D.W. ALLEY & Associates aquatic biology

2009 Juvenile Steelhead Densities in the San Lorenzo, Soquel, Aptos and Corralitos Watersheds, Santa Cruz County, CA; With San Lorenzo and Soquel Trend Analysis

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SUMMARY REPORT

Scope of Work

In fall 2009, 4 Santa Cruz County watersheds were sampled for juvenile steelhead with the purpose of comparing habitat quality and juvenile densities with past results. Results from steelhead and habitat monitoring are used in obtaining permits for bridge repairs and other public works projects and in guiding watershed management and enhancement projects for species recovery. Refer to maps in **Appendix A** that delineate reaches and sampling sites. The mainstem San Lorenzo River and 7 tributaries were sampled at 17 sites. Sampled tributaries included Branciforte, Zayante, Lompico, Bean, Fall, Newell, Boulder and Bear creeks. Nine half-mile segments were habitat typed to assess habitat conditions and select habitats of average quality to sample. For the remaining 8 sites, the 2008 sites were repeated in 2009. The mainstem Site 0a below Highway 1 and Newell Creek Site 16 were re-established in 2009. In Soquel Creek and its Branches, 8 half-mile segments were habitat typed and fish sampled, including between Girl Scout Falls I and II. 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, fish sampling included 4 sites in Corralitos Creek, 2 sites in Shingle Mill Gulch and 2 sites in Browns Creek, along with 7 associated half-mile reach segments habitat typed (except lower Shingle Mill Reach 1). In-depth analysis of data with all tables and figures are included in the detailed analysis section (**Appendix B**). Hydrographs of all previous sampling years are included in **Appendix E**.

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 Unpublished, independent research has shown that many returning adult steelhead in some local streams reached smolt size their first growing season (**Alley 2010; J.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 young-of-the-year (YOY) to Size Class II in their first growing season. These portions include the San Lorenzo River Lagoon, Aptos Lagoon, Soquel Lagoon, lower mainstem (all years) and middle mainstem (wet years only) of the San Lorenzo River and mainstem Soquel Creek. High baseflow in May−September increases the percentage of YOY reaching Size Class II. Increased production of Size Class II and III juveniles will 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).

Methods

Refer to Detailed Analysis for a more in-depth methods section. Monitored watersheds included the San Lorenzo, Soquel and Aptos, with the Pajaro sub-watershed of Corralitos Creek and some of its tributaries.

Prior to 2006 juvenile steelhead densities were estimated by reach. An index of juvenile steelhead production was estimated by reach and by watershed in the San Lorenzo and Soquel drainages. Indices of adult steelhead population size were also calculated from indices of juvenile population size. Prior to 2006, actual reach density and fish production could be compared between years and between reaches because fish densities by habitat type were extrapolated to reach density and an index of reach production with habitat proportions within reaches factored in.

Since 2006, fish densities at average habitat quality sampling sites in 4 Santa Cruz County watersheds (San Lorenzo, Soquel, Aptos and Corralitos) in previously determined reach segments have been compared to past years' fish densities. The proportion of habitat types sampled at each site within a reach was kept similar between years so that site densities could be compared between years in each reach. However, site density did not necessarily reflect fish densities for an entire reach because the habitat proportions sampled were not exactly similar to the habitat proportions of the reach. In most cases, habitat proportions at sites were roughly similar to habitat proportions in the reach because sampling sites were more or less continuous and lengths of each habitat type were roughly similar. However, in reaches where pools are less common, such as Reach 12a on the East Branch of Soquel Creek and Reach 2 in lower Valencia Creek, a higher proportion of pool habitat was sampled than exists in these respective reaches. More pool habitat was sampled because larger yearlings, almost exclusively utilize pool habitat in small streams, and changes in yearling densities in pools are the most important to monitor. In these two cases, site densities of yearlings were higher than reach densities.

In the San Lorenzo and Soquel watersheds since 1998 and Aptos and Corralitos watersheds since 2006, ½-mile reach segments were habitat-typed using a modified CDFG Level IV habitat inventory method in mainstem and tributary reaches; 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, however, to obtain more quantified, biologically relevant information.

Electrofishing was used at sampling sites to determine steelhead densities according to two juvenile age classes and three size classes in all 4 watersheds. 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 catch data in the middle mainstem reaches included in **Appendix C**, underwater censusing of deeper pools was incorporated into density estimates with electrofishing data from more shallow habitats.

2009 Steelhead Densities and Habitat Conditions Compared to 2008 and Long-term Averages

In All Watersheds (2009 compared to 2008):

1. Both 2008 and 2009 had much less than the median daily statistic in the third successive dry year (see USGS hydrographs below). However in 2009, larger stormflows came after March 1during a protracted rainy season, with higher spring/ summer/ fall flows than in 2008.

2. After another mild winter, yearling densities were generally similar between years at most sites and close to average, though sporadically higher in 2009 than 2008 at a few upper tributary sites.

3. With higher baseflow (especially in spring) than 2008 and fewer young-of-the-year (YOY) present, the growth rate of YOY was greater in 2009, with a higher proportion of YOY reaching Size Class II to sustain similar or higher densities of these larger juveniles.

4. In 2009, total and YOY densities were greatly reduced and below average except at some upper mainstem or tributary sites, even though both years were dry with similar baseflow.

5. The reduced YOY densities were likely caused by a shorter window of passage flows, later stormflows and fewer adult spawners in water year 2009. In 2009, much below average numbers of adult spawners were counted on the Carmel River (412 in 2008 vs. 95 in 2009 at San Clemente Dam) and estimated on Scott Creek (293 in 2008 vs. 126 in 2009). Later stormflows may have also reduced redd (nest) retention, egg survival and YOY survival after emergence from the gravel in 2009.

6. Highest YOY densities at uppermost sites indicated that most spawning effort and/or most spawning success was furthest upstream. However, in 2009 there were likely insufficient YOY produced at upstream locations to filter downstream and seed lower reaches.

7. In most cases, instream wood contributed a small amount of cover and less than 30% of the total pool escape cover in 16 of 28 reach segments (see graph below).

8. The 8 reach segments that provided the most wood as pool escape cover in ascending order, with percent of total pool cover as wood in parentheses, were Soquel 9a (34%), Fall 15 (32%), Aptos 4 (27%), Soquel 1 (19%), Aptos 3 (24%), Soquel 3 (28%), Bean 14b (32%) (much artificially added small, cut wood) and Valencia 3 (33%). Sampling sites in Fall 15 and Valencia 3 had the highest smolt-sized juvenile densities in the group and the highest of sites sampled (**Table 42**). However, sites in reaches Zayante 13d, Corralitos 5-6 and Corralitos 7 had similar smolt densities with escape cover as mainly unembedded boulders and little wood.

9. Reach segments which had the least wood cover in pools were those with steep canyon walls (Boulder 17a, Zayante 13d and Soquel 14b), those below dams (Newell 16) and sometimes those in close proximity to roads or houses (Corralitos 7, Soquel 7 and SLR mainstem 11). Reach segments in Boulder 17a and Corralitos 7 had no instream wood as pool escape cover.

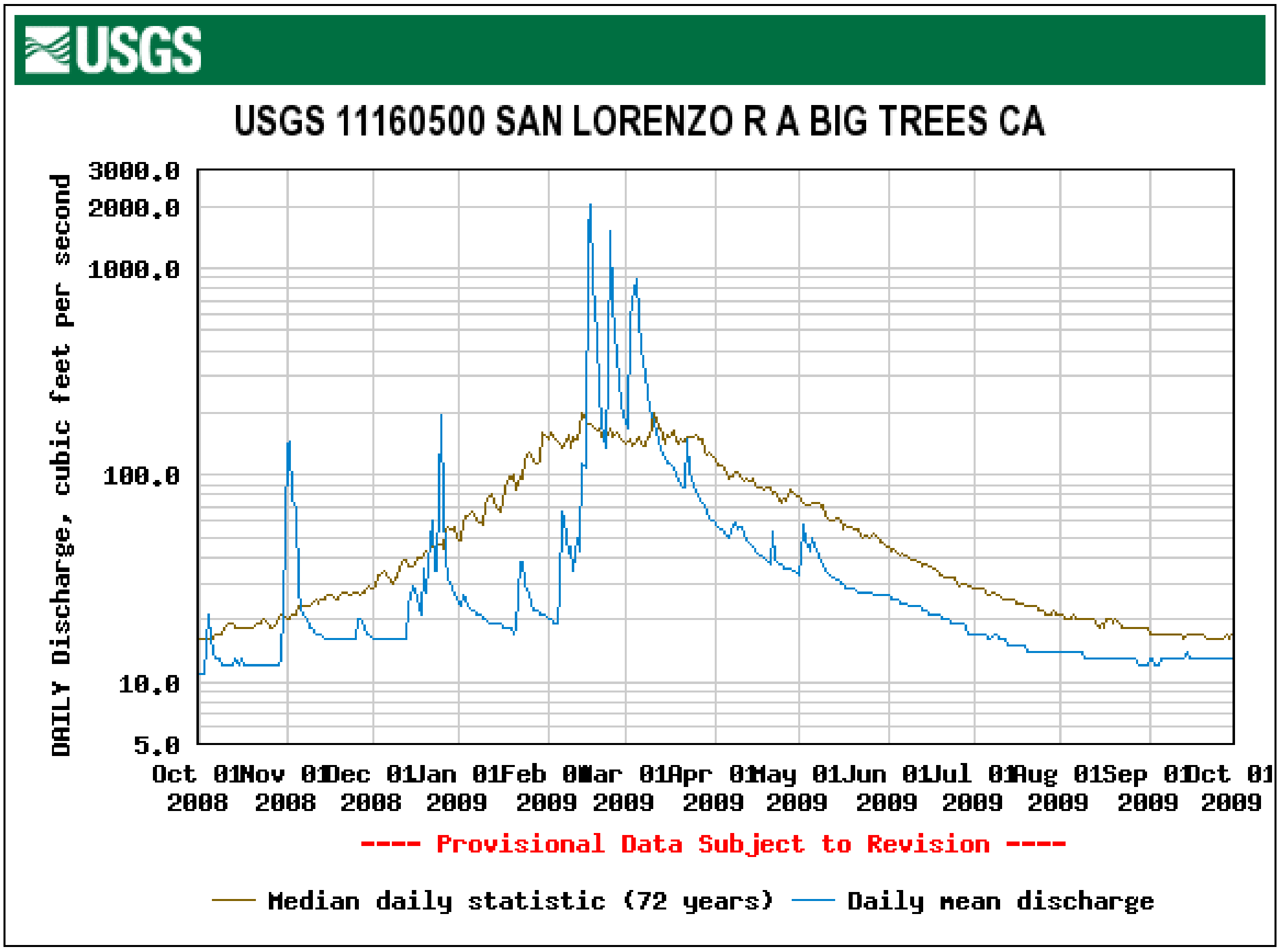
10. In comparing smolt-sized juvenile densities in fall and the average size of these large juveniles between the 4 watersheds, Corralitos Creek is the most productive and Soquel Creek is the least (see table below), except Soquel Lagoon is usually very productive (**Alley 2010**). Aptos and upper Valencia have intermediate densities of juvenile steelhead (upper Valencia may have a high proportion of resident rainbow trout). Sites in the San Lorenzo vary widely in smolt density, though middle and upper Zayante Creek and the lower mainstem San Lorenzo (SLR-4 below Zayante and SLR-2 in the Rincon which have been sampled in recent years and SLR-3 in the Gorge in years past) also can be relatively productive.

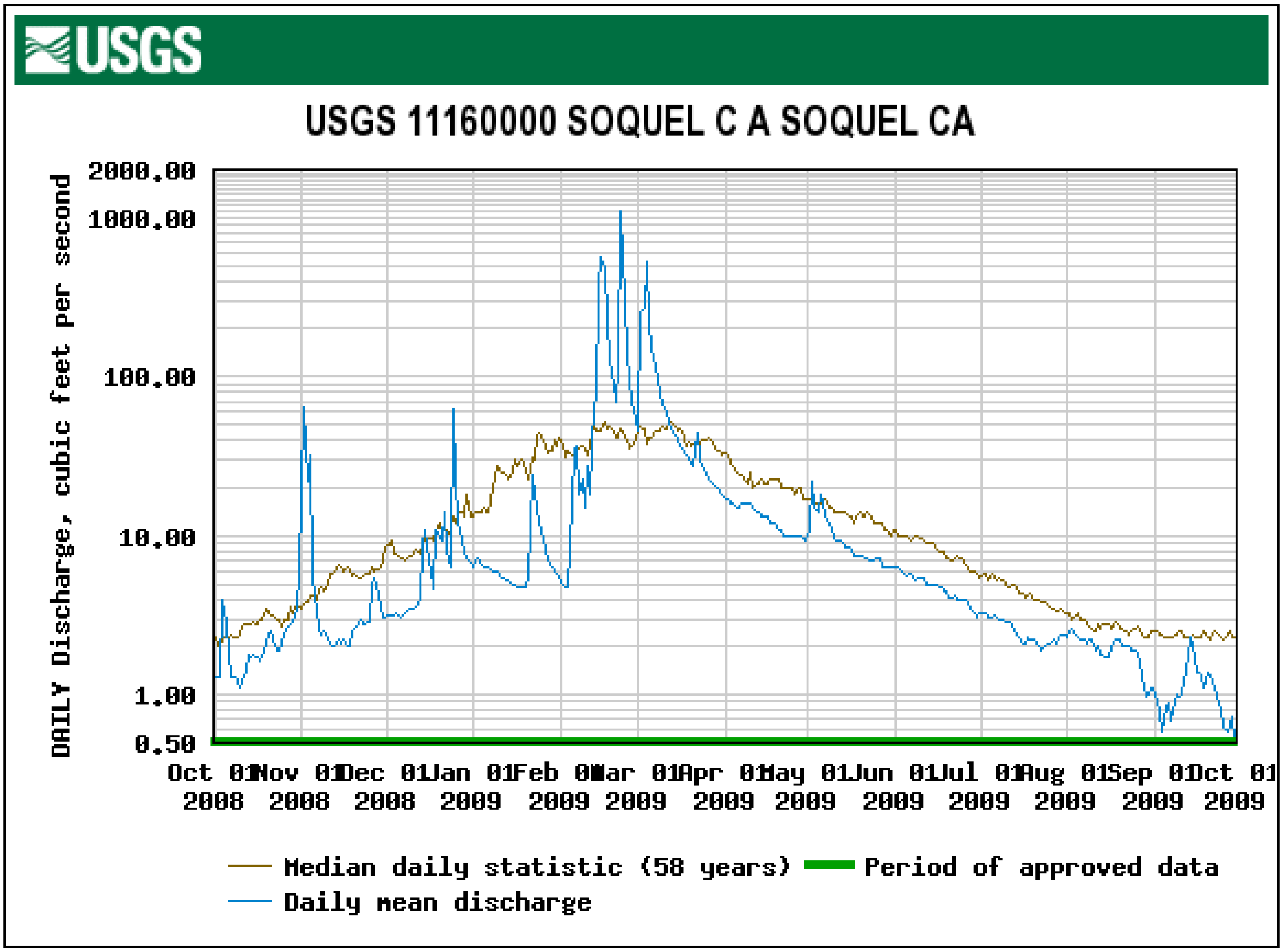
11. The lower San Lorenzo below Zayante Creek has sufficient baseflow to grow a large proportion of YOY to smolt size in one year, as does lower Soquel Creek below Moores Gulch. Nearly all YOY reared in Soquel Lagoon are smolt size by fall. Based on findings in Soquel Lagoon, the San Lorenzo Lagoon is also potentially very productive. In these reaches with high growth potential, factors that determine YOY densities, such as spawning success and/or recruitment of YOY from nearby tributaries, are important in determining smolt densities.

12. In most other reaches in Santa Cruz Mountain watersheds, smolt-sized juveniles are primarily yearlings (San Lorenzo tributaries, upper San Lorenzo, upper Soquel mainstem, Soquel Branches, Aptos Creek sub-watershed and Corralitos Creek sub-watershed), and densities of these larger fish are primarily determined by 1) over-wintering survival from 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.

13. There is a third, intermediate group of sites which may produce a higher proportion of YOY

that reach smolt size by fall if streamflow is high in addition to yearlings. These reaches include the middle mainstem San Lorenzo between Boulder and Zayante creek confluences, upper Soquel mainstem above the Moores Gulch confluence, lower East Branch Soquel, Aptos Creek mainstem and lower Corralitos below Rider Creek confluence. In above average baseflow years, these reaches may also be relatively productive for smolt-sized YOY.




USGS
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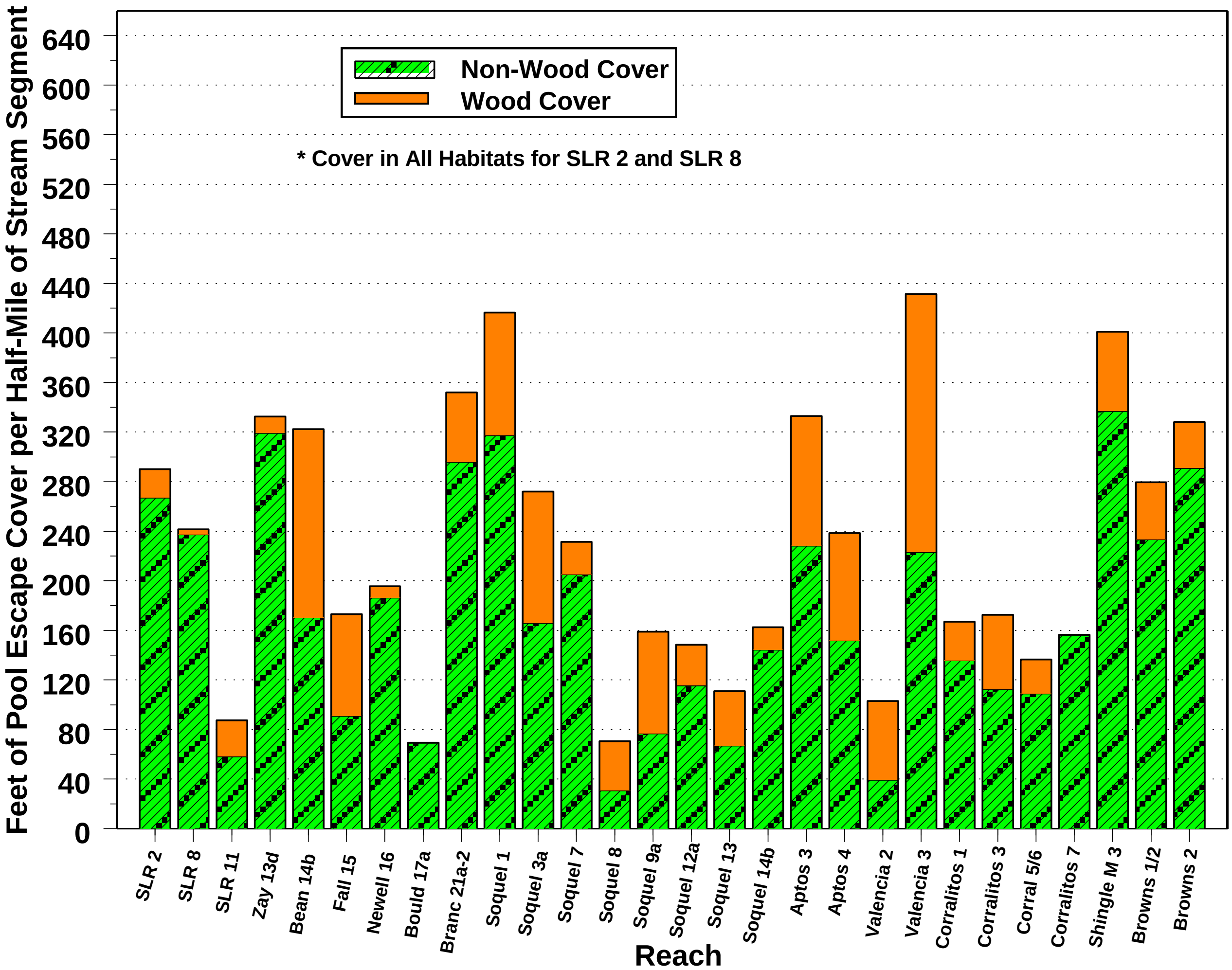
Mar 01 2009
Apr 01 2009
May 01 2009
Jun 01 2009
Jul 01 2009
Aug 01 2009
Sep 01 2009
Oct 01 2009
Median daily statistic (58 years)
Period of approved data
Daily mean discharge

Figure 54. Total Pool Escape Cover per Half-Mile Reach Segment, With Wood Contribution, in the San Lorenzo, Soquel, Aptos and Corralitos Watersheds in Fall 2009.



2009 Sampling Sites Rated by Smolt-Sized Juvenile Density (=>75 mm SL) and Average Smolt Size, with Physical Habitat Change since 2008. (Red denotes ratings of poor or very poor; purple denotes ratings of good and very good.)

Site	Multi-Year Avg. Density (Size Class II and III/100 ft)	2009 Smolt Density (per 100 ft)/ Avg Smolt Size (mm)	2009 Smolt Rating	Numerical Rating (1 to 7)	Physical Habitat Change by Reach Since 2008
Low. San Lorenzo #1	**10.5 (n=9)**	**3.4/125 mm**	Below Average	***	-
Low. San Lorenzo #2	**17.2 (n=8)**	**8.0/105 mm**	**Very Good**	******	**Slight Positive**
Low. San Lorenzo #4	17.7 (n=9)	13.9/85 mm	Below Average	***	Site Positive
Mid. San Lorenzo #6	**4.4 (n=12)**	**0.5/ 76 mm**	**Very Poor**	*	**Site Slight Pos.**
Mid. San Lorenzo #8	**6.9 (n=12)**	**3.5/ 95 mm**	**Poor**	**	**Slight Positive**
Up. San Lorenzo #11	**6.9 (n=12)**	**3.1/ 99 mm**	**Poor**	**	**Slight Positive**
Zayante #13a	10.6 (n=11)	12.1/ 85 mm	Below Average	***	Site Positive
Zayante #13c	11.8 (n=11)	10.4/ 91 mm	Fair	****	Site Similar
Zayante #13d	**18.1 (n=11)**	**16.9/ 97 mm**	**Good**	*****	**Positive**
Lompico #13e	7.1 (n=4)	4.9/ 92 mm	Below Average	***	Site Positive
Bean #14b	13.7 (n=12)	10.9/ 101 mm	Fair	****	Similar
Bean #14c	**13.0 (n=9)**	-	-	-	-
Fall #15	**14.6 (n=7)**	**18.7/ 111 mm**	**Good**	*****	**Negative**
Newell #16	12.0 (n=6)	4.4/94 mm	Below Average	***	Neg. Since 2006
Boulder #17a	11.5 (n=12)	5.5/ 98 mm	Below Average	***	Slightly Positive
Boulder #17b	**10.3 (n=12)**	10.7/ 96 mm	Fair	****	Site Positive
Bear #18a	**11.3 (n=12)**	**2.5/ 88 mm**	**Very Poor**	**	**Site Slight Pos.**
Branciforte #21a-1	**2.2 (n=2)**	-	-	-	-
Branciforte #21a-2	6.2 (n=9)	7.5/ 117 mm	Fair	****	Similar
Soquel #1	**3.9 (n=12)**	5.1/ 93 mm	Below Average	***	Similar
Soquel #4	10.1 (n=13)	8.1/ 96 mm	Fair	****	Slight Positive
Soquel #10	**8.7 (n=13)**	**6.2/ 80 mm**	**Poor**	**	**Negative**
Soquel #12	**8.3 (n=12)**	11.9/ 86 mm	Below Average	***	Negative
E. Branch Soquel #13a	**9.2 (n=13)**	11.2/ 88 mm	Below Average	***	Negative
E. Branch Soquel #16	10.1 (n=13)	13.1/ 98 mm	Fair	****	Positive
W. Branch Soquel #19	**5.1 (n=9)**	14.1/ 92 mm	Fair	****	Positive
W. Branch Soquel #21	10.0 (n=8)	6.8/ 97 mm	Below Average	***	Similar
Aptos #3	10.4 (n=5)	5.2/ 120 mm	Fair	****	Similar
Aptos #4	9.5 (n=5)	8.0/ 99 mm	Fair	****	Similar
Valencia #2	12.3 (n=5)	13.8/ 94 mm	Fair	****	Similar
Valencia #3	**13.9 (n=5)**	**18.5/ 95 mm**	**Good**	*****	**Similar**
Corralitos #1	10.5 (n=3)	13.7/ 96 mm	Fair	****	Similar
Corralitos #3	**10.3 (n=6)**	**9.3/ 112 mm**	**Good**	*****	**Negative**
Corralitos #8	**14.1 (n=6)**	**15.3/ 105 mm**	**Good**	*****	**Slightly Positive**
Corralitos #9	**21.5 (n=6)**	**19.7/ 102 mm**	**Good**	*****	**Negative**
Shingle Mill #1	12.7 (n=6)	6.7/ 103 mm	Fair	****	Site Slight Pos.
Shingle Mill #3	**4.4 (n=6)**	**7.2/ 85 mm**	**Poor**	**	**Positive**
Browns Valley #1	16.9 (n=6)	12.9/ 98 mm	Fair	****	Positive
Browns Valley #2	13.8 (n=6)	11.9/ 98 mm	Fair	****	Positive

<u>In the San Lorenzo River Watershed (2009 compared to 2008):</u>

1. ***In the lower and middle mainstem***, overall habitat quality improved primarily due to increased baseflow, deeper or wider fastwater habitat and more escape cover in fastwater habitat compared to 2008 (**Table 42** below).

