

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

Summer 2011 Monitoring Progress Report

Prepared for:

California Department of Fish and Game
P0830407



ON THE COVER

Electrofishing on Redwood Creek, Marin County, CA.
Photograph by: Sarah Carlisle

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Summer 2011 Monitoring Progress Report

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The Long-term Coho and Steelhead Monitoring progress reports are intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols provided by the National Park Service and were analyzed and interpreted within the guidelines of the protocols.

This report is available from the San Francisco Bay Area Network I&M program website (<http://www.sfnps.org/>) on the internet.

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Abstract

The 2011 summer monitoring of juvenile salmonids and salmonid habitat described in this report focused primarily on watersheds in the Point Reyes National Seashore and Golden Gate National Recreation Area, including Muir Woods National Monument, 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 coast of North America. Olema Creek had a population estimate of $4,570 \pm 2,183$ coho juveniles, which represents an increase of approximately 200% for the cohort from 2008 through 2011 (one generation). Redwood Creek had a population estimate of 270 ± 153 , marking a decline of over 37% for the cohort over the same time period (2008-2011). A population estimate was not feasible for Pine Gulch Creek, as no coho juveniles were observed during summer surveys in 2011.

1- Introduction

Ongoing monitoring of coho salmon within the Olema Creek, Pine Gulch Creek, and Redwood Creek watersheds in coastal Marin County is conducted under the management of the National Park Service (NPS) San Francisco Area Network (SFAN) Inventory and Monitoring Program (I&M Program), with support from the California Department of Fish and Game (CDFG) . This monitoring effort continues salmonid research initiated and conducted by the NPS since 1997. The primary focus of this monitoring program is to document federally and state listed endangered coho salmon (*Oncorhynchus kisutch*) population distribution and trends within these watersheds. In addition, monitoring documents population trends for federally threatened steelhead trout (*O. mykiss*) and other fish species within the monitored watersheds.

All Standard Operating Procedures (SOPs) referred to in this report can be found in the SFAN I&M Program Salmonid Monitoring Protocol v 4.0 (Reichmuth et al. 2010), which 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 2011. These watersheds are located within the Lagunitas Creek and Bolinas Hydrologic Sub-areas of the Bodega and Marin Hydrologic Units. The Recovery Strategy for Coho Salmon (CDFG 2004) categorizes each of these Hydrologic Sub-areas 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 2011 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, staff sampled a total of 15 legacy index reaches in these three watersheds. The results of basinwide and index reach survey information for Olema Creek, Pine Gulch Creek, and Redwood Creek are reported in this progress report.

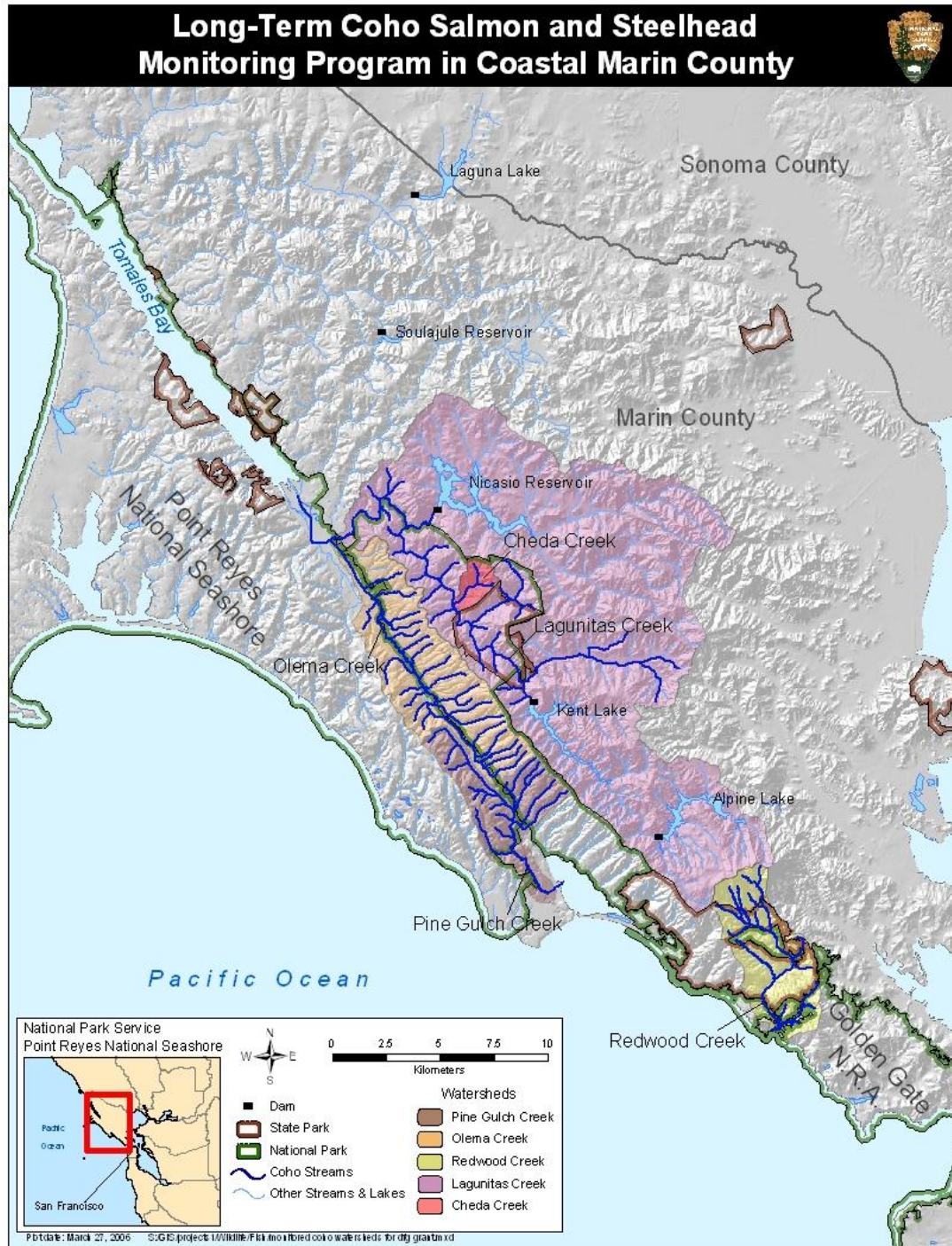


Figure 1. Streams supporting coho salmon in coastal Marin County monitored by the National Park Service.

1.1 Basinwide Surveys

Basinwide juvenile coho population estimates were developed for Olema Creek and Redwood Creek in 2011. Although a basinwide survey was performed on Pine Gulch Creek, no estimate was calculated due to the lack 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 not possible, multiple snorkel passes, called bounded counts (described in Reichmuth et al. 2010), 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 electrofishing 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 must anticipate fish movement, obstacles, cover, and suspended sediment in order to obtain an accurate juvenile coho count.

1.2 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 include both Olema and Pine Gulch Creeks in an effort to consistently monitor changes in salmonid populations and key habitats within the SFAN. The program documents annual change in habitat condition and size associated with winter runoff events and riparian structure. Analysis of this information by watershed will be valuable for predicting responses to environmental and climactic conditions, adjustments in land management strategies, and for evaluation of specific restoration activities. This form of survey is also performed in adjacent watersheds, including the Lagunitas and San Geronimo Creek Watersheds.

Complete index site histories are documented in the salmonid monitoring protocol for the SFAN I&M Program (Reichmuth et al. 2010). Not all of the index reaches are sampled every year due to budget constraints. The indexes chosen for sampling are those with the longest consecutive years of sampling.

1.3 Salmonids Monitored in the San Francisco Area Network Parks in 2010

The primary species monitored through this program are coho salmon and steelhead trout. However, other fish species including sculpin (*Cottus* spp.), California roach (*Hesperoleucus symmetricus*), lamprey (*Lampetra* spp.), Sacramento suckers (*Catostomus occidentalis*), and stickleback (*Gasterosteus aculeatus*) are captured and documented through our monitoring efforts.

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 salmon are known to exist in Lagunitas, Olema, Pine Gulch Creek Watersheds (Brown and Ketcham 2002), and the Redwood Creek Watershed (Smith 2001). Coho salmon are categorized into genetically-distinct populations for federal endangered-species protection purposes; the central California coast coho salmon evolutionarily significant unit (CCCESU) includes all naturally spawned populations of coho salmon from Punta Gorda in northern California south to and including the San Lorenzo River in central California, as well as populations in tributaries to San Francisco Bay, excluding the Sacramento-San Joaquin River system. This CCCESU was listed as a threatened species within in 1996 by the National Marine Fisheries Service (Federal Register 1996) and the CCCESU was downgraded in status (upgraded listing protection) to endangered in 2005 (Federal Register 2005). In 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 in 2005.

Steelhead are the anadromous form of rainbow trout and are iteroparous, meaning they can spawn more than once. Steelhead fry reside in near-shore areas, while the juveniles tend to use riffles and pool margins. Steelhead trout are known to exist in most perennial watersheds within Marin County. Because of dramatic declines in population numbers, NMFS was petitioned to list this species throughout much of the California coast. Steelhead were listed as a threatened species in 1997 (Federal Register 1997). The central California coast steelhead distinct population segment 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, San Pablo, and Suisun Bays eastward to Chipps Island at the confluence of the Sacramento and San Joaquin Rivers; excluding the Sacramento-San Joaquin River Basin. Also included are the artificially propagated stocks from the Don Clausen Fish Hatchery and the Kingfisher Flat Hatchery/Scott Creek (Federal Register 2006).

1.3.1 Historical Fishery Resources

Fish populations have declined dramatically since the turn of the last century. As early as 1892, reports of declines in fish abundance within the streams of western Marin County were circulated. Interviews with longtime 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-1950s. 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, SFAN parks 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.

For complete methodology, please refer to SOP 1, 2, 3, 9, and 11 (Reichmuth et al. 2010).

2.1 Habitat Surveys

Starting at the lowest elevation of the coho survey area and working upstream, staff numbered, classified, measured the length of each habitat unit, and estimated its average width. Units were classified to level III using the California Department of Fish and Game stream classification system (Flosi et al. 1998) as pool (scour pool, plunge pool, or mid-channel pool), flatwater, or riffle. Every fifth pool unit was flagged to designate pools to be snorkeled for visual estimation.

In addition to characterizing habitat types in the main channel, the field observers recorded the abundance of off-channel habitat types and woody debris in the stream channel. Off channel habitat types were categorized using the same methods as the main channel habitat typing. All large woody debris, alive or dead, providing instream shelter during summer baseflow conditions were counted and recorded within each habitat unit.

2.2 Basinwide Snorkel Surveys

This monitoring program adopted a two-stage sampling technique developed by Hankin and Reeves (Dollof et al. 1993) to efficiently estimate basinwide fish abundance. For stage one, project staff surveyed pools with a single 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.

The second sample stage was conducted by randomly selecting at least 20% of the snorkeled pools which were then electrofished the day after each snorkel survey. Electrofishing results were used to develop a calibration ratio for snorkel counts. 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 millimeter, 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 after sedation 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 the Point Reyes National Seashore Endangered Species Act permit issued by the National Marine Fisheries Service. Water quality parameters including dissolved oxygen, conductivity, and specific conductance 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 each year. Table 1 provides the timing for the 2011 summer/fall stream fish surveys.

Table 1. Basinwide survey/index reach survey timing, 2011.

Watershed	Stream	# of Index Reaches	In-Stream Sample Dates
Pine Gulch	Mainstem	4	07/05/11 – 07/28/11
Redwood	Mainstem	6	08/01/11 – 08/23/11
Olema	Mainstem	5	08/24/11 – 09/28/11

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 for Olema Creek, years 2000 through 2004 for Pine Gulch Creek, and years 1998 through 2004 for 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 2011 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 13.5 kilometers (km).

