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LONG-TERM COHO SALMON & STEELHEAD TROUT MONITORING IN COASTAL MARIN COUNTY

SUMMER 2009 MONITORING PROGRESS REPORT



Prepared for California Department of Fish and Game
Contract P0730408

ON THE COVER

Olema Creek juvenile salmonid snorkel survey conducted by Michael Reichmuth during the summer of 2008.

Photograph by: Sarah Carlisle

Long-term Coho Salmon & Steelhead Trout Monitoring in Coastal Marin County

Summer 2009 Monitoring Progress Report

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Abstract

The 2009 summer monitoring of juvenile salmonids and salmonid habitat focused primarily on watersheds in the Point Reyes National Seashore (PORE), Golden Gate National Recreation Area (GOGA), and Muir Woods National Monument (MUWO) that contain coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*O. mykiss*). These watersheds support some of the southernmost populations of coho salmon on the western Pacific Coast. Summer results corroborate poor observed spawning in the winter of 2008-2009, resulting in a catastrophic decline in summer juveniles for this cohort as a whole. Olema Creek suffered a total collapse of the year class, with only a single juvenile observed during summer surveys. This is the lowest observed count since summer monitoring began in 1999. A population estimate on Redwood Creek was not feasible due to the limited number of coho occurring in the calibration pools. However, a minimum raw count of 80 juvenile coho was observed through the combined methods of basinwide snorkel surveys and index reach electrofishing. The juvenile coho population in Redwood Creek represents a decline of more than 80% for the cohort. On a positive note, coho juveniles were observed on Pine Gulch for the first time since the summer of 2006, indicating at least some spawning success. With a population estimate of 386 ± 441 , Pine Gulch Creek actually had an increase of 31% since the last time this cohort was in the stream.

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1 - Introduction

Ongoing monitoring of coho salmon by the National Park Service (NPS) within the Olema Creek, Pine Gulch Creek, and Redwood Creek watersheds in coastal Marin County is conducted with support from the Department of Fish and Game (DFG) Grant P0730408. These monitoring efforts continue salmonid research initiated and conducted by the NPS since 1997. The primary focus of this monitoring grant is to document federally and state listed endangered coho salmon (*Oncorhynchus kisutch*) population distribution and trends within these watersheds. In addition, monitoring has been conducted to document information of federally threatened steelhead trout (*O. mykiss*) and other fish species within the monitored watersheds.

The draft San Francisco Bay Area Network Salmonid Monitoring Protocol v3.67 (Ketcham et. al. 2009) documents methods used by the NPS in salmonid monitoring within coastal Marin County since 1997.

This report includes results of habitat surveys, basinwide snorkel surveys, basinwide electrofishing surveys, and index reach surveys for Olema Creek, Pine Gulch Creek, and Redwood Creek during the summer of 2009. These watersheds are located within the Lagunitas Creek and Bolinas Hydrologic Sub-Areas (HSA) of the Bodega and Marin Hydrologic Units. The Recovery Strategy for Coho Salmon (CDFG 2004) categorizes each of these HSAs as high priority restoration areas for coho salmon. The monitoring efforts conducted through this program contribute to our understanding of population dynamics and condition within the coastal Marin County Area (Figure 1).

During the summer of 2009, staff conducted snorkel surveys and basinwide electrofishing on Olema Creek, Pine Gulch Creek, and Redwood Creek to develop basinwide estimates within these three watersheds. In addition, a total of 19 legacy index reaches in these three watersheds were sampled. The results of basinwide and index reach survey information for Olema Creek, Pine Gulch Creek, and Redwood Creek are reported in this progress report.



Basinwide juvenile coho population estimates were developed for Pine Gulch Creek for the summer 2009. Although basinwide surveys were performed on Olema and Redwood Creeks, no estimates were calculated due to the low number of juvenile coho detected. Basinwide surveys required a two stage sampling design: stage one habitat typing and stage two snorkel counts and calibration. Calibration of snorkel surveys was conducted by electrofishing a random selection of

snorkeled pools. Where access with electrofishing gear was an issue, multiple snorkel passes called bounded counts were used for calibration.

The summer basinwide surveys required approximately one month per watershed using the minimum field crew of two. The existing monitoring program has been able to recruit volunteers to assist with the basinwide electrofish surveys, making these field surveys feasible with a minimal number of field staff. Snorkel surveys required highly skilled observers with at least one season of snorkeling experience. This is a learned skill that required observers to identify juvenile coho within each sampling unit. Observers had to anticipate fish movement, obstacles, cover, and suspended sediment in order to obtain an accurate juvenile coho count.

1.2 Introduction and History of Index Reach Surveys

The first index reach monitoring program within the SFAN was established by Dr. Jerry Smith of San Jose State University on Redwood Creek during the fall of 1992. The index reach program was expanded in 1999 to both Olema and Pine Gulch Creeks in an effort to standardize physical and biotic monitoring of temporal changes to key salmonid habitats within the SFAN. Annual monitoring allows staff to document annual change in habitat condition and size associated with winter runoff events and riparian structure. Evaluation of this information on a watershed by watershed basis will be valuable for predicting response to environmental and climactic conditions, adjustments in land management strategies, and for evaluation of success with regard to specific restoration activities. This form of survey is also performed in adjacent watersheds, including the watersheds of Lagunitas and San Geronimo creeks.

Complete index site histories are documented in the Salmonid Monitoring Protocol v3.67 (Ketcham et. al. 2009). Not all of the index reaches are sampled every year. The indexes chosen for sampling are those with the longest consecutive years of sampling.

1.3 Fish Resources

The primary species monitored through this program are coho salmon and steelhead trout. However, other fish species including sculpin, roach, lamprey, suckers, and stickleback are captured and documented through our monitoring efforts.

1.3.1 Coho Salmon

Biology: The general biology of coho salmon is described in detail in Hassler (1987) and Sandercock (1991). The coho salmon is an anadromous, semelparous fish species, migrating from marine water back to freshwater for a single chance at reproduction. Coho generally return to natal streams after spending two years in the ocean. The spawning migrations begin after heavy late-fall or winter rains breach the sandbars at the mouth of coastal streams allowing the fish to move upstream. Spawning occurs in small to medium sized gravel at aerated sites, typically near the head of a riffle (Moyle 1976). These streams have summer temperatures seldom exceeding 21 degrees Centigrade (70 degrees Fahrenheit). Emergent fry use shallow near-shore areas, whereas optimal habitat conditions for juveniles and sub-adults are deep pools associated with rootwads, woody debris, and boulders in shaded stream sections (Laufle et al 1986).

Because of dramatic declines in population numbers, the National Marine Fisheries Service (NMFS) was petitioned to list this species coastwide (Federal Register 1996). Several runs were

listed along the central California coast and include regions occupied by California red-legged frogs. Causes of coho salmon declines in California include incompatible landuse practices such as logging and urbanization, loss of wild stocks, introduced diseases, over harvesting, and climactic changes.

Regulatory Protection: Coho salmon were listed as a threatened species within the central California coast coho salmon evolutionary significant unit (CCCESU) on October 31, 1996 by the National Marine Fisheries Service (NMFS) (Federal Register 1996). In their 2001 Status Review, NMFS acknowledged that within the CCCESU, the decision to list coho salmon as threatened may have been overly optimistic, concluding that the ESU population was presently endanger of extinction (NMFS 2001). As a result of these and further findings, NMFS completed a rulemaking process on June 28, 2005, which downgraded the coho status (upgraded listing protection) in the ESU to Endangered (Federal Register 2005). NMFS designated critical habitat for coho salmon on May 5, 1999 (Federal Register 1999). The critical habitat is designated to include all river reaches accessible to listed coho salmon in the CCCESU (Figure 2). Excluded are areas above specific dams or above longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years).

On April 5, 2001, the Fish and Game Commission accepted the petition to list coho salmon north of the Golden Gate as endangered under the State Endangered Species Act. On August 5, 2004, the Fish and Game Commission added coho salmon populations between San Francisco and Punta Gorda to the list of species protected under the Endangered Species Act (areas south of San Francisco were already listed as endangered). This listing became effective March 30, 2005.

1.3.2 Steelhead

Biology: Steelhead are the anadromous form of rainbow trout. Adult steelhead typically spawn in gravel riffles in the spring, from February to June. Steelhead are multiparous, meaning they can spawn more than once. Research conducted in the 1950s documented female steelhead returning to spawn in multiple years (Shapavolov and Taft 1954). Optimum temperatures for growth range from 13 to 21 degrees Centigrade (55 to 70 degrees Fahrenheit) (Moyle 1976). It is also noted that steelhead may persist in a broad range of pH (from 5.8 to 9.6) but prefer a pH between 7 and 8 (Moyle 1976). Steelhead fry reside in near-shore areas. Steelhead juveniles tend to use riffles and pool margins. Steelhead trout are known to exist in most perennial watersheds within Marin County.

Regulatory Protection: Steelhead were listed as a threatened species on August 17, 1997 (Federal Register 1997). As of February 6, 2006 the former steelhead Evolutionary Significant Unit has been changed to a Distinct Population Segment (DPS). The central California coast steelhead DPS includes all naturally spawned populations of steelhead (and their progeny) in California streams from the Russian River (inclusive) to Aptos Creek (inclusive), and the drainages of San Francisco Bay (Figure 2) (Federal Register 2006). Steelhead critical habitat was designated January 2, 2006 (Federal Register 2006). Critical habitat only encompasses the *O. mykiss* anadromous range.

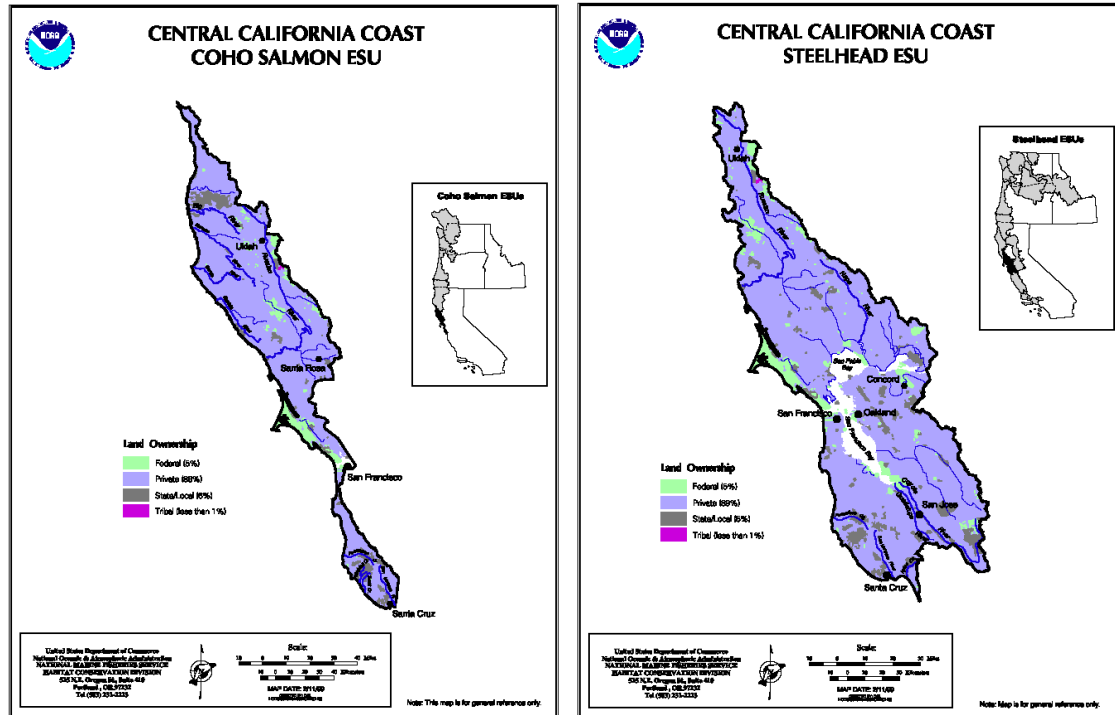


Figure 2. Coho salmon Evolutionarily Significant Units (ESU) and Steelhead ESU/Distinct Population Segment as identified by NMFS. Marin County is included within the Central California Coast ESU for coho salmon and steelhead.

1.3.3 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267) requires all Federal agencies to consult with NMFS on all actions, or proposed actions, permitted, funded, or undertaken by the agency, that may adversely affect Essential Fish Habitat (EFH). EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Monitored watersheds are considered EFH for coho salmon.

1.3.4 Historical Fishery Resources

Review of the historical background information shows that fisheries resources have declined dramatically since the turn of the century. As early as 1892, reports of declines in fish abundance within the streams of western Marin County were circulated. Interviews with long time residents and former as well as present fisheries resource managers support the contention that fisheries resources within the area have been declining for years and that the most significant and noticeable changes have occurred since the mid-1950's. It is well established that both the abundance and distribution of coho salmon and steelhead trout have declined throughout the area. It has been estimated that existing naturally spawning coho salmon stocks comprise only 1% of their historical number along the west coast and that as much as 46% of California's coho salmon populations have been extirpated from their watersheds (Brown et al. 1994).

