



Long-term Monitoring of Coho Salmon and Steelhead Trout During Freshwater Life Stages in Coastal Marin County

2012 Annual Report

Natural Resource Technical Report NPS/SFAN/NRTR—2014/887





ON THIS PAGE

Adult Female coho on Redwood Creek, Marin County, CA
Photograph by: Jessica Weinberg

ON THE COVER

Smolt on Redwood Creek, Marin County, CA
Photograph by: Jessica Weinberg

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Contents

	Page
Figures.....	vi
Tables.....	viii
Abstract.....	x
List of Acronyms	xii
1 Introduction.....	1
1.1 Background.....	1
1.2 Fishes Monitored by this Protocol.....	4
1.3 Monitoring Rationale.....	4
1.3.1 Monitoring Questions.....	5
1.3.2 Monitoring Objectives.....	5
1.4 Watershed Background	6
2 Sampling Design and Methods	8
2.1 Adult Salmon Escapement Surveys.....	8
2.1.1 Field Methods.....	8
2.1.2 Olema Creek.....	11
2.1.3 Lagunitas Creek Watershed - Cheda Creek.....	12
2.1.4 Redwood Creek	12
2.1.5 Pine Gulch Creek.....	12
2.1.6 Adult Coho Salmon Escapement Data Analysis	13
2.1.7 Other Monitoring Programs	14
2.2 Outmigrant Smolt Trapping	14
2.2.1 Smolt Trap Field Methods.....	14
2.2.2 Coho and Steelhead Handling	15
2.2.3 Trap Site Locations.....	15
2.2.4 Sampling Period	15
2.2.5 Smolt Trap Data Analysis	15
2.3 Juvenile Coho and Steelhead Surveys.....	16
2.4 Basinwide General Systematic Surveys	16

Contents (continued)

	Page
2.4.1 Habitat Surveys	16
2.4.2 Basinwide Snorkel Surveys.....	17
2.4.3 Index Reach Monitoring.....	17
2.4.4 Electrofishing/Handling	19
2.4.5 Juvenile Coho and Steelhead Survey Sample Periods.....	19
3 Monitoring Results.....	20
3.1 Rainfall	20
3.2 Data from Escapement Surveys.....	20
3.2.1 Olema Creek.....	20
3.2.2 Cheda Creek Coho and Steelhead Escapement	27
3.2.3 Redwood Creek Coho and Steelhead Escapement	30
3.2.4 Pine Gulch Creek Coho and Steelhead Escapement	35
3.3 Spring 2012 Outmigrant Coho Smolt Trapping Results	36
3.3.1 Coho Smolt Outmigration Environmental Conditions and Timing.....	36
3.3.2 Olema Creek Smolt Trapping Coho and Steelhead Results	38
3.3.3 Redwood Creek Smolt Trapping Coho and Steelhead Results	39
3.3.4 Coho and Steelhead Smolt Size and Condition	40
3.3.5 Smolt Trap Summary of Non-salmonid Total Catch.....	45
3.4 Juvenile Coho and Steelhead Basinwide 2012 Results	45
3.4.1 Olema Creek.....	45
3.4.2 Redwood Creek	51
3.4.3 Pine Gulch Creek.....	57
3.5 Coho and Steelhead Index Reach Monitoring Results	62
3.5.1 Olema Creek.....	62
3.5.2 Redwood Creek	63
3.5.3 Pine Gulch Creek.....	65
4 Discussion	68
5 Literature Cited	70

Contents (continued)

	Page
Appendix A. Historic Data Tables.....	74
Appendix B. Julian Week Numbers.....	92

Figures

	Page
Figure 1. Streams supporting coho salmon in coastal Marin County.	3
Figure 2. Olema Creek survey locations.	9
Figure 3. Redwood Creek survey locations.	10
Figure 4. Pine Gulch Creek survey locations.	11
Figure 5. Olema Creek adult coho run timing, based on number of live fish observed, average of 1997-2011 compared to winter 2011-2012.	21
Figure 6. Daily rainfall totals at Bear Valley and coho adult escapement survey results on Olema Creek mainstem, including live fish, carcasses, and redds, observed during surveys in 2011-2012.	22
Figure 7. Coho salmon redd results for the Olema Creek watershed by cohort for winter 1997-1998 through winter 2011-2012.	25
Figure 8. Olema Creek coho salmon PLD (Peak Live plus cumulative Dead) escapement estimates for winter 1994-1995 through winter 2011-2012.	26
Figure 9. Coho salmon redd results in the Lagunitas watershed by cohort winter 1997-1998 through winter 2011-2012.	30
Figure 10. Coho salmon redd numbers in the Redwood Creek watershed by cohort winter 1997-1998 through winter 2011-2012.	33
Figure 11. Redwood Creek watershed, coho salmon PLD (Peak Live plus Cumulative Dead) escapement estimates for winter 1994-1995 through winter 2011-2012.	34
Figure 12. Percent of total coho smolts captured in the trap by Julian week for Olema Creek in 2012 compared to the historical average, 2004-2011.	37
Figure 13. Percent of total coho smolts captured in the trap by Julian week for Redwood Creek in 2012 compared to the historical average, 2005-2011.	37
Figure 14. Box and whisker plot of coho salmon smolt fork length for Olema Creek, 2004-2012.	41
Figure 15. Box and whisker plot of coho salmon smolt fish weight for Olema Creek, 2004-2012.	41
Figure 16. Box and whisker plots for steelhead trout smolt fork lengths for Olema Creek, 2004-2012.	42
Figure 17. Box and whisker plots for coho salmon smolt fork lengths for Redwood Creek, 2005-2012.	43
Figure 18. Box and whisker plots for coho salmon smolt weights for Redwood Creek, 2005-2012.	43

Figures (continued)

	Page
Figure 19. Box and whisker plots for steelhead trout smolt fork lengths for Redwood Creek, 2006-2012.....	44
Figure 20. Olema Creek in-stream woody debris by type per 100 m wetted length for years 2005-2012.....	47
Figure 21. Box and whisker plot for coho salmon juvenile fork length for Olema Creek, summer 2010-2012.	49
Figure 22. Box and whisker plot for coho salmon juvenile weights for Olema Creek, summer 2010-2012.	49
Figure 23. Box and whisker plots for steelhead trout young of the year fork lengths for basinwide Olema Creek, summer 2009-2012.....	50
Figure 24. Box and whisker plots for steelhead trout aged 1+ fork lengths for basinwide Olema Creek, summer 2009-2012.	50
Figure 25. Redwood Creek in-stream woody debris by type per 100 m in wetted length for years 2005-2012.	53
Figure 26. Box and whisker plots for coho salmon juvenile fork lengths for basinwide Redwood Creek, summer 2010-2012 (no juveniles captured in 2009).....	55
Figure 27. Box and whisker plots for coho salmon juvenile weights for basinwide Redwood Creek, summer 2010-2012 (no coho captured in 2009).	55
Figure 28. Box and whisker plots for steelhead young of the year fork lengths for basinwide Redwood Creek, summer 2009 to 2012.....	56
Figure 29. Box and whisker plots for steelhead aged 1+ weights for basinwide Redwood Creek, summer 2009 to 2012.	56
Figure 30. Pine Gulch Creek in-stream woody debris by type per 100 m in wetted length for summers 2005-2012.	59
Figure 31. Box and whisker plots for steelhead young of the year fork lengths for basinwide Pine Gulch Creek, summer 2009-2012.....	61
Figure 32. Box and whisker plots for steelhead aged 1+ weights for basinwide Pine Gulch Creek, summer 2009-2012.	61
Figure 33. Coho and steelhead juvenile fish per meter according to index reach on Olema Creek, 2012.	63
Figure 34. Coho and steelhead juvenile densities according to index reach on Redwood Creek, summer 2012.	65
Figure 35. Steelhead juvenile densities according to index reach on Pine Gulch Creek, summer 2012.....	66

Tables

	Page
Table 1. Site location and number for Olema Creek summer index reach sites.	18
Table 2. Site location and number for Redwood Creek summer index reach sites.....	18
Table 3. Site location and number for Pine Gulch Creek summer index sites.....	18
Table 4. Index reach/basinwide survey sample dates, summer 2012.....	19
Table 5. Coho salmon spawning survey Area Under the Curve (AUC) estimates for Olema Creek mainstem, 2011-2012.....	24
Table 6. Sex ratio percentages and mean fork length (FL) of live coho within the Olema Creek mainstem and John West Fork tributary for the period 1997-2011 compared to 2011-2012.	27
Table 7. Sex ratio percentages and mean fork length (FL) of coho carcasses within the Olema Creek mainstem and John West Fork tributary for the period 1997-2011 compared to 2011-2012.	27
Table 8. Coho salmon spawning number of surveys, survey length, including Peak Live plus cumulative Dead (PLD) estimates, tally of total carcasses, and total redds for Cheda Creek.	28
Table 9. Total coho redds in Lagunitas Creek watershed, winter 1995-1996 through 2011-2012	29
Table 10. Coho salmon spawning survey Area Under the Curve (AUC) estimates for Redwood Creek mainstem, 2011-2012.....	32
Table 11. Sex ratio percentages and mean fork length (FL) of live coho within the Redwood Creek watershed for the period 1997-2011 compared to 2011-2012.	35
Table 12. Sex ratio percentages and mean fork length (FL) of coho carcasses within the Redwood Creek watershed for the period 1997-2011 compared to 2011-2012.	35
Table 13. Summary of coho and steelhead captured during Olema Creek trap operations, 2004-2012.	39
Table 14. Summary of coho and steelhead captured during Redwood Creek trap operations, 2005-2012.....	40
Table 15. Habitat composition of Olema Creek coho survey reach for 2012.	46
Table 16. Summary of basinwide instream woody debris (WD) per 100 m on Olema Creek during summer base flow conditions, average 2004-2011 compared to 2012.	47
Table 17. Summary of summer coho snorkel counts in Olema Creek, 2004-2012.....	48
Table 18. Coho density and population estimates; Olema Creek coho survey area, 2004- 2012.....	48

Tables (continued)

	Page
Table 19. Mean and median fork length, weight, and K-factor calculated for coho measured and weighed in the basinwide calibration pools on Olema Creek mainstem, summer 2012.....	51
Table 20. Mean and median fork length, weight, and K-factor calculated for steelhead measured and weighed in the basinwide calibration pools on Olema Creek mainstem, summer 2012.....	51
Table 21. Habitat composition of Redwood Creek coho survey reach, summer 2012.	52
Table 22. Summary of Redwood Creek basinwide instream woody debris (WD) per 100 m during summer base flow conditions, average 2005-2011 compared to 2012.....	53
Table 23. Summary of coho snorkel counts in Redwood Creek for summer 2005-2012.	54
Table 24. Coho density and population estimates; Redwood Creek coho survey area, 2005-2012.	54
Table 25. Mean and median fork length, weight, and K-factor for coho measured and weighed in the basinwide calibration pools on Redwood Creek mainstem, 2012.....	57
Table 26. Mean and median fork length, weight and K-factor calculated for steelhead measured and weighed in the basinwide calibration pools on Redwood Creek mainstem, 2012.....	57
Table 27. Habitat composition of Pine Gulch Creek coho survey reach, 2012.....	58
Table 28. Summary of basinwide instream woody debris (WD) per 100 m during summer base flow conditions in Pine Gulch Creek, average 2005-2011 compared to 2012.....	58
Table 29. Summary of coho snorkel counts in Pine Gulch Creek, summer 2005-2012.	60
Table 30. Coho density and population estimates; Pine Gulch coho survey area, summer 2005-2012.	60
Table 31. Mean and median fork length, weight, and K-factor calculated for steelhead weighed and measured in the basinwide calibration pools on Pine Gulch mainstem, 2012.....	62
Table 32. Summary of total catch by species within Olema Creek mainstem index reach sample locations, 2012.....	62
Table 33. Summary of historical salmonid fish per meter estimates from electrofishing surveys completed by Dr. Smith on Redwood Creek index reaches, 1992-2003 (Smith 2001).	64
Table 34. Summary of total catch by each species within Redwood Creek mainstem index reach sample locations, summer 2012.	64
Table 35. Summary of total catch for each species by reach within Pine Gulch Creek mainstem index reach sample locations, summer 2012.	66

Abstract

The San Francisco Bay Area Network (SFAN) monitors populations of coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*O. mykiss*) in watersheds at Point Reyes National Seashore, Golden Gate National Recreation Area, and Muir Woods National Monument. The watersheds, including Olema Creek, Redwood Creek, and Pine Gulch Creek, represent the majority of streams supporting salmonids in Marin County, California, and support the southernmost stable populations of coho salmon on the Pacific Coast. The National Park Service SFAN Inventory and Monitoring Program and California Department of Fish and Wildlife have supported monitoring of multiple coho salmon life stages in coastal Marin County watersheds since 1998. Monitoring includes:

- *adult escapement surveys*, which document the number of adult salmonids that successfully “escape” ocean fisheries and return to their natal streams to spawn, as well as the number of redds (gravel nests where salmonids lay their eggs) created; and
- *outmigrant smolt trapping*, where the number of smolts (at least year-old juvenile salmonids that have undergone changes to cope with a marine environment) are captured, measured and counted as they make their way toward the ocean; and
- *basinwide juvenile coho surveys* and *summer index reach monitoring* which seek to quantify the number of juvenile salmonids present in the watersheds during the summer months.

Monitoring of multiple life stages presents a more accurate picture of the coho population than monitoring only a single stage, especially given the complex life history of the coho salmon. Coho salmon have a three-year life-cycle in which they spend their first year of life in their natal stream followed by nearly two years in the ocean before returning to their natal stream to spawn. Since generations of related fish reproduce every third year, the coho population is divided into three distinct year classes, or cohorts. Cohorts may be labeled 1, 2, and 3. Cohort 1 was the first to be monitored by SFAN in 1997-1998 as one generation returned to spawn in the winter, and the next hatched and emerged in spring and were surveyed as juveniles during the summer. These fish were surveyed again when they left the creeks as smolts in 1999 and for a third time as spawning adults in the winter of 2000-2001. Succeeding generations of cohort 1 hatched in 2001, 2004, 2007, and 2010. Cohort 2 are those fish that hatched in 1999, 2002, 2005, 2008, and 2011, and cohort 3 fish hatched in 2000, 2003, 2006, 2009, and 2012. This report presents a summary of monitoring results for the 2011-2012 season. The adults and juveniles monitored belong to different generations of cohort 3, while the year-old outmigrating smolts belong to cohort 2.

Adult coho escapement surveys for 2011-2012 show an increase in the number of cohort 3 adults returning to spawn compared to the previous return of cohort 3 in 2008-2009. During the winter of 2008-2009, a major decline of cohort 3 was observed on Olema Creek with no coho spawning detected. In contrast, seven redds were observed on Olema Creek in 2011-2012. Redwood Creek also showed an increase in total coho redd production from the previous generation of cohort 3 with four coho redds observed during the winter of 2011-2012 compared to 2 coho redds counted in during the

winter of 2008-2009... In contrast, one coho redd was observed on Pine Gulch Creek, which marks a 50% decline from 2008-2009.

On Olema Creek, there was an estimated juvenile coho population of 330 ± 774 . The basinwide juvenile population estimate for Redwood Creek was 484 ± 249 . As no juvenile coho were observed on Pine Gulch Creek, no basinwide population estimate was created. The lack of coho observations in Pine Gulch Creek indicates that the one coho redd documented during the winter of 2011-2012.

Both steelhead young of year (YOY) and steelhead of one year in age or older (1+) fork lengths (fish length from snout to tail fork) and weights were comparable to previous years for Redwood Creek. In contrast, steelhead YOY on both Pine Gulch and Olema Creeks were significantly different in size both in terms of fork length and weight, with the trend indicating a decrease in size. Steelhead 1+ weights were comparable to previous years for all three creeks monitored. The only significant difference in size detected for steelhead 1+ was for fork length on Pine Gulch Creek, which indicated a decrease in fork length.

The coho smolt production estimate calculated for Olema Creek ($3,173 \pm 1,716$) was the third highest on record, out of nine years of trapping, but represents a decrease when compared to cohort 2 smolt production in 2009. Although no Redwood Creek smolt production estimate could be calculated in 2009 due to the insufficient number of marked and subsequently recaptured coho smolts the 2012 ($1,021 \pm 164$) estimate indicates an increase in smolt production. Based on the absence of juvenile coho during the summer of 2011, no smolt trap was placed in Pine Gulch Creek during the spring of 2012 and therefore no data were gathered for steelhead smolt.

Both coho smolt fork length and weight were comparable to previous years for Olema Creek. On Redwood Creek, smolts were significantly different in size both in terms of fork length and weight, with the trend indicating an increase in size. On average, Redwood Creek coho smolts were larger in both fork length and weight than Olema Creek which is only the second time this has occurred since smolt trapping was initiated on both creeks in 2005.

List of Acronyms

AUC	Area Under the Curve
CCCESU	Central California Coast Evolutionarily Significant Unit
CDFW	California Department of Fish and Wildlife
ENSO	El Niño Southern Oscillation
GOGA	Golden Gate National Recreation Area
GSS	General Systematic Survey
I&M	Inventory and Monitoring Program
MMWD	Marin Municipal Water District
MUWO	Muir Woods National Monument
NMFS	National Marine Fisheries Service
NPS	National Park Service
OE	Observer Efficiency
PLD	Peak Live + Cumulative Dead
PORE	Point Reyes National Seashore
SFAN	San Francisco Bay Area Network
SD	Standard Deviation
SPAWN	Salmon Protection and Watershed Network
YOY	Young of the Year
Year-Year	All year-year references refer to the spawning year

1 Introduction

The San Francisco Bay Area Network (SFAN) has identified salmonids as one of the network's vital signs, or indicators of ecosystem health. Monitoring a balanced and integrated set of vital signs meets the scientific monitoring needs of current park management, but will also help detect unanticipated environmental conditions in the future. Salmonids represent a particularly high priority vital sign for SFAN because coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*O. mykiss*) are important indicators of ecosystem health, provide important links between marine and freshwater ecosystems, have endangered or threatened status, and garner high public interest.

Salmonids are monitored at three National Park Service (NPS) units within SFAN including Golden Gate National Recreation Area (GOGA), Muir Woods National Monument (MUWO), and Point Reyes National Seashore (PORE). Ongoing monitoring of coho salmon by the SFAN within the Olema Creek, Pine Gulch Creek, and Redwood Creek watersheds in coastal Marin County is supported through the California Department of Fish and Wildlife (CDFW) Contract P0730408 to the Point Reyes National Seashore Association. 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 population distribution and trends within these watersheds. In addition, monitoring has been conducted to document information of federally threatened steelhead trout and other fish species within the monitored watersheds.

The SFAN Salmonid Monitoring Protocol v4.0 (Reichmuth et al. 2010) documents methods used by the SFAN in salmonid monitoring within coastal Marin County since 1997.

This report includes summary results of adult escapement, smolt trapping, habitat surveys, index reach surveys, and basinwide snorkel surveys for Olema Creek, Pine Gulch Creek, and Redwood Creek as well as adult escapement for Cheda Creek, a tributary to Lagunitas Creek, conducted during 2012, and summarized in comparison with all previous years of monitoring. Adult Escapement results summarized in this document include results through the 2011-2012 spawning year. All spawning years are referred to in a year-year format. SFAN monitored 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).

1.1 Background

Spawning populations of coho salmon and steelhead trout have declined significantly from historic numbers in the coastal streams of central California. 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 many as 46% of California's coho salmon populations have been extirpated from their watersheds (Brown et al. 1994).

Dramatic declines in salmonid populations throughout coastal watersheds have occurred with changes in watershed condition as a result of land use and development. Salmonids require connected surface flow for migration and dispersal (dams and culverts typically are barriers), cold temperatures (<70°F) and high dissolved oxygen levels (Moyle 2002). While most salmonids have been affected by watershed development, coho salmon are particularly susceptible due to their semelparous (they spawn only a single time prior to death) three-year life cycle requiring an entire year of residence in freshwater prior to smolting and migrating to the ocean. Although steelhead also require year-round high quality water, their ability to spawn more than once and to reside in either freshwater or marine systems for variable lengths of time allows the species far greater ability to adjust to changing watershed conditions.

Based on historic regional accounts, numbers of coho salmon and steelhead trout have been severely depleted. Coastal Marin County streams and their associated watersheds currently containing populations of coho salmon and steelhead trout include Olema and Lagunitas Creeks, Redwood Creek, and Pine Gulch Creek. Some of the factors believed to have contributed to the declines in anadromous fish runs within the parks include:

- dam construction and loss of hydrologic connectivity;
- historic logging and sediment delivery to the channel;
- removal of large woody debris and limited riparian areas;
- stream channel and habitat alteration;
- loss of spawning and rearing habitat;
- water withdrawals, extreme hydrologic and climatic events;
- marine over-harvesting;
- changes to ocean food webs, including reduced primary production.

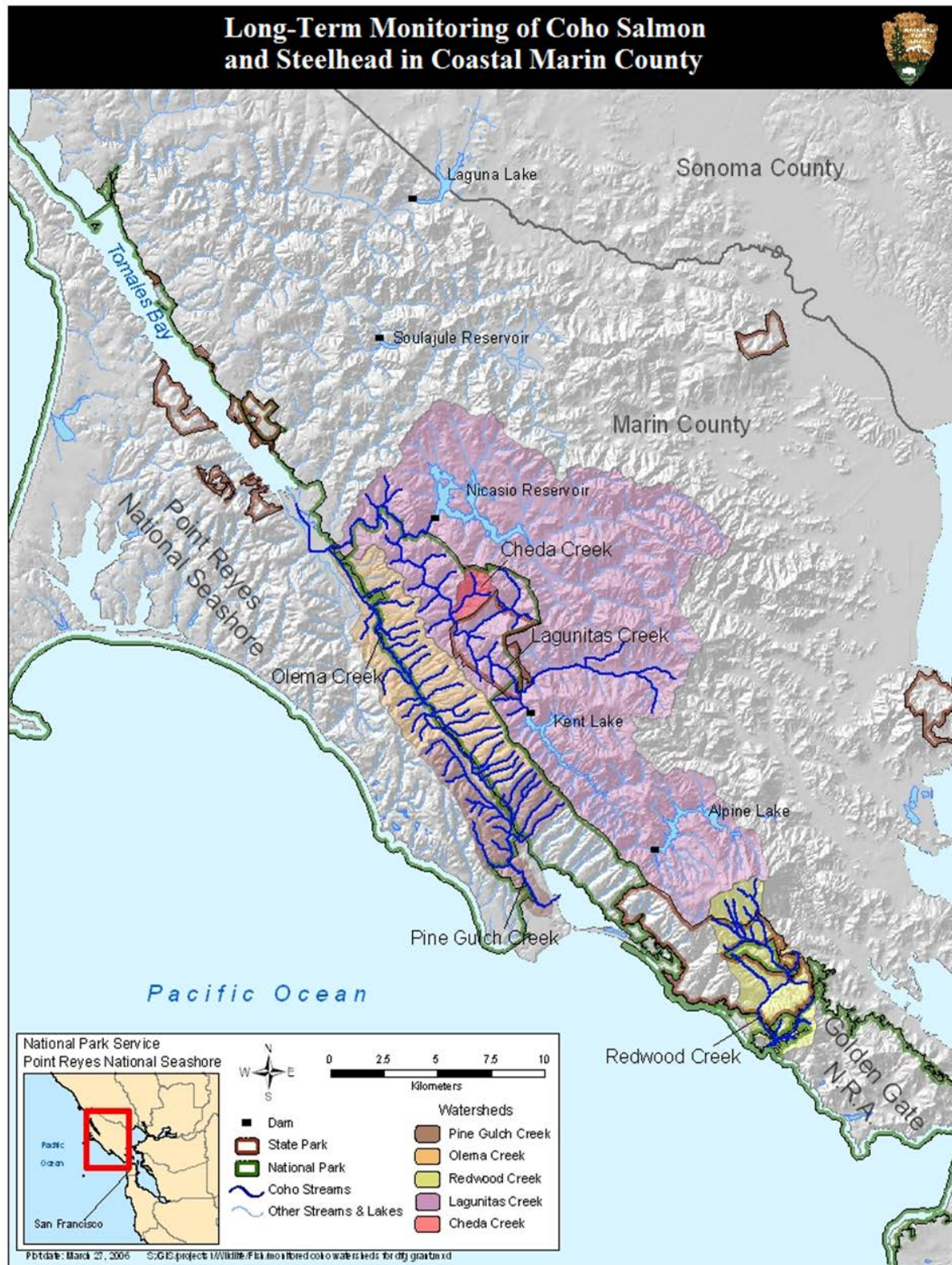


Figure 1. Streams supporting coho salmon in coastal Marin County. The National Park Service monitors streams in Point Reyes National Seashore (Olema and Pine Gulch Creeks) and Golden Gate National Recreational Area (Redwood and Cheda Creeks).

1.2 Fishes Monitored by this Protocol

The primary species monitored through this program are coho salmon and steelhead trout. However, other aquatic species including sculpin (*Cottus* spp.), California roach (*Hesperoleucus symmetricus*), lamprey (*Lampetra* spp.), and threespine 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. Natural populations of coho salmon are known to exist in the Lagunitas, Olema, Pine Gulch, and Redwood Creek watersheds (Smith 2001, Brown and Ketcham 2002). Coho salmon were listed as a threatened species within the central California coast coho salmon evolutionarily significant unit (CCCESU) in 1996 by the National Marine Fisheries Service (NMFS; Federal Register 1996) and the CCCESU was downgraded in status (upgraded listing protection) to endangered in 2005 (Federal Register 2005). The 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. In 2004, the California Fish and Wildlife Commission added coho salmon populations between San Francisco and Punta Gorda to the list of species protected under the California Endangered Species Act (coho populations south of San Francisco were already listed as endangered). This endangered listing became effective in 2005.

Steelhead are the anadromous form of rainbow trout. Steelhead are iteroparous, meaning they can spawn more than once. 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. 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. The artificially propagated stocks from the Don Clausen Fish Hatchery and the Kingfisher Flat Hatchery are also included (Federal Register 2006).

1.3 Monitoring Rationale

Salmonids produce high numbers of offspring per individual—a life history strategy that offsets high rates of mortality that occur throughout their life cycle. In freshwater systems, there is a large range of mortality rates experienced by coho juveniles during early development due to annual variations in stream condition and habitat quality (Moyle 2002). By winter, mortality rates generally begin to increase with higher flow events, peaking in the spring as fish smolt and move downstream (Chapman 1965, Manning 2001). In Lagunitas Creek researchers have observed high juvenile densities in the summer, followed by very low smolt outmigration the following spring (Stillwater Sciences 2008). In the north coast of California and Oregon, monitoring has shown that in areas

where adult escapement is adequate to seed watersheds, the production of coho smolts is likely limited by winter habitat availability and overwinter survival (Nickelson and Lawson 1998).

Our monitoring of multiple life stages will help characterize potential population bottlenecks in the watershed. Observation of adult escapement and redd density in the winter, juvenile density in the summer months, and smolt outmigration during the spring allows us to track cohorts through documented bottlenecks and identify if and where watershed-specific limiting factors exist.

1.3.1 Monitoring Questions

This monitoring program was developed to answer the following questions excerpted from the SFAN Salmonid Monitoring Protocol v4.0 (Reichmuth et al. 2010):

- What habitat constraints exist in the parks that currently impede or limit salmon recovery efforts?
- Are parks meeting resource protection mandates relative to salmonid habitat protection?
- Is the condition (e.g., length, weight, presence of abnormalities) of coho salmon changing over time?
- What is the annual production of juvenile coho salmon outmigrants in Redwood, Olema, and Pine Gulch Creeks?
- What is the annual escapement of returning adult coho salmon in Olema, Redwood, Pine Gulch, and Cheda Creeks?
- What is the annual abundance of juvenile coho salmon rearing within Redwood, Olema, and Pine Gulch Creeks at summer base flow conditions?
- What are the changes in salmonid densities at preexisting index reach locations on Redwood, Olema, and Pine Gulch Creeks?

The following questions may be answered in part by this monitoring protocol but additional information will need to be gathered through park or partner efforts:

- What is the survivorship between life stages for each coho cohort within Redwood, Olema, and Pine Gulch Creeks?
- What are the changes in timing and distribution of salmonid spawning, adult sex ratios, and escapement estimates in select streams at PORE and GOGA?
- What are the overall population trends of each coho salmon cohort within GOGA and PORE watersheds?

1.3.2 Monitoring Objectives

This monitoring program was developed to meet the following objectives excerpted from the SFAN Salmonid Monitoring Protocol v4.0 (Reichmuth et al. 2010):

1. Determine long-term trends in distribution and abundance, size (length) of spawning coho salmon by counting numbers of spawners, carcasses, and redds along reaches at Olema, Cheda, Redwood, and Pine Gulch Creeks.
2. Determine long-term trends in abundance and condition of coho salmon smolts by conducting spring smolt trapping near mouths of Olema, Redwood, and Pine Gulch Creeks.
3. Determine long-term trends in distribution, abundance, and condition of juvenile coho salmon by conducting summer basinwide surveys (general systematic surveys [GSS]) at Olema, Redwood, and Pine Gulch Creeks.
4. Determine long-term trends in summer density, size, and age composition of coho salmon at preexisting index reaches at Olema, Redwood, and Pine Gulch Creeks.
5. Identify gross changes in habitat (e.g., pool:riffle ratio) in Olema, Redwood, and Pine Gulch Creeks during basinwide GSS surveys.

1.4 Watershed Background

Olema Creek is the largest undammed watershed in coastal Marin County, California and an important stream for coho salmon and steelhead within the CCCESU. The 15.9 km stream flows northwest through the Olema Valley, the landward expression of the San Andreas Fault Zone. Its confluence with Lagunitas Creek lies at the head of the ecologically significant Tomales Bay. Protected from development, the 37.6 square km (14.5 square mile) watershed is primarily contained within the boundaries of PORE and the GOGA north district. The watershed provides habitat for four federally protected aquatic species: California freshwater shrimp (*Syncaris pacifica*) – endangered; coho salmon – endangered; steelhead – threatened; California red-legged frog (*Rana draytonii*) – threatened. Olema Creek is the focal point of hydrologic, water quality, and fisheries monitoring within PORE.

Lagunitas Creek and its tributaries (Nicasio Creek, San Geronimo Creek, Devil's Gulch, Cheda Creek, Bear Valley Creek, and Olema Creek) drain more than 230 square km of western Marin County. The headwaters of the Lagunitas Creek mainstem lay within the 53,000 ha watershed lands administered by the Marin Municipal Water District (MMWD). The mainstem originally totaled about 40 km of perennial stream draining the northern slope of Mt. Tamalpais, but was reduced by more than 50% by construction of Alpine Dam in 1918 and Peters Dam in 1953. Because neither dam has provision for fish passage, their construction resulted in permanent loss of the upper portion of the drainage to anadromous fish.

The portions of the Lagunitas drainage most significant for salmonids are under a number of ownerships. Approximately 12 km of the mainstem is bordered by NPS lands (north district GOGA). A major tributary, San Geronimo Creek, flows through privately held land in San Geronimo Valley. Devil's Gulch lies almost entirely within Samuel P. Taylor State Park with its headwaters in NPS lands. Only one smaller tributary of Lagunitas Creek, Cheda Creek, lies entirely within GOGA lands.

Cheda Creek is a small perennial tributary of the Lagunitas Creek watershed and provides critical habitat for steelhead trout and coho salmon. Past land-use within the Cheda Creek drainage has resulted in alterations to the natural hydrology and degraded riparian conditions of the creek. These factors have negatively impacted salmonid populations, water quality, and the ability of the aquatic ecosystem to function properly. The construction of a fish passage structure in the fall of 2000 was part of an overall watershed restoration project initiated by the NPS to restore the system to a more natural and sustainable condition.

