D.W. ALLEY & Associates aquatic biology

2010 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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Prepared For the

Santa Cruz County Environmental Health Department
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SUMMARY REPORT

Scope of Work

In fall 2010, 4 Santa Cruz County watersheds were sampled for juvenile steelhead with the purpose of primarily comparing juvenile abundance with past years and habitat conditions at sampling sites with those in 2009. 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. Tables and figures referenced in this summary report and not included may be found in **Appendix B**, the detailed analysis report. Hydrographs of all previous sampling years are included in **Appendix E**.

San Lorenzo River. The mainstem San Lorenzo River and 8 tributaries were sampled at 19 sites (7 mainstem and 12 tributary sites). Sampled tributaries included Branciforte, Zayante, Lompico, Bean, Fall, Newell, Boulder and Bear creeks. Five half-mile segments were habitat typed in the San Lorenzo system to assess habitat conditions and select habitats of average quality to sample. For the remaining 14 sites, the 2009 sites were replicated for fish sampling, and depth and cover measurements were made at all sampling sites.

Soquel Creek. In Soquel Creek and its branches, 8 fish sampling sites were replicated from 2009 (4 mainstem, 2 East Branch and 2 West Branch sites), and depth and cover measurements were made at all sampling sites.

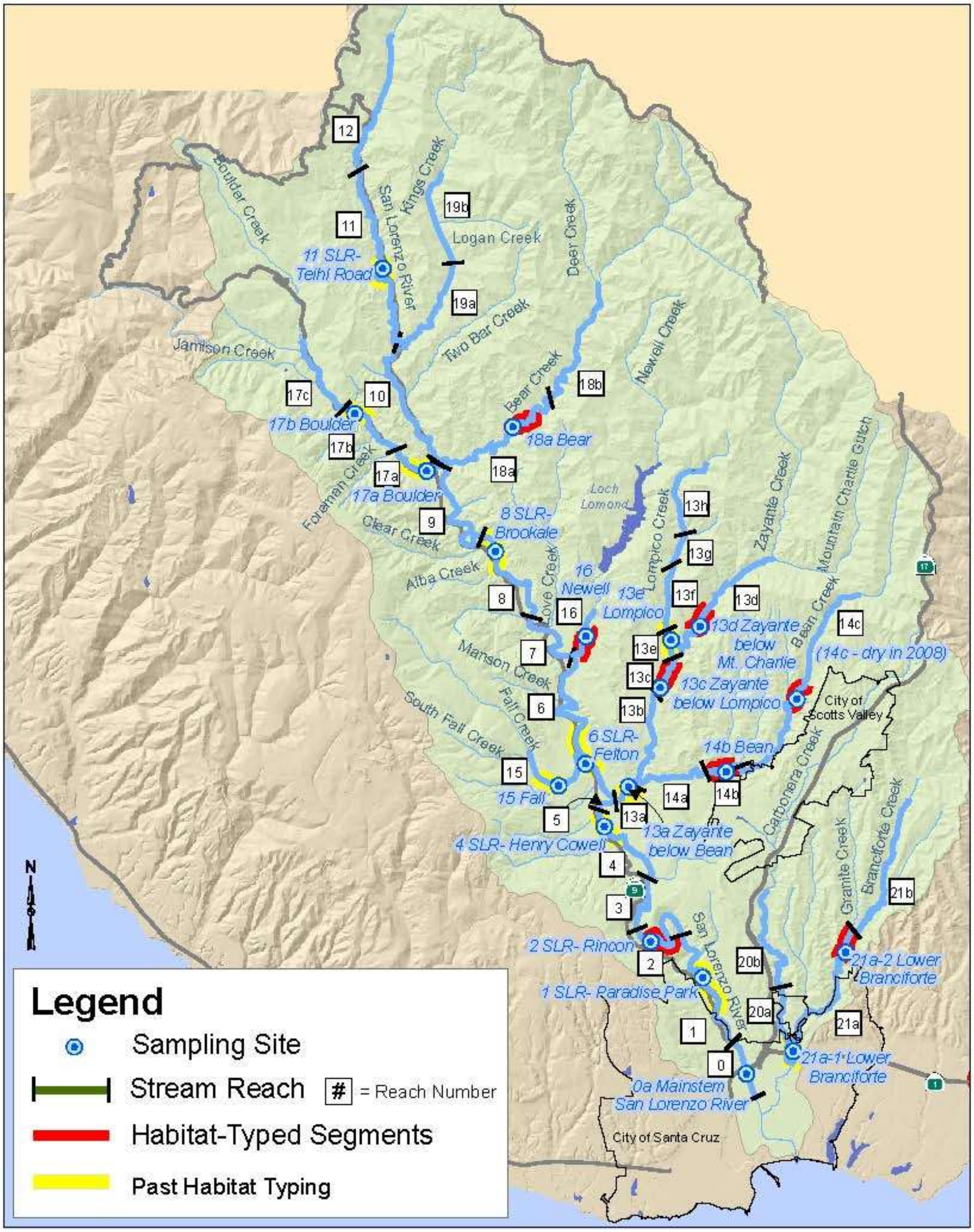
Aptos Creek. In the Aptos Creek watershed, 2 sites in Aptos Creek and 2 sites in Valencia Creek were sampled, and depth and cover measurements were made at all sampling sites.

Corralitos Creek. 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 1 associated half-mile reach segments habitat typed in lower Shingle Mill Reach 1. Depth and cover measurements were made at all sampling sites.

Methods

Refer to the Detailed Analysis Appendix B for more information. Section M-6 in Appendix B describes methods of assessing change in rearing habitat quality. Monitored watersheds included the San Lorenzo, Soquel, Aptos and Corralitos, a sub-watershed of the Pajaro River. Maps of sampling sites, habitat typed segments and reaches contained in **Appendix A** are provided below.

Prior to 2006 juvenile steelhead abundance was 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, estimated 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.



012-09 2011 Update

Figure A-2. San Lorenzo River Watershed.

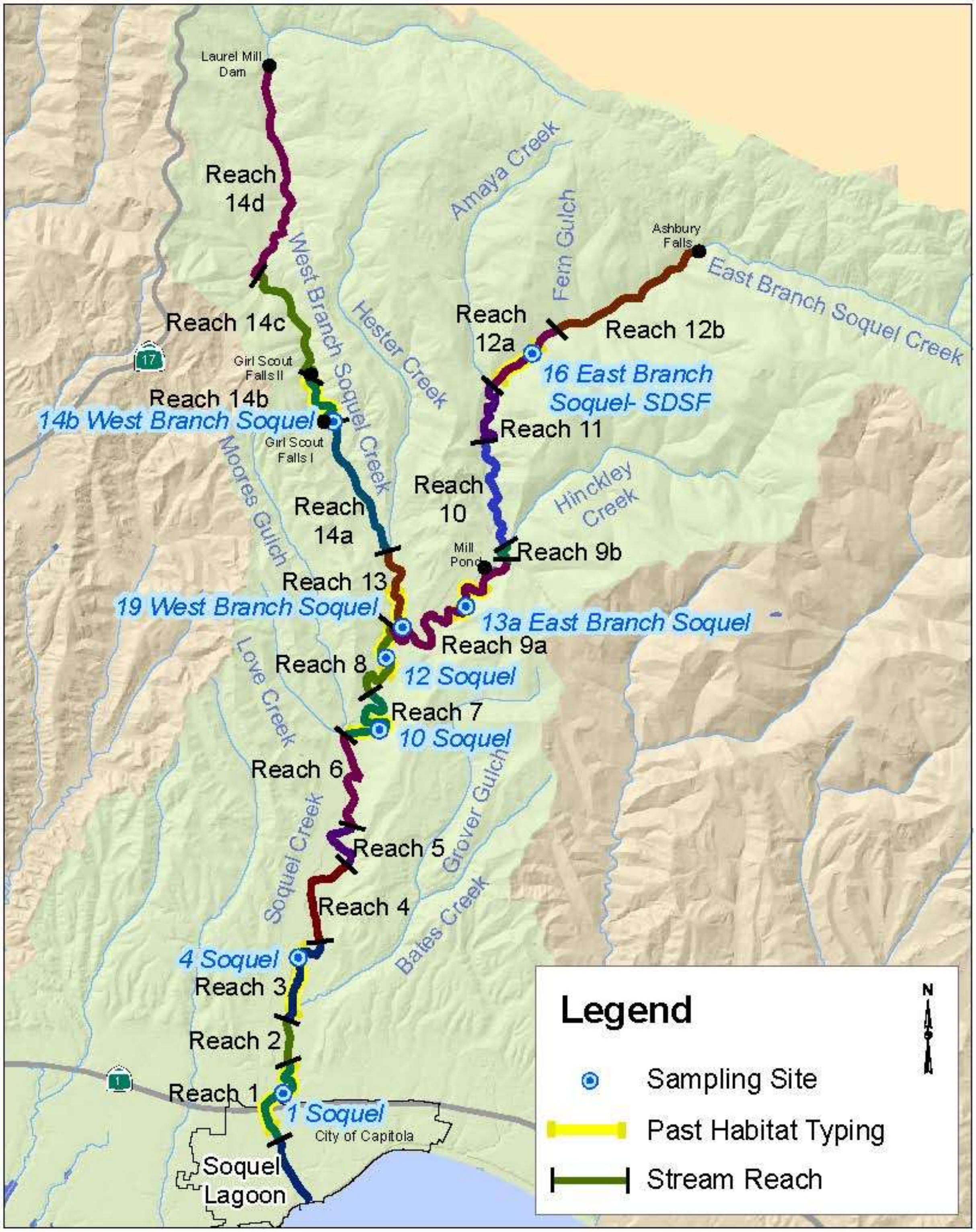


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Figure A-3. Soquel Creek Watershed.

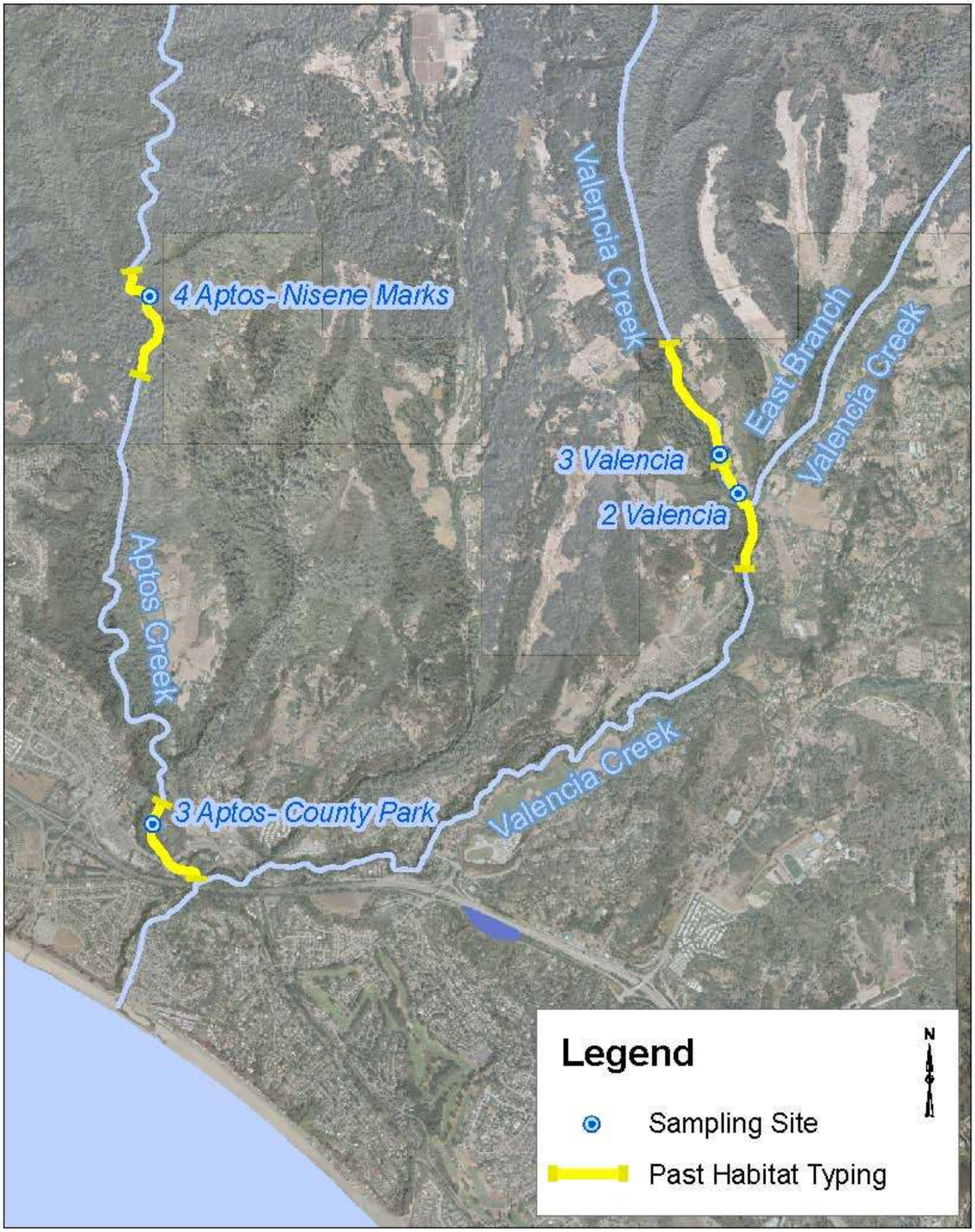

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Figure A-6. Aptos Creek Watershed.

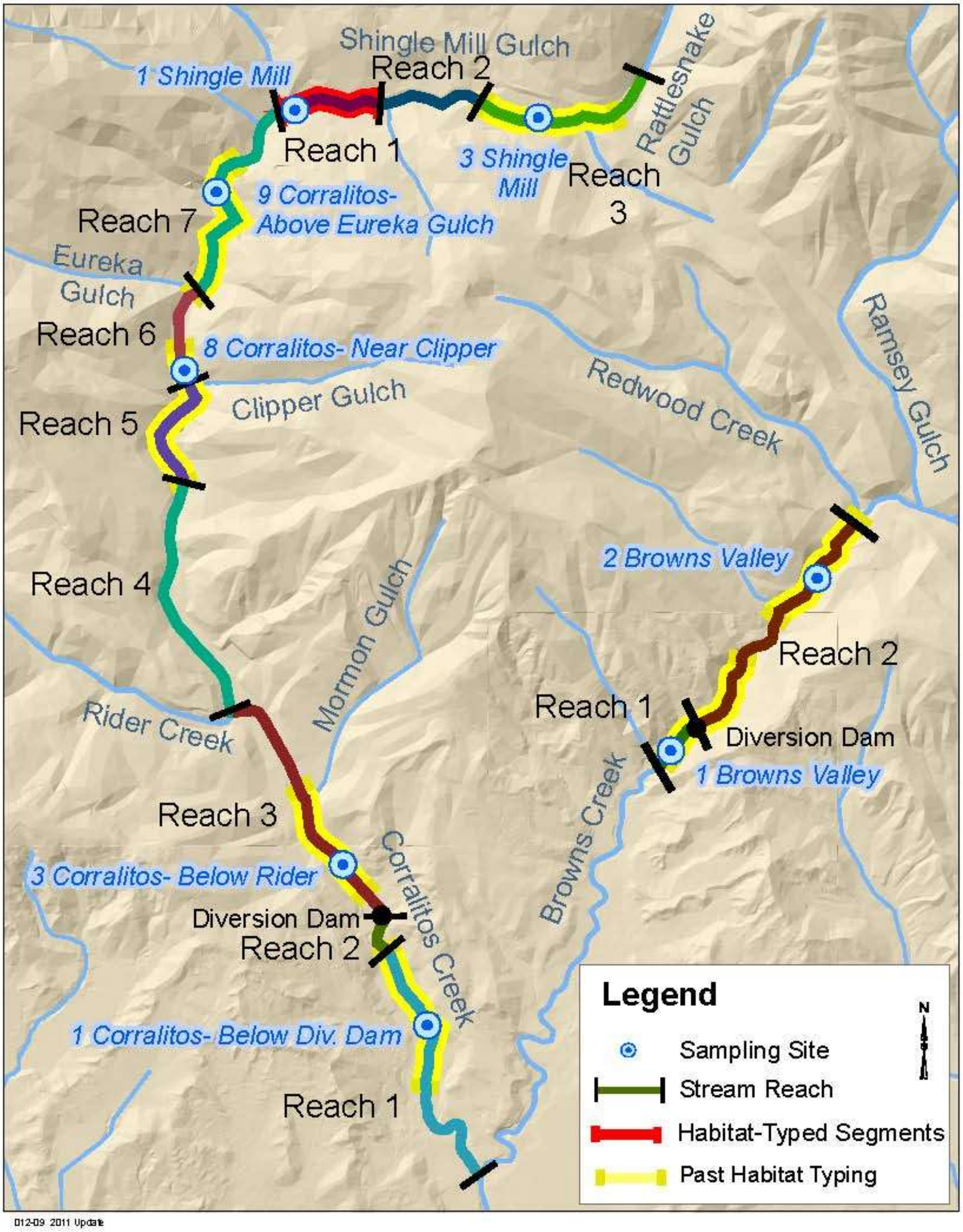


Figure A-7. Corralitos Creek Sub-Watershed.

Since 2006, fish abundance at sampling sites of average habitat quality in previously determined reach segments of 4 Santa Cruz County watersheds (San Lorenzo, Soquel, Aptos and Corralitos) have been compared to past years' abundances. Comparisons go back to 1997 in the San Lorenzo and Soquel watersheds, 2006 in the Aptos watershed and 1981 in the Corralitos sub-watershed, although consecutive years began in 2006. 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 entire reaches 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 reaches because sampling sites were more or less continuous and lengths of each habitat type were roughly similar to others within reaches. 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 in the 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 in **Appendix B** 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, substrate composition and tree canopy. Additional data were collected for escape cover, however, to better quantify it.

Electrofishing was used to measure steelhead abundance at sampling sites according to two juvenile age classes and three size classes. 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 in 3 passes, a fourth pass was performed, and the fish captured in 4 passes were assumed to be a total count 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 lower and middle mainstem reaches included in **Appendix C**, underwater censusing of deeper pools was incorporated into density estimates with electrofishing data from more shallow habitats.

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 fall 1978 in Uvas Creek after the drought of 1976-77 that had prevented adult access until winter of 1977-78 (**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 lower mainstem Soquel Creek (downstream of Moores Gulch). 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.

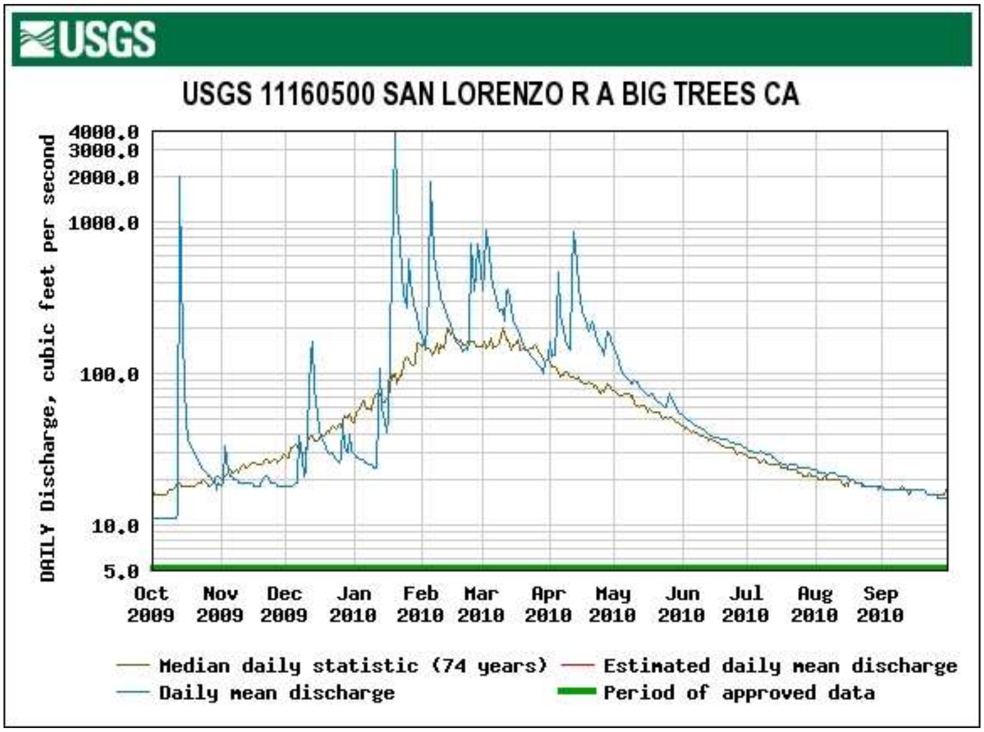
YOY emerge from the spawning gravels and spread (primarily downstream) throughout the watershed in spring and early summer. Since more adult steelhead spawning tends to occur in the upstream and tributary reaches of the watershed (barring passage difficulties), the highest initial YOY densities tend 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, the embeddedness of larger cobbles and boulders is reduced to provide more cracks and crevices for insects to use. Less sand and embeddedness provide better fish habitat with more escape cover for fish to hide under from predators and increased water depth around scour objects (more escape cover).

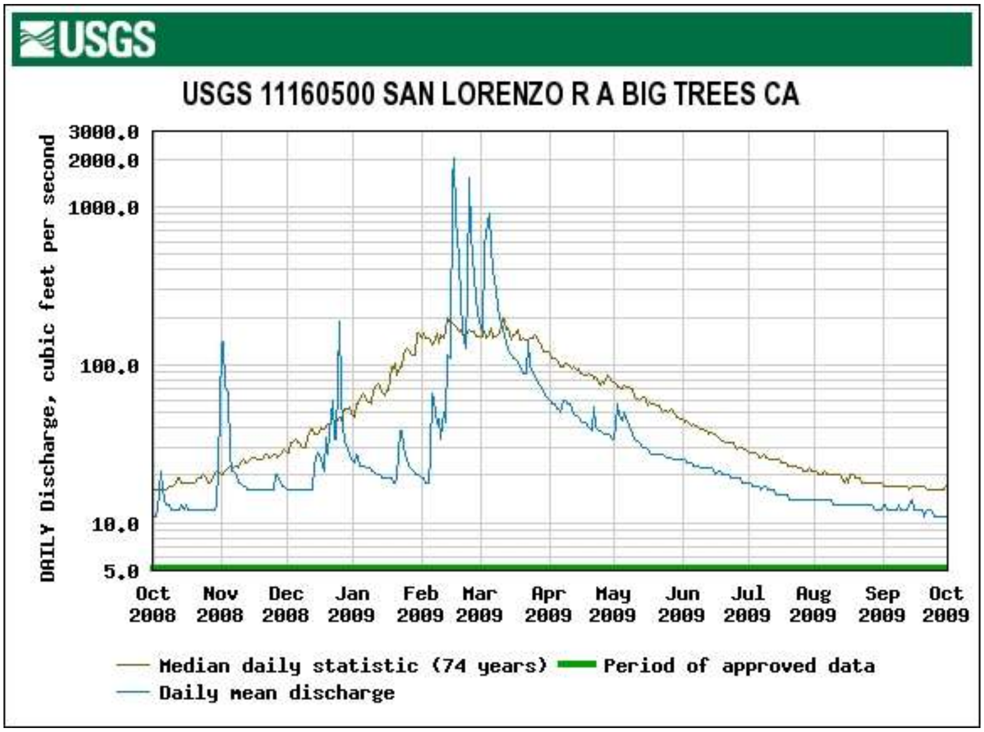
Growth of YOY steelhead and coho salmon appears to be regulated by available insect food (determined by substrate conditions in fastwater habitat and insect drift rate), although escape cover and water depth in pools, runs and riffles are also important in regulating juvenile numbers, especially for 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 (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. Study of steelhead growth in Soquel Creek has found that growth is higher in winter-spring compared to summer-fall (**Sogard et al. 2009**).

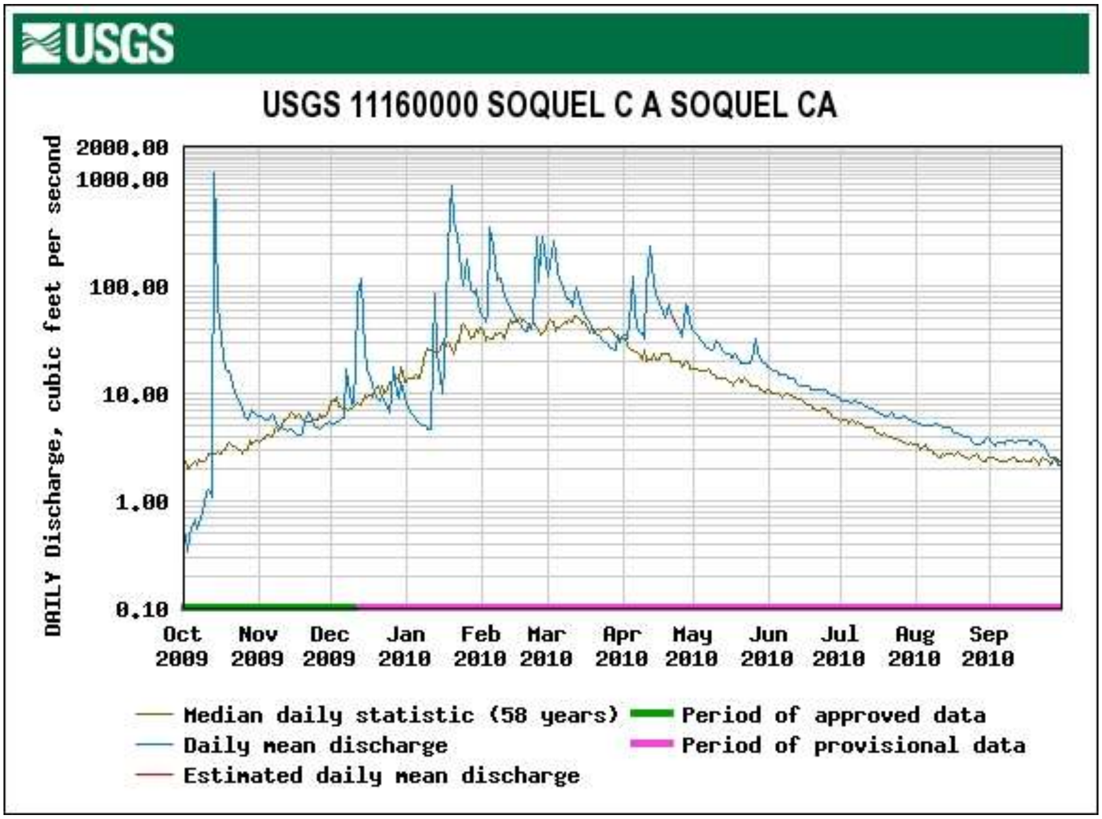
2010 Steelhead Abundance and Habitat Compared to 2009 and Long-term Averages

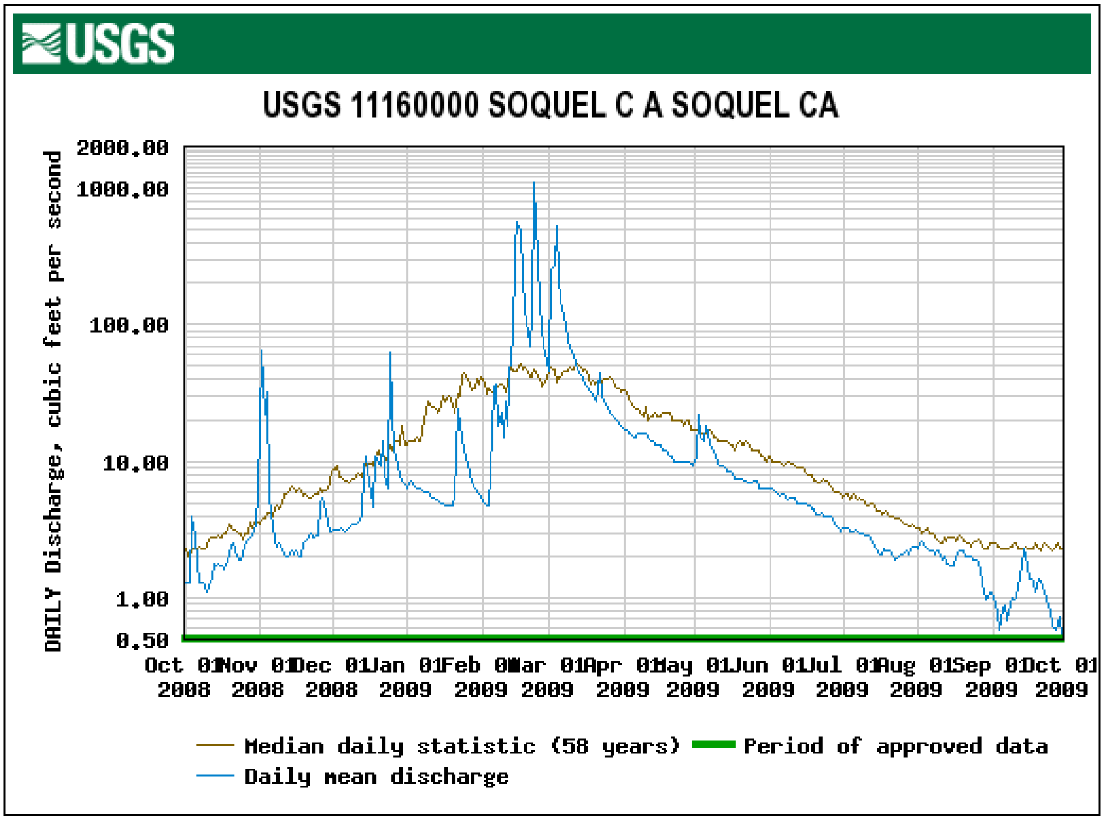
In All Watersheds (2010 compared to 2009):

1. WY2010 streamflows were considerably higher than in WY2009, with stormflows continuing late into April and much above median flows during the April-May growth period, followed by slightly above median baseflows through the dry season. This ended a 3-year dry period.






USGS
USGS 11160000 SOQUEL C A SOQUEL CA
DAILY Discharge, cubic feet per second
2000.00
1000.00
100.00
10.00
1.00
0.10
Oct 2009
Nov 2009
Dec 2009
Jan 2010
Feb 2010
Mar 2010
Apr 2010
May 2010
Jun 2010
Jul 2010
Aug 2010
Sep 2010
Median daily statistic (58 years)
Daily mean discharge
Estimated daily mean discharge
Period of approved data
Period of provisional data


USGS
USGS 11160000 SOQUEL C A SOQUEL CA
DAILY Discharge, cubic feet per second
2000.00
1000.00
100.00
10.00
1.00
0.50
Oct 01 2008
Nov 01 2008
Dec 01 2008
Jan 01 2009
Feb 01 2009
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)
Daily mean discharge
Period of approved data

2. Rearing habitat quality improved at most sites but declined at some upper tributary sites (Zayante 13d, Lompico 13e, Boulder 17b) and in the Corralitos-Shingle Mill creek complex. (Refer below to maps of reaches and sampling sites in the 4 watersheds.)

3. In comparing potential smolt-sized juvenile densities in fall and the average size of these large juveniles between the 4 watersheds, sites that made a 5 abundance rating were usually in the upper reaches, although lower mainstem San Lorenzo sites had a 5 abundance rating in 2010 with elevated YOY growth rate (**Tables S-1 and S-2 below**).

4. The lower San Lorenzo mainstem below Zayante Creek typically has sufficient baseflow every year to grow a high proportion of YOY to smolt size in one year, as does lower Soquel Creek below Moores Gulch. In these lower reaches with high growth potential, factors that determine YOY densities are important in determining smolt densities, such as spawning success and/or recruitment of YOY from nearby tributaries.

5. There is a group of sites with intermediate YOY growth potential which may produce a higher proportion of YOY that reach potential smolt size by fall in addition to yearlings if streamflow is high and/or YOY densities are low. 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 are relatively productive for potential smolt-sized YOY.

6. The high proportion of YOY reaching Size Class II in 2010, with low YOY densities and high spring baseflow, was responsible for a 5 potential smolt abundance rating in many sites throughout the 4 watersheds in addition to the lower mainstem San Lorenzo, those being Zayante 13c, Branciforte 21a-2, East Branch Soquel 13a, West Branch 21, Aptos 3, Corralitos 9, Browns 1 and Browns 2 (**Figures B-17 through B-20** below).

7. After a winter with multiple stormflows in WY2010, yearling densities were generally less and below average, though similarly low in the Soquel mainstem between years.

8. 2010 abundance of young-of-the-year (YOY) was generally greater in all watersheds except Corralitos, but still below average at most sites except in the San Lorenzo mainstem, with growth rate of YOY greater and more YOY reaching Size Class II to create higher abundance of these larger juveniles at above average levels in about half of the sites except in Corralitos.

9. Below average YOY abundance was likely caused by continued low numbers of adult spawners, high redd (nest) destruction from late spring storms and reduced YOY survival in spring during stormflows. (Continued low adult numbers in 2010 were counted at San Clemente Dam on the Carmel River and estimated on Scott Creek.)

10. The highest YOY densities at upper sites indicated that most spawning effort and/or spawning success was furthest upstream, except in Aptos Creek. However, there were likely insufficient YOY produced at upstream locations to filter downstream to seed most lower reaches.

Table S-1. Rating of Steelhead Rearing Habitat For Small, Central Coastal Streams.*
(From Smith 1982.)

1.Very Poor- less than 2 potential smolt-sized fish per 100 ft of stream.**

2.Poor* - from 2 to 4 " " "**

3.Below Average - 4 to 8 " " "

4.Fair - 8 to 16 " " "

5.Good - 16 to 32 " " "

6.Very Good - 32 to 64 " " "

7.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.

** Potential 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.

***The average standard length for potential 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.

Table S-2. 2010 Sampling Sites Rated by Potential Smolt-Sized Juvenile Density (=>75 mm SL) and Average Smolt Size, with Physical Habitat Change since 2010. (Red denotes ratings of 1 and 2 or negative habitat change; purple denotes ratings of 5 and 6. Methods for habitat change in M-6 of Appendix B).

Site	Multi-Year Avg. Potential Smolt Density Per 100 ft (Years of data)	2010 Potential Smolt Density (per 100 ft)/ Avg Smolt Size (mm)	2010 Smolt Rating	Numerical Rating (1 to 7)	Physical Habitat Change by Reach Since 2009
Low. San Lorenzo #0a	**9.2 (n=3)**	**19.8/ 106 mm**	**6**	******	Site Positive
Low. San Lorenzo #1	11.0 (n=10)	15.3/ 98 mm	4	****	Site Positive
Low. San Lorenzo #2	**17.7 (n=9)**	**22.4/ 91 mm**	**5**	*****	Reach Positive
Low. San Lorenzo #4	17.2 (n=10)	12.6/ 87 mm	3	***	Site Positive
Mid. San Lorenzo #6	**4.5 (n=13)**	**6.1/ 80 mm**	**2**	**	Site Positive
Mid. San Lorenzo #8	7.0 (n=13)	8.2/ 88 mm	3	***	Site Positive
Up. San Lorenzo #11	6.7 (n=13)	4.7/ 93 mm	3	***	Site Positive
Zayante #13a	11.3 (n=12)	18.8/ 89 mm	4	****	Site Positive
Zayante #13c	**11.9 (n=12)**	**24.5/ 90 mm**	**5**	*****	–
Zayante #13d	**17.4 (n=12)**	**9.1/ 101 mm**	4	****	**Site Negative**
Lompico #13e	7.4 (n=5)	8.7/ 96 mm	4	****	Site Positive
Bean #14b	13.3 (n=13)	8.4/ 87 mm	3	***	Site Positive
Bean #14c	12.4 (n=10)	6.7/ 99 mm	3	***	–
Fall #15	**14.6 (n=8)**	**14.3/ 118 mm**	**5**	*****	Site Positive
Newell #16	13.8 (n=7)	24.7/ 86 mm	4	****	Site Positive
Boulder #17a	11.5 (n=13)	11.8/ 89 mm	4	****	Site Similar
Boulder #17b	10.5 (n=13)	12.7/ 90 mm	4	****	**Site Negative**
Bear #18a	11.2 (n=13)	9.5/ 99 mm	4	****	–
Branciforte #21a-2	**6.9 (n=10)**	**12.6/ 105 mm**	**5**	*****	Reach Similar
Soquel #1	4.2 (n=13)	7.9/ 108 mm	4	****	Site Positive
Soquel #4	9.7 (n=14)	4.9/ 98 mm	3	***	Site Positive
Soquel #10	9.1 (n=14)	14.0/ 96 mm	4	****	Site Positive
Soquel #12	8.3 (n=13)	8.0/ 88 mm	3	***	Site Positive
E. Branch Soquel #13a	**10.9 (n=14)**	**32.8/ 88 mm**	**5**	*****	Site Positive
E. Branch Soquel #16	**10.1 (n=14)**	**8.0/ 106 mm**	**5**	*****	Site Positive
W. Branch Soquel #19	5.8 (n=10)	11.6/ 93 mm	4	****	Site Positive
W. Branch Soquel #21	**10.9 (n=9)**	**17.5/ 99 mm**	**5**	*****	Site Positive
Aptos #3	**11.5 (n=6)**	**17.2/ 90 mm**	**5**	*****	Site Positive
Aptos #4	9.5 (n=6)	9.7/ 96 mm	4	****	Site Positive
Valencia #2	11.7 (n=6)	8.7/ 100 mm	4	****	Site Positive
Valencia #3	**14.1 (n=6)**	**14.8/ 105 mm**	**5**	*****	Site Positive
Corralitos #1	10.1 (n=4)	8.7/ 99 mm	4	****	**Site Negative**
Corralitos #3	**9.6 (n=7)**	5.5/ 116 mm	4	****	**Site Negative**
Corralitos #8	**12.9 (n=7)**	6.0/ 90 mm	3	***	**Site Negative**
Corralitos #9	**20.0 (n=7)**	**11.2/ 104 mm**	**5**	*****	**Site Negative**
Shingle Mill #1	11.8 (n=7)	6.3/ 104 mm	4	****	–
Shingle Mill #3	4.7 (n=7)	6.1/ 99 mm	3	***	**Site Negative**
Browns Valley #1	**15.9 (n=7)**	**10.1/ 103 mm**	**5**	*****	Site Positive
Browns Valley #2	**13.2 (n=7)**	**9.4/ 104 mm**	**5**	*****	Site Positive

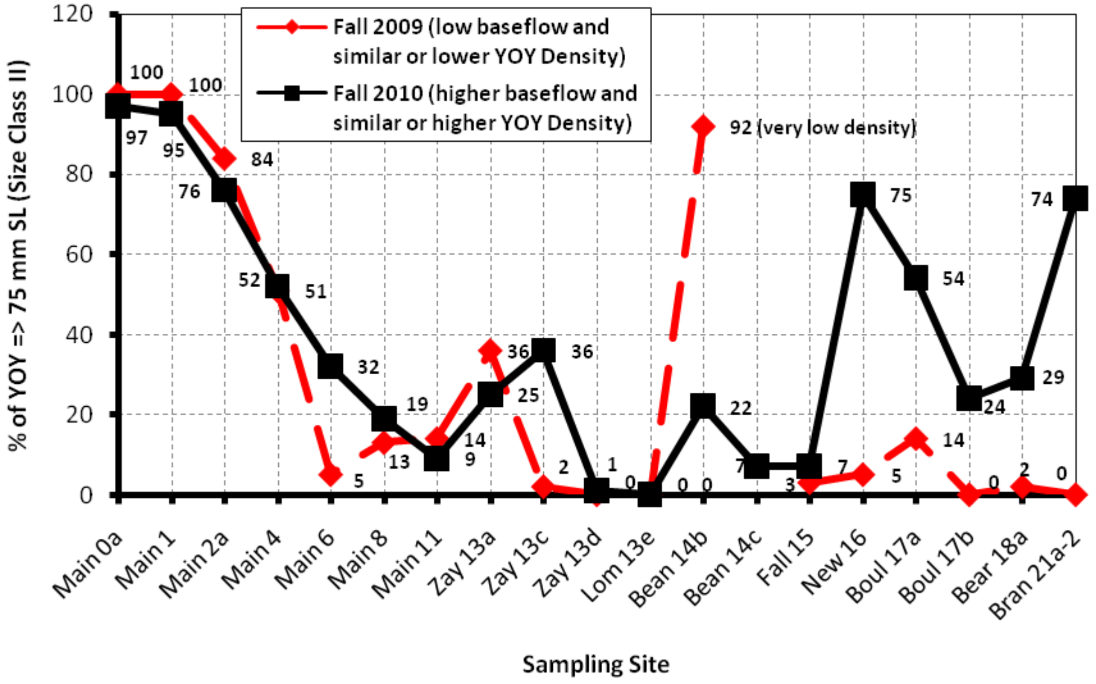


Figure 17. Percent of Young-of-the-Year Steelhead in Size Class II (=>75 mm SL) at San Lorenzo River Sites in 2009 and 2010.

