Mattole River Watershed Analysis

Fish Habitat Assessment

Appendix E

Public Review Draft

September 2011

Prepared by:
Alice Berg, Alice Berg & Associates
Dennis Halligan, Stillwater Sciences

With Contributions From:
Aaron Bleisner, Michael Stratman
Natural Resource Management Corporation

Michael Miles, Kathleen Sullivan
Humboldt Redwood Company, LLC

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PHOTOS

LIST OF MAPS (maps provided at end of report)

1.0 ABSTRACT

The Fish Habitat Assessment generally describes conditions within the Mattole River Watershed Analysis Unit (WAU; Map E-1). The WAU encompasses the Mattole River and Northern Subbasin, which extends from the estuary to Honeydew. The Fish Habitat Assessment more specifically describes conditions on lands owned by Humboldt Redwood Company, LLC (HRC), formerly owned by PALCO, within the Northern Sub-basin of the Mattole.

In general, the majority of streams within HRC's ownership are smaller, lower order tributaries with steep gradients and low sinuosity that dissipate energy along the longitudinal profile in steps and pools. Tributaries on HRC lands are only known to be occupied by steelhead trout and resident rainbow trout. However, McGinnis Creek is accessible to Chinook salmon and appears to have suitable habitat conditions for coho salmon. Historical habitat data is limited and trends cannot be assessed with confidence due to changes in survey methods, variability between surveyed reaches and dynamic watershed processes that continually reset habitat conditions. Geology is dominated by Franciscan Assemblages, a small amount of Yager Formation in the eastern portion, and small outcroppings of Quaternary River Terrace in the Oil Creek Drainage. Channel and valley morphology within HRC's ownership are the greatest influence on fish habitat including channel gradients, wood storage, gravel availability and storage, and fine sediment distribution.

Landslides are the predominant large wood recruitment mechanism and legacy effects of removing trees from these areas still limits wood loading. In addition to smaller wood size and channel morphology, in-stream wood loading remains low due to the lateral shifting of channels in Oil Creek, Rattlesnake Creek, McGinnis Creek, and winter peak flow events. Over-stream shade canopy provided primarily by hardwoods has increased significantly in recent years along all surveyed fish-bearing tributaries due primarily to continued hardwood growth in floodplain areas. Maximum Weekly Average

Temperatures (MWATs) have been on the decline over the last three years and met NOAA Properly Functioning Condition (PFC) targets (<16.8 ºC) in all three permanently monitored stream reaches (Sulphur, McGinnis, and Rattlesnake) in 2010 after observing a spike in water temperature in 2006.

Spawning substrate is limited to small pockets and side channels in most HRC streams, but generally considered fair to good in quality with PFC substrate targets being achieved in nearly all categories for the three permanently monitored streams. Available pool habitat currently makes up approximately 26 to 32 percent of total aquatic habitat type in the monitored reaches of these three streams with average residual pool depths of 0.5 meters. Deeper pools (> 3 feet) are generally limited to the larger drainages including the East Branch of the North Fork and Rattlesnake Creek. McGinnis Creek has shown improvement in average residual pool depth in recent years.

Fish habitat and riparian conditions are a result of periodic and frequent disturbance, primarily streamside landslides and mass wasting that continually reset instream habitat conditions. These processes dominate the landscape and drive existing conditions of fish habitat within HRC's ownership.

2.0 INTRODUCTION

2.1 ANALYSIS OVERVIEW

The goal of the Fish Habitat Assessment is to develop an understanding of the distribution of Pacific salmonids in the Mattole River WAU and the factors that appear to most strongly influence their abundance and distribution. The analysis is based on the habitat and biological requirements of Pacific salmonids including requirements of various life history stages on both a temporal and spatial scale. Pacific salmonids need several habitat types and large intact watershed systems to complete their life-cycle including adult migration routes, spawning and incubation habitat, rearing and foraging habitat, emigration habitat and estuarine habitat.

Habitat and channel features vary markedly from headwater streams to the estuary and Pacific salmonids use a range of accessible habitat types during completion of their life cycle. While there are no simple definitions of Pacific salmonid habitat requirements for the WAU, this analysis attempts to increase the understanding of current habitat conditions to help discern whether they are within the natural range for a particular system. Sub-watersheds within the WAU differ in their flow, temperature, sedimentation and physical and biological components. Fish populations have adapted to natural ranges of environmental fluctuations in these components, however, abundance and distribution of Pacific salmonids have been limited by anthropogenic impacts.

The biological requirements of salmonids are summarized herein and are the basis for rating current habitat conditions. Indicators of habitat quality for salmonids and other aquatic species have been defined in terms of the concept of properly functioning condition (PFC). The Aquatic PFC matrix (APFC matrix) developed for use on PALCO (now HRC) lands, lists target conditions for individual habitat indicators that were based on agency (NMFS 1997) review of available scientific literature. These PFC conditions were determined to be required to meet the habitat needs of aquatic species (NMFS 1997). However, based on stream-specific habitat and watershed-specific information collected over the landscape, the authors found that many of the habitat conditions prescribed in the APFC matrix are not within the current capability of individual streams in HRC's ownership. Alternatively, an earlier definition of PFC promulgated by NMFS (1996a) may be of more use in this context: PFC is the sustained presence of natural habitat-forming processes in a watershed that are necessary for the survival of species. From this perspective, specific indices of habitat conditions need to be based on habitat requirements of species as well as those instream habitat conditions that existed prior to logging and road impacts and that are known to have supported species prior to habitat changes. These conditions have not been documented in the WAU or on HRC's ownership, however, the degree of departure of existing stream conditions from full operating potential is a key question that we can begin to estimate by understanding conditions of watershed processes.

In general, the majority of streams within HRC's ownership are smaller, lower order tributaries typical of A and B channel types (relatively straight with high gradients). The spatial distribution of reach types on HRC's ownership in terms of source reaches (>20% gradient), transport reaches (4-20%) and response reaches (<4%) clearly influence instream habitat conditions, fish distribution, stream operating potential and recovery rates. Gradient distributions for each fish bearing stream within HRC's ownership are given below in Section 4.2.3 (Stream Summaries) and on Maps E-2, E-3, and E-4. The Stream Channel Assessment report (Appendix D) describes channel gradients and distributions within HRC ownership in detail.

This module presents a summary of key habitat indicators for streams accessible to Pacific salmonids within HRC's ownership including temperature, habitat access, substrate quality, large wood, pool habitat, and streambank stability. In keeping with the requirement to utilize the APFC matrix, comparison with the matrix is also provided to allow the reader to compare current conditions with APFC targets.

Consistent with the overall approach for this watershed analysis, fish habitat surveys and analysis efforts were concentrated on HRC's ownership in the WAU. Although most of the fish bearing streams were visited by the authors, habitat typing surveys were only conducted on select response reaches within fish-bearing streams on HRC lands. Available habitat information for areas downstream of HRC's ownership, within the WAU, was reviewed and incorporated as appropriate.

This assessment was generally conducted in accordance with the modified Washington Forest Practice Board methodology (Version 4.0) described in its Watershed Assessment Methods Manual (Washington DNR 1997). This module was designed to address critical questions (refer to Section 5.4) formulated to meet the objectives of the Washington DNR methodology.

S. Downie, California Department of Fish and Game (CDFG), was consulted for various fisheries and habitat information used in this report. The Mattole Salmon Group and the Mattole Restoration Council were included in field trips to various streams within HRC's ownership. Temperature and fish monitoring information from the Mattole Salmon Group's *State of the Salmon Report 2005* (Mattole Salmon Group 2005a) as well as other monitoring reports they provided were included in this report. The North Coast Watershed Assessment Program (NCWAP) *Mattole River Watershed Assessment Report* (Downie et al. 2003) contains a detailed assessment of available information and baseline conditions in the Mattole River basin and is cited throughout this report.

2.2 REPORT ORGANIZATION

Salmonid life history, distribution and abundance information is given in Section 3.0. Habitat information is given in Section 4.0 including a summary of past CDFG surveys, recent survey data and stream summaries. Opportunities were identified based on review of available information and field trips and are provided in Section 5.3. The level of confidence in work products is provided in Section 6.0 and critical questions are addressed in Section 5.4.

2.3 WATERSHED SETTING

The Mattole River drains an approximately 296 square mile (189,440 acres) watershed in the Coast Range within western Humboldt County and northern Mendocino County. The Mattole River drains northwestward to Petrolia before turning west to the Pacific Ocean. The Eel River basin is adjacent to the east, and Bear River lies to the north. The climate includes patterns of high intensity rainfall in the winter and warm dry summers. Annual rainfall averages range from 60 inches near Petrolia to 115 inches on the eastern ridgetops (Downie et al. 2003). Coastal fog moderates air temperatures at Petrolia and downstream to the mouth of the Mattole River. High summer temperatures and snowfall occur in higher elevations, including within the WAU, which contains smaller headwater tributaries to the Mattole River. The watershed supports a mix of Douglas-fir, tan oak and grasslands.

The WAU encompasses approximately 89,590 acres total (Map E-1) and includes the Mattole River's Northern Subbasin (the area that lies between the Mattole River estuary and Honeydew Creek) as well as a small part of the Western Subbasin encompassing the lower reaches of Squaw Creek. The WAU includes a total of 18,167 acres of lands formerly owned by PALCO, now owend and managed by HRC: 17,985 acres are HRC HCP-covered lands and 182 acres are HRC non-HCP lands (in the North Fork Mattole River). The WAU also includes 71,255 acres of private lands (non-HRC) and 168 acres of BLM land. The following tributaries are within the WAU, accessible to Pacific salmonids and occur on HRC's ownership:

- East Branch North Fork Mattole River and its tributaries (including Alwardt Creek and Sulphur Creek), presented as the "North Fork Mattole" sub-basins on Maps E-2, E-5, and E-8;
- Upper North Fork Mattole River and its major tributaries: Oil Creek (and tributaries) and Rattlesnake Creek (and tributaries), presented as the "Upper North Fork Mattole" sub-basins on Maps E-3, E-6, and E-9; and

- McGinnis and Pritchard Creek, presented as the "McGinnis/Pritchard Creeks" sub-basins on Maps E-4, E-7, and E-10.

Geology in the WAU is dominated by Franciscan Assemblages, a small amount of Yager Formation in the eastern portion, and small outcroppings of Quaternary River Terrace in the Oil Creek Drainage (refer to the Mass Wasting Module for more specific information relating to geology). The Mattole River basin has the second highest erosion rate in northern California, second only to the Eel River watershed (Griggs and Hein 1980). Young sedimentary rocks underlying the basin are highly erosive and often incompetent, easily fragmented and cracked. Disturbance events in the Mattole River watershed profoundly affect hillslope processes and instream habitat. Large-scale changes to the Mattole River occurred in response to the 1955 and 1964 floods, which coincided with peak years of logging and road building in the basin. Unstable bedrock and soil conditions combined with heavy rainfall and high regional uplift rates produce widespread naturally occurring landsliding with associated large volumes of sediment delivered to streams (Downie et al. 2003).

Tributaries in the WAU are flashy, rising quickly and receding to winter base flows shortly after each rain event. Summer base flows are low. Winter monthly stream flows in the Mattole River at Petrolia averaged between 1,710 and 4,170 cfs (Downie et al. 2003). Summer and fall low flows are a significant limiting factor for salmonids and result in unsuitable or marginal summer rearing habitat in the mainstem and certain tributaries, particularly in the upper Mattole basin. Temperatures within the WAU are far more extreme and wide-ranging than the coastal fog belt region of the lower Mattole River. Winter air temperatures drop below freezing and summer temperatures can exceed 38°C. Summer water temperatures also vary with maximum weekly average temperatures ranging from about 15 to 21°C, depending on the watercourse. In the Mattole headwaters area, upstream from Bridge Creek, juvenile salmonids become stranded in pools due to excessively low summer flows (exacerbated by aggradation and channel widening), causing fish mortality and necessitating fish rescues. Klein (2004) reported that the summer of 2002 was the driest in the 55-year record of flows on the

Mattole River near Petrolia and 2004 summer/fall conditions were of similarly low magnitude. Although climate has the greatest effect on stream discharge, human activities exacerbate conditions including water withdrawals, changes in runoff properties of hillslopes and changes in surface runoff due to streambed aggradation.

The Mattole River historically produced large runs of salmon and steelhead; however, habitat quality and quantity have been reduced. Downie et al. (2003) identified several limiting factors for Pacific salmonids in the Mattole River basin including excessive water extraction during summer low flows; chemical contamination in tributaries; low stream shade and low large woody debris recruitment to streams; high sediment production levels, high summer water temperatures, shallow channels and simplified habitat. Downie et al. (2003) also noted other factors including an absence of salmonid information and low fish densities in accessible habitat.

The mainstem Mattole River (particularly the lower 26 miles downstream from Honeydew) stores massive amounts of sediments contributed from higher gradient tributaries, a condition that is not uncommon in larger, low gradient alluvial valley reaches of rivers in Northern California. Stored sediments have severely impacted fish habitat quality and quantity in the mainstem Mattole River. Estuary habitat has been reduced and sedimentation has resulted in high summer water temperatures. Elevated summer water temperatures are one of the primary limiting factors for salmonids rearing in the Mattole River and impair salmon production at the reach and stream scales. Smaller tributaries generally have lower temperatures and can provide summer rearing refugia habitat as well as cool summer flows to the mainstem Mattole River. For example, maximum water temperatures in the Mattole's tributaries and portions of its mainstem outside of the WAU during 2008 ranged from 16 to 28ºC during the summer (MSG 2009). The lowest maximum temperature was recorded in Ancestor Creek (RM 60.8) on July 10, 2008. The highest maximum water temperature was recorded in the mainstem Mattole at RM 15 on the same date (MSG 2009).

In March of 1994, the Environmental Protection Agency added the Mattole River to its list of impaired watersheds (303d list). The Mattole River is impaired with regard to temperature, turbidity, and sedimentation.

Restoration within the Mattole River basin has been championed by local watershed and salmon restoration groups in cooperation with other private and public landowners since the 1970s. Projects have been focused in the estuary, the lower river, the headwaters area, and key salmon-producing tributaries. Timber harvest continues on private and industrial timberlands in forested uplands and throughout the upper watershed. Timber harvest practices have been modified relative to earlier practices to provide increased protection for aquatic habitat. No dams exist in the Mattole River although numerous small water diversions exist throughout the basin.

3.0 SALMONID LIFE HISTORY, ABUNDANCE AND DISTRIBUTION

The Mattole River WAU provides habitat for the following Evolutionarily Significant Units (ESUs) of Pacific salmonids:

- Northern California (NC) steelhead (*Oncorhynchus mykiss*)
- Southern Oregon-Northern California/ Coast (SONCC) coho salmon (*O. kisutch*)
- California Coastal (CC) Chinook salmon (*O. tshawytscha*)

SONCC coho salmon are listed under the federal Endangered Species Act (ESA) as threatened (62 FR 24588; May 6, 1997) and the California Endangered Species Act (CESA). Designated critical habitat (64 FR 24049; May 5, 1999) for SONCC coho salmon encompasses accessible reaches of all rivers between the Mattole River in California and the Elk River in Oregon, inclusive. The Mattole River represents the southern range of the SONCC coho salmon ESU. Relative to the WAU all habitat accessible to coho salmon is considered critical habitat. California Coastal Chinook salmon are listed under the ESA as threatened (64 FR 50394; September 16, 1999). Designated critical habitat (65 FR 7764; February 16, 2000) for CC Chinook salmon was withdrawn in 2002. NC steelhead are listed under the ESA as threatened (65 FR 36094; June 7, 2000) and no critical habitat has been designated.

In addition to critical habitat designations as described above, Essential Fish Habitat (EFH) has been identified for commercial species as a provision of the Magnuson-Stevens Act (MSA; as amended 1996). Habitat accessible to Chinook and/or coho salmon (Maps E-5, E-6, and E-7) within the WAU is considered EFH.

Other fish present in the Mattole River include Pacific lamprey (*Lampetra tridentata*), prickly sculpin (*Cottus asper*), river lamprey (*Lampetra ayresi*), western brook lamprey (*Lampetra richardsoni*), coastrange sculpin (*C. aleuticus*), Sacramento sucker (*Catostomas occidentalis*), and the three-spine stickleback (*Gasterosteus aculeatus*). Marine or estuarine dependent species include consist of surf smelt (*Hypomesus* *pretiosus*), topsmelt (*Atherinopsis affinis*), redtail surf perch (*Amphistichus rhodoterus*), shiner perch (*Cymatogaster aggregata*), walleye surf perch (*Hyperprosopon argenteum*), Pacific staghorn sculpin (*Leptocottus armatus*), speckled sanddab (*Citharichthys stigmeus*) and starry flounder (*Platichthys stellatus*).

3.1 SALMONID LIFE HISTORY AND ABUNDANCE

Downie et al. (2003) contains a synthesis of history and trends of salmonid populations in the Mattole River basin. Anecdotal and historical evidence indicates that runs of Pacific salmonids in the Mattole River basin were large and have experienced a sharp decline since the mid-1950s, however, little quantitative historic data exists (BLM 1996). Accounts from anglers who fished during 1945-1970 describe a sport fishery where a group of four or five anglers could expect to hook and release over a hundred fish, mostly steelhead, in a day of fishing (J. Clary pers. Comm. *in* Downie et al. 2003). The Department of Water Resources (DWR; *in* Downie et al. 2003) speculated that in 1965, the year following the second major flood event in ten years, that there had been a significant reduction in the size of runs possibly due to large increases in siltation and debris jams following land disturbance from intensive logging that started in the 1950s, coupled with two major flood events. This speculation is consistent with conditions described in the Stream Channel Assessment report (Appendix D) based on review of historical aerial photographs. The earliest photos in this study (1948) reveal closed canopy over channels along most of the upper tributaries across the Northern Subbasin, with the exception of stream-adjacent landslides and prairie areas. By 1955, significant harvesting and clearing can be seen across the Northern Subbasin. The 1965 aerial photos show widespread streamside landsliding and other types of erosion apparently triggered by the 1964 flood. Most channels appeared to have widened in response to the flood and accelerated sediment supply and transport. The 1997 and 2003 aerial photos show a changing pattern of erosion with previously harvested areas and streamside zones reforested.

The following sources were used for life history and species status information:

- Status review of west coast steelhead from Washington, Idaho, Oregon, and California (Busby et al. 1996).
- Status review of Chinook salmon from Washington, Idaho, Oregon, and California (Myers et al. 1998).
- Status review of coho salmon from Washington, Oregon, and California (Weitkamp et al. 1995).
- Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead (Good et al. 2005).

Table E-1 shows generalized life history information for Mattole River salmon and steelhead (Barnhart 1986; Brown 1972; Busby et al. 1996; Downie et al. 2003; Meehan 1991; Nickelson et al. 1992), modified by Gary D. Peterson (Mattole Salmon Group) based on 25 years of experience in Mattole salmonid monitoring and restoration work.

Table E-1. Life history patterns of salmon and steelhead in the Mattole River.

	Adults Return	Spawn	Eggs in Gravel	Young in Stream	Young Emigration	Estuary/Lagoon Residence	Ocean
Steelhead	Nov.-April (Winter-run); March-June (Summer-run)	Dec.-May	Dec.-July	1-2 years	Oct. -July	Variable	1-3 years
Chinook	Oct.- Jan.	Nov.-Jan.	Nov.-March	3-7 months	April/May-July	Days to months (if oversummering in the lagoon)	2-5 years
Coho	Nov.-Feb.	Dec.—Feb.	Dec.-April	Up to 15 months	March-June	Days to one month	2 years

3.1.1 STEELHEAD

Steelhead require a minimum depth of 0.18 m and a maximum velocity of 2.44 m/s for active upstream migration (Smith 1973). Spawning and initial rearing of juvenile steelhead generally take place in small, moderate-gradient (generally 3-5 percent) tributary streams (Nickelson et al. 1992). A minimum depth of 0.18 m, water velocity of 0.30-0.91 m/s (Smith 1973), and clean substrate 0.6-10.2 cm (Nickelson et al. 1992) are required for spawning. Steelhead spawn in 3.9-9.4°C water (Bell 1991). Depending on water temperature, steelhead eggs may incubate for 1.5 to 4 months (August 9, 1996, 61 FR 41542) before hatching, generally between February and June (Bell 1991). After two to three weeks, in late spring, and following yolk sac absorption, alevins emerge from the gravel and begin actively feeding. After emerging from the gravel, fry usually inhabit shallow water along banks of perennial streams. Fry occupy stream margins (Nickelson et al. 1992). Summer rearing takes place primarily in the faster parts of pools, although young-of-the-year are abundant in glides and riffles. Winter rearing occurs more uniformly at lower densities across a wide range of fast and slow habitat types. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small wood. Some older juveniles move downstream to rear in larger tributaries and mainstem rivers (Nickelson et al. 1992). Juveniles live in freshwater from one to four years (usually two years in the California ESU), then smolt and migrate to the ocean in spring and summer months. Winter steelhead populations generally smolt after two years in fresh water (Busby et al. 1996). Brown (1972) reported that juvenile steelhead moved downstream in the Mattole in May and June.

Because steelhead rear in freshwater year-round, adequate flow and temperatures are critical. Steelhead prefer water temperatures ranging from 12-15°C (Reeves et al. 1987). The North Coast Regional Water Quality Control Board's Mattole TMDL (Coates et al. 2002) described water temperature requirements for steelhead as follows: "good" <17ºC; "marginal" 17º-19ºC; and, "poor/unsuitable" >19ºC (based on Coates et al. 2002). Stream temperature data collected in Sulphur Creek, McGinnis Creek, and the Upper North Fork Mattole/Rattlesnake Creek have fallen within the "good" to "marginal" range since 2007; but previously ranged from "marginal" to "poor" where data were available (Sulphur Creek and Upper North Fork Mattole/Rattlesnake only). See Section 4.2 for further sub-basin specific water temperature discussion.

The Mattole Salmon Group has conducted dive surveys, many at temperature monitoring stations in the Mattole River, documenting the presence of steelhead (and Chinook and coho salmon). The Mattole Salmon Group (2005a) provides detailed information on temperature monitoring, dive surveys and spawner surveys conducted in the Mattole River watershed.

The Mattole Salmon Group (2005a) reported that there is a lack of historical data for Mattole River summer-run steelhead. For the past 12 years, summer steelhead surveys have been conducted throughout the mainstem (MSG 2008a). The observed population has been consistently below 20 individuals in all but one year. The maximum number of adult fish was 45 in 1998, and the lowest numbers were observed in 2003 (9 steelhead). The number of "half-pounders" observed per mile of survey effort in 2007 (1.21) was significantly higher than "half-pounders" observed per mile in 2006 (0.59), and 2005 (0.56) (MSG 2008a). The maximum count for "half-pounders" occurred in 2000 when 96 were observed in the 32.7 miles of surveyed reaches (MSG 2008a). Residents have observed summer steelhead in past years in the WAU within deep pools of the North Fork Mattole River (pers. Comm. S. Downie, CDFG, March 13, 2006) upstream of Grizzley Creek. Summer steelhead are considered rare in the Mattole River basin.

Monitoring of juvenile salmonid emigration with rotary screw and pipe traps on the lower mainstem Mattole River has been conducted by the Mattole Salmon Group since 1985. In 2004, the Mattole Salmon Group (2004) conducted downstream migration trapping from 14 June to 11 July 2004 on the lower Mattole River. They reported capturing 26,126 juvenile steelhead during the trapping period. It is possible that the late start of the trapping season may have resulted in missing a sizable portion of the downstream migrant population. The Mattole Salmon Group (2005b) reported downstream migration trapping results for 13 May 2005 through 01 Aug 2005: a total of 1,420 natural steelhead were caught. Ninety-one percent of the 2005 season steelhead catch were considered young of the year (YOY), 9% were considered age 1+, and no data were available for the number of smolts captured. However, the trap was inoperable for a total of 19 trapping days due to two unseasonable high flow storm events. These storm flows and the late start date could have resulted in a significant undercount of the actual juvenile steelhead downstream migration. In addition, the Mattole Salmon Group (2005b) hypothesized that the late rains could have delayed emigration for smolting steelhead considerably, possibly due to deeper pools and cooler temperatures throughout the watershed.

During the 2009 season, 12,340 YOY, 2441 parr, and 160 smolts were captured (Table E-2). In 2008, 23,515 YOY, 3,129 parr, and 377 smolts were recorded. Catch totals in 2007 were the highest of recent years in that 35,847 YOY, 1,834 parr, and 309 smolts were captured. A total of 15,461 YOY, 712 parr, and 189 smolts were captured in 2006. The number of smolts captured between 2006 and 2009 are likely not representative of the smolting run due to the late start of trapping. A review of the 2006 through 2009 data summary figures showed most of the enumerated smolts being caught early in the season and possibly after a sizable portion of the run already passed the trap site.