Redwood Creek is a 19.4 square km (7.5 square mile) coastal watershed in southern Marin County, California (Figure 1). Redwood Creek flows southwest from the flanks of Mt. Tamalpais, through MUWO, discharging to the Pacific Ocean through Big Lagoon at Muir Beach. Protected from development, the watershed is primarily contained within the boundaries of Mt. Tamalpais State Park, GOGA, and MUWO. The watershed provides habitat to three federally protected species (coho salmon – endangered; steelhead – threatened; and the California red-legged frog – threatened). According to the NMFS Genetics Laboratory, the coho salmon found in Redwood Creek represent a genetic outlier within the CCCESU with extreme genetic distance from all other samples collected within the CCCESU and the Southern Oregon-Northern California Coast Evolutionarily Significant Unit (Bjorkstedt et al. 2005).

Pine Gulch Creek drains a 19.4 square kilometer (7.5 square mile) watershed in coastal Marin County, California, and is the primary freshwater input to Bolinas Lagoon (Figure 1). Pine Gulch Creek is located within the CCCESU where coho salmon and steelhead occur. The watershed supports a population of steelhead and it is generally accepted that it supported a native self-sustaining population of coho salmon into the 1970s. It is likely the drought of the late 1970s coupled with in-stream damming during the same period severely depleted multiple cohorts and led to unsuitable conditions for continued survival of the species within the Pine Gulch watershed. In 2001, NPS documented the return of coho salmon to the watershed beginning with the recovery of a coho carcass, and subsequent documentation of coho juveniles in the watershed the following summer (Brown and Ketcham 2002). Based on genetic tests, the coho which have returned to Pine Gulch Creek are likely strays from Redwood Creek, demonstrating a natural expansion of the genetically distinct Redwood Creek stock into a nearby watershed in PORE (Garza and Gilbert-Horvath 2003).

2 Sampling Design and Methods

This program includes strategies to monitor coho salmon and steelhead at a variety of life stages. All Standard Operating Procedures (SOPs) for winter adult spawner surveys, spring outmigrant smolt trapping, summer juvenile coho basinwide surveys, and summer index reach surveys are documented in the SFAN Salmonid Monitoring Protocol version 4.0 (Reichmuth et al. 2010). The methods described in this report are provided as a summary of detailed methods in the SFAN Salmonid Monitoring Protocol. These methods have been used by the SFAN for salmonid monitoring within coastal Marin County since 1997. Many of the methods associated with the project are consistent with draft CDFW biotic monitoring guidelines (Collins 2003). Maps of Olema, Redwood, and Pine Gulch Creeks with survey locations are shown in Figures 2-4.

2.1 Adult Salmon Escapement Surveys

Annually, spawner surveys are conducted in watersheds within and adjacent to SFAN park units, including PORE, GOGA, and MUWO. These surveys concentrate primarily on federally endangered coho salmon and federally threatened steelhead in an attempt to quantify the adult salmon escapement. “Escapement” refers to the number of adult fish that successfully pass through a fishery to reach the spawning grounds located in the freshwater streams. Data collected as a part of these surveys contribute to Monitoring Objective 1 and include number of live fish observed (coho and steelhead), number of fish carcasses observed (coho and steelhead), and number of redds observed (coho and steelhead). These surveys were first conducted on Olema Creek in 1997, Cheda Creek in 1998, Redwood Creek in 1994, and Pine Gulch in 2000. Standard Operating Procedures 5, 6, 9, and 11 document field and analytical methods for the adult salmon escapement monitoring efforts (Reichmuth et al. 2010).

2.1.1 Field Methods

Program staff and trained volunteers conduct surveys for coho and steelhead spawners and redds each winter during the coho spawning season to quantify escapement and determine spawning density and distribution. Although the steelhead spawning season overlaps in timing with the coho spawning season, surveys are not performed throughout the steelhead spawning season.

Escapement surveys are conducted within a three-month period starting in late November continuing through early February. Start and end dates for each season vary depending on instream flows, and spawning activity. Adult coho salmon runs within the CCCESU are compressed into a very short window, with upstream migration coinciding with brief peak winter discharges, typically peaking in January (Weitkamp et al. 1995). Freshwater residence time is short (typically less than two weeks), though the SFAN program has documented some individuals spending up to 20 days in freshwater. Surveys are conducted approximately every week, although storms and high stream flows often dictate less frequent surveys. Teams of two to four observers walk upstream through 2-4 km creek reaches and along creek margins and banks (where possible) to look for live fish, carcasses, and redds. Live fish are identified to species and sex, and lengths are visually estimated. Carcasses are measured (fork length), identified to species and sex, and marked to prevent double counting. Carcass scales and tissue samples are collected for age and genetic analysis. Redds are measured and

marked with flagging on adjacent vegetation. Because redds are stationary and can be observed over time, redd monitoring is targeted to determine spawning success.

Particular care is taken not to disturb redds or actively spawning adults. Locations of all live fish, carcasses and redds are recorded in reference to permanent tags placed every 100 m along each stream. The survey data is used to generate index values and minimum population estimates for the assessment of long term trends.

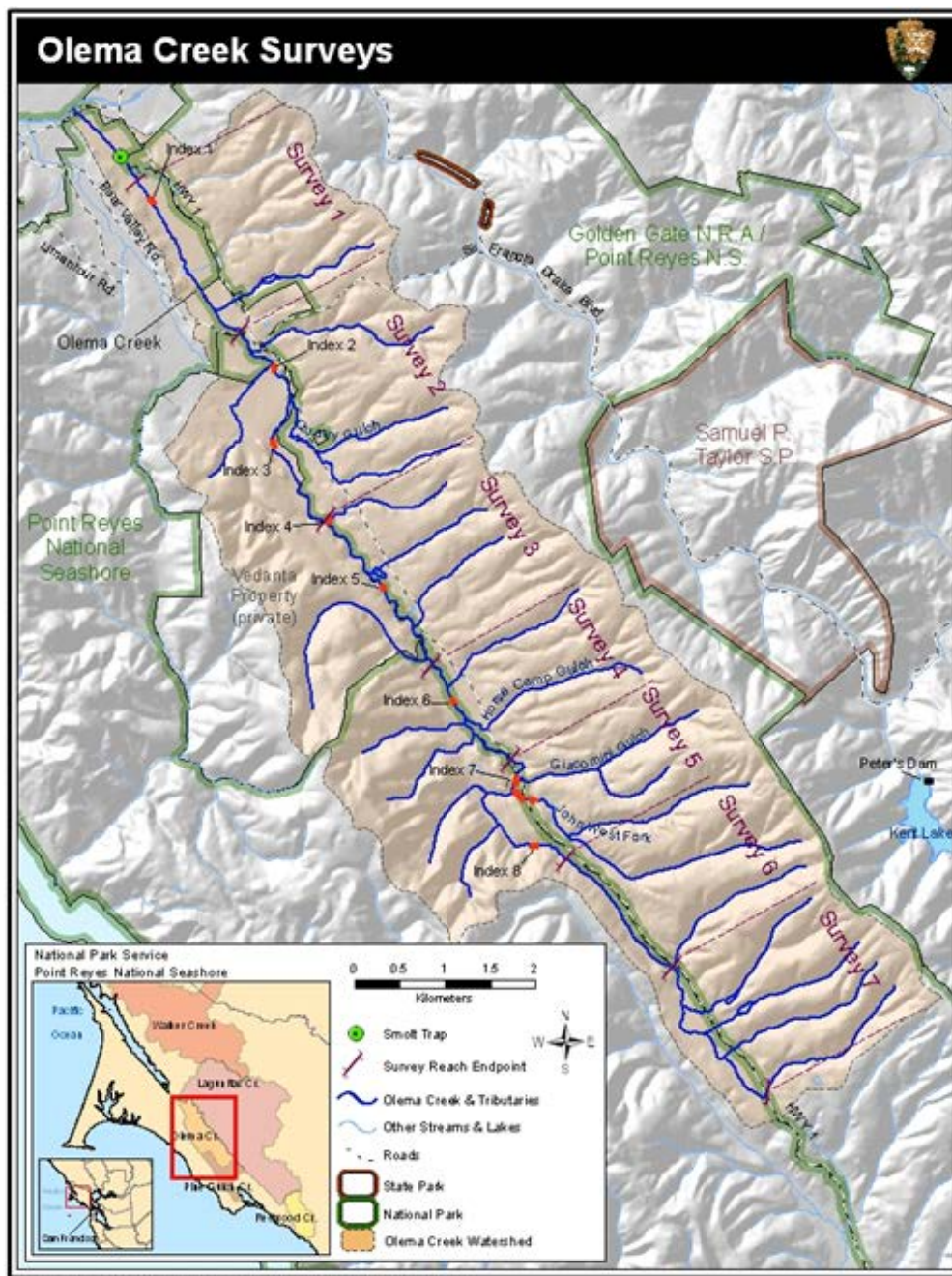


Figure 2. Olema Creek survey locations. Adult spawner reaches, summer index reaches, and smolt trap locations are shown.

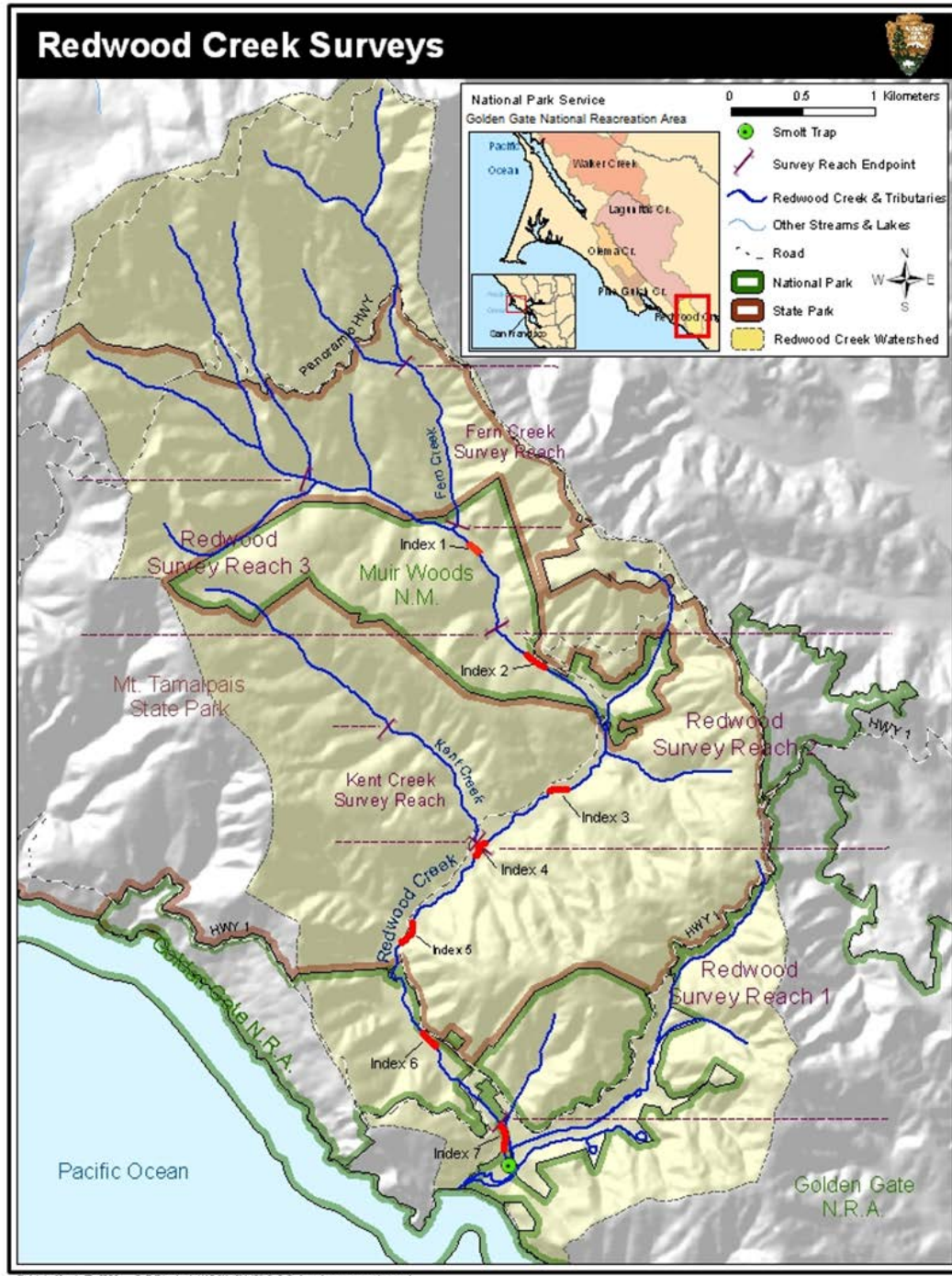


Figure 3. Redwood Creek survey locations. Adult spawner reaches, summer index reaches, and smolt trap locations are shown.

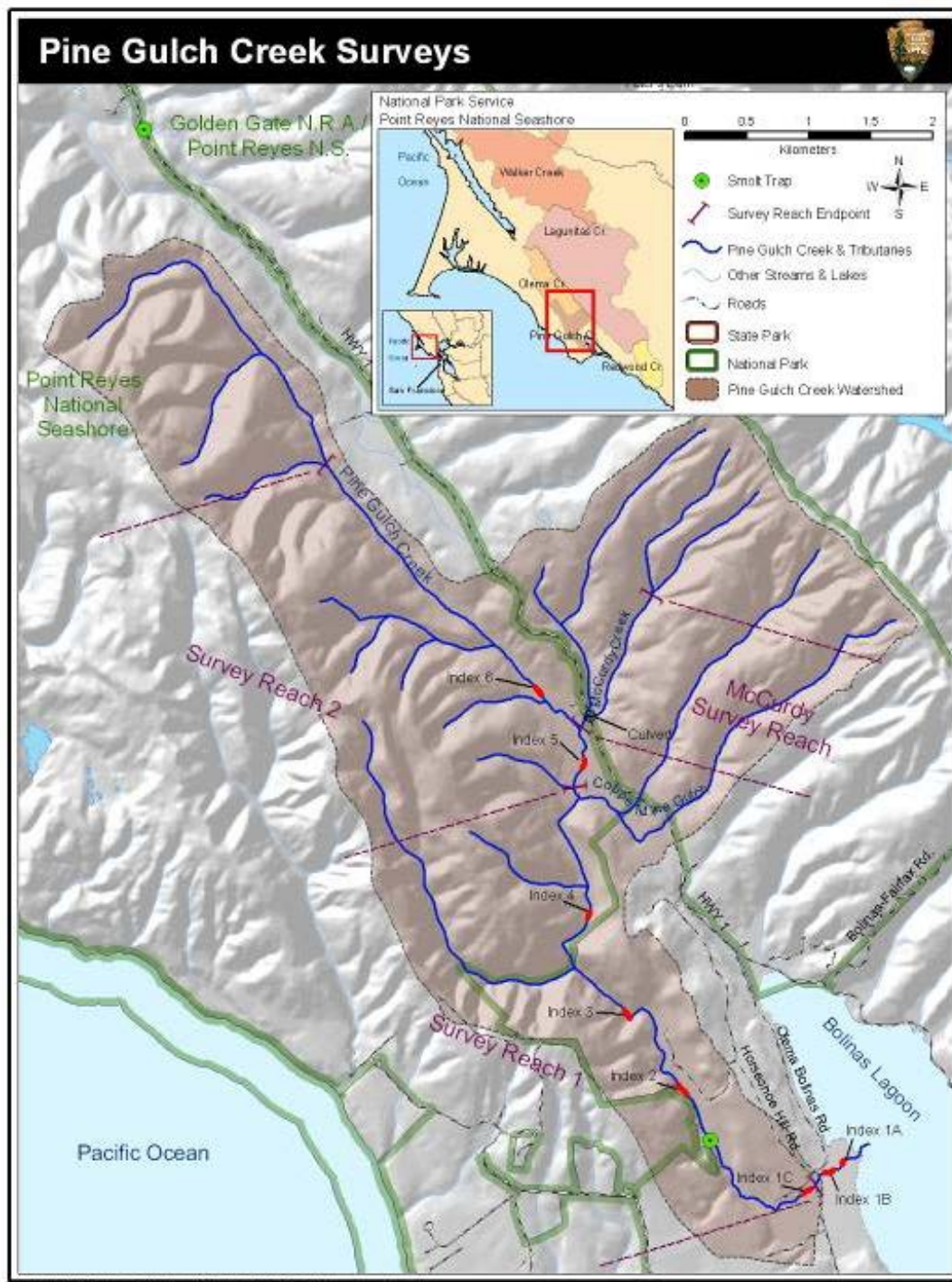


Figure 4. Pine Gulch Creek survey locations. Adult spawner reaches, summer index reaches, and smolt trap locations are shown.

2.1.2 Olema Creek

A large section of the mainstem of Olema Creek, 17.6 km, has been surveyed by the Tomales Bay Association (TBA), NPS staff, and volunteers since 1993. The section is currently divided into seven survey reaches starting 1 km above the confluence with Lagunitas Creek and ending at the Highway

1 culvert at milepost 19.94 (Figure 2). Reaches are delineated to facilitate sampling based on access, length, and the existence of permanent landmarks for reach boundaries.

In addition to the mainstem of Olema Creek, surveys are often conducted on some of the larger tributaries. Most tributary surveys conducted in the past were intended only to establish presence or absence of spawning coho and reach lengths varied widely. At present, complete surveys are conducted for the tributaries as personnel and flow conditions allow, based on an established priority order dependent on spawning abundance. John West Fork, which is the largest tributary to Olema Creek, has the highest priority and abundance of spawning activity. Since 2008 surveys on John West Fork are conducted on the same day as the mainstem of Olema Creek in an attempt to develop a more accurate escapement estimate. For each tributary, survey reaches start at the mouth and generally continue upstream until passage barriers are encountered or no more spawning activity is detected. Many of the tributaries are unnamed on U.S. Geological Survey 7.5 minute maps.

2.1.3 Lagunitas Creek Watershed - Cheda Creek

Cheda Creek, a Lagunitas Creek tributary, has been surveyed since 1996-1997 to detect the presence or absence of coho. The NPS completed a fish passage improvement project in the fall of 2000; coho salmon spawning in the upper part of the creek above the fish passage project site was detected in the 2004-2005 spawning season. Approximately 1.3 km of stream is typically surveyed, including a 0.8 km reach downstream of the fish passage improvement project and a 0.5 km reach upstream.

2.1.4 Redwood Creek

Since 1994, the NPS has conducted annual surveys along a 6.7 km section of the mainstem of Redwood Creek between a point 140 m downstream of the Pacific Way Bridge to approximately 500 m upstream of Bridge 4 in MUWO (Figure 3). The section encompasses most of the stream length used by coho salmon.

Portions of Fern and Kent Creeks, the two largest Redwood Creek tributaries, were also sampled. The reach on Kent Creek extends from the confluence with Redwood Creek to a waterfall, approximately 1 km upstream, which is impassable to migrating adults. The Fern Creek section has been surveyed since 1994 and extends between the Redwood Creek confluence and a series of steep cascades 1 km upstream.

2.1.5 Pine Gulch Creek

Since 1997, the NPS has conducted surveys along a 9 km section of the mainstem of Pine Gulch Creek (Figure 4). Coho salmon were first observed during surveys in the winter of 2000-2001. Due to private property access issues and the nature of the watershed, the survey reaches are longer than for other creeks.

The spawner surveys start at the Olema-Bolinas Road Bridge and extend upstream to monument marker 100. The section encompasses most of the stream length that would be potentially used by coho salmon. Although not currently sampled, the McCurdy Creek survey reach was established as a potential survey reach in spawner years when spawner abundance is high and flows allow access to this tributary.

2.1.6 Adult Coho Salmon Escapement Data Analysis

The analysis of spawner survey data is complicated by annual variability in environmental conditions and run characteristics. Accurate abundance estimates are difficult to generate without counting weirs or other intensive sampling techniques (Irvine et al. 1992). The SFAN monitoring program is, nonetheless, interested in developing precise indices of abundance for these small watersheds.

Because coho return to spawn over a one to three-month period (November through January, weather dependent) and residence time on the spawning grounds is variable, live fish may be double counted during repeated surveys. Three techniques, Peak Live plus cumulative Dead (PLD), Area Under the Curve (AUC), and redds are used to compute escapement estimates (Beidler and Nickelson 1980, Johnston et al. 1987, Irvine et al. 1992, Gallagher and Gallagher 2005). In addition to calculating the indices, we summarized the live fish, redd, carcass, and environmental data for each stream.

The PLD and AUC estimates provide different types of information relying on adult coho detections. The PLD estimate is derived by adding the peak number of live fish observed during a single survey to the number of carcasses recovered on or prior to that date, and is considered a minimum count. The AUC estimate is calculated using the total number of live fish observed during each survey and the average life of fish on the spawning grounds known as residence time (RT). This method requires more consistent surveys and allows for an estimate of survey quality known as observer efficiency (OE) and the RT of fish within the watershed. Calculating the AUC is created by plotting the live fish observations for each survey produces a quantity termed total fish-days. The escapement AUC is calculated using this equation:

$$AUC = 0.5 \{ \sum (t_i - t_{i-1}) (p_i + p_{i-1}) \}$$

where t_i is the number of days since the first fish entered the survey area and p_i is the total number of fish observed on the i^{th} day (Irvine et al. 1992). Dividing the total number of fish days by the RT gives the population estimate. Observer efficiency estimates, based on average water clarity over the duration of the spawner season for each creek, are also incorporated when possible. When RT and OE values cannot be determined, AUC estimates are calculated based on values from published coho spawner studies. Because we cannot always estimate residence time, separate AUC estimates are computed using the range of values presented in the literature, 8 to 17 days (Moring and Lantz 1975, Johnston et al. 1987, Irvine et al. 1992). The most frequently reported values were 11 and 13 days. Two of the eight studies reported OE values between 69% and 76% (Solazzi et al. 1984, Johnston et al. 1987). To consider a wider range of observer efficiencies, AUC estimates were calculated for OE values between 50% and 100%. Data collection typically stops after repeated surveys no longer indicate the presence of live coho. High flows prevented us from conducting surveys during significant portions of some spawner seasons. If fish were observed during the last survey of the season, the last date used for calculating the AUC estimate was arbitrarily set at 10 days after the final survey date. This method will tend to overestimate fish numbers where there are multiple peaks of fish or if there is a large interval between surveys.

Redd count and location are used to describe spawning density and spatial distribution. Cumulative redd observations are tallied for the spawner year (SY). Redd location is documented by distance

upstream from an established monument tag and can be compared annually to determine high density spawning reaches. Redd counts may be limited by OE and changes to the streambed associated with flow events. Since redd construction results in a visible streambed feature, the focus of escapement estimates are gravitating towards the use of redds as an estimator of adult escapement. Given the reliability of detecting redds over live fish and carcass counts during walking surveys, redds are the best current measure of adult escapement given the available dataset. Current and future redd data will be analyzed using methods outlined in Gallagher and Gallagher 2005.

2.1.7 Other Monitoring Programs

SFAN conducts escapement monitoring on Pine Gulch Creek, Cheda Creek and Redwood Creek, as well as Olema Creek. In addition, MMWD conducts similar monitoring programs on Lagunitas Creek, San Geronimo Creek, and Devil's Gulch. The Salmon Protection and Watershed Network (SPAWN) program conducts surveys on tributaries of San Geronimo Creek. The aggregate of these monitoring efforts provides detailed escapement results for two of the five coho salmon genetic subgroups within the CCCESU.

2.2 Outmigrant Smolt Trapping

For a detailed description of sampling design rationale and methods used during the outmigrant smolt trapping season, please refer to SOPs 3, 4, 6, and 11 in Reichmuth et al. 2010.

Outmigrant smolt trapping is performed annually from March through May on Olema and Redwood Creeks. Outmigrant trapping is also performed on Pine Gulch Creek in years when juvenile coho are detected during basinwide juvenile coho surveys performed in July of the previous year. Outmigrant trapping is intended to census the number of coho smolts leaving the watershed and the smolt data obtained through the trapping contributes to Monitoring Objective 2. Although trapping operations are focused on coho smolts, smolt trapping also provides information on steelhead smolt outmigration. Trapping results can also help quantify dates of fry emergence and growth rates through the spring season. Outmigrant traps provide presence/non-detect information and size data for other aquatic species during periods not covered by summer/fall monitoring activities.

2.2.1 Smolt Trap Field Methods

Trapping is conducted continually for a 2-3 month period during the spring and requires daily checking by field staff. The fyke/pipe traps used by this program are based on methods developed in northern California for trapping small streams (Manning and Roelofs 1996; Manning 2001) and have proven effective for the current monitoring sites. They are designed to catch fish moving downstream and effectively (with efficiency estimated via mark-recapture techniques, see 2.2.3 below) result in a census of smolt outmigration. Trap site locations within each watershed were determined by suitable channel morphology and access.

Traps are generally installed in mid-March, once flows have subsided from winter peaks and stabilized somewhat. In some years, spring rains occasionally raise flows enough to compromise trap operation. Coho smolt migration typically ends by late May or early June coinciding with a drop in stream flows, so traps are usually removed at this time. In each of the monitored watersheds, the

SFAN I&M program maintains a stream gage for measurement of average daily discharge. An Onset-brand temperature logger is deployed in each trap box for the duration of operation.

2.2.2 Coho and Steelhead Handling

Mark-recapture methods are used to estimate trap efficiency and smolt population size. Daily, no more than 30 smolts (or 50% of the catch that day) of coho smolts were anesthetized with carbon dioxide and marked with a passive integrated transponder (PIT) tag. A random sub-sample of steelhead parr (juveniles of at least one year of age that show no signs of smoltification), coho and steelhead smolts (fish of at least one year of age that have undergone physiological changes in preparation for heading out to sea), and coho and steelhead fry (recently hatched and emerged juveniles) are measured to the nearest mm and weighed to the nearest 0.01 g. This sub-sample is normally 10 of each species; however, if fish are anesthetized for mark-recapture purposes, they are also measured.

2.2.3 Trap Site Locations

For detailed site rationale and descriptions, refer to SOP 9 in Reichmuth et al. 2010.

The Olema mainstem trap was located on NPS lands approximately 400 m upstream of the mouth from 2004 to 2006. Due to high flow failure and the capture of California red-legged frog tadpoles and adults in the trap box during the 2005 and 2006 trapping seasons, the trap was relocated in 2007 approximately 1 km upstream. SFAN staff chose a trap location upstream of the previous location in an attempt to avoid red-legged frog breeding areas. On Redwood Creek, the trap is located at the most downstream end of the watershed, near the Muir Beach public parking area, below the restored channel. Due to the absence of any juvenile coho found within Pine Gulch Creek in the summer of 2011, no smolt trap was constructed during the 2012 smolt trap season.

2.2.4 Sampling Period

Past literature was reviewed to determine the appropriate start and ending points for the trapping season. Based on our trapping experience, we have observed outmigration primarily in April and May, with the peak occurring in late April to early May (Reichmuth et al. 2006, Del Real et al. 2008, Carlisle et al. 2011).

Currently during the trapping season, mid-March to May, the traps operate 24 hours per day, and are checked on a daily basis. This frequency was selected to balance labor efforts with the need to prevent fish injury due to prolonged trap residence. When possible, the trap was checked twice-daily to prevent incidental mortality of adult steelhead and steelhead fry. If possible, traps are opened in anticipation of high flows to avoid potential mortality. To minimize impacts to newly emerged fry, the trap box is fitted with a ¼-in mesh screen to allow smaller fish to pass through the box, while still catching smolts.

2.2.5 Smolt Trap Data Analysis

Information produced through this program includes weekly and daily totals of fish captured, including smolts, other age 1+ juveniles, and young-of-year (YOY). Weight-length relationships for smolts and other age 1+ coho salmon and steelhead are reported. Mark/recapture methods are used to estimate trap efficiency and population.

Mark/recapture data is analyzed using DARR (Darroch Analysis with Rank Reduction), a software application developed by Eric Bjorkstedt at the NMFS Southwest Fisheries Science Center (Bjorkstedt 2010). The software facilitates analysis of temporally stratified mark/recapture data based on methods developed by Darroch (1961).

Using the efficiency method to estimate a population could result in overestimates of the population. Estimates reported through this method would require the following assumptions: 1) there is no mortality of released fish; 2) there is no residualization or change in migration behavior; and 3) released fish are redistributed and have a constant probability of capture.

For fish biotics, including fish weight, length and condition score, a contrast (i.e., a numerical adjustment constant) is used to preserve the cohort effect on the population. The contrast uses the mean across years to test the differences at the year level. A two-sided t-test ($\alpha=0.05$) is then used to for each biotic parameter to test for differences between the current year and previous years. For other data analyses performed, refer to SOP 10 in Reichmuth et al. 2010.

2.3 Juvenile Coho and Steelhead Surveys

Monitoring juvenile salmonids during their freshwater residence phase provides information on overall population trends in distribution, abundance, and condition (Monitoring Objective 3), particularly when combined with adult spawning data and smolt emigration data (Collins 2003). Sampling is most effective during summer and fall base flow conditions, when water clarity is greatest and conditions are more conducive to observation and capture of juvenile salmonids.

The primary activities conducted in the watersheds include basinwide GSS and index reach monitoring during the summer/fall sampling period. Complete field methods are documented in SOPs 1, 2, 6, and 9 in Reichmuth et al. 2010. The descriptions of field methods for summer juvenile coho and steelhead monitoring are organized by survey type since a variety of surveys are utilized during the summer juvenile monitoring season. Although multiple survey techniques may be deployed within the same sampling period, each survey type is treated as a standalone survey.

2.4 Basinwide General Systematic Surveys

Basinwide survey techniques, developed by Hankin and Reeves (Dollof et al. 1993), provide a statistically valid estimate of stream habitat or population of a particular fish species for a broad area or entire stream. Basinwide surveys involve a two-stage sampling design using both snorkeling and electrofishing. This two-stage sampling combines labor-intensive data collection for a randomly selected subsample of units correlated with data from a less labor-intensive sampling technique to achieve representation while reducing effort.

2.4.1 Habitat Surveys

For a complete description of sites monitored, refer to SOP 9 in Reichmuth et al. 2010.

Starting at the bottom of the coho survey area and working upstream, surveyors number, classify, measure the length, and estimate the average width of each habitat unit. Units are classified to level III using the CDFW classification system (Flosi et al. 1998) as pool (scour pool, plunge pool, or mid-channel pool), flatwater, or riffle. Side channel and backwater units are also measured. The width of

each habitat unit is estimated visually. Every fifth pool unit is flagged for snorkeling and several measured widths are taken for the purpose of calibrating the estimated width. All large woody debris, live or dead, providing instream shelter during summer base flow conditions are counted and recorded within each habitat unit.

2.4.2 Basinwide Snorkel Surveys

Program staff survey 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 are counted but the presence of steelhead and non-salmonid fish is also noted.

Typically, snorkeling is calibrated by follow up electrofishing of randomly selected dive pools to provide an unbiased calibration method. When conditions do not allow for electrofishing (water quality, access concerns, etc.), a random subset of the snorkeled pools are immediately resampled using the method of bounded counts (Murphy and Willis 1996).

2.4.3 Index Reach Monitoring

Index reaches are sampled at SFAN parks during summer/fall base flow periods to assess fish abundance and distribution within each index on Olema Creek, Redwood Creek, and Pine Gulch Creek. Under this technique, established stream reaches approximately 100 m in length distributed intermittently along the creeks' full length, have been surveyed annually since the mid- to late-1990s. Index reach surveys include both fish sampling and detailed habitat assessments.

Each index reach contains two to ten contiguous habitat units, which are identified and sampled individually. Each habitat unit is isolated with block nets and sampled separately using standard multiple pass depletion electrofishing methods (Bohlin et al 1989). Habitat measurements and assessments are made for the index reaches after fish sampling is completed.