2. ***In San Lorenzo tributaries***, generally habitat conditions were similar to 2008 (Branciforte and Bean) or improved in 2009 (Zayante, Lompico, Boulder and Bear) usually with slightly increased baseflow, increased pool depth and increased pool escape cover. Two sites had reduced habitat quality (Fall and Newell (compared to 2006)).

3. Yearling densities at mainstem sites were similarly low in 2008 and 2009 and near average, despite the much above average YOY densities in 2008. This may be explained by early smolting of 2008 YOY able to grow well in a mild, less turbid spring of 2009.

4. Yearling densities at tributary sites were similar at 8 of 10 repeated sites between years and near average at 7 of 11 sites, despite high YOY densities in 2008. Bean, Bear and Newell sites were well below average and the Fall Creek site was much above average. This may be partially explained by early smolting of 2008 YOY able to grow well in the mild, low turbidity spring of 2009.

5. Densities of important larger Size Class II and III juvenile steelhead (=>75 mm SL; soon to smolt) were below average in 2009 at all 6 repeated mainstem sites and much less than 2008 at 3 sites (see graph below). This was because most large mainstem juveniles are typically fast-growing YOY, and there were fewer YOY in 2009.

6. Size Class II and III densities in 2009 were below average at 7 of 11 tributary sites, but close to average at 6 of 11 sites. Yearling overwinter survival was likely good because of the mild winter, but low baseflow conditions likely reduced rearing habitat.

7. Two of 10 tributary sites had slightly higher Size Class II and III juvenile densities in 2009, with 4 other sites doubling this size class density compared to 2008. This increase was consistent with similar or positive change in physical habitat in four of 5 habitat-typed reach segments and 5 other repeated tributary sampling sites, along with slightly increased baseflow throughout and high YOY densities in 2008 for recruitment into the larger size class.

8. Fall Creek Site 15 had the highest Size Class II and III density (may have a mix of migratory steelhead and residents), followed by upper Zayante Site 13d.

9. Despite mostly improved habitat, total and young-of-year (YOY) site densities decreased at all sites in 2009 except Lompico 13e. Total and YOY densities were all below average except at

Zayante 13c and Lompico 13e (Zayante 13d near average; see graphs below). These reduced densities may have been caused by a greatly reduced number of spawners and/or poor spawning success and egg survival consistent with later storm events after March 1.

10. The Lompico site had 5 times the 2008 YOY density and the highest of all sites sampled in the San Lorenzo watershed for the second time since 2006. Access to the site may have improved in 2009 with later storms and a downstream logjam blown out.

11. Four of 7 mainstem sites and 6 of 10 tributary sites had less than half the multi-year average YOY density, with very low densities in 6 of 7 mainstem sites, Bean 14b and Boulder 17a.

12. There were insufficient YOY produced in the mainstem and tributaries to fully seed the mainstem with YOY in 2009, based on much higher densities detected in 1997─1999 and 2008.

Table 42. 2009 Sampling Sites Rated by Smolt-Sized Juvenile Density (=>75 mm SL) and Average Smolt Size in Standard Length, with Physical Habitat Change from 2008 Conditions.

Site	2008 Smolt Density (per 100 ft)/ Avg Smolt Size (mm)	2008 Smolt Rating	2009 Smolt Density (per 100 ft)/ Avg Smolt Size (mm)	2009 Smolt Rating	Physical Habitat Change by Reach Since 2008
Low. San Lorenzo #1	4.9/ 91 mm	Below Average	3.4/125 mm	Below Average	-
Low. San Lorenzo #2	12.2/ 88 mm	Fair	8.0/105 mm	Very Good	Slight Positive
Low. San Lorenzo #4	13.2/ 82 mm	Below Average	13.9/85 mm	Below Average	Site Positive
Mid. San Lorenzo #6	2.2/ 82 mm	Very Poor	0.5/ 76 mm	Very Poor	Site Slight Pos.
Mid. San Lorenzo #8	3.6/ 87 mm	Very Poor	3.5/ 95 mm	Poor	Slight Positive
Up. San Lorenzo #11	2.8/ 98 mm	Poor	3.1/ 99 mm	Poor	Slight Positive
Zayante #13a	6.3/ 92 mm	Below Average	12.1/ 85 mm	Below Average	Site Positive
Zayante #13c	4.4/ 98 mm	Below Average	10.4/ 91 mm	Fair	Site Similar
Zayante #13d	22.5/ 89 mm	Good	16.9/ 97 mm	Good	Positive
Lompico #13e	6.4/ 89 mm	Below Average	4.9/ 92 mm	Below Average	Site Positive
Bean #14b	4.7/ 117 mm	Fair	10.9/ 101 mm	Fair	Similar
Bean #14c	Dry	-	-	-	-
Fall #15	15.8/ 107 mm	Good	18.7/ 111 mm	Good	Negative
Newell #16			4.4/94 mm	Below Average	Neg. Since 2006
Boulder #17a	7.2/ 112 mm	Fair	5.5/ 98 mm	Below Average	Slightly Positive
Boulder #17b	3.8/ 102 mm	Below Average	10.7/ 96 mm	Fair	Site Positive
Bear #18a	5.1/ 105 mm	Fair	2.5/ 88 mm	Very Poor	Site Slight Pos.
Branciforte #21a-1	0.5/ 133 mm	Poor	-	-	-
Branciforte #21a-2	5.7/ 105 mm	Average	7.5/ 117 mm	Fair	Similar
Soquel #1	3.8/ 96 mm	Poor	5.1/ 93 mm	Below Average	Similar
Soquel #4	4.9/ 98 mm	Below Average	8.1/ 96 mm	Fair	Slight Positive
Soquel #10	3.1/ 92 mm	Poor	6.2/ 80 mm	Poor	Negative
Soquel #12	1.5/ 82 mm	Very Poor	11.9/ 86 mm	Below Average	Negative
E. Branch Soquel #13a	4.0/ 99 mm	Poor	11.2/ 88 mm	Below Average	Negative
E. Branch Soquel #16	10.0/ 100 mm	Fair	13.1/ 98 mm	Fair	Positive
W. Branch Soquel #19	5.7/ 82 mm	Poor	14.1/ 92 mm	Fair	Positive
W. Branch Soquel #21	-	-	6.8/ 97 mm	Below Average	Similar
Aptos #3	6.0/ 93 mm	Below Average	5.2/ 120 mm	Fair	Similar
Aptos #4	5.5/ 112 mm	Good	8.0/ 99 mm	Fair	Similar
Valencia #2	11.0/ 92 mm	Fair	13.8/ 94 mm	Fair	Similar
Valencia #3	14.0/ 93 mm	Fair	18.5/ 95 mm	Good	Similar
Corralitos #1	8.7/ 105 mm	Good	13.7/ 96 mm	Fair	Similar
Corralitos #3	8.3/ 104 mm	Good	9.3/ 112 mm	Good	Negative
Corralitos #8	9.4/ 95 mm	Fair	15.3/ 105 mm	Good	Slightly Positive
Corralitos #9	17.1/ 100 mm	Good	19.7/ 102 mm	Good	Negative
Shingle Mill #1	5.6/ 98 mm	Below Average	6.7/ 103 mm	Average	Site Slight Pos.
Shingle Mill #3	0.7/ 83 mm	Very Poor	7.2/ 85 mm	Poor	Positive
Browns #1	11.5/ 102 mm	Good	12.9/ 98 mm	Fair	Positive
Browns #2	12.6/ 103 mm	Good	11.9/ 98 mm	Fair	Positive

Figure 3. Size Classes II and III Steelhead Site Densities in the San Lorenzo River in 2009 Compared to Average Density. (Averages based on 2 to 12 years of data.)

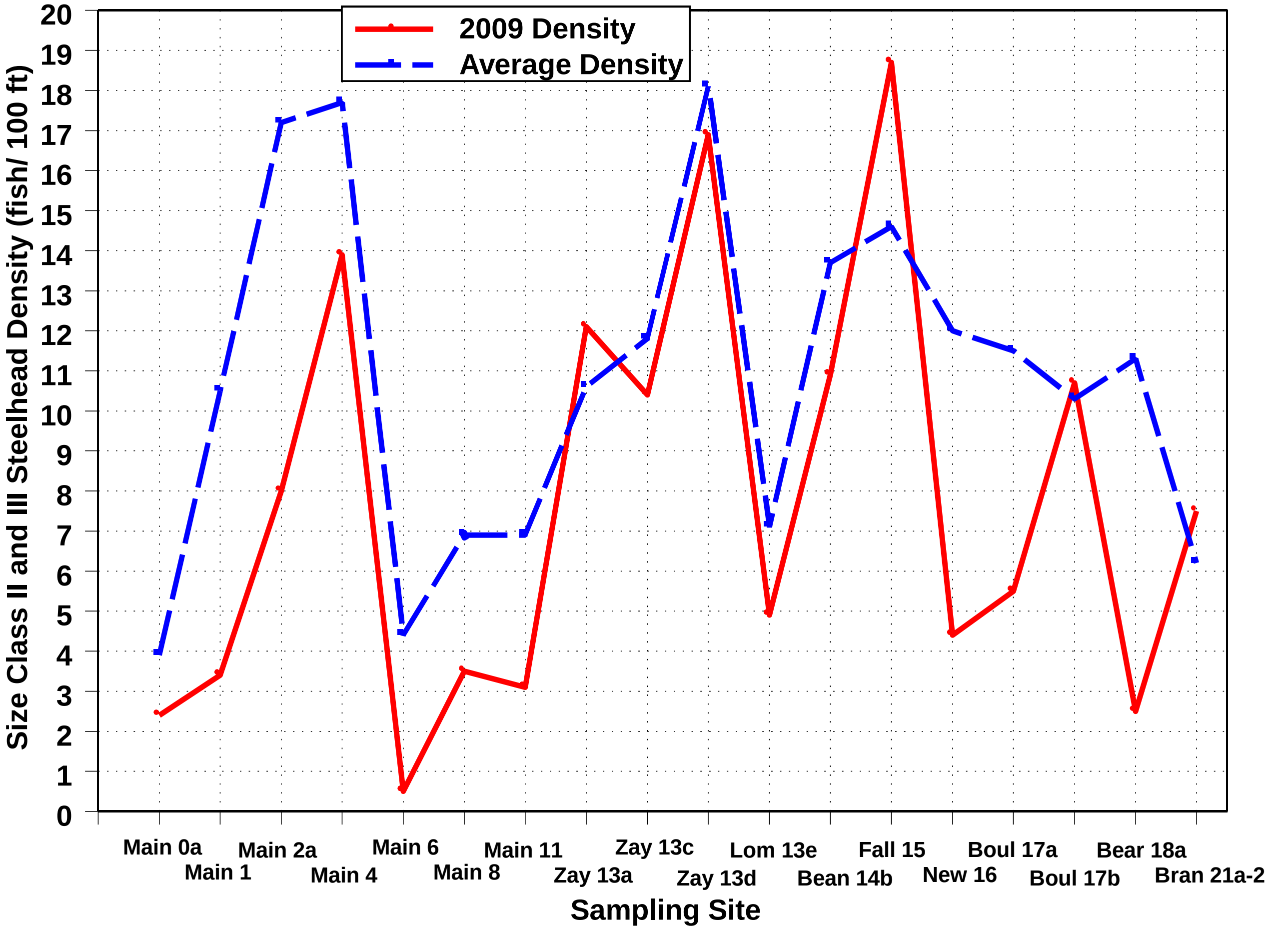


Figure 1. Total Juvenile Steelhead Site Densities in the San Lorenzo River in 2009 Compared to the Average Density. (Averages based on 2 to 12 years of data since 1997.)

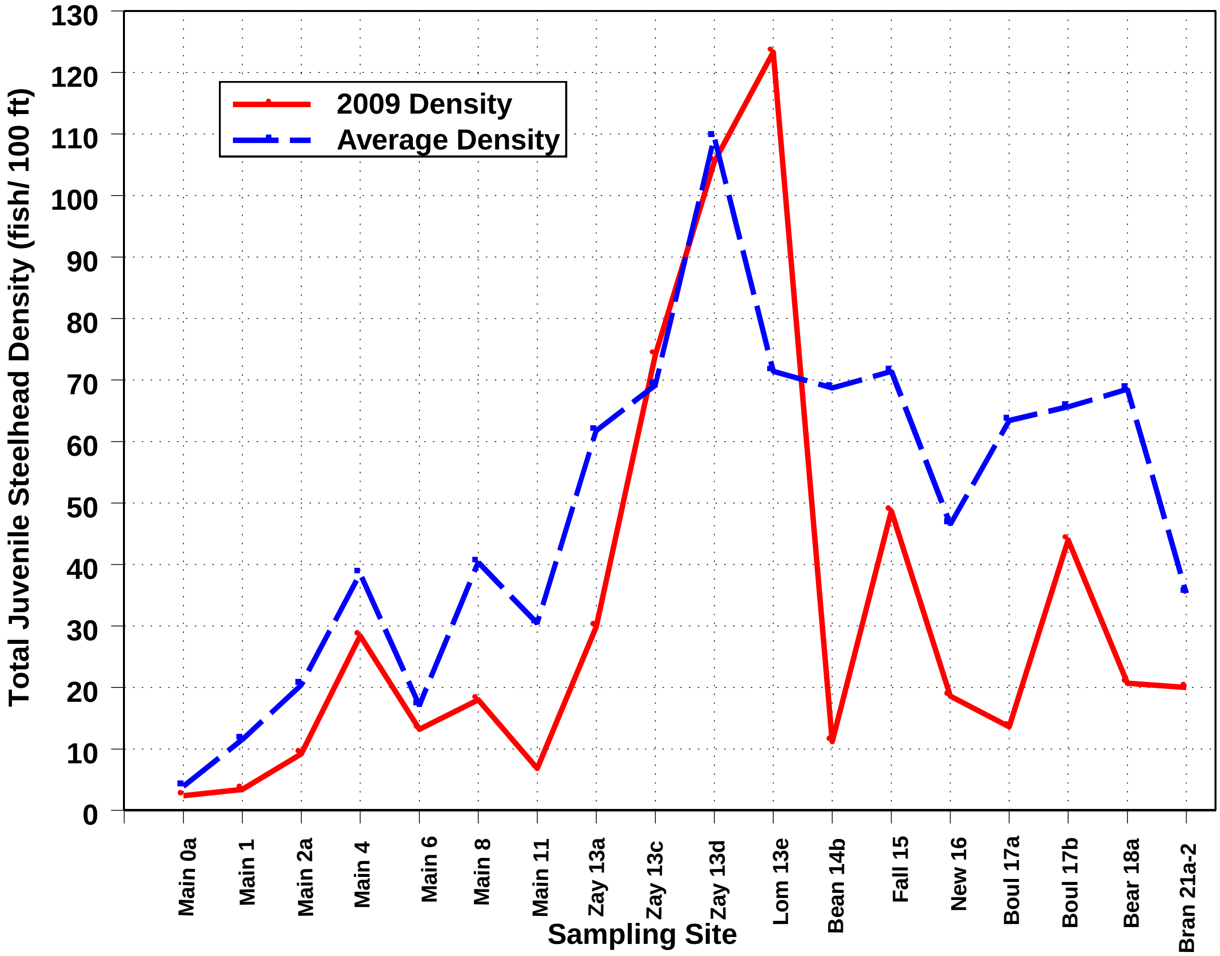
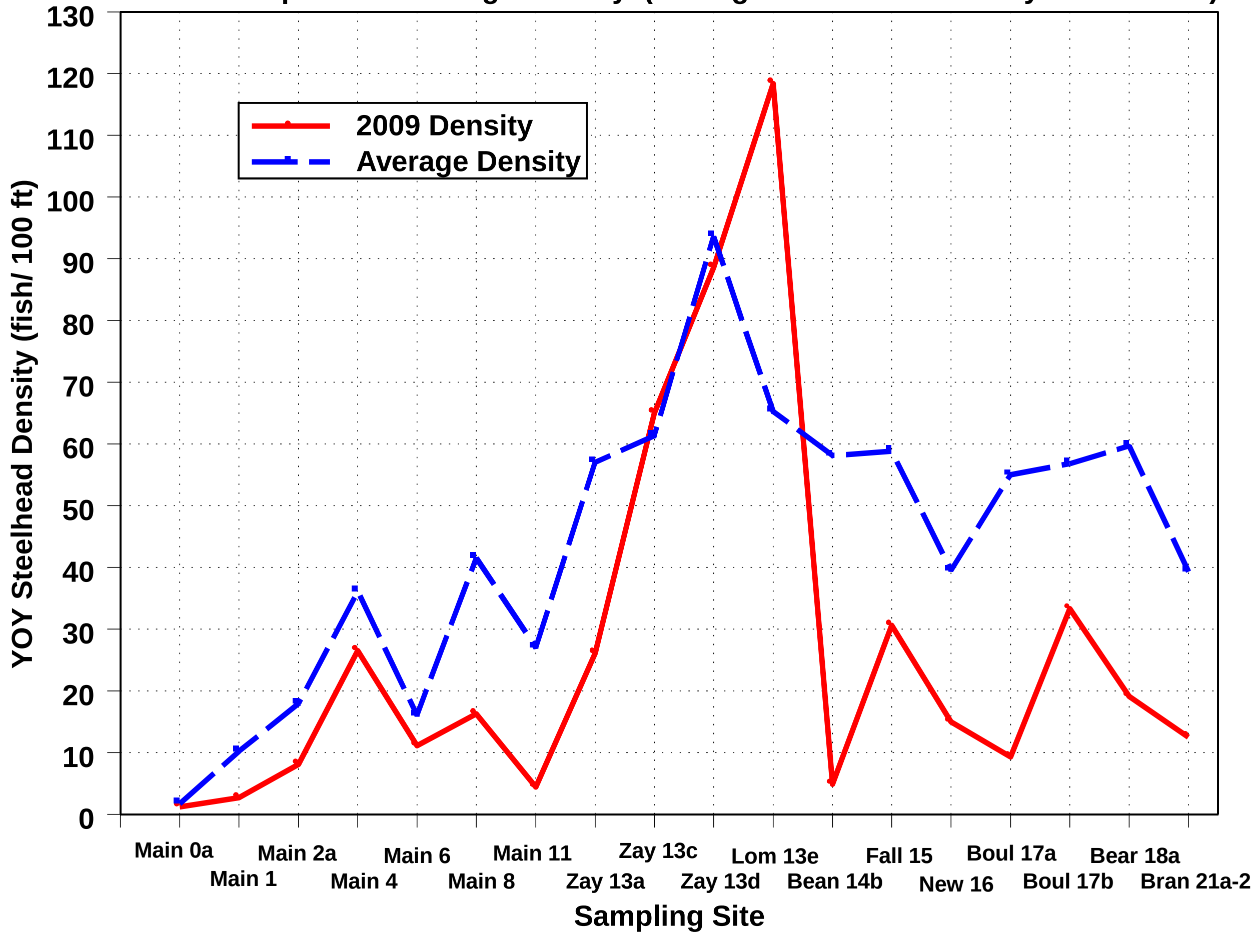


Figure 2. Young-of-the-Year Steelhead Site Densities in the San Lorenzo River in 2009 Compared to Average Density. (Averages based on 2 to 12 years of data.)



<u>In the Soquel Creek Watershed (2009 compared to 2008):</u>

1. The two upper mainstem and lower East Branch reaches had reduced habitat quality in 2009, with the other reaches generally having similar or slightly improved habitat quality. However, Reach 12a in the SDSF in the upper East Branch had much improved habitat quality with significantly more baseflow, deeper pool habitat, reduced riffle embeddedness and much more pool escape cover.

2. 2009 yearling densities remained low at most sites as previous years, but remained similarly higher at Site 16 on the East Branch in the SDSF compared to 2008 (mild winters), with densities slightly above average at 5 of 8 sites and double the average at Site 16.

3. 2009 densities of Size Class II and III juveniles were more than in 2008 at all 7 repeated sites, despite fewer YOY and similar yearling densities (**Table 42**). 2009 Size Class II and III juvenile densities were above average at 5 of 8 sites (see graph below). This was because higher spring flows (more insect drift) compared to 2008 and reduced competition for food between YOY allowed faster YOY growth rate and a higher percentage of YOY reaching Size Class II.

4. Total and young-of-the-year (YOY) juvenile steelhead densities were generally much lower in 2009 than 2008, and below average at 6 of 8 sampled sites (near average at 4 sites; see graphs below).

5. The 2009 juvenile steelhead population in Soquel Lagoon was only an estimated 449, which was much less than the 17-year average of 1,755 and much less than the 7,071 estimated for 2008. This indicated much less 2009 spawning above the lagoon compared to 2008.

Figure 6. Size Class II and III Steelhead Site Densities in Soquel Creek in 2009 Compared to the 13-Year Average (9th year for West Branch #19).