Basinwide snorkel surveys were conducted on 13.5 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 the lowest section (downstream of the Bear Valley Road Bridge) was not snorkled due to safety risk to staff from poor water quality. 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 human 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 monitoring process in collaboration with the San Francisco Bay Area Regional Water Quality Control Board.

Habitat Survey

A total of 958 mainstem habitat units were identified in the 13.5 km Olema Creek survey area. Pool units were the dominant habitat type available to fish, measuring a total of 7.7 km. Overall habitat composition by number of units was 44% pool, 35% riffle, and 18% flatwater (Table 2). Intermittent conditions were observed approximately 12.4 km upstream from the mouth of Olema Creek. Dry sections of streambed accounted for only 1.3% 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 87% of the total side channel habitat composition. Overall, 755 meters (m) of side channel habitat and 280 m of backwater habitat units were measured during the basinwide habitat survey.

A comparison between visually estimated and measured surface area was conducted for 83 pools to determine a surface area correction factor. The correlation between the estimated surface area and measured surface area was high ($R^2 = 0.91$), and similar to the correlations found in Hankin

and Reeves (1988). Based on this, a calibration ratio of 0.987 was used to correct the estimated surface area of all units (Figure 2).

Table 2. Habitat composition of Olema Creek coho survey area, 2011.

Unit type	2011			
	# of units	%	Total length (m)	%
Pool	417	44	7,681	56
Flatwater	175	18	2,169	16
Riffle	341	35	3,523	26
Dry	25	3	180	1
Total	958		13.5 km	

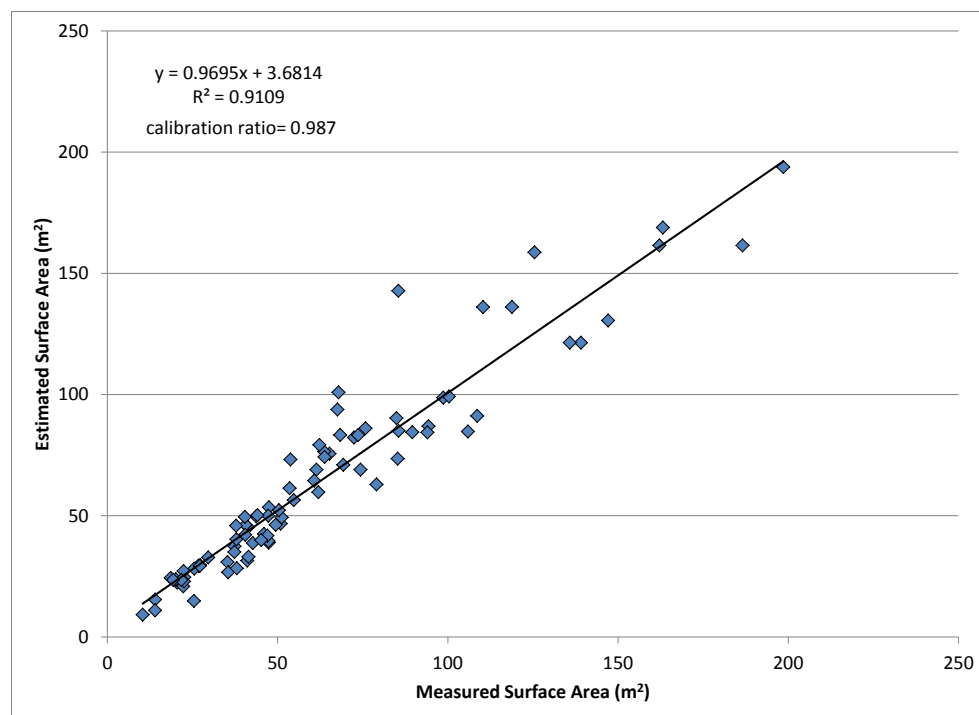


Figure 2. Correlation between measured and visually estimated surface area of 83 pools, Olema Creek, 2011.

Snorkel Counts

Snorkel surveys were conducted on 78 (19%) of the delineated pools. Of the pools snorkeled, coho were found in 53 (68%).

Fifteen of the 78 snorkeled pools (19%) were sampled for calibration within a day following the snorkel counts; thirteen of those were electrofished while two pools were resnorkeled immediately following the initial pass using the method of bounded counts. *Microfish* and bounded count population estimates for the calibration pools were used to calibrate the snorkel counts. A calibration ratio of 1.3 was used to correct the snorkel counts for all of the pools (Figure 3).

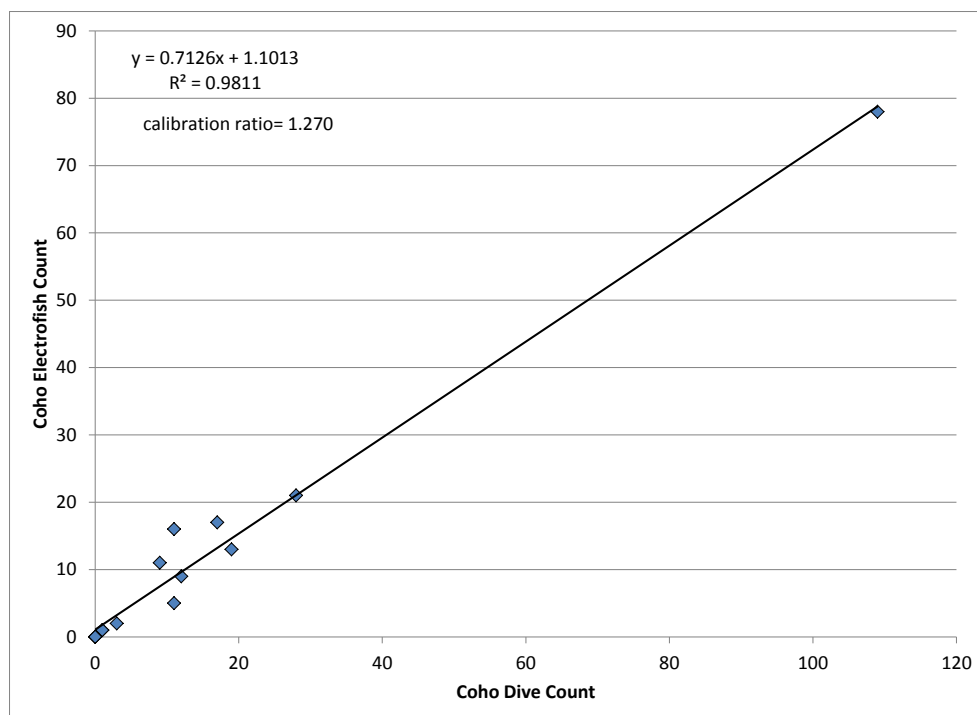


Figure 3. Correlation between electrofishing estimates and snorkel counts for Olema Creek, 2011.

A summary of the snorkel counts for Olema Creek is presented in Table 3. This table includes both the raw total number of coho counted in the snorkel surveys and the calibrated total number of coho. 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 4. The 2011 coho population estimate for Olema Creek is $4,570 \pm 2,183$. For historical 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, 2011.

Year	Total snorkel survey stream length (km)	Total number of habitat units	Number of Pools			Coho Counted	
			Total	Snorkeled	w/ Coho	Raw	Calibrated
2011	13.5	958	417	78	53	673	855

Table 4. Coho density and population estimates; Olema Creek coho survey area, 2011.

Year	Avg. Coho per pool		Density		Population Estimate	95% confidence Interval
	Raw	Calibrated	Coho/m	Coho/m ²		
2011	8.63	10.96	0.59	0.158	4,570	$\pm 2,183$

Woody Debris Counts

As in-stream woody debris constitutes fish habitat, woody debris can help to monitor complex habitat available to salmonids over time. Table 5 represents instream woody debris frequency per 100 m within the basinwide habitat survey area. Woody debris tallies represent instream wood

counted during summer baseflow conditions and are based only on wetted length, presented by size class: 10-20 centimeters (cm), 20-50 cm, and greater than 50 cm.

Table 5. Summary of basinwide instream woody debris per 100 m of wetted length during summer baseflow conditions on Olema Creek, 2011.

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
Olema Creek mainstem	2011	13.3	0.7	0.6	0.5	3.0	2.3	0.9

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. Histograms are presented for coho (Figure 4) and steelhead (Figure 5).

Within the Olema Creek sample, 126 coho were measured for fork length and weighed. The size range for coho was 51 to 95 millimeters (mm) in length.

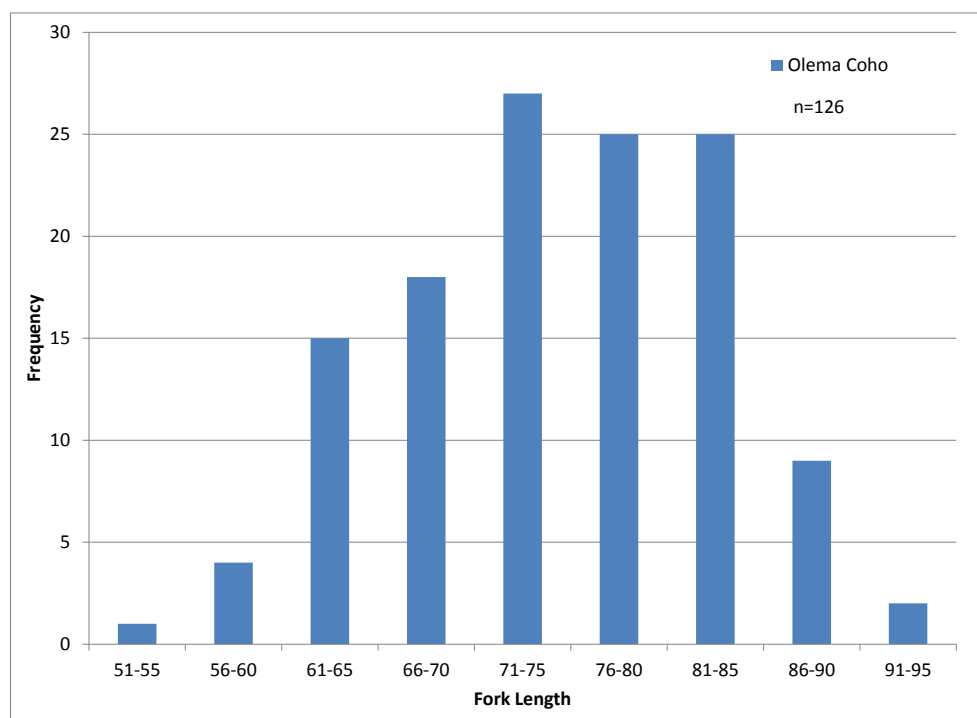


Figure 4. Coho histogram for fish measured in the basinwide calibration pools on Olema Creek mainstem, 2011. Fork length is represented in 5 millimeter (mm) bins.

A total of 306 steelhead were measured for fork length. Of those, 299 (98% of the total basinwide steelhead catch) were also weighed. The size range for steelhead was 36 to 215 mm in length.