Index reach surveys provide baseline fish distribution information and abundance/density estimates. *MicroFish* software is used to analyze data. The software is based on removal-depletion methods to account for detection error. Measurements of individual fish weight and length are also used to generate biotic condition factors for salmonids in each watershed. Juvenile salmonid cohort abundance varies depending on returns of adult spawners and environmental conditions. By comparing the baseline fish density estimates derived from consecutive survey years, the variations in cohort abundance can be monitored. Because steelhead often spend in excess of one year in freshwater, annual surveys may provide information on the overwintering success of different cohorts.

Index reach monitoring was initiated at seven sites on Olema Creek in 1999 (Table 1, Figure 2). See SOP 9 in Reichmuth et al. 2010 for detailed index reach locations and maps. In 2000, Index Reach 8 was added to represent the intermittent portion of the upper mainstem.

Table 1. Site location and number for Olema Creek summer 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

Dr. Jerry Smith of San Jose State University established five index reaches on Redwood Creek in 1992. Monitoring of these sites was shared between Dr. Smith and NPS until 2004. Since 2004, all seven index reaches have been monitored by SFAN staff (Table 2, Figure 3). Two additional index sites, MUWO boardwalk and Banducci, were added by GOGA in 2001 to represent habitat units not being covered by Dr. Smith.

Table 2. Site location and number for Redwood Creek summer 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 monitoring was initiated at eight sites on Pine Gulch Creek in 2000 (Table 3, Figure 4). The stream kilometer (km) location of each index reach is presented in Table 3.

Table 3. Site location and number for Pine Gulch Creek summer index sites.

Index site	Name/location	Location (stream km)
1a	Marin County Open Space District	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

2.4.4 Electrofishing/Handling

All captured fish are documented as part of the monitoring effort. To reduce fish handling impacts, a subsample of 10 fish per species per pass is processed. Fish are kept in aerated holding buckets before and after handling, and allowed to recover fully before being released. Processed fish are sedated using carbon dioxide (Alka SeltzerTM), identified to species and age class, measured, and weighed. In some cases, fish scale samples or fin clip samples are also collected for age and/or genetic analysis. All other fish are identified to species, counted, and transferred directly to the recovery buckets.

An electrofishing log is kept of all settings, pertinent environmental conditions, fish response, and total catch for each unit. All electrofishing information is reported annually to NMFS, as required by the PORE Endangered Species Section 10 permit for coho salmon. Water quality parameters including temperature (°C), dissolved oxygen (mg/l and %), conductivity (uS), and specific conductivity (uS) are measured and recorded.

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

2.4.5 Juvenile Coho and Steelhead Survey Sample Periods

Index reaches and basinwide surveys for each stream are sampled during the same general time of year on an annual basis (Table 4). Sampling occurs during summer base flow conditions when intermittent stream flow conditions typically occur. During the 2008 sampling season, the Olema Creek sampling period was moved to September to better represent summer base flow conditions. Prior to 2008, Olema Creek was sampled in late June before flows reached summer base flow conditions.

Table 4. Index reach/basinwide survey sample dates, summer 2012.

Watershed	Stream	# of index reaches sampled	Range of in-stream sample dates
Pine Gulch	Mainstem	5	07/09/12 – 07/26/12
Redwood	Mainstem	6	07/30/12 – 08/27/12
Olema	Mainstem	5	08/28/12 – 09/27/12

3 Monitoring Results

Monitoring data presented below are organized first by monitoring procedure (escapement surveys, outmigrant smolt surveys, basinwide juvenile surveys, and index reach juvenile surveys) and then by watershed. For context, rainfall data are also presented.

3.1 Rainfall

The data collected at the Bear Valley rain gage shows that the 2012 water year (October 2011 – September 2012) was drier than the average year when compared to the historic data set collected since 1965. The total rainfall for water year 2012 was 33.22 inches whereas the average for the last 47 years was 38.96 inches. During December, which can be a critical time for spawning activity of coho salmon, the 2012 total of 0.63 inches was well below the historical December average of 6.97 inches and the 2012 January total of 6.97 inches was below the average of 8.30 inches.

3.2 Data from Escapement Surveys

In the 2011-2012 the SFAN conducted escapement surveys starting in late November and continuing through the beginning of March. Surveys were conducted in Olema, Cheda, Redwood, and Pine Gulch Creeks.

These surveys were first conducted on Redwood Creek in 1994, Olema Creek in 1997, Cheda Creek in 1998, and Pine Gulch in 2000. Historical results for all streams monitored in Marin County by the NPS, MMWD, and SPAWN are presented in Appendix A, Table A1.

3.2.1 Olema Creek

Coho escapement monitoring information on Olema Creek shows that run timing is highly dependent on the rainfall-runoff conditions within the watershed. Unlike Lagunitas Creek, Olema Creek is an unregulated stream. This makes Olema Creek far more vulnerable to the variable environmental conditions that limit flows in the winter season. Adult coho salmon runs within the CCCESU are compressed into a very short window, with upstream migration coinciding with brief peak winter discharges, typically peaking in January (Weitkamp et al. 1995). Freshwater residence time is short (typically less than two weeks), though the SFAN program has documented some individuals spending up to 20 days in freshwater under ideal conditions.

Olema Creek watershed spawner survey information includes data collected on 15.1 km of the mainstem of Olema Creek, primarily Reaches 2 through 6, and John West Fork, a tributary to Olema (Figure 3). In addition, spawner surveys were conducted on Quarry Gulch, Boundary Gulch, Horse Camp Creek, and Giacomini Creek. When possible, the mainstem of Olema Creek and the John West Fork tributary are combined for analysis.

Adult Coho Survey Timing and Environmental Conditions

Our monitoring efforts have documented some years when flows necessary to allow entry into the watershed did not occur until mid-January. In those years, coho were observed in the estuary waiting for Olema Creek attraction flows. In other years, rains in November have resulted in flows that would allow coho access to the watershed. Even when the early entry opportunity has occurred in November, few coho have been observed. For the most part, peak spawning activity within Olema

Creek is between mid-December and mid-January. Typically, the peak count will follow a large flow event, encouraging fish that were waiting at the mouth of the watershed to enter and spawn. Figure 5 shows the approximate entry and spawning window monitored for coho salmon for 2011-2012 compared to the average for 1997 to 2011. Due to the lack of rain in December and most of January, the fish were forced to wait for storms at the end of January in order to enter the system (Figure 6). Typically, historic peak spawning activity within Olema Creek is between mid-December (Julian weeks 50 and 51) and mid-January (Julian weeks 1-3; Figure 5). Typically, the peak count will follow a large flow event, encouraging fish that were waiting at the mouth of the watershed to enter and spawn. Data on historical timing of the coho run, rainfall during the run, and spawning activity observed on Olema Creek and John West Fork can be found in Appendix A, Tables A2 and A3.

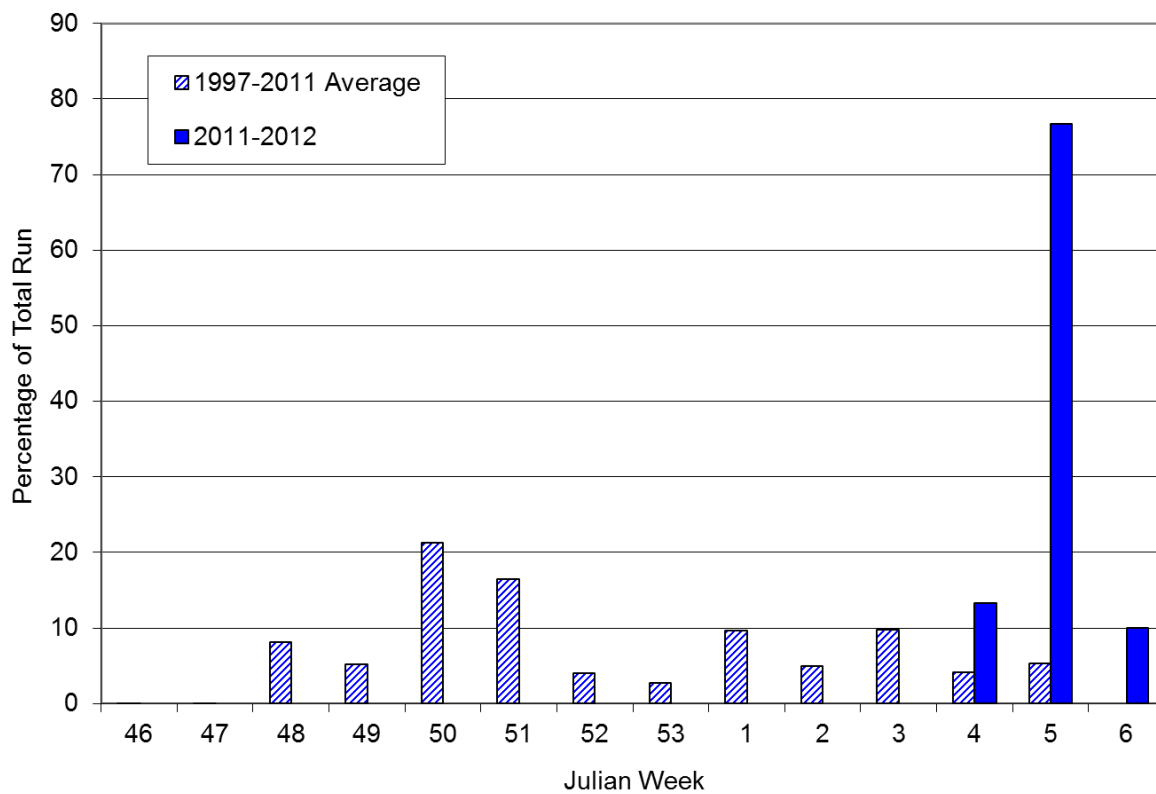


Figure 5. Olema Creek adult coho run timing, based on number of live fish observed, average of 1997-2011 compared to winter 2011-2012.

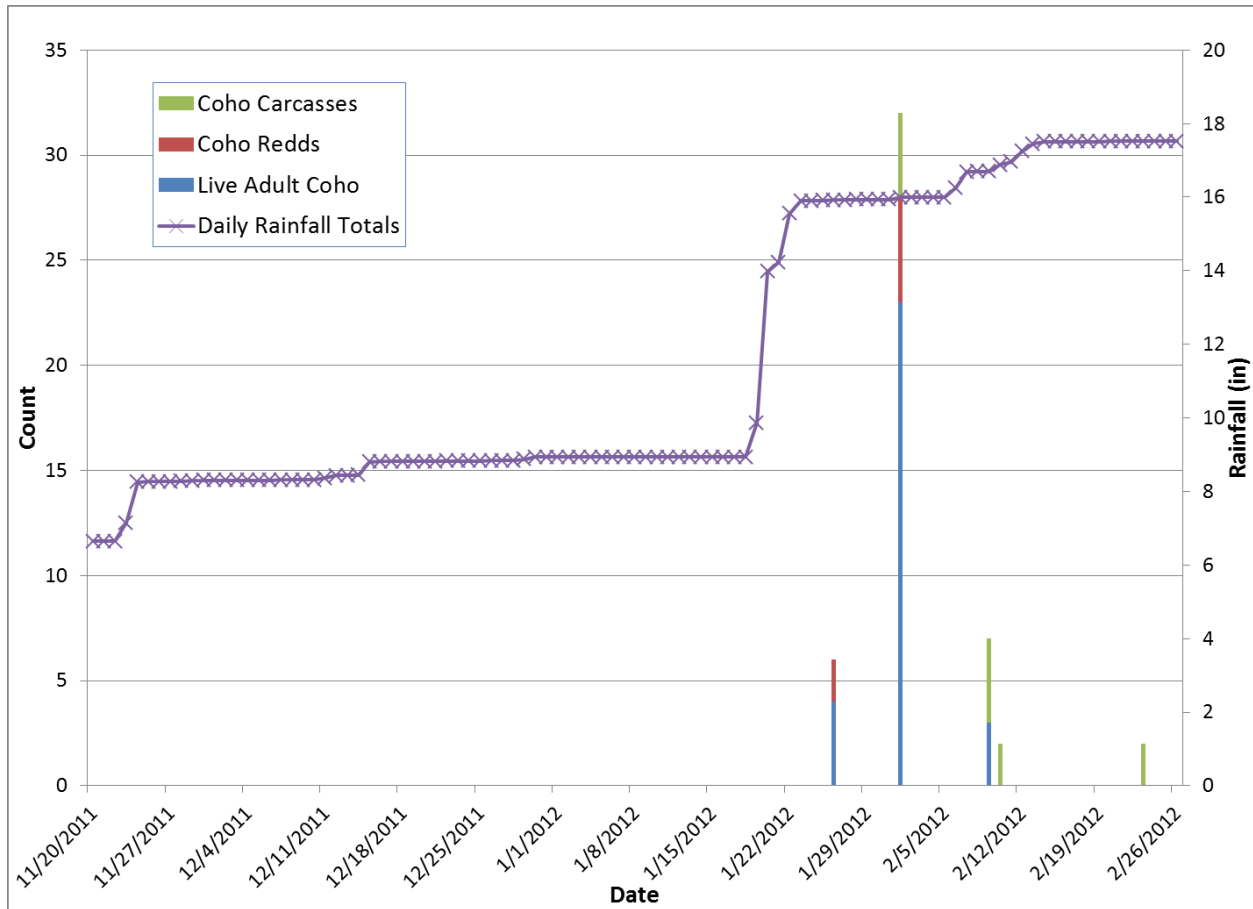


Figure 6. Daily rainfall totals at Bear Valley and coho adult escapement survey results on Olema Creek mainstem, including live fish, carcasses, and redds, observed during surveys in 2011-2012.

For the 2011-2012 season, 14 surveys were conducted in Olema Creek between 22 November 2011 and 23 February 2012. The mean interval between surveys was seven days. Seven day rainfall totals ranged from a low of 0.0 in during Julian weeks 1 and 2 and a high of 5.3 in during Julian week 3. Average water clarity at the time of surveys ranged from 50 cm to 101 cm. The onset of rainfall and subsequent higher flows appeared to be related to live fish observations (Figure 6). Flows did not get high enough to allow spawner access to most of the watershed until early February, which is later than normal.

Due to the lack of sufficient rainfall, only five surveys were conducted on 2 km of John West Fork (Reaches 1 and 2) between 23 January 2012 and 9 February 2012. The mean interval between surveys was four days with a seven day rainfall total low of 0.06 inches during Julian week 5 and a high of 1.7 inches during Julian week 4. Average water clarity at the time of surveys ranged from 35 cm to 100 cm.

In addition to John West Fork, three other tributaries to the Olema mainstem were surveyed between December and February. For these tributaries (Giacomini Creek, Horse Camp Creek, and Boundary Gulch), the timing of surveys generally preceded the mainstem surveys and were dependent on flow.

Live Coho and Steelhead

Spawner surveys of the Olema Creek mainstem and John West Fork Creek tributary were performed between 22 November 2011 and 23 February 2012. While live coho observations do not represent the total number of spawning adults, a total of 30 live adult coho were observed between November and February. Three live coho were observed on John West Fork.

Three additional tributaries to the Olema mainstem (Boundary Gulch, Horse Camp Creek, and Giacomini Creek) were surveyed during the month of January. No adult spawners were observed in any of the tributaries surveyed. Complete results for Olema tributaries can be found in Appendix A, Table A4.

Although adult steelhead are not a primary focus of this study, observations of steelhead were recorded in the same fashion as live adult coho. Because of their behavior, actual live adult steelhead counts are assumed to be much higher than the observed counts. Thirty-seven live steelhead adults were observed on Olema Creek mainstem and six adult steelhead were found on John West Fork. No live adults were seen on any of the other tributaries.

Coho and Steelhead Carcasses

Twelve confirmed coho carcasses were observed during spawner surveys on Olema Creek mainstem. No carcasses were discovered on John West Fork during any of the surveys.

Thirteen steelhead carcasses were observed on the Olema Creek mainstem. No steelhead carcasses were found on any of the Olema Creek tributaries during any of the surveys.

Coho and Steelhead Redds

Redds are the best means of spatially representing spawning densities within the watershed. Within Olema Creek, monitoring efforts have allowed spatial representations of redd density per 100 m section since 1997-1998. Accumulation of this data show high use areas for spawning within the Olema and John West Fork watersheds.

Seven confirmed coho redds were observed in the mainstem of Olema Creek during the 2011-2012 season, with an average redd area of 5.60 m² and a density of 0.5 redds/km. No coho redds were observed on John West Fork.

Thirty-three steelhead redds were observed on the mainstem of Olema Creek and one definite steelhead redd identified in John West Fork. The average steelhead redd area on Olema Creek mainstem was 2.20 m² while the average steelhead redd area on John West Fork was 1.20 m². The redd density was 2.2 redds/km on the mainstem and 0.5 redds/km on John West Fork.

Peak Live Plus Accumulative Dead (PLD) Coho Escapement Estimates

Due to the three-month spawning period and the variability in residence time on the spawning grounds, the same live fish are often double counted during repeated surveys. An estimate derived from adding the peak number of live fish observed during a single survey to the number of carcasses recovered prior to that date provides a minimum spawner escapement estimate. The 2011-2012 PLD

estimate in the Olema Creek mainstem is 27, taken from a peak on 1 February 2012. The PLD for John West Fork is three, taken from a peak on 24 January 2012.

The PLD dataset for adult escapement within Olema Creek includes 18 years of survey information but prior to 1997-1998, redds and carcasses were not consistently counted. The John West Fork tributary has been the focus of extensive restoration and monitoring and is often used as a proxy of conditions in the mainstem. Tables A2, A3, and A4 in Appendix A show historical PLD estimates for the Olema Creek mainstem, John West Fork, and other Olema Creek tributaries.

Area Under the Curve (AUC) Coho Escapement Estimates

The SFAN has also used the AUC method to estimate adult escapement within Olema Creek and the John West Fork tributary. Only live fish are calculated using this technique. AUC estimates in the Olema Creek section ranged from 13 to 27 coho at 100% OE and 25 to 53 fish at 50% OE (Table 5). Estimates from the most commonly reported OE (70-80%) and RT (11-13 days) values ranged from 20 to 28 fish in Olema Creek. Based on our survey OE (80-90%), AUC estimates for coho salmon in Olema Creek range from 18 to 24. No residence time could be estimated due to lack of repeat sightings of fish. No AUC estimate was calculated on John West Fork.

Table 5. Coho salmon spawning survey Area Under the Curve (AUC) estimates for Olema Creek mainstem, 2011-2012

Creek	Number of surveys	Date of entry	Mean survey interval (days)	Survey reaches	Survey length (km)	AUC range 100% OE ^a	AUC range 50% OE ^a	AUC range 70-80% OE ^a	PLD
Olema mainstem	14	26 Jan 2012	7	1-6	15.1	13-27	25-53	20-28	27

OE= observer efficiency, PLD = Peak Live plus cumulative Dead, Date of entry = estimated date in which adult coho migration began in Olema Creek.

^a Residence Time (RT) 11 -13 days

Olema Creek Watershed Coho Escapement History

Escapement estimates for adults in Olema Creek have been made using total coho redds counted, PLD, and AUC methods. In years where persistent high flows resulted in a low number of surveys, all three methods likely under-represented the true escapement number due to low OE. AUC estimates for past years for Olema Creek mainstem and John West Fork are in Appendix A, Tables A2 and A3.

Annual escapement estimates for Olema Creek in the past show a range of 2 to 184 for the mainstem and a range of 0 to 86 for John West Fork using the PLD estimate. Estimates using the AUC method are much higher, with estimates reaching beyond 300 adults in some years. Coho escapement estimates for Olema Creek using total redd observations fall between the PLD and AUC estimates with a range of 0 to 274 assuming 2 adult coho spawners per redd observed.

Coho Spawning Trends

Overall trends in coho spawning based on observed redds in the Olema watershed are shown in Figure 7. The three cohorts are represented as primary colors (yellow-1, blue-2, and red-3) to show relationships between spawning runs. Cohort 2 shows a rapid increasing trend in spawning over the last three generations before falling off sharply in 2007-2008. It has since held relatively steady. Cohort 1 likewise suffered a sharp decline in 2009-2010. Cohort 3 continued to struggle with a dramatic decline between 2002-2003 and 2005-2006, before no adult coho, coho carcasses, or coho redds were observed in 2008-2009. This year marks the first time since that cohort has returned, and the increased number in returns is promising. Each section of the Olema watershed is shown in a different pattern to illustrate the location of spawning activity from year to year as well as within cohorts.

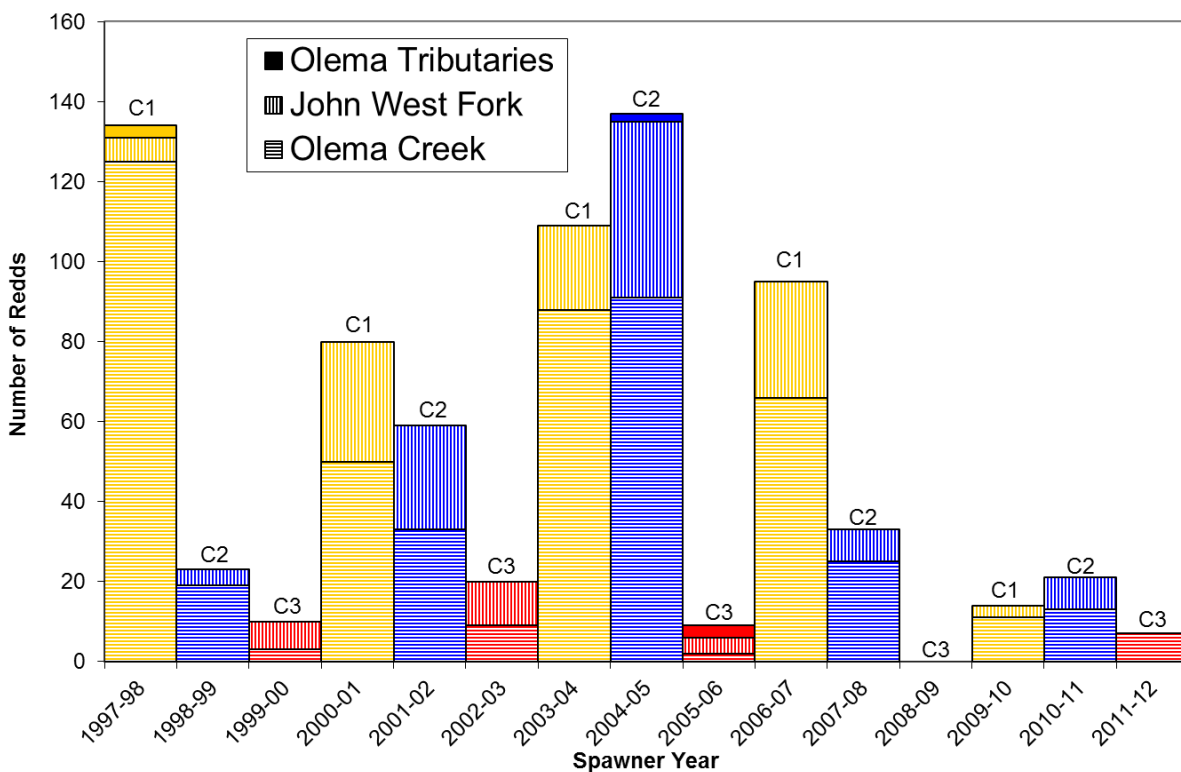


Figure 1. Coho salmon redd results for the Olema Creek watershed by cohort for winter 1997-1998 through winter 2011-2012. Cohorts are designated by color (cohort 1 shown in yellow, cohort 2 shown in blue, cohort 3 shown in red) and creeks are designated by pattern (Olema Creek in horizontal lines, John West Fork in vertical, and other Olema tributaries in a solid color).

Overall trends in coho spawning based on PLD observations in the Olema Creek mainstem are shown in Figure 8. Cohort 1 had shown a steady increase in population size since 1994-1995 until the generation in 2006-2007 during which a major reduction was observed. Cohort 2 shows a rapidly increasing trend in spawning since 1998-1999 until 2007-2008, when the numbers fell dramatically. Cohort 3 continues to struggle with a dramatic decline beginning with 1999-2000 and the non-

detection observation of the 2008-2009 spawning year. As seen with the redd numbers, the increase in PLD in 2011-2012 is a positive sign.

Trends in coho spawning for John West Fork based on PLD observations show that cohort 1 peaked in 2000-2001, declining in the last three returns. Like Olema mainstem, cohort 2 shows an increasing trend in spawning over four generations before a sharp decline was observed in 2007-2008. Finally, cohort 3, after failing in 2008-2009, has shown a small increase in numbers in 2011-2012.

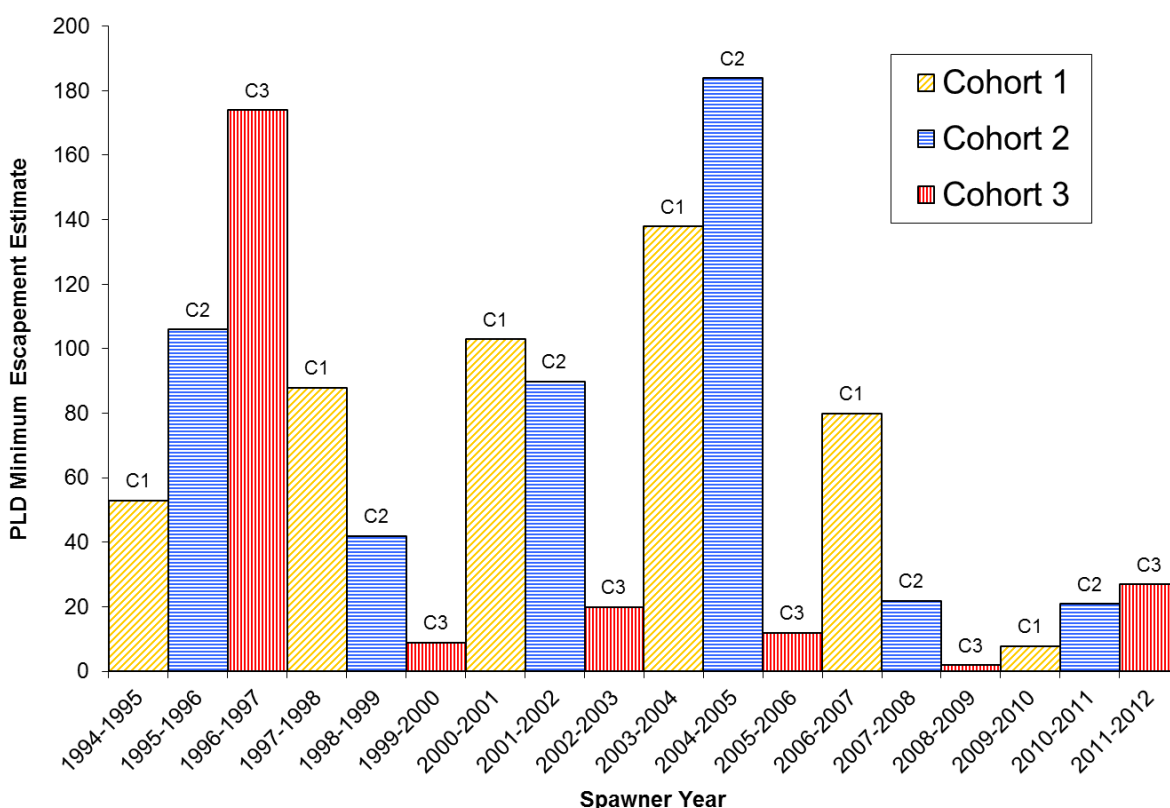


Figure 8. Olema Creek coho salmon PLD (Peak Live plus cumulative Dead) escapement estimates for winter 1994-1995 through winter 2011-2012. Cohorts are designated by color (cohort 1 shown in yellow diagonal lines, cohort 2 shown in blue horizontal lines, cohort 3 shown in red vertical lines).

Live Coho and Coho Carcass Biotics

Information on live adult coho and coho carcasses were collected during each field survey.

Information on sex ratios for live coho and carcasses are reported in Tables 6 and 7, respectively.

While live coho lengths are estimated to the nearest cm, coho carcasses are handled to definitively determine sex, spawning success, fork length (FL), and for collection of a genetic sample. The results of historical coho carcass measurements show that male FLs are between 57 and 75 cm, with females between 58 and 67 cm and jacks (precocious males) between 36 and 42 cm.

Table 6. Sex ratio percentages and mean fork length (FL) of live coho within the Olema Creek mainstem and John West Fork tributary for the period 1997-2011 compared to 2011-2012.

		Live Coho					
		Year	Sample Size	Sex Ratio%	N for FL	Mean FL (cm)	FL SD (cm)
Cumulative	M	1997-2011	596	37	567	73	5.7
	F	1997-2011	769	48	749	70	2.5
	J	1997-2011	234	15	234	39	2.0
	Unk	1997-2011	85		46	56	7.8
Current	M	2011-2012	16	52	16	53	3.5
	F	2011-2012	6	19	6	61	5.9
	J	2011-2012	9	29	9	43	3.6
	Unk	2011-2012	2		2	65	0
	All		33		33		

M= Male, F= Female, J=Jack, Unk= Unknown, n= Number of fish measured for FL

SD= Standard Deviation

Table 7. Sex ratio percentages and mean fork length (FL) of coho carcasses within the Olema Creek mainstem and John West Fork tributary for the period 1997-2011 compared to 2011-2012.

		Carcasses					
		Year	Sample Size	Sex Ratio%	N for FL	Mean FL (cm)	FL SD (cm)
Cumulative	M	1997-2011	121	38	91	67	3.3
	F	1997-2011	159	50	136	63	1.8
	J	1997-2011	38	12	38	42	1.7
	Unk	1997-2011	53		9	66	4.4
Current	M	2011-2012	8	67	8	55	12.0
	F	2011-2012	2	17	2	66	0
	J	2011-2012	2	17	2	42	0.7
	Unk	2011-2012	0		0	0	n/a
	All		12		12		

M= Male, F= Female, J=Jack, Unk= Unknown, n= Number of fish measured for FL

SD= Standard Deviation

3.2.2 Cheda Creek Coho and Steelhead Escapement

Cheda Creek is a small but important tributary of the Lagunitas Creek watershed and provides critical habitat for coho salmon and steelhead trout. Cheda Creek spawner survey information includes data collected on 1.3 km distributed between Reaches 1 and 2

Survey Timing and Environmental Conditions

Three surveys were performed on Cheda Creek between January and February 2012. The mean number of days between surveys was 12. Seven day rainfall ranged from 0.06 in in Julian week 5 and a high of 1.70 in for Julian week 4. Estimated water clarity for all three surveys was 30 cm. The

2011-2012 survey season was the first time that coho were observed on Cheda Creek since 2007-2008.

Live Coho and Steelhead

Eleven live coho adults were observed on Cheda Creek during the 2011-2012 spawner survey season. No live steelhead were detected.

Coho and Steelhead Carcasses

One coho carcass was found during the 2011-2012 spawner survey season on Cheda Creek. No steelhead carcasses were observed.

Coho and Steelhead Redds

Four coho redds were observed on Cheda Creek during the 2011-2012 spawner survey season. No steelhead redds were found.

Cheda Creek Watershed Coho Escapement History

The dataset for adult coho escapement within Cheda Creek includes 14 years of survey information and has documented the return of coho to this small tributary stream of Lagunitas Creek (Table 8). Due to its small size and presence in the Lagunitas system, Cheda Creek spawner patterns are directly connected to those observed in the mainstem Lagunitas Creek. Our observations of Cheda Creek are intended to determine how a small downstream tributary is used by spawners before and after restoration.

Table 8. Coho salmon spawning number of surveys, survey length, including Peak Live plus cumulative Dead (PLD) estimates, tally of total carcasses, and total redds for Cheda Creek.

Year	Number of surveys	Survey length (km)	PLD Estimate	Total carcasses	Total redds
1998-1999	2	N/A	0	0	0
1999-2000	1	N/A	0	0	0
2000-2001 ^b	2	1.4	0	0	0
2001-2002	5	1.2	4	0	3
2002-2003	3	1.2	2	1	1
2003-2004	3	1.2	1	0	6
2004-2005	5	1.3	17 ^a	1	6
2005-2006	4	1.3	1	1	2
2006-2007	3	1.3	5	1	7
2007-2008	5	1.3	0	0	1
2008-2009	1	1.3	0	0	0
2009-2010	3	1.3	0	0	0
2010-2011	5	1.3	0	0	0
2011-2012	4	1.3	7	1	4

^a Includes two peaks, 3 weeks apart.

