Southern California Steelhead Monitoring: Santa Ynez River, Conception Coast, and Ventura River 2013–2015

Report for the California Department of Fish and Wildlife

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Abstract

This project was established to increase understanding of endangered southern California steelhead *(Oncorhynchus mykiss)* and to lay the groundwork for a long-term monitoring program. Working in cooperation with the California Department of Fish and Wildlife (CDFW) and National Marine Fisheries Service, Pacific States Marine Fisheries Commission staff conducted a number of field studies throughout the Conception Coast Biogeographic Population Group (BPG) and the Ventura River Basin (part of the Monte Arido Highlands BPG) from June 2013 to January 2016. Field data collection included habitat assessments, snorkel surveys, redd surveys, and DIDSON camera deployment. Using these methods, we examined *O. mykiss* distribution, spatial structure, and population productivity. Additionally, we developed protocols for estimating population abundances, which will be used by CDFW for future monitoring of anadromous streams. We also developed a preliminary sampling frame, which will be crucial to all future sampling efforts. All aspects of this project were affected by the extreme drought, which persisted for the entirety of the data collection period. Despite this challenge we were able to continue previous survey efforts, collect data on previously-unstudied stream systems, test newly-established methodologies, and develop standardized protocols to monitor *O. mykiss* populations in southern California. Given that very little is understood about these populations, our findings contribute significantly to both continued monitoring efforts and the broader understanding of southern California *O. mykiss* ecology.

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Introduction

Oncorhynchus mykiss, commonly referred to as coastal rainbow or steelhead trout, exhibit two main life history strategies (resident and anadromous, respectively). These strategies allow *O. mykiss* to persist in diverse habitats and endure a wide range of environmental conditions. Despite this flexibility in life history, steelhead numbers have declined dramatically in recent decades throughout southern California. Due to these declines, *O. mykiss* populations between the Santa Maria River and the US-Mexico border have been listed under the Endangered Species Act (NMFS 2012). In response to this listing, the National Marine Fisheries Service (NMFS) created the Southern California Steelhead Recovery Plan (NMFS 2012), which outlines the actions needed to manage and recover *O. mykiss*, with the ultimate goal of delisting the species. These recovery actions rely on a thorough understanding of *O. mykiss* ecology and long-term monitoring of *O. mykiss* populations. However, little is known about the current abundance, distribution, productivity, and diversity of *O. mykiss* populations in southern California.

To address these data gaps, Pacific States Marine Fisheries Commission (PSMFC), California Department of Fish and Wildlife (CDFW), and NMFS are developing a large-scale monitoring program specific to southern California that contributes to the statewide California Coastal Salmonid Monitoring Plan (CMP; Adams et al. 2011). In line with CMP development, we (PSMFC) conducted this project to define a preliminary sampling frame, gather baseline data for future monitoring, and develop standardized protocols specific to *O. mykiss* in southern California. Specifically, we focused on methods for examining *O. mykiss* distribution, spatial structure, and population productivity, estimating population abundances, and quantifying habitat availability in the Conception Coast and Monte Arido Highland Biogeographic Population Groups (BPG; NMFS-defined regions of unique physical and ecological characteristics; NMFS 2012).

To examine adult abundance and population productivity, we installed dual-frequency identification SONAR (DIDSON) cameras in three watersheds designated as high priority for recovery (Core 1; NMFS 2012): Salsipuedes Creek (a critical spawning tributary in the lower Santa Ynez River watershed), Carpinteria Creek, and the Ventura River. These underwater cameras record the movement of *O. mykiss*, and are the best available means for obtaining adult count data under challenging southern California conditions (e.g., flashy streams, high turbidity). In particular, we used DIDSON as a means to estimate both freshwater (i.e., out-migrating smolts) and saltwater productivity (i.e., migrating anadromous adults). As a continuation of previously-funded PSMFC DIDSON monitoring efforts, this project tested and further developed the existing methodologies and infrastructure of DIDSON deployment, which will serve as a blueprint for future DIDSON monitoring projects throughout southern California.

To examine *O. mykiss* distribution and spatial structure, we conducted snorkel surveys and redd surveys in a number of systems throughout the Conception Coast and Monte Arido Highlands. Snorkel surveys are a cost-effective means of identifying systems in which *O. mykiss* are present and providing relative abundance counts. The snorkeling surveys conducted in this project were the first to monitor focal streams while working to develop CMP compliant protocols. Redd surveys provide a method for assessing adult spawning distribution and are a means to validate adult counts obtained using DIDSON. Redd survey efforts in the Ventura Basin are a continuation of previously-funded PSMFC monitoring efforts.

To quantify *O. mykiss* habitat availability and quality, we conducted habitat assessment surveys for priority systems throughout Santa Barbara and Ventura Counties. Specifically, we used methods presented in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998), in which we examined large woody debris availability, shelter quantity and quality, bankside metrics, and spawning habitat availability. These methods have been used extensively in northern California to assess areas in need of restoration work, but have been used rarely in southern California systems. The findings presented here will be used to assess current habitat quality and quantity, as well as help determine whether additional monitoring activities are warranted.

To estimate population abundances, we tested a double-phase sampling design on two focal watersheds: Upper North Fork Matilija and upper Matilija, two non-anadromous systems within the Ventura River Basin. Using a combination of habitat typing, snorkeling, and electrofishing methods, we calculated population abundances using methodologies utilized in northern California, but not-yet established in southern California. By testing and refining these protocols, we will provide the CDFW with verified methods that will be used to monitor *O. mykiss* population trends in anadromous reaches of southern California.

As part of the larger effort to develop a monitoring program for southern California, we created a preliminary sampling frame from which priority systems will be selected for future monitoring. We first defined a sampling universe (the area in which we can sample) and then defined sampling reaches (areas which will be selected for surveys) to create a sampling frame for the Conception Coast and the Ventura River Basin. This will be the first sampling frame developed for this region and will therefore be vital to future monitoring efforts.

This report summarizes the methodologies and findings of PSMFC efforts in DIDSON deployment, monitoring (redd, snorkel, and habitat assessment surveys), abundance estimations, and sampling frame development from 2013 to 2016. Our findings will aid in the development of protocols specific to southern California, as well as contribute to the establishment of a long-term, region-wide monitoring program.

Watershed Overviews

Conception Coast Biogeographic Population Group

The Conception Coast BPG is made up of a 50-mile long expanse of the south facing coast line running through southern Santa Barbara and southwestern Ventura County (NMFS 2012). NMFS lists 29 priority watersheds throughout the area (NMFS 2012). These watersheds are generally characterized by being fairly short in length with lower gradient, wider stream channels in the lower reaches that transition into steeper, narrower reaches in the upper watersheds (NMFS 2012). Degrees and mode of land usage varies across the landscape, but tends towards heavier alteration and use in the lower watersheds where population densities are higher and more pristine habitat in the upper less accessible (often federally owned) sections (NMFS 2012). We present a map of the Conception Coast BPG streams sampled in this report in Figure 1.

Cañada de la Gaviota Creek

Gaviota Creek (LLID: 1202260344703; DFGWaterID: 27713755) is a tributary to the Pacific Ocean (Goleta, CA), a watershed designated as important to steelhead recovery implementation (Core 2; NMFS 2012) in the Conception Coast. Gaviota Creek's legal description at the confluence of the Pacific Ocean is T5N R30W. Gaviota Creek is a third-order stream that drains a watershed of 20.12 square miles. Elevations range from approximately 0 to 2813 feet. Coast live oak dominates the watershed (CALVEG 2015). Most of Gaviota occurs on privately owned grazing land. Vehicle access exists via Highway 101.

Arroyo Hondo Creek

Arroyo Hondo Creek (LLID: 1192992344853) is a watershed designated as important to the connectivity of steelhead populations, but not high priority in recovery implementation on the

Conception Coast (Core 3; NMFS 2012). Arroyo Hondo Creek flows into the Pacific Ocean (Santa Barbara County, CA) and its legal description at the confluence with the Pacific Ocean is T05N R23W S28. Arroyo Hondo drains a watershed of approximately 5.26 square miles. Elevations range from approximately 0 feet at the mouth of the creek to 2849 feet in the headwaters. Oak and alder woodlands and mixed conifer forests dominate the watershed. Most of Arroyo Hondo occurs on federally-protected United States Forest Service property. Vehicle access exists via Highway 101.

Arroyo Quemado Creek

Arroyo Quemado Creek (LLID: 1201180344700; DFGWaterID: 27719109) runs into the Pacific Ocean (Santa Barbara County, CA) and has been listed as Core 3 for *O. mykiss* recovery within the Conception Coast Biogeographic Population Group. Arroyo Quemado's legal description at the confluence with the Pacific Ocean is T5N R30W. Arroyo Quemado is a second-order stream that drains a watershed of 3.41 square miles. Elevations range from about 0 feet at the mouth of the creek to 2594 feet in the headwater areas. Coast live oak dominates the watershed (CALVEG 2015). The watershed is primarily county-owned land, used predominantly for agriculture. Vehicle access exists via the Baron Ranch Trail.

Cañada del Corral Creek

Cañada del Corral Creek (LLID: 1200442344625; DFGWaterID: 27719133) starts at Refugio Beach State Park in Santa Barbara County and is a watershed designated as important in promoting connectivity between steelhead populations, but not high priority in recovery implementation on the Conception Coast (Core 3; NMFS 2012). Cañada del Corral's legal description at the confluence with the Pacific Ocean is T5N R30W. Cañada del Corral Creek is a third-order stream that drains a watershed of 6.51 square miles. Elevations range from approximately 0 to 3734 feet. Coastal mixed hardwood and lower montane mixed chaparral dominate the watershed (CALVEG 2015). Cañada del Corral Creek occurs on the 8,876-acre Rancho Cañada del Corral property that extends along the Pacific coast into the Santa Ynez Mountains. Vehicle access exists via Freeway 101.

Rattlesnake Creek

Rattlesnake Creek (LLID: 1197079344483; DFGWaterID: 27716713) is a tributary to the Mission Creek (Santa Barbara County, CA), a watershed designated as high priority for steelhead recovery in the Conception Coast (Core 1; NMFS 2012). Rattlesnake Creek's legal description at the confluence with Mission Creek is T4N R27W S9. Rattlesnake Creek is a second-order stream that drains a watershed of 3.04 square miles. Elevations range from approximately 488 to 3765 feet. Coast live oak dominates the watershed (CALVEG 2015). Most of Rattlesnake occurs on federally-protected United States Forest Service property. Vehicle access exists via Highway 192.

Montecito Creek

Montecito Creek (LLID: 1196334344167; DFGWaterID: 27716787) flows directly into the Pacific Ocean (Santa Barbara County, CA). The Montecito Creek watershed is designated as important in promoting connectivity between steelhead populations, but not high priority in recovery implementation (Core 3; NMFS 2012) on the Conception Coast. Montecito Creek's legal description at the confluence with the Pacific Ocean is T4N R27W. Montecito Creek is a third-order stream that drains a watershed of 6.80 square miles. Elevations range from approximately 0 to 3800 feet. Non-native and ornamental hardwoods dominate the watershed (CALVEG 2015). Most of Montecito occurs on federally-protected United States Forest Service property. Vehicle access exists via Olive Mill Road off of Highway 101.

Hot Springs Creek

Hot Springs Creek (LLID: 1196494344430; DFGWaterID: 27716757) is a tributary to Montecito Creek (Santa Barbara County, CA), a watershed designated as important in promoting connectivity between steelhead populations, but not high priority in recovery implementation (Core 3; NMFS 2012) in the Conception Coast (Core 3; NMFS 2012). Hot Springs Creek's legal description at the confluence with Montecito Creek is T4N R26W S6. Montecito Creek is a second-order stream that drains a watershed of 1.14 square miles. Elevations range from approximately 407 to 3203 feet. Coast live oak and coast mixed hardwood dominate the watershed (CALVEG 2015). Most of Hot Springs occurs in Los Padres National Forest. Vehicle access exists off of Hot Springs Road.

Cold Springs Creek

Cold Springs (LLID: 1196334344167; DFGWaterID: 27716759) is a tributary to the Montecito Creek (Montecito, CA), a watershed designated as important to the connectivity of steelhead populations, but not high priority in recovery implementation in the Conception Coast (Core 3; NMFS 2012). Cold Springs Creek's legal description at the confluence with Montecito is T4N R27W S1. Cold Springs Creek is a third-order stream that drains a watershed of 3.88 square miles. Elevations range from approximately 407 to 3800 feet. Coast live oak dominates the watershed (CALVEG 2015). Most of Cold Springs occurs on federally-protected United States Forest Service property. Vehicle access exists via East Mountain Drive off of Highway 192.

East Fork Cold Springs Creek

East Fork Cold Springs Creek (LLID: 1196532344594; DFGWaterID: 27716689) is tributary to Cold Springs within the Montecito Creek watershed (Santa Barbara County, CA), a watershed important in promoting connectivity between steelhead populations, but not high priority in recovery implementation on the Conception Coast (Core 3; NMFS 2012). East Fork Cold Springs Creek's legal description at the confluence with Montecito Creek is T04N R27W S01. East Fork Cold Springs Creek is second-order stream that drains a watershed of 1.52 square miles. Elevations range from approximately 864 to 3800 feet. Lower montane mixed chaparral, coastal mixed hardwood, and coast live oak dominate the watershed (CALVEG 2015). Most of East Fork Cold Springs Creek occurs entirely on a combination of privately owned, State Park, National Park, National Forest, and Bureau of Land Management land and is managed for timber production, rangeland, and recreation. Vehicle access exists via East Mountain Drive off of Highway 192.

West Fork Cold Springs Creek

West Cold Springs Creek (LLID: 1196532344595; DFGWaterID: 27716759) is a tributary to the main stem of Cold Springs creek, which in turn is a tributary to Montecito Creek (Santa Barbara County, CA), a watershed designated as important in promoting connectivity between steelhead populations, but not high priority in recovery implementation (Core 3; NMFS 2012) on the Conception Coast. West Cold Springs Creek's legal description at the confluence with Cold Spring Creek is T04N R27W S01. West Cold Springs Creek is a second-order stream that drains a watershed of 1.90 square miles. Elevations range from approximately 865 to 3733 feet. Coastal mixed hardwood dominates the watershed (CALVEG 2015). Most of Cold Springs occurs on federally-protected United States Forest Service property. Vehicle access exists via East Mountain Road off of Highway 192.

San Ysidro Creek

San Ysidro Creek (LLID: 1196244344191; DFGWaterID: 27713155) is located in Montecito (Santa Barbara County, CA) and is a watershed designated as important in promoting connectivity between steelhead populations, but not high priority in recovery implementation (Core 3; NMFS 2012) on the

Conception Coast . San Ysidro's legal description at the confluence with the Pacific Ocean is T4N R25W. San Ysidro Creek is a third-order stream that drains a watershed of 4.60 square miles. Elevations range from 0 to 3659 feet. Coast live oak dominates the watershed (CALVEG 2015). Most of San Ysidro occurs on United States Forest Service property. Vehicle access exists via Highway 101.

Romero Creek

Romero Creek (LLID: 1196198344186; DFGWaterID: 27713159) flows directly to the Pacific Ocean on California's Conception Coast. Romero has been designated as important to promoting connectivity between steelhead populations, but not high priority in recovery implementation (Core 3; NMFS 2012). Romero Creek's legal description at the confluence with the Pacific Ocean is T4N R26W S3. Romero Creek is a second-order stream that drains a watershed of 5.69 square miles. Elevations range from approximately 28 to 3465 feet. Coast live oak dominates the watershed (CALVEG 2015). Most of Romero Creek occurs on federally-protected United States Forest Service property. The watershed is vehicle access exists via Sheffield Drive off of Highway 101.

Carpinteria Creek

The Carpinteria Creek main stem (LLID: 1195195343904; DFGWaterID: 27713225) flows directly into the Pacific Ocean (Santa Barbara, CA). Carpinteria Creek is designated as a high priority for steelhead recovery in the Conception Coast Biogeographic Population Group (Core 1; NMFS 2012). Carpinteria Creek is located within a region that is part of a land grant predating California's statehood. Carpinteria Creek is a fourth-order stream that drains a watershed of approximately 6 square miles. Elevations range from 0 to 3,905 feet. Coast Live Oak and Coastal Mixed Hardwood dominate the watershed (CALVEG 2015). Most of Carpinteria Creek occurs on privately owned residential property. Vehicle access exists via Highway 192.

Gobernador Creek

Gobernador Creek (LLID: 1194851344012; DFGWaterID: 27720653) is a tributary to Carpinteria Creek designated as a high priority for steelhead recovery in the Conception Coast Biogeographic Population Group (Core 1; NMFS 2012). Gobernador Creek's legal description at the confluence with Carpinteria Creek is T4N R25W. Gobernador Creek is a third-order stream that drains a watershed of approximately 7.75 square miles. Elevations range from 0 to 4,634 feet. Riparian Mixed Hardwood and Lower Montane Mixed Chaparral dominate the watershed (CALVEG 2015). Most of Gobernador Creek exists on agricultural and residential land. Vehicle access exists via Highway 192.

Monte Arido Highlands Biogeographic Population Group

The Monte Arido Highlands BPG consists of four large, high priority watersheds including the Santa Maria River, Santa Ynez River, Ventura River and Santa Clara River (Core 1; NMFS 2012). This combined space incorporates portions of San Luis Obispo, Santa Barbara and Ventura counties (NMFS 2012). These systems exhibit a high degree of variability with regards to specific physical geography, but share the general characteristics of steep upper watersheds combined with relatively flat lower reaches (NMFS 2012). Land usage varies across the landscape with the greatest human impacts occurring at lower elevations, coinciding with the largest population centers (NMFS 2012). Upper watersheds tend to be uninhabited and primarily consist of federally-protected United States Forest Service property (NMFS 2012). Vehicle access is widespread across lower reaches, but becomes less available for upper, more remote areas. We present a map of the Monte Arido Highlands BPG streams sampled in this report in Figure 2.

Ventura River Basin

Ventura River Main Stem

The Ventura River main stem (LLID: 1193067342740; DFGWaterID: 26489245) flows directly into the Pacific Ocean (Ventura County, CA) and encompasses a large portion of the Ventura River Basin, a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands Biogeographic Population Group (Core 1; NMFS 2012). Ventura River's legal description at the confluence with Pacific Ocean is T3N R24W. Ventura River is a fifth-order stream that drains a watershed of 226.05 square miles. Elevations range from approximately 0 to 6,015 feet. Lower montane mixed chaparral dominates the watershed (CALVEG 2015). Most of the Ventura River occurs on federally-protected United States Forest Service property. Vehicle access exists via Highway 33.

Lower Matilija Creek

Matilija Creek (LLID: 1192992344853; DFGWaterID: 26486801) is a tributary to the Ventura River (Ventura County, CA), a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands (Core 1; NMFS 2012). Matilija Creek's legal description at the confluence with Ventura River is T05N R23W S28. Matilija Creek is a fifth-order stream that drains a watershed of 54.57 square miles. Elevations range from approximately 921 to 6,015 feet. Coast live oak dominates the watershed (CALVEG 2015). Most of Matilija occurs on federally-protected United States Forest Service property. Vehicle access exists via South Matilija Road off of Highway 33. In this report, we focused on lower Matilija Creek, a section of Matilija that occurs below the Matilija Dam.

San Antonio Creek

San Antonio Creek (LLID: 1193065343796; DFGWaterID: 26487265) is a tributary to the Ventura River (Ventura County, CA), a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands (Core 1; NMFS 2012). San Antonio Creek's legal description at the confluence with Ventura River is T4N R23W. San Antonio Creek is a fourth-order stream that drains a watershed of 51.10 square miles. Elevations range from approximately 307 to 5,573 feet. Lower montane mixed chaparral dominates the watershed (CALVEG 2015). Most of San Antonio occurs on agricultural and residential land. Vehicle access exists via Highway 33.

Stewart Creek

Stewart Creek (LLID: 1192469344344; DFGWaterID: 26487705) is a tributary to San Antonio Creek in the Ventura River Basin (Ventura County, CA), a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands (Core 1; NMFS 2012). Stewart Creek's legal description at the confluence with San Antonio Creek is T5N R22W. Stewart Creek is a first-order stream that drains a watershed of 5.99 square miles. Elevations range from approximately 638 to 4413 feet. Lower montane mixed chaparral dominates the watershed (CALVEG 2015). Most of Stewart occurs on federally-owned recreational property. Vehicle access exists via Highway 150.

Thacher Creek

Thacher Creek (LLID: 1192306344425; DFGWaterID: 26487679) is a tributary to the San Antonio Creek within the Ventura River Basin (Ventura County, CA), a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands. Thacher Creek's legal description at the confluence with San Antonio Creek is T5N R22W S34. Thacher Creek is a third-order stream that drains a watershed of 10.71 square miles. Elevations range from approximately 719 to 5514 feet. Lower montane mixed chaparral and riparian mixed hardwood dominate the watershed. Most of Thacher Creek occurs on the federally-protected United States Forest Service property. Vehicle access exists via Highway 150.

East Fork Thacher Creek

East Fork Thacher (LLID: 1191687344757; DFGWaterID: 26487573) is a tributary to Thacher Creek in the Ventura River Basin (Ventura County, CA), a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands (Core 1; NMFS 2012). East Fork Thacher Creek's legal description at the confluence with Thacher River is T05N R22W S34. East Fork Thacher Creek is a first-order stream that drains a watershed of 0.99 square miles. Elevations range from approximately 1999 to 5527 feet. Riparian mixed hardwood dominates the watershed (CALVEG 2015). Most of East Fork Thacher occurs on federally-protected United States Forest Service property. Vehicle access exists via Highway 150.

North Fork Matilija Creek

North Fork Matilija Creek (LLID: 1192992344852; DFGWaterID: 26486785) is a tributary to the Ventura River (Ventura County, CA), a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands Biogeographic Population Group (NMFS 2012). North Fork Matilija Creek's legal description at the confluence with Ventura River is T05N R23W S28. North Fork Matilija Creek is a fourth-order stream that drains a watershed of 16.09 square miles. Elevations range from approximately 917 to 5036 feet. Lower montane mixed chaparral dominates the watershed (CALVEG 2015). Most of Matilija occurs on federally-protected United States Forest Service property. Vehicle access exists via Highway 33.

North Fork Matilija Tributary

North Fork Matilija Tributary (DFGWaterID: 26489565) is a tributary to North Fork Matilija in the Ventura River Basin (Ventura County, CA), a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands (Core 1; NMFS 2012). North Fork Matilija Tributary's legal description at the confluence with North Fork Matilija is T05N R23W. North Fork Matilija Tributary is a second-order stream that drains a watershed of 0.99 square miles. Elevations range from approximately 1993 to 4844 feet. Lower montane mixed chaparral and riparian mixed hardwood dominate the watershed (CALVEG 2015). Most of Matilija occurs on federally-protected United States Forest Service property. Vehicle access exists via Highway 33.

Bear Creek

Bear Creek (LLID: 1192727345129; DFGWaterID: 26489607) is a tributary to North Fork Matilija Creek within the Ventura River Basin (Ventura County, CA), a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands (Core 1; NMFS 2012). Bear Creek's legal description at the confluence with North Fork Matilija is T05N R23W S14. Bear Creek is a second-order stream that drains a watershed of 2.59 square miles. Elevations range from approximately 1798 at the mouth of Bear to 4661 feet at its headwaters. Lower montane mixed chaparral dominates the watershed (CALVEG 2015). Most of Bear occurs on federally-protected United States Forest Service property. Vehicle access exists via Highway 33.

Cannon Creek

Cannon Creek (LLID: 1192708345180; DFGWaterID: 26489567) is a tributary to North Fork Matilija Creek within the Ventura River Basin (Ventura, CA), a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands (Core 1; NMFS 2012). Cannon Creek's legal description at the confluence with North Fork Matilija Creek is T05N R23W S15. Cannon Creek is a third-order stream that drains a watershed of 2.98 square miles. Elevations range from approximately 1925 to 5043 feet. Lower montane mixed chaparral dominates the watershed (CALVEG 2015). Most of Cannon Creek occurs on federally owned recreational land. Vehicle access exists via Highway 33.

Murietta Creek

Murietta Creek (LLID: 1193780345057; DFGWaterID: 26488459) is a tributary to Matilija Creek in the Ventura River Basin (Ventura County, CA), a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands. Murietta Creek's legal description at the confluence with Matilija River is T05N R24W S29. Murietta Creek is a third-order stream that drains a watershed of 5.93 square miles. Elevations range from approximately 1574 to 4805 feet. Lower montane mixed chaparral dominates the watershed (CALVEG 2015). Most of Murietta occurs on federally-protected United States Forest Service property. Vehicle access exists via Forest Road 5N13. The entirety of Murietta Creek exists above the Matilija Dam, and therefore above anadromy. While the dam limits *O. mykiss* movement to the ocean, these *O. mykiss* are still important to recovery efforts as a relatively protected population.

Murietta Creek Tributary

Murietta Creek Tributary (LLID: 1193952344982; DFGWaterID: 26489753) is a tributary to Murietta Creek which is a tributary to Matilija Creek. These streams are all part of the Ventura River Basin, a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands. Murietta tributary's legal description at the confluence with Matilija Creek is T05N R24W S29. This second-order stream drains a watershed of 1.28 square miles. Elevations range from approximately 1912 to 4644 feet. Riparian mixed hardwood dominates the watershed (CALVEG 2015). Murietta Creek Tributary occurs on federally-protected United States Forest Service property. Vehicle access exists via Forest Road 5N13.

Upper Matilija Creek

Matilija Creek (LLID: 1192992344853; DFGWaterID: 26486801) is a tributary to the Ventura River (Ventura County, CA), a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands (Core 1; NMFS 2012). Matilija Creek's legal description at the confluence with Ventura River is T05N R23W S28. Matilija Creek is a fifth-order stream that drains a watershed of approximately 54.57 square miles. Elevations range from approximately 921 to 6015 feet. Lower montane mixed chaparral dominates the watershed (CALVEG 2015). Most of Matilija occurs on federally-protected United States Forest Service property. Vehicle access exists via Forest Road 5N13.

In this report, we focused on upper Matilija Creek, a section of Matilija that occurs above the Matilija Dam, and therefore above anadromy. While the dam limits *O. mykiss* movement to the ocean, these *O. mykiss* are still important to recovery efforts as a relatively protected population.

Upper North Fork

Upper North Fork Matilija Creek (LLID: 1193829345092; DFGWaterID: 26488447) is a tributary to Matilija Creek within the Ventura River Basin, a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands (Core 1; NMFS 2012). Upper North Fork Matilija Creek's legal description at the confluence with Matilija Creek is T05N R24W S15. Upper North Fork Matilija is a fourth-order stream that drains a watershed of 12.45 square miles. Elevations range from approximately 1608 to 5730 feet. Lower montane mixed chaparral dominates the watershed (CALVEG 2015). Most of Upper North Fork Matilija occurs on federally-protected United States Forest Service property. Vehicle access exists via Forest Road 5N13.

In this report, we examined a tributary of Matilija Creek that occurs above the Matilija Dam, and therefore above anadromy. While the dam limits *O. mykiss* movement to the ocean, these *O. mykiss* are still important to recovery efforts as a relatively protected population.

Santa Ana Creek

Santa Ana Creek (LLID: 1193412343780; DFGWaterID: 26487425) is a tributary to Coyote Creek, which is a tributary to the Ventura River (Ventura County, CA). The Ventura River Basin is a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands (Core 1; NMFS 2012). Santa Ana Creek's legal description at the confluence with Coyote Creek is T04N R24W S24. This third-order creek drains a watershed of 10.54 square miles. Elevations range from approximately 519 to 4802 feet. Riparian mixed hardwood, lower montane mixed chaparral, and ceanothus mixed chaparral dominate the watershed (CALVEG 2015). Most of Santa Ana Creek occurs on federally owned land, along with some agricultural land. Vehicle access exists via a private road off of Highway 150.

West Fork Santa Ana Creek

West Fork Santa Ana Creek (LLID: 1193456344538; DFGWaterID: 26486929) is a tributary to the Coyote Creek in the Ventura River Basin (Ventura County, CA), a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands (Core 1; NMFS 2012). West Fork Santa Ana Creek's legal description at the confluence with Santa Ana Creek is T04N R24W S01. West Fork Santa Ana is a second-order stream that drains a watershed of approximately 3.37 square miles. Elevations range from approximately 1172 to 4802 feet. Riparian mixed hardwood, lower montane mixed chaparral, and ceanothus mixed chaparral dominate the watershed (CALVEG 2015). Most of West Fork Santa Ana occurs on federally-protected United States Forest Service property. Vehicle access exists via Highway 150.

North Fork Santa Ana

North Fork Santa Ana (LLID: 1193456344539; DFGWaterID: 26486927) is a tributary to Santa Ana Creek, which is a tributary to Coyote Creek, which is a tributary to the Ventura River (Ventura County, CA), a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands (Core 1; NMFS 2012). This creek is located above a total natural barrier. North Fork Santa Ana Creek's legal description at the confluence with Santa Ana Creek is T04N R24W S01. North Fork Santa Ana Creek is a second-order stream that drains a watershed of 2.10 square miles. Elevations range from approximately 1172 to 4545 feet. Lower montane mixed chaparral dominates the watershed (CALVEG 2015). North Fork Santa Ana Creek occurs on federally-owned land. Vehicle access exists via De La Garrigue Road off of Highway 150.

Figures

Figure 1. Map of sampled streams in the Conception Coast Biogeographic Population Group.

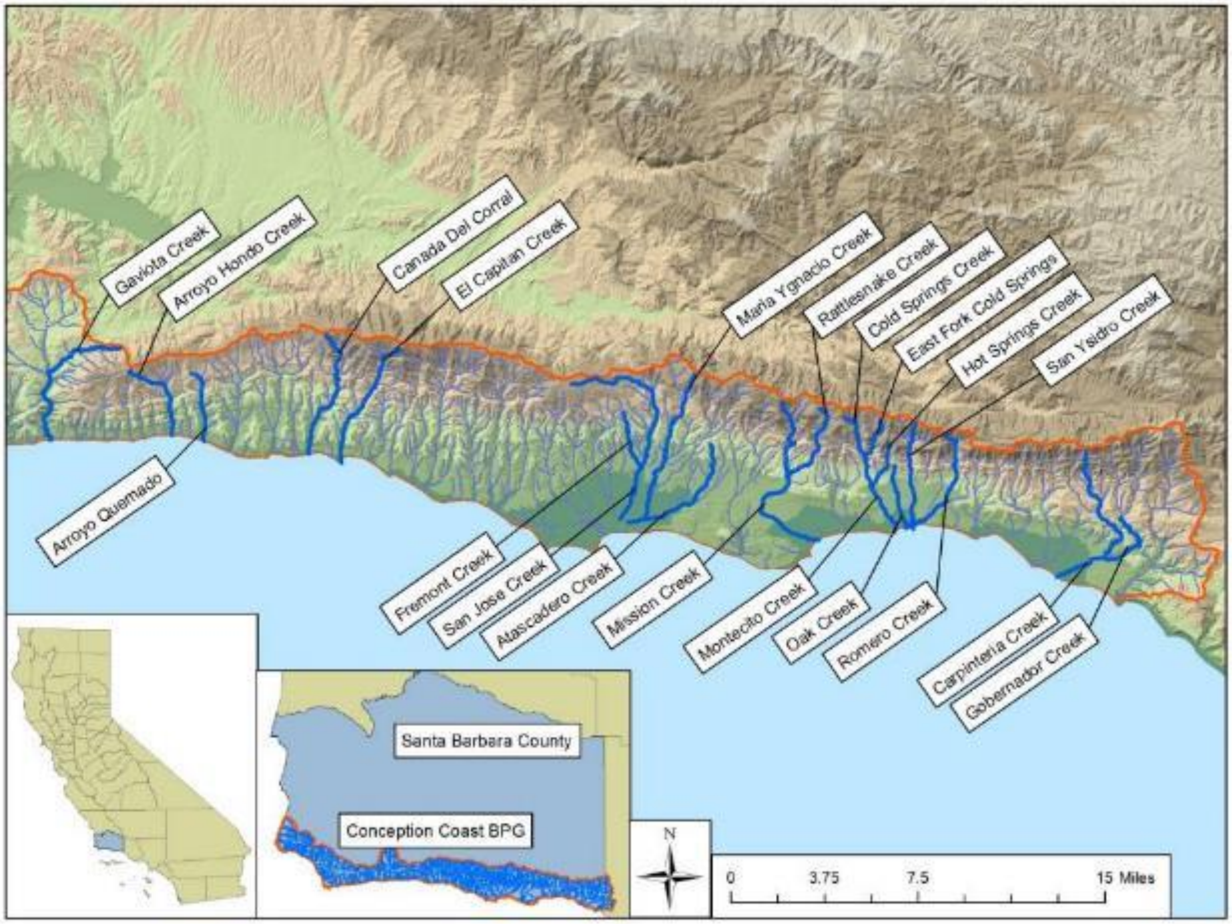
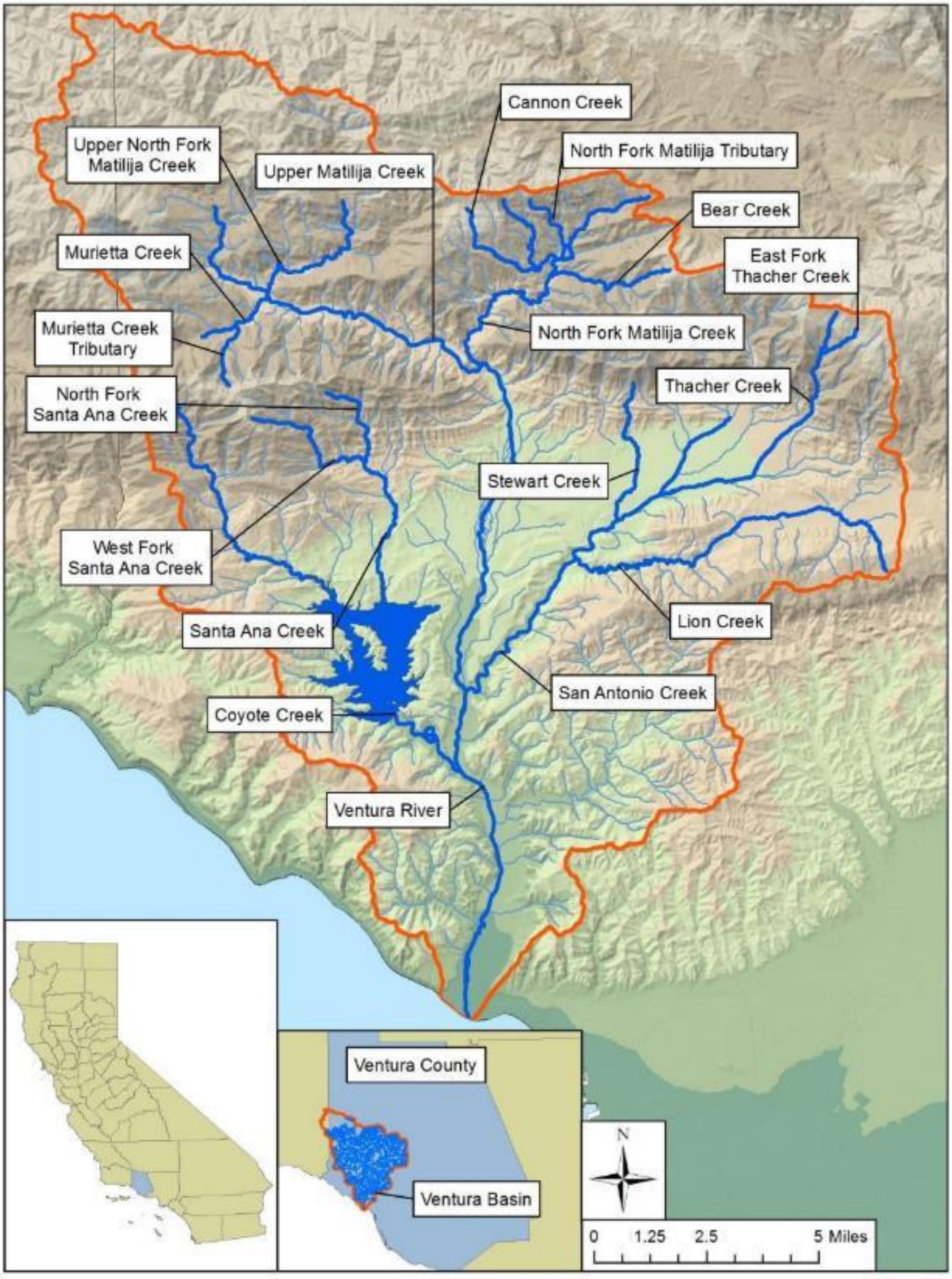


Figure 2. Map of sampled streams in the Monte Arido Highlands Biogeographic Population Group.



Abundance estimation of *Oncorhynchus mykiss* in upper Matilija and Upper North Fork Matilija Creeks in 2015

Introduction

Oncorhynchus mykiss is a Pacific salmon species native to North America. *O*ften referred to as coastal rainbow or steelhead trout, *O. mykiss* exhibit two main life history strategies (resident and anadromous, respectively). These strategies allow *O. mykiss* to persist in diverse habitats and through large environmental events. However, despite these varied life history strategies, *O. mykiss* in southern California are listed as endangered under the Federal Endangered Species Act. The National Marine Fisheries Service has identified a number of recovery actions necessary for *O. mykiss* to be delisted in southern California (NMFS 2012). Underlying these actions is the need for a thorough understanding of *O. mykiss* ecology, including trout abundance and distribution. In this study, we tested a method of abundance estimation. Specifically, we estimated *O. mykiss* abundance in upper Matilija Creek and Upper North Fork Matilija Creek using a double sampling design modified from Hankin & Reeves (1988) and described by McCanne & Reisberger (2005). In doing so, we hope to develop and refine protocols for abundance estimation to enhance our continued monitoring of *O. mykiss* in southern California.

Methods

Watershed Overview

In this report, we focus on two creeks that occur above the Matilija Dam, and therefore above anadromy. While the dam limits the movement of anadromous *O. mykiss* into these reaches, resident *O. mykiss* in these creeks are still important to recovery efforts as a relatively protected population that could contribute to the production of anadromous *O. mykiss* (Clemento et al. 2008).

Upper Matilija Creek

Matilija Creek (LLID: 1192992344853; DFGWaterID: 26486801) is a tributary to the Ventura River (Ventura County, CA), a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands (Core 1; NMFS 2012). Matilija Creek is a fifth-order stream that drains a watershed of approximately 54.57 square miles. Elevations range from approximately 921 to 6015 feet. Lower montane mixed chaparral dominates the watershed (CALVEG 2015). Most of Matilija Creek occurs on federally-protected United States Forest Service property. Vehicle access exists via Forest Road 5N13.

Upper North Fork Matilija Creek

Upper North Fork Matilija Creek (LLID: 1193829345092; DFGWaterID: 26488447) is a tributary to Matilija Creek within the Ventura River Basin, a watershed designated as high priority for steelhead recovery in the Monte Arido Highlands (Core 1; NMFS 2012). Upper North Fork Matilija Creek is a fourth-order stream that drains a watershed of 12.45 square miles. Elevations range from approximately 1608 to 5730 feet. Lower montane mixed chaparral dominates the watershed (CALVEG 2015). Most of Upper North Fork Matilija occurs on federally-protected United States Forest Service and agricultural properties. Vehicle access exists via Forest Road 5N13.

Field Methods

Field data were collected from 15 June to 15 September 2015 by Pacific States Marine Fisheries Commission, with help from the California Department of Fish and Wildlife.

Upper Matilija was surveyed for 10,686 feet starting at 34.51464°N, -119.40226°W (Figure 3). This reach encompassed a wetted portion of Matilija Creek in which *O. mykiss* were previously observed. The endpoint (34.53710°N, -119.40388°W) was a total natural barrier to fish passage.

Upper North Fork Matilija Creek was surveyed 6,019 feet upstream from the survey start at the confluence of Upper North Fork Matilija and Matilija Creeks (34.50898°N, -119.38358°W; Figure 3). The endpoint (34.51557°N, -119.37271°W) was the start of a prolonged dry section of the creek.

Field sampling comprised of three parts: habitat typing, snorkeling, and electrofishing. For habitat typing, the stream was delineated into discrete habitat units, whose dimensions were measured. Based on these dimensions, units were separated into unsnorkelable and snorkelable units. For unsnorkelable units, a subset was systematically-selected to be electrofished. For snorkelable units, a subset was systematically-selected to be snorkeled. Within those that were snorkeled, a further subset was systematically-selected to be electrofished (i.e., double-phase sampling). To prevent disturbances between surveys that might otherwise influence fish counts, we avoided snorkeling and electrofishing units on the same day.

Habitat Typing

For habitat typing, we delineated the wetted stream channel into discrete, natural units of similar habitat (Hankin 1984) using a protocol modified from the *California Salmonid Stream Habitat Restoration Manual (Flosi et al. 1998). We surveyed units* starting from the downstream end of the reach and worked upstream. Habitat units were classified as riffles, pools, or runs (level II habitat types). These units were then measured for length, mean width, mean depth, and maximum depth. Based on habitat type, mean depth, and maximum depth, these units were considered to be either snorkelable or unsnorkelable and were flagged for later snorkeling and electrofishing.

Snorkeling

Snorkelable units were those with mean depths greater than or equal to 0.7 feet and that lacked any debris or structures that could be dangerous for a snorkeler. The 0.7-foot threshold was the minimum depth at which snorkelers could reliably count fish (O'Neal 2007). Only pools and runs were considered to be snorkelable (McCanne & Reisberger 2005); riffles were usually too shallow to be adequately snorkeled (4.4% of all riffles sampled had mean depths of 0.7 feet or greater). Every other snorkelable unit was snorkeled. For snorkeling, a single diver entered the unit from the downstream end and counted the number of fish visually observed while moving towards the upstream end of the unit. Each unit was snorkeled once.

Depletion Electrofishing

We used depletion electrofishing to calibrate snorkel counts. Depletion electrofishing assumes that each successive electrofishing pass catches fewer fish than in the previous pass (White et al. 1982). Additional passes are required if this assumption is violated (McCanne & Reisberger 2005). This method further assumes that fish do not move between units and that equal effort is used across passes (Raleigh & Short 1981, White et al. 1982, McCanne & Reisberger 2005). Each of these assumptions was addressed in the methodology described below.

A final assumption of depletion electrofishing is that all individuals (fish) have an equal probability of being caught (Raleigh & Short 1981, White et al. 1982). This assumption was unlikely to be strictly true in this study, given the general size biases of electrofishing (Temple & Pearsons 2007). We did not correct for these possible biases in our analyses due to time constraints.

Within snorkel<u>ed</u> and unsnorkel<u>able</u> units, a subset was electrofished. Electrofished units were systematically-selected as every fifth snorkel<u>ed</u> unit and every tenth unsnorkel<u>able</u> unit in which electrofishing was possible, using independent random starts. This sampling selection was conservative and was chosen to minimize unnecessary electrofishing trauma to *O. mykiss*. Electrofished units excluded any units with a maximum depth of 3.6 feet or greater and units with complex structures that prevented effective netting or use of the electrofishing anode. The 3.6-foot threshold was the maximum depth at which a backpack electrofisher could be safely used without becoming submerged.

For electrofishing, block nets were placed at the upstream and downstream ends of the unit to prevent fish passage between units. Water temperature and conductivity were measured prior to each pass. Due to concern for fish health, units were only electrofished if temperatures were below 21°C (70°F). For a given pass, a single electrofisher and two netters worked from the downstream end of the unit upstream, shocking the water and netting fish affected by the electrical field. Electrofishing of a unit was complete if no fish were caught in the first two passes (minimum of two passes) or if at least 25% fewer fish were caught in the last pass than in the previous pass. A maximum of five electrofishing passes was allowed per unit (D. McCanne, California Department of Fish & Wildlife, *personal communication*). The time spent electrofishing was recorded for each pass and effort was made in the field to ensure that approximately equal effort was spent on each pass of a given unit. Electrofishing settings were 100–130 volts, 35 hertz, and 30% duty cycle.

Abundance Estimation

Fish abundances were calculated for Upper Matilija and Upper North Fork Matilija Creeks separately. These estimates were applicable only to shallow units (maximum depth less than 3.6 feet). We included unit area (calculated as unit length * mean width) as an auxiliary variable in our calculations (Hankin 1984). The equations used to calculate abundances are described in Appendix I.

To estimate fish abundance, we first excluded any units with maximum depths of 3.6 feet or greater (maximum electrofishable depth) and units that did not meet the above outlined parameters for electrofishing and snorkeling. We calculated a jackknife estimator for each electrofished unit using Equation 1 (Appendix I). These jackknife estimators were then used for subsequent calculations of fish abundance.

We estimated the fish abundance for snorkelable and unsnorkelable units separately, using Equations 2 and 3 (Appendix I), respectively. Snorkelable units were defined as pools or runs with mean depths of 0.7 feet or greater. Habitat units meeting these requirements included a subset of units that were snorkeled, a further subset of which were both snorkeled and electrofished (double sampled). Unsnorkelable units were defined as all riffle units and any pool or run with a mean depth less than 0.7 feet. These unsnorkelable units included a subset of units that were electrofished (Figure 1).

The total within-reach abundance of fish estimated was calculated as the sum of the snorkelable and unsnorkelable abundance estimates. Within-reach variance was calculated as the sum of snorkelable and unsnorkelable variances. Ninety-five percent confidence intervals were calculated based on these variances (Equation 4, Appendix I).

All data management and calculations were completed using R (vers. 3.2.2, R Core Team 2015).

Results

Upper Matilija

Sampled Units

We surveyed 276 habitat units, 257 of which were shallow. Of these shallow units, 121 were snorkelable and 136 were unsnorkelable. Of the snorkelable units, 74 were snorkeled, 14 of which were also electrofished. Of the unsnorkelable units, 10 were electrofished (Table 1).

In this survey, more snorkelable units than expected (>50%) were snorkeled in upper Matilija Creek. This was because units flagged from a separate, unrelated survey were additionally snorkeled. We included these additional units in this study, as they were snorkeled during the same survey period and increased our sample size.

Abundance Estimation

The estimated fish abundance of shallow units in Upper Matilija Creek was 1443 ± 550 fish (± 95% CI; Table 1).

Upper North Fork Matilija Creek

Sampled Units

We surveyed 194 habitat units, 191 of which were shallow. Of these shallow units, 92 were snorkelable and 99 were unsnorkelable. Of the snorkelable units, 45 were snorkeled, 8 of which were also electrofished. Of the unsnorkelable units, 9 were electrofished (Table 1).

Abundance Estimation

The estimated fish abundance of shallow units in Upper North Fork Matilija Creek was 475 ± 355 fish (± 95% CI; Table 1).

Discussion

We calculated fish abundances for Upper Matilija and Upper North Fork Matilija Creeks. We estimated that there were 1443 ± 550 *O. mykiss* (± 95% CI) within shallow units of upper Matilija and 475 ± 355 *O mykiss* in shallow units of Upper North Fork Matilija. Although these two estimates are not currently informative *per se*, they are the basis for future abundance comparisons across reaches and through time, and therefore contribute to continued monitoring efforts. Additionally, the methods we used to estimate abundances will inform the California Department of Fish & Wildlife in their development of protocols for population estimations of anadromous river systems in southern California.

These estimations were limited to the shallow units sampled; we could not electrofish deeper pools and therefore could not make inferences about fish abundance within these pools. However, deep pools comprised only a small percentage of the total units habitat typed (6.9% of upper Matilija and 1.5% of Upper North Fork Matilija), and estimates of abundance for shallow units still provide important data for comparisons across reaches and time. Future research could explore alternative estimation methods for *O. mykiss* in deep or complex habitats.

Future estimations of abundance can be improved by including bias corrections, which were excluded from this study due to time constraints during the reporting period. Furthermore, our estimations may benefit from increased electrofishing sample size. We conservatively electrofished 18–19% of snorkeled units and 7–9% of unsnorkelable units, whereas McCanne & Reisberger (2005) sampled 33% of snorkelable and 10% of unsnorkelable units. Increased effort in electrofishing may provide less variable abundance estimates, although this must be balanced carefully with electrofishing mortality concerns. In addition, temporally-variable flow conditions should be considered when designing study sample size. For example, our study was conducted during the fourth consecutive year of severe drought, which likely contributed to several units being excluded from snorkel and/or electrofish sampling. In these cases, units were habitat typed and measured as having certain water depths, but were found to be dewatered during later snorkeling and electrofishing, despite efforts to snorkel and electrofish soon after habitat typing (dewatered as soon as three days after).

Tables

Table 1. Sample sizes and estimated abundances for upper Matilija and Upper North Fork Matilija Creeks.

Creek	Total # Habitat Units	Snorkelable Units			Unsnorkelable Units		Est. Fish Abund. ± 95% CI
		Total #	# Snorkeled	# Snorkeled + E-fished	Total #	# E-fished	
Upper Matilija	276	121	74	14	136	10	1443 ± 550
Upper North Fork Matilija	194	92	45	8	99	9	475 ± 355

Figures

Figure 3. Map showing the areas of upper Matilija and Upper North Fork Matilija sampled.

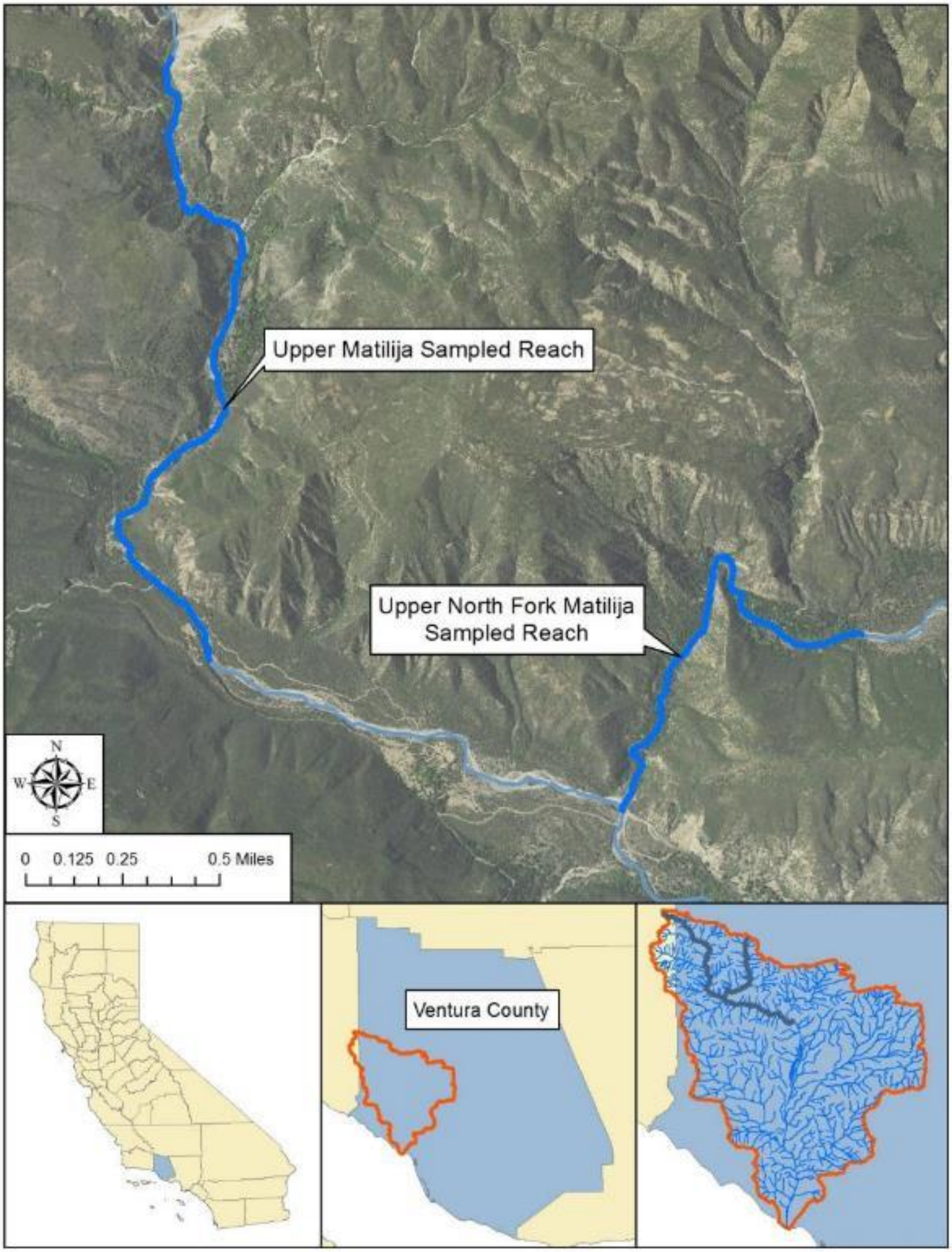
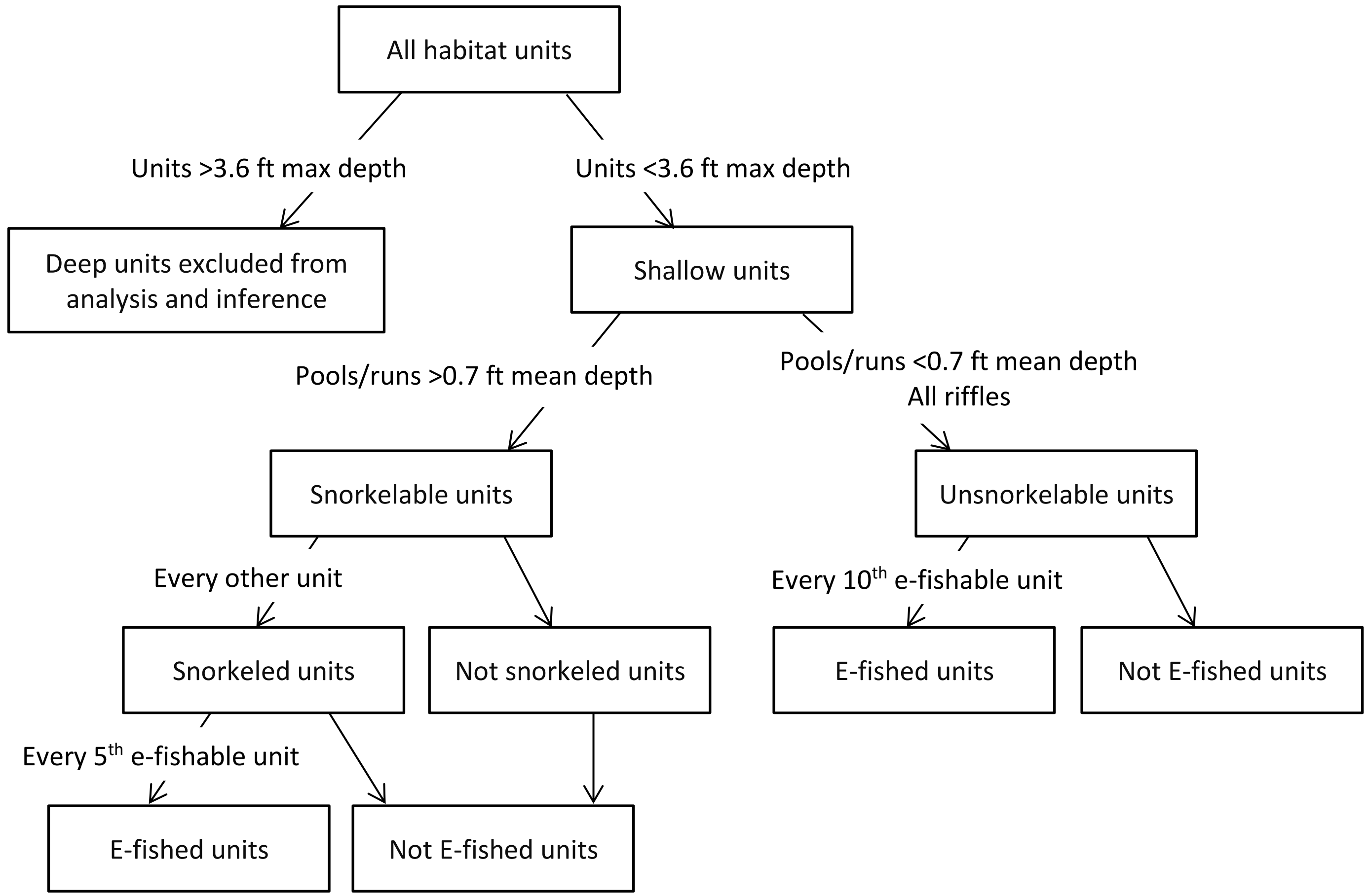


Figure 4. Flow diagram of parameters defining and relationships between data subsets



Appendix I. Equations used to estimate fish abundances

Equation 1. Electrofishing Jackknife Estimation

Jackknife estimation for electrofishing data where the total number of fish ($\hat{y}_i$) and sampling variance ($\hat{V}(\hat{y}_i)$) in unit *i* are estimated by (modified from Pollock & Otto 1983, as notated in McCanne & Reisberger 2005):

$$\hat{y}_i = \sum_{j=1}^{r_i - 1} c_{i \cdot j} + r_i c_{r_i}$$

$$\hat{V}(\hat{y}_i) = r_i(r_i - 1)c_{r_i}$$

where

r_i = the number of electrofishing passes conducted in the i^{th} habitat unit,
c_{r_i} = the number of fish captured in the r^{th} (last) pass in the i^{th} habitat unit, and
$c_{i \cdot j}$ = the number of fish captured in the j^{th} pass in the i^{th} habitat unit.

Equation 2. Abundance Estimation for Snorkelable Units

Estimation for snorkelable units. Snorkelable units included pools and runs that were shallow (maximum depth less than 3.6 feet) and had mean depths greater than or equal to 0.7 feet. A subset of snorkelable units were snorkeled (referred to as phase one sampling in McCanne & Reisberger 2005). A further subset of these snorkeled units were also electrofished and were denoted below as snorkeled + e-fished units (referred to as phase two sampling in McCanne & Reisberger 2005). We used unit area (unit length * mean width) as an auxillary variable (Hankin 1984).

The total number of fish in snorkelable units ($\hat{T}_S$) and sampling variance ($\hat{V}(\hat{T}_S)$) are estimated by (modified from Särndal et al.1992, as notated in McCanne & Reisberger 2005):

$$\hat{T}_S = N\bar{\hat{y}}_2\left(\frac{\bar{x}_1}{\bar{x}_2} + \frac{\bar{A} - \bar{a}_1}{\bar{a}_2}\right)$$

$$\hat{V}(\hat{T}_S) \approx N^2\left(1 - \frac{n_1}{N}\right)\left(\frac{\bar{A}}{\bar{a}_1}\right)^2 \frac{s^2_{\hat{y}|a}}{n_1} + N^2\left(1 - \frac{n_2}{n_1}\right)\left(\frac{\bar{x}_1}{\bar{x}_2}\right)^2 \frac{s^2_{\hat{y}|x}}{n_2}$$

$$s^2_{\hat{y}|a} = \frac{1}{n_2 - 1}\sum_{i=1}^{n_2}\left(\hat{y}_i - \bar{\hat{y}}_2\frac{a_i}{\bar{a}_2}\right)^2$$

$$s^2_{\hat{y}|x} = \frac{1}{n_2 - 1}\sum_{i=1}^{n_2}\left(\hat{y}_i - \bar{\hat{y}}_2\frac{x_i}{\bar{x}_2}\right)^2$$

where

N = the total number of snorkelable units,
$\hat{y}_i$= the jackknife estimate of the true number of fish in the i^{th} unit (within snorkeled + e-fished units; calculated from Equation 1),
$\bar{\hat{y}}_2$ = the mean jackknife estimate of the true number of fish in all snorkeled + e-fished units,
x_i = the observed number of fish counted during snorkeling in the i^{th} unit (within snorkeled + e-fished units),
$\bar{x}_1$= the mean number of fish counted during snorkeling in units that were snorkeled,
$\bar{x}_2$= the mean number of fish counted during snorkeling in units that were snorkeled + e-fished,
$\bar{A}$ = the mean area of all snorkelable units,
a_i= the area of the i^{th} unit (within snorkeled + e-fished units),
$\bar{a}_1$= the mean area of units that were snorkeled,
$\bar{a}_2$= the mean area of units that were snorkeled + e-fished,
n_1 = the number of units that were snorkeled, and
n_2 = the number of units that were snorkeled + e-fished.

Equation 3. Abundance Estimation for Unsnorkelable Units

Estimation for unsnorkelable units. Unsnorkelable units were shallow (maximum depth less than 3.6 feet), included all riffles, and included pools and runs with mean depths less than 0.7 feet. A subset of unsnorkelable units were electrofished.

The total number of fish in unsnorkelable units ($\hat{T}_U$) and sampling variance ($\hat{V}(\hat{T}_U)$) are estimated by (modified from Hankin 1984 and Cochran 1977, as notated in McCanne & Reisberger 2005):

$$\hat{T}_U = N\bar{\hat{y}}\left(\frac{\bar{A}}{\bar{a}}\right)$$

$$\hat{V}(\hat{T}_U) \approx N^2\left(1-\frac{n}{N}\right)\frac{s^2_{\hat{y}|a}}{n} + \frac{N}{n}\sum_{i=1}^{n}\hat{V}(\hat{y}_i)$$

$$s^2_{\hat{y}|a} = \frac{1}{n-1}\sum_{i=1}^{n}\left(\hat{y}_i - \bar{\hat{y}}\frac{a_i}{\bar{a}}\right)^2$$

where

N = the total number of unsnorkelable units,
n = the number of electrofished units,
$\hat{y}_i$= the jackknife estimate of the true number of fish in the i^{th} unit (within electrofished units; calculated in Equation 1),
$\bar{\hat{y}}$ = the mean jackknife estimate of the number of fish across all electrofished units,
$\bar{A}$ = the mean area of all unsnorkelable units,
a_i = the area of the i^{th} unit (within electrofished units), and
$\bar{a}$ = the mean area of electrofished units.

Equation 4. Within-Reach Estimation

Because each stratum (snorkelable and unsnorkelable units in this case) was sampled independently, within-reach estimates ($\hat{T}_{reach}$) were calculated as the sum of both individual estimates (Hankin 1984):

$$\hat{T}_{reach} = \sum_{hab=1}^{j} \hat{T}_{hab}$$

where *j* is the total number of strata (in this case, there were two strata: snorkelable and unsnorkelable units).

The total sampling variance across ($\hat{V}(\hat{T}_{reach})$) was estimated by the sum of individual variances (Hankin 1984):

$$\hat{V}(\hat{T}_{reach}) = \sum_{hab=1}^{j} \hat{V}(\hat{T}_{hab})$$

where *j* is the total number of strata.

Ninety-five percent confidence intervals were estimated by (Cochran 1977, as notated in McCanne & Reisberger 2005):

$$t_{0.025,n-1}\sqrt{\hat{V}(\hat{T}_{reach})}.$$

Sampling Frame

Introduction

A sampling frame defines the area from which study sites are selected and from which data are collected. Sampling frames account for potential data requirements, methodologies, sampling schemes, and statistical requirements of a study. For this project, we developed a preliminary sampling frame for the southern California steelhead monitoring in the Conception Coast BPG and Ventura River basin.

For the scope of this grant, our sampling universe encompassed southern California steelhead habitat in the Conception Coast biogeographic population group (BPG) and the Ventura River basin (located in Santa Barbara and Ventura counties, respectively). The Conception Coast BPG covers an area of 375.17 square miles with 668 uniquely defined blue-line streams comprising 865.9 miles of stream habitat. The Ventura basin encompasses an area of 226.05 square miles with 540 uniquely-identified blue-line streams comprising 638.9 miles of stream habitat (Figure 5).

Methods and Results

Sampling Universe

We began defining our sampling universe by first acquiring blue-line streams in the California Streams digital hydrography dataset (CDFW California Streams 2016; Figure 5). This hydrography dataset contained many stream lines inaccessible to or unsuitable for salmonid spawning or rearing. As a result, we limited our sampling universe to include only anadromous stream areas accessible to southern California steelhead. Specifically, we selected anadromous streams identified in the Southern California Steelhead Recovery Plan as critical habitat for southern California steelhead (NMFS 2012). Critical habitat streams were selected by NMFS based on their ability to support the recovery of steelhead and include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. The resulting NMFS-identified sampling universe included 55 unique blue-line streams and 271.75 miles of critical habitat in the Conception Coast BPG and 11 unique blue-line streams and 48 miles of critical habitat in the Ventura River basin (Figure 6).

NMFS defines the upper and lower limits of anadromy within each critical habitat stream based on natural and man-made barriers to fish passage. However, man-made barriers can be and are sometimes removed, thereby opening up large areas of newly-anadromous waters. Furthermore, some total natural barriers are not listed by NMFS, but are described in the California Passage Assessment Database (PAD 2016). Given this, we modified the sampling universe to include areas above man-made barriers and remove areas above PAD-listed total natural barriers. The resulting frame identified 51 unique blue-line streams and 202.2 miles of stream habitat in the Conception Coast BPG. Within the Ventura Basin, steelhead critical habitat was expanded beyond man-made barriers, resulting in 18 unique blue-line streams and 130.4 miles of stream habitat (Figure 7).

Next, we refined our sampling universe based on information provided by local field biologists regarding *O. mykiss* distribution and the presence of total natural barriers not listed in PAD. As a result, the sampling universe was expanded to include otherwise-excluded streams holding extant or historical populations of *O. mykiss* and was pruned to areas below PAD-excluded total natural barriers. The resulting sampling frame included 60 unique blue-line streams and 211.95 miles of stream habitat in the Conception Coast BPG and 27 unique blue-line streams and 156.1 miles of stream habitat in the Ventura Basin (Figure 8).

Sample Reaches

We separated each stream within our sampling universe into sample reaches. Sample reaches were intended to be approximately two miles in length, but were modified to match historically-sampled CDFW monitoring reaches and include distinctive features that would serve as obvious start and end points for field crews (e.g., bridges, road crossings, geologic features). Final sampling reaches ranged in length from 0.3 to 4.6 miles, with a mean length of 2.12 miles.

After reaches were defined, we organized streams according to guidelines presented by McCanne and Reisberger (2005). Within each stream, reaches were then numbered continuously from the river mouth to the headwaters by stream order, starting with the main stem and ending with tributaries. Numbering started from the northwestern-most stream entering the ocean and ended the southeastern-most stream, with all tributaries numbered within a stream system before starting the next stream.

Discussion

Based on NMFS critical habitat and the knowledge of local field biologists, the sampling frame presented here accurately encompasses both current and potential anadromous habitat available to southern California steelhead in the Conception Coast BPG and Ventura Basin. This sampling frame will continue to develop as the protocols and objectives of the southern California steelhead monitoring program are established. Further development of this sampling frame should include more long-term and extensive *O. mykiss* distribution data, given that relatively little is currently understood about these populations. Additionally, stream gradient and discharge metrics may aid in identifying potential salmonid habitat. While these metrics are currently utilized to create sampling frames in northern California, these metrics have not yet been tested for use under the unique conditions of southern California.

Figures

Figure 5. Sampling universe including all California Streams digital hydrography across the Conception Coast BPG and the Ventura River Basin.

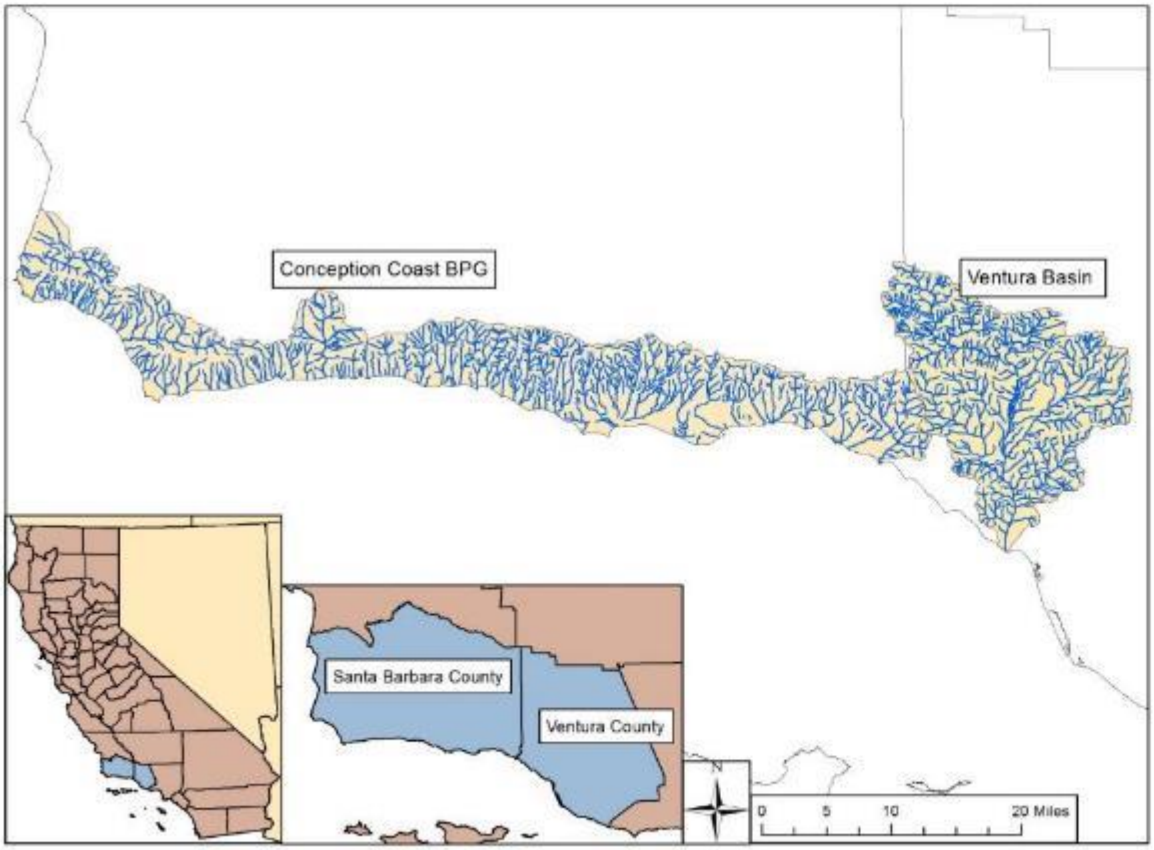


Figure 6. Sampling universe limited to NMFS critical habitat within the Conception Coast BPG and the Ventura basin.

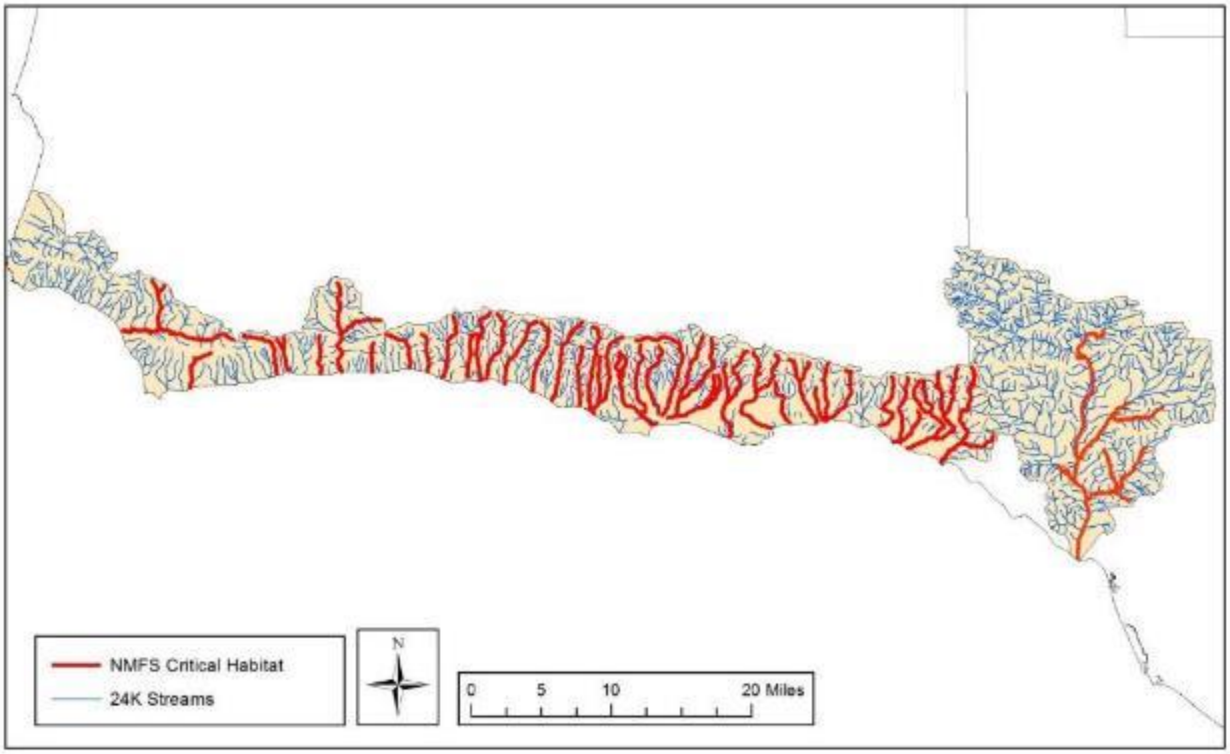


Figure 7. Sampling universe expanded above man-made barriers and limited to NMFS critical habitat below PAD-listed total natural barriers in the Conception Coast and Ventura River Basin.

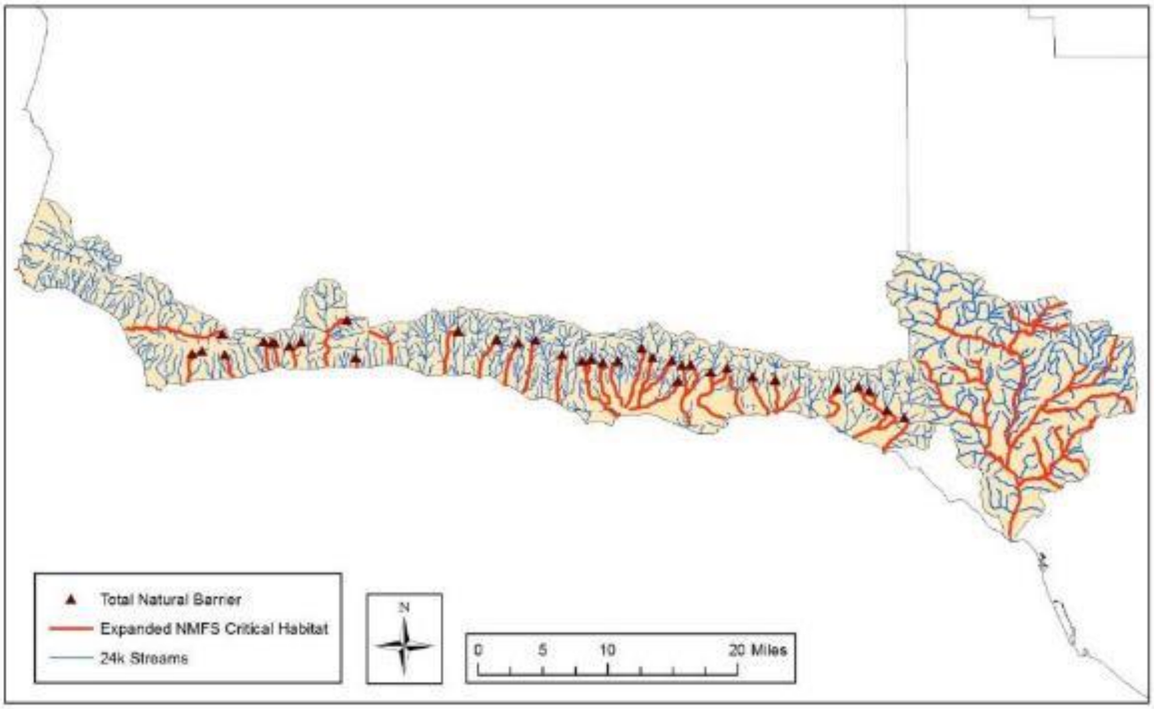
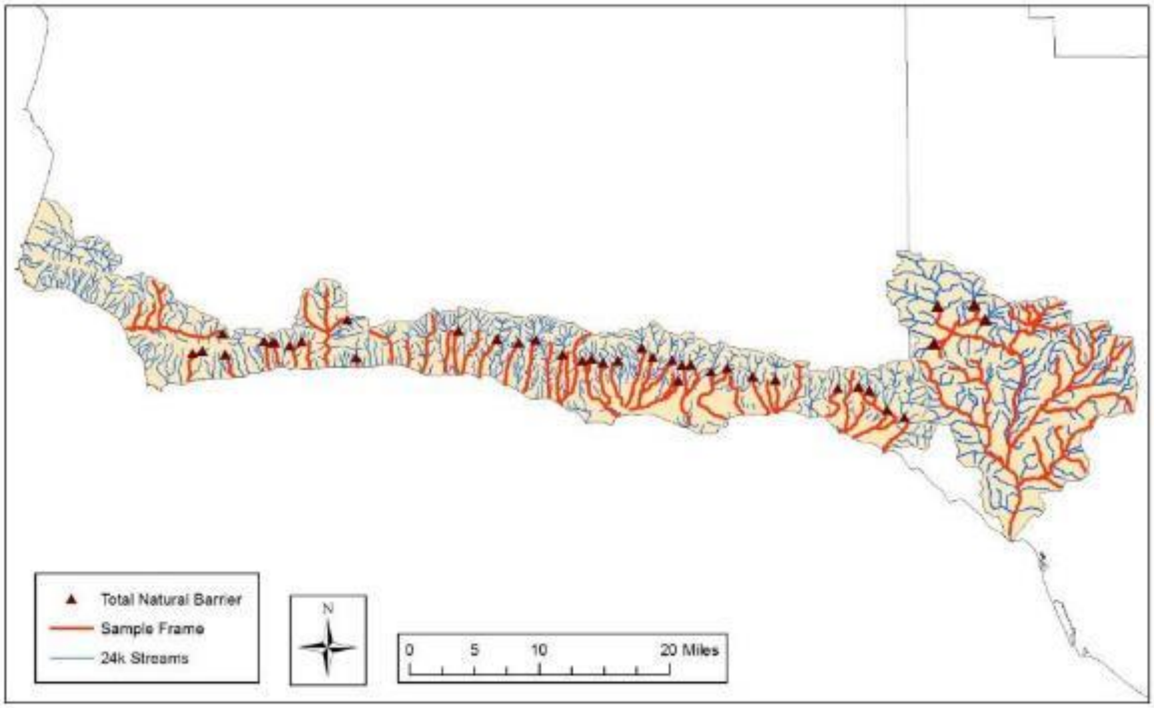


Figure 8. Sampling frame after incorporating field biologist recommendations regarding *O. mykiss* distribution and the presence of total natural barriers not listed in PAD.



Field Methods

Snorkel Surveys

Snorkel surveys were conducted using a protocol adapted from methodologies designed by the American Fisheries Society in the Salmonid Field Protocol Handbook (O'Neil 2007) and the United States Department of Agriculture in the Underwater Methods for Study of Salmonids in the Intermountain West (Thurow 1994). Snorkel survey objectives were to obtain an index of abundance and to document *O. mykiss* distribution for selected reaches.

Survey crews consisted of at least one diver and one data recorder. Survey personnel selected, marked, and then dove every other habitat unit with an average depth of at least of 0.7 feet. Of these habitat units, surveyors skipped pools unfit for snorkeling due to conditions unsuitable for a diver (e.g., oil slick, dead animal) or unsuitable for data collection (e.g., large woody debris, poor visibility).

Divers were equipped with neoprene wet suits, vests, gloves, masks, snorkels and dive lights while data recorders carried GPS, camera, thermometers, and stadia rod. Dive teams observed known protocols (Thurow 1994 and O'Neal 2007) which state that for units with a channel width of less than 15 feet, where a diver can see bank to bank, a single diver is needed to survey the entire length of the unit, moving in an upstream direction. Where channels are wider than 15 feet or a complex habitat makes it difficult for a single diver to observe fish from bank to bank, protocol necessitates two divers simultaneously survey the unit, moving upstream in tandem and making counts within their respective dive lanes to ensure all fish are accounted for.

Divers enumerated and sorted observed *O. mykiss* into 2-inch size classes (i.e., 0-1.99 in, 2-3.99 in, 4-5.99 in, etc.) and reported any additional observations of note (e.g., fish exhibiting signs of black spot disease) to the bankside data recorder. Counts were also be made for special status species of interest, including the California Red-legged Frog (*Rana draytonii)*; however this is not a focus of the overall study and these counts are not always recorded. Additionally presence and visual estimates of other fish species were recorded including Arroyo Chub (*Gila orcutti*) and Threespine Stickleback (*Gasterosteus aculeatus*).

Upon finishing a unit, the diver would also assign shelter and visibility values. Visibility is recorded on a scale of zero to three. A value of zero indicates the diver is unable to perform the survey due to visibility, one is poor, two is average, and three is clear/excellent visibility. Shelter values are estimated on a scale of zero to three based on Flosi et al. (2010) as shown in Table 2.

In addition to fish counts, habitat metrics were also recorded for each snorkeled unit. Habitat unit length, mean width, mean depth, and maximum depth were measured with a stadia rod. For each survey day, weather conditions were also noted. Water and air temperatures were recorded at the beginning of the survey day and at the beginning of each data sheet. GPS points were recorded for each individual sampled unit and at the beginning of a new data sheet.

Tables

Table 2. Shelter value ratings for snorkel and habitat assessment surveys.

Value	**Instream Shelter Complexity Value Examples**
0	• **No Shelter**
1	• One to five boulders • Bare undercut bank or bedrock ledge • Single piece of large wood (>12” diameter and 6’ long) defined as Large woody debris (LWD)
2	• One or two pieces of LWD associated with any amount of small wood (<12” diameter) defined as small woody debris (SWD) • Six or more boulders per 50 feet • stable undercut bank with root mass, and less than 12” undercut • A single root wad lacking complexity • Branches in or near the water • Limited submersed vegetative fish cover • Bubble curtain
3	Combinations of (must have at least two cover types): • LWD/boulders/root wads • Three or more pieces of LWD combined with SWD • Three or more boulders combined with LWD/SWD • Bubble curtain combined with LWD or boulders • Stable undercut bank with greater than 12” undercut, associated with root mass or LWD • Extensive submersed vegetative fish cover

Habitat Assessment Surveys

Within the systems surveyed, we delineated the wetted stream channel into discrete units of similar habitat based on a protocol modified from *California Salmonid Stream Habitat Restoration Manual. We surveyed units* starting from the downstream end of the reach and working upstream. Habitat units were classified according to habitat type and sampled for the metrics outlined below. For all units, we measured unit length, substrate composition, and large woody debris presence. For habitat types encountered for the first time within a day and for one randomly-selected unit per ten units, we additionally quantified the size, shelter rating and type, canopy cover, bank composition, and bank vegetation of the unit. These more intensively-sampled units comprised at least 10% of all sampled units, and were called "100% units".

Habitat Inventory Components

A standardized habitat inventory form was modified from the *California Salmonid Stream Habitat Restoration Manual and used to* record all measurements and observations (Figure 9). This form was comprised of ten components:

1. Temperatures:

At every tenth habitat unit (starting with the first unit of the day), we measured and recorded water and air temperatures, as well as the time of measurement. Temperature was measured in degrees Fahrenheit at the downstream end of the habitat unit for water temperature and within one foot of the water's surface for air temperature.

2. Habitat Type:

Habitat units were numbered sequentially and assigned one of 24 habitat classification types defined by McCain et al. (1990). Dewatered units were labeled "dry". Habitat typing was conducted using a standard, basin-level measurement criteria, in which the minimum length of a unit must be equal to or greater than the stream's mean wetted width for non-pool units.

3. Unit Measurements

We measured the length of every unit. For all 100% and pool units, we also measured the mean width, mean depth, and maximum depth of the unit. All measurements were taken in feet using a hip chain or stadia rod.

4. Pool Metrics:

For all pool units, we measured the crest of tail-outs for the dominant substrate, the embeddedness of substrate, and depth. To measure embeddedness, we visually estimated the degree to which substrate suitable for spawning (cobble or gravel) was embedded in pool tail-outs. Embeddedness was measured as the percentage that cobble was buried in fine sediment. Values were recorded using the following ranges: 0–25% (value 1), 26–50% (value 2), 51–75% (value 3), and 76–100% (value 4) embedded. Using this scale, a value of 1 indicated the best spawning conditions, while a value of 4 indicated the worst. A value of 5 was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate, such as bedrock, log sills, or boulders, or due to other considerations.

5. Shelter:

Instream shelter rating was used to quantify the elements within the wetted stream channel that could potentially provide protection from predation, reduce water velocity to provide refugia, or separate territorial units to reduce competition among juvenile *O. mykiss*. We calculated the shelter rating for each 100% habitat unit by multiplying the percent cover by shelter value. Percent cover was determined by visually estimating the percentage of wetted habitat unit covered by shelter (from an overhead view). Shelter values quantified the complexity of cover within the unit and ranged from 0 (no cover) to 3 (highly-complex cover). Ratings were defined using criteria outlined in Table 2, which were the same criteria used for snorkel surveys (see above). Based on the product of percent cover and shelter value, shelter ratings ranged from 0–300. Using this scale, 0 indicated that no cover was present, while 300 indicated that the unit had a shelter value of 3 and 100% of the unit was covered by shelter.

In addition to these measurements of shelter rating, we also visually estimated the percentage that different shelter types comprised the total shelter within a habitat unit. Shelter types included undercut banks, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater or bubble curtain, boulders, and bedrock ledges.

6. Substrate Composition:

In all units, we visually estimated the most dominant and second-most-dominant substrate types of the wetted stream bed. Substrate types consisted of seven size classes that ranged from silt/clay-sized particles to bedrock.

7. Canopy Cover:

Canopy cover density was defined as the percentage of the wetted stream that was shaded from sun exposure by canopy. Cover density was measured using a modified handheld spherical densitometer, as described in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998). Measurements were taken from the center of the upstream end of the unit. We measured canopy for all 100% units, as well as for two additional, randomly-selected units per ten units. Thus, at least 30% of all units sampled included cover measurements.

We also visually estimated the percentage of canopy cover that was derived from deciduous trees and evergreen trees.

8. Bank Composition and Vegetation:

To measure factors influencing the ability of stream banks to withstand winter flows, we quantified the dominant substrate type of both right and left banks for each 100% unit. Substrate composition was estimated from the area immediately adjacent to the wetted channel to bankfull. Bank substrate composition ranged in size from silt/clay/sand to bedrock.

In addition to substrate composition, we also quantified the vegetation of both right and left banks, measuring from bankfull to 20 ft. above bankfull. Specifically, we quantified the dominant type of vegetation present (grass, brush, trees, etc.) and visually estimated the percentage of bank covered by vegetation (including downed trees, logs, and root wads).

9. Large Woody Debris Count:

Because large woody debris (LWD) is important to fish habitat and channel formation, we recorded all pieces of LWD observed partially or fully below the elevation of bankfull discharge in wetted units. LWD was considered to be any dead wood that was at least one foot in diameter and at least six feet long.

10. Bankfull Width:

Bankfull width can be a factor influencing habitat components, such as canopy density, water temperature, and pool depth. In this inventory, we measured bankfull at the first appropriate velocity crossover for every ten units.

Data Analysis

Habitat Metrics

Data were entered into Stream Habitat 2.0.19, a Visual Basic data entry program developed by Karen Wilson (Pacific States Marine Fisheries Commission) in conjunction with the California Department of Fish and Wildlife. This program processed and summarized the data, producing a number of habitat metrics. These metrics were used to report habitat type, pool metrics, shelter, canopy cover, bankside metrics, and bankfull (numbers 1–13 and 15). LWD (number 14) was calculated by hand.

Habitat Type

1) the percentage of units and percentage of total stream length characterized as riffle, flatwater, or pool types,
2) the percentage of units and percentage of total stream length by habitat type,

Pool Metrics

3) the percentage of pool units by pool habitat type,
4) the number of pools by residual depth (maximum depth minus tail-out depth),
5) the percentage of pool units by dominant substrate,
6) the percentage of pool units by tail-out substrate embeddedness value,

Shelter

7) the mean shelter rating of units characterized as pools, riffles, and flatwaters,
8) the mean shelter rating of pool units by pool type,
9) the mean percentage of shelter across all 100% units by shelter type,
10) the mean percentage of shelter in 100% pools by shelter type,

Canopy Cover

11) the percentage of canopy cover by tree type,

Bankside Metrics

12) the mean percentage of banks (two banks measured per unit) by dominant bank substrate type,
13) the mean percentage of banks by bank vegetation type,

Large Woody Debris

14) the number of LWD per 100 feet of wetted stream length,

Bankfull

15) the mean bankfull width of the entire surveyed stream.

All graphs were produced in R (R Core Team, 2015, vers. 3.2.2).

Figures

Figure 9. Field data form for habitat assessment surveys.

Habitat Inventory Data Form Level 4								Actual Form # ______ of _____			
Date / /		Stream Name:						Field Form # _______ of ______			
Quad:		Channel Type:			Reach:			BFW		at HU:	
Surveyors:				Lat:			Long:				
Time: H20		Air		Flow		Pg Length:			Total Length:		
Camera:		GPS:			US or DS of			(write other crew initials)			
Field Habitat Unit Number											
Habitat Unit Type											
Side Channel Type											
Length											
Mean Width											
Mean Depth											
Max Depth											
Depth Pool Tail Crest											
Pool Tail Substrate											
Pool Tail Embeddedness											
LWD Count D>1L &6to 20											
LWD Count D<1 & L>20											
Shelter Rating	Shelter Value										
	% Unit Covered										
	% undercut bank										
	% swd (d<12")										
	% lwd (d>12")										
	% root mass										
	% terr. Vegetation										
	% aqua. Vegetation										
	% bubble curtain										
	% boulders										
	% bedrock ledges										
Substrate Composition 2 Most Dominate	A) Silt/Clay										
	B) Sand										
	C) Gravel (0.08-2.5")										
	D) Sm. Cobble										
	E) Lg. Cobble (5-10")										
	F) Boulder										
	G) Bedrock										
Percent Exposed Substrate											
Percent Total Canopy											
	% Deciduous										
	% Evergreen										
Bank Composition & Vegetation	Rt Bk Composition										
	Rt Bk Dominant Vg										
	% Rt Bk Vegetated										
	Lft Bk Composition										
	Lft Bk Dominant Vg										
	% Lft Bk Vegetated										
Spawning Gravel (ft^2)											
Cemented Gravel (ft^2)											
Bank Composition Types 1) Bedrock 2) Boulder 3) Cobble/Gravel 4) Slit/Clay/Sand											
Vegetation Types 5) Grass 6) Brush 7) Deciduous Trees 8) Evergreen Trees 9) No Vegetation											

Redd Surveys

Redd surveys were conducted from December 10, 2014 through June 1, 2015 in the Ventura River watershed using protocols and reach designations developed by NMFS (Table 3 [in present paper]; Figure 10; Bush 2012). Reaches were surveyed every month until the first redd was observed. Thereafter, crews surveyed every reach biweekly.

During redd surveys, teams of two or more walked stream reaches looking for new and old redds, live *O. mykiss, O. mykiss* carcasses and other species of interest. Crews also recorded GPS points of intermittent and dry stretches of the surveyed reaches to monitor seasonal variations in wettedness and potential drought effects. All data was collected using paper data forms. The summaries of these protocols are presented below.

Survey Header Data

Date, watershed, stream name, reach, method (e.g., walking), weather (e.g., sunny, cloudy, etc.), air temperature, water temperature, water visibility, and surveyors' names were recorded prior to the beginning of any survey.

Redd Counting Protocol

Because no other redd forming species exist in southern California, all observed redds can be assumed to be a product of *O. mykiss* (Adams et al. 2011). All newly observed redds were flagged and measured for pot length (P_L), pot width (P_w), pot depth (D), pot substrate (P_s), tail spill length (TS_L), tail spill widths (TS_W; taken from 1/3 and 2/3 the distance from the top of the tail spill) and tail spill substrate (Figure 11).

GPS data was collected using a handheld Garmin Rino 655t unit. Flagging tape indicating the date, redd record number, bearing and distance from the flag to the center of the redd, the total redd length (the combined pot and tail spill lengths of the redd), the redd age and the year was attached downstream of each newly detected redd. This flagging was used to avoid double counting redds and to track any change in redd dimensions between subsequent surveys. Redd age was assigned according to the following rubric:

1= New since last survey
2= Previously identified and still measurable
3= No longer measurable but still visible
4= No redd apparent, only flag
5= Poor conditions, cannot see substrate

Tables

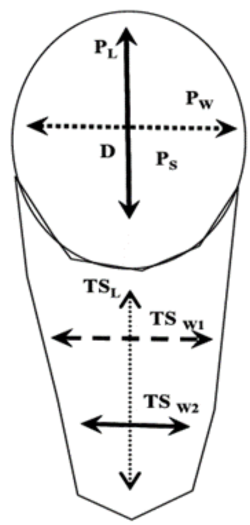
Table 3. List of redd survey reaches with location codes and GPS points for the Ventura River basin. Reach abbreviations that are used throughout this report are noted here.

Description	Location Code	Latitude Downstream	Longitude Downstream	Latitude Upstream	Longitude Upstream	Distance (mi)
Ventura River Reach 1	1	34.28189	119.30885	34.33662	119.29708	4.04
Ventura River Reach 2	2	34.33662	119.29708	34.37942	119.30752	3.48
Ventura River Reach 3	3	34.37942	119.30752	34.42503	119.30159	3.48
Ventura River Reach 4	4	34.42503	119.30159	34.46509	119.2895	3.36
Ventura River Reach 5	5	34.46509	119.2895	34.48456	119.30843	1.68
Ventura / Matilija Reach	5.1	34.485269	119.300042	34.484413	119.30853	0.65
Matilija Creek Reach 1	6	34.49466	119.33091	34.50217	119.37057	2.80
Matilija Creek Reach 2	7	34.50217	119.37057	34.51756	119.40476	2.49
San Antonio Crk Reach 1	8	34.37942	119.30752	34.4221	119.26424	4.66
San Antonio Crk Reach 2	9	34.4221	119.26424	34.45434	119.22169	3.85
San Antonio Crk Reach 3	10	34.45434	119.22169	34.46603	119.20564	1.43
San Antonio (Lion) Reach 4	11, 11.1	34.4221	119.26424	34.441936	119.24276	1.58
North Fork Matilija Reach 1	12	34.4853	119.29973	34.50691	119.29518	2.17
North Fork Matilija Reach 2	13	34.50691	119.29518	34.5129	119.27386	2.11
North Fork Matilija Reach 3	14, 14.1, 14.2	34.5129	119.27386	34.51854	119.2814	1.40
NF Matilija (Bear) Reach 4	15	34.5129	119.27386	34.51152	119.25447	1.24
Matilija Creek (UNF) Reach 3	16	34.509104	119.383623	34.515639	119.372944	1.24

Figures

Figure 10. Ventura River watershed redd survey reaches and corresponding location codes.

Figure 11. Redd measurement locations.



DIDSON

Project staff assisted in DIDSON deployment and data collection and site development for three DIDSON monitoring stations located on Salsipuedes Creek (a tributary to the Santa Ynez River), Carpinteria Creek and the Ventura River. These sites were previously established through the efforts of a prior Fisheries Restoration Grant Program project staffed by Pacific States Marine Fisheries Commission personnel as were data collection and analysis methodologies. A detailed description of these actions can be found in the corresponding project final report for Fisheries Restoration Grants Program project number P1050004 (Bankston and Block 2015).

Results and Discussion

Conception Coast

Cañada de la Gaviota Creek

Habitat Assessment

Results

The habitat inventory was conducted from 3 August to 23 September 2015 by Tom van Meeuwen, Kyle Evans, Marisa Morse, Terra Dressler, Philip Hunter, and Taylor Berryman from Pacific States Marine Fisheries Commission. The survey extended 18,613 feet upstream from the survey start (34.47117 °N, -120.22646°W; Figure 12). The survey endpoint (34.51074°N, -120.22844 °W) was the end of landowner access. Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 61 to 70°F. Air temperature ranged from 63 to 82°F.

Habitat type

Of the total number of habitat units surveyed (n = 156 units), 25.6% of units were dry, 17.3% were flatwaters, 34.0% were pools, 18.6% were riffles, and 4.5% were not surveyable. Of the total length of the reach surveyed, 52.4% was dry, 12.2% was composed of flatwaters, 14.5% was composed of pools, and 7.2% was composed of riffles, and 13.8% was not surveyable (Figure 13).

We identified ten habitat types in Gaviota Creek (excluding unsurveyable units). Based on the frequency of units sampled, mid-channel pools (26.9%), dry (25.6%), and low gradient riffles (17.3%) were the most common habitat types (Table 4). Based on total stream length, dry (52.4%), unsurveyable units (13.8%), and mid-channel pools (10.6%) composed the greatest stream lengths.

Pool Metrics

A total of 53 pools were identified within the survey reach. Main channel pools were most frequently encountered (86.8% of pool units sampled) and comprised 91.0% of the total length of all pools. Only main channel and scour pools were encountered; no backwater pools were recorded. Eight of 52 pools (15%) had residual depths of three feet or greater (Figure 14).

Within pool tail-outs, silt/clay was the most frequently observed dominant substrate (58.9% of pool units), followed by boulders (14.3%) and bedrock (12.5%; Figure 15).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (92.7%; Figure 16).

Shelter

Within 100% units (n = 39 units), riffle habitat types had a mean shelter rating of 69.4, flatwaters had a mean shelter rating of 80.6, and pools had a mean shelter rating of 43.8.

Of the pool units in which shelter was assessed (n = 17 units), main channel pools had a mean shelter rating of 43.5, and scour pools had a mean shelter rating of 45.0.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that aquatic vegetation provided the most shelter (50.4% of all shelter), followed by boulders (30.3%; Figure 17). When we examined the percentage of shelter by shelter type within pools only, we found that aquatic vegetation (40.6%) and boulders (40.3%) were the most dominant cover types (Figure 18).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 71.5%. Within the canopy cover present, 71.8% of canopy was composed of deciduous trees and 28.2% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were sand/silt/clay (50.0%), bedrock (27.6%), and boulder (22.4%; Figure 19). The mean percentage of vegetation covering the right bank in sampled units was 52.6%, and the mean percentage of vegetation covering the left bank was 60.5%. Brush was the dominant vegetation type, having been observed in 56.6% of the bank surveyed (Figure 20).

Large Woody Debris

We observed three pieces of LWD that were 6 to 20 feet long and one piece that was greater than 20 feet long within 6292.5 feet of wetted stream length. Across both LWD sizes, the number of

LWD observed was 0.06 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 41.0 feet.

Discussion

Temperature

The water temperature of units measured ranged from 61 to 70°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Very Good to Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining Gaviota Creek in terms of pool, flatwater, and riffle frequency, we found that most units were dry or pools. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools or dry. When we examined the reach in terms of length, we found that most of the reach was dry or unsurveyable and that mid-channel pools comprised the greatest percentage of wetted, surveyable stream length. These results suggest that the current severe drought, which has extended into its fourth consecutive year, is greatly affecting the amount of habitat available to *O. mykiss.*

Pool Metrics

Pool depth is an important indicator of habitat quality, as deeper pools can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in Gaviota, we found that most pools had residual depths of 1–1.99 feet deep and that only 15% of pools had residual depths of three feet or greater. Given that a residual depth of at least three feet is needed to be considered good habitat (Kier Associates & NMFS 2008), there may not be many pools that can provide adequate hiding and rearing space for *O. mykiss* in Gaviota.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was silt/clay, comprising 58.9% of pool units. Pool units most frequently had an embeddedness value of five (92.7%). Together, these metrics suggest that, pools in Gaviota are poor in both providing spawning habitat and providing good hiding cover and rearing space. Such conditions may be attributable or exacerbated by the current lack of water and flow events that might normally create deeper pools with less silt.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of 100% riffle, flatwater, and pool units, we found that flatwaters had the highest shelter rating, while pools had the lowest.

When examining pool habitat units specifically, we found that main channel and scour pool shelter ratings were similar to one another (43.5 and 45.0, respectively). However, it is important to note the large difference in sample size between the two pool types; shelter was measured in 46 main channel pools and only seven scour pools.

When we examined shelter types both across all 100% units and within pools only, we found that aquatic vegetation and boulders were the most dominant cover types.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In Gaviota, we estimated a mean canopy cover of 71.5%, consisting predominantly of deciduous trees. This suggests that Gaviota has a moderately high amount of cover (Kier Associates & NMFS 2008), but this cover is likely to vary greatly through time, given the seasonality of deciduous trees.

Bankside Metrics

The predominant substrate composing stream banksides was sand/silt/clay, followed by bedrock. The mean percentage of vegetation covering the right and left banks was 52.6% and 60.5%, respectively. Brush was the most common dominant vegetation observed (56.6%). Together these bankside metrics suggest that these banks may be vulnerable to erosion during high flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In Gaviota Creek, we found 0.06 pieces of LWD per 100 feet, which was extremely low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Gaviota lacks LWD, it may have boulder elements that improve habitat quality.

Tables

Table 4. Percentage of all units by habitat type for Gaviota Creek (n = 156).

Habitat Type	% of Units
Mid-Channel Pool	26.92%
Dry	25.64%
Low Gradient Riffle	17.31%
Run	10.26%
Step Run	6.41%
Not Surveyable	4.49%
Lateral Scour, bedrock-formed	3.21%
Step Pool	2.56%
Bedrock Sheet	1.28%
Plunge Pool	1.28%

Figures

Figure 12. Map of the habitat assessment survey area in Gaviota.

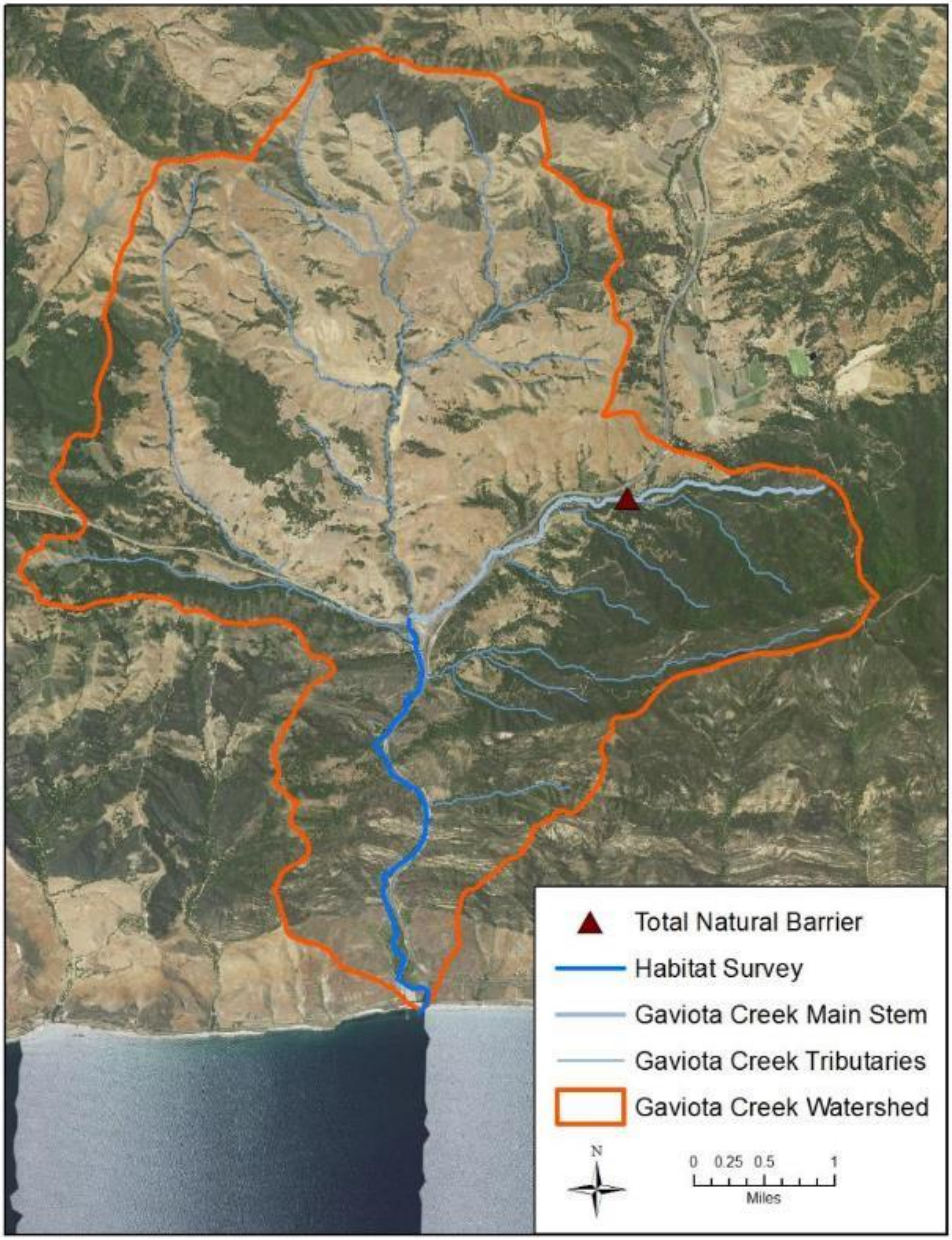


Figure 13. Percentage of total stream length categorized as pools, flatwaters, riffles, dry, or not surveyable for Gaviota Creek.

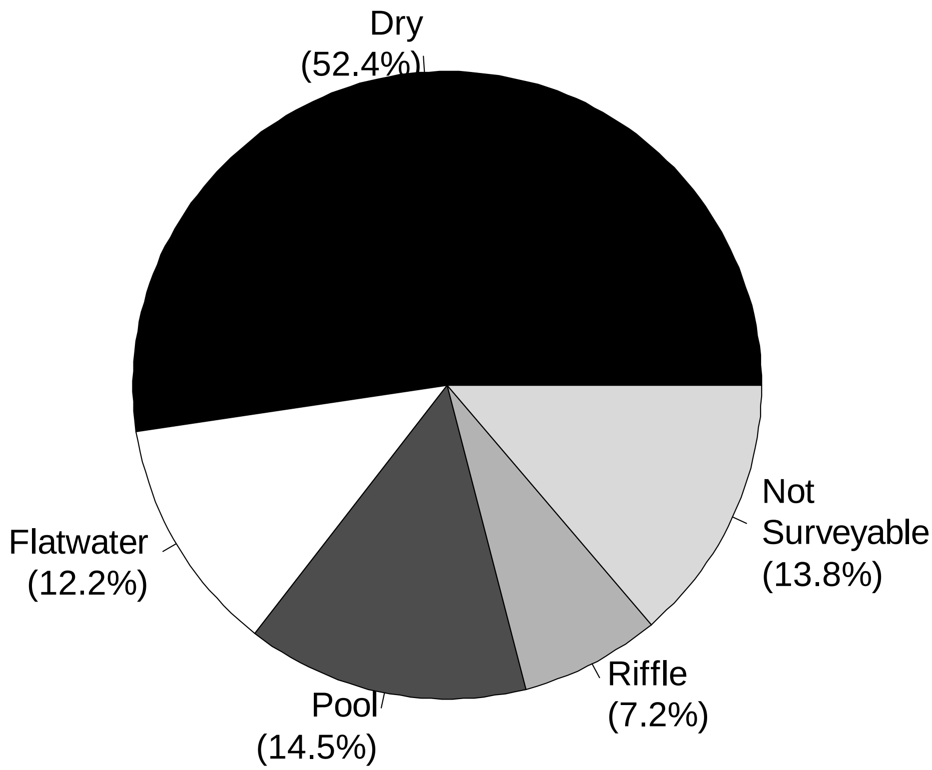


Figure 14. Histogram of residual pool depths in one-foot bins for Gaviota Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

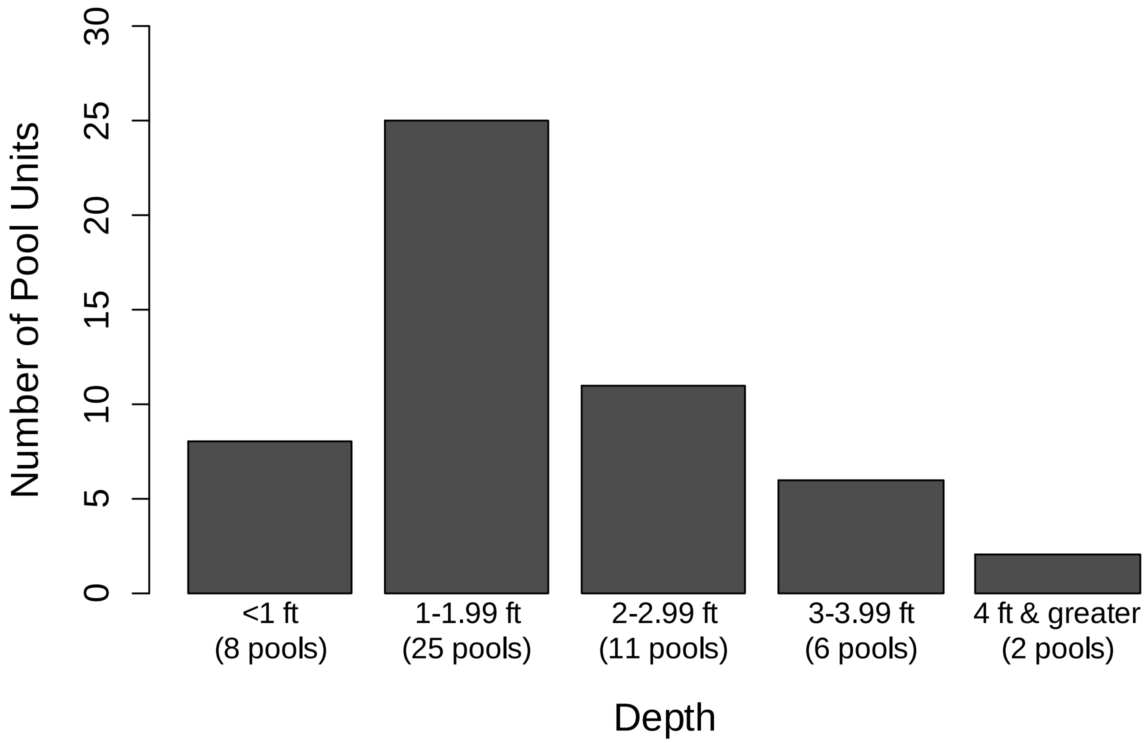


Figure 15. Percentage of pool tail-outs (n = 53 pools) by dominant substrate for Gaviota Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

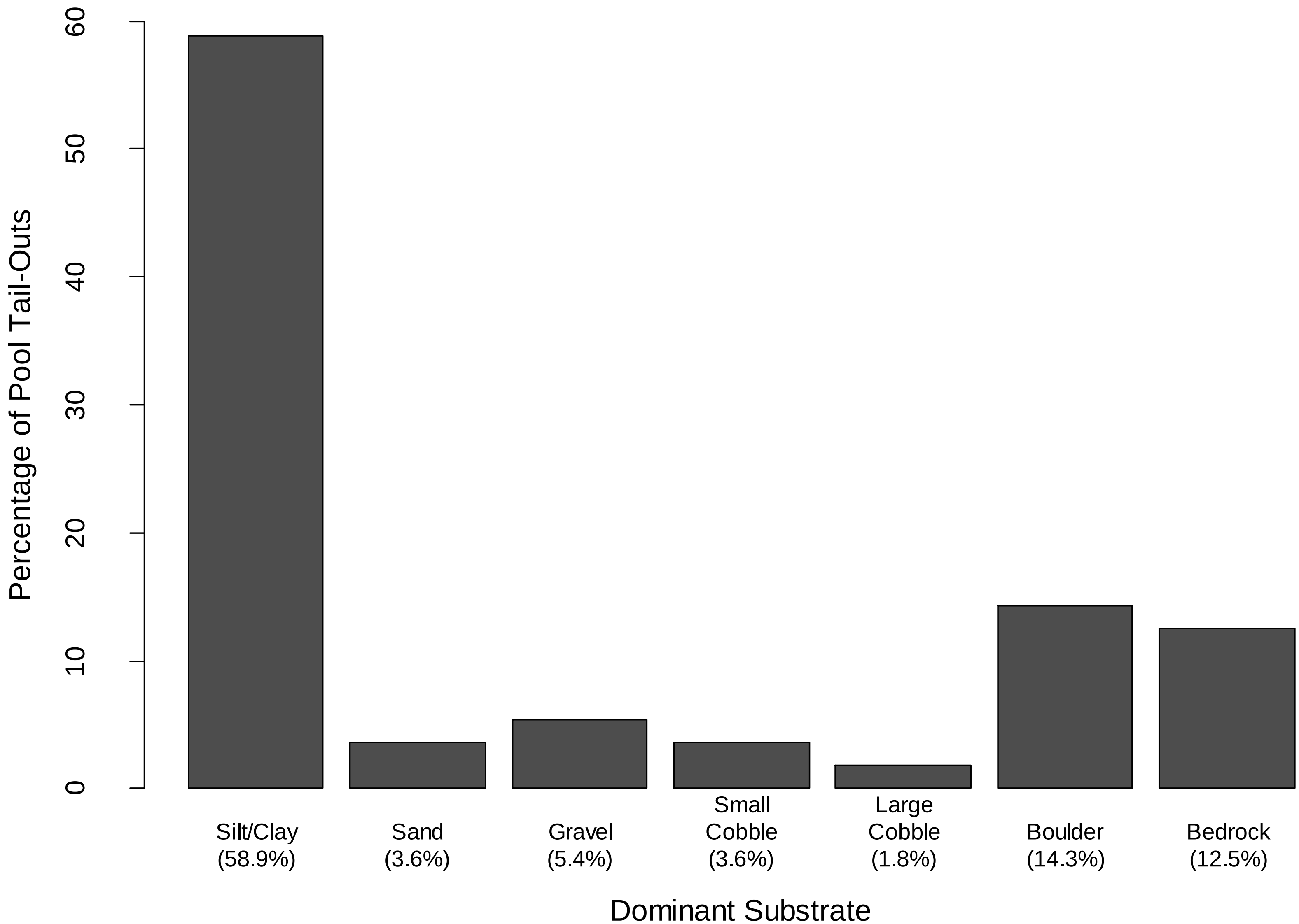


Figure 16. Percentage of all pool units (n = 53 pools) assigned a pool tail-out embeddedness value of 1 to 5 in Gaviota Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning. In this survey, pool tail-outs did not have embeddedness values of 3 or 4.

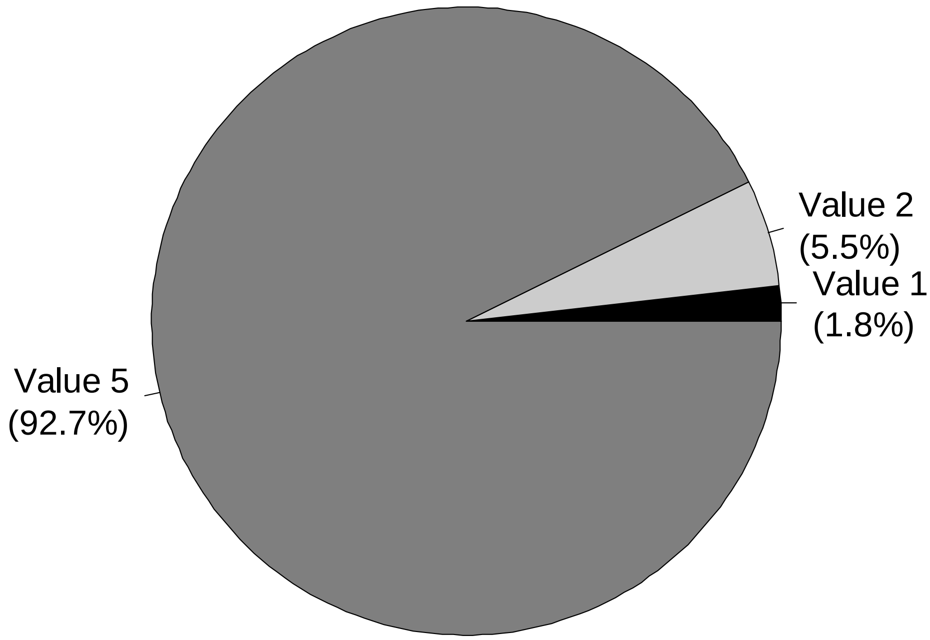


Figure 17. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 39 units) for Gaviota Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

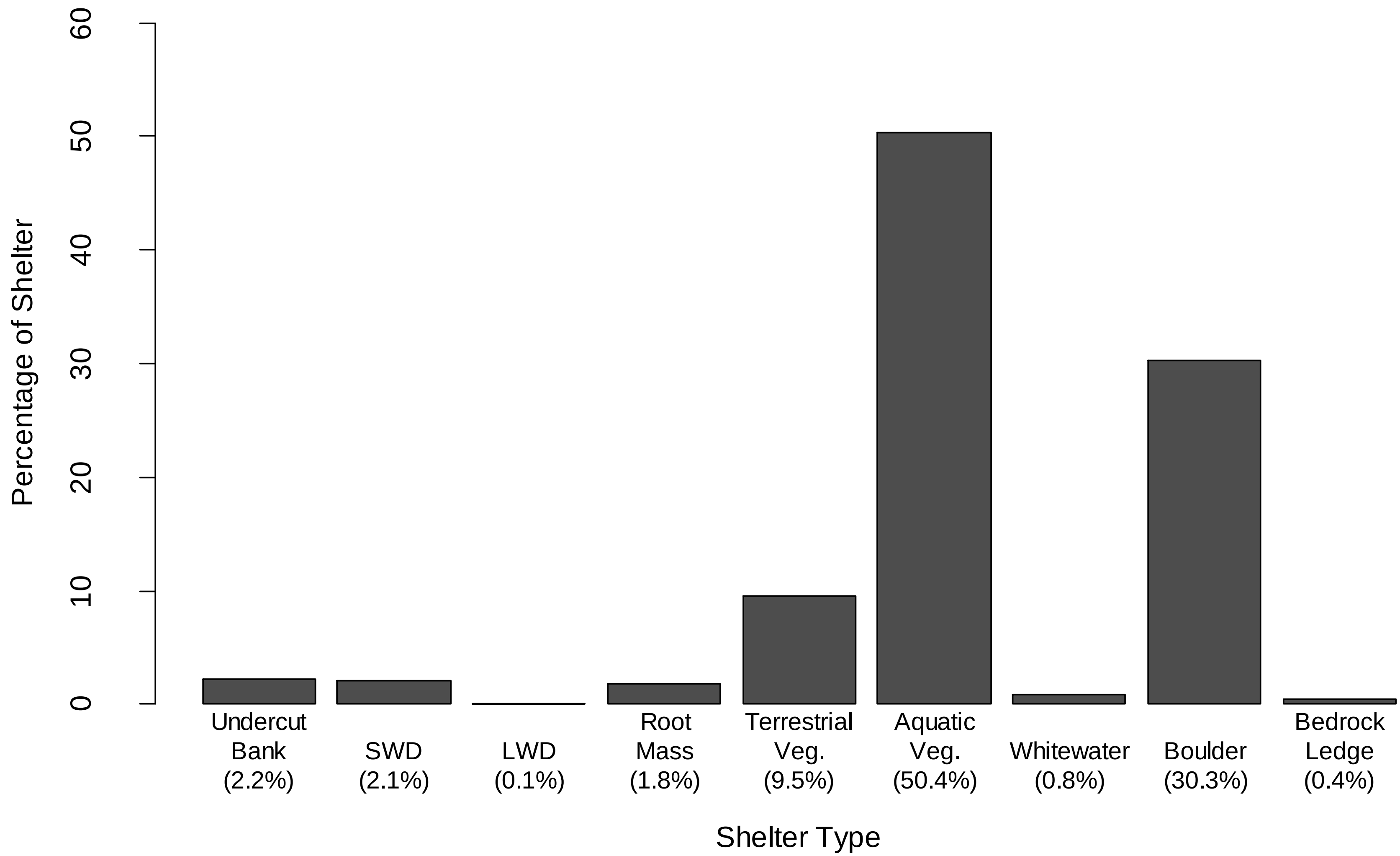


Figure 18. The percentage of instream shelter by shelter type across all pool units in which shelter was measured (n = 17 pools) for Gaviota Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

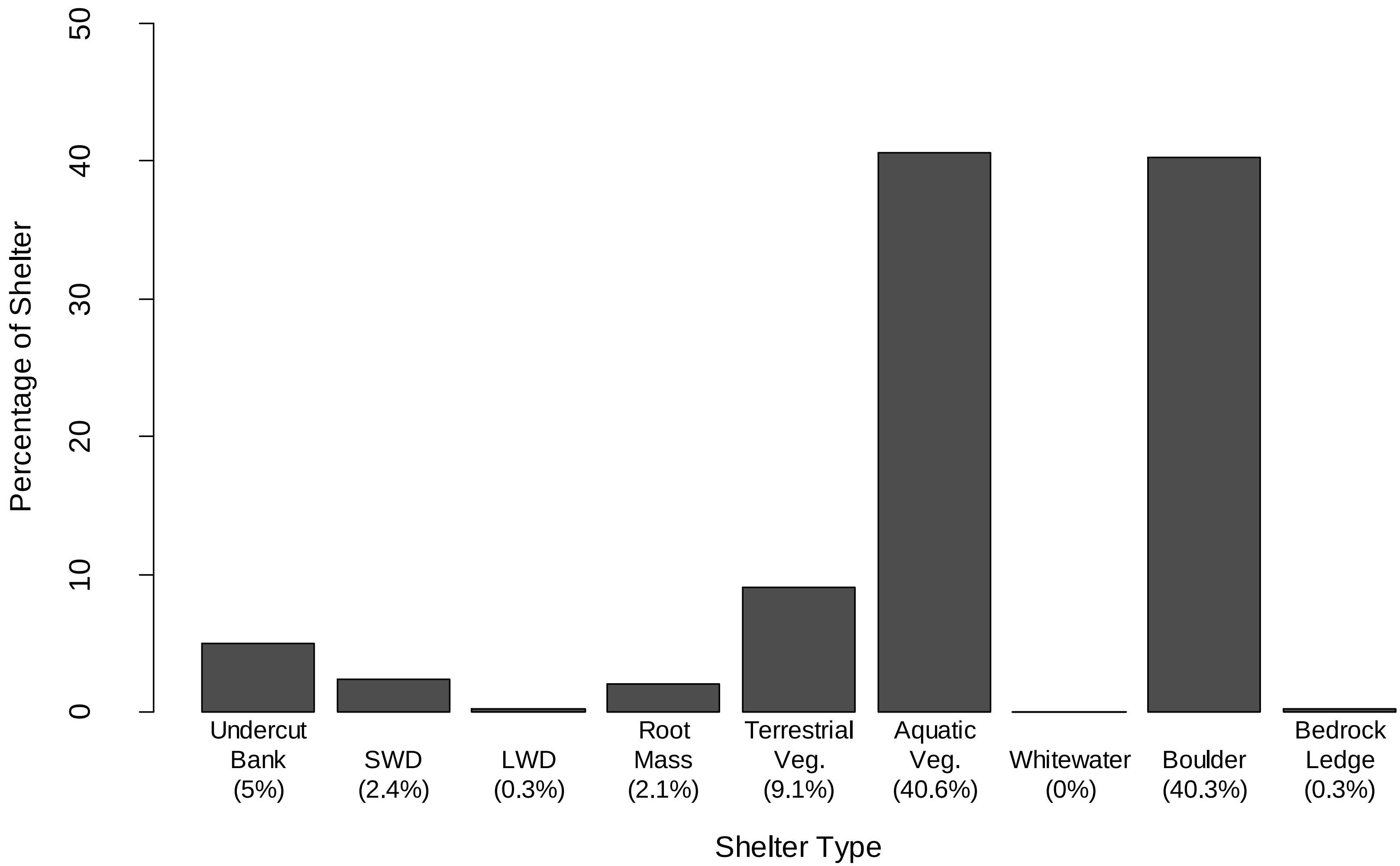


Figure 19. Percentage of banks by dominant substrate composition in Gaviota Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock. In this survey, cobble/gravel was not a dominant bankside substrate.

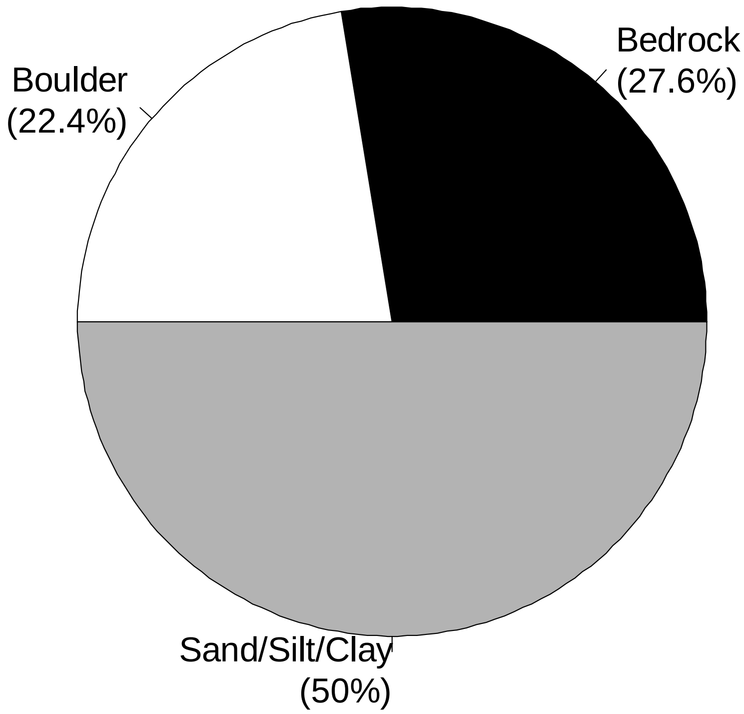
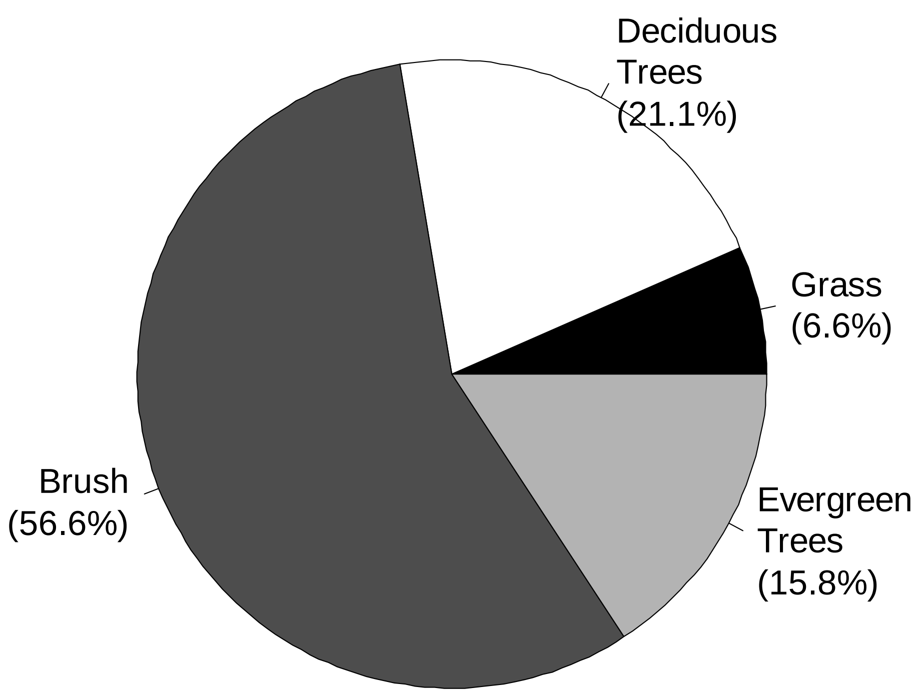


Figure 20. Percentage of banks by dominant vegetation type for Gaviota Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



Arroyo Hondo Creek

Snorkel Survey (2014)

Results

Between July 1, 2014 and July 9, 2014, a snorkel survey was conducted on a stretch of Arroyo Hondo Creek. 137 individual *O. mykiss* were observed in 37 of the 74 pools snorkeled.

In the 1.75 mile surveyed stretch, a total of 137 *O. mykiss* were observed in varying size classes (Table 5). The total length of all snorkeled units was 1,546.5 feet within the 1.75 mile (9,240 ft.) survey reach.

The average number of *O. mykiss* per unit length calculates to be 8.859×10^{-2} fish/ft. This was calculated by taking total of observed fish and dividing by the sum of all the lengths of snorkeled units. The average number of *O. mykiss* per unit area calculates to be 8.549×10^{-3} fish/ft^2. This was calculated by taking the total number of fish observations and dividing by sum of all the individual surface areas for each snorkeled unit. We have also summarized *O. mykiss* counts for shelter values below (Table 6). We also plotted *O. mykiss* observations with respect to total surface area of each habitat unit and this is shown in below (Figure 24). Additionally we plotted the number of *O. mykiss* observations with respect to the length of each habitat unit and this is shown below (Figure 25).

Discussion

Between July 1, 2014 and July 9, 2014, a snorkel survey was conducted on a 1.75 mile stretch of Arroyo Hondo Creek located approximately 0.5 mile up from the Pacific Ocean to a total natural barrier on the Gaviota coast. The purpose of this snorkel survey was to gain an understanding of the abundance and distribution of *O. mykiss* in Arroyo Hondo Creek, located in the Conception Coast BPG, in Santa Barbara County. Due to potential drought effects, a 0.5 mile dry section of the creek was not surveyed.

Size class distributions of *O. mykiss* observed show the majority of observed fish were within the 0-1.99" size class while overall distributions ranged from 0-1.99 inches to 8-9.99 inches (Figure 21). We suspect that since this spawning season had concluded by our July snorkel surveys, that most of the observed fish were from the 2014 year's recruitment class.

The map of the surveyed section of Arroyo Hondo Creek indicates the distribution of the observed *O. mykiss*. The larger circles indicate a greater number of fish observations within 10 surveyed units. We do not have individual observations on the map as GPS locations were only recorded on the first unit out of ten on a data sheet. The smaller circles indicate a lesser number of fish observations. There are no clear differences seen between different sections of the creek. The only observation that can be made is that distribution is throughout the entire reach and not confined to any particular area. The only exception being that there were no fish observed in the last 12 snorkeled habitat units.

Figure 24 and Figure 25 show the number of *O. mykiss* observed versus the surface area and length of the pools they were found in. There was no distinct correlation between *O. mykiss* observations and the surface area and length of the pools they were found in. *O. mykiss* density was then calculated in relation to the total length of the surveyed pools (1,546.5 feet) as well as the combined total surface area of the surveyed pools (16,026 square feet). Again this returned no obvious relationships most likely due to low fish counts. The average number of *O. mykiss* per unit length calculates to be 8.859×10^{-2} fish/ft while the average number of *O. mykiss* per unit area calculates to be 8.549×10^{-3} fish/ft^2. Again, these numbers are relatively insignificant due to the small sample size.

We also choose to look at shelter values which can range on a scale of 0 to 3. A shelter value of 0 means the surveyed unit has no components of shelter (e.g., no undercut, boulders, woody debris, etc.), whereas a value of 3 means the shelter in the surveyed unit has at least three shelter components including large woody debris (LWD). Large woody debris is uncommon in Southern California streams; therefore shelter values of 3 are not as common as shelter values of 2. In Arroyo Hondo Creek, 86.5 % of the surveyed units had a shelter value of 2, 10.8% of the surveyed units had a shelter value of 1, 1.3 % had a shelter value of 0, and 1.3 % of the pools had a shelter value of 3. Figure 23 is a histogram showing the number of *O. mykiss* observed for each of the shelter values. It is not surprising that most of the fish observations were in pools with a shelter value of 2, since the majority of the surveyed pools had a shelter value of 2. This discrepancy in shelter value distribution may be explained by the importance of large woody debris and complex features in the shelter rating system. LWD is fairly uncommon in Southern California streams. Below average rainfall and water levels may have reduced the availability of complex features.

There were slight deviations from our chosen protocol, as divers initially chose which units were considered snorkelable. Divers had to estimate if the average depth was sufficient prior to the taking of habitat measurement. As a result, a few habitat units were snorkeled that had a mean depth of less than 0.7 feet.

Some snorkelers also collected observation data on California Newts (*Taricha torosa*), but this was not the emphasis of this study. Due to the inconsistencies in recorded observations, this data was not included in this report.

As these surveys took place during ever increasing drought conditions, divers also collected data on potential relocation pools, counting the numbers of fish already present and habitat metrics. If divers encountered pools that were in danger of drying up, these were also snorkeled and flagged if eventual rescue might be needed. Both relocation and rescue data was recorded on the data sheets but was not included in any of the analysis.

Overall, this snorkel summary report shows us a snapshot of what size classes were present and where these *O. mykiss* were distributed on Arroyo Hondo Creek. We were able to calculate an index of fish densities but without additional survey seasons, no reliable inferences can be made. We can make no reliable estimates of population abundance since we did not conduct electrofished calibration of the snorkel counts. Additional survey seasons must be completed in order to make a comparison of our observations. Subsequent surveys should include electrofishing to we can make accurate abundance estimates as per Hankin & Reeves 1988.

Tables

Table 5. Table of the first pass *O. mykiss* size classes for Arroyo Hondo Creek in 2014.

***O. mykiss* Size Class (in)**	**Number *O. mykiss* Observed**
0-1.99	45
2-3.99	37
4-5.99	33
6-7.99	18
8-9.99	4
10-11.99	0

Table 6. *O. mykiss* counts and number of habitat units with respect to shelter values for Arroyo Hondo Creek in 2014.

Habitat Unit Shelter Values	*O. Mykiss* Observed per Shelter Value	# of Habitat Units with Shelter Value
0	0	1
1	7	8
2	120	64
3	10	1

Figures

Figure 21. Observed *O. mykiss* size class distribution for Arroyo Hondo Creek in 2014.

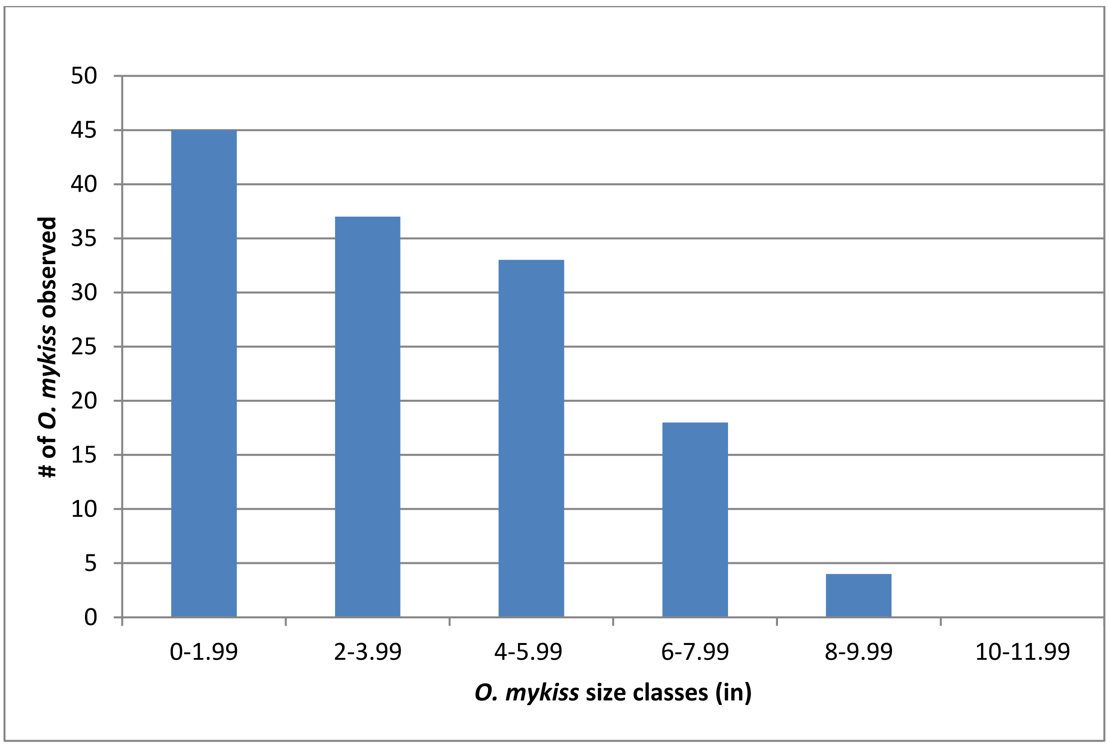


Figure 22. Distribution map of *O. mykiss* observed on surveyed section of Arroyo Hondo Creek in 2014.

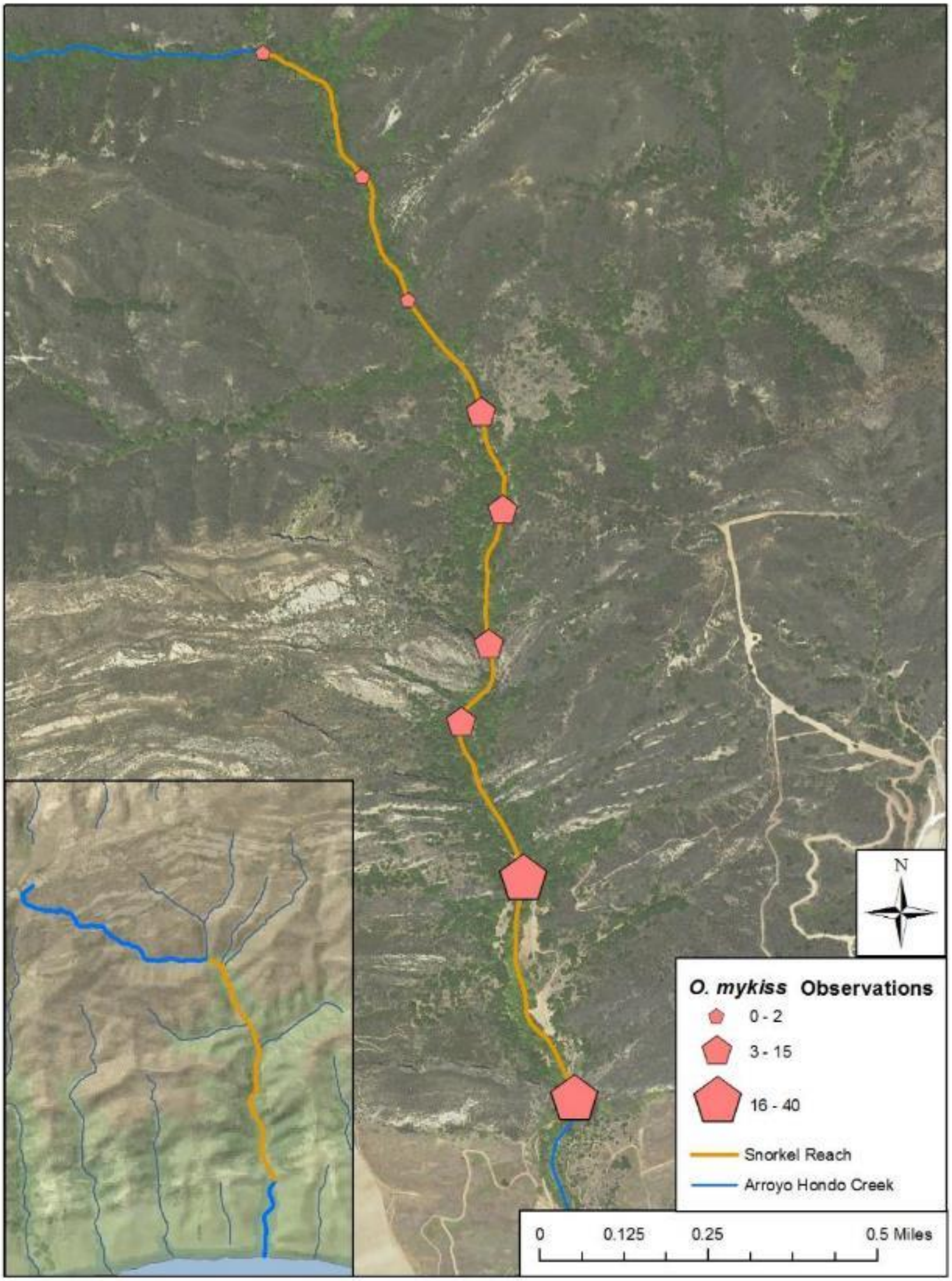


Figure 23. *O. mykiss* size class observations plotted against shelter values for Arroyo Hondo Creek in 2014.

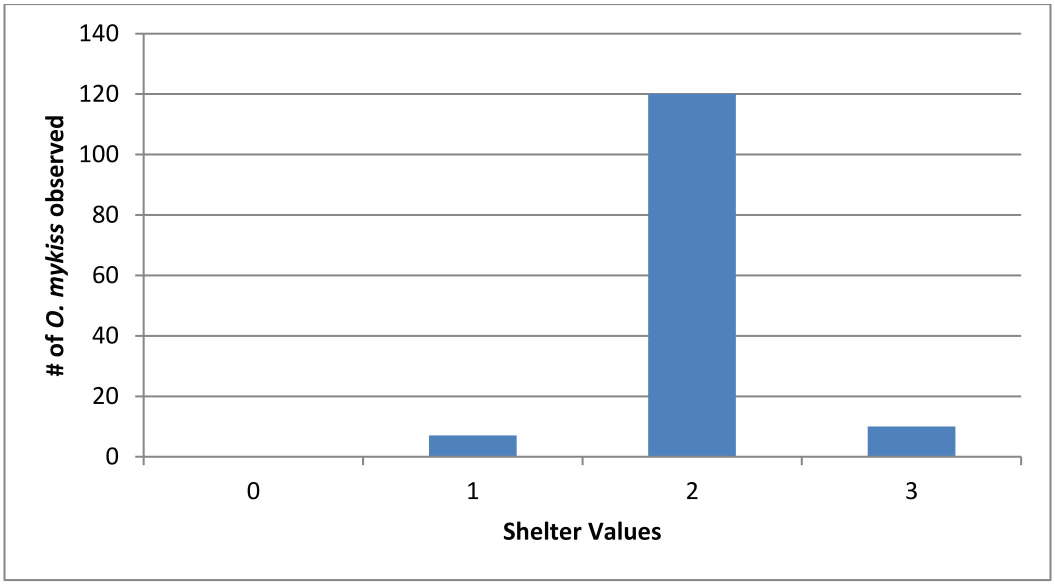


Figure 24. *O. mykiss* observations plotted over habitat unit surface area for Arroyo Hondo Creek in 2014.

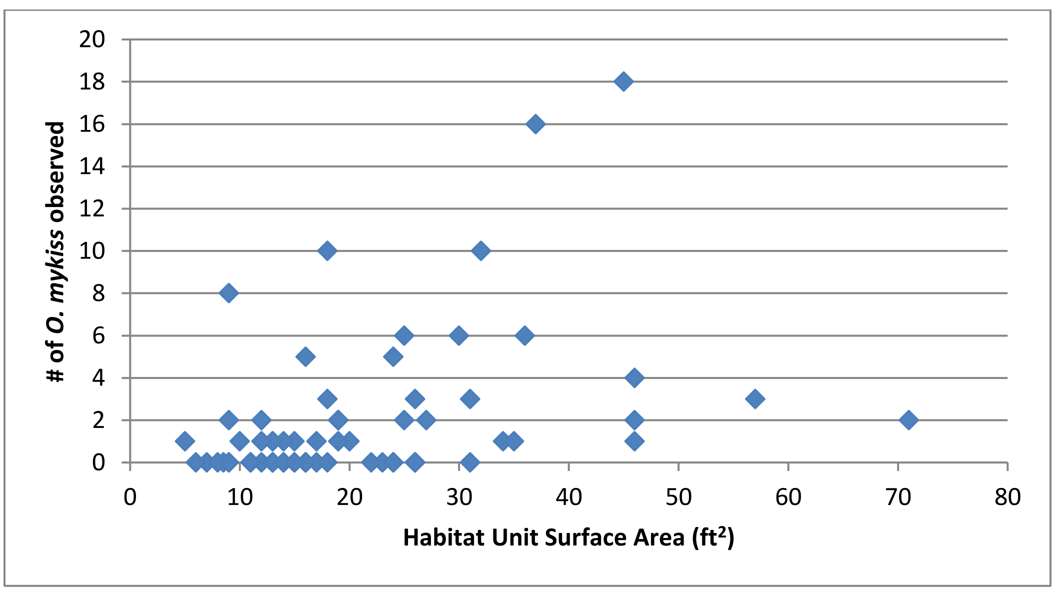


Figure 25. *O. mykiss* observations plotted over habitat unit length for Arroyo Hondo Creek in 2014.

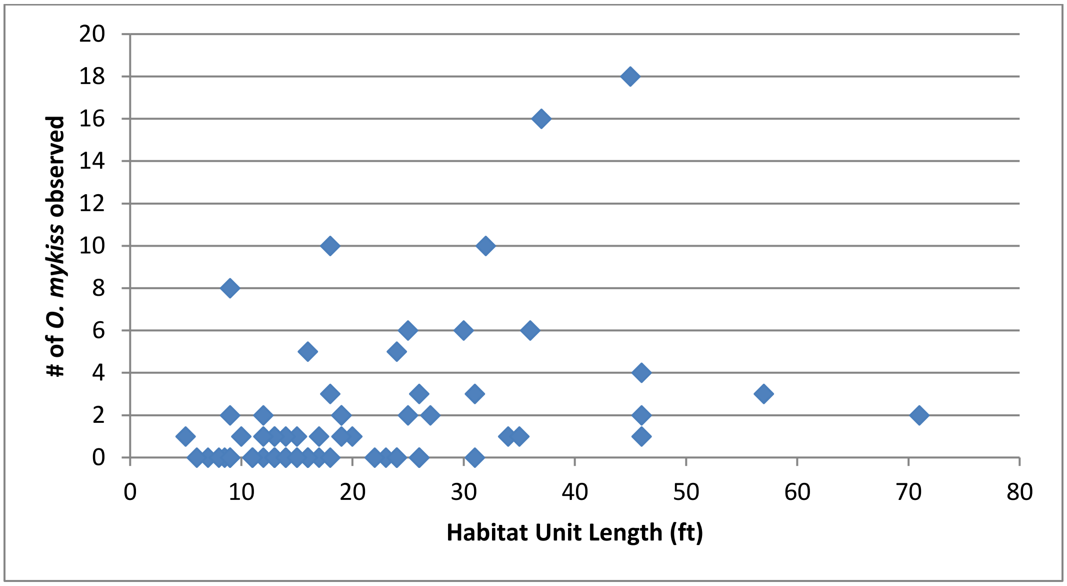


Figure 26. Photo of three of the ten observed *O. mykiss* observed in Unit 43 in Arroyo Hondo Creek, 2014.

Figure 27. Photo of a 7 inch dead *O. mykiss* found in Unit 34 in Arroyo Hondo Creek, 2014.

Snorkel Survey (2015)

Results

From September 29-30th, 2015, a snorkel survey was conducted on a stretch of Arroyo Hondo Creek. In the 2.3 mile (12,144-foot) surveyed stretch, 5,914 feet of habitat was snorkeled (Figure 29). A total of 53 *O. mykiss* were observed in 24 of the 42 units snorkeled. These fish were observed in varying size classes as indicated in Table 7 below. The distribution of these observations is indicated in Figure 28.

The average number of *O. mykiss* per unit length calculates to 8.96×10^{-3} fish/ft. This was calculated by dividing the number of observed fish by the sum of the lengths of the snorkeled units. The average number of *O. mykiss* per unit area calculates to 6.03×10^{-3} fish/ft^2. This was calculated by dividing the number of observed fish by the sum of the surface areas of the snorkeled units.

The number of *O. mykiss* observed with respect to the total surface area of each unit is plotted in Figure 30 and the number of *O. mykiss* observed with respect to the total length of each unit in plotted in Figure 31. *O. mykiss* counts per habitat unit shelter value are summarized in Table 8.

Discussion

A snorkel survey was conducted on a 2.3-mile stretch of Arroyo Hondo Creek from September 29-30th, 2015. The objective of this survey was to increase our understanding of the abundance and distribution of southern California steelhead (*O. mykiss*) in this watershed.

Another method for estimating total abundance of fish populations is an electrofishing calibrated snorkel survey. This involves electrofishing subsample of habitat units in a stream. We did not conduct a calibrated electrofishing snorkel survey in 2015, as we did not want to add to the significant stress placed on these fish by the current, severe drought. Thus, we conducted a single-pass snorkel survey in order to obtain a relative abundance estimate by comparing our counts to one of the passes from the year before.

A total of 53 fish were observed in the 2015 Arroyo Hondo snorkel survey, while 141 were observed during the 2014 survey. There are multiple factors that could be contributing to this decrease in fish observations. It is possible that there were fewer fish present in this watershed in 2015 due to increasing habitat loss from continuing drought effects. However, there are too many operational differences between the 2014 and 2015 snorkel surveys to be able to draw this conclusion. In 2014, the survey was conducted in early July while the 2015 survey was conducted in late September. The difference in *O. mykiss* observations could be due in large part to seasonal fluctuations in abundance dictated primarily by the young of the year cohort. In 2015, no fish in the 0-1.99 inch size class were observed, which may have been partially due to summer-die off of young of the year. Additionally, severe drought conditions could have contributed to low spawning success and poor recruitment due to lack of suitable habitat. Furthermore, surviving young of the year may have grown enough by this time of year to be included in the 2-3.99 inch size class.

Shelter value was assessed in each unit on a scale of 0-3. A shelter value of 0 indicates an absence of shelter components, while a shelter value of 3 indicates at least 3 shelter components (e.g., boulders, woody debris, undercut bank, etc.). The protocol we used requires the presence of large woody debris for a pool to have a shelter value of 3. Since large woody debris is relatively uncommon in Southern California, pools with shelter values of 3 are uncommon compared to those with a shelter value of 2. We would expect fish to be more easily observable in pools with lower shelter values, as the fish have fewer places to hide. The majority of fish observed in Arroyo Hondo were seen in pools with a shelter value of 2 (Table 9). This is not surprising considering the majority (66.7%) of the units snorkeled had a shelter value of 2 while 14.3% had a shelter value of 0 and 19.0% had a shelter value of 1. None of the units snorkeled in Arroyo Hondo had a shelter value of 3. These survey results allow us to confirm the presence of *O. mykiss* in Arroyo Hondo Creek. Once habitat conditions improve, an electrofishing-calibrated survey is recommended to make a reach level abundance estimate for *O. mykiss* in this watershed.

Tables

Table 7. Size class distribution of observed *O. mykiss* for Arroyo Hondo Creek in 2015.

***O. mykiss* Size Class (in)**	**Number *O. mykiss* Observed**
0-1.99	0
2-3.99	26
4-5.99	19
6-7.99	8
8-9.99	0
10-11.99	0

Table 8. *O. mykiss* counts per habitat unit shelter value for Arroyo Hondo Creek in 2015.

Habitat Unit Shelter Values	***O. Mykiss* Observed per Shelter Value**	**# of Habitat Units with Shelter Value**
0	2	6
1	4	8
2	47	28
3	0	0

Figures

Figure 28. Size class distribution of observed *O. mykiss* for Arroyo Hondo Creek in 2015.

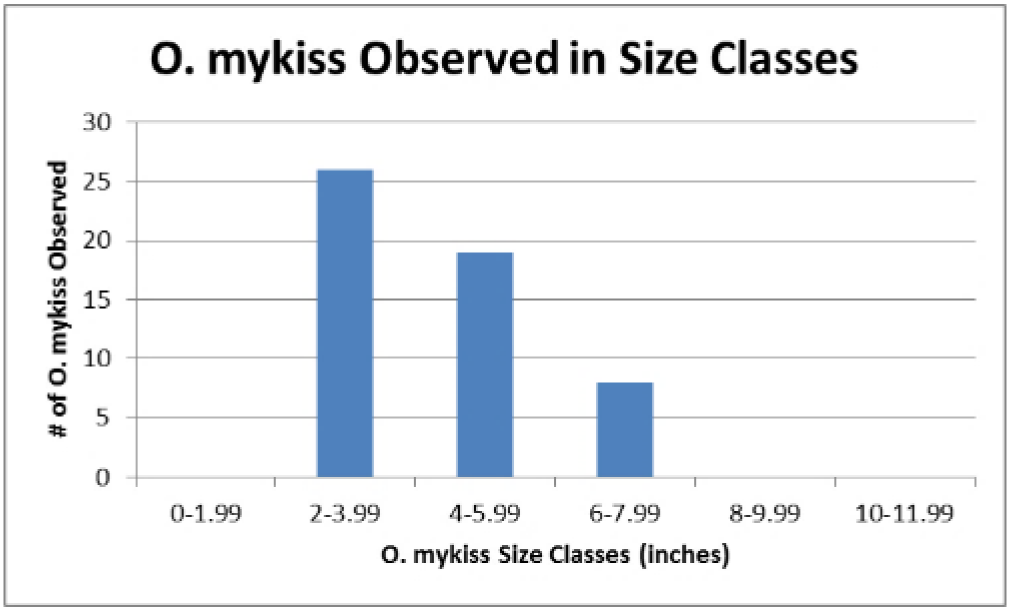


Figure 29. Arroyo Hondo Creek survey reach and the surrounding watershed in 2015.

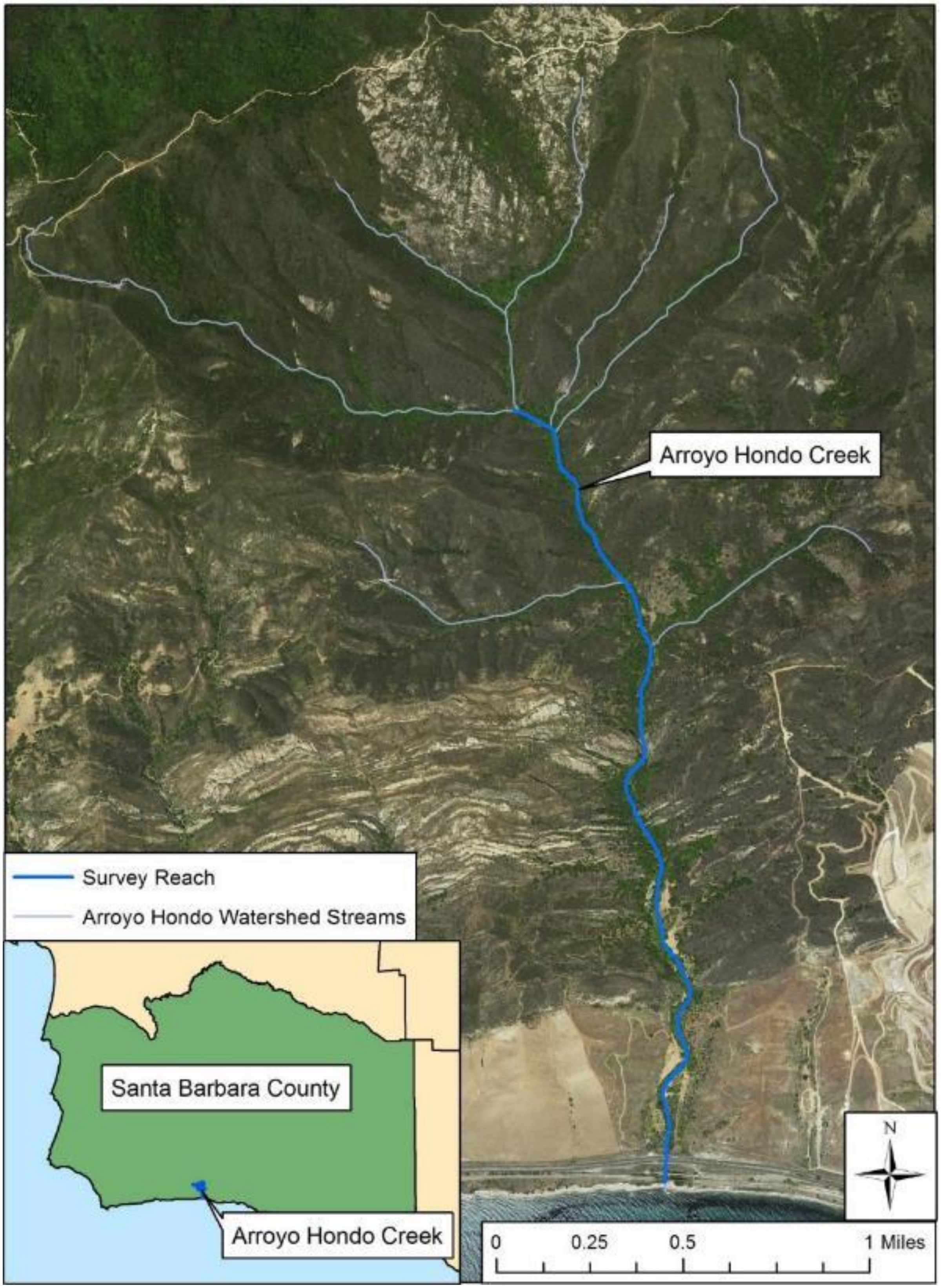


Figure 30. *O. mykiss* observations plotted over habitat unit surface area for Arroyo Hondo Creek in 2015.

