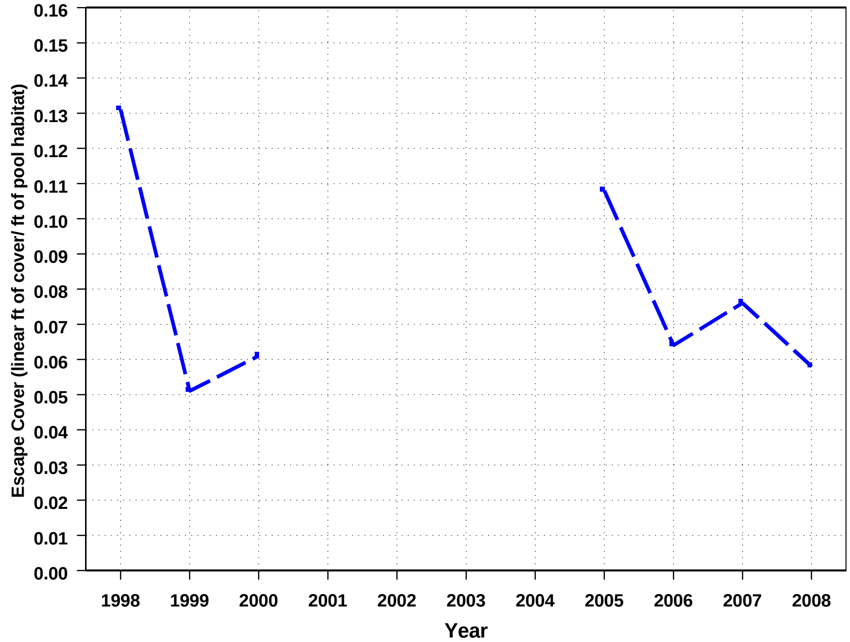


Figure 37b. Escape Cover Index for Pool Habitat at Site 17a in Boulder Creek, 1997-2001 and 2003-2008.

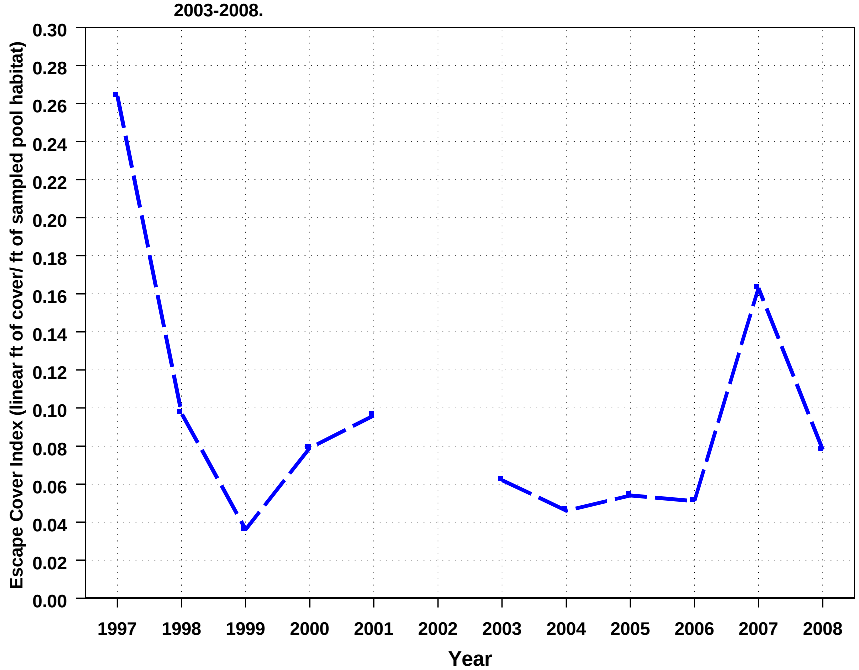
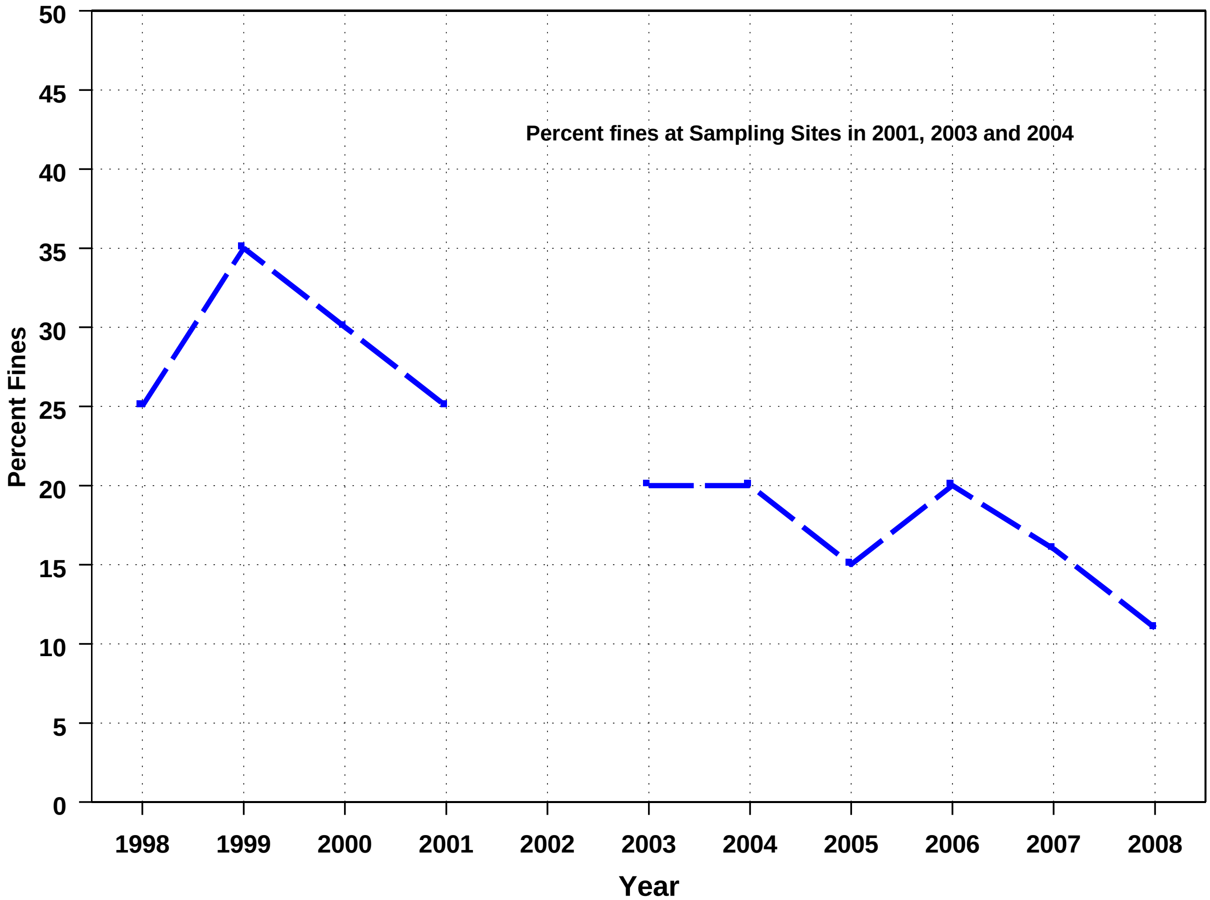


Figure 38. Averaged Percent Fines in Step-Run Habitat in Reach 17a of Boulder Creek, 1998-2001 and 2003-2008.



TRENDS IN JUVENILE STEELHEAD DENSITY AND HABITAT CONDITIONS IN SOQUEL CREEK, 1997-2008

Trends in Juvenile Steelhead Density and Habitat Quality in the Soquel Creek Mainstem

At the 4 mainstem sites tracked for the past 12 years, annual trends in total and YOY juvenile densities paralleled each other, for the most part (**Figures 19 and 21**). Because the juvenile population in the mainstem is largely YOY, spawning effort, spawning success and early YOY survival largely dictate total juvenile densities in these reaches. In drier years with milder winter stormflows (or mostly early stormflows and few late stormflows) and reduced baseflow, total and YOY juvenile steelhead densities were relatively higher in the Soquel Creek mainstem than in wetter years (**Tables 19, 21 and 26**). The years of highest YOY and total juvenile density corresponded to years with the lowest averaged mean monthly streamflow (May–September), indicating the drier years or at least years with few late winter and spring storms (**Figure 26**). These are also typically the years when the lagoon population of juveniles is the greatest (**Alley 2009**). This inverse relationship may be explained by reasoning that during milder winters, adult spawners probably have poorer access to the upper watershed, having more shallow riffles and other impediments to pass. Thus they expend more spawning effort in the mainstem. Also, in drier years, survival of eggs and emerging YOY may be increased without substantial late stormflows to scour or smother redds and wash away YOY. We learned from our spawning gravel study, which involved streambed coring and particle size analysis, that spawning gravel conditions in the mainstem were reasonably good in 2002, a year that was likely without large bankfull stormflows that would move considerable sediment (**Alley 2003c**). The exception to this inverse relationship was 2001, when YOY and total juvenile densities were relatively low despite the mild winter (except for the uppermost mainstem site with densities all increasing from 2000 to 2001). Higher YOY and total densities occurred in 1997, 2002, 2004, 2007 and 2008.

The pattern of densities of larger Size Class II and III juveniles in relation to baseflow is more complex than for YOY. In wetter years, there may be less spawning effort and spawning success in the mainstem until late in the spawning season. However, the above median daily baseflow results in faster water velocity, increased insect drift and deeper feeding stations in fastwater habitat, at least in the spring. All of these factors promoted faster growth rate, leading to a higher proportion of YOY reaching Size Class II their first year and higher densities of larger juveniles. There can be wet years with associated high baseflow, relatively low YOY densities, yet relatively high Size Class II densities. The wet years of 1998 and 2005 are in this category (**Figures 23 and 26**). However, 2006 was very wet but did not generate high Size Class II and III densities. This was likely because YOY densities were so low in the mainstem (many large storms occurred in April and May to destroy mainstem steelhead redds, and spawning access to the upper watershed was good even in late spring), that faster growth rate could not make up for the fewer YOY juveniles in the mainstem (**Figure 78**).

The other year having especially high densities of larger juveniles in the mainstem was 1997, which had large storms before 1 February to boost the baseflow and virtually nothing after that. Very stable conditions for spawning and YOY emergence were created. That year had high YOY densities, and a high proportion reached Size Class II, presumably because spawning effort and success were likely high in early February. This would allow early emergence and early spring growth despite the lower baseflow later on. The year 2002 had a similar hydrograph pattern to 1997 in that the larger stormflows came early (but they were smaller than in 1997), and a series of smaller storms came in February and March (**Figure 74**). Most spawning may have occurred later in 2002 than 1997, leaving primarily late emerging YOY that would have less time to grow to Size Class II than in 1997, before baseflow diminished in late spring. So, 2002 had high densities of YOY in the mainstem, but not as many reached Size Class II as in 1997. In addition, 1997 had much more escape cover for larger juveniles than 2002, as indicated in Reaches 1 (**Figure 40a**) and Reach 7 (**Figure 43a**). Instream wood was common in 1997, and escape cover was relatively high in all mainstem reaches after high peak flows in January 1995 and December 1996 (**Alley 2003b**). The years 2004, 2007 and 2008 had previously mild winters (**Figures 76, 79 and 80**), likely had heavy spawning in the mainstem, and produced relatively high densities of YOY. However, baseflow was insufficient to grow many to Size Class II, leading to low mainstem densities of Size Class II and III juveniles.

Since 1997, rearing habitat quality in the lower mainstem (as indicated by Reach 1) has improved with regard to increased average maximum pool depth and has declined with regard to reduced escape cover (**Figures 39 and 40a**). During the instream wood survey in 2002, this reach was noted for its lack of large wood (**Alley 2003c**). However, riffle conditions for aquatic insects and steelhead food supply have improved regarding less embeddedness (**Figure 41**). In the lower mainstem, densities of larger juveniles were not well associated with rearing habitat conditions. Spring and summer baseflow and associated growth rate of YOY appeared to overshadow non-flow related habitat conditions to determine densities of larger juveniles. This was partly a result of extremely low yearling densities in the mainstem. After the two winters with the lowest peak flows since sampling began, 1994 (900 cfs) and 2007 (614 cfs), slightly higher densities of yearlings were detected at some mainstem sites compared to other years. This may indicate that if more overwintering shelter was present (in the form of large instream wood), survival of yearlings might increase in the mainstem of Soquel Creek (**Alley 1995a; 2008**).

In summary, since 1997 in Reach 1, rearing habitat quality has improved with increased average maximum pool depth and has declined with regard to reduced escape cover. However, riffle conditions for aquatic insects and steelhead food supply have improved. During the instream wood survey in 2002, this reach was noted for its lack of large wood (Alley 2003c).

Figure 19. Plot of Annual Total Juvenile Densities at Mainstem Soquel Creek Sites, 1997-2008.

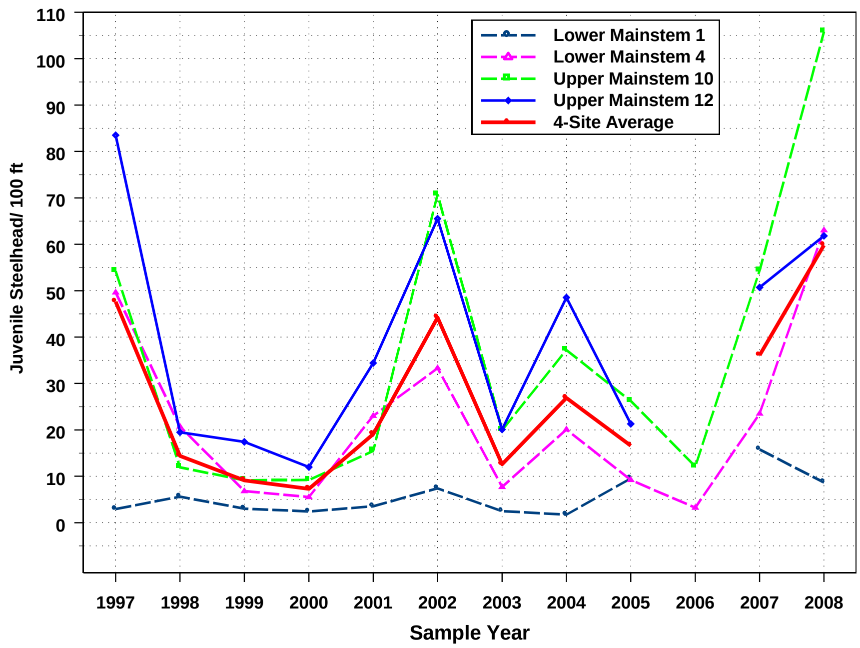


Figure 21. Plot of Annual YOY Densities at Mainstem Soquel Creek Sites, 1997-2008.

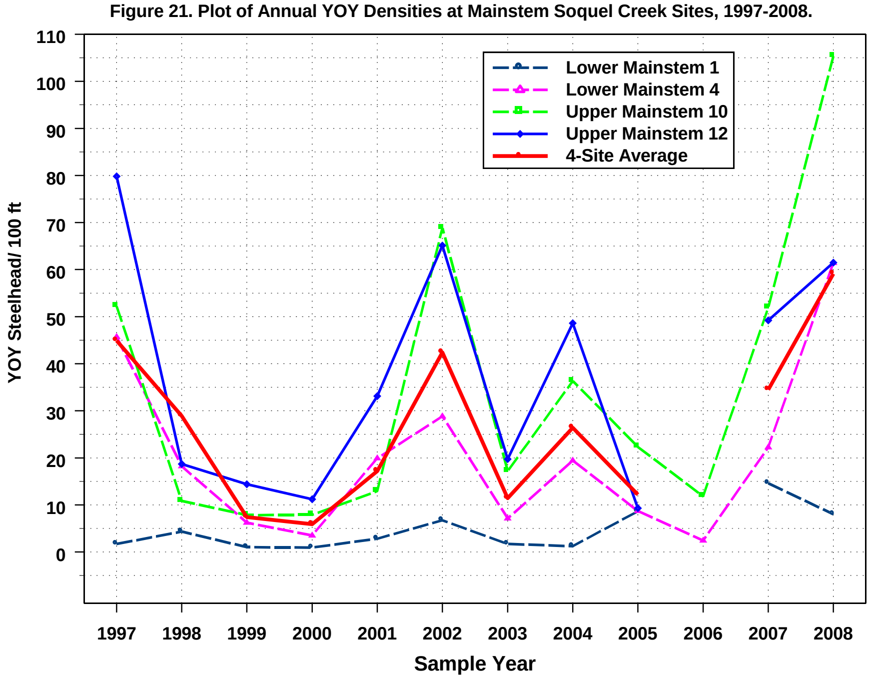


Figure 26. Averaged Mean Monthly Streamflow for May–September, 1997–2008 at the Soquel Village Gage on Soquel Creek.

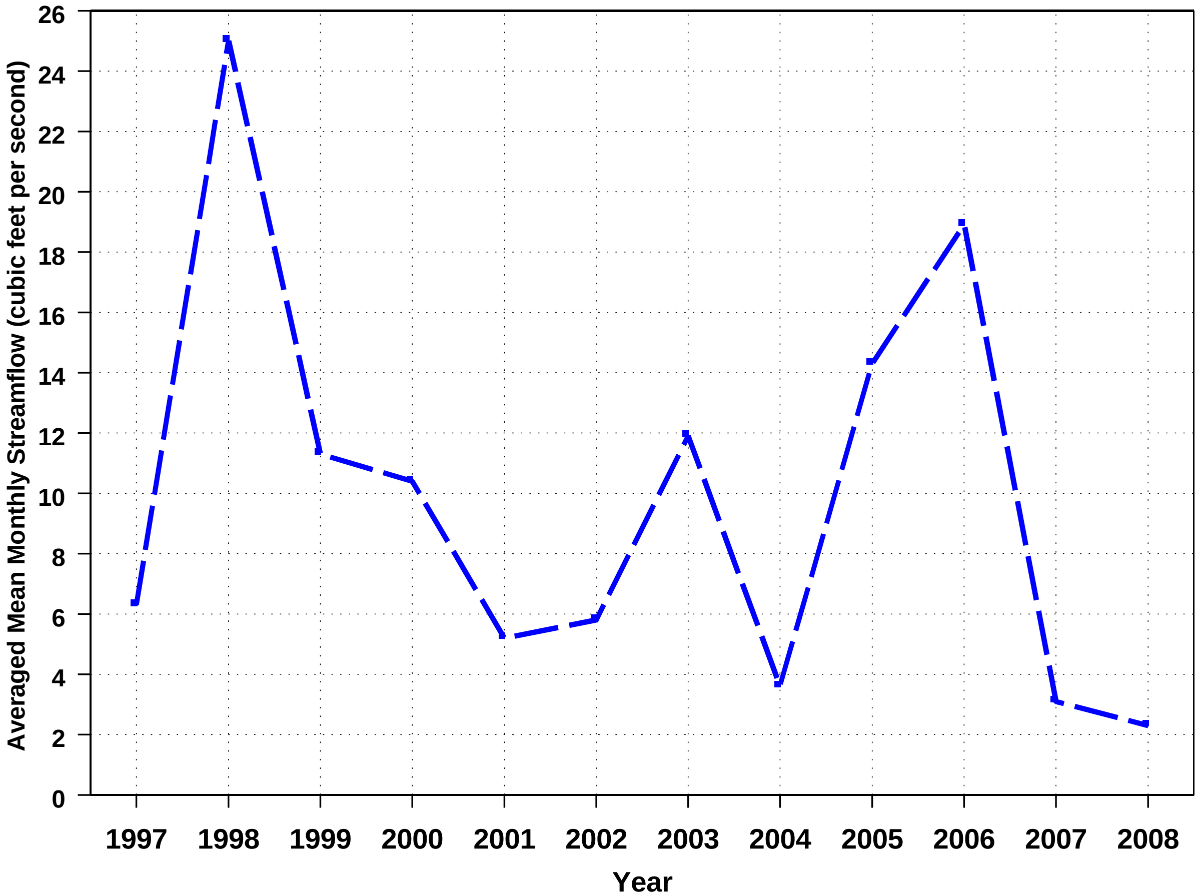


Figure 23. Plot of Annual Size Class II/ III Juvenile Densities at Soquel Mainstem Sites, 1997-2008.

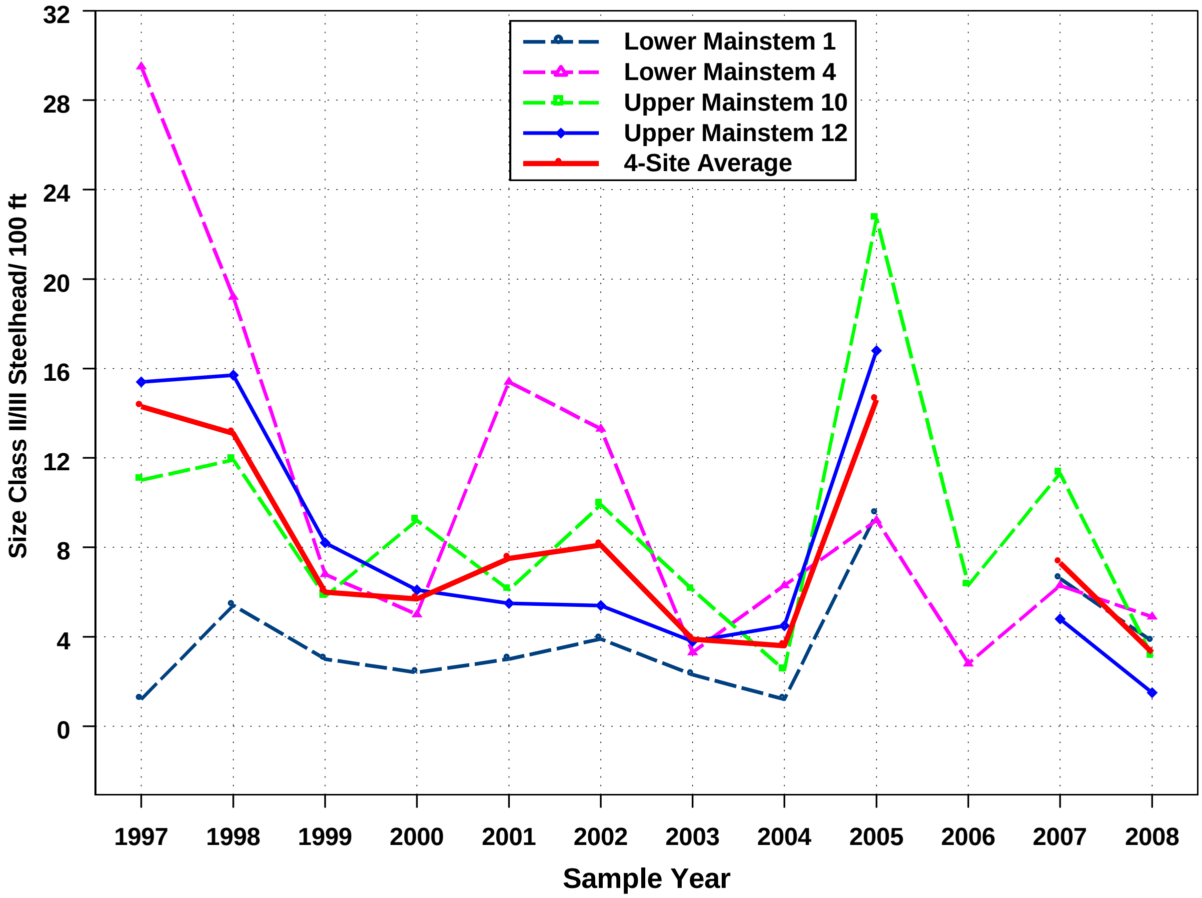


Figure 39. Averaged Maximum and Mean Pool Depth in Reach 1 of Soquel Creek, 1997-2008.

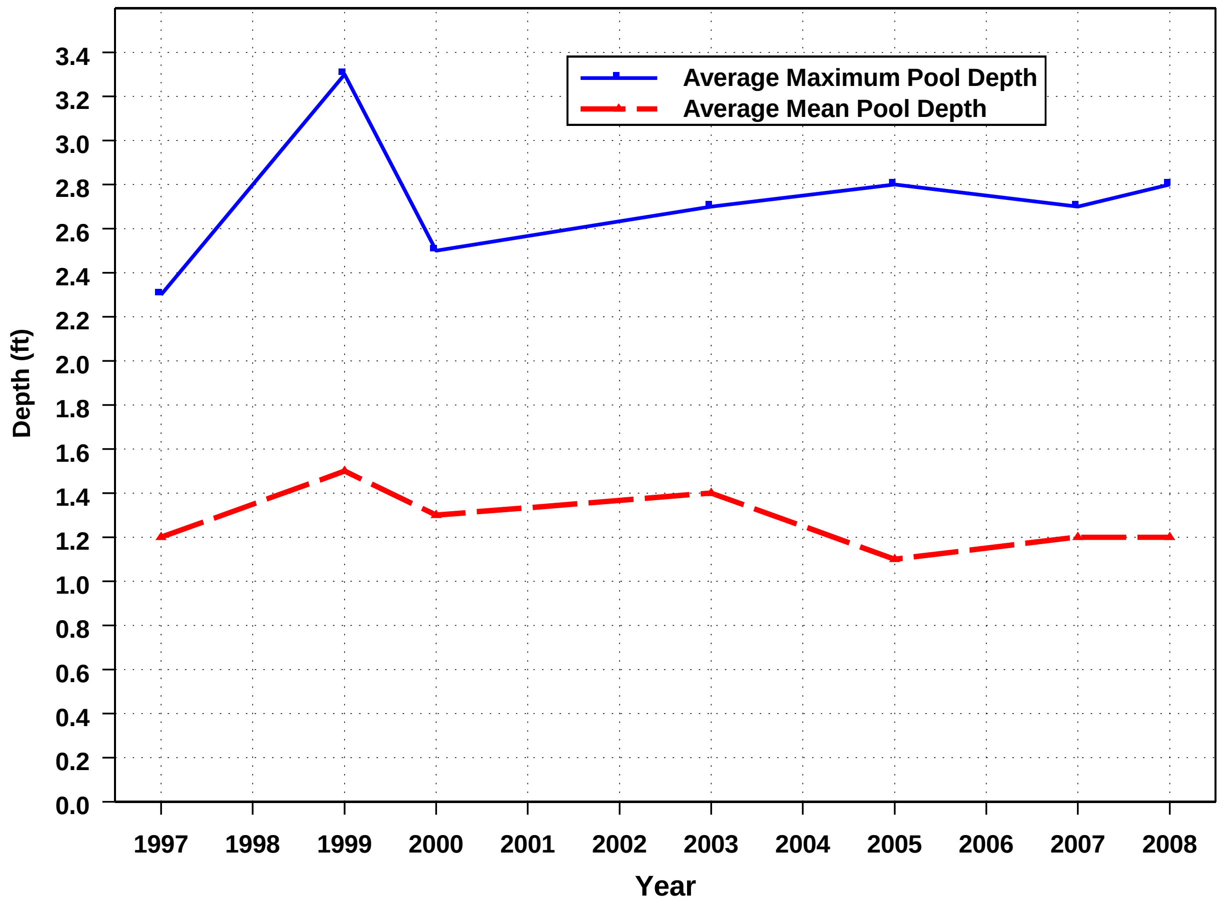


Figure 40a. Escape Cover Index for Pool Habitat in Reach 1 of Soquel Creek, 1997-2008.

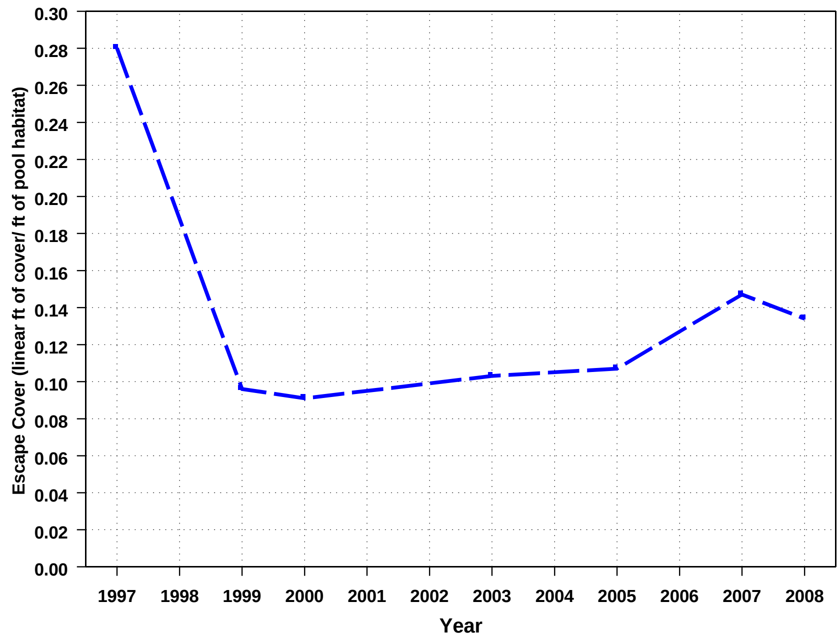


Figure 40b. Escape Cover Index for Pool Habitat at Site 1 in Soquel Creek, 1997-2006 and 2008.

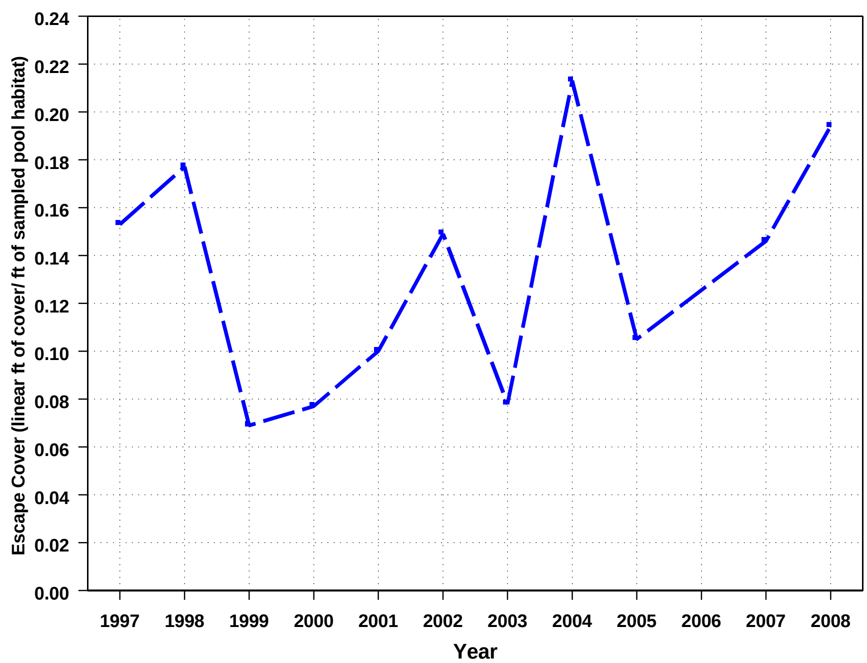
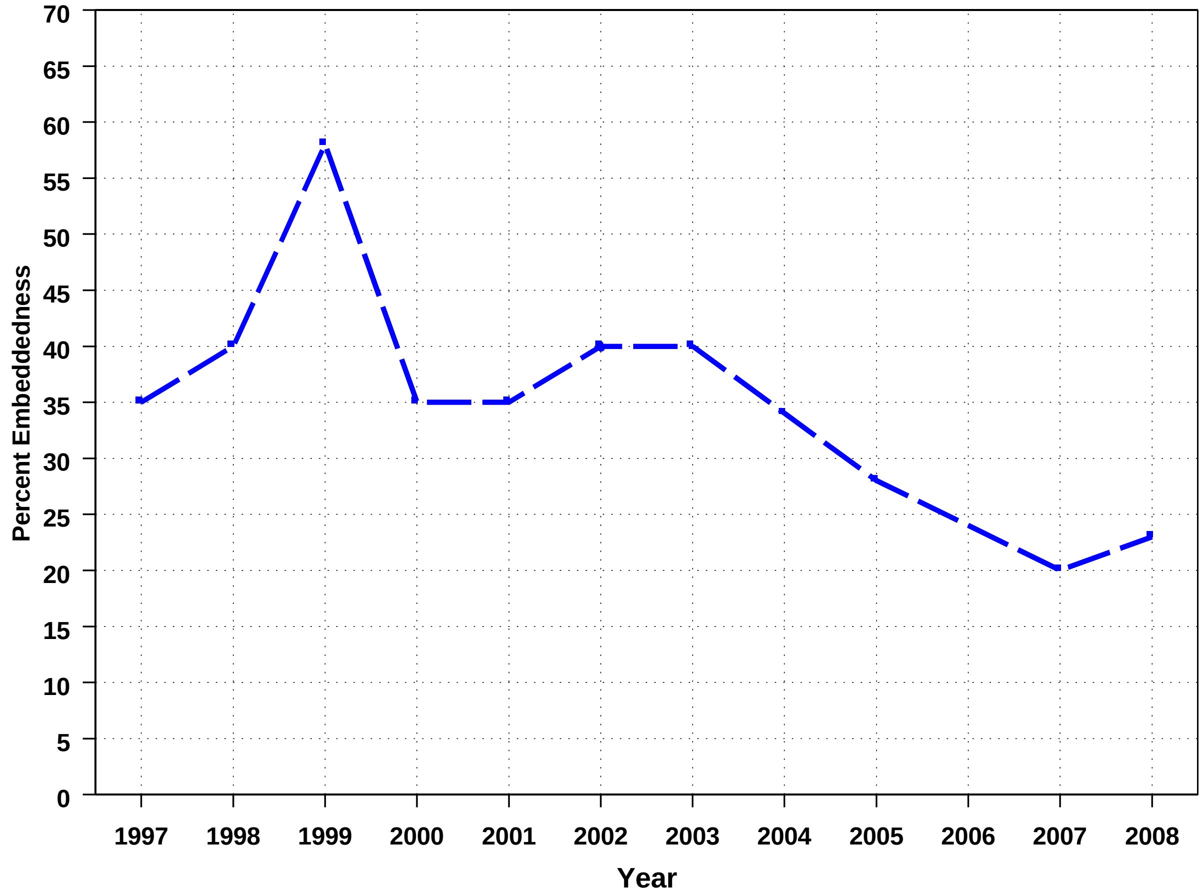


Figure 41. Average Embeddedness for Riffle and Run Habitat at the Sampling Site in Reach 1, of Soquel Creek, 1997-2008.



In the upper mainstem (upstream of the Moores Gulch confluence in Reach 7), densities of larger juveniles (Size Class II and III) (**Figure 23**) were not associated with reach-wide changes in pool depth or escape cover, except for escape cover in 1997. However, fluctuations in larger juveniles were consistent with fluctuations in pool escape cover at sampling sites (except 2004), but the amplitude of fluctuations was not consistent (**Figure 43b**). Spring and summer baseflow and associated growth rate of YOY appeared to overshadow non-flow related habitat conditions to determine densities of larger juveniles. This was partly a result of low yearling densities in the mainstem.

Habitat conditions in Reach 7 (between the Moores Gulch confluence and the Purling Brook ford) were analyzed since 1997. Overall rearing habitat quality declined since 1997 in the upper mainstem (as indicated by Reach 7) regarding pools filling with sediment and less escape cover (**Figures 42 and 43a**), though maximum pool depth increased slightly in 2008, and escape cover has steadily improved from the low point of 1999. During the instream wood survey in 2002, this reach was noted for its lack of large wood (**Alley 2003c**).

Changes in reach-wide pool depth somewhat paralleled changes in averaged mean monthly flow rate (May- September) until 2005 (**Figures 26 and 42**). In 2005, depths decreased despite increased streamflow, indicating pool filling with sediment. Data from the lower half of the reach in 2006−2008 indicated that that pool depth has not likely recovered, leading to an overall decline in pool depth since 1997. Reach-wide escape cover was highest in 1997, showed a substantial two-thirds decline by 1999 and a steady increase to 2008, although it was still about ½ the 1997 level (**Figure 43a**). (Escape cover at sampling sites varied more than it did reach-wide, indicating the difficulty in finding pool habitat that fit average conditions for both depth and escape cover in this reach (**Figure 43b**).) Riffle and run embeddedness at sampling sites fluctuated annually since 1997 and was similar in 2008 as in 1997 (within the range of error for visual estimates) (**Figure 44**). It did not fluctuate in an inverse way to averaged mean monthly streamflow (May-September), as might be expected if one assumed that higher winter flow would bring more erosion and sedimentation that would lead to increased embeddedness. However, streamflow in the late spring and summer does not necessarily correlate positively with the size of stormflows earlier in the winter. 2008 had a much higher peak flow on 25 January (assumed, based on San Lorenzo Big Trees gage data because Soquel data are not yet available) than occurred in 2007, though its baseflow was less. In addition, if the larger storms occur early in the winter, there is more time and lower flows after to transport sediment away than if larger storms occur later in the winter. We see the largest increase in embeddedness in 2001 when the largest storm came in early March (**Figure 72**). We see the largest decrease in embeddedness in 2002 when the largest storms came in November and early January (**Figure 73**). However, the decrease in 2005 came despite the largest storm in April. **In summary, overall rearing habitat quality declined in Reach 7 since 1997 because of pool filling with sediment and less escape cover. During the instream wood survey in 2002, this reach was noted for its lack of large wood (Alley 2004).**

Figure 42. Averaged Maximum and Mean Pool Depth in Reach 7 (Above Moores Gulch) of Soquel Creek, 1997-2008.

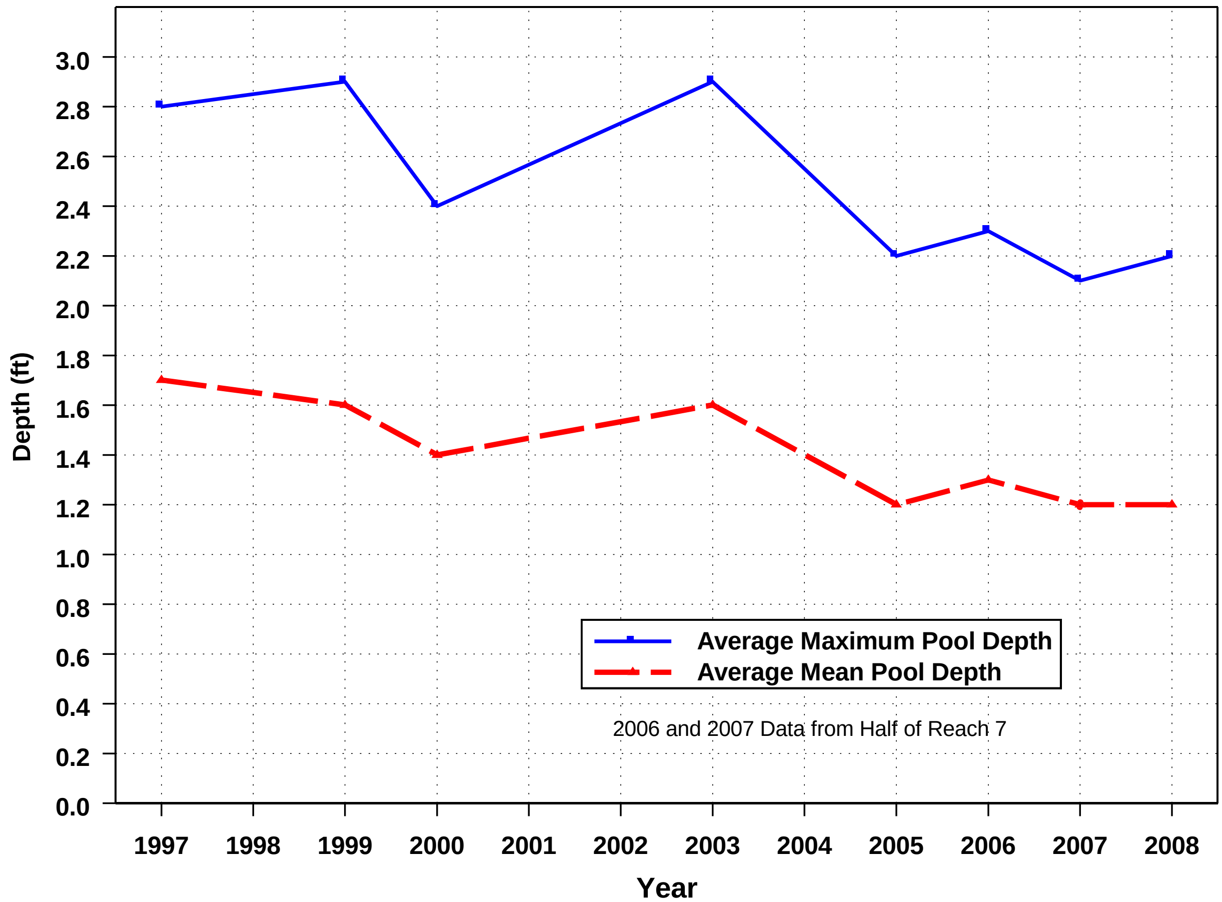


Figure 43a. Escape Cover Index for Pool Habitat in Reach 7 (Above Moores Gulch) of Soquel Creek, 1997-2008.

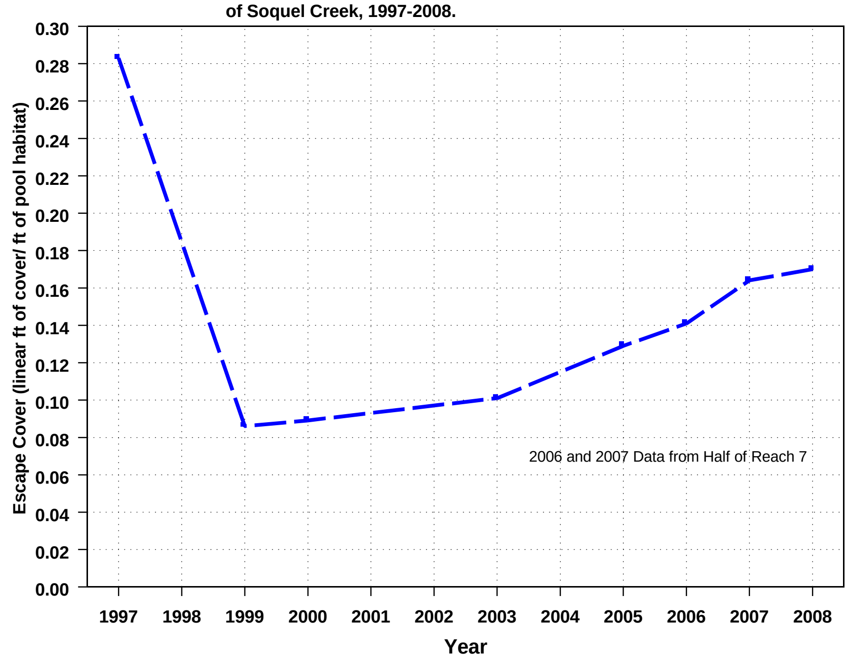


Figure 43b. Escape Cover Index for Pool Habitat at Site 10 (Reach 7 Above Moores Gulch) in Soquel Creek, 1997-2008.

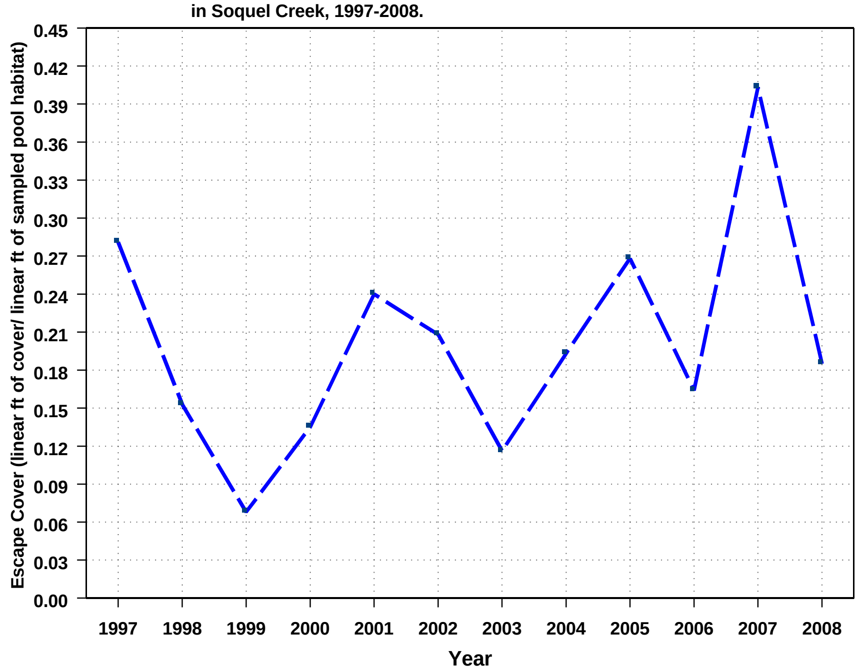
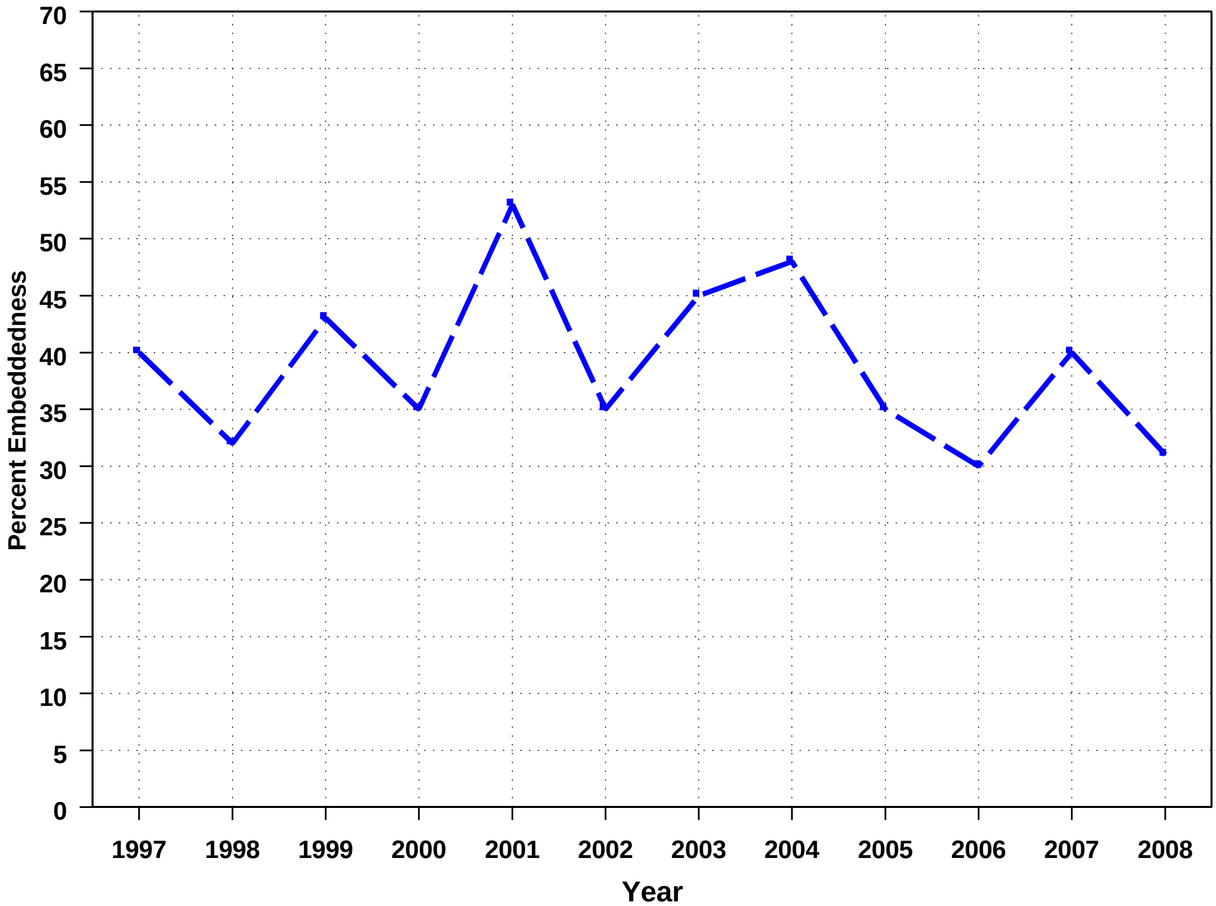


Figure 44. Average Embeddedness for Riffle and Run Habitat at Sampling Site 10 in Reach 7 (Above Moores Gulch) of Soquel Creek, 1997-2008.



Trends in Juvenile Steelhead Density and Habitat Quality in the East Branch Soquel Creek

In the East Branch of Soquel Creek, trends in juvenile steelhead densities were tracked since 1997 at Sites 13a (Reach 9a) and 16 (Reach 12a). Site 13a is located downstream of the Amaya Creek confluence, the quarry water diversion, the Hinckley Creek confluence and the Mill Pond water diversion and outfall (under new ownership prior to the 2006 sampling). Site 13a is in a geomorphically unstable reach where streambank erosion and fallen trees are common, and streambed rocks are poorly sorted by size (**Barry Hecht, personal observation**). Habitat conditions in Reach 9a may change considerably during high winter stormflows. Site 16 is located in the Soquel Demonstration State Forest (SDSF) and above permanent water diversions. During and after drier winters, spawning access and summer baseflow are much less at Site 16 than Site 13a. Usually, less than 10% of the juveniles at these sites were larger yearlings. YOY growth rate is less at Site 16, with only a few YOY reaching Size Class II after the wettest winters. A higher proportion of YOY reach Size Class II in wetter years because more food is available during higher spring baseflow.

In East Branch Soquel Creek, total and YOY densities annually fluctuated in a dissimilar fashion in lower East Branch (Site 13a) and upper East Branch (Site 16), except they increased at both locations from 2001 to 2002 and decreased at both locations in 2006 (**Figures 20 and 22**). After reaching a 12-year high in 2004, total and YOY densities in the lower East Branch declined in 2005 and then again in 2006 to almost zero but rebounded in 2007 and 2008. Higher YOY densities in drier years in the lower East Branch may have resulted from 1) greater spawning effort than in wetter years, 2) more spawning success and 3) higher survival of YOY after emergence. In wetter years, more adult steelhead likely continued further up the East Branch into the Soquel Demonstration State Forest (SDSF). Though 2008 was a very dry year in the SDSF, it had larger storms early on than 2007 to provide better spawning access than 2007, with corresponding higher YOY density. With the streambed instability of the lower East Branch, redd (nest) scour or burial in sediment may have been more common in winters with higher stormflows. During the instream wood inventory in 2002, this reach was identified as one with small quantities of large instream wood (**Alley 2003c**). If the incidence of large instream wood were to increase substantially, rearing habitat quality and improved over-winter survival in intermediate to wetter years may play more important roles in increasing Size Class II and III densities.

Overall rearing habitat quality declined in the lower East Branch from 1997 to 2008, primarily with regard to fastwater habitat important to YOY juveniles and aquatic insects. Other factors related to the turbidity and thin silt layer on the substrate observed at the sampling site in 2006 and 2007 (downstream of the Mill Pond outfall) may also indicate reduced habitat quality. Turbidity and the fine silt layer seemed more localized in 2008.

In Reach 9a, since the same pools were sampled for steelhead in 1997–1999 and for 2000–2004, and sampled pools in 2000 were chosen to represent average habitat conditions for depth and escape cover for the reach in 2000, then graphing of pool escape cover at sampled pools since 1997 may reflect general trends in escape cover.

At Site 13a, annual densities of Size Class II and III juveniles (**Figure 24**) were not associated with changes in pool escape cover at sampling sites except in 2008 (**Figure 46b**). Insufficient years of data were available for reach-wide changes in pool depth, escape cover or percent fines in run and step-run habitat to make comparisons with trends in juvenile densities (**Figures 45, 46a and 47**). In 2005–2007, densities were not associated with these habitat parameters. In 2008, increased densities of larger juveniles were positively associated with increased maximum pool depth and higher escape cover at the interrupted, incomplete sample site. (Capture of coho salmon at the first pool in 2008 prevented the sampling of a pool with less escape cover.) Average embeddedness in riffles and runs at sampling sites generally increased through the years as densities declined in 1997–2000 (**Figure 48**). But densities were not associated with changes in embeddedness in 2001–2005. The relatively high density in 1997 was consistent with the highest escape cover in sampled pool habitat (provided by instream wood) and the lowest embeddedness in sampled riffle and run habitat in 12 years.

The typical disconnect between non-streamflow related rearing habitat conditions and Size Class II and III densities in the lower East Branch indicated that rearing habitat quality within the observed range in the last 12 years was overshadowed by poor over-winter survival of yearlings in years that were not wet enough to grow many YOY to Size Class II. Over-winter survival did not appear good in any year. The effect of non-streamflow related rearing habitat conditions was also overshadowed by the added potential for growth of some YOY to Size Class II in intermediate to wet years. The years with highest densities of Size Class II and III juveniles in the lower East Branch occurred in 1998 and 2005 (**Figure 24**), two relatively wet years (**Figures 70 and 77**) with moderate YOY densities (**Figure 22**). There had been a steady decline in densities of large juveniles from 1998 to a low in 2004. Higher growth rate during these high spring-baseflow years of 1998 and 2005 (**Figure 26**) allowed a higher proportion of YOY to reach Size Class II, leading to higher densities of larger juveniles in 1998 and 2005.

In summary, data indicated that overall rearing habitat quality in 2008 in Reach 9a of the lower East Branch was similar to 2000 conditions with regard to pool depth and escape cover. Other factors related to the turbidity and thin silt layer on the substrate observed at the sampling site in 2006 and 2007 may indicate lower habitat quality in the upper part of the reach, though it was more localized in 2008. During the instream wood inventory in 2002, this reach was identified as one with small quantities of large instream wood (Alley 2003c). Retention of more instream wood would enhance overwintering survival of yearlings and rearing habitat.

Figure 20. Plot of Annual Total Juvenile Densities at East Branch Soquel Creek Sites, 1997-2008.

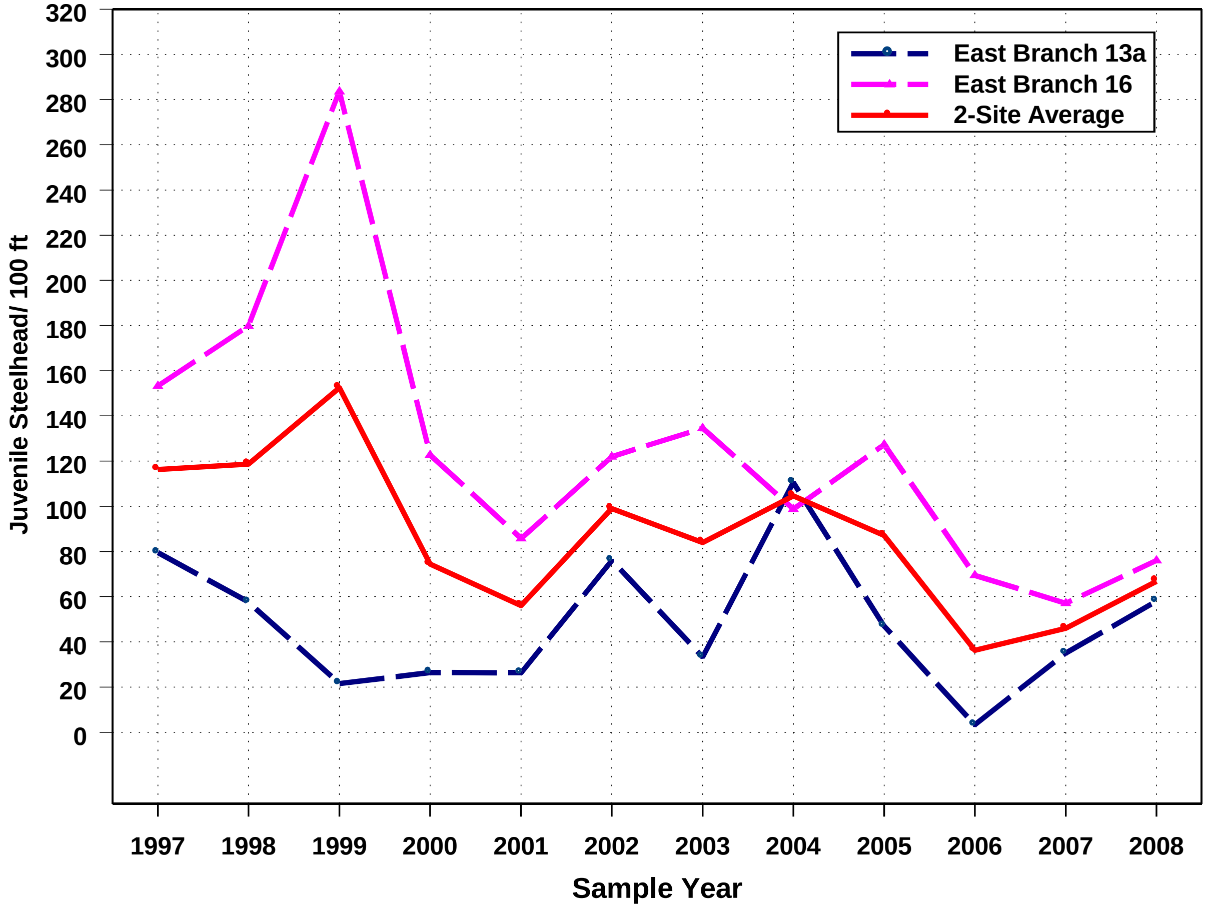


Figure 22. Plot of Annual YOY Densities at East Branch Soquel Creek Sites, 1997-2008.