^b First winter after fish passage project was completed

N/A-Survey Length Not Defined

The PLD estimate ranges from zero adults for the first three survey years to 17 adults observed in 2004-2005 (Table 8). While the presence of spawning activity above the fish passage structure constructed in 2000 is a promising sign of recovery and a documentation of the projects success, the failure in spawner returns for 2008-2009 through 2010-2011 reflects the lower return rates for the region as a whole. 2011-2012 was the first time in four years that adult coho spawning has been observed in Cheda Creek.

Lagunitas Creek Watershed Coho Escapement History

Data to calculate a PLD estimate have not been consistently gathered for all creeks in the project area between 1995 and the present, and the data varies in quality, the number of surveys conducted, and other factors.

Coho Spawning Trends

Redd count data indicate the high annual variability in coho spawning activity and the relative importance of Olema Creek to spawning in the Lagunitas Creek drainage (Table 9). Olema Creek is of particular management concern due to the entire mainstem flowing within or adjacent to NPS lands. Escapement estimates based on redds for Olema Creek, which is a tributary to Lagunitas Creek, have ranged between 0% in 2008-2009 and 35% in 1997-1998 of the total escapement estimated for the Lagunitas Creek watershed (Table 9). A summary table of redd density within the Lagunitas Creek watershed is provided as Table A1 in Appendix A.

Table 9. Total coho redds in Lagunitas Creek watershed, winter 1995-1996 through 2011-2012 (data from Marin Municipal Water District and National Park Service).

Year	Lagunitas Creek mainstem	San Geronimo Creek (mainstem+tribs)	Devil's Gulch (+ Cheda)	Olema Creek (mainstem+tribs)	Total redds	Olema Creek redd proportion ^a
1995-1996	70	6	10	N/A	86	N/A
1996-1997	98	115	42	N/A	255	N/A
1997-1998	80	121	52	134	387	35%
1998-1999	92	60	32	23	207	11%
1999-2000	139	61	3	10	213	5%
2000-2001	119	74	11	80	284	28%
2001-2002	79	145	62	59	345	17%
2002-2003	71	61	26	20	178	11%
2003-2004	124	205	54	109	492	22%
2004-2005	120	258	118	138	634	22%
2005-2006	53	102	35	9	199	5%
2006-2007	128	143	62	95	433	22%
2007-2008	87	55	7	33	182	18%
2008-2009	25	1	0	0	26	0%
2009-2010	42	7	2	14	65	22%
2010-2011	32	42	6	21	101	21%
2011-2012	96	25	16	7	144	5%

^a Olema Creek proportion provided due to the importance NPS management decisions on park lands surrounding Olema Creek.

N/A = not available.

Overall trends in coho spawning based on observed redds in the Lagunitas Creek watershed are shown in Figure 9. Cohort 2 (blue) shows decreasing trend in spawning over three generations. Cohort 1 (yellow) likewise has seen a decrease in spawning. Cohort 3 (red) has shown an increase for the first time in three spawning generations.

Coho spawner counts and redd data collected since 1982 show that most of the spawning activity takes place on Lagunitas Creek tributaries versus the mainstem (Ettlenger et al. 2012). Spawning on the mainstem takes place largely in Samuel P. Taylor State Park, upstream of PORE-administered GOGA lands.

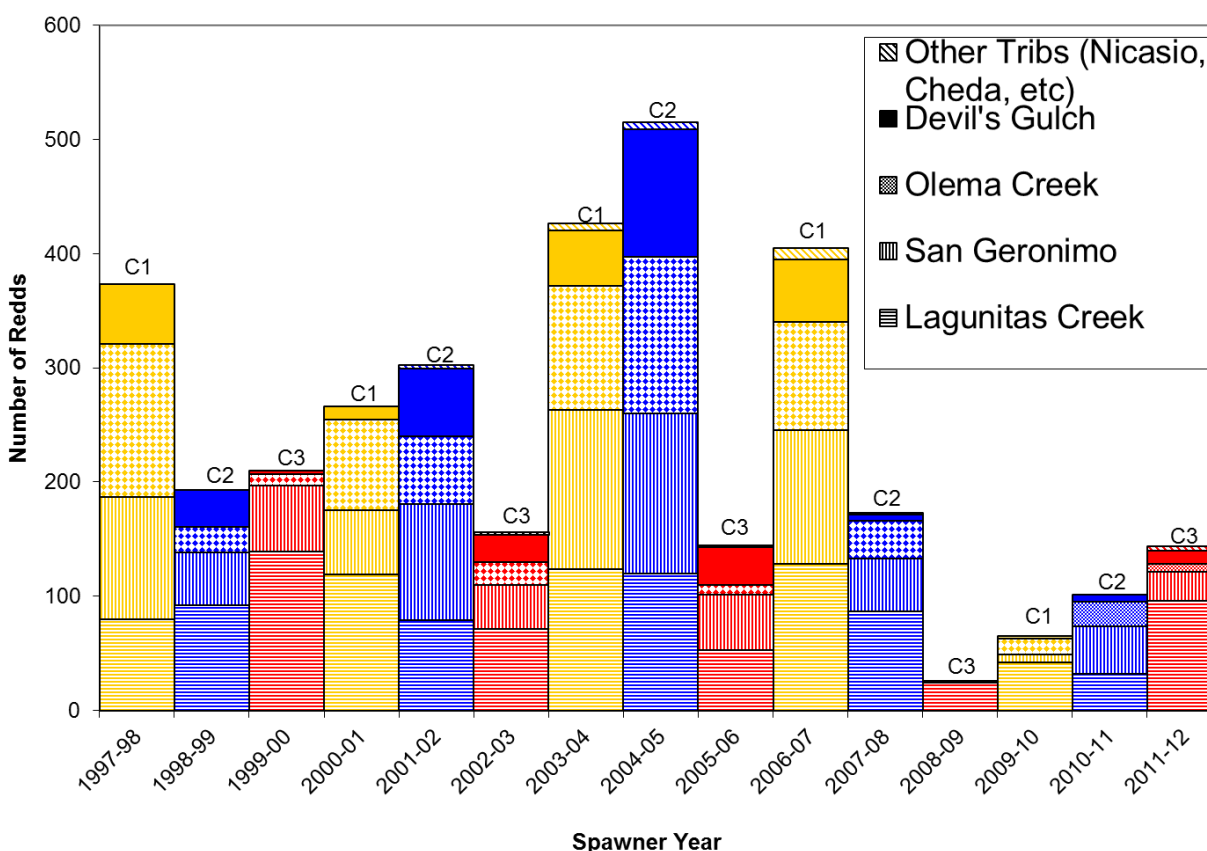


Figure 9. Coho salmon redd results in the Lagunitas watershed by cohort winter 1997-1998 through winter 2011-2012. Cohorts are designated by color (cohort 1 shown in yellow, cohort 2 shown in blue, cohort 3 shown in red) and creeks are designated by pattern (Lagunitas Creek mainstem in horizontal lines, San Geronimo Creek in vertical lines, Olema Creek in checkered, and Devil's Gulch in a solid color).

3.2.3 Redwood Creek Coho and Steelhead Escapement

Survey Timing and Environmental Conditions

Review of the past 18 years of coho salmon escapement monitoring information on Redwood Creek indicates that run timing is highly dependent on the rainfall-runoff condition within the watershed (Appendix A, Table A5). Redwood Creek is an unregulated stream with variable environmental

conditions that limit flows in the winter season. During most years, initial fish access to Redwood Creek depends on the breaching of a sand bar at its confluence with the Pacific Ocean. Adult coho salmon upstream migration coincides with brief peak winter discharges, typically peaking in January (Weitkamp et al. 1995). Freshwater residence time for adults is short (typically less than 2 weeks), though the SFAN program has documented some individuals spending up to 20 days in the freshwater.

Fourteen surveys were conducted in Redwood Creek between 23 November 2011 and 8 March 2012. The mean interval between surveys was eight days. Julian week rainfall totals ranged from a low of 0 in during Julian weeks 48, 49, 51, 1, and 2 and a high of 3.56 inches during Julian week 3. Average water clarity at the time of surveys ranged from 62 cm to 101 cm. Historical information on timing of past runs, rainfall during the run period, and spawning activity observed on Redwood Creek can be found in Appendix A, Table A5.

Redwood Creek watershed spawner survey information includes data collected on 7.4 km of the mainstem of Redwood Creek, Reaches 1 through 3. Kent Canyon and Fern Creek were surveyed when volunteer and staff turnout was high enough to cover both the mainstem and tributary reaches. Tributary reaches were surveyed on the same day as the mainstem reaches to eliminate the possibility of double counting.

Live Coho and Steelhead

Nine live adult coho were observed within the Redwood Creek mainstem. No live adult coho were observed in either Kent or Fern Creeks.

A total of 11 confirmed steelhead adults were seen on the mainstem of Redwood Creek. No steelhead were observed in either of the tributaries surveyed.

Coho and Steelhead Carcasses

Eight coho carcasses were found in Redwood Creek during the 2011-2012 spawner season. No coho carcasses were observed on any of the tributaries surveyed.

Four steelhead carcasses were observed during the spawner survey season on the mainstem. No steelhead carcasses were found on either of the tributaries surveyed.

Coho and Steelhead Redds

Four confirmed coho redds were observed during the 2011-2012 spawner season. The mean surface area of the coho redds was 4.20 m². The total density of redds in the mainstream section surveyed was 0.54 redds/km.

A total of 23 definite steelhead redds were observed in the mainstem of Redwood Creek, with an additional steelhead redd observed on Fern Creek. The total density of redds in the 7.4 km mainstem section surveyed was 3.11 redds/km, and 1.25 redds/km on the tributary of Fern Creek. The mean surface area of the mainstem steelhead redds was 1.65 m².

Peak Live Plus Cumulative Dead (PLD) Coho Escapement Estimates

The 2008-2009 PLD estimate for Redwood Creek was 10 fish, derived from a peak observed on 31 January 2012.

Area Under the Curve (AUC) Coho Escapement Estimates

The SFAN has also used the AUC method to estimate adult coho escapement within Redwood Creek watershed. Only live fish are calculated using this technique. AUC estimates in Redwood Creek ranged from three to five coho at 100% OE and five to 11 fish at 50% OE (Table 10). Estimates from the most commonly reported OE (70-80%) and RT (11-13 days) values ranged from four to six fish in Redwood Creek. Based on our survey OE (90-100%), AUC estimates for coho salmon in Redwood Creek range from three to four fish. No residence time could be estimated due to lack of repeat sightings of fish. Table 10 summarizes AUC estimates for Redwood Creek mainstem for 2011-2012. Historic AUC estimates for Redwood Creek mainstem are in Appendix A, Table A5.

Table 10. Coho salmon spawning survey Area Under the Curve (AUC) estimates for Redwood Creek mainstem, 2011-2012

Creek	Number of surveys	Date of entry	Mean survey interval (days)	Survey reaches	Survey length (km)	AUC range 100% OE ^a	AUC range 50% OE ^a	AUC range 70-80% OE ^a	PLD
Redwood mainstem	14	29 Nov 2011	8	1-3	7.4	3-5	5-11	4-5	10

OE= observer efficiency, PLD = Peak Live plus cumulative Dead, Date of entry = estimated date in which adult coho migration began in Redwood Creek.

^a Residence Time (RT) 11 -13 days

Redwood Creek Watershed Coho Escapement History

Escapement estimates for coho adults in Redwood Creek have been made using total redds counted, PLD, and AUC methods. In years where persistent high flows resulted in a low number of surveys, all three methods likely under-represent the true coho escapement.

Coho Spawning Trends

Overall trends in coho spawning based on redds observed in the Redwood Creek watershed are shown in Figure 10. The three cohorts are represented as primary colors (yellow-1, blue-2, and red-3) to show relationships between spawning runs. Cohort 1 has remained relatively constant over four generations but decreased during 2006-2007. Cohort 2 shows an increasing trend in spawning since 1995-1996, with an abrupt crash during the 2007-2008 spawner season and very limited recovery since then. Cohort 3 continues to struggle since a decline beginning with 1999-2000. Within each year, the data is broken down into the creeks where spawning occurred. Cohort 3 redds have been observed only in the mainstem of Redwood Creek, with a noticeable increase in the number of redds during the 2005-2006 spawner season. For all years, the majority of spawning occurs in the mainstem of Redwood Creek.

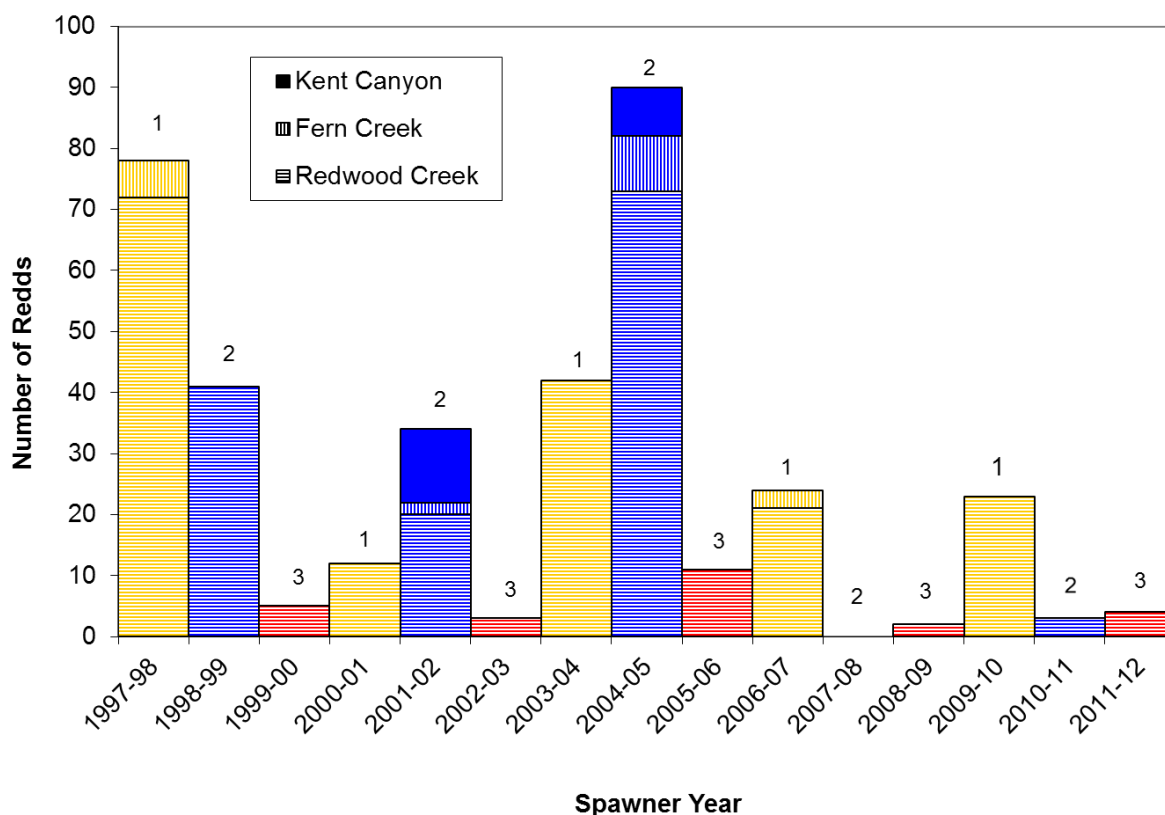


Figure 10. Coho salmon redd numbers in the Redwood Creek watershed by cohort winter 1997-1998 through winter 2011-2012. Cohorts are designated by color (cohort 1 shown in yellow, cohort 2 shown in blue, cohort 3 shown in red), and creeks are designated by pattern (Redwood Creek in horizontal lines, Fern Creek in vertical, and Kent Creek in a solid color).

The PLD dataset for adult coho escapement within Redwood Creek includes 18 years of survey information. It should be noted that prior to 1997-1998, redds and carcasses were not consistently counted. PLD estimates have ranged from 0 to 171 (Appendix A, Table A5). The results of 1999-2000, 2002-2003, and 2005-2006 are not considered representative of actual mainstem escapement due to poor survey conditions. The 2004-2005 spawner surveys had the highest PLD (171 adult coho) in the 18-year survey history. This is believed to be the strongest coho run since documentation of spawners were initiated in 1994-1995. This is further supported by the total number of observed redds and carcasses (72 and 63, respectively). However the next generation experienced a 99% decline followed by the 2008-2009 spawner season that suffered an 85% decline in return numbers when compared to 2005-2006. Historical coho spawning information for the Redwood Creek watershed, including PLD estimate, tally of total carcasses, and total redds can be found in Appendix A, Table A5.

Coho spawning by cohort based on PLD escapement estimates in the Redwood Creek watershed are shown in Figure 11 with similar trends to those observed with number of redds. The three cohorts are represented as primary colors (yellow-1, blue-2, and red-3) to show relationships between spawning

runs. Cohort 1 has remained relatively constant over the previous four generations but decreased during the 2006-2007 and again in 2009-2010. Cohort 2 shows an increasing trend in spawning since 1995-96 until 2007-2008, when the population collapsed; it has had an extremely limited recovery since that collapse occurred. Cohort 3 continues to struggle since a decline beginning with 1999-2000, with a slight increase in returning coho observed during the 2005-2006 spawner season before decreasing again in the 2008-2009 spawner season. The returns for 2011-2012, while an increase since 2008-2009, still has not recovered to pre-2006-2007 adult escapement abundance.

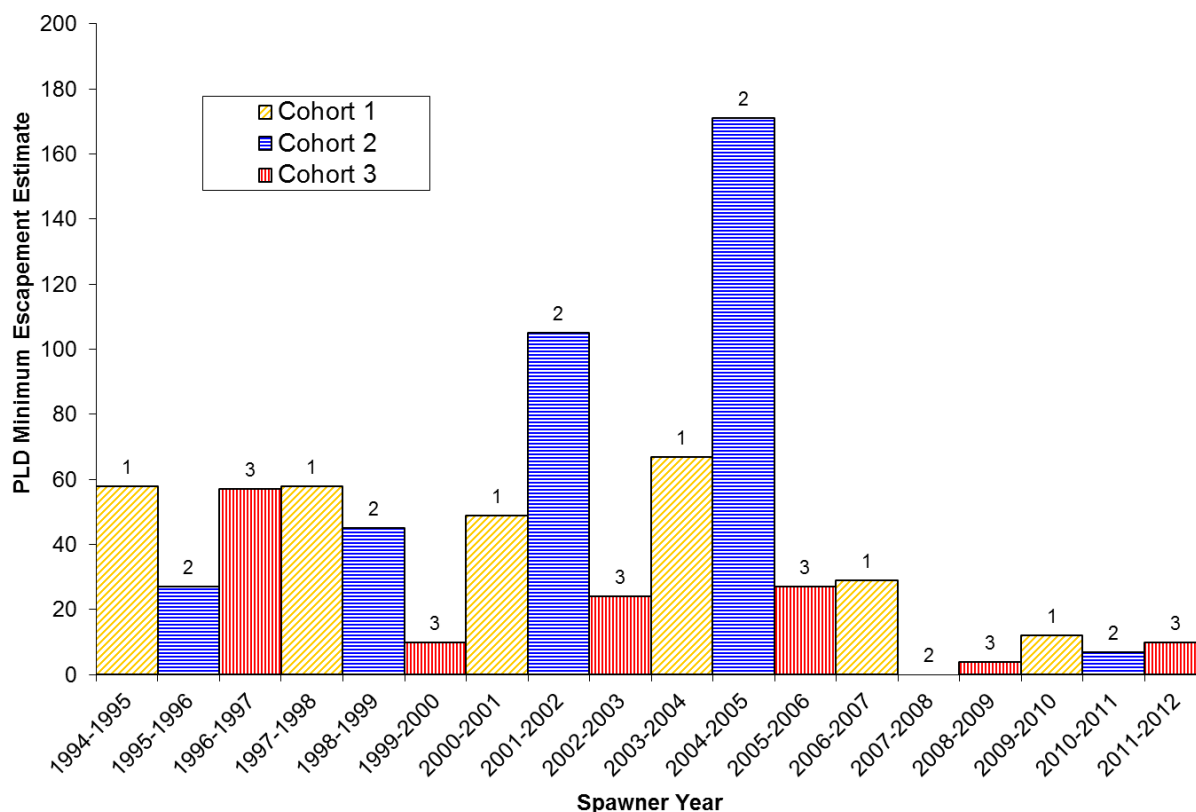


Figure 11. Redwood Creek watershed, coho salmon PLD (Peak Live plus Cumulative Dead) escapement estimates for winter 1994-1995 through winter 2011-2012. Cohorts are designated by color (cohort 1 shown in yellow diagonal lines, cohort 2 shown in blue horizontal lines, cohort 3 shown in red vertical lines).

Live Coho and Coho Carcass Biotics

Information on live adult coho and coho carcasses are collected during each field survey. Sex ratios for live coho and coho carcasses are reported for 2011-2012 in Tables 11 and 12. While live coho lengths are estimated (length to nearest 5 cm), carcasses are handled to definitively determine sex, spawning success, FL, and to collect a genetic sample. The cumulative results of coho carcass measurements show that male FLs range from 56 and 71 cm, females from 52 and 68 cm, and jacks (two year old males) from 37 and 49 cm.

Table 11. Sex ratio percentages and mean fork length (FL) of live coho within the Redwood Creek watershed for the period 1997-2011 compared to 2011-2012.

		Live Coho					
		Year	Sample Size	Sex Ratio%	N for FL	Mean FL	FL SD
Cumulative	M	1997-2011	334	37	332	61	5.7
	F	1997-2011	433	48	419	58	2.7
	J	1997-2011	134	15	134	41	3.3
	Unk	1997-2011	116		92	56	3.4
Current	M	2011-2012	2	22	2	50	0
	F	2011-2012	5	56	5	60	7.1
	J	2011-2012	2	22	2	45	0
	Unk	2011-2012	0		0	0	0
	All		9		9		

M= Male, F= Female, J=Jack, Unk= Unknown, N= Number of fish measured for FL
SD= Standard Deviation

Table 12. Sex ratio percentages and mean fork length (FL) of coho carcasses within the Redwood Creek watershed for the period 1997-2011 compared to 2011-2012.

		Carcasses					
		Year	Sample Size	Sex Ratio%	N for FL	Mean FL	FL SD
Cumulative	M	1997-2011	53	31	48	63	5.0
	F	1997-2011	95	56	89	62	5.7
	J	1997-2011	21	12	21	42	4.0
	Unk	1997-2011	40		14	64	3.8
Current	M	2011-2012	2	40	2	50	0.7
	F	2011-2012	2	40	2	68	2.1
	J	2011-2012	1	20	1	37	0
	Unk	2011-2012	0		0	0	0
	All		5		5		

M= Male, F= Female, J=Jack, Unk= Unknown, N= Number of fish measured for FL
SD= Standard Deviation

3.2.4 Pine Gulch Creek Coho and Steelhead Escapement

Survey Timing and Environmental Conditions

One survey was conducted in Pine Gulch on 27 January 2012. The seven day rainfall total during that Julian week was 0.93 inches. Water clarity at the time of surveys was 50 cm.

Live Coho and Steelhead

Two live coho were observed on Pine Gulch Creek during the 2011-2012 spawner season. The male and female were together on a redd.

Eight live adult steelhead were observed on the 27 January 2012 Pine Gulch Creek survey.

Coho and Steelhead Carcasses

No coho or steelhead carcasses were discovered on Pine Gulch during the survey.

Coho and Steelhead Redds

One coho redd and three steelhead redds were observed during the 2011-2012 spawner season on Pine Gulch Creek.

Peak Live Plus Cumulative Dead (PLD) Coho Escapement Estimates

The 2011-2012 PLD estimate for Pine Gulch Creek was 2 coho.

Area Under the Curve (AUC) Coho Escapement Estimates

No AUC estimate was created for Pine Gulch Creek in 2011-2012.

Pine Gulch Creek Watershed Coho Escapement History

The dataset for the adult coho escapement within Pine Gulch Creek includes 12 years of survey information following the discovery of one adult coho salmon during 2000-2001. Since this discovery, live adult coho and/or coho spawning activity have been sighted in the watershed during seven out of the 12 years (Appendix A, Table A6).

3.3 Spring 2012 Outmigrant Coho Smolt Trapping Results

Results for coho smolt trapping are reported by Julian week (Appendix B) to support analysis between monitoring years and watersheds. In all years, trapping operations were conducted within an 11 week time frame starting in mid-March and ending in early June. Actual start and end dates for each year vary depending on instream flows and coho smolt captures. Trapping operations were initiated on Pine Gulch in 2002, Olema Creek in 2004, and Redwood Creek in 2005. Due to the lack of juvenile coho observed during the summer 2011 surveys, Pine Gulch Creek was not monitored for smolt outmigration. Therefore, only Olema Creek data and Redwood Creek data appear below. Smolt production estimates are only calculated for coho due to differences in smolt outmigration timing between coho and steelhead smolts. Anecdotal steelhead smolt, 1+ steelhead, steelhead fry, and coho fry are also summarized below.

3.3.1 Coho Smolt Outmigration Environmental Conditions and Timing

Spring weather patterns, including rainfall and temperature, changes in stream flow and lunar phases may all influence the timing and rate of coho smolt outmigration. Smolt outmigration historically peaks during Julian weeks 17-19 (late April – early May). On average, the majority of Olema Creek outmigration occurs in weeks 16-18, with the majority of Redwood Creek outmigration occurring during weeks 18 and 19 (Figures 12 and 13, respectively). In 2012, downstream migration of coho smolts remained low throughout Julian weeks 14 through 16, with both creeks peaking in Julian week 17, and both peaking earlier than the historical average.

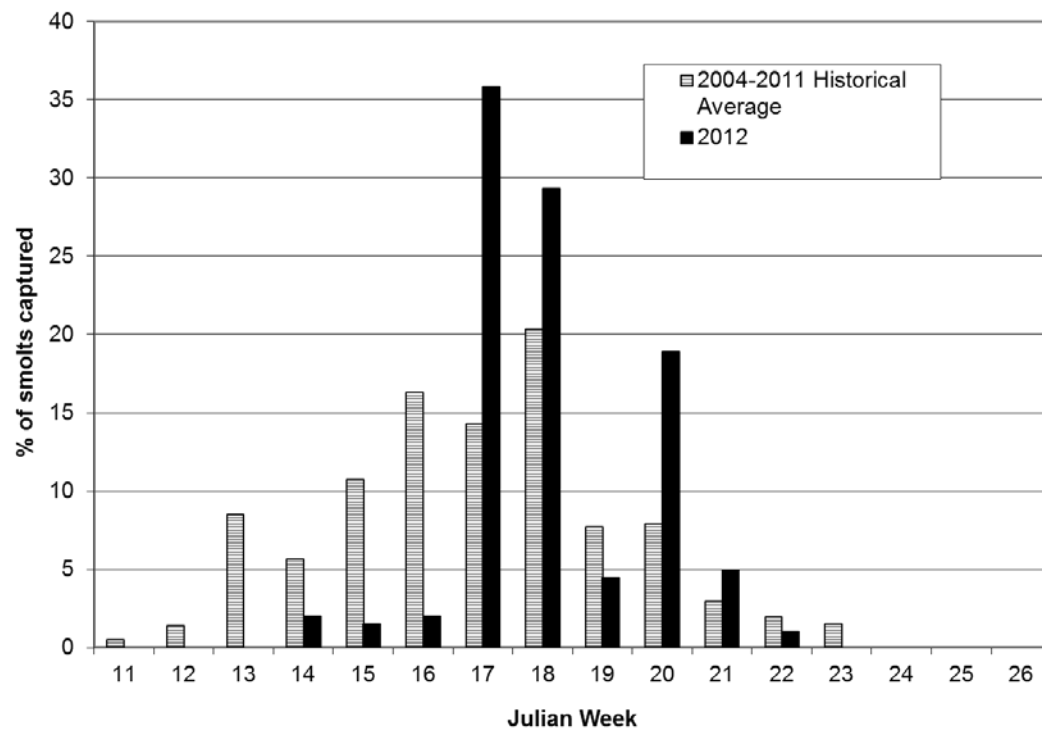


Figure 12. Percent of total coho smolts captured in the trap by Julian week for Olema Creek in 2012 compared to the historical average, 2004-2011.

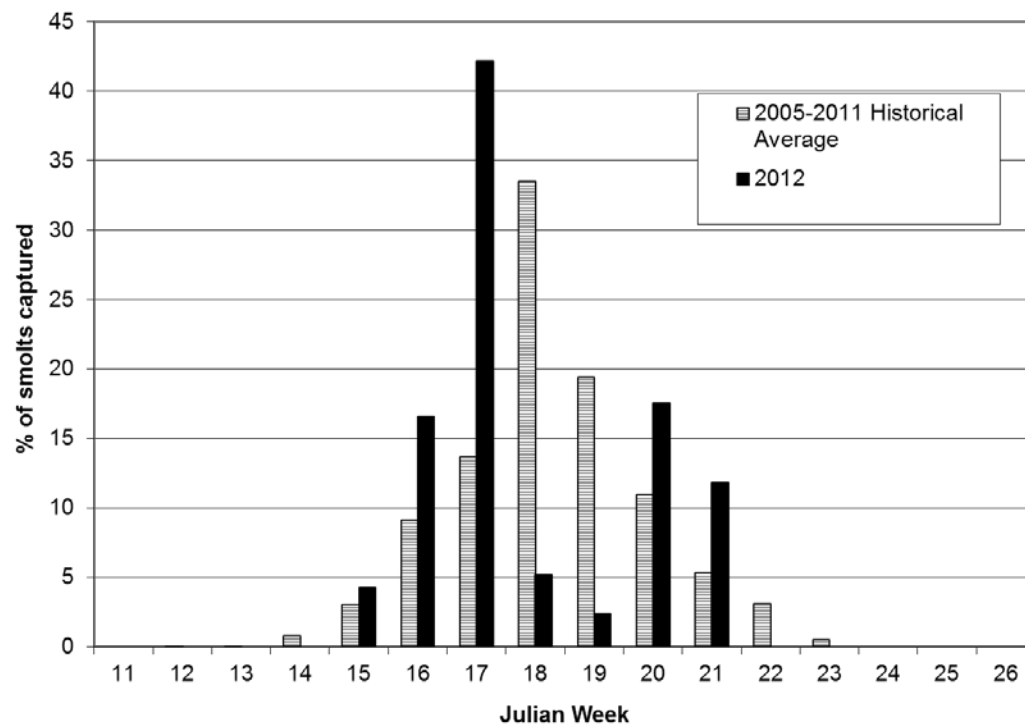


Figure 13. Percent of total coho smolts captured in the trap by Julian week for Redwood Creek in 2012 compared to the historical average, 2005-2011.

Spring Coho Outmigration Rainfall

Rainfall amounts were collected from a rain gage located at the Bear Valley Headquarters and are used to represent the rainfall for all trapping operations. Conditions were drier than normal during April and May of the trapping season. Most of the recorded precipitation occurred in early March with 12.26 inches of rainfall measured before the traps were installed. The remainder of the season was drier than the historical average.

Spring Coho Smolt Trap Water Temperature

The highest mean temperature, 13.4°C (1.1 SD), for the trapping duration was recorded at the lower Redwood Creek trap. The lowest mean temperature, 12.4°C (1.8 SD), for the trapping duration was recorded at the upper Redwood Creek trap. The lowest minimum temperature, 10.1°C was recorded at the lower Redwood Creek trap. The highest maximum temperature, 19.0°C was recorded on Olema Creek.