Table E-2. Mattole Salmon Group's downstream migrant trap results for juvenile steelhead – 2006-2009 (MSG 2006, 2007, 2008b, 2009a).

Year	Number of Young of the Year (YOY)	Number of Parr	Number of Smolts	Trapping dates
2006	15,461	701	189	3 May to 2 July 2006
2007	35,847	1,834	309	9 April to 3 July 2007
2008	23,515	3,129	377	10 April to 9 July 2008
2009	12,340	2,441	160	24 April to 7 July 2009

Relative to tributaries in the Northern Subbasin, there has been limited population monitoring. CDFG conducted electroshocking from 1992-1995 in Oil Creek, Oil Creek Tributary #1 (Green Ridge Creek) and Rattlesnake Creek/Upper North Fork Mattole and indicated stable multi-year class populations of juvenile steelhead (Hopelain et al. 1997).

3.1.2 CHINOOK SALMON

Table E-1 summarizes generalized life history information for Mattole River Chinook salmon. Chinook salmon adults enter the Mattole River basin in fall-winter months. McGinnis Creek is the only Mattole tributary on HRC's ownership that provides readily accessible habitat for Chinook salmon. Post-emergent fry seek out shallow, near-shore areas with slow current and good cover, and begin feeding on small terrestrial and aquatic insects and aquatic crustaceans. The optimum temperature range for rearing Chinook salmon fry is 10-12°C (Rich 1997, Seymour 1956) and for fingerlings is 12-15°C (Rich 1997). In preparation for their entry into a saline environment, juvenile salmon undergo physiological transformations known as smoltification that adapt them for their transition to salt water. Chinook salmon in the Mattole River watershed exhibit an ocean-type life history and smolts out-migrate predominantly as sub-yearlings, generally during April through July. Brown (1972; 1973) conducted downstream migrant trapping in the lower Mattole along with a standing salmonid stock assessment and creel census. Downstream migrant trapping was conducted in April through June 1972 on the mainstem Mattole River. Downstream migrant nets were deployed 1.5 miles above the Petrolia Bridge and 100 yards below Bear Creek in the upper watershed. Brown (1972) reported that juvenile Chinook outmigrations began in April and carried through to May. Chinook salmon spend between 2 and 5 years in the ocean (Bell 1991; Healey 1991), before returning to freshwater to spawn.

The status of Chinook salmon throughout California was assessed in 1998 (Myers et al. 1998). There has been substantial scientific disagreement about biological data and its interpretation of this document. Results were reconsidered in a subsequent status review update (NMFS 1999). The primary cause for concern with this ESU was low abundance, reduced distribution and generally negative trends in abundance. Nelson et al. (1991) identified three putative populations: Humboldt Bay, Mattole River and Russian River populations. These populations were identified as being at high risk of extinction. Higgins et al. (1992) identified seven "stocks of concern" of which two populations (tributaries to Humboldt Bay and the Mattole River) were considered to be at high risk of extinction. Good et al. (2005) reported historical estimates of abundance of Mattole River basin Chinook salmon populations as 5,000 (based on CDFG 1965) and 1,000 (Wahle and Pearson 1987).

The Mattole Salmon Group operated a small hatchbox program for native Chinook supplementation from 1980 through 2004. Target production levels in recent years were approximately 40,000 eggs from approximately 10 females to supplement and restore Chinook salmon and other salmonids in the Mattole River (Good et al. 2005). Beginning in 1993, all propagated Chinook were marked before release, but no rigorous estimate of hatchery contributions to adult escapement is possible. Hatchery outmigrants comprised approximately 17.3% (weighted average) of outmigrants trapped during 1997, 1998, and 2000 (Mattole Salmon Group 2000). Trapping efforts did not fully span the period of natural outmigration, so this may overestimate the contribution of hatchbox production to total production in the basin (Good et al. 2005).

Estimates made by the Mattole Salmon Group based on annual spawning surveys and weir counts from 1981 to 1999 indicates that between 1989 and 1992, estimated adult Chinook salmon numbers ranged between 100 and 400 individuals. These were the lowest individual escapement counts on record. While numbers reached 1,000 individuals in 1996-1997, the estimated escapement has not surpassed 1,000 individuals since 1986-1987. The Mattole Salmon Group (2005a) has observed that coho salmon primarily use tributaries for spawning while Chinook salmon generally utilize mainstem spawning habitat. The total number of Chinook redds observed by the Mattole Salmon Group (2010) were reported as follows (all reaches combined – includes mainstem and some tributaries): 1994-1995 (40); 1995-1996 (39); 1996-1997 (80); 1997-1998 (85); 1998-1999 (27); 1999-2000 (57); 2000-2001 (45); 2001-2002 (88); 2002-2003 (45); 2003-2004 (68); 2004-2005 (69); 2005-2006 (145); 2006-2007 (86); 2007-2008 (78); 2008-2009 (62); 2009-2010 (36). The level of effort for the annual spawning surveys typically varies depending on flow conditions, staff availability, funding, and access issues. Therefore, although the best efforts are given each year to collect as much spawning data as possible, there are still a significant number of reaches that are not sufficiently monitored and as such the reported data should be considered conservative. In addition, each year's summary data show a number of redds not being differentiated as either Chinook or coho origin, or completely unidentified as to species (MSG 2010). This could also lead to a conservative estimate regarding individual species' redd numbers.

The Mattole Salmon Group (2005b, 2006, 2007, 2008b, and 2009a) described downstream migrant trapping results from 2005 through 2009 and presented trap catch data for Age 0+ Chinook salmon, coho salmon and steelhead. The total number of Chinook captured in the traps is as follows: 2004 (3,032); 2005 (3,229); 2006 (8,008); 2007 (10,953); 2008 (18,457); and 2009 (15,988). The Mattole Salmon Group estimated juvenile Chinook salmon abundance based on trap efficiency estimates for the years 2006 through 2009. Juvenile Chinook abundance estimates with 95% confidence intervals are as follows: 2006 (53,000 to 92,000); 2007 (118,844 to 183,964); 2008 (97,765 to145,824); and 2009 (95,361 to 164,062). As with the steelhead smolt numbers, these abundance estimates should be considered conservative in nature. This is because an unknown portion of the smolting migration could have occurred prior to installation of the trap.

Mattole Salmon Group divers typically observe steelhead and Chinook, and usually small numbers of coho, in the estuary in the early summer every year (MSG 2009b). By late summer, few Chinook remain. In years when the mouth is open into mid-summer, most Chinook migrate to the ocean, but when the mouth closes earlier in the summer, habitat is poor for survival. The Mattole Salmon Group (2009b) reported that weekly dive surveys have documented the complete decline of thousands of Chinook over the summers of 2007 and 2008. Divers noted Chinook became increasingly emaciated as the season progressed, indicating food availability and/or energetic constraints to feeding at high water temperatures may be a key factor limiting over-summer survival of Chinook in the estuary (MSG 2009b).

High summer temperatures, lack of deep water habitat and cover in the Mattole River estuary-lagoon represent a limiting factor for Chinook salmon. Coho salmon, steelhead and Chinook salmon all utilize the Mattole River estuary-lagoon during their life cycles, however, the estuary is critical for Chinook salmon populations (Downie et al. 2003). Chinook salmon juveniles emigrate in spring months, continuing through July. Juveniles that emigrate when the river mouth is closed must over-summer in the lagoon. Busby et al. (1988) reported a decline of over 100,000 juveniles rearing in the lagoon between June and September 1987, following a May 28th river mouth closure (about a month earlier than "normal"). High temperatures and lack of deep water habitat in the estuary likely caused this significant mortality. The Mattole Salmon Group operated a juvenile survival enhancement project from 1994 through 2004 to divert a portion of emigrating Chinook into a rearing facility to be raised in ponds, marked, and then released in the fall after the mouth opens.

3.1.3 COHO SALMON

Table E-1 summarizes generalized life history information for coho salmon in the Mattole River (based on Shapovalov and Taft 1954; Hassler 1987; Sandercock 1991; Weitkamp et al. 1995). Downie et al. (2003) reported that no coho salmon have been detected in the Northern Subbasin. In the Mattole River basin, summer water temperatures appear to be a primary limiting factor for coho salmon distribution and abundance. Welsh et al. (2001) concluded that "Mean Weekly Maximum Temperatures greater than 18ºC or Mean Weekly Average Temperatures greater than 16.8ºC may preclude the presence of coho salmon in the Mattole. It seems very unlikely that streams with temperatures above these thresholds could provide appreciable rearing habitat for coho salmon." The North Coast Regional Water Quality Control Board's Mattole TMDL described water temperature requirements for coho salmon as follows: "good" <15ºC; marginal 15-17ºC; and, "poor/unsuitable" >17ºC (based on Coates et al. 2002). Welsh et al. (2001) studied distribution of juvenile coho salmon relative to temperatures in 21 Mattole tributaries and found no juvenile coho salmon in tributaries with Maximum Weekly Average Temperatures (MWATs) greater than 16.7ºC, or Maximum Weekly Maximum Temperatures (MWMTs) greater than 18ºC.

The Mattole Salmon Group (2005a) reported that other than headwater streams, there are only a handful of lower river tributaries where maximum temperatures do not exceed thresholds for coho salmon survival including Stansberry Creek, Mill Creek, East Mill Creek, Clear Creek, Wild Turkey Creek, Woods Creek, Saunders Creek, Fourmile Creek, Sholes Creek, Middle Creek, Westlund Creek, Big Finley Creek and Eubanks Creek. Temperature data for tributaries in the Northern Subbasin were compiled in the NCWAP report (Downie et al. 2003) and all sites monitored (North Fork Mattole River, Conklin Creek, Rodgers Creek, Sulphur Creek and Rattlesnake Creek/Upper North Fork Mattole) had temperatures exceeding coho absence thresholds determined by Welsh et al. (2001). Results of temperature monitoring conducted by the Mattole Salmon Group at numerous mainstem sites indicated that there is a general trend of cooler water temperatures in upper reaches of the Mattole River with temperatures increasing further downstream. However, temperatures throughout the mainstem Mattole River regularly exceed the threshold associated with coho absence. The Mattole Salmon Group (2005a) presents further details including locations of cooler pools and other temperature monitoring results.

Available historical data and most recent published coho salmon abundance for California are summarized in NOAA status reviews and updates (Weitcamp et al. 1995; Good et al. 2005). Coho salmon populations continue to be depressed relative to historical numbers and there are strong indications that breeding groups have been lost from a significant percentage of streams within their historical range (Good et al. 2005). The 2001 brood year appears to be one of the strongest perhaps of the last decade, and it followed a number of relatively weak years (Good et al. 2005). Risk factors include severe declines from historical run sizes, frequency of local extinctions, long-term downward trends, degraded freshwater habitat, reduction of carrying capacity and presence of Sacramento pikeminnow (*Ptychocheilus grandis*) in the Eel River basin.

Surveys conducted in 1982 by the Coastal Headwaters Association indicated that coho salmon were present in the Western Subbasin of the Mattole River and juvenile coho salmon were either observed or trapped in Honeydew Creek, Woods Creek, Clear Creek, Bear Creek and Indian Creek. In the summer and fall of 2001, CDFG conducted basin-wide coho salmon “presence surveys” using a modified ten-pool snorkeling protocol, and reported that coho salmon were detected in Woods, Honeydew, Fourmile, Sholes, Grindstone,Upper Mill (RM 56.2), Baker, and Thompson creeks (CDFG 2002, Appendix C, pp. 8-9). CDFG continued these snorkel surveys in 2002 and reported juvenile coho presence in the following additional tributaries: Squaw, Blue Slide, Bear, South Fork Bear, Eubanks, Bridge, McKee, Van Arken, and Anderson creeks (CDFG 2004, pp. D.8 – D.9). CDFG (2004) also listed key Mattole tributaries with historical coho distribution, and perhaps occasional presence, as “sites to establish populations” – including several tributaries in the Northern Subbasin – namely the North Fork Mattole River, East Mill Creek (RM 5.5), Upper North Fork Mattole River, Oil Creek, and Devils Creek (tributary to Oil Creek). Coho were also detected in Mill Creek (RM 2.8) during CDFG habitat and electro-shocking surveys conducted in 1966, 1984, 1989, 1993 and 1996 and in East Mill Creek (RM 5.5) in 1966. The Mattole Salmon Group (2005a) reported that juvenile coho salmon were observed during spring snorkel surveys in 2003 and 2004 in East Mill Creek in the Northern Subbasin.

Historical presence information in the Mattole River is given in NOAA updated status report (Good et al. 2005). The number of streams in the Mattole River basin with historical presence was listed as 56. For the 1987-1989 brood year, five streams were surveyed, 60% of those streams surveyed had coho present, and 40% had no coho salmon. For the 1999-2001 brood year, 41 streams were surveyed, 37% had coho and 63% did not. Relative to the entire ESU, there was considerable year-to-year variation in estimated occupancy rates, but there was no dramatic change in the percent of coho salmon streams occupied from the late 1980s and early 1990s to 2000 (Good et al. 2005). The authors also concluded that the proportion of streams sampled within any individual watershed was sufficiently small or had variable time periods to make interpretation of local trends difficult.

Three coho salmon (two age 0+ and one 1+) were recovered from East Anderson Creek, during a culvert replacement project in September 2002 (Berg 2002). East Anderson

Creek is tributary to the Mattole River at the Briceland-Thorne Road near Whitethorn. The Mattole Salmon Group (2005a) reported that Anderson Creek is an example of a tributary where water temperatures remain in the range for juvenile coho rearing. Note that CDFG (2004) reported coho presence in Anderson Creek, based on 2002 snorkel survey data (see above).

The Mattole Salmon Group implemented coho salmon enhancement projects in Mill Creek from 1981 to 1987, and this tributary has provided the only known spawning and rearing habitat consistently occupied by coho salmon in the lower 27 miles of the Mattole River. However, two recent publications (CDFG 2002, CDFG 2004) reported coho presence in three other tributaries of the lower Mattole, namely Squaw, Woods, and Honeydew creeks.

For the Mattole basin as a whole, the Mattole Salmon Group (2000) estimated an escapement of 500 coho spawners in 1981-1982, a peak of about 1,000 spawners in 1987-1988, an all-time low of about 50 adult coho in 1989-90, and 300 or less thereafter until the 1998-1999 season. In 1987, a hatchbox program for coho salmon was implemented in an attempt to avoid the extinction of native Bear Creek coho salmon. The hatchbox program in Bear Creek was abandoned in 1995 due to the lack of a consistent supply of native coho eggs.

The Mattole Salmon Group (2010) reported monitoring results for the total number of coho salmon redds observed as follows (all reaches combined – includes mainstem and some tributaries): 1994-1995 (15); 1995-1996 (7); 1996-1997 (50); 1997-1998 (34); 1998-1999 (8); 1999-2000 (23); 2000-2001 (17); 2001-2002 (53); 2002-2003 (30); 2003-2004 (40); 2004-2005 (68); 2005-2006 (15); 2006-2007 (18); 2007-2008 (31); 2008-2009 (9); 2009-2010 (1). The level of effort for the annual spawning surveys typically varies depending on flow conditions, staff availability, funding, and access issues. Therefore, although the best efforts are given each year to collect as much spawning data as possible, there are still a significant number of reaches that are not sufficiently monitored and as such the reported data should be considered conservative.

Monitoring of juvenile salmonid emigration with rotary screw and pipe traps on the Mattole River has been conducted by the Mattole Salmon Group since 1985. The Mattole Salmon Group (2005b, 2006, 2007, 2008b, and 2009a) reported downstream migrant trapping results from 2004 through 2009. The total number of juvenile coho salmon captured in the traps during those years was as follows: 2004 (2); 2005 (71); 2006 (452); 2007 (222); 2008 (313); and 2009 (225). The number of coho captures was so low that trap efficiencies could not be determined and abundance estimates could not be calculated. In any event, the extremely low number of coho smolts being produced in the Mattole watershed is alarming. The trapping data suggest that in certain years, YOY coho do rear in the lower river and estuary. However, estuarine water temperature conditions tend to deteriorate during the summer and juvenile coho survival may be low.

3.2 CURRENT SALMONID DISTRIBUTION IN THE WAU

Distribution of salmonid populations in the Mattole River basin, including the WAU and within HRC's ownership is currently affected by poor estuarine habitat conditions, lack of habitat complexity in mainstem and tributary habitat, high instream sediment levels, high summer water temperatures, inadequate summer flows and reduced basin-wide coho and Chinook meta-populations (Downie et al. 2003). DWR (1965 *in* Downie et al. 2003) estimated that increases in siltation and debris jams following intensive logging that started in 1952 has caused a significant reduction in the size and distribution of anadromous runs since 1955 (Downie et al. 2003).

Pacific salmonids utilizing habitat within the WAU include fall-run Chinook salmon, coho salmon, winter-run steelhead and summer-run steelhead. Spring-run Chinook salmon may have been present historically, but have been extirpated (Downie et al. 2003) and summer-run steelhead are rare.

Downie et al. (2003) presented maps showing estimated historical distribution of coho salmon, Chinook salmon and steelhead in the Northern Subbasin. Maps E-5, E-6, and E-7 show coho and Chinook salmon distribution based on Downie et al. (2003). These maps show steelhead distribution, based on Downie et al. (2003), with modifications to include additional lower order channels that were determined to be accessible according to the stream gradient criteria applied by PALCO, and information collected by PALCO fisheries biologists during the 2005 electroshocking and barrier surveys. Downie et al. (2003) steelhead distribution limits were initially defined as reaches of 1000 feet or more with a gradient in excess of 10%. These estimates were based on 10 meter DEM model analyses and preliminary range estimates were then reviewed by a team of CDFG, BLM and MSG biologists as well as Mattole Basin residents. PALCO staff used a gradient criteria of stream reaches >20% for >200 feet to define upper limits of distribution (or other surveyed barriers that were impassable). Distribution of steelhead vs. resident rainbow trout as observed during electroshocking surveys is not differentiated on Maps E-5, E-6, and E-7. These maps also shows distribution of steelhead off of HRC's property. This information has not been verified and LIDAR maps are not available for these areas. Distribution off-property was based on Downie et al. (2003) and was modified to include blue line streams shown on USGS topographic maps. Limits of coho and Chinook salmon estimates were defined by Downie et al. (2003) as reaches of 1000 feet or more with a gradient in excess of 5%. These estimates were based on 10-meter DEM model analyses and preliminary range estimates were then reviewed by a team of CDFG, BLM and MSG biologists as well as Mattole Basin residents. As mentioned above, Maps E-5, E-6, and E-7 reflect results presented in Downie et al. (2003) for coho and Chinook salmon.

Based on the best available information (Downie et al. 2003 distribution maps), McGinnis Creek is the only stream on HRC lands that is accessible to Chinook salmon. Chinook salmon may also access lower gradient reaches of the North Fork Mattole River and East Branch North Fork Mattole River, and Upper North Fork Mattole River downstream of HRC's ownership.

A 1966 CDFG stream survey included juvenile coho salmon observations in Devils Creek (tributary to Oil Creek). The authors contacted S. Downie, CDFG, during preparation of this report to obtain more information on this coho salmon observation within the WAU. Mr. Downie relayed the following information: the surveyors' fish observation expertise is not in question but the 1966 survey was a streamside observation and not made with fish in hand nor was it a snorkel survey; in CDFG's stream habitat survey in Devils Creek Aug. 7-8 1991 no biological sampling was conducted so they cannot use that for verification or comparison; in the extensive survey and monitoring work CDFG did in Oil Creek (Hopelain et al. 1997) less than two miles downstream from Devils Creek during the 1990s, there were no coho observations; CDFG cannot simply discount the 1966 observations, but holds them as a single stream bank observation record that has not been subsequently verified, and it occurred at a very marginal site for coho; that observation is also considered in the context of extensive and intensive CDFG Oil Creek depletion electrofishing, from its mouth to less than two miles downstream of the 1966 Devils Creek site, that occurred for several years during the decade of the 1990s and included fish in hand.

Several survey efforts in recent years, including a 2001 CDFG coho salmon inventory, were unable to find coho salmon on HRC's ownership. These "presence surveys" were done by snorkeling short reaches of the most suitable habitat on the ownership in summer-fall 2001 (CDFG 2002) and 2002 (CDFG 2004), including the mainstems of Oil Creek and McGinnis Creek. Potential suitable habitat not surveyed is present in other reaches in HRC tributaries based on having cool summer water temperatures, however migration access is generally limited to steelhead.

A juvenile coho salmon study was conducted from 1997 to 1999 by Redwood Sciences Lab (Welsh et al. 2001), though the inventory did not include any reaches within HRC's holdings. Other survey efforts included various other CDFG habitat surveys and electro-shocking sampling efforts described herein, and a CDFG electro-shocking/monitoring effort conducted on Green Ridge Creek, Oil Creek and Rattlesnake Creek/Upper North Fork Mattole from 1992 to 1995.

The Stream Channel Assessment report (Appendix D) included an analysis of a habitat index known as intrinsic potential (IP), used as part of a computerized terrain model. IP indices have been used to identify potential rearing habitat for coho salmon and steelhead

(Burnett et al. 2003) and are based on empirical relationships between physical channel characteristics (gradient, confinement and mean annual flow) and salmon abundance. In the WAU, moderate to high IP values for coho salmon were concentrated in lower reaches of tributaries along the mainstem Mattole River as well as the lower reaches of the North Fork Mattole and Upper North Fork Mattole River. The same model predicted high IP values for steelhead in upper reaches of tributaries in the WAU, and in particular on HRC's ownership (refer to Figures 18 and 20 in the Stream Channel Assessment report [Appendix D]). Predicted IP values indicate that the best coho and steelhead rearing habitat are, for the most part, spatially segregated.

Stream surveys conducted by CDFG in 1966, 1982, 1985, 1991, and 1997; the Coastal Headwaters Association in 1982; and by PALCO biologists in 2005, have documented the presence of steelhead and rainbow trout within HRC's ownership in the following streams: East Branch North Fork Mattole River, Alwardt Creek, Sulphur Creek, McGinnis Creek, Pritchard Creek, Rattlesnake Creek/Upper North Fork Mattole (and tributaries), Fox Camp Creek, Oil Creek (and tributaries). These findings are generally consistent with IP predictions as described in the Stream Channel Assessment report (Appendix D): the model predicted moderate to high IP values for steelhead in the upper portions of tributaries in the Northern Sub-basin.

3.2.1 BARRIERS TO UPSTREAM MIGRATION WITHIN HRC'S OWNERSHIP

In 2005, PALCO staff identified barriers to upstream migration and the upper extent of distribution of salmonids using an electro-shocker and a two-person fisheries biologist crew (Table E-3). Methods were based on Bliesner and Robison (2005) and are described in detail in PALCO's (2005) Watershed Operating Protocol (WOP) *Upper Extent of Fish Field Protocol-WOP 43*.

Barrier surveys were conducted by PALCO biologists in 2005 to verify Class I/II breaks for timber harvest planning purposes within the following tributaries (refer to Maps E-8, E-9, and E-10): Alwardt Creek, six tributaries to Oil Creek (Left Bank Tributary

#1/Green Ridge Creek, Left Bank Tributary #2, Left Bank Tributary #3, Right Bank Tributary #4, Right Bank Tributary #5, Left Bank Tributary #6); Upper North Fork Mattole (AKA Left Bank Tributary to Rattlesnake Creek) and Fox Camp Creek. Maps E-5, E-6, and E-7 show barriers on HRC lands that were surveyed during the electroshocking effort. All fish recovered during electroshocking were juvenile steelhead or rainbow trout.

Table E-3. Upstream limits of salmonid migration within HRC ownership.