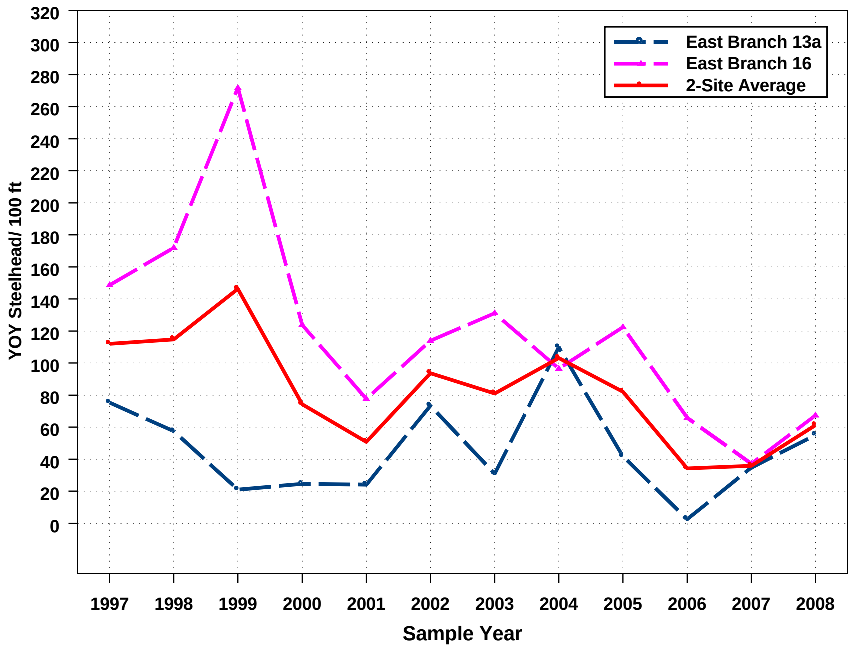


Figure 24. Plot of Annual Size Class II/ III Juvenile Densities at East Branch Soquel Creek Sites, 1997-2008.

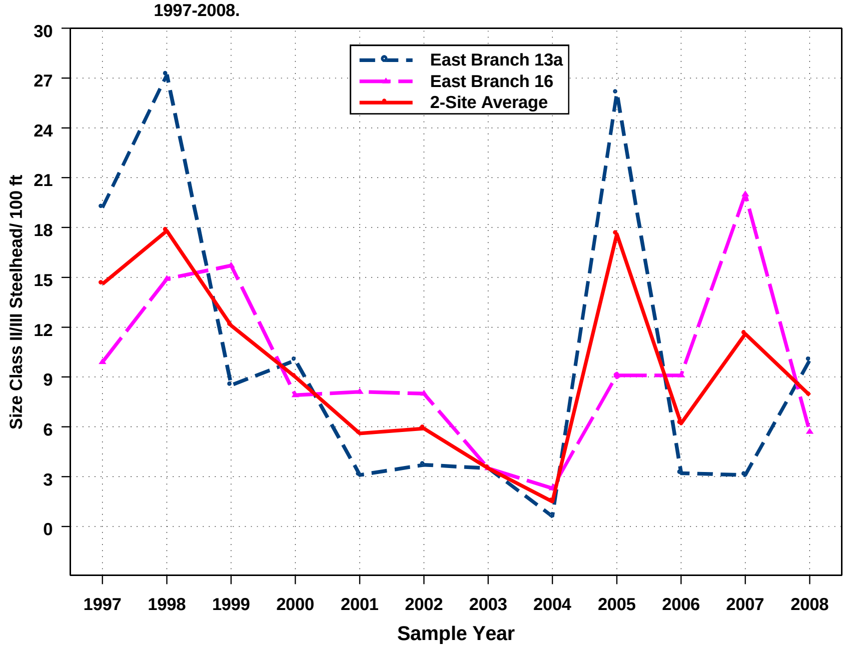


Figure 45. Average Maximum and Mean Pool Depth in Reach 9a (below Mill Pond) of East Branch Soquel Creek, 2000 and 2005-2008.

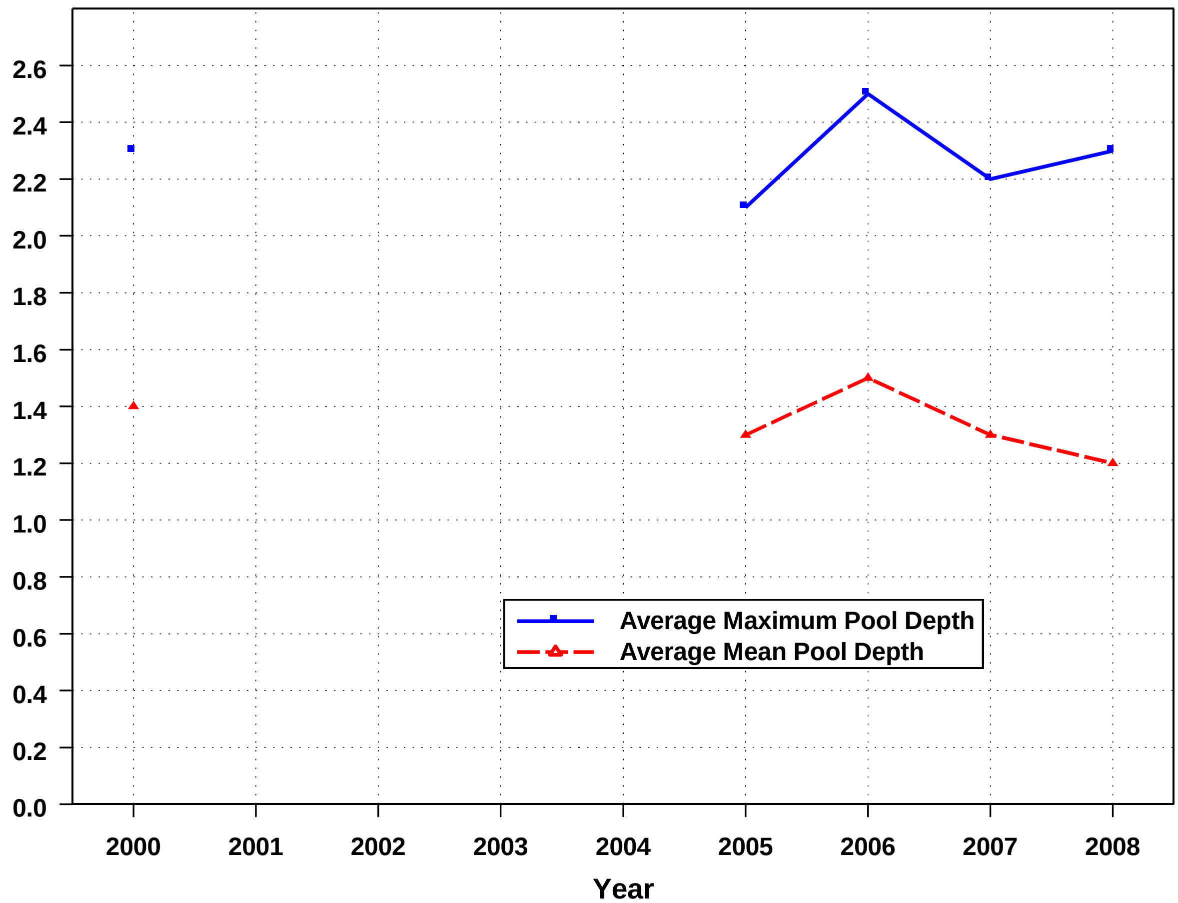


Figure 46a. Escape Cover Index for Pool Habitat in Reach 9a (below Mill Pond) of East Branch Soquel Creek, 2000 and 2005-2008.

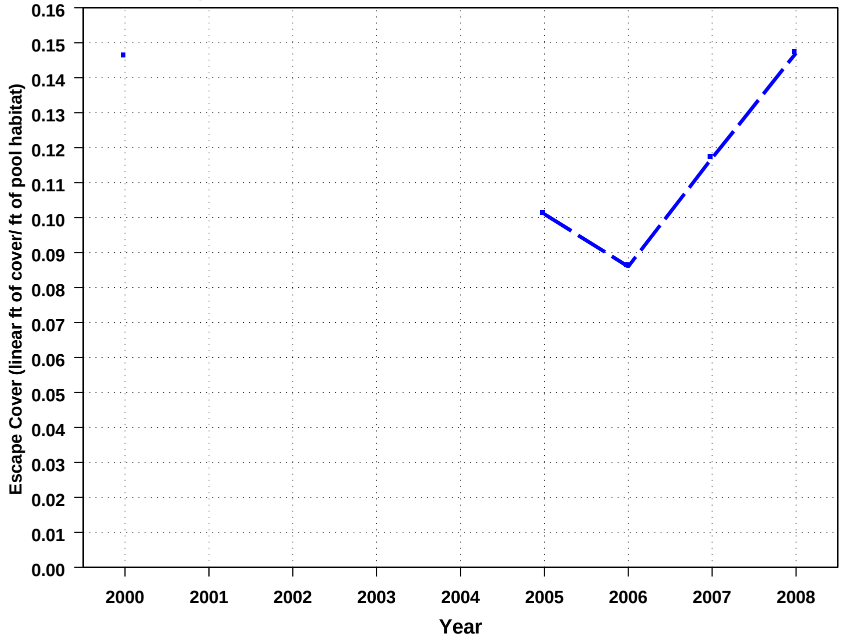


Figure 46b. Escape Cover Index for Pool Habitat at Site 13a (Reach 9a below Mill Pond) in East Branch Soquel Creek, 1997-2008.

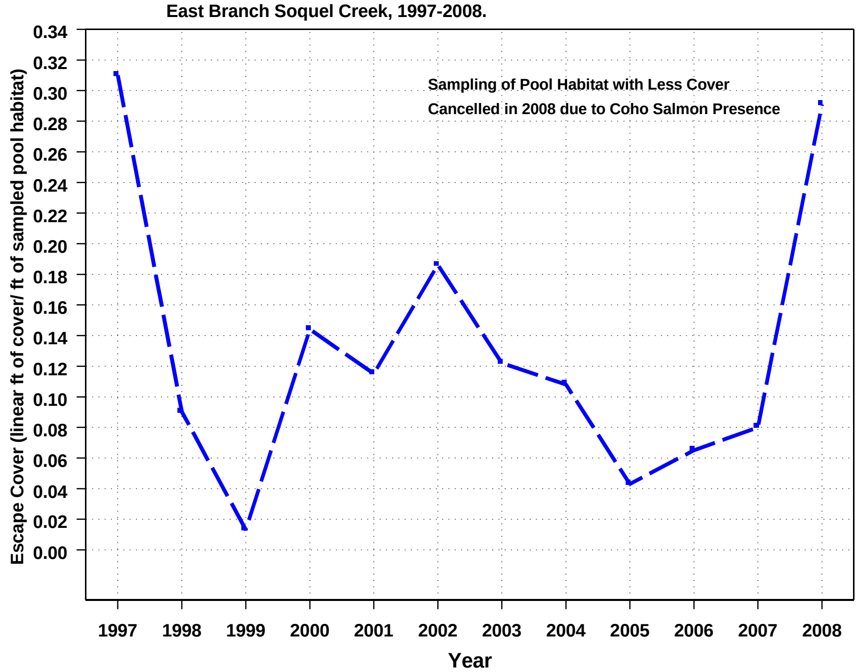


Figure 47. Averaged Percent Fines in Run and Step-Run Habitat in Reach 9a (below Mill Pond) of East Branch Soquel Creek, 2000 and 2005-2008.

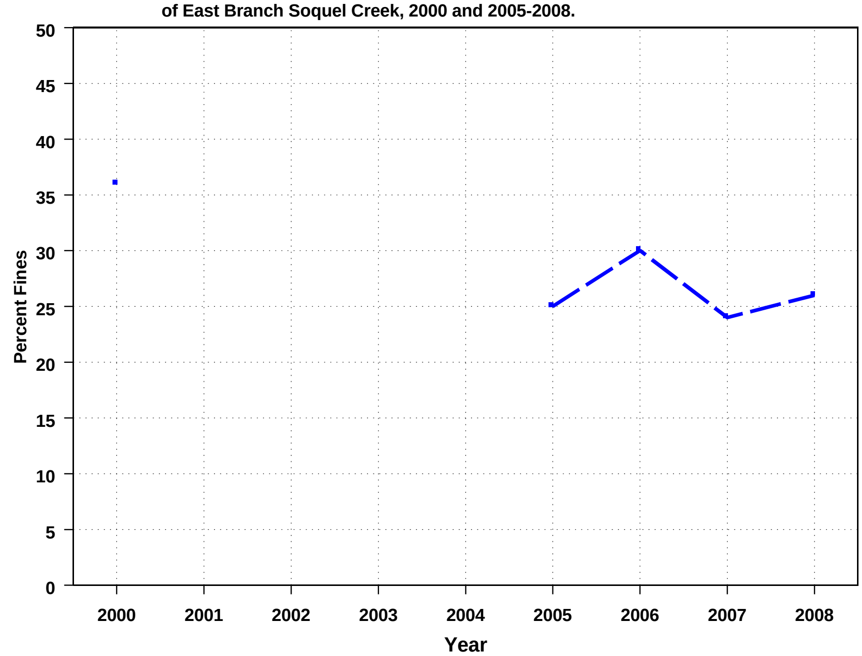
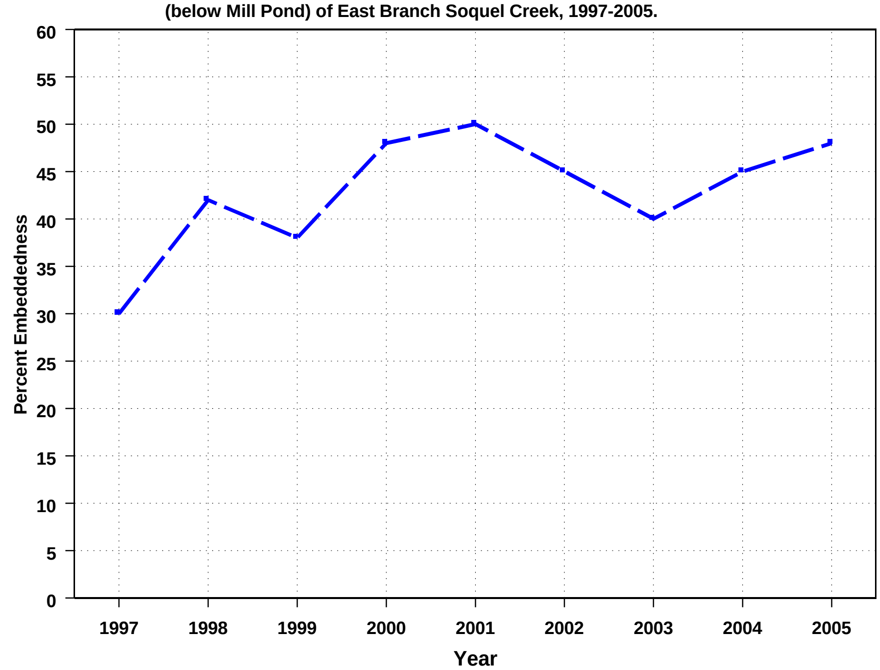


Figure 48. Average Embeddedness for Riffle and Run Habitat at the Sampling Site in Reach 9a (below Mill Pond) of East Branch Soquel Creek, 1997-2005.



In the upper East Branch at Site 16 in the SDSF, densities of Size Class II and III increased during 1997–1999, with a steady decline to less than one-fifth the 1999 density by 2004. Then the density increased up to the highest density in 12 years in the dry year of 2007 (**Figure 24**). The relatively high density of Size Class II and III juveniles (20/ 100 ft) was likely due to at least moderate numbers of YOY in 2006 and good over-winter survival of yearlings during a mild winter. However, the yearling density declined substantially in 2008 to reduce the density of larger juveniles. This was partially due to low recruitment of YOY from 2007 (**Figure 22**) and likely a bankfull event during the 2007/2008 winter that flushed some yearlings downstream.

The three highest Size Class II and III densities in the upper East Branch did not correspond to any hydrologic category. They were 1998 (very wet year), 1999 (intermediate rainfall year with relatively mild peak flow) and 2007 (very dry year). Both 1998 and 1999 had sufficient spring baseflows to grow some YOY into Size Class II. The dry year likely had very good over-winter survival of yearlings, although rearing conditions worsened. In addition, adult access may have been hampered in the dry 2006/2007 winter, resulting in lower YOY production and reduced competition for food to benefit yearlings. Retrieval of PIT-tagged juveniles has indicated very limited movement of tagged individuals from their original locations. If the incidence of large instream wood were to increase substantially in the East Branch Soquel Creek, rearing habitat quality and improved over-winter survival of yearlings may play more important roles in increasing Size Class II and III densities.

In the Upper East Branch (above the stream gaging station) habitat conditions in Reach 12a (between Amaya Creek confluence to the gradient increase and the beginning of bedrock pools) were analyzed primarily since 2000. Data indicated that habitat quality in 2008 in Reach 12a of the SDSF was similar to conditions in 2000, after flow-related conversion of step-run habitat to shallow pool habitat was taken into account in the dry years of 2007 and 2008 (**Figure 49**). However, pool rearing habitat quality increased in years between (greater pool depth in 2006; much greater pool escape cover in 2004 and higher amounts of pool escape cover in all years between 2000 and 2008 (**Figures 50a and 50b**)).

As in Reach 9a, reach-wide pool depth in Reach 12a increased in 2006, consistent with higher averaged mean monthly streamflow (May–September) and decreased in 2007 and 2008, consistent with lower baseflow (**Figures 26 and 49**). Level of baseflow likely affected reach-wide measure of pool depth because former step-run habitat during higher baseflow conditions may have become shallow pool habitat in 2007 and 2008 with only a trickle of streamflow. Reach-wide pool depths in 2007 and 2008 were less than in 2000 but may have been due more to conversion of step-run habitat to pool habitat in a very dry year than to pools filling with sediment. Reach-wide escape cover increased from 2000 to 2005 and has decreased in 2006–2008 to just less than 2000 levels **(Figure 50a**). Since sampled pools in 2000 were chosen to represent average habitat conditions for depth and escape cover for the reach in 2000 and were sampled repeatedly for fish for 5 years, graphing of pool escape cover at the same sampled pools for 2000–2004 may reflect general trends in escape cover for the reach. These results from sampled pools indicated that pool escape cover increased from 2000 to 2002, declined in 2003 and increased to an 8-year high in 2004 (**Figure 50b**). Then it declined reach-wide during the last three years down to slightly less than the 2000 level. Reach-wide percent fines in important step-run habitat declined less than 10% since 2000, not indicating a real change (**Figure 51**). Percent fines at sampled step-runs were similar between 2000 and 2008, as well (**Figure 52**).

At Site 16, annual densities of Size Class II and III juveniles were not associated with changes in pool escape cover at sampling sites (**Figure 50b**). In fact, densities were the lowest in 2004 when pool escape cover at sampling sites was the highest. Densities increased from 2004 to 2007 despite a decline in pool escape cover at sampling sites. Insufficient years of data were available for reach-wide changes in pool depth and escape cover or in percent fines in run and step-run habitat for comparison to trends in juvenile densities (**Figures 49, 50a and 51**). Densities of Size Class II and III juveniles were not positively associated with changes in these habitat parameters but, in fact, increased despite reach-wide decline in pool escape cover for 2005–2007. However, the decline in these smolt-sized fish in 2008 did correlate with decreased pool depth and escape cover (**Figures 49, 50a and 50b**). But it also coincided with low YOY densities in 2007 for low recruitment as yearlings. The density decline in 2000–2004 was associated with relatively high percent embeddedness in riffles and step-runs at sampling sites except for the less embeddedness in 2003 (**Figure 52**). Densities increased in 2005 with less embeddedness.

The apparent disconnect between rearing habitat conditions and Size Class II and III densities at Site 16 indicated that rearing habitat quality within the observed range in the last 12 years was overshadowed by 1) poor over-winter survival of yearlings in years that were not wet enough to grow many YOY to Size Class II, 2) the potential for growth of some YOY to Size Class II in intermediate to wet years and 3) high over-winter survival of yearlings in dry years. If the incidence of large instream wood were to increase substantially, rearing habitat quality and improved over-winter survival in intermediate to wetter years may play more important roles in increasing Size Class II and III densities.

In summary, although improvement in pool rearing habitat in Reach 12a was detected in some years (greater pool depth in 2006 and much greater pool escape cover in 2004), data indicate that habitat quality in 2008 was similar to conditions in 2000. Increased incidence of large instream wood would substantially improve rearing habitat in this reach with limited pool development, shallow pools and very limited escape cover in most years.

Figure 49. Averaged Maximum and Mean Pool Depth in Reach 12a (SDSF) of East Branch Soquel Creek, 2000 and 2005-2008.

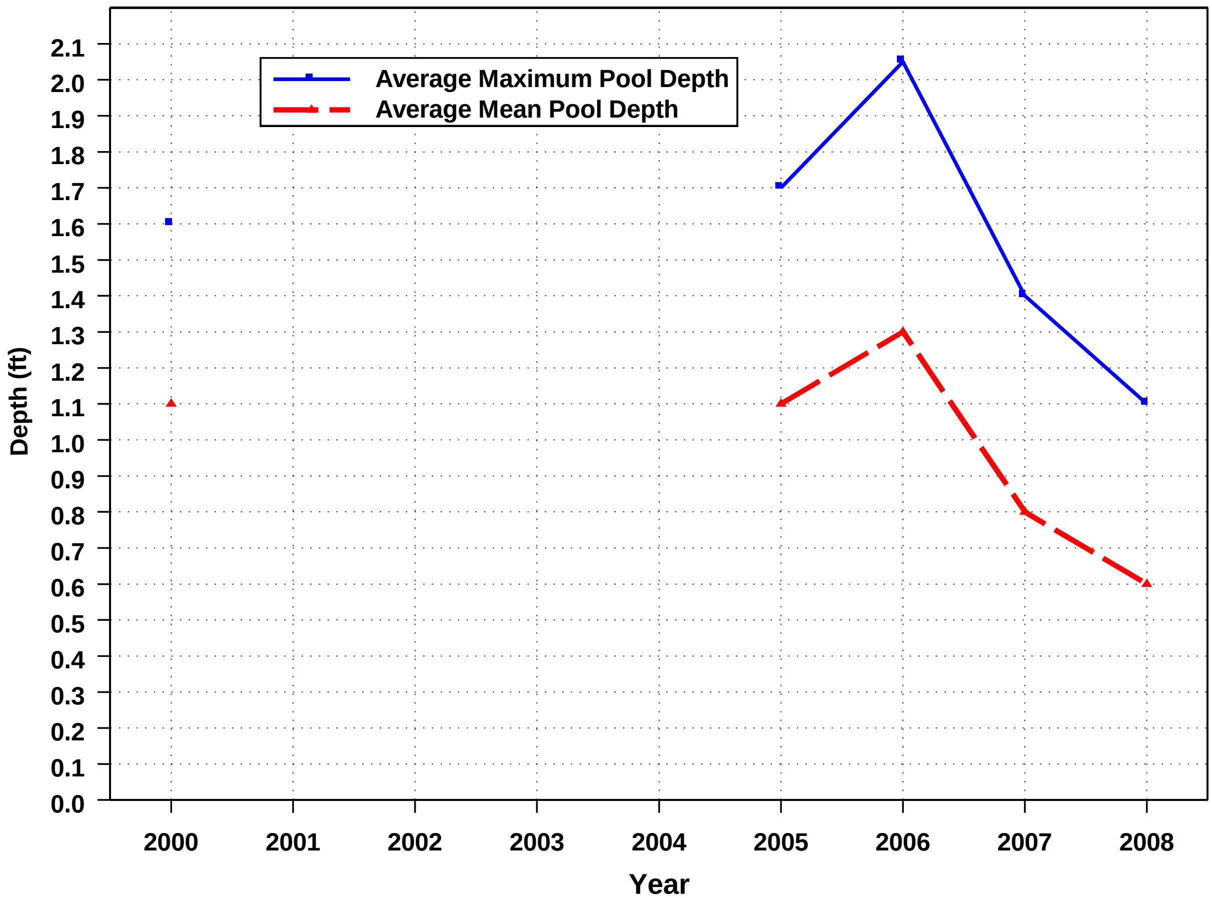


Figure 50a. Escape Cover Index for Pool Habitat in Reach 12a (SDSF) of East Branch Soquel Creek, 2000 and 2005-2008.

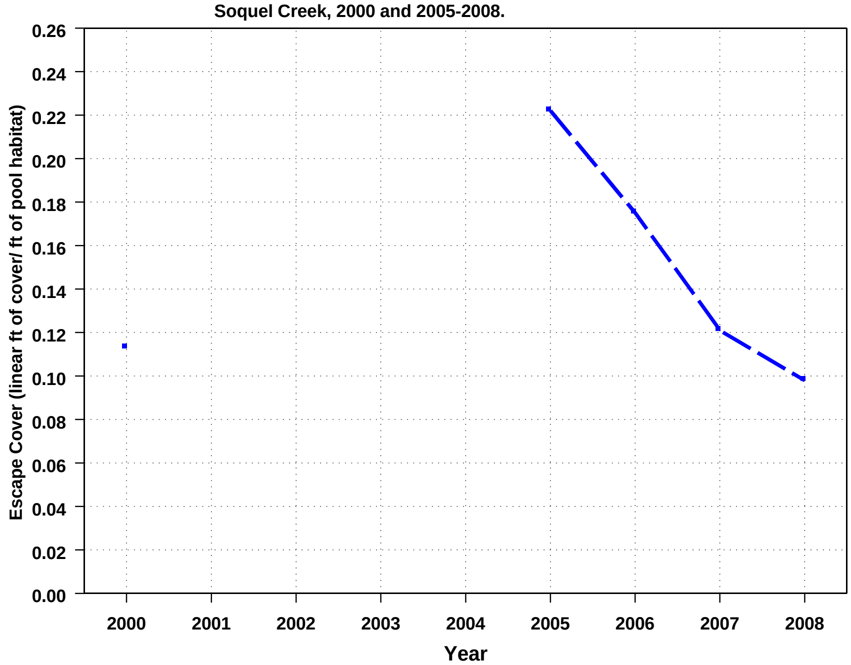


Figure 50b. Escape Cover Index for Pool Habitat at Site 16 (Reach 12a in SDSF) in East Branch Soquel Creek, 2000-2008.

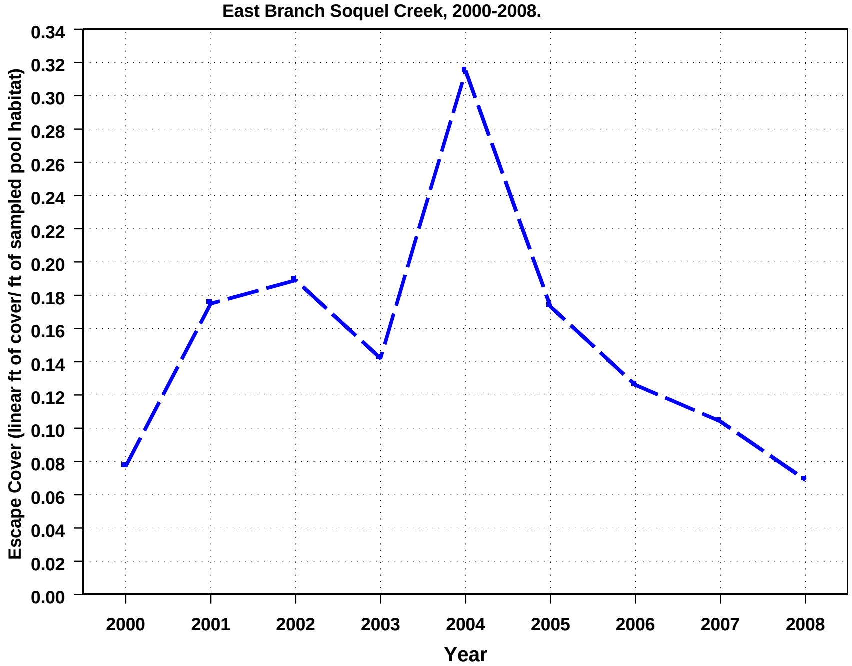


Figure 51. Averaged Percent Fines in Step-Run Habitat in Reach 12a (SDSF) of East Branch Soquel Creek, 2000 and 2005-2008.

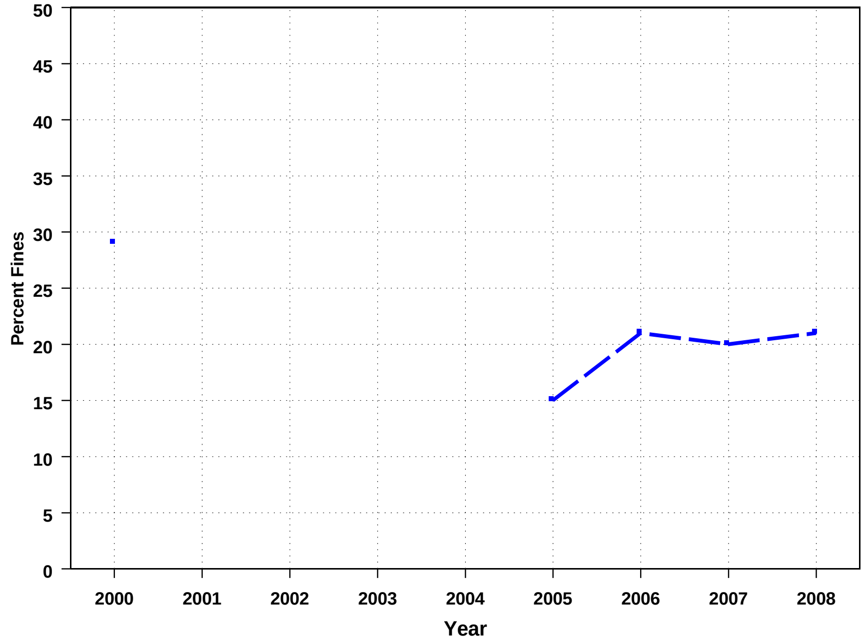
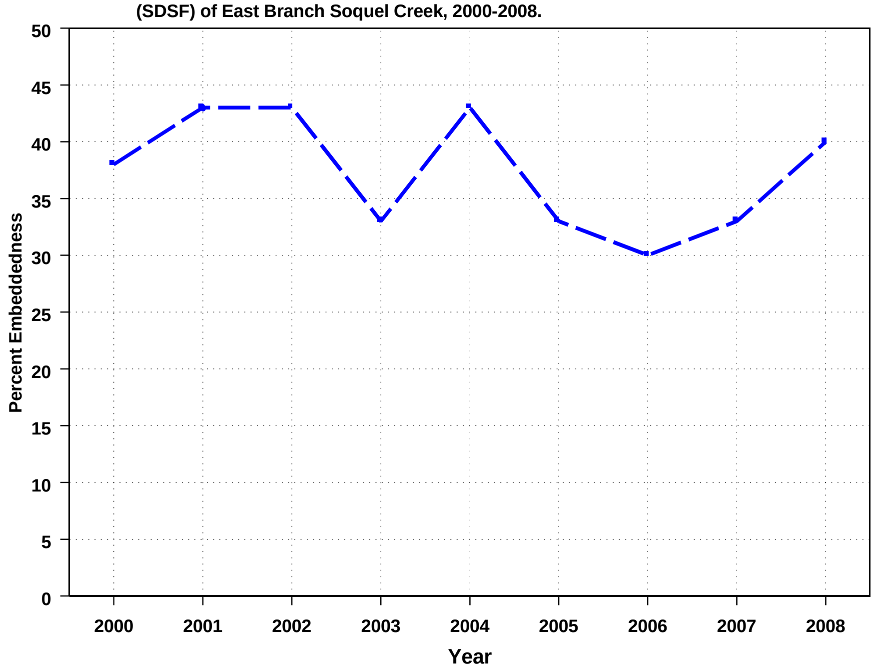


Figure 52. Average Embeddedness for Riffle and Step-run Habitat at the Sampling Site in Reach 12a (SDSF) of East Branch Soquel Creek, 2000-2008.



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FIGURES

Figure 1. Total Juvenile Steelhead Site Densities in the San Lorenzo River in 2008 Compared to the 10-Year Average Density. (8th year for Mainstem (1), 7th year for Mainstem (2a), 3rd year for Lompico (13e) and 2nd Year for Branciforte (21a-1)).

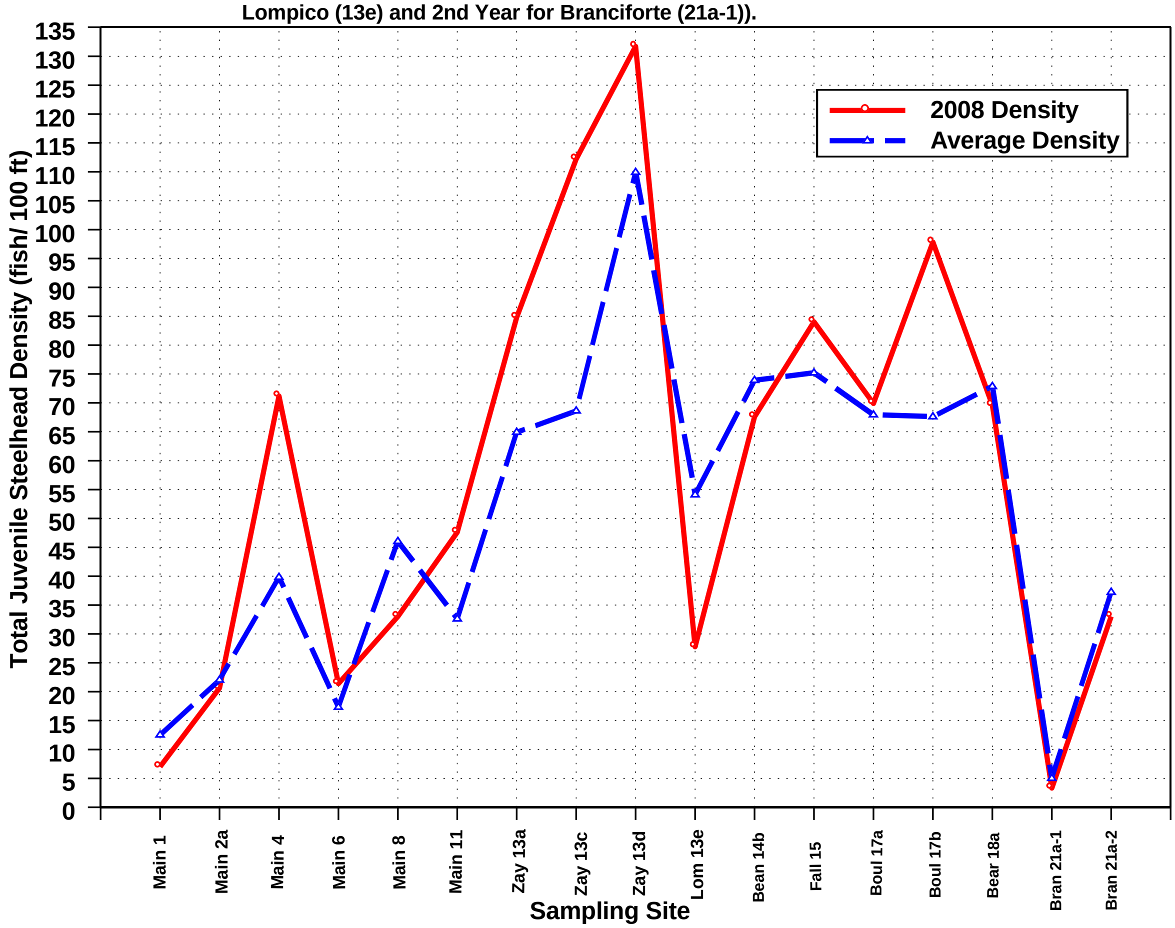


Figure 2. Juvenile Steelhead Site Densities for Young-of-the-Year in the San Lorenzo River in 2008 Compared to the 10-Year Average. (8the year for Mainstem (1), 7th year for Mainstem (2a), 3rd year for Lompico (13e) and 2nd Year for Branciforte (21a-1).

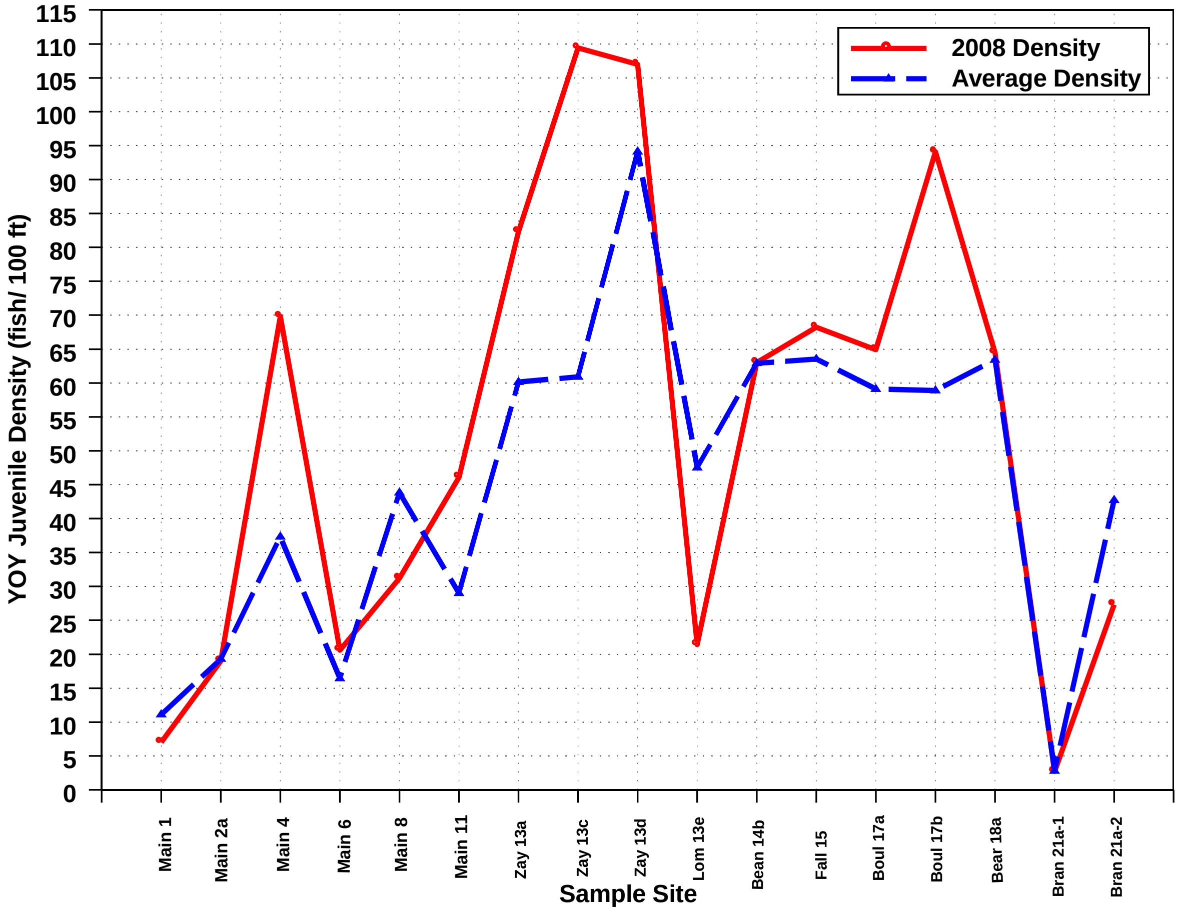


Figure 3. Juvenile Steelhead Site Densities for Size Classes II and III in the San Lorenzo River in 2008 Compared to the 10-Year Average. (8th year for Mainstem (1), 7th year for Mainstem (2a), 3rd Year for Lompico (13e) and 2nd Year for Branciforte (21a-1).

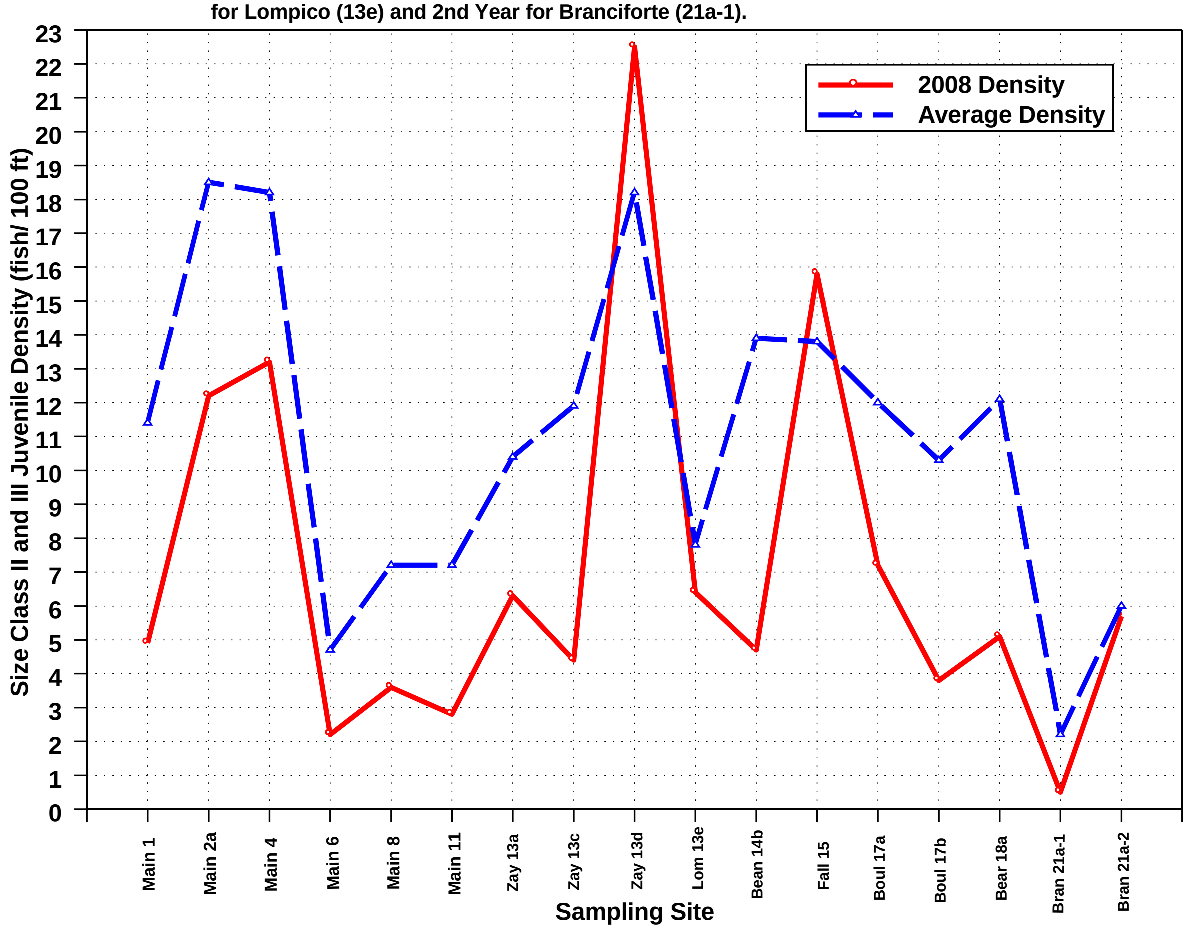


Figure 4. Total Juvenile Steelhead Site Densities in Soquel Creek in 2008 Compared to the 12-Year Average. (8th year West Branch (19).

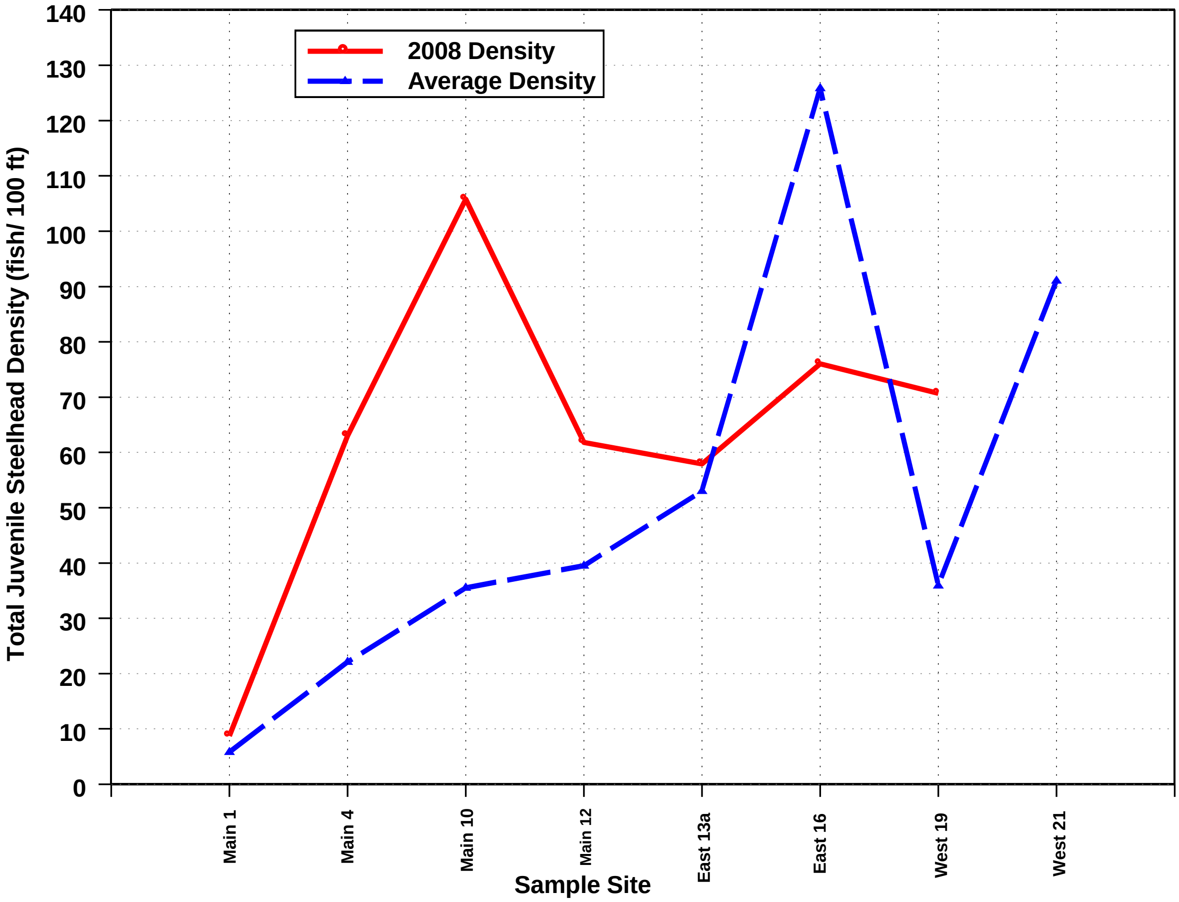


Figure 5. Juvenile Steelhead Site Densities for Young-of-the-Year in Soquel Creek in 2008 Compared to the 12-Year Average (8th Year West Branch (19)).

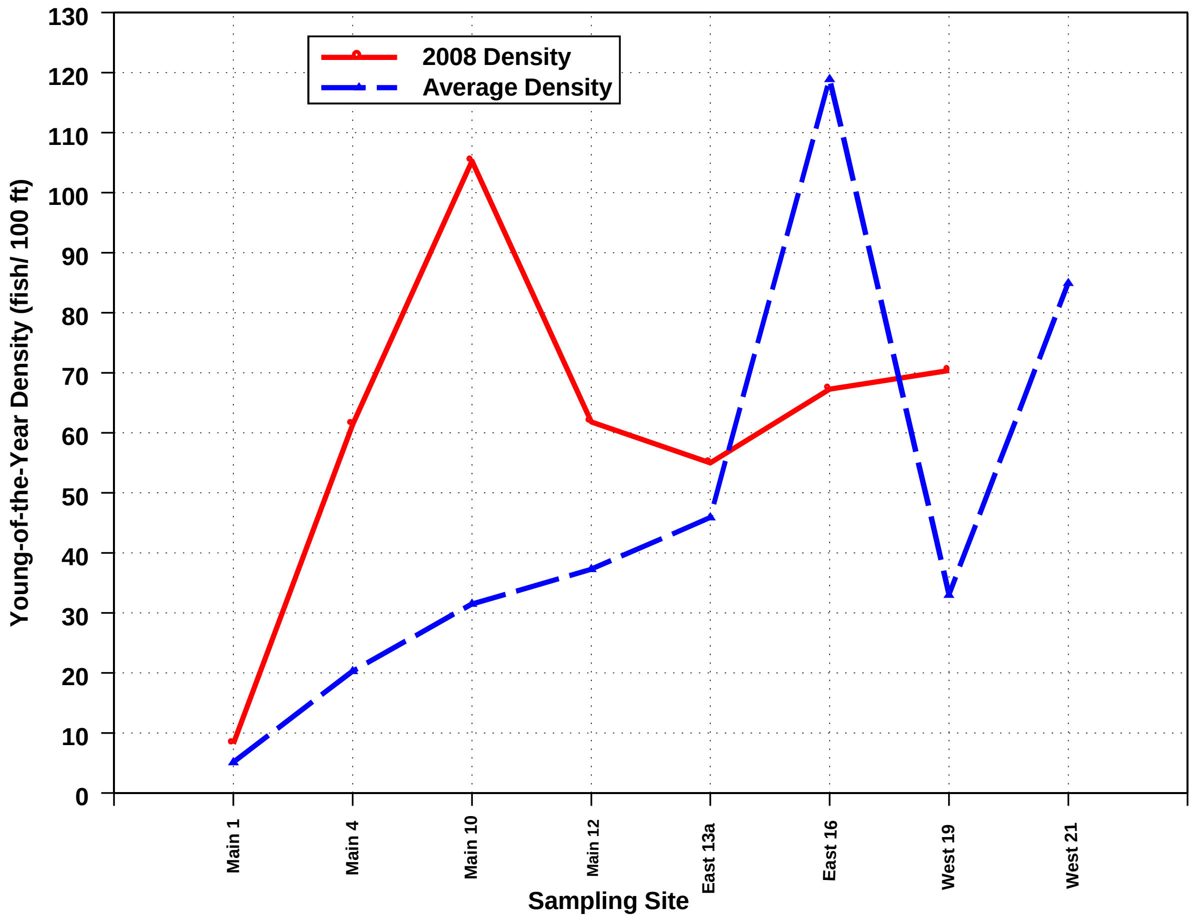


Figure 6. Juvenile Steelhead Site Densities for Size Classes II and III in Soquel Creek in 2008 Compared to the 12-Year Average Density (8th Year West Branch (19)).

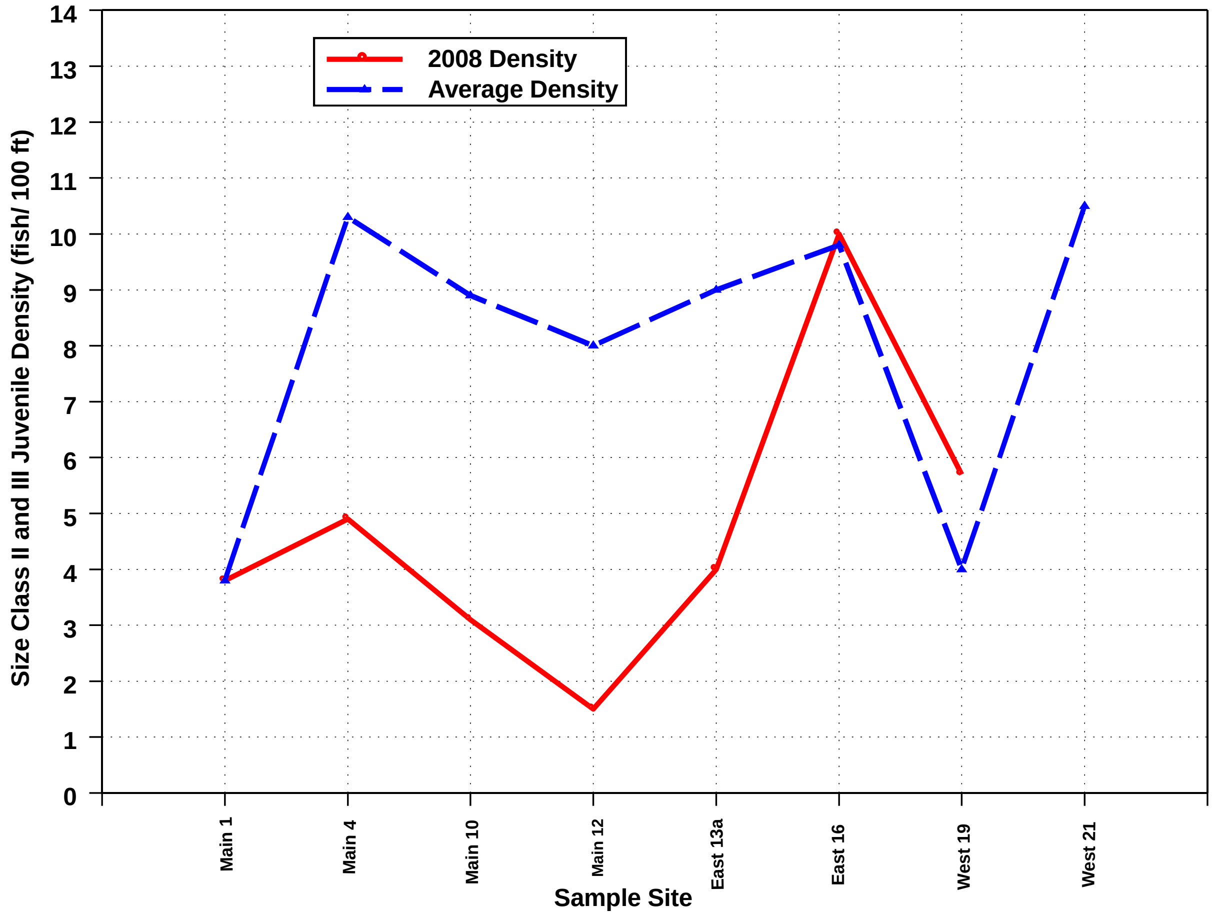


Figure 7. Total Juvenile Steelhead Site Densities in Aptos and Valencia Creeks in 2007, 2008 and 4-Year Average, Including 1981 and 2006.