Water temperatures within trap boxes were within the tolerable temperature range ($< 22^{\circ}\text{C}$) for coho salmon (Moyle 2002) during the entire trapping season at both trapping locations. All three trap locations had a mean temperature within the optimal range for juvenile coho rearing (12°C to 14°C) (Moyle 2002).

3.3.2 Olema Creek Smolt Trapping Coho and Steelhead Results

During the 2012 outmigrant trapping study, the Olema Creek trap was in place for 58 days (3 April 2012-31 May 2012) and was fully operational for 46 days. A storm in mid-April disabled the trap for six days.

The trap captured a total of 200 coho smolts. The overall recapture rate for marked coho smolts was 11% (11/98). DARR analysis of the coho smolt data stratified by week estimated capture probability at approximately 5% for the first five weeks before increasing to approximately 19% for the final three weeks. The total Olema Creek coho smolt estimate is 3,173 (1,716 standard error). PIT tag recapture data show the time tagged coho smolts spent in the system before continuing their outward migration ranged from 4 to 24 days, with a mean of 11.1 days and a median of 10 days.

Additionally, the trap captured a total of eight 1+ steelhead smolts and 25 1+ steelhead parr, 158 steelhead fry, and 37 coho fry. Coho fry capture peaked at the end of April (week 18), and steelhead fry capture peaked in early May (week 19). Two adult steelhead were captured during trapping operations on Olema Creek, and were immediately released downstream of the trap. Table 13 shows a summary of salmonid capture information on Olema Creek smolt traps between 2004 and 2012. Smolt production estimates are calculated for coho only.

Table 13. Summary of coho and steelhead captured during Olema Creek trap operations, 2004-2012. A coho smolt production estimate was not calculated for 2004 due to insufficient recapture data and in 2010 due to the very low numbers of smolts captured.

Trap operation dates				Steelhead				Coho		Coho production estimate	
				Juvenile			Adult				
			Days in operation ^a	Smolt	Parr	Fry	Ocean-run	Smolt	Fry	Estimate	Standard Error
Year	From	To									
2004	30-Mar	28-May	28	13	5	140	0	229	32	N/A	N/A
2005	1-Apr	9-May	31	9	8	1,218	1	87	14	362 ^b	145
2006	10-Apr	9-Jun	45	6	19	497	0	368	51	3,793	784
2007	14-Mar	27-May	66	233	136	462	12	330	739	1,485	207
2008	18-Mar	30-May	72	62	9	38	3	934	8	2,885	336
2009	12-Mar	29-May	62	117	104	32	0	1,072	1	4,088	1,041
2010	19-Mar	21-May	42	34	26	858	0	10	13	N/A	N/A
2011	6-Apr	3-Jun	51	19	25	294	3	423	18	1,334	444
2012	3-Apr	31-May	46	8	25	158	2	200	37	3,173	1,716

Smolt, parr, and fry refer to life stages within the salmonid life cycle. Ocean-run refers to spawned adults returning to the ocean.

Coho and steelhead presmolts are included in the coho and steelhead smolt totals.

^a Does not include days when trap was partially functional.

^b Estimate is calculated using the Chapman modification of the Petersen estimate equation, not using the DARR program.

3.3.3 Redwood Creek Smolt Trapping Coho and Steelhead Results

During the 2012 outmigration season, a total of two traps were operated on Redwood Creek. In addition to the primary outmigrant trap detailed in the approved protocol, a second trap was installed approximately 600 m upstream (just upstream of the Pacific Way bridge) to support a mark recapture study. The upstream trap was operated in association with current restoration activities in lower Redwood Creek.

The primary outmigrant trap in Redwood Creek was in place for 58 days (3 April 2012-31 May 2012) and was fully operational for 53 days. The upstream trap was in place for 58 days and fully operational for 49 days. Both traps were left open and were not operable during a storm event in early April. The data reported for Redwood Creek include fish sampled at both mainstem traps.

The mainstem traps captured a total of 203 coho smolts. To avoid double counting fish, the coho total includes all fish marked at the upper trap and unmarked fish caught at the lower mainstem trap. The overall recapture rate for marked coho smolts was 38% (53/141). DARR analysis of the coho smolt data stratified by week estimated capture probability at approximately 52% for the first four weeks before decreasing to approximately 16% for the final four weeks. The DARR estimate for Redwood Creek coho smolts in 2012 was 1,021 (164 standard error). PIT tag recapture data show the time tagged fish spent in the system before continuing their outward migration passed the lower trap ranged from 2 to 30 days, with a mean of 7.8 days and a median of 6 days.

Also captured during this season on the mainstem were 43 steelhead smolts, 25 1+ steelhead parr, 434 steelhead fry, and one coho fry. The total for the steelhead smolts is only from the upper trap since steelhead smolts were not marked. Steelhead fry capture peaked in mid-May (week 20), while the one coho fry was captured on 15 April. No adult steelhead were captured at either of the traps. Table 14 shows a summary of salmonid capture information on Redwood Creek smolt traps between 2005 and 2012. Smolt production estimates are calculated for coho only.

Table 14. Summary of coho and steelhead captured during Redwood Creek trap operations, 2005-2012. A coho smolt production estimate for 2009 was not calculated due to recapture pattern anomalies.

Year	Trap operation dates		Days in operation ^b	Steelhead				Coho		Coho production estimate	
	From	To		Juvenile			Adult	Smolt	Fry	Estimate	Standard Error
2005	27-Mar	31-May	35	Smolt	Parr	Fry	Ocean-run	301	535	1,977	430
2006	18-Apr	9-Jun	49	18	0	24	0	1,048	27	2,502	257
2007	16-Mar	27-May	66	17	5	585	1	330	97	1,353	307
2008	19-Mar	30-May	70	18	3	151	0	890	3	2,046	163
2009	11-Mar	29-May	65	69 ^a	16	199	2	163 ^a	4	N/A	N/A
2010	19-Mar	28-May	59	51 ^a	62	53	0	120 ^a	98	389	409
2011	6-Apr	3-Jun	57	9 ^a	21	10	2	1,122 ^a	1	3,459	276
2012	4-Apr	31-May	53	43 ^c	25	434	0	203 ^a	1	1,021	164

Smolt, parr, and fry refer to life stages within the salmonid life cycle. Ocean-run refers to spawned adults returning to the ocean. Coho and steelhead presmolts are included in the coho and steelhead smolt totals.

^a Includes total from lower mainstem site and new tagged fish from upper site.

^b Does not include days when trap was partially functional.

^c Total from upper trap in order to avoid double counting fish.

3.3.4 Coho and Steelhead Smolt Size and Condition

Length and weight data provide critical information that contributes to an understanding of fish health, survival, and condition. In addition, length and weight data allow for estimating fork length frequency, growth rates, and biomass production. Throughout the 2012 smolt trap operations, staff recorded fork lengths (FL) to the nearest mm and weights to the nearest 0.01 g of a subsample of fish caught in each trap.

The statistical analysis comparing the 2012 mean measurements to historical mean measurements for smolts assumes that there is no correlation between years within each creek. Due to the three-year life cycle of coho, testing for correlation requires a longer dataset than currently exists for smolts in any of the three creeks. Testing for correlation between years will be performed as longer datasets become available. Analyses of fork-length frequency, weight-length relationships, and Fulton's Condition Factor are included for coho salmon and steelhead captured in both Olema and Redwood creeks.

Olema Creek Coho and Steelhead Smolt Fork Length and Weight

Coho fork lengths measured throughout the spring 2012 monitoring efforts on Olema Creek ranged from 86 to 145 mm. The highest frequency of fork lengths for coho smolts occurred within the 111 to 115 mm length interval, representing 21% of the subsample of coho measured in 2012. The 2012 mean length of 117 mm for coho smolts was not significantly different ($p=0.189$) from the historical mean length (2004-2011) using a two-sided t-test. This indicates the 2012 coho smolt mean length was consistent with the historical mean length.

The 2012 mean weight of 14.6 g was also not significantly different ($p=0.095$) than the 2004 to 2011 mean weight.

Figures 14 and 15 show representations of fork lengths and fish weights, respectively, for coho caught on Olema Creek, 2004 to 2012.

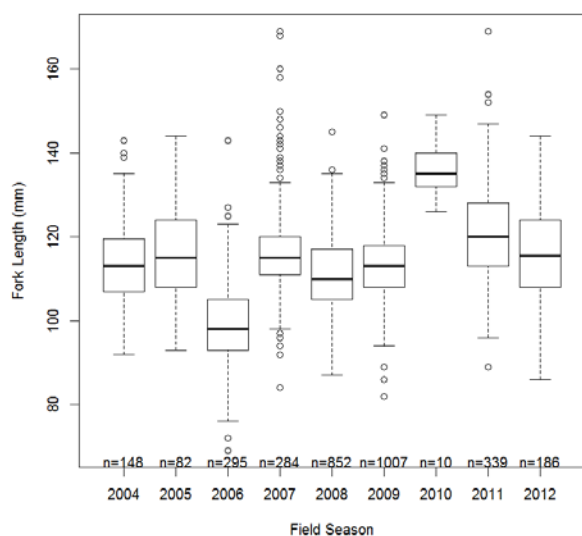


Figure 14. Box and whisker plot of coho salmon smolt fork length for Olema Creek, 2004-2012. Dark lines represent medians, circles represent outliers.

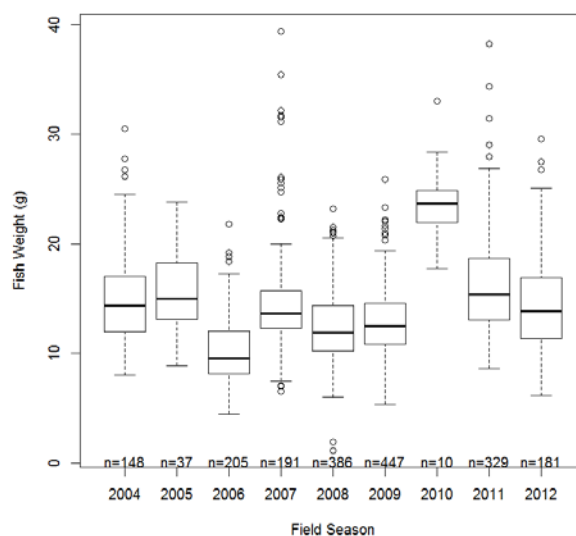


Figure 15. Box and whisker plot of coho salmon smolt fish weight for Olema Creek, 2004-2012. Dark lines represent medians, circles represent outliers.

Steelhead fork lengths measured throughout the 2012 spring monitoring of Olema Creek ranged from 141 to 200 mm. The highest frequency of fork lengths for steelhead smolts occurred within the 166 to 170 mm and 176 to 180 mm length intervals, representing 33% of the sample. For Olema Creek steelhead smolts, the 2012 average length of 173 mm was significantly different ($p=0.029$) from the 2004 to 2011 average length using a two-sided t-test. The point estimate of the difference between the 2012 mean length and the historical mean length was 18 with a 95% confidence interval of 2 to 34. This indicates the mean length for 2012 steelhead smolts was larger than the historical mean. Figure 16 shows length information collected from steelhead smolts on Olema Creek.

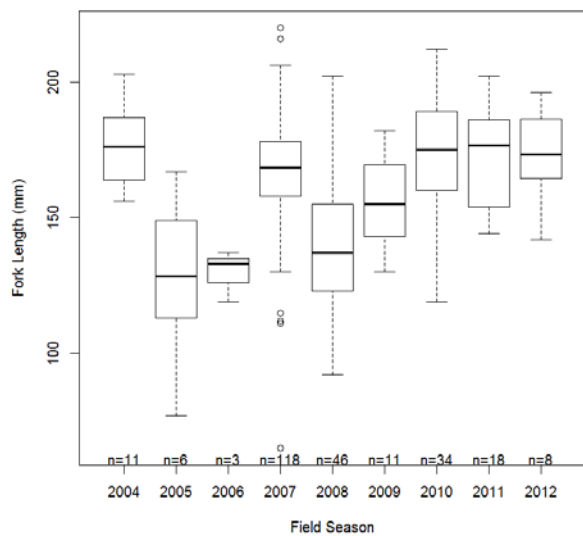


Figure 16. Box and whisker plots for steelhead trout smolt fork lengths for Olema Creek, 2004-2012. Dark lines represent medians, circles represent outliers.

The 2012 mean weight of 40.0 g for steelhead smolts on Olema Creek was not significantly different ($p=0.625$) than the 2004 to 2011 mean smolt weight using a two-sided t-test, indicating the 2012 mean weight was consistent with the historical mean weight.

Redwood Creek Coho and Steelhead Smolt Fork Length and Weight

Coho fork lengths measured throughout the 2012 spring monitoring of Redwood Creek ranged from 91 to 160 mm (Figure 17). The highest length frequency for smolts (18%) was observed in the 116 to 120 mm length interval. For Redwood Creek, the 2012 mean length of 119 mm for coho smolts was significantly different ($p<0.001$) than the 2005 to 2011 historical mean length using a two-sided t-test. The point estimate of the difference between the 2012 mean and the historical mean was 7 with a 95% confidence interval of 6 to 9, indicating that the 2012 mean was larger than the historical mean.

The 2012 mean weight of 15.3 g for coho smolts on Redwood Creek (Figure 18) was also significantly different ($p<0.001$) than the historical mean, using a two-sided t-test. The point estimate of the difference between the 2012 mean weight and the 2005 to 2011 mean weight was 2.4 with a 95% confidence interval of 2.2 to 2.6. These values indicate that the 2012 mean is larger than the historical mean. This added mass could increase the chances of ocean survival for these coho smolts.

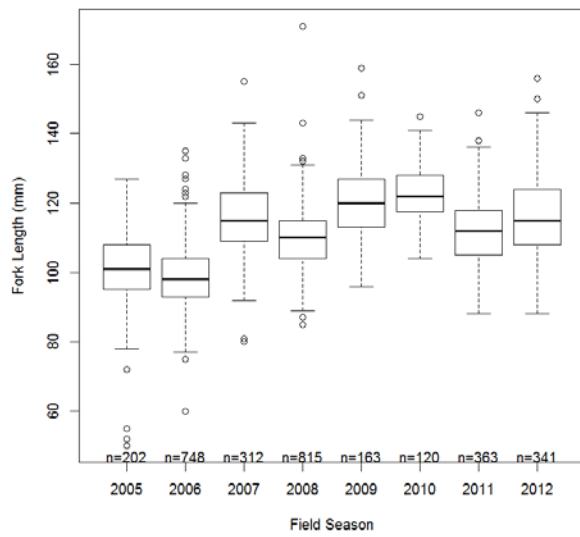


Figure 17. Box and whisker plots for coho salmon smolt fork lengths for Redwood Creek, 2005-2012. Dark lines represent medians, circles represent outliers.

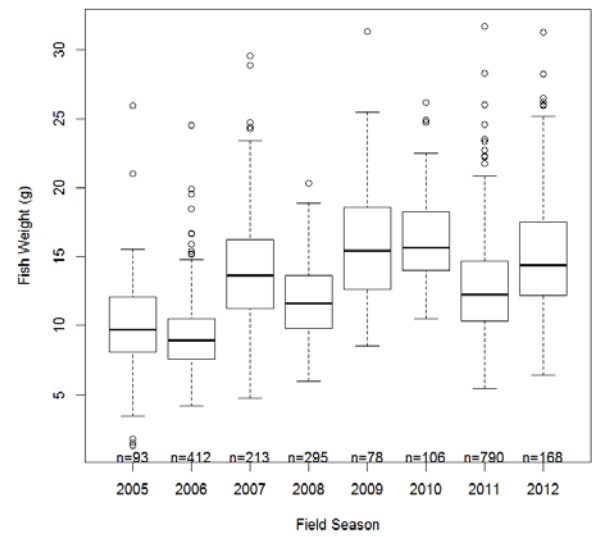


Figure 18. Box and whisker plots for coho salmon smolt weights for Redwood Creek, 2005-2012. Dark lines represent medians, circles represent outliers.

Steelhead fork lengths on Redwood Creek ranged from 146 to 200 mm for 2012, with the highest length frequency of smolts (24%) occurring within the 161 to 165 mm length interval. For steelhead smolts, the 2012 mean length of 163 mm (Figure 19) was not significantly different ($p=0.288$) than the historical mean length using a two-sided t-test. The 2012 mean weight was also not significantly different ($p=0.391$) than the historical mean. This indicates that the 2012 mean weight and length were consistent with the historical mean weight and length. The sample sizes were smaller than ideal for a two-sided t-test and no steelhead smolts were measured in 2005 so only 2006 to 2011 are included in the historical mean. Fewer length categories of steelhead smolts were represented in 2012.

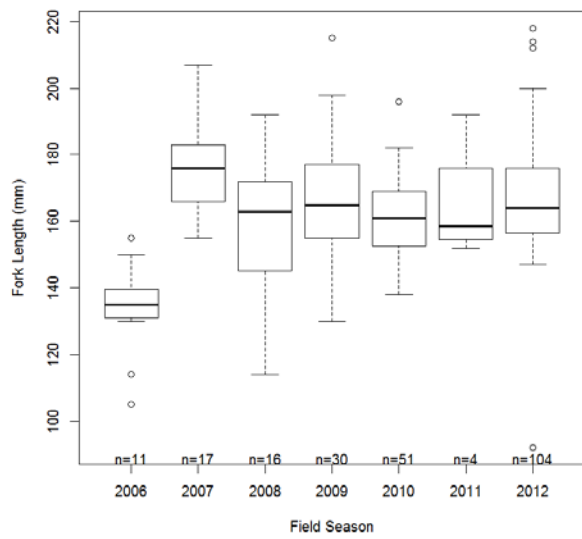


Figure 19. Box and whisker plots for steelhead trout smolt fork lengths for Redwood Creek, 2006-2012. No steelhead smolts were measured in 2005. Dark lines represent medians, circles represent outliers.

Coho and Steelhead Fulton's Condition Factor

Combined length and weight data provide critical information that contributes to the understanding of fish health and condition at the time of outmigration. Length is the principal factor affecting fish weight, however there can be significant differences in weight distribution between 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's condition factors (K) to establish comparable indices of condition (Murphy and Willis 1996). Condition factors are ratios relating fish length to fish weight, thereby quantifying the relative biomass of each fish. Historical K-factor tables for Olema and Redwood Creeks can be found in Appendix A, Tables A7-A10.

On Olema Creek, the 2012 mean K-factor of 0.89 for coho smolts was significantly different ($p < 0.001$) than the historical mean K-factor. The point estimate of the difference between the 2012 mean K-factor and the historical mean K-factor was -0.06 with a 95% confidence interval of -0.07 to -0.04. This test indicates that the 2012 mean coho K-factor is smaller than the historical mean K-factor.

The 2012 mean K-factor of 0.77 for steelhead smolts on Olema Creek was also significantly different ($p = 0.001$) from the historical mean K-factor. The point estimate of the difference between the 2012 mean steelhead K-factor and the historical mean steelhead K-factor was -0.17 with a 95% confidence interval of -0.26 to -0.07. This indicates that the 2012 mean steelhead K-factor is smaller than the historical mean steelhead K-factor.

On Redwood Creek, the coho smolt K-factor, a two-sided t-test with an alpha value of 0.05 shows that the 2012 mean K-factor of 0.90 is significantly different ($p = 0.043$) than the historical mean K-factor. The point estimate of the difference between the 2012 mean and the historical mean was -0.02

with a 95% confidence interval of -0.05 to -0.001, indicating that the 2012 coho mean is smaller than the historical coho mean.

For steelhead smolts, the 2012 mean K-factor of 0.77 was significantly different ($p=0.003$) than the historical mean steelhead K-factor using a two-sided t-test with an alpha value of 0.05. The point estimate of the difference between the 2012 mean K-factor and the historical mean K-factor was -0.08 with a 95% confidence interval of -0.13 to -0.03. These values indicate that the 2012 mean steelhead K-factor is smaller than the historical mean. The sample sizes were smaller than ideal for a two-sided t-test. No steelhead smolts were captured on Redwood Creek in 2005, so the historical average includes only fish from 2006 through 2011.

3.3.5 Smolt Trap Summary of Non-salmonid Total Catch

On Olema Creek, the majority of the non-salmonid catch was comprised of threespine stickleback (33%), sculpin species (30%), and California roach (27%). These three species have consistently been the best-represented non-salmonids caught in the Olema Creek smolt trap. The total number of non-salmonids trapped, 719, was 75% lower in 2012 compared to the historical average. A change in mesh size on the trap from one-eighth inch to one-quarter inch mesh starting in 2008 has allowed smaller non-salmonids the ability to escape the trap. As stickleback tend to be between 1.2 and 2.0 inches (30-50 mm) long (Moyle 2002), the fish in the smaller size ranges have shallow enough bodies to slip through the one-quarter inch mesh and out of the trap.

On Redwood Creek, sculpin species and threespine stickleback were the most common of the represented non-salmonid species caught in 2012, representing 37% and 50% of the catch, respectively. Rough skinned newts (*Taricha granulosa*) were also caught frequently (13% of the catch). The total non-salmonid catch of 2,094 increased on Redwood Creek in 2012 compared to the historical average.

One non-native mosquito fish (*Gambusia affinis*) was captured during the trapping season on Olema Creek; no non-native fish were captured on Redwood Creek. Historical non-salmonid catch information is in Appendix A, Tables A11 and A12.

3.4 Juvenile Coho and Steelhead Basinwide 2012 Results

Summer juvenile monitoring results are provided for Olema Creek, Redwood Creek, and Pine Gulch Creek.

3.4.1 Olema Creek

The 2012 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 13.3 km.

Basinwide snorkel surveys were conducted on 13.3 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. The section between the smolt trap site and Bear

Valley Road Bridge 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.

Coho Habitat Survey

A total of 1,014 mainstem habitat units were identified and 13,273 m measured within the Olema Creek survey reach. Pool units were the dominant habitat type available to fish, measuring a total of 7,220 m. Overall habitat composition by number of units was 39% pool, 25% riffle, and 26% flatwater (Table 15). Intermittent conditions were observed approximately 9.7 km upstream from the mouth of Olema Creek. Dry sections of streambed accounted for 10% 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 82% of the total side channel habitat composition. Overall, 863 m of side channel habitat and 277 m of backwater habitat units were measured during the basinwide habitat survey.

Total wetted survey length was 12,245 m and was used to calculate side channel density and backwater density, which were 6.7 m per 100 m and 2.3 m per 100 m, respectively. Compared to previous years, both backwater density and side channel density increased (2004-2011 average of 5.3 m per 100 m for side channels, 2004- 2011 average of 2.1 m per 100 m for backwaters).

Table 15. Habitat composition of Olema Creek coho survey reach for 2012. Measured length is used to calculate percentages of length per habitat type.

Unit Type	Total length (m)	% of length	# of units	% of units
Pool	7,220	54	392	39
Flatwater	2,865	22	266	26
Riffle	2,160	16	254	25
Dry	1,028	8	102	10
Total	13,273	100	970	100

Woody debris information collected during the basinwide habitat survey is summarized for 2005 to 2012 (Table 16, Figure 20) and may be used to identify trends in woody debris availability and recruitment trends over time. Within Olema Creek, the density of root wads, 2.2 per 100 m, was the highest on record, as was the density of logs with diameters greater than 50 cm, 1.3 per 100 m. While the density of 20 to 50 cm diameter logs, 2.4 per 100 m, was higher than the historical mean, it still fell within previously recorded densities (1.72 per 100 m in 2006 to 2.81 per 100 m in 2009).

Table 16. Summary of basinwide instream woody debris (WD) per 100 m on Olema Creek during summer base flow conditions, average 2004-2011 compared to 2012.

Field season	Survey length (# 100 m sections)	Root Wads per 100 m	LWD Jams per 100 m	SWD Jams per 100 m	10-20cm WD per 100 m	20-50cm WD per 100 m	>50cm WD per 100 m
2004-2011 Average	114.9	1.2	0.6	0.7	2.6	2.2	0.8
2012	116.9	2.2	0.6	0.5	2.4	2.4	1.3

LWD Jams= 10 or more pieces of large woody debris

SWD Jams= 10 or more pieces of small woody debris

10-20 cm, 20-50 cm, >50 cm refer to diameter of individual pieces of woody debris

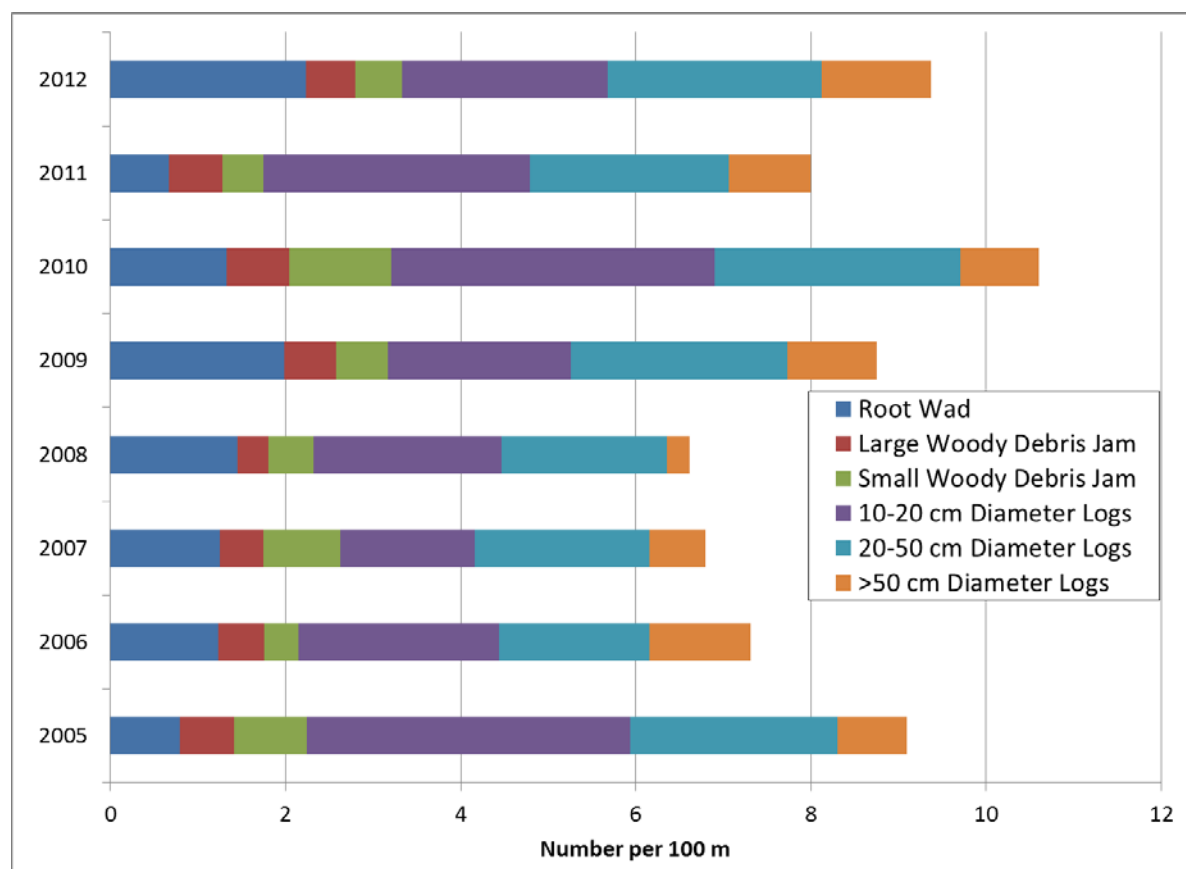


Figure 20. Olema Creek in-stream woody debris by type per 100 m wetted length for years 2005-2012.

Coho Snorkel Counts

A total of 985 habitat units were delineated within the 12.7 km Olema Creek snorkel survey area, with pool units representing 38% of all surveyed units. Snorkel surveys were conducted on 19% of the delineated pools, with coho being found in 16% (12 of 73). Sixty-nine coho were counted in the 73 delineated pools, giving a raw estimate of 1 coho per pool. Fourteen of the 73 snorkeled pools (19%) were electrofished within a day following the snorkel counts. Two additional 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. Table 17 shows a summary of the snorkel survey for Olema Creek 2004 to 2012. This table includes both the raw total number of coho counted in the snorkel surveys and the calibrated total number of coho. The calibrated coho count is derived by multiplying the raw coho count by a scaling factor calculated from the comparison of snorkel and electrofishing counts.

Table 17. Summary of summer coho snorkel counts in Olema Creek, 2004-2012.

Year	Total snorkel survey stream length (km)	Total number of habitat units	Number of Pools			Coho Counted	
			Total	Snorkeled	w/ Coho	Raw	Calibrated
2004	13.3	825	348	69	69	5,751	4,473
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	984	836
2009	13.0	970	358	71	1	1	N/A
2010	13.8	1,036	470	86	41	357	321
2011	13.5	958	417	76	53	673	855
2012	12.7	985	376	73	12	69	64

Coho Basinwide Estimate

Summer 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 reach since 2004 (Table 18).

Table 18. Coho density and population estimates; Olema Creek coho survey area, 2004-2012.

Year	Total snorkel survey stream length (km)	Avg. Coho per pool		Density		Population estimate	95% confidence interval
		Raw	Calibrated	Coho/m	Coho/m ²		
2004	13.3	83.3	64.8	3.199	0.864	22,561	± 8,183
2005	11.9	115.2	94.0	3.613	1.025	29,887	± 9,974
2006	11.6	5.3	5.5	0.297	0.092	1,793	± 869
2007	11.8	75.0	87.8	4.175	1.312	32,298	± 4,018
2008	7.8	18.6	15.8	0.500	0.130	3,328	± 696
2009	13.0	0.0	N/A	N/A	N/A	N/A	N/A
2010	13.8	4.2	3.7	0.182	0.039	1,755	± 693
2011	13.5	8.9	11.3	0.602	0.163	4,690	± 2,929
2012	12.7	1.0	0.9	0.035	0.007	330	± 744

Summer Coho and Steelhead 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.

Coho fork lengths measured throughout the summer 2012 monitoring efforts on Olema Creek ranged from 60 to 80 mm. The highest frequency of fork lengths for coho juveniles occurred within the 66 to 70 mm length interval, representing 42% of the subsample of coho measured in 2012. The 2012 mean length of coho juveniles was significantly different ($p < 0.001$) from the historical mean length (2010 to 2011, no juveniles captured in 2009) using a two-sided t-test. The point estimate of the difference between the 2012 mean length and the historical mean length was -7 with a 95% confidence interval of -10 to -5. This indicates that the mean length for 2012 coho juveniles was smaller than the historical mean.

Using a two-sided t-test with the same parameters as above, the 2012 mean weight was also significantly different ($p < 0.001$) than the 2010 to 2011 mean weight. The point estimate of the difference between the 2012 mean weight and the historical mean weight was -1.5 with a 95% confidence interval of -2.0 to -1.0. This indicates that the mean weight for 2012 coho juveniles was smaller than the historical mean. Figures 21 and 22 show representations of fork lengths and fish weights, respectively, for coho caught on Olema Creek for summers 2010 through 2012.

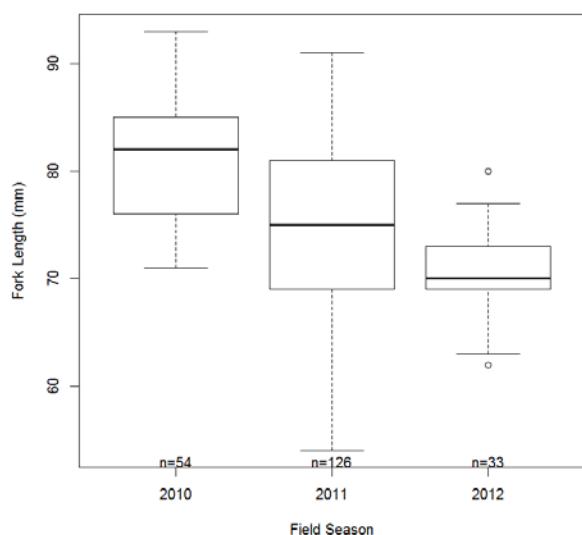


Figure 21. Box and whisker plot for coho salmon juvenile fork length for Olema Creek, summer 2010-2012. Dark lines represent medians, circles represent outliers.