2 - Sampling Design and Methods

The summer/fall stream fish and habitat monitoring protocol includes the monitoring of stream habitat and fish communities, including juvenile salmonids, at Parks in the San Francisco Bay Area Network (SFAN) during summer and fall base flow conditions. Two primary activities are conducted in the watersheds including General Systematic Basinwide snorkel surveys and index reach monitoring.

In addition to information included below, complete field methods are documented in Salmonid Monitoring Protocol v3.67 (Ketcham et al. 2009).

2.1 Habitat Surveys

Starting at the bottom of the coho survey area and working upstream, staff numbered, classified, measured the length, and estimated the average width of each habitat unit. Units were classified to level III using the CDFG classification system (Flosi et al 1998) as pool (scour pool, backwater pool, plunge pool, or mid-channel pool), flatwater, or riffle. The width of each habitat unit was estimated visually. Every fifth pool unit was flagged for snorkeling and several measured widths were taken for the purpose of calibrating the estimated width. Pools located within indexes were included in the basinwide surveys instead of the index reach surveys for the purposes of snorkel survey calibrations.

In addition to the delineation of main channel habitat types, both off channel habitat types and woody debris were recorded at summer base flow conditions as ancillary data. Off channel habitat types were categorized using the same methods as the main channel habitat typing using the level III CDFG classification system (Flosi et al. 1998). During summer basinwide habitat surveys, all large woody debris (LWD), alive or dead, providing instream shelter during summer baseflow conditions were counted and recorded within each habitat unit.

To qualify as LWD, individual logs had to meet specific size requirements. Logs were required to be at least 2 m (6 ft.) in length and were tallied in the following diameter classes: 10-20 cm (4-8 in.), 20-50 cm (8-20 in.), and greater than 50 cm (>20 in.). Diameter was measured at the mid-point of the log. Stumps with their root structure intact that were less than 2 m long and at least 20 cm in diameter were tallied separately. These “rootwads” are very stable structures and can provide excellent juvenile fish habitat. Accumulations of more than 10 individual pieces of LWD constitute a large woody debris jam. Each jam was tallied separately. Pieces of wood that were between 5 and 10 cm in diameter were considered small woody debris (SWD). We did not count individual pieces of SWD. Ten or more pieces of SWD were recorded as SWD jams.

2.2 Basinwide Snorkel Surveys

When a statistically accurate estimate of stream habitat or population of a particular fish species was needed for a broader area or entire stream, basinwide survey techniques developed by Hankin and Reeves (Dollof et al 1993) were used. Basinwide surveys involved a two step sampling design using both snorkeling and electrofishing. During step one, project staff surveyed each of the previously determined pools with a single to triple pass snorkel count, using dive lights to search under vegetation, woody debris, and undercut banks. Only coho were counted but the presence of steelhead and non-salmonid fish was also noted. The number of divers in the water varied from one to two, depending on the width and complexity of the unit. Strategies were

used to divide the fish between the divers and filter them in such a way that the divers could be confident of their counts.

Step two was conducted by randomly selecting at least 20% of the snorkeled pools which were then electrofished the day after each snorkel survey. Calibration for the snorkel surveys was conducted using electrofishing results. A subsample of the fish caught were weighed and measured. Where access to the pools was deemed to be unsafe for electrofishing crews, bounded counts were used to calibrate the unit.

2.2.1 Electrofishing/handling

Captured fish were sedated using carbon dioxide (Alka SeltzerTM), identified to species and age class, measured to the nearest mm, and weighed to the nearest hundredth of a gram. To reduce impacts due to handling the fish, a subsample of 10 per pass, per species were measured and weighed. The remaining fish were then only counted. Fish were kept in aerated holding buckets before and after handling and allowed to recover fully before being released.

An electrofishing log was kept of all settings, pertinent environmental conditions, fish response, and total catch for each unit. All electrofishing information is reported annually in accordance with our section 10 permit 1046 issued by the NMFS. Water quality parameters were measured and recorded.

For habitat units sampled by multiple pass electrofishing, a maximum likelihood model, *Microfish* (VanDeventer and Platts 1989) was used to calculate fish population estimates and confidence intervals by species/age class. Total catch was used as the population estimate for poor multiple pass depletions or no captures after the third pass, and for index reach units.

2.3 Index Reach Monitoring

Index reach sampling was conducted within each watershed after the basinwide surveys were concluded. Index reaches were sampled at SFAN parks during summer/fall base flow periods to assess fish abundance and distribution on the mainstem of Olema Creek, Redwood Creek, and Pine Gulch Creek. Under this technique, stream reaches approximately 100 meters in length were chosen as sampling sites and surveyed on a yearly basis to monitor changes in juvenile salmonid densities and overall fish species composition and biomass within the index reaches.

Each index reach contains from two to ten contiguous habitat units, which are identified and sampled individually. Each habitat unit was isolated with block nets and sampled separately using standard multiple pass depletion electrofishing methods (Bohlin et al 1989).

Habitat measurements and assessments were made for the index reaches after fish sampling was completed. The length, average width, maximum depth, crest depth and instream shelter complexity (Flosi et. al. 1998) were quantified in each habitat unit. Instream shelter complexity values were estimated for pool and flatwater units. Additional habitat parameters including bank erosion, riparian cover, and woody debris were then determined for the index site as a whole. The habitat portion of index reach monitoring was completed the same day as fish sampling or very soon thereafter.

Index reach surveys included both fish sampling and detailed habitat assessments, including habitat unit size, instream shelter, and riparian condition. The results of the index reach surveys provide baseline fish distribution information and abundance/density estimates specific to the index reach. Juvenile salmonid year class abundance varies depending on returns of adult spawners and environmental conditions.

2.4 Sample Timing

Index reaches and basinwide surveys for each stream are sampled during the same general time of year on an annual basis. Table 1 provides the timing for the 2009 summer/fall stream fish surveys.

Table 1. Basinwide Survey/Index Reach Timing, 2009.

Watershed	Stream	# of Index Reaches	In-Stream Sample Dates
Pine Gulch	Mainstem	6	06/29/09 – 7/23/09
Redwood	Mainstem	6	07/21/09 – 8/25/09
Olema	Mainstem	7	08/12/09 – 10/08/09

3 – Results

3.1 Historical Data

Currently, older datasets are undergoing internal review and are not included in this progress report or appendices. These datasets include years 1999 through 2004 on Olema Creek, years 2000 through 2004 on Pine Gulch Creek, and years 1998 through 2004 on Redwood Creek.

3.2 Summer Basinwide Survey

Basinwide habitat survey lengths and total number of habitat units vary from year to year. The total number of habitat units and habitat composition varies depending on the water year, survey area, and interpretation of the physical habitat by the surveyor.

3.2.1 Olema Creek

The 2009 summer habitat survey of Olema Creek was initiated at monument tag 15, at the current Olema Creek Smolt Trapping site and surveyed accessible areas through monument tag 150, adjacent to the Randall Ranch House. The measured basinwide survey length for the main channel was 13.0 km.

Basinwide snorkel surveys were conducted on 13.0 km of the Olema Creek mainstem starting at the Olema Creek smolt trapping site and ending adjacent to the Randall Ranch House. Stream segments totaling approximately 1.0 km were not sampled as they were deemed not accessible due to water quality concerns or dangerous stream conditions. This portion of the creek was sampled in an attempt to include the entire range of juvenile coho habitat upstream of the spring smolt trapping location. In previous years this section was not sampled due to water quality concerns during snorkel surveys. Based on recent water quality monitoring results, the section of stream from the smolt trapping location to the Bear Valley Road bridge was determined to be within the allowable limit for recreational contact. Snorkel surveys in the area around the town of Olema were avoided based upon water quality conditions not meeting contact recreational use standards near the time of the surveys. This water quality monitoring information has been collected as part of the total maximum daily load (TMDL) monitoring process in collaboration with the Regional Water Quality Control Board.

Habitat Survey: A total of 970 mainstem habitat units were identified in the 13.0 km Olema Creek survey area. Pool units were the dominant habitat type available to fish, measuring a total of 6.3 km. Overall habitat composition by number of units was 37% pool, 25% riffle, and 23% flatwater (Table 2). Intermittent conditions were observed approximately 9.8 km upstream from the mouth of Olema Creek. Dry sections of streambed accounted for 16% of the total length surveyed. Side channel and backwater units were also measured but not incorporated into the basinwide habitat analysis. Flatwater and riffle habitat types made up 89% of the total side channel habitat composition. Overall, 500 meters of side channel habitat and 178 meters of backwater habitat units were measured during the basinwide habitat survey.

A comparison between visually estimated and measured surface area was conducted for 71 pools to determine a surface area correction factor. The correlation between the estimated surface area and measured surface area was good ($R^2 = 0.97$). Based on this, a calibration ratio of 0.9929 was used to correct the estimated surface area of all units (Figure 3).

Table 2. Habitat composition of Olema Creek coho survey area, 2009.

Unit type	2009			
	# of units	%	Total length (m)	%
Pool	358	37	6,256	48
Flatwater	227	23	2,256	17
Riffle	243	25	2,471	19
Dry	142	15	2,030	16
Total	970		13.0 km	

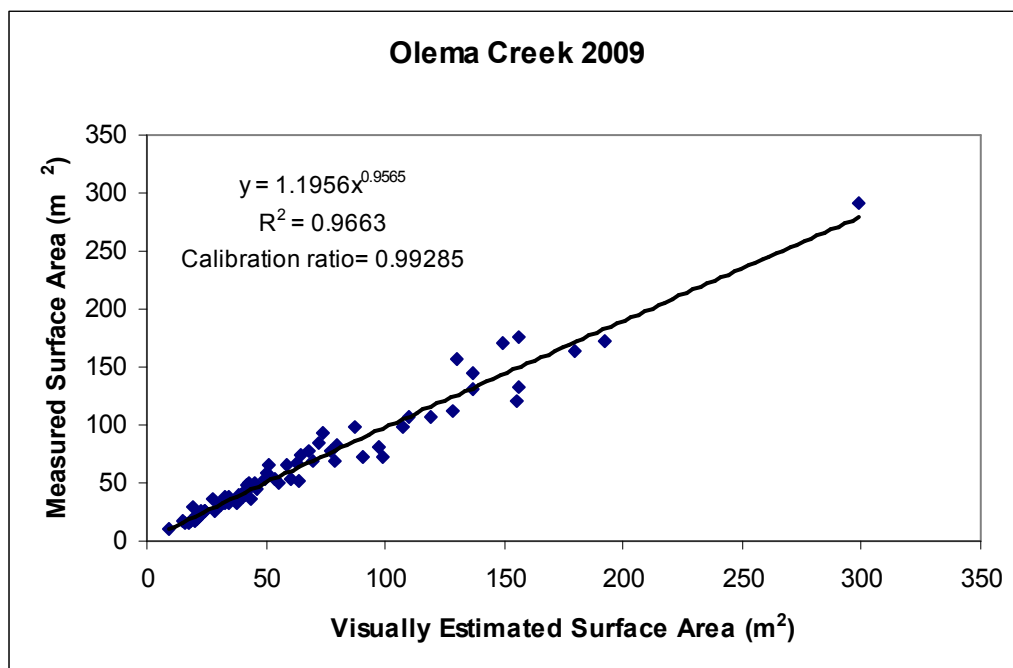


Figure 3. Correlation between measured and visually estimated surface area of 71 pools; Olema Creek, 2009.

Snorkel counts: A total of 970 habitat units were delineated within the 13.0 km Olema Creek snorkel survey area, with pool units representing 37% of all surveyed units. Snorkel surveys were conducted on 20% of the delineated pools. Only one coho was found in the 71 snorkeled pools. This is the lowest count on record, and it is possible that the one juvenile was actually a hold-over from the previous year.

Seventeen of the 71 snorkeled pools (24%) were electrofished within a day following the snorkel counts. No coho were captured in the 17 electrofished pools. Table 3 shows a summary of the snorkel survey for Olema Creek in 2009. As only one coho was observed during snorkel surveys, and none observed during the electrofishing surveys, no densities or population estimates were calculated. For historic Olema Creek snorkel counts, coho densities, and population estimates, refer to Appendix A, Tables A1 and A2.

Table 3. Summary of coho snorkel counts in Olema Creek, 2009.

Year	Total snorkel survey stream length (km)	Total number of habitat units	Number of Pools			Coho Counted	
			Total	Snorkeled	w/ Coho	Raw	Calibrated
2009	13.0	970	358	71	1	1	N/A

Woody debris counts: Table 4 represents instream woody debris frequency per 100 meters within the basinwide habitat survey area. Woody debris tallies represent instream wood counted during summer baseflow conditions and are based only on wetted length.

Table 4. Summary of basinwide instream woody debris per 100 meters during summer baseflow conditions on Olema Creek, 2009.