Stream	Distance From Mouth (ft.)	Association of Upstream Limit to Distribution	Barrier Cause[1]	Barrier Type	Height or Length (ft)	Jump pool depth (ft)	% Gradient
Alwardt Creek	11,150	Barrier	Log	Wood/Gradient	4.9	<2	90
Left Bank Trib. #1 to Oil Creek (Green Ridge)	6800	Barrier	N	Boulder	5.9	<2	90
Left Bank Trib. #1 to Oil Creek	7120	Barrier	N	Boulder	4.6	<2	90
Left Bank Trib. #2 to Oil Creek	2296 (from Oil Creek)	Barrier	N	Gradient/Boulder	49	-	28
Left Bank Trib. #2 to Oil Creek	2397 (from Oil Creek)	Barrier	N	Boulder	5.2	<1	90
Left Bank Trib. #2 to Oil Creek	2508 (from Oil Creek)	Barrier	N	Boulder	3.9	-	90
Left Bank Trib. #3 to Oil Creek	0	Barrier	N	Boulder	14	-	45
Left Bank Trib. #3 to Oil Creek	41	Barrier	N	Boulder	59	-	49
Left Bank Trib. #3 to Oil Creek	158	Barrier	N	Boulder	82	-	49
Left Bank Trib. #3 to Oil Creek	266	Barrier	N	Boulder/Gradient	-	-	38
Right Bank Trib. #4 to Oil Creek	671	Barrier	N	Boulder/Wood	3.6	<2	90
Right Bank Trib. #4 to Oil Creek	819	Barrier	N	Wood	4.6	-	90
Right Bank Trib. #4 to Oil Creek	1,032	Barrier	N	Bedrock	9.2	-	52
Right Bank Trib. #5 to Oil Creek	0	Barrier	N	Bedrock/Boulder	40	-	50
Right Bank Trib. #5 to Oil Creek	103	Barrier	N	Bedrock	8.2	-	90
Right Bank Trib. #5 to Oil Creek	117	Barrier	N	Boulder	28	<3	90
Left Bank Trib. #6 to Oil Creek	194	Channel	N	Boulder	72	-	32
Trib. #1 to Rattlesnake (UNFMR[2])	78	Barrier	N	Bedrock	4.3	<2	90
Trib. #1 to Rattlesnake (UNFMR)e	293	Barrier	N	Boulder/Wood	4.3	-	90
Fox Camp Creek	4348	Barrier	N	Boulder	5.6	<2	90

[1] Barrier abbreviations: M=manmade; N= natural; L=log jam

[2] UNFMR=Upper North Fork Mattole River

4.0 FISH HABITAT ANALYSIS

4.1 *HISTORIC HABITAT CONDITIONS*

There is no documentation of historic habitat conditions that existed prior to logging, road building and large flood events. CDFG surveys conducted in 1966 on select tributaries in the WAU represent the only available "historic" information and are qualitative in nature. These surveys occurred after the combined impacts of historic logging and road building that were coupled with large flood events. Thus, this survey information does not represent historic conditions in terms of those conditions that existed prior to large-scale watershed disturbance. However, the 1966 CDFG surveys are the only available information on past habitat conditions and are summarized below in Table E-4 along with subsequent CDFG surveys conducted in the 1980s and 1990s. CDFG habitat data was also incorporated into stream summaries given below.

Table E-4. Summary of 1966-1999 CDFG stream survey information.

	Upper North Fork Mattole River	East Branch North Fork Mattole		Sulphur Creek		Sulphur Creek Trib. #1	Sulphur Creek Trib. #2	McGinnis Creek		
Survey Year	1966	1966	1982	1988	1999	1998	1999	1966	1985[2]	1999[3]
Unit Length (ft)	~21,120	~31,680	~34,320	10,032	7,136	598	2,632	18,480	~15,000	16,044
Pool:Riffle:Run	nd	60:40[1]	1:5[1]	15:55:30	11:50:39	N/A	8:43:48	1:3[1]	1:5[1]	N/A
Average pool depth	Nd	nd	~2ft	1	2.4	1	1.1	nd	1	1.3
% Pool >3ft deep	Nd	nd	nd	nd	14%	0%	0%	nd	nd	8%
Canopy Closure	5%	40%	10%	30%	72%	87%	64%	50%	50%	61%
Spawning habitat	Good	3 miles	fair	good	good	fair	fair	good	Good; poor us 12,650 ft	fair
Log jams	nd	17	nd	nd	nd	nd	nd	nd	6+	
Barriers*	0	1	6	2	2	N/A	N/A	1	2	N/A

Table E-4 continued.

Stream	Oil Creek		Left Bank Trib. #1 to Oil Creek (Green Ridge)	Devils Creek	Rattlesnake Creek/Upper North Fork Mattole			Pritchard Creek	
Survey Year	1966	1991	1991	1966	1966	1991	1991	1966	1985
Unit Length (ft)	21,120	13,014	3,710	15,840	7,920	3,885	22,452	15,840	7,920
Pool:Riffle:Run ratio	2:1*	16:45:38	10:4:86	1:1	1:1*	15:14:72	16:43:41	1:5*	1:15 to 1:7
Average pool depth	nd	1.1	nd	nd	nd	1	1.4	nd	1.5
Log jams	3	nd	nd	29	nd	nd	nd	17	nd
% Pool >3ft deep	nd	4%	0%	nd	nd	6%	30%	nd	nd
Canopy Closure	nd	14%	21%	nd	nd	7%	13%	nd	30%
Spawning habitat	good	fair	poor	fair	400 yards	good	poor	good	poor
Barriers*	3	0	2	2	1	2	3	1	0

[1]Pool to riffle
[2]All numeric values are approximations
[3]From NCWAP (Downie et al. 2003) abbreviated summary

4.2 Current Habitat Conditions

4.2.1 Methods

A number of stream surveys, including CDFG stream surveys, PALCO habitat typing, ATM and stream walks conducted by the authors in 2005 and 2010, were conducted within PALCO's (now HRC's) ownership and are integrated here to assess current habitat conditions. General information is summarized, and dates of surveys and sources of information provided, in the following individual stream summaries. Maps E-8, E-9, and E-10 show locations of stream surveys and ATM stations. Where sufficient data exist, a matrix comparing existing habitat conditions with APFC targets is included for each fish-bearing tributary.

4.2.1.1 INSTREAM HABITAT SURVEYS

Instream habitat surveys using a modified (to exclude channel typing and flow measurements) version of the CDFG (Flosi et al. 1998) protocol were conducted by PALCO staff in the summer-fall of 2005. Refer to PALCO (2003) *Stream Habitat Typing and Measurements-WOP 14* for a complete description of methods. Habitat typing was conducted over a distance equal to approximately 30 times the average bankfull width in lower gradient response reaches in the following streams: Sulphur Creek (4,139-foot survey reach starting from the mouth), East Branch North Fork Mattole River (1,699-foot survey reach near the Sulphur Creek confluence), Oil Creek (9,126-foot survey reach covering all of HRC's ownership), McGinnis Creek (13,364-foot survey reach starting just upstream of the mouth and extending over most of HRC's ownership) and Rattlesnake Creek/Upper North Fork Mattole (4,489-foot survey reach starting at the mouth). Lower Rattlesnake Creek and Left Bank Tributary to Rattlesnake Creek are referred to as Upper North Fork Mattole River in PALCO (now HRC) habitat data files. For purposes of this report, and based on information from CDFG (pers. Comm. S. Downie, CDFG, March 13, 2006) the Upper North Fork Mattole River is considered to end at "the forks", at the confluence of Oil Creek and Rattlesnake Creek.

Habitat data were also collected in 1998-2010 at two permanent Aquatic Trends Monitoring (ATM) stations located on Rattlesnake Creek/Upper North Fork Mattole (#169) and Sulphur Creek (#133); and at a more recently (2005) established ATM station (#219) on McGinnis Creek (refer to Maps E-8, E-9, and E-10 for locations). Physical channel monitoring also occurred including longitudinal profile and cross-section monitoring at the two ATM stations (#133 and #169) from 1998-2004. Results of physical channel monitoring are summarized and discussed in the Stream Channel Assessment report (Appendix D).

All stream surveyors underwent habitat typing training with CDFG prior to data collection in PALCO's (now HRC's) ownership. Habitat typing was conducted on stream reaches to assess the abundance (i.e., the percentage of channel length composed of pools), size, and depth of pools. Habitat typing provided information for the APFC matrix regarding desired targets including pool-to-pool spacing, percent of surface area comprised of pool habitat, number of pools associated with large wood and average residual pool depth. Other habitat attributes noted during surveys included migration barriers, maximum pool depth, pool forming elements, and the number of functional and key pieces of large wood. Results are given in Table E-5, as discussed below in Section 4.2.2.

Habitat data were also collected during surveys by NRM and PALCO fisheries biologists for upstream migration barriers on smaller tributaries (described earlier). These surveys focused on steeper source and transport reaches near Class I/II breaks and basic physical measurements were taken including widths, depths and pool to riffle ratios. Results are given in Table E-6, as discussed below in Section 4.2.2; however, these habitat data were collected at the upper extent of streams (i.e. small headwater tributaries) which do not represent downstream response reach conditions and, therefore, is not included in the PFC tables.

4.2.1.2 SUBSTRATE MONITORING

Refer to PALCO (2003) *Surface and Sub-surface Sediment Sampling-WOP 13* for methods. In summary, pebble counts (after Wolman 1954) were conducted at ATM stations to document the surface particle size distribution of coarse riverbed material. Pebble counts were conducted at riffles using a transect method, within the bankfull channel, and across three riffles within ATM stations #133 and #169. D50 values were calculated for each of the three riffle transects and then averaged for the reach. Bulk sediment samples were taken at pool tailouts: three sediment samples were collected using a standard shovel (after Hames et al., 1996) from three pool tailouts within ATM stations #133 and #169. Samples collected at that time were processed at the PALCO Sediment Laboratory using a dry-sieve method. Bulk samples were washed through a series of sieves. The volume of material collected by each sieve was measured and the percent composition of each particle size range calculated. Percent fines were reported as the proportion of the total sediment sample less than 0.85 mm and particles less than 6.35 mm. A change in methodologies (refer to Stream Channel Assessment report [Appendix D] Section 3.4.4.2) occurred between two sampling intervals, 1998-2001 and 2002-present, making comparisons among the two time intervals problematic.

4.2.1.3 Canopy Measurements

Refer to PALCO (2003) *Stream and Riparian Canopy Cover Measurement-WOP 12* for methods. In summary, canopy cover was recorded at 200-foot intervals throughout each ATM station using a concave densiometer. Measurements were taken along transects at mid-channel, bankfull and within riparian zones. Data were reported as 1) the average of measurements taken only at mid-channel points located 50, 100 and 150 feet upstream of the station start; 2) average of density of canopy within riparian zone throughout the reach; 3) overall average canopy cover for the reach including all points sampled.

4.2.1.4 Water Temperature Monitoring

Refer to PALCO (2003) *Temperature Instrumentation and Deployment-WOP 09* for methods. Measurements of water temperature were taken using continuous recording data logger devices (Hobos or Optic Stowaways). Temperature data loggers were placed into the stream at locations with thermal mixing, cover and the ability to maintain sufficient flow during summer months. Loggers were retrieved in the fall and data downloaded onto a computer. Data were used to develop Maximum Weekly Average Temperature (MWAT) for the monitoring locations. MWAT is defined as the average daily mean temperature for the warmest consecutive 7-days during the monitoring period. MWAT calculations are described further in PALCO (2003) *Stream Temperature Monitoring-WOP 09).* Water temperatures were measured during summer 1999-2010 at ATM stations within Sulphur Creek and Rattlesnake Creek/Upper North Fork Mattole, and from 2005-2010 at the ATM station on McGinnis Creek. Data loggers are typically removed in mid-September.

4.2.1.5 LARGE WOOD INVENTORIES

Refer to PALCO (2003) *Habitat Typing and Measurements-WOP 14* and PALCO (2005) *Large Woody Debris-WOP 32* for methods. PALCO staff conducted large wood inventories during the 2005 habitat typing surveys within Oil Creek, Rattlesnake Creek/Upper North Fork Mattole, East Branch North Fork Mattole, Sulphur Creek and McGinnis Creek. All pieces of large wood greater than one-foot in diameter and six feet long were counted and categorized by size. Key pieces of large wood were tallied and were defined as follows: wood that is independently stable within the bankfull channel; wood that is not functionally held by another factor; i.e. pinned by another log, buried, trapped against a rock or bedform; and, wood that retains (or has the potential to retain) other pieces of large wood. Diameter measurements were made at mid-piece and length measurements were made of the entire piece. In the calculation of mean lengths, diameters and volumes of portions of large wood within and out of the bankfull channel were used. Frequency of occurrence was calculated based on the number of pieces per 100 feet of stream length at the survey reach.

4.2.2 RESULTS

Results of surveys and monitoring activities are presented in this section. Maps E-8, E-9, and E-10 show the locations of stream surveys conducted by PALCO biologists in 2005, PALCO (now HRC) ATM stations, and past CDFG survey locations.

Table E-5 summarizes habitat data collected by PALCO biologists in 2005 within low to moderate gradient (1-8 percent) reaches of the following streams: East Branch North Fork Mattole River, Sulphur Creek, McGinnis Creek, Oil Creek and Rattlesnake Creek/Upper North Fork Mattole. Data collected during end of fish distribution surveys conducted in smaller tributaries near Class I/II breaks represent habitat conditions in steeper, transport and source reaches and are summarized in Table E-6. Time-series summaries of ATM results are also presented for:

- Substrate monitoring (Figures E-1 through E-3);
- Canopy/temperature monitoring (Figures E-4 and E-5);

- Pool characteristics (Figures E-6 through E-9); and
- In-stream Large Woody Debris (LWD) (Figures E-10 through E-13).

Table E-5. 2005 habitat information from PALCO habitat typing surveys.

	East Branch North Fork Mattole River	McGinnis Creek	Oil Creek	Sulphur Creek	Rattlesnake Creek/UNFM
Dominant geology in fish-bearing reaches	Coastal Belt Franciscan Complex	Coastal Belt Franciscan Complex	Coastal Belt Franciscan Complex	Coastal Belt Franciscan Complex	Coastal Belt Franciscan Complex
Gradient	1-8	1-8	1-8	1-8	1-8
Survey distance (ft)	1,699	13,364	9,126	4,139	4,489
Bankfull width (ft)	50.3	26.6	35.8	36.8	44.6
# Pools in survey (pools per mile)	12(37)	87(34)	87(50)	12(15)	41(48)
Pool Frequency (channel widths/pool)	4.33	4.57	3.03	11.14	2.94
% Pool by Length	23%	24%	33%	9%	34%
% Pool Area	No data	25.0%	45.5%	13.6%	No data
% Pools Associated with LWD	8%	24%	6%	16%	2%
% Pools >=3 ft Deep	33%	6%	14%	18%	44%
Pool:Riffle:Flatwater Ratio (%)	23:57:20	21:56:23	33:37:30	9:64:26	34:48:18
Pieces LWD/100ft>1 ft dia. & >6 ft long	0.49	2.42	0.74	1.05	0.39
Volume LWD/100 ft	11	49	14	20	8
Mean LWD Piece Volume (cubic feet)	16.7	20.3	18.3	19.2	21.6
# Key Pieces/100 ft	0.18	0.17	0.03	0.17	0.02
Av. Key Piece Volume (cubic feet)	597	256	352	250	110
Key LWD Pieces/Channel Width	0.09	0.04	0.01	0.06	0.01
Canopy Closure %	83%	91%	51%	79%	55%

Table E-6. 2005 habitat data from PALCO migration barrier surveys (upper extent of fish-bearing reach).

	Alwardt Creek	Left Bank Trib. #1 to Oil Creek	Left Bank Trib. #2 to Oil Creek	Right Bank Trib. #4 to Oil Creek	Left Bank Trib. #6 to Oil Creek	Upper North Fork Mattole (AKA Trib. #1 to Rattlesnake Creek)	Fox Camp Creek
Dominant geology in fish-bearing reaches	Coastal Belt Franciscan Complex	Coastal Belt Franciscan Complex	Coastal Belt Franciscan Complex	Coastal Belt Franciscan Complex	Coastal Belt Franciscan Complex	Coastal Belt Franciscan Complex	Coastal Belt Franciscan Complex
Gradient range of surveyed reach	4-35	4-20	4-20	8-20	8-35	8-20	1-20
Survey distance (ft)	360	366	716	594	480	458	1,115
Bankfull width (ft)	20.1	20.4	16.9	20.7	19.8	27.6	15.8
# Pools in survey (pools per mile)	3(44)	7(100)	5(37)	6(53)	4(44)	4(46)	5(24)
Pool Frequency (channel widths/pool)	11.19	4.37	14.1	8.97	7.12	7.55	14.41
% Pool by Length	9%	23%	7%	11%	14%	11%	7%
% Pool Area	10%	29%	14%	15%	16%	13%	9%
% Pools >3 ft Deep	0%	0%	0%	0%	0%	0%	40%
Pool:Riffle:Flatwater Ratio (%)	9:91:0	23:77:0	7:80:0	11:87:2	14:86:0	11:69:9	7:92:1

Figure E-1. Sediment D50 size

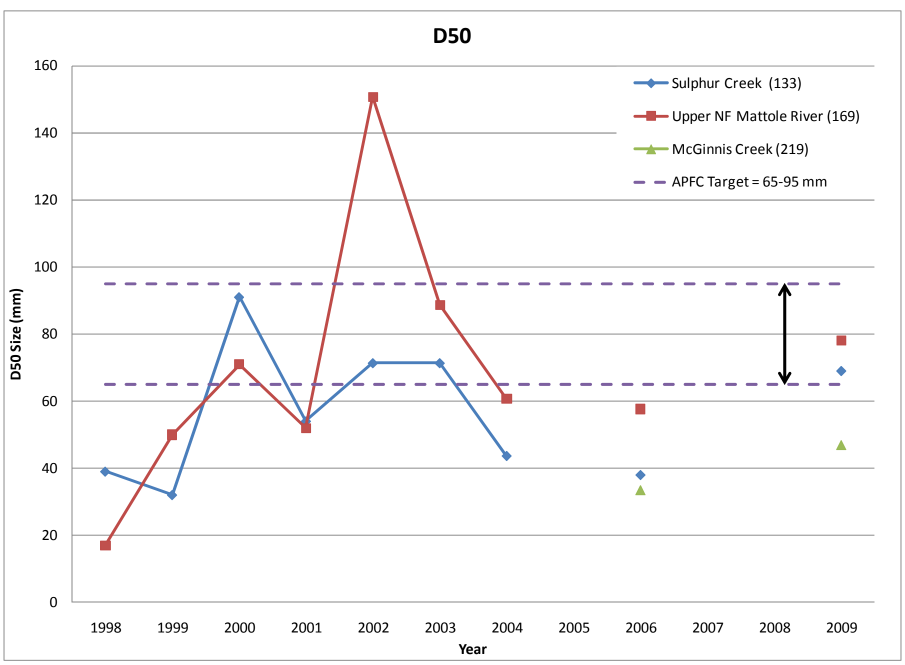


Figure E-2. Percent sediment <0.85 mm in diameter

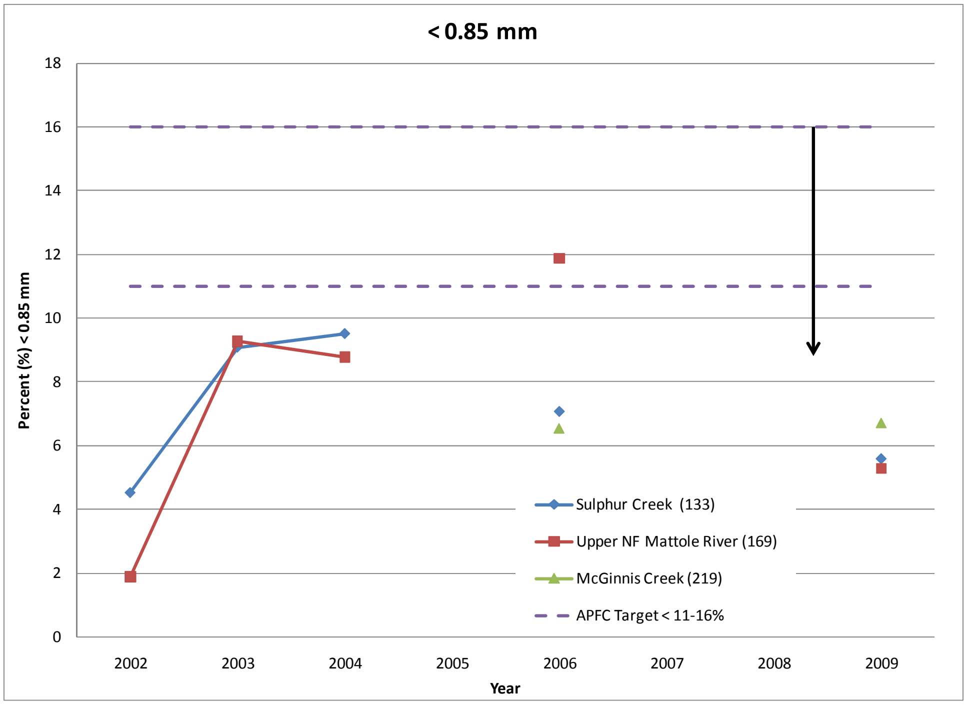


Figure E-3. Percent sediment <6.35 mm in diameter

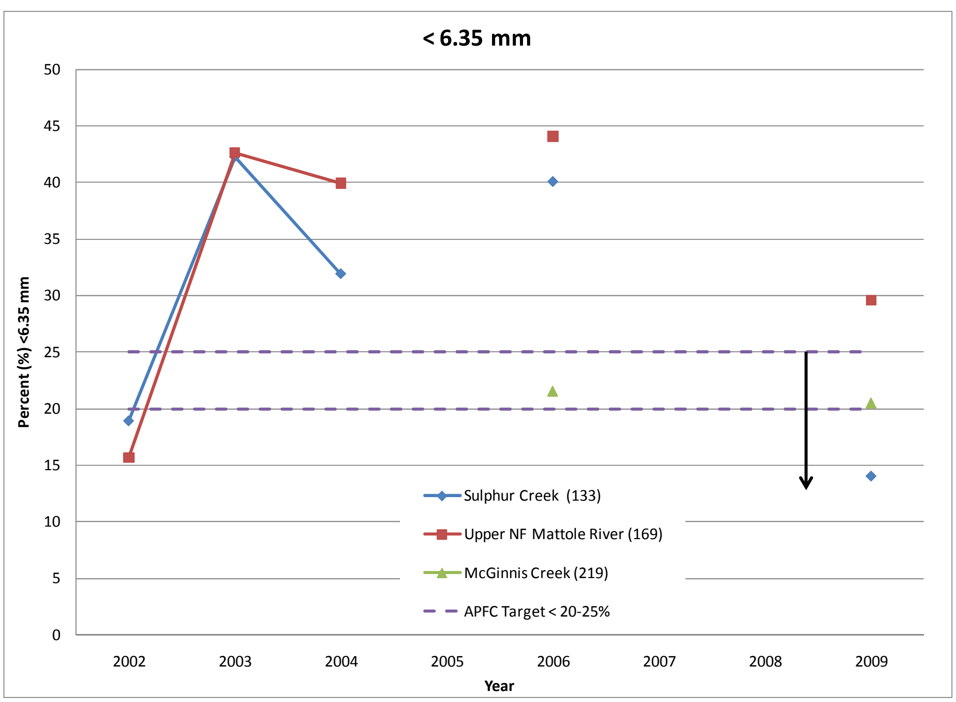


Figure E-4. Percent mid-channel canopy cover

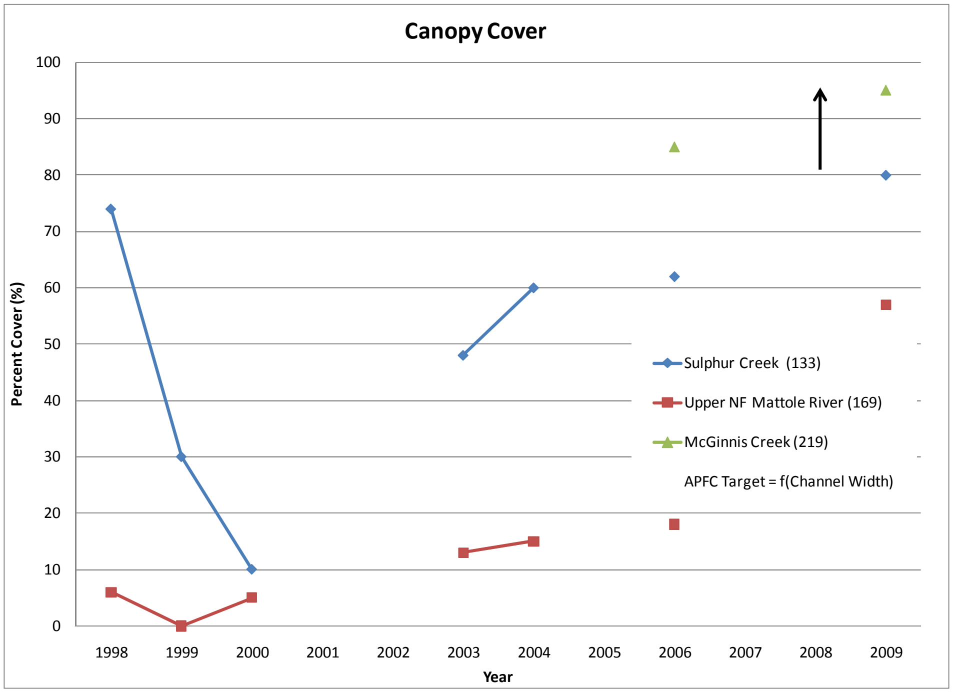


Figure E-5. Maximum Weekly Average Temperature (MWAT)