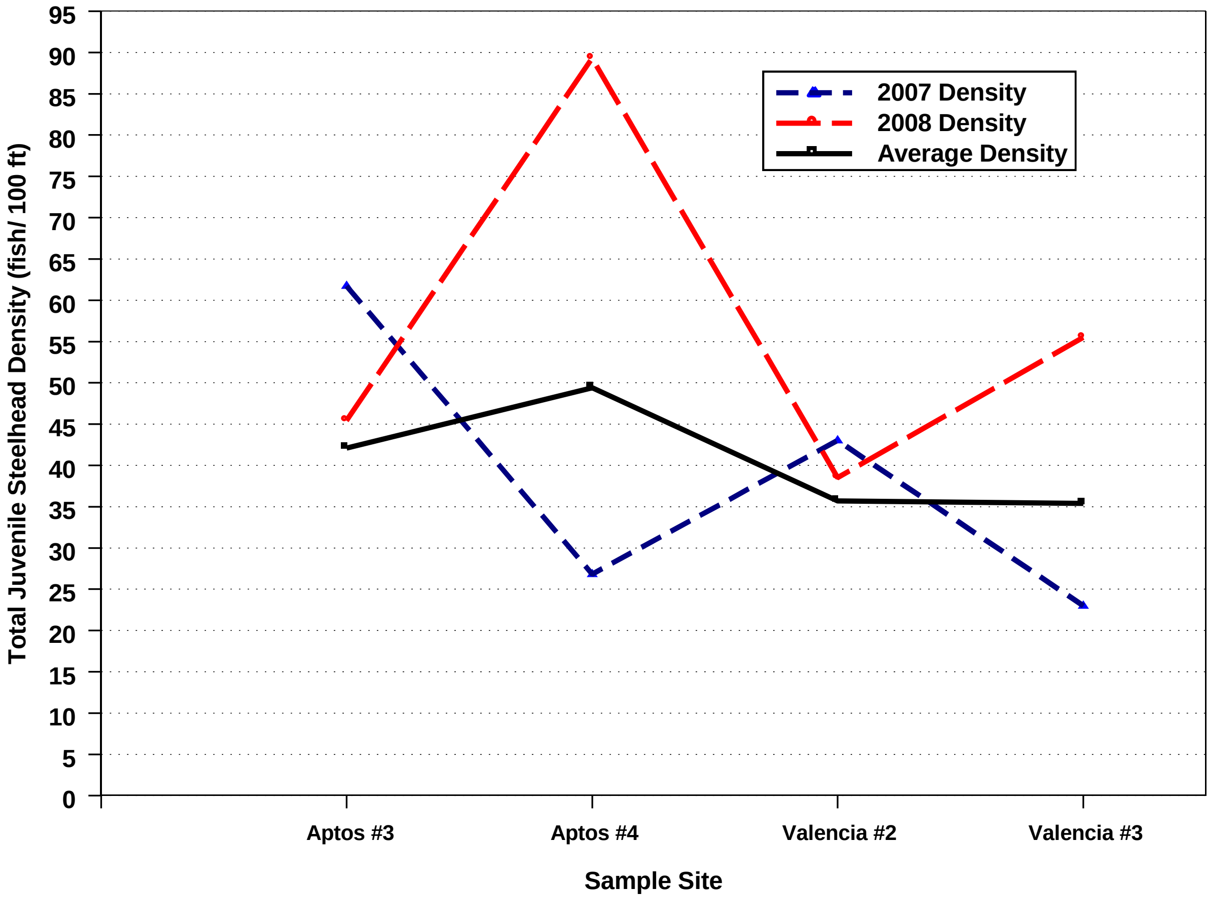


Figure 8. Juvenile Steelhead Site Densities for Young-of-the-Year in Aptos and Valencia Creeks in 2007, 2008 and the Average, Including 1981 and 2006.

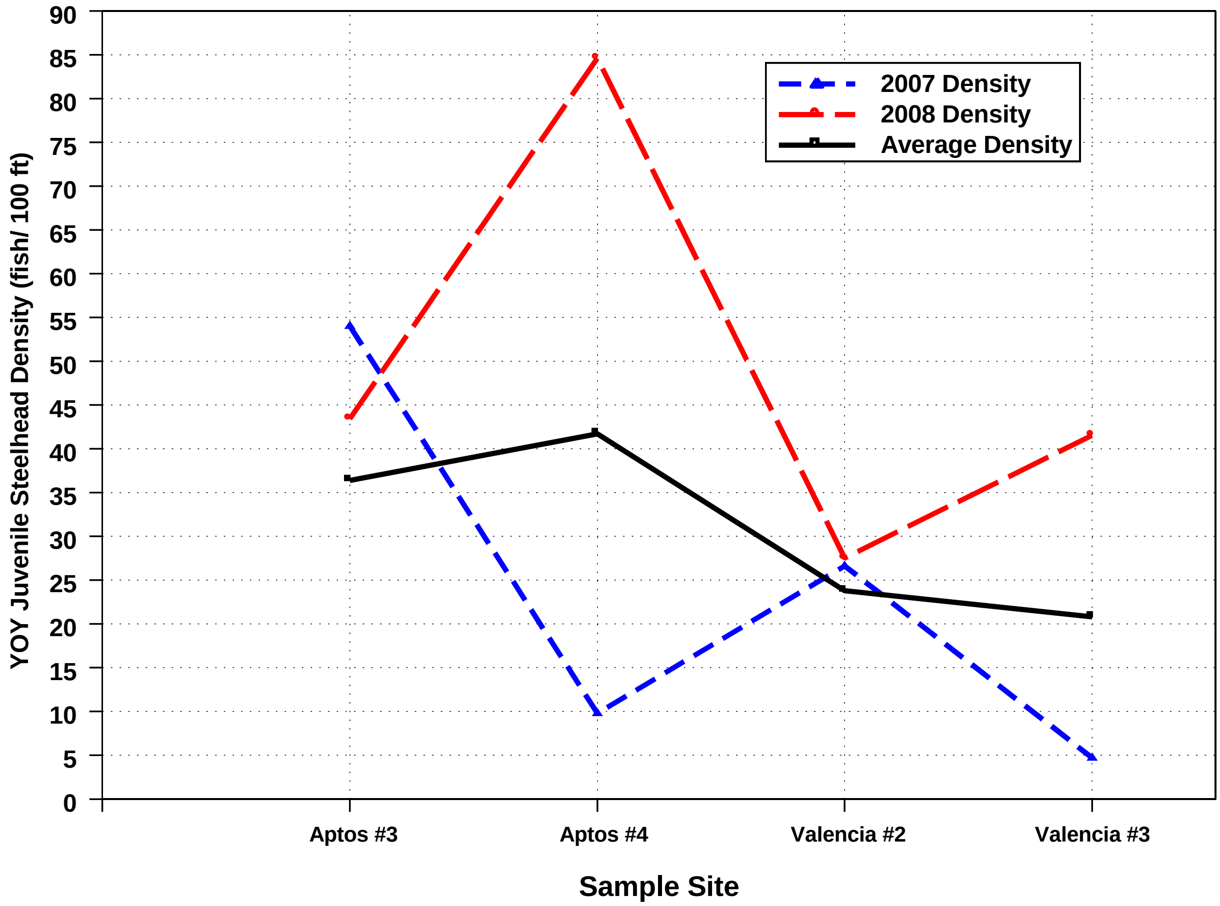


Figure 9. Juvenile Steelhead Densities for Size Classes II and III in Aptos and Valencia Creeks in 2007, 2008 and the Average, Including 1981 and 2006.

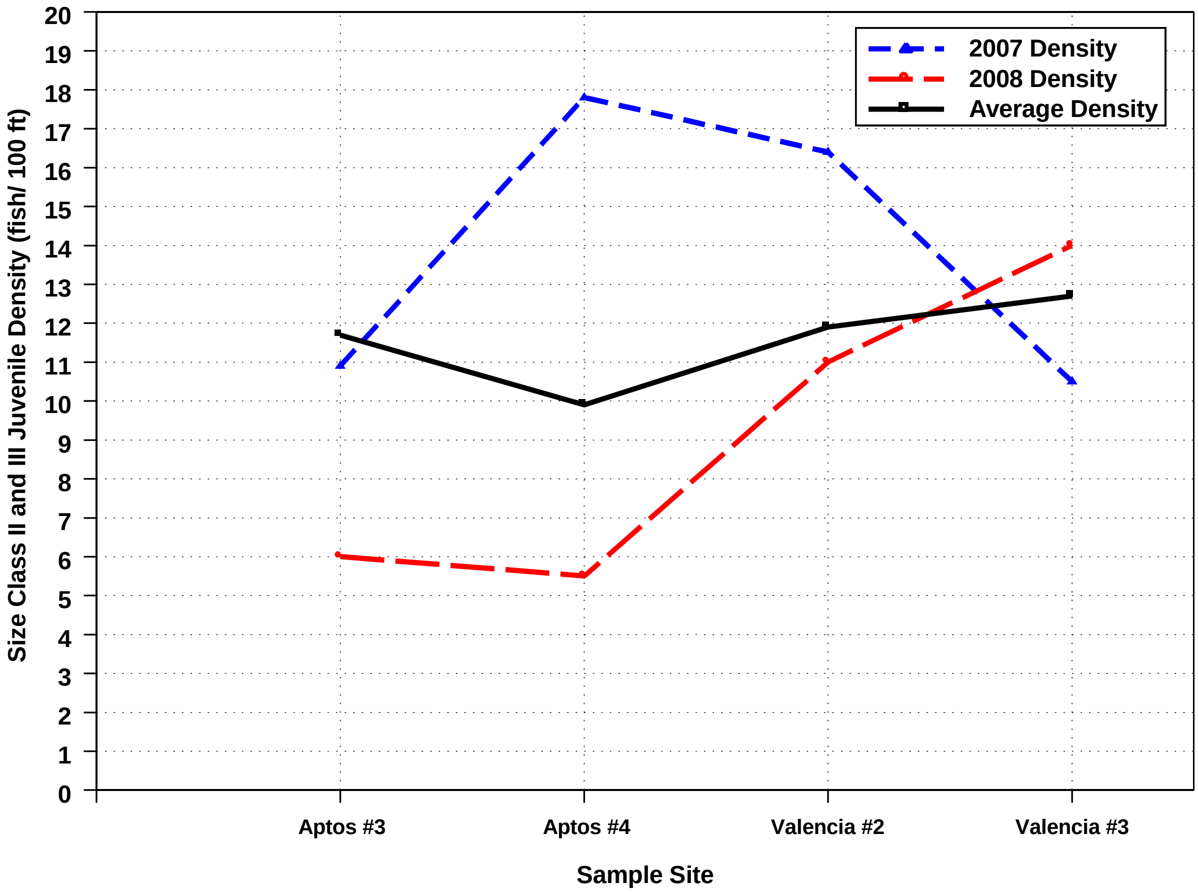


Figure 10. Total Juvenile Steelhead Site Densities in Corralitos, Shingle Mill and Browns Valley Creeks in 2007, 2008 and the Average, Including 1981, 1994 and 2006.

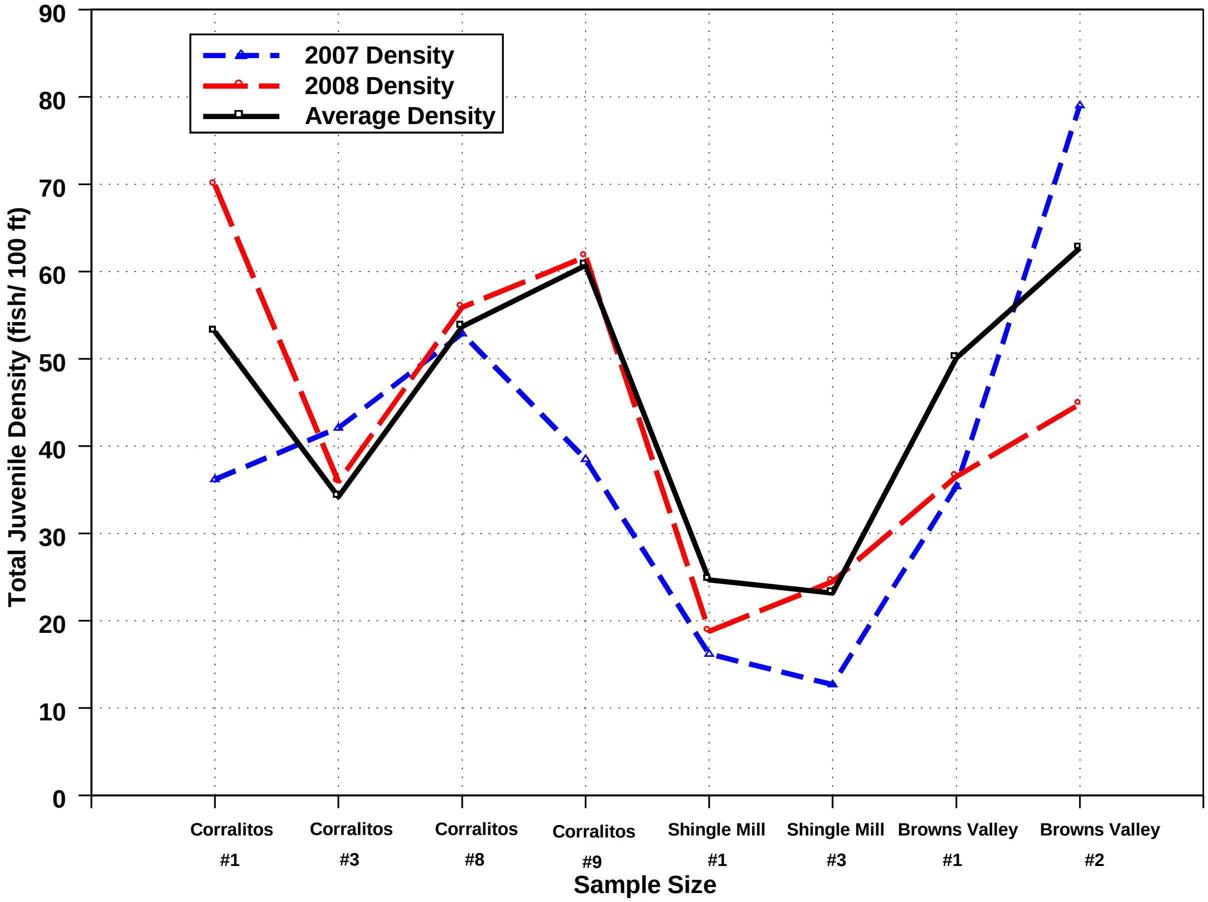


Figure 11. Juvenile Steelhead Densities for Young-of-the-Year in Corralitos, Shingle Mill and Browns Valley Creeks in 2007, 2008 and the Average, Including 1981, 1994 and 2006.

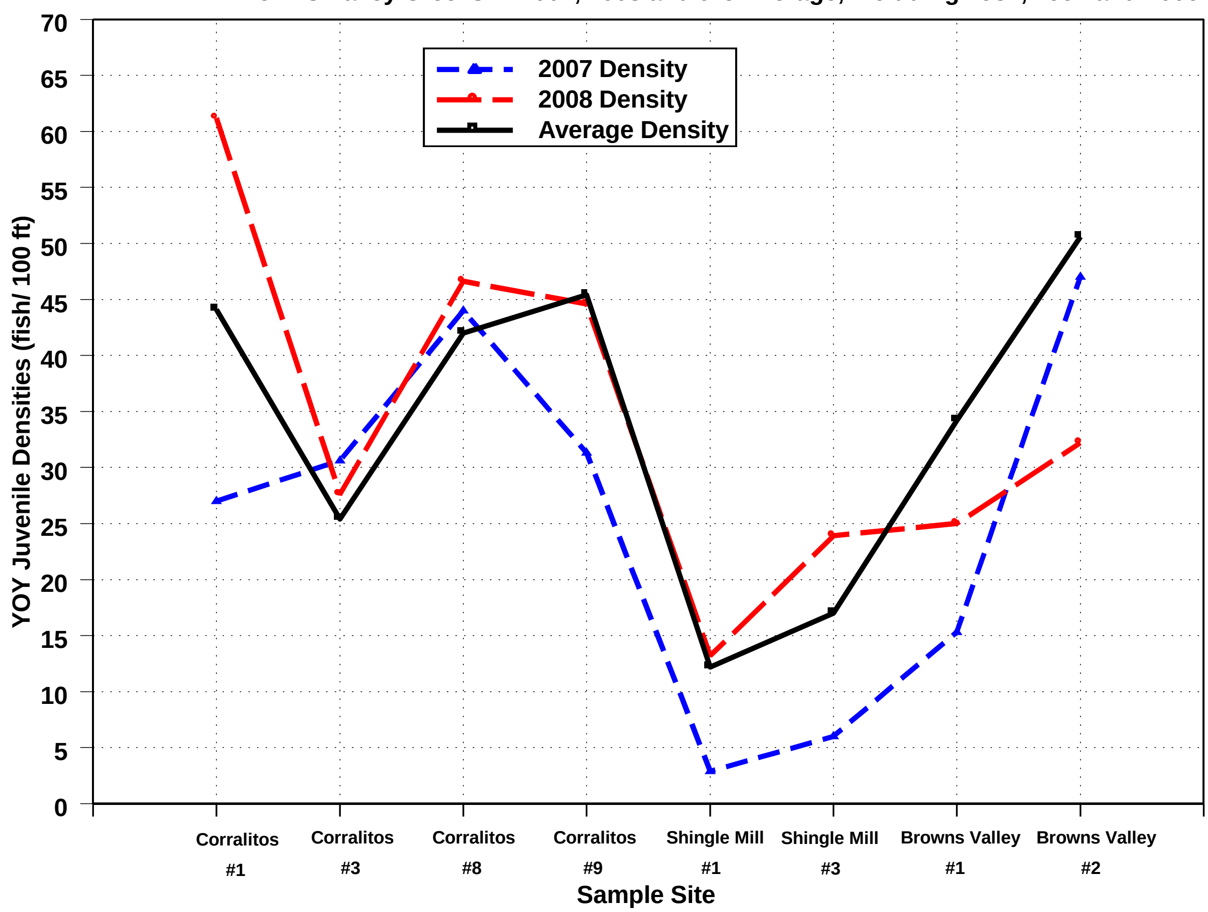


Figure 12. Juvenile Steelhead Densities for Size Classes II and III in Corralitos, Shingle Mill and Browns Valley Creeks in 2007, 2008 and the Average, Including 1981, 1994 and 2006.

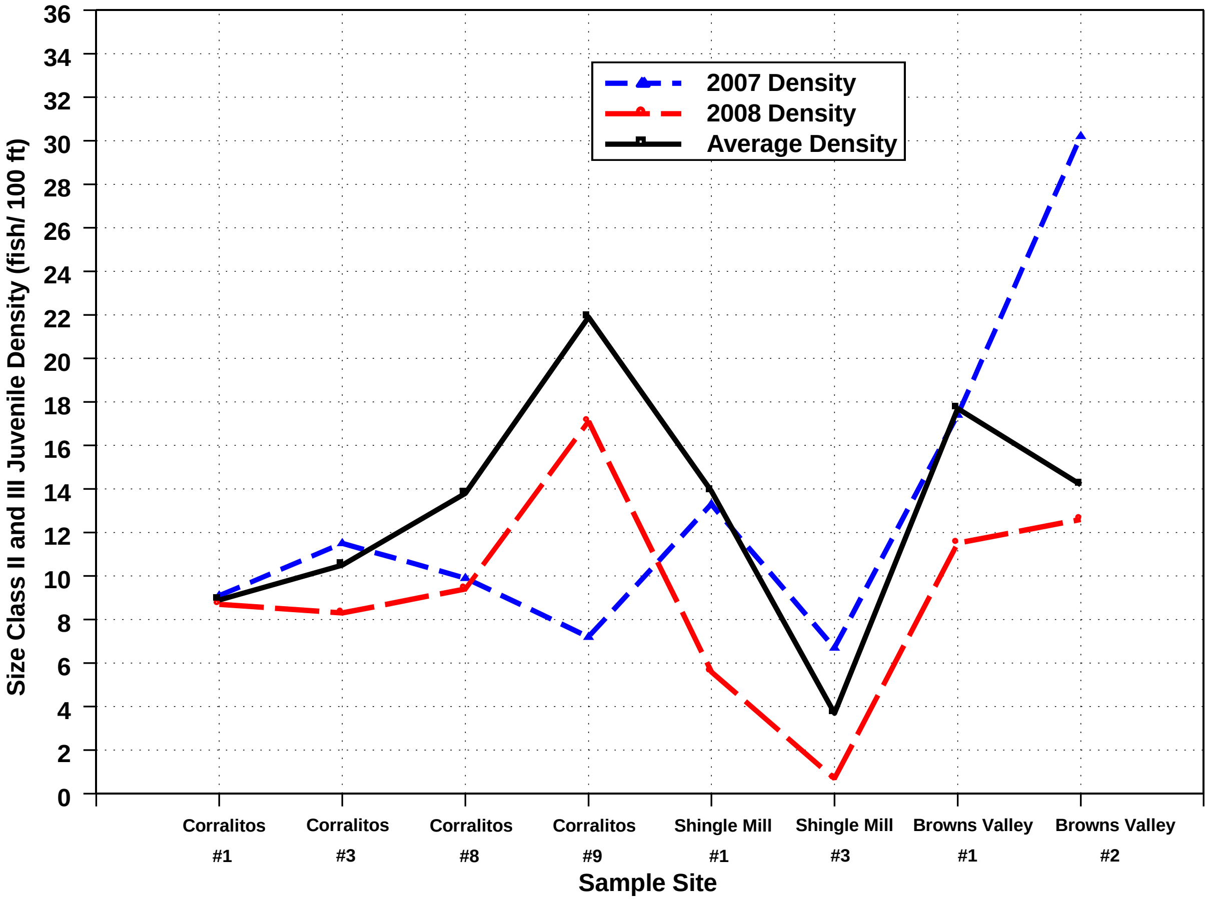


Figure 13. Plot of Annual Total Juvenile Densities at San Lorenzo Mainstem Sites, 1997-2008.

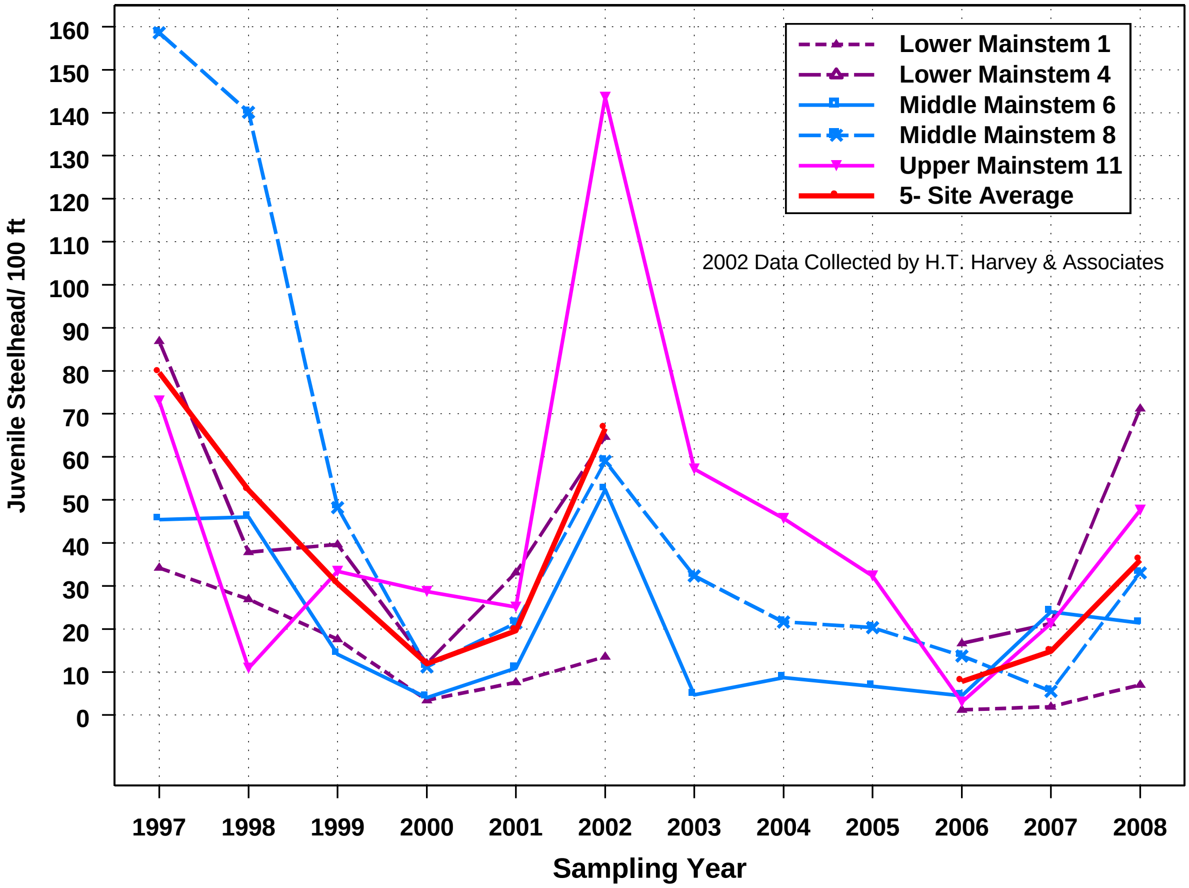


Figure 14. Plot of Annual Total Juvenile Densities at San Lorenzo Tributary Sites, 1997-2008.

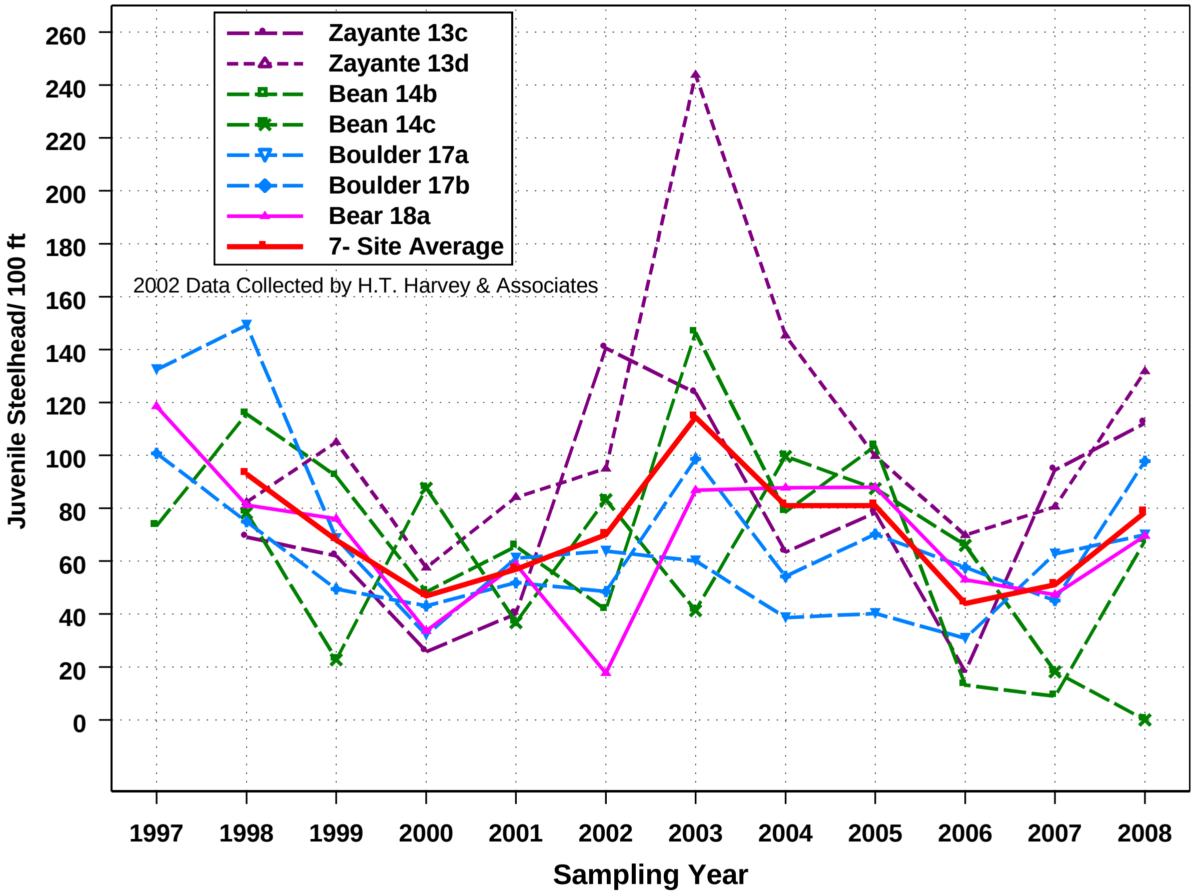


Figure 15. Plot of Annual YOY Juvenile Densities at San Lorenzo Mainstem Sites, 1997-2008.

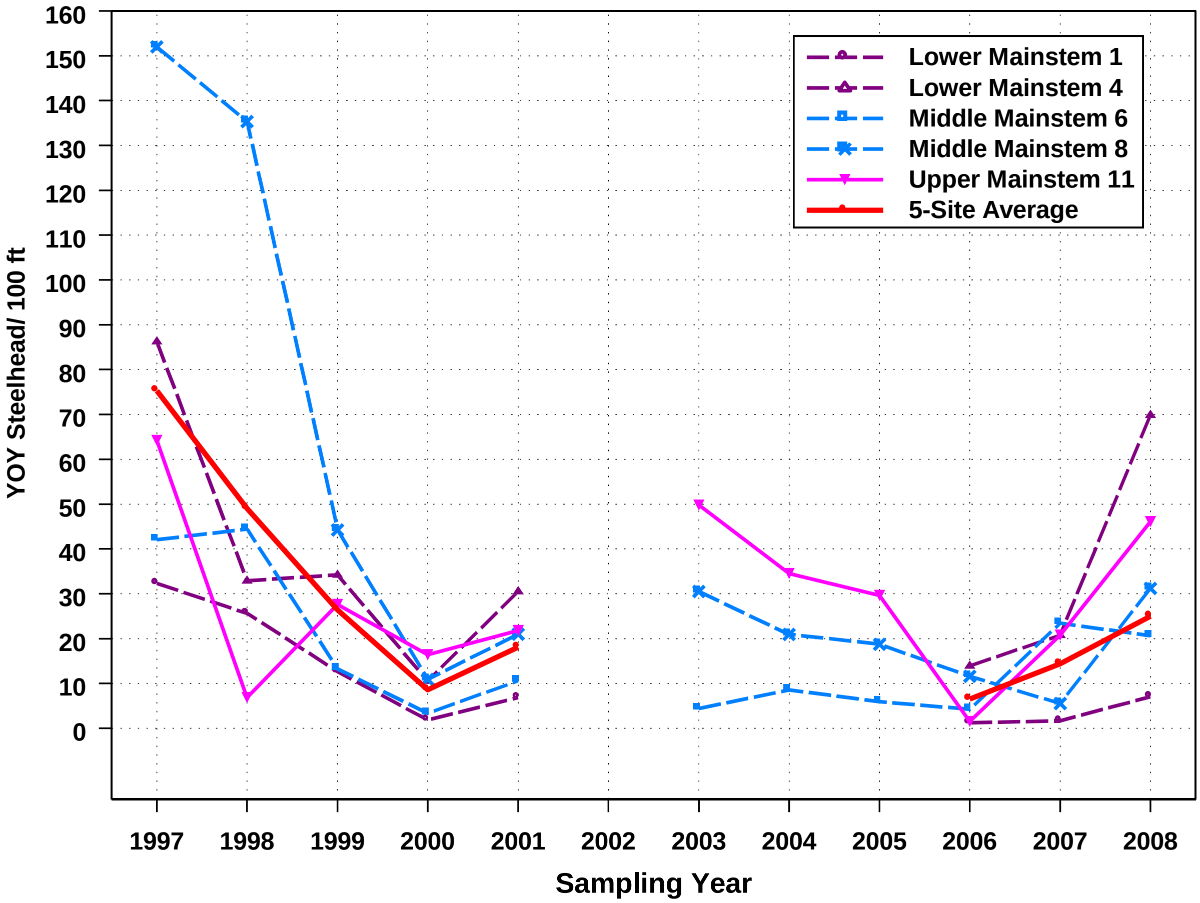


Figure 16. Plot of Annual YOY Juvenile Densities at San Lorenzo Tributary Sites, 1997-2008.

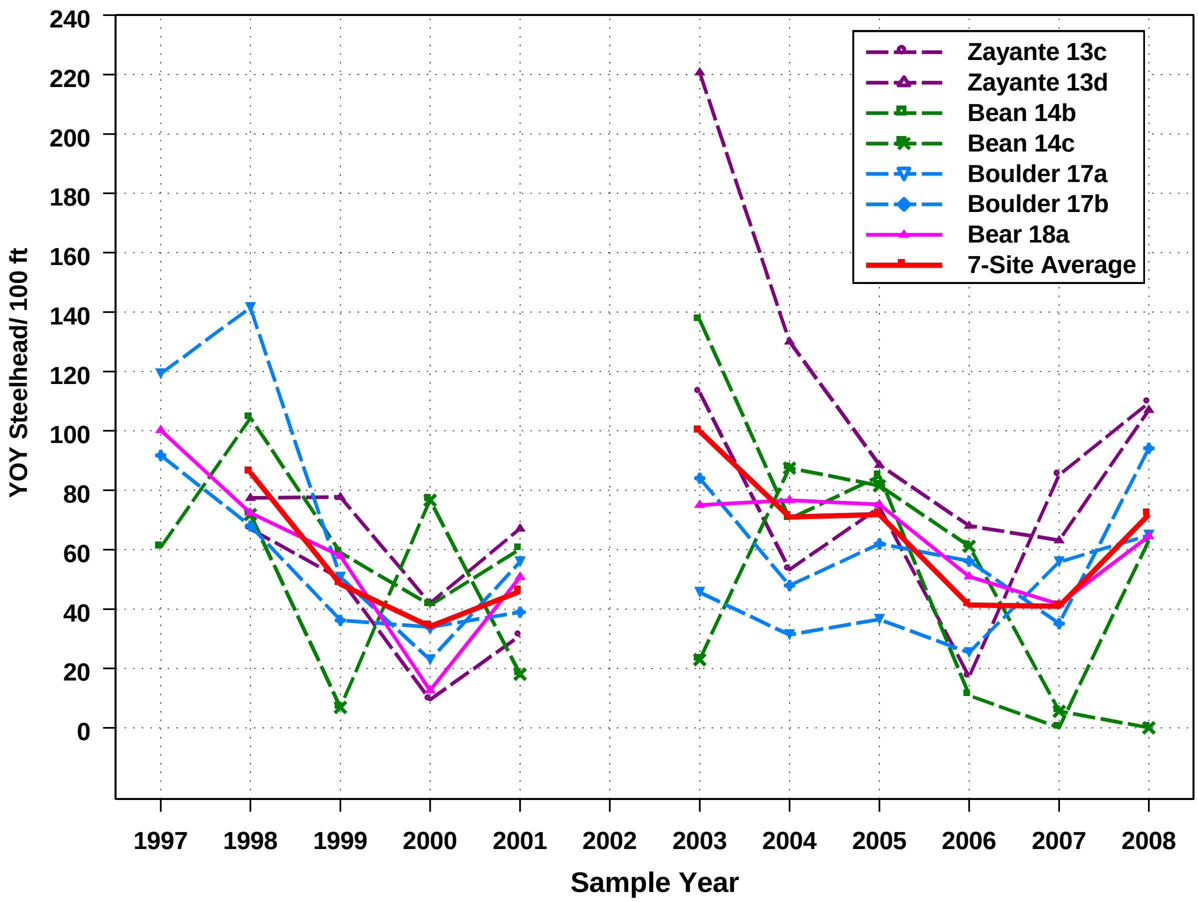


Figure 17. Scatter Plot of Annual Size Class II/ III Juvenile Densities at San Lorenzo Mainstem Sites, 1997-2008.

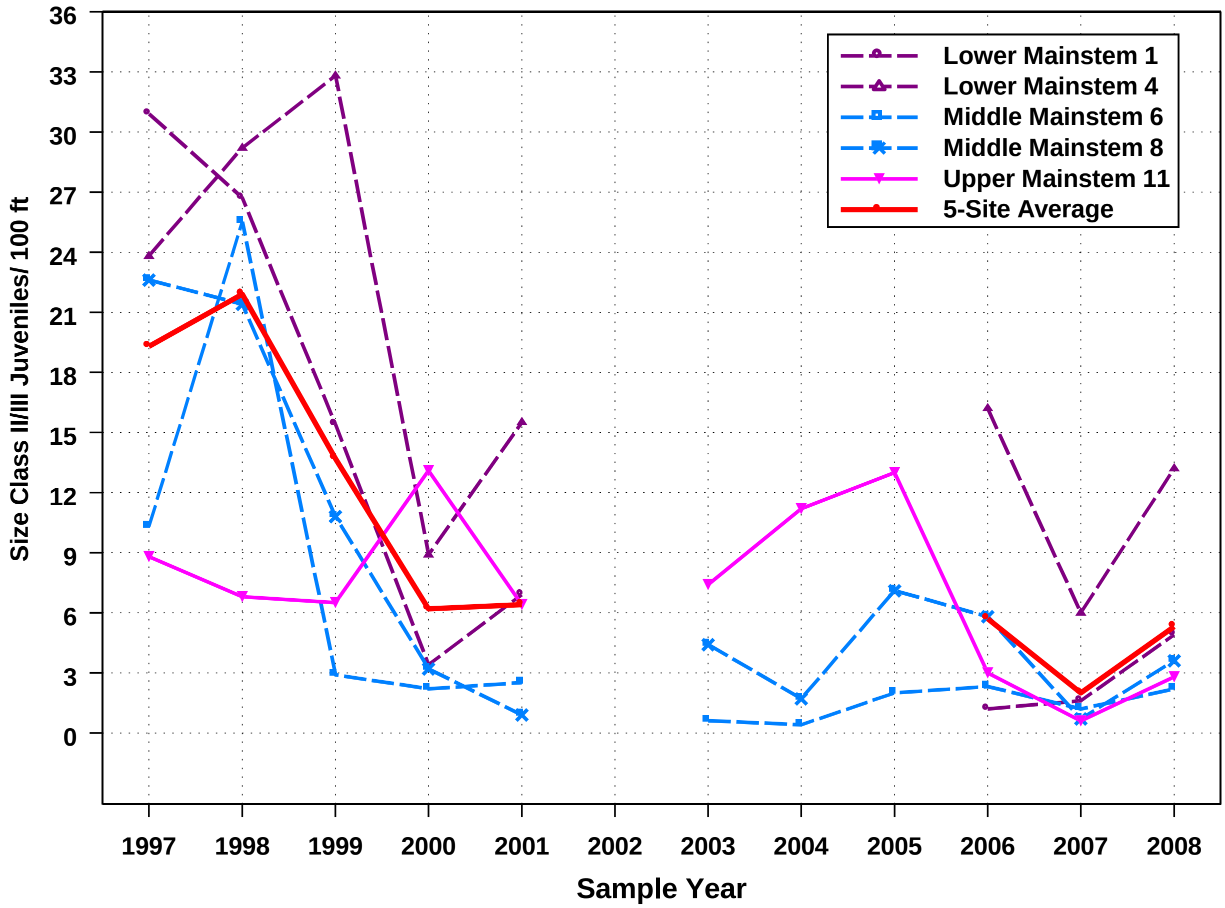


Figure 18. Plot of Annual Size Class II/ III Juvenile Densities at San Lorenzo Tributary Sites, 1997-2008.

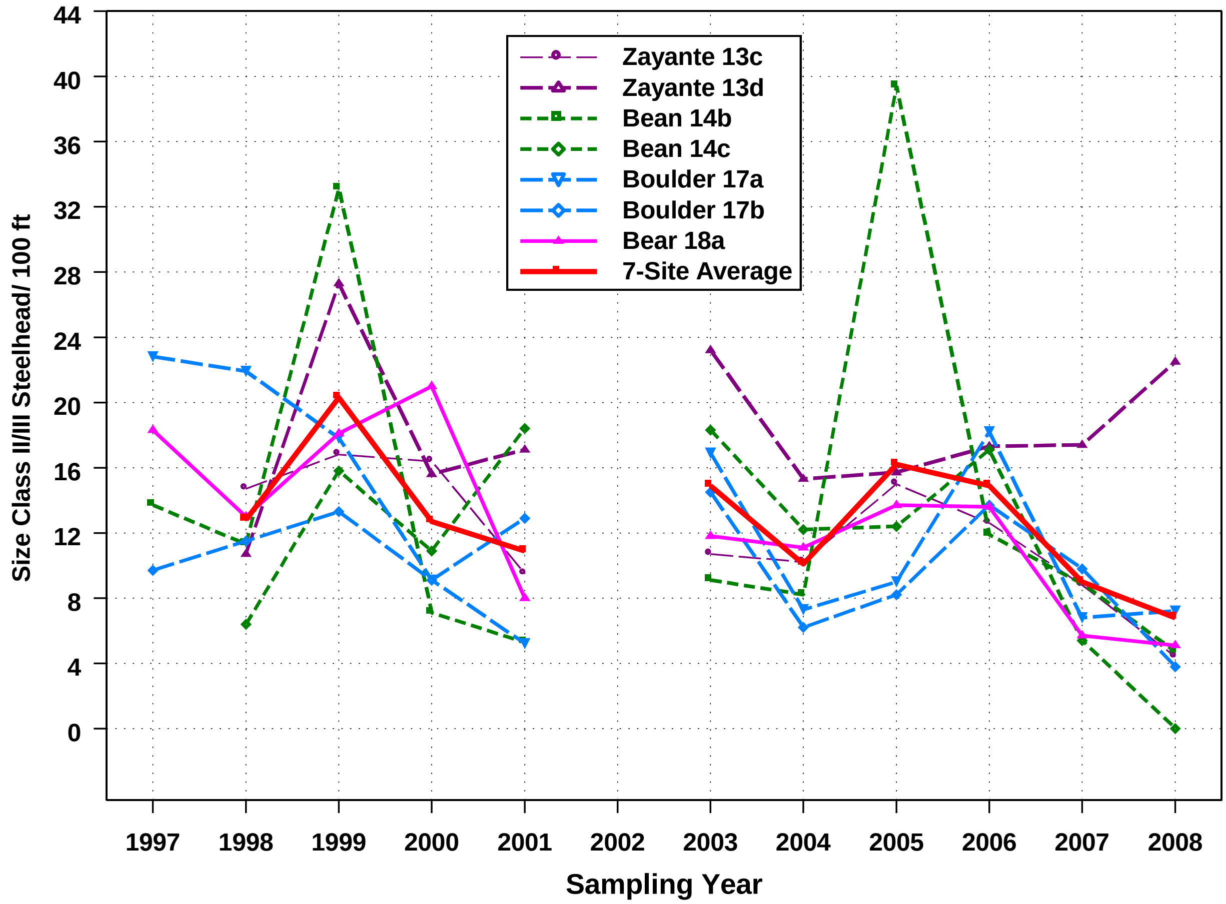


Figure 19. Plot of Annual Total Juvenile Densities at Mainstem Soquel Creek Sites, 1997-2008.

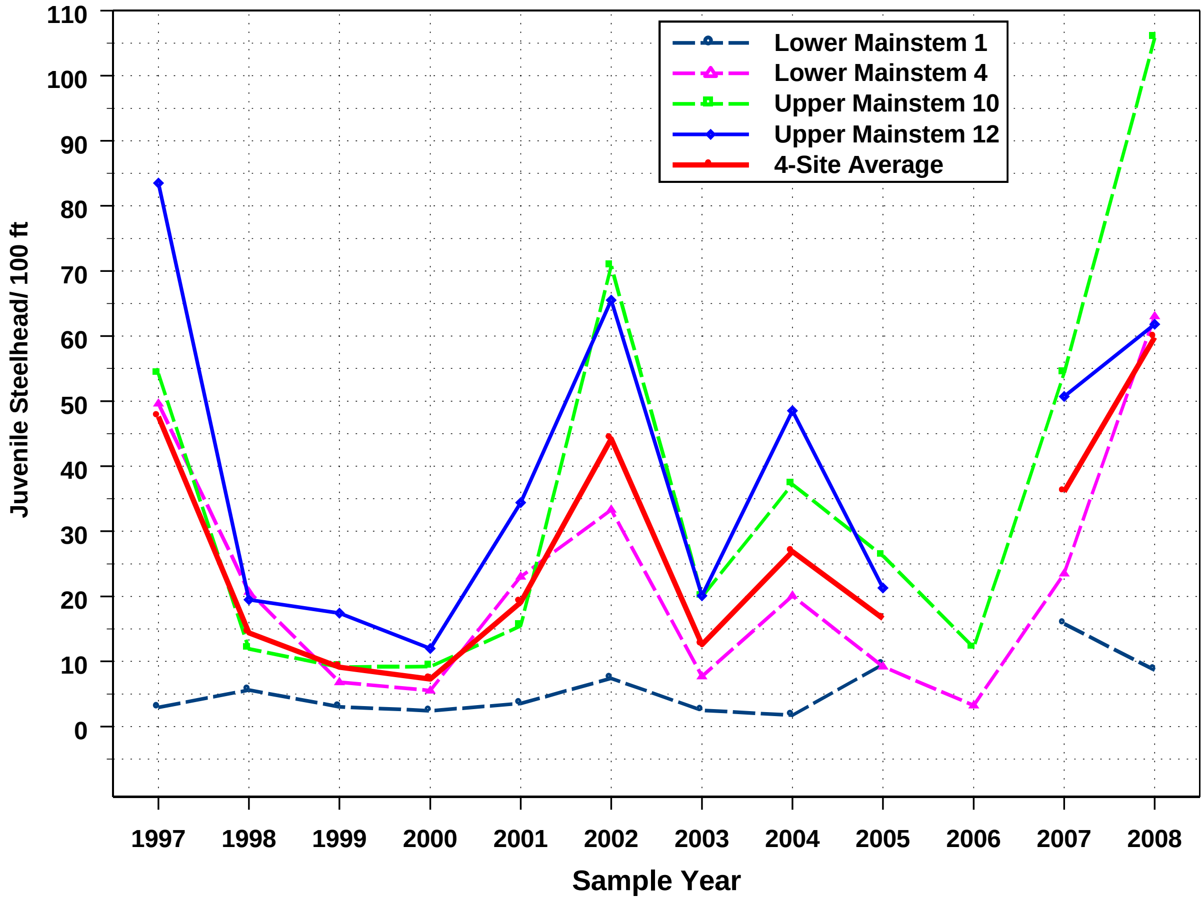


Figure 20. Plot of Annual Total Juvenile Densities at East Branch Soquel Creek Sites, 1997-2008.

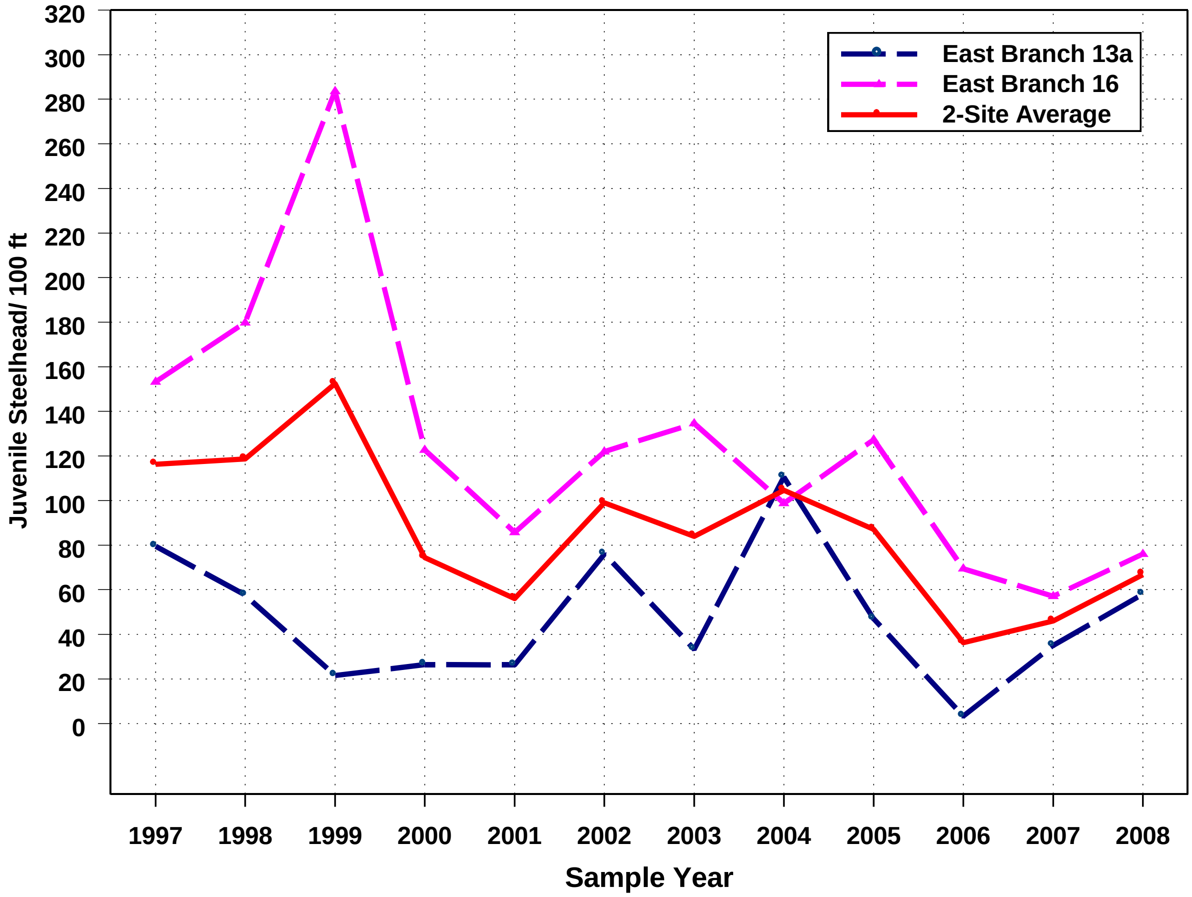


Figure 21. Plot of Annual YOY Densities at Mainstem Soquel Creek Sites, 1997-2008.

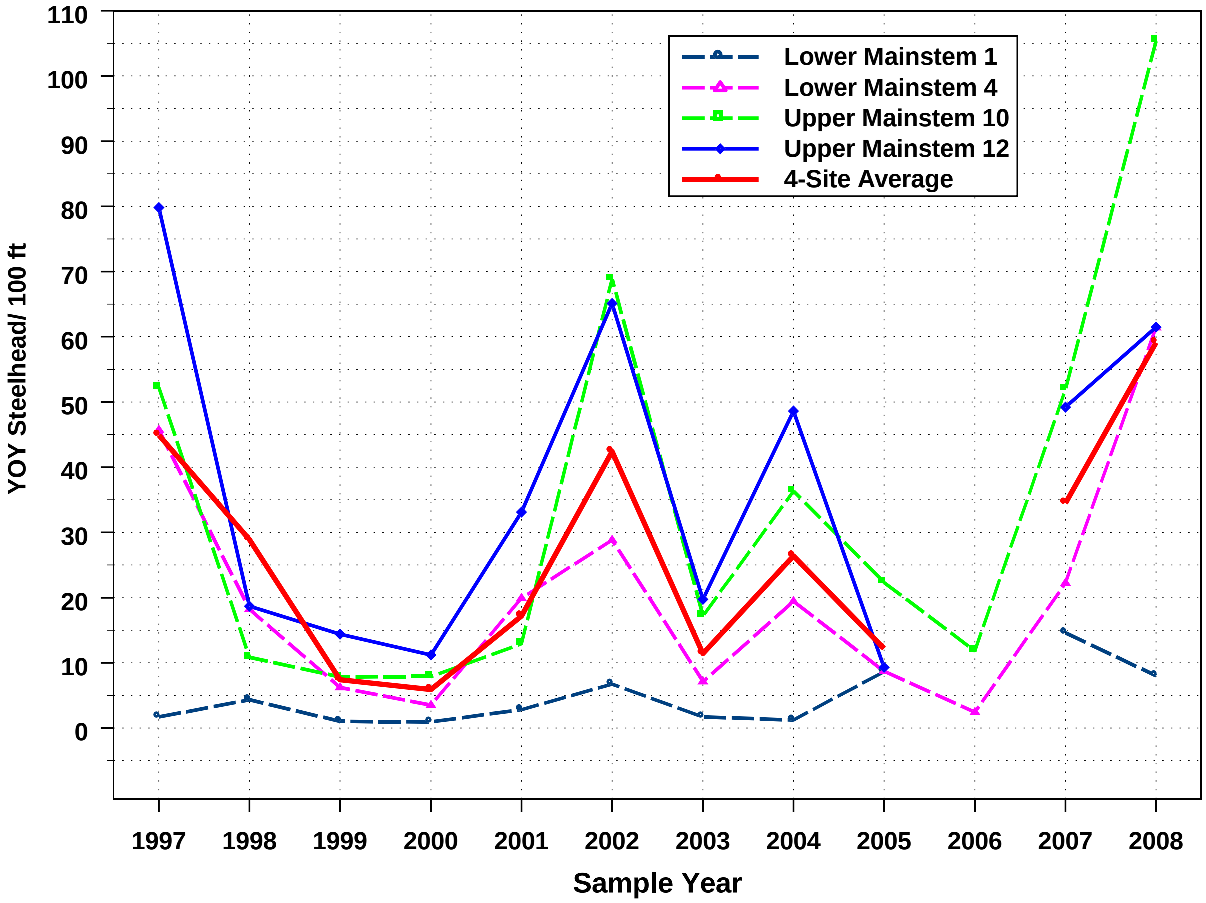


Figure 22. Plot of Annual YOY Densities at East Branch Soquel Creek Sites, 1997-2008.

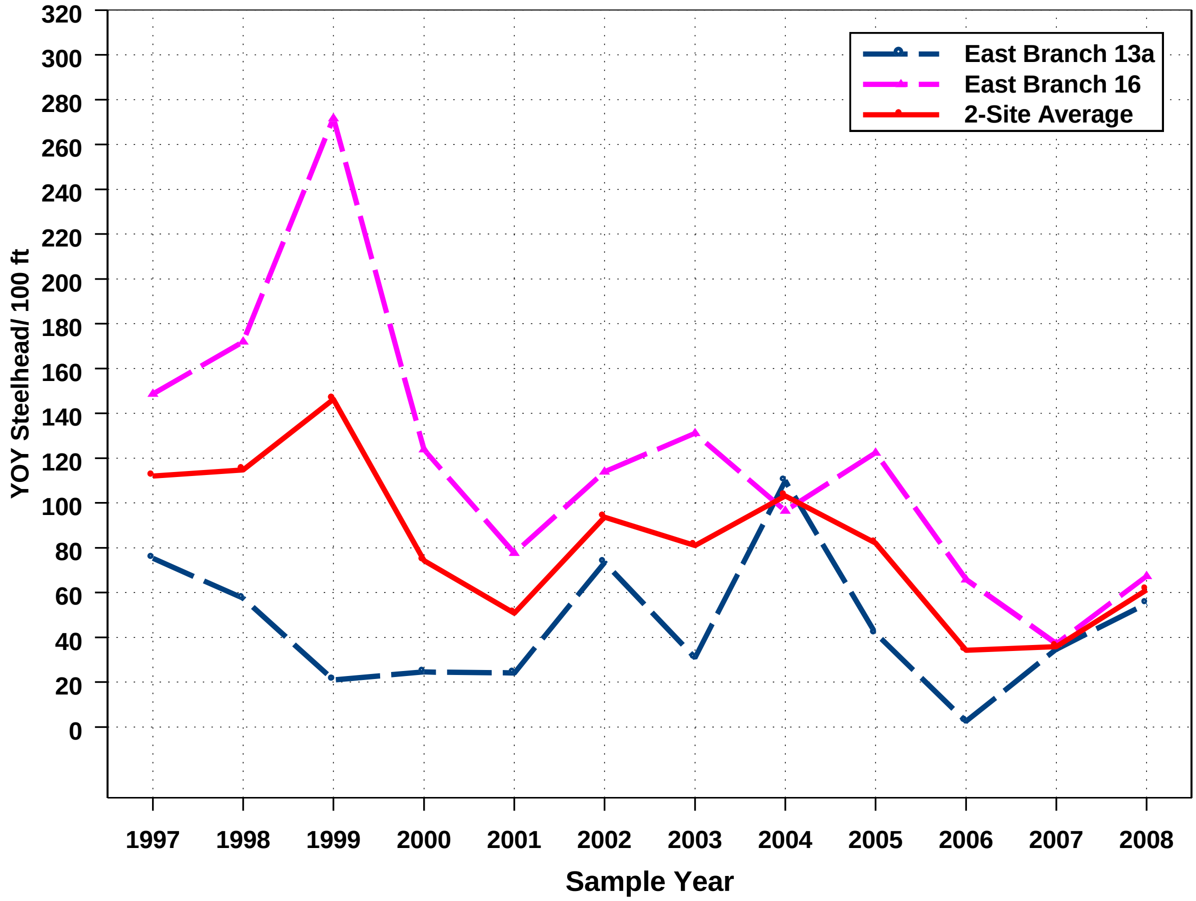


Figure 23. Plot of Annual Size Class II/ III Juvenile Densities at Soquel Mainstem Sites, 1997-2008.