Stream Name	Field Season	Survey Length (km)	Rootwads Density per 100 m	LWD	SWD	10-20cm	20-50cm	>50cm
				Jams Density per 100 m	Jams Density per 100 m	WD Density per 100 m	WD Density per 100 m	WD Density per 100 m
Olema Creek mainstem	2009	11.0	2.0	0.6	0.6	2.1	2.5	1.0

Summer fish measurement information: As part of the summer monitoring program, a subsample of fish are weighed and measured within each sampled habitat unit during the basinwide surveys. As no coho were caught during the 2009 summer surveys, histograms are presented for steelhead only (Figure 4).

Within the Olema Creek sample, 284 steelhead were measured for fork length. Of those 284, 241 steelhead (67% of the total basinwide steelhead catch) were also weighed. The size range for steelhead was 51 to 180 millimeters.

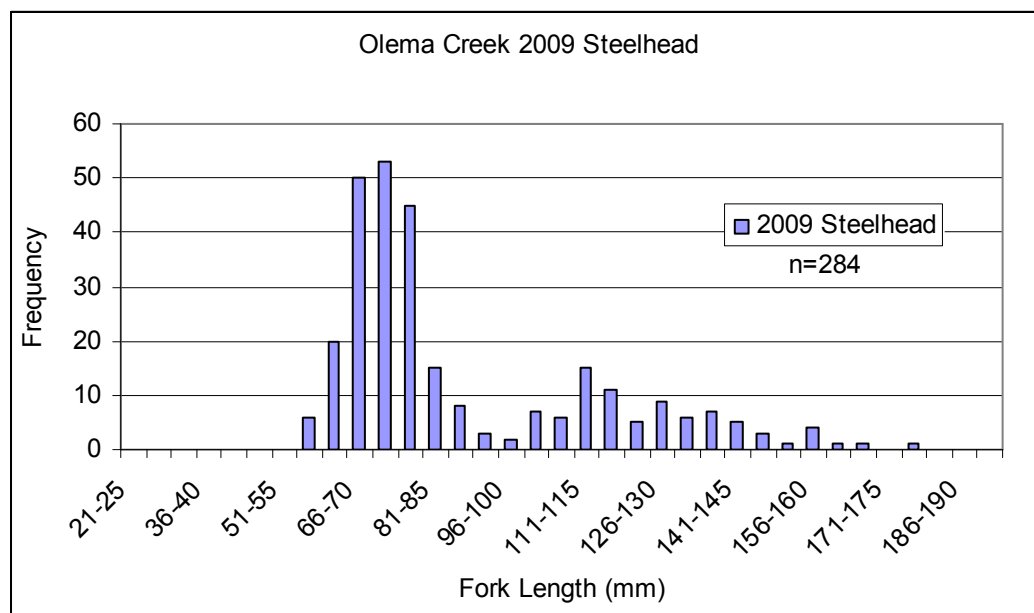


Figure 4. Steelhead histogram for fish measured in the basinwide calibration pools on Olema Creek mainstem, 2009. Fork length is represented in 5 millimeter bins. Multiple peaks represent multiple year classes of *O. mykiss*.

Length is the principal factor affecting the weight of fishes. In spite of this, there can be significant differences in weight distribution among similar size fish of the same species within a particular watershed and within the surrounding region. In order to compare length-weight relationships, we applied the Fulton Condition Factors (K) to establish comparable indices of condition (Murphy and Willis 1996). Condition factors are a ratio relating fish length to fish weight therefore measuring the relative biomass of a fish. Table 5 shows the length, weight, and K-factor for steelhead young of the year (YOY) and steelhead 1 + caught during basinwide sampling on Olema Creek.

Table 5. Mean Length, Weight, and K factor calculated for steelhead measured and weighed in the basinwide calibration pools on Olema Creek mainstem, 2009.

Species	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
Steelhead	YOY	167	73.38	6.79	73.00	4.10	1.16	3.87	1.02	0.10
Steelhead	1+	74	125.34	19.03	123.50	19.72	9.19	17.14	0.95	0.09

3.2.2 Pine Gulch Creek

The 2009 summer habitat survey of Pine Gulch Creek was initiated at monument tag 00, at the bridge within the Marin County Open Space District, and continued upstream to monument tag 95, above the Teixeira ranch within the Point Reyes National Seashore. The measured basinwide habitat survey length for the main channel was 10.1 km.

Basinwide snorkel surveys were conducted on 9.5 km of the Pine Gulch Creek mainstem starting above the Olema Bolinas Road Bridge, upstream from tag 5 and ended at monument tag 95, upstream of the Teixeira ranch within Point Reyes National Seashore.

Habitat Survey: A total of 666 mainstem habitat units were identified in the 10.1 km Pine Gulch Creek survey area. Pool and riffle units comprised the majority of the habitat types measuring a total of 9.0 km. Overall habitat composition by habitat unit was 45% pool, 42% riffle, and 13% flatwater (Table 6). Side channel and backwater units were also measured but not incorporated into the basinwide habitat calculations. Flatwater and riffle habitat types made up 94% of the total side channel habitat composition. Overall, 599 meters of side channel habitat and 195 meters of backwater habitat units were measured during the basinwide habitat survey.

A comparison between visually estimated and measured surface area was conducted for 71 pools to determine a surface area correction factor. The correlation between the estimated surface area and measured surface area was adequate ($R^2 = 0.90$). Based on this, a calibration ratio of 0.9488 was used to correct the estimated surface area of all units (Figure 5).

Table 6. Habitat composition of Pine Gulch coho survey area, 2009.

Unit type	2009			
	# of units	%	Total length (m)	%
Pool	302	45	3,876	38
Flatwater	87	13	1,091	11
Riffle	277	42	5,091	51
Total	666		10.1km	

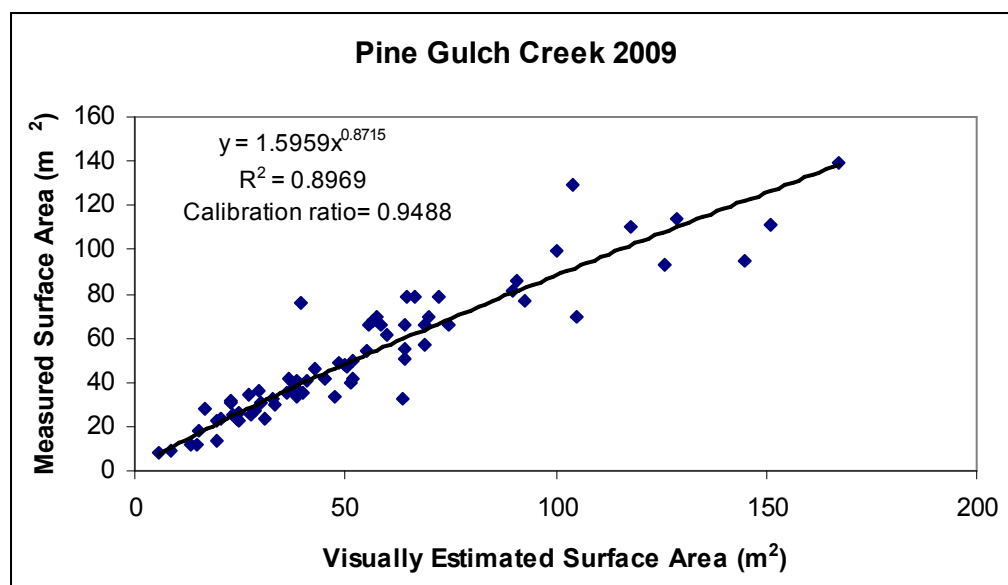


Figure 5. Correlation between measured and visually estimated surface area of 71 pools; Pine Gulch Creek, 2009.

Snorkel counts: A total of 621 habitat units were delineated within the 9.5 km Pine Gulch Creek snorkel survey area with pool units representing 45% of all surveyed units. Snorkel surveys were conducted on 24% of the delineated pools. Coho were observed in 16 (24%) of the pools snorkeled.

Twelve of the 67 snorkeled pools (18%) were electrofished within a day following the snorkel counts. In addition to the 12 electrofished pools, four pools were resnorkeled immediately following the initial pass using the method of bounded counts. *Microfish* and bounded count population estimates for the electrofished pools were used to calibrate the snorkel counts. A calibration ratio of 1.1905 was used to correct the snorkel counts for all of the pools (Figure 6). The observed low R^2 was due to the small sample size of pools containing juvenile coho and the variability between electrofishing and snorkel counts. A summary of the snorkel counts for Pine Gulch Creek is presented in Table 7. This table includes both the raw total number of coho counted in the snorkel surveys and the calibrated total number of coho.

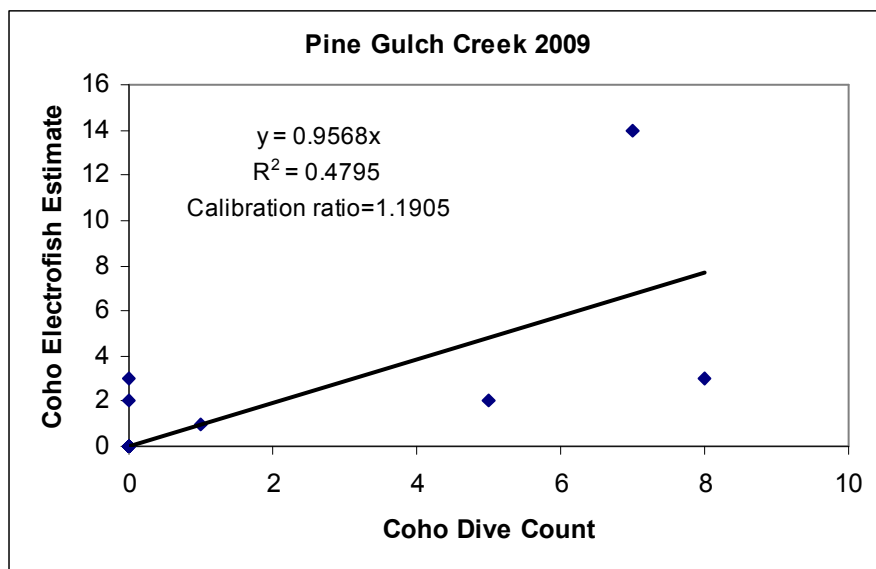


Figure 6. Correlation between electrofishing and bounded count estimates and snorkel counts for 16 pools; Pine Gulch Creek, 2009.

Coho densities (by both pool length and calibrated pool surface area) and a population estimate with 95% confidence interval were calculated for the coho survey area, and are shown in Table 8. The 2009 coho population estimate for Pine Gulch Creek is 386 ± 441 . The large 95% confidence interval for the basinwide estimate is due to the small number of observed coho and the low correlation between electrofishing and snorkel counts. For historic Pine Gulch Creek snorkel counts, coho densities, and population estimates, refer to Appendix A, Tables A3 and A4.

Table 7. Summary of coho snorkel counts in Pine Gulch Creek, 2009.

Year	Total snorkel survey stream length (km)	Total number of habitat units	Number of Pools			Coho Counted	
			Total	Snorkeled	w/ Coho	Raw	Calibrated
2009	9.5	621	302	67	16	72	86

Table 8. Coho density and population estimates; Pine Gulch Creek coho survey area, 2009.

Year	Avg. Coho per pool		Density		Population Estimate	Variance	95% confidence Interval
	Raw	Calibrated	Coho/m	Coho/m ²			
2009	1.08	1.28	0.08	0.022	386	42,878	± 441

Woody debris counts: Table 9 represents instream woody debris frequency per 100 meters within the basinwide habitat survey area. Woody debris tallies represent instream wood counted during summer baseflow conditions and only include wetted length.

Table 9. Summary of basinwide instream woody debris per 100 meters during summer baseflow conditions on Pine Gulch Creek, 2009.

Stream Name	Field Season	Survey Length (km)	Rootwads Density per 100 m	LWD Jams Density per 100 m	SWD Jams Density per 100 m	10-20cm WD Density per 100 m	20-50cm WD Density per 100 m	>50cm WD Density per 100 m
Pine Gulch mainstem	2009	10.1	1.7	0.6	1.2	2.9	1.8	2.3

Summer fish measurement information: As part of the summer monitoring program, a subsample of fish are weighed and measured within each sampled habitat unit of the basinwide survey. A histogram is presented for coho (Figure 7) and steelhead (Figure 8).

Within the Pine Gulch Creek sample, 8 coho salmon and 126 steelhead were measured for fork length. Of those 8 coho, 7 (88% of the total basinwide coho catch) were also weighed. Of the 126 steelhead, 119 steelhead trout (94% of the total basinwide steelhead catch) were also weighed. The size range for juvenile coho was observed to be 66 to 85 millimeters, while the size range for steelhead was 36 to 240 millimeters.