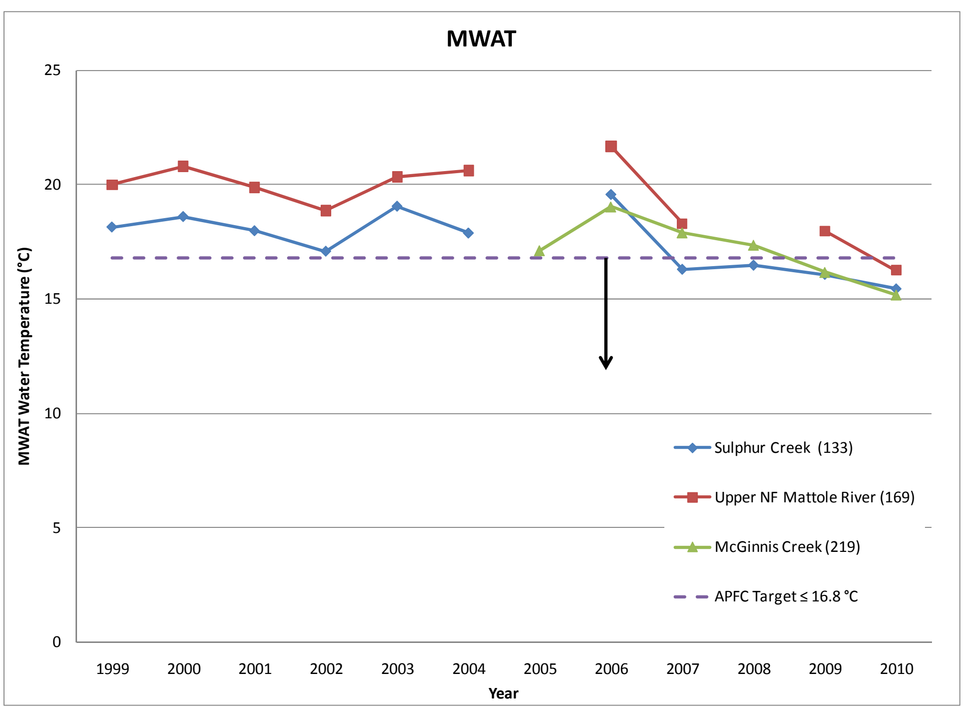


Figure E-6. Percent pool area

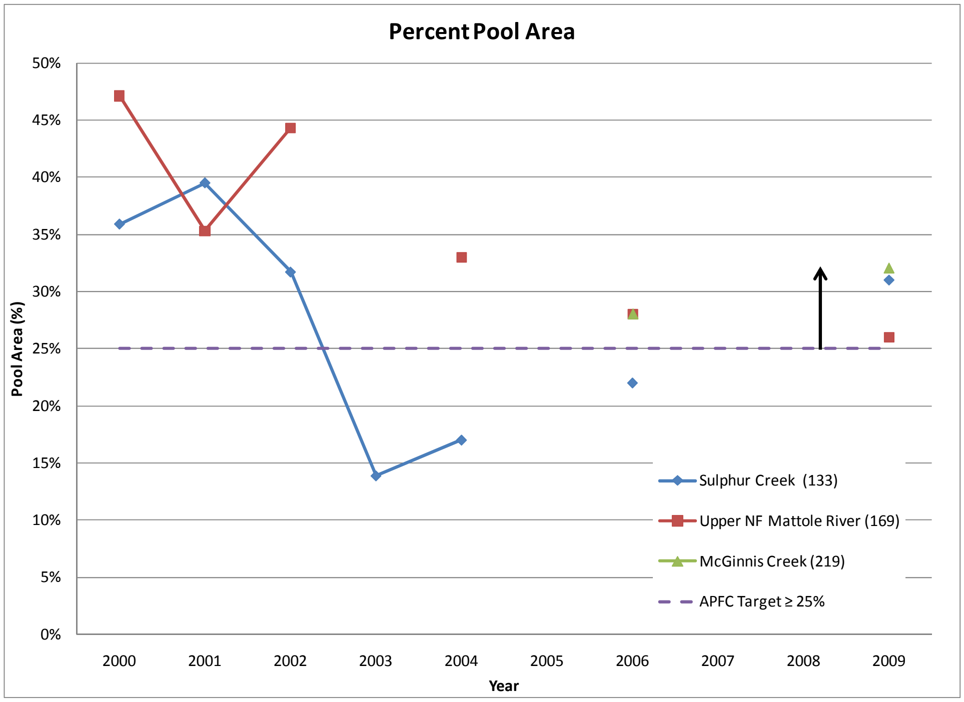


Figure E-7. Pool frequency

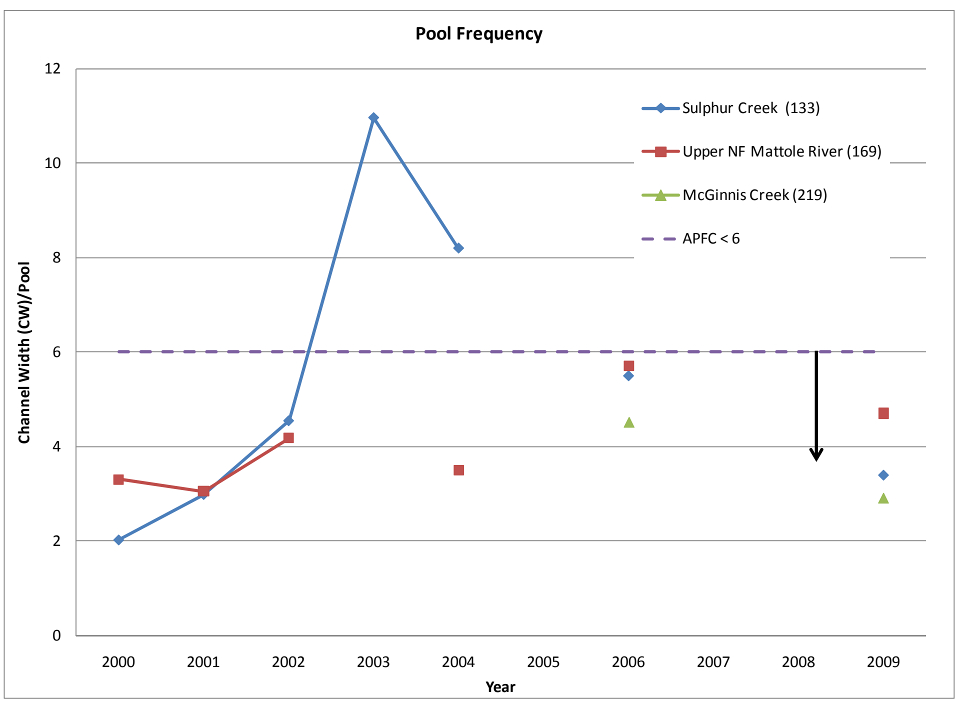


Figure E-8. Average residual pool depth

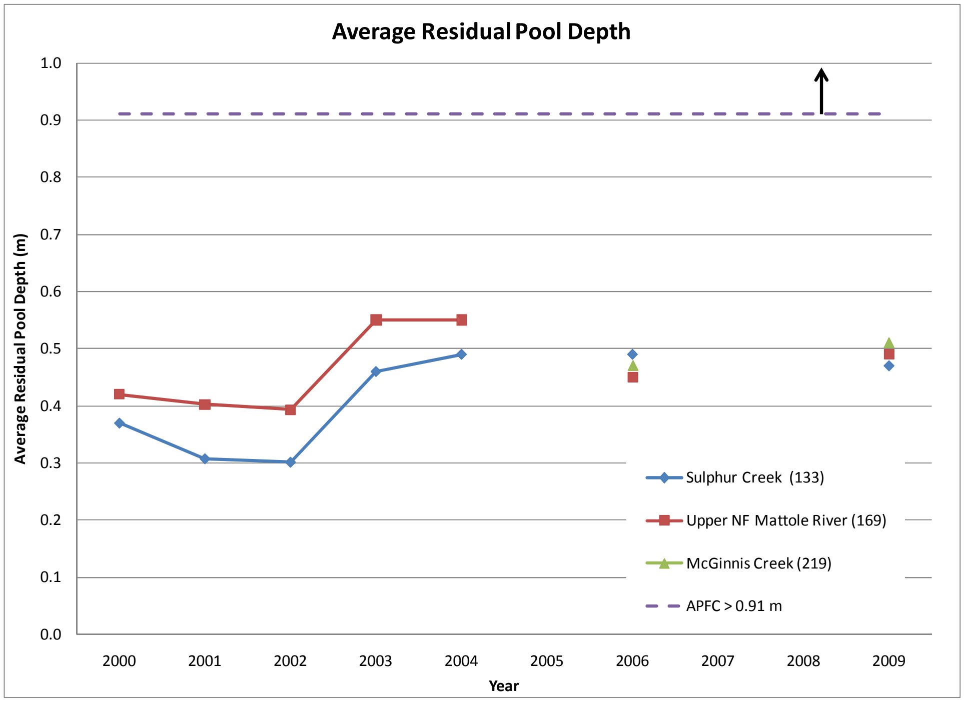


Figure E-9. Percent pools associated with wood

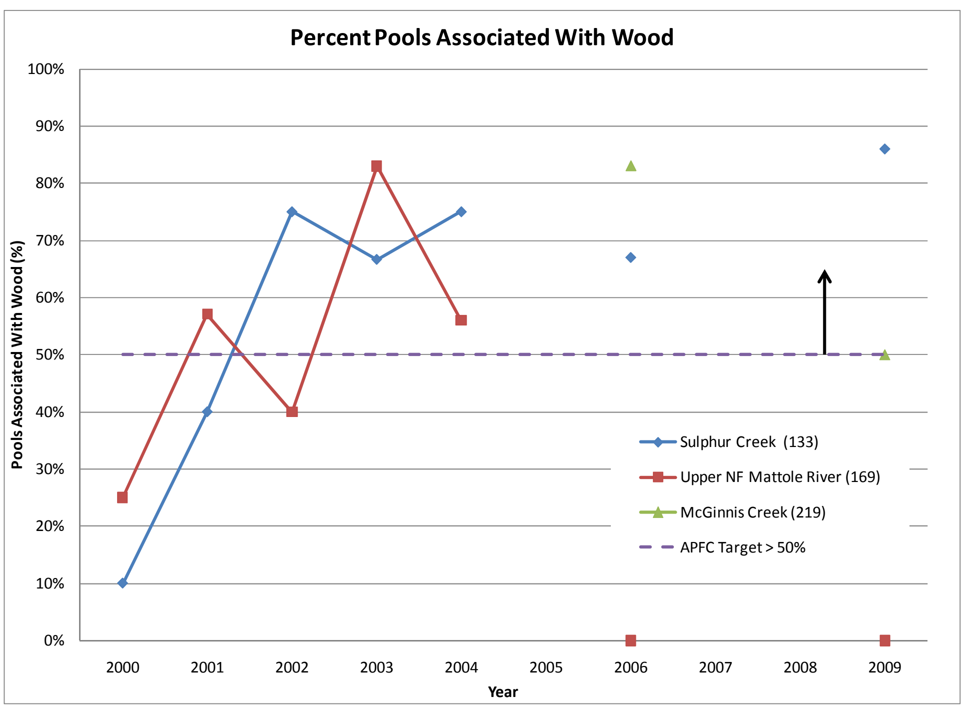


Figure E-10. Total piece frequency

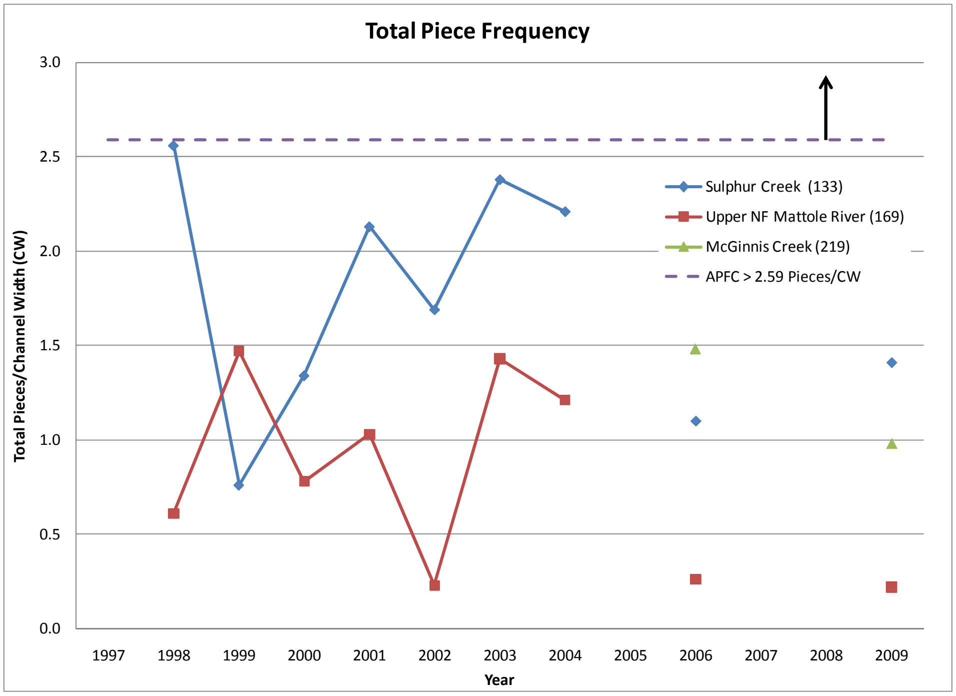


Figure E-11. Key piece frequency

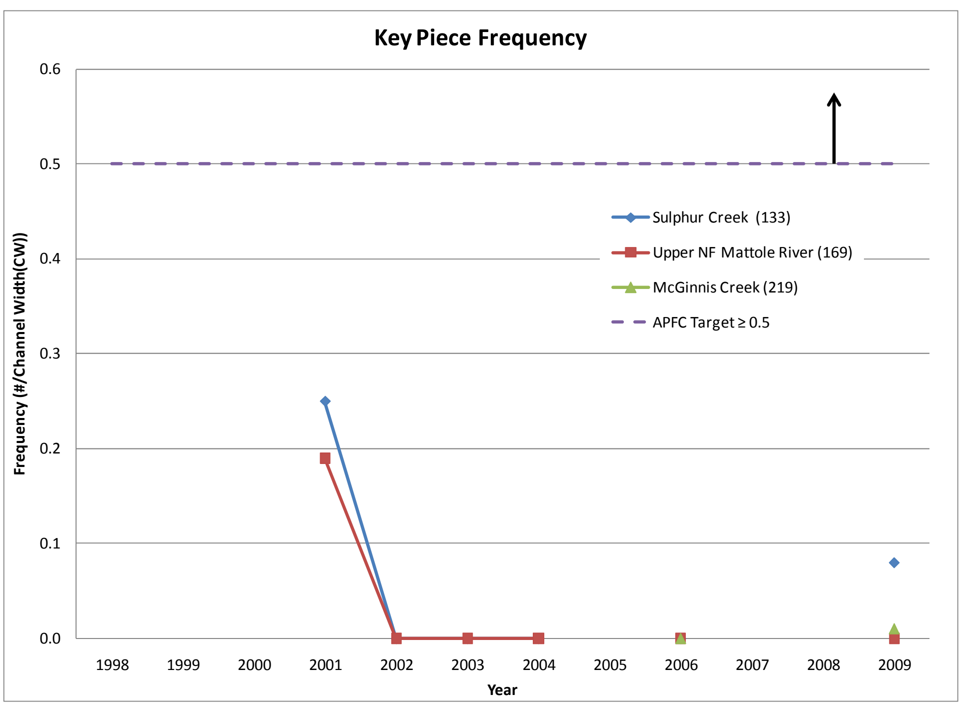


Figure E-12. Total piece average diameter

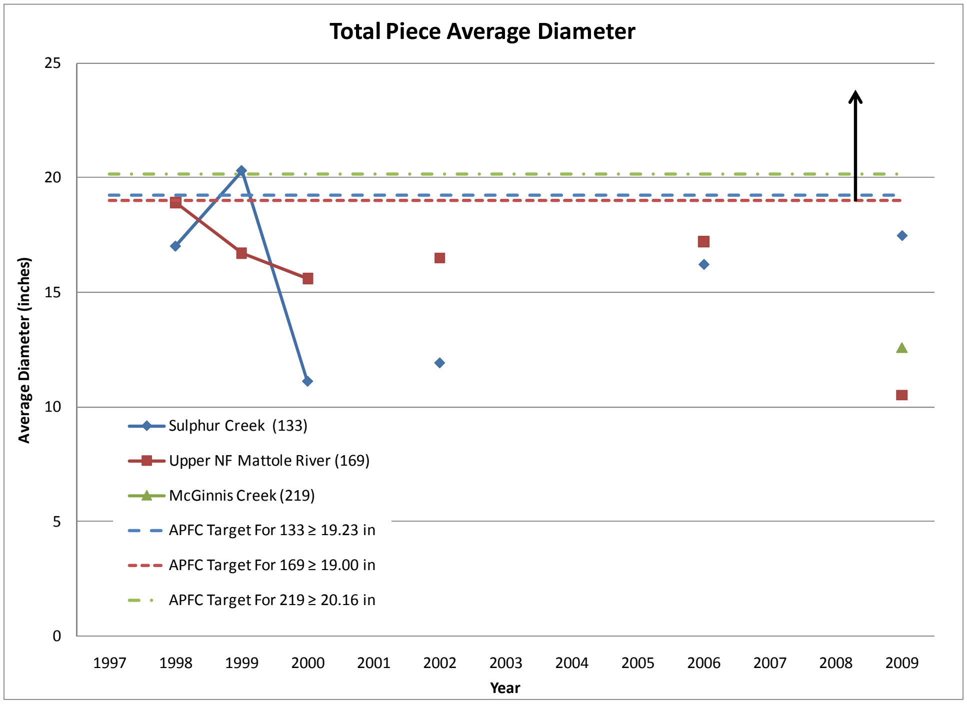
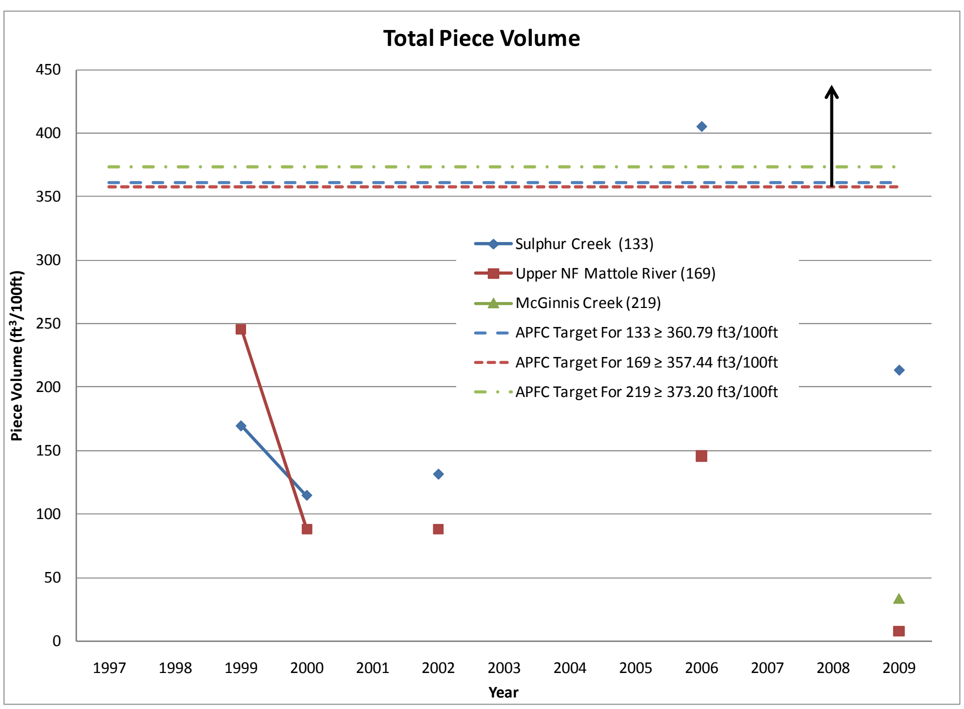


Figure E-13. Total piece volume



4.2.3 STREAM SUMMARIES

4.2.3.1 NORTH FORK MATTOLE RIVER

The North Fork Mattole River is tributary to the Mattole River (at 40º19’5.10”N/ 124º17’27.19”N), near Petrolia, California, which is within the WAU, but downstream of HRC’s ownership. The North Fork Mattole River, upstream of its confluence with the East Branch North Fork Mattole River, has a watershed area totaling 6,662 acres, of which 1,369 acres are owned by HRC and managed under the HCP including approximately 1.1 mile of fish-bearing habitat. The North Fork Mattole River is highly aggraded in its lower reaches. Historical photos from the turn of the century show the aggraded channel conditions existed prior to large scale logging and road building (pers. Comm. S. Downie, CDFG, March 13, 2006). Upstream of the confluence with Grizzly Creek, the channel becomes very confined within a bedrock canyon and provides excellent adult holding habitat up to the confluence with the East Branch North Fork Mattole River. At this bifurcation, spawning habitat becomes available, as well as some deep holding pools.

Summer water temperatures are a limiting factor. The Mattole Salmon Group (refers to this tributary as the Lower North Fork Mattole River) (unpublished data on file) reported that the MWAT in 1997 and 1998 was 20.9ºC. The MSG (2009) reported that the maximum weekly maximum temperature (MWMT) at river mile 4.7 continually exceeded 21.1 ºC during the summer months of 2007 and 2008. Mean canopy density is low, although steep canyon walls provide topographic shading to mid-reaches. Pool habitat is limited in lower alluvial reaches. Adult holding habitat, in the form of deep bedrock pools, occurs in mid-reaches within and upstream of the bedrock canyon. The authors obtained a single temperature and dissolved oxygen (DO) reading on September 15, 2005, at the Mattole Road Bridge crossing (lower reach of North Fork Mattole River): water temperatures were 21.4ºC at 3:00 p.m. and DO was 8.7 mg/l. Based on this information and past CDFG surveys, summer water temperatures in the lower reaches are a limiting factor. One measurement of DO concentrations is not representative but indicates that DO concentrations were within acceptable levels on the day and location sampled. DO levels of 8-9 mg/l or more are needed to ensure normal physiological functions of salmonids (Spence et al. 1996). Based on anecdotal observations (made by residents) of adult summer steelhead within mid-basin bedrock canyon reaches, summer stream temperatures may be more suitable in the deep bedrock pools.

4.2.3.2 EAST BRANCH NORTH FORK MATTOLE RIVER

The East Branch North Fork (EBNF) Mattole River is tributary to the North Fork Mattole River (at 40º21’23.63”N/124º15’7.41”W) with their confluence located approximately three miles downstream of HRC lands (Map E-2). The EBNF Mattole drains approximately 18 square miles and provides a total of 8 miles of perennial stream habitat (Downie et al. 2003), with approximately 1.4 miles of fish-bearing habitat within HRC HCP-covered lands. The lower (off-property) watershed consists of a broad canyon running through rolling hills with a low gradient aggraded channel for approximately 2.5 miles. This lower reach has an abundance of spawning substrates. Upstream of the lower gradient segment, the channel alternates between narrow U-shaped canyons with boulder roughs confined by bedrock to broader V-shaped canyons.

On HRC lands, and within the reach surveyed by PALCO biologists in 2005 immediately downstream of Sulphur Creek, the East Branch North Fork Mattole River is within a fluvial confluence zone (refer to Stream Channel Assessment report [Appendix D], Figures 14 and 15) characterized by high sedimentation, a relatively unconstrained channel with relatively smaller substrates. Just downstream of the surveyed reach is a debris flow confluence zone that is boulder dominated. Downstream of the debris flow zone is a rock landslide zone dominated by boulder cascades.

Adequate spawning and rearing habitat is available for coho and Chinook salmon for approximately the first 2.5 miles of the EBNF, however occurrence of either species has not been documented (CDFG 1982, Downie et al 2003). Frequent log jams, boulder cascades, and increases in stream gradient up to 20 percent minimize potential for

Chinook and coho use past this point. Steelhead and resident rainbow trout have been documented in the river and its tributaries further upstream (Map E-5).

CDFG habitat surveys were conducted on June 22, 1966 and June 30-July 2, 1982 on East Branch North Fork Mattole River from the mouth to Sulphur Creek; a distance of approximately 6 miles. CDFG habitat data are summarized in Table E-4. The segment below Alwardt Creek was identified as having sufficient areas for salmon and steelhead spawning. Numerous debris jams were noted in the 1966 survey in more confined reaches.

Surveys conducted by PALCO biologists in 2005 extended over 1,699 feet from the PALCO (now HRC) property line to the mouth of Sulphur Creek (Table E-7), spanning both a lower gradient fluvial confluence zone near the mouth of Sulphur Creek (Photo E-1) and a fluvial-moderate gradient-boulder cascade zone. Spawning habitat was characterized as being "mixed" due to a large proportion of pool tailouts that had embedded gravel and a significant amount of non-spawnable boulder tailouts. On HRC lands, spawning habitat is limited because many pool tailout substrates are too large (cobble/ boulder) and have only small pockets of gravel. Lower off-property reaches of the mainstem were identified by CDFG as containing most of the suitable spawning substrate in this stream.