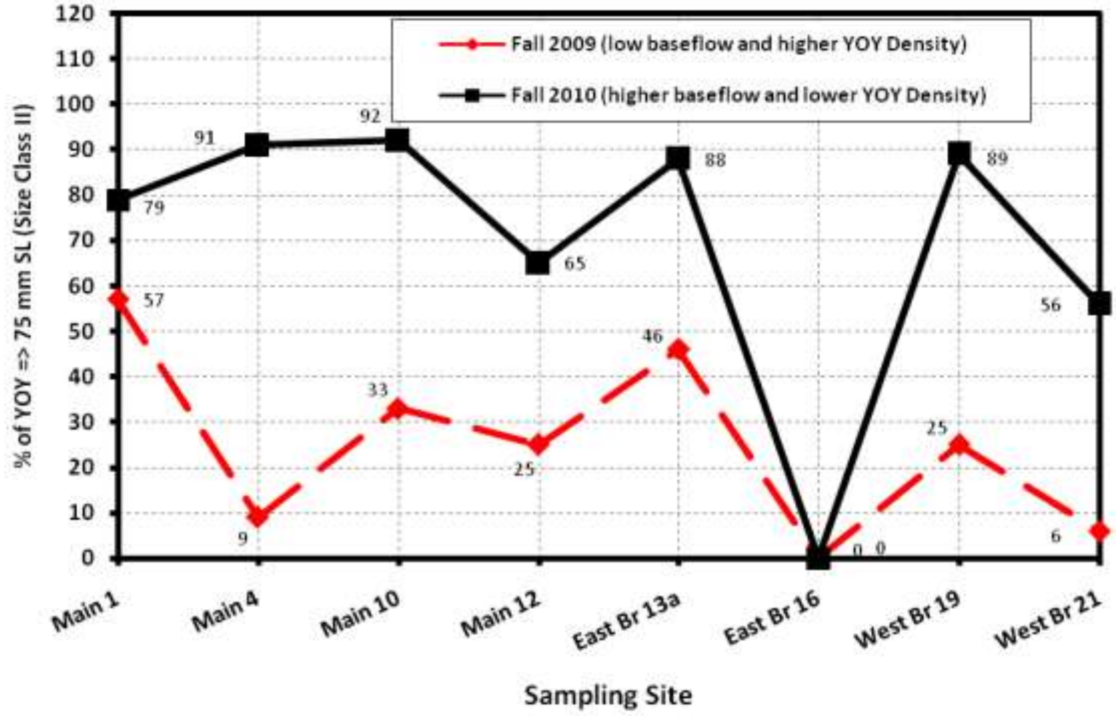


Figure 18. Percent of Young-of-the-Year Steelhead in Size Class II (=>75 mm SL) at Soquel Creek Sites in 2009 and 2010.

Figure 19. Percent of Young-of-the-Year Steelhead in Size Class II (=>75 mm SL) at Aptos and Valencia Creek Sites in 2009 and 2010.

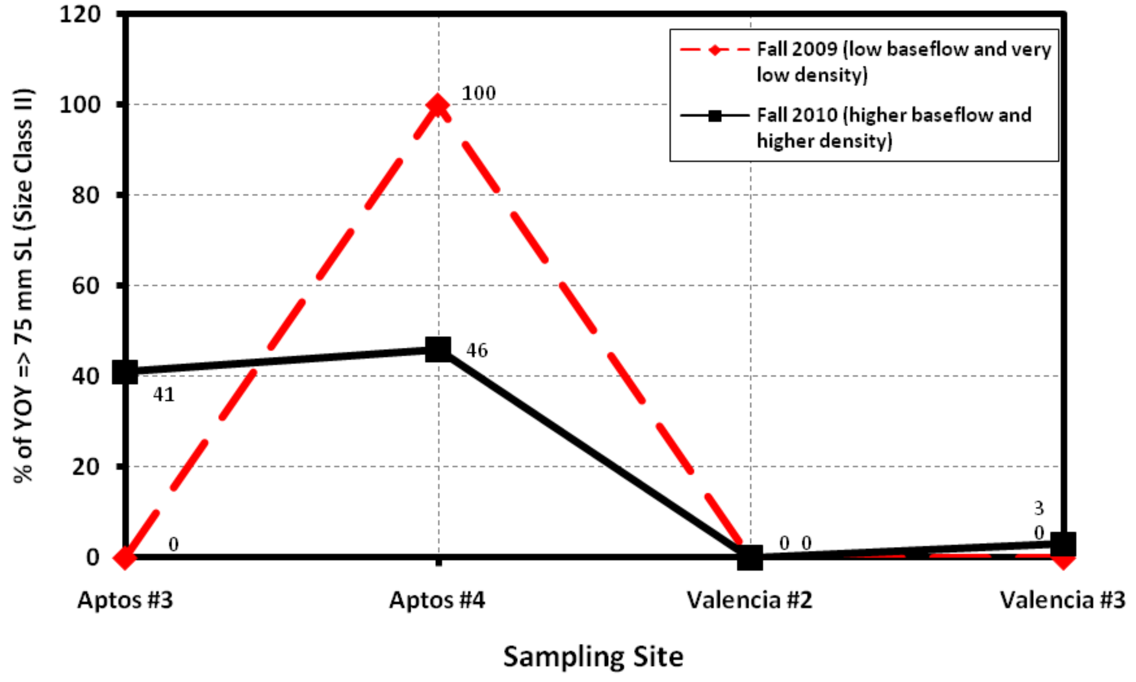
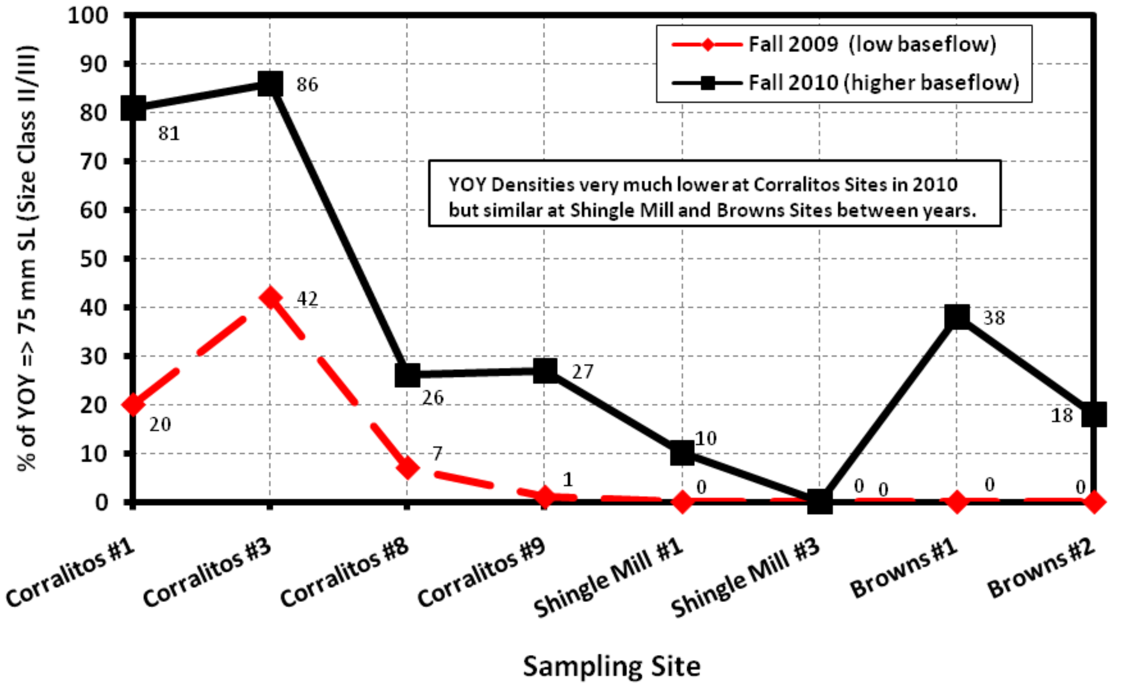


Figure 20. Percent of Young-of-the-Year Steelhead in Size Class II (=>75 mm SL) at Corralitos Watershed Sites in 2009 and 2010.



YOY Densities very much lower at Corralitos Sites in 2010 but similar at Shingle Mill and Browns Sites between years.

In the San Lorenzo River Watershed (2010 compared to 2009 and Average Densities):

1. Stream water temperature was likely 2−3°F (1−1.5 °C) cooler at most sites in the 4 watersheds and appeared to diminish the faster YOY growth rate that would have been expected from higher 2010 baseflow (May−September daily average of 37 cfs compared to 19 cfs in 2009 at nearby Big Trees Gage) at the sunny San Lorenzo mainstem Site 4 (similar Size Class II densities and fish lengths both years) (**Appendix B Figures 52, 59−60, 63−66** below and **Table S-3** below). Temperature data were provided by the City of Santa Cruz Water Department for Figures 63-66 (**Holloway 2011**). Growth rate may have been slowed by cooler temperatures in other typically warmer, lower reaches of watersheds.

Figure 52. Averaged Mean Monthly Streamflow for May – September in the San Lorenzo and Soquel Watersheds, 1997-2010.

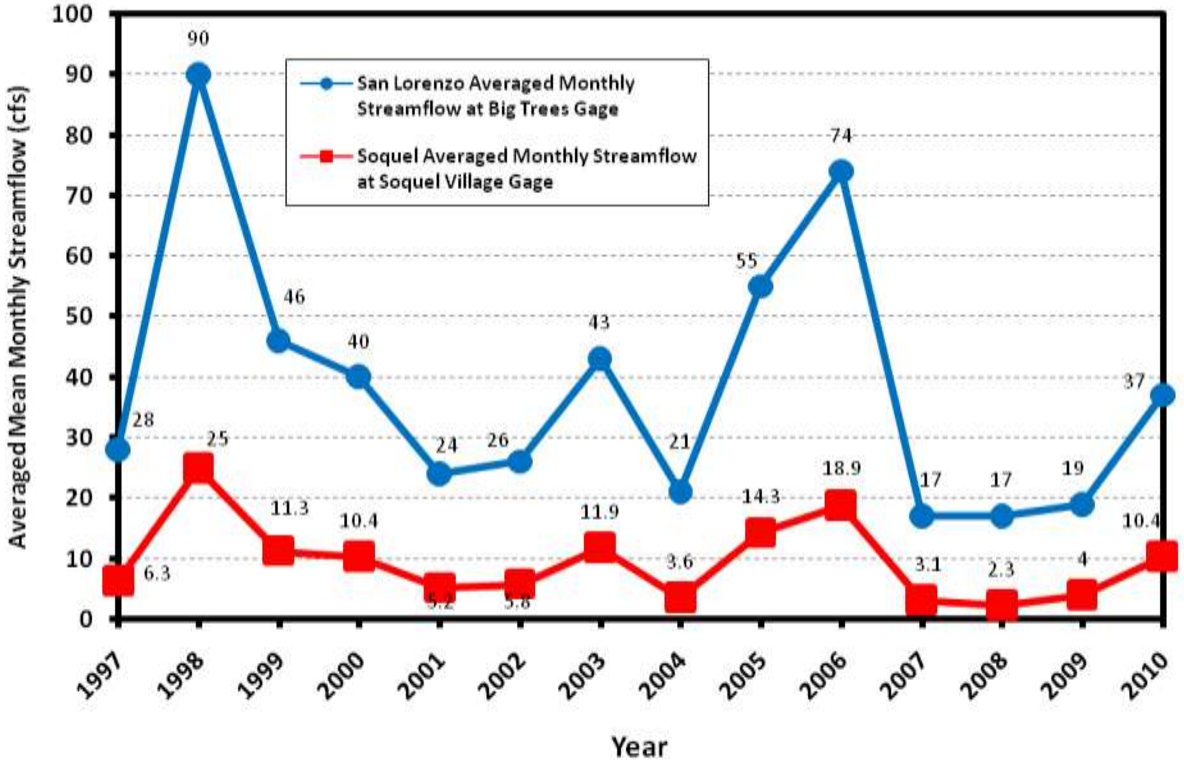


Figure 59. Water Temperature (*F) Above the Lagoon (Nob Hill) in Soquel Creek, 25 May - 4 October 2009 (30-minute interval).

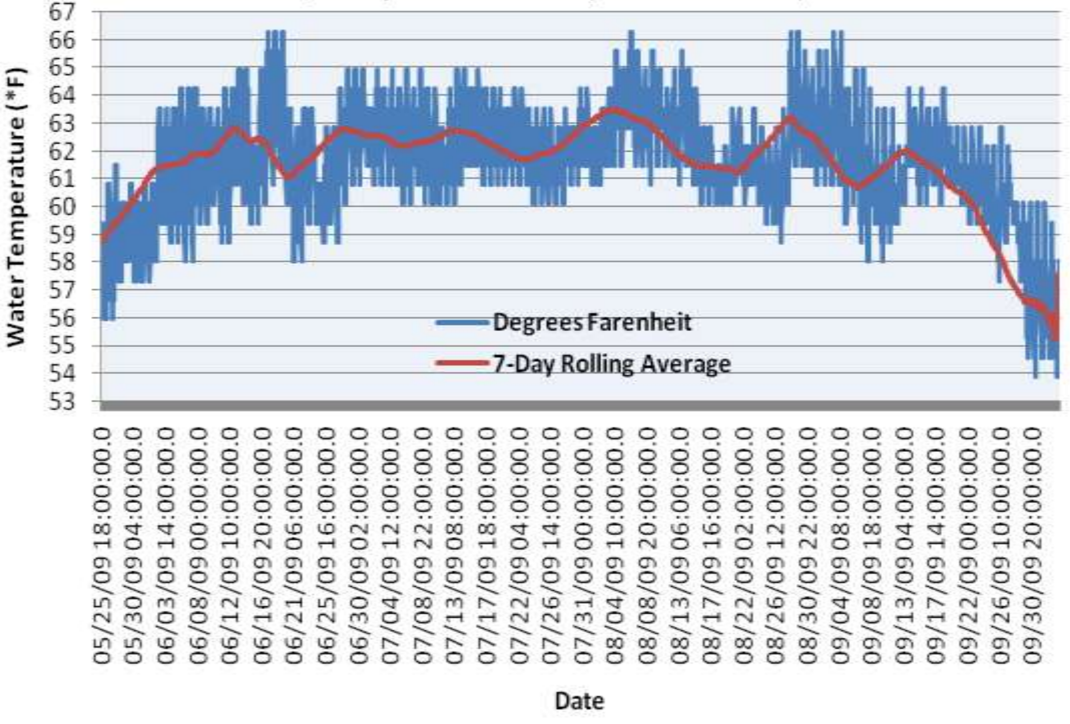


Figure 60. Water Temperature (*F) Above the Lagoon (Nob Hill) in Soquel Creek, 4 June - 9 October 2010 (30-minute interval).

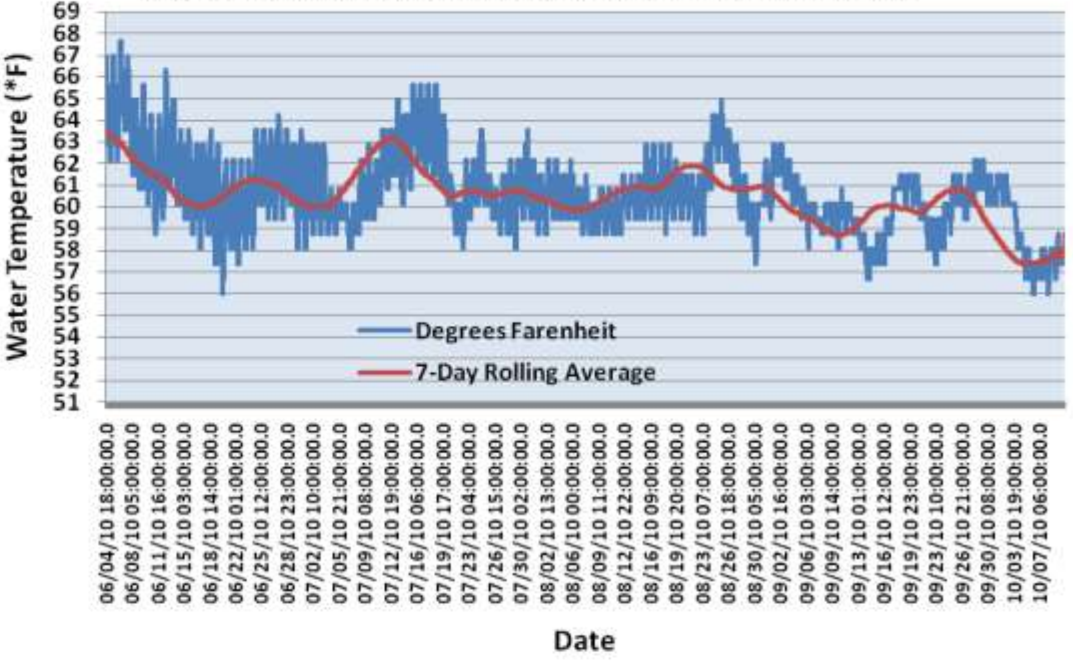


Figure 63. 2009 Water Temperature in Upper Bean Creek at 30-minute Intervals with the 7-day Rolling Average, 5 August- 18 October.

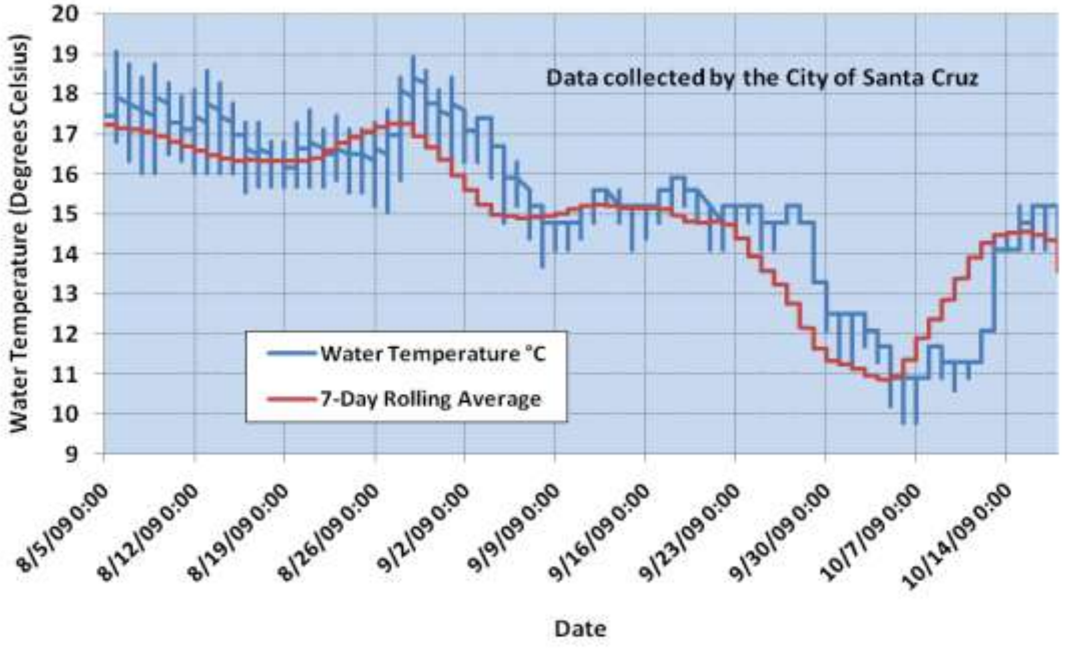
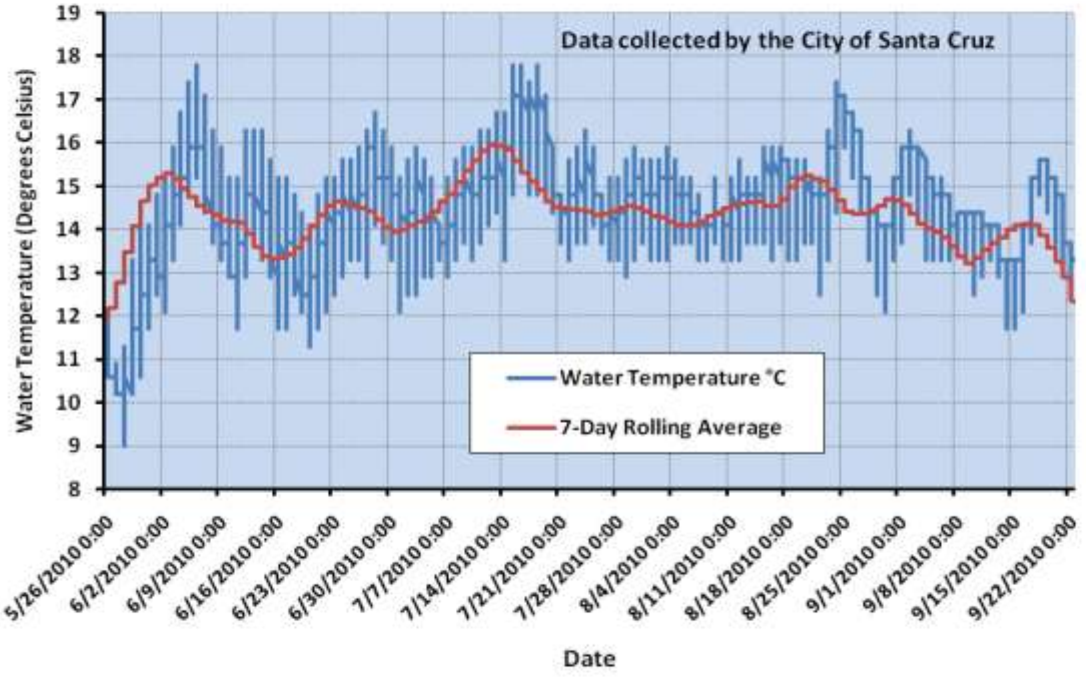


Figure 64. 2010 Water Temperature in Upper Bean Creek at 30-minute Intervals with the 7-day Rolling Average, 26 May- 22 September.



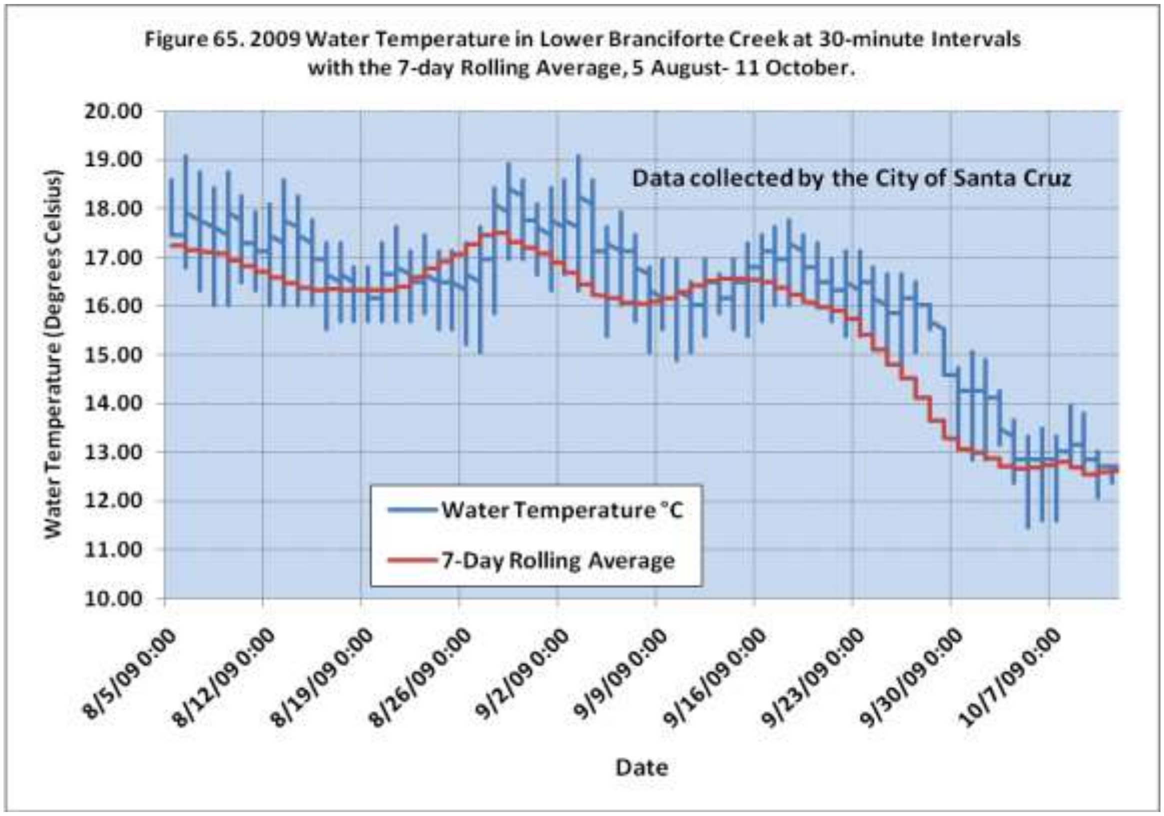


Figure 65. 2009 Water Temperature in Lower Branciforte Creek at 30-minute Intervals
with the 7-day Rolling Average, 5 August- 11 October.
20.00
19.00
18.00
17.00
16.00
15.00
14.00
13.00
12.00
11.00
10.00
Water Temperature (Degrees Celsius)
Data collected by the City of Santa Cruz
Water Temperature °C
7-Day Rolling Average
8/5/09 0:00
8/12/09 0:00
8/19/09 0:00
8/26/09 0:00
9/2/09 0:00
9/9/09 0:00
9/16/09 0:00
9/23/09 0:00
9/30/09 0:00
10/7/09 0:00
Date

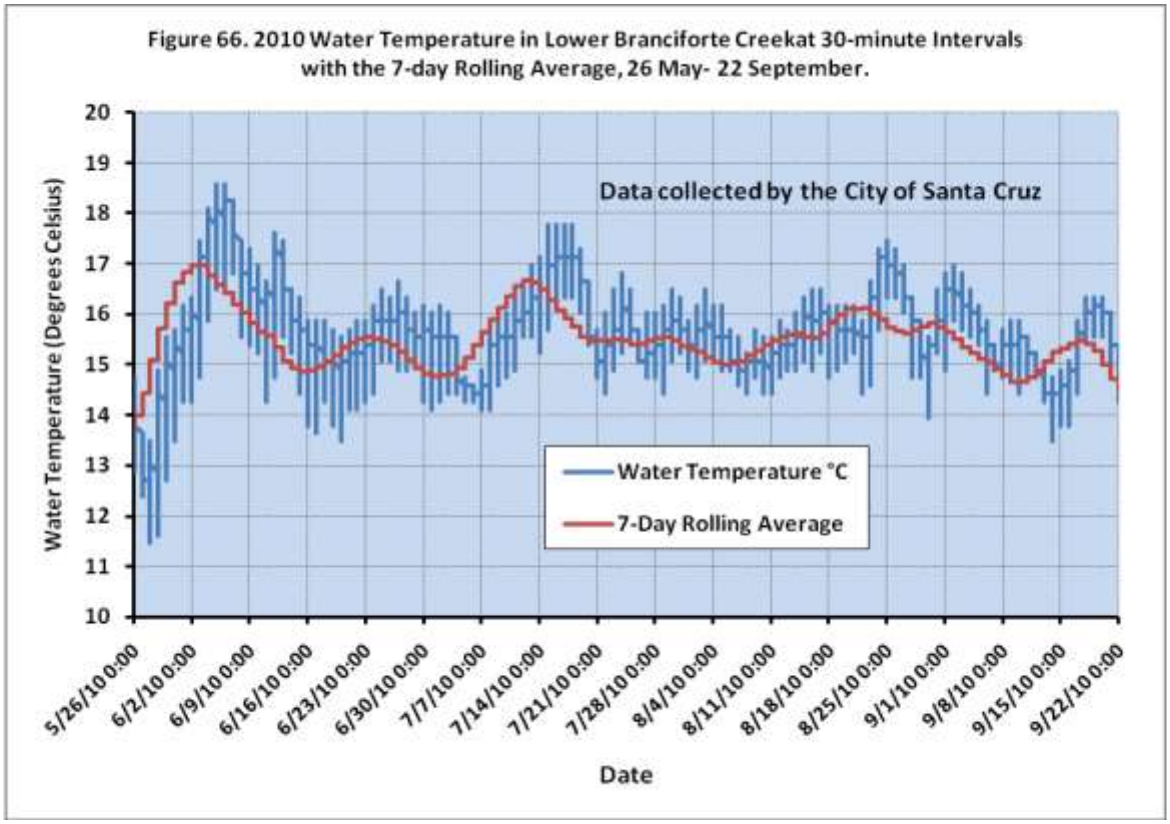


Figure 66. 2010 Water Temperature in Lower Branciforte Creekat 30-minute Intervals
with the 7-day Rolling Average, 26 May- 22 September.
20
19
18
17
16
15
14
13
12
11
10
Water Temperature (Degrees Celsius)
Data collected by the City of Santa Cruz
Water Temperature °C
7-Day Rolling Average
5/26/10 0:00
6/2/10 0:00
6/9/10 0:00
6/16/10 0:00
6/23/10 0:00
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7/14/10 0:00
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8/4/10 0:00
8/11/10 0:00
8/18/10 0:00
8/25/10 0:00
9/1/10 0:00
9/8/10 0:00
9/15/10 0:00
9/22/10 0:00
Date

2. ***In the lower and middle mainstem***, overall habitat quality improved at most replicated sampling sites primarily due to increased baseflow, deeper fastwater habitat and more escape cover in fastwater habitat compared to 2009 (**Table S-3** below).

3. ***All tributary reaches*** likely had better habitat quality in spring 2010 due to much higher baseflows for fish growth (**Hydrographs** above), as indicated by the percent of YOY reaching Size Class II in the first growing season (**Figure B-17** above**;** *size histograms in **Appendix D***).

4. ***In San Lorenzo River tributaries***, of the 4 reaches with segments habitat typed, Newell 15 had improved habitat quality in fall 2010 (deeper, less sediment, similar embeddedness, similar escape cover, higher percent of YOY reaching Size Class II) (***Tables 6a, 7, 8, 12a and 13** in Appendix B***;** **Figure B-17** above). Zayante 13d had reduced habitat quality (deeper primarily because shallow pools in 2009 were typed as runs in 2010, similar sediment but more embedded and half as much escape cover) (***Figures 46-49** in Appendix B*). Bean 14b had similar habitat quality (similar depth, similar embeddedness, less fines in pools, slightly more escape cover), as did lower Branciforte 21a-2 (similar depth, similar sediment and embeddedness except more in runs, similar escape cover).

5. ***In San Lorenzo tributaries where only sampling sites were evaluated,*** Zayante Site 13a improved (higher baseflow, deeper pools, slightly less pool cover) (***Tables 6b and 12b** in Appendix B*). Fall Site 15 improved (deeper pools, more pool escape cover). Lompico Site 13e declined (shallower pools, less escape cover). Fall conditions in Boulder Site 17a remained similar (similar depth, similar pool escape cover), and Boulder Site 17b declined (similar depth, much less pool escape cover). However, spring growth conditions were better as indicated by a much higher percentage of YOY reaching Size Class II in 2010 with higher densities at Boulder 17a and similar densities at Boulder 17b (***Table 22** in Appendix B***; Figure B-17** above).

6. ***Densities of important larger Size Class II and III steelhead*** (=>75 mm SL; potential smolt) ***at mainstem sites*** were near average and more abundant at all sites than in 2009 (statistically significant) (***Table 21 and Figure 23** in Appendix B***; Figure B-4** below).

7. ***Size Class II and III abundance in tributaries*** was below average at 4 of 12 sites, but close to average at 5 of 12 sites and much above average at 3 sites (Zayante 13a, Zayante 13c and Newell 16) (**Figure B-4** below). This was in a year with low YOY recruitment to yearlings from low 2009 YOY abundance. Sites which were near average or above were so because sizeable numbers of YOY reached Size Class II with the high spring baseflow and generally low YOY densities that resulted in less competition for food.

8. Eight of 10 tributary sites had higher Size Class II and III abundance than in 2009 (statistically significant), with sizeable increases that were much above average at Zayante 13a and 13c, and

Newell 16 (***Table 25*** *and* ***Figure 26*** *in Appendix B*). Higher abundance was consistent with higher spring baseflow, faster YOY growth rate (**Figure B-17** above) and similar or improved habitat at 6 of 9 comparable sites. There was half the 2009 density at Zayante 13d and much below average. This decline was consistent with reduced habitat quality, likely reduced overwinter survival of yearlings and the site's inability to grow YOY to Size Class II in one growing season.

9. Newell 16 (24.7/ 100 ft) and Zayante 13c (24.5/ 100 ft) had the highest Size Class II and III density, followed closely by San Lorenzo 2 (22.4/ 100 ft), San Lorenzo 0a (19.8/ 100 ft) and Zayante 13a (18.8/ 100 ft). All of these sites had in common a high percent of YOY reaching Size Class II (**Figure B-17** above).

10. ***Yearling densities at mainstem sites*** were similarly low in 2010 as they have been since 2000 and were slightly below average (**Figure B-3** below), consistent with much below average YOY densities in 2009. This may also be partially explained by early smolting of 2009 YOY able to grow well in the high baseflow of spring 2010 and overwinter mortality during a wetter winter.

11. ***Yearling densities at tributary sites*** were generally less than in 2009 and much below average at most sites except Lompico 13e and Fall 15 (**Figure B-3** below). This may be partially explained by low recruitment from poor 2009 YOY abundance and reduced overwinter survival.

12. ***YOY abundance at most mainstem sites*** was greater than in 2009 (statistically significant) (***Table 23*** *and* ***Figure 22*** *in Appendix B*), above average at 3 of 4 lower mainstem sites and near average at the 2 middle mainstem sites (**Figure B-2** below). Increased abundance was consistent with improved spring and summer rearing conditions.

13. ***YOY abundance at tributary sites*** was generally similar or greater than in 2009 (***Table 23*** *and* ***Figure 25*** *in Appendix B*) but still much below average at most sites (**Figure B-2** below). The highest YOY densities were at the 3 Zayante Creek sites (58 to 83/ 100 ft). The continued below average YOY densities were consistent with likely fewer adult spawners and poor egg survival with the late spring storms and more frequent stormflows throughout the winter.

14. There were insufficient YOY produced in the mainstem and tributaries to fully seed the mainstem with YOY in 2010, based on much higher densities detected at some mainstem sites in 1997—1999 and 2008 (***Table 18*** *and* ***Figure 22*** *in Appendix B*).

Table S-3. 2010 Sampling Sites Rated by Potential Smolt-Sized Juvenile Density (=>75 mm SL) and Their Average Size in Standard Length, with Physical Habitat Change from 2009 Conditions. (Red denotes ratings of 1−3 and negative habitat change and purple denotes ratings of 5−7. Methods for habitat change in M-6 of Appendix B.**)**

Site	2010 Potential Smolt Density (per 100 ft)/ Avg Smolt Size SL (mm)	2010 Smolt Rating (With Size Factored In)	2009 Potential Smolt Density (per 100 ft)/ Avg Smolt Size SL (mm)	2009 Smolt Rating (With Size Factored In)	Physical Habitat Change by Reach/Site Since 2009
Low. San Lorenzo #0a	19.8/ 106 mm	6	2.4/ 124 mm	3	+
Low. San Lorenzo #1	15.3/ 98 mm	4	3.4/125 mm	3	+
Low. San Lorenzo #2	22.4/ 91 mm	5	8.0/105 mm	6	+
Low. San Lorenzo #4	12.6/ 87 mm	3	13.9/85 mm	3	+
Mid. San Lorenzo #6	6.1/ 80 mm	2	0.5/ 76 mm	1	+
Mid. San Lorenzo #8	8.2/ 88 mm	3	3.5/ 95 mm	2	+
Up. San Lorenzo #11	4.7/ 93 mm	3	3.1/ 99 mm	2	+
Zayante #13a	18.8/ 89 mm	4	12.1/ 85 mm	3	+
Zayante #13c	24.5/ 90 mm	5	10.4/ 91 mm	4	NA
Zayante #13d	9.1/ 101 mm	4	16.9/ 97 mm	5	–
Lompico #13e	8.7/ 96 mm	4	4.9/ 92 mm	3	–
Bean #14b	8.4/ 87 mm	3	10.9/ 101 mm	4	=
Bean #14c	6.7/ 99 mm	3	–	–	NA
Fall #15	14.3/ 118 mm	5	18.7/ 111 mm	6	+
Newell #16	24.7/ 86 mm	4	4.4/94 mm	3	+
Boulder #17a	11.8/ 89 mm	4	5.5/ 98 mm	3	=
Boulder #17b	12.7/ 90 mm	4	10.7/ 96 mm	4	–
Bear #18a	9.5/ 99 mm	4	2.5/ 88 mm	1	NA
Branciforte #21a-2	12.6/ 105 mm	5	7.5/ 117 mm	4	=
Soquel #1	7.9/ 108 mm	4	5.1/ 93 mm	3	+
Soquel #4	4.9/ 98 mm	3	8.1/ 96 mm	4	+
Soquel #10	14.0/ 96 mm	4	6.2/ 80 mm	2	+
Soquel #12	8.0/ 88 mm	3	11.9/ 86 mm	3	+
East Branch Soquel #13a	32.8/ 88 mm	5	11.2/ 88 mm	3	+
East Branch Soquel #16	8.0/ 106 mm	5	13.1/ 98 mm	4	+
West Branch Soquel #19	11.6/ 93 mm	4	14.1/ 92 mm	4	+
West Branch Soquel #21	17.5/ 99 mm	5	6.8/ 97 mm	3	+
Aptos #3	17.2/ 90 mm	5	5.2/ 120 mm	4	+
Aptos #4	9.7/ 96 mm	4	8.0/ 99 mm	4	+
Valencia #2	8.7/ 100 mm	4	13.8/ 94 mm	4	+
Valencia #3	14.8/ 105 mm	5	18.5/ 95 mm	5	+
Corralitos #1	8.7/ 99 mm	4	13.7/ 96 mm	4	–
Corralitos #3	5.5/ 116 mm	4	9.3/ 112 mm	5	–
Corralitos #8	6.0/ 90 mm	3	15.3/ 105 mm	5	–
Corralitos #9	11.2/ 104 mm	5	19.7/ 102 mm	5	–
Shingle Mill #1	6.3/ 104 mm	4	6.7/ 103 mm	4	NA
Shingle Mill #3	6.1/ 99 mm	3	7.2/ 85 mm	2	–
Browns #1	10.1/ 103 mm	5	12.9/ 98 mm	4	+
Browns #2	9.4/ 104 mm	5	11.9/ 98 mm	4	+

Figure 4. Size Class II and III Steelhead Site Densities in the San Lorenzo River in 2010 Compared to Average Density. (Averages based on 3 to 13 years of data.)