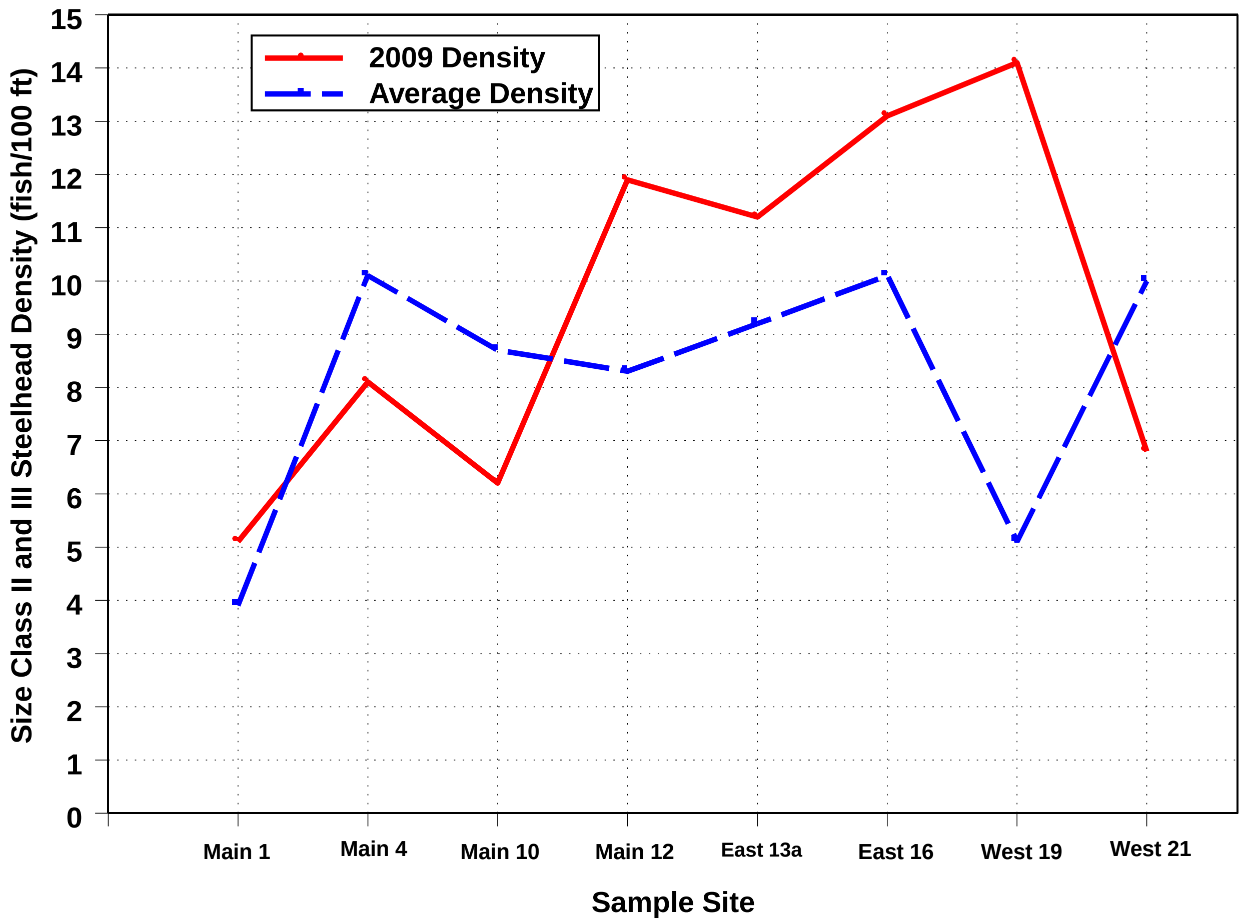


Figure 4. Total Juvenile Steelhead Site Densities in Soquel Creek in 2009 Compared to the 13-Year Average (9th year at West Branch #19).

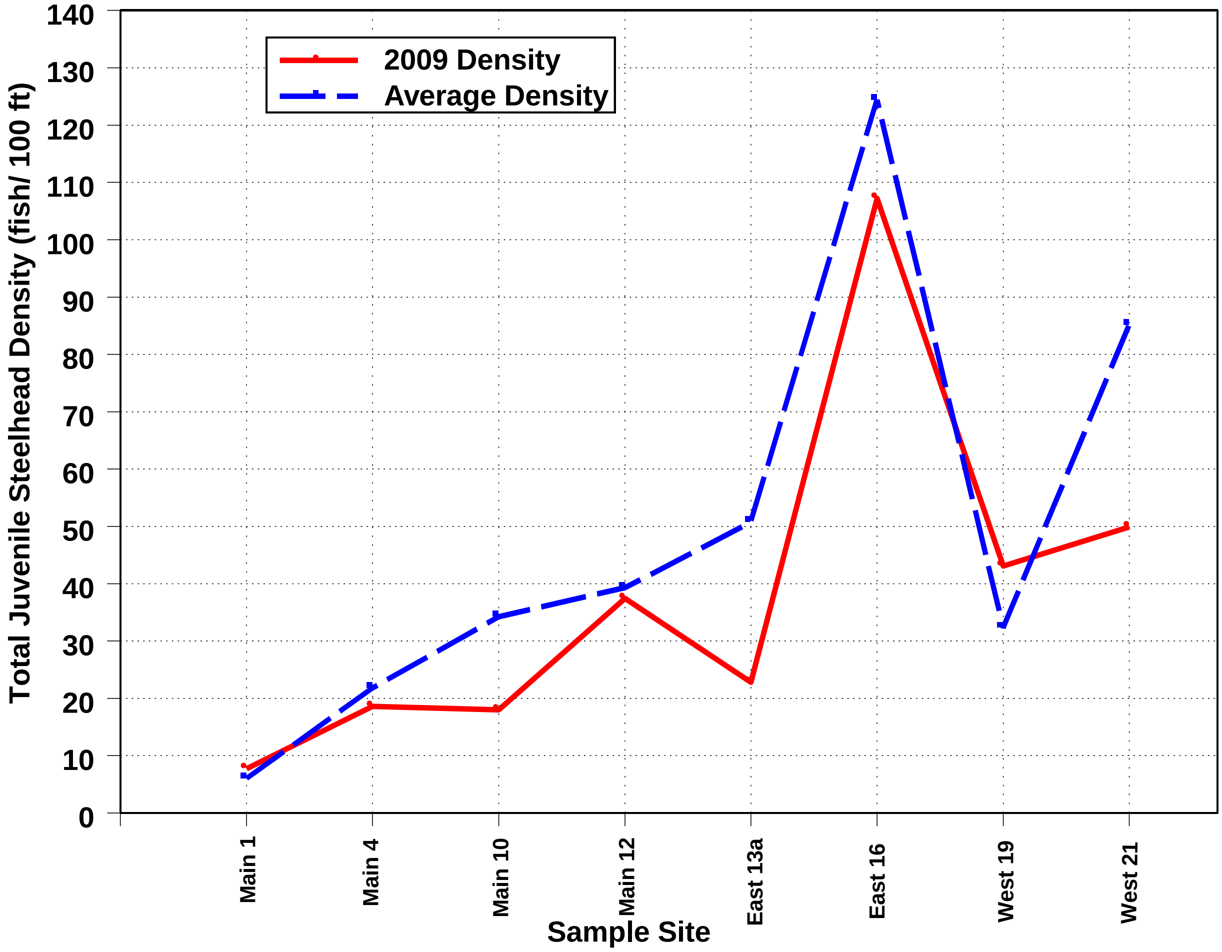
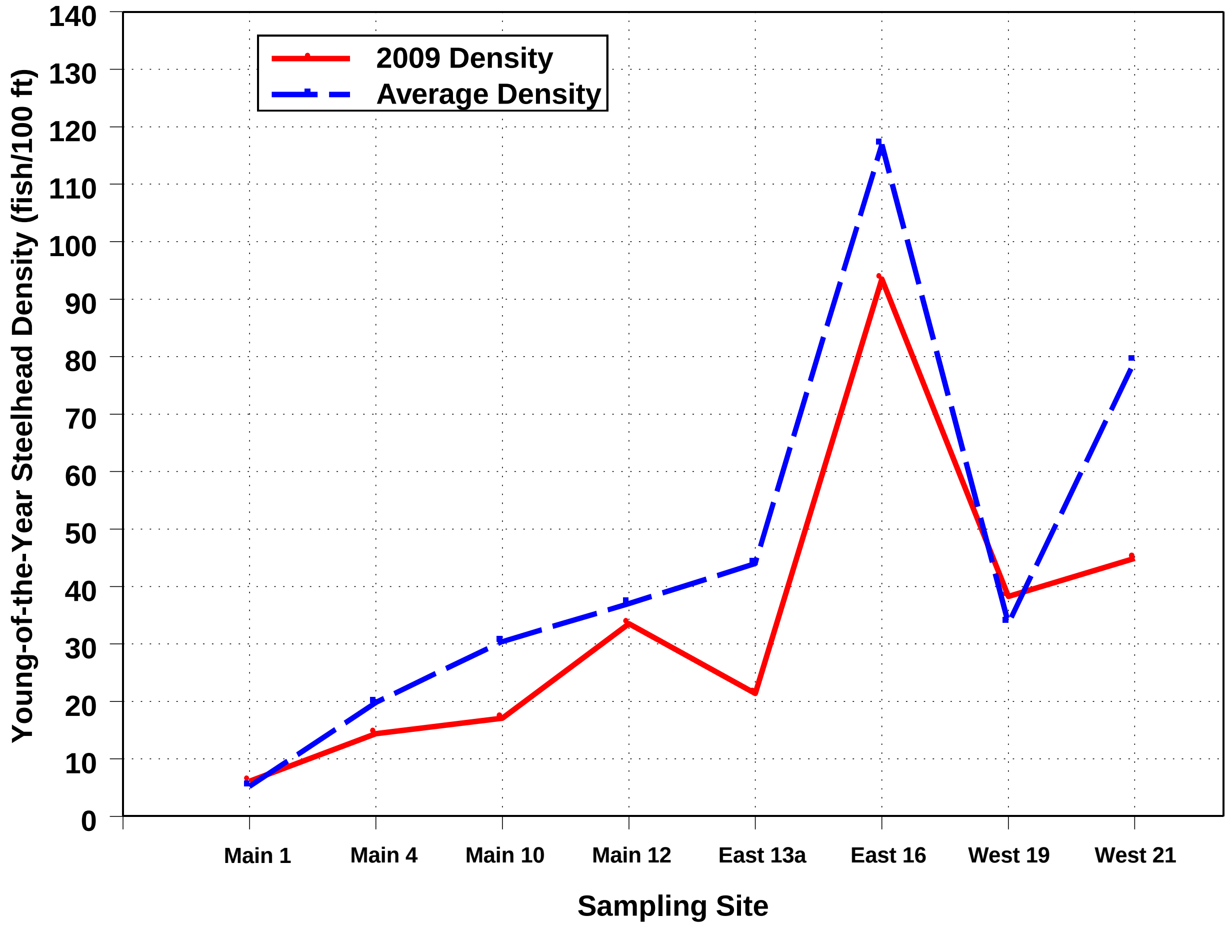


Figure 5. Young-of-the-Year Steelhead Site Densities in Soquel Creek in 2009 Compared to the 13-Year Average (9th year for West Branch #19).



In the Aptos Creek Watershed (2009 compared to 2008):

1. Densities of larger juveniles (Size Classes II and III => 75 mm SL) were similar at one site and slightly greater at 3 sites in 2009 compared to 2008; densities were below average at Aptos sites and above average at sites in Valencia Creek (**Table 42; see graph below**). The similarities between years with larger fish were consistent with similar habitat quality and yearling densities.

2. Similar overall habitat conditions (depth, escape cover, embeddedness and fine sediment) existed in the 4 monitored reaches of Aptos and Valencia creeks between 2008 and 2009.

3. Despite similar habitat conditions between years, total and YOY juvenile steelhead densities in 2009 were much lower than 2008 and below average (see graphs below). This indicated much fewer adult spawners in 2009 and/or reduced survival of eggs and young YOY.

4. Despite high YOY densities in 2008, yearling densities were only slightly higher at 3 of 4 sites in 2009 compared to 2008 (both mild winters) and similarly low in upper Aptos, Yearling densities were slightly below average at both Aptos sites and above average at both Valencia sites. This may be explained by early smolting of 2008 YOY able to grow well in a mild, less turbid spring of 2009.

5. Consistent with very low YOY densities, densities of smaller juveniles (Size Class I < 75 mm SL) were also much less in 2009 than 2008 and below average at all 4 sites.

Figure 9. Size Class II and III Steelhead Site Densities in Aptos and Valencia Creeks in 2008 and 2009, with a 5-Year Average (1981; 2006-2009).

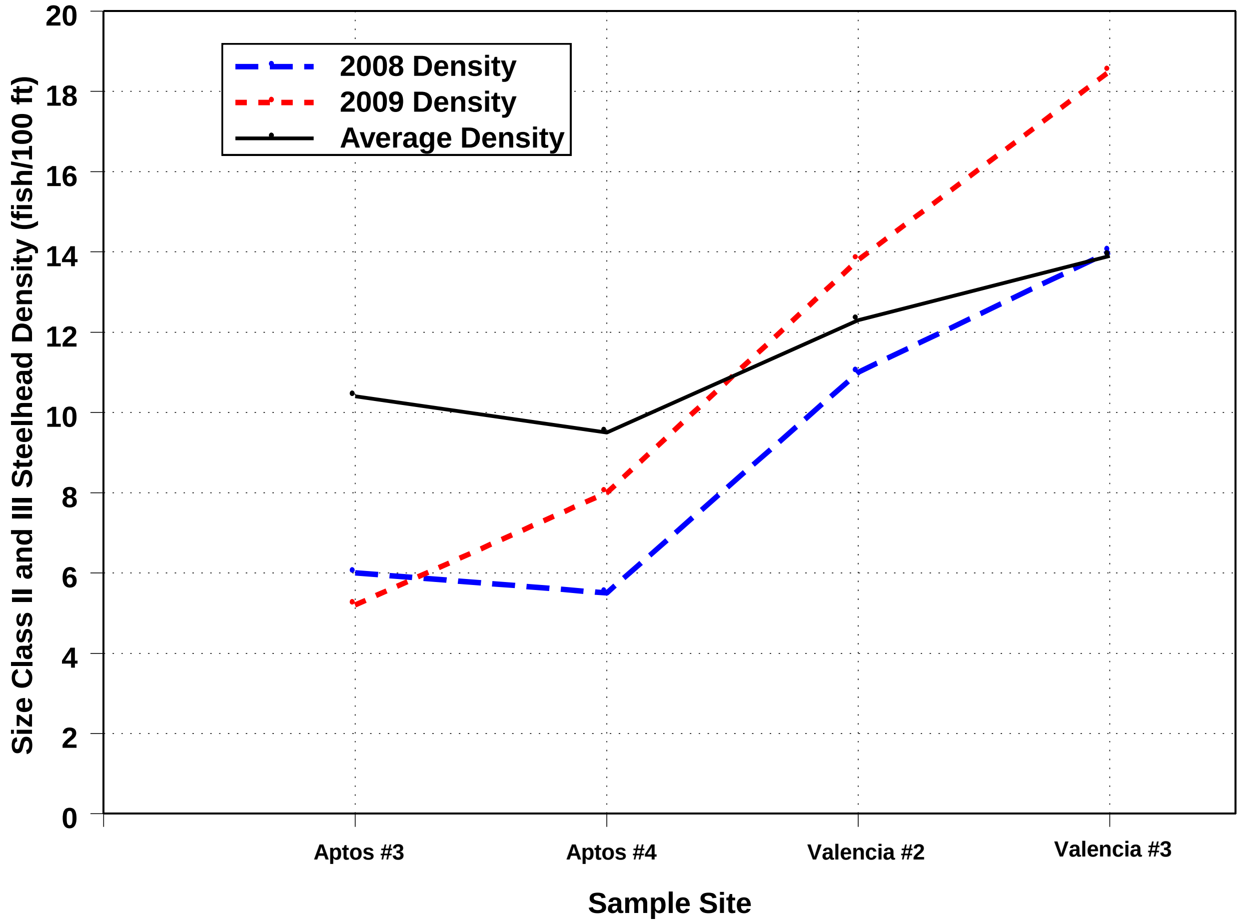


Figure 7. Total Juvenile Steelhead Site Densities in Aptos and Valencia Creeks in 2008 and 2009, with a 5-Year Average (1981; 2006-2009).

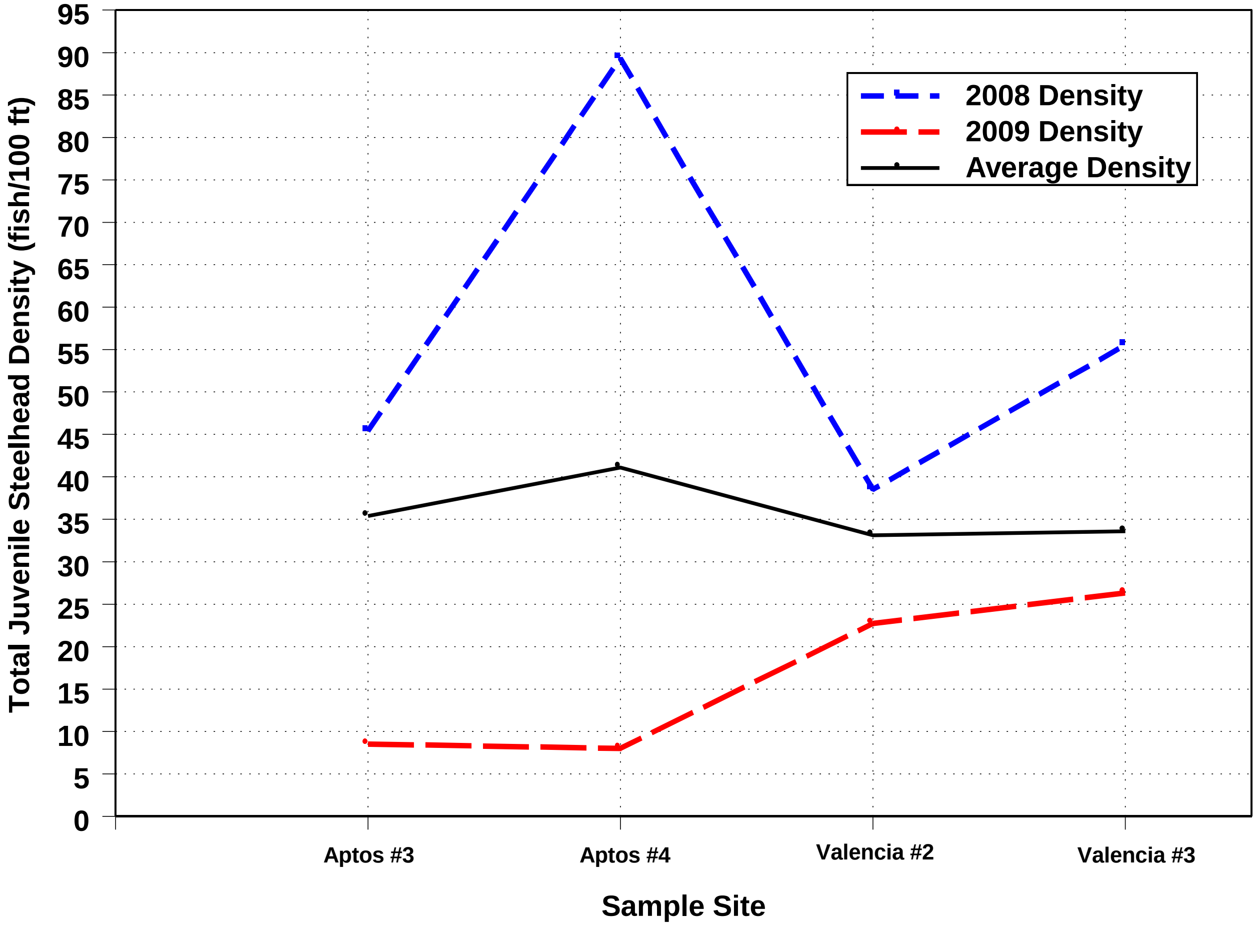
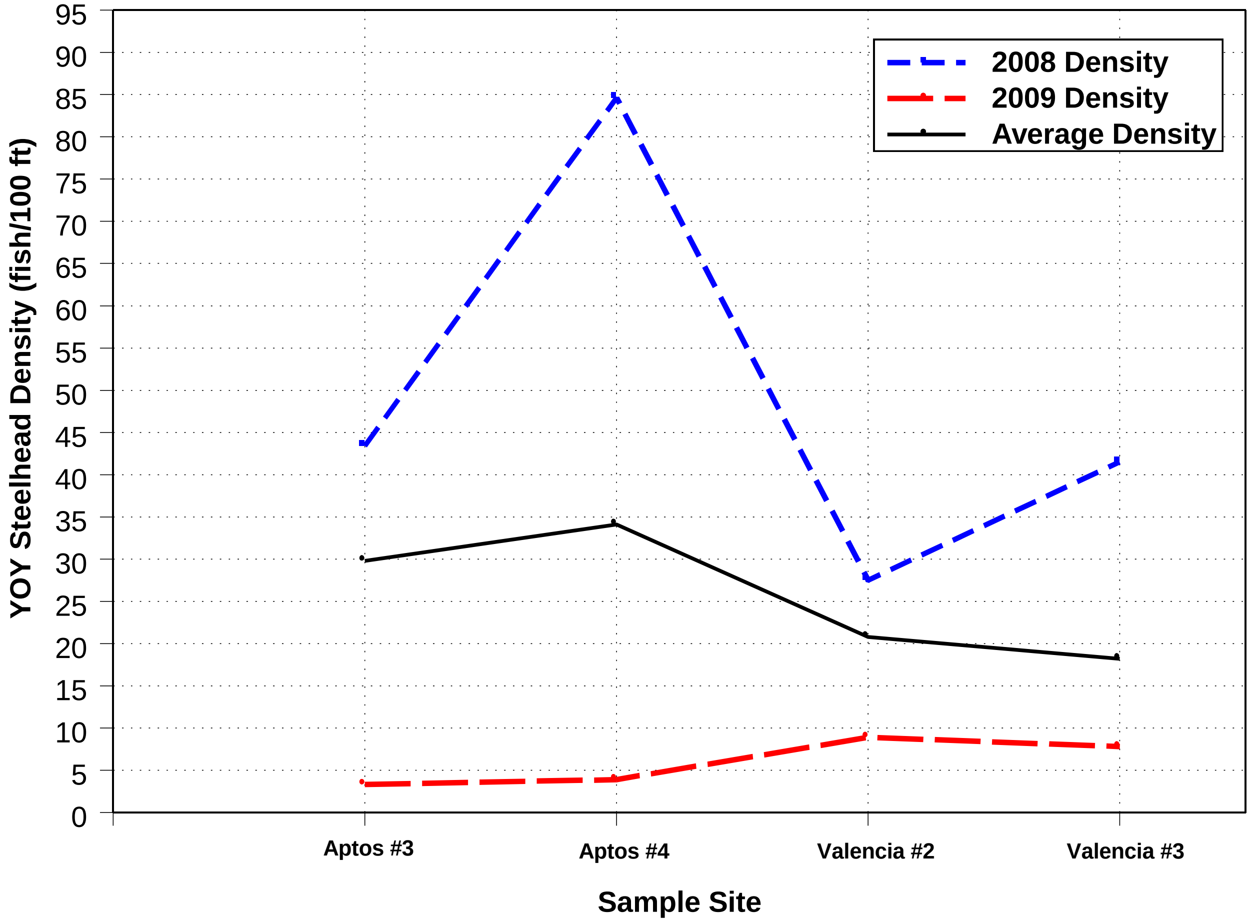


Figure 8. Young-of-the-Year Steelhead Site Densities in Aptos and Valencia Creeks in 2008 and 2009, with a 5-Year Average (1981; 2006-2009).