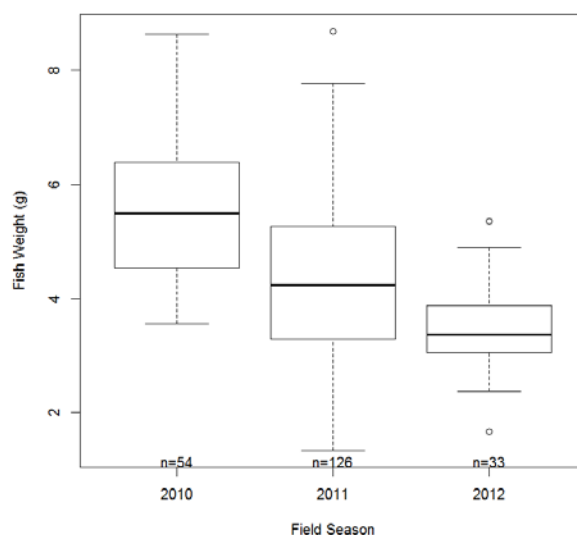


Figure 22. Box and whisker plot for coho salmon juvenile weights for Olema Creek, summer 2010-2012. Dark lines represent medians, circles represent outliers.

Within the Olema Creek sample, 388 steelhead were measured for fork length. Of those 388, 341 steelhead (88% of the total basinwide steelhead catch) were also weighed. The size range for steelhead was 36 to 210 mm. Fork length frequencies were used to establish year class bins. The highest frequency of fork lengths for steelhead YOY occurred within the 61 to 65 mm length interval representing 19% of the sample. For Olema Creek steelhead YOY, the 2012 average length was significantly different ($p < 0.001$) from the 2009 to 2011 average length using a two-sided t-test and an

alpha value of 0.05. The point estimate of the difference between the 2012 mean length and the historical mean length was -10 with a 95% confidence interval of -11 to -8. This indicates that the mean length for 2012 steelhead YOY was smaller than the historical mean.

The 2012 mean weight for steelhead YOY on Olema Creek, 2.6 g, was significantly different ($p < 0.001$) than the 2009 to 2011 mean steelhead YOY weight using a two-sided t-test with an alpha value of 0.05. The point estimate of the difference between the 2012 mean weight and the historical mean weight was -1.2 with a 95% confidence interval of -1.4 to -1.0. This indicates that the mean weight for 2012 steelhead YOY was smaller than the historical mean

The highest frequency of fork lengths for steelhead 1+ occurred between 101 to 105 mm length interval, representing 15% of the sample. For Olema Creek steelhead 1+, the 2012 average length, 117 mm, was not significantly different ($p = 0.147$) from the historical average length using a two-sided t-test. The 2012 mean weight, 16.3 g, was also not significantly different ($p = 0.067$) than the historical mean. This indicates that the 2012 mean weight and length were consistent with the historical mean weight and length. Figure 23 shows length information collected from steelhead YOY on Olema Creek. Figure 24 shows length information collected from Olema Creek steelhead 1+ for summers 2009 through 2012.

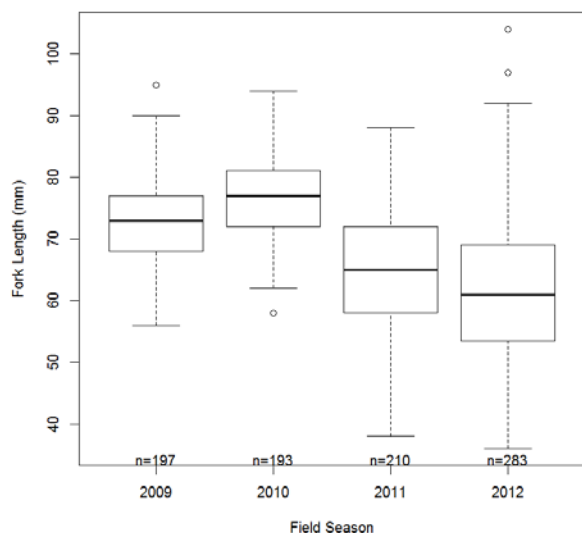


Figure 23. Box and whisker plots for steelhead trout young of the year fork lengths for basinwide Olema Creek, summer 2009-2012. Dark lines represent medians, circles represent outliers.

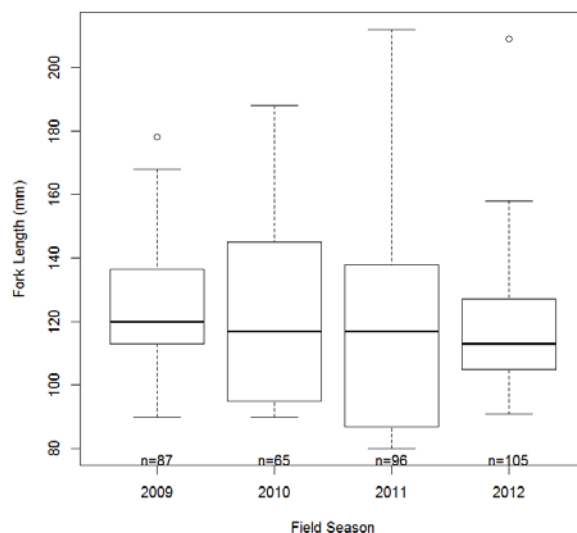


Figure 24. Box and whisker plots for steelhead trout aged 1+ fork lengths for basinwide Olema Creek, summer 2009-2012. Dark lines represent medians, circles represent outliers.

Coho and Steelhead Fulton's Condition Factor

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. To compare length-weight relationships, we applied

the Fulton's condition factor (K) to establish comparable indices of condition (Murphy and Willis 1996). Fulton's condition factor is a ratio relating fish length to fish weight, allowing for the measurement of the relative biomass of a fish.

On Olema Creek, the 2012 mean K-factor for basinwide coho juveniles, 0.97, was significantly different ($p=0.004$) than the historical mean K-factor (2010-2011) using a two-sided t-test. The point estimate of the difference between the 2012 mean K-factor and the historical mean K-factor was -0.04 with a 95% confidence interval of -0.07 to -0.01. This test indicates that the 2012 mean coho K-factor is smaller than the historical mean K-factor. The 2012 mean K-factors for steelhead YOY, 0.99, was not significantly different ($p=0.554$) from the historical mean (2009-2011). Likewise, the mean K-factor for steelhead 1+, 0.92, was not significantly different ($p=0.067$) from the historical mean K-factor (2009-2011). This indicates that the K-factors for steelhead YOY and steelhead 1+ were consistent with the historical mean K-factors.

Table 19 shows length, weight, and K-factor for coho captured during basinwide sampling on Olema Creek, while Table 20 shows the length, weight, and K-factor for steelhead YOY and steelhead 1 + caught during basinwide sampling on Olema Creek.

Table 19. Mean and median fork length, weight, and K-factor calculated for coho measured and weighed in the basinwide calibration pools on Olema Creek mainstem, summer 2012.

Species	Sample Size	Mean Fork Length (mm)	Fork Length Standard Deviation	Median Fork Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
Coho	33	71	4.1	124	3.5	0.75	3.4	0.97	0.10

Table 20. Mean and median fork length, weight, and K-factor calculated for steelhead measured and weighed in the basinwide calibration pools on Olema Creek mainstem, summer 2012.

Species	Life Stage	Sample Size	Mean Fork Length (mm)	Fork Length Standard Deviation	Median Fork Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
Steelhead	YOY	283	62	12.2	61	2.6	1.38	2.3	0.99	0.14
Steelhead	1+	105	117	18.3	113	16.3	10.47	14.3	0.92	0.11

YOY= young of the year, 1+ = one year of age or older

3.4.2 Redwood Creek

The 2012 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. An additional 875 m were surveyed on Fern Creek, a tributary to Redwood Creek.

Basinwide snorkel surveys were conducted on 8.3 km of the Redwood Creek mainstem starting at the pedestrian bridge at the Muir Beach picnic area and ending upstream within the Mt. Tamalpais State Park. Snorkel surveys were also performed on Fern Creek.

Coho Habitat Survey

A total of 634 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 4,459 m. Overall habitat composition by habitat unit was 42% pool, 36% riffle, and 22% flatwater (Table 21). Side channel and backwater units were also measured but not incorporated into the basinwide habitat analysis. Riffle habitat types accounted for 50% of the side channel habitat composition. Overall, 490 m of side channel habitat and 231 m of backwater units were measured during the basinwide habitat survey. Total wetted length of the surveyed area was 8,289 m and was used to calculate the densities of side channel and backwater habitat, 5.9 m per 100 m and 2.8 m per 100 m, respectively. The density of both side channel habitat and backwater habitat on Redwood Creek in 2012 was higher than the historical average (2004 to 2011 side channel average is 3.5 m per 100 m, 2004 to 2011 backwater average is 1.2 m per 100 m).

Table 211. Habitat composition of Redwood Creek coho survey reach, summer 2012. Measured length is used to calculate percentages of length per habitat type.

Unit Type	Total length (m)	% of length	# of units	% of units
Pool	4,459	54	266	42
Flatwater	1,582	19	138	22
Riffle	2,248	27	230	36
Dry	0	0	0	0
Total	8,289		634	

An additional 875 m were surveyed in Fern Creek, a tributary to Redwood Creek. A total of 81 units were identified within Fern Creek, with riffle units making up the majority (67%) of the length. Pools made up 14% of the length, while flatwaters made up 19%.

In addition to habitat, woody debris information collected during the basinwide habitat survey is summarized for 2005 to 2012 (Table 22, Figure 25) and may be used to identify trends in woody debris availability and recruitment trends over time. Within Redwood Creek, the 2012 root wads per 100 m was the highest on record. Large woody debris jams also had an increase in number per 100 m. The rest of the metrics were the same or below average when compared to the historical dataset.

Table 222. Summary of Redwood Creek basinwide instream woody debris (WD) per 100 m during summer base flow conditions, average 2005-2011 compared to 2012.

Field season	Survey length (# 100 m sections)	Root wads per 100 m	LWD Jams per 100 m	SWD Jams per 100 m	10-20cm WD per 100 m	20-50cm WD per 100 m	>50cm WD per 100 m
2005-2011 Average	78.4	0.9	0.5	0.8	3.1	2.5	1.2
2012	82.9	2.0	0.6	0.5	2.3	1.7	1.2

LWD Jams= 10 or more pieces of large woody debris

SWD Jams= 10 or more pieces of small woody debris

10-20 cm, 20-50 cm, >50 cm refer to diameter of individual pieces of woody debris

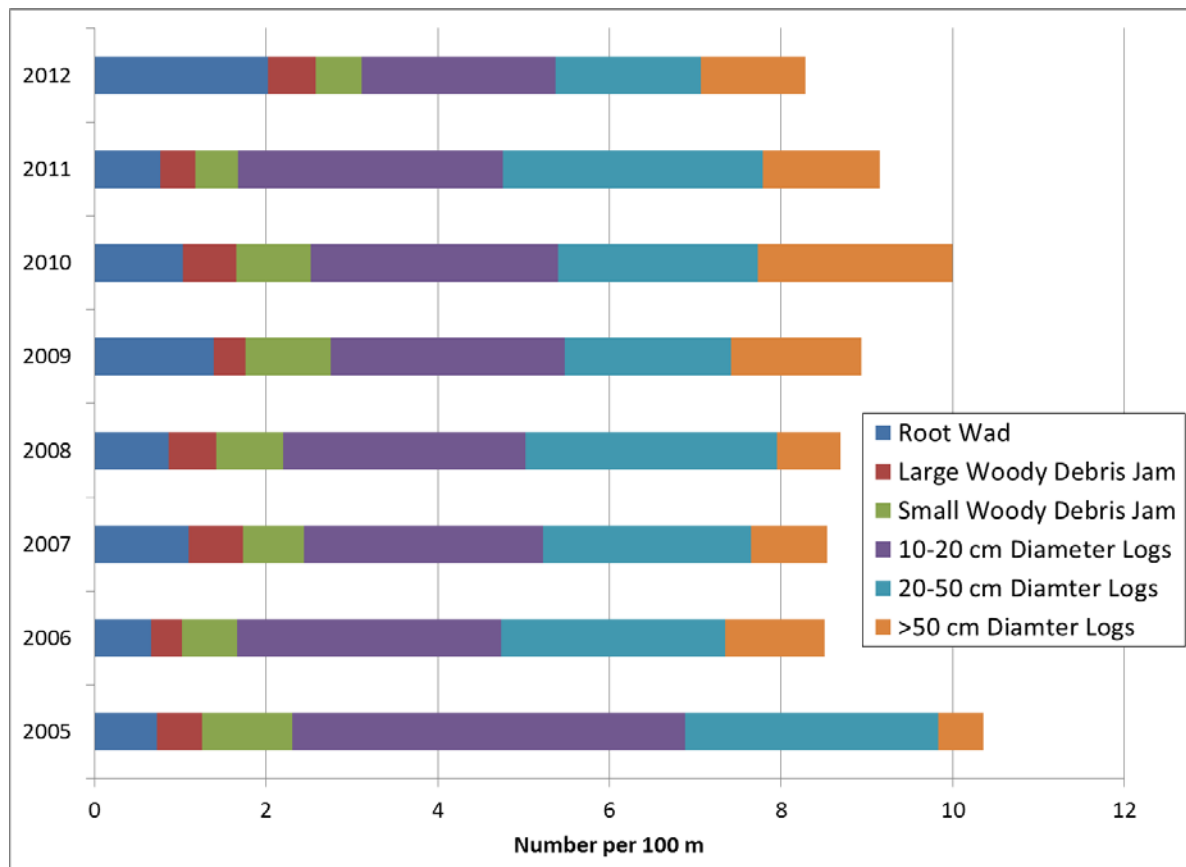


Figure 25. Redwood Creek in-stream woody debris by type per 100 m in wetted length for years 2005-2012.

Woody debris information was also collected on Fern Creek. The highest number was for 10 to 20 cm woody debris, 3.1 per 100 m. The lowest numbers were for root wads and >50 cm woody debris, 0.6 per 100 m.

Coho Snorkel Counts

A total of 634 habitat units were delineated within the 8.3 km Redwood Creek snorkel survey reach with pool units representing 42% of all surveyed units. Snorkel surveys were conducted on 25% of the delineated pools with coho observed in 46% of the sampled pools. A total of 188 coho were counted in the 67 snorkeled pools, giving a raw average of 2.8 coho per pool. An additional two pools were snorkeled on Fern Creek. No coho juveniles were observed in any of the pools on Fern Creek.

Fifteen of the 67 snorkeled pools (22%) were electrofished within a day following the snorkel counts. *Microfish* population estimates for the electrofished pools were used to calibrate the snorkel counts. A summary of the snorkel counts for Redwood Creek in 2012 is presented in Table 23. This table contains the raw total number of coho counted in the snorkel surveys. On Fern Creek one pool with a snorkel count of zero coho was subsequently electrofished for calibration resulting in no coho captured.

Table 23. Summary of coho snorkel counts in Redwood Creek for summer 2005-2012.

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	558
2011	7.6	531	237	58	24	99	66
2012	8.3	634	266	67	31	188	123

Coho Basinwide Estimate

The 2012 coho population estimate for Redwood Creek was 484 ± 249 (SE), shown historical numbers in Table 24.

Table 24. Coho density and population estimates; Redwood Creek coho survey area, 2005-2012.

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	44.9	44.53	1.937	0.458	8,594	$\pm 1,652$
2006	7.7	3.1	4.61	0.297	0.072	1,050	± 486
2007	8.1	24.4	29.89	1.857	0.482	7,832	$\pm 1,640$
2008	8.5	1.7	1.77	0.091	0.025	431	± 271
2009	8.3	0.8	N/A	N/A	N/A	N/A	N/A
2010	8.1	12.5	11.39	0.805	0.213	3,064	1,373
2011	7.6	1.7	1.13	0.066	0.016	270	153
2012	8.3	2.8	1.82	0.122	0.036	484	249

Summer Coho and Steelhead Measurement Information

Coho fork lengths measured throughout the 2012 summer monitoring of Redwood Creek ranged from 61 to 85 mm. The highest length frequency for juveniles (47%) was observed in the 71 to 75 mm length interval. The 2012 average length, 73 mm, was not significantly different ($p=0.357$) from the 2010 to 2011 average length using a two-sided t-test (no coho juveniles were captured during basinwide surveys in 2009). The 2012 mean weight, 0.41 g, was also not significantly different ($p=0.129$) than the historical mean. This indicates that the 2012 mean weight and length were consistent with the historical mean weight and length. Figures 26 and 27 show representations of fork lengths and fish weights for coho caught on Redwood Creek for summers 2010 through 2012.

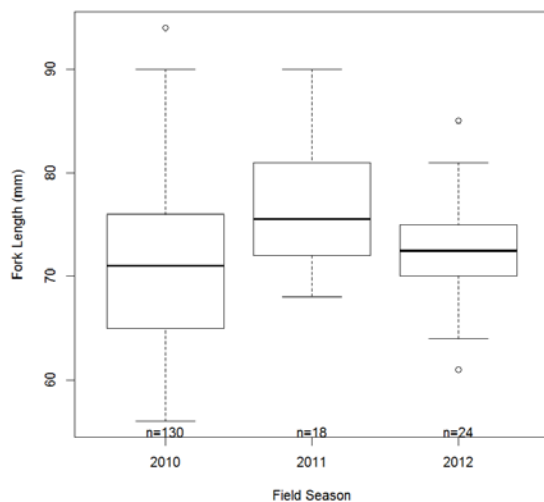


Figure 26. Box and whisker plots for coho salmon juvenile fork lengths for basinwide Redwood Creek, summer 2010-2012 (no juveniles captured in 2009). Dark lines represent medians, circles represent outliers.

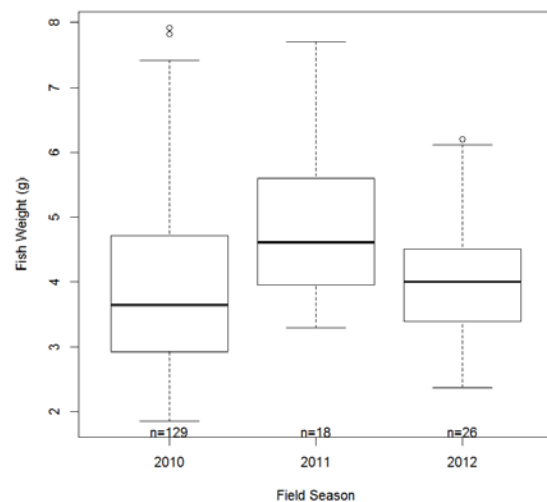


Figure 27. Box and whisker plots for coho salmon juvenile weights for basinwide Redwood Creek, summer 2010-2012 (no coho captured in 2009). Dark lines represent medians, circles represent outliers.

Within the Redwood Creek sample, 269 steelhead were measured for fork length. Of those 269, 261 steelhead (97% of the total basinwide steelhead catch) were also weighed. The size range for steelhead was 36 to 175 mm. Fork length frequencies were used to determine year class bins. The highest frequency of fork lengths for steelhead YOY occurred within the 51 to 55 mm length interval, representing 18% of the sample. For basinwide Redwood Creek steelhead YOY, the 2012 average length, 64 mm, was not significantly different ($p=0.177$) from the 2009 to 2011 average length using a two-sided t-test. The 2012 mean weight, 3.1 g, was not significantly different ($p=0.384$) than the historical mean. This indicates that the 2012 mean weight and length was consistent with the historical mean weight and length.

The highest frequency of fork lengths for steelhead 1+ occurred within the 131 to 135 mm length interval, representing 14% of the sample. For basinwide Redwood Creek steelhead 1+, the 2012 average length, 127 mm, was not significantly different ($p=0.160$) from the 2009 to 2011 average length; likewise, the mean weight, 20.8 g, was also not significantly different ($p=0.227$) than the

historical mean. This indicates that the 2012 mean weight and length for steelhead 1+ were consistent with the historical values. Figures 28 and 29 show representations of fish lengths for steelhead YOY and 1+ captured on Redwood Creek for summers 2009 through 2012.

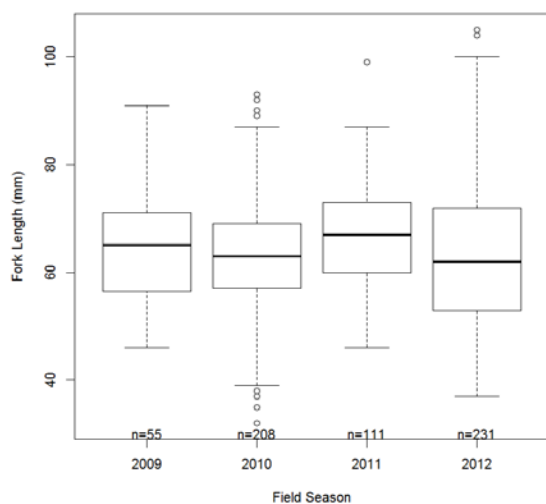


Figure 28. Box and whisker plots for steelhead young of the year fork lengths for basinwide Redwood Creek, summer 2009 to 2012. Dark lines represent medians, circles represent outliers.

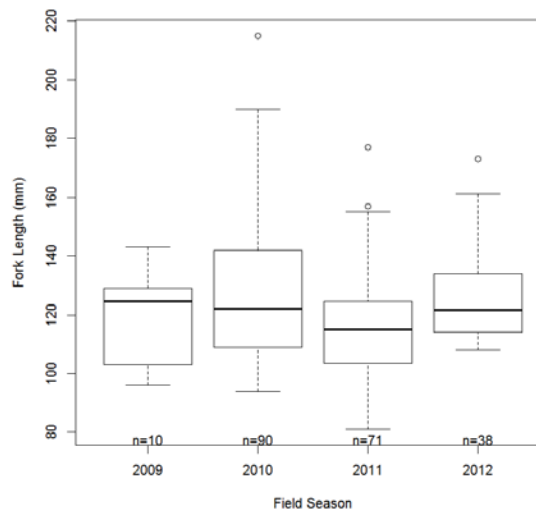


Figure 29. Box and whisker plots for steelhead aged 1+ weights for basinwide Redwood Creek, summer 2009 to 2012. Dark lines represent medians, circles represent outliers.

Fulton's Condition Factor

The 2012 mean K-factor for coho juveniles on Redwood Creek, 1.05, was not significantly different ($p=0.196$) from the historical mean (2010-2011). Similarly, the 2012 mean K-factor for steelhead 1+, 0.98, was not statistically different ($p=0.067$) from the historical mean K-factor (2009-2011). This indicates that the K-factors for juvenile coho and steelhead 1+ on Redwood Creek are consistent with the historical mean K-factors. However, the 2012 mean K-factor for steelhead YOY, 1.00, on Redwood Creek was significantly different ($p=0.035$) than the historical mean K-factor (2009-2011). The point estimate of the difference between the 2012 mean K-factor and the historical mean K-factor was 0.02 with a 95% confidence interval of 0.001 to 0.04. This test indicates the 2012 mean steelhead YOY K-factor is larger than the historical mean K-factor.

Table 25 shows length, weight, and K-factors for coho captured during basinwide sampling on Redwood Creek in summer 2012. Table 26 shows the comparisons between steelhead YOY and steelhead 1+ length, weight, and K-factors for Redwood Creek.

Table 25. Mean and median fork length, weight, and K-factor for coho measured and weighed in the basinwide calibration pools on Redwood Creek mainstem, 2012.

Species	Sample Size	Mean Fork Length (mm)	Fork Length Standard Deviation	Median Fork Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
Coho	24	73	5.2	73	4.1	0.95	4.1	1.05	0.10

Table 26. Mean and median fork length, weight and K-factor calculated for steelhead measured and weighed in the basinwide calibration pools on Redwood Creek mainstem, 2012.

Species	Life Stage	Sample Size	Mean Fork Length (mm)	Fork Length Standard Deviation	Median Fork Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
Steelhead	YOY	231	64	14.3	62	3.1	2.20	2.4	1.00	0.12
Steelhead	1+	38	127	15.8	122	20.8	8.30	17.9	0.98	0.07

YOY= young of the year, 1+ = one year of age or older

3.4.3 Pine Gulch Creek

The 2012 summer habitat survey of Pine Gulch Creek was initiated at monument tag 15 and continued upstream to monument tag 95, above the Teixeira Ranch within PORE. The measured basinwide habitat survey length for the main channel was 8.3 km.

Basinwide snorkel surveys were conducted on 8.3 km of the Pine Gulch Creek mainstem starting at tag 15 and ending at monument tag 95, upstream of the Teixeira Ranch within PORE.

Coho Habitat Survey

A total of 679 mainstem habitat units were identified in the 8.3 km Pine Gulch Creek survey reach. Pool and riffle units comprised the majority of the habitat types measuring a total of 6,829 m. Overall habitat composition by habitat unit was 41% pool, 41% riffle, and 18% flatwater (Table 27). No dry units were observed on Pine Gulch Creek so the total wetted survey length was equal to the total survey length of 8,287 m. Side channel and backwater units were also measured but not incorporated into the basinwide habitat calculations. Riffle habitat types made up 65% of the total side channel habitat composition. Overall, 676 m of side channel habitat and 113 m of backwater habitat units were measured during the basinwide habitat survey, with a side channel density of 8.2 m per 100 m of wetted survey length and a backwater density of 1.4 m per 100 m. Both side channel and backwater densities were lower than the historical averages (side channel summers 2005 through 2011 average density 8.6, backwater summers 2005 through 2011 average density 1.5).

Table 27. Habitat composition of Pine Gulch Creek coho survey reach, 2012. Measured length is used to calculate percentages of length per habitat type.

Unit Type	Total length (m)	% of length	# of units	% of units
Pool	3,917	47	278	41
Flatwater	1,458	18	125	18
Riffle	2,912	35	276	41
Dry	0	0	0	0
Total	8,287	100	679	100

Woody debris information collected during the basinwide habitat survey is summarized for summers 2005 through 2012 (Table 28, Figure 30) and may be used to identify trends in woody debris availability and recruitment over time. Within Pine Gulch Creek, all metrics stayed the same or decreased in number.

Table 28. Summary of basinwide instream woody debris (WD) per 100 m during summer base flow conditions in Pine Gulch Creek, average 2005-2011 compared to 2012.

Field season	Survey length (# 100 m sections)	Root Wads per 100 m	LWD Jams per 100 m	SWD Jams per 100 m	10-20cm WD per 100 m	20-50cm WD per 100 m	>50cm WD per 100 m
2005-2011 Average	96.9	1.1	0.5	1.0	3.4	3.0	1.4
2012	82.9	0.7	0.5	0.5	1.7	2.0	0.5

LWD Jams= 10 or more pieces of large woody debris

SWD Jams= 10 or more pieces of small woody debris

10-20 cm, 20-50 cm, >50 cm refer to diameter of individual pieces of woody debris

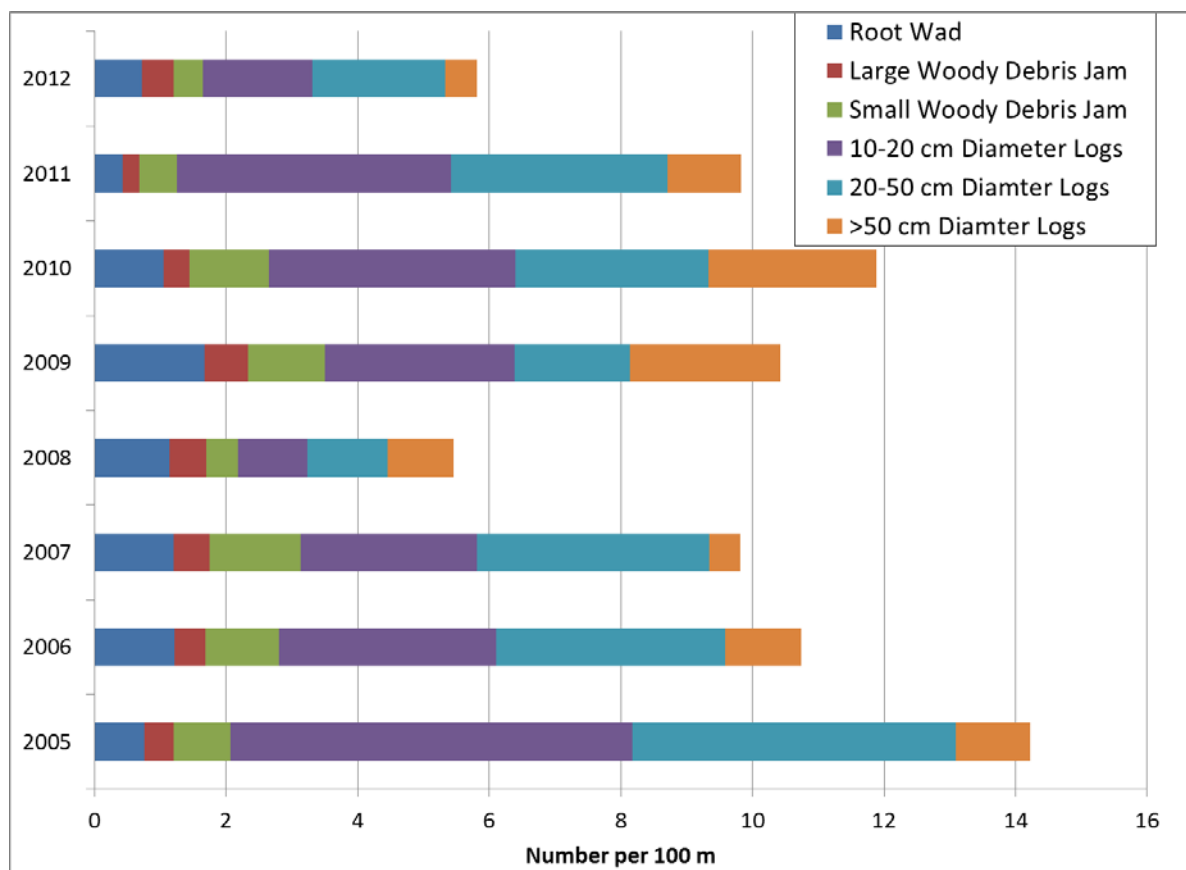


Figure 30. Pine Gulch Creek in-stream woody debris by type per 100 m in wetted length for summers 2005-2012.

Coho Snorkel Counts

A total of 679 habitat units were delineated within the 8.3 km Pine Gulch Creek snorkel survey area with pool units representing 41% of all surveyed units. Snorkel surveys were conducted on 26% of the delineated pools. No coho were observed in any of the 72 snorkeled pools.

Eleven of the 72 snorkeled pools (15%) were electrofished within a day following the snorkel counts and no coho were caught. In addition to the 11 electrofished pools, four pools (6%) 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 summary of the snorkel counts for Pine Gulch Creek is presented in Table 29. This table includes both the raw total number of coho counted in the snorkel surveys and the calibrated total number of coho.

Table 29. Summary of coho snorkel counts in Pine Gulch Creek, summer 2005-2012.

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	10.1	826	363	78	0	0	0
2009	9.5	621	302	67	16	72	86
2010	9.8	739	335	84	2	2	N/A
2011	8.0	644	293	75	0	0	0
2012	8.3	679	278	72	0	0	0

Coho Basinwide Estimate

As no coho were observed during the 2012 summer survey, no basinwide estimate could be calculated. Table 30 shows a summary of basinwide estimates for Pine Gulch between 2005 and 2012.

Table 30. Coho density and population estimates; Pine Gulch coho survey area, summer 2005-2012.

