

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

Adult Salmon Escapement Monitoring Summary 2010-2011

Prepared for:

California Department of Fish and Game
P0830407



ON THE COVER

Female coho salmon on Redwood Creek in Muir Woods, 2010-2011 spawner season.

Photograph by: Jessica Weinberg

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

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

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

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Abstract

The National Park Service has conducted adult salmon escapement surveys in Marin County watersheds since 1994, wherein the adult salmon that survive their time in the ocean and successfully return to their natal streams for reproduction are observed and counted. 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. National Park Service results show that these watersheds have supported annual runs of coho salmon ranging from less than 10 to more than 200 individuals. With the exception of Redwood Creek, results of 2010-2011 coho escapement indicate a much lower return than expected for this cohort. Results indicate that this is the 5th consecutive year of reduced spawning for most coho bearing streams in West Marin.

The primary spawner season (November through January) showed above-average rainfall, with the first series of heavy storms occurring in November, and December receiving a total of 12.28 inches. A total of 29 live coho and eight carcasses were observed during 11 Olema Creek mainstem surveys, resulting in a Peak Live plus cumulative Dead index (PLD) of 15. A total of 13 redds were observed during these surveys. This represents a 32% decline in redd numbers for the Spawner Year (SY) 2010-2011 cohort compared to SY 2007-2008 when the cohort was previously observed. John West Fork, a tributary to Olema Creek, had a total of 37 live coho and four carcasses observed during the 12 surveys performed, resulting in a PLD of 11. A total of eight redds were also observed on John West Fork. No spawning activity was observed on any of the other tributaries in the watershed. In total 21 redds were observed in the Olema Creek watershed, which takes into account John West Fork and smaller tributaries, representing a decline of 20% from the 2007-2008 spawner season.

A total of 11 live adult coho and one coho carcass were observed on Redwood Creek during 11 spawner surveys resulting in a PLD of 6. Three redds were observed during the Redwood Creek surveys. Overall, Redwood Creek showed a 50% increase in coho redds for the 2010-2011 cohort when compared to the previous return in 2007-2008. While no redds were observed during SY 2007-2008, observations of juveniles during later surveys indicated the presence of 1-2 redds for that year. With the continuing poor returns of Cohort 2 (SY 2010-2011) and Cohort 3 (SY 2008-2009), Cohort 1 (SY 2009-2010) is left as the strongest cohort when compared to the average from the past 13 years of monitoring.

On Pine Gulch, no coho spawners or redds were detected, however very limited spawning activity was observed in SY 2007-2008 and no juvenile coho were observed during summer surveys in 2008. Therefore, very limited returns for this cohort were expected. SY 2010-2011 marks the first spawning absence observed in this cohort since re-colonization was first documented in SY 2000-2001 (Cohort 1). No coho spawning activity was observed on Cheda Creek in SY 2010-2011. This is the first spawner season for Cohort 2 on Cheda Creek without observed coho spawning activity since the completion of a fish passage improvement project in 2000.

Acknowledgments

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We also wish to thank the numerous volunteers who helped us with the fieldwork during winter 2010-2011. In particular, we would like to thank our 2010-2011 reach leaders Richard James, Julie Litwin, NoahLani Litwinsella, and Peter Van der Naillen for their dedication and flexibility throughout the year.

1- Introduction

Annually, spawner surveys are conducted in watersheds within and adjacent to San Francisco Bay Area Network (SFAN) Park units, including Point Reyes National Seashore (PORE), Golden Gate National Recreation Area (GOGA), and Muir Woods National Monument (MUWO). These surveys concentrate primarily on federal and state endangered central California coast Evolutionarily Significant Unit (CCCESU) coho salmon (*Oncorhynchus kisutch*) and federally threatened Central Coast Distinct Population Segment (DPS) steelhead (*O. mykiss*). The spawner surveys, which focus on adult returns, are part of a monitoring program that covers three distinct life stages within the coho life cycle. When combined with surveys which focus on out-migrating smolts during the spring and coho juveniles in the summer, the adult salmon escapement surveys are a critical part of the over-all population monitoring program as it provides data for interpreting long term trends in distribution and abundance within the region. The watersheds within Coastal Marin County and summarized in this report, including Olema Creek, Cheda Creek, Redwood Creek, and Pine Gulch Creek (Figure 1) are considered to support some of the most southerly populations of coho salmon.

The National Park Service (NPS) has conducted adult salmon escapement surveys in Marin County watersheds since 1994. This research is conducted under the Endangered Species Act Section 10 Permit #1046 Modification 2 authorization managed by the National Marine Fisheries Service. Funding to support monitoring activities was provided through the NPS - SFAN Inventory and Monitoring (I&M) Program and the California Department of Fish and Game (CDFG) Fisheries Restoration Grant Program Contract P0830407.

National Park Service results show that these watersheds have supported annual runs of coho ranging from less than 10 to more than 200 individuals. This report presents the summary information of coho salmon adult escapement results for the 2010-2011 spawning season for Olema Creek, Redwood Creek, Pine Gulch Creek, and Cheda Creek.

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 much as 46% of California's coho salmon populations have been extirpated from their watersheds (Brown et al. 1994).

Coho salmon were listed as a threatened species within the CCCESU on October 31, 1996 by the National Marine Fisheries Service (NMFS) (Federal Register 1996). In their 2001 Status Review, NMFS acknowledged that within the CCCESU, the decision to list coho salmon as threatened may have been overly optimistic, concluding that the CCCESU population was presently in danger of extirpation (NMFS 2001). As a result of these and further findings, NOAA-Fisheries completed a rulemaking process on June 28, 2005, which downgraded the coho status (upgraded listing protection) in the CCCESU to endangered (Federal Register 2005).

In association with the coho threatened listing NMFS designated critical habitat for coho salmon on May 5, 1999 (Federal Register 1999). The critical habitat is designated to include all river reaches accessible to listed coho salmon in the CCCESU. Excluded are areas above specific

dams or above longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years).

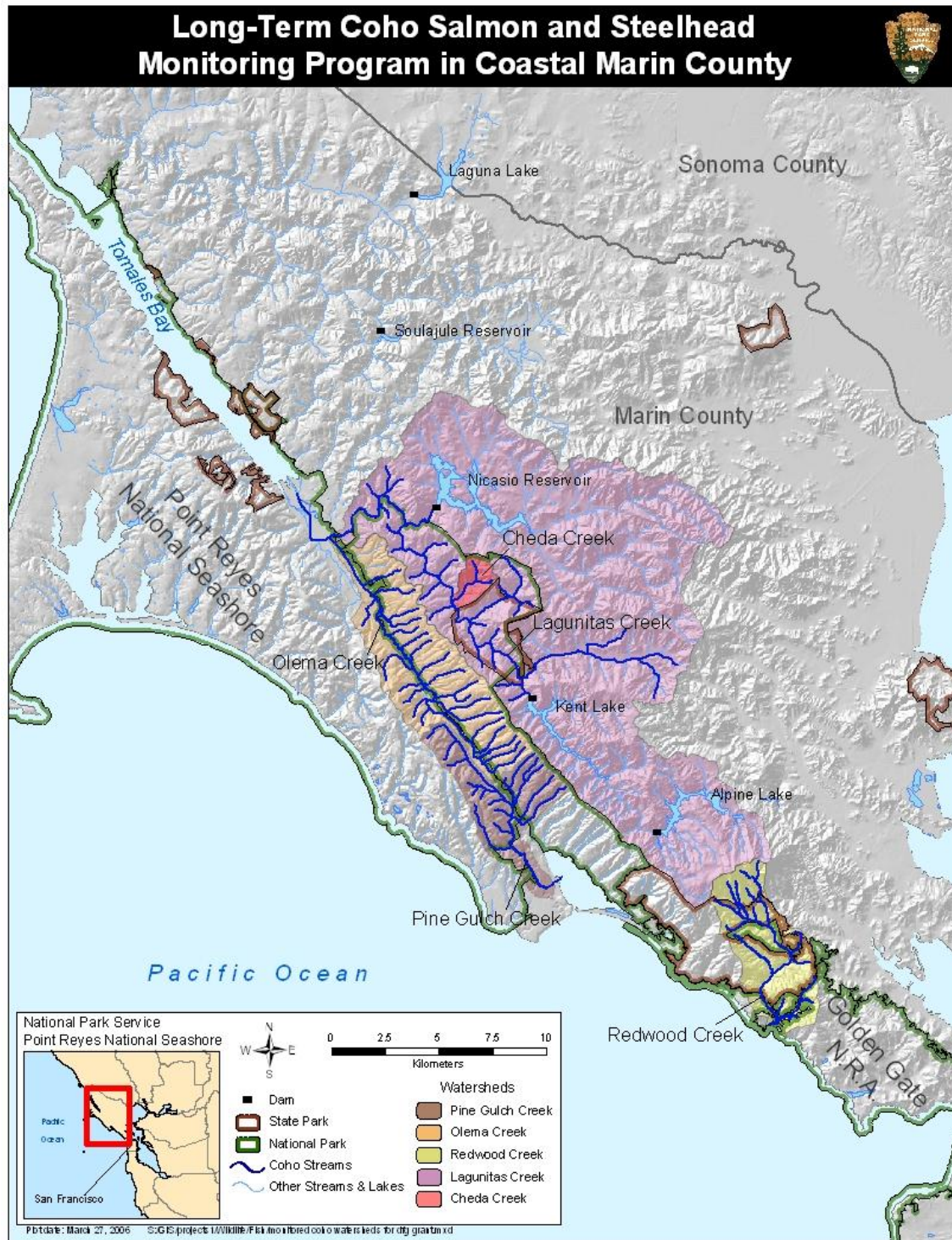


Figure 1. Map of streams in Marin County that support coho salmon. The National Park Service monitors streams in Point Reyes National Seashore (Olema and Pine Gulch Creeks) and Golden Gate National Recreational Area (Redwood and Cheda Creeks).

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

1.1.1 Introduction and History

There is a long history of adult spawner observations in the project watersheds. Muir Woods National Monument staff began recording spawning fish observations on portions of Redwood Creek in 1944. Infrequent surveys were performed by the CDFG and local visitors from 1969 to 1986. In 1993, GOGA and PORE biologists initiated more detailed surveys on Redwood Creek and assisted the Tomales Bay Association with surveys on Olema Creek. Systematic monitoring within the SFAN watersheds was initiated beginning in spawner year (SY) 1996-1997.

The original listing criteria for coho salmon stated that the Lagunitas/Olema Creek population accounted for more than 10% of the wild coho population (Brown et al 1994) in the CCCESU. Recent research through the NPS, Marin Municipal Water District (MMWD), and Salmon Protection and Watershed Network (SPAWN) has shown that the Lagunitas population likely represents more than 20% of the CCCESU population.