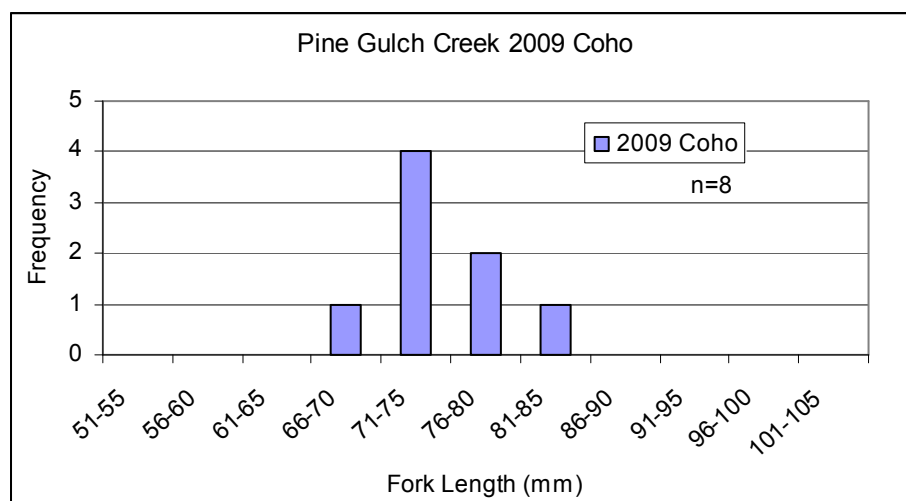


Figure 7. Coho histogram for fish measured in the basinwide calibration pools on Pine Gulch mainstem, 2009. Fork length is represented in 5 millimeter bins.

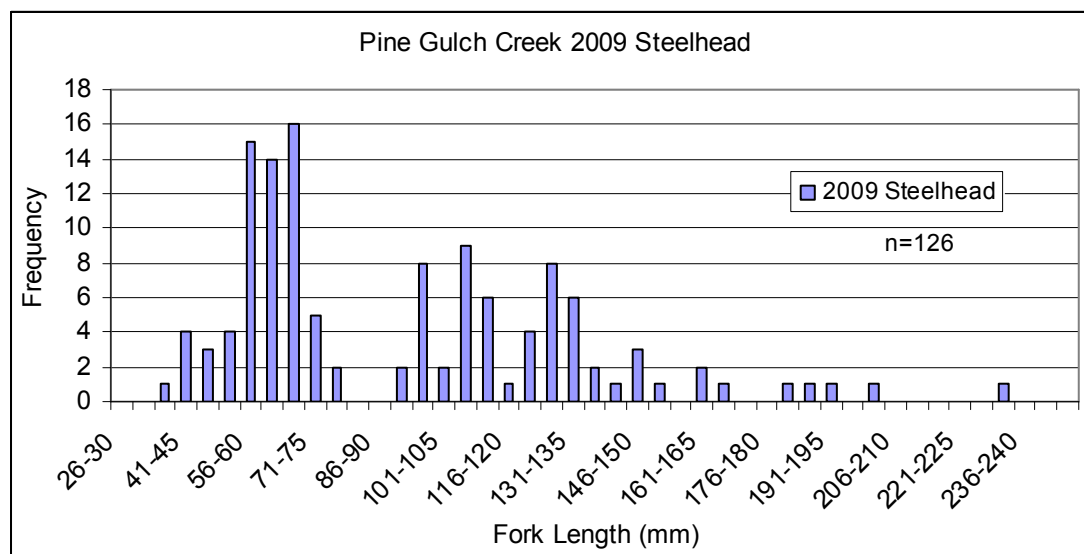


Figure 8. Steelhead histogram for fish measured in the basinwide calibration pools on Pine Gulch mainstem, 2009. Fork length is represented in 5 millimeter bins. Multiple peaks represent multiple year classes of *O. Mykiss*.

Table 10 shows the length, weight, and K-factor for coho caught during basinwide sampling on Pine Gulch Creek. Table 11 shows the comparisons between steelhead young of the year (YOY) and steelhead 1+ length, weight, and K-factors for basinwide monitoring on Pine Gulch Creek.

Table 10. Mean Length, Weight, and K factor calculated for coho measured and weighed in the basinwide calibration pools on Pine Gulch mainstem, 2009.

Species	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
Coho	YOY	7	76.00	4.24	75.00	4.94	1.11	4.58	1.11	0.12

Table 11. Mean Length, Weight, and K factor calculated for steelhead measured and weighed in the basinwide calibration pools on Pine Gulch mainstem, 2009.

Species	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
Steelhead	YOY	62	61.71	8.43	62.00	2.30	0.83	2.25	0.94	0.13
Steelhead	1+	57	126.42	25.81	124.00	22.16	14.65	18.74	0.99	0.09

3.2.3 Redwood Creek

The 2009 summer habitat survey of Redwood Creek was initiated at the pedestrian bridge at the Muir Beach parking lot and continued upstream to monument tag 74, within the Mt. Tamalpais State Park. The measured basinwide survey length for the main channel was 8.3 km.

Basinwide snorkel surveys were conducted on 8.3 km of the Redwood Creek mainstem starting at the spring smolt trapping location adjacent to the Muir Beach picnic area and ending within the Mt. Tamalpais State Park.

Habitat Survey: A total of 620 mainstem habitat units were identified within the 8.3 km Redwood Creek survey area. Pool units were the primary habitat type measuring a total of 4.4 km. Overall habitat composition by habitat unit was 45% pool, 39% riffle, and 16% flatwater (Table 12). Side channel and backwater units were also measured but not incorporated into the basinwide habitat analysis. Riffle habitat types accounted for 54 % of the side channel habitat composition. Overall, 298 meters of side channel habitat and 157 meters of backwater units were measured during the basinwide habitat survey.

A comparison between visually estimated and measured surface area was conducted for 55 pools to determine a surface area correction factor. The correlation between the estimated surface area and measured surface area was adequate ($R^2=0.94$). Based on this, a calibration ratio of 0.9474 was used to correct the estimated surface area of all units (Figure 9).

Table 12. Habitat composition of Redwood Creek coho survey area, 2009.

Unit type	2009			
	# of units	%	Total length (m)	%
Pool	278	45	4,355	53
Flatwater	102	16	1,077	13
Riffle	239	39	2,846	34
Dry	1	<1	4	<1
Total	620		8.3 km	

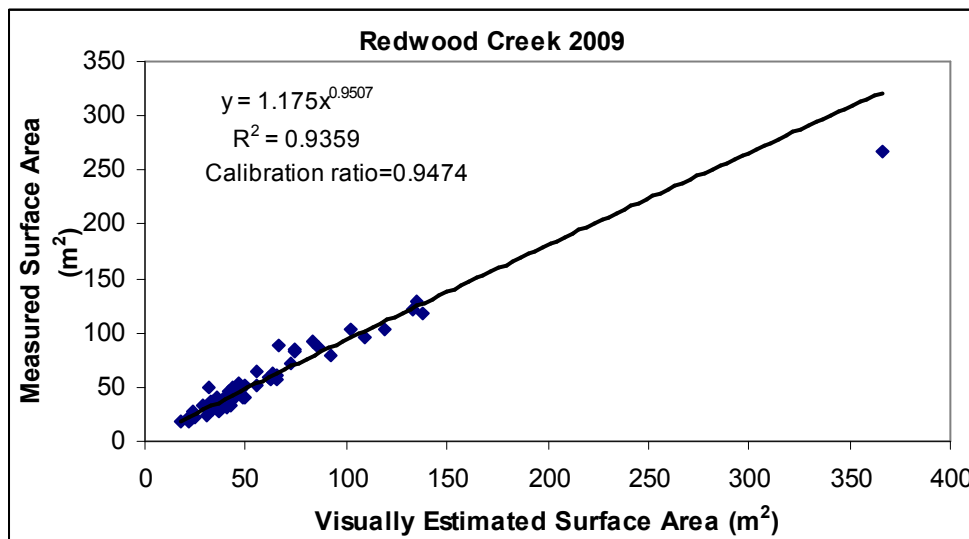


Figure 9. Correlation between measured and visually estimated surface area of 55 pools; Redwood Creek, 2009.

Snorkel counts: A total of 620 (including dry units) habitat units were delineated within the 8.3 km Redwood Creek snorkel survey area with pool units representing 45% of all surveyed units. Snorkel surveys were conducted on 19% of the delineated pools with coho being observed in 28% of the sampled pools. A total of 41 coho were counted in the 54 snorkeled pools, giving a raw average of 0.76 coho per pool.

Thirteen of the 54 snorkeled pools (24%) were electrofished within a day following the snorkel counts. *Microfish* population estimates for the electrofished pools were used to calibrate the snorkel counts. Only one coho was captured in the 13 electrofished pools. The sample size was deemed to be insufficient to generate an adequate calibration ratio. A summary of the snorkel counts for Redwood Creek in 2009 is presented in Table 13. This table contains the raw total number of coho counted in the snorkel surveys.

The 2009 coho population estimate for Redwood Creek is was not calculated due to the low numbers of juvenile coho detected by observers and the lack of coho caught during the calibration process. We are currently looking into ways of refining the methods in order to develop population estimates during years when juvenile numbers are low and/or the population is not evenly distributed throughout the watershed. For historic Redwood Creek snorkel counts, coho densities, and population estimates, refer to Appendix A, Tables A5 and A6.

Table 13. Summary of coho snorkel counts in Redwood Creek, 2009.

Year	Total snorkel survey stream length (km)	Total number of habitat units	Number of Pools			Coho Counted	
			Total	Snorkeled	w/ Coho	Raw	Raw per pool
2009	8.3	620	278	54	15	41	0.76

Woody debris counts: Table 14 represents instream woody debris frequency per 100 meters within the basinwide habitat survey area. Woody debris tallies represent instream wood counted during summer baseflow conditions and only include wetted length.

Table 14 Summary of basinwide instream woody debris per 100 meters during summer baseflow conditions on Redwood Creek, 2009.

Stream Name	Field Season	Survey Length (km)	Rootwads Density per 100 m	LWD Jams Density per 100 m	SWD Jams Density per 100 m	10-20cm WD Density per 100 m	20-50cm WD Density per 100 m	>50cm WD Density per 100 m
Redwood Creek mainstem	2009	8.3	1.4	0.4	1.0	2.7	1.9	1.5

Summer fish measurement information: As part of the summer monitoring program, a subsample of fish are weighed and measured within each sampled habitat unit. As no coho were caught during the basinwide sampling, a histogram is presented for steelhead only (Figure 10).

Within the Redwood Creek sample, 65 steelhead trout were measured for fork length. Of those 65 steelhead, 63 (90% of the total basinwide catch) were also weighed.. The size range for steelhead was 46 to 145 millimeters.

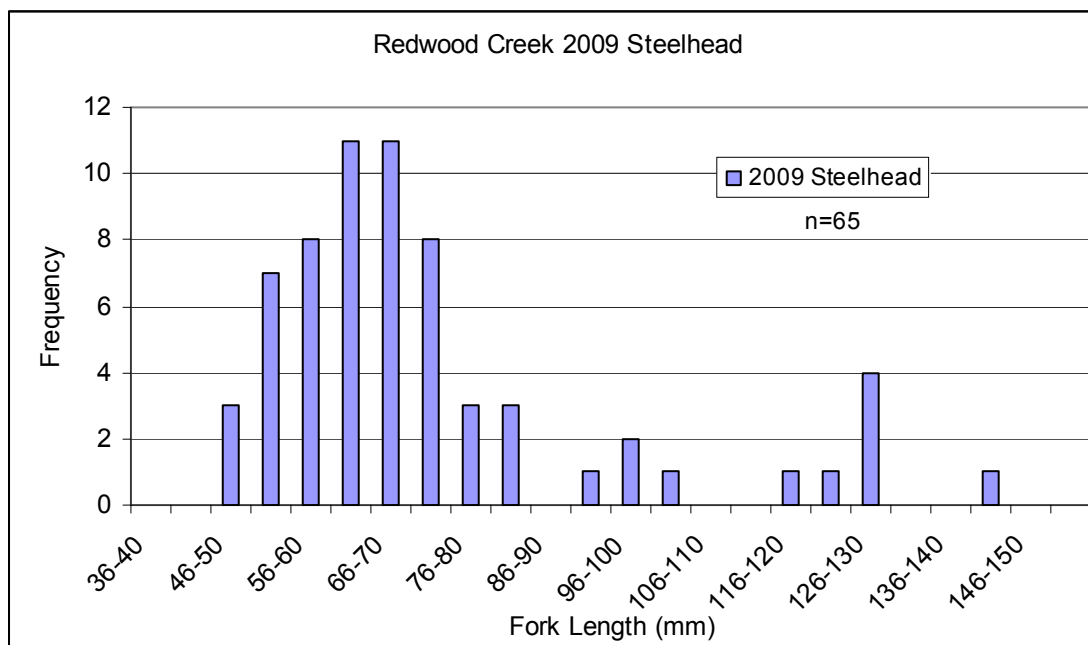


Figure 10. Steelhead histogram for fish measured in the basinwide calibration pools on Redwood Creek mainstem, 2009. Fork length is represented in 5 millimeter bins. Multiple peaks represent multiple year classes of *O. Mykiss*.