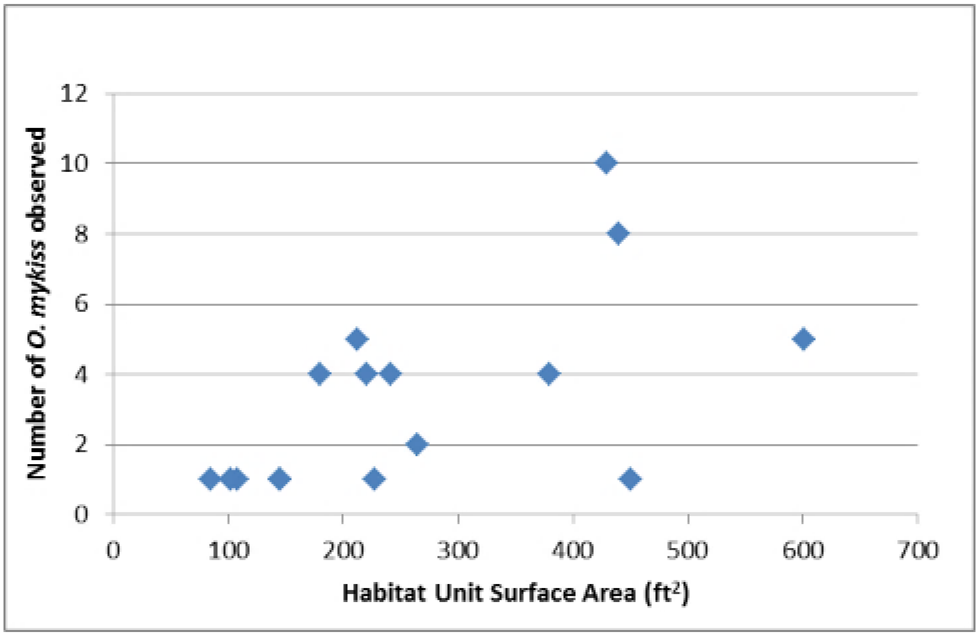


Figure 31. *O. mykiss* observations plotted over habitat unit length for Arroyo Hondo Creek in 2015.

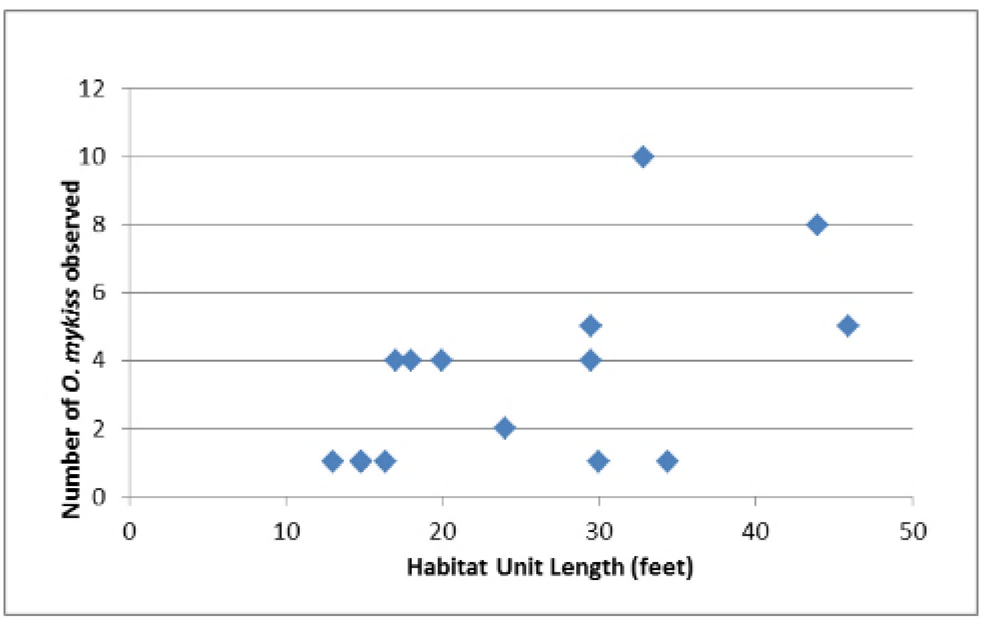
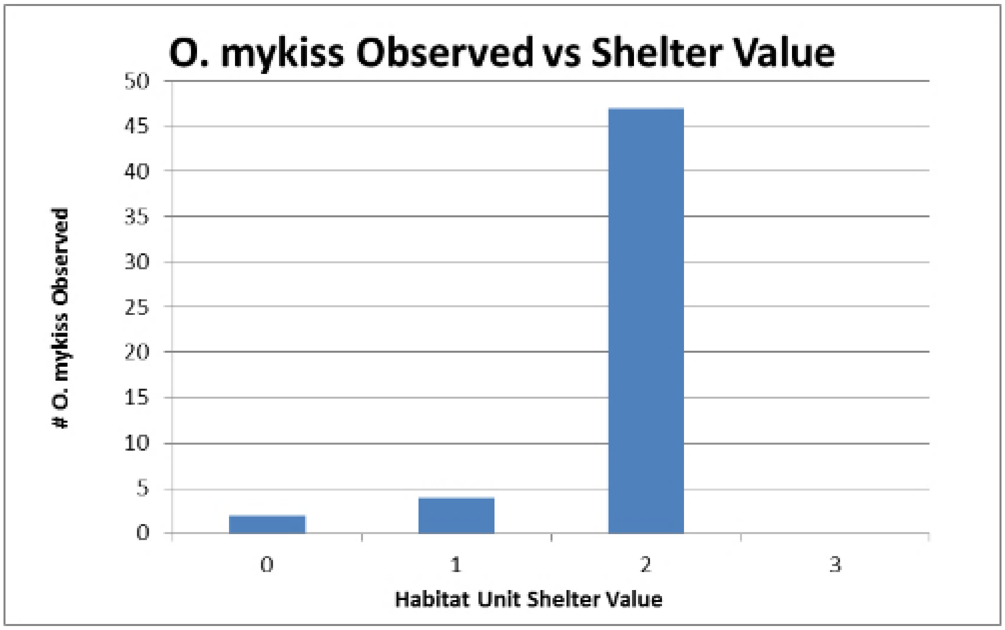


Table 9. *O. mykiss* size class observations plotted against shelter values for Arroyo Hondo Creek in 2015.



Habitat Assessment

<u>Results</u>

The habitat inventory was conducted from 28 January to 18 February 2014 by Patrick Riparetti, Karissa Willits, Sam Bankston, Kate McLaughlin, Tom van Meeuwen, and Ben Lakish from Pacific States Marine Fisheries Commission, Chris Lima with the California Department of Fish & Wildlife, and Kayti Christianson from the Watershed Stewards Program. The survey extended 14,057 feet upstream from the survey start (34.47380°N, -120.14120 °W), and included 148 feet of side channel. The survey endpoint (34.50377°N, -120.14809°W) was a total natural barrier to fish passage (Figure 32). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 48 to 60°F. Air temperature ranged from 49 to 66°F.

Habitat type

Of the total number of habitat units surveyed (n = 247 units), 10.1% of units were dry, 19.0% were flatwaters, 35.6% were pools, 34.4% were riffles, 0.4% were culvert, and 0.4% were unsurveyable. Of the total length of the reach surveyed, 33.6% was dry, 23.4% was composed of flatwaters, 19.2% was composed of pools, 20.0% was composed of riffles, 3.5% was culvert, and 0.3% unsurveyable (Figure 33).

We identified 14 habitat types in Arroyo Hondo Creek. Based on the frequency of units sampled, mid-channel pools (24.7%), low-gradient riffles (16.2%), and high-gradient riffles (13.0%) were the most common habitat types (Table 10). Based on total stream length, dry (33.6%), mid channel pools (10.8%), and step runs (10.1%) composed the greatest stream lengths.

Pool Metrics

A total of 88 pools were identified within the survey reach. Main channel pools were most frequently encountered (83.0% of pool units sampled) and comprised 84.0% of the total length of all pools. Only main channel and scour pools were encountered; no backwater pools were recorded.

Seven of 88 pools (8%) had residual depths of three feet or greater (Figure 34).

Within pool tail-outs, gravel was the most frequently observed dominant substrate (36.0% of pool units), followed by small cobble (24.4%; Figure 35).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (34.8%) or two (33.7%; Figure 36).

Shelter

Within 100% units (n = 71 units), riffle habitat types had a mean shelter rating of 48.7, flatwater habitat types had a mean shelter rating of 50.8, and pools had a mean shelter rating of 57.3.

Of the pool units in which shelter was assessed (n = 30 units), main channel pools had a mean shelter rating of 51.7 and scour pools had a mean shelter rating of 65.8.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that boulders provided the most shelter (57.8% of all shelter; Figure 37). When we examined the percentage of shelter by shelter type within pools only, we found that boulders were the most dominant cover type (58.0% of the total cover; Figure 38).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 87.3%. Within the canopy cover present, 24.7% of the canopy was composed of deciduous trees and 75.3% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were predominantly boulder (46.5%) and bedrock (26.8%;Figure 39). The mean percentage of vegetation covering the right bank in sampled units was 36.4%, and the mean percentage of vegetation covering the left bank was 37.1%. Evergreen trees were the dominant vegetation type, having been observed in 69.0% of the banks surveyed (Figure 40).

Large Woody Debris

We observed 25 pieces of LWD that were 6 to 20 feet long and 21 pieces that were greater than 20 feet long within 8888.5 feet of wetted stream length. Across both LWD sizes, the mean number of LWD observed was 0.52 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 29.8 feet.

Discussion

Temperature

The water temperature of units measured ranged from 48 to 60°F. According to the Guide to the Reference Values Used in South-Central/Southern California Coast Steelhead Conservation Action Planning Workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools or riffles. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools, low-gradient riffles, or high-gradient riffles. When we examined the reach in terms of length, we found that most of the reach was dry or flatwaters. Mid-channel pools and step runs comprised the greatest percentage of wetted stream length.

Pool Metrics

Pool depth is an important indicator of habitat quality, as deeper pools can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). A residual depth of at least 3 feet is needed to be considered good habitat (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in Arroyo Hondo, we found that only 8% had residual depths greater than 3 feet. Thus, it appears that pools in Arroyo Hondo lack the depth needed to provide good hiding cover and rearing space. This may be due in part to the current, severe drought, which has extended into its fourth consecutive year.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was gravel, comprising 36.1% of pool units. Pool units most frequently had an embeddedness value of either a 5 or 2. When we examined pools with gravel tail-outs specifically, we found that 84% had embeddedness values of 1 or 2 (30% of all pool tail-outs). Together, these metrics suggest that, although pools may not provide the ideal depth for cover or rearing space, some pool tail-outs in Arroyo Hondo provide good spawning habitat for *O. mykiss*, assuming that flows are adequate.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that pools had the highest mean shelter rating and riffles had the lowest. However, all three mean shelter ratings were low (ratings of 48.7–57.3 on a scale ranging from 0–300).

When examining pool habitat units specifically, we found that scour pools had a higher mean shelter rating than main channel pools.

When we examined the percentage shelter by shelter type, we found the boulders provided the most shelter across all 100% units and within 100% pools only, suggesting that boulders are a common and important feature to *O. mykiss* habitat in Arroyo Hondo.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In Arroyo Hondo, we estimated a mean canopy cover of 87.3%, consisting predominantly of evergreen trees. This suggests that Arroyo Hondo has a high amount of cover (Kier Associates & NMFS 2008) that should persist through time. In addition to cover provided by canopy, boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing even more cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was boulder, followed by bedrock. The mean percentage of vegetative cover for the right and left banks was 36.4% and 37.1%, respectively. Evergreen trees were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively protected from erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In Arroyo Hondo Creek, we found 0.52 pieces of LWD per 100 feet, which was low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Arroyo Hondo lacks LWD, it has boulder elements that improve habitat quality. Specifically, boulders provide the greatest amount of shelter across all 100% units (57.8% of all shelter).

Tables

Table 10. Percentage of units (n = 247) by habitat type in Arroyo Hondo Creek.

Habitat Type	% of Units
Mid Channel Pool	24.70%
Low Gradient Riffle	16.19%
High Gradient Riffle	12.96%
Run	10.12%
Dry	10.12%
Step Run	8.91%
Step Pool	4.86%
Bedrock Sheet	3.64%
Lateral Scour Pool, root wad formed	1.62%
Lateral Scour Pool, boulder formed	1.62%
Plunge Pool	1.62%
Cascade	1.62%
Lateral Scour Pool, bedrock formed	0.81%
Lateral Scour Pool, log-enhanced	0.40%
Culvert	0.40%
Not Surveyable	0.40%

Figures

Figure 32. Map of the habitat assessment survey area in Arroyo Hondo.

Figure 33. Percentage of total stream length categorized as pools, flatwaters, or riffles in Arroyo Hondo Creek.

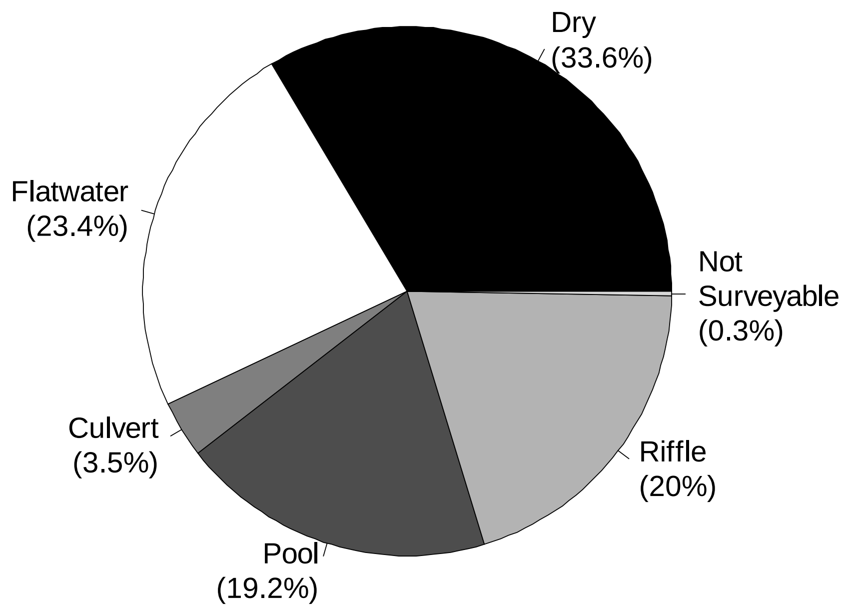


Figure 34. Histogram of residual pool depths in one-foot bins for Arroyo Hondo Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

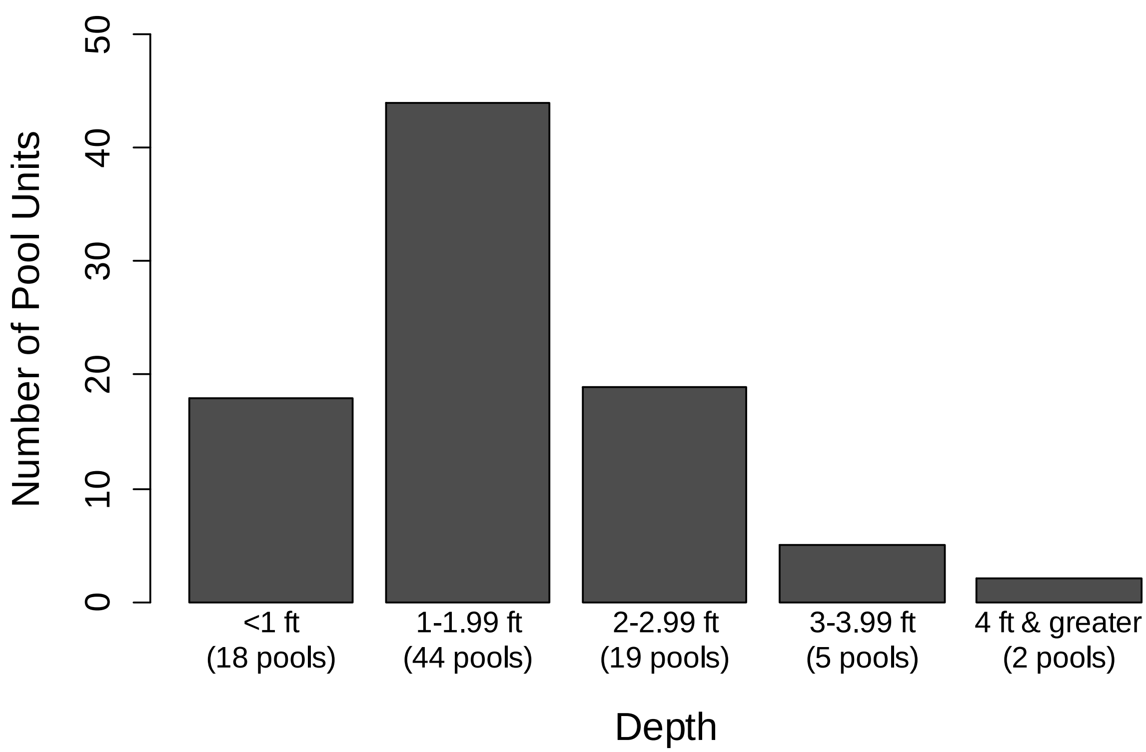


Figure 35. Percentage of pool tail-outs (n = 88 pools) by dominant substrate in Arroyo Hondo Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

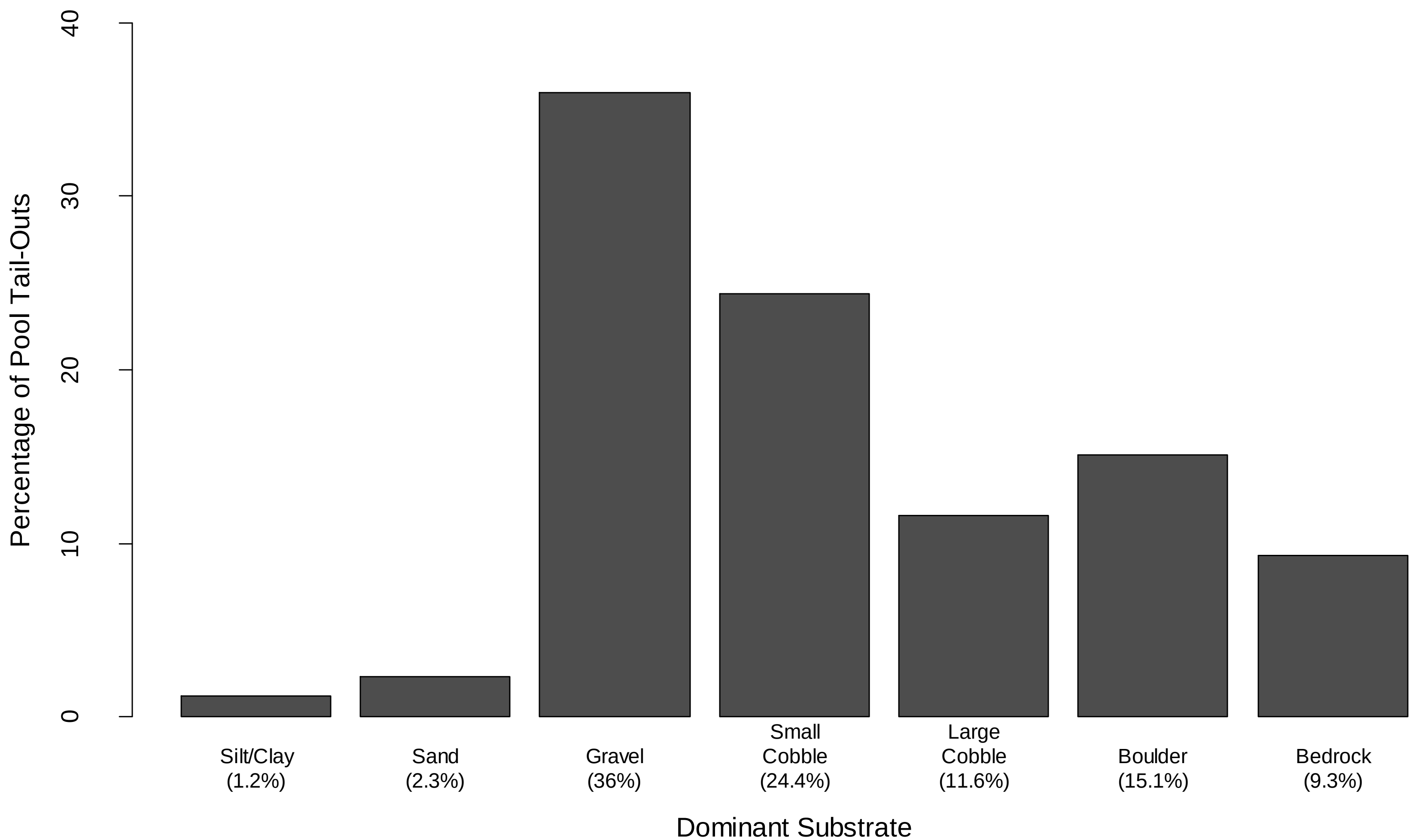


Figure 36. Percentage of all pool units (n = 88 pools) assigned a pool tail-out embeddedness value of 1 to 5 for Arroyo Hondo Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning.

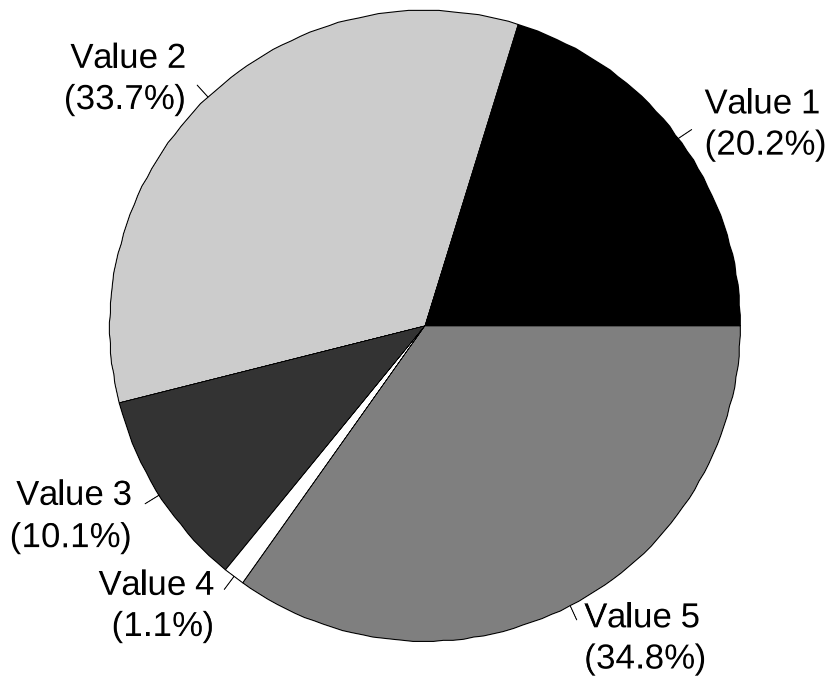


Figure 37. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 71 units) for Arroyo Hondo Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

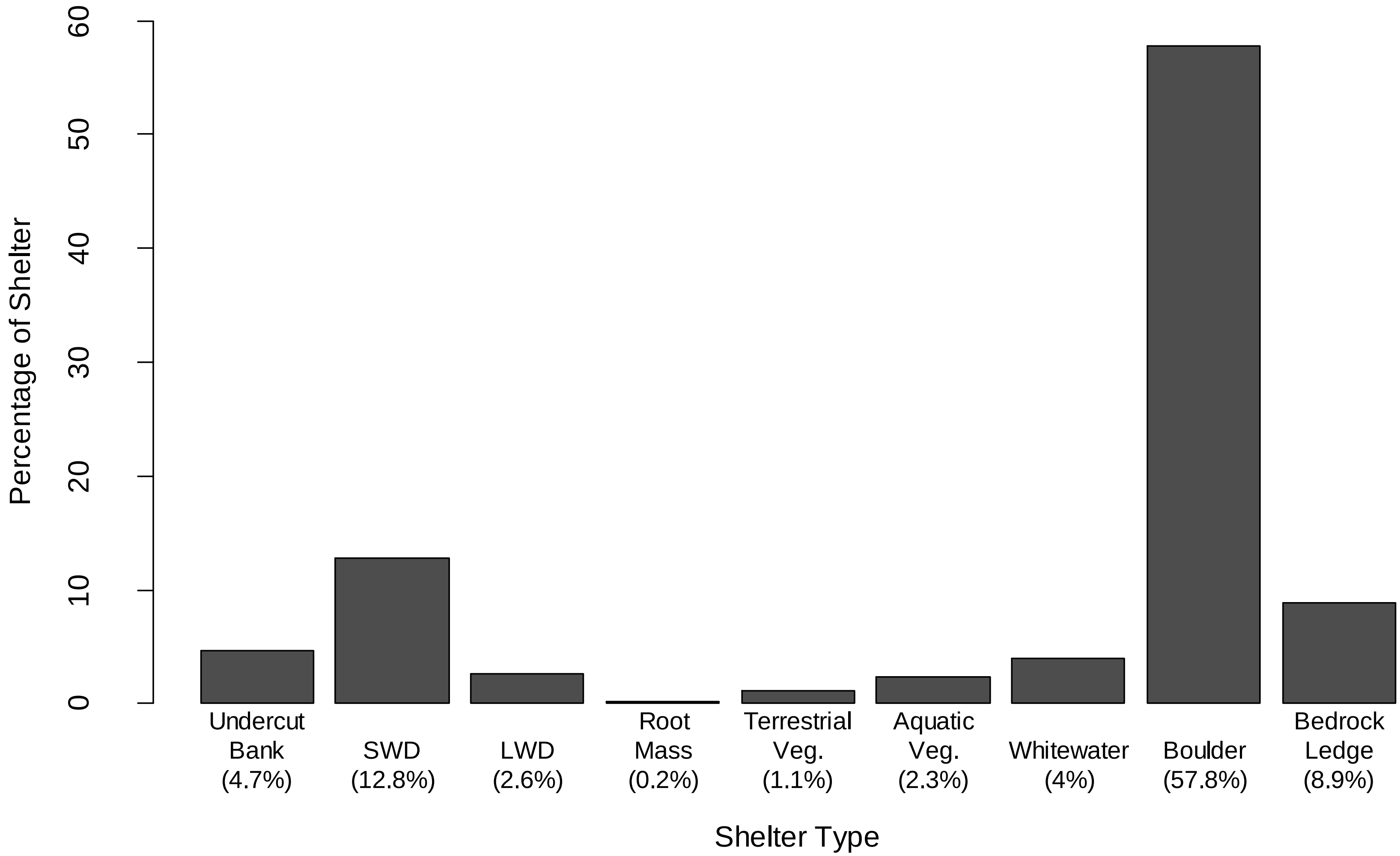


Figure 38. The percentage of shelter by shelter type across all pool units in which shelter was measured for Arroyo Hondo Creek (n = 30 pools). Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

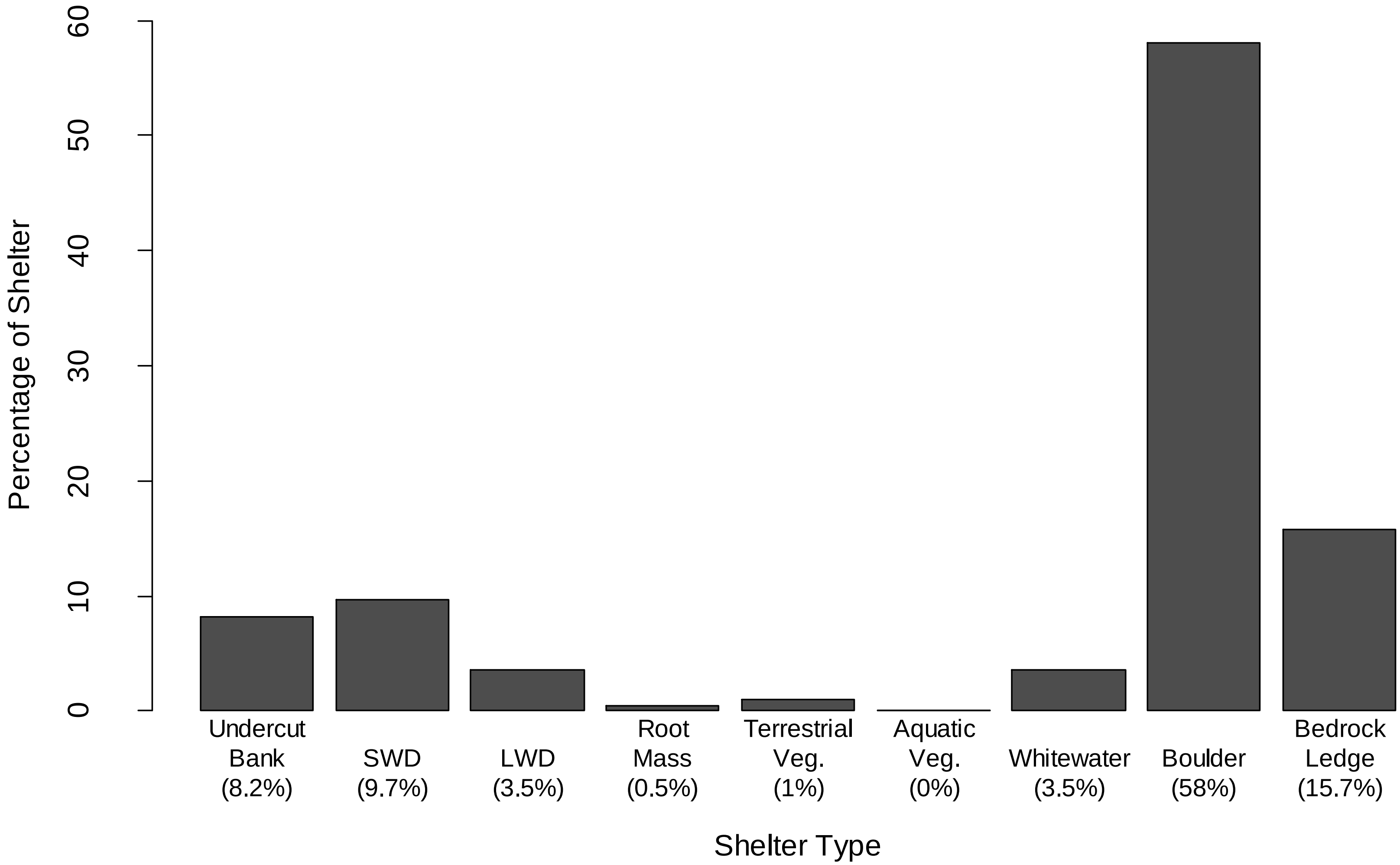


Figure 39. Percentage of banks by dominant substrate composition for Arroyo Hondo Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock.

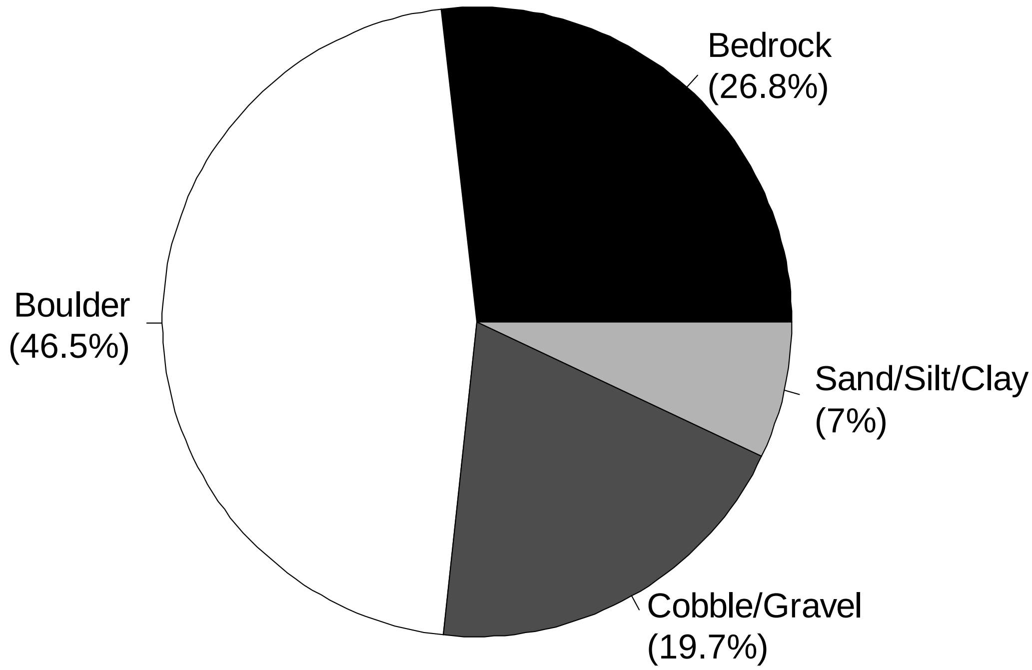
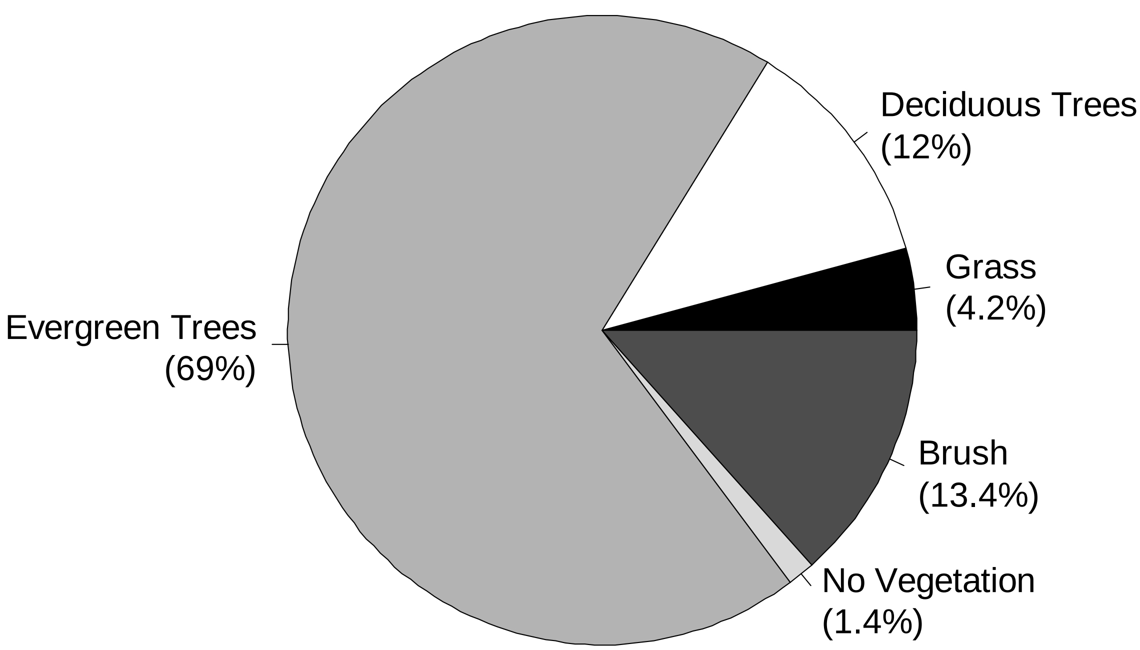


Figure 40. Percentage of banks by dominant vegetation type for Arroyo Hondo Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



Arroyo Quemado Creek

Habitat Assessment

Results

The habitat inventory was conducted from 25 to 27 August 2015, was conducted by Kyle Evans, Yi-Jiun Tsai, Terra Dressler Marisa Morse, and Taylor Berryman from Pacific States Marine Fisheries Commission. The total length of the stream surveyed was 10,962 feet. The survey started at 34.47140°N, -120.11932°W and ended at 34.50014°N, -120.12045°W (Figure 41). This endpoint was chosen due to extended steep, dry channel that is likely impassable by fish even during high flow events. Stream flow was not measured.

Temperature

Water temperatures ranged from 66 to 70 degrees Fahrenheit. Air temperatures ranged from 69 to 80 degrees Fahrenheit.

Habitat Type

Table 2 summarizes the frequency of each observed habitat unit type for the 50 surveyed units. Based on frequency of occurrence there were 22.0% dry units, 38.0% pool units, 20.0% flatwater units, and 20.0% riffle units. Based on total stream length, habitat types there were 90.8% dry units, 2.6% pool units, 4.6% flatwater units, and 2.0% riffle units (Figure 42).

Seven habitat types were identified in Arroyo Quemado (Table 11). The most frequent habitat types by percent occurrence were 30.0% mid-channel pool units, 22.0% dry units, and 20.0% low gradient riffle units. Based on percent total length the most frequent habitat types were 90.8% dry units, 2.8% run units, 1.8% step run units, and 2.0% low gradient riffle units.

Pool Metrics

A total of 19 pools were identified within the survey reach. Main channel pools were the most frequently encountered (94.7%) and comprised 92.0% of the total length of all pools. Only main channel and scour pools were encountered; no backwater pools were recorded.

None of the 19 surveyed pools had a residual depth of two feet or greater (Figure 43).

Within pool tail-outs, silt/clay was the most frequently observed substrate (84.2% of pool units), followed by bedrock (15.8%; Figure 44). When we examined pool tail-outs for substrate embeddedness, we found that all pool tails had embeddedness values of five.

Shelter

Within 100% units, riffle habitat types had a mean shelter rating of 20.0, flatwater habitat types had a mean shelter rating of 66.0, and pool habitats had a mean shelter rating of 35.6. Of the pool types, Main Channel pools had a mean shelter rating of 37.1 and scour pools had a mean shelter rating of 25.0.

Fish cover type in Arroyo Quemado Creek was dominated by boulders (32.9% of all cover) and small woody debris (26.8% of all cover; Figure 45) across all 100% units. When we examined the percentage of shelter by shelter type within pools only (n = 8 units), we found that boulders were the most dominant cover type (28.1%), followed by small woody debris (25.6%; Figure 46).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 82.8%. Of the canopy present, the mean percentages of deciduous and evergreen trees were 70.5% and 29.4%, respectively.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing both right and left stream banks were sand/silt/clay (62.5%) and boulder (25.0%; Figure 47). The mean percentage of vegetation covering the right bank was 50.8%. The mean percentage of vegetation covering the left bank was 51.2%. Deciduous trees were the dominant vegetation type, having been observed in 58.3% of the banks surveyed. Additionally, 25.0% of the banks surveyed had evergreen trees and 16.7% had brush as the dominant vegetation (Figure 48).

Large Woody Debris

We observed three pieces of LWD that were 6 to 20 feet long and one piece that was greater than 20 feet long within 1003.7 feet of wetted length. Across both LWD sizes, the number of LWD observed was 0.40 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 27.4 feet.

Discussion

The water temperature of units measured in Arroyo Quemado ranged from 66 to 70°F. According to the Guide to the Reference Values Used in South-Central/Southern California Coast Steelhead Conservation Action Planning Workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools or dry units. When we examined the reach in terms of length, we found that the majority (91%) of this system was dry. This is likely due to severe drought conditions coupled with water removal for agriculture. Pools were relatively shallow. None of the 19 pools had residual depths greater than 1.99 feet. None of the pools observed in Arroyo Quemado can be considered good quality *O. mykiss* habitat, as a residual depth of at least three feet is needed for this designation.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). However, all 19 pool tail-outs in Arroyo Quemado had silt or bedrock as the dominant substrate. This is generally considered unsuitable for spawning salmonids.

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. The mean shelter rating for pools in Arroyo Quemado was 36. The shelter rating in the flatwater habitats was 66. A pool shelter rating of approximately 100 is desirable. Of the existing cover, boulders are the dominant cover type in pools followed by small woody debris. The relatively poor shelter ratings are likely a result of shallowness of units.

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In Arroyo Quemado Creek, the mean percent canopy density for the stream was 83%, consisting predominantly of deciduous trees. This suggests that Arroyo Quemado has a moderately high amount of cover (Kier Associates & NMFS 2008), but this cover is likely to vary greatly through time, given the seasonality of deciduous trees. However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

The predominant substrate composing the stream banks in Arroyo Quemado was sand/silt/clay, followed by boulder. The percentage of right and left bank covered with vegetation was 50.8% and 51.2%, respectively. Deciduous and evergreen trees were the most common dominant vegetation observed. Together, these bankside metrics suggest that these banks may be moderately susceptible to erosion resulting from large flow events.

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In Arroyo Quemado Creek, we found 0.4 pieces of LWD per 100 feet, which was low compared to the amount reported in northern systems (Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Arroyo Quemado lacks LWD, it may have boulder elements that improve habitat quality (32.9% of all shelter).

Overall, the majority of this creek was dry. The small portion of this system containing water had little water and thus poor habitat quality.

Tables

Table 11. Percentage of all units (n = 50) by habitat type for Arroyo Quemado.

Habitat Type	% of Units
Mid-Channel Pool	30.00%
Dry	22.00%
Low Gradient Riffle	20.00%
Run	12.00%
Step Run	8.00%
Step Pool	6.00%
Lateral Scour Pool, boulder-formed	2.00%

Figures

Figure 41. Map of the habitat assessment survey area in Arroyo Quemado.

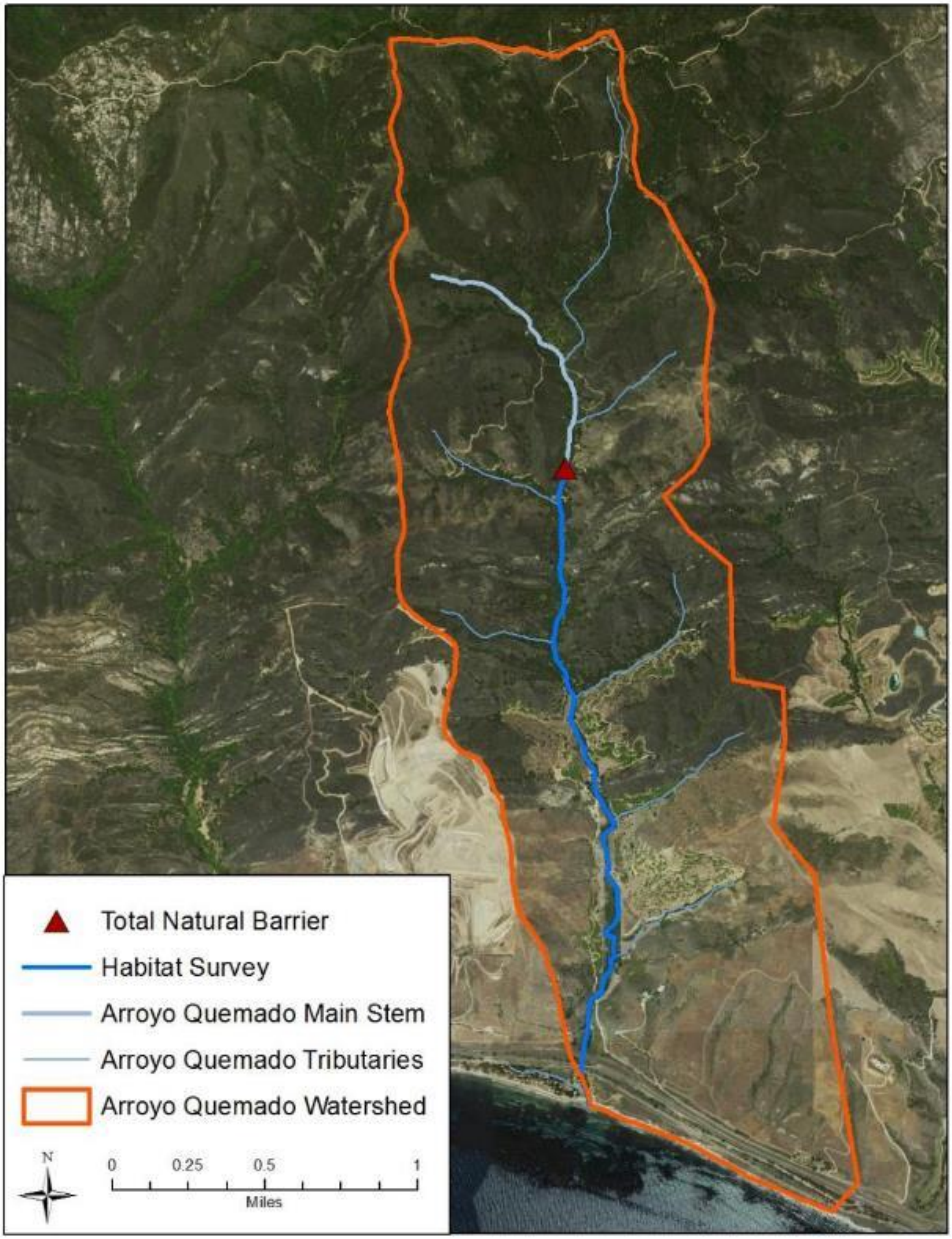


Figure 42. Percentage of total stream length categorized as pools, flatwaters, riffles, or dry in Arroyo Quemado Creek.

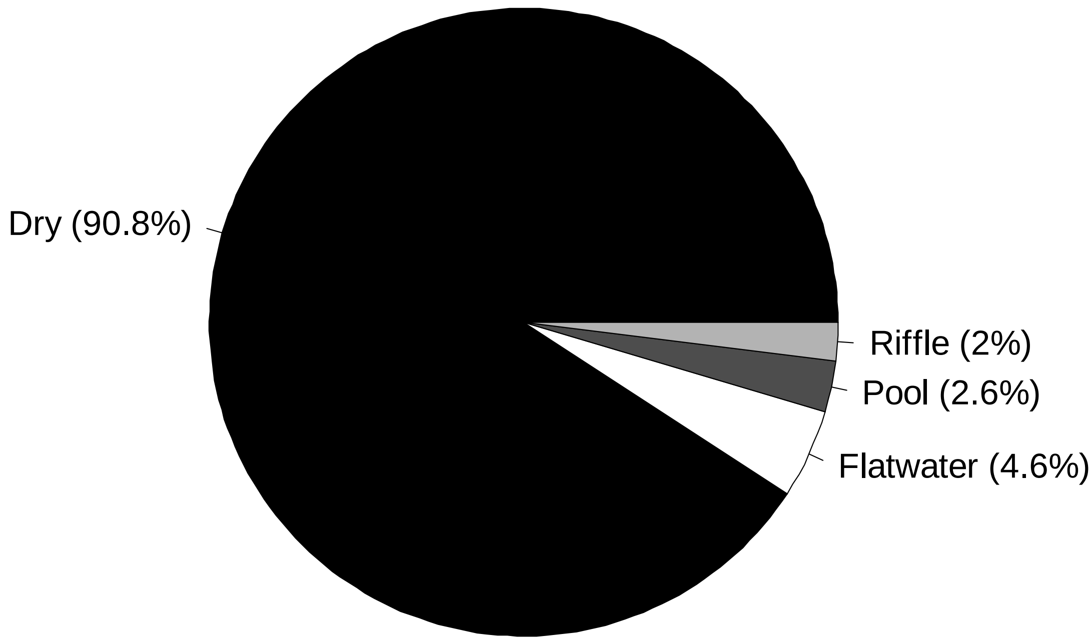


Figure 43. Histogram of residual pool depths in one-foot bins for Arroyo Quemado Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

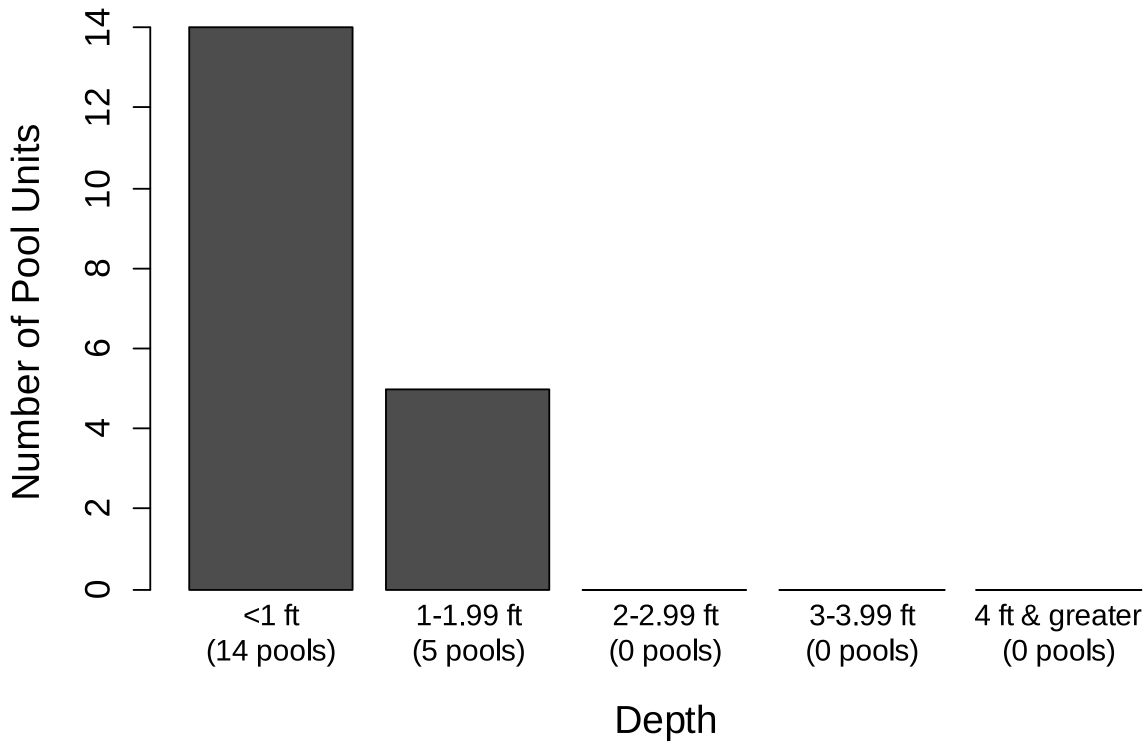


Figure 44. Percentage of pool tail-outs (n = 19 pools) by dominant substrate in Arroyo Quemado Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

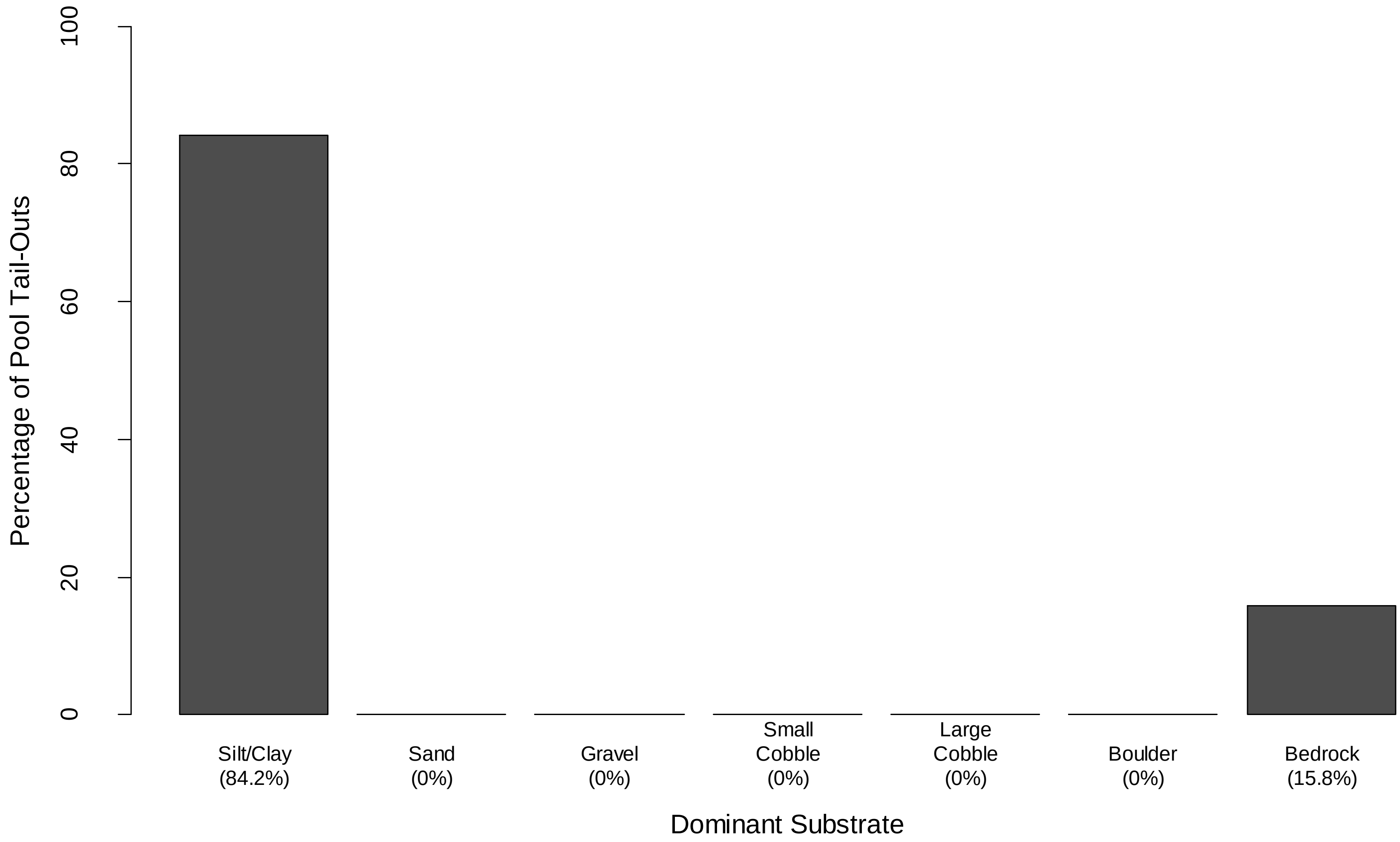


Figure 45. The percentage of instream shelter by shelter type across all units in which shelter was measured in Arroyo Quemado Creek (n = 14 units). Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

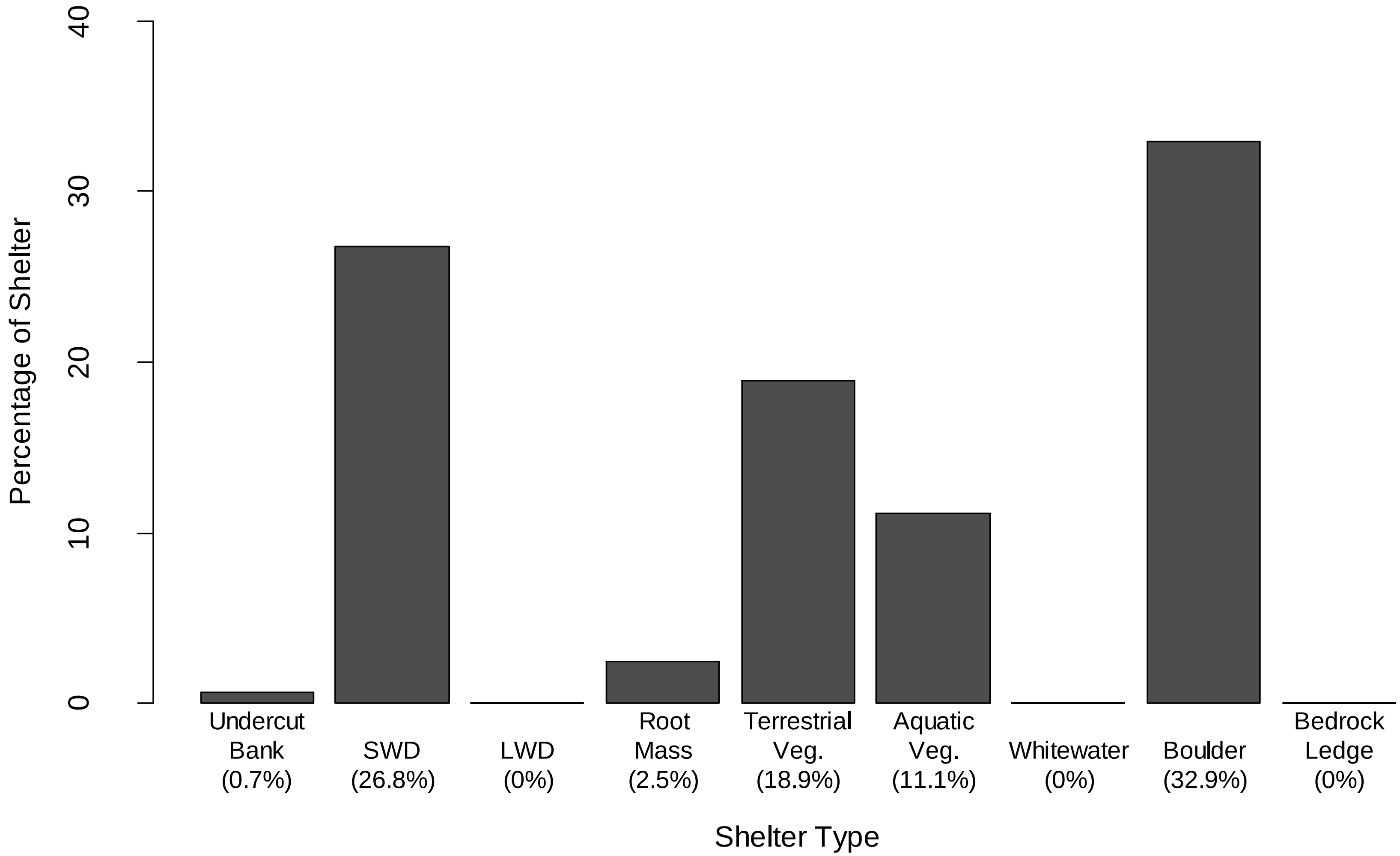


Figure 46. The percentage of shelter by shelter type across all pool units in which shelter was measured in Arroyo Quemado Creek (n = 8 pools). Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

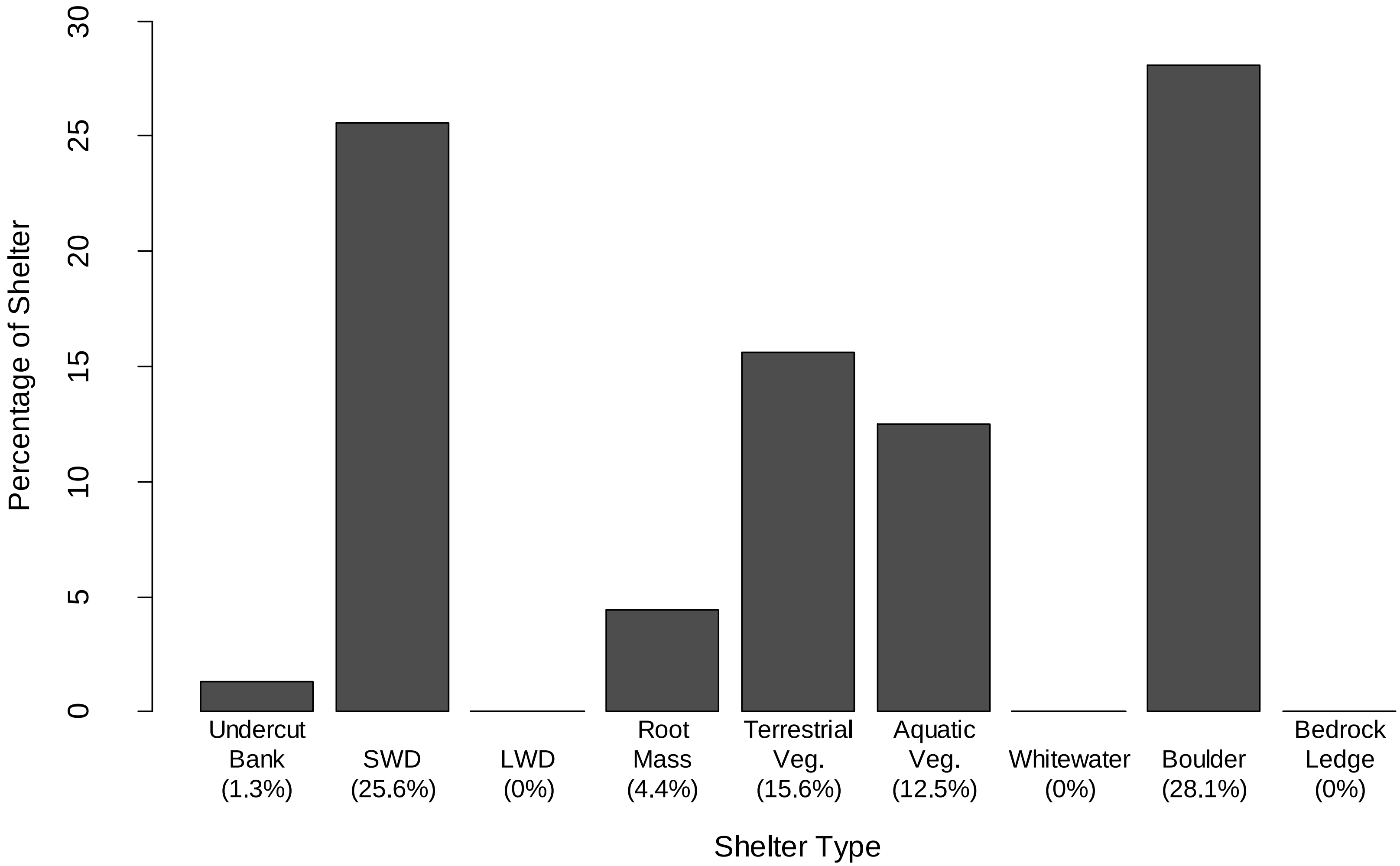


Figure 47. Percentage of banks by dominant substrate composition for Arroyo Quemado Creek. Substrate types include sand/silt/clay, cobble/gravel, boulder, and bedrock.

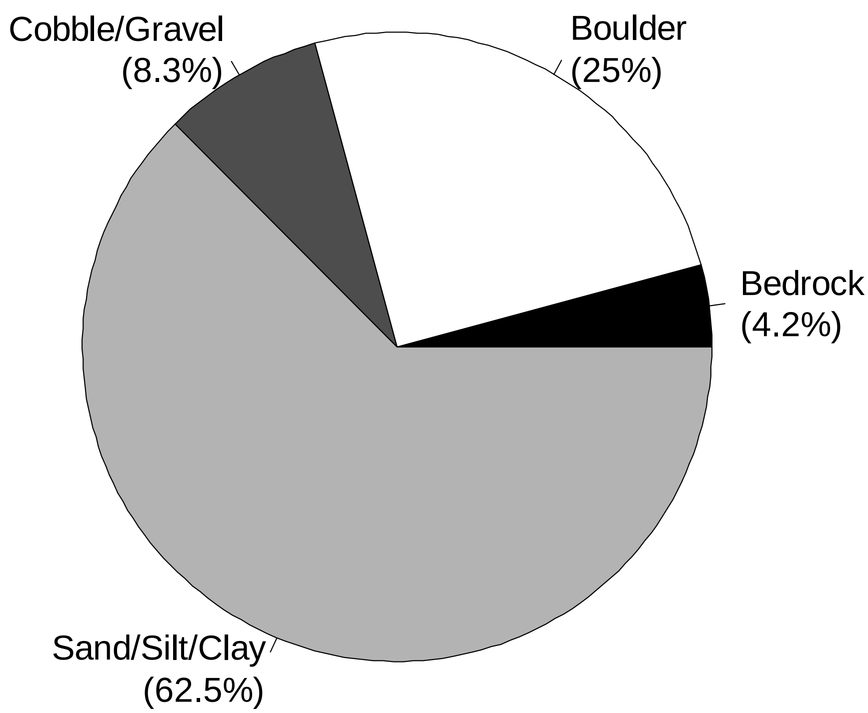
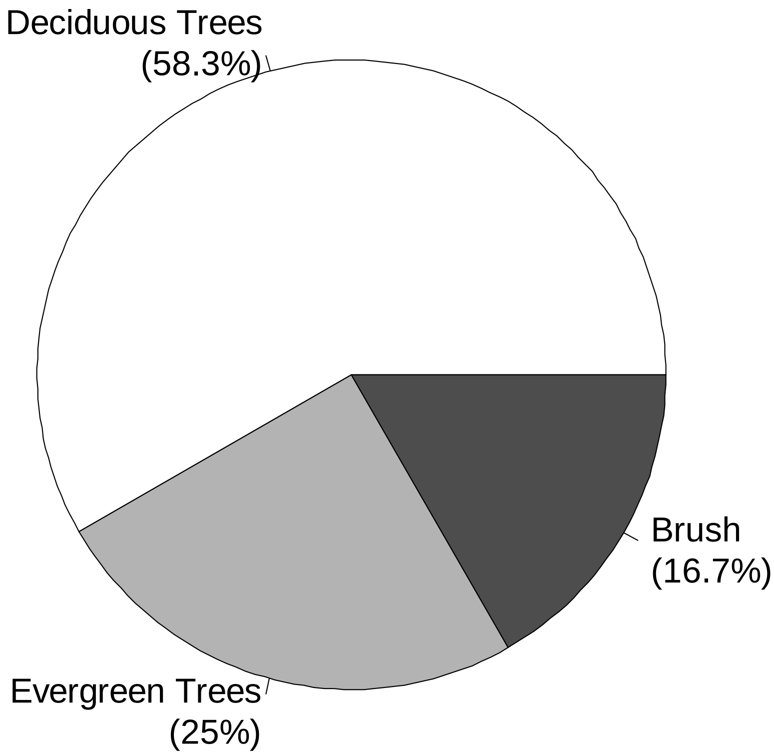


Figure 48. Percentage of banks by dominant vegetation type for Arroyo Quemado Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush. In this survey, grass was not recorded

as a dominant bankside vegetation type.



Cañada del Corral Creek

Habitat Assessment

<u>Results</u>

The habitat inventory was conducted from 27 July to 30 July 2015 by Kyle Evans, Sam Bankston, Terra Dressler, Marisa Morse, and Taylor Berryman from Pacific States Marine Fisheries Commission and Brain Smith from Exxon Mobile Production Company. The survey extended 19,715 feet upstream from the survey start (34.46424°N, -120.04560°W). The survey endpoint (34.51070°N, -120.02553°W) was a vertical bedrock that acted as a total natural barrier for fish passage (Figure 49). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 60 to 66°F. Air temperature ranged from 62 to 70°F.

Habitat type

Of the total number of habitat units surveyed (n = 86 units), 27.9% of units were dry, 12.8% were flatwaters, 43.0% were pools, and 16.3% were riffles. Of the total length of the reach surveyed, 91.1% was dry, 2.3% was composed of flatwaters, 4.2% was composed of pools, and 2.3% was composed of riffles (Figure 50).

We identified six habitat types in Cañada del Corral Creek. Based on the frequency of units sampled, mid-channel pools (39.5%), dry units (27.9 %), and low-gradient riffles (16.3%) were the most common habitat types (Table 12). Based on total stream length, dry (91.2%), mid-channel pools (3.5%), and low-gradient riffles (2.4%) composed the greatest stream lengths.

Pool Metrics

A total of 37 pools were identified within the survey reach. Main channel pools were the only pool type encountered.

Four of 37 pools (11%) had residual depths of three feet or greater (Figure 51).

Within pool tail-outs, bedrock was the most frequently observed dominant substrate (22.2% of pool units), followed by boulders (19.4%) and gravel (16.7%; Figure 52).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (81.1%), four (8.1%), or one (8.1%; Figure 53).

Shelter

Within 100% units (n = 14 units), riffle habitat types had a mean shelter rating of 50.0, flatwater habitat types had a mean shelter rating of 130.0, and pools had a mean shelter rating of 36.5.

When we examined the mean percentage of shelter by shelter type across all 100% units (n = 14 units), we found that boulders provided the most shelter (71.8% of all shelter; Figure 54). When we examined the percentage of shelter by shelter type within pools only (n = 10 units), we found that boulders were the most dominant cover type (75.5% of the total cover), followed by small woody debris (11.0%; Figure 55).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 82.0%. Within the canopy cover present, 53.5% of the canopy was composed of deciduous trees and 46.5% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were bedrock (42.3%), silt/sand/clay (30.8%), boulder (19.2%), and cobble/gravel (11.5%; Figure 56). The mean percentage of vegetation covering the right bank in sampled units was 51.4%, and the mean percentage of vegetation covering the left bank was 58.9%. Brush was the dominant vegetation type, having been observed in 50.0% of the banks surveyed. Additionally, 30.8% of the banks surveyed had evergreen trees and 19.2% had deciduous trees as the dominant vegetation (Figure 57).

Large Woody Debris

We observed six pieces of LWD that were 6 to 20 feet long and one piece that was greater than 20 feet long within 1745.8 feet of wetted length. Across both LWD sizes, the number of LWD observed was 0.40 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 21.8 feet.

Discussion

Temperature

The water temperature of units measured ranged from 60 to 66°F. According to the Guide to the Reference Values Used In South-Central/Southern California Coast Steelhead Conservation Action Planning Workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Good to Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools, dry, or riffles. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools and dry units. When we examined the reach in terms of length, we found that most of the reach was dry, with mid-channel pools and low-gradient riffles comprising the greatest percentage of wetted stream length.

Pool Metrics

Pool depth is an important indicator of habitat quality, as deeper pools can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in Cañada del Corral, we found that most pools had residual depths of 1–1.99 feet deep. Only 11% of pools had residual depths of three feet or greater, the depth needed to be considered good habitat (Kier Associates & NMFS 2008). Thus, it appears that pools in Cañada del Corral may lack the depth needed to provide good hiding cover and rearing space. This may be due in part to the current, severe drought, which has extended into its fourth consecutive year.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was bedrock, comprising 22.2% of pool units. Pool units most frequently had an embeddedness value of five. These metrics suggest that many pool tail-outs in Cañada del Corral Creek lack spawning habitat for *O. mykiss*.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that flatwater habitats had the greatest mean shelter rating, while pools had the lowest mean shelter rating. However, it is important to note that only two riffles and two flatwaters were measured for shelter, compared to 10 pools. Thus, sample sizes between shelter types may not be comparable.

When we examined the percentage shelter by shelter type across all 100% units, we found that boulders provided the most shelter by far (71.8% of all shelter). When we examined percentage of shelter by shelter type within pools only, we found that boulders were the dominant cover type (75.5% of total cover). This data suggests that boulders are a common and potentially important feature to O. mykiss habitat in Cañada del Corral Creek.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In Cañada del Corral Creek, we estimated a mean canopy cover of 82.0%, consisting both of deciduous and evergreen trees. This suggests that Cañada del Corral has a moderately high amount of cover (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was bedrock, followed by silt/sand/clay. The percentage of vegetation cover for the right and left banks was 51.4% and 58.9%, respectively. Brush was the most common dominant vegetation observed, followed by coniferous trees and hardwood trees. Together these metrics suggest that these banks may be relatively vulnerable to erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In Cañada del Corral, we found 0.4 pieces of LWD per 100 feet, which was low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Cañada del Corral lacks LWD, it has boulder elements that improve habitat quality. Specifically, boulders provided the greatest amount of shelter across all units in which shelter was assessed (71.8% of all shelter).

Tables

Table 12. Percentage of units (n = 86) by habitat type for Cañada del Corral Creek.

Habitat Type	% of Units
Mid Channel Pool	39.53%
Dry	27.91%
Low Gradient Riffle	16.28%
Run	11.63%
Step Pool	3.49%
Step Run	1.16%

<u>Figures</u>

Figure 49. Map of the habitat assessment survey area in Cañada del Corral Creek.

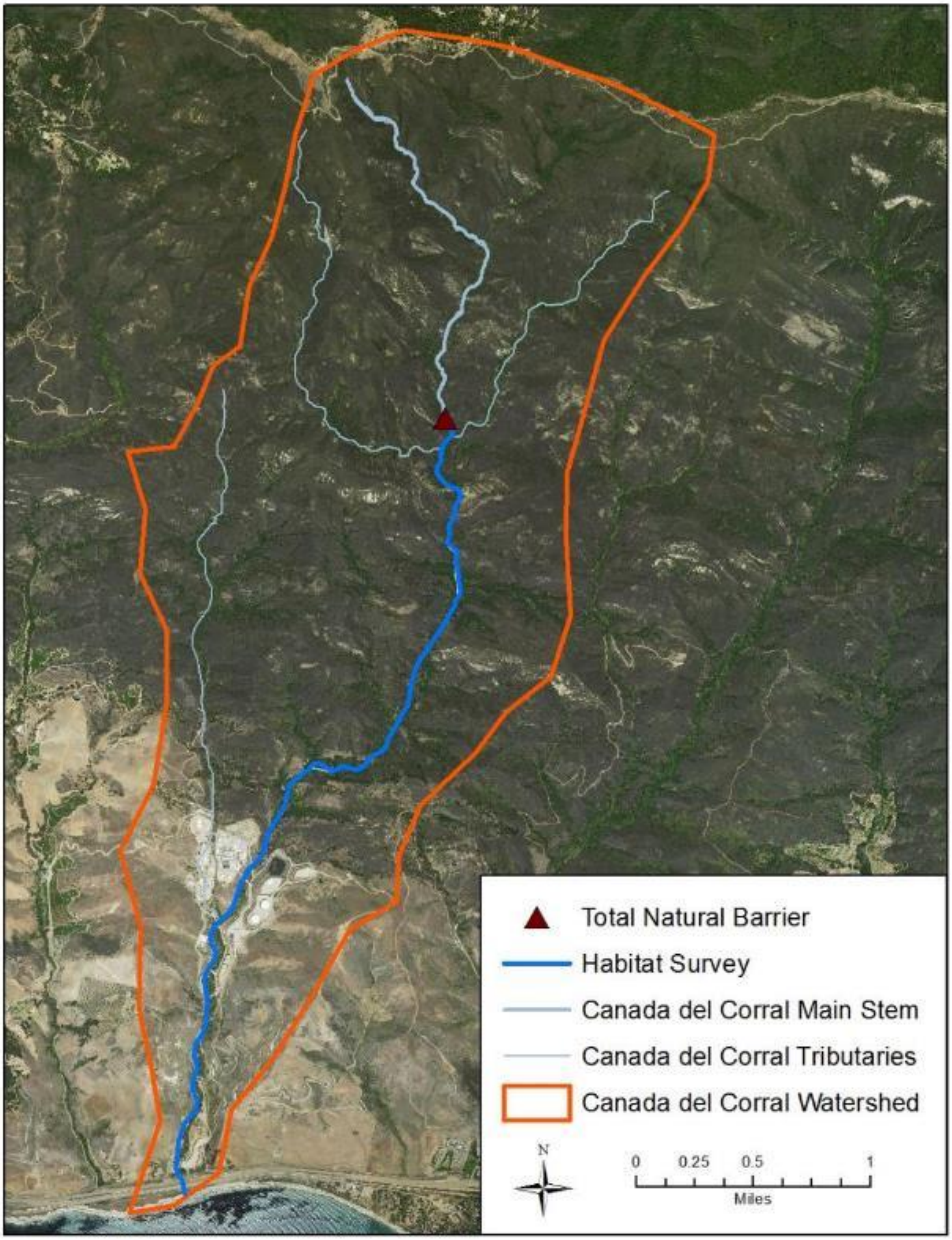


Figure 50. Percentage of total stream length categorized as pools, flatwaters, riffles, or dry in Cañada del Corral Creek.

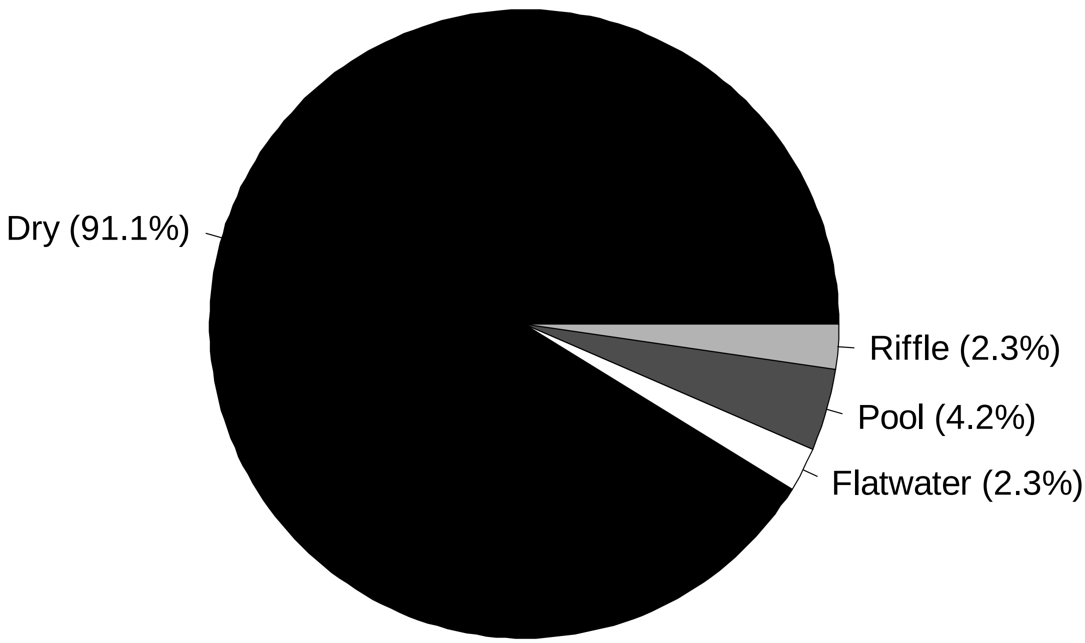


Figure 51. Histogram of residual pool depths in one-foot bins for Cañada del Corral Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

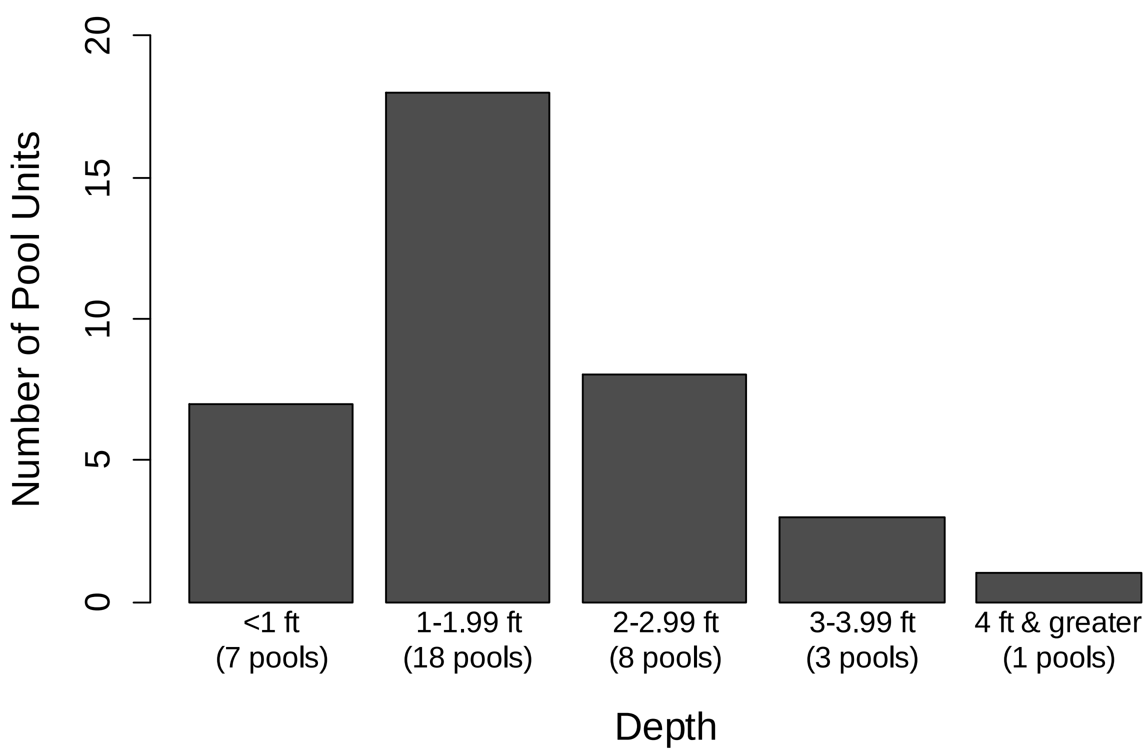


Figure 52. Percentage of pool tail-outs (n = 37 pools) by dominant substrate for Cañada del Corral Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

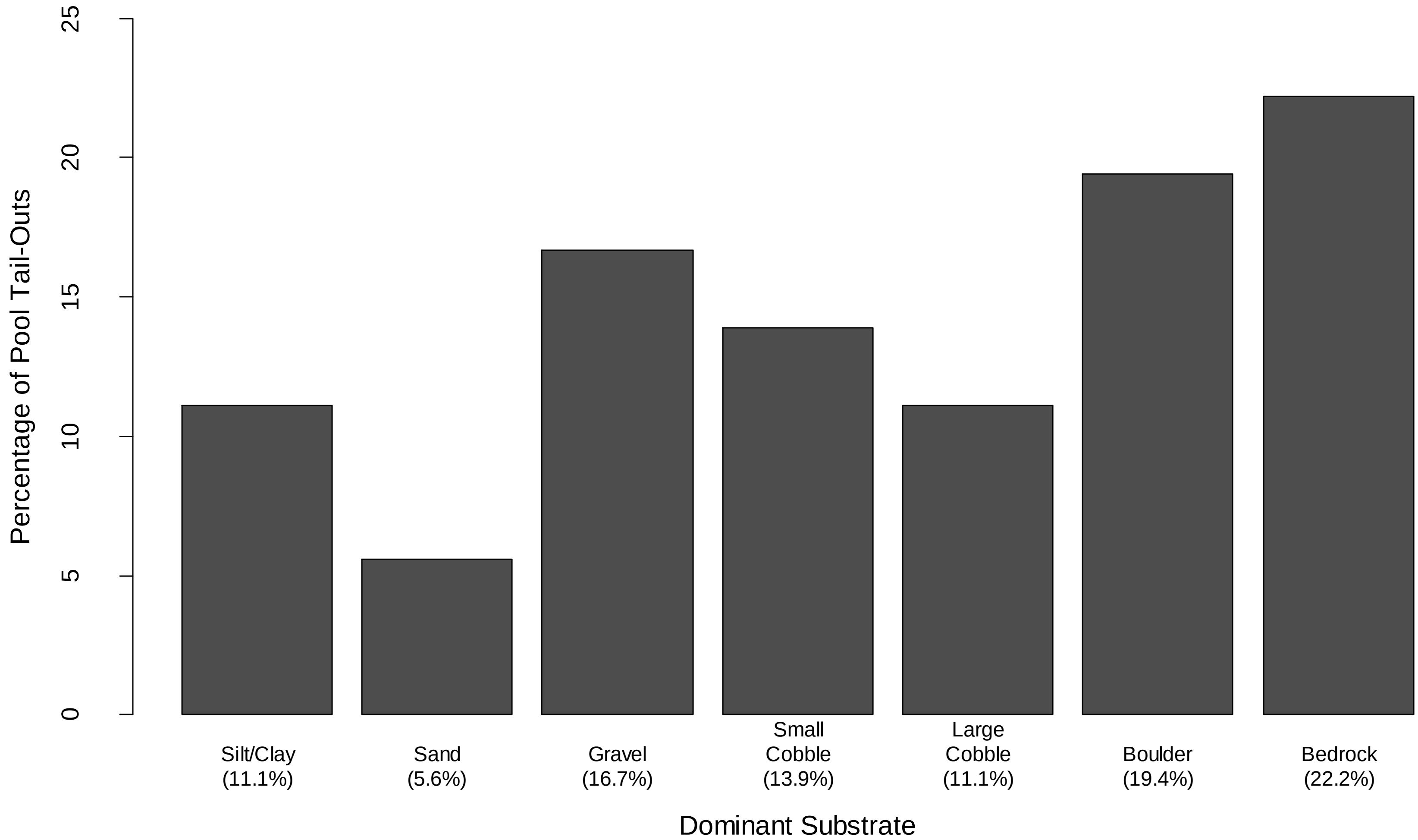


Figure 53. Percentage of all pool units (n = 37 pools) assigned a pool tail-out embeddedness value of 1 to 5 for Cañada del Corral Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning. In this survey, no pool tail-outs had an embeddedness value of three.

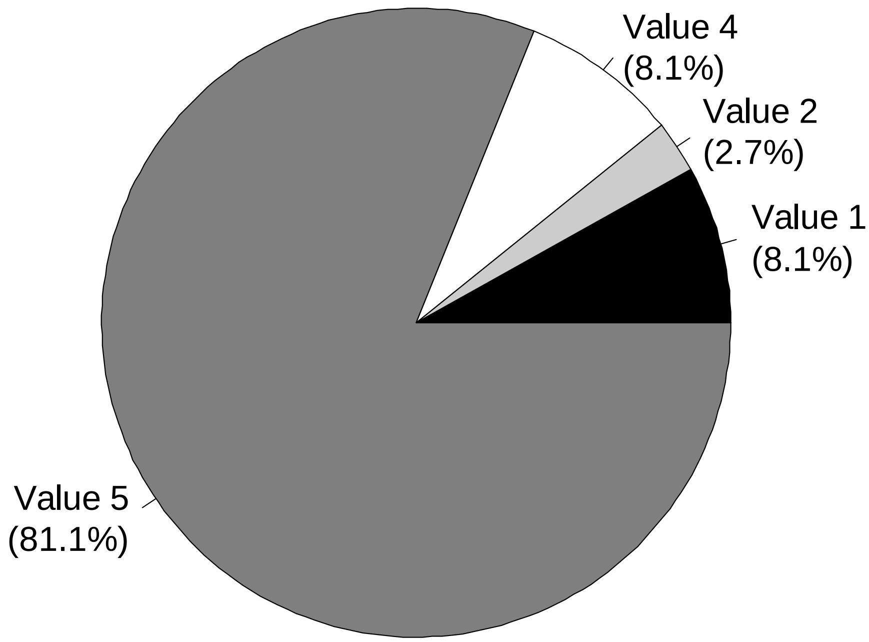


Figure 54. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 14 units) for Cañada del Corral Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

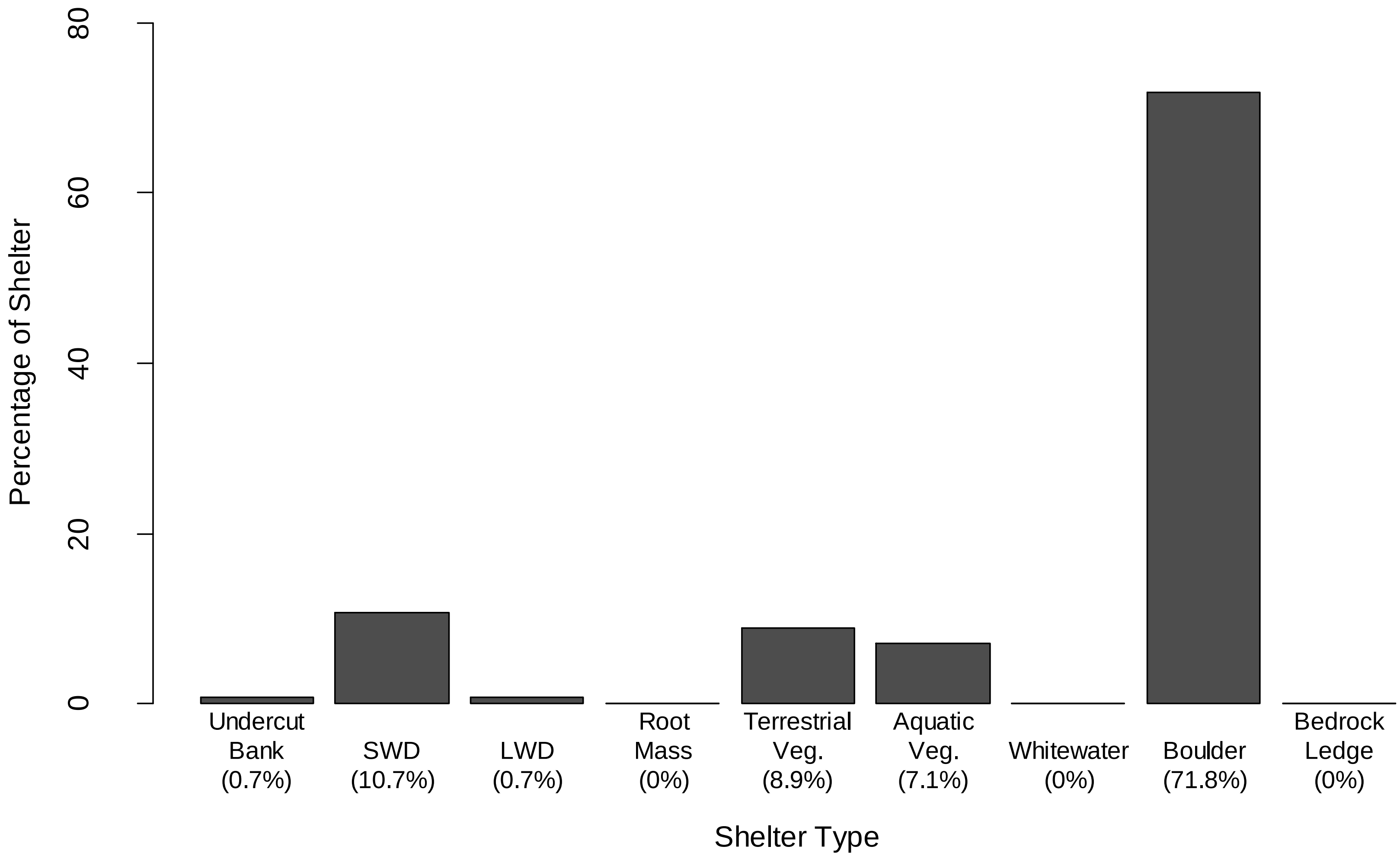


Figure 55. The percentage of shelter by shelter type across all pool units in which shelter was measured (n = 10 pools) in Cañada del Corral Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

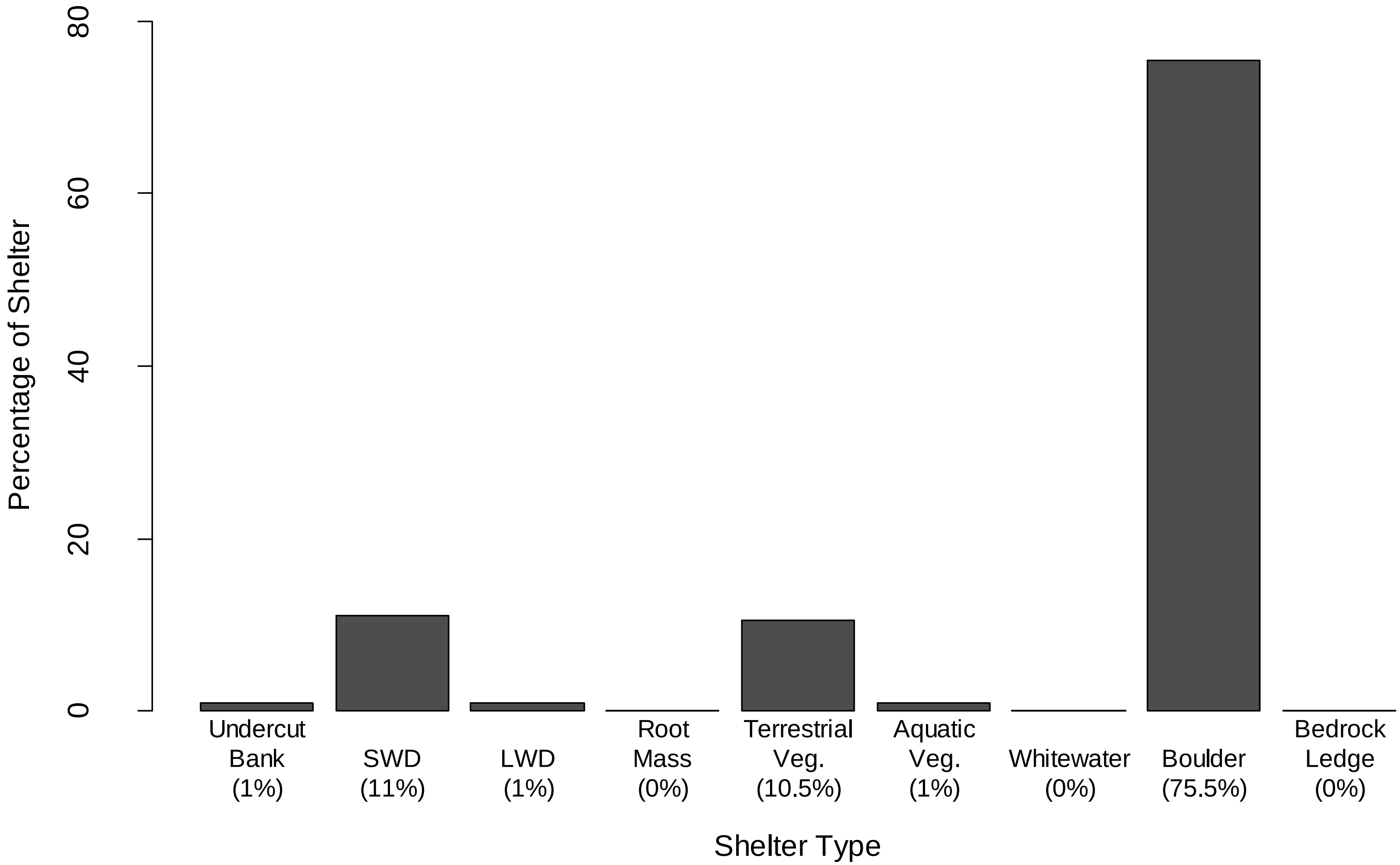


Figure 56. Percentage of banks by dominant substrate composition for Cañada del Corral Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock .

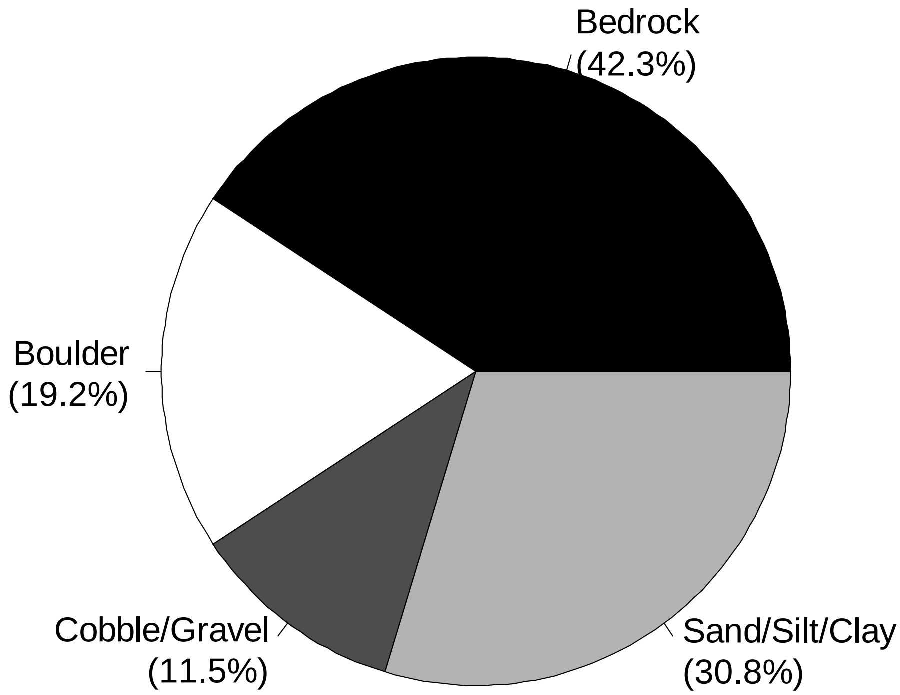
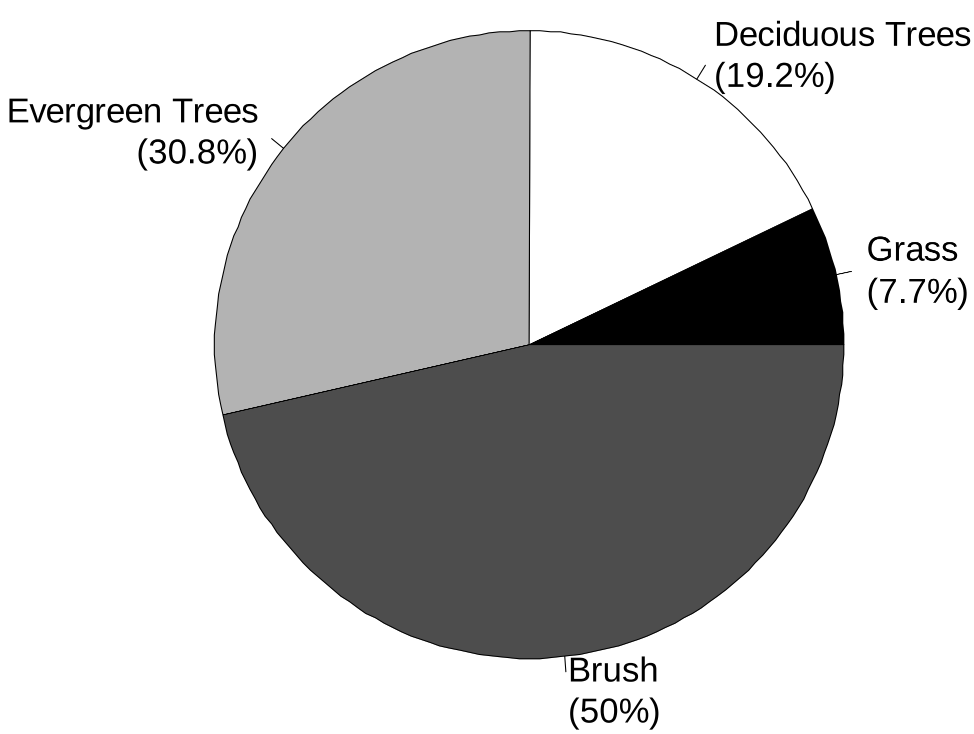


Figure 57. Percentage of banks by dominant vegetation type for Cañada del Corral Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



Cañada del Capitan Creek

Habitat Assessment

Results

The habitat inventory was conducted from 11–13 August 2014 by Karissa Willits, Patrick Saldaña, and Tom Van Meeuwen from Pacific States Marine Fisheries Commission and Erin McCanne and Terra Dressler from CA Department of Fish and Wildlife. The survey extended 11,412.5 feet upstream from the survey start (34.45792°N, -120.02209°W). The survey endpoint (34.48606°N, -120.01377 °W) was the confluence of East and West Fork Cañada del Capitan (Figure 58). Stream flow was not measured.

Temperature

Water temperature was recorded only once and was 70 °F. Air temperature was recorded twice and ranged from 68 to 76°F.

Habitat type

Of the total number of habitat units surveyed (n = 21 units), 28.6% of units were dry, 33.3% were pools, 28.6% were riffles, and 9.5% were culverts. No flatwater units were recorded during this survey. Of the total length of the reach surveyed, 89.6% was dry, 1.7% was composed of pools, 3.6% was composed of riffles, and 5.1% was composed of culverts (Figure 59).

We identified four habitat types in Cañada del Capitan. Based on the frequency of units sampled, mid-channel pools (28.6%), low gradient riffles (28.6%), and dry units (28.6%) were the most common habitat types (Table 13). Based on total stream length, dry (89.6%), culvert (5.1%), and low-gradient riffles (3.6%) composed the greatest stream lengths.

Pool Metrics

A total of seven pools were identified within the survey reach. Main channel pools were most frequently encountered (85.7% of pool units sampled) and comprised 79.9% of the total length of all pools. Only main channel and scour pools were encountered; no backwater pools were recorded.

No pools had residual depths of three feet or greater (Figure 60).

Within pool tail-outs, small (20.0%) and large cobble (80.0%) were the only dominant substrates observed in pool tails (Figure 61).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (42.9%) or two (28.6%; Figure 62).

Shelter

Within 100% units (n = 7 units), riffle habitat types had a mean shelter rating of 86.7 and pools had a mean shelter rating of 160.0.

Of the pool units in which shelter was assessed (n = 4 units), main channel pools had a mean shelter rating of 186.7. The only scour pool measured for shelter had a rating of 80.0.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that boulders provided the most shelter (46.4% of all shelter; Figure 63). When we examined the percentage of shelter by shelter type within pools only, we found that boulders again were the most dominant cover type (42.5% of the total cover), followed by aquatic vegetation (30.0%; Figure 64).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 95.0%. Within the canopy cover present, 82.9% of the canopy was composed of deciduous trees and 17.1% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were boulder (35.7%), cobble/gravel (7.1%), and silt/sand/clay (57.1%; Figure 65). The mean percentage of vegetation covering the right bank in sampled units was 82.9%, and the mean percentage of vegetation covering the left bank was 68.6%. Deciduous trees were the dominant vegetation type, having been observed in 57.1% of the banks surveyed (Figure 66).

Large Woody Debris

We observed no pieces of LWD that were 6 to 20 feet long and one piece that was greater than 20 feet long within 600.5 feet of wetted stream length. The mean number of LWD observed was 0.17 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 28.4 feet.

Discussion

Only 21 units were surveyed within Cañada del Capitan. Of these, only thirteen of these units were wetted; 94.7% of stream length was dry or culvert and therefore unsuitable for assessing steelhead habitat. The lack of water in this stream is likely due, in part, to the current, severed drought that has extended into its fourth consecutive year. Seven units were surveyed as 100% units and were therefore the only units in which shelter, canopy cover, and bankside metrics were assessed. Given the limited data gathered from Cañada del Capitan, we could not make general conclusions regarding the habitat.

Tables

Table 13. Percentage of units (n = 21) by habitat type in Cañada del Capitan.

Habitat Type	%
Low Gradient Riffle	28.57%
Mid Channel Pool	28.57%
Dry	28.57%
Culvert	9.52%
Lateral Scour Pool, boulder-formed	4.76%

Figures

Figure 58. Map of the habitat assessment survey area in Cañada del Capitan.

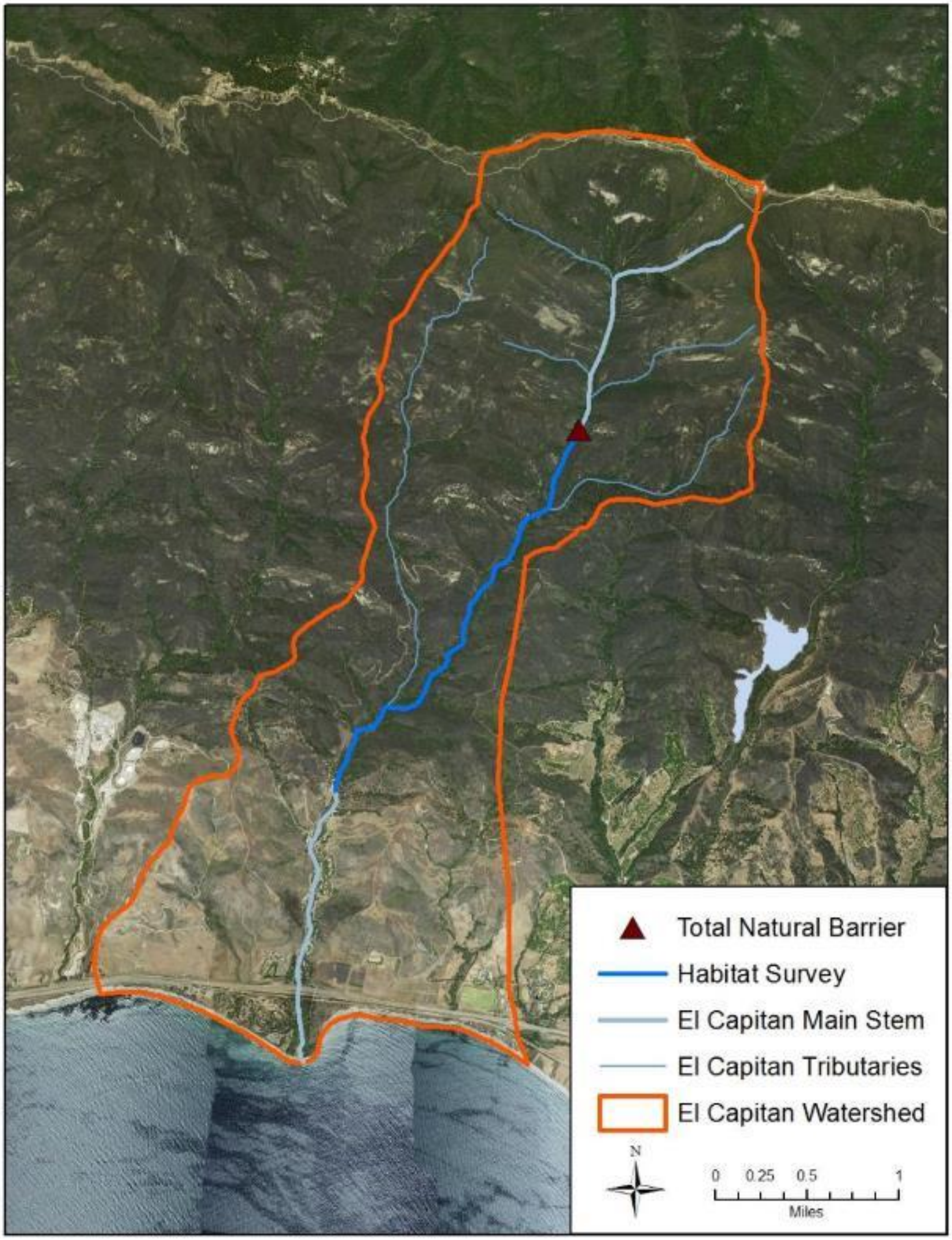


Figure 59. Percentage of total stream length categorized as pools, flatwaters, or riffles for Cañada del Capitan.

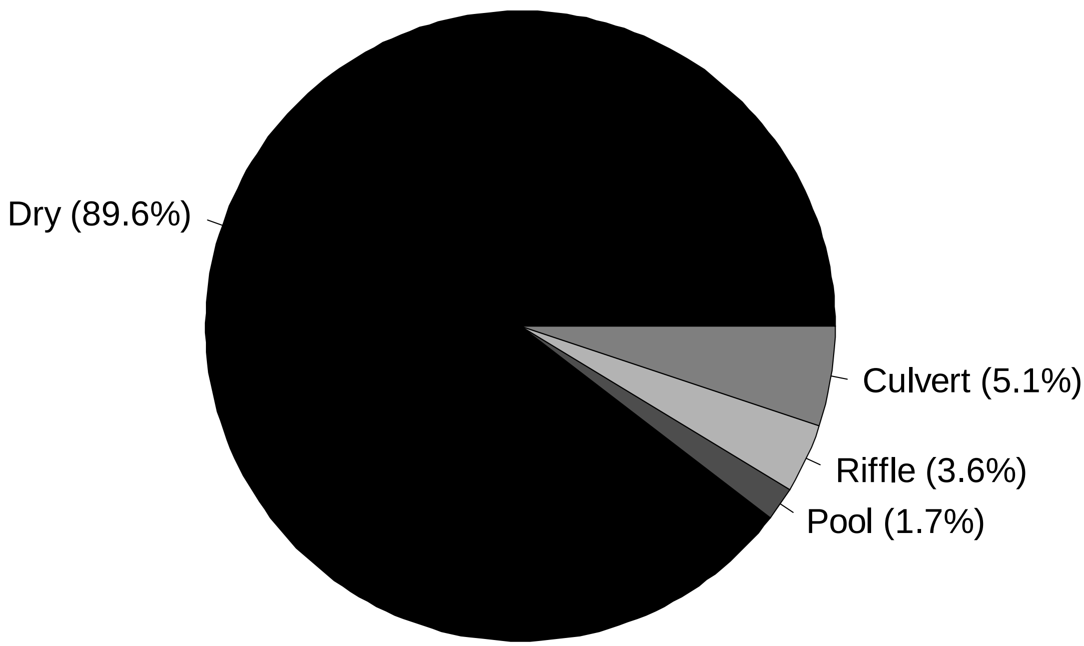


Figure 60. Histogram of residual pool depths in one-foot bins for Cañada del Capitan. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

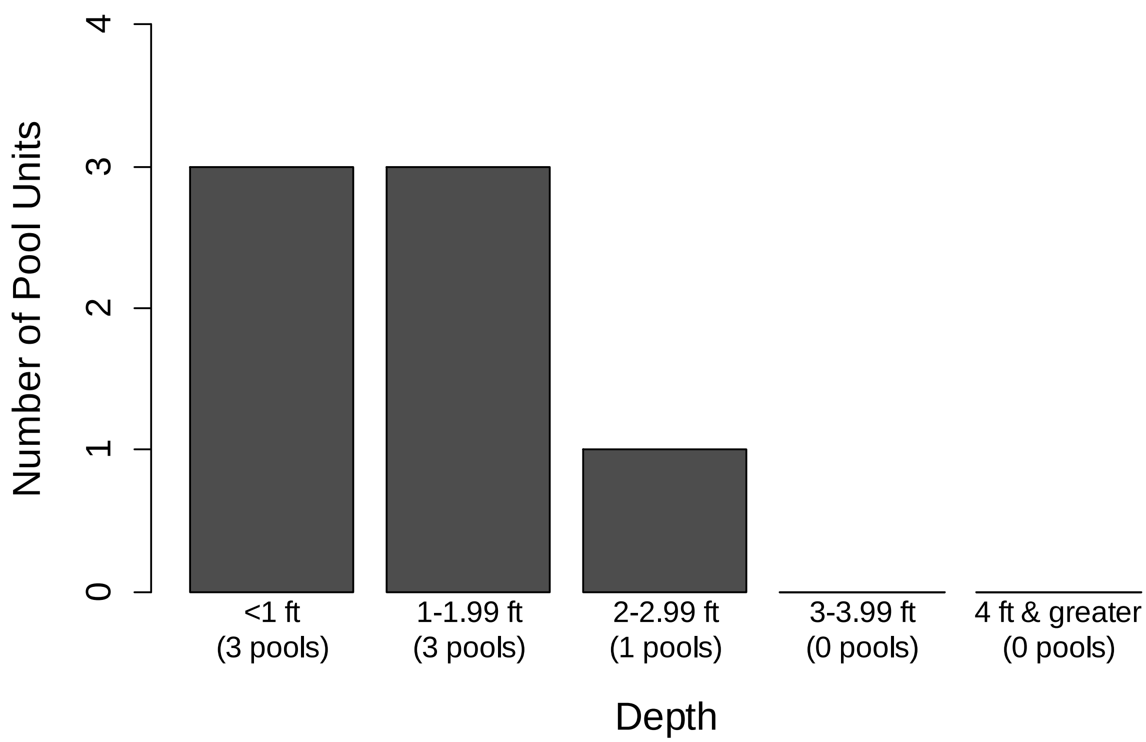


Figure 61. Percentage of pool tail-outs (n = 7 pools) by dominant substrate for Cañada del Capitan. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

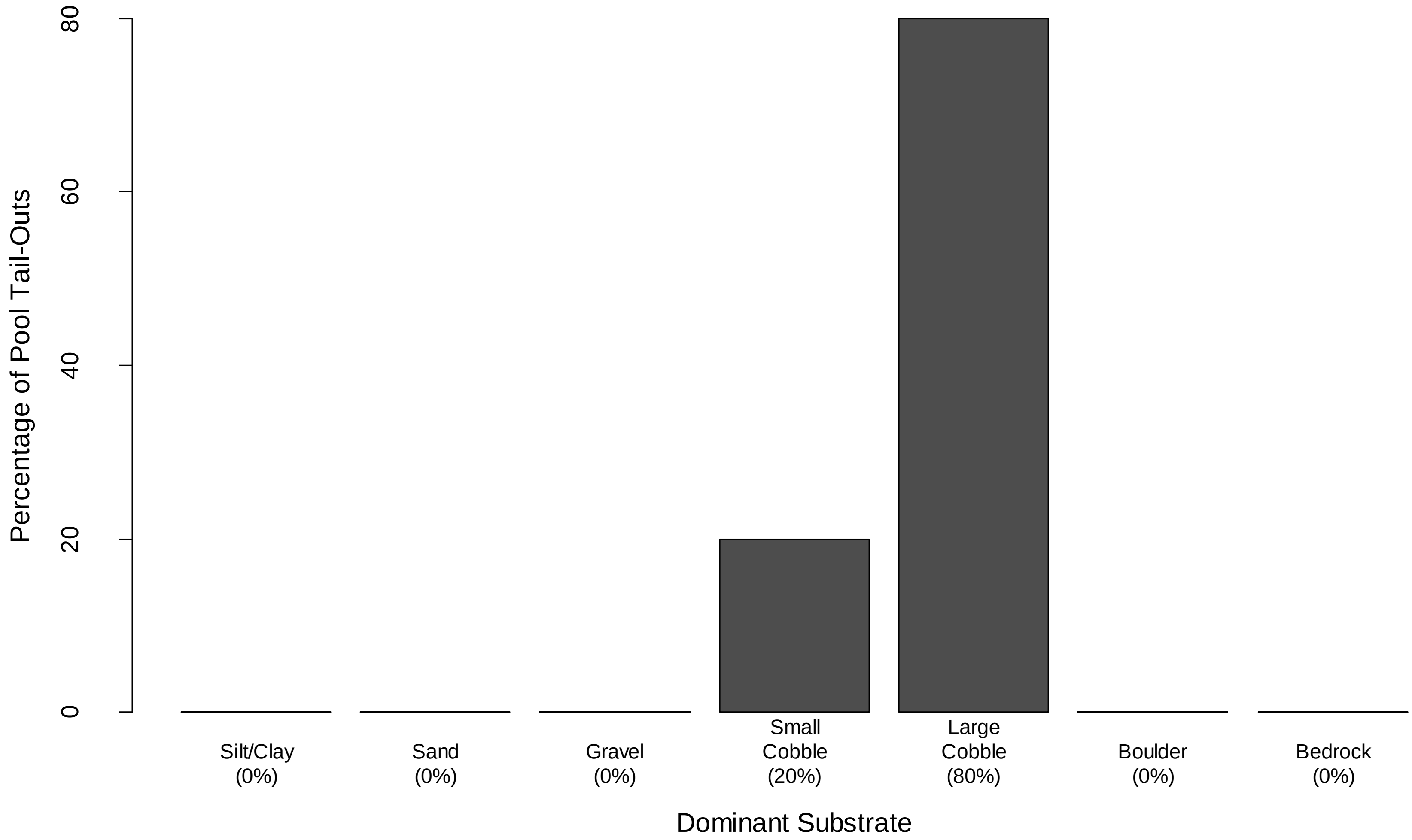


Figure 62. Percentage of all pool units (n = 7 pools) assigned a pool tail-out embeddedness value of 1 to 5 for Cañada del Capitan. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning. In this survey, no pool tail-outs had an embeddedness value of one.

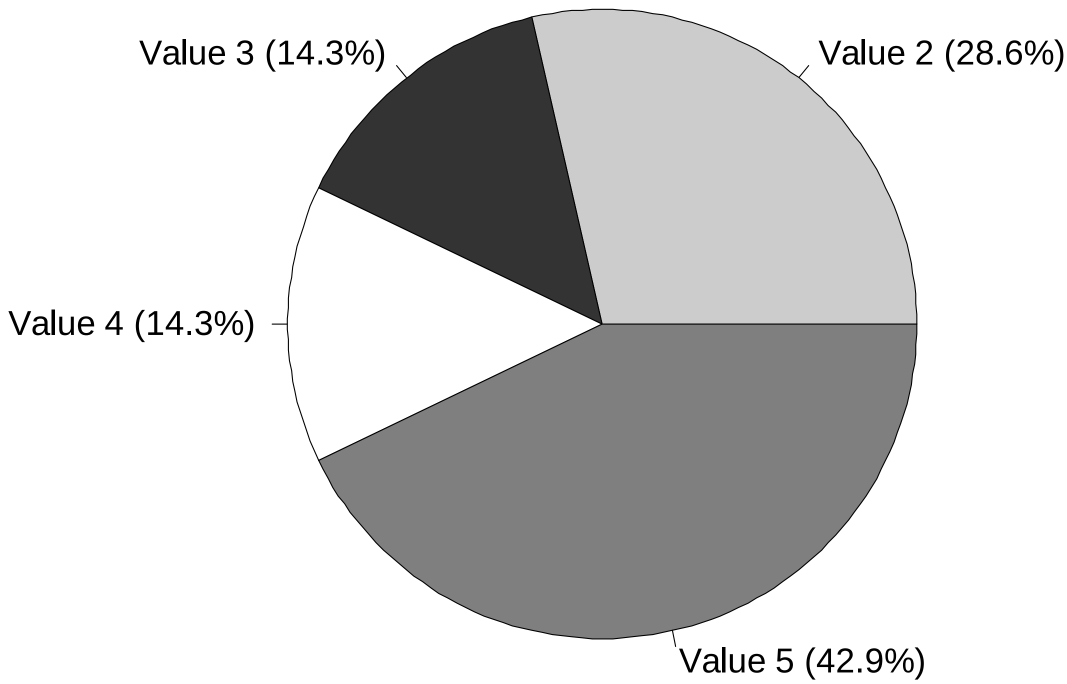


Figure 63. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 7 units) for Cañada del Capitan. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

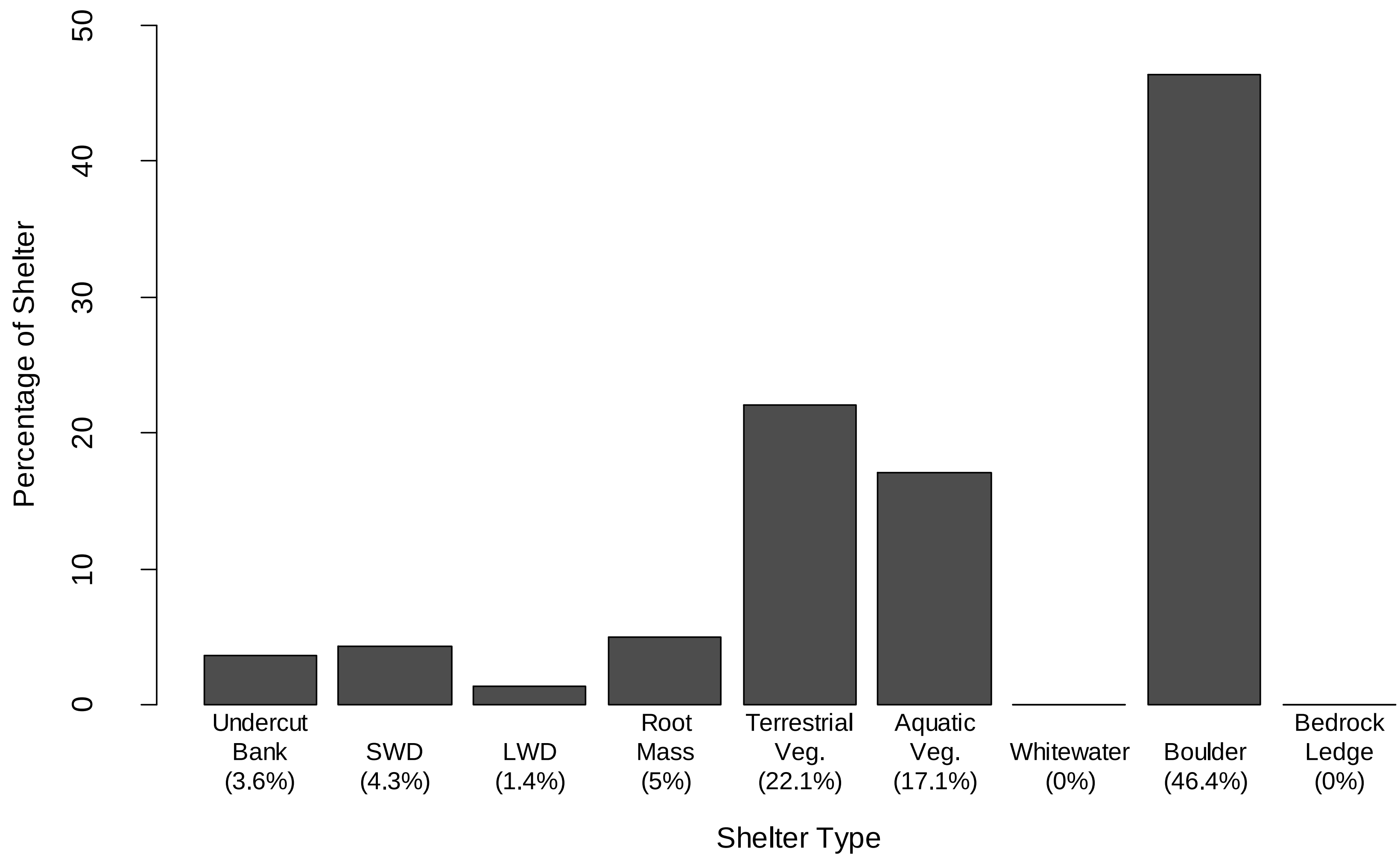


Figure 64. The percentage of shelter by shelter type across all pool units in which shelter was measured (n = 4 pools) for Cañada del Capitan. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

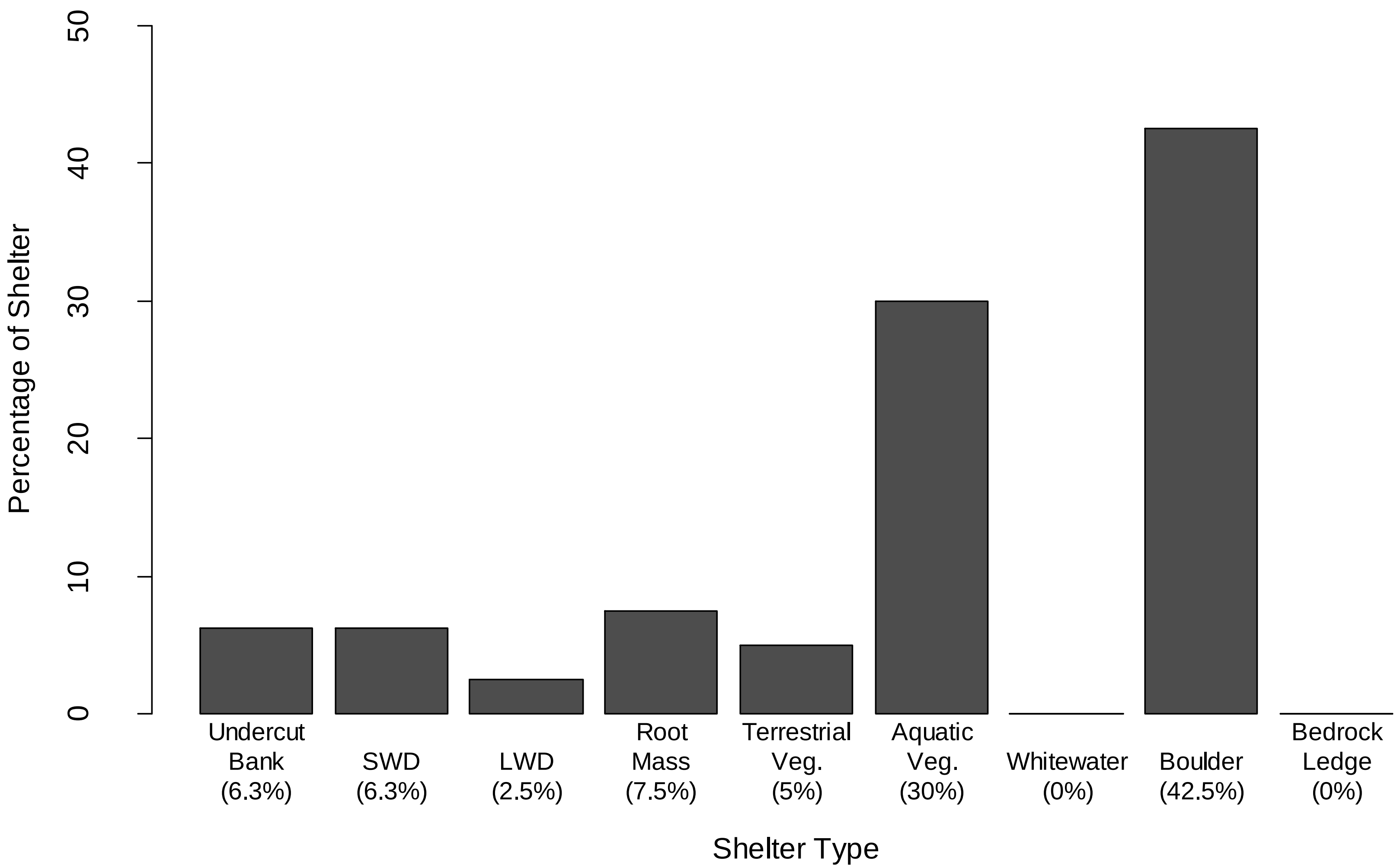


Figure 65. Percentage of banks by dominant substrate composition for Cañada del Capitan. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock. In this survey, no units had bedrock recorded as the dominant bankside substrate.

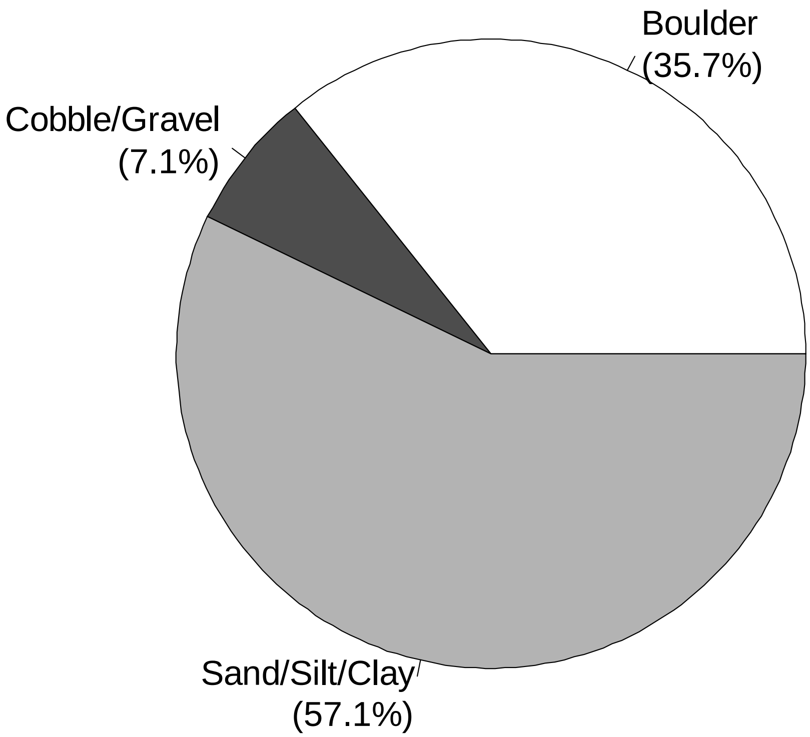
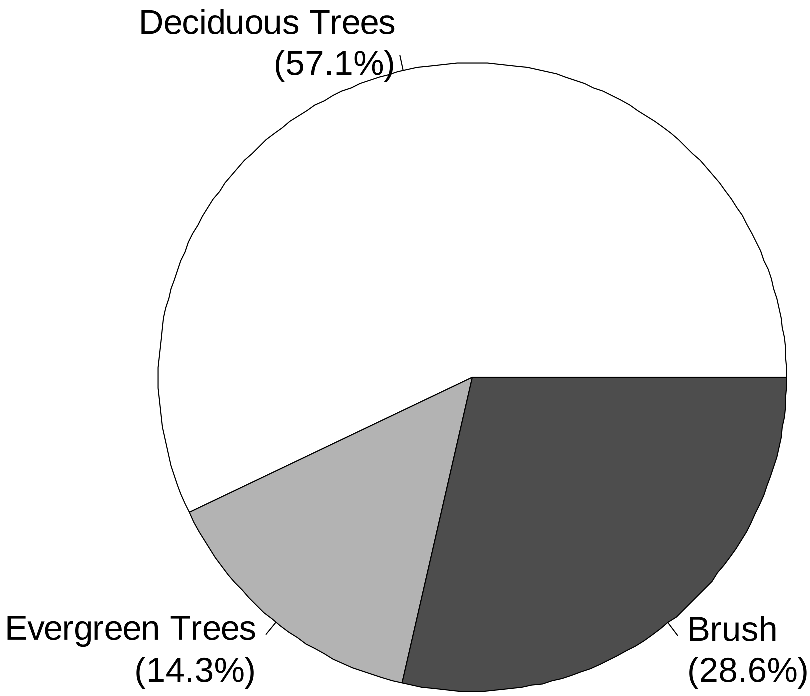


Figure 66. Percentage of banks by dominant vegetation type for Cañada del Capitan. Vegetation types included deciduous trees, evergreen trees, grass, and brush. In this survey, no units had grass recorded

as the dominant bankside vegetation.



Rattlesnake Creek

Snorkel Survey (2014)

<u>Results</u>

On April 15, 2014, a snorkel survey was conducted on a section of Rattlesnake Creek. The survey reach began at the confluence of Rattlesnake and Mission Creek (34.44810, -119.70900) and extended 1.1 miles (5,600.) upstream ending at the last snorkelable pool observed within the wetted reach of Rattlesnake Creek (34.45562, -119.69529).

One *O. mykiss* was observed in a total of 21 pools that were snorkeled. This single fish was in the 6-7.99" size class and was found in 43 foot long by pool with an average width of 14 feet. The pool had a maximum depth of 3.7 feet and the shelter value of 3. No additional species of interest were observed during this survey. Figure 67 shows the distribution of *O. mykiss* over the surveyed reach.

In the 1.1 mile surveyed stretch, the total length of all snorkeled units was 418 feet .The average number of *O. mykiss* per unit length calculates to be 2.392×10^{-3} fish/ft. This was calculated by taking total of observed fish and dividing by the sum of all the lengths of snorkeled units. The average number of *O. mykiss* per unit area calculates to be 1.99×10^{-4} fish/ft^2. This was calculated by taking the total number of fish observations and dividing by sum of all the individual surface areas for each snorkeled unit.

<u>Discussion</u>

On April 15, 2014, a snorkel survey was conducted on a 1.1 mile stretch of Rattlesnake Creek. The purpose of this snorkel survey was to gain an understanding of abundance and distribution of Southern California Steelhead (*O. mykiss*) in Rattlesnake Creek.

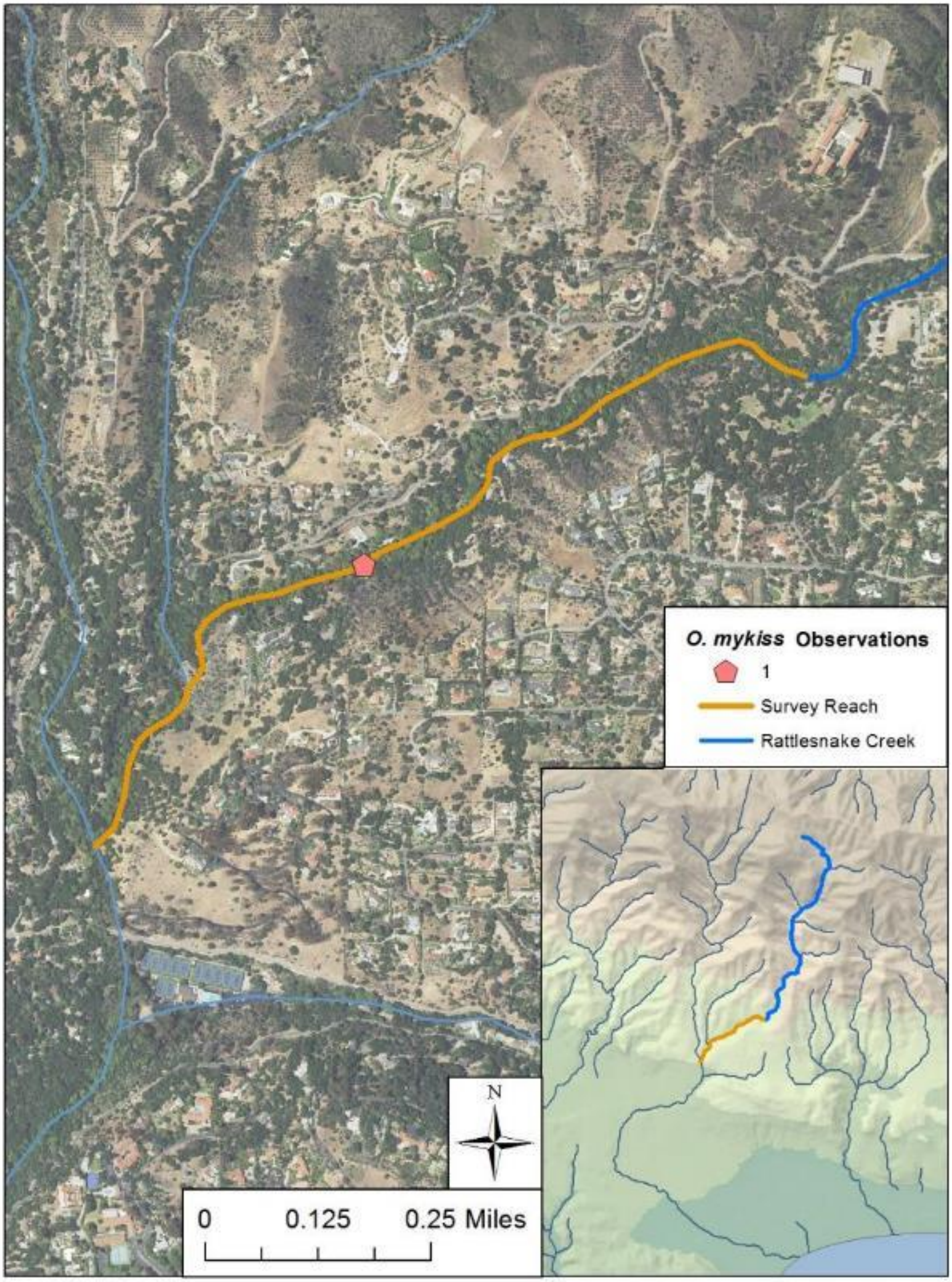
Surveyors recorded one observation of *O. mykiss*. As of the survey date, a severe drought, extending back three years in the southern California, was underway. Rattlesnake is a tributary to Mission Creek, which drains a relatively small area of 6.06 square miles. It is possible that the pronounced dry sections in Rattlesnake Creek are a product of drought effects combined with a relatively small drainage.

This surveyed differed from standard protocol in that two surveyors captured the habitat measurements for every unit within the 1.1 mile stretch. The snorkeler proceeded ahead and flagged every pool that was snorkeled. A quantitative assessment of the amount of spawning gravel present for each unit was also taken and recorded.

Overall, this snorkel summary report shows us a snapshot of what age classes were present and where these *O. mykiss* were distributed on Rattlesnake Creek. We were able to obtain an index of fish density but without subsequent survey seasons, no reliable inferences can be made. Additional survey seasons must be completed in order to make a comparison of our observations. Subsequent surveys should include electrofishing to we can make accurate population estimates as per Hankin & Reeves 1988.

Figures

Figure 67. Distribution map of *O. mykiss* observed in Rattlesnake Creek in 2014.



Habitat Assessment

Results

The habitat inventory was conducted from 21 Jan 2014 to 30 November 2015 by Ben Lakish, Karissa Willits, Patrick Riparetti, Kate McLaughlin, Tom van Meeuwen, Yi-Jiun Tsai, Marisa Morse, and Philip Hunter from Pacific States Marine Fisheries Commission. The survey extended 10,785 feet upstream from the survey start (34.45593°N, -119.69763°W). The survey ended (34.47455°N, -119.68768°W) at a dry stretch of stream above a natural barrier to fish passage (Figure 68). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 47 to 58°F. Air temperature ranged from 49 to 67°F.

Habitat type

Of the total number of habitat units surveyed (n = 333 units), 12.3% of units were dry, 15.3% were flatwaters, 38.7% were pools, and 33.0% were riffles, and 0.6% was culvert. Of the total length of the reach surveyed, 30.7% was dry, 14.8% was composed of flatwaters, 25.5% was composed of pools, 27.7% was composed of riffles, and 1.3% was culvert (Figure 69).

We identified 13 habitat types in Rattlesnake Creek. Mid-channel pools (30.0%) and low gradient riffles (17.7%) were the most frequently encountered habitat types (Table 14). Dry (30.7%), mid-channel pools (17.0%), and low-gradient riffles (14.8%) composed the greatest stream lengths.

Pool Metrics

A total of 129 pools were identified within the survey reach. Main channel pools were most frequently encountered (87.6% of pool units sampled), and comprised 88.0% of the total length of all pools. Only main channel and scour pools were encountered; no backwater pools were recorded.

Nine of 129 pools (7%) had residual depths of three feet or greater (Figure 70).

Within pool tail-outs, gravel was the most frequently observed dominant substrate (27.3% of pool units), followed by boulders (17.2%; Figure 71).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (50.4%) or two (26.4%; Figure 72).

Shelter

Within 100% units (n = 73 units), riffle habitat types had a mean shelter rating of 67.9, flatwater habitat types had a mean shelter rating of 76.9, and pools had a mean shelter rating of 79.9.

Of the pool units in which shelter was assessed (n = 35 units), main channel pools had a mean shelter rating of 79.0 and scour pools had a mean shelter rating of 82.0.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that boulders (36.7% of the total cover) and small woody debris (36.2%) provided the most shelter (Figure 73). When we examined the percentage of shelter by shelter type within pools only, we found that boulders were the most dominant cover type (42.9%), followed by small woody debris (31.3%; Figure 74).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 87.9%. Within the canopy cover present, 49.2% of the canopy was composed of deciduous trees and 50.8% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were bedrock (28.7% of units sampled), boulder (26.0%), cobble/gravel (7.3%), and silt/sand/clay (38.0%; Figure 75). The mean percentage of vegetation covering the right bank in sampled units was 52.8%, and the mean percentage of vegetation covering the left bank was 50.1%. Evergreen trees and brush were the dominant vegetation type, having been observed in 46.0% and 28.7% of the banks surveyed, respectively (Figure 76).

Large Woody Debris

We observed 26 pieces of LWD that were 6 to 20 feet long and 27 pieces that were greater than 20 feet long within 7335.6 feet of wetted stream length. Across both LWD sizes, the mean number of LWD observed was 0.72 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 30.7 feet.

Discussion

Temperature

The water temperature of units measured ranged from 47 to 58°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools or riffles. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools and low-gradient riffles. When we examined the reach in terms of length, we found that most of the reach was dry or riffles. Mid-channel pools and low gradient riffles comprised the greatest percentage of wetted stream length.

Pool Metrics

Pool depth is an important of indicator of habitat quality, as deeper pools can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). A residual depth of at least there feet is needed to be considered good habitat (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in Rattlesnake, we found that only 7% of pools had residual depths three feet or greater. Thus, it appears that pools in Rattlesnake may lack the depth needed to provide good hiding cover and rearing space. This may be due in part to the current, severe drought, which has extended into its fourth consecutive year.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was gravel, comprising 27.3% of pool units. Among pool tail-outs with gravel, most had embeddedness values of one or two (85.7% of tail-outs with gravel substrate). Across all pool units, most had an embeddedness value of either five or two. Together, these metrics suggest that, although pools may not provide the ideal depth for cover or rearing space, some pool tail-outs in Rattlesnake may provide good spawning habitat for *O. mykiss*, assuming that flows are adequate.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all 100% riffle, flatwater, and pool units, we found that pools had the highest shelter ratings, while riffles had the lowest. However, all ratings were relatively low (ratings of 67.9–79.9 on a scale ranging from 0–300).

When examining pool habitat units specifically, we found that scour pools had slightly higher shelter ratings than main channel pools.

When we examined the percentage shelter by shelter type, we found the boulders and small woody debris provided the most shelter both across all 100% units and within 100% pools only. This suggests that boulders and deciduous trees are common and important features to in Rattlesnake Creek.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In Rattlesnake, we estimated a mean canopy cover of 87.9%. This suggests that Rattlesnake has a high amount of cover (Kier Associates & NMFS 2008).

Bankside Metrics

The most common dominant substrate composing stream banksides was silt/sand/clay. The mean percentage of vegetation covering the right and left banks was 52.8% and 50.1%, respectively. Evergreen trees and brush were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively vulnerable to erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In Rattlesnake Creek, we found 0.72 pieces of LWD per 100 feet, which was low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Rattlesnake lacks LWD, it has boulder elements that improve habitat quality. Specifically, boulders provided the greatest amount of shelter across all units in which shelter was assessed (36.7% of all shelter).

Tables

Table 14. Percentage of units (n = 333) by habitat type for Rattlesnake Creek.

Habitat Type	%
Mid Channel Pool	30.03%
Low Gradient Riffle	17.72%
Dry	12.31%
Run	12.01%
High Gradient Riffle	10.51%
Bedrock Sheet	3.90%
Step Pool	3.60%
Step Run	3.30%
Lateral Scour Pool, bedrock formed	2.10%
Plunge Pool	2.10%
Cascade	0.90%
Lateral Scour Pool, boulder formed	0.60%
Culvert	0.60%
Trench Pool	0.30%

Figures

Figure 68. Map of the habitat assessment survey area in Rattlesnake Creek.

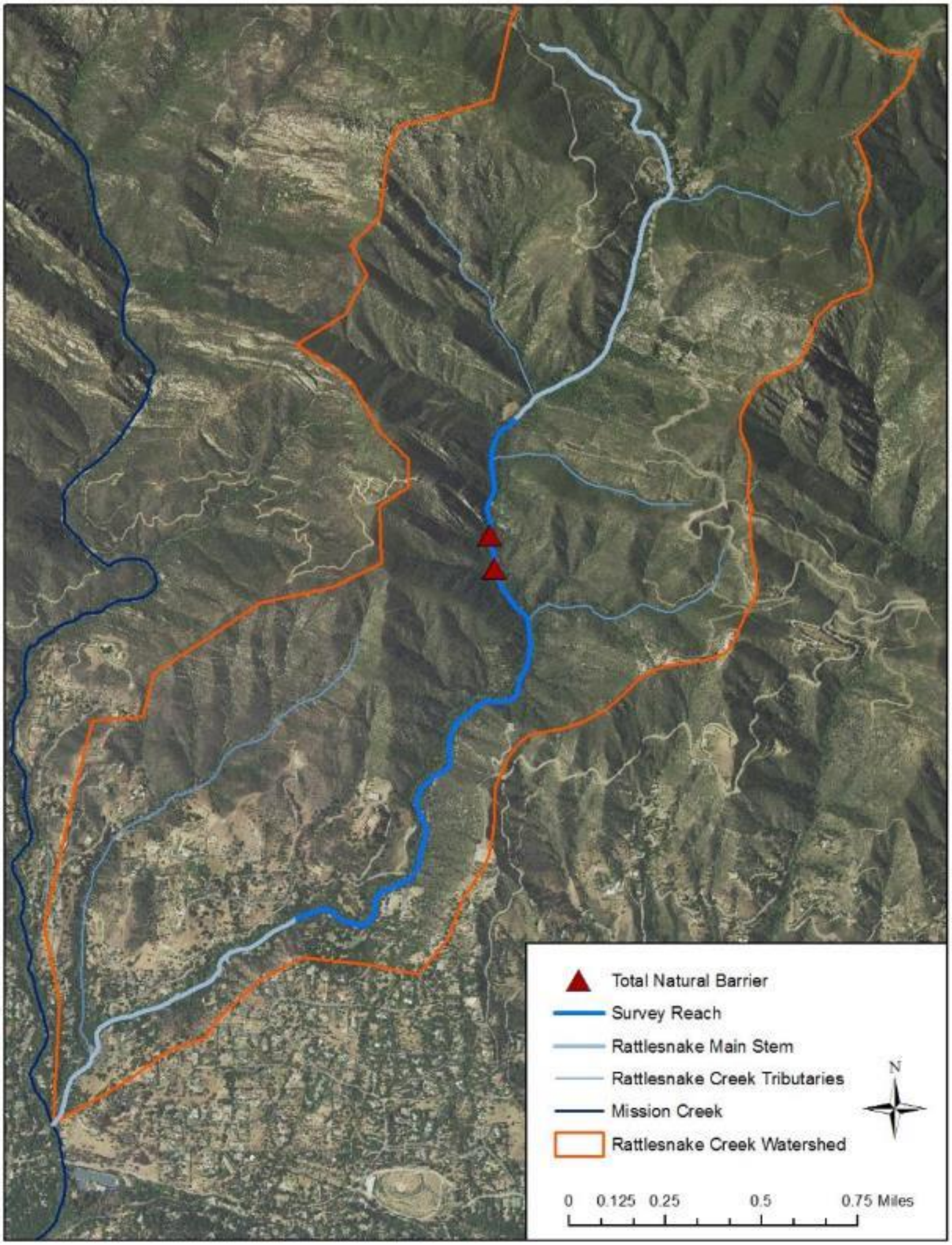


Figure 69. Percentage of total stream length categorized as pools, flatwaters, riffles, or culverts for Rattlesnake Creek.

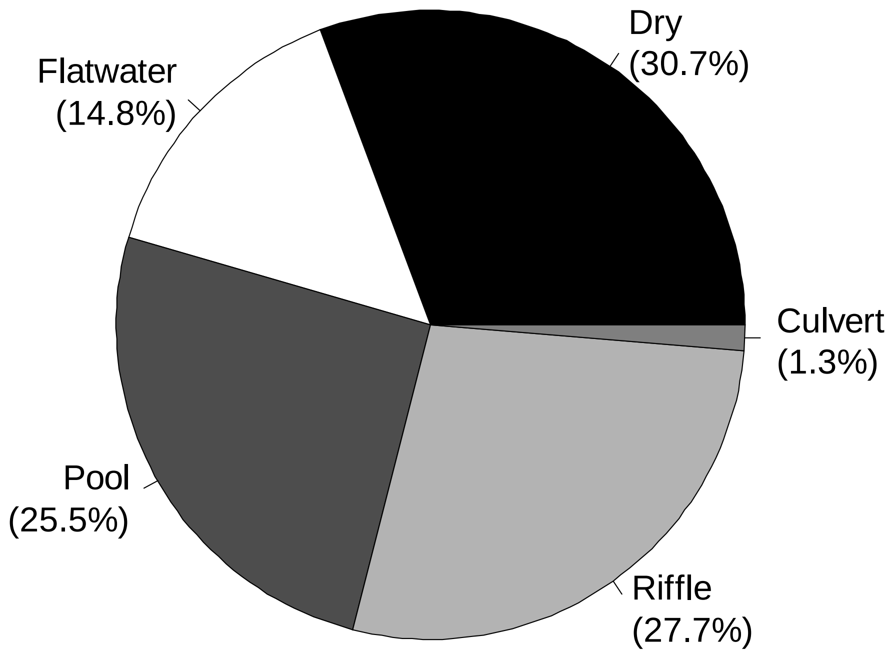


Figure 70. Histogram of residual pool depths in one-foot bins. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth for Rattlesnake Creek.

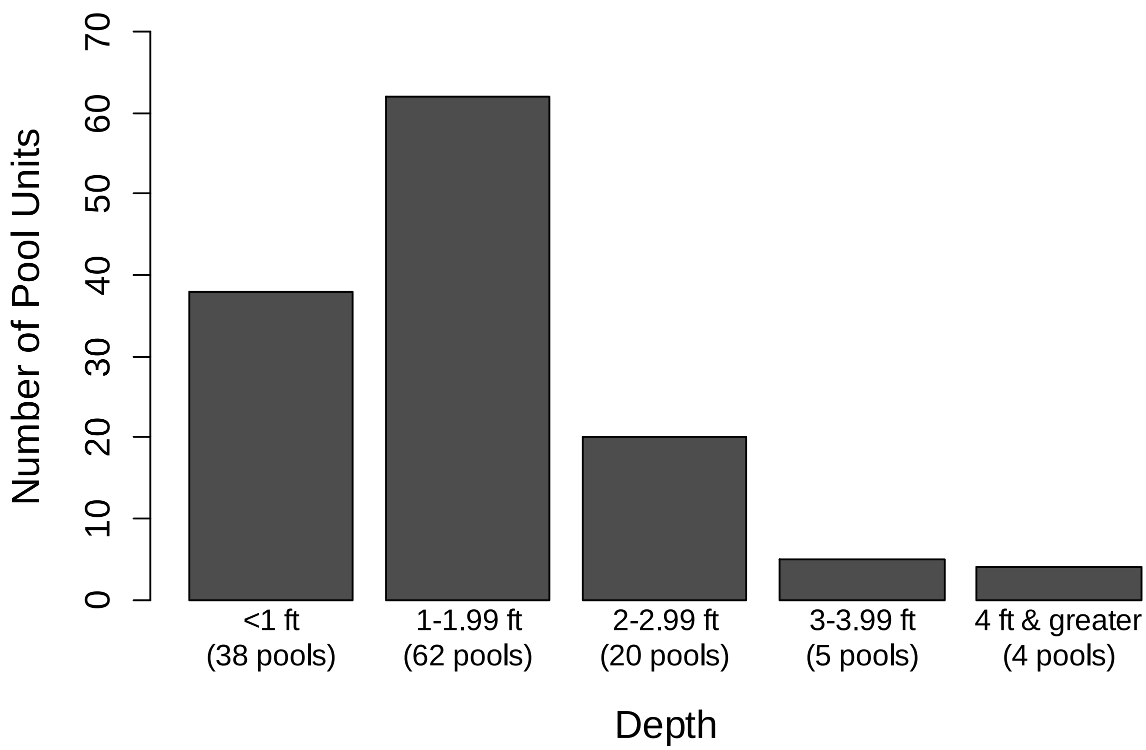


Figure 71. Percentage of pool tail-outs (n = 129 pools) by dominant substrate for Rattlesnake Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

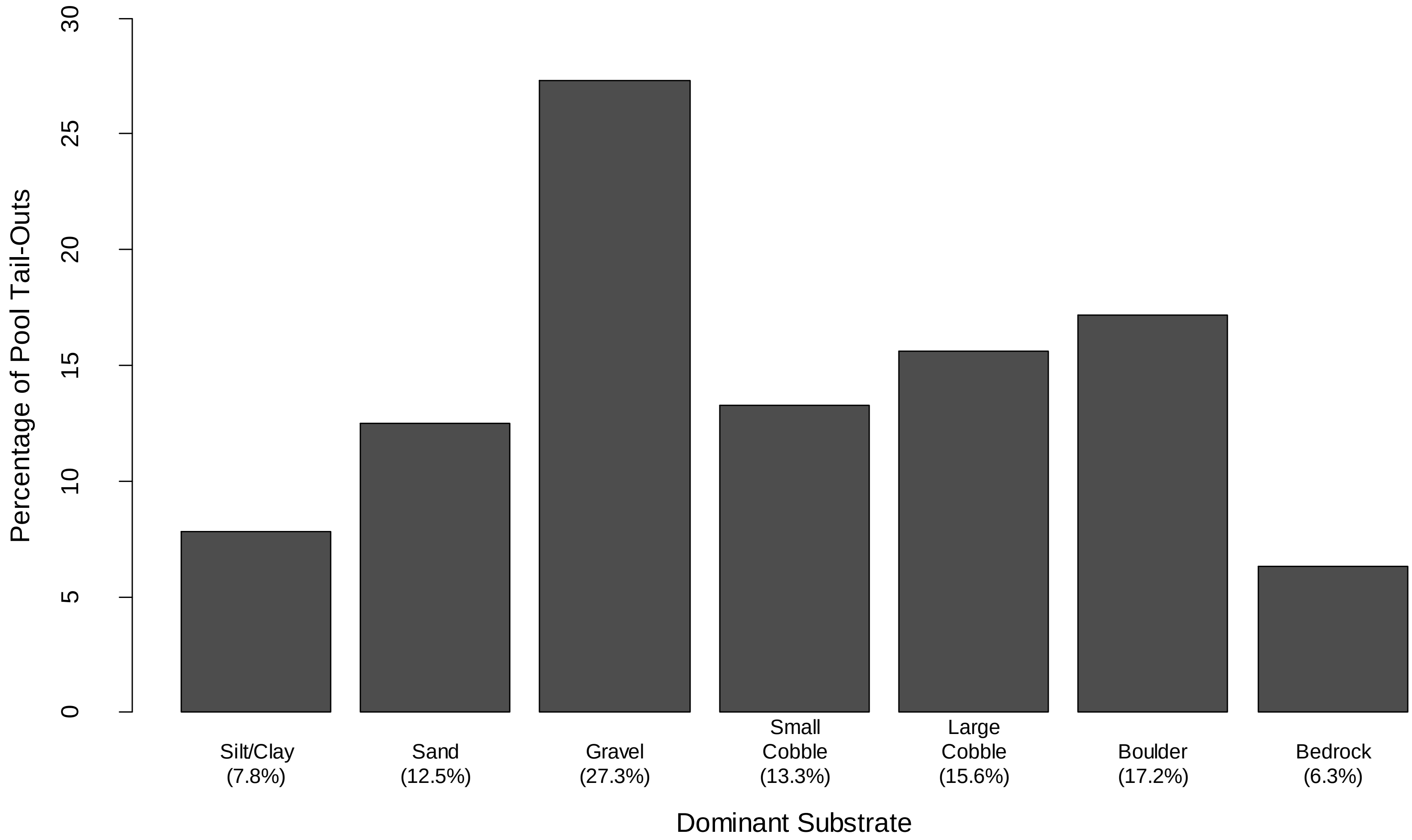


Figure 72. Percentage of all pool units (n = 129 pools) assigned a pool tail-out embeddedness value of 1 to 5 for Rattlesnake Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning.

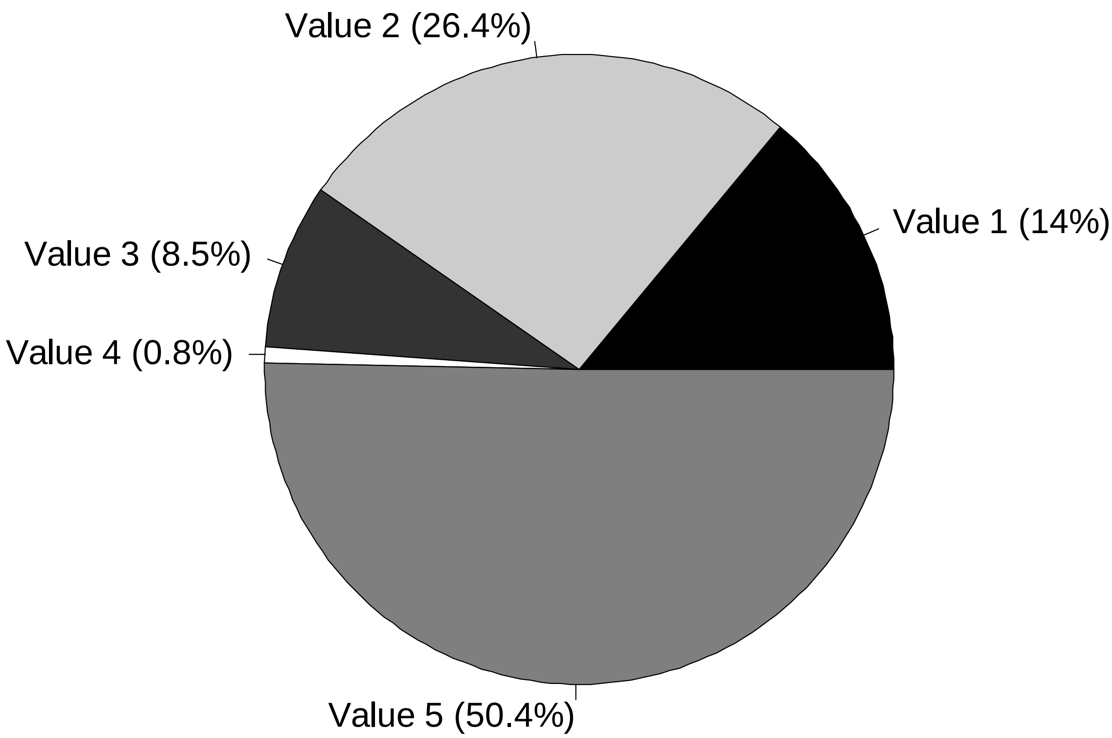


Figure 73. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 73 units) for Rattlesnake Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

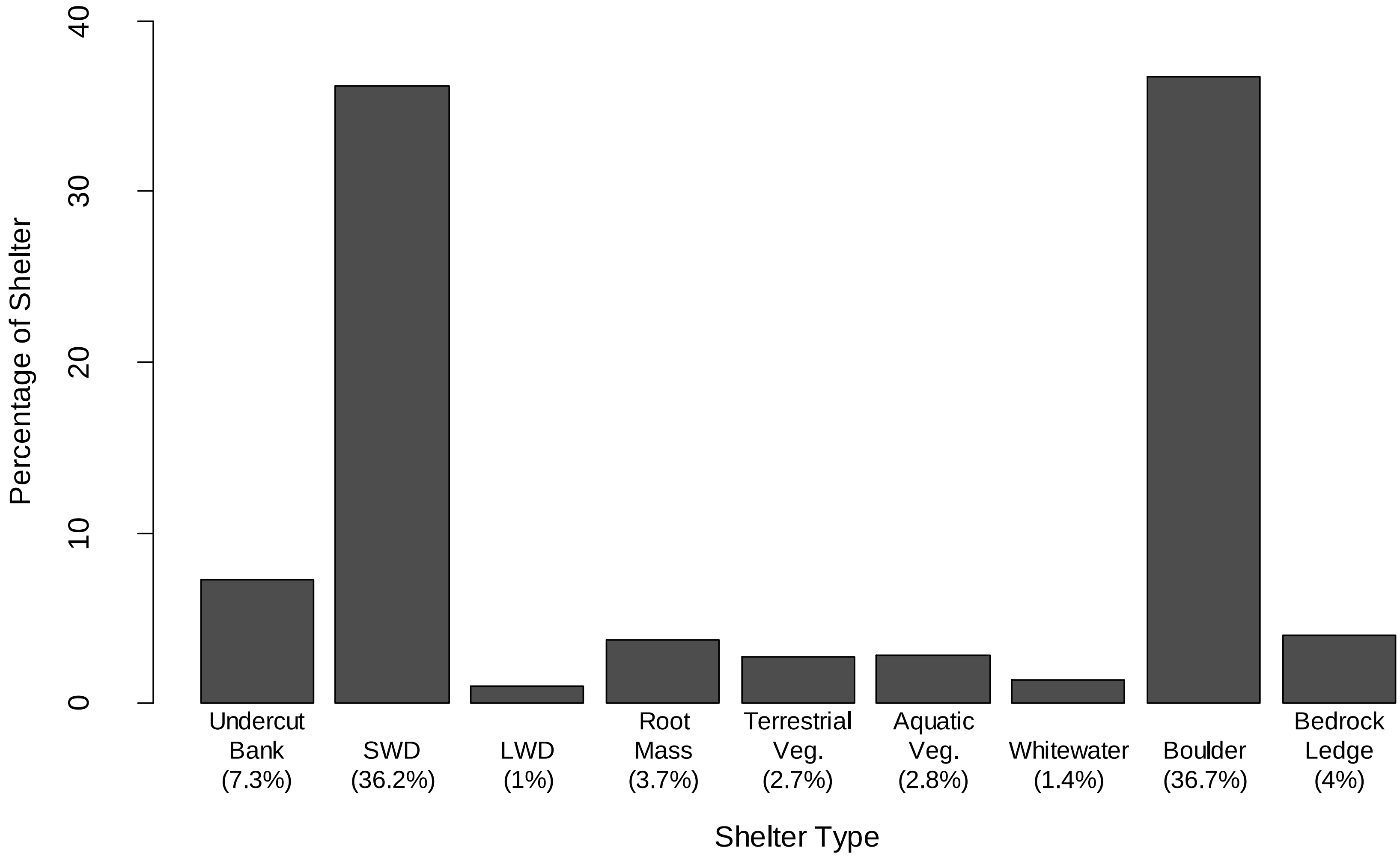


Figure 74. The percentage of shelter by shelter type across all pool units in which shelter was measured (n = 35 pools). Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge for Rattlesnake Creek.