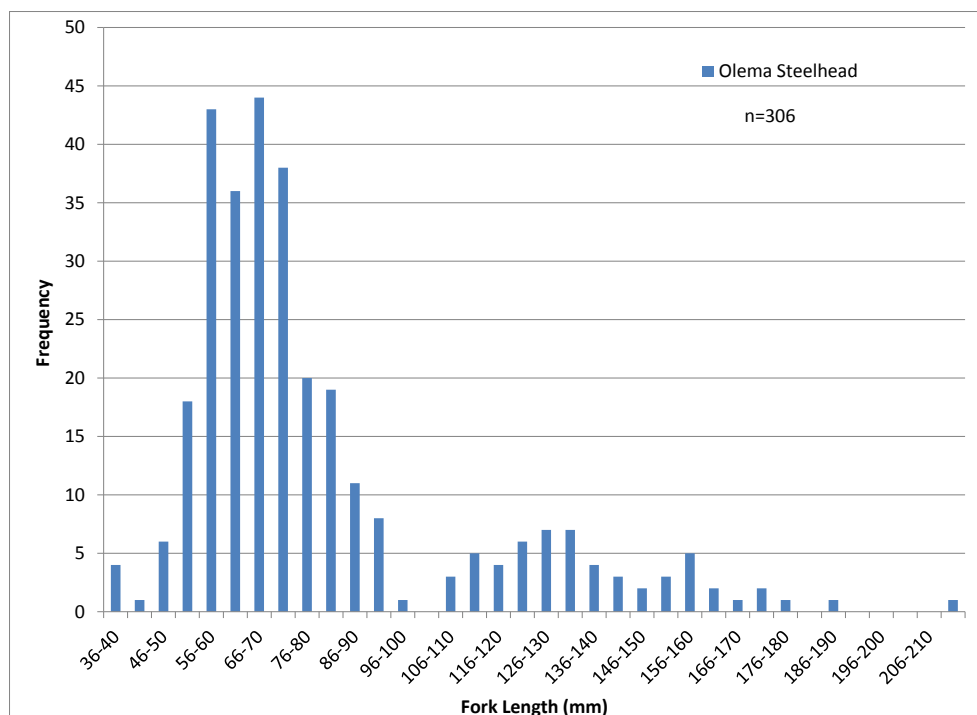


Figure 5. Steelhead histogram for fish measured in the basinwide calibration pools on Olema Creek mainstem, 2011. Fork length is represented in 5 millimeter (mm) bins. Multiple peaks represent multiple year classes of steelhead.

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 Fulton Condition Factors (K-factor) 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 6 shows the length, weight (in grams (g)), and K-factor for coho caught during basinwide sampling on Olema Creek. Table 7 shows the length, weight, and K-factor for steelhead young of the year (YOY) and steelhead 1 + (fish that are at least one year in age).

Table 6. Mean and median length, weight, and K-factor calculated for coho measured and weighed in the basinwide calibration pools on Olema Creek mainstem, 2011.

Species	Sample Size	Mean Length (mm)	Median Length (mm)	Length Standard Deviation	Mean Weight (g)	Median Weight (g)	Weight Standard Deviation	Mean K-Factor	K-Factor Standard Deviation
Coho	126	74.87	75.00	7.86	4.31	4.24	1.37	0.99	0.07

Table 7. Mean and median length, weight, and K-factor calculated for steelhead measured and weighed in the basinwide calibration pools on Olema Creek mainstem, 2011. YOY= young of the year; fish one year or older= 1+

Species	Life Stage	Sample Size	Mean Length (mm)	Median Length (mm)	Length Standard Deviation	Mean Weight (g)	Median Weight (g)	Weight Standard Deviation	Mean K-Factor	K-Factor Standard Deviation
Steelhead	YOY	243	68.46	68.00	10.96	3.40	2.99	1.70	0.98	0.09
Steelhead	1+	56	137.00	132.50	19.43	25.08	20.94	10.62	0.93	0.07

3.2.2 Redwood Creek

The 2010 summer habitat survey of Redwood Creek was initiated of the Pacific Way bridge and continued upstream to monument tag 74, within the Mt. Tamalpais State Park. The measured basinwide survey length for the main channel was 7.6 km.

Basinwide snorkel surveys were conducted on 7.6 km of the Redwood Creek mainstem starting the Pacific Way bridge and ending within the Mt. Tamalpais State Park.

Habitat Survey

A total of 531 mainstem habitat units were identified within the 7.6 km Redwood Creek survey area. Pool units were the primary habitat type measuring a total of 3.8 km. Overall habitat composition by habitat unit was 45% pool, 41% riffle, and 14% flatwater (Table 8). Side channel and backwater units were also measured but not incorporated into the basinwide habitat analysis. Riffle habitat types accounted for 52 % of the side channel habitat composition. Overall, 395 m of side channel habitat and 76 m of backwater units were measured during the basinwide habitat survey.

Table 8. Habitat composition of Redwood Creek coho survey area, 2011.

Unit type	2011			
	# of units	%	Total length (m)	%
Pool	237	45	3,796	50
Flatwater	73	14	1,065	14
Riffle	221	41	2,967	36
Dry	0	0	0	0
Total	531		7.6 km	

A comparison between visually estimated and measured surface area was conducted for 58 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 0.971 was used to correct the estimated surface area of all units (Figure 6).

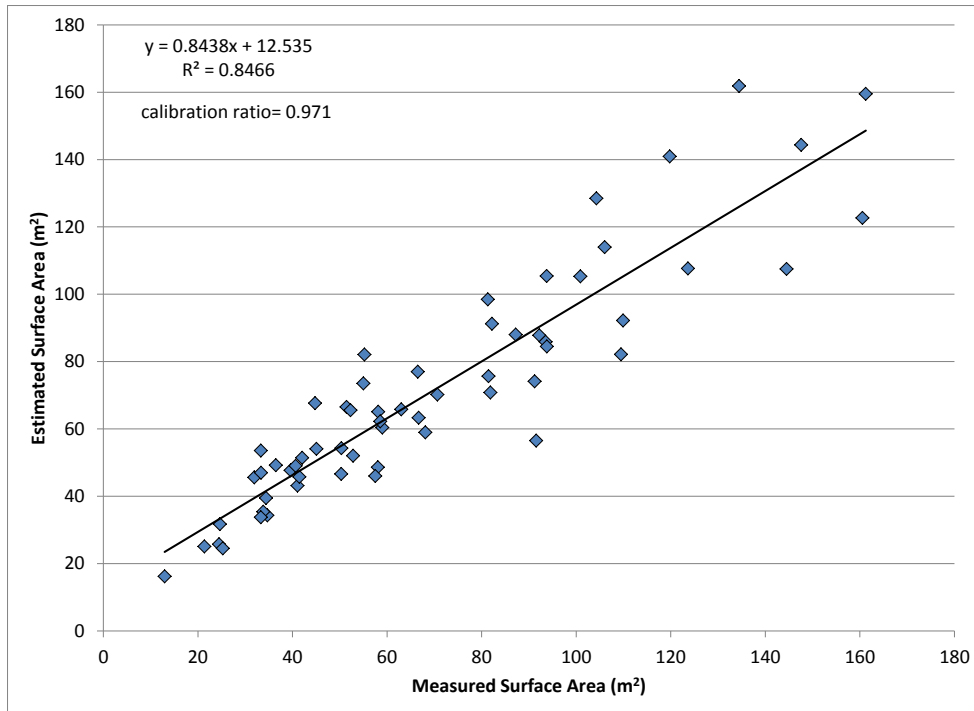


Figure 6. Correlation between measured and visually estimated area of 58 pools, Redwood Creek, 2011.

Snorkel Counts

Snorkel surveys were conducted on 58 (22%) of the delineated pools with coho being observed in 24 (41%) of the sampled pools. A total of 99 coho were counted in the 58 snorkeled pools, giving a raw average of 1.71 coho per pool.

Twelve of the 58 snorkeled pools (21%) were electrofished within a day following the snorkel counts. *Microfish* population estimates for the electrofished pools were used to calibrate the snorkel counts. A calibration ratio of 0.667 was used to correct the snorkel counts for all of the pools (Figure 7). The observed low calibration ratio was due to the variability between electrofishing and snorkel counts.

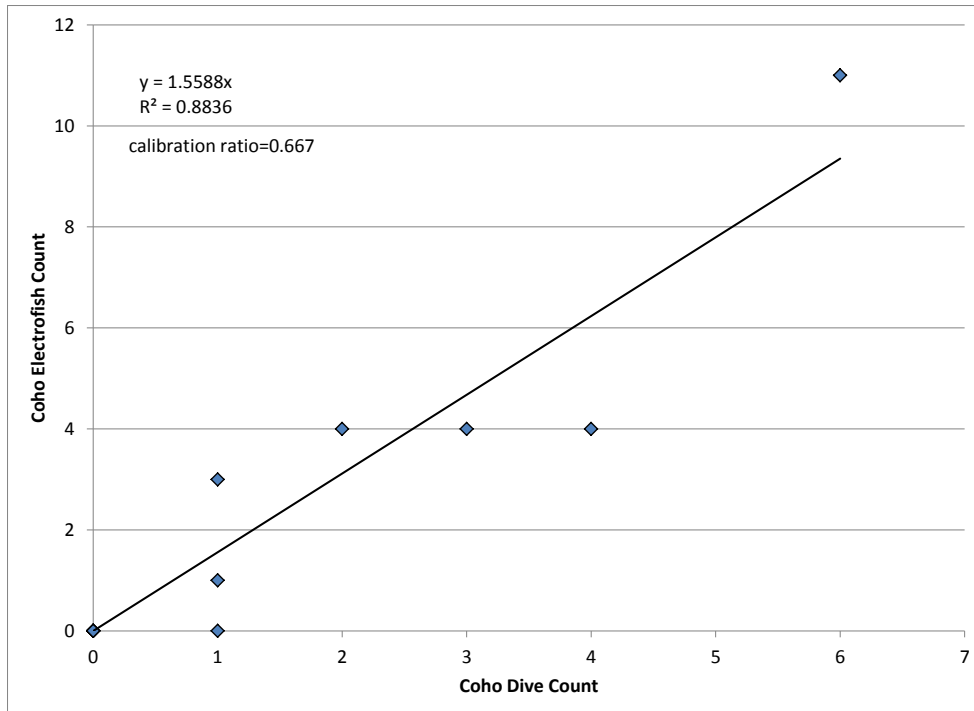


Figure 7. Correlation between electrofishing estimates and snorkel counts for 12 pools, Redwood Creek, 2011.

A summary of the snorkel counts for Redwood Creek in 2011 is presented in Table 9. This table contains the raw total number of coho counted in the snorkel surveys. 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 10. The 2011 coho population estimate for Redwood Creek is 270 ± 153 . For historical Redwood Creek snorkel counts, coho densities, and population estimates, refer to Appendix A, Tables A5 and A6.

Table 9. Summary of coho snorkel counts in Redwood Creek, 2011.

Year	Total snorkel survey stream length (km)	Total number of habitat units	Number of Pools			Coho Counted	
			Total	Snorkeled	w/ Coho	Raw	Calibrated
2011	7.6	531	237	58	24	99	66

Table 10. Coho density and population estimates; Redwood Creek coho survey area, 2011.

Year	Avg. Coho per pool		Density		Population Estimate	95% confidence Interval
	Raw	Calibrated	Coho/m	Coho/m ²		
2011	1.71	1.14	0.07	0.016	270	± 153

Woody Debris Counts

Table 11 represents instream woody debris frequency per 100 m within the basinwide habitat survey area. Woody debris tallies represent instream wood counted during summer baseflow conditions and only include wetted length.

Table 11. Summary of basinwide instream woody debris per 100 m of wetted length during summer baseflow conditions on Redwood Creek, 2011.

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	2011	7.6	0.8	0.4	0.5	3.1	3.0	1.4

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 8) and steelhead (Figure 9)

Within the Redwood Creek sample, 18 coho were measured for fork length weighed to the nearest g. The size range for coho was 66 to 90 mm in fork length.

A total of 181 steelhead trout were measured for fork length and weighed to the nearest g on Redwood Creek. The size range for steelhead was 46 to 180 mm.