In the Corralitos Creek Sub-Watershed (2009 compared to 2008):

1. With regard to adult steelhead passage above the Corralitos Creek diversion dam and fish ladder between Corralitos Site 1 and Site 3, adult steelhead have passed the dam in 2006─2009. This is based on consistently moderate YOY densities above the dam at Corralitos Sites 8 and 9 during those years (see graph below). The fish ladder may have impeded late spawners in 2008 because the highest YOY density that year was at the site below the dam and much higher than the site just upstream of the dam. The site just upstream of the dam had lower YOY densities again in 2009 than below the dam, but the difference was much less, and the YOY densities at the two uppermost Corralitos sites were higher than below the dam. It appeared in 2009 that there were fewer spawners, in general, and that the adults that passed the fish ladder spawned considerable distance upstream of the dam. Adult counts on the Carmel River and Scott Creek showed much below average spawners, as did low 2009 YOY densities in other watersheds compared to 2008. The suspected low number of adult spawners in 2009 makes it difficult to judge passability of the fish ladder late in the spawning season.

2. Overall habitat quality for Reach 1 was similar between 2008 and 2009, though pool escape cover declined 20%. Reach 3 had overall reduced habitat quality primarily due to 30% less pool escape. Reaches 5/6 had slightly improved habitat quality between 2008 and 2009, with slightly higher baseflow and deeper pool habitat. Reach 7 had reduced habitat quality with 27% less pool escape cover, increased fine sediment and increased embeddedness.

3. Repeated Shingle Mill Site 1 had slightly improved habitat quality in 2009 with slightly higher baseflow and slightly more pool escape cover. In Shingle Mill Reach 3, baseflow was very low for the third year. Overall habitat quality improved with slightly higher baseflow, deeper pools and runs and an 18% increase in pool cover.

4. On Browns Creek, overall habitat quality improved in 2009 at both sites with more pool escape cover and slightly increased baseflow.

5. Yearling densities were similar between 2008 and 2009 (mild winters) and slightly higher at 5 sites in 2009. Yearling densities were below average at 5 of 8 sites but near average at 6 sites.

6. 2009 densities of Size Class II and III juveniles were similar to 2008 at 5 of 8 sites and greater at 7 of 8 sites. The slight increases in smolt density in Corralitos Sites 3 and 9 from 2008 to 2009 were inconsistent with the net negative physical habitat changes (**Table 42**). However, the reduced YOY densities (less competition) and increased baseflows (more food) at Corralitos Sites 1 and 3 allowed some YOY to reach smolt size in 2009 and offset negative physical habitat changes. The increase in Size Class II and III densities in 2009 was statistically significant.

7. Densities of Size Class II and III juveniles were below average at 5 of 8 sites, with 4 sites near average (see graph below).

8. Total juvenile steelhead densities were generally lower in 2009 (6 of 8 sites) and generally below average (6 of 8 sites), though close to average at 3 of the below average sites (see graphs below). The two uppermost sites in Corralitos (#9) and Browns creeks (#2) had increased total density in 2009 due to increased YOY density at those sites.

9. YOY densities were generally much less at 6 of 8 sites in 2009, except upper Corralitos and upper Browns had higher 2009 densities than in 2008. YOY densities were above average at only 2 of 8 sites but near average at 4 of 8 sites.

10. YOY densities were closer to average than in the other 3 watersheds in 2009 and had the highest YOY densities at uppermost sites, consistent with other watersheds in 2009.

Figure 12. Size Class II and III Steelhead Site Densities in Corralitos, Shingle Mill and Browns Creeks in 2008 and 2009, with a 6-Year Average (1981; 1994; 2006-2009).

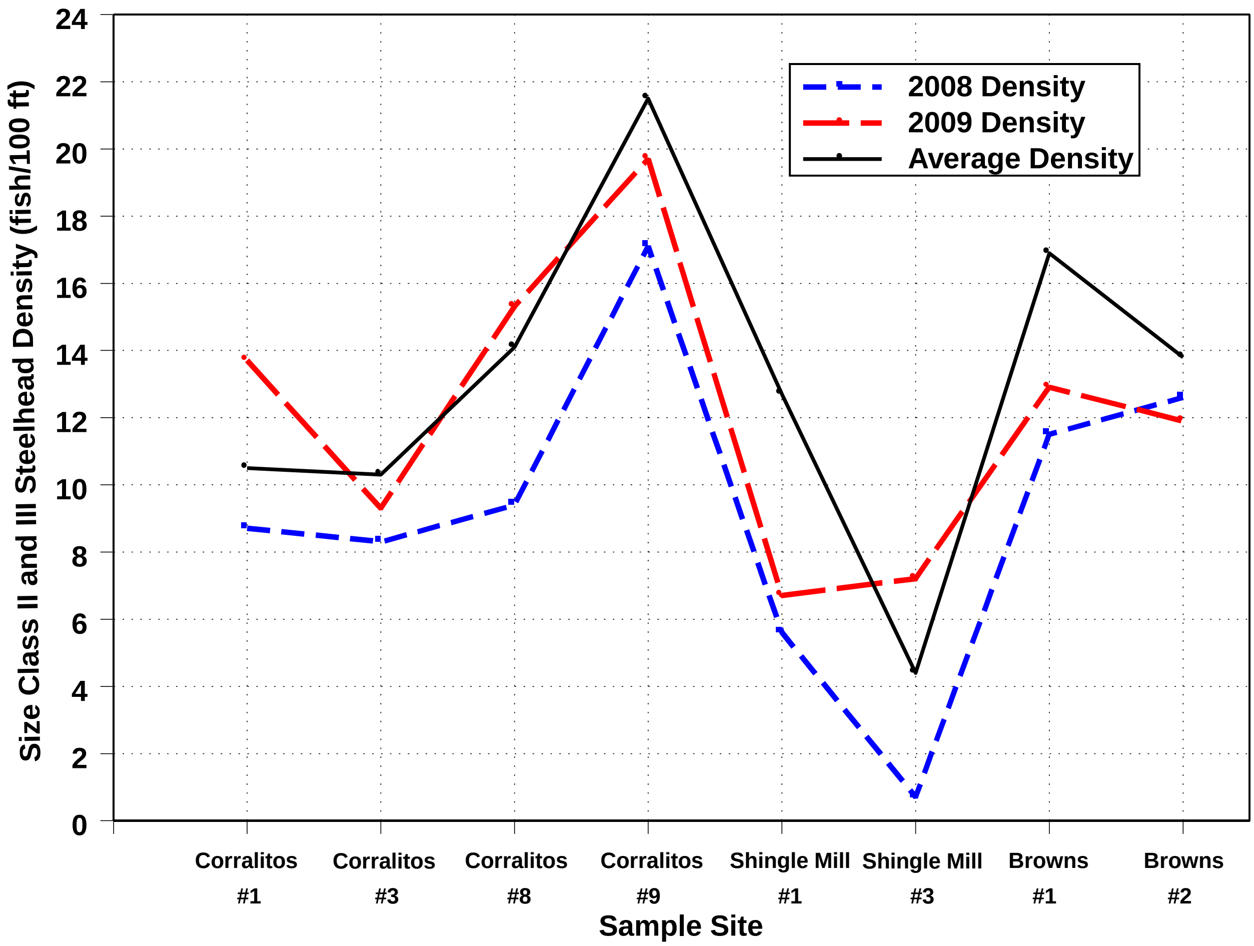


Figure 10. Total Juvenile Steelhead Site Densities in Corralitos, Shingle Mill and Browns Creeks in 2008 and 2009, with a 6-Year Average (1981; 1994; 2006-2009).

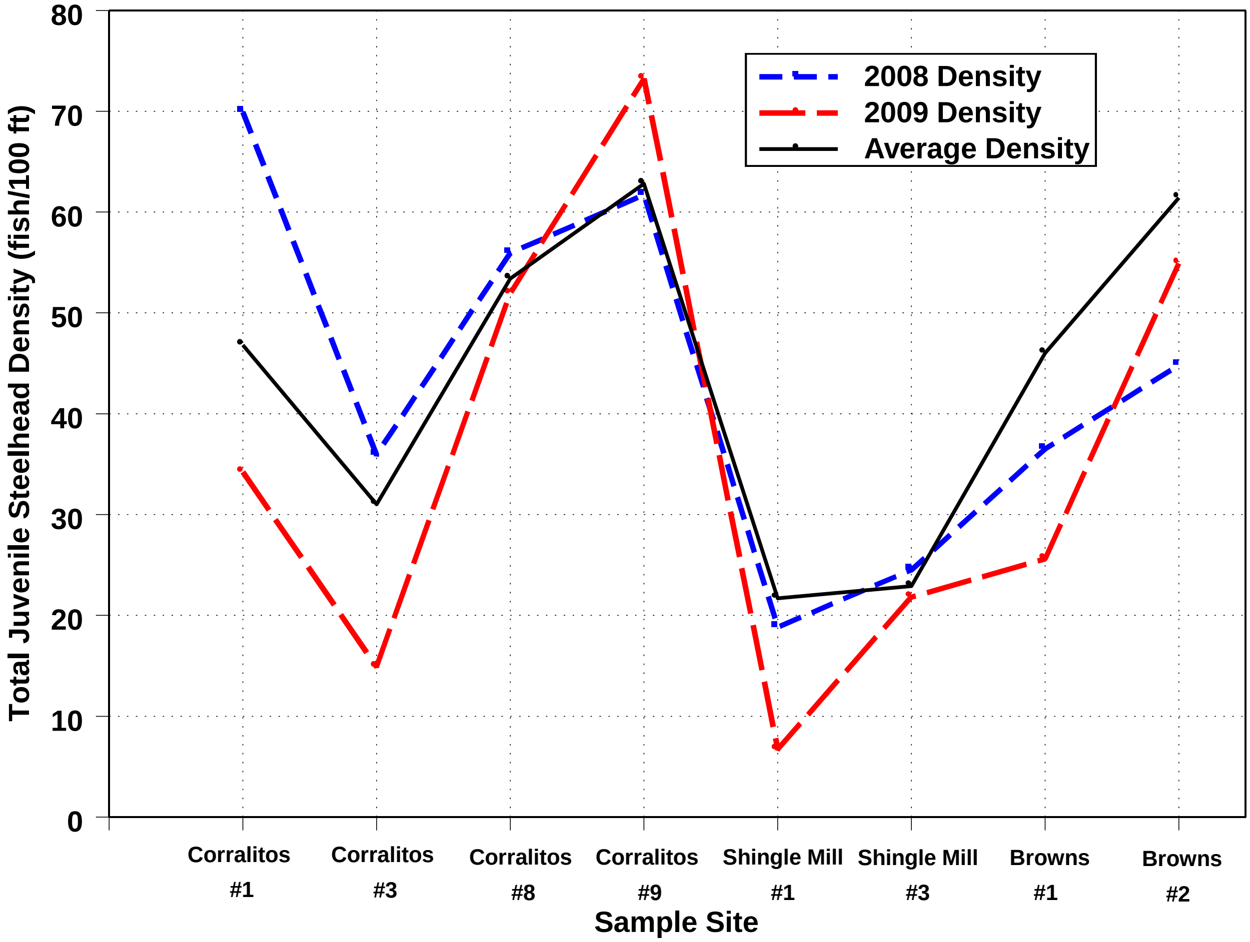
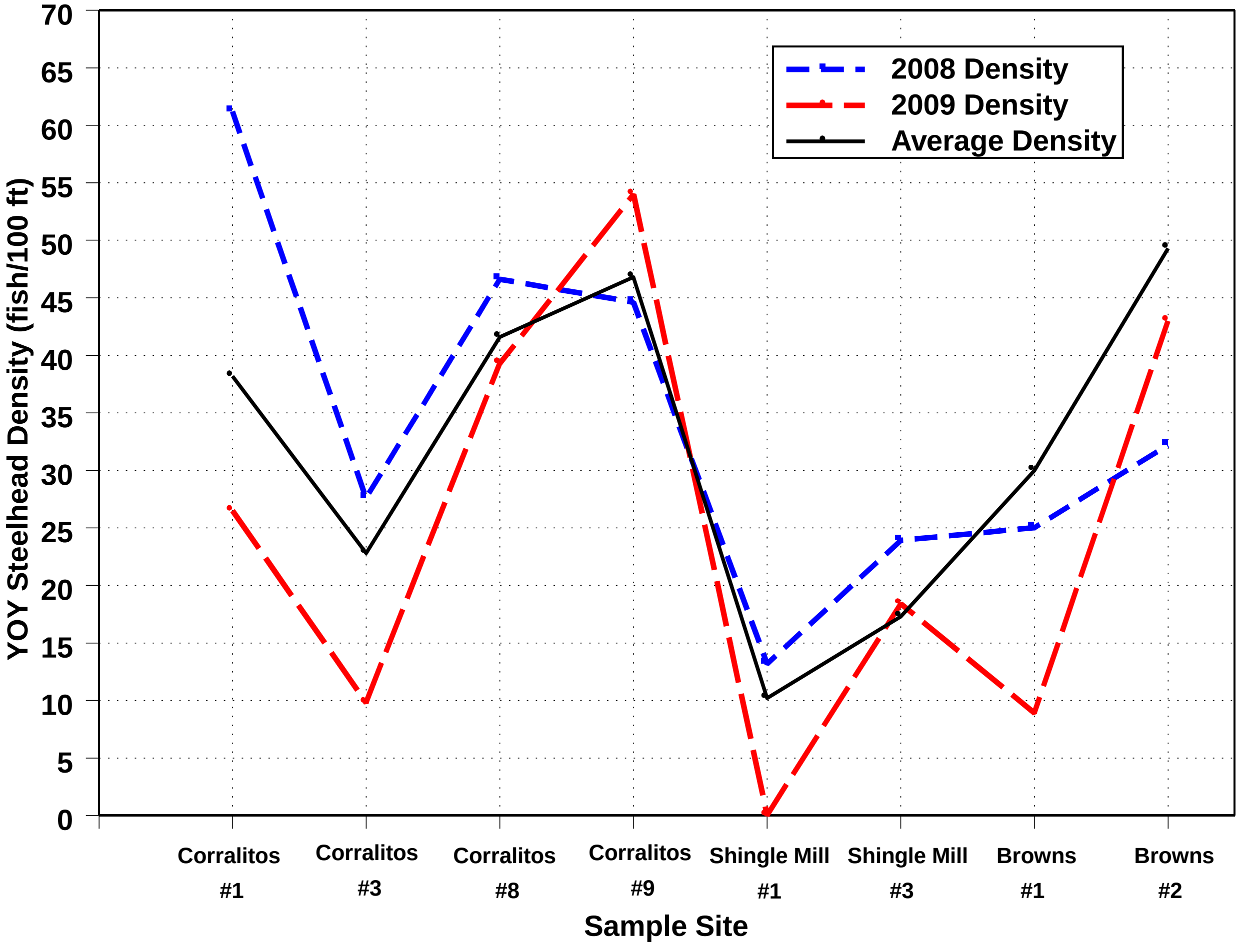


Figure 11. Young-of-the-Year Steelhead Site Densities in Corralitos, Shingle Mill and Browns Creeks in 2008 and 2009, with a 6-Year Average (1981;1994; 2006-2009).



<u>Habitat Conditions Rated, Based on Smolt-Sized Juvenile Densities</u>

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 probably were not met in mainstem reaches in 2009 due to low YOY densities or in Newell, lower Boulder and lower Bear creeks with much below average smolt-size densities and apparently few yearling holdovers. Streamflows were too low to grow many YOY in the lower and middle mainstem San Lorenzo to smolt size in 2009. Aptos was probably below carrying capacity for larger juveniles for the same reasons of few yearling holdovers and slow YOY growth that prevented most of them from reaching Size Class II.

Refer to the following summary table and **Table 42** for smolt-sized juvenile densities and ratings. Figures 3, 6, 9 and 12 provided above with graphs of fish densities have been excerpted from the Detailed Analysis **Appendix B** to compare 2009 smolt densities to averages calculated from all monitoring years of data.

2009 Sampling Sites Rated by Smolt-Sized Juvenile Density (=>75 mm SL) and Average Smolt Size, with Physical Habitat Change since 2008. (Red denotes ratings of poor or very poor; purple denotes ratings of good and very good.)

Site	Multi-Year Avg. Density (Size Class II and III/100 ft)	2009 Smolt Density (per 100 ft)/ Avg Smolt Size (mm)	2009 Smolt Rating	Numerical Rating (1 to 7)	Physical Habitat Change by Reach Since 2008
Low. San Lorenzo #1	10.5 (n=9)	3.4/125 mm	Below Average	***	-
Low. San Lorenzo #2	17.2 (n=8)	8.0/105 mm	Very Good	******	Slight Positive
Low. San Lorenzo #4	17.7 (n=9)	13.9/85 mm	Below Average	***	Site Positive
Mid. San Lorenzo #6	4.4 (n=12)	0.5/ 76 mm	Very Poor	*	Site Slight Pos.
Mid. San Lorenzo #8	6.9 (n=12)	3.5/ 95 mm	Poor	**	Slight Positive
Up. San Lorenzo #11	6.9 (n=12)	3.1/ 99 mm	Poor	**	Slight Positive
Zayante #13a	10.6 (n=11)	12.1/ 85 mm	Below Average	***	Site Positive
Zayante #13c	11.8 (n=11)	10.4/ 91 mm	Fair	****	Site Similar
Zayante #13d	18.1 (n=11)	16.9/ 97 mm	Good	*****	Positive
Lompico #13e	7.1 (n=4)	4.9/ 92 mm	Below Average	***	Site Positive
Bean #14b	13.7 (n=12)	10.9/ 101 mm	Fair	****	Similar
Bean #14c	13.0 (n=9)	-	-	-	-
Fall #15	14.6 (n=7)	18.7/ 111 mm	Good	*****	Negative
Newell #16	12.0 (n=6)	4.4/94 mm	Below Average	***	Neg. Since 2006
Boulder #17a	11.5 (n=12)	5.5/ 98 mm	Below Average	***	Slightly Positive
Boulder #17b	10.3 (n=12)	10.7/ 96 mm	Fair	****	Site Positive
Bear #18a	11.3 (n=12)	2.5/ 88 mm	Very Poor	**	Site Slight Pos.
Branciforte #21a-1	2.2 (n=2)	-	-	-	-
Branciforte #21a-2	6.2 (n=9)	7.5/ 117 mm	Fair	****	Similar
Soquel #1	3.9 (n=12)	5.1/ 93 mm	Below Average	***	Similar
Soquel #4	10.1 (n=13)	8.1/ 96 mm	Fair	****	Slight Positive
Soquel #10	8.7 (n=13)	6.2/ 80 mm	Poor	**	Negative
Soquel #12	8.3 (n=12)	11.9/ 86 mm	Below Average	***	Negative
E. Branch Soquel #13a	9.2 (n=13)	11.2/ 88 mm	Below Average	***	Negative
E. Branch Soquel #16	10.1 (n=13)	13.1/ 98 mm	Fair	****	Positive
W. Branch Soquel #19	5.1 (n=9)	14.1/ 92 mm	Fair	****	Positive
W. Branch Soquel #21	10.0 (n=8)	6.8/ 97 mm	Below Average	***	Similar
Aptos #3	10.4 (n=5)	5.2/ 120 mm	Fair	****	Similar
Aptos #4	9.5 (n=5)	8.0/ 99 mm	Fair	****	Similar
Valencia #2	12.3 (n=5)	13.8/ 94 mm	Fair	****	Similar
Valencia #3	13.9 (n=5)	18.5/ 95 mm	Good	*****	Similar
Corralitos #1	10.5 (n=3)	13.7/ 96 mm	Fair	****	Similar
Corralitos #3	10.3 (n=6)	9.3/ 112 mm	Good	*****	Negative
Corralitos #8	14.1 (n=6)	15.3/ 105 mm	Good	*****	Slightly Positive
Corralitos #9	21.5 (n=6)	19.7/ 102 mm	Good	*****	Negative
Shingle Mill #1	12.7 (n=6)	6.7/ 103 mm	Fair	****	Site Slight Pos.
Shingle Mill #3	4.4 (n=6)	7.2/ 85 mm	Poor	**	Positive
Browns Valley #1	16.9 (n=6)	12.9/ 98 mm	Fair	****	Positive
Browns Valley #2	13.8 (n=6)	11.9/ 98 mm	Fair	****	Positive

Trend Analysis−Juvenile Densities and Habitat in Lower/ Middle Mainstem San Lorenzo

The density and size of juvenile steelhead in the lower and middle mainstem San Lorenzo River depend on several 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 few yearlings. In relatively drier winter/springs, more successful spawning effort usually 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 13 years, 1997, 2001, 2002, 2004 and 2007─2009 were drier, based on averaged mean monthly streamflow (May–September) (**Figure 25**). Increased total and YOY densities occurred in the lower and middle mainstem in these years, except in 2009 (**Figures 13 and 15**). There may have been much fewer adults spawning over the 2008-2009 winter, making spawning effort and YOY densities spotty. 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 positive blip in YOY and total juvenile densities seen in the mainstem in 2008 was followed by lower densities in 2009, more typical of recent years.

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, although a positive blip occurred in 2008 at Site 4 below the Zayante Creek confluence in a year when YOY survival was likely higher (**Figure 17**). The years 1998 and 2006 had similarly wet winters prior to fall sampling, when faster growth of YOY into Size Class II was to be expected. However, 1998 densities of larger juveniles were substantially higher than in 2006 when YOY densities were lower. 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 streamflow (higher water velocity and greater insect drift) 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 13 years (**Figure 17**). Densities remained similarly low in 2009 and 2008, indicating more stability than YOY densities from 2008 to 2009.

Figure 25. Averaged Mean Monthly Streamflow for May–September, 1997–2009 at the Big Trees Gage on the San Lorenzo River.

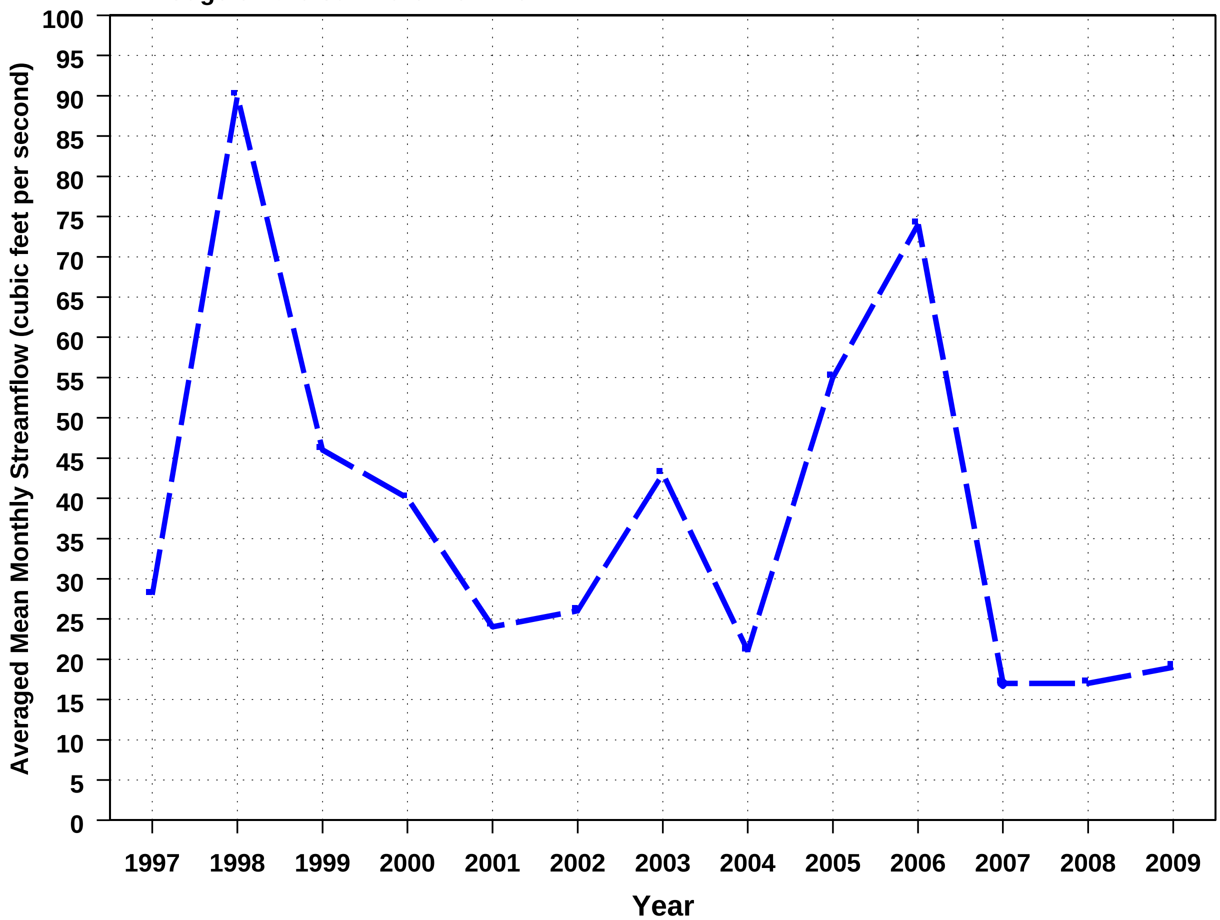


Figure 13. Plot of Annual Total Juvenile Densities at San Lorenzo Mainstem Sites, 1997-2009.