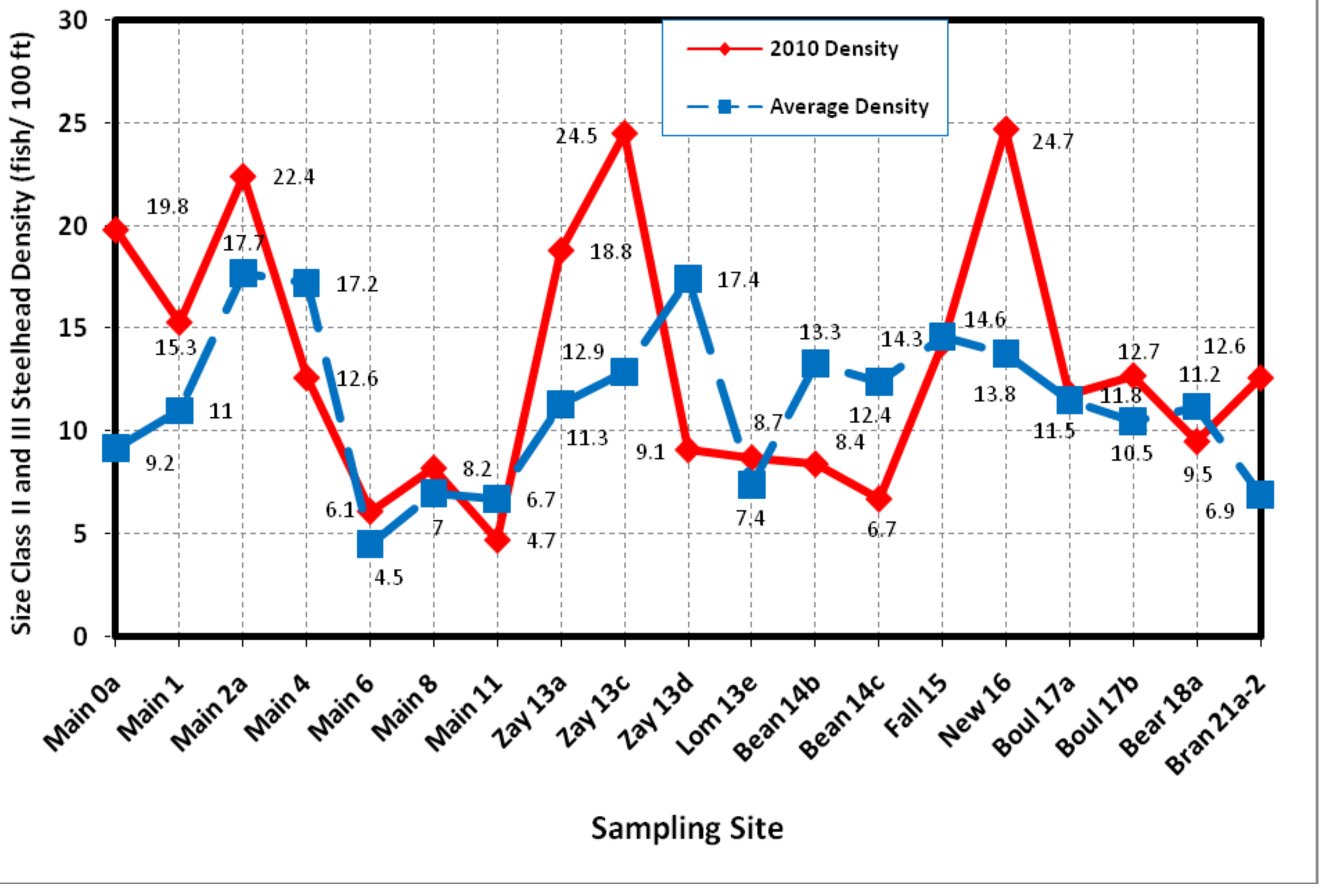


Figure 3. Yearling and Older Steelhead Site Densities in the San Lorenzo River in 2010 Compared to Average Density. (Averages based on 3 to 13 years of data.)

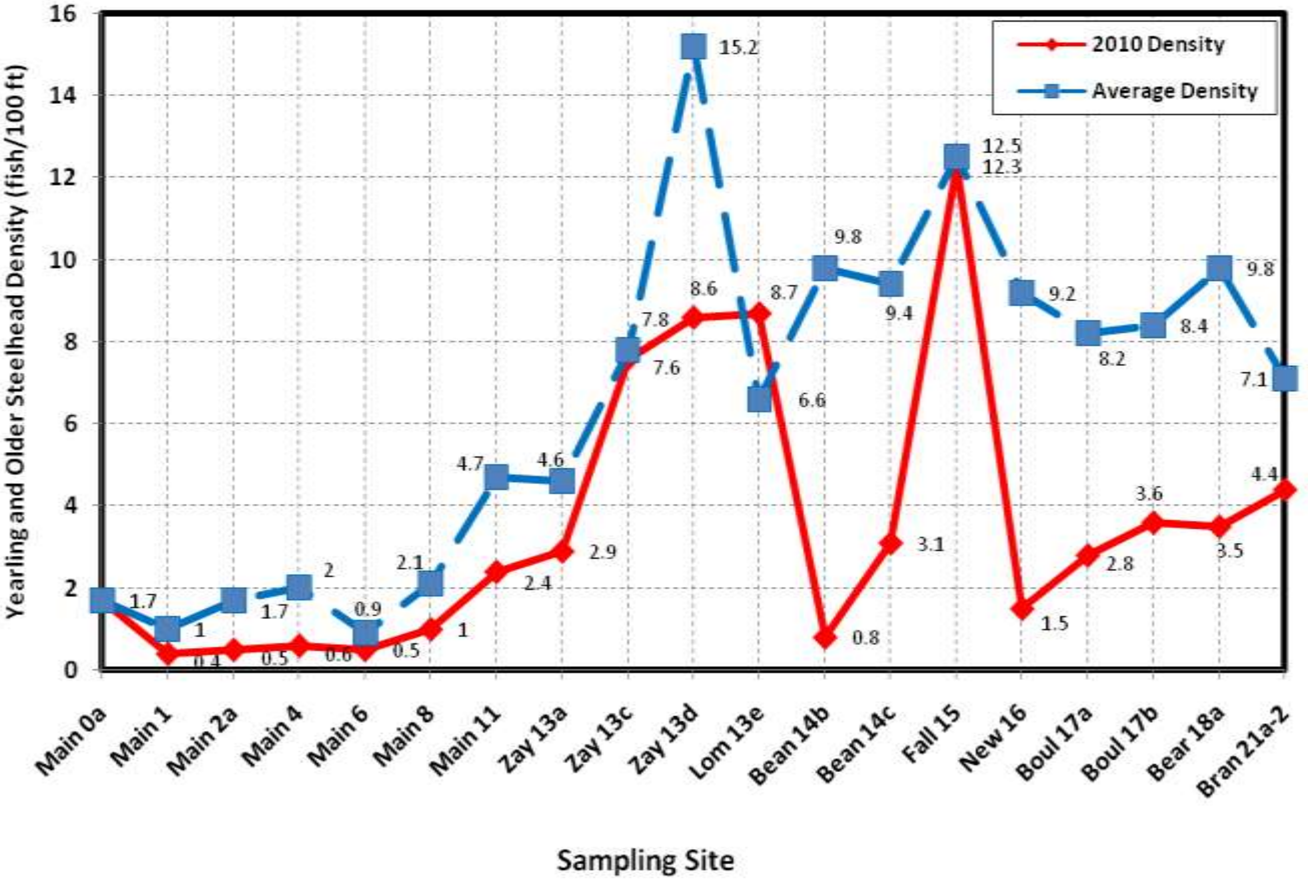
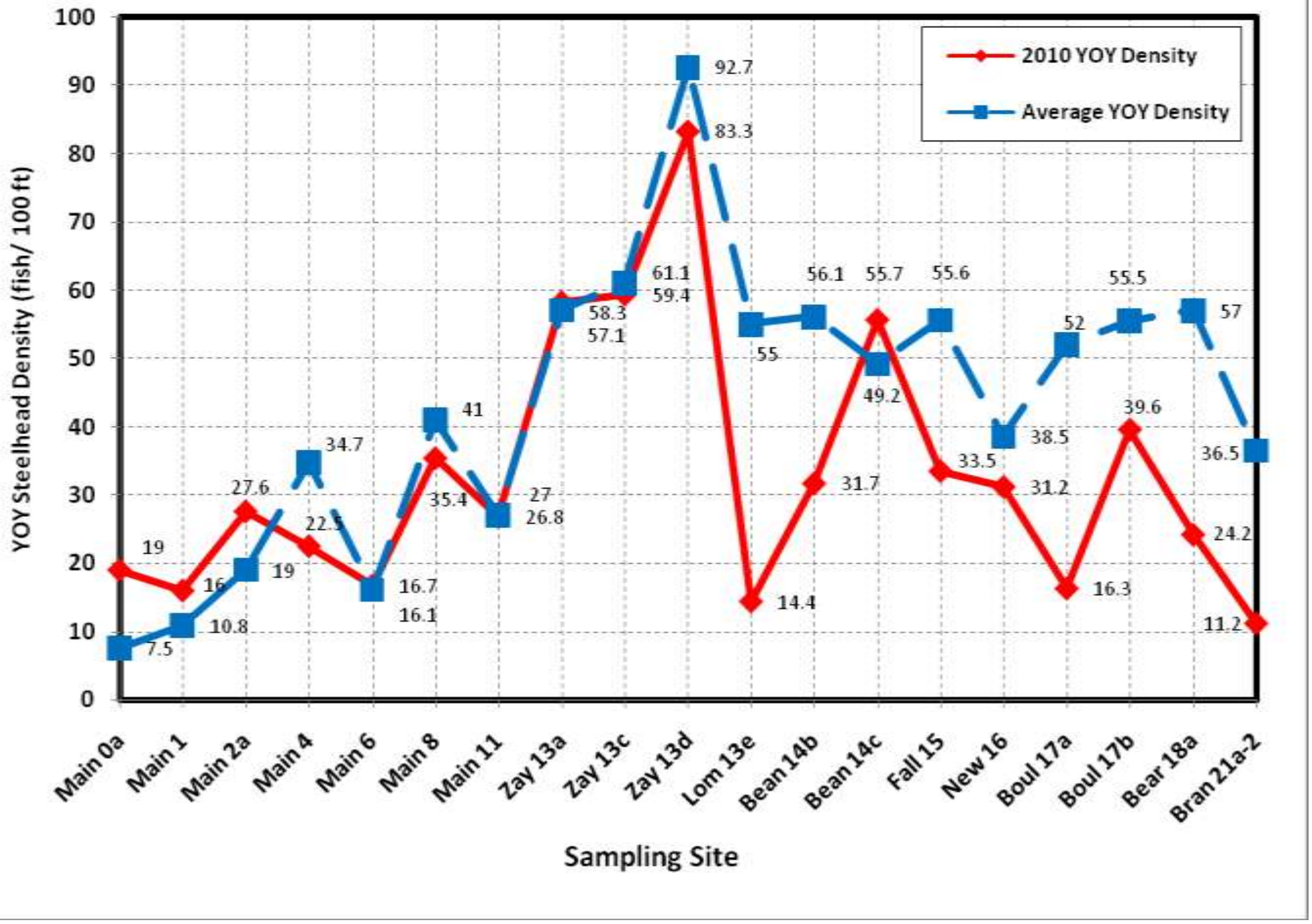


Figure 2. Young-of-the-Year Steelhead Site Densities in the San Lorenzo River in 2010 Compared to Average Density. (Averages based on 3 to 13 years of data.)



In the Soquel Creek Watershed (2010 compared to 2009 and Average Densities):

1. All habitat data was collected at sampling sites only. All reaches had higher baseflow in 2010 than 2009, especially in the spring due to later storms in 2010 (**Hydrographs** above). This provided more food and better growth rates in all reaches. Of the 8 sampling sites examined, all had overall positive habitat change based on more baseflow, greater water depth and generally more pool escape cover (6 of 8 sites).

2. Due to faster YOY growth rate associated with low YOY densities, 5 of 8 sites had above average ***Size Class II and III abundance*** (**Figures B-8 and B-18** below), and 5 of 8 sites had greater abundance and improved potential smolt ratings compared to 2009 (***Tables 30** in Appendix B* and **S-3** above). In the mainstem, two sites had ratings of 3 and two sites had ratings of 4 in 2010. East Branch Site 13a showed considerably higher abundance than other sites due to fast growing YOY, which brought a 5 potential smolt rating. East Branch Site 16 also had a 5 rating due to good (though reduced) yearling density. The two West Branch sites had 4 and 5 ratings each. Higher potential smolt densities resulted from higher spring flows (more insect drift) and reduced competition for food between fewer YOY allowing faster YOY growth rate and a higher percentage of YOY reaching Size Class II.

3. ***Yearling abundance*** remained similarly low as in 2009 and near or slightly below average, with density cut in half at the upper East Branch 16 site (***Table 28** in Appendix B* and **Figure B-7** below), similar to the decrease in upper Zayante 13d in the San Lorenzo watershed.

4. ***Total and young-of-the-year (YOY) abundance*** was generally much lower in 2010 than 2009, and below average at all 8 sampled sites (***Tables 26−27** in Appendix B* and **Figure B-6** below). Difference in total density was statistically significant.

5. The 2010 juvenile steelhead population in Soquel Lagoon was an estimated 1,174, which was much less than the 18-year average of 1,723 but twice the 2009 estimate (**Alley 2010a**). The 2010 population size fit the typical pattern for wetter years when less spawning occurs near the lagoon and lagoon numbers are down.

Figure 18. Percent of Young-of-the-Year Steelhead in Size Class II (=>75 mm SL) at Soquel Creek Sites in 2009 and 2010.

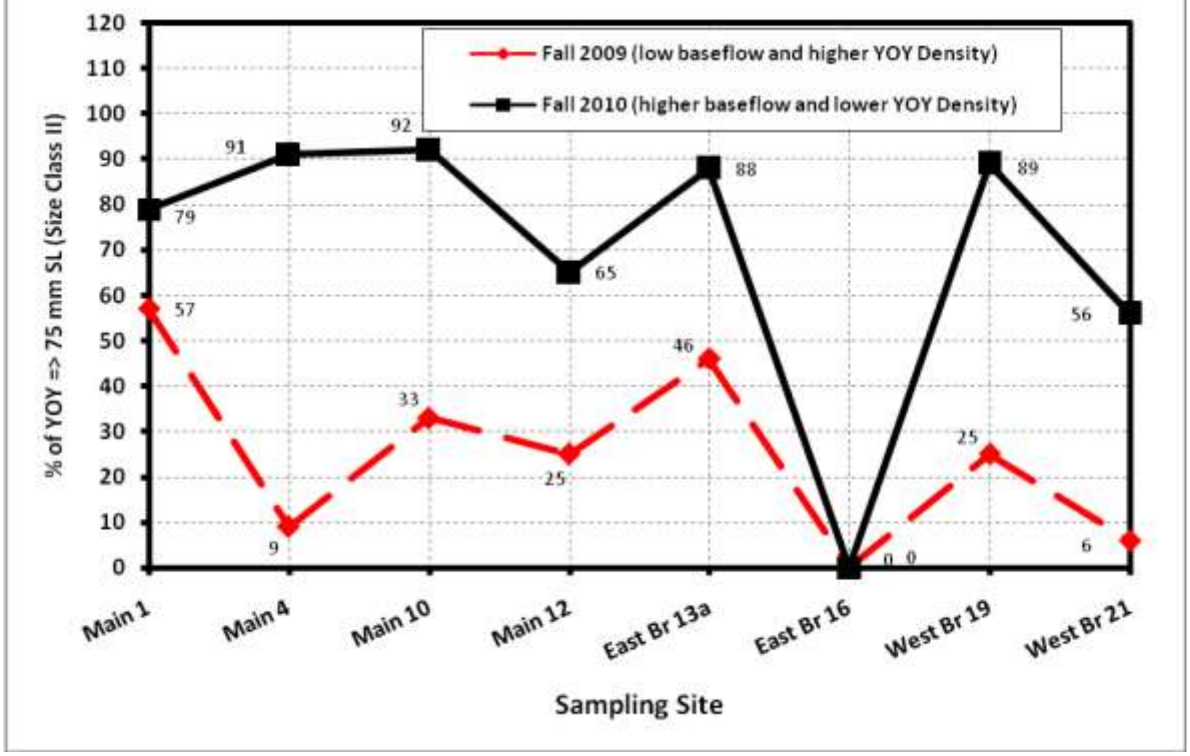
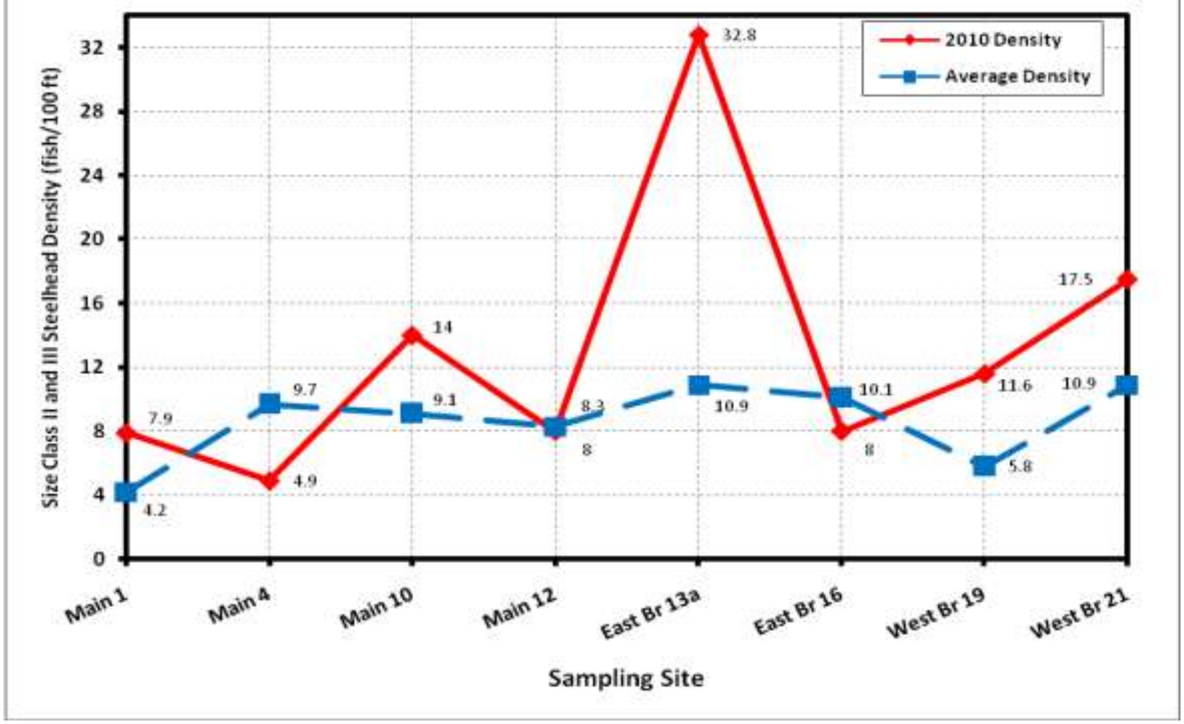


Figure 8. Size Class II and III Steelhead Site Densties in Soquel Creek in 2010 Compared to the 14-Year Average (10th year for West Branch #19.)



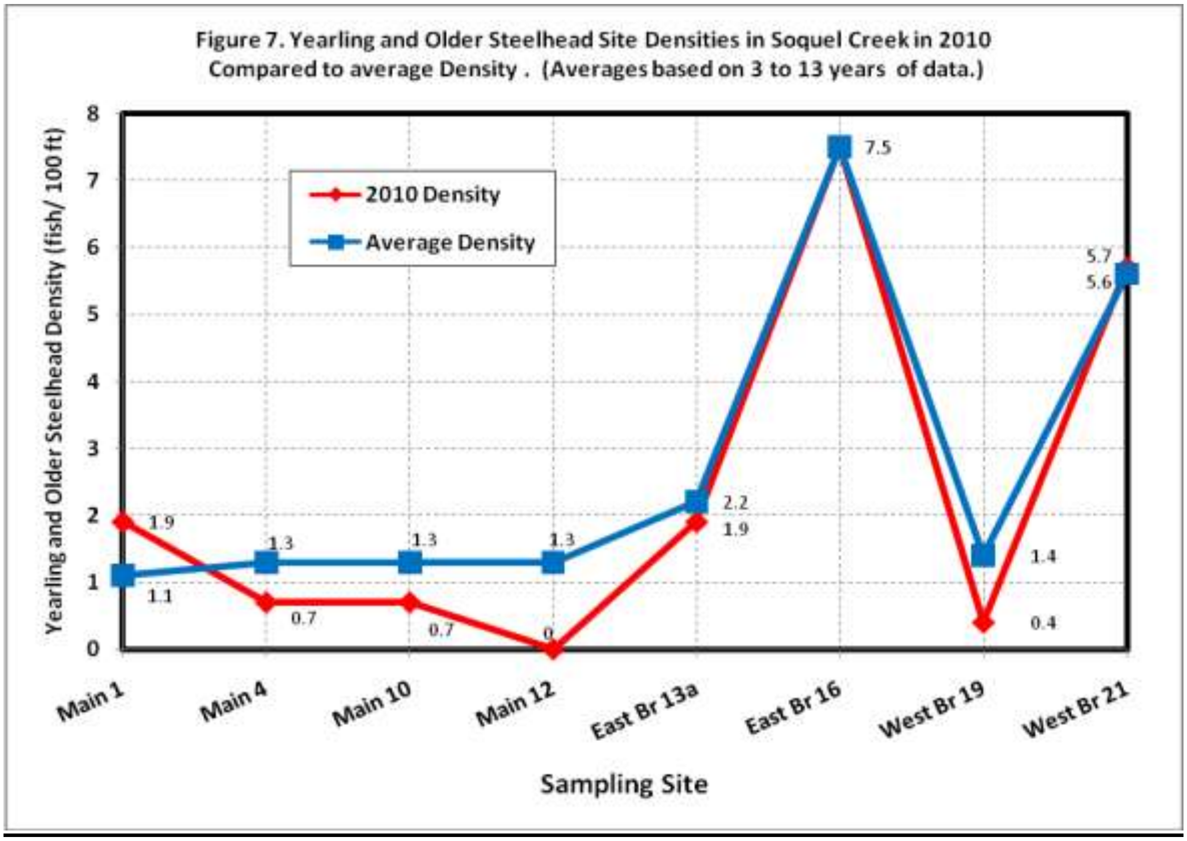


Figure 7. Yearling and Older Steelhead Site Densities in Soquel Creek in 2010 Compared to average Density . (Averages based on 3 to 13 years of data.)

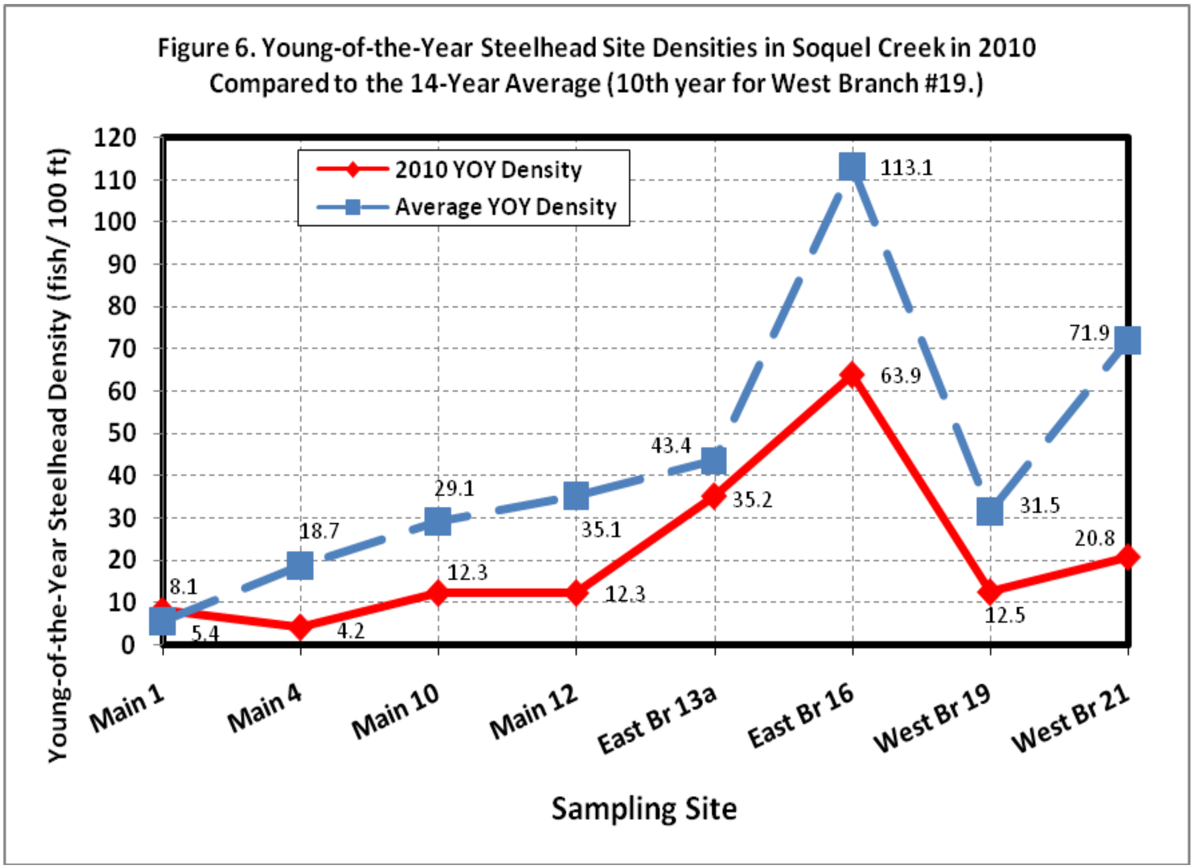


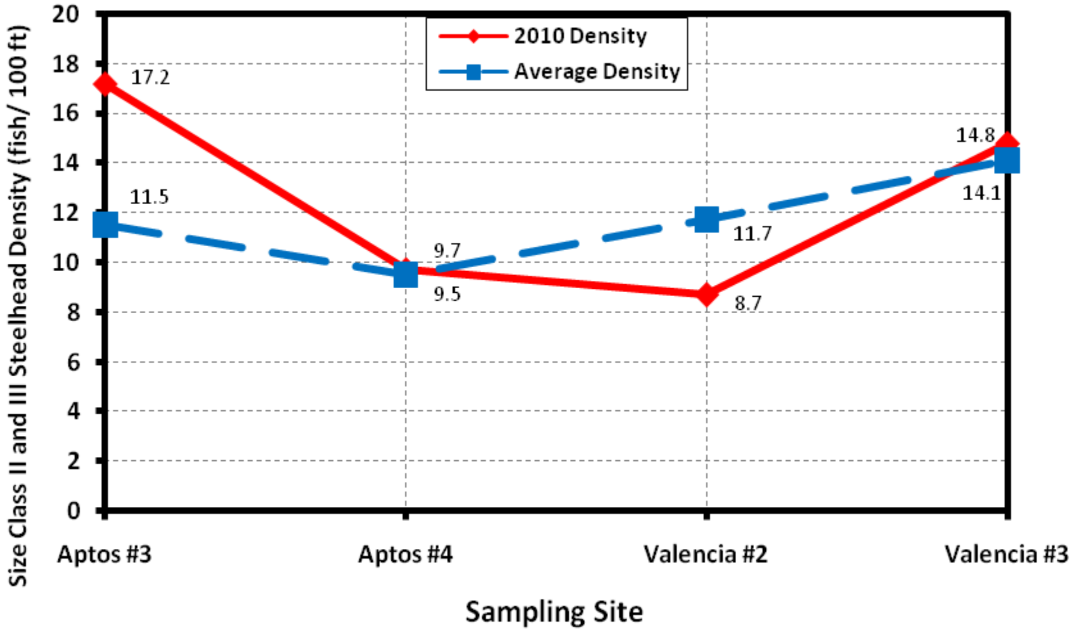
Figure 6. Young-of-the-Year Steelhead Site Densities in Soquel Creek in 2010 Compared to the 14-Year Average (10th year for West Branch #19.)

In the Aptos Creek Watershed (2010 compared to 2009 and Average Densities):

1. Habitat improved in Aptos Creek with higher baseflow, slightly deeper habitat and 10-20% more escape cover at both Sites 3 and 4 (***Table 16** in Appendix B*). Habitat improved in Valencia Creek with higher baseflow and 13-25% more pool escape cover at Sites 2 and 3, although pools were shallowed by sedimentation. In this sediment-laden tributary with already shallow pools, escape cover is more important than pool depth in determining steelhead density.

2. ***Abundance of larger juveniles*** (Size Classes II and III => 75 mm SL) were close to average at 3 of 4 sites (above average in lower Aptos) (**Figure B-12** below). Compared to 2009, abundance went up in Aptos and down in Valencia (***Table 34** in Appendix B*). It went up in Aptos because most juveniles in this size class were YOY, and more YOY reached Size Class II in 2010. It went down in Valencia because juveniles in this size class were yearlings, and yearling abundance decreased likely because of higher overwinter mortalities. Smolt ratings were 5 for lower Aptos and upper Valencia and 4 at the other sites, with improved rating at lower Aptos (**Table S-3** above).

Figure 12. Size Class II and III Steelhead Site Densities in Aptos and Valencia Creeks in 2010, with a 6-Year Average (1981; 2006-2010).



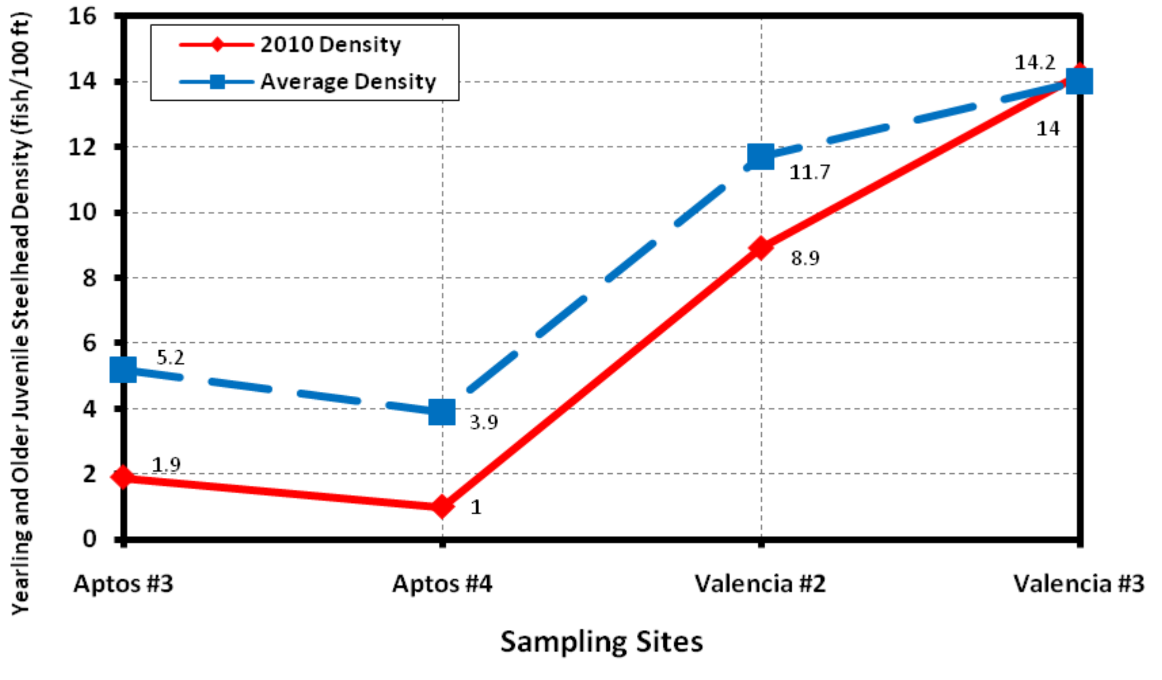
3. ***Below average yearling and older densities*** in the Aptos watershed followed the pattern found in two of the three other watersheds except the upper Valencia site, which remained average with resident trout likely present (**Figure B-11** below). Abundance decreased at all sites compared to 2009 (***Table 33*** *in Appendix B*), and it was statistically significant. Causal factors for reduced abundance included low YOY recruitment from 2009, likely greater overwinter mortality with more stormflows and early emigration because high spring baseflows allowed faster yearling growth.

4. Rearing habitat was likely under-utilized in upper Aptos with only average Size Class II and III abundance despite improved habitat conditions and higher baseflow.

5. ***YOY abundance*** was above average at lower Aptos and upper Valencia sites (**Figure B-10** below). It was higher at all 4 sites (statistically significant) compared to very low densities in 2009 (***Table 32*** *in Appendix B*). The below average abundance in upper Aptos and the atypical lower abundance than at the lower Aptos site indicated spotty spawning success and likely continued low adult spawner numbers in 2010.

6. Despite higher YOY densities in 2010, a higher percent of YOY reached Size Class II than in 2009 at Aptos Site 3 and nearly half did at upper Site 4 (**Figure B-19** above). Elevated spring flows likely stimulated growth. YOY growth rate continued to be slow in Valencia Creek.

Figure 11. Yearling and Older Juvenile Steelhead Site Densities in Aptos and Valencia Creeks in 2010, with a 6-Year Average (1981; 2006-2010).



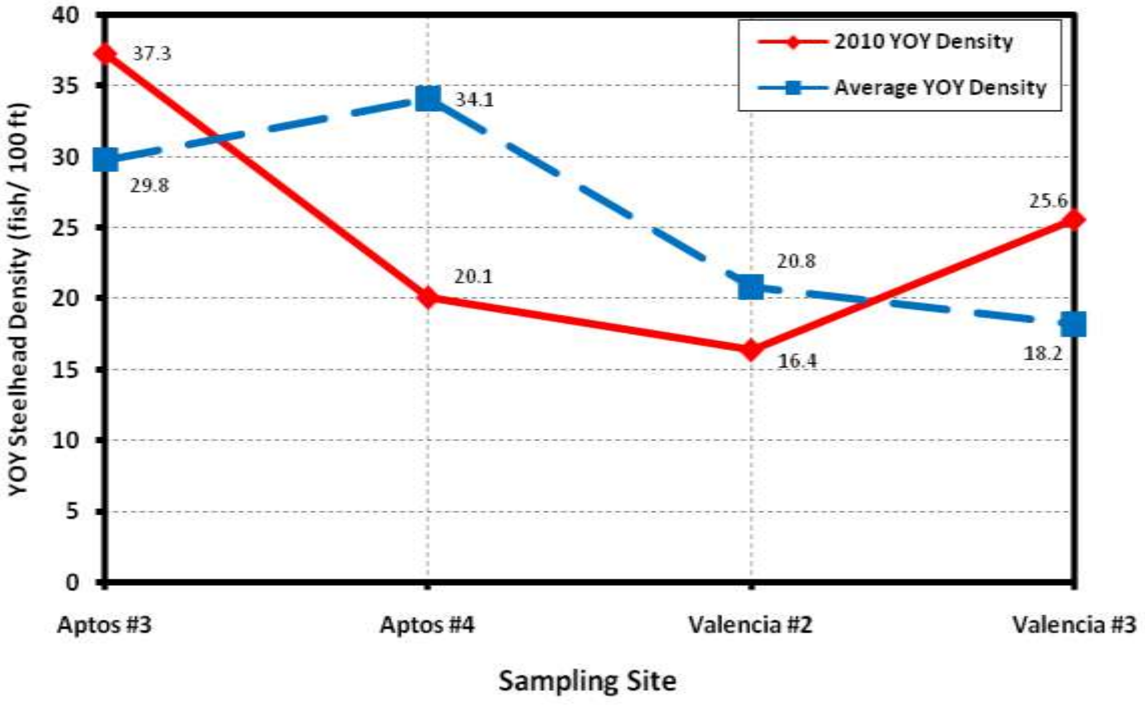
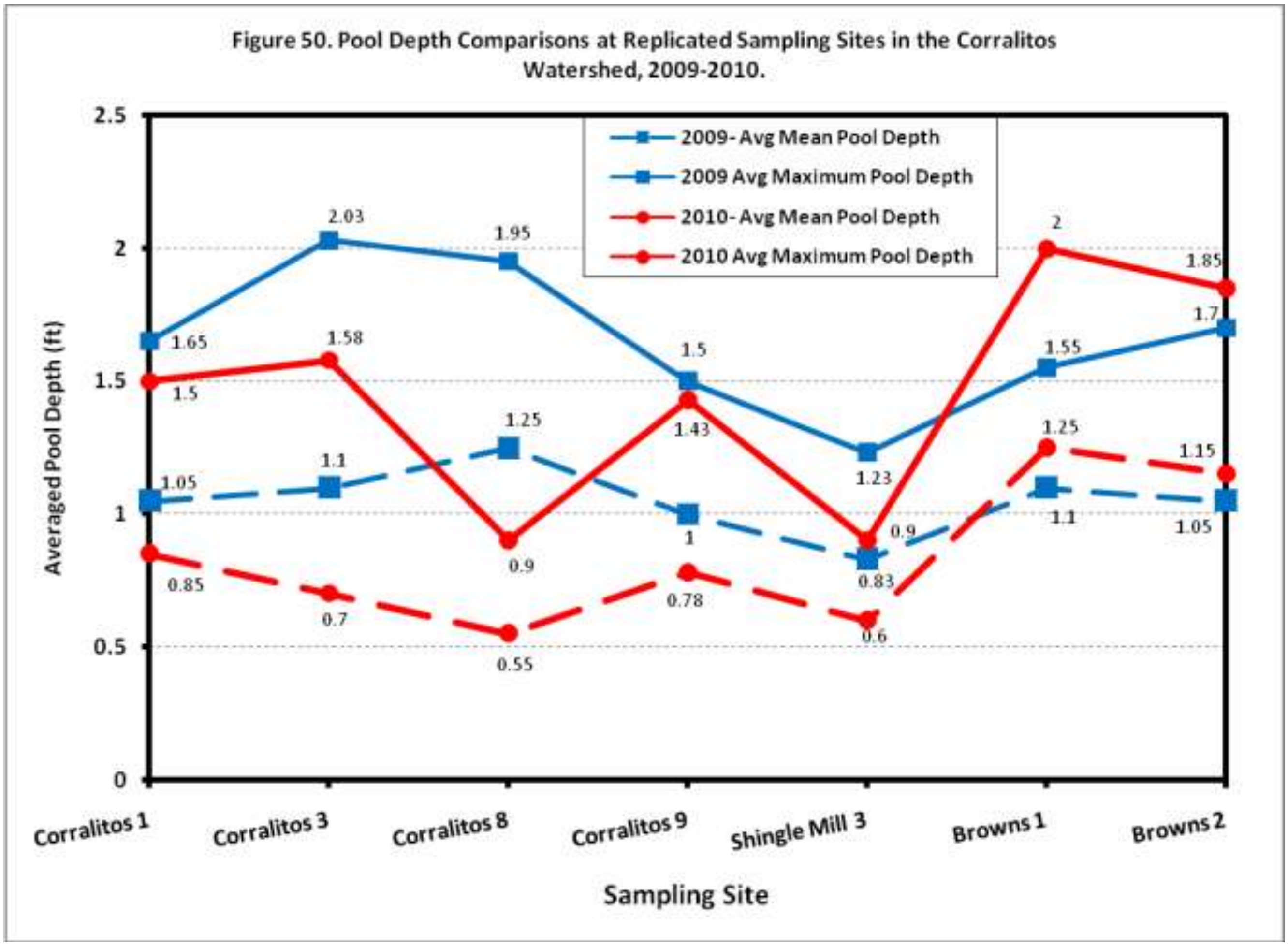


Figure 10. Young-of-the-Year Steelhead Site Densties in Aptos and Valencia Creeks in 2010, with a 6-Year Average (1981; 2006-2010).