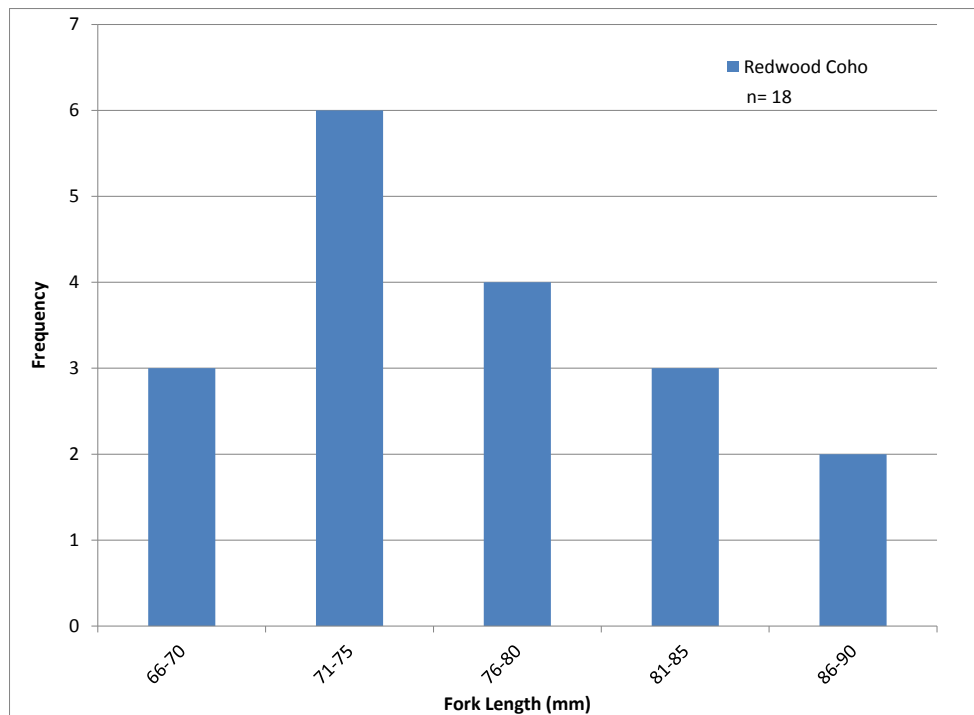


Figure 8. Coho histogram for fish measured in the basinwide calibration pools on Redwood Creek mainstem, 2011. Fork length is represented in 5 mm bins.

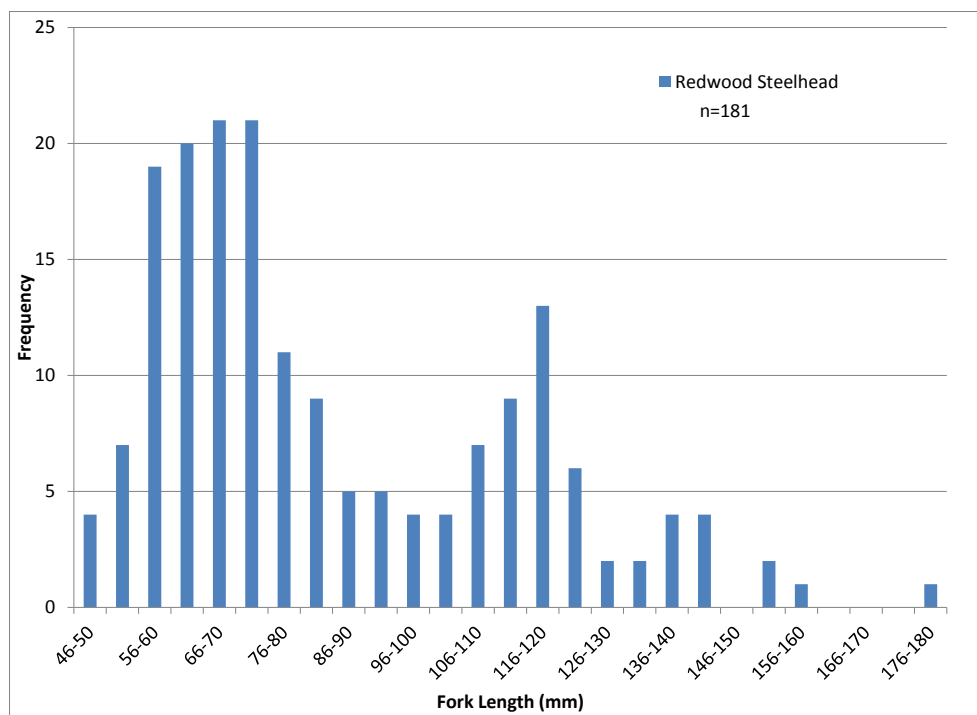


Figure 9. Steelhead histogram for fish measured in the basinwide calibration pools on Redwood Creek mainstem, 2011. Fork length is represented in 5 mm bins. Multiple peaks represent multiple year classes of steelhead.

Table 12 shows the length, weight, and K-factor for coho measured during the 2011 basinwide surveys on Redwood Creek. Table 13 shows the comparisons between steelhead YOY and steelhead 1+ length, weight, and K-factors for Redwood Creek.

Table 12. Mean and median length, weight, and K-factor calculated for coho measured and weighed in the basinwide calibration pools on Redwood Creek mainstem, 2011.

Species	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	126	74.87	7.86	75.00	4.31	1.37	4.24	0.99	0.07

Table 13. Mean and median length, weight, and K-factor calculated for steelhead measured and weighed in the basinwide calibration pools on Redwood Creek mainstem, 2011. YOY= young of the year; fish one year or older= 1+

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	126	82.38	27.87	72.00	7.47	3.79	8.72	0.99	0.08
Steelhead	1+	55	122.62	15.38	118.00	18.35	7.94	16.06	0.95	0.08

3.2.3 Pine Gulch Creek

The 2011 summer habitat survey of Pine Gulch Creek was initiated at monument tag 13, in Paradise Valley, 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 8.0 km.

Basinwide snorkel surveys were conducted on 8.0 km of the Pine Gulch Creek mainstem starting at tag 13 and ending at monument tag 95, upstream of the Teixeira ranch within Point Reyes National Seashore.

Habitat Survey

A total of 644 mainstem habitat units were identified in the 8.0 km Pine Gulch Creek survey area. Pool and riffle units comprised the majority of the habitat types measuring a total of 6.9 km. Overall habitat composition by habitat unit was 46% pool, 40% riffle, and 14% flatwater (Table 14). Side channel and backwater units were also measured but not incorporated into the basinwide habitat calculations. Flatwater and riffle habitat types made up 79% of the total side channel habitat composition. Overall, 872 m of side channel habitat and 63 m of backwater habitat units were measured during the basinwide habitat survey.

Table 14. Habitat composition of Pine Gulch coho survey area, 2011.

Unit type	2011			
	# of units	%	Total length (m)	%
Pool	293	46	4,017	50
Flatwater	93	14	1,092	14
Riffle	258	40	2,857	36
Total	644		8.0 km	

A comparison between visually estimated and measured surface area was conducted for 72 pools to determine a surface area correction factor. The correlation between the estimated surface area and measured surface area was good ($R^2 = 0.88$). Based on this, a calibration ratio of 1.011 was used to correct the estimated surface area of all units (Figure 10).

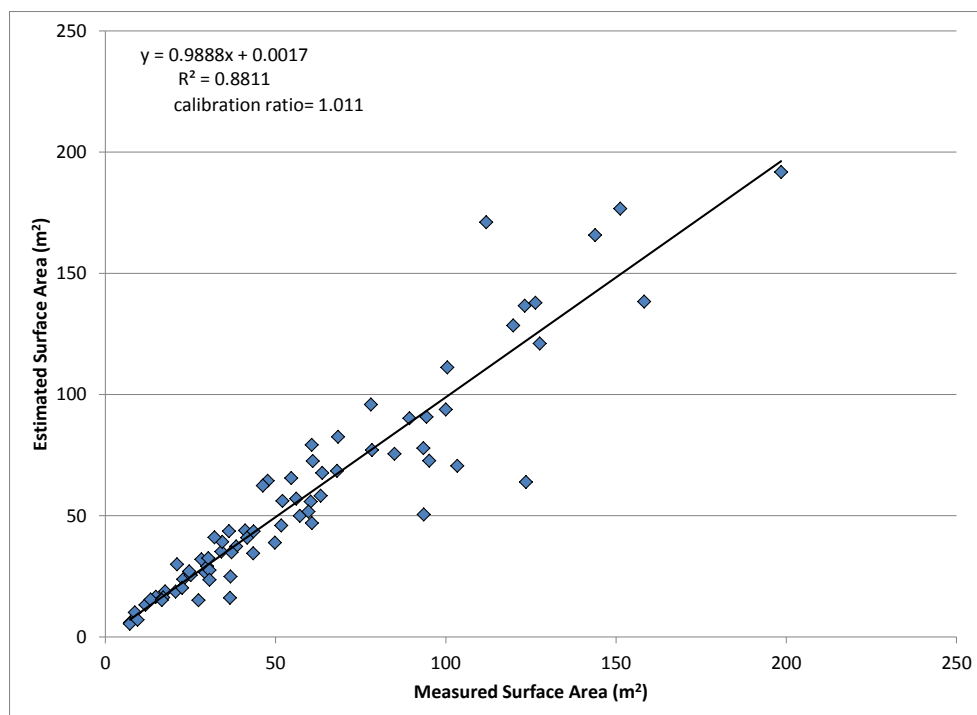


Figure 10. Correlation between measured and visually estimated surface area of 83 pools, Pine Gulch Creek, 2011.

Snorkel Counts

Snorkel surveys were conducted on 75 (26%) of the delineated pools. No coho were observed during snorkel surveys.

Twelve of the 75 snorkeled pools (16%) were electrofished within a day following the snorkel counts. In addition to the 12 electrofished pools, two 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. As no juveniles were observed, no population estimate could be created. A summary of the snorkel counts for Pine Gulch Creek is presented in Table 15. For historical Pine Gulch Creek snorkel counts, coho densities, and population estimates, refer to Appendix A, Tables A3 and A4.

Table 15. Summary of coho snorkel counts in Pine Gulch Creek, 2011.

Year	Total snorkel survey stream length (km)	Total number of habitat units	Number of Pools			Coho Counted	
			Total	Snorkeled	w/ Coho	Raw	Calibrated
2010	8.0	644	293	72	0	0	0

Woody Debris Counts

Table 16 represents instream woody debris frequency per 100 m within the basinwide habitat survey area. Woody debris tallies represent instream wood counted during summer baseflow conditions and only include wetted length.

Table 16. Summary of basinwide instream woody debris per 100 m of wetted length during summer baseflow conditions on Pine Gulch Creek, 2011.

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	2011	8.0	0.4	0.3	0.6	4.2	3.3	1.1

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 steelhead (Figure 11).

Within the Pine Gulch Creek sample, 216 steelhead were measured for fork length. Of those, 175 steelhead trout (81% of the total basinwide steelhead catch) were also weighed. The size range for steelhead was 36 to 220 mm.

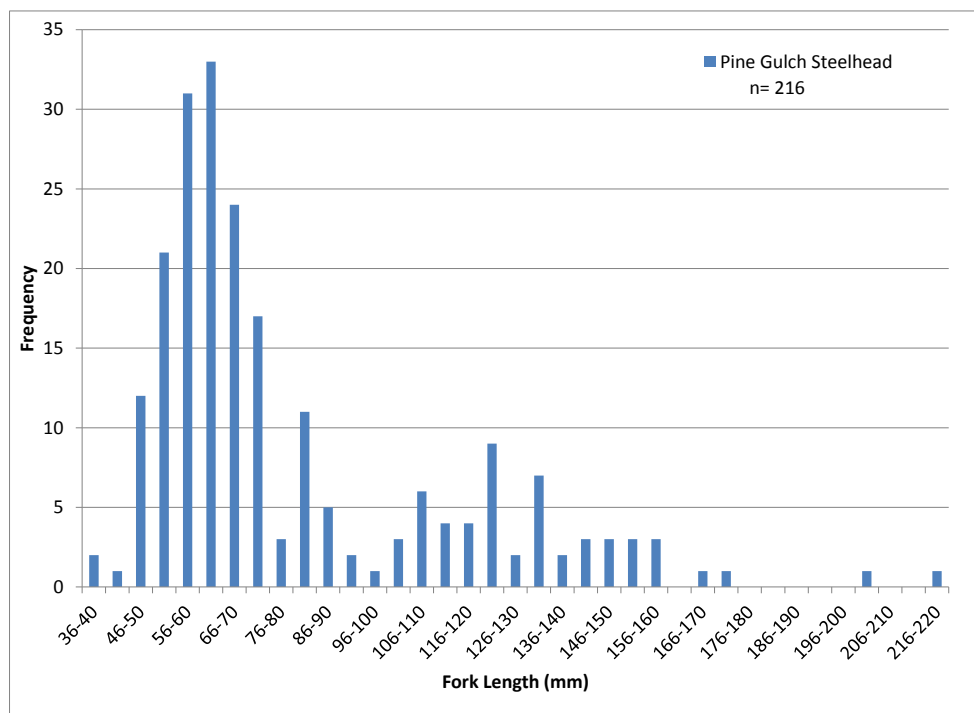


Figure 11. Steelhead histogram for fish measured in the basinwide calibration pools on Pine Gulch mainstem, 2011. Fork length is represented in 5 mm bins. Multiple peaks represent multiple year classes of steelhead.

