



**OLEMA CREEK WATERSHED SUMMARY MONITORING REPORT,  
MARIN COUNTY, CA  
1997-2005**



**PORE/NR/WR/06-02**

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## ABSTRACT

Olema Creek is the largest undammed watershed in coastal Marin County, California and an important stream for threatened coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*O. mykiss*) within the central California coast Evolutionarily Significant Unit (CCCESU). Though dramatically reduced from the mid-1900s populations, the Lagunitas Creek watershed (including Olema Creek) supports at least 10% of coho salmon (Brown et. al. 1994) and is considered a keystone population of the CCCESU. The National Park Service (NPS) has conducted adult escapement surveys, smolt trapping, and summer juvenile index reach monitoring in the Olema Creek watershed since 1998. Basinwide coho juvenile population estimates were added in 2003 in order to develop survival rates between life stages. NPS results show that this watershed has supported annual runs of coho ranging from less than 50 to more than 200, with associated juvenile densities (95% CI) ranging from 0.259 ( $\pm$  0.019) coho per meter in 1999 to 4.22 ( $\pm$  0.68) coho per meter in 2004. The Olema Creek fisheries monitoring program will continue with support through the NPS Inventory and Monitoring Program and the California Department of Fish and Game Salmonid Restoration funds. In addition, these data will be integrated into future watershed scale limiting factors assessments that may help identify biotic bottlenecks within the system and will complement existing wetland restoration and water quality monitoring within the Lagunitas Creek and Tomales Bay watersheds.

This report presents and analyzes results from adult escapement surveys between 1997 and 2006, outmigrant smolt trapping between 1998 and 2005, summer index reach monitoring between 1999 and 2005 and a basinwide coho juvenile population estimate between 2003 and 2005. Recommendations related to the monitoring protocols and analyses are also provided.

## ACKNOWLEDGEMENTS

We would like to express special thanks to Donald Brown (GIS Technician) and Casey Del Real (Fisheries Technician) at Point Reyes National Seashore for their contributions to this report.

Monitoring efforts on Olema Creek date back to 1994, with the institution of winter adult spawner surveys by volunteers of the Tomales Bay Association in cooperation with NPS staff. This effort evolved into a five-year National Park Service funded Coho and Steelhead Restoration Project (CSRP). The current monitoring program was initiated under the CSRP with original development by David Manning, Ron Smith, Brannon Ketcham and David Press. Through the years, volunteers have contributed thousands of hours to these programs assisting with all aspects of our monitoring efforts.

We also would like to express our appreciation to Darren Fong, Aquatic Ecologist at Golden Gate National Recreation Area, who has provided continual technical review and assistance for the program since drafting the original proposal in 1996. This research is conducted under the Endangered Species Act Section 10 Permit #1046 authorization managed by NOAA - Fisheries.

Funding to support monitoring activities between 1997 and 2002 was provided through a National Park Service Natural Resources Preservation Program grant. Additional NPS funding has been provided through various sources, including base funding as well as support through the Point Reyes National Seashore Association. Since 2003, funding is provided through the National Park Service - San Francisco Bay Area Network Inventory and Monitoring Program and the California Department of Fish and Game Fisheries Restoration Grant Program Contract P0330431.

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# TABLE OF CONTENTS

|                                                                                    |           |
|------------------------------------------------------------------------------------|-----------|
| <b>ABSTRACT .....</b>                                                              | <b>3</b>  |
| <b>ACKNOWLEDGEMENTS .....</b>                                                      | <b>4</b>  |
| <b>TABLE OF CONTENTS .....</b>                                                     | <b>5</b>  |
| <b>1.0 INTRODUCTION .....</b>                                                      | <b>7</b>  |
| 1.1 BACKGROUND.....                                                                | 7         |
| 1.2 FISH RESOURCES.....                                                            | 8         |
| 1.2.1 Coho Salmon .....                                                            | 8         |
| 1.2.2 Steelhead .....                                                              | 10        |
| 1.2.3 Chinook Salmon .....                                                         | 11        |
| 1.2.4 Essential Fish Habitat.....                                                  | 11        |
| 1.3 MONITORING RATIONALE .....                                                     | 12        |
| 1.4 PHYSICAL SETTING .....                                                         | 12        |
| 1.4.1 Watershed Description.....                                                   | 12        |
| 1.4.2 Watershed History.....                                                       | 13        |
| 1.4.3 Olema Creek Hydrologic Response .....                                        | 13        |
| 1.4.4 Rainfall Information.....                                                    | 14        |
| <b>2.0 METHODS.....</b>                                                            | <b>16</b> |
| 2.1 ADULT ESCAPEMENT SURVEYS.....                                                  | 16        |
| 2.1.1 Adult Escapement Monitoring Objectives & Questions .....                     | 16        |
| 2.1.2 Field Methods .....                                                          | 16        |
| 2.1.3 Rationale for selecting this sampling design.....                            | 17        |
| 2.1.4 Sampling site locations .....                                                | 17        |
| 2.1.5 Analysis .....                                                               | 19        |
| 2.1.6 Other Monitoring Programs .....                                              | 20        |
| 2.2 Monitoring Objectives and Questions.....                                       | 20        |
| 2.2.2 Field Methods .....                                                          | 21        |
| 2.2.4 Site location.....                                                           | 21        |
| 2.2.5 Analysis .....                                                               | 22        |
| 2.3 SUMMER JUVENILE ESTIMATES.....                                                 | 22        |
| 2.3.1.1 Index Reach Monitoring Objectives and Questions .....                      | 23        |
| 2.3.1.2 Index Reach Field Methods.....                                             | 23        |
| 2.3.1.5 Analysis .....                                                             | 25        |
| 2.3.2.1 Basinwide Survey Monitoring Objectives and Questions.....                  | 26        |
| 2.3.3 Juvenile Fish Abundance, Distribution, and Mortality in Isolated Pools ..... | 27        |
| 2.4 GENETIC ANALYSIS .....                                                         | 27        |
| 2.5 DATA MANAGEMENT .....                                                          | 27        |
| <b>3.0 RESULTS.....</b>                                                            | <b>29</b> |
| 3.1 ADULT ESCAPEMENT SURVEYS .....                                                 | 29        |
| 3.1.1 Survey Timing and Environmental Conditions.....                              | 29        |
| 3.1.2 Watershed Escapement History and Estimates .....                             | 30        |
| 3.1.3 Live Fish, Carcass, and Redd Observations .....                              | 35        |
| 3.2 OUTMIGRANT SMOLT TRAP .....                                                    | 38        |
| 3.2.2 John West Fork .....                                                         | 40        |
| 3.3 INDEX REACH SURVEYS.....                                                       | 42        |
| 3.3.1 Index reach total salmonid catch .....                                       | 42        |
| 3.3.2 Index reach total fish catch of other species .....                          | 43        |
| 3.3.2 Index Reach Habitat Information.....                                         | 46        |
| 3.3.3 Salmonid density by habitat type.....                                        | 48        |

|            |                                                                                                                     |           |
|------------|---------------------------------------------------------------------------------------------------------------------|-----------|
| 3.3.4      | <i>Salmonid Index Reach Density</i> .....                                                                           | 49        |
| 3.3.5      | <i>Summer fish measurement information</i> .....                                                                    | 50        |
| 3.4        | POPULATION ESTIMATES.....                                                                                           | 53        |
| 3.4.1      | <i>Juvenile Fish Abundance, Distribution, and Mortality in Isolated Pools</i> .....                                 | 53        |
| 3.4.2      | <i>Summer Basinwide Surveys</i> .....                                                                               | 54        |
| 3.5        | EXTRAPOLATED COHO SALMON POPULATION ESTIMATES COMPARING INDEX REACH MONITORING AND<br>SNORKEL SURVEY ESTIMATES..... | 60        |
| 3.6        | GENETICS AND RECOVERY .....                                                                                         | 61        |
| <b>4.0</b> | <b>ANALYSIS</b> .....                                                                                               | <b>63</b> |
| <b>5.0</b> | <b>RECOMMENDATIONS</b> .....                                                                                        | <b>72</b> |
| 5.1        | ADULT ESCAPEMENT .....                                                                                              | 72        |
| 5.2        | SMOLT TRAP OPERATIONS .....                                                                                         | 72        |
| 5.3        | INDEX REACH MONITORING .....                                                                                        | 72        |
| 5.4        | BASINWIDE POPULATION ESTIMATE .....                                                                                 | 72        |
| <b>6.0</b> | <b>REFERENCES</b> .....                                                                                             | <b>74</b> |

## 1.0 INTRODUCTION

Olema Creek is the largest undammed watershed in coastal Marin County, California (Figure 1.1) and an important stream for endangered coho salmon (*Oncorhynchus kisutch*) within the central California coast Evolutionarily Significant Unit (Figure 1.2) and threatened steelhead trout (*O. mykiss*) within the central California coast Distinct Population Segment. The 15.9 km stream flows northwest through the Olema Valley, the landward expression of the San Andreas Fault Zone. It's confluence with Lagunitas Creek lies at the head of the ecologically significant Tomales Bay. Protected from development, the 14.5 square mile watershed is primarily contained within the boundaries of Point Reyes National Seashore and the Golden Gate National Recreation Area North District. The watershed provides habitat to four federally protected aquatic species (California freshwater shrimp – endangered; coho salmon – endangered; steelhead trout – threatened; California red-legged frog – threatened). Olema Creek is the focal point of hydrologic, water quality, and fisheries monitoring within Point Reyes National Seashore.

In 1997 the National Park Service (NPS) initiated the Coho Salmon and Steelhead Trout Restoration Project (CSRP) to assess watershed and fishery condition in Marin County, and develop recommendations to enhance local populations of these anadromous species. The project watersheds including Redwood Creek, Pine Gulch Creek, and tributaries of Lagunitas Creek (Olema Creek, Cheda Creek, and Devil's Gulch) are located in western Marin County, and within the National Marine Fisheries Service (NMFS) designated central California coast Evolutionarily Significant Unit (CCCESU). Anadromous fish populations throughout the state of California are estimated to be 1% of historic populations. Though dramatically reduced from the mid 1900s, the Lagunitas Creek watershed contains 10% of the remaining fish (Brown and Moyle 1991) and is considered the keystone population of the CCCESU.

This report represents a comprehensive summary of monitoring data for various life stages of coho salmon and steelhead trout collected by the National Park Service since 1998 in the Olema Creek watershed. It includes summaries of adult escapement, smolt trapping, basinwide surveys, and juvenile index reach monitoring efforts initiated through the NPS Coho Salmon and Steelhead trout Restoration Project (CSRP) and continued through support by the San Francisco Bay Area Network Inventory and Monitoring Program and a California Department of Fish and Game Salmonid Restoration grant to the Point Reyes National Seashore Association (P0330431).

### 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).

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 Fahrenheit) and high dissolved oxygen levels. While most salmonids have been affected by watershed development, coho salmon are particularly susceptible due to their, semelparous (spawn once) three year life cycle requiring an entire year of residence in the 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. Major NPS streams and their associated watersheds currently containing populations of coho salmon and steelhead trout include Olema/Lagunitas Creek, 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; and
- Marine over-harvesting and poor productivity during El Niño events.

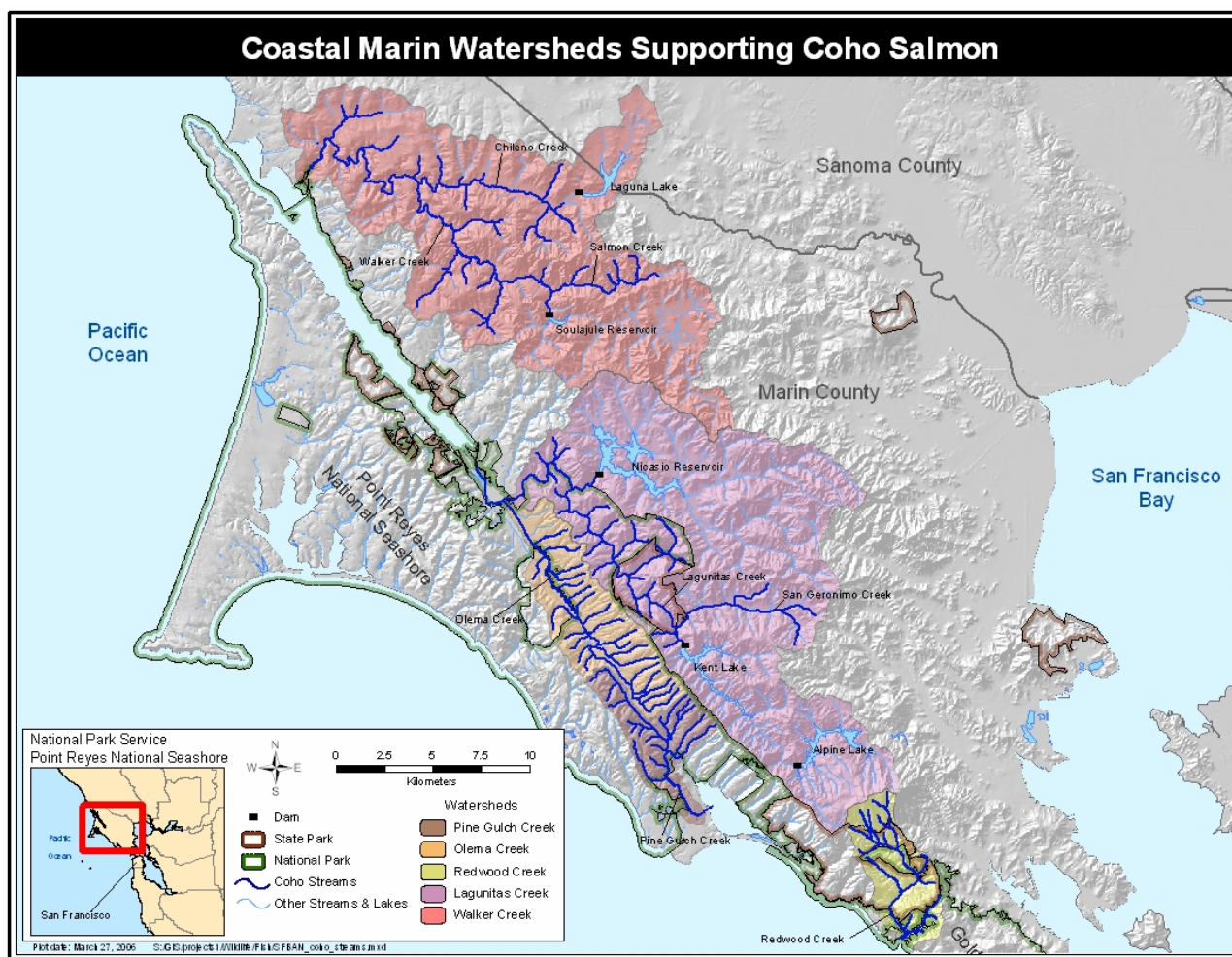


Figure 1.1 Streams supporting coho salmon in coastal Marin County.

## 1.2 Fish Resources

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

### 1.2.1 Coho Salmon

#### **Biology**

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

Because of dramatic declines in population numbers, the National Marine Fisheries Service (NMFS) was petitioned to list this species coastwide (Federal Register 1996). Several runs were listed along the central California coast and include regions occupied by California red-legged frogs. Causes of coho salmon declines in California include incompatible land use practices such as logging and urbanization, loss of wild stocks, introduced diseases, over harvesting, and climactic changes.

Coho salmon are known to exist in watersheds including Lagunitas, Olema, Pine Gulch (Brown and Ketcham 2002), and Redwood Creeks. Walker Creek, which flows into Tomales Bay, likely supported coho salmon and is part of a larger coho recovery program conducted by the California Department of Fish and Game and NOAA-Fisheries.



### **Regulatory Protection**

#### *NOAA-Fisheries*

Coho salmon were listed as a threatened species within the central California coast coho salmon ESU (CCCESU) on October 31, 1996 by the National Marine Fisheries Service (NOAA-Fisheries) (Federal Register 1996). The CCCESU (Figure 1.2) 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. The original listing criteria 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) have shown that the Lagunitas population likely represents more than 20% of the CCCESU population.

In association with the coho threatened listing NOAA-Fisheries 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 from Punta Gorda in northern California south to the San Lorenzo River in central California, including Mill Valley (Arroyo Corte Madera Del Presidio) and Corte Madera Creeks, tributaries to San Francisco Bay. Excluded are areas above specific dams or above longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years). Major river basins containing spawning and rearing habitat for this ESU comprise approximately 4,152 square miles in California. The following counties lie partially or wholly within these basins: Lake, Marin, Mendocino, San Mateo, Santa Clara, Santa Cruz, and Sonoma.

In their 2001 Status Review, NOAA-Fisheries acknowledged that within the CCCESU, the decision to list coho salmon as threatened may have been overly optimistic, concluding that the ESU population was presently endangered of extinction (NMFS 2001). As a result of these and further findings, NOAA-Fisheries completed a rulemaking process in June 28, 2005, which downgraded the coho status (upgraded listing protection) in the ESU to Endangered (Federal Register 2005).

#### *California Department of Fish and Game*

On April 5, 2001, the Fish and Game Commission accepted the petition to list coho salmon north of the Golden Gate as endangered under the State Endangered Species Act. As a response to this petition, the DFG prepared a status review of California which concluded that the coho salmon within the central California coast ESU (as designated by NOAA Fisheries – Figure 1.2) are in serious danger of becoming extinct throughout all or a significant portion of its range, and that the endangered listing is warranted (CDFG 2002). As a response, the CDFG released a draft Recovery Strategy for coho salmon in November 2003, which was adopted as revised by the Fish and Game Commission on February 6, 2004. On August 5, 2004, the Fish and Game Commission added coho salmon populations between San Francisco and

Punta Gorda to the list of species protected under the Endangered Species Act (areas south of San Francisco were already listed as endangered). This listing became effective March 30, 2005.

### 1.2.2 Steelhead

#### **Biology**

Steelhead are the anadromous form of rainbow trout; adult steelhead typically spawn in gravel riffles in the spring, from February to June. Steelhead are multiparous, meaning they can spawn more than once. Research conducted in the 1950s documented female steelhead returning to spawn in multiple years (Shapavolov and Taft 1954). Optimum temperatures for growth range from 13 to 21 degrees Centigrade (55 to 70 degrees Fahrenheit) (Moyle 1976). It is also noted that steelhead may persist in a broad range of pH (from 5.8 to 9.6) but prefer a pH between 7 and 8 (Moyle 1976). Steelhead fry reside in near-shore areas. Steelhead juveniles tend to use riffles and pool margins. Because of dramatic declines in population numbers, the National Marine Fisheries Service (NMFS) was petitioned to list this species throughout much of the California coast.

Steelhead trout are known to exist in most perennial watersheds within Marin County.

#### **Regulatory Protection**

Steelhead were listed as a threatened species on August 17, 1997 (Federal Register 1997). As of February 6, 2006 the former steelhead Evolutionary Significant Unit has been changed to a Distinct Population Segment (DPS). The central California coast steelhead DPS includes all naturally spawned populations of steelhead (and their progeny) in California streams from the Russian River (inclusive) to Aptos Creek (inclusive), and the drainages of San Francisco, 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/Scott Creek are also included (Federal Register 2006). As of the 2006 Federal Register, only ocean-run *O. mykiss* (steelhead trout, not resident rainbow trout) are protected under the ESA. In 2000, critical habitat was designated for steelhead along the California coast. In 2002 these designations were withdrawn due to a National Marine Fisheries Service (NMFS) decree and weren't reinstated until a final ruling in August 2005. This critical habitat became effective January 2, 2006 (Federal Register 2006). Critical habitat only encompasses the *O. mykiss* anadromous range.

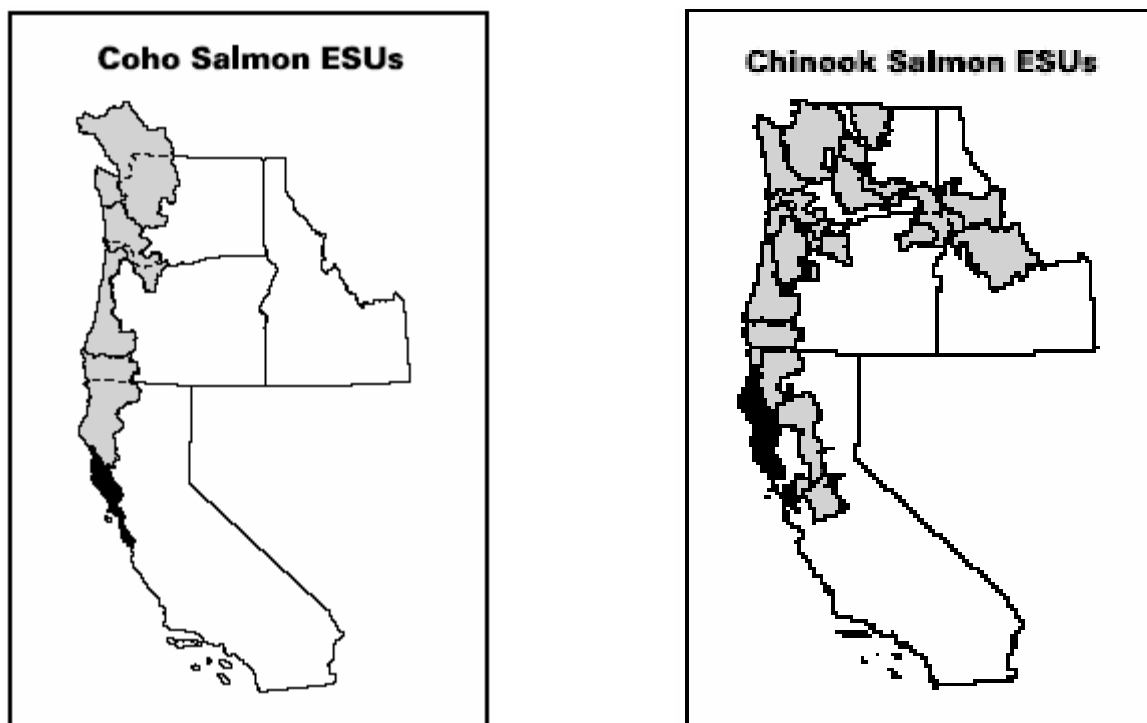


**Figure 1.2 Coho salmon Evolutionarily Significant Units and Chinook salmon Evolutionarily Significant Units as identified by NOAA Fisheries. Marin County is included within the Central California Coast ESU for coho salmon (left).**

### 1.2.3 Chinook Salmon

California Coastal Chinook salmon were listed as threatened on [September 16, 1999](#); threatened status reaffirmed on [June 28, 2005](#). The ESU includes all naturally spawned populations of Chinook salmon from rivers and streams south of the Klamath River to the Russian River, California (Figure 1.2). Though not included in the listed area, adult Chinook salmon have been observed within Lagunitas Creek in increasing numbers since 2000 (MMWD 2006b). The increasing frequency of Chinook salmon within Lagunitas Creek may indicate the development of a self-sustaining population, but whether this will persist is unclear (NOAA Fisheries 2004). Because of the proximity of these fish to the southern boundary of the ESU, NOAA Fisheries has treated this watershed population as part of the California Coastal listed population for the purposes of other consultations on the lands of Point Reyes National Seashore and Golden Gate National Recreation Area (NOAA Fisheries 2004).

### 1.2.4 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267) requires all Federal agencies to consult with NMFS on all actions, or proposed actions, permitted, funded, or undertaken by the agency, that may adversely affect Essential Fish Habitat (EFH). EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." "Waters" include aquatic areas and their associated physical, chemical and biological properties. "Substrate" includes sediment underlying the waters. "Necessary" means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem. Spawning, breeding, feeding, or growth to maturity covers all habitat types utilized by a species throughout its life cycle. NMFS would provide recommendations to conserve EFH to Federal or state agencies for activities that would adversely affect EFH.

### Historical Fishery Resources

Review of the historical background information shows that fisheries resources have declined dramatically since the turn of the century. As early as 1892, reports of declines in fish abundance within the streams of western Marin County were circulated. Response to declines and recreational demand included planting of a variety of salmonid species

within the Lagunitas Creek watershed including coho salmon, chinook salmon, steelhead trout, and eastern brook trout. Direct plants to Olema Creek included eastern brook trout in 1892, and chinook salmon in 1897 and 1910.

Interviews with long time residents and former as well as present fisheries resource managers support the contention that fisheries resources within the area have been declining for years and that the most significant and noticeable changes have occurred since the mid-1950's. It is well established that both the abundance and distribution of coho salmon and steelhead trout has declined throughout the area. Interestingly, though most of the changes in fish populations have occurred within the past 50 years, the majority of the most exploitive land use practices (dairy and logging) ended more than seventy years ago.

There is little doubt that historic exploitation of the forest, grassland, and fisheries associated with the Olema Valley has severely impacted the extent of existing coho salmon and steelhead trout populations.

### ***1.3 Monitoring Rationale***

Salmonid reproduction rates are high, matching the rates of mortality that occur throughout their life cycle. In freshwater systems, mortality rates for coho juveniles typically peak in early summer and stabilize by the fall. 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 the north coast of California and Oregon, researchers have observed high juvenile densities in the summer, followed by very low smolt outmigration the following spring (Duffy 2004 personal communication). 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 et al 1992).

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

### ***1.4 Physical Setting***

The Olema Valley has a rich and varied land use history. Beginning in the early 1800s traditional hunting and burning by the Coast Miwok shifted to intensive livestock production. The first major Mexican land grants included livestock and sheep grazing as well as extractive uses such as logging. In the later 1800s production converted primarily to dairy operations, and western Marin County became one of the state leaders in dairy production. The dairy business lost appeal in the mid-1900s with many of the operations converting to beef cattle production. Acquisition of the land in the Olema Valley by the National Park Service's Point Reyes National Seashore and Golden Gate National Recreation Area began in the mid 1970s. Currently, 35% of the Olema Creek watershed is within the designated Pastoral Zone and managed for beef cattle. Agricultural land use is primarily limited to the east side of Olema Valley and the Bolinas Ridge. The exception to this is the private lands operated by the Vedanta Society.

#### ***1.4.1 Watershed Description***

Olema Creek's hydrologic regime is inextricably linked to the San Andreas Fault and the area's Mediterranean climate. East of the fault, intermittent tributaries flow from the serpentine bedrock and thin soils of Bolinas Ridge and across the alluvial valley bottom. West of the fault, perennial tributaries draining the deep marine sedimentary deposits of Inverness Ridge to the west follow much steeper stream gradients before joining the mainstem of Olema Creek. The intermittent Bolinas Ridge tributaries provide the most significant fisheries habitat and watershed area, while the perennial but steep Inverness Ridge tributaries supply the important summer base flow to the mainstem, which contains the majority of the aquatic habitat within the watershed.

The Olema Valley was dramatically affected by the 1906 San Francisco earthquake. The quake resulted in surface ruptures from Bolinas Lagoon to Tomales Bay with lateral offsets measured up to 20 feet. Geologic investigations have

shown that such events reoccur on this section of the fault on the order of once every 300 years (Niemi 2002 personal communication). The location and actions along the fault insure some level of instability within the watershed.

The watershed condition reflects impacts of more than a century of intensive agricultural land use, combined with the instability of its location along the highly active San Andreas Fault. The effects of past land-use practices (logging, agriculture, and grazing) have changed the condition of the watershed, altering its ability to support fish populations at their historic levels. Although land-use activities have been greatly reduced and upgraded to a more environmentally sustainable land-use ethic, present land-use continues to influence water quality conditions within the watershed. Loss of native perennial vegetation, soil compaction and loss, hillside trailing, gullying, and incision of swales and meadows have changed the runoff patterns and reduced the capacity of the watershed to attenuate pollutant loading and surface runoff.

#### 1.4.2 Watershed History

The landforms observed throughout western Marin County have been formed by a combination of extreme climactic events and plate tectonics. While the geologic setting and climate have been described, it is the extremes associated with these conditions that have played the greatest role in shaping the valley, stream channel, and habitat for the anadromous fisheries known to prefer this watershed. The Olema Valley was the site of a surface rupture trending to the northwest following the 1906 San Francisco earthquake, with extensive land rupture of up to 21 feet occurring along the central shutter ridge feature (Gilbert 1908). In many other ways, the fault zone has resulted in very unusual geomorphic features, including parallel streams flowing opposite directions within the same valley (Olema and Pine Gulch Creeks).

Discounting the cumulative impacts of human alteration and ocean conditions, and assuming that anadromous fish populations were relatively strong in the mid 1960s as the NPS began acquiring land, it is the extreme climactic events that have impacted the habitat and ultimately populations of coho salmon and steelhead trout.

The last thirty years have been marked by two major droughts (1976-77 and 1985-90), two El Nino events (1983 and 1998), and a 500 year storm event (1982). While the drought weakened fish populations throughout the coastal watersheds, it was the 500 year flood followed the next year by the first documented El Nino event that severely impacted habitat and fish populations for 2/3 of the coho salmon year class. The major storm events resulted in catastrophic debris flows and delivery of sediment to the channel. In some areas we are still observing major sediment deposition resulting from the mobilization of materials deposited in the channels in 1982 and 1983. In addition to these issues, abandoned road facilities within the Seashore persist as sources of sediment to the stream.

#### 1.4.3 Olema Creek Hydrologic Response

Within the Olema Creek system, hydrologic response is rapid and short-lived. In this Mediterranean climate, the flow of Olema Creek ranges from less than 0.5 cubic feet per second (cfs) in the summer to more than 2,500 cfs in the winter. An indicator often used to describe stream channel condition is the bankfull or effective discharge. This is a flow that occurs approximately on a two-year repeat interval and is calculated at approximately 500 cfs (Dunne & Leopold 1978). The 14.5 square mile watershed is quite linear with a measured lag time between peak rainfall and runoff at the Bear Valley Bridge on the order of three to four hours. The rainfall-runoff response time in most tributaries is between 15 to 45 minutes, depending on watershed size.

Past land use has altered the hydrologic response of Olema Creek. Incision through meadow and floodplain features has reduced the lag time and increased peak flows within the watershed. The result of these physical alterations and increased winter discharge is a reduced groundwater storage capacity in the tributary floodplains and meadows. The alterations to the wetland systems have resulted in a greater range of flow between winter and summer.

Seven to nine inches of cumulative rainfall are required to initiate significant response and connectivity of the entire system. If this rainfall is spread across more than 60 days, additional precipitation is necessary to saturate the watershed. Once tributaries are connected to the mainstem, runoff response at the Bear Valley Bridge increases dramatically.

This event is considered the first flush water quality event, delivering accumulated sediment and pollutants from land-based source areas. This runoff event often coincides with the initial upstream migration by coho salmon into the stream system. Until most of the intermittent tributaries are flowing, response in the main channel is not adequate to accommodate fish passage to most of the spawning habitat within the system.