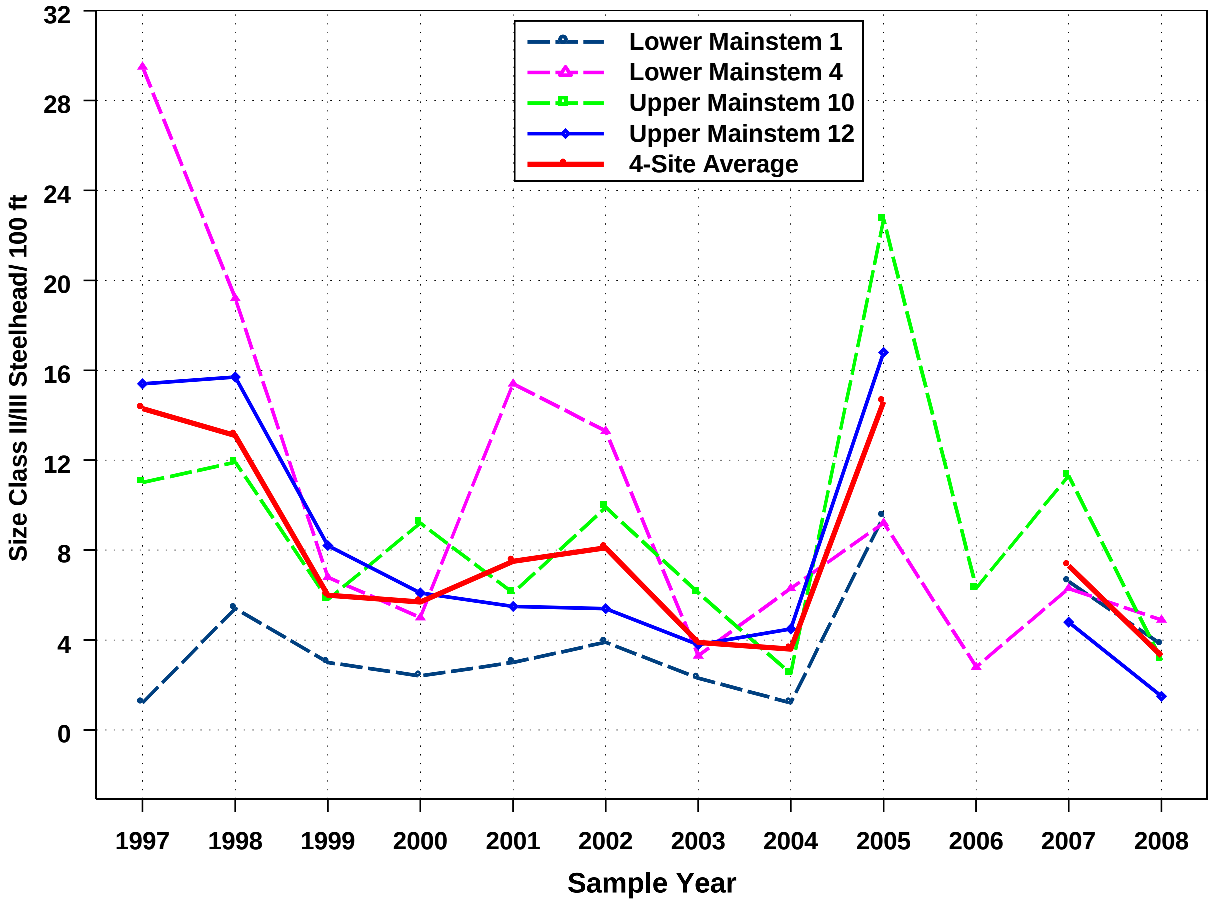


Figure 24. Plot of Annual Size Class II/ III Juvenile Densities at East Branch Soquel Creek Sites, 1997-2008.

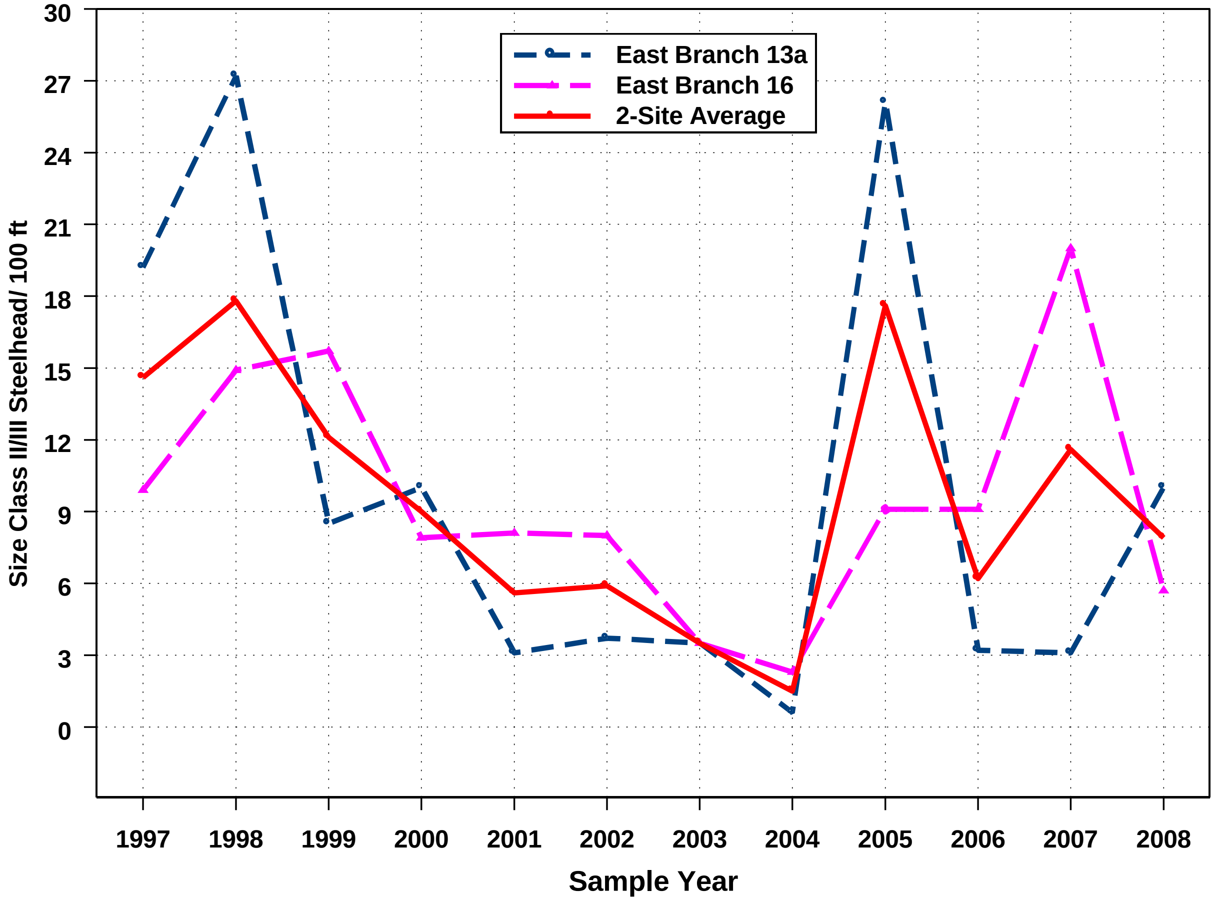


Figure 25. Averaged Mean Monthly Streamflow for May–September, 1997–2008 at the Big Trees Gage on the San Lorenzo River.

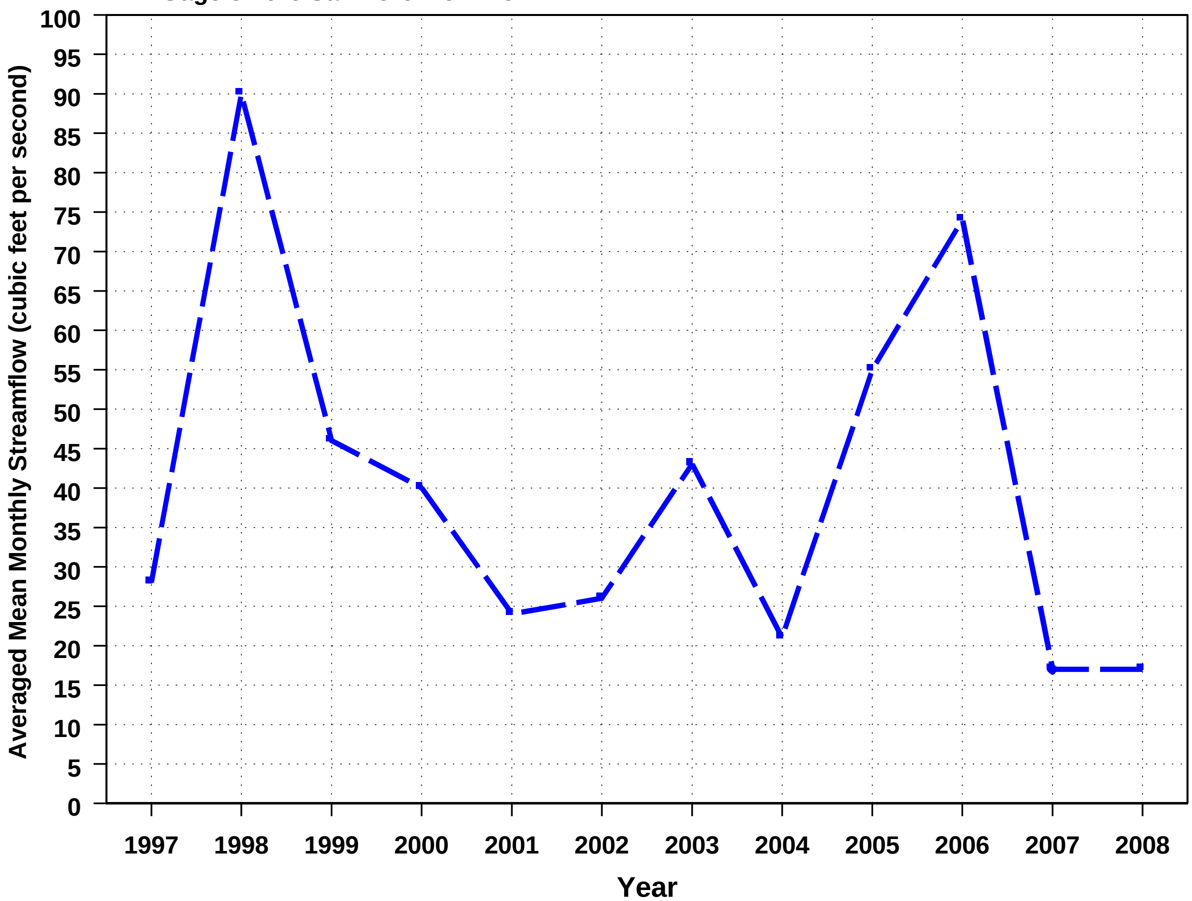


Figure 26. Averaged Mean Monthly Streamflow for May–September, 1997–2008 at the Soquel Village Gage on Soquel Creek.

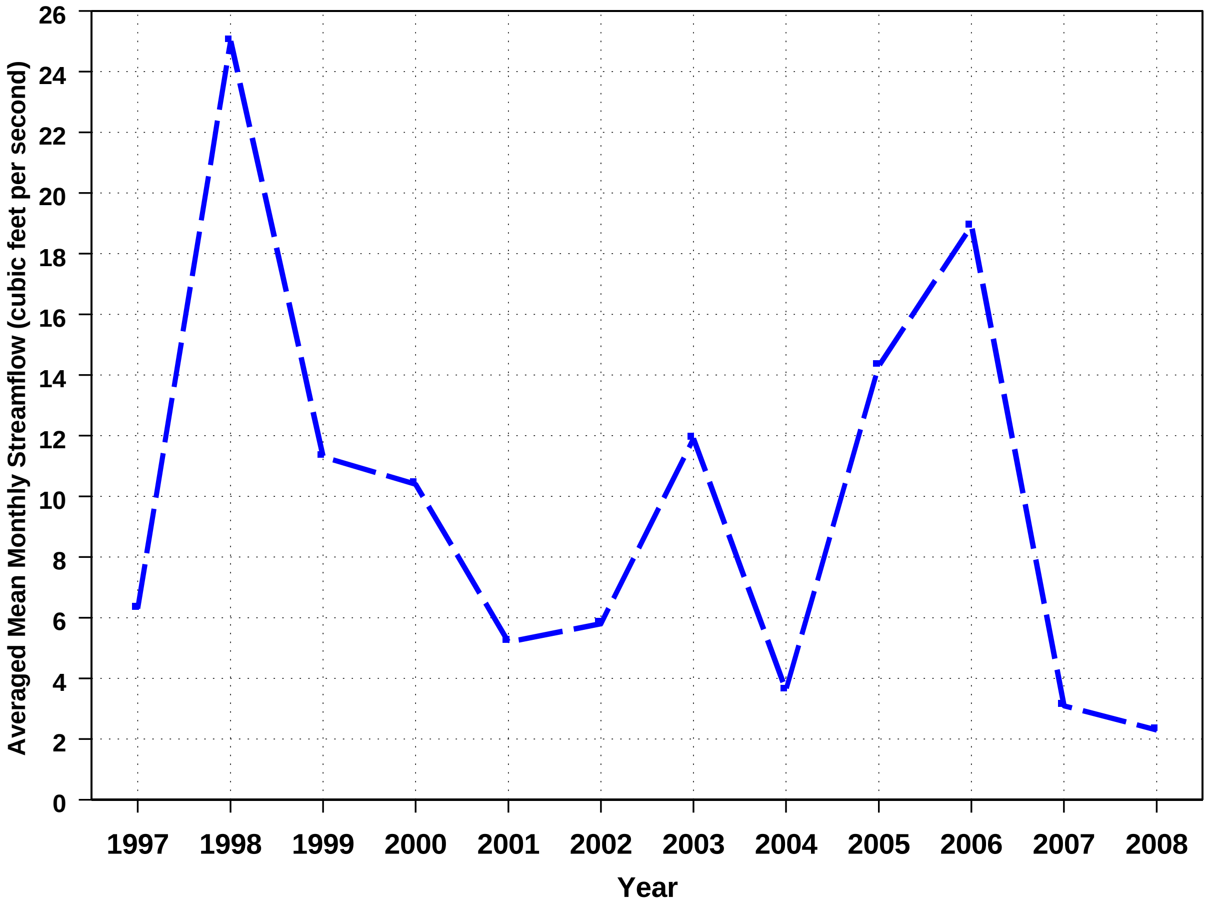


Figure 27. Averaged Maximum and Mean Riffle Depth in Reach 4 of the Lower Mainstem San Lorenzo River, 1997-2002 and 2006-2008.

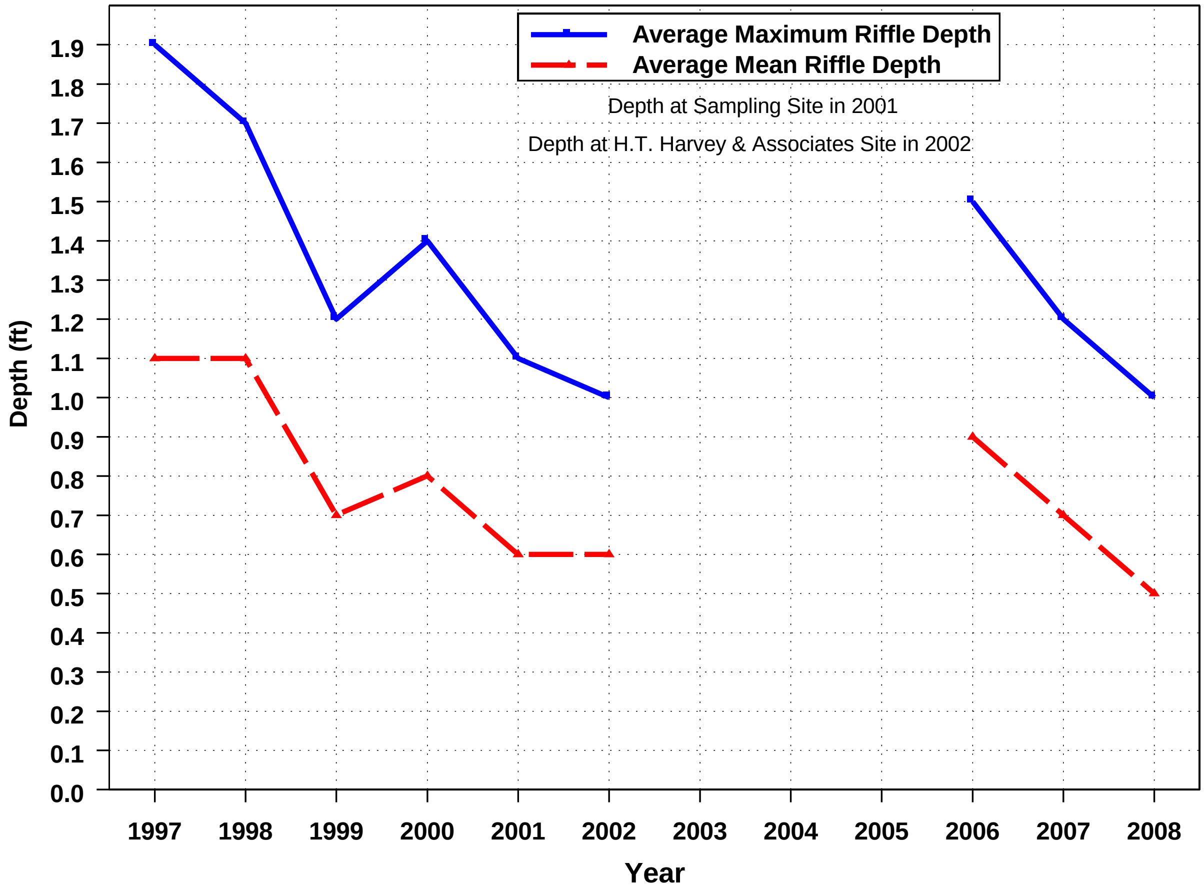


Figure 28. Escape Cover Index for Riffle Habitat in Reach 4 of the Lower Mainstem San Lorenzo River, 1998-2000 and 2006-2008.

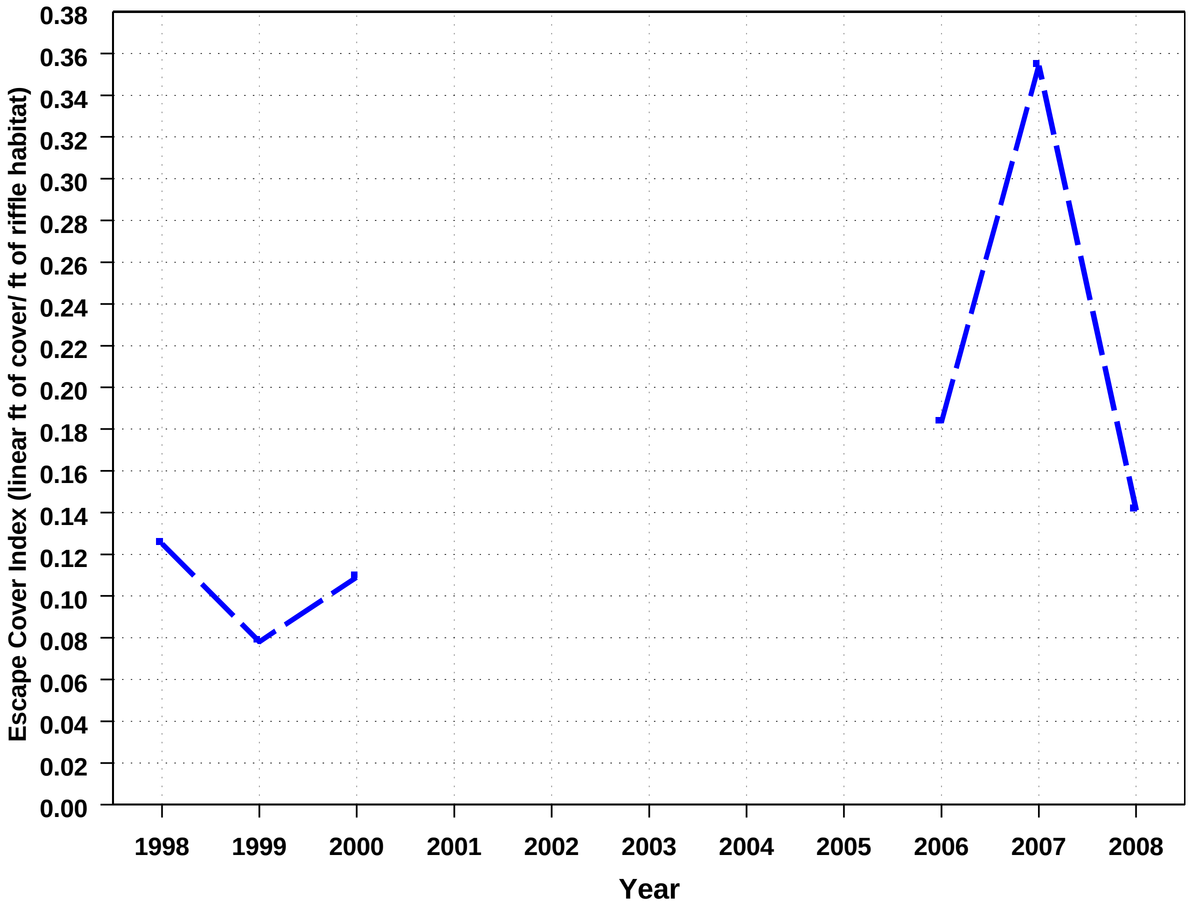


Figure 29. Averaged Percent Fines in Riffle Habitat in Reach 4 of the Lower Mainstem San Lorenzo River, 1997-2001 and 2006-2008.

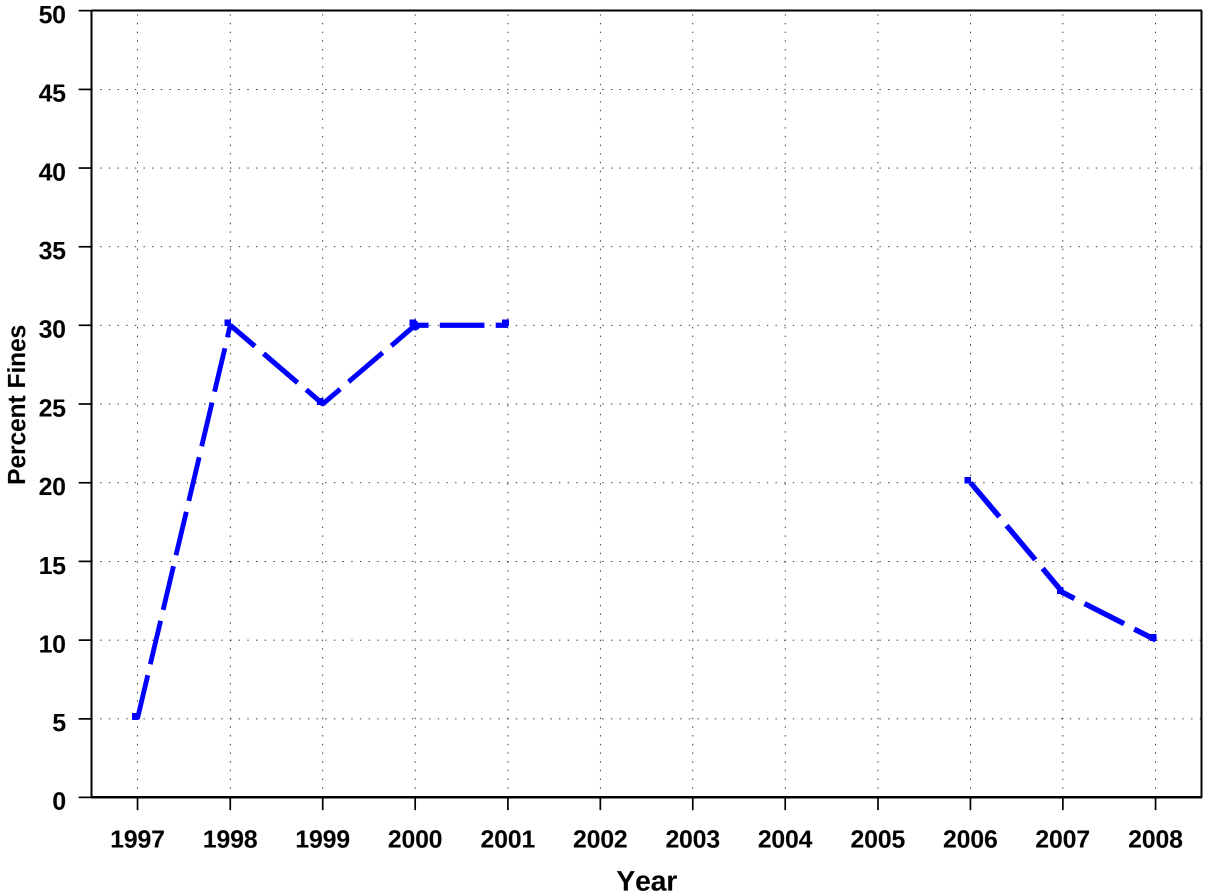


Figure 30. Averaged Maximum and Mean Riffle Depth in Reach 8 of the Middle Mainstem San Lorenzo River, 1997-2008.

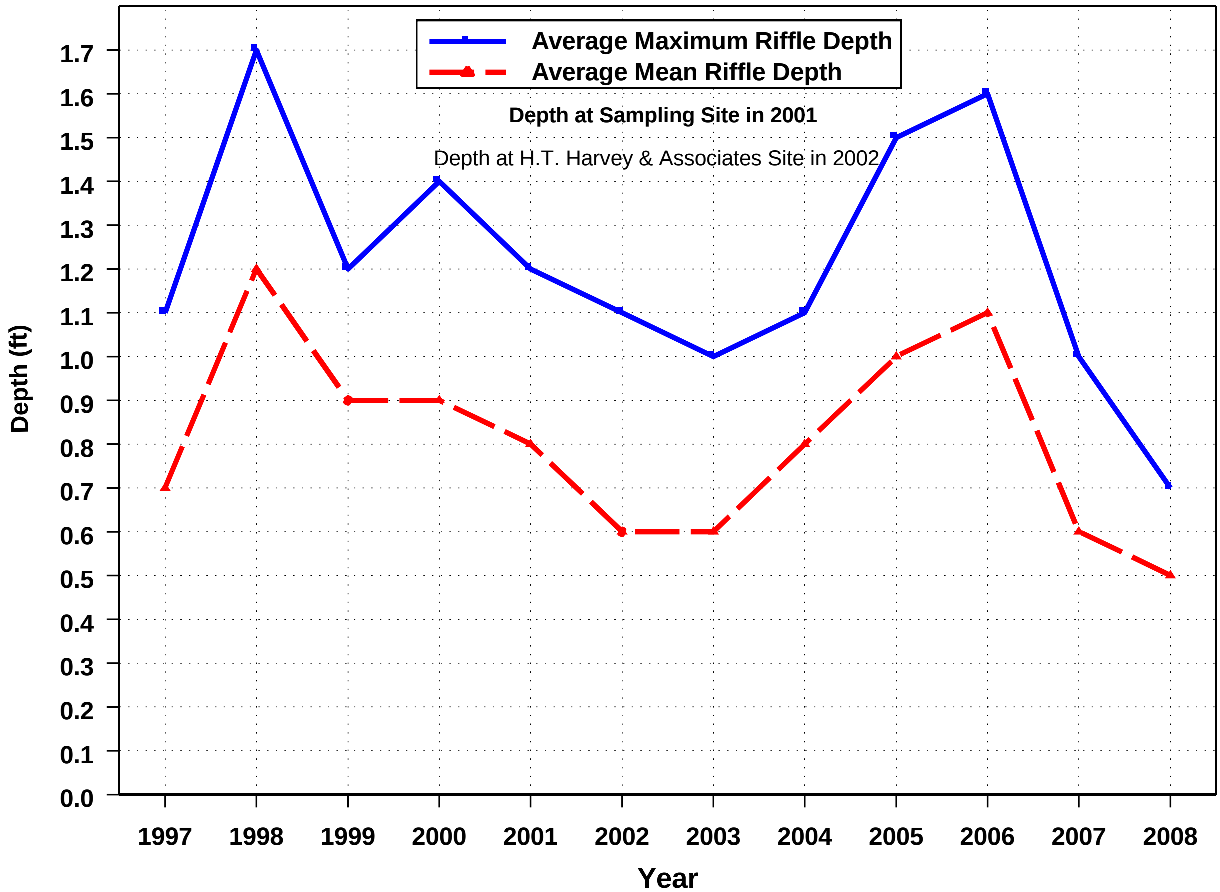


Figure 31. Escape Cover Index for Riffle Habitat in Reach 8 of the Middle Mainstem San Lorenzo River, 1998-2000, 2003 and 2005-2008.

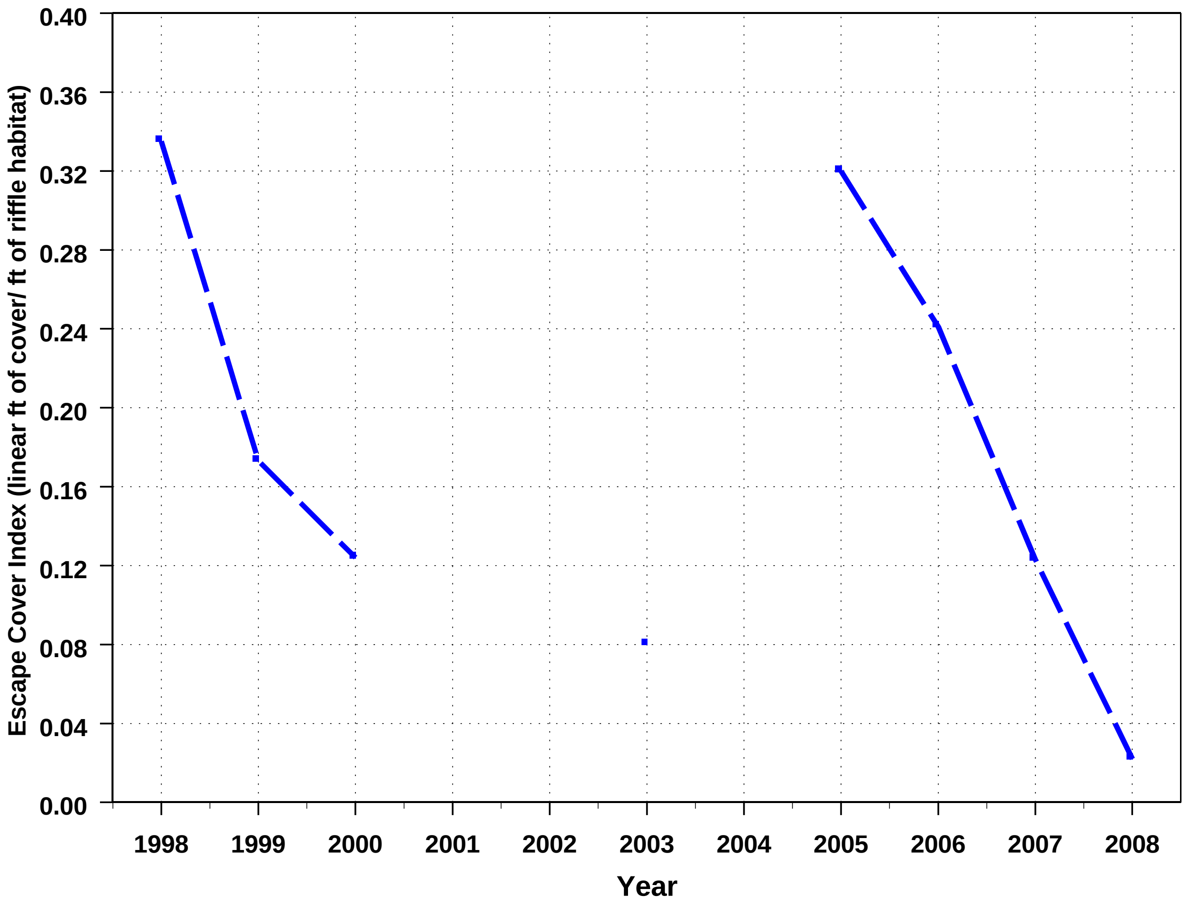


Figure 32. Averaged Percent Fines in Riffle Habitat in Reach 8 of the Middle Mainstem San Lorenzo River, 1997-2001, 2003 and 2005-2008.

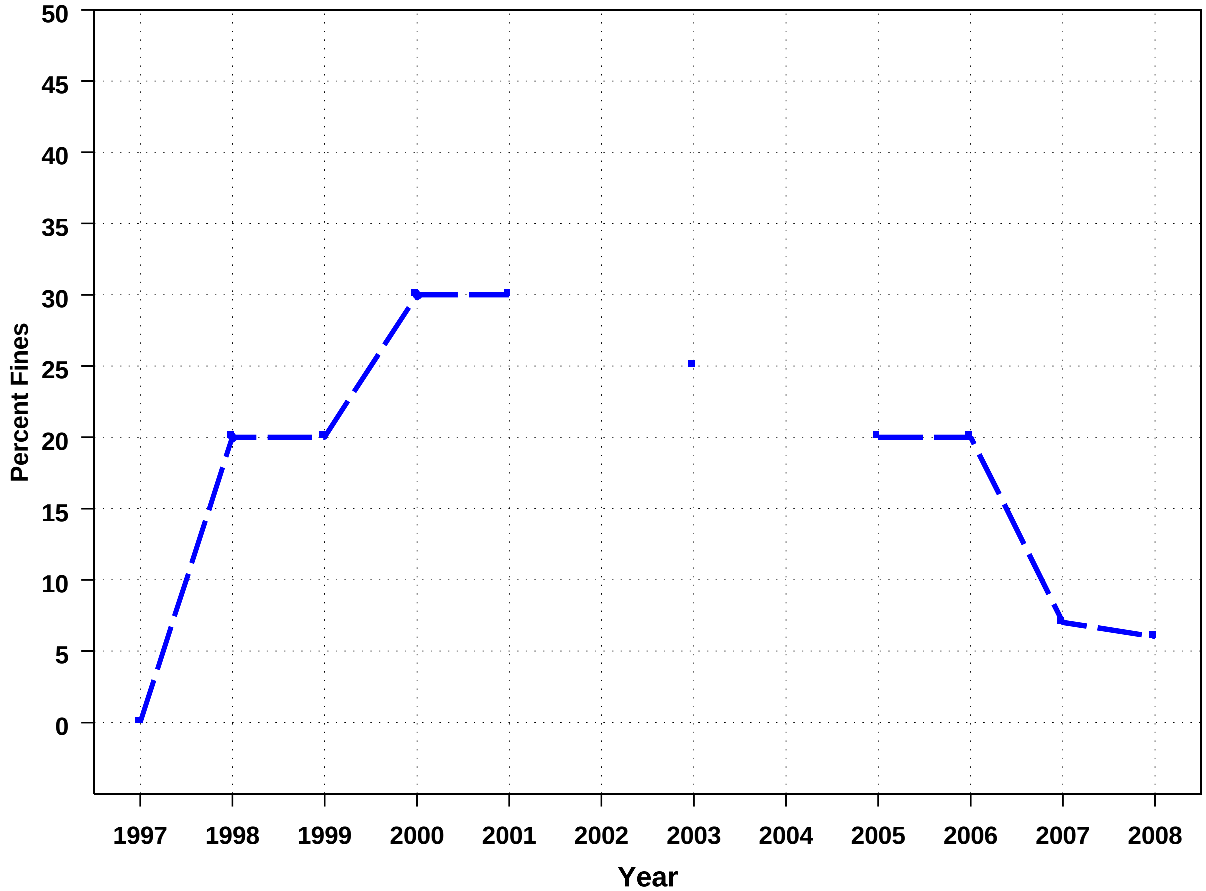


Figure 33. Averaged Maximum and Mean Pool Depth in Reach 13d of Zayante Creek, 1998-2000, 2003 and 2005-2008.

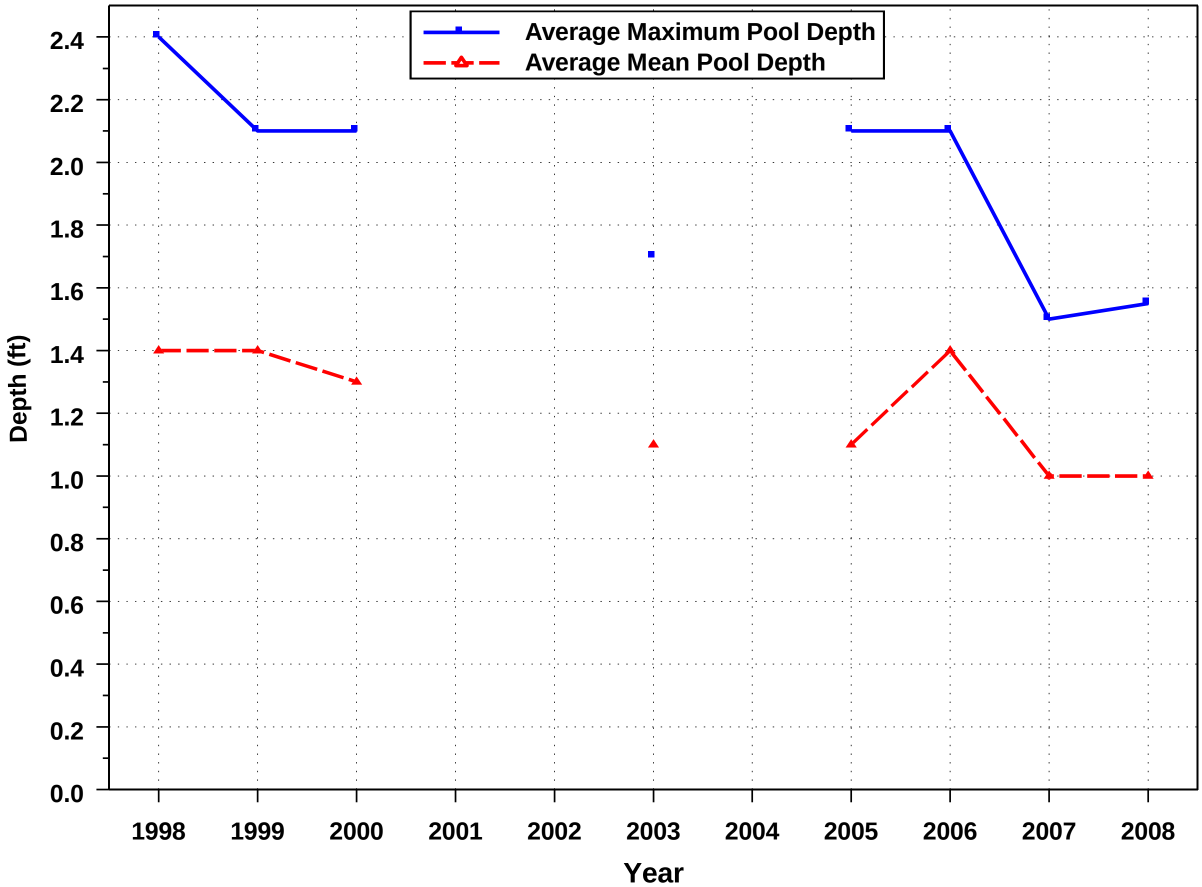


Figure 34a. Escape Cover Index for Pool Habitat in Reach 13d of Zayante Creek, 1998-2000, 2003 and 2005-2008.

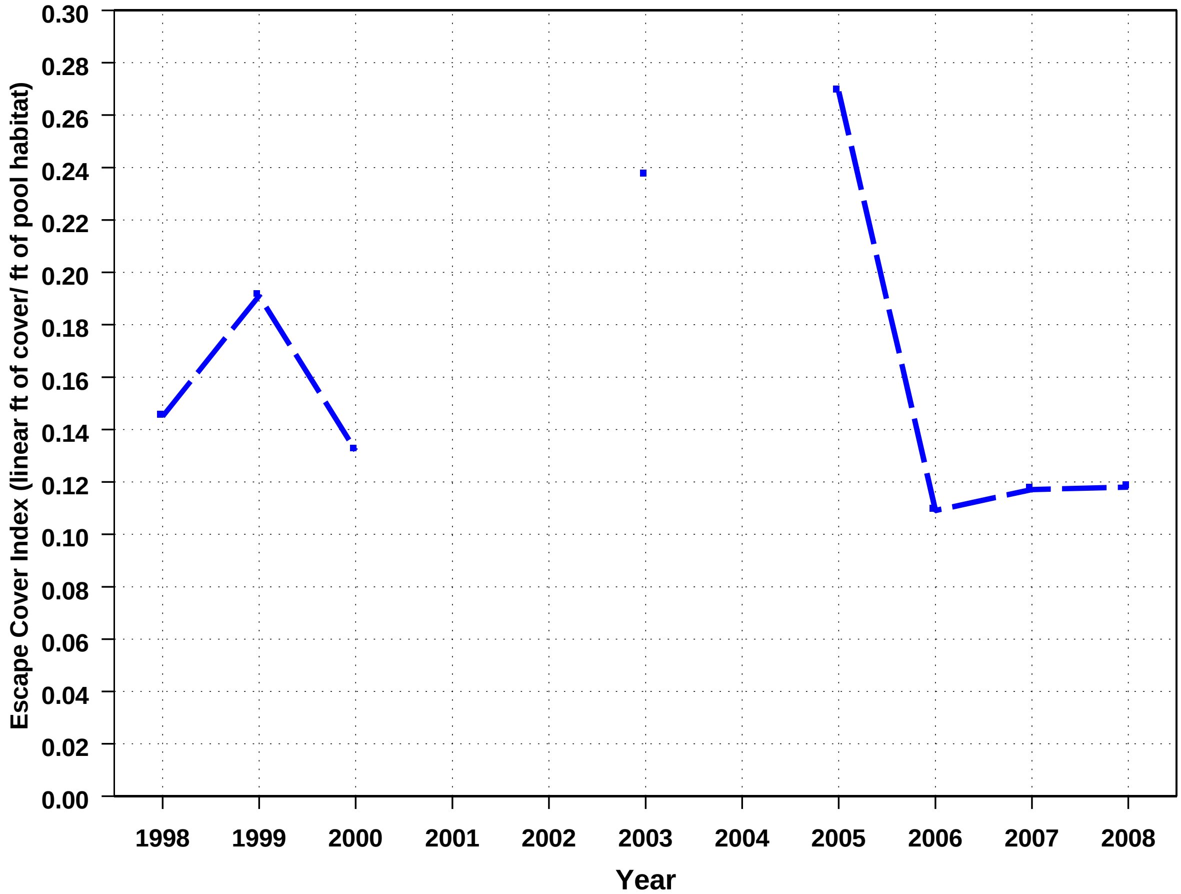


Figure 34b. Escape Cover Index for Pool Habitat at Site 13d in Zayante Creek, 1998-2001 and 2003-2008.

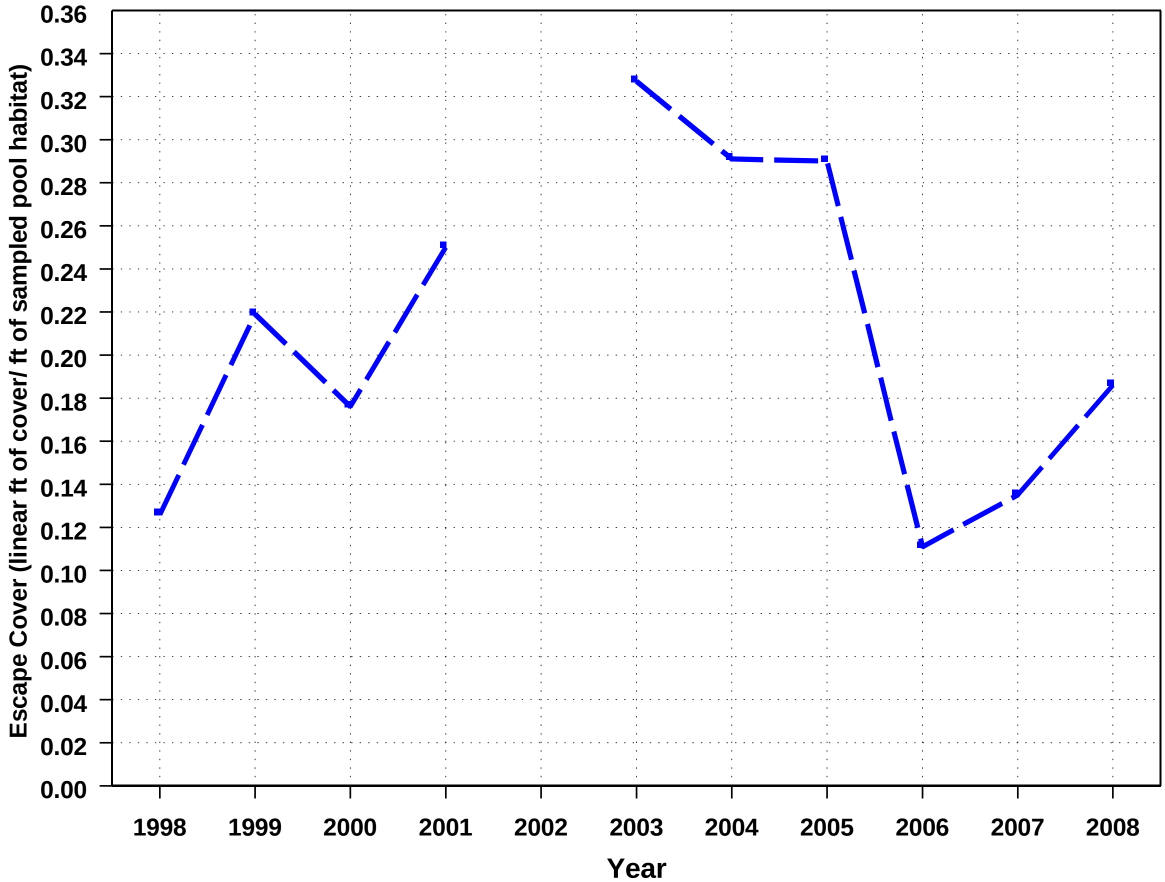


Figure 35. Averaged Percent Fines in Step-Run Habitat in Reach 13d of Zayante Creek, 1998-2001, 2003-2008.

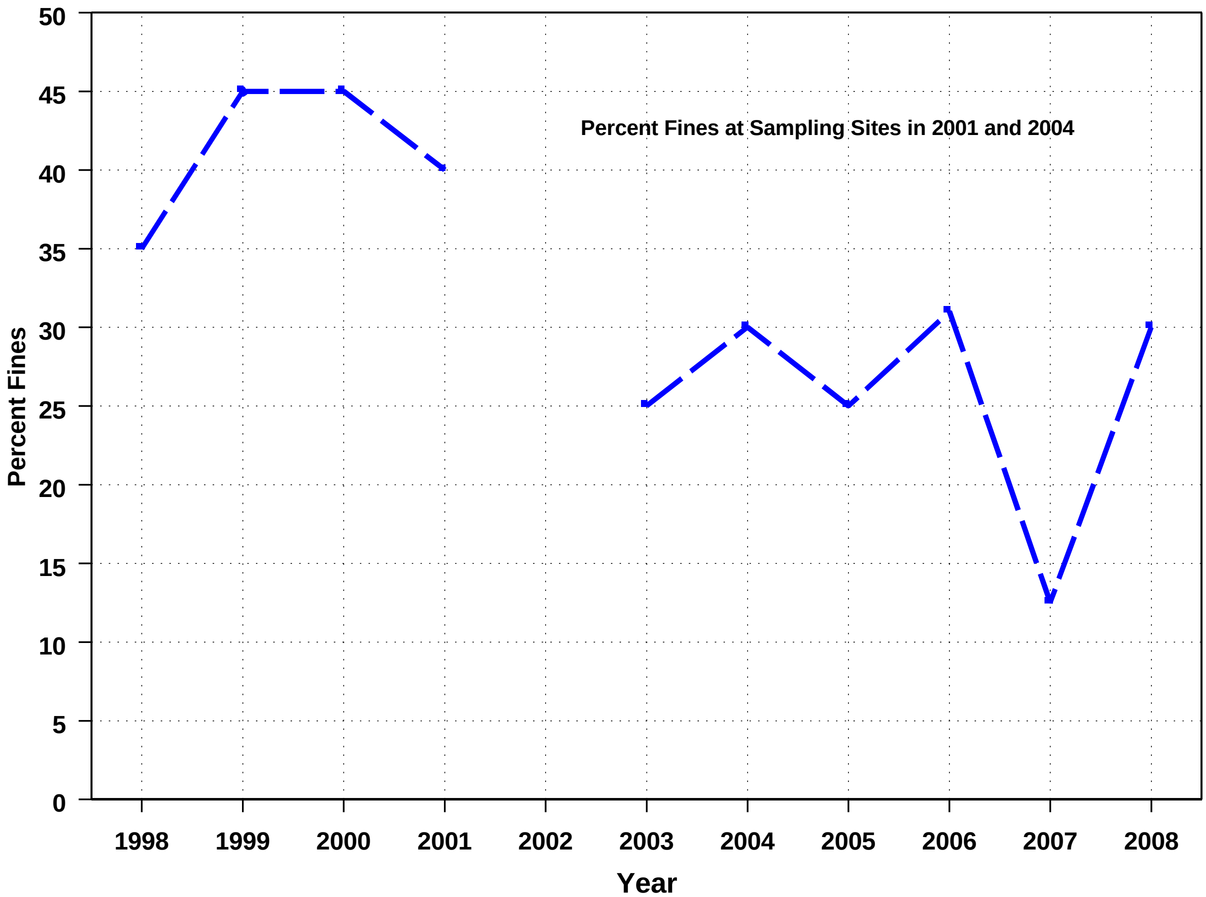


Figure 36. Averaged Maximum and Mean Pool Depth in Reach 17a of Boulder Creek, 1998-2000 and 2005-2008.

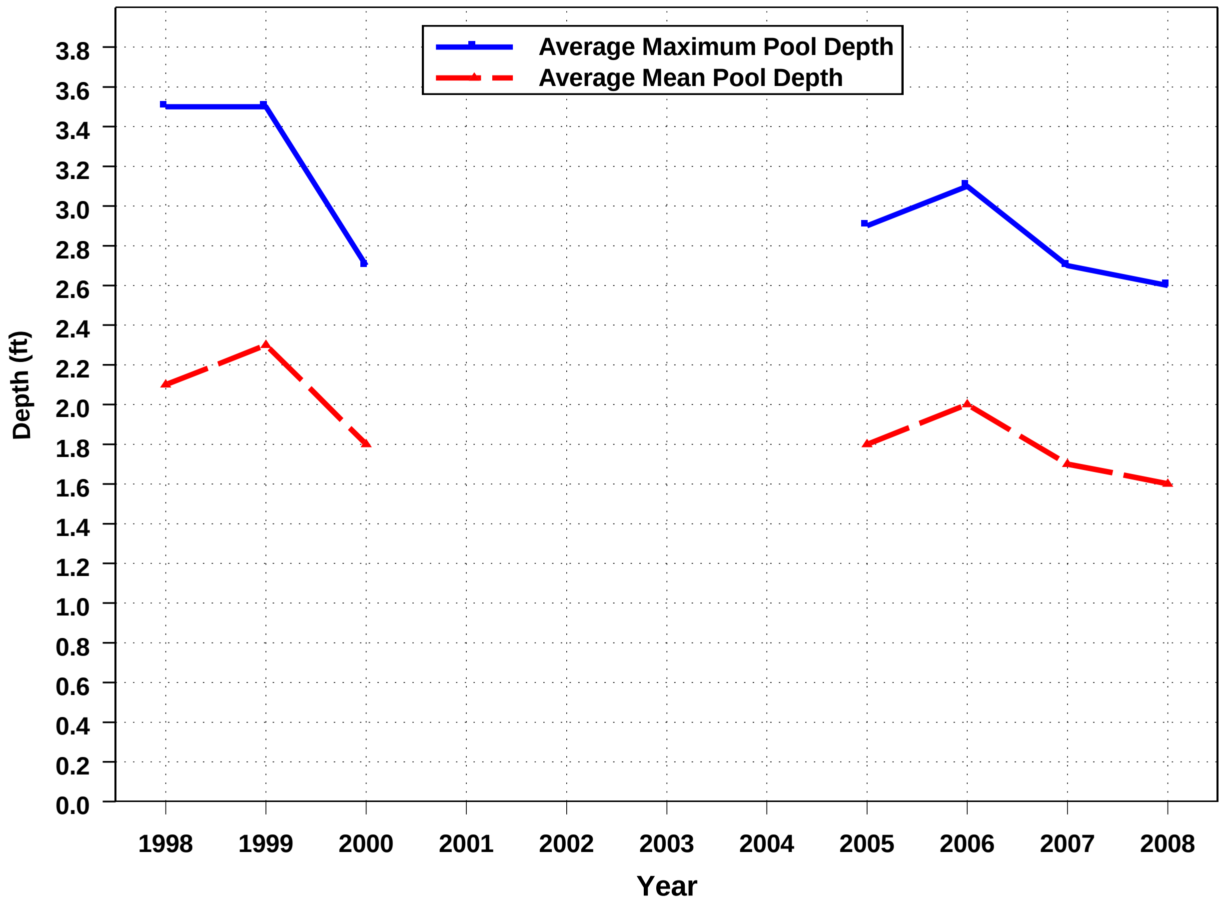


Figure 37a. Escape Cover Index for Pool Habitat in Reach 17a of Boulder Creek, 1998-2000 and 2005-2008.