Table 17 shows the length, weight, and K-factor for coho caught during basinwide sampling on Pine Gulch Creek. Table 17 shows the comparisons between steelhead YOY and steelhead 1+ length, weight, and K-factors for basinwide monitoring on Pine Gulch Creek.

Table 17. Mean and median length, weight, and K-factor calculated for steelhead measured and weighed in the basinwide calibration pools on Pine Gulch mainstem, 2011. YOY= young of the year; fish one year or older= 1+

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	115	61.19	7.69	61.00	2.36	0.94	2.24	0.98	0.10
Steelhead	1+	60	118.72	30.04	118.00	19.24	16.53	15.88	0.98	0.09

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 18. In 2011, five of the eight index reaches on the mainstem of Olema Creek were sampled.

Table 18. Site location and number for Olema Creek index reach sites.

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

^a not surveyed in 2012

Index reach total salmonid catch: The results presented in Table 19 are the 2011 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 three pass electrofishing. Historic Olema Creek index reach total catch data is presented in Appendix A, Table A7.

Table 19. Summary of total catch for each species by reach within Olema Creek mainstem index reach sample locations for 2011; shows distribution within watershed. YOY= young of the year; fish one year or older= 1+

Year	Species	Index Reach								total
		1	2	3	4	5	6	7	8	
2011	CO		31	19		28	29	94		201
	SH YOY	Not sampled	40	90	Not sampled	101	75	30	Not sampled	336
	SH 1+		34	28		27	13	9		111

Index Reach Habitat Information

In 2011, all index reaches sampled included the presence of both coho and steelhead. Other aquatic species sampled at each index reach are documented. Index reaches 1, 4, and 8 are no longer sampled due to time constraints and because they had the lowest numbers of consecutive sampling years of the eight index reaches on Olema Creek.

Index reach 2 was sampled on 09/23/11. 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 five habitat units, including four pools and one riffle unit. The total length of the reach was 75.3 m and the total surface area was 300.7 m². Pool units made up 90.1% of the total length and 95.6% of the total surface area. A total of 31 coho, 40 steelhead YOY, and 34 steelhead 1+ were caught in the index. Also captured in index reach 2 were lamprey ammocetes, California roach, threespine stickleback, Sacramento suckers, sculpin, and crayfish (*Pacifastucus leniusculus*).

Index reach 3 was sampled on 09/21/11. 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 five habitat units. The five units included three pool units and two riffle units. The total length of the index reach was 95.5 m and the total surface area was 534.0 m². Pools comprised 75.0% of the length and 85.1% of the surface area. A total of 19 coho, 90 steelhead YOY, and 28 steelhead 1+ were caught in the index. Also captured in index reach 3 were lamprey ammocetes, California roach, threespine stickleback, sculpin, crayfish, and California giant salamanders (*Dicamptodon ensatus*).

Index reach 5 was sampled on 09/22/11. It is located near stream km 7.6 near Park Residence 168. A total of four habitat units were sampled, including three pool units and one flatwater unit. The total length of the reach was 71.5 m and the total surface area was 388.4 m². Pool units made up 86.4% of the total length and 93.9% of the total surface area. A total of 28 coho, 101 steelhead YOY, and 27 steelhead 1+ were caught in the index. Also captured in index reach 5 were lamprey ammocetes, California roach, threespine stickleback, sculpin, and crayfish.

Index reach 6 was sampled on 09/20/11. It is located near stream km 9.4 adjacent to the Stewart Horse Ranch pasture. Index reach 6 contained a total of six units, including two pool units, two riffle units, and two flatwater units. The total length of the index reach was 87.0 m and the total surface area was 363.5 m². Pool units made up 44.0% of the sampled length and 58.1% of the sampled surface area. A total of 29 coho, 75 steelhead YOY, and 13 steelhead 1+ were caught in the index. Also captured in index reach 6 were threespine stickleback, sculpin, and crayfish.

Index reach 7 was sampled on 09/28/11. 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 three habitat units, including two pool units and one riffle unit. The length of the sampled reach was 53.4 m and the sampled surface area was 233.9 m². Pool units made up 86.0% of the sampled length and 93.0% of the sampled surface area. A total of 94 coho, 30 steelhead YOY, and nine steelhead 1+ were caught in the index. Also captured in index reach 7 were threespine stickleback, California roach, sculpin, crayfish, and California giant salamanders.

Salmonid Density by Habitat Type

The results of our monitoring efforts show distinct differences in salmonid numbers and densities based on habitat type (Table 20). Coho showed a distinct preference for pools, with a density 0.66 fish/m. Steelhead YOY, however, appeared to prefer flatwater habitat, with densities of 1.02 fish/m. Historical Olema Creek salmonid numbers and densities based on habitat type are presented in Appendix A, Table A8 and A9.

Table 20. Summary of population and density estimates for each species by habitat unit on Olema Creek, Summer 2011; illustrates variation in distribution between habitat types. YOY= young of the year; fish one year or older= 1+

Habitat Type	Species (age)	Total Catch	Density	
		# of Fish	Fish/m	Fish/m ²
Pools (n=14)	CO	193	0.66	0.14
	SH YOY	276	0.99	0.20
	SH (1+)	106	0.36	0.07
Riffles (n=5)	CO	0	0.00	0.00
	SH YOY	6	0.15	0.04
	SH (1+)	2	0.06	0.01
Flatwater (n=4)	CO	8	0.22	0.09
	SH YOY	54	1.02	0.36
	SH (1+)	3	0.07	0.03
	CO		0.29	0.08
	Average Density	SH YOY	0.72	0.20
		SH (1+)	0.16	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 12) and steelhead (Figure 13).

Within the Olema Creek sample, 157 coho were measured for fork length. Of those 157, 155 (99% of the total index reach catch) were also weighed. The size range for coho was 61 to 100 mm.

Within the Olema Creek sample, 374 steelhead were measured for fork length. Of those 374, 366 (98% of the total index reach catch) were also weighed. The size range for steelhead was 36 to 240 mm.

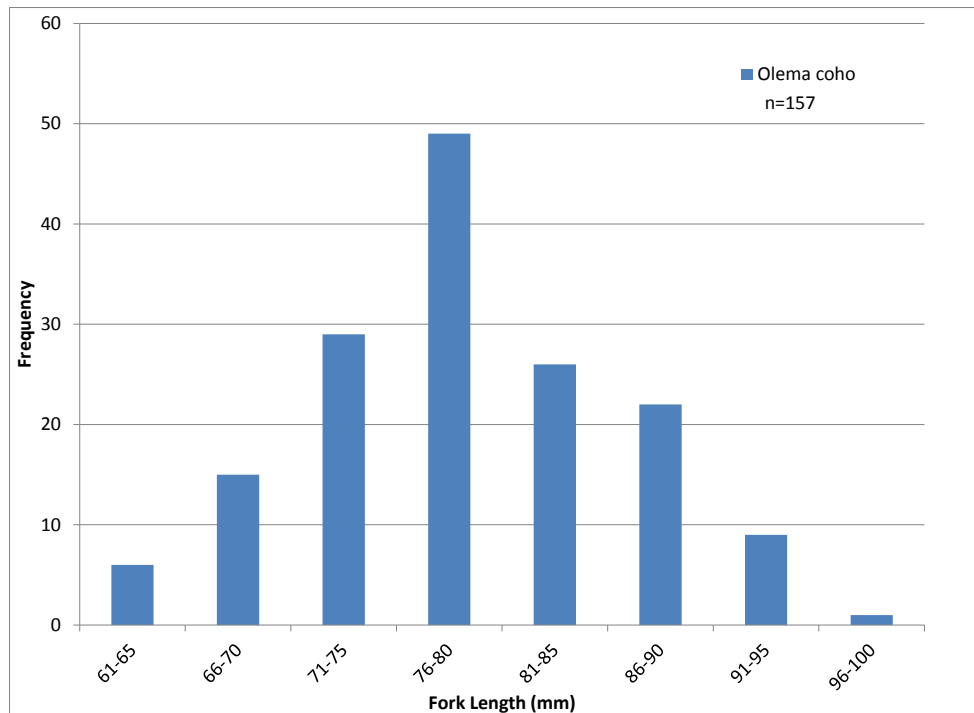


Figure 12. Coho histogram for fish measured in five Olema Creek index reaches, 2011. Fork length is represented in 5 mm bins.

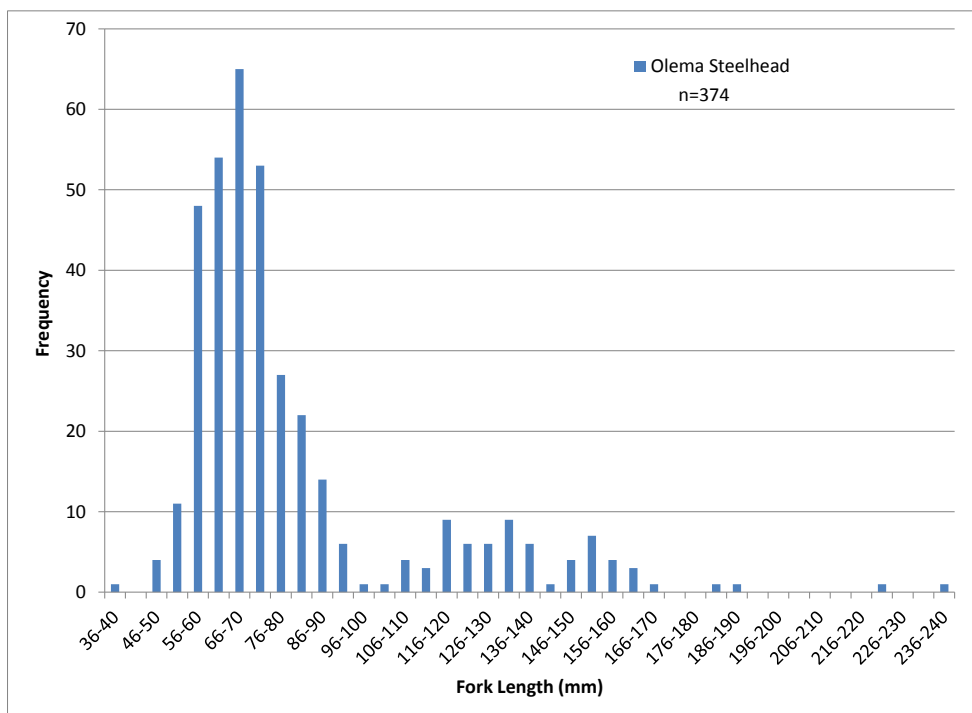


Figure 13. Steelhead histogram for fish measured in five Olema Creek index reaches, 2011. Fork length is represented in 5 mm bins. Multiple peaks represent multiple year classes of steelhead.