The most significant tributaries with regard to water, habitat, and fish are the John West Fork, Quarry Gulch, Giacomini Creek, Randall Gulch, and Boundary Gulch. These tributaries provide some perennial habitat sections in the upper and middle portions of the channel, while going intermittent as the creek stretches across the alluvial valley bottom. Habitat within these streams is viable for both coho salmon and steelhead trout.

Tributaries draining Inverness Ridge are perennial, and are significant contributors to the summer base flow. In normal years the upper 30% of the Olema mainstem, lacking connection to Inverness Ridge, is intermittent. Beginning just south of Five Brooks and progressing north, these steep tributaries join the mainstem. While ripe with water supply, most of these steep drainages provide little to no habitat. Where there is habitat, it primarily fits the needs of steelhead trout for both access and rearing (riffle dominated). Most significant of these watersheds are Davis/Boucher and Vedanta Creeks.

#### 1.4.4 Rainfall Information

Daily rainfall totals have been recorded at the Bear Valley Headquarters since 1968. In 1997, the Seashore installed a weather station to collect and compile hourly weather information. Annual rainfall for the period 1968 to the present is 39.39 inches at Bear Valley headquarters, with approximately 90% of that occurring between November and April. Of the past 38 years, 17 have exceeded the rainfall normal.

**Table 1.1 Annual Rainfalls Monthly Averages at Bear Valley, 1965-2005**

|                | <b>Total</b> | <b>Oct</b> | <b>Nov</b> | <b>Dec</b> | <b>Jan</b> | <b>Feb</b> | <b>Mar</b> | <b>April</b> | <b>May</b> | <b>June</b> | <b>July</b> | <b>Aug</b> | <b>Sept</b> |
|----------------|--------------|------------|------------|------------|------------|------------|------------|--------------|------------|-------------|-------------|------------|-------------|
| <b>Average</b> | 39.39        | 2.02       | 5.49       | 7.39       | 8.21       | 6.50       | 5.48       | 2.43         | 1.13       | .23         | .08         | .13        | .32         |
| <b>Min</b>     | 15.03        | 0.00       | 0.61       | 0.01       | 0.40       | 0.47       | 0.24       | 0.00         | 0.00       | 0.00        | 0.00        | 0.00       | 0.00        |
| <b>Max</b>     | 79.84        | 5.74       | 18.20      | 22.99      | 22.39      | 24.68      | 24.28      | 6.60         | 6.35       | 1.86        | 2.58        | 1.82       | 2.54        |

### Annual Rainfall Totals at Bear Valley, Point Reyes National Seashore

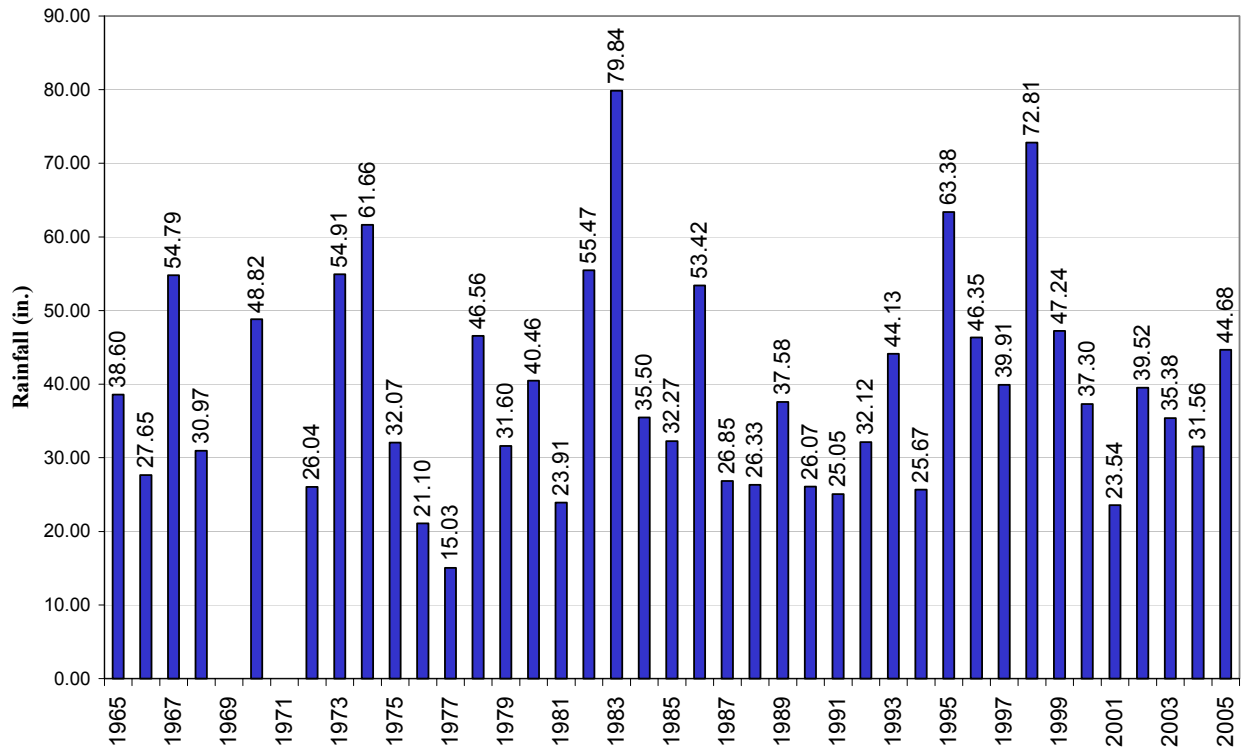


Figure 1.3 Annual Rainfall Monthly Averages at Bear Valley, Water Years 1965-2005

## 2.0 METHODS

This program includes strategies to monitor salmonids at a variety of life stages. Methods for adult spawner surveys, outmigrant smolt trapping, summer juvenile index reach surveys, and a basinwide coho juvenile population estimate are documented in the draft San Francisco Bay Area Network Stream Aquatic Resource Monitoring Protocol (NPS 2003). These methods have been used by the National Park Service (NPS) for salmonid monitoring within coastal Marin County since 1997. Many of the methods associated with the project are consistent with draft California Department of Fish and Game biotic monitoring guidelines (Collins 2003).

### 2.1 Adult Escapement Surveys

Beginning in the winter of 1997-98, the NPS conducted spawner surveys in portions of the Lagunitas, Olema, and Redwood Creek watersheds. NPS staff and volunteers counted redds, live fish, and carcasses in an attempt to better understand trends in adult coho salmon abundance and distribution.

#### 2.1.1 Adult Escapement Monitoring Objectives & Questions

##### **Monitoring Objectives**

1. Determine long-term changes in coho escapement and distribution within Olema Creek watershed using redds, live, and dead adult counts in order to determine contribution of Park waters to California Coho Recovery Plan escapement goals.

##### **Monitoring Questions**

1. For each coho cohort, what is the long-term status and trend?
2. Does the distribution and density of annual redd observations (e.g., redd superimposition) within a watershed indicate the presence of barriers to adult passage, both natural or human-caused?

#### 2.1.2 Field Methods

NPS staff and trained volunteers conduct surveys each winter during the coho spawning season to quantify escapement and determine spawning density and distribution. Although surveys focus on coho, steelhead spawners and redds are also observed and counted. 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, and 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. Scales samples are only collected from fresh (both eyes are still clear) carcasses that have not been mauled by scavengers. Redds are measured and marked with flagging. Because redds are stationary and can be observed over time, redd monitoring is targeted to determine spawning success. In northern California, a model has been developed to estimate spawning population based upon redd count and redd effort (Gallagher and Gallagher 2005). Redd effort is determined by redd size measurements. The NPS currently collects these redd measurements and plans to work with CDFG researchers to calibrate the model to this area.

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 meters along each stream. Through experience, we have found volunteers effective at documenting live fish and carcasses, but not as effective at documenting redd presence or sex of the individual fish. SFAN staff conduct follow-up redd surveys to confirm those marked, and identify those missed in earlier surveys. The survey data is used to generate index values and minimum population estimates for the assessment of long term trends.

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. Reported spawning escapement estimates are made using the Peak Live + 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. 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 escapement estimates using the Area Under the Curve (AUC) method (Irvine et al. 1992).

Spawner surveys for a watershed the size of Olema require the mobilization of 10-15 volunteers from the local community. Many of these observers are experienced and are able to lead teams for the survey. SFAN program staff led as many teams as feasible.

### 2.1.3 Rationale for selecting this sampling design

The methodologies currently used for spawner surveys have been used to estimate escapement for a variety of salmonids throughout the Pacific Northwest (Johnston et al. 1987; Irvine et al. 1992; Anderson and McGuire 1994; Downie and Peterson (undated)). Although both steelhead and coho are present in PORE and GOGA watersheds, the surveys focus on coho because their life history pattern and behavior is more amenable to accurate data collection. Coho spawner survey data tends to be more accurate than steelhead information because:

1. coho spawn earlier than steelhead (typically in December or January);
2. unlike steelhead, coho remain in the watershed until they die after spawning, which makes carcasses readily collectible;
3. steelhead spawn over a longer period than coho, from January to May, which makes the frequent collection of data more difficult.

### 2.1.4 Sampling site locations

A large section of the mainstem of Olema Creek, 17.6 km, has been surveyed by the TBA and PORE staff and volunteers since 1993. The section is currently divided into 7 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 2.1). 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);

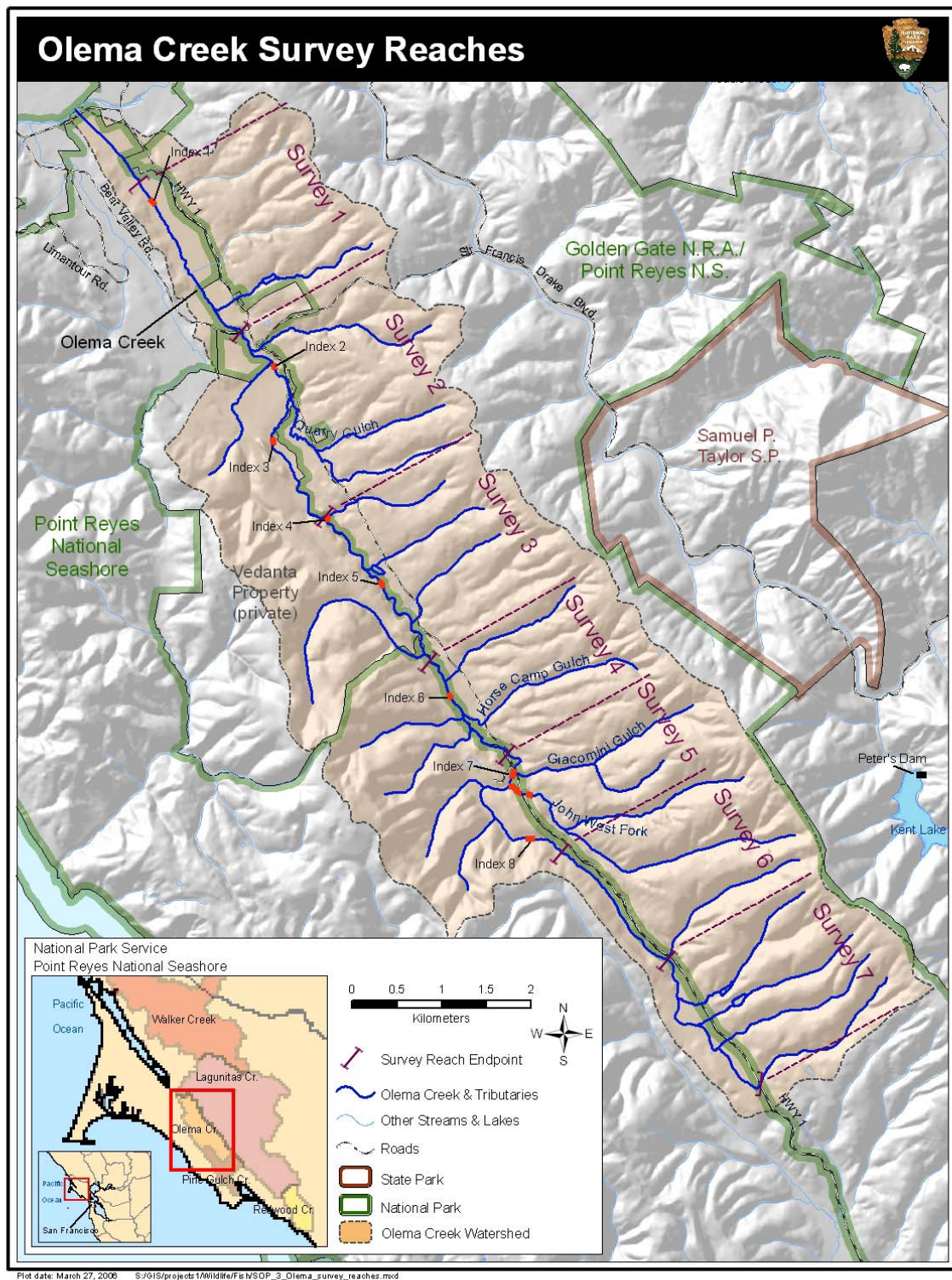


**Figure 2.1 Olema Creek Spawn Survey Reach Map**

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 order of priority. For each tributary, surveys reaches start at the mouth and continue upstream as long as no passage barriers exist. The tributaries, many of them unnamed on U.S. Geological Survey (USGS) 7.5 minute maps, are named in Figure 2.1 and listed below in order of survey priority:

1. John West Fork located 10.9 km above the mouth of Olema Creek at Hwy. 1 milepost 22.67. (Survey reach 1 is from trib mouth to Hwy 1 culvert crossing, reach 2 is from the Hwy 1 culvert crossing to 2.0 km upstream of the confluence with Olema Creek, and reach 3 is the North Fork of John West Fork Creek from the confluence to approximately 0.4 km upstream.)
2. Quarry Gulch located close to the Olema Cemetery 4.1 km above the mouth of Olema Creek at Hwy. 1 milepost 25.35.
3. Giacomini Gulch located 10.8 km above the mouth of Olema Creek at Hwy. 1 milepost 22.78.
4. Horse Camp Gulch located 9.6 km above the mouth of Olema Creek at Hwy. 1 milepost 23.26.
5. The Headwaters of Olema Creek (considered a tributary for the purposes of the survey due to its physical characteristics) beginning at Hwy.1 milepost 19.94.

### 2.1.5 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 NPS monitoring program is, nonetheless, interested in developing precise indices of abundance. Two techniques, Peak Live Plus cumulative Dead (PLD) and Area Under the Curve (AUC) are used to compute index values (Beidler and Nickelson 1980; Johnston et al. 1987). 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. While the PLD index produces a minimum instantaneous estimate, the AUC method is used to calculate a total population estimate. The PLD index is computed as the name suggests. The peak number of live fish observed during a single day of the spawning season is added to the cumulative number of unmarked carcasses observed prior to that date. 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). Calculating the area under the curve created by plotting the live fish observations for each survey, produces a quantity termed total fish-days. The area under the escapement curve was 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. Because we did not estimate residence time, separate AUC estimates were computed using the range of 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 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.

Because the necessary conditions for accurate AUC estimates are not always met, we also quantified spawning runs using the Peak Live + 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 count. Redd count and location is used to describe spawning density and spatial distribution.

### 2.1.6 Other Monitoring Programs

NPS conducts escapement monitoring on Pine Gulch Creek, Cheda Creek and Redwood Creek as well as Olema Creek. In addition, the Marin Municipal Water District 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 for detailed escapement results for two of the five coho salmon genetic subgroups within the central California coast ESU.

## **2.2 Outmigrant Smolt Trap**

Outmigrant trapping is intended to census the number of smolts leaving the watershed. Trapping results can also help quantify dates of fry emergence and growth rates through the spring season. Outmigrant traps also provide presence/absence information and size data for other aquatic species during periods not covered by summer/fall monitoring activities.

The NPS operated a smolt trap annually from 1998 to 2004 on the John West Fork, an important tributary of Olema Creek, upstream of a culvert modified to improve passage in 1999. In addition to the John West Fork trap, the NPS operated four other traps in 1999 that showed the importance of tributaries to overall watershed smolt production. In 2004 the NPS initiated trapping at the downstream end of Olema Creek.

Smolt trap monitoring, in conjunction with other life stage monitoring activities, allows the NPS to characterize aggregate watershed productivity for salmonids and permits an evaluation of abundance during three of five distinct freshwater salmonid life stages. The smolt trap information can be compared with adult spawner indices to describe potential ocean productivity and survival. Overwintering survival rates can be assessed by comparing smolt productivity to summer juvenile population estimates. In this manner, change may be detected within each watershed for each monitored salmonid year class. Because coho salmon have a three-year life cycle, monitoring must span this time in order to elicit any type of trend information for the year class. Variation between years can be used to describe the differing conditions and populations of each year class.

At the time of smoltification, coho have spent more than 14 months in the watershed, and steelhead have spent 1-4 years in the system. Smolt production, therefore, is the best aggregate measure of watershed condition and productivity. The response of coho and steelhead populations to changes in habitat quality can not be properly assessed without a measure of smolt production.

Smolt trapping is a valuable resource for directing long-term management and restoration actions. Smolt trapping can indicate the success of restoration projects as shown by the dramatic response in smolt productivity after adult passage improvements through the State Route 1 culvert. An understanding of the environmental factors and dates that result in cessation of downstream smolt movement may also be used to determine instream construction windows that would not impair movement of smolts.

### 2.2.1 Monitoring Objectives and Questions

#### **Monitoring Objectives**

1. Determine health condition factor of salmonid smolts within Olema Creek.
2. Estimate the annual production of coho smolts within Olema Creek using spring outmigration trapping.

#### **Monitoring questions**

1. How does Olema Creek coho and steelhead condition factors compare between small coastal drainages in PORE/GOGA watersheds, Central California Coast ESU, and the northern California-southern Oregon ESU?
2. What is the time of peak outmigration?

### 2.2.2 Field Methods

Pipe style traps and fyke/pipe style 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. John West Fork smolt trapping employed the pipe-style trap, but the higher flows on Olema Creek require a combination pipe/fyke trap (Gale 2000) design intended for larger creeks. The fyke/pipe trap on the mainstem of Olema Creek and Redwood Creek is based on a design used by CDFG on the Noyo River (Gallagher 2000, Barrineau and Gallagher 2001). The fyke/pipe trap is designed to minimize impingement under high flows and in-trap predation of fry by larger juvenile salmonids and other fish. The trap is installed in mid-March and removed at the end of May. A 4' x 5' x 20' fyke net is supported by t-posts and a frame consisting of 1" galvanized pipe. Several 4' x 8' weir panels, each consisting of a 2x4" frame and ½" mesh hardware cloth, are secured with t-posts and zip ties to direct fish into the mouth of the fyke net. The throat of the fyke net is attached to a series of 6" x 20' PVC pipes, which are connected to a 125 x 74 x 50 cm live box constructed of plywood and 1/8" mesh hardware cloth. The live box is situated in a shaded pool, and contains rocks, vegetation, and a ½" mesh divider screen to provide a refugium for fry. In addition, the weir contains several vents that allow any late spawning adult steelhead to migrate upstream unimpeded during higher flows.

The trap is checked daily and all captured fish are processed and released. All 1+ salmonids are anesthetized using Alka Seltzer™. Captured fish are identified to species, age class, and counted. A subsample of each species and age class is measured by fork length to the nearest mm and are weighed to the nearest 0.10 gram. Fry under 50 mm are not weighed. Fish are kept in aerated holding buckets before and after handling, and are allowed to fully recover before being released. The trap targets salmonid smolts, parr, and fry but the numbers, lengths, and weights of a subsample of all captured species are recorded. A subsample of smolts and presmolts are marked and re-released upstream each day to estimate trap efficiency. Smolts are marked using either small fin clips, tattooed with dye using a needleless injector, or stained using Bismark Brown Y dye.

Environmental conditions are also noted, including stream water level, weather, and instantaneous water temperature. For more detailed data on the water temperature regime, a temperature logger (Onset Optic Stowaway) is deployed and left in the trap box for the duration of operation.

### 2.2.3 Rationale for sampling design

Past literature was reviewed to determine the appropriate start and ending points for the trapping season. In Waddell and Scott Creeks (Santa Cruz County), outmigration of coho smolts began in mid-March and peaked in mid-May (Shapovalov and Taft 1954). In Lagunitas Creek (Marin Co.), results from smolt trapping from 1983-1985 indicated that coho emigration began in early April and ended in late June (Bratovich and Kelley 1988). Steelhead emigration generally begins in early-March and ends by June (Bratovich and Kelley 1988). Based on our trapping experience, we have observed outmigration primarily in April and May, with the peak occurring in late April-early May.

Currently during the trapping season, mid March – May, the traps operate 24 hours per day, and are checked on a daily basis. This frequency was selected to balance excessive labor efforts with the need to prevent injury because of prolonged trap residence. Twice-daily trap visits on Lagunitas Creek were abandoned because few or no fish were captured between the morning and afternoon (Bratovich and Kelley 1988). We have observed similar trends, with most movement into the traps occurring at night. Under high flow events, the trap is checked frequently during the day to remove accumulated debris within the trap and at the weir or the trap box is left open to allow safe passage for fish. If possible, traps are opened prior to high flows to avoid potential or excess mortality. We typically see peak runoff 3-4 hours after peak rainfall.

### 2.2.4 Site location

Smolt traps should be located as far downstream as possible in the sampled watershed, preferably near the mouth of the stream, to provide the most accurate smolt productivity index for the watershed upstream of the trap. Channel character, accessibility, and protection are equally important. The site must have adequate vertical gradient to push water through the pipe as well as an area of low energy to house the trap box. The structure should be located in an area where equipment can be easily carried to the site. In addition, it is important that the trap be located in a place where vandalism is not likely.

The Olema mainstem trap is located on NPS lands approximately 400m upstream of the mouth. 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 season, the trap will be relocated in 2007. NPS staff is currently investigating potential trap locations upstream of the major red-legged frog breeding areas.

### 2.2.5 Analysis

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

A simple Petersen estimator can be used to generate smolt population estimates from the mark-recapture data (Thedinga et al. 1994). Trap efficiency, the proportion of marked smolts recaptured, will be calculated as

$$E = R / M$$

where R is the number of marked smolts recaptured and M is the number of marked smolts released. Trap efficiency can then be used to expand the unmarked catch and produce population estimates as

$$N = U / E$$

where N is the estimated population size and U is the unmarked catch. The marked and recaptured fish from subsequent days should be pooled into strata before estimating N. The numbers of marked smolts recaptured and marked smolts released from each stratum can be tested for independence using a chi-square test. If no differences are detected, a single estimate of N can be made for the entire migration. Variances and 95 percent confidence intervals can be determined by the Bootstrap method using 1,000 iterations (Efron and Tibshirani 1986).

Mark/recaptured data can also be analyzed using DARR (Darroch Analysis with Rank Reduction), a software application developed by Eric Bjorkstedt at the NMFS Southwest Fisheries Science Center (Bjorkstedt 2000). The software facilitates analysis of temporally stratified mark/recapture data based on methods developed by Darroch (1961).

Using the efficiency method to estimate population could result in overestimates of 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 behavior change (far more probable in steelhead than coho); and 3) released fish are redistributed and have a constant probability of capture

In addition, tissue and scale samples are collected from a subsample of fish moving through the smolt trap during each year. This will allow for further genetic analysis of central California coast salmonids, as well as age-length relationships and determination of smolt age for both coho and steelhead.

## **2.3 Summer Juvenile Estimates**

A combination of index reach surveys and modified Hankin and Reeves basinwide surveys are used to generate mainstem coho juvenile summer population estimates. Combining the two allows for both the intensive sampling data derived from the index reach surveys and the extensive sampling and statistically valid population estimates of basinwide surveys, and eliminates the additional electrofishing that would be needed if both were conducted independently. This is especially important when dealing with the permitting issues associated with sampling ESA listed salmonids.

### 2.3.1 Index Reach Surveys

Index reach surveys include both fish sampling and detailed habitat assessments. Index reach surveys provide baseline fish distribution information and abundance/density estimates. It is likely that juvenile salmonid year class abundance will vary depending on returns of adult spawners and environmental conditions. By comparing the baseline fish density estimates derived from consecutive survey years, the variations in year class abundance can be monitored. Because steelhead often spend in excess of one year in freshwater, annual surveys also may provide information on the overwintering success of different year classes.

The limitations of index reach surveys are well known. Sample site selection is not systematic, sample size is small relative to the overall number of habitat units, and distribution of fish throughout stream reaches is not necessarily consistent. The fish and habitat parameters collected via index reach surveys can be very accurate for the sampled area, but are not necessarily applicable to the rest of the stream or watershed. Although total fish population may be extrapolated from density estimates within index reaches, it is not possible to determine the statistical accuracy of such extrapolated estimates (Dollof et al 1993).

#### 2.3.1.1 Index Reach Monitoring Objectives and Questions

##### **Monitoring Objectives**

1. Determine the composition and abundance of fish assemblage within Olema Creek using electrofishing.
2. Determine health condition factor of juvenile salmonids within Olema Creek.
3. Identify gross changes in pool: riffle composition within Olema Creek.

##### **Monitoring Questions**

1. Is population size increasing within each coho cohort, within each watershed?
2. What is the distribution of non-native fish?
3. What is the distribution of non-salmonid fish?
4. How does Olema Creek coho and steelhead abundance compare between small coastal drainages in PORE/GOGA watersheds, Central California Coast ESU, and the northern California-southern Oregon ESU?
5. How does Olema Creek coho and steelhead condition factors compare between small coastal drainages in PORE/GOGA watersheds, Central California Coast ESU, and the northern California-southern Oregon ESU?

#### 2.3.1.2 Index Reach Field Methods

Each index reach consists of a 30-100 meter reach, containing from 3 to 10 contiguous habitat units, which are identified and sampled individually. Habitat units are isolated with seine nets and electrofished separately using standard multiple pass depletion methods. Most riffle units are sampled with a single pass. Captured fish are sedated using carbon dioxide (Alka Seltzer<sup>TM</sup>), identified to species and age class, measured, and weighed. Some individuals are handled to collect fin clips or scale samples for age and/or genetic analysis. Fish are kept in aerated holding buckets before and after handling, and are allowed to recover fully before being released.

Habitat measurements and assessments are made for the index reaches after fish sampling is completed. The length, average width and depth, substrate composition, and instream shelter complexity (Flosi et. al. 1998) are quantified in each habitat unit. Transects are set up across each habitat unit and depth and substrate type recorded at points along each transect. Instream shelter complexity values are estimated for pool and flatwater units. Additional habitat parameters, including bank erosion, riparian cover, and woody debris are then determined for the index site as a whole. Ideally the habitat portion of index reach monitoring will be completed the same day as fish sampling, but may be conducted up to two days afterwards if necessary as long as habitat conditions do not change significantly.

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 in Section 10 Reports to NOAA Fisheries. Water quality parameters are also measured and recorded.

#### 2.3.1.3 Rationale for sampling design

Salmonid monitoring has occurred in Marin County streams for several decades, and most of the past and current juvenile sampling efforts have utilized some variant of index reach methodology. MMWD and Dr. Jerry Smith of

SJSU have monitored index reaches on the Lagunitas and Redwood Creek watersheds, respectively, for a decade or more. GOGA and NPS staff has sampled index reaches on various NPS watersheds since the late 1990's. Continuing these methods will allow comparison of data with an established long term dataset on abundance, density, and distribution of juvenile salmonid and other fish within Marin County streams.

By focusing intensive sampling over small portions of the creek, index reach monitoring allows for collection of detailed fish and habitat information when personnel, budget, and time are limited. Overall species composition and biomass can be assessed since all species present in a selected reach can be effectively sampled, particularly when electrofishing. Length and weight measurements of individual fish, as well as scale and tissue samples, can also be easily collected. Since a small area is being sampled, transporting the additional equipment associated with more intensive sampling is minimized.

#### 2.3.1.4 Site locations

Index reaches are situated at somewhat regular intervals throughout the mainstem of each creek, and generally correspond to stream reaches determined by Rosgen (Rosgen 1996) channel type, land use patterns, other habitat characteristics, and professional judgement and knowledge of the watersheds. Where possible, water quality and aquatic invertebrate monitoring sites coincide with the location of the index reaches. The composition of habitat types within the index reaches is intended to reflect the overall habitat conditions of the stream segments they represent, as determined by the habitat typing surveys that have been completed for each watershed. Using similar criteria, tributary index reaches are situated upstream, downstream, and within restoration sites.

Eight index sites were established in 1999 and 2000 within the mainstem of Olema Creek for long-term annual monitoring of juvenile salmonids and other fish (Table 2.1; Figure 2.2). Additional index reaches are located on the John West Fork and Quarry Gulch, two tributaries with planned or completed restoration projects.

**Table 2.1. Olema Creek Rosgen Stream Reach and Index Section Locations, 1999.**

| Rosgen Stream Reach Number | Rosgen Stream Type | Stream kms. | Location Description                                           | Index Section (Section Name, km)                                                               |
|----------------------------|--------------------|-------------|----------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| 1                          | Da                 | 0-2.3       | Confluence w/ Lagunitas Creek to Single Channel at Monument 23 | 1 (Lower Stewart's, 1.2 km)                                                                    |
| 2                          | B                  | 2.3-3.2     | Single channel to tributary at Olema Ranch Campground          |                                                                                                |
| 3                          | F                  | 3.2-9.6     | OL-21 to Horse Camp Creek                                      | 2 (Vedanta, 3.7),<br>3 (Quarry/Upper Stewart's, 4.9),<br>4 (Truttman 6.2),<br>5 (Shook's, 7.6) |
| 4                          | B                  | 9.7-11.9    | Horse Camp Creek to tributary OL-07                            | 6 (Horse Camp 9.4),<br>7 (Five Brooks 10.8)                                                    |
| 5                          | F                  | 11.9-15.0   | OL-07 to Randall Gulch                                         | 8 (Lime Kilns 13.0)                                                                            |
| 6                          | C                  | 15.0-16.2   | Randall Gulch to South Hagmaier                                | Dry                                                                                            |
| 7                          | E/C                | 16.3-17.4   | South Hagmaier to Hwy. 1                                       | Dry                                                                                            |

### 2.3.1.5 Analysis

For habitat units sampled by multiple pass electrofishing, fish population estimates and confidence intervals for each species/age class are generated by *Microfish* (VanDeventer and Platts 1989) using the maximum likelihood model. 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. Confidence intervals for each habitat unit were established by developing a correlation between estimated population and standard error for the habitat units where multiple electrofishing passes and estimates were completed. Though we anticipated separate correlation values by year, the available data resulted in correlation equations for each salmonid species and age class from the watershed. The correlation was derived based on sampling results collected between 1999 and 2003. This resulted in development of a 95% confidence interval (CI) population estimate for each habitat unit. Population estimate and 95% CI for each index reach presented in Section 3 are derived from adding each individual result (95% CI low, population estimate, and 95% CI high). The density calculations for each index reach, including fish per meter and fish per square meter, are derived from the summary index results, and not an average of each habitat unit.