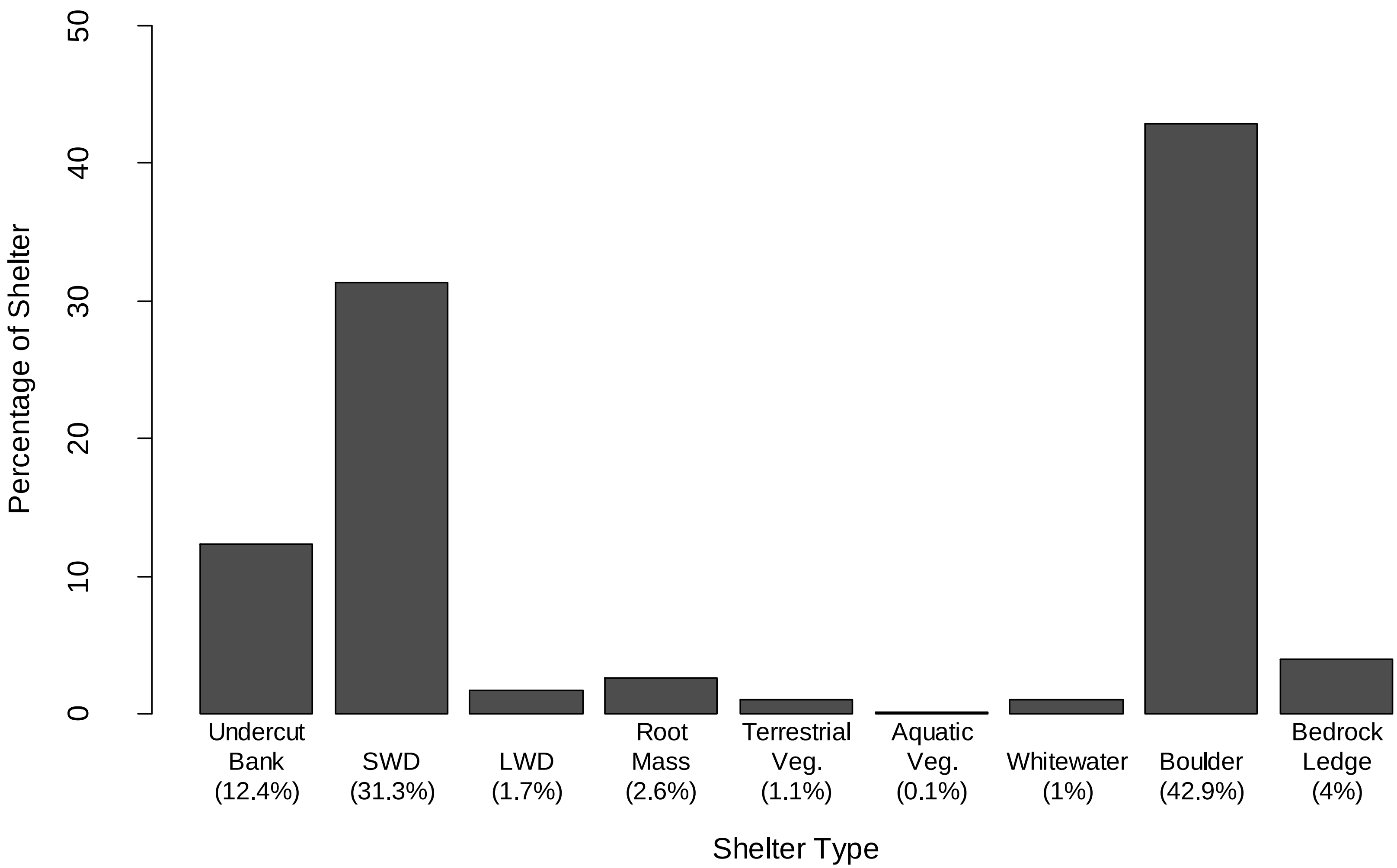


Figure 75. Percentage of banks by dominant substrate composition for Rattlesnake Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock.

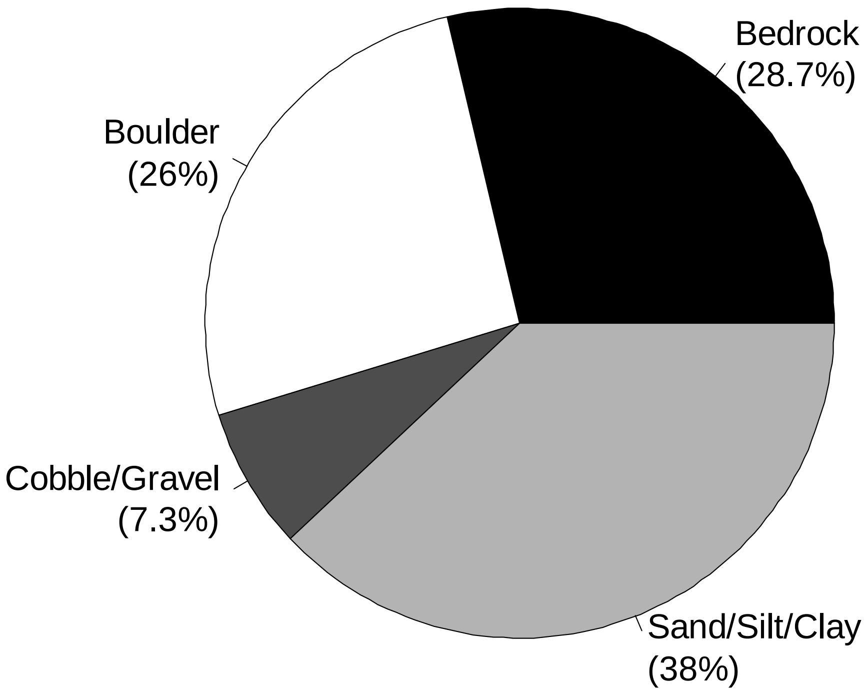
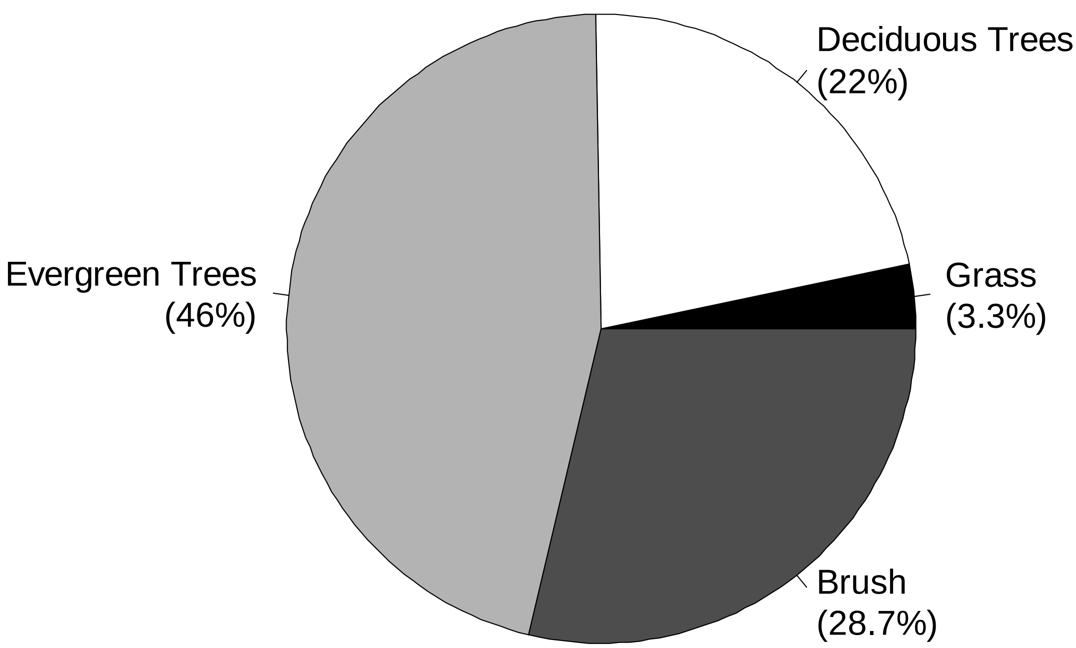


Figure 76. Percentage of banks by dominant vegetation type for Rattlesnake Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



Montecito Creek

Habitat Assessment

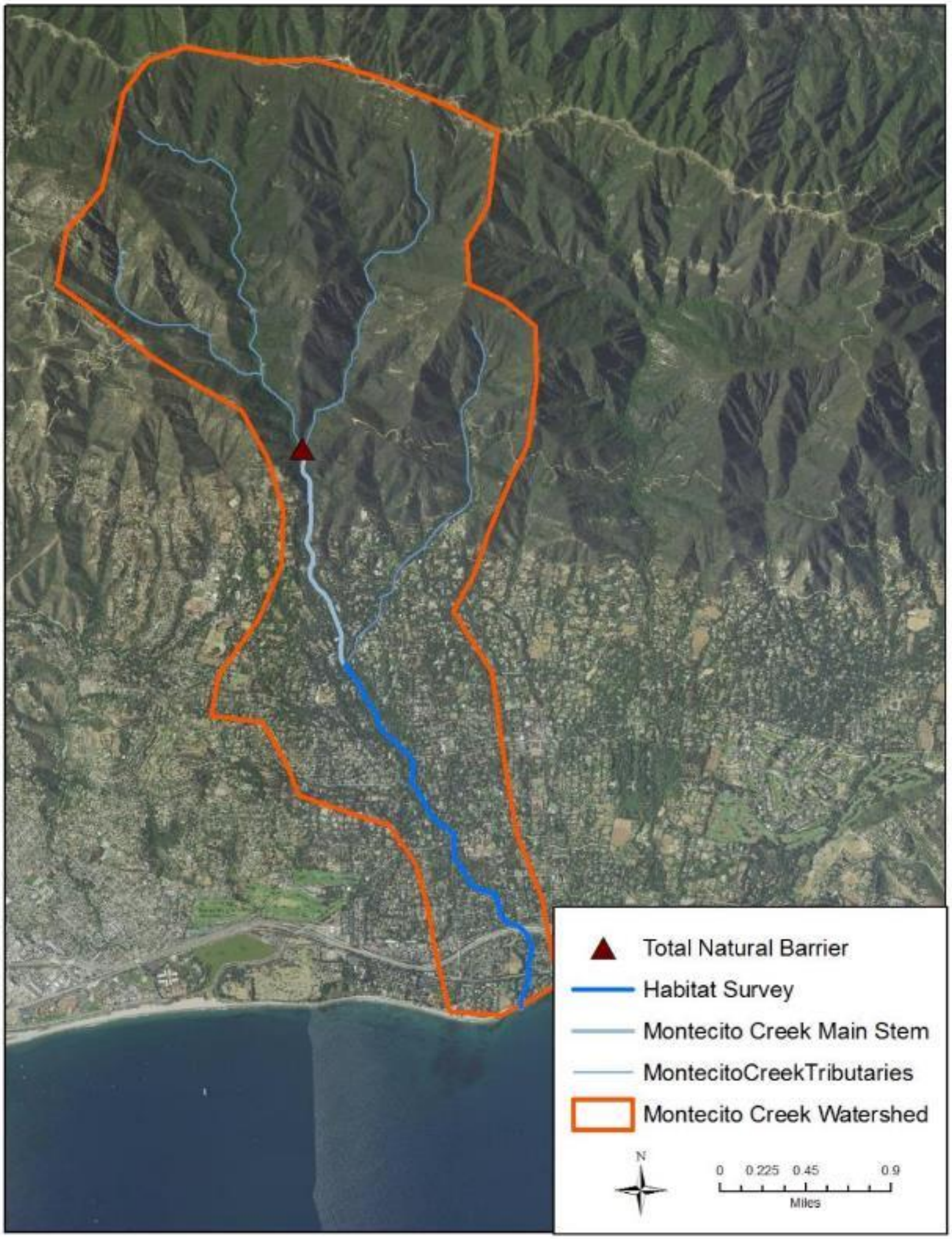
Results and Discussion

The habitat inventory was conducted on 23 September 2015 by Yi-Jiun Tsai and Marisa Morse from Pacific States Marine Fisheries Commission. The survey extended 11,240 feet upstream from the survey start (34.41774°N, -119.63407°W). The survey endpoint (34.44327°N, -119.65053°W) was the start of Hot Springs Creek, a tributary of Montecito Creek (Figure 77). Stream flow was not measured.

Montecito Creek was either completely dry or a (dry) culvert. Based on the frequency of units measured, 50.0% of Montecito was dry and 50.0% was culvert. Based on stream length, 9.6% was culvert and 90.4% was dry. It is likely that the current and severe drought, which is entering its fourth consecutive year, contributed to these dry conditions.

Figures

Figure 77. Map of the habitat assessment survey area in Montecito Creek.



Hot Springs Creek

Snorkel Survey (2015)

Results

On September 8, 2015, a snorkel survey was conducted on a stretch of Hot Springs Creek. No *O. mykiss* were observed in any of the 16 habitat units that were snorkeled. The total snorkeled length of snorkeled units was 168.5 feet. The surveyed stretch was 0.31 miles (1636.8 ft) beginning at 34.45454, -119.63975 and ending at 34.45967, -119.63915 (Figure 78). One individual *R. draytonii* was observed within the wetted reach, however no other notable species were found during the snorkel survey of Hot Springs Creek. Densities of fish counts per sum of habitat unit lengths (feet) and fish counts per sum of surface area (square foot) of habitat units are both 0.0 as no *O. mykiss* were observed.

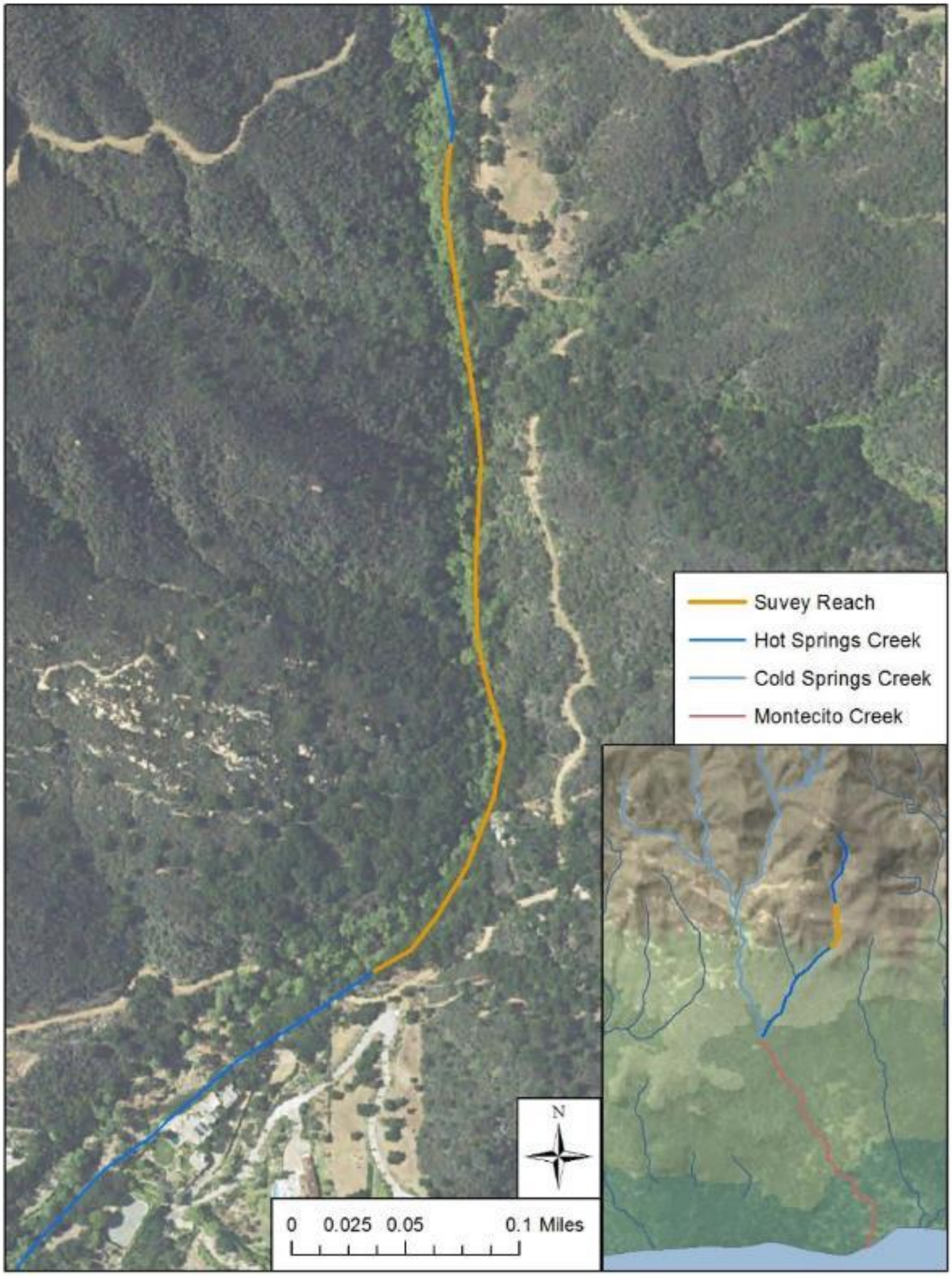
Discussion

On September 8, 2015, a snorkel survey was conducted on a 0.38 mile stretch of Hot Springs Creek from the first snorkelable pool above the confluence with Montecito Creek to the last observed snorkelable pool within the reach. The surveyed stretch is shown in Figure 78. The purpose of this snorkel survey was to gain an understanding of the abundance and distribution of Southern California Steelhead (*O. mykiss*) in Hot Springs Creek, located in the Conception Coast Biogeographic Population Group, in Santa Barbara County.

Overall, this snorkel summary report shows us a snapshot of current *O. mykiss* distribution in Hot Springs Creek. The surveyors did not record any observations of *O. mykiss* within Hot Springs Creek; however, we cannot definitively say that fish were not present. Additional survey seasons must be completed in order to make a comparison of our observations. Subsequent surveys should include electrofishing to we can make accurate population estimates as per Hankin & Reeves 1988.

<u>Figures</u>

Figure 78. Map of the surveyed reach for Hot Springs Creek in 2014.



Habitat Assessment

Results

The habitat inventory was conducted from 31 August to September 24, 2015 by Yi-Jiun Tsai, Phillip Hunter, Ben Lakish, Marisa Morse, Taylor Berryman, and Kyle Evans from Pacific States Marine Fisheries Commission. The survey extended 8,344 feet upstream from the survey start (34.44326°N, -119.65056°W; Figure 79). The survey endpoint (34.46115°N, -119.63941°W) was determined because further progress was obstructed by dense brush. Approximately 0.1 miles past the end point, a ~50 ft bedrock slide served as a total natural fish passage barrier. Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 63 to 70°F. Air temperature ranged from 66 to 78°F.

Habitat type

Of the total number of habitat units surveyed (n = 115 units), 13.0% of units were dry, 17.4% were flatwaters, 26.1% were pools, 40.0% were riffles, and 3.5% was culvert. Of the total length of the reach surveyed, 68.0% was dry, 4.2% was composed of flatwaters, 4.2% was composed of pools, 19.5% was composed of riffles, and 4.1% was composed of culverts (Figure 80).

We identified 10 habitat types in Hot Springs Creek (excluding culverts). Based on the frequency of units sampled, low gradient riffles (32.2%), mid-channel pools (22.6%), and runs (14.8%) were the most common habitat types (Table 15). Based on total stream length, dry sections (68.0%), low-gradient riffles (18.6%), and culverts (4.1%) composed the greatest stream lengths.

Pool Metrics

A total of 30 pools were identified within the survey reach. Main channel pools were most frequently encountered (93.3% of pool units sampled) and comprised 94.7% of the total length of all pools. Only main channel and scour pools were encountered; no backwater pools were recorded.

No pools had residual depths of three feet or greater (Figure 81).

Within pool tail-outs, gravel was the most frequently observed dominant substrate (50.0% of pool units), followed by boulders (13.3%), silt/clay (13.3%), and small cobble (13.3%; Figure 82).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of three (36.0%) or five (32.0%; Figure 83).

Shelter

Within 100% units (n = 28 units), riffle habitat types had a mean shelter rating of 22.1, flatwater habitat types had a mean shelter rating of 72.0, and pools had a mean shelter rating of 87.2

Of the pool units in which shelter was assessed (n = 9 units), main channel pools had a mean shelter rating of 79.4 and scour pools had a mean shelter rating of 150.0.

When we examined the mean percentage of shelter by shelter type across all units in which shelter was measured, we found that terrestrial vegetation provided the most shelter (22.7% of all shelter; Figure 84). When we examined the percentage of shelter by shelter type within pools only (n = 9 units), we found that boulders were the most dominant cover type (27.8% of the total cover), followed by small woody debris (18.3%; Figure 85).

Canopy Cover

Across units sampled for canopy cover, the mean percentage of canopy was 75.0%. Within the canopy cover present, 58.5% of the canopy was composed of deciduous trees and 38.8% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were sand/silt/clay (30.4%), bedrock (30.4%), boulder (28.3%), and cobble/gravel (10.9%; Figure 86). The mean percentage of vegetation covering the right bank in sampled units was 45.9%, and the mean percentage of vegetation covering the left bank was 42.0%. Brush was the dominant vegetation type, having been observed in 56.5% of banks surveyed. Additionally, 28.3% of the banks surveyed had hardwood trees and 15.2% had coniferous trees as the dominant vegetation (Figure 87).

Large Woody Debris

We observed six pieces of LWD that were 6 to 20 feet long and one piece that was greater than 20 feet long within 2327.2 feet of wetted stream length (excluding culvert and dry lengths). Across both LWD sizes, the number of LWD observed was 0.30 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 20.2 feet.

Discussion

Temperature

Water temperatures taken during the survey period ranged from 63 to 70°F. According to the Guide to the Reference Values Used in South Central/Southern California Coast Steelhead Conservation Action Planning (CAP) Workbooks (Keir and Associates and NFMS, 2008), these values are within the "Good" temperature range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

The dominant habitat types along the entire survey based on frequency were riffles and pools. These habitat units were mostly composed of low-gradient riffles and mid-channel pools. Taking a closer look at habitat types in terms of length revealed that dry sections and riffles accounted for the greatest length along the reach, with low-gradient riffles comprising the greatest wetted percentage.

Pool Metrics

Pool depth is an important indicator of habitat quality, as deeper pools can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). A residual depth of at least three feet is necessary to be considered good habitat (Kier Associates & NMFS 2008). When the habitat metrics for pools in Hot Springs Creek were analyzed, no pools encountered had residual depths greater than 2.99 feet. Our findings suggest that Hot Springs Creek lacks suitable depth to provide O. mykiss with good hiding cover and rearing space. This may be due in part to the current, severe drought, which has extended into its fourth consecutive year.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs were used as indicators of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was gravel, comprising 50.0% of pool units. Pool units most frequently had an embeddedness value of either a three or a five. These metrics suggest that Hot Springs Creek does not provide ideal depth or spawning habitat for *O. mykiss*.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that pools had the greatest mean shelter value, followed by flatwater habitats.

When examining pool habitat units specifically, we found that scour pools had the highest mean shelter rating, followed by main channel pools. While it may initially appear that scour pools provided the best salmonid habitat based on these shelter ratings, this may not actually be the case when considering that there were only two scour pool units.

When we examined the shelter by shelter type percentage, we found terrestrial vegetation provided the most shelter (22.7% of all shelter), followed by boulders and small woody debris. When we focused on shelter by shelter type within pools only, boulder was the most dominant cover type.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In Hot Springs Creek, we estimated a mean canopy cover of 75%, consisting predominantly of deciduous trees. Although Hot Springs Creek displayed a moderately high amount of cover, the deciduous tree canopy is due to vary seasonally. However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was equally silt/sand/clay and bedrock, followed by boulder. The mean percentage of vegetation covering the right and left banks was 45.9% and 42.0%, respectively. Brush and hardwood trees were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively protected from erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In Hot Springs Creek we found 0.3 pieces of LWD per 100 feet, which was extremely low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Hot Springs Creek lacks LWD, it may have boulder elements that improve habitat quality.

Tables

Table 15. Percentage of all units (n = 115 units) by habitat type in Hot Springs Creek.

Habitat Type	% of units
Low Gradient Riffle	32.17%
Mid Channel Pool	22.61%
Run	14.78%
Dry	13.04%
Bedrock Sheet	6.96%
Culvert	3.48%
Step Run	2.61%
Plunge Pool	1.74%
Cascade	0.87%
Trench Pool	0.87%
Step Pool	0.87%

Figures

Figure 79. Map of the habitat assessment survey area in Hot Springs Creek.

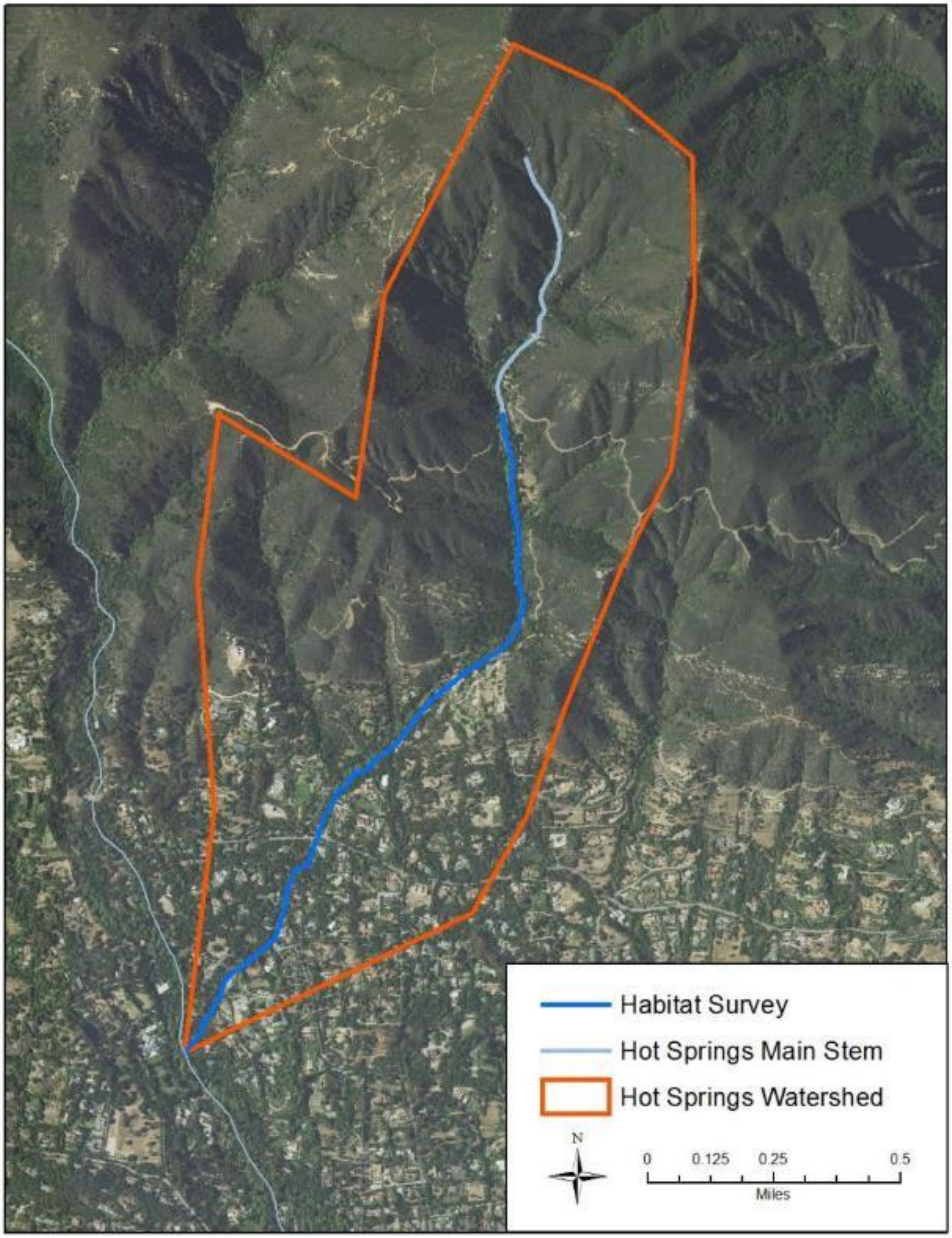


Figure 80. Percentage of total stream length categorized as pools, flatwaters, riffles, dry, or culverts for Hot Springs Creek.

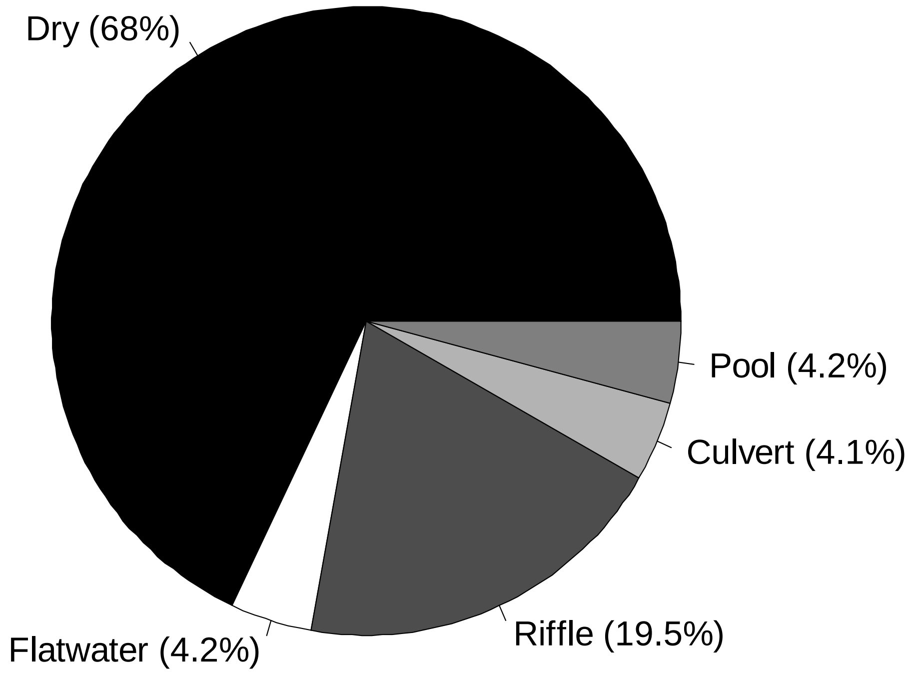


Figure 81. Histogram of residual pool depths in one-foot bins for Hot Springs Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

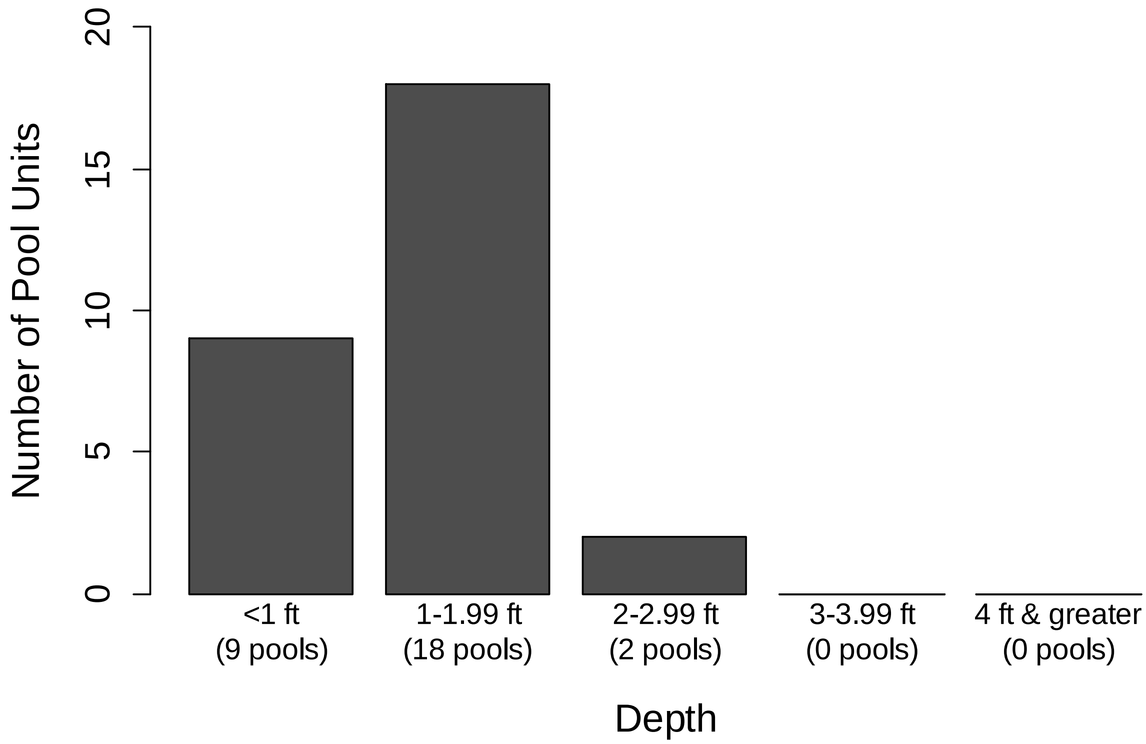


Figure 82. Percentage of pool tail-outs (n = 30 pools) by dominant substrate for Hot Springs Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

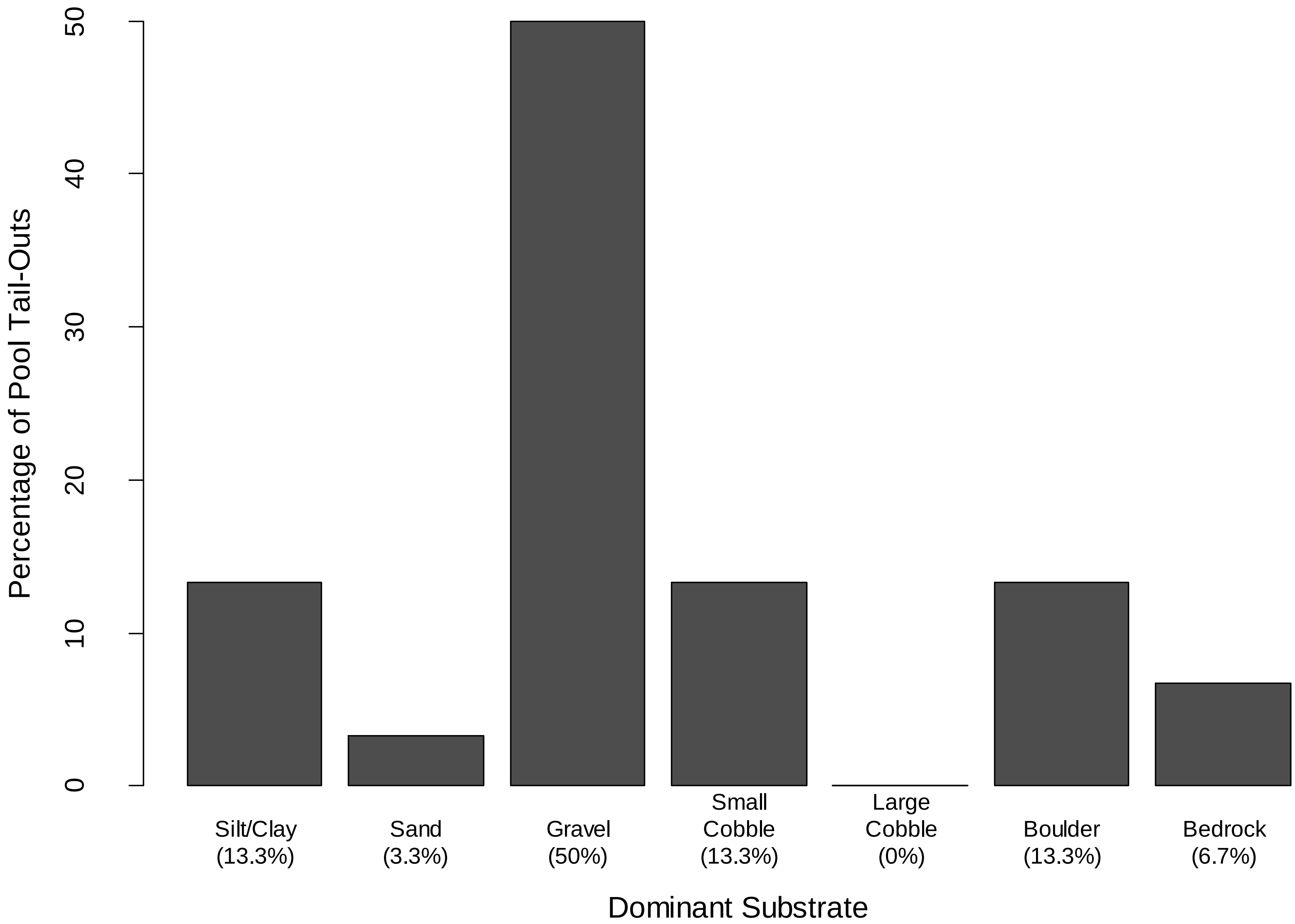


Figure 83. Percentage of all pool units (n = 30 pools) assigned a pool tail-out embeddedness value of 1 to 5 in Hot Springs Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning. In this survey, no pools were assigned an embeddedness value of 1.

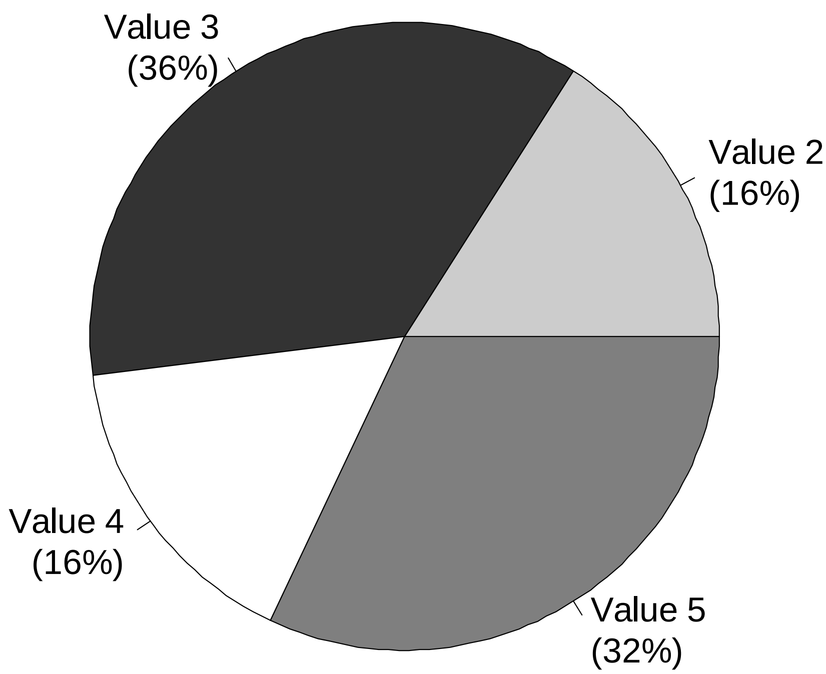


Figure 84. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 28 units) for Hot Springs Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

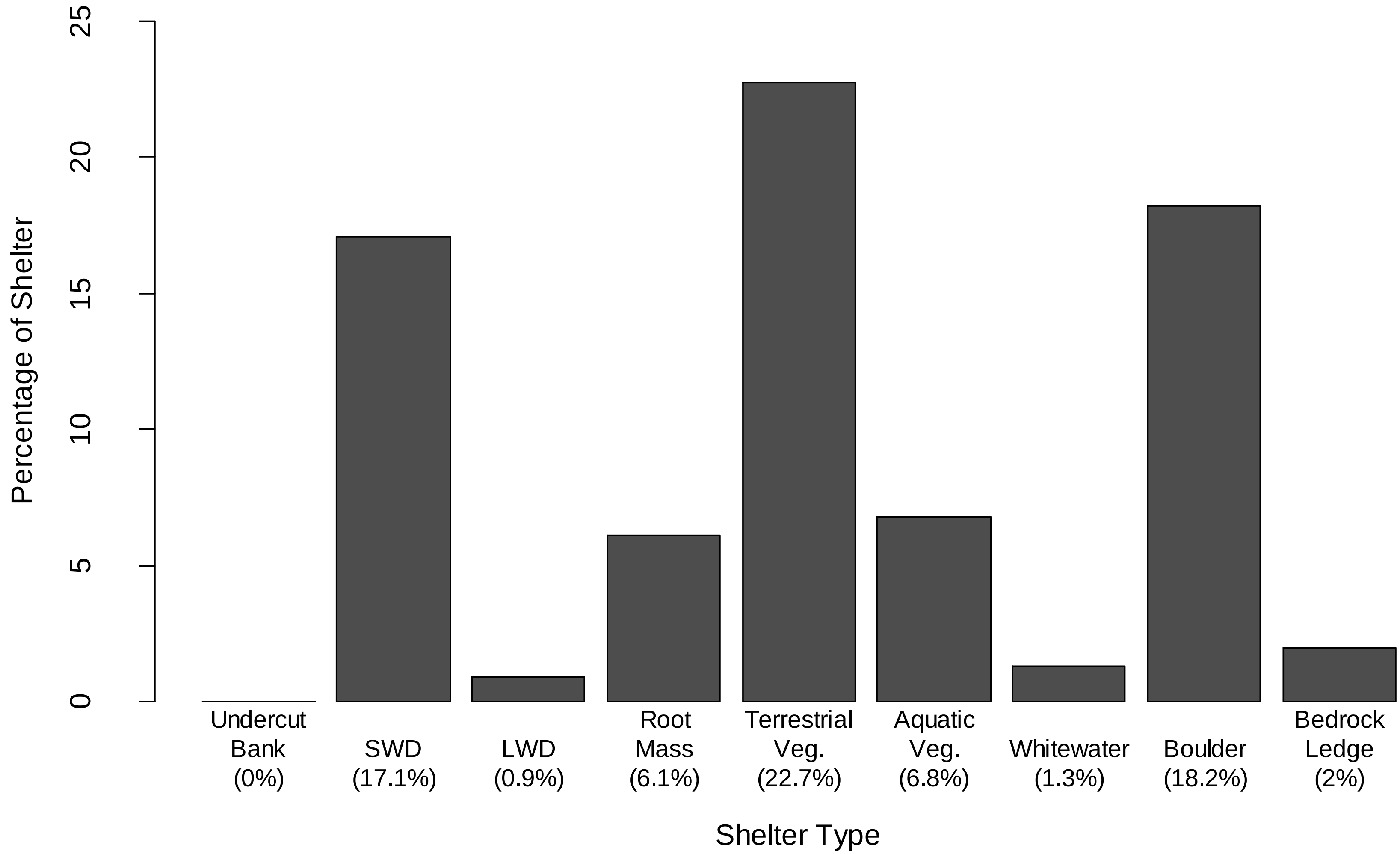


Figure 85. The percentage of instream shelter by shelter type across all pool units in which shelter was measured (n = 9 pools) for Hot Springs Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

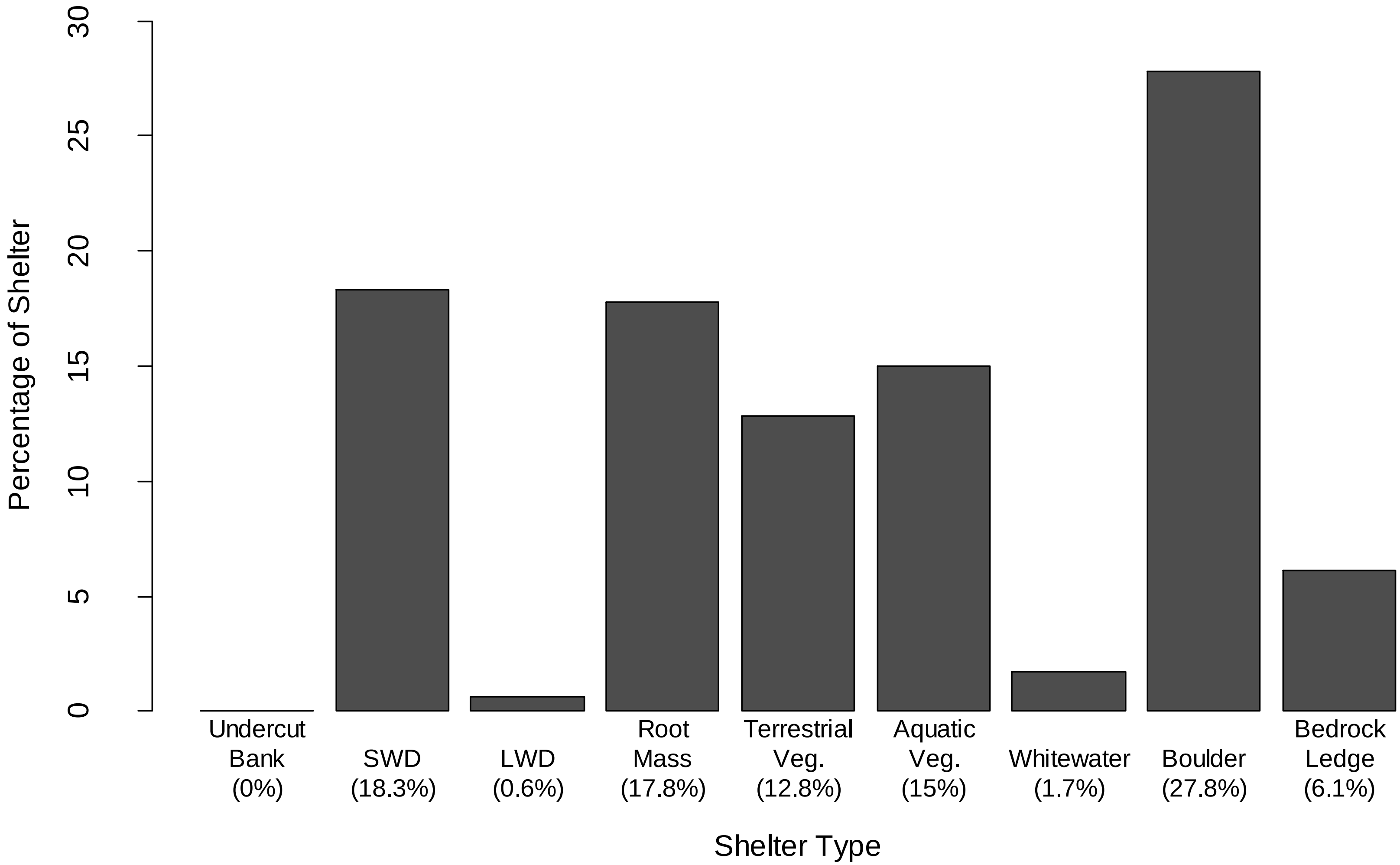


Figure 86. Percentage of banks by dominant substrate composition in Hot Springs Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock.

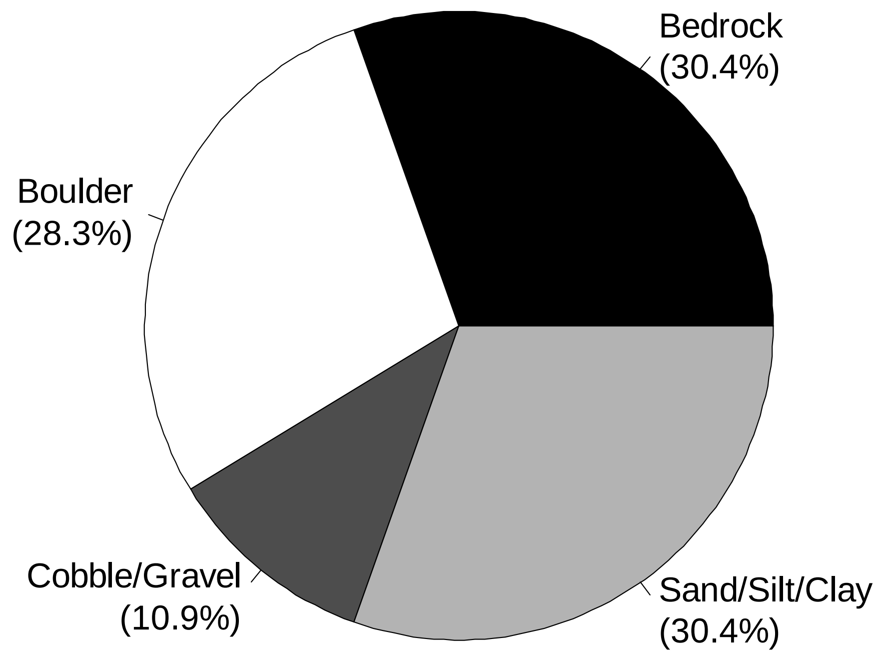
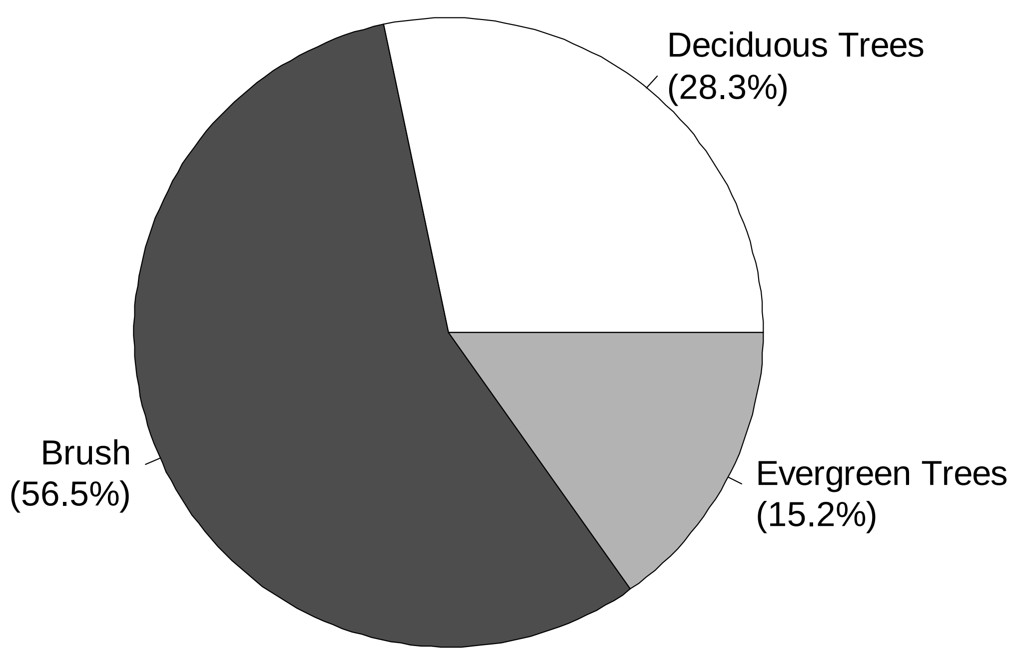


Figure 87. Percentage of banks by dominant vegetation type for Hot Springs Creek. Vegetation types included deciduous trees, evergreen trees, grass, brush, and no vegetation. In this survey, grass was not recorded as a dominant bankside vegetation type.



Cold Springs Creek

Habitat Assessment

Results

The habitat inventory was conducted from 9–23 September 2015 by Marisa Morse, Kyle Evans, Yi-Jiun Tsai, and Phillip Hunter from Pacific States Marine Fisheries Commission. The survey extended 6,861 feet upstream from the survey start (34.44327°N, -119.65053°W). The survey endpoint (34.45865°N, -119.65439°W) was the confluence of Cold Springs main stem and West Fork Cold Springs (Figure 88). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 67 to 72°F. Air temperature ranged from 69 to 84°F.

Habitat type

Of the total number of habitat units surveyed (n = 32 units), 43.8% of units were dry, 6.3% were flatwaters, 43.8% were pools, and 6.3% were riffles. Of the total length of the reach surveyed, 96.1% was dry, 0.8% was composed of flatwaters, 2.2% was composed of pools, and 0.8% was composed of riffles (Figure 89).

We identified six habitat types in Cold Springs Creek. Based on the frequency of units sampled, dry (43.8%) and mid channel pools (34.4%) were the most common habitat types (Table 16). Based on total stream length, dry (96.1%) and mid channel pools (1.7%) composed the greatest stream lengths.

Pool Metrics

A total of 14 pools were identified within the survey reach. Main channel pools were most frequently encountered (85.7% of pool units sampled) and comprised 87.2% of the total length of all pools. Only main channel and scour pools were encountered; no backwater pools were recorded.

No pools had residual depths of two feet or greater (Figure 90).

Within pool tail-outs, silt/clay was the most frequently observed dominant substrate (35.7% of pool units), followed by boulder (28.6%) and bedrock (14.3%;Figure 91).

When we examined pool tail-outs for substrate embeddedness, we found that pools had embeddedness values of either five (87.5%) or four (12.5%).

Shelter

Within 100% units (n = 9 units), riffle habitat types had a mean shelter rating of 47.5, flatwater habitat types had a mean shelter rating of 80.0, and pools had a mean shelter rating of 71.7.

Of the pool units in which shelter was assessed (n = 6 units*)*, main channel pools had a mean shelter rating of 85.0 and scour pools had a mean shelter rating of 5.0.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that boulders provided the most shelter (32.8% of all shelter), followed by small woody debris (28.9%;Figure 92). When we examined the percentage of shelter by shelter type within pools only, we found that small woody debris was the most dominant cover type (34.2% of the total cover), followed by boulder (23.3%; Figure 93).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 80.0%. Within the canopy cover present, 66.9% of the canopy was composed of deciduous trees and 33.1% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were bedrock (38.9%), boulder (27.8%), and silt/sand/clay (33.3%; Figure 94). The mean percentage of vegetation covering the right bank in sampled units was 63.9%, and the mean percentage of vegetation covering the left bank was 70.6%. Evergreen trees were the dominant vegetation type, having been observed in 44.4% of the banks surveyed (Figure 95).

Large Woody Debris

We observed two pieces of LWD that were 6 to 20 feet long within 266.2 feet of wetted stream length. The number of LWD observed was 0.75 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 46.0 feet.

Discussion

Temperature

The water temperature of units measured ranged from 67 to 72°F. According to the Guide to the Reference Values Used in South-Central/Southern California Coast Steelhead Conservation Action Planning Workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When we examined Cold Springs Creek in terms of stream length and unit frequency, we found that the stream was predominantly dry. This is likely due in part to the current, severe drought, which is entering its fourth consecutive year.

Pool Metrics

Pool depth is an important indicator of habitat quality, as deeper pools can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). A residual depth of at least 3 feet is needed to be considered good salmonid habitat (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in Cold Springs, we found that no pools had residual depths greater than 1.99 feet. Thus, pools in Cold Springs lack the depth needed to provide good hiding cover and rearing space. This is unsurprising, given that most of the pools were isolated on an otherwise dry creek.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was silt/clay, comprising 35.7% of pool units. Pool units had an embeddedness value of either a five or a four. Together, these metrics suggest that pools in Cold Springs are mostly silty, and therefore do not provide good spawning habitat for *O. mykiss*.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that flatwaters had the highest mean shelter rating and riffles had the lowest. However, the low sample size of units measured for shelter (one flatwater, two riffle, and six pool units) precluded comparisons between habitat types.

When we examined the percentage shelter by shelter type, we found the boulders and small woody debris provided the most shelter, suggesting that boulders and deciduous trees are common features in Cold Springs Creek.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In Cold Springs, we estimated a mean canopy cover of 80.0%, consisting mostly of deciduous trees. This suggests that Cold Springs has a high amount of cover (Kier Associates & NMFS 2008), but this cover may vary greatly through time, given the seasonality of deciduous trees. However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was bedrock, followed by silt/sand/clay. The mean percentage of vegetation cover for the right and left banks was 63.9% and 70.6%, respectively. Evergreen and deciduous trees were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively protected from erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In Cold Springs Creek, we found 0.75 pieces of LWD per 100 feet, which was low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Cold Springs Creek lacks LWD, it may have boulder elements that improve habitat quality.

Tables

Table 16. Percentage of all units (n = 32 units) by habitat type for Cold Springs Creek.

Habitat Type	% of units
Dry	43.75%
Mid Channel Pool	34.38%
Low Gradient Riffle	6.25%
Step Run	6.25%
Dammed Pool	6.25%
Step Pool	3.13%

Figures

Figure 88. Map of the habitat assessment survey area in Cold Springs Creek.

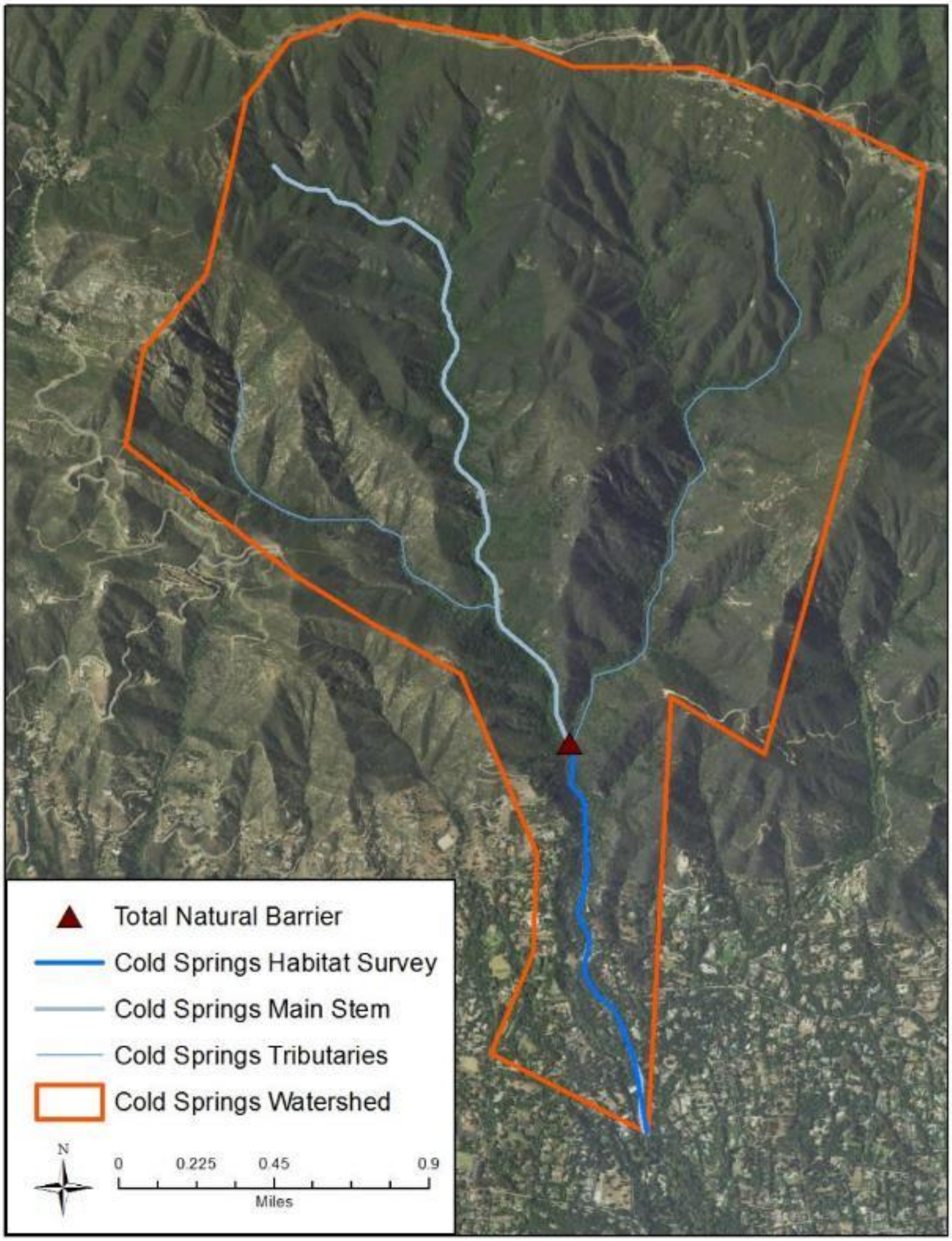


Figure 89. Percentage of total stream length categorized as pools, flatwaters, riffles, or dry for Cold Springs Creek.

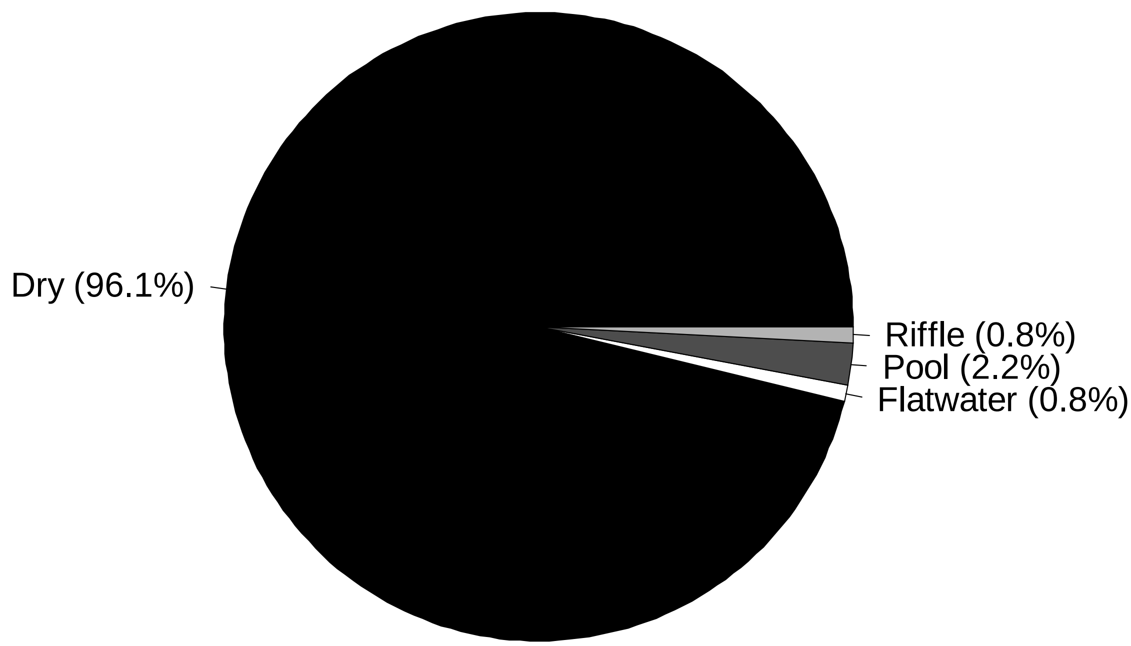


Figure 90. Histogram of residual pool depths in one-foot bins for Cold Springs Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

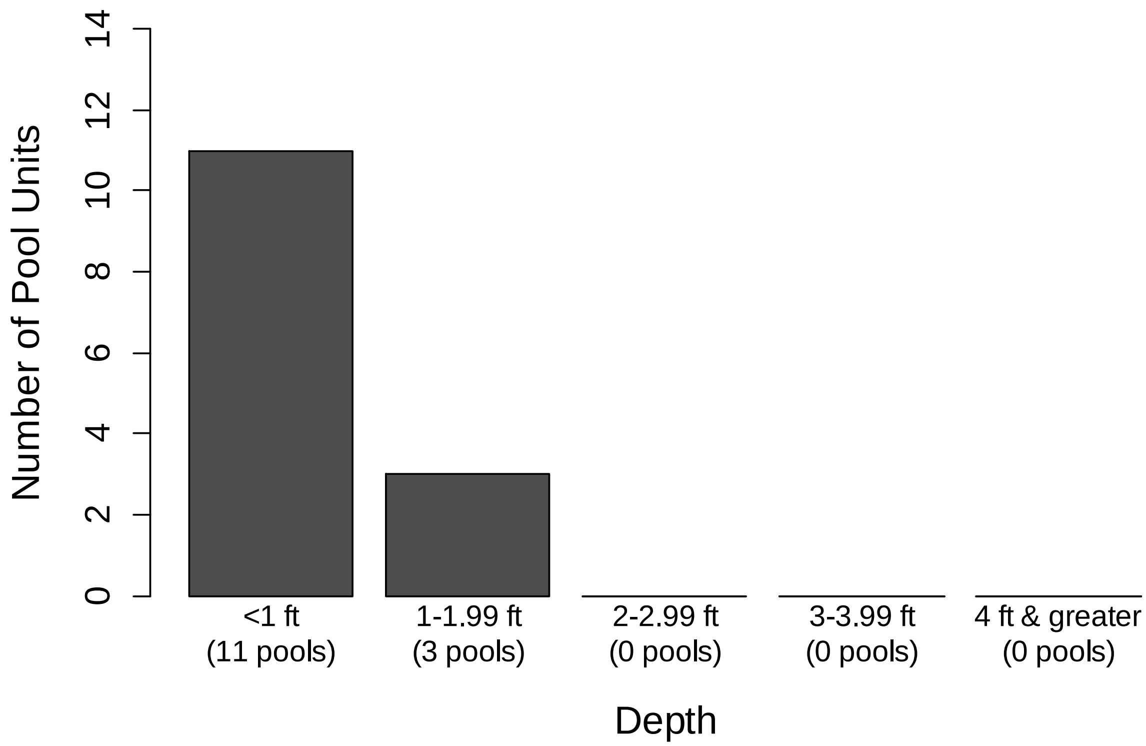


Figure 91. Percentage of pool tail-outs (n = 14 pools) by dominant substrate for Cold Springs Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

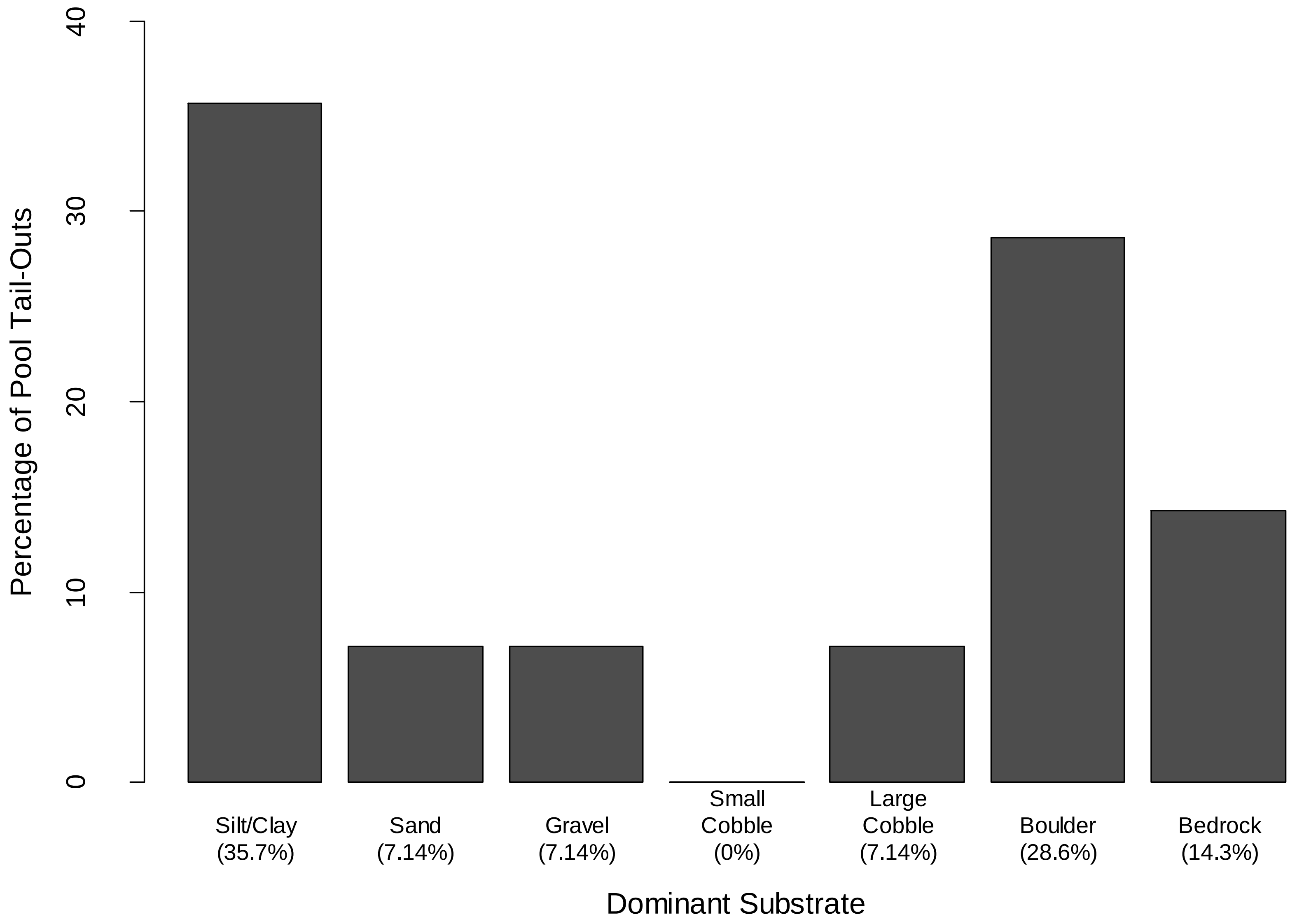


Figure 92. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 9 units) for Cold Springs Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

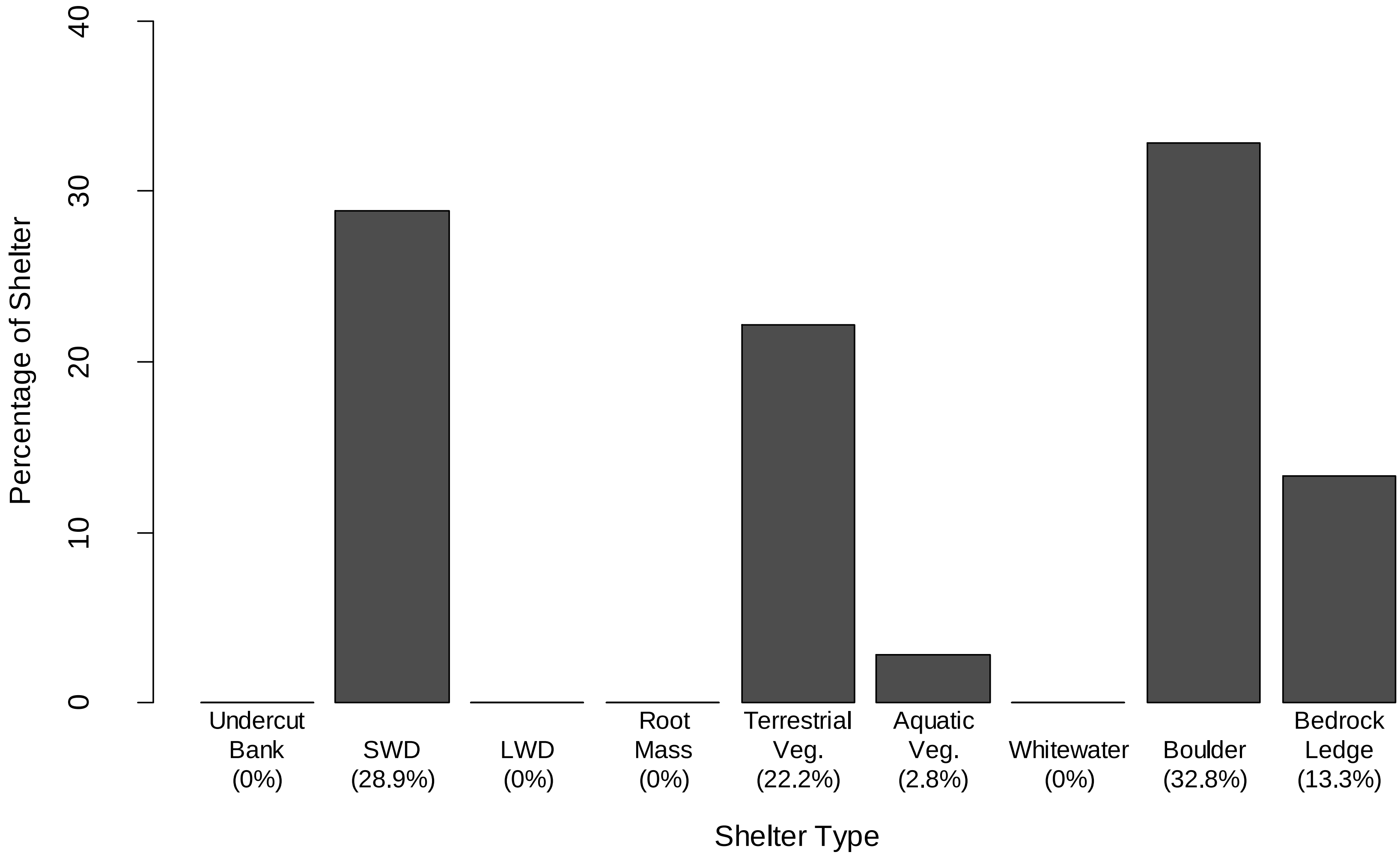


Figure 93. The percentage of shelter by shelter type across all pool units in which shelter was measured (n = 6 pools) for Cold Springs Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

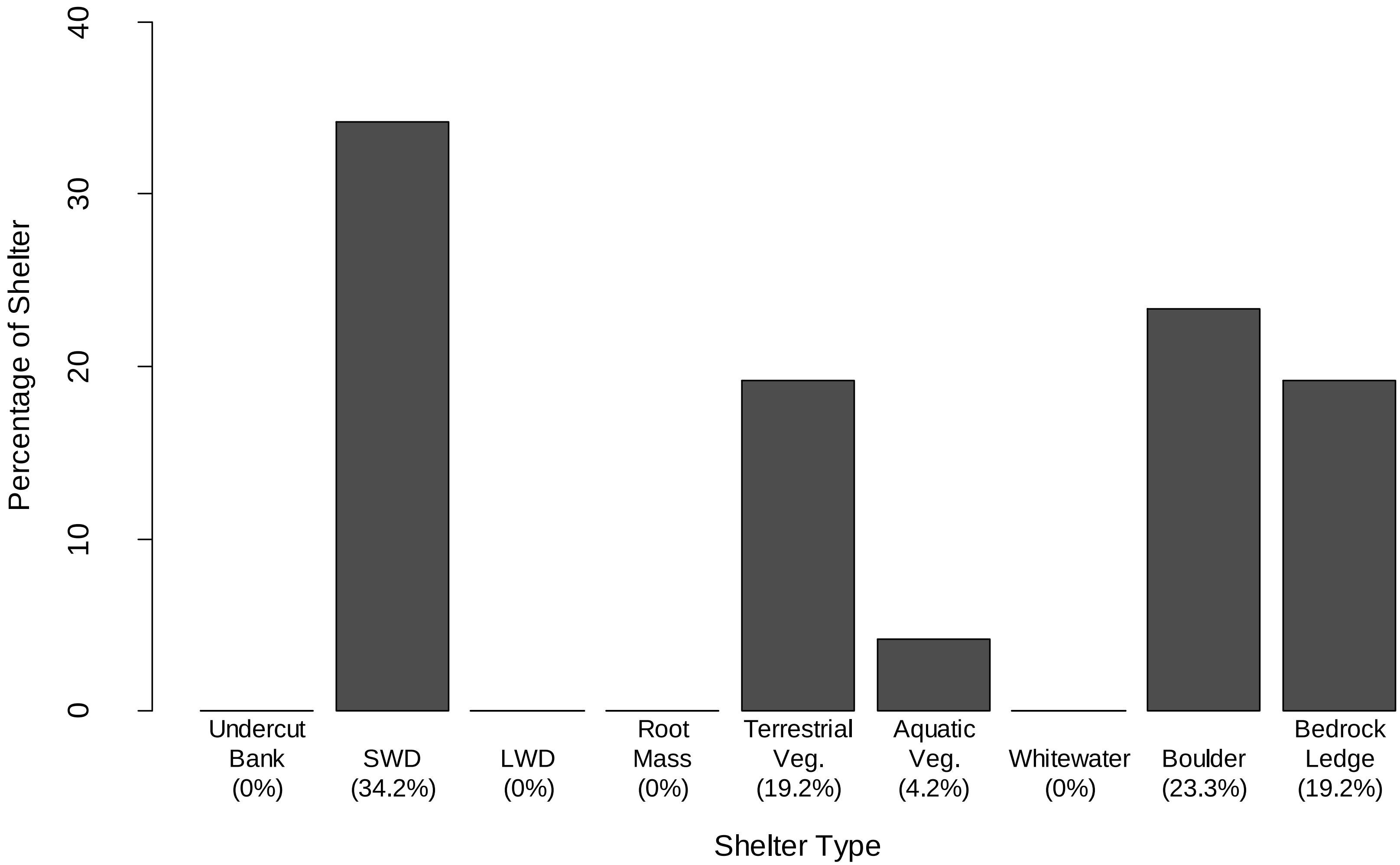


Figure 94. Percentage of banks by dominant substrate composition for Cold Springs Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock. No cobble/gravel was recorded as

the dominant bankside substrate during this survey.

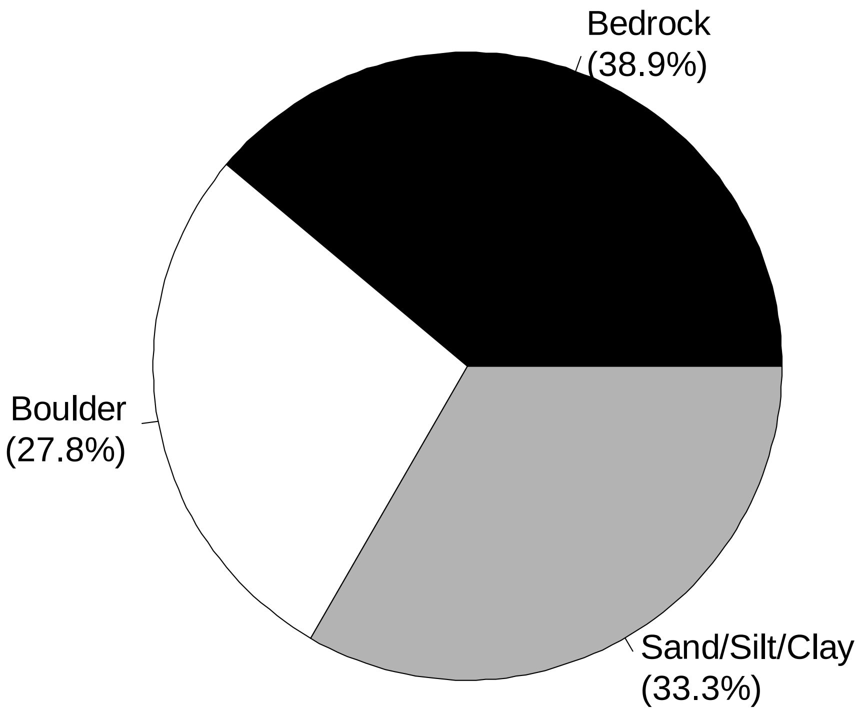
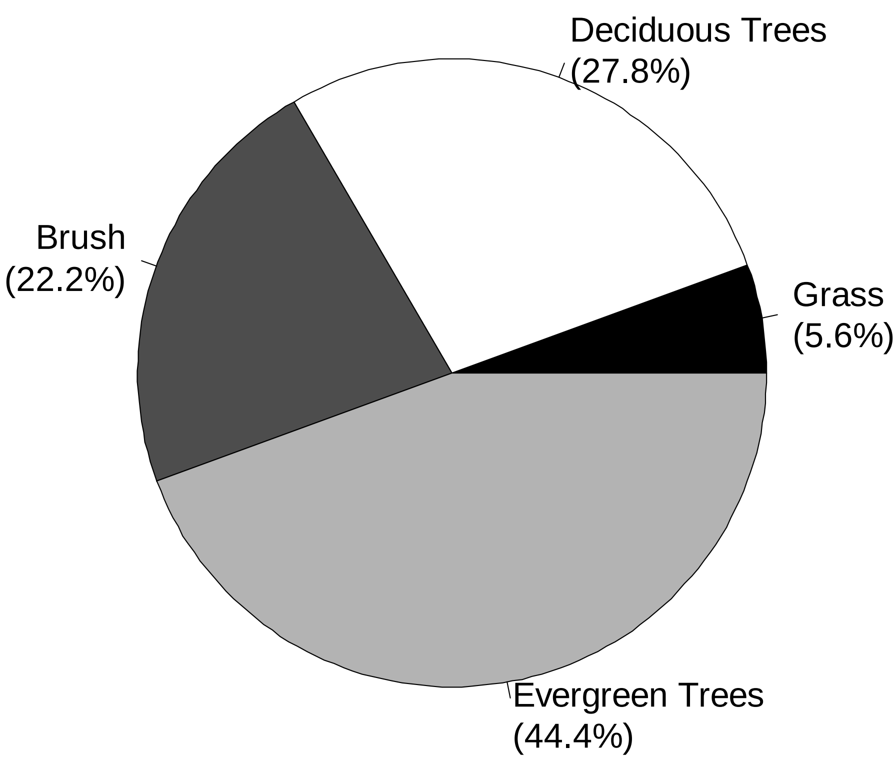


Figure 95. Percentage of banks by dominant vegetation type for Cold Springs Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



East Fork Cold Springs Creek

Snorkel Survey (2015)

Results

The snorkel survey for East Fork was conducted between June 17, 2015 and September 24, 2015. The survey began at the confluence of East and West Fork Cold Springs (34.45973°N, -119.65410°W) and extended approximately 4,377 feet upstream. The endpoint of the survey (34.46978°N, -119.64860°W) was the start of a prolonged dry stretch (Figure 96).

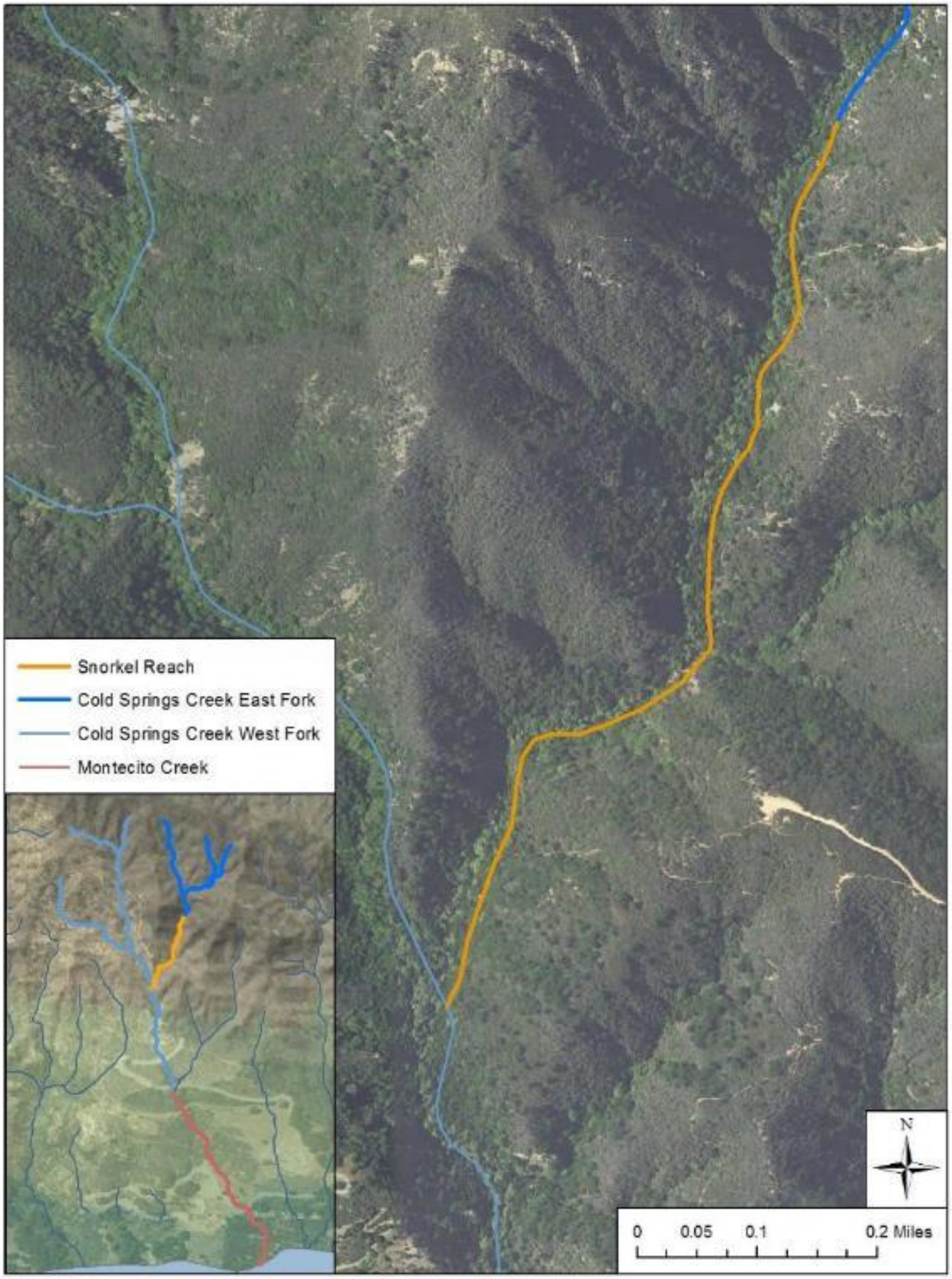
For East Fork Cold Springs, we snorkeled 25 units. Snorkeled units had a mean visibility of 2.24 (range=1–3) and a mean shelter rating of 2.04 (range = 1–3). No *O. mykiss* were observed.

Discussion

No *O. mykiss* were observed in East Fork Fork Cold Springs. This was perhaps unsurprising given the current water conditions, in which a severe drought in its fourth consecutive year has contributed to dewatering in a substantial portion of the Montecito watershed. These drought conditions, exacerbated by heavy urbanization and channelization of the stream bed (NMFS 2012), have left very little available and viable habitat for *O. mykiss*. However, steelhead have historically occupied the Montecito Creek watershed (Boughton et al. 2006) and it is hopeful that they could reoccupy this watershed should conditions improve.

Figures

Figure 96. Map of the snorkeled reach in East Fork Cold Springs in 2015.



Habitat Assessment

Results

The habitat inventory was conducted from 10 September to 21 September 2015 by Marisa Morse, Terra Dressler, Yi-Jiun Tsai, and Taylor Berryman from Pacific States Marine Fisheries Commission. The survey extended 4970 feet upstream from the survey start (34.45908°N, -119.65411°W). The survey endpoint (34.47001°N, -119.64848°W) was the beginning of a steep, rocky gradient that occurred after a prolonged dry section (Figure 97). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 60 to 70°F. Air temperature ranged from 60 to 83°F.

Habitat type

Of the total number of habitat units surveyed (n = 125 units), 11.2% of units were dry, 8.0% were flatwaters, 40.8% were pools, 35.2% were riffles, and 4.8% were not surveyable. Of the total length of the reach surveyed, 61.8% was dry, 2.8% was composed of flatwaters, 16.8% was composed of pools, 14.9% was composed of riffles, and 3.8% was not surveyable (Figure 98).

We identified nine habitat types in East Fork Cold Springs Creek. Based on the frequency of units sampled, mid-channel pools (33.6%) and low gradient riffles (20.8%) were the most common habitat types (Table 17). Based on total stream length, dry (61.8%), mid-channel pools (11.5%), and low-gradient riffles (10.1%) composed the greatest stream lengths.

Pool Metrics

A total of 51 pools were identified within the survey reach. Main channel pools were most frequently encountered (96.1% of pool units sampled) and comprised 96.3% of the total length of all pools. Only main channel and scour pools were encountered; no backwater pools were recorded.

Three of 49 pools (6%) had residual depths of three feet or greater (Figure 99).

Within pool tail-outs, boulder was the most frequently observed dominant substrate (32.7% of pool units), followed by silt/clay (30.6%) and bedrock (24.5%; Figure 100).

When we examined pool tail-outs for substrate embeddedness, we found that 100.0% of pools had an embeddedness value of five.

Shelter

Within 100% units (n = 32 units), riffle habitat types had a mean shelter rating of 63.6, flatwater habitat types had a mean shelter rating of 110.0, and pools had a mean shelter rating of 74.1.

Of the pool units in which shelter was assessed (n = 17 units*)*, main channel pools had a mean shelter rating of 76.7, and scour pools had a mean shelter rating of 55.0.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that small woody debris provided the most shelter (37.7% of all shelter; Figure 101). When we examined the percentage of shelter by shelter type within pools only, we found that small woody debris provided the most shelter (39.4% of the total cover; Figure 102).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 86.2%. Within the canopy cover present, 83.5% of the canopy was composed of deciduous trees and 16.5% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were bedrock (43.5%), boulder (40.3%), sand/silt/clay (11.3%), and cobble/gravel (4.8%; Figure 103). The mean percentage of vegetation covering the right bank in sampled units was 55.2%, and the mean percentage of vegetation covering the left bank was 48.9%. Deciduous trees were the dominant vegetation type, having been observed in 48.4% of the banks surveyed (Figure 104).

Large Woody Debris

We observed four pieces of LWD that were 6 to 20 feet long and five pieces that were greater than 20 feet long within 1711 feet of wetted stream length (excluding dry and unsurveyable lengths). Across both LWD sizes, the number of LWD observed was 0.53 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 32.9 feet.

Discussion

Temperature

The water temperature of units measured ranged from 60 to 70°F. According to the Guide to the Reference Values Used in South-Central/Southern California Coast Steelhead Conservation Action Planning Workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Good to Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools or riffles. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools or low-gradient riffles. When we examined the reach in terms of length, we found that most of the reach was dry or pools, with mid-channel pools and low gradient riffles comprising the greatest percentages of wetted stream length.

Pool Metrics

Pool depth is an important indicator of habitat quality, as deeper pools can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in East Fork Cold Springs, we found that most pools had residual depths less than 2 feet deep. However, a residual depth of at least 3 feet is needed to be considered good habitat (Kier Associates & NMFS 2008). Thus, it appears that pools in East Fork Cold Springs may lack the depth needed to provide good hiding cover and rearing space. This may be due in part to the current, severe drought, which has extended into its fourth consecutive year.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was boulder and silt/clay. All pool tail-outs had a substrate embeddedness value of five. Together, these metrics suggest that there are no pool tail-outs in East Fork Cold Springs that provide good spawning habitat for *O. mykiss* under the current water flow conditions.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of riffle, flatwater, and pool units, we found that flatwaters had the highest mean shelter rating, while riffles had the lowest.

When examining pool habitat units specifically, we found that main channel pools had a higher mean shelter rating than scour pools. However, only two scour pools were measured for shelter, compared to 15 main channel pools. Thus, these shelter ratings may not be comparable, given the large difference between sample sizes.

When we examined the percentage shelter by shelter type, we found that small woody debris provided the most shelter, both across all 100% units (37.7% of all shelter) and within 100% pool units only (39.4%).

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In East Fork Cold Springs, we estimated a mean canopy cover of 86.2%, consisting predominantly of deciduous trees. This suggests that East Fork Cold Springs has a high amount of cover (Kier Associates & NMFS 2008), but this cover is likely to vary greatly through time, given the seasonality of deciduous trees. However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008). The high occurrence of deciduous trees in East Fork Cold Springs may also help explain the high percentage of instream shelter provided by small woody debris.

Bankside Metrics

The predominant substrate composing stream banksides was boulder, followed by bedrock. The mean percentage of vegetation cover for the right and left banks was 55.2% and 48.9%, respectively. Deciduous trees were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively protected from erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In East Fork Cold Springs, we found 0.53 pieces of LWD per 100 feet, which was low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while East Fork Cold Springs Creek lacks LWD, it may have boulder elements that improve habitat quality.

Tables

Table 17. Percentage of all units (n = 125 units) by habitat type for East Fork Cold Springs Creek.

Habitat Type	% of units
Mid Channel Pool	33.60%
Low Gradient Riffle	20.80%
Bedrock Sheet	11.20%
Dry	11.20%
Run	6.40%
Step Pool	5.60%
Not Surveyable	4.80%
Cascade	3.20%
Step Run	1.60%
Plunge Pool	1.60%

Figures

Figure 97. Map of the habitat assessment survey area in East Fork Cold Springs Creek.

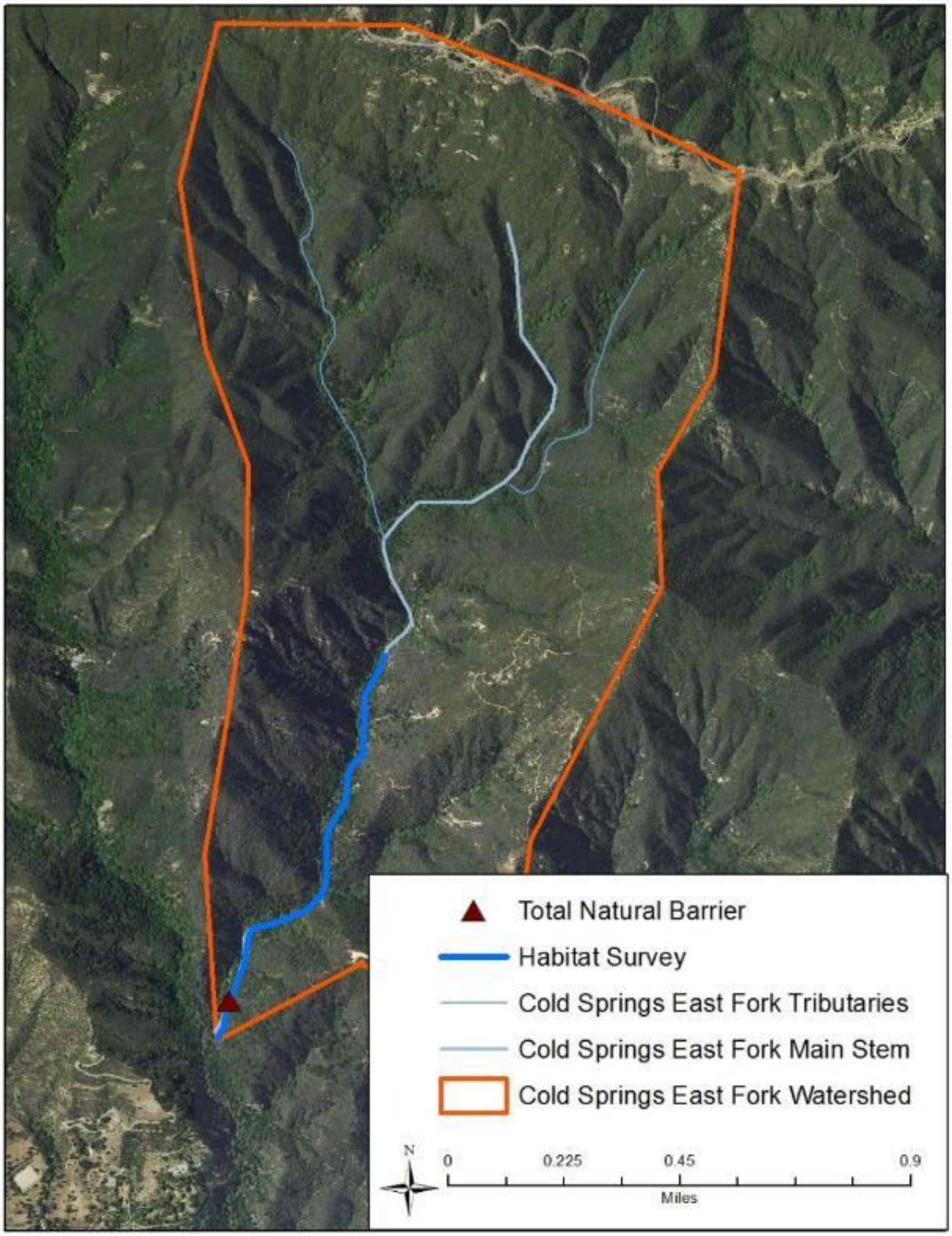


Figure 98. Percentage of total stream length categorized as pools, flatwaters, riffles, dry, or not surveyable for East Fork Cold Springs Creek.

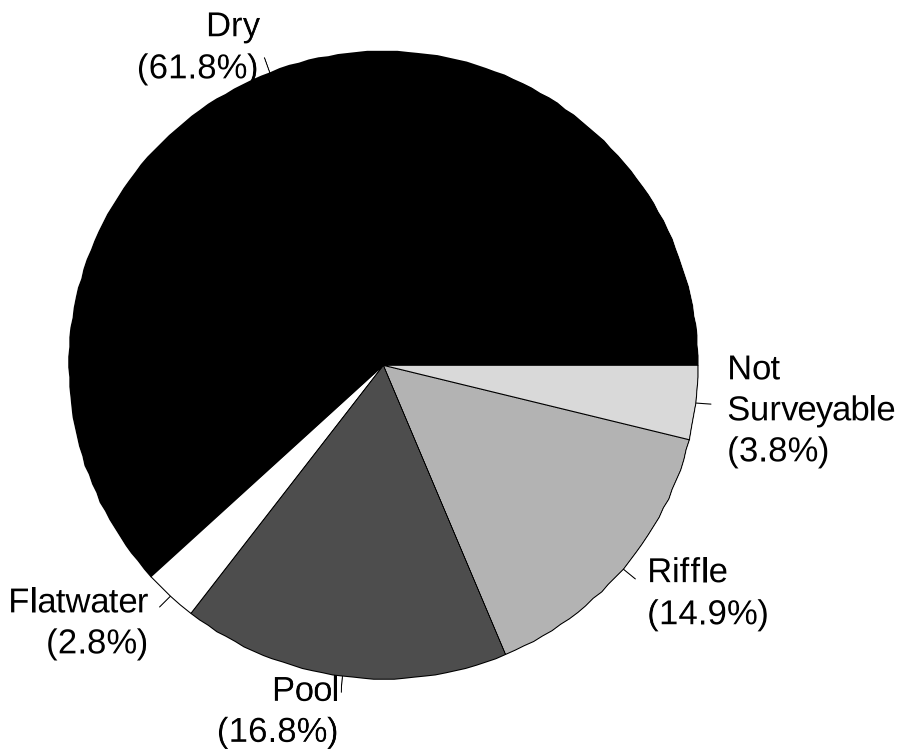


Figure 99. Histogram of residual pool depths in one-foot bins for East Fork Cold Springs Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth for East Fork Cold Springs Creek.

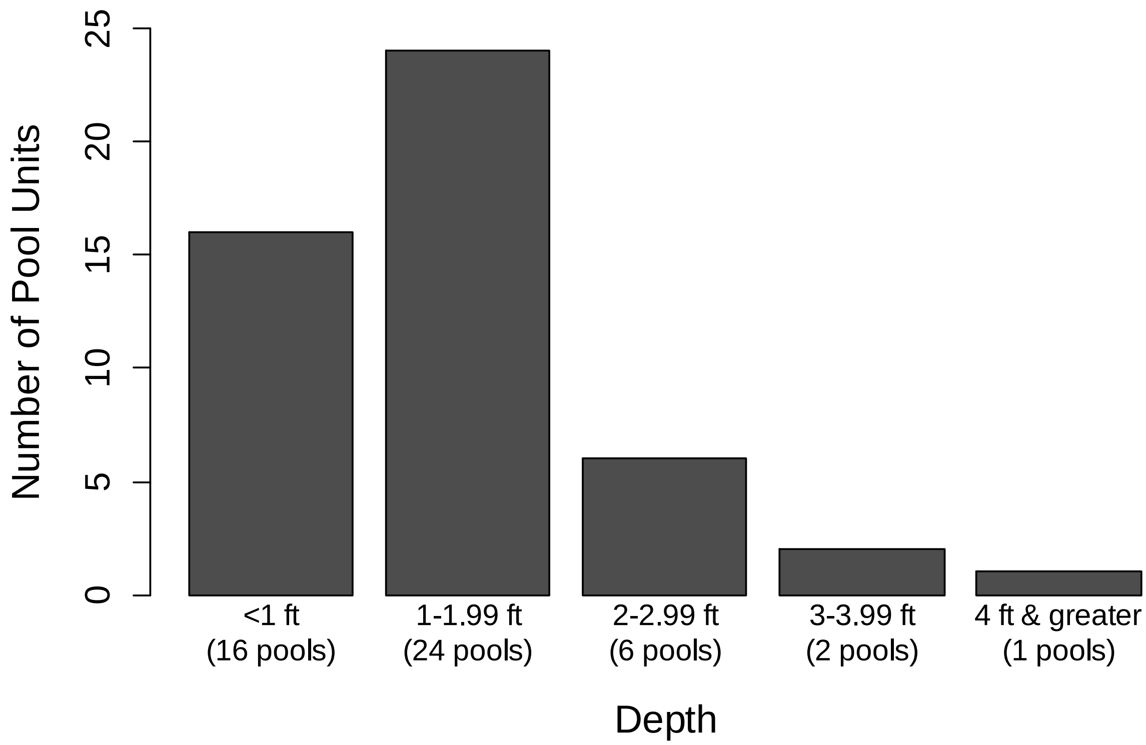


Figure 100. Percentage of pool tail-outs (n = 51 pools) by dominant substrate for East Fork Cold Springs Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

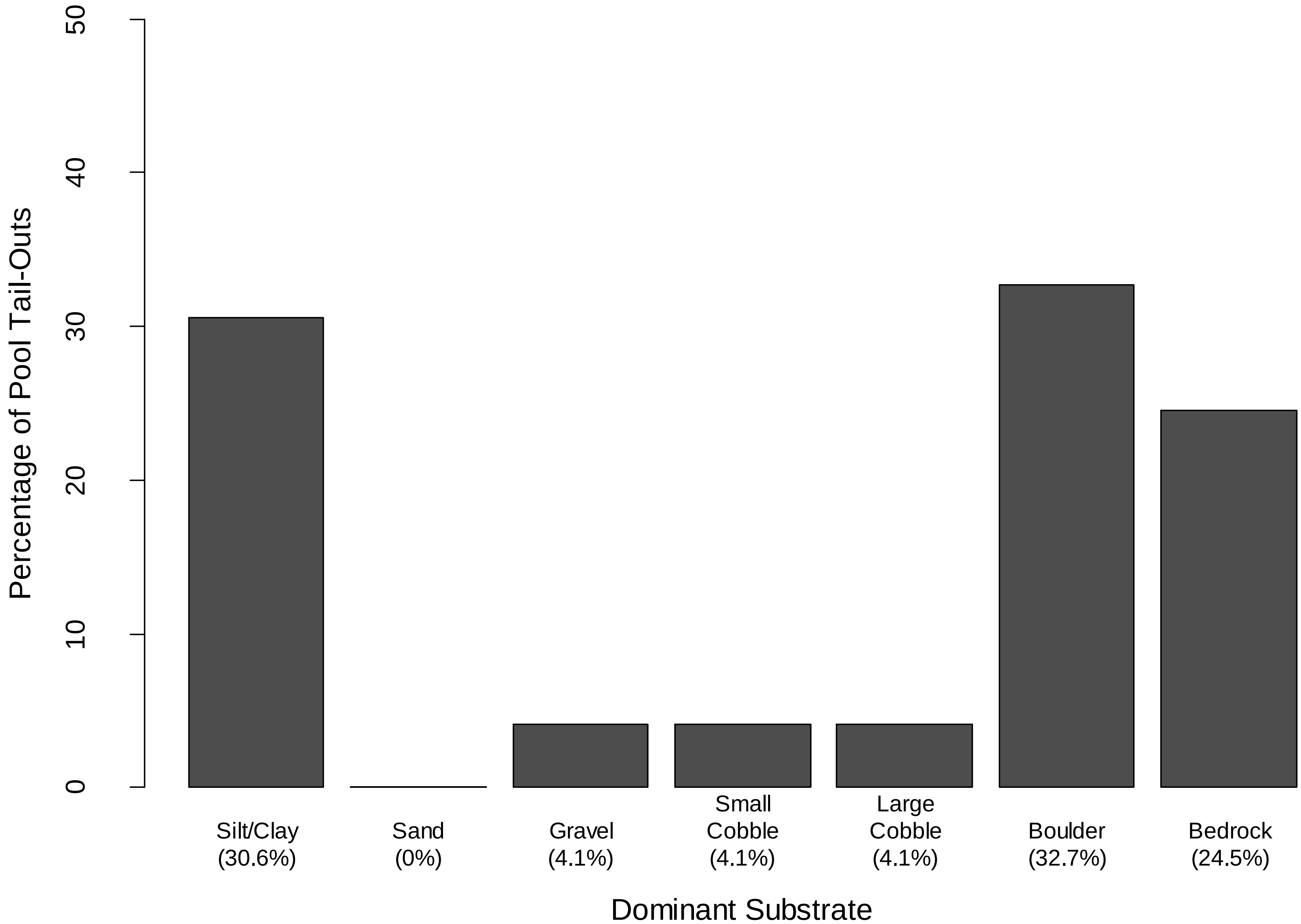


Figure 101. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 32 units) for East Fork Cold Springs Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

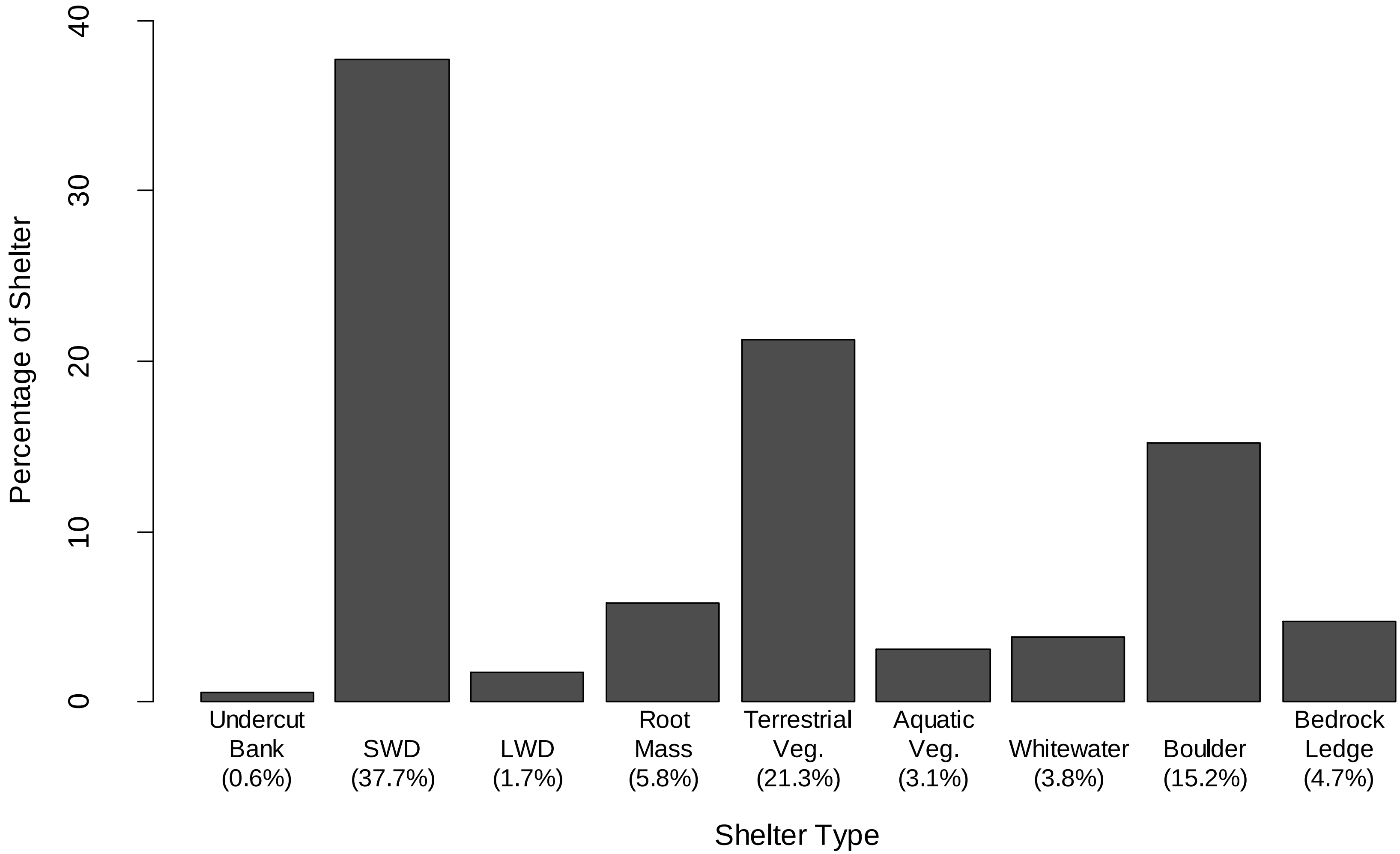


Figure 102. The percentage of instream shelter by shelter type across all pool units in which shelter was measured (n = 17 pools) for East Fork Cold Springs Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

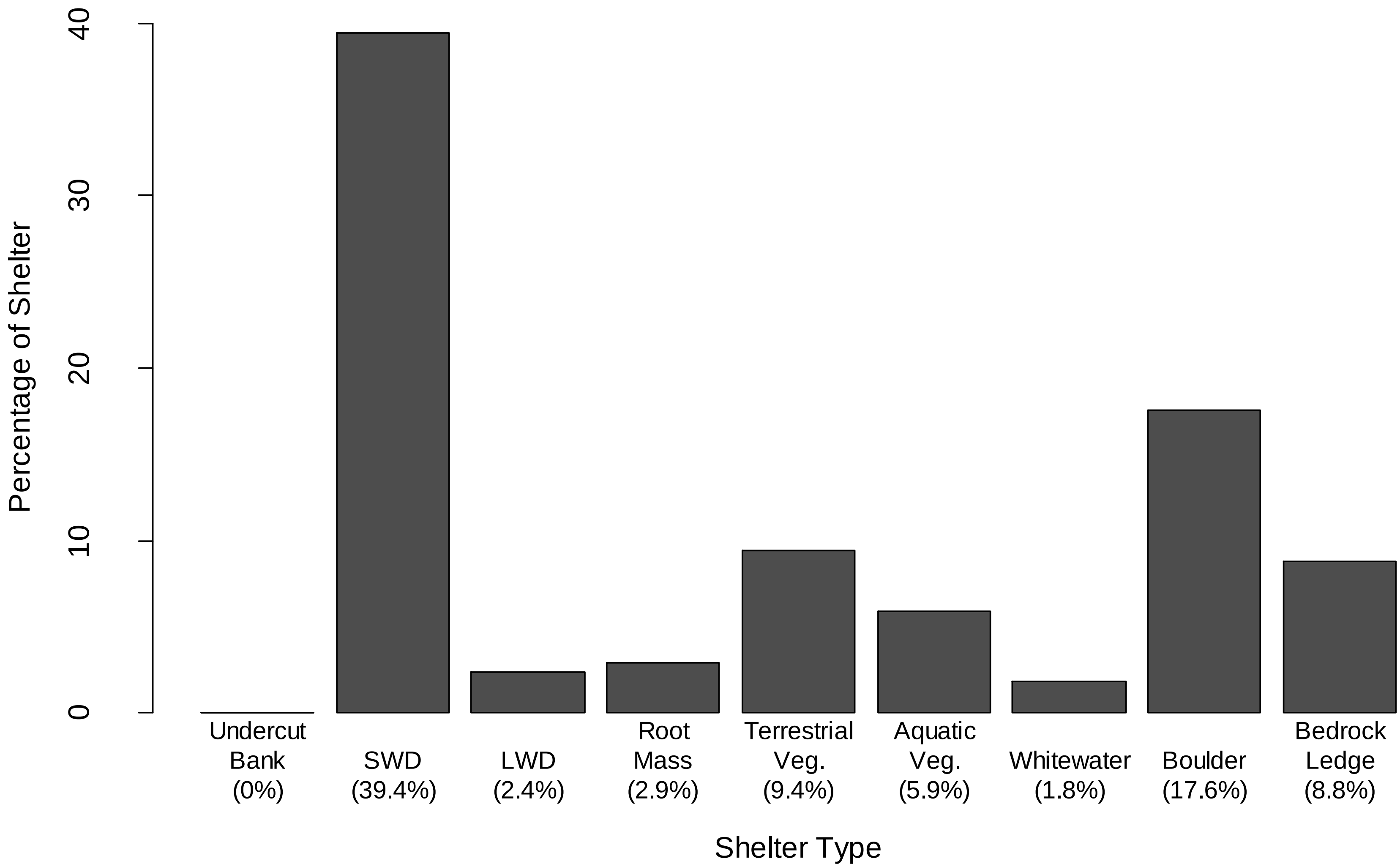


Figure 103. Percentage of banks by dominant substrate composition for East Fork Cold Springs Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock.

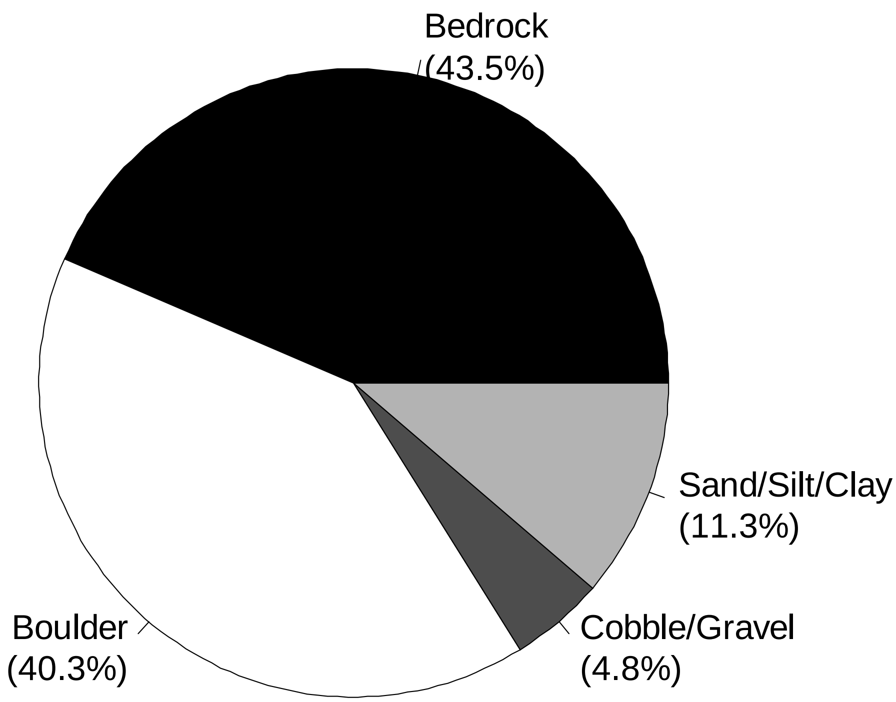
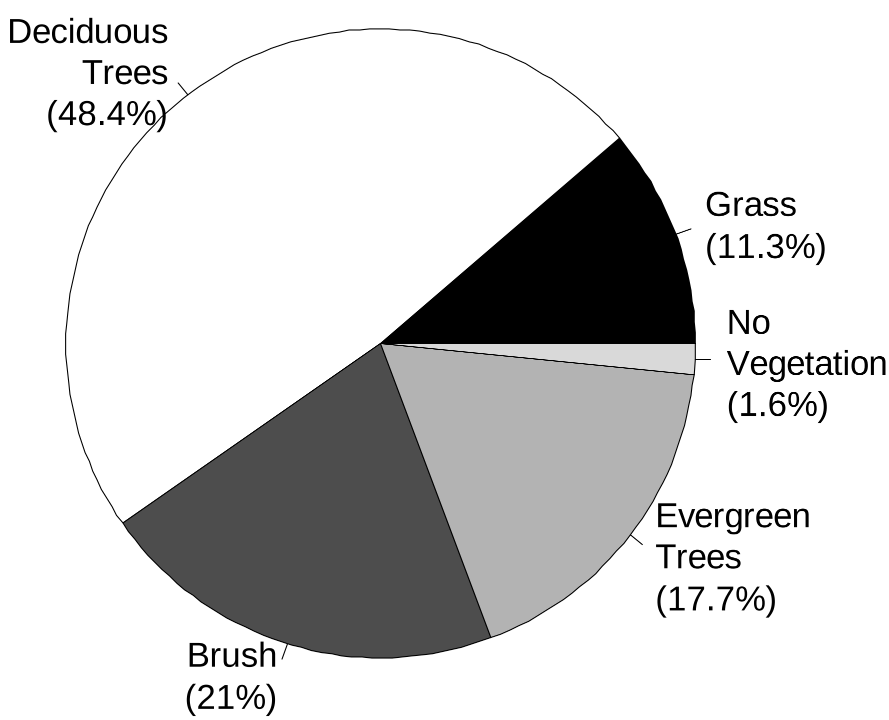


Figure 104. Percentage of banks by dominant vegetation type for East Fork Cold Springs Creek. Vegetation types included deciduous trees, evergreen trees, grass, brush, and no vegetation.



West Fork Cold Springs Creek

Snorkel Survey (2015)

<u>Results</u>

The snorkel survey for West Fork was conducted on Jun 17, 2015. The survey began at 34.45607°N, -119.65325°W (the first snorkelable unit available for this reach) and extended approximately 3,534 feet upstream. The endpoint of the survey (34.46722°N, -119.65926°W) was a total natural barrier to fish passage (Figure 105).

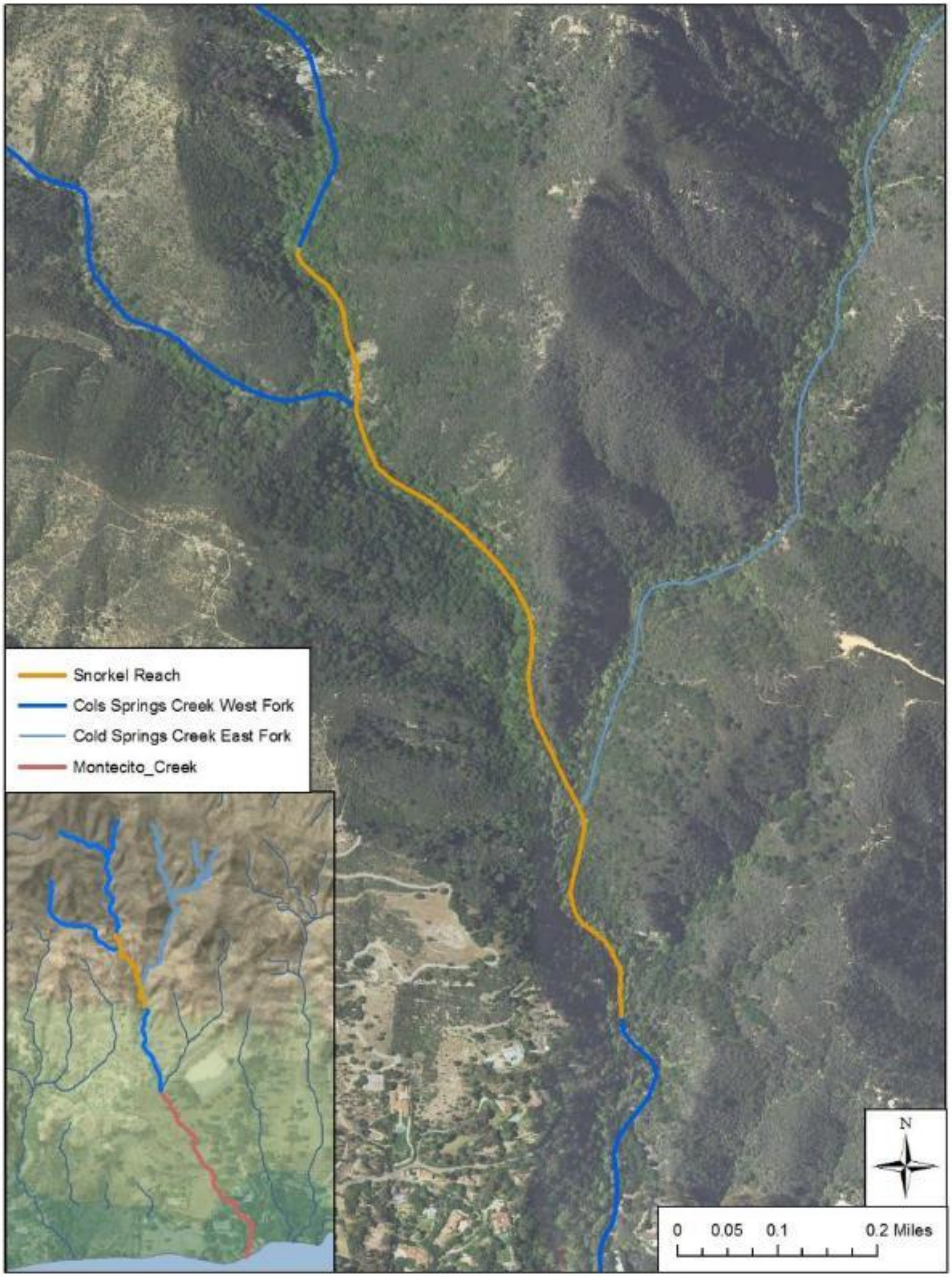
For West Fork Cold Springs, we snorkeled 11 units. Snorkeled units had mean visibility of 2.36 (range = 1–3). All units had shelter ratings of two. No *O. mykiss* were observed.

<u>Discussion</u>

No *O. mykiss* were observed in West Fork Cold Springs. This was perhaps unsurprising given the current water conditions, in which a severe drought in its fourth consecutive year has contributed to dewatering in a substantial portion of the Montecito watershed. These drought conditions, exacerbated by heavy urbanization and channelization of the stream bed (NMFS 2012), have left very little available and viable habitat for *O. mykiss*. However, steelhead have historically occupied the Montecito Creek watershed (Boughton et al. 2006) and it is hopeful that they could reoccupy this watershed should conditions improve.

Figures

Figure 105. Snorkeled reach of West Fork Cold Springs in 2015



Habitat Assessment

Results

The habitat inventory was conducted from 9 September to 14 September 2015 by Kyle Evans, Yi-Jiun Tsai, Marisa Morse, and Phillip Hunter from Pacific States Marine Fisheries Commission The survey extended 4727.3 feet upstream from the survey start (34.45865°N, -119.65439°W). The survey endpoint (34.46950°N, -119.65880°W) was a total natural barrier to fish passage (Figure 106). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 63 to 69°F. Air temperature ranged from 66 to 88°F.

Habitat type

Of the total number of habitat units surveyed (n = 52 units), 25% of units were dry, 3.8% were flatwaters, 46.2% were pools, and 25% were riffles. Of the total length of the reach surveyed, 87.4% was dry, 0.8% was composed of flatwaters, 7.5% was composed of pools, and 4.2% was composed of riffles (Figure 107).

We identified nine habitat types in West Cold Springs Creek. Based on the frequency of units sampled, mid-channel pools (36.5%), dry units (25.0%), and low-gradient riffles (17.3%) were the most common habitat types (Table 18). Based on total stream length, dry (87.4%), mid-channel pools (4.3%), and low-gradient riffles (2.6%) composed the greatest stream lengths.

Pool Metrics

A total of 24 pools were identified within the survey reach. Main channel pools were only pool habitat type encountered.

One of the twenty-four pools (4%) had a residual depth of three feet or greater (Figure 108).

Within pool tail-outs, silt/clay was the most frequently observed dominant substrate (58.3% of pool units), followed by boulders (16.7%) and small cobble (12.5%; Figure 109).

When we examined pool tail-outs for substrate embeddedness, we found that pools had embeddedness values of five (88.9%), one (5.6%), or two (5.6%; Figure 110).

Shelter

Within 100% units (n = 15 units), riffle habitat types had a mean shelter rating of 92.5, flatwater habitat types had a mean shelter rating of 45.0, and pools had a mean shelter rating of 50.6.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that small woody debris provided the most shelter (42.7% of all shelter; Figure 111). When we examined the percentage of shelter by shelter type within pools only, we found that small woody debris was the most dominant cover type (37.2% of the total cover), followed by bedrock ledges (22.2%) and terrestrial vegetation (21.7%; Figure 112).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 93.1%. Within the canopy cover present, 65.5% of the canopy was composed of deciduous trees and 34.5% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks were bedrock (42.9%), boulder (14.3%), cobble/gravel (25.0%), and silt/sand/clay (17.9%; Figure 113). The mean percentage of vegetation covering the right bank in sampled units was 63.6%, and the mean percentage of vegetation covering the left bank was 64.3%. Deciduous trees were the dominant vegetation type, having been observed in 75.0% of the banks surveyed. Additionally, 14.3% of the banks surveyed had brush and 10.7% had evergreen trees as the dominant vegetation (Figure 114).

Large Woody Debris

We observed three pieces of LWD that were 6 to 20 feet long and one piece that was greater than 20 feet long within 594.3 feet of wetted stream length. Across both LWD sizes, the number of LWD observed was 0.67 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 39.8 feet.

Discussion

Temperature

The water temperature of units measured ranged from 63 to 69°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools, dry units, or riffles. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools, dry units, or low-gradient riffles. When we examined the reach in terms of length, we found that most of the reach was dry or pools, with mid-channel pools comprising the greatest percentage of wetted stream length.

Pool Metrics

Pool depth is an important indicator habitat quality, as greater pool depths can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). A residual depth of at least three feet is needed to be considered good habitat (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in West Cold Springs Creek, we found that only one of 24 pools (4%) had a residual depth greater of three feet or greater. Thus, it appears that pools in West Cold Springs lack the depth needed to provide good hiding cover and rearing space. This may be due in part to the current, severe drought, which has extended into its fourth consecutive year.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was silt/clay, comprising 58.3% of pool units. Pool units, in large part, had an embeddedness value of five (88.9% of all units measured). Together, these metrics suggest that suitable habitat space for *O. mykiss* is lacking in West Cold Springs Creek presently.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O.*

mykiss. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that riffles had the highest shelter rating, followed by pools.

When we examined the percentage shelter by shelter type, we found that small woody debris provided the most shelter by far (42.7% of all shelter).

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In West Cold Springs Creek, we estimated a mean canopy cover of 93.1% across all units, consisting predominantly of deciduous trees. This suggests that West Cold Springs Creek has a very high amount of cover (Kier Associates & NMFS 2008), but this cover is likely to vary greatly through time, given the seasonality of deciduous trees.

Bankside Metrics

The predominant substrate composing stream banksides was bedrock, followed by boulder. The mean percentage of vegetation covering the right and left banks was 63.6% and 64.3%, respectively. Deciduous trees were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively protected from erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In West Cold Springs Creek, we found 0.67 pieces of LWD per 100 feet, which was low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while West Fork Cold Springs lacks LWD, it may have boulder elements that improve habitat quality.

Tables

Table 18. Percentage of units (n = 52 units) by habitat type for West Fork Cold Springs Creek.

Habitat Type	% of Units
Mid Channel Pool	36.54%
Dry	25.00%
Low Gradient Riffle	17.31%
Bedrock Sheet	5.77%
Step Pool	5.77%
Trench Pool	3.85%
Cascade	1.92%
Run	1.92%
Step Run	1.92%

Figures

Figure 106. Map of the habitat assessment survey area in West Fork Cold Springs Creek.

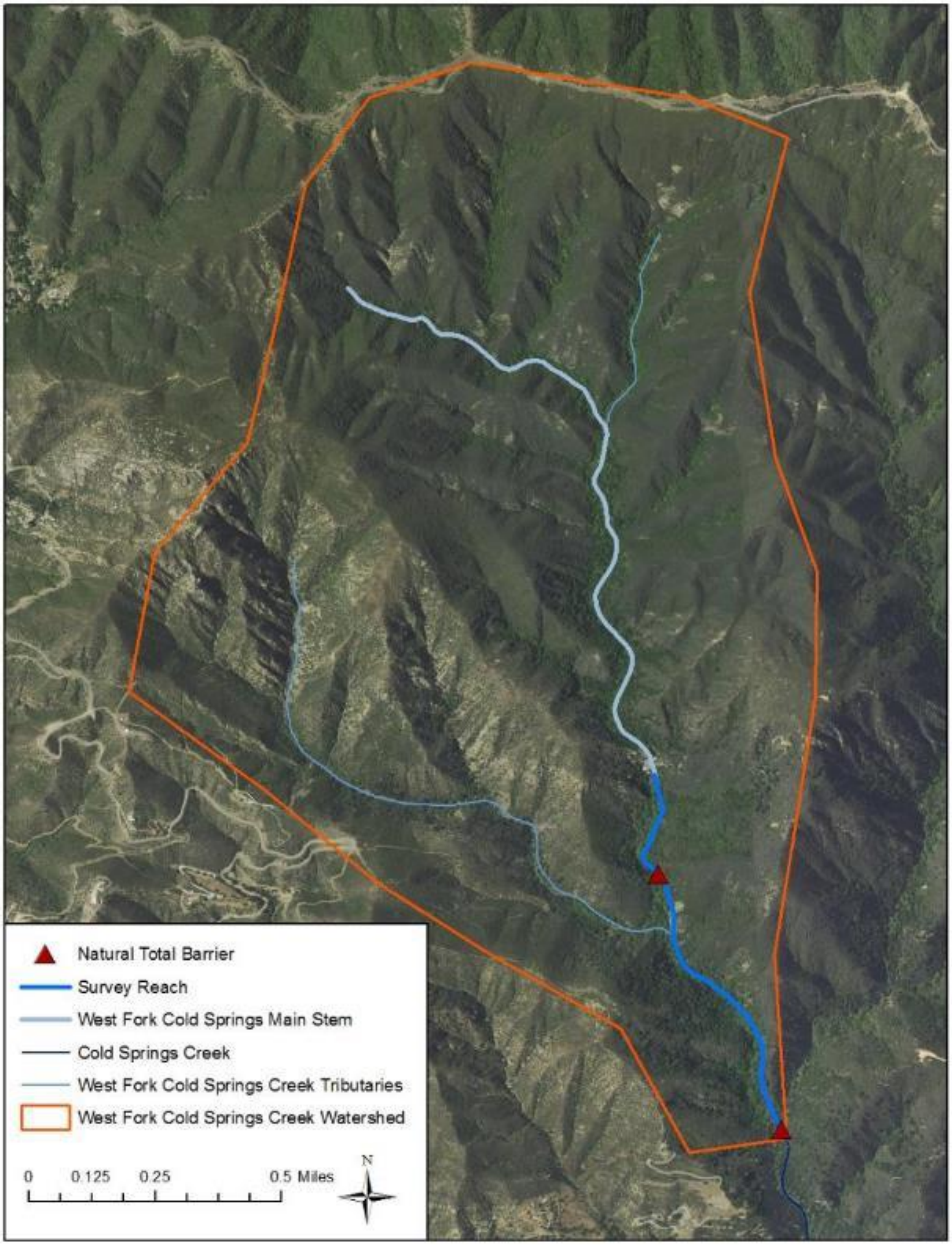


Figure 107. Percentage of total stream length categorized as pools, flatwaters, or riffles for West Fork Cold Springs Creek.

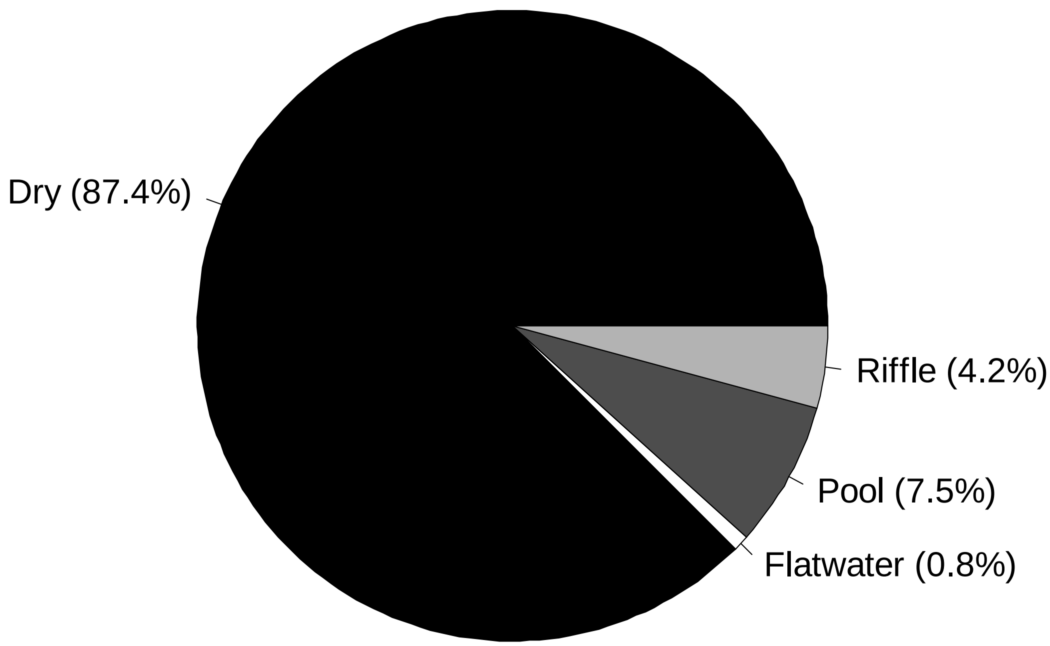


Figure 108. Histogram of residual pool depths in one-foot bins for West Fork Cold Springs Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

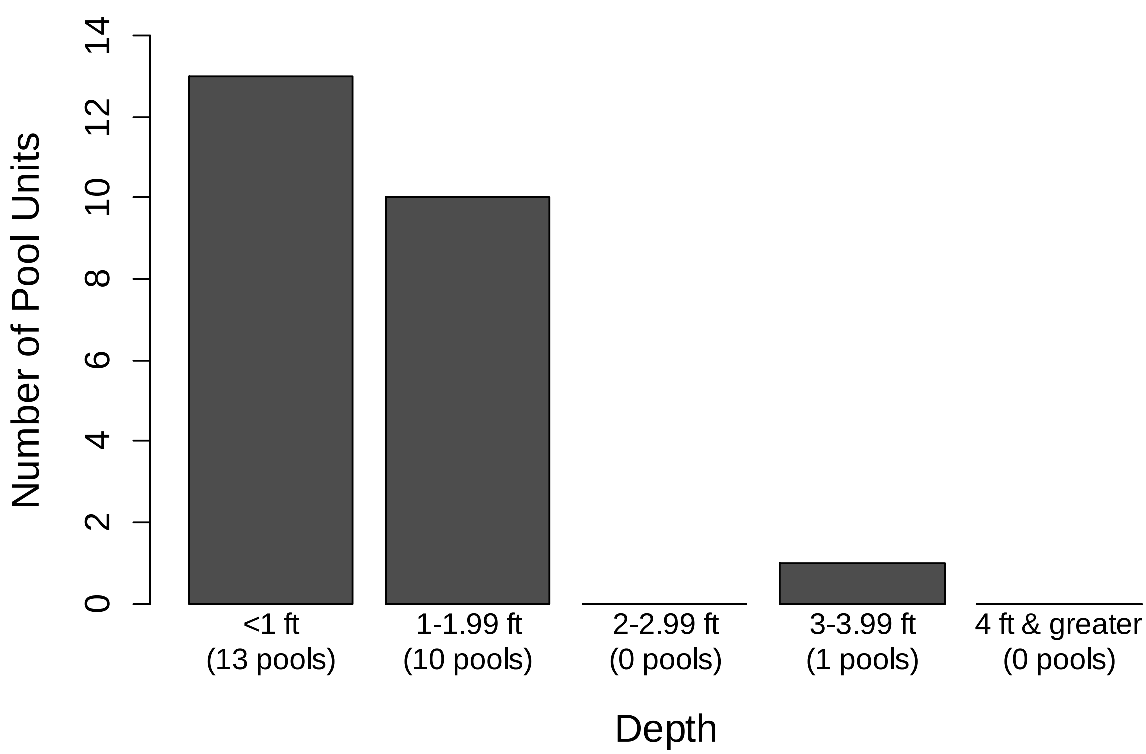


Figure 109. Percentage of pool tail-outs (n = 24 pools) by dominant substrate for West Fork Cold Springs Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

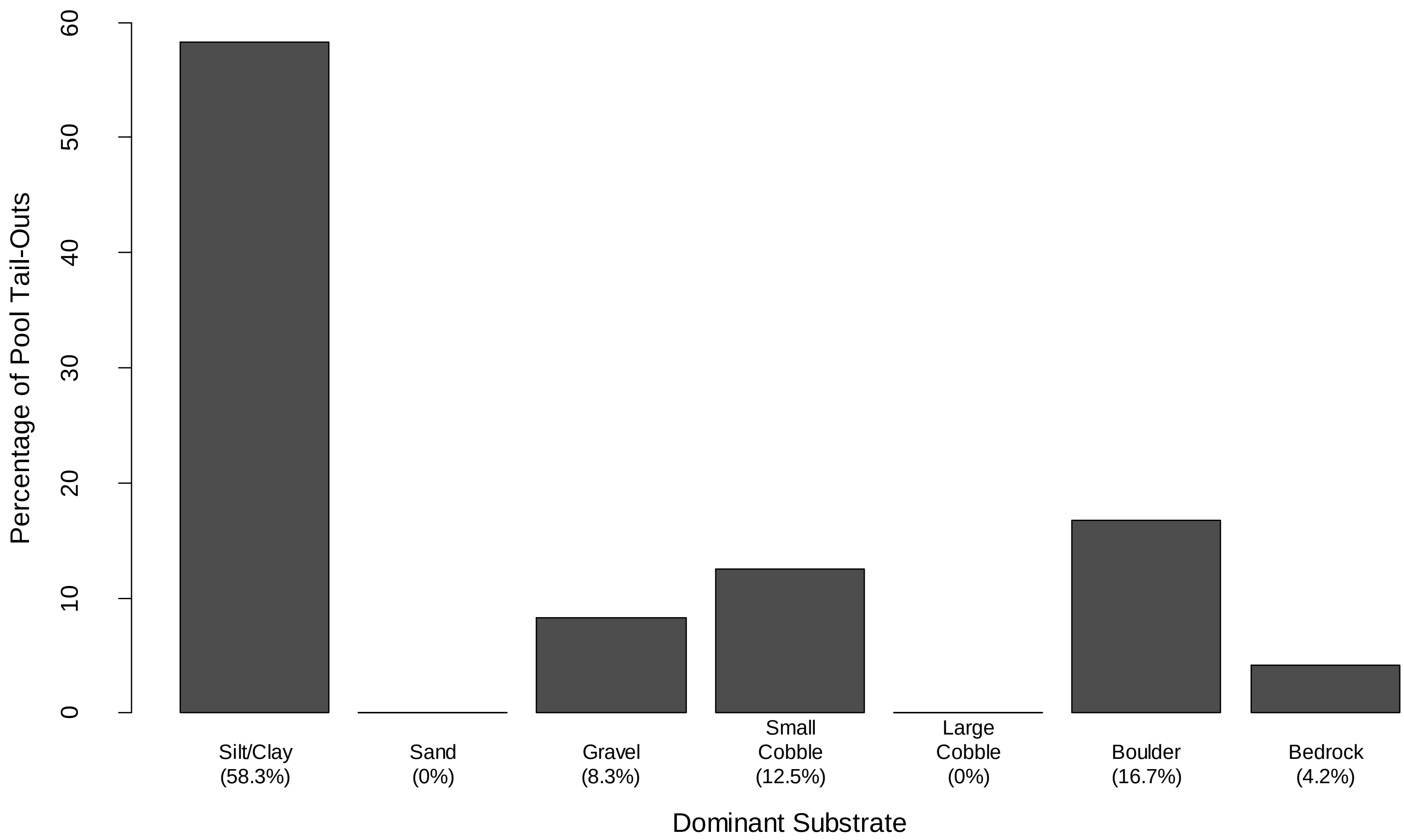


Figure 110. Percentage of all pool units (n = 24 pools) assigned a pool tail-out embeddedness value of 1 to 5 for West Fork Cold Springs Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning. We did not record embeddedness values of 3 or 4 in this survey.

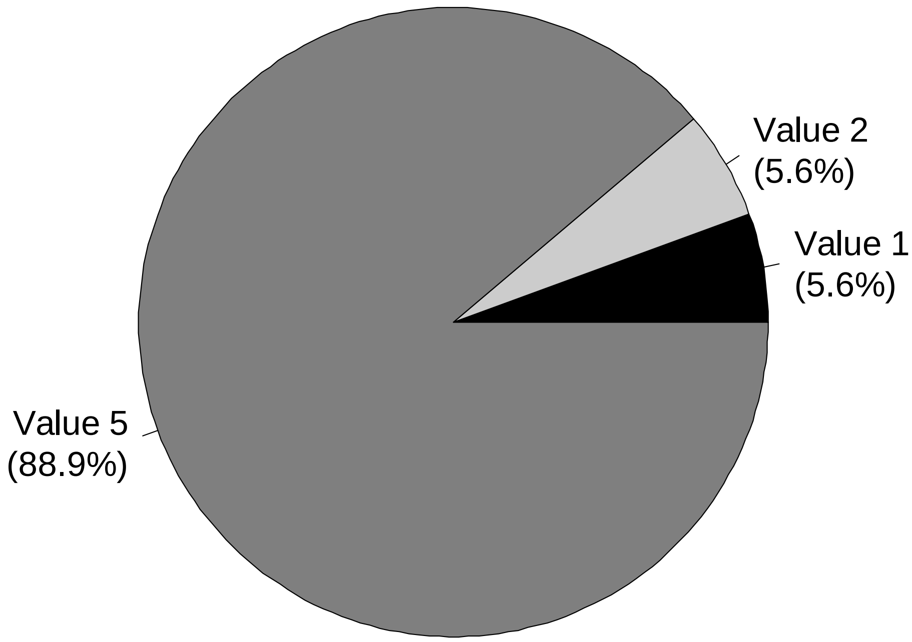


Figure 111. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 15 units) for West Fork Cold Springs Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

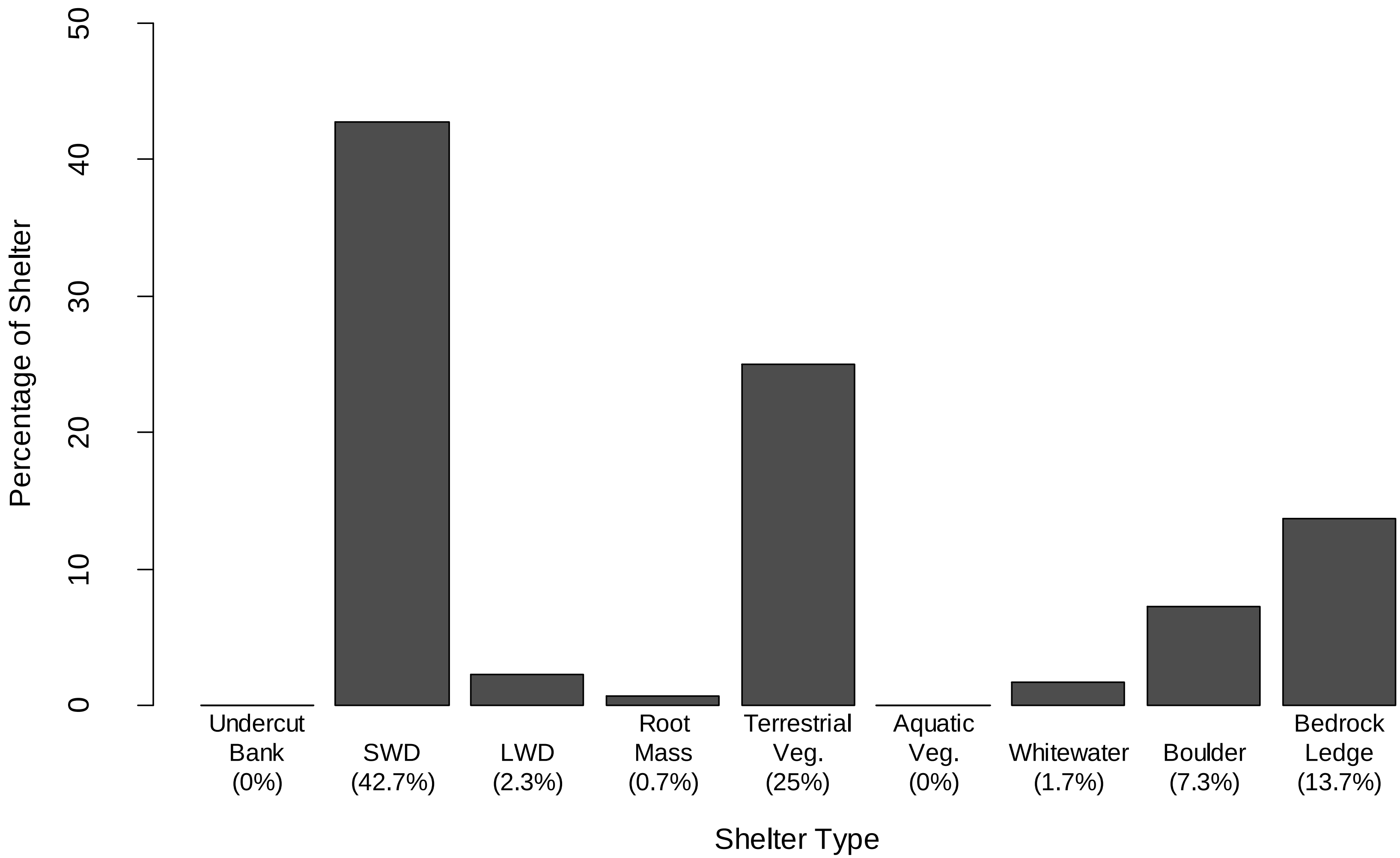


Figure 112. The percentage of shelter by shelter type across all pool units in which shelter was measured (n = 9 pools) for West Fork Cold Springs Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

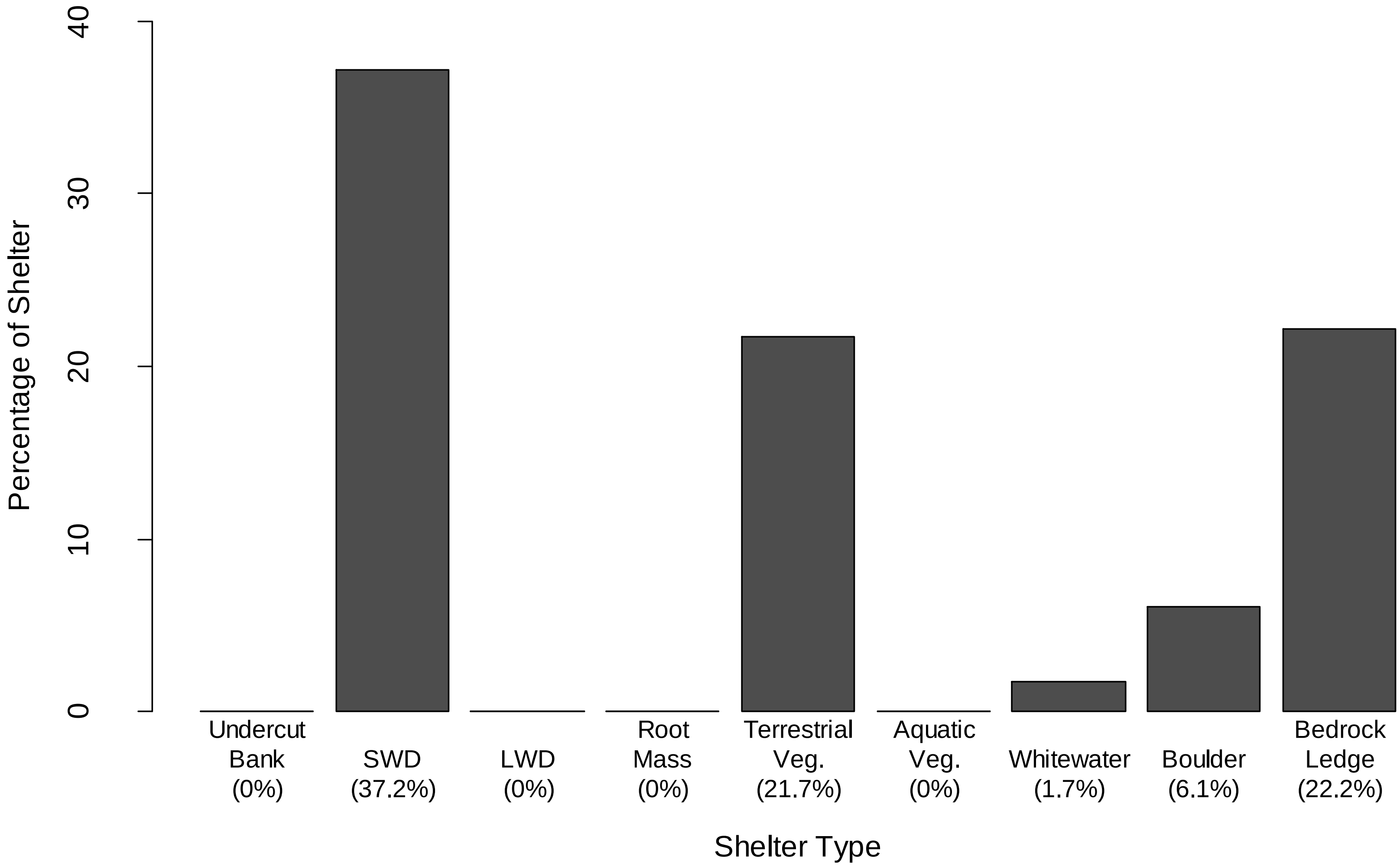


Figure 113. Percentage of banks by dominant substrate composition for West Fork Cold Springs Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock.

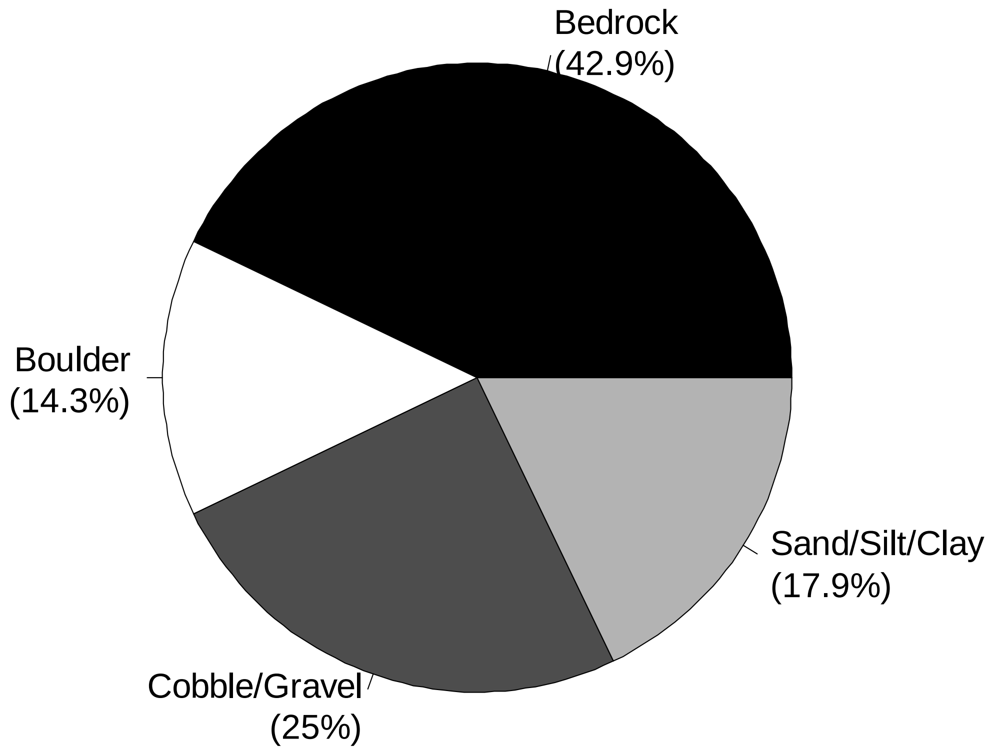
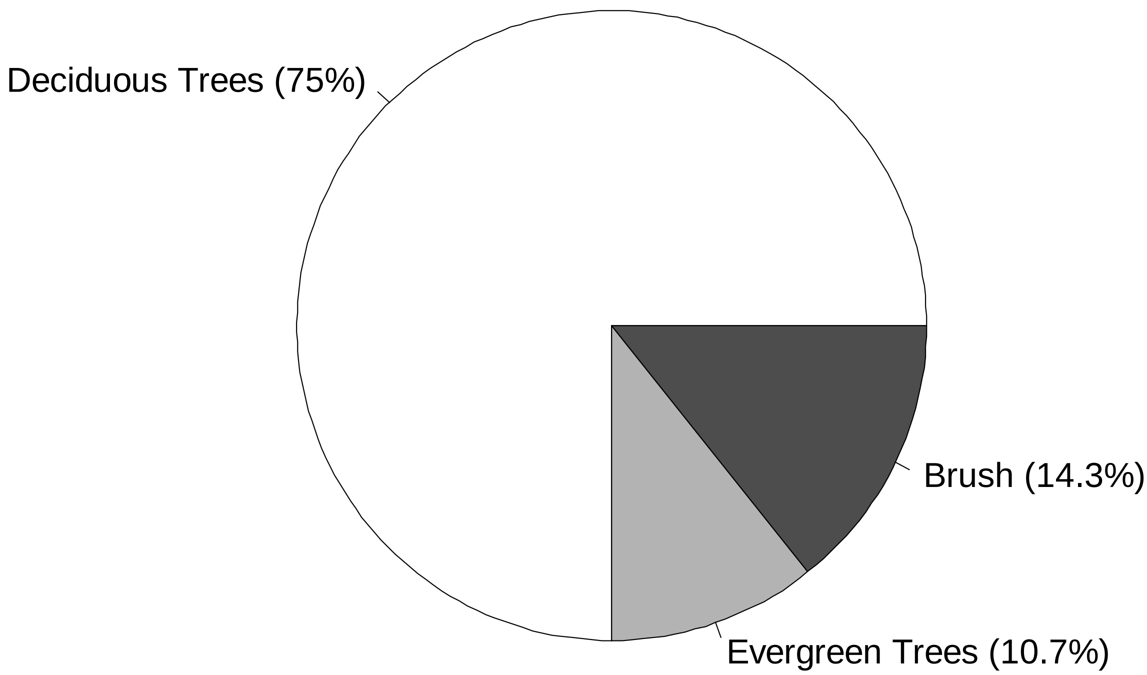


Figure 114. Percentage of banks by dominant vegetation type for West Fork Cold Springs Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush. In this survey, grass was not recorded as bankside vegetation.



San Ysidro

Snorkel Survey

2015

<u>Results</u>

Between August 3, 2015 and August 11, 2015, a snorkel survey was conducted on a stretch of San Ysidro Creek. 19 *O. mykiss* were observed in 8 of the 61 pools snorkeled over a surveyed length of 1 mile. The 19 *O. mykiss* were observed in varying size classes as indicated in the Table 19 and Figure 115 below.

The total length of all snorkeled units was 1,636.5 feet within the 1 mile (5,495 ft.) reach. The combined length of all habitat units with *O. mykiss* observations was 222 feet. Figure 117 shows the distribution of O. mykiss over the surveyed reach

The average number of *O. mykiss* per unit length calculates to be 1.161×10^{-2} fish/ft. This was calculated by taking total of observed fish and dividing by the sum of all the lengths of snorkeled units. The average number of *O. mykiss* per unit area calculates to be 1.272×10^{-3} fish/ft^2. This was calculated by taking the total number of fish observations and dividing by sum of all the individual surface areas for each snorkeled unit. We have also summarized *O. mykiss* counts for shelter values in Table 20 and Figure 116 below.