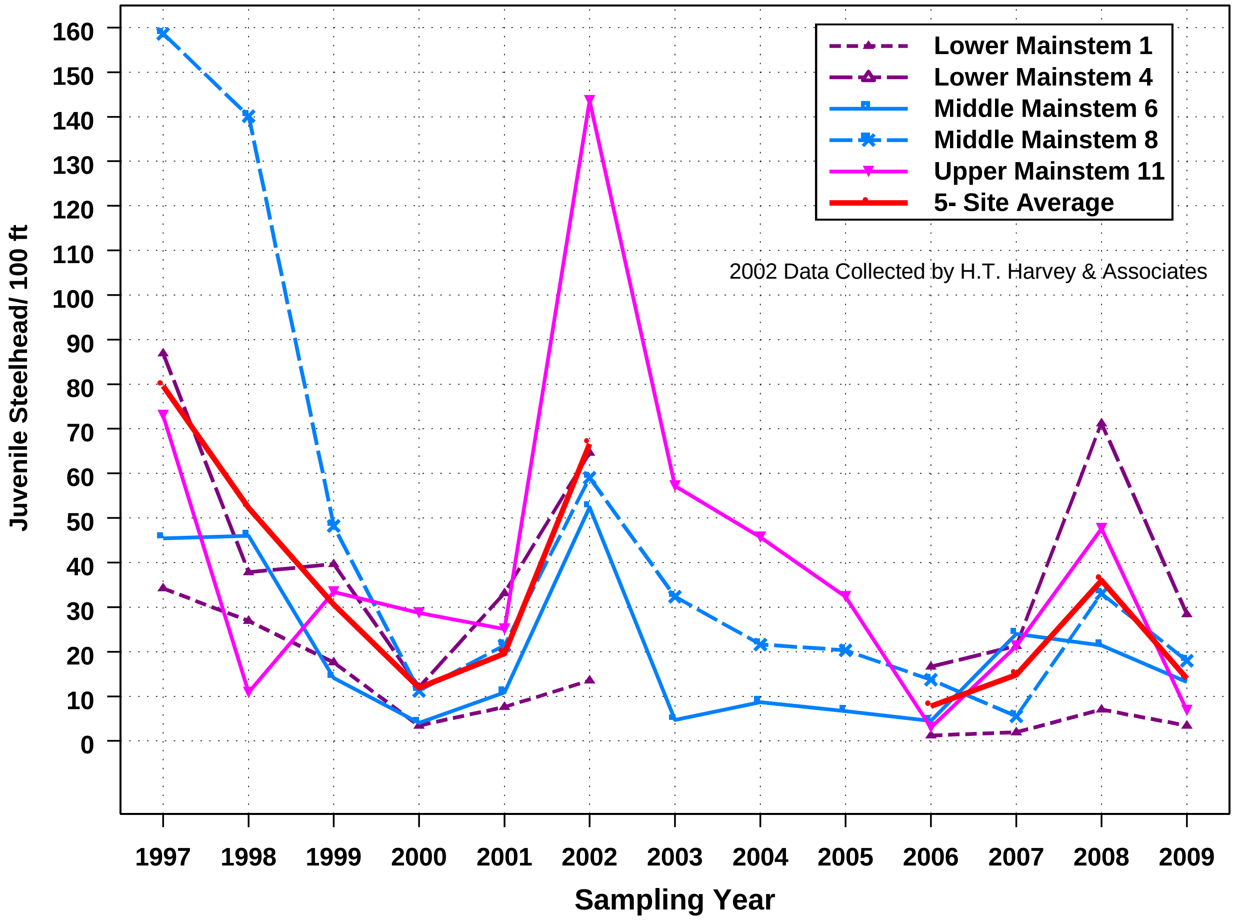


Figure 15. Plot of Annual YOY Juvenile Densities at San Lorenzo Mainstem Sites, 1997-2009.

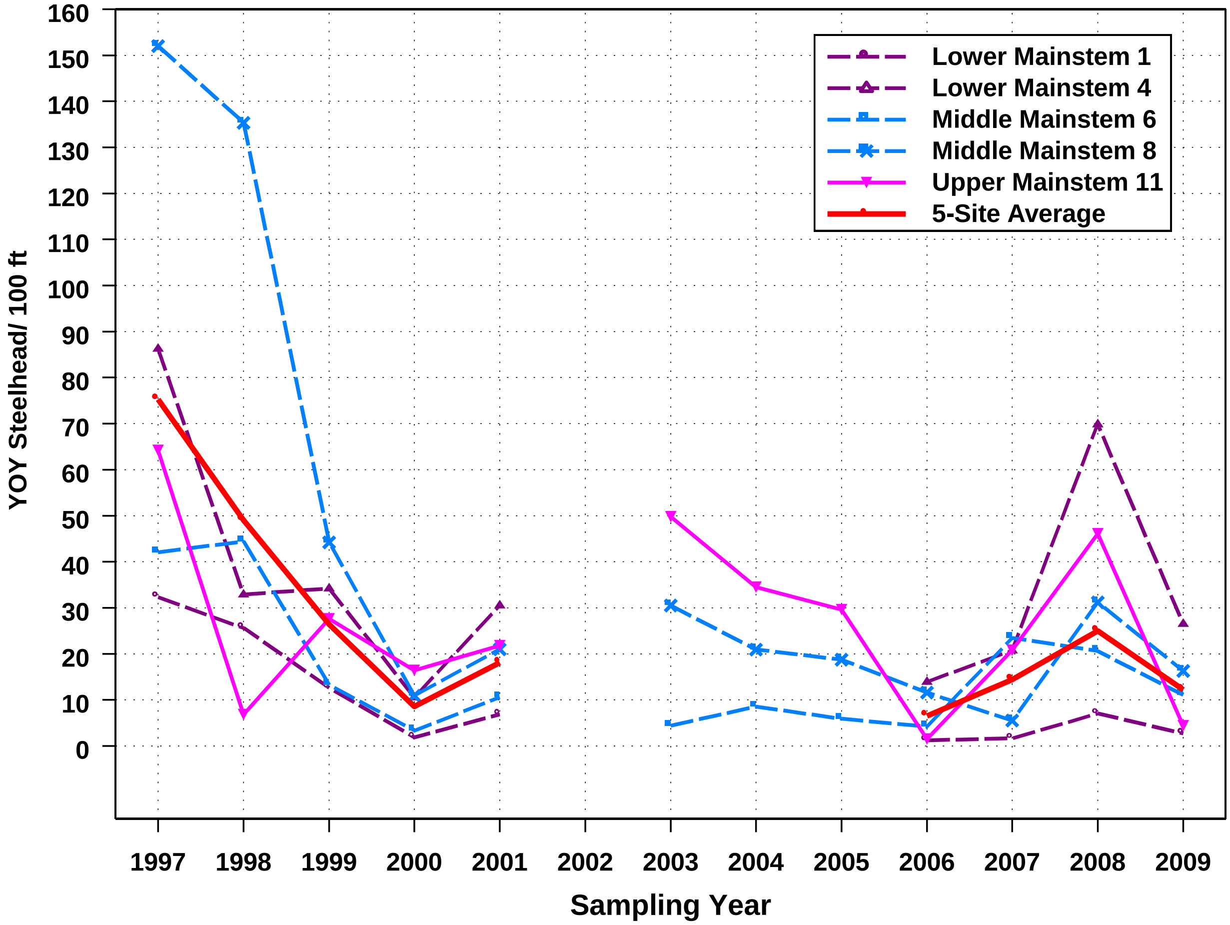
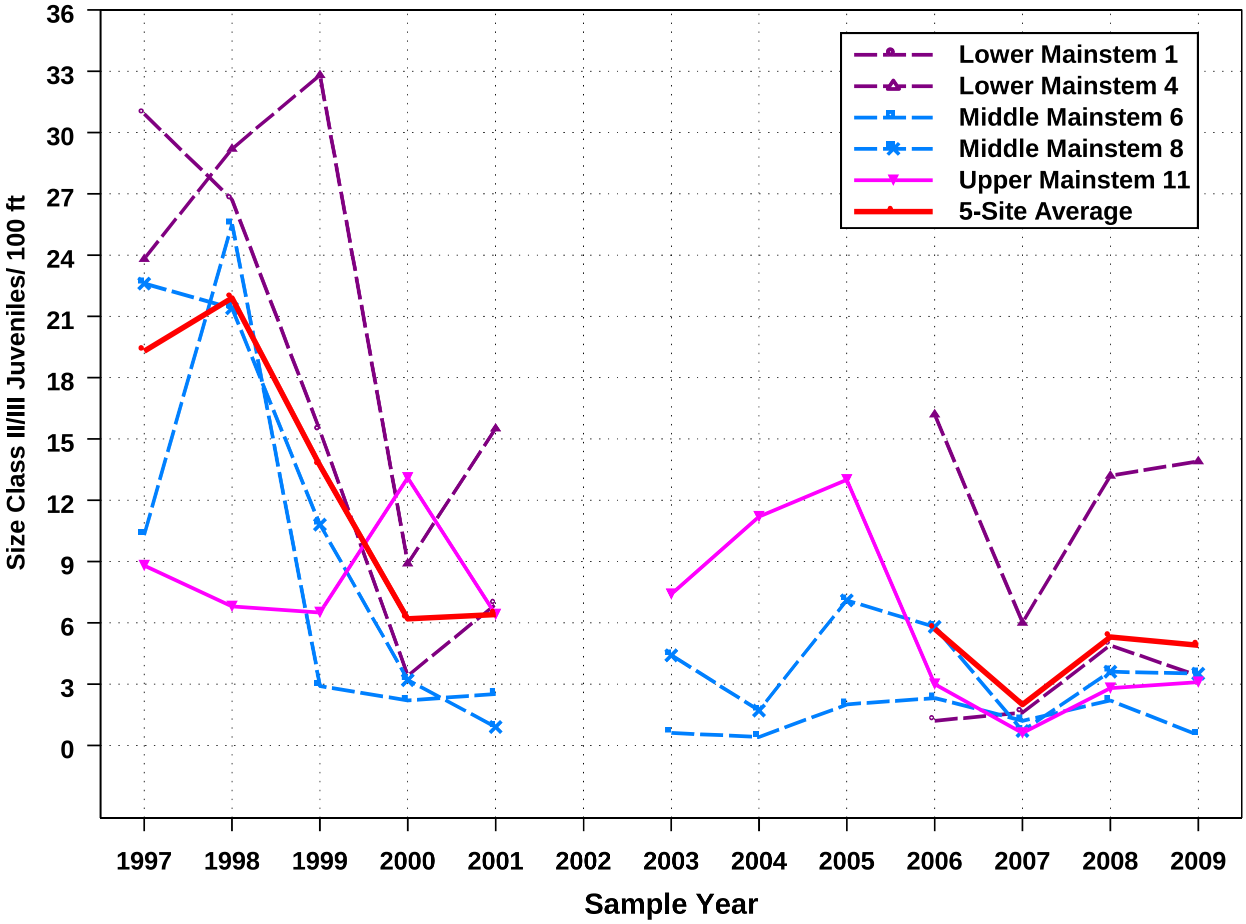


Figure 17. Scatter Plot of Annual Size Class II/ III Juvenile Densities at San Lorenzo Mainstem Sites, 1997-2009.



Habitat Trends in the Middle Mainstem Reach 8. Rearing habitat conditions in riffle habitat in Reach 8 (middle mainstem) in 2009 have improved since 1999 regarding reduced embeddedness (43% in 1999 (**Alley 2000a**) and 19% in 2009) (**Table 8 and Figure 32**). However, 1999 riffle conditions were better with regard to slightly more escape cover (**Figure 31**) and greater habitat depth compared to 2009, primarily because of the low baseflows in late summer 2009 (**Figure 30**). If baseflows had been the same in 1997 and 2009, habitat conditions in Reach 8 riffles may have been similar between years with regard to depth, but 1997 had less percent fines (none in riffles and 10% in runs) compared to 2009 (12% in riffles and 25% in runs). 1997 the riffles had deeper maximum depth pockets (1.2 feet) compared to 2009 (1.0 feet) but both years had similar average riffle depth (0.7 feet in 1997 and 0.65 feet in 2009). We have no reach segment estimates for escape cover and embeddedness in 1997 for comparisons.

Figure 30. Averaged Maximum and Mean Riffle Depth in Reach 8 of the Middle Mainstem San Lorenzo River, 1997-2009.

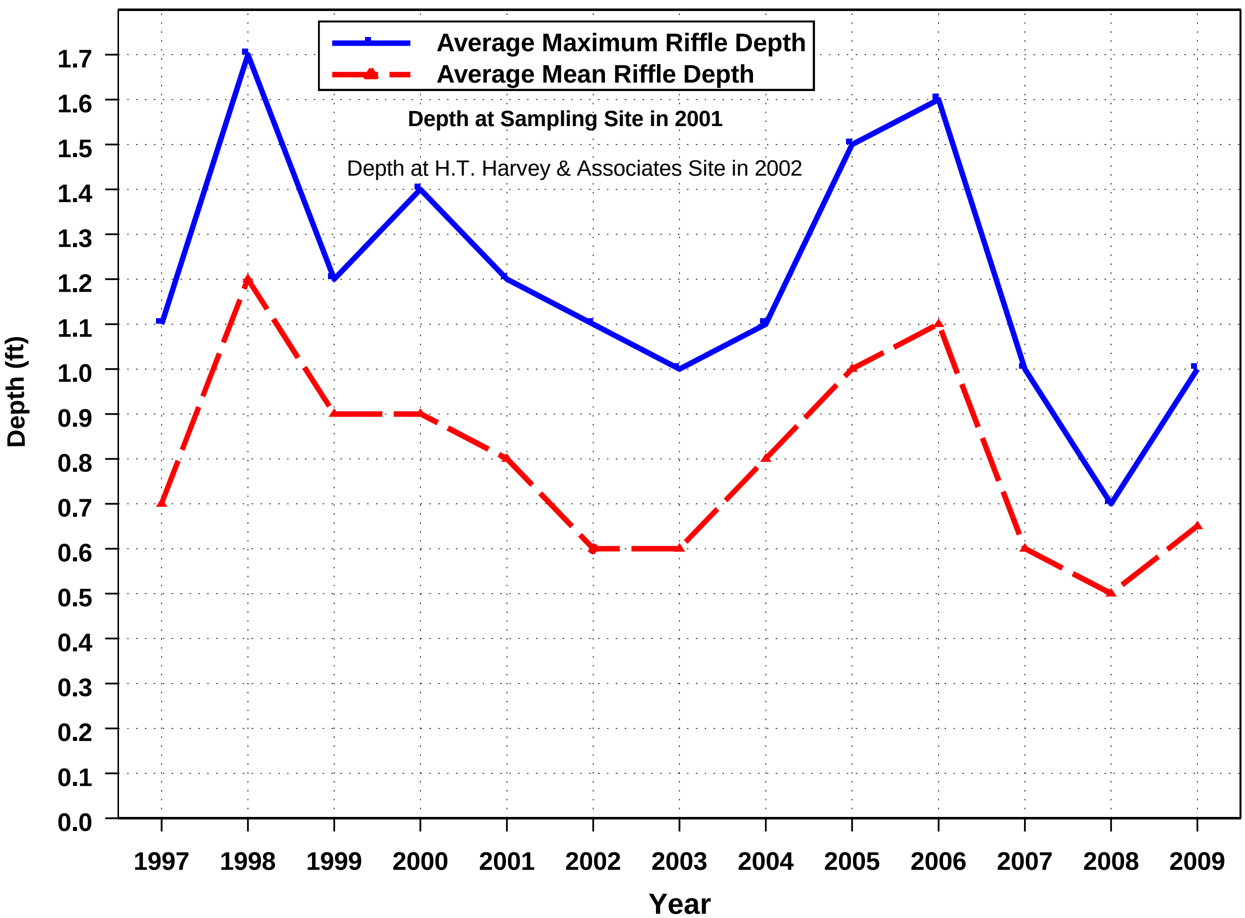


Figure 31. Escape Cover Index for Riffle Habitat in Reach 8 of the Middle Mainstem San Lorenzo River, 1998-2000, 2003 and 2005-2009.

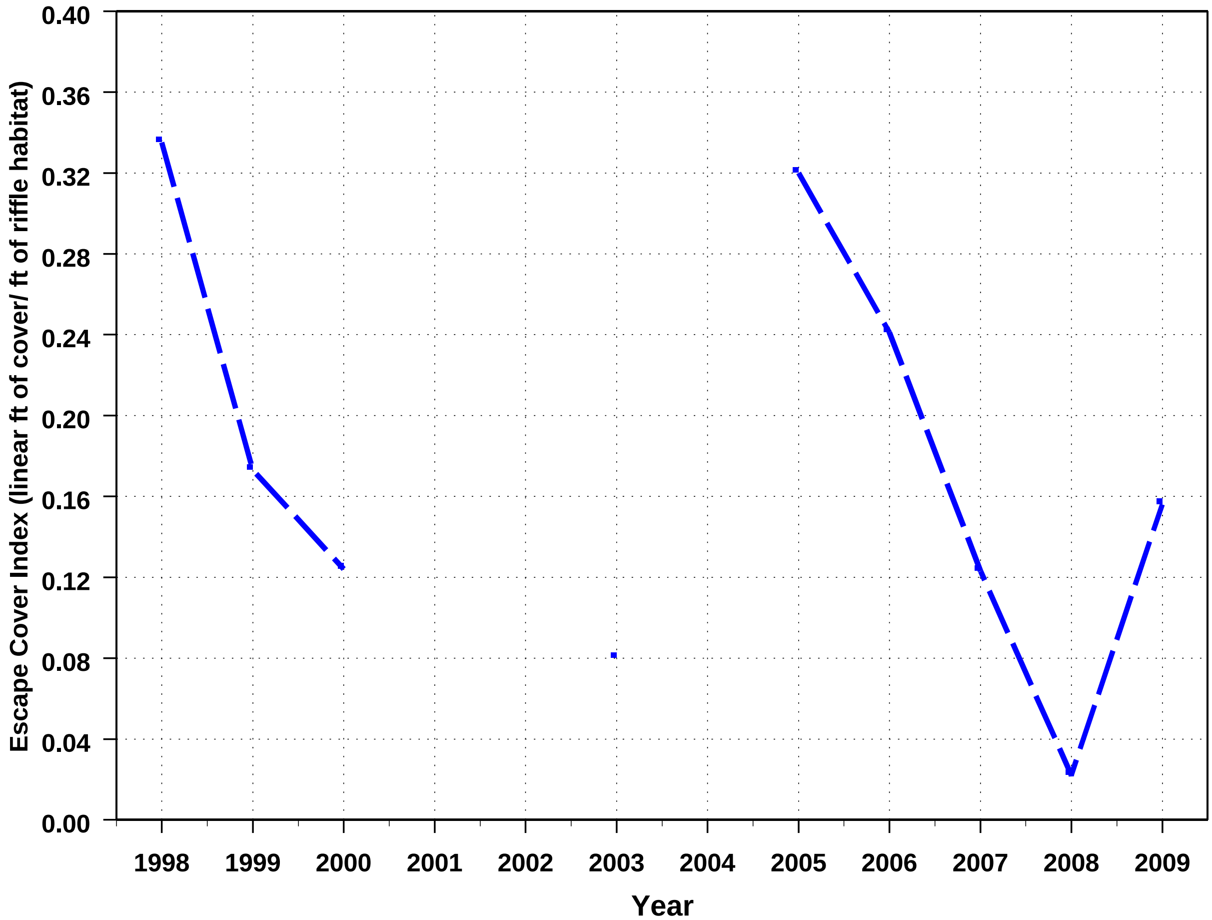
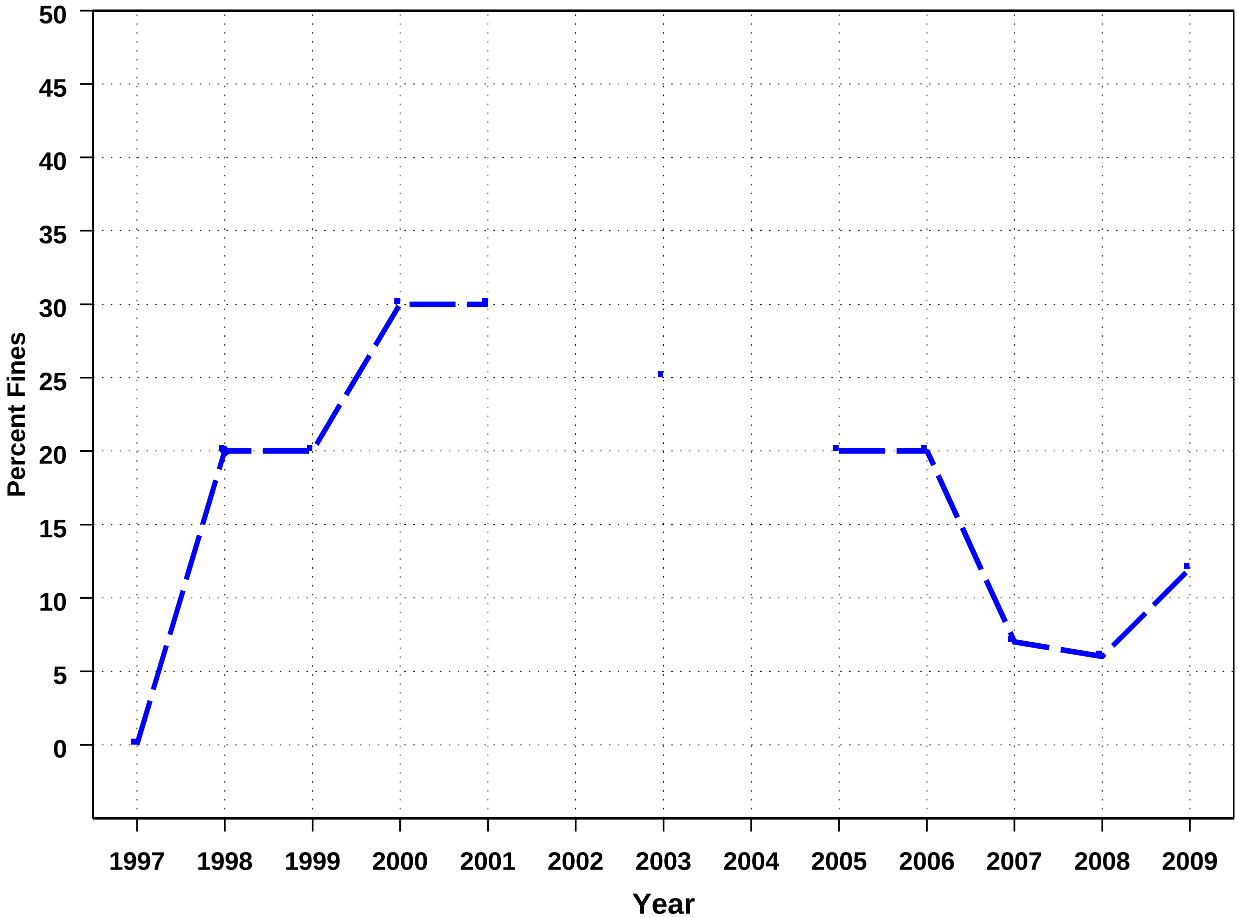


Figure 32. Averaged Percent Fines in Riffle Habitat in Reach 8 of the Middle Mainstem San Lorenzo River, 1997-2001, 2003 and 2005-2009.