The Coho and Steelhead Monitoring Program (CSMP) was initiated in 1997 and continued the work began by the Tomales Bay Association and previous NPS biologists with comprehensive surveys of Olema Creek, Redwood Creek, and Cheda Creek (a Lagunitas Creek tributary). Spawner surveys in Pine Gulch documented the return of coho during the winter of 2000-2001. In 2003, the fisheries monitoring efforts were incorporated into the SFAN Stream Aquatic Monitoring Program.

The patterns represented in our monitoring data suggest regional influences on the coho salmon escapement observed over the past decade. 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. Coho escapement within Marin County watersheds were on an upward trend after the 1997-1998 El Niño Southern Oscillation (ENSO) event likely triggered by the Pacific Decadal Oscillation (PDO), shifting the dominant productivity from the Alaska Current to the California Current in the late 1990s (McClatchie, et al.2008). Between winter 1999-2000 and 2004-2005, all three coho cohorts in coastal Marin watersheds showed strong increases in response to increased ocean productivity patterns, including the return of coho salmon to the Pine Gulch Creek watershed in winter 2000-2001. The last five years have represented reduced salmon escapement results from previous cohorts for most of the creeks surveyed, with three of the last four spawning seasons (SY 2007-2008, SY 2008-2009, and SY 2009-2010) showing >75% declines from previous returns. The exceptions to this trend were Redwood Creek in SY 2009-2010 and SY 2010-2011, where no decline or a slight increase in redd production was observed.

Based on 17 years of monitoring data, the SY 2008-2009 cohort (Cohort 3) represented the return of the weakest cohort to the coastal Marin watersheds, in that returns were only 8.5% of the average. The past three generations of this cohort had represented low watershed coho escapement results. The 2007-2008 spawner season (Cohort 2) also had extensive declines in coho escapement across the CCCESU (MacFarlane et. al. 2008), declines which were observed again in SY 2010-2011 for Olema Creek, although not as dramatic as those seen in SY 2007-2008. Even those creeks that did not see a decline had low numbers when compared to historical returns.

1.2 Monitoring Objectives

This 2010-2011 Coho Escapement Monitoring Program Summary addresses Objective 1:

Conduct winter surveys at Olema, Pine Gulch, Redwood, and Cheda Creeks by counting numbers of spawners, carcasses, and redds along spawner reaches to determine long-term trends in distribution and abundance, size (length) of spawning coho salmon within the reaches.

1.3 Watershed Overview

1.3.1 Lagunitas Creek

Lagunitas Creek and its tributaries (Nicasio Creek, San Geronimo Creek, Devil's Gulch, Cheda Creek, Bear Valley Creek, and Olema Creek) drain more than 88 mi² (230 km²) of western Marin County. The headwaters of the Lagunitas Creek mainstem lay within the 53,000 ha watershed lands administered by 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 Creek 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. Two important salmon supporting tributaries of Lagunitas Creek, Olema Creek and Cheda Creek, lay entirely within NPS lands.

1.3.2 Olema Creek

Olema Creek, a major tributary to Lagunitas 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 14.5 mi² (37.56 km²) watershed is primarily contained within the boundaries of PORE and the GOGA North District.

Review of sixteen years of salmon escapement data for Olema Creek shows that run timing and strength is similar to that observed on Lagunitas Creek. Results differ between Lagunitas and Olema Creeks in years when the unregulated flows on Olema Creek are much lower than

Lagunitas Creek for the same time period. While the mouth of the creek flows to the estuarine portion of Lagunitas Creek and Tomales Bay, minimum flows to attract fish into Olema Creek are approximately 25 cfs. In years where winter rains are minimal and these flows are not achieved, Olema Creek fish may wait near the mouth, or eventually choose to migrate into Lagunitas Creek.

1.3.3 Cheda Creek

Cheda Creek is a small but important tributary of the Lagunitas Creek watershed and provides critical habitat for steelhead and coho salmon. Past land-use within the Cheda Creek drainage has resulted in serious alterations to the natural hydrologic and riparian condition 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.

1.3.4 Redwood Creek

Redwood Creek is a 7.5 mi² (19.4 km²) coastal watershed in southern Marin County, California. Redwood Creek flows southwest from the flanks of Mt Tamalpais, through MUWO, discharging to the Pacific Ocean through Big Lagoon at Muir Beach, CA. Protected from development, the watershed is primarily contained within the boundaries of Mt Tamalpais State Park, GOGA, and MUWO.

Review of the sixteen years of salmon escapement monitoring information on Redwood Creek indicates that run timing is highly dependent on the rainfall-runoff condition within the watershed. Redwood Creek is an unregulated stream with variable environmental conditions that limit flows in the winter season. The outlet is controlled by an ocean built sand bar at Muir Beach. Entry for salmon into Redwood Creek is constrained by the presence of a sand bar at the mouth of the watershed. Adult coho salmon upstream migration coincides with brief peak winter discharges, typically peaking in January (Weitkamp et.al. 1995).

1.3.5 Pine Gulch Creek

Pine Gulch Creek drains a 7.5 mi² (19.4 km²) watershed in coastal Marin County, California, and is the primary freshwater input to Bolinas Lagoon. 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 that 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 recovery of a coho carcass, and subsequent documentation of coho juveniles in the watershed the following summer (Brown and Ketcham 2002). Monitoring indicates that all three coho cohort cohorts were present within Pine Gulch Creek from 2001 to 2006 (Ketcham and Brown 2003, Del Real et al. 2007). On Pine Gulch, population and detection levels are still too low to make inferences on cohort trends.

2 - Sampling Design and Methods

Field and analytical methods used for this report are documented in Standard Operating Procedures 5, 6, 8, 9, 10, and 11 of the Salmonid Monitoring Protocol for the SFAN (Reichmuth et al. 2010). National Park Service staff and trained volunteers conduct surveys each winter during the coho spawning season to quantify salmon escapement and determine spawning density and distribution. Although surveys focus on coho, steelhead spawners and redds are also observed and counted during the surveys. Surveys are spaced 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 reaches, along creek margins and banks where possible.

Live fish, carcasses, and redds are documented along the entirety of the survey. 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. The genetic analyses using these tissue samples are performed by researchers at the NMFS Genetics Laboratory in Santa Cruz, CA. Scale samples are only collected from fresh (both eyes are still clear) carcasses that have not been mauled by scavengers. Age analyses using these scale samples are performed by researchers at UC Berkeley. Redds are measured and marked with flagging. Redd monitoring is targeted as they are stationary and can be monitored over time to determine spawning success. In northern California, it was determined that redd counts are a reliable indices of escapement when compared to estimates derived from an adult counting weir (Gallagher et al 2010). These estimates are derived from redd measurements currently collected through the monitoring protocol.

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.

Coho typically return to spawn over a one to three-month period from November through early February (weather dependent). As residence time on the spawning grounds is variable, live fish may be double counted during repeated surveys. Reported spawning salmon escapement estimates are made using the Peak Live plus cumulative Dead (PLD) index. This index 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 estimate. Carcass information is also used to calibrate observer length and sex estimates. Redd counts are used to describe spawning density and spatial distribution. Where survey frequency is adequate, reporting will include salmon escapement estimates using the Area Under the Curve (AUC) method (Irvine et al. 1992).

2.1 Site selection

Watersheds that are part of the adult salmon escapement monitoring program include Olema, Pine Gulch, Redwood and Cheda Creeks. These watersheds are primarily or wholly within the NPS legislative boundaries. Salmonids in these watersheds are not monitored by other entities,

therefore collection of these watershed data are important for park managers. Spawner surveys have been conducted on many of these watersheds since the early to mid-1990s.

2.2 Number and location of sampling sites

2.2.1 Olema Creek

A large section of the mainstem of Olema Creek, 17.6 km, has been surveyed since 1993. The mainstem is divided into seven survey reaches starting one kilometer above the confluence with Lagunitas Creek and ending at the Highway 1 culvert at milepost 19.94. Reaches are delineated to facilitate sampling based on access, length, and the existence of permanent landmarks for reach boundaries (Figure 2). The existing seven reaches extend from:

1. One kilometer above the confluence with Lagunitas Creek to the Bear Valley Road Bridge in the town of Olema (1.6 km).
2. The Bear Valley Bridge to the confluence with Truttman Creek (3.2 km).
3. Truttman Creek to the horse trail crossing at the Stewart Ranch (2.6 km).
4. Stewart Ranch to the first Hwy. 1 bridge at Five Brooks (1.3 km).
5. Five Brooks to the abandoned Lime Kilns (2.8 km).
6. The Lime Kilns to the abandoned Randall ranch House (1.7 km).
7. The Randall House to the Hwy. 1 culvert at milepost 19.94 (4.1 km).

In addition to the mainstem of Olema Creek, surveys are often conducted on some of the larger tributaries. John West Fork, the largest tributary of Olema Creek, is documented to support significant numbers of spawning salmon and is surveyed on the same day as the Olema Creek mainstem reaches. Complete surveys on other tributaries are conducted as personnel and flow conditions allow. For each tributary, surveys start at the mouth and generally continue upstream as long as no passage barriers exist. The tributaries are named in Figure 2 and listed in order from downstream to upstream:

1. Quarry Gulch located close to the Olema Cemetery 4.1 km above the mouth of Olema Creek at Hwy. 1 milepost 25.35.
2. Boundary Gulch located 8.3 km above the mouth of Olema Creek at Hwy. 1 milepost 24.30.
3. Horse Camp Gulch located 9.6 km above the mouth of Olema Creek at Hwy. 1 milepost 23.26.
4. Giacomini Gulch located 10.8 km above the mouth of Olema Creek at Hwy. 1 milepost 22.78.
5. John West Fork located 10.9 km above the mouth of Olema Creek at Hwy. 1 milepost 22.67 (survey reach from trib. mouth to 2 km upstream).

2.2.2 Redwood Creek

Since 1994, the NPS has conducted annual surveys along a 6.7 km section of the mainstem of Redwood Creek (Figure 3) between a point 140 m below the Pacific Way Bridge and 500 m above Bridge 4 in MUWO. To facilitate sampling, the section is divided into three reaches;

1. Pacific Way Bridge to the Kent Creek confluence in Mt. Tamalpais State Park (2.7 km),
2. Kent Creek confluence to Bridge 1 in MUWO (2.4 km) and,
3. Bridge 1 to 500 m above Bridge 4 (1.6 km) in Mt. Tamalpais State Park.

Portions of Fern and Kent Creeks, the two largest Redwood Creek tributaries, are also surveyed. The reach on Kent Creek extends upstream 1 km from the confluence to an impassable waterfall. The Fern Creek section extends 1 km upstream from the confluence to a series of steep cascades.