Because the 2005 surveys conducted by PALCO biologists covered only the uppermost extent of past CDFG survey reaches (1966, 1982), and because there is considerable spatial variability in channel geomorphic units (and associated habitat characteristics), a comparison of habitat data over time is of little meaning.

Temperature data are generally lacking, however, CDFG (1982) reported stream temperature on June 30, 1982 of 16.7°C (air 18.9°C) five miles downstream of the confluence with Sulphur Creek. The water temperature was 13.3°C (air 14.4°C) on July 1, 1982, at the Sulphur Creek confluence (CDFG 1982). The westerly aspect of the

EBNF results in partial topographic shading provided by steep inner gorges, in addition to shade provided by streamside canopy.

Photo E-1. East Branch North Fork Mattole River, fluvial confluence reach downstream of Sulphur Creek, August 2005.

Table E-7. East Branch North Fork Mattole River habitat conditions relative to PFC.

	Parameter	PFC Target	Measured Value	Meets Goal or Quality Rating
Stream Information	Channel Type		<8% gradient	
	Bankfull Channel Width (ft.)		50.3	
	Class I Streamlength (ft.)		48,048	
	Survey Length (ft.)--CDFG Method		1,699	
	Basin Area (acres)		11,520	
	Dominant Geology of Class I		Coastal Belt FC	
Pools	Pool Frequency (cw/p)	<6 cw/p	4.33	yes
	Ave. Residual Pool Depth (ft.)	>3 ft	2.2	no
	% Pool Area	>+25% area	nd	nd
	% Pools Associated with LWD	50%	8%	no
	% Pools >=3 ft Deep	>50%	33%	no
LWD	Volume LWD/100 ft.	416.7	11	no
	# Key Pieces / 100 ft	1	0.18	no
	Ave. Key LWD Piece Volume (ft^3)	271.2	597	yes
	# Key LWD Pieces / CW	0.5	0.09	no
	#Tot Pieces / CW	2.59	0.24	no
Substrates	Percent <0.85mm	11-16%	nd	nd
	Percent <6.34mm	<30%	nd	nd
	D_{50} of Surface Particles	64-96 mm	nd	nd
Canopy	Canopy closure %	>85%	83%	no
Temperature	MWAT	<16.8°C	nd	nd

"nd" indicates no data available.

Survey Source:

- 2005 PALCO habitat survey from PALCO property line upstream 1,699 feet to the confluence of Sulphur Creek.

Summary:

- HRC lands provide habitat for steelhead and resident rainbow trout.
- Potential use by coho and Chinook salmon is limited to the East Branch mainstem off-property downstream of Alwardt Creek.
- Suitable spawning substrates exist primarily in lower reaches of the East Branch mainstem downstream of Alwardt Creek.

- The amount of spawning habitat is limited on HRC lands and occurs in small pockets within lower gradient reaches.
- Large wood storage is currently low on HRC lands.

4.2.3.3 ALWARDT CREEK

Alwardt Creek is tributary to the East Branch North Fork Mattole River (at 040º21' 15.04"N/124º12'13.16"W) and provides 3.2 miles of perennial stream habitat (plus 1.4 miles on the tributary Rodgers Creek) (Downie et al. 2003). The Alwardt Creek watershed drains an area of approximately 2,400 acres, of which 1,750 acres are owned by HRC and managed under the HCP. The stream has a south to southwest channel aspect with moderate to high gradients. Stream survey data are completely lacking for this stream, with the exception of limited data collected during the 2005 barrier surveys conducted by NRM and PALCO biologists in headwater areas (Table E-6). CDFG (1966a) walked the lower reach during a survey of the East Branch North Fork and observed a migration barrier 210 feet up from the mouth and observed that steelhead were more abundant below this barrier. Subsequent CDFG surveys (1982) for the East Branch North Fork Mattole River reported that Alwardt Creek was not suitable for anadromous fish and that fish observed were likely resident trout. Stream temperature data are lacking.

Barrier and electroshocking surveys conducted by NRM and PALCO biologists in August 2005 in a headwater reach (refer to Map E-8) documented what were likely residential rainbow trout as far up as 11,150 feet from the mouth, at which point upstream migration was blocked by a log jam combined with increased stream gradient. Habitat within this headwater reach was dominated by riffles with few (shallow) pools.The surveyed reach ended 14,086 feet upstream from the mouth where the surveyors encountered channel gradients that exceeded 30 percent for a distance of more than 600 feet. No fish were found above the log jam barrier at the 11,150-foot mark.

Benthic macroinvertebrate sampling was conducted in Alwardt Creek at Station 30 located near the confluence of Rodgers Creek (Map E-8) from 1998-2000 and nine benthic macroinvertebrate metrics were reported. Taxa richness values indicated that diversity has been relatively consistent over the sampling period. The Ephemeroptera, Plecoptera, and Trichoptera/Chironomidae (EPT) ratio indicated poor biotic conditions. However, an increase in the proportion of EPT was evident in 1999. Skewed populations having a disproportionate number of Chironomidae relative to the more sensitive organisms indicate environmental stress. The relative proportion of Chironomidae was high (with the exception of the 1999 sample) possibly indicating perturbation.

The Forest Science Project collected temperature data near the mouth of Rodgers Creek and reported that the MWAT was 17.9°C and 17.4°C in 1996 and1997, respectively.

4.2.3.4 SULPHUR CREEK

Sulphur Creek is tributary to the East Branch of the North Fork of the Mattole River (at 040º21’11.55”N/124º09’50.23”W) and provides 2.5 miles of perennial mainstem habitat plus 2.2 miles of tributary habitat (Downie et al. 2003). The watershed has a drainage area of 2,456 acres, of which 1,178 acres are owned by HRC and managed under the HCP. Sulphur Creek is riffle-dominated with irregularly spaced pools, boulder/cobble substrate and moderate gradients. The lower section of the channel is a response reach with gradients from 2 to 8% with short, steep reaches of 16 to 35%.

Resident rainbow trout and YOY steelhead have been regularly observed in Sulphur Creek (CDFG 1988, CDFG 1999, among others). Coho and Chinook salmon have not been documented in this stream system and are unlikely to use the watershed due to downstream migration impediments in the East Branch North Fork and Sulphur Creek’s moderate channel gradient characteristics. The 1999 CDFG survey concluded the predominant use of the stream by fish ended 7,100 feet upstream of the mouth due to log debris accumulation and increased stream gradient. No fish were observed within 0.5 miles upstream of this point during the 1999 survey. An anecdotal, but as of yet, unconfirmed report suggests a permanent large boulder barrier exists approximately 9,200 feet up from the mouth.

Both the 1998 CDFG survey and data collected more recently at a permanent Aquatic Trends Monitoring (ATM) Station located approximately 0.5 miles upstream from the mouth suggest spawning substrates are not significantly embedded. However, the authors of this report observed relatively little in the way of suitable spawning substrates during a field trip in 2005, but instead noted a predominance of cobble and boulders in pool tail-outs. The most suitable substrates were observed in pockets within side channels and occasionally in pool tail-outs and in lower velocity areas along banks in the main channel.

The authors walked segments upstream of the ATM monitoring reach (Photo E-2) that were characterized (refer to the Stream Channel Assessment report [Appendix D] Figures 14 and 15) as “earthflow flats” (low gradient, unconfined with floodplains) and observed high amounts of stored alluvial sediments within narrow floodplains on either side of the active channel. It was evident that the active channel was cutting through this material, leaving terraces 4 to 5 feet high in many locations. These observations were consistent with past observations made by CDFG (1988) that Sulphur Creek was recovering from past floods as indicated by “flood terraces.”

A comparison of CDFG stream surveys (Table E-4) suggests overall pool habitat decreased slightly from 1988 to 1999 while average pool depth increased by nearly 150 percent. Canopy closure increased significantly over the same decade from 30 percent in 1988 following logging operations along the west side of the lower portion of the basin to 72 percent in 1999. More recent habitat surveys conducted by PALCO biologists in 2005, starting at the mouth and continuing upstream for a distance of 4,100 feet, reported a small but further decline in overall percent pool area while average pool depths and overstream canopy closure increased. The 2005 survey data suggested large wood storage in the system was low compared to ATM data taken in 2004 and 2006.

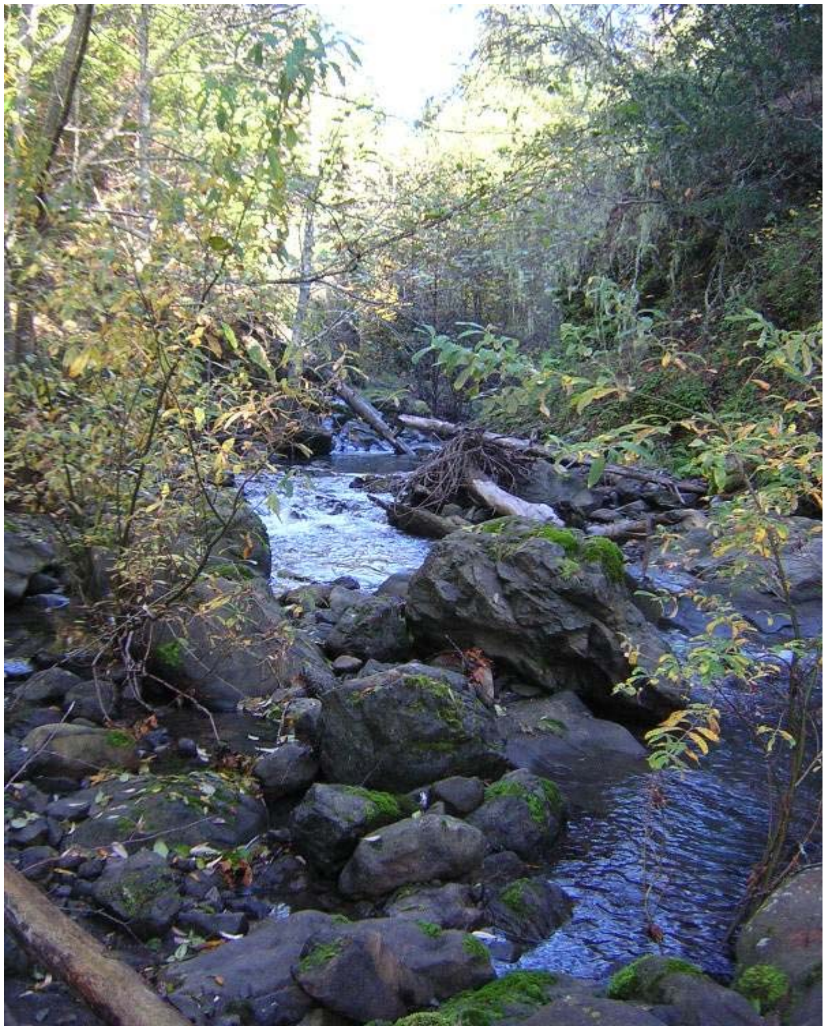


Photo E-2. Sulphur Creek, upper end of ATM monitoring reach, September 2005.

Data collected at ATM 133, which monitors a shorter 1,000 foot stream reach, indicates average residual pool depth has increased over the past decade, but remains shallower than the PFC target depth of three feet (Table E-8). Pools associated with large woody debris have met PFC targets consistently for the last seven years. Percent pool habitat within the ATM reach has fluctuated up and down over the past decade, meeting PFC targets at the start of the decade before failing to do so for a five-year period until 2009 when the target was again met. Temporal and spatial variations in these parameters may result to some extent from methodology, i.e. permanent ATM stations versus periodic stream habitat surveys. However, the data appear to support findings in the Stream Channel Assessment terrain analysis that indicate high spatial variability of physical parameters, which drive localized habitat conditions.

The observed increase in average residual pool depth reflects ongoing localized scour at permanent boulder and bedrock structures. It would also seem to suggest a rate of sediment delivery from hillslopes commensurate with or less than what the stream is capable of transporting downstream.

ATM data show a high percentage of pools associated with LWD (Table E-8). However, much of Sulphur Creek is boulder-dominated and has a channel gradient and configuration such that LWD would not typically be expected to play a significant morphological role in channel or habitat form. While it is well established that the primary functions of large wood include pool formation, providing cover, and storing sediment; generally these functions occur in relatively low gradient channels with deformable gravel beds. Furthermore the authors observed a general lacking of LWD recruitment potential in landslide driven (inner gorge) recruitment zones within the lower basin due to past timber harvesting. Further analysis of piece size may be of interest to assist in determining the origin of the LWD.

CDFG reported that stream temperatures ranged from 16 to 25°C (air 26 to 28°C) in September 1988 and 13.3 to 19.5°C (air 18 to 29.5°F) in June 1999, indicating that summer and fall water temperatures in many areas exceed those preferred by salmonids and reach lethal levels. PALCO, and more recently HRC, staff collected stream temperature data using continuous data loggers during the summer months from 1999-2010 at ATM station 133 and reported the following MWAT values (Figure E-5): 18.1°C (1999); 18.6°C (2000); 18.0°C (2001); 17.1°C (2002); 19.0°C (2003) 17.9°C (2004); 19.6°C (2006); 16.3°C (2007); 16.5°C (2008); 16.1°C (2009) and 15.4°C (2010). Through 2006, these values exceeded the APFC target MWAT value of 16.8°C. However, the MWAT target has been achieved since then, presumably due at least in part to the growth and maintenance of abundant streamside canopy cover.

Benthic macroinvertebrate data indicates good biotic conditions in Sulphur Creek over the period sampled (1998-2001). Sampling was conducted by PALCO staff at the ATM station in Sulphur Creek. Taxa richness values indicated that diversity has been relatively consistent over the sampling period. A decrease would indicate increasing perturbation. Percent scrapers indicated that a significant proportion of the sample was comprised of specialized feeders, as opposed to generalists such as collectors and filterers. Specialized feeders are more sensitive and are thought to be well represented in healthy systems (Barbour et al. 1999). This metric indicates a stable and abundant trend over the period of sampling. The EPT ratio also indicated good biotic conditions. Samples had a relatively even distribution among all four major groups. An increase in the proportion of EPT was evident in the most recent (2001) sample (27.5% Chironomidae and 57.8% EPT) indicating improving biotic conditions. In general, skewed populations having a disproportionate number of Chironomidae relative to more sensitive organisms indicate environmental stress. The Hilsenhoff biotic index decreased over the sampling period also indicating improved biotic conditions. This index uses tolerance values to weight abundance in an estimate of overall pollution, and an increase in this index indicates increasing perturbation (Barbour et al. 1999).

In addition to the mainstem, CDFG conducted habitat inventories on two Sulphur Creek Tributaries (tributary #1 and #2) on June 29-30, 1999 (Map E-8). Sulphur Creek Tributary #1 provides 0.9 miles of perennial stream habitat in its lower reaches, is gravel dominated, meandering, deeply incised in gentle terrain with a moderate to high sediment supply. Water temperatures ranged from 14.5 to 16ºC (air 21 to 24.5ºC) and canopy was 87%. Sulphur Creek Tributary #2 provides approximately 1.2 miles of perennial stream habitat in its lower reaches, is moderately entrenched with gravel substrate. Channel morphology is riffle dominated with infrequently spaced scour pools. Stream temperatures were 17ºC (air 13.9-18.3ºC) and canopy density was 64%. Thus, Tributaries #1 and #2 likely provide critical thermal refugia for salmonids in their lower reaches during summer and fall months and cool water inflows to Sulphur Creek as well as provide critical spawning sites for steelhead.

Table E-8. Sulphur Creek habitat conditions relative to PFC (ATM #133).

	Parameter	PFC Target	Measured Value (2009 ATM data)	Meets Goal or Quality Rating
ATM Stream Reach Information	Channel Type		response	
	Bankfull Channel Width (ft)		43	
	Length (ft)		1,056	
	Basin Area (acres)		~2,560	
	Dominant Geology of Class I		Coastal Belt FC	
Pools	Pool Frequency (cw/p)	<6 cw/p	3.4	yes
	Ave. Residual Pool Depth (ft)	>3 ft	1.54	no
	% Pool Area	>+25% area	31%	yes
	% Pools Associated with LWD	50%	86%	yes
	% Pools >=3 ft Deep	>50%	0%	no
LWD	Volume LWD/100 ft.	395.3	213	no
	# Key Pieces / 100 ft	1.4	0.57	no
	Ave. Key LWD Piece Volume (ft^3)	144.9	264	yes
	# Key LWD Pieces / CW	0.5	0.08	No
	#Tot Pieces / CW	2.59	0.43	No
Substrates				
	Percent <0.85mm	11-16%	5.6	yes
	Percent <6.34mm	<30%	14.0	yes
	D_{50} of Surface Particles	64-96 mm	69	yes
Canopy	Canopy closure %	>85%	80%	no
Temperature	MWAT (^{o}C)	<16.8	15.4 (2010 data)	yes

Summary:

- The lower reach of Sulphur Creek and several of its tributaries provides spawning and rearing habitat for steelhead and resident rainbow trout.
- Pool habitat area has fluctuated over the past decade while average residual depth has deepened until reaching a plateau currently less than the PFC target of 3 feet.
- The role of LWD in aquatic habitat development appears limited throughout most of the sub-basin due to channel gradient, configuration, and substrate characteristics.
- LWD recruitment potential has been adversely impacted in lower basin by 1980s intensive timber harvesting within historical wood recruitment zones.

- Large amounts of stored sediment remain in old flood terraces adjacent to the channel in reaches upstream of the ATM station.
- Riparian canopy cover has recovered in part since harvest-related reductions in the 1980s and nearly meets PFC targets, although it is predominantly comprised of hardwoods and young conifers in the lower reaches.
- Stream temperatures have met PFC targets consistently over the last several years.
- Tributary #1 and #2 (and possibly others that were not measured) provide critical thermal refugia, cool-water inflow, and suitable spawning substrate for steelhead and resident rainbow trout.

4.2.3.5 McGinnis Creek

McGinnis Creek is a major tributary to the Mattole River (at 040º21’11.55”N/ 124º09’50.23”W) draining approximately 4,700 acres and providing 5 miles of perennial fish-bearing stream habitat (Downie et al. 2003). HRC owns and manages approximately 2,200 acres of the watershed including 3.6 miles of fish-bearing habitat (Maps E-4, E-7, and E-10). While the authors could find no record of documented detections, McGinnis Creek appears the most likely stream on HRC’s Mattole ownership to provide readily accessible habitat for Chinook and coho salmon. Several habitat typing surveys of McGinnis Creek have been conducted (CDFG 1966, 1985a, 1999, PALCO 2005) and HRC maintains a recently established (2005) permanent ATM station approximately 0.5 miles upstream from the mouth (ATM Station 219). The system appears to have a moderate to high sediment supply as evidenced by depositional features such as point bars and aggraded channel conditions. The channel is susceptible to shifts in both lateral and vertical stability associated with changes in flow and sediment regimes.

Spawning habitat is abundant in lower reaches and is of fair to good quality with PFC streambed targets being met for two out of three categories in 2009 (Table E-9). Pool habitat has fluctuated from 20 to 32 percent over the last 25 years and is currently at the upper end of that range meeting PFC targets for pool frequency, overall percent habitat, and association with LWD. However quality of rearing habitat appears limited due to lack of pool depth and cover, although some improvement has been seen in recent years. Rearing habitat improves inherently with a change in channel geomorphology approximately 6,800 feet upstream with a marked increase in boulder substrate, woody debris, and instream cover as noted by CDFG (1985a) and the authors in 2005.

Past surveys (CDFG 1966c; 1999) indicate that until recently, summer water temperatures have been a limiting factor for rearing juvenile salmonids in lower reaches, but that temperatures have historically decreased in upstream reaches to within preferred ranges due in large part to topographic shading. More recently, a decrease in lower reach stream temperatures favorable to salmonid life cycles has been reported. The authors obtained a single temperature and DO reading in McGinnis Creek on September 15, 2005, near the mouth: water temperatures were 11ºC at 10:00 a.m. and DO concentrations were 11.7 ppm. Water temperatures in Conklin Creek, on the same day at 9:00 a.m. were 12.8ºC and DO was 10.6 ppm. Stream temperature data collected at ATM station 219 since 2005 using continuous data loggers during the summer months has reported the following MWAT values (Figure E-5): 17.1°C (2005); 19.0°C (2006); 17.9°C (2007); 17.4°C (2008); 16.2°C (2009) and 15.2°C (2010). The improvements in temperature correlate with an observed increase in canopy density provided primarily by hardwoods on floodplains and stream banks. Hardwood stands in floodplains appear somewhat transient and are likely periodically reset by flood events. Streambanks in lower reaches are susceptible to accelerated bank erosion and rates of lateral adjustment (meandering) appeared to be influenced by the presence, condition and maturity of riparian vegetation.

The authors walked the lower and mid-reaches of McGinnis Creek in September 2005 (Photo E-3) and again in October 2010 (Photo E-4). In 2005, the authors observed that pool frequency was low and that shallow flatwater units were the dominant habitat type. Lower reaches were severely aggraded, with little structure or habitat complexity. Biologists surmised that large wood may be buried under the abundant, smaller sized bed material. The lack of wood, boulder or root wad structure resulted in fairly homogenous habitat. Small, critically important micro-pool habitat features formed at hard points in the channel such as at infrequent small boulders, bedrock and small wood pieces. Mid- to upper reaches were confined by steep bedrock inner gorges, and were dominated by riffle habitat with larger substrates. Consistent with the 1985 CDFG survey, rearing habitat was observed to improve in these reaches due to increased structure and associated scour. Topographic shading is provided in mid-reaches.

During the 2010 field visit, the biologists observed that habitat complexity appeared to have improved during the preceding 5 years. The lower reach was meandering through the alluvial deposits, which resulted in some bank erosion, pool formation, and delivery of alder-dominated large and small woody debris along the outside of the meander bends (Photo E-4; note exposed woody debris, root mass, and pool with alder woody debris recruitment). Pools were also observed along bedrock exposures. It appeared that pools made up about 40% of the stream length. Pool depths ranged from about 1.5 to 3 feet. Evidence of channel downcutting was present as seen by relatively recent exposures of old alder stumps that were previously buried under alluvium. The majority of pools observed in 2010 resulted from development of the meander pattern and associated scour around the recruited hardwood woody debris.

YOY steelhead have been described as “extremely abundant” (Coastal Headwaters Association 1983) and one hundred YOY steelhead per 100 m of stream was estimated by CDFG in 1985. A 10-foot bedrock fall was identified by CDFG (Downie et al. 2003; CDFG 1966c) as being a barrier to coho and Chinook salmon, located 1.6 miles upstream from the mouth. A 20-foot fall was identified by CDFG (Downie et al. 2003) as being a barrier to steelhead, located five miles upstream of the mouth. Subsequent surveys have not noted this barrier because surveys ended downstream.

Photo E-3. McGinnis Creek, lower reaches, September 2005.

Photo E-4. McGinnis Creek, lower reaches, October 2010.

Table E-9. McGinnis Creek habitat conditions relative to PFC (ATM #219).

	Parameter	PFC Target	Measured Value (2009 ATM Data)	Meets Goal or Quality Rating
ATM Stream Reach Information	Channel Type		response	
	Bankfull Channel Width (ft)		44.3	
	Length (ft)		1,037	
	Basin Area (acres)		~3840	
	Dominant Geology of Class I		Coastal Belt FC	
Pools	Pool Frequency (cw/p)	<6 cw/p	2.9	Yes
	Ave. Residual Pool Depth (ft)	>3 ft	1.67	No
	% Pool Area	>+25% area	32.0%	Yes
	% Pools Associated with LWD	50%	50%	Yes
	% Pools >=3 ft Deep	>50%	6%	No
LWD	Volume LWD/100 ft.	355.7	34	No
	# Key Pieces / 100 ft	1.9	0.10	No
	Ave. Key LWD Piece Volume (ft^3)	106.9	72	No
	# Key LWD Pieces / CW	0.5	0.01	No
	#Tot Pieces / CW	2.59	1.0	No
Streambed				
	Percent <0.85mm	11-16%	6.7	Yes
	Percent <6.34mm	<30%	20.5	Yes
	D_{50} of Surface Particles	64-96 mm	47	No
Canopy	Canopy closure %	>85%	95%	Yes
Temperature	MWAT	<16.8°C	15.2 (2010 data)	Yes

Summary:

- While use has not been documented, McGinnis Creek provides potential Chinook and coho salmon habitat. Steelhead use is well documented.
- McGinnis Creek provides an abundance of suitable spawning habitat.
- Lack of pool depth and cover have historically been limiting factors to rearing habitat value for juvenile salmonids; however pool depth and association with LWD has improved in recent years.
- Summer temperatures in lower reaches have improved in recent years meeting PFC targets in 2009 and 2010.
- Downie et al. (2003) reported a barrier to Chinook and coho salmon located 1.6 miles upstream from the mouth and a barrier to steelhead migration five miles upstream of the mouth.