<u>In the Corralitos Creek Sub-Watershed (2010 compared to 2009 and Average Densities):</u>

1. Consistently more shallow pools at Corralitos and Shingle Mill sites indicate stream-wide sedimentation and steelhead habitat degradation despite above median baseflows (***Table 16** in Appendix B*; **Figure B-50** and **Hydrograph** below). Erosion leading to sedimentation was likely caused by the Summit fire in 2008 (**map below**). Pool escape cover was generally slightly reduced except at Site 8, downstream of Eureka Gulch it was less than half due to substantial sedimentation. However, it was similar to 2009 at the site above (**Figure B-51** below). Pool length also decreased at Site 8 with lower pool habitat converted to shallow, sandy glide and poor spawning substrate. Habitat conditions improved in Browns Creek with regard to increased baseflow and scour indicated by pool deepening and more escape cover at the upper site (***Table 16** in Appendix B*; **Figures B-50 and B-51** below).



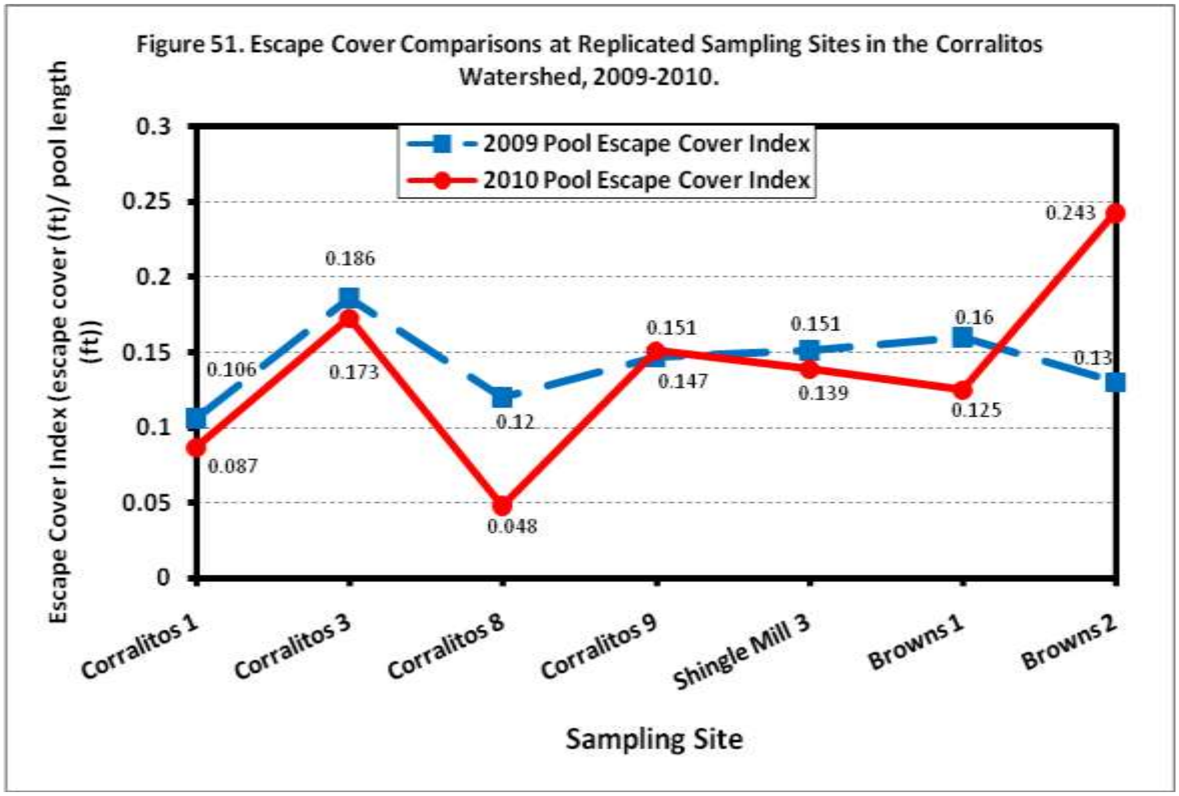
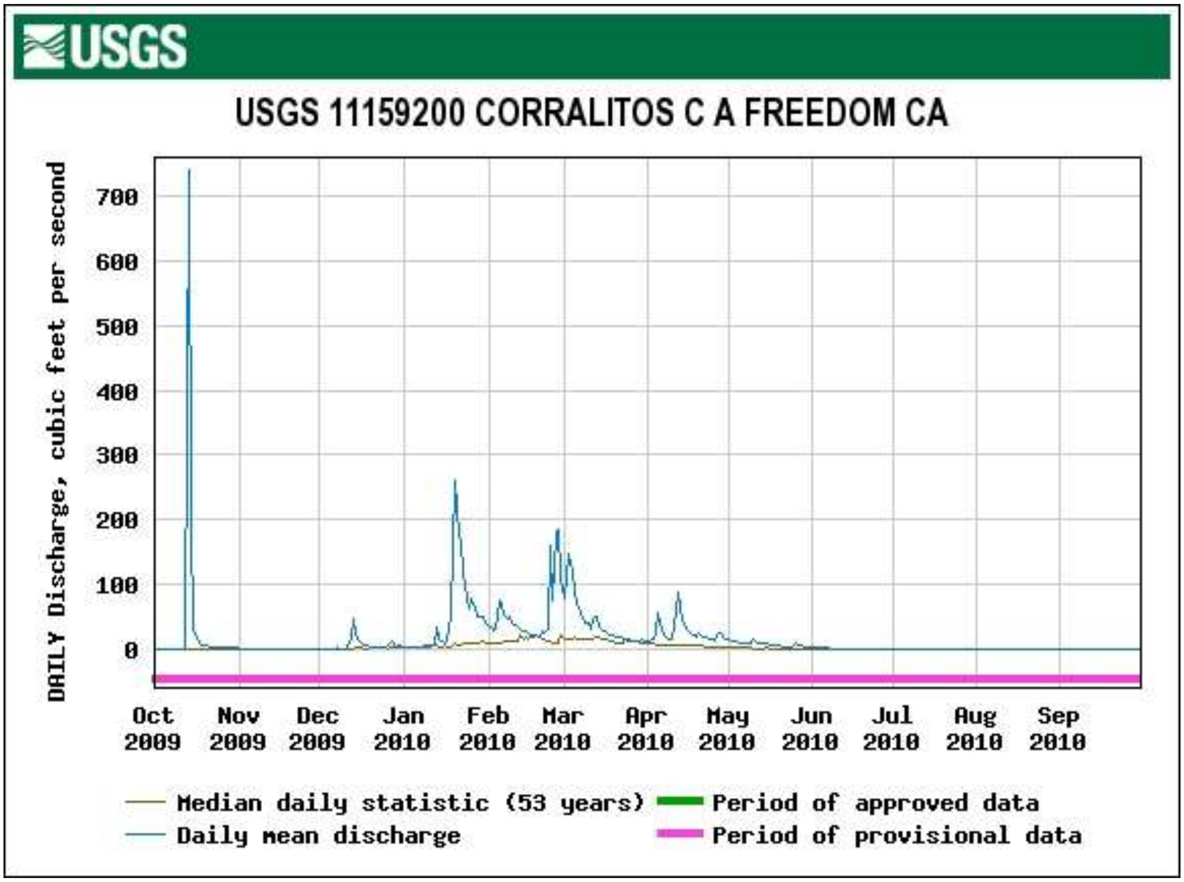
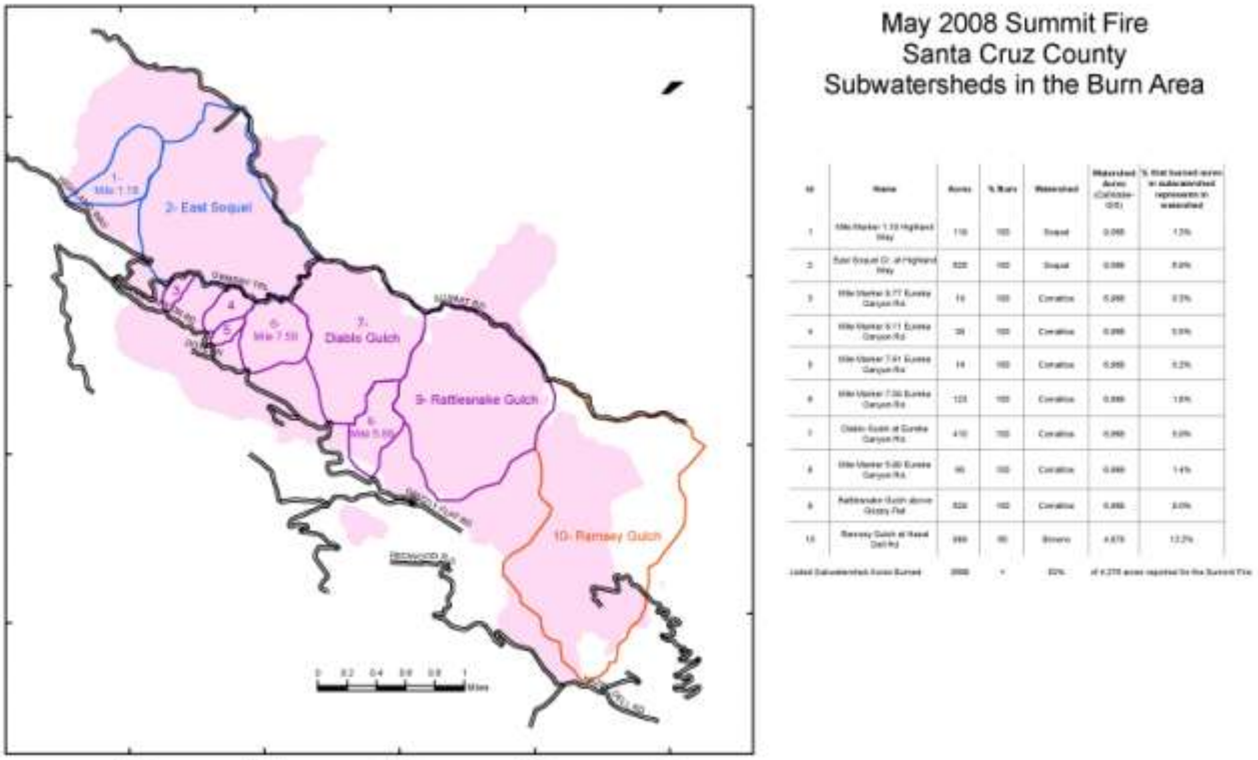


Figure 51. Escape Cover Comparisons at Replicated Sampling Sites in the Corralitos Watershed, 2009-2010.





2. ***Size Class II and III abundance*** was below the long term average at all sites except upper Shingle Mill and less at all 8 sampling sites compared to 2009 (statistically significant) (***Table 34*** *in Appendix B*, **Tables S-2 and S-3** below and **Figure B-16** below). This resulted from low yearling densities and few YOY to grow into Size Class II at lower Corralitos sites, though they did at higher percentages (**Figure B-20** below). The three Corralitos sites below Eureka Gulch had potential smolt ratings of 3 and two 4 ratings. The Corralitos site above Eureka Gulch retained a 5 rating, as did both Browns Creek sites. Shingle Mill Gulch sites were rated 3 and 4.

3. ***Yearling abundance*** was much below average (7 of 8 sites with the upper Shingle Mill 3 site having near average densities) (**Figure B-15** below) and less than in 2009 at all sites (statistically significant) (***Table 33*** *in Appendix B*). The decline was likely caused by poor overwinter survival in the face of high sediment movement and generally low YOY recruitment from 2009 (***Table 32*** *in Appendix B*). The early, mid-October stormflow was very large (mean daily flow of 700+ cfs) and likely caused substantial displacement and mortality (**Hydrograph** above).

4. ***YOY abundance*** was below average at 7 of 8 sites (except upper Shingle Mill) and less at 5 of 8 sites compared to in 2009 (statistically significant for Corralitos Creek only) (***Table 32*** *in Appendix B* and **Figure B-14** below). The below average abundance in Browns and Corralitos likely resulted partially from low adult spawner numbers. In Corralitos there was also likely very low spawning success and egg survival with the added sedimentation problem.

Table S-2. 2010 Sampling Sites Rated by Potential Smolt-Sized Juvenile Density (=>75 mm SL) and Average Smolt Size, with Physical Habitat Change since 2010. (Red denotes ratings of 1 and 2 or negative habitat change; purple denotes ratings of 5 and 6. Methods for habitat change in M-6 of Appendix B.)

Site	Multi-Year Avg. Potential Smolt Density Per 100 ft (Years of data)	2010 Potential Smolt Density (per 100 ft)/ Avg Smolt Size (mm)	2010 Smolt Rating	Numerical Rating (1 to 7)	Physical Habitat Change by Reach Since 2009
Low. San Lorenzo #0a	**9.2 (n=3)**	**19.8/ 106 mm**	6	******	Site Positive
Low. San Lorenzo #1	11.0 (n=10)	15.3/ 98 mm	4	****	Site Positive
Low. San Lorenzo #2	**17.7 (n=9)**	**22.4/ 91 mm**	5	*****	Reach Positive
Low. San Lorenzo #4	17.2 (n=10)	12.6/ 87 mm	3	***	Site Positive
Mid. San Lorenzo #6	**4.5 (n=13)**	**6.1/ 80 mm**	2	**	Site Positive
Mid. San Lorenzo #8	7.0 (n=13)	8.2/ 88 mm	3	***	Site Positive
Up. San Lorenzo #11	6.7 (n=13)	4.7/ 93 mm	3	***	Site Positive
Zayante #13a	11.3 (n=12)	18.8/ 89 mm	4	****	Site Positive
Zayante #13c	**11.9 (n=12)**	**24.5/ 90 mm**	5	*****	–
Zayante #13d	**17.4 (n=12)**	**9.1/ 101 mm**	4	****	**Site Negative**
Lompico #13e	7.4 (n=5)	8.7/ 96 mm	4	****	Site Positive
Bean #14b	13.3 (n=13)	8.4/ 87 mm	3	***	Site Positive
Bean #14c	12.4 (n=10)	6.7/ 99 mm	3	***	–
Fall #15	**14.6 (n=8)**	**14.3/ 118 mm**	5	*****	Site Positive
Newell #16	13.8 (n=7)	24.7/ 86 mm	4	****	Site Positive
Boulder #17a	11.5 (n=13)	11.8/ 89 mm	4	****	Site Similar
Boulder #17b	10.5 (n=13)	12.7/ 90 mm	4	****	**Site Negative**
Bear #18a	11.2 (n=13)	9.5/ 99 mm	4	****	–
Branciforte #21a-2	**6.9 (n=10)**	**12.6/ 105 mm**	5	*****	Reach Similar
Soquel #1	4.2 (n=13)	7.9/ 108 mm	4	****	Site Positive
Soquel #4	9.7 (n=14)	4.9/ 98 mm	3	***	Site Positive
Soquel #10	9.1 (n=14)	14.0/ 96 mm	4	****	Site Positive
Soquel #12	8.3 (n=13)	8.0/ 88 mm	3	***	Site Positive
E. Branch Soquel #13a	**10.9 (n=14)**	**32.8/ 88 mm**	5	*****	Site Positive
E. Branch Soquel #16	**10.1 (n=14)**	**8.0/ 106 mm**	5	*****	Site Positive
W. Branch Soquel #19	5.8 (n=10)	11.6/ 93 mm	4	****	Site Positive
W. Branch Soquel #21	**10.9 (n=9)**	**17.5/ 99 mm**	5	*****	Site Positive
Aptos #3	**11.5 (n=6)**	**17.2/ 90 mm**	5	*****	Site Positive
Aptos #4	9.5 (n=6)	9.7/ 96 mm	4	****	Site Positive
Valencia #2	11.7 (n=6)	8.7/ 100 mm	4	****	Site Positive
Valencia #3	**14.1 (n=6)**	**14.8/ 105 mm**	5	*****	Site Positive
Corralitos #1	10.1 (n=4)	8.7/ 99 mm	4	****	**Site Negative**
Corralitos #3	**9.6 (n=7)**	5.5/ 116 mm	4	****	**Site Negative**
Corralitos #8	**12.9 (n=7)**	6.0/ 90 mm	3	***	**Site Negative**
Corralitos #9	**20.0 (n=7)**	**11.2/ 104 mm**	5	*****	**Site Negative**
Shingle Mill #1	11.8 (n=7)	6.3/ 104 mm	4	****	–
Shingle Mill #3	4.7 (n=7)	6.1/ 99 mm	3	***	**Site Negative**
Browns Valley #1	**15.9 (n=7)**	**10.1/ 103 mm**	5	*****	Site Positive
Browns Valley #2	**13.2 (n=7)**	**9.4/ 104 mm**	5	*****	Site Positive

Table S-3. 2010 Sampling Sites Rated by Potential Smolt-Sized Juvenile Density (=>75 mm SL) and Their Average Size in Standard Length, with Physical Habitat Change from 2009 Conditions. (Red denotes ratings of 1−3 and negative habitat change and purple denotes ratings of 5−7. Methods for habitat change in M-6 of Appendix B.**)**

Site	2010 Potential Smolt Density (per 100 ft)/ Avg Smolt Size SL (mm)	2010 Smolt Rating (With Size Factored In)	2009 Potential Smolt Density (per 100 ft)/ Avg Smolt Size SL (mm)	2009 Smolt Rating (With Size Factored In)	Physical Habitat Change by Reach/Site Since 2009
Low. San Lorenzo #0a	19.8/ 106 mm	6	2.4/ 124 mm	3	+
Low. San Lorenzo #1	15.3/ 98 mm	4	3.4/125 mm	3	+
Low. San Lorenzo #2	22.4/ 91 mm	5	8.0/105 mm	6	+
Low. San Lorenzo #4	12.6/ 87 mm	3	13.9/85 mm	3	+
Mid. San Lorenzo #6	6.1/ 80 mm	2	0.5/ 76 mm	1	+
Mid. San Lorenzo #8	8.2/ 88 mm	3	3.5/ 95 mm	2	+
Up. San Lorenzo #11	4.7/ 93 mm	3	3.1/ 99 mm	2	+
Zayante #13a	18.8/ 89 mm	4	12.1/ 85 mm	3	+
Zayante #13c	24.5/ 90 mm	5	10.4/ 91 mm	4	NA
Zayante #13d	9.1/ 101 mm	4	16.9/ 97 mm	5	–
Lompico #13e	8.7/ 96 mm	4	4.9/ 92 mm	3	–
Bean #14b	8.4/ 87 mm	3	10.9/ 101 mm	4	=
Bean #14c	6.7/ 99 mm	3	–	–	NA
Fall #15	14.3/ 118 mm	5	18.7/ 111 mm	6	+
Newell #16	24.7/ 86 mm	4	4.4/94 mm	3	+
Boulder #17a	11.8/ 89 mm	4	5.5/ 98 mm	3	=
Boulder #17b	12.7/ 90 mm	4	10.7/ 96 mm	4	–
Bear #18a	9.5/ 99 mm	4	2.5/ 88 mm	1	NA
Branciforte #21a-2	12.6/ 105 mm	5	7.5/ 117 mm	4	=
Soquel #1	7.9/ 108 mm	4	5.1/ 93 mm	3	+
Soquel #4	4.9/ 98 mm	3	8.1/ 96 mm	4	+
Soquel #10	14.0/ 96 mm	4	6.2/ 80 mm	2	+
Soquel #12	8.0/ 88 mm	3	11.9/ 86 mm	3	+
East Branch Soquel #13a	32.8/ 88 mm	5	11.2/ 88 mm	3	+
East Branch Soquel #16	8.0/ 106 mm	5	13.1/ 98 mm	4	+
West Branch Soquel #19	11.6/ 93 mm	4	14.1/ 92 mm	4	+
West Branch Soquel #21	17.5/ 99 mm	5	6.8/ 97 mm	3	+
Aptos #3	17.2/ 90 mm	5	5.2/ 120 mm	4	+
Aptos #4	9.7/ 96 mm	4	8.0/ 99 mm	4	+
Valencia #2	8.7/ 100 mm	4	13.8/ 94 mm	4	+
Valencia #3	14.8/ 105 mm	5	18.5/ 95 mm	5	+
Corralitos #1	8.7/ 99 mm	4	13.7/ 96 mm	4	–
Corralitos #3	5.5/ 116 mm	4	9.3/ 112 mm	5	–
Corralitos #8	6.0/ 90 mm	3	15.3/ 105 mm	5	–
Corralitos #9	11.2/ 104 mm	5	19.7/ 102 mm	5	–
Shingle Mill #1	6.3/ 104 mm	4	6.7/ 103 mm	4	NA
Shingle Mill #3	6.1/ 99 mm	3	7.2/ 85 mm	2	–
Browns #1	10.1/ 103 mm	5	12.9/ 98 mm	4	+
Browns #2	9.4/ 104 mm	5	11.9/ 98 mm	4	+

5. With below average YOY and yearling abundance, ***total juvenile abundance*** was much below average (except at upper Shingle Mill), and less than in 2009 at 6 of 8 sites (excepting Shingle Mill Sites 1 and 3) (statistically significant for Corralitos sites only) (***Table 31*** *in Appendix B* and **Figure B-13** below).

6. Steelhead at upper Shingle Mill Site 3 appear to have a sizeable resident trout component because YOY and yearling-and-older abundance did not decline there as they did at other sites.

7. With regard to adult steelhead passage above the Corralitos Creek diversion dam between Corralitos Sites 1 and 3, passage conditions should have improved in 2010 with higher winter stormflows than 2009 (***Figures 55 and 58*** *in Appendix B*). However, the sedimentation factor and exceptionally low YOY densities in the Corralitos Branch showed no evidence of it. However, the upper Corralitos sites had the highest YOY density in 2010, indicating that some adult steelhead successfully spawned upstream of the dam (***Table 32*** *in Appendix B* and **Figure B-14** below).

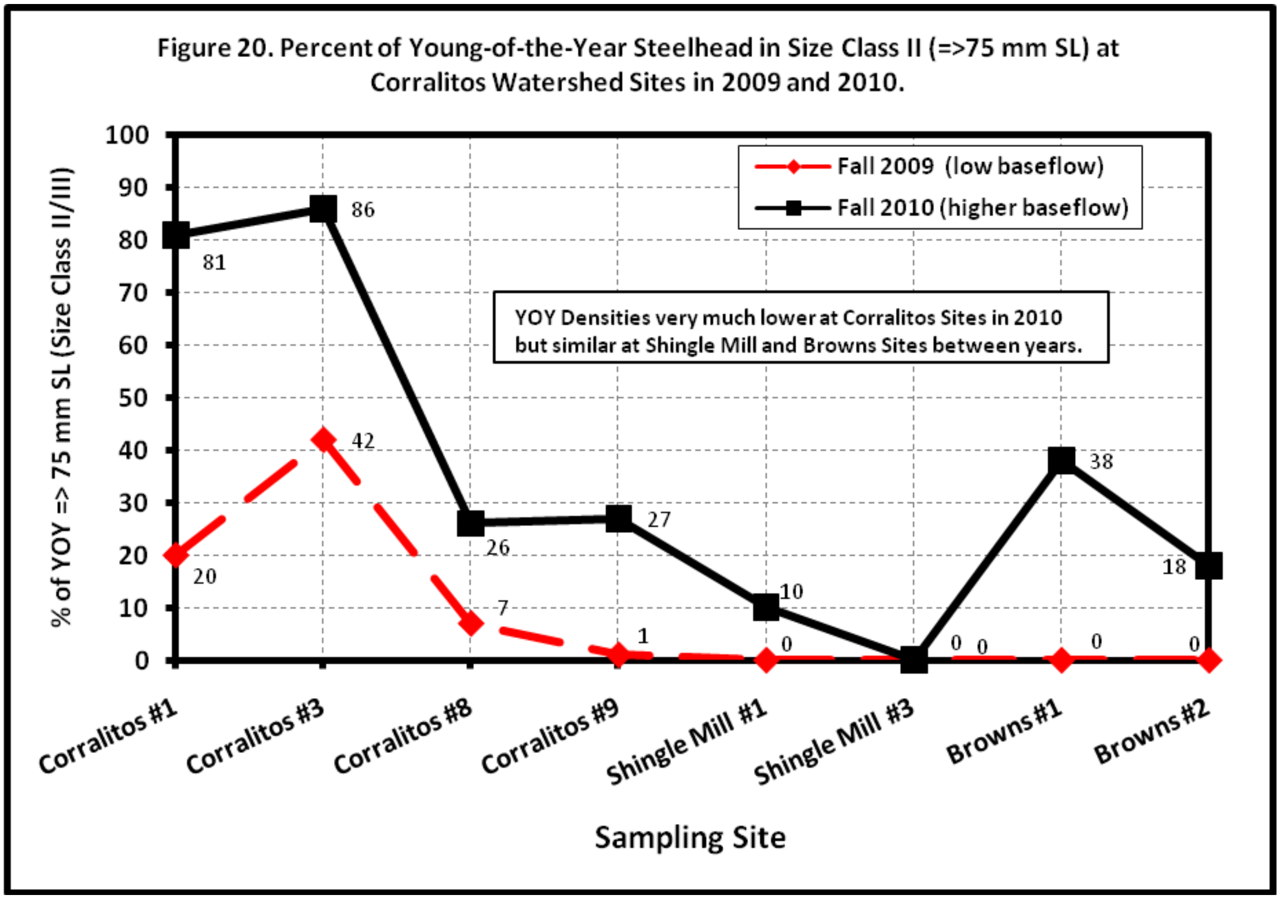


Figure 20. Percent of Young-of-the-Year Steelhead in Size Class II (=>75 mm SL) at Corralitos Watershed Sites in 2009 and 2010.

YOY Densities very much lower at Corralitos Sites in 2010 but similar at Shingle Mill and Browns Sites between years.

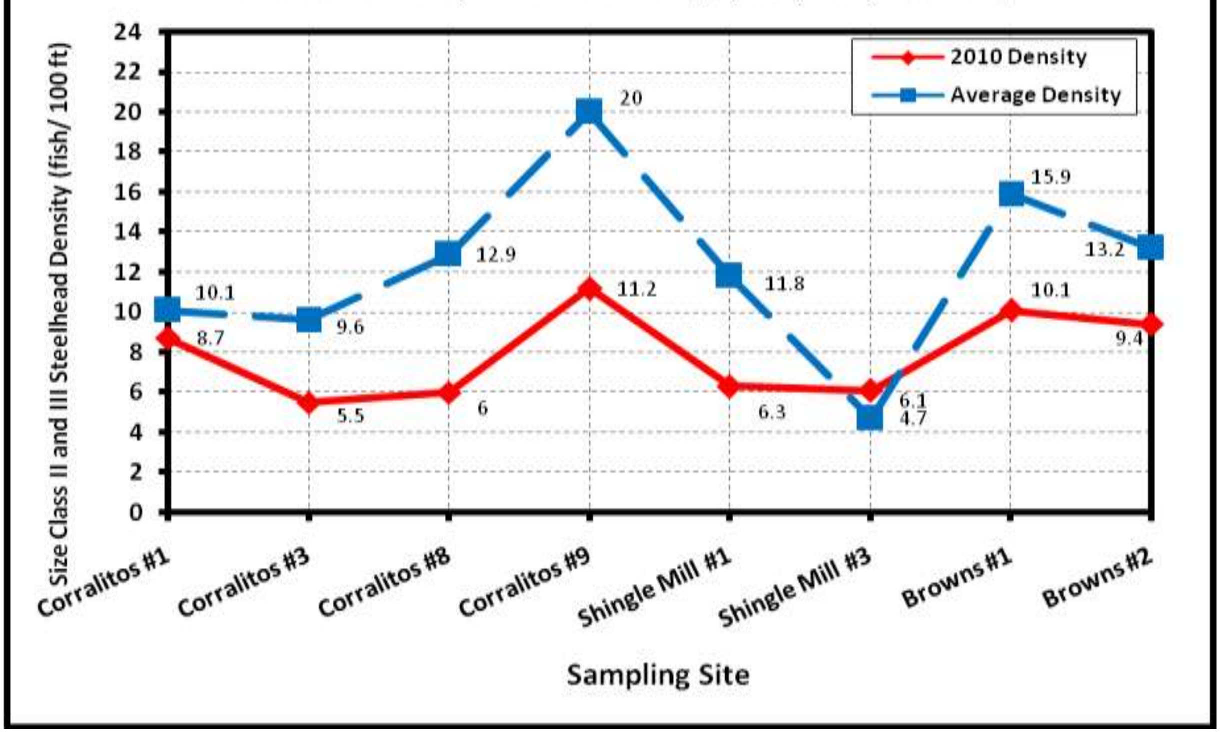


Figure 16. Size Class II and III Steelhead Site Densities in Corralitos, Shingle Mill and Browns Creeks in 2010, with a 7-Year Average (1981; 1994; 2006-2010).

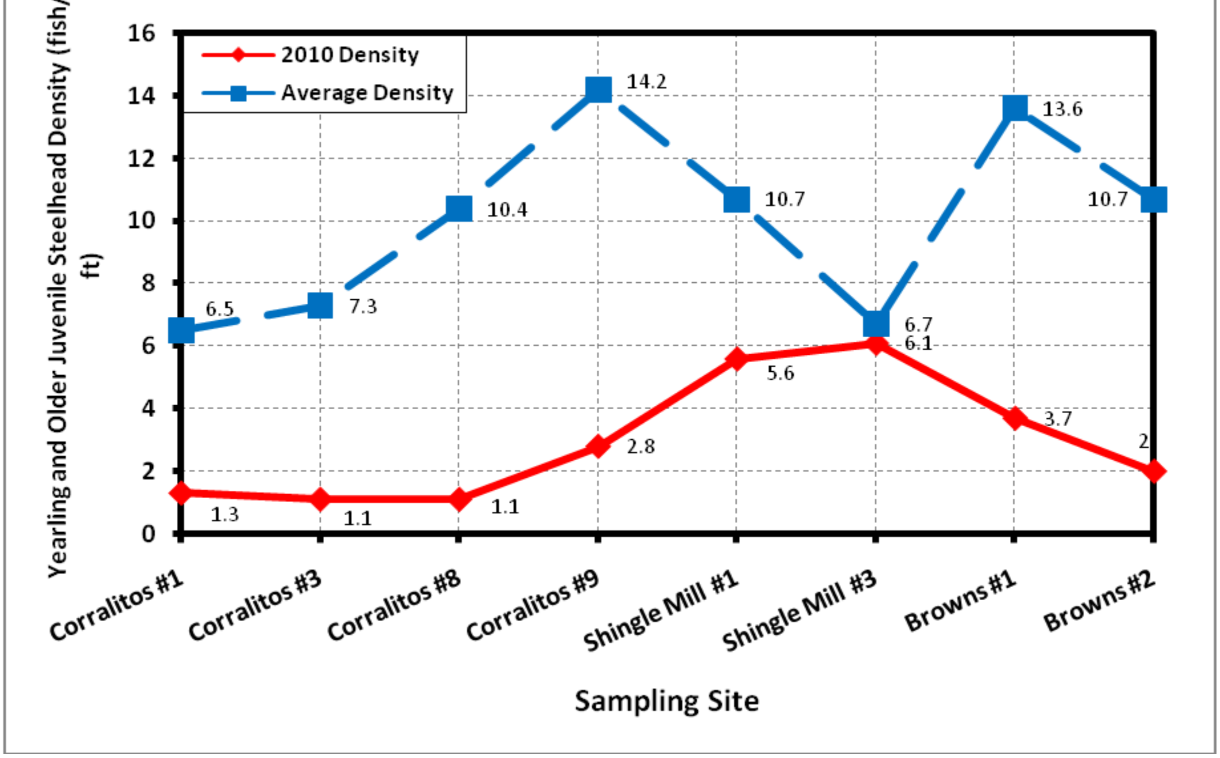


Figure 15. Yearling and Older Steelhead Site Densities in Corralitos, Shingle Mill and Browns Creeks in 2010, with a 7-Year Average (1981; 1994; 2006-2010).

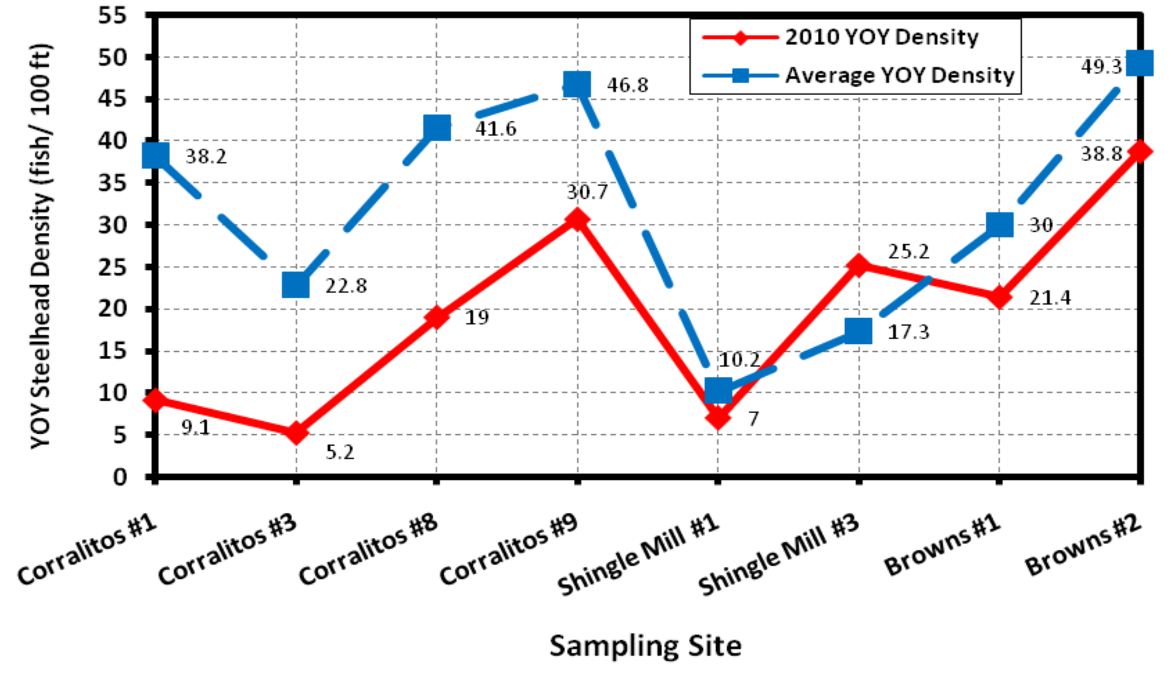


Figure 14. Young-of-the-Year Steelhead Site Densities in Corralitos, Shinglemill and Browns Creeks in 2010, with a 7-Year Average (1981; 1994; 2006-2010).

Habitat Conditions Rated, Based on Potential Smolt-Sized Juvenile Densities

Habitat at sampling sites in the four watersheds was rated, based on potential smolt-sized (=>75 mm SL) juvenile steelhead density and average smolt size according to the rating scheme developed by Smith (**1982; Table S-1** above). This rating scheme assumed that rearing habitat was usually near saturation with potential smolt-sized juveniles, at least in tributaries where 2 years are usually required to reach smolt size. It 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 San Lorenzo sites in 2010 due to low YOY densities compared to 1997−1999 (**Figure B-23** below). It was likely not met in San Lorenzo tributary sites with much below average potential smolt densities (Zayante 13d, Bean 14b and Bean 14c) (**Figure B-4** above). Aptos Site 4 was probably not fully seeded because of few yearling holdovers and much lower densities than in 2007 when overwinter survival of yearlings was high, along below average YOY densities and only average potential smolt densities (***Table 35*** *in Appendix B* and **Figures B-10 through B-12** above). Corralitos Site 9 and Browns Sites 1 and 2 were likely less than fully seeded because of few yearling holdovers, below average potential smolt densities where good escape cover existed (**Figure B-16** above), much lower densities than in 2006- a water year more similar to 2010 (***Table 35*** *in Appendix B*) and below average YOY where a high percentage of YOY can reach Size Class II (**Figure 14** above). Refer to the following **Table S-2** for 2010 potential smolt-sized juvenile densities and ratings.

In the San Lorenzo watershed, the highest rating of 5 and 6 were assigned to 2 lower mainstem Sites 0a and 2, Zayante 13c and 13d, Fall 15 and Branciforte 21a-2 (**Table S-3** below). The Fall and Branciforte sites qualified because Branciforte had a combination of fast-growing YOY and larger yearlings while Fall had large average yearling and older sizes (probably some residents). Newell 15 did not qualify despite high densities because their average size was small. In the Soquel watershed, upper sites were rated 5, including East Branch Sites 13a and 16 and West Branch Site 21. Site 16 qualified because of the large average yearling size. In the Aptos watershed, lower Aptos 3 was rated 5 with its many fast growing YOY and Valencia 3 was rated 5 because of its large yearling and older sizes (probably some residents). In the Corralitos sub-watershed of the Pajaro, upper Corralitos 9, Browns 1 and Browns 2 were rated 5 because of their large YOY and yearling sizes.

The 2 or 3 ratings of middle and upper mainstem San Lorenzo sites in 2010 is pretty typical for recent years, though with the high spring baseflows they should have been higher if fully seeded (**Table S-3** below). The 3 ratings of Bean Sites 14b and 14c are unusually low, as they are for mainstem Soquel 4 and 12. The combination of few yearlings and low spawners likely resulted in these low ratings. The 3 rating for Corralitos 8 is unusually low and caused by sedimentation. The 3 rating for upper Shingle Mill 3 is typical for a reach with a small channel, low baseflow and limited rearing habitat.