Table 21 shows the length, weight, and K-factor for coho caught during index reach sampling on Olema Creek in 2011. Table 22 shows the comparisons between steelhead 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 21. Mean and median length, weight, and K-factor calculated for coho measured and weighed in the five Olema Creek index reaches, 2011.

Species	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	155	78.81	7.43	78.00	5.25	1.51	5.11	1.04	0.07

Table 22. Mean and median length, weight, and K-factor calculated for steelhead measured and weighed in the five Olema Creek index reaches, 2011. YOY= young of the year; fish one year or older= 1+

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	303	69.15	9.55	68.00	3.55	1.56	3.18	1.01	0.07
Steelhead	1+	63	136.14	18.87	134.00	24.41	9.65	22.78	0.93	0.10

3.3.2 Redwood Creek

Jerry Smith (San Jose State University) established five index reaches on Redwood Creek in 1992; monitoring of these sites were shared between Dr. Smith and the 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. 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 23. In 2011, six of the seven index reaches on the mainstem of Redwood Creek were sampled.

Table 23. 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 ^a	Pacific Way Bridge	0.1

^a not sampled in 2011.

Index reach Total Salmonid Catch

The results presented in Table 24 are the 2011 real catch documented through electrofishing activities, as well as salmonid sample size variation between reaches. Historical Redwood Creek index reach total catch data is presented in Appendix A, Table A13.

Table 24. Summary of total catch for each species by reach within Redwood Creek mainstem index reach sample locations for 2010. YOY= young of the year; fish one year or older= 1+

Year	Species	Index Reach							Total
		1	2	3	4	5	6	7	
2011	CO	0	14	6	2	2	0	Not Sampled	24
	SH YOY	79	71	20	38	39	15		262
	SH 1+	13	55	24	33	29	25		179

Index Reach Habitat Information

In 2011, 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.

Six of the seven index reaches were sampled in 2011. Index reach 7 was not sampled due to restoration activities that were taking place at the time of the sampling.

Index reach 1 was sampled on 08/23/11. It is located within MUWO. Index reach 1 consisted of eight habitat units, including two pool units, two flatwater units, and four riffle units. The total length of the index reach was 104.6 m and the total surface area was 367.6 m². Pool units made up 35.7% of the total length and 30.6% of the total surface area. A total of 79 steelhead YOY and 13 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 08/22/11. It is located behind the MUWO restrooms. Index reach 2 consisted of six habitat units, including three pool units, two riffle units, and one flatwater unit. A cascade unit was also present but was not sampled. The total length of the index reach was 123.6 m and the total surface area was 654.9 m². Pool units made up 41.8% of the total length and 47.8% of the total surface area. A total of 14 coho, 71 steelhead YOY, and 55 steelhead 1+ were caught in the index. Also captured in index reach 2 were sculpin, California giant salamanders, and crayfish.

Index reach 3 was sampled on 08/18/11. It is located near stream km 3.8 at the Miwok Trail footbridge crossing. Index reach 3 consisted of six habitat units, including three pool units, one flatwater unit, and two riffle units. The total length of the index reach was 69.3 m and the total surface area was 238.2 m². Pool units made up 86.0% of the total length and 87.9% of the total surface area. A total of 6 coho, 20 steelhead YOY, and 24 steelhead 1+ were caught in the index. Also captured in index reach 3 were sculpin and California giant salamanders.

Index reach 4 was sampled on 08/17/11. It is located near stream km 2.9 at the Kent Creek confluence on Redwood Creek. Index reach 4 consisted of ten habitat units, including four pool units, four riffle units, and two flatwater units. The total length of the surveyed index reach was 97.8 m and the total surface area was 351.6 m². Pool units made up 56.4% of the total length and 72.8% of the total surface area. A total of two coho, 38 steelhead YOY, and 33 steelhead 1+ were caught in the index. Also captured in index reach 4 were sculpin and crayfish.

Index reach 5 was sampled on 08/15/11. 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 and two riffle units. The total length of the surveyed index reach was 94.6 m and the total surface

area sampled was 464.9 m². Pool units made up 61.8% of the total length and 68.7% of the total surface area. A total of two coho, 39 steelhead YOY, and 29 steelhead 1+ were caught in the index. Also captured in index reach 5 were sculpin, threespine stickleback, and crayfish.

Index reach 6 was sampled on 08/16/11. 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 and four riffle units. The total length of the index reach was 90.8 m and the total surface area was 390.4 m². Pool units made up 69.1% of the total length and 79.0% of the total surface area. A total of 15 steelhead YOY and 25 steelhead 1+ were caught in the index. Also captured in index reach 6 were sculpin and threespine stickleback.

Salmonid Density by Habitat Type

The results of our monitoring efforts show distinct differences in salmonid numbers and densities based on habitat type (Table 25). The results show distinct use of pools by both coho and steelhead 1+ with fish densities of 0.07 fish/meter and 0.56 fish/meter respectively. Steelhead YOY appeared to favor flatwater habitat, with a density of 0.90 fish/meter. Historical Redwood Creek salmonid numbers and densities based on habitat type are presented in Appendix A, tables A14 and A15.

Table 25. Summary of population and density estimates for each species by habitat unit on Redwood Creek, Summer 2011; illustrates variation in distribution between habitat types. YOY= young of the year; fish one year or older= 1+

Habitat Type	Species (age)	Total Catch	Density	
		# of Fish	Fish/m	Fish/m ²
Pools (n=19)	CO	22	0.07	0.01
	SH YOY	174	0.56	0.12
	SH (1+)	155	0.52	0.11
Riffles (n=18)	CO	0	0.00	0.00
	SH YOY	43	0.18	0.05
	SH (1+)	10	0.05	0.02
Flatwater (n=6)	CO	2	0.02	0.00
	SH YOY	45	0.90	0.27
	SH (1+)	14	0.24	0.06
	CO		0.03	0.01
	Average Density	SH YOY	0.55	0.15
		SH (1+)	0.27	0.07

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 14) and steelhead (Figure 15).

Within the Redwood Creek sample, 16 coho salmon were measured for fork length. Of those 16, 15 (94% of the total index reach catch), were also weighed. The size range for juvenile coho was observed to be 61 to 85 mm.

A total of 364 steelhead trout were measured for fork length. Of those 364 steelhead, 273 (75% of the total index reach catch) were also weighed. The size range for steelhead was 36 to 260 mm.

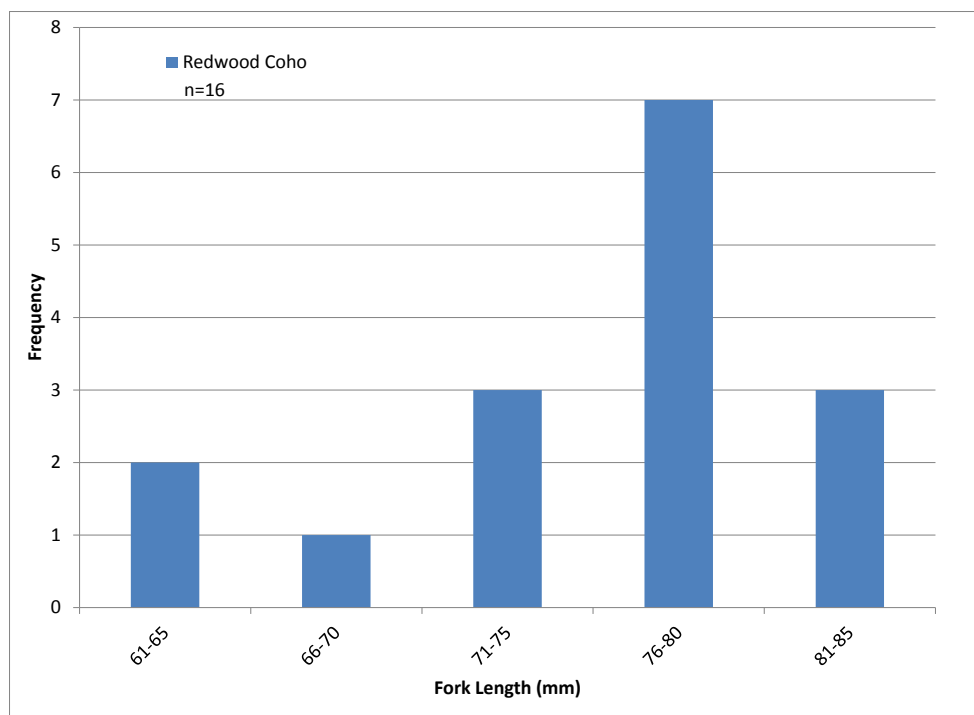


Figure 14. Coho histogram for fish measured in the seven Redwood Creek index reaches, 2011. Fork length is represented in 5 millimeter (mm) bins.

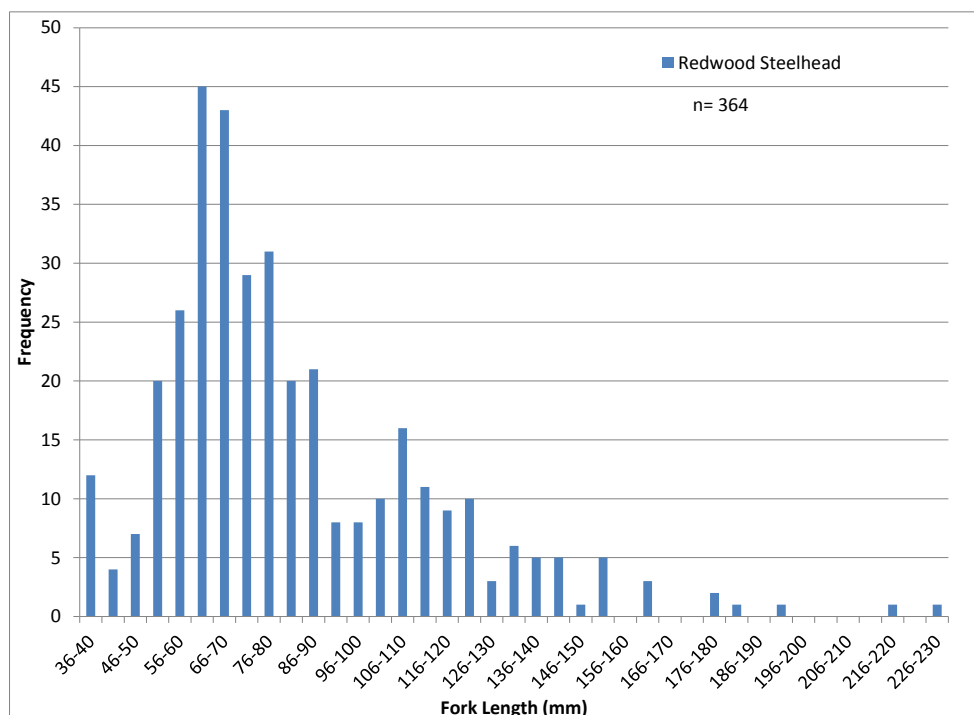


Figure 15. Steelhead histogram for fish measured in the seven Redwood Creek index reaches, 2011. Fork length is represented in 5 millimeter (mm) bins. Multiple peaks represent multiple year classes of *O. Mykiss*.

Table 26 shows the coho length, weight, and K-factor for Redwood Creek. Table 27 shows the comparisons between steelhead between YOY and steelhead 1+ length, weight, and K-factors for Redwood Creek. Historical data for length, weight, and K factor for Redwood Creek can be found in Appendix A, tables A16, A17, and A18

Table 26. Mean and median length, weight, and K-factor calculated for coho measured and weighed in the six Redwood Creek index reaches, 2011.