2.2.3 Pine Gulch Creek

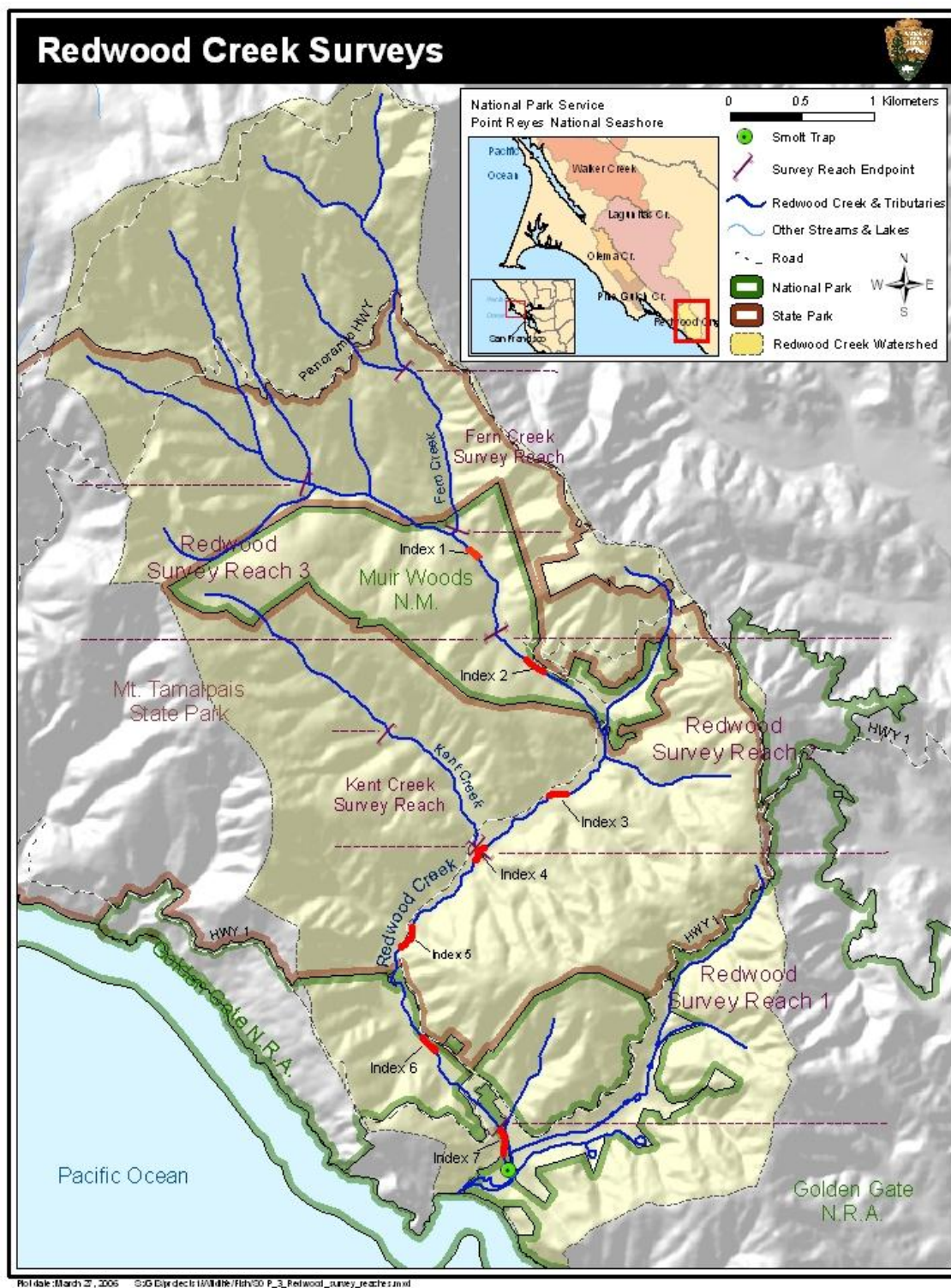
Since 1997, the NPS has conducted adult salmon surveys along a 9 km section of the mainstem of Pine Gulch Creek. Coho salmon were first spotted during surveys in the winter of 2000-2001. Due to private property access issues and the nature of the watershed, the survey reaches are longer than normal (Figure 4). This requires a solid day to conduct the survey with two teams. The spawner surveys start at the Olema-Bolinas Road Bridge and extend upstream to at-least the Teixeira Ranch. Complete surveys should extend up the mainstem to the Pacific Coast Learning Center/Hagmaier complex. The section encompasses most of the stream length that would be potentially used by coho salmon.

Currently sampled reaches include:

1. Olema-Bolinas Road Bridge to the Copper Mine Gulch confluence (6.0 km).
2. Copper Mine Gulch confluence to upstream beyond Teixeira to approximately monument marker 100 (3.5 km).

2.2.4 Lagunitas Creek Watershed - Cheda Creek

Cheda Creek (Figure 5), a Lagunitas Creek tributary, has been surveyed since 1996-1997 to detect the presence or absence of coho. The NPS completed a fish passage 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 below the fish passage improvement and 0.5 km reach above.



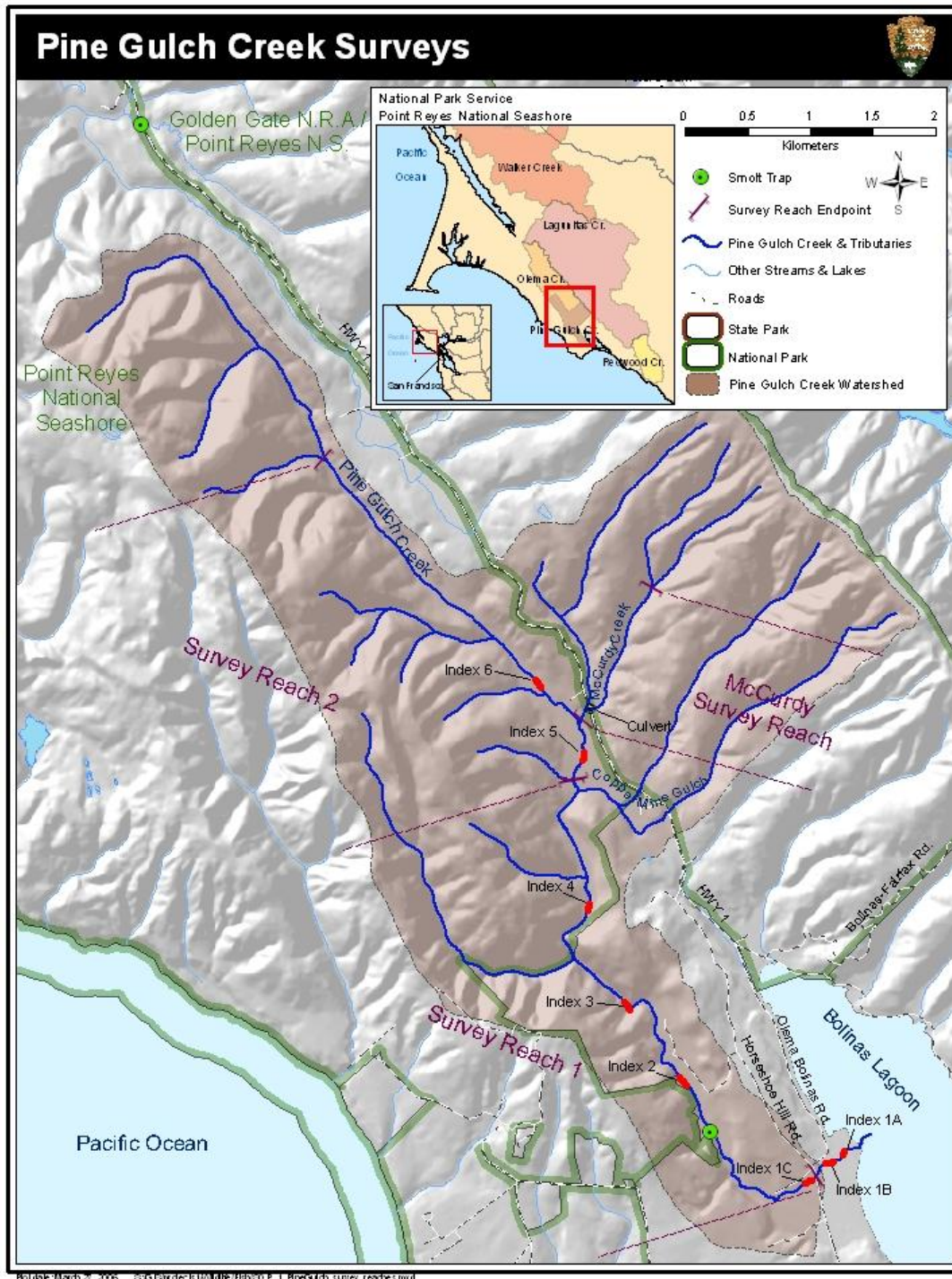


Figure 4. Pine Gulch Creek spawner survey reach map.