Biotic condition results for both salmonid species, including the weight-length power curve relationship and the Fulton condition factor, are also reported. The power curve relationship (below) with an  $r^2$  value is reported for each species and each index reach where W=weight, FL=fish fork length, a=derived coefficient, and b=power relationship.

$$W=aFL^b$$

Fish condition can be assessed using Fulton's condition factor as well as weight-length power function (Anderson and Gutreuter 1983). Fulton's condition factor (K) is represented by:

$$K = \frac{Weight \ (g)}{Length \ (mm)^3} \times 100,000$$

and will be calculated automatically by the database for all fish with both length and weight. Mean K can then be calculated for each species/age class within a reach or habitat type. Typically, "plumper" fish have higher K and b values than "skinny" fish.

Standing biomass for each habitat unit is calculated by extrapolating the mean weight per individual (from weighed individuals of each species/age class) to the population estimate for each species/age class. Biomass estimates for the salmonid components of the sample are reported as information within the document.

### 2.3.2 Basinwide Surveys

Unlike index reaches, basinwide surveys provide a sample site selection that is systematic, with a sample size that is adequate relative to the overall number of habitat units, and a distribution of fish throughout stream. Basinwide surveys were initiated during the summer of 2003 in an attempt to provide a better representation of the population size and distribution of coho salmon in the mainstem of Olema Creek. Since the collection of detailed information is limited during basinwide surveys, field staff have the ability to survey the entire mainstem in a relatively short amount of time. Basinwide population estimates are a key component in the multiple life stage monitoring for coho salmon as they can provide insight on the validity of the adult coho estimates from the previous year. Basinwide population estimates can also be used to determine mortality rates from egg to juvenile and juvenile to smolt life stages.

### 2.3.2.1 Basinwide Survey Monitoring Objectives and Questions

#### **Monitoring Objectives**

1. Determine the annual population size of juvenile coho within Olema Creek using basinwide estimates.
2. Identify gross changes in pool: riffle composition within the Olema Creek drainage.

#### **Monitoring Questions**

1. Is population size increasing within each coho cohort, within Olema Creek?
2. Is there change in the distribution of juvenile coho along mainstem channel over time?

### 2.3.2.2 Field Methods

#### **Habitat Typing**

Starting at the bottom of the coho survey area and working upstream, project staff number, classify, measure the length, and estimate the average width of each habitat unit. Units are classified as pool (scour pool, backwater pool, plunge pool, or mid-channel pool), flatwater, riffle, or cascade. 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.

#### **Snorkel Counts**

Project staff surveys each of the previously determined pools with one or more snorkel passes, using dive lights to search under vegetation, woody debris, and undercut banks. Coho are counted, and the presence of steelhead and non-salmonid fish and other aquatic species are documented, as well as cover, habitat complexity, and general survey conditions. The number of divers in the water varies from 1 to 3, depending on the width and complexity of the unit. Strategies are used to divide the fish between the divers and filter them in such a way that the divers can be confident of their counts.

Pools are calibrated either by electrofishing or bounded snorkel counts. Pools from all index reaches within the survey area are also included in the snorkel surveys. These pools are electrofished the day after each snorkel survey. Calibration for the snorkel surveys is normally conducted using electrofishing results. In 2005, when conditions allowed for multiple passes, bounded snorkel counts were used as a calibration (4 snorkel passes). After the initial pass, the field data recorder would notify the diver(s) if the pool was to be a calibration pool. If there was sufficient flow into the pool to allow for multiple passes, then 3 additional passes would be completed. For detailed information on bounded counts refer to Fisheries Techniques, Second Edition (Murphy and Willis 1996).

### 2.3.2.3 Rationale for sampling design

When a statistically accurate estimate of stream habitat or fish population is needed for a broader area or an entire stream, basinwide survey techniques developed by Hankin and Reeves (Dolloff et al 1993) will also be used. The advantages of basinwide surveys are well established (Dolloff et al 1993). The results of such surveys yield estimates of total stream habitat surface area and total fish population size and include calculated statistical error. Combining index reach surveys with basinwide surveys provides a sampling design that is consistent with the three-tiered approach outlined by Moyle et al (1998) for assessing fish condition. Under this approach “good condition” is defined as “healthy individual fish in healthy populations that [are] part of healthy biotic communities”. The length and weight measurements collected in the index reach surveys allow us to assess relative health of individual fish. Index reach abundance/density indices and basinwide survey population estimates provide a means to track the population of each species.

### 2.3.2.4 Site locations

Since basinwide surveys were initiated in 2003, the summer habitat survey has covered between 9.2 km and 12.7 km of Olema Creek. Habitat surveys have begun between stream km 2.3, downstream of the Olema Ranch Campground, and stream km 3.7, at the Vedanta bridge, and have continued upstream to between stream km 11.5, the Five Brooks horse pasture, and stream km 15.0, the Randall Ranch House. The snorkel surveys covered between 7.8 km and 11.3 km of the mainstem, beginning at stream km 3.7, located at the Vedanta Bridge, and continuing upstream to between stream km 11.5 and 15.0. Snorkel surveys are not conducted below stream km 3.7 due to water quality concerns.

### 2.3.2.5 Analysis

Basinwide surveys result in a summary of habitat composition for the length of creek sampled. Visually estimated widths and measured habitat unit surface area are correlated and a calibration ratio is determined to correct the estimated surface area of all units. Snorkel counts are summarized and snorkeled index reach pools are correlated with electrofishing estimates to develop coho densities and population estimates. Bounded counts are also used to calibrate single dive passes when conditions allow for repeat dive passes on a single unit. See section 2.3.1.5 for methods regarding electrofishing Microfish estimates. A juvenile coho population estimate is determined based on the calibrated juvenile coho counts and the number of pools observed in the survey area.

### 2.3.3 Juvenile Fish Abundance, Distribution, and Mortality in Isolated Pools

In both the summers of 1999 and 2004 a Hankin-Reeves type Basinwide Visual Estimation Technique (BVET) (Dollof, et. al. 1993) survey was employed on the upstream isolated pool reach of Olema Creek. The surveys were done in order to better understand the contribution of isolated pools to the overall carrying capacity of Olema Creek. The locations for the evaluated upper reaches of Olema Creek were between the mainstem confluences of John West Fork and Randall Gulch (11.8-15.0 km) in 1999 and between upper Five Brooks and the mainstem confluence of Randall Gulch (12.0-15.0 km) in 2004. In order to assess the change in available fish habitat and survival/growth of threatened salmonids in isolated pools, the surveys were repeated after increased drying conditions in October 1999 and September 2004.

Specific objectives of the fish abundance and distribution surveys in isolated pool habitats in upper Olema Creek were to:

- evaluate fish species composition, abundance, and distribution;
- document changes in available juvenile rearing habitat during periods of low flow;
- estimate survival and growth rates of juvenile salmonids in intermittent pool habitat; and assess the value of isolated pool habitats to overall salmonid populations.

## **2.4 Genetic Analysis**

Tissue samples have been collected for genetic analysis by the NOAA - Fisheries Genetics Lab in Santa Cruz, California. Sample collection follows NOAA - Fisheries protocol and is performed as part of the Section 10 permit 1046. Samples are primarily collected from adult carcasses and smolts, although samples from young of year salmon have also been collected.

The genetics of coho salmon within the CCCESU have become more well-defined in the past years in association with the completion of analysis of coho salmon genetic samples from across the state of California (Hedgecock et. al. 2002). In conjunction with the Russian River Broodstock Reintroduction Program, the NOAA-Fisheries Genetics Lab has conducted extensive genetic characterization on samples from more than 300 fish per year for development of a spawning matrix (Garza and Gilbert-Horvath 2003).

## **2.5 Data Management**

Analytical techniques for each of the monitoring program components are described in the sections above. Field data are currently recorded on survey specific sheets, and entered and stored in a Microsoft Access database. The current Microsoft Access database is designed to meet the standards recommended through the NPS Inventory and Monitoring Program.

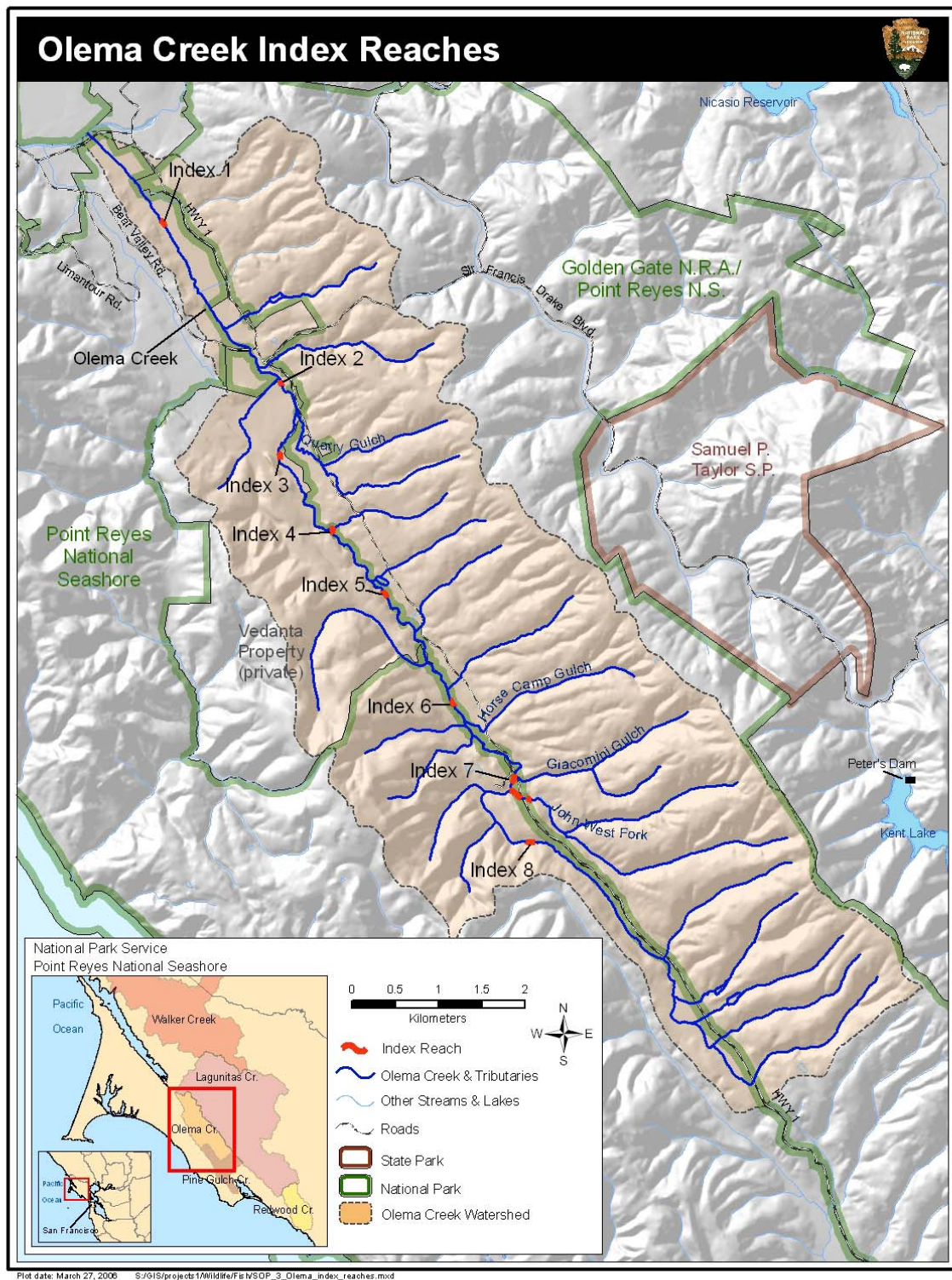


**Figure 2.2 Olema Creek Index Reach Location Map**

## 3.0 RESULTS

### 3.1 Adult Escapement Surveys

Efforts dating back to the mid-1980s by the Tomales Bay Association (TBA) documented coho salmon spawning in Olema Creek, though comprehensive surveys were not initiated until the winter of 1994-95. Spawner surveys were led by the TBA between 1994 and 1996. Beginning in 1997, monitoring efforts have been coordinated by National Park Service fisheries staff. A comprehensive report of adult escapement information for west Marin County watersheds was compiled in 1999 by David Manning of the NPS (Manning 1999).

#### 3.1.1 Survey Timing and Environmental Conditions

Review of the nine years of escapement monitoring information on Olema Creek shows that run timing is highly dependent on the rainfall-runoff condition within the watershed (table 3.1). Unlike Lagunitas Creek, Olema Creek is an unregulated stream. This makes conditions 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 2 weeks), though the NPS program has documented some individuals spending up to 20 days in freshwater under ideal conditions.

**Table 3.1 Monthly environmental and physical factors monitored in Olema Creek for spawner years 1997-98 through 2005-06.**

| Spawner Year | Total Rainfall (in) |       |       |       | Mean Daily Discharge (cfs) |       |       |       | Max Daily Discharge (cfs) |        |       |        |
|--------------|---------------------|-------|-------|-------|----------------------------|-------|-------|-------|---------------------------|--------|-------|--------|
|              | Nov                 | Dec   | Jan   | Feb   | Nov                        | Dec   | Jan   | Feb   | Nov                       | Dec    | Jan   | Feb    |
| 1997-1998    | 10.32               | 3.47  | 16.49 | 24.68 | 24.2                       | 28.5  | 168.7 | 372.6 | 207.6                     | 93.5   | 663   | 1339.6 |
| 1998-1999    | 7.48                | 2.21  | 7.66  | 15.61 | 9.6                        | 23.5  | 52.8  | 98.2  | 140                       | 132    | 218   | 311    |
| 1999-2000    | 5.2                 | 0.99  | 7.15  | 12.77 | 2.1                        | 1.9   | 37.8  | 120   | 4.5                       | 3.7    | 278   | 777    |
| 2000-2001    | 1.54                | 1.31  | 6.45  | 8.07  | 1.8                        | 2.4   | 30.1  | 83.1  | 2.6                       | 4      | 193.4 | 423.1  |
| 2001-2002    | 9.81                | 15.03 | 5.08  | 3.55  | 21.7                       | 103.1 | 103.5 | 45.4  | 169.4                     | 373.7  | 840.2 | 165.3  |
| 2002-2003    | 3.3                 | 17.33 | 3.75  | 2.34  | 2.3                        | 117   | 65.1  | 21.8  | 5.4                       | 383.9  | 177.3 | 110.3  |
| 2003-2004    | 2.71                | 12.14 | 5.13  | 7.68  | 1.9                        | 109.1 | N/a   | N/a   | 2.9                       | 1018.3 | N/a   | N/a    |
| 2004-2005    | 0.65                | 10.13 | 4.85  | 5.33  | 1.1                        | 59.1  | 48.9  | 44.7  | 1.5                       | 705.8  | 98.8  | 157.6  |
| 2005-2006    | 3.10                | 22.99 | 6.36  | 6.68  | N/a                        | N/a   | N/a   | N/a   | N/a                       | N/a    | N/a   | N/a    |

Our monitoring efforts have shown some years where flows necessary to allow entry into the watershed did not occur until mid-January. In those years, fish were stacked 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 of spawning 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. Table 3.2 shows the approximate entry and spawning window monitored for coho salmon between spawner year (SY) 1997-98 and SY 2005-06.

Conditions where Olema Creek run timing was far different than that observed in Lagunitas Creek occurred in 1999-2000 and 2000-2001, where Olema entry flow was delayed by 2 months, and in 2002-2003 and 2003-2004, where Olema entry flows were delayed by one month. Surveys indicated that coho did indeed wait to enter the watershed, and that once in the stream, spawning occurred almost immediately. This behavior has raised an important question regarding how populations maintain themselves in a watershed with regulated and unregulated channels. The escapement and timing within the unregulated Olema Creek watershed may be affected negatively by outside influences. Under State Water Resources Control Board Order 95-17, the Marin Municipal Water District is required to release winter attraction flows (>25 cfs for three days) through Lagunitas Creek prior to December 1 each year. Such releases in a low-flow year could attract fish that would otherwise move up Olema Creek. In addition, the estuary at the mouth of Olema Creek is highly constrained by levees associated with Sir Francis Drake Blvd and the Giacomini Dairy. For fish that do remain near the mouth of Olema Creek for an attraction flow, the shallow, exposed pools may make

adult salmon susceptible to both temperature effects and predation. Each of these factors may play in to the escapement in years where natural rainfall runoff conditions are temporally distinct from the winter reservoir releases.

**Table 3.2 Coho salmon run timing, average daily discharge by month, and Olema Creek Peak Live plus Cumulative Dead (PLD), total carcasses and redds documented in the surveys for spawner years 1997-98 through 2005-06 within the Olema Creek mainstem.**

| Spawner Year (SY)      | Run Timing |     |     |     | Average Daily Discharge (cfs) |       |       |       | Olema Creek PLD  |                  |                 |                 |
|------------------------|------------|-----|-----|-----|-------------------------------|-------|-------|-------|------------------|------------------|-----------------|-----------------|
|                        | Nov        | Dec | Jan | Feb | Nov                           | Dec   | Jan   | Feb   | Survey Area (km) | PLD Index        | Total Carcasses | Total New Redds |
| 1997-1998              |            |     |     |     | 24.2                          | 28.5  | 168.7 | 372.6 | 13.4             | 88               | 39              | 126             |
| 1998-1999              |            |     |     |     | 9.6                           | 23.5  | 52.8  | 98.2  | 11.6             | 42 <sup>a</sup>  | 13              | 42              |
| 1999-2000 <sup>b</sup> |            |     |     |     | 2.1                           | 1.9   | 37.8  | 120   | 7.2              | 9                | 9               | 10              |
| 2000-2001              |            |     |     |     | 1.8                           | 2.4   | 30.1  | 83.1  | 11.6             | 103              | 65              | 86              |
| 2001-2002              |            |     |     |     | 21.7                          | 103.1 | 103.5 | 45.4  | 11.6             | 90 <sup>c</sup>  | 28              | 58              |
| 2002-2003 <sup>b</sup> |            |     |     |     | 2.3                           | 117   | 65.1  | 21.8  | 11.6             | 20               | 17              | 5               |
| 2003-2004              |            |     |     |     | 1.9                           | 109.1 | 59.0  | 46.0  | 11.6             | 138 <sup>d</sup> | 34              | 88              |
| 2004-2005              |            |     |     |     | 1.1                           | 59.1  | 48.9  | 44.7  | 11.6             | 184 <sup>d</sup> | 63              | 92              |
| 2005-06                |            |     |     |     | N/A                           | N/A   | N/A   | N/A   | 11.6             | 13 <sup>e</sup>  | 13              | 2               |

a/ Includes two peaks, 7 weeks apart.

b/ Surveys missed peak numbers.

c/ Includes two peaks, 4 weeks apart

d/ Includes two peaks, 3 weeks apart

e/ Includes two peaks, 5 weeks apart

Initial findings in the Lagunitas Creek watershed based on information gathered by the MMWD imply that juvenile densities are directly related to peak winter flow (inverse correlation) and redd production in tributaries (Ettlinger 2004 personal communication). This implies that in wet years, redd success and juvenile production is higher in the tributaries since redds in the mainstem are subject to scour and other impacts related to high flow conditions.

### 3.1.2 Watershed Escapement History and Estimates

Escapement estimates for adults in Olema Creek have been made using both the Peak Live plus cumulative Dead (PLD) and Area Under the Curve (AUC) methods. In years where persistent high flows resulted in a low number of surveys, both methods likely under-represented the true escapement number. The AUC method is dependent on two variables, observer efficiency (OE) and fish residence time (RT) in the freshwater following entry. In years where flows were high, both OE and RT were assumed to be lower than normal.

Annual escapement estimates for the Olema Creek watershed, including the John West Fork, show a range of 27-180 using the PLD index. Estimates using the AUC method are much higher with estimates reaching beyond 300 adults in some years. The Olema Creek escapement estimates represent 20-40% of the total escapement estimated for the Lagunitas Creek watershed.

#### PLD Index Results

The PLD dataset for adult escapement within Olema Creek includes 12 years of survey information. It should be noted that prior to SY 1997-98, redds and carcasses were not consistently counted. Olema Creek mainstem (Table 3.3) and the John West Fork tributary (JWF) (Table 3.4) are reported separately. PLD estimates have ranged from 9 to 184 for the mainstem and 8-86 for JWF. The John West Fork tributary has been the focus of extensive restoration and monitoring, and is often used as the proxy of conditions in the mainstem. In the SY 1999-00 and SY 2002-03, PLD estimates and live fish observations on the 2 kilometer survey area of JWF exceeded those of the 13 kilometer mainstem. In the Olema mainstem, SY 1999-00, SY 2002-03, and 2005-06 are considered minimum representation of actual mainstem escapement. During these years poor survey conditions resulted in low observer efficiencies which most likely resulted in missed live adult coho observations.

**Table 3.3. Coho Salmon Spawning Survey including Peak Live plus Cumulative Dead (PLD) Index, tally of total carcasses, and total redds for the Olema Creek mainstem.**

| Year                 | Number of Surveys | Survey Area (km) | PLD Index        | Total Carcasses | Total New Redds | Source                        |
|----------------------|-------------------|------------------|------------------|-----------------|-----------------|-------------------------------|
| 1994/95              | 3                 | 13.4             | 53               | 1               | 9               | Tomales Bay Association (TBA) |
| 1995/96              | 2                 | 13.4             | 106              | 37              | N.A.            | Manning 1999                  |
| 1996/97              | 2                 | 15.6             | 174              | 16              | N.A.            | Manning 1999                  |
| 1997/98              | 8                 | 13.4             | 88               | 39              | 126             | Manning 1999                  |
| 1998/99              | 6                 | 11.6             | 42 <sup>a</sup>  | 13              | 42              | NPS-PRNS                      |
| 1999/00 <sup>b</sup> | 2                 | 7.2              | 9                | 9               | 10              | NPS-PRNS                      |
| 2000/01              | 4                 | 11.6             | 103              | 65              | 86              | NPS-PRNS                      |
| 2001/02              | 4                 | 11.6             | 90 <sup>c</sup>  | 28              | 58              | NPS-PRNS                      |
| 2002/03 <sup>b</sup> | 4                 | 11.6             | 20               | 17              | 5               | NPS-PRNS                      |
| 2003/04              | 6                 | 11.6             | 138 <sup>d</sup> | 34              | 88              | NPS-PRNS                      |
| 2004/05              | 6                 | 11.6             | 184 <sup>d</sup> | 63              | 92              | NPS-PRNS                      |
| 2005-06              | 3                 | 11.6             | 13 <sup>e</sup>  | 13              | 2               | NPS-PRNS                      |

a/ Includes two peaks, 7 weeks apart.

b/ Surveys missed peak numbers.

c/ Includes two peaks, 4 weeks apart

d/ Includes two peaks, 3 weeks apart

e/ Includes two peaks, 5 weeks apart

N.A. = not available.

**Table 3.4. Coho Salmon Spawning Survey including Peak Live plus Cumulative Dead (PLD) Index, tally of total carcasses, and total redds for the John West Fork of Olema Creek.**

| Year                 | Number of Surveys | Survey Area (km) | PLD Index       | Total Carcasses | Total New Redds | Source   |
|----------------------|-------------------|------------------|-----------------|-----------------|-----------------|----------|
| 1995/96              | N.A.              | <1.0             | 8 <sup>a</sup>  | N.A.            | N.A.            | NPS-PRNS |
| 1996/97              | N.A.              | N.A.             | N.A.            | N.A.            | N.A.            | NPS-PRNS |
| 1997/98              | 5                 | 1.3              | 12              | 0               | 7               | NPS-PRNS |
| 1998/99              | 2                 | 1.2              | 9               | 0               | 1               | NPS-PRNS |
| 1999/00 <sup>b</sup> | 3                 | 1.1              | 18              | 0               | 7               | NPS-PRNS |
| 2000/01              | 4                 | 1.9              | 58              | 30              | 48              | NPS-PRNS |
| 2001/02              | 6                 | 1.9              | 20              | 5               | 31              | NPS-PRNS |
| 2002/03              | 7                 | 1.3              | 27 <sup>c</sup> | 0               | 12              | NPS-PRNS |
| 2003/04              | 6                 | 2.4              | 41              | 7               | 21              | NPS-PRNS |
| 2004/05              | 7                 | 2.4              | 86 <sup>d</sup> | 12              | 45              | NPS-PRNS |
| 2005/06              | 7                 | 2.4              | 11 <sup>e</sup> | 0               | 3               | NPS-PRNS |

a/ Includes live fish only, no carcass data.

b/ Surveys missed peak numbers.

c/ Includes two peaks, 4 weeks apart

d/ Includes two peaks, 3 weeks apart

e/ Includes two peaks, 17 days apart

N.A. = not available.

Table 3.5 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, Giacomini Gulch, Horse Camp Gulch, Boundary Gulch, Randall Gulch, and Olema Creek Headwaters.

| Year    | Number of Creeks Surveyed | Total Live | Total Carcasses | Total New Redds | Source   |
|---------|---------------------------|------------|-----------------|-----------------|----------|
| 1997/98 | 6                         | 4          | 1               | 3               | NPS-PRNS |
| 1998/99 | 0                         | 0          | 0               | 0               | NPS-PRNS |
| 1999/00 | 2                         | 0          | 0               | 0               | NPS-PRNS |
| 2000/01 | 4                         | 0          | 0               | 0               | NPS-PRNS |
| 2001/02 | 4                         | 1          | 0               | 0               | NPS-PRNS |
| 2002/03 | 0                         | 0          | 0               | 0               | NPS-PRNS |
| 2003/04 | 2                         | 0          | 0               | 1               | NPS-PRNS |
| 2004/05 | 6                         | 2          | 3               | 3               | NPS-PRNS |
| 2005/06 | 4                         | 3          | 0               | 2               | NPS-PRNS |

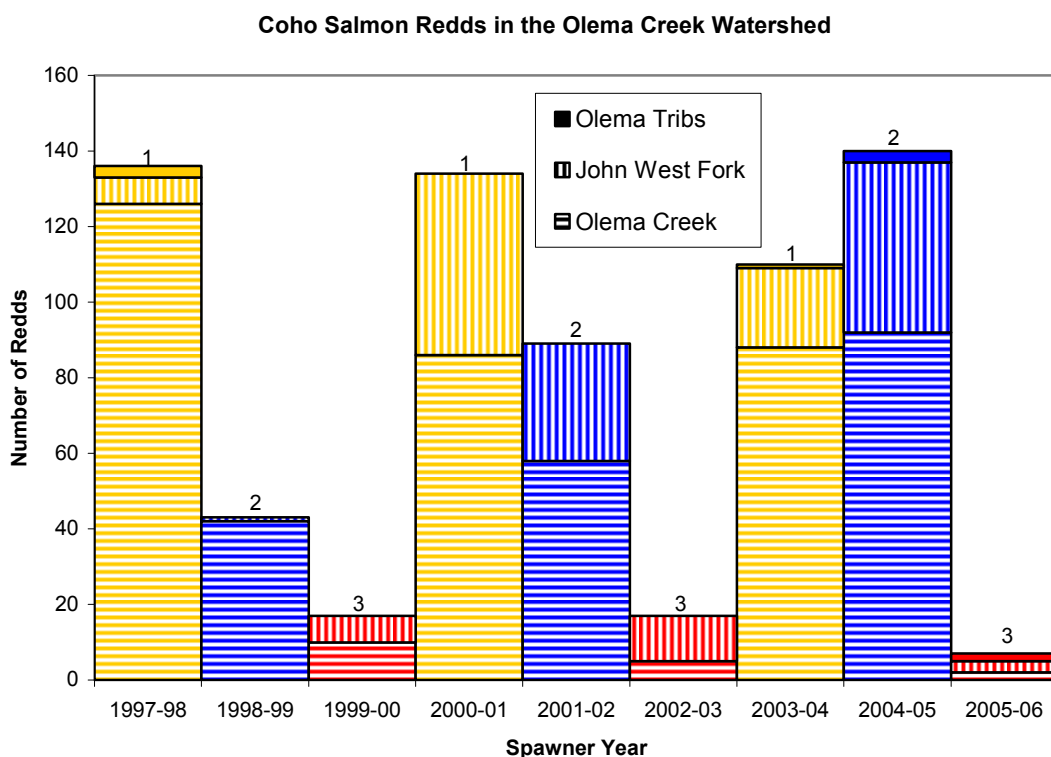


Figure 3.1 Olema Creek, John West Fork, and other Olema Creek tributaries Coho Salmon redd results by year class winter 1994-1995 thorough winter 2005-2006. Year classes are designated by color (Year Class 1 shown in yellow, Year Class 2 shown in blue, Year Class 3 shown in red).

Overall trends in coho spawning based on redd observations in the Olema watershed are shown in Figure 3.1. The three year classes are represented as primary colors (yellow-1, blue-2, and red-3) to show relationships between spawning runs. Year class 2 shows an increasing trend in spawning over the last three generations. Year class 1 has remained relatively constant over the past three generations and may be the most stable cohort. Year class 3 continues to struggle with a dramatic decline between 2002-03 and 2005-06.