Table 15 shows the comparisons between steelhead young of the year (YOY) and steelhead 1+ length, weight, and K-factors for Redwood Creek.

Table 15. Mean Length, Weight and K factor calculated for steelhead measured and weighed in the basinwide calibration pools on Redwood Creek mainstem, 2009.

Species	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
Steelhead	YOY	53	64.64	9.72	65.00	2.81	1.37	2.62	0.98	0.15
Steelhead	1+	10	119.50	15.23	124.50	16.77	6.26	17.19	0.94	0.05

3.3 Index Reach Surveys

3.3.1 Olema Creek

Index reach monitoring was initiated at seven sites on Olema Creek in 1999. In 2000, index reach 8 was added to represent the intermittent portion of the upper mainstem. The stream kilometer (km) location of each index reach is presented in Table 16. In 2009, five of the eight index reaches on the mainstem of Olema Creek were sampled.

Table 16. Site location and number for Olema Creek index reach sites.

Index Site	Name/Location	Location Stream km
1*	Lower Stewarts Pasture/ Olema Flat	1.2
2	Vedanta	3.7
3	Cemetery Pond/ Upper Stewart's Pasture	4.9
4*	Truttman	6.3
5	Bldg 168/Shook's house	7.6
6	Horse Camp	9.4
7	5 Brooks	10.8
8*	Lime Kilns/Upper Olema	13.0

*not surveyed in 2009

Index reach total salmonid catch: The results presented in Table 17 are the 2009 real catch documented through electrofishing activities, as well as salmonid sample size variation between reaches, and are used for additional density calculations in this report. Salmonid density results are determined based upon the habitat information described in the next section and the total catch determined from the multiple pass depletion method. Historic Olema Creek index reach total catch data is presented in Appendix A, Table A7.

Table 17. Summary of total catch for each species by reach within Olema Creek mainstem index reach sample locations for 2009; shows distribution within watershed.

Year	Species	Index Reach								total
		1	2	3	4	5	6	7	8	
2009	CO	Not	0	0	Not sampled	0	0	0	Not sampled	0
	SH YOY	sampled	11	16		48	21	25		121
	SH 1+		12	19		6	6	5		48

Index reach habitat information: In 2009, no index reaches included the presence of coho, although steelhead were found in all sampled indexes. Other aquatic species sampled at each index reach are documented. Index reaches 1, 4, and 8 were not sampled in 2009 because they had the lowest numbers of consecutive sampling years of the eight index reaches on Olema Creek.

Index reach 1 was not sampled in 2009.

Index reach 2 was sampled on 9/28/09. It is located just upstream of the Vivekananda Bridge (Vedanta Retreat) near the town of Olema at stream km 3.7. Index reach 2 consisted of six habitat units, including two pools, two riffles, and two flatwater units. The total length of the reach was 83.6 m and the total surface area was 254.5 m². Pool units made up 51.3% of the total length and 62.6% of the total surface area. A total of 11 steelhead YOY and 12 steelhead 1+ were caught in the index. Also captured in index reach 2 were lamprey ammocetes, roach, stickleback, suckers, sculpin, and crayfish.

Index reach 3 was sampled on 09/29/09. It is located near stream km 4.9. This reach is fenced away from a heavily grazed field on the right bank and varies greatly in canopy cover. The riparian habitat is primarily hardwood including alder and bay trees. Index reach 3 consisted of three habitat units, all of which were pool units. The total length of the index reach was 82.3 m and the total surface area was 387.4 m². A total of 16 steelhead YOY and 19 steelhead 1+ were caught in the index. Also captured in index reach 3 were lamprey ammocetes, roach, stickleback, sculpin, suckers, and crayfish.

Index reach 4 was not sampled in 2009.

Index reach 5 was sampled on 10/01/09. It is located near stream km 7.6 near Park Residence 168. A total of five habitat units were sampled, including three pool units, and two riffles. The total length of the reach was 120.6 m and the total surface area was 472.2 m². Pool units made up 57.6% of the total length and 68.7% of the total surface area. A total of 48 steelhead YOY and six steelhead 1+ were caught in the index. Also captured in index reach 5 were roach, stickleback, sculpin, and crayfish.

Index reach 6 was sampled on 10/02/09. It is located near stream km 9.4 adjacent to the Stewart Horse Ranch pasture. Index reach 6 contained a total of three units, two of which were sampled. The two units sampled were a flatwater and a pool. The riffle unit was skipped due to low water conditions. The total length of the sampled index reach was 60.7 m and the total surface area was 189.6 m². Pool units made up 41.9% of the sampled length and 56.3% of the sampled surface area. A total of 21 steelhead YOY and six steelhead 1+ were caught in the index. Also captured in index reach 6 were stickleback, and sculpin.

Index reach 7 was sampled on 10/05/09. It is located near stream km 10.8, between the confluences of Giacomini Gulch and John West Fork within the Five Brooks area. The index reach contained a total of seven habitat units, including three pool units, one flatwater unit, and three riffle units. Only two of the three pools and the flatwater unit were sampled. The riffles were skipped due to low water levels, and the third pool was skipped as it had already been electrofished during the basinwide sampling. For the purposes of habitat composition, however, the basinwide pool data from the third pool is included. The length of the sampled reach was 43.1 m and the sampled surface area was 107.3 m². Pool units made up 87.2% of the sampled length and 88.2% of the sampled surface area. A total of 25 steelhead YOY and five steelhead 1+ were caught in the index. Also captured in index reach 7 were stickleback, roach, and sculpin.

Index reach 8 was not sampled in 2009.

Salmonid density by habitat type: The results of our monitoring efforts show distinct differences in salmonid numbers and densities based on habitat type (Table 18). While past years have shown coho to have a distinct preference for pools, with the extremely low numbers of coho observed on Olema (one juvenile), no densities were calculated. Steelhead young-of-year appeared to prefer pool and flatwater habitats equally, with densities of 0.32 fish/meter. Historic Olema Creek salmonid numbers and densities based on habitat type are presented in Appendix A, Table A8 and A9.

Table 18. Summary of population and density estimates for each species by habitat unit on Olema Creek, Summer 2009; illustrates variation in distribution between habitat types.

Habitat Type	Species (age)	Total Catch	Density	
		# of Fish	Fish/m	Fish/m ²
Pools (n=12)	CO	0	0.00	0.00
	SH YOY	101	0.32	0.09
	SH (1+)	45	0.15	0.04
Riffles (n=4)	CO	0	0.00	0.00
	SH YOY	16	0.13	0.04
	SH (1+)	1	0.05	0.04
Flatwater (n=4)	CO	0	0.00	0.00
	SH YOY	15	0.26	0.12
	SH (1+)	5	0.12	0.06
Average Density		CO	0.00	0.00
		SH YOY	0.29	0.09
		SH (1+)	0.12	0.04

Summer fish measurement information: As part of the summer monitoring program, a subsample of fish are weighed and measured within each sampled habitat unit. Histograms are presented for steelhead (Figure 11).

Within the Olema Creek sample, 144 steelhead were measured for fork length. Of those 144, 142 (84% of the total index reach catch) were also weighed. The size range for steelhead was 61 to 180 millimeters.

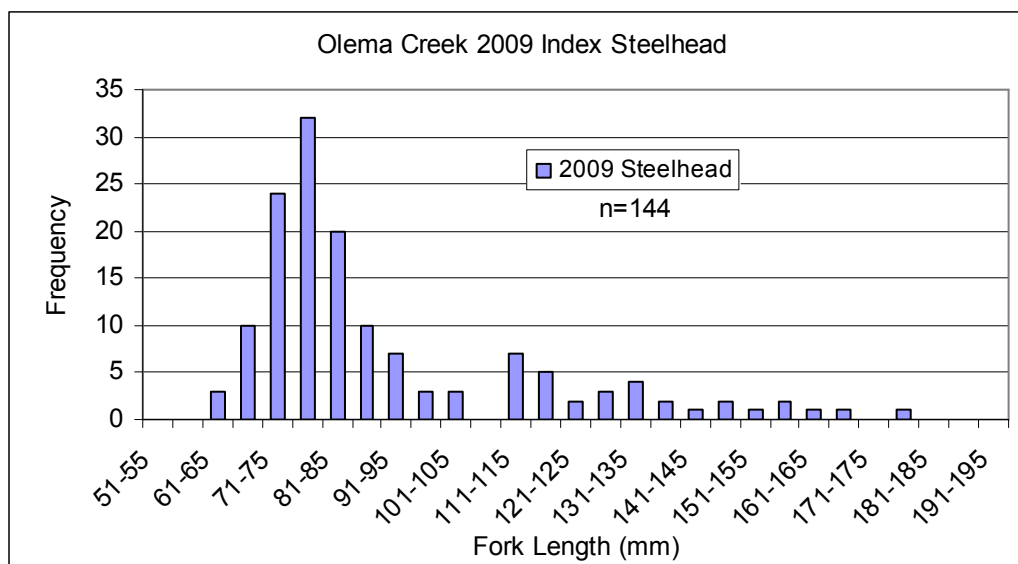


Figure 11. Steelhead histogram for fish measured in five Olema Creek index reaches, 2009. Fork length is represented in 5 millimeter bins. Multiple peaks represent multiple year classes of *O. mykiss*.

Table 19 shows the comparisons between steelhead young of the year (YOY) and steelhead 1+ length, weight, and K-factors for Olema Creek. For historical data on length, weight, and K-factors on Olema Creek, refer to Appendix A, tables A10, A11, and A12.

Table 19. Mean Length, Weight, and K factor calculated for steelhead measured and weighed in the seven Olema Creek index reaches, 2009.

Species	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
Steelhead	YOY	99	77.87	6.60	78.00	5.02	1.35	4.91	1.04	0.07
Steelhead	1+	43	123.42	22.38	120.00	19.95	11.06	16.54	0.98	0.08

3.3.2 Pine Gulch Creek

Index reach monitoring was initiated at eight sites on Pine Gulch Creek in 2000. The stream kilometer (km) location of each index reach is presented in Table 20. In 2009, five of the eight index reaches on the mainstem of Pine Gulch Creek were sampled. Index reach electrofishing surveys were conducted on Pine Gulch Creek from July 16 through August 23, 2009.

Table 20. Site location and number for Pine Gulch Creek index sites.

Index Site	Name/Location	Location Stream km
1a*	Marin County Open Space District (MCOSD)	0.2
1b*	Murch	0.4
1c	Weber	0.7
2	Paradise Valley	2.7
3	Pine Gulch Gorge	3.9
4*	BCPUD pasture	5.1
5	Lower Teixeira	6.8
6	Upper Teixeira	7.8

*not sampled in 2009 due to access issues.

Index reach total salmonid catch: The results presented in Table 21 are the 2009 real catch documented through electrofishing activities, as well as salmonid sample size variation between reaches. Historic Pine Gulch index reach total catch data is presented in Appendix A, Table A13.

Table 21. Summary of total catch for each species by reach within Pine Gulch Creek mainstem index reach sample locations for 2009.

Year	Species	Index Reach								Total
		1a	1b	1c	2	3	4	5	6	
2009	CO			0	0	0		3	0	3
	SH YOY	Not sampled	Not Sampled	3	3	26	Not sampled	6	8	46
	SH 1+			14	7	12		5	5	43

Index reach habitat information: In 2009, coho were found within the index reach 5, and steelhead were present in all sampled index reaches. Other aquatic species sampled at each index reach are documented.

Pine Gulch Creek Index 1a through 1c were established to represent the lower reaches of the watershed where the stream flows through organic agricultural cropland. The NPS and other agencies are working with these landowners to enhance operations to protect instream flow for the benefit of coho salmon and steelhead trout. Sampling in these private lands is done with the cooperation of the landowners.

Index reach 1a was not sampled in 2009 due to obstruction by a large woody debris jam.

Index reach 1b was not sampled in 2009 as it was felt that index reach 1c was representative of both sites.

Index reach 1c was sampled on 7/16/09. It is located 100 m upstream of the Olema-Bolinas Road Bridge on the Star Route Farms property. Index reach 1c consisted of seven habitat units, including four pool units, two flatwater units and one riffle. The total length of the index reach

was 57.1 m and the total surface area was 209.2 m². Pool units made up 68.8% of the total length and 78.1% of the total surface area. A total of three steelhead YOY and 14 steelhead 1+ were caught in the index. Also captured in index reach 1c were lamprey ammocetes, stickleback, and sculpin.

Index reach 2 was sampled on 7/20/09. It is located near stream km 2.8. This reach is located in Paradise Valley on land recently purchased from the Martinelli Family Trust. The riparian habitat is primarily hardwood such as alder and bay trees. Index reach 2 consisted of five habitat units, including four pool units and one riffle unit. The total length of the surveyed reach was 64.9 m and the total surface area was 284.0 m². Pool units made up 83.1% of the total length and 81.9% of the total surface area. A total of three steelhead YOY and seven steelhead 1+ were caught in the index. Also captured in index reach 2 were lamprey ammocetes, stickleback, sculpin, rough skinned newts, California giant salamanders, bullfrogs, and crayfish.