Species	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	15	74.47	5.63	76.00	4.40	1.02	4.59	1.05	0.07

Table 27. Mean and median length, weight, and K-factor calculated for steelhead measured and weighed in the six Redwood Creek index reaches, 2011. YOY= young of the year; fish one year or older= 1+

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	195	67.08	11.32	66.00	3.30	1.75	2.86	1.00	0.09
Steelhead	1+	78	120.99	26.11	113.00	18.62	12.16	13.78	0.99	0.17

3.3.3 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 28. In 2011, four of the eight index reaches on the mainstem of Pine Gulch Creek were sampled.

Table 28. Site location and number for Pine Gulch Creek index sites.

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

^a not sampled in 2011

Index Reach Total Salmonid Catch

The results presented in Table 29 are the 2011 real catch documented through electrofishing activities, as well as salmonid sample size variation between reaches. Historical Pine Gulch index reach total catch data is presented in Appendix A, Table A19.

Table 29. Summary of total catch for each species by reach within Pine Gulch Creek mainstem index reach sample locations for 2011. YOY= young of the year; fish one year or older= 1+

Year	Species	Index Reach								Total
		1a	1b	1c	2	3	4	5	6	
2010	CO				0	0		0	0	0
	SH YOY	Not sampled	Not Sampled	Not Sampled	32	42	Not sampled	47	38	159
	SH 1+				20	18		16	7	61

Index Reach Habitat information

In 2011, coho were not found in any of the index reaches, while 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. In 2011, four of the eight index reaches were sampled on Pine Gulch Creek. Index reaches 1a through 1c and index reach 4 were not sampled due to access issues.

Index reach 2 was sampled on 07/25/2011. It is located near stream km 2.8. This reach is located in Paradise Valley on land owned by the Martinelli Family Trust. The riparian habitat is primarily hardwood such as alder and bay trees. Index reach 2 consisted of four habitat units, including three pool units and one riffle unit. The total length of the surveyed reach was 73.0 m and the total surface area was 331.1 m². Pool units made up 63.3% of the total length and 73.8% of the total surface area. A total of 32 steelhead YOY and 20 steelhead 1+ were caught in the index. Also captured in index reach 2 were lamprey ammocetes, threespine stickleback, sculpin and rough skinned newts (*Taricha granulosa*).

Index reach 3 was sampled on 07/26/11. 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 four habitat units, including two pool units, one riffle unit, and one flatwater unit. The total length of the surveyed index reach was 64.7 m and the total surface area sampled was 270.9 m². Pool units made up 71.4% of the total length and 71.7% of the total surface area. A total of 42 steelhead YOY and 18 steelhead 1+ were caught in the index. Also captured in index reach 3 were lamprey ammocetes and sculpin.

Index reach 5 was sampled on 07/27/11. It is located near stream km 6.8 within the Teixeira Flats area. A total of four habitat units were sampled, including three pool units and one riffle unit. The total length of the index reach was 60.0 m and the total surface area was 186.5 m². Pool units made up 88.3% of the total length and 87.1% of the total surface area. A total of 47 steelhead YOY and 16 steelhead 1+ were caught in the index. Also captured in index reach 5 were lamprey ammocetes and sculpin.

Index reach 6 was sampled on 07/28/11. 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 and two riffle units. The total length of the index reach was 79.8 m and the total surface area was

197.1 m². Pool units made up 55.8% of the total length and 72.6% of the total surface area. A total of 38 steelhead YOY and seven steelhead 1+ were caught in the index. Also captured in index reach 6 were lamprey ammocetes, scuplin, and crayfish.

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 30 shows the breakout of habitat units and fish densities. As no coho were observed during 2010 index reach sampling, no densities could be calculated. As observed in Olema and Redwood Creeks, steelhead occur in all habitat types, though in varying densities. Both steelhead YOY and steelhead 1+ appear to favor pool habitats, with densities of 0.69 fish/m and 0.27 fish/m, respectively. Historical Pine Gulch coho and steelhead numbers and densities based on habitat type are presented in Appendix A, Tables A20 and A21.

Table 30. Summary of population and density estimates for each species by habitat unit on Pine Gulch Creek, Summer 2011; illustrates variation in distribution between habitat types. YOY= young of the year; fish one year or older= 1+

Habitat Type	Species (age)	Total Catch	Density	
		# of Fish	Fish/m	Fish/m ²
Pools (n=10)	CO	0	0.00	0.00
	SH YOY	128	0.69	0.19
	SH (1+)	50	0.27	0.07
Riffles (n=5)	CO	0	0.00	0.00
	SH YOY	25	0.29	0.10
	SH (1+)	9	0.08	0.02
Flatwater (n=2)	CO	0	0.00	0.00
	SH YOY	6	0.30	0.16
	SH (1+)	2	0.09	0.05
	Average	CO	0.00	0.00
	Density	SH YOY	0.43	0.15
		SH (1+)	0.15	0.05

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 16).

Within the Pine Gulch Creek sample, a total of 205 steelhead trout were measured for fork length. Of those 205 steelhead, 157 (77% of the total index reach steelhead catch) were also weighed. The size range for steelhead trout was 36 to 225 mm.

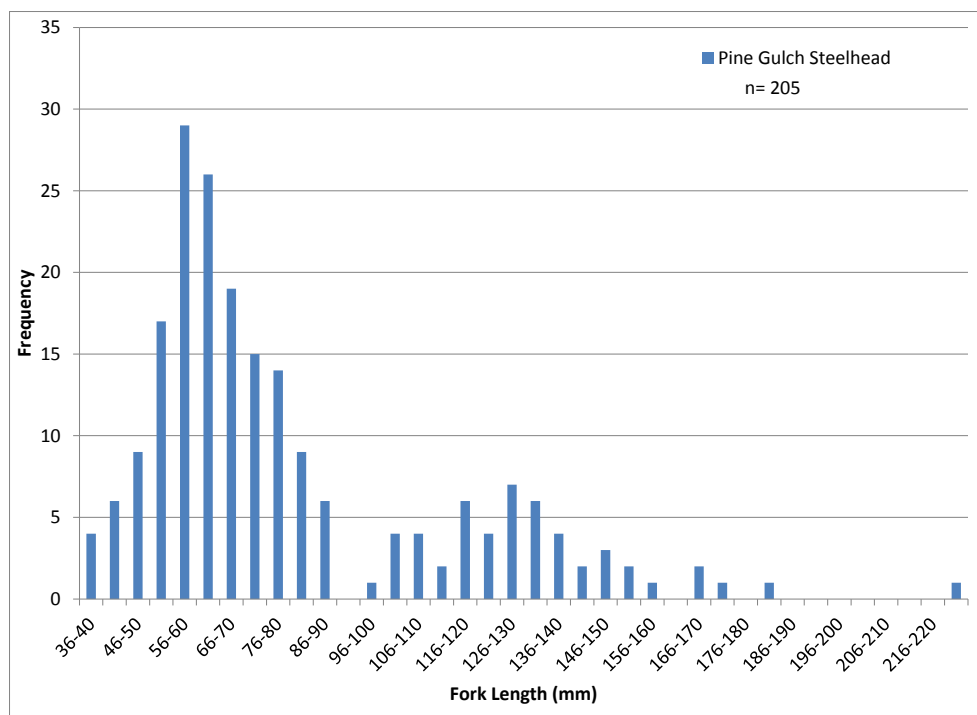


Figure 16. Steelhead histogram for fish measured in the six Pine Gulch Creek index reaches, 2011. Fork length is represented in 5 millimeter (mm) bins. Multiple peaks represent multiple year classes of steelhead.

Condition factors are a ratio relating fish length to fish weight therefore measuring the relative biomass of a fish. Table 31 shows the comparisons between steelhead YOY and steelhead 1+ length, weight, and K-factors for Pine Gulch Creek. Historical data for length, weight, and K factors for Pine Gulch Creek are found in Appendix A, Tables A22, A23, and A24.

Table 31. Mean and median length, weight, and K-factor calculated for steelhead measured and weighed in the five Pine Gulch Creek index reaches, 2011. YOY= young of the year; fish one year or older= 1+

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	116	63.60	11.71	62.50	2.88	1.59	2.58	1.02	0.12
Steelhead	1+	37	127.95	19.55	127.00	21.58	10.57	19.69	0.97	0.06

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Appendix A

Table A1. Summary of coho snorkel counts in Olema Creek, 2005-2011.

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
2010	13.8	1,037	470	87	41	357	321
2011	13.5	958	417	78	53	673	855

Table A2. Coho density and population estimates; Olema Creek coho survey area, 2005-2011.

Year	Total snorkel survey stream length (km)	Avg. Coho per pool		Density		Population Estimate	95% confidence Interval
		Raw	Calibrated	coho/m	Coho/m ²		
2005	11.9	115.2	93.99	3.61	1.025	29,887	± 9,974
2006	11.6	5.29	5.53	0.30	0.092	1,793	± 869
2007	11.8	75.05	86.77	4.18	1.312	31,936	± 4,127
2008	7.8	19.92	10.75	0.326	0.081	2,268	± 1,037
2009	13.0	0.01	N/A	N/A	N/A	N/A	N/A
2010	13.8	4.10	3.69	0.18	0.039	1,736	± 659
2011	13.5	8.63	10.96	0.59	0.158	4,570	± 2,183

Table A3. Summary of coho snorkel counts in Redwood Creek, 2005-2011.

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
2010	8.1	611	269	49	42	614	12.53
2011	7.6	531	237	58	24	99	66

Table A4. Coho density and population estimates; Redwood Creek coho survey area, 2005-2011.

Year	Total snorkel survey stream length (km)	Avg. Coho per pool		Density		Population Estimate	95% confidence Interval
		Raw	Calibrated	Coho/ m	Coho/m ²		
2005	7.7	44.87	44.53	1.94	0.458	8,594	± 1,652
2006	7.7	3.14	4.61	0.30	0.072	1,050	± 486
2007	8.1	24.40	29.89	1.86	0.482	7,832	± 1,640
2008	8.5	1.71	1.77	0.09	0.025	431	± 271
2009	8.3	0.76	N/A	N/A	N/A	N/A	N/A
2010	8.1	12.53	11.39	0.81	0.212	3,064	± 1,373
2011	7.6	1.71	1.14	0.07	0.016	270	± 153

Table A5. Summary of coho snorkel counts in Pine Gulch, 2005-2011.

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
2010	9.8	739	335	84	2	2	0
2011	8.0	644	293	72	0	0	0

Table A6. Coho density and population estimates; Pine Gulch coho survey area, 2005-2011.

Year	Total snorkel survey stream length (km)	Avg. Coho per pool		Density		Population Estimate	95% confidence Interval
		Raw	Calibrated	coho/m	coho/m ²		
2005	9.9	3.27	3.72	0.22	0.072	1,150	± 554
2006	10.3	0.56	0.83	0.07	0.030	295	± 201
2007	10.3	0	N/A	N/A	N/A	N/A	N/A
2008	10.3	0	N/A	N/A	N/A	N/A	N/A
2009	10.1	1.08	1.28	0.08	0.021	386	± 441
2010	9.8	0.02	N/A	N/A	N/A	N/A	N/A
2011	8.0	0	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 2011.

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	72	97	not	180	67	38	44	498
	SH 1+	sampled	10	5	sampled	13	15	7	7	57
2006	CO		92	36	0	4	2	9	18	161
	SH YOY	not	55	77	93	80	65	37	43	450
	SH 1+	sampled	37	67	24	54	32	6	20	240
2007	CO	not	123	170	233	332	217	156	160	1,391
	SH YOY	sampled	112	135	241	120	51	10	36	705
	SH 1+		9	22	16	19	15	3	8	92
2008	CO	not	3	42	12	22	9	7	0	95
	SH YOY	sampled	113	145	181	103	40	23	2	607
	SH 1+		3	9	13	6	4	1	1	37
2009	CO	not	0	0		0	0	0		0
	SH YOY	sampled	11	16	not	48	21	25	not	121
	SH 1+		12	19	sampled	6	6	5	sampled	48
2010	CO	not	28	9		8	10	41		96
	SH YOY	sampled	91	42	not	69	61	61	not	324
	SH 1+		45	16	sampled	4	11	11	sampled	87
2011	CO		31	19		28	29	94		201
	SH YOY	not	40	90	not	101	75	30	not	336
	SH 1+	sampled	34	28	sampled	27	13	9	sampled	111

Table A8. Summary of population and density estimates from electrofishing surveys for coho salmon by habitat unit Olema Creek, 2005-2011.