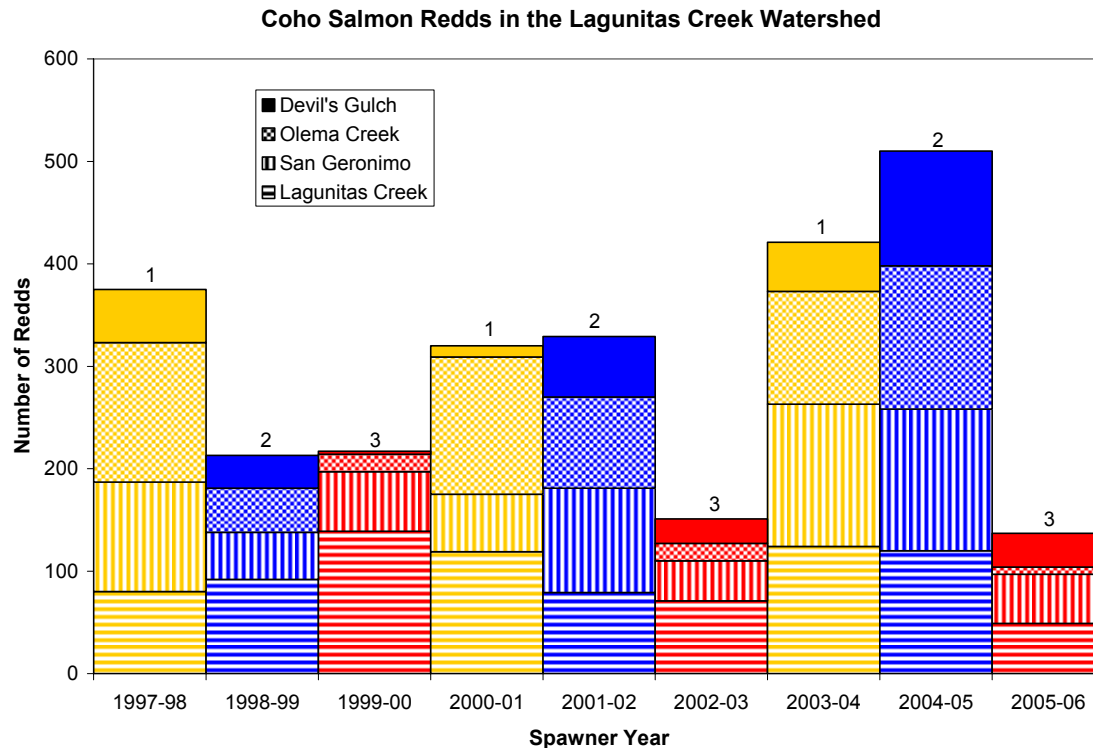


**Figure 3.2 Lagunitas Creek, San Geronimo Creek, Devil's Gulch, and Olema Creek Coho Salmon redd results by year class winter 1994-1995 thorough winter 2005-2006. Year classes are designated by color (Year Class 1 shown in yellow, Year Class 2 shown in blue, Year Class 3 shown in red). Data provided by MMWD (MMWD 2006b).**

Overall trends in coho spawning based on redd observations in the Lagunitas Creek watershed are shown in figure 3.2. The three year classes are represented as primary colors (yellow-1, blue-2, and red-3) to show relationships between spawning runs. As with Olema, year class 1 has remained relatively stable in terms of spawning over the last three generations. There has been an increase in spawning over the past three generations in year class 2 which is now the strongest year class to date. Like Olema Creek, year class 1 is has the lowest number of redd observations in the Lagunitas Creek watershed. However, unlike Olema Creek, the Lagunitas Creek watershed indicates a steady decline in spawning over the past three generations in year class 3.

#### AUC Escapement Estimate

The PLD index is assumed to be a minimum count of fish within a watershed, as it is based on actual observations. The NPS has also used the AUC method to estimate adult escapement within Olema Creek (Table 3.6) and the John West Fork (Table 3.7). This method requires more consistent surveys and allows for an estimate of survey quality (observer efficiency) and the residence time of fish within the watershed. This method will tend to overestimate fish numbers where there are multiple peaks of fish or if there is a large interval between surveys. Only live fish are calculated using this technique. Detailed results of the AUC estimates are included in the Olema Creek Annual Escapement Monitoring Report.

Summary AUC results for Olema Creek and the John West Fork are presented in tables 3.6 and 3.7, respectively. AUC estimates are reported for a range (8-17 days) of fish residence time (RT) at 100%<sup>1</sup> and 50%<sup>2</sup> observer efficiency (OE), where the low estimate represents 17 day survival, and the high estimate represents 8 day survival. Estimates using commonly reported values for OE (70-80%) and RT (11-13 days) are compared to locally observed conditions in years where environmental factors reduced/increased average RT or allowed for high/low OE for that specific survey year. The PLD index for each year is included for reference.

**Table 3.6 Coho salmon spawning survey Area Under the Curve (AUC) estimates for Olema Creek, 1997-98 through 2005-06.**

| Year    | Number of Surveys | Date of Entry | Mean Survey interval (days) | Survey Reaches | Survey Area (km) | AUC Range 100% OE <sup>1</sup> | AUC Range 50% OE <sup>2</sup> | AUC Range for OE & RT reported in literature | AUC for locally observed conditions | OLM Mainstem PLD |
|---------|-------------------|---------------|-----------------------------|----------------|------------------|--------------------------------|-------------------------------|----------------------------------------------|-------------------------------------|------------------|
| 1997/98 | 7                 | 15 Nov 97     | 7.9                         | 2-4            | 4.5              | 56-118                         | 112-236                       | 91-123                                       | 91-123                              | 88               |
| 1998/99 | 5                 | 19 Nov 98     | 12.1                        | 2-6            | 11.6             | 35-74                          | 69-148                        | 57-77                                        | 57-77                               | 42 <sup>d</sup>  |
| 1999/00 | 2                 | 18 Jan 00     | N.A.                        |                |                  | N.A.                           | N.A.                          | N.A.                                         | N.A.                                | 9                |
| 2000/01 | 2                 | 10 Jan 01     | 7.3                         | 2-6            | 11.6             | 75-159                         | 149-317                       | 122-165                                      | 101-132 <sup>a</sup>                | 103              |
| 2001/02 | 3                 | 24 Nov 01     | 12.3                        | 2-6            | 11.6             | 105-224                        | 210-447                       | 172-232                                      | 186-256 <sup>b</sup>                | 90 <sup>e</sup>  |
| 2002/03 | 2                 | 13 Dec 02     | N.A.                        |                |                  | N.A.                           | N.A.                          | N.A.                                         | N.A.                                | 20               |
| 2003/04 | 4                 | 14 Dec 03     | 11.8                        | 2-6            | 11.6             | 138-293                        | 275-585                       | 225-304                                      | 217-293 <sup>c</sup>                | 138 <sup>f</sup> |
| 2004/05 | 6                 | 15 Dec 04     | 10.8                        | 2-6            | 11.6             | 149-316                        | 298-632                       | 243-328                                      | 243-328                             | 184 <sup>f</sup> |
| 2005/06 | 3                 | 1 Dec 05      | 25.0                        | 2-6            | 11.6             | N.A.                           | N.A.                          | N.A.                                         | N.A.                                | 13 <sup>g</sup>  |

N.A. – Survey data for mainstem not adequate to develop AUC estimate.

a- OE 80-90% / RT 12-14 days

b- OE 70-80% / RT 10-12 days

c- OE 80-90% / RT 10-12 days

d- Surveys missed peak numbers.

e- Includes two peaks, 4 weeks apart

f- Includes two peaks, 3 weeks apart

g- Includes two peaks, 5 weeks apart

**Table 3.7 Coho salmon spawning survey Area Under the Curve (AUC) estimates for John West Fork, 1997-98 through 2005-06.**

| Year    | Number of Surveys | Date of Entry | Mean Survey interval (days) | Reaches | Survey Area (km) | AUC Range 100% OE | AUC Range 50% OE | AUC Range for OE & RT reported in literature | AUC for locally observed conditions | John West Fork PLD |
|---------|-------------------|---------------|-----------------------------|---------|------------------|-------------------|------------------|----------------------------------------------|-------------------------------------|--------------------|
| 1997/98 | NA                | 15 Nov 97     | 7.9                         |         |                  |                   |                  |                                              |                                     | 12                 |
| 1998/99 | NA                | 19 Nov 98     | 12.1                        |         |                  |                   |                  |                                              |                                     | 9                  |
| 1999/00 | 3                 | 18 Jan 00     | 4.7                         | 1-2     | 1.1              | 7-15              | 14-30            | 12-16                                        | 16-22 <sup>a</sup>                  | 18                 |
| 2000/01 | 4                 | 10 Jan 01     | 9.4                         | 1-2     | 1.9              | 42-90             | 85-180           | 69-94                                        | 57-75 <sup>b</sup>                  | 58                 |
| 2001/02 | 6                 | 24 Nov 01     | 7.4                         | 1-2     | 1.9              | 25-53             | 50-107           | 41-55                                        | 44-61 <sup>c</sup>                  | 20                 |
| 2002/03 | 6                 | 13 Dec 02     | 6.9                         | 1-2     | 1.3              | 14-30             | 28-61            | 23-31                                        | 23-31                               | 27 <sup>d</sup>    |
| 2003/04 | 4                 | 14 Dec 03     | 9.6                         | 1-3     | 2.4              | 30-64             | 60-129           | 49-67                                        | 49-67                               | 41                 |
| 2004/05 | 7                 | 10 Dec 04     | 8.8                         | 1-3     | 2.4              | 60-127            | 120-255          | 98-132                                       | 98-132                              | 86                 |
| 2005/06 | 7                 | 1 Dec 05      | 7.0                         | 1-3     | 2.4              | 8-18              | 17-36            | 14-19                                        | 19-26 <sup>a</sup>                  | 11 <sup>e</sup>    |

NA – Survey data for mainstem not adequate to develop AUC estimate.

a- OE 60-70% / RT 9-11 days

b- OE 80-90% / RT 12-14 days

c- OE 70-80% / RT 10-12 days

d- Includes two peaks, 4 weeks apart

e- Includes two peaks, 17 days apart

### Summary

The emerging picture from 12 winters of coho spawner surveys (Figure 3.1) reveals the presence of two strong year classes (year classes 1 and 2) and one weak year class (year class 3). Previously, year class 3 was probably the strongest of the three, with a PLD index of 180 during the 1996-97 spawning run. However, the resulting cohort probably suffered high mortality during the last large-scale El Nino Southern Oscillation (ENSO) event in 1997-98. This event caused high flows during the winter of 1997-98 which may have resulted in low overwinter survival for the juvenile coho. Results of adult escapement and summer juvenile density monitoring indicate that the overwintering year class during the height of El Nino was the most heavily impacted and marks the shift of that cohort to the weakest

year class. Although low spawner counts for the last three runs of this year class may be due in part to poor survey conditions during the winters of 1999-2000, 2002-03, and 2005-06 juvenile density observations support the notion that this became, and now remains the weakest year class.

Results from the JWF are represented and reported separately. Coho spawning activity in this important tributary has increased dramatically in the six winters since culvert modifications improved fish passage. In the 1999-2000 and 2002-2003 spawning years, JWF counts exceeded mainstem results, likely due in part to lower flows and better survey conditions on the tributary.

Overall coho escapement within Olema Creek has been trending upward since the 1997 ENSO event likely triggered the observed regime shift in the Pacific Decadal Oscillation (PDO) patterns across the California Coast. For the past two generations, two of the three year classes (year classes 1 and 2) have shown an increasing trend in the number of returning adults. This upward trend has been documented in other coastal Marin County watersheds, and is most prominent in the documented return of coho salmon to the Pine Gulch Creek watershed in winter 2000-2001. Increases in adult escapement have translated into large shifts in juvenile coho density and smolt production at all monitoring locations. Continued monitoring efforts will allow for better characterization of year classes in terms of both annual productivity of coho salmon within Olema Creek and relationships with other coastal Marin County watersheds.

### 3.1.3 Live Fish, Carcass, and Redd Observations

Survey protocol collects information on live fish, carcasses, and redds. Information on sex ratios for live fish and carcasses are reported in table 3.8. While live fish lengths are estimated, carcasses are handled to definitively determine sex, spawn success, fork length (FL), and for collection of a genetic sample. The results of carcass measurements show that adult males average 66.8 cm (SD=6.4), with females averaging 64.0 cm (SD=5.6) and jacks averaging 44.1 cm (SD=3.5).

**Table 3.8 Sex ratios of live coho and carcasses, and size observations of carcasses within Olema Creek.**

|         |     | Live Coho |      | Carcasses |         |             |      |
|---------|-----|-----------|------|-----------|---------|-------------|------|
|         |     | #         |      | #         | mean FL | FL SD       |      |
| 1997-98 | M   | 71        | 30%  | 16        | 47%     | 63.9 (n=15) | 5.1  |
|         | F   | 95        | 40%  | 12        | 35%     | 59.1 (n=11) | 3.1  |
|         | J   | 42        | 18%  | 5         | 15%     | 45.4 (n=5)  | 4.3  |
|         | Unk | 29        | 12%  | 1         | 3%      |             |      |
|         | All | 237       | 100% | 34        | 100%    |             |      |
| 1998-99 | M   | 11        | 21%  | 4         | 31%     | 64.0 (n=2)  | 1.4  |
|         | F   | 25        | 47%  | 4         | 31%     | 61.0 (n=4)  | 3.4  |
|         | J   | 7         | 13%  | 3         | 23%     | 45.7 (n=3)  | 2.1  |
|         | Unk | 10        | 19%  | 2         | 15%     |             |      |
|         | All | 53        | 100% | 13        | 100%    |             |      |
| 1999-00 | M   | 1         | 50%  | 2         | 22%     | 65 (n=1)    |      |
|         | F   | 1         | 50%  | 6         | 67%     | 58.3 (n=6)  | 8.2  |
|         | J   | 0         | 0%   | 1         | 11%     |             |      |
|         | Unk | 0         | 0%   | 0         | 0%      |             |      |
|         | All | 2         | 100% | 9         | 100%    |             |      |
| 2000-01 | M   | 42        | 34%  | 22        | 34%     | 66.3 (n=22) | 6.4  |
|         | F   | 61        | 50%  | 35        | 54%     | 65.4 (n=35) | 4.7  |
|         | J   | 17        | 14%  | 8         | 12%     | 44.9 (n=8)  | 2.0  |
|         | Unk | 3         | 2%   | 0         | 0%      |             |      |
|         | All | 123       | 100% | 65        | 100%    |             |      |
| 2001-02 | M   | 38        | 40%  | 8         | 30%     | 72.5 (n=6)  | 2.7  |
|         | F   | 46        | 48%  | 12        | 44%     | 66.7 (n=6)  | 6.3  |
|         | J   | 6         | 6%   | 1         | 4%      | 45 (n=1)    |      |
|         | Unk | 5         | 5%   | 6         | 22%     |             |      |
|         | All | 95        | 100% | 27        | 100%    |             |      |
| 2002-03 | M   | 0         | 0%   | 7         | 41%     | 68.8 (n=4)  | 6.3  |
|         | F   | 2         | 67%  | 0         | 0%      |             |      |
|         | J   | 1         | 33%  | 2         | 12%     | 37.5 (n=2)  | 3.5  |
|         | Unk | 0         | 0%   | 8         | 47%     | 57.5 (n=4)  | 14.4 |
|         | All | 3         | 100% | 17        | 100%    |             |      |
| 2003-04 | M   | 37        | 26%  | 7         | 21%     | 74.3 (n=4)  | 1.5  |
|         | F   | 68        | 48%  | 11        | 32%     | 66.3 (n=10) | 6.3  |
|         | J   | 31        | 22%  | 6         | 18%     | 45.2 (n=6)  | 2.0  |
|         | Unk | 5         | 4%   | 10        | 29%     | 60.0 (n=4)  | 12.2 |
|         | All | 141       | 100% | 34        | 100%    |             |      |
| 2004-05 | M   | 72        | 27%  | 24        | 38%     | 68.7 (n=14) | 6.1  |
|         | F   | 114       | 42%  | 25        | 40%     | 65.7 (n=20) | 3.3  |
|         | J   | 72        | 14%  | 1         | 1%      | 47.0 (n=1)  |      |
|         | Unk | 46        | 17%  | 13        | 21%     | 59.0 (n=4)  | 11.5 |
|         | All | 269       | 100% | 63        | 100%    |             |      |
| 2005-06 | M   | 1         | 33%  | 3         | 27%     | 57.0 (n=1)  |      |
|         | F   | 1         | 33%  | 4         | 36%     | 58.7 (n=3)  | 7.2  |
|         | J   | 1         | 33%  | 2         | 18%     | 40.0 (n=2)  | 7.1  |
|         | Unk | 0         |      | 2         | 18%     |             |      |
|         | All | 3         | 99%  | 11        | 99%     |             |      |

As a measure of the overall watershed, escapement, carcass, and redd information is reported as density per kilometer. This measure may be used for comparative purposes with the juvenile and smolt densities observed within the

monitored areas. Density per kilometer for parameters measured or estimated during the spawner surveys are included for Olema Creek (Table 3.9) and John West Fork (Table 3.10). It should be noted that the survey areas used to calculate PLD, carcass and redd densities may be different from the survey area used to calculate the AUC estimate.

**Table 3.9 Density information (per kilometer) for parameters measured or estimated during spawner surveys for Olema Creek. Survey areas used to calculate PLD, carcass and redd densities may be different from the survey area used to calculate the AUC estimate.**

| Olema Creek |           | Density (# / km)            |                              |                 |             |
|-------------|-----------|-----------------------------|------------------------------|-----------------|-------------|
|             | PLD Index | AUC<br>OE=80%<br>RT=13 days | AUC<br>OE=70%<br>RT= 11 days | Total Carcasses | Total Redds |
| 1997/98     | 7         | 20                          | 27                           | 2.9             | 9.4         |
| 1998/99     | 4         | 5                           | 7                            | 1.1             | 3.6         |
| 1999/00*    | 1*        |                             |                              | 1.3             | 1.4         |
| 2000/01     | 9         | 11                          | 14                           | 5.6             | 7.4         |
| 2001/02     | 8         | 15                          | 20                           | 2.4             | 5.0         |
| 2002/03*    | 2*        |                             |                              | 1.5             | 0.4         |
| 2003/04     | 12        | 20                          | 26                           | 2.9             | 7.6         |
| 2004/05     | 16        | 21                          | 28                           | 5.4             | 7.9         |
| 2005/06*    | 1*        |                             |                              | 1.1             | 0.2         |

\*Survey data for mainstem not adequate to develop AUC estimate

**Table 3.10 Density information (per kilometer) for parameters measured or estimated during spawner surveys for John West Fork. Survey areas used to calculate PLD, carcass and redd densities may be different from the survey area used to calculate the AUC estimate.**

| John West Fork |           | Density (# / km)            |                              |                 |             |
|----------------|-----------|-----------------------------|------------------------------|-----------------|-------------|
|                | PLD Index | AUC<br>OE=80%<br>RT=13 days | AUC<br>OE=70%<br>RT= 11 days | Total Carcasses | Total Redds |
| 1997/98        | 9         | 11                          | 15                           | 0.0             | 5.4         |
| 1998/99        | 8         | 36                          | 50                           | 0.0             | 0.8         |
| 1999/00        | 16        | 22                          | 29                           | 0.0             | 6.4         |
| 2000/01        | 31        | 18                          | 24                           | 15.8            | 25.3        |
| 2001/02        | 11        | 20                          | 28                           | 2.6             | 16.3        |
| 2002/03        | 21        | 11                          | 15                           | 0.0             | 9.2         |
| 2003/04        | 17        | 36                          | 50                           | 2.9             | 8.8         |
| 2004/05        | 36        | 41                          | 55                           | 5.0             | 18.8        |
| 2005/06        | 5         | 6                           | 8                            | 0.0             | 1.3         |

## 3.2 Outmigrant smolt trap

### 3.2.1 Olema Creek

#### Smolt outmigration timing

The outmigrant traps are operated between mid-March and June of each year. While it is likely that smolts are moving past the trap location beginning in February, the results show that the peak of outmigration occurs in early April of each year. Outmigration within the Olema Creek watershed is affected by weather patterns, typically showing an increase with rainfall and runoff events. In 2005 trapping operations were ceased early due to the destruction of several key trapping materials during a late spring high flow event.

#### Smolt Totals and Population Estimates

During the 2004 trapping season a total of 229 coho smolts and 18 steelhead 1+, including 11 smolts, 2 presmolts, and 5 parr were captured. The mortality rate for 1+ coho was 3.1% (7/229). There were no 1+ steelhead mortalities. The overall recapture rate for 1+ coho was 24% (29/122). DARR analysis of the coho smolt data stratified by week showed the estimated capture probability at around 37% for the first five weeks of trap operation, then dropping to around 17% for the last four weeks, resulting in a total coho smolt estimate of 830.6 ( $\pm 167.2$  s.d.). Two coho smolts were captured in the Olema trap that had been marked with caudal fin clips and released from the John West Fork trap, 10.5 km upstream. No steelhead 1+ were recaptured although 12 were marked and released above the trap. The Olema trap was built with a bypass to allow adult steelhead spawners to migrate up and downstream past the weir, possibly explaining why no marked steelhead 1+ were recaptured. Peak capture for both steelhead smolt/presmolts and coho smolts occurred in mid-late April, during week 6.

During the 2005 trapping season a total of 86 coho smolts and 17 steelhead 1+, including 6 smolts, 3 presmolts, and 8 parr were captured. One adult steelhead was captured and released downstream on April 25. The mortality rate for 1+ coho was 1.2% (1/86). There were no 1+ steelhead mortalities. The overall recapture rate for 1+ coho was only 6.1% (3/49). The low recapture rate was most likely due to multiple storm events that caused the trap to run inefficiently. DARR analysis of the coho smolt data stratified by week showed the estimated capture probability at less than 10% for the three weeks of mark recapture operation, resulting in a total coho smolt estimate of 1296 ( $\pm 723.6$  s.d.). No steelhead 1+ were recaptured although four were marked and released above the trap. Peak capture for both steelhead smolt/presmolts and coho smolts occurred in late April and early May, during weeks 18 and 19.

**Table 3.11 Summary information for Olema Creek trap operations spring 2004 – spring 2005.**

| Trap Operation<br>Dates |        |        | SH       |    |       |          |       |     | CO       |           |
|-------------------------|--------|--------|----------|----|-------|----------|-------|-----|----------|-----------|
|                         |        |        | Juvenile |    |       |          | Adult |     |          |           |
|                         |        |        | From     | To | smolt | presmolt | parr  | fry | resident | ocean-run |
| 2004                    | 30-Mar | 28-May | 11       | 2  | 5     | 140      | 0     | 0   | 229      | 32        |
| 2005                    | 1-Apr  | 9-May  | 6        | 3  | 8     | 1218     | 0     | 1   | 87       | 14        |

#### Smolt size and condition

A variety of research has shown that ocean survival of smolts is dependent on fish size as they enter the ocean. Within intermittent stream systems such as upper Olema Creek and the John West Fork, fish tend to grow in the spring and early summer when feeding conditions are best. In the summer, as surface flow recedes, isolated and intermittent pools form. Within these isolated pools, water temperatures increase and the food supply decreases dramatically. Temperature and dissolved oxygen stratification in these pools often occurs, with cool water and adequate DO near the bottom. Although pools become isolated between June and October, from our observations, they still support salmonid survival (both coho and steelhead). As part of the California Department of Fish and Game - Russian River coho salmon broodstock reintroduction program (RRCBRP), coho were captured from intermittent sections of Olema Creek

and John West Fork in 2001-2003. The fish condition at the time they were captured (late summer - September) was marginal. Fish were observed to be very small and skinny compared with fish captured from areas with perennial flow. It is our deduction that feeding rates are reduced during these low flow summer months, and that the Olema watershed reared fish must quickly catch up in the late fall – prior to major winter storms, and spring, before outmigrating to the ocean. It is clear that these fish have the capacity to “catch up” as shown in growth patterns of the fish captured through the RRCBRP, where undersized Olema watershed fish caught up to their counterparts within the first few months of hatchery feeding operations (Wilson 2004 personal communication).

Staff record length and weight of the fish captured in the traps. Figure 3.3 shows the mean, median, and range of coho smolt fork lengths and corresponding Fulton Condition Factors (K) for the 2004 and 2005 smolt trapping seasons. Fork lengths on Olema Creek have ranged from 92 mm to 144 mm. K factors have ranged from 0.69 to 1.47. 2005 coho smolts were slightly larger and plumper than 2004 coho smolts.

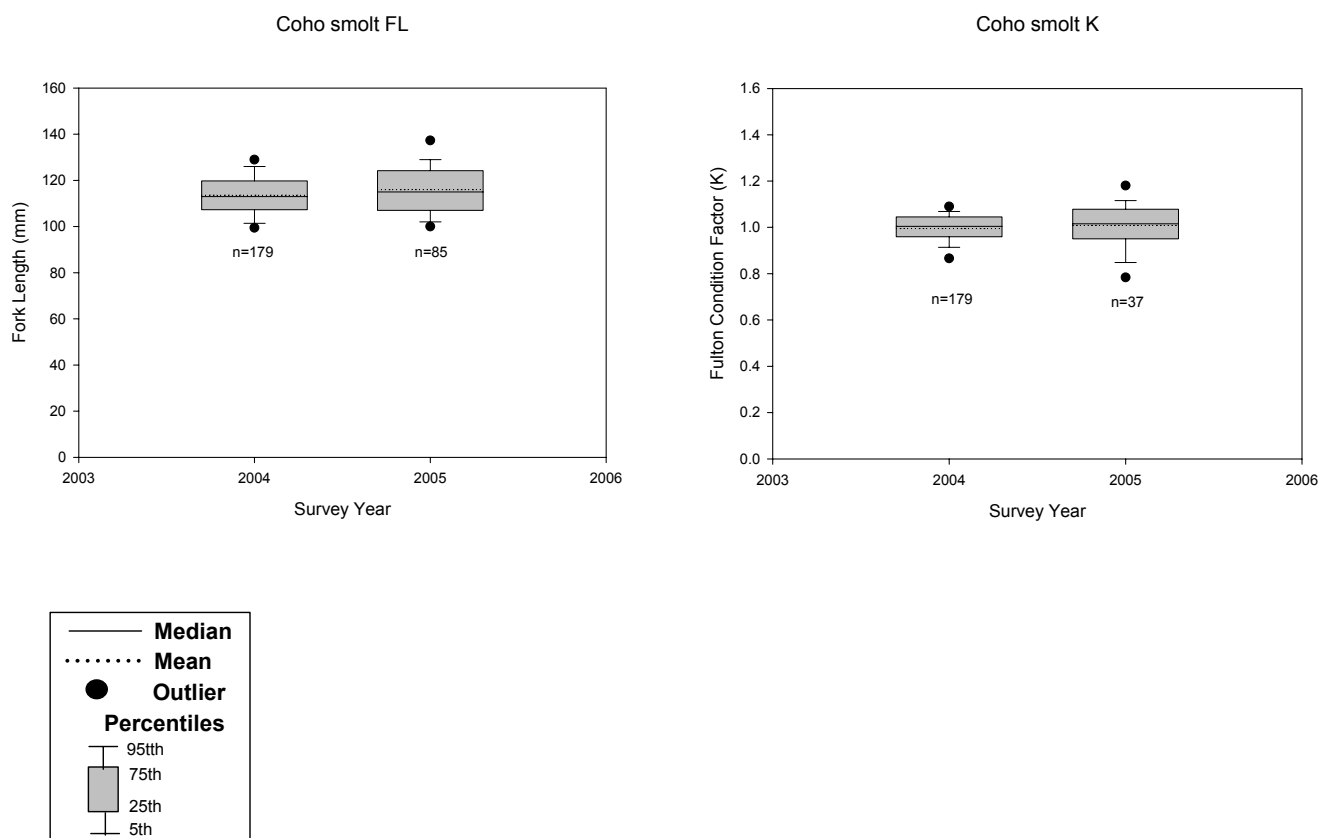


**Figure 3.3 Coho smolt fork length and Fulton Condition Factor (K) box and whisker plots depicting mean, median, 5<sup>th</sup>, 25<sup>th</sup>, 75<sup>th</sup> and 95<sup>th</sup> percentiles, and outliers from Olema Creek 2004-2005.**

### 3.2.2 John West Fork

#### Smolt outmigration timing

Smolt trapping was performed on John West Fork from 1998-2004 to evaluate a fish passage project completed in 1999. The trap was discontinued in 2004 as efforts expanded to other watersheds. Since then downstream migrant trapping efforts have been focused on determining the total smolt production for the entire watershed instead of focusing staff time and equipment on trapping tributaries.

**Table 3.12 Summary information for John West Fork trap operations spring 1998 – spring 2004.**

| Trap Operation Dates |        |        | SH       |    |       |                   |       |     | CO       |                    |
|----------------------|--------|--------|----------|----|-------|-------------------|-------|-----|----------|--------------------|
|                      |        |        | Juvenile |    |       |                   | Adult |     |          |                    |
|                      |        |        | From     | To | smolt | presmolt          | parr  | fry | resident | ocean-run          |
| 1998                 | 20-Mar | 20-Aug | 30       | 12 | 2     | 6599 <sup>a</sup> | 8     | 0   | 21       | 1,061 <sup>a</sup> |
| 1999**               | 12-Mar | 1-Jul  | 15       | 22 | 14    | 228               | 2     | 6   | 0        | 0                  |
| 2000**               | 29-Mar | 19-Jul | 2        | 25 | 22    | 6620              | 2     | 1   | 0        | 14                 |
| 2001**               | 14-Mar | 4-Jun  | 10       | 19 | 72    | 481               | 1     | 0   | 3        | 6563               |
| 2002**               | 19-Mar | 11-Jun | 18       | 5  | 8     | 269               | 0     | 0   | 104      | 5711               |
| 2003                 | 22-Mar | 30-May | 18       | 25 | 3     | 1962 <sup>b</sup> | 3     | 1   | 181      | 1561 <sup>b</sup>  |
| 2004                 | 25-Mar | 28-May | 17       | 14 | 32    | 4133              | 0     | 1   | 112*     | 1575               |

Totals include mortalities, but not recaptures.

\*number includes coho identified as presmolts that were probably coho smolts.

<sup>a</sup> 1,061 fry originally identified as coho were probably steelhead

<sup>b</sup> number does not include 62 unidentified fry

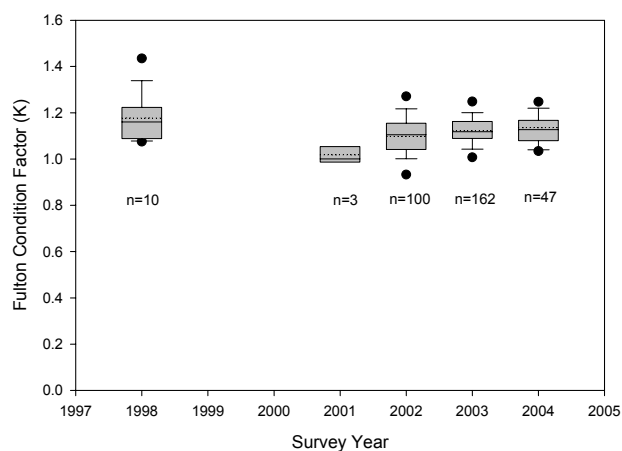
\*\*includes totals from upper trap installed 800 meters upstream of the confluence with Olema Creek.

Results presented in tables 3.12 show a wide variability in juvenile production for both coho salmon and steelhead trout, as well as an increasing trend in coho smolt production since fish passage restoration in 1999.