Index reach 3 was sampled on 7/21/09. It is located near stream km 3.9, at the lower end of the gorge. This is a steep canyon area with dense riparian cover, and deep stable bedrock controlled habitat. Index reach 3 consisted of three habitat units, including two pool units and one riffle unit. Only one pool unit and the riffle were sampled during index reach electrofishing, as the second pool unit had been sampled earlier during basinwide electrofishing. The total length of the surveyed index reach was 65.8 m and the total surface area sampled was 250.3 m². Pool units made up 72.6% of the total length and 79% of the total surface area. A total of 26 steelhead YOY and 12 steelhead 1+ were caught in the index. Also captured in index reach 3 were stickleback, lamprey ammocetes, rough skinned newts and sculpin.

Index reach 4 of Pine Gulch has not been possible to electrofish since 2001 due to site access issues.

Index reach 5 was sampled on 7/22/09. It is located near stream km 6.8 within the Teixeira Flats area. A total of six habitat units were sampled, including three pool units, one flatwater unit, and two riffles. The total length of the index reach was 60.1 m and the total surface area was 171.9 m². Pool units made up 49.6% of the total length and 54.5% of the total surface area. A total of three coho, six steelhead YOY, and five steelhead 1+ were caught in the index. Also captured in index reach 5 were lamprey ammocetes, stickleback, sculpin, rough skinned newts, and California giant salamanders.

Index reach 6 was sampled on 7/23/09. It is located near stream km 7.8 upstream of the Teixeira House. Index reach 6 contained a total of six habitat units, including four pool units, one flatwater unit, and one riffle unit. The total length of the index reach was 58.1 m and the total surface area was 136.5 m². Pool units made up 66.6% of the total length and 77.5% of the total surface area. A total of eight steelhead YOY and five steelhead 1+ were caught in the index. Also captured in index reach 6 were lamprey ammocetes and sculpin.

Salmonid density by habitat type: Pools are typically the best habitat for both coho salmon and steelhead trout, and consistently support higher densities than flatwater and riffle units. Table 22 shows the breakout of habitat units and fish densities. Coho were observed in one of the five index reaches sampled in 2009. As observed in Olema Creek, steelhead occur in all habitat types, though in varying densities. Historic Pine Gulch coho and steelhead numbers and densities based on habitat type are presented in Appendix A, A14 and A15.

Table 22. Summary of population and density estimates for each species by habitat unit on Pine Gulch Creek, Summer 2009; illustrates variation in distribution between habitat types.

Habitat Type	Species (age)	Total Catch	Density	
		# of Fish	Fish/m	Fish/m ²
Pools (n=17)	CO	3	0.02	0.01
	SH YOY	34	0.13	0.04
	SH (1+)	39	0.19	0.05
Riffles (n=6)	CO	0	0.00	0.00
	SH YOY	9	0.10	0.06
	SH (1+)	3	0.05	0.02
Flatwater (n=4)	CO	0	0.00	0.00
	SH YOY	3	0.09	0.03
	SH (1+)	1	0.03	0.01
Average Density		CO	0.01	0.006
		SH YOY	0.12	0.04
		SH (1+)	0.14	0.04

Summer fish measurement information: As part of the summer monitoring program, a subsample of fish are weighed and measured within each sampled habitat unit. A histogram is presented for steelhead (Figure 12).

Within the Pine Gulch Creek sample, three coho salmon (100% of the total index reach coho catch) were measured for fork length and weighed. A total of 75 steelhead trout were measured for fork length. Of those 75 steelhead, 73 (97% of the total index reach steelhead catch) were also weighed. The size range for coho was 71 to 80 millimeters while the range for steelhead trout was 41 to 240 millimeters.

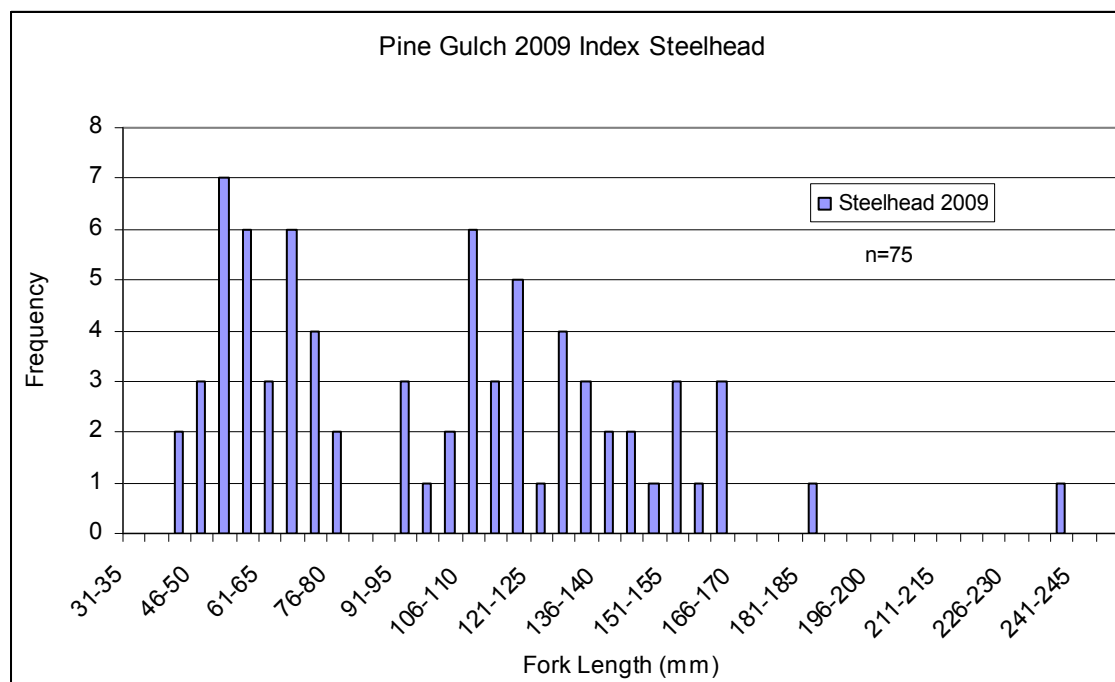


Figure 12. Steelhead histogram for fish measured in the six Pine Gulch Creek index reaches, 2009. Fork length is represented in 5 millimeter bins. Multiple peaks represent multiple year classes of *O. Mykiss*.

Condition factors are a ratio relating fish length to fish weight therefore measuring the relative biomass of a fish. Table 23 shows the condition factor for coho caught in the Pine Gulch Creek index reaches while Table 24 shows the comparisons between steelhead young of the year (YOY) and steelhead 1+ length, weight, and K-factors for Pine Gulch Creek. Historic data for length, weight, and K factors for Pine Gulch Creek are found in Appendix A, tables A16, A17, and A18.

Table 23. Mean Length, Weight, and K factor calculated for coho measured and weighed in the five Pine Gulch Creek index reaches, 2009.

Species	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
Coho	YOY	3	77.33	2.52	77.00	4.87	0.60	4.91	1.05	0.04

Table 24. Mean Length, Weight, and K-factor calculated for steelhead measured and weighed in the five Pine Gulch Creek index reaches, 2009.

Species	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
Steelhead	YOY	32	59.97	9.83	58.50	2.22	1.13	1.90	0.95	0.11
Steelhead	1+	41	126.10	23.81	122.00	21.55	12.06	16.68	0.98	0.08

3.3.3 Redwood Creek

Dr. Jerry Smith (SJSU) established five index reaches on Redwood Creek in 1992; monitoring of these sites were shared between Dr. Smith and NPS until 2004. Two additional index sites, Muir Woods National Monument (MUWO) boardwalk and Banducci, were added by Golden Gate National Recreation Area (GOGA) in 2001 to represent habitat units not being covered by Dr. Jerry Smith. Since 2004, all seven index reaches have been monitored by NPS staff. The stream kilometer (km) location of each index reach is presented in Table 25. In 2009, all of the seven index reaches on the mainstem of Redwood Creek were sampled.

Table 25. Site location and number for Redwood Creek index reach sites.

Index Site	Name/Location	Location Stream km
1	MUWO boardwalk	6.3
2	MUWO restroom	5.2
3	Miwok Trail Crossing	3.8
4	Kent Creek	2.9
5	Frank Valley Road Bridge	1.9
6	Banducci	0.8
7	Pacific Way Bridge	0.1

Index reach total salmonid catch: The results presented in Table 26 are the 2009 real catch documented through electrofishing activities, as well as salmonid sample size variation between reaches. Historic Redwood Creek index reach total catch data is presented in Appendix A, Table A19.

Table 26. Summary of total catch for each species by reach within Redwood Creek mainstem index reach sample locations for 2009.

Year	Species	Index Reach							Total
		1	2	3	4	5	6	7	
2009	CO	0	5	2	27	2	0	0	36
	SH YOY	104	87	85	55	27	21	25	404
	SH 1+	14	7	20	40	15	2	3	101

Index reach habitat information: In 2009, coho were found in index reaches 2 through 5, while all index reaches included the presence of steelhead. Other aquatic species sampled at each index reach are documented.

Index reach 1 was sampled on 8/25/09. It is located within MUWO. Index reach 1 consisted of seven habitat units, including two pool units, two flatwater units and three riffle units. The total length of the index reach was 123.1 m and the total surface area was 444.5 m². Pool units made up 35.7% of the total length and 32.3% of the total surface area. A total of 104 steelhead YOY and 14 steelhead 1+ were caught in the index. Also captured in index reach 1 were sculpin, California giant salamanders, and crayfish.

Index reach 2 was sampled on 8/24/09. It is located behind the MUWO restrooms. Index reach 2 consisted of three habitat units, including two pool units and one riffle unit. A cascade unit was also present but was not sampled. The total length of the index reach was 34.5 m and the total surface area was 181.3 m². Pool units made up 52.2% of the total length and 63.8% of the total surface area. A total of five coho, 87 steelhead YOY and seven steelhead 1+ were caught in the index. Also captured in index reach 2 were sculpin and crayfish.

Index reach 3 was sampled on 8/20/09. It is located near stream km 3.8 at the Miwok Trail footbridge crossing. Index reach 3 consisted of six habitat units, including four pool units, and two riffle units. The total length of the index reach was 78.9 m and the total surface area was 236.4 m². Pool units made up 78.2% of the total length and 81.5% of the total surface area. A total of two coho, 85 steelhead YOY and 20 steelhead 1+ were caught in the index. Also captured in index reach 3 were California giant salamanders and crayfish.

Index reach 4 was sampled on 8/19/09. It is located near stream km 2.9 at the Kent Creek confluence on Redwood Creek. Index reach 4 consisted of seven habitat units, including five pool units and two riffle units. The total length of the surveyed index reach was 99.2 m and the total surface area was 331.5 m². Pool units made up 86.0% of the total length and 91.5% of the total surface area. A total of 27 coho, 55 steelhead YOY and 40 steelhead 1+ were caught in the index. Also captured in index reach 4 were sculpin and crayfish.

Index reach 5 was sampled on 8/18/09. It is located near stream km 1.9 upstream of the Frank Valley Road bridge. Index reach 5 consisted of five habitat units, including three pool units, one flatwater unit and one riffle unit. The total length of the surveyed index reach was 96.6 m and the total surface area sampled was 373.5 m². Pool units made up 83.6% of the total length and 82.7% of the total surface area. A total of two coho, 27 steelhead YOY and 15 steelhead 1+ were caught in the index. Also captured in index reach 5 were sculpin and crayfish.

Index reach 6 was sampled on 8/17/09. It is located near stream km 0.8 at the Banducci restoration site. Index reach 6 contained a total of eight habitat units, including four pool units, one flatwater unit, and three riffle units. The total length of the index reach was 97.0 m and the total surface area was 409.2 m². Pool units made up 78.4% of the total length and 83.5% of the total surface area. A total of 21 steelhead YOY and two steelhead 1+ were caught in the index. Also captured in index reach 6 were sculpin, rough skinned newts, and crayfish.

Index Reach 7 was sampled on 8/13/09. It is located near the Pacific Way Bridge, at stream km 0.1. Index reach 7 contained a total of five habitat units, including one pool unit, three flatwater units and one riffle unit. The total length of the index reach was 77.5 m and the total surface area was 231.2 m². Pool units made up 24.3% of the total length and 31.1% of the total surface area. A total of 25 steelhead YOY and three steelhead 1+ were caught in the index. Also captured in index reach 7 were stickleback and sculpin.

Salmonid density by habitat type: The results of our monitoring efforts show distinct differences in salmonid numbers and densities based on habitat type (Table 27). The results show distinct use of pools by both coho and steelhead (YOY and 1+) with fish densities of 0.13 fish/meter, 1.00 fish/meter, and 0.28 fish/meter respectively. Historic Redwood Creek salmonid numbers and densities based on habitat type are presented in Appendix A, tables A20 and A21.