Table S-2. 2010 Sampling Sites Rated by Potential Smolt-Sized Juvenile Density (=>75 mm SL) and Average Smolt Size, with Physical Habitat Change since 2010. (Red denotes ratings of 1 and 2 or negative habitat change; purple denotes ratings of 5 and 6. Methods for habitat change in M-6 of Appendix B.)

Site	Multi-Year Avg. Potential Smolt Density Per 100 ft (Years of data)	2010 Potential Smolt Density per 100 ft/ Avg Smolt Size (mm)	2010 Smolt Rating	Numerical Rating (1 to 7)	Physical Habitat Change by Reach Since 2009
Low. San Lorenzo #0a	**9.2 (n=3)**	**19.8/ 106 mm**	**6**	******	Site Positive
Low. San Lorenzo #1	11.0 (n=10)	15.3/ 98 mm	4	****	Site Positive
Low. San Lorenzo #2	**17.7 (n=9)**	**22.4/ 91 mm**	**5**	*****	Reach Positive
Low. San Lorenzo #4	17.2 (n=10)	12.6/ 87 mm	3	***	Site Positive
Mid. San Lorenzo #6	**4.5 (n=13)**	**6.1/ 80 mm**	**2**	**	Site Positive
Mid. San Lorenzo #8	7.0 (n=13)	8.2/ 88 mm	3	***	Site Positive
Up. San Lorenzo #11	6.7 (n=13)	4.7/ 93 mm	3	***	Site Positive
Zayante #13a	11.3 (n=12)	18.8/ 89 mm	4	****	Site Positive
Zayante #13c	**11.9 (n=12)**	**24.5/ 90 mm**	**5**	*****	–
Zayante #13d	**17.4 (n=12)**	**9.1/ 101 mm**	4	****	**Site Negative**
Lompico #13e	7.4 (n=5)	8.7/ 96 mm	4	****	Site Positive
Bean #14b	13.3 (n=13)	8.4/ 87 mm	3	***	Site Positive
Bean #14c	12.4 (n=10)	6.7/ 99 mm	3	***	–
Fall #15	**14.6 (n=8)**	**14.3/ 118 mm**	**5**	*****	Site Positive
Newell #16	13.8 (n=7)	24.7/ 86 mm	4	****	Site Positive
Boulder #17a	11.5 (n=13)	11.8/ 89 mm	4	****	Site Similar
Boulder #17b	10.5 (n=13)	12.7/ 90 mm	4	****	**Site Negative**
Bear #18a	11.2 (n=13)	9.5/ 99 mm	4	****	–
Branciforte #21a-2	**6.9 (n=10)**	**12.6/ 105 mm**	**5**	*****	Reach Similar
Soquel #1	4.2 (n=13)	7.9/ 108 mm	4	****	Site Positive
Soquel #4	9.7 (n=14)	4.9/ 98 mm	3	***	Site Positive
Soquel #10	9.1 (n=14)	14.0/ 96 mm	4	****	Site Positive
Soquel #12	8.3 (n=13)	8.0/ 88 mm	3	***	Site Positive
E. Branch Soquel #13a	**10.9 (n=14)**	**32.8/ 88 mm**	**5**	*****	Site Positive
E. Branch Soquel #16	**10.1 (n=14)**	**8.0/ 106 mm**	**5**	*****	Site Positive
W. Branch Soquel #19	5.8 (n=10)	11.6/ 93 mm	4	****	Site Positive
W. Branch Soquel #21	**10.9 (n=9)**	**17.5/ 99 mm**	**5**	*****	Site Positive
Aptos #3	**11.5 (n=6)**	**17.2/ 90 mm**	**5**	*****	Site Positive
Aptos #4	9.5 (n=6)	9.7/ 96 mm	4	****	Site Positive
Valencia #2	11.7 (n=6)	8.7/ 100 mm	4	****	Site Positive
Valencia #3	**14.1 (n=6)**	**14.8/ 105 mm**	**5**	*****	Site Positive
Corralitos #1	10.1 (n=4)	8.7/ 99 mm	4	****	**Site Negative**
Corralitos #3	9.6 (n=7)	5.5/ 116 mm	4	****	**Site Negative**
Corralitos #8	12.9 (n=7)	6.0/ 90 mm	3	***	**Site Negative**
Corralitos #9	**20.0 (n=7)**	**11.2/ 104 mm**	**5**	*****	**Site Negative**
Shingle Mill #1	11.8 (n=7)	6.3/ 104 mm	4	****	–
Shingle Mill #3	4.7 (n=7)	6.1/ 99 mm	3	***	**Site Negative**
Browns Valley #1	**15.9 (n=7)**	**10.1/ 103 mm**	**5**	*****	Site Positive
Browns Valley #2	**13.2 (n=7)**	**9.4/ 104 mm**	**5**	*****	Site Positive

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

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 total abundance, YOY age class and Size Class II and III abundance from 1999 onward (**Figures 21−23** below). However, due to high growth rate of YOY in 2010, Size Class II and II abundance improved from 2009 levels.

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, number of sediment-moving, redd-scouring storms are over the wet season, 3) spawning success (survival rate from egg to emerging fry), 4) survival of emerging YOY in spring, 5) the number of juveniles that enter the lower and middle mainstem from tributaries 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 14 years, 1997, 2001, 2002, 2004 and 2007─2009 were drier, based on averaged mean monthly streamflow (May–September) (**Figure B-52** below). Increased total and YOY densities occurred in the lower and middle mainstem in these years, except in 2009 (**Figures B-21 and B-22** below). There may have been much fewer adults spawning over the 2008-2009 winter, making spawning effort and YOY densities spotty. Low adult spawning may have occurred in the wetter 2010 because YOY abundance at some tributary sites was greater than in 2009 and at others less, although YOY abundance at most mainstem sites was up in 2010. 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.

Positive blips in YOY abundance occurred at most mainstem sites below Zayante Creek in 2008 and in 2010, when YOY abundance increased at Sites 0a, 1, 2a, 6 and 8 compared to 2009. However, in 2008 this did not translate into higher Size Class II densities because YOY growth rate was down (**Figure B-23** below). Late spawning and elevated spring rearing flows in 2010 made more favorable rearing conditions for YOY that survived the late spring storms than during the 3 prior dry years. The years 1998 and 2006 had similarly wet winters, when faster growth of YOY into Size Class II was to be expected. However, 1998 densities of YOY and larger juveniles were substantially higher than in 2006. 1998 conditions were better than in 2006 with greater depth in fastwater habitat (riffles), higher baseflow (higher water velocity and greater insect drift) and more escape cover in fastwater habitat as indicated in the middle mainstem Reach 8 (**Alley 2010b**). 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 were the same in 1998 and 2006. YOY growth rate remained high in 2010 despite higher YOY densities, as indicated by a high percent reaching Size Class II (**Table S-3 and Figure B-17;** above).

Size Class II and III abundance in the lower and middle mainstem were higher in the years 1997−1999 than later, with relatively low densities from 2000 until 2010 and 2007 having the lowest densities in the last 14 years (**Figure 23** below). Densities increased in 2010 due to faster YOY growth rate.

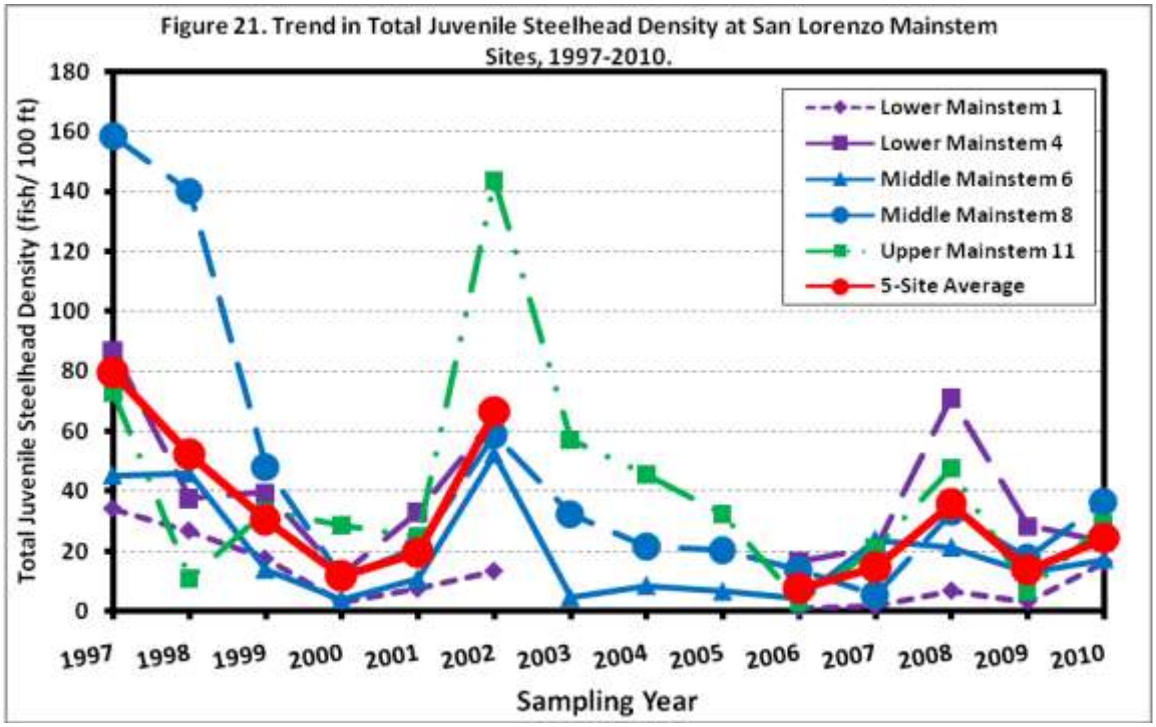


Figure 21. Trend in Total Juvenile Steelhead Density at San Lorenzo Mainstem Sites, 1997-2010.

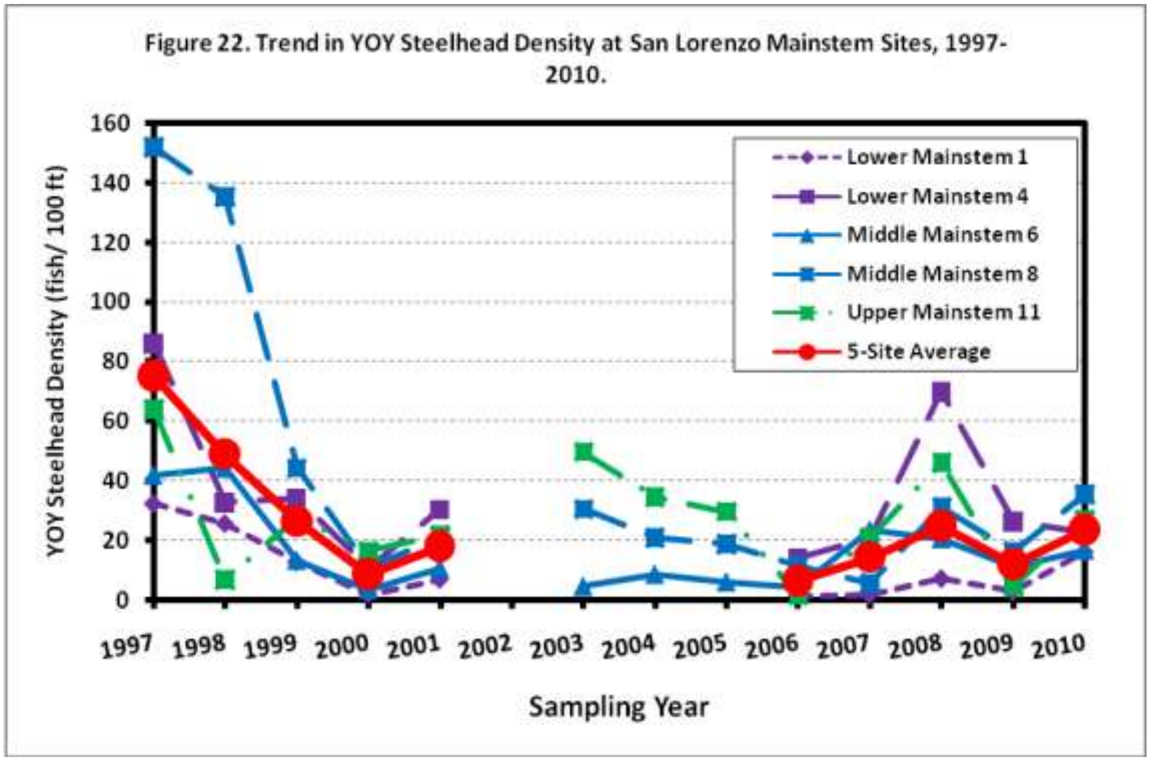


Figure 22. Trend in YOY Steelhead Density at San Lorenzo Mainstem Sites, 1997-2010.

Figure 23. Trend in Size Class II/III Juvenile Steelhead at San Lorenzo Mainstrem Sites, 1997-2010.

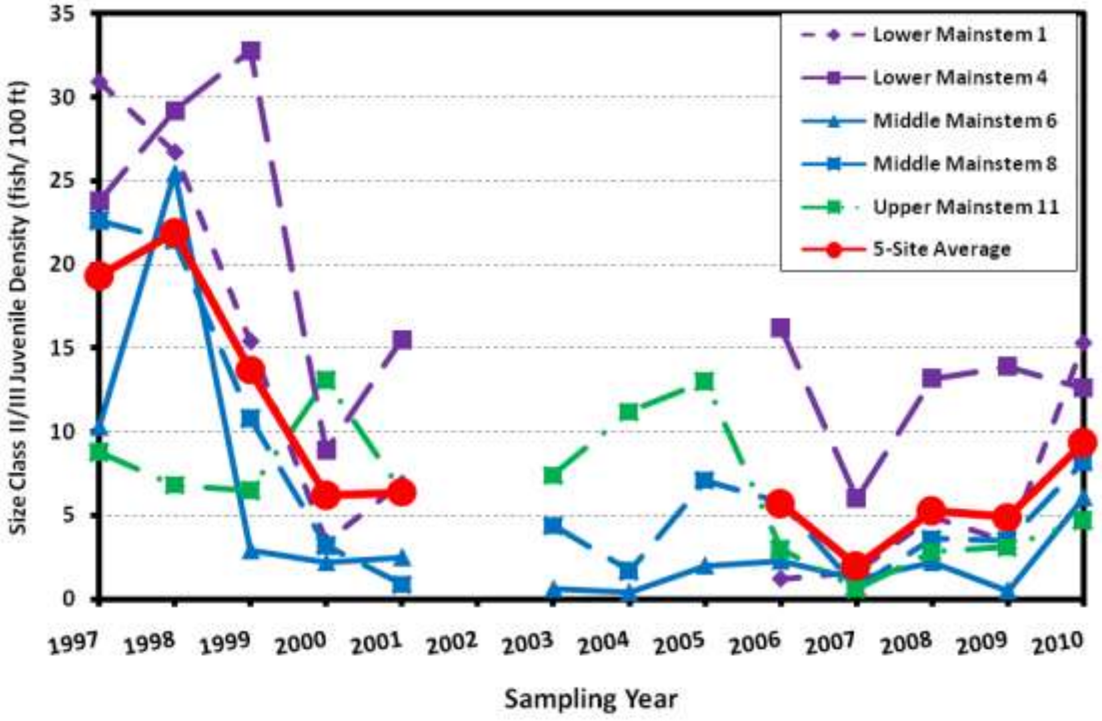
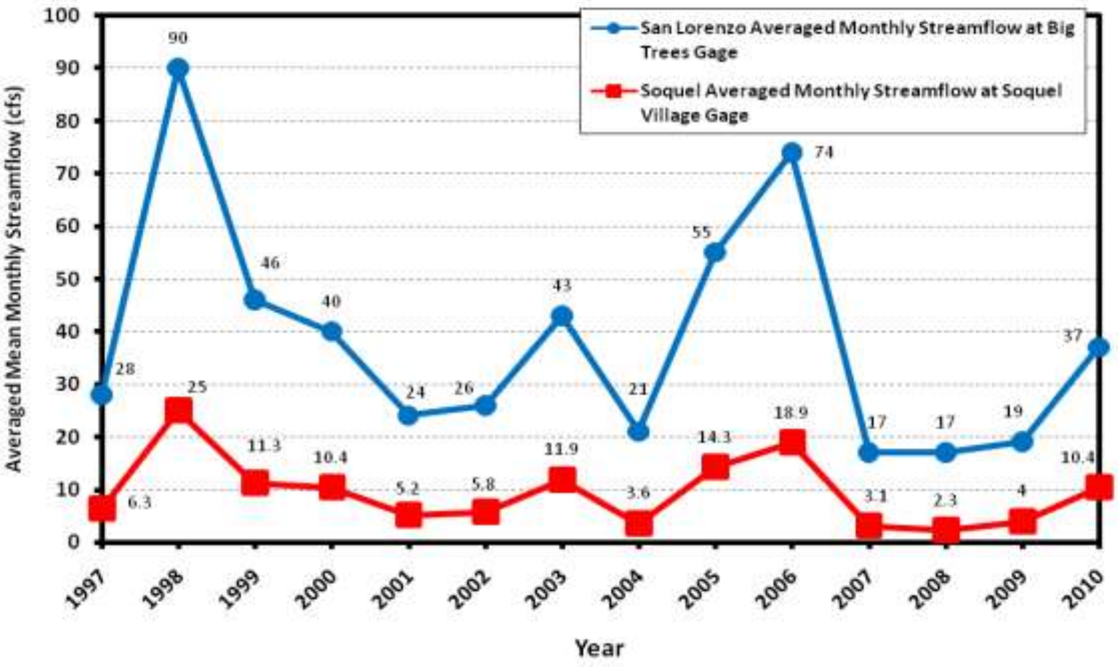


Figure 52. Averaged Mean Monthly Streamflow for May – September in the San Lorenzo and Soquel Watersheds, 1997-2010.



Habitat Trends in the Lower Mainstem Reach 2

In the lower mainstem (downstream of the Zayante Creek confluence) habitat conditions in Reach 2 (in the Rincon area below the gorge and the Felton water diversion) were analyzed in detail in 1999─2000 and 2007−2010, with no habitat typing in the years between. 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. Riffle habitat conditions have worsened in Reach 2 between 1999 and 2010 primarily due to shallower conditions with much less escape cover. Riffle depth has been fairly constant in 2007−2010 but much shallower than in 2000 (**Figure B-42** below). Part of the difference may be the above median baseflows in 2000 than in the 3 dry years and median year of 2010 (**Appendix E**). Some deeper runs of recent years may have been classified as riffles in 2000 with higher flows, as well. However, the deeper riffle conditions indicated by the graph for 2000 are likely real. Escape cover in riffles has also declined substantially since 1999 and 2000, which may be partially explained by higher baseflows in the earlier years (**Figure B-43** below). However, with nearly 5 times the escape cover measured in 1999 compared to 2010, conditions were certainly better in 1999. Percent embeddedness has increased significantly since 2007 while percent fines have remained similarly low (**Figures B-44 and B-45** below).

Figure 42. Trend in Averaged Maximum and Mean Riffle Depth in Reach 2 of the Lower Mainstem San Lorenzo River, 2000 and 2007-2010.

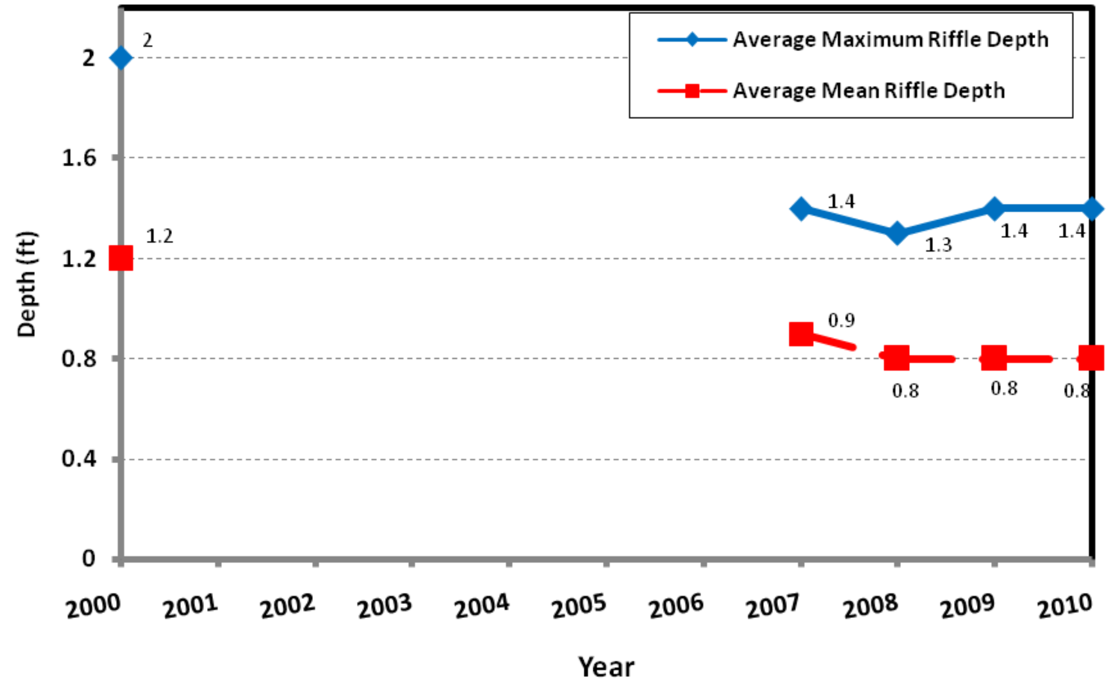


Figure 43. Trend in Escape Cover Index for Reach 2 Riffles in the Lower Mainstem San Lorenzo River, 1999-2000 and 2007-2010.

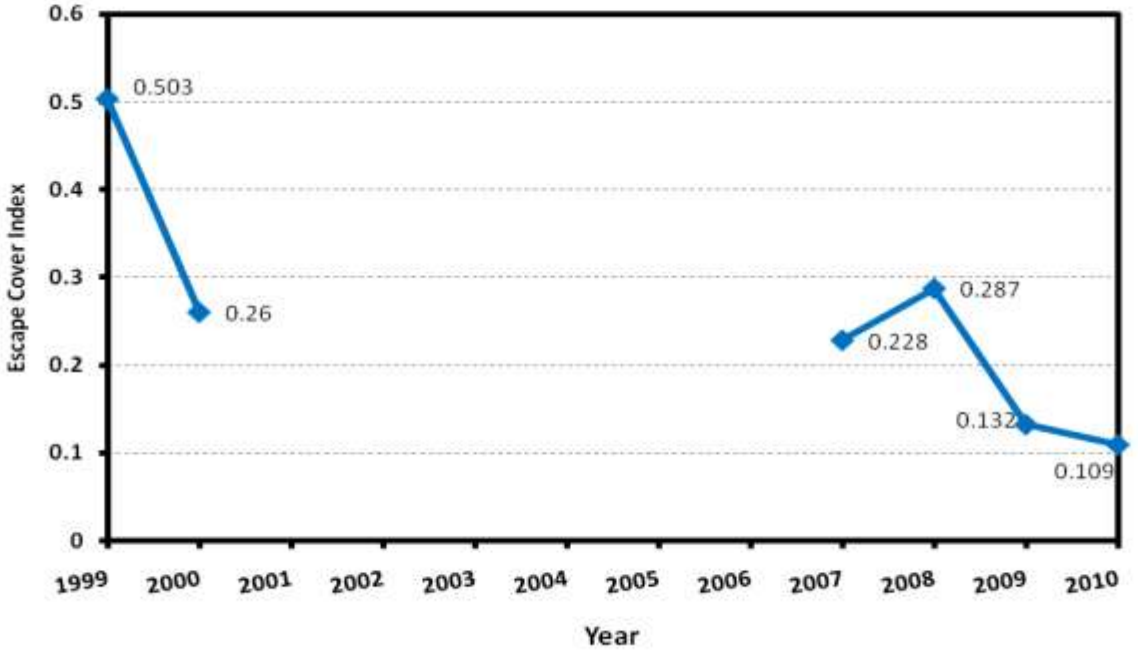


Figure 44. Trend in Average Percent Fines for Riffles in Reach 2 of the Mainstem San Lorenzo River, 2000 and 2007-2010.

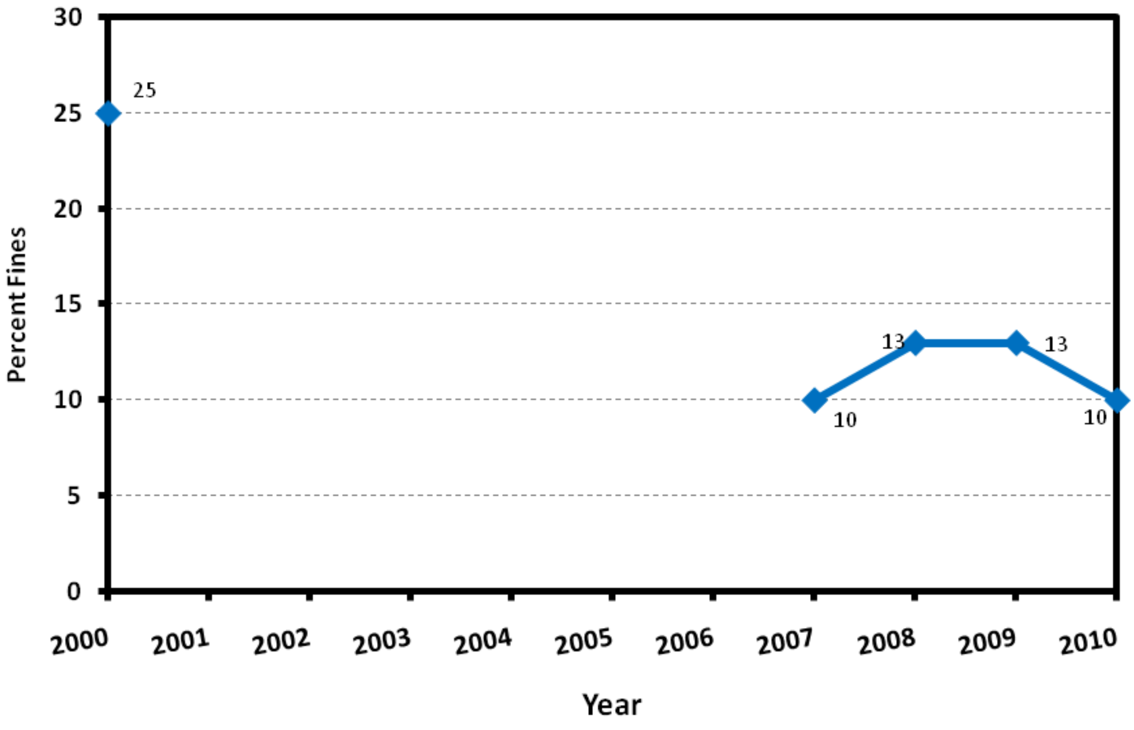
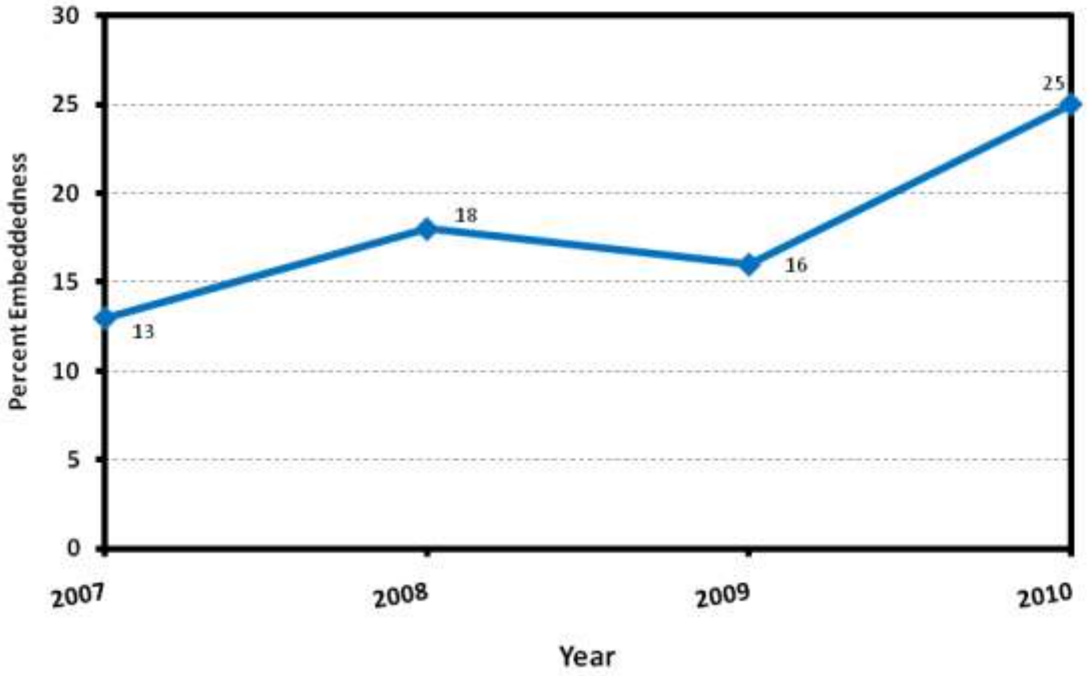


Figure 45. Trend in Average Percent Embeddedness for Riffles in Reach 2 of the Mainstem San Lorenzo River, 2007-2010.



Recommendations for Improved Habitat in the Mainstem of the San Lorenzo River

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, Fall, Bear and Boulder creeks, to seed the mainstem more heavily with YOY that may grow more quickly in the mainstem, downstream of the Boulder Creek confluence. The quality of adult spawning and juvenile rearing 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 for percolation into the groundwater, especially in Scotts Valley, 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. Capture of a portion of high winter flows for groundwater injection and aquifer recharge may improve spring and summer baseflow to increase YOY steelhead growth rates and smolt abundance.

The lagoon has great potential to raise many large juveniles with high survival rate to adult spawner. Steelhead abundance in the stream habitat sampled in 2010, with higher summer-fall baseflow immediately above the lagoon/estuary (approximately 8-10 cfs), was much higher than in 2009 when summer-fall baseflow was low (approximately 1 cfs). Based on our experience in Soquel Lagoon, after the sandbar is formed during the dry season, with sufficient baseflow the saline layer on the bottom is flushed out to convert the lagoon to freshwater. Removal of the saline layer promotes good water quality and excellent steelhead nursery habitat. After the lagoon converts to freshwater, baseflow may be relatively low to maintain a healthy lagoon. After the sandbar forms, artificial breaching should be avoided to prevent saltwater from entering and being trapped in the lagoon. Saline water that enters after breaching will form a stagnant layer on the bottom. Then temperature and oxygen stratification occurs, and the entire lagoon's water temperature escalates with anoxic conditions developing in the saline layer. Juvenile steelhead are forced higher in the water column where bird predation increases. Individuals who artificially breach the sandbar should be prosecuted.

Trend Analysis−Juvenile Steelhead Abundance and Habitat for San Lorenzo Tributaries

Most of the juvenile population in tributaries and the upper mainstem (above the Boulder Creek confluence as represented by Reach 11) consists of YOY juveniles. In these reaches, YOY abundance is 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, there was a general decline in total and YOY abundance from 1997 to 2000, with a general increase from 2000 to 2003, followed by a general decline from 2003 to 2007, a rebound in 2008 followed by an overall decline in 2009 that continued in 2010 at Zayante sites but not others which rebounded slightly (**Figures B-24 and B-25**). The extremely high juvenile density measured in 2002 at Site 11 by HTH (**2003**) seemed highly unusual, considering our 16 other years of sampling experience with Reach 11 in the upper mainstem. 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 densities at Site 14c in upper Bean Creek fluctuated the most. Baseflow in this reach is likely strongly influenced by local well pumping. During 2003–2009, 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 site was dry and prevented YOY recruitment. YOY densities rebounded at Site 14b in 2010, with more wetted channel in Reach 14c above.

YOY density at Site 13c in Zayante Creek annually fluctuated up and down and had the greatest steelhead abundance in the watershed in 2008−2010 resulting from high YOY abundance. Site 13d on Zayante Creek declined significantly in YOY and total densities in 2007, with its 2007 densities the second lowest in 14 years. However, it rebounded in 2008 and declined somewhat in 2009 and 2010. 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 was modified in 2008. The 2009 and 2010 sampling sites were above this modified boulder cluster.

YOY densities in San Lorenzo tributaries may be relatively higher in years like 1997 and 2002 (**Figure B-25** below) because of no large, late storms but sufficient smaller late storms to promote spawning through the winter and spring. YOY densities in tributaries 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 (**Appendix E**). 1999 had relatively large stormflows in April and May that may have reduced YOY survival, which may have also been the case in 2006, 2009 and 2010. 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 small 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. These smolts would have contributed to the 2000 adult return. 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 (**Appendix E**). 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 (**Appendix E**). The year 2007 had only very small storms in January, providing limited access to tributaries and only two moderate stormflows in March, providing access and flows conducive to spawning in tributaries (**Appendix E**). Limited stormflows likely limited spawning effort in tributaries. Egg survival was likely good but competition for food associated with low baseflow in April−May likely reduced YOY survival in 2007. The low 2009 YOY densities likely had four causal factors involved, including 1) fewer spawners after 3 previous years with poor ocean conditions and low smolt-sized juvenile abundance in 2006, 2) low spawning flows in early winter, 3) followed by the principle stormflows occurring later in the winter/early spring in a short time frame to scour previous redds and wash away emerging YOY, 4) but a below-average baseflow in late spring to limit rearing habitat (**Hydrograph** at beginning of summary report). The continued low YOY abundance in 2010 had three likely causal factors, including 1) likely few spawners after previous poor ocean conditions affecting smolts that would return as adults, 2) likely poor lagoon production of smolts due to poor water quality in 2007 after insufficient stream inflow to convert it to freshwater and 3) low YOY survival during late stormflows occurring into April (**Hydrograph** at beginning of summary report). However, YOY densities rebounded in 2010 with relatively high spring baseflow to stimulate YOY growth and survival after the rainy season as indicated by increased averaged mean monthly streamflow for May−September 2010 after 3 previous dry years (**Figure B-52** above). Despite high spring baseflow, summer baseflow declined rapidly to median levels because of the 3 antecedent dry years still affecting water tables and baseflow.

Tributary abundance of larger Size Class II and III juveniles in fall (almost entirely yearlings except in years with high spring baseflow) is determined mainly by 1) YOY abundance the previous year, 2) over-wintering survival from the previous winter, 3) growth rate in spring that may allow early smolting of yearlings their first spring while allowing some YOY to reach Size Class II and 4) rearing habitat quality through the summer that affects survival.

Tributary abundance of Size Class II and III (smolt size) showed no general trend, though as a group their annual average density was relatively low in 2007−2009 at mainstem and tributary sites (**Figures B-23** above **and B-26** below). Years that had overall low tributary site densities of larger juveniles were 2001, 2004, 2007─2009, all of which had relatively low averaged mean monthly streamflow for May−September over the last 14 years and below the median daily flow for the years of record (**Figure B-52** above and **Appendix E**). After wetter winters, densities of larger juveniles generally increased the most, as occurred in 1999, 2003, 2005 and 2006. Densities were similar between 1997 and 1998 but generally increased in 1999 to a 14-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 (3,200 cfs), and it continued to rain through April for a relatively wet winter but without creating bankfull flow intensity (2,800– 4,300 cfs at Big Trees gage; (**Alley 1999a**)) to move sediment and scour redds (**Appendix E**). Spring and summer baseflow in 1999 was above the median (**Appendix E**). The averaged mean monthly streamflow for May−September was intermediate for the last 13 years (**Figure B-25** below). Densities of these larger juveniles declined at all sites under consideration in the drier years of 2007─2008 except for upper Zayante Creek #13d, which increased in 2008 to the highest in the watershed. In 2009, densities increased at some tributary sites and continued to plummet at others during a third consecutive dry year, remaining low on average. They and rebounded in 2010 at mainstem and tributary sites due to faster growth of more YOY to Size Class II resulting from high spring baseflow and near median baseflow soon after.

When one takes a less detailed look at the changes in larger juvenile densities at tributary sites, there has been little overall change except in 2007─2009. In these 3 dry years, they mostly declined substantially, compared to earlier years. If adult returns are to substantially improve, densities of these larger, soon to smolt, juveniles must greatly increase from much improved tributary habitat quality.

Habitat Trends in Relation to Size Class II/III Abundance in Zayante Reach 13d, an Eastern Tributary Reach of the San Lorenzo River

Annual trends in Size Class II and III densities at the upper Zayante Site 13d (**Figure B-24** below) did not correlate well with changes in reach-wide pool depth for the years of available data (**Figure B-46** below). However, no reach data were available for drier years of 2001, 2002 or 2004. Changes in large juvenile fish density were associated with changes in sampling site escape cover in pools until densities began to level out for 2004−2009 (except for a blip in 2008), despite reduced escape cover from 2006 onward (***Table 12b*** *in Appendix B* **and Alley 2010b**). They may have remained constant because of higher baseflow in 2006 and higher over-winter survival in 2007─2009 after mild winters. However, reduced large juvenile abundance was correlated with the halving of pool escape cover in 2010. Densities increased in 2008 as escape cover remained similar to 2007 at Site 13d but declined somewhat despite increased escape cover in 2009. Density changes also coincided well with changes in reach-wide escape cover in 1998–2000 and 2003 and 2010 (**Figure B-47** below). 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 B-48** below). Reduced Size Class II and III abundance at Site 13d was correlated with increased step-run embeddedness in 2010 (**Figure B-49** below). Step-run embeddedness had remained similar in 2005−2009 and was substantially higher in 2010 (51%) than in 2003 (33%), indicating a trend in more highly sedimented conditions.

Habitat Trends in Relation to Size Class II/III Abundance in Boulder Reach 17a, a Western Tributary Reach of the San Lorenzo River

Analysis of continued reach-wide habitat change with associated change in Size Class II and III abundance in the important western tributary reach, Boulder Creek, was not possible in 2010 because no habitat typing was done there. Trend in habitat change through 2009 may be found in **Alley 2010b**.

Annual trends in density of Size Class II and III juveniles at the lower Boulder Creek Site 17a were correlated with reach-wide changes in pool depth for most years of data (1998–2000 and 2005–2008) until 2009 when smolt densities remained low despite increased pool depth (***Table 6a*** *in Appendix B*; **Figure B-26** below). In 2010, Size Class II and III abundance rebounded with deeper pools and more escape cover at Site 17a compared to 2009 (***Tables 6b and 12b*** *in Appendix B*). This may be because a higher percent of YOY reached this size class in 2010 (54%) compared to 2009 (14%) (**Figure B-17** above). Changes in potential smolt density were not well correlated with changes in escape cover in sampled pools or with reach-wide changes in pool escape cover prior to 2010 (**Alley 2010b**). 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 Size Class II and III 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 at times positively correlated with increased percent fines in step-runs, though percent fines did not increase substantially except from 1998 to 1999 (**Alley 2010b**). This is the opposite of what was expected because increase in 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 24. Trend in Total Juvenile Steelhead Density at San Lorenzo Tributary Sites, 1997-2010.