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	3.3	3.7	0.219	0.072	1,150	± 554
2006	10.3	0.6	0.8	0.073	0.030	295	± 201
2007	10.3	0.0	0	0	0	0	0
2008	10.1	0.0	0	0	0	0	0
2009	9.5	1.1	1.3	0.08	0.022	386	± 441
2010	9.8	0.0	N/A	N/A	N/A	N/A	N/A
2011	8.0	0	0	0	0	0	0
2012	8.3	0	0	0	0	0	0

Summer Steelhead Measurement Information

A total of 184 steelhead were measured for fork length during the summer surveys on Pine Gulch Creek. Of those 184, 166 steelhead (90% of the total basinwide steelhead catch) were also weighed. The size range for steelhead was 26 to 225 mm. Fork length frequencies were used to determine year class bins. The highest frequency of fork lengths for steelhead YOY occurred within the 41 to 45 mm length interval, representing 21% of the sample. For Pine Gulch Creek steelhead YOY, the 2012 average fork length, 53 mm, was significantly different ($p < 0.001$) from the 2009 to 2011 average fork length using a two-sided t-test. The point estimate of the difference between the 2012 and historical mean length was -10.70 with a 95% confidence interval of -13.08 to -8.31. This indicates that the mean length for 2012 steelhead YOY was smaller than the historical mean.

The 2012 mean weight for steelhead YOY, 2.1 g, on Pine Gulch Creek was significantly different ($p < 0.001$) than the 2009 to 2011 mean YOY weight using a two-sided t-test with an alpha value of

0.05. The point estimate of the difference between the 2012 and historical mean weight was -0.70 with a 95% confidence interval of -1.01 to -0.38. This indicates that the mean weight for 2012 steelhead YOY was smaller than the historical mean

The highest frequency of fork lengths for steelhead 1+ occurred between 91 to 95 mm length interval, representing 14% of the sample. For Pine Gulch Creek steelhead 1+, the 2012 average fork length, 122 mm, was significantly different ($p=0.025$) from the 2009 to 2011 average length using a two-sided t-test. The point estimate of the difference between the 2012 mean length and the historical mean length was -9.12 with a 95% confidence interval of -17.07 to -1.16. This indicates that the mean length for 2012 steelhead 1+ was smaller than the historical mean. The 2012 mean weight, 20.5 g, was not significantly different ($p=0.152$) than the historical mean. This indicates that the 2012 mean weight was consistent with the historical mean weight. Figure 31 shows steelhead YOY length information and Figure 32 shows steelhead 1+ length information collected from Pine Gulch Creek for summers 2009 through 2012.

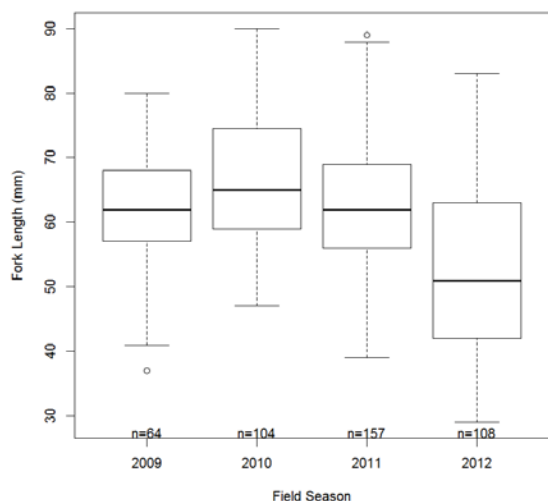


Figure 31. Box and whisker plots for steelhead young of the year fork lengths for basinwide Pine Gulch Creek, summer 2009-2012. Dark lines represent medians, circles represent outliers.

Steelhead Fulton's Condition Factor

The 2012 mean K-factor for steelhead YOY, 1.00, on Pine Gulch Creek was not significantly different ($p=0.550$) from the historical mean (2010-2011). Similarly, the 2012 mean K-factor for steelhead 1+, 0.97, was not statistically different ($p=0.789$) from the historical mean K-factor (2009-2011). This indicates that the K-factors for steelhead YOY and steelhead 1+ on Pine Gulch Creek are consistent with the historical mean K-factors.

Table 31 shows a summary of steelhead YOY and steelhead 1+ fork length, weight, and K-factors for basinwide monitoring on Pine Gulch Creek.

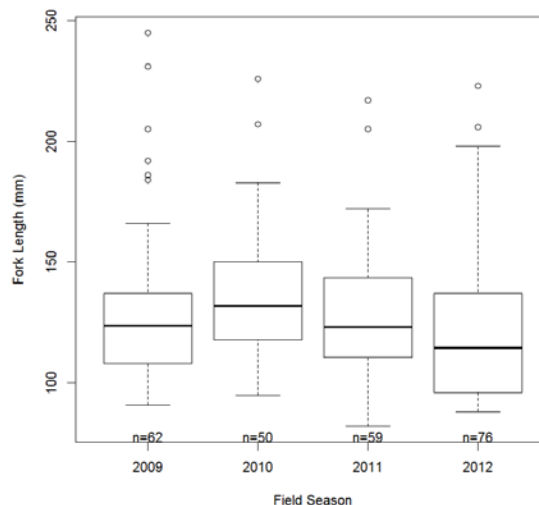


Figure 32. Box and whisker plots for steelhead aged 1+ weights for basinwide Pine Gulch Creek, summer 2009-2012. Dark lines represent medians, circles represent outliers.

Table 31. Mean and median fork length, weight, and K-factor calculated for steelhead weighed and measured in the basinwide calibration pools on Pine Gulch mainstem, 2012.

Species	Life Stage	Sample Size	Mean Fork Length (mm)	Fork Length Standard Deviation	Median Fork Length (mm)	Mean Weight (g)	Weight Standard Deviation	Median Weight (g)	Mean K-Factor	K-Factor Standard Deviation
Steelhead	YOY	108	53	12.8	51	2.1	1.41	1.7	1.00	0.21
Steelhead	1+	76	122	29.9	115	20.5	17.01	13.9	0.97	0.10

YOY= young of the year, 1+ = one year of age or older

3.5 Coho and Steelhead Index Reach Monitoring Results

Index reach juvenile monitoring results are provided for Olema Creek, Redwood Creek, and Pine Gulch Creek.

3.5.1 Olema Creek

Index Reach 1 has not been sampled in the past nine years. In 2009, Index Reaches 4 and 8 were removed from the sampling regime due to access and staffing considerations.

Index Reach Habitat and Total Salmonid Catch

The results presented in Table 32 are the 2012 total 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. Historical catch numbers can be found in Appendix A, Table A13.

Table 32. Summary of total catch by species within Olema Creek mainstem index reach sample locations, 2012.

Year	Species	Index Reach								total
		1	2	3	4	5	6	7	8	
2012	CO		1	0		1	0	0		2
	SH YOY	Not sampled	84	194	Not sampled	39	27	39	Not sampled	383
	SH 1+		12	15		5	9	15		56

CO= coho salmon; SH= steelhead trout; YOY= young of the year 1+ = one year of age or older

In 2012, only index reaches 2 and 5 had coho, steelhead were found in all sampled indexes.

Index Reach Habitat Information

In 2012, the habitat surveys of the index reaches showed an equal to or higher percentage of pool habitats when compared to historical averages. Index reach habitat composition for 2012 can be found in Appendix A, Table A14.

Salmonid per Meter by Index Reach

The results of our monitoring efforts show distinct differences in salmonid numbers and fish per meter based on habitat type. Fish numbers are calculated using the best available catch estimate,

either total catch from electrofishing surveys or catch calculated by *Microfish*. Numbers used in Figure 33 were determined from all habitat units surveyed within each index reach in 2012, and can be viewed in Appendix A, Table A15. Steelhead 1+ numbers were more evenly distributed, while steelhead YOY numbers were highest at the two lowest reaches surveyed.

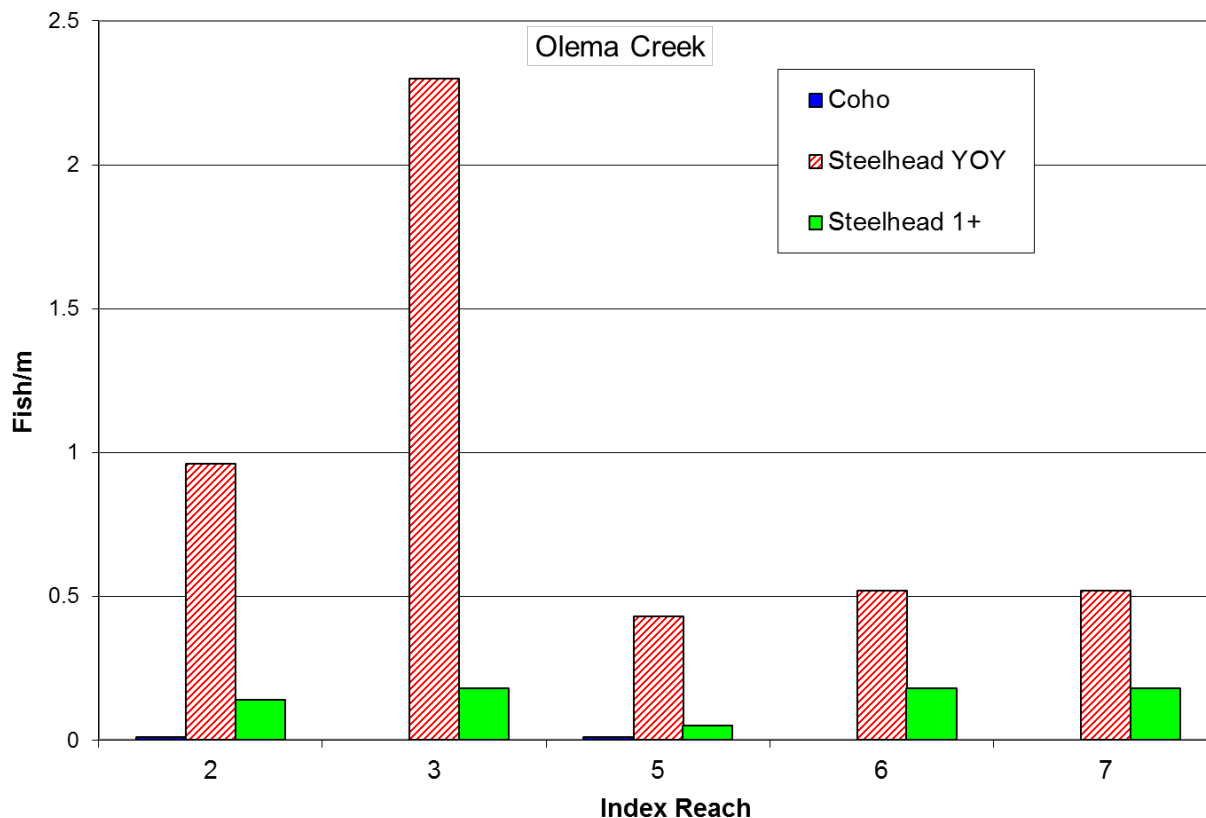


Figure 33. Coho and steelhead juvenile fish per meter according to index reach on Olema Creek, 2012.

Juvenile Coho and Steelhead Fork Length per Index Reach

As part of the summer monitoring program, a subsample of fish are weighed and measured within each sampled habitat unit. Only two coho were captured on Olema Creek during index reach sampling. The ages of the steelhead are based on fork length frequencies, with each sample year having different fork length size ranges. Within the Olema Creek sample, 262 steelhead were measured for fork length. Of those 262, 239 (91% of the total index reach catch) were also weighed. The size range for steelhead young of year was 36 to 90 mm (n=212), while the size range for the steelhead 1+ was 91 to 180 mm (n=50).

3.5.2 Redwood Creek

Historical average salmonid density estimates from electrofishing surveys completed by Jerry Smith (San Jose State University) on Redwood Creek from 1992 to 2001 are located below in Table 33. Survey results from 1999 to 2003 in Table 33 represent combined efforts between Dr. Smith and the NPS. In 2012, six of the seven index reaches were surveyed by SFAN staff.

Table 33. Summary of historical salmonid fish per meter estimates from electrofishing surveys completed by Dr. Smith on Redwood Creek index reaches, 1992-2003 (Smith 2001).

Year	Total # of sampled indexes	Length sampled (m)	Density		
			CO/m	SH YOY/m	SH 1+/m
1992	4 ^a	314.6	1.48	0.75	0.13
1993	4	289.9	1.51	1.84	0.13
1994	7	392.3	0.07	2.26	0.46
1995	4	242.6	1.38	3.18	0.13
1996	3	184.1	1.28	1.08	0.36
1997	5 ^a	299.9	0.75	0.49	0.16
1998	5	357.8	1.05	1.54	0.13
2000	6	328.3	0.04	1.28	0.49
2001	5 ^a	291.4	0.89	0.20	0.20
2002	4	239.9	1.87	0.36	0.10
2003	4	213.7	0.89	0.98	0.26

^a One or both of the sites downstream of the well were intermittent or dry.

CO= coho salmon; SH= steelhead trout; YOY= young of the year; 1+ = one year of age or older

Index Reach Habitat and Total Salmonid Catch

The results presented in Table 34 are the total catch documented through electrofishing activities in the Redwood Creek index reaches for 2012. In 2012, coho were found in all sampled index reaches. For historical index reach catch 2004 through 2011, refer to Appendix A, Table 16.

Table 34. Summary of total catch by each species within Redwood Creek mainstem index reach sample locations, summer 2012.

Year	Species	Index Reach							Total
		1	2	3	4	5	6	7	
2012	CO	13	11	16	8	1	2		51
	SH YOY	85	79	32	84	64	22	Not Sampled	366
	SH 1+	5	16	7	17	13	7		65

CO= coho salmon; SH= steelhead trout; YOY= young of the year; 1+ = one year of age or older

Index Reach Habitat Information

In 2012, five of the six index reaches had a higher than average percentage of pool habitat, compared to the 2004 through 2011 historic catch, while the remaining index reach had an average percentage of pool habitat. Index reach habitat composition for 2012 can be found in Appendix A, Table A17.

Salmonid per Meter by Index Reach

Number of fish per meter are calculated using the best available catch estimate, either total catch from electrofishing surveys or catch estimate calculated by *Microfish*. Fish numbers used in Figure 34 are determined from all habitat units surveyed within each index reach and can be viewed in Appendix A, Table A18. Coho numbers were highest in Index Reaches 1 and 2, although they were present in all index reaches surveyed. Likewise, steelhead YOY numbers were highest in Index Reaches 1 and 2, while steelhead 1+ numbers were highest in Index Reach 6, at the lower end of the stream.

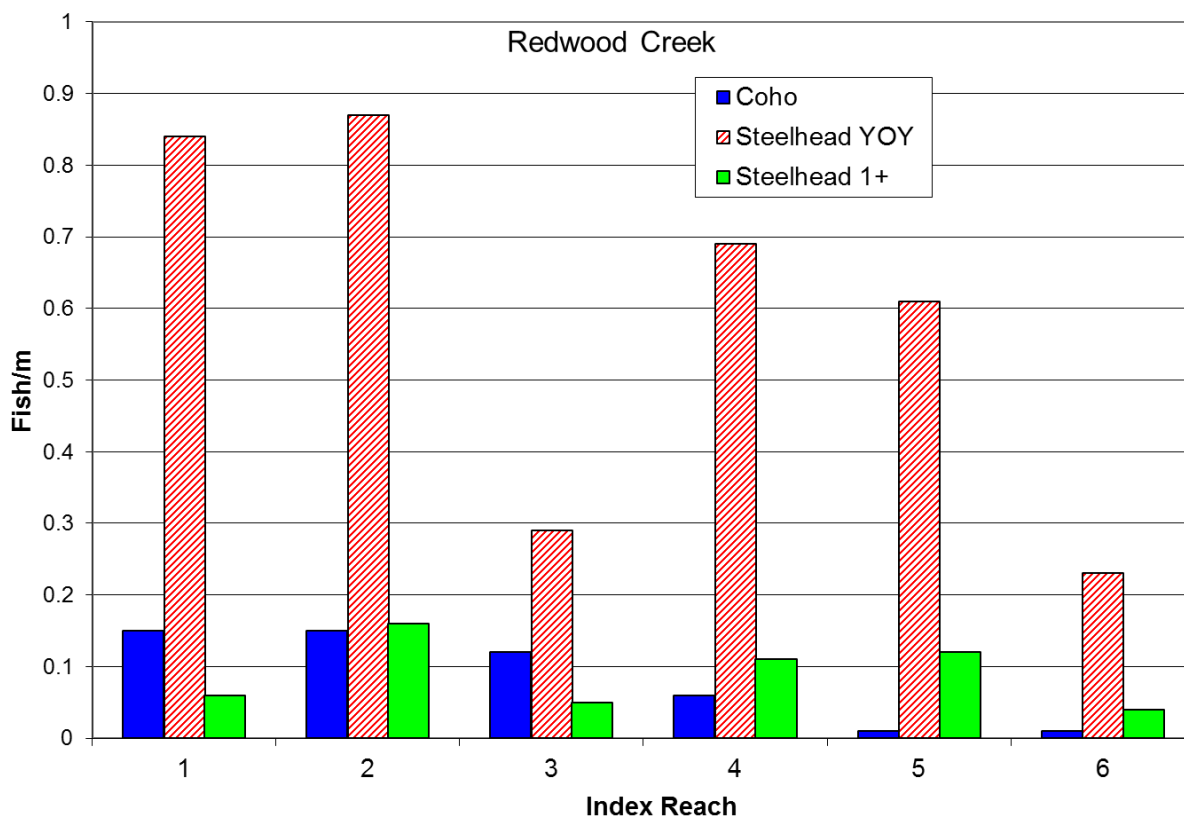


Figure 34. Coho and steelhead juvenile densities according to index reach on Redwood Creek, summer 2012.

Juvenile Coho and Steelhead Fork Length per Index Reach

As part of the summer monitoring program, a subsample of fish are weighed and measured within each sampled habitat unit. Age classes for steelhead were determined using fork length frequencies.

Within the Redwood Creek sample, 49 coho salmon (100% of the total index reach catch) and 366 steelhead trout (96% of the total index reach catch) were weighed and measured. An additional 14 steelhead were measured only. The size range for juvenile coho was observed to be 61 to 95 mm. The size range for steelhead YOY was 30 to 105 mm (n=323) while the size range for steelhead 1+ was 106 to 221 mm (n=57).

3.5.3 Pine Gulch Creek

In 2012, four of eight index reaches on the mainstem of Pine Gulch Creek were sampled. Index Reach 4 has not been sampled since 2000 because of access issues. Index Reaches 1a and 1b were removed from the sampling regime due to their proximity to Index Reach 1c. Access issues prevented the sampling of Index Reach 1c.

Index Reach Habitat and Total Salmonid Catch

The results presented in Table 35 are the 2012 real catch documented through electrofishing activities, as well as salmonid sample size variation between reaches. No coho were captured in any of the index reaches. Historical catch results can be found in Appendix A, Table A19.

Table 35. Summary of total catch for each species by reach within Pine Gulch Creek mainstem index reach sample locations, summer 2012.

Year	Species	Index Reach								Total
		1a	1b	1c	2	3	4	5	6	
2012	CO				0	0		0	0	0
	SH YOY	Not sampled	Not Sampled	Not Sampled	19	37	Not sampled	18	28	46
	SH 1+				25	24		16	23	43

CO= coho salmon; SH= steelhead trout; YOY= young of the year; 1+ = one year of age or older

Index Reach Habitat Information

During the 2012 summer monitoring season, four of the five surveyed index reaches had a higher than historic average percentage of pool habitat. Index reach habitat composition for 2012 can be found in Appendix A, Table A20.

Salmonid Fish per Meter by Index Reach

Number of fish per meter are calculated using the best available catch estimate, either total catch from electrofishing surveys or catch calculated by *Microfish*, and can be viewed in Appendix A, Table A21. The highest steelhead numbers were observed in Index Reach 3, whereas highest numbers for steelhead 1+ occurred in Index Reach 2.

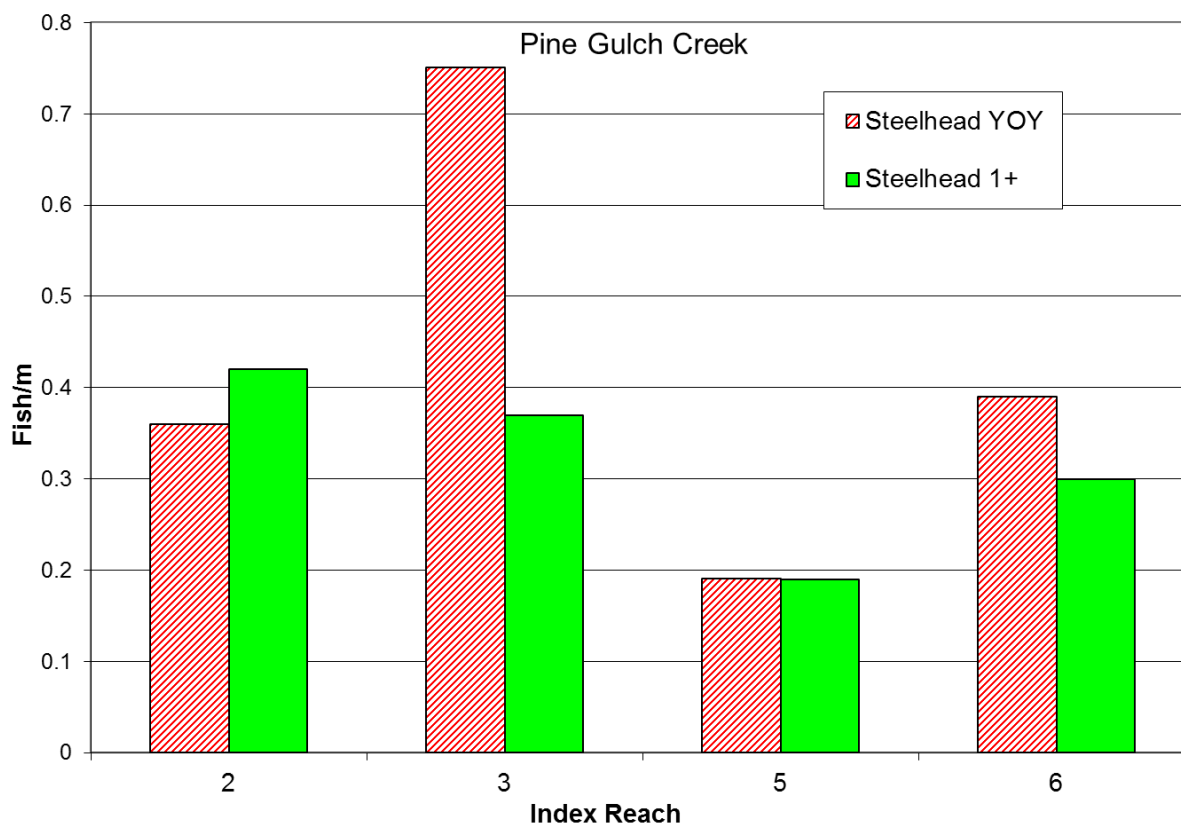


Figure 35. Steelhead juvenile densities according to index reach on Pine Gulch Creek, summer 2012.

Juvenile Steelhead Fork Length per Index Reach

As part of the summer monitoring program, a subsample of fish are weighed and measured within each sampled habitat unit. A total of 162 steelhead trout were measured for fork length; 137 of those (85% of total catch) were also weighed. The size range for steelhead YOY was 31 to 75 mm (n=85), while the size range for steelhead 1+ was 85 to 240 mm (n=77).

4 Discussion

Coastal Marin County watersheds are some of the most intensely monitored watersheds for coho salmon within the CCCESU. In addition to our SFAN/CDFW funded monitoring efforts on Olema Creek, Redwood Creek, Pine Gulch Creek, and Cheda Creek, extensive monitoring is conducted by MMWD on Lagunitas Creek, Devils Gulch, and the mainstem of San Geronimo Creek, and by SPAWN on tributaries of San Geronimo Creek. Through our SFAN monitoring efforts, we have documented significant information about coho salmon behavior, life history, distribution, and use of Olema Creek, Pine Gulch Creek, and Redwood Creek watersheds. The intensity of our life-cycle monitoring programs allow for larger scale characterization of patterns observed in the area. Though a relatively small geographic area, the coastal Marin County watersheds support a significant proportion of the CCCESU coho salmon, as well as two genetically distinct subpopulations. Genetic evaluations suggest that coho salmon occurring in Olema Creek and Cheda Creek constitute part of the Lagunitas/Olema genetic subgroup that would likely encompass the entire Tomales Bay watershed (Bjorkstedt et al. 2005). Genetic evaluation also suggests that the Pine Gulch Creek population represents an expansion of the Redwood Creek coho population to a new watershed (Garza and Gilbert-Horvath 2003).

The observed return rates for 2011-22012 coho salmon cohort, based on the 2010 smolt production estimate, showed some of the highest rates of ocean survival yet observed (28% on Olema Creek and 2.1% on Redwood Creek) since smolt trapping was initiated. As the 2008-2009 redd count for Olema Creek was zero, the seven redds observed in 2011-2012 were a dramatic increase for the cohort. In addition, these seven redds give insight on adult coho use of Olema Creek by coho that likely originated in the mainstem of Lagunitas Creek. Redwood also showed an increase, from two redds observed in 2008-2009 to four redds observed in 2011-2012. Although two spawning adult coho were observed on Pine Gulch during 2011-2012, no juveniles were observed during summer surveys in 2012, indicating that coho may be extirpated from the watershed.

The 2012 smolt production estimates on both Olema and Redwood Creek watersheds were higher than expected based on the juvenile population estimates calculated during the summer of 2011. Part of this may have been due to an increased rate of overwinter survival. However, part of it may be attributed to the effect of uncertainties on a small population and under-detection of juveniles during the summer of 2011. We are currently looking into ways of refining the summer monitoring 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.

This summary also documents extensive information on length and weight of outmigrating coho salmon observed leaving the monitored watersheds. Smolt size is directly related to ocean survival (Miller and Sandros 2003), with smolts of larger size at the time of ocean entrance having a higher chance of surviving to adulthood. In most years of sampling, Redwood Creek has had smaller smolt outmigration sizes than Olema Creek, although in 2012, they were larger in size compared to the smolts from Olema Creek. While the Olema Creek smolts were of average size when compared to the historical data set, the Redwood smolts were larger than the historical average. Comprehensive

smolt trapping is in its eighth year of operation at both Olema and Redwood Creeks. Additional years of data will help refine our understanding of variation and the range in size of smolts leaving these coastal Marin County watersheds.

The juvenile basinwide counts performed during the summer of 2012 on Olema, Redwood, and Pine Gulch creeks supports the low adult escapement observations during the 2011-2012 coho spawning season. On Olema Creek, a basinwide population estimate of 330 ± 744 was calculated. The high uncertainties surrounding the Olema Creek juvenile estimate are reflective of the low densities observed and a poor correlation between snorkel counts and electrofishing estimates in calibration units. The population estimate for Redwood Creek was 484 ± 249 coho juveniles. No coho juveniles were observed on Pine Gulch Creek.

Fish fork length and weight from the basinwide sampling reaches of Olema, Pine Gulch, and Redwood Creeks has been collected since the initiation of the SFAN Salmonid Monitoring Protocol during the summer of 2009. Based on this limited dataset, the average Olema Creek juvenile coho fork length was significantly different than in previous years with a point estimate indicating a reduction in fish size. In contrast, there was no significant change detected in smolt size on Redwood Creek. Smolt trapping operations during the spring of 2013 will provide insight on Olema Creek juvenile coho growth patterns from the late summer to spring growing period.

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Appendix A. Historic Data Tables

Tables

	Page
Table A1. Coho spawner survey redd density history for mainstem Lagunitas Creek, San Geronimo Creek, Devil’s Gulch, Olema Creek, Redwood Creek, and Pine Gulch including total redds, survey length (km) and red per km.	76
Table A2. Coho salmon run timing, average total rainfall by month, total carcasses and redds documented in surveys for spawner years 1997-1998 through 2011-2012 on the Olema Creek mainstem, plus Peak Live plus Cumulative Dead (PLD) and Area Under the Curve (AUC) estimates.	77
Table A3. Coho salmon run timing, average total rainfall by month, total carcasses and redds documented in surveys for spawner years 1997-1998 through 2011-2012 on the John West Fork tributary to Olema Creek, plus Peak Live plus Cumulative Dead (PLD) and Area Under the Curve (AUC) estimates.	78
Table A4. Coho salmon spawning survey including Peak Live plus Cumulative Dead (PLD) Index, tally of total carcasses, and total redds for all of the tributaries of the Olema Creek watershed excluding the John West Fork. These tributaries include Quarry Gulch and Giacomini Creek, Horse Camp Creek, Boundary Gulch, 1997-2012.	79
Table A5. Coho salmon run timing, average daily discharge by month, total carcasses and redds documented in surveys for spawner years 1997-1998 through 2011-2012 on the Redwood Creek watershed, plus Peak Live plus Cumulative Dead (PLD) and Area Under the Curve (AUC) estimates.	80
Table A6. Coho salmon spawning survey including Peak Live plus Cumulative Dead (PLD) Index, tally of total carcasses, and total redds for the Pine Gulch Creek mainstem.	81
Table A7. Mean Length, Weight, and K-factor calculated for coho smolts measured and weighed in the Olema Creek smolt trap 2004-2012.	81
Table A8. Mean Length, Weight, and K-factor calculated for steelhead smolts measured and weighed in the Olema Creek smolt trap 2004-2012.	81
Table A9. Mean Length, Weight, and K-factor calculated for coho smolts measured and weighed in the Redwood Creek smolt trap, 2005-2012.	82
Table A10. Mean Length, Weight, and K-factor calculated for steelhead smolts measured and weighed in the Redwood Creek smolt trap, 2006-2012 (no steelhead smolts caught in 2005).	82
Table A11. Summary of non-salmonid information for Olema Creek trap operations, 2004-2012.	83
Table A12. Summary of non-salmonid information for Redwood Creek trap operations, 2005-2012.	83

Tables (continued)

	Page
Table A13. Summary of total salmonid catch by species within Olema Creek mainstem index reach sample locations, 2004-2012. Shows variation between years and distribution within watershed.	84
Table A14. Summary of habitat composition; shows extent of area sampled and variation between reaches; Olema Creek, 2012.	85
Table A15. Summary of total salmonid catch and density estimates for each species by reach on Olema Creek; summer 2012 illustrates variation between reaches and provides a general idea of distribution within watershed.	86
Table A16. Summary of total salmonid catch (not including Dr. Smith information) for each species by reach within Redwood Creek mainstem index reach sample locations, 2004-2012.	87
Table A17. Summary of habitat composition; shows extent of area sampled and variation between reaches; Redwood Creek 2012.	88
Table A18. Summary of total salmonid catch and density estimates for each species by reach on Redwood Creek; summer 2012 illustrates variation between reaches and provides a general idea of distribution within watershed.	89
Table A19. Summary of total salmonid catch for each species by reach within Pine Gulch Creek mainstem index reach sample locations, 2005-2012.	90
Table A20. Summary of habitat composition; shows extent of area sampled and variation between reaches; Pine Gulch Creek, 2012.....	91
Table A21. Summary of total salmonid catch and density estimates for each species by reach on Pine Gulch Creek, summer 2012; illustrates variation between reaches and provides a general idea of distribution within watershed.	91

Table A1. Coho spawner survey redd density history for mainstem Lagunitas Creek, San Geronimo Creek, Devil's Gulch, Olema Creek, Redwood Creek, and Pine Gulch including total redds, survey length (km) and red per km.