Table 27. Summary of population and density estimates for each species by habitat unit on Redwood Creek, Summer 2009; illustrates variation in distribution between habitat types.

Habitat Type	Species (age)	Total Catch	Density	
		# of Fish	Fish/m	Fish/m ²
Pools (n=21)	CO	40	0.13	0.03
	SH YOY	321	1.00	0.25
	SH (1+)	96	0.28	0.07
Riffles (n=13)	CO	0	0.00	0.00
	SH YOY	58	0.28	0.10
	SH (1+)	2	0.02	0.00
Flatwater (n=7)	CO	0	0.00	0.00
	SH YOY	57	0.62	0.20
	SH (1+)	3	0.03	0.01
Average Density		CO	0.07	0.02
		SH YOY	0.71	0.19
		SH (1+)	0.15	0.04

Summer fish measurement information: As part of the summer monitoring program, a subsample of fish are weighed and measured within each sampled habitat unit. Histograms are presented for coho (Figure 13) and steelhead (Figure 14).

Within the Redwood Creek sample, 36 coho salmon (100% of the total index reach catch) were measured for fork length and weighed. A total of 403 steelhead trout were measured for fork length. Of those 403 steelhead, 400 (79% of the total index reach catch) were also weighed. The size range for juvenile coho was observed to be 66 to 90 millimeters, while the size range for steelhead was 41 to 180 millimeters.

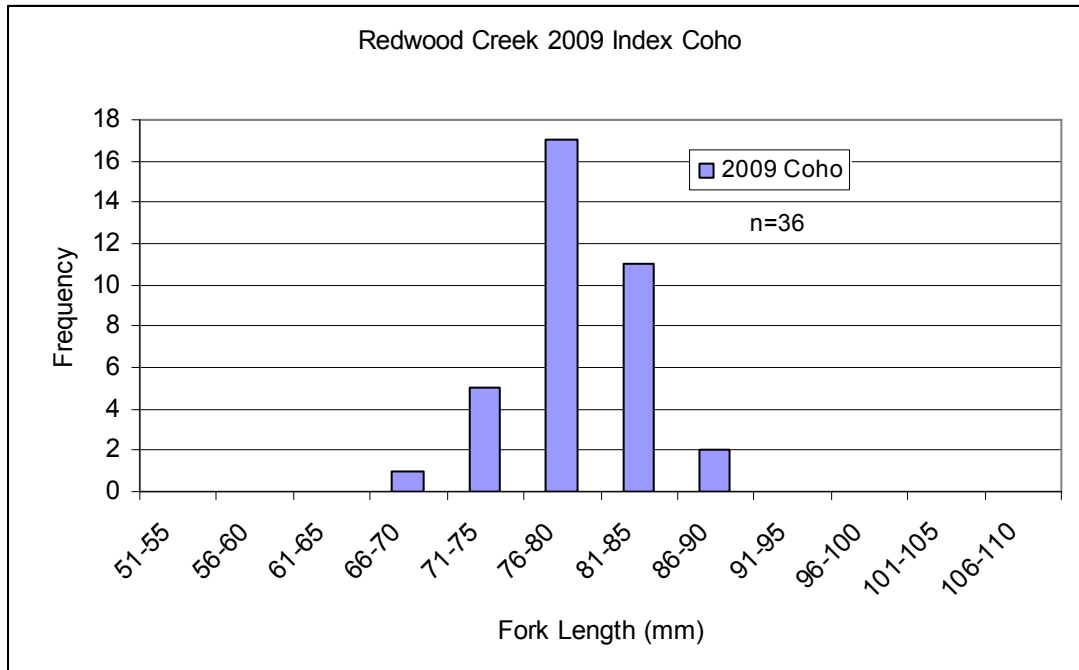


Figure 13. Coho histogram for fish measured in the seven Redwood Creek index reaches, 2009. Fork length is represented in 5 millimeter bins.

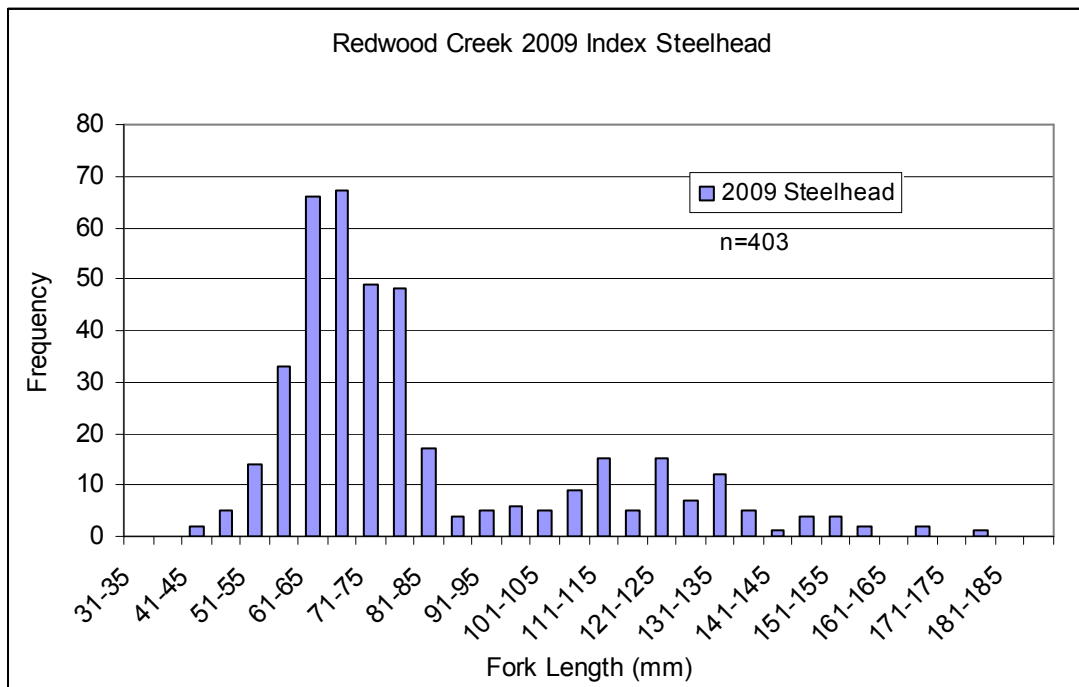


Figure 14. Steelhead histogram for fish measured in the seven Redwood Creek index reaches, 2009. Fork length is represented in 5 millimeter bins. Multiple peaks represent multiple year classes of *O. Mykiss*.

Table 28 shows the coho length, weight, and K-factor for Redwood Creek. Table 29 shows the comparisons between steelhead young of the year (YOY) and steelhead 1+ length, weight, and

K-factors for Redwood Creek. Historic data for length, weight, and K factor for Redwood Creek can be found in Appendix A, tables A22, A23, and A24.

Table 28. Mean Length, Weight, and K factor calculated for coho measured and weighed in the seven Redwood Creek index reaches, 2009.

Species	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
Coho	YOY	36	79.33	4.20	79.00	5.25	0.86	5.05	1.04	0.05

Table 29. Mean Length, Weight, and K factor calculated for steelhead measured and weighed in the seven Redwood Creek index reaches, 2009.

Species	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
Steelhead	YOY	306	68.40	8.98	68.00	3.38	1.33	3.15	1.01	0.09
Steelhead	1+	94	123.04	16.80	122.50	18.84	7.68	17.30	0.96	0.07

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Appendix A

Table A1. Summary of coho snorkel counts in Olema Creek, 2005-2009.

Year	Total snorkel survey stream length (km)	Total number of habitat units	Number of Pools			Coho Counted	
			Total	Snorkeled	w/ Coho	Raw	Calibrated
2005	11.9	671	318	74	74	8,527	6,955
2006	11.6	859	324	75	52	397	415
2007	11.8	917	368	89	86	6,679	7,811
2008	7.8	474	211	53	44	1,056	570
2009	13.0	970	358	71	1	1	N/A

Table A2. Coho density and population estimates; Olema Creek coho survey area, 2005-2009.

Year	Total snorkel survey stream length (km)	Avg. Coho per pool		Density		Population Estimate	Variance	95% confidence Interval
		Raw	Calibrated	coho/m	Coho/m ²			
2005	11.9	115.23	93.99	3.61	1.025	29,887	22,537, 780	± 9,974
2006	11.6	5.29	5.53	0.30	0.092	1,793	169,577	± 869
2007	11.8	75.05	86.77	4.18	1.312	31,936	3,950,948	± 4,127
2008	7.8	19.92	10.75	0.326	0.081	2,268	226,266	± 1,037
2009	13.0	0.01	N/A	N/A	N/A	N/A	N/A	N/A

Table A3. Summary of coho snorkel counts in Pine Gulch, 2005-2009.

Year	Total snorkel survey stream length (km)	Total number of habitat units	Number of Pools			Coho Counted	
			Total	Snorkeled	w/ Coho	Raw	Calibrated
2005	9.9	616	309	67	42	219	249
2006	10.3	844	357	104	21	58	86
2007	10.3	860	339	95	0	0	0
2008	10.3	859	363	78	0	0	0
2009	10.1	666	302	67	16	72	86

Table A4. Coho density and population estimates; Pine Gulch coho survey area, 2005-2009.

Year	Total snorkel survey stream length (km)	Avg. Coho per pool		Density		Population Estimate	Variance	95% confidence Interval
		Raw	Calibrated	coho/m	coho/m ²			
2005	9.9	3.27	3.72	0.22	0.072	1,150	66,615	± 554
2006	10.3	0.56	0.83	0.07	0.030	295	9,419	± 201
2007	10.3	0	N/A	N/A	N/A	N/A	N/A	N/A
2008	10.3	0	N/A	N/A	N/A	N/A	N/A	N/A
2009	10.1	1.08	1.28	0.08	0.021	386	42,879	± 441

Table A5. Summary of coho snorkel counts in Redwood Creek, 2005-2009.

Year	Total snorkel survey stream length (km)	Total number of habitat units	Number of Pools			Coho Counted	
			Total	Snorkeled	w/ Coho	Raw	Calibrated
2005	7.7	423	193	61	61	2,737	2,716
2006	7.7	536	228	63	35	198	290
2007	8.1	598	262	81	74	1,976	2,421
2008	8.5	726	244	66	22	113	117
2009	8.3	620	278	54	15	41	N/A

Table A6. Coho density and population estimates; Redwood Creek coho survey area, 2005-2009.

Year	Total snorkel survey stream length (km)	Avg. Coho per pool		Density		Population Estimate	Variance	95% confidence Interval
		Raw	Calibrated	Coho/m	Coho/m ²			
2005	7.7	44.87	44.53	1.94	0.458	8,594	606,987	± 1,652
2006	7.7	3.14	4.61	0.30	0.072	1,050	54,241	± 486
2007	8.1	24.40	29.89	1.86	0.482	7,832	621,780	± 1,640
2008	8.5	1.71	1.77	0.09	0.025	431	16,439	± 271
2009	8.3	0.76	N/A	N/A	N/A	N/A	N/A	N/A

Table A7. Summary of total catch for each species by reach within Olema Creek mainstem index reach sample locations between 2005 and 2009.

Year	Species	Index Reach								total
		1	2	3	4	5	6	7	8	
2005	CO		206	255		269	361	191	186	1,468
	SH YOY	not sampled	72	97	not sampled	180	67	38	44	498
	SH 1+		10	5		13	15	7	7	57
2006	CO		92	36	0	4	2	9	18	161
	SH YOY	not sampled	55	77	93	80	65	37	43	450
	SH 1+		37	67	24	54	32	6	20	240
2007	CO	not sampled	123	170	233	332	217	156	160	1,391
	SH YOY		112	135	241	120	51	10	36	705
	SH 1+		9	22	16	19	15	3	8	92
2008	CO	not sampled	3	42	12	22	9	7	0	95
	SH YOY		113	145	181	103	40	23	2	607
	SH 1+		3	9	13	6	4	1	1	37
2009	CO	not sampled	0	0		0	0	0		0
	SH YOY		11	16	not sampled	48	21	25	not sampled	121
	SH 1+		12	19		6	6	5		48

Table A8. Summary of population and density estimates from electrofishing surveys for coho salmon by habitat unit Olema Creek, 2005-2009.

Year	Habitat Type	# of Habitat Units	Total Catch	Density	
			# of Fish	Fish/m	Fish/m ²
2005	Pool	11	1,562	4.01	0.87
	Riffle	4	3	0.07	0.02
	Flatwater	2	1	0.11	0.04
2006	Pool	14	120	0.24	0.05
	Riffle	3	0	0.00	0.00
	Flatwater	4	0	0.00	0.00
2007	Pool	16	1,452	4.56	1.10
	Riffle	6	3	0.06	0.03
	Flatwater	3	10	0.56	0.27
2008	Pool	16	90	0.24	0.07
	Riffle	14	0	0.00	0.00
	Flatwater	6	5	0.03	0.02
2009	Pool	12	0	0.00	0.00
	Riffle	4	0	0.00	0.00
	Flatwater	4	0	0.00	0.00

Table A9. Summary of population and density estimates from electrofishing surveys for steelhead YOY by habitat unit Olema Creek, 2005-2009.