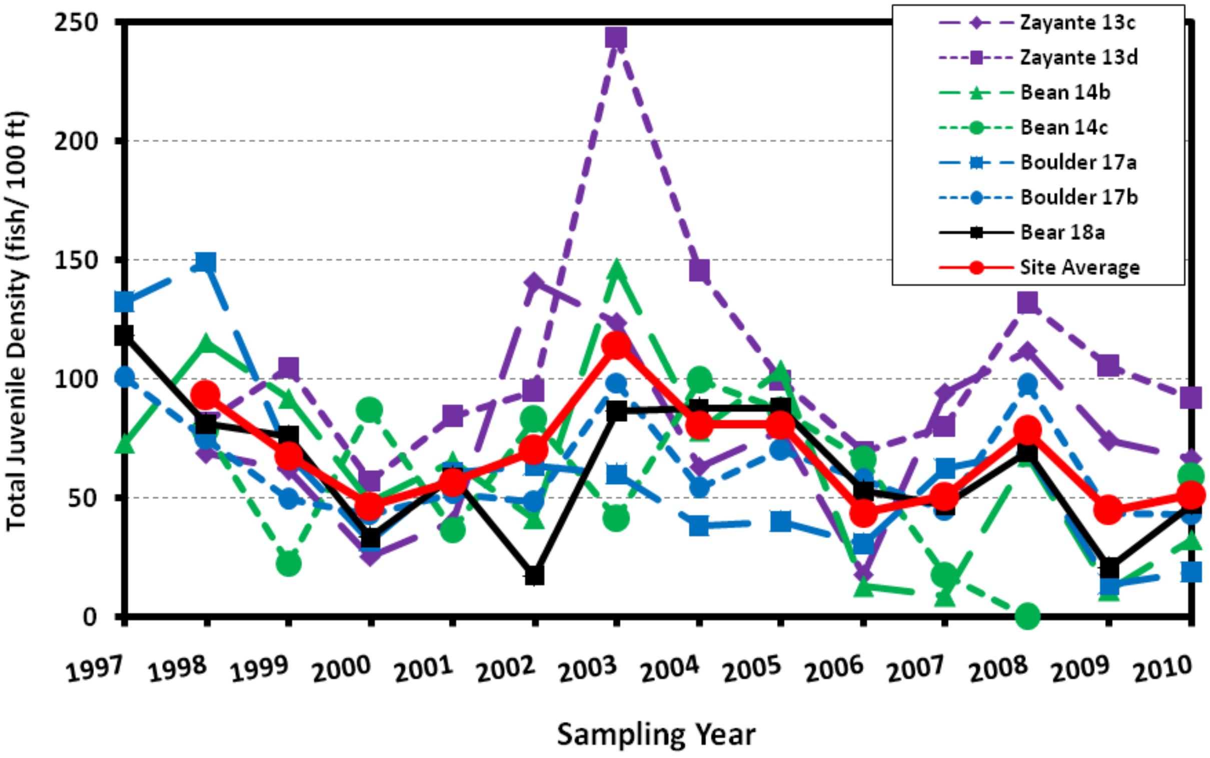


Figure 25. Trend in YOY Steelhead Density at San Lorenzo Tributary Sites, 1997-2010.

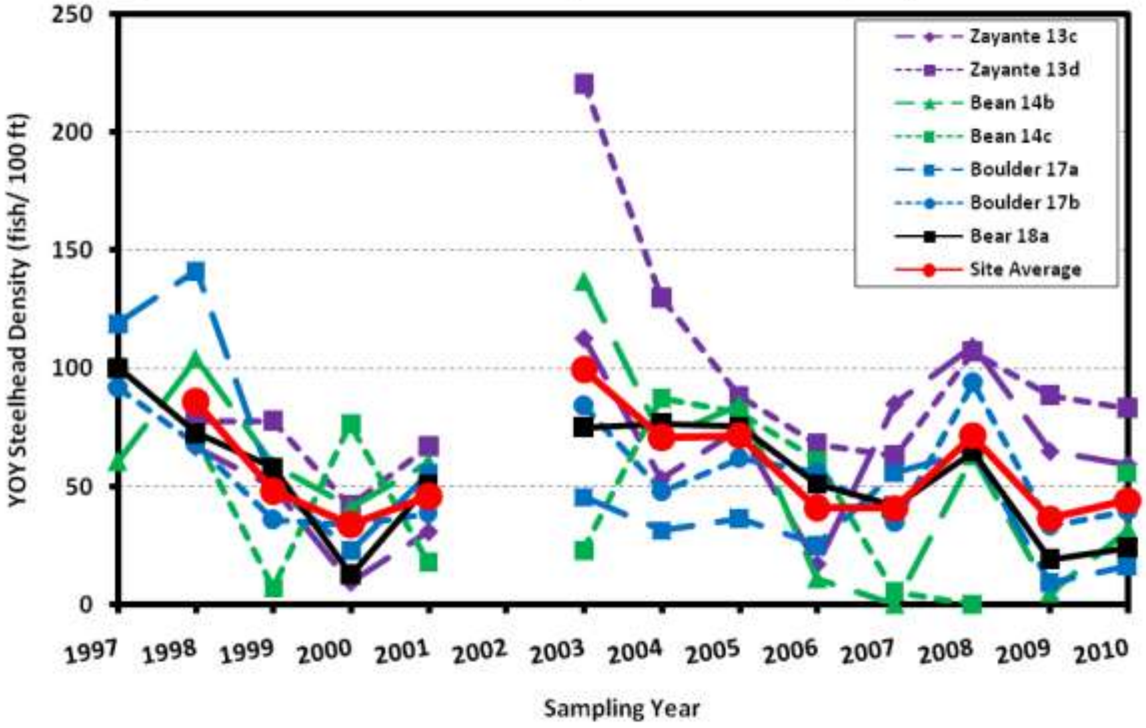


Figure 26. Trend in Size Class II/III Juveniles Steelhead Density at San Lorenzo Tributary Sites, 1997-2010.

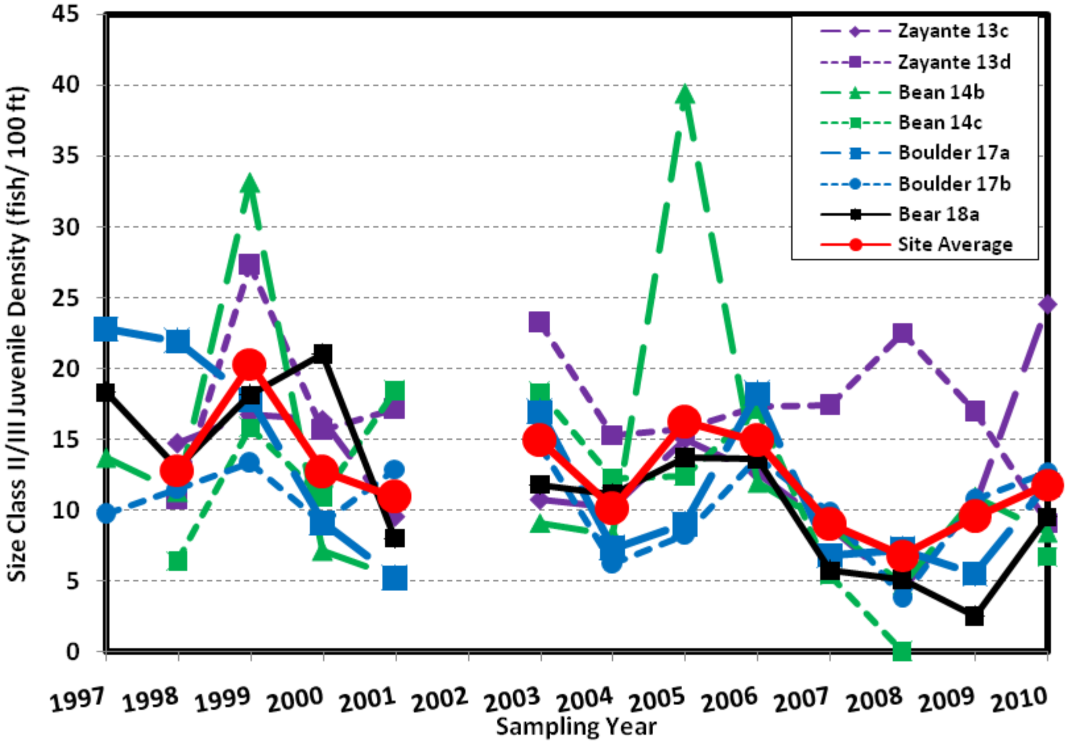


Figure 46. Trend in Averaged Maximum and Mean Pool Depth in Reach 13d of Zayante Creek.

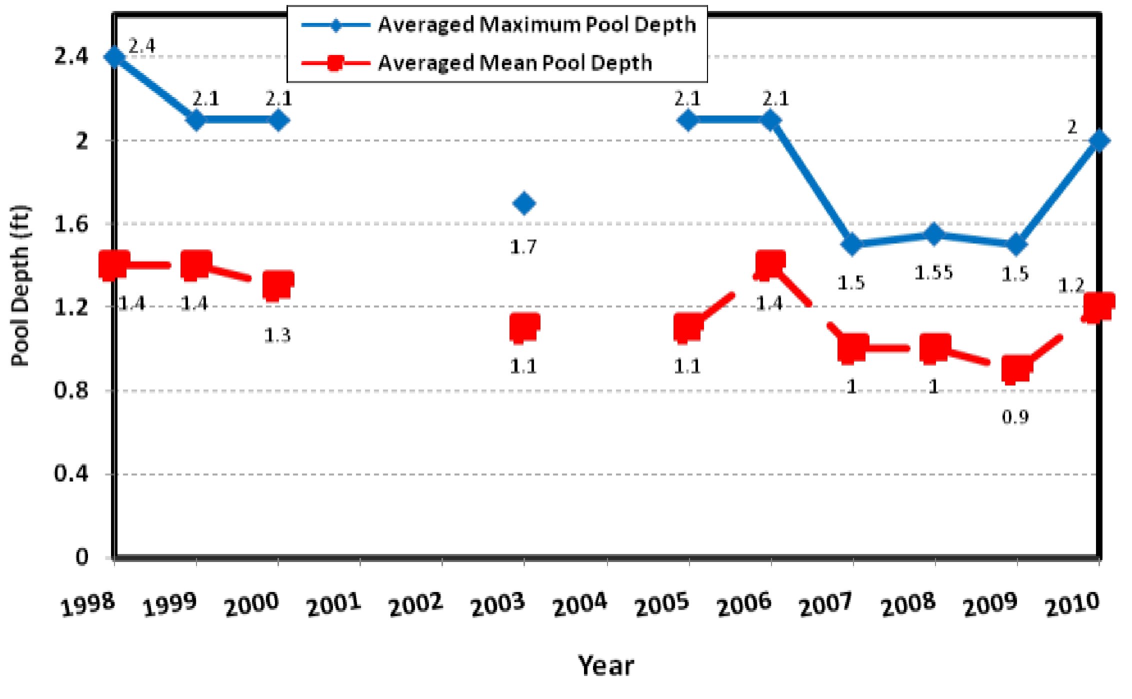


Figure 47. Trend in Pool Escape Cover Index for Zayante Creek Reach 13d.

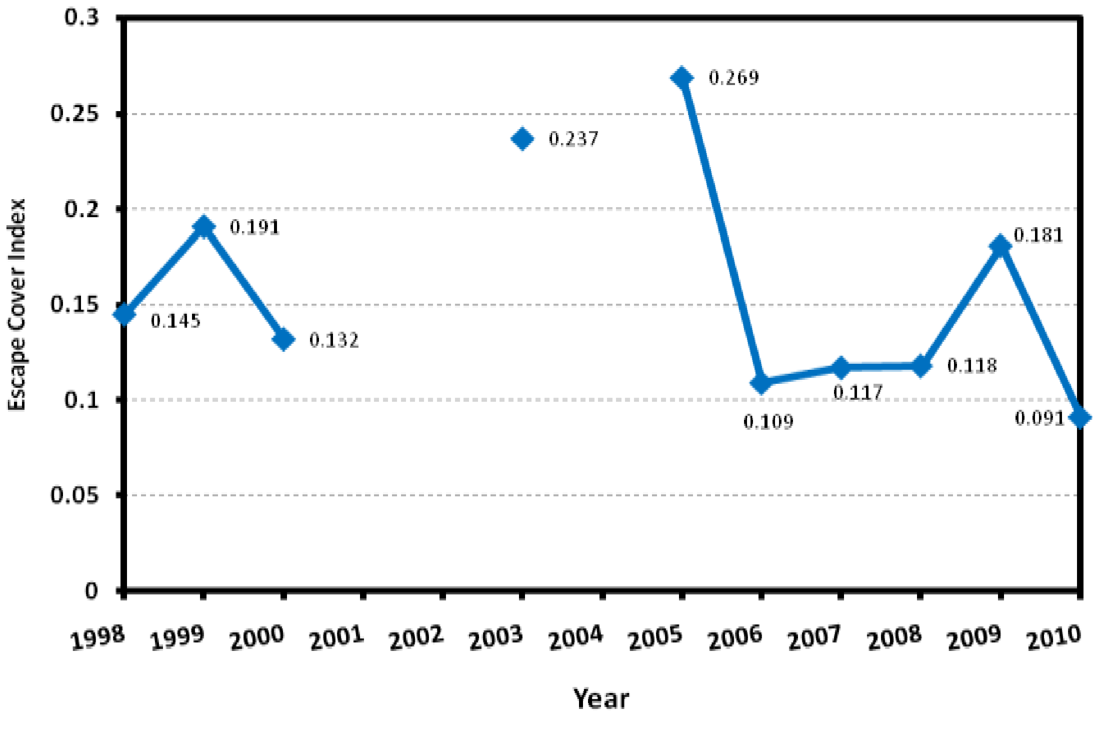


Figure 48. Trend in Average Percent Fines in Step-Runs of Zayante Reach 13d.

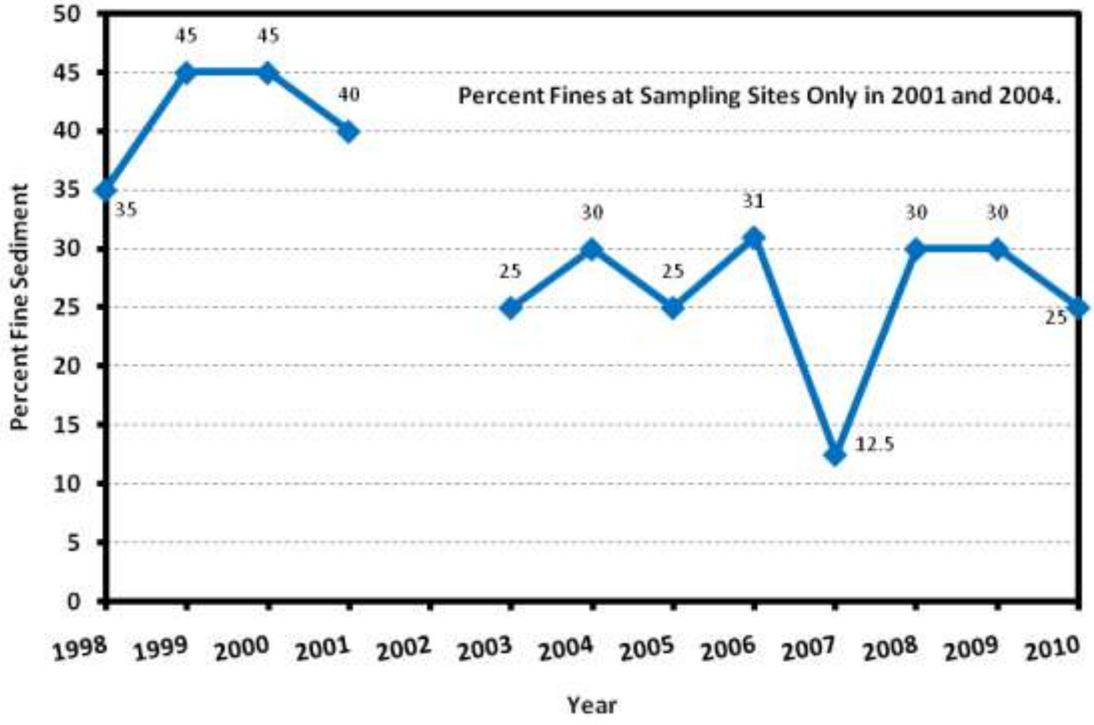
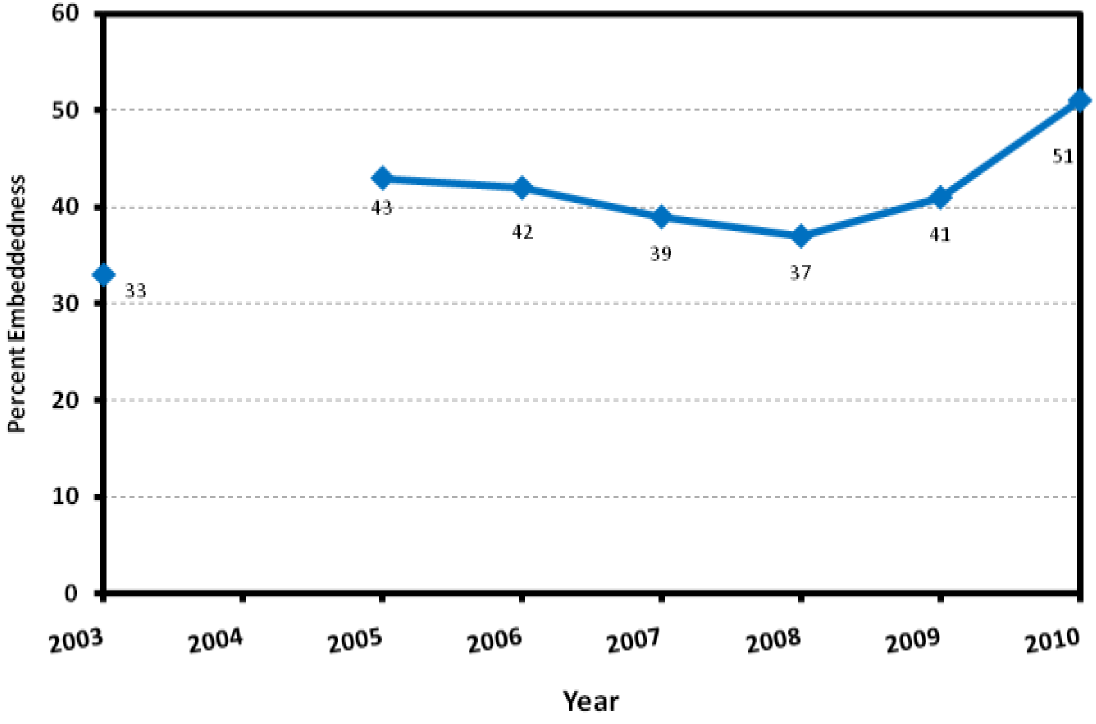

Percent Fines at Sampling Sites Only in 2001 and 2004.

Figure 49. Trend in Run/Step-run Embeddedness in Zayante Creek Reach 13d.



Recommendations for Improved Habitat in San Lorenzo Tributaries

Reduced abundance of yearlings occurred at most tributary sites in 2010 after a winter with more stormflow than the 3 previous mild winters. This was likely caused partially by low YOY recruitment into the yearling age class from low YOY abundance in 2009. Another likely cause was poor overwinter survival of yearlings. Yearling survival would improve with retention of more large, in-channel wood to provide shelter during near-bankfull stormflows. More in-channel wood would better sort spawning gravel, provide more scour objects to deepen pools and create more escape cover for larger juveniles during the rearing season. Better retention and percolation of storm runoff, especially in Scotts Valley, will also increase winter recharge of aquifers to increase spring and early summer baseflow, which will increase YOY steelhead growth into Size Classes II and III in the lower mainstem. Capturing of a portion of high winter flows and injection into groundwater aquifers for recharge may improve spring and early summer baseflow to improve steelhead growth rates in tributaries. Reduced summer well pumping with better winter water retention and storage will prevent dewatering of the stream channel in drier years and protect valuable steelhead and coho salmon rearing habitat.

Bear Creek has experienced considerable decline in YOY abundance in 2009 and 2010 with very low yearling abundance for 2006−2010. A passage impediment for adult spawners may exist somewhere downstream of the Hopkins Gulch confluence. This section should be surveyed to the creekmouth to assess adult passage. Retention of more instream wood in Bear Creek would likely improve overwinter survival of yearlings and provide more escape cover during other times. Many bedrock pools have very limited escape cover in Bear Creek Reach 18a, and the overall escape cover index is much below Fall Creek levels where much more instream wood is present (***Table 12a*** *in Appendix B*). With more in-channel wood and better adult passage, Bear Creek may develop improved steelhead abundance.

Upper Bean Creek Reach 14c had relatively high YOY abundance in 2010 despite very low baseflow (0.02 cfs in September) after an above median spring baseflow in the watershed. This implies that the reach is more heavily used by spawning adults than many tributary reaches. Yearling abundance was very low in 2010, likely because YOY recruitment was low from 2009, when much of the reach was likely dry. The reach above MacKenzie Creek confluence was mostly dewatered in 2007 and 2008 and 2009 (**C. Berry pers. comm. 2011**). Prior to 2007, extremely low baseflow and dewatering upstream of the MacKenzie Creek confluence was not observed. During the years 1999−2004, when annual baseflow was above median or baseflow of the immediately antecedent year was above median, yearling densities in this reach were relatively moderate to high for tributary sites (***Table 24*** *in Appendix B*). Low baseflow and dewatered portions imply reduced steelhead survival due to localized well pumping. If better water conservation measures were implemented, steelhead survival and abundance would likely improve. Educational outreach to capture and store more winter rains and reduce summer groundwater pumping should be directed to streamside landowners and nearby vintners, thus insuring year round surface flow in this important steelhead and potential coho reach.

YOY abundance **in Fall Creek** has been below average in 2009 and 2010, indicating possibly limited adult spawning access and/or poor egg survival. A large Douglas fir trunk spans the creek downstream of the bridge that may impede adult passage. The lowermost of a series of weirs at the San Lorenzo Valley Water District water diversion may also be a passage impediment. Larger than typical steelhead were captured upstream in this heavily shaded stream where growth rate is low. These factors imply that the salmonid population has a significant resident component resulting from poor steelhead access. Improved passage over the downed Douglas fir and the downstream weir may ultimately improve YOY and yearling abundance. The Douglas fir log could be notched, and an additional hydraulic control (perhaps cabled boulders) could be placed downstream of the weir in a bedrock section to improve passage. Others have observed that there is water leakage at the lowermost weir, which should be repaired.

Wide annual fluctuations in YOY abundance have occurred in **Lompico Creek**, sometimes out of synch with other tributary sites (***Table 23*** *in Appendix B*). This implies that passage for adult spawners may be problematic, and few adults may successfully spawn in this small tributary. Improved passage conditions 1) at the fish ladder (better water deflection into the ladder and better weir baffling design which would make it more self-cleaning), 2) in the bedrock section immediately above the fish ladder (deeper jump pools in the bedrock section) and 3) at the abandoned flashboard dam spillway (remove it) downstream of the sampling site may improve spawning access, YOY production and ultimately yearling abundance. Consistently higher YOY production in Lompico Creek will aide in seeding Zayante Creek with YOY where rearing habitat is better.

Trend Analysis−Juvenile Steelhead Abundance and Habitat for Mainstem Soquel Creek

At 4 mainstem sites tracked for the past 14 years, annual trends in total and YOY juvenile densities paralleled each other, for the most part (**Figures B-27 and B-28** below). Because the juvenile population in the mainstem is largely YOY, then spawning effort, spawning success and survival of young YOY largely dictate total juvenile densities in these reaches. 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. In drier years with milder winter stormflows (or mostly early stormflows and few late stormflows) and reduced baseflow (as averaged mean monthly streamflow (May–September)), total and YOY juvenile steelhead densities were relatively higher in the Soquel Creek mainstem than in wetter years (Appendix B **Figures 27, 28, 52** below **and Appendix E**). Years with higher densities were 1997, 2002, 2004, 2007 and 2008. However, the drier years of WY2001 and WY2009 did not fit this pattern because, although they were dry, storms came in a short time frame just before and after March 1 with likely few adult spawners (***Figure 54****; Appendix E*).

In these drier years, typically the lagoon population of juveniles is the highest, although 2001 and 2009 did not fit this pattern, likely because of few spawners (**Alley 2010a**). The typical pattern may be explained by assuming that during milder winters, late adult spawners probably have limited access to the upper watershed. They having more shallow riffles and other impediments to pass especially later in the season. Thus, they spawning more 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**).

Figure 27. Trend in Total Juvenile Steelhead Density at Soquel Mainstem Sites, 1997-2010.

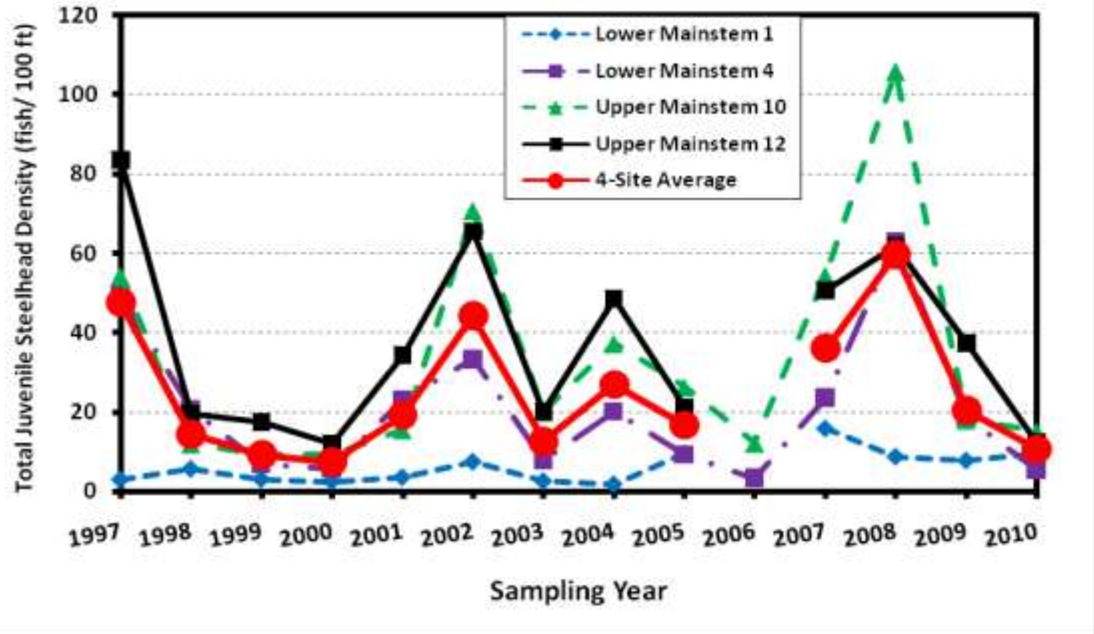


Figure 28. Trend in YOY Steelhead Density at Soque Mainstem Sites, 1997-2010.

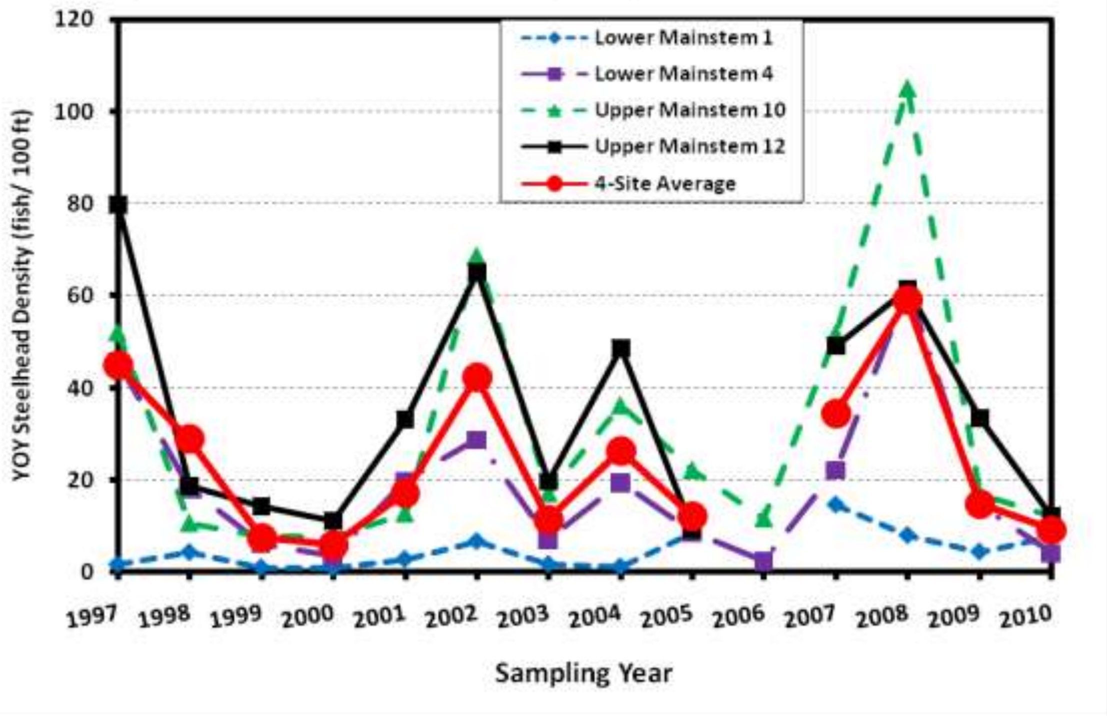
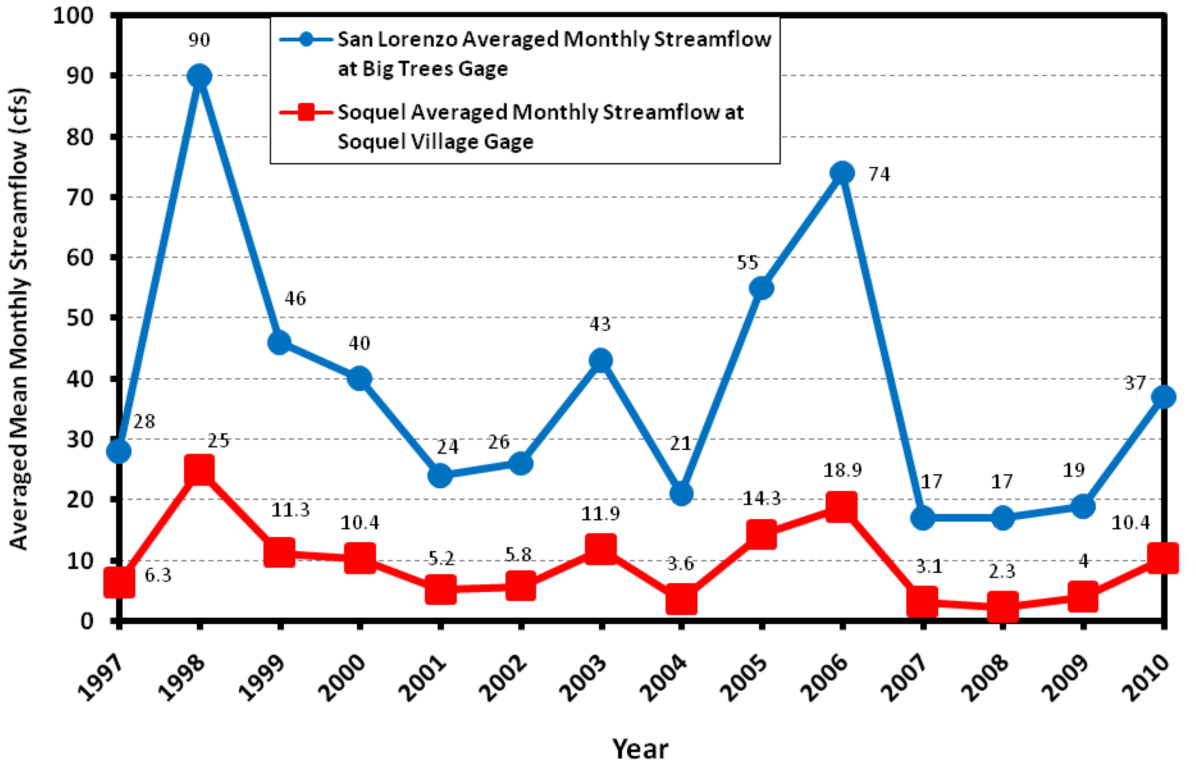


Figure 52. Averaged Mean Monthly Streamflow for May – September in the San Lorenzo and Soquel Watersheds, 1997-2010.



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 in the mainstem, yet relatively high Size Class II densities because a high proportion of YOY reached Size Class II. The wet years of 1998 and 2005 are in this category (**Figure B-29** below). 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 (**Figure B-28** above) (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.

The other year that registered 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 YOY densities in the mainstem, but not as many reached Size Class II as in 1997 (**Figures B-28 and B-29** below). In addition, 1997 had much more escape cover for larger juveniles than 2002, as indicated in Reaches 1 and 7 (**Alley 2010b**). 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**), 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 in 2009, allowing a higher proportion to reach smolt-size the first growing season. We see in 2010 that the Size Class II densities increased at 2 mainstem sites compared to 2009 despite lower or similar YOY densities. This was due to faster YOY growth rates and a higher percent reaching Size Class II in 2010 (**Figure B-18** below).

Changes in habitat conditions in mainstem Reaches 1 and 7 during 1997−2009 were described in **Alley 2010b**. 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. Overall rearing habitat quality declined in Reach 7 since 1997 because of pool-filling by sediment and less escape cover, though pool depth increased and embeddedness in fastwater habitat declined during the 2007─2009 drier years. During the 2002 wood survey, Reaches 1 and 7 had little large, in-channel wood (**Alley 2003b**).

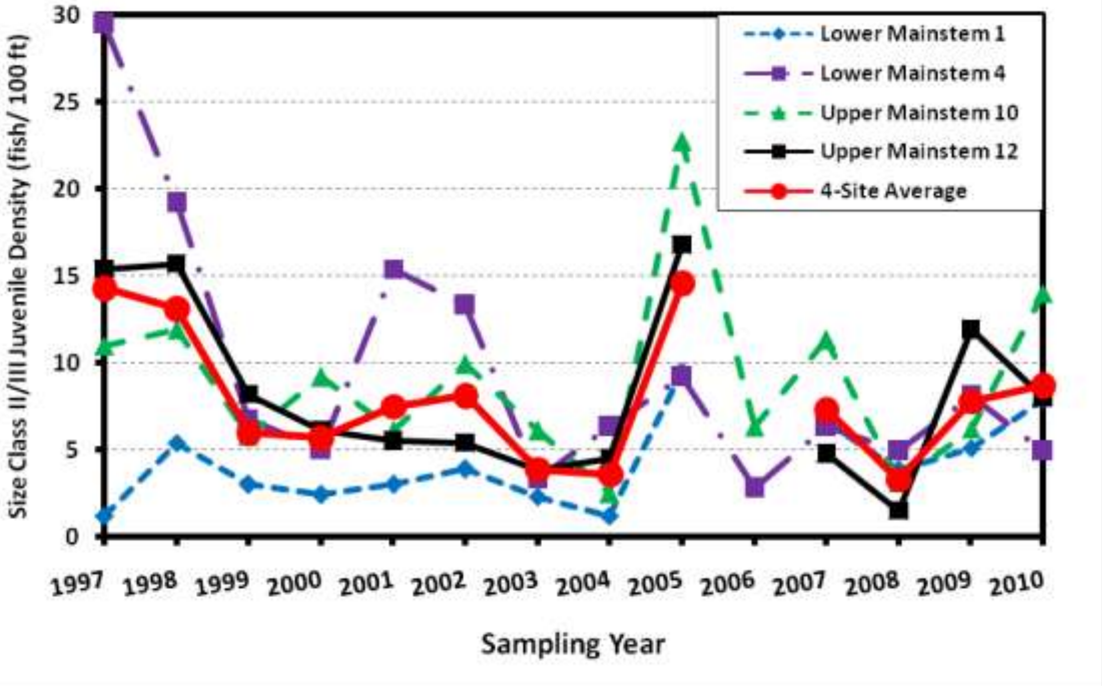


Figure 29. Trend in Size Class II/III Juvenile Steelhead at Soquel Mainstrem Sites, 1997-2010.

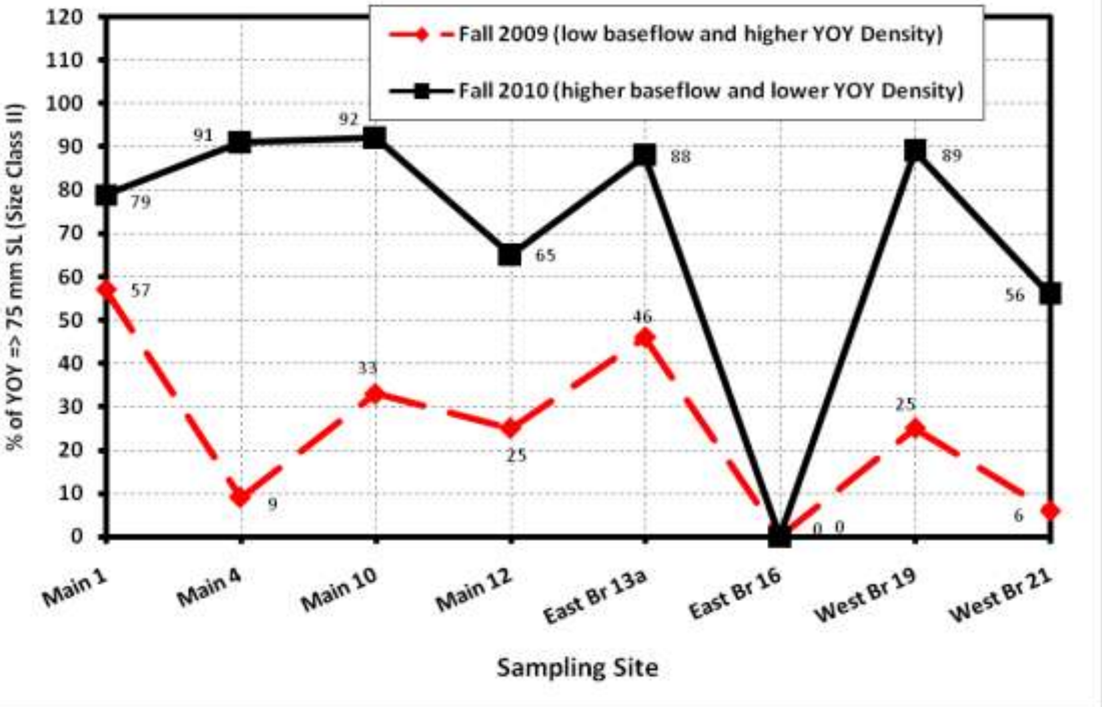


Figure 18. Percent of Young-of-the-Year Steelhead in Size Class II (=>75 mm SL) at Soquel Creek Sites in 2009 and 2010.