We also plotted *O. mykiss* observations with respect to total surface area of each habitat unit and this is shown in Figure 118 below. Additionally we plotted the number of *O. mykiss* observations with respect to the length of each habitat unit and this is shown below in Figure 119.

Discussion

Between August 3, 2015 and August 11, 2015, a snorkel survey was conducted on a one mile stretch of San Ysidro Creek from 241 feet above the San Ysidro trailhead to last snorkelable pool within the surveyed section of the system. The purpose of this snorkel survey was to gain an understanding of the abundance and distribution of southern California steelhead in San Ysidro Creek, located in the Conception Coast BPG, in Ventura County.

Size class distributions of *O. mykiss* observed show the majority of observed fish were within the 0-1.99", 2-3.99", and 4-5.99" size classes while overall distributions ranged in size from 0-1.99" to 10-11.99". We suspect that since this spawning season had concluded by our August snorkel surveys, that the 2015 year's recruitment class was meagerly represented by the five fish in the 0-1.99" size class. This could be indicative of poor survival of this cohort; potentially due to cumulative years of drought effects as shrinking habitat could lead to increased predation and decreased food availability.

The map of the surveyed section of San Ysidro Creek indicates the distribution of the observed *O. mykiss*. The larger circles indicate a greater number of fish observations for each surveyed unit. The smaller circles indicate a lesser number of fish observations in a single unit. There are clear differences seen between different sections of the creek. There is significantly less water and suitable habitat in the lower section of the creek. As the survey progressed upstream, there was more water, thus more available habitat for *O. mykiss*. As shown in Figure 117, the distribution of trout is restricted to the upper portions of the surveyed reach in San Ysidro Creek.

Figure 118 and Figure 119 show the number of *O. mykiss* observed versus the surface area and length of the pools they were found in. There was no distinct correlation between *O. mykiss* observations and the surface area and length of the pools they were found in. *O. mykiss* density was then calculated in relation to the total length of the surveyed pools (222 feet) as well as the combined total surface area of the surveyed pools (3026.5 ft^2). The average number of *O. mykiss* per unit length calculates to be 1.161×10^{-2} fish/ft while the average number of *O. mykiss* per unit area calculates to be 1.272×10^{-3} fish/ft^2. Again, these numbers are relatively insignificant due to the small sample size.

We also choose to look at shelter values which can range on a scale of 0 to 3. A shelter value of 0 means the surveyed unit has no components of shelter (e.g., no undercut, boulders, woody debris, etc.), whereas a value of 3 means the shelter in the surveyed unit has at least three shelter components including large woody debris (LWD). Large woody debris is uncommon in Southern California streams; therefore shelter values of 3 are not as common as shelter values of 2. In San Ysidro Creek, 91.8% of the surveyed units had a shelter value of 2, 4.9% of the surveyed units had a shelter value of 1, and only 3.2% of the pools had a shelter value of 3. Figure 116 is a histogram showing the number of *O. mykiss* observed for each of the shelter values. It is not surprising that most of the fish observations were in pools with a shelter value of 2, since the majority of the surveyed pools had a shelter value of 2. This discrepancy in shelter value distribution may be explained by the importance of large woody debris and complex features in the shelter rating system. Large woody debris is fairly uncommon in southern California streams. Additionally, below average rainfall and water levels may have reduced the availability of complex habitat features.

As these surveys took place during persistent drought conditions, divers also collected data on potential relocation pools, counting the numbers of fish already present and habitat metrics. If diver's encountered pools that were in danger of drying up, these were also snorkeled and flagged if possible rescue might not be needed. Both relocation and rescue data was recorded on the data sheets but was not included in any of the analysis.

Overall, this snorkel summary report shows us a snapshot of what age classes were present and where these *O. mykiss* were distributed on San Ysidro Creek. We were able to calculate an index of fish density but without additional survey seasons, no reliable inferences can be made. We can make no reliable estimates of population abundance since we did not conduct electrofished calibration of the snorkel counts. Additional survey seasons must be completed in order to make a comparison of our observations. Subsequent surveys should include electrofishing to we can make accurate population estimates as per Hankin and Reeves 1988.

Tables

Table 19. Table of the first pass *O. mykiss* size class distribution in San Ysidro Creek, 2015.

***O. mykiss* Size Class (in)**	**Number *O. mykiss* Observed**
0-1.99	5
2-3.99	6
4-5.99	3
6-7.99	4
8-9.99	0
10-11.99	1

Table 20. *O. mykiss* counts and number of habitat units with respect to shelter values in San Ysidro Creek, 2015.

Habitat Unit Shelter Values	***O. mykiss* Observed per Shelter Value**	**Number of Habitat Units with Shelter Value**
0	0	0
1	5	0
2	71	18
3	2	1

Figures

Figure 115. Size class distribution of *O. mykiss* observations in San Ysidro Creek, 2015.

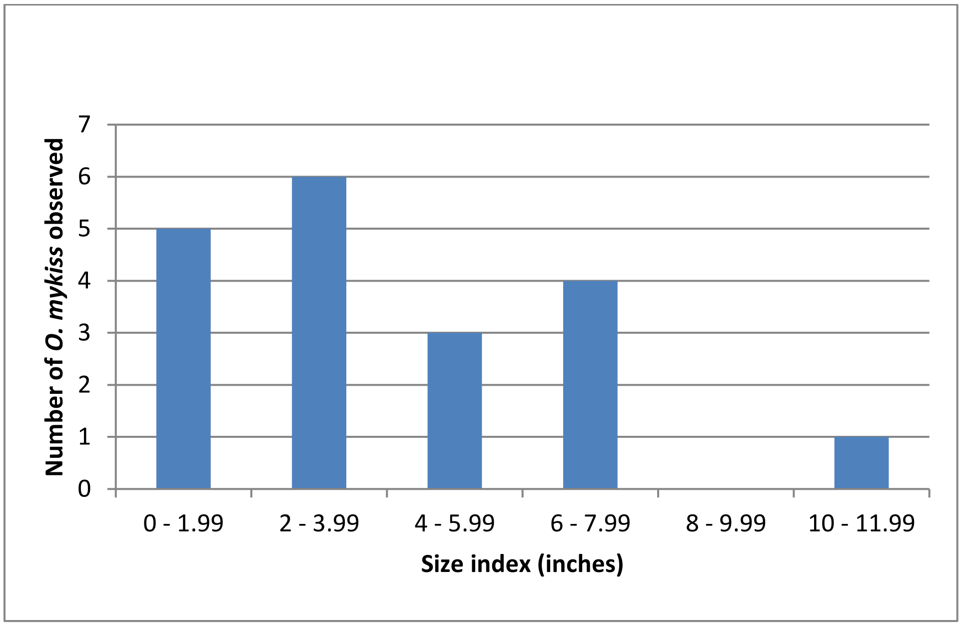


Figure 116. Shelter values plotted against the number of *O. mykiss* observed in San Ysidro Creek, 2015.

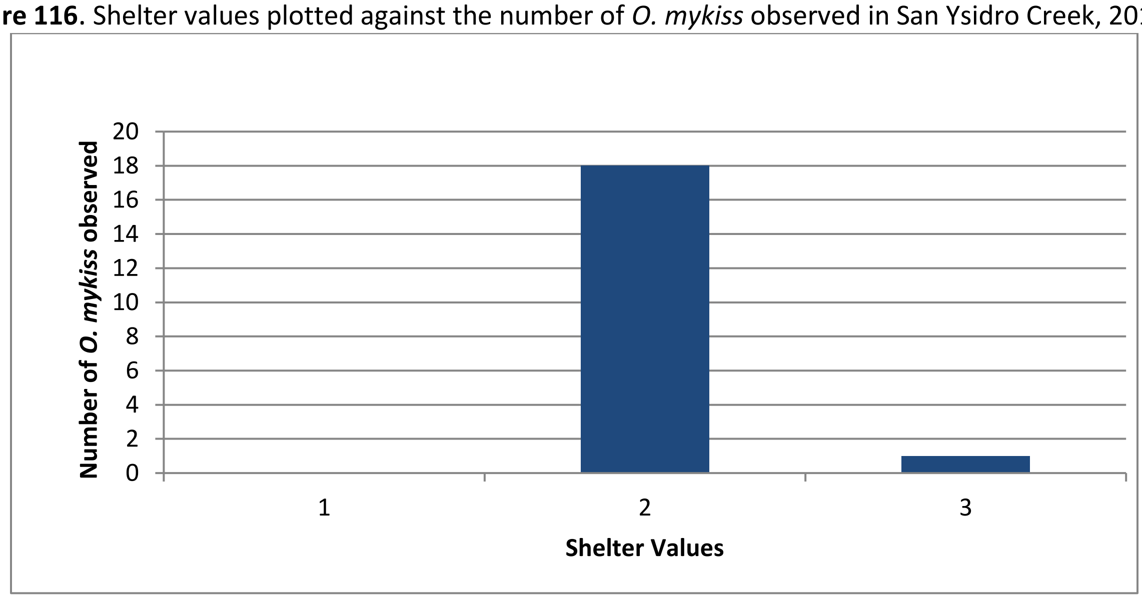


Figure 117. Surveyed section of San Ysidro Creek, 2015 showing the distribution of observed *O. mykiss*.

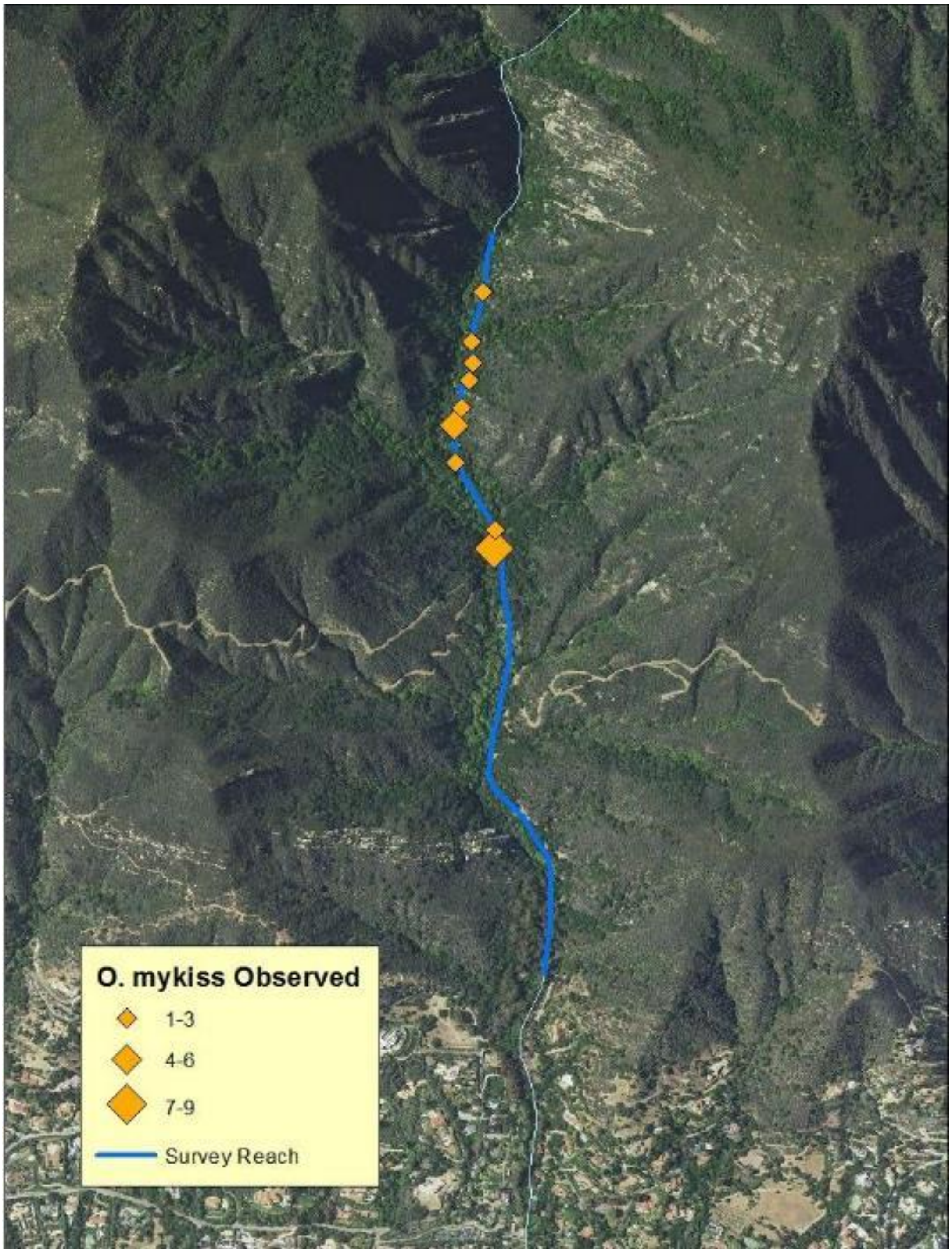


Figure 118. *O. mykiss* observations plotted over habitat unit surface area in San Ysidro Creek, 2015.

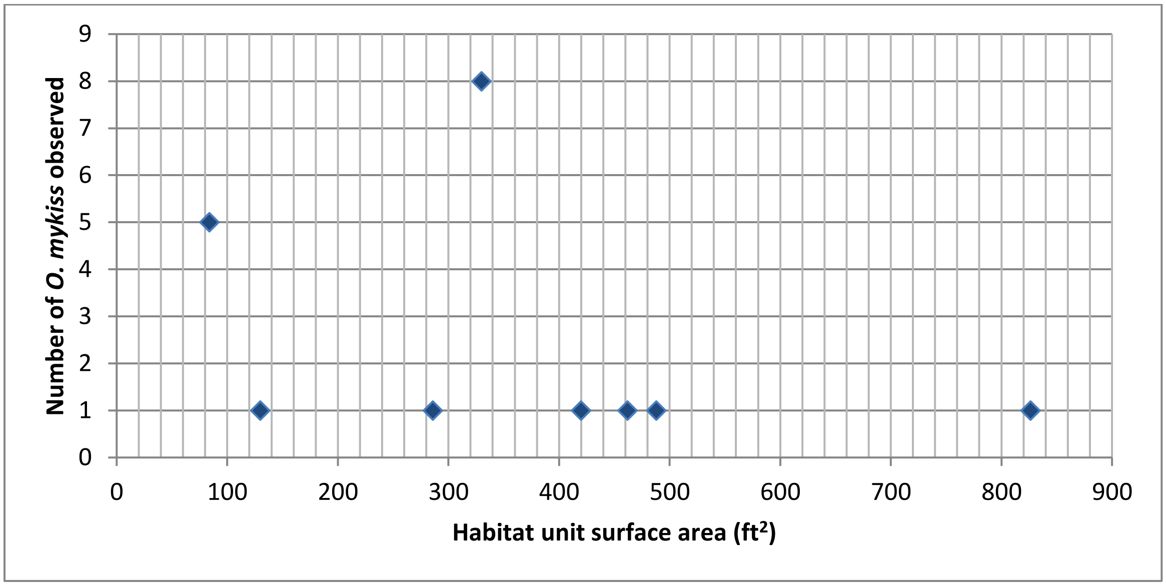
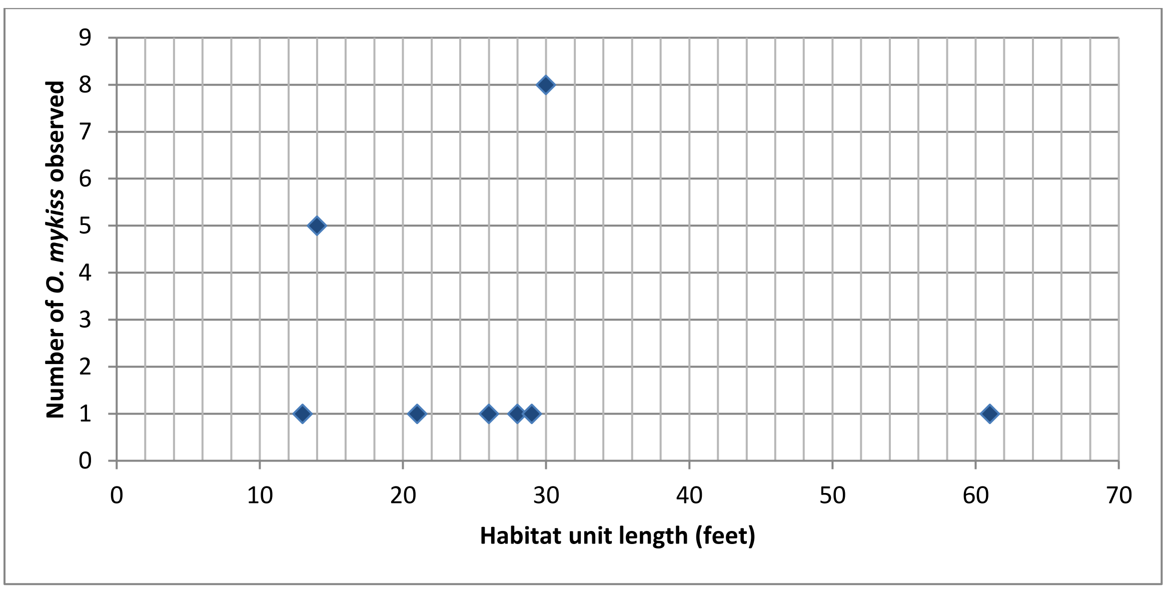


Figure 119. *O. mykiss* observations plotted over habitat unit length in San Ysidro Creek, 2015.



Habitat Assessment

Results

The habitat inventory was conducted from 29 June to 22 September 2015 by Terra Dressler, Benjamin Lakish, Colleen Del Vecchio, Patrick Saldaña, Leah Gonzalez, Jean Tsai, Phillip Hunter, and Marisa Morse from Pacific States Marine Fisheries Commission. The survey extended 17,845 feet upstream from the survey start (34.41926°N, -119.62532°W). The survey endpoint (34.46538°N, -119.62305°W) was a >16ft high waterfall that served as an impassible barrier (Figure 120). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 59 to 67°F. Air temperature ranged from 57 to 75°F.

Habitat type

Of the total number of habitat units surveyed (n = 203 units), 7.9% of units were dry, 24.6% were flatwaters, 38.9% were pools, and 28.6% were riffles. Of the total length of the reach surveyed, 69.0% was dry, 12.5% was composed of flatwaters, 9.8% was composed of pools, and 8.7% was composed of riffles (Figure 121).

We identified 12 habitat types in San Ysidro Creek. Based on the frequency of units sampled, mid-channel pools (32.0%), low gradient riffles (25.6%), and runs (14.8%) were the most common habitat types (Table 21). Based on total stream length, dry (69.0%), low-gradient riffles (8.1%), and mid-channel pools (7.1%) composed the greatest stream lengths.

Pool Metrics

A total of 79 pools were identified within the survey reach. Main channel pools were most frequently encountered (92.4% of pool units sampled; Figure 3) and comprised 92.5% of the total length of all pools. 6.3% of pools encountered were scour pools and 1.3% of pools were backwater pools.

Five of 75 pools (7%) had a residual depth of three feet or greater (Figure 123).

Within pool tail-outs, gravel was the most frequently observed dominant substrate (32.9% of pool units), followed by boulders (21.1%), large cobble (13.2%), and small cobble (13.2%; Figure 124).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (39.5%) or four (19.7%; Figure 125).

Shelter

Within 100% units (n = 49 units), riffle habitat types had a mean shelter rating of 48.7, flatwater habitat types had a mean shelter rating of 75.3, and pools had a mean shelter rating of 72.9.

Of the pool units in which shelter was assessed (n = 17 units), main channel pools had a mean shelter rating of 76.2, scour pools had a mean shelter rating of 80.0, and backwater pools had a mean shelter rating of 10.0.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that boulders provided the most shelter (40.0% of all shelter;

Figure 126). When we examined the percentage of shelter by shelter type within pools only, we found that boulders were the most dominant cover type (41.2% of the total cover), followed by small woody debris (17.9%; Figure 127).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 85.4%. Within the canopy cover present, 55.5% of the canopy was composed of deciduous trees and 44.5% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were bedrock (20.0%), boulder (46.0%), cobble/gravel (17.0%), and silt/sand/clay (18.0%;Figure 128). The mean percentage of vegetation covering the right bank in sampled units was 69.7%, and the mean percentage of vegetation covering the left bank was 67.9%. Brush was the dominant vegetation type, having been observed in 56.0% of the banks surveyed. Additionally, 36.0% of the banks surveyed had evergreen trees and 8.0% had hardwood trees as the dominant vegetation (Figure 129).

Large Woody Debris

We observed nine pieces of LWD that were 6 to 20 feet long and nine pieces that were greater than 20 feet long within 5537.5 feet of wetted stream length. Across both LWD sizes, the number of LWD observed was 0.33 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 35.7 feet.

Discussion

Temperature

The water temperature of units measured ranged from 59 to 67°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Good to Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools or low-gradient riffles. When we examined the reach in terms of length, we found that most of the reach was dry, with low-gradient riffles comprising the greatest percentage of wetted stream length.

Pool Metrics

Pool depth is an important indicator of habitat quality, as greater pool depths can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in San Ysidro, we found that no pools had a residual depth of at least three feet, which is required for a pool to be considered good habitat (Kier Associates & NMFS 2008). Thus, it appears that pools in San Ysidro lack the depth needed to provide good hiding cover and rearing space. This may be due in part to the current, severe drought, which has extended into its fourth consecutive year.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was gravel, comprising 32.9% of pool units. Pool units most frequently had an embeddedness value of either a five or four. Together, these metrics suggest that pools may not provide the ideal depth for cover and rearing space or provide good spawning habitat for *O. mykiss* in San Ysidro Creek.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When examining mean shelter rating within 100% units, we found that flatwaters had the greatest mean shelter rating, followed by pools.

When examining pool habitat units specifically, we found that main channel pools had the highest shelter rating, followed by scour and backwater pools.

When we examined the percentage shelter by shelter type, we found the boulders provided the most shelter (40% of all shelter), suggesting that boulders are a common and important feature to *O. mykiss* habitat in San Ysidro.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In San Ysidro Creek, we estimated a mean canopy cover of 85.4%, consisting predominantly of deciduous trees. This suggests that San Ysidro has a moderately high amount of cover (Kier Associates & NMFS 2008), but this cover is likely to vary greatly through time, given the seasonality of deciduous trees. However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was boulder, followed by bedrock. The mean percentage of vegetation covering the right and left banks was 69.7% and 67.9%, respectively. Brush and coniferous trees were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively protected from erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In San Ysidro, we found 0.33 pieces of LWD per 100 feet, which was extremely low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while San Ysidro lacks LWD, it has boulder elements that improve habitat quality. Specifically, boulders provided the greatest amount of shelter across all units in which shelter was assessed (40.0% of all shelter).

Tables

Table 21. Percentage of units (n = 203) by habitat type for San Ysidro Creek.

Habitat Type	% of Units
Mid Channel Pool	32.02%
Low Gradient Riffle	25.62%
Run	14.78%
Step Run	9.36%
Dry	7.88%
Step Pool	3.94%
Cascade	1.97%
Lateral Scour, boulder-formed	1.48%
Bedrock Sheet	0.99%
Corner Pool	0.99%
Edgewater	0.49%
Backwater Pool, boulder-formed	0.49%

Figures

Figure 120. Map of the habitat assessment survey area in San Ysidro Creek.

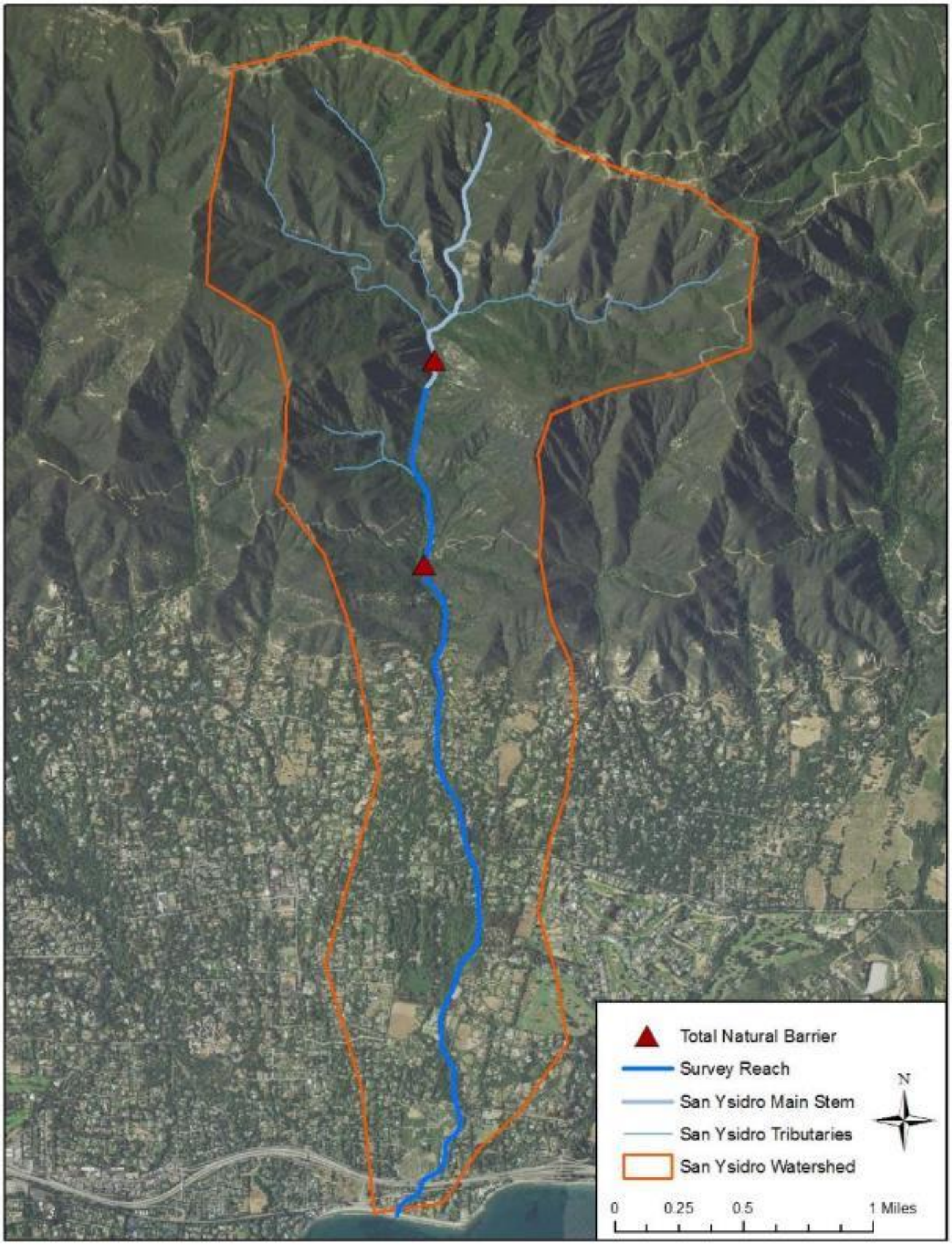


Figure 121. Percentage of total stream length categorized as pools, flatwaters, riffles, or dry for San Ysidro Creek.

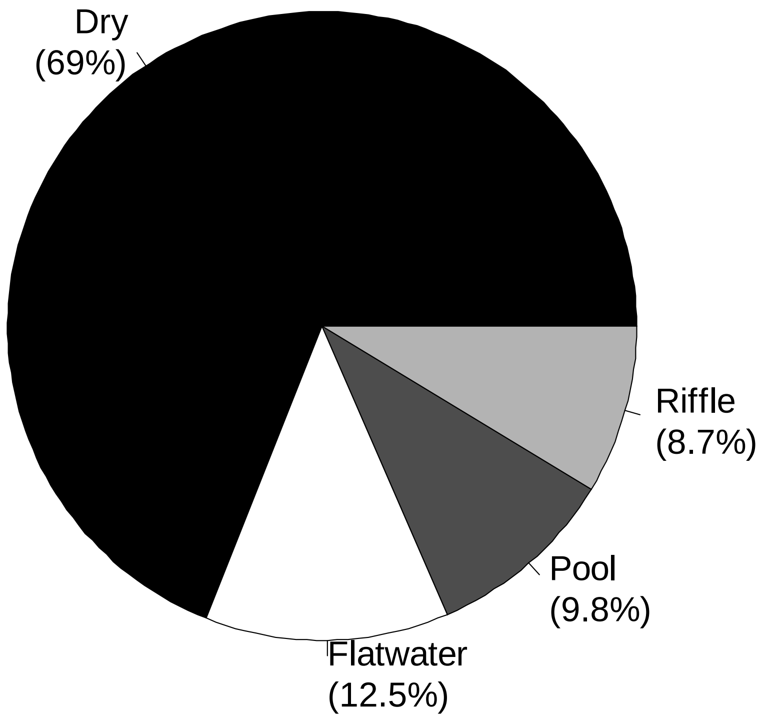


Figure 122. Percentage of all pool units (n = 79 pools) categorized by pool type (main channel, backwater, or scour pool) for San Ysidro Creek.

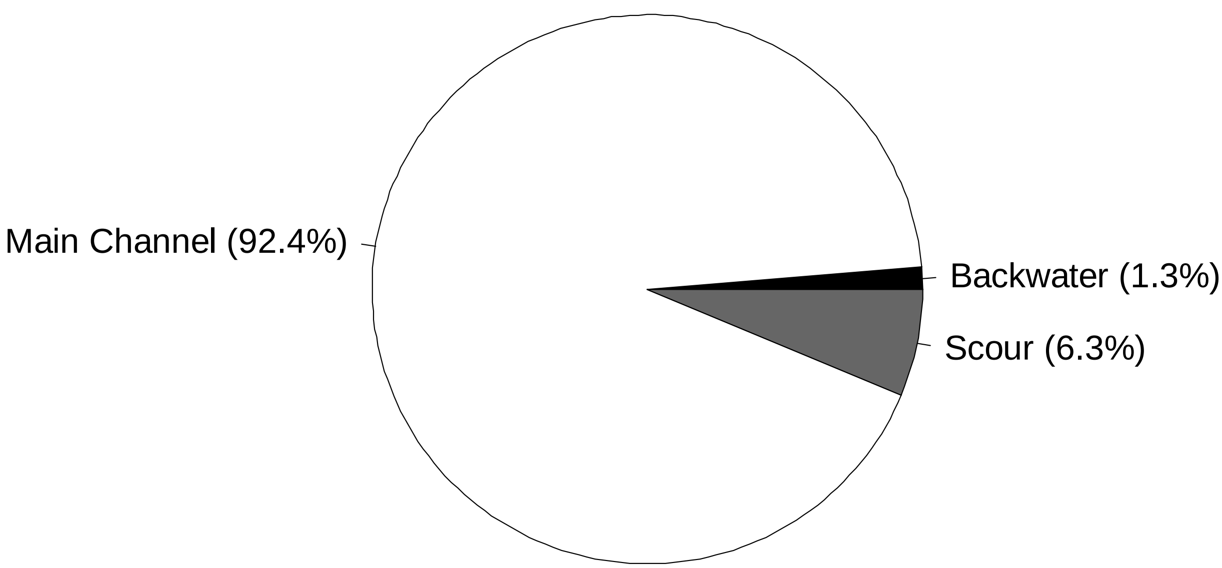


Figure 123. Histogram of residual pool depths in one-foot bins for San Ysidro Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

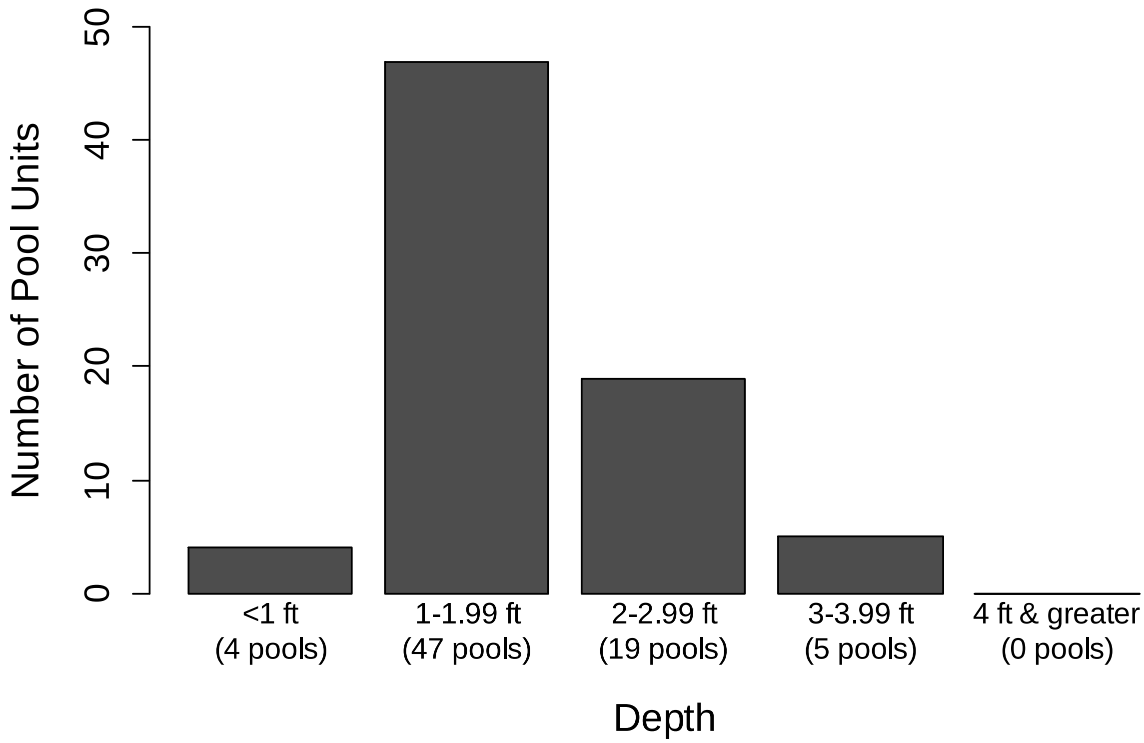


Figure 124. Percentage of pool tail-outs (n = 79 pools) by dominant substrate for San Ysidro Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

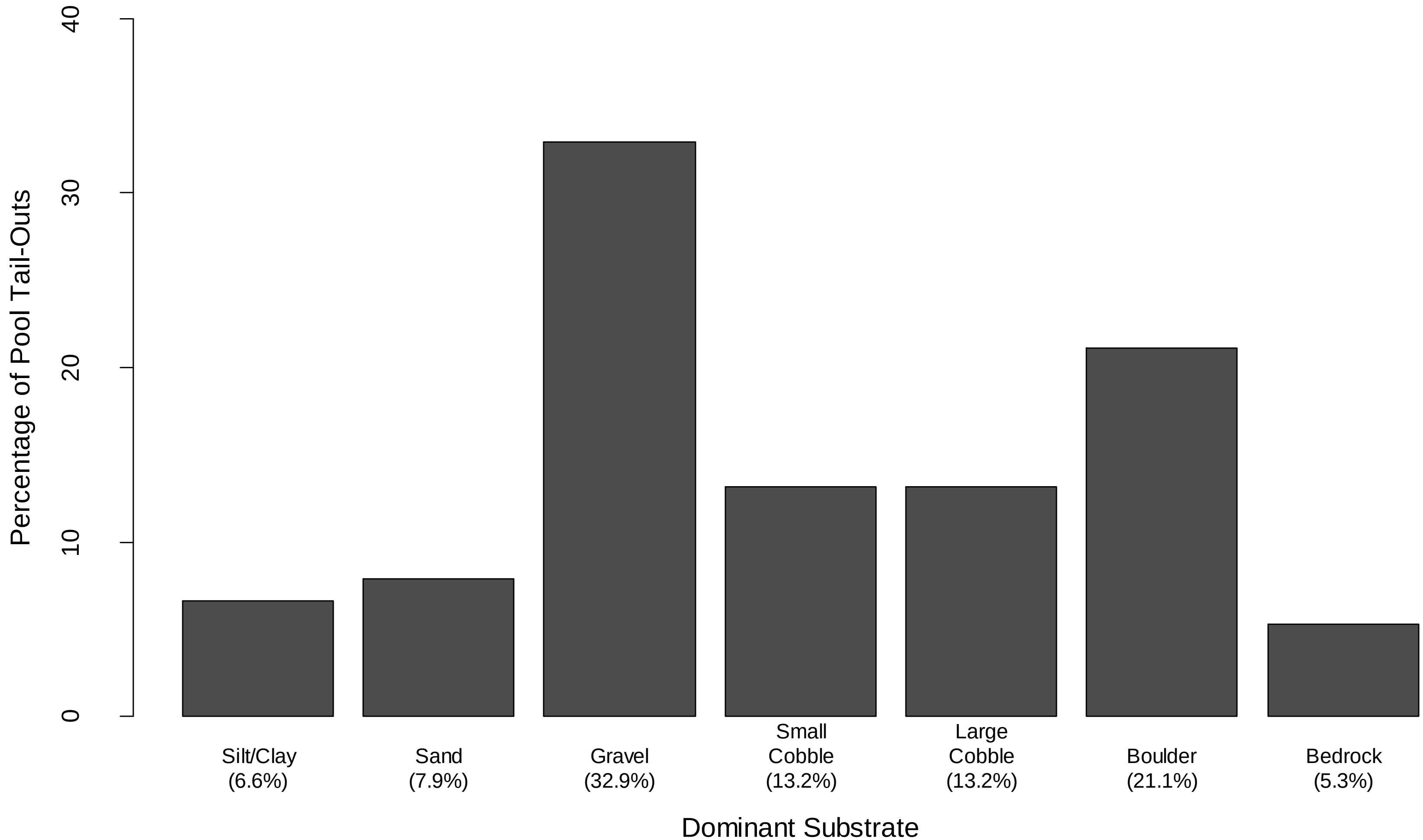


Figure 125. Percentage of all pool units (n = 79 pools) assigned a pool tail-out embeddedness value of 1 to 5 for San Ysidro Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning.

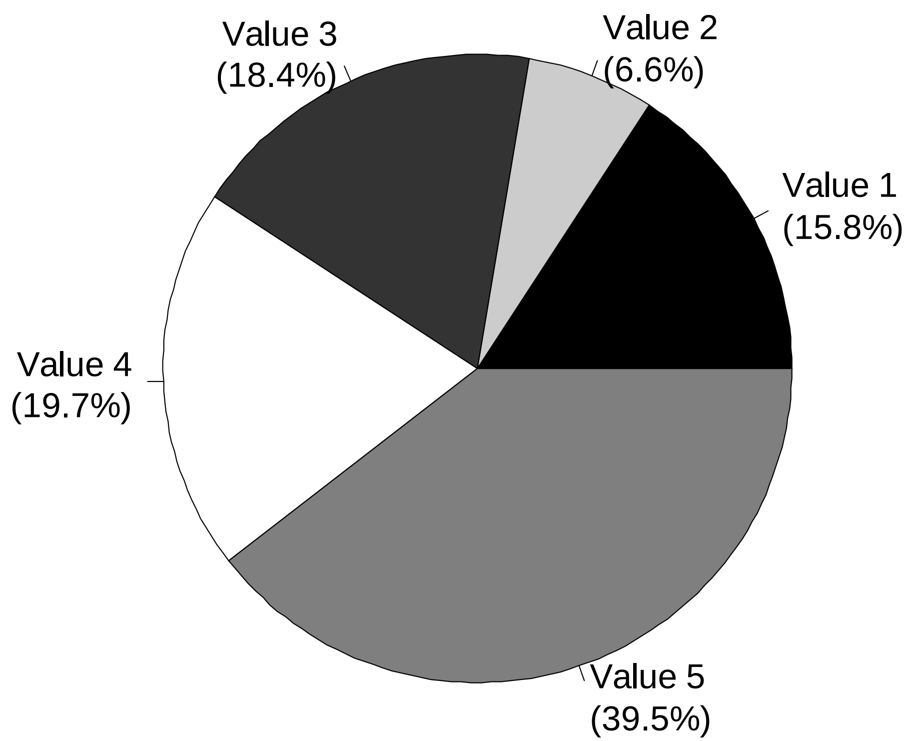


Figure 126. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 49 units) for San Ysidro Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

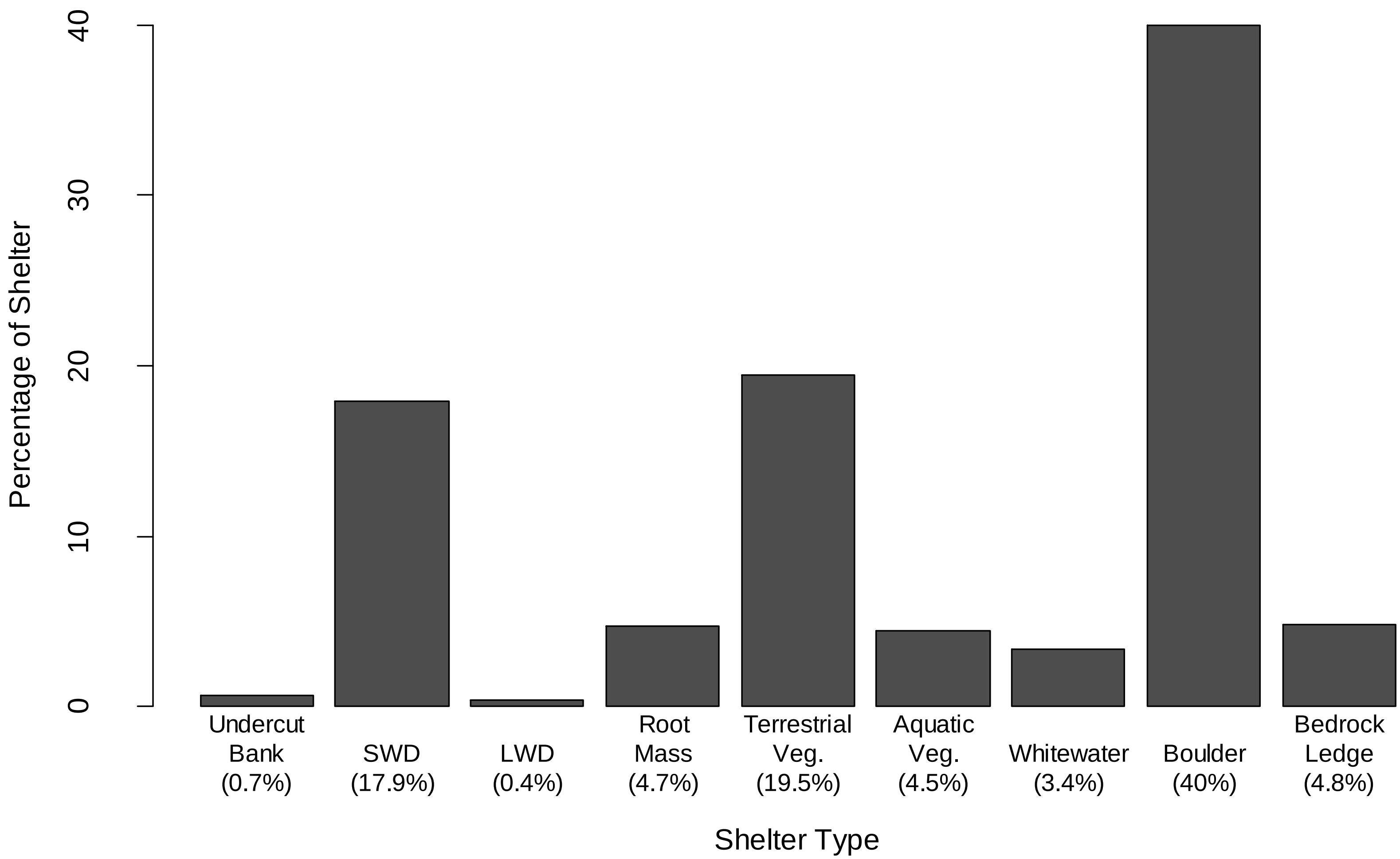


Figure 127. The percentage of shelter by shelter type across all pool units in which shelter was measured (n = 17 pools) for San Ysidro Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

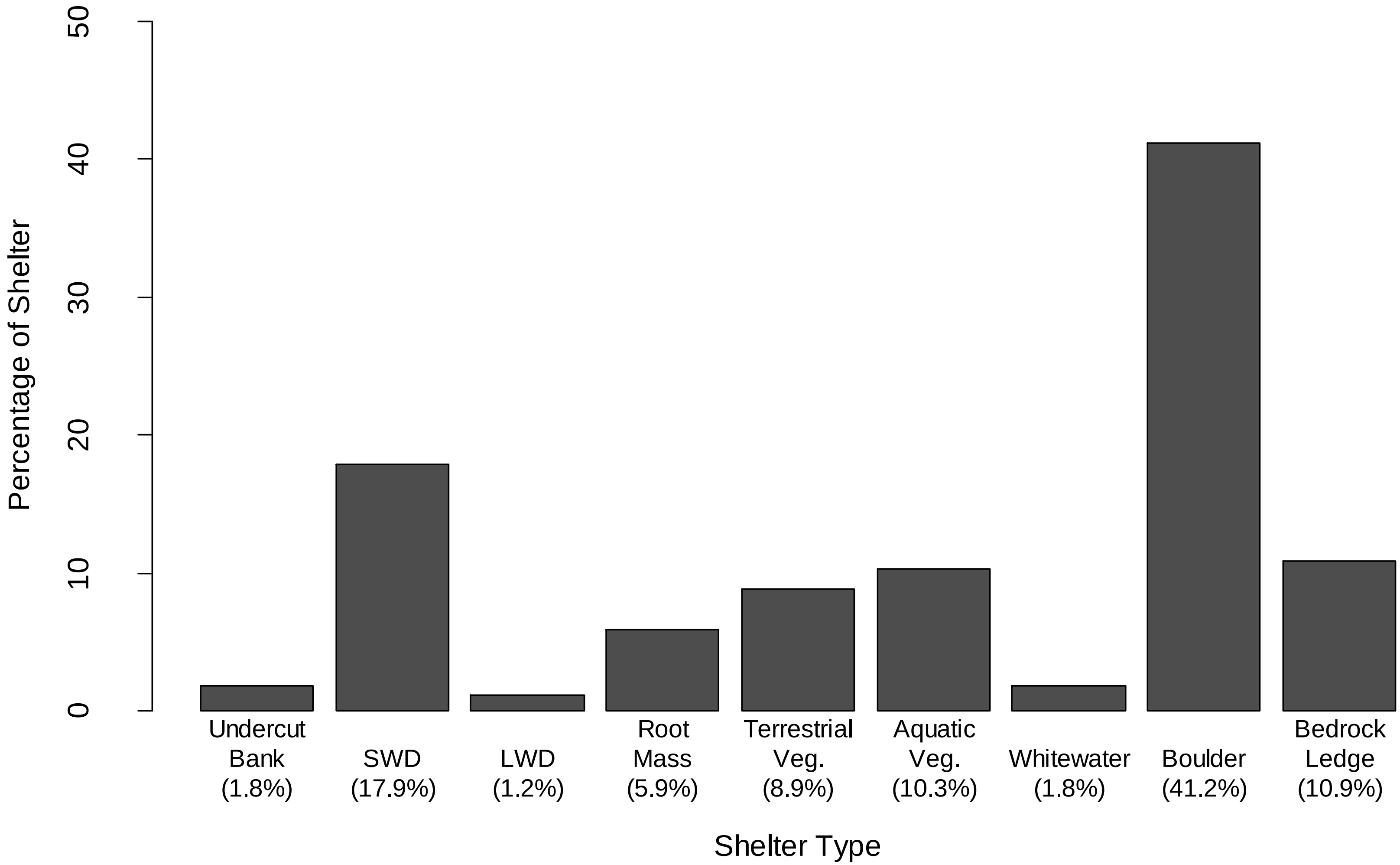


Figure 128. Percentage of banks by dominant substrate composition for San Ysidro Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock.

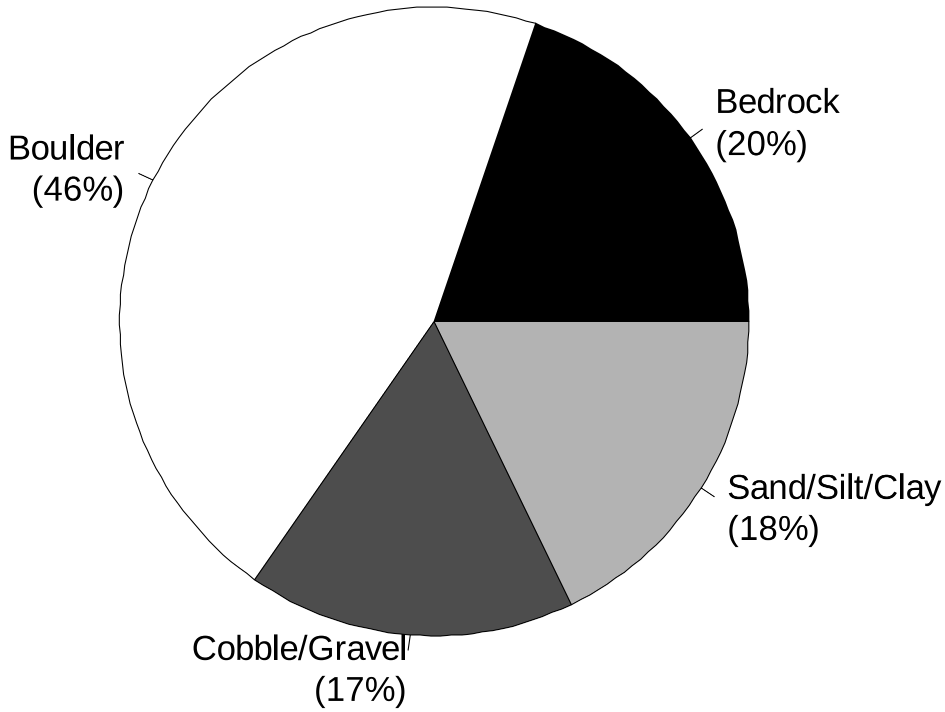
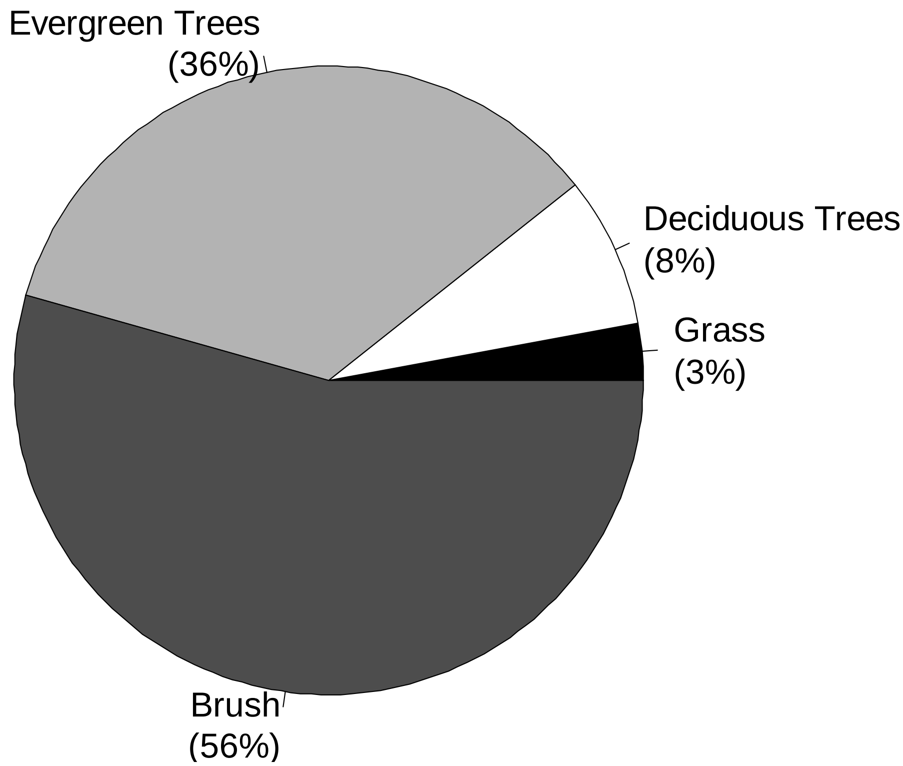


Figure 129. Percentage of banks by dominant vegetation type for San Ysidro Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



Romero Creek

Snorkel Survey

Results

On October 13, 2015, a snorkel survey was conducted on a stretch of Romero Creek . The survey reach began at the first snorkelable pool above the crossing of Romero Canyon Road with Romero Creek (34.45860, -119.59125) and extended 0.61 miles (3,3232 ft.) upstream ending at the last snorkelable pool observed within the wetted reach of Romero Creek (34.46728, -119.59080). The surveyed stretch is shown in Figure 130.

No individual *O. mykiss* were observed in any of the 16 habitat units that were snorkeled. No additional notable species were found during the snorkel survey of Romero Creek. The total snorkeled length of snorkeled units was 288.5 feet. Densities of fish counts per sum of habitat unit lengths (feet) and fish counts per sum of surface area (square foot) of habitat units are both 0.0 as no *O. mykiss* were observed.

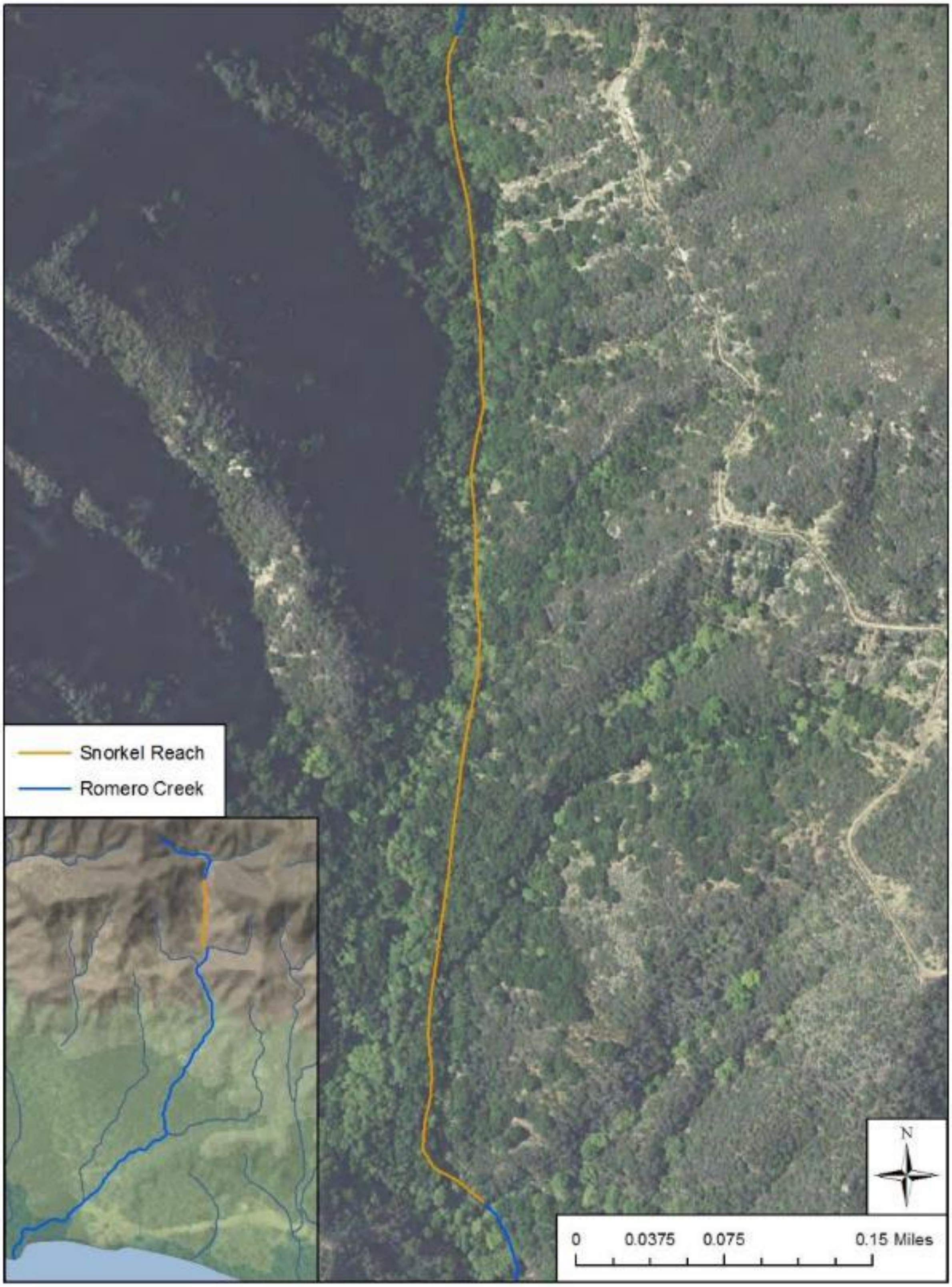
Discussion

On October 13, 2015, a snorkel survey was conducted on a 0.61 mile stretch of Romero Creek from the first snorkelable pool above the intersection with Romero Canyon Road to the last observed snorkelable pool within the reach. The purpose of this snorkel survey was to gain an understanding of the abundance and distribution of Southern California Steelhead (*O. mykiss*) in Romero Creek, located in the Conception Coast BPG, in Santa Barbara County.

Overall, this snorkel summary report shows us a snapshot of current *O. mykiss* abundance and distribution in Romero Creek. While surveyors did not record any observations of *O. mykiss* within Romero Creek, we cannot definitively say that fish were not present. No reliable estimates of population abundance can be made since we did not conduct electrofished calibration of the snorkel counts. Additional survey seasons must be completed in order to make a comparison of our observations. Subsequent surveys should include electrofishing to we can make accurate population estimates as per Hankin & Reeves 1988.

Figures

Figure 130. Map of surveyed reach for Romero Creek, 2015.



Habitat Assessment

Results

The habitat inventory was conducted from 29 September to 8 October 2015 by Yi-Jiun Tsai, Terra Dressler, Marisa Morse, and Phillip Hunter from Pacific States Marine Fisheries Commission. The survey extended 7,227 feet upstream from the survey start (34.45292°N, -119.59081°W). The survey endpoint (34.46962°N, -119.58942°W) followed a prolonged dry stretch near the headwaters of Romero Creek (Figure 131). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 59 to 64°F. Air temperature ranged from 61 to 82°F.

Habitat type

Of the total number of habitat units surveyed (n = 213 units), 13.62% of units were dry, 14.6% were flatwaters, 38.5% were pools, 32.4% were riffles, and 0.9% was not surveyable. Of the total length of the reach surveyed, 52.7% was dry, 8.5% was composed of flatwaters, 14.3% was composed of pools, 24.1% was composed of riffles, and 0.4% was not surveyable (Figure 132).

We identified nine habitat types in Romero Creek. Mid-channel pools (28.6%), low gradient riffles (27.2%), and dry units (13.6%) were the most frequently recorded habitat types (Table 22). Dry (52.7%) and low-gradient riffles (22.4%) composed the greatest stream lengths.

Pool Metrics

A total of 82 pools were identified within the survey reach. Main channel pools were the only pool habitat unit type encountered within the reach.

No pools had residual depths of three feet or greater (Figure 133).

Within pool tail-outs, silt/clay was the most frequently observed dominant substrate (31.3% of pool units), followed by boulders (16.3%; Figure 134).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (82.7%; Figure 135)

Shelter

Within 100% units (n = 36), riffle habitat types had a mean shelter rating of 41.9, flatwaters had a mean shelter rating of 37.9, and pools had a mean shelter rating of 68.1.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that small woody debris provided the most shelter (38.8% of all shelter; Figure 136). When we examined the percentage of shelter within pools only, we found that small wood debris was the most dominant cover type (32.5% of the total cover), followed by terrestrial vegetation (25.3%; Figure 137).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 88.7%. Within the canopy cover present, 46.4% of the canopy was composed of deciduous trees and 53.6% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were bedrock (16.3%), boulder (45.0%), and silt/sand/clay (38.8%; Figure 138). The mean percentage of vegetation covering the right bank in sampled units was 55.9%, and the mean percentage of vegetation covering the left bank was 51.9%. Evergreen trees were the dominant vegetation type, having been observed in 48.8% of the banks surveyed. Additionally, 32.5% of banks surveyed had brush and 12.5% had deciduous trees as the dominant vegetation (Figure 139).

Large Woody Debris

We observed four pieces of LWD that were 6 to 20 feet long and one piece that was greater than 20 feet long within 3395.5 feet of wetted stream length (excluding dry and unsurveyable lengths). Across both LWD sizes, the number of LWD observed was 0.15 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 17.6 feet.

Discussion

Temperature

The water temperature of units measured ranged from 59 to 64°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Good to Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools or riffles. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools or low-gradient riffles. When we examined the reach in terms of length, we found that most of the reach was dry or riffles, with low-gradient riffles comprising the greatest percentage of wetted stream length.

Pool Metrics

Pool depth is an important indicator of habitat quality, as deeper pools can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in Romero Creek, we found that most pools had residual depths less than two feet deep. However, a residual depth of at least three feet is needed to be considered good habitat (Kier Associates & NMFS 2008). Thus, it appears that pools in Romero may lack the depth needed to provide good hiding cover and rearing space. This may be due in part to the current, severe drought, which has extended into its fourth consecutive year.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was silt/clay, comprising 31.3% of pool units. Pool units most frequently had an embeddedness value of five. Together, these metrics suggest that, pools in Romero Creek does not provide good spawning habitat for *O. mykiss*.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that pools had the highest shelter ratings and that flatwaters had the lowest.

When we examined the percentage shelter by shelter type, we found small woody debris provided the most shelter both across all 100% units and within pool units only.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In Romero Creek, we estimated a mean canopy cover of 88.7%, consisting of high percentages of both evergreen and deciduous trees. This suggests that Romero has a moderately high amount of cover (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was boulder, followed by bedrock. The mean percentage of vegetation covering the right and left banks was 55.9% and 51.9%, respectively. Evergreen trees and brush were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively protected from erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In Romero Creek, we found 0.15 pieces of LWD per 100 feet, which was extremely low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Romero Creek lacks LWD, it may have boulder elements that improve habitat quality.

Tables

Table 22. Percentage of units (n = 213) by habitat type for Romero Creek.

Habitat Type	% of units
Mid Channel Pool	28.64%
Low Gradient Riffle	27.23%
Dry	13.62%
Run	11.74%
Step Pool	9.86%
Bedrock Sheet	3.76%
Step Run	2.82%
Cascade	0.94%
Not Surveyable	0.94%
High Gradient Riffle	0.47%

Figures

Figure 131. Map of the habitat assessment survey area in Romero Creek.

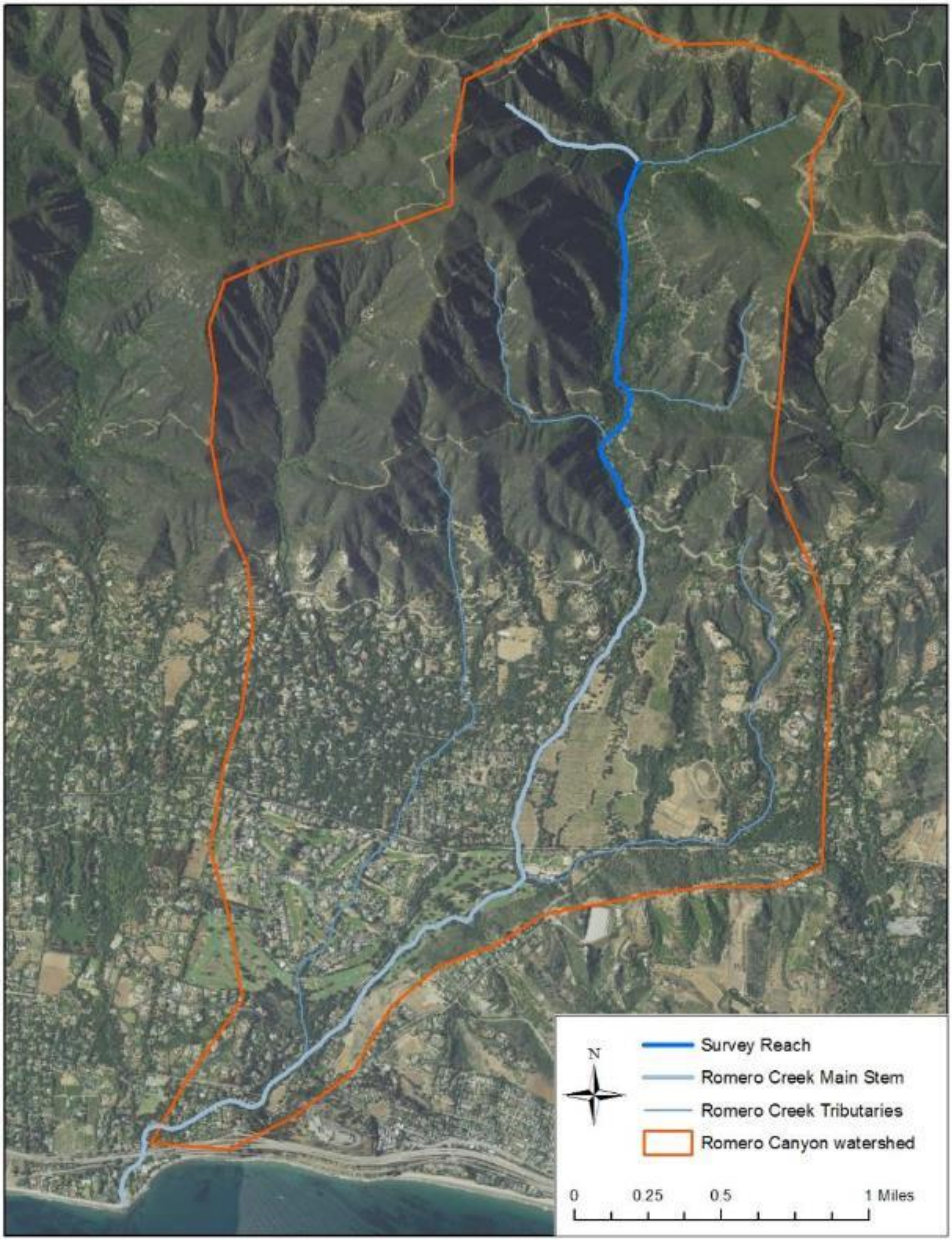


Figure 132. Percentage of total stream length categorized as pools, flatwaters, riffles, dry or not surveyable for Romero Creek.

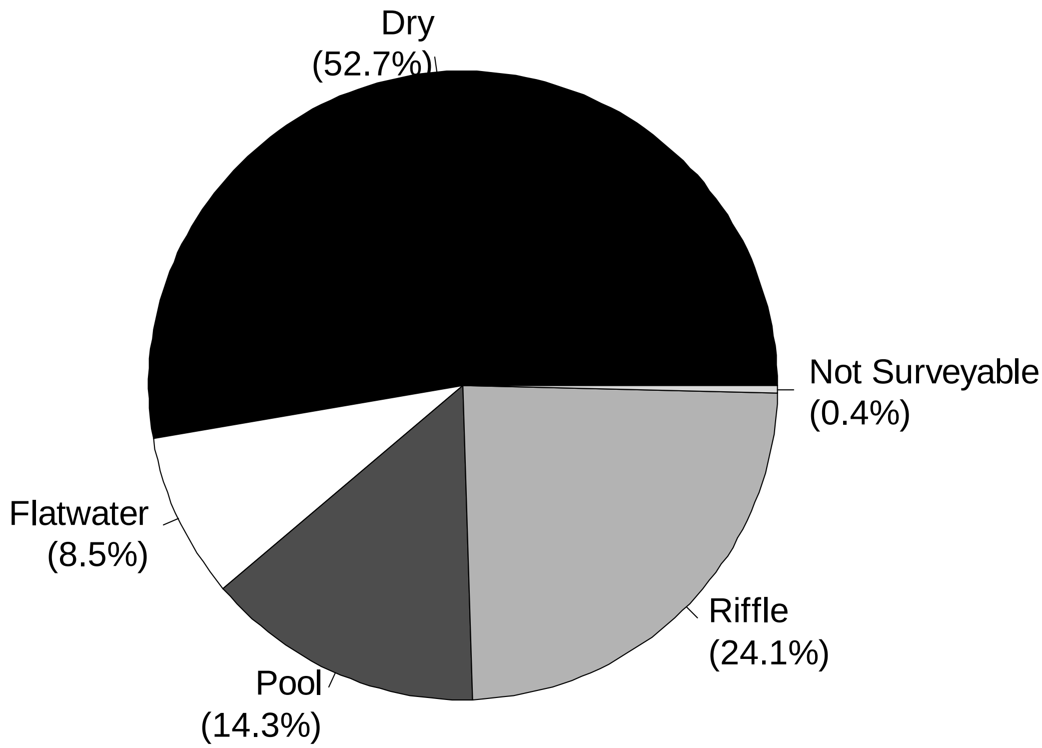


Figure 133. Histogram of residual pool depths in one-foot bins for Romero Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

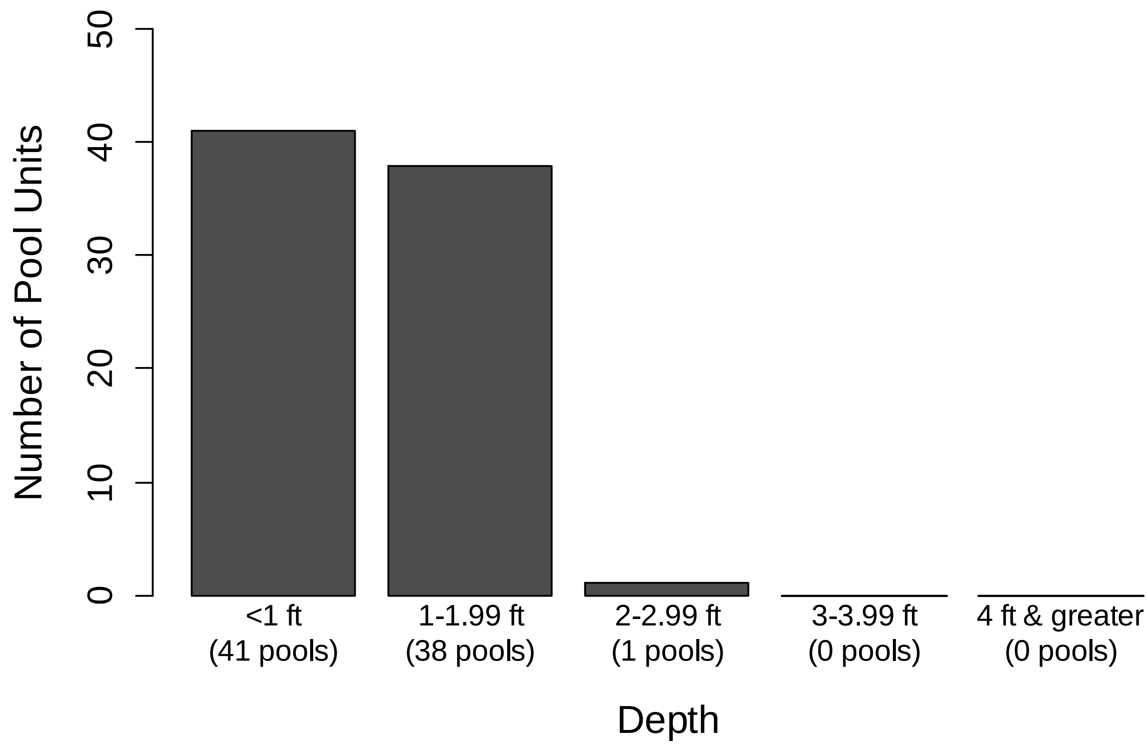


Figure 134. Percentage of pool tail-outs (n = 82 pools) by dominant substrate for Romero Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

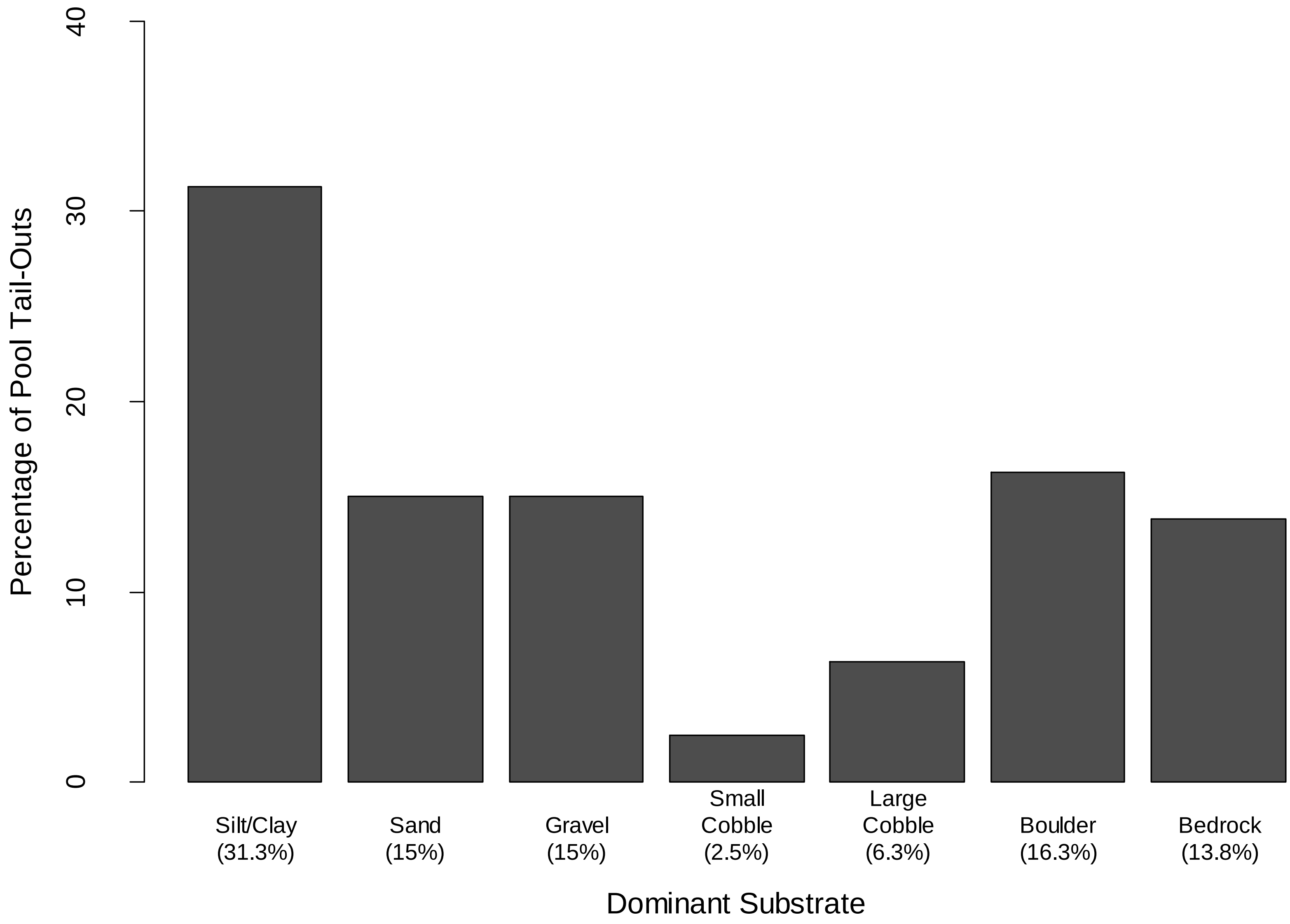


Figure 135. Percentage of all pool units (n = 82 pools) assigned a pool tail-out embeddedness value of 1 to 5 for Romero Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning. In this survey, no pool tail-outs were assigned an embeddedness value of 4.

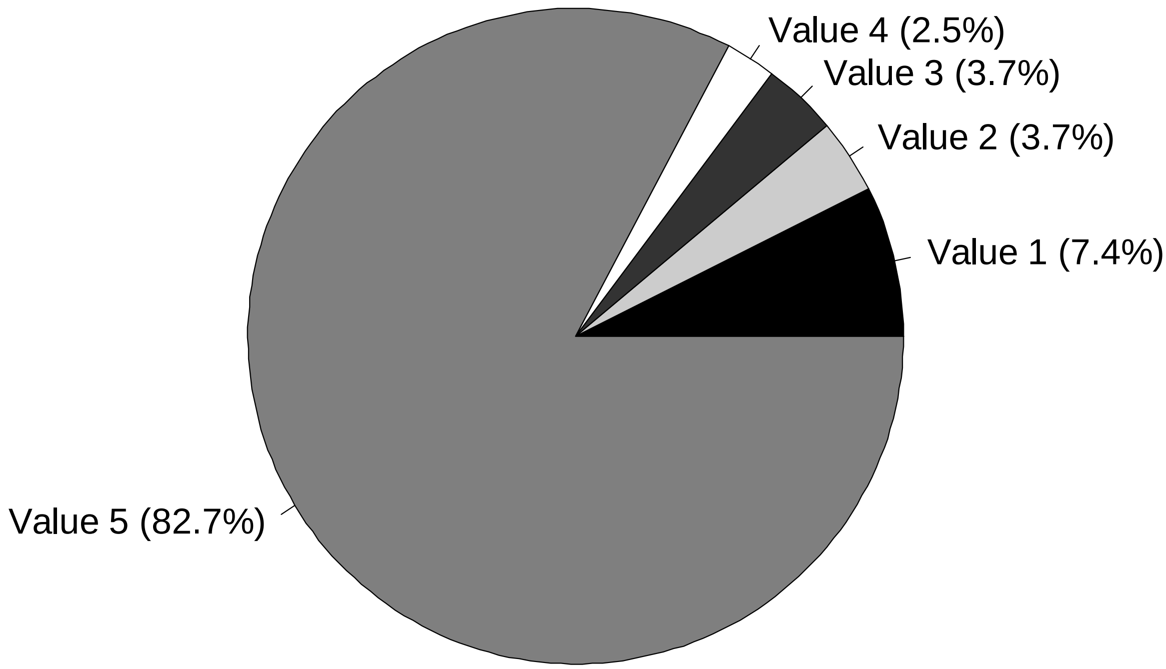


Figure 136. The percentage of instream shelter by shelter type across all units in which shelter was measured (n =36 units). Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

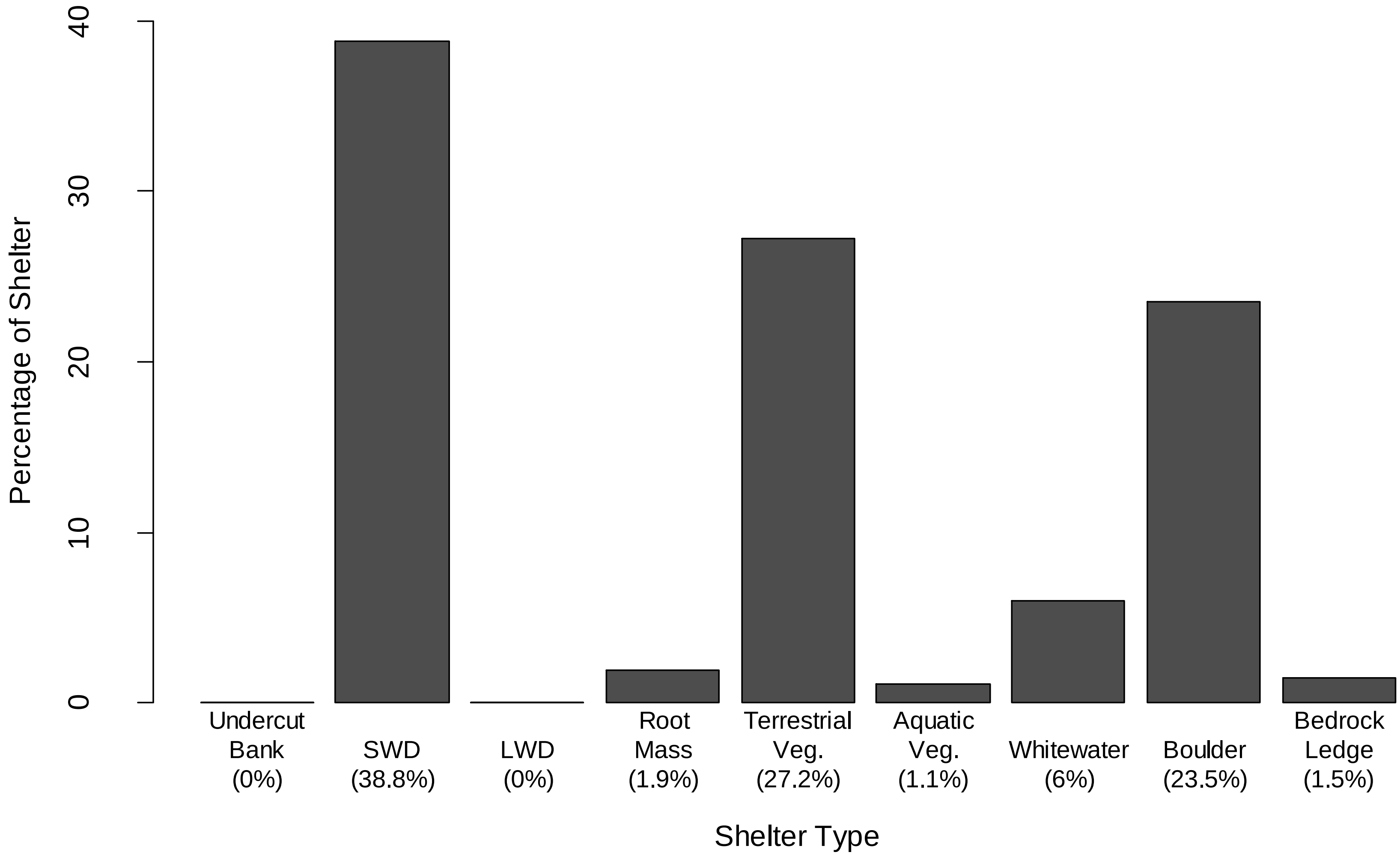


Figure 137. The percentage of shelter by shelter type across all pool units in which shelter was measured (n = 16 pools). Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

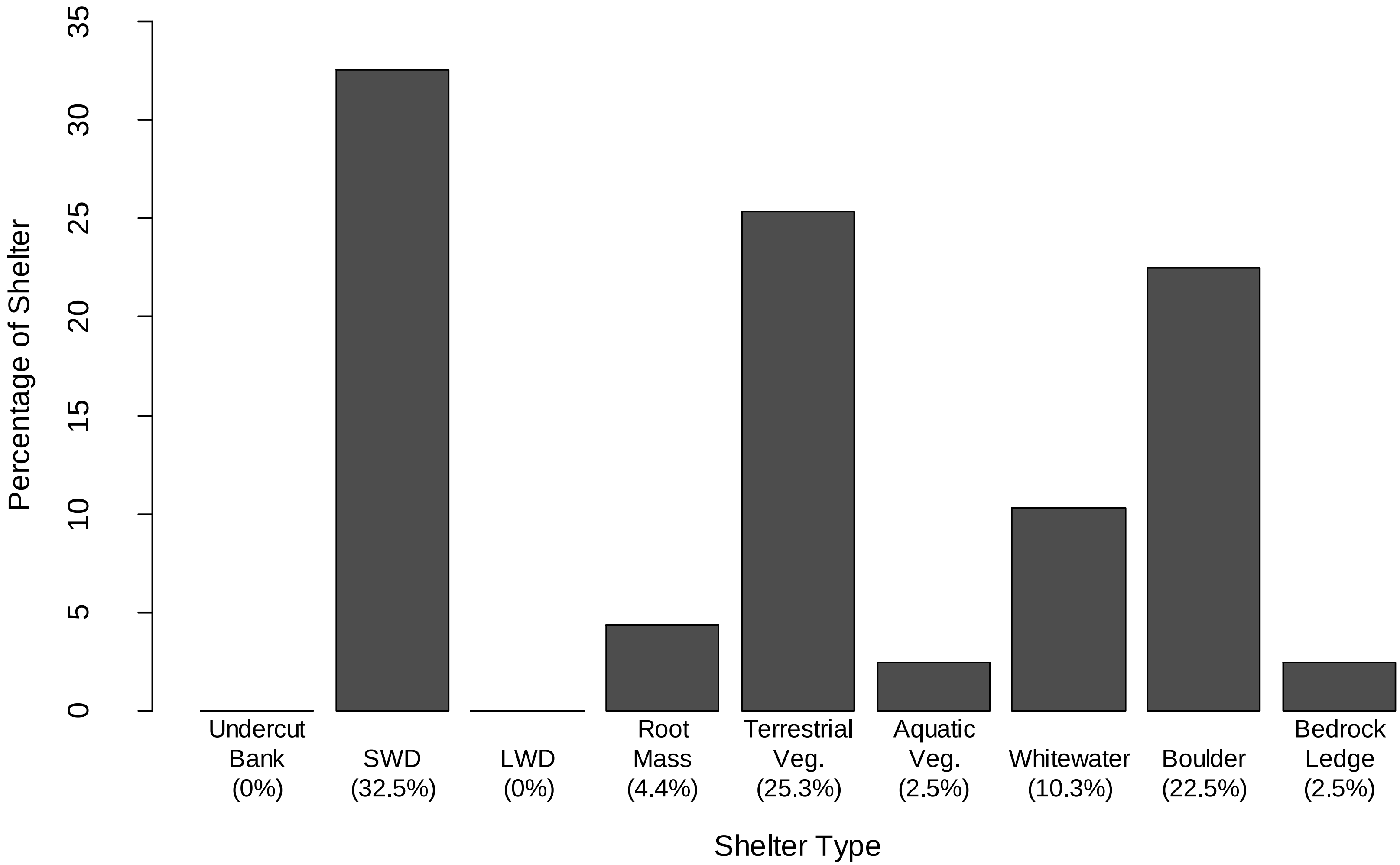


Figure 138. Percentage of banks by dominant substrate composition for Romero Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock.

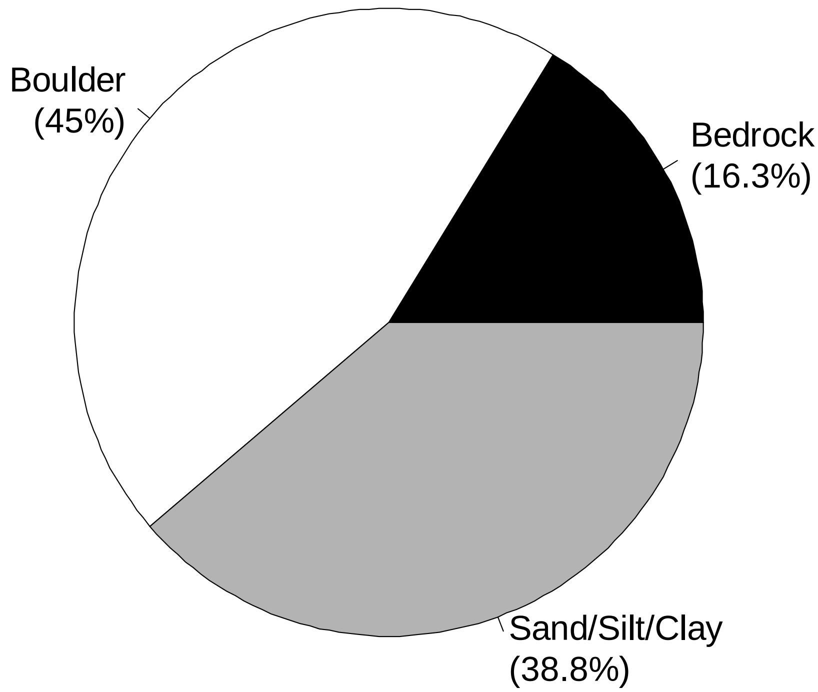
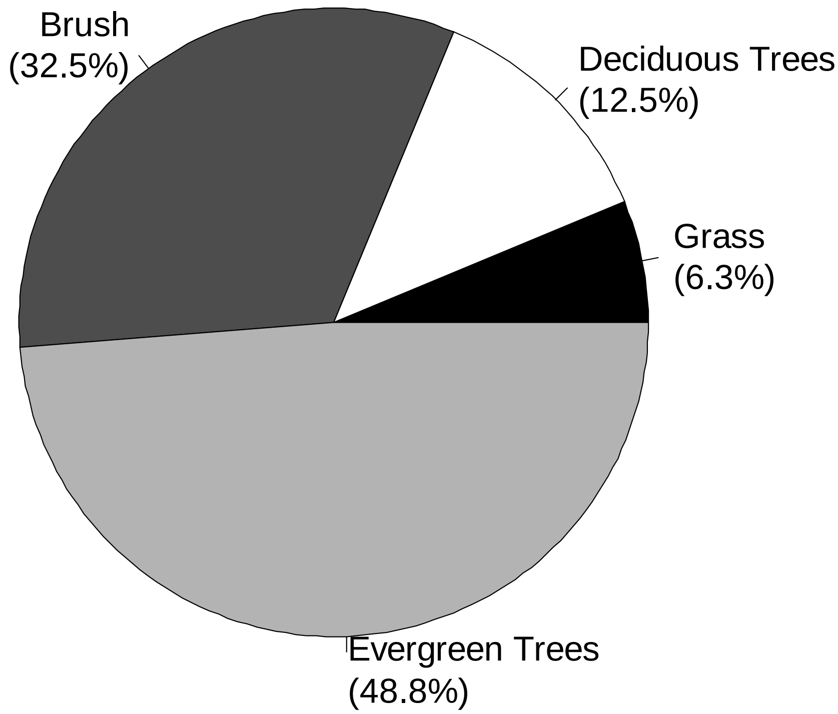


Figure 139. Percentage banks by dominant vegetation type for Romero Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



Carpinteria Creek

Snorkel Survey (2014)

<u>Results</u>

On November 17 and 18, 2014, a snorkel survey was conducted on a stretch of Carpinteria Creek. In the 0.85 mile surveyed stretch, a total of nine *O. mykiss* were observed in varying size classes indicated in

Table 23 and Figure 140 below. The total length of all snorkeled units was 1,336.5 feet within the 0.85 mile (4,498 ft) reach. *O. mykiss* were observed in 6 of the 53 individual habitat units surveyed. Figure 141 shows the distribution of *O. mykiss* over the surveyed reach.

The average number of *O. mykiss* per unit length calculates to be 6.73 x 10^{-3} fish/ft. This was calculated by taking total of observed fish and dividing by the sum of all the lengths of snorkeled units. The average number of *O. mykiss* per unit area calculates to be 6.46 x 10^{-4} fish/ft^2. This was calculated by taking the total number of fish observations and dividing by sum of all the individual surface areas for each snorkeled unit.

We have also summarized *O. mykiss* counts for shelter values below in

Table **24** and Figure 142. In addition, we plotted *O. mykiss* observations with respect to total surface area of each habitat unit and this is shown in Figure 143 below. The number of *O. mykiss* observations with respect to the length of each habitat unit was also plotted and this is shown below in Figure 144.

Discussion

On November 17 and 18, 2014, a snorkel survey was conducted on a 0.85 mile stretch of Carpinteria Creek. The purpose of this snorkel survey was to gain an understanding of the abundance and distribution of southern California steelhead (*O. mykiss*) inhabiting the creek. The nine observed fish ranged in size from 2 to 10 inches, with the majority of the observed fish being between 4 and 8 inches.

There was no distinct correlation between *O. mykiss* observations and the surface area and length of the pools they were found in. This is most likely due to the small sample size of nine fish. *O. mykiss* density was then calculated in relation to the total length of the surveyed pools as well as the combined total surface area of the surveyed pools. Again this returned no significant relationships most like due to very low fish counts.

In Carpinteria Creek, 85% of the surveyed units had a shelter value of 2, 11% of the surveyed units had a shelter value of 1, and only 4% of the pools had a shelter value of 3. It is not surprising that most of the fish observations were in pools with a shelter value of 2, since the majority of the surveyed pools had a shelter value of 2. This discrepancy in shelter value distribution may be explained by the importance of large woody debris and complex features in the shelter rating system. Large woody debris is uncommon in Southern California streams. In addition, below average rainfall and water levels may have reduced the availability of complex habitat features.

Snorkelers collected observation data on California Newts, but this was not the emphasis of this study. Due to the large number of observations of this species and the inconsistencies in observational methodology, this data was not included in this report.

Overall, this snorkel summary report shows us a snapshot of what age classes were present and where *O. mykiss* were distributed on Carpinteria Creek. We were able to calculate an index of fish density but without additional survey seasons; no reliable inferences can be made. We can make no reliable estimates of population abundance since we did not conduct electrofished calibration of the snorkel counts. Additional survey seasons must be completed in order to make a comparison of our observations. Subsequent surveys should include electrofishing to we can make accurate population estimates as per Hankin and Reeves 1988.

Tables

Table 23. First pass *O. mykiss* observations by size class for Carpinteria Creek, 2014.

***O. mykiss* Size Class (in)**	**Number of *O. mykiss* Observed**
0-1.99	0
2-3.99	1
4-5.99	4
6-7.99	3
8-9.99	1
10-11.99	0

Table 24. *O. mykiss* counts and number of habitat units with respect to shelter values for Carpinteria Creek, 2014.

Habitat Unit Shelter Values	*O. mykiss* Observed per Shelter Value	# of Habitat Units with Shelter Value
0	0	0
1	1	6
2	7	45
3	1	2

Figures

Figure 140. Size class distributions of *O. mykiss* observations for Carpinteria Creek, 2014.

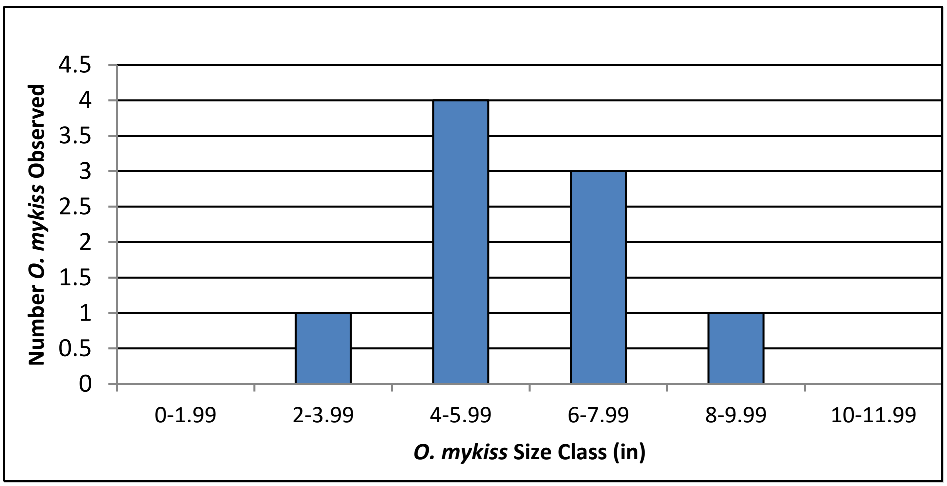


Figure 141. Distribution map of *O. mykiss* observed in Carpinteria Creek, 2014.

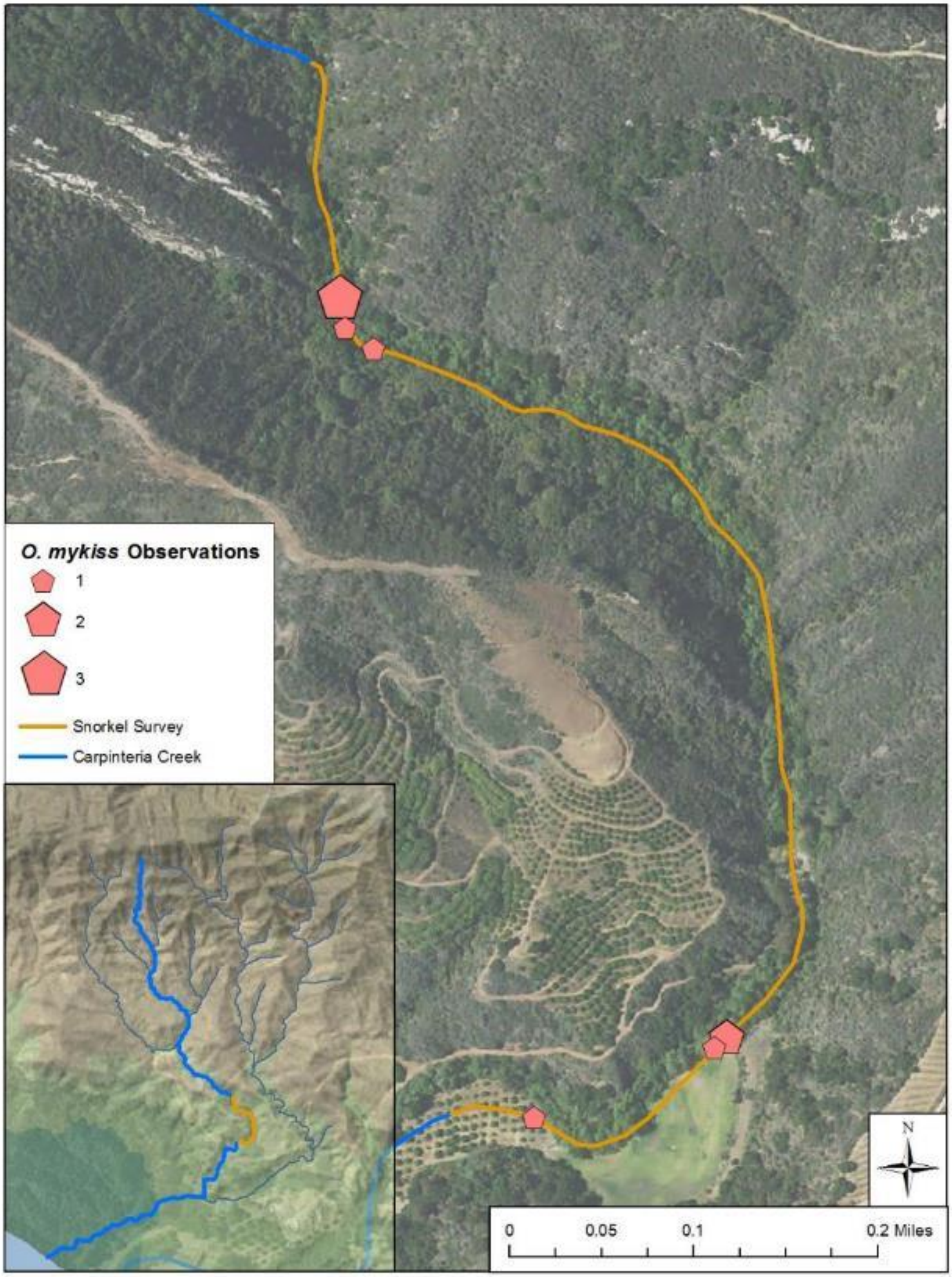


Figure 142. *O. mykiss* size class observations plotted against shelter values for Carpinteria Creek, 2014.

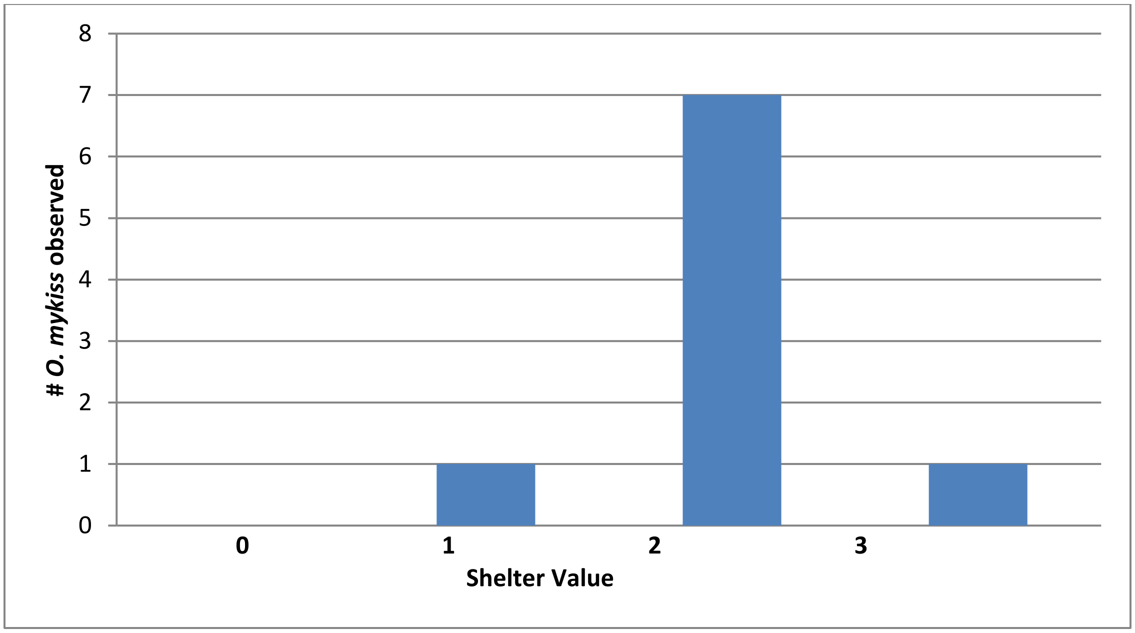


Figure 143. *O. mykiss* observations plotted over habitat unit surface area for Carpinteria Creek, 2014.

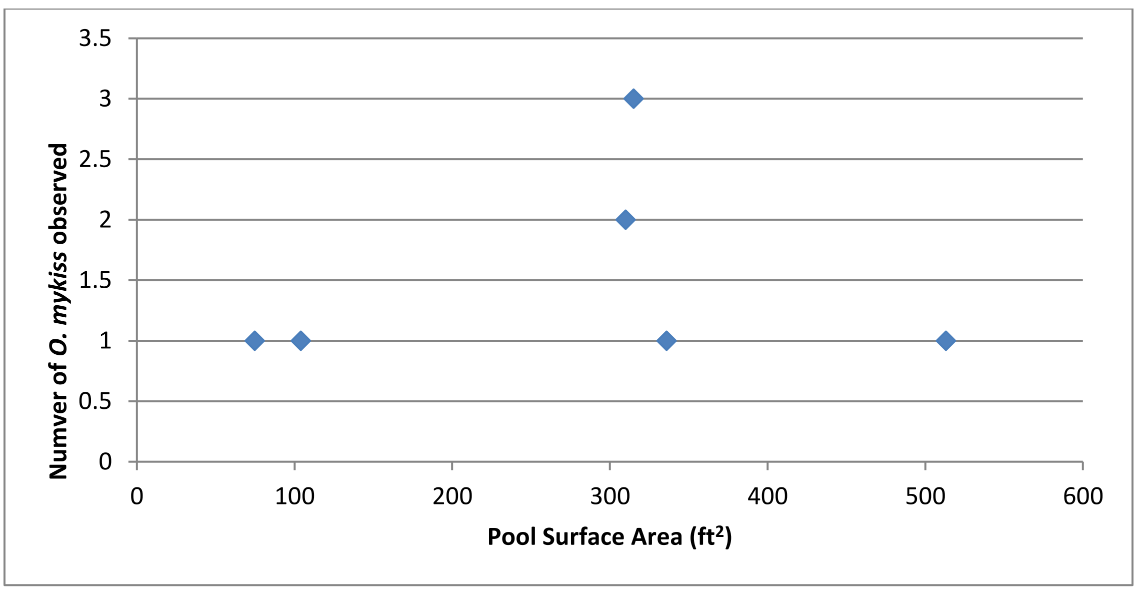
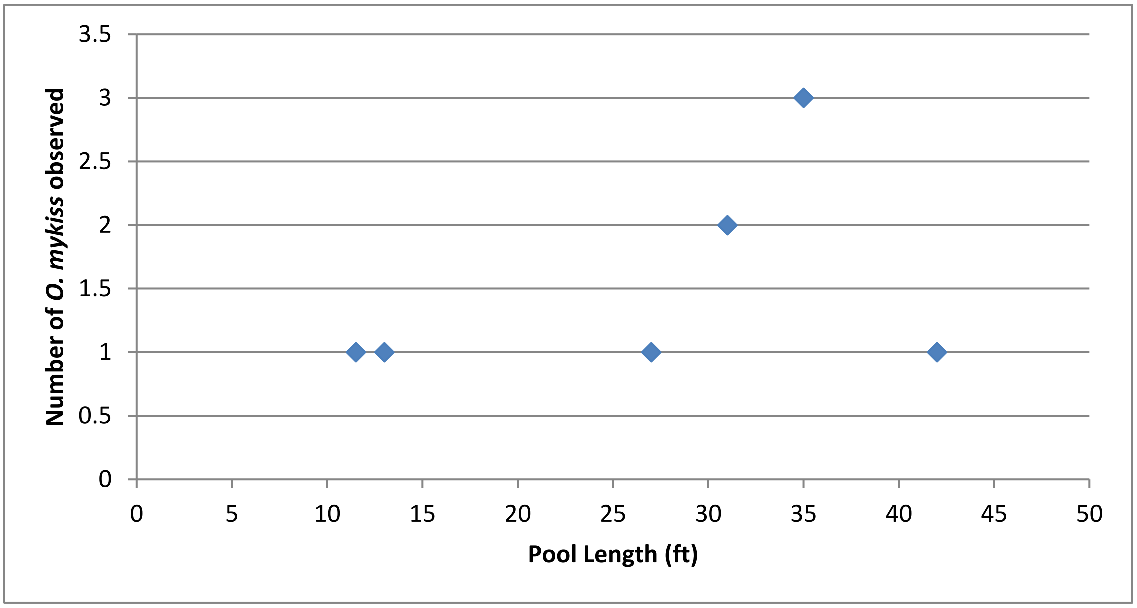


Figure 144. *O. mykiss* observations plotted over habitat unit length for Carpinteria Creek, 2014.



Snorkel Survey (2015)

Results

Survey summary data is graphically represented in the tables and figures section below.

Discussion

The goal of this report was to obtain an abundance index and distribution data for *O. mykiss* in Carpinteria Creek of Santa Barbara County. Snorkel survey data for June 3 and October 20 of 2015 were compared. 35 more units and 890 feet more were snorkeled in October than June.

We have summarized the counts, habitat units measurements and densities in Table 25. We also compared the total observations in 2014 and 2015 by sorting fish into size classes as shown in Table 26. Lastly, we show *O. mykiss* observations as seen by shelter value for both 2014 and 2015 in Table 27.

When analyzing *O. mykiss* distribution, we noticed that although six trout total were observed in June, 4 of them were observed within 225 feet of one another. In addition, eight trout total were observed in October and 6 of the trout were witnessed within 230 feet of each other. Of the 14 total observations of trout in 2015, 10 fish observations occurred within 335 feet of length.

The size class with the greatest *O. mykiss* frequency was 6-7.99 in for both dates surveyed in 2015. However, there were only 14 total fish observations on both snorkel surveys, so these values should be considered with caution.

Observed *O. mykiss* presence within shelter value of 2 had the greatest frequency. However, since both surveys yielded a low frequency of trout observations, these values can lead to a misrepresentation of how fish presence correlates to habitat complexity.

In conclusion, this data reveals little of the total abundance of *O. mykiss* populations in Carpinteria Creek. With so few fish observed, distribution was also inconclusive. Overall, this snorkel summary report shows us a snapshot of what age classes were present and where *O. mykiss* were distributed on Carpinteria Creek. We were able to calculate an index of fish density but without additional survey seasons; no reliable inferences can be made. We can make no reliable estimates of population abundance since we did not conduct electrofished calibration of the snorkel counts.

Additional survey seasons must be completed in order to make a comparison of our observations. Subsequent surveys should include electrofishing to we can make accurate population estimates as per Hankin and Reeves 1988.

Tables

Table 25. *O. mykiss* density based on total units, length snorkeled, and total surface area for two surveys in Carpinteria Creek, 2015.

Date	03-Jun	20-Oct
O. mykiss Abundance	6	8
Units Snorkeled	40	75
Total Length (ft) Snorkeled	877	1767
Total Surface Area (ft^2) Snorkeled	9,643	16,883
O. mykiss Density per Unit	1.50×10^{-1}	1.07×10^{-1}
O. mykiss Density per Length (ft)	6.84×10^{-3}	4.53×10^{-3}
O. mykiss Density per Surface Area (ft^2)	6.22×10^{-4}	4.74×10^{-4}

Table 26. Carpinteria Creek *O. mykiss* abundance observed within each size class for two surveys in Carpinteria Creek, 2015.

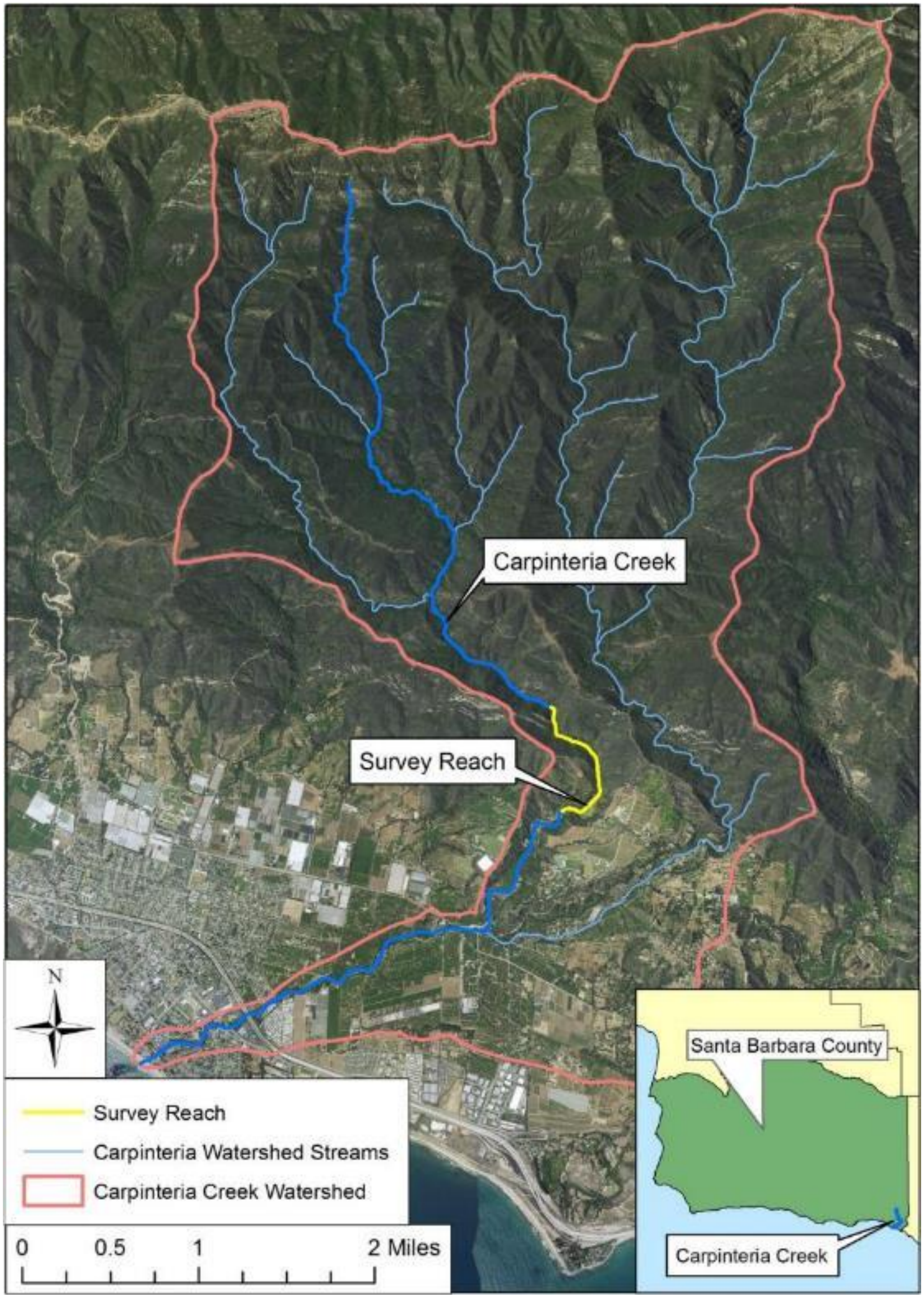
Observed *O. mykiss* Size Class Distribution						
Date	0-1.99	2-3.99	4-5.99	6-7.99	8-9.99	10-11.9
03-Jun	0	0	1	4	0	1
20-Oct	0	0	3	4	1	0

Table 27. *O. mykiss* abundance and presence by habitat complexity for two surveys in Carpinteria Creek, 2015.

Date	03-Jun			20-Oct		
Shelter Value	1	2	3	1	2	3
O. mykiss Abundance	0	5	1	0	8	0
Total Surface Area (sq^2)	973	8,378	292	2,551	14,332	0
Unit Count with O. mykiss	0	5	1	0	6	0
Total Units	4	35	1	15	60	0

Figures

Figure 145. The Carpinteria Creek 2015 snorkel survey reach and surrounding watershed.



Gobernador Creek

Snorkel Survey (2015)

Results

A length of approximately 1.43 miles was snorkel surveyed on October 20, 2015. The survey began at the confluence of Carpinteria Creek and ended at a bedrock and boulder waterfall that served as a total natural barrier (Figure 146). A total of 6 *O mykiss* were observed in 2015. The average number of *O. mykiss* per unit length calculates to be3.13 x 10^{-2} fish/ft. This was calculated by taking total of observed fish and dividing by the sum of all the lengths of snorkeled units. The average number of *O. mykiss* per unit area calculates to be 3.39 x 10^{-3} fish/ft^2. This was calculated by taking the total number of fish observations and dividing by sum of all the individual surface areas for each snorkeled unit.

A similar snorkel survey was conducted by CDFW, PSMFC and SCHR on November 17, 2014. We have summarized the counts, habitat units measurements and densities in Table 28. We also compared the total observations in 2014 and 2015 by sorting fish into size classes as shown in Table 29. Lastly we show O. mykiss observations as seen by shelter value for both 2014 and 2015 in Table 30.

Discussion

The goal of this report was to obtain an abundance index and distribution data for *O. mykiss* in Gobernador Creek of Santa Barbara County. Snorkel survey data for 2014 and 2015 were compared. Three more units were surveyed in 2014 than 2015, but 43 feet more of length was snorkeled in 2015.

The size class with the greatest *O. mykiss* frequency was 2-3.99 in for the snorkel survey conducted in 2014. In 2015, the size range of 4-5.99 in had the greatest frequency. However, there were only 14 total fish observations on both snorkel surveys, so these values should be considered with caution.

Observed *O. mykiss* presence within shelter value of 2 had the greatest frequency. However, since both surveys yielded a low frequency of trout observations and few snorkeled units, these values could lead to a misrepresentation of how fish presence correlates to habitat complexity.

In conclusion, this data reveals little of the total abundance of *O. mykiss* populations in Gobernador Creek. With so few fish observed, distribution was also inconclusive. More research needs to be done to understand *O. mykiss* population density, abundance, and distribution in Gobernador Creek of the Carpinteria watershed. Overall, this snorkel summary report shows us a snapshot of what age classes were present and where *O. mykiss* were distributed on Gobernador Creek. We were able to calculate an index of fish density but without additional survey seasons; no reliable inferences can be made. We can make no reliable estimates of population abundance since we did not conduct electrofished calibration of the snorkel counts. Additional survey seasons must be completed in order to make a comparison of our observations. Subsequent surveys should include electrofishing to we can make accurate population estimates as per Hankin and Reeves 1988.

Tables

Table 28. *O. mykiss* density based on total units, length snorkeled, and total surface area for surveys conducted in 2014 and 2015 in Gobernador Creek.

Year	**2014**	**2015**
O. mykiss Abundance	8	6
Units Snorkeled Count	8	5
Total Length (ft) Snorkeled	149	192
Total Surface Area (ft^2) Snorkeled	831	1,768
O. mykiss Density per Unit	1.00	1.20
O. mykiss Density per Length (ft)	5.37×10^{-2}	3.13×10^{-2}
O. mykiss Density per Surface Area (ft^2)	9.63×10^{-3}	3.39×10^{-3}

Table 29. Gobernador Creek *O. mykiss* abundance observed within each size class for surveys conducted in the same reach in 2014 and 2015.

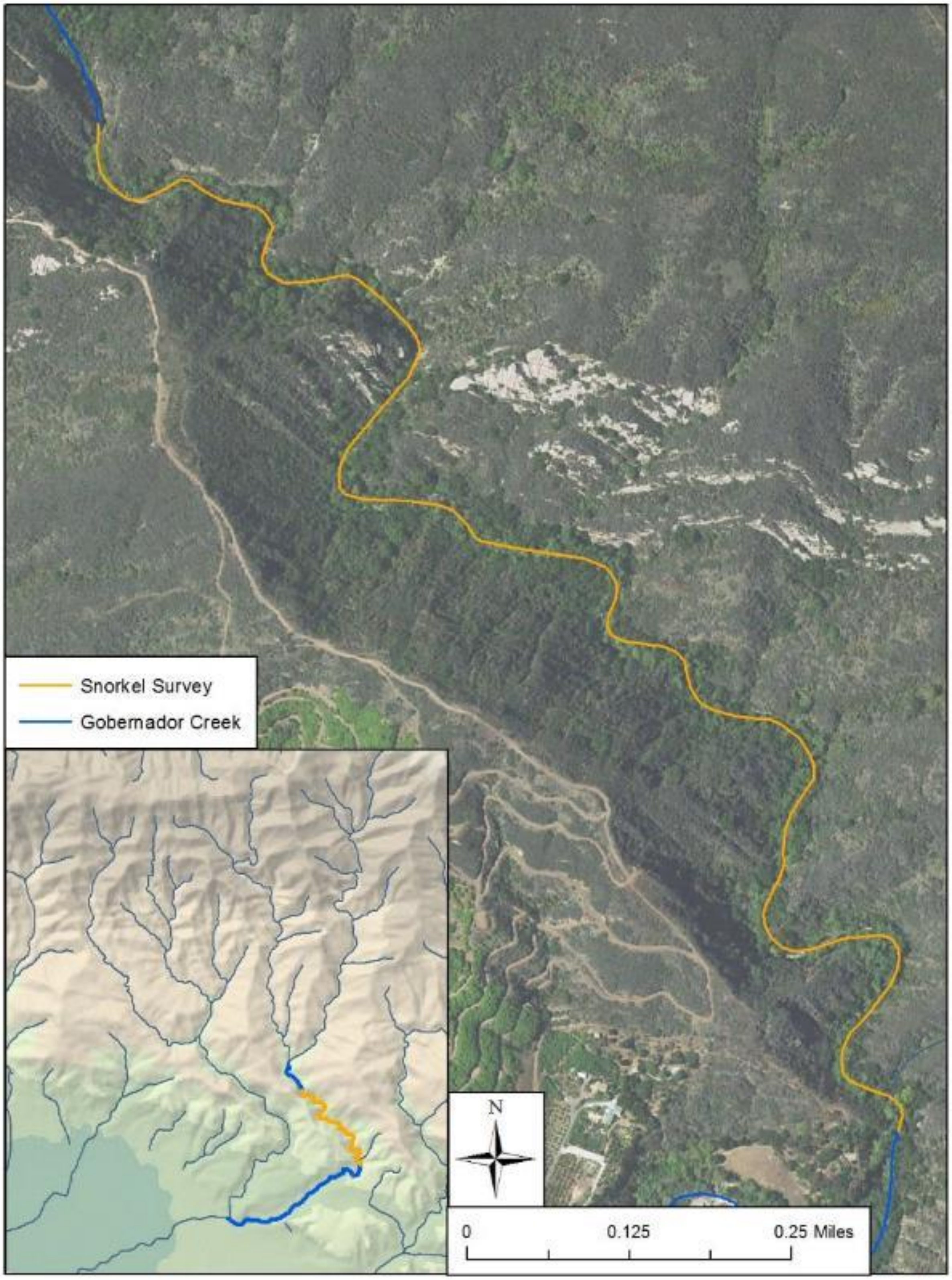
Observed *O. mykiss* Size Class Distribution						
Year	**0-1.99**	**2-3.99**	**4-5.99**	**6-7.99**	**8-9.99**	**10-11.9**
2014	0	5	1	2	0	0
2015	0	0	4	1	1	0

Table 30. *O. mykiss* abundance and presence by habitat complexity for surveys conducted in the same reach in 2014 and 2015.

Date	**2014**			**2015**		
Shelter Value	**1**	**2**	**3**	**1**	**2**	**3**
O. mykiss Abundance	0	8	0	0	6	0
Total Surface Area (ft^2)	46	785	0	0	1,768	0
Unit Count with O. mykiss	0	2	0	0	1	0
Total Unit Count	2	6	0	0	5	0

Figures

Figure 146. Map of the snorkeled reach in Gobernador Creek in 2014.



Ventura River

DIDSON

Results

2014

DIDSON deployment opportunities were limited to times when target systems exhibited sufficient migration flows coupled with connectivity to the ocean, allowing for potential passage of anadromous adults. For the 2014 DIDSON season, this amounted to a single deployment event brought on by the largest observed rainfall event for the year. Flow response and duration varied between field sites and consequently, so did DIDSON deployment duration (Table 31). Cameras were removed once flow and water levels reached a point where sites were no longer accessible to anadromous individuals. During this time, no anadromous adults were detected at any of our three sites.

2015

Due to historic lows in rainfall throughout the region, flow requirements were not met for any of our sites resulting in no deployments for the season.

2016

A single deployment event has been captured thus far for the 2016 season. This event occurred in response to a series of winter storms leading to the breaching of seasonal sand berms and stream connectivity for Carpinteria Creek and Ventura River. Deployment duration is shown in Table 32 below. Once again, cameras were removed once flow and water levels reached a point where sites were no longer accessible to anadromous individuals. Preliminary analysis suggests that no adult steelhead were observed at either site.

Tables

Table 31. Deployment dates for the 2014 DIDSON season.

Site	Deployment Dates	Peak Flow
Salsipuedes Creek	Feb 27 – March 13	158 ft^3/s
Carpinteria Creek	Feb 28 – March 2	37 ft^3/s
Ventura River	Feb 27 – March 25	3180 ft^3/s

Table 32. Deployment events for the 2016 season to date.

Site	Deployment Dates	Peak Flow
Carpinteria Creek	Feb 28 – March 2	37 ft^3/s
Ventura River	January 5 – January 11	906 ft^3/s

Redd Surveys

2014

Results

A total of 13 redds were observed during the 2014 survey season in five reaches throughout the Ventura River watershed including the Ventura River reach 5 (VR5), San Antonio Creek reaches 1 and 2 (SA 1 and 2), and North Fork Matilija Creek reaches 1 and 2 (NFM 1 and 2). Table 33 indicates the number of redds observed by date. Though redds were recorded as early as February 13, 2014, these and any other existing redds were destroyed by rains from a significant storm system that occurred from February 27 to March 2, 2014. During these four days the city of Ventura received 4.7 inches of rain (Ventura County Watershed Protection District 2014). The majority of redds were observed after the storm between March 24 and April 14, 2014 with most occurring in North Fork Matilija reaches 1 and 2 (Table 33). The average total length (average pot length plus average tail spill length) for observed redds in the Ventura River watershed was 62.22 cm (24.5 in). Table 34 and Table 35 outline the average measurements for redds in the surveyed reaches as well as the averages for the watershed as a whole.

It is important to note that 2011-2014 has been the second driest three year period in California since at least 1895 (Seager et al. 2014). With extreme drought persisting in California, many crucial sections of creeks became dry. Some redds, including the one pictured in Figure 147, were in sections that dewatered. The number of redds detected and the measurements recorded were potentially affected by sections of creek going dry.

***Oncorhynchus mykiss* Observation Results**

Bankside *O. mykiss* observations were recorded opportunistically during each redd survey. Individual fish were potentially recorded more than once with repeat surveys of the same reaches on different days. *O. mykiss* were observed in 6 of the 10 surveyed reaches: Ventura 1 and 5 (Table 36); San Antonio 1, 2, and 4 (Table 37) and North Fork Matilija 1 and 2 (Table 38). North Fork Matilija Creek had the most *O. mykiss* observations with 68 individuals recorded between the two reaches (Table 38; Figure 148). Counts were low in San Antonio Creek (n=4) and in the Ventura River main stem (n=2), likely due in part to long dry stretches in those reaches. Only fish 10 cm or greater were recorded as *O. mykiss*, due to difficulty in distinguishing smaller fish from other species found in these systems.

Other Species Observations Results

Observations of special status species including the Two-striped Gartersnake (*Thamnophis hammondii*), California Red-legged frog (*Rana draytonii*), and Southern Western Pond turtle (*Actinemys pallida*) were also recorded during redd surveys. Field crew members, differing in their ability to identify species, recorded these observations opportunistically while following normal redd survey protocols.

California Red-Legged Frogs

California Red-legged frogs (CRLF) are a federally threatened species and opportunistic sightings of adult individuals (Figure 149) and egg masses (Figure 150) were recorded during surveys.

All CRLF observations were in San Antonio Creek with the majority in reach 1 (Table 39). Efforts were made to not double count egg masses by referencing GPS points of previous surveys.

Two-striped Gartersnake

Observations of Two-striped Gartersnakes (TSGS) were recorded when individuals could be positively identified. These snakes were seen from January through May, during the entirety of the spawning season, and were observed in most reaches in all systems (Table 40; Figure 151).

Southern Western Pond Turtles

Southern Western Pond Turtles (WPT) were observed in most surveyed reaches, with the largest concentration in San Antonio Creek during the entirety of the survey season from late January to late May (Table 41; Figure 152). It is likely that some double-counting occurred as individuals were never marked or tagged. When possible, carapace lengths and sex were recorded.

Discussion

Since 2010, California has experienced extremely dry years causing a severe drought throughout most of the state. On January 17, 2014 Governor Jerry Brown declared a “Drought State of Emergency” for this unprecedented period of low rainfall (California Drought 2014). Such conditions have dramatically affected the Ventura River watershed by reducing flows and water levels and creating intermittency in streams. With rainfall totals throughout the state reaching record lows for the 2013-2014 water year, opportunity for steelhead migration has been limited. During this water year, downtown Ventura only received 6.14 inches of rain which amounts to about 42 % of average annual rainfall totals (Ventura Watershed Protection District 2014). In 2013, the city only received 44 % of average annual rainfall. In 2014, the first significant rainfall occurred on February 27, 2014 from a strong storm system that caused periods of heavy rainfall through March 02, 2014. This system caused a short lived high flow event causing flows in the Ventura River main stem to break the sand berm where the river meets the ocean and briefly allow for fish passage into the estuary. Peak flow was measured at 3,180 cubic feet per second (ft^3/s) with the USGS gauge height at 12.86 feet on March 1, 2014 (USGS 2014). However, this measurement is not indicative of average flow for this system. Figure 153 shows how quickly flow decreased after the storm passed, with flow returning to virtually zero after a few days and remaining at that level for the rest of the year.

As the city of Ventura received 77% of its rainfall from this single rain event (Ventura Watershed Protection District 2014), the migration window for steelhead to move up through the watershed from the ocean was extremely limited. Our results suggest a very low likelihood of any migrating steelhead in the Ventura watershed. In addition to there being a very small window for any *O. mykiss* to move into the river during the few days that the berm was open and allowed passage, the redds that we observed averaged 62.22 cm in length. Research indicates that steelhead redds are substantially larger than resident rainbow trout redds with average lengths approximately 28% larger in anadromous individuals (Zimmerman and Reeves 2000). The largest redd measured had a total length of 88 cm, still far smaller than a steelhead redd would likely be. A study conducted in Mendocino County, California found the average steelhead redd length to be 224 cm (Gallagher 2003). We would expect any steelhead redds to far exceed the redd sizes we observed. In addition, CDFW staff and PSMFC field crew members monitored the Ventura River main stem with DIDSON sonar cameras from February 27, 2014 to March 27, 2014. There were no *O. mykiss* identified through this monitoring effort with the camera recording continuously through this time period.

Based on the data from our redd surveys, limited connectivity of the Ventura River to the ocean and our DIDSON survey results, no anadromous *O. mykiss* are presumed to have spawned in the Ventura River watershed during the 2013-2014 water year.

In the Ventura River watershed for the 2013-2014 water year, 13 resident *O. mykiss* redds were detected. While this number can be used to track relative abundance of spawning female resident *O. mykiss* over time, we are unable to infer from this value the number of non-spawning resident females or the number of males without further study.

One potential source of error in our redd counts was that surveys were not always done biweekly due to necessary staff placement in other monitoring efforts. DIDSON monitoring of the Ventura River main stem in particular took a substantial amount of time and personnel resources. Due to these staffing limitations, it is possible that redds deteriorated and were no longer visible by the time crews returned to a reach, thereby influencing our redd counts. Regularity of redd surveys will be taken into consideration in future redd surveys, as funding, staffing levels and workloads allow.

With the continued drought persisting in California, the lack of suitable habitat will likely contribute to a decline in spawning steelhead until rainfall increases. During this spawning season, a large amount of steelhead habitat went dry. The largest recorded redd (Figure 154) was observed on March 17, 2014 in San Antonio Creek with a total length of 188 cm. This redd dried up along with its respected section of creek by May 16, 2014.

In 2013, 23 redds were recorded in this watershed. During the 2014 water year, only 13 redds were observed. These low numbers suggest that both resident and anadromous *O. mykiss* populations may not adequately be able to reproduce until drought conditions subside and rainfall increases. Further research on the effects of drought conditions on *O. mykiss* in southern California may prove especially useful in determining the role of climate change on partial migration strategies within the species' population groups. While we can infer that no southern steelhead migrated up the Ventura River this year, we must also consider the possibility that steelhead in the ocean that originated from the Ventura River could have migrated and spawned elsewhere. The ongoing drought in California is making it increasingly difficult for fish to access their natal spawning grounds and so it is highly possible that Ventura River fish are attempting to migrate into other streams exhibiting connectivity with the ocean. The data from this survey and from the DIDSON upstream migrant survey gives us no information on the number of steelhead currently in the ocean. Until rainfall increases and access between the river and ocean improves significantly, this number will remain difficult to estimate.

Tables

Table 33. New 2014 redd observations by stream reach (Ventura River Basin). Redd observations are listed for each survey date and stream reach. The number of redds seen on the survey is shown in red.

When a survey was complete but no new redds were found a black 0 is used. Blank cells indicate days where no survey occurred on the reach in question.

Survey Date	Stream Reach									
	VR1	VR2	VR3	VR4	VR5	SA1	SA2	SA4	NFM1	NFM2
1/22/2014	0									
1/27/2014							0			
1/30/2014									0	0
2/6/2014		0	0	0						
2/13/2014									1	0
2/21/2014						0				
2/26/2014									0	3
3/12/2014	0									
3/14/2014		0								
3/17/2014						1	0			
3/20/2014			0							
3/24/2014									2	
3/26/2014	0									
3/27/2014		0								
3/28/2014										2
4/2/2014									1	0
4/3/2014						0	2			
4/4/2014					0					
4/9/2014	0	0								
4/10/2014								0		
4/11/2014									0	0
4/14/2014					1					
4/18/2014						0	0			
4/21/2014	0									
4/23/2014		0								
5/2/2014						0	0			
5/5/2014	0									
5/8/2014		0								
5/9/2014									0	0
5/12/2014					0					
5/16/2014						0				
5/19/2014	0									
5/21/2014									0	0
5/28/2014					0					

Table 34. Average 2014 redd measurements for each surveyed reach and averages for all the surveyed reaches within the watershed (Ventura River Basin).

Reach	# of Redds	Average Pot Length (cm)	Average Pot Width (cm)	Average Pot Depth (cm)	Average Pot Substrate Size (cm)	Average Pot Area (cm)	Average Tail Spill Length (cm)	Average Tail Spill Width (cm)	Average Spill Subtrate Size (cm)	Tail Spill Average Area (cm)	Average Total Length (cm)
VR1	0	-	-	-	-	-	-	-	-	-	-
VR2	0	-	-	-	-	-	-	-	-	-	-
VR3	0	-	-	-	-	-	-	-	-	-	-
VR4	0	-	-	-	-	-	-	-	-	-	-
VR5	1	17	16	6	1	213.63	34	15.5	0.5	527	51
SA1	1	30.5	27.4	3.05	3.05	656.69	33.5	32	1.2	1073.03	64
SA2	2	31	43	3.75	1.25	1041.44	54	38.25	0.75	2088.5	85
SA4	0	-	-	-	-	-	-	-	-	-	-
NFM1	4	25.8	21.6	2.6	1.38	472.18	35.8	19.5	0.51	751.5	61.6
NFM2	5	22	20	4.5	1.75	345.58	27.5	17.25	0.75	473.75	49.5
Watershed Total	**13**	**25.26**	**25.60**	**3.98**	**1.69**	**545.90**	**36.96**	**24.50**	**0.74**	**982.76**	**62.22**

Table 35. Average 2014 redd measurements for each surveyed reach and averages for all the surveyed reaches within the watershed (Ventura River Basin).

Reach	# of Redds	Average Pot Length (in)	Average Pot Width (in)	Average Pot Depth (in)	Average Pot Substrate Size (in)	Average Pot Area (in)	Average Tail Spill Length (in)	Average Tail Spill Width (in)	Average Spill Subtrate Size (in)	Tail Spill Average Area (in)	Average Total Length (in)
VR1	0	-	-	-	-	-	-	-	-	-	-
VR2	0	-	-	-	-	-	-	-	-	-	-
VR3	0	-	-	-	-	-	-	-	-	-	-
VR4	0	-	-	-	-	-	-	-	-	-	-
VR5	1	6.69	6.30	2.36	0.39	84.11	13.39	6.10	0.20	207.48	20.08
SA1	1	12.01	10.79	1.20	1.20	258.54	13.19	12.60	0.47	422.45	25.20
SA2	2	12.20	16.93	1.48	0.49	410.02	21.26	15.06	0.30	822.24	33.46
SA4	0	-	-	-	-	-	-	-	-	-	-
NFM1	4	10.16	8.50	1.02	0.54	185.90	14.09	7.68	0.20	295.87	24.25
NFM2	5	8.66	7.87	1.77	0.69	136.05	10.83	6.79	0.30	186.52	19.49
Watershed Total	**13**	**9.94**	**10.08**	**1.57**	**0.66**	**214.92**	**14.55**	**9.65**	**0.29**	**386.91**	**24.50**

Table 36. *O. mykiss* observations in Ventura River main stem reaches in 2014. The number of *O. mykiss* observed during each survey is indicated in red. A black zero signifies that a survey was carried out but

no *O. mykiss* were observed. Blank cells indicate days where no survey occurred on the reach in question.

Survey Date	***O. Mykiss* Observations**				
	VR1	VR2	VR3	VR4	VR5
1/22/2014	0				
2/6/2014		0	0	0	
3/12/2014	0				
3/14/2014		0			
3/20/2014			0		
3/26/2014	0				
3/27/2014		0			
4/4/2014					1
4/9/2014	0	0			
4/14/2014					0
4/21/2014	0				
4/23/2014		1			
5/5/2014	0				
5/8/2014		0			
5/12/2014					0
5/19/2014	0				
5/28/2014					0

Table 37. *O mykiss* observations in San Antonio Creek in 2014by reach and survey date. The number of *O. mykiss* observed during each survey is indicated in red. A black zero signifies that a survey was carried out but no *O. mykiss* were observed. Blank cells indicate days where no survey occurred on the reach in question**.**

Survey Date	SA1	SA2	SA4
1/27/2014		2	
3/17/2014	2	0	
4/3/2014	0	0	
4/10/2014			0
4/18/2014	0	0	
5/2/2014	0	0	
5/16/2014	0		

Table 38. *O. mykiss* observations in North Fork Matilija Creek in 2014 by reach and survey date. The number of *O. mykiss* observed during each survey is indicated in red. A black zero signifies that a survey

was carried out but no *O. mykiss* were observed. Blank cells indicate days where no survey occurred on the reach in question.

Survey Date	NFM1	NFM2
1/30/2014	2	10
2/13/2014	4	13
2/26/2014	13	11
3/24/2014	0	0
3/28/2014	0	7
4/2/2014	2	1
4/11/2014	0	3
5/9/2014	0	1
5/21/2014	1	0

Table 39. California Red-Legged Frog observations in all surveyed reaches in 2014 (Ventura River Basin). Blue numbers represent CRLF egg masses while red numbers indicate the number of adult frogs. A black zero signifies that a survey was carried out but no CRLF were observed. Blank cells indicate days where

no survey occurred on the reach in question. While CRLF tadpoles were observed during some surveys, they were not included in this table due to difficulty in accurately quantifying their numbers.

Survey Date	Red Legged Frog Counts (Blue represents egg mass, red represents frog)									
	VR1	VR2	VR3	VR4	VR5	SA1	SA2	SA4	NFM1	NFM2
1/22/2014	0									
1/27/2014							0			
1/30/2014									0	0
2/6/2014		0	0	0						
2/13/2014									0	0
2/21/2014						2				
2/26/2014									0	0
3/12/2014	0									
3/14/2014		0								
3/17/2014						12, 3	2			
3/20/2014			0							
3/24/2014									0	
3/26/2014	0									
3/27/2014		0								
3/28/2014										0
4/2/2014									0	0
4/3/2014						2	0			
4/4/2014					0					
4/9/2014	0	0								
4/10/2014								0		
4/11/2014									0	0
4/14/2014					0					
4/18/2014						0	0			
4/21/2014	0									
4/23/2014		0								
5/2/2014						0	0			
5/5/2014	0									
5/8/2014		0								
5/9/2014									0	0
5/12/2014					0					
5/16/2014						0				
5/19/2014	0									
5/21/2014									0	0
5/28/2014					0					

Table 40. Observations of Two-striped Gartersnakes in the Ventura River Basin in 2014. Red number indicate Two-striped Gartersnake observations in surveyed reaches. Black zeros indicate a completed survey with no TSGS observations. Blank cells indicate days when no survey was completed.

Survey Date	Stream Reach									
	VR1	VR2	VR3	VR4	VR5	SA1	SA2	SA4	NFM1	NFM2
1/22/2014	0									
1/27/2014							0			
1/30/2014									0	1
2/6/2014		0	0	0						
2/13/2014									0	0
2/21/2014										
2/26/2014									0	0
3/12/2014	0									
3/14/2014		0								
3/17/2014						0	0			
3/20/2014			0							
3/24/2014									0	
3/26/2014	0									
3/27/2014		0								
3/28/2014										0
4/2/2014									0	0
4/3/2014						0	0			
4/4/2014					0					
4/9/2014	1	1								
4/10/2014								2		
4/11/2014									0	1
4/14/2014					0					
4/18/2014						0	0			
4/21/2014	0									
4/23/2014		0								
5/2/2014						0	0			
5/5/2014	0									
5/8/2014		0								
5/9/2014									0	0
5/12/2014					0					
5/16/2014						2				
5/19/2014	0									
5/21/2014									2	0
5/28/2014					0					

Table 41. Observations of Southern Western Pond Turtles in surveyed reaches of the Ventura River Basin in 2014. Individual counts are indicated by red numbers. Black zeros indicate that no WPTs were observed during a completed survey. Blank cells represent days when no survey was completed.

Survey Date	Stream Reach									
	VR1	VR2	VR3	VR4	VR5	SA1	SA2	SA4	NFM1	NFM2
1/22/2014	1									
1/27/2014							0			
1/30/2014									0	0
2/6/2014		0	0	0						
2/13/2014									0	0
2/21/2014						1				
2/26/2014									1	1
3/12/2014	4									
3/14/2014		0								
3/17/2014						6	4			
3/20/2014			0							
3/24/2014									2	
3/26/2014	7									
3/27/2014		4								
3/28/2014										0
4/2/2014									0	1
4/3/2014						3	0			
4/4/2014					2					
4/9/2014	6	4								
4/10/2014								19		
4/11/2014									1	0
4/14/2014					1					
4/18/2014						6	11			
4/21/2014	2									
4/23/2014		1								
5/2/2014						0	1			
5/5/2014	0									
5/8/2014		1								
5/9/2014									0	0
5/12/2014					0					
5/16/2014						3				
5/19/2014	1									
5/21/2014									4	0
5/28/2014					0					

Figures

Figure 147. Observed redd in San Antonio Creek March 17, 2014.

Figure 148. The number of bankside observations of *O. mykiss* in North Fork Matilija Creek. Blue columns represent counts of *O. mykiss* in North Fork Matilija Creek reach 1 and red columns indicate

counts in North Fork Matilija Creek reach 2 by date. Zeros indicate that no *O. mykiss* were recorded on that survey.

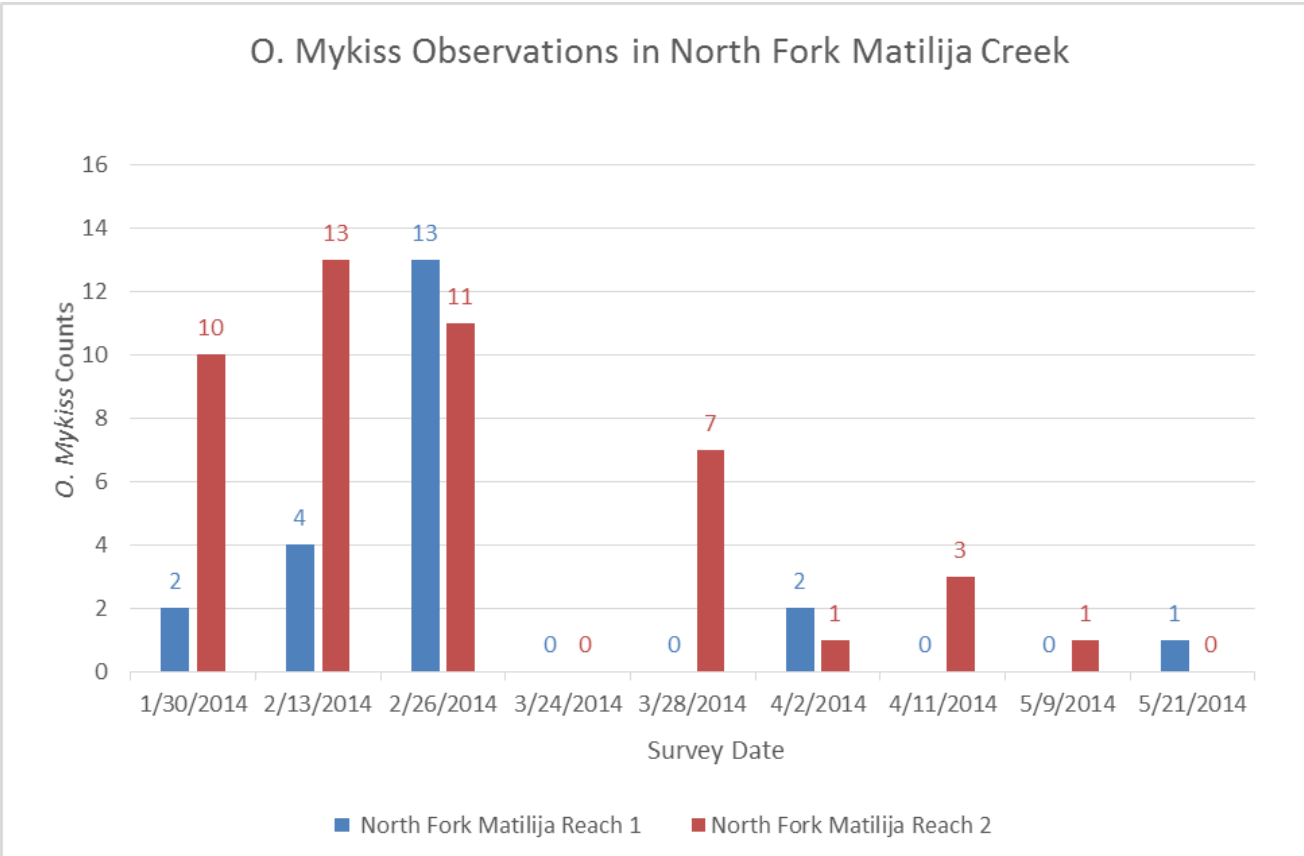


Figure 149. California Red-legged Frog observed in San Antonio Creek March 17, 2014.

Figure 150. California Red-legged Frog egg mass observed in San Antonio Creek March 17, 2014.

Figure 151. Two-striped Gartersnake observed in North Fork Matilija Creek on April 11, 2014.

Figure 152. Southern Western Pond Turtle observed in San Antonio Creek on March 17, 2014.

Figure 153. USGS graph indicating peak flow in the Ventura River main stem for the 2013 water year (USGS 2014).

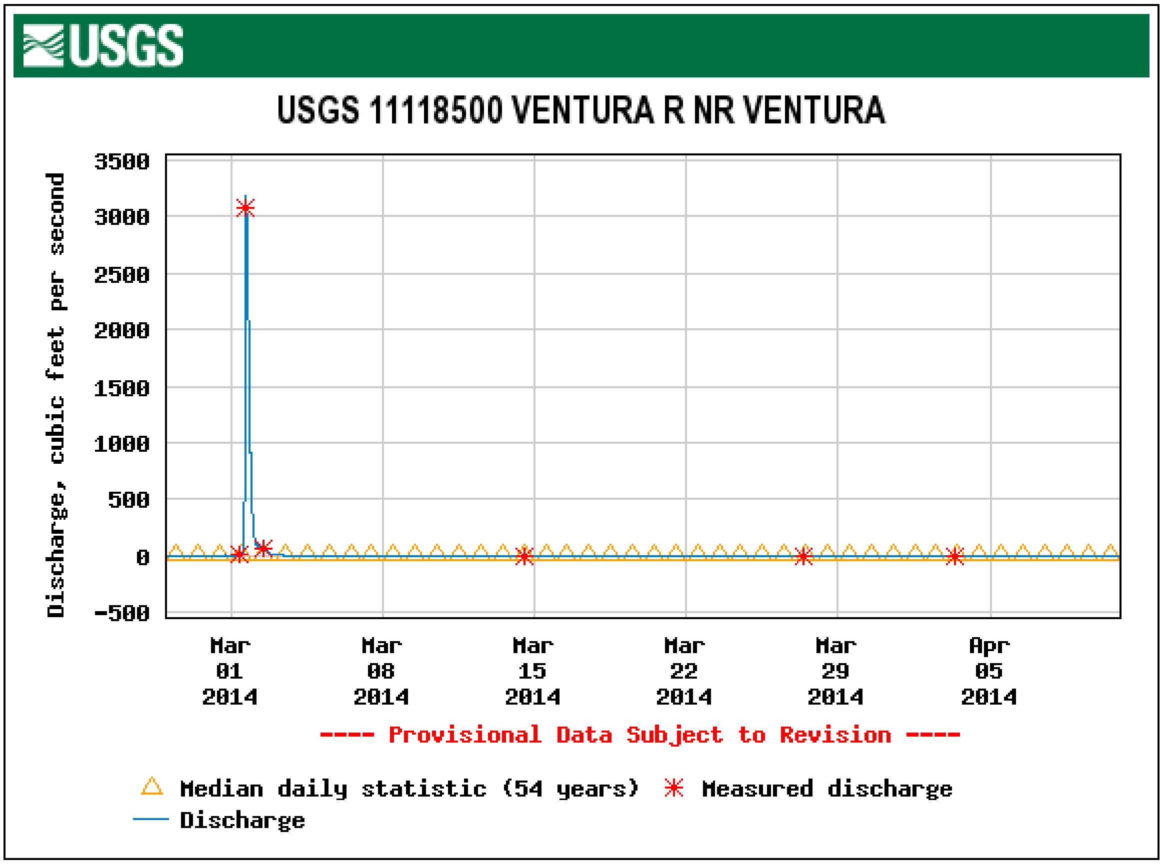


Figure 154. Observed redd in San Antonio Creek Reach 1, March 17, 2014, that later became dry.

2015

Results

A total of 24 redds were observed during the 2015 survey season in five reaches throughout the Ventura River watershed. Redds were observed in Upper Matilija reach 2, North Fork Matilija reaches 1, 2, and 4 (Bear Creek), and Upper North Fork. However, only two of the surveyed reaches in which redds were observed are considered anadromous. These are North Fork Matilija reaches 1, 2, and 4 (Bear Creek). All redds found in Matilija Creek and Upper North Fork Matilija Creek are assumed to be products of freshwater resident *O. mykiss* due to the Matilija Dam's prevention of anadromous migration to these reaches. All new redds were observed between February 12, 2015 and April 14, 2015. Tables

Table **42** displays each new redd observation by date and stream reach. The average total length (average pot length plus average tail spill length) for observed redds in the Ventura River watershed was 74.5 cm (29.3 in).

Table **43** and

Table 44 outline the average measurements for redds in the surveyed reaches as well as the averages for the watershed as a whole.

It is important to note that two potential redds were observed during a routine spot check on Ventura River Reach 2 on February 26, 2015. These potential redds were located just upstream of the Ventura River Levee Pool and had been flagged by Casitas Municipal Water District personnel. However, when PSMFC crew members returned for an official survey, a man known to frequent this area had raked the gravel and any redds that may have been there were destroyed. These were the only potential redds observed in the Ventura River main stem this season. They have not been included in our results tables since they were not assessed on an official spawner survey.

***Oncorhynchus mykiss* Observation Results**

Bankside *O. mykiss* observations were recorded opportunistically during each redd survey. Individual fish were potentially recorded more than once with repeat surveys of the same reaches on different days. *O. mykiss* were observed on 7 of the 17 surveyed reaches: San Antonio 1, North Fork Matilija reaches 1, 2, and 4, Upper Matilija Reaches 1 and 2, and Upper North Fork. Only one fish was observed in San Antonio Creek (

Table **45**), most likely due to a combination of poor water visibility and large sections of dry creek. The North Fork Matilija reaches had 75 individuals recorded between four survey reaches (Table 46). The reaches of Matilija Creek located above the Matilija Dam had the most *O. mykiss* observations with 108 individuals recorded between the three reaches (Table 47). No *O. mykiss* were observed in the Ventura main stem reaches. This can most likely be attributed to poor water visibility and excessive vegetative cover in the lower reaches (Ventura 1 and 2) and large dry sections throughout the Ventura main stem. It is important to stress that these numbers are based on opportunistic bankside observations only, and that no other methods were employed to assess fish presence during redd surveys.

Other Species Observations Results

Southern Western Pond Turtles

Southern Western Pond Turtles (*Actinemys pallida)* were observed in most surveyed reaches, with the largest concentration in San Antonio Creek during the entirety of the survey season from early December to early June (Table 48). It is likely that some double-counting occurred as individuals were never marked or tagged. When possible, carapace length and sex were recorded.

California Red-Legged Frogs

California Red-legged Frogs (*Rana draytonii)* (CRLF) are a federally threatened species and opportunistic sightings of adult individuals and egg masses were recorded during surveys (Table 49). CRLF adults and egg masses were observed in Upper Matilija Creek and San Antonio Creek (Table 49). Crew members were not trained to differentiate CRLF tadpoles from other species, so tadpole observations were not recorded.

Two-striped Gartersnake Observations

Observations of Two-striped Gartersnakes (*Thamnophis hammondii*) (TSGS) were recorded when individuals could be positively identified (Table 50). TSGS were observed from early March to the end of the survey season in the Ventura River main stem, Upper Matilija Creek, and North Fork Matilija Creek (Table 50).

Discussion

Since 2010, California has experienced a considerable lack of precipitation causing a severe drought throughout most of the state. These conditions caused streams in Ventura country, including most of the Ventura River Basin, to exhibit low flows and increased seasonal drying during the 2015 water year. From October 1, 2014 to September 30, 2015, downtown Ventura (city hall station) received 7.93 inches of rain. Based on rainfall averages from October 1957 through September 1992 (the most representative 35-year period for long term average in Ventura county), this station receives 14.71 inches of rain during a year of average rainfall (Ventura County Watershed Protection District 2015). As this was the fifth consecutive year of insufficient rainfall, some reaches in the Ventura River Basin remained dry throughout the entirety of the spawning season and others were wetted only briefly. There were few opportunities for steelhead to migrate during the 2015 spawning season, as southern California steelhead require flow events capable of maintaining migration corridors in order to travel upstream to spawn. Discharge measured by the USGS gauge in the Ventura River main stem for this time period never exceeded 4.5 cubic feet per second. During the previous water year, a single storm event generating flows in excess of 3,000 ft^3/s represented the only opportunity for steelhead migration into and throughout the Ventura River watershed. It is likely that stream flow in the Ventura River main stem never entered a high enough range to support upstream *O. mykiss* migration during the 2015 spawning season.

With sparse rainfall, the berm at the mouth of the Ventura River breached only briefly with associated flows insufficient to prompt steelhead migration. Even if steelhead made it into the river during this time, channel-spanning invasive vegetation in four different locations in the lowest survey reach (Ventura 1) would have prevented them from migrating into the upper reaches to spawn (Figure 161). Furthermore, the largest observed redd in an anadromous reach had a total length of 140 cm. Most of the observed redds were much smaller, with an average total length of 74.5 cm. Steelhead redds are typically much larger than this. A study conducted throughout Mendocino County, California found the average observed steelhead redd length to be 224 cm (Gallagher 2003). Due to the small size of the observed redds and the lack of suitable conditions to support migration, we can infer that redds observed in anadromous reaches were most likely the result of resident *O. mykiss* and that no anadromous steelhead spawned in the Ventura River Basin during the 2015 spawning season.

Due to increased staffing, seven additional reaches were surveyed during the 2015 spawning season that were not covered during 2014. Three of these reaches (Upper Matilija Reaches 1 and 2, Upper North Fork) are located above a man-made total barrier (the Matilija Dam) and are currently non-anadromous. Should this barrier be removed, the *O. mykiss* populations behind them would gain the ability to interact with anadromous populations. 42% of the observed redds were located upstream of the Matilija Dam. This is not surprising, as these reaches contain a significant amount of high quality spawning habitat and experience much less water diversion, human waste input, and exposure to invasive species compared to lower reaches in the Ventura River Basin.

Although 11 more redds were observed this season compared to last season, most of the 2015 redds were observed in reaches that were not surveyed the previous spawning season. Seven total redds were observed in reaches surveyed the year before (Ventura River main stem, San Antonio Reaches 1 and 2, North Fork Matilija Reaches 1 and 2) whereas 13 redds were seen in these areas during the 2014 season. No redds were observed in San Antonio Creek this year, while three redds were observed in this stream in 2014. One redd was observed in Ventura River reach 5 in 2014, while none were observed in 2015. Seven redds were observed in North Fork Matilija in 2015 (excluding Bear Creek), while nine were observed in this creek in 2014.

One potential source of error in redd counts is that poor water clarity and extensive invasive vegetation (mostly primrose) made it impossible for crew members to see the river bottom throughout most of the lower Ventura River. However, it is also important to note that these lower sections are typically dominated by silt and cobble substrate, and viable spawning gravel was rarely observed in these river reaches. There is generally a greater amount of spawning habitat present in the upper reaches, hence the increased redd observations in these areas. However, it will be important to continue to survey these lower reaches in consecutive years since substrate composition can change with streamflow.

During the 2013 spawning season, 23 redds were recorded in the Ventura River Basin (surveyed reaches included Ventura River main stem reaches 1 through 5, San Antonio reaches 1 and 2, and North Fork Matilija reaches 1 and 2). In 2014, 13 redds were observed in these reaches. In 2015, only 7 redds were observed in these reaches. This decline in redd observations as drought conditions persist suggests that both resident and anadromous have been impacted. Further research on the effects of drought conditions on *O. mykiss* in southern California may prove especially useful in determining the role of climate change on partial migration strategies within the species' population groups. While data suggests that no southern California steelhead migrated up the Ventura River this year, we must also consider the possibility that steelhead in the ocean that originated from the Ventura River could have migrated and spawned elsewhere. The ongoing drought in California is making it increasingly difficult for fish to access their natal spawning grounds and so it is possible that Ventura River fish are straying into other streams exhibiting connectivity with the ocean. The data from this survey gives us no information on the number of steelhead currently in the ocean. Until rainfall increases and access between the river and ocean improves significantly, this number will remain difficult to estimate.

Tables

Table 42. New 2015 redd observations by stream reach in the Ventura River Basin. Redd observations are listed for each survey date and stream reach. The number of redds seen on the survey is shown in red. When a survey was complete but no new redds were found a black 0 is used. Blank cells indicate days where no survey occurred .

	Stream Reach																
Survey Date	**VR1**	**VR2**	**VR3**	**VR4**	**VR5**	**VR5.1**	**MAT1**	**MAT2**	**MAT3 (UNF)**	**SA1**	**SA2**	**SA3**	**SA4 (Lion)**	**NF1**	**NF2**	**NF3**	**NF4 (Bear)**
12/10/2014	0																
12/15/2014										0							
12/16/2014														0			
12/20/2014			0														
12/22/2014															0		
12/29/2014		0															
12/30/2014											0						
1/2/2015																0	
1/5/2015						0											
1/7/2015				0	0												
1/8/2015							0	0									
1/12/2015																	0
1/13/2015	0	0															
1/20/2015									0								
1/21/2015													0				
1/22/2015										0	0						
1/28/2015															0		
2/2/2015				0	0							0					
2/4/2015							0	0									
2/10/2015						0											
2/12/2015																	1
2/18/2015									0				0				
2/23/2015	0	0															
2/25/2015										0	0						
2/26/2015				0	0												
3/2/2015							0										
3/3/2015														2	3		
3/4/2015								0									
3/5/2015																	1
3/9/2015	0																
3/10/2015		0															
3/11/2015										0	0						
3/12/2015				0	0												
3/16/2015																	3
3/17/2015								0									
3/18/2015														1	1		
3/19/2015									4								
3/23/2015	0	0															
3/24/2015													0				
3/25/2015										0	0						
3/26/2015				0	0												
3/30/2015							0	1									
4/1/2015														0	0		
4/2/2015									3								1
4/6/2015	0	0															
4/7/2015										0	0						
4/9/2015					0												
4/13/2015									1								
4/14/2015								1									
4/15/2015														0	0		
4/16/2015																	1
4/20/2015	0	0															
4/21/2015			0										0				
4/22/2015										0	0						
4/27/2015								0									
4/28/2015									0								
4/29/2015															0		0
5/4/2015		0															
5/5/2015											0						
5/6/2015					0					0							
5/12/2015								0	0								
5/13/2015														0	0		
5/18/2015																	0
5/19/2015							0										
5/20/2015													0				
5/21/2015	0	0															
5/27/2015														0	0		
5/28/2015										0	0						
5/29/2015																	0
6/1/2015								0	0								
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**8**	**0**	**0**	**0**	**0**	**3**	**4**	**0**	**7**

Table 43. Average redd survey measurements for each surveyed reach and averages for all the surveyed reaches within the Ventura River Basin in 2015. Measurements are in centimeters.