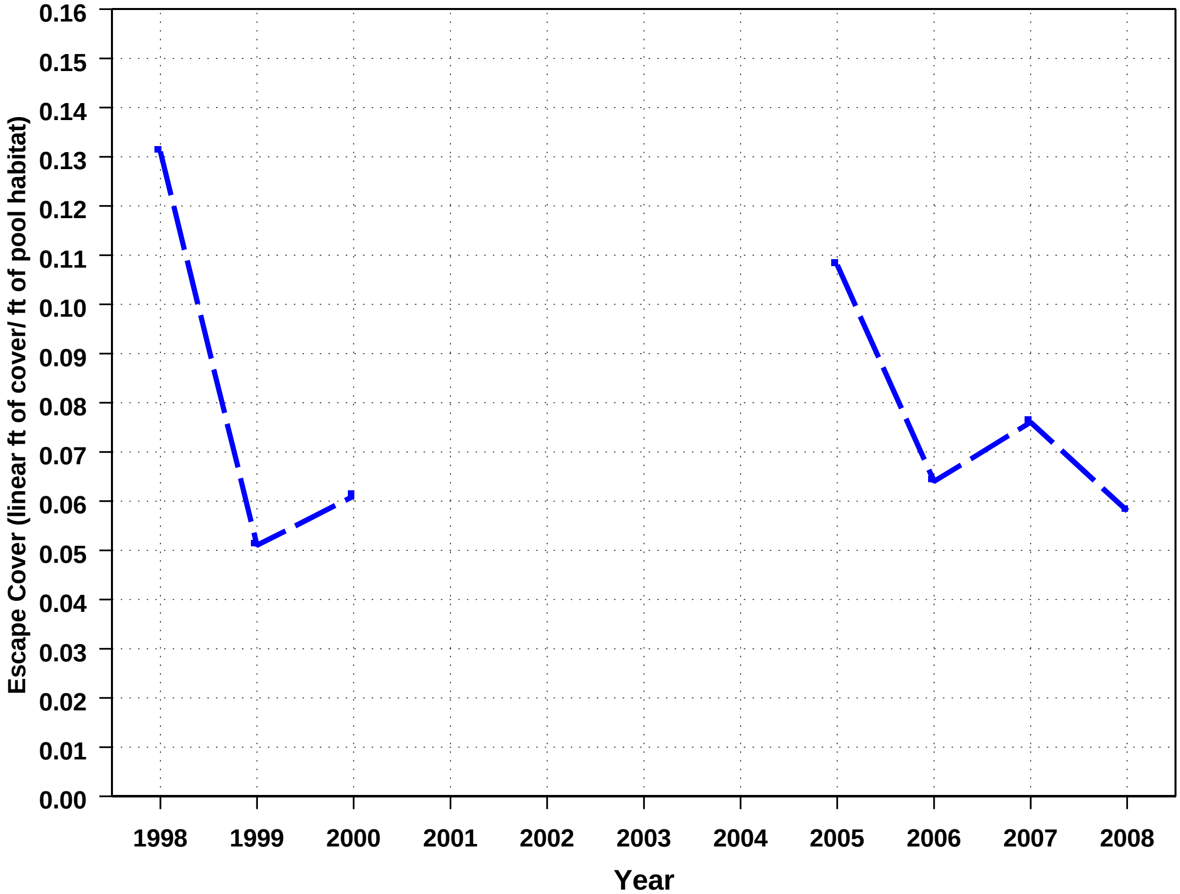


Figure 37b. Escape Cover Index for Pool Habitat at Site 17a in Boulder Creek, 1997-2001 and 2003-2008.

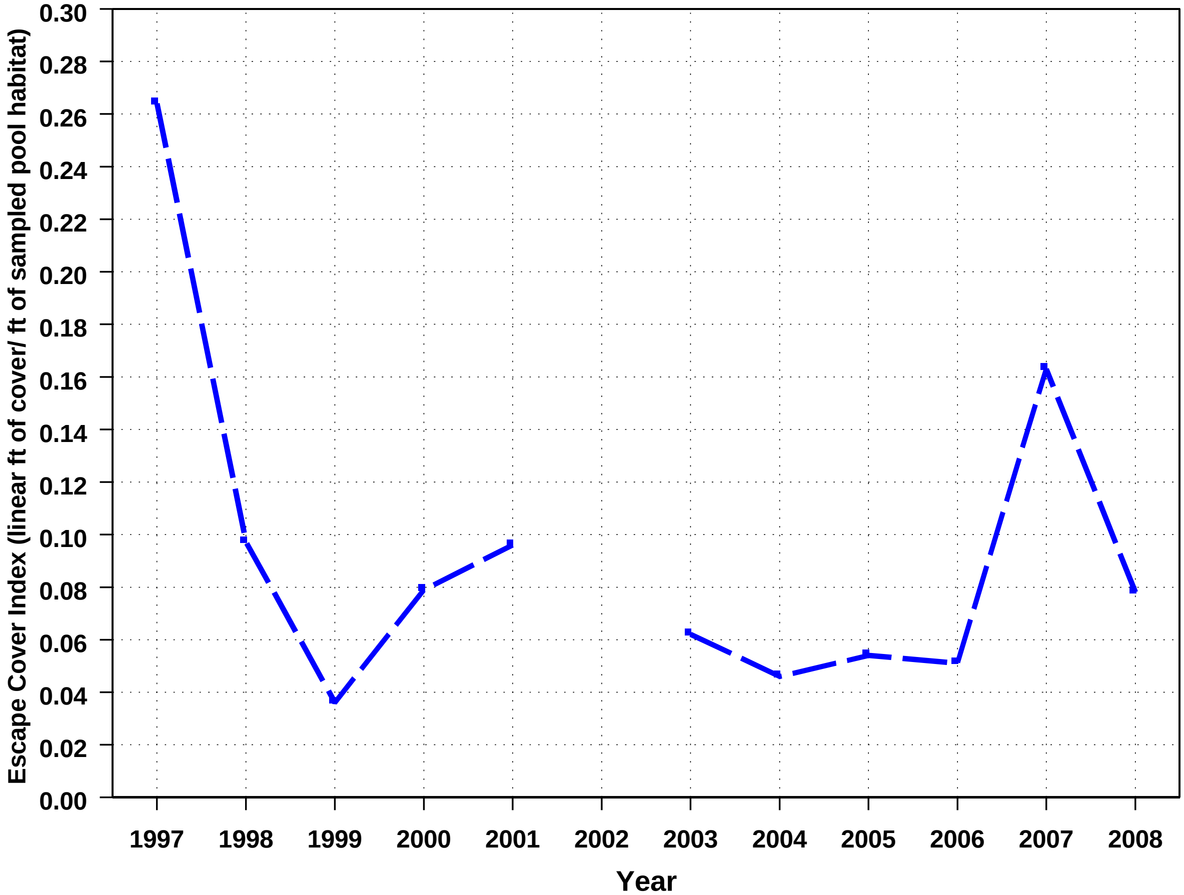


Figure 38. Averaged Percent Fines in Step-Run Habitat in Reach 17a of Boulder Creek, 1998-2001 and 2003-2008.

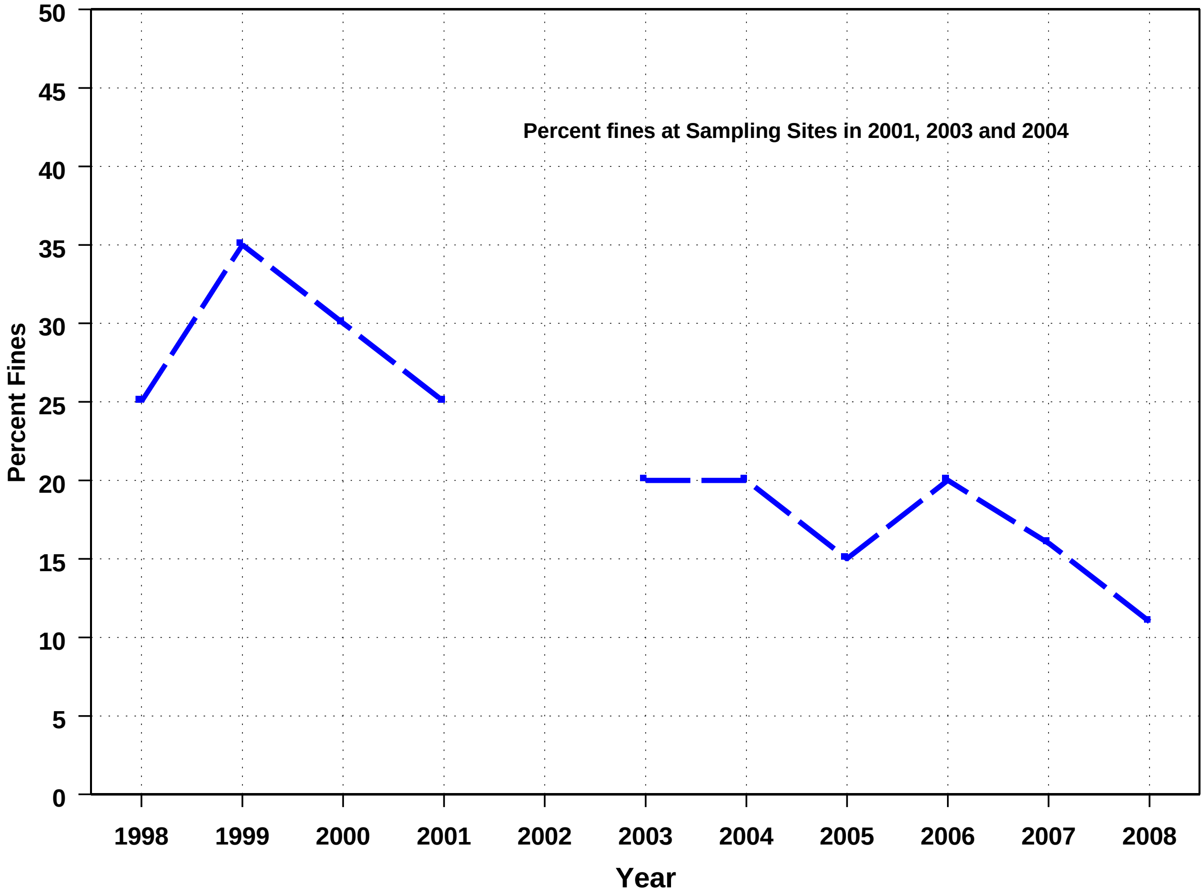


Figure 39. Averaged Maximum and Mean Pool Depth in Reach 1 of Soquel Creek, 1997-2008.

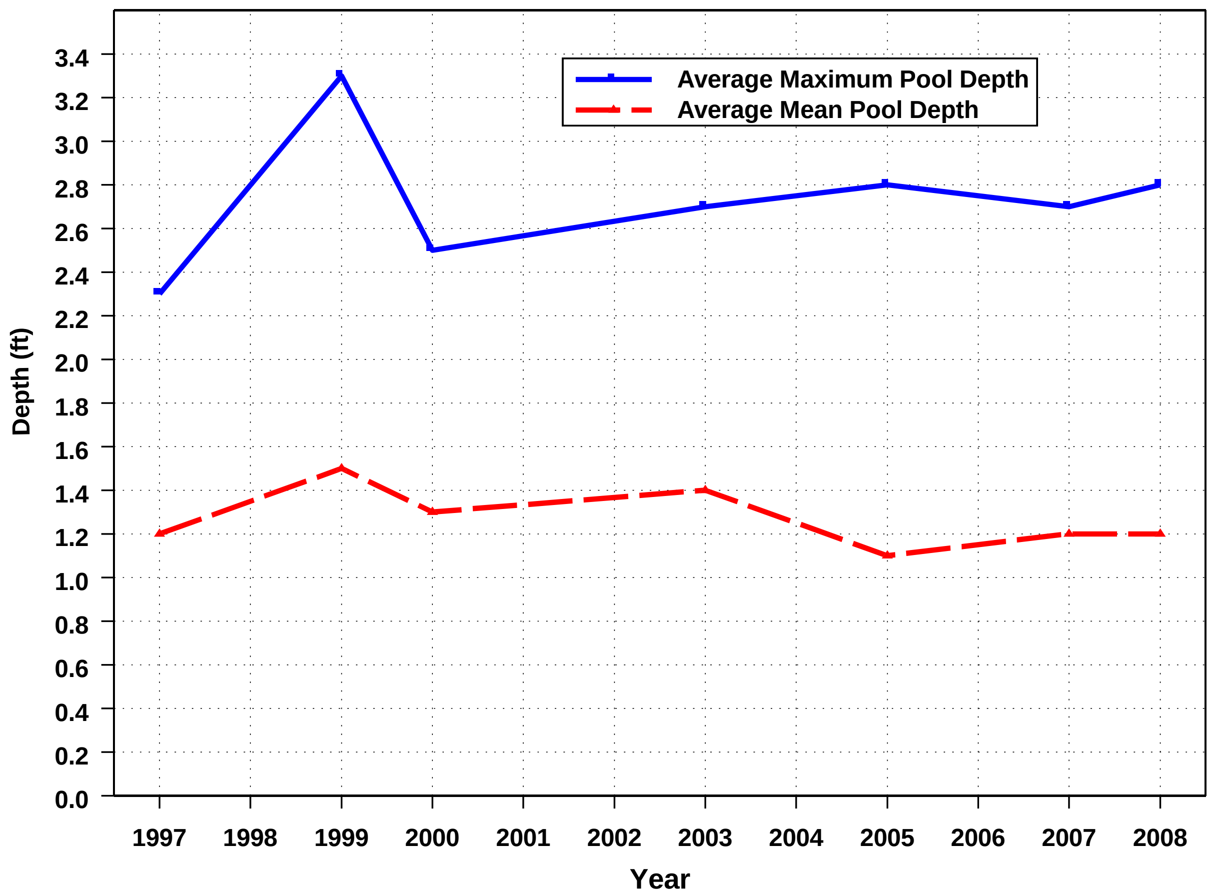


Figure 40a. Escape Cover Index for Pool Habitat in Reach 1 of Soquel Creek, 1997-2008.

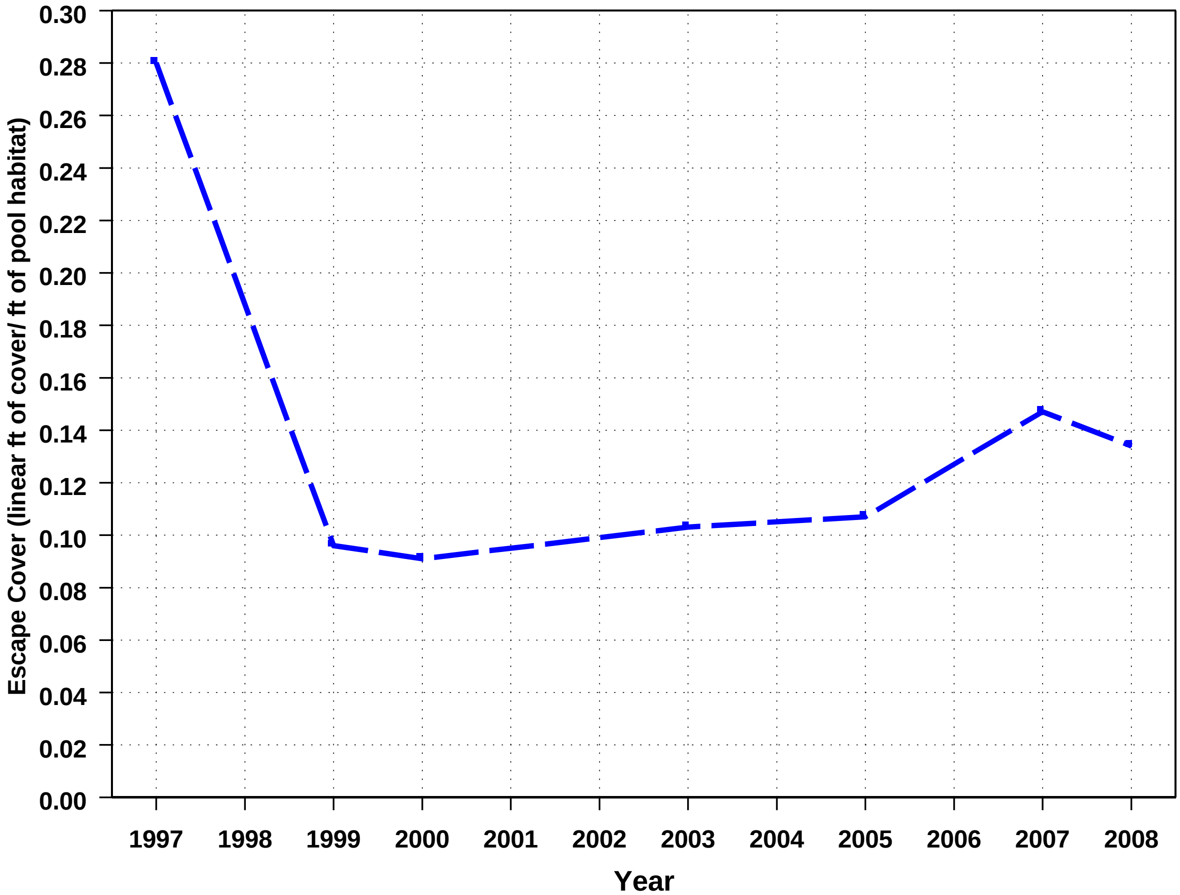


Figure 40b. Escape Cover Index for Pool Habitat at Site 1 in Soquel Creek, 1997-2006 and 2008.

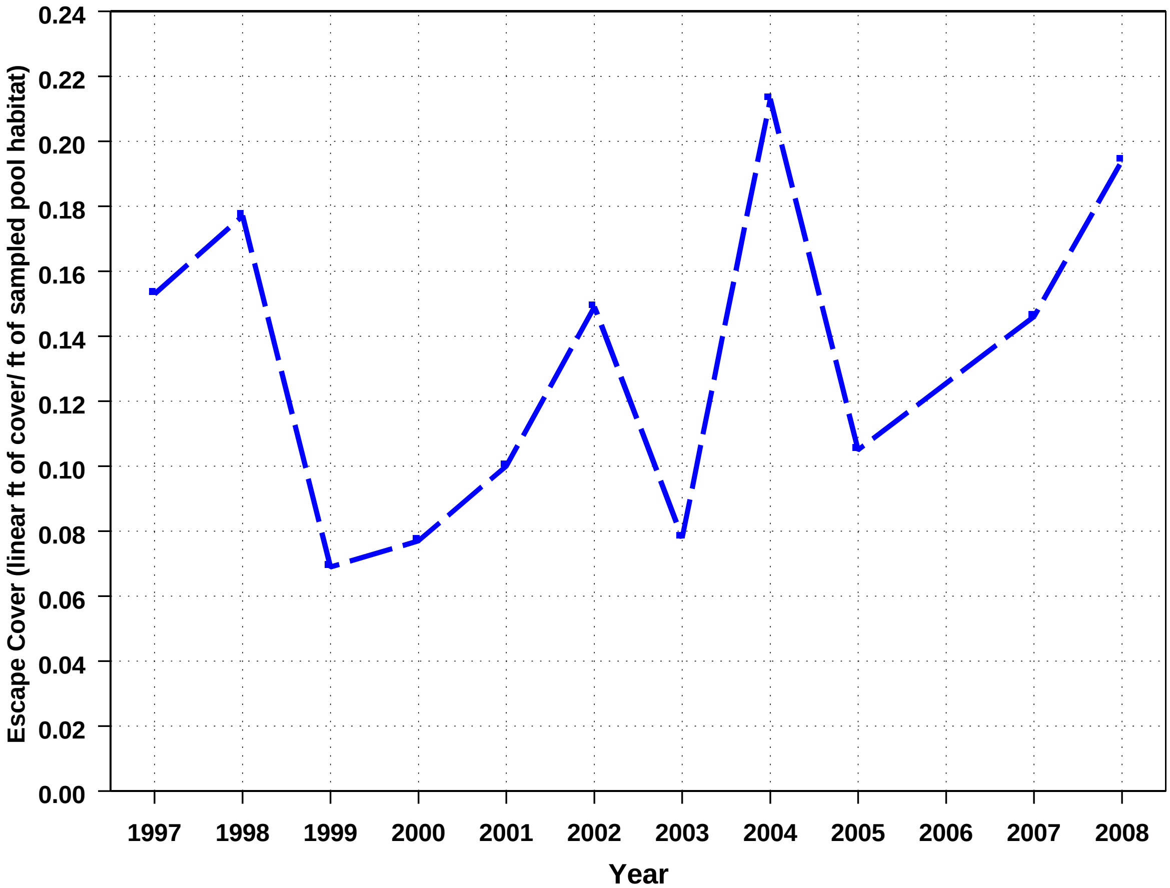


Figure 41. Average Embeddedness for Riffle and Run Habitat at the Sampling Site in Reach 1, of Soquel Creek, 1997-2008.

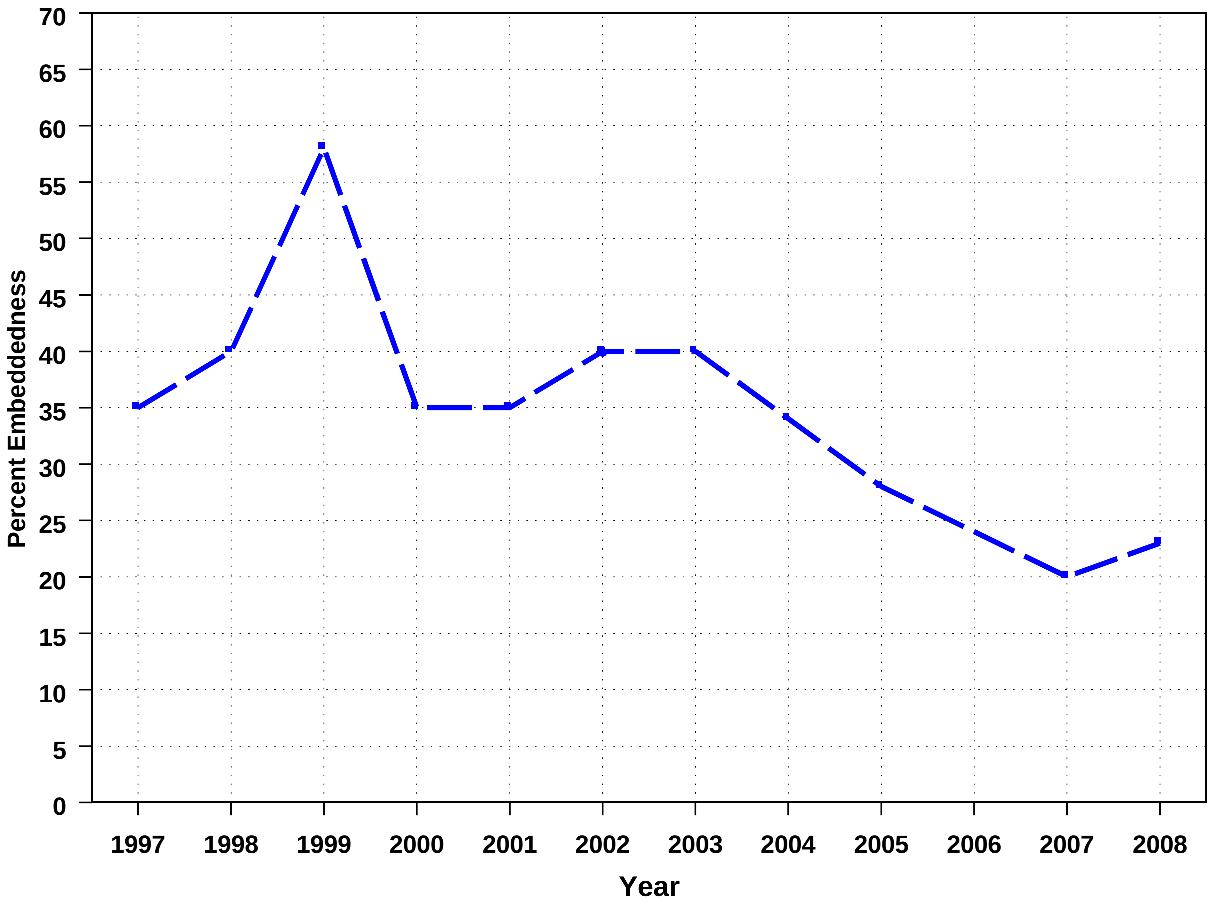


Figure 42. Averaged Maximum and Mean Pool Depth in Reach 7 (Above Moores Gulch) of Soquel Creek, 1997-2008.

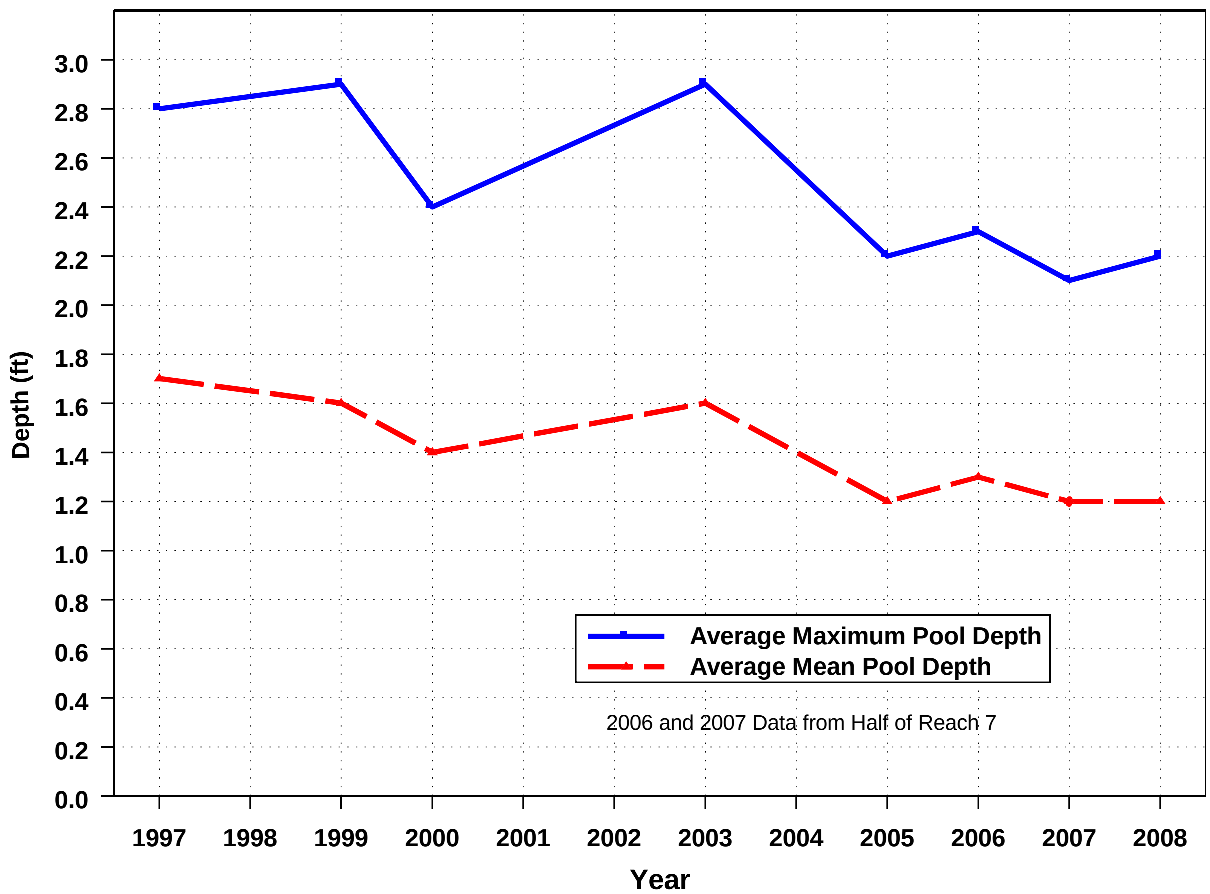


Figure 43a. Escape Cover Index for Pool Habitat in Reach 7 (Above Moores Gulch) of Soquel Creek, 1997-2008.

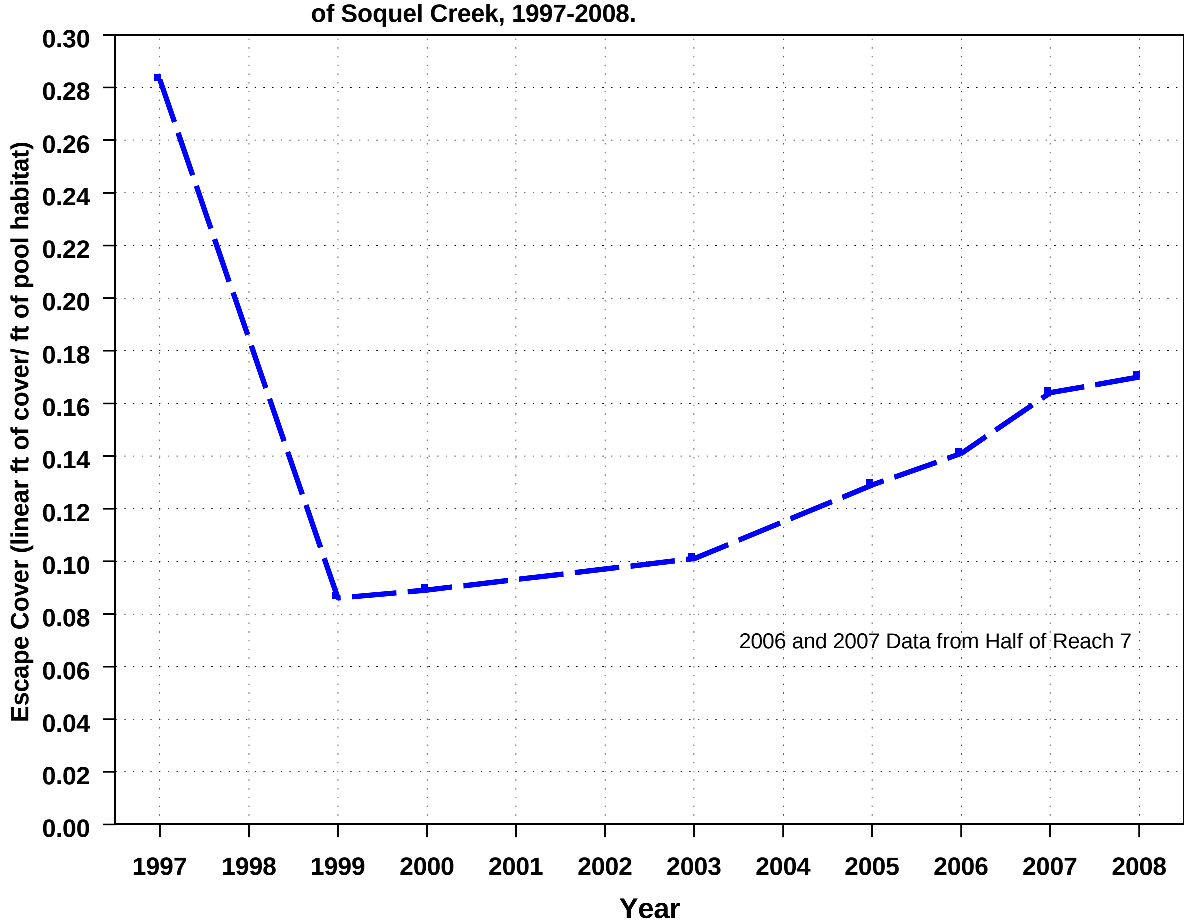


Figure 43b. Escape Cover Index for Pool Habitat at Site 10 (Reach 7 Above Moores Gulch) in Soquel Creek, 1997-2008.

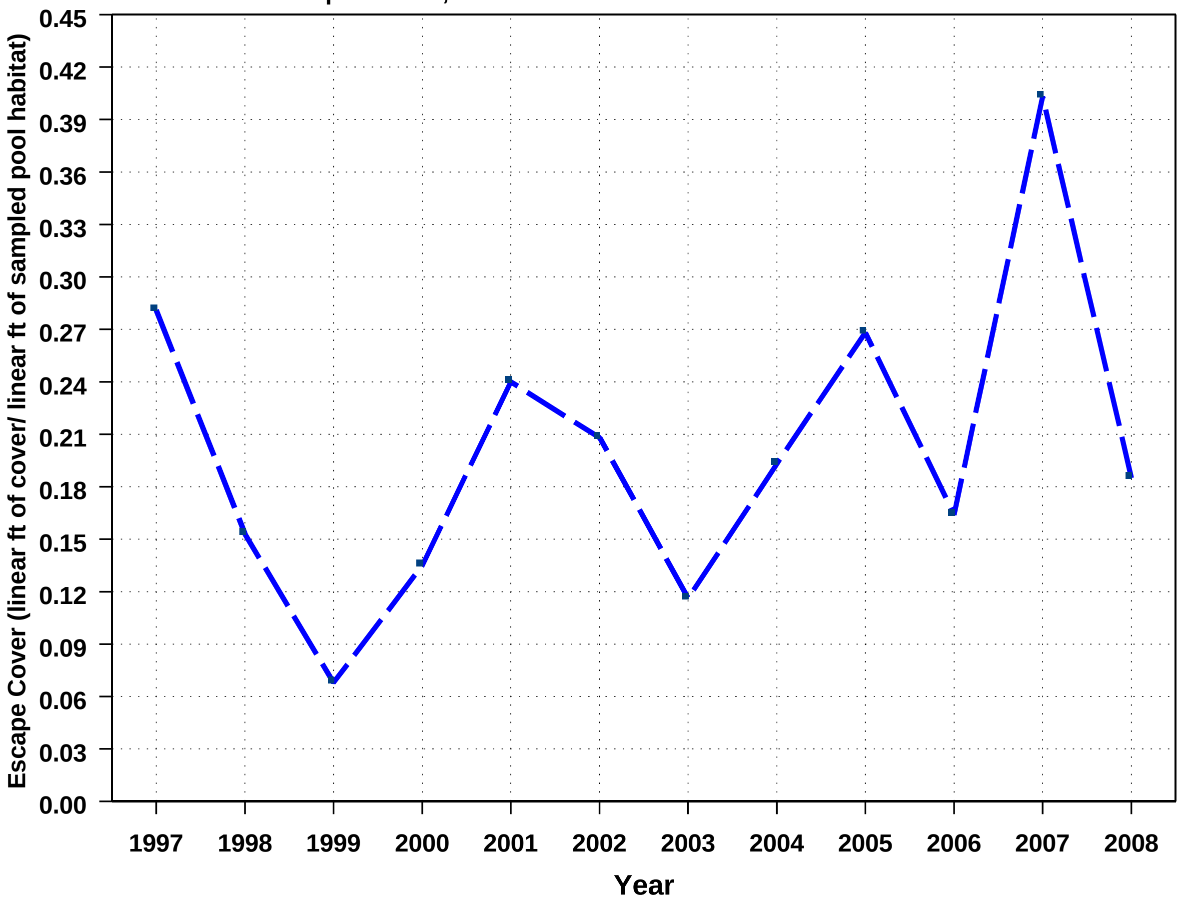


Figure 44. Average Embeddedness for Riffle and Run Habitat at Sampling Site 10 in Reach 7 (Above Moores Gulch) of Soquel Creek, 1997-2008.

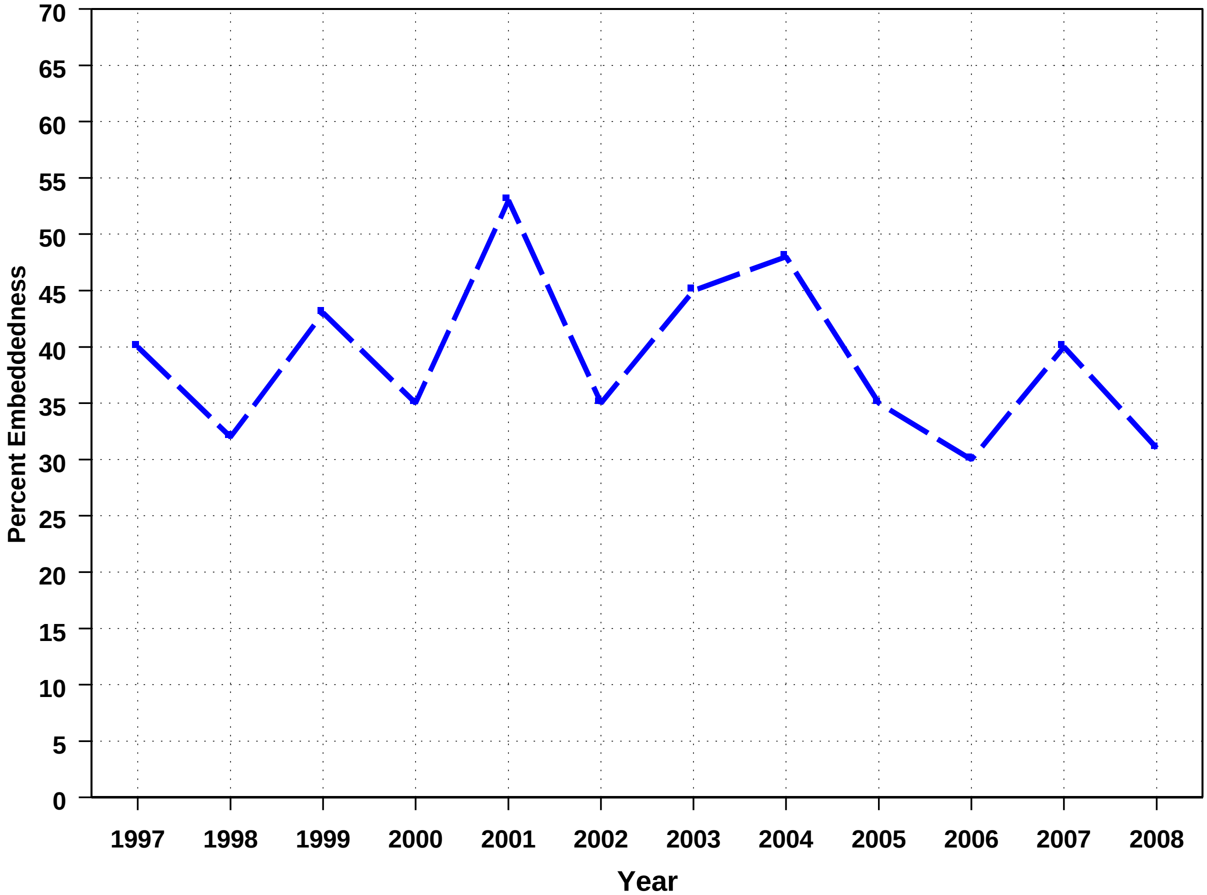


Figure 45. Average Maximum and Mean Pool Depth in Reach 9a (below Mill Pond) of East Branch Soquel Creek, 2000 and 2005-2008.

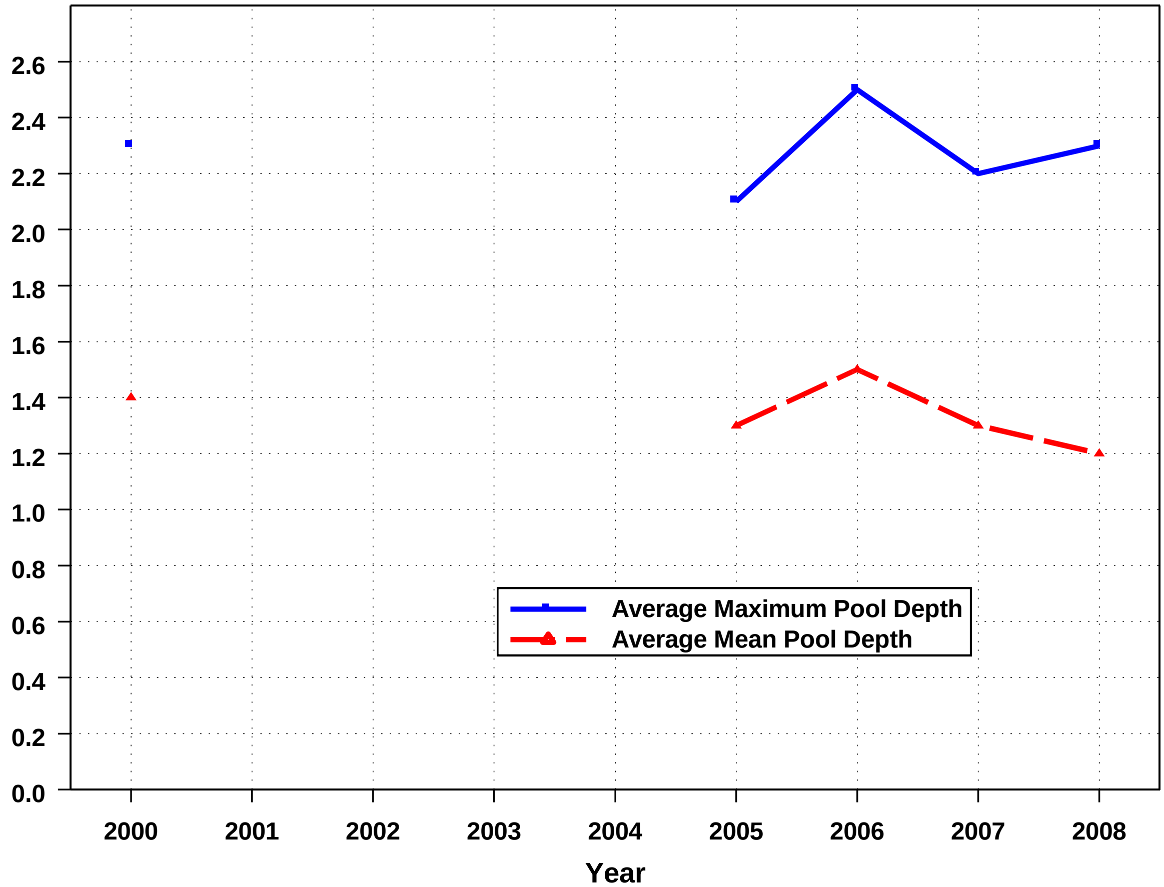


Figure 46a. Escape Cover Index for Pool Habitat in Reach 9a (below Mill Pond) of East Branch Soquel Creek, 2000 and 2005-2008.

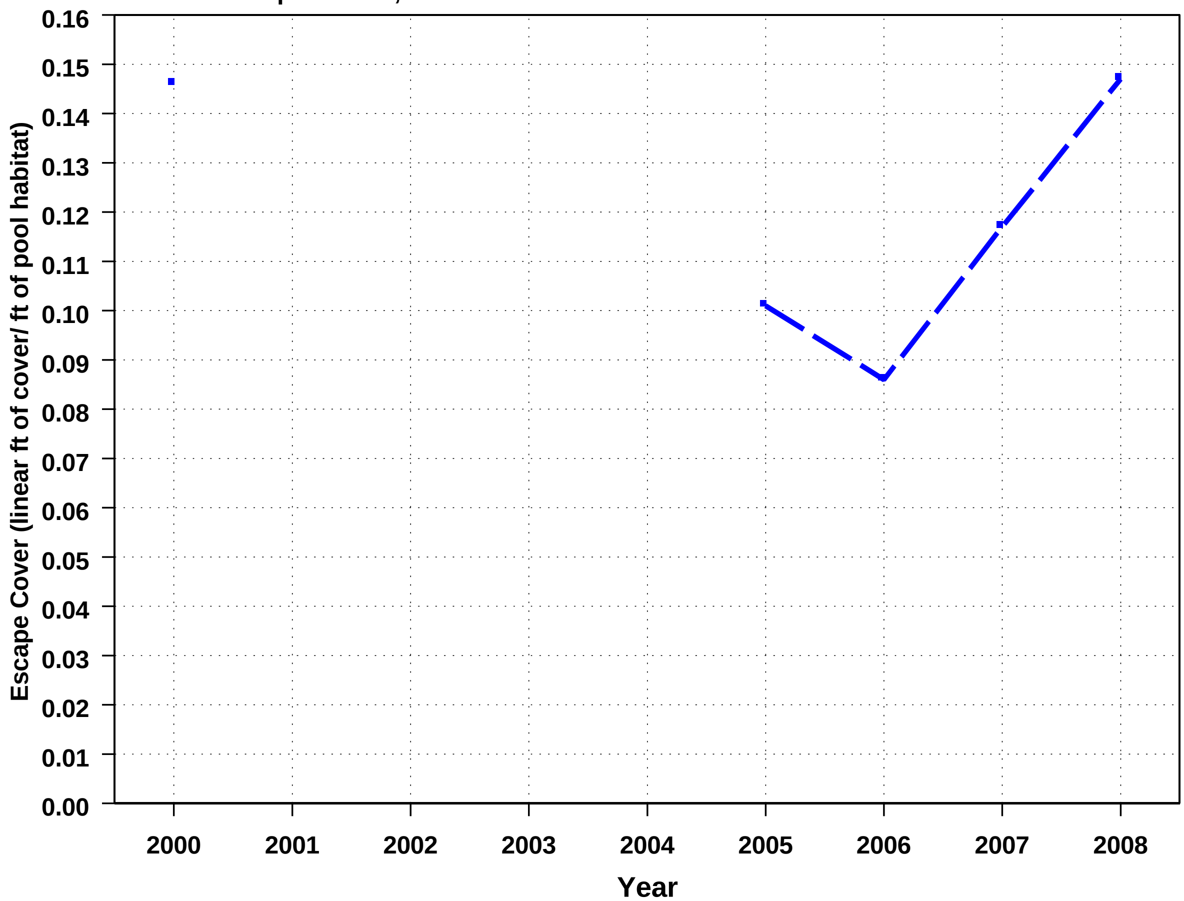


Figure 46b. Escape Cover Index for Pool Habitat at Site 13a (Reach 9a below Mill Pond) in East Branch Soquel Creek, 1997-2008.

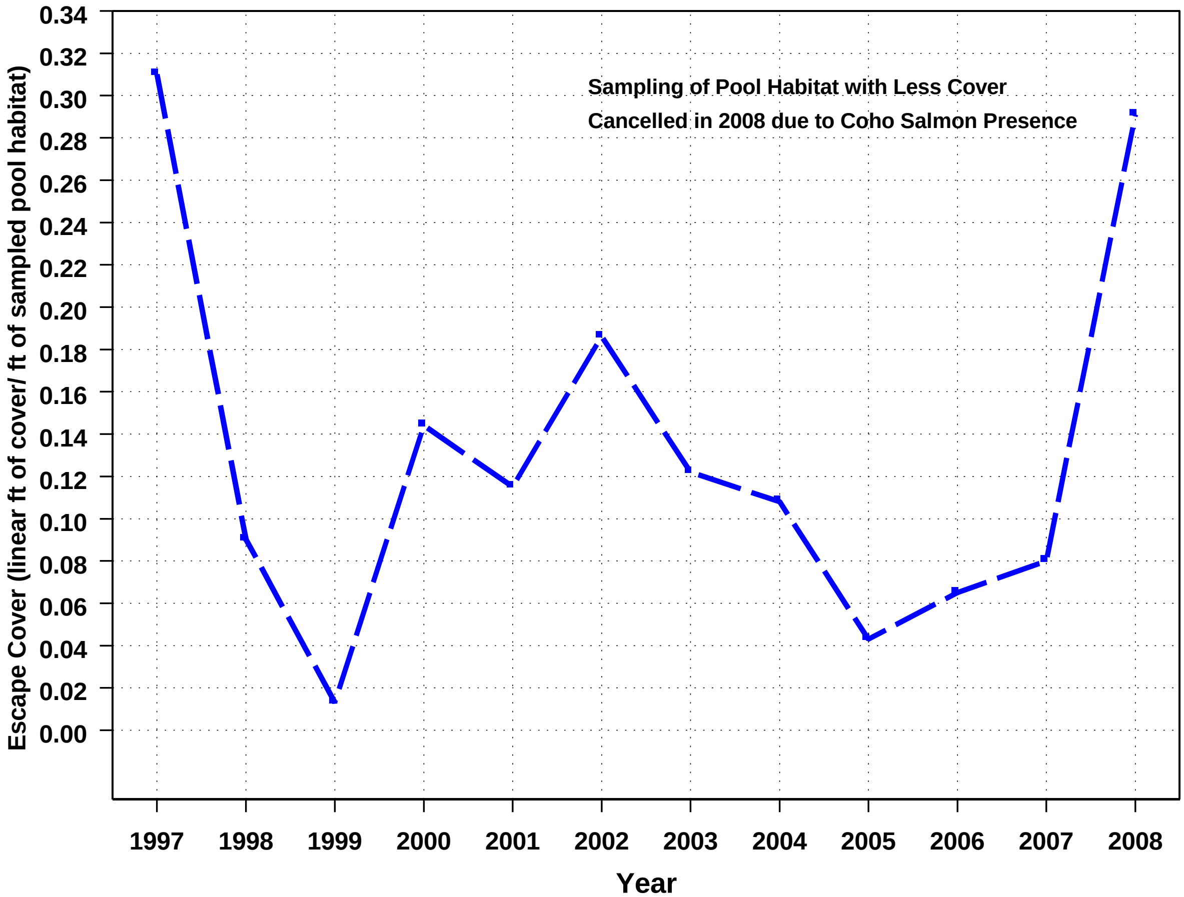


Figure 47. Averaged Percent Fines in Run and Step-Run Habitat in Reach 9a (below Mill Pond) of East Branch Soquel Creek, 2000 and 2005-2008.

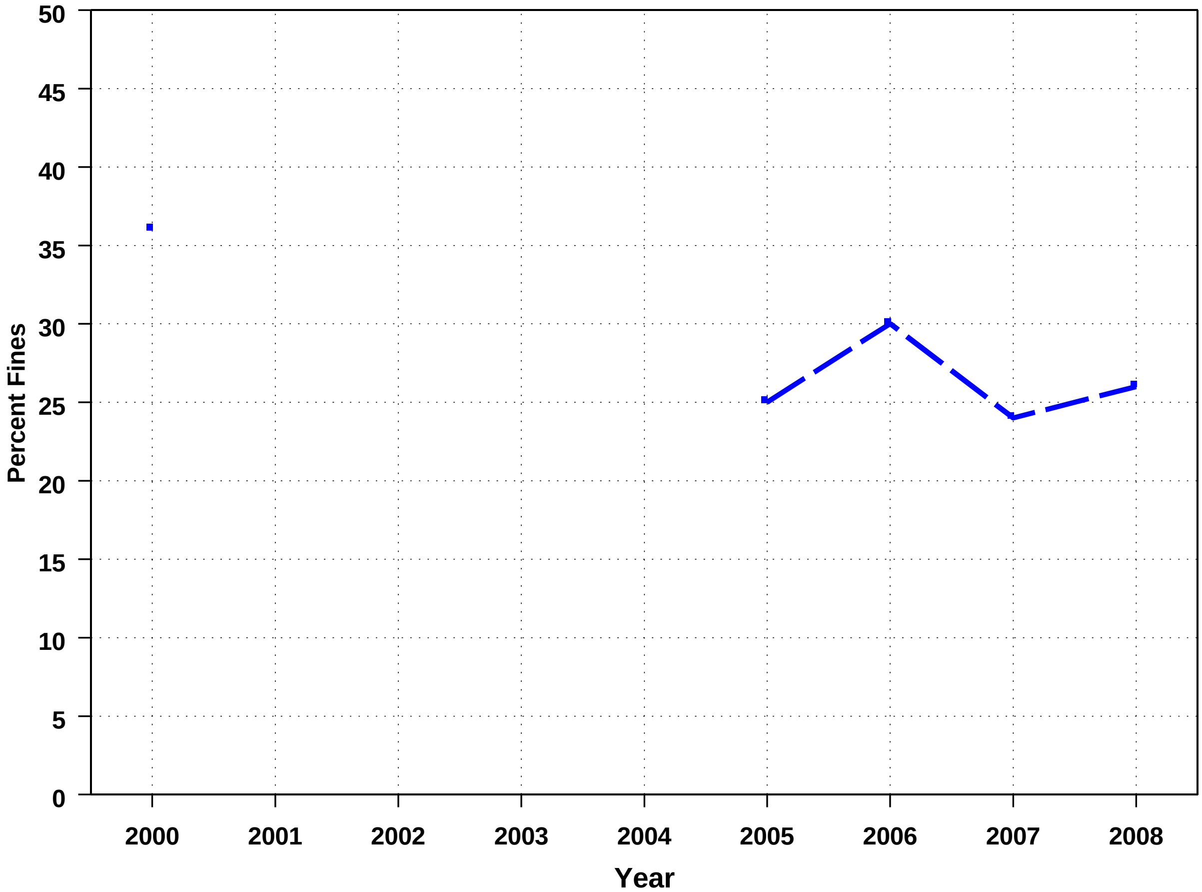


Figure 48. Average Embeddedness for Riffle Habitat in Reach 9a (below Mill Pond) of East Branch Soquel Creek, 2005-2008.

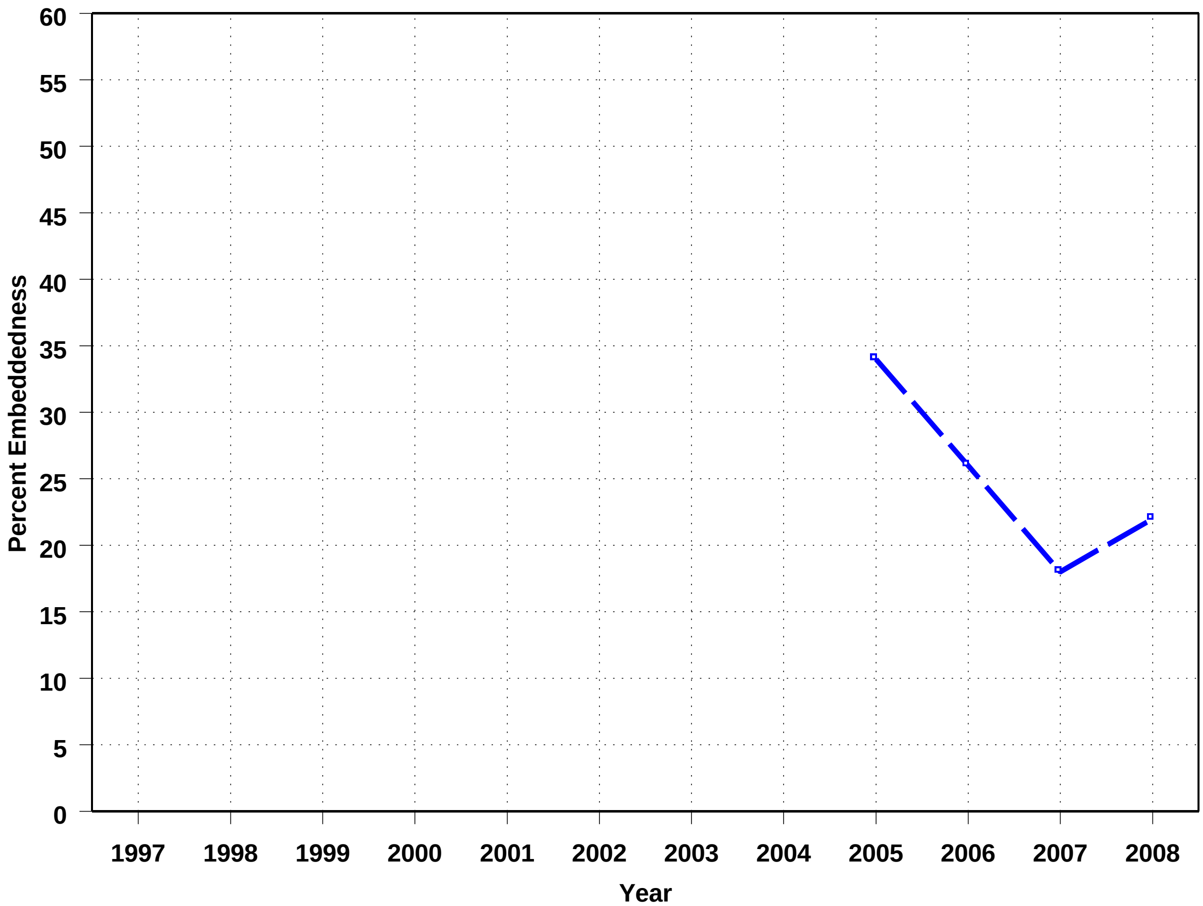


Figure 49. Averaged Maximum and Mean Pool Depth in Reach 12a (SDSF) of East Branch Soquel Creek, 2000 and 2005-2008.