#### Smolt size and condition

Smolts outmigrating through the John West Fork from 1998-2004 have ranged from 77 mm to 141 mm in size. Figure 3.4 shows the mean, median, and range of coho smolt fork lengths and corresponding Fulton Condition Factors (K) for John West Fork during monitoring seasons 1998 through 2004. K factors have ranged from 0.78 to 1.91. For more information on this project see Ketcham et al. 2004.

1998-2004 Smolt K Factor



1998-2004 Coho FL

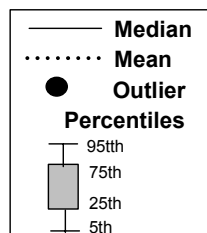
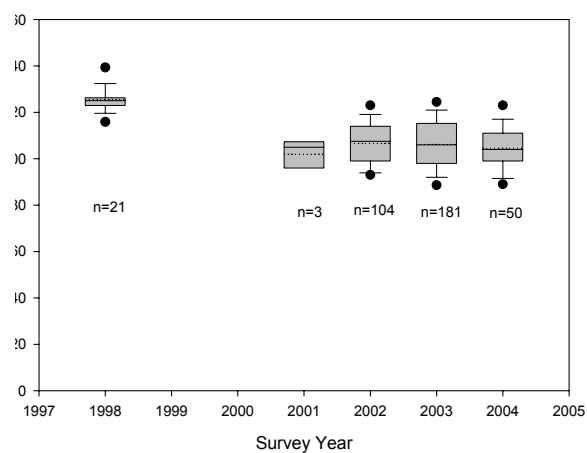


Figure 3.4 Coho smolt fork length and Fulton Condition Factor (K) box and whisker plots depicting mean, median, 5<sup>th</sup>, 25<sup>th</sup>, 75<sup>th</sup> and 95<sup>th</sup> percentiles, and outliers from John West Fork 1998-2004.

### 3.3 Index Reach Surveys

Index reach monitoring was initiated at seven sites on Olema Creek in 1999. In 2000, Index Reach 8 was added to represent the intermittent portion of the upper mainstem. In 2002, lower Olema Creek avulsed from its former channel and was disconnected from mainstem flow. As a result, index reach 1 has not been surveyed since 2002. Index reach 4 has not been surveyed since 2003 due its remote location and difficulty to electrofish. In 2005, 6 of 8 index reaches on the mainstem of Olema Creek were sampled. The location of each index reach is shown in Figure 2.1 and Table 3.13.

**Table 3.13 Site location and number for Olema Creek index reach sites.**

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

\*not surveyed consistently since 1999

#### 3.3.1 Index reach total salmonid catch

The index reach total catch (Table 3.14) provides a general sense of the annual variation in fish numbers within and distribution between index reaches monitored since 1999. The summer monitoring information shows a dramatic increase in coho numbers in 2001 and 2002. These higher juvenile numbers correspond to similar patterns observed in adult spawner survey and spring outmigrant smolt trapping efforts conducted by the NPS.

The results presented in Table 3.14 are the total number of fish captured during electrofishing surveys. *Microfish* population estimates are used to calculate fish density and other derived data. Index reach population estimates and fish density for each species/age class are reported with 95% confidence. Density results presented in Section 3.3.3 are determined based upon the habitat information measured for the given year of monitoring.

**Table 3.14 Summary of total catch for each species by reach within Olema Creek mainstem index reach sample locations between 1999 and 2005; shows variation between years (e.g. higher coho #'s in 2002, 2004, and 2005) and distribution within watershed.**

| Year   | Species | Index Reach    |     |     |                |     |     |     |                | total |
|--------|---------|----------------|-----|-----|----------------|-----|-----|-----|----------------|-------|
|        |         | 1              | 2   | 3   | 4              | 5   | 6   | 7   | 8              |       |
| 1999   | CO      | 4              | 25  | 23  | 36             | 15  | 51  | 62  | not<br>sampled | 216   |
|        | SH YOY  | 65             | 222 | 200 | 341            | 220 | 159 | 192 |                | 1,399 |
|        | SH 1+   | 17             | 19  | 27  | 39             | 46  | 31  | 17  |                | 196   |
| 2000   | CO      | 1              | 64  | 21  | 140            | 34  | 76  | 23  | 0              | 359   |
|        | SH YOY  | 99             | 342 | 376 | 232            | 256 | 190 | 168 | 209            | 1,872 |
|        | SH 1+   | 24             | 19  | 11  | 24             | 22  | 12  | 19  | 6              | 137   |
| 2001   | CO      | 39             | 23  | 73  | 257            | 213 | 205 | 241 | 156            | 1,207 |
|        | SH YOY  | 22             | 132 | 202 | 151            | 354 | 40  | 30  | 20             | 951   |
|        | SH 1+   | 15             | 26  | 17  | 37             | 34  | 29  | 26  | 7              | 191   |
| 2002   | CO      | 3              | 114 | 123 | not<br>sampled | 260 | 323 | 332 | 310            | 1,465 |
|        | SH YOY  | 26             | 102 | 439 |                | 267 | 118 | 139 | 203            | 1,294 |
|        | SH 1+   | 7              | 7   | 9   |                | 16  | 7   | 5   | 0              | 51    |
| 2003   | CO      | not<br>sampled | 22  | 5   | 60             | 210 | 152 | 202 | 72             | 723   |
|        | SH YOY  |                | 35  | 111 | 26             | 134 | 139 | 136 | 79             | 660   |
|        | SH 1+   |                | 8   | 7   | 11             | 27  | 21  | 9   | 9              | 92    |
| 2004*  | CO      | not<br>sampled | 186 | 347 | not<br>sampled | 295 | 239 | 175 | 164            | 1,406 |
|        | SH YOY  |                | 146 | 230 |                | 182 | 44  | 20  | 39             | 661   |
|        | SH 1+   |                | 6   | 10  |                | 26  | 24  | 10  | 8              | 84    |
| 2005** | CO      | not<br>sampled | 206 | 255 | not<br>sampled | 269 | 361 | 191 | 186            | 1,468 |
|        | SH YOY  |                | 72  | 97  |                | 180 | 67  | 38  | 44             | 498   |
|        | SH 1+   |                | 5   | 5   |                | 13  | 15  | 7   | 7              | 52    |

\*In 2004 only one pass was electrofished due to equipment failure on both Index 2 & Index 5.

\*\*In 2005 only one pass was electrofished due to equipment failure on Index 2 and only one unit was electrofished on Index 3 due to high water temperatures (18.4° C).

### 3.3.2 Index reach total fish catch of other species

The index reach total catch (Table 3.15) provides a general sense of the annual variation in non-salmonid fish numbers within and distribution between index reaches monitored since 1999. The results presented in Table 3.15 are the total number of non-salmonid fish captured during electrofishing surveys.

**Table 3.15 Summary of total catch for each species by reach within Olema Creek mainstem index reach sample locations between 1999 and 2005; shows variation between years and distribution within watershed.**

| Year   | Species | Index Reach |     |     |             |     |     |     |             | total |
|--------|---------|-------------|-----|-----|-------------|-----|-----|-----|-------------|-------|
|        |         | 1           | 2   | 3   | 4           | 5   | 6   | 7   | 8           |       |
| 1999   | AM      | 0           | 19  | 0   | 9           | 8   | 10  | 13  | not sampled | 59    |
|        | RO      | 0           | 89  | 0   | 22          | 13  | 10  | 3   |             | 137   |
|        | SCU     | 0           | 76  | 0   | 117         | 107 | 21  | 66  |             | 387   |
|        | STK     | 0           | 40  | 0   | 34          | 13  | 24  | 9   |             | 120   |
| 2000   | AM      | 17          | 10  | 19  | 14          | 6   | 16  | 6   | 0           | 88    |
|        | RO      | 5           | 30  | 0   | 6           | 26  | 4   | 0   | 0           | 71    |
|        | SCU     | 68          | 64  | 66  | 108         | 69  | 89  | 106 | 37          | 607   |
|        | STK     | 6           | 82  | 47  | 34          | 36  | 34  | 11  | 0           | 250   |
| 2001   | AM      | 5           | 41  | 35  | 8           | 4   | 2   | 7   | 0           | 102   |
|        | RO      | 8           | 47  | 7   | 18          | 6   | 4   | 0   | 0           | 90    |
|        | SCU     | 43          | 62  | 27  | 105         | 81  | 62  | 174 | 4           | 558   |
|        | STK     | 39          | 61  | 39  | 81          | 54  | 35  | 37  | 0           | 346   |
| 2002   | AM      | 20          | 67  | 48  | not sampled | 7   | 11  | 0   | 0           | 153   |
|        | RO      | 3           | 79  | 8   |             | 9   | 2   | 0   | 1           | 102   |
|        | SCU     | 40          | 118 | 131 |             | 89  | 34  | 85  | 14          | 511   |
|        | STK     | 53          | 519 | 924 |             | 54  | 28  | 17  | 0           | 1595  |
| 2003   | AM      | not sampled | 35  | 13  | 4           | 34  | 11  | 5   | 0           | 102   |
|        | RO      |             | 207 | 2   | 0           | 0   | 2   | 0   | 0           | 211   |
|        | SCU     |             | 91  | 99  | 65          | 107 | 40  | 83  | 20          | 505   |
|        | STK     |             | 529 | 218 | 28          | 52  | 30  | 54  | 0           | 911   |
| 2004*  | AM      | not sampled | 38  | 16  | not sampled | 7   | 2   | 1   | 0           | 64    |
|        | RO      |             | 254 | 94  |             | 48  | 2   | 0   | 0           | 398   |
|        | SCU     |             | 217 | 340 |             | 207 | 121 | 103 | 31          | 1019  |
|        | STK     |             | 176 | 132 |             | 52  | 33  | 45  | 0           | 438   |
| 2005** | AM      | not sampled | 8   | 9   | not sampled | 5   | 0   | 1   | 0           | 23    |
|        | RO      |             | 88  | 116 |             | 6   | 0   | 0   | 0           | 210   |
|        | SCU     |             | 56  | 88  |             | 77  | 51  | 29  | 34          | 335   |
|        | STK     |             | 181 | 240 |             | 53  | 74  | 42  | 0           | 590   |

\*In 2004 only one pass was electrofished due to equipment failure on both Index 2 & Index 5.

\*\*In 2005 only one pass was electrofished due to equipment failure on Index 2 and only one unit was electrofished on Index 3 due to high water temperatures (18.4° C).

**Table 3.16 Summary of summer habitat composition and average daily discharge on Olema Creek Summer Index Reaches 1999-2005.**

| Sample dates              | Habitat Type | # of Units | Length      |            | Surface area              |            | Average Discharge during sampling period (cfs) | Estimated # of coho | 95% C.I. | Juvenile Coho Density |          |                     |          |
|---------------------------|--------------|------------|-------------|------------|---------------------------|------------|------------------------------------------------|---------------------|----------|-----------------------|----------|---------------------|----------|
|                           |              |            | Sampled (m) | % of total | Sampled (m <sup>2</sup> ) | % of total |                                                |                     |          | Coho/m                | 95% C.I. | Coho/m <sup>2</sup> | 95% C.I. |
| July 15-August 5<br>1999  | Pool         | 19         | 382.1       | 72.1%      | 1590.8                    | 84.1%      | 0.67                                           | 99                  | 7.23     | 0.259                 | 0.019    | 0.062               | 0.004    |
|                           | Riffle       | 9          | 120.8       | 22.8%      | 228.4                     | 12.1%      |                                                | 0                   |          |                       |          |                     |          |
|                           | Flatwater    | 2          | 27.1        | 5.1%       | 73.0                      | 3.8%       |                                                | 0                   |          |                       |          |                     |          |
|                           | TOTAL        | 30         | 530.0       | 100.0%     | 1892.2                    | 100.0%     |                                                | 99                  | 7.23     | 0.259                 | 0.019    | 0.062               | 0.004    |
| July 20-August 14<br>2000 | Pool         | 14         | 297.0       | 62.0%      | 1298.1                    | 70.9%      | 1.07                                           | 240                 | 89.84    | 0.808                 | 0.302    | 0.185               | 0.069    |
|                           | Riffle       | 7          | 117.6       | 24.5%      | 282.6                     | 15.4%      |                                                | 0                   |          |                       |          |                     |          |
|                           | Flatwater    | 3          | 64.7        | 13.5%      | 251.4                     | 13.7%      |                                                | 1                   | 0.00     | 0.015                 | 0        | 0.004               | 0        |
|                           | TOTAL        | 24         | 479.3       | 100.0%     | 1832.1                    | 100.0%     |                                                | 241                 | 89.84    | 0.503                 | 0.187    | 0.132               | 0.049    |
| July 17-August 2<br>2001  | Pool         | 15         | 264.6       | 56.0%      | 1083.3                    | 60.8%      | 0.64                                           | 657                 | 63.24    | 2.483                 | 0.239    | 0.606               | 0.058    |
|                           | Riffle       | 5          | 73.2        | 15.5%      | 162.7                     | 9.1%       |                                                | 14                  | 1.27     | 0.191                 | 0.017    | 0.086               | 0.008    |
|                           | Flatwater    | 7          | 134.3       | 28.5%      | 536.7                     | 30.1%      |                                                | 142                 | 28.89    | 1.057                 | 0.215    | 0.265               | 0.054    |
|                           | TOTAL        | 27         | 472.1       | 100.0%     | 1782.7                    | 100.0%     |                                                | 813                 | 93.4     | 1.722                 | 0.198    | 0.456               | 0.052    |
| July 24-August 7<br>2002  | Pool         | 9          | 180.7       | 39.9%      | 742.4                     | 42.3%      | 1.58                                           | 993                 | 73.85    | 5.495                 | 0.409    | 1.338               | 0.099    |
|                           | Riffle       | 4          | 89.7        | 19.8%      | 272.8                     | 15.6%      |                                                | 12                  | 1.20     | 0.134                 | 0.013    | 0.044               | 0.004    |
|                           | Flatwater    | 7          | 183.2       | 40.4%      | 738.0                     | 42.1%      |                                                | 211                 | 10.94    | 1.152                 | 0.060    | 0.286               | 0.015    |
|                           | TOTAL        | 20         | 453.6       | 100.0%     | 1753.2                    | 100.0%     |                                                | 1216                | 85.99    | 2.681                 | 0.190    | 0.694               | 0.049    |
| July 24-August 12<br>2003 | Pool         | 11         | 252.6       | 60.0%      | 1073.0                    | 57.4%      | 1.55                                           | 588                 | 102.41   | 2.328                 | 0.405    | 0.549               | 0.096    |
|                           | Riffle       | 4          | 39.1        | 9.3%       | 103.1                     | 5.5%       |                                                | 4                   | 1.58     | 0.102                 | 0.040    | 0.039               | 0.015    |
|                           | Flatwater    | 6          | 129.3       | 30.7%      | 692.8                     | 37.1%      |                                                | 44                  | 4.82     | 0.340                 | 0.037    | 0.064               | 0.007    |
|                           | TOTAL        | 21         | 421.0       | 100.0%     | 1868.9                    | 100.0%     |                                                | 636                 | 108.81   | 1.511                 | 0.258    | 0.340               | 0.058    |
| July 19-August 10<br>2004 | Pool         | 14         | 291.7       | 68.2%      | 1396.0                    | 66.9%      | 0.71                                           | 1243                | 206.00   | 4.26                  | 0.71     | 0.89                | 0.15     |
|                           | Riffle       | 0          | 0.0         | 0.0%       | 0.0                       | 0.0%       |                                                | 0                   |          |                       |          |                     |          |
|                           | Flatwater    | 5          | 135.7       | 31.8%      | 690.8                     | 33.1%      |                                                | 399                 | 59.00    | 2.94                  | 0.43     | 0.58                | 0.08     |
|                           | TOTAL        | 19         | 389.0       | 100.0%     | 1967.0                    | 100.0%     |                                                | 1642                | 265      | 4.22                  | 0.68     | 0.83                | 0.13     |
| July 25-August 5<br>2005  | Pool         | 11         | 357.7       | 80.9%      | 1826.6                    | 83.6%      |                                                | 1429                | 120.55   | 3.99                  | 0.34     | 0.78                | 0.07     |
|                           | Riffle       | 4          | 60.2        | 13.6%      | 302.5                     | 13.9%      |                                                | 3                   | 39.00    | 0.05                  | 0.65     | 0.01                | 0.13     |
|                           | Flatwater    | 2          | 24.1        | 5.5%       | 54.6                      | 2.5%       |                                                | 1                   | 16.00    | 0.04                  | 0.66     | 0.02                | 0.30     |
|                           | TOTAL        | 17         | 442.0       | 100.0%     | 2183.7                    | 100.0%     |                                                | 1433                | 175.55   | 3.24                  | 0.40     | 0.66                | 0.08     |

Index reaches 1, 4, and 8 are not included due to inconsistent sampling.

Sampling dates are defined as the period from the first day an index was snorkeled to the last day an index was electrofished

### 3.3.2 Index Reach Habitat Information

Table 3.17 shows the average habitat composition for each index reach, the average extent of area sampled, and average variation between reaches from 1999 to 2005. Sample area boundaries and the number and types of habitat units may vary from year to year to track changes in the stream channel within each index reach. Occasional large changes in index reaches occur; for example, the stream channel encompassed by index reach 5 has migrated laterally more than 50 feet since it was established in 1999. Table 3.16 shows the variation between years in the total number of habitat units within index reaches, the extent of area sampled per unit type, the average daily discharge, and juvenile coho densities for each year's sampling period.

Table 3.17 Summary of average summer habitat composition by index reach on Olema Creek Summer 1999-2005.

| Index | Habitat   | Average Length     |     | Average Surface area |      |              |       |
|-------|-----------|--------------------|-----|----------------------|------|--------------|-------|
| Reach | Type      | Average # of Units | SD  | Sampled (m)          | SD   | Sampled (m²) | SD    |
| 1     | Pool      | 4.0                | 0.0 | 65.9                 | 3.0  | 219.3        | 19.6  |
|       | Riffle    | 0.8                | 0.5 | 5.4                  | 4.2  | 13.3         | 14.3  |
|       | Flatwater | 0.0                | 0.0 | 0.0                  | 0.0  | 0.0          | 0.0   |
|       | TOTAL     | 4.8                | 0.5 | 71.3                 | 6.7  | 232.6        | 21.5  |
| 2     | Pool      | 2.4                | 0.8 | 56.6                 | 22.9 | 231.0        | 154.5 |
|       | Riffle    | 1.0                | 0.6 | 14.8                 | 10.5 | 33.3         | 33.8  |
|       | Flatwater | 0.9                | 0.9 | 23.1                 | 25.1 | 167.9        | 176.1 |
|       | TOTAL     | 4.3                | 1.1 | 94.5                 | 30.4 | 432.2        | 130.3 |
| 3     | Pool      | 1.6                | 1.1 | 40.4                 | 24.2 | 241.2        | 125.0 |
|       | Riffle    | 0.1                | 0.4 | 1.4                  | 3.6  | 3.4          | 9.0   |
|       | Flatwater | 1.6                | 1.0 | 39.4                 | 25.9 | 120.4        | 119.0 |
|       | TOTAL     | 3.3                | 1.7 | 81.2                 | 12.4 | 365.0        | 107.7 |
| 4     | Pool      | 2.3                | 0.5 | 85.2                 | 27.7 | 415.6        | 134.3 |
|       | Riffle    | 0.8                | 1.0 | 8.2                  | 9.6  | 48.1         | 39.4  |
|       | Flatwater | 0.0                | 0.0 | 0.0                  | 0.0  | 26.0         | 51.9  |
|       | TOTAL     | 3.1                | 1.4 | 93.4                 | 34.6 | 489.7        | 87.8  |
| 5     | Pool      | 2.3                | 1.4 | 57.0                 | 30.1 | 263.9        | 158.3 |
|       | Riffle    | 1.4                | 0.8 | 22.7                 | 12.8 | 80.2         | 63.8  |
|       | Flatwater | 1.0                | 1.0 | 17.4                 | 17.0 | 49.4         | 62.5  |
|       | TOTAL     | 4.7                | 1.7 | 97.1                 | 19.4 | 393.5        | 114.0 |
| 6     | Pool      | 2.7                | 0.8 | 63.7                 | 19.9 | 287.0        | 89.6  |
|       | Riffle    | 0.7                | 0.5 | 6.5                  | 5.6  | 14.0         | 17.2  |
|       | Flatwater | 0.6                | 0.5 | 15.2                 | 14.6 | 49.3         | 48.2  |
|       | TOTAL     | 4.0                | 0.6 | 85.4                 | 34.5 | 350.3        | 68.2  |
| 7     | Pool      | 3.6                | 1.1 | 57.1                 | 14.4 | 201.6        | 59.0  |
|       | Riffle    | 1.4                | 1.4 | 21.4                 | 20.0 | 51.8         | 48.7  |
|       | Flatwater | 0.4                | 0.5 | 4.2                  | 5.4  | 9.8          | 16.7  |
|       | TOTAL     | 5.4                | 2.6 | 82.7                 | 31.3 | 263.2        | 85.8  |
| 8     | Pool      | 3.2                | 1.3 | 48.6                 | 13.5 | 351.1        | 557.8 |
|       | Riffle    | 0.2                | 0.4 | 1.0                  | 2.4  | 28.7         | 70.3  |
|       | Flatwater | 0.2                | 0.4 | 0.8                  | 1.8  | 117.5        | 281.8 |
|       | TOTAL     | 3.6                | 1.0 | 50.4                 | 14.4 | 497.4        | 909.7 |
| Total | Pool      | 22.1               |     | 474.5                |      | 2210.7       |       |
|       | Riffle    | 6.4                |     | 81.4                 |      | 272.9        |       |
|       | Flatwater | 4.6                |     | 99.9                 |      | 540.3        |       |
|       | TOTAL     | 33.1               |     | 655.9                |      | 3023.9       |       |

Index 1 not sampled in 2003, 2004, or 2005; Index 4 not sampled in 2002, 2004, or 2005; Index 8 not sampled in 1999.

### 3.3.3 Salmonid density by habitat type

The results of our monitoring efforts show distinct differences in salmonid numbers and densities based on habitat type. Coho salmon primarily use pools, while steelhead use pools and flatwaters almost equally.

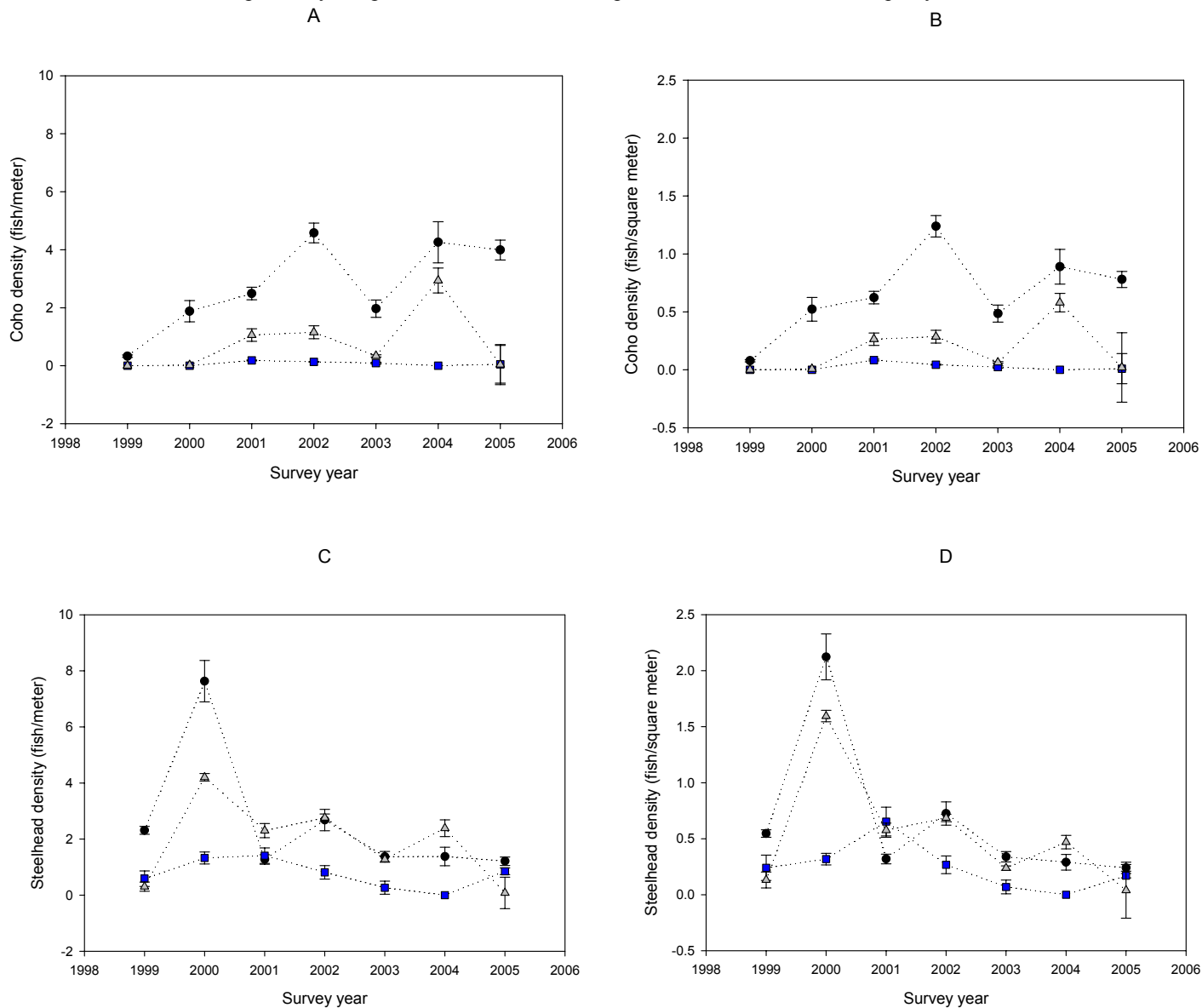
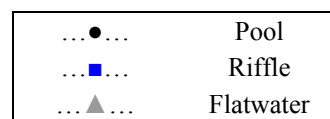


Figure 3.5 Temporal change in salmonid density between pool, flatwater, and riffle habitat within eight Olema Creek index reaches, Summer 1999-2005. Error bars represent 95% confidence intervals.

- Density of juvenile coho per meter.
- Density of juvenile coho per square meter.
- Density of YOY steelhead per meter.
- Density of YOY steelhead per square meter.



### 3.3.4 Salmonid Index Reach Density

Densities shown in Figures 3.6 and 3.7 are determined from all habitat units surveyed within each index reach. Juvenile coho densities have tended to be highest in index reaches 5, 6, and 7. Coho densities were also high in index 8 in 2001, 2002, and 2004, corresponding to high levels of spawning activity in the area during the previous winters.

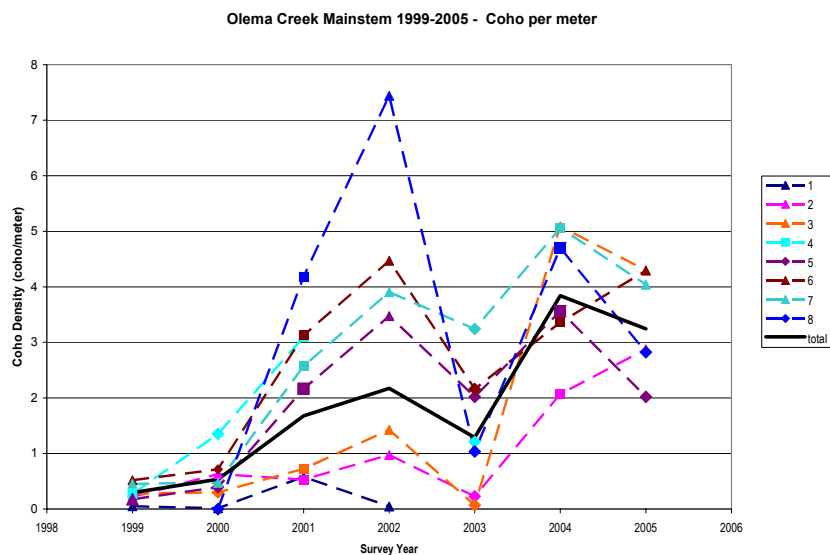


**Figure 3.6. Summer juvenile coho salmon densities (coho/meter) for eight index sites in Olema Creek from 1999-2005. Heavy line without symbols indicates means for all sites. Symbols represent cohort year classes.**

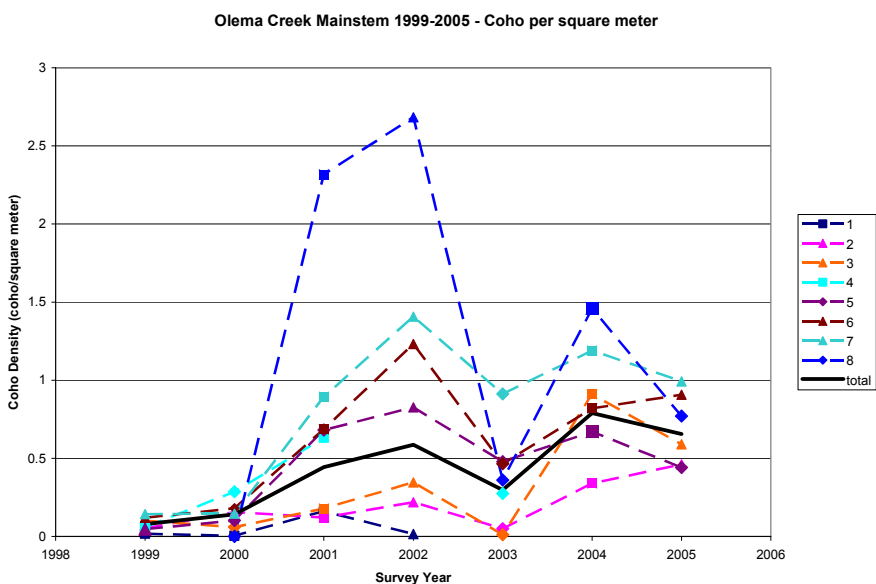


**Figure 3.7. Summer juvenile coho salmon densities (coho/square meter) for eight index sites in Olema Creek from 1999-2005. Heavy line without symbols indicates means for all sites. Symbols represent cohort year classes.**

Overall densities for coho, steelhead YOY, and steelhead 1+ are shown in Figure 3.8. Juvenile coho density seems to be on the rise, ranging from  $0.30 (\pm 0.03)$  fish/m and  $0.08 (\pm 0.01)$  fish/m<sup>2</sup> in 1999 to  $3.84 (\pm 0.62)$  fish/m and  $0.79 (\pm 0.01)$  fish/m<sup>2</sup> in 2004. Monitoring shows a subtle decline in young of year steelhead density from  $2.46 (\pm 0.26)$  fish/m and  $0.64 (\pm 0.07)$  fish/m<sup>2</sup> in 2000 to  $1.70 (\pm 0.32)$  fish/m and  $0.35 (\pm 0.07)$  fish/m<sup>2</sup> in 2004. Steelhead 1+ density has shown little variation over the years, averaging around 0.2 fish/m and 0.05 fish/m<sup>2</sup>.