Years	Lagunitas Creek			San Geronimo Creek			Devil's Gulch			Olema Creek ^a			Redwood Creek			Pine Gulch		
	Total redds	Survey length	Redd per km	Total redds	Survey length	Redd per km	Total redds	Survey length	Redd per km	Total redds	Survey length	Redd per km	Total redds	Survey length	Redd per km	Total redds	Survey length	Redd per km
1997-1998	80	10.7	7.5	107	7.0	15.3	52	3.2	16.3	134	14.7	9.1	72	7.4	6.9	N/A	N/A	N/A
1998-1999	92	10.7	8.6	46	7.0	6.6	32	3.2	10	23	12.8	1.8	41	7.4	5.5	N/A	N/A	N/A
1999-2000	139	10.7	13.0	58	7.0	8.3	3	3.2	0.9	10	8.3	1.2	5	7.4	0.7	N/A	N/A	N/A
2000-2001	119	12.8	9.3	56	7.0	8.0	11	3.2	3.4	80	13.5	5.9	12	7.4	1.6	0	9.5	0
2001-2002	79	12.8	6.2	102	7.0	14.5	59	3.7	16.1	59	13.5	4.4	20	7.4	2.7	2	9.5	0.2
2002-2003	71	12.8	5.5	39	7.0	5.6	24	3.7	6.6	20	12.9	1.6	3	7.4	0.4	1	9.5	0.1
2003-2004	124	12.8	9.7	139	7.0	19.8	48	3.7	13.1	109	14.0	7.8	42	7.4	5.7	0	9.5	0
2004-2005	120	12.8	9.4	140	7.0	19.7	112	3.7	30.6	138	14.0	9.9	73	7.4	9.9	3	9.5	0.3
2005-2006	53	12.8	4.1	48	7.0	6.9	33	3.7	8.9	9	14.0	0.6	11	7.4	1.5	1	9.5	0.1
2006-2007	128	12.8	10	117	7.0	16.7	55	3.7	14.9	95	14.0	5.8	21	7.4	2.8	0	9.5	0
2007-2008	87	12.8	6.8	46	7.0	6.6	6	3.7	1.6	33	17.5	1.9	0	7.4	0	2	9.5	0.2
2008-2009	25	12.8	2.0	1	7.0	0.1	0	3.7	0	0	17.5	0	2	7.4	0.3	0	9.5	0
2009-2010	42	12.8	3.3	7	7.0	1	0	3.7	0	14	17.5	0.8	23	7.4	3.1	0	9.5	0
2010-2011	32	12.8	2.5	40	7.0	5.7	0	3.7	0	21	17.5	1.2	3	7.4	0.4	0	9.5	0
2011-2012	94	12.8	7.3	3	7.0	0.4	0	3.7	0	7	17.5	0.4	4	7.4	0.5	1	9.5	0.1

^a Olema Creek includes redds from all surveyed tributaries to Olema Creek.

Table A2. Coho salmon run timing, average total rainfall by month, total carcasses and redds documented in surveys for spawner years 1997-1998 through 2011-2012 on the Olema Creek mainstem, plus Peak Live plus Cumulative Dead (PLD) and Area Under the Curve (AUC) estimates.

Spawner year (SY)	Run timing				Total monthly rainfall (inches)				Olema Creek spawner summary					
	Nov	Dec	Jan	Feb	Nov	Dec	Jan	Feb	Survey reach (km)	# surveys	Total carcass counts	Total redds	PLD	AUC range 70-80% OE RT 11-13 days
1997-1998 ^e					10.32	3.47	16.49	24.68	13.4	8	39	125	88	91-123
1998-1999					7.48	2.21	7.66	15.61	11.6	6	13	19	39 ^a	57-77
1999-2000					5.2	0.99	7.15	12.77	7.2	2	9	3	9 ^b	N/A
2000-2001					1.54	1.31	6.45	8.07	11.6	4	65	50	103	122-165
2001-2002					9.81	15.03	5.08	3.55	11.6	4	26	33	88 ^c	172-232
2002-2003					3.3	17.33	3.75	2.34	11.6	4	16	9	23 ^b	N/A
2003-2004					2.71	12.14	5.13	7.68	11.6	6	33	88	138 ^d	225-304
2004-2005					0.65	10.13	4.85	5.33	11.6	6	60	91	184 ^d	243-328
2005-2006					3.27	19.9	7.94	4.76	11.6	3	11	2	12 ^b	N/A
2006-2007					5.54	6.43	1.09	9.93	11.6	6	27	66	80 ^d	131-177
2007-2008					1.09	6.76	14.66	N/A	13.2	8	5	25	22 ^d	30-40
2008-2009					3.14	3.16	1.22	11.12	13.2	11	0	0	2	N/A
2009-2010					1.41	5.15	12.51	7.23	17.5	9	6	11	8	5-6
2010-2011					5.21	12.28	2.09	6.97	17.5	11	9	13	15	24-33
2011-2012					5.58	0.63	6.97	2.29	17.5	14	12	7	27	20-28

^a Includes two peaks, 7 weeks apart.

^c Includes two peaks, 4 weeks apart.

^e Data source Manning 1999.

^b Surveys missed peak numbers.

^d Includes two peaks, 3 weeks apart.

N/A = not available or survey data was not adequate to develop AUC estimate.

Table A3. Coho salmon run timing, average total rainfall by month, total carcasses and redds documented in surveys for spawner years 1997-1998 through 2011-2012 on the John West Fork tributary to Olema Creek, plus Peak Live plus Cumulative Dead (PLD) and Area Under the Curve (AUC) estimates.

Spawner year (SY)	Run timing				Total monthly rainfall (inches) ^d				John West Fork spawner summary					
	Nov	Dec	Jan	Feb	Nov	Dec	Jan	Feb	Survey reach (km)	# surveys	Total carcass counts	Total redds	PLD	AUC range 70-80% OE RT 11-13 days
1997-1998					10.32	3.47	16.49	24.68	1.3	5	0	6	12	N/A
1998-1999					7.48	2.21	7.66	15.61	1.2	2	0	4	9	N/A
1999-2000					5.2	0.99	7.15	12.77	1.1	3	0	7	18 ^a	12-16
2000-2001					1.54	1.31	6.45	8.07	1.9	4	31	30	58	69-94
2001-2002					9.81	15.03	5.08	3.55	1.9	6	4	26	20	41-55
2002-2003					3.3	17.33	3.75	2.34	1.3	7	0	11	27 ^b	23-31
2003-2004					2.71	12.14	5.13	7.68	2.4	6	7	21	41	49-67
2004-2005					0.65	10.13	4.85	5.33	2.4	7	12	44	73 ^c	98-132
2005-2006					3.27	19.9	7.94	4.76	2.4	7	0	4	8	14-19
2006-2007					5.54	6.43	1.09	9.93	2.4	7	5	29	20	26-35
2007-2008					1.09	6.76	14.66	N/A	2.4	7	0	8	11	5-6
2008-2009					3.14	3.16	1.22	11.12	2.4	3	0	0	0	N/A
2009-2010					1.41	5.15	12.51	7.23	2.4	3	0	3	5	N/A
2010-2011					5.21	12.28	2.09	6.97	2.4	12	4	8	11	18-21
2011-2012					5.58	0.63	6.97	2.29	2.4	5	0	0	3	N/A

^a Includes two peaks, 7 weeks apart.

^c Includes two peaks, 4 weeks apart.

^b Surveys missed peak numbers.

^d Same rainfall data as for Olema Creek mainstem.

N/A = not available or survey data was not adequate to develop AUC estimate.

Table A4. Coho salmon spawning survey including Peak Live plus Cumulative Dead (PLD) Index, tally of total carcasses, and total redds for all of the tributaries of the Olema Creek watershed excluding the John West Fork. These tributaries include Quarry Gulch and Giacomini Creek, Horse Camp Creek, Boundary Gulch, 1997-2012.

Year	Number of creeks surveyed	Total live	Total carcasses	Total redds	Source
1997-1998	6	4	1	3	NPS-PORE
1998-1999	0	0	0	0	NPS-PORE
1999-2000	2	0	0	0	NPS-PORE
2000-2001	4	0	0	0	NPS-PORE
2001-2002	4	1	0	0	NPS-PORE
2002-2003	0	0	0	0	NPS-PORE
2003-2004	2	0	0	0	NPS-PORE
2004-2005	6	2	3	3	NPS-PORE
2005-2006	4	3	0	3	NPS-PORE
2006-2007	3	3	0	0	NPS-PORE
2007-2008	4	0	0	0	NPS-PORE
2008-2009	4	0	0	0	NPS-PORE
2009-2010	3	0	0	0	NPS-PORE
2010-2011	4	1	0	0	NPS-PORE
2011-2012	4	0	0	0	NPS-PORE

Table A5. Coho salmon run timing, average daily discharge by month, total carcasses and redds documented in surveys for spawner years 1997-1998 through 2011-2012 on the Redwood Creek watershed, plus Peak Live plus Cumulative Dead (PLD) and Area Under the Curve (AUC) estimates.

Spawner year (SY)	Run timing				Total monthly rainfall (inches)				Redwood Creek spawner summary					
	Nov	Dec	Jan	Feb	Nov	Dec	Jan	Feb	Survey reach (km)	# surveys	Total carcass counts	Total redds	PLD	AUC range 70-80% OE RT 11-13 days
1997-1998									9.4 ^a	7	24	78	55	145-195
1998-1999					3.28	1.49	5.27	8.47	9.4 ^a	11	10	41	38 ^c	64-87
1999-2000					2.72	0.59	5.95	0.00	8.4 ^b	6	1	5	10	13-18
2000-2001					0.00	0.00	4.39	6.07	9.4 ^a	5	11	12	55	121-163
2001-2002					0.00	0.00	0.83	3.56	9.4 ^a	5	50	34	106 ^d	190-257
2002-2003					2.18	13.04	1.23	1.83	9.4 ^a	5	3	3	23 ^e	35-48
2003-2004					2.62	3.45	7.21	6.38	9.4 ^a	5	25	42	67	70-94
2004-2005					0.8	7.59	3.66	3.09	9.4 ^a	7	63	90	171 ^d	276-373
2005-2006					2.19	12.57	0.00	3.48	9.4 ^a	5	5	11	27 ^e	45-61
2006-2007					2.58	4.27	0.63	3.63	9.4 ^a	9	6	24	29 ^f	39-51
2007-2008					1.79	7.84	16.23	2.23	9.4 ^a	8	0	0	0	N/A
2008-2009					N/A	3.62	1.03	8.92	8.4 ^b	10	2	2	4	N/A
2009-2010					1.15	4.01	9.33	3.96	9.4 ^a	8	10	23	12	13-18
2010-2011					2.62	10.27	1.90	5.90	9.4 ^a	13	1	3	6	18-24
2011-2012					2.31	0.52	4.45	1.75	9.4 ^a	14	8	4	10	4-5

^a Includes the mainstem of Redwood Creek, Fern Creek, and Kent Creek.

^b Includes the mainstem of Redwood Creek and Fern Creek.

^c Includes two peaks, 7 weeks apart.

^d Includes two peaks, 3 weeks apart.

^e Includes two peaks, 33 days apart.

^f Includes three peaks, 26 and 24 days apart.

Table A6. Coho salmon spawning survey including Peak Live plus Cumulative Dead (PLD) Index, tally of total carcasses, and total redds for the Pine Gulch Creek mainstem.

Year	Year class	Number of surveys	Survey reach (km)	PLD Index	Total carcasses	Total redds	Source
2000-2001	1	3	7.0	1	0	0	NPS-PORE
2001-2002	2	2	9.0	2	0	2	NPS-PORE
2002-2003	3	2	8.0	2	2	1	NPS-PORE
2003-2004	1	6	9.0	0	0	0	NPS-PORE
2004-2005	2	3	10.0	3	0	3	NPS-PORE
2005-2006	3	4	9.5	1	0	1	NPS-PORE
2006-2007	1	4	9.5	0	0	0	NPS-PORE
2007-2008	2	3	9.5	1	0	2	NPS-PORE
2008-2009	3	1	9.5	0	0	0	NPS-PORE
2009-2010	1	1	9.5	0	0	0	NPS-PORE
2010-2011	2	1	9.5	0	0	0	NPS-PORE
2011-2012	3	1	9.5	2	0	1	NPS-PORE

Table A7. Mean Length, Weight, and K-factor calculated for coho smolts measured and weighed in the Olema Creek smolt trap 2004-2012.

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
2004	Smolt	148	114	9.7	113	14.4	4.03	14.4	1.00	0.07
2005	Smolt	37	116	9.5	116	16.0	3.89	15.0	1.01	0.08
2006	Smolt	205	99	9.6	98	10.2	3.08	9.6	1.04	0.11
2007	Smolt	191	116	11.0	115	14.7	4.73	13.6	0.91	0.07
2008	Smolt	386	111	9.2	110	12.4	3.20	11.9	0.90	0.09
2009	Smolt	447	113	8.1	113	12.9	2.79	12.5	0.89	0.06
2010	Smolt	10	136	6.7	135	24.1	4.17	23.6	0.94	0.06
2011	Smolt	376	122	10.7	121	16.2	4.24	15.5	0.89	0.06
2012	Smolt	180	117	10.7	115	14.6	4.40	13.8	0.89	0.06

Table A8. Mean Length, Weight, and K-factor calculated for steelhead smolts measured and weighed in the Olema Creek smolt trap 2004-2012.

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
2004	Smolt	11	177	15.4	176	55.3	14.37	50.6	0.99	0.09
2005	Smolt	6	127	32.5	129	22.9	15.85	22.3	0.94	0.13
2006	Smolt	3	130	9.5	133	25.0	6.39	28.6	1.13	0.09
2007	Smolt	109	168	19.2	166	41.7	13.59	39.7	0.85	0.08
2008	Smolt	34	141	25.7	138	27.3	13.01	24.9	0.92	0.09
2009	Smolt	11	156	17.4	155	33.6	10.43	32.6	0.87	0.54
2010	Smolt	31	174	22.7	175	48.2	17.80	44.9	0.88	0.07
2011	Smolt	15	172	18.8	174	42.3	13.16	42.2	0.80	0.04
2012	Smolt	8	173	17.6	174	40.0	8.70	40.2	0.77	0.11

Table A9. Mean Length, Weight, and K-factor calculated for coho smolts measured and weighed in the Redwood Creek smolt trap, 2005-2012.

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	Smolt	90	100	9.4	99	10.4	3.12	9.8	1.02	0.11
2006	Smolt	412	98	8.4	97	9.3	2.41	9.0	0.98	0.07
2007	Smolt	213	115	10.9	115	14.2	4.08	13.6	0.90	0.07
2008	Smolt	295	109	8.8	109	11.8	2.84	11.6	0.90	0.10
2009	Smolt	83	120	11.0	120	15.8	4.18	15.3	0.89	0.05
2010	Smolt	106	123	7.7	123	16.2	3.16	15.7	0.86	0.05
2011	Smolt	1,262	112	9.4	111	12.5	3.06	12.0	0.88	0.07
2012	Smolt	169	119	11.6	117	15.3	4.38	14.8	0.90	0.08

Table A10. Mean Length, Weight, and K-factor calculated for steelhead smolts measured and weighed in the Redwood Creek smolt trap, 2006-2012 (no steelhead smolts caught in 2005).

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
2006	Smolt	10	132	13.9	135	22.9	5.91	22.0	0.99	0.11
2007	Smolt	16	177	13.4	177	43.7	12.87	42.0	0.77	0.13
2008	Smolt	12	159	22.4	163	40.5	20.16	41.5	0.96	0.36
2009	Smolt	26	169	17.6	168	39.5	12.17	37.1	0.80	0.06
2010	Smolt	46	160.	11.2	160	34.5	7.10	34.7	0.83	0.06
2011	Smolt	13	157	17.6	157	32.0	10.42	31.1	0.80	0.08
2012	Smolt	30	163	12.7	162	33.8	6.69	33.0	0.77	0.07

Table A11. Summary of non-salmonid information for Olema Creek trap operations, 2004-2012.

Watershed	Year	Trap dates		CH	GSF	GSH	LAM	PL	RO	SCU	STK	SUC	BF	CRAY	RLF	RSN	WPT	MF	Totals
		From	To																
Olema Creek	2004	30-Mar	28-May	2	1	1	15	0	274	243	3,083	144	19	14	0	0	0	0	3,796
	2005	1-Apr	9-May	0	0	0	33	0	1,006	117	648	58	234	0	0	0	1	0	2,097
	2006	10-Apr	9-Jun	0	0	0	6	1	420	644	2,998	3	4	5	52	0	5	0	4,138
	2007	15-Mar	26-May	0	0	0	35	0	3,190	364	1,110	140	6	16	1	0	2	0	4,864
	2008	18-Mar	30-May	0	0	0	2	3	158	228	30	2	11	17	7	1	1	0	460
	2009	12-Mar	29-Mar	0	0	0	109	0	554	335	782	8	1	12	77	1	2	3	1,884
	2010	19-Mar	21-May	0	0	0	27	0	3,187	110	1,353	7	1	3	44	2	0	0	4,734
	2011	6-Apr	3-Jun	0	0	0	1	1	677	212	485	6	0	4	1	0	0	1	1,388
	2012	3-Apr	31-May	0	0	0	0	0	195	217	234	0	0	13	57	2	1	0	719
Total average				<1	<1	<1	29	<1	1,183	281	1,311	46	35	9	23	<1	1	<1	2,919

Species Code: CH = Chinook salmon (*O. tshawytscha*), GSF = green sunfish (*Lepomis cyanellus*, non-native), GSH = golden shiner (*Notemigonus crysoleucas*, non-native), LAM = lamprey spp. (*Lampetra* spp.), PL= Pacific lamprey, RO = California roach, SCU = sculpin spp., STK = threespine stickleback, SUC = Sacramento sucker (*Catostomus occidentalis*), BF = bullfrog (*Rana catesbeiana*, non-native), CRAY = signal crayfish (*Pacifastacus leniusculus*), RLF = California red-legged frog (*Rana draytonii*), RSN = rough-skinned newt (*Taricha granulosa*), WPT = western pond turtle (*Clemmys marmorata*), MF = mosquito fish (*Gambusia affinis*, non-native).

Table A12. Summary of non-salmonid information for Redwood Creek trap operations, 2005-2012.

Watershed	Year	Trap dates		SCU	STK	CRAY	RLF	RSN	CAN	Totals
		From	To							
Redwood Creek	2005	27-Mar	31-May	24	5,343	0	0	0	11	5,378
	2006	18-Apr	9-Jun	133	117	7	0	8	2	267
	2007	18-Mar	26-May	93	57	44	0	48	2	244
	2008	19-Mar	30-May	151	38	33	0	61	1	284
	2009	11-Mar	29-May	220	74	9	0	49	0	352
	2010	19-Mar	28-May	407	394	15	0	425	4	1,245
	2011	1-Apr	3-Jun	912	103	9	1	1,218	197	2,440
	2012	4-Apr	31-May	764	1,051	11	0	268	0	2,094
Total average				277	875	17	<0	258	31	1,459

Species Code: SCU = sculpin spp., STK = threespine stickleback, CRAY = signal crayfish (*Pacifastacus leniusculus*), RLF = California red-legged frog (*Rana draytonii*), RSN = rough-skinned newt (*Taricha granulosa*), CAN = California newt (*Taricha torosa*),

Table A13. Summary of total salmonid catch by species within Olema Creek mainstem index reach sample locations, 2004-2012. Shows variation between years and distribution within watershed.

Year	Species	Index reach								Total
		1	2	3	4	5	6	7	8	
2004	CO		186	352		295	239	175	164	1,411
	SH YOY	Not	147	231	Not	182	44	20	39	663
	SH 1+	Sampled	6	10	Sampled	26	24	10	8	84
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		123	170	233	332	217	156	160	1,391
	SH YOY	Not	112	135	241	120	51	10	36	705
	SH 1+	Sampled	9	22	16	19	15	3	8	92
2008	CO		3	42	12	22	9	7	0	95
	SH YOY	Not	113	145	181	103	40	23	2	607
	SH 1+	Sampled	3	9	13	6	4	1	1	37
2009	CO		0	0		0	0	0		0
	SH YOY	Not	11	16	Not	48	21	25	Not	121
	SH 1+	Sampled	12	19	Sampled	6	6	5	Sampled	48
2010	CO		28	9		8	10	41		96
	SH YOY	Not	91	42	Not	69	61	61	Not	324
	SH 1+	Sampled	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
2012	CO		1	0		1	0	0		2
	SH YOY	Not	84	194	Not	39	27	39	Not	383
	SH 1+	sampled	12	15	sampled	5	9	15	sampled	56

CO= coho salmon

SH= steelhead trout

YOY= young of the year

1+ = one year of age or older

Table A14. Summary of habitat composition; shows extent of area sampled and variation between reaches; Olema Creek, 2012.

Index reach	Habitat type	# of units	Length		Surface area	
			sampled (m)	% of total	Sampled (m ²)	% of total
1			Not Sampled			
	Pool	3	66.6	82.43	338.30	88.82
2	Riffle	0	0.0	0.00	0.00	0.00
	Flatwater	1	14.2	17.57	42.60	11.18
	TOTAL	4	80.8		380.90	
	Pool	2	53.2	68.12	314.24	77.23
	Riffle	1	5.0	6.40	19.50	4.79
3	Flatwater	1	19.9	25.48	73.13	17.97
	TOTAL	5	78.1		406.87	
4			Not Sampled			
	Pool	3	53.1	76.73	309.91	91.53
	Riffle	2	16.1	23.27	28.67	8.47
5	Flatwater	0	0.0	0.00	0.00	0.00
	TOTAL	5	79.2		338.58	
	Pool	3	39.8	71.84	248.02	74.76
	Riffle	0	0.0	0.00	0.00	0.00
6	Flatwater	1	15.6	28.16	83.72	25.24
	TOTAL	4	55.4		331.74	
	Pool	3	41.6	73.24	164.11	89.23
	Riffle	3	15.2	26.76	19.63	10.68
7	Flatwater	0	0.0	0.00	0.00	0.00
	TOTAL	6	56.8		183.85	
8			Not Sampled			
	Pool	14	254.3	74.73	1,374.58	83.72
	Riffle	6	36.3	10.67	67.80	4.13
Total	Flatwater	3	49.7	14.60	199.45	12.15
	TOTAL	23	340.3		1,641.83	

Table A15. Summary of total salmonid catch and density estimates for each species by reach on Olema Creek; summer 2012 illustrates variation between reaches and provides a general idea of distribution within watershed.

Index reach	Species (age)	Total catch # of fish	Fish/m	Density Fish/m ²
1		Not Surveyed		
	CO	1	0.01	0.00
2	SH YOY	84	0.96	0.25
	SH (1+)	12	0.14	0.03
	CO	0	0.00	0.00
3	SH YOY	194	2.30	0.47
	SH (1+)	15	0.18	0.04
4		Not Surveyed		
	CO	1	0.01	0.00
5	SH YOY	39	0.43	0.10
	SH (1+)	5	0.05	0.01
	CO	0	0.00	0.00
6	SH YOY	27	0.52	0.14
	SH (1+)	9	0.18	0.04
	CO	0	0.00	0.00
7	SH YOY	39	0.52	0.13
	SH (1+)	15	0.18	0.04
8		Not Surveyed		

CO= coho salmon

SH= steelhead trout

YOY= young of the year

1+ = one year of age or older

Table A16. Summary of total salmonid catch (not including Dr. Smith information) for each species by reach within Redwood Creek mainstem index reach sample locations, 2004-2012.

Year	Species	Index Reach							Total
		1	2	3	4	5	6	7	
2004	CO		42	95	74	158	71		440
	SH YOY	Not sampled	6	22	19	24	4	Not sampled	75
	SH 1+		19	8	17	15	13		72
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	3	9	0	98
	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	5	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
2012	CO	13	11	16	8	1	2		51
	SH YOY	85	79	32	84	64	22	Not Sampled	366
	SH 1+	5	16	7	17	13	7		65

CO= coho salmon

SH= steelhead trout

YOY= young of the year

1+ = one year of age or older

Table A17. Summary of habitat composition; shows extent of area sampled and variation between reaches; Redwood Creek 2012.

Index reach	Habitat type	# of units	Length		Surface area	
			sampled (m)	% of total	sampled (m ²)	% of total
1	Pool	2	21.9	20.11	63.73	16.79
	Riffle	4	67.7	62.17	232.31	61.20
	Flatwater	2	19.3	17.72	83.52	22.00
	TOTAL	8	108.9		379.56	
2	Pool	4	39.2	34.18	172.67	33.47
	Riffle	3	38.0	35.13	130.62	19.19
	Flatwater	2	37.5	32.69	192.63	37.34
	TOTAL	9	114.7		495.92	
3	Pool	3	58.1	68.84	229.89	80.74
	Riffle	3	21.2	25.12	41.31	14.51
	Flatwater	1	5.1	6.04	13.52	4.75
	TOTAL	7	84.4		284.72	
4	Pool	5	60.5	62.31	174.97	68.37
	Riffle	4	24.4	25.13	61.44	24.01
	Flatwater	1	12.2	12.56	19.52	7.63
	TOTAL	10	97.1		255.93	
5	Pool	4	66.1	74.44	318.11	81.19
	Riffle	4	24.4	25.13	61.44	24.01
	Flatwater	0	0.0	0.00	0.00	0.00
	TOTAL	8	90.5		379.55	
6	Pool	3	59.8	69.53	264.22	77.59
	Riffle	3	15.1	17.56	46.23	13.58
	Flatwater	2	11.1	12.91	30.09	8.84
	TOTAL	8	86.0		340.54	
7				Not Sampled		
Total	Pool	21	305.6	52.55	1,223.59	57.54
	Riffle	21	190.8	32.80	573.35	12.88
Total	Flatwater	8	85.2	14.65	329.18	15.48
	TOTAL	50	581.6		2,126.12	

Table A18. Summary of total salmonid catch and density estimates for each species by reach on Redwood Creek; summer 2012 illustrates variation between reaches and provides a general idea of distribution within watershed.

Index reach	Species (age)	Total catch	Density	
		# of fish	Fish/m	Fish/m ²
1	CO	13	0.15	0.05
	SH YOY	85	0.84	0.27
	SH (1+)	5	0.06	0.02
2	CO	11	0.15	0.04
	SH YOY	79	0.87	0.30
	SH (1+)	16	0.16	0.03
3	CO	16	0.12	0.04
	SH YOY	32	0.29	0.11
	SH (1+)	7	0.05	0.02
4	CO	8	0.06	0.02
	SH YOY	84	0.69	0.28
	SH (1+)	17	0.11	0.03
5	CO	1	0.01	0.00
	SH YOY	64	0.61	0.15
	SH (1+)	13	0.12	0.02
6	CO	2	0.01	0.00
	SH YOY	22	0.23	0.08
	SH (1+)	7	0.04	0.01
7	Not Sampled			

CO= coho salmon

SH= steelhead trout

YOY= young of the year

1+ = one year of age or older

Table A19. Summary of total salmonid catch for each species by reach within Pine Gulch Creek mainstem index reach sample locations, 2005-2012.

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	Not Sampled	0	0	0	0	Not Sampled	0	0	0
	SH YOY		9	22	87	147		37	53	355
	SH 1+		4	15	12	16		15	10	72
2009	CO	Not Sampled	Not Sampled	0	0	0	Not Sampled	3	0	3
	SH YOY			3	3	26		6	8	46
	SH 1+			14	7	12		5	5	43
2010	CO	Not Sampled	Not Sampled	0	0	0	Not Sampled	0	0	0
	SH YOY			18	53	52		40	22	185
	SH 1+			19	24	14		16	6	79
2011	CO	Not Sampled	Not Sampled	Not Sampled	0	0	Not Sampled	0	0	0
	SH 1+				32	42		47	38	159
	SH YOY				20	18		16	7	61
2012	CO	Not sampled	Not Sampled	Not Sampled	0	0	Not sampled	0	0	0
	SH YOY				19	37		18	28	46
	SH 1+				25	24		16	23	43

CO= coho salmon

SH= steelhead trout

YOY= young of the year

1+ = one year of age or older

Table A20. Summary of habitat composition; shows extent of area sampled and variation between reaches; Pine Gulch Creek, 2012.

Index reach	Habitat type	# of units	Length		Surface area	
			sampled (m)	% of total	Sampled (m ²)	% of total
1a			Not Sampled			
1b			Not Sampled			
1c			Not Sampled			
	Pool	3	47.9	93.37	205.50	97.58
	Riffle	1	3.4	6.63	5.10	2.42
2	Flatwater	0	0.0	0.00	0.00	0.00
	TOTAL	4	51.3		210.50	
	Pool	2	27.8	47.28	70.81	43.76
	Riffle	1	18.8	31.97	32.43	20.04
3	Flatwater	1	12.2	20.75	58.56	36.19
	TOTAL	4	58.8		161.80	
4			Not Sampled			
	Pool	2	38.2	65.75	94.17	68.24
	Riffle	2	7.4	12.74	17.16	12.43
5	Flatwater	1	12.5	21.51	26.67	19.32
	TOTAL	5	58.1		138.00	
	Pool	5	55.7	82.15	156.22	88.32
	Riffle	2	12.1	17.85	20.66	11.68
6	Flatwater	0	0.0	0.00	0.00	0.00
	TOTAL	7	67.8		176.88	
	Pool	12	169.6	71.86	551.40	77.45
	Riffle	6	41.7	17.67	75.35	10.58
Total	Flatwater	2	24.7	10.47	85.23	11.97
	TOTAL	20	236.0		711.98	

Table A21. Summary of total salmonid catch and density estimates for each species by reach on Pine Gulch Creek, summer 2012; illustrates variation between reaches and provides a general idea of distribution within watershed.

Index reach	Species (age)	Total catch # of fish	Density	
			Fish/m	Fish/m ²
1a		Not Sampled		
1b		Not Sampled		
1c		Not Sampled		
	CO	0	0.00	0.00
2	SH YOY	19	0.36	0.09
	SH (1+)	25	0.42	0.10
	CO	0	0.00	0.00
3	SH YOY	37	0.75	0.24
	SH (1+)	24	0.37	0.14
4		Not Sampled		
	CO	0	0.00	0.00
5	SH YOY	18	0.19	0.08
	SH (1+)	16	0.19	0.08
	CO	0	0.00	0.00
6	SH YOY	28	0.39	0.15
	SH (1+)	23	0.30	0.09

CO= coho salmon; SH= steelhead trout; YOY= young of the year; 1+ = one year of age or older

Appendix B. Julian Week Numbers

Table B1. List of Julian weeks and their calendar equivalents in a leap year.

Julian week number	Inclusive dates	Julian week number	Inclusive dates
1	Jan 01 - Jan 07	27	Jul 01 - Jul 07
2	Jan 08 - Jan 14	28	Jul 08 - Jul 14
3	Jan 15 - Jan 21	29	Jul 15 - Jul 21
4	Jan 22 - Jan 28	30	Jul 22 - Jul 28
5	Jan 29 - Feb 04	31	Jul 29 - Aug 04
6	Feb 05 - Feb 11	32	Aug 05 - Aug 11
7	Feb 12 - Feb 18	33	Aug 12 - Aug 18
8	Feb 19 - Feb 25	34	Aug 19 - Aug 25
9	Feb 26 - Mar 03	35	Aug 26 - Sep 01
10	Mar 04 - Mar 10	36	Sep 02 - Sep 08
11	Mar 11 - Mar 17	37	Sep 09 - Sep 15
12	Mar 18 - Mar 24	38	Sep 16 - Sep 22
13	Mar 25 - Mar 31	39	Sep 23 - Sep 29
14	Apr 01 - Apr 07	40	Sept 30 - Oct 06
15	Apr 08 - Apr 14	41	Oct 07 - Oct 13
16	Apr 15 - Apr 21	42	Oct 14 - Oct 20
17	Apr 22 - Apr 28	43	Oct 21 - Oct 27
18	Apr 29 - May 05	44	Oct 28 - Nov 03
19	May 06 - May 12	45	Nov 04 - Nov 12
20	May 13 - May 21	46	Nov 13 - Nov 17
21	May 20 - May 26	47	Nov 18 - Nov 24
22	May 27 - Jun 02	48	Nov 25 - Dec 01
23	Jun 03 - Jun 09	49	Dec 02 - Dec 08
24	Jun 10 - Jun 16	50	Dec 09 - Dec 15
25	Jun 17 - Jun 23	51	Dec 16 - Dec 22
26	Jun 24 - Jun 30	52	Dec 23 - Dec 29
		53	Dec 30 - Dec 31

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