Recommendations for Improved Habitat in Mainstem Soquel Creek

Because the juvenile population in the mainstem is largely YOY, then spawning effort, spawning success, survival of young YOY and the level of spring and early summer baseflow affecting YOY growth rate largely dictate Size Class II abundance in these reaches. In-channel wood is scarce (**Alley 2003**) and yearling abundance is low, indicating low overwinter survival. In wetter winters when large stormflows come after March 1, YOY abundance is reduced due to presumed poor egg survival. Enhancement of habitat would include much greater retention of in-channel wood to better sort gravel and reduce armoring in a highly sand-laden channel, dissipate energy during high stormflow to reduce scour of spawning redds and improve overwinter survival of yearlings. With much more in-channel wood, the relationship between pool escape cover and Size Class II abundance may become stronger. Other enhancement entails better water management/ conservation and reduced summer water diversion/pumpage to maximize spring and early summer baseflow, especially below the Moores Gulch confluence. Educational outreach to capture and store more winter rains should be directed to streamside landowners, agriculturalists and nurseries. The goal is to reduce late spring/summer groundwater pumping and water diversion. Higher baseflow will maximize the percent of YOY steelhead reaching Size Class II the first growing season and ultimately increase adult returns.

Trend Analysis−Juvenile Steelhead Abundance 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. After intermediate to wetter winters, a proportion of YOY at Site 13a commonly reach Size Class II in one growing season.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 30 and 31** below). After reaching a 14-year high in 2004, total and YOY densities in the lower East Branch 13a declined in 2005 and then to almost zero in 2006 but rebounded in 2007 and 2008. As was the pattern at other downstream sites in 2009, total and YOY densities declined at Site 13a. Unlike at most downstream sites in 2010, YOY densities increased somewhat. 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 than in 2007. However, YOY density declined at Site 16 in 2010 despite better spawning access during a wetter winter, perhaps because of fewer adult spawners and late spring storms that reduced egg survival. 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 Reach 9a, redd (nest) scour or burial in sediment may have been more common in winters with higher stormflows. 2010 YOY density remained relatively low after late spring stormflows. During the instream wood inventory in 2002, this reach was identified as one with small quantities of large instream wood (**Alley 2003b**). A segment of it was again inventoried for wood in 2010. 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 had declined in the lower East Branch Reach 9a from 1997 to 2009, with regard to reduced pool escape cover (**Alley 2010b**). However, other habitat conditions improved with pool depths deepening since 2005, even during drier years with lower baseflows. Run and step-run habitat has improved since 2000 regarding less percent fines, and riffle embeddedness has also improved (lessened) since 2005. 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 B-32** below) were unassociated with changes in pool escape cover at sampling sites except in 2008 and 2010, when densities increased with more escape cover (***Table 15*** *in Appendix B*). Insufficient 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. 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. This was certainly the case in 2010 (**Figure B-18** above).

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 14 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. Highest densities of Size Class II and III juveniles in the lower East Branch occurred in 1998, 2005 and 2010 (**Figure B-32** below), three relatively wet years (especially in spring) (***Figures 70 and 77***; *Appendix E*) with moderate to lower YOY densities (**Figure B-31** below). There had been a steady decline in densities of large juveniles from 1998 to a low in 2004. Higher growth rate during the relatively high spring and summer baseflow years of 1998 and 2005 and at least high spring baseflows in 2010 (***Figures 52 and 57***; *Appendix E*) allowed a high proportion of YOY to reach Size Class II, leading to higher densities of larger juveniles (**Figure 18**; above).

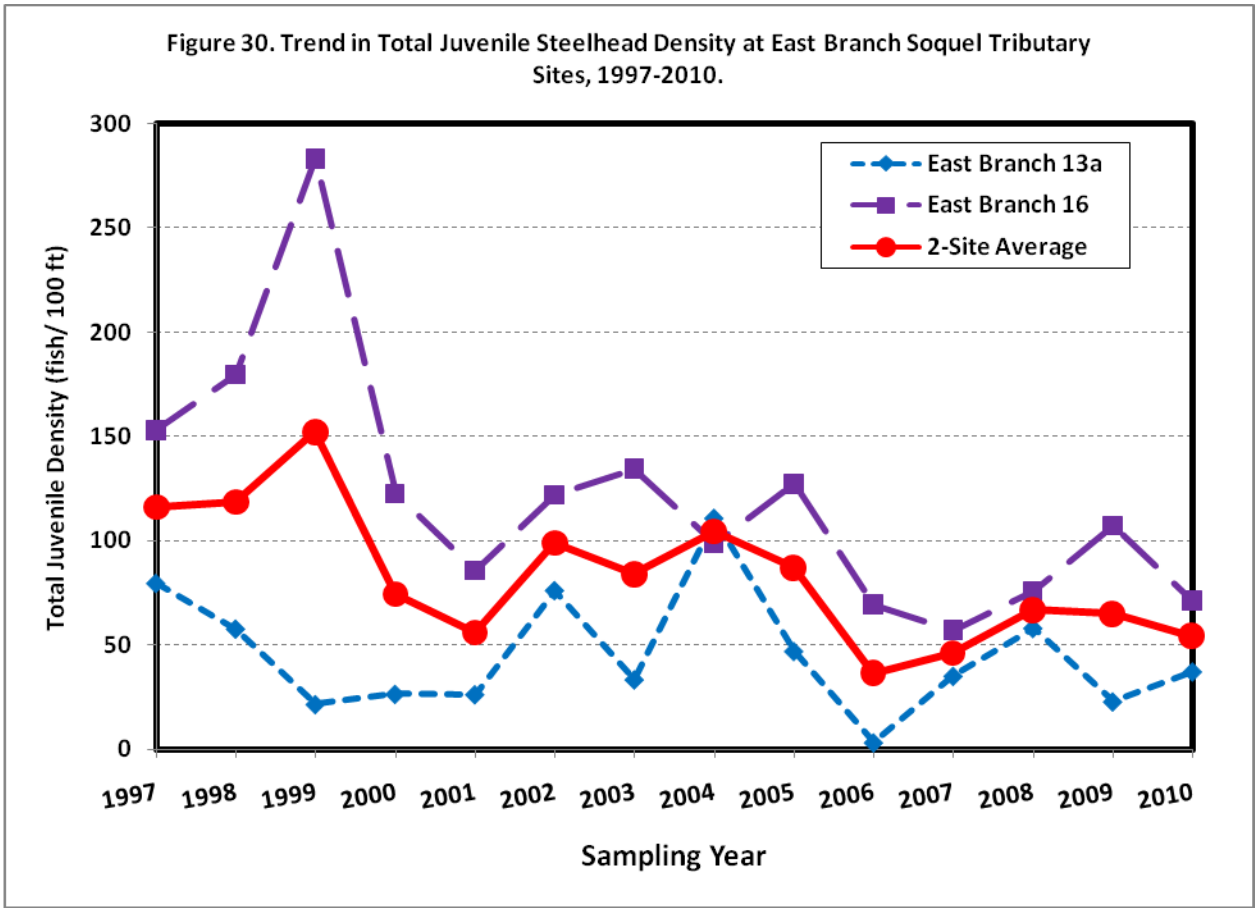


Figure 31. Trend in YOY Steelhead Density at East Branch Soquel Tributary Sites, 1997-2010.

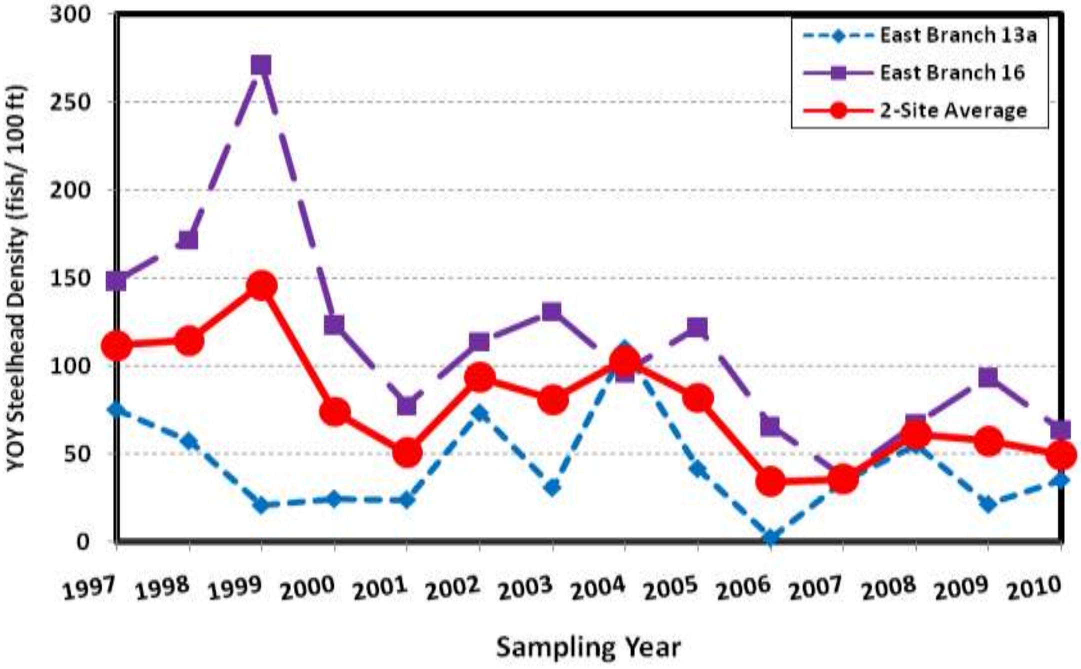
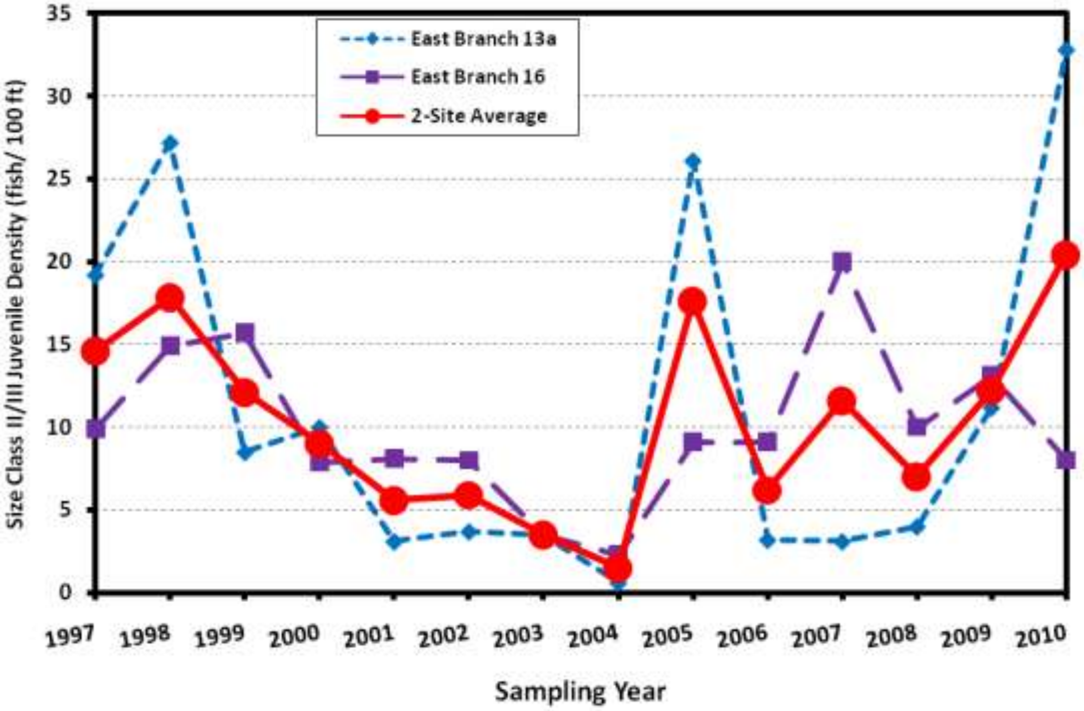


Figure 32. Trend in Size Class II/III Juveniles Steelhead Density at East Branch Soquel Sites, 1997-2010.



In the upper East Branch at Site 16 in the SDSF, abundance 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 B-32** above). The relatively high density of Size Class II and III juveniles (20/ 100 ft) in 2007 was likely due to at least moderate numbers of YOY in 2006 and good over-winter survival of yearlings during a mild winter. However, abundance of yearlings and associated larger juveniles declined substantially in 2008. This was partially due to low recruitment of YOY from 2007 (**Figure B-31** above), poor rearing conditions with very low baseflows and likely a bankfull event during the 2007/2008 winter that flushed some yearlings downstream. Next, Size Class II and III (yearling) abundance increased in 2009 with higher baseflow after the Summit fire of 2008, higher yearling recruitment from high YOY densities in 2008 and a milder winter to allow greater overwinter survival than 2008. Size Class II and III (yearling) abundance declined in 2010 after a much wetter winter that may have flushed yearlings downstream with more than one bankfull event (**Figure B-31** above and ***Table 28*** *in Appendix B*).

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 intermediate summer baseflows) and 2007 (very dry year). Both 1998 and 1999 had sufficient spring baseflows to grow some YOY into Size Class II. The dry 2007 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 (**Sogard et al. 2009**). A segment of Reach 12a was surveyed for wood in 2010 with analysis pending. 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 in 2000−2009 (**Alley 2010b**). 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. 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.

At Site 16 in Reach 12a, annual densities of Size Class II and III juveniles (usually yearlings) were not positively correlated with changes in pool escape cover at sampling sites, except in 2008 and 2009 (**Alley 2010b**). In fact, densities were the lowest in 2004 when pool escape cover at sampling sites was the highest (0.32). Densities increased from 2004 to 2007 despite a decline in pool escape cover at sampling sites. Densities decreased in 2010 despite a doubling of pool escape cover (***Table 15*** *in*

Appendix B). 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. 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. 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. So, in the dry years with mild winters of 2007−2009, the size of the YOY population the previous year is an important factor in determining the yearling density the following year.

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 14 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 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 yearling over-winter survival in intermediate to wetter years may play more important roles in increasing Size Class II and III densities.

Recommendations for Improved Habitat in the East and West Branches of Soquel Creek

There is an apparent disconnect between summer rearing conditions in the existing pool habitat (pool depth and escape cover at existing levels) and Size Class II and III abundance in the lower East Branch 9 below Hinckley Creek and Mill Pond. Their abundance is more dependent on overwinter survival of yearlings and successful spawning and egg survival in years when spring baseflow is sufficient to grow YOY to Size Class II. Good overwinter survival of yearlings would help, but yearling densities have always been low in this reach. Recommendations for habitat improvement would include protection of spring baseflows to promote a high percent of YOY to reach Size Class II. Retention of more in-channel wood would improve overwinter yearling survival and create more pool habitat (usually only about 50% of the habitat length). The pool escape cover index has always been about average in this reach for Soquel Creek in most years, and rearing conditions would benefit considerably from more instream wood (**Alley 2004; 2005; 2010b**).

There is an apparent disconnect between summer rearing conditions in the existing pool habitat (pool depth and escape cover at existing levels) and Size Class II and III abundance in the upper East Branch Reach 12 in the SDSF. Their abundance is more dependent on heavy recruitment of YOY into the yearling class from the previous year and variable overwinter survival of yearlings dependent on size of winter storms. Spawning access may be reduced in winters without bankfull events, and late spring stormflows may greatly reduce egg survival and YOY abundance. This reach seldom has sufficient spring baseflow to grow many YOY into Size Class II. But dry streambed and reduced YOY survival may occur in drier years. Recommended enhancement would involve retention or creation of more in-channel wood to increase overwinter survival of yearlings and to scour out more pool habitat (usually consisting of only about 40% of the habitat length and being shallow) to make more pools for yearlings in the non-bedrock controlled reaches of the East Branch (**Alley 2004; 2005; 2010b**). Existing pools had above average escape cover indices through the years, but pool habitat has been limited. With more structural wood, pools will scour deeper and more escape cover for rearing will be available for larger juveniles. Passage conditions at the weir between Reaches 10 and 11 should be evaluated for adult passage.

Educational outreach to capture and store more winter precipitation should be directed along both branches to streamside landowners, agriculturalists and quarries. The goal is to reduce late spring/summer groundwater pumping and water diversion. Higher baseflow will maximize the percent of YOY steelhead reaching Size Class II in their first growing season and will ultimately increase adult returns. Stabilization, or at least reduced stream sedimentation, from the large Highland Way slide through erosion control, revegetation, re-contouring, etc., would improve spawning and rearing conditions. We recommend improvement of adult steelhead passage over Girl Scout Falls II (**Appendix A and Alley 2003b**), which would make 4+ miles of the West Branch readily accessible to spawning and juvenile rearing every winter instead of only in especially wet winters.

Trend Analysis−Juvenile Steelhead Abundance in the Aptos Watershed

Total juvenile abundance increased, on average, from 2006 to 2008, followed by a sharp decline in 2009 and a rebound in 2010 to 2006 levels (**Figure B-33** below). The trend in YOY abundance was similar except that average density was similar in 2006 and 2007, though differences between sites in 2010 were great and cancelled each other out (**Figure B-34** below). Upper Aptos 4 showed considerable year-to-year variability in juvenile densities. Lower Valencia 2 had similar YOY abundance in 2006−2008 before it crashed in 2009.

Annual abundance of Size Class II and III juveniles showed no consistent pattern for all sites considered together (**Figure B-35** below). This was partially because at Aptos sites these larger juveniles consisted of both fast growing YOY and yearlings where growth potential was much greater than at Valencia sites. In wetter years (2006 and 2010) when fewer yearlings were retained at Aptos sites (***Table 33*** *in Appendix B*), faster growth of YOY into Size Class II (**Figure B-19** below) compensated for their loss and bolstered the larger size class density. In drier years, yearlings were retained in greater numbers while YOY growth rate was slowed. At Valencia sites the Size Class II and III juveniles were only yearlings or older. In addition, there was likely a resident trout component to the upper Valencia site which discouraged outmigration of larger individuals and maintained higher densities. However, Valencia 2 and 3 both increased in yearlings from 2008 to 2009 and then declined in 2010.

A very small adult steelhead population in the Aptos watershed, with spotty and low spawning success is indicated by 1) generally low YOY densities except at upper Aptos 4 in 2008, 2) wide annual fluctuation in YOY at the mainstem Aptos sites and 3) much higher YOY densities at lower Aptos 3 than upper Aptos 4 in two years and similar densities the other two years. If enough spawners were present, YOY abundance is typically highest at upper sites where relatively good habitat is present (compared to downstream sites), as in upper Aptos and Valencia creeks.

Figure 33. Trend in Total Juvenile Steelhead Density in Aptos and Valencia Creek Sites, 2006-2010.

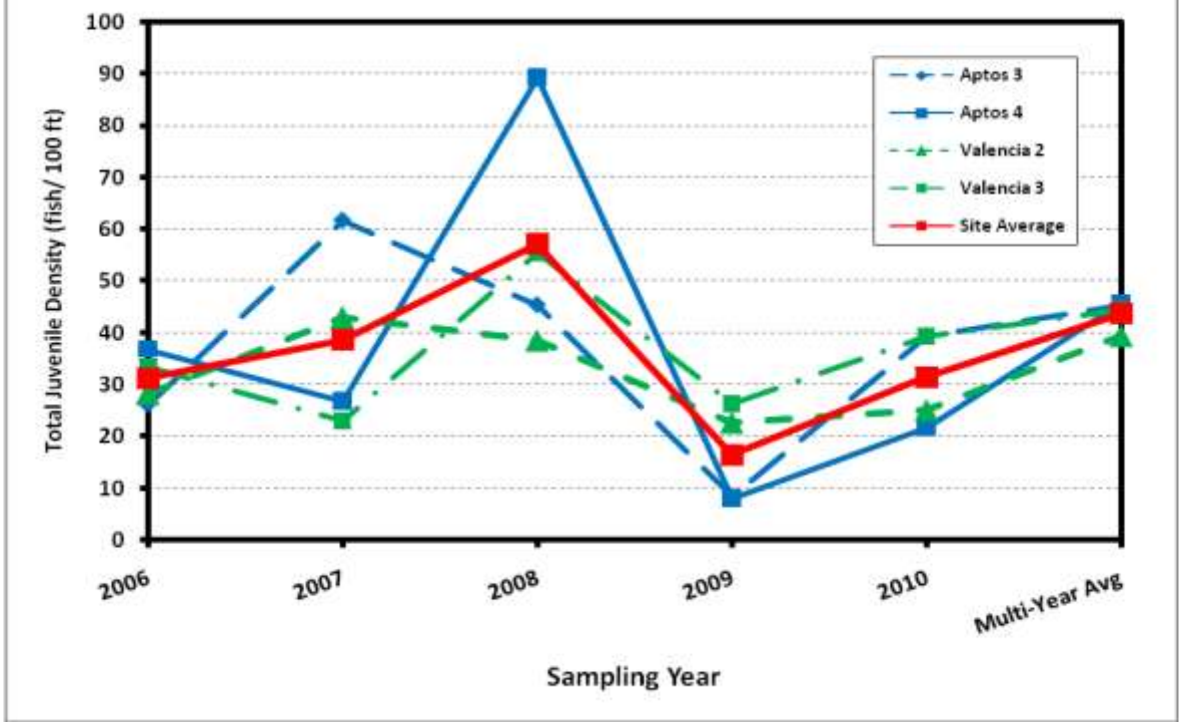


Figure 34. Trend in YOY Juvenile Steelhead Density in Aptos and Valencia Creek Sites, 2006-2010.

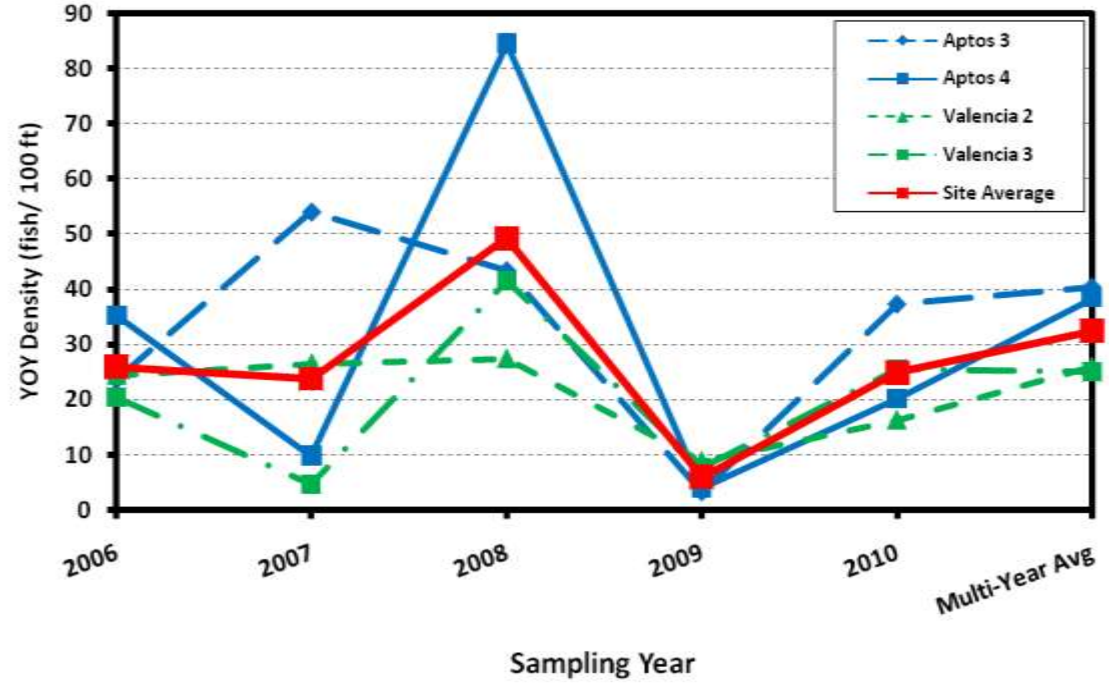
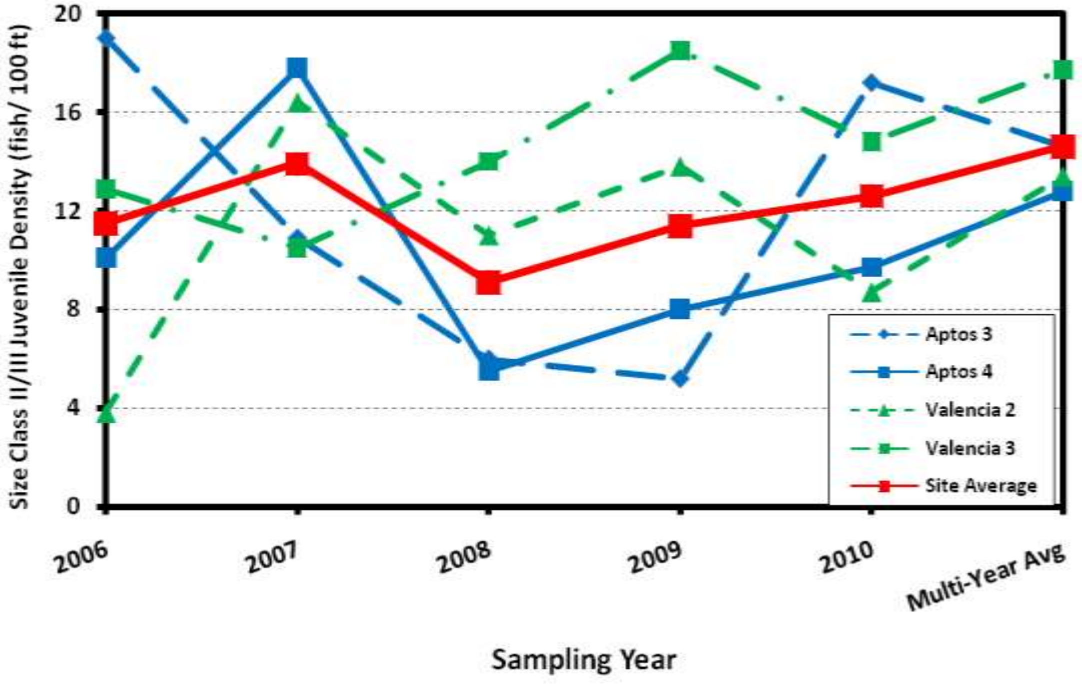


Figure 35. Trend in Size Class II/III Juveniles Steelhead Density at Aptos and Valencia Creek Sites, 2006-2010.



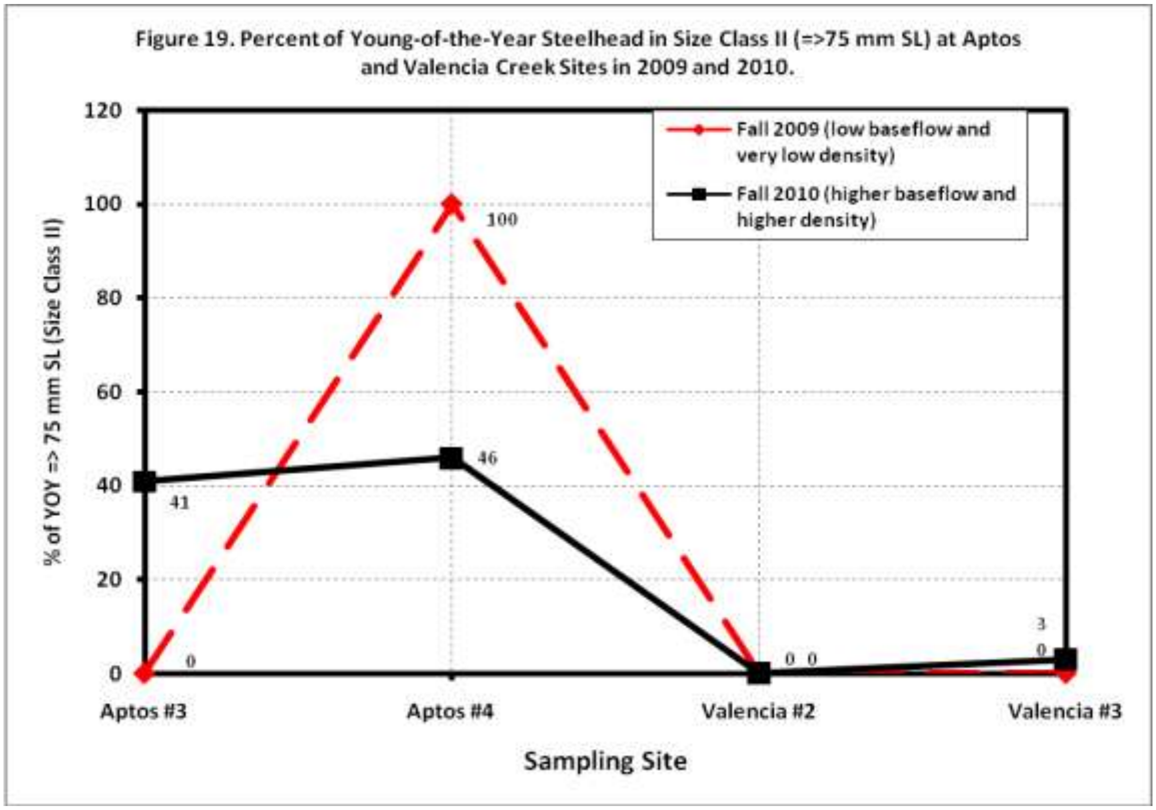


Figure 19. Percent of Young-of-the-Year Steelhead in Size Class II (=>75 mm SL) at Aptos and Valencia Creek Sites in 2009 and 2010.

Recommendations for Improved Habitat in Aptos Creek

Work done in Scott Creek by NOAA Fisheries has indicated that lagoon production of smolts is very important to the size of the adult steelhead population (**Sean Hayes personal communication**). Past work by NOAA Fisheries at Aptos Lagoon indicated repeated artificial breaching of the sandbar during the dry season and a steady diminution of the lagoon's juvenile population size by the fall. We recommended that Aptos Lagoon be closely monitored for artificial breaching, juvenile abundance and water quality. Individuals who artificially breach the sandbar should be prosecuted. Develop a lagoon management plan which includes an educational component that emphasizes the fishery value of the lagoon and the need to maintain an intact sandbar in the summer.

Trend Analysis−Juvenile Steelhead Abundance in Corralitos Sub-Watershed

The trend by site of total and YOY abundance in 2006−2010 for the Corralitos Creek side of the sub-watershed was somewhat higher densities below the diversion dam at Corralitos 1, a decline at the first site upstream (Corralitos 3) and then progressively higher densities up to Corralitos 9 above Eureka Gulch (**Figures B-36 and B-37** below). The higher YOY abundance below the dam in 2008 and 2009 may indicate that some adults were deterred from migrating past the fish ladder and spawned below it instead. However, 2007 had the smallest winter stormflows of the 2007−2009 drought, and YOY densities were higher at Corralitos 3 than Corralitos 1. The YOY densities above the fish ladder at Corralitos 3 and below it at Corralitos 1 were similar in the wetter 2010. But 2010 YOY densities were generally depressed at all Corralitos sites likely due to sedimentation effects. Unfortunately, no sampling occurred below the fish ladder in the wetter 2006 to compare YOY densities above and below. This spawning deterrence may have occurred late in the spawning season when passage flows were reduced.

Those adults that passed the fish ladder each year may have then migrated to upper reaches before spawning, resulting in lower YOY densities at the Corralitos 3 site. In 2007, with the very low winter stormflows, YOY abundance decreased at Corralitos 9 compared to Corralitos 8 (unlike other years), indicating possible adult access problems in between. There is a steep, narrow chute between those sites that may be difficult to pass during very dry winters. Higher YOY densities commonly occur in upper reaches of tributaries in the San Lorenzo, Soquel and Corralitos watersheds (Zayante 13d, Bean 14c, Soquel 16, Corralitos 9 and Browns 2), indicating this behavior of adult steelhead to prefer spawning in upper reaches rather than lower reaches.

In Shingle Mill Gulch, YOY densities decreased greatly at the lower Shingle Mill 1 compared to those at Corralitos 9 and improved slightly at the upper Shingle Mill 3 (**Figure B-37**). YOY densities were less there than downstream because of its much smaller size and limited spawning habitat.

In the Browns Creek side of the sub-watershed, YOY densities increased from below the dam at Browns 1 to above the dam at Browns 2 (**Figure B-37**). Total and YOY site densities throughout the sub-watershed were relatively high in 2006, the wettest year, especially at Corralitos 9 and in Browns Creek. YOY densities were generally low in 2010, the wettest year since 2006, after 3 consecutive dry years with likely difficult adult spawning access and smolt outmigration access, along with poor estuary conditions and poor ocean conditions.

The trend by site of Size Class II and III abundance in 2006−2010 for the Corralitos Creek side of the sub-watershed was for similar abundance at the 3 lower Corralitos sites and Shingle Mill 1, with a greater abundance at Corralitos 9 above Eureka Gulch (**Figure B-38** below). Abundance was consistently lowest at Shingle Mill 3. Abundance at Browns 1 and 2 were similar and at intermediate levels for the 8 sites sampled. Browns Creek also had high Size Class II and III abundance in 2007, presumably due to a previously mild winter with good yearling survival and retention.

Figure 36. Trend by Site in Total Juveniles Steelhead Density at Corralitos, Shingle Mill and Browns Creek Sites, 2006-2010.

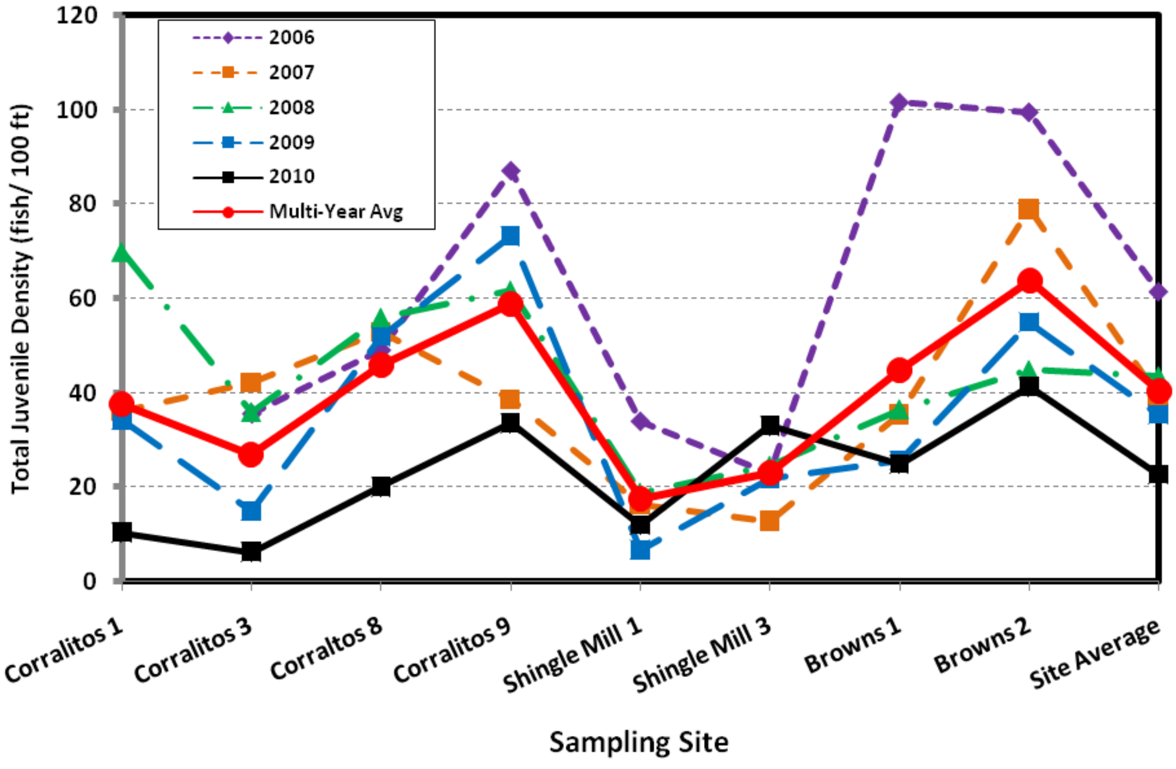


Figure 37. Trend by Site in YOY Steelhead Density at Corralitos, Shingle Mill and Browns Creek Sites, 2006-2010.

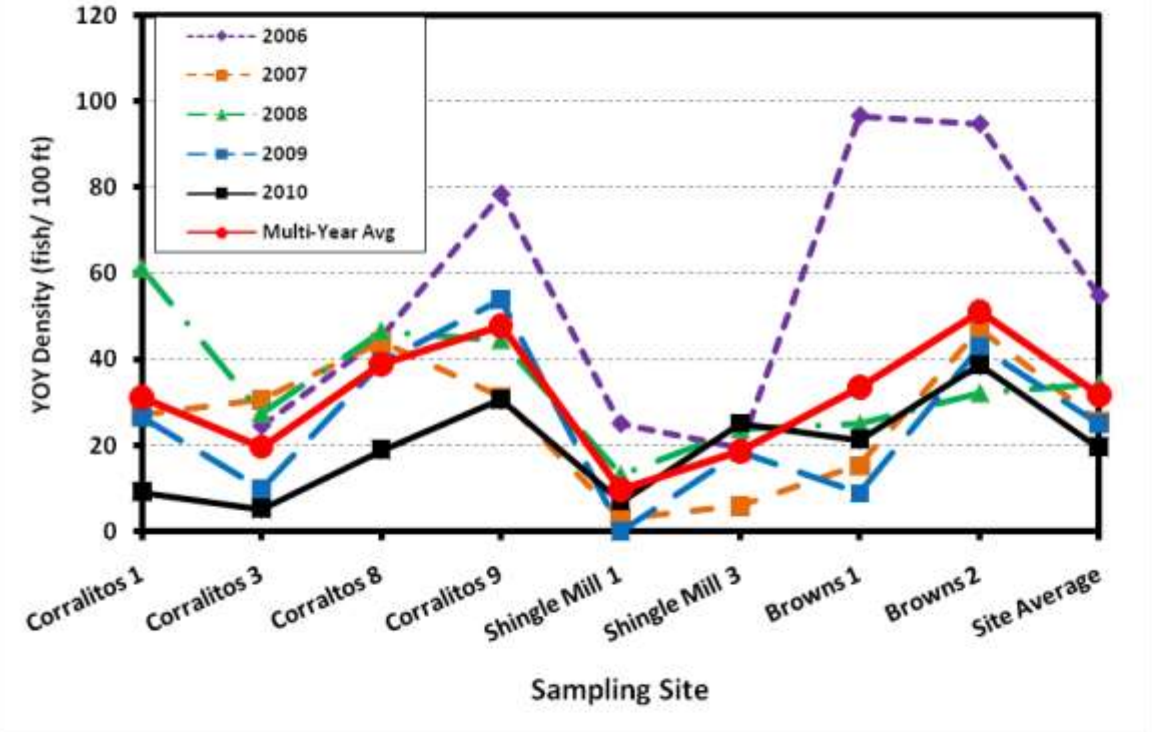
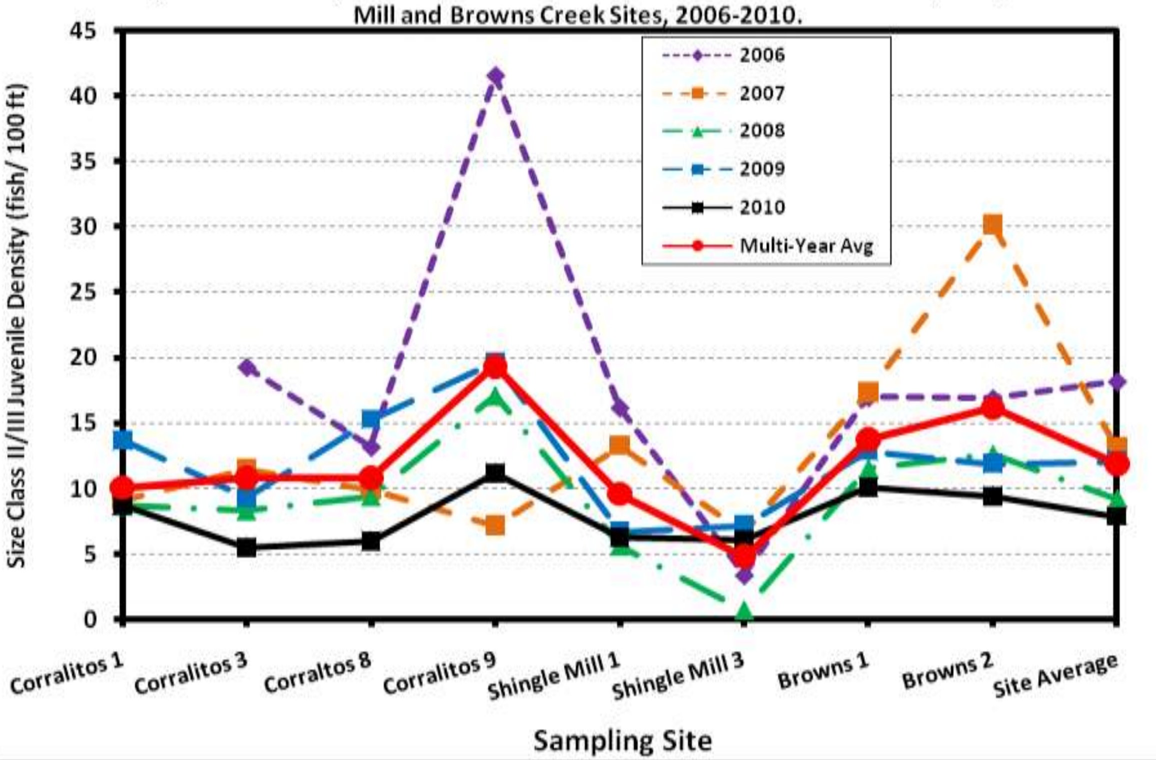


Figure 38. Trend by Site in Size Class II/III Steelhead Density at Corralitos, Shingle Mill and Browns Creek Sites, 2006-2010.