Reach	Number of Redds	Average Pot Length	Average Pot Width	Average Pot Depth	Average Pot Substrate Size	Average Pot Area	Average Tail Spill Length	Average Tail Spill Width	Average Tail Substrate Size	Average Tail Spill Area	Average Total Length
VR1	0	-	-	-	-	-	-	-	-	-	-
VR2	0	-	-	-	-	-	-	-	-	-	-
VR3	0	-	-	-	-	-	-	-	-	-	-
VR4	0	-	-	-	-	-	-	-	-	-	-
VR5	0	-	-	-	-	-	-	-	-	-	-
VR5.1	0	-	-	-	-	-	-	-	-	-	-
MAT1	0	-	-	-	-	-	-	-	-	-	-
MAT2	2	26.0	25.0	2.7	2.5	530.4	39.0	18.7	1.1	733.2	65.0
SA1	0	-	-	-	-	-	-	-	-	-	-
SA2	0	-	-	-	-	-	-	-	-	-	-
SA3	0	-	-	-	-	-	-	-	-	-	-
SA4	0	-	-	-	-	-	-	-	-	-	-
NFM1	3	43.8	41.0	4.5	2.5	1428.4	81.3	32.4	1.4	2700.6	125.0
NFM2	4	25.0	26.5	3.3	1.5	529.3	44.8	20.9	0.6	1094.4	69.8
NFM3	0	-	-	-	-	-	-	-	-	-	-
NFM4	7	21.1	19.7	3.7	1.0	331.8	31.9	19.7	0.4	678.9	53.0
UNF	8	22.6	22.8	3.4	1.3	442.0	37.1	18.6	0.7	778.8	59.7
Watershed Total	**24**	**27.7**	**27.0**	**3.5**	**1.8**	**652.4**	**46.8**	**22.0**	**0.8**	**1197.2**	**74.5**

Table 44. Average redd measurements for each surveyed reach and averages for all the surveyed reaches within the Ventura River Basin in 2015. Measurements are in inches.

Reach	Number of Redds	Average Pot Length	Average Pot Width	Average Pot Depth	Average Pot Substrate Size	Average Pot Area	Average Tail Spill Length	Average Tail Spill Width	Average Tail Substrate Size	Average Tail Spill Area	Average Total Length
VR1	0	-	-	-	-	-	-	-	-	-	-
VR2	0	-	-	-	-	-	-	-	-	-	-
VR3	0	-	-	-	-	-	-	-	-	-	-
VR4	0	-	-	-	-	-	-	-	-	-	-
VR5	0	-	-	-	-	-	-	-	-	-	-
VR5.1	0	-	-	-	-	-	-	-	-	-	-
MAT1	0	-	-	-	-	-	-	-	-	-	-
MAT2	2	10.2	9.8	1.0	1.0	208.8	15.4	7.3	0.4	288.6	25.6
SA1	0	-	-	-	-	-	-	-	-	-	-
SA2	0	-	-	-	-	-	-	-	-	-	-
SA3	0	-	-	-	-	-	-	-	-	-	-
SA4	0	-	-	-	-	-	-	-	-	-	-
NFM1	3	17.2	16.1	1.8	1.0	562.4	32.0	12.8	0.5	1063.2	49.2
NFM2	4	9.8	10.4	1.3	0.6	208.4	17.6	8.2	0.2	430.8	27.5
NFM3	0	-	-	-	-	-	-	-	-	-	-
NFM4	7	8.3	7.8	1.4	0.4	130.6	12.6	7.7	0.2	267.3	20.9
UNF	8	8.9	9.0	1.3	0.5	174.0	14.6	7.3	0.3	306.6	23.5
Watershed Total	**24**	**10.9**	**10.6**	**1.4**	**0.7**	**256.8**	**18.4**	**8.7**	**0.3**	**471.3**	**29.3**

Table 45. *O. mykiss* observations in San Antonio Creek by reach and survey date for 2015. The number of *O. mykiss* observed during each survey is indicated in red. A black zero signifies that a survey was carried out but no *O. mykiss* were observed. Blank cells indicate days where no survey occurred on the reach in question. Total observations for each reach are in bold.

Survey Date	SA1	SA2	SA3	SA4 (LION)
12/15/2014	0			
12/30/2014		0		
1/21/2015				0
1/22/2015	0	0		
2/2/2015			0	
2/18/2015				0
2/25/2015	0	0		
3/11/2015	0	0		
3/24/2015				0
3/25/2015	0	0		
4/7/2015	0	0		
4/21/2015				0
4/22/2015	1	0		
5/5/2015		0		
5/6/2015	0			
5/20/2015				0
Total	**1**	**0**	**0**	**0**

Table 46. *O. mykiss* observations in North Fork Matilija Creek by reach and survey date for 2015.The number of *O. mykiss* observed during each survey is indicated in red. A black zero signifies that a survey was carried out but no *O. mykiss* were observed. Blank cells indicate days where no survey occurred on the reach in question. Total observations for each reach are in bold.

Survey Date	NFM1	NFM2	NFM3	NFM4 (Bear)
12/16/2014	3			
12/22/2014		0		
1/2/2015			0	
1/12/2015				1
1/21/2015	0			
1/28/2015		0		
2/12/2015				4
3/3/2015	0	6		
3/5/2015				0
3/16/2015				1
3/18/2015	3	13		
4/1/2015	2	4		
4/2/2015				1
4/15/2015	0	1		
4/16/2015				7
4/29/2015	6	2		4
5/13/2015	1	4		
5/18/2015				3
5/27/2015	3	6		
Total	**18**	**36**	**0**	**21**

Table 47.*O. mykiss* observations in Matilija Creek reaches located above the Matilija Dam in 2015. The number of *O. mykiss* observed during each survey is indicated in red. A black zero signifies that a survey was carried out but no *O. mykiss* were observed. Blank cells indicate days where no survey occurred on the reach in question. Total observations for each reach are in bold.

Survey Date	MAT1	MAT2	MAT3 (UNF)
1/8/2015	0	1	
1/20/2015			0
2/4/2015	0	4	
2/18/2015			13
3/2/2015	0		
3/4/2015		8	
3/17/2015		6	
3/19/2015			27
3/30/2015	0	9	
4/2/2015			8
4/13/2015			3
4/14/2015		3	
4/27/2015		2	
4/28/2015	1		12
5/12/2015		1	7
5/19/2015	0		
6/1/2015		0	3
Total	**1**	**34**	**73**

Table 48. Observations of Southern Western Pond Turtles in surveyed reaches of the Ventura River Basin in 2015. Individual counts are indicated by red numbers. Black zeros indicate that no observations were recorded during a completed survey. Blank cells represent days when no survey was completed.

	Stream Reach																
Survey Date	VR1	VR2	VR3	VR4	VR5	VR5.1	MAT1	MAT2	MAT3 (UNF)	SA1	SA2	SA3	SA4 (Lion)	NF1	NF2	NF3	NF4 (Bear)
12/10/2014	0																
12/15/2014										1							
12/16/2014														0			
12/20/2014			0														
12/22/2014															0		
12/29/2014		0															
12/30/2014											0						
1/2/2015																0	
1/5/2015						0											
1/7/2015				0	0												
1/8/2015							0	0									
1/12/2015																	0
1/13/2015	0																
1/20/2015									0								
1/21/2015													5	0			
1/22/2015										2	0						
1/28/2015															0		
2/2/2015				0	0							0					
2/4/2015							0	0									
2/10/2015						1											
2/12/2015																	0
2/18/2015									1				8				
2/23/2015	4	0			2												
2/25/2015										0	0						
2/26/2015				0	1												
3/2/2015							3										
3/3/2015														0	0		
3/4/2015								1									
3/5/2015																	0
3/9/2015	5																
3/10/2015		4															
3/11/2015										21	3						
3/12/2015				0	3												
3/16/2015																	0
3/17/2015								6									
3/18/2015														3	0		
3/19/2015									3								
3/23/2015	1	2															
3/24/2015													7				
3/25/2015										8	3						
3/26/2015				0	3												
3/30/2015							0	2									
4/1/2015														0	0		
4/2/2015									3								1
4/6/2015	0	1															
4/7/2015										3	0						
4/9/2015					1												
4/13/2015									0								
4/14/2015								2									
4/15/2015														1	0		
4/16/2015																	1
4/20/2015	0	0															
4/21/2015			1										6				
4/22/2015										4	0						
4/27/2015								2									
4/28/2015							8		1								
4/29/2015														1	2		
5/4/2015		0															
5/5/2015											0						
5/6/2015					1					3	7						
5/12/2015								0	1								
5/13/2015														0	0		
5/18/2015																	1
5/19/2015							4										
5/20/2015													11				
5/21/2015	1	1															
5/27/2015														0	0		
5/28/2015										4	1						
5/29/2015																	0
6/1/2015								2	1								
Total	11	8	1	0	11	1	15	15	10	45	14	0	37	5	2	0	3

Table 49. California Red-legged Frog (CRLF) observations in all surveyed reaches of the Ventura River Basin in 2015. Blue numbers represent CRLF egg masses, while red numbers indicate the number of adult frogs. A black zero signifies that a survey was carried out but no CRLF were observed. Blank cells indicate days where no survey occurred on the reach in question. Total observations for each reach are in bold.

	Stream Reach																
Survey Date	**VR1**	**VR2**	**VR3**	**VR4**	**VR5**	**VR5.1**	**MAT1**	**MAT2**	**MAT3 (UNF)**	**SA1**	**SA2**	**SA3**	**SA4 (Lion)**	**NF1**	**NF2**	**NF3**	**NF4 (Bear)**
12/10/2014	0																
12/15/2014										0							
12/16/2014														0			
12/20/2014			0														
12/22/2014															0		
12/29/2014		0															
12/30/2014											0						
1/2/2015																0	
1/5/2015						0											
1/7/2015				0	0												
1/8/2015							0	0									
1/12/2015																	0
1/13/2015	0																
1/20/2015									0								
1/21/2015													0	0			
1/22/2015										0	0						
1/28/2015															0		
2/2/2015				0	0		0					0					
2/4/2015								0									
2/10/2015						0											
2/12/2015																	0
2/18/2015									0				0				
2/23/2015	0	0			0												
2/25/2015										0	0						
2/26/2015				0	0												
3/2/2015							5										
3/3/2015														0	0		
3/4/2015								1									
3/5/2015																	0
3/9/2015	0																
3/10/2015		0															
3/11/2015										1	12						
3/12/2015				0	0												
3/16/2015																	0
3/17/2015								9, 2									
3/18/2015														0	0		
3/19/2015									0								
3/23/2015	0	0															
3/24/2015													0				
3/25/2015										2	0						
3/26/2015				0	0												
3/30/2015							0	2									
4/1/2015														0	0		
4/2/2015									0								0
4/6/2015	0	0															
4/7/2015										1	0						
4/9/2015					0												
4/13/2015									0								
4/14/2015								2, 1									
4/15/2015														0	0		
4/16/2015																	0
4/20/2015	0	0															
4/21/2015			0										0				
4/22/2015										1	2						
4/27/2015								2									
4/28/2015							3		1								
4/29/2015														0	0		0
5/4/2015		0															
5/5/2015											1						
5/6/2015					0					0							
5/12/2015								2	2								
5/13/2015														0	0		
5/18/2015																	0
5/19/2015							0										
5/20/2015													0				
5/21/2015	0	0															
5/27/2015														0	0		
5/28/2015										0	0						
5/29/2015																	0
6/1/2015								2	0								
Total	**0**	**0**	**0**	**0**	**0**	**0**	**5, 3**	**11, 12**	**3**	**1, 4**	**12, 3**	**0**	**0**	**0**	**0**	**0**	**0**

Table 50. Observations of Two-striped Gartersnakes in surveyed reaches of the Ventura River Basin in 2015. Red numbers indicate the number of gartersnakes observed. Black zeros indicate a completed survey with no TSGS observations. Blank cells indicate days when no survey was completed. Total observations for each reach are in bold.

	Stream Reach																
Survey Date	**VR1**	**VR2**	**VR3**	**VR4**	**VR5**	**VR5.1**	**MAT1**	**MAT2**	**MAT3 (UNF)**	**SA1**	**SA2**	**SA3**	**SA4 (Lion)**	**NF1**	**NF2**	**NF3**	**NF4 (Bear)**
12/10/2014	0																
12/15/2014										0							
12/16/2014														0			
12/20/2014			0														
12/22/2014															0		
12/29/2014		0															
12/30/2014											0						
1/2/2015																0	
1/5/2015						0											
1/7/2015				0	0												
1/8/2015							0	0									
1/12/2015																	0
1/13/2015	0																
1/20/2015									0								
1/21/2015													0	0			
1/22/2015										0	0						
1/28/2015															0		
2/2/2015				0	0		0					0					
2/4/2015								0									
2/10/2015						0											
2/12/2015																	0
2/18/2015									0				0				
2/23/2015	0	0			0												
2/25/2015										0	0						
2/26/2015				0	0												
3/2/2015							0										
3/3/2015														0	0		
3/4/2015								1									
3/5/2015																	0
3/9/2015	0																
3/10/2015		0															
3/11/2015										0	0						
3/12/2015				0	0												
3/16/2015																	0
3/17/2015								1									
3/18/2015														1	0		
3/19/2015									0								
3/23/2015	0	1															
3/24/2015													0				
3/25/2015										0	0						
3/26/2015				0	0												
3/30/2015							1	1									
4/1/2015														0	0		
4/2/2015									0								0
4/6/2015	0	0															
4/7/2015										0	0						
4/9/2015					0												
4/13/2015									0								
4/14/2015								2									
4/15/2015														0	2		
4/16/2015																	0
4/20/2015	0	0															
4/21/2015			0										0				
4/22/2015										0	0						
4/27/2015								1									
4/28/2015							3		1								
4/29/2015														1	0		0
5/4/2015		0															
5/5/2015											0						
5/6/2015					0					0							
5/12/2015								0	1								
5/13/2015														2	0		
5/18/2015																	0
5/19/2015							1										
5/20/2015													0				
5/21/2015	0	0															
5/27/2015														1	2		
5/28/2015										0	0						
5/29/2015																	0
6/1/2015								3	0								
Total	**0**	**1**	**0**	**0**	**0**	**0**	**5**	**9**	**2**	**0**	**0**	**0**	**0**	**5**	**4**	**0**	**0**

Figures

Figure 155. A redd observed at Upper North Fork Matilija Creek on April 2nd, 2015.

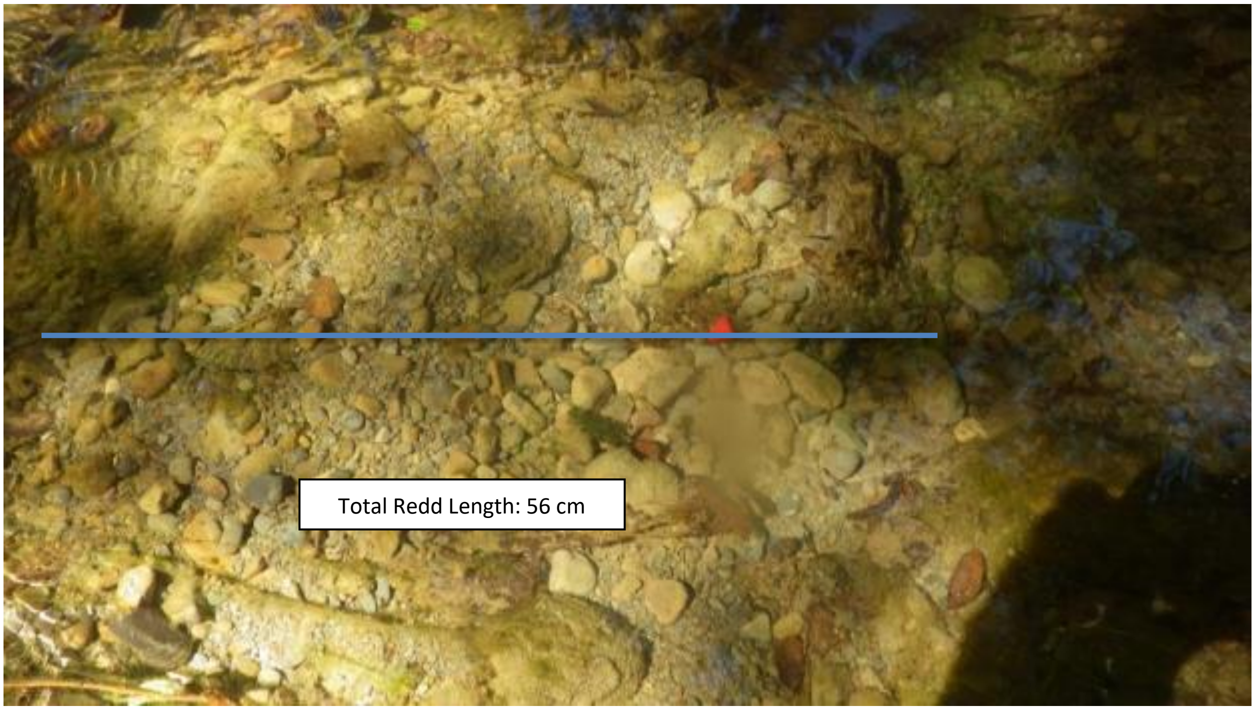


Figure 156. Juvenile *O. mykiss* observed in North Fork Matilija Creek on April 15, 2015.

Figure 157. Southern Western Pond Turtle observed in Upper Matilija Creek on March 2nd, 2015.

Figure 158. California Red-Legged Frog observed in Upper Matilija Creek on March 4th, 2015.

Figure 159. California Red-Legged Frog egg mass observed in San Antonio Creek on March 11, 2015.

Figure 160. Two-Striped Gartersnake observed at Upper Matilija Creek on March 30, 2015.

Figure 161. Invasive primrose formed barrier observed on the lower Ventura River main stem on January 13, 2015. This barrier was 1 m in height and spanned the entire wetted channel.

Ventura Main stem

Habitat Assessment

Results

The habitat inventory was conducted from 17 September to 15 October 2013 by Sam Bankston, Heidi Block, Ben Lakish, Patrick Riparetti, Tom Van Meeuwen, and Karissa Willits from Pacific States Marine Fisheries Commission. The survey extended 85,115 feet upstream from the survey start (34.28028°N, -119.30825°W), with an additional 3,105 feet of side channel. The survey endpoint (34.48524°N, -119. 29969°W) was the confluence of Matilija Creek and North Fork Matilija Creek (Figure 162). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 57 to 70°F. Air temperature ranged from 59 to 81°F.

Habitat type

Of the total number of habitat units surveyed (n = 239 units), 2.1% of units were dry, 37.7% were flatwaters, 20.1% were pools, 39.3% were riffles, and 0.4% were culverts. Of the total length of the reach surveyed, 57.4% was dry, 23.8% was composed of flatwaters, 7.9% was composed of pools, 10.9% was composed of riffles, and 0.02% was composed of culverts (Figure 163).

We identified 13 habitat types in the Ventura River main stem. Based on the frequency of units sampled, low gradient riffles (37.24%), and runs (33.47%) were the most common habitat types (Table 51). Based on total stream length, dry units (57.4%), runs (21.1%), and low gradient riffles (10.6%) composed the greatest stream lengths.

Pool Metrics

A total of 48 pools were identified within the survey reach. Main channel pools were most frequently encountered (77.1% of pool units sampled) and comprised 73.6% of the total length of all pools.

Fourteen of 46 pools (30%) had residual depths of three feet or greater (Figure 164).

Within pool tail-outs, small cobble was the most frequently observed dominant substrate (34.1% of pool units), followed by large cobble (15.9%) and gravel (15.9%; Figure 165).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (51.1%) or two (23.4%; Figure 166).

Shelter

Within 100% units (n = 74 units), riffle habitat types had a mean shelter rating of 83.2, flatwater habitat types had a mean shelter rating of 89.5, and pools had a mean shelter rating of 67.2.

Of the pool units in which shelter was assessed (n = 32 units), main channel pools had a mean shelter rating of 67.3, scour pools had a mean shelter rating of 82.9, and backwater pools had a mean shelter rating of 30.0.

When we examined the mean percentage of shelter by shelter type across all units, we found that terrestrial vegetation provided the most shelter (33.0% of all shelter; Figure 167). When we examined the percentage of shelter by shelter type within pools only (n = 32 units), we found that terrestrial vegetation was the most dominant cover type (35.3% of the total cover), followed by boulders (22.7%; Figure 168).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 51.5%. Within the canopy cover present, 15.4% of the canopy was composed of deciduous trees and 83.6% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks were sand/silt/clay (46.1%), cobble/gravel (24.0%), boulder (21.4%), and bedrock (7.8%; Figure 169). The mean percentage of vegetation covering the right bank in sampled units was 64.2%, and the mean percentage of vegetation covering the left bank was 66.4%. Evergreen trees were the dominant vegetation type, having been observed in 63.6% of the banks surveyed. Additionally, 26.0% of the banks surveyed had deciduous trees and 10.4% had brush as the dominant vegetation (Figure 170).

Large Woody Debris

We observed three pieces of LWD that were 6 to 20 feet long and two pieces that were greater than 20 feet long within 36731.8 feet of wetted stream length (excluding dry, unsurveyable, and culvert lengths). Across both LWD sizes, the number of LWD observed was 0.01 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 54.0 feet.

Discussion

Temperature

The water temperature of units measured ranged from 57 to 70°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Good to Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were riffles or flatwater units. Looking at more detailed habitat types, we found that units were most frequently low-gradient riffles or runs. When we examined the reach in terms of length, we found that most of the reach was dry. Runs and low-gradient riffles comprised the greatest percentages of wetted stream length.

Pool Metrics

Pool depth is an important indicator habitat quality, as greater pool depths can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). A residual depth of at least three feet is needed to be considered good habitat (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in the Ventura River main stem, we found that 30.4% of pools had residual depths of three feet or greater. Thus, it appears that pools in the Ventura River may provide vital hiding cover and rearing space for *O. mykiss*.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was small cobble. Many pools tail-outs were dominated by large cobble or silt, which have particle sizes that are insufficient for *O. mykiss* spawning. Pool units most frequently had an embeddedness value of either a five or two. Together, these metrics suggest that, although pool tail-outs in the Ventura River main stem may not provide ideal substrate for spawning, many pools have sufficient depth to serve as hiding cover and rearing space for *O. mykiss*.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that flatwater units had the highest average shelter rating.

When examining pool habitat units specifically, we found that scour pools had the highest shelter rating, followed by main channel pools and then backwater pools.

When we examined the percentage shelter by shelter type, we found the terrestrial vegetation provided the most shelter, followed by aquatic vegetation and boulders. It is worth noting that much of the aquatic and terrestrial vegetation observed in the Ventura River main stem was invasive (primarily Giant Reed and Uruguay Water-Primrose). While these invasive plant species provided instream shelter in many units, they were often overgrown to the point of blocking fish passage. This could be extremely harmful to the *O. mykiss* populations inhabiting in this watershed, as the Ventura River main stem serves as a vital migration corridor. These invasive vegetation barriers could prevent steelhead from making it to the upper reaches to spawn.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In the Ventura River main stem, we estimated a mean canopy cover of 52% across all units, consisting predominantly of evergreen trees. This suggests that Ventura River has a relatively low amount of canopy cover (Kier Associates & NMFS 2008). However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was sand/silt/clay, followed by cobble/gravel. The mean percentage of vegetation covering the right and left banks was 64% and 66%, respectively. Evergreen and deciduous trees were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively susceptible to erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In the Ventura River main stem, we found 0.1 pieces of LWD per 100 feet, which was extremely low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while the Ventura River lacks LWD, it contains boulder elements that improve habitat quality (33.0% of all instream shelter).

Tables

Table 51. Percentage of all units (n = 239) by habitat type for the Ventura River main stem.

Habitat Type	% of Units
Low Gradient Riffle	37.24%
Run	33.47%
Mid-Channel Pool	12.55%
Step Pool	2.51%
Lateral Scour, bedrock-formed	2.51%
High Gradient Riffle	2.09%
Glide	2.09%
Step Run	2.09%
Dry	2.09%
Lateral Scour, boulder-formed	0.84%
Dammed Pool	0.84%
Channel Confluence Pool	0.42%
Backwater Pool, boulder-formed	0.42%
Culvert	0.42%
Not Surveyable	0.42%

Figures

Figure 162. Map of the habitat assessment survey area in Ventura mainstem.

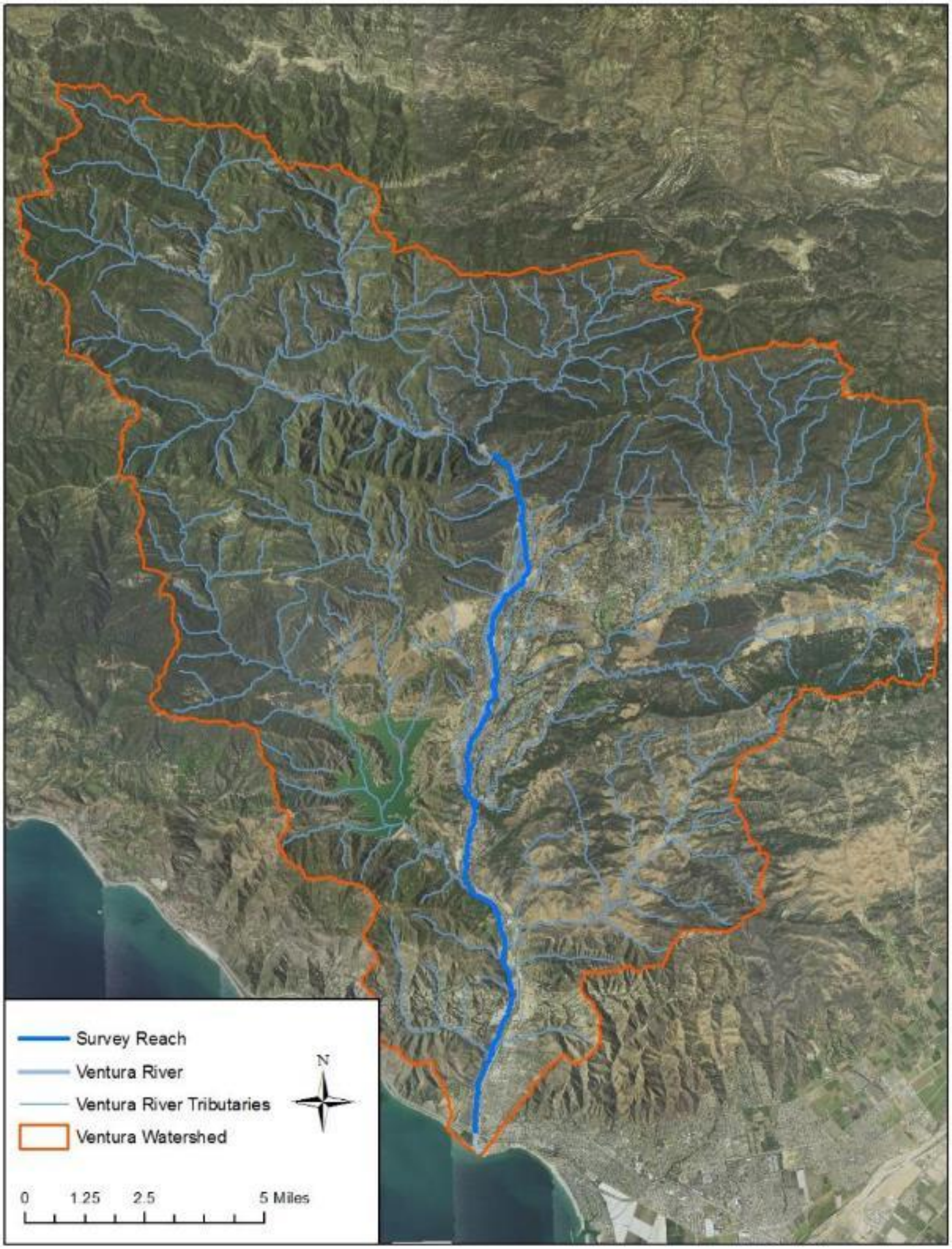


Figure 163. Percentage of total stream length categorized as pools, flatwaters, riffles, dry, or culverts for the Ventura River main stem. Units that were not surveyable were excluded from this graph, as it comprised only 0.001% of the total stream length.

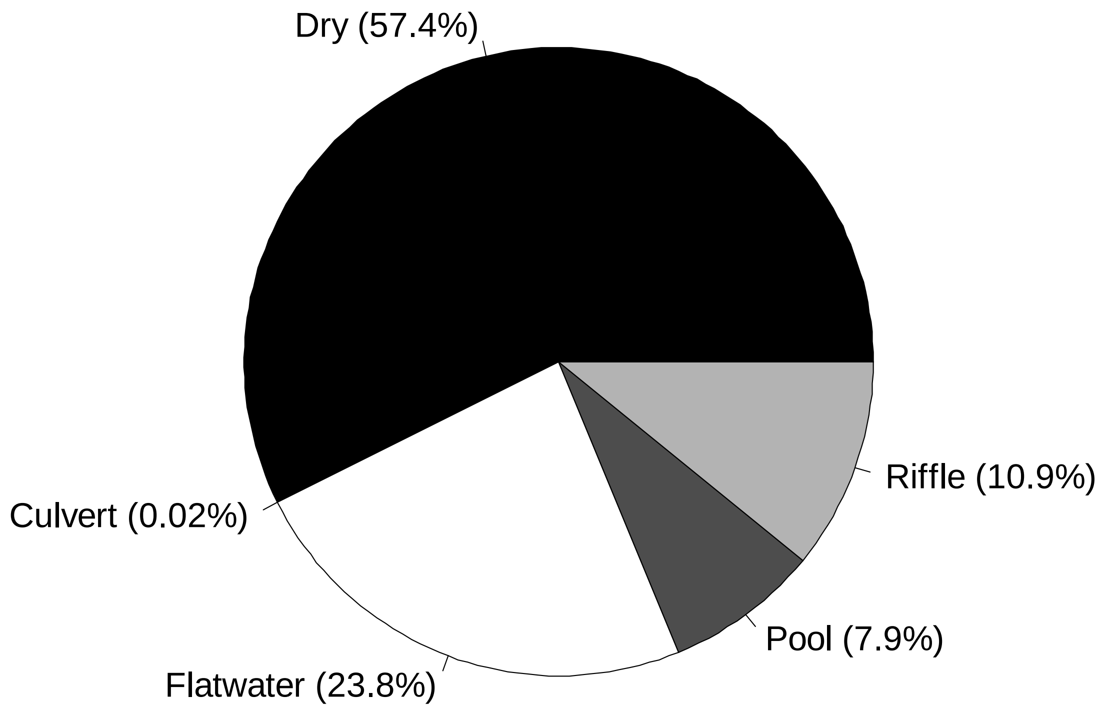


Figure 164. Histogram of residual pool depths in one-foot bins for the Ventura River main stem. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

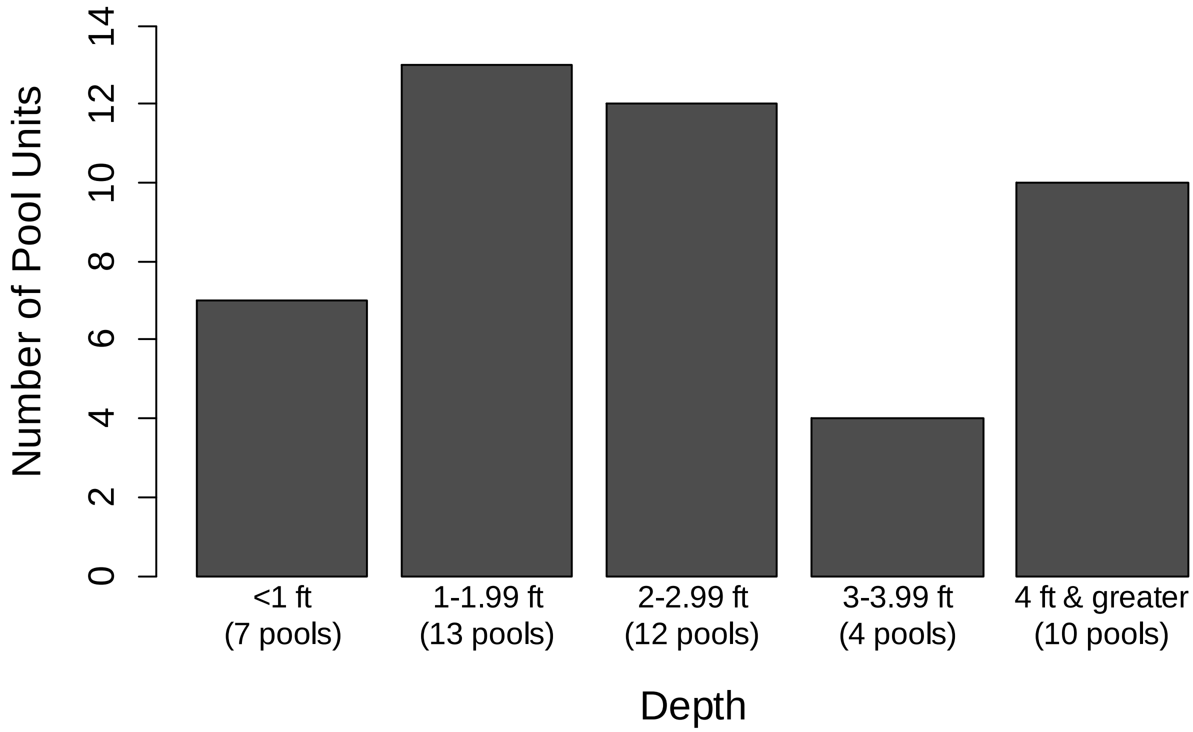


Figure 165. Percentage of pool tail-outs (n = 48 pools) by dominant substrate for the Ventura River main stem. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

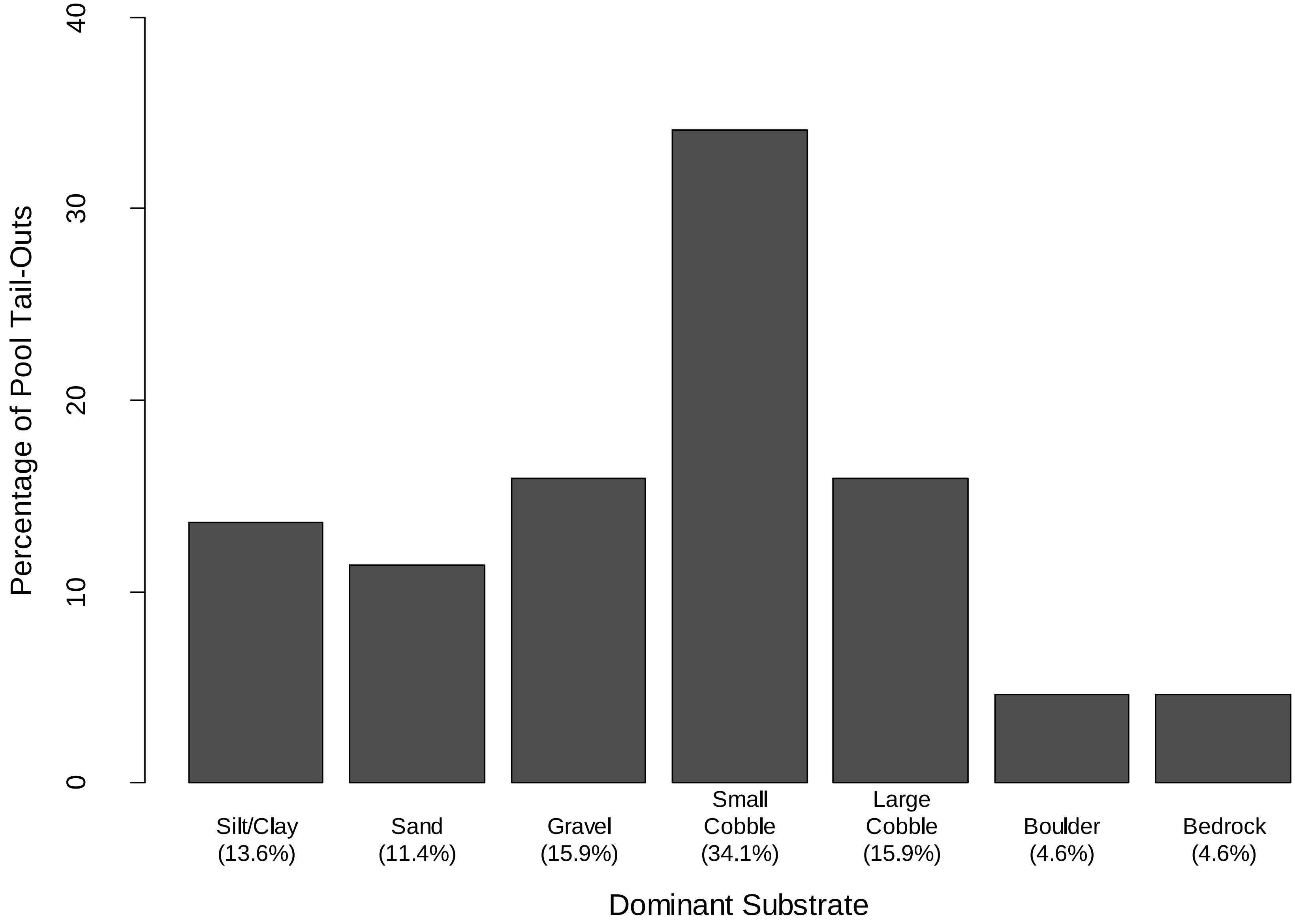


Figure 166. Percentage of all pool units (n = 48 pools) assigned a pool tail-out embeddedness value of 1 to 5 for the Ventura River main stem. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning.

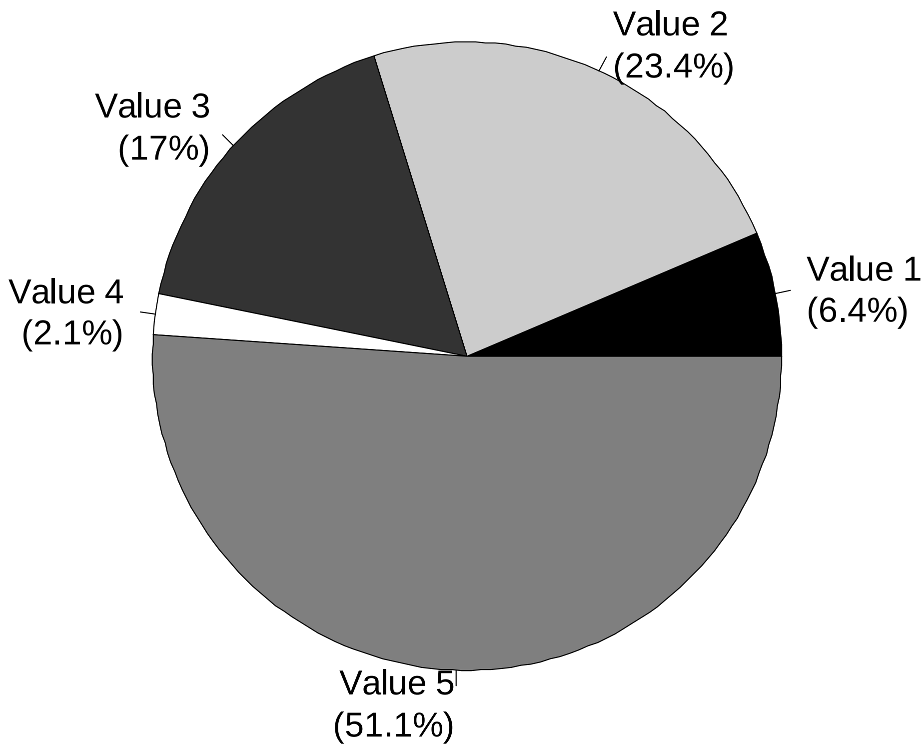


Figure 167. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 74 units) for the Ventura River main stem. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge**.**

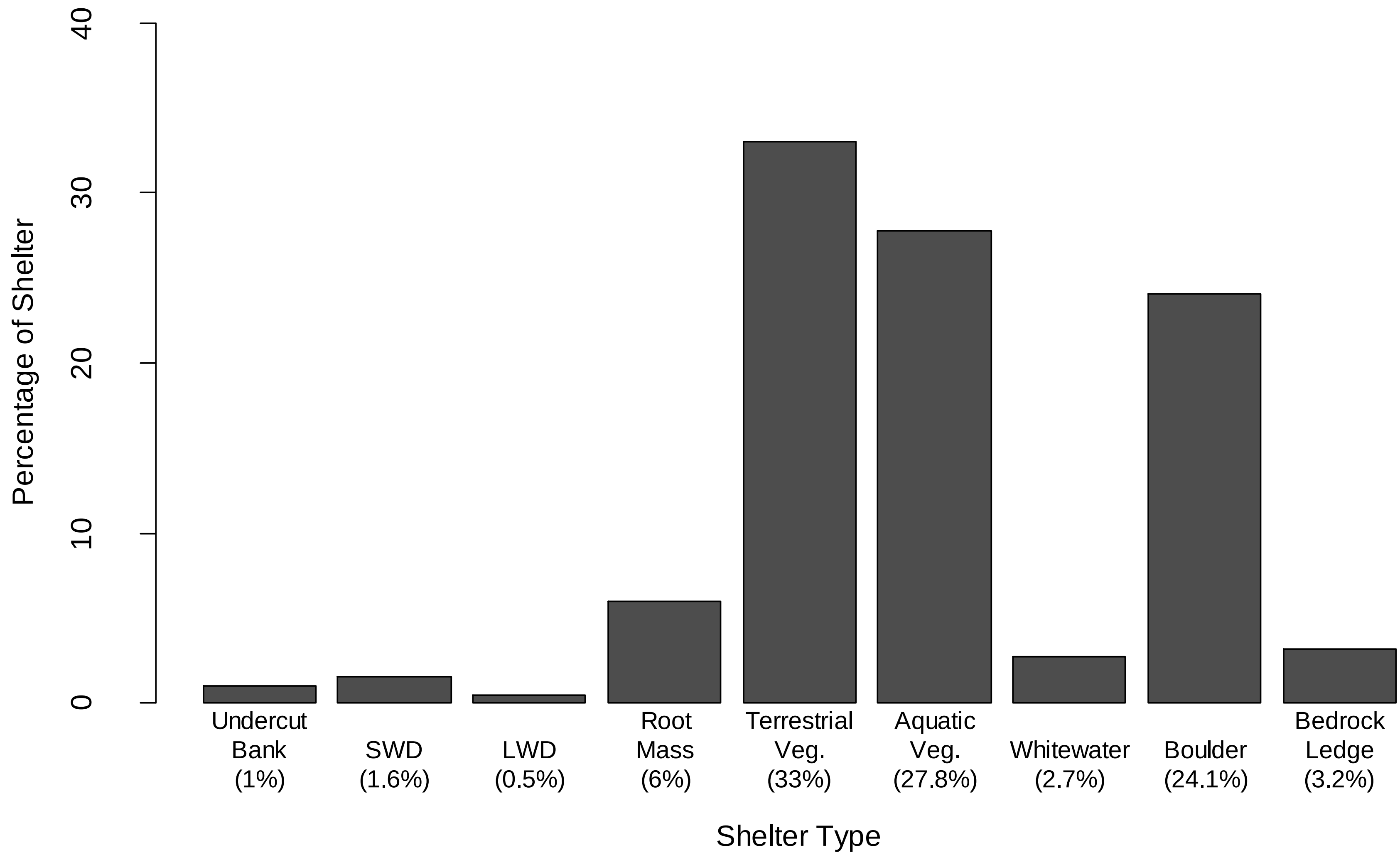


Figure 168. The percentage of instream shelter by shelter type across all pool units in which shelter was measured (n = 32 pools) for the Ventura River main stem. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

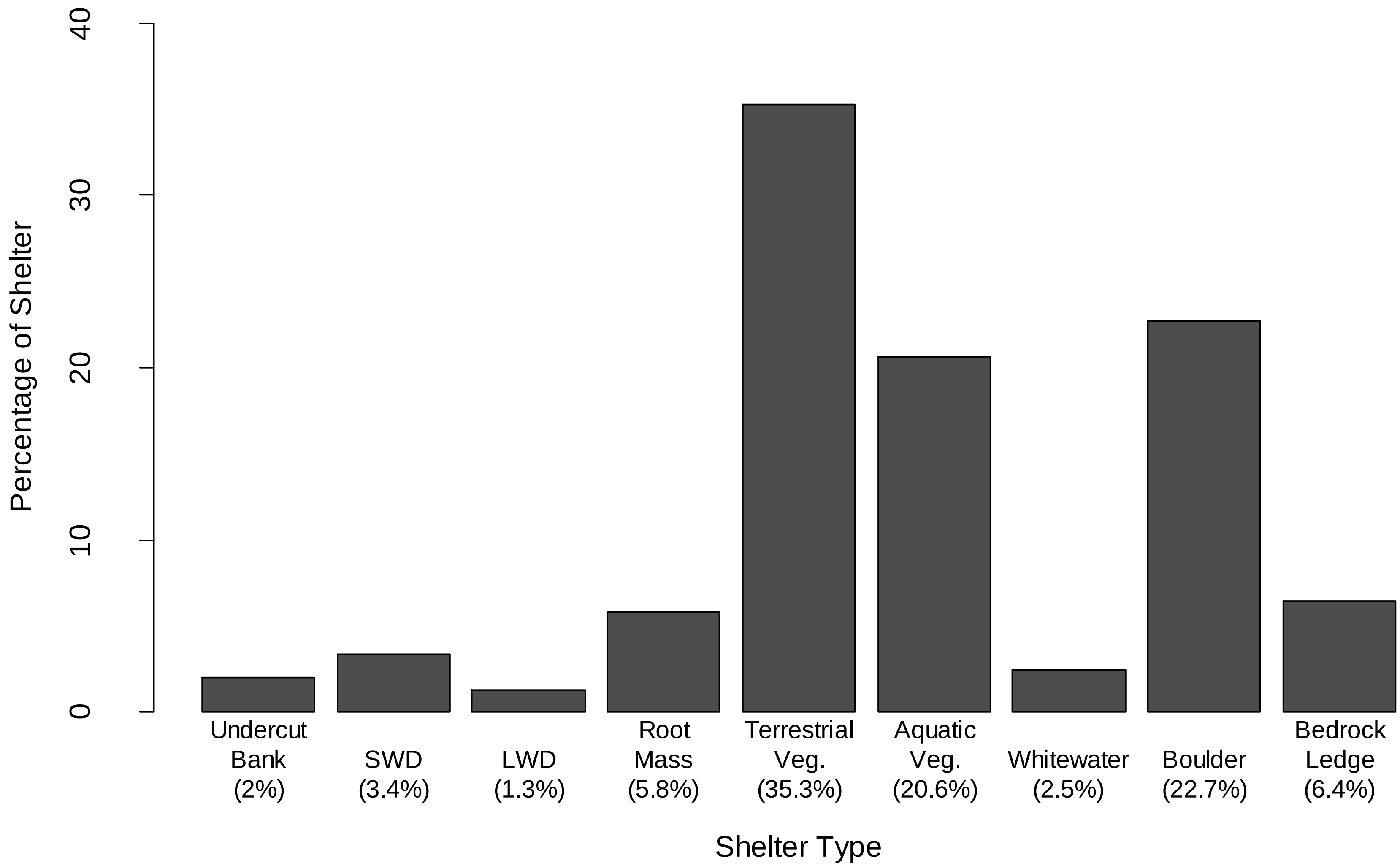


Figure 169. Percentage of banks by dominant substrate composition for the Ventura River main stem. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock.

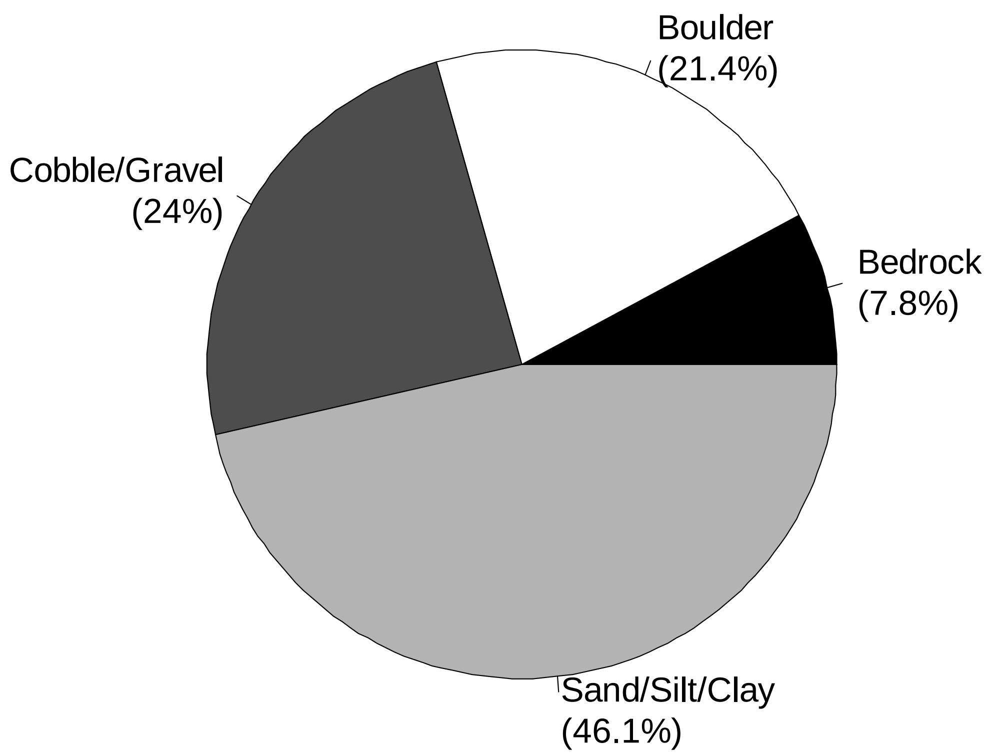
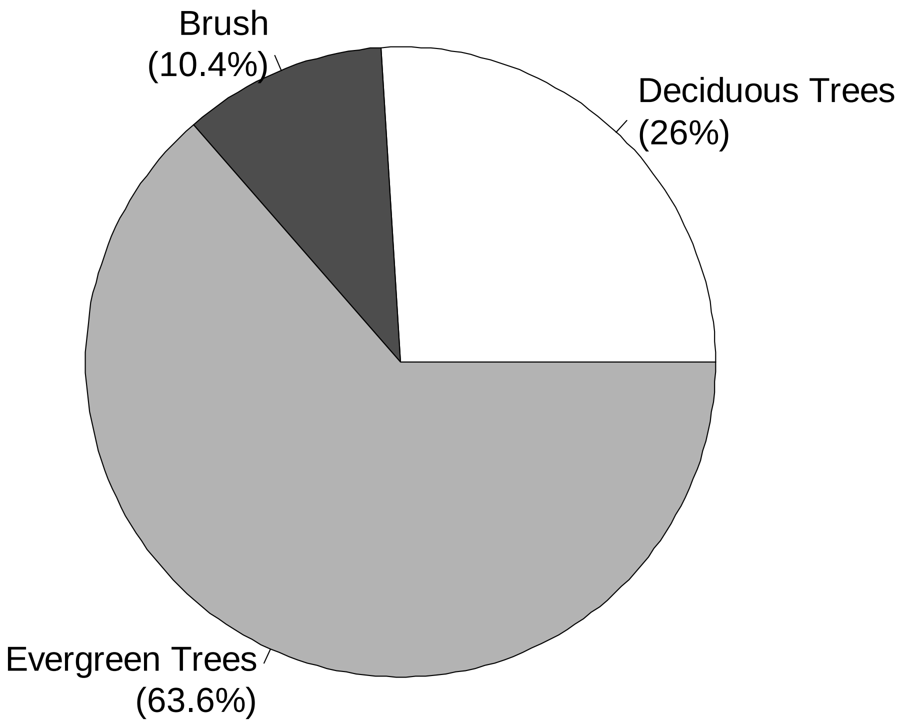


Figure 170. Percentage of banks by dominant vegetation type for the Ventura River main stem. Vegetation types included deciduous trees, evergreen trees, grass, and brush. In this survey, grass was

not recorded as a dominant bankside vegetation type.



Lower Matilija

Habitat Assessment

<u>Results</u>

The habitat inventory was conducted from 15–18 October 2013 by Ben Lakish, Kate McLaughlin, Patrick Riperetti, Karissa Willits, and Tom Van Meeuwen from Pacific States Marine Fisheries Commission and David Gottesman from the Watershed Stewards Program. The survey extended 3,968 feet upstream from the survey start (34.48516°N, -119.30020°W), with an additional 41 feet of side channel. The survey endpoint (34.48432°N, -119.30840°W) was at the Matilija Dam (Figure 171). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 55 to 63°F. Air temperature ranged from 60 to 82°F.

Habitat type

Of the total number of habitat units surveyed (n = 61 units), 16.4% were flatwaters, 52.5% were pools, and 31.1% were riffles. Of the total length of the reach surveyed, 19.6% was composed of flatwaters, 60.4% was composed of pools, and 20.0% was composed of riffles (Figure 172).

We identified nine habitat types in lower Matilija Creek. Based on the frequency of units sampled, low gradient riffles (24.6%) and mid-channel pools (21.3%) were the most common habitat types (Table 52). Based on total stream length, mid-channel pools (25.4%), dammed pools (19.9%), and low gradient riffles (16.1%) composed the greatest stream lengths.

Pool Metrics

A total of 32 pools were identified within the survey reach. Main channel pools were most frequently encountered (40.6% of pool units sampled; Figure 173) and comprised 42.0% of the total length of all pools.

Thirteen of 23 pools (57%) had residual depths of three feet or greater (Figure 174).

Within pool tail-outs, boulder was the most frequently observed dominant substrate (60.9% of pool units), followed by silt/clay (13.0%) and large cobble (13.0%; Figure 175).

When we examined pool tail-outs for substrate embeddedness, we found that pools had embeddedness values of either five (95.7%) or one (4.3%).

Shelter

Within 100% units (n = 21 units), riffle habitat types had a mean shelter rating of 42.5, flatwater habitat types had a mean shelter rating of 85.0, and pools had a mean shelter rating of 103.1.

Of the pool units in which shelter was assessed (n = 13 units), main channel pools had a mean shelter rating of 72.5, scour pools had a mean shelter rating of 122.5, and backwater pools had a mean shelter rating of 112.0.

When we examined the mean percentage of shelter by shelter type across all units, we found that boulders provided the most shelter (66.0% of all shelter; Figure 176). When we examined the percentage of shelter by shelter type within pools only (n = 44 units), we found that boulders were the most dominant cover type (65.8% of all shelter; Figure 177).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 60.0%. Within the canopy cover present, 42.5% of the canopy was composed of deciduous trees and 57.5% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were usually boulder (61.9%) or bedrock (23.8%; Figure 178). The mean percentage of vegetation covering the right bank in sampled units was 44.0%, and the mean percentage of vegetation covering the left bank was 44.7%. Deciduous trees were the dominant vegetation type, having been observed in 71.4% of the banks surveyed (Figure 179).

Large Woody Debris

We observed one piece of LWD that was greater than 20 feet long within 4009.2 feet of wetted stream length. Across both LWD sizes, the number of LWD observed was 0.03 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 39.5 feet.

Discussion

Temperature

The water temperature of units measured ranged from 55 to 63°F. According to the Guide to the

Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Good to Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining lower Matilija Creek in terms of pool, flatwater, and riffle frequency, we found that most units were pools or riffles. When we examined the reach in terms of length, we found that the reach was mostly comprised of pools, with mid-channel pools making up the greatest percentage of stream length.

Pool Metrics

Pool depth is an important indicator of habitat quality, as deeper pools can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). A residual depth of at least three feet is needed to be considered good habitat (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in lower Matilija, we found that 57% of pools were at least three feet deep, suggesting that many pools in lower Matilija are deep enough to provide adequate *O. mykiss* habitat.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). However, pool tails in Lower Matilija Creek were dominated by boulder (60.9%), silt/clay (13.0%), and large cobble (13.0%) substrate. This is generally considered unsuitable for spawning salmonids due to insufficient substrate size. Only 4.3% of pools tails were deemed suitable for *O. mykiss* spawning based on substrate size and embeddedness value. Thus, it appears that the pools in lower Matilija Creek are not a significant source of spawning habitat, but may provide important hiding cover and rearing space.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this survey, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that pools had the highest mean shelter rating, followed by flatwaters and then riffles. When we examined shelter ratings of pool types, we found that scour pools had the highest rating and that main channel pools had the lowest.

When we examined the percentage shelter by shelter type, we found the boulders provided the most shelter by far (66% of all shelter), suggesting that boulders are a common and important feature to *O. mykiss* habitat in lower Matilija.

Canopy Cover

Canopy cover is important in regulating the water temperature of streams (Kier Associates & NMFS 2008). In lower Matilija Creek, the mean percent canopy density for the stream was 60%, with 43% of this canopy cover being composed of deciduous trees. This suggests that lower Matilija has a fair amount of canopy cover (Kier Associates & NMFS 2008), although this cover may vary through time, given the seasonality of deciduous trees. However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was boulder, followed by bedrock. The mean percentage of vegetation cover on the right and left banks was 44.0% and 44.7%, respectively. Deciduous trees were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively protected from erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In Lower Matilija Creek, we found 0.03 pieces of LWD per 100 feet, which was extremely low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while lower Matilija lacks LWD, it has boulder elements that improve habitat quality. Specifically, boulders provided the greatest amount of shelter across all units in which shelter was assessed (66.0% of all shelter).

Tables

Table 52. Percentage of all units (n = 61) by habitat type for lower Matilija.

Habitat Type	% of Units
Low Gradient Riffle	24.59%
Mid-Channel Pool	21.32%
Run	11.48%
Dammed Pool	11.48%
Lateral Scour Pool, boulder-formed	8.20%
High Gradient Riffle	6.56%
Lateral Scour Pool, bedrock-formed	6.56%
Step Run	4.92%
Backwater Pool, boulder-formed	4.92%

Figures

Figure 171. Map of the habitat assessment survey area in lower Matilija Creek.

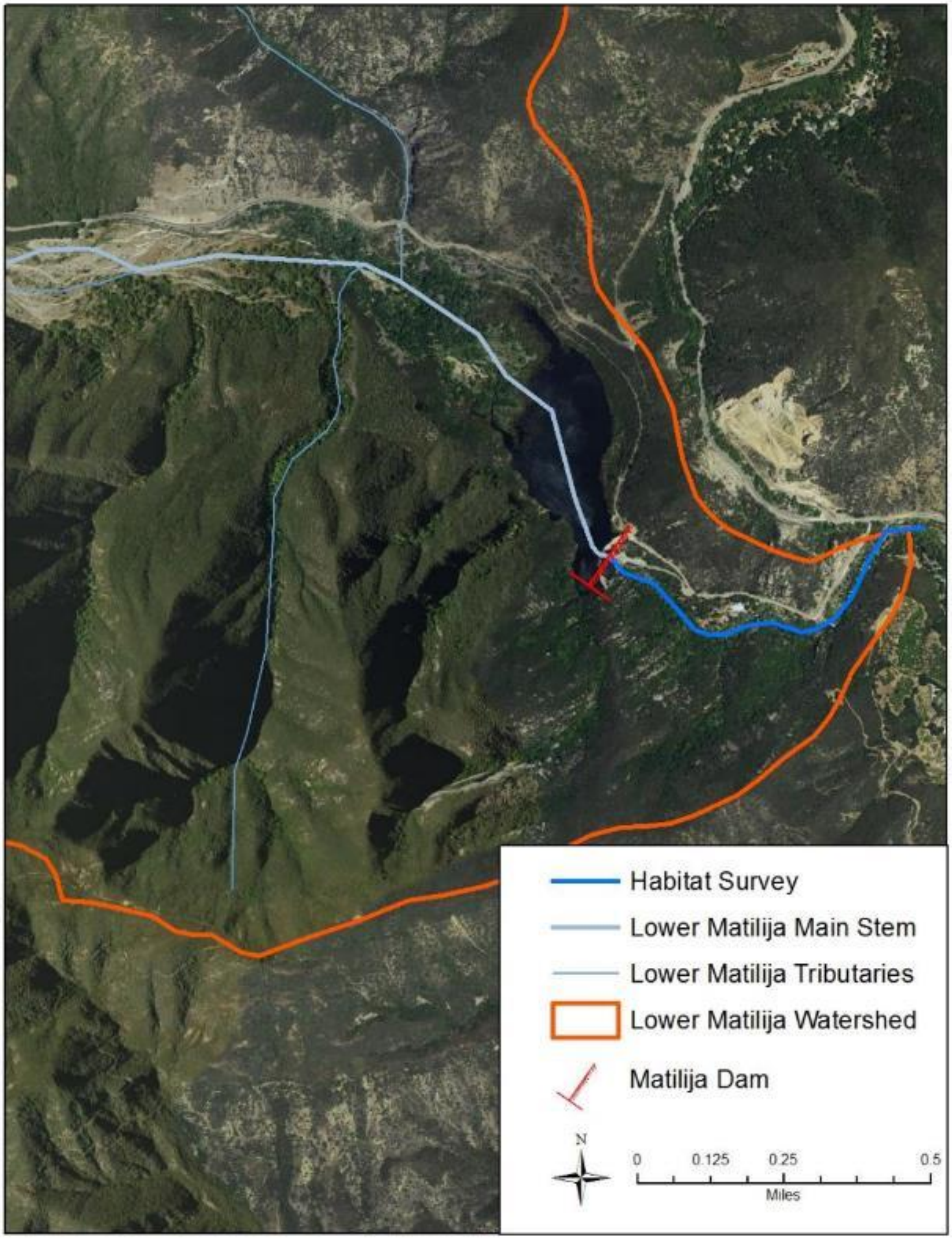


Figure 172. Percentage of total stream length categorized as pools, flatwaters, or riffles for lower Matilija.

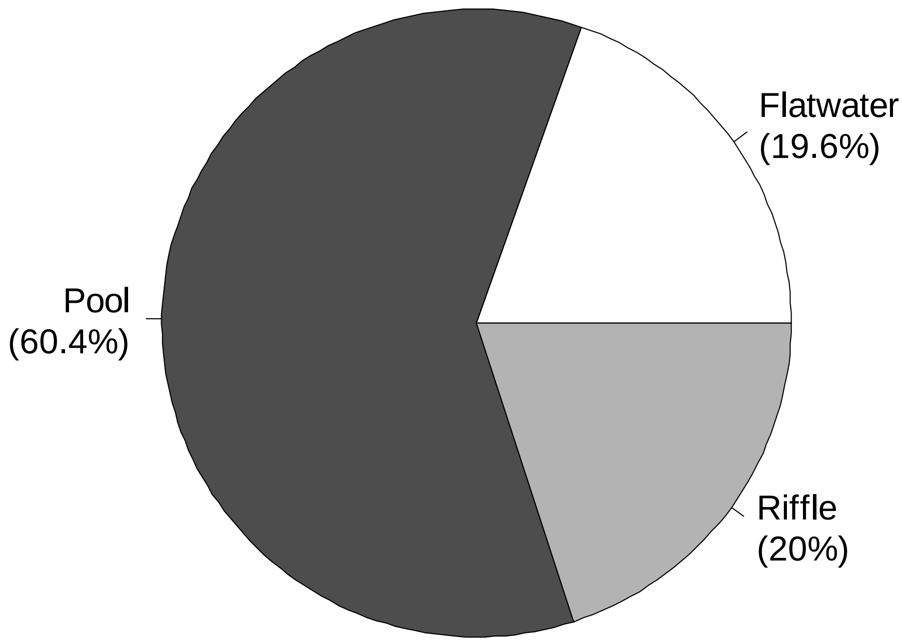


Figure 173. Percentage of all pool units (n = 32 pools) categorized by pool type (main channel, backwater, or scour pool) for lower Matilija.

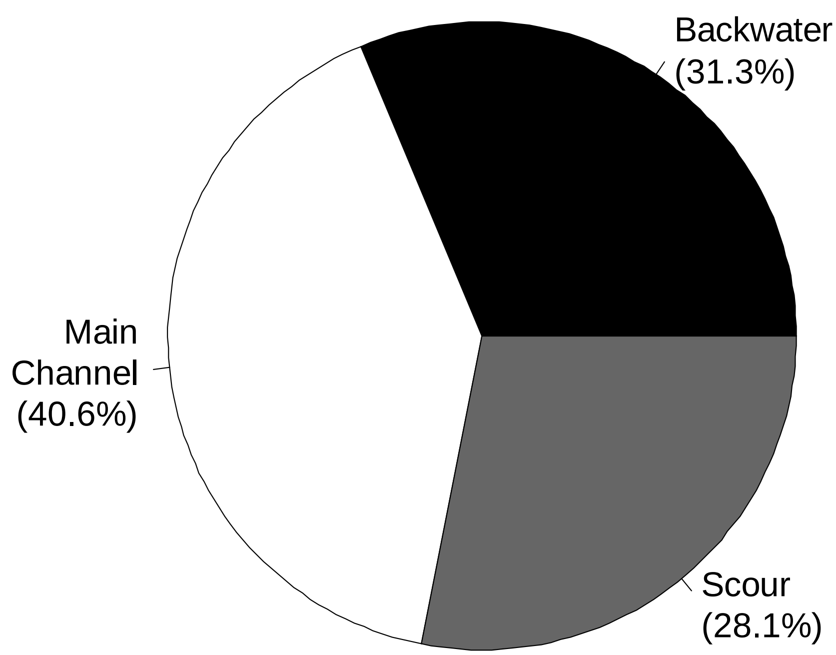


Figure 174. Histogram of residual pool depths in one-foot bins for lower Matilija. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

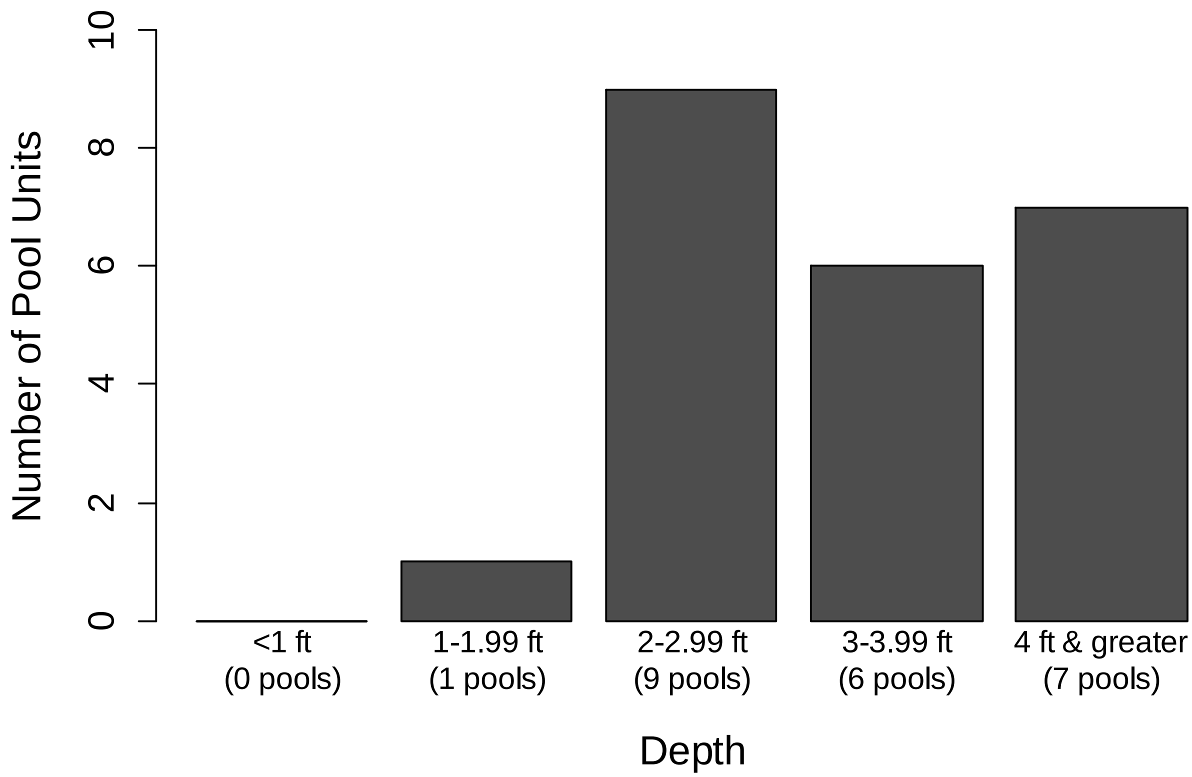


Figure 175. Percentage of pool tail-outs (n = 32 pools) by dominant substrate for lower Matilija. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

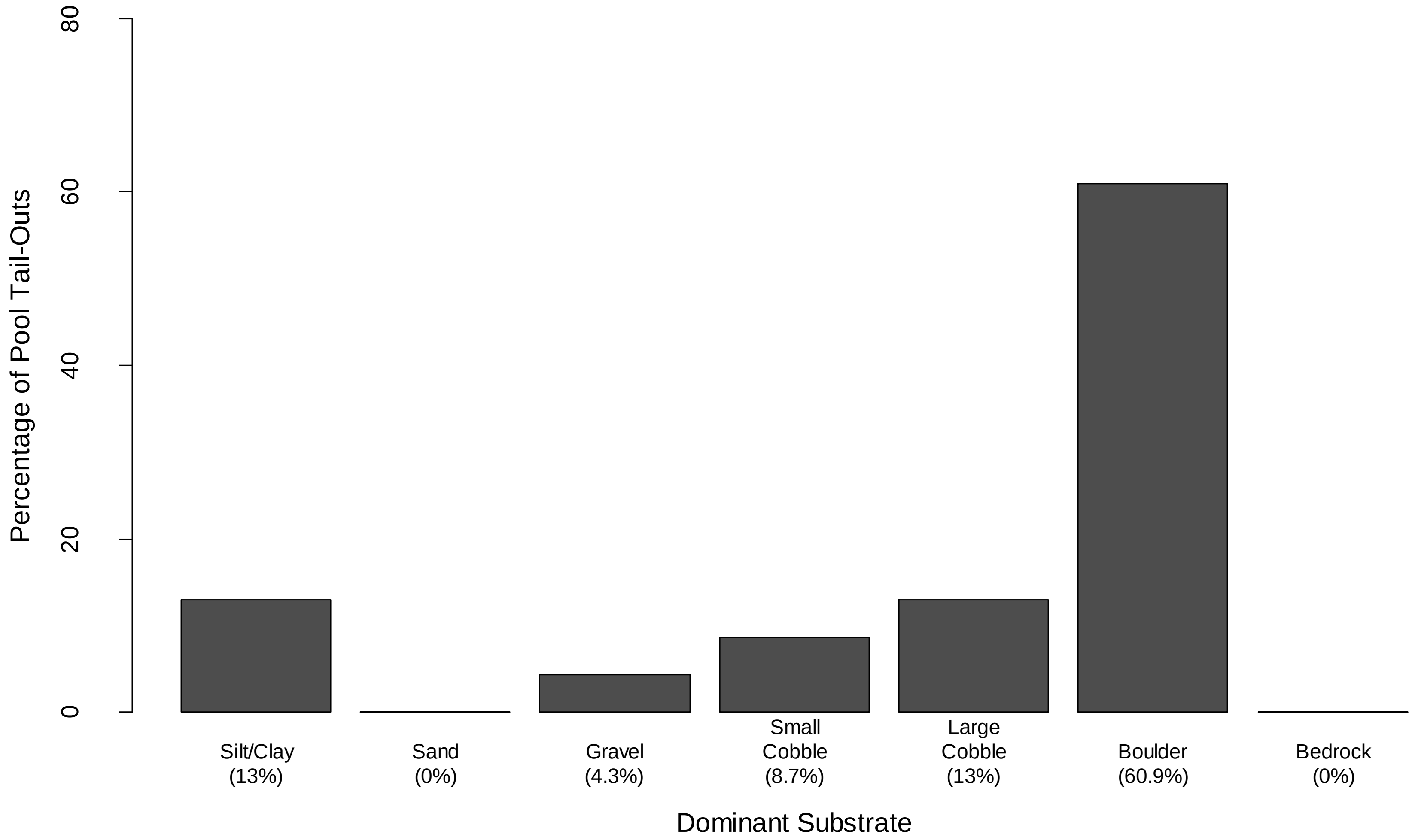


Figure 176. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 21 units) for lower Matilija. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

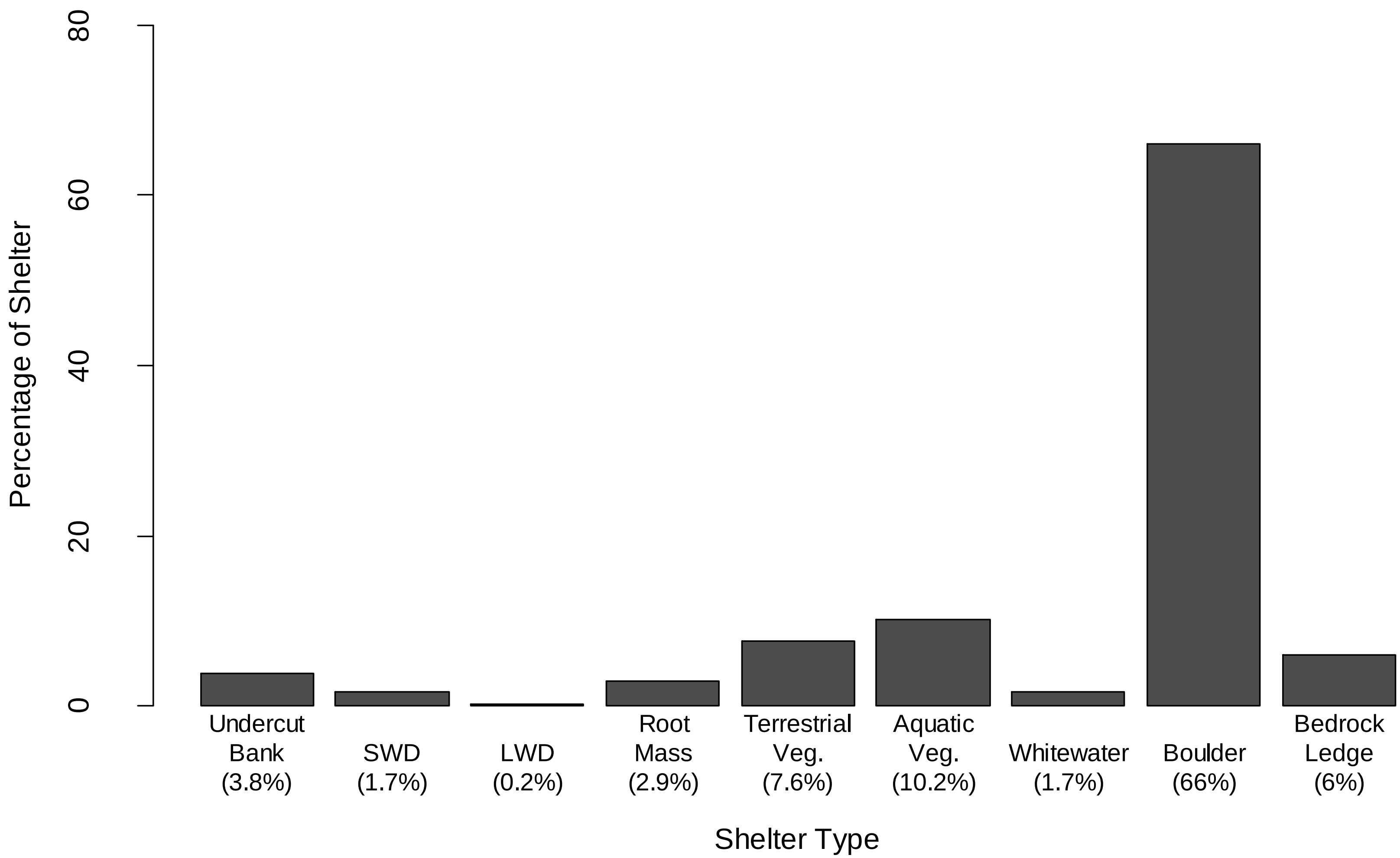


Figure 177. The percentage of instream shelter by shelter type across all pool units in which shelter was measured (n = 13 pools) for lower Matilija. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

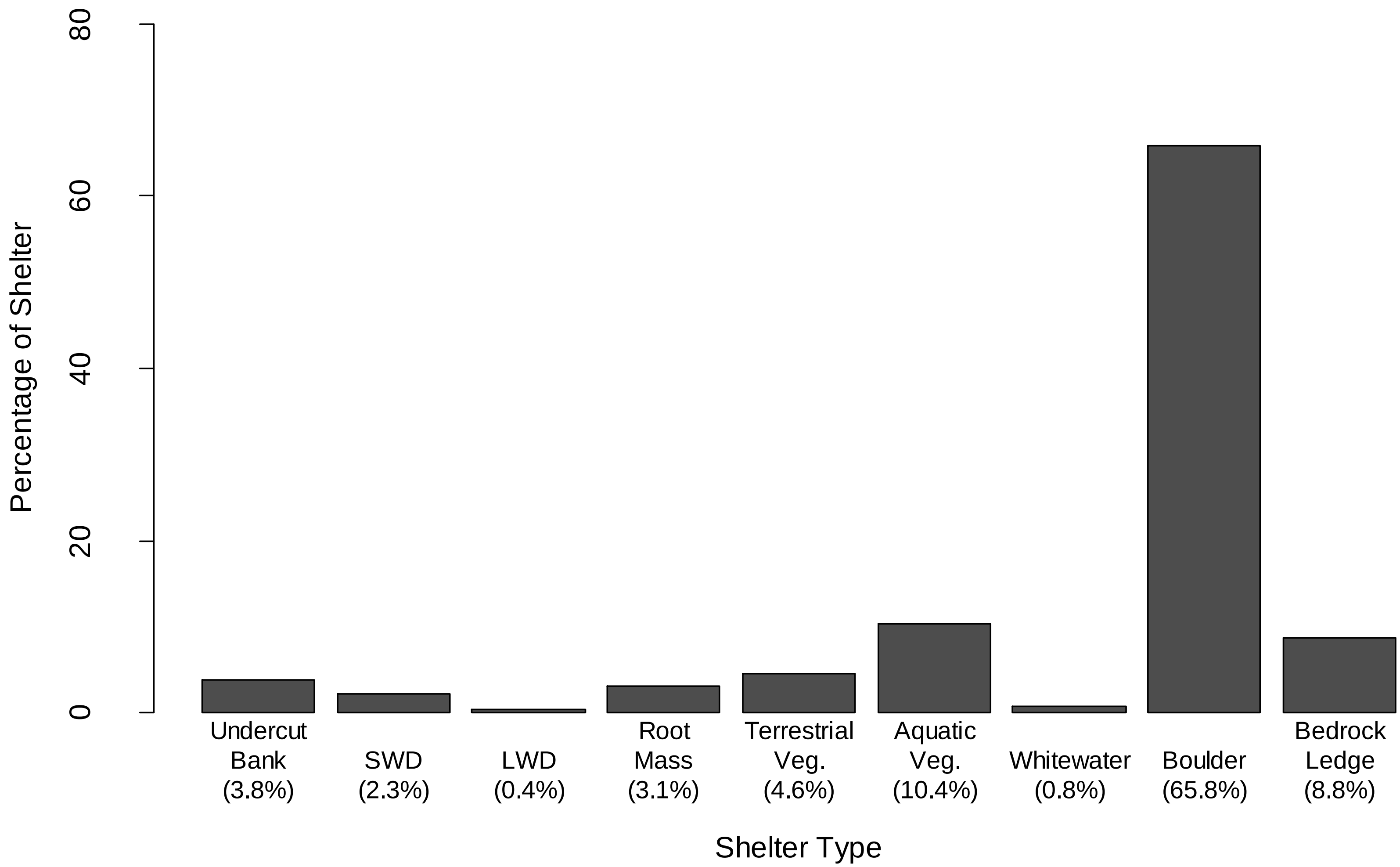


Figure 178. Percentage of banks by dominant substrate composition for lower Matilija. Substrate types include sand/silt/clay, cobble/gravel, boulder, and bedrock.

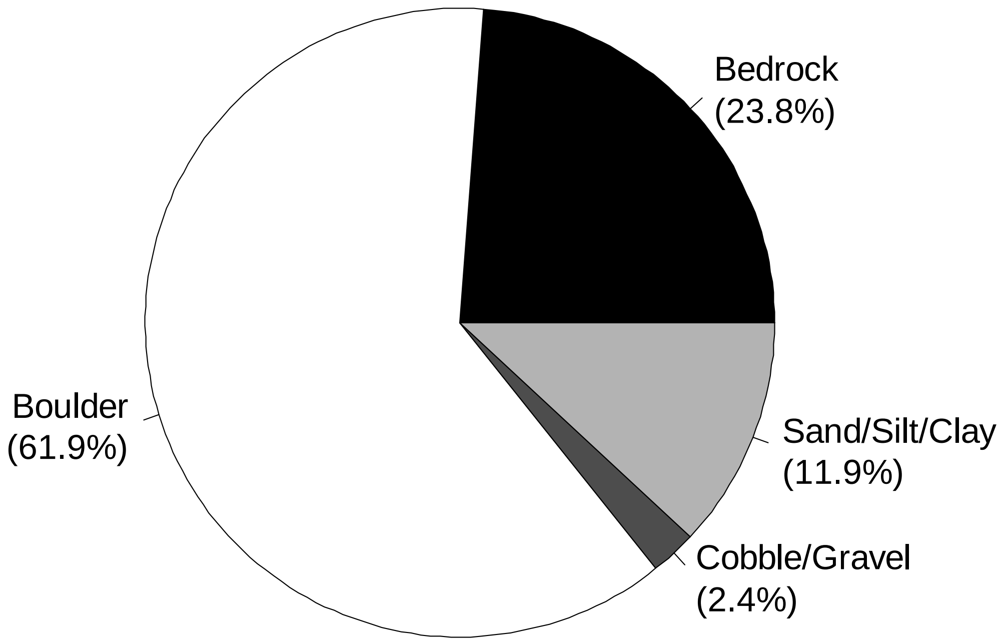
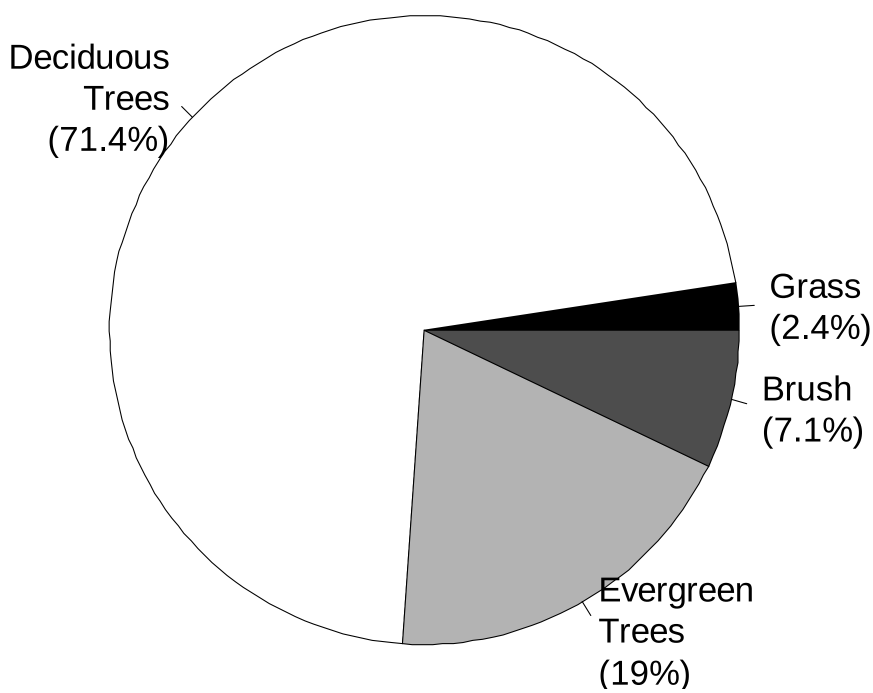


Figure 179. Percentage of banks by dominant vegetation type for lower Matilija. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



San Antonio

Habitat Assessment

Results

The habitat inventory was conducted from 28 October to 4 November 2013 by Ben Lakish, Tom Van Meeuwen, Kate McLaughlin, Patrick Riparetti, and Karissa Willits from Pacific States Marine Fisheries Commission and David Gottesman from the Americorps Watershed Stewards Program. The survey extended 45,674 feet upstream from the survey start (34.38072°N, -119.30743°W). The survey endpoint (34.43575°N, -119.24569°W) was chosen based on the end of the NMFS-designated spawner survey reach for San Antonio (Figure 180). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 53.6 to 64°F. Air temperature ranged from 55 to 72°F.

Habitat type

We identified 11 habitat types in San Antonio Creek. Of the total number of habitat units surveyed (n = 139 units), 18.7% of units were dry, 20.9% were flatwaters, 31.7% were pools, 28.1% were riffles, and 0.7% were culverts. Of the total length of the reach surveyed, 82.4% was dry, 5.6% was flatwater, 6.2% was composed of pools, 5.8% was composed of riffles, and 0.04% was composed of culvert (Figure 181).

Low gradient riffles (27.3%), mid-channel pools (22.3%), runs (18.7%) and dry units (18.7%) were the most frequently encountered habitat types (Table 53). Dry (82.4%), low-gradient riffles (5.6%), and mid-channel pools (4.6%) composed the greatest stream lengths.

Pool Metrics

A total of 37 pools were identified within the survey reach. Main channel pools were most frequently encountered (75.0% of pool units sampled) and comprised 77.4% of the total length of all pools. Only main channel and scour pools were encountered; no backwater pools were recorded

No pools had residual depths of three feet or greater (Figure 182).

Within pool tail-outs, gravel was the most frequently observed dominant substrate (45.5% of pool units), followed by small cobble (27.3%; Figure 183).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of two (40.5%) or five (27.0%; Figure 184).

Shelter

Within 100% units (n = 33 units), riffle habitat types had a mean shelter rating of 55.0, flatwater habitat types had a mean shelter rating of 40.0, and pools had a mean shelter rating of 50.8.

Of the pool units in which shelter was assessed (n = 18 units), main channel pools had a mean shelter rating of 43.3 and scour pools had a mean shelter rating of 58.3.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that terrestrial vegetation provided the most shelter (36.2% of all shelter; Figure 185), followed by boulders (25.2% of all shelter). When we examined the percentage of shelter by shelter type within pools only (n = 44 units), we found that terrestrial vegetation was the most dominant cover type (33.9% of the total cover), followed by boulders (16.7%; Figure 186).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 84.1%. Within the canopy cover present, 25.2% of the canopy was composed of deciduous trees and 75.1% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were silt/sand/clay (72.1%), cobble/gravel (14.7%), and bedrock (11.8%; Figure 187). The mean percentage of vegetation covering the right bank in sampled units was 70.1%, and the mean percentage of vegetation covering the left bank was 62.4%. Deciduous trees were the dominant vegetation type, having been observed in 44.1% of the banks surveyed. Additionally, 32.4% of the banks surveyed had coniferous trees, 17.6% had brush and 5.9% had grass as the dominant vegetation (Figure 188).

Large Woody Debris

We observed five pieces of LWD that were 6 to 20 feet long and five pieces that were greater than 20 feet long within 8037 feet of wetted stream length (excluding dry and culvert lengths). Across both LWD sizes, the number of LWD observed was 0.12 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 32.2 feet.

Discussion

Temperature

The water temperature of units measured ranged from 53.6 to 64°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Good to Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools or riffles. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools and low-gradient riffles. When we examined the reach in terms of length, we found that most of the reach was dry, riffles, or pools with low-gradient riffles comprising the greatest percentage of wetted stream length. It is worth noting that 82% of the stream length was dry, as this demonstrates the low amount of *O. mykiss* habitat availability observed in San Antonio Creek.

Pool Metrics

Pool depth is an important indicator of habitat quality, as greater pool depths can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in San Antonio Creek, we found that no pools had residual depths of at least three feet, which is required for a pool to be considered good habitat (Kier Associates & NMFS 2008). Thus, it appears that pools in San Antonio may lack the depth needed to provide good hiding cover and rearing space. This may be due in part to water extraction for agriculture coupled with severe drought effects.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was gravel, comprising 45.5% of pool units. Pool units most frequently had an embeddedness value of either a two or five. Together, these metrics suggest that, although pools may not provide the ideal depth for cover or rearing space, some pool tail-outs in San Antonio provide good spawning habitat for *O. mykiss*, assuming that flows are adequate.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that riffles and pools had similar shelter ratings, and that flatwater had slightly lower shelter ratings. This suggests that riffle and pool units provide slightly better shelter than flatwater in San Antonio. However, it is important to note that these shelter ratings are highly influenced by the estimated percent of shelter covering the unit; most shelters were assigned a cover complexity value of two (86.7% of all units assigned a shelter value) and therefore did not contribute greatly to the variation in shelter rating. It is also important to note that shelter ratings for pool, riffle, and flatwater habitats were all relatively low. A good shelter rating for a pool habitat is 100, and the average pool shelter rating was 51 on San Antonio Creek. This suggests that there is not much habitat available for *O. mykiss* in this system.

When we examined the percentage shelter by shelter type, we found that terrestrial vegetation provided the most shelter (36.2% of all shelter), followed by boulders (25.2% of all shelter). This suggests that terrestrial vegetation and boulders are common, important features to *O. mykiss* habitat in San Antonio.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In San Antonio Creek, we estimated a mean canopy cover of 84%, consisting predominantly of evergreen trees. This suggests that San Antonio has a moderately high amount of cover (Kier Associates & NMFS 2008). This cover is likely to vary through time, given the seasonality of deciduous trees (comprising about 25% of the canopy cover). However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was sand/silt/clay, followed by cobble/gravel and bedrock. The mean vegetation cover for the right and left banks was 70% and 62%, respectively. Deciduous and evergreen trees were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively vulnerable to erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In San Antonio Creek, we found 0.12 pieces of LWD per 100 feet, which was extremely low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while San Antonio lacks LWD, it may have boulder elements that improve habitat quality.

Tables

Table 53. Percentage of all units (n = 139) by habitat type for San Antonio Creek.

Habitat Type	% of Units
Low Gradient Riffle	27.34%
Mid-Channel Pool	22.30%
Run	18.71%
Dry	18.71%
Lateral Scour, bedrock-enhanced	4.32%
Step Run	2.16%
Corner Pool	2.16%
Step Pool	1.44%
High Gradient Riffle	0.72%
Lateral Scour, root wad-enhanced	0.72%
Plunge Pool	0.72%
Culvert	0.72%

Figures

Figure 180. Map of the habitat assessment survey area in San Antonio Creek.

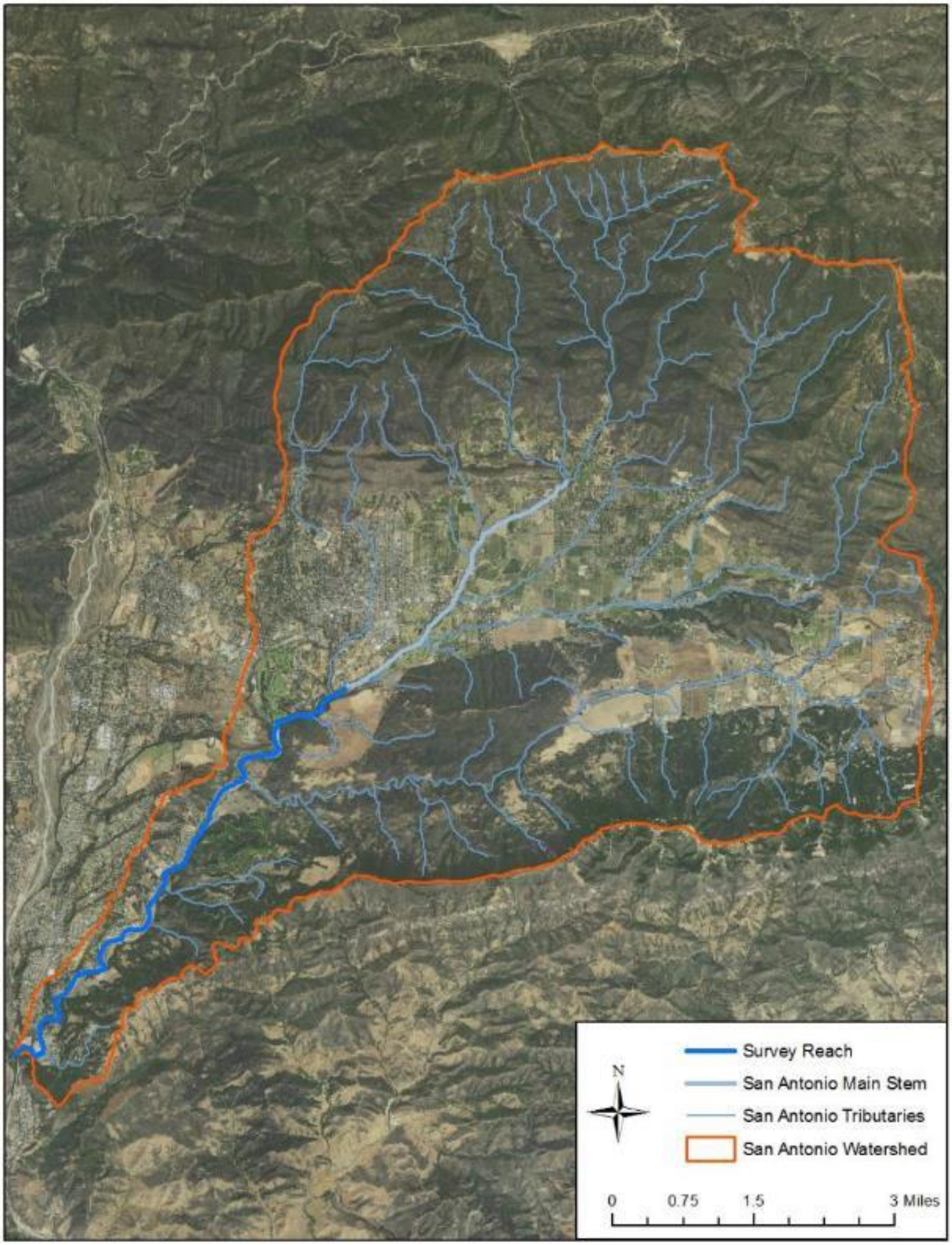


Figure 181. Percentage of total stream length categorized as pools, flatwaters, riffles, dry, or culverts for San Antonio Creek.

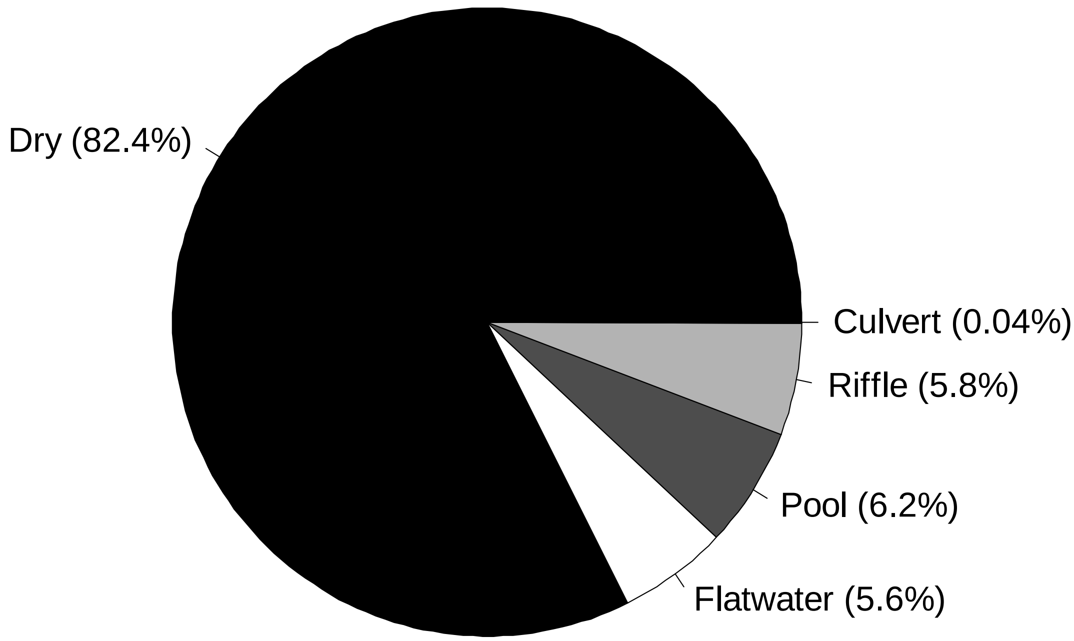


Figure 182. Histogram of residual pool depths in one-foot bins for San Antonio Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

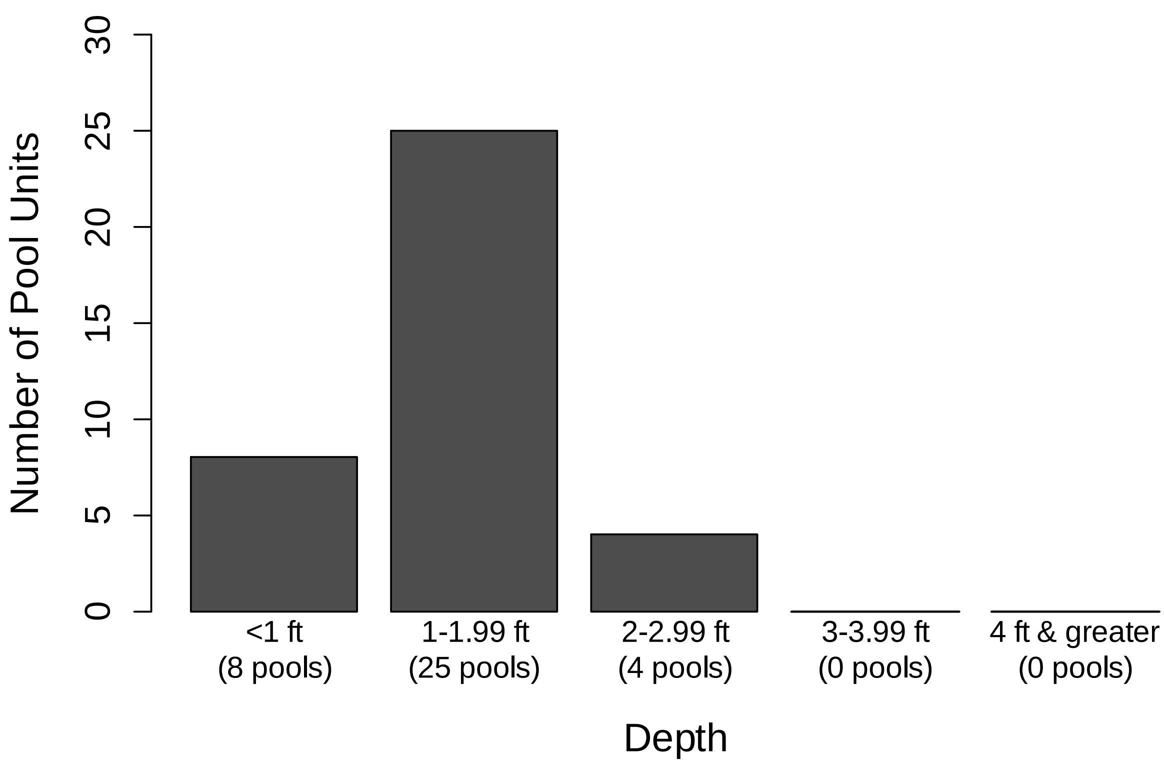


Figure 183. Percentage of pool tail-outs (n = 44 pools) by dominant substrate for San Antonio. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

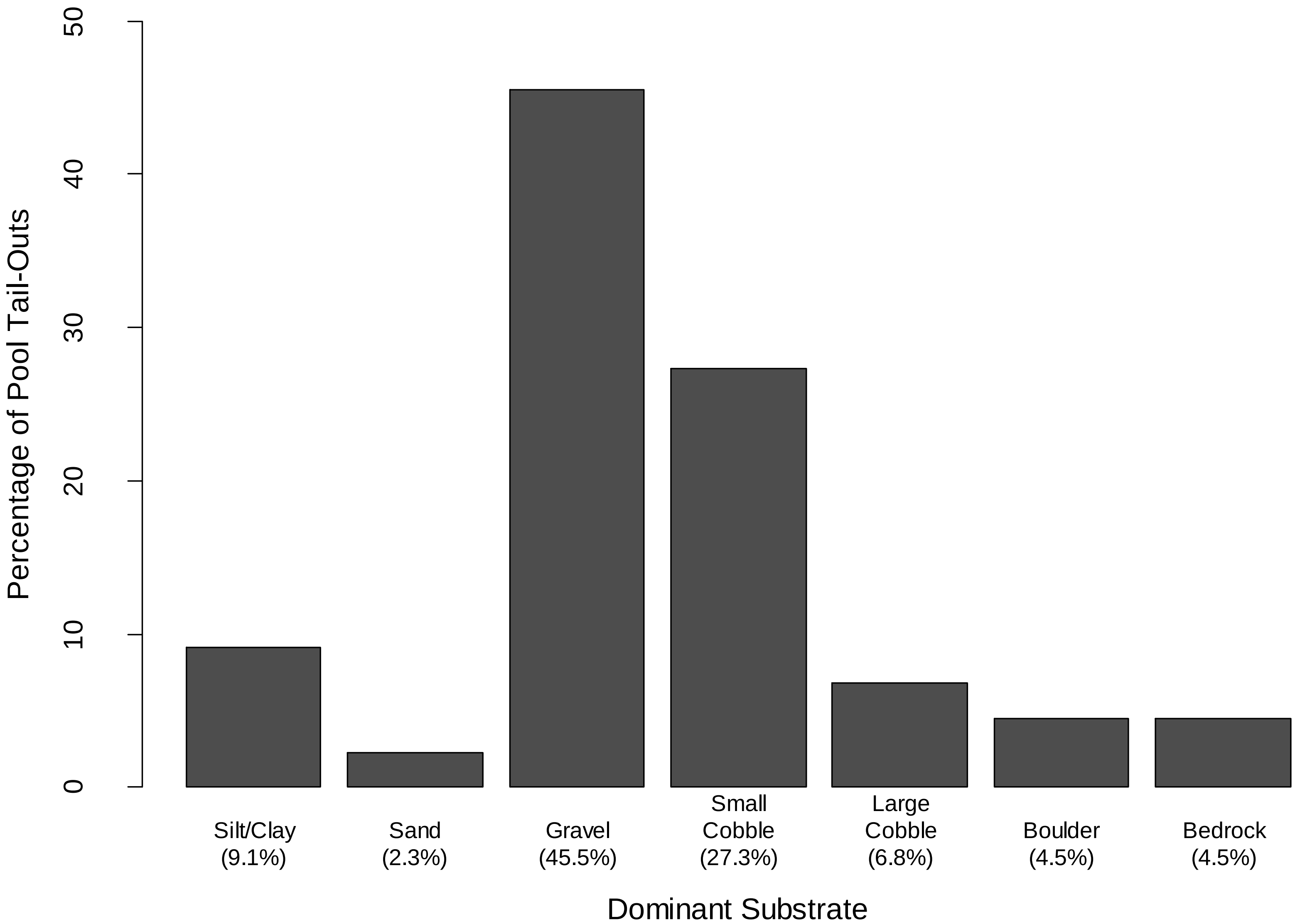


Figure 184. Percentage of all pool units (n = 44 pools) assigned a pool tail-out embeddedness value of 1 to 5 for San Antonio Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning.

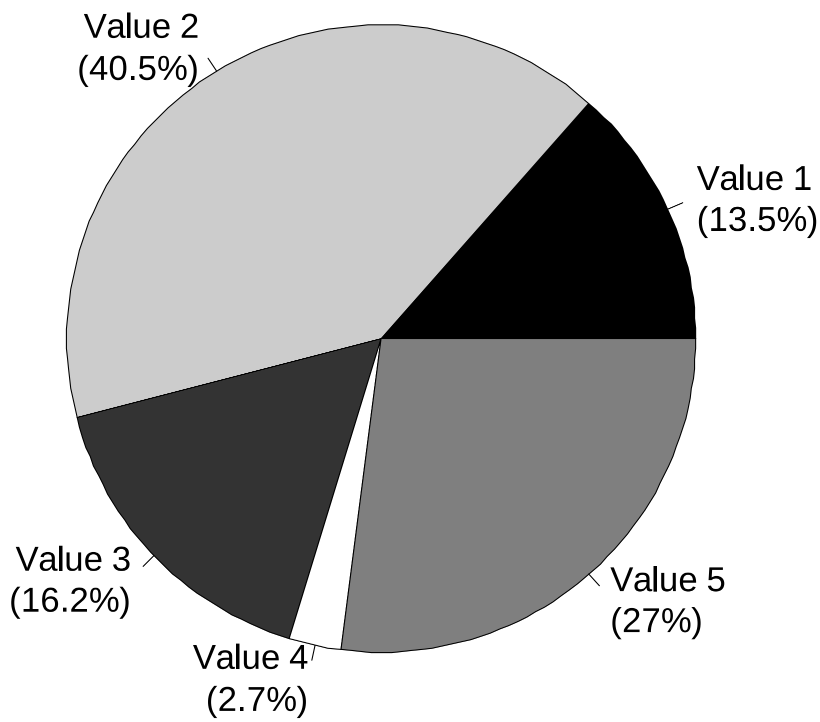


Figure 185. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 33 units) for San Antonio Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

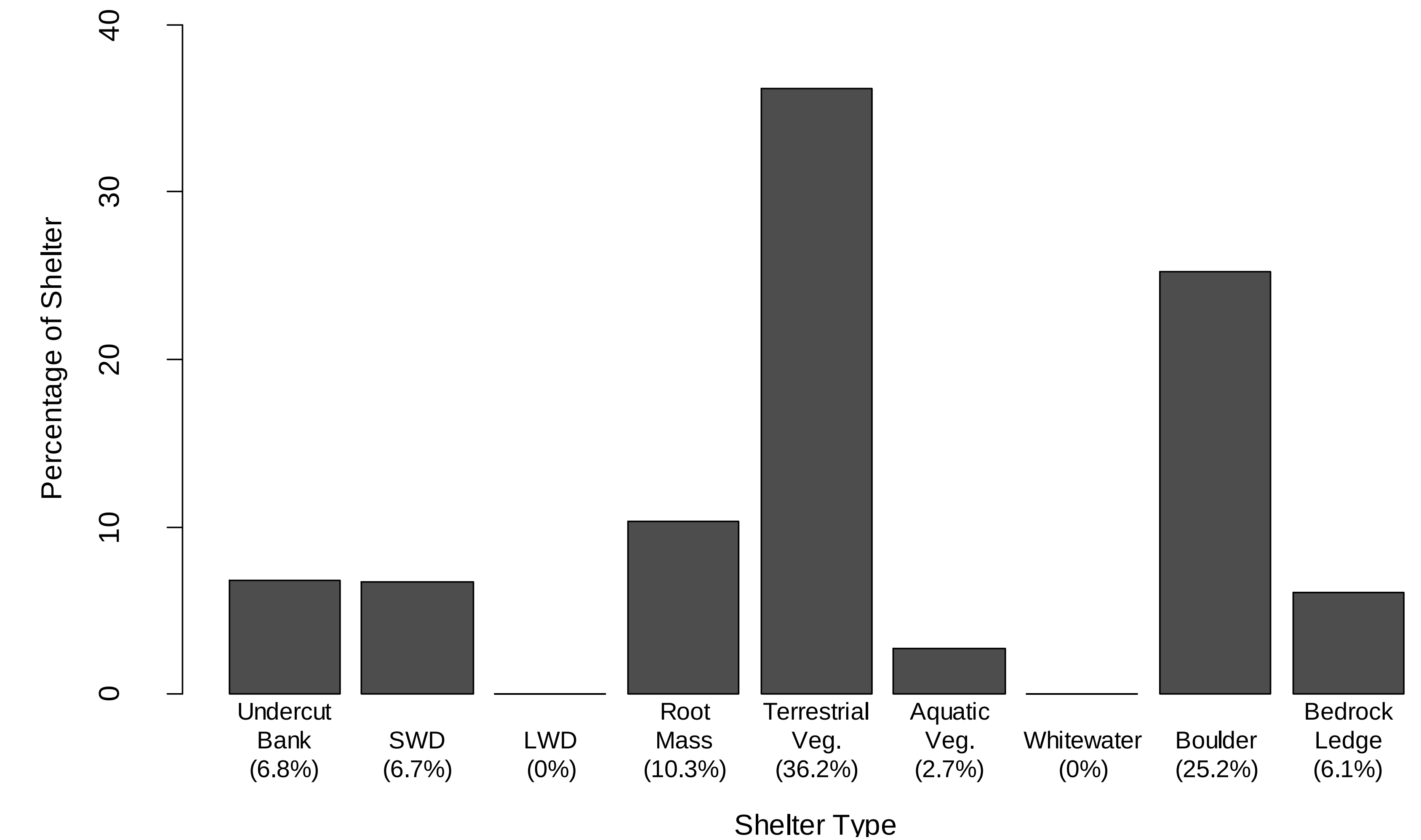


Figure 186. The percentage of instream shelter by shelter type across all pool units in which shelter was measured (n = 18 pools) for San Antonio Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

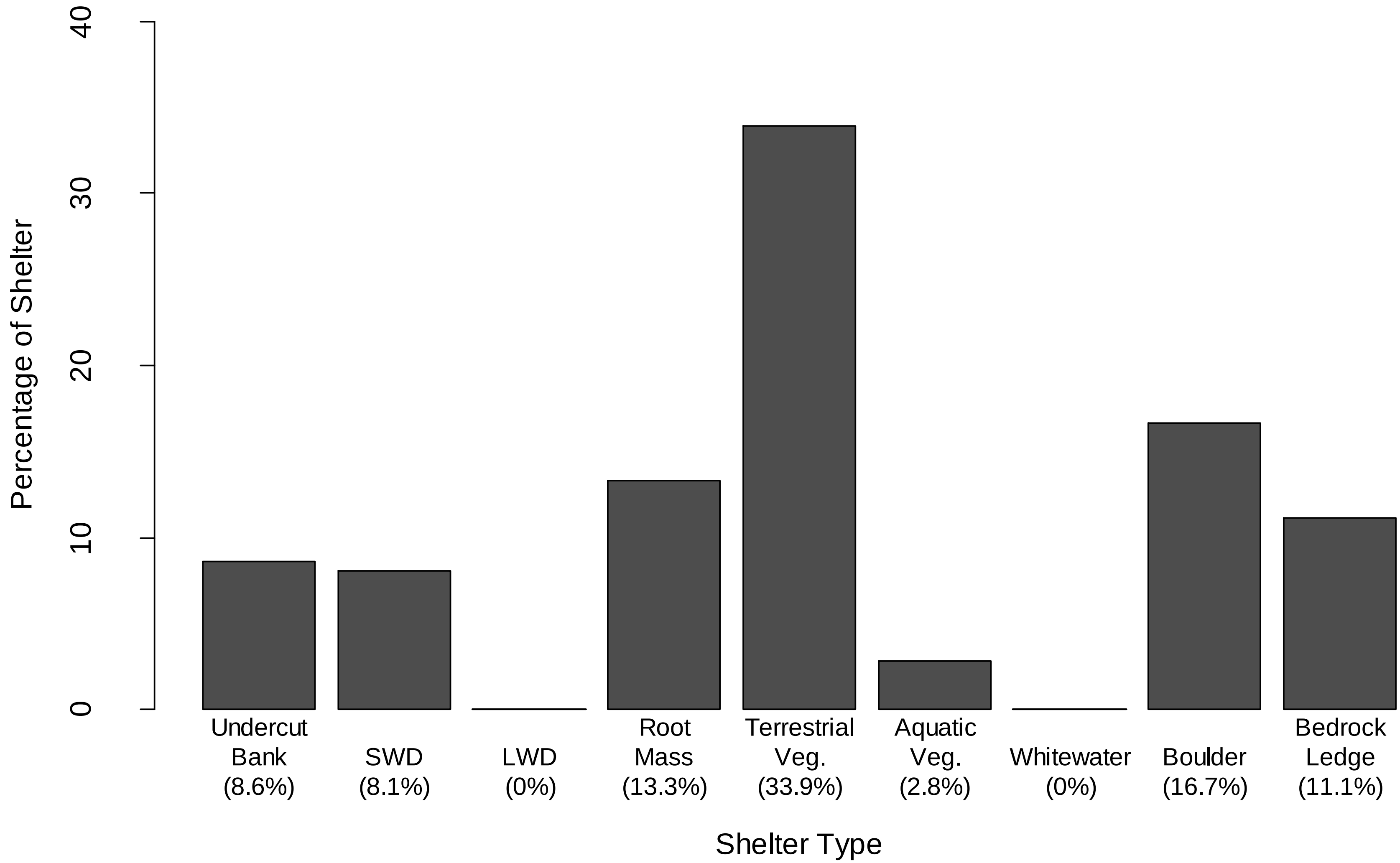


Figure 187. Percentage of banks by dominant substrate composition for San Antonio Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock.

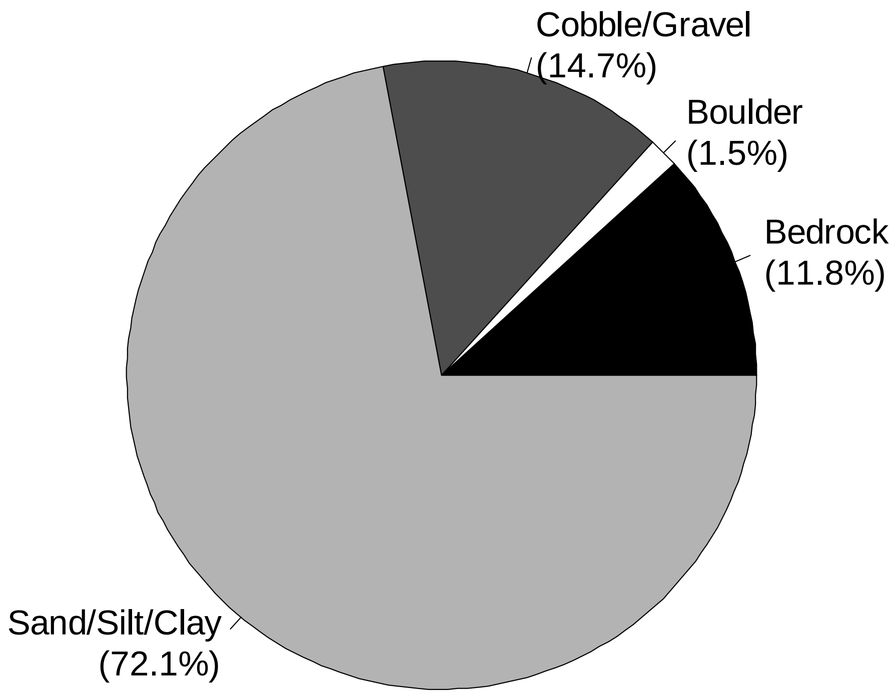
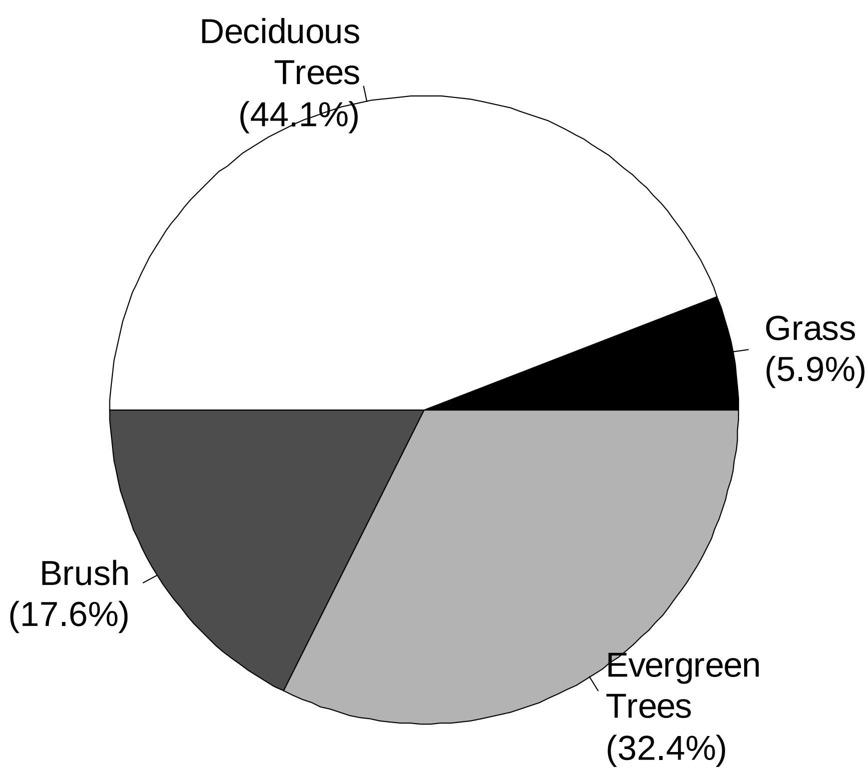


Figure 188. Percentage of banks by dominant vegetation type for San Antonio Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



Stewart Creek

Habitat Assessment

Results

The habitat inventory was conducted from 4–18 November 2013 by Patrick Riparetti, Ben Lakish, Kate McLaughlin, Karissa Willits, and Tom van Meeuwen from Pacific States Marine Fisheries Commission. The survey extended 7,184 feet upstream from the survey start (34.43340°N, -119.24946°W), with an additional 1,092 feet of side channel. The survey endpoint (34.44177°N, -119.24827°W) was determined by land owner access and the presence of a concrete-made channel at the end of the reach (Figure 189). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 51 to 57°F. Air temperature ranged from 59 to 66°F.

Habitat type

Of the total number of habitat units surveyed (n = 88 units), 6.8% of units were dry, 21.6% were flatwaters, 37.5% were pools, 26.1% were riffles, 3.4% were culverts, and 4.5% were not surveyable. Of the total length of the reach surveyed, 48.0% was dry, 14.3% was composed of flatwaters, 15.9% was composed of pools, and 13.5% was composed of riffles, 2.0% was composed of culverts, and 6.3% was unsurveyable (Figure 190).

We identified eleven habitat types Stewart Creek (excluding culvert and unsurveyable units). Based on the frequency of units sampled, low gradient riffles (26.1%), runs (20.5%), and mid-channel pools (14.8%) were the most common habitat types (Table 54). Based on total stream length, dry (48.0%), low gradient riffles (13.5%), and runs (13.4%) composed the greatest stream lengths.

Pool Metrics

A total of 33 pools were identified within the survey reach. Scour pools were most frequently encountered (51.5% of pool units sampled; Figure 191) and comprised 50.7% of the total length of all pools.

Two of 30 pools (7%) had residual depths of three feet or greater (Figure 192).

Within pool tail-outs, gravel was the most frequently observed dominant substrate (41.9% of pool units), followed by silt/clay (19.4%), and sand (16.1%; Figure 193).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of two (38.7%) or five (25.8%; Figure 194).

Shelter

Within 100% units (n = 31 units), riffle habitat types had a mean shelter rating of 13.3, flatwater habitat types had a mean shelter rating of 28.3, and pools had a mean shelter rating of 51.5.

Of the pool units in which shelter was assessed (n = 20 units), main channel pools had a mean shelter rating of 40.0, scour pools had a mean shelter rating of 66.0, and backwater pools had a mean shelter rating of 10.0.

When we examined the mean percentage of shelter by shelter type across all units in which we measured shelter (n = 31), we found that terrestrial vegetation provided the most shelter (32.9% of all shelter; Figure 195). When we examined the percentage of shelter by shelter type within pools only (n =

20 units), we found that terrestrial vegetation was the most dominant cover type (32.0% of the total cover), followed by root mass (24.3%; Figure 196).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 84.9%. Within the canopy cover present, 34.2% of the canopy was composed of deciduous trees and 65.8% of evergreen.

Bankside Metrics

Across units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were bedrock (10.3%), cobble/gravel (5.2%), and sand/silt/clay (84.5%; Figure 197). The mean percentage of vegetation covering the right bank in sampled units was 47.9%, and the mean percentage of vegetation covering the left bank was 38.5%. Evergreen trees and grass were the dominant vegetation types, each having been observed in 29.3% of the banks surveyed (Figure 198).

Large Woody Debris

We observed six pieces of LWD that were 6 to 20 feet long and three pieces that were greater than 20 feet long within 3621 feet of wetted stream length (excluding culvert, dry, and unsurveyable units). Across both LWD sizes, the number of LWD observed was 0.25 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 25.6 feet.

Discussion

Temperature

The water temperature of units measured ranged from 51 to 57°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools or riffles. Looking at more detailed habitat types, we found that units were most frequently low gradient riffles, runs, or mid-channel pools. When we examined the reach in terms of length, we found that most of the reach was dry or pools. When looking at more detailed habitat types, dry comprised the greatest stream length and low gradient riffles and runs comprised the greatest wetted stream length.

Pool Metrics

Pool depth is an important indicator of habitat quality, as greater pool depths can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). A residual depth of at least three feet is needed to be considered good habitat (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in Stewart Creek, we found that only 7% of pools had residual depths three feet or greater. Thus, it appears that pools in Stewart may not provide good hiding cover and rearing space for salmonids. This may be due in part to the current, severe drought, which has extended into its fourth consecutive year.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was gravel, comprising 41.9% of pool units. Pool units most frequently had an embeddedness value of either a two (38.7%) or five (25.8%). Together, these metrics suggest that, although pools may not provide the ideal depth for cover or rearing space, many pool tail-outs in Stewart provide good spawning habitat for *O. mykiss*, assuming that flows are adequate.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that most shelter rating were low (below 52 on a scale of 0 to 300). Specifically, pools had the best mean shelter rating, while riffles had the worst. This suggests that pools provide better shelter than riffles or flatwaters, although this system does not provide adequate shelter for *O. mykiss* in general. However, statistical analyses are needed to verify these hypotheses.

When examining pool habitat units specifically, we found that scour pools had better shelter ratings than main channel pools, although both ratings were low (66.0 and 40.0, respectively). Only one backwater pool was sampled and was therefore excluded from these qualitative comparisons.

When we examined the percentage of shelter across all 100% units and within only 100% pools, we found the terrestrial vegetation provided the greatest amount of shelter, followed by root mass.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In Stewart Creek, we estimated a mean canopy cover of 84.9% across all units, consisting predominantly of evergreen trees. This suggests that Stewart has a high amount of cover (Kier Associates & NMFS 2008), and that this cover is likely to remain throughout the season.

Bankside Metrics

The predominant substrate composing stream banksides was sand/silt/clay. The mean percentage of vegetation covering the right and left banks was 47.9% and 38.5% for right and left bank, respectively. Evergreen trees and grass were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be vulnerable to erosion resulting from large flow events, despite the presence of evergreen trees.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In Stewart Creek, we found 0.25 pieces of LWD per 100 feet, which was extremely low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern

California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Stewart Creek lacks LWD, it may have boulder elements that improve habitat quality.

Tables

Table 54. Percentage of units (n = 88) by habitat type in Stewart Creek.

Habitat Type	% of Units
Low Gradient Riffle	26.14%
Run	20.45%
Mid Channel Pool	14.77%
Plunge Pool	6.82%
Dry	6.82%
Lateral Scour, root wad-enhanced	5.68%
Lateral Scour, log-enhanced	4.55%
Not Surveyed	4.55%
Culvert	3.41%
Channel Confluence Pool	2.27%
Lateral Scour, boulder formed	2.27%
Step Run	1.14%
Dammed Pool	1.14%

Figures

Figure 189. Map of the habitat assessment survey area in Stewart Creek.

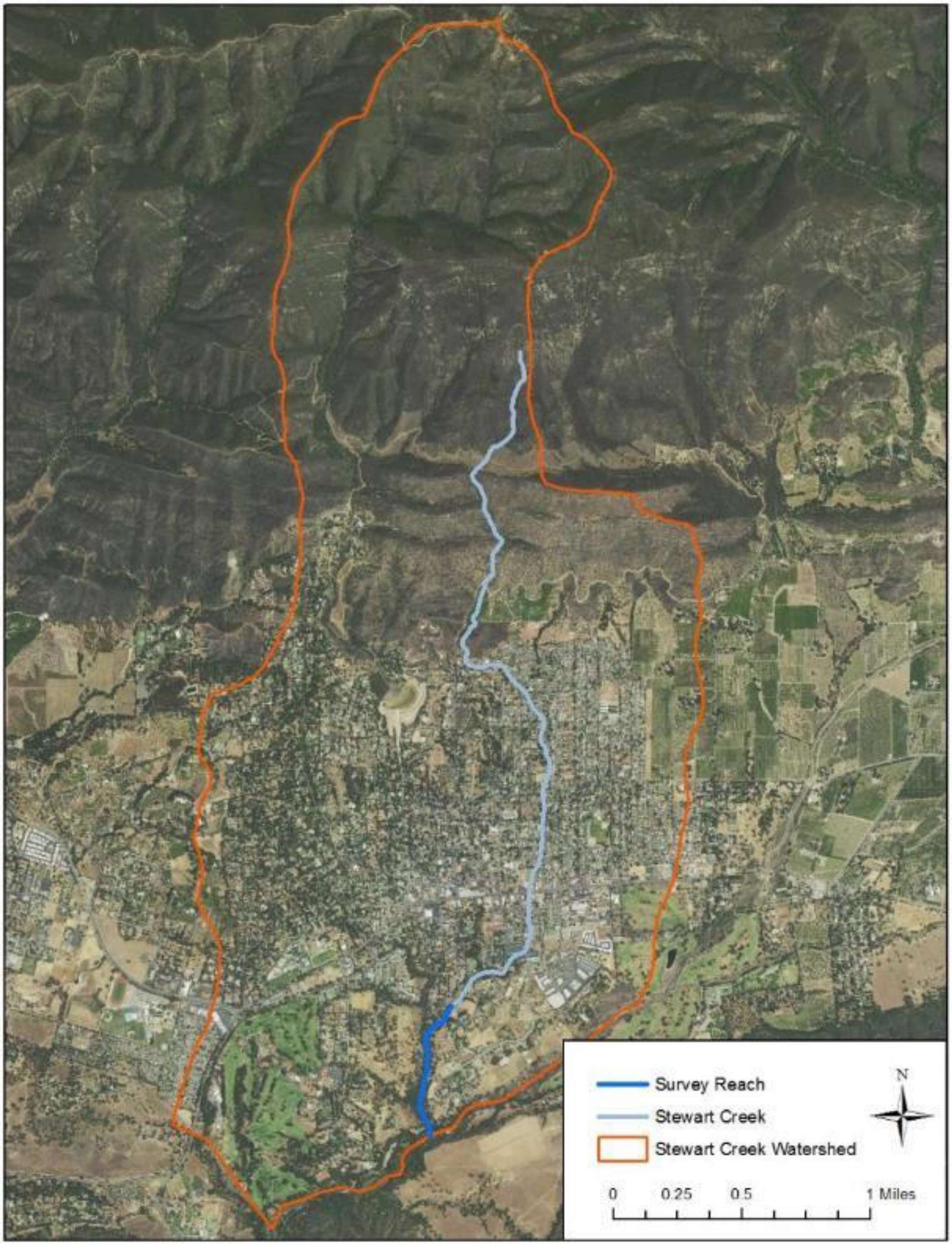


Figure 190. Percentage of total stream length categorized as pools, flatwaters, riffles, culverts, or not surveyable in Stewart Creek.

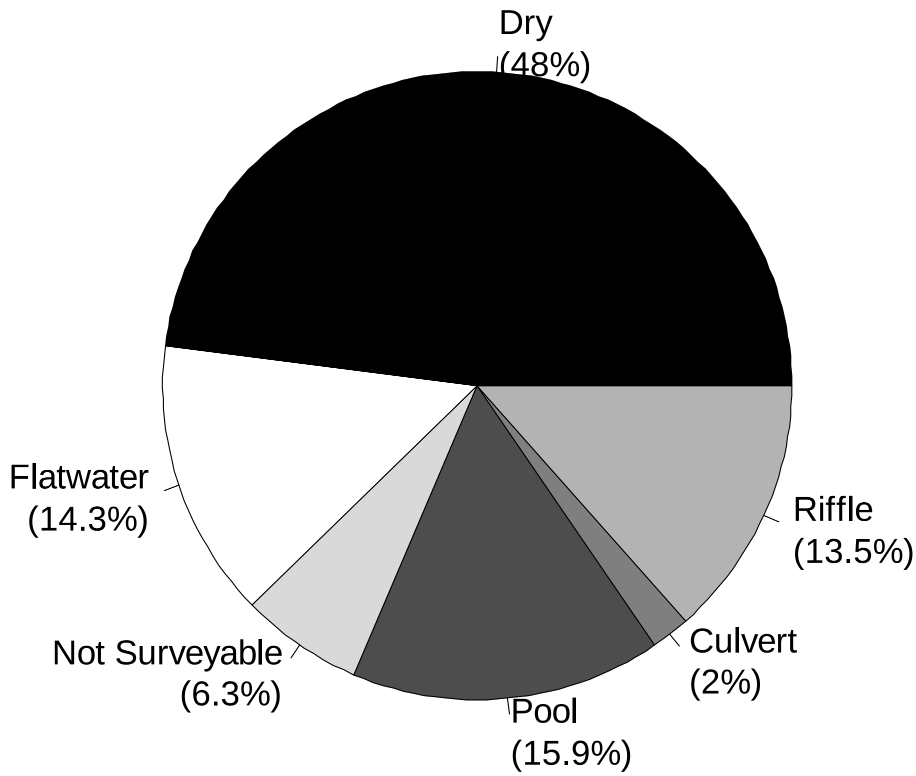


Figure 191. Percentage of all pool units (n = 33 pools) in Stewart Creek categorized by pool type (main channel, backwater, or scour pool).

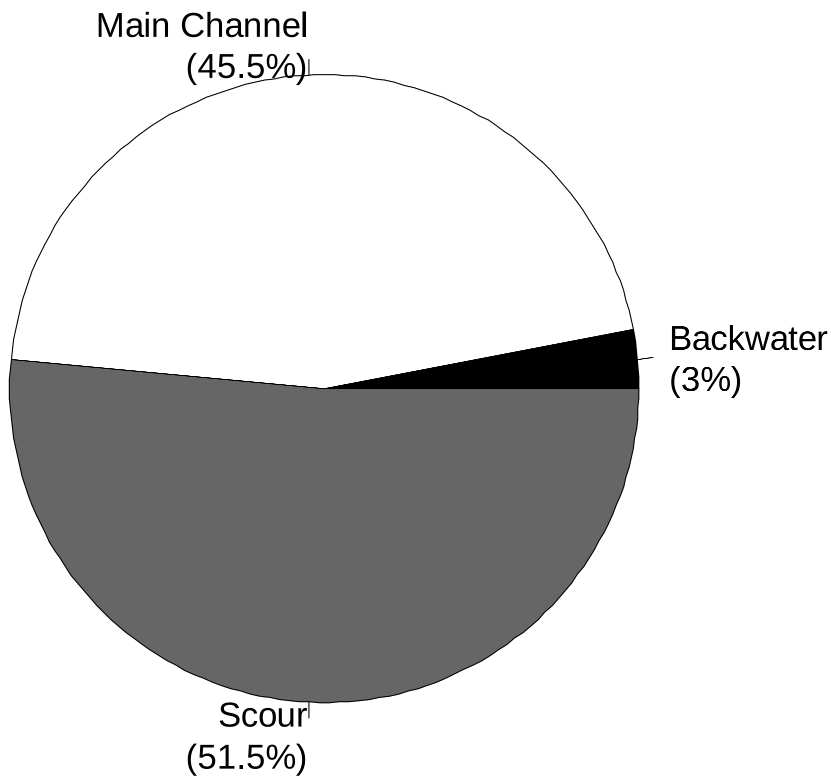


Figure 192. Histogram of residual pool depths in one-foot bins for Stewart Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

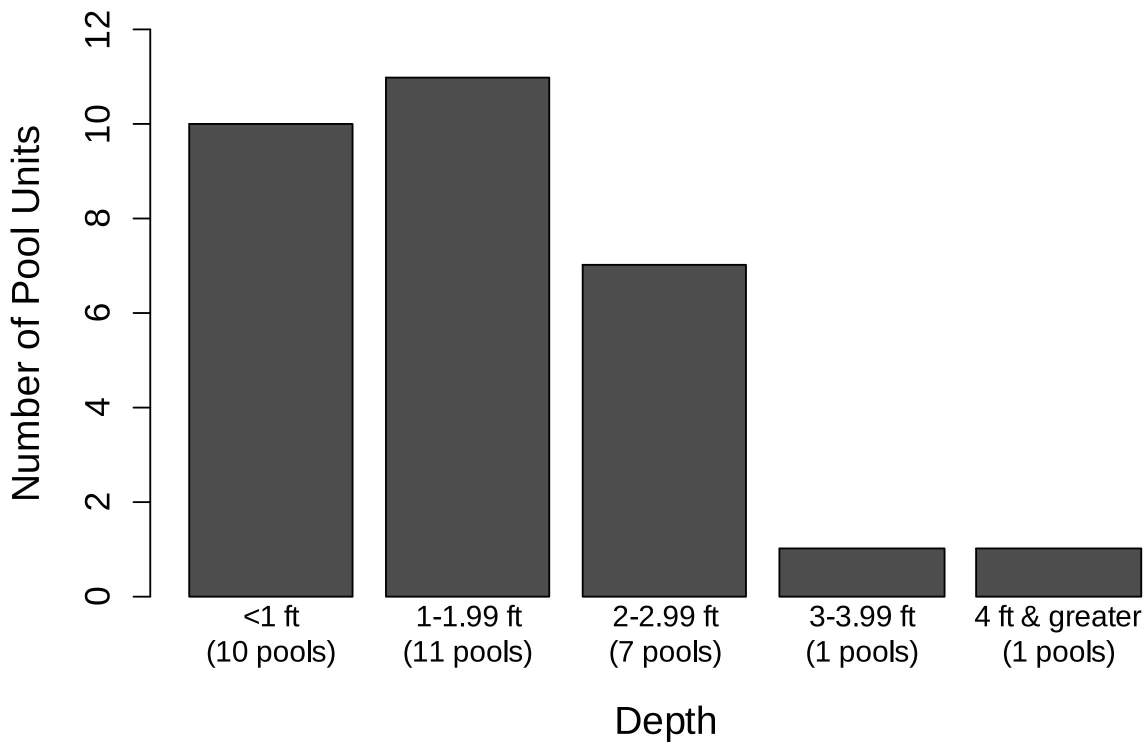


Figure 193. Percentage of pool tail-outs by dominant substrate for Stewart Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

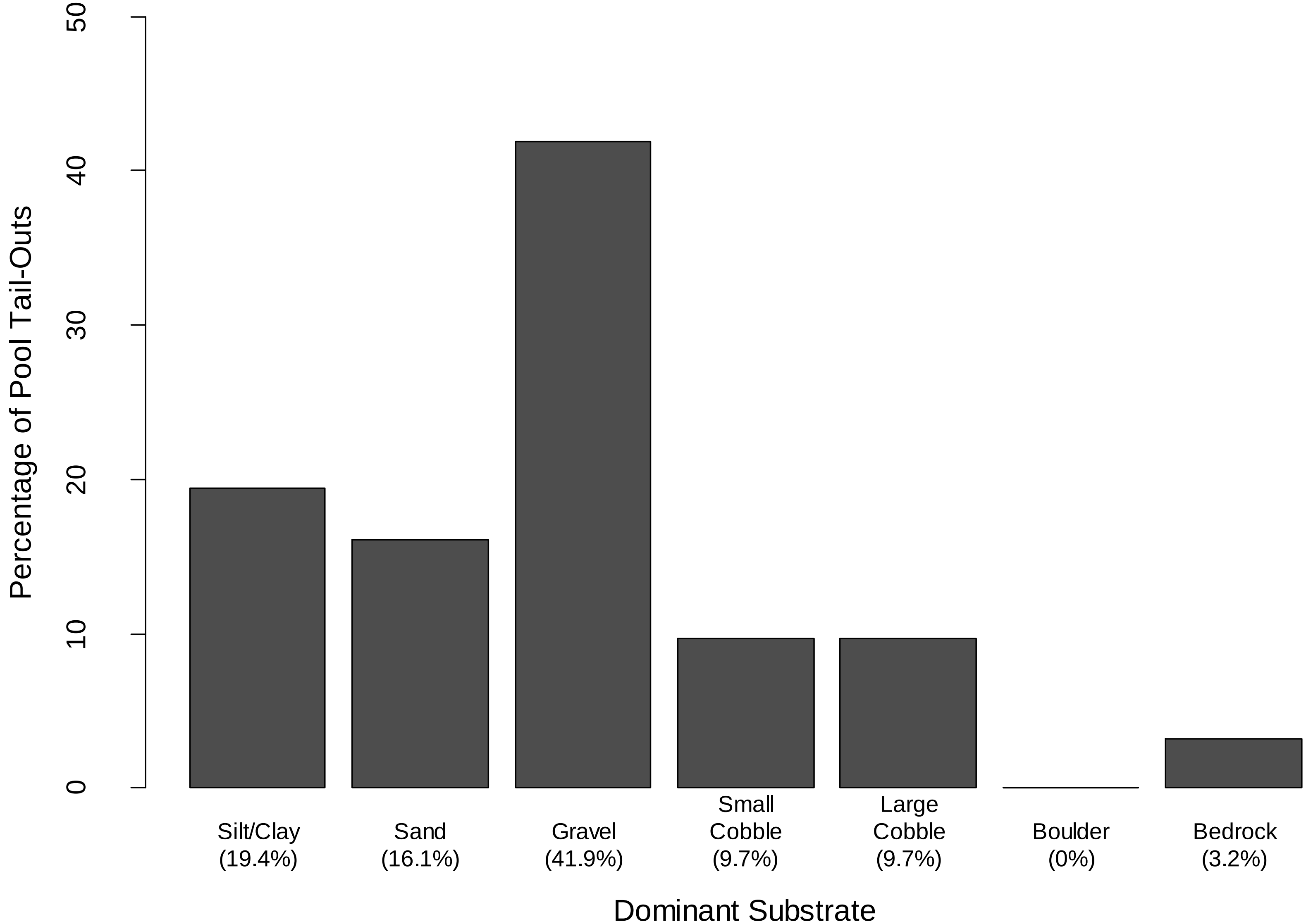


Figure 194. Percentage of all pool units assigned a pool tail-out embeddedness value of 1 to 5 for Stewart Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning.

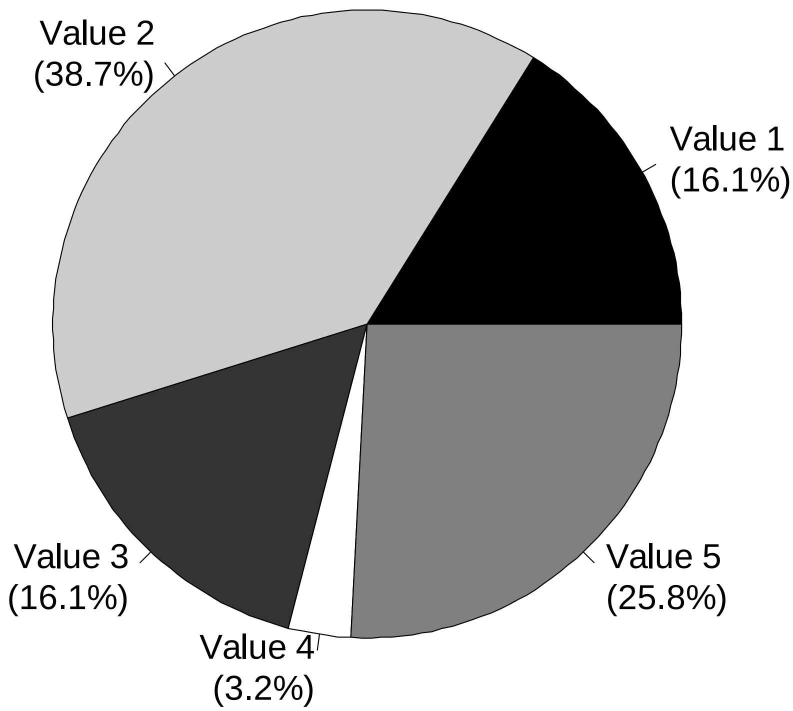


Figure 195. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 31 units) for Stewart Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

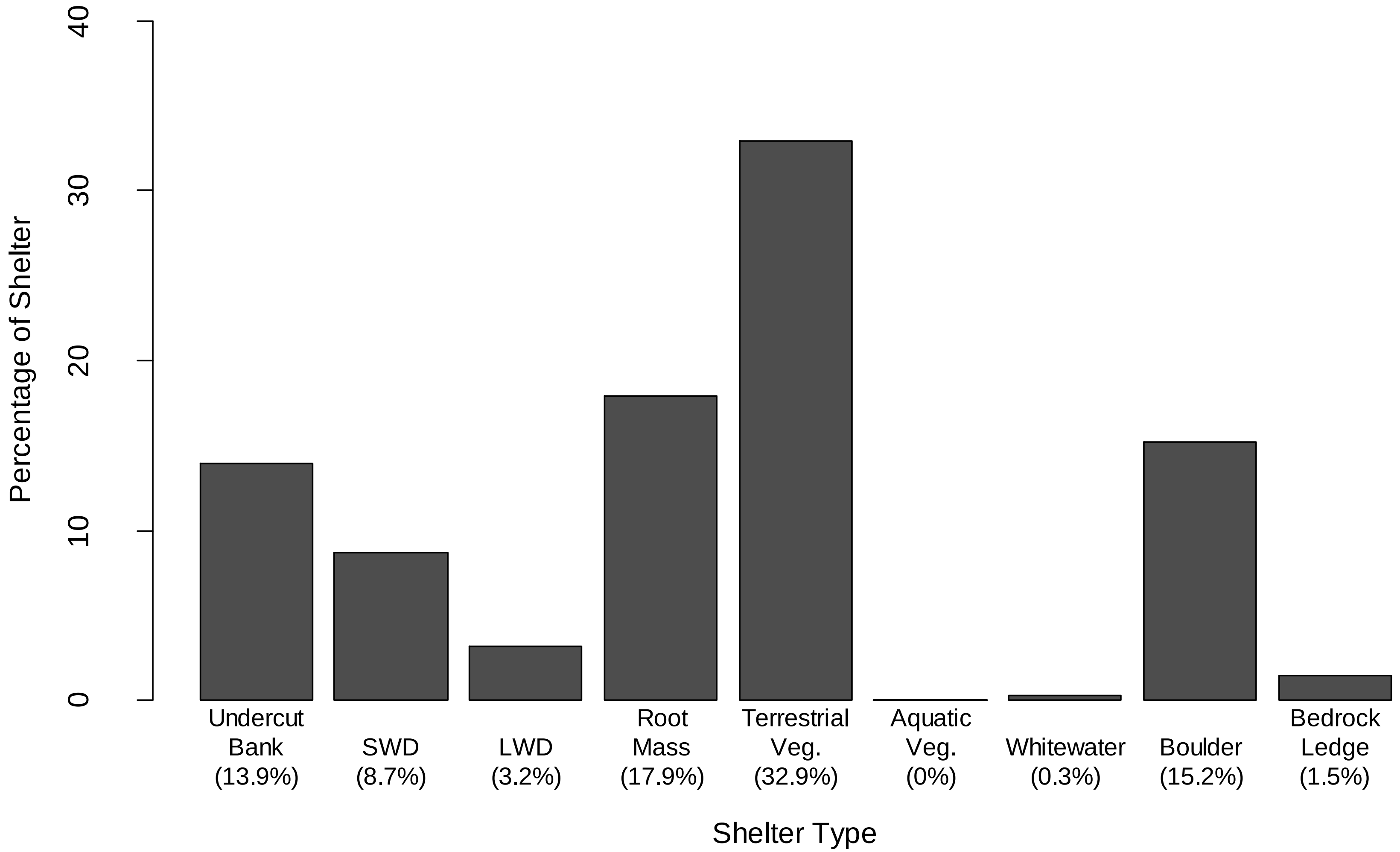


Figure 196. The percentage of shelter by shelter type across all pool units in which shelter was measured (n = 20 pools) for Stewart Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

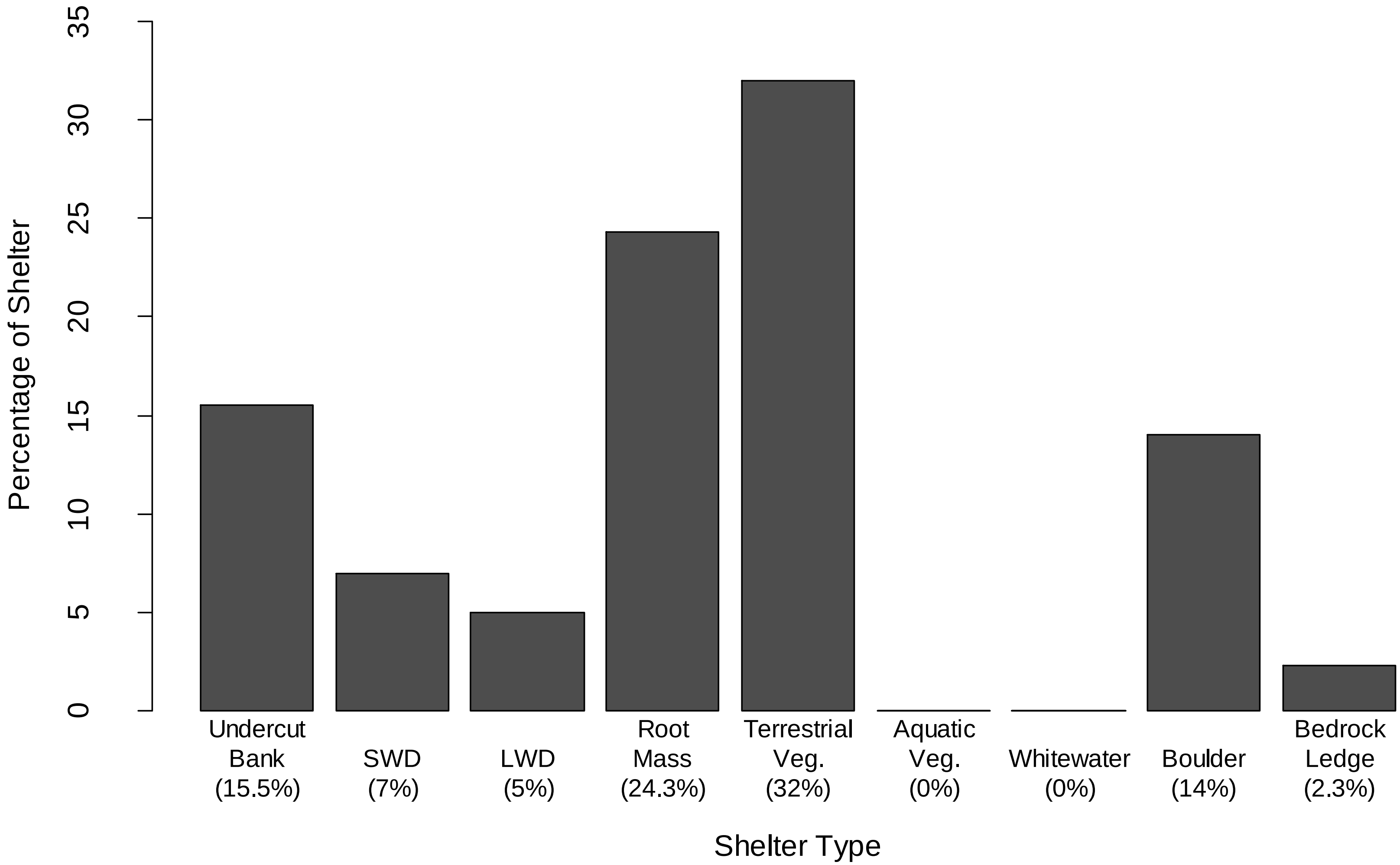


Figure 197. Percentage of banks by dominant substrate composition for Stewart Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock. No boulder substrate was recorded as the dominant bankside substrate in this survey.

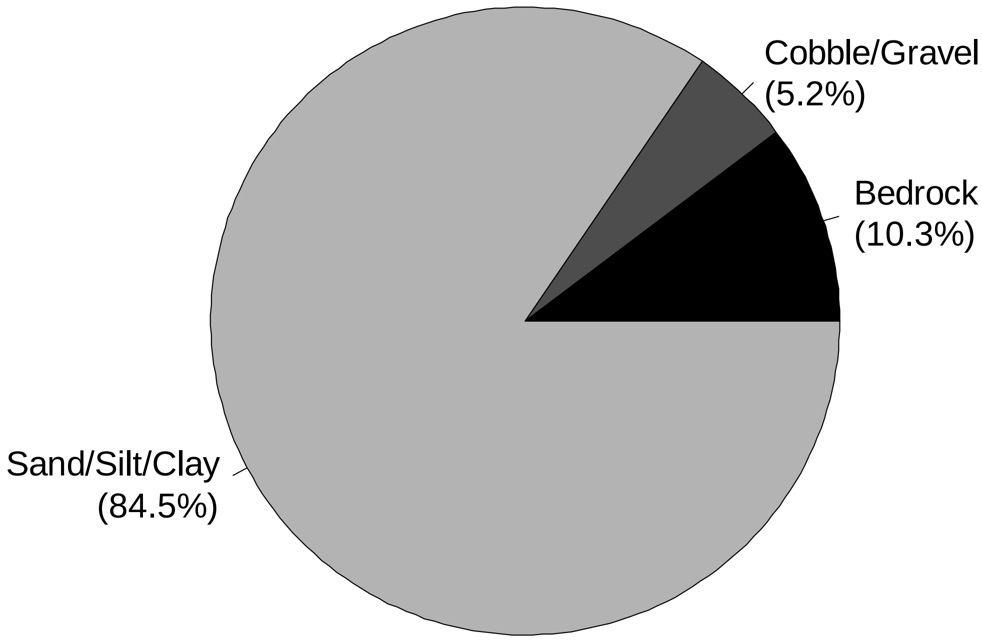
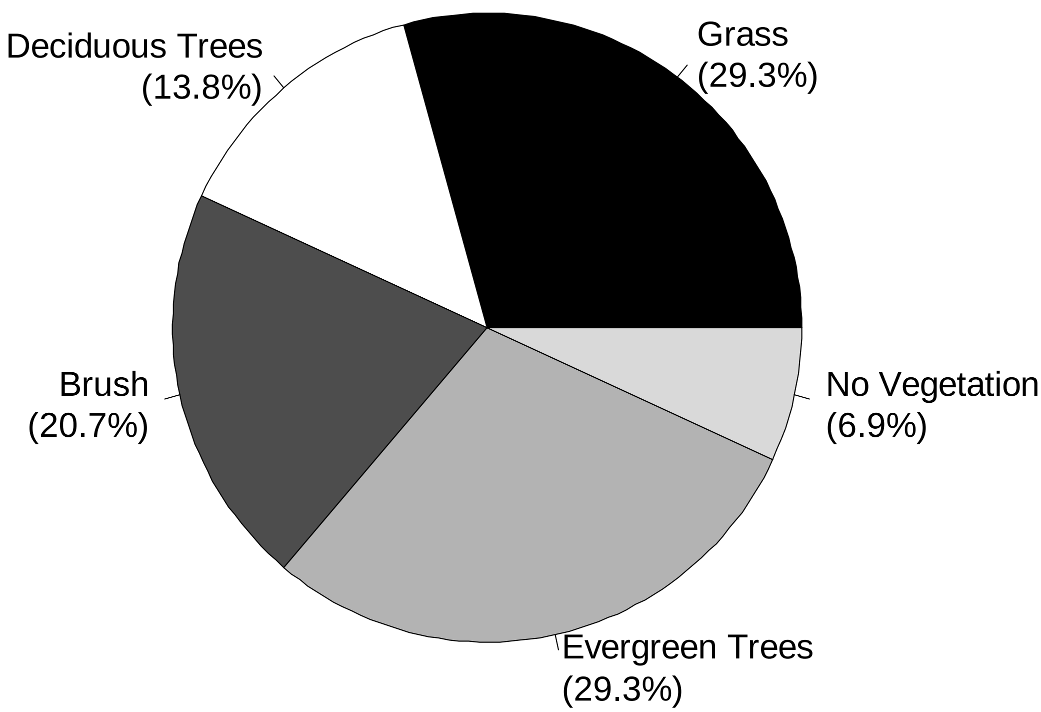


Figure 198. Percentage of banks by dominant vegetation type for Stewart Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



Thacher Creek

Snorkel Survey

Results

The survey reach began at the first snorkelable unit in the wetted section located above Thacher School in Ojai, California. This first snorkelable unit was located 0.54 miles upstream of the intersection of Thacher Road and Forest Route 5N10 (34.46891, -119.17175) and extended 0.84 miles (4,437 ft.) upstream ending at the last snorkelable pool observed within the wetted reach of Thacher Creek (34.47986, -119.17065). The surveyed stretch is shown in Figure 199.

No individual *O. mykiss* were observed in any of the 45 habitat units that were snorkeled. No additional notable species were found during the snorkel survey of Thacher Creek. The total snorkeled length of snorkeled units was 1063.5 feet. Densities of fish counts per sum of habitat unit lengths (feet) and fish counts per sum of surface area (square foot) of habitat units are both 0.0 as no *O. mykiss* were observed.

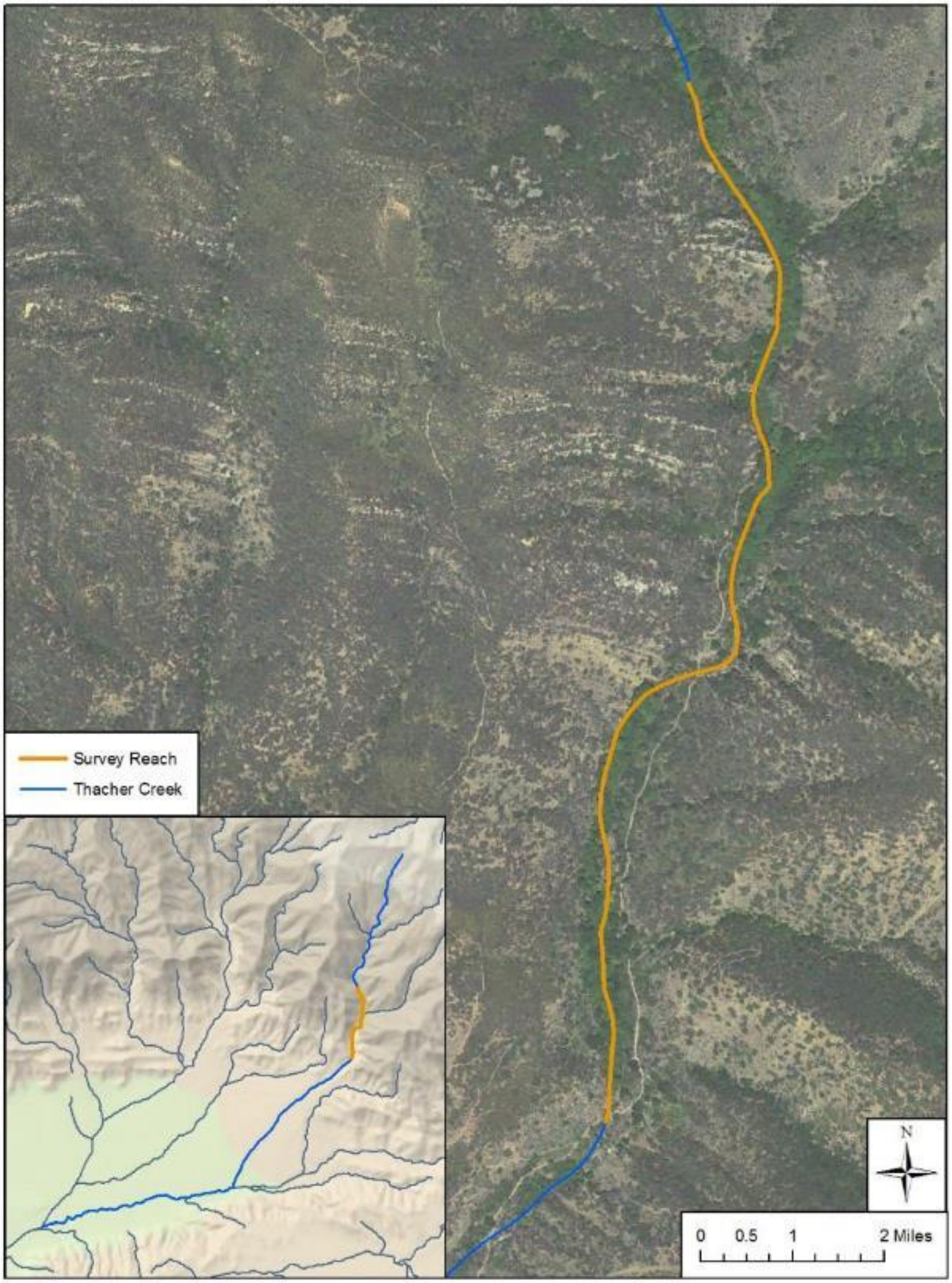
Discussion

On November 3 & 4,2015 a snorkel survey was conducted on a 0.84 mile stretch of Thacher Creek from the first snorkelable pool above the intersection with Thacher Road and Forest Route 5N10 to the last observed snorkelable pool within the reach. The purpose of this snorkel survey was to gain an understanding of the abundance and distribution of Southern California Steelhead (*O. mykiss*) in Thacher Creek, located in the Monte Arido Highlands BPG, in Ventura County.