Year	Habitat Type	# of Habitat Units	Total Catch	Density	
			# of Fish	Fish/m	Fish/m ²
2005	Pool	11	466	1.19	0.27
	Riffle	4	51	0.39	0.07
	Flatwater	2	2	0.22	0.08
2006	Pool	14	397	1.14	0.25
	Riffle	3	2	0.11	0.04
	Flatwater	4	46	0.70	0.21
2007	Pool	16	719	2.31	0.59
	Riffle	6	19	0.48	0.20
	Flatwater	3	22	1.29	0.61
2008	Pool	16	448	1.51	0.49
	Riffle	14	57	0.30	0.09
	Flatwater	6	133	0.98	0.36
2009	Pool	12	101	0.32	0.09
	Riffle	4	16	0.13	0.04
	Flatwater	4	15	0.26	0.12

Table A10. Mean Coho Length, Weight, and K factor calculated for coho measured and weighed in the Olema Creek index reaches 2005-2009.

Year	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
2005	YoY	287	64.00	7.09	64.00	3.14	1.07	3.01	1.16	0.08
2006	YoY	81	75.63	7.23	75.00	5.13	1.60	5.00	1.15	0.08
2007	YoY	335	63.95	8.80	64.00	2.86	1.28	2.70	1.04	0.20
2008	YoY	80	76.29	7.09	75.50	4.52	1.29	4.50	0.99	0.07
2009	YoY	0	0	0	0	0	0	0	0	0

Table A11. Mean Steelhead Length, Weight, and K factor calculated for steelhead YOY measured and weighed in the Olema Creek index reaches 2005-2009.

Year	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
2005	YoY	239	68.59	10.14	67.00	3.90	1.90	3.41	1.13	0.12
2006	YoY	218	67.44	7.95	68.00	3.62	1.23	3.67	1.13	0.10
2007	YoY	241	54.08	7.82	53.00	1.74	0.78	1.52	1.04	0.12
2008	YoY	321	67.51	9.08	66.00	3.38	1.53	3.01	1.05	0.10
2009	YoY	99	77.87	6.60	78.00	5.02	1.35	4.91	1.04	0.07

Table A12. Mean Steelhead Length, Weight, and K factor calculated for steelhead 1+ measured and weighed in the Olema Creek index reaches in 2005-2009.

Year	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
2005	1+	53	140.92	27.52	137.00	32.77	22.49	26.66	1.05	0.07
2006	1+	137	108.55	25.88	101.00	16.53	12.19	11.28	1.14	0.19
2007	1+	80	121.73	17.51	118.00	18.74	8.13	16.49	0.99	0.12
2008	1+	35	113.86	24.89	104.00	15.38	10.50	11.18	0.94	0.08
2009	1+	43	123.42	22.38	120.00	19.95	11.06	16.54	0.98	0.08

Table A13. Summary of total catch for each species by reach within Pine Gulch Creek mainstem index reach sample locations between 2005 and 2009.

Year	Species	Index Reach								total
		1a	1b	1c	2	3	4	5	6	
2005	CO	3	1	0	2	15		16	8	45
	SH YOY	25	18	44	78	41	not sampled	40	33	279
	SH 1+	8	5	33	18	17		24	7	112
2006	CO	0	0	0	0	0		4	10	14
	SH YOY	9	22	17	17	45	not sampled	39	20	169
	SH 1+	31	28	38	13	18		17	18	163
2007	CO	0	0	0	0	0		0	0	0
	SH YOY	3	39	61	145	153	not sampled	55	52	508
	SH 1+	2	21	29	23	13		23	14	125
2008	CO		0	0	0	0		0	0	0
	SH YOY	not sampled	9	22	87	147	not sampled	37	53	355
	SH 1+		4	15	12	16		15	10	72
2009	CO			0	0	0		3	0	3
	SH YOY	Not sampled	Not Sampled	3	3	26	Not sampled	6	8	46
	SH 1+			14	7	12		5	5	43

Table A14. Summary of population and density estimates from electrofishing surveys for coho by habitat unit Pine Gulch Creek, 2005-2009.

Year	Habitat	# of Habitat	Total Catch	Density	
	Type	Units	# of Fish	Fish/m	Fish/m ²
2005	Pool	12	43	0.16	0.05
	Riffle	6	0	0.00	0.00
	Flatwater	6	2	0.02	0.01
2006	Pool	15	14	0.09	0.03
	Riffle	11	0	0.00	0.00
	Flatwater	5	0	0.00	0.00
2007	Pool	16	0	0.00	0.00
	Riffle	10	0	0.00	0.00
	Flatwater	4	0	0.00	0.00
2008	Pool	17	0	0.00	0.00
	Riffle	8	0	0.00	0.00
	Flatwater	3	0	0.00	0.00
2009	Pool	17	3	0.02	0.01
	Riffle	6	0	0.00	0.00
	Flatwater	4	0	0.00	0.00

Table A15. Summary of population and density estimates from electrofishing surveys for steelhead YOY by habitat unit Pine Gulch Creek, 2005-2009.

Year	Habitat Type	# of Habitat Units	Total Catch	Density	
			# of Fish	Fish/m	Fish/m ²
2005	Pool	12	233	0.91	0.27
	Riffle	6	15	0.94	0.61
	Flatwater	6	36	0.48	0.18
2006	Pool	15	147	0.66	0.20
	Riffle	11	9	0.07	0.03
	Flatwater	5	15	0.32	0.12
2007	Pool	16	404	1.57	0.48
	Riffle	10	79	0.88	0.27
	Flatwater	4	44	0.83	0.24
2008	Pool	17	292	1.51	0.45
	Riffle	8	81	0.75	0.32
	Flatwater	3	8	0.15	0.08
2009	Pool	17	34	0.13	0.04
	Riffle	6	9	0.10	0.06
	Flatwater	4	3	0.09	0.03

Table A16. Mean Length, Weight, and K factor calculated for coho measured and weighed in the Pine Gulch Creek index reaches 2005-2009.

Year	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
2005	YoY	40	80.48	4.71	80.50	5.84	1.10	5.67	1.11	0.06
2006	YoY	14	81.14	5.64	83.50	5.85	1.18	6.10	1.09	0.12
2007	YoY	0	0	0	0	0	0	0	0	0
2008	YoY	0	0	0	0	0	0	0	0	0
2009	YoY	3	77.33	2.52	77.00	4.87	0.60	4.91	1.05	0.04

Table A17. Mean Length, Weight, and K factor calculated for steelhead YOY measured and weighed in the Pine Gulch Creek index reaches 2005-2009.

Year	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
2005	YoY	213	71.17	9.68	70.00	4.45	1.83	4.04	1.17	0.07
2006	YoY	157	78.72	8.84	79.00	5.84	1.91	5.83	1.16	0.10
2007	YoY	300	64.73	10.42	65.00	2.97	1.46	2.77	1.00	0.10
2008	YoY	252	66.47	11.07	66.00	3.23	1.63	2.92	1.02	0.19
2009	YoY	32	59.97	9.83	58.50	2.22	1.13	1.90	0.95	0.11

Table A18. Mean Length, Weight, and K factor calculated for steelhead 1+ measured and weighed in the Pine Gulch Creek index reaches 2005-2009.

Year	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
2005	1+	106	130.52	27.44	120.00	27.29	22.45	19.51	1.08	0.08
2006	1+	123	123.43	26.21	120.00	22.12	13.42	18.46	1.09	0.12
2007	1+	117	131.79	21.05	129.00	24.32	12.26	20.92	0.99	0.06
2008	1+	72	134.46	26.99	129.00	25.34	18.16	19.71	0.93	0.09
2009	1+	41	126.10	23.81	122.00	21.55	12.06	16.68	0.98	0.08

Table A19. Summary of total catch (Not including Dr. Jerry Smith information) for each species by reach within Redwood Creek mainstem index reach sample locations from 2005-2009.

Year	Species	Index Reach							total
		1	2	3	4	5	6	7	
2005	CO	23	59	77	93	164	236	339	991
	SH YOY	44	38	41	70	77	178	82	530
	SH 1+	5	12	12	10	14	9	4	66
2006	CO	6	21	21	38	10	9	0	105
	SH YOY	36	77	26	20	5	17	4	185
	SH 1+	2	23	21	20	11	20	1	98
2007	CO	54	138	215	120	146	89	8	770
	SH YOY	90	161	305	170	212	392	144	1,474
	SH 1+	8	43	10	11	7	11	7	97
2008	CO	0	2	6	0	23	3		34
	SH YOY	84	79	103	120	101	79	not sampled	566
	SH 1+	10	19	23	20	21	12		105
2009	CO	0	5	2	27	2	0	0	36
	SH YOY	104	87	85	55	27	21	25	404
	SH 1+	14	7	20	40	15	2	3	101

Table A20. Summary of population and density estimates from electrofishing surveys for coho salmon by habitat unit Redwood Creek, 2005-2009.

Year	Habitat Type	# of Habitat Units	Total Catch	Density	
			# of Fish	Fish/m	Fish/m ²
2005	Pool	19	1,050	2.04	0.52
	Riffle	5	1	0.00	0.00
	Flatwater	3	12	0.24	0.10
2006	Pool	22	103	0.29	0.07
	Riffle	13	0	0.00	0.00
	Flatwater	6	0	0.00	0.00
2007	Pool	22	761	2.03	0.49
	Riffle	13	2	0.05	0.06
	Flatwater	10	12	0.09	0.04
2008	Pool	18	33	0.10	0.03
	Riffle	11	0	0.00	0.00
	Flatwater	13	2	0.01	0.00
2009	Pool	21	40	0.13	0.03
	Riffle	13	0	0.00	0.00
	Flatwater	7	0	0.00	0.00

Table A21. Summary of population and density estimates from electrofishing surveys for steelhead YOY by habitat unit Redwood Creek, 2005-2009.

Year	Habitat Type	# of Habitat Units	Total Catch	Density	
			# of Fish	Fish/m	Fish/m ²
2005	Pool	19	515	1.03	0.28
	Riffle	5	18	0.10	0.02
	Flatwater	3	37	0.75	0.33
2006	Pool	22	151	0.46	0.10
	Riffle	13	18	0.10	0.03
	Flatwater	6	19	0.29	0.09
2007	Pool	22	1,200	3.05	0.79
	Riffle	13	57	0.43	0.22
	Flatwater	10	255	1.47	0.57
2008	Pool	18	443	1.52	0.47
	Riffle	11	27	0.16	0.05
	Flatwater	13	119	0.89	0.43
2009	Pool	21	321	1.00	0.25
	Riffle	13	58	0.28	0.10
	Flatwater	7	57	0.62	0.20

Table A22. Mean Length, Weight, and K factor calculated for coho measured and weighed in the Redwood Creek index reaches, 2005-2009.

Year	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
2005	YoY	337	72.15	8.04	71.00	4.39	1.58	4.02	1.13	0.07
2006	YoY	79	78.35	7.32	77.00	5.52	1.65	4.94	1.13	0.10
2007	YoY	294	73.73	8.38	73.00	4.15	1.49	3.89	1.00	0.08
2008	YoY	32	76.53	18.73	79.50	4.79	3.14	4.54	0.90	0.09
2009	YoY	36	79.33	4.20	79.00	5.25	0.86	5.05	1.04	0.05

Table A23. Mean Length, Weight, and K factor calculated for steelhead YOY measured and weighed in the Redwood Creek index reaches, 2005-2009.

Year	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
2005	YoY	340	72.16	10.85	72.00	4.50	2.00	4.20	1.12	0.07
2006	YoY	156	77.99	9.60	78.00	5.43	2.03	5.20	1.10	0.11
2007	YoY	547	63.52	9.61	62.00	2.76	1.30	2.42	1.00	0.11
2008	YoY	372	66.83	9.15	67.00	3.03	1.26	2.86	0.96	0.08
2009	YoY	306	68.40	8.98	68.00	3.38	1.33	3.15	1.01	0.09

Table A24. Mean Length, Weight, and K factor calculated for steelhead 1+ measured and weighed in the Redwood Creek index reaches, 2005-2009.

Year	Life Stage	Sample Size	Mean Length (mm)	Length Standard Deviation	Median Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
2005	1+	64	133.66	28.01	128.00	29.00	21.02	23.21	1.08	0.07
2006	1+	89	130.53	26.13	128.00	26.38	21.04	22.58	1.06	0.09
2007	1+	79	121.72	26.32	119.00	19.38	13.12	15.07	0.95	0.11
2008	1+	93	116.45	18.09	116.00	15.40	7.26	14.62	0.92	0.06
2009	1+	94	123.04	16.80	122.50	18.84	7.68	17.30	0.96	0.07