The trend by year of total and YOY abundance for the 4 Corralitos Creek sites was, on average, the highest in 2006, followed by a decline in 2007, a slight increase in 2008 and a steady decline in 2009 and 2010 at 3 of 4 sites (**Figures B-39 and B-40** below). The trend by year in Size Class II and III abundance in the 4 Corralitos sites was, on average, highest in the wettest year 2006 (fast YOY growth rate to Size Class II), followed by a large decline in the driest 2007 (slow YOY growth rate) (**Figure B-41** below). Then densities remained similar for 2008−2010, with 2010 the lowest on average. Low densities in 2010 at most sites were likely due to low numbers of YOY available to grow into Size Class II and low yearling densities (***Table 33***; *Appendix B*). The percent of YOY growing into Size Class II was higher in 2010 than 2009 due to increased baseflow and low juvenile density with less competition (**Figure B-20** below).

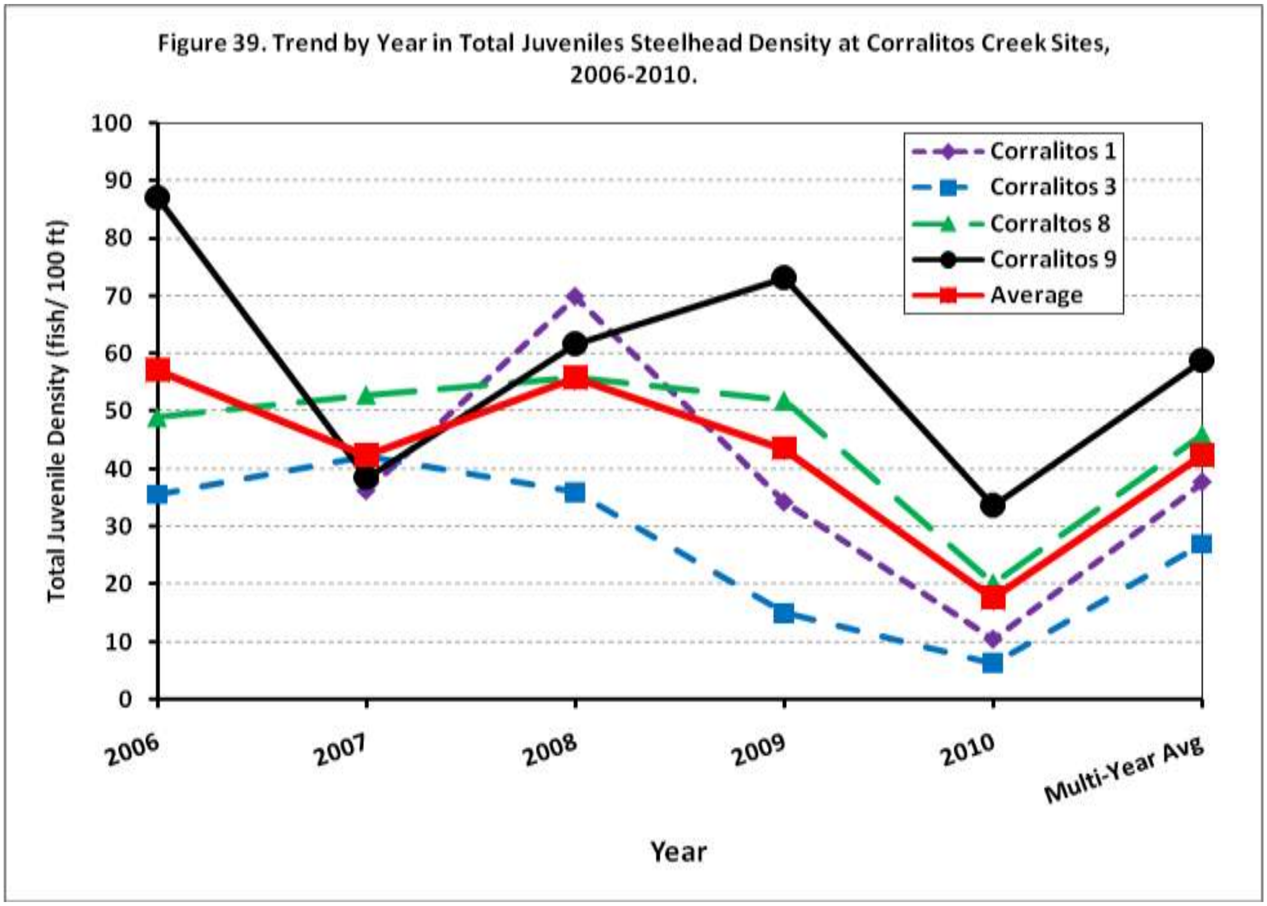


Figure 39. Trend by Year in Total Juveniles Steelhead Density at Corralitos Creek Sites, 2006-2010.

Figure 40. Trend by Year in YOY Juveniles Steelhead Density at Corralitos Creek Sites, 2006-2010.

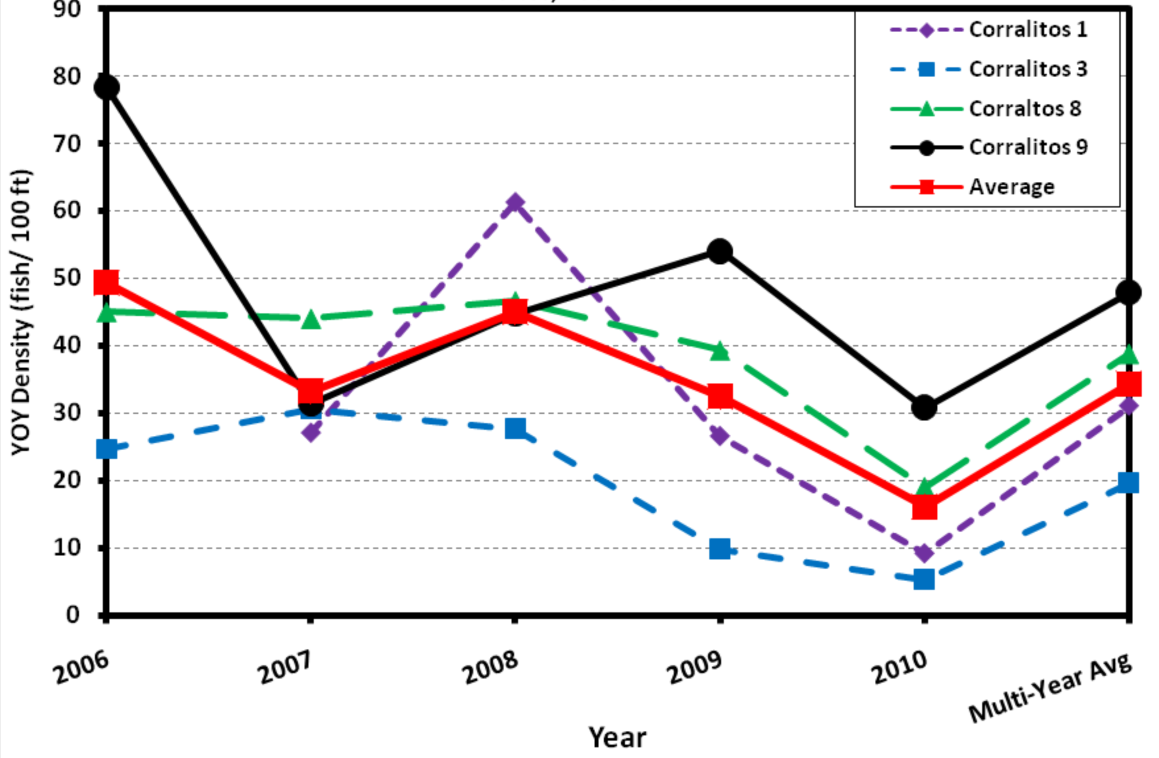


Figure 41. Trend by Year in Size Class II/III Juveniles Steelhead Density at Corralitos Creek Sites, 2006-2010.

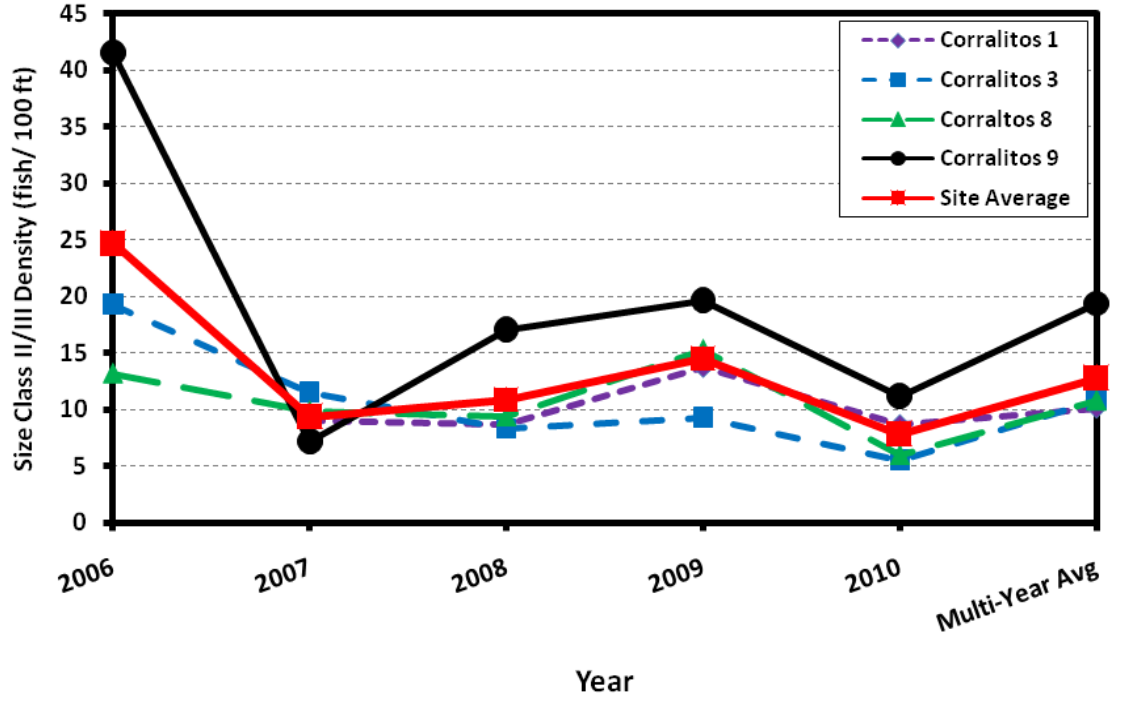
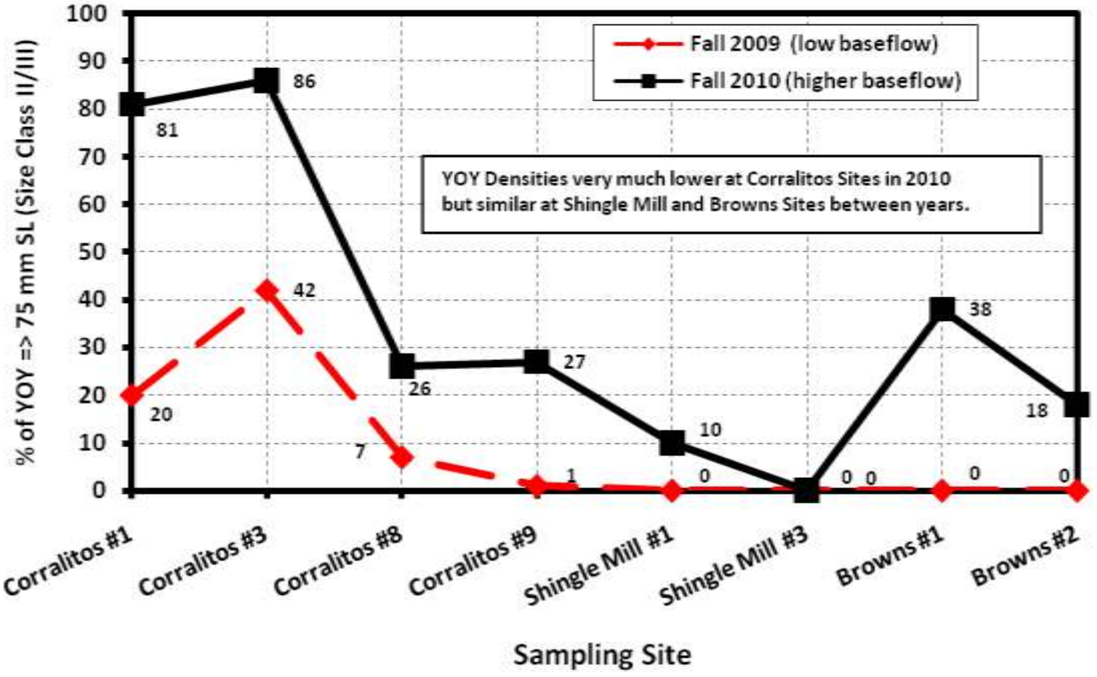


Figure 20. Percent of Young-of-the-Year Steelhead in Size Class II (=>75 mm SL) at Corralitos Watershed Sites in 2009 and 2010.



Recommendations for Improved Habitat in the Corralitos Watershed

Significant streambed sedimentation was observed in 2010 on the Corralitos Creek side of the watershed, likely reducing the juvenile population substantially. Although effects were detected in Shingle Mill Gulch and upper Corralitos above Eureka Canyon Gulch, it was most observed downstream of Eureka Canyon Gulch. The Eureka Gulch sub-watershed may have been most severely impacted by the Summit Fire. It is recommended that the source of this sedimentation be identified and erosion control and revegetation measures be taken to reduce future sedimentation. A substantial portion of lower Corralitos/Carnedero Creek goes dry each year. Carry out a study that examines the passability of the Pajaro drainage to out migrant smolts and in migrant adult steelhead to and from the Corralitos sub-watershed. If passability proves to be difficult in drier years, develop a program of well pumping and water diversion that is compatible with steelhead migration.

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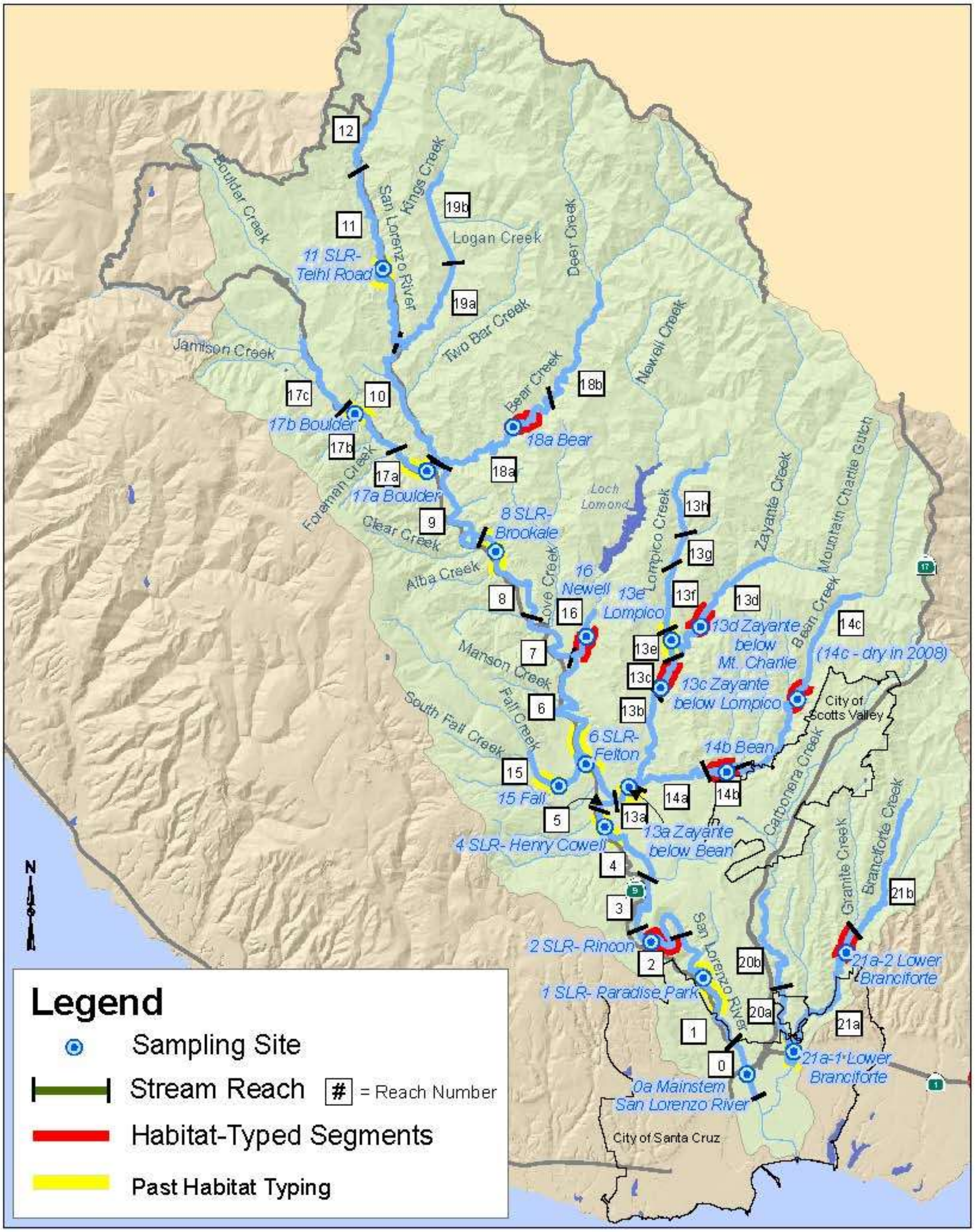
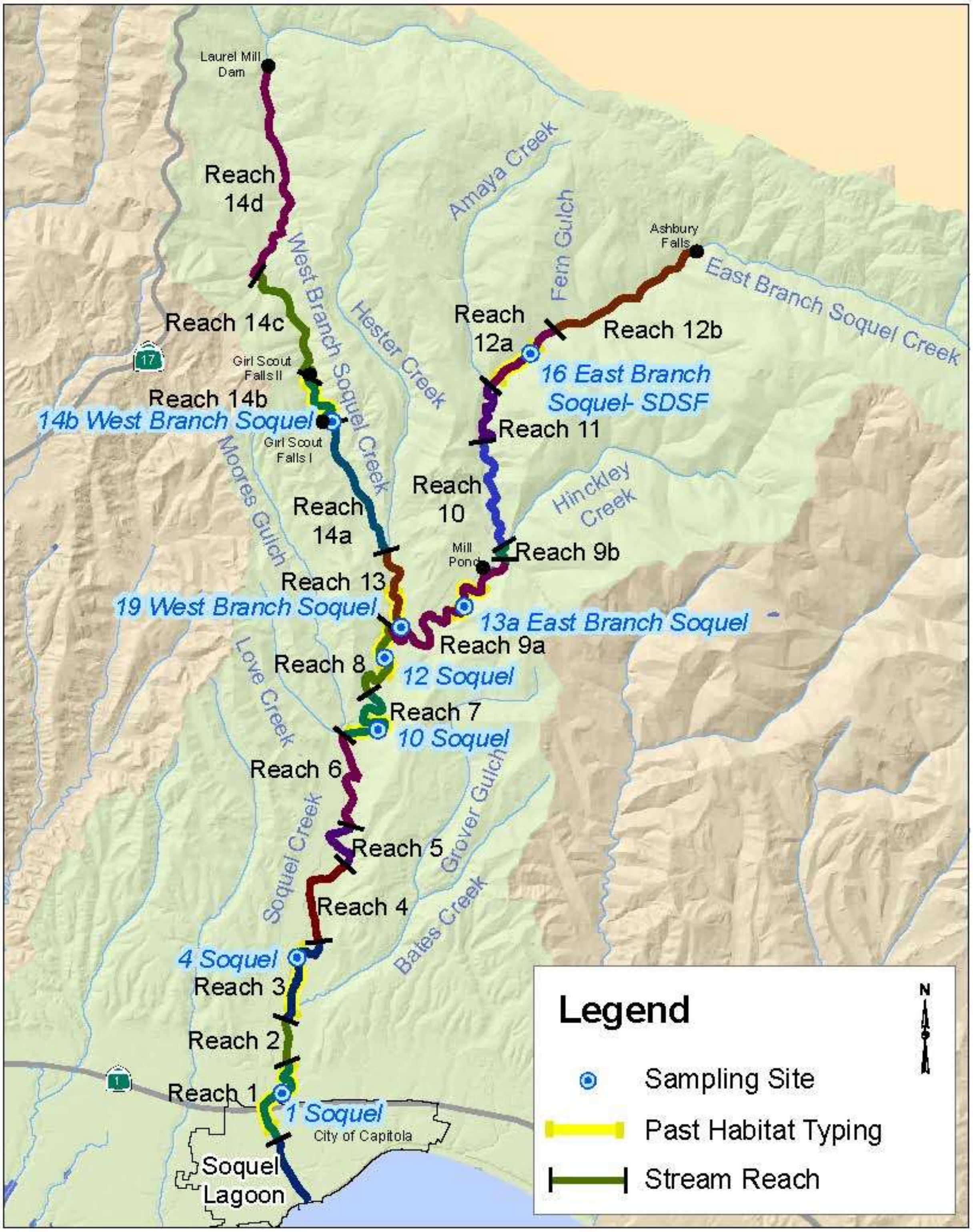
APPENDIX A. WATERSHED MAPS.

Figure 1. Santa Cruz County Watersheds.



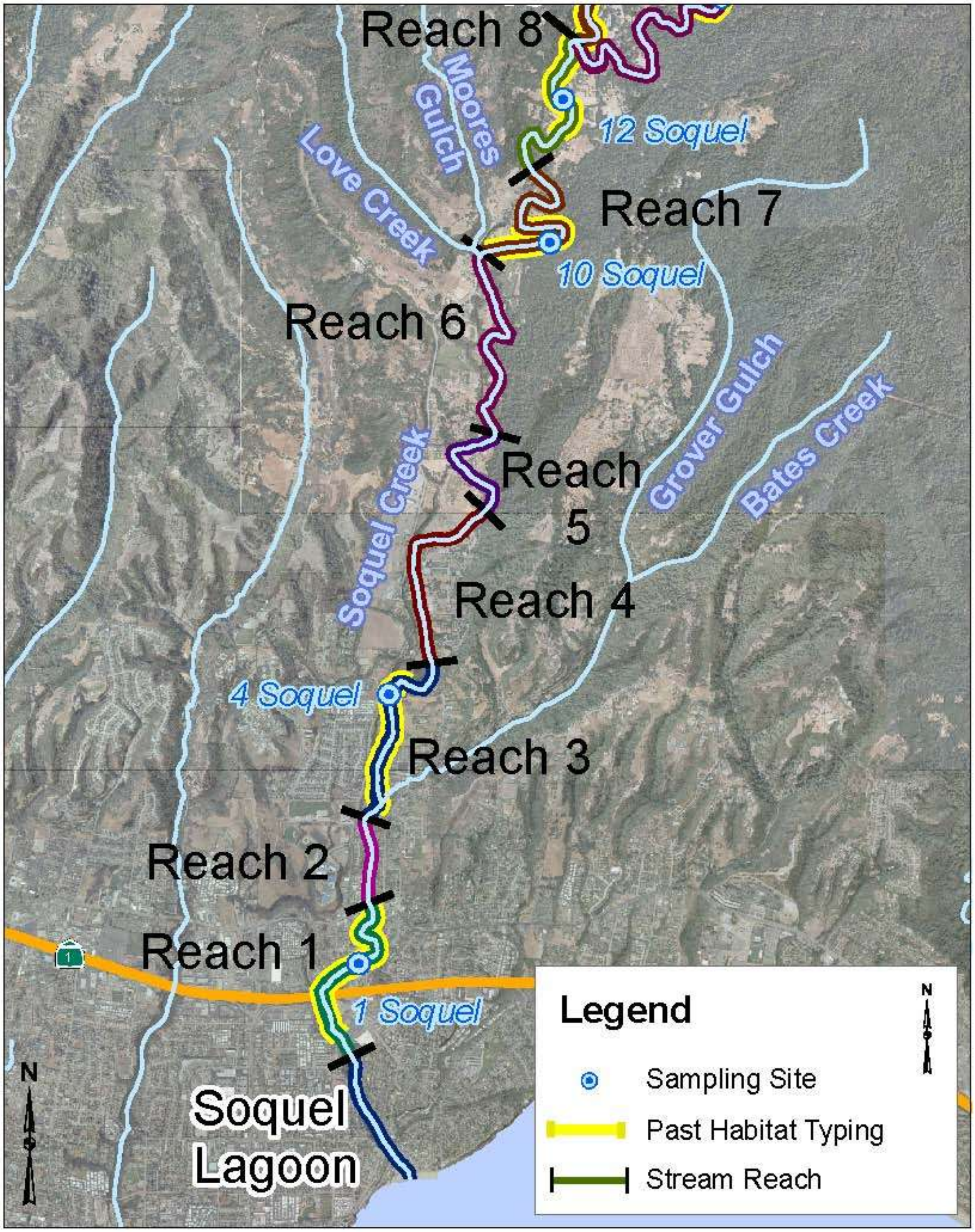
012-09 2011 Update

Figure 2. San Lorenzo River Watershed– Sampling Sites and Reaches.



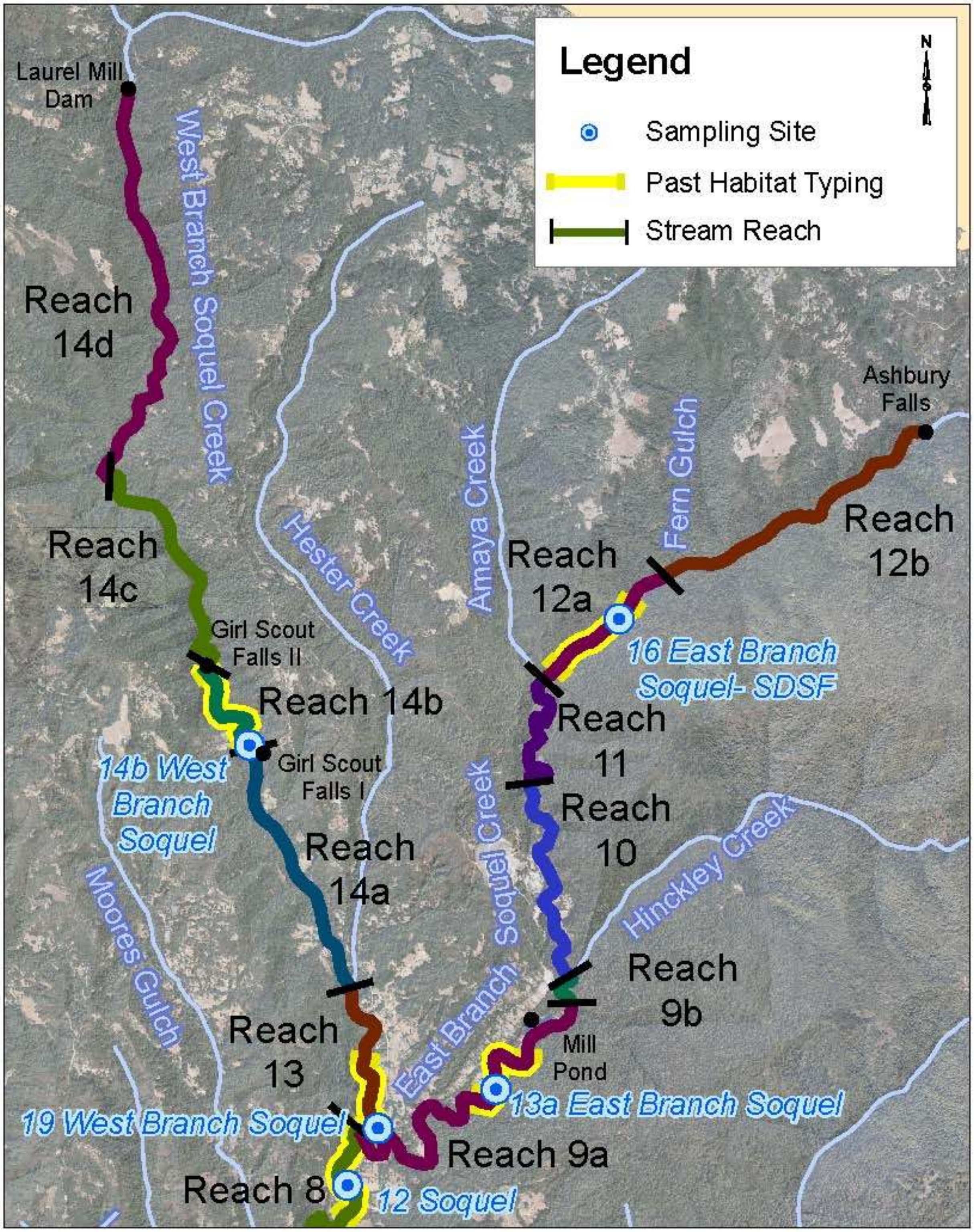
012-09 2011 Update

Figure 3. Soquel Creek Watershed.



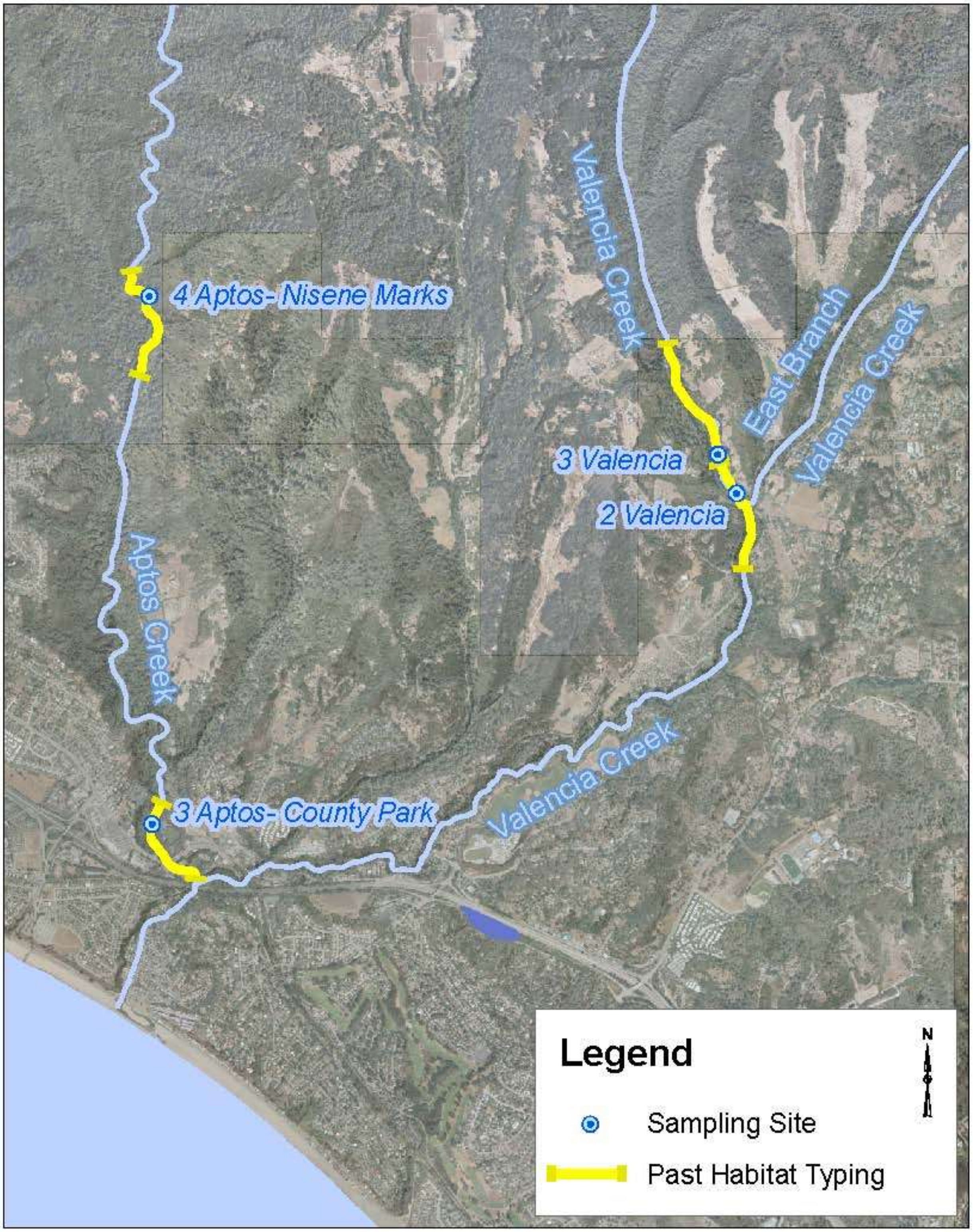
012-09 2011 Update

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



012-09 2011 Update

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



012-09 2011 Update

Figure 6. Aptos Creek Watershed.

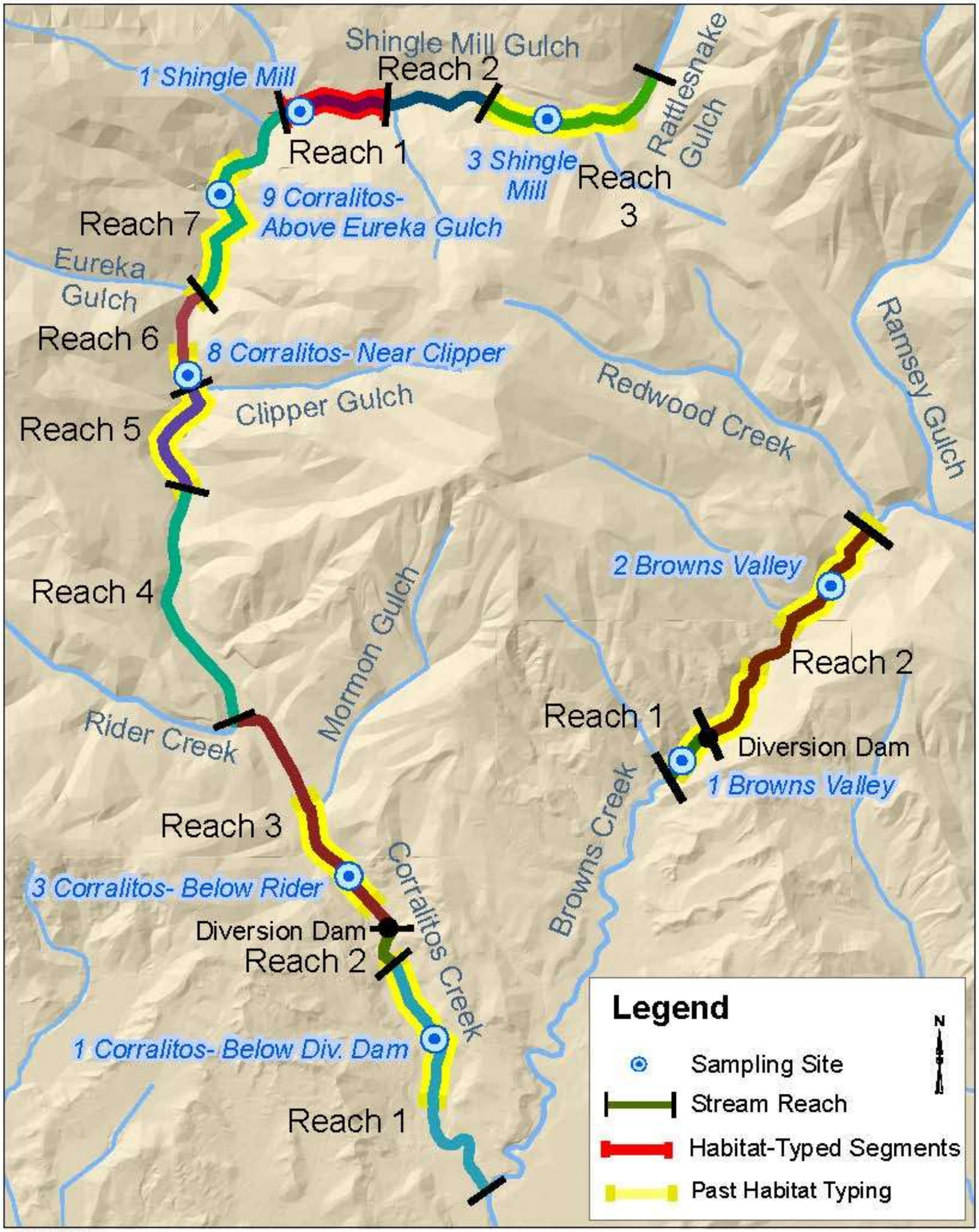


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Figure 7. Upper Corralitos Creek Sub-Watershed of the Pajaro River Watershed.

APPENDIX B. DETAILED ANALYSIS OF 2010 STEELHEAD MONITORING IN THE SAN LORENZO, SOQUEL, APTOS AND CORRALITOS WATERSHEDS

(Provided electronically in a separate PDF file.)

APPENDIX C. SUMMARY OF 2010 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.)