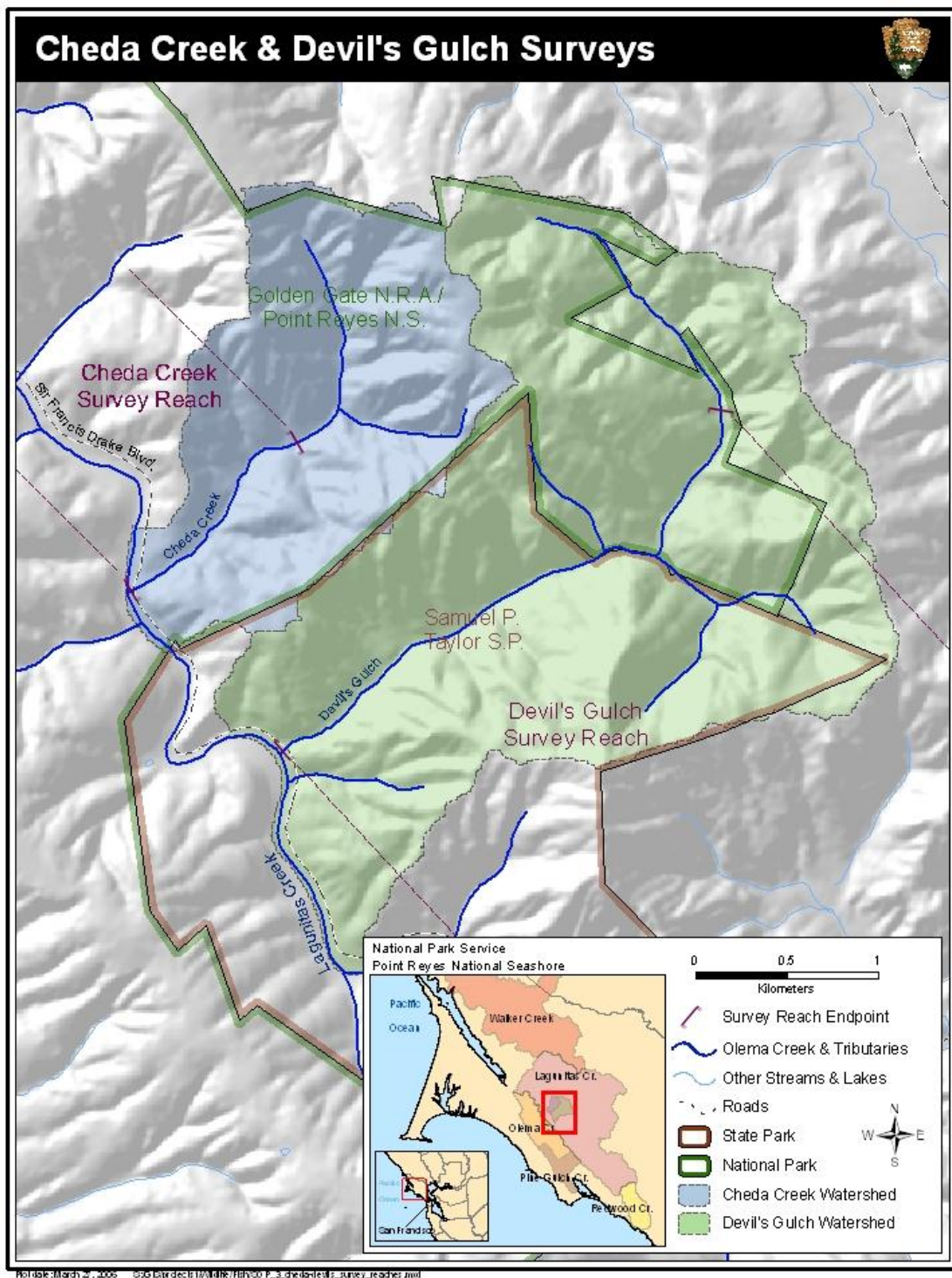


Figure 5. Cheda Creek spawner survey reach map.

2.3 Recommended frequency and timing of sampling

Adult escapement sampling duration is driven by both stream flow and visibility conditions. In these unregulated watersheds, adequate flows facilitating salmon access to the watersheds occur between November and January. The typical spawning season for coho is late November into early February, while steelhead typically enter the watersheds between January and April. Within our unregulated watersheds, spawner response is concentrated around storm events related to flow or freshet events.

Based on female redd residency times, watersheds should be surveyed weekly to accurately capture redd timing (Burton et al. 2002; van den Berghe and Gross 1986). Surveys are confounded by environmental factors (stream discharge and turbidity), and are often less frequent.

2.4 Routine data summaries and statistical analyses to detect change

The analysis of spawner survey data is complicated by annual variability in environmental conditions and run characteristics. Because accurate abundance estimates are difficult to generate without counting weirs or other intensive sampling techniques (Irvine et al. 1992), the NPS salmonid monitoring program uses an escapement index and estimating technique, in addition to cumulative redd counts to estimate adult coho salmon abundance. The Peak Live plus cumulative Dead (PLD) index and Area Under the Curve (AUC) estimate are used to compute coho salmon escapement values (Beidler and Nickelson 1980; Johnston et al. 1987). In addition to calculating these indices, live fish, redd, carcass, and environmental data are summarized for each stream.

The PLD and AUC estimates provide different types of information. While the PLD index produces a minimum estimate based on the spawning peak, the AUC method is used to calculate a total population estimate. 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 (residence time). The AUC is calculated by plotting the live fish observations for each survey, producing a quantity termed “total fish-days”. The area under the curve is given by:

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

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 residence time gives the population estimate. AUC estimates were computed using the range of residence time values, 8 to 17 days, presented in the literature (Moring and Lantz 1975; Johnston et al. 1987; Irvine et al. 1992). Data collection typically stops after repeated surveys no longer indicate the presence of live coho. High flows often prevent staff from conducting surveys during significant portions of some spawner seasons.

The PLD index 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. Redd count and location is used to describe spawning density, spatial distribution, success, and can also be used as a measure of salmon escapement.

3 - Results

Returns on Redwood Creek were higher than observations in 2007-2008, the last time this cohort was observed spawning, but were lower than 2007-2008 on Olema Creek. No coho spawning was observed on either Pine Gulch Creek or Cheda Creek.

3.1 SY 2010-2011 Rainfall Totals – Bear Valley Headquarters

The 2010-2011 spawner season had above average rainfall in all months with the exception of January. The first pulse of rain came in late October, which had a higher than average monthly rainfall in 2010. November was also higher than average, while December was close to twice the historical mean (Table 1).

Early storms allowed coho access into the mainstems of the creeks throughout their normal spawning window. Strong storms in late December and February, however, could have destroyed or damaged redds created earlier in the season. On surveys late in the season, previously noted redds were often flattened, filled in, or no longer visible.

Table 1. Average monthly and yearly rainfall (inches) at Bear Valley Headquarters, Water Years 1965-2010 compared with Water Year 2011. Each Water Year accounts for rainfall from October through September. Average monthly rainfall presented below encompasses the entire coho spawning season.

	Total	Oct	Nov	Dec	Jan	Feb	Mar
Average	38.62	2.16	4.94	6.85	8.45	6.55	4.96
Min	15.03	0.00	0.61	0.01	0.49	0.47	0.24
Max	79.84	6.82	18.20	17.33	22.39	24.68	15.02
SY 2010-2011	53.72	5.76	5.21	12.28	2.09	6.97	14.30

3.2 Olema Creek Adult Coho Escapement – SY 2010-2011

3.2.1 Survey Timing and Environmental Conditions

With strong storms in late October, the first survey was performed on 4 November 2010 on the lower four reaches of Olema Creek. Eleven surveys were conducted in Olema Creek between 4 November 2010 and 3 February 2011 (Table 2). The mean interval between surveys was 8.1 days. Seven day rainfall totals during Julian weeks ranged from a low of 0.01 in during Julian weeks 46 and 4 and a high of 4.91 in during Julian week 51. Water clarity encompassing several reaches for a given survey day was calculated by averaging the clarity values obtained from those reaches surveyed on that day. Average water clarity at the time of each survey ranged from 43 cm to 107 cm. The onset of rainfall and subsequent higher flows appeared to be related to live fish observations (Figure 6).

Twelve surveys were conducted on John West Fork tributary (reaches 1-2) between 30 November 2010 and 20 January 2011 (Table 2). Seven of the 12 surveys were conducted on the same day as the Olema Creek mainstem surveys. The mean interval between surveys was 5.6 days. Seven day rainfall totals during Julian weeks ranged from a low of 0.04 in during Julian week 3 and a high of 4.91 in during Julian week 51. Average water clarity at the time of surveys ranged from 40 cm to 100 cm.

In addition to John West Fork, four other tributaries to the Olema mainstem were surveyed in December and January. The timing of tributary surveys generally preceded the mainstem surveys and were dependent on flow. Sections of Giacomini Gulch, Horse Camp Gulch, Boundary Gulch, and Quarry Gulch were surveyed.

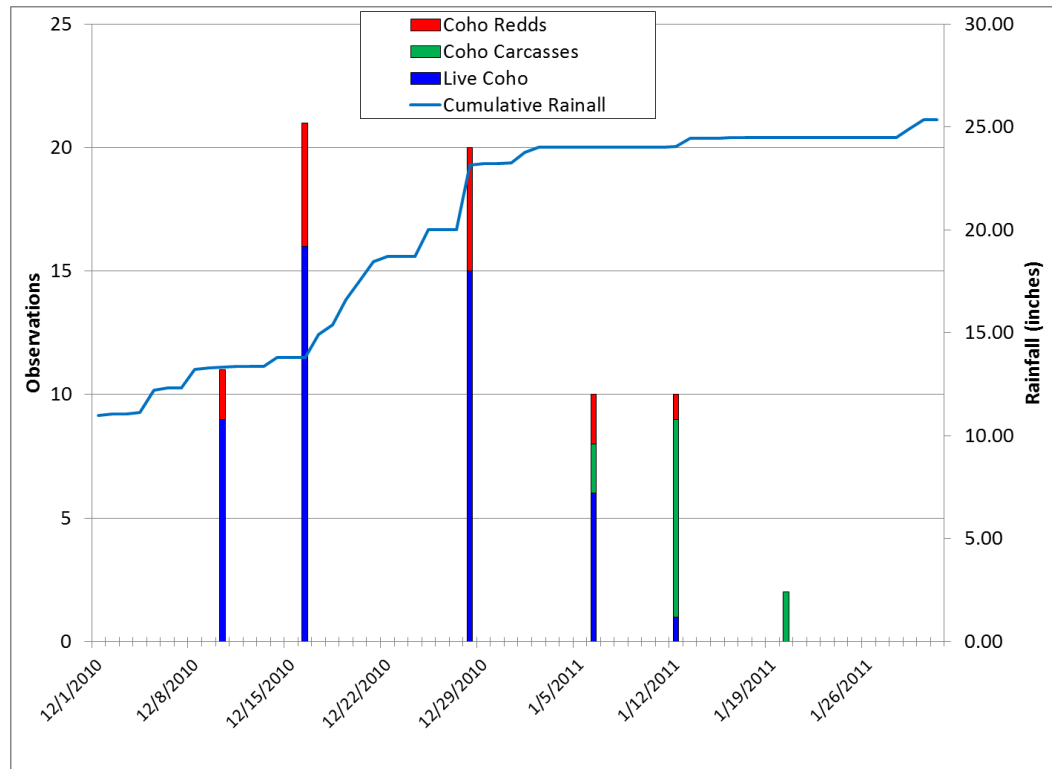


Figure 6. Representation of daily cumulative rainfall totals for Water Year 2011, starting October 2010, and coho adult escapement survey results on Olema Creek watershed, including live fish and redds, observed during surveys in 2010-2011.

Table 2. Seven day total rainfall per Julian week, average water clarity, and the number of coho redds, coho carcasses, and live coho observed in 2010-2011 on Olema Creek. Parentheses denote more than one survey conducted within one Julian week.

Julian Week	Survey Date	Survey Reaches	Calendar Day	7 Day Rainfall during Julian Week (in)	Average Survey Water Clarity (cm)	Coho Redds	Coho Carcass	Live Coho
43				4.90				
44	4 Nov 10	1-4	308	0.67	95	0	0	0
45				1.89				
46	18 Nov 10	1-3	322	0.01	107	0	0	0
47	23 Nov 10	1-4	327	2.13	68	0	0	0
48	30 Nov 10	2-6, JWF	334	1.26	68	0	0	0
49	6 Dec 10	JWF	340	2.22	50	0	0	0
(49)	9 Dec 10	JWF	343	(2.22)	40	0	0	0
50	10 Dec 10	2-5, JWF	344	0.53	43	2	0	9
(50)	16 Dec 10	2-6, JWF	350	(0.53)	70	7	0	16
51	21 Dec 10	JWF	355	4.91	45	2	0	4
(51)	23 Dec 10	JWF	357	(4.91)	50	1	0	9
52	28 Dec 10	3-6, JWF	362	4.53	43	5	0	15
1	3 Jan 11	JWF	3	0.77	40	1	1	6
(1)	6 Jan 11	2-6, JWF	6	0.77	55	2	2	6
2	12 Jan 11	2-6, JWF	12	0.43	84	1	8	1
3	20 Jan 11	2-5, JWF	20	0.04	94	0	2	0
4				0.01				
5	3 Feb 11	1-5	34	0.85	93	0	0	0

Reach 1: One kilometer above the confluence with Lagunitas Creek to the Bear Valley Road Bridge in the town of Olema

Reach 2: Bear Valley Bridge to the confluence with Truttman Creek (3.2 km).