Recommendations. For adult steelhead returns to increase substantially, the mainstem will need to again have 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. Improved mainstem spawning conditions would increase YOY and Size Class II densities, though sandy conditions will make this unlikely. More YOY must be produced in lower tributary reaches of Zayante, Bear and Boulder creeks, to seed the mainstem more heavily with YOY that may grow more quickly downstream of the Boulder Creek confluence. 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 causes 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−Juvenile Densities and Habitat for San Lorenzo Tributaries

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 destroy many spawning redds because of the preponderance of 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 (above the Boulder Creek confluence as represented by Reach 11), there was a general decline in total and YOY densities from 1997 to 2000, with a general increase from 2000 to 2003, followed by a general decline from 2003 to 2007 (**Figures 14 and 16**). YOY rebounded in 2008, only to slip to 2007 levels in 2009. The extremely high juvenile density measured at HTH's Site 11 in 2002 (**H.T. Harvey & Associates 2003**) seemed highly unusual, considering our 15 other years of sampling experience with Reach 11 in the upper mainstem.

YOY density at Site 14c in upper Bean Creek fluctuated the most of tributary sites. This reach is greatly impacted by well pumping. During the 2003–2009 period, Site 14b in middle Bean Creek surprisingly had no YOY in 2007 and very low densities in 2009, presumably because a long segment of the creek upstream of the Ruins Creek confluence went dry and reduced 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 it being the second lowest in 13 years. However, it rebounded in 2008 and declined somewhat in 2009.

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, 55 and 56; Appendix E**). 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 one 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 (**Appendix E**). 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 Zayante Reach 13d, an important eastern tributary reach, rearing habitat conditions improved from 1998 to 2009. Although it appeared that pools were deeper in 1998, this was likely caused by step-runs in 1998 being typed as pools in 2009, a year with much reduced baseflow. With higher baseflow in 1998, the proportion of pools in the reach was 50%, and the proportion of step-runs was 40% compared to 71% pools and 23% step-runs in 2009. Pool escape cover was greater in 2009 and percent fines in step-runs was similar to 1998.

Overall rearing habitat quality in Boulder Reach 17a, in an important western tributary, has declined from 1997 to 2009 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**). The residence time of instream wood in Boulder Creek is limited because it tends to be flushed out in a channel with steep to near vertical banks being common. Reach-wide pool escape cover was highest in 1998, declined considerably in 1999, rebounded in 2005 but declined in 2006 and remained low in 2007─2009. 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 2009. Escape cover in runs and step-runs was higher than in pools, but was unchanged from 2008 and much less than previous years, showing a similar decline as pool escape cover (**Table 13**). Escape cover was generally less in lower in west side Boulder Creek 17a than in east side Reach 13d in Zayante Creek. Percent fines in Boulder 17a were generally less than in the Zayante Creek 13d (**Figures 35 and 38**).

Figure 14. Plot of Annual Total Juvenile Densities at San Lorenzo Tributary Sites, 1997-2009.

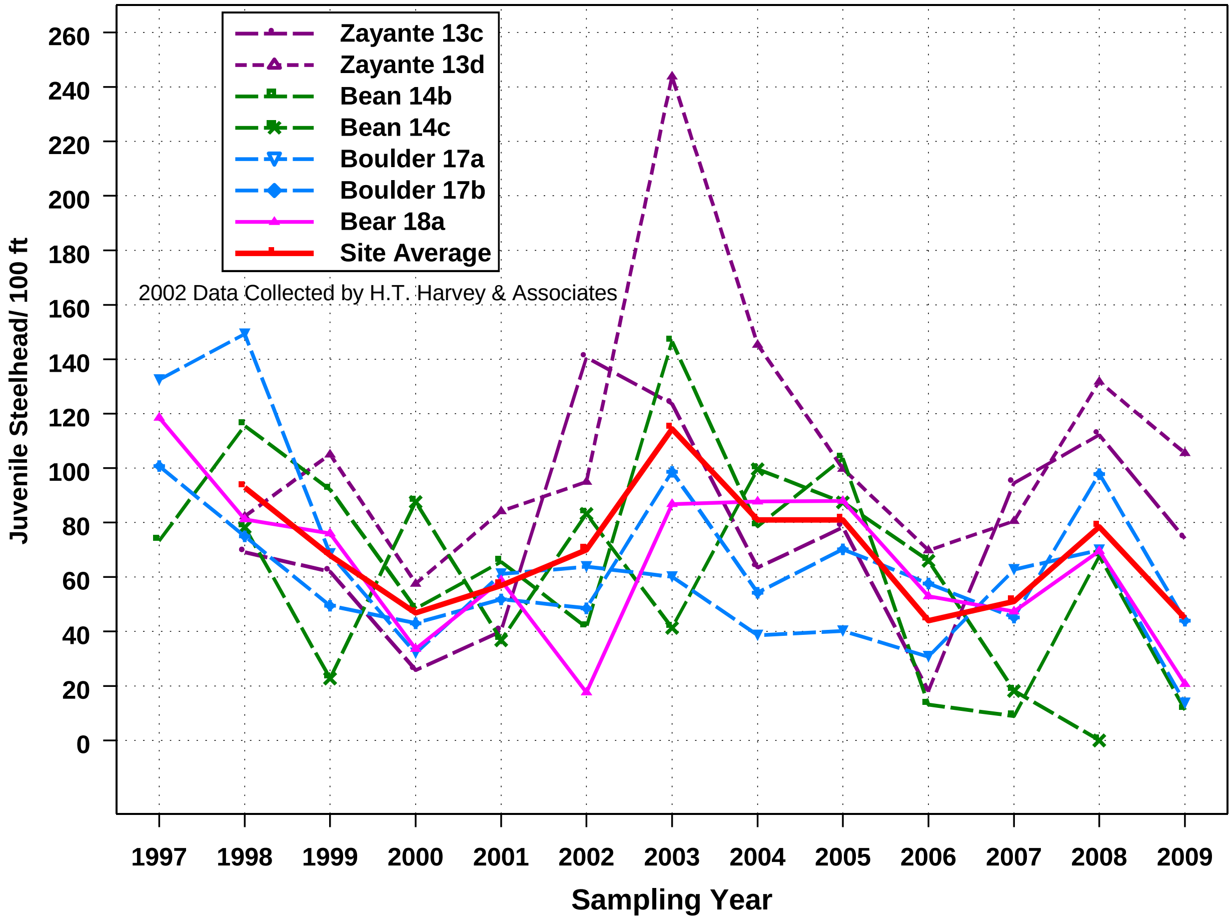


Figure 16. Plot of Annual YOY Juvenile Densities at San Lorenzo Tributary Sites, 1997-2009.

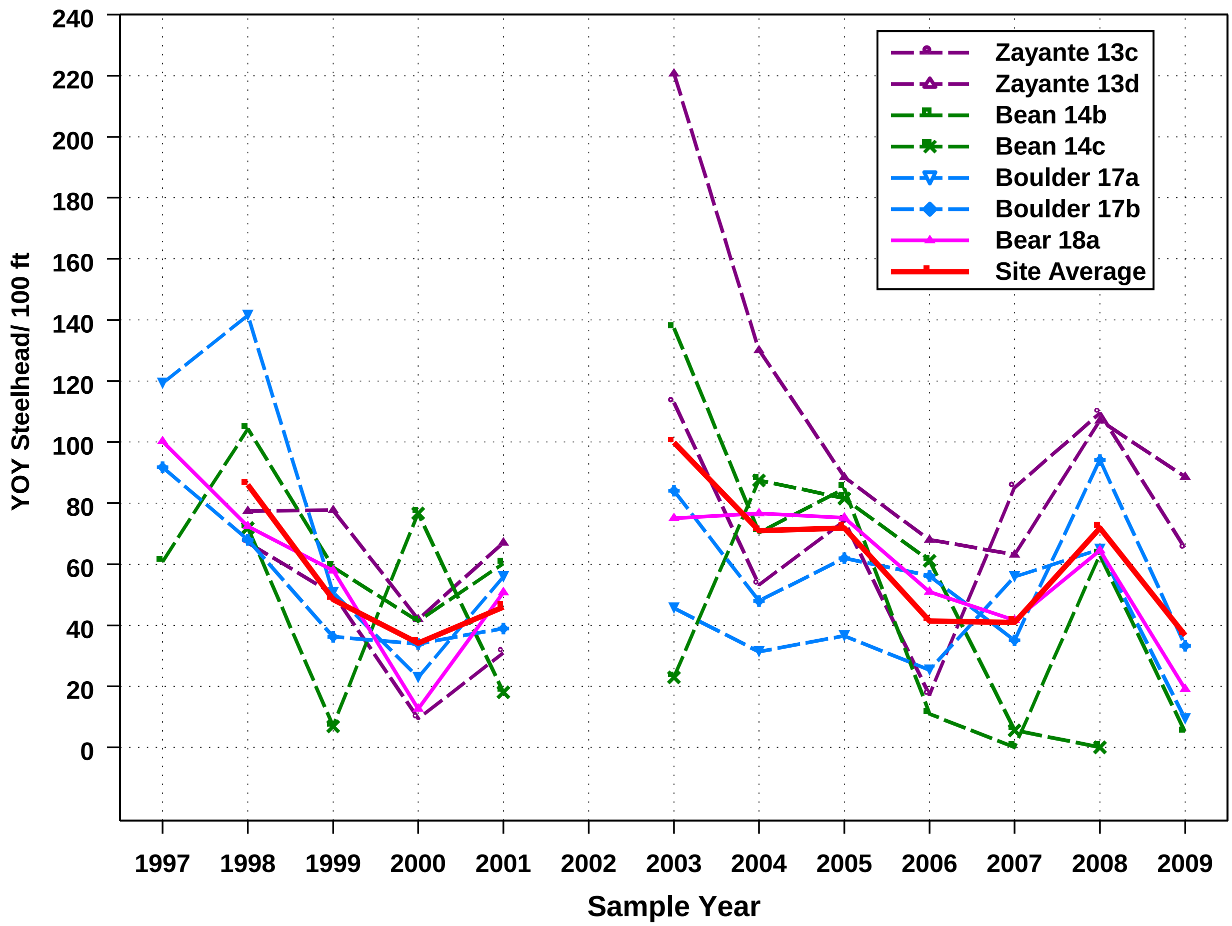
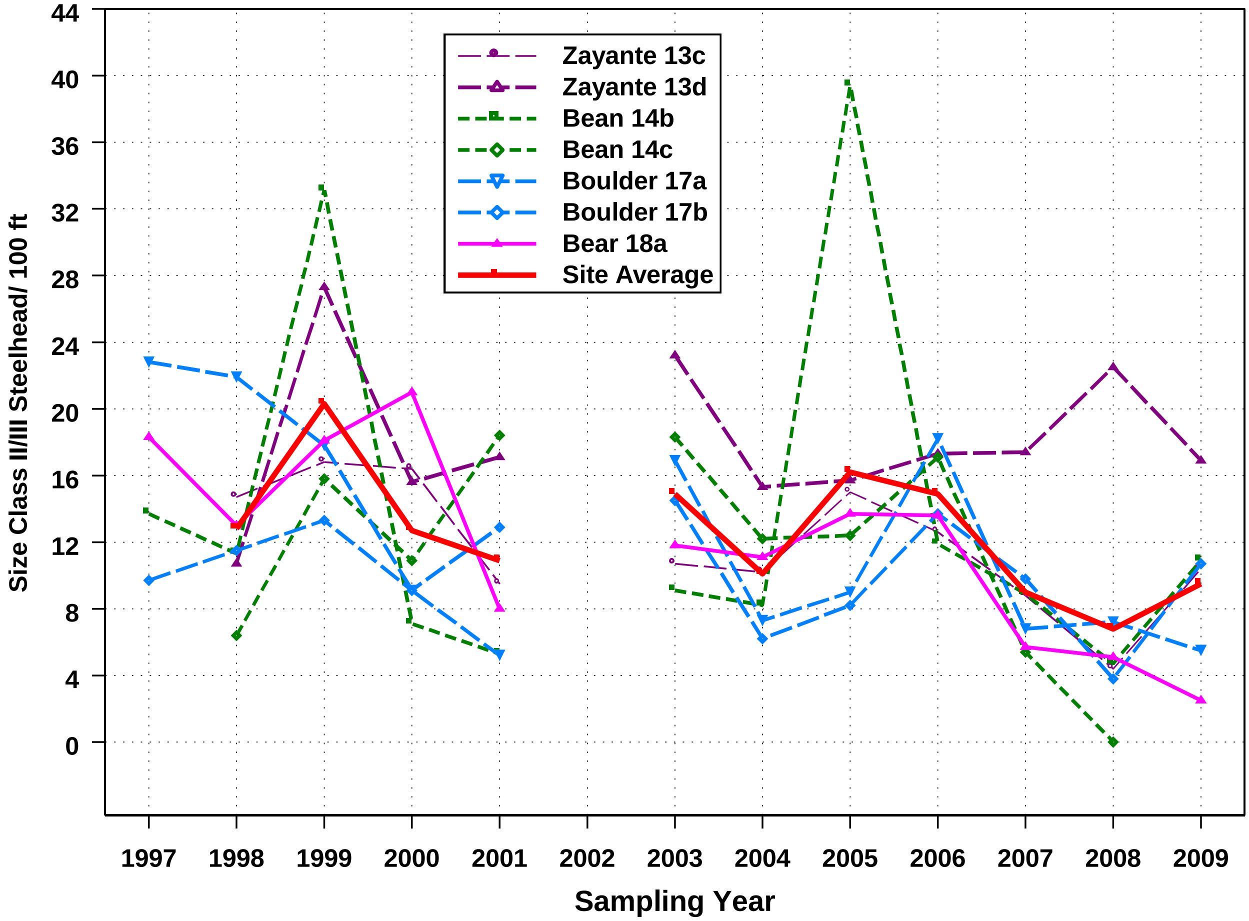


Figure 18. Plot of Annual Size Class II/ III Juvenile Densities at San Lorenzo Tributary Sites, 1997-2009.



Trend Analysis−Juvenile Densities and Habitat for Mainstem Soquel Creek

At 4 mainstem sites tracked for the past 13 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 survival of young 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, 22 and 27**). Fall YOY densities are very sensitive to timing of stormflow events, with higher YOY densities occurring when larger stormflows are absent after approximately March 1. This indicates that redds are scoured by later storms and/or small YOY are washed away by later storms.

The years of highest YOY and total juvenile density corresponded to years with the some of the lowest averaged mean monthly streamflow (May–September) (1997, 2002, 2004, 2007 and 2008), indicating that the drier years or at least years with few late winter and spring storms (**Figure 26; Appendix E**). 2009 did not fit this pattern because although it was dry, the storms came later and were in a short time frame (**Figure 57**). In these drier years, typically the lagoon population of juveniles is the highest, although 2009 did not fit this pattern either (**Alley 2010**). The typical pattern may be explained by assuming that during milder winters, late adult spawners probably have limited access to the upper watershed, having more shallow riffles and other impediments to pass especially later in the season. 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 analysis in 2002 that spawning gravel conditions in the mainstem/lower East Branch were fair in 2002, a year that was without large bankfull stormflows that could move considerable sediment (**Alley 2003c**). Exceptions to the typical pattern were 2001 and 2009, when YOY and total juvenile densities were relatively low despite mild winters. Low adult returns likely produced fewer YOY in both of those years.

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 promote 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 (**Appendix D**).

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 (**Appendix E**). 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 (**Appendix E and Figure 58**), 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. The rebound in smolt-sized juveniles from 2008 to 2009 in the mainstem likely resulted from much less competition between YOY due to their very low density, allowing a higher proportion to reach smolt-size the first growing season.

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 (i.e. large instream wood), survival of yearlings might increase in mainstem 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**).

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 and 2009), but the amplitude of fluctuations was inconsistent (**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. In 2009, there were so few YOY at Site 10 that the reduced competition allowed a higher proportion to grow into Size Class II than in 2008 despite the low baseflow of a dry year.

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 2009. During the instream wood survey in 2002, this reach was noted for its lack of large wood (**Alley 2003c**).

In summary, overall rearing habitat quality declined in Reach 7 since 1997 because of pool filling with sediment and less escape cover, though pool depth increased and embeddedness in fastwater habitat declined during the 2007─2009 drier years. During the instream wood survey in 2002, this reach was noted for its lack of large wood (**Alley 2003c**).

Figure 26. Averaged Mean Monthly Streamflow for May–September, 1997–2009 at the Soquel Village Gage on Soquel Creek.

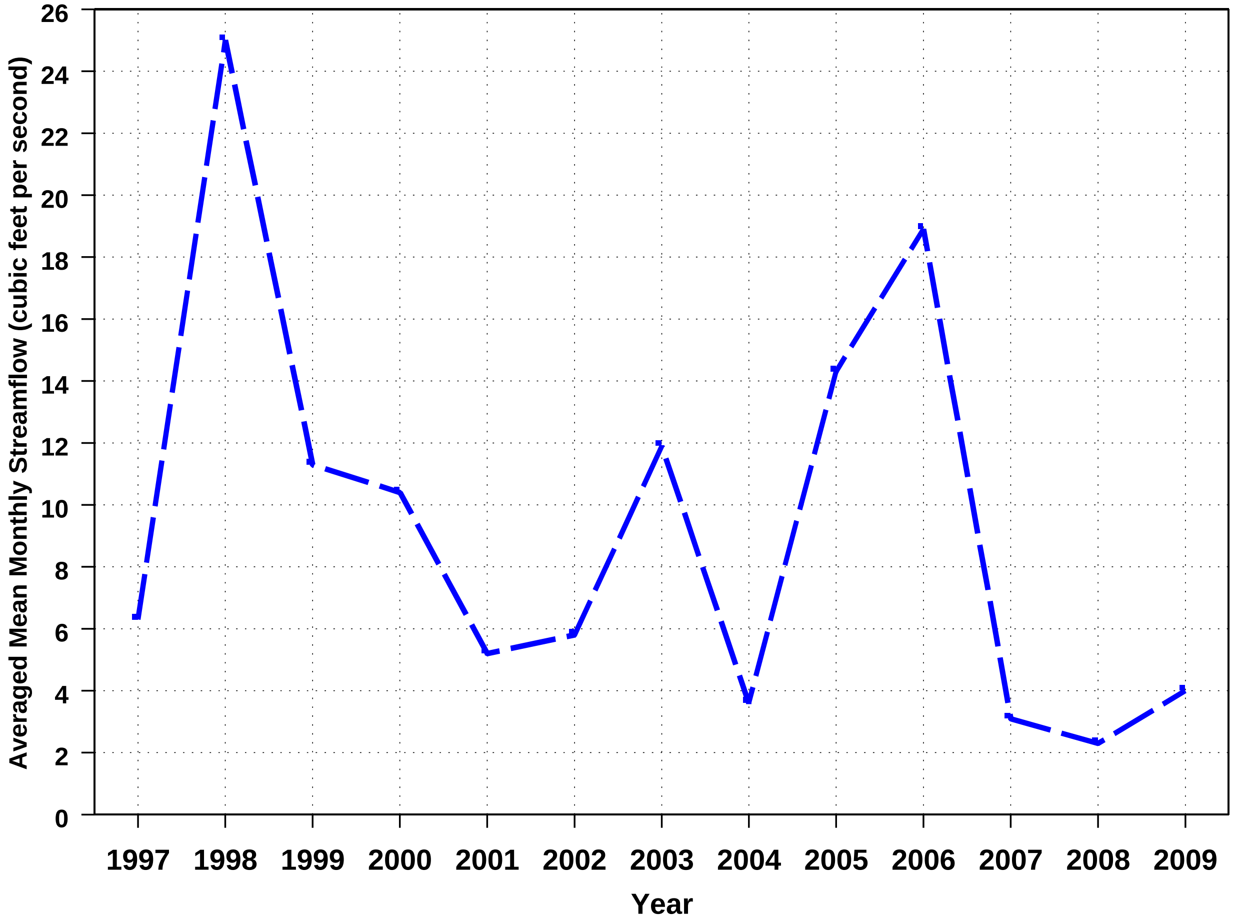


Figure 19. Plot of Annual Total Juvenile Densities at Mainstem Soquel Creek Sites, 1997-2009.