- Could benefit from additional instream LWD and off-channel habitat development to improve conditions for juvenile coho salmon rearing.

4.2.3.6 PRITCHARD CREEK

Pritchard Creek is tributary to the Mattole River (at 040º19’4.96”N/124º11’19.88”W) draining a watershed area totaling 4,762 acres and providing 5.2 miles of perennial stream habitat (Downie et al. 2003). HRC owns and manages 817 acres in the watershed including 2.3 miles of fish-bearing habitat.

CDFG conducted stream surveys on August 6, 1966 and April 5, 1985, from the mouth upstream 3.0 miles and from the mouth upstream 1.5 miles, respectively. These historical surveys reported a stream with a 2 percent gradient in the lower that flows through flat open pastures with low unstable streambanks. Pritchard Creek has a south by southwest channel aspect, and lower reaches are dry during summer months. Further upstream, the channel has a 5% gradient and is confined within a V-shaped bedrock canyon with an abundance of hardwoods on banks and floodplains. The quality of spawning habitat was observed as good in 1966, but as poor in 1985 due to siltation and embeddedness, and angular substrates that are dominant in lower and upper reaches. The 1985 survey also reported poor rearing habitat due to aggradation, lack of pools, subsurface flows and warm summer temperatures. Wood storage was noted as occurring primarily within log jams caused by landslides and bank erosion.

Steelhead adults, fingerlings and redds have been documented (CDFG 1985b) in Pritchard Creek. A 10-foot waterfall bedrock barrier located 1.6 miles upstream from the mouth was noted in 1985 (CDFG). Based on Downie et al. (2003) distribution maps, Chinook salmon do not utilize Pritchard Creek, and the bedrock falls is likely a barrier to coho salmon, but not to steelhead.

Summary:

- Pritchard Creek provides habitat for steelhead up to headwater areas (no barriers identified) and coho salmon in the lower 1.6 miles downstream from HRC ownership.
- Chinook salmon do not utilize Pritchard Creek.
- Current habitat information is lacking.

4.2.3.7 UPPER NORTH FORK MATTOLE RIVER

The Upper North Fork Mattole River is a major tributary to the Mattole River providing 4.7 miles of low gradient perennial fish-bearing stream habitat up to “the forks” at the Oil Creek and Rattlesnake Creek confluence (Downie et al. 2003). As mentioned earlier, there is a discrepancy as to where the Upper North Fork Mattole River ends and Rattlesnake Creek begins. Based on information from CDFG (pers. Comm. S. Downie, CDFG, March 13, 2006) the Upper North Fork Mattole River is considered to end at “the forks”. However, maps and data bases maintained by PALCO (now HRC) show the Upper North Fork continuing upstream into the Rattlesnake Creek sub-basin (as delineated for watershed analysis). The brief discussion here focuses primarily downstream of “the forks”, while discussions specific to Oil Creek and Rattlesnake Creek are included in Sections 4.2.3.8 and 4.2.3.16, respectively.

CDFG (pers. Comm. S. Downie, March 13, 2006) reported that there have been reliable observations (by residents) of salmonids spawning in the mainstem Upper North Fork Mattole River and prior to the 1955 flood, there was increased spawning activity occurring in the mainstem. CDFG (pers. Comm. S. Downie, March 13, 2006) indicated that the Upper North Fork Mattole River is accessible to coho and Chinook salmon up to “the forks” (located at the confluence of Oil Creek). Barriers to coho and Chinook salmon are reportedly located 4,000 feet upstream from “the forks” within Oil Creek (downstream of HRC property) and in Rattlesnake Creek/Upper North Fork Mattole just upstream of the confluence with Oil Creek. Welsh et al. (2001) reported an MWAT of 21.5°C in the Upper North Fork Mattole River and no coho salmon were documented during the coho distribution study. The MSG (2009) reported an MWAT for 2008 of 20.8°C approximately 4 miles downstream of HRC property. Steelhead fry, fingerlings and age 1+ steelhead have been documented (CDFG 1966g; Coastal Headwaters Association 1982) in the Upper North Fork Mattole River.

HRC has only minimal ownership of lands draining directly to the Upper North Fork Mattole River downstream of the Oil/Rattlesnake confluence (Map E-3).

4.2.3.8 OIL CREEK

Oil Creek is tributary to the Upper North Fork Mattole River (at 040º17’27.52”N/ 124º06’36.53”W) and has a watershed area totaling 6,089 acres, of which 4,023 acres are owned by HRC and managed under the HCP. The Oil Creek mainstem provides 4.6 miles of perennial stream habitat (Downie et al. 2003); perennial stream habitat also occurs in the Oil Creek tributaries of Green Ridge Creek (2.0 miles) and Devils Creek (2.3 miles) (Downie et al. 2003). Discussion specific to Green Ridge Creek and Devils Creek can be found in Sections 4.2.3.9 and 4.2.3.15, respectively.

Multiple stream surveys have been conducted in Oil Creek over the years including by CDFG on August 16, 1966 (from the confluence, upstream four miles to the confluence of Devils Creek); by CDFG on August 5-7 and August 14, 1991 (starting from 3,000 feet up from the mouth upstream for 3.1 miles); and by PALCO biologists in 2005 (starting from 7,920 feet [1.5 miles] upstream of the mouth [near HRC’s property line] for 9,126 feet [1.7 miles] upstream, Table E-10.) Also, one pool was electro-shocked by CDFG on August 27, 1991, approximately 5,110 feet upstream from the mouth.

Oil Creek’s stream gradient on HRC ownership ranges primarily from 2-4 percent with short reaches up to 8 percent. Steelhead production has been well documented (CDFG 1966d; CDFG 1991c; Hopelain et al. 1997; PALCO 2005) and Oil Creek has been described as very productive by CDFG as evidenced by the over-all fitness of juvenile salmonids captured (pers. Comm. S. Downie, March 13, 2006). A 9-foot natural bedrock fall is located approximately 4,000 feet upstream from the mouth near the first major left bank tributary, and is considered to be a barrier to coho and Chinook salmon, but not to steelhead (pers. comm. S. Downie, CDFG, March 13, 2006). The authors observed an abundance of age 0+, 1+ and 2+ steelhead in pools upstream of this barrier on September 12, 2005. While potential exists downstream of HRC's ownership, no confirmed record of Chinook or Coho salmon use has been documented.

The author walked the lower reach of Oil Creek in 2005 and noted that the active channel was small relative to the bankfull channel, which was structurally controlled by steep eroding banks and inner gorges (Photo E-5). The active channel was subject to areas of vertical and lateral shifts that periodically cut through large deposits of alluvium stored in the floodplain, which indicated a high sediment supply. The young age of vegetation growing within the bankfull channel coupled with the transient appearance of stored alluvium also indicated that this was a high energy stream with flashy flows in response to storm events. Further discussion regarding the significant channel incision observed in Oil Creek can be found in Appendix D.

Oil Creek has a southeast facing basin, resulting in high amounts of solar radiation, and coupled with a general lack of riparian canopy, has elevated mainstem water temperatures that may be a limiting factor to rearing salmonids. The authors measured water temperatures in Tributary #5 (left bank) on September 12, 2005: temperatures were 13.3ºC, indicating that smaller tributaries, many of which have natural barriers in lower reaches, provide critical cool summer inflows to the mainstem. Thus, accessible lower reaches of these tributaries provide thermal refugia habitat. CDFG (pers. comm. S. Downie, March 13, 2006) reported that during electroshocking surveys conducted in Oil Creek from 1992-1995, surveyors had to begin shocking at daylight and quit by 9:00 a.m. due to high stream temperatures. CDFG surveyors noticed that juvenile steelhead utilized mainstem habitat during early morning hours (and presumably night time) and moved up into tributary mouths or held at cool seeps and springs during the hottest part of the day. An extensive forest fire occurred in this watershed in 1990 and may be partially responsible for the pockets of Douglas-fir regeneration growing along portions of the stream (pers. comm. S. Downie, CDFG March 13, 2006).

CDFG rated spawning gravel quality from 1991-1995 as fair to poor (percent <0.85 mm ranged from 13.4-22.2%). Embeddedness of spawning substrates was rated as fair to poor. Wood storage is low and streamside landslides are the dominant delivery mechanism. Pool quantity has increased over time and pool quality is fair (average residual pool depth was 1.6 feet). Pools are more abundant in upper reaches (Photo E-6). Although there are few deep pools, the availability of pool habitat does not appear to be a limiting factor for rearing salmonids. Pool spacing is controlled by bedrock and boulders and these permanent structures form the primary pools in upper reaches. Unstable eroding banks in lower reaches transition to bedrock banks in upper reaches, which are stable and contribute only small amounts of sediment during runoff. Lower reaches have erosive, steep banks (Photo E-7) that are subject to failure during bankfull events.

A quick field review of the lower 300 feet of Oil Creek was conducted on October 14, 2010. The biologists observed a pool:riffle ratio of about 1:1, pool depths of 1 to 2 feet, canopy closure of about 60%, and substrate dominated by boulders and small cobbles. The large substrate appeared to be relatively unembedded, which indicated that winter rearing habitat for steelhead (within the substrate) was likely of relatively high quality. The biologists also observed that age 2+ steelhead were very common, which supported the idea that winter rearing habitat was of fairly good quality.

Photo E-5. Oil Creek, upper reach, August 2005.

Photo E-6. Oil Creek just upstream of its mouth, October 2010.

Photo E-7. Oil Creek, lower reach, August 2005.

Table E-10. Oil Creek habitat conditions relative to PFC.

	Parameter	PFC Target	Measured Value (2005 Stream Survey)	Meets Goal or Quality Rating
Stream Information	Gradient/Channel Type		2-8% A1,B2, A2	
	Bankfull Channel Width (ft)		35.8	
	Class I Streamlength (ft)		26,664	
	Survey Length (ft)--CDFG Method		9,126	
	Basin Area (acres)		6,016	
	Dominant Geology of Class I		Coastal Belt FC	
Pools	Pool Frequency (cw/p)	<6 cw/p	3.03	yes
	Ave. Residual Pool Depth (ft)	>3 ft	1.6	no
	% Pool Area	>+25% area	46%	yes
	% Pools Associated with LWD	50%	6%	no
	% Pools >=3 ft Deep	>50%	14%	no
LWD	Volume LWD/100 ft.	392.8	14	no
	# Key Pieces / 100 ft	1.4	0.03	no
	Ave. Key LWD Piece Volume (ft^3)	168.2	352	yes
	# Key LWD Pieces / CW	0.5	0.01	no
	#Tot Pieces / CW	2.59	0.25	no
Streambed				
	Percent <0.85mm	11-16%	13-22%	no
	Percent <6.34mm	<30%	nd	nd
	D_{50} of Surface Particles	64-96 mm	nd	nd
Canopy	Canopy Type(% Conifer)	Conifer>75%	39%	no
	Canopy closure %	>85%	51%	no
Temperature	MWAT	<16.8^{o}C	nd	nd

Summary:

- The lower 4,000 feet of Oil Creek is accessible to coho and Chinook salmon, downstream of HRC lands.
- On HRC lands, Oil Creek provides habitat for steelhead and rainbow trout.
- Summer and fall water temperatures in the mainstem are likely a limiting factor for rearing juvenile salmonids.
- Good quality winter rearing habitat for steelhead is available within large substrate interstitial spaces.
- Small tributaries to Oil Creek provide critical refugia and cool water inflows to Oil Creek.

- Steelhead migration barriers have not been documented within the mainstem.
- Spawning habitat is abundant but substrate quality is fair to poor due to relatively high embeddedness levels.
- Large wood storage is low.
- Pool habitat is more abundant in upper reaches however there are few deep pools.

4.2.3.9 LEFT BANK TRIBUTARY #1 TO OIL CREEK (GREEN RIDGE CREEK)

Left Bank Tributary #1 to Oil Creek (Green Ridge Creek, see Photo E-8) is a second order tributary to Oil Creek (at 040º18’45.44”N/ 124º08’11.60”W). Left Bank Tributary #1 is a very well confined, steep, boulder dominated channel that provides 6,800 feet of habitat for steelhead and rainbow trout until migration is impeded by a natural boulder barrier.

A stream survey was conducted by CDFG on September 9, 1991, from the mouth upstream 3,710 feet (0.7 mile). The CDFG also conducted fish monitoring on a 65-foot reach in 1993-1995. Electro-shocking and a barrier survey were conducted by PALCO biologists in August 2005 starting from 4,830 feet (0.9 mile) upstream of the mouth to 466 feet (to the confluence of Oil Creek Tributary #2). In addition, Left Bank Tributary #2 was electroshocked to identify the upstream extent of fish migration/use.

Stream gradients are between 4-12% in lower reaches, increasing in upper reaches to an average of 8 to 20%, with some short reaches approaching 35%. Boulders are the pool forming structure, and also provide abundant cover and channel bed and bank stability. Spawning substrates are limited to small pockets behind boulders and quality has improved over time: percent fines <0.85 mm ranged from a high of 44.7% in 1992 to a low of 7.5% in 1995, possibly related to recovery after an extensive forest fire that burned in this watershed in 1990. Large wood storage is low. The function of large wood is reduced relative to pool formation and cover, which is provided by bedrock and boulders. Pieces of large wood observed by surveyors were suspended over the channel.

High gradient step runs and flatwater habitat are the dominant habitat types. The authors observed moderate size streamside landslides associated with an old road that runs parallel to the left bank.

Steelhead (YOY) have been documented in Left Bank Tributary #1. CDFG (1997) conducted depletion sampling and reported that population estimates for the period of 1993 to 1995 ranged from 8 to 82 fish. In 2005, PALCO biologists observed high densities of fish up to a migration barrier (a boulder step) located 6,800 feet upstream from the mouth. The high densities of fish in this small tributary confirmed earlier observations made by CDFG that higher water temperatures in the mainstem of Oil Creek drive fish up into tributaries. Left Bank Tributary #1 was revisited by PALCO biologists and the author on September 12, 2005, and juvenile steelhead were absent, possibly indicating that water temperatures had cooled in Oil Creek and fish had moved downstream. Hopelain et al. (1997) noted that coho salmon were not observed in any of the Upper North Fork Mattole River Tributaries sampled including Left Bank Tributary #1.

Water temperature data are limited but indicate that summer water temperatures are not a limiting factor for salmonids. This tributary provides critical thermal refugia during summer months for rearing salmonids. Shade canopy is low, however, this is a high energy, steep gradient stream that is predominantly step runs, step pools and plunge pools. Solar radiation may have less of an influence on water temperatures relative to the dynamic physical conditions of the stream coupled with adequate base flows.

Photo E-8. Left Bank Tributary #1 (Green Ridge Creek), upstream migration barrier, August 2005.

Summary:

- Left Bank Tributary #1 to Oil Creek provides 6,800 feet of habitat for steelhead and rainbow trout.
- A steelhead migration barrier is located 6,800 feet upstream from the mouth.
- Lower reaches provide critical thermal refugia for rearing salmonids.
- Left Bank Tributary #1 has little suitable spawning habitat.
- Water temperature data are lacking, but historic data and recent fish observations indicate that this creek provides thermal refugia in summer months.
- Embeddedness ratings and McNeil samples indicate poor quality spawning substrates, likely due to frequent streamside landslides and past fires.
- Large wood storage is low. Large wood function is limited relative to habitat forming structure due to steep, deeply entrenched, boulder dominated step pool morphology.

- Pools are relatively shallow however the depth of pools does not appear to be a limiting factor for rearing salmonids.

4.2.3.10 LEFT BANK TRIBUTARY #2 TO OIL CREEK

In 2005, PALCO biologists conducted a barrier survey in Left Bank Tributary #2 to Oil Creek. Left Bank Tributary #2 has a south by southwest channel aspect. Channel gradients range from 10 to16%. PALCO biologists surveyed from the mouth upstream 740 feet and noted that the first 96 feet of the channel was dry. A migration barrier was documented 334 feet upstream from the mouth (2,296 feet upstream from Oil Creek), consisting of a boulder cascade measuring 49.5 feet long with a gradient of 28%. Inner gorge landsliding was common and substrates were predominantly cobble and boulders (Photo E-9). Large wood was more common relative to other streams. High sediment inputs associated with land sliding were causing aggradation and subsurface flows in lower reaches.

Photo E-9. Left Bank Tributary #2 to Oil Creek, August 2005.

4.2.3.11 LEFT BANK TRIBUTARY #3 TO OIL CREEK

PALCO biologists conducted an electro-shocking and migration barrier survey during August 2005 on Left Bank Tributary #3 (Photo E-10) from the confluence upstream 355 feet (refer to Map E-9). This tributary has a southwest channel aspect. Channel gradients are between 20-30%. The surveyed reach was 100% riffle habitat with a cascade located near the mouth, which was determined to be an upstream migration barrier for steelhead. Three other barriers were documented upstream of the mouth, all boulder/gradient barrier types. Streamside landslides were common and caused aggradation and subsurface flow upstream of the survey. PALCO biologists indicated that the stream would not support fish due to its excessive gradient and barrier near the mouth.

Photo E-10. Left Bank Tributary #3 to Oil Creek, August 2005.

4.2.3.12 RIGHT BANK TRIBUTARY #4 TO OIL CREEK

PALCO biologists conducted an electro-shocking and barrier survey in Right Bank Tributary #4 (Photo E-11) in August 2005 starting 468 feet upstream from the confluence with Oil Creek. This tributary has an east by northeast channel aspect. Channel gradients range from 10-14%. Three barriers were identified (Table E-3). The first barrier was located 671 feet from the mouth. Barriers were comprised of boulder and wood or bedrock. Substrates are predominantly cobble and boulder. Inner gorge areas and stream banks appeared stable, with few landslides. Relatively significant amounts of large wood were observed in the channel.

Photo E-11. Right Bank Tributary #4 to Oil Creek, upstream migration barrier, August 2005.

4.2.3.13 Right Bank Tributary #5 to Oil Creek

PALCO biologists conducted an electro-shocking and barrier survey on Right Bank Tributary #5 in August 2005, from the mouth upstream 117 feet (refer to Map E-9). This tributary has a northeast channel aspect. Channel gradients are predominantly in the range of 20-30%, with numerous reaches over 30%. PALCO biologists identified a migration barrier at the mouth that consisted of a boulder cascade measuring 40 feet long with a gradient of 50%. Two more barriers were identified upstream within the survey reach.

4.2.3.14 Left Bank Tributary #6 to Oil Creek

PALCO biologists conducted an electro-shocking and barrier survey on Left Bank Tributary #6 in August 2005, from the mouth upstream 480 feet. This tributary has a south by southwest channel aspect. Channel gradients average 10% in lower reaches, but increase upstream to 8-20%. PALCO biologists identified a migration barrier consisting of a boulder cascade located 194 feet upstream from the mouth. Extensive inner gorge landslides were observed throughout and above the survey reach, resulting in aggradation and associated degraded habitat. CDFG (pers. Comm. S. Downie, CDFG, on March 13, 2006) refers to this stream as Tent City, and indicated that steelhead have been documented in the lower reaches and that a culvert and road crossing exists that needs upgrading.

4.2.3.15 Devils Creek

Devils Creek is the largest tributary to Oil Creek (at 40º19’29’ N. latitude, 124º08’41”W) in its headwaters and has a watershed area of 1,613 acres. Devils Creek provides a total of 2.3 miles of perennial stream habitat (Downie et al. 2003). Portions of this sub-basin were subject to extensive forest fires in the summer of 1990. The channel aspect is south by southwest and only portions of the two main forks of this drainage are located within HRC holdings. On HRC lands, gradients range from 8 to 30%.

Stream surveys were conducted by CDFG on August 16, 1966 (from the mouth upstream 1.5 miles) and on August 7-8, 1991 (from the mouth upstream 1.4 miles). Both CDFG surveys were conducted primarily downstream of PALCO (now HRC) lands, although the 1966 survey contained 600 feet of survey reach on HRC lands within the branch of Devils Creek.

The lower 1.5 miles of Devils Creek is moderately entrenched with gradients of 2-4%, channel bed morphology is dominated by boulders and habitat is characterized by a series of rapids with irregular spaced scour pools. The lower reaches provide areas of good spawning gravels. Rearing habitat is limited due to shallow pools. Upstream, the channel is steep, deeply entrenched and confined in course depositional materials dominated by cobble. The stream is high energy with a high sediment supply. Banks are unstable and contribute large amounts of sediment.

Based on limited data, summer water temperatures appear to exceed those preferred by salmonids and canopy density is low. Spawning gravels are limited and stored in pools. Cobble and boulder are dominant in pool tail-outs. Boulders provide the dominant pool forming structure and cover. Pools are shallow and step runs are the dominant habitat type.

Steelhead have been documented in Devils Creek (CDFG 1966b). The only potential observation (unconfirmed) of coho salmon on PALCO (now HRC) lands in the Mattole River basin occurred in Devils Creek. This observation was made by CDFG in 1966, from the bank, and is suspect given the complete absence of coho salmon observations in all other surveys in downstream areas (refer to discussion in Section 2.2.3).

Summary:

- Devils Creek provides 6,000 feet of habitat for steelhead and rainbow trout primarily where the stream flows through lands not owned by HRC.
- No current data on stream temperatures is available. Limited information indicates that temperatures may be a limiting factor to summer rearing.
- Spawning substrates are limited.
- Pools are boulder formed and step runs are the dominant habitat type.

4.2.3.16 RATTLESNAKE CREEK/UPPER NORTH FORK MATTOLE

The Rattlesnake Creek sub-basin (Map E-3) is tributary to the Upper North Fork Mattole River (at 40º17’34.47 N. latitude and 124º 05’49.85”W). The sub-basin drains 5,711 acres, of which 4,757 acres are owned and managed by HRC. Discussion of the sub-basin can be confounded by a discrepancy in where the Upper North Fork Mattole ends and Rattlesnake Creek begins. Lower Rattlesnake Creek and its first significant Left Bank Tributary were referred to as the Upper North Fork Mattole River in PALCO habitat data files and on maps inherited by HRC; while CDFG (pers. Comm. S. Downie, CDFG, March 13, 2006) considers the Upper North Fork Mattole River to end at its confluence with Oil Creek (“the forks”). Both names are often used in reference to this lower reach. In any event, beginning at the confluence with Oil Creek, the mainstem provides a total of 4.8 miles of perennial stream habitat (Downie et al. 2003); while the entire sub-basin provides an estimated 14 miles of fish-bearing habitat including the Rattlesnake/Upper North Fork mainstem and all tributaries including Fox Camp Creek (discussed in Sections 4.2.3.18 and 4.2.3.19). HRC’s ATM station #169 is located within the reach referred to as either Rattlesnake Creek (CDFG) or Upper North Fork Mattole (HRC).

Stream surveys were conducted by CDFG on August 16, 1966 (from the mouth upstream 3.5 miles) and on August 5-14, 1991 (from the mouth upstream 4.2 miles). Also, juvenile salmonid abundance surveys were conducted by CDFG from 1992-1994 and McNeil sampling was conducted from 1991-1995. Results were reported in Hopelain et al. (1997). In 2005, a habitat survey was conducted by PALCO biologists from the mouth upstream 4,489 feet.

Channel gradients in lower reaches typically range between 2-8%, with some short reaches of up to 16%. Upper reaches (upstream of the confluence with Fox Camp Creek) are steeper with average gradients between 8-16% and short reaches of 20%.
Steelhead have been documented in Rattlesnake Creek/Upper North Fork Mattole (CDFG 1966f; CDFG 1991d). The depletion sampling for 1992-1994, reported by Hopelain et al.

(1997), indicated that juvenile steelhead abundance had declined from 1992 (302) to 1994 (163).

The Stream Channel Assessment report (Appendix D) identifies distinct channel geomorphic units that, presumably, influence fish habitat conditions including a fluvial confluence zone near the mouth of Rattlesnake Creek, a rocky landslide influence zone upstream and a fluvial-moderate gradient zone above (refer to Figure 14 in the Stream Channel Assessment report [Appendix D]). PALCO biologists conducted habitat typing in 2005 starting at the mouth and continuing up through the fluvial confluence zone, just downstream of the landslide zone. The Stream Channel Assessment report (Appendix D) also describes Rattlesnake Creek, its tributaries, upper Oil Creek and Devils Creek as having a "semi-continuous streamside zone of earthflow or deep-seated landslide activity." As a consequence of these conditions, there is a high rate of sediment supply and many reaches appeared "open and disturbed" on air photos over time since the 1960s. These chronic sources of sediment cause large scale aggradation downstream (e.g. mouth of Upper North Fork Mattole River) and affect fish habitat on the reach scale. Thus, comparisons of habitat data collected from HRC's ATM station and habitat typing survey reach, both located within the fluvial confluence zone of Rattlesnake Creek/Upper North Fork Mattole, may not be useful in terms of obtaining trends in response to land management. Rather, changes in habitat attributes over time would more likely reflect inherent susceptibility of the fluvial confluence zone to periodic influxes of sediment from extensive streamside landslides (Photo E-12) that produce aggradation, followed by degradation/scour and other large scale channel changes associated with high sediment rates.