Reach 3: Truttman Creek to the Davis-Boucher Creek confluence at the Stewart Ranch (2.6 km).

Reach 4: Steward Ranch to the Hwy 1 bridge at 5 Brooks (1.3 km).

Reach 5: Five Brooks to the abandoned Lime Kilns (2.8 km).

Reach 6: The Lime Kilns to the abandoned Randall ranch house (1.7 km).

JWF: John West Fork tributary, confluence with Olema Creek to tag OL-12-20 (2.0 km).

3.2.2 Live Fish (Coho)

A total of 29 live adult coho were observed during 11 surveys on the Olema Creek mainstem between November and February and 37 live adult coho were observed during 12 surveys on John West Fork tributary between December and February. The first fish on both Olema Creek mainstem and John West Fork were observed on 10 December.

Four additional tributaries to the Olema mainstem (Quarry Gulch, Boundary Gulch, Horse Camp Creek, and Giacomini Creek) were surveyed during December and January. One adult was observed on Horse Camp Gulch on 21 December, but no subsequent coho spawning activity was observed in any of the tributaries.

3.2.3 Live Fish (Steelhead)

Observations of steelhead are recorded in the same fashion as live adult coho. Actual live adult steelhead counts are assumed to be higher than the observed counts. No live adult steelhead were observed during the 2010-2011 spawner surveys on Olema Creek or any of its tributaries. One

unknown adult salmonid was observed on Reach 1 on 2 February but could not be positively identified as either a steelhead or a coho.

3.2.4 Carcasses (Coho)

Nine confirmed coho carcasses were recovered on the mainstem of Olema Creek during the 2010-2011 spawner season. In partnership with a fisheries research lab in UC Berkeley's Department of Environmental Science, Policy and Management, otoliths were extracted from four of the nine carcasses and were sent for analysis. The information obtained from studying the otoliths from a particular fish include: species, age, diet, time of ocean entry, and natal stream. Four coho carcasses were observed on John West Fork, with otoliths sampled from one of the four.

3.2.5 Carcasses (Steelhead)

No steelhead carcasses were observed on either Olema Creek mainstem or on the Olema Creek tributaries.

3.2.6 Redds (Coho)

Thirteen confirmed coho redds were observed in the mainstem of Olema Creek and eight confirmed coho redds were observed on John West Fork during the 2010-2011 season. Coho redds were found on reaches 2-6 on the mainstem and on reaches 1-2 of John West Fork. No coho redds were observed on the other Olema tributaries. The average coho redd surface area was 4.26 m² and the density of redds on the mainstem was 0.87 redds/km. Cohort trends in observed coho redd production in the Olema Creek watershed are shown in Figure 7.

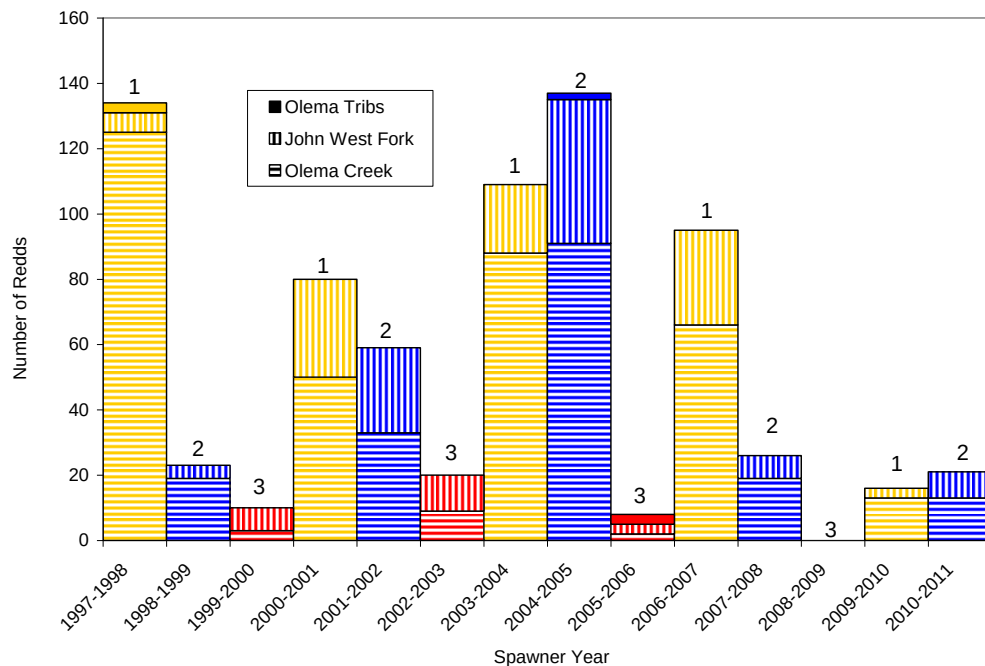


Figure 7 Coho salmon redd results for the Olema Creek Watershed by cohort for winter 1997-1998 through winter 2010-2011. Cohorts are designated by color (Cohort 1 shown in yellow, Cohort 2 shown in blue, Cohort 3 shown in red) and creeks are designated by pattern (Olema Creek in horizontal lines, John West Fork in vertical, and other Olema tributaries in solid).

3.2.7 Redds (Steelhead)

Seven steelhead redds were observed on the mainstem of Olema Creek. No steelhead redds were observed on John West Fork. The average steelhead redd surface area was 3.30 m² and the density was 0.47 redds/km.

3.2.8 Salmon Escapement Estimates (Area Under the Curve)

Area Under the Curve estimates were generated for live fish on the Olema Creek mainstem during the 2010-2011 spawner surveys. When possible, residence time (RT) was estimated based on observations of female coho holding on redds with the RT period equaling the previous storm event at time of entrance to the last observation of an individual female coho holding on a redd location. Observations of individual female coho at the same redd location from one survey week to the next were considered to be the same fish. Observer efficiency (OE) was also estimated when possible based on average water clarity over the duration of the spawner season for each creek. When RT and OE values could not be determined, AUC estimates were calculated based on values from published coho spawner studies. Eight studies were reviewed and had RT values ranging from eight to seventeen days. The most frequently reported values were eleven and thirteen days. Two of the eight studies reported OE values between 69 and 76 percent (Solazzi 1984, Johnston et al. 1987). To consider a wider range of observer efficiencies, AUC estimates were calculated for OE values between 50 and 100 percent.

Population estimates in the Olema Creek mainstem section ranged from 15 to 32 coho at 100% OE and 30 to 63 fish at 50% OE. Estimates from the most commonly reported OE (70-80%) and RT (11-13 days) values ranged from 24-33 fish in Olema Creek. A RT value was not determined for the 2010-2011 spawner surveys due to the inconsistencies in survey timing created by storms. The calculated OE for the 2010-2011 spawner surveys was 75% which falls within the range of most commonly reported values.

Population estimates in the John West Fork section ranged from 10 to 22 coho at 100% OE and 19 to 40 fish at 50% OE. Estimates from the most commonly reported OE (70-80%) and RT (11-13 days) values ranged from 18 to 21 fish in John West Fork. A RT value of 12 days was calculated for the 2010-2011 spawner surveys based on repeat observations of fish during surveys. This RT value falls within the most commonly reported RT values of 11-13 days. The calculated OE for the 2010-2011 spawner surveys was 57% which falls below the range of most commonly reported values. Taking into account the OE, the AUC values for John West Fork ranged from 21 to 29 fish.

3.2.9 Salmon Escapement Estimates (Peak Live plus Cumulative Dead)

The 2010-2011 PLD index was 15 taken from a survey conducted on December 16. A PLD index of 11 for John West Fork was taken from a survey on December 28.

The PLD dataset for adult salmon escapement within Olema Creek includes 17 years of survey information that ranged from 2-190 coho in the Olema Creek mainstem (Figure 8) and 0-85 coho in John West Fork (Figure 9). The SY 2010-2011 results represent the lowest PLD in Olema Creek mainstem for this cohort.

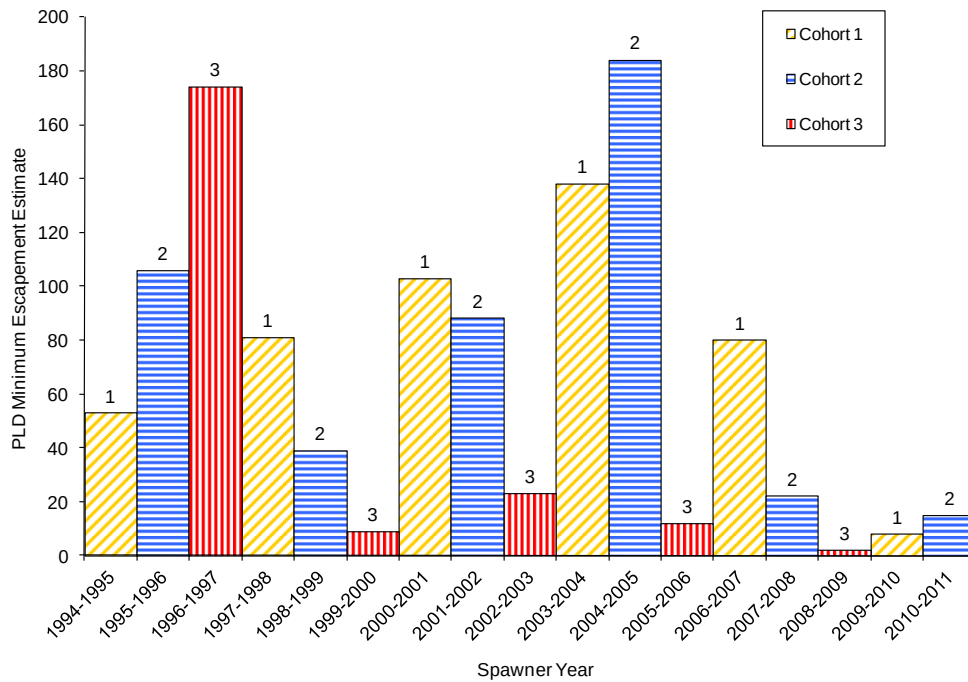


Figure 8 Olema Creek coho salmon Peak Live plus cumulative Dead (PLD) index escapement results, winter 1994-1995 through winter 2010-2011. Cohorts are designated by color and pattern (Cohort 1 shown in yellow diagonal, Cohort 2 shown in blue horizontal, Cohort 3 shown in red vertical).