Overall, this snorkel summary report provides a snapshot of current *O. mykiss* abundance and distribution in Thacher Creek. While surveyors did not record any observations of *O. mykiss* within Thacher Creek, we cannot definitively say that fish were not present. It was notable that water temperatures were very low (51 – 54 F) and *O. mykiss* are known to be inactive and more difficult to observe in colder temperatures. Additionally, no reliable estimates of population abundance can be made since we did not conduct electrofished calibration of the snorkel counts. Additional survey seasons must be completed in order to make a comparison of our observations. Subsequent surveys should include electrofishing to we can make accurate population estimates as per Hankin & Reeves 1988.

Figures

Figure 199. Map of the snorkel survey reach for Thacher Creek, 2015.



Habitat Assessment

Results

The habitat inventory was conducted from 14 October to 27 October 2015 by Kyle Evans, Phillip Hunter, Terra Dressler, Yi-Jiun Tsai, and Marisa Morse from Pacific States Marine Fisheries Commission, Jane Westfall and Shannon Mueller from the Watershed Stewards Program, and Mandy Wegmann from the CA Department of Fish and Wildlife. The survey extended 13,640 upstream from the survey start (34.46404°N, -119.17915°W). The survey endpoint (34.49031°N, -119.16038°W; Figure 200) was determined because an extended dry section became very steep. Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 54 to 67°F. Air temperature ranged from 58 to 80°F.

Habitat type

Of the total number of habitat units surveyed (n = 304 units), 8.9% of units were dry, 12.5% were flatwaters, 31.9% were pools, and 46.7% were riffles. Of the total length of the reach surveyed, 48.8% was dry, 7.0% was composed of flatwaters, 11.9% was composed of pools, and 32.3% was composed of riffles (Figure 201).

We identified 12 habitat types in Thacher Creek. Based on the frequency of units sampled, low gradient riffles (32.6%), mid-channel pools (20.7%), and bedrock sheets (10.9%) were the most common habitat types (Table 55). Based on total stream length, dry units (48.8%), low gradient riffles (28.7%), and step pools (6.9%) composed the greatest stream lengths.

Pool Metrics

A total of 97 pools were identified within the survey reach. Main channel pools were most frequently encountered (93.8% of pool units sampled; Figure 202) and comprised 95.2% of the total length of all pools. Scour pools represented 3.1% of pool units encountered and comprised 1.6% of length. In addition, backwater pools represented 3.1% of pool units encountered and comprised 3.2% of length.

Two of 96 pools (2%) had residual depths of three feet or greater (Figure 203).

Within pool tail-outs, silt/clay was the most frequently observed dominant substrate (40.2% of pool units), followed by gravel (21.7%) and boulder (13.4%; Figure 204).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (79.4%) or two (10.3%; Figure 205).

Shelter

Within 100% units (n = 77 units), riffle habitat types had a mean shelter rating of 35.5, flatwater habitat types had a mean shelter rating of 47.2, and pools had a mean shelter rating of 67.8.

Of the pool units in which shelter was assessed (n = 29 units), main channel pools had a mean shelter rating of 63.7, scour pools had a mean shelter rating of 66.7, and backwater pools had a mean shelter rating of 100.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that small woody debris provided the most shelter (42.8% of all shelter; Figure 206). When we examined the percentage of shelter by shelter type within pools only, we found that small woody debris was the most dominant cover type (32.5% of the total cover), followed by boulder (18.0%; Figure 207).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 90.8%. Within the canopy cover present, 87.1% of the canopy was composed of deciduous trees and 12.1% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks were sand/silt/clay (46.6%), boulder (29.7%), bedrock (19.6%), and cobble/gravel (4.1%; Figure 208). The mean percentage of vegetation covering the right bank in sampled units was 47.8%, and the mean percentage of vegetation covering the left bank was 60.5%. The dominant vegetation types observed on stream banks were deciduous trees (42.6%), brush (27.7%), coniferous trees (23.6%), and grass (6.1%; Figure 209).

Large Woody Debris

We observed 30 pieces of LWD that were 6 to 20 feet long and 25 pieces that were greater than 20 feet long within 7159.5 feet of wetted stream length. Across both LWD sizes, the number of LWD observed was 0.77 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 29.6 feet.

Discussion

Temperature

The water temperature of units measured ranged from 54 to 67°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Good to Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools or riffles. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools or low-gradient riffles. When we examined the reach in terms of length, we found that most of the reach was dry or riffles, with low gradient riffles comprising the greatest percentage of wetted stream length.

Pool Metrics

Pool depth is an important indicator of habitat quality, as greater pool depths can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in Thacher Creek, we found that most pools had residual depths less than two feet deep. However, a residual depth of at least three feet is needed to be considered good habitat (Kier Associates & NMFS 2008). Thus, it appears that pools in Thacher Creek may lack the depth needed to provide good hiding cover and rearing space. This may be due in part to the current, severe drought, which has extended into its fourth consecutive year.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was silt/clay, comprising 40.2% of pool units. Pool units most frequently had an embeddedness value of either a five or two. Together, these metrics suggest that pools may not provide the ideal depth for cover or rearing space and that many pool tail-outs in Thacher Creek lack good spawning habitat for *O. mykiss*.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage.

When examining pool habitat units specifically, we found that backwater pools had the highest shelter rating, followed by scour and then main channel pools. While it may initially appear that backwater pools provided the best salmonid habitat based on these shelter ratings, this may not actually be the case when considering that there were only three backwater pool units in which shelter was measured.

When we examined the percentage shelter by shelter type, we found the small woody debris provided the most shelter by far (42.8% of all shelter; 32.5% of pool units).

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In Thacher Creek, we estimated a mean canopy cover of 90.8%, consisting predominantly of deciduous trees. This suggests that Thacher has a moderately high amount of cover (Kier Associates & NMFS 2008), but this cover is likely to vary greatly through time, given the seasonality of deciduous trees. However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was sand/silt/clay, followed by boulder. The mean percentage of vegetation covering the right and left banks was 47.8% and 60.5%, respectively. Deciduous trees and brush were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively susceptible to erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In Thacher Creek, we found 0.77 pieces of LWD per 100 feet, which was low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Thacher lacks LWD, it may contain boulder elements that improve habitat quality.

Tables

Table 55. The percentage of units (n = 304) by habitat type in Thacher Creek.

Habitat Type	% of Units
Low Gradient Riffle	32.57%
Mid Channel Pool	20.72%
Bedrock Sheet	10.86%
Step Pool	9.21%
Dry	8.88%
Run	8.55%
Step Run	3.95%
Cascade	1.97%
High Gradient Riffle	1.32%
Dammed Pool	0.99%
Plunge Pool	0.66%
Lateral Scour Pool, boulder-formed	0.33%

Figures

Figure 200. Map of the habitat assessment survey area in Thacher Creek.

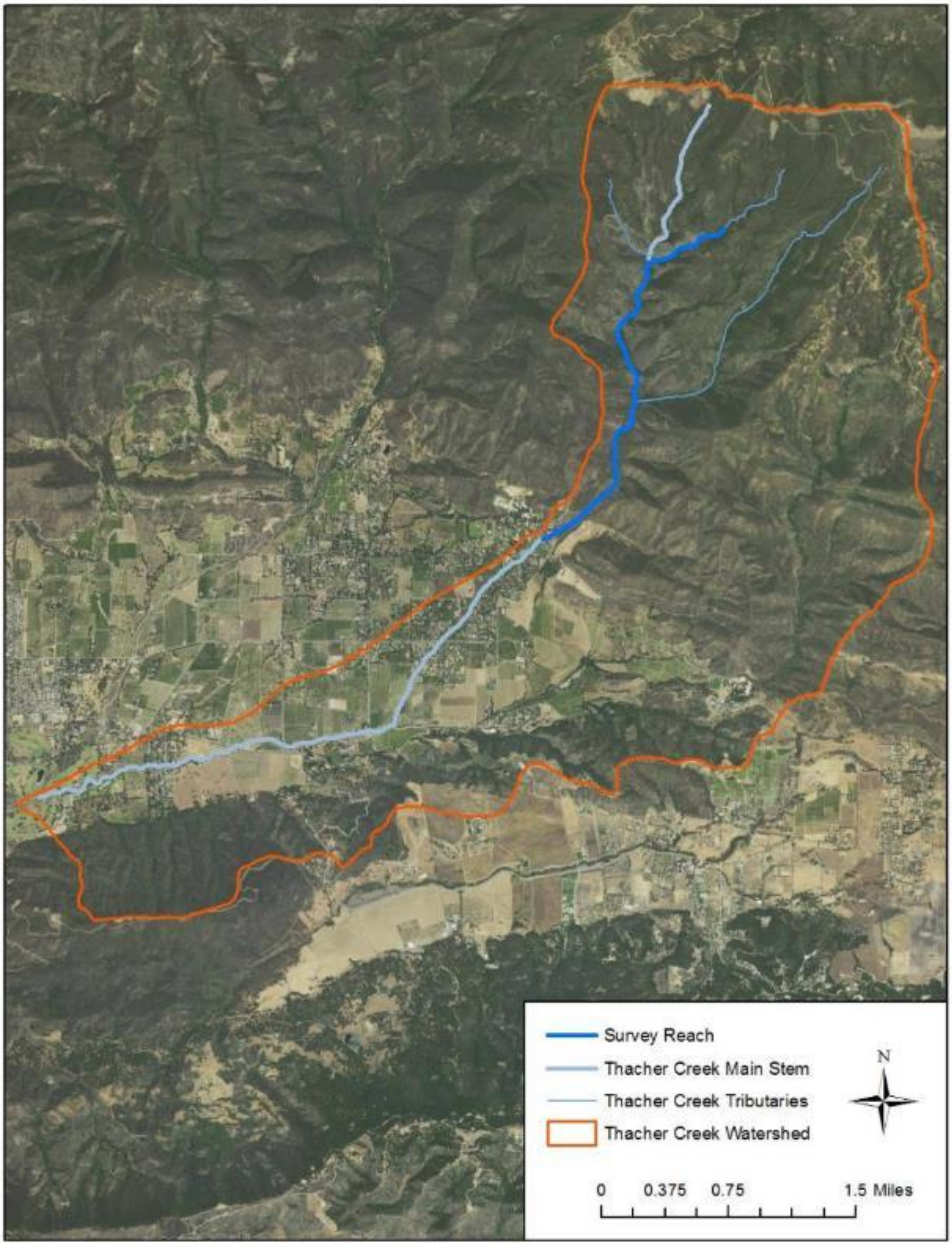


Figure 201. Percentage of total stream length categorized as pools, flatwaters, riffles, or dry in Thacher Creek.

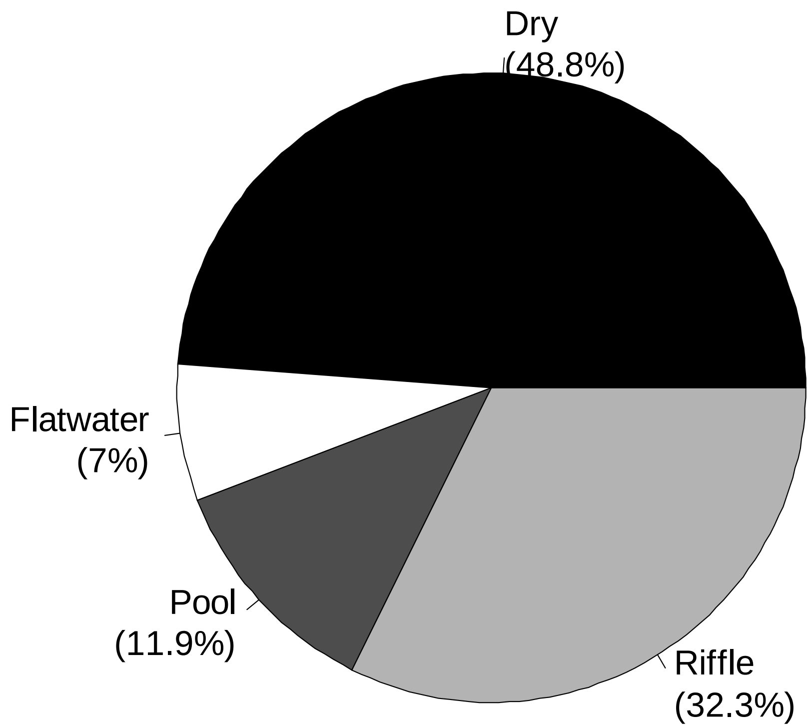


Figure 202. The percentage of all pool units (n = 97 pools) categorized by pool type (main channel, backwater, or scour pool) in Thacher Creek.

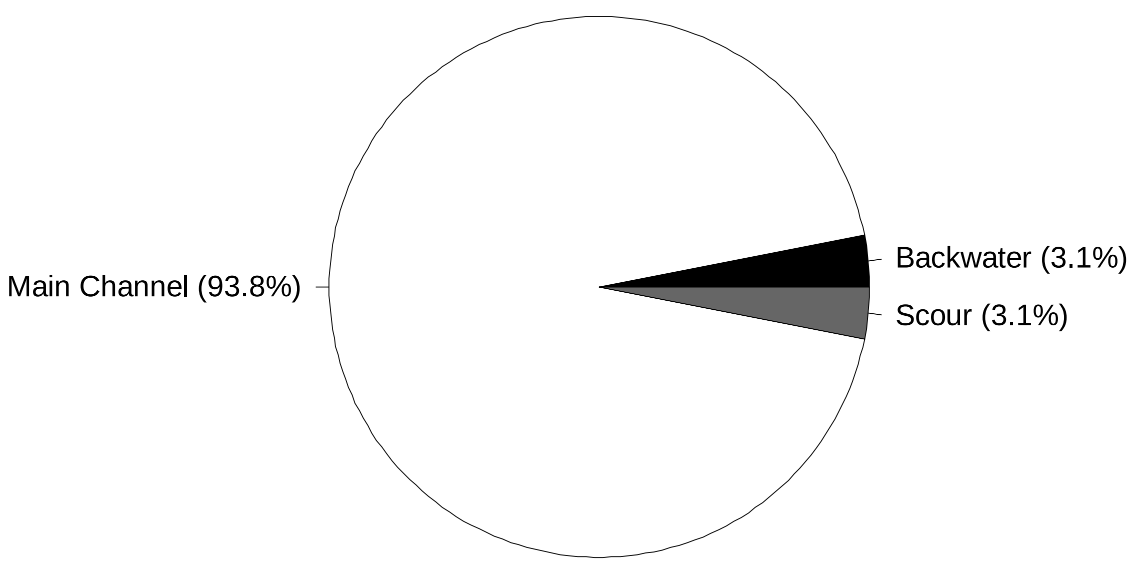


Figure 203. Histogram of residual pool depths in Thacher Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

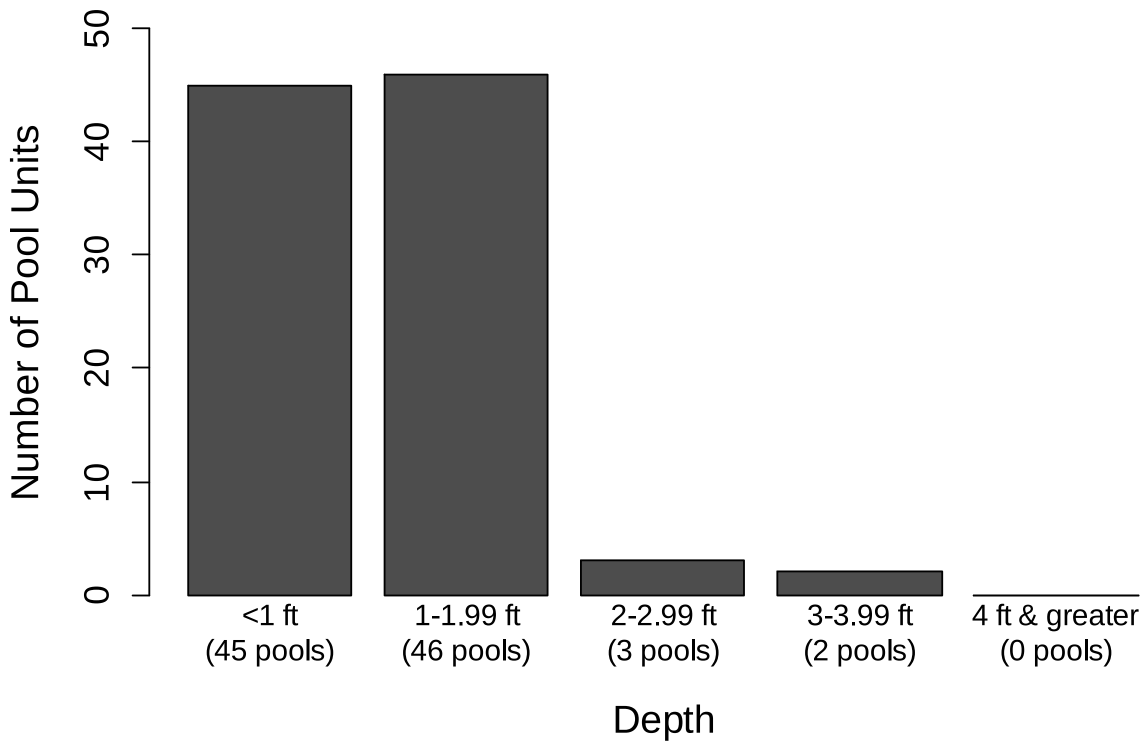

Number of Pool Units
0
10
20
30
40
50
<1 ft
(45 pools)
1-1.99 ft
(46 pools)
2-2.99 ft
(3 pools)
3-3.99 ft
(2 pools)
4 ft & greater
(0 pools)
Depth

Figure 204. Percentage of pool tail-outs (n = 97 pools) by dominant substrate in Thacher Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

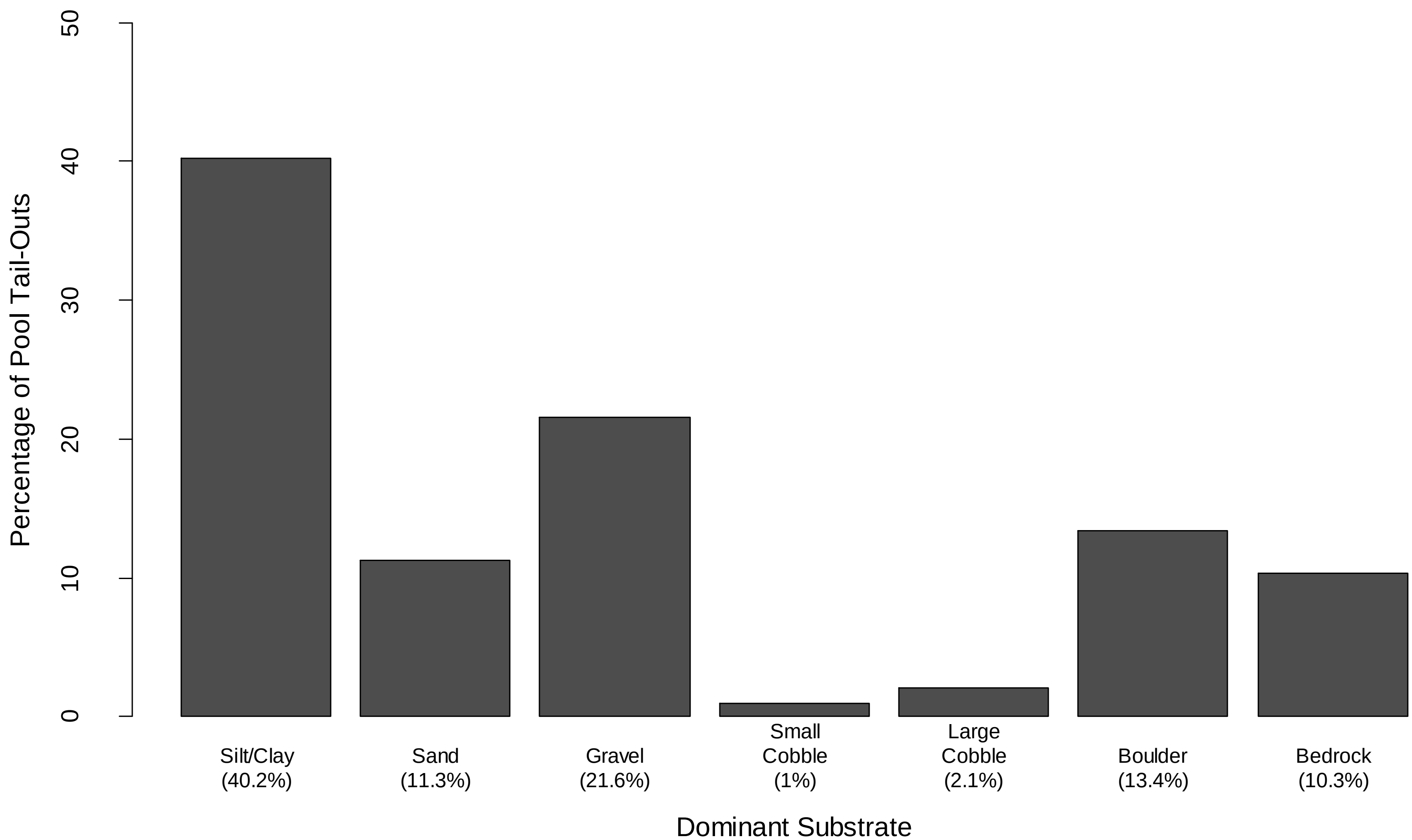


Figure 205. Percentage of all pool units (n = 97 pools) assigned a pool tail-out embeddedness value of one to five in Thacher Creek. Value one indicates 0–25% embeddedness (best for spawning), value two indicates 25–50% embeddedness, value three indicates 50–75% embeddedness, value four indicates 75–100% embeddedness, and value five indicates that the substrate was not suitable for spawning.

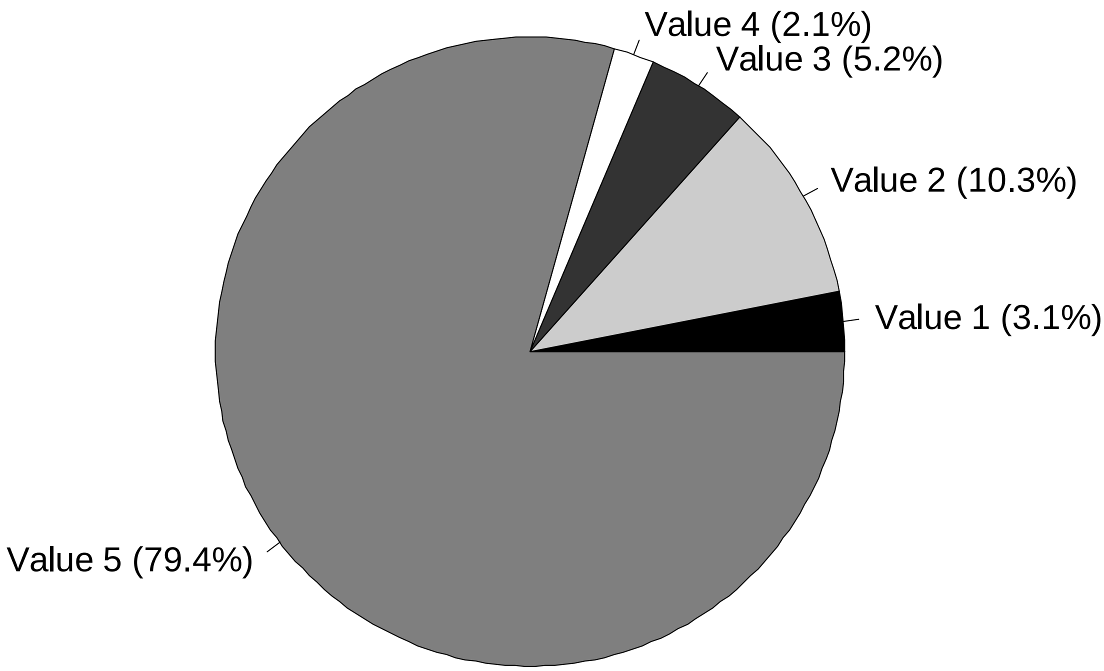


Figure 206. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 77 units) in Thacher Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

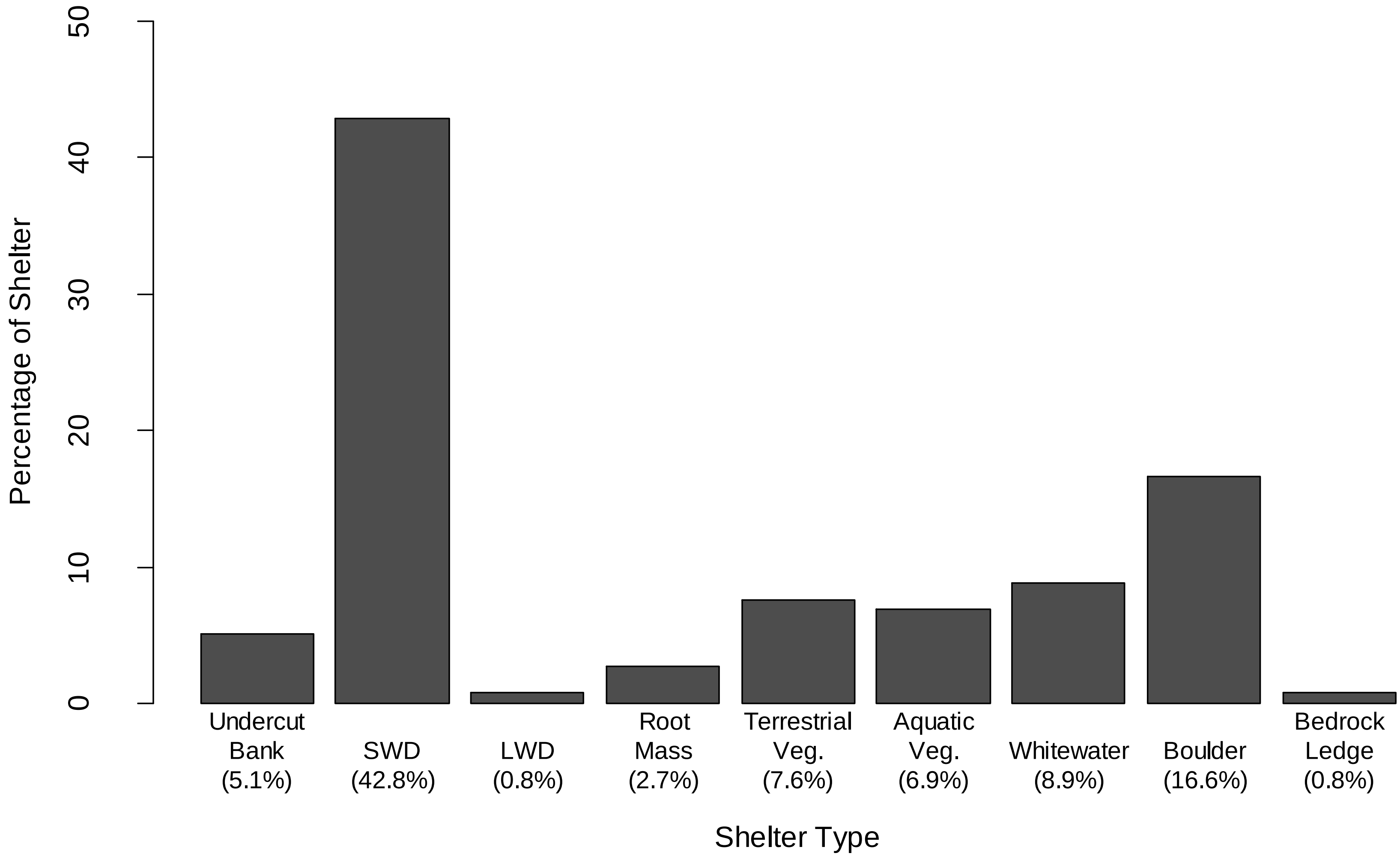


Figure 207. The percentage of shelter by shelter type across all pool units in which shelter was measured (n = 29 pools) in Thacher Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

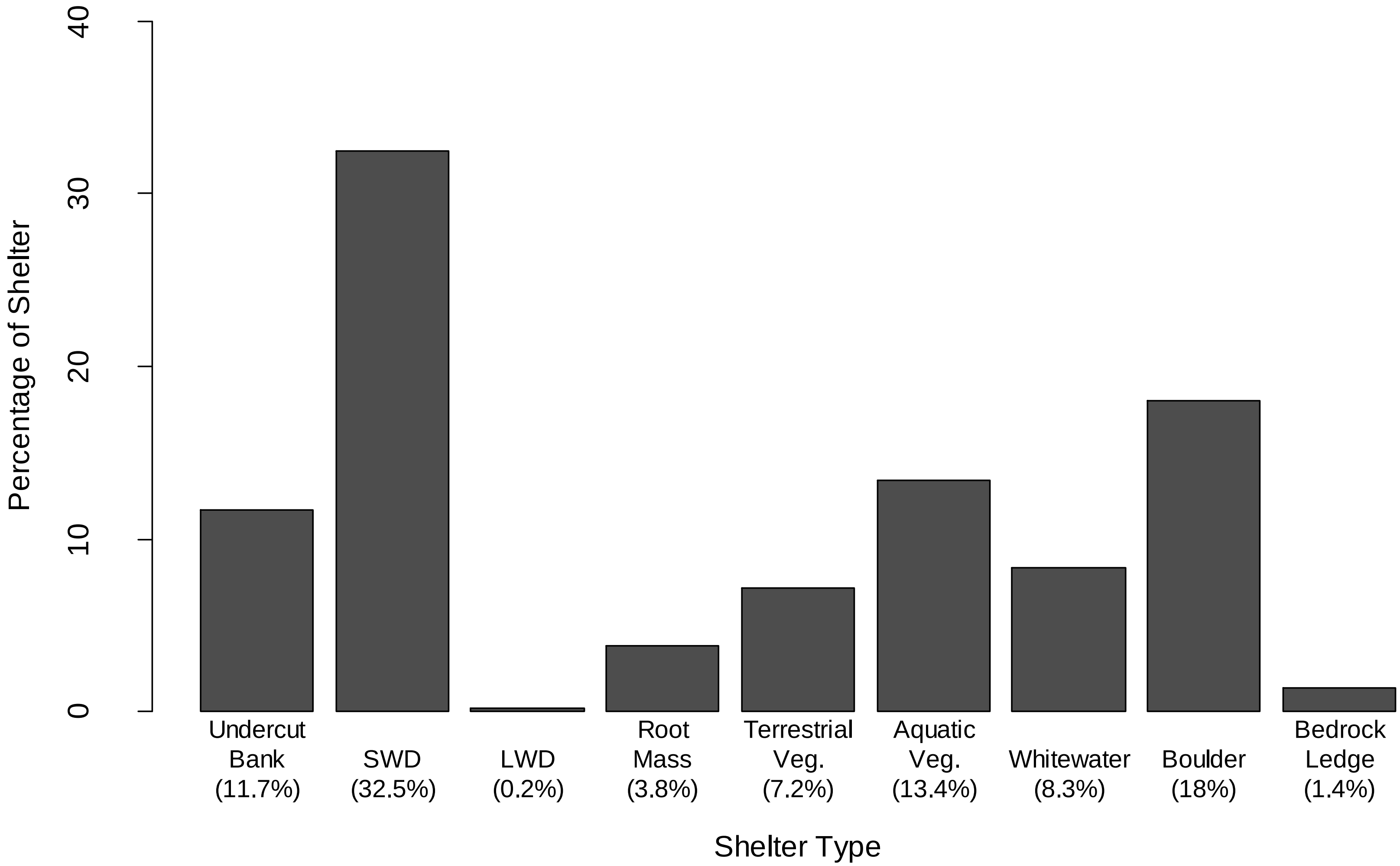


Figure 208. Percentage of banks in which sand/silt/clay, cobble/gravel, boulder, or bedrock was the dominant substrate in Thacher Creek.

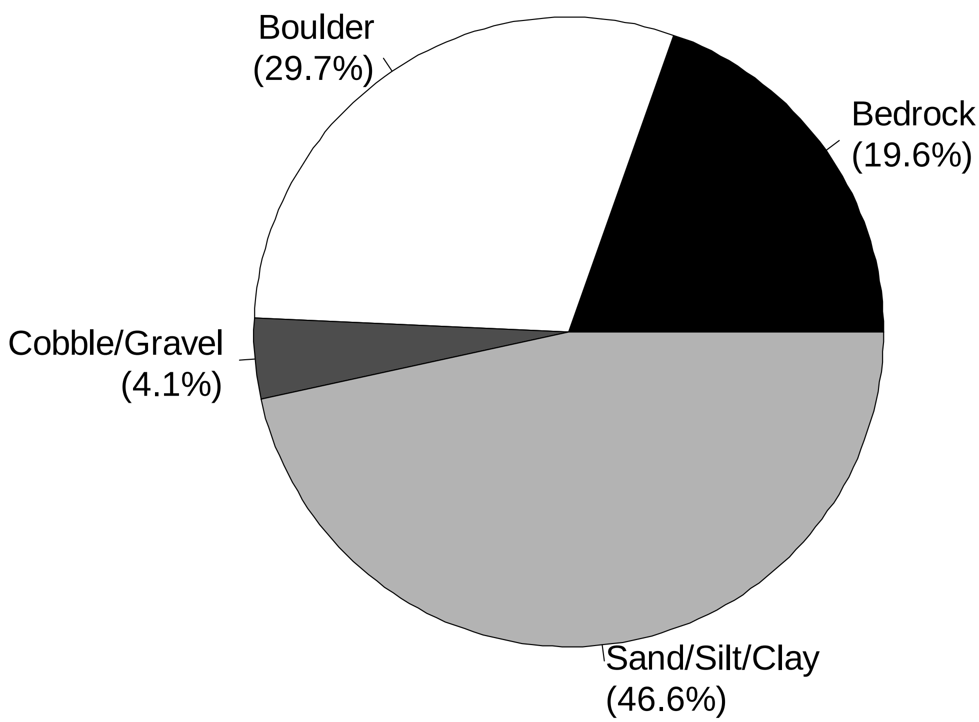
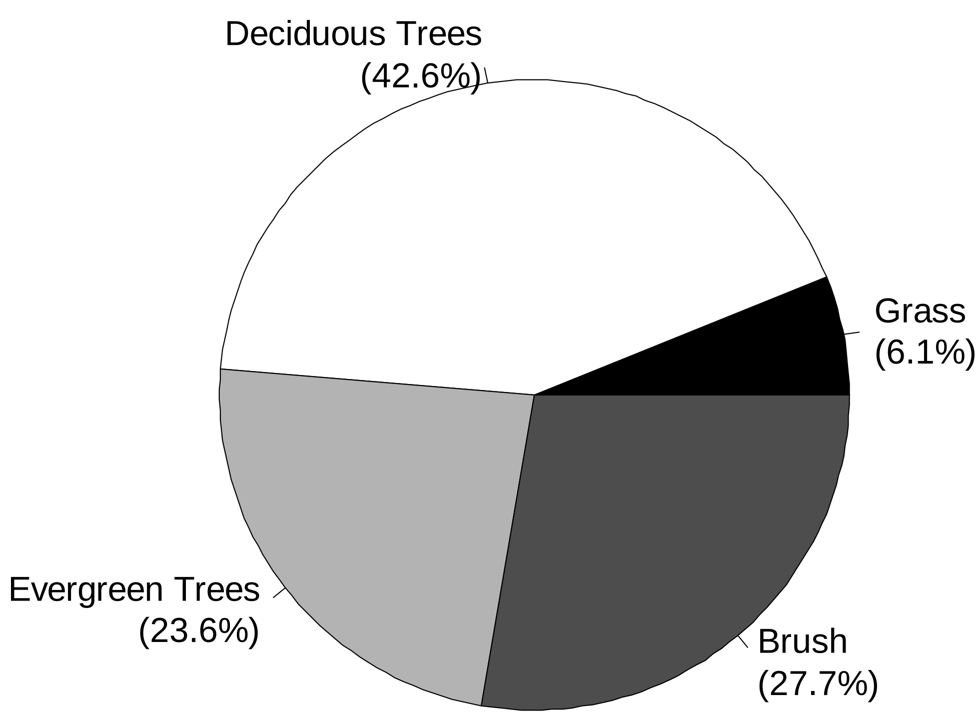


Figure 209. Percentage of banks in which grass, brush, deciduous trees, or evergreen trees was the dominant vegetation type in Thacher Creek.



East Fork Thacher Creek

Habitat Assessment

Results

The habitat inventory was conducted on 28 October 2015 by Yi-Jiun Tsai and Marisa Morse from Pacific States Marine Fisheries Commission. The survey extended 3,411 feet upstream from the survey start (34.47552°N, -119.16961°W). The survey endpoint (34.47908°N, -119.16103°W) was at a 41-foot, steep bedrock sheet that acted as a total natural fish passage barrier (Figure 210). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 58 to 60°F. Air temperature ranged from 69 to 72°F.

Habitat type

Of the total number of habitat units surveyed (n = 29 units), 31.0% of units were dry, 3.4% were flatwaters, 27.6% were pools, and 37.9% were riffles. Of the total length of the reach surveyed, 88.5% was dry, 0.2% was composed of flatwaters, 1.7% was composed of pools, and 9.6% was composed of riffles (Figure 211).

We identified seven habitat types in East Fork Thacher Creek. Based on the frequency of units sampled, dry (31.0%), mid-channel pools (27.6%), and low gradient riffles (24.1%) were the most common habitat types (Table 56). Based on total stream length, dry (88.5%) and low gradient riffles (7.7%) composed the greatest stream lengths.

Pool Metrics

A total of eight pools were identified within the survey reach. Main channel pools were the only pools encountered; no scour or backwater pools were recorded.

No pools had residual depths greater than two feet (Figure 212).

Within pool tail-outs, silt/clay was the most frequently observed dominant substrate (62.5% of pool units). Silt/clay, sand, small cobble, and large cobble were the only other substrates observed (12.5% each; Figure 213).

When we examined pool tail-outs for substrate embeddedness, we found all pools sampled had embeddedness values of five.

Shelter

Within 100% units (n = 6 units), riffle habitat types had a mean shelter rating of 61.3, flatwater habitat types had a mean shelter rating of 30.0, and pools had a mean shelter rating of 90.0.

Only one pool was assessed for shelter. This main channel pool had a shelter rating of 90.0.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that small woody debris provided the most shelter (88.3% of all shelter; Figure 214). Within the one pool in which shelter was assessed, small woody debris comprised all shelter.

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 92.8%. Within the canopy cover present, 63.6% of the canopy was composed of deciduous trees and 36.4% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were bedrock (21.4%) and sand/silt/clay (78.6%). The mean percentage of vegetation covering the right bank in sampled units was 60.0%, and the mean percentage of vegetation covering the left bank was 55.7%. Evergreen trees were the dominant vegetation type, having been observed in 92.9% of the banks surveyed. Brush was the only other bankside vegetation type observed (7.1%).

Large Woody Debris

We observed one piece of LWD that was 6 to 20 feet long and five pieces that were greater than 20 feet long within 392.5 feet of wetted stream length. Across both LWD sizes, the number of LWD observed was 1.53 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 27.3 feet.

Discussion

Temperature

The water temperature of units measured ranged from 58 to 60°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Very Good range for California steelhead. However, this temperature range was derived from only three measurements taken on a single day. Thus, our temperature results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools or riffles. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools or low-gradient riffles. When we examined the reach in terms of length, we found that most of the reach was dry or pools, with mid-channel pools comprising the greatest percentage of wetted stream length.

Pool Metrics

Pool depth is an important indicator of habitat quality, as deeper pools can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). A residual depth of at least three feet is needed to be considered good habitat (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in East Fork Thacher, we found that all pools had residual depths less than two feet deep and therefore lacked the depth needed to provide good habitat for *O. mykiss*. This is likely due in part to the current, severe drought, which has rendered the majority of East Fork Thacher dry.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was silt/clay, comprising 62.5% of pool units. All pool tail-outs had an embeddedness value of five. Together, these metrics suggest that pools in East Fork Thacher do not provide adequate spawning habitat for *O. mykiss*.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. However, shelter was only measured in six units: one pool, one flatwater, and four riffles. Thus, sample sizes were too small to draw conclusions regarding shelter.

Canopy Cover and Bankside Metrics

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In East Fork Thacher, we estimated a mean canopy cover of 92.8% across all units, consisting mostly of deciduous trees. This suggests that East Fork Thacher has a high amount of cover (Kier Associates & NMFS 2008), but this cover is likely to vary greatly through time, given the seasonality of deciduous trees.

The predominant substrate composing stream banksides was sand/silt/clay. The mean percentage of vegetative cover for the right and left banks was 60.0% and 55.7%, respectively. Evergreen trees were the dominant bankside vegetation type. Together these bankside metrics suggest that these banks may be relatively susceptible to erosion resulting from large flow events.

In the case of both canopy cover and bankside metrics, the results must be considered with caution, considering the low sample size of units measured (n = 6 units).

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In East Fork Thacher Creek, we found 1.53 pieces of LWD per 100 feet, which is low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while East Fork Thacher Creek lacks LWD, it may have boulder elements that improve habitat quality.

Tables

Table 56. Percentage of units (n = 29) by habitat type in East Fork Thacher Creek.

Habitat Type	% of Units
Dry	31.03%
Mid Channel Pool	27.59%
Low Gradient Riffle	24.14%
Bedrock Sheet	6.90%
High Gradient Riffle	3.45%
Cascade	3.45%
Run	3.45%

Figures

Figure 210. Map of the habitat assessment survey area in East Fork Thacher Creek.

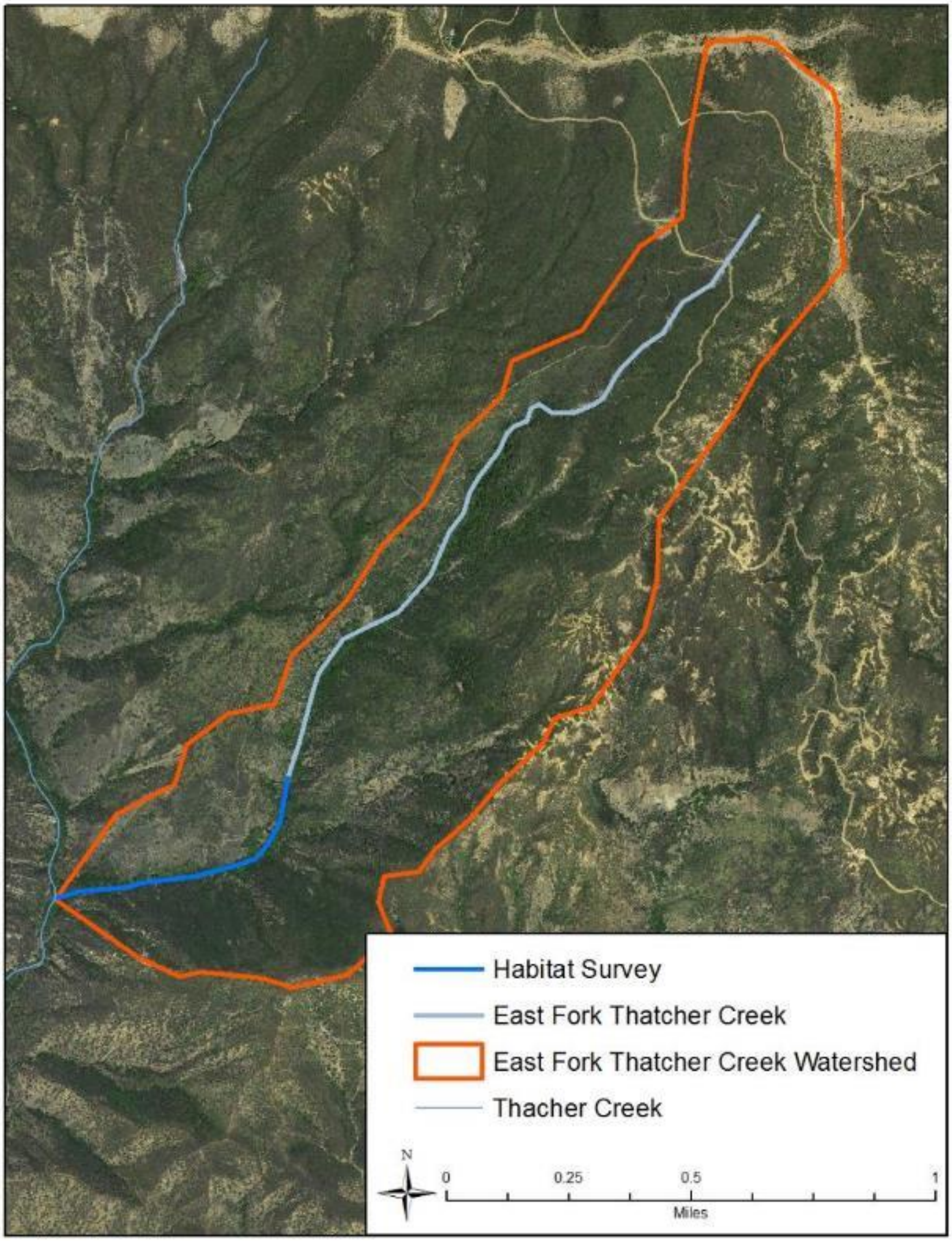


Figure 211. Percentage of total stream length categorized as pools, flatwaters, or riffles in East Fork Thacher Creek.

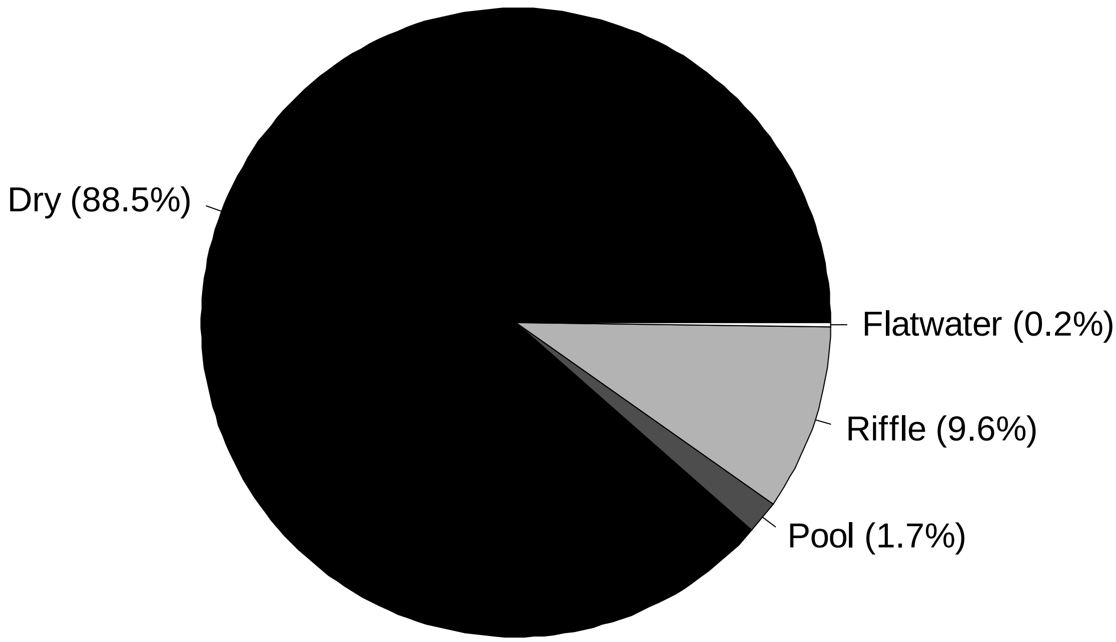


Figure 212. Histogram of residual pool depths in one-foot bins for East Fork Thacher Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

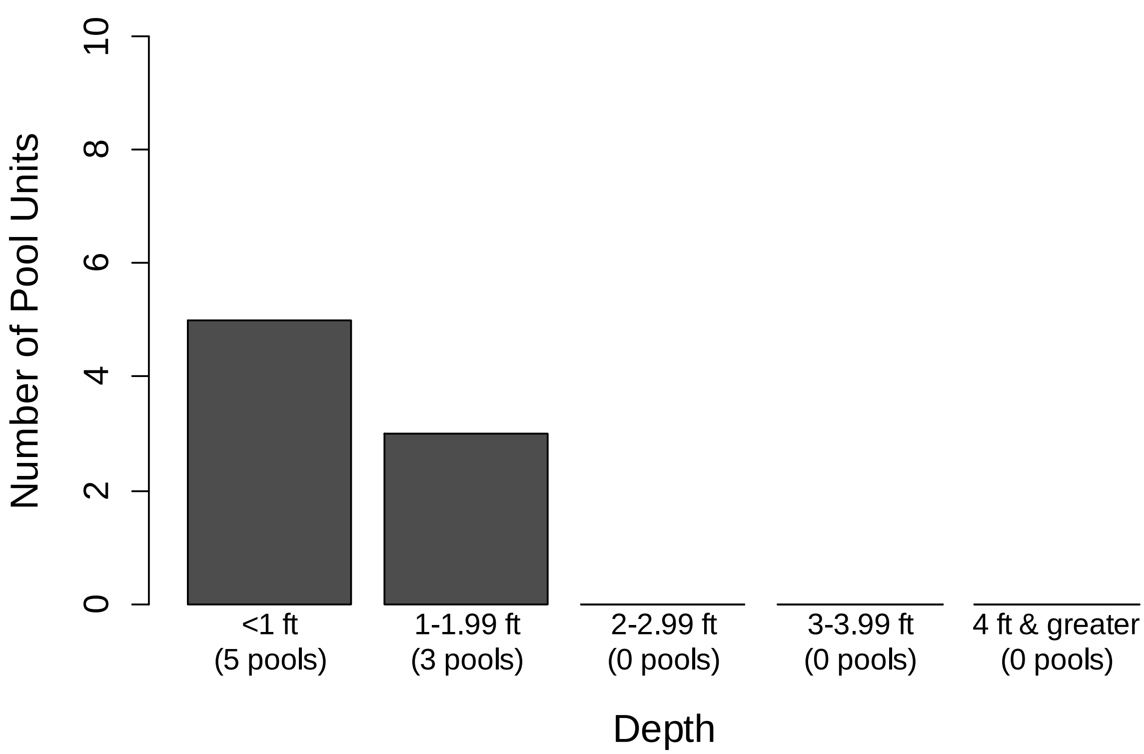


Figure 213. Percentage of pool tail-outs (n = 8 pools) by dominant substrate for East Fork Thacher Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

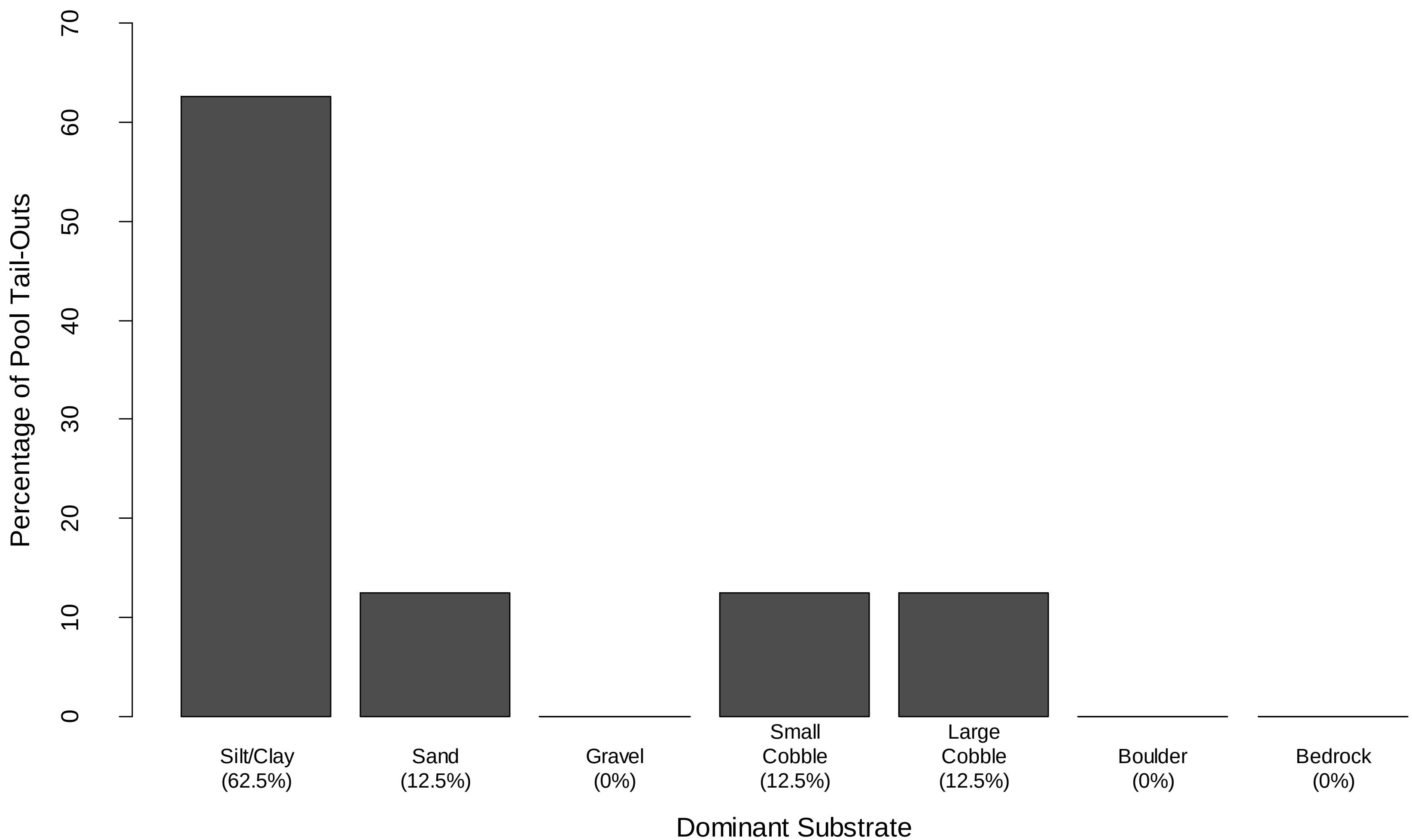
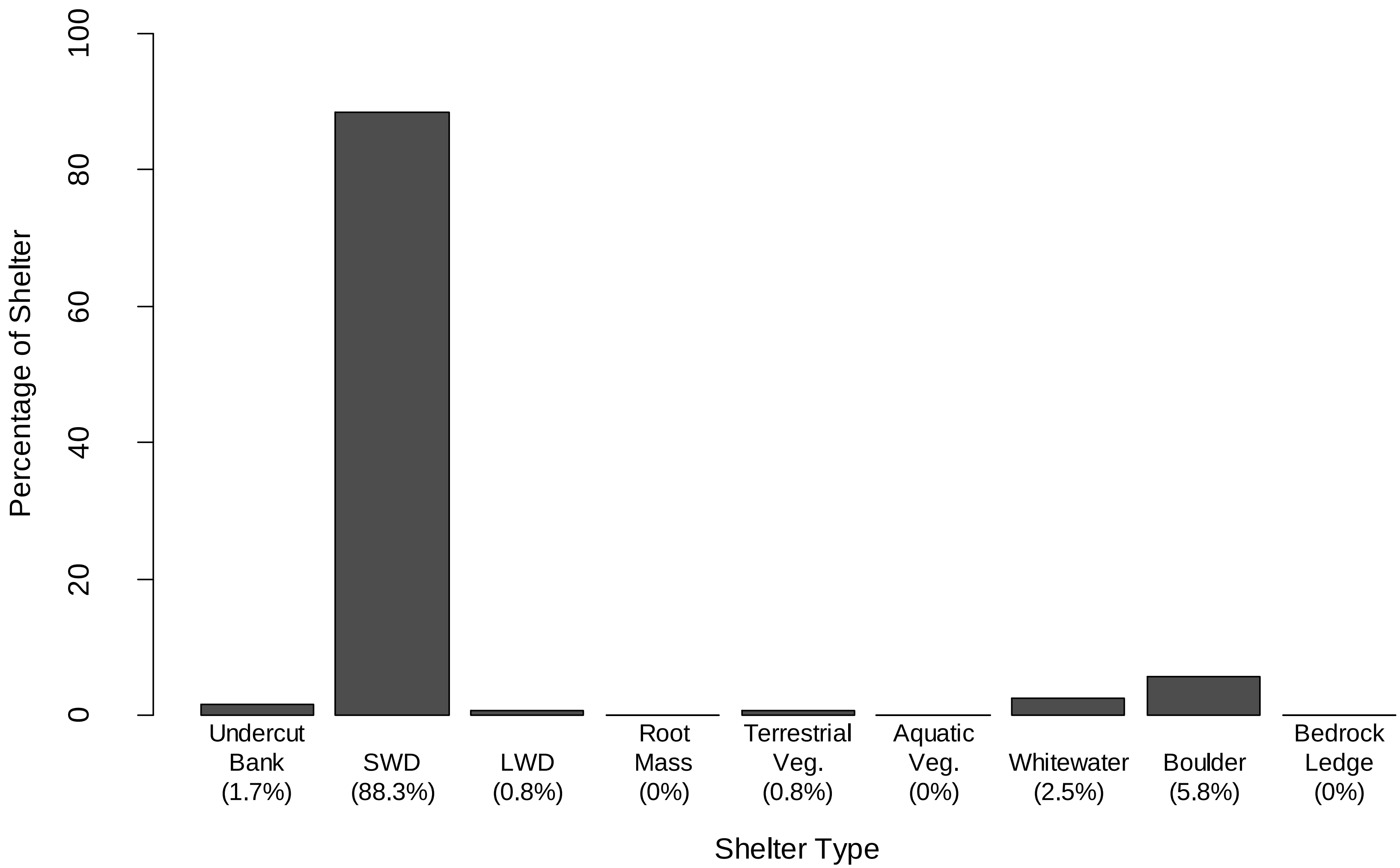


Figure 214. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 6 units) for East Fork Thacher Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.



North Fork Matilija

Snorkel Survey (2014)

Results

In the 4.35 mile study reach, a total of 78 *O. mykiss* were observed in varying size classes in 39 of the 148 pools surveyed as indicated in

Table 57 and Figure 215.

The total length of all snorkeled units was 4,494 feet within the 4.35 mile (22968 ft.) reach. 48 *O. mykiss* were observed in individual habitat units within the surveyed stretch of North Fork Matilija. Figure 216 shows the distribution of *O. mykiss* over the surveyed reach.

The average number of *O. mykiss* per unit length calculates to be 1.736×10^{-2} fish/ft. This was calculated by taking total of observed fish and dividing by the sum of all the lengths of snorkeled units. The average number of *O. mykiss* per unit area calculates to be 1.299×10^{-2} fish/ft^2. This was calculated by taking the total number of fish observations and dividing by sum of all the individual surface areas for each snorkeled unit. We have also summarized *O. mykiss* counts for shelter values in table Table 58 and Figure 217.

We also plotted *O. mykiss* observations with respect to total surface area of each habitat unit and this is shown in Figure 218. Additionally we plotted the number of *O. mykiss* observations with respect to the length of each habitat unit and this is shown below in Figure 219**.**

Discussion

Between July 8, 2014 and July 28, 2014, a snorkel survey was conducted on a 4.35 mile stretch of North Fork Matilija Creek from the confluence of the Ventura River to the total barrier at Wheeler Campground in Ojai, California. The purpose of this snorkel survey was to gain an understanding of the abundance and distribution of southern California steelhead (*O. mykiss*) in North Fork Matilija Creek, located in the Monte Arido BPG, in Ventura County. Due to conflicts with private property access, a 0.3 mile section of the creek was not surveyed.

Size class distributions of *O. mykiss* observed show the majority of observed fish were within the 2-3.99” size class while overall distributions ranged from 0-1.99 in to 10-11.99 in. We suspect that since this spawning season had concluded by our July snorkel surveys, that the 2014 year’s recruitment class was particular poor as only 10 fish of the 0-1.99 in size class were observed. This could be due to cumulative years of drought effects as shrinking habitat could lead to increased predation and decreased food sources.

The map of the surveyed section of North Fork Matilija Creek (Figure 216) indicates the distribution of the observed *O. mykiss*. The larger circles indicate a greater number of fish observations within 10 surveyed units. We do not have individual observations on the map as GPS locations were only recorded on the first unit out of ten on a data sheet. The smaller circles indicate a lesser number of fish observations in a single unit. There are no clear differences seen between different sections of the creek. The only observation that can be made is that distribution is throughout the entire reach and not confined to any particular areas.

Figure 218 and Figure 219 show the number of *O. mykiss* observed versus the surface area and length of the pools they were found in. There was no distinct correlation between *O. mykiss* observations and the surface area and length of the pools they were found in. *O. mykiss* density was then calculated in relation to the total length of the surveyed pools (4,436 feet) as well as the combined total surface area of the surveyed pools (60,034 square feet). Again this returned no obvious relationships most likely due to low fish counts. The average number of *O. mykiss* per unit length calculates to be 1.736×10^{-2} fish/ft while the average number of *O. mykiss* per unit area calculates to be 1.299×10^{-3} fish/ft^2. Again, these numbers are relatively insignificant due to the small sample size.

We also choose to look at shelter values which can range on a scale of 0 to 3. A shelter value of 0 means the surveyed unit has no components of shelter (e.g., no undercut, boulders, woody debris, etc.), whereas a value of 3 means the shelter in the surveyed unit has at least three shelter components including large woody debris (LWD). Large woody debris is uncommon in Southern California streams; therefore shelter values of 3 are not as common as shelter values of 2. In North Fork Matilija Creek, 88.5% of the surveyed units had a shelter value of 2, 10% of the surveyed units had a shelter value of 1, and only 1.5% of the pools had a shelter value of 3 (Figure 217). Figure 217 is a histogram showing the number of *O. mykiss* observed for each of the shelter values. It is not surprising that most of the fish observations were in pools with a shelter value of 2, since the majority of the surveyed pools had a shelter value of 2. This discrepancy in shelter value distribution may be explained by the importance of large woody debris and complex features in the shelter rating system. LWD is fairly uncommon in Southern California streams. Below average rainfall and water levels may have reduced the availability of complex features.

There were slight deviations from our chosen protocol, as divers initially chose which units were considered snorkelable. Divers had to estimate if the average depth was sufficient prior to the taking of habitat measurement. As a result, a few habitat units were snorkeled that had a mean depth of less than 0.7 feet.

Some snorkelers also collected observation data on Arroyo Chub and Threespine Stickleback, but this was not the emphasis of this study. Due to large numbers of observations of these species and the inconsistencies in observations, this data was not included in this report.

As these surveys took place during ever increasing drought conditions, divers also collected data on potential relocation pools, counting the numbers of fish already present and habitat metrics. If divers encountered pools that were in danger of drying up, these were also snorkeled and flagged if eventual rescue might be needed. Both relocation and rescue data was recorded on the data sheets but was not included in any of the analysis.

Additionally, we continued our snorkel survey above the known limits of anadromy and collected habitat and fish observations above the Wheeler Campground. In the interests on continuity and our research efforts focusing on anadromous reaches within the Ventura Watershed, this data was not included in this report. It may however be summarized in a future report.

Overall, this snorkel summary report shows us a snapshot of what age classes were present and where these *O. mykiss* were distributed on North Fork Matilija Creek. We were able to calculate an index of fish densities but without additional survey seasons, no reliable inferences can be made. We can make no reliable estimates of population abundance since we did not conduct electrofished calibration of the snorkel counts. Additional survey seasons must be completed in order to make a comparison of our observations. Subsequent surveys should include electrofishing to we can make accurate population estimates as per Hankin & Reeves 1988.

Tables

Table 57. Table of the first pass *O. mykiss* size class

O. mykiss **Size Class (in)**	**Number O. mykiss Observed**
0-1.99	10
2-3.99	48
4-5.99	13
6-7.99	5
8-9.99	1
10-11.99	1

Figures

Figure 215. Observed *O. mykiss* size distribution in North Fork Matilija Creek, 2014.

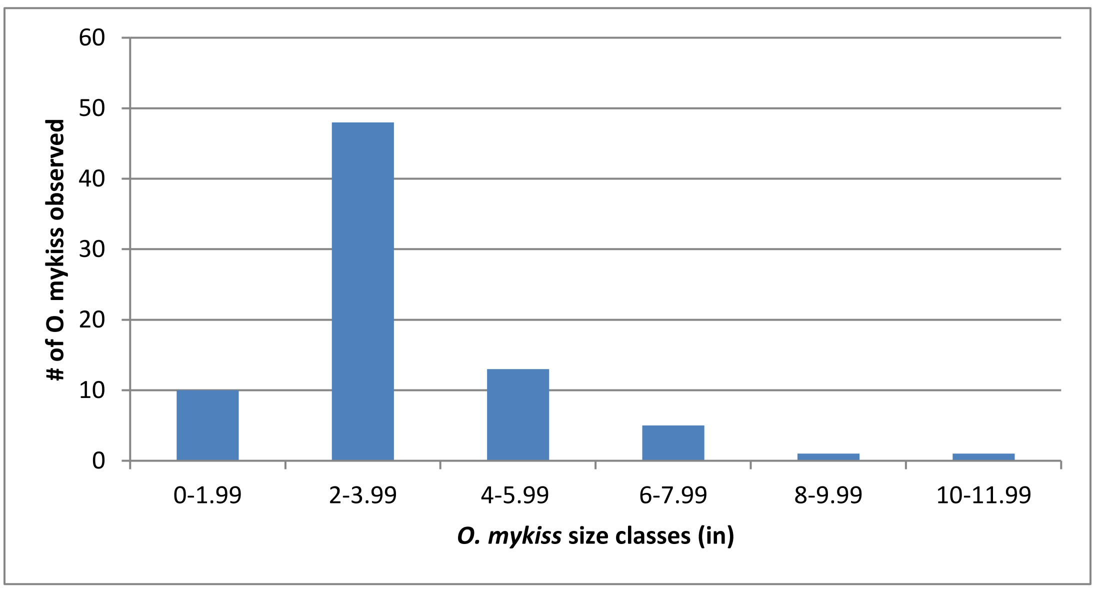


Table 58. *O. mykiss* counts and number of habitat units with respect to shelter values in North Fork Matilija Creek, 2014.

Habitat Unit Shelter Values	***O. Mykiss*** **Observed per Shelter Value**	**# of Habitat Units with Shelter Value**
0	0	0
1	5	15
2	71	131
3	2	2

Figure 216. Distribution map of *O. mykiss* on surveyed section of North Fork Matilija Creek, 2014.

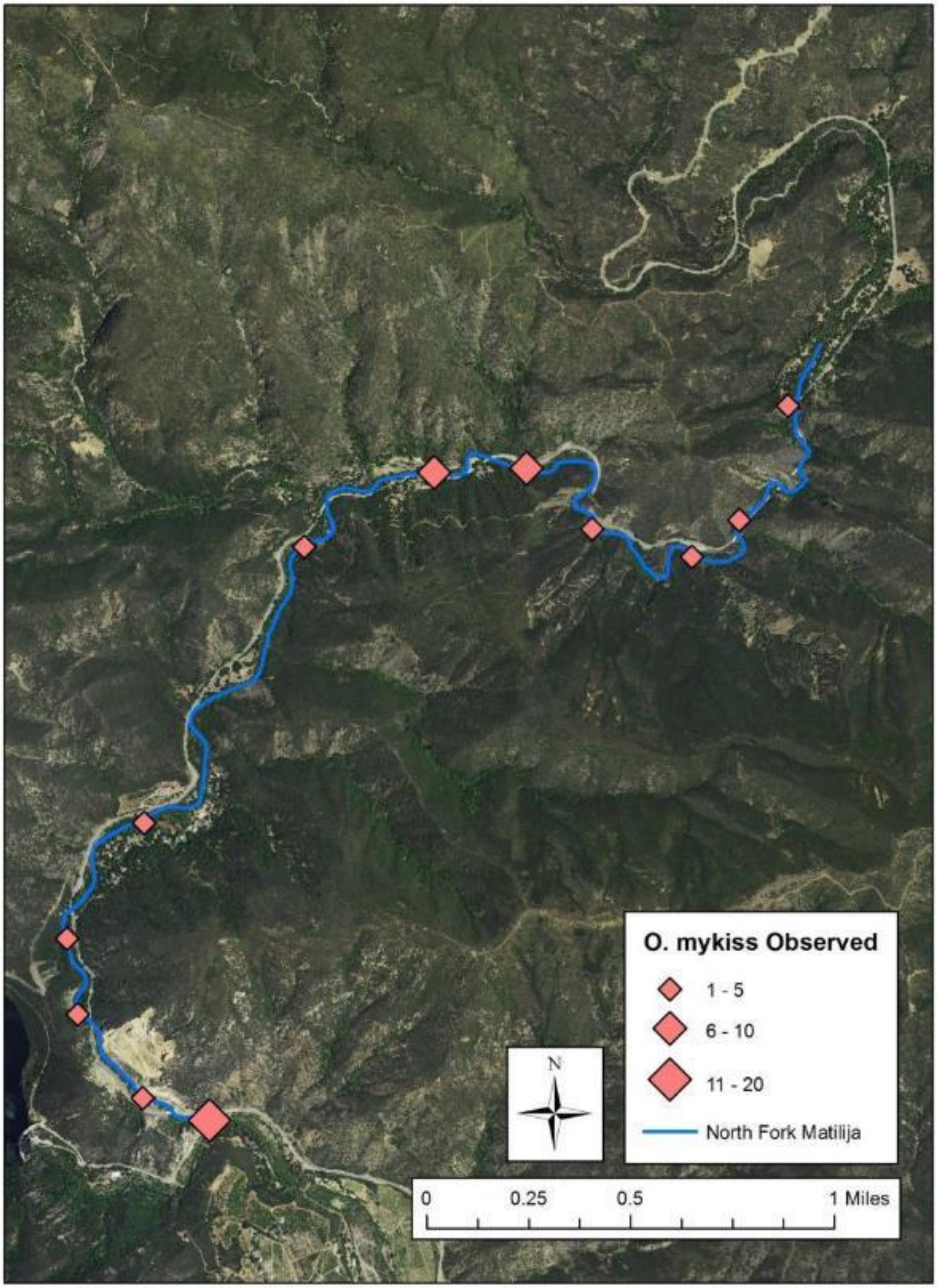


Figure 217. *O. mykiss* size class observations plotted against shelter values in North Fork Matilija Creek, 2014.

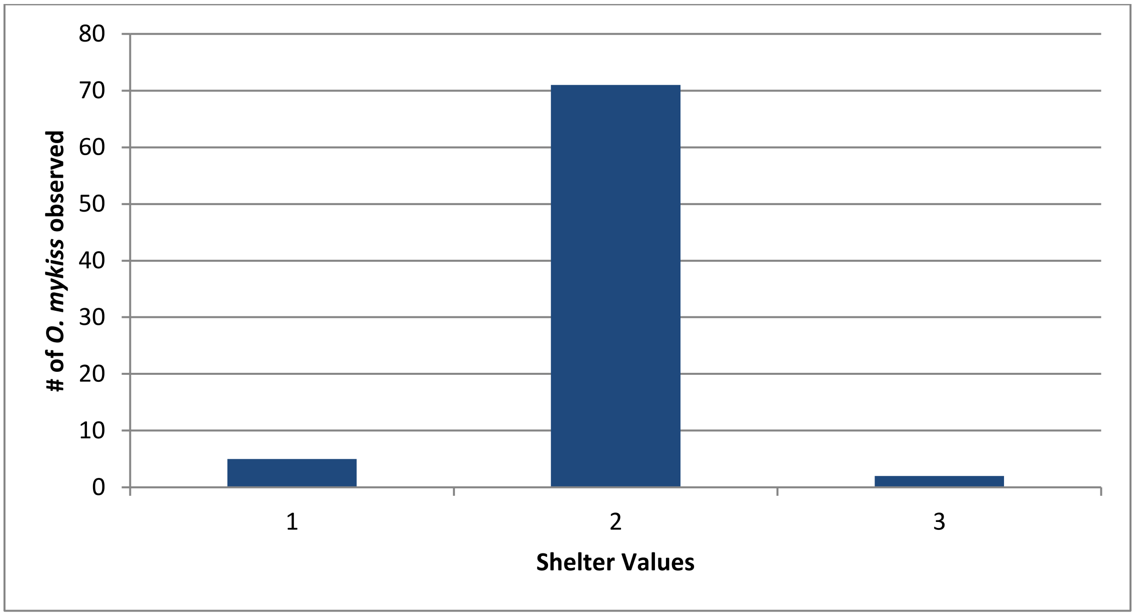


Figure 218. *O. Mykiss* observations plotted over habitat unit surface area in North Fork Matilija Creek, 2014.

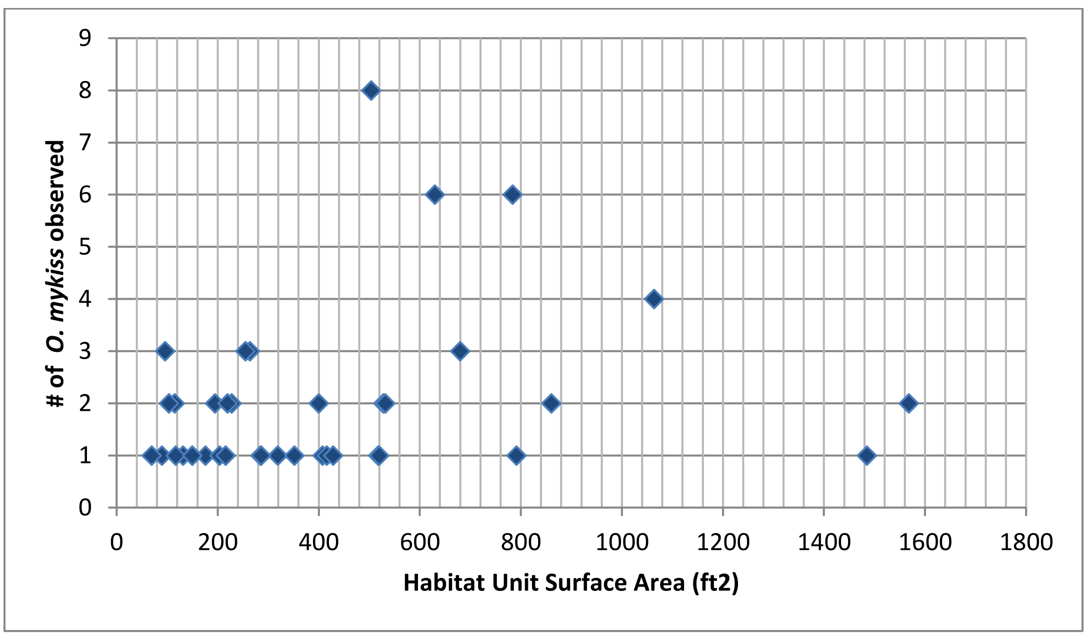
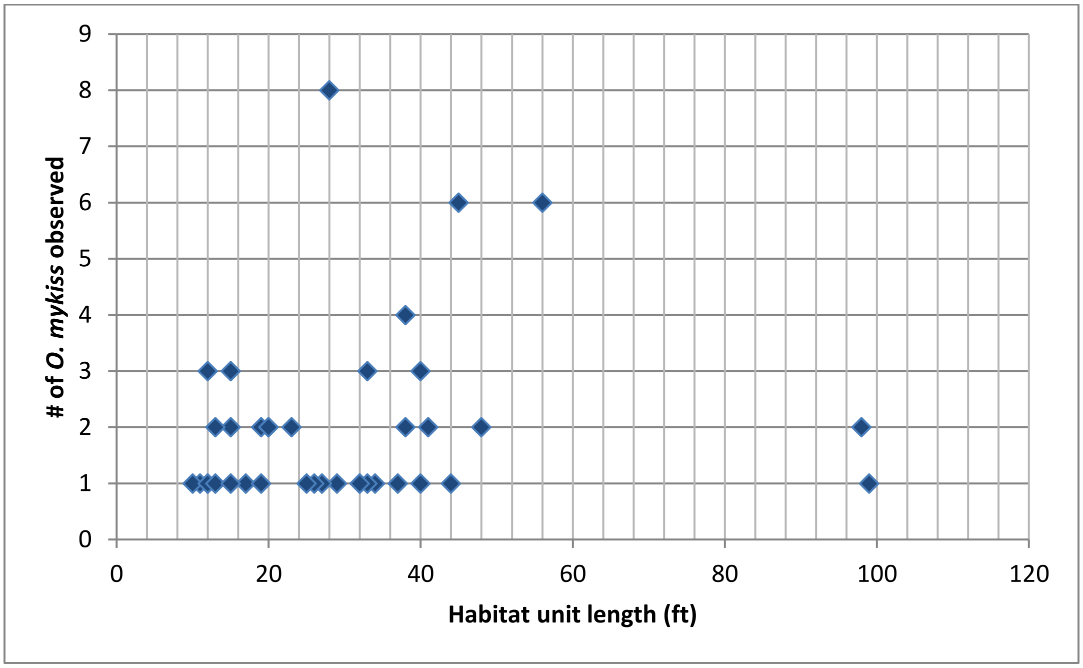


Figure 219. *O. mykiss* observations plotted over habitat unit length in North Fork Matilija Creek, 2014.



Snorkel Survey (2015)

Results

Between July 28 and August 13, 2015, a single pass snorkel survey took place on North Fork Matilija Creek in Ventura County. A similar snorkel survey took place in 2014. We have summarized the *O. mykiss* observations, habitat unit lengths and calculated densities in Table 59. We have also compared size class distributions for both 2014 and 2015 in Table 60 and Figure 221. Additionally we looked at O. mykiss observation counts as compared to recorded habitat shelter values and these are shown in Table 61 and Figure 222. A graduated symbol distribution map showing the locations of O. mykiss observations is shown in Figure 220.

Discussion

The goal of this report was to estimate population abundance and distribution of *O. mykiss* in North Fork Matilija of the Ventura Basin. Due to conflicts with private property access, a 0.3 mile section of the creek was unsurveyable. Snorkel survey data for years 2014 and 2015 were compared. 14 more units and 571 feet more of length was snorkeled in 2014 than 2015. For the length of North Fork Matilija that was surveyed, observed *O. mykiss* abundance was greater in 2015 than 2014. *O. mykiss* density based on either unit count, length (ft), or surface area (ft^2) was also greater. Snorkelers observed *O. mykiss* presence in 38 of 148 (25.7%) habitat units in 2014 and 53 of 134 (39.6%) habitat units in 2015. Observed trout distribution demonstrated that *O. mykiss* were present along the entire surveyed area of North Fork Matilija. In addition,

The size class with the greatest *O. mykiss* frequency was 2-3.99" for both 2014 and 2015 data. Both years showed a decrease in trout frequency for each consecutive 2" size class until 10-11.99".

Observed *O. mykiss* presence within shelter value bins (1, 2, and 3) increased from 2014 to 2015. In addition, for both years, fish presence to total habitat units increased with shelter value and habitat complexity. However, since both years yielded a low frequency of habitat value 3, these values should be considered with caution. In 2015, 100% of habitat units with a shelter value of 3 had fish presence; however a closer look revealed that shelter value of 3 was represented by only 4 units. The shelter value of 1 constitutes 7.4% of the total surface area surveyed for 2014 and 2015. 89.9% of the total surface area had a shelter value of 2 and 2.7% had a shelter value of 3. Recordings of habitat units with a shelter value of 1 or 3 were rare and could lead to a misrepresentation of how fish presence correlates to habitat complexity.

In conclusion, this data reveals little of the total abundance of *O. mykiss* populations in North Fork Matilija. More research needs to be done to understand *O. mykiss* population density and abundance in the North Fork Matilija Creek. Overall, this snorkel summary report shows us a snapshot of what age classes were present and where these *O. mykiss* were distributed on North Fork Matilija Creek. We were able to calculate an index of fish densities but without additional survey seasons, no reliable inferences can be made. We can make no reliable estimates of population abundance since we did not conduct electrofished calibration of the snorkel counts. Additional survey seasons must be completed in order to make a comparison of our observations. Subsequent surveys should include electrofishing to we can make accurate population estimates as per Hankin & Reeves 1988.

Tables

Table 59. *O. mykiss* density based on total units, length snorkeled, and total surface area for 2014 and 2015 in North Fork Matilija Creek.

Year	2014	2015
***O. mykiss* Abundance**	75	84
Units Snorkeled Count	148	134
Total Length (ft) Snorkeled	4496	3925
***O. mykiss* Density per Length (ft)**	1.67×10^{-2}	2.14×10^{-2}
***O. mykiss* Density per Surface Area (ft^2)**	1.30×10^{-3}	1.60×10^{-3}

Table 60. North Fork Matilija *O. mykiss* abundance observed within each size class for 2014 and 2015.

Observed *O. mykiss* Size Class Distribution						
Year	**0-1.99**	**2-3.99**	**4-5.99**	**6-7.99**	**8-9.99**	**10-11.9**
2014	10	47	12	5	1	1
2015	1	43	24	12	2	2

Table 61. *O. mykiss* abundance and presence by habitat complexity for 2014 and 2015.

Year	2014			2015		
Shelter Value	**1**	**2**	**3**	**1**	**2**	**3**
***O. mykiss* Abundance**	5	69	2	5	75	4
Total Surface Area (ft^2)	3322	43018	418	4000	46085	2297
***O. mykiss* Observations**	3	34	1	5	44	4
Shelter Value Observations	15	131	2	22	108	4

Figures

Figure 220. Observed O. mykiss distribution along North Fork Matilija in 2015. Portions were not surveyed (brown) due to ungranted access on private property.

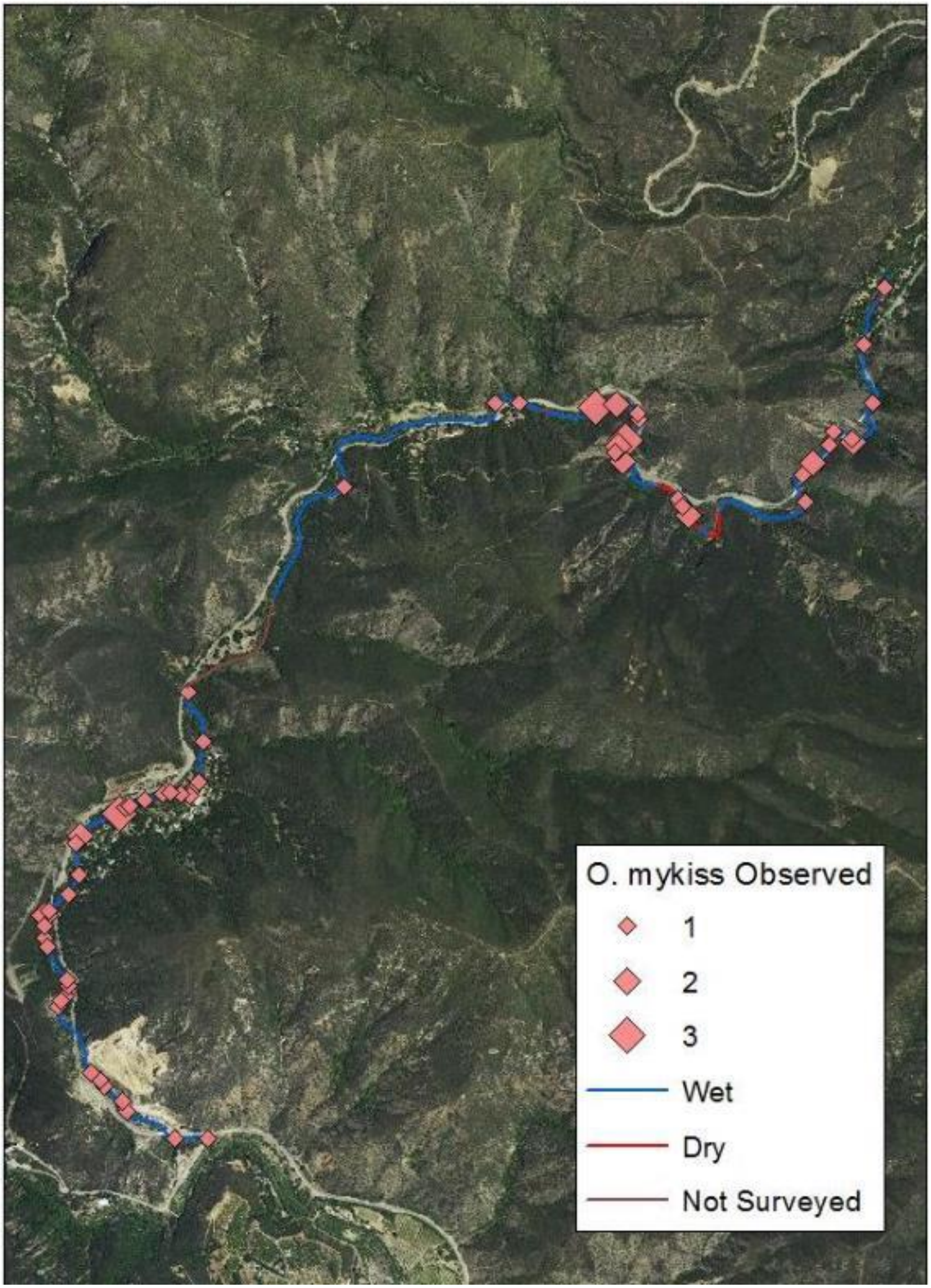


Figure 221. Observed *O. mykiss* abundance within each 2" size class for North Fork Matilija in 2014 and 2015.

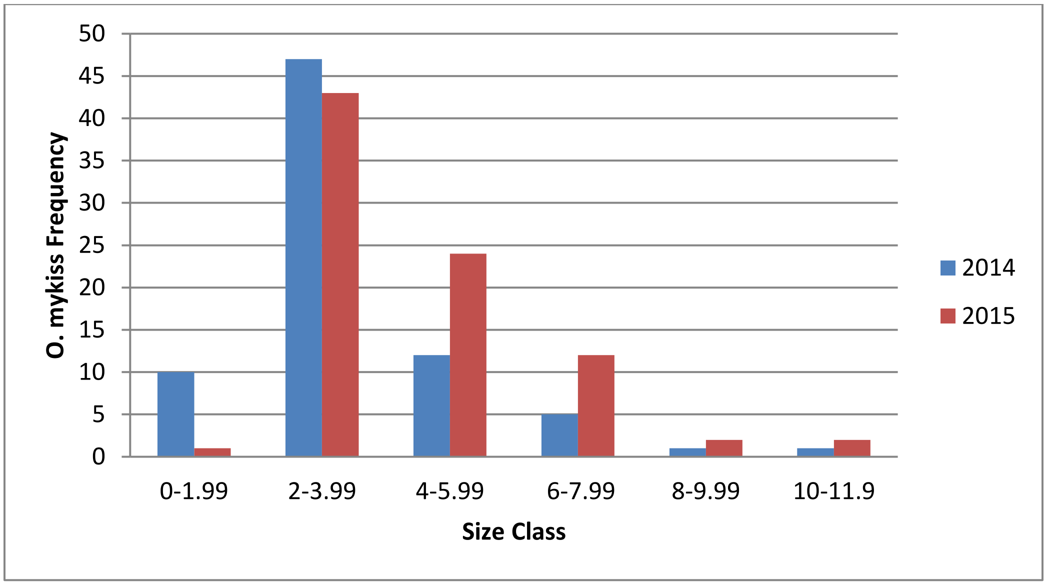
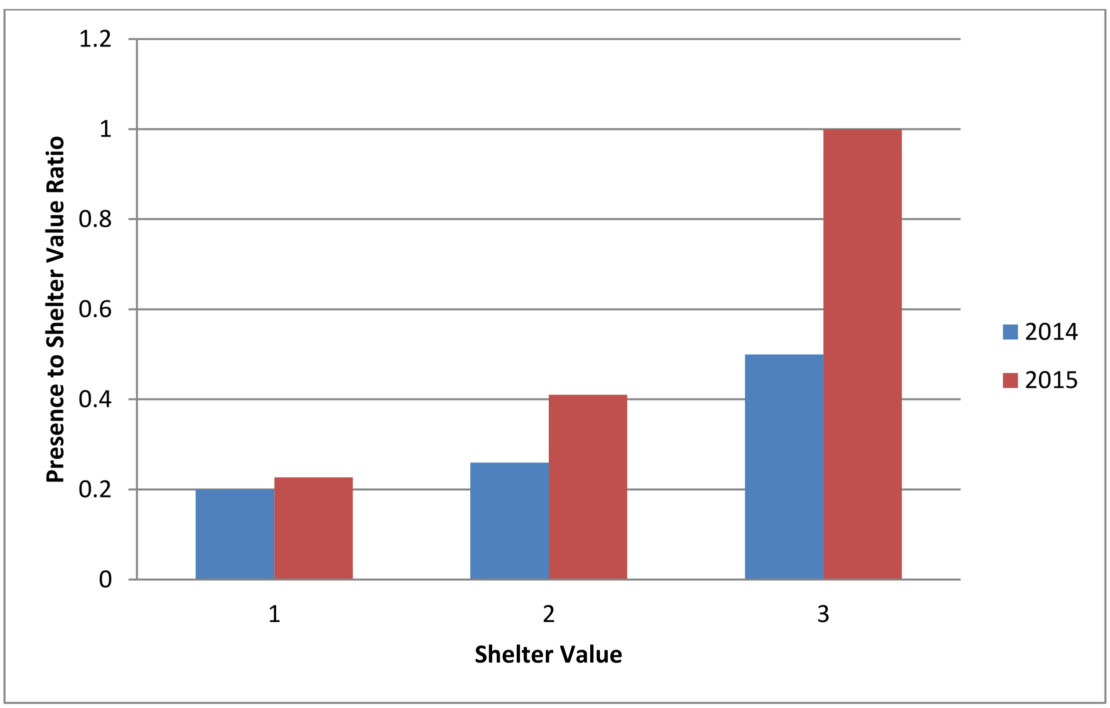


Figure 222. Ratio between *O. mykiss* presence and shelter value frequency for North Fork Matilija in 2014 and 2015.



Habitat Assessment

Results

The habitat inventory was conducted from 10 October 2013 to 18 November 2015 by Karissa Willits, Ben Lakish, Patrick Riparetti, Tom Van Meeuwen, Kate McLaughlin, Toby Moyneur, Terra Dressler, Phillip Hunter, and Marissa Morse from Pacific States Marine Fisheries Commission and Kayti Christianson and Davis Gottesman from the Watershed Stewards Program. The survey extended 38,471 feet upstream from the survey start (34.48523°N, -119.30019°W), with an additional 637 feet of side channel. The survey endpoint (34.536825°N, -119.244739°W) was a manmade total barrier to fish passage where Highway 33 crosses the stream (Figure 223). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 50 to 63°F. Air temperature ranged from 51 to 76°F.

Habitat type

Of the total number of habitat units surveyed (n = 517 units), 4.4% of units were dry, 19.7% were flatwaters, 37.3% were pools, 38.3% were riffles, and 0.2% was unsurveyable due to a landowner access conflict. Of the total length of the reach surveyed, 29.6% was dry, 16.5% was composed of flatwaters, 20.7% was composed of pools, 26.6% was composed of riffles, and 6.5% was unsurveyable (Figure 224).

We identified 14 habitat types in North Fork Matilija Creek. Based on the frequency of units sampled, low-gradient riffles (23.0%), mid-channel pools (20.3%), and runs (15.1%) were the most common habitat types (Table 62). Based on total stream length, dry (29.6%), low-gradient riffles (15.9%), and runs (10.6%) composed the greatest stream lengths.

Pool Metrics

A total of 193 pools were identified within the survey reach. Main channel pools were most frequently encountered (71.0% of pool units sampled; Figure 225) and comprised 70.0% of the total length of all pools.

Twenty-two of 187 measured pools (11.8%) had residual depths of three feet or greater (Figure 226).

Within pool tail-outs, gravel was the most frequently observed dominant substrate (38.7% of pool units), followed by sand (16.7%) and boulder (13.4%; Figure 227).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (44.2%), three (17.4%), or one (16.8%; Figure 228).

Shelter

Within 100% units (n = 137 units), riffle habitat types had a mean shelter rating of 54.1, flatwater habitat types had a mean shelter rating of 41.7, and pools had a mean shelter rating of 53.8.

Of the pool units in which shelter was assessed (n = 73 units), main channel pools had a mean shelter rating of 52.5, scour pools had a mean shelter rating of 58.0, and backwater pools had a mean shelter rating of 50.9.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that boulders provided the most shelter (44.8% of all shelter; Figure 229). When we examined the percentage of shelter by shelter type within pools only, we found that boulders were the most dominant cover type (39.6% of the total cover), followed by bedrock ledges (12.7%; Figure 230).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 83.2%. Within the canopy cover present, 84.7% of the canopy was composed of deciduous trees and 15.3% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were bedrock (28.6%), boulder (29.7%), cobble/gravel (6.5%), and silt/sand/clay (35.1%; Figure 231). The mean percentage of vegetation covering the right bank in sampled units was 36.3%, and the mean percentage of vegetation covering the left bank was 37.6%. Deciduous trees were the dominant vegetation type, having been observed in 79.0% of the banks surveyed. Additionally, 10.5% of the banks surveyed had brush, 5.1% had evergreen trees, and 5.1% had grass as the dominant vegetation type (

Figure **232**).

Large Woody Debris

We observed 30 pieces of LWD that were 6 to 20 feet long and 44 pieces that were greater than 20 feet long within 24966.7 feet of wetted stream length. Across both LWD sizes, the number of LWD observed was 0.30 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 39.1 feet.

Discussion

Temperature

The water temperature of units measured ranged from 50 to 63°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Good to Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were riffles or pools. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools or low-gradient riffles. When we examined the reach in terms of length, we found that most of the reach was dry or riffles, with low-gradient riffles comprising the greatest percentage of wetted stream length.

Pool Metrics

Pool depth is an important indicator of habitat quality, as deeper pools can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in North Fork Matilija, we found that most pools had residual depths of 1–1.99 feet deep. However, a residual depth of at least 3 feet is needed to be considered good habitat (Kier Associates & NMFS 2008). Thus, it appears that most pools in North Fork Matilija may lack the depth needed to provide good hiding cover and rearing space. This may be due in part to the current, severe drought, which has extended into its fourth consecutive year.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was gravel, comprising 38.7% of pool units. Pool units most frequently had an embeddedness value of either five or three. However, pool tail-outs with gravel substrate often had an embeddedness value of one (53% of tail-outs with gravel substrate). Together, these metrics suggest that, although pools may not currently provide the ideal depth for cover or rearing space, many pool tail-outs in North Fork Matilija provide good spawning habitat for *O. mykiss*, assuming that flows are adequate.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all 100% units, we found that pools and riffles had similar mean shelter ratings, and flatwater units had a mean shelter rating only slightly lower than pools and riffles. This suggests that these three habitat types provide similar shelter quality for salmonids throughout the stream reach.

When examining pool habitat units specifically, we found that scour pools had the highest shelter rating, followed by main channel and then backwater pools. Main channel and backwater pools had similar shelter ratings.

When we examined the percentage shelter by shelter type, we found the boulders provided the most shelter by far (44.8% of all shelter within all 100% units and 39.6% of shelter within 100% pools), suggesting that boulders are a common and important feature to *O. mykiss* habitat in North Fork Matilija.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In North Fork Matilija Creek, we estimated a mean canopy cover of 83.2%, consisting predominantly of deciduous trees. This suggests that North Fork Matilija has a moderately high amount of cover (Kier Associates & NMFS 2008), but this cover is likely to vary greatly through time, given the seasonality of deciduous trees. However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was sand/silt/clay, followed by boulder and bedrock. The mean percentage of vegetation cover for the right and left banks was 36.3% and 37.6%, respectively. Deciduous trees were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively susceptible to erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In North Fork Matilija Creek, we found 0.30 pieces of LWD per 100 feet, which was extremely low compared to the amount reported in northern systems (e.g., Fox &

Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while North Fork Matilija lacks LWD, it has boulder elements that improve habitat quality. Specifically, boulders provided the greatest amount of shelter across all units in which shelter was measured (44.8% of all shelter).

Tables

Table 62. Percentage of units (n = 517) by habitat type for North Fork Matilija Creek.

Habitat Type	% of Units
Low Gradient Riffle	23.02%
Mid Channel Pool	20.31%
Run	15.09%
High Gradient Riffle	12.77%
Step Pool	5.42%
Step Run	4.64%
Dry	4.45%
Lateral Scour Pool, bedrock-formed	4.26%
Dammed Pool	4.26%
Cascade	1.74%
Plunge Pool	1.35%
Lateral Scour Pool, boulder-formed	0.97%
Bedrock Sheet	0.77%
Trench Pool	0.77%
Not Surveyed	0.19%

Figures

Figure 223. Map of the habitat assessment survey area in North Fork Matilija Creek.

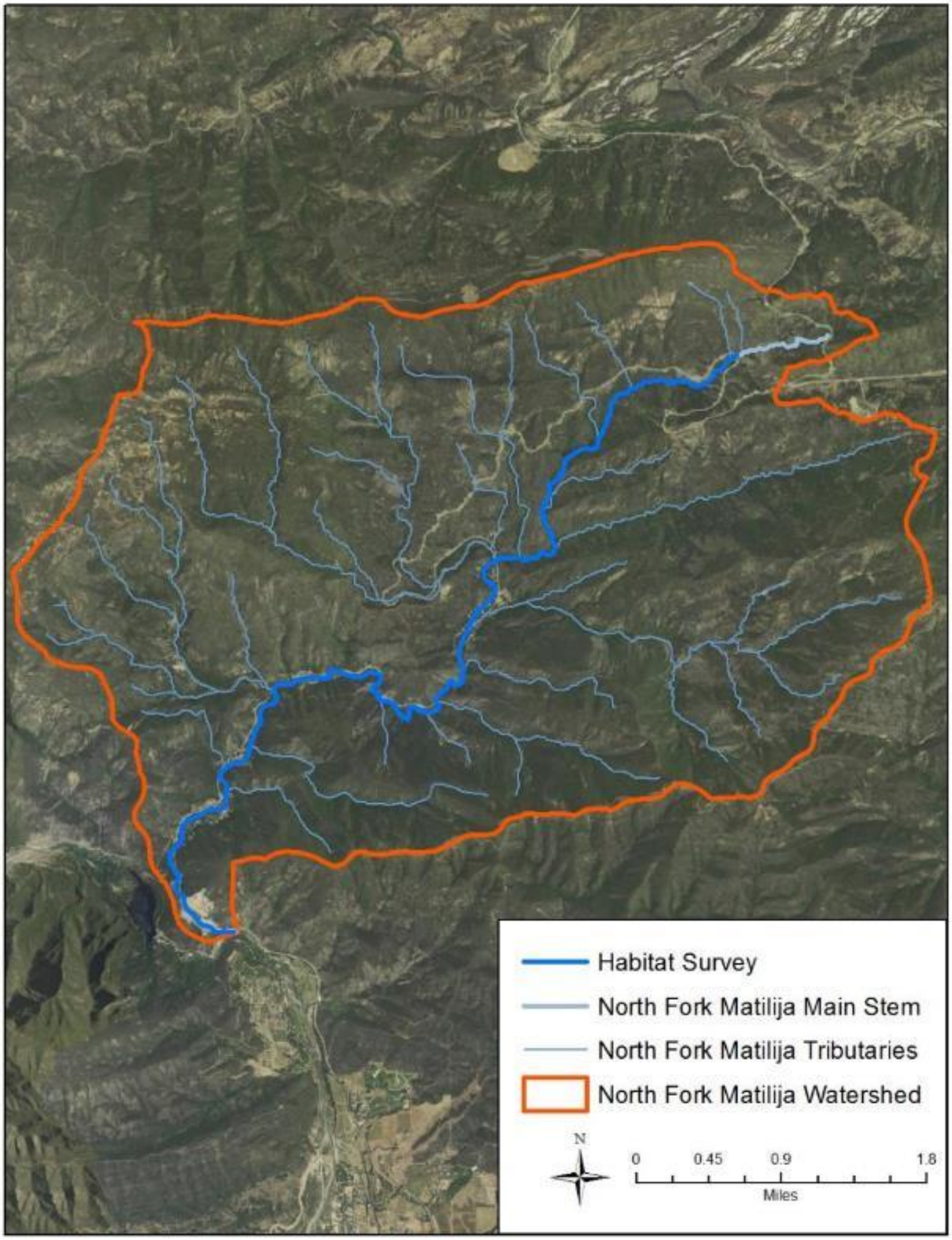


Figure 224. Percentage of total stream length categorized as pools, flatwaters, riffles, dry, or not surveyable in North Fork Matilija Creek.

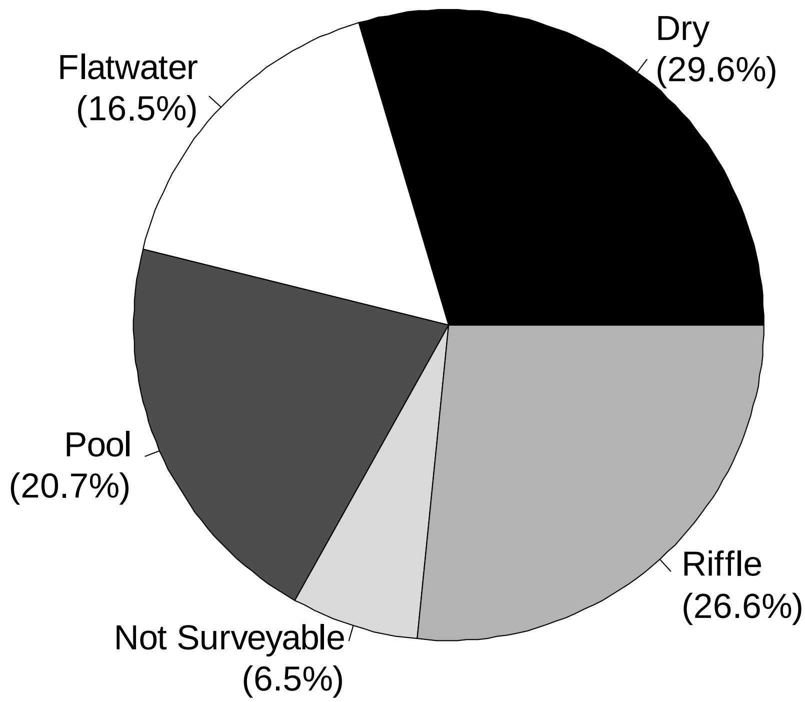


Figure 225. Percentage of all pool units (n = 193 pools) categorized by pool type (main channel, backwater, or scour pool) in North Fork Matilija Creek.

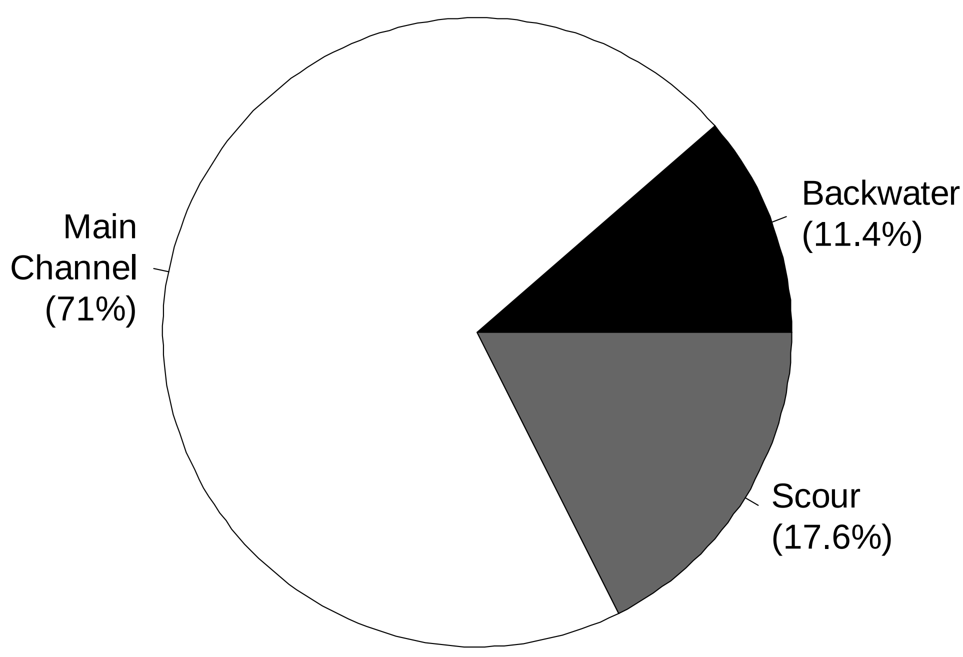
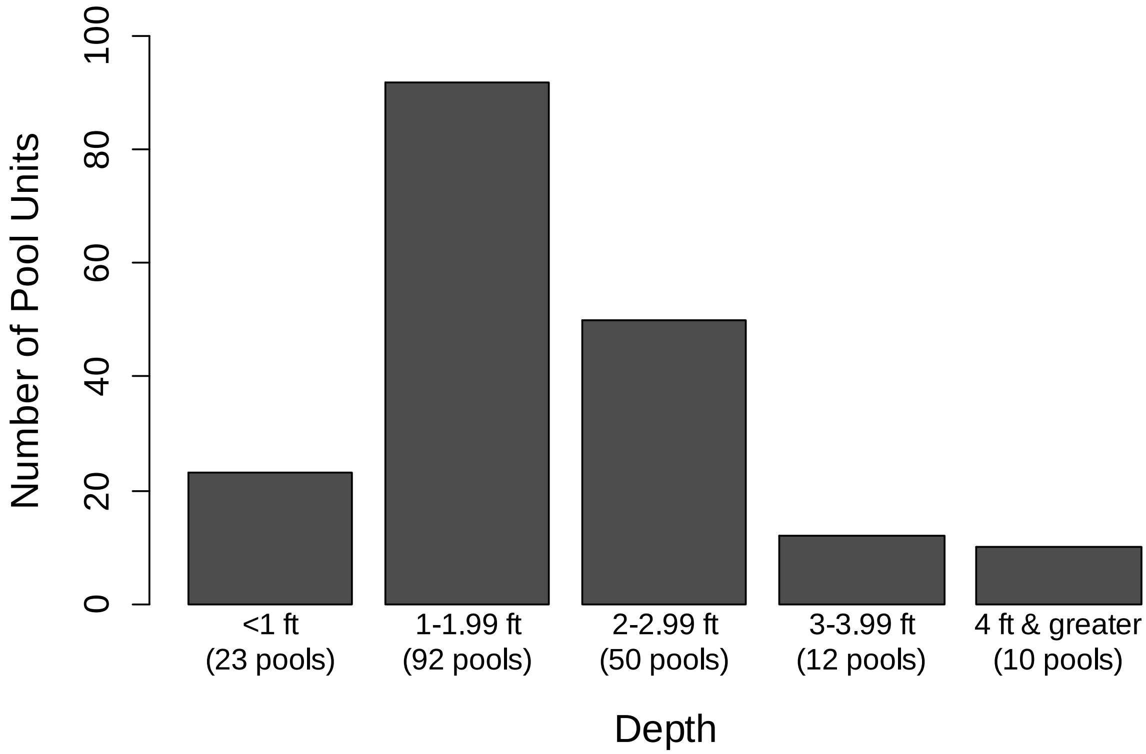


Figure 226. Histogram of residual pool depths in one-foot bins for North Fork Matilija Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.



Number of Pool Units
0
20
40
60
80
100
<1 ft
(23 pools)
1-1.99 ft
(92 pools)
2-2.99 ft
(50 pools)
3-3.99 ft
(12 pools)
4 ft & greater
(10 pools)
Depth

Figure 227. Percentage of pool tail-outs (n = 193 pools) in North Fork Matilija Creek by dominant substrate. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

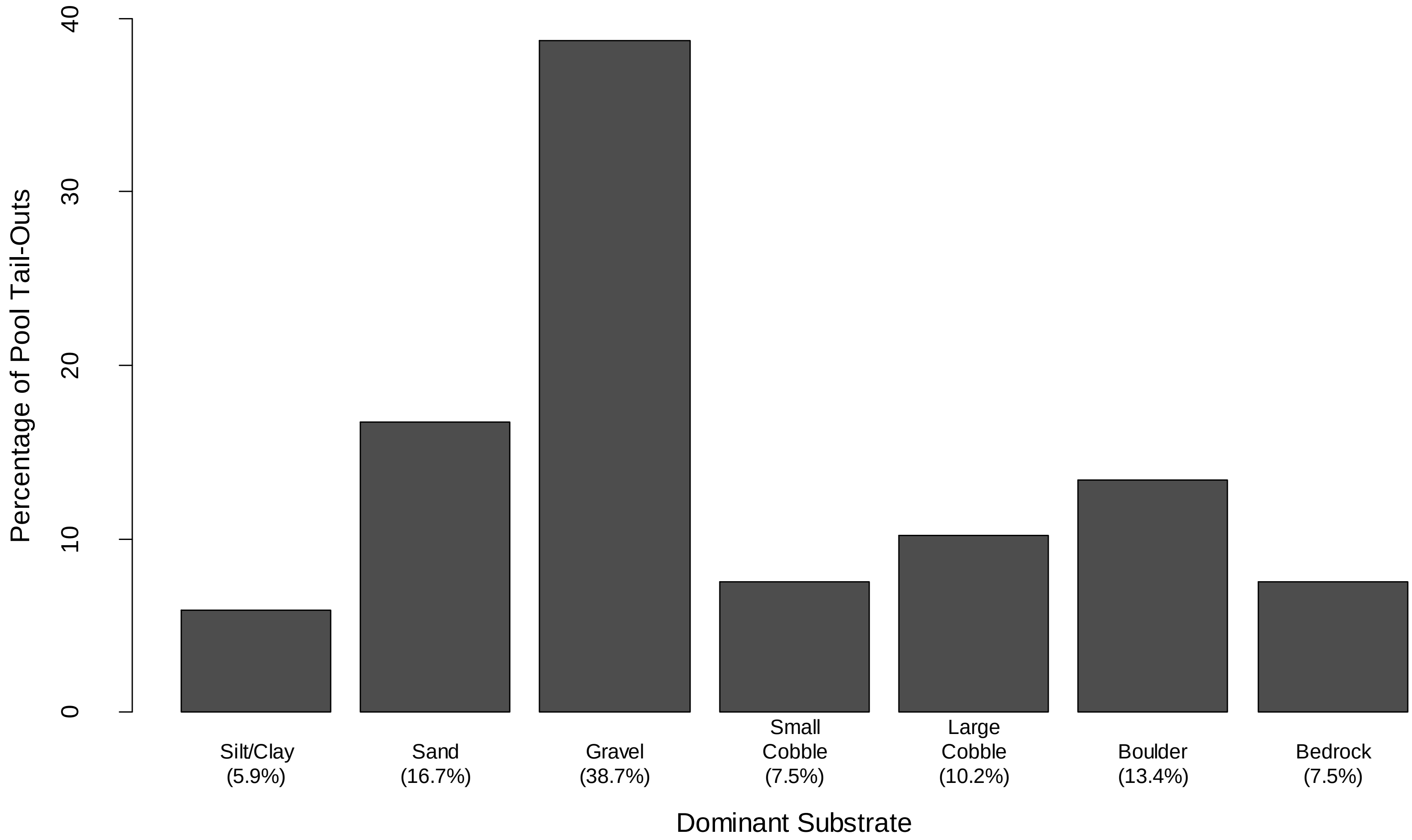


Figure 228. Percentage of all pool units (n = 193 pools) assigned a pool tail-out embeddedness value of 1 to 5 for North Fork Matilija Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning.

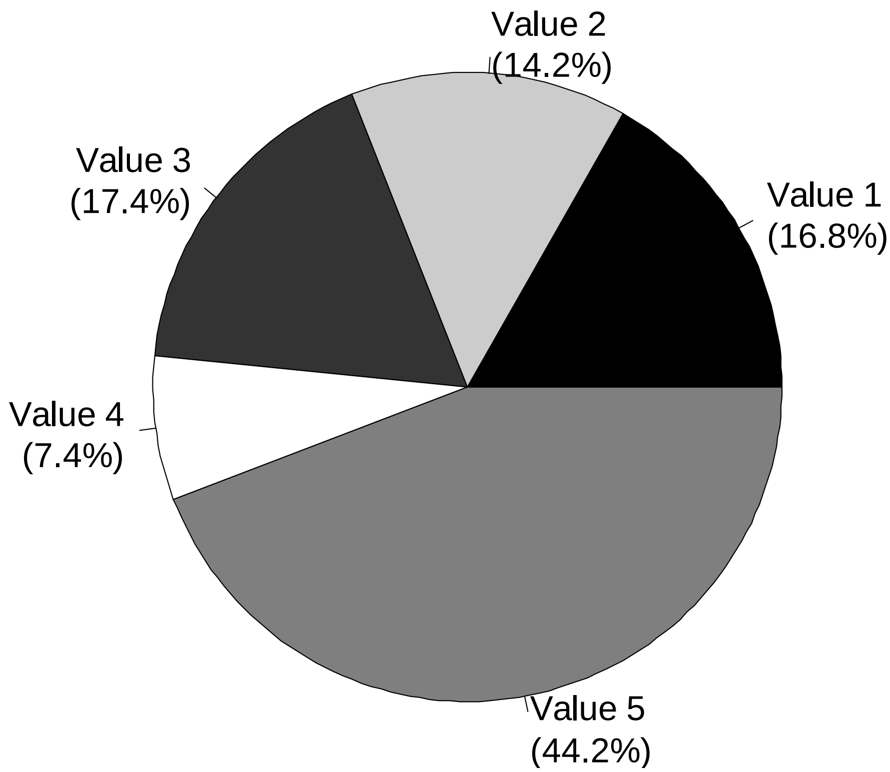


Figure 229. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 137 units) for North Fork Matilija Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

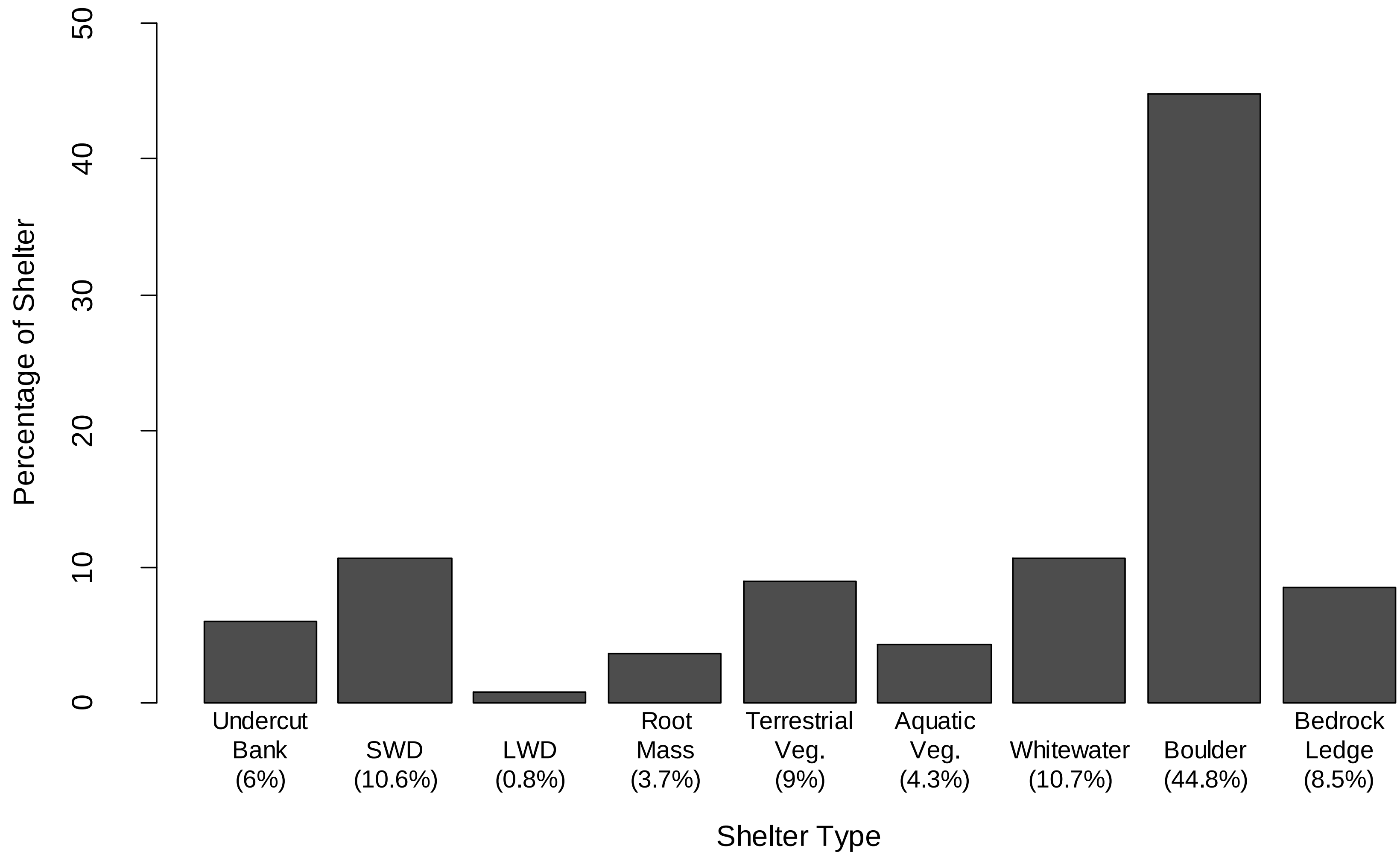


Figure 230. The percentage of shelter by shelter type across all pool units in which shelter was measured (n = 73 pools) for North Fork Matilija Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

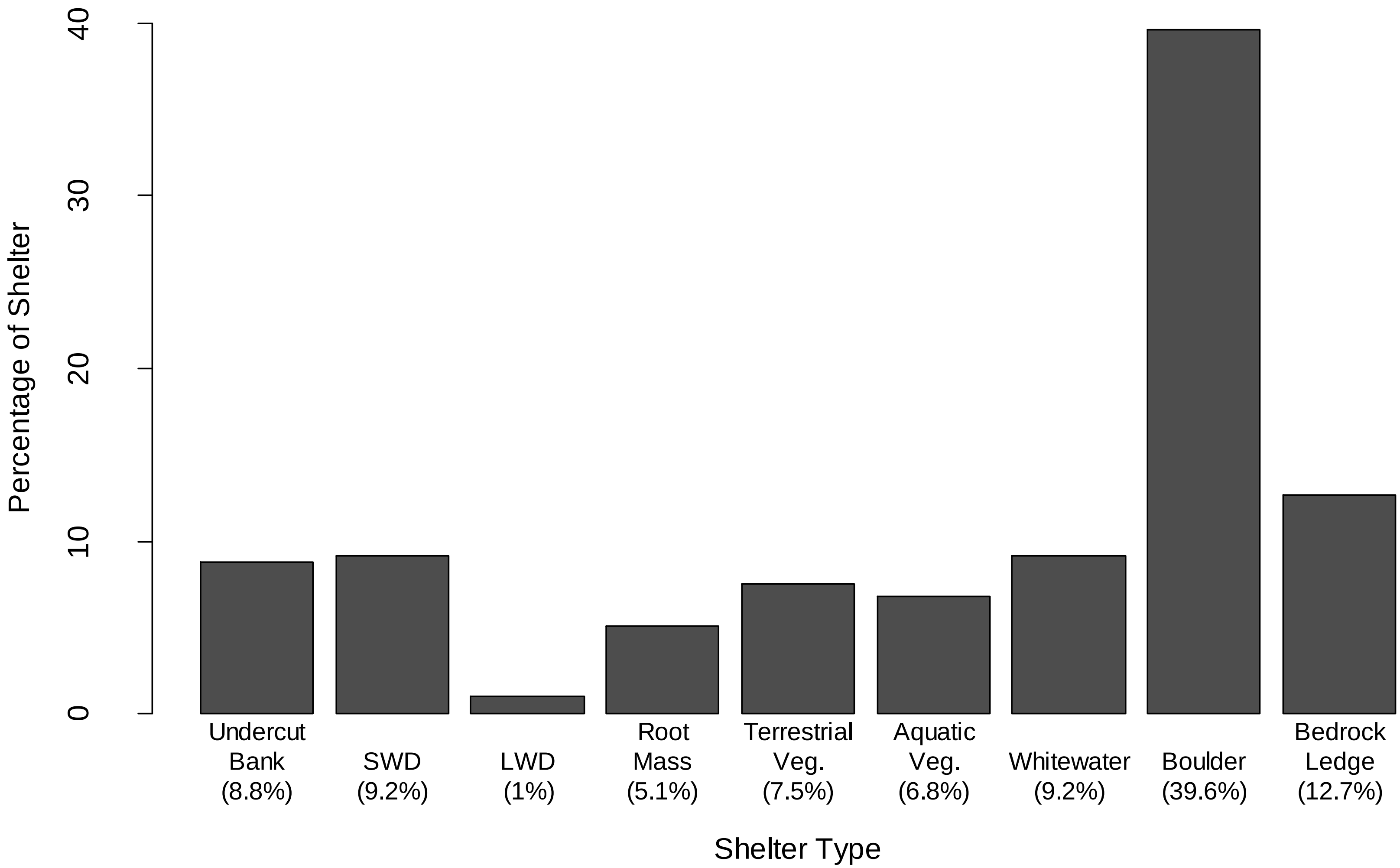


Figure 231. Percentage of banks by dominant substrate composition for North Fork Matilija Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock.

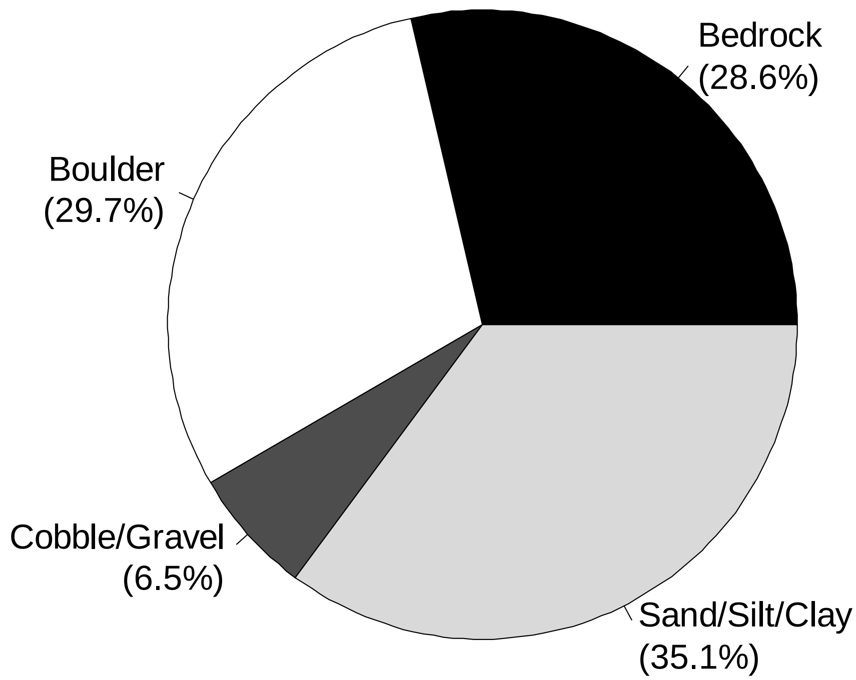
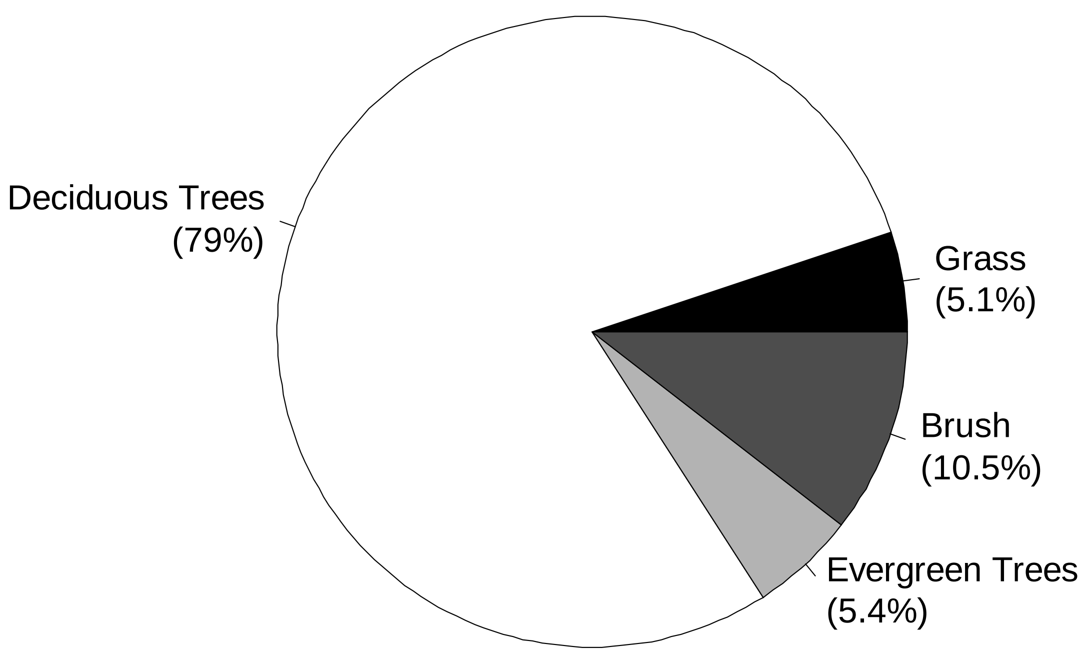


Figure 232. Percentage of banks by dominant vegetation type for North Fork Matilija Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



North Fork Matilija Tributary

Habitat Assessment

Results

The habitat inventory was conducted from 10–17 November 2015 by Terra Dressler, Philip Hunter, Andrea Dransfield, Yi-Jiun Tsai, and Marisa Morse from Pacific States Marine Fisheries Commission. The survey extended 4,889 feet upstream from the survey start (34.51891°N, -119.26872°W), with an additional 273 feet of side channel. The survey endpoint (34.52988°N, -119.27003°W) was a concrete waterfall at a road crossing on highway 33 (Figure 233). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 44 to 56°F. Air temperature ranged from 49 to 70°F.

Habitat type

Of the total number of habitat units surveyed (n = 165 units), 0.6% of units were dry, 15.8% were flatwaters, 27.9% were pools, and 55.8% were riffles. Of the total length of the reach surveyed, 0.1% was dry, 9.7% was composed of flatwaters, 11.4% was composed of pools, and 78.8% was composed of riffles (Figure 234).

We identified ten habitat types in North Fork Matilija Tributary. Low gradient riffles (41.8%) and mid channel pools (20.6%) were the most frequently encountered habitat types (Table 63). Low gradient riffles (74.2%), mid channel pools (5.7%), and step pools (5.6%) composed the greatest stream lengths.

Pool Metrics

A total of 46 pools were identified within the survey reach. Main channel pools were the only pools encountered; no scour or backwater pools were recorded.

No pools had residual depths of three feet or greater (
Figure **235**).

Within pool tail-outs, silt/clay (39.1%) and sand (26.1%) were the most common dominant substrates (Figure 236).

When we examined pool tail-outs for substrate embeddedness, we found that pools had embeddedness values of either five (97.8%) or one (2.2%).

Shelter

Within 100% units (n = 39 units), riffle habitat types had a mean shelter rating of 38.0, flatwater habitat types had a mean shelter rating of 29.3, and pools had a mean shelter rating of 60.5.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that small woody debris provided the most shelter (66.5% of all shelter; Figure 237). When we examined the percentage of shelter by shelter type within pools only (n = 10 pools), we found that small woody debris was again the most dominant cover type (50.0% of the total cover; Figure 238).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 87.0%. Within the canopy cover present, 75.6% of the canopy was composed of deciduous trees and 24.4% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were sand/silt/clay (81.6%), bedrock (11.8%), and boulder (6.6%; Figure 239). The mean percentage of vegetation covering the right bank in sampled units was 54.9%, and the mean percentage of vegetation covering the left bank was 51.4%. Evergreen trees were the dominant vegetation type, having been observed in 61.8% of the banks surveyed (Figure 240).

Large Woody Debris

We observed eight pieces of LWD that were 6 to 20 feet long and 15 pieces that were greater than 20 feet long within 5156 feet of wetted stream length. Across both LWD sizes, the number of LWD observed was 0.45 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 21.0 feet.

Discussion

Temperature

The water temperature of units measured ranged from 44 to 56°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of both frequency and length, we found that most units and the majority of stream length were riffles or pools. Looking at more detailed habitat types, we found that mid-channel pools and low-gradient riffles composed the most frequent units, as well as the greatest stream length.

Pool Metrics

Pool depth is an important indicator of habitat quality, as deeper pools can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). A residual depth of at least three feet is needed to be considered good habitat (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in North Fork Matilija Tributary, we found that no pools had residual depths greater than 2.99 feet. Thus, pools in North Fork Matilija Tributary lack the depth needed to provide good hiding cover and rearing space. This may be due in part to the current, severe drought, which has extended into its fourth consecutive year.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was silt/clay or sand. Pool units most frequently had an embeddedness value of a five. Together, these metrics suggest that few pool tail-outs in North Fork Matilija Tributary provide good spawning habitat for *O. mykiss* under the current water flow conditions.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of 100% units, we found that pools had the highest mean shelter rating, while flatwaters had the lowest. However, the mean shelter ratings for all three habitat types were low (below 61 on a scale ranging from 0 to 300).

When we examined the percentage shelter by shelter type, we found that small woody debris provided the most shelter by far, both across all 100% units (66.5% of shelter) and within pools only (50.0% of shelter).

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In North Fork Matilija Tributary, we estimated a mean canopy cover of 87.0%, consisting predominantly of deciduous trees. This suggests that North Fork Matilija Tributary has a moderately high amount of cover (Kier Associates & NMFS 2008), but this cover is likely to vary greatly through time, given the seasonality of deciduous trees. However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was sand/silt/clay. The mean percentage of vegetation covering the right and left banks was 54.9% and 51.4%, respectively. Evergreen trees were the dominant vegetation type. Together these bankside metrics suggest that these banks may be relatively vulnerable to erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In North Fork Matilija Tributary, we found 0.45 pieces of LWD per 100 feet, which was low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while North Fork Matilija Tributary lacks LWD, it may have boulder elements that improve habitat quality.

Tables

Table 63. Percentage of units (n = 165) by habitat type in North Fork Matilija Tributary.

Habitat Type	% of Units
Low Gradient Riffle	41.82%
Mid Channel Pool	20.61%
Run	12.73%
Bedrock Sheet	10.91%
Step Pool	6.67%
Step Run	3.03%
High Gradient Riffle	2.42%
Cascade	0.61%
Trench Pool	0.61%
Dry	0.61%

Figures

Figure 233. Map of the habitat assessment survey area in North Fork Matilija Tributary.

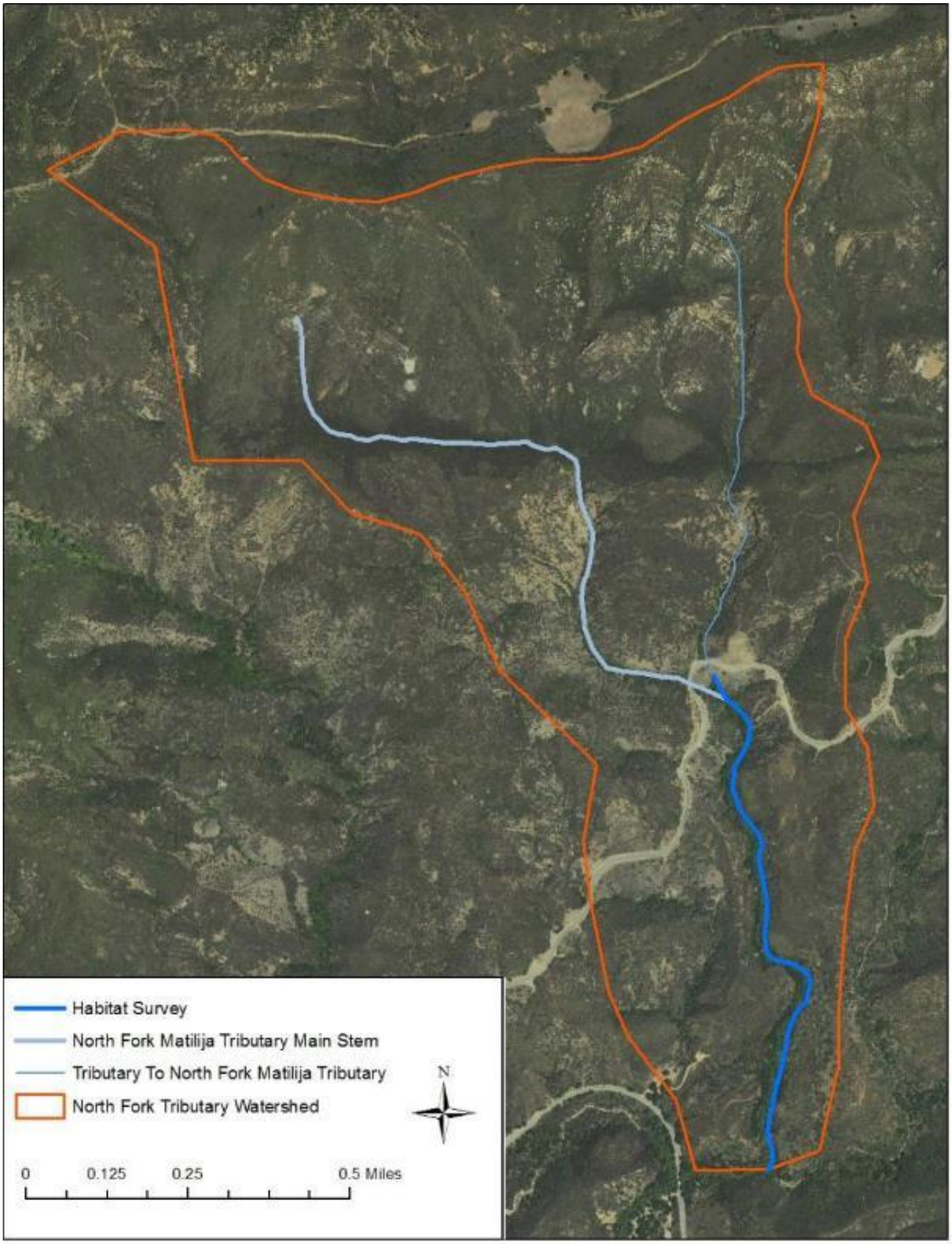


Figure 234. Percentage of total stream length categorized as pools, flatwaters, or riffles in North Fork Matilija Tributary.

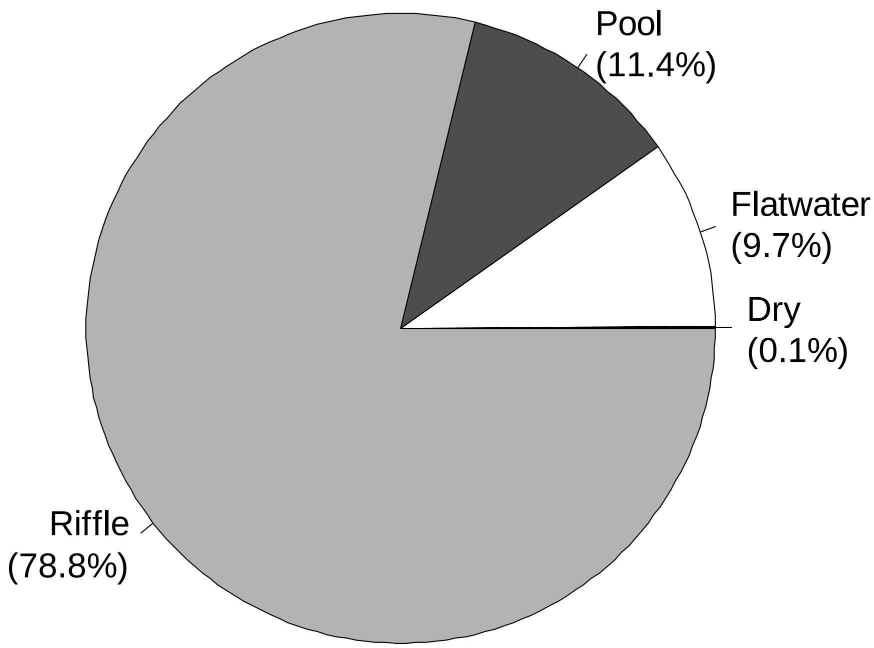


Figure 235. Histogram of residual pool depths in one-foot bins for North Fork Matilija Tributary. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

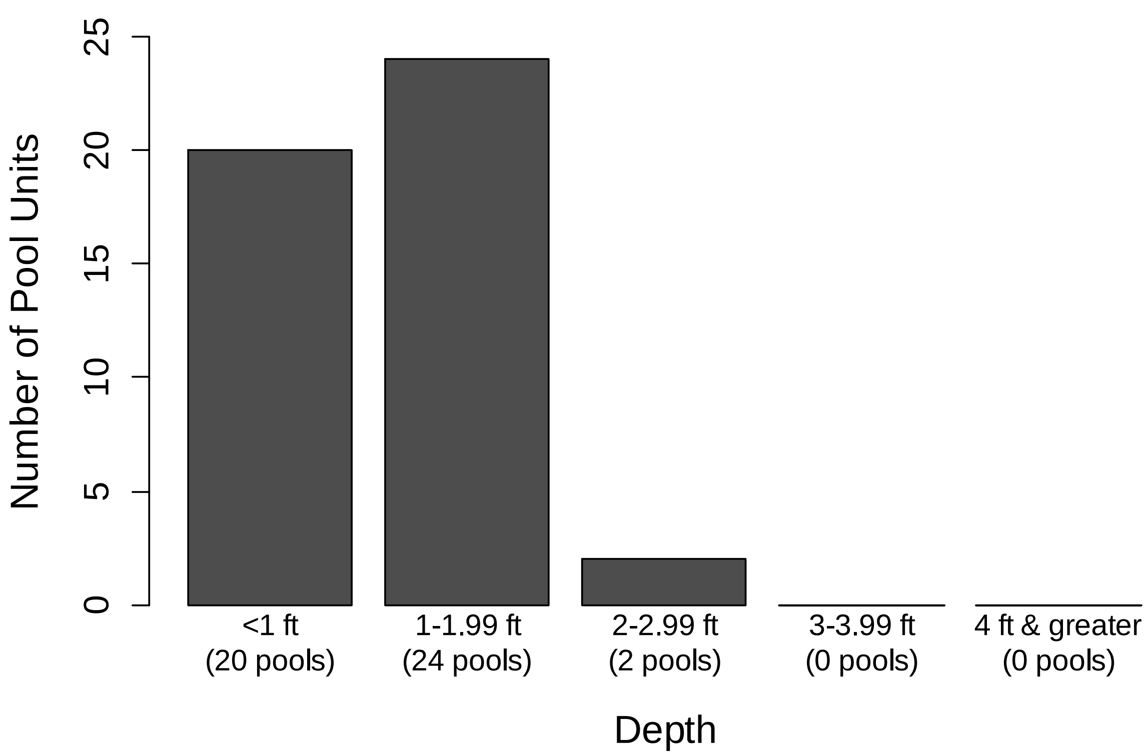


Figure 236. Percentage of pool tail-outs (n = 46 pools) by dominant substrate for North Fork Matilija Tributary. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

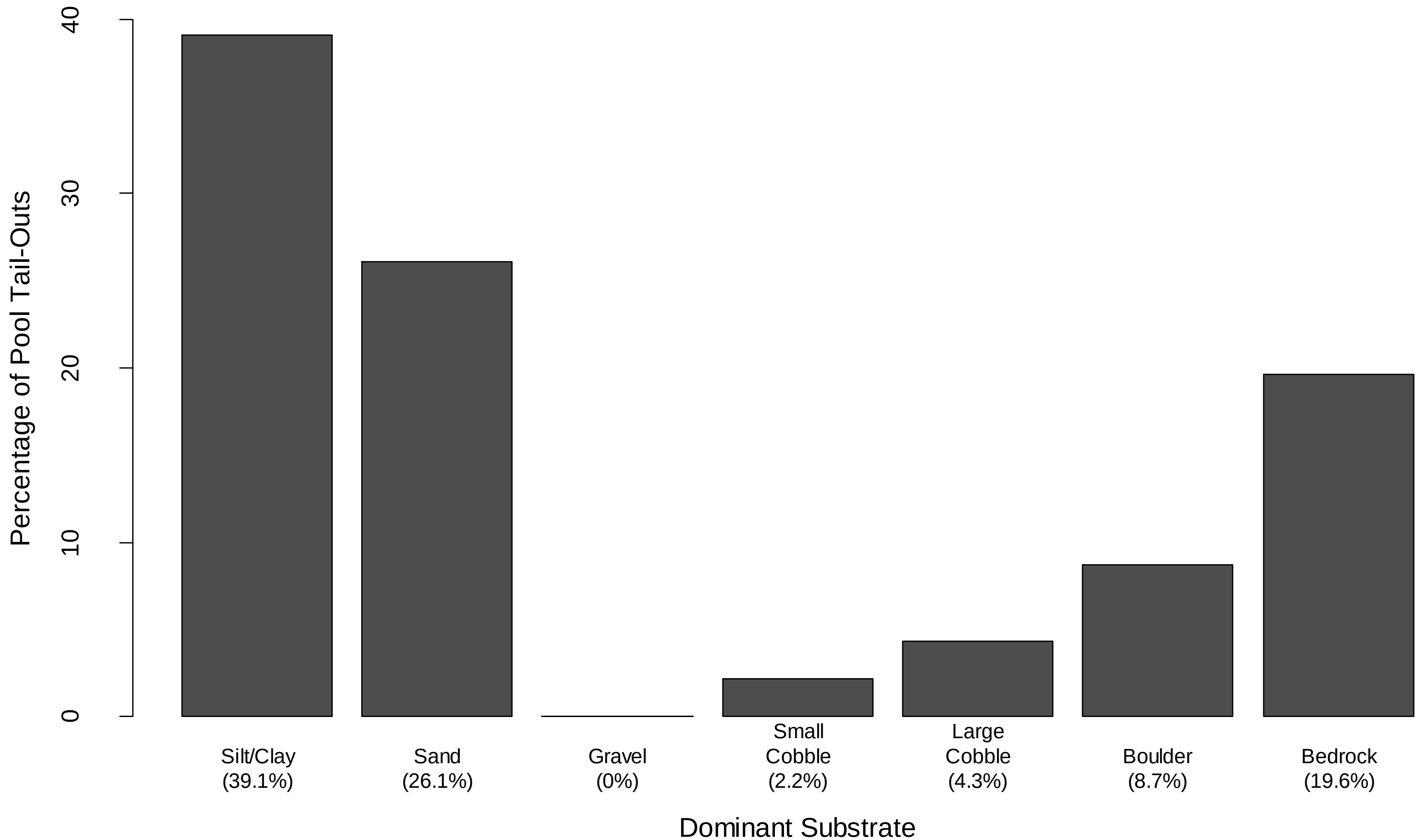


Figure 237. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 39 units) in North Fork Matilija Tributary. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

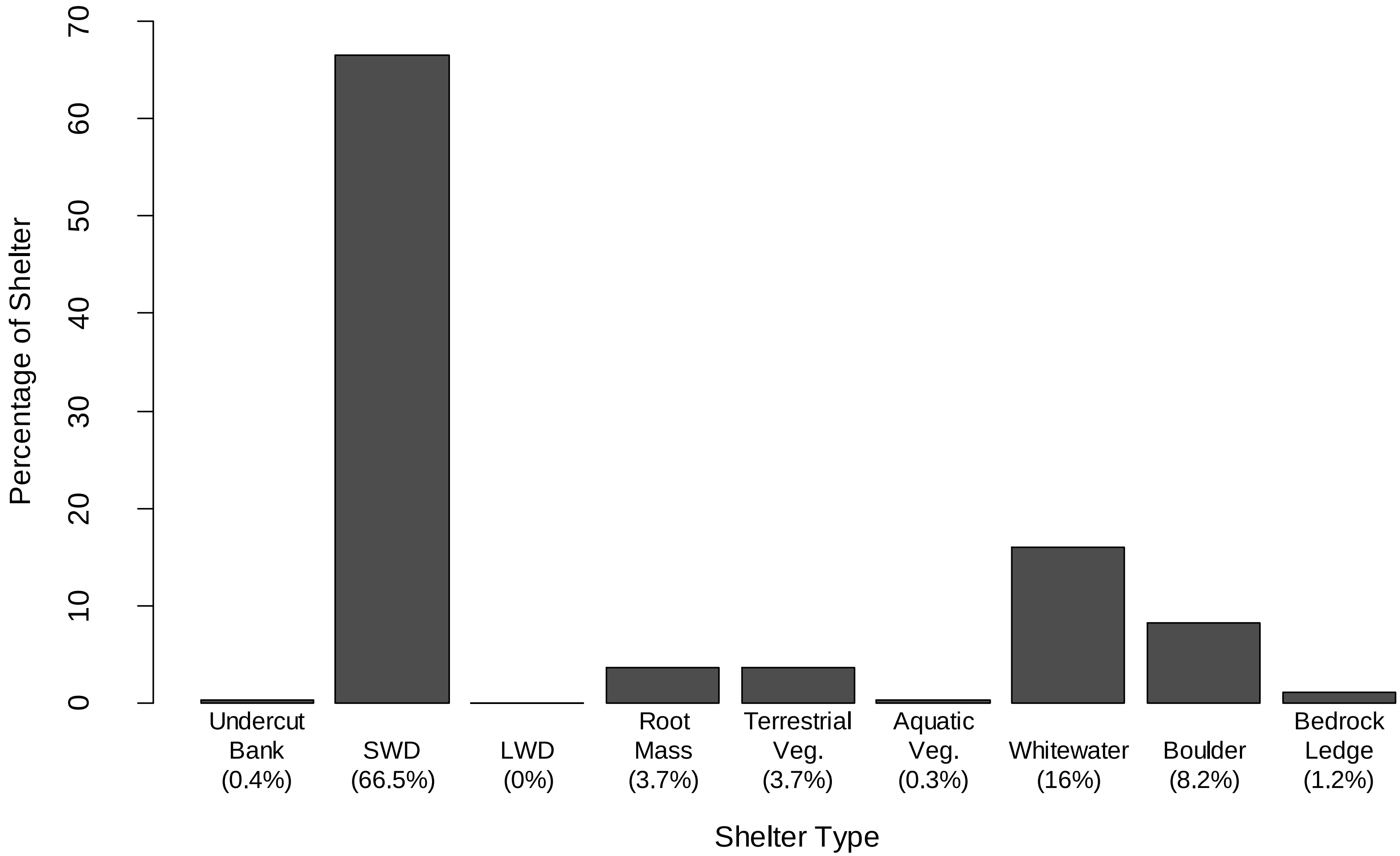


Figure 238. The percentage of shelter by shelter type across all pool units in which shelter was measured (n = 10 pools) in North Fork Matilija Tributary. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

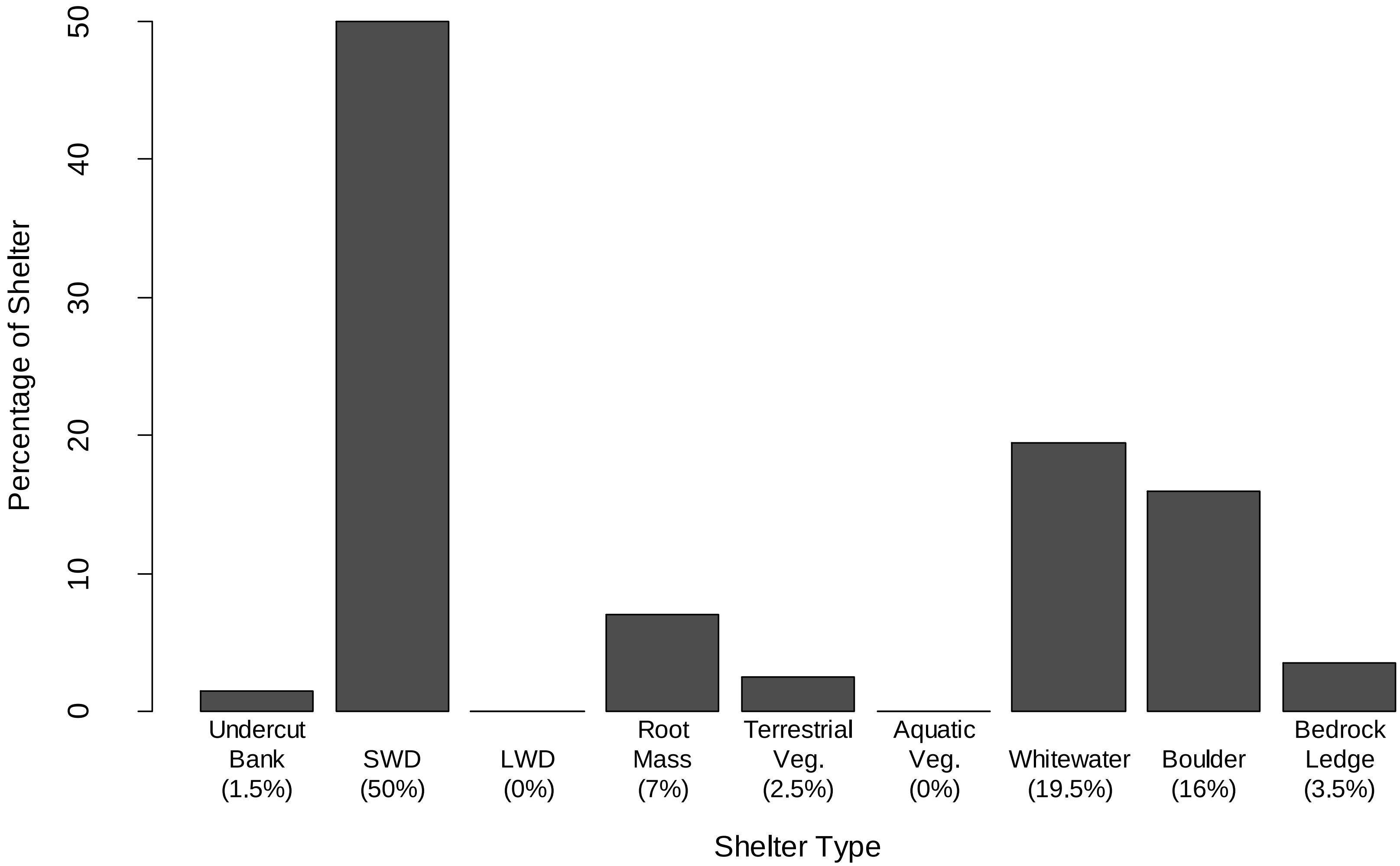


Figure 239. Percentage of banks by dominant substrate composition for North Fork Matilija Tributary. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock. No cobble/gravel was observed as the dominant bankside substrate in this survey.

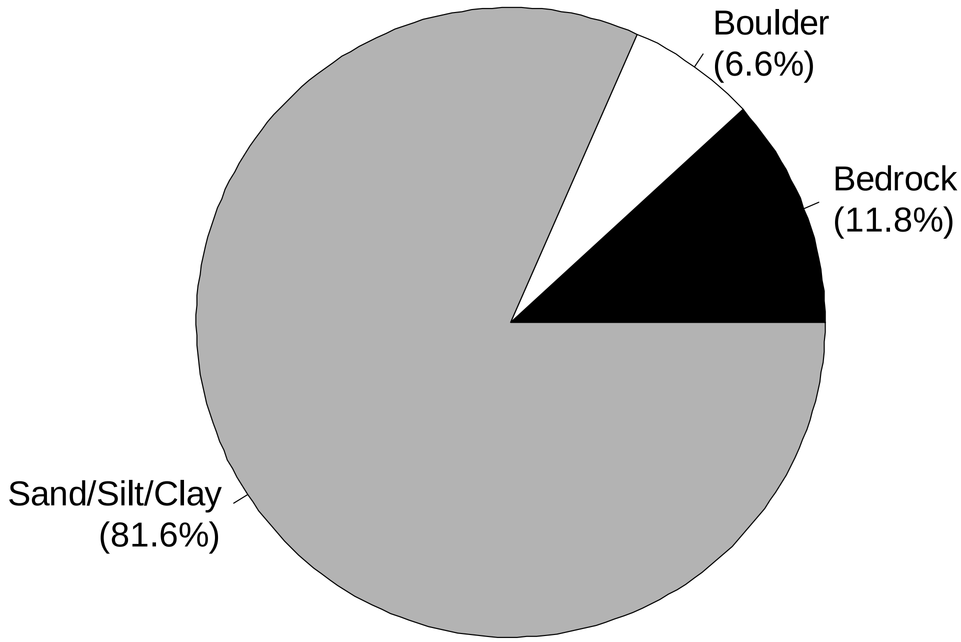
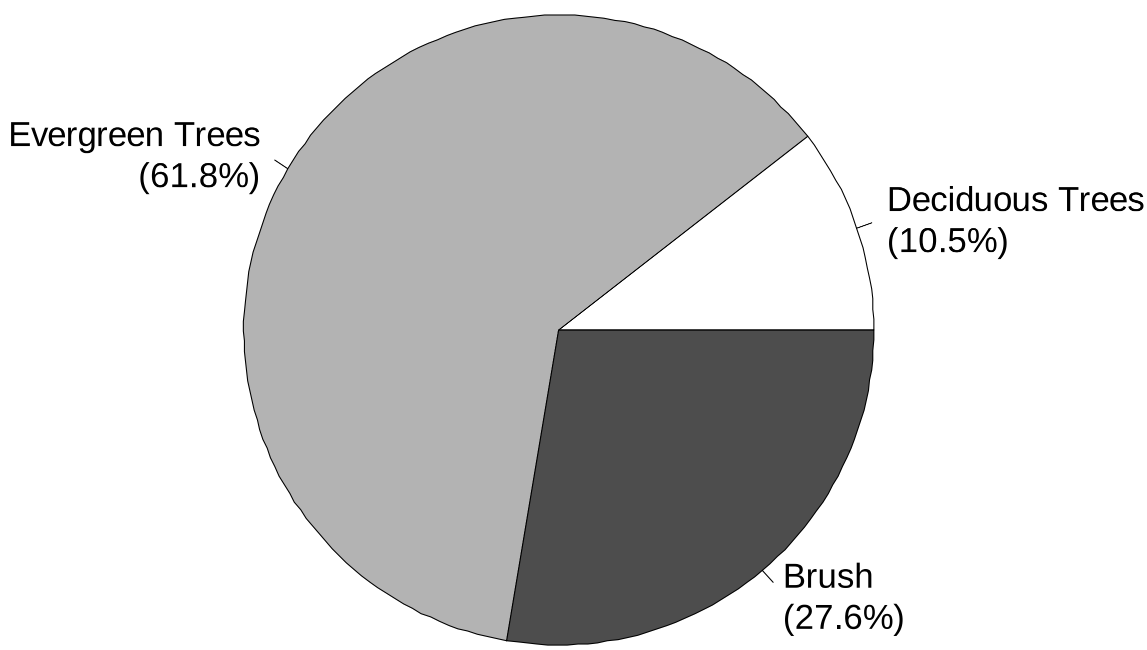


Figure 240. Percentage of banks by dominant vegetation types in North Fork Matilija Tributary. Vegetation types included deciduous trees, evergreen trees, grass, and brush. No grass was observed as the dominant bankside vegetation in this survey.



Bear Creek

Habitat Assessment

Results

The habitat inventory was conducted from 13–20 November 2013 by Patrick Riparetti, Karissa Willits, Ben Lakish, Kate McLaughlin, and Tom van Meeuwen from Pacific States Marine Fisheries Commission and Kayti Christianson from Watershed Stewards Program. The survey extended 7,029 feet upstream from the survey start (34.51240°N, -119.27426°W), with an additional 507 feet of side channel. The survey end point (34.51163°N, -119.25453°W) was determined by dry stream bed upstream of a partial fish passage barrier (Figure 241). Stream flow was not measured

Temperature

Water temperatures ranged from 53 to 61°F. Air temperature ranged from 59 to 79°F.