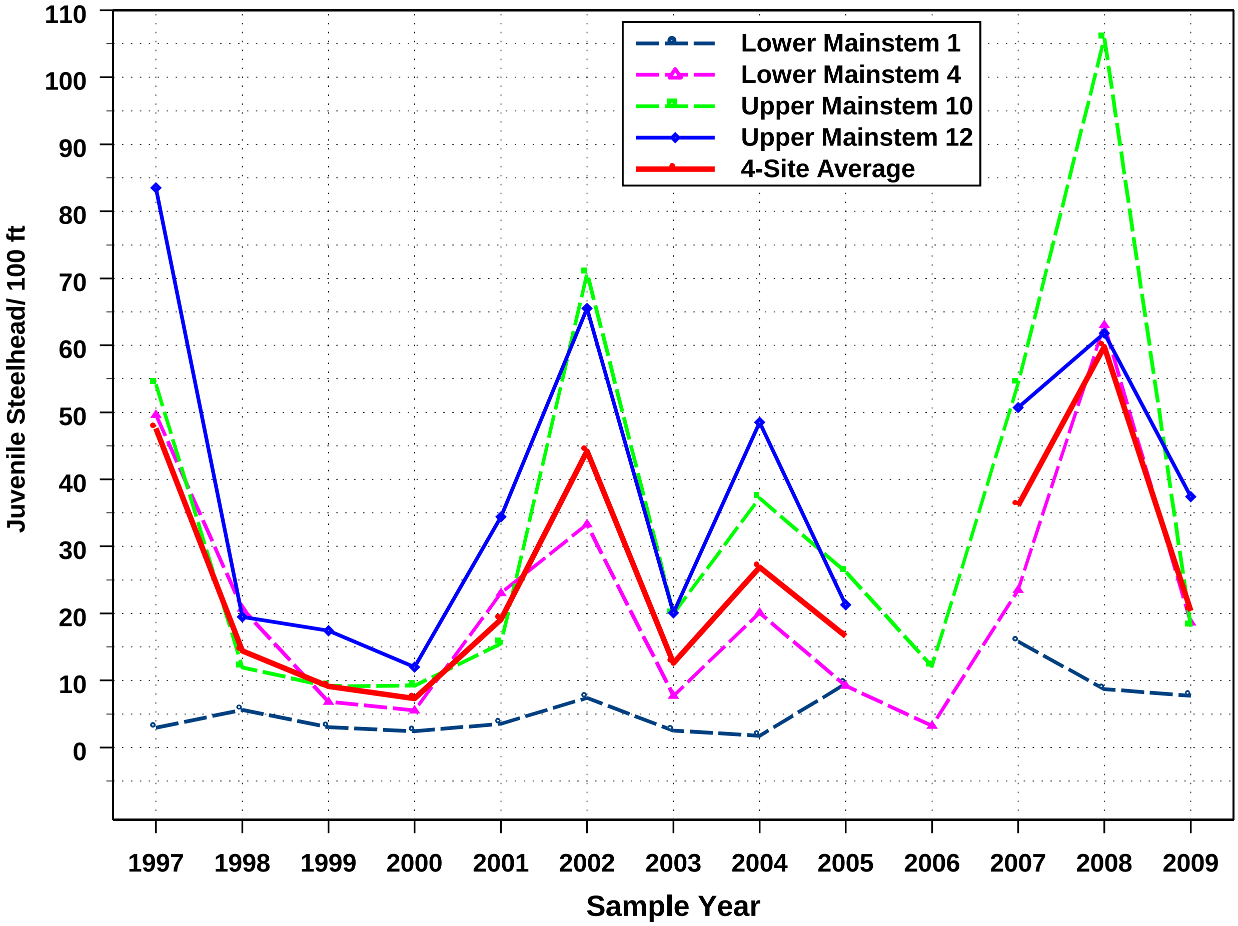
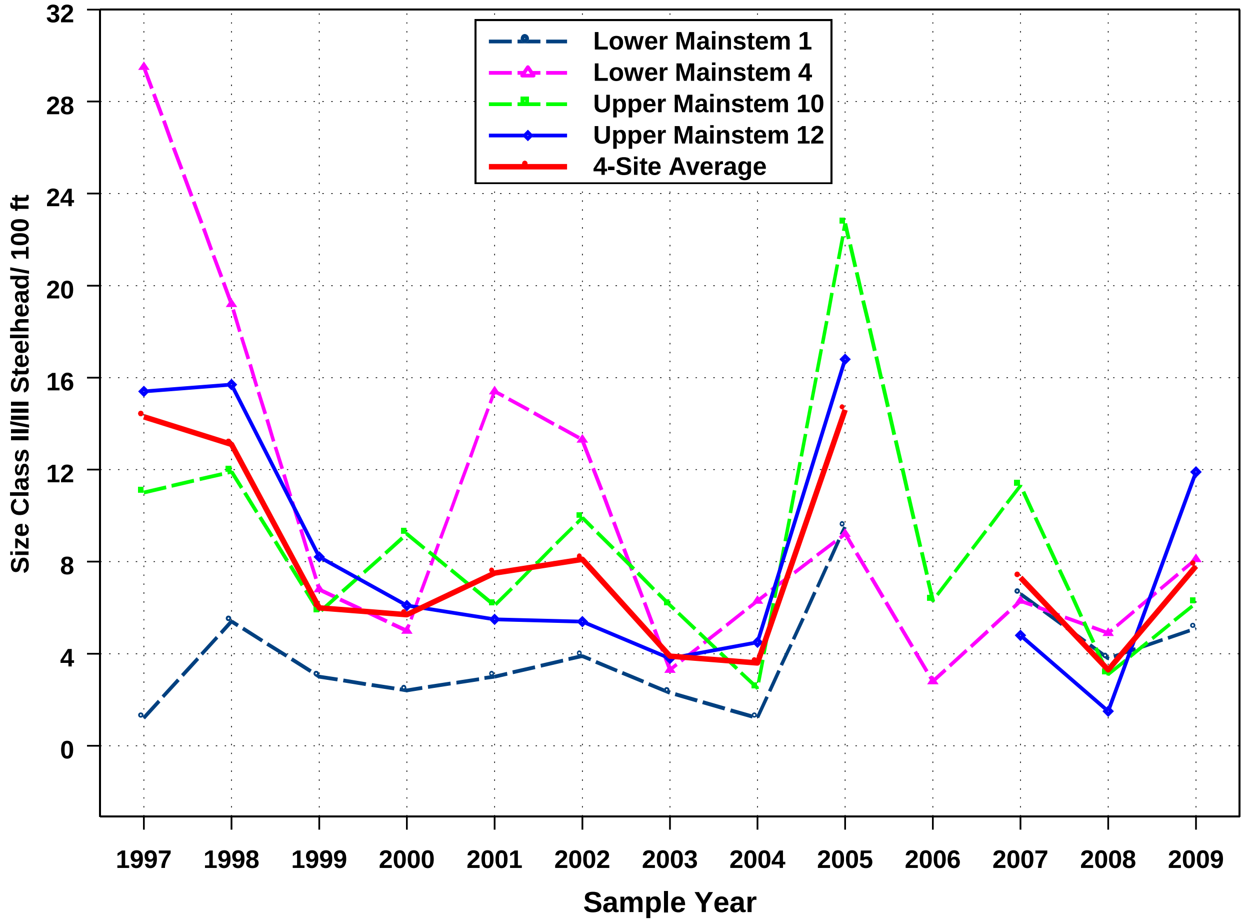


Figure 23. Plot of Annual Size Class II/ III Juvenile Densities at Soquel Mainstem Sites, 1997-2009.



Trend Analysis−Juvenile Densities and Habitat for East Branch Soquel

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 in the Soquel Demonstration State Forest (SDSF). 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) (Map in **Appendix A**). 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 usually 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 the lower East Branch (Site 13a) compared to the 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 13-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. As was the pattern at other downstream sites in 2009, total and YOY densities declined at Site 13a. Higher YOY densities in most dry 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 SDSF. Though 2008 and 2009 had relatively low baseflows (especially 2008) because of few winter storms, there were storms in excess of 2,000 cfs peak flow that were absent in 2007 to provide better spawning access than 2007. These sizeable stormflows brought correspondingly higher YOY density at Site 16 in the SDSF in 2008 and 2009. The 2009 baseflow appeared to be elevated due to the 2008 fire upstream of Site 16. 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.

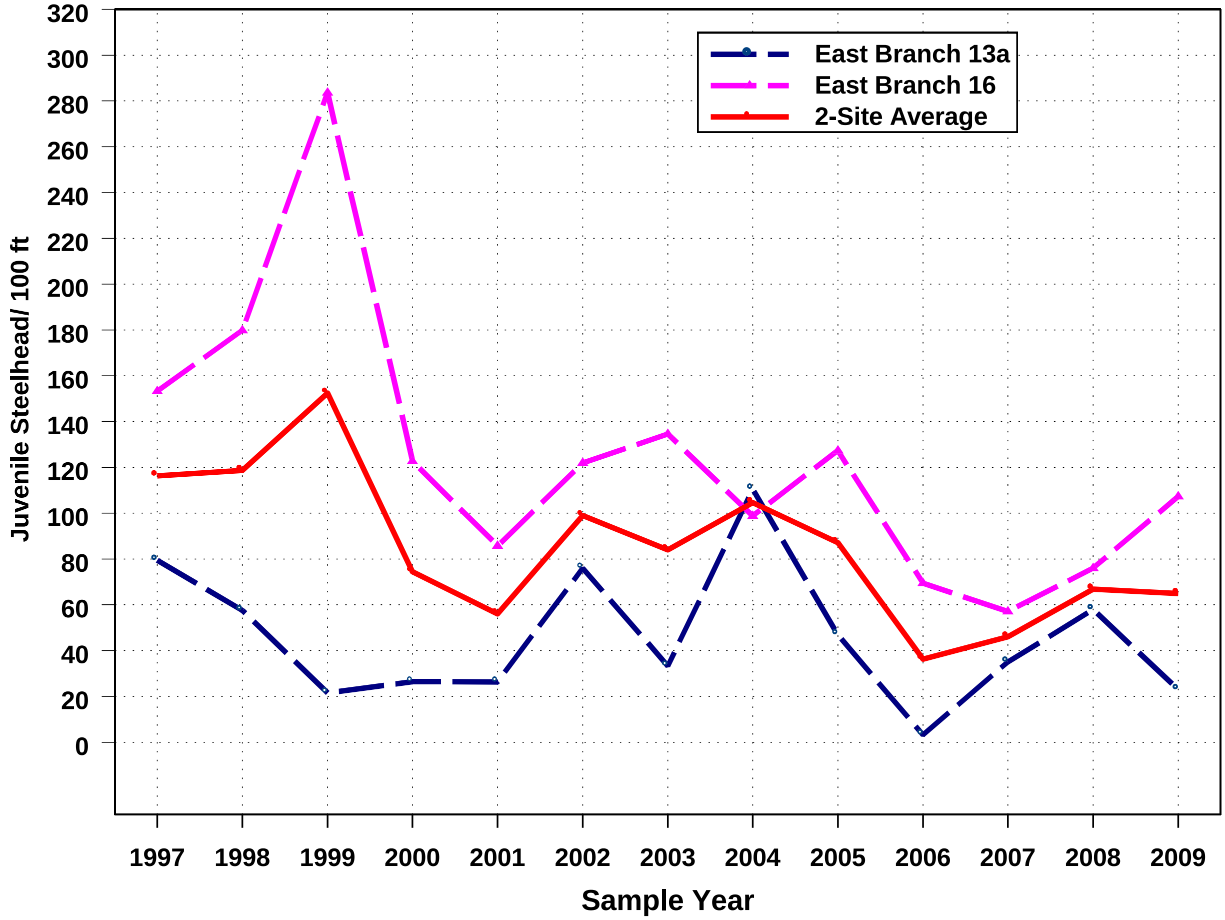
Overall rearing habitat quality has declined in the lower East Branch from 1997 to 2009, with regard to reduced pool escape cover (**Figures 46a-b**). However, other habitat conditions have improved with pool depths deepening since 2005, even during drier years with lower baseflows (**Figure 45**). Run and step-run habitat has improved since 2000 regarding less percent fines (**Figure 47**), and riffle embeddedness has also improved (lessened) since 2005 (**Figure 48**). 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 immediately below the Mill Pond outfall and was absent in 2009.

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 when densities increased with more escape cover (**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 2007-2008, YOY and total densities were positively correlated with increased pool escape cover at sampling sites. In 2005–2006, densities were not associated with these habitat parameters. Densities of larger juveniles increased in 2009 despite reduced pool escape cover. This may have happened because more YOY reached Size Class II in 2009 with reduced competition between fewer YOY.

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 13 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, or even drier years if YOY density was low, such as 2009. 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 2009 in Reach 9a of the lower East Branch was similar to 2000 conditions with regard to pool depth but worse with less pool 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 and absent in 2009. 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 yearling steelhead and enhance rearing habitat.

Figure 20. Plot of Annual Total Juvenile Densities at East Branch Soquel Creek Sites, 1997-2009.



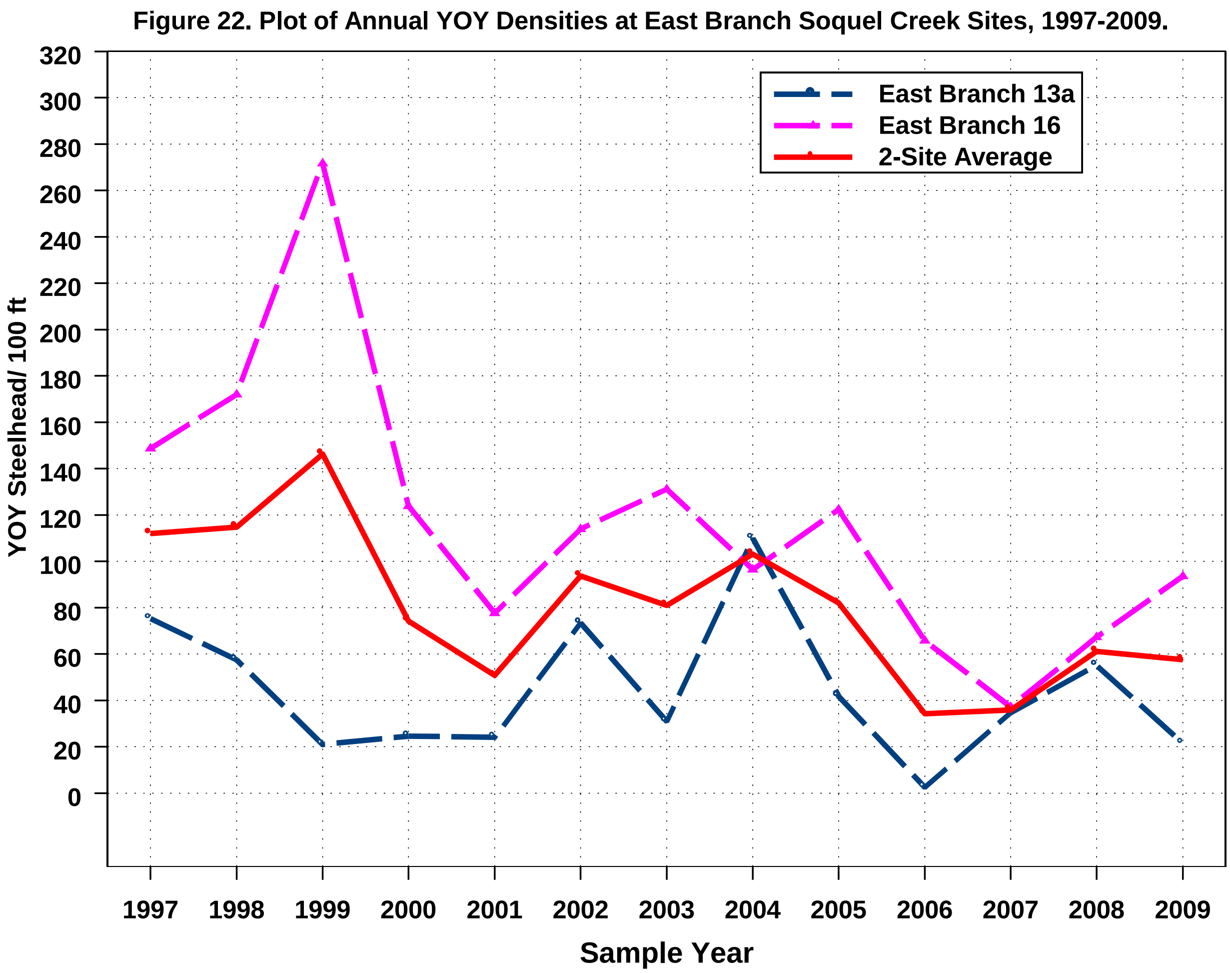
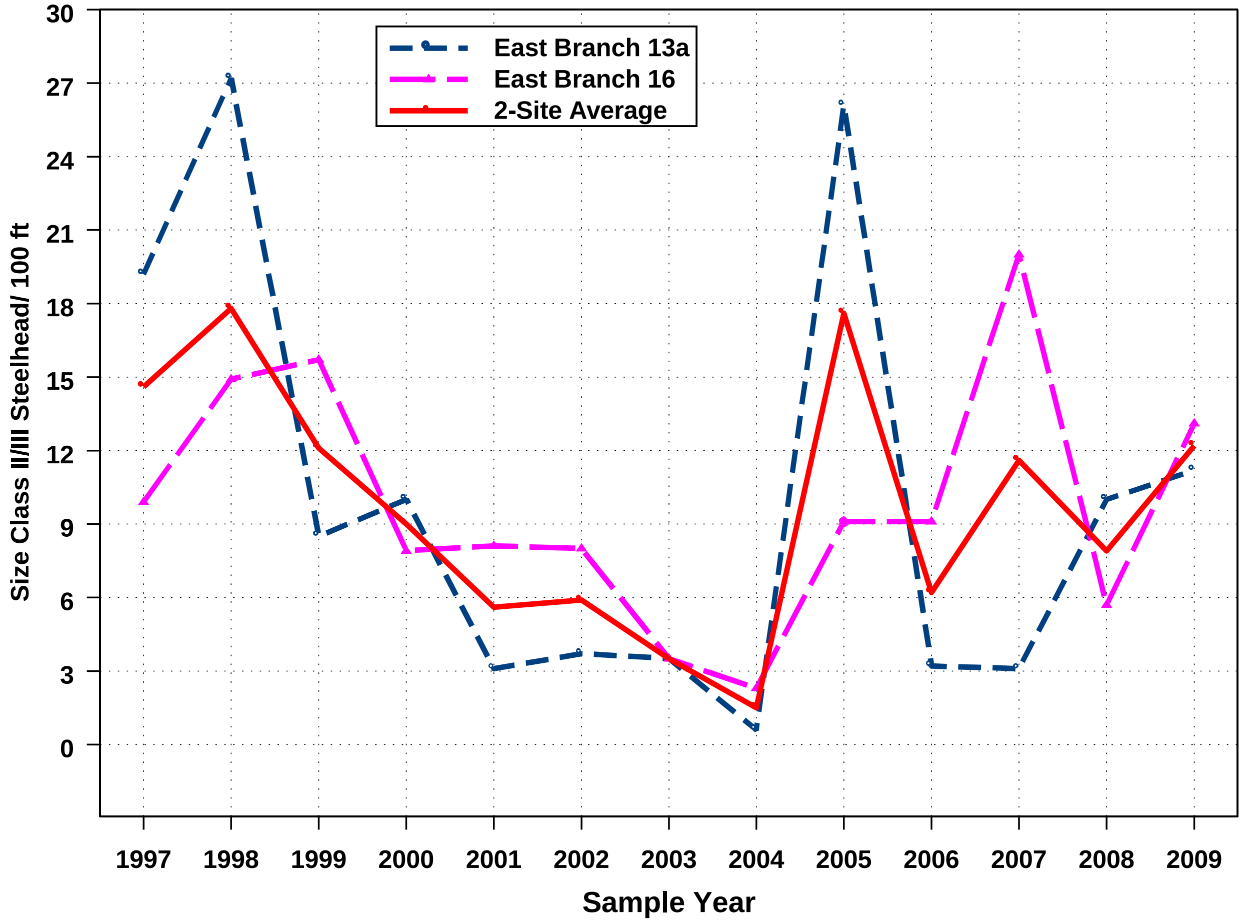


Figure 22. Plot of Annual YOY Densities at East Branch Soquel Creek Sites, 1997-2009.
East Branch 13a
East Branch 16
2-Site Average
YOY Steelhead/ 100 ft
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Sample Year

Figure 24. Plot of Annual Size Class II/ III Juvenile Densities at East Branch Soquel Creek Sites, 1997-2009.



In the upper East Branch at Site 16 in the SDSF, densities of Size Class II and III (nearly all yearlings) 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 13 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**), poor rearing conditions with very low baseflows and likely a bankfull event during the 2007/2008 winter that flushed some yearlings downstream. Then Size Class II and III densities increased in 2009 with higher baseflow after a fire, higher YOY densities in 2008 for higher recruitment to yearlings and a milder winter to allow greater overwinter survival than 2008.

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**). Then with higher baseflow in 2009 after a fire (visually estimated at 0.15 cfs), pool depth increased. 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, decreased in 2006−2008 to just less than 2000 levels and then increased in 2009 to above 2007 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 in 2006─2008 down to slightly less than the 2000 level but improved slightly in 2009. Reach-wide percent fines in important step-run habitat declined less than 10% since 2000, not indicating a real change to 2009 (**Figure 51**). Percent fines at sampled step-runs were similar between 2000 and 2009, as well (**Figure 52**).

At Site 16, annual densities of Size Class II and III juveniles were not positively correlated with changes in pool escape cover at sampling sites, except in 2008 and 2009 (**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. Smolt-sized juvenile densities increased in 2009 with increased pool depth and escape cover but also coincided with a larger YOY density in 2008 to recruit from compared to 2007. 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 except in 2008 when baseflow was a trickle and 2009 when baseflow was likely enhanced by previous forest fire, indicated that rearing habitat quality within the observed range in most of the last 13 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 mild 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 2009 was similar to conditions in 2000. Percent of fines in runs and step-runs has decreased to improve conditions, but embeddedness has remained similar since 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.

REFERENCES AND COMMUNICATIONS

Alley, D.W. 1995a. Comparison of Juvenile Steelhead Densities in 1981 and 1994 with Estimates of Total Numbers of Mainstem Juveniles and Expected Numbers of Adults Returning to the San Lorenzo River, Soquel Creek and Corralitos Creek, Santa Cruz County, California.

Alley, D.W. 1995b. Comparison of Juvenile Steelhead Densities in 1981, 1994 and 1995 with an Estimate of Juvenile Population Size in the Mainstem San Lorenzo River, with Expected Numbers of Adults Returning from Juveniles Rear in the Mainstem River, Santa Cruz County, California.

Alley D.W. 2000a. Comparisons of Juvenile Steelhead Densities, Population Estimates and Habitat Conditions for the San Lorenzo River, Santa Cruz County, California, 1995-1999; with an Index of Adult Returns.

Alley, D.W. 2003b. Comparison of Juvenile Steelhead Densities, Population Estimates and Habitat Conditions in Soquel Creek, Santa Cruz County, California, 1997-2002; with an Index of Expected Adult Returns.

Alley, D.W. 2003c. Appendix C. Fisheries Assessment. Contained in the Soquel Creek Watershed Assessment and Enhancement Project Plan. November 2003. Prepared by D.W. ALLEY & Associates for the Resource Conservation District of Santa Cruz County.

Alley, D.W. 2008. 2007 Juvenile Steelhead Densities in the San Lorenzo, Soquel, Aptos and Corralitos Watersheds, Santa Cruz County, California, With Trend Analysis in the San Lorenzo and Soquel Watersheds, 1997-2007.

Alley, D.W. 2010. Soquel Lagoon Monitoring Report, 2009. Prepared for the City of Capitola.

Flosi, G., S. Downie, J. Hopelain, M. Bird, R. Coey and B. Collins. 1998. California Salmonid Stream Habitat Restoration Manual. State of California Resources Agency, Depart. Fish & Game.

Freund, E. 2005. Personal Communication. NOAA Fisheries Laboratory, Santa Cruz, CA.

Hecht, Barry. 2002. Personal Communication. Geomorphologist. Balance Hydrologics. 800 Bancroft Way, Suite 101, Berkeley, CA 94710-2227. Phone no. 510-704-1000.

H.T. Harvey & Associates. 2003. Salmonid Monitoring in the San Lorenzo River, 2002. Prepared for the City of Santa Cruz. Project No. 2163-01.

Smith, J.J. 1982. Fish Habitat Assessments for Santa Cruz County Stream. Prepared for Santa Cruz County Planning Department by Harvey and Stanley Associates.

REFERENCES AND COMMUNICATIONS (continued)

Smith, J.J. and H.W. Li. 1983. Energetic factors influencing foraging tactics of juvenile steelhead trout (Salmo gairdneri), D.L.G. Noakes et al. (4 editors) in The Predators and Prey in Fishes. Dr. W. Junk publishers, The Hague, pages 173-180.

Smith, Jerry J. 2005. Personal Communication. Biology Department. San Jose State University, San Jose, CA. Phone no. 408-924-4855.

APPENDIX A. WATERSHED MAPS.

Figure 1. Santa Cruz County Watersheds.