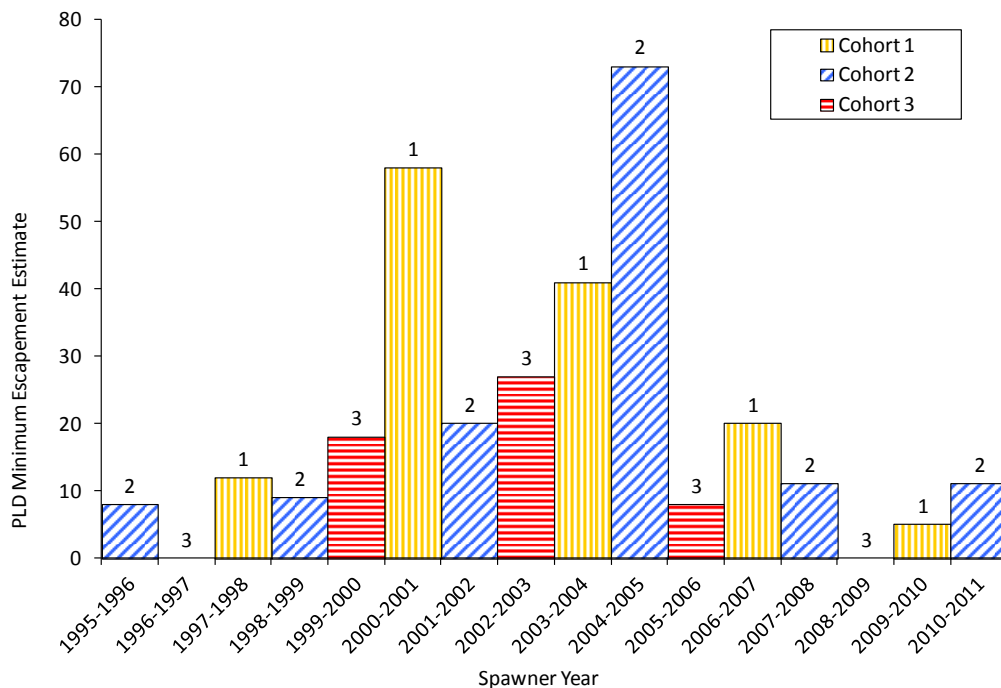


Figure 9 John West Fork Creek coho salmon Peak Live plus cumulative Dead (PLD) index escapement results, winter 1995-1996 through winter 2010-2011. Cohorts are designated by color and pattern (Cohort 1 shown in yellow vertical, Cohort 2 shown in blue diagonal, Cohort 3 shown in red horizontal).

3.3 Redwood Creek Adult Coho Escapement – SY 2010-2011

3.3.1 Survey Timing and Environmental Conditions

Thirteen surveys were conducted in Redwood Creek between 3 November 2010 and 28 February 2011 (Table 3). The mean interval between surveys was 9.4 days. Seven day rainfall totals during Julian weeks ranged from a low of 0.00 in during Julian weeks 46, 3, 4, and 6 and a high of 4.07 in during Julian week 51. Average water clarity at the time of each survey ranged from 50 cm to 111 cm.

The Redwood Creek mainstem reaches 1 through 3 were consistently sampled during nine of the 13 surveys performed. Fern Creek was surveyed later in the season when water levels were high enough to allow fish access into the tributaries. Tributary reaches were surveyed on the same day as the mainstem reaches to eliminate the possibility of double counting. The onset of rainfall and subsequent higher flows appeared to be related to live fish observations (Figure 10).

Table 3. Seven Day total rainfall per Julian week, average water clarity, and the number of coho redds, coho carcasses, and live coho observed in 2010-2011 on the mainstem of Redwood Creek.

Julian Week	Survey Date	Survey Reaches	Calendar Day	7 Day Rainfall during Julian Week (in)	Average Survey Water Clarity (cm)	Coho Redds	Coho Carcass	Live Coho
43				2.08				
44	3 Nov 10	1-2	307	0.47	111	0	0	0
45				0.98				
46				0.00				
47	22 Nov 10	1	326	1.27	101	0	0	0
48	29 Nov 10	1-3	333	0.47	101	0	0	0
(48)	2 Dec 10	1	336	(0.47)	101	0	0	2
49	7 Dec 10	1-4	341	2.32	101	0	0	0
50	13 Dec 10	1-4	347	0.55	84	0	0	0
51				4.07				
52	24 Dec 10	1-4	358	3.23	61	1	0	0
(52)	27 Dec 10	2-3	361	(3.23)	50	1	0	6
1	5 Jan 11	1-3	5	1.06	69	0	0	0
2	11 Jan 11	1-4	11	0.36	86	1	0	3
3	21 Jan 11	1-4	21	0.00	87	0	1	0
4				0.00				
5	2 Feb 11	1-3	33	0.48	101	0	0	0
6				0.00				
7				3.30				
8				2.60				
9	28 Feb 11	1-4	59	0.47	71	0	0	0

Reach 1: Pacific Way Bridge to the Kent Creek confluence (stream km 0.1 to 2.8).

Reach 2: Kent Creek confluence to Bridge 1 in Muir Woods (stream km 2.8 to 5.4).

Reach 3: Bridge 1 to 500 m above Bridge 4 (stream km 5.4 to 7.4).

Reach 4: Fern Creek- confluence to steep cascade (stream km 0 to 1).

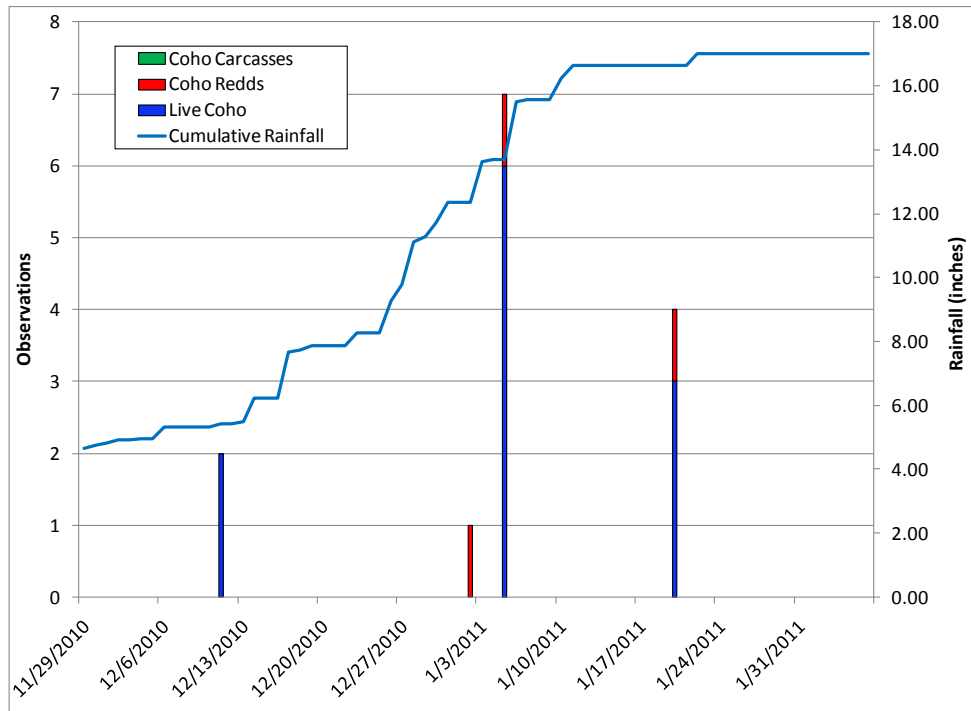


Figure 10. Representation of daily cumulative rainfall totals for Water Year 2011, starting October 2010, and coho adult escapement survey results on Redwood Creek mainstem, including live fish, carcasses, and redds, observed during surveys in 2010-2011.

3.3.2 Live Fish (Coho)

A total of 11 live adult coho spawners were observed during the 13 spawner surveys on Redwood Creek. All of the live spawners were observed in the mainstem.

3.3.3 Live Fish (Steelhead)

Steelhead observations were recorded in the same way as coho but the actual number of steelhead spawners is assumed to be higher than the observed number. A total of five confirmed steelhead adults were observed in the mainstem of Redwood Creek.

3.3.4 Carcasses (Coho)

One coho carcass was recovered on Redwood Creek during the 2010-2011 spawner season. One additional carcass was observed that could not be identified to species.

3.3.5 Carcasses (Steelhead)

No steelhead carcasses were observed during the spawner survey season.

3.3.6 Redds (Coho)

Three coho redds were observed during the 2010-2011 spawner season. Redds were only observed in Reach 3 of the mainstem, and only between 24 December 2010 and 11 January 2011. The mean coho redd surface area was 3.46 m². The total density of redds in the mainstem section surveyed was 0.41 redds/km. Cohort trends in observed coho redd production in the Redwood Creek watershed are shown in Figure 11.

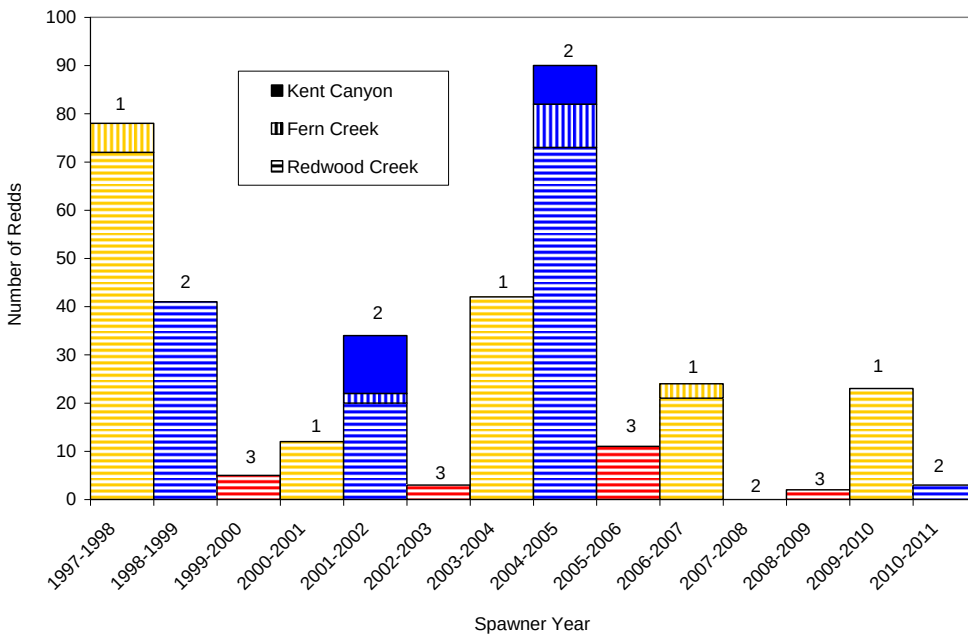


Figure 11 Coho salmon redd results for the Redwood Creek Watershed by cohort for winter 1997-1998 through winter 2010-2011. Cohorts are designated by color (Cohort 1 shown in yellow, Cohort 2 shown in blue, Cohort 3 shown in red) and creeks are designated by pattern (Redwood Creek in horizontal lines, Fern Creek in vertical, and Kent Canyon in a solid color).