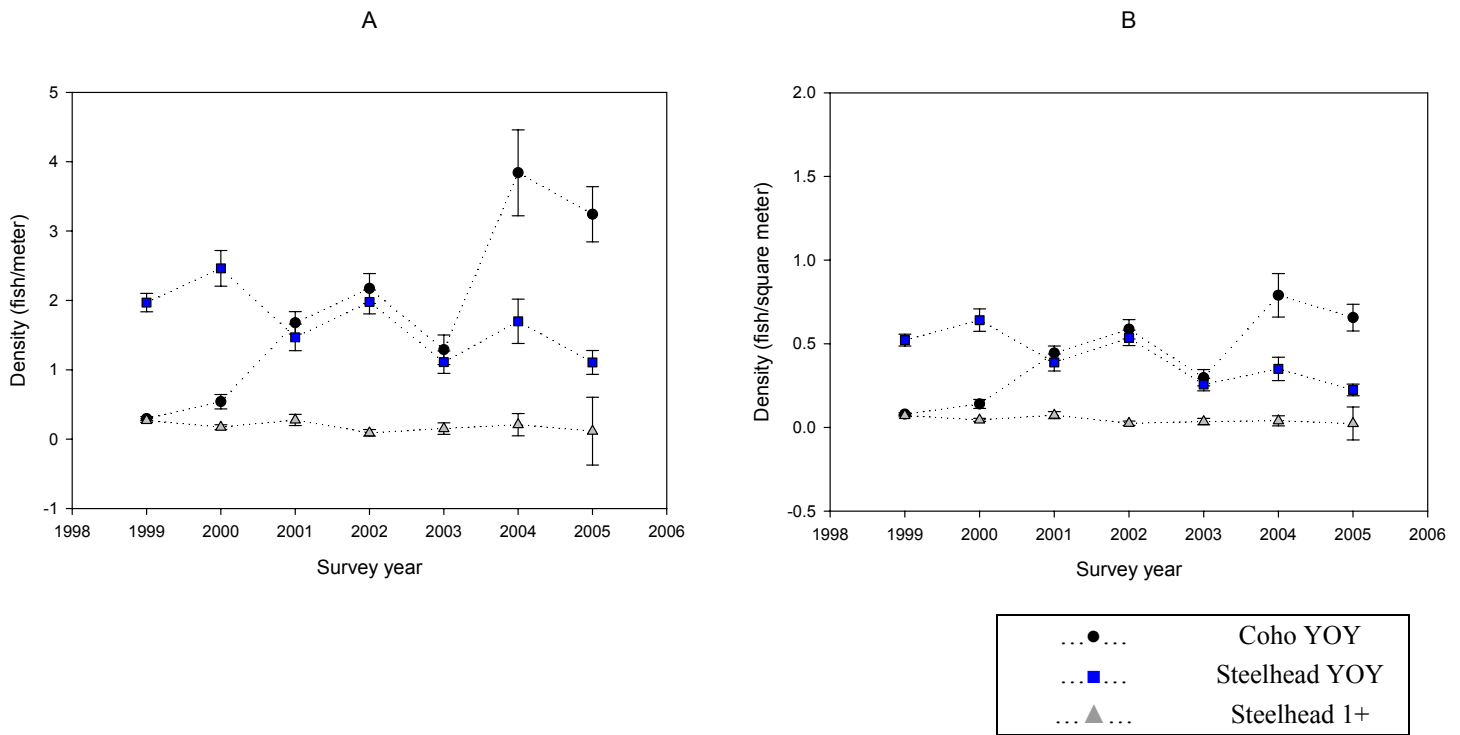


**Figure 3.8. Presents the average density (with 95% CI) of salmonids Summer, 1999 - 2005.**  
**A) fish/m and B) fish/m²**

### 3.3.5 Summer fish measurement information

As part of the summer monitoring program, a subsample of fish are weighed and measured within each sampled habitat unit. Annual results including histograms, weight-length charts, as well as Fulton condition factor, mean weight, and biomass for each of the salmonid species and steelhead age classes were previously reported in the Annual Index Reach Monitoring Summary.

Synthesis of this detailed information is presented in Figure 3.9 and 3.10 in box and whisker plots. The charts show the size range of coho salmon both spatially, between index reaches, and temporally, between monitoring years. There is clearly a trend of shorter fork length in relation to location in the watershed. The largest coho juveniles on average have been documented in the lower reaches of the watershed. This is reasonable considering the lower reaches likely include larger habitat units and warmer water, resulting in increased productivity and fish growth.

The range of coho juvenile fork length in fish captured through the summer monitoring efforts (July – August of each summer) is 37 to 121 millimeters, with most fish at this age grouped in the 60 to 80 millimeter FL.

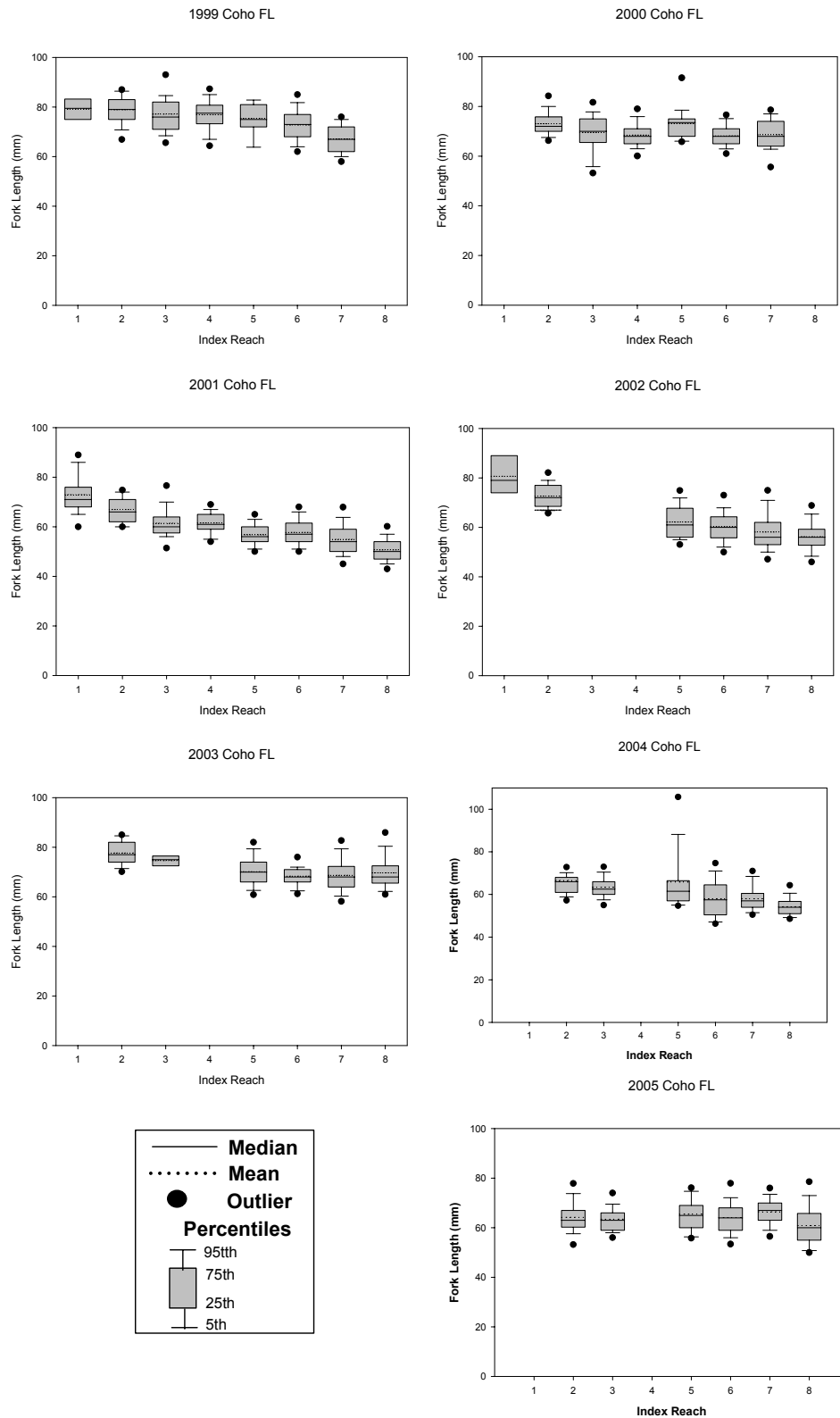


Figure 3.9 Box and whisker plots depicting mean, median, 5<sup>th</sup>, 25<sup>th</sup>, 75<sup>th</sup> and 95<sup>th</sup> percentiles, and outliers of juvenile coho salmon fork length within the eight Olema Creek index reaches, summers 1999 – 2005.

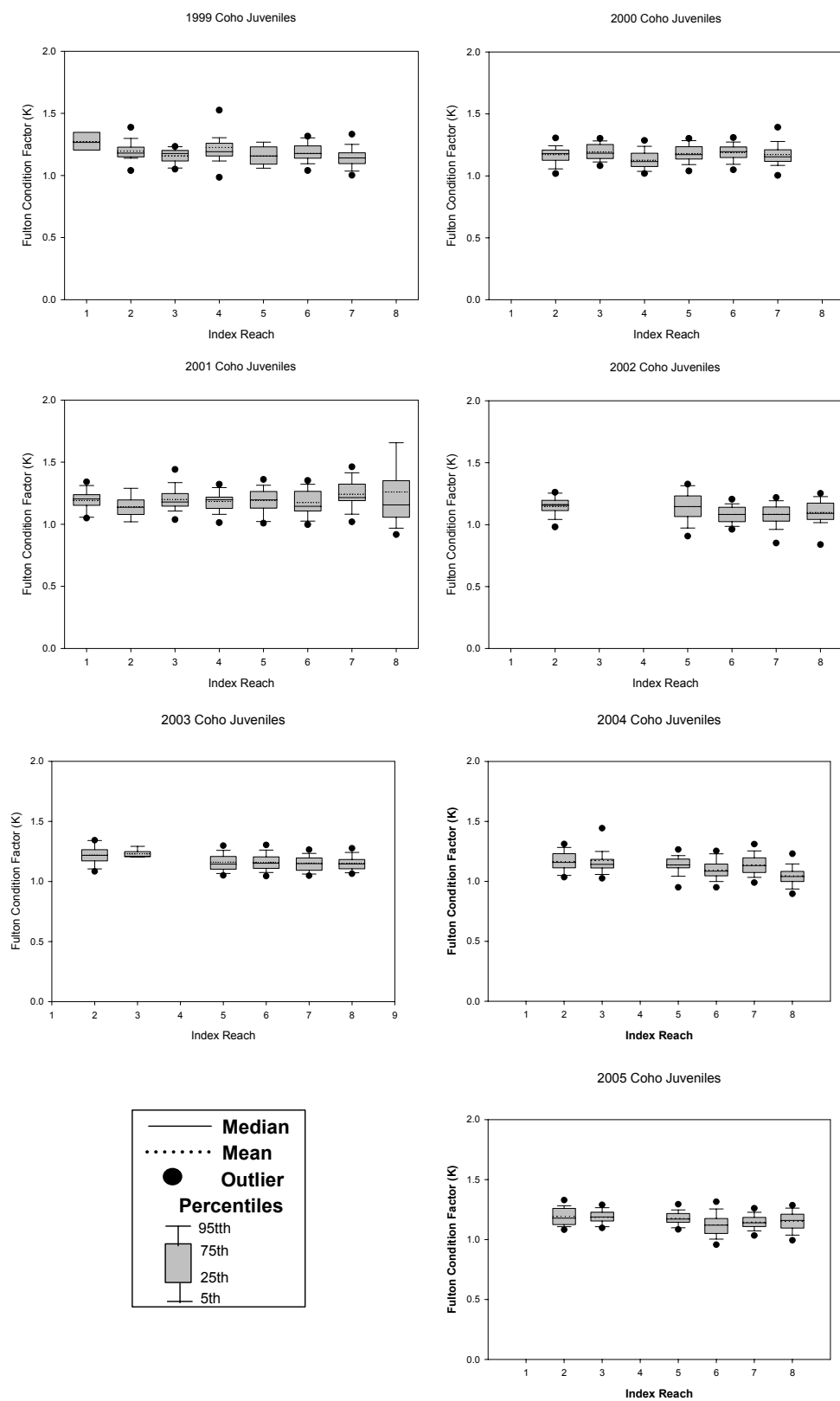


**Figure 3.10** Box and whisker plots depicting mean, median, 5<sup>th</sup>, 25<sup>th</sup>, 75<sup>th</sup> and 95<sup>th</sup> percentiles, and outliers of juvenile coho salmon Fulton Condition Factor within the eight Olema Creek index reaches, summers 1999 – 2005.

### 3.4 Population estimates

#### 3.4.1 Juvenile Fish Abundance, Distribution, and Mortality in Isolated Pools

The upper reaches of Olema Creek were targeted for evaluation in 1999 and 2004 because of typical high winter spawning densities and drying conditions in the summer. The intent of the investigations was to determine the level of use during summer conditions before and after the low flow period. The results of the surveys indicated significant use of this habitat by juvenile coho. High mortality and low growth rates occur throughout the summer/fall low flow period. Mortality is mainly the result of lowered water quality and/or complete desiccation of habitat units. Evidence of mammalian and avian predation was evident along the margins of habitat units as well. The most drastic change was observed in pool surface area which decreased by 37% in 1999 and by 48% in 2004 from early to late summer. Although habitat decreased, fish density did not increase in reaction to the loss of available rearing habitat. Instead, fish densities decreased which suggests that both food and shelter from predation is limited in pools once they become isolated along the stream continuum. For further information on the 1999 juvenile fish abundance, distribution, and mortality in isolated pools subproject please refer to Ketcham et al. 2004.

In 2004 the comparison between July and September surveys on Olema Creek resulted in some marked contrast in habitat availability and quality, in addition to distribution and connectivity. Total habitat units assessed during the survey was up from 262 in July 2004 to 326 in September (Table 3.18). The length of these surveys varied slightly, due to the change in the thalweg in the drying sections, from 3,187 meters in August up to 3,226 meters in September. In July, habitat units were well represented, with pool, flatwater, and dry channel units most dominant; 76 pool units comprised 33% of the total length, while 87 flatwater and 52 dry channel units accounted for 30% and 22% of the unit lengths respectively. By September, 148 dry channel units comprised 58% of the total length of the survey area with 114 flatwater and 50 pool units accounting for 22% and 17% of the total length respectively.

**Table 3.18 Level II habitat type composition by length (m) and surface area (m<sup>2</sup>). Upper Olema Creek, Marin County, CA. Habitat survey, July and September 2004.**

| Habitat Type          | Number of Units | Total Length per Habitat Type | Percent of Total Length | Average Length per Habitat Type | Total Surface Area per Habitat Type | Percent of Total Surface Area | Average Surface Area per Habitat Type |
|-----------------------|-----------------|-------------------------------|-------------------------|---------------------------------|-------------------------------------|-------------------------------|---------------------------------------|
| <b>July 2004</b>      |                 |                               |                         |                                 |                                     |                               |                                       |
| Pool                  | 76              | 1065.5                        | 33                      | 14.0                            | 3161.4                              | 58                            | 41.6                                  |
| Dry Channel           | 52              | 715                           | 22                      | 13.8                            | n.a.                                | n.a.                          | n.a.                                  |
| Riffle                | 36              | 275.4                         | 9                       | 7.7                             | 249.8                               | 5                             | 6.9                                   |
| Flatwater             | 87              | 961.9                         | 30                      | 11.1                            | 1783.4                              | 33                            | 20.5                                  |
| Cascade               | 9               | 161.1                         | 5                       | 17.9                            | 264.9                               | 5                             | 29.4                                  |
| Backwater             | 2               | 8                             | <1                      | 4.0                             | m                                   | m                             | m                                     |
| <b>Totals</b>         | <b>262</b>      | <b>3186.9</b>                 | <b>100</b>              |                                 | <b>5459.5</b>                       | <b>100</b>                    |                                       |
| <b>September 2004</b> |                 |                               |                         |                                 |                                     |                               |                                       |
| Pool                  | 50              | 556.8                         | 17                      | 11.14                           | 1486.7                              | 56                            | 29.7                                  |
| Dry Channel           | 148             | 1874.3                        | 58                      | 12.66                           | n.a.                                | n.a.                          | n.a.                                  |
| Riffle                | 7               | 54.7                          | 2                       | 7.81                            | 42.2                                | 2                             | 6.0                                   |
| Flatwater             | 114             | 714.5                         | 22                      | 6.27                            | 1062.0                              | 40                            | 9.3                                   |
| Backwater             | 7               | 26.1                          | 1                       | 3.73                            | 45.8                                | 2                             | 6.5                                   |
| <b>Totals</b>         | <b>326</b>      | <b>3226.4</b>                 | <b>100</b>              |                                 | <b>2636.7</b>                       | <b>100</b>                    |                                       |

m = missing data

Correlation ratios between visually estimated and measured surface areas were calculated for both July and September. The correlation in July 2004 was high ( $R^2 = 0.93$ ) and a calibration ratio of 1.03 was used (NPS 2005). In September

2004, the correlations for pools and flatwaters were ( $R^2 = 0.81$ ) and ( $R^2 = 0.99$ ) respectively and calibration ratios of 1.09 and 1.04 respectively were used to correct visually estimated surface areas. The total surface area of Upper Olema Creek in July was 5459.5 m<sup>2</sup>. Due to the drying patterns between July and September, approximately 48% of the total surface area was lost between the July and September surveys.

Snorkel surveys were conducted on a subsample (~17%) of the pool habitat on the upper Olema Creek in July 2004 and then again in September after the increase in summer drying conditions. In July, thirteen pool units with a total surface area of 476.7 m<sup>2</sup> were snorkeled and 589 coho were counted (Table 3.19). In September, eight pools (of the original thirteen) with a total surface area of 221.5 m<sup>2</sup> were able to be re-snorkeled and 322 coho were counted. Between the July and September snorkel surveys there was a loss of about 46% in pool surface area and about 55% less coho were counted. In September, all pools had habitat loss and five had less coho seen than in July. Of the pools snorkeled there were three pools that had higher coho counts in September than in July, all three pools were not isolated from the mainstem Olema Creek and there was potential for juvenile coho movement between habitat units. It is also possible that the counts done in July missed coho due to larger pool size and habitat complexity, which was greatly reduced by September.

**Table 3.19 Number of juvenile coho counted and measured surface areas (m<sup>2</sup>). Upper Olema Creek, California. Basinwide snorkel and habitat surveys, July and September 2004.**

|               | July<br>coho<br>count | July<br>Surface<br>Area (m <sup>2</sup> ) | Sept.<br>coho<br>count | Sept.<br>Surface<br>Area (m <sup>2</sup> ) |
|---------------|-----------------------|-------------------------------------------|------------------------|--------------------------------------------|
| Pool A        | 22                    | 33.0                                      | 0                      | 0.0                                        |
| Pool B        | 70                    | 60.0                                      | 46                     | 35.9                                       |
| Pool C        | 28                    | 46.9                                      | 20                     | 23.1                                       |
| Pool D        | 38                    | 20.1                                      | 0                      | 0.0                                        |
| Pool E        | 53                    | 54.6                                      | 37                     | 36.3                                       |
| Pool F        | 49                    | 39.5                                      | 31                     | 17.2                                       |
| Pool G        | 19                    | 23.7                                      | 35                     | 22.5                                       |
| Pool H        | 43                    | 40.5                                      | 63                     | 39.1                                       |
| Pool I        | 51                    | 37.2                                      | 63                     | 24.4                                       |
| Pool J        | 50                    | 17.3                                      | 0                      | 0.0                                        |
| Pool K        | 36                    | 53.6                                      | 0                      | 0.0                                        |
| Pool L        | 95                    | 28.8                                      | 0                      | 0.0                                        |
| Pool M        | 35                    | 21.5                                      | 27                     | 23.0                                       |
| <b>TOTALS</b> | <b>589</b>            | <b>476.7</b>                              | <b>322</b>             | <b>221.5</b>                               |

The results of snorkel surveys on the isolated pool section of Upper Olema Creek indicate that this reach is significant to the overall juvenile salmonid population in Olema Creek. Much like the intermittent tributaries, this portion of the watershed is not subject to excessive flows, provides limited winter refugia and good habitat for spawning. As we have observed in other tributaries, the number of fish using these intermittent habitat units is high.

### 3.4.2 Summer Basinwide Surveys

Survey length and total number of habitat units has varied during the last three years. Total number of habitat units and habitat composition will vary depending on the water year, survey area, and interpretation of the physical habitat by the surveyor. The habitat surveys usually encompassed a greater area than the snorkel surveys due to poor water quality in the snorkel pools on lower Olema. Overall percentage of pool units have remained relatively constant ranging from 47% in 2004 and 2005 to 51% in 2003. Flatwater and riffle units are more inconsistent; percentage of flatwaters has ranged from 13% to 29%, and percentage of riffles has ranged from 24% to 36% (Table 3.20). The correlation between

the estimated surface area and measured surface area has consistently been adequate with  $R^2$  value ranging from 0.9215 to 0.937. Based on this, a calibration ratio was used to correct the estimated surface area of all units for each year (Figure 3.11, Figure 3.12, Figure 3.13).

**Table 3.20 Habitat composition of Olema Creek Basinwide survey area, July-August, 2003-2005**

| Unit type     | 2003       |    | 2004       |    | 2005       |    |
|---------------|------------|----|------------|----|------------|----|
|               | # of units | %  | # of units | %  | # of units | %  |
| pool          | 275        | 51 | 373        | 47 | 360        | 47 |
| flatwater     | 69         | 13 | 230        | 29 | 177        | 23 |
| rifle         | 193        | 36 | 195        | 24 | 222        | 29 |
| total         | 537        |    | 798        |    | 759        |    |
| Survey length | 9.2 km     |    | 12.4 km    |    | 12.7 km    |    |

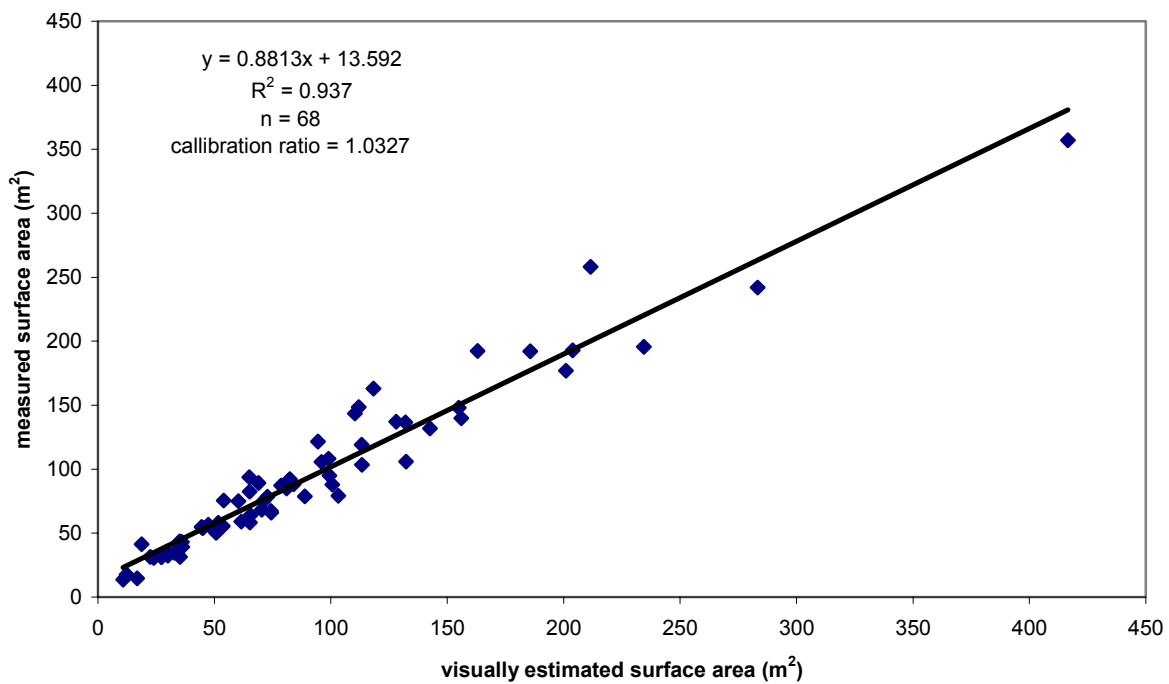


**Figure 3.11 Correlation between measured and visually estimated surface area of 68 pools; Olema Creek, July-August 2003.**

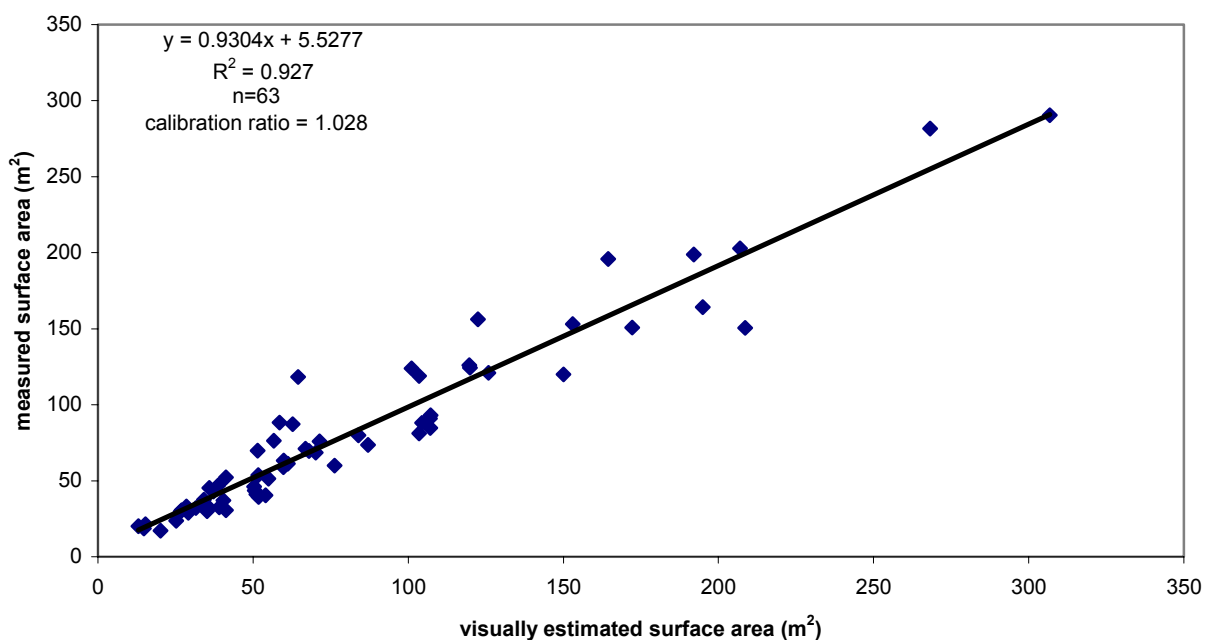


**Figure 3.12** Correlation between measured and visually estimated surface area of 63 pools; Olema Creek, July-August 2004.

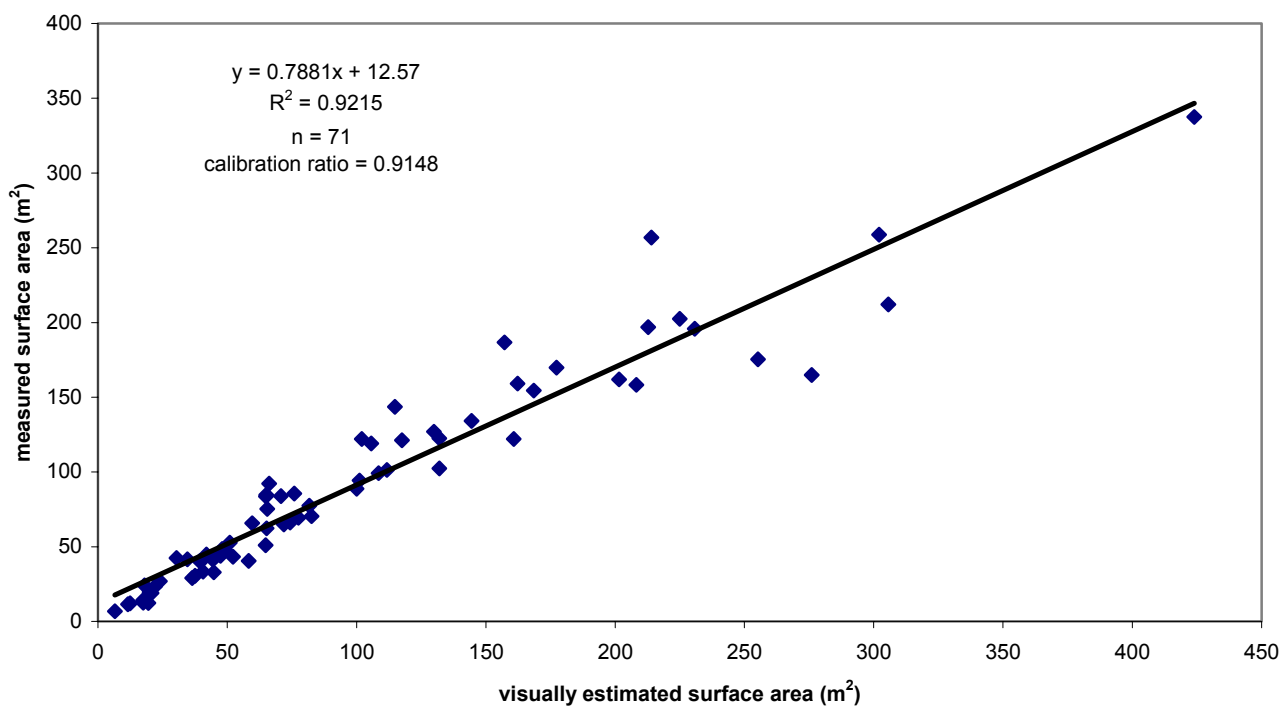


**Figure 3.13** Correlation between measured and visually estimated surface area of 71 pools; Olema Creek, July-August 2005.