Past CDFG surveys occurred over all of the channel geomorphic units described above (from the mouth up 3-4 miles). CDFG surveys indicate that there has been a decrease in the number of pools relative to riffle habitat over the period of survey (1966 to 1991). In 1966, the first mile of the lower reach was described as containing good quantities of loose spawning substrate. By 1991, spawning habitat was described as poor, with 75% of pool tailouts described as heavily embedded (>50% embedded). McNeil samples were taken by CDFG in 1991, and a combined mean of 33% for fine sediments <4.7mm and the combined mean for sediments <0.86mm of 13% was reported. The 2005 pool tailout embeddedness measurements, by PALCO biologists, show substrate becoming less embedded since 1991 within the ATM station. Average pool tail substrate in reaches surveyed by PALCO staff was cobble in 2005.

PALCO biologists reported that the amount of available spawning habitat is low and wood storage was low in surveyed reaches. The function of large wood was limited in lower reaches relative to habitat forming structure due to large substrates. The amount of pool habitat was low; habitat was dominated by flatwater units, indicative of chronic sedimentation. The limited number of pools was associated with scour at boulders.

Summer water temperatures exceed those preferred by salmonids and are likely a limiting factor for rearing juveniles. Temperature data were collected at ATM station #169 from 1999-2010, providing the following MWAT values (Figure E-5): 20.0°C (1999); 20.8°C (2000); 19.9°C (2001); 18.9°C (2002); 20.3°C (2003); 20.6°C (2004); 21.7°C (2006); 18.3°C (2007); 18.0°C (2009); and 16.3°C (2010). No flow measurements were taken. All of these values exceed the APFC target MWAT value of 16.8°C, except the MWAT of 16.3°C for the most recent year (2010). Steep canyon walls provide some shade to the stream during a portion of the day, however, the channel is open and exposed for a majority of its length. Canopy density has increased over time due to hardwood growth near the channel, but over-all shade canopy is low.

Benthic macroinvertebrate sampling was conducted in Rattlesnake Creek/Upper North Fork Mattole at Station 169 located near the confluence (Map E-9) from 1998-2001. Taxa richness values indicated that diversity has been relatively consistent over the sampling period, with a slight decrease in 2000. The EPT ratio indicated degrading biotic conditions in the most recent sample (2001).

A field review was conducted in the lower 2,000 ft reach of Rattlesnake Creek/Upper North Fork Mattole during October 2010 (upstream of the confluence of the Upper North Fork Mattole with Oil Creek, see Photo E-13 and Table E-11). The stream in this reach had a 3-5% gradient, step pool morphology, with large cobble and boulder-dominated substrate. Spawning habitat was suitable for steelhead, but was restricted to small pockets of gravel. The large substrate and small gravel pockets were indicative a high energy stream. The large substrate was relatively unembedded and appeared to offer suitable high flow winter cover habitat for steelhead. Age 0+, 1+, and 2+ steelhead were observed throughout the reach.

Photo E-12. Rattlesnake Creek, streamside landslide, May 2005.

Photo E-13. Rattlesnake Creek/Upper North Fork Mattole River upstream of its confluence with Oil Creek.

Table E-11. Rattlesnake Creek (Upper North Fork Mattole) habitat conditions relative to PFC (ATM #169).

	Parameter	PFC Target	Measured Value (updated with 2010 habitat measurements)	Meets Goal or Quality Rating
ATM Stream Reach Information	Gradient/Channel Type		2-20/B2-B1	
	Bankfull Channel Width (ft)		37.4	
	Length (ft)		1,047	
	Basin Area (acres)		5,507	
	Dominant Geology of Class I		Coastal Belt FC	
Pools	Pool Frequency (cw/p)	<6 cw/p	4.7	yes
	Ave. Residual Pool Depth (ft)	>3 ft	1.60	no
	% Pool Area	>+25% area	26	yes
	% Pools Associated with LWD	50%	0%	no
	% Pools >=3 ft Deep	>50%	44%	no
LWD	Volume LWD/100 ft.	410.2	8	no
	# Key Pieces / 100 ft	1.1	0.0	no
	Ave. Key LWD Piece Volume (ft^3)	230.4	0	no
	# Key LWD Pieces / CW	0.5	0.00	no
	#Tot Pieces / CW	2.59	0.19	no
Substrates				
	Percent <0.85mm	11-16%	5.3	yes
	Percent <6.34mm	<30%	29.6	yes
	D_{50} of Surface Particles	64-96 mm	78	yes
Canopy	Canopy closure %	>85%	57%	no
Temperature	MWAT	<16.8^{o}C	16.3	yes

Summary:

- Rattlesnake Creek provides migration and rearing habitat for steelhead and rainbow trout.
- Spawning habitat is limited to small gravel pockets.
- Shade canopy is low.
- Large wood storage is low.
- Pool quality has generally increased over time, though pool depth was decreased in 2010 based on habitat measurements within the ATM station reach.
- Streamside landslides are common.
- Summer water temperatures are a limiting factor for rearing salmonids although the 2010 MWAT was slightly below the APFC target.

- Smaller tributaries provide critical thermal refugia.

4.2.3.17 Rattlesnake Tributary #1 (Upper North Fork Mattole)

Rattlesnake Tributary #1 is shown as the Upper North Fork Mattole in attached maps. CDFG considers this stream as a tributary to Rattlesnake Creek. Thus, both names will be used herein. PALCO biologists conducted electroshocking and barrier surveys on Rattlesnake Creek Tributary #1/Upper North Fork Mattole in 2005. This tributary has a north by northwest aspect. Channel gradients average 8-16% with short, steep reaches of 16-30% gradient. A 4.2-foot high bedrock step was observed 78 feet upstream from the mouth and is a barrier to upstream migration. A second barrier was identified 293 feet upstream from the mouth consisting of boulder and accumulated wood.

4.2.3.18 Fox Camp Creek

Rattlesnake Creek forks in its headwaters and the south fork is known as Fox Camp Creek. Fox Camp Creek has an 807-acre watershed area with average gradients of 4-12%, and short reaches of 16-30% gradient. A barrier to upstream migration exists 4,348 feet upstream from the confluence and consists of a 5.6-foot high bedrock step. Below the barrier, surveyors documented the presence of a distinct resident rainbow trout population and steelhead population. Resident fish displayed sides and ventral regions that were white with well pronounced rainbow patterning down the sides. Steelhead were darker in color, had an orange hue in the ventral region and appeared “smolty”. Stream temperatures in Fox Camp Creek were the lowest encountered by surveyors within PALCO’s (now HRC’s) ownership: afternoon temperatures were 16.1ºC while air temperatures were above 33.9ºC. Thus, Fox Camp Creek provides critical thermal refugia for salmonids as well as cool water inflows to Rattlesnake Creek.

4.2.3.19 Fox Camp Creek Tributary

In 2005, PALCO biologists conducted a barrier survey on a small right bank tributary to Fox Camp Creek, located approximately 5,000 feet upstream from Fox Camp Creek’s confluence. LIDAR gradient maps show approximately 300 feet of channel gradient in excess of 30% at the mouth, which constitutes a barrier to upstream migration (Oregon Department of Forestry and Oregon Department of Fish and Wildlife 1995, Sullivan 1997, Ministry of Environment Lands and Parks 2001, Latterell et al. 2003, and Bliesner and Robison 2005). Gradients remain too steep for the entire length of the tributary to support fish.

5.0 SUMMARY

In general, the majority of streams within HRC's ownership are smaller, lower order tributaries with steep gradients and low sinuosity that dissipate energy along the longitudinal profile in steps and pools. Tributaries on HRC lands are only known to be occupied by steelhead trout and resident rainbow trout. Although they haven't been observed, McGinnis, Oil, and Rattlesnake creeks are accessible to coho and Chinook salmon. Suitable habitat conditions for coho salmon exist in McGinnis Creek.

Geology is dominated by Franciscan Assemblages with a small amount of Yager Formation in the eastern portion, and small outcroppings of Quaternary River Terrace in the Oil Creek Drainage. Channel and valley morphology within HRC's ownership are the greatest influence on fish habitat including channel gradients, wood storage, gravel availability and storage, and fine sediment distribution. Landslides are the predominant wood recruitment mechanism and legacy effects of removing trees still affects wood loading. Reduced recruitment potential, smaller wood size, lateral shifting of channels in Oil Creek, Rattlesnake Creek, McGinnis Creek, and relatively high winter flow stream power also reduces wood storage. Over-stream shade canopy provided primarily by hardwoods has increased significantly in recent years along all surveyed fish-bearing tributaries due primarily to continued hardwood growth in floodplain areas.

Maximum Weekly Average Temperatures (MWATs) have been on the decline over the last three years and met NOAA Properly Functioning Condition (PFC) targets (<16.8 ºC) in all three permanently monitored streams in 2010 after observing a spike in water temperature in 2006.

Spawning substrate is limited to small pockets and side channels in most HRC streams, but generally considered fair to good in quality with PFC substrate targets being achieved in nearly all categories for the three permanently monitored streams (Sulphur Creek, McGinnis Creek, and Rattlesnake Creek). Pool habitat currently makes up approximately 26 to 32 percent of total aquatic habitat type in the monitored reaches of these three streams with average residual pool depths of 0.5 meters and deep pools are generally lacking. Fish habitat and riparian conditions are a result of periodic and frequent disturbance, primarily streamside landslides and mass wasting that continually reset instream habitat conditions.

Distinct relationships between channel morphology and valley morphology exist within HRC's ownership (HCP-covered lands), and are the greatest influence on fish habitat including channel gradients, wood storage, gravel availability and storage, and fine sediment distribution. Landslides are the predominant wood recruitment mechanism and legacy effects of removing trees from these areas still affect wood loading. Wood storage is low, also affected by channel morphology and stream power. The Stream Channel Assessment report (Appendix D) indicates that large segments of channels in the Northern Sub-basin have relatively low sedimentation potential (i.e. sediment accumulation potential) due to moderate gradients and generally confined channels resulting in high stream power. However, overall, most channels were predicted to have a moderate potential. Fish habitat (e.g. pools and spawning substrate) is periodically and frequently reset due to sediment inputs from streamside landslides, tributary debris flows and mass wasting. These processes dominate the landscape and drive existing conditions of fish habitat on HRC's ownership.

In general, the primary role of large wood in streams includes formation of pools, providing cover, and storing sediment. Generally, these functions of large wood occur in relatively low gradient channels with a deformable bed (i.e., gravels). HRC lands have a preponderance of moderately steep and boulder-bedded channels that result in habitat conditions that do not respond to large wood, i.e. large wood does not play a significant morphological role in channel form (see Stream Channel Assessment report [Appendix D]).

The Stream Channel Assessment used a computerized terrain analysis and identified a high degree of spatial heterogeneity in channel, valley, and near-stream environments. Physical parameters were highly variable including channel gradient, valley width, valley confinement, large wood accumulation, near stream roughness, tributary confluence effects, and sediment supply. The high degree of spatial variability in these parameters results in variable habitat conditions including substrate characteristics, wood storage and habitat patterns. Thus, habitat surveys represent local conditions, limiting the conclusions that can be drawn regarding overall habitat conditions.

5.1 HABITAT CONDITIONS BY SALMONID LIFE STAGE

5.1.1 ADULT MIGRATION

Streams on HRC's ownership provide migration routes for steelhead and rainbow trout, which are widely distributed. Chinook and coho salmon can access habitat in the WAU including the mainstem Mattole River, the North Fork Mattole River, East Mill Creek, lower reaches of the East Branch North Fork Mattole River, lower reaches of Conklin Creek, lower reaches of McGinnis Creek, Upper North Fork Mattole River and lower reaches of Oil Creek (see Maps E-5, E-6, and E-7). Within these watersheds, mainstem barriers to Chinook and coho upstream migration exist just downstream of HRC lands (with the exception of McGinnis Creek and possibly Rattlesnake and Oil creeks) and consist of natural bedrock and boulder falls coupled with steep stream gradients.

Steelhead have access to all major tributaries in the WAU and on HRC's ownership. There is one documented mainstem steelhead migration barrier in McGinnis Creek in upper reaches. In general, steelhead distribution is widespread and limited only by steep gradients in headwater reaches.

- The frequency, size and depth of pools along migration corridors in mainstem rivers are less than suitable for adult use during summer months.
- High summer and early fall water temperatures and low flows may be a limiting factor for adult migration of summer steelhead.
- Winter migration habitat is suitable due to increased flows.

5.1.2 ADULT SPAWNING AND EGG INCUBATION

- There is no documentation of coho or Chinook salmon spawning within HRC's ownership.
- Winter-run steelhead and resident rainbow trout spawn and rear within HRC's ownership.
- Spawning habitat is limited in HRC's ownership due to the relatively high gradient of the fishbearing channels and preponderance of large substrate (boulder and large cobble) in pool tailouts within HRC's ownership.
- With the exception of McGinnis Creek, spawning habitat occurs in small pockets within lower gradient reaches and side channels and is more suitable for steelhead than coho or Chinook salmon.
- Where available spawning substrate quality is fair to good and currently (2009 data) meets PFC targets for percent fines (0.85mm; 6.35mm) in most instances at permanent Class I monitoring stations (Sulphur Creek, McGinnis Creek, Upper NF/Rattlesnake Creek.

5.1.3 SUMMER REARING

- The quantity and extent of habitat data is insufficient to characterize trends in pool habitat given predicted high spatial variability in habitat conditions. Based on data available as of 2009, contemporary percent pool habitat area ranges from 26 to 45 percent with Rattlesnake Creek currently at the low end of the spectrum and Oil Creek at the high end. An average residual pool depth of approximately 0.5 meters is fairly consistent among the three ATM stations.
- Deep pools (>3 feet) are generally lacking in all mainstem reaches accessible to salmonids with the exception of the East Branch North Fork Mattole and Rattlesnake Creek.
- Subsurface flows occur in lower reaches of Pritchard Creek and Left Bank Tributary #2 to Oil Creek. Past CDFG surveys indicate more streams and more

extensive reaches with subsurface flows due to aggradation. However, flow information was lacking in all stream survey data.

- In general, larger order streams have high summer stream temperatures and, coupled with shallow pools, represent a potential limiting factor for salmonid rearing in the Mattole basin.
- Smaller order watercourses, including those on HRC property, tend to have cooler water temperatures and are therefore, critical to the survival of juvenile steelhead.
- The range of water temperatures documented in HRC's ownership during summer months appears to play a critical role in the distribution of juvenile salmonids. For example, surveyors observed that juvenile steelhead may utilize mainstem tributary habitat in early and mid-summer months then move up into small tributaries as temperatures warm in late summer. Diurnal migration of juvenile steelhead has also been observed as mainstem habitat becomes too warm, fish move upstream into lower reaches of small tributaries.
- Smaller tributaries have limited accessible habitat but provide critical thermal refugia in their lower reaches and cool water inflow to mainstem reaches including Left Bank Tributary #1 to Oil Creek (Green Ridge Creek) and Fox Camp Creek. Other small tributaries may also provide cooler summer inflows to mainstem habitat but summer temperatures have not been measured in all small tributaries.
- Large wood storage is low across streams in HRC's ownership. The number of debris jams documented by CDFG in the past indicated more storage occurred in the past. However, debris jams may have been associated with past logging practices.
- Streamside landslides are the dominant large wood delivery mechanism.
- Large wood function relative to pool formation and habitat complexity is reduced in tributaries on HRC lands due to channel bed form/large substrates.
- Boulders, rather than large wood, are the dominant pool-forming structure in many streams within HRC's ownership and are the dominant pool cover type.

5.2 SALMONID DISTRIBUTION AND ABUNDANCE

The Mattole River is impaired with regard to temperature, turbidity, and sedimentation affecting the distribution and abundance of salmonids in the basin, including within the WAU and on HRC lands.

The Mattole River historically produced large runs of salmon and steelhead; however, habitat quality and quantity has been reduced and populations are depressed in the basin. Historic and current distribution and abundance information for salmonids within the WAU and HRC ownership is lacking.

Large-scale changes to the Mattole River, including the WAU, occurred in response to the 1955 and 1964 floods, which coincided with peak years of logging and road building in the basin.

Salmonid production has been reduced due to the massive amount of sediments stored in the mainstem Mattole River as well as in response reaches of tributaries, contributed from higher gradient tributaries including from streamside landslides. This stored sediment has impacted fish habitat quality and quantity.

The WAU provides an abundance of suitable habitat for steelhead. Channels with gradients from 3-5% with step pool morphology are abundant. These channel types are relatively resilient to impacts and recover relatively rapidly following disturbance (see Stream Channel Assessment report [Appendix D]).

Estuary habitat, a crucial link in the life cycle of Pacific salmonids, has been reduced by excessive sedimentation, which has also resulted in higher water temperatures and adverse impacts to food resources. Reduced function and habitat quality in the estuary continues to impact the abundance of salmonids in the Mattole River basin and the WAU.

Elevated summer water temperatures are one of the primary limiting factors for salmonids rearing in the Mattole River basin and impair salmonid production at the watershed, stream and reach scales in the WAU.

The range of water temperatures documented in the WAU during summer months appears to play a critical role in the distribution of juvenile salmonids and ultimately adults returning to natal streams.

5.3 OPPORTUNITIES

The following opportunities were identified through the Fish Habitat Module analysis:

- Conduct spawning surveys for coho and Chinook in McGinnis Creek.
- Investigate the feasibility of placing large wood in lower McGinnis Creek and constructing off-channel habitat.
- Coordinate with CDFG and repeat steelhead monitoring done by CDFG in Oil Creek in past years.
- Investigate potential restoration opportunities on an old road and culvert in Left Bank Tributary #6 to Oil Creek (identified by CDFG) and on an old skid trail that runs parallel to lower Left Bank Tributary #1 to Oil Creek (Green Ridge Creek).
- Consider modifying habitat typing reaches in Oil Creek and Rattlesnake Creek/Upper North Fork Mattole to span fluvial moderate gradient zones, excluding more dynamic channel geomorphic units such as debris flow confluence zones, rocky landslide zones and earthflow flats.
- Conduct electro-shocking surveys in upper reaches of Sulphur Creek, upstream of a barrier identified by CDFG, to investigate whether fish are above the barrier.

5.4 CRITICAL QUESTIONS

1. **What is the distribution of each salmonid species in the WAU?**

   Refer to Maps E-5, E-6, and E-7. Steelhead and rainbow trout are widely distributed in the WAU and HRC ownership. Within the WAU, Chinook and coho salmon can access the mainstem Mattole River, the North Fork Mattole River, Mill Creek, lower reaches of the East Branch North Fork Mattole River, lower reaches of

Conklin Creek, lower reaches of McGinnis Creek, Upper North Fork Mattole River and lower reaches of Oil Creek. McGinnis Creek is the only stream accessible to Chinook and coho salmon on HRC lands.

2. Do non-native species that may adversely affect native salmonids occur within the WAU?

No.

3. Is there any evidence of changes in distribution from historic conditions?

Maps E-5, E-6, and E-7 represent CDFG's estimate of historic ranges for steelhead, coho and Chinook salmon. Summer steelhead data are lacking, however, these runs were more widely distributed in the past. Instream water temperatures, which may be warmer than historically, likely limit the distribution of coho salmon within the Mattole basin.

4. What are the existing habitat conditions as compared to the PFC targets in the WAU?

See Table E-12 for the most recent ATM data compared with PFC targets. At the ATM locations of data collection, with the exception of residual pool depth, the target values for substrate, pool characteristics, water temperature, and riparian overstory were generally met (or nearly met) for the Sulphur Creek (#133) and McGinnis Creek (#219) stations. The Upper North Fork (#169) station met or exceeded the targets for fewer parameters than the Sulphur Creek and McGinnis Creek stations, though the targets were met for D50, percent <0.85 mm, pool area, pool frequency, and water temperature. All three stations met the targets for pool area, pool frequency, and water temperature. None of the three stations met targets for residual pool depth and LWD.

Table E-12. Mattole Watershed Analysis Area stream status relative to PFC targets.

2009	Parameter	Target Value	133 Sulphur Cr	169 Upper NF Mattole R	219 McGinnis Cr
Bed surface	D50 mm	65-95	69	78	47
Bed Subsurface	%<0.85 mm	<11-16	5.6	5.3	6.7
	%<6.35 mm	<20-25	14.0	29.6	20.5
	Geomean mm	>20	23.8	15.4	22.7
	Fredle Index	>9	3.7	5.8	6.6
Pool Characteristics	Pool Area (%)	≥25%	31	26	32
	Pool Spacing	<6 CW/pool	3.4	4.7	2.9
	Residual Pool Depth (m)	>.91 m	0.47	0.49	0.51
	% Pools Assoc. w/wood	>50%	86	0	50
Large Woody Debris	Total Piece Frequency #/100 ft	f(CW)	3.1	0.5	2.2
	Key Piece Frequency # Pieces/CW	≥.5	0.26	0.00	0.04
	Total Piece Diameter (in)	f(CW)	17.5	10.5	12.6
	Total Piece length (ft)	f(CW)	19.7	15.1	12.4
	Total Piece Volume ft^3/100 ft	f(CW)	213	8	34
Water Temperature (2010)	MWAT °C	≤16.8	15.4	16.3	15.2
Riparian Overstory	% Canopy Over Stream	f(CW)	80	58.2	95
	% Canopy of Rip Forest	>85%	86	57	78

Last measured: Sediment, habitat, LWD, Riparian overstory 2009; Temperature 2010; Mid-channel canopy 2009

Using PFC targets is problematic given that they were derived from areas outside the WAU, targets may not be within the capabilities of streams within the WAU, and targets do not reflect spatial and temporal variability inherent in dynamic systems (as have been described for the WAU). Formulating an improved approach that includes assessing the function of watershed processes, would better serve the intended goals of the HCP.

5. **What are the location and nature of migration barriers?**

Migration barriers are shown on Maps E-5, E-6, and E-7 and described in Table E-3. All barriers assessed and mapped were natural and most consisted of boulder jams coupled with steep gradients.

6. **What is the annual cycle of water temperature within the WAU under study?**

Winter temperatures are unknown but can be presumed to be within acceptable levels given the amount of precipitation that occurs during winter months and known cool climatic conditions. Elevated summer water temperatures are considered a primary limiting factor for salmonids rearing in the mainstem of the Mattole River. Summer and early fall stream temperatures in mainstem tributaries located on HRC ownership have until recently exceeded those preferred by salmonids. All three monitored mainstem tributaries (Sulphur Creek, Upper North Fork/Rattlesnake, and McGinnis Creek) have met the PFC target (<16.8°C) in 2009 and 2010 with the exception of the Upper North Fork in 2009 when the MWAT was 18.0°C. See Figure E-5 for multi-year record. Smaller Class I and II streams provide critical thermal refugia in lower accessible reaches as well as cool water inflows to mainstem tributaries. High summer and early fall stream temperatures are a limiting factor for rearing juvenile salmonids, limit habitat capacity and affect the abundance and distribution of salmonids in the WAU.

7. **In areas where data are available, do the recorded water temperatures approach or exceed PFC targets? Specifically, are there reaches that impede**

migration, spawning, or rearing due to water temperatures? If so, where are they located?

The Upper North Fork Mattole/Rattlesnake has the highest recorded MWAT on HRC lands, and along with Oil Creek, is the most likely sub-basin in which movement and survival of juvenile salmonids may be impeded during summer and early fall months. Although no temperature data have been collected in Oil Creek, it is likely a situation similar to Rattlesnake exists considering similar canopy cover and a fairly exposed southeast aspect. Adult migration and spawning is not impeded by temperature regimes due to run timing that coincides with significant rain events. See Figure E-5 for a summary of ATM MWAT monitoring results.

8. In areas where data are available, do dissolved oxygen concentrations in the WAU ever fall within levels considered to pose a risk to salmonids over an annual cycle? Specifically, are there reaches that impede migration, spawning, or rearing due to depressed oxygen conditions at any time of year? If so, where are they located?

Two samples obtained in 2005 indicate DO concentrations were suitable at specific locations sampled. However, there is not enough data to draw conclusions.

9. In areas where data are available, is dissolved oxygen at or above 90% saturation throughout the year?

No data.

10. In areas where data are available, what are the turbidity conditions in the WAU?

No data.

11. In areas where data are available, what proportion of the turbidity is attributable to suspended sediment (SS)?

No data.

12. In areas where data are available, do turbidity/SS levels in the WAU exceed nominal thresholds for acute and chronic effects on salmonid health, as documented in the scientific literature?

No data.

13. In areas where data are available, do winter turbidity levels fall rapidly following cessation of high flows? Does turbidity show a pattern of chronically elevated levels during the winter?