3.3.7 Redds (Steelhead)

A total of nine definite steelhead redds were observed in the mainstem of Redwood Creek starting January 4, 2010. One additional steelhead redd was observed on Fern Creek, a tributary to Redwood Creek. The total density of redds in the 7.4 km mainstem section surveyed was 0.81 redds/km. The mean steelhead redd surface area was 2.48 m².

3.3.8 Salmon Escapement Estimates (Area Under the Curve)

Population estimates for the Redwood Creek watershed ranged from 11 to 23 coho at 100% OE and 18 to 39 fish at 50% OE. Estimates from the most commonly reported OE (70-80%) and RT (11-13 days) values ranged from 18 to 24 fish in Redwood Creek. A RT value of 15 days was calculated for Redwood for the 2010-2011 spawner season. The calculated OE for the 2010-2011 spawner surveys was 86%, which, when taken into account with the RT value, indicates values ranging from 14 to 18 spawners in Redwood Creek.

3.3.9 Salmon Escapement Estimates (Peak Live plus Cumulative Dead)

The 2010-2011 PLD index for Redwood Creek was 6 fish, derived from a peak of live fish observed on 27 December.

Figure 12 represents a 17 year dataset for adult coho for Redwood Creek. Peak live plus cumulative dead estimates have ranged from 0 to 171 fish. The 2007-2008 spawner season was the first season on record where no adult coho were observed returning to the Redwood Creek watershed since watershed surveys were initiated by NPS in 1993. The 2010-2011 spawner

season, while improved from the 2007-2008 returns, still demonstrates a marked drop in return rates from previous years.

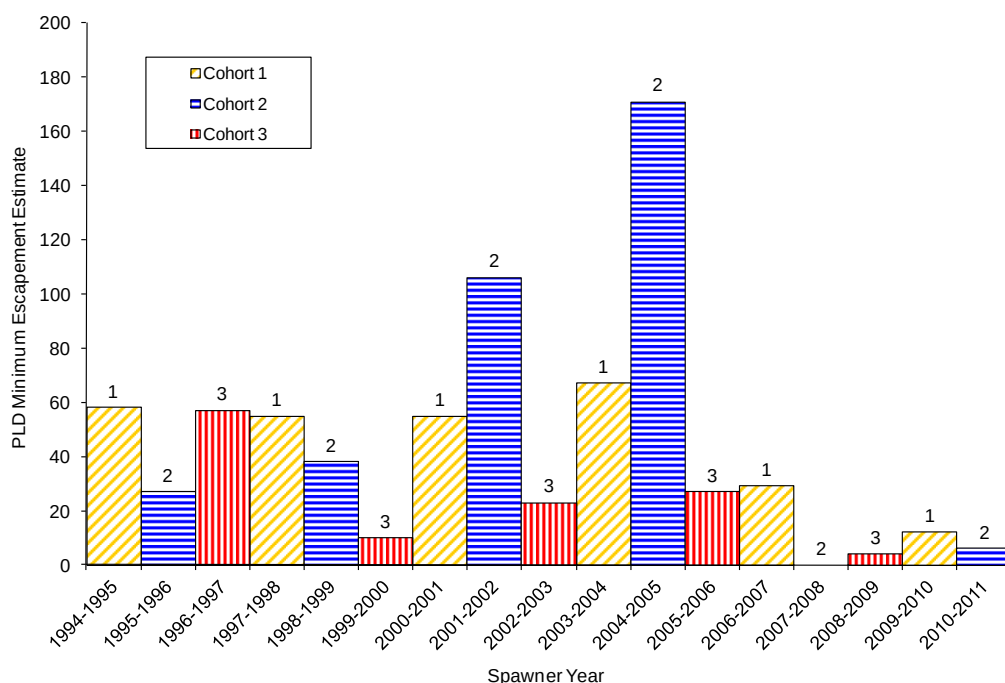


Figure 12 Redwood Creek coho salmon Peak Live plus cumulative Dead (PLD) index escapement results, winter 1994-1995 through winter 2010-2011. Cohorts are designated by color and pattern (Cohort 1 shown in yellow diagonal, Cohort 2 shown in blue horizontal, Cohort 3 shown in red vertical).

3.4 Pine Gulch Creek Adult Coho Escapement – SY 2010-2011

The dataset for the adult salmon escapement within Pine Gulch Creek includes ten years of survey information following the discovery of one adult coho salmon during SY 2000-2001. Since this discovery, live adult coho and/or coho spawning activity have been observed in the watershed during six out of the last ten years. Summer juvenile coho surveys and spring downstream migrant traps have confirmed that a self-propagating coho run does occur in Pine Gulch Creek. However, as only one cohort of juveniles has been observed (summer 2009) in the past three years, this run may be functionally extirpated.

No coho spawning activity was observed on Pine Gulch Creek during the 2010-2011 spawner season. While no adults were found, summer juvenile surveys will be conducted to confirm the presence/absence of coho on Pine Gulch Creek.

3.4.1 Survey Timing and Environmental Conditions

Three surveys were conducted in Pine Gulch from 7 January 2011 to 4 February 2011 (Table 4). The mean interval between surveys was 14 days. Seven day rainfall totals during Julian weeks ranged from a low of 0.01 in during Julian week 4 and a high of 4.53 in during Julian week 52. Rainfall data was based on the Bear Valley weather station. Average water clarity at the time of surveys ranged from 60 cm to 101 cm.

Table 4. Seven day total rainfall per Julian week, average water clarity, and the number of coho redds, coho carcasses, and live coho observed in 2010-2011 on the mainstem of Pine Gulch Creek. Rainfall is taken from the gage on Olema Creek, as rainfall data were not available for Pine Gulch Creek as of the writing of this report.

Julian Week	Survey Date	Survey Reaches	Calendar Day	7 Day Rainfall during Julian Week (in)	Average Survey Water Clarity (cm)	Coho Redds	Coho Carcass	Live Coho
52				4.53				
1	7 Jan 11	1-2	7	0.77	60	0	0	0
2	13 Jan 11	1-2	13	0.43	60	0	0	0
3				0.04				
4				0.01				
5	4 Feb 11	1	35	0.85	101	0	0	0

Reach 1: Olema-Bolinas Road Bridge to Copper Mine Gulch Confluence (6.0 km)

Reach 2: Copper Mine Gulch Confluence to upstream of Teixeira (approximately monument marker 100).

3.4.2 Live Fish (Coho and Steelhead)

No live coho or steelhead adults were observed on Pine Gulch Creek during the 2010-2011 spawner season.

3.4.3 Carcasses

No carcasses were discovered on Pine Gulch Creek during any of the surveys.

3.4.4 Redds (Coho)

No coho redds were discovered on Pine Gulch Creek during any of the surveys.

3.4.5 Redds (Steelhead)

Ten steelhead redds were identified on Reach 1 of Pine Gulch Creek. The average steelhead redd surface area was 2.48m² and the density was 1.05 redds/km.

3.4.6 Salmon Escapement Estimates

With no adult coho or carcasses seen during the spawning season on Pine Gulch Creek no adult salmon escapement estimates were calculated.

3.5 Cheda Creek Adult Coho Escapement – SY 2010-2011

The dataset for adult salmon escapement within Cheda Creek includes 13 years of survey information and has documented the return of coho to the small tributary stream of Lagunitas Creek. 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 in the context of the entire watershed.

No coho spawning activity was observed on Cheda Creek during the 2010-2011 spawner season, which marks the fourth consecutive winter in which no coho spawning activity was observed.

3.5.1 Survey Timing and Environmental Conditions

Five surveys were performed on Cheda Creek during December and January (Table 5). The mean interval between surveys was 7 days. Seven day rainfall totals during Julian weeks ranged from a low of 0.53 in during Julian week 50 and a high of 4.91 in during Julian week 51. Average water clarity ranged from less than 30 cm to 50 cm.

Table 5. Seven day total rainfall per Julian week, average water clarity, and the number of coho redds, coho carcasses, and live coho observed in 2010-2011 on Cheda Creek.

Julian Week	Survey Date	Survey Reaches	Calendar Day	7 Day Rainfall during Julian Week (in)	Average Survey Water Clarity (cm)	Coho Redds	Coho Carcass	Live Coho
48				1.26				
49	6 Dec 10	1-2	340	2.22	40	0	0	0
50				0.53				
51	21 Dec 10	1-2	355	4.91	<30	0	0	0
(51)	23 Dec 10	1-2	357	(4.91)	35	0	0	0
52	27 Dec 10	1-2	361	4.53	50	0	0	0
1	3 Jan 11	1-2	3	0.77	40	0	0	0

Reach 1: Confluence with Lagunitas Creek to 0.8 km upstream.

Reach 2: Upstream extent of the fish passage restoration site at 0.8 km upstream to 1.3 km upstream.

3.5.2 Live Fish (Coho and Steelhead)

No live coho or steelhead adults were observed on Cheda Creek during the 2010-2011 season.

3.5.3 Carcasses

No carcasses were discovered on Cheda Creek during any of the surveys.

3.5.4 Redds

No redds were observed on Cheda Creek during any of the surveys.

3.5.5 Salmon Escapement Estimates

With no adult coho or carcasses observed during the spawning season on Cheda Creek, no adult salmon escapement estimates were calculated.

3.6 Watershed Summary

With the poor returns of Cohort 1 (2009-2010), Cohort 2 (2007-2008), and Cohort 3 (2008-2009), there have been three consecutive years of poor returns on Olema Creek, and it would appear that Olema Creek has no strong remaining cohort. All three cohorts have shown a 75% decline from previous generations. The current returns observed in 2010-2011 show a 32% decrease in redd production from 2007-2008, indicating a continuing decline for this cohort.

The returns for the 2010-2011 season on Redwood Creek showed a slight increase when compared to 2007-2008, the last time this cohort was observed in the watershed. Though no spawning activity was observed in the 2007-2008 spawning season, juvenile coho observations during the summer of 2008 indicated at least 2 redds were constructed. With 3 redds observed in 2010-2011, this cohort showed a 50% increase in production. However, 3 redds is still a 95%

decrease in cohort production when compared to previous years. This leaves Redwood Creek with two cohorts (Cohorts 2 and 3) in decline and one cohort (Cohort 1) remaining stable.