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
2010	Pool	12	96	0.31	0.06
	Riffle	5	0	0.00	0.00
	Flatwater	4	0	0.00	0.00
2011	Pool	14	193	0.66	0.14
	Riffle	5	0	0.00	0.00
	Flatwater	4	8	0.22	0.09

Table A9. Summary of population and density estimates from electrofishing surveys for steelhead young of year by habitat unit Olema Creek, 2005-2011.

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
2010	Pool	12	302	1.00	0.21
	Riffle	5	1	0.04	0.01
	Flatwater	4	21	0.64	0.20
2011	Pool	14	276	0.99	0.20
	Riffle	5	6	0.15	0.04
	Flatwater	4	54	1.02	0.36

Table A10. Mean coho length, weight, and K-factor calculated for coho measured and weighed in the Olema Creek index reaches 2005-2011.

Year	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	287	64.00	7.09	64.00	3.14	1.07	3.01	1.16	0.08
2006	81	75.63	7.23	75.00	5.13	1.60	5.00	1.15	0.08
2007	335	63.95	8.80	64.00	2.86	1.28	2.70	1.04	0.20
2008	80	76.29	7.09	75.50	4.52	1.29	4.50	0.99	0.07
2009	0	0	0	0	0	0	0	0	0
2010	91	81.82	6.40	82.00	5.65	1.39	5.57	1.01	0.07
2011	155	78.81	7.43	78.00	5.25	1.51	5.11	1.04	0.07

Table A11. Mean steelhead length, weight, and K factor calculated for steelhead young of year measured and weighed in the Olema Creek index reaches 2005-2011.

Year	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	239	68.59	10.14	67.00	3.90	1.90	3.41	1.13	0.12
2006	218	67.44	7.95	68.00	3.62	1.23	3.67	1.13	0.10
2007	241	54.08	7.82	53.00	1.74	0.78	1.52	1.04	0.12
2008	321	67.51	9.08	66.00	3.38	1.53	3.01	1.05	0.10
2009	99	77.87	6.60	78.00	5.02	1.35	4.91	1.04	0.07
2010	224	76.21	9.13	77.00	4.61	1.60	4.49	1.00	0.07
2011	303	69.15	9.55	68.00	3.55	1.56	3.18	1.01	0.07

Table A12. Mean steelhead length, weight, and K factor calculated for steelhead greater than one year old measured and weighed in the Olema Creek index reaches in 2005-2011.

Year	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	53	140.92	27.52	137.00	32.77	22.49	26.66	1.05	0.07
2006	137	108.55	25.88	101.00	16.53	12.19	11.28	1.14	0.19
2007	80	121.73	17.51	118.00	18.74	8.13	16.49	0.99	0.12
2008	35	113.86	24.89	104.00	15.38	10.50	11.18	0.94	0.08
2009	43	123.42	22.38	120.00	19.95	11.06	16.54	0.98	0.08
2010	77	123.12	27.62	116.00	20.02	14.63	14.21	0.94	0.12
2011	63	136.14	18.87	134.00	24.41	9.65	22.78	0.93	0.10

Table A13. Summary of total catch (not including information from J. Smith) for each species by reach within Redwood Creek mainstem index reach sample locations from 2005-2011.

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
2010	CO	0	19	53	34	69	49		224
	SH YOY	63	125	92	93	102	51	not sampled	526
	SH 1+	14	45	38	26	29	33		185
2011	CO	0	14	6	2	2	0		24
	SH YOY	79	71	20	38	39	15	not sampled	262
	SH 1+	13	55	24	33	29	25		179

Table A14. Summary of population and density estimates from electrofishing surveys for coho salmon by habitat unit Redwood Creek, 2005-2011.

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
2010	Pool	19	210	0.66	0.17
	Riffle	16	1	0.01	0.00
	Flatwater	4	13	0.28	0.06
2011	Pool	19	22	0.07	0.01
	Riffle	18	0	0.00	0.00
	Flatwater	6	2	0.02	0.00

Table A15. Summary of population and density estimates from electrofishing surveys for steelhead young of year by habitat unit Redwood Creek, 2005-2011.

Year	Habitat Type	# of Habitat Units	Total Catch # of Fish	Fish/m	Density 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
2010	Pool	19	365	1.15	0.30
	Riffle	16	78	0.48	0.14
	Flatwater	4	83	1.78	0.44
2011	Pool	19	174	0.56	0.12
	Riffle	18	43	0.18	0.05
	Flatware	6	45	0.90	0.27

Table A16. Mean coho length, weight, and K factor calculated for coho measured and weighed in the Redwood Creek index reaches, 2005-2011.

Year	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	337	72.15	8.04	71.00	4.39	1.58	4.02	1.13	0.07
2006	79	78.35	7.32	77.00	5.52	1.65	4.94	1.13	0.10
2007	294	73.73	8.38	73.00	4.15	1.49	3.89	1.00	0.08
2008	32	76.53	18.73	79.50	4.79	3.14	4.54	0.90	0.09
2009	36	79.33	4.20	79.00	5.25	0.86	5.05	1.04	0.05
2010	91	81.82	6.40	82.00	5.65	1.39	5.57	1.01	0.07
2011	15	74.47	5.63	76.00	4.40	1.02	4.59	1.05	0.07

Table A17. Mean steelhead length, weight, and K factor calculated for steelhead young of year measured and weighed in the Redwood Creek index reaches, 2005-2011.

Year	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	340	72.16	10.85	72.00	4.50	2.00	4.20	1.12	0.07
2006	156	77.99	9.60	78.00	5.43	2.03	5.20	1.10	0.11
2007	547	63.52	9.61	62.00	2.76	1.30	2.42	1.00	0.11
2008	372	66.83	9.15	67.00	3.03	1.26	2.86	0.96	0.08
2009	306	68.40	8.98	68.00	3.38	1.33	3.15	1.01	0.09
2010	383	66.90	9.85	66.00	3.17	1.43	2.88	0.99	0.11
2011	195	67.08	11.32	66.00	3.30	1.75	2.86	1.00	0.09

Table A18. Mean steelhead length, weight, and K factor calculated for steelhead greater than one year old measured and weighed in the Redwood Creek index reaches, 2005-2011.

Year	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	64	133.66	28.01	128.00	29.00	21.02	23.21	1.08	0.07
2006	89	130.53	26.13	128.00	26.38	21.04	22.58	1.06	0.09
2007	79	121.72	26.32	119.00	19.38	13.12	15.07	0.95	0.11
2008	93	116.45	18.09	116.00	15.40	7.26	14.62	0.92	0.06
2009	94	123.04	16.80	122.50	18.84	7.68	17.30	0.96	0.07
2010	168	123.24	19.81	119.00	19.13	9.51	15.93	0.95	0.06
2011	78	120.99	26.11	113.00	18.62	12.16	13.78	0.99	0.17

Table A19. Summary of total catch for each species by reach within Pine Gulch Creek mainstem index reach sample locations between 2005 and 2011.

Year	Species	Index Reach								total
		1a	1b	1c	2	3	4	5	6	
2005	CO	3	1	0	2	15	not sampled	16	8	45
	SH YOY	25	18	44	78	41		40	33	279
	SH 1+	8	5	33	18	17		24	7	112
2006	CO	0	0	0	0	0	not sampled	4	10	14
	SH YOY	9	22	17	17	45		39	20	169
	SH 1+	31	28	38	13	18		17	18	163
2007	CO	0	0	0	0	0	not sampled	0	0	0
	SH YOY	3	39	61	145	153		55	52	508
	SH 1+	2	21	29	23	13		23	14	125
2008	CO		0	0	0	0	not sampled	0	0	0
	SH YOY	not sampled	9	22	87	147		37	53	355
	SH 1+		4	15	12	16		15	10	72
2009	CO			0	0	0	not sampled	3	0	3
	SH YOY	not sampled	not sampled	3	3	26		6	8	46
	SH 1+			14	7	12		5	5	43
2010	CO			0	0	0	not sampled	0	0	0
	SH YOY	not sampled	not sampled	18	53	52		40	22	185
	SH 1+			19	24	14		16	6	79
2010	CO			0	0	0	not sampled	0	0	0
	SH YOY	not sampled	not sampled	not sampled	32	42		47	38	159
	SH 1+				20	18		16	7	61

Table A20. Summary of population and density estimates from electrofishing surveys for coho by habitat unit Pine Gulch Creek, 2005-2011.

Year	Habitat Type	# of Habitat Units	Total Catch		Density	
			# 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	
2010	Pool	17	0	0.00	0.00	
	Riffle	7	0	0.00	0.00	
	Flatwater	1	0	0.00	0.00	
2011	Pool	10	0	0.00	0.00	
	Riffle	5	0	0.00	0.00	
	Flatwater	2	0	0.00	0.00	

Table A21. Summary of population and density estimates from electrofishing surveys for steelhead young of year by habitat unit Pine Gulch Creek, 2005-2011.

Year	Habitat Type	# of Habitat Units	Total # of Fish	Fish/m	Density 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
2010	Pool	17	173	0.67	0.20
	Riffle	7	11	0.17	0.05
	Flatwater	1	1	0.14	0.05
2011	Pool	10	128	0.69	0.19
	Riffle	5	25	0.29	0.10
	Flatwater	2	6	0.09	0.05

Table A22. Mean coho length, weight, and K factor calculated for coho measured and weighed in the Pine Gulch Creek index reaches 2005-2011.

Year	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	40	80.48	4.71	80.50	5.84	1.10	5.67	1.11	0.06
2006	14	81.14	5.64	83.50	5.85	1.18	6.10	1.09	0.12
2007	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0
2009	3	77.33	2.52	77.00	4.87	0.60	4.91	1.05	0.04
2010	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0

Table A23. Mean steelhead length, weight, and K factor calculated for steelhead young of year measured and weighed in the Pine Gulch Creek index reaches 2005-2011.

Year	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	213	71.17	9.68	70.00	4.45	1.83	4.04	1.17	0.07
2006	157	78.72	8.84	79.00	5.84	1.91	5.83	1.16	0.10
2007	300	64.73	10.42	65.00	2.97	1.46	2.77	1.00	0.10
2008	252	66.47	11.07	66.00	3.23	1.63	2.92	1.02	0.19
2009	32	59.97	9.83	58.50	2.22	1.13	1.90	0.95	0.11
2010	150	68.83	11.72	68.00	3.51	1.78	3.11	0.99	0.10
2011	116	63.60	11.71	62.50	2.88	1.59	2.58	1.02	0.12

Table A24. Mean steelhead length, weight, and K factor calculated for steelhead greater than one year old measured and weighed in the Pine Gulch Creek index reaches 2005-2011.

Year	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	106	130.52	27.44	120.00	27.29	22.45	19.51	1.08	0.08
2006	123	123.43	26.21	120.00	22.12	13.42	18.46	1.09	0.12
2007	117	131.79	21.05	129.00	24.32	12.26	20.92	0.99	0.06
2008	72	134.46	26.99	129.00	25.34	18.16	19.71	0.93	0.09
2009	41	126.10	23.81	122.00	21.55	12.06	16.68	0.98	0.08
2010	68	138.37	28.52	131.50	28.78	20.18	21.18	0.96	0.07
2011	37	127.95	19.55	127.00	21.58	10.57	19.69	0.97	0.06