Habitat type

Of the total number of habitat units surveyed (n = 106 units), 7.5% of units were dry, 18.9% were flatwaters, 29.2% were pools, and 44.3% were riffles. Of the total length of the reach surveyed, 34.2% was dry, 17.0% was composed of flatwaters, 8.3% was composed of pools, and 40.5% was composed of riffles (Figure 242).

We identified nine habitat types in Bear Creek. Based on the frequency of units sampled, mid-channel pools (23.6%), high gradient riffles (22.6%), and low gradient riffles (21.7%) were the most common habitat types (Table 64). Based on total stream length, dry (34.2%), low gradient riffles (20.3%), and high gradient riffles (20.2%) composed the greatest stream lengths.

Pool Metrics

A total of 31 pools were identified within the survey reach. Main channel pools were most frequently encountered (90.3% of pool units sampled) and comprised 91.8% of the total length of all pools. Only main channel and scour pools were encountered; no backwater pools were recorded.

No pools had residual depths of three feet or greater (
Figure **243**).

Within pool tail-outs, gravel was the most frequently observed dominant substrate (77.8% of pool units), followed by sand (7.4%; Figure 244).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of two (35.5%), one (22.6%), or five (22.6%; Figure 245).

Shelter

Within 100% units (n = 21 units), riffle habitat types had a mean shelter rating of 56.7, flatwater habitat types had a mean shelter rating of 48.3, and pools had a mean shelter rating of 45.0.

Of the pool units in which shelter was assessed (n = 9), main channel pools had a mean shelter rating of 47.9 and scour pools had a mean shelter rating of 35.0.

When we examined the mean percentage of shelter by shelter type across all 100% units (n = 21 units), we found that small woody debris provided the most shelter (25.0%), followed by boulders (24.2%; Figure 246). When we examined the percentage of shelter by shelter type within 100% pools only (n = 9 units), we found that boulders were the most dominant cover type (21.7% of the total cover), followed by undercut bank (19.4%; Figure 247).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 93.6%. Within the canopy cover present, 97.9% of the canopy was composed of deciduous trees and 2.1% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were boulder (10.0%) and sand/silt/clay (90.0%). The mean percentage of vegetation covering the right bank in sampled units was 55.8%, and the mean percentage of vegetation covering the left bank was 56.0%. Deciduous trees were the dominant vegetation type, having been observed in 67.5% of the banks surveyed (Figure 248).

Large Woody Debris

We observed six pieces of LWD that were 6 to 20 feet long and three pieces that were greater than 20 feet long within 4961 feet of wetted length. Across both LWD sizes, the number of LWD observed was 0.18 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 20.9 feet.

Discussion

Temperature

The water temperature of units measured ranged from 53 to 61°F. According to the Guide to the Reference Values Used in South-Central/Southern California Coast Steelhead Conservation Action Planning Workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Good to Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were riffles. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools and high gradient riffles. When we examined the reach in terms of length, we found that most of the reach was dry or riffles, with low gradient and high gradient riffles comprising the greatest percentage of wetted stream length.

Pool Metrics

Pool depth is an important indicator of habitat quality, as deeper pools can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). A residual depth of at least 3 feet is needed to be considered good habitat (Kier Associates & NMFS 2008).When we examined the habitat metrics for pools in Bear, we found that most pools had residual depths of 1–1.99 feet deep and that no pool had a depth greater than 2.99 feet. Thus, pools in Bear may lack the depth needed to provide good hiding cover and rearing space.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was gravel, comprising 77.8% of pool units. Pool units most frequently had an embeddedness value of two (35.5%). Together, these metrics suggest that, although pools may not provide the ideal depth for cover or rearing space, many pool tail-outs in Bear may provide good spawning habitat for *O. mykiss*, assuming that flows are adequate.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that all three habitat types had relatively low shelter ratings (shelter ratings of 56.7, 48.3, and 45, respectively, on a scale ranging from 0 to 300). This suggests that Bear Creek may not provide adequate shelter for *O. mykiss* in terms of complexity and coverage.

When we examined the percentage of shelter by shelter type across all 100% units, we found the small woody debris provided the most shelter (25.0% of all shelter). This may be explained by the high occurrence of deciduous trees in the area; deciduous trees comprised 97.9% of the canopy cover. When we examined shelter across only pool units, we found that boulders were the dominant cover type.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In Bear Creek, we estimated a mean canopy cover of 93.6%, consisting predominantly of deciduous trees. This suggests that Bear has a high amount of cover (Kier Associates & NMFS 2008), although this cover is may vary through time, given the seasonality of deciduous trees.

Bankside Metrics

The predominant substrate composing stream banksides was sand/silt clay. The mean percentage of vegetation covering the right and left banks was 55.8% and 56.0%, respectively. Deciduous trees and brush were the most common dominant vegetation observed. Together these metrics suggest that the banks of Bear Creek may be relatively vulnerable to erosion during large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In Bear Creek, we found 0.18 pieces of LWD per 100 feet, which was extremely low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Bear Creek lacks LWD, it may have boulder elements that improve habitat quality.

Tables

Table 64. Percentage of all units (n = 106) by habitat type in Bear Creek.

Habitat Type	% of Units
Mid-Channel Pool	23.58%
High Gradient Riffle	22.64%
Low Gradient Riffle	21.70%
Run	12.26%
Dry	7.55%
Step Run	6.60%
Step Pool	2.83%
Lateral Scour Pool, boulder-formed	1.89%
Lateral Scour Pool, bedrock-formed	0.94%

Figures

Figure 241. Map of the habitat assessment survey area in Bear Creek.

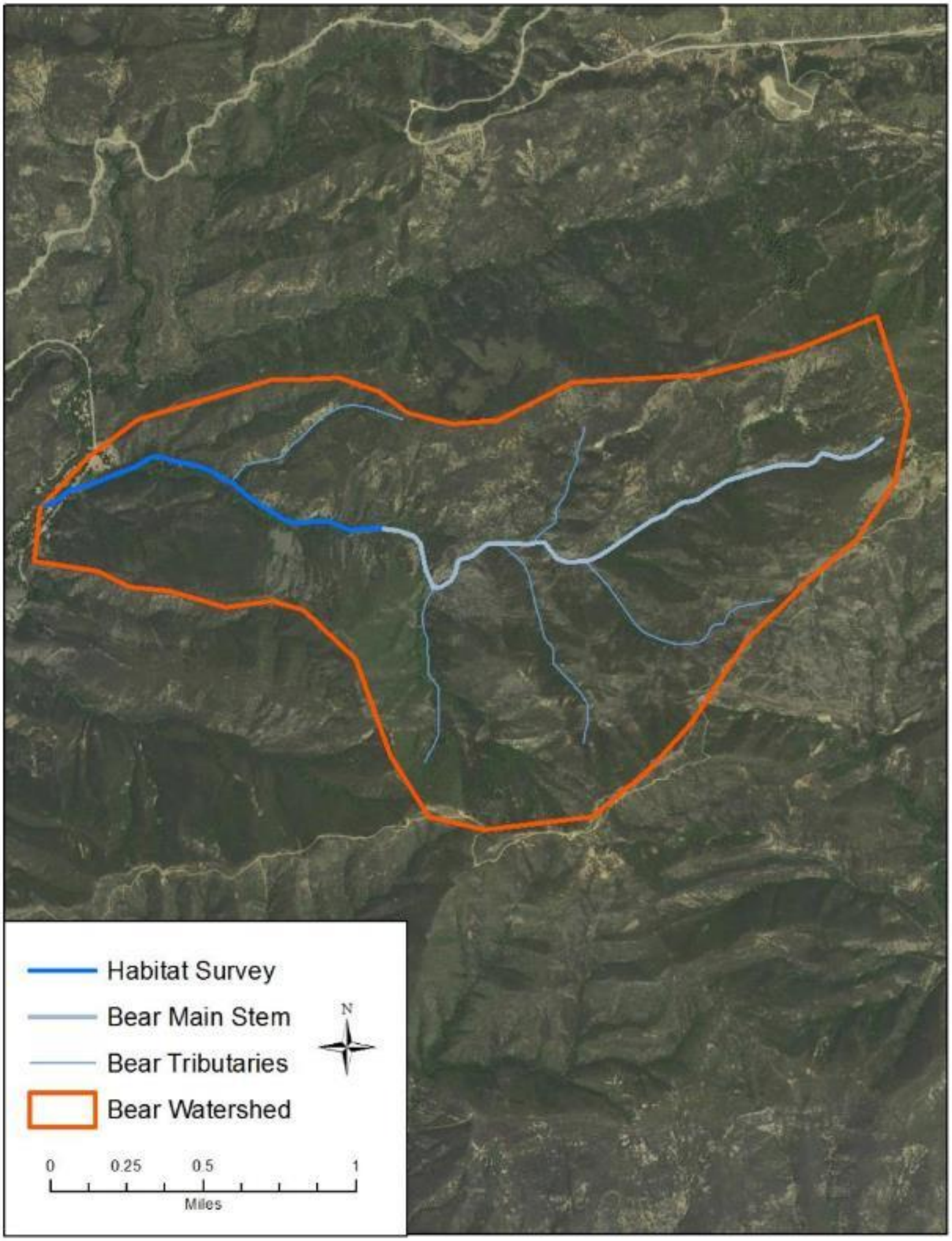


Figure 242. Percentage of the total stream length categorized as pools, flatwaters, riffles, or dry in Bear Creek.

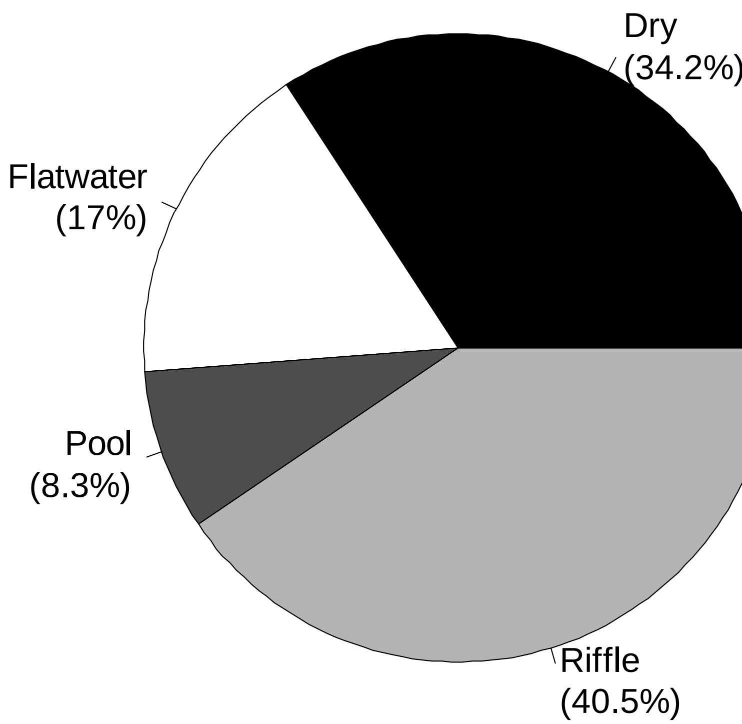


Figure 243. Histogram of residual pool depths in one-foot bins for Bear Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

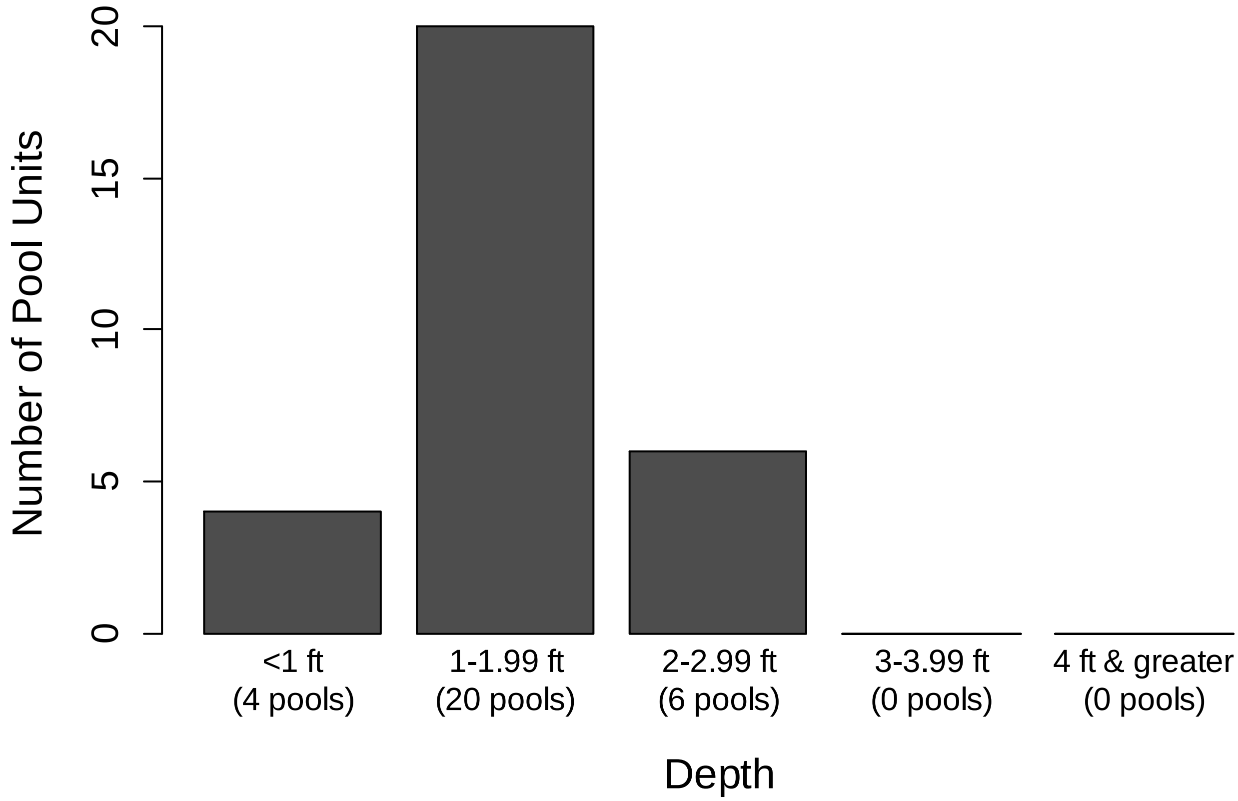


Figure 244. Percentage of pool tail-outs (n = 31 pools) by dominant substrate for Bear Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

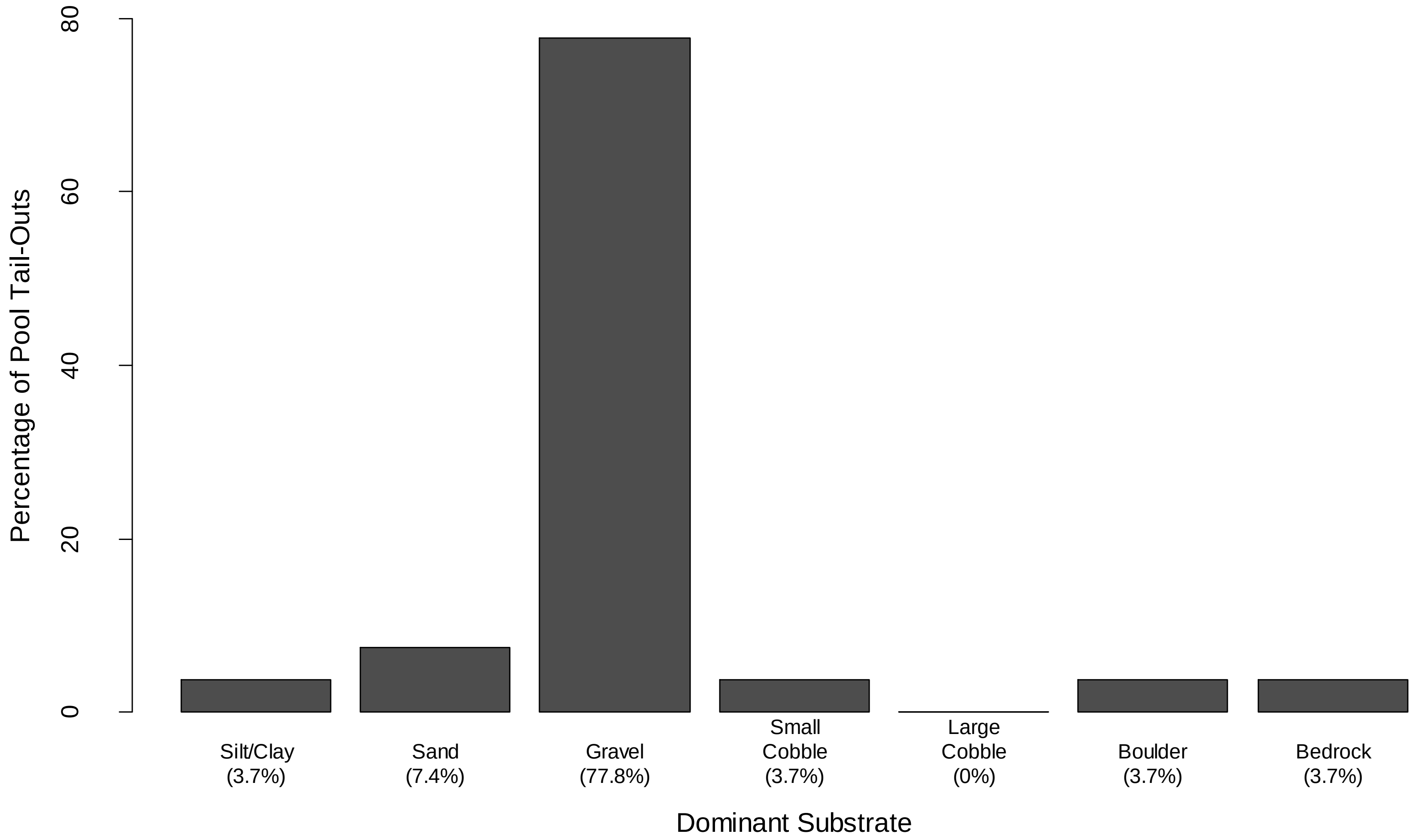


Figure 245. Percentage of all pool units (n = 31 pools) assigned a pool tail-out embeddedness value of 1 to 5 for Bear Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning.

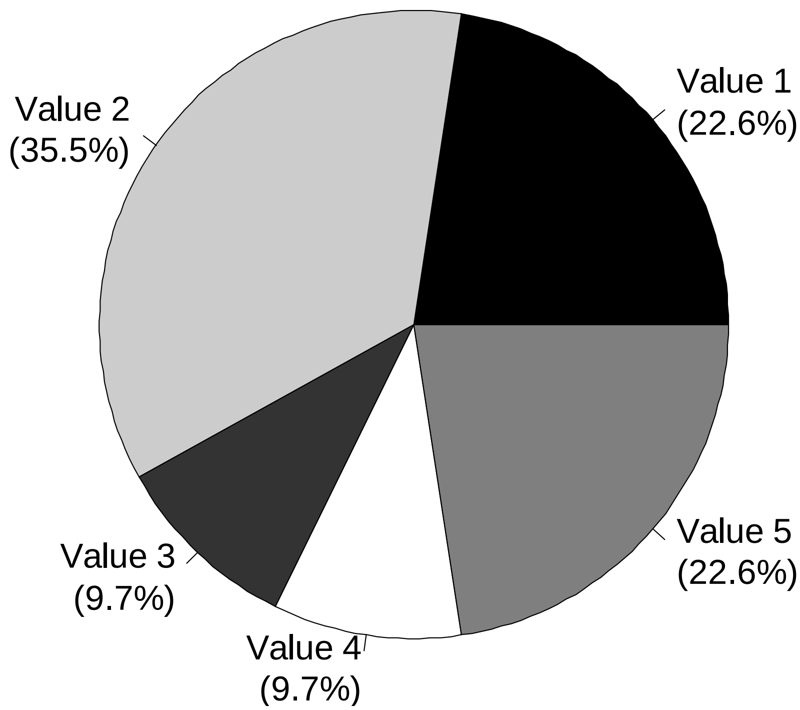


Figure 246. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 21 units) for Bear Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock. ledge.

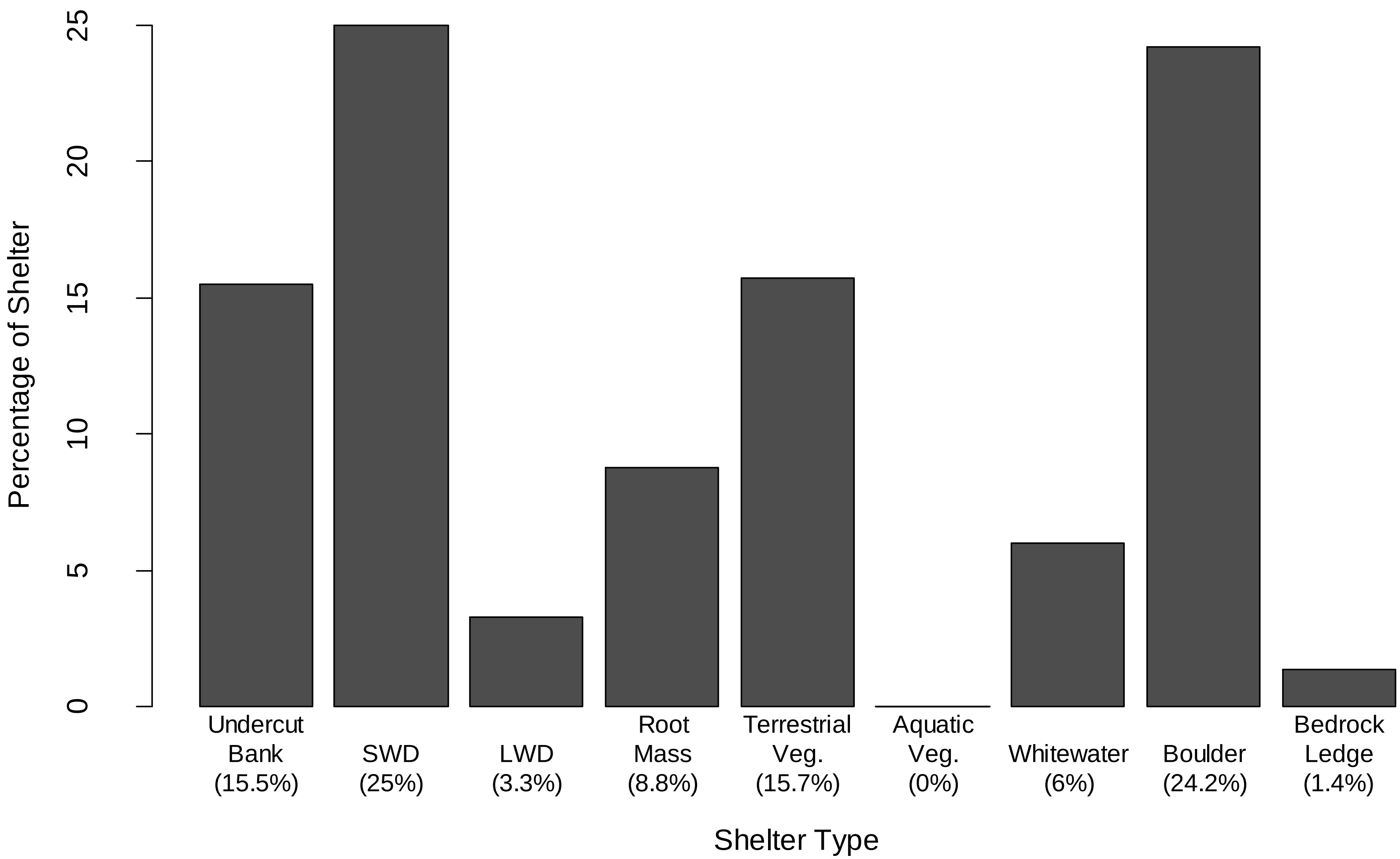


Figure 247. The percentage of instream shelter by shelter type across pool units in which shelter was measured (n = 9 pools) for Bear Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

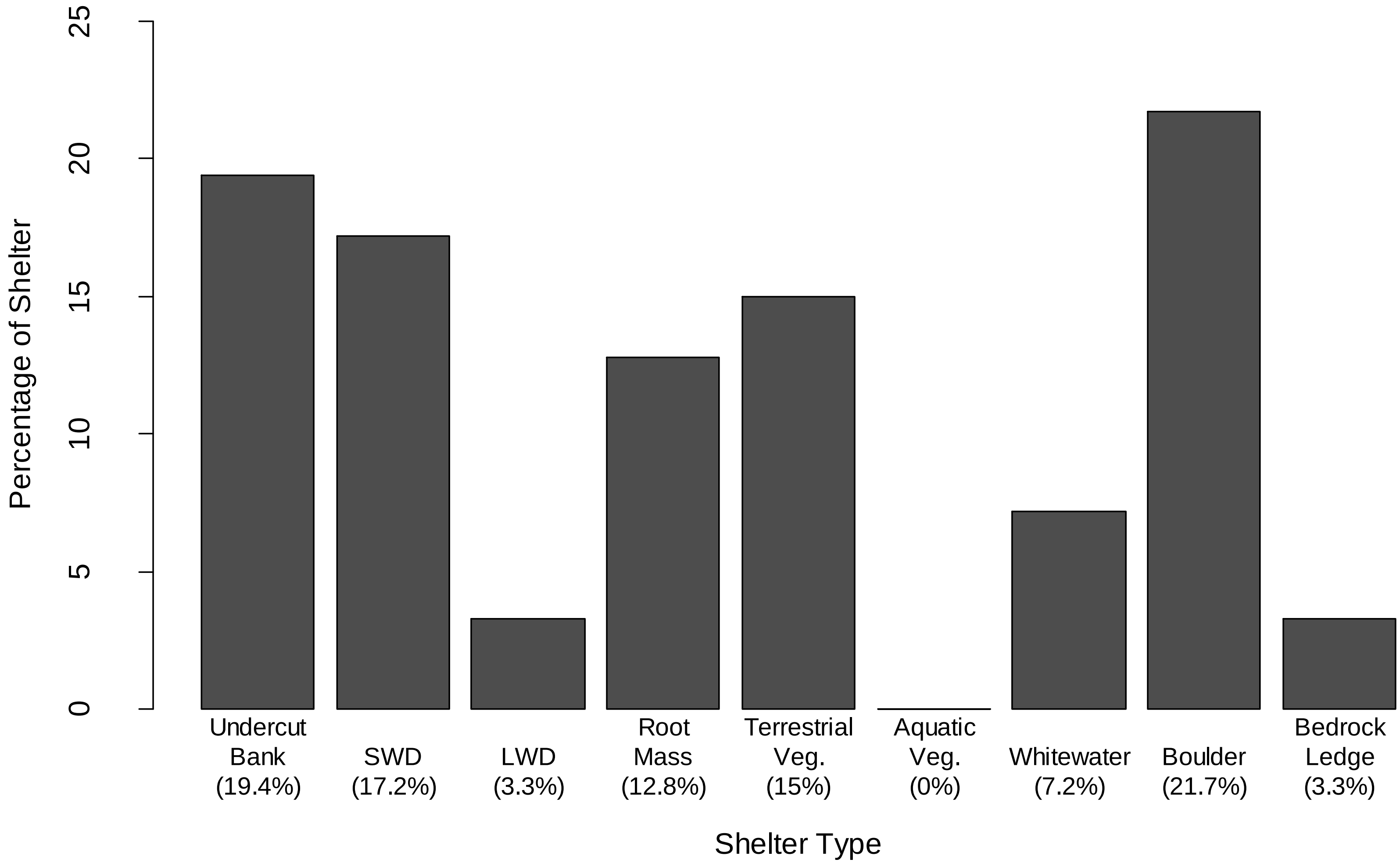
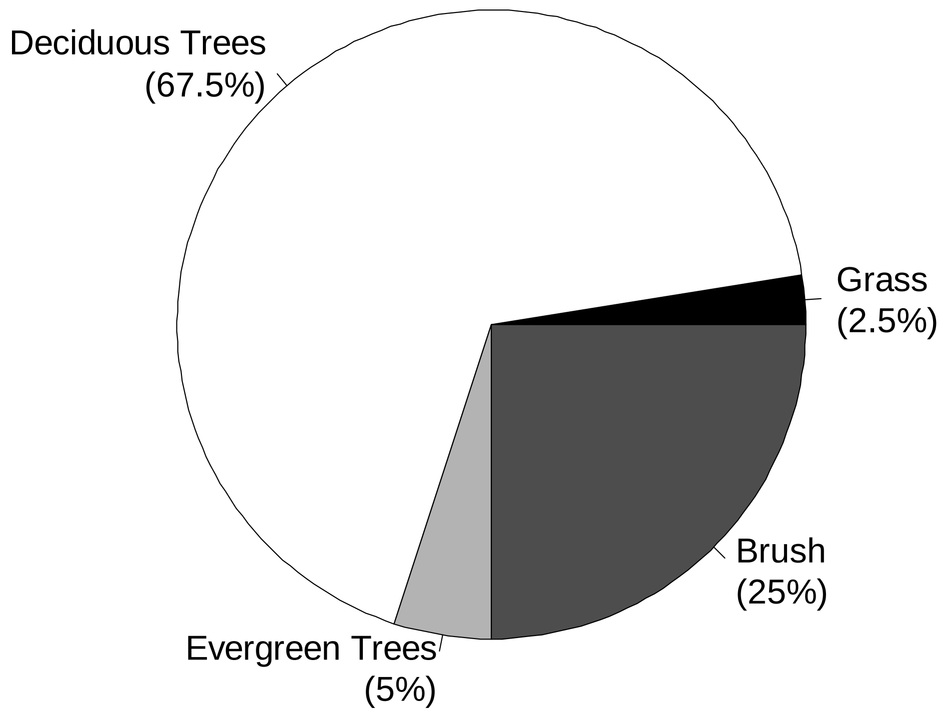


Figure 248. Percentage of banks by dominant vegetation type for Bear Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



Cannon Creek

Habitat Assessment

Results

The habitat inventory was conducted on 13 November 2013 by Ben Lakish, Tom van Meeuwen, Patrick Riperetti from Pacific States Marine Fisheries Commission and Kayti Christianson from the Watershed Stewards Program. The survey extended 433 feet upstream from the survey start (34.51854°N, -119.27105°W). The survey endpoint (34.51494°N, -119.28316°W) was determined as the end of the National Marine Fisheries Service-monitored reach (Figure 249). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 52 to 56°F. Air temperature ranged from 70 to 75°F.

Habitat type

Of the total number of habitat units surveyed (n = 12 units), 8.3% was dry, 25.0% were flatwaters, 33.3% were pools, and 33.3% were riffles. Of the total length of the reach surveyed, 91.8% was dry, 3.1% was composed of flatwaters, 1.7% was composed of pools, and 3.4% was composed of riffles (Figure 250).

We identified four habitat types in Cannon Creek. Based on the frequency of units sampled, high gradient riffles (33.3%), step runs (25.0%), and mid-channel pools (25.0%) were the most common habitat types (Table 65). Based on total stream length, dry (91.8%), high gradient riffles (3.4%), and step runs (3.1%) composed the greatest stream lengths.

Pool Metrics

A total of four pools were identified within the survey reach. Main channel pools were most frequently encountered (75.0% of pool units sampled) and comprised 74.4% of the total length of all pools. Only main channel and scour pools were encountered; no backwater pools were recorded

No pools had residual depths of two feet or greater (Figure 251).

Within pool tail-outs, sand was the most frequently observed dominant substrate (75% of pool units), followed by boulder (25%).

When we examined pool tail-outs for substrate embeddedness, we found that pools had embeddedness values of two (50.0% of pools), three (25.0%), or four (25.0%;

Figure **252**).

Shelter

Within 100% units (n = 4 units), riffle habitat types had a mean shelter rating of 20.0, flatwater habitat types had a mean shelter rating of 60.0, and pools had a mean shelter rating of 40.0.

Of the two pool units in which shelter was assessed, the main channel pool had a shelter rating of 60.0 and the scour pool had a shelter rating of 20.0.

When we examined the mean percentage of shelter by shelter type across all 100% units (n = 4 units), we found that boulders provided the most shelter (57.5% of total shelter; Figure 253). When we examined the percentage of shelter by shelter type within 100% pools only (n = 2 units), we found that boulders were the most dominant cover type (75.0% of total shelter), followed by small woody debris (20.0%; Figure 254).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 81.6%. Canopy was composed entirely of deciduous trees.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were boulder (12.5%), bedrock (25.0%), and silt/sand/clay (62.5%). The mean percentage of vegetation covering the right bank in sampled units was 50.0%, and the mean percentage of vegetation covering the left bank was 55.0%. Deciduous trees were the dominant vegetation type, having been observed in all banks surveyed.

Large Woody Debris

We observed one piece of LWD that was 6 to 20 feet long within 433 feet of wetted stream length. The number of LWD observed was 0.23 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 26.5 feet.

Discussion

Only twelve units were surveyed within Cannon Creek. Of these, only four of these units were pools. Four units were 100% units and were therefore the only units from which data regarding shelter, canopy cover, and bankside metrics were taken. Given the limited data gathered within Cannon Creek, we could not make general conclusions regarding habitat.

Tables

Table 65. Percentage of all units (n = 12) by habitat type in Cannon Creek.

Habitat Type	% of Units
High Gradient Riffle	33.33%
Step Run	25.00%
Mid-Channel Pool	25.00%
Dry	8.33%
Lateral Scour Pool, bedrock-formed	8.33%

Figures

Figure 249. Map of the habitat assessment survey area in Cannon Creek.

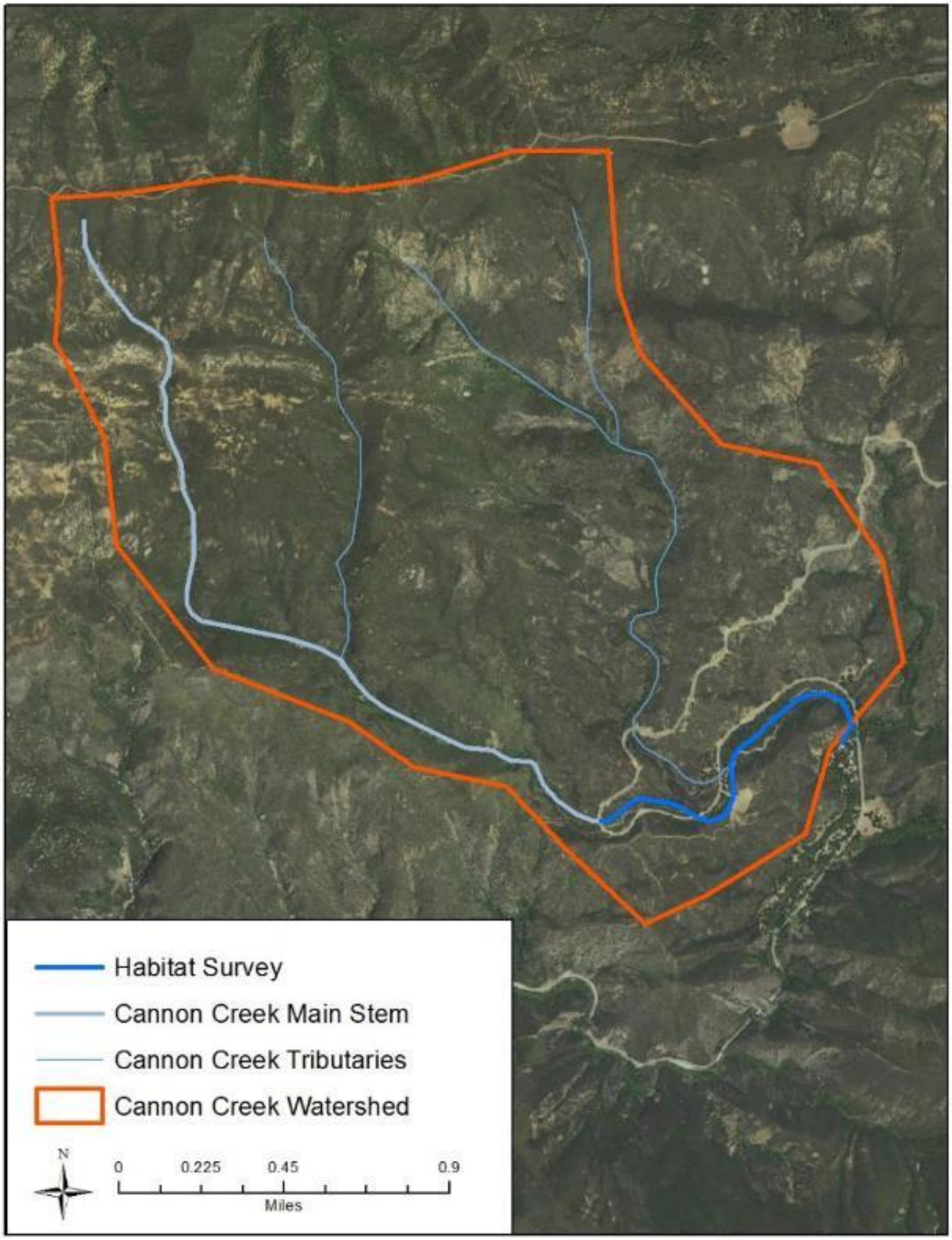


Figure 250. Percentage of the total stream length categorized as dry, pools, flatwaters, or riffles in Cannon Creek.

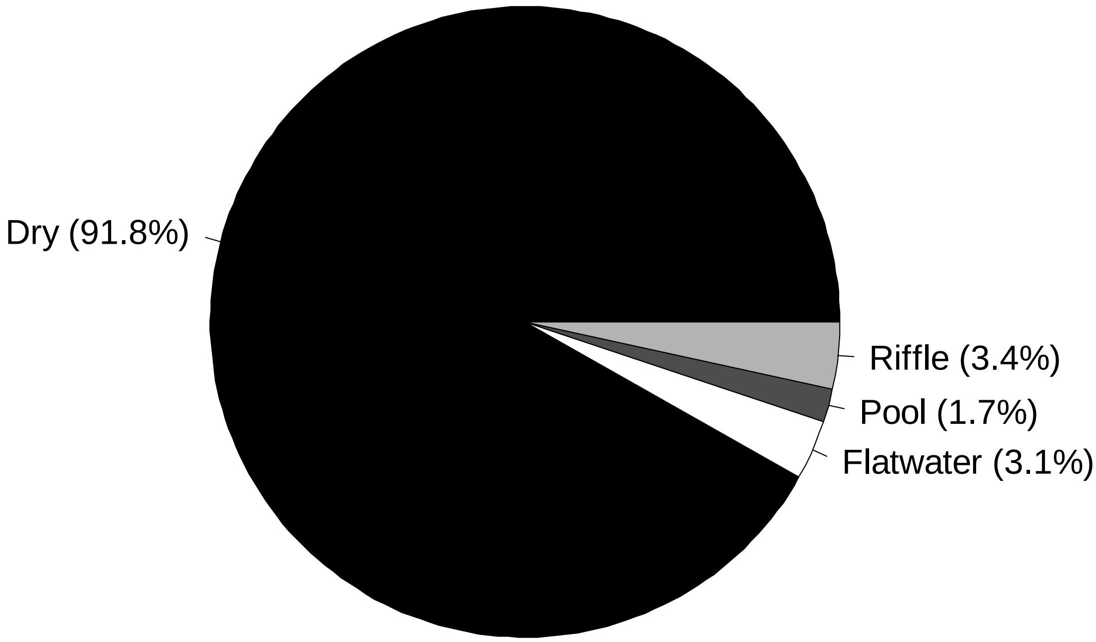


Figure 251. Histogram of residual pool depths in one-foot bins for Cannon Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

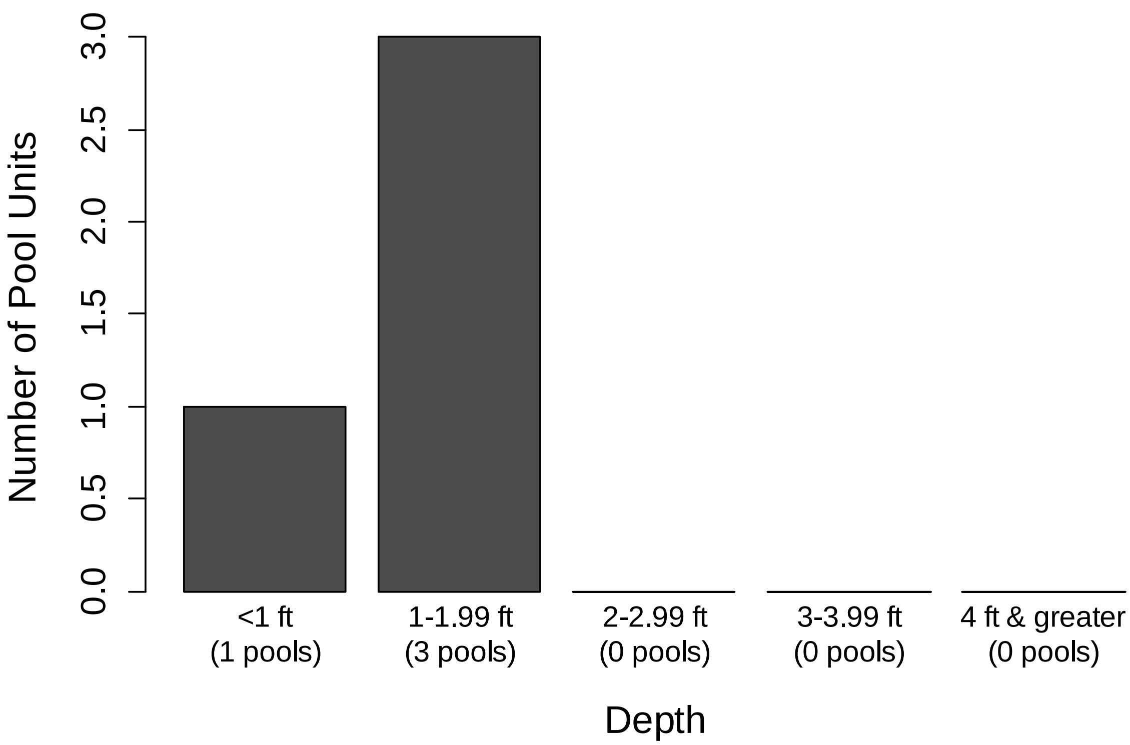


Figure 252. Percentage of all pool units (n = 4 pools) in Cannon Creek assigned a pool tail-out embeddedness value of 1 to 5. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning. In this survey, there were no pool tail-outs with embeddedness values of 1 or 5.

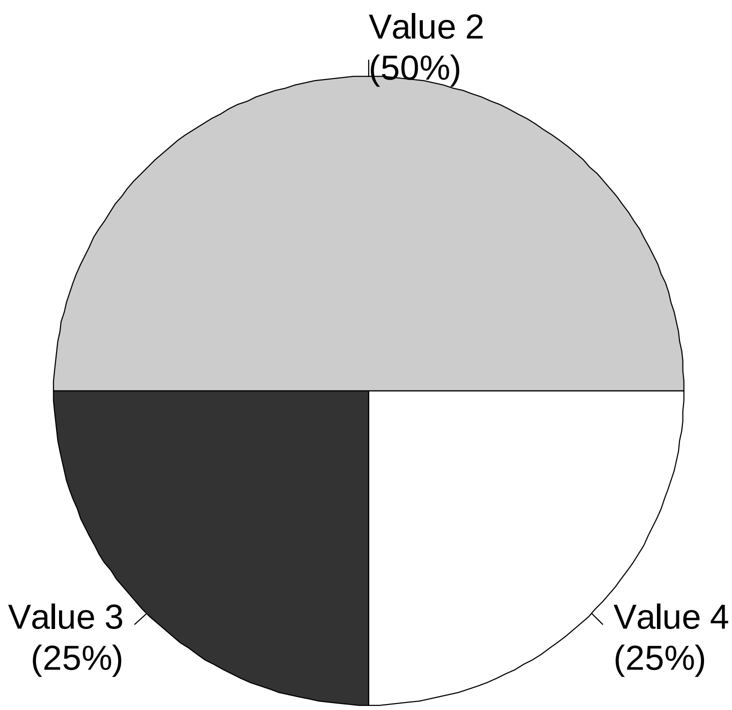


Figure 253. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 4 units) for Cannon Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

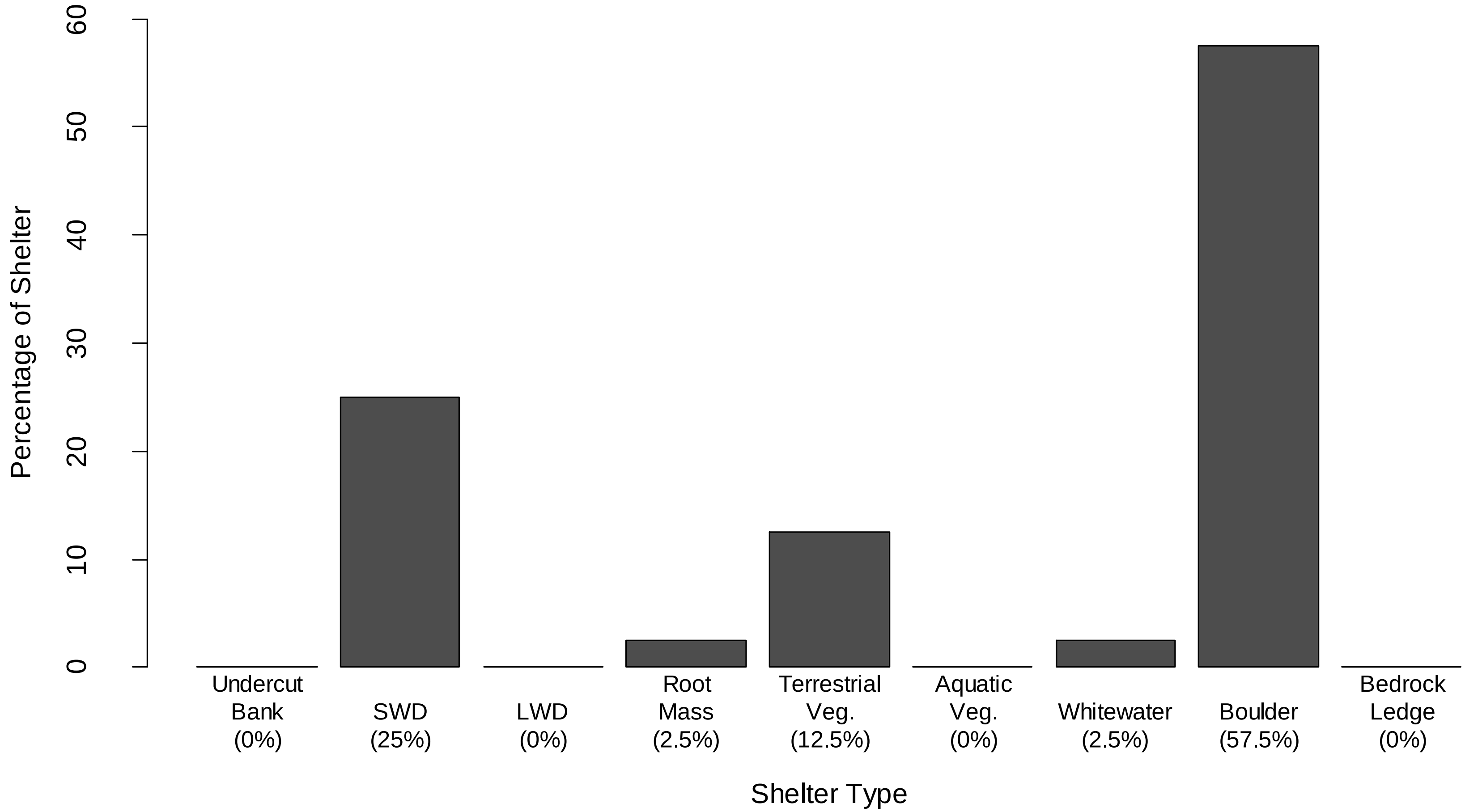
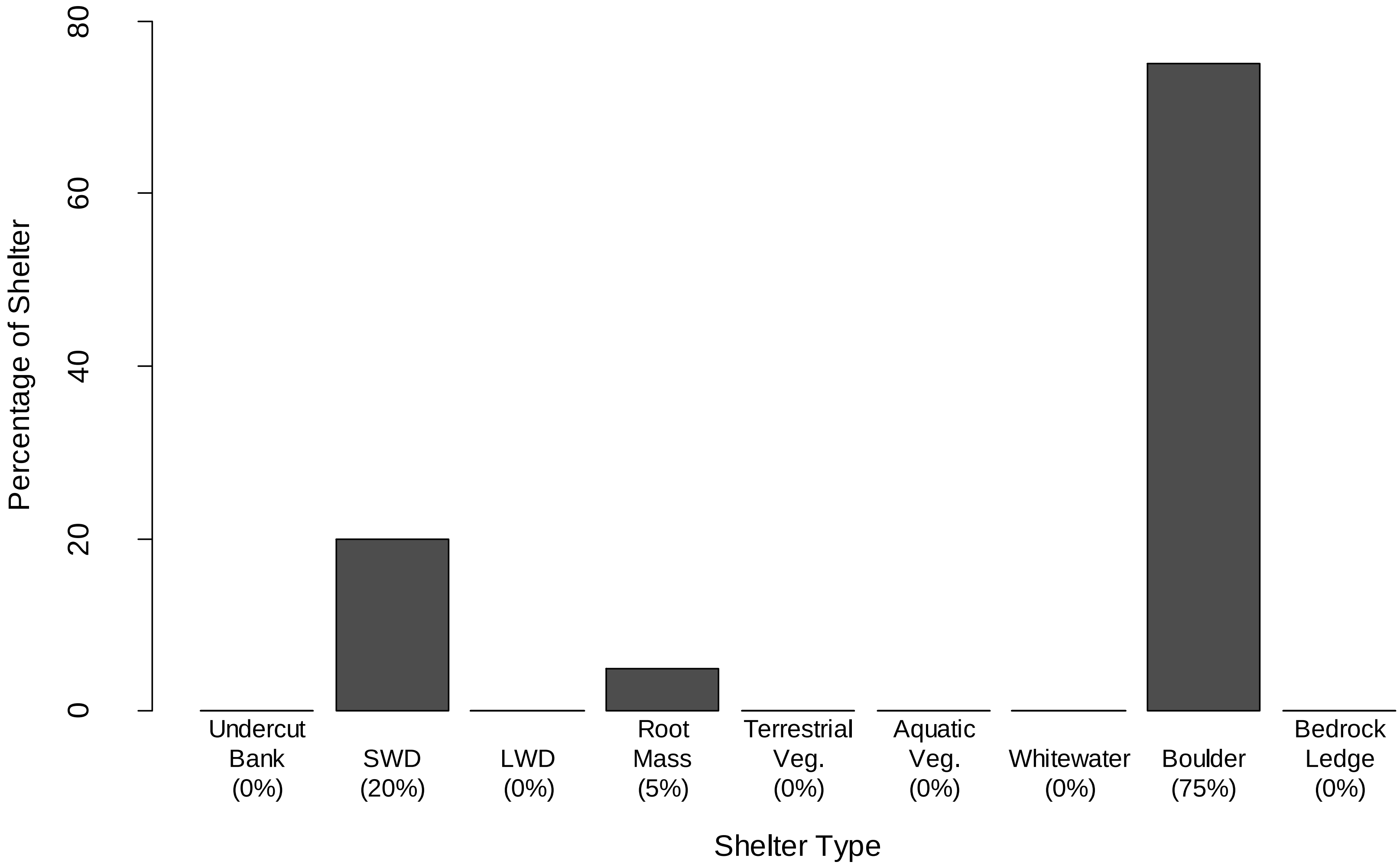


Figure 254. The percentage of shelter by shelter type across all pool units in which shelter was measured (n = 2 pools) for Cannon Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.



Murietta Creek

Habitat Assessment

Results

The habitat inventory was conducted from 16–30 December 2013 by Sam Bankston, Ben Lakish, Kate McLaughlin, Karissa Willits, Patrick Riperetti, and Tom Van Meeuwen from Pacific States Marine Fisheries Commission and David Gottesman and Kayti Christianson from the Watershed Stewards Program. The survey extended 15,522 feet upstream from the survey start (34.50621°N, -119.38252°W). The survey endpoint (34. 48932°N, -119.42517°W) was determined by thick, overgrown vegetation, including poison oak (Figure 255). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 46 to 55°F. Air temperature ranged from 54 to 66°F.

Habitat type

Of the total number of habitat units surveyed (n = 99 units), 18.2% of units were dry, 14.1% were flatwaters, 38.4% were pools, and 28.3% were riffles. Of the total length of the reach surveyed, 79.4% was dry, 5.9% was composed of flatwaters, 7.5% was composed of pools, and 7.2% was composed of riffles (Figure 256).

We identified 11 habitat types in Murietta Creek. Mid-channel pools (30.3%), dry (18.1%), and low gradient riffles (17.2%) were the most frequently recorded habitat types (Table 2). Dry (79.4%) and mid-channel pools (4.8%) composed the greatest stream lengths.

Pool Metrics

A total of 38 pools were identified within the survey reach. Main channel pools were most frequently encountered (94.7% of pool units sampled; Figure 257) and comprised 96.2% of the total length of all pools.

Four of 38 pools (10.5%) had residual depths of three feet or greater (Figure 258).

Within pool tail-outs, gravel was the most frequently observed dominant substrate (27.0% of pool units), followed by boulders (24.3%) and large cobble (21.6%; Figure 259).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (48.6%) or two (24.3%; Figure 260).

Shelter

Within 100% units (n = 24 units), riffle habitat types had a mean shelter rating of 73.3, flatwater habitat types had a mean shelter rating of 57.5, and pools had a mean shelter rating of 46.4.

Of the pool units in which shelter was assessed (n = 14 units*)*, main channel pools had a mean shelter rating of 44.2. There was only one scour pool and one backwater pool, both with shelter ratings of 60.0.

When we examined the mean percentage of shelter by shelter type across all units, we found that boulders provided the most shelter 61.5% of all shelter; Figure 261). When we examined the percentage of shelter by shelter type within pools only, we found that boulders were the most dominant cover type (58.9% of the total shelter), followed by small woody debris (18.2%; Figure 262).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 94.9%. Within the canopy cover present, 95.0% of the canopy was composed of deciduous trees and 5.0% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were predominantly boulder (48.0%) and sand/silt/clay (40.0%; Figure 263). The mean percentage of vegetation covering the right bank in sampled units was 53.8%, and the mean percentage of vegetation covering the left bank was 55.8%. Deciduous trees were the dominant vegetation type, having been observed in 58.0% of the banks surveyed (Figure 264).

Large Woody Debris

No large woody debris was observed in Murietta Creek during this habitat inventory.

Bankfull

The mean bankfull width across the reach sampled was 31.5 feet.

Discussion

Temperature

The water temperature of units measured ranged from 46 to 55°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach, we found that most units were pools, riffles, or dry. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools, dry units, and low-gradient riffles. When we examined the reach in terms of length, we found that most of the reach was dry (79.4%). Mid-channel pools comprised the greatest percentage of wetted stream length.

Pool Metrics

Pool depth is an important indicator of habitat quality, as deeper pools can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in Murietta, we found that only 10.5% of pools had residual depths of three feet or greater. A residual depth of at least three feet is needed to be considered good habitat (Kier Associates & NMFS 2008). Thus, it appears that pools in Murietta may lack the depth needed to provide good hiding cover and rearing space. This may be due in part to seasonal wettedness changes compounded by drought effects.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was gravel (27.0%), boulders (24.3%), and large cobble (21.6%). Additionally, pool tail-outs most frequently had an embeddedness value of either a five or two (48.6% and 24.3%, respectively). Together, these metrics suggest that, although there is spawning habitat available, it may be limited.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that riffles had higher shelter ratings than pools and flatwaters, and that flatwaters had only slightly higher shelter ratings than pools. This suggests that riffle units provide better shelter than pools and flatwaters in Murietta, although this was not statistically tested.

When examining pool habitat units specifically, we found that main channel pools had a lower mean shelter rating than either backwater or scour pools. However, there was only one backwater pool and one scour pool in which shelter was assessed, compared to 12 main channel pools. Thus, these shelter ratings are not comparable between pool types.

When we examined the percentage of shelter by shelter type, we found the boulders provided the most shelter across all units and when examining pools specifically (61.5% of total shelter across all units and 58.9% of total shelter within pools). This suggests that boulders are a common and important feature to *O. mykiss* habitat in Murietta.

Canopy

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In Murietta Creek, we estimated a mean canopy cover of 94.9%, consisting predominantly of deciduous trees (95.0%). This suggests that Murietta has a very high amount of cover (Kier Associates & NMFS 2008), although this cover is likely to vary greatly through time, given the seasonality of deciduous trees. However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was boulder, followed by sand/silt/clay. The mean percentage of vegetation cover for the right and left banks was 53.8% and 55.8%, respectively. Deciduous trees were the most common dominant vegetation observed. Together, these bankside metrics suggest that these banks may be relatively vulnerable to erosion during high flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. We found no large woody debris in Murietta Creek. However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Murietta lacks LWD, it has boulder elements that improve habitat quality.

Tables

Table 66. Percentage of all units (n = 99) by habitat type in Murietta Creek.

Habitat Type	% of Units
Mid-Channel Pool	30.30%
Dry	18.18%
Low Gradient Riffle	17.17%
High Gradient Riffle	11.11%
Run	8.08%
Step Run	6.06%
Step Pool	5.05%
Cascade	1.01%
Channel Confluence Pool	1.01%
Lateral Scour Pool, bedrock-formed	1.01%
Dammed Pool	1.01%

Figures

Figure 255. Map of the habitat assessment survey area in Murietta Creek.

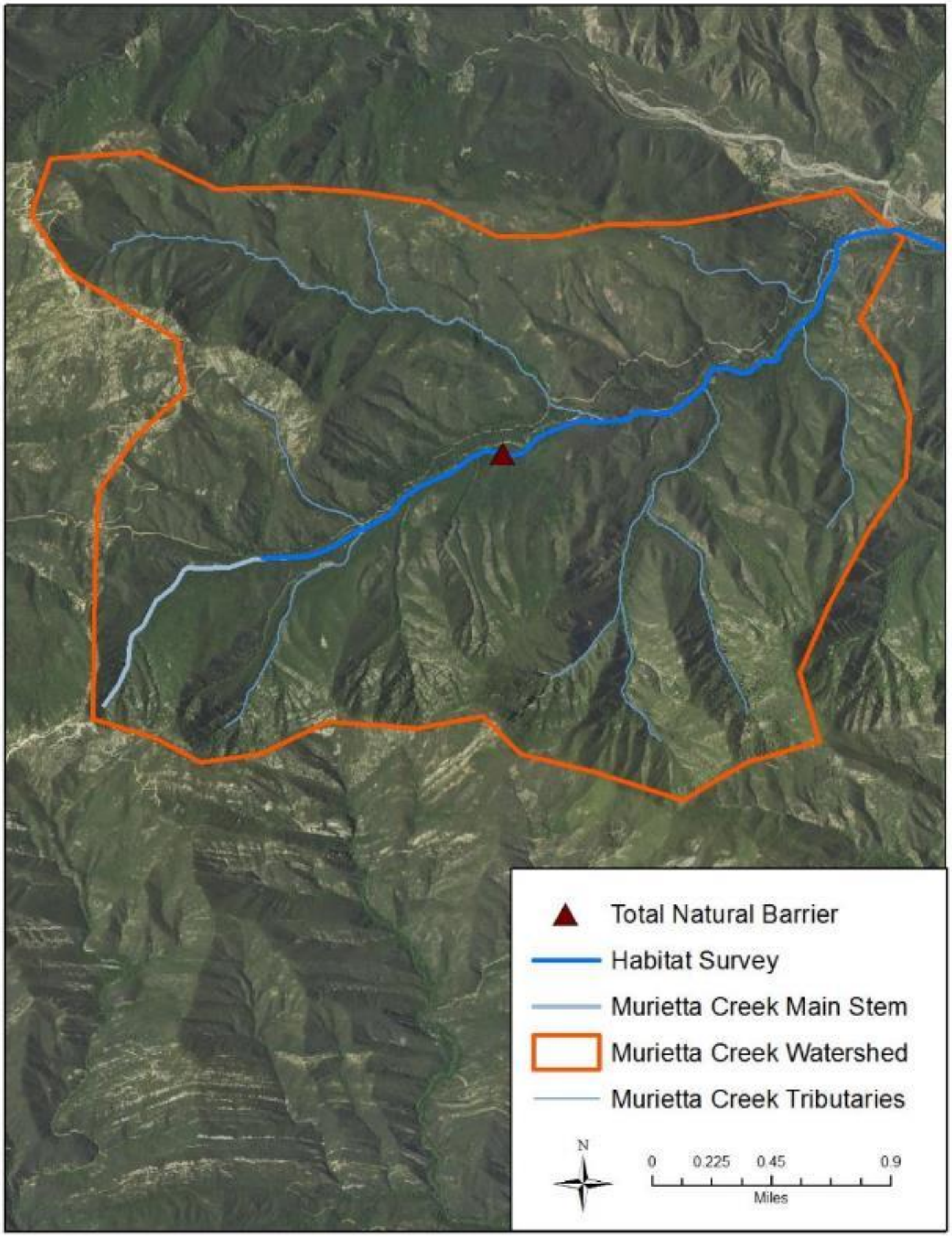


Figure 256. Percentage of total stream length categorized as pools, flatwaters, riffles, or dry in Murietta Creek.

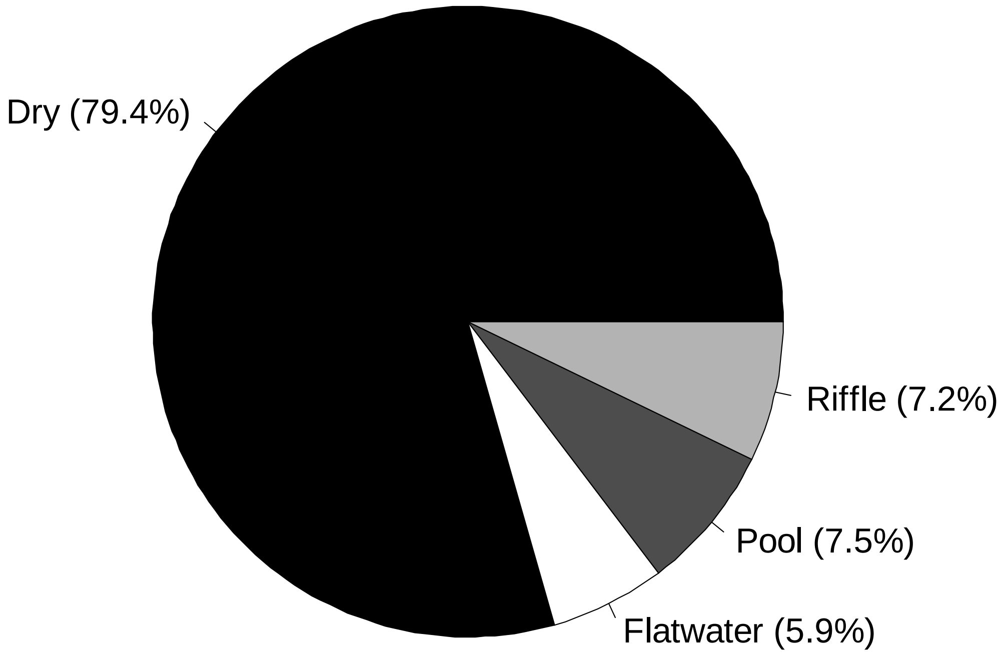


Figure 257. Percentage of all pool units (n = 38 pools) categorized by pool type (main channel, backwater, or scour pool) for Murietta Creek.

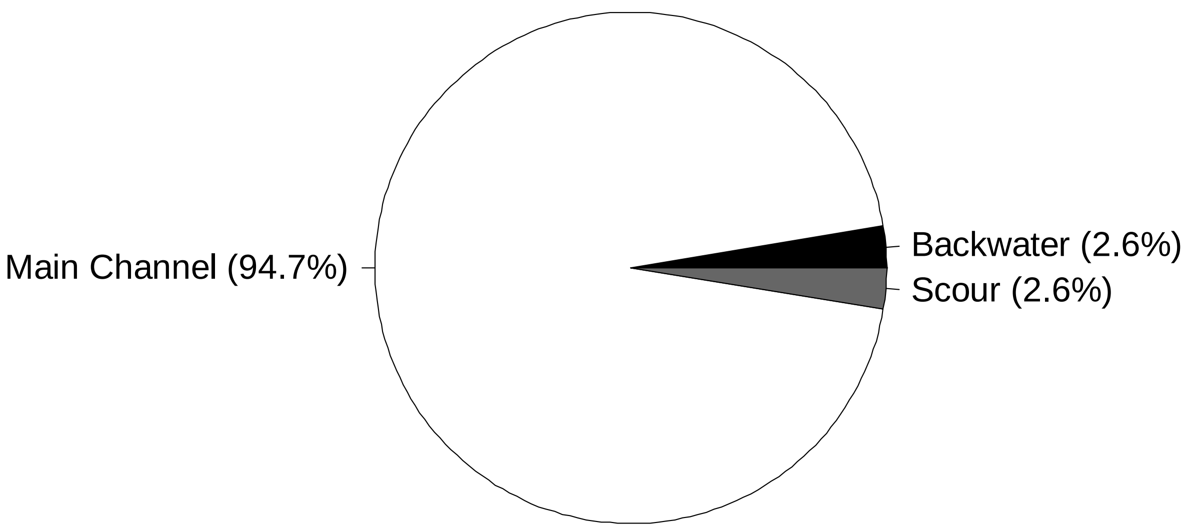
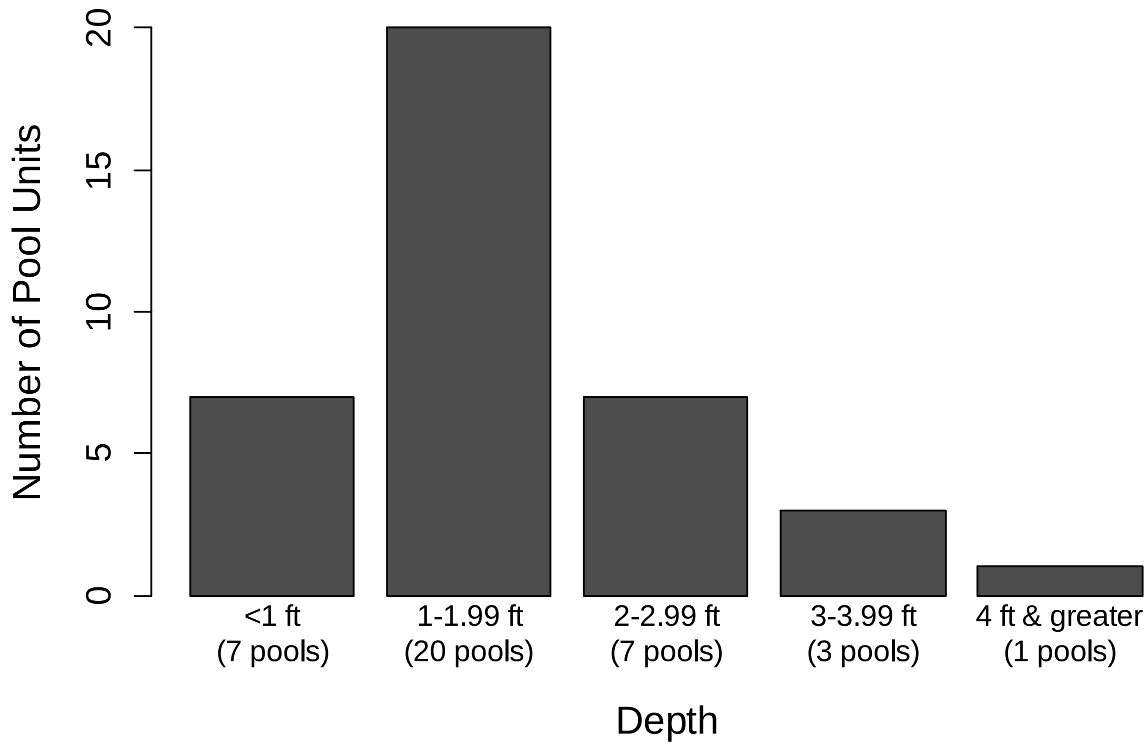


Figure 258. Histogram of residual pool depths in one-foot bins for Murietta Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.



Number of Pool Units
0
5
10
15
20
<1 ft
(7 pools)
1-1.99 ft
(20 pools)
2-2.99 ft
(7 pools)
3-3.99 ft
(3 pools)
4 ft & greater
(1 pools)
Depth

Figure 259. Percentage of pool tail-outs (n = 38 pools) by dominant substrate for Murietta Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

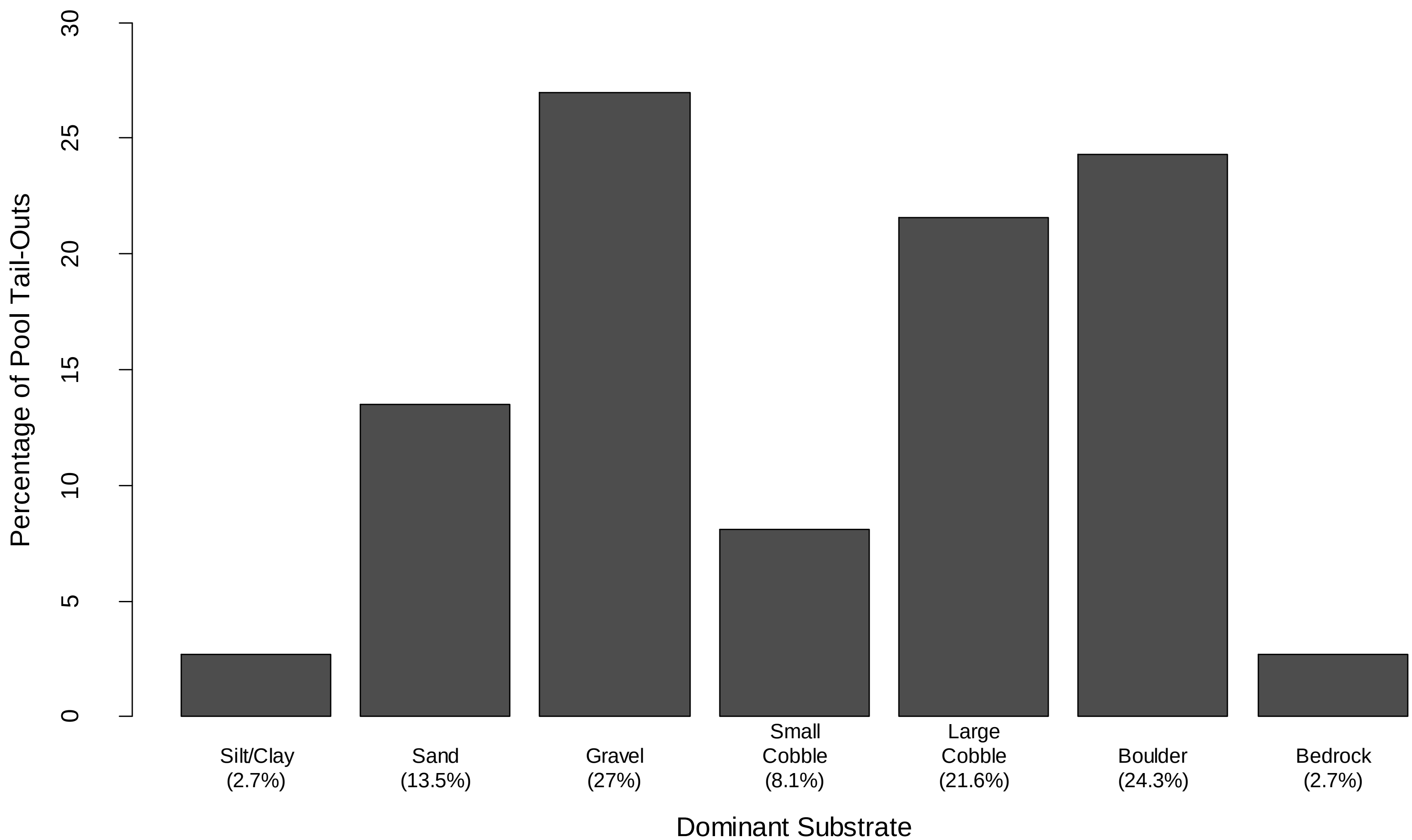


Figure 260. Percentage of all pool units (n = 38 pools) assigned a pool tail-out embeddedness value of 1 to 5 for Murietta Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning. In this survey, there were no pool tail-outs with an embeddedness value of 4.

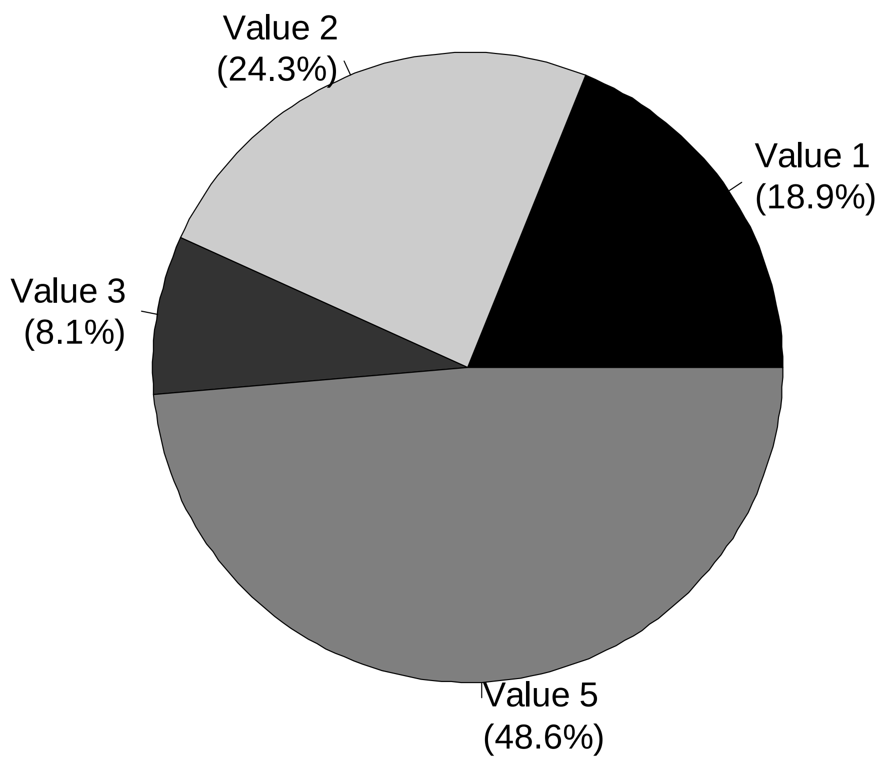


Figure 261. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 24 units) for Murietta Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

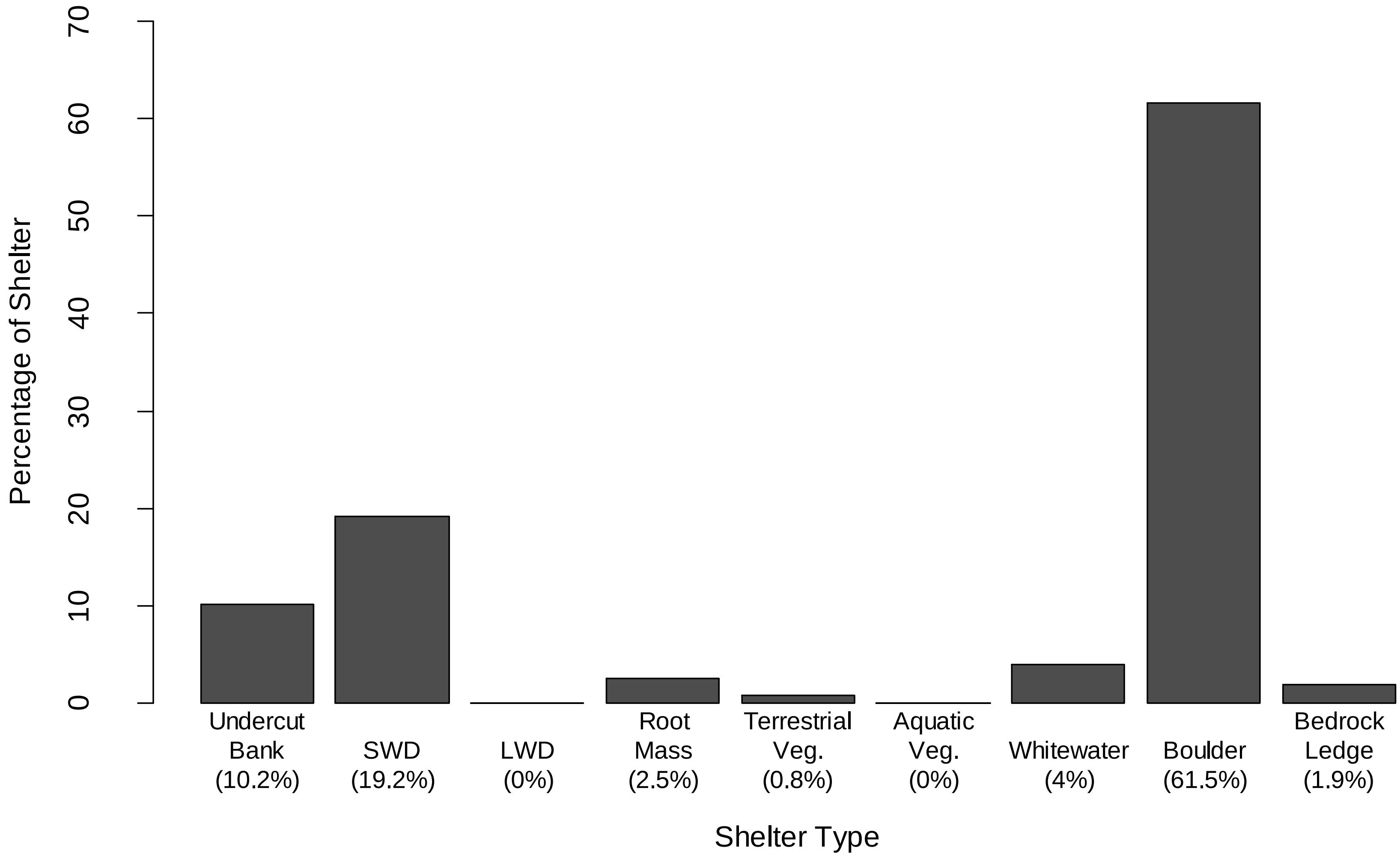


Figure 262. The percentage of instream shelter by shelter type across all pool units in which shelter was measured (n = 14 pools) for Murietta Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

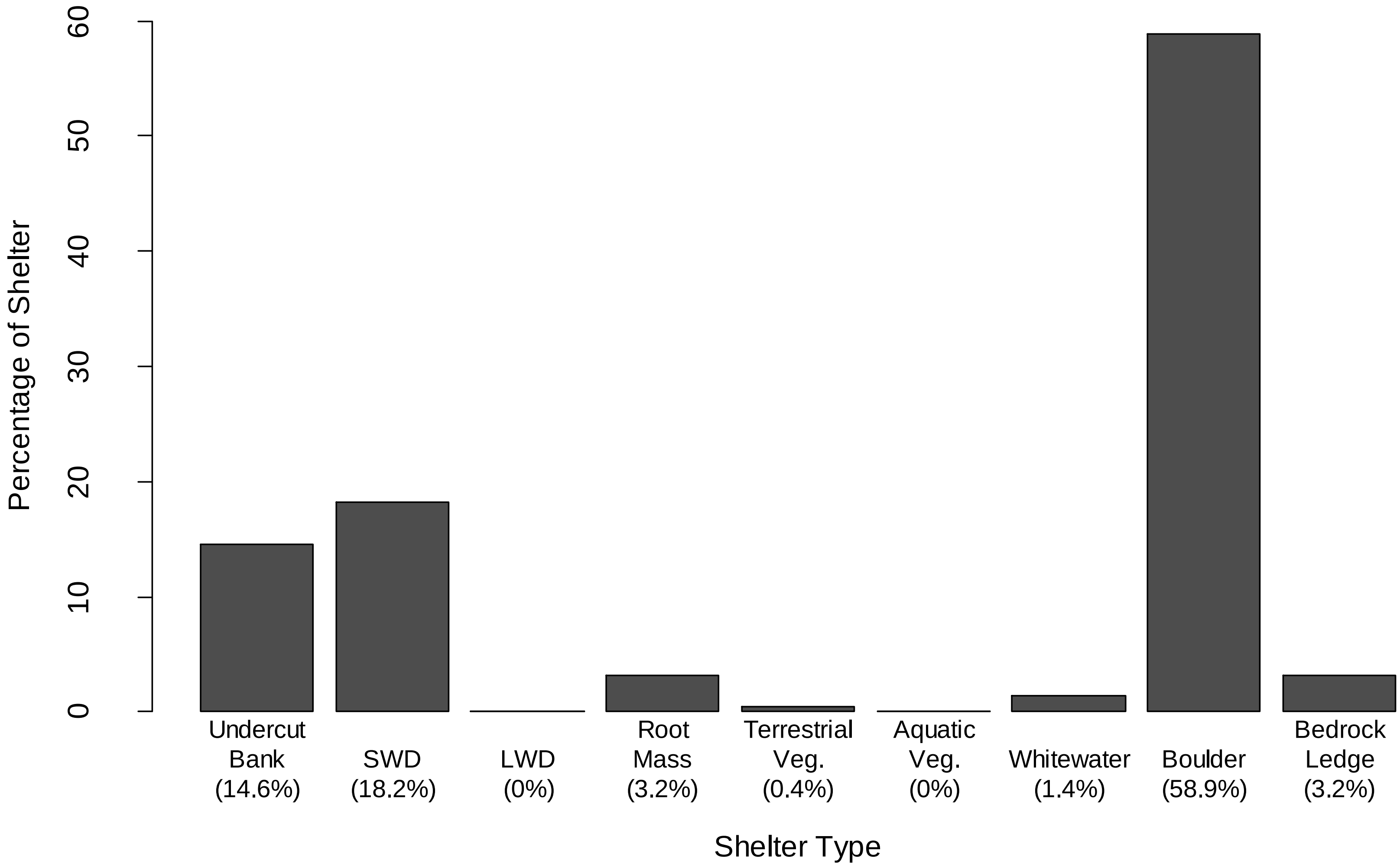


Figure 263. Percentage of banks by dominant substrate composition for Murietta Creek. Substrate types include sand/silt/clay, cobble/gravel, boulder, and bedrock.

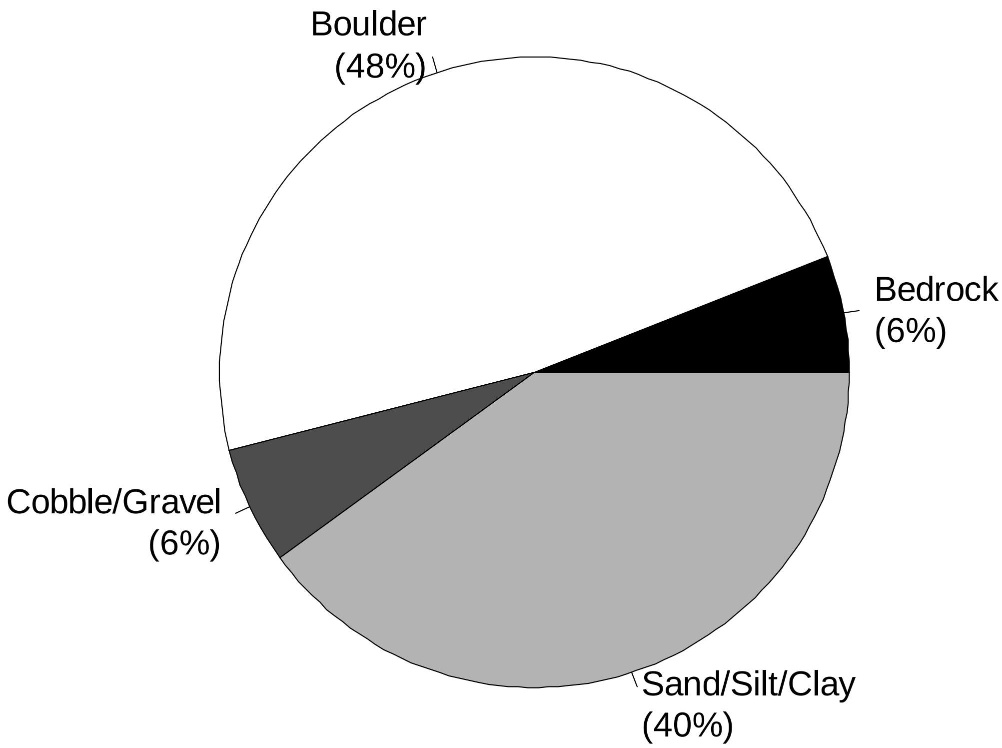
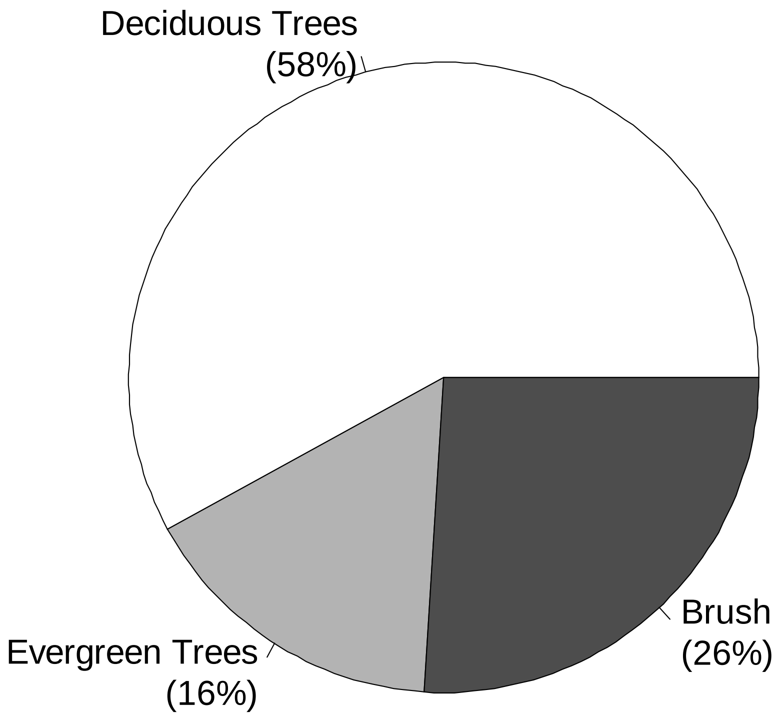


Figure 264. Percentage of banks by dominant vegetation type for Murietta Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush. In this survey, grass was not recorded as a dominant bank vegetation type.



Murietta Creek Tributary

Habitat Assessment

<u>Results</u>

The habitat inventory was conducted from 23 December 2013 to 8 January 2014 by Ben Lakish, Karissa Willits, and Kate McLaughlin from Pacific States Marine Fisheries Commission and David Gottesman from the Watershed Stewards Program. The survey extended 3,815.7 feet upstream from the survey start (34.49863°N, -119.39639°W). The survey endpoint (34.49196°N, -119.39961°W) was a waterfall deemed impassable to fish (Figure 265. Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 42 to 48°F. Air temperature ranged from 45 to 54°F.

Habitat type

Of the total number of habitat units surveyed (n = 97 units), 44.3% were pools, 25.8% were flatwaters, 25.8% were riffles, and 4.1% of units were dry. Of the total length of the reach surveyed, 37.9% was composed of flatwaters, 30.6% was composed of riffles, 26.7% was composed of pools, and 4.8% was dry (Figure 266).

We identified nine habitat types in Murietta Creek Tributary. Based on the frequency of units sampled, mid-channel pools (37.1%), high gradient riffles (19.6%), and step runs (17.5%) were the most common habitat types (Table 67). Based on total stream length, step runs (31.4%), high gradient riffles (26.5%), and mid-channel pools (19.0%) were the most common habitat types.

Pool Metrics

A total of 43 pools were identified within the survey reach. Main channel pools were most frequently encountered (95% of pool units sampled) and comprised 97% of the total length of all pools. Only main channel and scour pools were encountered; no backwater pools were recorded.

One of 43 pools (2.3%) had a residual depth of three feet or greater (Figure 267).

Within pool tail-outs, boulders were the most frequently observed dominant substrate (32.6% of pool units), followed by gravel (20.9%) and small cobble (20.9%; Figure 268).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (51.2%), one (20.9%), or two (18.6%; Figure 269).

Shelter

Within 100% units (n = 28 units), riffle habitat types had a mean shelter rating of 111.1, flatwater habitat types had a mean shelter rating of 93.6, and pools had a mean shelter rating of 66.3.

Of the pool units in which shelter was assessed, main channel pools had a mean shelter rating of 70.0 and scour pools had a mean shelter rating of 55.0. There were no backwater pools observed in the Murietta Tributary.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that boulders provided the most shelter (49.8% of all shelter; Figure 270). When we examined the percentage of shelter by shelter type within pools only (n = 44 units), we found that boulders were the most dominant cover type (57.5% of the total cover), followed by small woody debris (20.0%; Figure 271).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 96.0%. Within the canopy cover present, 85.2% of the canopy was composed of deciduous trees and 14.8% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were boulder (57.1%) and silt/sand/clay (32.1%; Figure 272). The mean percentage of vegetation covering the right bank in sampled units was 47.9%, and the mean percentage of vegetation covering the left bank was 46.1%. Evergreen trees were the most dominant vegetation type, having been observed in 39.3% of the banks surveyed. Additionally, 32.1% of banks had deciduous trees and 28.6% had brush (Figure 273).

Large Woody Debris

We observed 12 pieces of LWD that were 6 to 20 feet long and eight pieces that were greater than 20 feet long within 3632.7 feet of wetted stream length. Across both LWD sizes, the number of LWD observed was 0.55 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 41.4 feet.

Discussion

Temperature

The water temperature of units measured ranged from 42 to 48°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that the numbers of units under each of these categories were fairly even. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools, high gradient riffles, or step runs. When we examined the reach in terms of length, these three habitat types still dominated.

Pool Metrics

Pool depth is an important indicator of habitat quality, as deeper pools can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in Murietta tributary, we found that most pools had residual depths of 1–1.99 feet. One pool had a residual depth of at least three feet, which is needed to be considered good habitat (Kier Associates & NMFS 2008). Thus, it appears that the majority of pools in the Murietta Creek tributary may lack the depth needed to provide good hiding cover and rearing space.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was boulder, comprising 32.6% of pool units. Additionally, 20.9% of pool tails were dominated by gravel and 20.9% were dominated by small cobble. Pool units most frequently had an embeddedness value of either a five, one, or two. These results indicate a moderate availability of spawning habitat in Murietta Tributary pool tails.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that riffles and flatwaters had significantly higher shelter ratings than pools. This suggests that flatwater and riffle units provide better shelter than pools in Murietta Tributary. However, it is important to note that these shelter ratings were highly influenced by the estimated percent of shelter covering the unit; most shelters were assigned a cover complexity value of two and therefore did not contribute greatly to the variation in shelter rating.

When we examined the percentage shelter by shelter type across all 100% units, we found the boulders provided the most shelter (49.8% of all shelter), suggesting that boulders are a common and important feature to *O. mykiss* habitat in Murietta Tributary.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In Murietta Creek Tributary, we estimated a mean canopy cover of 96%, consisting predominantly of deciduous trees. This suggests that Murietta Tributary has a moderately high amount of canopy cover (Kier Associates & NMFS 2008). However, this cover is likely to vary greatly through time, given the seasonality of deciduous trees. More permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was boulder, followed by sand/silt/clay. The mean percentage of vegetation cover for the right and left banks was 48% and 46%, respectively. Evergreen trees were the most dominant vegetation type observed. Together these bankside metrics suggest that these banks may be moderately protected from erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In the Murietta Creek Tributary, we found 0.55 pieces of LWD per 100 feet, which was low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Murietta Tributary lacks LWD, it has boulder elements that improve habitat quality. Specifically, boulders provided the greatest amount of shelter across all units in which shelter was assessed (49.8% of all shelter).

Tables

Table 67. Percentage of all units (n = 97) by habitat type for Murietta Creek Tributary.

Habitat Type	% of Units
Mid-Channel Pool	37.11%
High Gradient Riffle	19.59%
Step Run	17.53%
Run	8.25%
Low Gradient Riffle	6.19%
Channel Confluence Pool	4.12%
Dry	4.12%
Lateral Scour Pool, root wad enhanced	2.06%
Step Pool	1.03%

Figures

Figure 265. Map of the habitat assessment survey area in Murietta Creek Tributary.

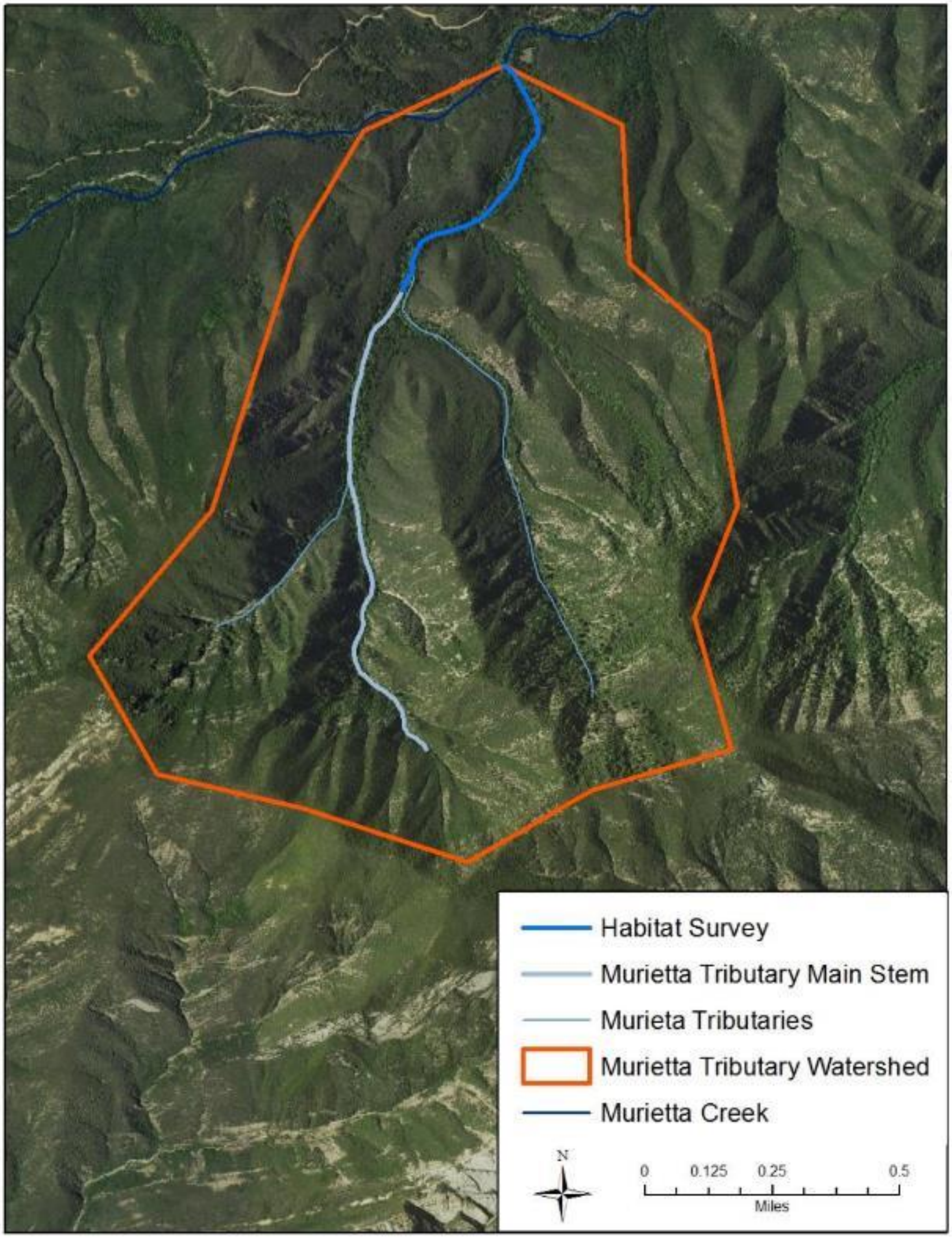


Figure 266. Percentage of total stream length categorized as pools, flatwaters, riffles, or dry for Murietta Creek Tributary.

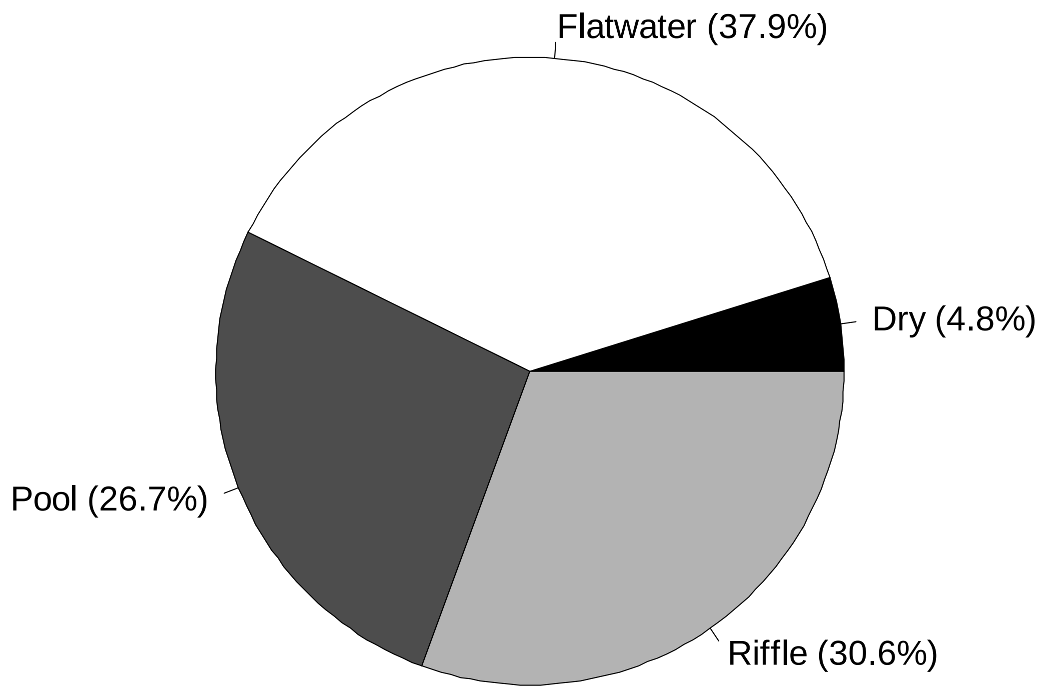


Figure 267. Histogram of residual pool depths in one-foot bins for Murietta Creek Tributary. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

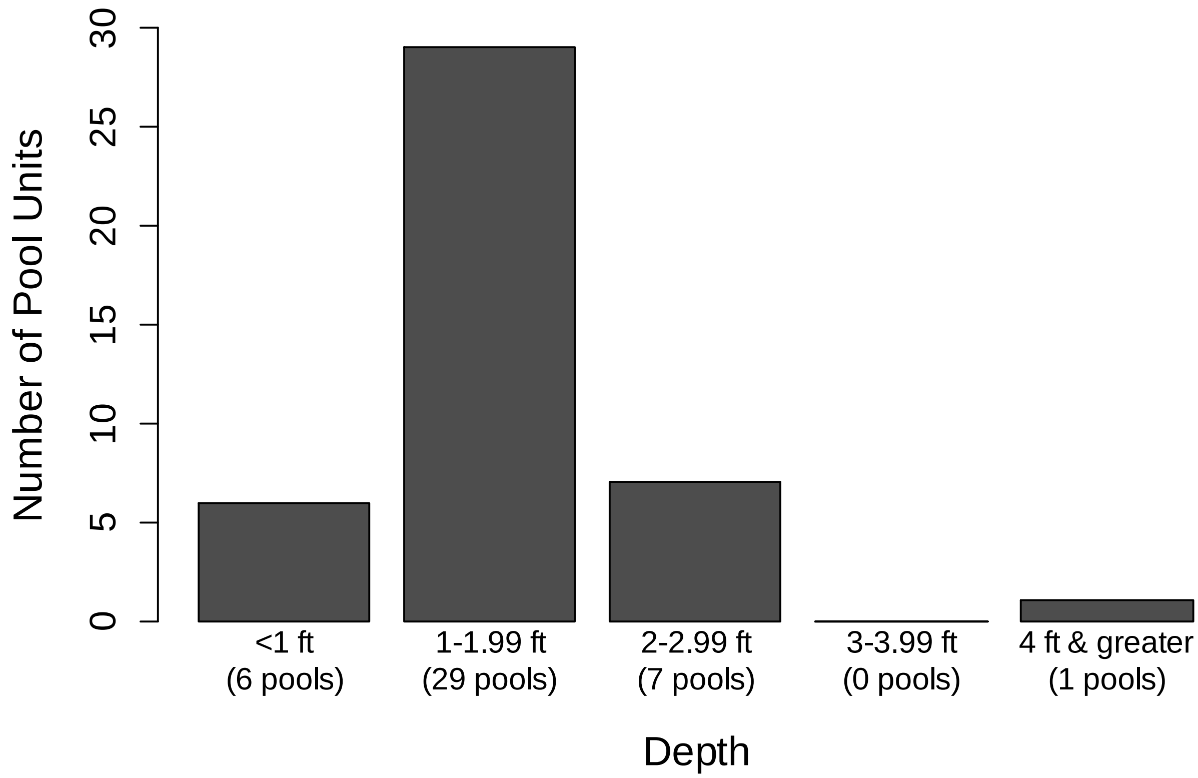


Figure 268. Percentage of pool tail-outs (n = 43 pools) by dominant substrate for Murietta Creek Tributary. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

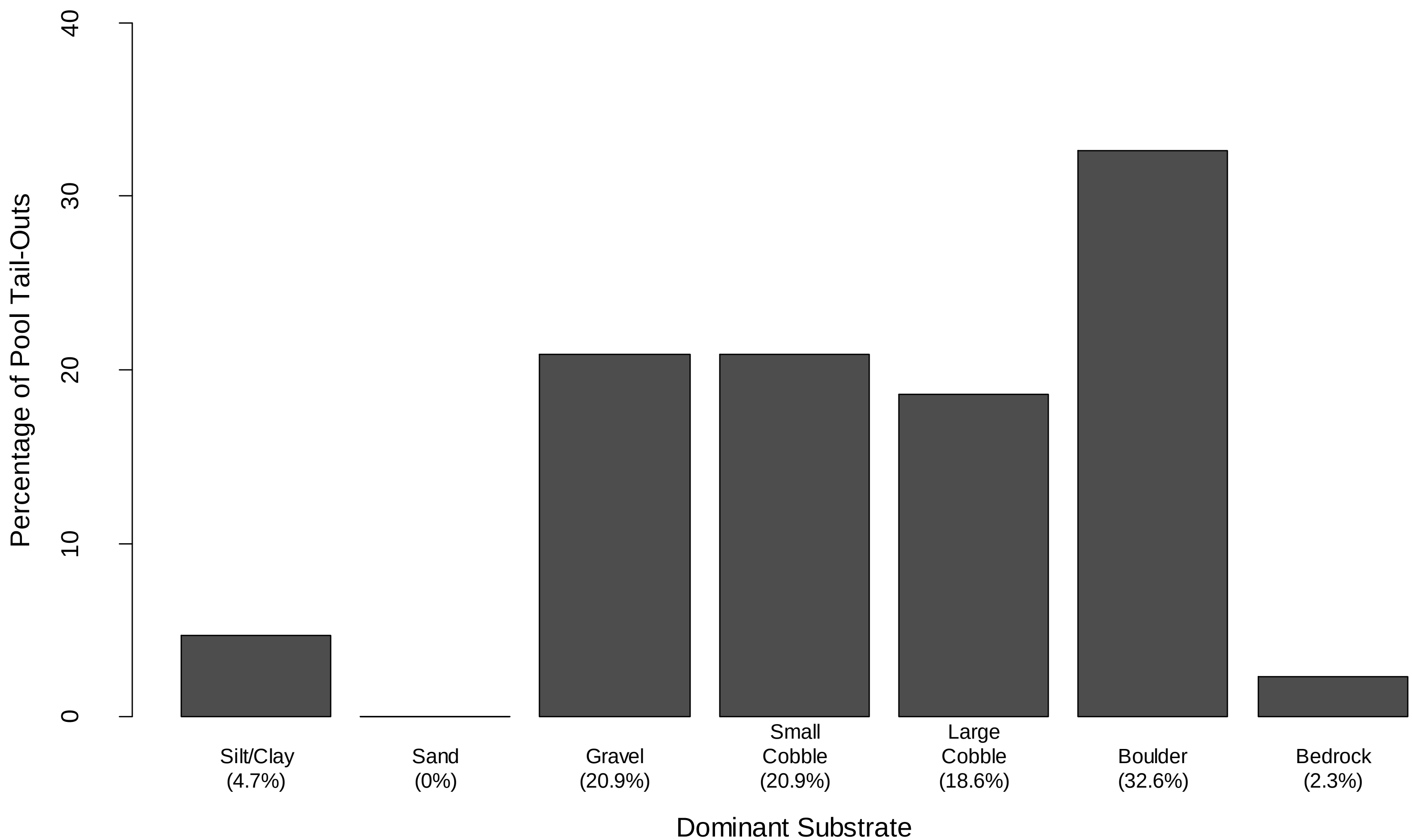


Figure 269. Percentage of all pool units (n = 43 pools) assigned a pool tail-out embeddedness value of 1 to 5 for Murietta Creek Tributary. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning.

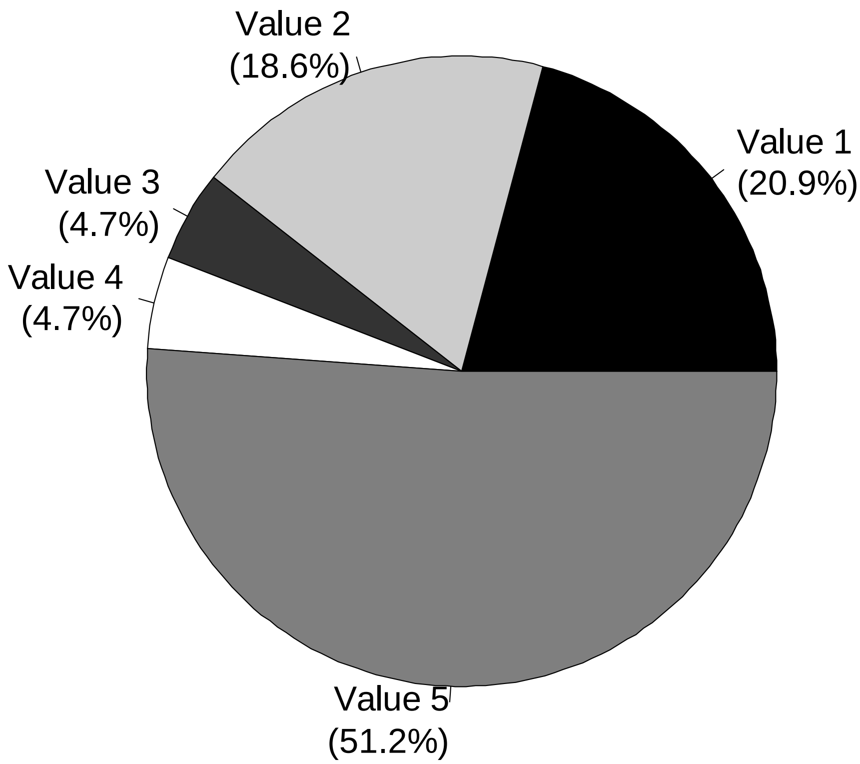


Figure 270. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 28 units) for Murietta Creek Tributary. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

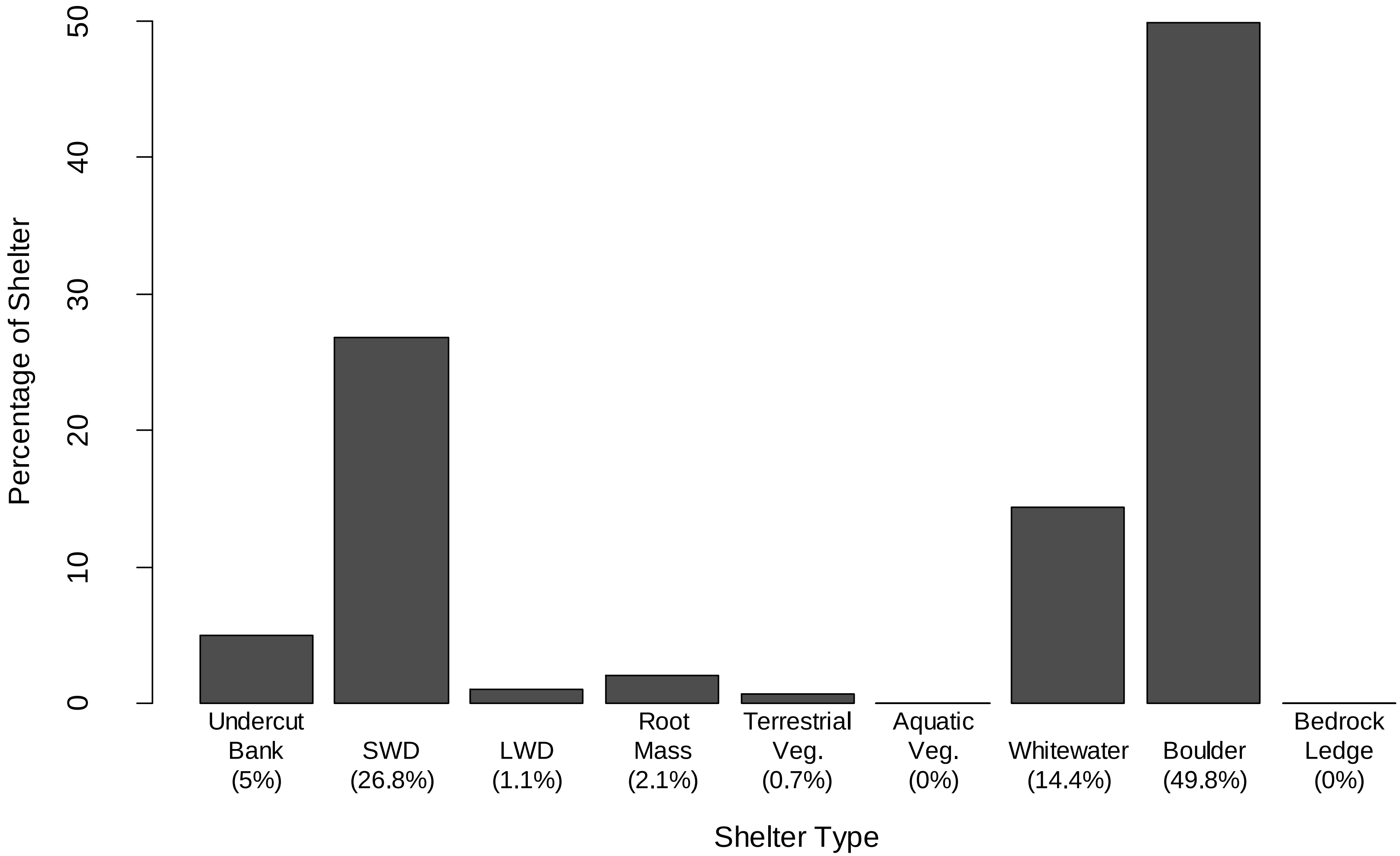


Figure 271. The percentage of instream shelter by shelter type across all pool units in which shelter was measured (n = 8 pools) for Murietta Creek Tributary. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

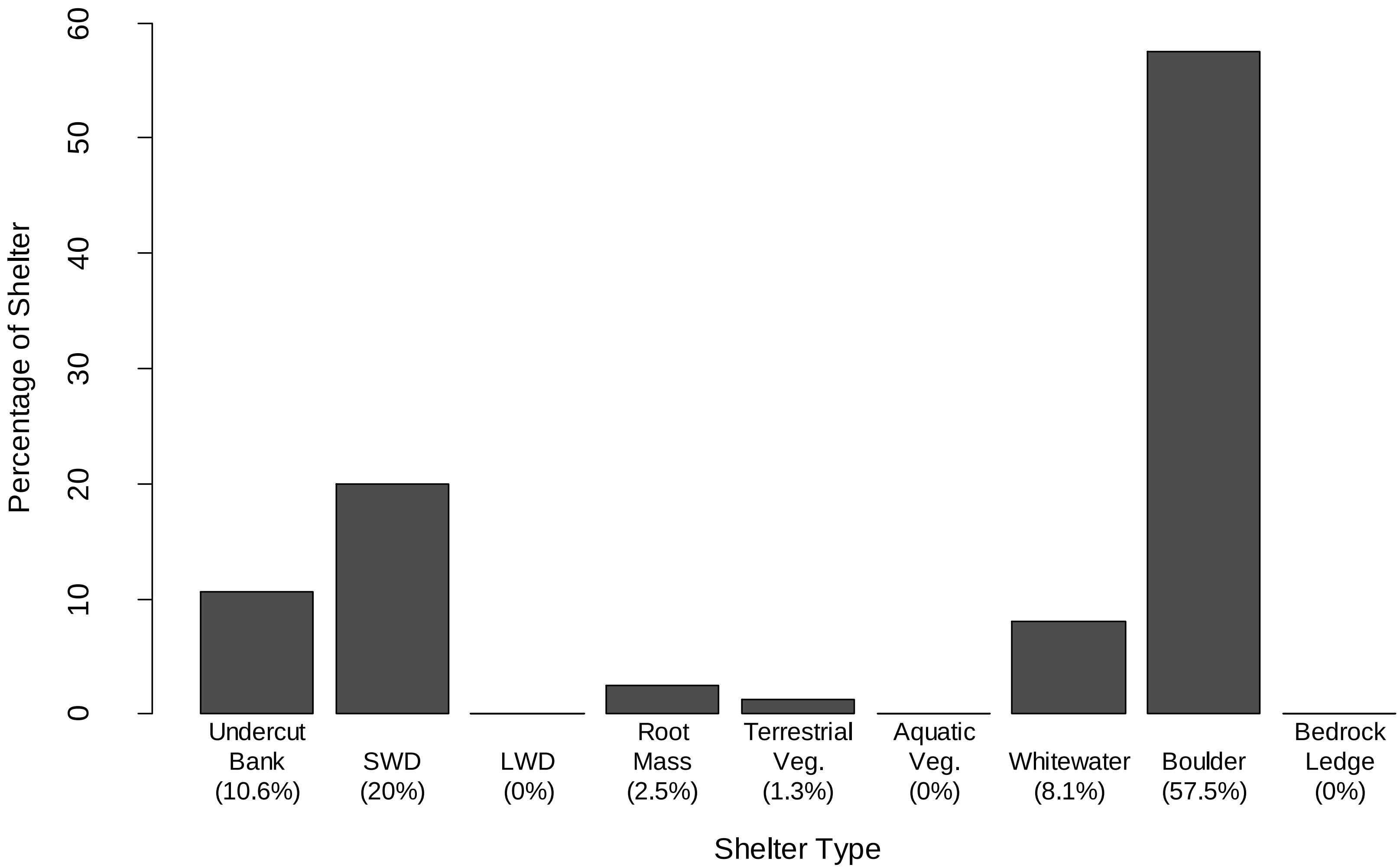


Figure 272. Percentage of banks by dominant substrate composition for Murietta Creek Tributary. Substrate types include sand/silt/clay, cobble/gravel, boulder, and bedrock.

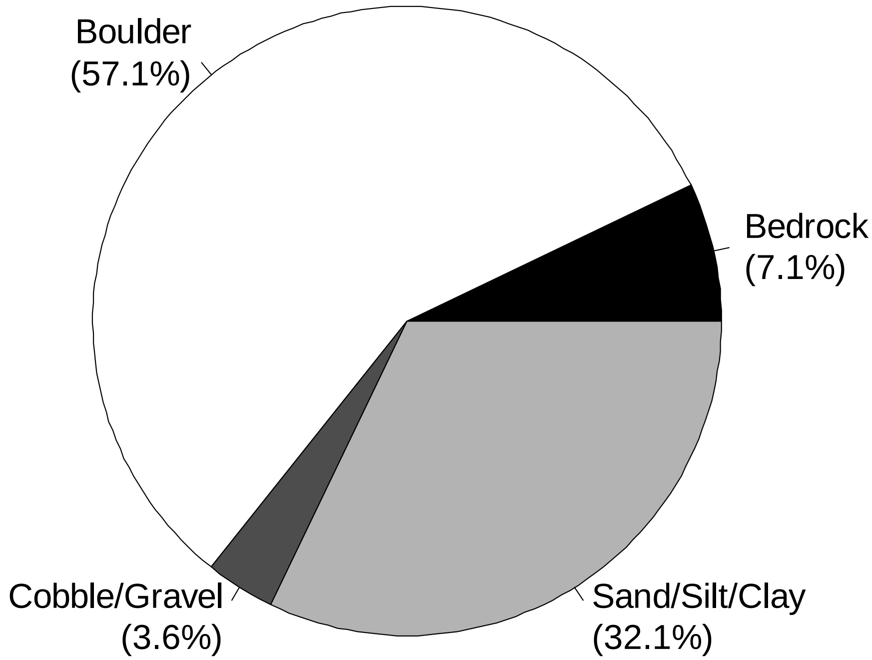
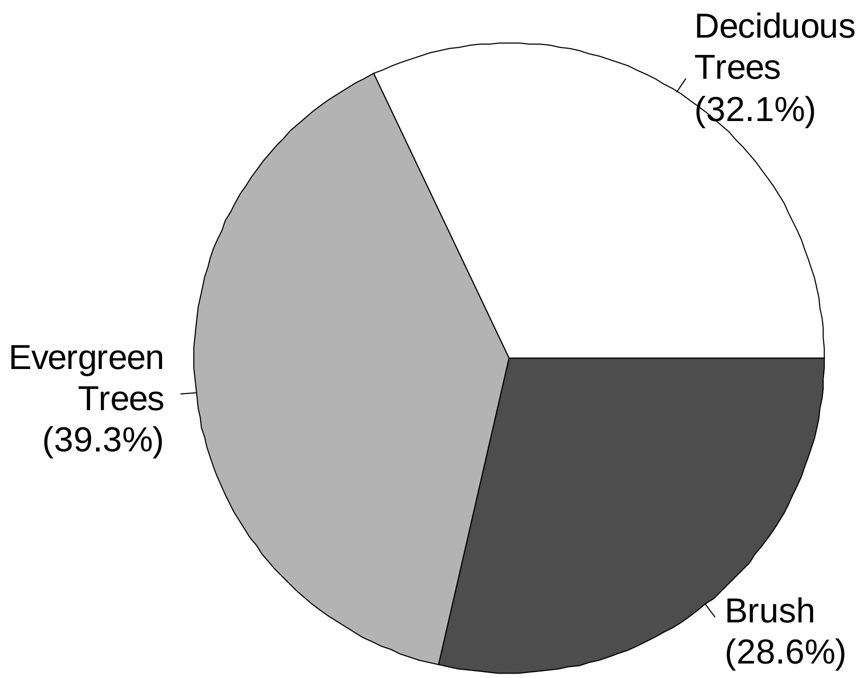


Figure 273. Percentage of banks by dominant vegetation types for Murietta Creek Tributary. Vegetation types included deciduous trees, evergreen trees, grass, and brush. In this survey, grass was not recorded as a dominant bank vegetation type.



Upper Matilija

Snorkel Survey (2014)

<u>Results</u>

Between August 14, 2014 and October 27, 2014, a snorkel survey was conducted on a stretch of Upper Matilija Creek. The survey reach began approximately 2.25 miles upstream of Matilija Lake (34.50157 ^{o}N, -119.34663 ^{o}W) and extended 5.7 miles (30,096 ft.) ending at a pool (34.54057^{o}N, -119.40614^{o}W) just below a total natural barrier to fish passage. The purpose of this survey was to gain an understanding of the abundance and distribution of southern California steelhead (*O. mykiss*).

In the 5.7 mile surveyed stretch, a total of 184 *O. mykiss* were observed in 39 of 128 pools sampled in varying size classes as indicated in Table 68 and Figure 274. The total length of all snorkeled units was 3,765.2 feet within the 5.7 mile (30,096 ft.) reach. Figure 275 shows the distribution of *O. mykiss* over the surveyed reach.

The average number of *O. mykiss* per unit length calculates to be 4.887 x 10^{-2} fish/ft. This was calculated by taking total of observed fish and dividing by the sum of all the lengths of snorkeled units. The average number of *O. mykiss* per unit area calculates to be 3.013 x 10^{-3} fish/ft^2. This was calculated by taking the total number of fish observations and dividing by sum of all the individual surface areas for each snorkeled unit. We have also summarized *O. mykiss* counts for shelter values in Figure 276. We also plotted *O. mykiss* observations with respect to total surface area of each habitat unit and this is shown in Figure 277. Additionally we plotted the number of *O. mykiss* observations with respect to the length of each habitat unit and this is shown in Figure 278.

Black Spot Disease was present within the survey reach, but was confined to a limited number of pools. Black Spot disease refers to the infestation of multiple genera of digenic trematodes on freshwater fish. Life cycles of trematodes are complex and can house a variety of hosts. Out of the 39 pools where trout were seen, 23 pools contained fish with Black Spot Disease. These fish have raised black spots on their skin due to the presence of a parasitic trematode. Little is known about the effects of this parasite on the livelihood of fish.

Discussion

Size class distributions of *O. mykiss* observed show the majority of observed fish were within the 2-3.99" (n=113) size class while overall distributions ranged from 0-1.99 in to 12-13.99 in. We suspect that since this spawning season had concluded by our August snorkel surveys, that most of the observed fish were from the 2014 year's recruitment class.

The map of the surveyed section of Upper Matilija Creek in Figure 275 indicates the distribution of the observed *O. mykiss*. The larger circles indicate a greater number of fish observations within 10 surveyed units. The smaller circles indicate a lesser number of fish observations in a single unit. There are no clear differences seen between different sections of the creek. The only observation that can be made is that distribution is throughout the entire reach and not confined to any particular areas. . We do not have individual observations on the map as the only consistent GPS points recorded were the start points on each page of data sheet. Individual pool GPS points were taken on the upper stretches of the survey as crews adapted their protocol to better capture location information. This pool location information was collected as reference points should a fish rescue be warranted.

Figure 277 and Figure 278 show the number of *O. mykiss* observed versus the surface area and length of the pools they were found in. There was no distinct correlation between *O. mykiss* observations and the surface area and length of the pools they were found in. *O. mykiss* density was then calculated in relation to the total length of the surveyed pools (3,765.2 feet) as well as the combined total surface area of the surveyed pools (61,073 square feet). Again this returned no obvious relationships most likely due to low fish counts. The average number of *O. mykiss* per unit length calculates to be 4.887×10^{-2} fish/ft while the average number of *O. mykiss* per unit area calculates to be 3.013×10^{-3} fish/ft^2. Again, these numbers are relatively insignificant due to the small sample size.

We also choose to look at shelter values which can range on a scale of 0 to 3. A shelter value of 0 means the surveyed unit has no components of shelter (e.g., no undercut, boulders, woody debris, etc.), whereas a value of 3 means the shelter in the surveyed unit has at least three shelter components including large woody debris (LWD). Large woody debris is uncommon in Southern California streams; therefore shelter values of 3 are not as common as shelter values of 2. In Upper Matilija Creek, 93.75 % of the surveyed units had a shelter value of 2, 6.25% of the surveyed units had a shelter value of 1, 0 % had a shelter value of 0, and 0 % of the pools had a shelter value of 3 (Figure 276). Figure 276 is a histogram showing the number of *O. mykiss* observed for each of the shelter values. It is not surprising that most of the fish observations were in pools with a shelter value of 2, since the majority of the surveyed pools had a shelter value of 2. This discrepancy in shelter value distribution may be explained by the importance of large woody debris and complex features in the shelter rating system. LWD is fairly uncommon in Southern California streams. Below average rainfall and water levels may have reduced the availability of complex features.

There were slight deviations from our chosen protocol, as divers initially chose which units were considered snorkelable. Divers had to estimate if the average depth was sufficient prior to the taking of habitat measurement. As a result, a few habitat units were snorkeled that had a mean depth of less than 0.7 feet.

In addition to noting the numbers of *O. mykiss* and other species of special concern, the snorkelers noted any presence of Black Spot Disease. Figure 279 is an image showing a trout with the disease. The presence of Black Spot Disease was noted in 23 habitat units within the survey reach. Black Spot is present in other tributaries within the same watershed and distributed more evenly throughout those reaches. The effect of Black Spot Disease on trout is not known to be fatal. The trematodes live within the water column and select a host, meaning that not all trout within one habitat unit will show signs of the disease and the distribution of the disease can be widespread or localized in any given reach.

Overall, this snorkel summary report shows us a snapshot of what age classes were present and where these *O. mykiss* were distributed on Upper Matilija Creek. We were able to calculate an index of fish densities but without additional survey seasons, no reliable inferences can be made. We can make no reliable estimates of population abundance since we did not conduct electrofished calibration of the snorkel counts. Additional survey seasons must be completed in order to make a comparison of our observations. Subsequent surveys should include electrofishing to we can make accurate population estimates as per Hankin & Reeves 1988.

Tables

Table 68. First pass *O. mykiss* size class distribution, Upper Matilija 2014

***O. mykiss* Size Class (in)**	**Number O. mykiss Observed**
0-1.99	22
2-3.99	113
4-5.99	23
6-7.99	21
8-9.99	33
10-11.99	1
12-13.99	1

Table 69. *O. Mykiss* counts and number of habitat units with respect to shelter values, Upper Matilija 2014

Habitat Unit Shelter Values	***O. Mykiss* Observed per Shelter Value**	**# of Habitat Units with Shelter Value**
0	0	0
1	4	8
2	180	120
3	0	0

Figures

Figure 274. *O. mykiss* Size class distribution, Upper Matilija 2014

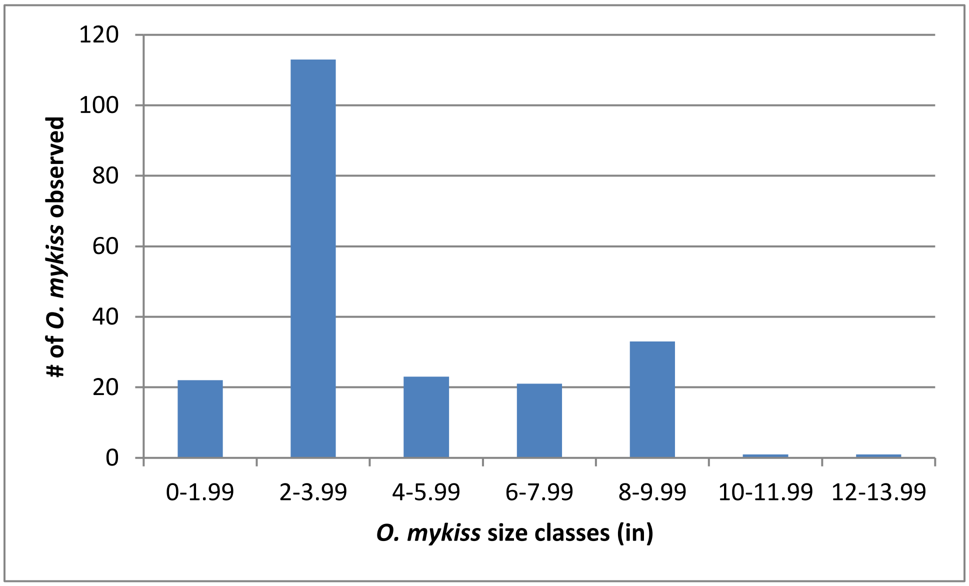


Figure 275. Distribution map of *O. mykiss* observed in the surveyed section of Upper Matilija Creek , 2014

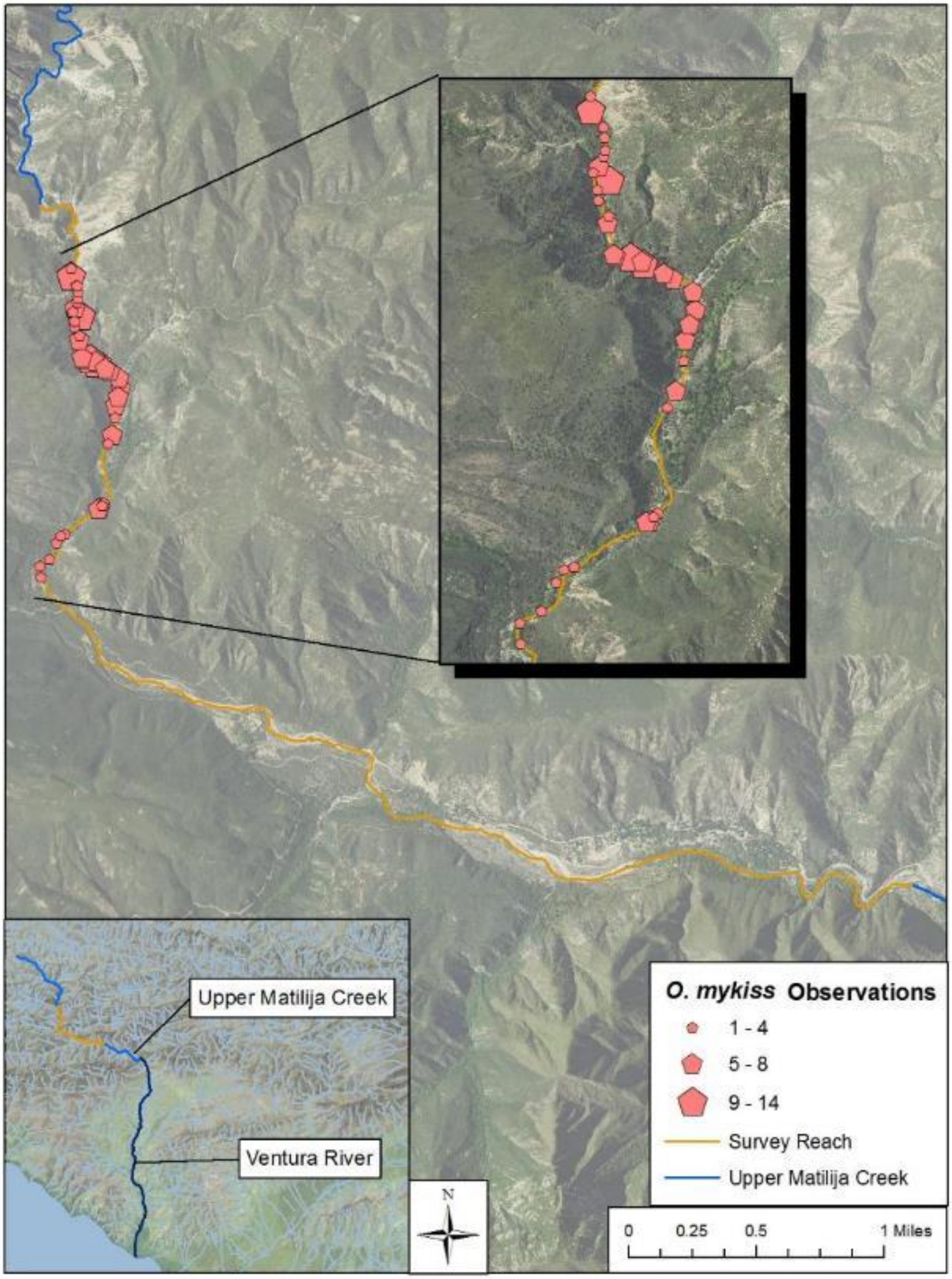


Figure 276. *O. mykiss* observations over shelter value, Upper Matilija 2014

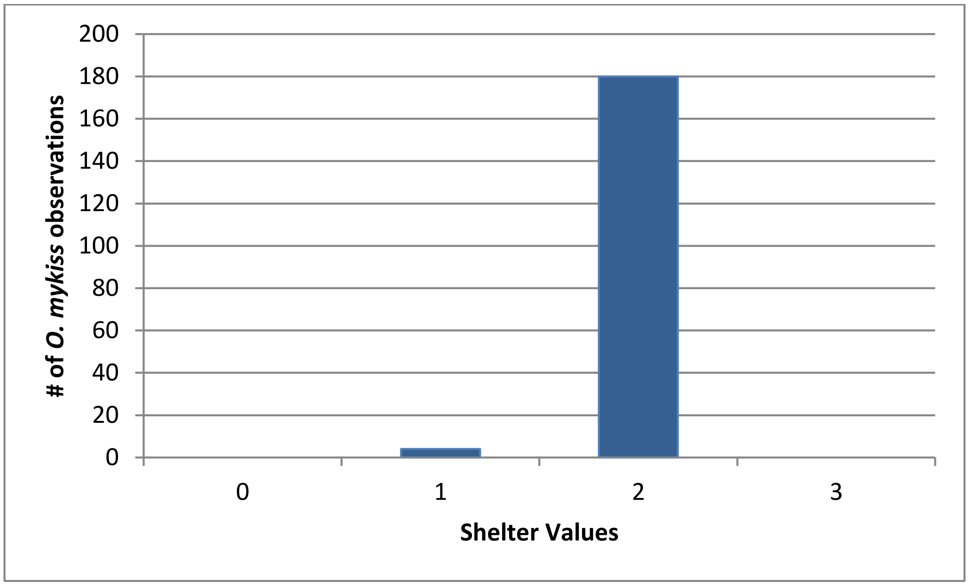


Figure 277. *O. mykiss* observations plotted over habitat unit surface area, Upper Matilija 2014

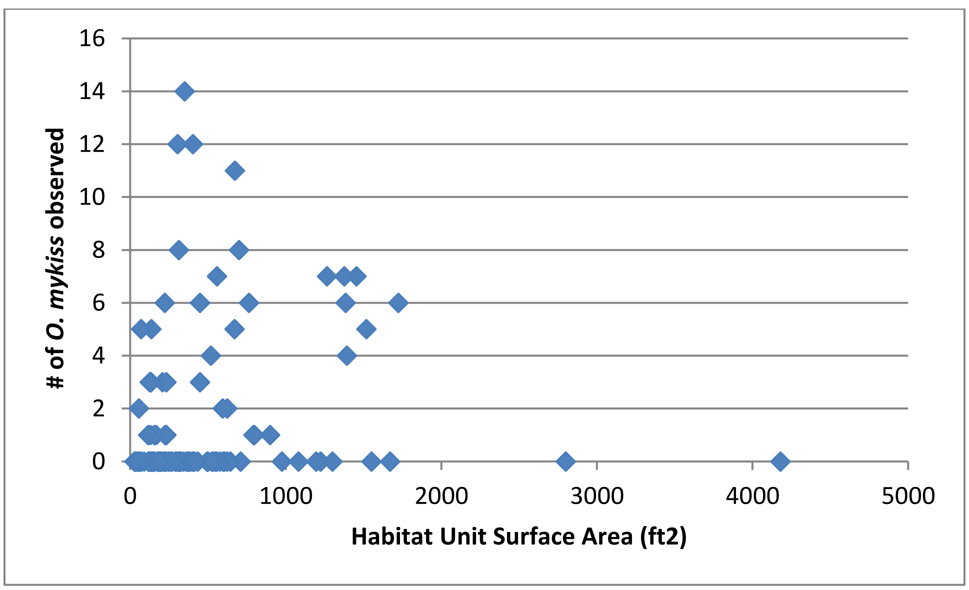


Figure 278 *O. mykiss* observations plotted over habitat unit length, Upper Matilija 2014

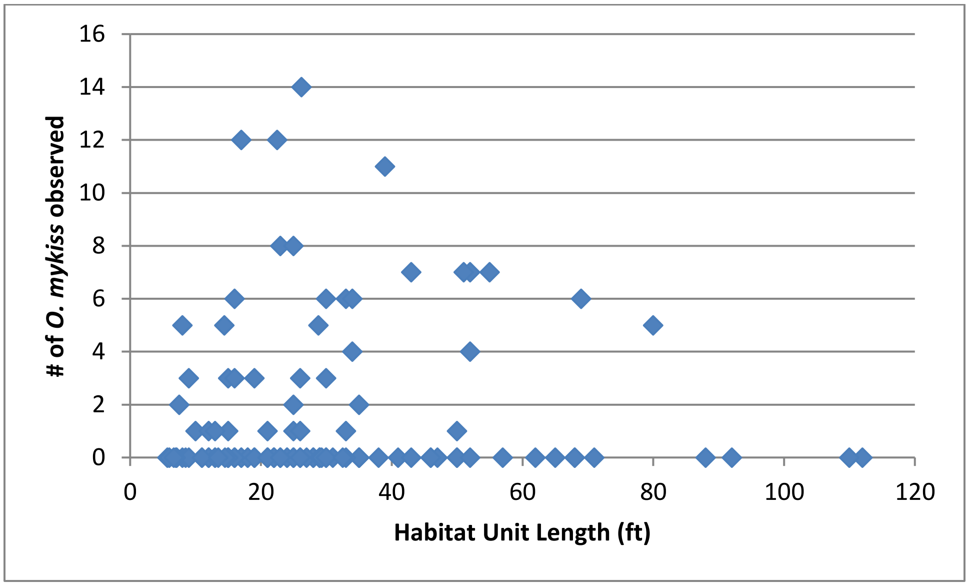


Figure 279 Black spot disease on *O. mykiss* in Upper Matilija, 2014

Habitat Assessment

Results

The habitat inventory was conducted from 7 May to 16 June 2015 by Sam Bankston, Ben Lakish, Patrick Saldaña, Kyle Evans, and Tom van Meeuwen from Pacific States Marine Fisheries Commission, Yi-

Jiun Tsai from the Watershed Stewards Program, Kate McLaughlin from the CA Department of Fish and Wildlife, and Danielle Yaconelli from the California Conservation Corps in Camarillo. The survey extended 17,118 feet upstream from the survey start (34.50900°N, -119.38361°W). The endpoint (34.53646°N, -119.40395°W) was a total natural barrier to fish passage (Figure 280).

Temperature

Water temperatures taken during the survey period ranged from 56 to 68°F. Air temperature ranged from 59 to 88°F.

Habitat type

Of the total number of habitat units surveyed (n = 278 units), 0.4% of units were dry, 24.5% were flatwaters, 38.8% were pools, and 36.3% were riffles. Of the total length of the reach surveyed, 35.9% was dry, 19.9% was composed of flatwaters, 23.4% was composed of pools, and 20.8% was composed of riffles (Figure 281).

We identified 15 habitat types in upper Matilija Creek. Based on the frequency of units sampled, mid-channel pools (23.7%), low gradient riffles (21.2%), and runs (16.2%) were the most common habitat types (Table 70). Based on total stream length, dry units (35.9%), mid-channel pools (14.5%), and low-gradient riffles (12.9%) composed the greatest stream lengths.

Pool Metrics

A total of 108 pools were identified within the survey reach. Main channel pools were most frequently encountered (75.9% of pool units sampled; Figure 282) and comprised 78.4% of the total length of all pools.

Twenty-three of 108 pools (21%) had residual depths of three feet or greater (Figure 283).

Within pool tail-outs, gravel was the most frequently observed dominant substrate (43.9% of pool units), followed by boulders (19.6%) and bedrock (18.7%; Figure 284).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (40.7%) or one (33.3%; Figure 285).

Shelter

Within 100% units (n = 113 units), riffle habitat types had a mean shelter rating of 50.0 ± 7.0 (n = 41 units), flatwater habitat types had a mean shelter rating of 75.5 ± 7.1 (n = 28 units), and pools had a mean shelter rating of 84.8 ± 5.8 (n = 44 units).

Of the pool units in which shelter was assessed (n = 44), main channel pools had a mean shelter rating of 76.5 ± 7.9 (n = 26 units), scour pools had a mean shelter rating of 93.3 ± 6.5 (n = 15 units), and backwater pools had a mean shelter rating of 113.3 ± 40.6 (n = 3 units).

We found that boulders provided the most shelter across all 100% units (41.5% of all shelter; n = 113 units; Figure 286). When we examined the percentage of shelter by shelter type within pools only (n = 44 units), we found that boulders were the most dominant cover type (35.2% of the total cover), followed by bedrock ledges (13.9%; Figure 287).

Canopy Cover

Across the units sampled for canopy cover (n = 130 units), the mean percentage of canopy was 72.4%. Within the canopy cover present, 83.8% of the canopy was composed of deciduous trees and 16.2% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics (n = 116 units), the dominant substrates composing stream banks were boulder (52.2%), bedrock (31.3%), cobble/gravel (13.9%), and silt/sand/clay (3.0%; Figure 288). The mean percentage of vegetation covering the right bank in sampled units was 54.1%, and the mean percentage of vegetation covering the left bank was 57.0%. Deciduous trees were the dominant vegetation type, having been observed in 47.8% of the banks surveyed (Figure 289).

Large Woody Debris

We observed 20 pieces of LWD that were 6 to 20 feet long and nine pieces that were greater than 20 feet long within 10968.2 feet of wetted stream length. Across both LWD sizes, the number of LWD observed was 0.26 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 74.9 feet.

Discussion

Temperature

The water temperature of units measured ranged from 56 to 68°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Good to Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools or riffles. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools or low-gradient riffles. When we examined the reach in terms of length, we found that most of the reach was dry or pools, with mid-channel pools comprising the greatest percentage of wetted stream length.

Pool Metrics

Pool depth is an important indicator habitat quality, as greater pool depths can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). A residual depth of at least 3 feet is needed to be considered good habitat (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in upper Matilija, we found that 21% of pools had residual depths greater than three feet. Thus, it appears that pools in Matilija may lack the depth needed to provide good hiding cover and rearing space. This may be due in part to the current, severe drought, which has extended into its fourth consecutive year.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was gravel, comprising 43.9% of pool units. Pool units most frequently had an embeddedness value of either a five or one. Pool tail-outs with gravel substrate often also had an embeddedness value of one (69% of tail-outs with gravel substrate; 30% of all pool tail-outs). Together, these metrics suggest that, although pools may not provide the ideal depth for cover or rearing space, many pool tail-outs in upper Matilija provide good spawning habitat for *O. mykiss*, assuming that flows are adequate.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that riffles had the lowest shelter ratings, and that pools had the highest. This suggests that flatwater and pool units provide better shelter than riffles in upper Matilija. However, it is important to note that these shelter ratings are highly influenced by the estimated percent of shelter covering the unit; most shelters were assigned a cover complexity value of 2 (86.7% of all units assigned a shelter value) and therefore did not contribute greatly to the variation in shelter rating.

When examining pool habitat units specifically, we found that backwater pools had the highest shelter rating, followed by scour and then main channel pools. However, these ratings should be interpreted with caution because there were only three backwater pool units that were sampled for shelter.

When we examined the percentage shelter by shelter type, we found that boulders provided the most shelter by far (41.5% of all shelter), suggesting that boulders are a common and important feature to *O. mykiss* habitat in upper Matilija.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In upper Matilija Creek, we estimated a mean canopy cover of 72% across all units, consisting predominantly of deciduous trees. This suggests that Matilija has a moderately high amount of cover (Kier Associates & NMFS 2008), but this cover is likely to vary greatly through time, given the seasonality of deciduous trees. However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was boulder, followed by bedrock. The mean percentage of vegetation covering the right and left banks was 54% and 57%, respectively. Deciduous trees and brush were the most common dominant vegetation observed. Together, these bankside metrics suggest that these banks may be relatively protected from erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In Matilija Creek, we found 0.26 pieces of LWD per 100 feet, which was extremely low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Matilija lacks LWD, it has boulder elements that improve habitat quality. Specifically, boulders provided the greatest amount of shelter across all units in which shelter was assessed (41.5% of all shelter).

Tables

Table 70. Percentage of all units (n = 50) by habitat type for upper Matilija Creek.

Habitat Type	% of Units
Mid-Channel Pool	23.74%
Low Gradient Riffle	21.22%
Run	16.19%
Step Run	7.91%
Bedrock Sheet	6.83%
Cascade	5.40%
Lateral Scour Pool, bedrock-formed	3.96%
Step Pool	3.60%
High Gradient Riffle	2.88%
Plunge Pool	2.88%
Trench Pool	1.80%
Lateral Scour Pool, boulder-formed	1.44%
Dammed Pool	1.08%
Glide	0.36%
Channel Confluence Pool	0.36%
Dry	0.36%

<u>Figures</u>

Figure 280. Map of the habitat assessment survey area in upper Matilija.

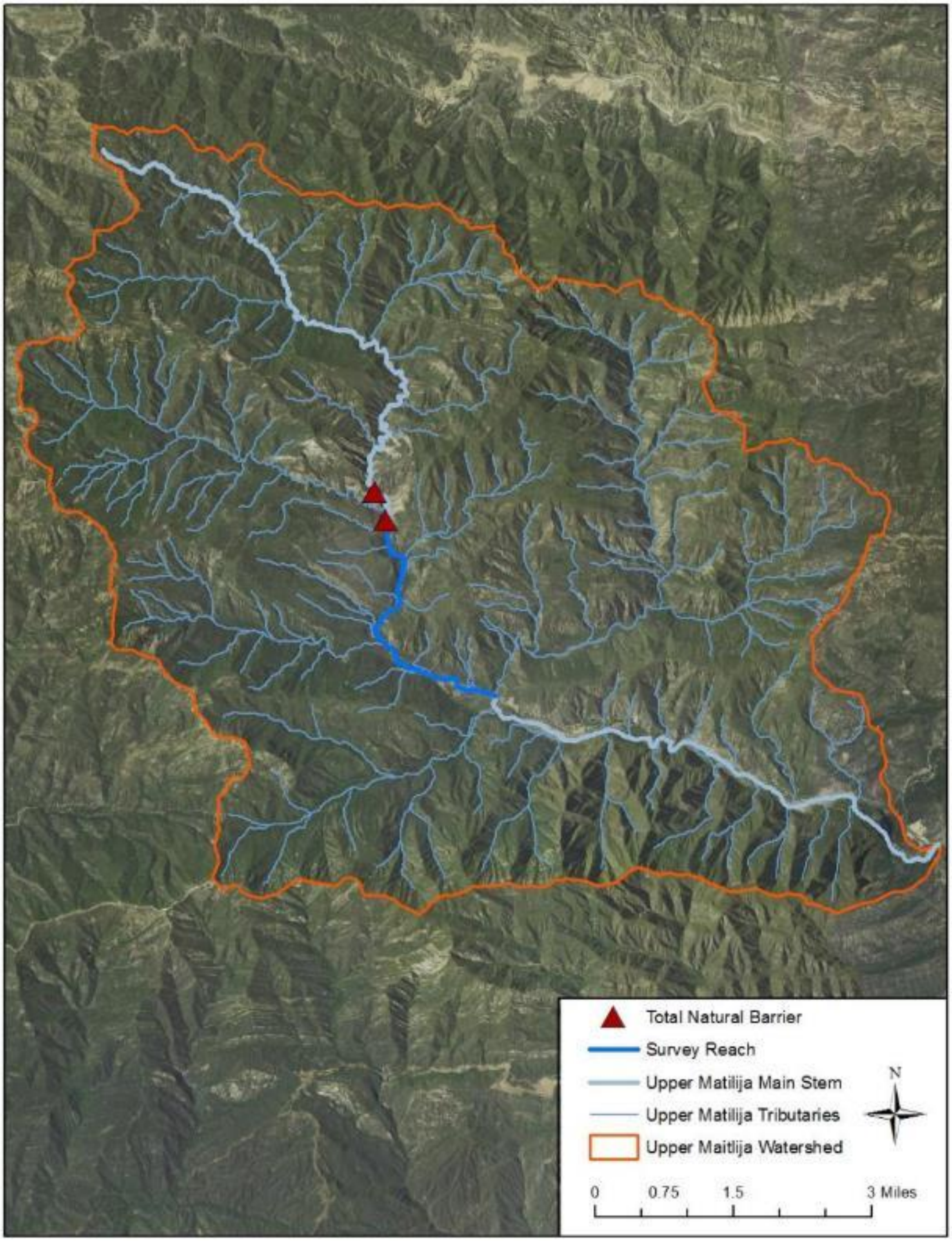


Figure 281. Percentage of total stream length categorized as pools, flatwaters, riffles, or dry for upper Matilija Creek.

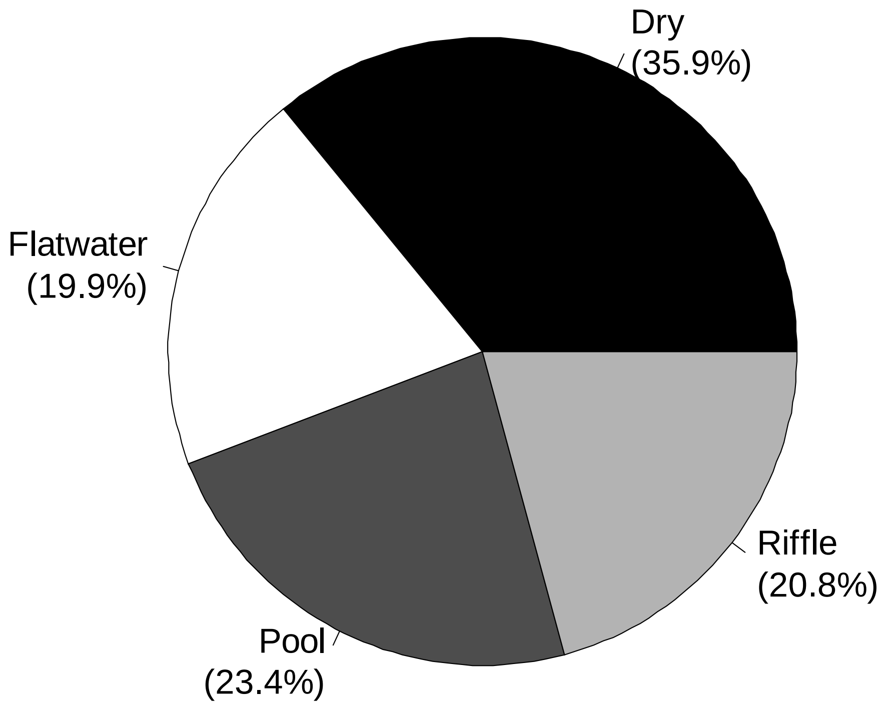


Figure 282. Percentage of all pool units (n = 108 pools) categorized by pool type (main channel, backwater, or scour pool) for upper Matilija Creek.

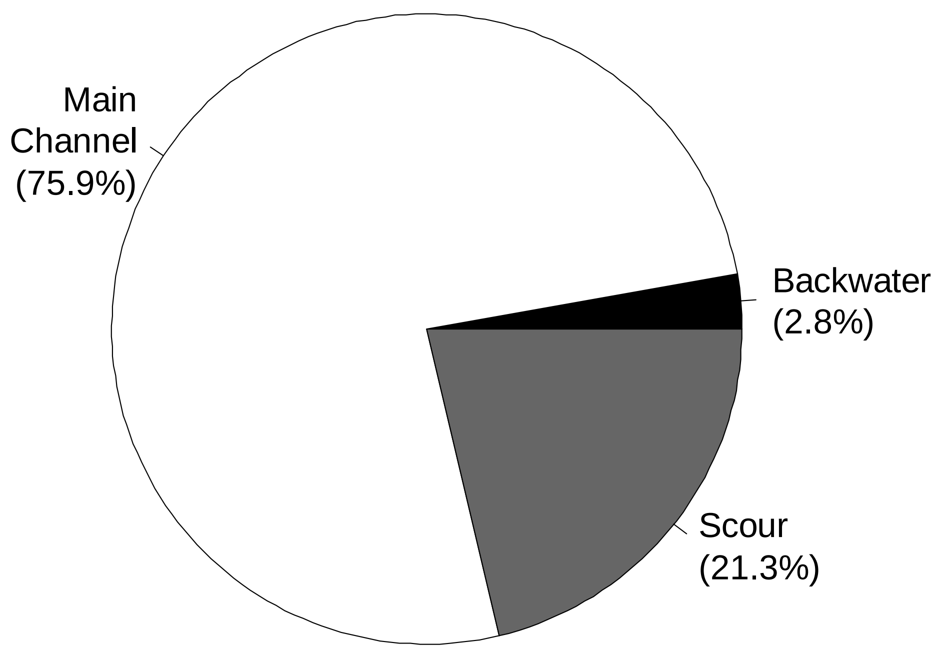


Figure 283. Histogram of residual pool depths in one-foot bins for upper Matilija Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

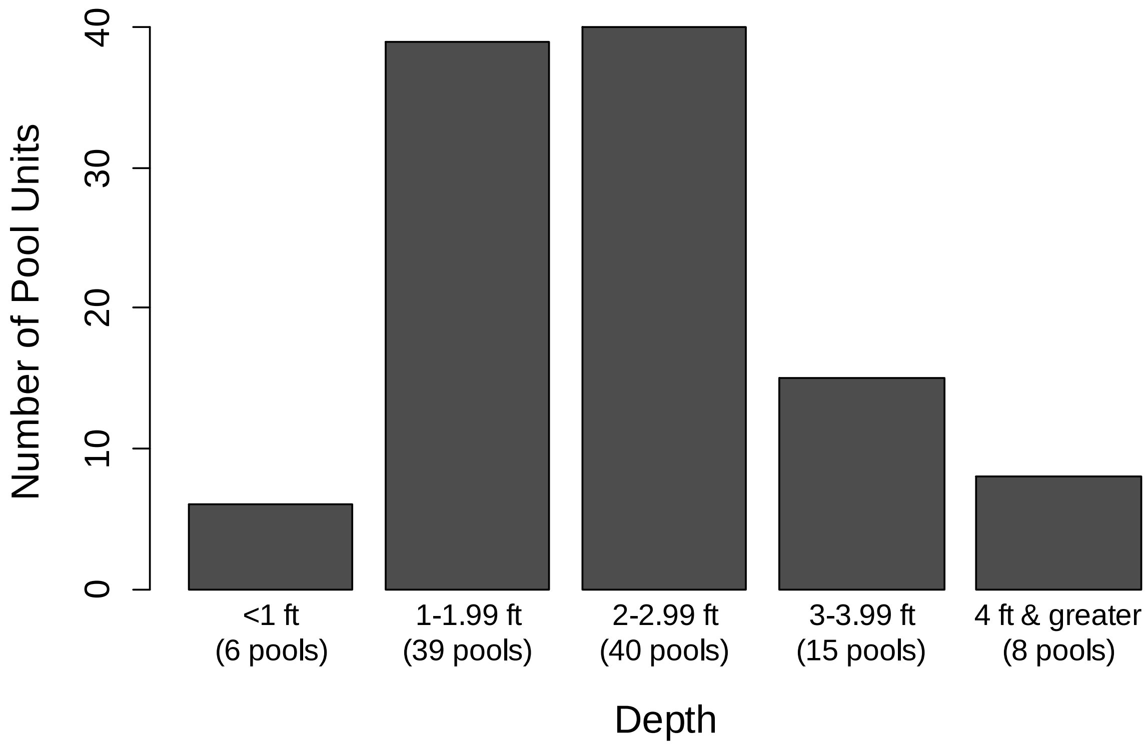


Figure 284. Percentage of pool tail-outs (n = 108 pools) by dominant substrate for upper Matilija Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

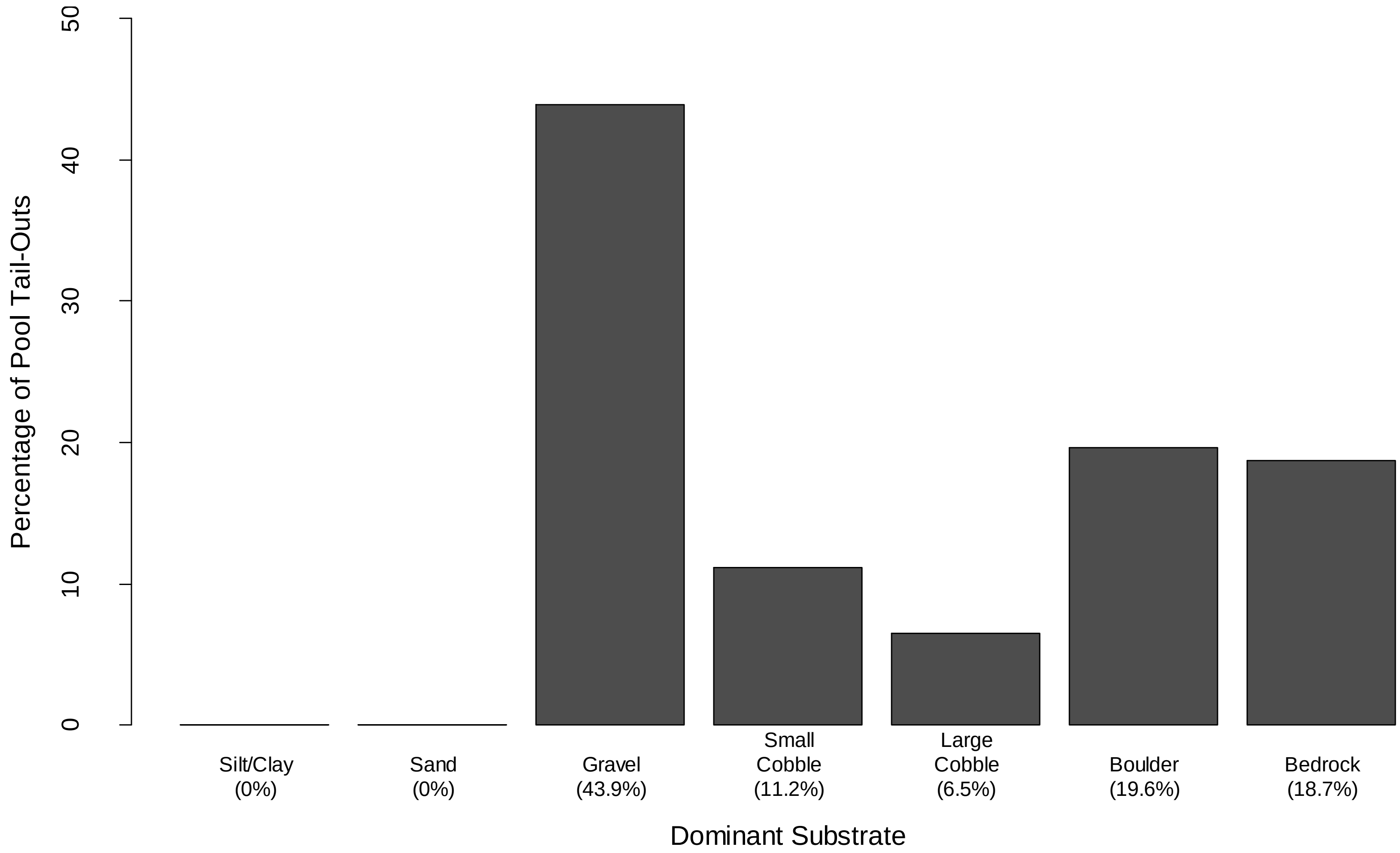


Figure 285. Percentage of all pool units (n = 108 pools) assigned a pool tail-out embeddedness value of 1 to 5 for upper Matilija Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning.