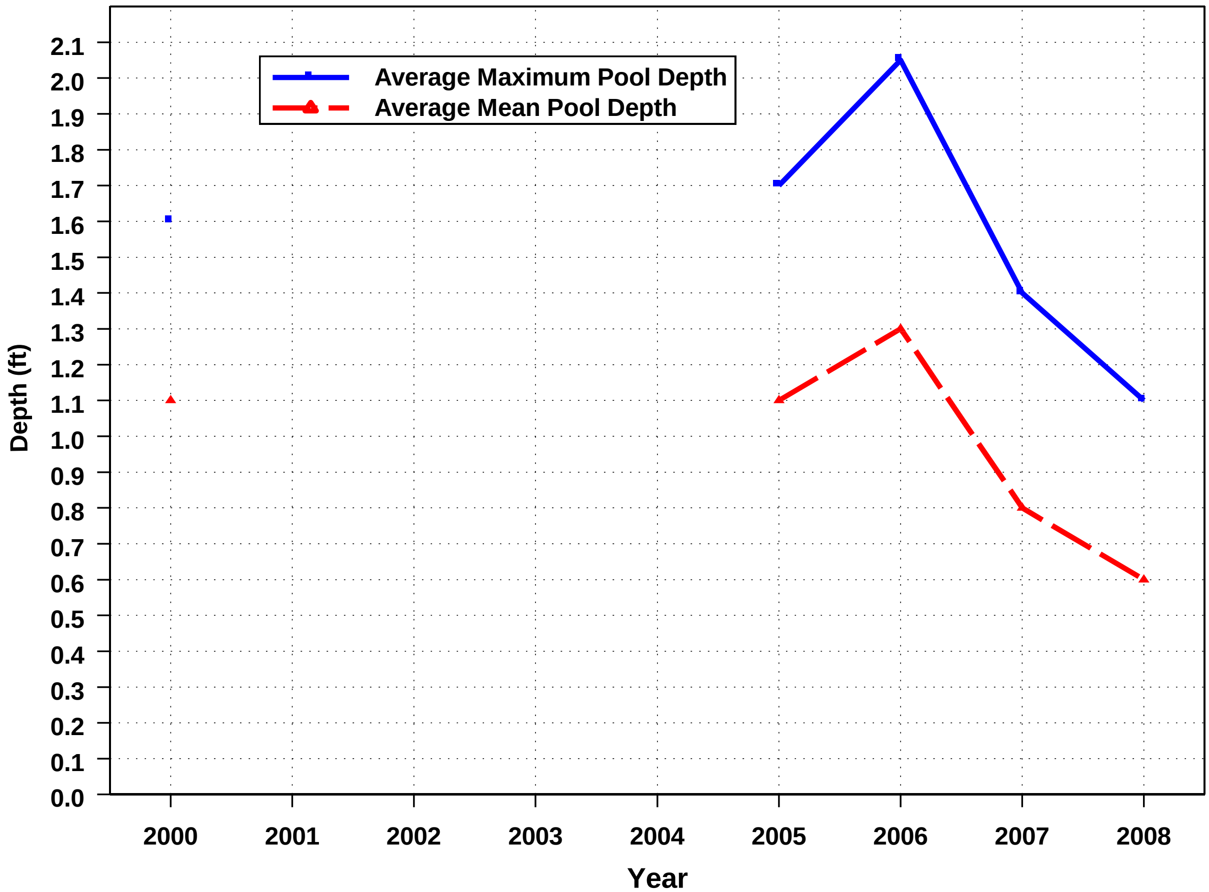


Figure 50a. Escape Cover Index for Pool Habitat in Reach 12a (SDSF) of East Branch Soquel Creek, 2000 and 2005-2008.

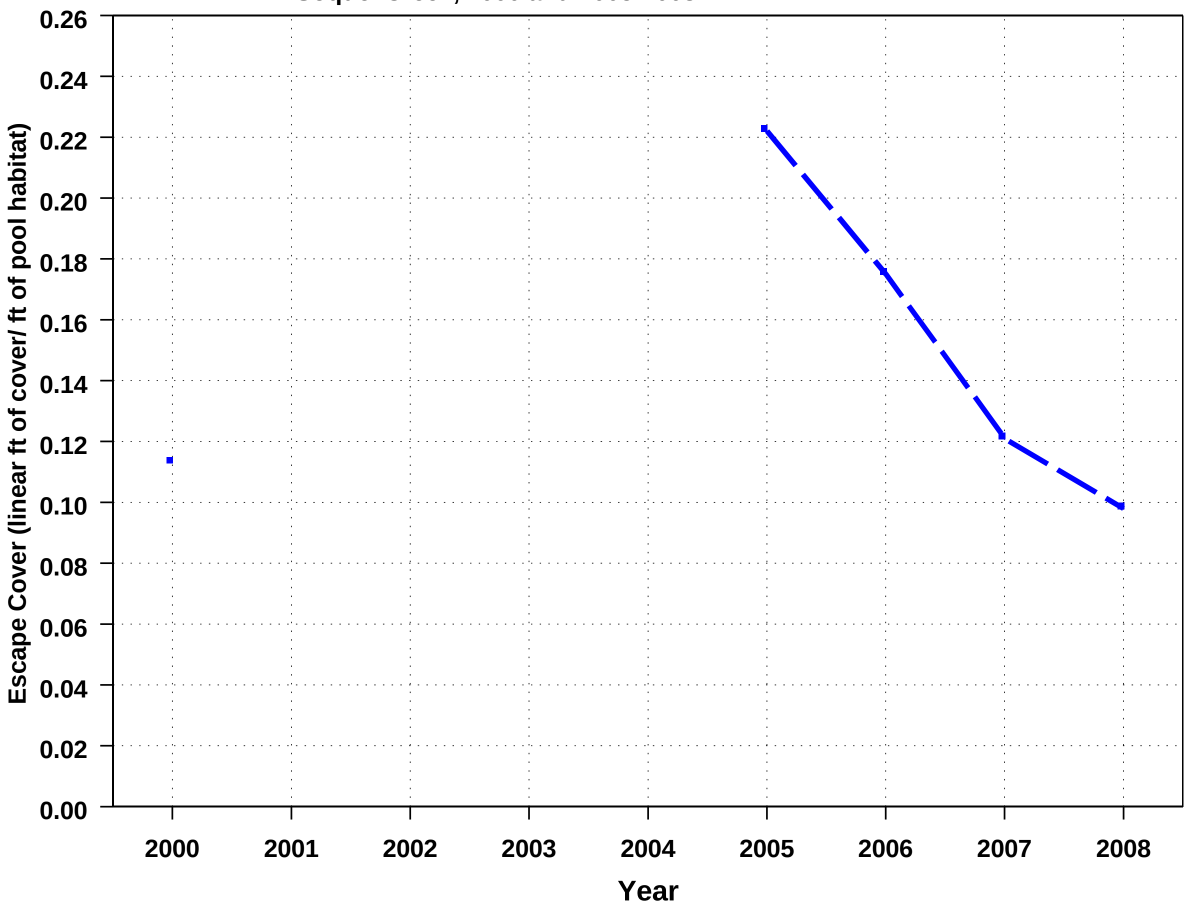


Figure 50b. Escape Cover Index for Pool Habitat at Site 16 (Reach 12a in SDSF) in East Branch Soquel Creek, 2000-2008.

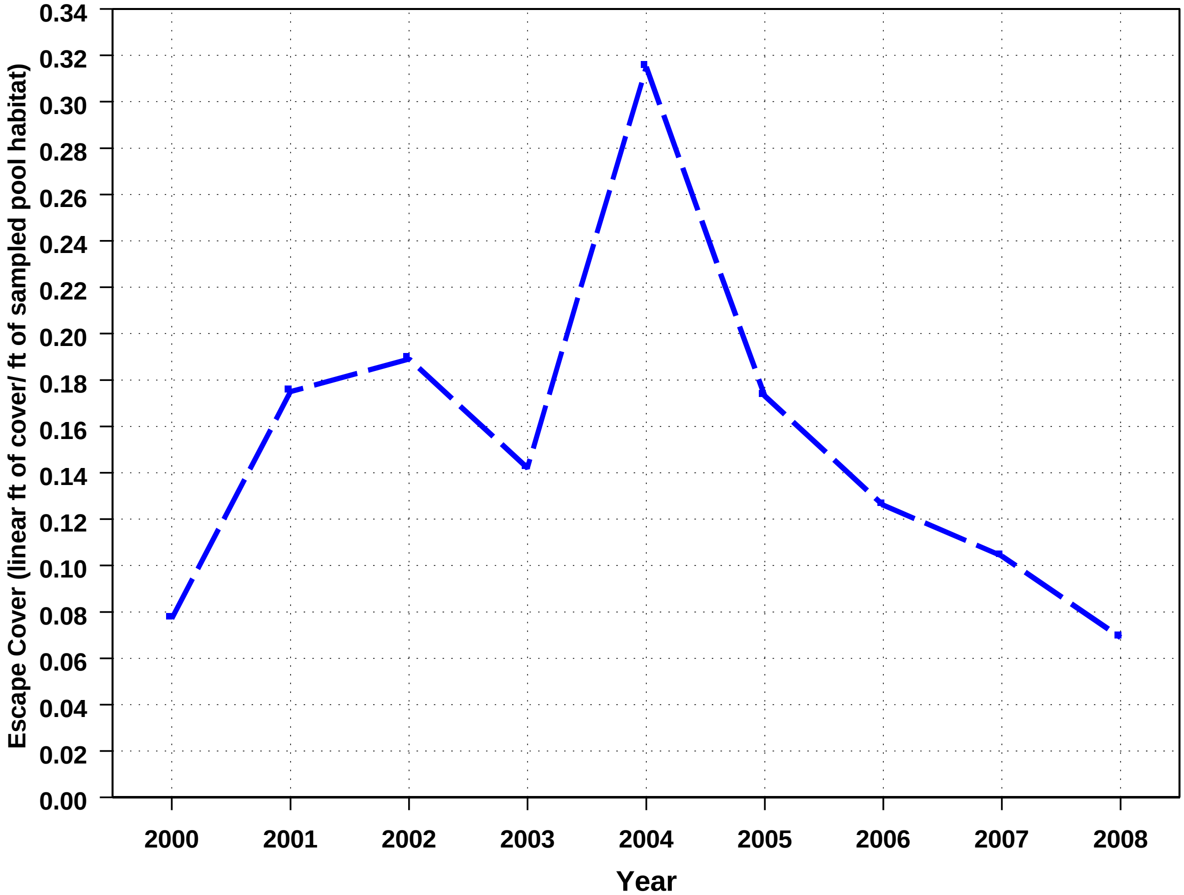


Figure 51. Averaged Percent Fines in Step-Run Habitat in Reach 12a (SDSF) of East Branch Soquel Creek, 2000 and 2005-2008.

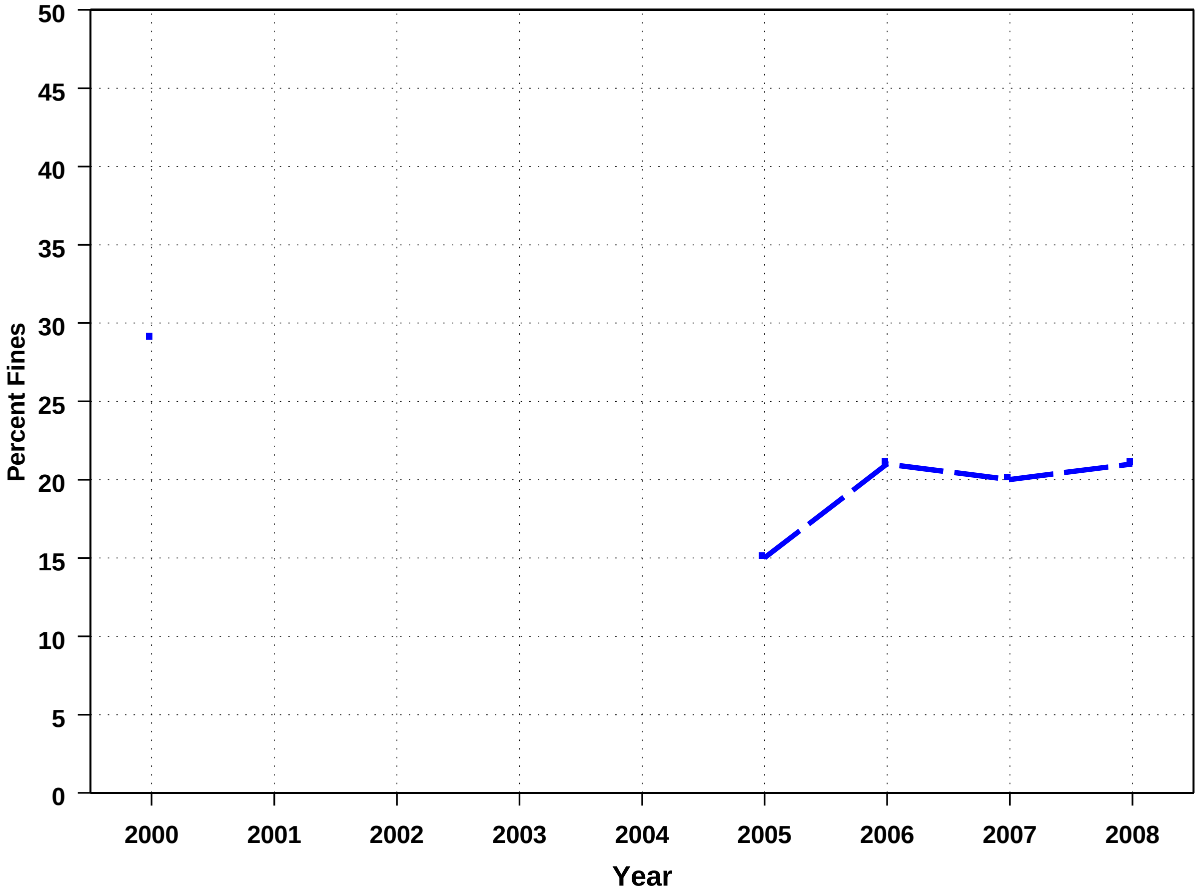


Figure 52. Average Embeddedness for Riffle and Step-run Habitat at the Sampling Site in Reach 12a (SDSF) of East Branch Soquel Creek, 2000-2008.

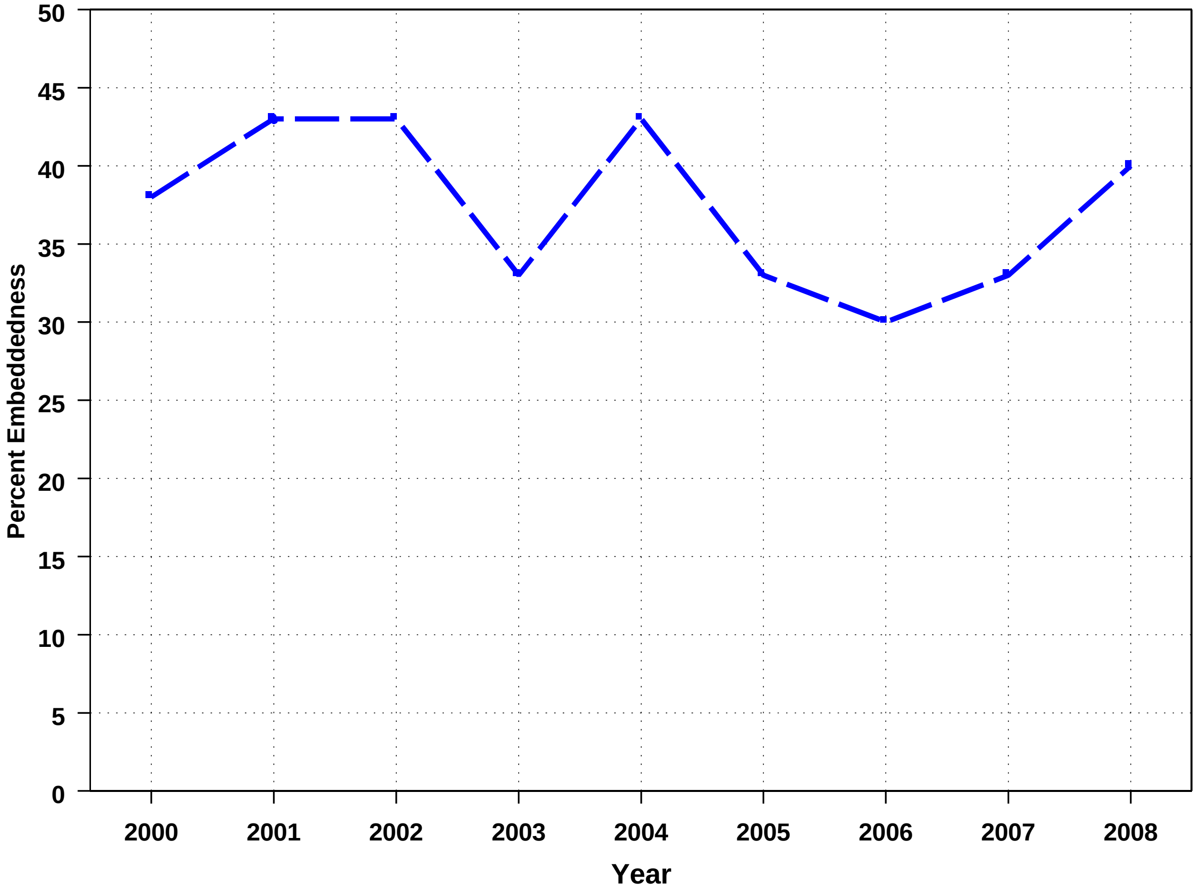


Figure 53a. The 1994 Daily Average Discharge for the USGS Gage and Median Daily Flow of Record On the San Lorenzo River at Big Trees.

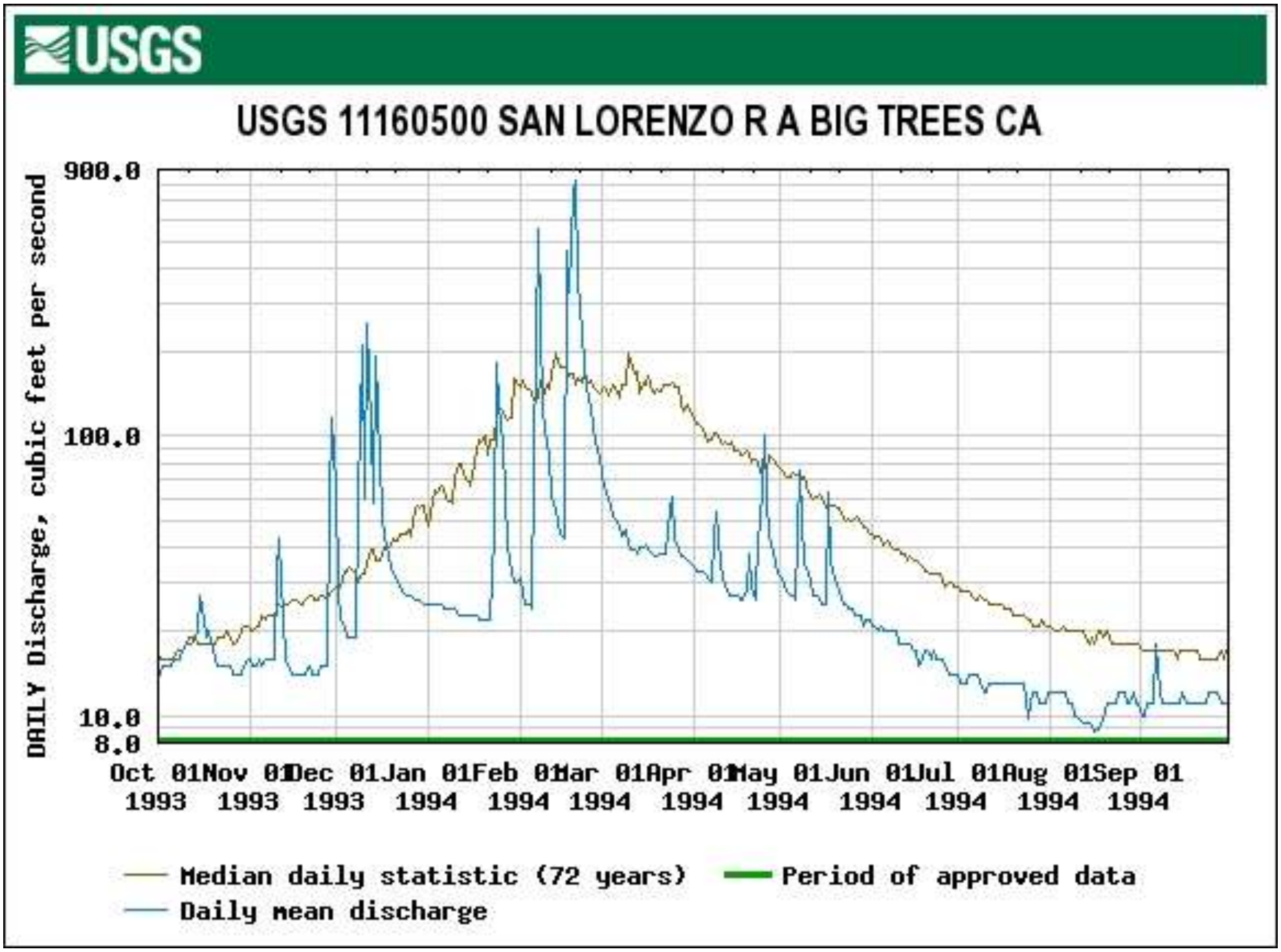


Figure 53b. The 1995 Daily Average Discharge for the USGS Gage and Median Daily Flow of Record On the San Lorenzo River at Big Trees.

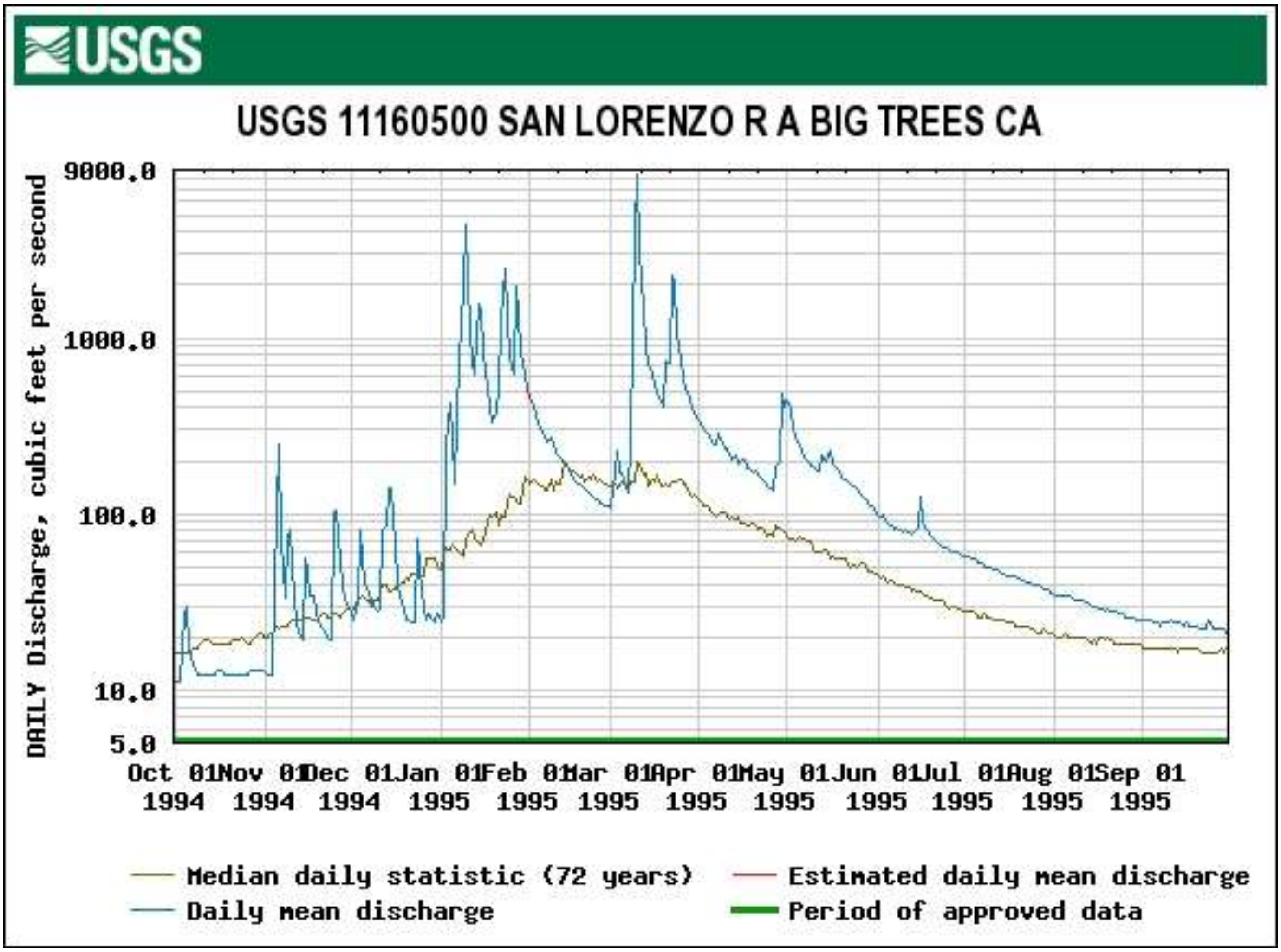


Figure 54. The 1997 Daily Average Discharge for the USGS Gage and Median Daily Flow of Record On the San Lorenzo River at Big Trees.

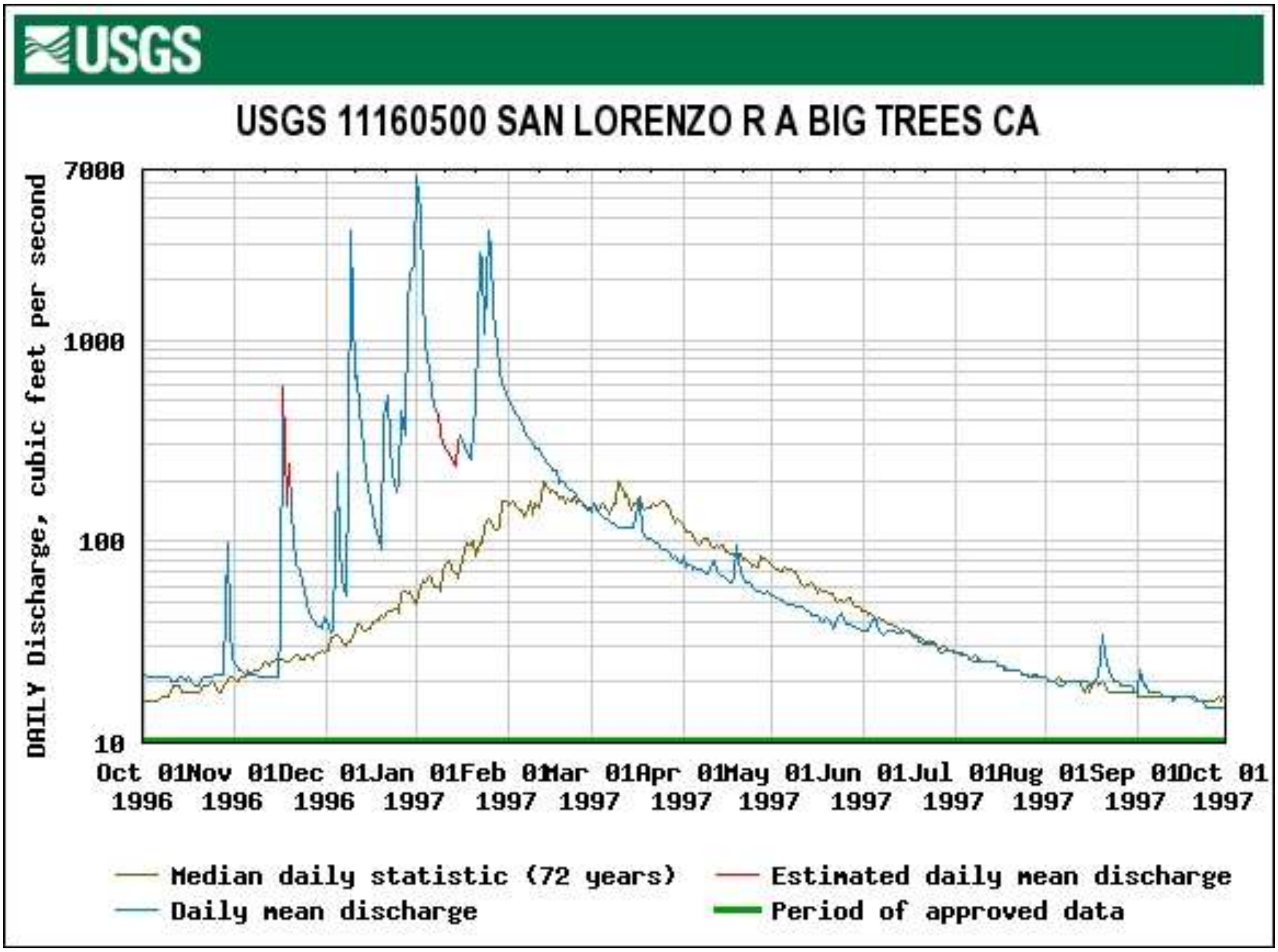


Figure 55. The 1998 Daily Average Discharge for the USGS Gage and Median Daily Flow of Record On the San Lorenzo River at Big Trees.

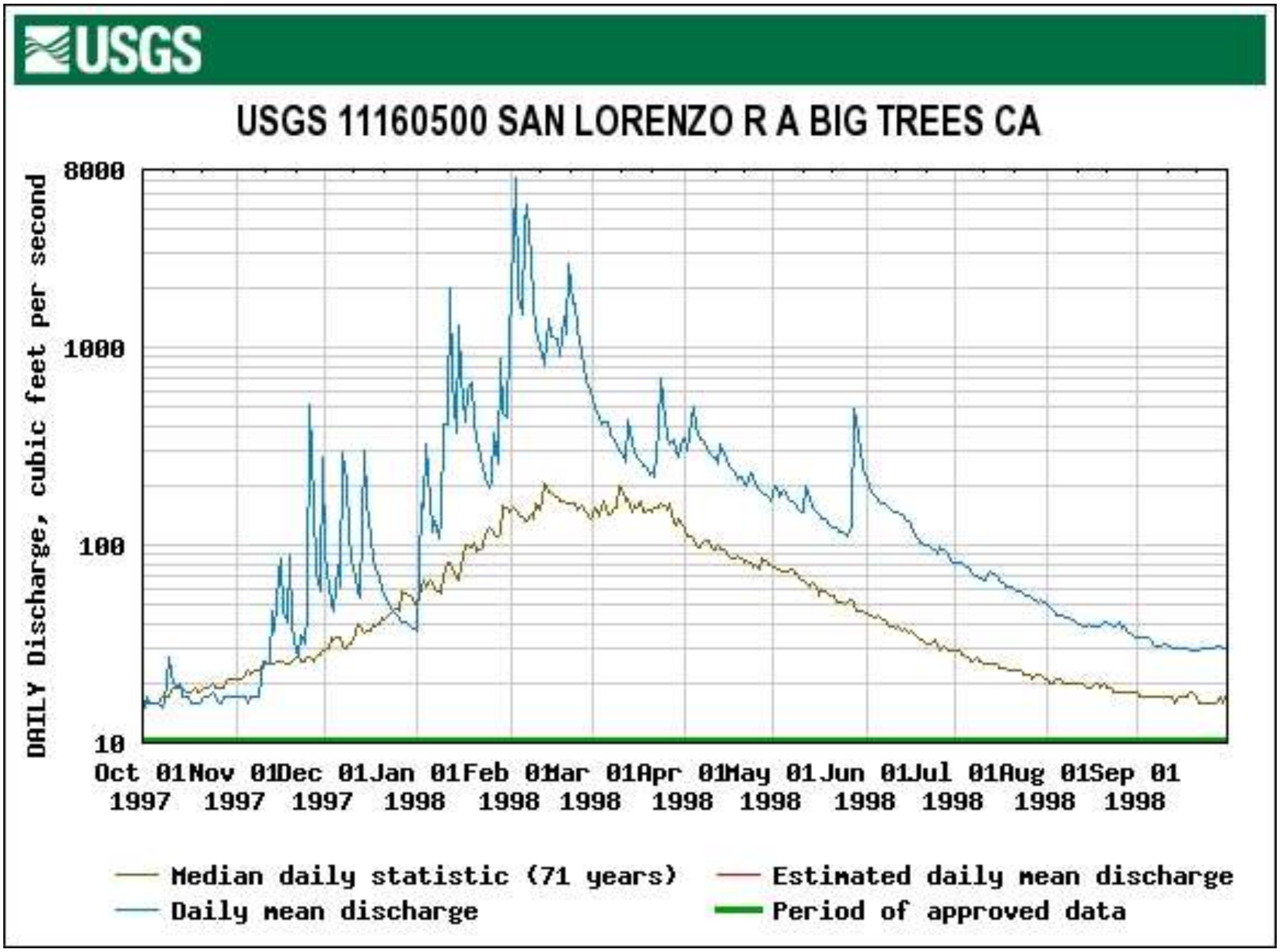


Figure 56. The 1999 Daily Average Discharge for the USGS Gage and Median Daily Flow of Record On the San Lorenzo River at Big Trees.

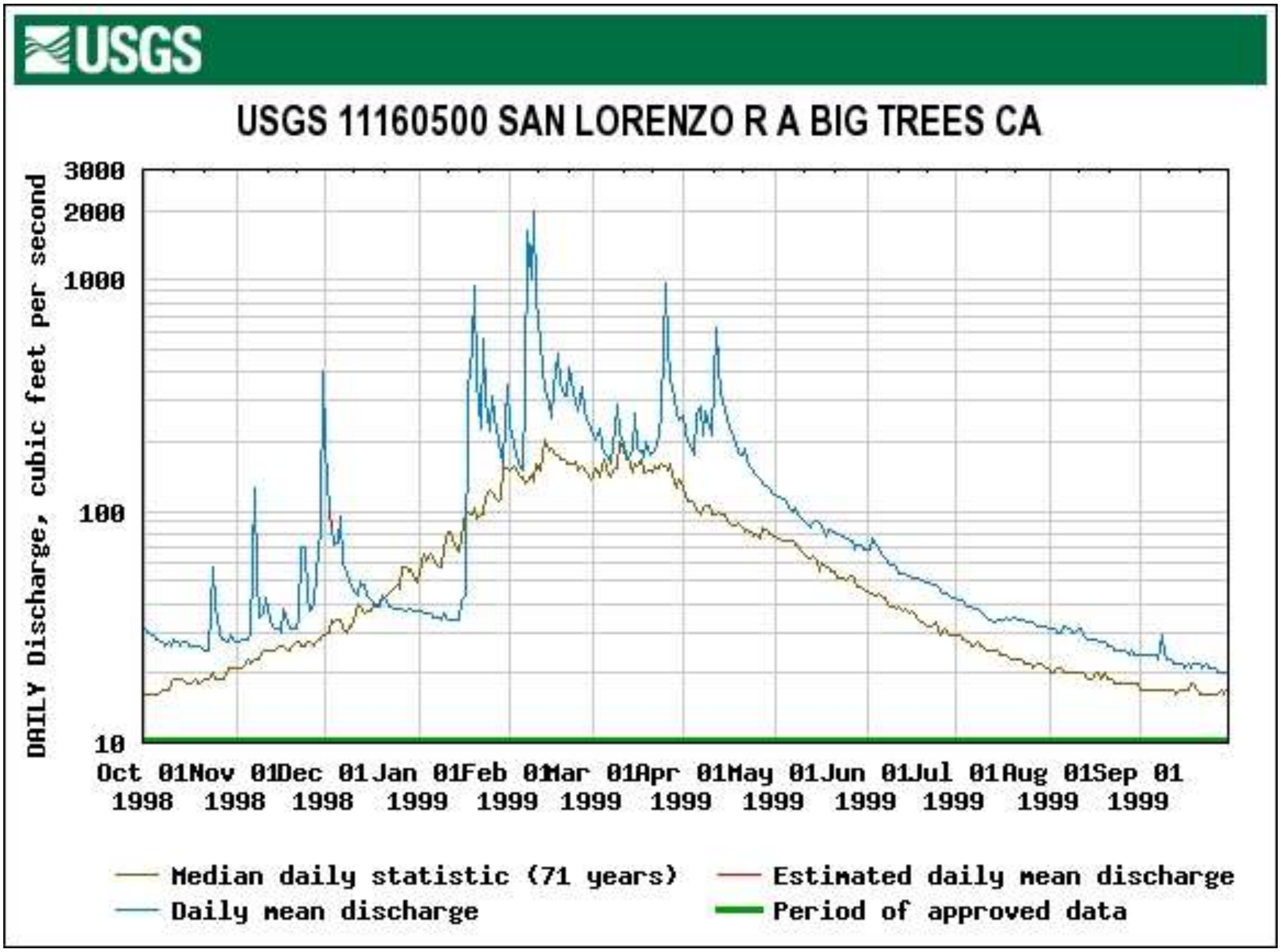


Figure 57. The 2000 Daily Average Discharge for the USGS Gage and Median Daily Flow of Record On the San Lorenzo River at Big Trees.

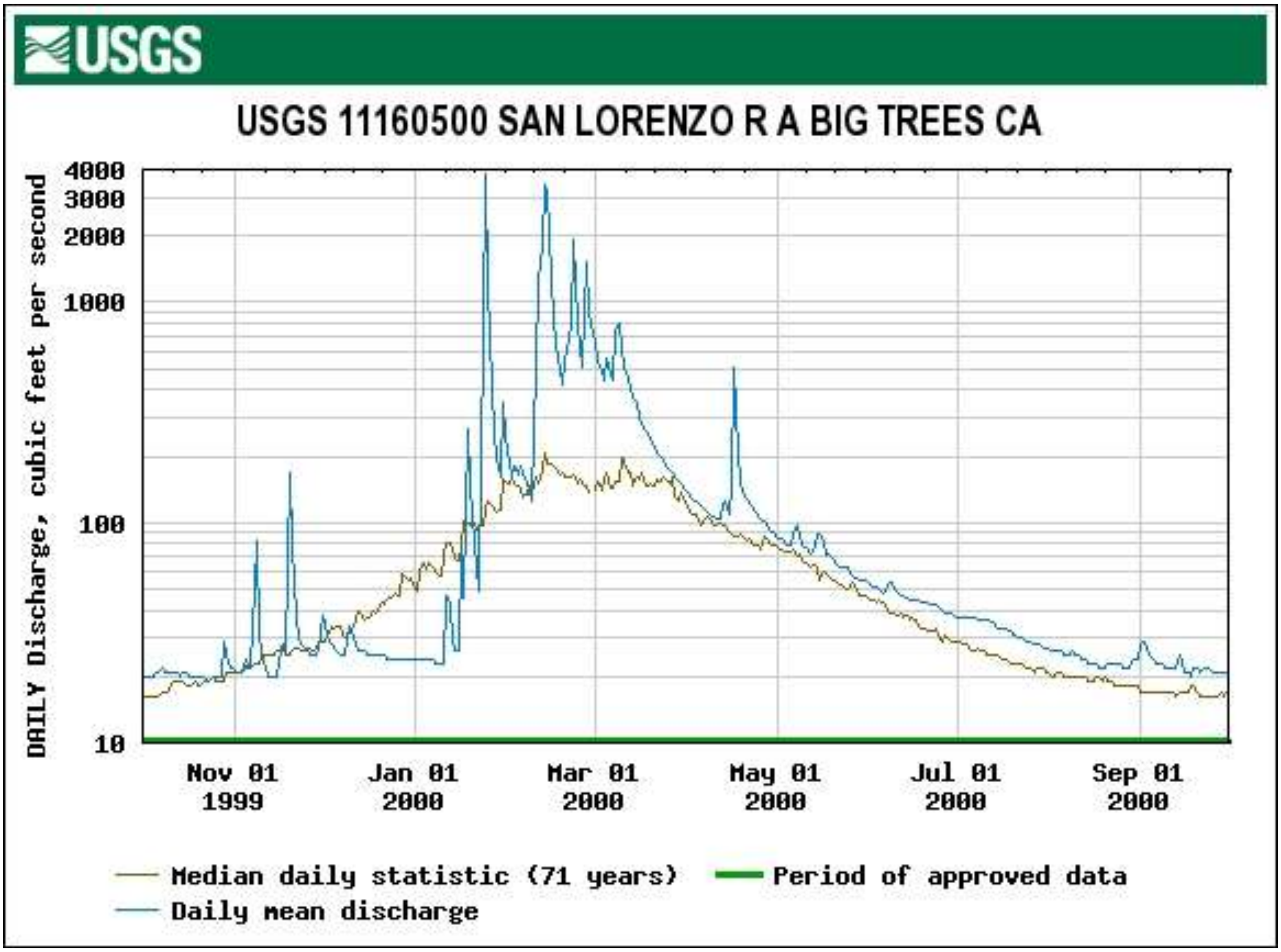


Figure 58. The 2001 Daily Average Discharge for the USGS Gage and Median Daily Flow of Record On the San Lorenzo River at Big Trees.

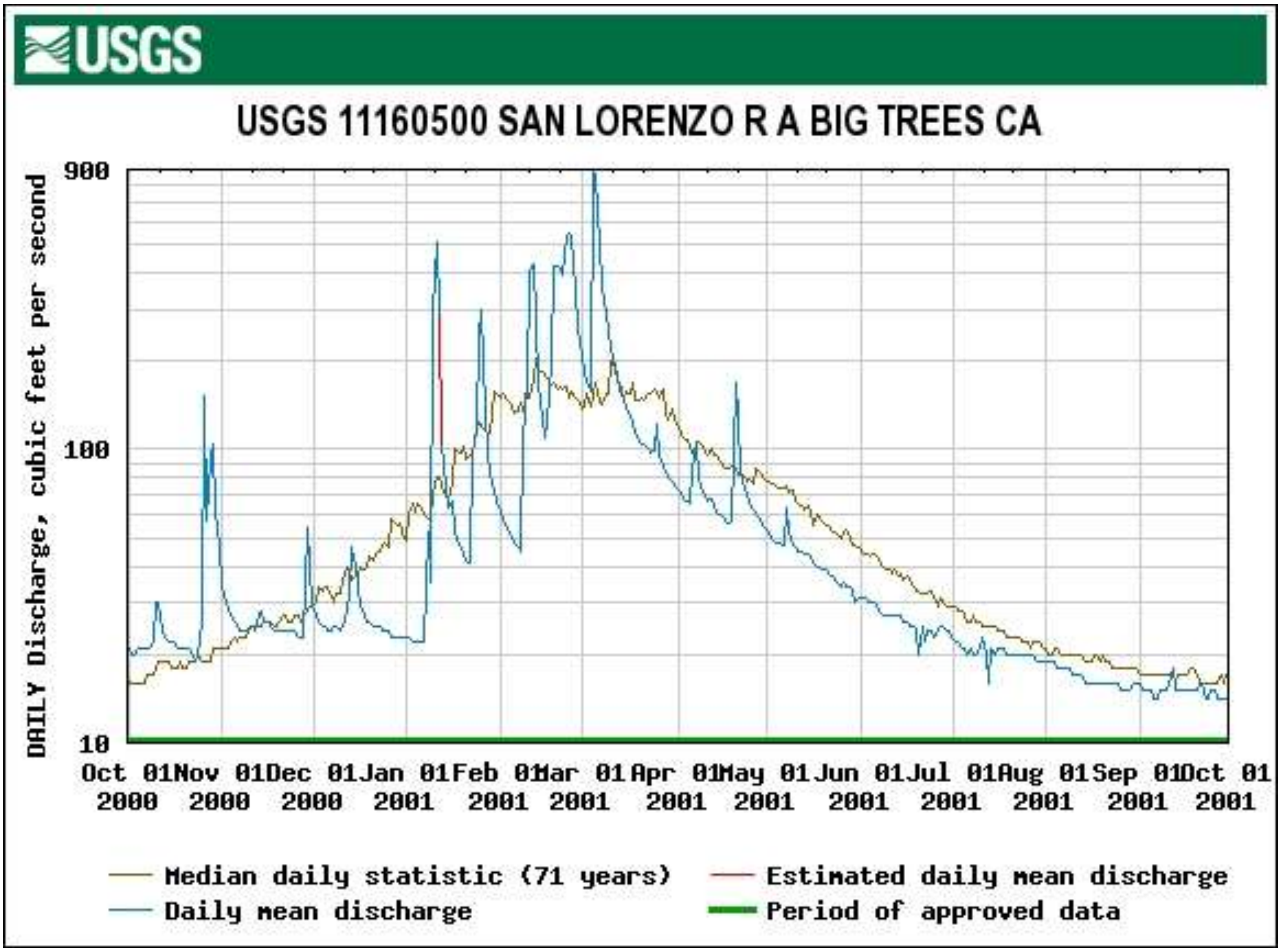


Figure 59. The 2002 Daily Average Discharge for the USGS Gage and Median Daily Flow of Record On the San Lorenzo River at Big Trees.

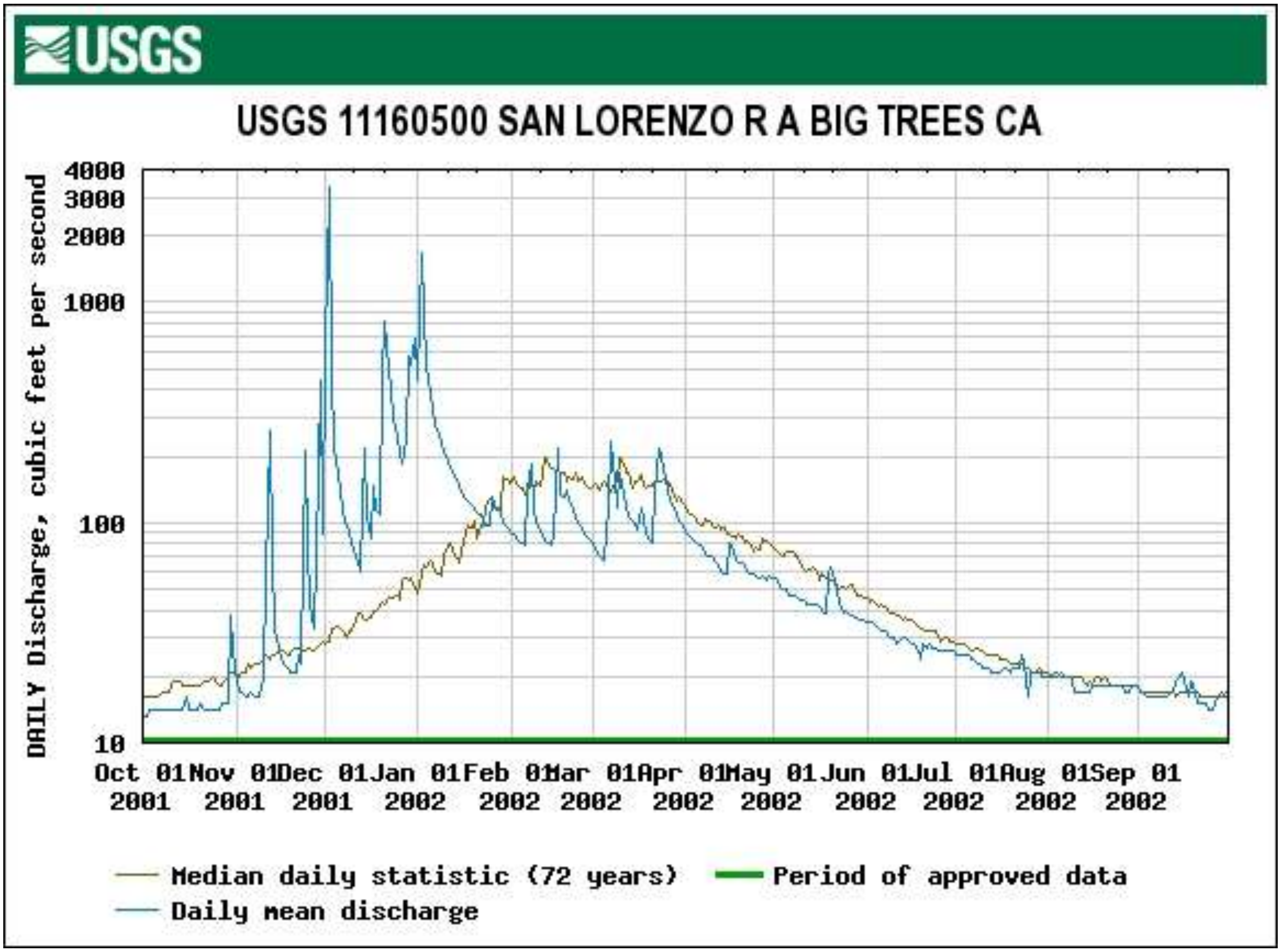


Figure 60. The 2003 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.

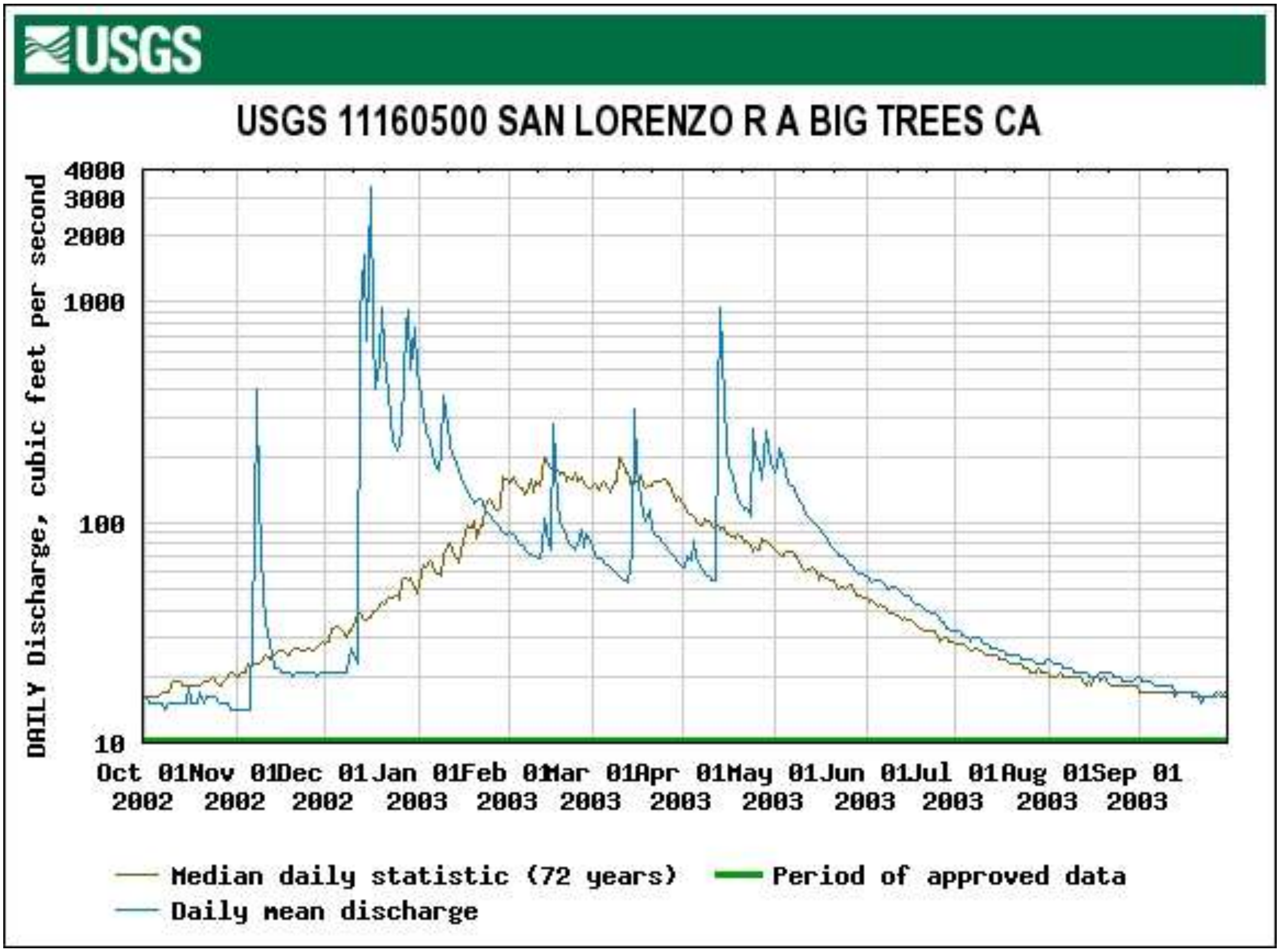


Figure 61. The 2004 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.

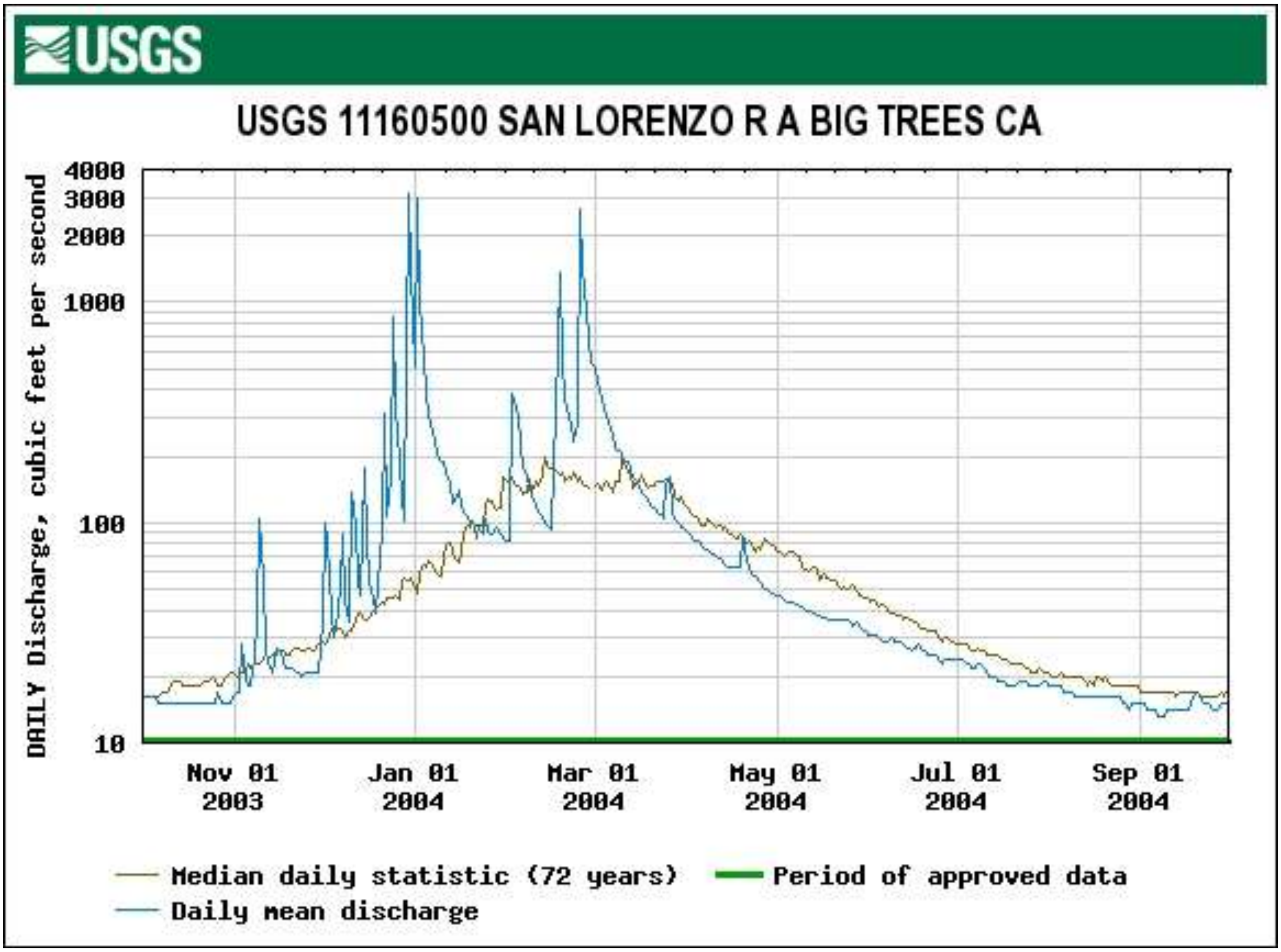


Figure 62. The 2005 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.