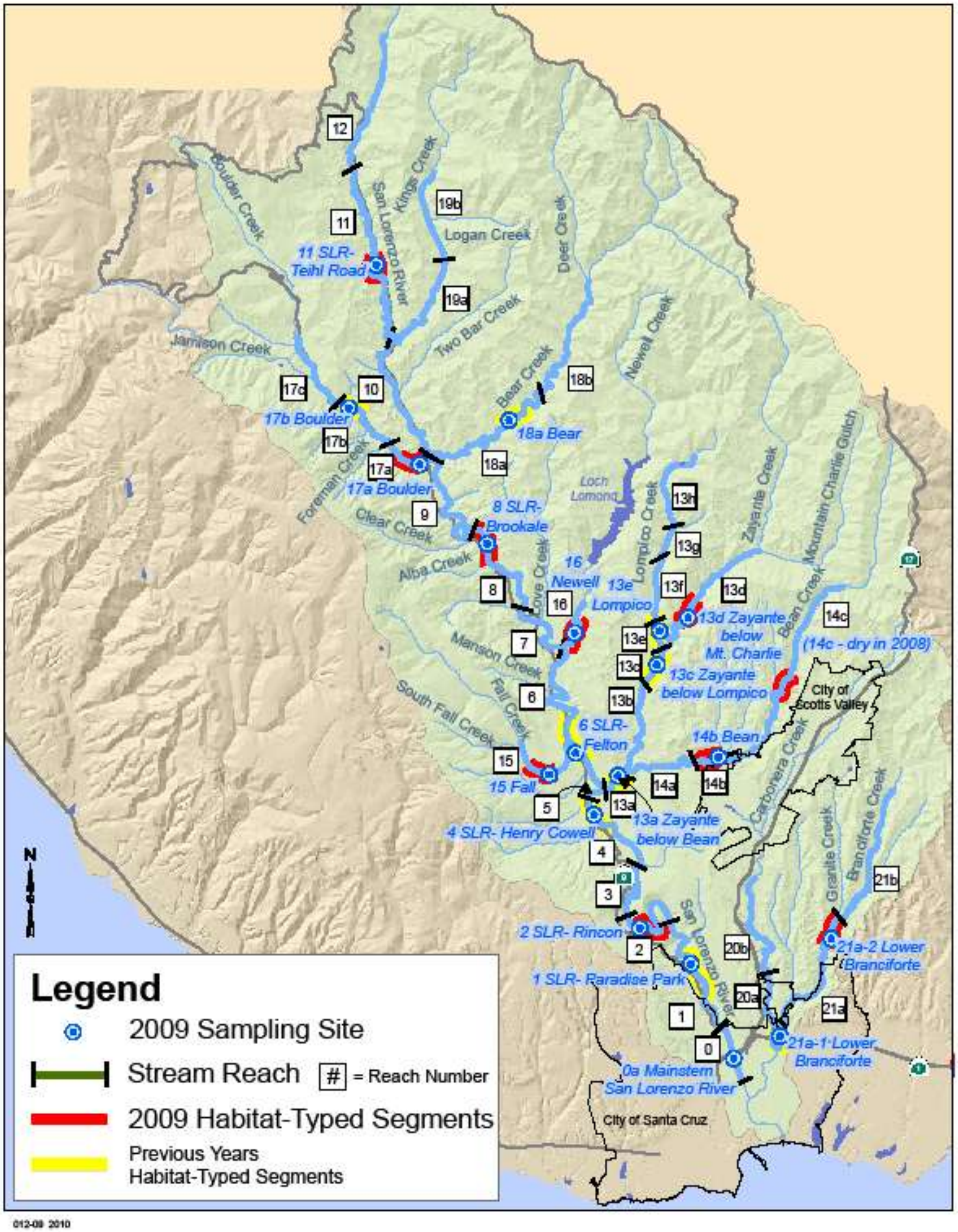


Figure 2. San Lorenzo River Watershed

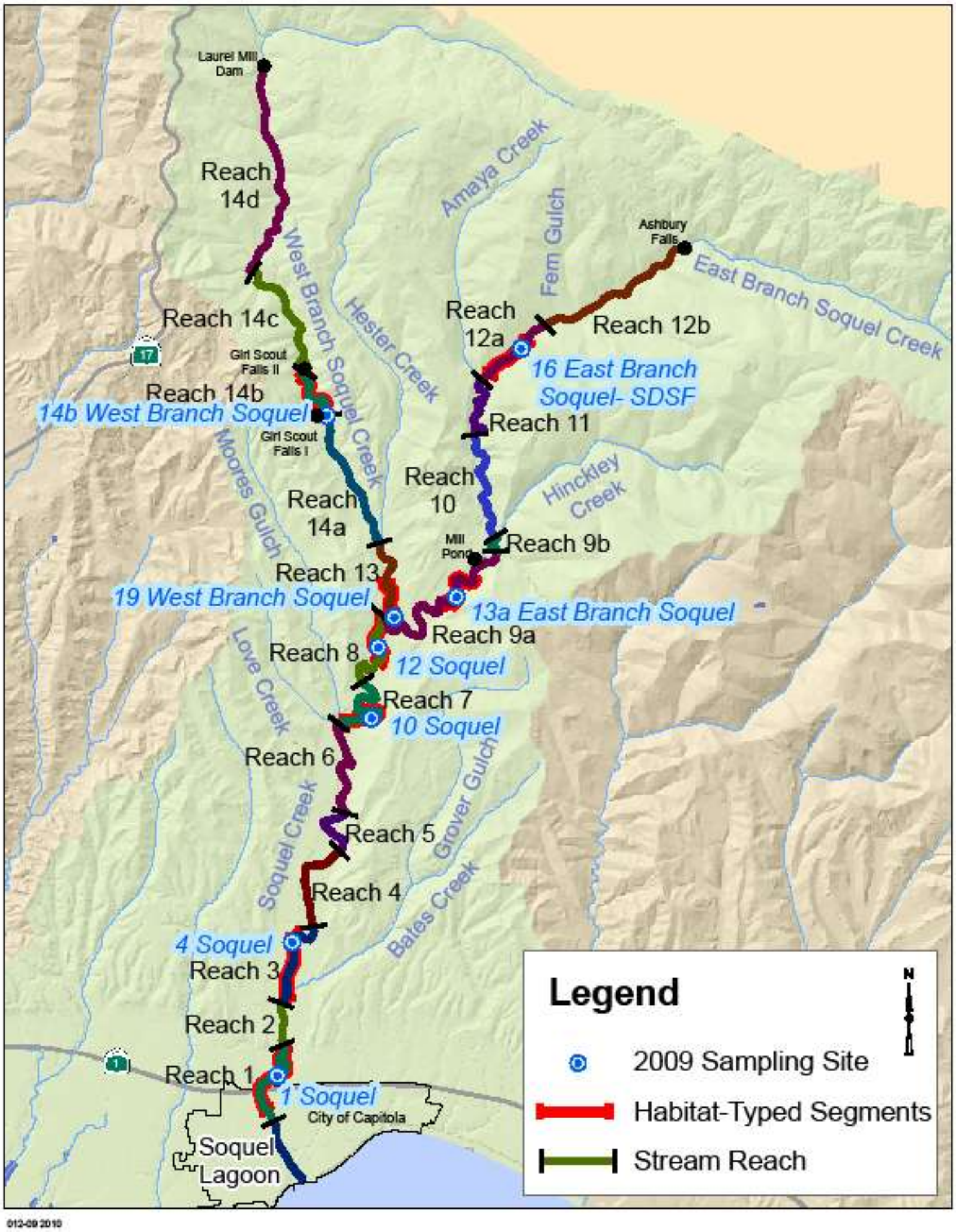


Figure 3. Soquel Creek Watershed.

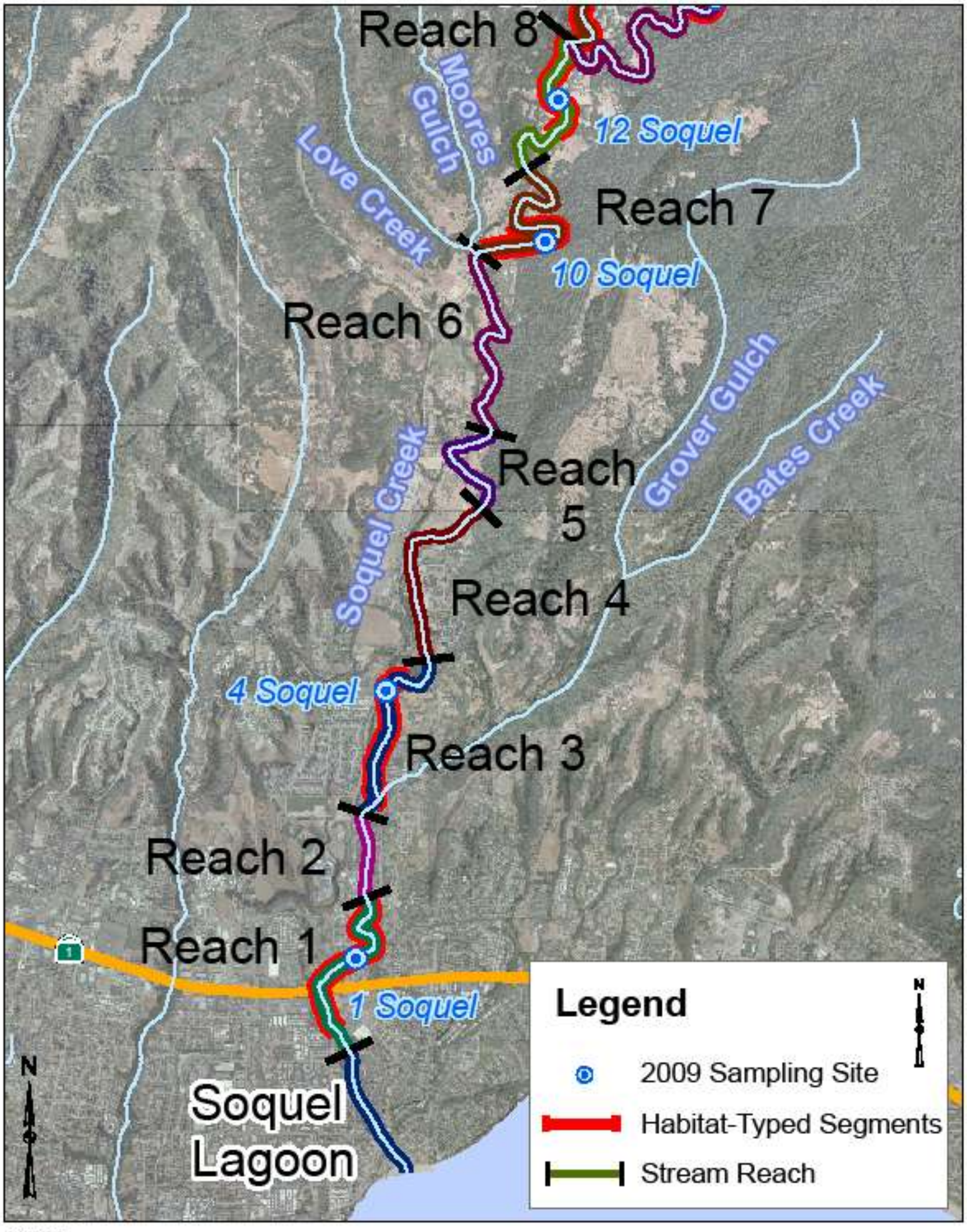


Figure 4. Lower Soquel Creek (Reaches 1–8 on Mainstem).

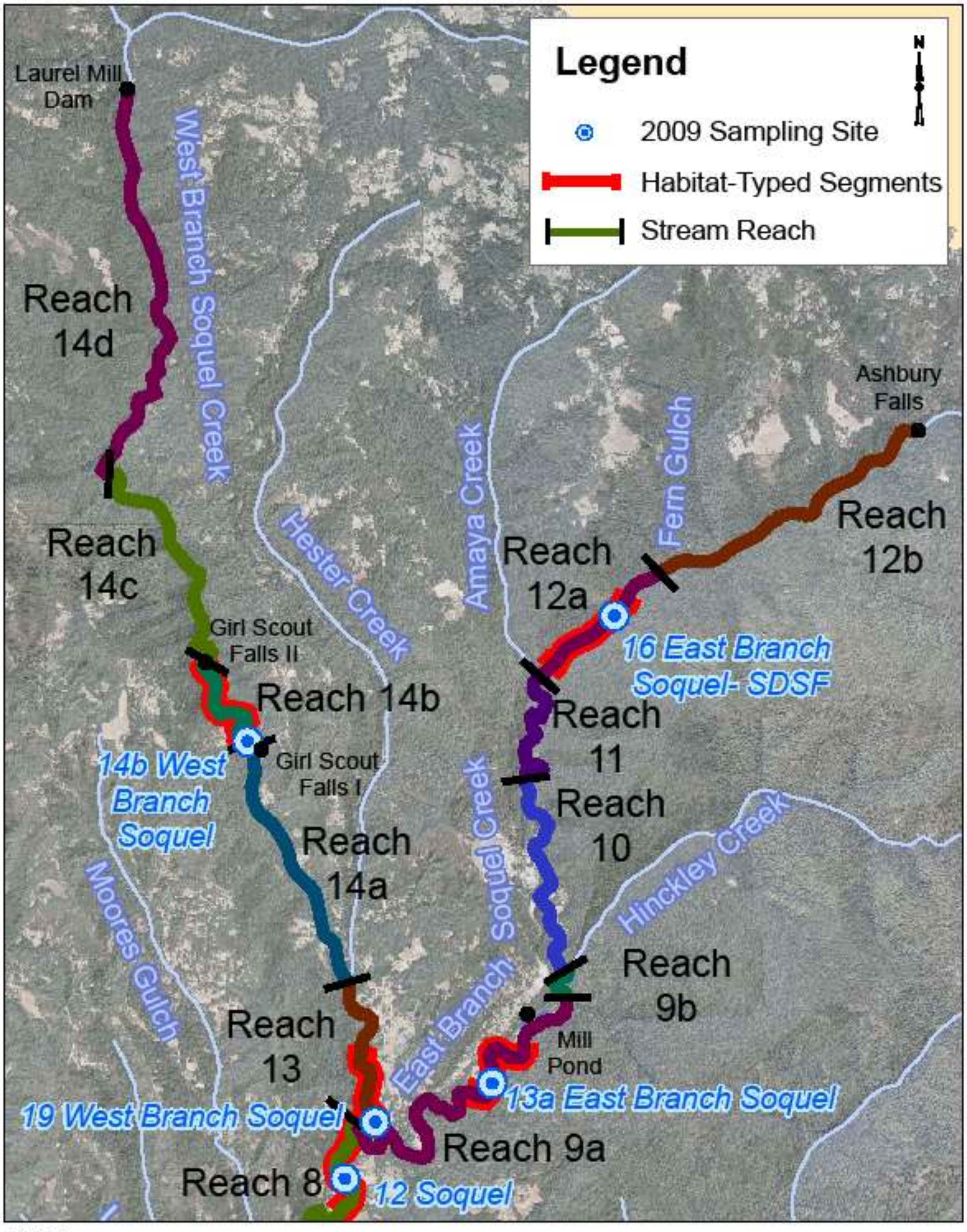


Figure 5. Upper Soquel Creek Watershed (East and West Branches).

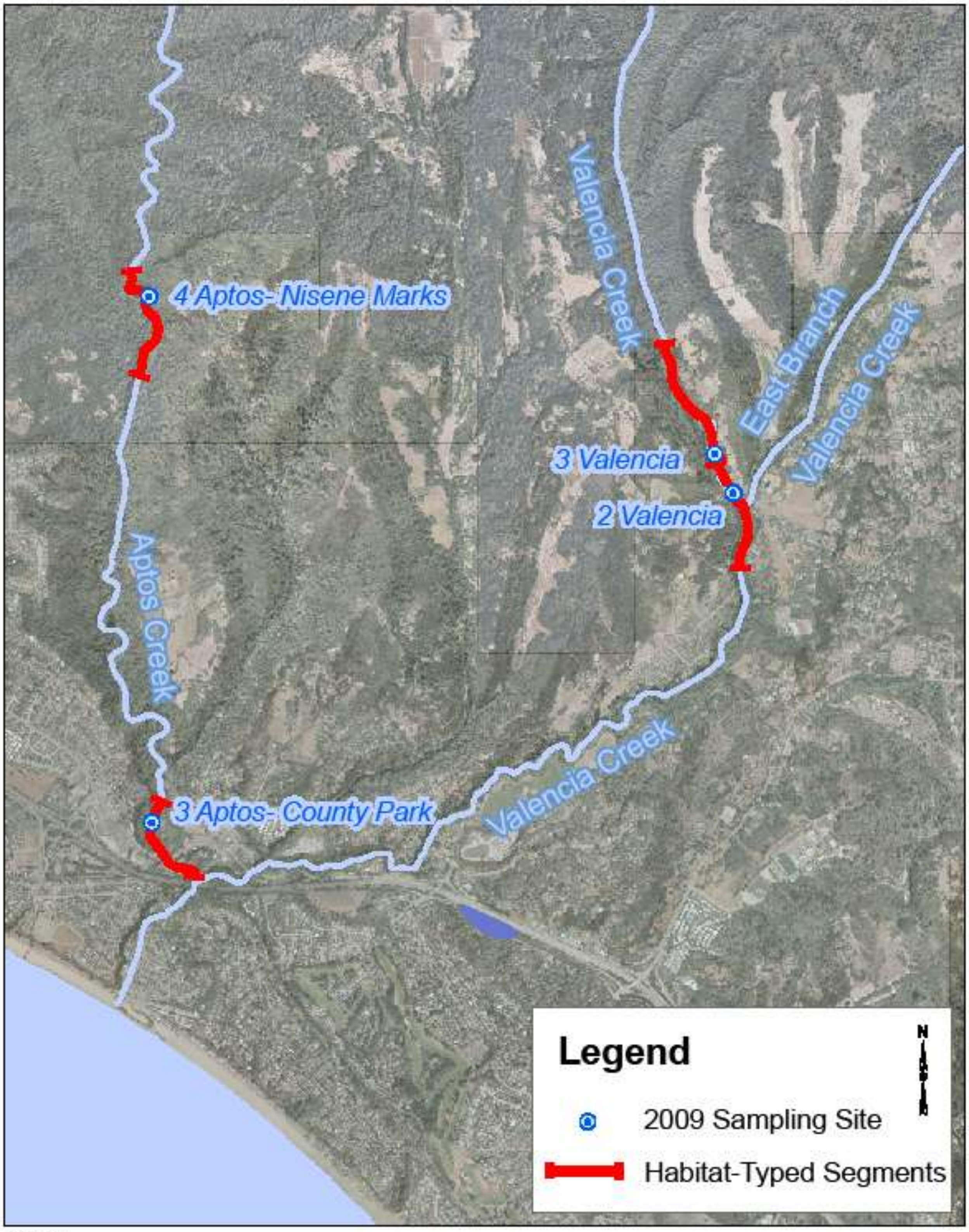


Figure 6. Map from Smith (1982) with Site #3 designation on Valencia Creek at 2006 location.

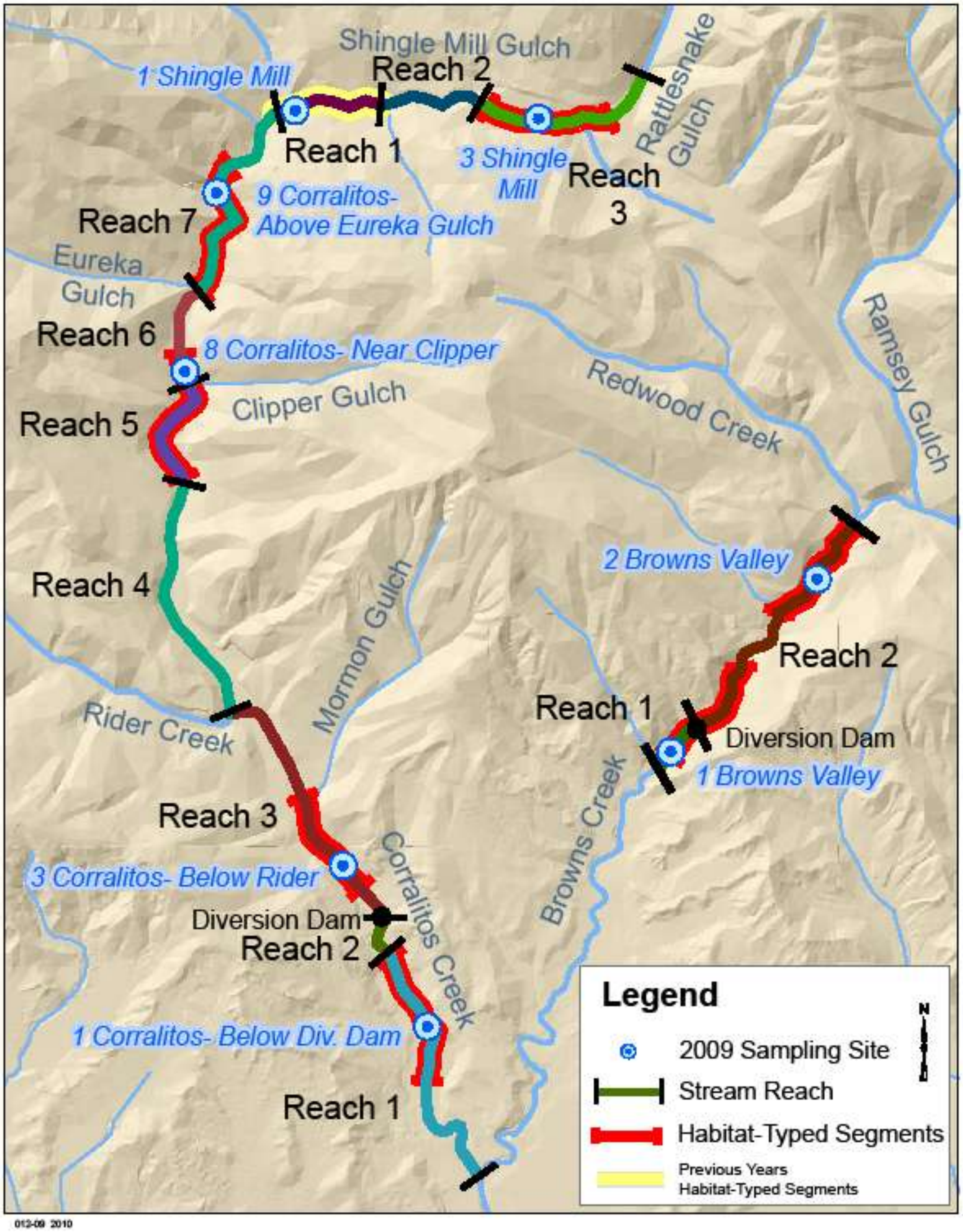


Figure 7. Upper Corralitos Creek Sub-Watershed of the Pajaro River Watershed.

APPENDIX B. DETAILED ANALYSIS OF 2009 STEELHEAD MONITORING IN THE SAN LORENZO, SOQUEL, APTOS AND CORRALITOS WATERSHEDS

(Provided electronically in a separate PDF file.)

APPENDIX C. SUMMARY OF 2009 CATCH DATA AT SAMPLING SITES.

(Provided electronically in the PDF file with the Detailed Analysis, Appendix B.)

APPENDIX D. HABITAT AND FISH SAMPLING DATA WITH SIZE HISTOGRAMS.

(Provided electronically in a separate PDF file.)

APPENDIX E. HYDROGRAPHS OF SAN LORENZO, SOQUEL AND CORRALITOS WATERSHEDS.

(Provided electronically in a separate PDF file.)