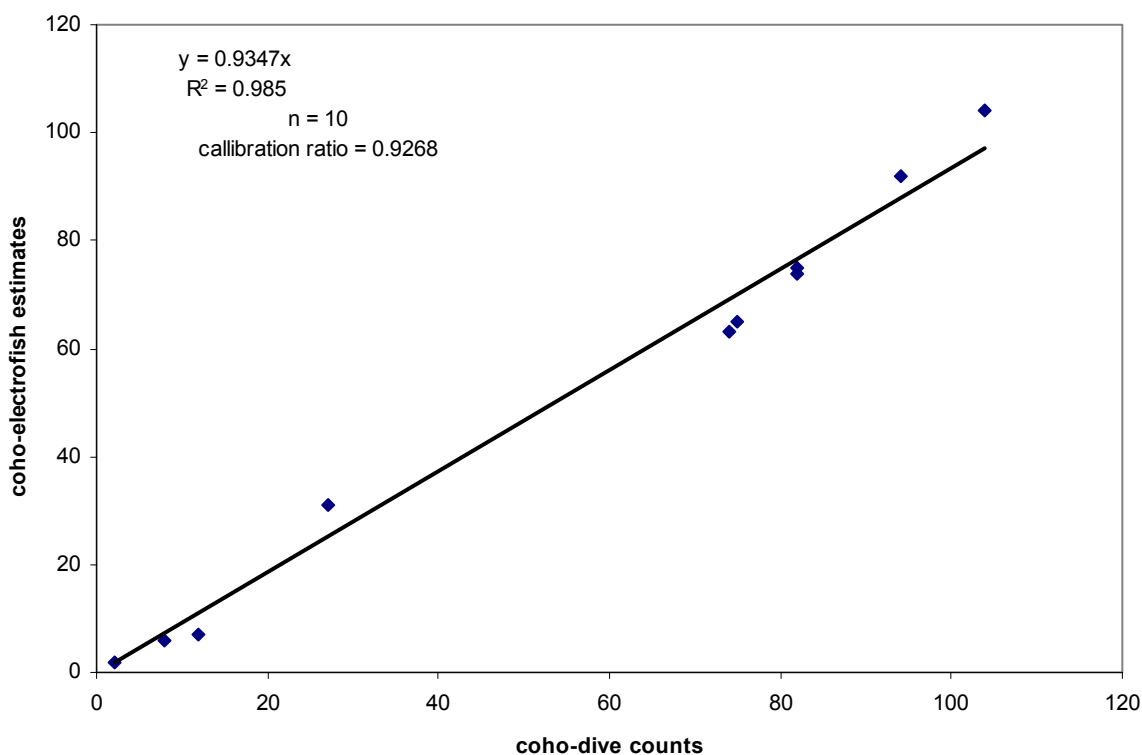


**Figure 3.14** Correlation between electrofishing estimates and snorkel counts for 10 pools; Olema Creek, July-August 2003.

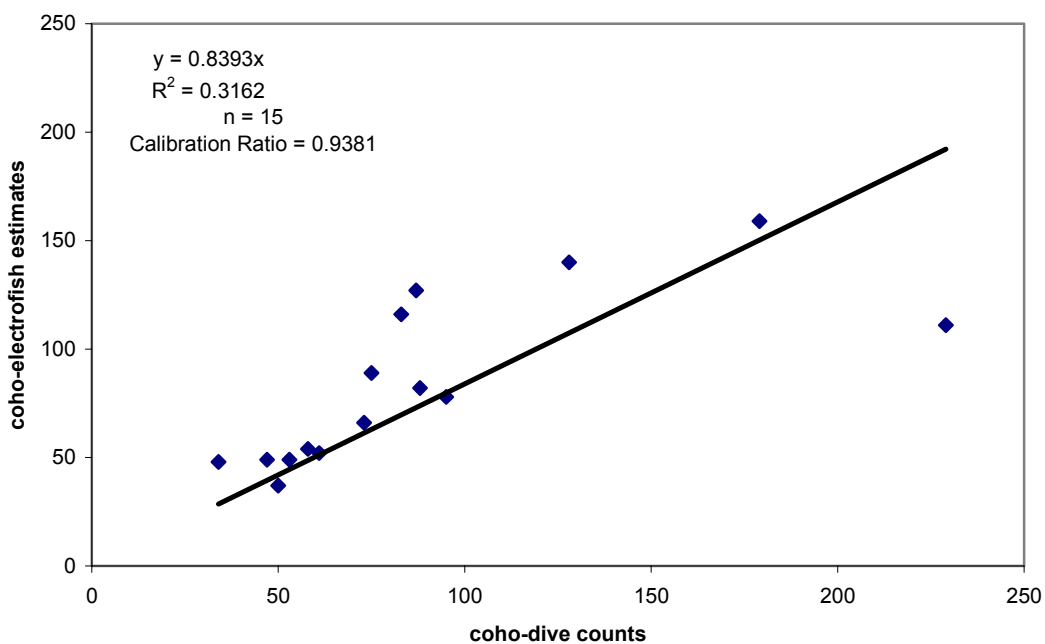


**Figure 3.15** Correlation between electrofishing estimates and snorkel counts for 15 pools; Olema Creek, July-August 2004.

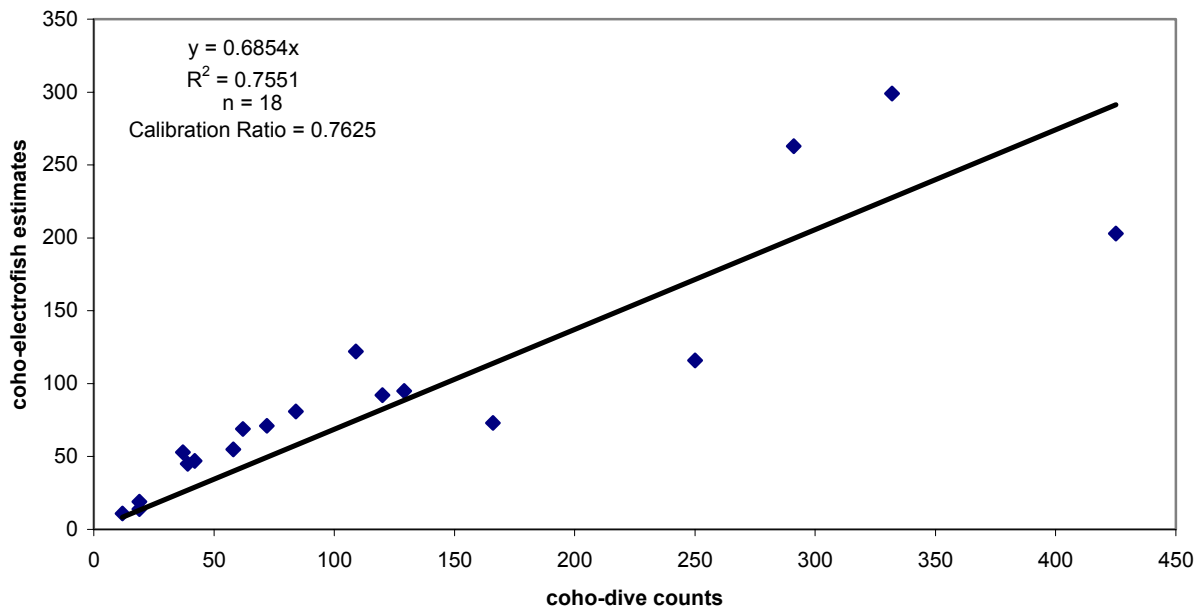


**Figure 3.16 Correlation between electrofishing estimates and snorkel counts for 18 pools; Olema Creek, July-August 2005.**

#### **Snorkel counts**

Basinwide juvenile coho estimates have increased over the past three years from an estimated 10,233 in 2003 to 27,943 in 2005. Total survey length has also increased from 7.8 km in 2003 to 11.2 km surveyed in 2004. The percentage of pools sampled has also increased from 19.5% in 2003 to 23.3% in 2005. During the last three survey years coho were present in all but two of the snorkeled pools. The percentage of pools electrofished for calibration from 2003 to 2005 was 21.7 %, 21.7%, and 24.3% respectively. Correlation values have varied through all three years with  $R^2$  values ranging from 0.32 to 0.98. The respective calibration ratios used from 2003 to 2005 were 0.9268, 0.9381, and 0.7625 (Figure 3.14, Figure 3.15, Figure 3.16). A summary of the snorkel counts is shown in Table 3.21. Coho densities (by both pool length and calibrated surface area), population estimate, and 95% confidence interval were calculated for the coho survey area as a whole (Table 3.22).

**Table 3.21 Summary of coho snorkel counts in Olema Creek, July-August 2003-2005.**

| Year | Total stream length surveyed (km) | Total number of habitat units | Number of Pools |           |         | Coho Counted |            |
|------|-----------------------------------|-------------------------------|-----------------|-----------|---------|--------------|------------|
|      |                                   |                               | Total           | Snorkeled | w/ Coho | Raw          | Calibrated |
| 2003 | 7.8                               | 465                           | 236             | 46        | 44      | 2,153        | 1,995      |
| 2004 | 11.2                              | 761                           | 331             | 69        | 69      | 5,746        | 5,390      |
| 2005 | 10.9                              | 671                           | 318             | 74        | 74      | 8,527        | 6,502      |

**Table 3.22 Coho density and population estimates; Olema Creek coho survey area, July-August 2003-2005.**

| Year | Avg. Coho per pool |            | Density |                     | Population Estimate | Variance   | 95% confidence Interval |
|------|--------------------|------------|---------|---------------------|---------------------|------------|-------------------------|
|      | Raw                | Calibrated | coho/m  | Coho/m <sup>2</sup> |                     |            |                         |
| 2003 | 46.79              | 43.36      | 1.93    | 0.441               | 10,235              | 1,467,802  | ± 2,740                 |
| 2004 | 83.28              | 78.12      | 3.66    | 0.835               | 25,857              | 488,082    | ± 1,499                 |
| 2005 | 115.23             | 87.87      | 3.38    | 0.958               | 27,943              | 14,582,443 | ± 8,057                 |

### 3.5 Extrapolated coho salmon population estimates comparing index reach monitoring and snorkel survey estimates

This section includes three extrapolated population estimates for coho salmon in Olema Creek for years 2003 thru 2005. This includes estimates based on index reach derived densities of coho per meter and coho per square meter. While standard error and confidence intervals can be developed for the index reach fish densities, it is important to note that this error is calculated on the quality of the estimate within each habitat unit. The weakness of extrapolating these densities into a basinwide estimate is that it does not account for the natural variability of fish between pools within the basin. Furthermore, index reaches are non-random and therefore may misrepresent the basin. However, Basinwide estimates are not problem free, as they most likely under estimate the population by only sampling pool units. Based on index reach sampling, over 15% of the coho captured were in flatwater units in three out of the last seven years.

In order to evaluate the utility in using index reaches to describe the entire basin, we have developed fish estimates on the number of fish per pool, derived from the pools included in the index reach sample process. While we are able to derive an extrapolated estimate using this method, we still do not have a means of developing a confidence interval at this time.

Table 3.23 is provided as a comparison of estimates derived from the two survey techniques (index reach and basinwide surveys). Extrapolated population values based on index reach monitoring were calculated for only the pool units used in developing the basinwide juvenile coho population estimate. In all three years the index reach population estimate using the number of pool units only is higher than the basinwide population estimate. The deviation in the two population estimate methods remain inconsistent between years with index reach estimates ranging from 13.7% to 47.8% higher than the basinwide estimate. Such variability alleviates the possibility of developing a calibration factor to adjust index reach based population estimates.

**Table 3.23 Extrapolated population estimates for Olema Creek using three density based methods (Coho per unit, coho per meter, and coho per square meter) multiplied by basinwide habitat results. Basinwide coho population estimates are provided for comparison. The estimates reported in this table are for information only, as they do not contain any error estimates.**

| Year | Pool Units from Hankin Reeves/Basinwide Survey |            |                                | Coho densities from Index Reach Surveys |        |                     | Coho population estimate based on Index Reach densities |                    |                                        | Basinwide Population Estimate |
|------|------------------------------------------------|------------|--------------------------------|-----------------------------------------|--------|---------------------|---------------------------------------------------------|--------------------|----------------------------------------|-------------------------------|
|      | # of units                                     | length (m) | Surface area (m <sup>2</sup> ) | coho/unit                               | coho/m | coho/m <sup>2</sup> | by # (coho/unit)                                        | by length (coho/m) | by surface area (coho/m <sup>2</sup> ) | By # (coho/unit)              |
| 2003 | 236                                            | 3,817      | 16,548                         | 50.3                                    | 2.19   | 0.54                | 11,871                                                  | 8,359              | 8,936                                  | 10,235 ± 2,740                |
| 2004 | 331                                            | 5,819      | 25,545                         | 88.8                                    | 4.26   | 0.89                | 29,393                                                  | 24,789             | 22,735                                 | 25,857 ± 1,499                |
| 2005 | 318                                            | 7,821      | 33,172                         | 129.9                                   | 3.99   | 0.78                | 41,308                                                  | 31,206             | 25,874                                 | 27,943 ± 8,057                |

Table 3.24 shows the results for Olema Creek, and extrapolated estimates for the survey area described in Section 3.4.2. These calculations also extrapolate fish numbers for flatwater and riffle habitat units. These habitat units are not included in the basinwide analysis used in Section 3.4.

It should be noted that despite the fact that these extrapolated population values are not supported with an error range, all three methods of estimating provide a result that is higher than the reported range using the basinwide analysis. Although the higher estimates provided by the index reach extrapolations can be explained by the incorporation of estimates from all three habitat types, one must keep in mind the estimates using pool units only is also higher than the basinwide estimate. In the most extreme case the index reach estimate using all habitat types was 99% higher than the estimate provided by the basinwide estimate. This further supports the notion that extrapolations using our current index reaches will over estimate the true population of the basin. One explanation of this phenomena is the non-random

selection of index reach units which has caused a misrepresentation of the coho population in the Olema mainstem. In all years there is a large variation in estimates between each extrapolation method which would decrease the reliability in the estimated values. We present this information as conditional, and hope that it leads to some investigations that could allow us to present these types of estimates with statistical support.

**Table 3.24 Extrapolated population estimates for Olema Creek using three density based methods (Coho per unit, coho per meter, and coho per square meter) multiplied by habitat results. The estimates reported in this table are for information only, as they do not contain any error estimates.**

| Year | Unit type    | Habitat Units from Hankin Reeves/Basinwide Survey |               |                                | Coho densities from Index Reach Surveys |             |                     | Coho population estimate based on Index Reach densities |                    |                                        |
|------|--------------|---------------------------------------------------|---------------|--------------------------------|-----------------------------------------|-------------|---------------------|---------------------------------------------------------|--------------------|----------------------------------------|
|      |              | # of units                                        | length (m)    | surface area (m <sup>2</sup> ) | coho/unit                               | coho/m      | coho/m <sup>2</sup> | by # (coho/unit)                                        | by length (coho/m) | by surface area (coho/m <sup>2</sup> ) |
| 2003 | pool         | 275                                               | 6,192         | 27,274                         | 50.3                                    | 2.19        | 0.54                | 13,832                                                  | 13,560             | 14,728                                 |
|      | flatwater    | 69                                                | 1,240         | 4,321                          | 7.3                                     | 0.34        | 0.06                | 504                                                     | 422                | 259                                    |
|      | riffle       | 193                                               | 2,207         | 6,707                          | 0.8                                     | 0.09        | 0.02                | 154                                                     | 199                | 134                                    |
|      | <b>total</b> | <b>537</b>                                        | <b>9,639</b>  | <b>38,302</b>                  | <b>31.6</b>                             | <b>1.57</b> | <b>0.36</b>         | <b>14,490</b>                                           | <b>14,181</b>      | <b>15,121</b>                          |
| 2004 | pool         | 373                                               | 7,089         | 29,006                         | 88.8                                    | 4.26        | 0.89                | 33,122                                                  | 30,199             | 25,815                                 |
|      | flatwater    | 230                                               | 3,704         | 12,002                         | 79.8                                    | 2.94        | 0.58                | 18,354                                                  | 11,075             | 6,961                                  |
|      | riffle       | N/A                                               | N/A           | N/A                            | N/A                                     | N/A         | N/A                 | N/A                                                     | N/A                | N/A                                    |
|      | <b>total</b> | <b>603</b>                                        | <b>10,793</b> | <b>41,008</b>                  | <b>86.4</b>                             | <b>3.84</b> | <b>0.79</b>         | <b>51,476</b>                                           | <b>41,274</b>      | <b>32,776</b>                          |
| 2005 | pool         | 360                                               | 9,224         | 41,466                         | 129.9                                   | 3.99        | 0.78                | 46,764                                                  | 36,804             | 32,343                                 |
|      | flatwater    | 177                                               | 3,167         | 11,327                         | 0.5                                     | 0.04        | 0.02                | 89                                                      | 127                | 227                                    |
|      | riffle       | 222                                               | 2,369         | 7,308                          | 0.8                                     | 0.05        | 0.01                | 178                                                     | 1,895              | 73                                     |
|      | <b>total</b> | <b>759</b>                                        | <b>14,760</b> | <b>60,101</b>                  | <b>84.3</b>                             | <b>3.24</b> | <b>0.66</b>         | <b>47,031</b>                                           | <b>38,826</b>      | <b>32,643</b>                          |

### 3.6 Genetics and Recovery

NOAA Fisheries has conducted extensive genetic analysis on CCCESU coho salmon and CCCDPS steelhead over the past five years. The NPS has participated in these efforts through the collection and submission of multiple genetic samples through the years. Additional detailed genetic studies were conducted on approximately 300 juvenile coho salmon for participation in the Russian River Coho Broodstock Reintroduction Program, a cooperative effort led by the California Department of Fish and Game.

The first coho salmon genetic investigations were conducted through the University of California Bodega Marine Lab. Analysis of coho salmon genetic samples collected from multiple year classes observed in 14 watersheds within the CCCESU and Southern Oregon/Northern California (SONC) ESU found that the genetics generally supported the ESU structure, with statistically significant clusters of samples corresponding to CCC and SONC ESUs (Hedgecock et. al. 2002). In addition, they found correlations among samples collected from watersheds south of the Golden Gate (state endangered at the time of publication). Analysis of coho samples collected from Olema Creek from 1996 to 2004 showed a close affinity to Lagunitas Creek, and also an influence from Noyo River coho. This reflects the extreme recovery efforts taken in the early 1980s by Trout Unlimited in Lagunitas Creek (R. Plant 2004, personal communication), and likely means that the Olema Creek populations was primarily derived from this same hatch-box recovery effort. Currently the NOAA-Fisheries Genetics Laboratory reports that the coho salmon in the CCCESU are represented by five general subpopulations. Populations of coho within Olema Creek and Lagunitas Creek are generally considered to occur within a Tomales Bay sub-population, with no significant genetic distinction between Olema and Lagunitas Creek.

This investigation also found significant departures from random mating and suggests a potential inbreeding depression in many of the smaller populations. Temporal comparisons of different year classes from the same watershed showed that in Olema Creek the 1996 year class was significantly different from the 1997 and 1998 year classes (which were

considered homogeneous) (Hedgecock et. al. 2002). Some adult samples analyzed for Olema Creek from winter 1996-97 showed excesses of individuals with homozygous multi-loci genotypic categories, implying general departure from random mating (e.g. inbreeding).

In 2005, Garza and Spence (NOAA) reported results of a statewide steelhead genetic analysis. One of the most pertinent findings to this study area were that the steelhead samples from coastal Marin watersheds, Lagunitas, Olema, and Redwood Creek watersheds showed the greatest number of allele, used as an indicator for population robustness through the NOAA-Genetics Lab (Garza and Spence 2005)

## **4.0 ANALYSIS**

### **Coho salmon**

Olema Creek is one of the most intensely monitored watersheds for coho salmon within coastal Marin County. Through NPS monitoring efforts, the program has documented significant information about coho salmon behavior, distribution, and use of this small coastal watershed.

The NPS has evaluated salmonid habitat within Olema Creek, and has identified approximately 9 kilometers of year-round high quality habitat in the perennial reaches of the mainstem, beginning upstream from the town of Olema and extending just south of the Five Brooks area. Eastern tributaries draining from Bolinas Ridge are intermittent, but provide important habitat for winter spawning and overwintering juvenile coho. Access and use of many of these eastern tributaries are restricted by road crossings associated with State Route 1. An analysis commissioned by the County of Marin Department of Public Works identified the Giacomini Gulch and John West Fork culverts as the two highest priorities for restoration within the county (Taylor and Associates 2003). Tributaries draining Inverness Ridge from the west provide the perennial flow to the mainstem but the steep, narrow canyons do not provide any coho habitat.

Genetic evaluations suggest that coho salmon occurring in Olema Creek constitute part of the Lagunitas/Olema genetic subgroup that would likely encompass the entire Tomales Bay watershed. Our data show a strong correlation between adult spawner density and the summer juvenile density, suggesting that year class is the dominant factor associated with population observations in the watershed. Since 1999, all three coho year classes have shown a strong response to changed ocean productivity patterns described in association with the Pacific Decadal Oscillation (PDO) shifted the dominant productivity from the Alaska Current to the California Current in the late 1990s. This shift was likely triggered by the last major El Nino Southern Oscillation Event (ENSO) in 1997. We have observed that high winter spawner numbers have been consistent with increased juvenile densities the following summer, with peaks following Spawner Years 2000-2001, SY 2001-2002, SY 2002-03, and SY 2004-05 (Figure 4.1).

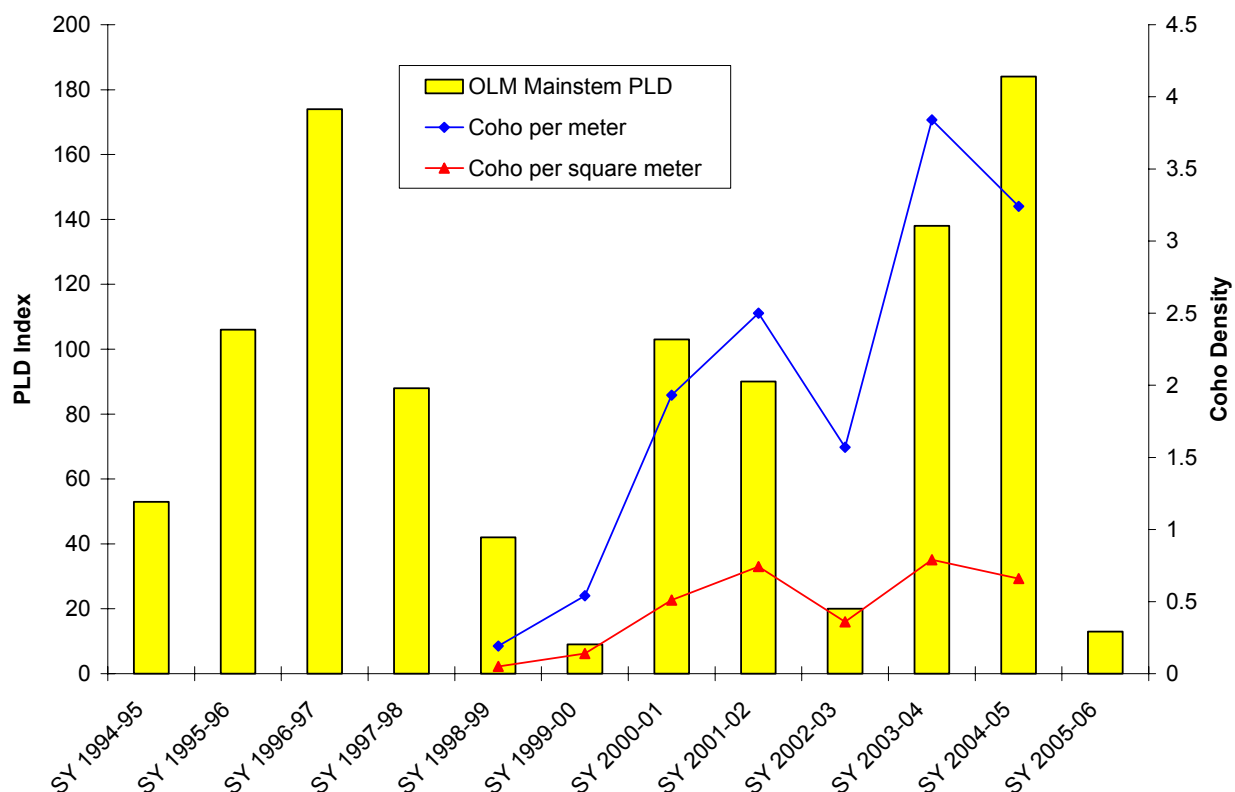


**Figure 4.1. Adult coho escapement and subsequent juvenile coho salmon density observed at 8 index reaches within the Olema Creek Watershed. Spawner Year (SY) represents the winter of adult return, therefore SY 1998-1999 represents spawners from the winter 1998-99, and juveniles from the summer of 1999.**

After the initiation of basinwide snorkel estimates for a 7.6 km reach of the watershed, we have been able to better characterize overall watershed trends for coho salmon. In spring 2004, we implemented outmigrant smolt trapping on the lower Olema mainstem, to complement the summer juvenile estimate. Research suggests that smolt trapping is the most important measure of watershed condition and productivity. Smolt traps also allow us to characterize overwinter survival within Olema Creek. It is likely that overwinter survival is a potential population bottleneck in these watersheds, as has been observed in watersheds in the north coast (Walt Duffy 2004, personal communication). In Pine Gulch Creek, where we have conducted smolt trap monitoring since 2002, we have estimated overwinter survival of juvenile coho ranging from 9% to 48% when compared to summer juvenile basinwide estimates (Reichmuth et al 2006). Long-term life-stage monitoring efforts for two watersheds in Oregon have reported annual overwinter survival ranging from 11% to 51% (Oregon Department of Fish and Wildlife 2003).

#### *John West Fork Observations*

Intensive monitoring of the John West Fork, an intermittent tributary to Olema Creek, has documented juvenile rearing and survival, although each localized pool represents highly stressful conditions. We have observed habitat units to remain isolated for up to six months, while still supporting survival of salmonids in high densities. It is likely that there is some groundwater flow that maintains these pools throughout the summer. Surveys conducted in preparation for the Russian River Coho Broodstock Recovery Program in 2001 showed stratification within the isolated pools, with pockets of cooler water and higher dissolved oxygen near the bottom of the pools.

On mainstem Olema, the observer efficiency of fish and redd counts is assumed to be between 60% and 80%. Within the two km spawning habitat of the John West Fork, the observer efficiency of both fish and redd counts is higher. Using rough calculations, we derived egg to smolt and juvenile to smolt survival rates for 5 years of data from the John

West Fork (Table 4.1). Egg deposition is calculated at 2,500 eggs per female (Moring and Lantz 1975). Because we counted redds rather than individual females, and females do not always lay all their eggs in a single redd, we used an estimate of 1,000 eggs per redd for our calculations.

**Table 4.1. Multiple life stage observations of coho salmon within the John West Fork above the restored culvert since 1999. Note culvert fish passage restoration completed summer 1999.**

|                                                          | Spawner Year (SY) |                  |                  |                   |                  |
|----------------------------------------------------------|-------------------|------------------|------------------|-------------------|------------------|
|                                                          | 1999-00           | 2000-01          | 2001-02          | 2002-03           | 2003-04          |
| Maximum Live Coho count Male                             | 5                 | 21               | 6                | 12                | 21               |
| Maximum Live Coho count Female                           | 3                 | 29               | 7                | 6                 | 20               |
| Redds                                                    | 3                 | 40               | 25               | 12                | 19               |
| Estimated number of Eggs                                 | 3,000             | 40,000           | 25,000           | 12,000            | 19,000           |
| Young of Year Coho passing through trap                  | 13                | 6,520            | 5,399            | 1,561             | 1,575            |
| Summer index reach density [coho/meter]                  | 0. 0 <sup>a</sup> | 8.4 <sup>a</sup> | 9.7 <sup>a</sup> | 0. 6 <sup>a</sup> | 5.1 <sup>c</sup> |
| Juvenile survival estimate assuming 1,000 meters habitat | 0                 | 8,400            | 9,700            | 600               | 5,100            |
| Smolt outmigration (year old coho)                       | 5                 | 98               | 181              | 144 <sup>b</sup>  | N/A              |
| Egg to smolt survival                                    | 0.16%             | 0.25%            | 0.72%            | 1.20%             | N/A              |
| Estimated juvenile to smolt survival                     | NA                | 1.16%            | 1.87%            | 24.00%            | N/A              |

<sup>a</sup> counts conducted in 3 pool units and two riffles above the culvert

<sup>b</sup> derived based on total catch of 112 coho smolts, and trap efficiency of 78%.

<sup>c</sup> counts conducted in 7 pool units

Coho smolt production within John West Fork increased dramatically from when trapping was initiated in 2000 to 2003. The estimates presented in Table 4.1 assume that the system above the culvert is closed to juveniles overwinter.

### Regional observations

Habitat condition and coho response is controlled by the hydrologic regime within the watershed. With year class taken into account, our observations show that since 1999, we have seen an increasing trend in adult escapement and subsequent juvenile density and smolt conditions. The responses we have observed are not limited to Olema Creek, but are regional in nature. We analyzed the response of juvenile densities within the Lagunitas, San Geronimo/Devil's Gulch, Pine Gulch and Redwood Creek. For all watersheds we are able to compare coho density per meter and per square meter. Results of these comparisons show that the same general trend in juvenile coho densities are occurring, with the highest observed densities in 2001, 2002, 2004, and 2005. In all watersheds we have seen a drop in coho juvenile density associated with the SY 2002-2003 year class. Figures 4.2 through 4.6 show coho density results from different watersheds through the last decade.