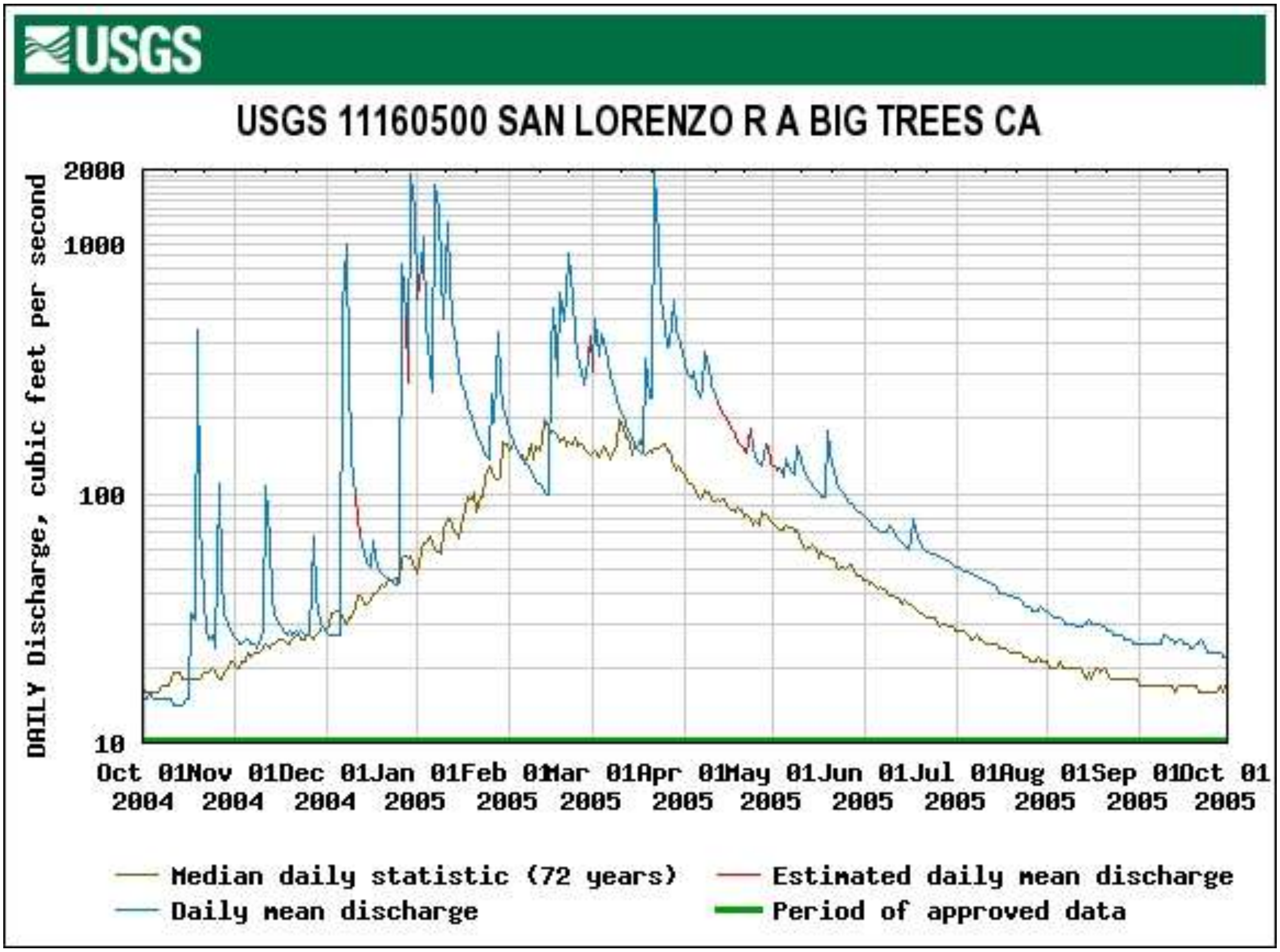


Figure 63. The 2005 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Santa Cruz. (Included because of equipment malfunction at the Big Trees Gage during a stormflow in early January.)

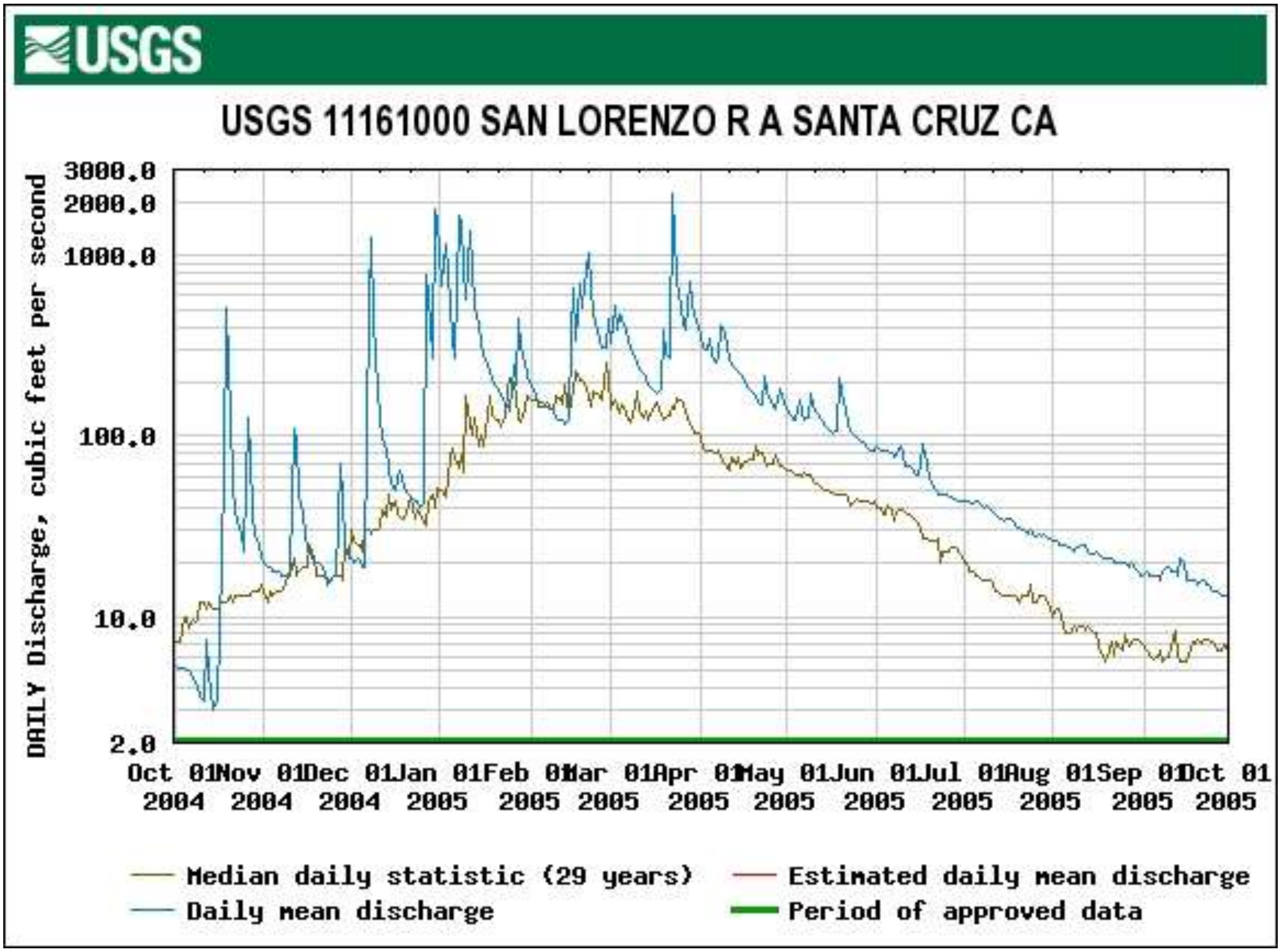


Figure 64. The 2006 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.

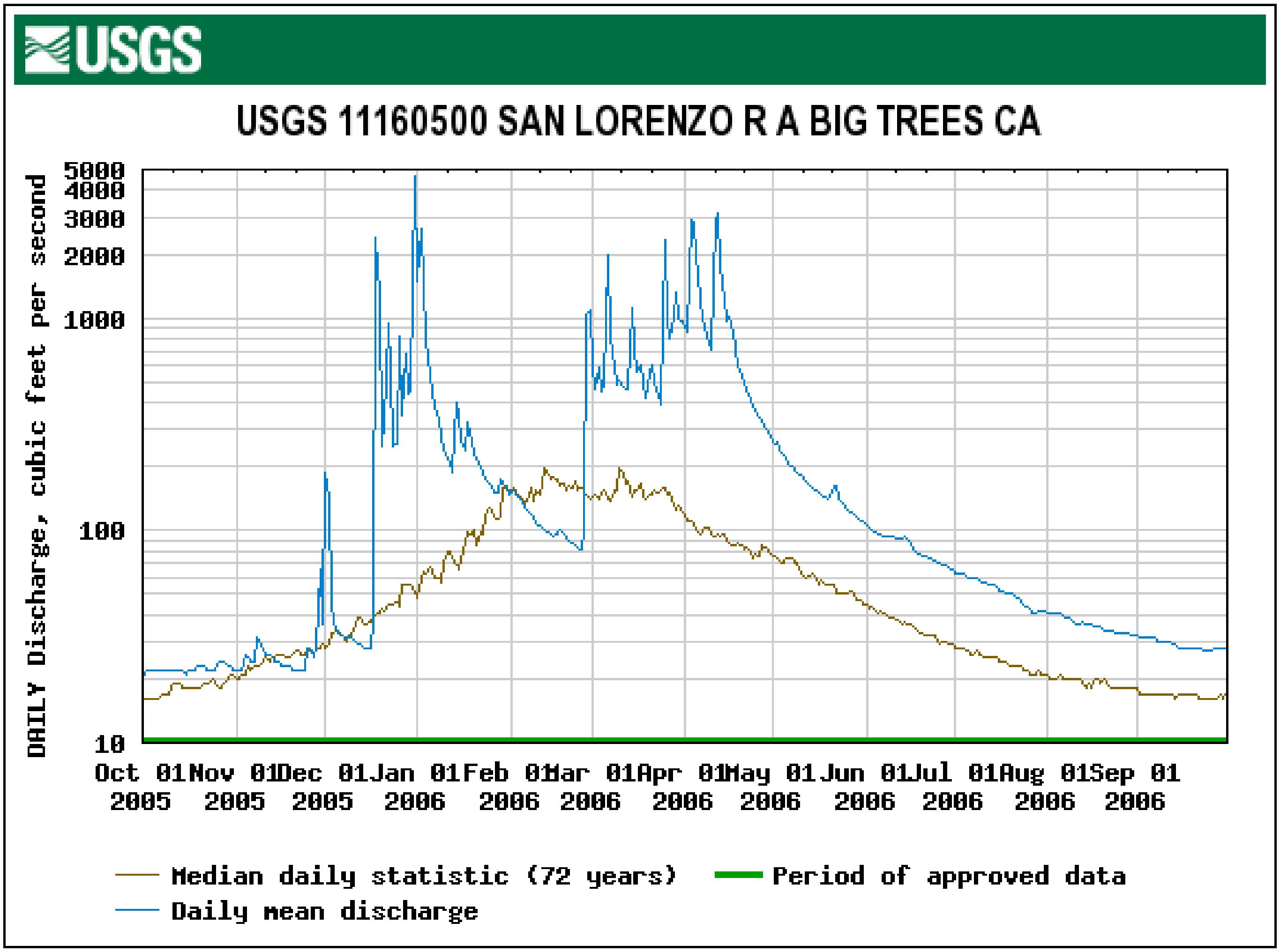


Figure 65. The 2007 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.

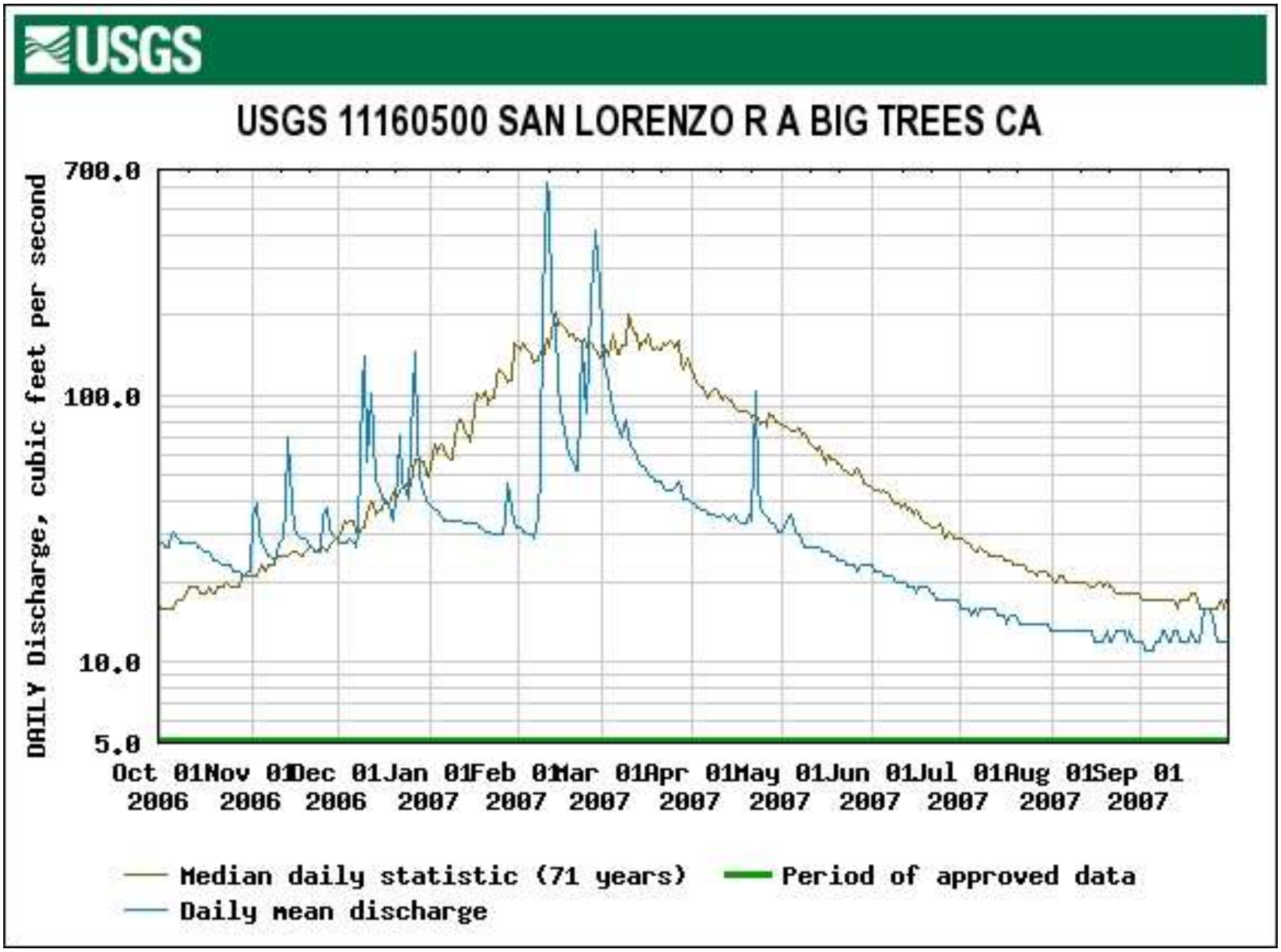


Figure 66. The 2008 Daily Average Discharge and Median Daily Flow of Record for the USGS Gage On the San Lorenzo River at Big Trees.

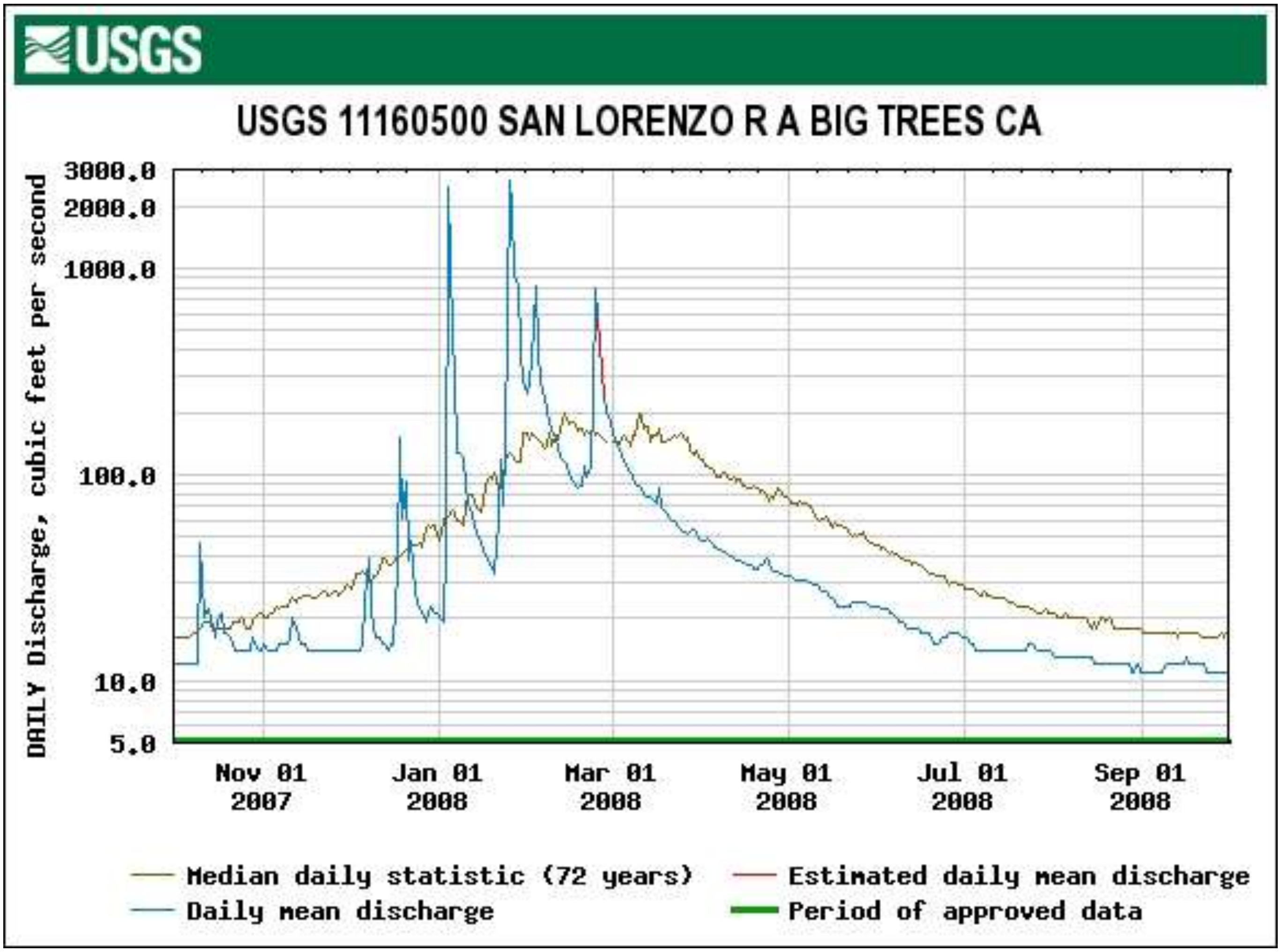


Figure 67. The 1995 Daily Mean and Peak Flood Flow at the USGS Gage on Soquel Creek at Soquel.

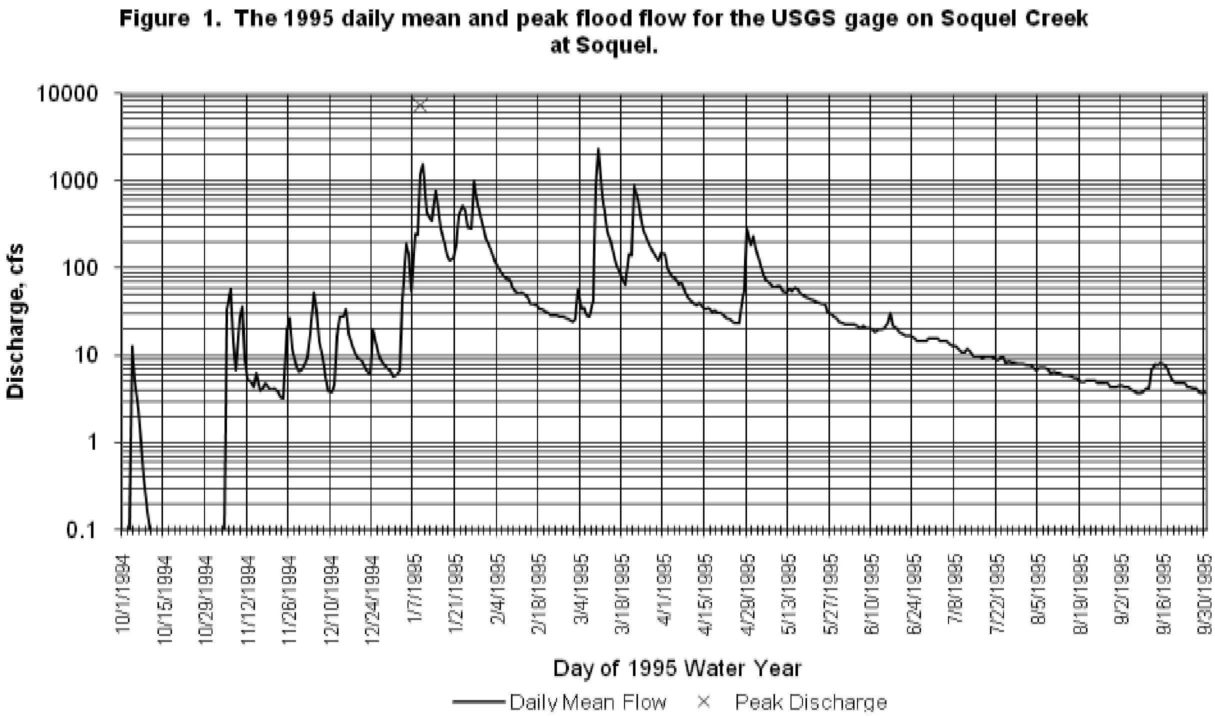


Figure 68. The 1996 Daily Mean and Peak Flood Flow at the USGS Gage on Soquel Creek at Soquel.

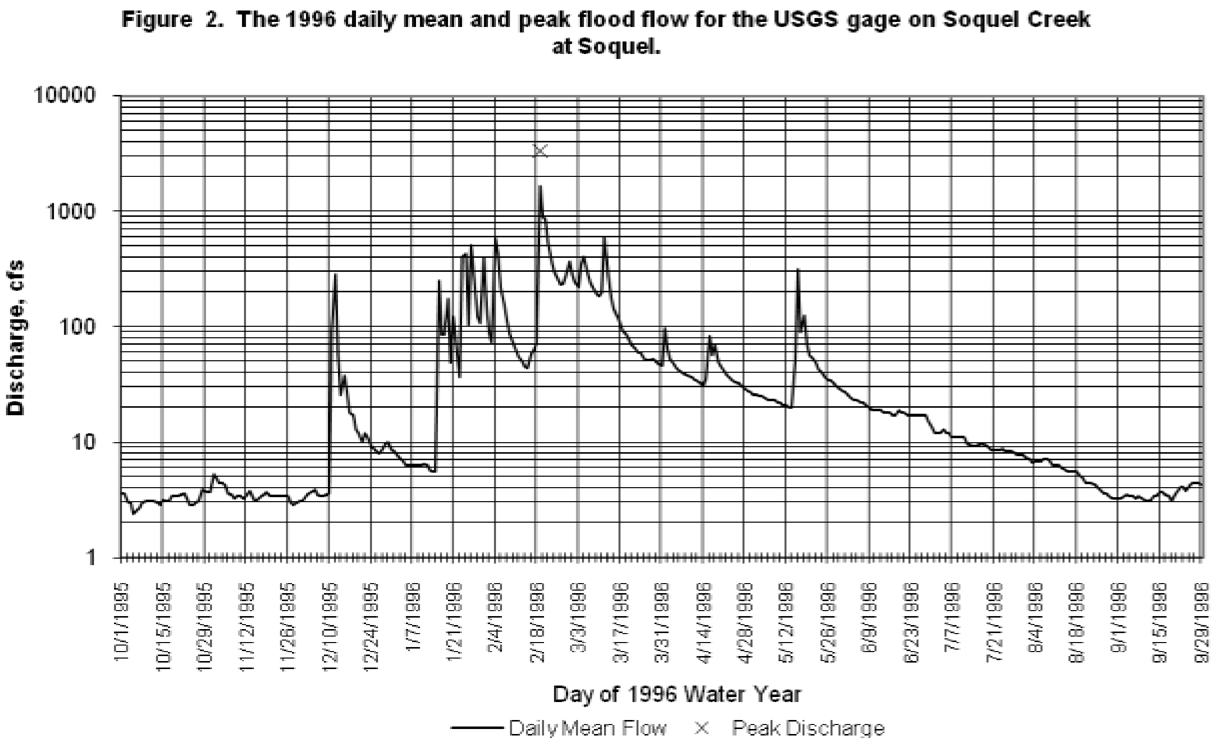


Figure 69. The 1997 Daily Mean and Peak Flood Flow at the USGS Gage on Soquel Creek at Soquel.

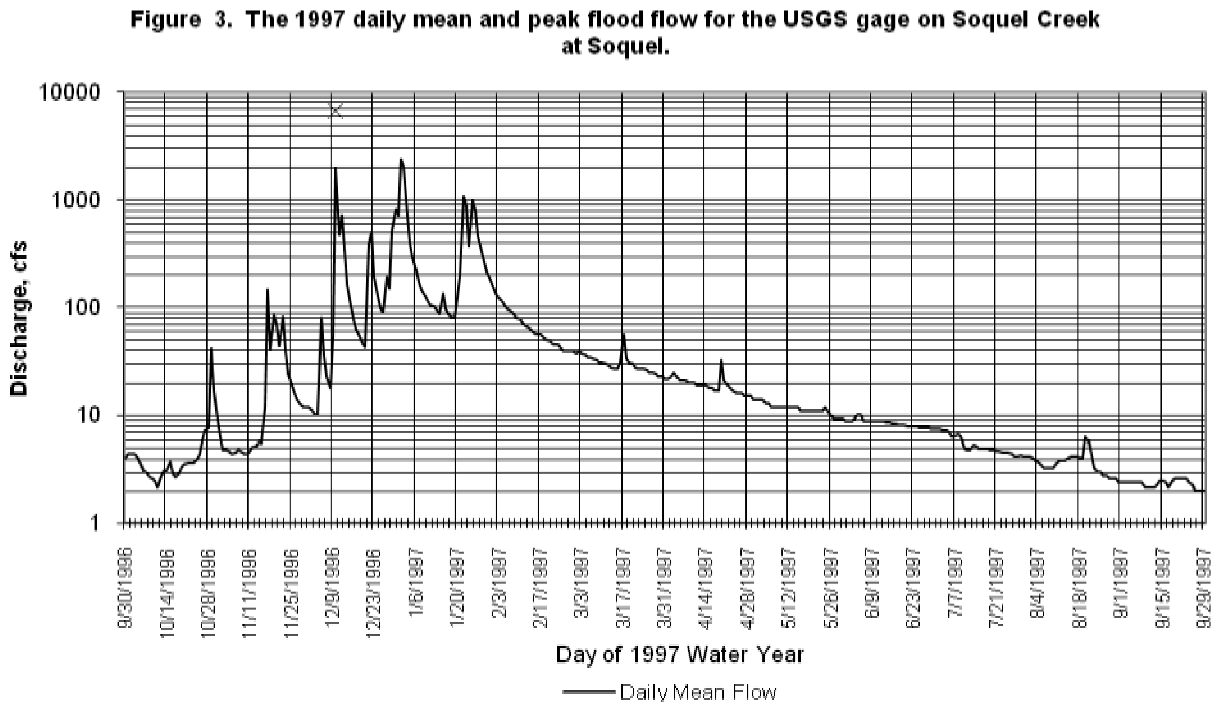


Figure 70. The 1998 Daily Mean and Peak Flood Flow at the USGS Gage on Soquel Creek at Soquel.

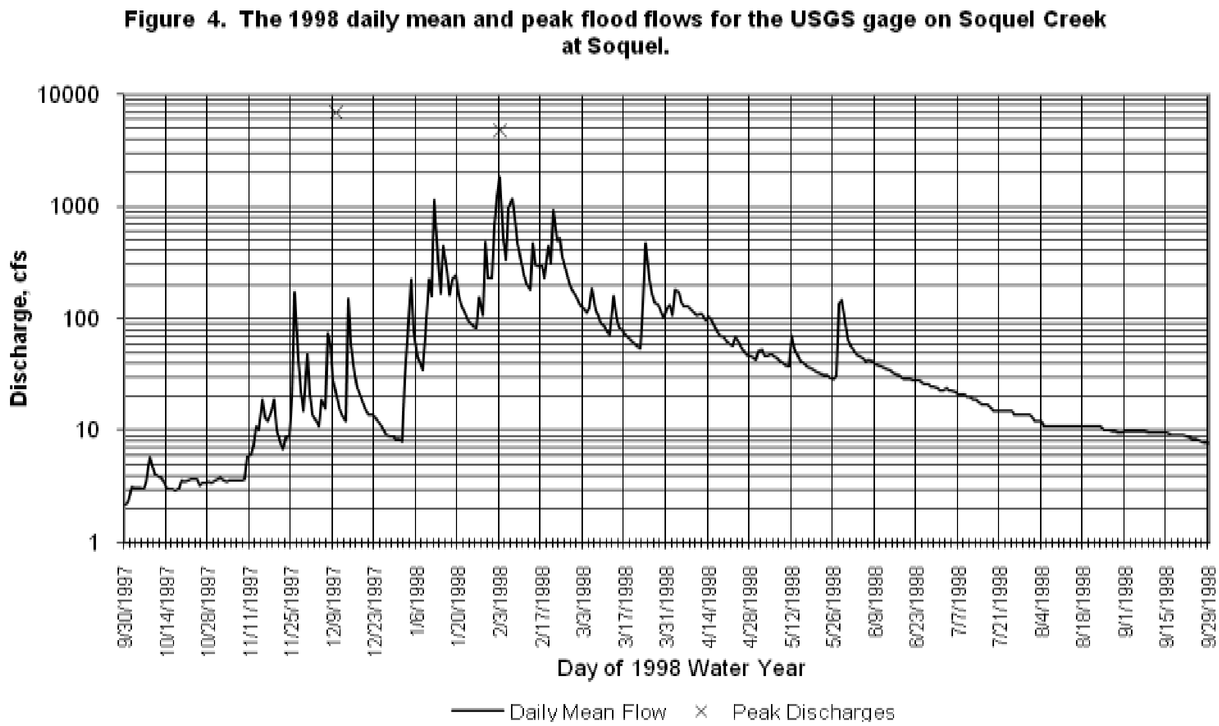


Figure 71. The 1999 Daily Mean and Peak Flood Flow at the USGS Gage on Soquel Creek at Soquel.

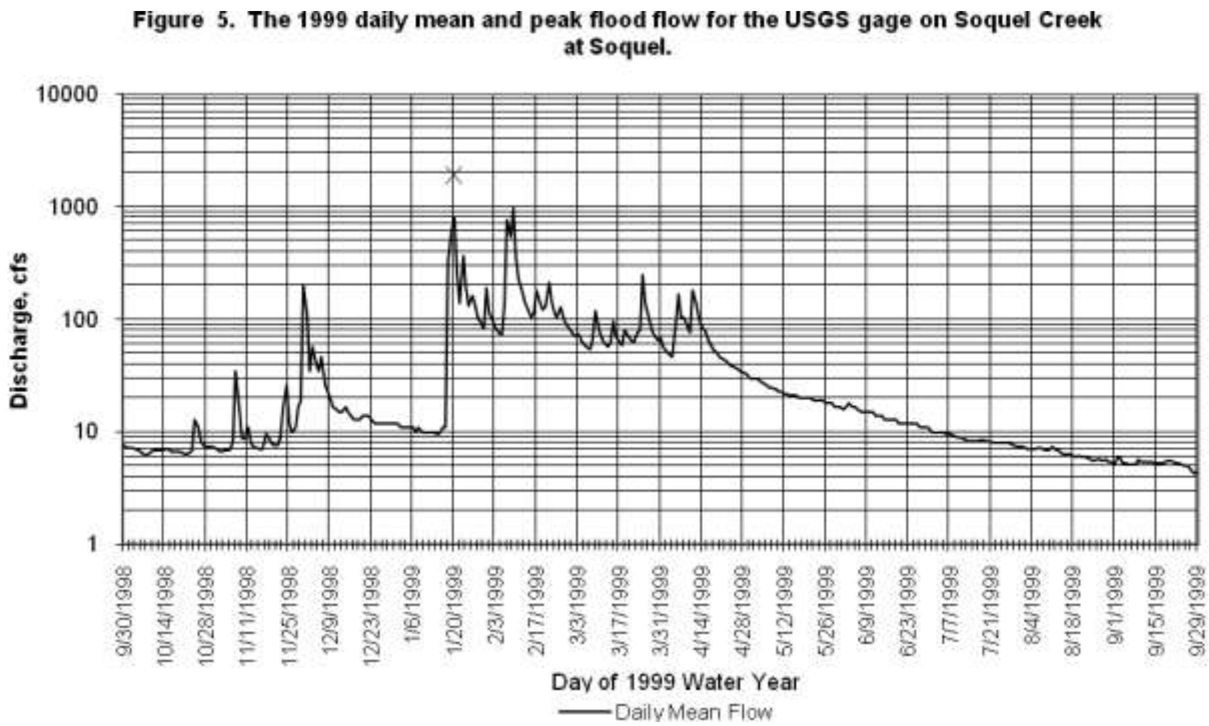


Figure 72. The 2000 Daily Mean and Peak Flood Flow at the USGS Gage on Soquel Creek at Soquel.

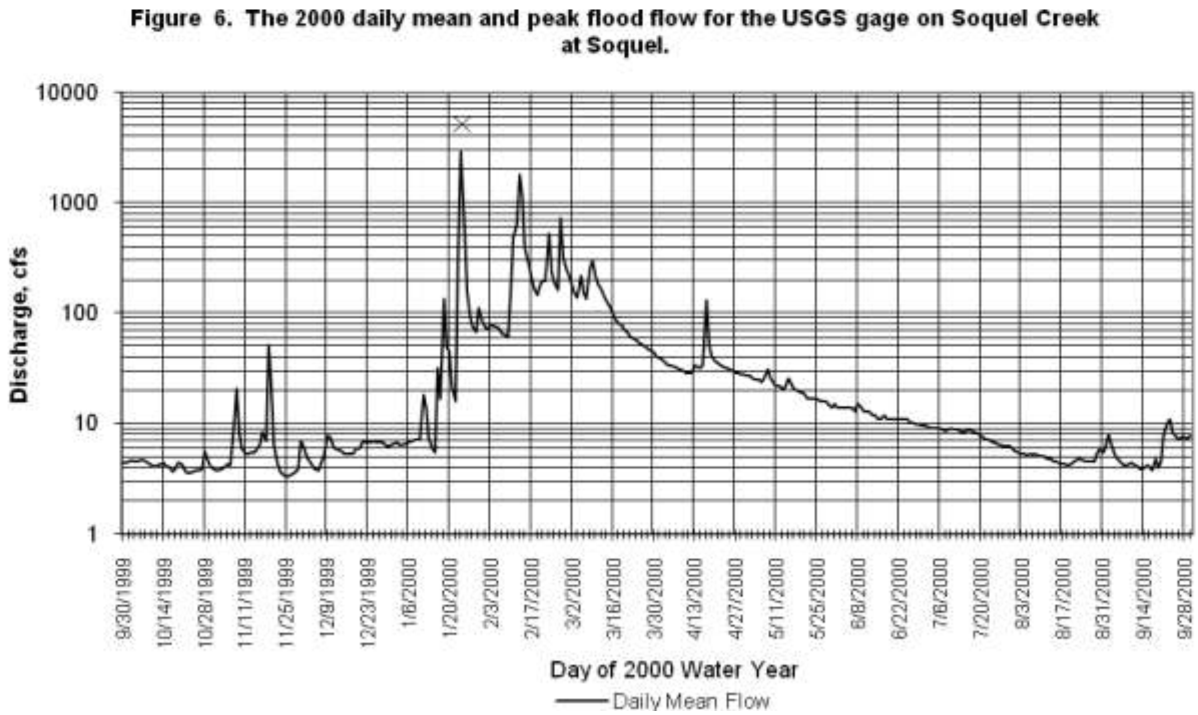


Figure 73. The 2001 Daily Mean and Peak Flood Flow at the USGS Gage on Soquel Creek at Soquel.

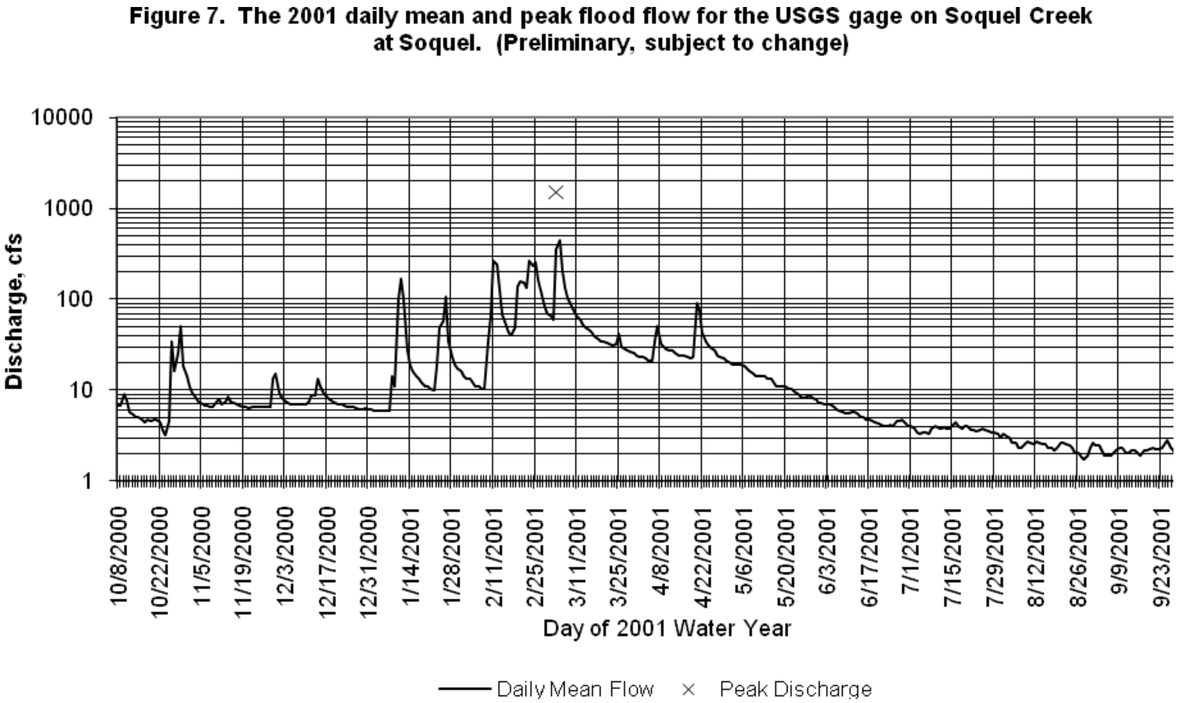


Figure 74. The 2002 Daily Mean and Peak Flood Flow at the USGS Gage on Soquel Creek at Soquel.

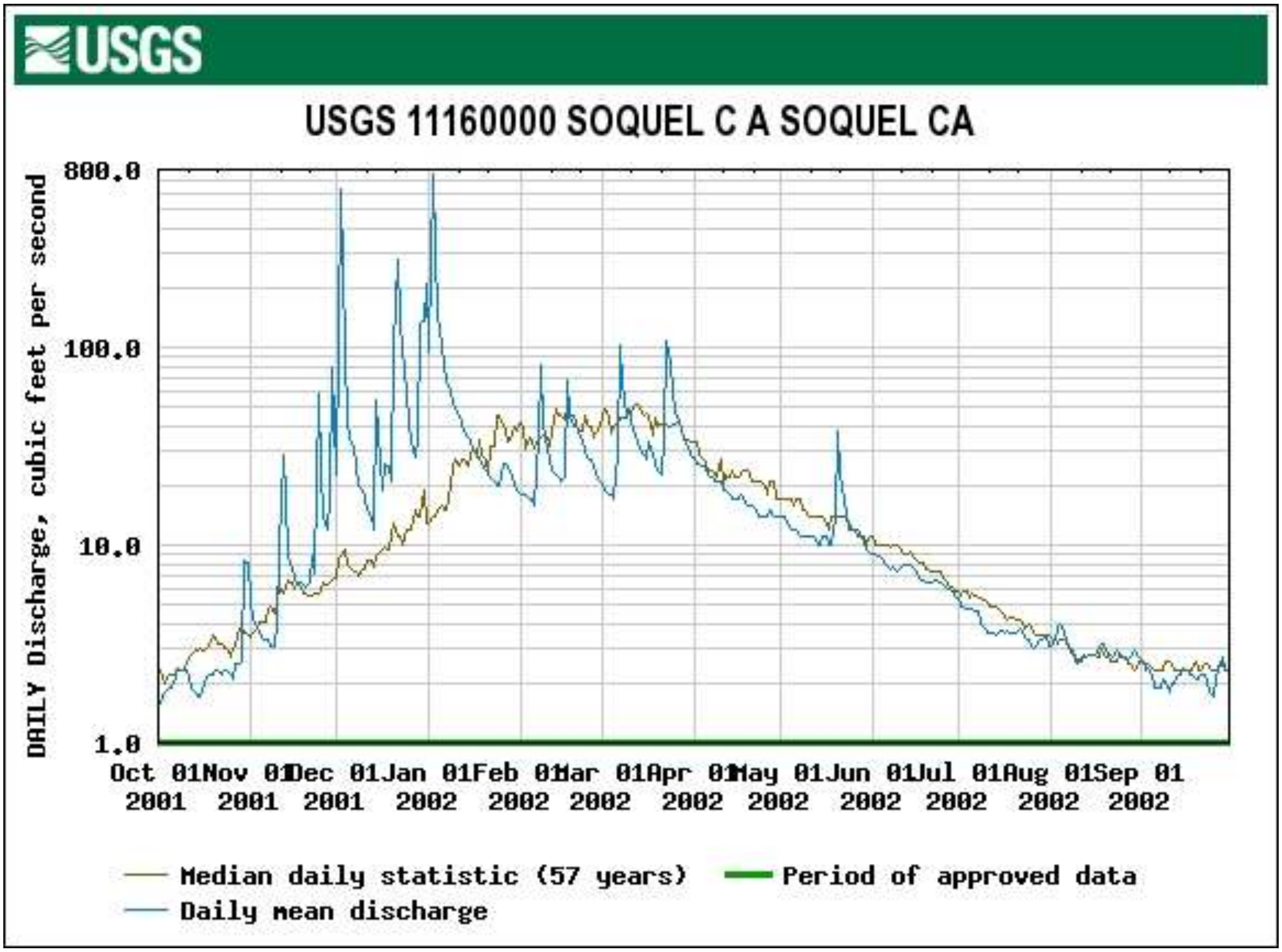


Figure 75. The 2003 Daily Mean and Median Flow at the USGS Gage on Soquel Creek at Soquel.

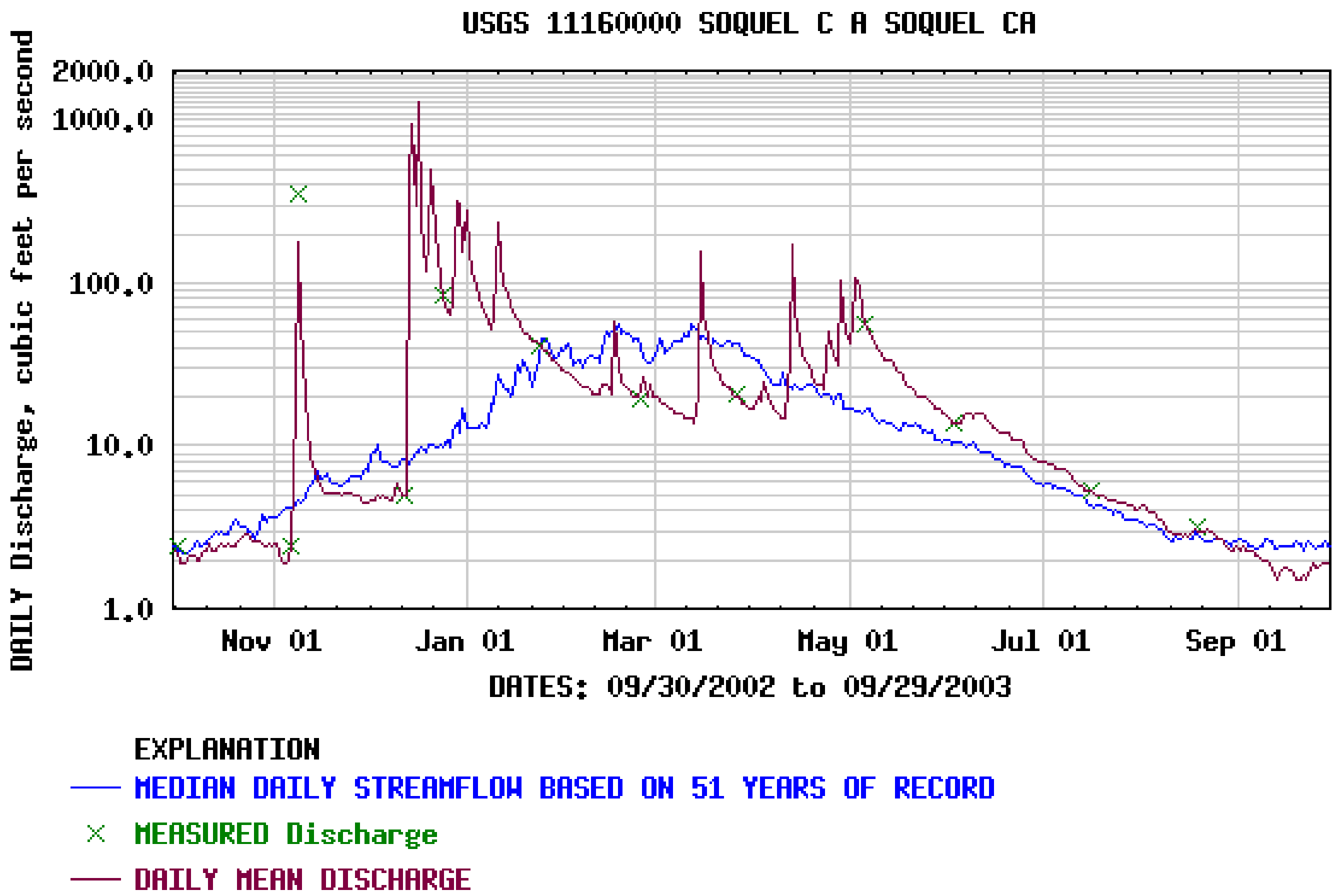


Figure 76. The 2004 Daily Mean and Median Flow at the USGS Gage on Soquel Creek at Soquel.

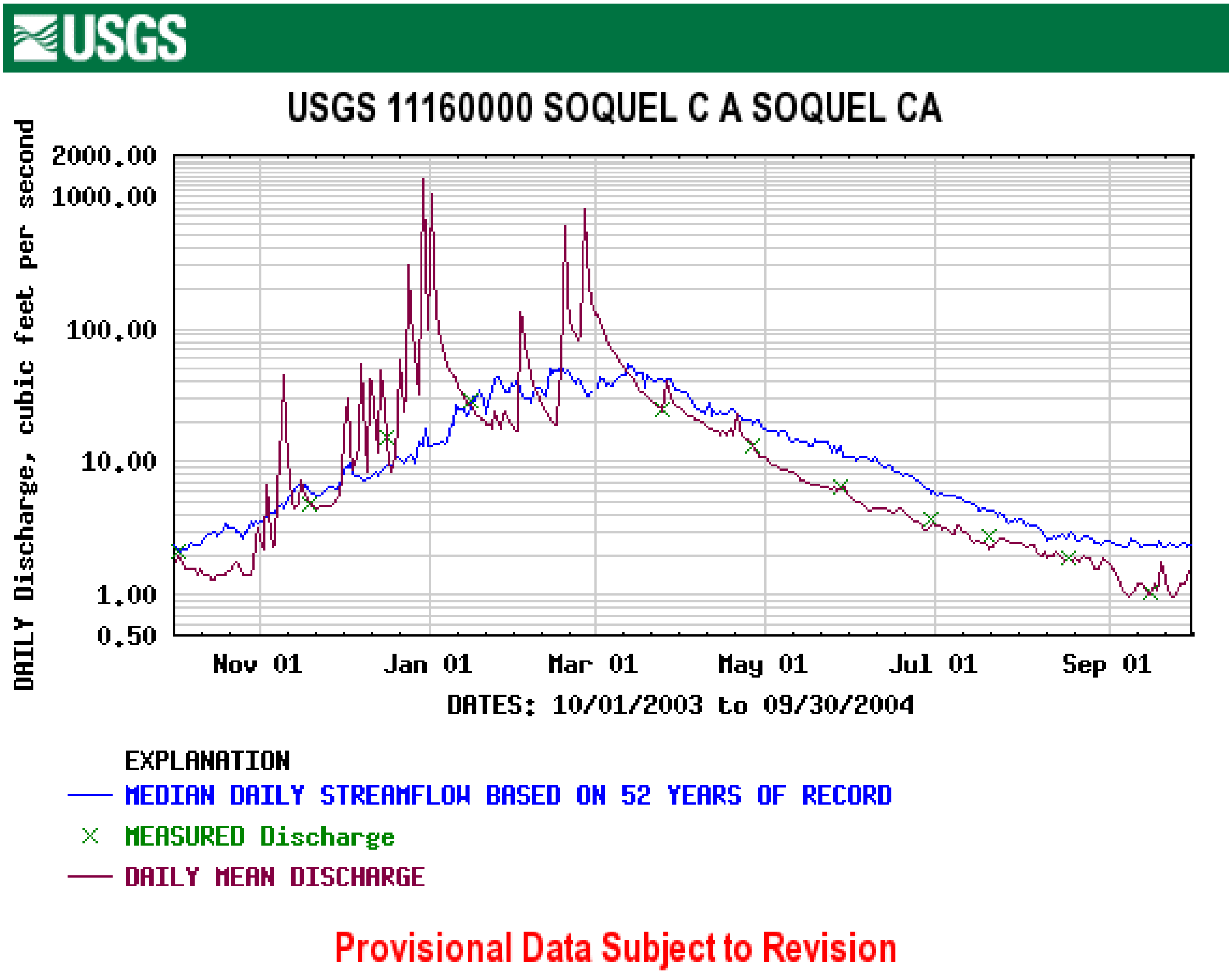


Figure 77. The 2005 Daily Mean and Median Flow at the USGS Gage on Soquel Creek at Soquel.

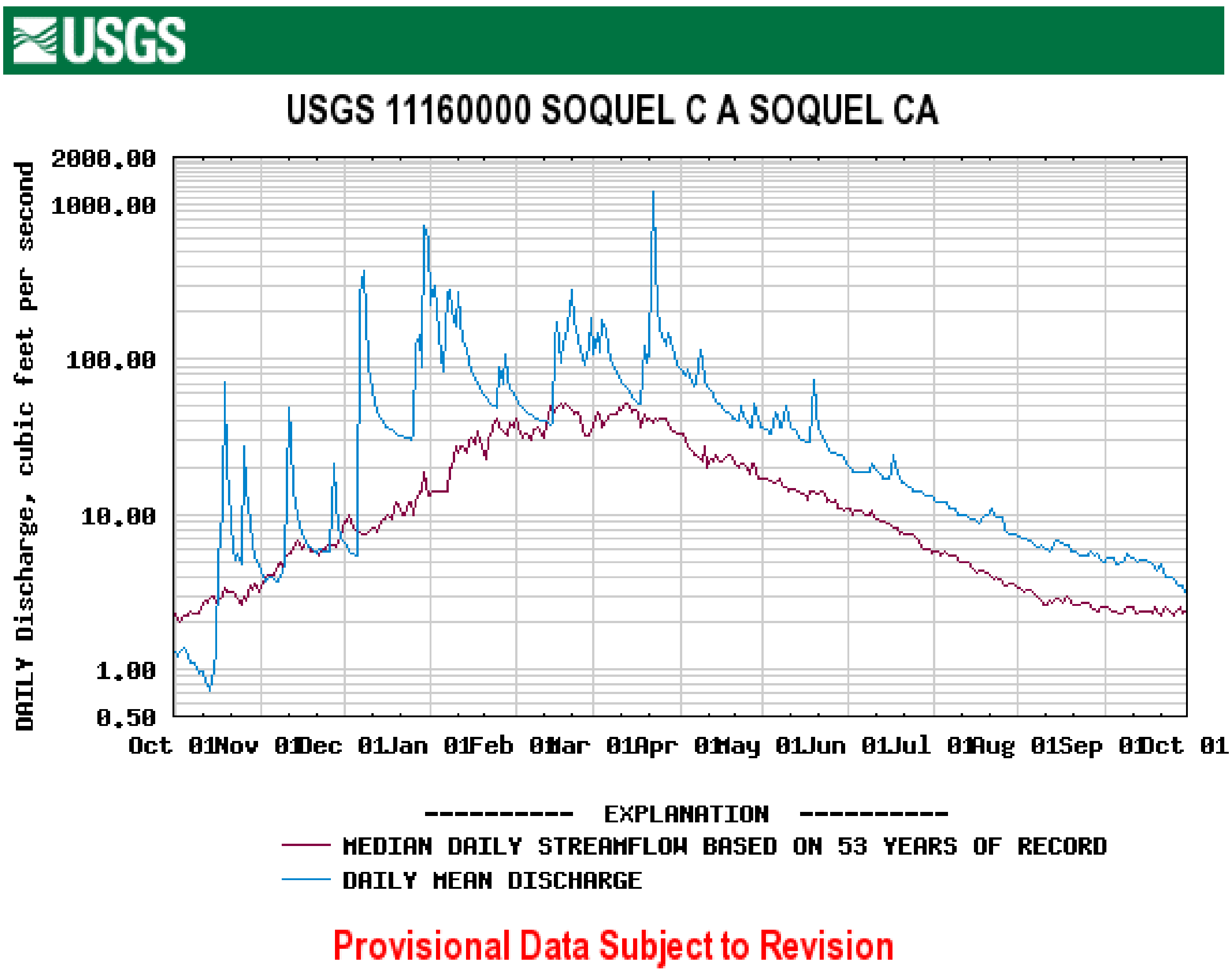


Figure 78. The 2006 Daily Mean and Median Flow at the USGS Gage on Soquel Creek at Soquel.

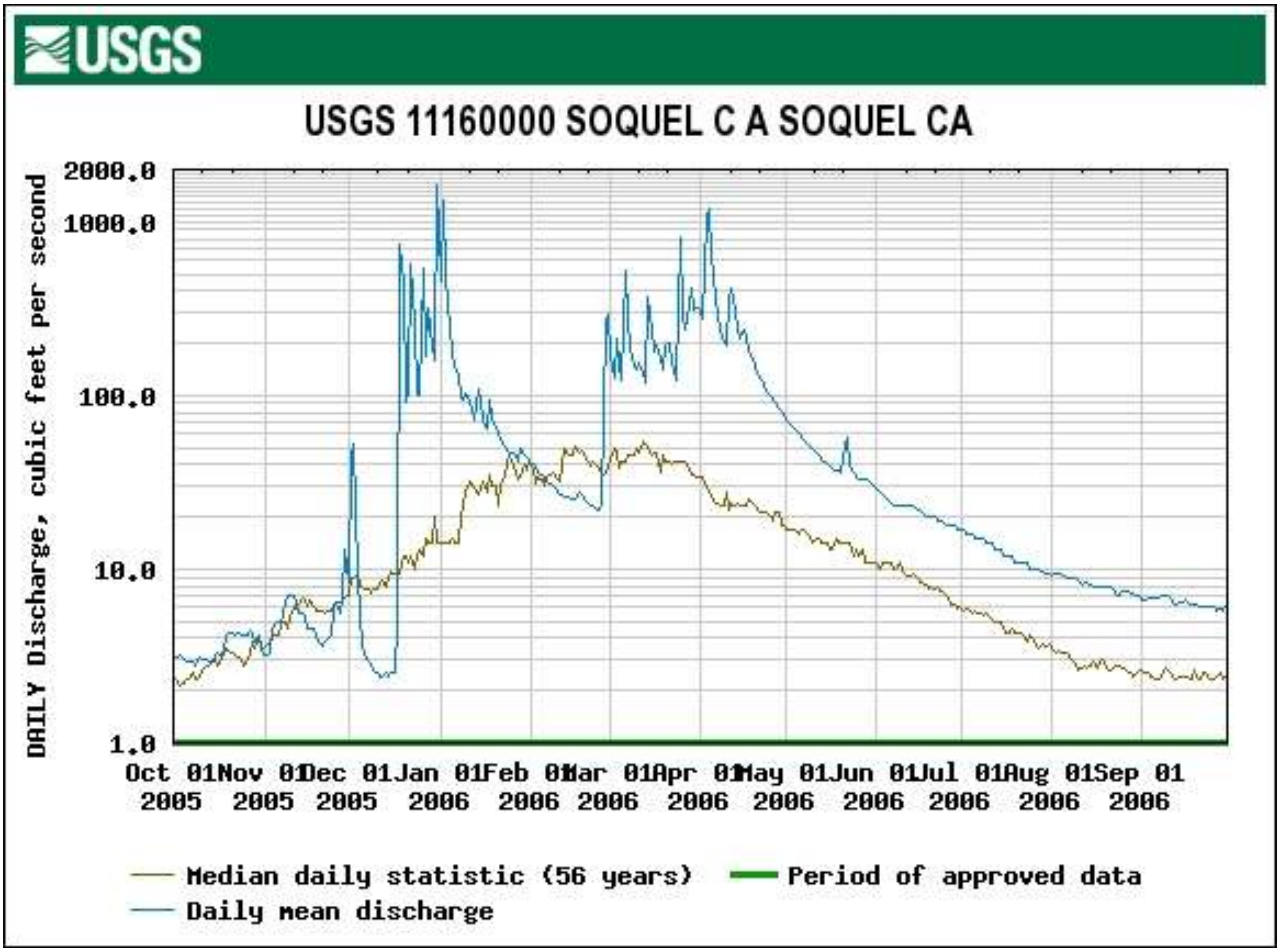


Figure 79. The 2007 Daily Mean and Median Flow at the USGS Gage on Soquel Creek at Soquel.