Expectations for returns on Pine Gulch Creek this season were relatively low considering the lack of juveniles observed during summer 2008 snorkel surveys.

3.6.1 Olema Creek

A total of 29 live coho and nine carcasses were observed during 11 Olema Creek mainstem surveys, resulting in a PLD of 15. A total of 13 redds were observed during these surveys. John West Fork had a total of 37 live coho and four carcasses observed during the 12 surveys performed, resulting in a PLD of 11. A total of eight redds were also observed on John West Fork. No spawning activity was observed on any of the other tributaries in the watershed resulting in a total of 21 redds observed within the Olema Creek watershed. This represents a 32% decrease in redds in the mainstem from SY 2007-2008 (the last time this cohort was in-system) and a 20% decrease in redds for the Olema Creek watershed.

The SY 2010-2011 results also represent a decrease of 32% in PLD for Olema Creek from the 2007-2008 spawner season. While the PLD for John West Fork was unchanged from 2007-2008, the overall PLD for Olema Creek was the fifth lowest since monitoring was initiated.

Area Under the Curve population estimates in the Olema Creek mainstem ranged from 24 to 33 using the most commonly reported OE (70-80%) and RT (11-13 days) values. Area Under the Curve population estimates in John West Fork ranged from 21 to 29 fish when using the calculated OE of 57%.

During the 2009 smolt trapping operations, Olema Creek had a calculated production estimate of 4,088 ($\pm 1,041$ SD) coho smolts. Smolt size (both length and weight) is directly related to ocean survival (Miller and Sandros 2003) with smolts being of larger size at time of ocean entrance having a higher chance at surviving to adult. Although the average smolt length, 113 mm, was within the acceptable range for outmigrating coho smolts, the mean K-factor, 0.89, was the lowest since monitoring began in 2003 (Reichmuth et al 2012). Based on the smolt outmigration and low ocean survival (2%) it was anticipated that Olema Creek would support adult returns of approximately 80 coho salmon. Instead, the observed smolt to adult survival was lower than predicted with an observed smolt to adult survival of approximately 1%.

This is the first time this cohort has returned since the drastic reduction in numbers suffered in 2007-2008. With the poor returns for SY 2010-2011, it appears that this cohort is continuing to decrease in population size.

3.6.2 Redwood Creek

A total of 11 live fish and one carcass were observed on Redwood Creek during 13 spawner surveys resulting in a PLD of six. Area Under the Curve population estimates in the Redwood Creek watershed ranged 14 to 18 adult coho using the calculated OE (86%) and RT (13-15 days). Only three redds were observed during the Redwood Creek surveys. While this number was far below the historical average for the stream, it was an increase from the redd numbers observed in 2007-2008. No redds were observed during the 2007-2008 spawner season; however, later

juvenile surveys indicated the presence of 1-2 redds for SY 2007-2008. Taking this into account, the 2010-2011 redd numbers showed an increase of approximately 50%.

During the 2009 smolt trapping operations, Redwood Creek captured 163 coho smolts. Due to the unusual distribution of recaptured PIT tagged fish, a calculated production estimate could not be made. However, based on rough trap efficiencies and an ocean survival of 1-2%, it was anticipated that Redwood Creek would support returns of 4-8 fish.

In SY 2007-2008, Cohort 2 suffered an almost complete collapse, leaving only Cohort 1 (SY 2009-2010) as a moderately stable cohort, and Cohorts 2 and 3 in relatively low abundance in comparison. The low returns in SY 2010-2011, while anticipated, supports the notion that Cohort 2 is at a critically low population size.

3.6.3 Pine Gulch Creek

No coho activity was observed on Pine Gulch Creek. No activity was expected given that spawner surveys performed in 2007-2008 yielded only two coho redds and no juveniles were observed in the summer of 2008. This leaves Pine Gulch with what is probably only an intermittent or functionally extirpated population.

3.6.4 Cheda Creek

Unlike Pine Gulch, Cheda Creek is a tributary to Lagunitas Creek and may see future coho spawners in this cohort depending on spawning conditions in Lagunitas Creek. Similar to Olema Creek, Cheda Creek has supported two cohorts with relatively consistent returns and one weak cohort (Cohort 3) in comparison. After the completion of the Cheda Creek fish passage restoration project in 2000 Cheda Creek began to have coho activity in the section above the restoration; however, for the third straight survey year since 2008-2009 no coho activity was observed.

Literature Cited

- Beidler, W. M. and T. E. Nickelson. 1980. An evaluation of the Oregon Department of Fish and Wildlife standard spawning fish survey system for coho salmon. Oregon Department of Fish and Wildlife Information Report Series, Fisheries Number 80-9.
- Brown, G.G. and B.J. Ketcham. 2002. Documentation of Coho Salmon (*Oncorhynchus kisutch*) in Pine Gulch Creek, Marin County, CA. Coho Salmon and Steelhead Trout Restoration Project. PORE-NR-WR-02/02. 12pp. Plus appendices.
- Brown, L. R., P. B. Moyle, and R. M. Yoshiyama. 1994. Historical decline and current status of coho salmon in California. North American Journal of Fisheries Management 14:237-261.
- Burton, K., L. Lowe, and H. Berge. 2002. Cedar River Chinook Salmon (*Oncorhynchus tshawytscha*) redd survey report, 2001: spatial and temporal distribution of redds, carcass age, sex and size frequency distribution, redd residency duration and the incidence of redd superimposition on incubating Chinook redd mounds. Seattle Public Utilities, Seattle, Washington.
- Del Real, S.C., Carlisle, S.J., Reichmuth, M., Ketcham, B.J. 2007. Adult Escapement Monitoring Program Summary 2006-2007. Natural Resource Technical Report NPS/SFAN/NRTR 2007/001. National Park Service, San Francisco Bay Area Network Inventory and Monitoring Program, Point Reyes Station, CA.
- Federal Register. 1996. Final Rule. Endangered and threatened species: Threatened status for Central California Coast coho salmon evolutionarily significant unit (ESU), October 31, 1996. 61 (212): 56138-56149.
- Federal Register. 1997. Final Rule. Endangered and threatened species: Listing of several evolutionary significant units (ESUs) of west coast steelhead, August 18, 1997. 62(159): 43937-43954.
- Federal Register. 1999. Final Rule and Correction. Endangered and threatened species: Designation of Critical Habitat; Central California Coast and Southern Oregon/Northern California Coasts Coho Salmon. May 5, 1999. 64(86): 24049-24062.
- Federal Register. 2005. Final Rule. Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs, June 28, 2005. 70(123): 37160-37204.
- Federal Register. 2006. Final Rule. Endangered and threatened species: Final listing determinations for 10 distinct population segments of west coast steelhead, January 5, 2006. 71(3): 834-862.
- Gallagher, S. P., P. B. Adams, D. W. Wright, and B. W. Collins. 2010. Performance of Spawner Survey Techniques at Low Abundances Levels. Nor. Amer. J. Fish. Mngt, 30(5):1086-1097.

- Irvine, J. R., R. C. Bocking, and K. K. English, and M. Labelle. 1992. Estimating coho salmon (*Oncorhynchus kisutch*) escapements by conducting visual surveys in areas selected using stratified random and stratified index sampling designs. *Canadian Journal of Fisheries and Aquatic Sciences* 49: 1972-1981.
- Johnston, N. T., J. R. Irvine, and C. J. Perrin. 1987. Instream indexing of coho salmon (*Oncorhynchus kisutch*) escapement in French Creek, British Columbia. *Canadian Technical Report of Fisheries and Aquatic*, No. 1573.
- Ketcham B.J., and G.G. Brown. 2003. Coho Salmon (*Oncorhynchus kisutch*) in Pine Gulch Creek, Marin County, CA. 2002 Monitoring Report. Coho Salmon and Steelhead Trout Restoration Program. PORE-NR-WR-03/01. 18pp. Plus appendices.
- Reichmuth, M., B.J. Ketcham, D. Fong, S. Carlisle, E. Brown, and M. Koenen. 2010. Salmonid Monitoring Protocol for the San Francisco Bay Area Network: narrative and appendices – version 4.0. Natural Resource Report NPS/SFAN/NRR—2010/202. National Park Service, Fort Collins, Colorado.
- Reichmuth, M., S. Carlisle, A. Dedrick, and A. Rodoni. 2012. Long-term coho salmon and steelhead trout monitoring in coastal Marin County 2009 annual monitoring progress report. Natural Resource Technical Report, Unpublished Report, Point Reyes National Seashore, California.
- MacFarlane, R.B., S. Hayes, and B. Wells. 2008. Coho and Chinook salmon decline in California during the spawning seasons of 2007/08. Unpublished report. prepared by Southwest Fisheries Science Center, Santa Cruz Laboratory, Santa Cruz, CA.
- McClatchie, S., R. Goericke, F.B. Swhing, S.J. Bograd, W.T. Peterson, R. Emmett, R. Charter, W. Watson, N. Lo, K. Hill, and others. 2008. The state of the California Current, spring 2007-2008: La Nina conditions and their effects on the ecosystem. *California Cooperative Oceanic Fisheries Investigations*, CalCOFI Rep., Vol. 49, 2008.
- Miller, B.A., and S. Sandros. 2003 Residence time and seasonal movement of juvenile coho salmon in the ecotones and lower estuary of Winchester Creek, South Slough, Oregon. *Transactions of the American Fisheries Society* 132:546-559.
- Moring, J. R., and R. L. Lantz. 1975. The Alsea watershed study: effects of logging on the aquatic resources of three headwater streams of the Alsea River, Oregon. Part I- Biological studies. Oregon Department of Fish Wildlife, Fish. Res. Rep. 9, 66 p.
- National Marine Fisheries Service (NMFS). 2001. Status review and update for coho salmon (*Oncorhynchus kisutch*) from the central California coast and the California portion of the southern Oregon/northern California coasts Evolutionary Significant Units. Prepared by the Southwest Fisheries Science Center, Santa Cruz Laboratory, Santa Cruz, CA. 40pp.

- Solazzi M.F. 1984. Relationships between visual counts of coho salmon (*Oncorhynchus kisutch*) from spawning fish surveys and the actual number of fish present, p. 175-186. In P. E. K. Symons and M. Waldichuk (Eds.) Proceedings of the workshop on stream indexing for salmon escapement estimation. *Canadian Technical Report of Fisheries and Aquatic Sciences* 1326:258
- Van den Berghe, E. F. and M. R. Gross. 1986. Length of breeding life of coho salmon (*Oncorhynchus kisutch*). *Canadian Journal of Zoology* 64:1482-1486.
- Weitkamp, L. A., T. C. Wainwright, G. J. Bryant, G. B. Milner, D. J. Teel, R. G. Kope, and R. S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-24. 25.