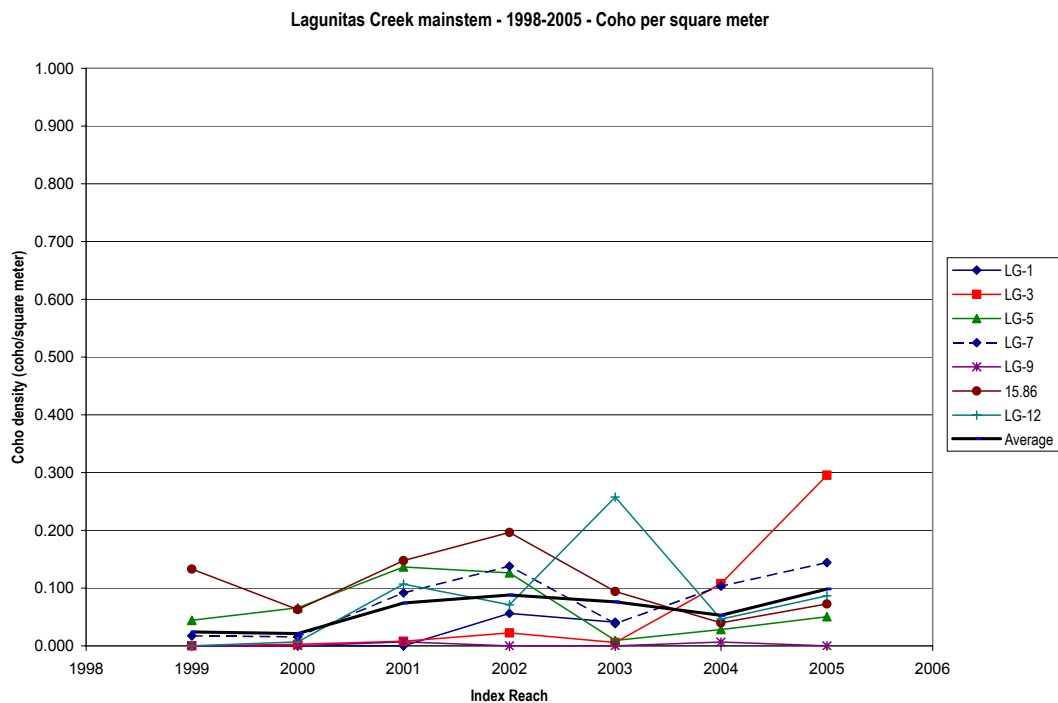
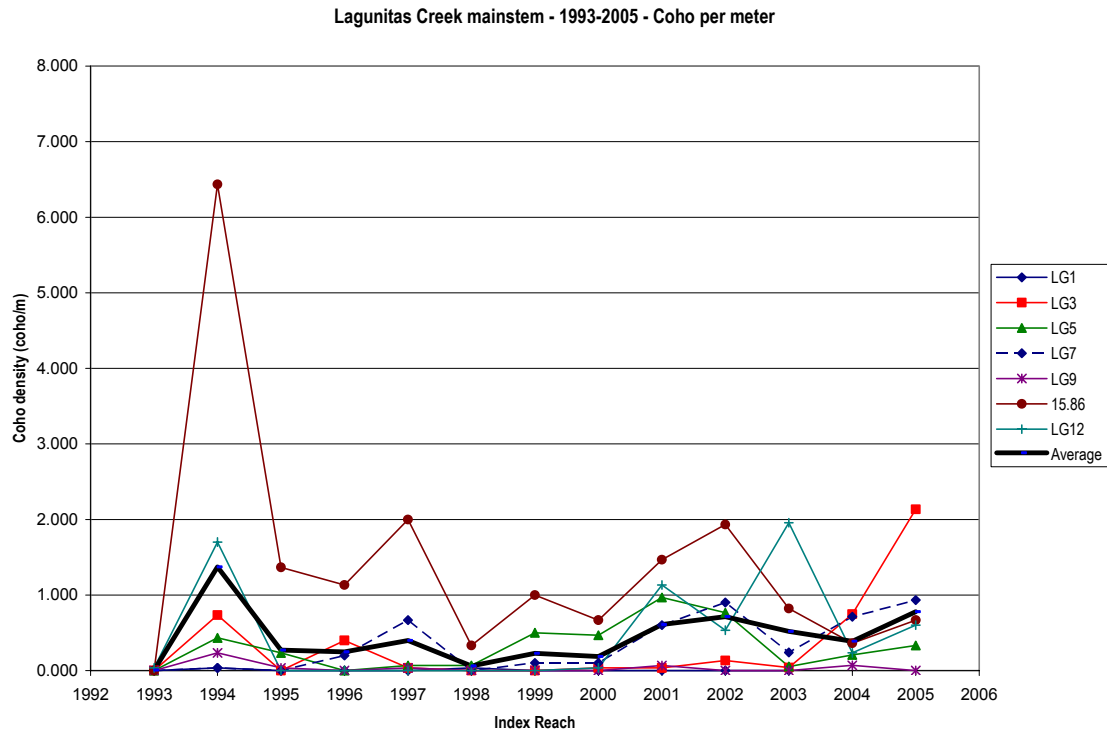


**Figure 4.2 Juvenile coho salmon density per meter observed in seven index reach locations within the mainstem of Lagunitas Creek (above), four index reach locations in San Geronimo Creek (below), and two index reach locations in Devil's Gulch (below), Marin County, CA, 1993-2005 (MMWD 2006a). Top: fish/m 1993-2005; Bottom: fish/m<sup>2</sup> 1999-2005.**

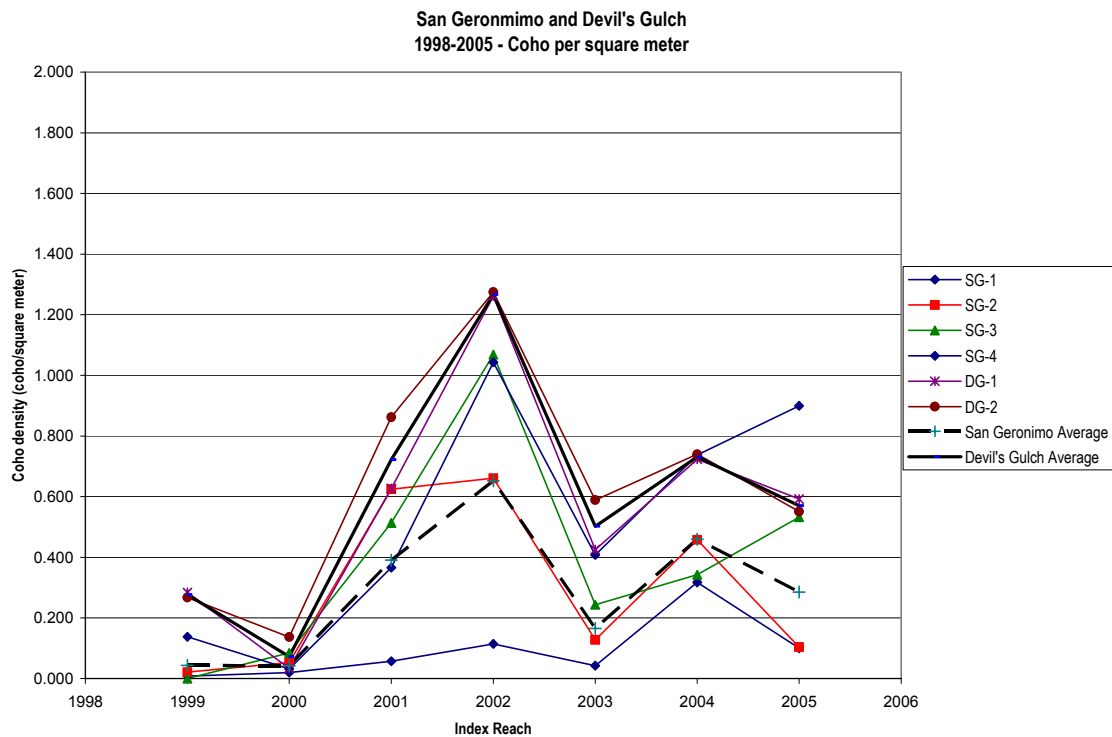
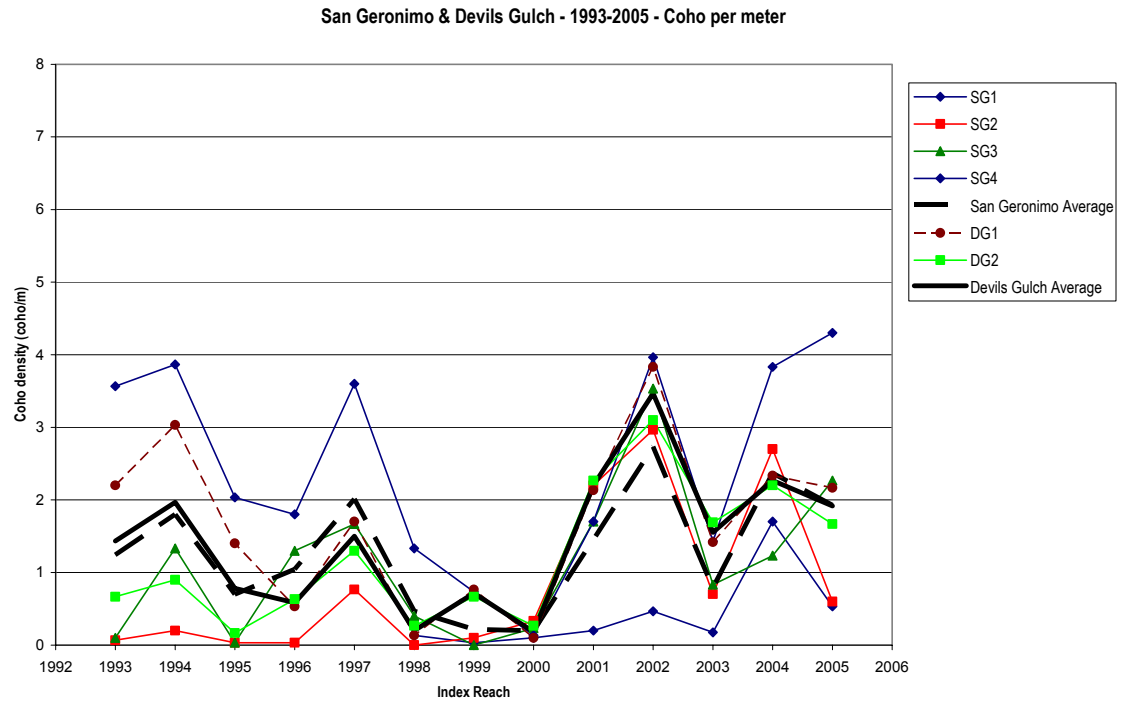


**Figure 4.3 Juvenile coho salmon density per meter observed in four index reach locations in San Geronimo Creek (below), and two index reach locations in Devil's Gulch (below), Marin County, CA, 1993-2005 (MMWD 2006a). Top: fish/m 1993-2005; Bottom: fish/m<sup>2</sup> 1999-2005.**

San Geronimo Creek and Devil's Gulch are the major tributaries of Lagunitas Creek upstream of the estuarine waters. MMWD (Ettlinger 2004 personal communication) has shown a correlation between spawning density in the San Geronimo Creek watershed and increased juvenile density in the mainstem of Lagunitas Creek. Watershed average densities range from 0.1 to 1.3 coho per meter in the mainstem, while tributary ranges are from 0.2 to more than 3 coho per meter

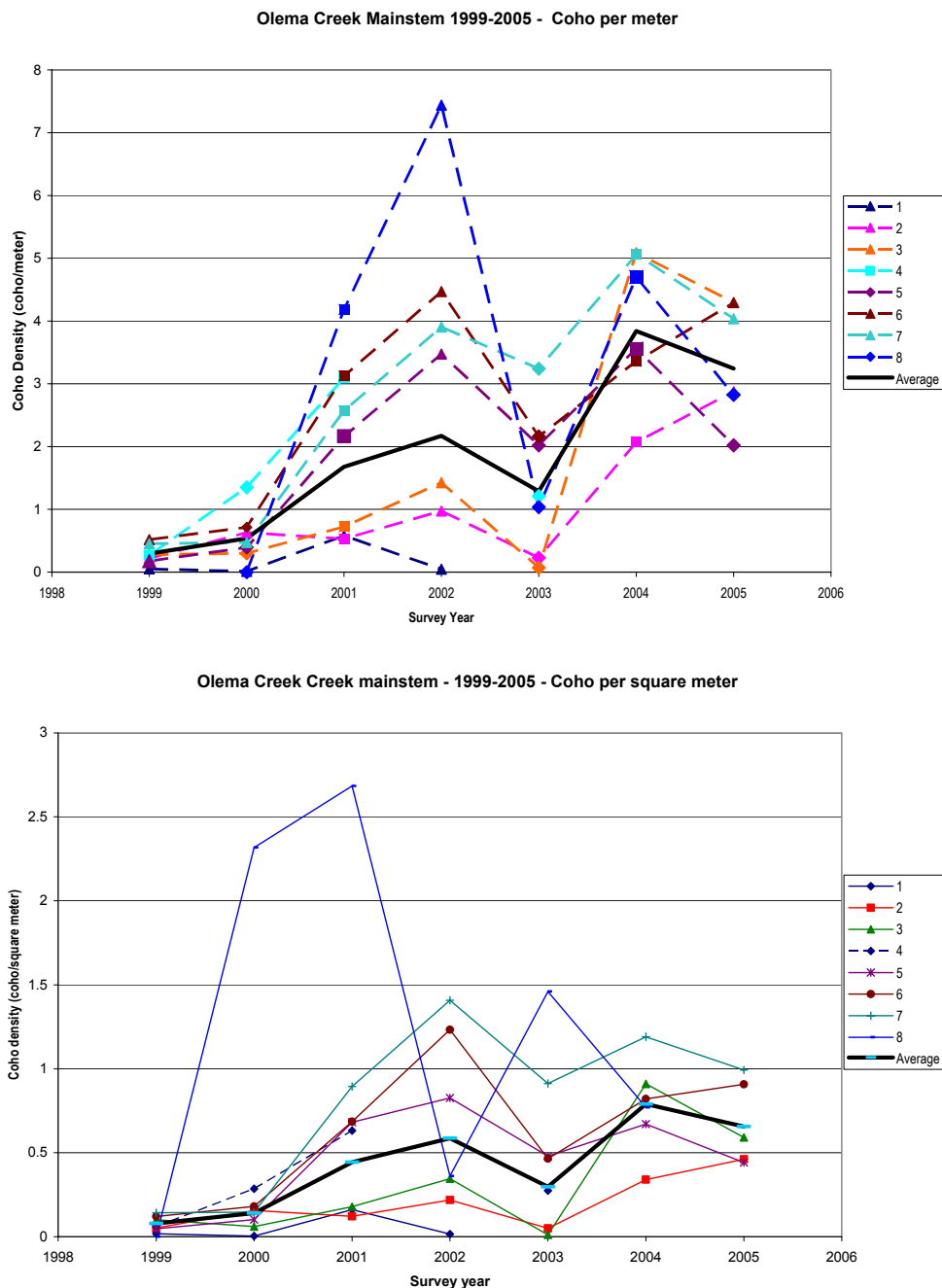


**Figure 4.4 Juvenile coho salmon density per meter observed in eight index reach locations within the mainstem of Olema Creek Marin County, CA, 1999-2005 (NPS data). Top: fish/m; Bottom: fish/m<sup>2</sup>.**

Results from Olema Creek show a watershed wide response by coho during all survey years in indexes 2 thru 7. Average watershed densities for all index reaches have ranged from 0.30 to 3.8 coho per meter. The reduced density in 2003 corresponded with the weakest spawning year class and a 7.8 kilometer mainstem juvenile snorkel based estimate of  $10,235 \pm 2,740$  coho.

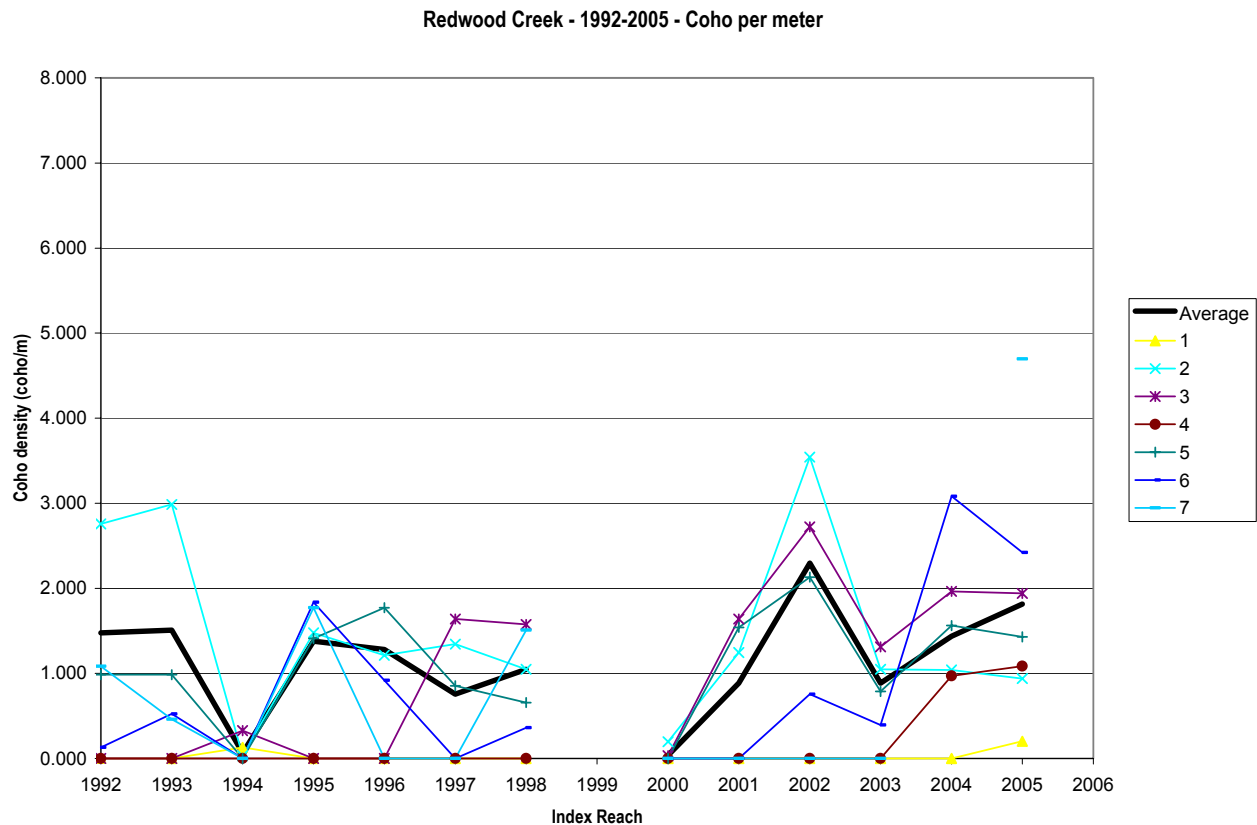


**Figure 4.5 Juvenile coho salmon density per meter observed in seven index reach locations within the mainstem of Redwood Creek Marin County, CA, 1992-2005 (J. Smith-SJSU and NPS data).**

The index reach locations within Redwood Creek are responsive to spatial distribution to spawning habitat, and densities are also effected by summer water use patterns. Densities have fluctuated from very near 0 to greater than 4.7, with a recent resurgence of juvenile densities corresponding to density increases along the Marin County coast.

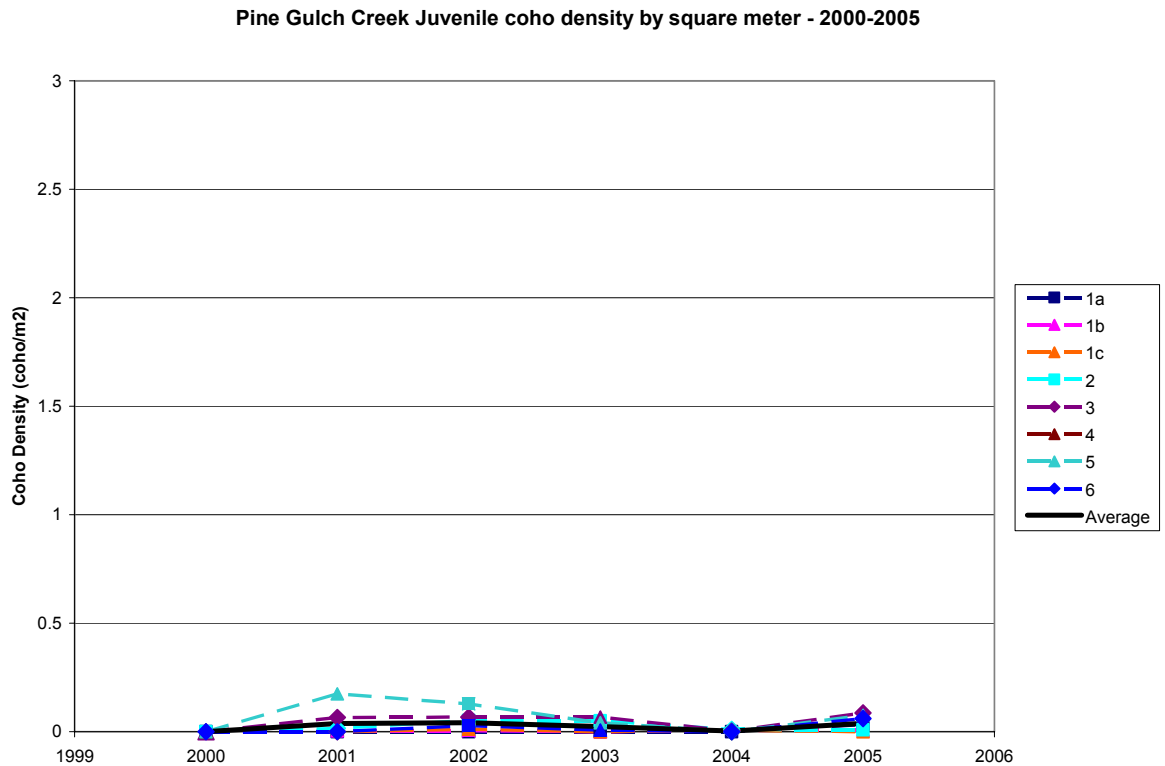
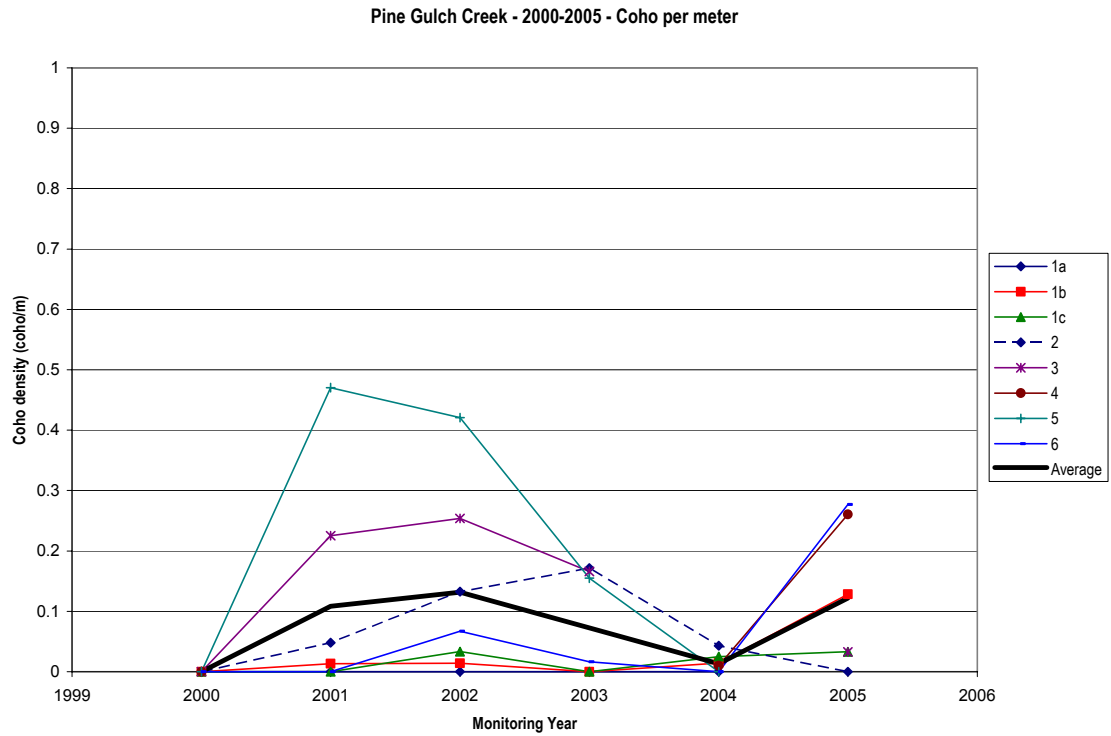


**Figure 4.6 Juvenile coho salmon density per meter observed in seven index reach locations within the mainstem of Pine Gulch Creek, Marin County, CA, 2000-2005 (NPS data). Top: fish/m; Bottom: fish/m².**

The index reach locations within the Pine Gulch mainstem are representative of overall watershed conditions, even at very low coho densities. These data are included to show a potential signal corresponding to a natural return of coho to a small coastal watershed. While density was very low, we found a rather broad distribution of coho throughout the watershed. It should be noted that no juvenile coho were observed in the watershed prior to 2001, despite implementation of the index reach monitoring program in 2000.

### **Steelhead**

While monitoring of coho salmon shows strong adult escapement, juvenile density, and smolt density correlation between year classes, steelhead do not track in the same manner. Steelhead are elusive, making adult counts difficult, and when we have encountered them on redds, they seem more likely to flush great distances. Due to these difficulties and potential negative impacts of surveys on steelhead spawners, we have determined targeted steelhead surveys to be incompatible with our monitoring goals. With that said, steelhead are ubiquitous in the Olema Creek watershed. They are present throughout the perennial and intermittent sections of Olema Creek and up nearly all tributaries. Their reproductive and life cycle flexibility make them far more persistent in these watersheds than coho.

Despite all of our winter monitoring efforts, we have not actually observed spawning by resident rainbow trout, though it is very likely to occur. When we have observed female steelhead on a redd, a large male has often been seen in accompaniment. When a smaller male has been observed, we could not determine whether this was a resident, or a “jack” that may have returned early.

Our program has not attempted to conduct basinwide estimates for steelhead because, as with adult steelhead, juvenile steelhead are very skittish fish, and their behavior is not conducive to accurate snorkel counts. Staff does, however, document their presence or absence in conjunction with other surveys. We have encountered steelhead in every sample location and nearly every habitat feature sampled. Our data do not show distinct year class distinctions in steelhead, because due to their flexible lifecycle, juvenile steelhead density is likely based on a combination of ocean-run and resident reproduction. Index reach monitoring results over the past seven years do show a steady decline in observed steelhead juvenile density.

This brings up the effects coho reintroduction might have on steelhead populations. In the Olema watershed, the declines we have observed could be due to the large increase in coho over the past few years, but other environmental factors, such as the amount of spring rainfall, could be affecting the success of steelhead as well. For steelhead, spawning occurs in late winter and early spring. While we have not observed limitations on the ability of ocean-run steelhead to access the watershed, we have observed some very dry spring conditions that likely limited fry emergence from steelhead redds. This is most acute in the John West Fork tributary, where steelhead young of year observed moving downstream through the smolt trap have ranged from 47 to 6,603 (Table 3.9). It is likely that this response is limited to the intermittent tributaries, but it is a sign of how steelhead respond in these drier springs.

## **5.0 RECOMMENDATIONS**

### **5.1 *Adult Escapement***

Adult spawner surveys have been conducted when environmental conditions allow. Staff should try to conduct weekly surveys, even if conditions are suboptimal. Increasing survey frequency could improve the accuracy of our Area Under the Curve (AUC) estimates. Survey frequency on tributaries should also be increased so that the contribution of each subsystem to the watershed can be understood.

Volunteer participation is essential to conducting watershed based surveys. However, we have not been able to determine volunteer observer efficiency in fish and redd identification. One staff member should be on each survey team whenever possible. Staff should continue to follow up watershed scale surveys with redd based surveys to collect more detailed redd measurements and confirm redd identification and/or missed redds.

All of our spawner surveys data are shared with the MMWD and reported as part of the Lagunitas Creek watershed, but the only compatible measure is redd counts. In order to compare results, the NPS and MMWD should coordinate to use some of the same survey methods. Currently, MMWD surveys different reaches on different days. MMWD could recruit and train volunteers to assist them in their spawner surveys so that the entire creek could be surveyed the same day.

### **5.2 *Smolt trap operations***

Smolt trap operations have been modified over the years to increase trap efficiency and reduce handling stress to the fish. Trap design should continue to be adjusted and improved to reduce modifications to the channel, perform under high flow conditions, and effectively capture fish. Each year, methods should be reviewed and revised as needed. Fish should not be double marked. Staff should continue to investigate different marking techniques so that stress and side effects on the fish are reduced as much as possible. NPS staff should coordinate with MMWD and SPAWN staff to increase efficiency in trap operations and increase data compatibility.

### **5.3 *Index Reach Monitoring***

NPS staff should continue to assess the conditions at each index reach to determine if sampling efforts are still effective. As recommended in NOAA electrofishing guidelines, the NPS has begun to seine out as many fish as possible prior to electrofishing. The NPS should hire a statistician to determine how to include the seining numbers in the electrofishing *Microfish* estimates.

In 2005, the NPS began surveying tributaries using General Systematic Sampling (GSS). GSS methodology and survey reaches should be assessed and modified each year as habitat changes and restoration projects are completed.

Index reach monitoring habitat should be analyzed more closely to determine its effect on the population.

### **5.4 *Basinwide population estimate***

Basinwide habitat survey methodology and measurements should be re-evaluated each season to most efficiently collect information. In the past, the NPS has used primarily index reach pool units as the snorkel survey calibration units, but because the index reach habitat units are not randomly selected, this may introduce bias. Other methods of calibration should be investigated. In 2005, the NPS calibrated 20% of the snorkel units outside of the index reaches using bounded snorkel counts. Bounded snorkel counts should be assessed as a possible alternative to index reach electrofishing.

### **5.5 *Population extrapolation***

Index reach *Microfish* fish numbers should be used to estimate the population within each index reach, and only basinwide survey estimates should be used to determine watershed population estimates. Population estimates collected through our adult escapement surveys, smolt traps, and summer juvenile surveys should be compared to other regional data. Estimated mortality at different lifestages should also be compared to regional information in

order to better gauge how the Olema watershed populations are performing. In this way, indices could be developed to assess overall watershed health.

### ***5.6 Genetic Analysis***

The NPS will continue to collect genetic samples for analysis through the NOAA-Fisheries Genetics Lab.

### ***5.7 Other Monitoring Efforts***

A number of other monitoring efforts have been conducted through the years in association with this program. These include watershed habitat and condition assessment, woody debris analysis, and water quality monitoring.

Repetition of the extensive habitat surveys conducted in the initial stages of this program would be valuable to evaluate habitat changes over time (Beamish 2000). Likewise, repetition of the detailed woody debris surveys could help us better understand its role in habitat formation over time (Opperman 2003).

Extensive water quality monitoring is conducted within the watershed and is reported separately. Evaluation of data in 2001 showed that Giacomini Gulch and Quarry Gulch were significant sources of sediment and pathogens to the mainstem of Olema Creek. Further evaluation on these subwatersheds identified potential sources and solutions. Water quality monitoring should be reported and compared with fish population estimates.

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