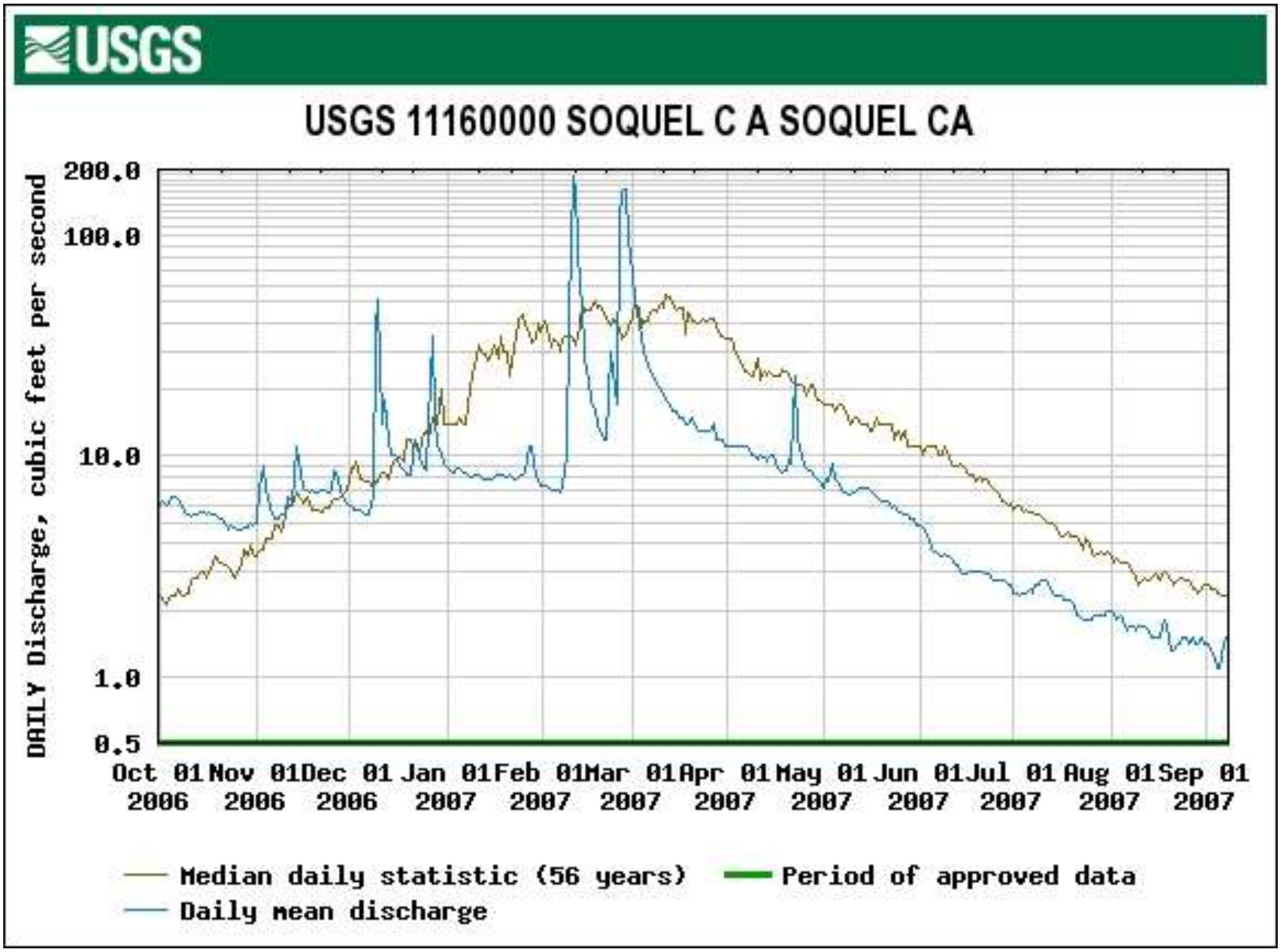


Figure 80. The 2008 Daily Mean and Median Flow at the USGS Gage on Soquel Creek at Soquel.

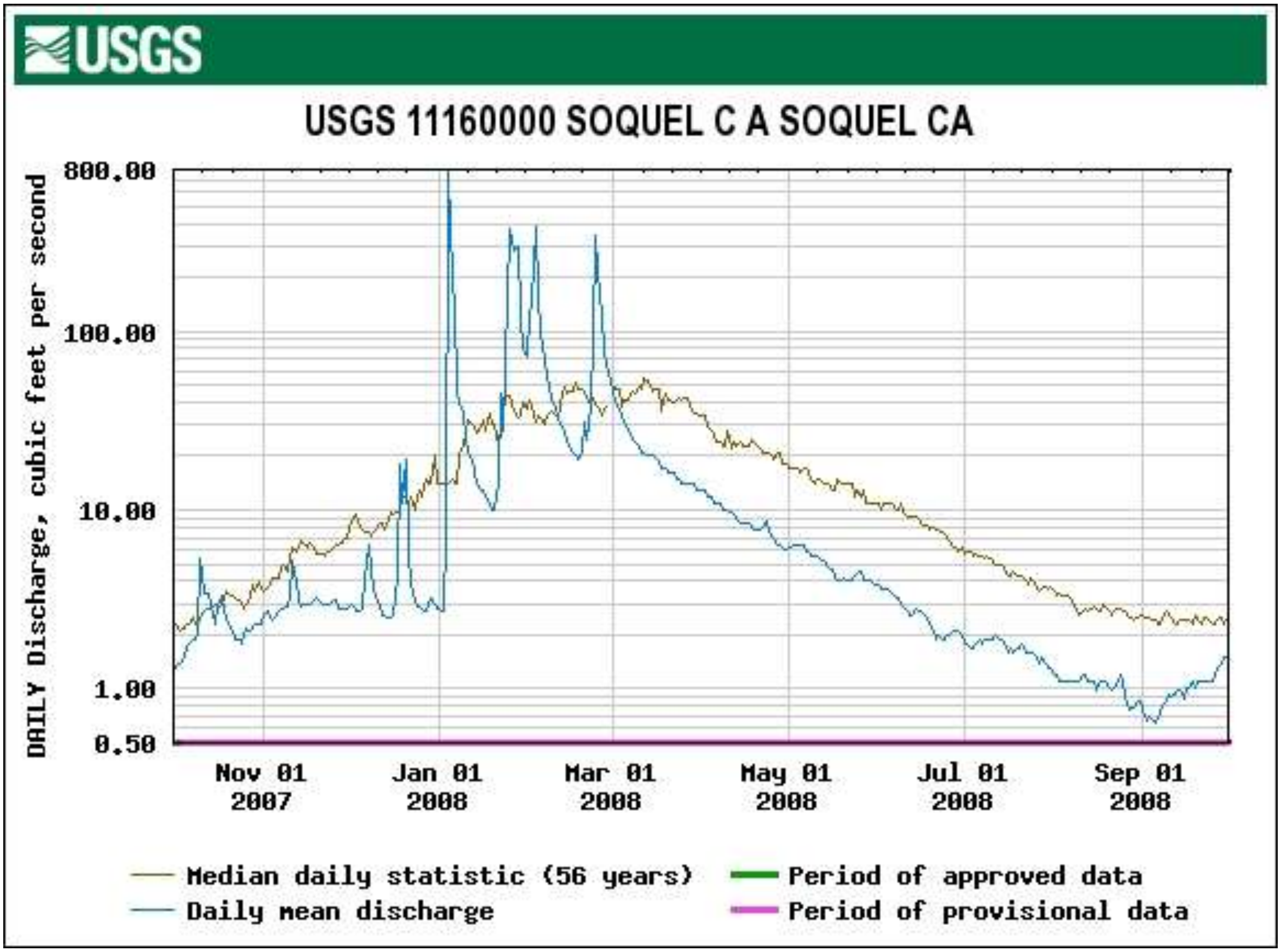


Figure 81. The 1981 Daily Mean Flow at the USGS Gage on Corralitos Creek at Freedom. (USGS website would not provide logarithmic scale of discharge.)

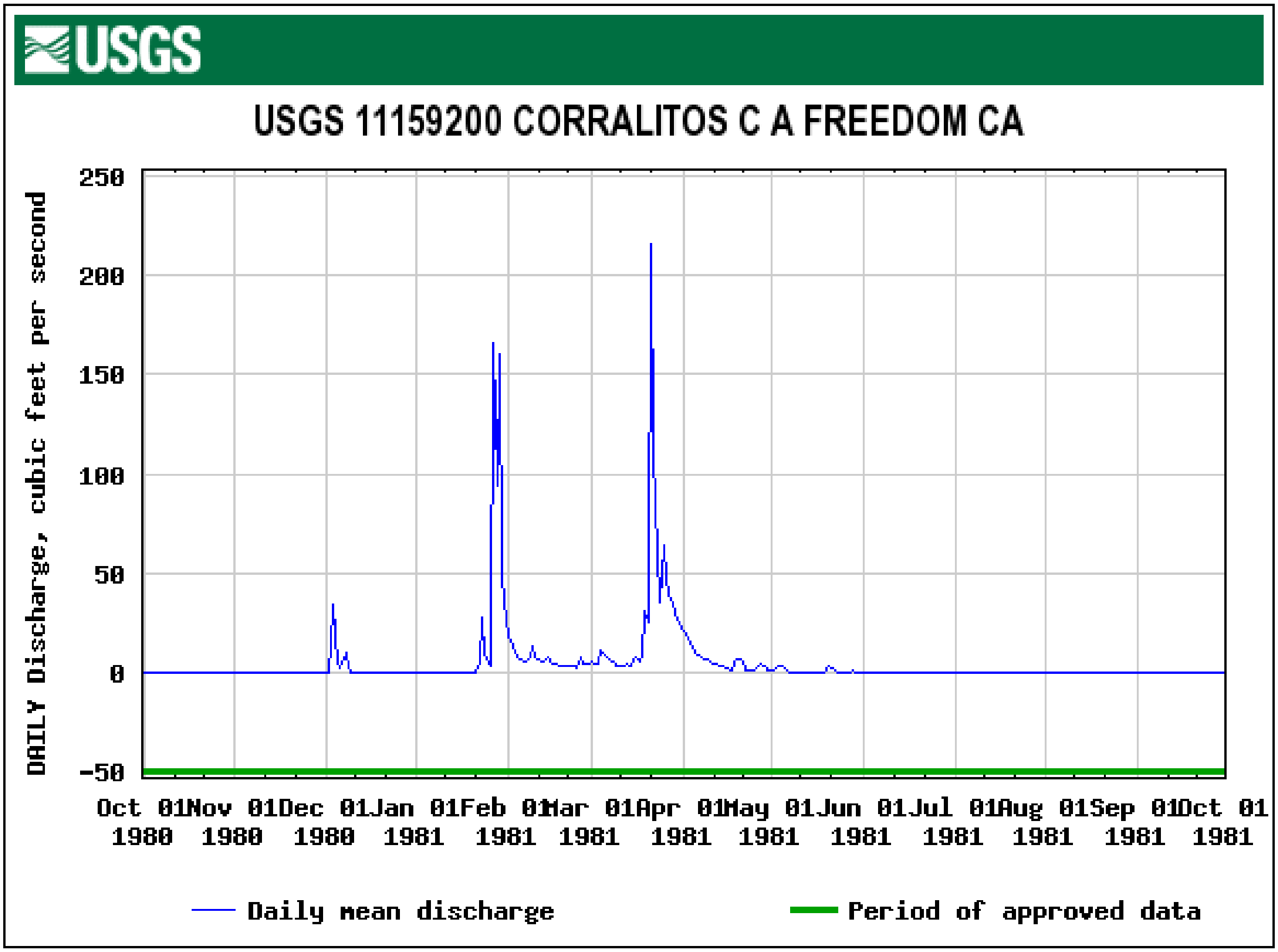


Figure 82. The 1994 Daily Mean Flow at the USGS Gage on Corralitos Creek at Freedom. (USGS website would not provide logarithmic scale of discharge.)

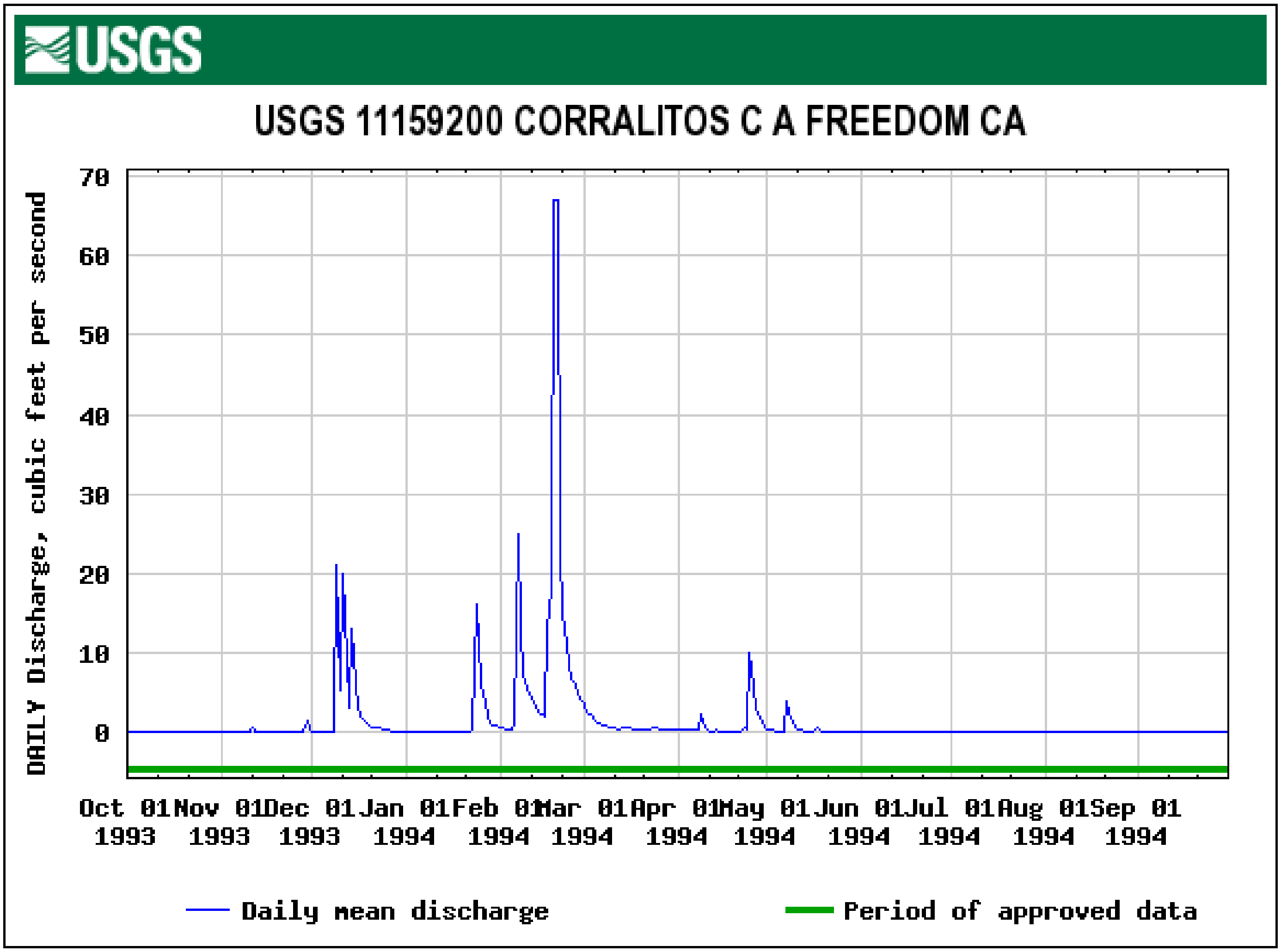


Figure 83a. The 2006 Daily Mean Flow at the USGS Gage on Corralitos Creek at Freedom.

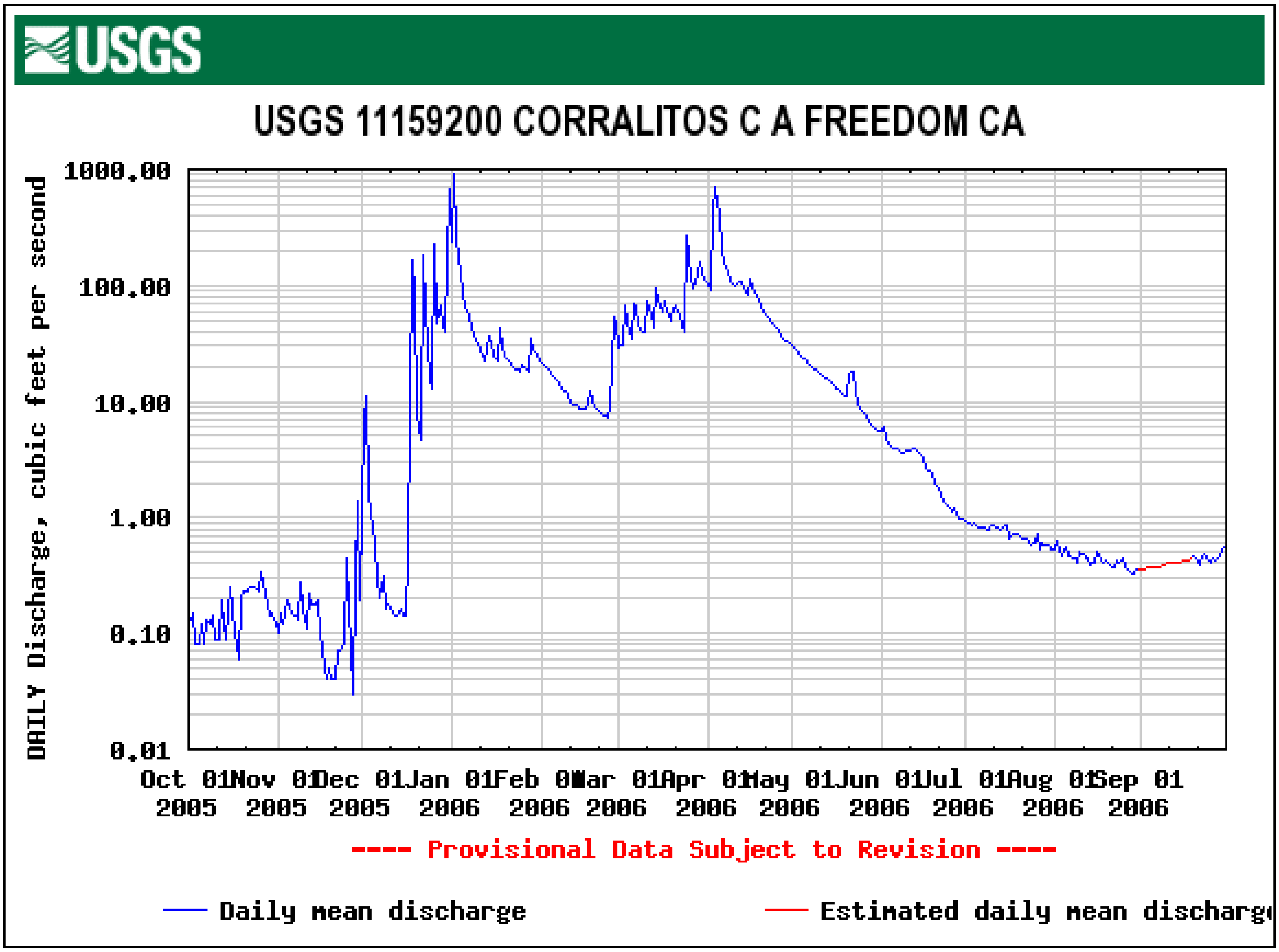


Figure 83b. The 2006 Daily Mean Flow at the USGS Gage on Corralitos Creek at Freedom with Median Flow Statistics.

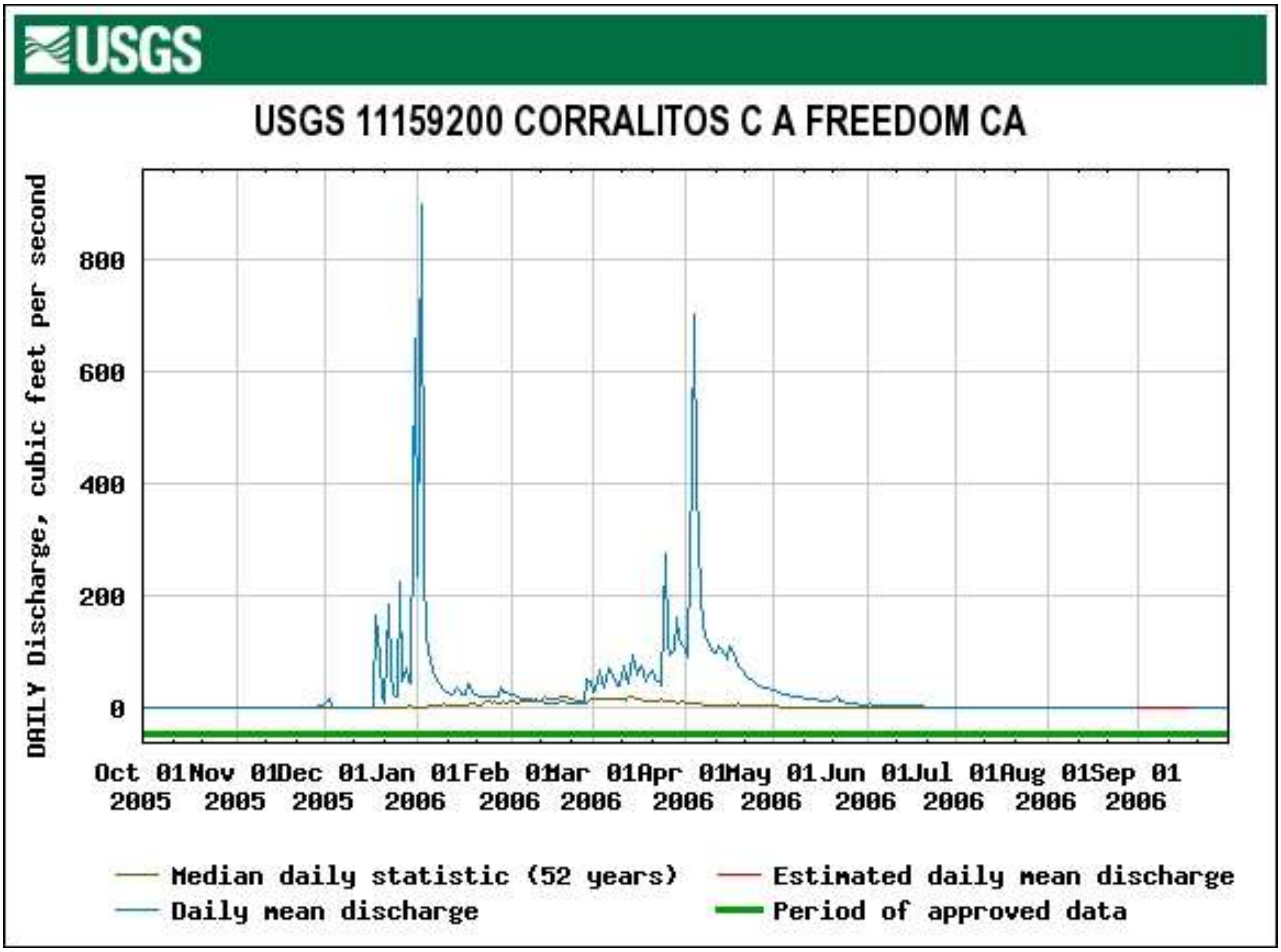


Figure 84. The 2007 Daily Mean and Median Flow at the USGS Gage on Corralitos Creek at Freedom. (USGS website would not provide a logarithmic scale of discharge).

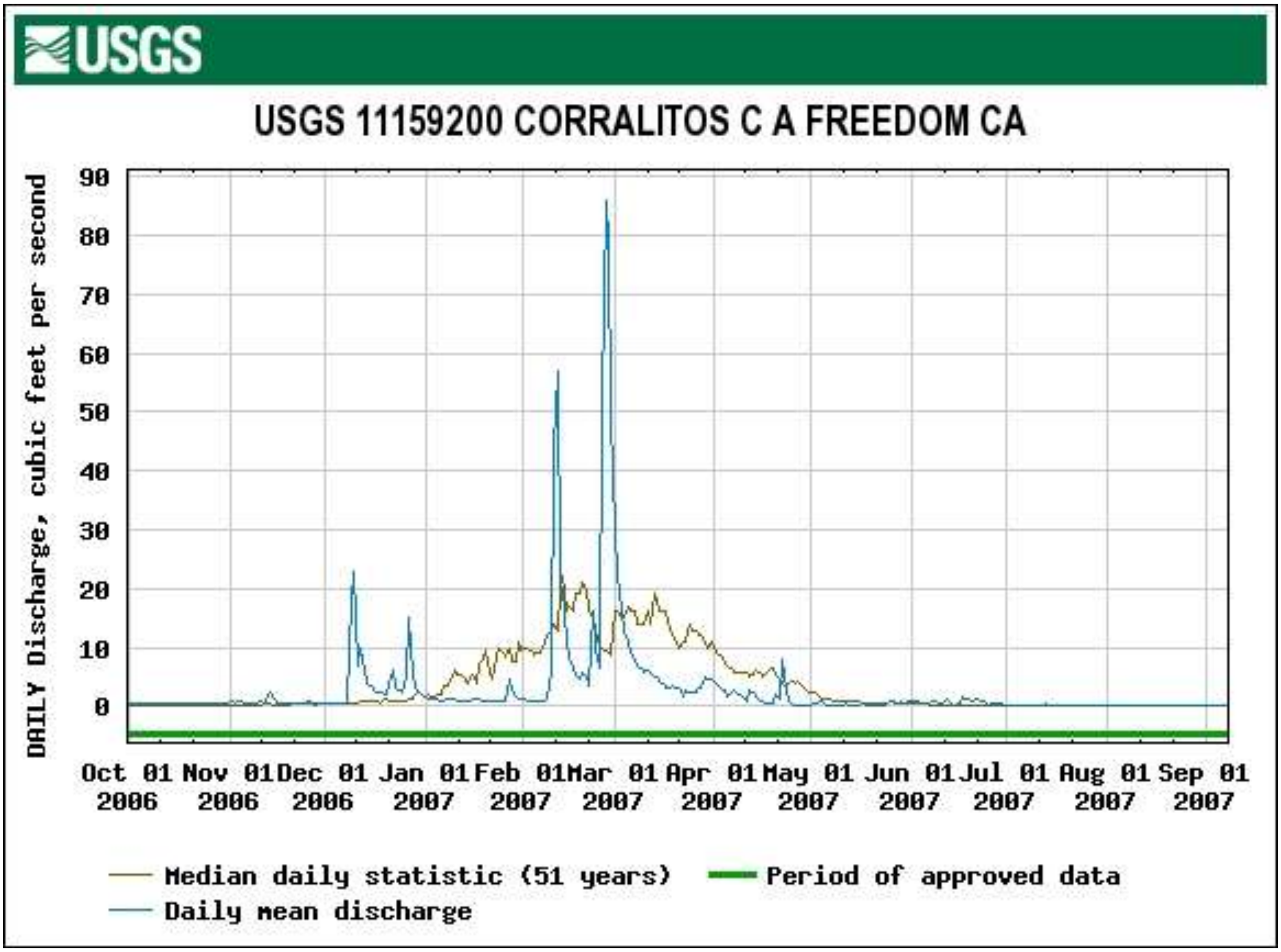
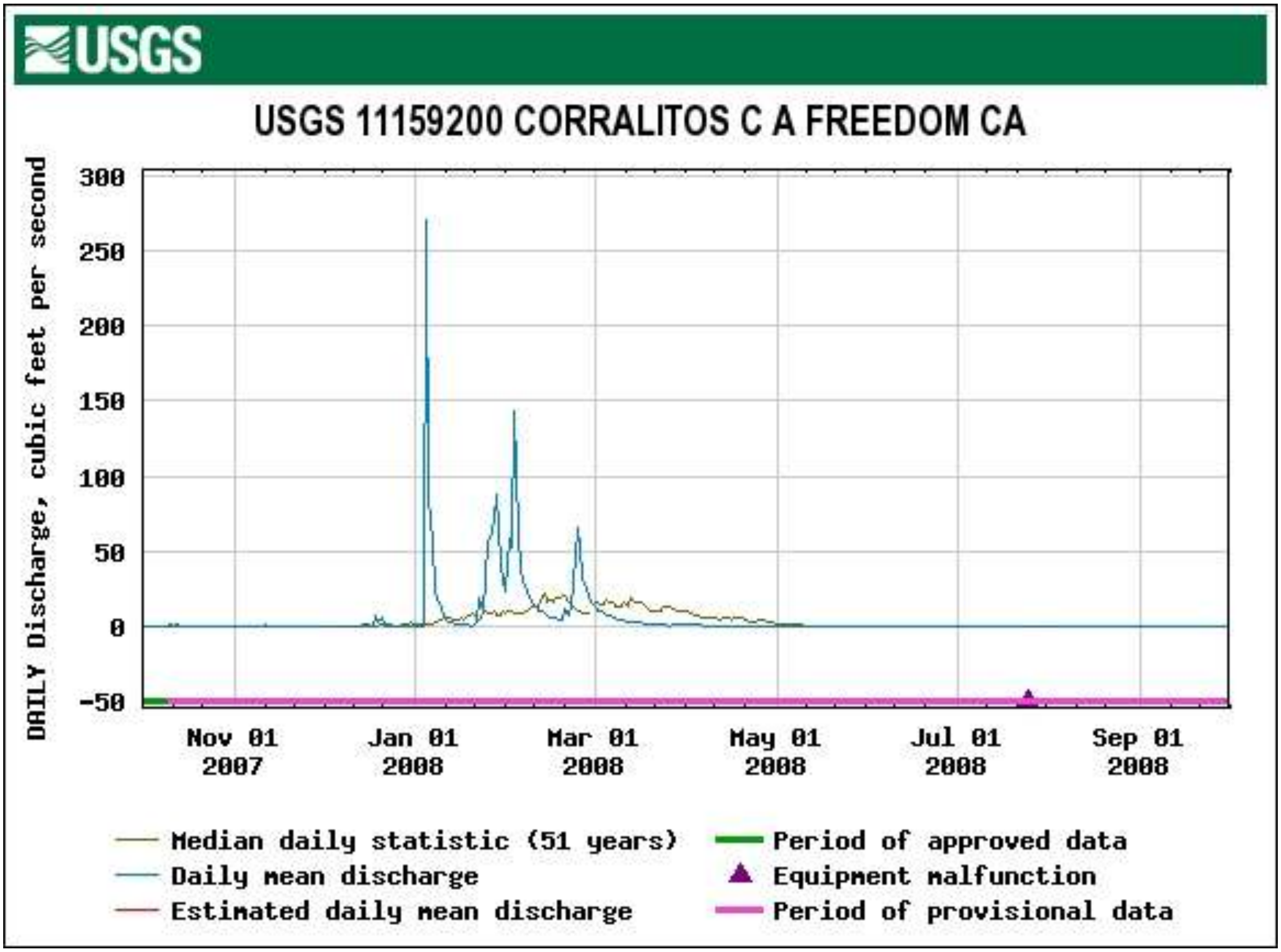


Figure 85. The 2008 Daily Mean and Median Flow at the USGS Gage on Corralitos Creek at Freedom. (USGS website would not provide a logarithmic scale of discharge).



APPENDIX A. Watershed Maps.

Figure 1. Santa Cruz County Watersheds.

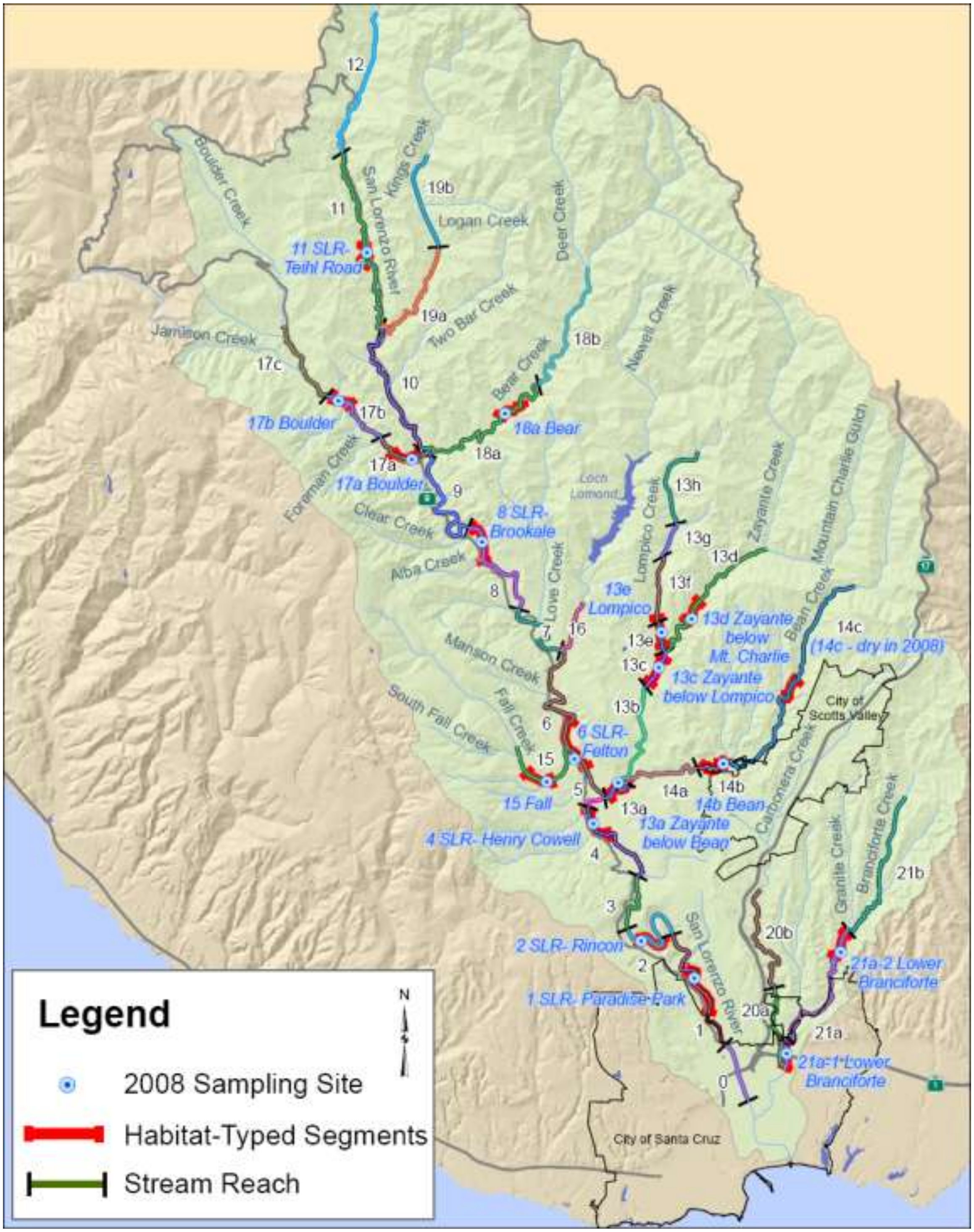


Figure 2. San Lorenzo River Watershed

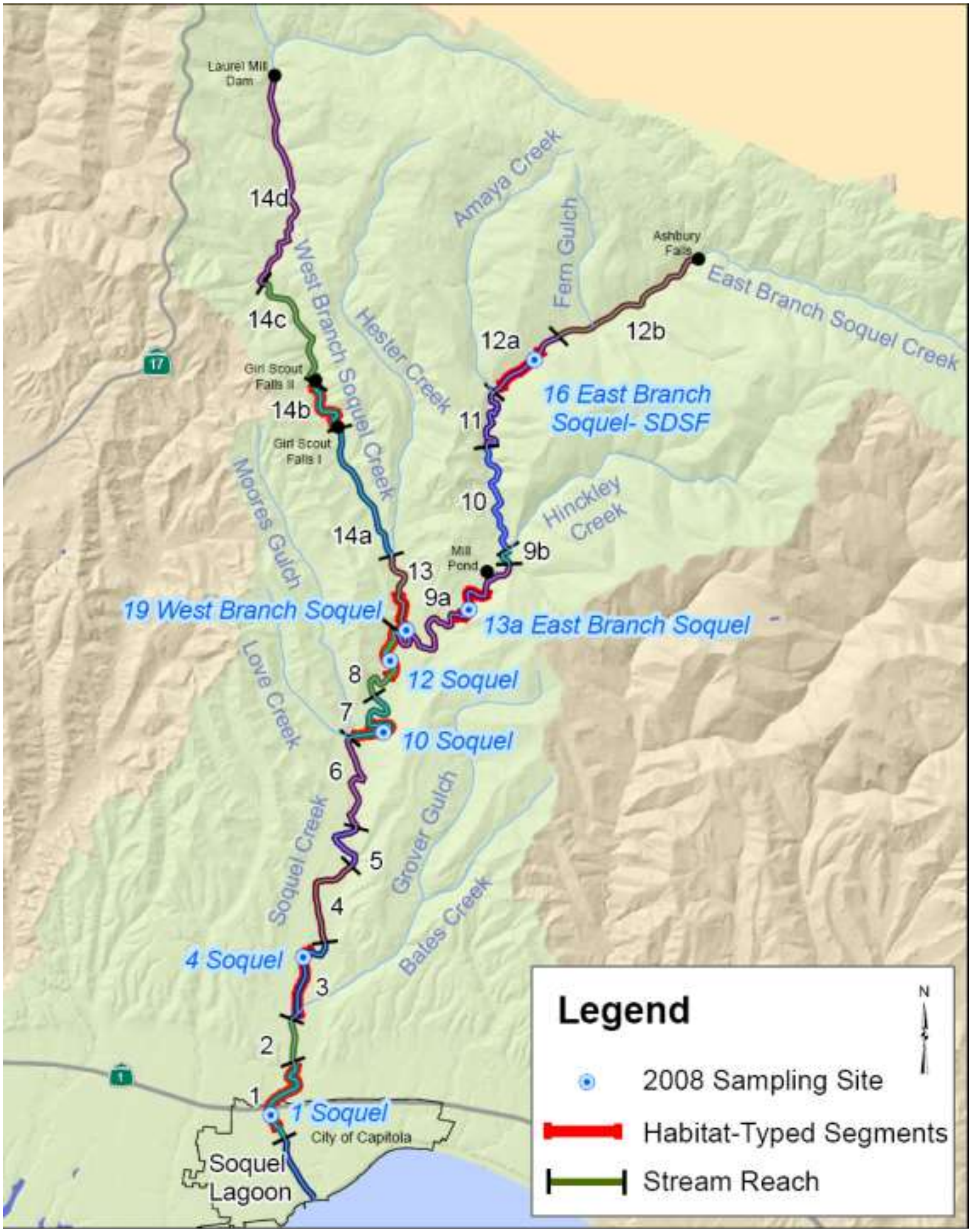


Figure 3. Soquel Creek Watershed.

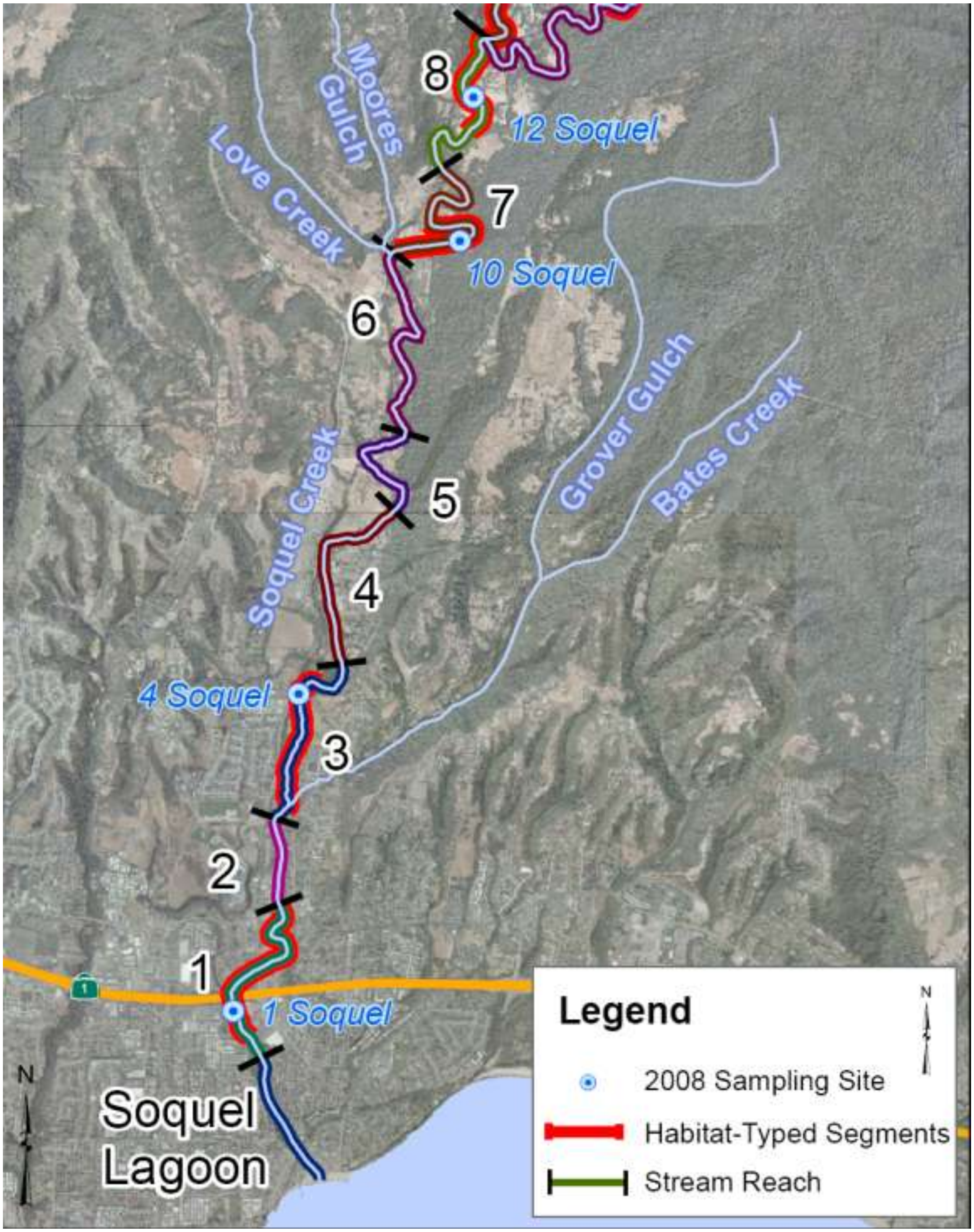


Figure 4. Lower Soquel Creek (Reaches 1–8 on Mainstem).

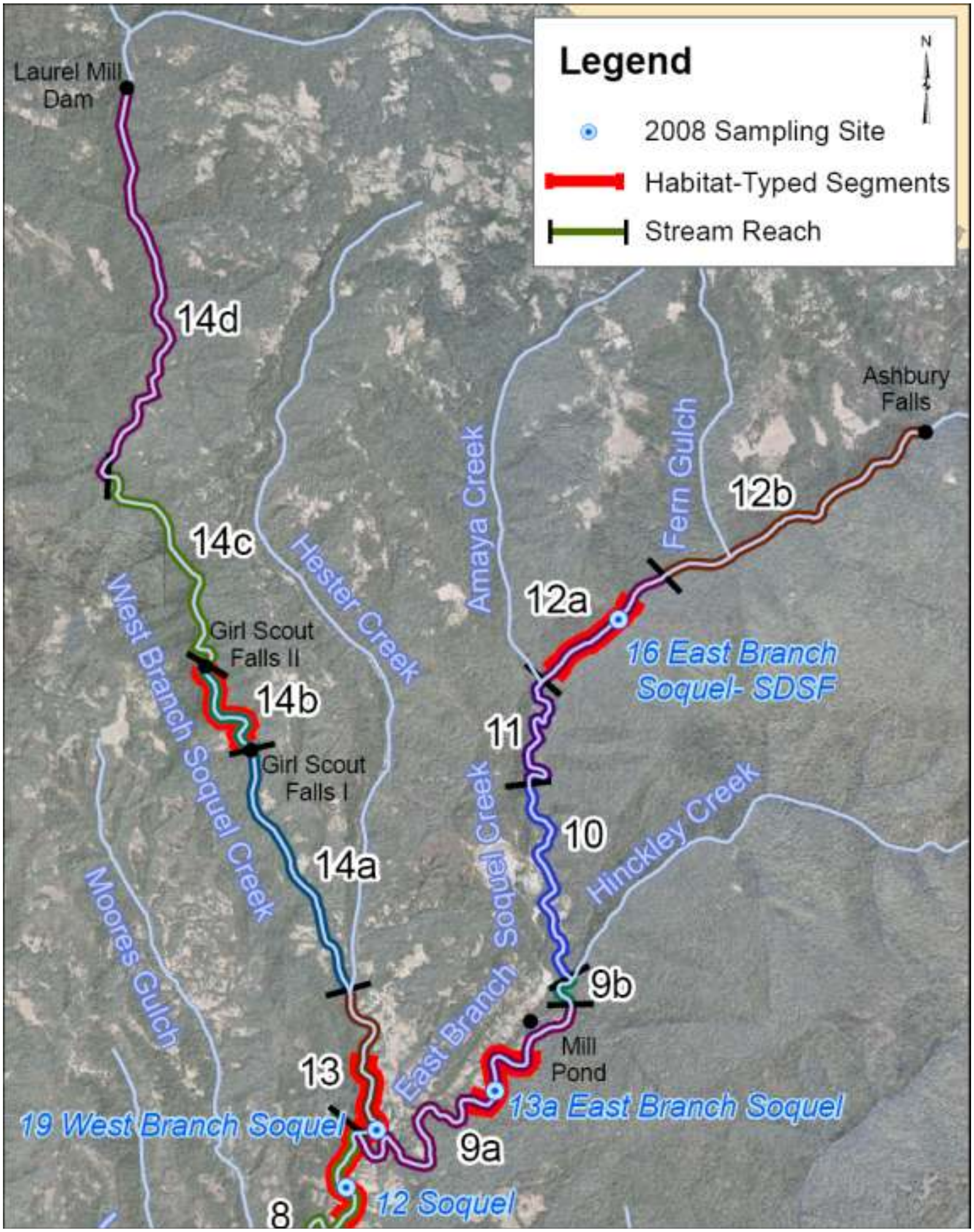


Figure 5. Upper Soquel Creek Watershed (East and West Branches).

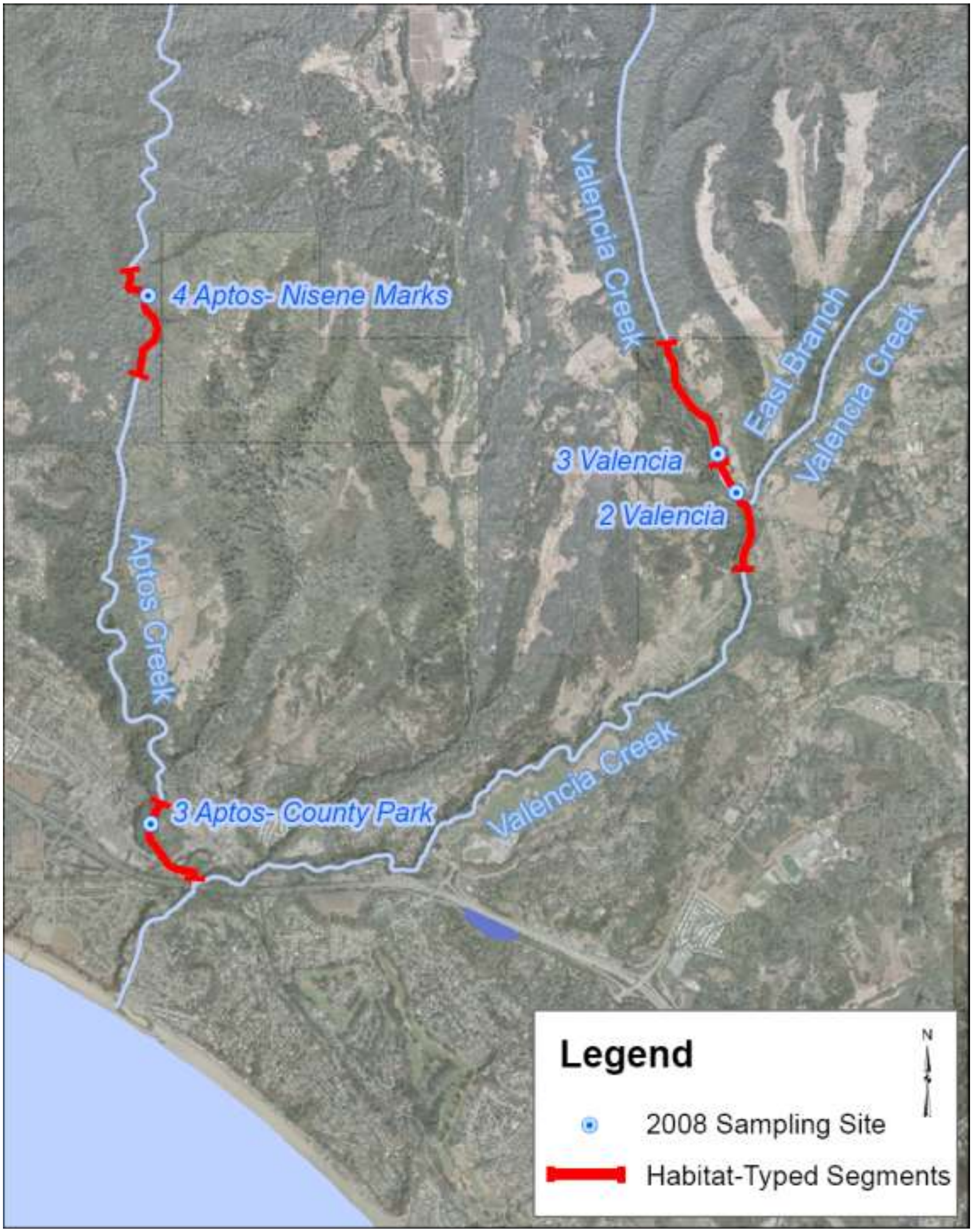


Figure 6. Map from Smith (1982) with Site #3 designation on Valencia Creek at 2006 location.

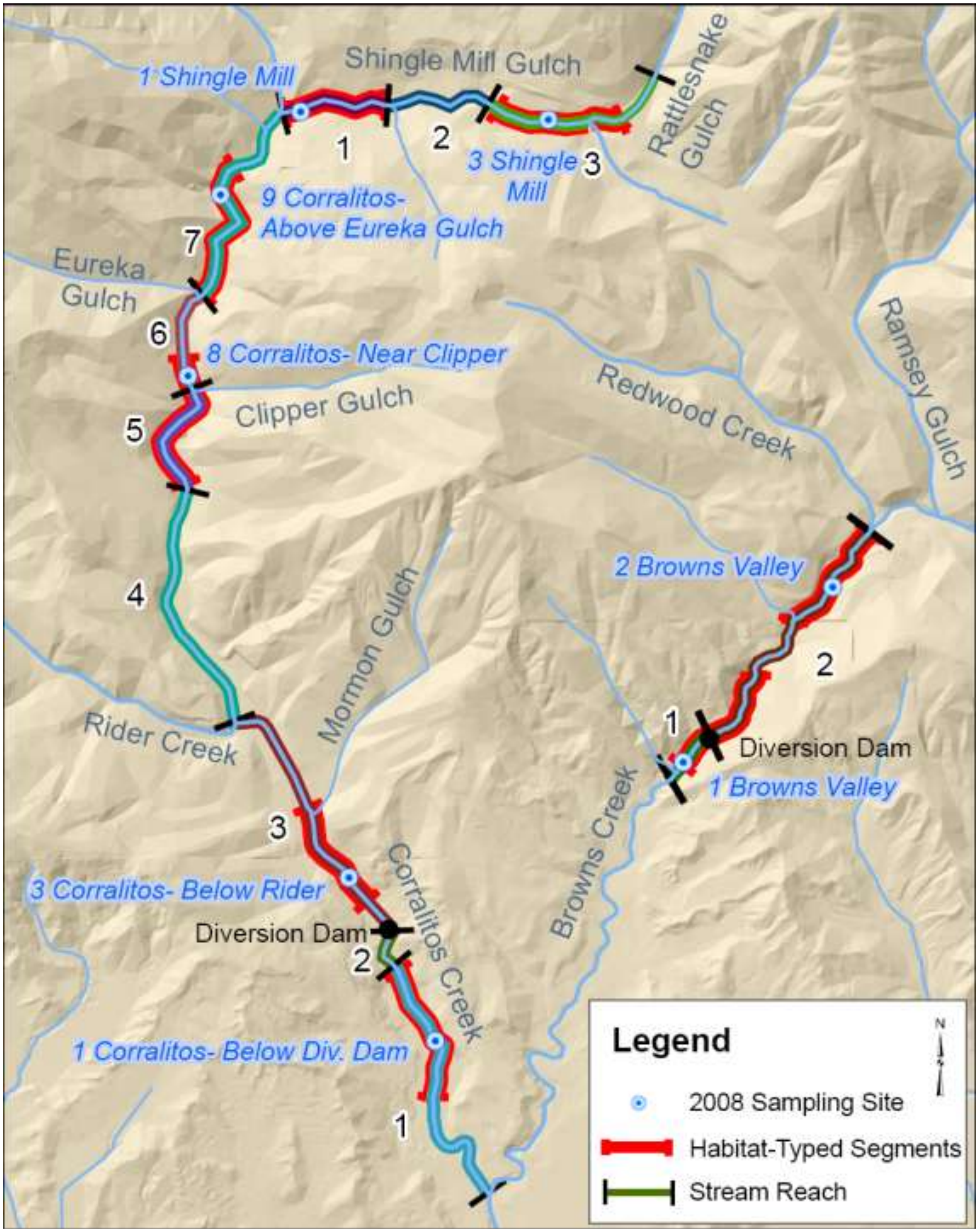


Figure 7. Upper Corralitos Creek Sub-Watershed of the Pajaro River Watershed.

APPENDIX B. Summary of 2008 Catch Data at Sampling Sites.

(Included electronically in a separate PDF file.)

APPENDIX C. Habitat and Fish Sampling Data With Size Histograms.
(Included electronically in a separate PDF file.)