No data.

6.0 CONFIDENCE IN WORK PRODUCTS

6.1 HABITAT CONDITIONS

Documentation of habitat conditions that existed prior to large scale anthropogenic changes in the WAU, which were coupled with large flood events, are absent: historic reference conditions are unknown. Historic information reported herein is based on limited, mostly qualitative data sets consisting of CDFG stream survey summaries from 1966, which represent conditions that existed after major flood events and large scale anthropogenic changes. Thus, confidence in historic habitat conditions descriptions is low.

CDFG surveys were used to document current habitat conditions and to compare conditions over time. CDFG surveys occurred over many of the fish-bearing streams in the WAU. These surveys were the basis of discussions in this report and provided fairly wide coverage of accessible reaches and associated habitat conditions in the WAU. HRC field data collection provided more current habitat information and overlapped some of CDFG's surveyed reaches. However, different survey methodologies were used and error and bias is inherent in individuals and in surveying techniques. Therefore, confidence in assessments of habitat change over time is low to moderate. There was not sufficient habitat information to be reasonably confident that all areas of concern could be fully assessed. The authors' field reviews along with those conducted by the Stream Channel Assessment report (Appendix D) author helped increase confidence and provided the appropriate context for review of all survey data, however, all streams were not visited due to time and access limitations. Thus, over-all confidence in descriptions of existing habitat conditions in tributary streams is moderate.

6.2 SALMONID DISTRIBUTION AND ABUNDANCE

Status and species account information was obtained from agency and peer reviewed published sources. Abundance information for the WAU is not available. Thus, confidence is low relative to whether habitat conditions are fully supportive of viable fish populations. Confidence in steelhead distribution information for streams surveyed by

PALCO biologists during barrier surveys is high due to consistent and peer reviewed methodologies.

7.0 REFERENCES

Adams, T.N. and K. Sullivan. 1989. The physics of forest stream heating: a simple model. California Department of Forestry and Fire Protection TFW-WQ3-90-007. Sacramento, California. 30 pp.

Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002.

Barnhart, R.A. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)--steelhead. *U.S. Fish and Wildl. Serv. Biol*. Rep. 82(11.60). 21 pages.

Bartholow, J.M. 1989. Stream temperature investigations: field and analytic methods. Instream Flow Information Paper No. 13. Biological Report 89(17). U.S. Fish and Wildlife Service. Fort Collins, Colorado.

Bathurst, J. 1981. Discussion of Bar Resistance of Gravel-bed Streams. Journal of the Hydraulics Division, American Society of Civil Engineers 107(HY10): 1276-1278.

Bell, M.C. 1973. Fisheries handbook of engineering requirements and biological criteria. Useful factors in life history of most common species. DRAFT. Fish.-Eng. Res. Prog., Corps of Eng., North Pacific Division. Portland, OR.

Bell, M. 1991. Fisheries handbook of engineering requirements and biological criteria. Portland, OR: U.S. Army Corps of Engineers, Fish Passage Development and Evaluation Program, North Pacific Division.

Berg, A. 2002. Salmonid relocation report: East Anderson Creek, Mattole River basin. Prepared for Humboldt County Department of Public Works by A. Berg & Associates, P.O. Box 1091, Ferndale CA 95536.

Beschta, R., R. Bilby, G. Brown, L. Holtby, and T. Hofstra. 1988. Stream temperature and aquatic habitat: Fishery and forestry interactions. Pages 191-232 *In* Streamside Management: Forestry and Fishery Interactions. Contribution No. 57. Seattle, WA: University of Washington, Institute of Forest Resources. Seattle, WA. 471 pp.

Bisson, P., K. Sullivan, and J. Nielsen. 1988. Channel hydraulics, habitat use, and body form of juvenile coho salmon, steelhead, and cutthroat trout in streams. Transactions of the American Fisheries Society 117: 262-273.

Bliesner, A.K. and E.G. Robison. 2005. Detecting the Upstream Extent of Fish in the Redwood Region of Northern California. USDA Forest Service Gen. Tech. Rep.

Bureau of Land Management (BLM). 1996. Honeydew Creek Watershed Analysis. Arcata, CA, BLM.

Burnett K.M., G. Reeves, D. Miller, S. Clarke, K. Christiansen and K. Vance-Borland. 2003. A first step toward a broad-scale identification of freshwater protected areas for Pacific salmon and trout in Oregon, USA. Pages 144-154 in J.P. Beumer, A. Grant and D. Smith. Editors. Aquatic Protected Areas. Australian Society for Fish Biology, Cairns, Australia.

Busby M.S., R.A. Barnhart and P.P. Petros. 1988. Natural Resources of the Mattole River estuary, California: Natural resources and habitat inventory summary report. Prepared for the Bureau of Land Management, Arcata Resource Area, Arcata, CA. California Cooperative Fishery Research Unit, Humboldt State University, Arcata, CA. 81 pp.

Brett, J.R. 1952. Temperature tolerance in young Pacific salmon, genus *Oncorhynchus*. Journal of the Fisheries Research Board of Canada 9: 265-323.

Brown, C.J. 1972. Downstream Migrations of Salmonids in the Mattole River, April through June 1972., CDFG, Region 1, Redding, CA in cooperation with DWR, Northern District, Red Bluff, CA. 8pp.

Brown, C.J. 1973. Standing Stock Estimates for Mattole River Salmonids, July-August 1973. Mattole River, selected tributaries, Humboldt County, CDFG, Region 1 in cooperation with the CA Dept. of Water Resources, Northern District, Red Bluff, CA Bay Delta and Special Water Projects Division: 10 pp.

Brown, C.J. 1973. Creel Census/Fisherman-Use Count of the Mattole River. 9pp.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-27. 261 pages.

California Department of Fish and Game (CDFG). 1965. California fish and wildlife plan. Volume III supporting data: Part B, inventory salmon-steelhead and marine resources. Available from CDFG, 1416 Ninth St., Sacramento, CA 95814.

California Department of Fish and Game (CDFG). 1966a. Stream survey report for East Branch North Fork Mattole River. Unpublished stream inventory report on file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 1966b. Stream survey report for Devils Creek. Unpublished stream inventory report on file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 1966c. Stream survey report for McGinnis Creek. Unpublished stream inventory report on file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 1966d. Stream survey report for Oil Creek. Unpublished stream inventory report on file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 1966e. Stream survey report for Pritchard Creek. Unpublished stream inventory report on file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 1966f. Stream survey report for Rattlesnake Creek. Unpublished stream inventory report on file at CDFG 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 1966g. Stream survey report for Upper North Fork Mattole River. Unpublished stream inventory report on file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 1982. Stream survey report for East Branch North Fork Mattole River. Unpublished stream inventory report on file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 1985a. Stream survey report for McGinnis Creek. Unpublished stream inventory report on file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 1985b. Stream survey report for Pritchard Creek. Unpublished stream inventory report on file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 1988. Stream survey report for Sulphur Creek. Unpublished stream inventory report on file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 1991a. Stream survey report for Devils Creek. Unpublished stream inventory report on file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 1991b. Stream survey report for Green Ridge Creek. Unpublished stream inventory report on file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 1991c. Stream survey report for Oil Creek. Unpublished stream inventory report on file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 1991d. Stream survey report for Rattlesnake Creek. Unpublished stream inventory report on file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 1999. Stream survey report for McGinnis Creek. Unpublished stream inventory report on file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

California Department of Fish and Game (CDFG). 2002. Status review of California coho salmon north of San Francisco. Report to the California Fish and Game Commission. CDFG, Sacramento, CA, Candidate Species Status Review Report 2002-3. 336 p. Available online at http://www.dfg.ca.gov/nafwb/coho_status_2002_04.html

California Department of Fish and Game (CDFG). 2004. Recovery strategy for California coho salmon. Report to the California Fish and Game Commission. CDFG, Native Anadromous Fish and Watershed Branch, Sacramento, CA. 594 p. Available online at http://www.dfg.ca.gov/nafwb/CohoRecovery/

California Regional Water Quality Control Board, North Coast Region. 2001. Surface Water Ambient Monitoring Program. Unpublished chemical-physical data from 3 sites, Mattole River, 2001.

Carling, P., and N. Reader. 1982. Structure, composition and bulk properties of upland stream gravels. Earth Surface Processes and Landforms 7:349-365.

Coastal Headwaters Association. 1982. Mattole Survey Program, first annual report. Whitethorn, CA, Coastal Headwaters Association. 51 pp.

Coastal Headwaters Association. 1983. Stream survey contract. On file at CDFG, 1455 Sandy Prairie Court, Fortuna CA.

Coates D.A., W. Hobsen, B. McFadin and C. Wilder. 2002. Mattole River watershed technical support document for the TMDLs for sediment and temperature. Draft for public review California Regional Water Quality Control Board, North Coast Region.

Downie, S., T. Scott, C.W. Davenport, E. Dudik, F. Yee and J. Clements. 2003. Mattole River Watershed Assessment Report. North Coast Watershed Assessment Program. 441 p plus Appendices. California Resources Agency and California Environmental Protection Agency, Sacramento, Calif.

Downie S. 2006. Personal communication regarding streams in the Northern Subbasin, Mattole River basin. CDFG, 1455 Sandy Prairie Court, Fortuna CA.

Environmental Protection Agency. 1996. *Revision to* Rapid bioassessment protocols for use in streams and rivers: periphyton, benthic macroinvertebrate, and fish. Assessment and Watershed Protection Division, Washington, D.C. EPA/444/4-89-001.

Flosi, G., S. Downie, J. Hopelain, M. Bird, R. Coey, and B. Collins. 1998. California Salmonid Stream Habitat Restoration Manual. Third Edition. Inland Fisheries Division, California Department of Fish and Game.

Frissell, C., W. Liss, C.Warren, and M. Hurley. 1986. A hierarchical framework for stream classification: viewing streams in a watershed context. Environmental Management 10:199-214.

Forest Science Project. 1998. Stream Temperature Monitoring.

Good, T.P., R.S. Waples and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-66, 598 p.

Griggs G.B. and J.R. Hein. 1980. Sources, dispersal, and clay mineral composition of fine-grained sediment off central and northern California. Journal of Geology 88:541-566.

Hassler, T.J. 1987. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)--coho salmon. *U.S. Fish and Wildl. Serv. Biol. Rep*. 82(11.70). 19 pages.

Hames D.S., B. Conrad, A. Pleus and D. Smith. 1996. TFW Ambient Monitoring Program Report: Field comparison of the McNeil sampler with three shovel-based methods used to sample spawning substrate composition in small streams. Northwest Indian Fisheries Commission. May 1996.

Hawkins, C., J. Kershner, P. Bisson, M. Bryant, L. Decker, S. Gregory, D. McCullogh, C. Overton, G. Reeves, R. Steedman, and M.Young. 1993. A hierarchical approach to classifying stream habitat features. Fisheries 18:3-12.

Healey, M.C. 1991. The life history of Chinook salmon (*Oncorhynchus tshawytscha*). Pages 213-393 *In*: C. Groot and L. Margolis (eds.), Life history of Pacific salmon. Univ. B.C. Press, Vancouver, B.C.

Higgins P., S. Dobush and D. Fuller. 1992. Factors in Northern California threatening stocks with extinction. Available from Humboldt Fish Action Council, 500 Freshwater Road, Eureka, CA 95521.

Hopelain J.S., G. Flosi and S. Downie. 1997. Stream monitoring progress report for five small streams in Northwestern California, Lawrence, Shaw, Oil, Rattlesnake, and Green Ridge Creeks 1991-1995. CDFG Inland Fisheries Administrative Report No. 97-6.

Klein R. 2004. Preliminary hydrologic assessment of low flows in the Mattole River basin. Prepared for Sanctuary Forest, Inc. and Mattole Restoration Council.

Latterell, J.J., R. J. Naiman, B. R. Fransen, and P. A. Bisson. 2003. Physical constraints on trout (*Oncorhynchus* spp.) distribution in the Cascade Mountains: a comparison of logged and unlogged streams. Canadian Journal of Fisheries and Aquatic Sciences 60:1007-1017.

Lewis, T., D. Lamphear, D. McCanne, A. Webb, J. Krieter, and W. Conroy. 2000. Regional assessment of stream temperatures across Northern California and their relationship to various landscape-level and site-specific attributes. Forest Science Project. Humboldt State University Foundation, Arcata, CA. 420 pp.

Lisle, T. and S. Hilton. 1992. The volume of fine sediment in pools: an index of sediment supply in gravel-bed streams. Water Resources Bulletin 28(2): 371-383.

Lisle, T. E. 1987. Using residual depths to monitor pool depths independently of discharge. Res. Note PSW-394. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture. 4 p.

Mattole Salmon Group (MSG). 2010. Final Report , Spawning Ground Surveys, 2009-2010 Season, Mattole River Watershed. Submitted in fulfillment of: United States Department of the Interior, Bureau of Land Management Assistance Agreement #: BCA072012 Amendment # 003 (L08AC14502) and National Conservation System Foundation Mattole 2009 King Range Stewardship Initiative Contract # OF110509.

Mattole Salmon Group (MSG). 2009a. Juvenile salmonid monitoring on the mainstem Mattole River at Petrolia, CA, 2009, Final Report. Mattole Salmon Group P.O. Box 188 Petrolia, CA 95558.

Mattole Salmon Group (MSG). 2009b. Summary report of water temperature and juvenile salmonid presence/absence monitoring, May-October 2008, Mattole River Watershed. Submitted in partial fulfillment of Task Order 002, Cooperative Agreement BAA020030, Bureau of Land Management, Arcata Field Office and Task 2.4, Agreement No. 02-128. California Coastal Conservancy, Mattole River and Range Partnership.

Mattole Salmon Group (MSG). 2008a. Final report summer steelhead survey, 2007 season, Mattole River Watershed. Submitted in fulfillment of California State Coastal Conservancy Mattole River and Range Partnership, Phase 2, #05-015. Mattole Salmon Group P.O. Box 188 Petrolia, CA 95558.

Mattole Salmon Group (MSG). 2008b. Juvenile salmonid monitoring on the mainstem Mattole River at Petrolia, CA, 2008, Final Report. Prepared for the United States Department of the Interior, Bureau of Land Management. Agreement # BCA072012.

Mattole Salmon Group (MSG). 2007. Juvenile salmonid monitoring on the mainstem Mattole River at Petrolia, CA, 2007, Final Report. Prepared for The California Dept. of Fish and Game Fisheries Restoration Grant Program Grant # P0610515.

Mattole Salmon Group (MSG). 2006. Juvenile salmonid monitoring on the mainstem Mattole River at Petrolia, CA, 2006, Final Report. Prepared for The California Dept. of Fish and Game Fisheries Restoration Grant Program Grant # P0510525.

Mattole Salmon Group (MSG). 2005a. State of the Salmon Report 2005. Mattole Salmon Group P.O. Box 188 Petrolia, CA 95558.

Mattole Salmon Group (MSG). 2005b. Mattole River Juvenile Salmonid Migration Monitoring 2005 Final Report. Mattole Salmon Group P.O. Box 188 Petrolia, CA 95558.

Mattole Salmon Group (MSG). 2004. Final Report Downstream Migrant Trapping, 2004 Season Mattole River Agreement #PO210558.

Mattole Salmon Group (MSG). 2000. Five-year management plan for salmon stock rescue operations 2000-2001 through 2004-2005 seasons. Mattole Salmon Group P.O. Box 188 Petrolia, CA 95558.

Mattole Salmon Group (MSG). 1997. Unpublished data: Stream temperatures Mattole River and tributaries-1995 through 1997. Mattole Salmon Group P.O. Box 188 Petrolia, CA 95558.

Mattole Salmon Group (MSG). 1981-1999. Adult escapement estimates for the Mattole River Basin. Mattole Salmon Group P.O. Box 188 Petrolia, CA 95558.

McCain, M., D. Fuller, L. Decker, and K. Overton. 1990. Stream habitat classification and inventory procedures for Northern California. FHR Currents: R-5's Fish Habitat Relationships Technical Bulletin. 15 pp.

Meehan, W.R., editor. 1991. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19.

Myers, J.M, R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T.Lindley, and R.S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Of Commer., NOAA Tech. Memo. NMFS-NWFSC-35, 443 pp.

Ministry of Environment Lands and Parks (MELP). 2001. Guidelines for non-fish bearing status report preparation. Region 6-BC MELP, Habitat Protection Section. Skeena Region, British Columbia. 3 pp.

Montgomery, D., J. Buffington, R. Smith, K. Schmidt, and G. Pess. 1995. Pool spacing in forest channels. Water Resources Research 31(4):1097-1105.

Moyle, P.B. 1976. Inland fishes of California. University of California Press, Berkeley and Los Angeles, California.

Nehlsen, W., J.E. Williams, and J.A. Lichatowich. 1991. Pacific salmon at the crossroads: Stocks at risk from California, Oregon, Idaho, and Washington. *Fisheries* 16(2):4-21.

Nickelson, T.E., J.W. Nicholas, A.M. McGie, R.B. Lindsay, D.L. Bottom, R.J. Kaiser, and S.E. Jacobs. 1992. Status of anadromous salmonids in Oregon coastal basins. Unpublished.

North Coast Watershed Assessment Program (NCWAP). 2003. Mattole River Watershed Assessment Report. State of California, California Resources Agency and California Environmental Protection Agency. March.

National Marine Fisheries Service (NMFS). 1995. Proposed recovery plan for Snake River Salmon. NMFS 525 NE Oregon St., Suite 500, Portland OR 97232.

National Marine Fisheries Service (NMFS). 1996a. Making Endangered Species Act determinations of effect for individual or grouped actions at the watershed scale. Nonfederal version, draft. NOAA Fisheries, National Marine Fisheries Service, Portland, Oregon.

National Marine Fisheries Service (NMFS). 1996b. Supplemental report of the Biological Review Team on central California coast coho salmon. Memorandum dated 17 October 1996 from M. Schiewe to W. Stelle. Available from Environmental and Technical Services Division, NMFS, 525 NE Oregon St., Portland OR 97232.

National Marine Fisheries Service (NMFS). 1997. Aquatic Properly Functioning Condition Matrix. Work in Progress for the Pacific Lumber Company Habitat Conservation Plan. NMFS, Arcata, CA.

National Marine Fisheries Service (NMFS). 1999. Status review update for deferred ESUs of West Coast Chinook salmon (*Oncorhynchus tshawytscha*) from Washington, Oregon, California, and Idaho. Memorandum dated 16 July 1999 to U. Varanasi, Northwest Fisheries Science Center, and M. Tillman, Southwest Fisheries Science Center, 2725 Montlake Blvd. E, Seattle, WA 98112.

Oregon Department of Forestry (ODF) and Oregon Department of Fish and Wildlife (ODFW). 1995. Surveying forest streams for fish use. ODF Forest Practices Section, ODFW Habitat Conservation Division. Salem, OR. Portland, OR. 29 pp.

Pacific Lumber Company (PALCO). 1999a. Final Environmental Impact Statement/Environmental Impact Report for the Headwaters Forest Acquisition and the PALCO Sustained Yield Plan and Habitat Conservation Plan, Pacific Lumber Company.

Pacific Lumber Company (PALCO). 1999b. Habitat Conservation Plan for the properties of The Pacific Lumber Company Scotia Pacific Holding Company and Salmon Creek Corporation. Appendix P and F.

Platts, W.S. 1974. Geomorphic and aquatic conditions influencing salmonids and stream classification, with applications to ecosystem management, SEAM Program, US Department of Agriculture. Billings, MT.

Reeves, G.H., F.H. Everest, and J.D. Hall. 1987. Interactions between the redside shiner (*Richardsonius balteatus*) and the steelhead trout (*Salmo gairdneri*) in western Oregon: the influence of water temperature. *Can. J. Fish. Aquat. Sci*. 44:1603-1613.

Rich, A.A. 1997. Testimony of Alice A. Rich, Ph.D., regarding water rights applications for the Delta Wetlands Project, proposed by Delta Wetlands Properties for Water Storage on Webb Tract, Bacon Island, Bouldin Island, and Holland Tract in Contra Costa and San Joaquin Counties. July. Calif. Dept. of Fish and Game Exhibit DFG-7. Submitted to State Water Resources Control Board.

Robison, E. 1998. Reach scale sampling metrics and longitudinal pattern adjustments of small streams. Dissertation Oregon State University. 254 pp.

Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology 1481 Stevens Lake Road, Pagosa Springs, Colorado.

Sandercock, F.K. 1991. Life history of coho salmon. Pages 397-445 *In* C. Groot and L. Margolis (eds.), Pacific salmon life histories. Univ. British Columbia Press, Vancouver. 564 pages.

Scotia Pacific (PALCO). 2000. Methods to Complete Watershed Analysis on Pacific Lumber Company Lands in Northern California. On file at The Pacific Lumber Company, Scotia, California.

Scotia Pacific (PALCO). 2003. Stream temperature monitoring-WOP 09; On file at the Pacific Lumber Company, 125 Main, Scotia CA.

Scotia Pacific (PALCO). 2003. Temperature instrumentation and deployment-WOP 09. On file at The Pacific Lumber Company, 125 Main, Scotia CA.

Scotia Pacific (PALCO). 2003. Stream and riparian canopy cover measurements-WOP 12. On file at The Pacific Lumber Company, 125 Main, Scotia CA.

Scotia Pacific (PALCO). 2003. Surface and subsurface sampling-WOP 13. On file at The Pacific Lumber Company, 125 Main, Scotia CA.

Scotia Pacific (PALCO). 2003 Stream habitat typing and measurements-WOP 14. On file at The Pacific Lumber Company, 125 Main, Scotia CA.

Scotia Pacific (PALCO). 2005. Large woody debris surveys (in progress)-WOP 32. On file at The Pacific Lumber Company, 125 Main, Scotia CA.

Scotia Pacific (PALCO). 2005 Upper extent of fish field protocol-WOP 43. On file at The Pacific Lumber Company, 125 Main, Scotia CA.

Scotia Pacific (PALCO). 2005. Unpublished habitat data for Mattole River WAU. On file at The Pacific Lumber Company, 125 Main, Scotia CA.

Seymour, A.H. 1956. Effects of temperature on young Chinook salmon. Ph.D. thesis. University of Washington, Seattle, WA.

Shapovalov L. and A.C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with specific reference to Waddell Creek, California and recommendations regarding their management. Calif. Dep. Fish Game Bull. 98. 375 pp.

Smith, A.K. 1973. Development and application of spawning velocity and depth criteria for Oregon salmonids. *Trans. Am. Fish. Soc*. 102(2):312-316.

Spence, B.C., G.A. Lomnicky, R.M. Hughes and R.P. Novitzki. 1996. An Ecosystem Approach to Salmonid Conservation. TR-4501-96-6507. page 219, 228.

Sullivan, K. 1986. Hydraulics and fish habitat in relation to channel morphology. PhD dissertation. Johns Hopkins University. Baltimore, MD. 409 pp.

Sullivan, K., T. Lisle, C. Dolloff, G. Grant, and L. Reed. 1987. Stream channels; the link between forests and fishes, in Streamside Management: Forestry and Fishery Interactions. University of Washington. Seattle, WA.

Sullivan, K., M. Liquori, R. Periann, D. Glass, and J. Light. 1997. Protocol for surveying the physical characteristics of small streams: Version 1.0 Survey level methods. Washington Forest Protection Association. 14 pp.

Sullivan, K., J. Tooley, K. Doughty, J. Caldwell, and P. Knudsen. 1990. Evaluation of prediction models and characterization of stream temperature regimes in Washington. Timber/Fish/Wildlife Rep. No. TFW-WQ3-90-006. Washington Department of Natural Resources. Olympia, Washington. 224 pp.

Taylor, R. and M. Love. 2003. California salmonid stream habitat restoration manual, Part IX: Fish passage evaluation at stream crossings. California Department of Fish and Game. 100 pp.

Wahle, R.J., and R.E. Pearson. 1987. A listing of Pacific coast spawning streams and hatcheries producing Chinook and coho salmon with estimates on numbers of spawners and data on hatchery releases. U.S. Department of Commerce, NOAA Technical Memorandum NMFS F/NWC-122.

Washington Department of Natural Resources (WDNR). 1997. Washington Forest Practices Board Manual: Standard Methodology for Conducting Watershed Analysis. Version 4.0. WDNR Olympia, WA.

Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. U.S. Dep. Commer., NOAA Tech Memo. NMFS-NWFSC-24, Northwest Fisheries Science Center, Seattle, Washington. 258 pages.

Welsh, H. Jr., G. Hodgson, B. Harvey, and M. Roche. 2001. Distribution of juvenile coho salmon in relation to water temperatures in tributaries of the Mattole River, California. North American Journal of Fisheries Management 21(3): 464-470.

Zwieniecki, M., and M. Newton. 1999. Influence of streamside cover and stream features on temperature trends in forested streams of western Oregon. Western Journal of Applied Forestry 14(2): 106-113.