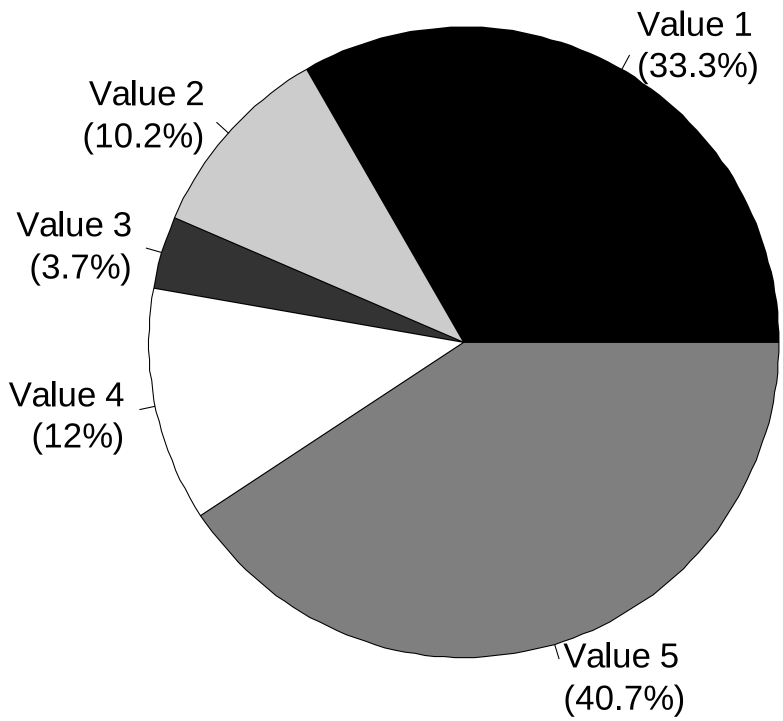


Figure 286. The percentage of instream shelter by shelter type across all units in which shelter was measured (n =113 units) for upper Matilija Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

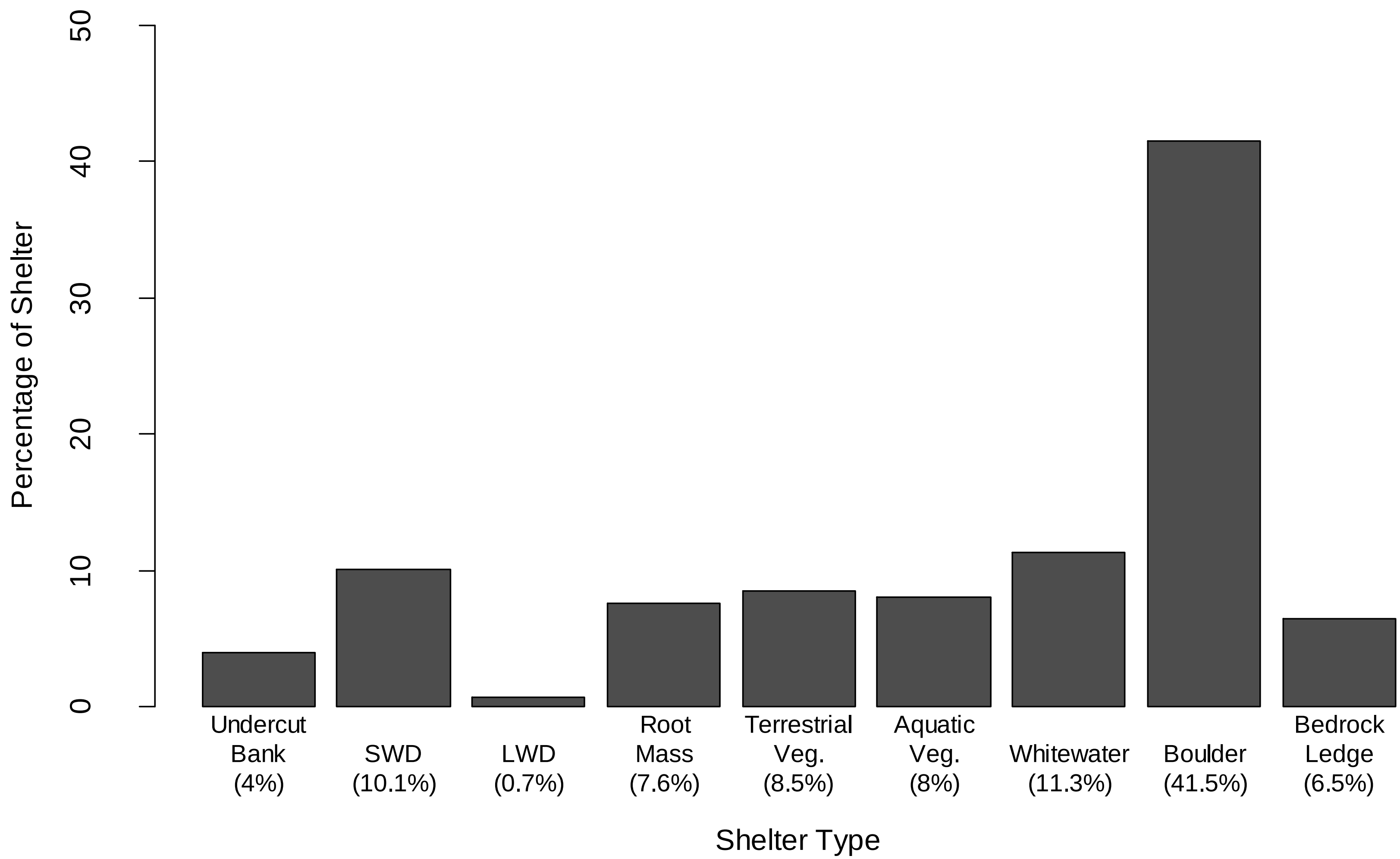


Figure 287. The percentage of shelter by shelter type across all pool units in which shelter was measured (n = 44 pools) for upper Matilija Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

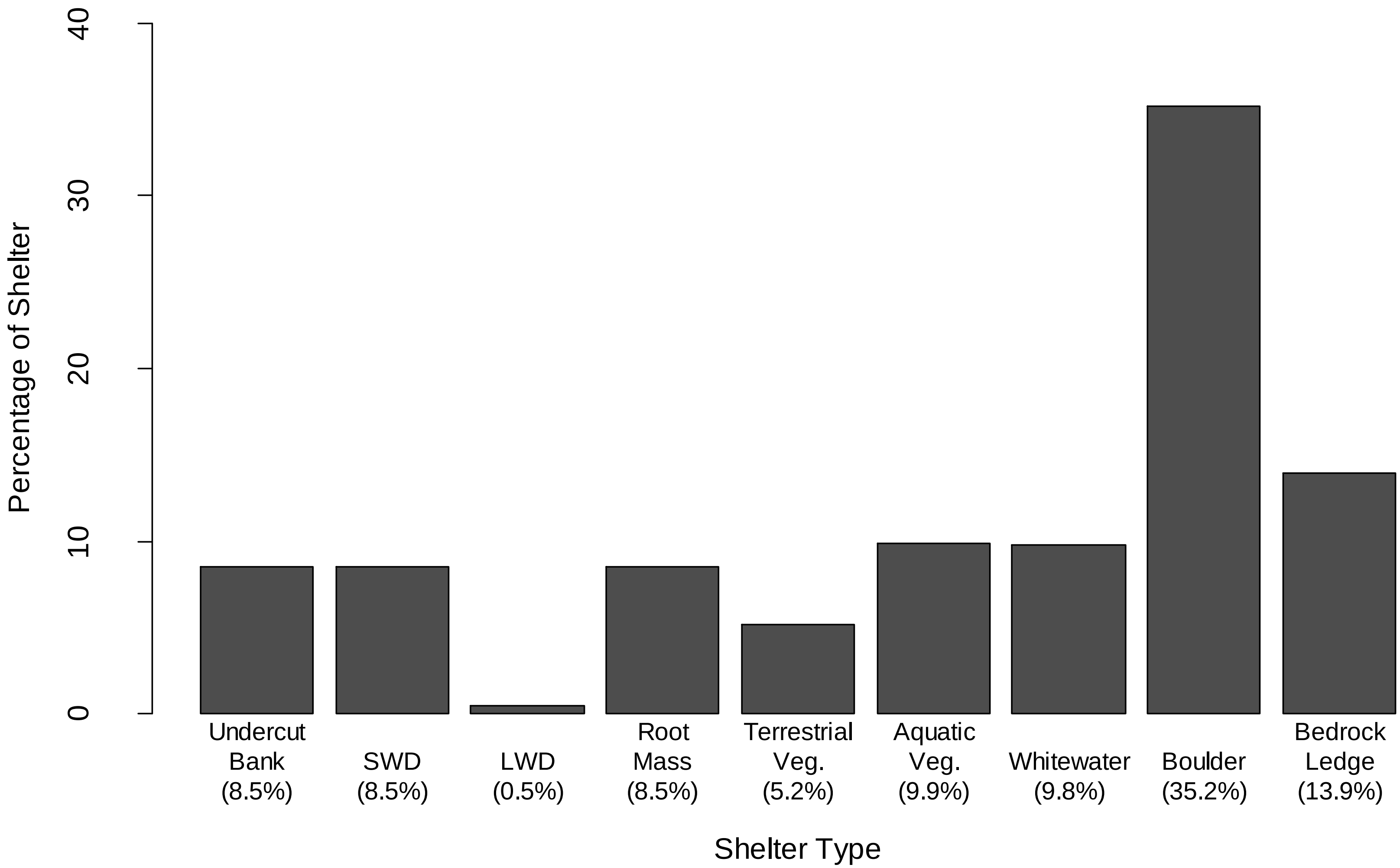


Figure 288. Percentage of banks by dominant substrate composition (n = 116 units) for upper Matilija Creek. Substrate types include sand/silt/clay, cobble/gravel, boulder, and bedrock.

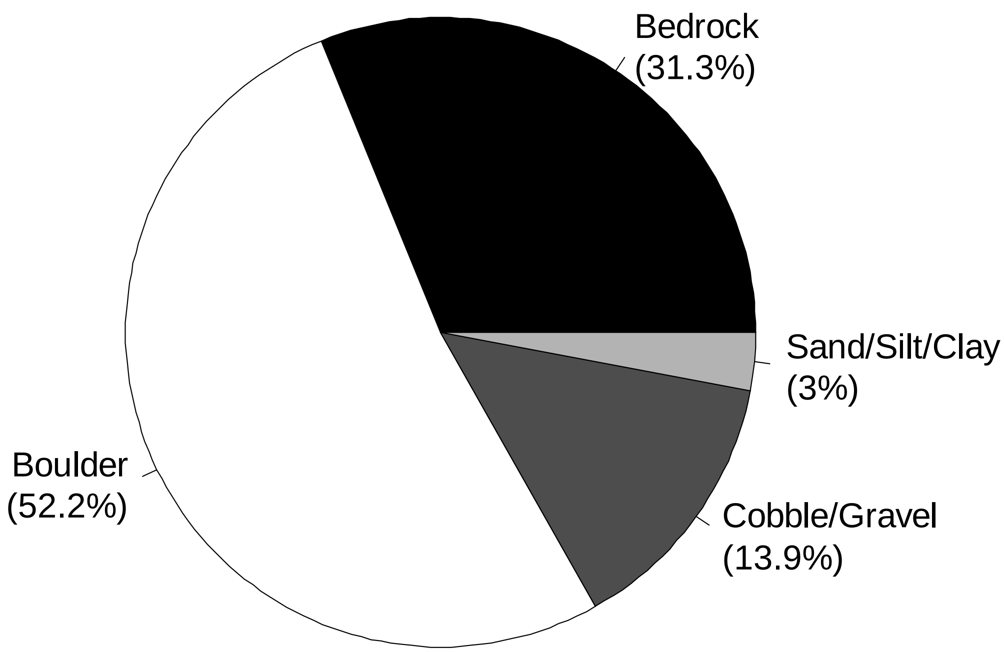
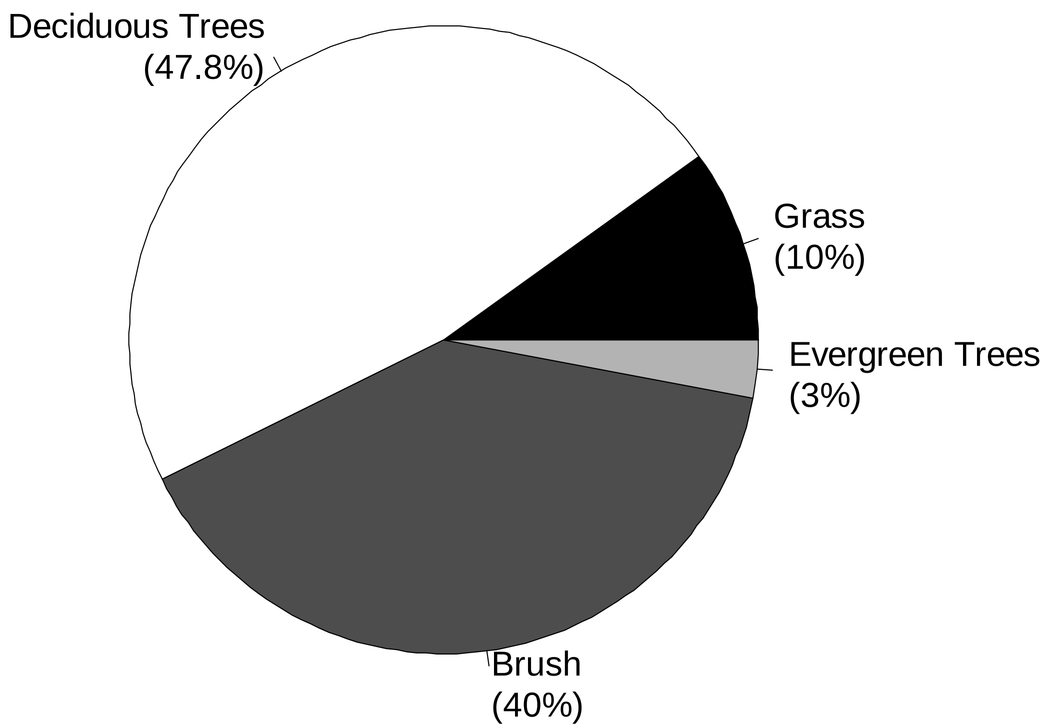


Figure 289. Percentage of banks (n = 116 units) by dominant vegetation type for upper Matilija Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



Upper North Fork Matilija

Snorkel Survey (2014)

<u>Results</u>

Between July 30, 2014 and August 15, 2014, a snorkel survey was conducted on a stretch of Upper North Fork Matilija Creek. 119 individual *O. mykiss* were observed in 35 of the 51 pools snorkeled. In the 1.12 mile surveyed stretch (Figure 290), a total of 119 *O. mykiss* were observed in varying size classes indicated in Table 71 and Figure 291. The total length of all snorkeled units was 1,292.55 feet within the 1.12 mile (5,913 ft.) reach. 119 *O. mykiss* were observed in individual habitat units within the surveyed stretch of Upper North Fork Matilija Creek. Figure 292 shows the distribution of *O. mykiss* over the surveyed reach.

The average number of *O. mykiss* per unit length calculates to be 9.207×10^{-2} fish/ft. This was calculated by taking total of observed fish and dividing by the sum of all the lengths of snorkeled units. The average number of *O. mykiss* per unit area calculates to be 7.897×10^{-3} fish/ft^2. This was calculated by taking the total number of fish observations and dividing by sum of all the individual surface areas for each snorkeled unit. We have also summarized *O. mykiss* counts for shelter values below in Table 71. We also plotted *O. mykiss* observations with respect to total surface area of each habitat unit and this is shown in Figure 293. Additionally we plotted the number of *O. mykiss* observations with respect to the length of each habitat unit and this is shown in

Figure 294.

Black Spot Disease was present within the survey reach, but was confined to a limited number of pools. Black Spot Disease refers to the infestation of multiple genera of digenetic trematodes on freshwater fish. Life cycles of trematodes are complex and can house a variety of hosts. The presence of Black Spot Disease was observed in seven discrete pools within the surveyed reach, shown in Figure 295. A total of 29 *O. mykiss* were observed with Black Spot Disease.

Discussion

Between July 30, 2014 and August 15, 2014, a snorkel survey was conducted on a stretch of Upper North Fork Matilija Creek. The survey reach began at the confluence of Upper North Fork Matilija Creek and Matilija Creek and extended 1.12 miles (5,897ft) upstream ending at a point where the creek dried. The purpose of this survey was to gain an understanding of the abundance and distribution of southern California steelhead (*O. mykiss*). Initially the snorkeling began in the upper section of the survey stretch, but after discussion it was decided to include the lower section starting at the confluence.

Size class distributions of *O. mykiss* observed show the majority of observed fish were within the 2-3.99 in size class (n=64) while overall distributions ranged from 0-1.99 in to 8-9.99 in. In prior steelhead population and habitat assessments (Allen, 2015), a 10 cm criteria was used to distinguish between 0+ and 1+ age classifications. Age 0+ represents fry, or young of the year, and age 1+ represents a juvenile fish in their second summer of life. The 10 cm criterion dictates that trout measuring less than 3.94 inches are considered to be fry or young of the year. Trout larger than 3.94 inches but less than 20 cm are considered juveniles. The *O. mykiss* observed within the surveyed reach represent both fry and juveniles by this criterion, with the majority of observed trout being fry or young of the year. The survey was conducted approximately 4 months after spawning season and thus we expect to see an abundance of young of the year trout. In subsequent years, including 2008, 2010, 2011, and 2012, fry were the dominant size class in Upper North Fork Matilija, (Allen 2015). We suspect that since this spawning season had concluded by our July snorkel surveys, that most of the observed fish were from that year's recruitment class.

The map of the surveyed section of Upper North Fork Matilija Creek in Figure 292 indicates the distribution of the observed *O. mykiss*. The larger circles indicate a greater number of fish observations within 10 surveyed units. We do not have individual observations on the map as GPS locations were only recorded on the first unit out of ten on a data sheet. The smaller circles indicate a lesser number of fish observations in a single unit. There are no clear differences seen between different sections of the creek. The only observation that can be made is that distribution is throughout the entire reach and not confined to any particular areas.

Figure 293 and

Figure 294 show the number of *O. mykiss* observed versus the surface area and length of the pools they were found in. There was no distinct correlation between *O. mykiss* observations and the surface area and length of the pools they were found in. *O. mykiss* density was then calculated in relation to the total length of the surveyed pools (1,292.5 feet) as well as the combined total surface area of the surveyed pools (15,068 square feet). Again this returned no obvious relationships most likely due to low fish counts. The average number of *O. mykiss* per unit length calculates to be 9.207×10^{-2} fish/ft while the average number of *O. mykiss* per unit area calculates to be 7.897×10^{-3} fish/ft^2. Again, these numbers are relatively insignificant due to the small sample size.

We also choose to look at shelter values which can range on a scale of 0 to 3. A shelter value of 0 means the surveyed unit has no components of shelter (e.g., no undercut, boulders, woody debris, etc.), whereas a value of 3 means the shelter in the surveyed unit has at least three shelter components including large woody debris (LWD). Large woody debris is uncommon in Southern California streams; therefore shelter values of 3 are not as common as shelter values of 2. In Arroyo Hondo Creek, 94.1 % of the surveyed units had a shelter value of 2, 5.9% of the surveyed units had a shelter value of 1, 0 % had a shelter value of 0 or 3 (

Table 72). It is not surprising that most of the fish observations were in pools with a shelter value of 2, since the majority of the surveyed pools had a shelter value of 2. This discrepancy in shelter value distribution may be explained by the importance of large woody debris and complex features in the shelter rating system. LWD is fairly uncommon in Southern California streams. Below average rainfall and water levels may have reduced the availability of complex features.

There were slight deviations from our chosen protocol, as divers initially chose which units were considered snorkelable. Divers had to estimate if the average depth was sufficient prior to the taking of habitat measurement. As a result, a few habitat units were snorkeled that had a mean depth of less than 0.7 feet.

In addition to noting the numbers of *O. mykiss* and other species of special concern, the snorkelers noted any presence of Black Spot Disease. Figure 295 illustrates the distribution of Black Spot Disease within the surveyed reach and Figure 296 is an example of a trout with the disease. The presence of Black Spot Disease was noted in seven discrete pools within the survey reach. The reach was wetted throughout enabling fish to migrate between connecting pools, although the presence of black spot was isolated. Black Spot is present in other tributaries within the same watershed and distributed more evenly throughout those reaches. The effect of Black Spot Disease on trout is not known to be fatal. The trematodes live within the water column and select a host, meaning that not all trout within one habitat unit will show signs of the disease and the distribution of the disease can be widespread or localized in any given reach.

Overall, this snorkel summary report shows us a snapshot of what age classes were present and where these *O. mykiss* were distributed on Upper North Fork Matilija Creek. We were able to calculate an index of fish densities but without additional survey seasons, no reliable inferences can be made. We can make no reliable estimates of population abundance since we did not conduct electrofished calibration of the snorkel counts. Additional survey seasons must be completed in order to make a comparison of our observations. Subsequent surveys should include electrofishing to we can make accurate population estimates as per Hankin & Reeves 1988.

Tables

Table 71. *O. mykiss* size class for Upper North Fork Matilija Creek, 2014.

O. mykiss **Size Class (in)**	**Number O. mykiss Observed**
0-1.99	16
2-3.99	64
4-5.99	28
6-7.99	8
8-9.99	3
10-11.99	0

Table 72. *O. mykiss* counts and number of habitat units with respect to shelter values for Upper North Fork Matilija Creek, 2014.

Habitat Unit Shelter Values	*O. mykiss* Observed per Shelter Value	# of Habitat Units with Shelter Value
0	0	0
1	0	3
2	119	48
3	0	0

Figures

Figure 290. Map of the surveyed stretch of Upper North Fork Matilija Creek 2014.

Figure 291. Size class distribution for Upper North Fork Matilija Creek, 2014.

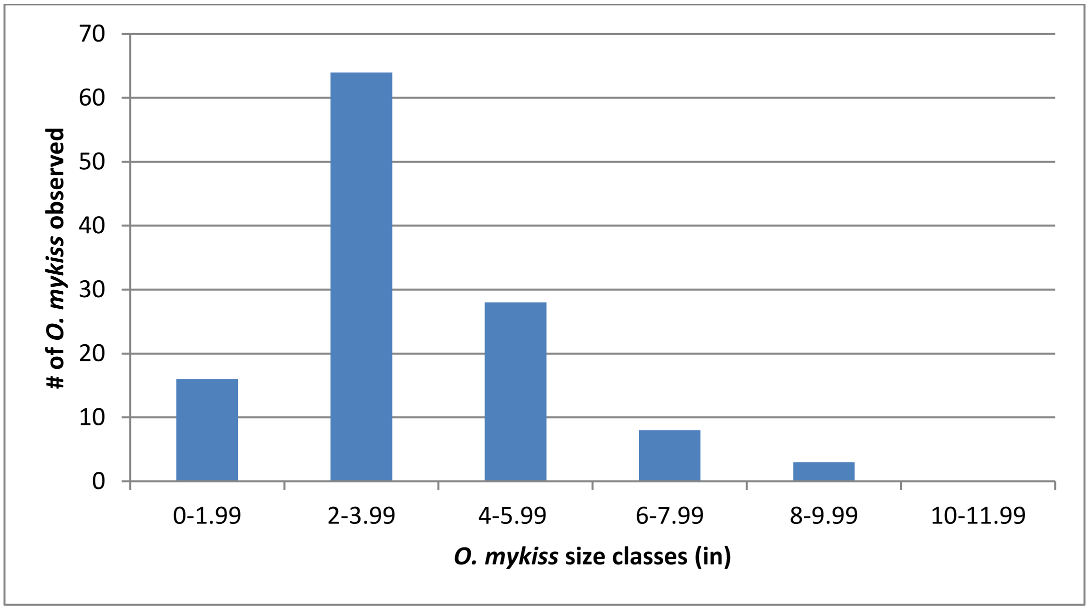


Figure 292. Distribution map of *O. mykiss* on surveyed section of Upper North Fork Matilija Creek, 2014.

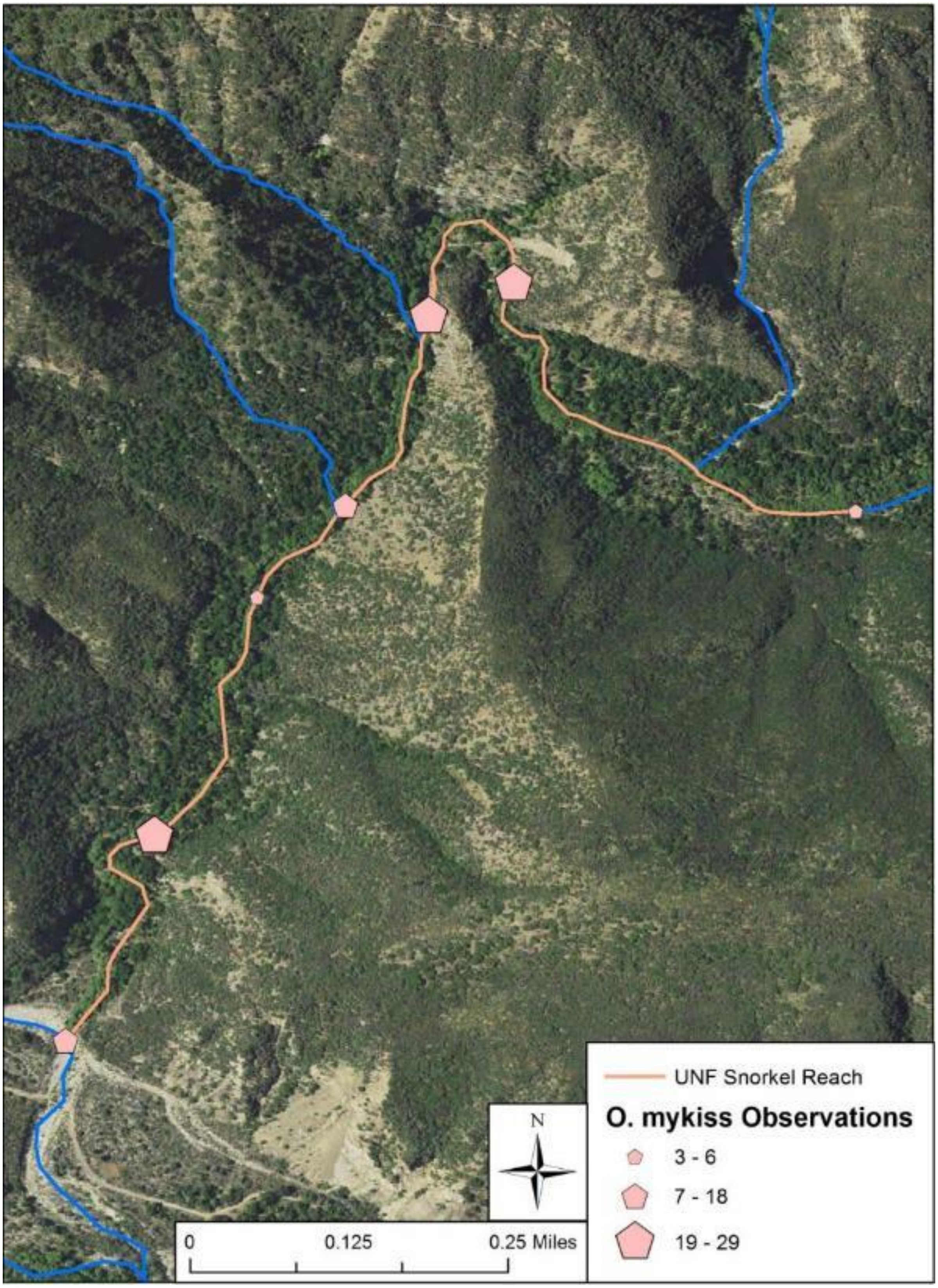


Figure 293. *O. mykiss* observations plotted over habitat unit surface area for Upper North Fork Matilija Creek, 2014.

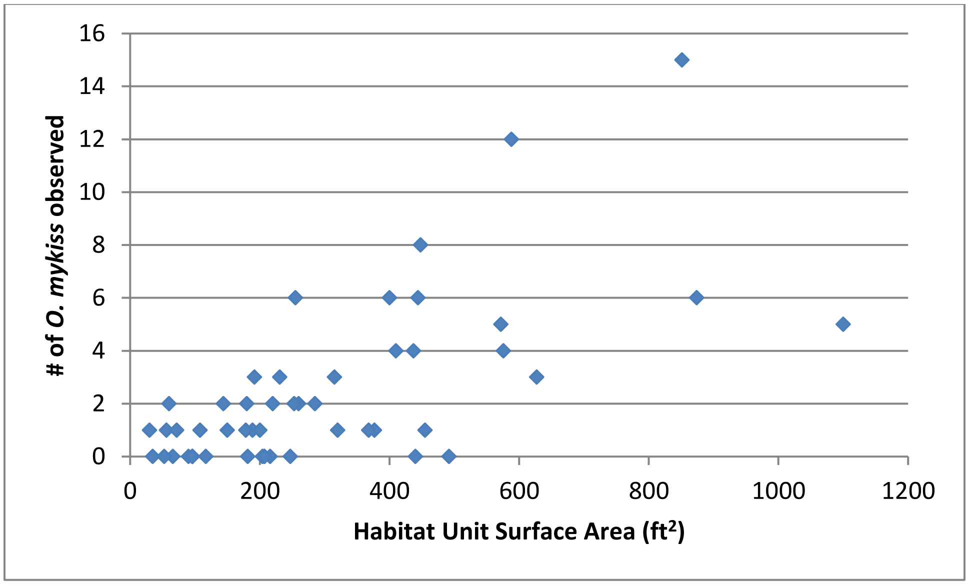


Figure 294. *O. mykiss* observations plotted over habitat unit length for Upper North Fork Matilija Creek, 2014.

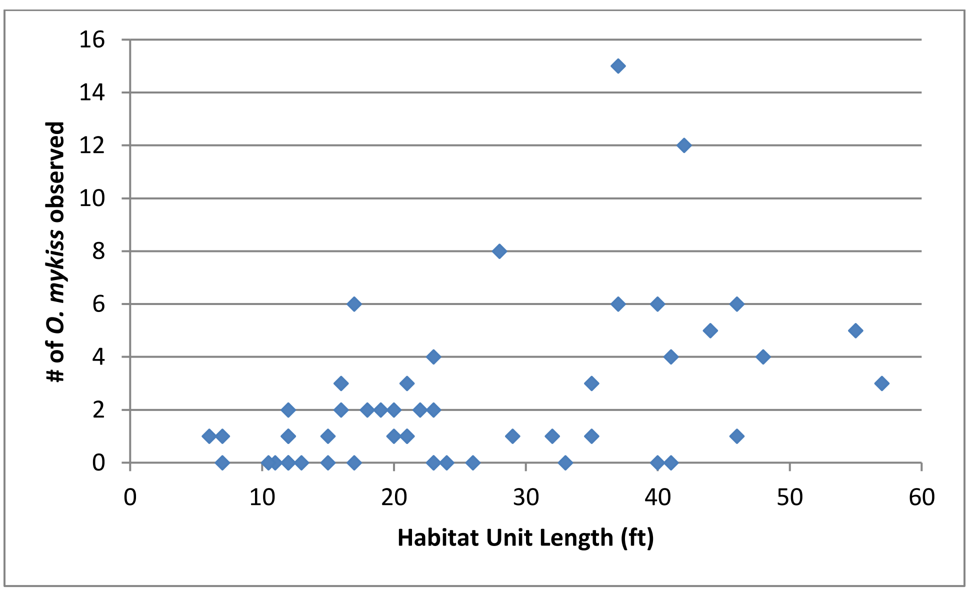


Figure 295. Distribution of Black Spot Disease amongst *O. mykiss* in Upper North Fork Matilija Creek.

Figure 296. Black Spot Disease on *O. mykiss* in Upper North Fork Matilija, 2014.

Figure 297. Snorkel survey on Upper North Fork Matilija Creek on 08/06/2014

Habitat Assessment

Results

The habitat inventory was conducted from 4 December 2013 to 15 January 2014 by Patrick Riparetti, Tom van Meeuwen, Kate McLaughlin, Karissa Willits, and Ben Lakish from Pacific States Marine Fisheries Commission and David Gottesman and Kayti Christianson from the Watershed Stewards Program. The survey extended 34,112 upstream from the survey start (34.50618°N, -119.38263°W). The survey endpoint (34.55999°N, -119.35670°W) was a total natural fish passage barrier (Figure 298). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 37 to 58°F. Air temperature ranged from 32 to 70°F.

Habitat type

Of the total number of habitat units surveyed (n = 704 units), 2.6% of units were dry, 24.9% were flatwaters, 42.3% were pools, 30.1% were riffles, and 0.1% was unsurveyable. Of the total length of the reach surveyed, 20.8% was dry, 29.5% was composed of flatwaters, 28.4% was composed of pools, 20.8% was composed of riffles, and 0.4% was unsurveyable (Figure 299).

We identified 17 habitat types in Upper North Fork Matilija Creek. Based on the frequency of units sampled, mid-channel pools (22.7%), low gradient riffles (15.2%), and runs (13.8%) were the most common habitat types (Table 73). Based on length, dry (20.8%) and step runs (17.5%) composed the greatest stream lengths.

Pool Metrics

A total of 298 pools were identified within the survey reach. Main channel pools were most frequently encountered (74.8% of pool units sampled; Figure 300) and comprised 80.6% of the total length of all pools.

Eight of 291 pools (3%) had residual depths of three feet or greater (Figure 301).

Within pool tail-outs, gravel was the most frequently observed dominant substrate (31.8% of pool units), followed by sand (27.7%; Figure 302).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (52.0%) or three (23.3%; Figure 303).

Shelter

Within 100% units (n = 180 units), riffle habitat types had a mean shelter rating of 57.6, flatwater habitat types had a mean shelter rating of 49.2, and pools had a mean shelter rating of 64.1.

Of the pool units in which shelter was assessed (n = 86 pools), main channel pools had a mean shelter rating of 56.6, scour pools had a mean shelter rating of 77.9, and backwater pools had a mean shelter rating of 61.7.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that boulders provided the most shelter (39.6% of all shelter; Figure 304). When we examined the percentage of shelter by shelter type within 100% pool units only, we found that boulders were again the most dominant cover type (36.9% of the total cover; Figure 305).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 87.5%. Within the canopy cover present, 82.6% of the canopy was composed of deciduous trees and 17.4% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks were bedrock (21.1%), boulder (17.7%), cobble/gravel (8.4%), and silt/sand/clay (52.8%; Figure 306). The mean percentage of vegetation covering the right bank in sampled units was 48.8%, and the mean percentage of vegetation covering the left bank was 48.6%. Deciduous trees were the dominant vegetation type, having been observed in 50.0% of the banks surveyed (
Figure **307**).

Large Woody Debris

We observed 58 pieces of LWD that were 6 to 20 feet long and 45 pieces that were greater than 20 feet long within 26856 feet of wetted stream length (excluding dry and unsurveyable lengths). Across both LWD sizes, the number of LWD observed was 0.38 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 29.7 feet.

Discussion

Temperature

The water temperature of units measured ranged from 37 to 58°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools or riffles. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools or low-gradient riffles. When we examined the reach in terms of length, we found that most of the reach was composed of flatwaters or pools. When we examined length in more detail, we found that dry and step runs comprised the greatest percentage of stream length.

Pool Metrics

Pool depth is an important indicator habitat quality, as greater pool depths can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). A residual depth of at least 3 feet is needed to be considered good habitat (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in Upper North Fork Matilija, we found that only 3% of pools in Upper North Fork Matilija had residual depths of over three feet. Thus, it appears these pools may lack the depth needed to provide good hiding cover and rearing space. This may be due in part to the current, severe drought, which has extended into its fourth consecutive year.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was gravel (31.8% of pools). Pool units most frequently had an embeddedness value of either a five or three. Together, these metrics suggest that, although pools may not provide the ideal depth for cover or rearing space, some pool tail-outs in Upper North Fork Matilija provide good spawning habitat for *O. mykiss*, assuming that flows are adequate.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that pools had the highest mean shelter rating, while flatwaters had the lowest, although all three ratings were similarly low. This suggests that these three types of habitats provide comparably low cover to *O. mykiss*.

When examining pool habitat units specifically, we found that scour pools had the highest mean shelter rating, while main channel pools had the lowest. However, it is important to note that there were 51 main channel pools, 29 scour pools, and only 6 backwater pools in which shelter was measured. Thus, sample sizes for these pool types may not be comparable.

When we examined the percentage shelter by shelter type, we found the boulders provided the most shelter by far, both across all units in which shelter was measured (39.6% of all shelter) and in pools only (36.9%). This suggests that boulders are a common and important feature to *O. mykiss* habitat in Upper North Fork Matilija Creek.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In Upper North Fork Matilija Creek, we estimated a mean canopy cover of 87.5% across all units, consisting predominantly of deciduous trees. This suggests that Upper North Fork Matilija has a high amount of cover (Kier Associates & NMFS 2008), but this cover is likely to vary greatly through time, given the seasonality of deciduous trees. However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008). Furthermore, deciduous trees may provide small woody debris cover within the wetted stream once leaves are shed into the water.

Bankside Metrics

The predominant substrate composing stream banksides was silt/sand/clay. The mean percentage of vegetation covering the right and left banks was 48.8% and 48.6%, respectively. Deciduous trees and brush were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be somewhat vulnerable to erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In Upper North Fork Matilija Creek, we found 0.38 pieces of LWD per 100 feet, which was extremely low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012;

Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Upper North Fork lacks LWD, it has boulder elements that improve habitat quality. Specifically, boulders provided the greatest amount of shelter across all units in which shelter was assessed (39.6% of all shelter).

Tables

Table 73. Percentage of units (n = 704) by habitat type for Upper North Fork Matilija Creek.

Habitat Type	% of Units
Mid Channel Pool	22.73%
Low Gradient Riffle	15.20%
Run	13.78%
High Gradient Riffle	11.79%
Step Run	11.08%
Step Pool	8.81%
Plunge Pool	4.83%
Lateral Scour Pool, bedrock-formed	2.70%
Dry	2.56%
Cascade	2.41%
Lateral Scour Pool, boulder-formed	1.70%
Dammed Pool	0.99%
Bedrock Sheet	0.71%
Channel Confluence Pool	0.14%
Corner Pool	0.14%
Lateral Scour Pool, root-wad-enhanced	0.14%
Backwater Pool, boulder-formed	0.14%
Not Surveyable	0.14%

Figures

Figure 298. Map of the habitat assessment survey area in Upper North Fork Matilija Creek.

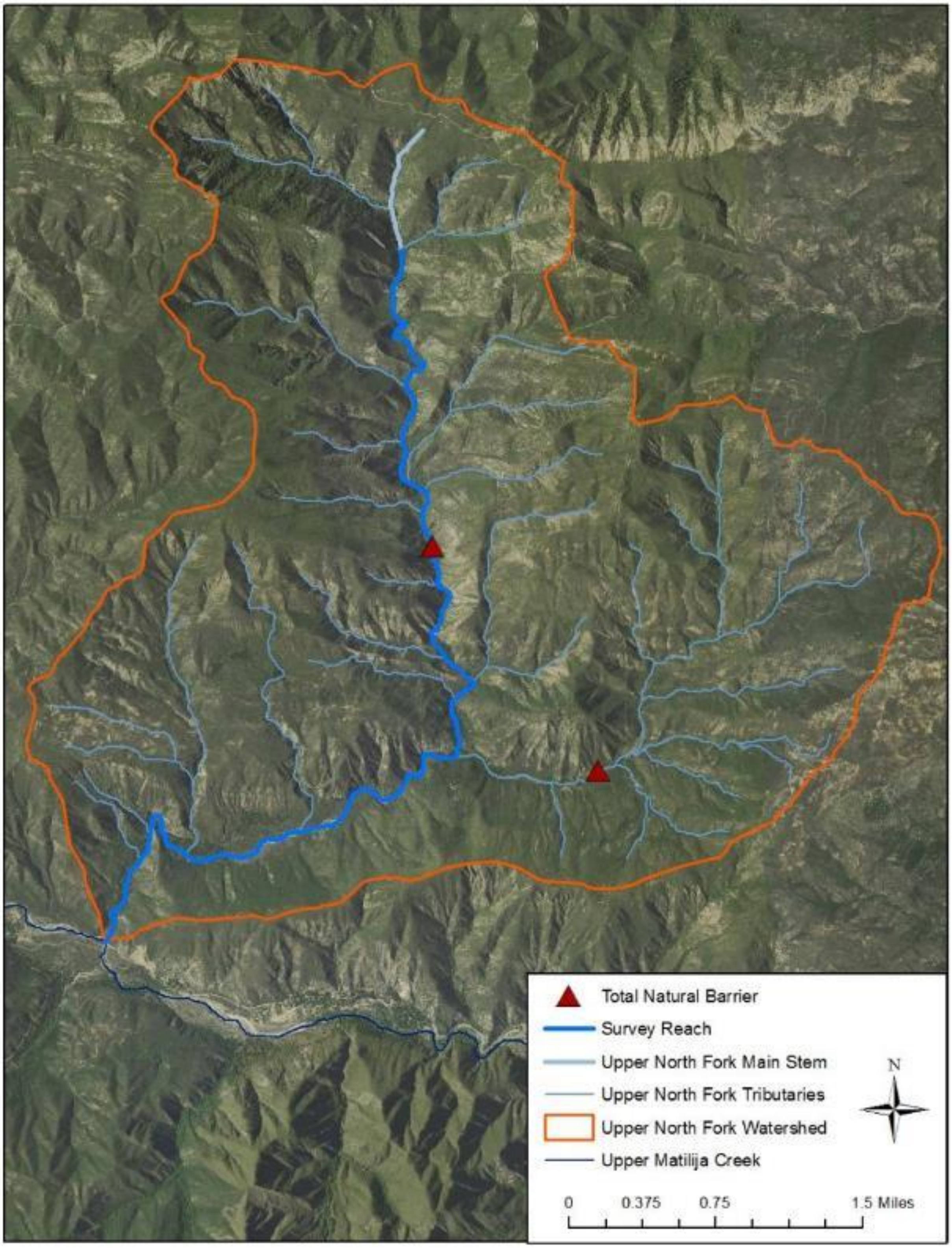


Figure 299. Percentage of total stream length categorized as pools, flatwaters, riffles, dry, or not surveyable for Upper North Fork Matilija Creek.

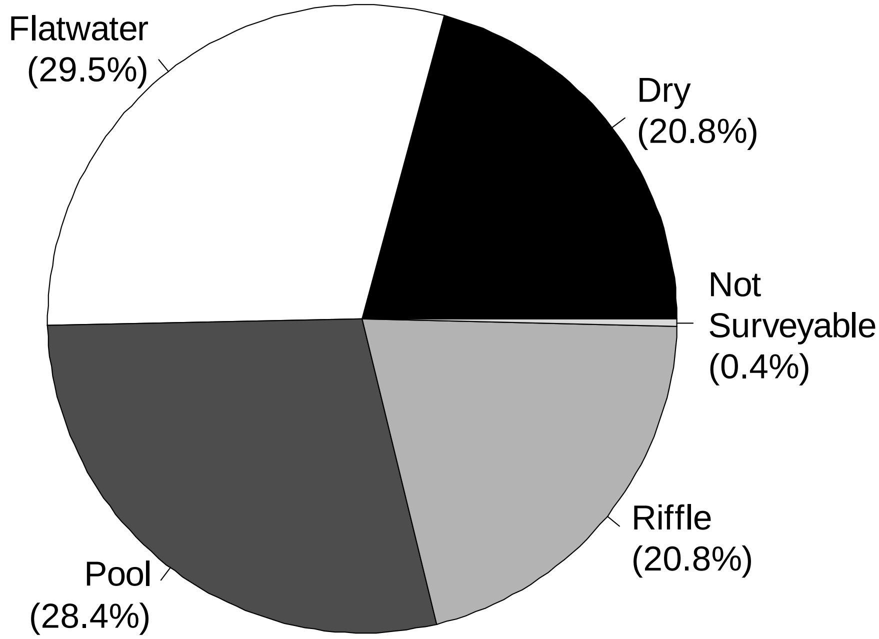


Figure 300. Percentage of all pool units (n = 298 pools) categorized by pool type (main channel, backwater, or scour pool) for Upper North Fork Matilija Creek.

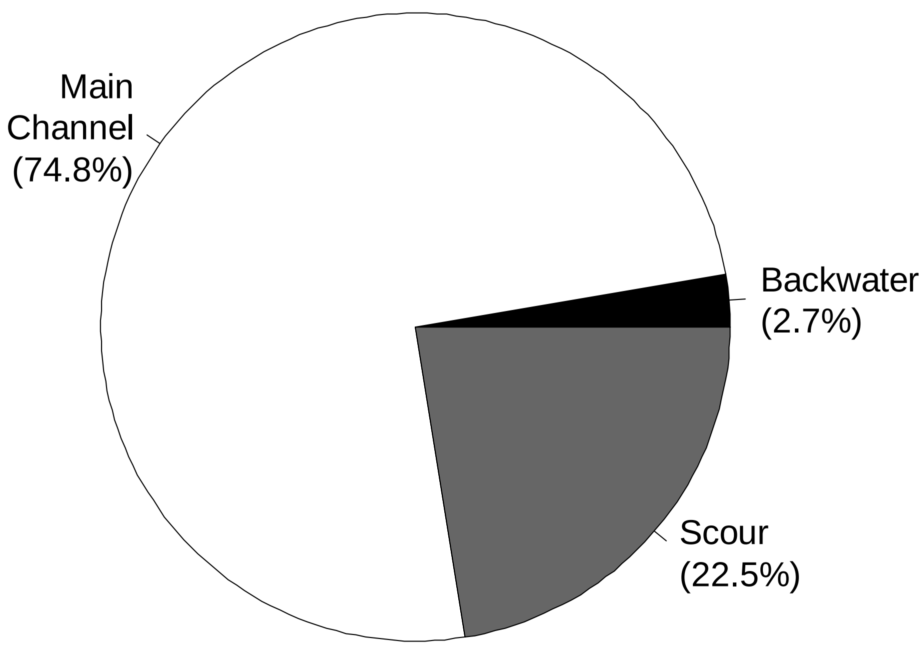


Figure 301. Histogram of residual pool depths in one-foot bins for Upper North Fork Matilija Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

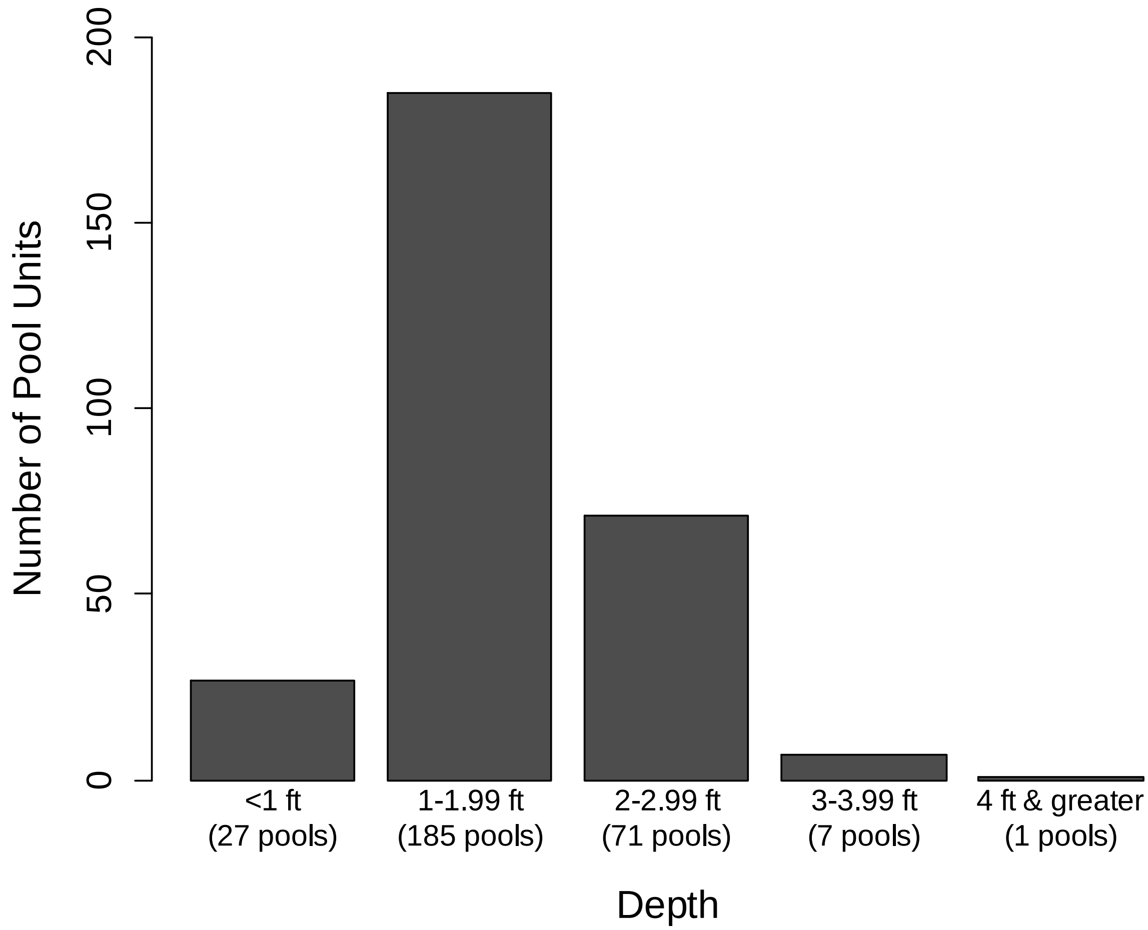


Figure 302. Percentage of pool tail-outs (n = 298 pools) by dominant substrate for Upper North Fork Matilija Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

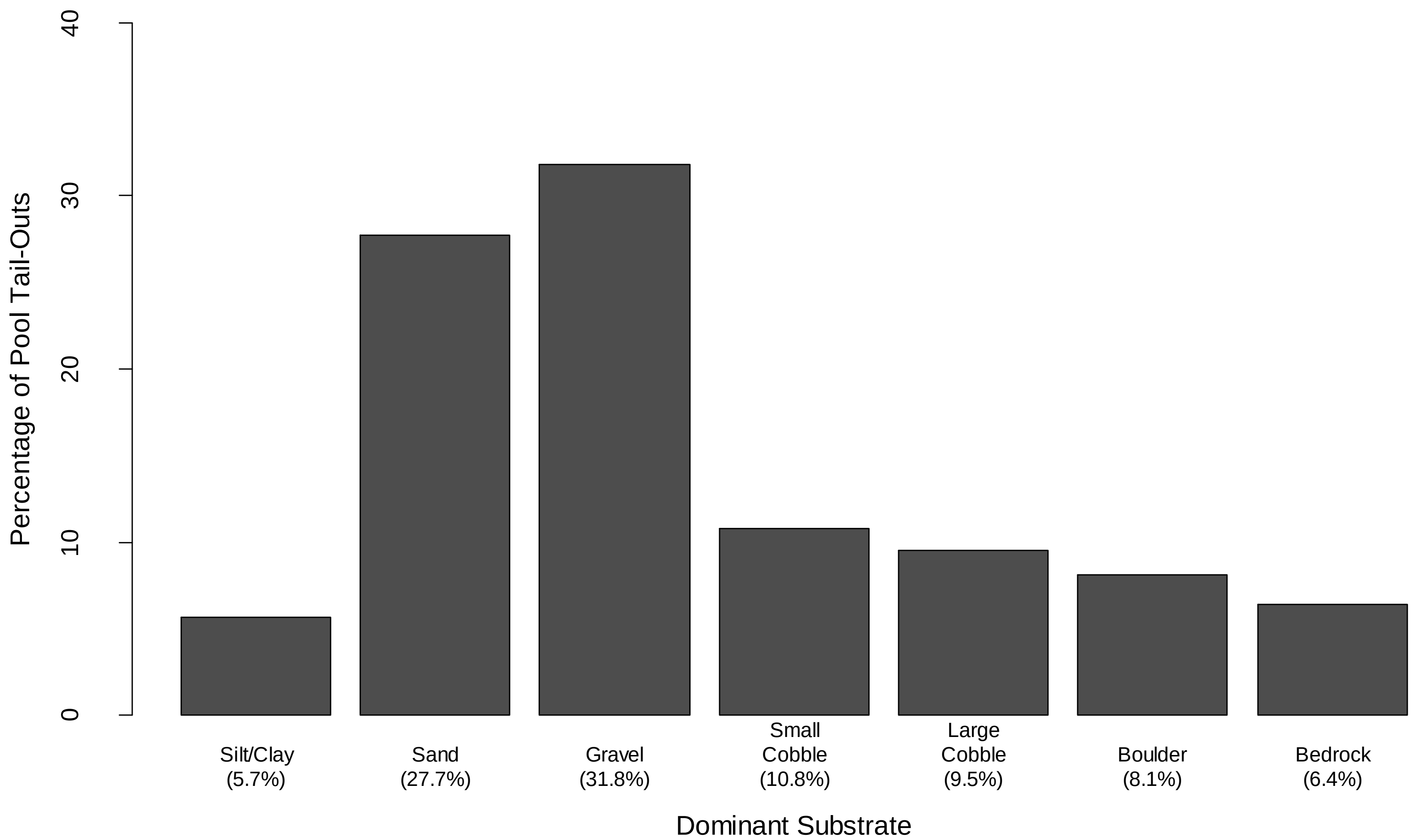


Figure 303. Percentage of all pool units (n = 298 pools) assigned a pool tail-out embeddedness value of 1 to 5 for Upper North Fork Matilija Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning.

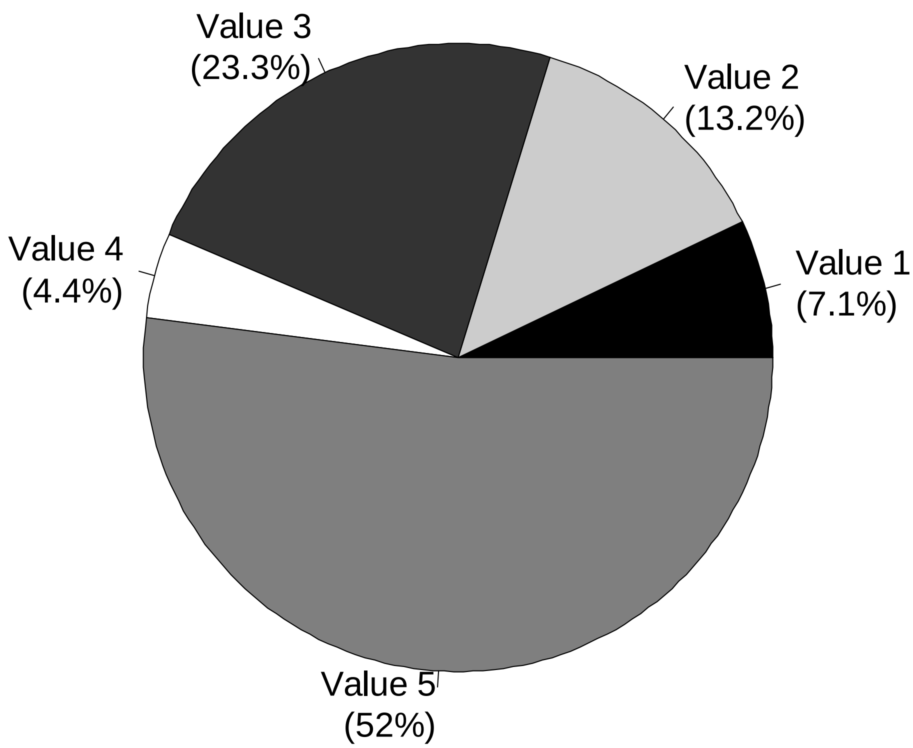


Figure 304. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 180 units) for Upper North Fork Matilija Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

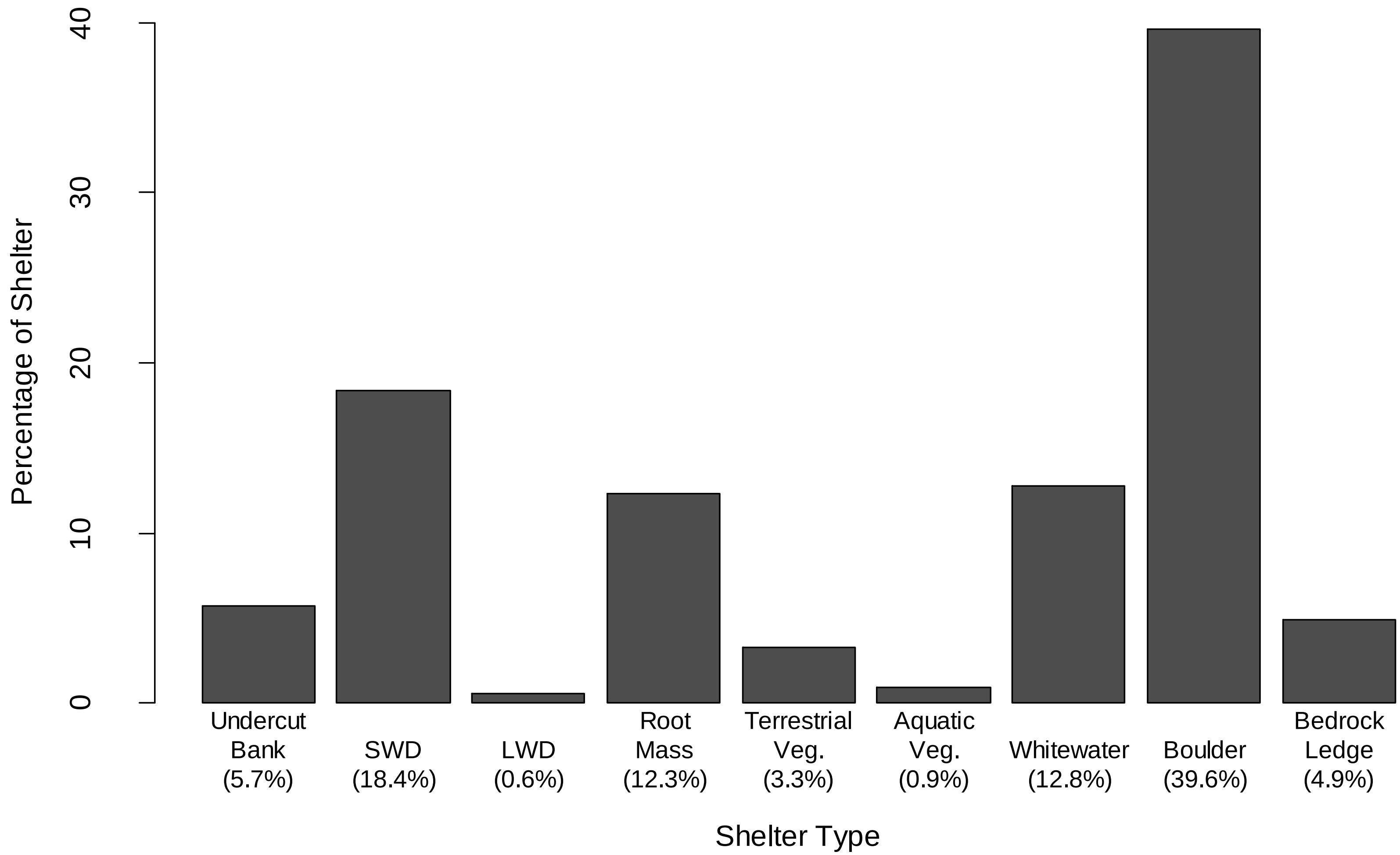


Figure 305. The percentage of shelter by shelter type across all pool units in which shelter was measured (n = 86 pools) for Upper North Fork Matilija Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

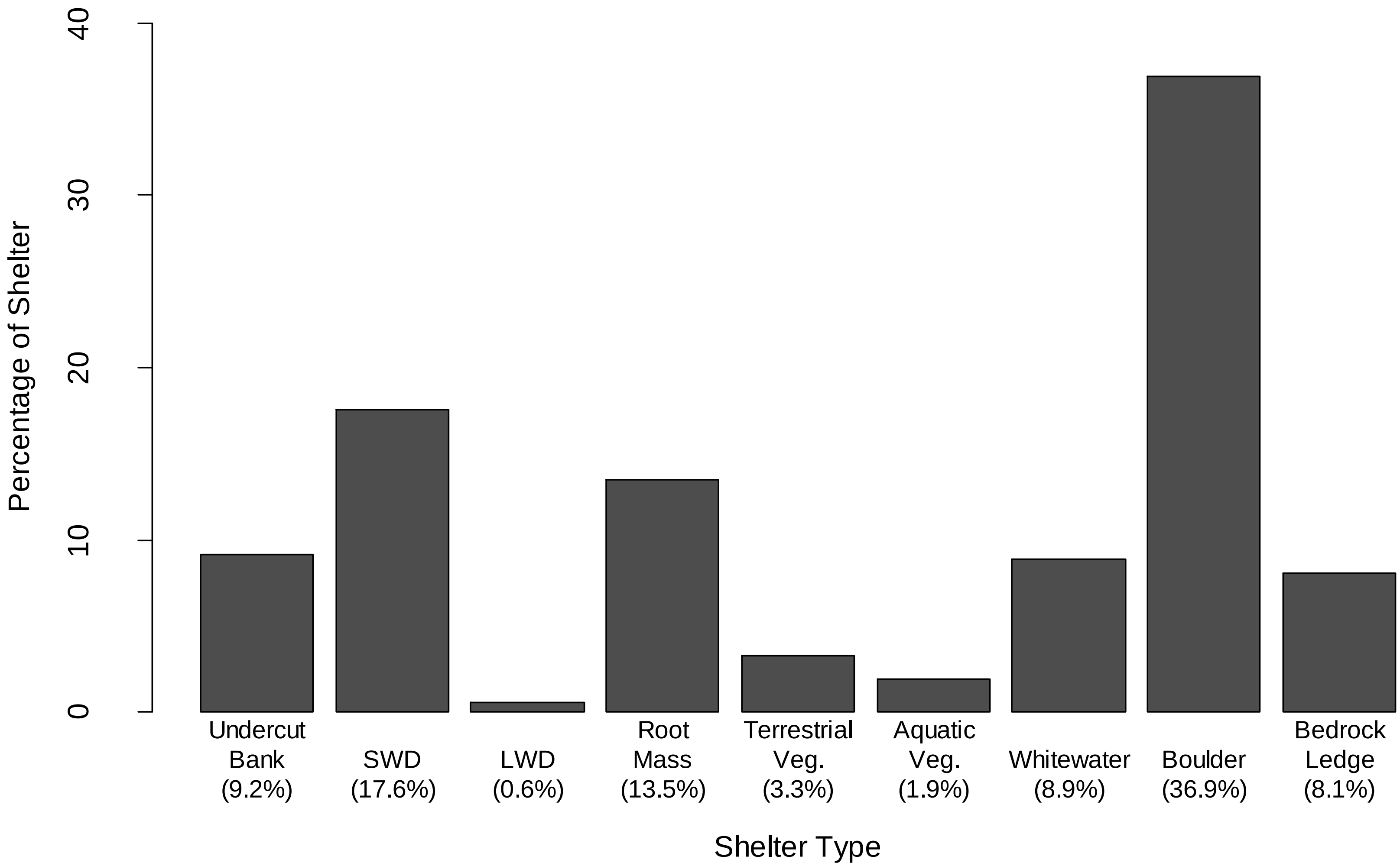


Figure 306. Percentage of banks by dominant substrate composition for Upper North Fork Matilija Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock.

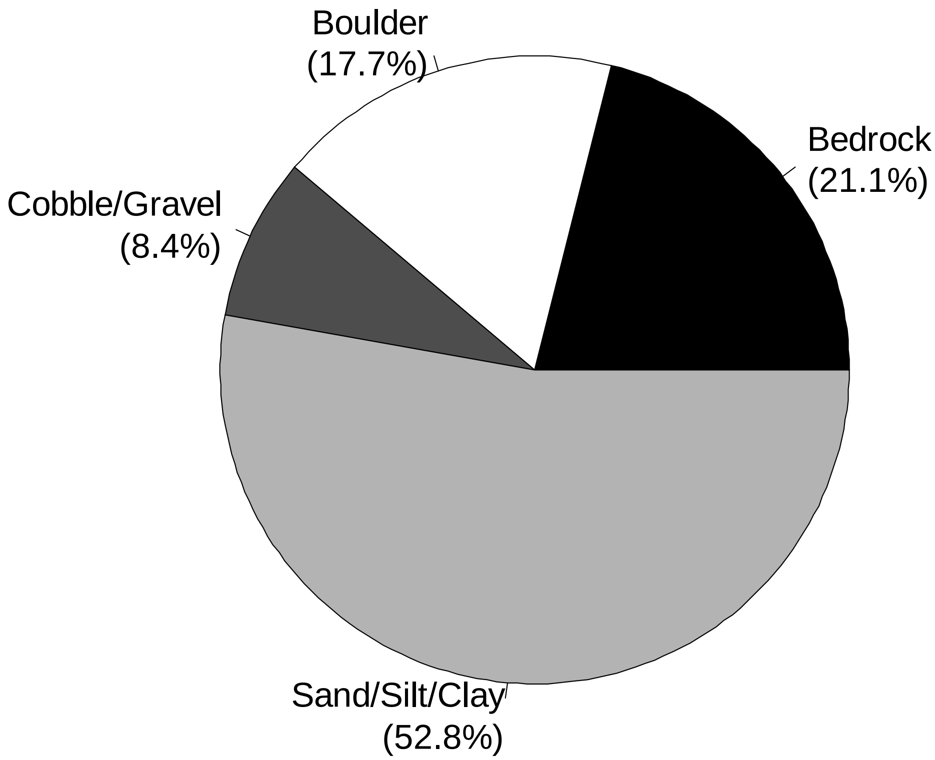
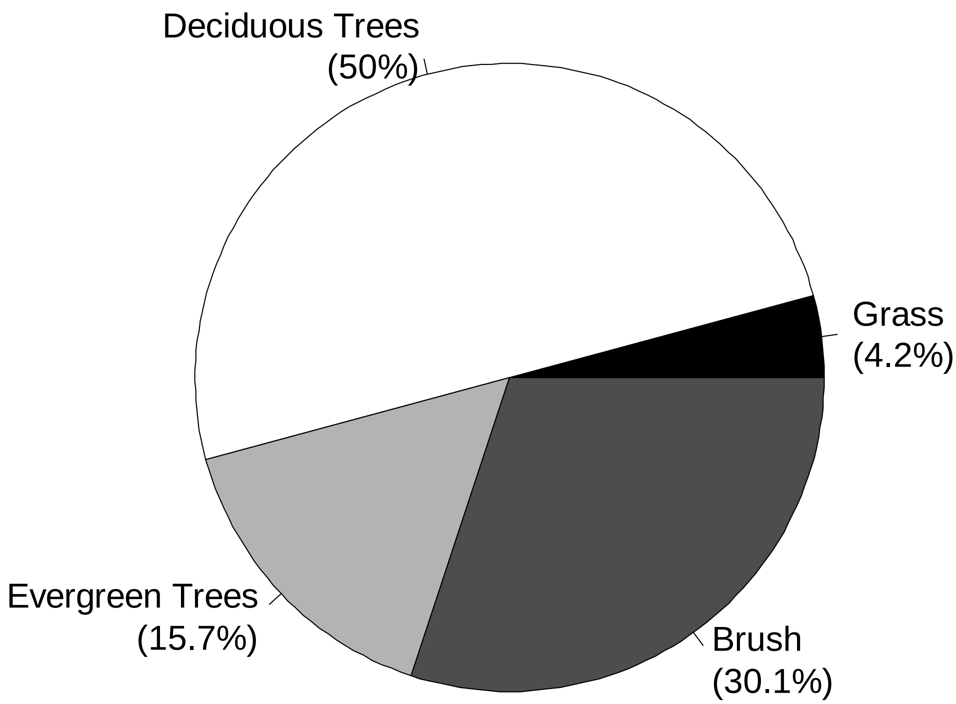


Figure 307. Percentage of banks by dominant vegetation type for Upper North Fork Matilija Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



Santa Ana Creek

Habitat Assessment

<u>Results</u>

The habitat inventory was conducted from 4 June to 9 June 2014 by Karissa Willits, Patrick Riparetti, Katherine McLaughlin, Patrick Saldaña, Tom Van Meeuwen, Megan Meyers, and Toby Moyneur from Pacific States Marine Fisheries Commission, Jill Taylor from the California Conservation Corps, and Kayti Christianson from the Watershed Stewards Program.. The survey extended 19,610 feet upstream from the survey start (34.40697°N, -119.33945°W). The survey endpoint (34.42891N, -119.33971°W) was the confluence of North Fork and West Fork Santa Ana (Figure 308). Separate habitat surveys were conducted in these reaches. Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 60 to 82°F. Air temperature ranged from 64 to 84°F.

Habitat type

Of the total number of habitat units surveyed (n =174 units), 20.7% of units were dry, 16.7% were flatwater units, 33.9% were pools, 27.0% were riffles and 1.7% were culverts. Of the total length of the reach surveyed, 67.9% was dry, 9.9% was composed of flatwater units, 10.6% was composed of pools, 11.2% was composed of riffles, and 0.3% was composed of culverts (Figure 309).

We identified 12 habitat types in Santa Ana Creek. Based on the frequency of units sampled, low gradient riffles (25.9%), mid-channel pools (21.8%), and dry units (20.7%) were the most common habitat types (Table 74). Based on total stream length, dry (67.9%), low-gradient riffles (10.7%), and runs (7.9%) composed the greatest stream lengths.

Pool Metrics

A total of 59 pools were identified within the survey reach. Main channel pools were most frequently encountered (69.5% of pool units sampled) and comprised 65.5% of the total length of all pools. Only main channel and scour pools were recorded; no backwater pools were observed.

Seven of the 59 pools (11.8%) had residual depths of three feet or greater (Figure 310).

Within pool tail-outs, boulders were the most frequently observed dominant substrate (55.9% of pool units), followed by small cobble (13.6%) and large cobble (11.9%; Figure 311).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (76.3%) or one (10.2%; Figure 312).

Shelter

Within 100% units (n = 46 units), riffle habitat types had a mean shelter rating of 70.5, flatwater habitat types had a mean shelter rating of 76.0, and pools had a mean shelter rating of 66.2.

Of the pool units in which shelter was assessed (n = 46 units), main channel pools had a mean shelter rating of 65.7 and scour pools had a mean shelter rating of 66.9.

When we examined the mean percentage of shelter by shelter type across all units, we found that boulders provided the most shelter (68.4% of all shelter; Figure 313), followed by aquatic vegetation (14.9% of all shelter). When we examined the percentage of shelter by shelter type within pools only (n = 27 units), we found that boulders were the most dominant cover type (61.1% of the total cover; Figure 314), followed by aquatic vegetation (20.6% of the total cover).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 73.8%. Within the canopy cover present, 92.9% of the canopy was composed of deciduous trees and 7.1% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were boulder (69.6%), silt/sand/clay (12.0%), bedrock (9.8%), and cobble/gravel (8.7%; Figure 315). The mean percentage of vegetation covering the right bank in sampled units was 50.4%, and the mean percentage of vegetation covering the left bank was 49.9%. Deciduous trees were the dominant vegetation type, having been observed in 46.7% of the banks surveyed. Additionally, 20.7% of the banks surveyed had brush, 18.5% had evergreen trees and 10.0% had grass as the dominant vegetation (Figure 316).

Large Woody Debris

We observed 11 pieces of LWD that were 6 to 20 feet long and four pieces that were greater than 20 feet long within 6227 feet of wetted stream length (excluding culvert and dry lengths). Across both LWD sizes, the number of LWD observed was 0.24 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 36.4 feet.

Discussion

Temperature

The water temperature of units measured ranged from 60 to 82°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Poor to Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools or riffles. Looking at more detailed habitat types, we found that units were most frequently low gradient riffles or mid-channel pools. When we examined the reach in terms of length, we found that most of the reach was dry.

Pool Metrics

Pool depth is an important indicator of habitat quality, as greater pool depths can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in Santa Ana, we found that only 12% of pools had residual depths of three feet or greater, the depth needed to be considered good habitat (Kier Associates & NMFS 2008). Thus, it appears that pools in Santa Ana may lack the depth needed to provide good hiding cover and rearing space. This may be due to severe drought conditions coupled with water removal for agriculture.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was boulder. Pool units most frequently had an embeddedness value of five. This indicates that the majority of pool tail-outs in Santa Ana creek are considered unsuitable for *O. mykiss* spawning.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of sampled riffle, flatwater, and pool units, we found that riffles, pools, and flatwaters had fairly similar shelter ratings. This suggests that these habitat types provide relatively equal quality *O. mykiss* habitat in Santa Ana Creek.

When we examined the percentage shelter by shelter type, we found the boulders provided the most shelter by far, suggesting that boulders are a common and important feature to *O. mykiss* habitat in Santa Ana Creek.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In Santa Ana Creek, we estimated a mean canopy cover of 73.8% across all units, consisting predominantly of deciduous trees. This suggests that Santa Ana has a moderately high amount of cover (Kier Associates & NMFS 2008), but this cover is likely to vary greatly through time, given the seasonality of deciduous trees. However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was boulder, followed by sand/silt/clay and bedrock. The mean percentage of vegetation covering the right and left banks was 50.4% and 49.9%, respectively. Deciduous trees were by far the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively protected from erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In Santa Ana Creek, we found 0.24 pieces of LWD per 100 feet, which was extremely low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while Santa Ana Creek lacks LWD, it has boulder elements that improve habitat quality. Specifically, boulders provided the greatest amount of shelter across all units in which shelter was assessed (68.4% of all shelter).

Tables

Table 74. Percentage of all units (n = 174) by habitat type for Santa Ana Creek.

Habitat Type	% of Units
Low Gradient Riffle	25.86%
Mid-Channel Pool	21.84%
Dry	20.69%
Run	14.37%
Lateral Scour Pool, bedrock-formed	4.60%
Lateral Scour Pool, boulder-formed	4.02%
Step Run	2.30%
Culvert	1.72%
High Gradient Riffle	1.15%
Step Pool	1.15%
Lateral Scour Pool, root wad enhanced	1.15%
Channel Confluence Pool	0.57%

<u>Figures</u>

Figure 308. Map of the habitat assessment survey area in Santa Ana Creek.

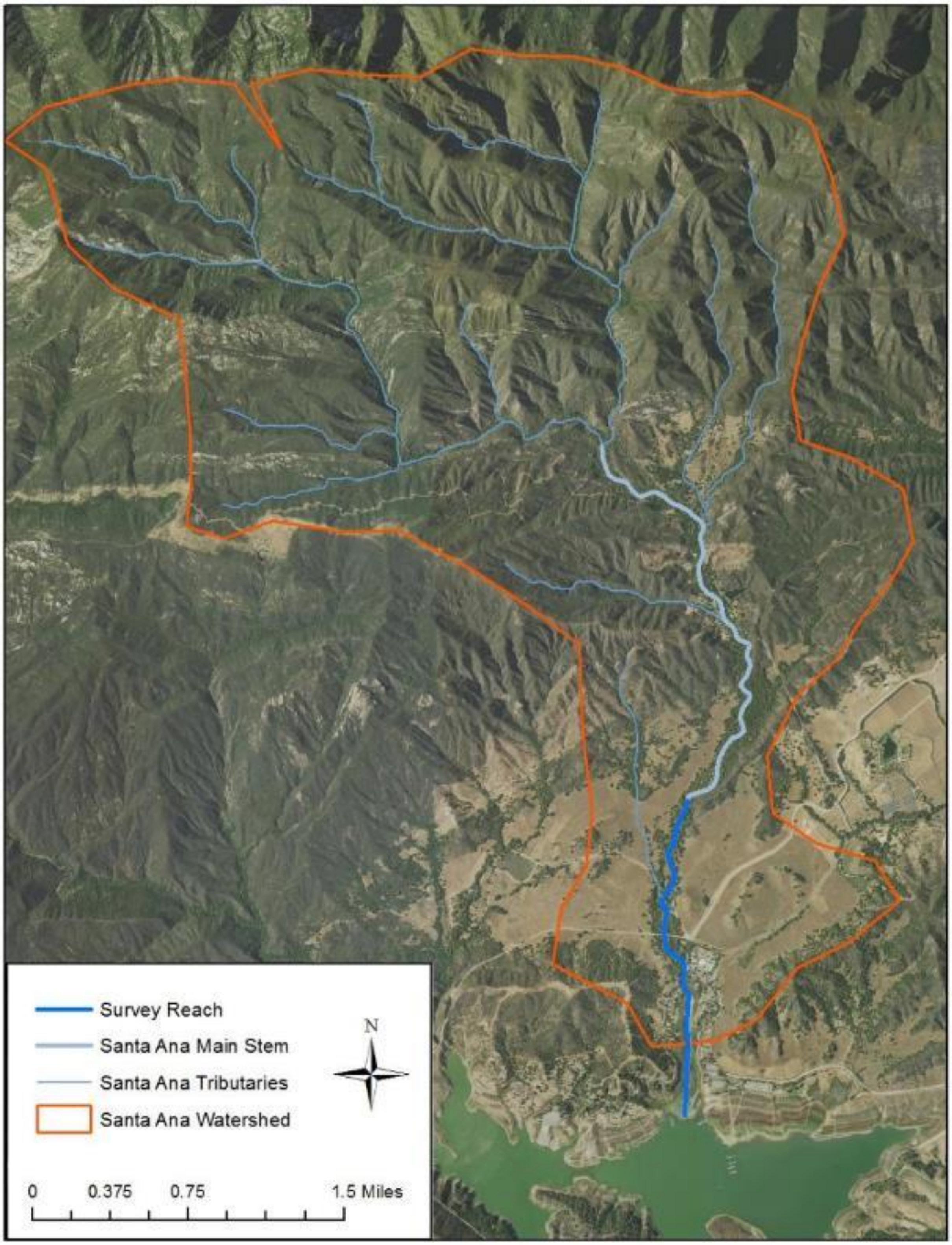


Figure 309. Percentage of total stream length categorized as pools, flatwaters, riffles, dry, or culverts for Santa Ana Creek.

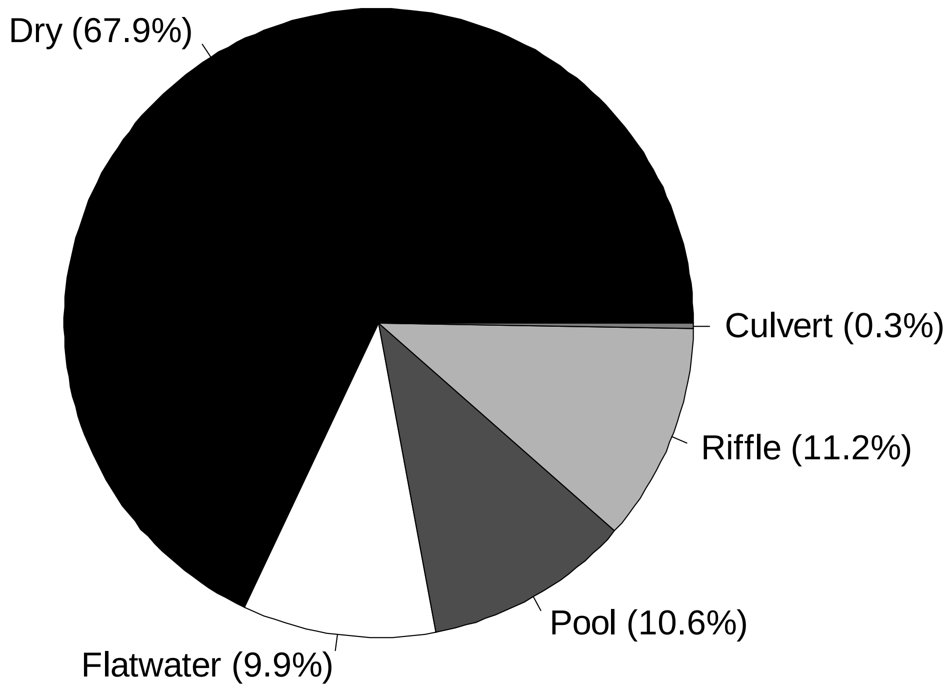


Figure 310. Histogram of residual pool depths in one-foot bins for Santa Ana Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

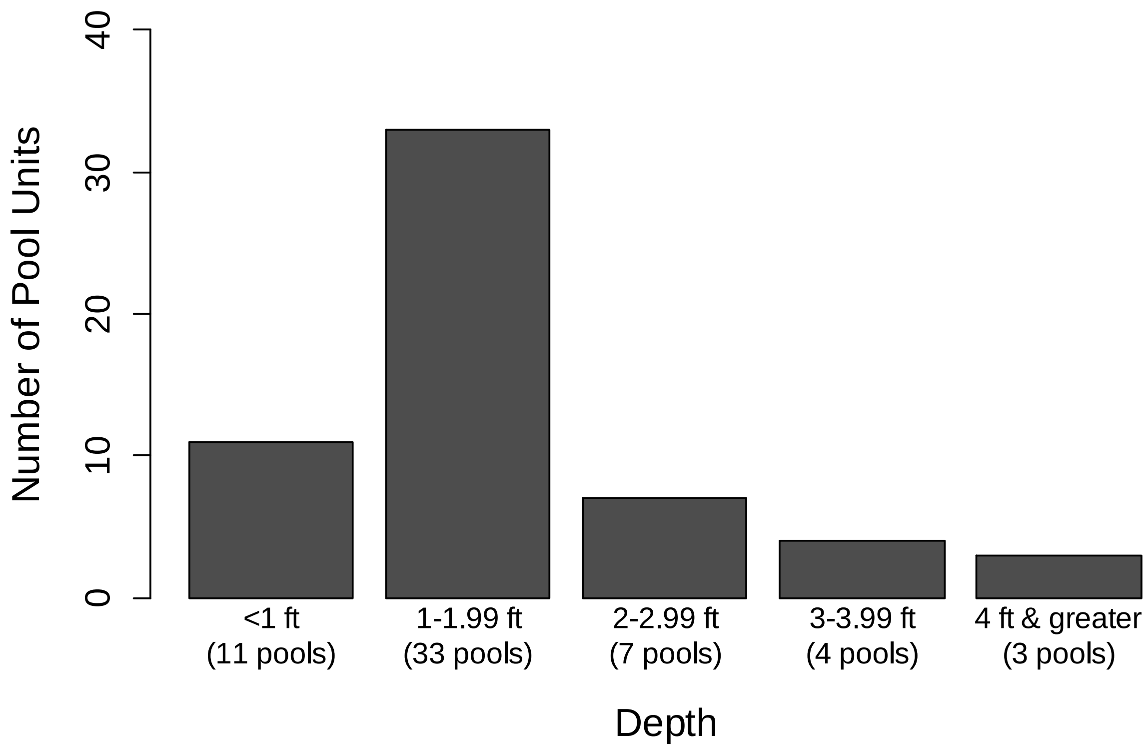


Figure 311. Percentage of pool tail-outs (n = 59 pools) by dominant substrate for Santa Ana Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

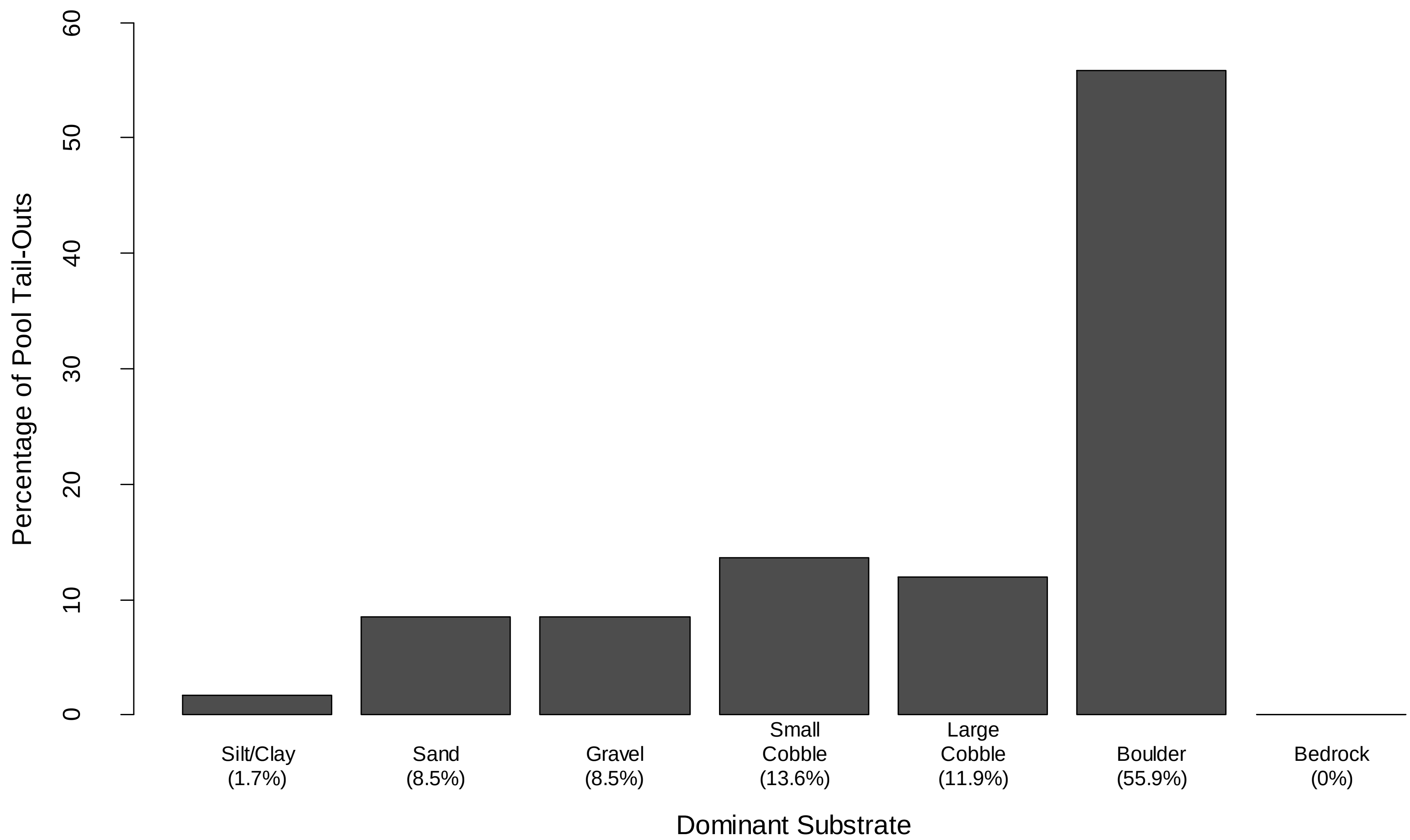


Figure 312. Percentage of all pool units (n = 59 pools) assigned a pool tail-out embeddedness value of 1 to 5 for Santa Ana Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning. In this survey, there were no pool tail-outs with an embeddedness value of four.

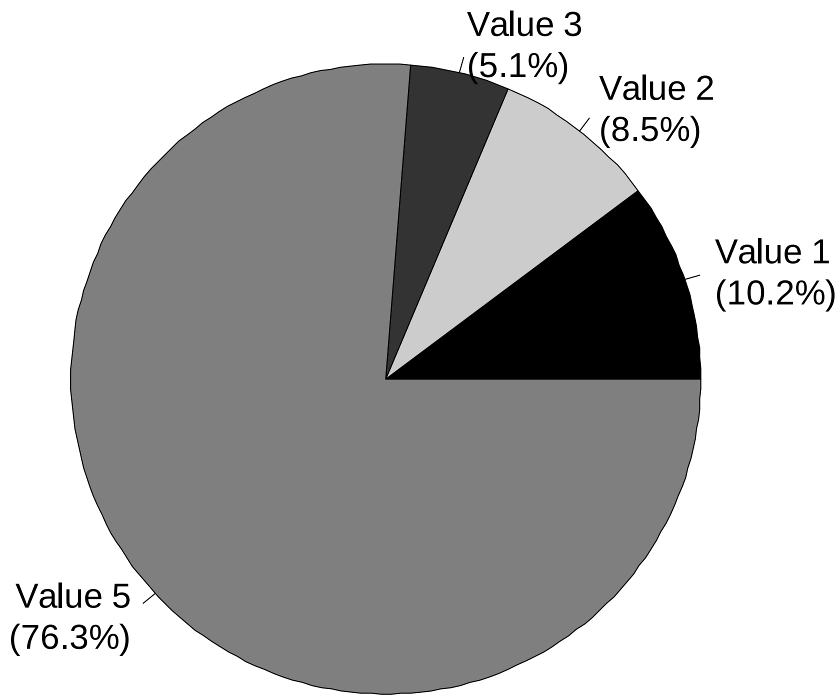


Figure 313. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 46 units) for Santa Ana Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

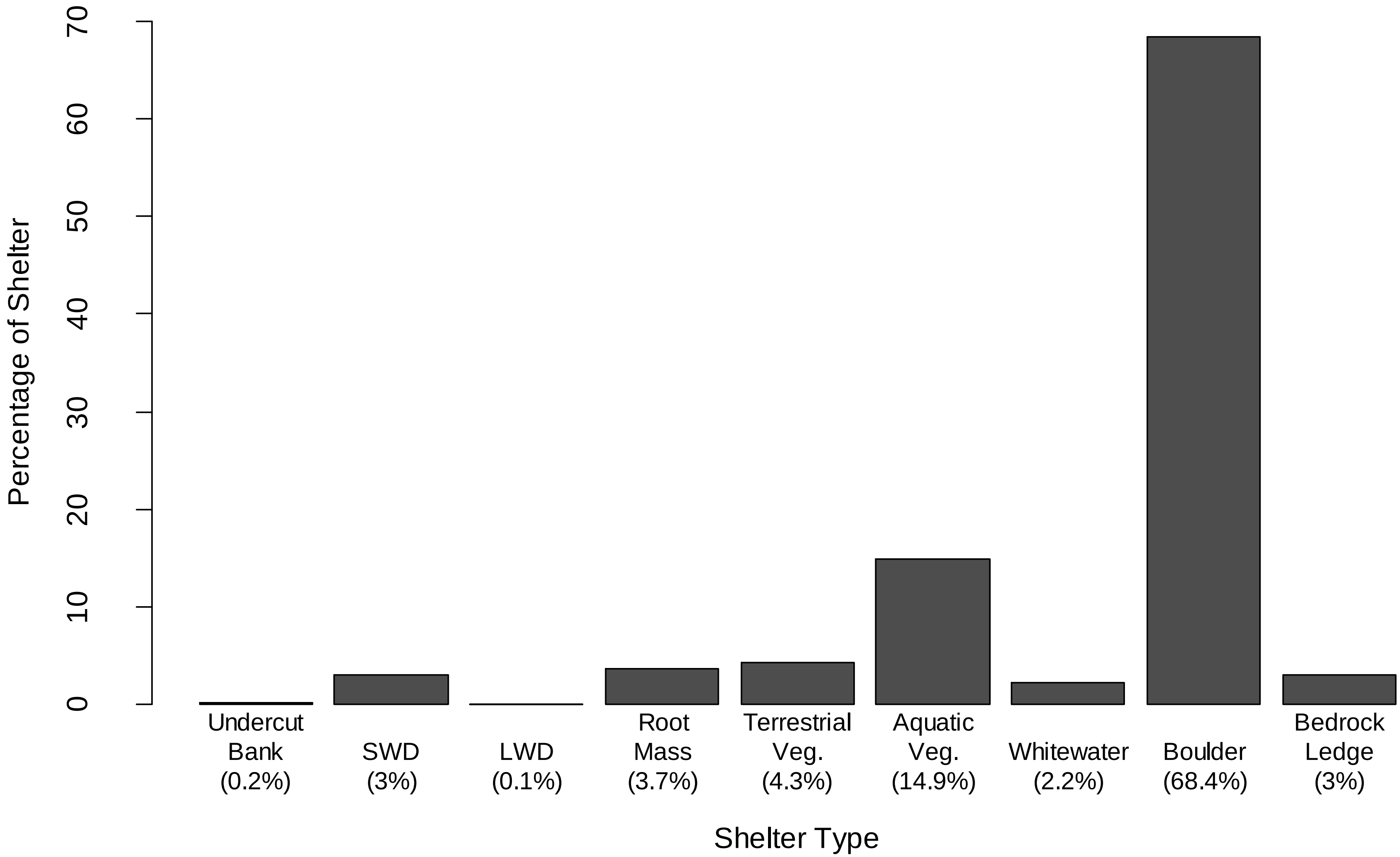


Figure 314. The percentage of instream shelter by shelter type across all pool units in which shelter was measured (n = 27 pools) for Santa Ana Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

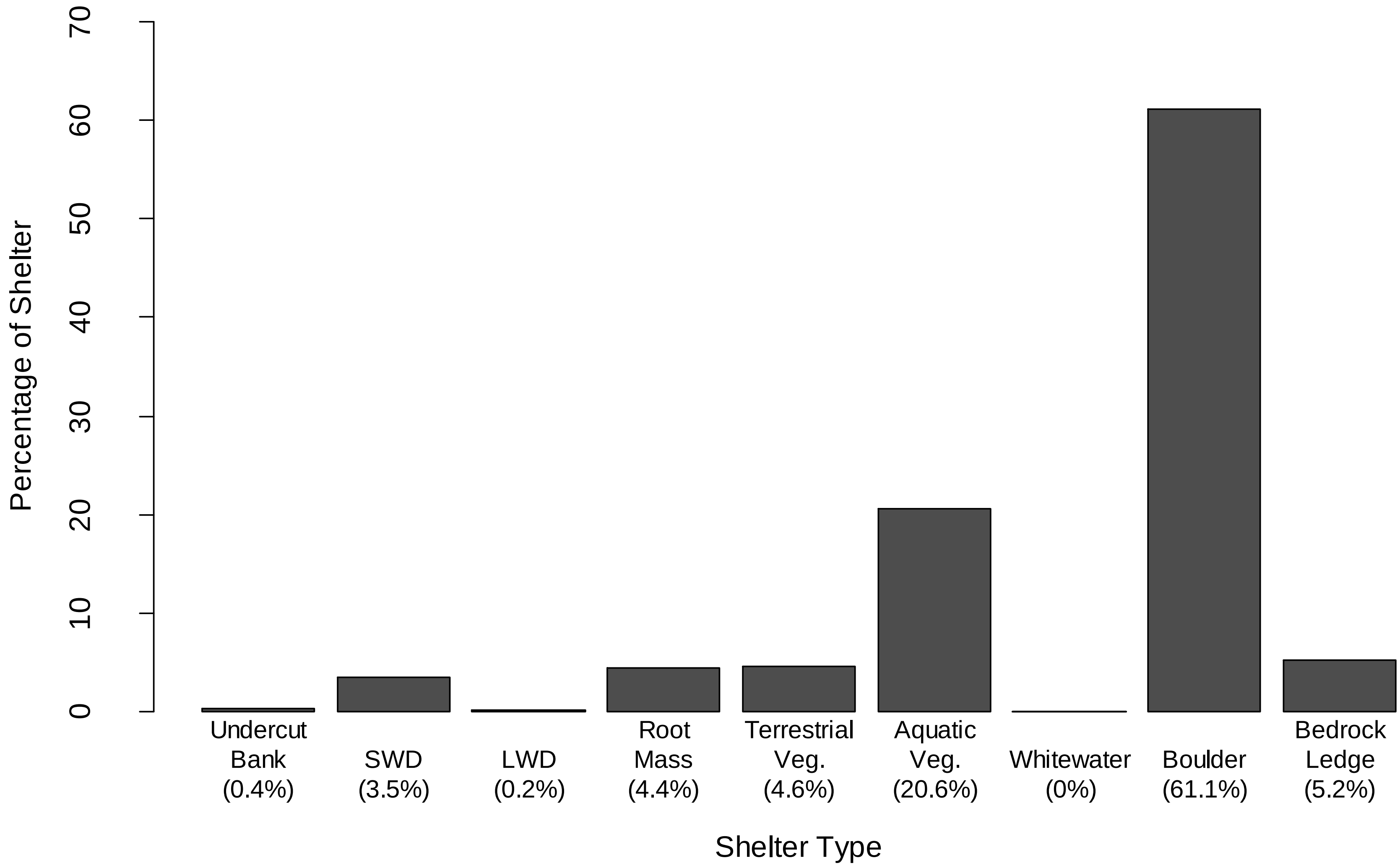


Figure 315. Percentage of banks by dominant substrate composition for Santa Ana Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock.

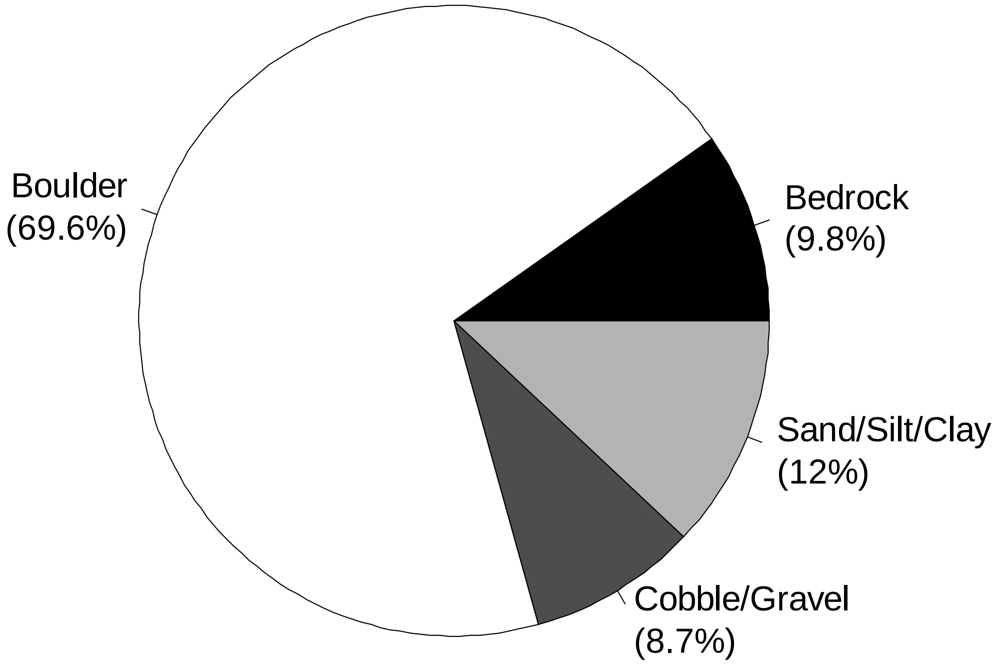
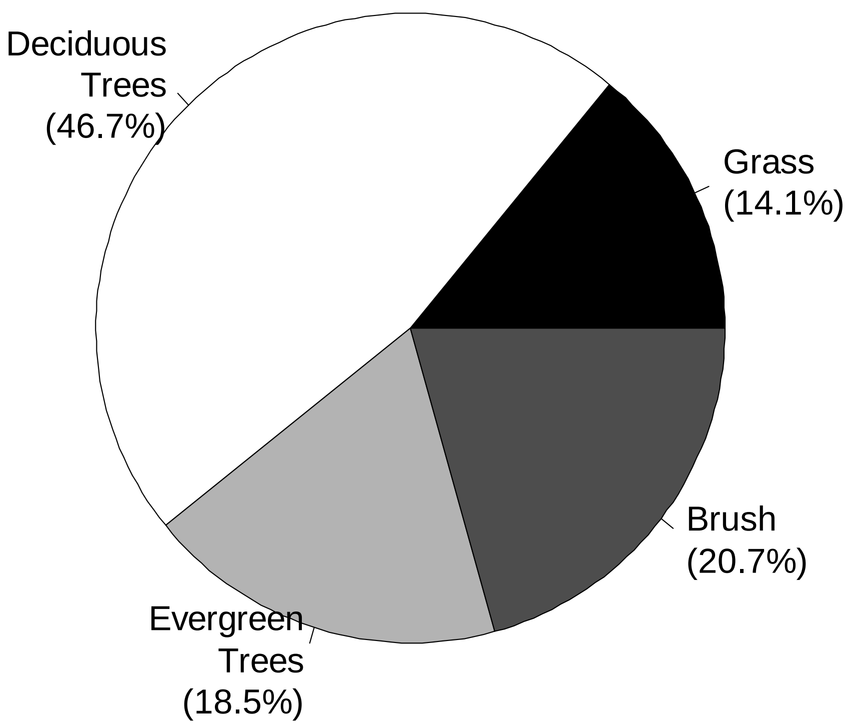


Figure 316. Percentage of banks by dominant vegetation type for Santa Ana Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



West Fork Santa Ana

Habitat Assessment

Results

The habitat inventory was conducted from 9 June to 13 June 2014 by Karissa Willits, Tom Van Meeuwan, Benjamin Lakish, Patrick Saldana, Toby Moyner, and Patrick Rippareti from Pacific States Marine Fisheries Commission and Yi-Jiun Tsai from the Watershed Stewards Program. The survey extended 5,492 feet upstream from the survey start (34.45369°N, -119.34657°W). The survey endpoint (34.45335°N, -119.36028°W) was determined due to accessibility issues, potential barriers, and no fish above the dry section (Figure 317). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 60 to 78°F. Air temperature ranged from 64 to 81°F.

Habitat type

Of the total number of habitat units surveyed (n = 88 units), 19.3% of units were dry, 9.1% were flatwaters, 40.9% were pools, and 30.7% were riffles. Of the total length of the reach surveyed, 64.5% was dry, 5.4% was composed of flatwaters, 17.3% was composed of pools, and 12.8% was composed of riffles (Figure 318).

We identified 13 habitat types in West Fork Santa Ana. Based on the frequency of units sampled, mid-channel pools (22.7%), dry units (19.3%), and low-gradient riffles (13.6%) were the most common habitat types (Table 75). Based on total stream length, dry (64.5%), mid-channel pools (8.2%), and low-gradient riffles (7.1%) composed the greatest stream lengths.

Pool Metrics

A total of 36 pools were identified within the survey reach. Main channel pools were most frequently encountered (72.2% of pool units sampled; Figure 319) and comprised 60.6% of the total length of all pools. Backwater pools represented 2.8% of pool units sampled and 2.1% of the surveyed length. In addition, scour pools were 25% of pool units sampled and 37.3% of the surveyed length.

Eight of 36 pools (22%) had residual depths of three feet or greater (Figure 320).

Within pool tail-outs, boulder was the most frequently observed dominant substrate (27.8% of pool units), followed by bedrock (22.2%) and sand (16.7%; Figure 321).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (80.6%) or two (11.1%; Figure 322).

Shelter

Within 100% units (n = 30 units), riffle habitat types had a mean shelter rating of 64.1, flatwater habitat types had a mean shelter rating of 90.0, and pools had a mean shelter rating of 93.1.

Of the pool units in which shelter was assessed (n = 16 units), main channel pools had a mean shelter rating of 95.0, scour pools had a mean shelter rating of 74.3, and backwater pools had a mean shelter rating of 210.0.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that boulders provided the most shelter (61% of all shelter; Figure 323). When we examined the percentage of shelter by shelter type within pools only, we found that boulders were the most dominant cover type (60.3% of the total cover), followed by aquatic vegetation (19.4%; Figure 324)

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 81.1%. Within the canopy cover present, 88.0% of the canopy was composed of deciduous trees and 12.0% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were boulder (58.1%), bedrock (37.1%), and silt/sand/clay (4.8%; Figure 325). The mean percentage of vegetation covering the right bank in sampled units was 62.9%, and the mean percentage of vegetation covering the left bank was 37.8%. Brush was the dominant vegetation type, having been observed in 46.8% of the banks surveyed. Additionally, 43.5% of the banks surveyed had hardwood trees and 6.5% had coniferous trees as the dominant vegetation (Figure 326).

Large Woody Debris

We observed 11 pieces of LWD that were 6 to 20 feet long and 19 pieces that were greater than 20 feet long within 1952 feet of wetted stream length. Across both LWD sizes, the number of LWD observed was 1.54 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 38.5 feet .

Discussion

Temperature

The water temperature of units measured ranged from 60 to 78°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Poor to Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were pools or riffles. Looking at more detailed habitat types, we found that units were most frequently mid-channel pools or dry sections. When we examined the reach in terms of length, we found that most of the reach was dry or pools, with mid-channel pools comprising the greatest percentage of wetted stream length.

Pool Metrics

Pool depth is an important indicator habitat quality, as greater pool depths can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). A residual depth of at least three feet is needed to be considered good habitat (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in West Fork Santa Ana, we found that 22% of pools had residual depths greater than three feet. Thus, it appears that some pools in West Fork Santa Ana may provide good hiding cover and rearing space.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was boulder, comprising 27.8% of pool units. Pool units most frequently had an embeddedness value of either a five or two. Together, these metrics suggest that pools in Santa Ana West Fork may not provide good spawning habitat for *O. mykiss*.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage.

When examining pool habitat units specifically, we found that backwater pools had the highest shelter rating, followed by main channel pools and then scour pools. While it may initially appear that backwater pools provided the best salmonid habitat based on these shelter ratings, this may not actually be the case when considering that there were only eight backwater pool units.

When we examined the percentage shelter by shelter type, we found the boulders provided the most shelter by far (61.0% of all shelter), suggesting that boulders are a common and important feature to *O. mykiss* habitat in West Fork Santa Ana.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In West Fork Santa Ana, we estimated a mean canopy cover of 81.1% across all sampled units, consisting predominantly of deciduous trees. This suggests that West Fork Santa Ana has a moderately high amount of cover (Kier Associates & NMFS 2008), but this cover is likely to vary greatly through time, given the seasonality of deciduous trees. However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was boulder, followed by bedrock. The mean percentage of vegetation covering the right and left banks was 62.9% and 37.8%, respectively. Brush and deciduous trees were the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively protected from erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In West Fork Santa Ana, we found 1.54 pieces of LWD per 100 feet, which was low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while West Fork Santa Ana lacks LWD, it has boulder elements that improve habitat quality. Specifically, boulders provide the greatest amount of shelter across all units in which shelter was assessed (61.0% of all shelter).

Tables

Table 75. Percentage of units (n = 88) by habitat type for West Fork Santa Ana Creek.

Habitat Type	% of Units
Mid Channel Pool	22.73%
Dry	19.32%
Low Gradient Riffle	13.64%
Bedrock Sheet	9.09%
Run	9.09%
High Gradient Riffle	6.82%
Trench Pool	5.68%
Lateral Scour, bedrock-formed	5.68%
Lateral Scour, boulder-formed	2.27%
Plunge Pool	2.27%
Cascade	1.14%
Step Pool	1.14%
Dammed Pool	1.14%

Figures

Figure 317. Map of the habitat assessment survey area in West Fork Santa Ana Creek.

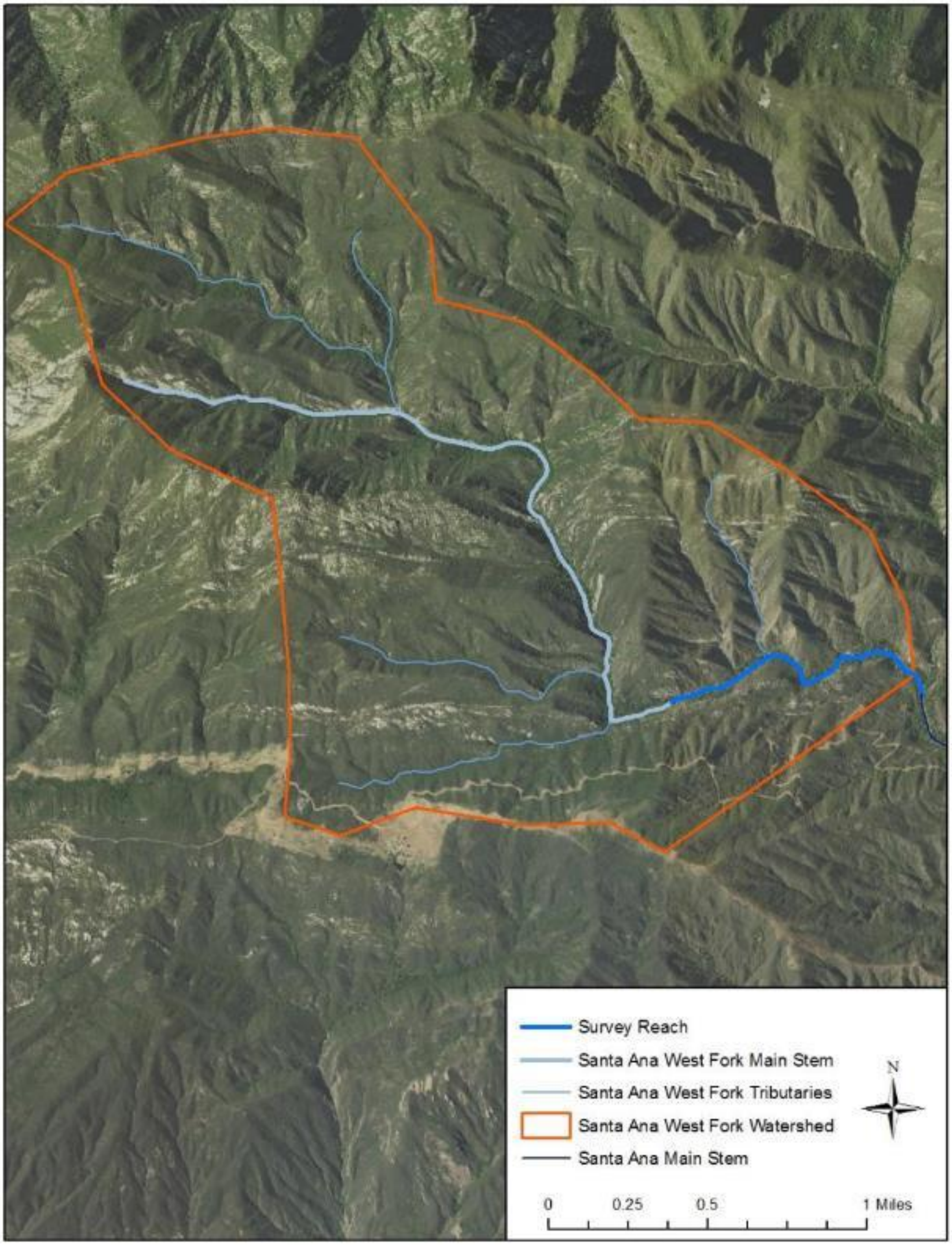


Figure 318. Percentage of total stream length categorized as pools, flatwaters, riffles, or dry for West Fork Santa Ana Creek.

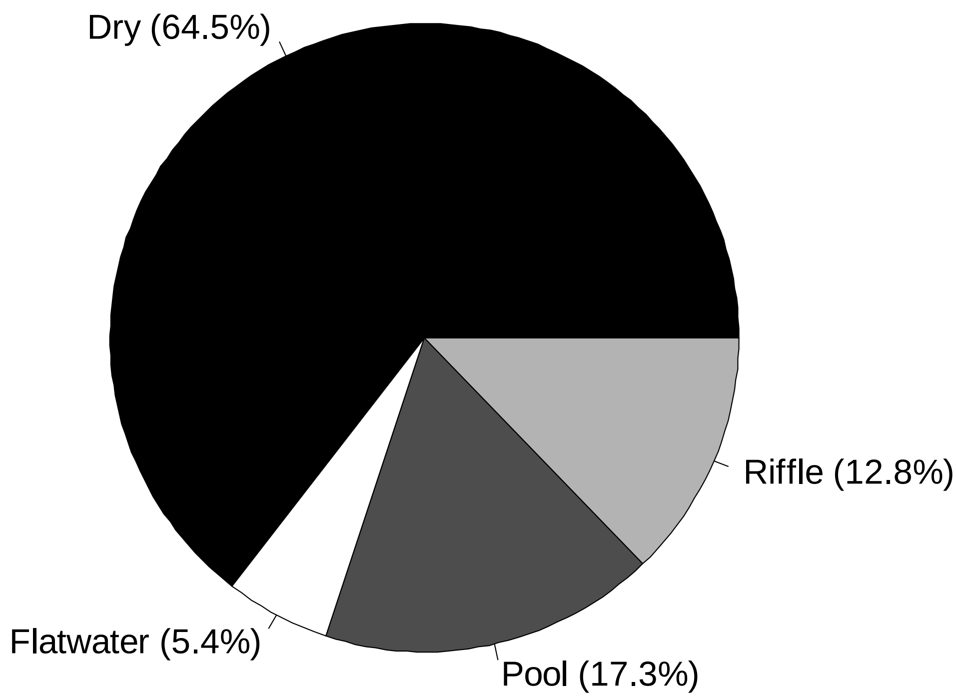


Figure 319. Percentage of all pool units (n = 36 pools) categorized by pool type (main channel, backwater, or scour pool) for West Fork Santa Ana Creek.

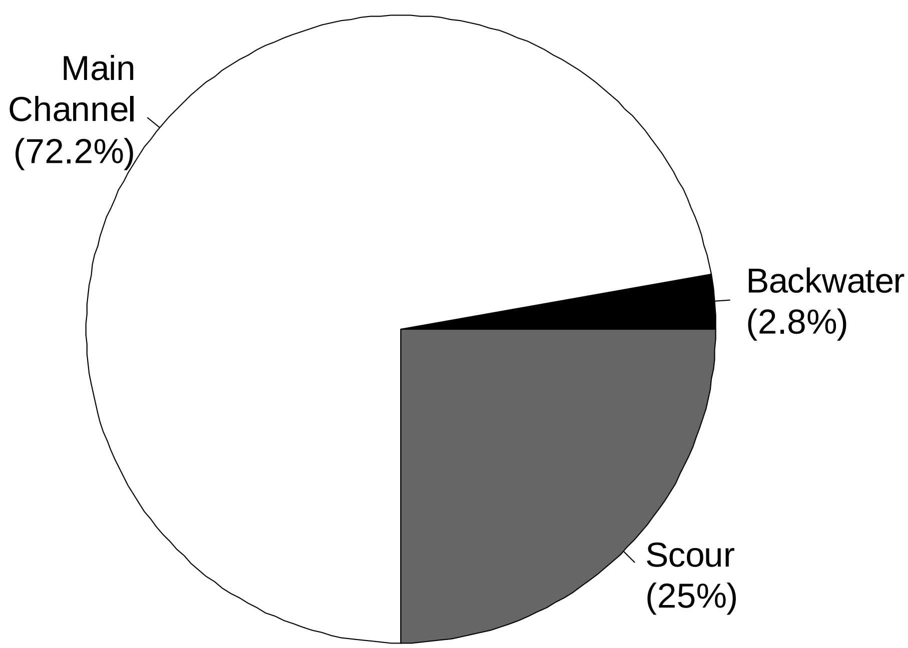


Figure 320. Histogram of residual pool depths in one-foot bins for West Fork Santa Ana Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

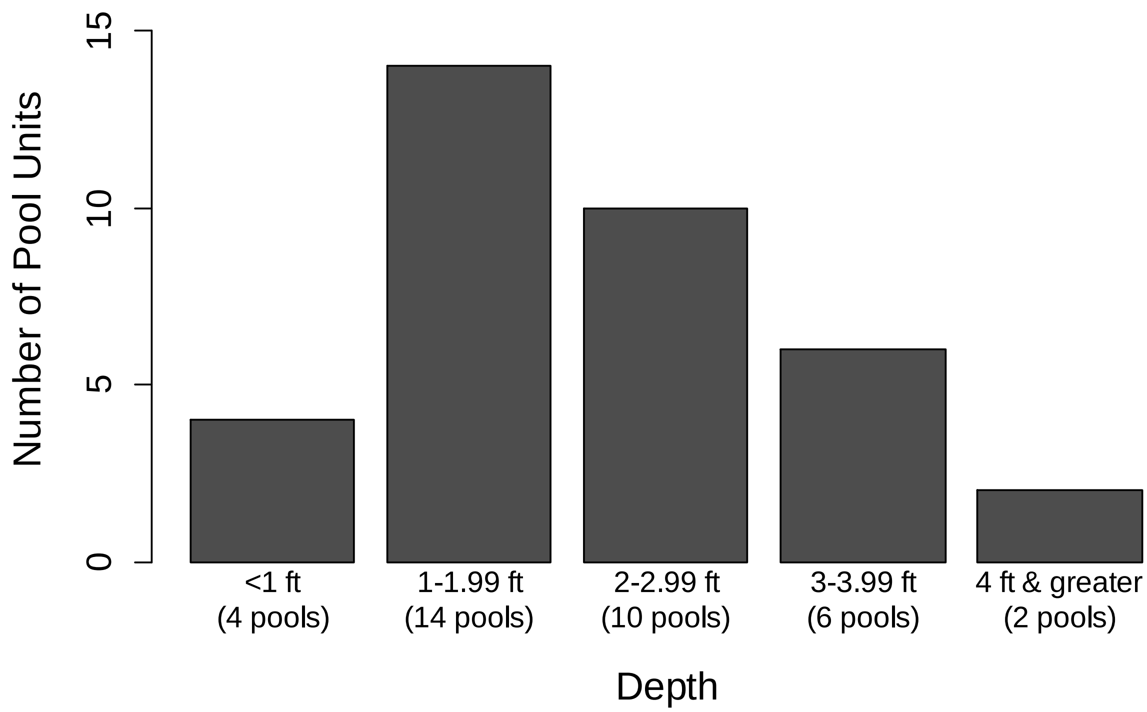


Figure 321. Percentage of pool tail-outs (n = 36 pools) by dominant substrate for West Fork Santa Ana Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

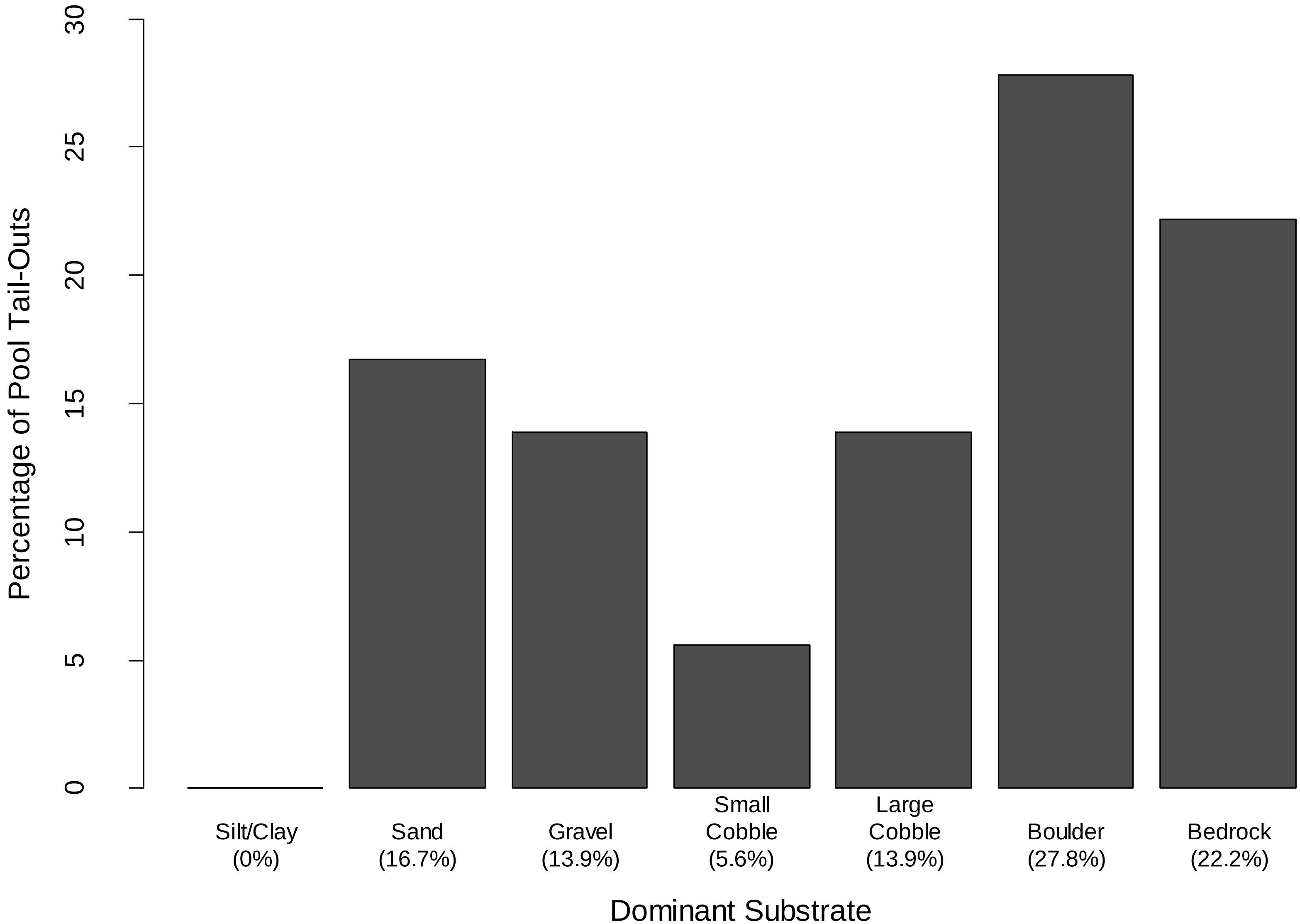


Figure 322. Percentage of all pool units (n = 36 pools) assigned a pool tail-out embeddedness value of 1 to 5 for West Fork Santa Ana Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning. In this survey, no pool tail-outs had an embeddedness value of four.

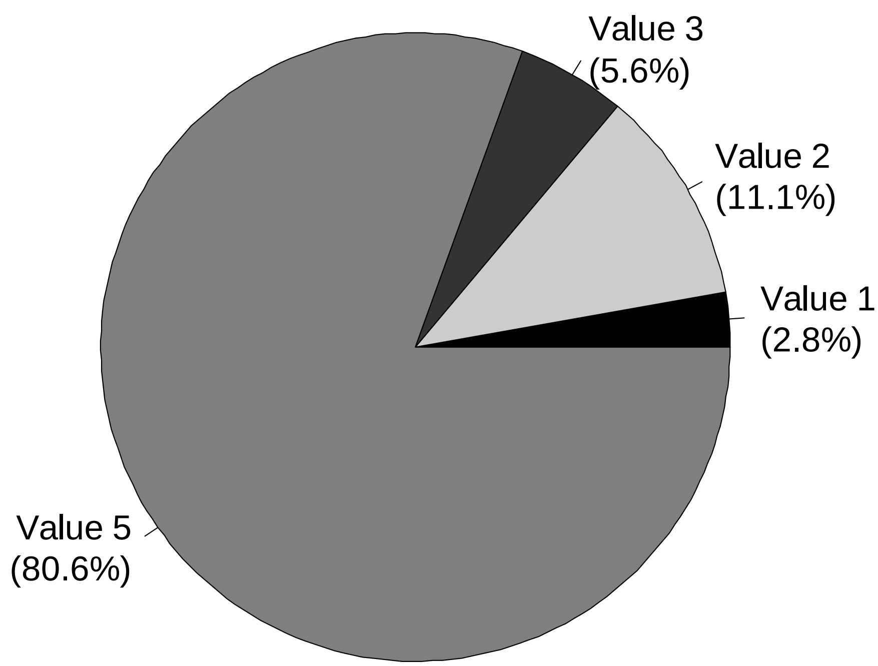


Figure 323. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 30 units) for West Fork Santa Ana Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

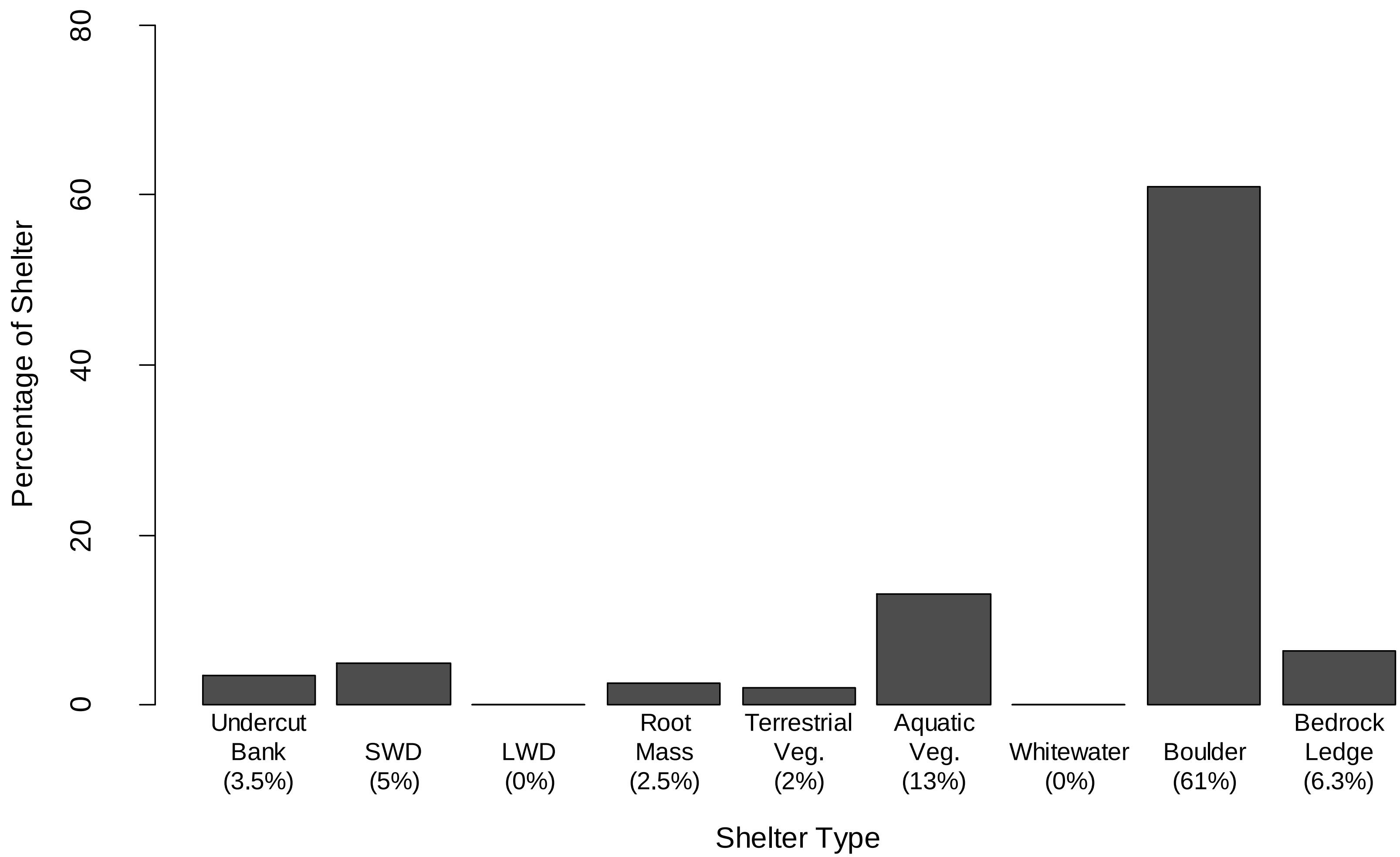


Figure 324. The percentage of shelter by shelter type across all pool units in which shelter was measured (n = 16 pools) for West Fork Santa Ana Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

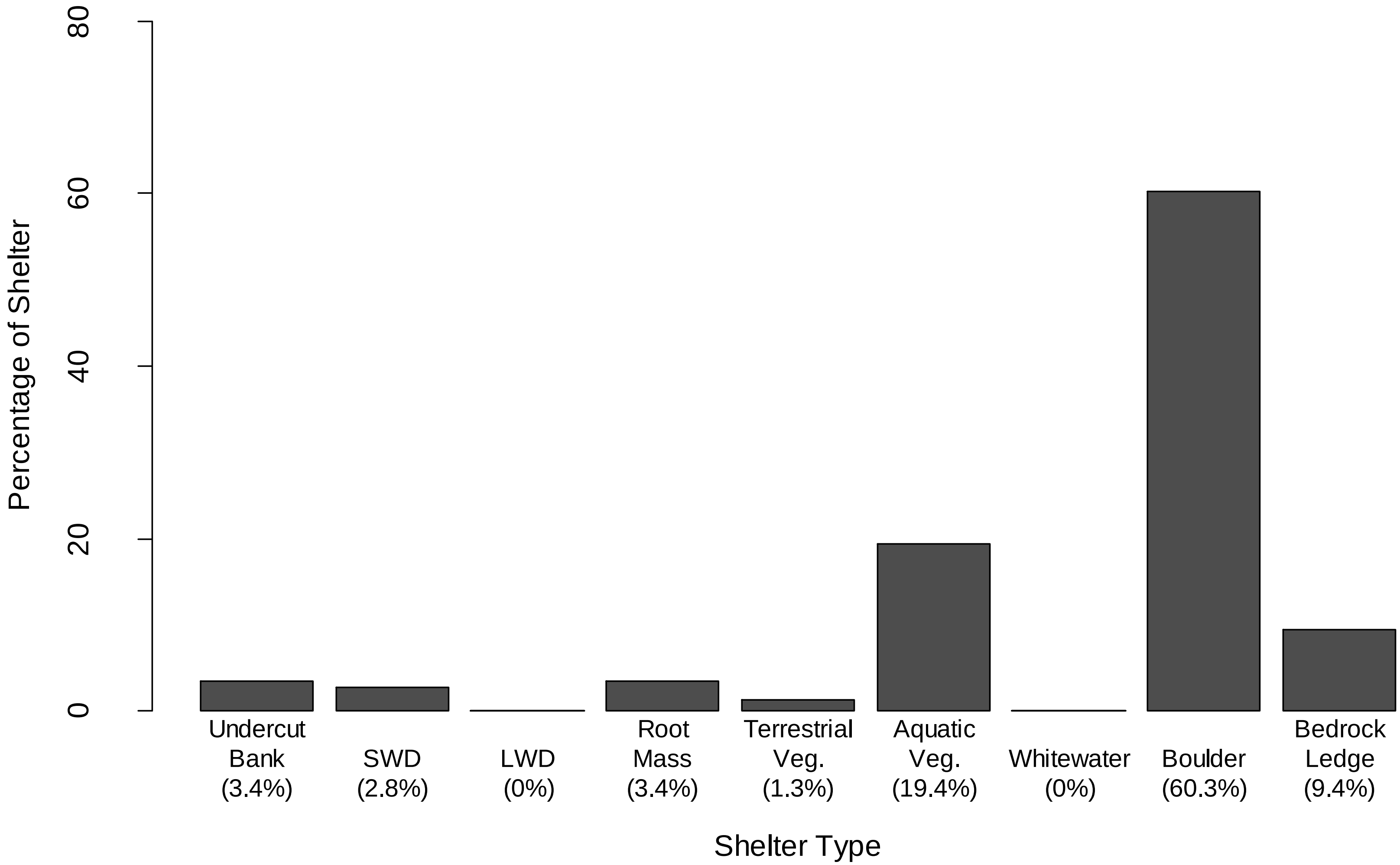


Figure 325. Percentage of banks by dominant substrate composition for West Fork Santa Ana Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock.

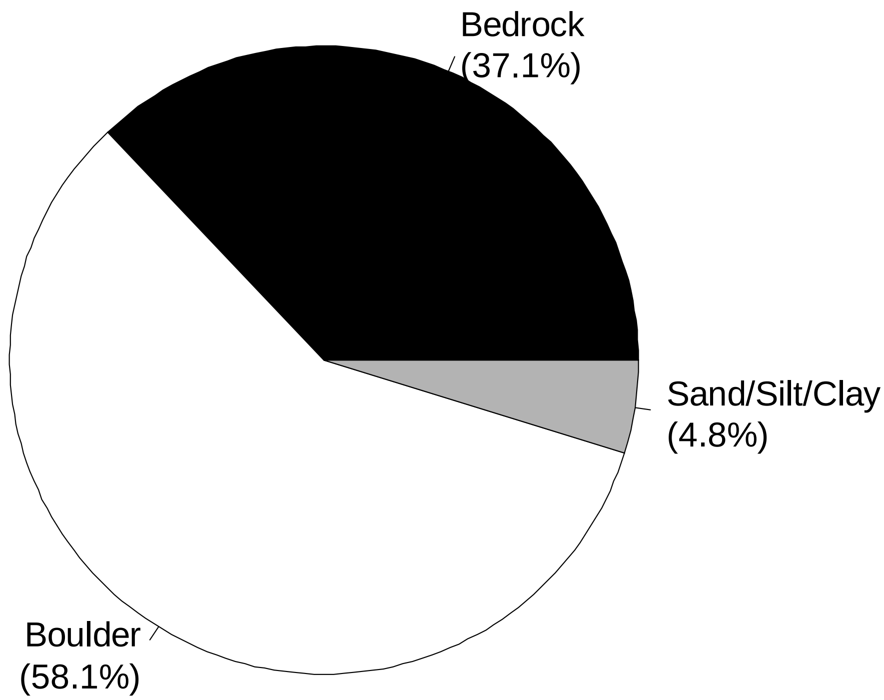
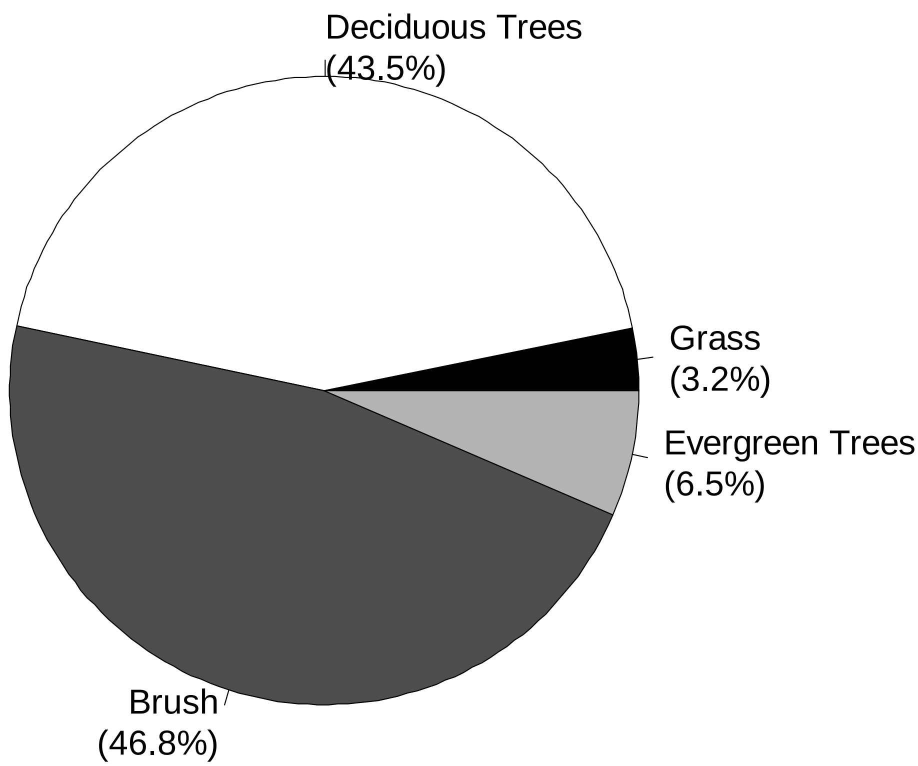


Figure 326. Percentage of banks by dominant vegetation type for West Fork Santa Ana Creek. Vegetation types included deciduous trees, evergreen trees, grass, and brush.



North Fork Santa Ana Creek

Habitat Assessment

<u>Results</u>

The habitat inventory was conducted from 16 to 23 June 2014 by Karissa Willits, Kate McLaughlin, and Ben Lakish from the Pacific States Marine Fisheries Commission, Kayti Christianson from the Watershed Stewards Program, and Jill Taylor from the California Conservation Corps in Camarillo. The survey extended 5,693 feet upstream from the survey start (34.45370°N, -119.34657°W). The survey endpoint (34.46489 °N, -119.34566°W) was where the stream went dry (Figure 327). Stream flow was not measured.

Temperature

Water temperatures taken during the survey period ranged from 60 to 72°F. Air temperature ranged from 56 to 72°F.

Habitat type

Of the total number of habitat units surveyed (n = 119 units*),* 6.7% of units were dry, 17.6% were flatwaters, 35.3% were pools, and 40.3% were riffles. Of the total length of the reach surveyed, 36.6% was dry, 19.8% was composed of flatwaters, 19.6% was composed of pools, and 24.0% was composed of riffles (Figure 328).

We identified 14 habitat types in North Fork Santa Ana Creek. Step runs (13.5%), mid-channel pools (12.6%), low gradient riffles (11.8%), high gradient riffles (11.8%), and bedrock sheets (11.8%) were the most frequently encountered habitat types (Table 76). Dry (36.6%) and step runs (16.4%) composed the greatest stream lengths.

Pool Metrics

A total of 42 pools were identified within the survey reach. Main channel pools were most frequently encountered (66.7% of pool units sampled; Figure 329) and comprised 72.3% of the total length of all pools.

Fourteen of the measured pools (35.0%) had residual depths of three feet or greater (Figure 330).

Within pool tail-outs, boulders were the most frequently observed dominant substrate (32.5% of pool units), followed by bedrock (25.0%) and small cobble (12.5%; Figure 331).

When we examined pool tail-outs for substrate embeddedness, we found that pools most frequently had embeddedness values of five (80.0%) or three (10.0%; Figure 332).

Shelter

Within 100% units (n = 39 units), riffle habitat types had a mean shelter rating of 50.0, flatwater habitat types had a mean shelter rating of 56.7, and pools had a mean shelter rating of 65.8.

Of the pool units in which shelter was assessed (n = 19 units), main channel pools had a mean shelter rating of 61.8, scour pools had a mean shelter rating of 66.7, and backwater pools had a mean shelter rating of 85.0.

When we examined the mean percentage of shelter by shelter type across all 100% units, we found that boulders provided the most shelter (45.5% of all shelter; Figure 333). When we examined the percentage of shelter by shelter type within pools only, we found that boulders were the most dominant cover type (44.7% of the total cover), followed by bedrock ledges (17.4%; Figure 334).

Canopy Cover

Across the units sampled for canopy cover, the mean percentage of canopy was 87.5%. Within the canopy cover present, 92.1% of the canopy was composed of deciduous trees and 7.8% of evergreen.

Bankside Metrics

Across the units sampled for bankside metrics, the dominant substrates composing stream banks (both right and left) were boulder (48.7%), bedrock (47.4%), cobble/gravel (2.6%), and silt/sand/clay (1.3%; Figure 335). The mean percentage of vegetation covering the right bank in sampled units was 49.1%, and the mean percentage of vegetation covering the left bank was 51.9%. Brush was the dominant vegetation type, having been observed in 72.4% of the banks surveyed. Additionally, 18.4% of the banks surveyed had deciduous trees, 6.6% had grass as the dominant vegetation (Figure 336).

Large Woody Debris

We observed 15 pieces of LWD that were 6 to 20 feet long and 17 pieces that were greater than 20 feet long within 3611 feet of wetted stream length. Across both LWD sizes, the number of LWD observed was 0.89 pieces per 100 feet of wetted length.

Bankfull

The mean bankfull width across the reach sampled was 26.8 feet.

Discussion

Temperature

The water temperature of units measured ranged from 60 to 72°F. According to the Guide to the Reference Value Used in South-Central and Southern California Coast Steelhead Conservation Action Planning workbooks (Keir & Associates and NMFS 2008), these temperatures were within the Good to Very Good range for California steelhead. However, these results are limited in scope, and more continuous water temperatures taken in various habitat types are needed to better understand daily and seasonal temperature fluctuations that may affect *O. mykiss* survival and habitat use.

Habitat Type

When examining the surveyed reach in terms of pool, flatwater, and riffle frequency, we found that most units were riffles or pools. Looking at more detailed habitat types, we found that units were most frequently step runs, mid-channel pools, high gradient riffles, and low gradient riffles. When we examined the reach in terms of length, we found that most of the reach was dry and that step runs comprised the greatest percentage of wetted stream length.

Pool Metrics

Pool depth is an important indicator of habitat quality, as greater pool depths can provide hiding cover and rearing space for salmonids (Kier Associates & NMFS 2008). A residual depth of at least three feet is needed to be considered good habitat (Kier Associates & NMFS 2008). When we examined the habitat metrics for pools in North Fork Santa Ana, we found that 35% of pools had residual depths of at least three feet. Thus, it appears that, although some pools in North Fork Santa Ana may be deep enough to provide good hiding cover and rearing space for *O. mykiss*, most lack the depth needed to provide this type of habitat.

The tail-outs of pools are often used for spawning by salmonids (Kier Associates & NMFS 2008). Based on this, substrate availability and embeddedness at pool tail-outs was used as an indicator of spawning habitat quality. We found that the dominant substrate in most pool tail-outs was boulder, comprising 32.5% of pool units. Pool units most frequently had an embeddedness value of five. These metrics suggest that pool tail-outs in North Fork Santa Ana are not ideal for salmonid spawning.

Shelter

Instream shelter is critical to *O. mykiss* in providing cover from predation, reducing water velocity to provide refugia, or separating territorial units to reduce competition among juvenile *O. mykiss*. In this inventory, we used shelter rating as a measure of habitat complexity and coverage. When we examined the shelter ratings of all riffle, flatwater, and pool units, we found that pools had the highest mean shelter rating, suggesting that pools provide better shelter for *O. mykiss* than riffles or flatwater units in this system.

When examining pool habitat units specifically, we found that backwater pools had the highest shelter rating, followed by scour and then main channel pools, suggesting that backwater pools provide the best salmonid habitat in this reach.

When we examined the percentage shelter by shelter type, we found the boulders provided the most shelter by far (45.5% of all shelter across all 100% units), suggesting that boulders are a common and important feature to *O. mykiss* habitat in North Fork Santa Ana.

Canopy Cover

Canopy cover is important to regulating the water temperature of streams (Kier Associates & NMFS 2008). In North Fork Santa Ana, we estimated a mean canopy cover of 87.5%, consisting predominantly of deciduous trees. This suggests that North Fork Santa Ana has a moderately high amount of cover (Kier Associates & NMFS 2008), but this cover is likely to vary greatly through time, given the seasonality of deciduous trees. However, more permanent boulder elements common to southern California stream systems may supplement shelter provided by canopy, thereby providing adequate cover for *O. mykiss* (Kier Associates & NMFS 2008).

Bankside Metrics

The predominant substrate composing stream banksides was boulder, followed by bedrock. The mean percentage of vegetation covering the right and left banks was 49% and 52%, respectively. Brush was the most common dominant vegetation observed. Together these bankside metrics suggest that these banks may be relatively protected from erosion resulting from large flow events.

Large Woody Debris

LWD plays an important role in forming pools, retaining organic matter and nutrients, transporting and storing sediment, and changing sediment size, which results in increased stream productivity, spawning habitat availability, and cover from predators and high flow (reviewed by Negishi & Richardson 2003; Thompson et al. 2008; Roni et al. 2015). LWD is therefore generally considered to be critical to healthy salmonid systems. In North Fork Santa Ana Creek, we found 0.89 pieces of LWD per 100 feet, which was low compared to the amount reported in northern systems (e.g., Fox & Bolton 2007). However, recent literature suggests that LWD may not be as important in southern California, where large wood species are generally lacking (Boughton et al. 2009; Thompson et al. 2012; Sloat & Osterback 2013; Keller, Bean, & Best 2015). Instead, boulders are thought to play a more critical role in southern California where streams are dominated by boulder elements (Boughton et al. 2009; Thompson et al. 2012; Keller, Bean, & Best 2015). Thus, while North Fork Santa Ana lacks LWD, it has boulder elements that improve habitat quality. Specifically, boulders provided the greatest amount of shelter across all units in which shelter was sampled (45.5% of all shelter).

Tables

Table 76. Percentage of all units (n = 119 units) by habitat type for North Fork Santa Ana Creek.

Habitat Type	% of units
Step Run	13.45%
Mid Channel Pool	12.61%
Low Gradient Riffle	11.76%
High Gradient Riffle	11.76%
Bedrock Sheet	11.76%
Step Pool	8.40%
Dry	6.72%
Cascade	5.04%
Plunge Pool	5.04%
Run	4.20%
Lateral Scour Pool, bedrock formed	3.36%
Trench Pool	2.52%
Dammed Pool	2.52%
Lateral Scour Pool, root wad enhanced	0.84%

Figures

Figure 327. Map of the habitat assessment survey area in North Fork Santa Ana Creek.

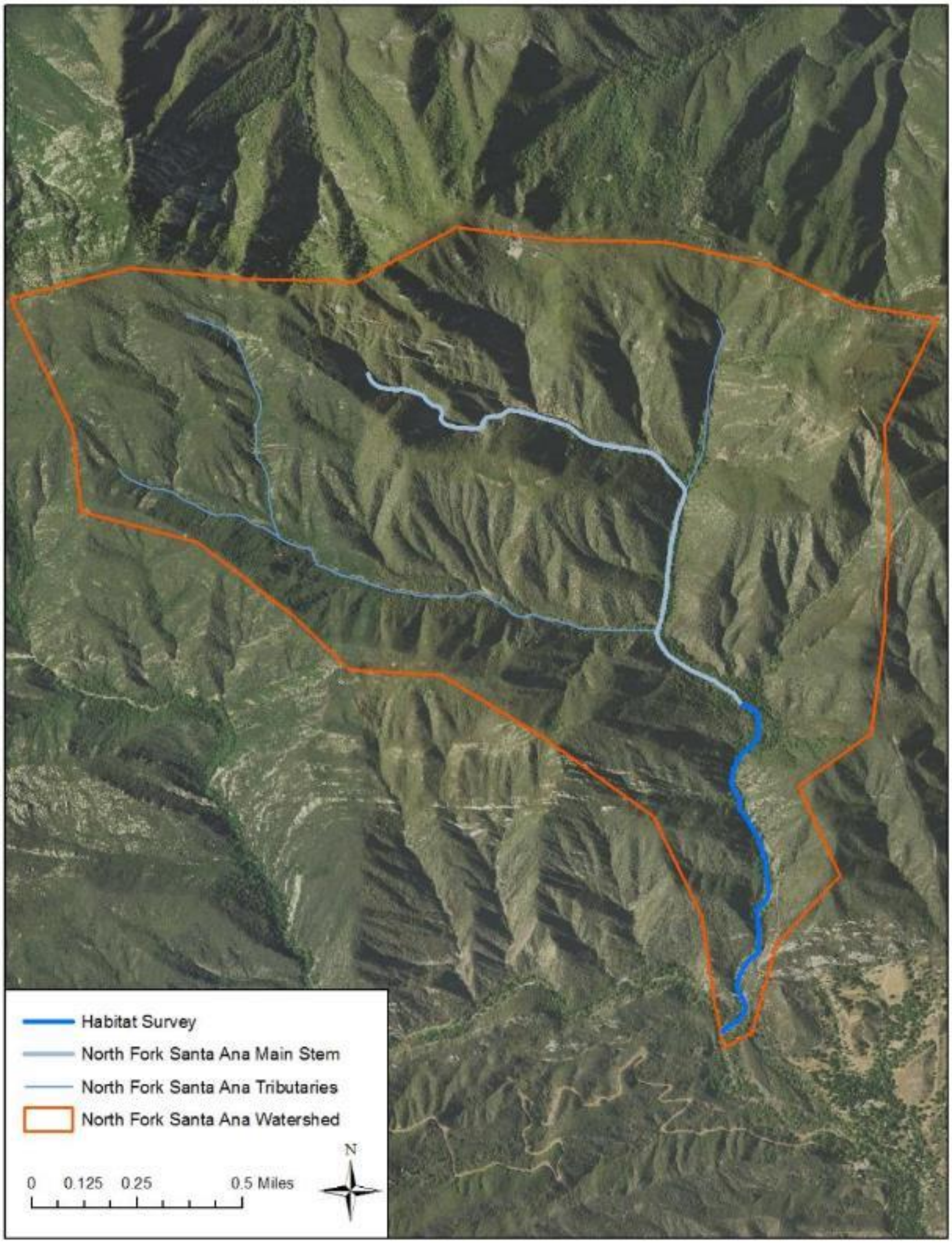


Figure 328. Percentage of total stream length categorized as pools, flatwaters, riffles, or dry for North Fork Santa Ana Creek.

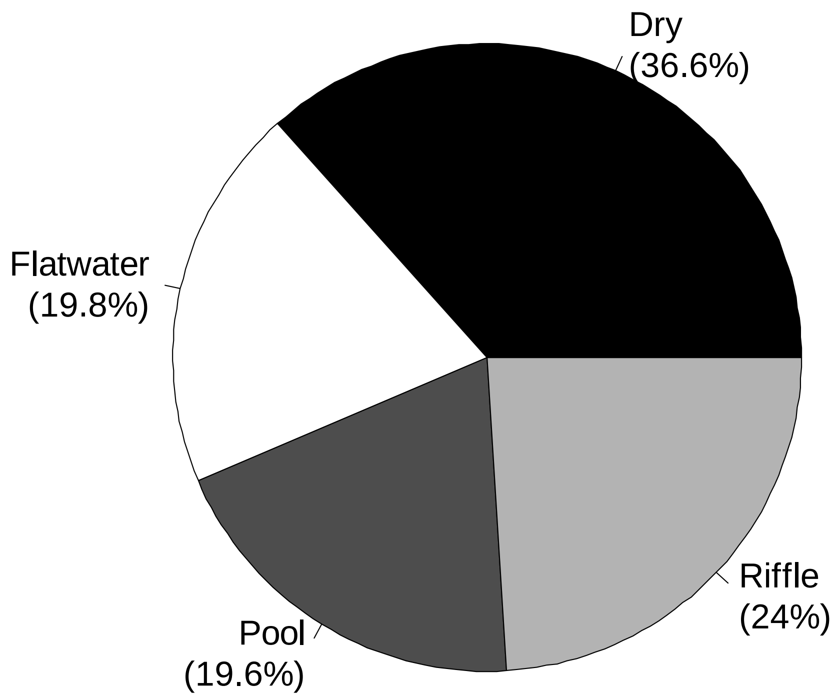


Figure 329. Percentage of all pool units (n = 42 pools) categorized by pool type (main channel, backwater, or scour pool) for North Fork Santa Ana Creek.

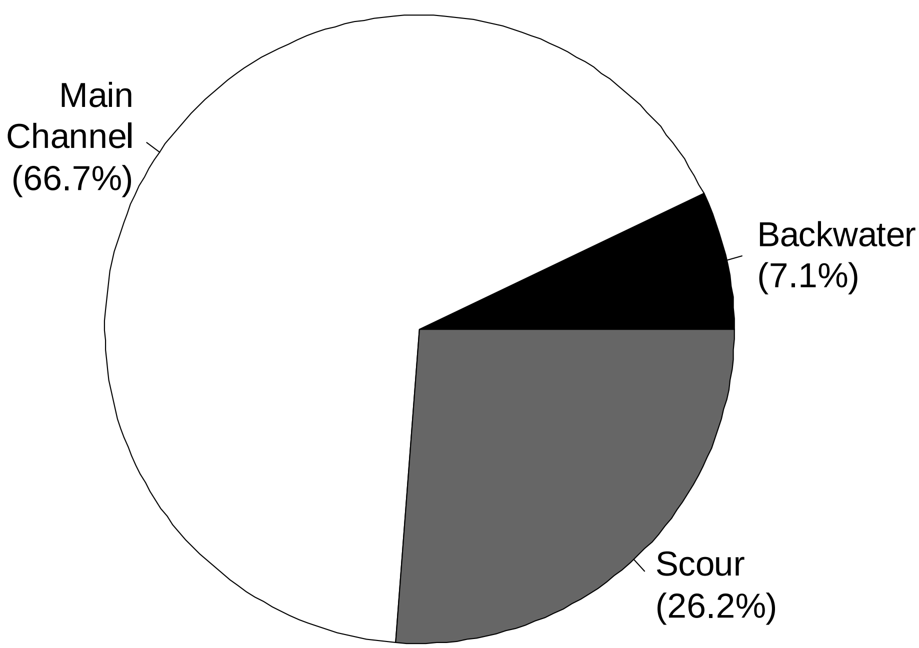


Figure 330. Histogram of residual pool depths in one-foot bins for North Fork Santa Ana Creek. Residual pool depth was calculated as the maximum pool depth minus the pool tail-out depth.

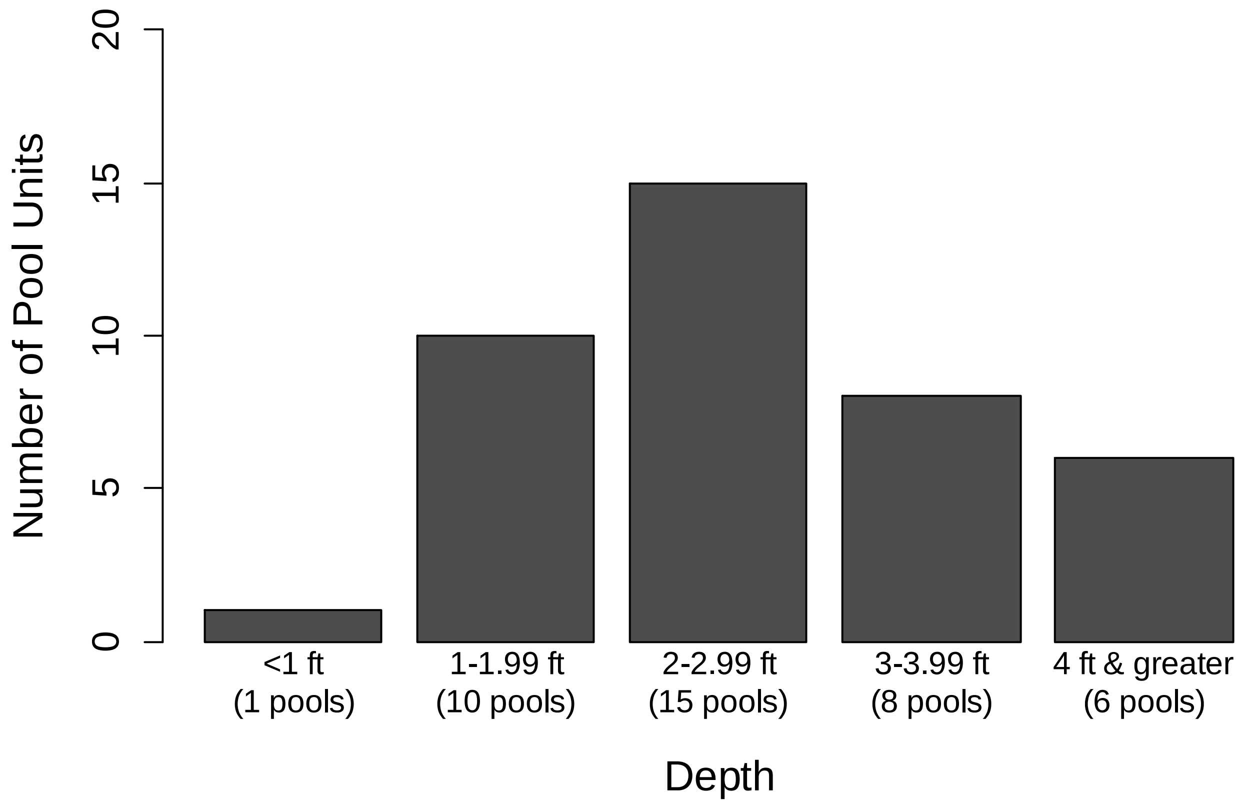


Figure 331. Percentage of pool tail-outs (n = 42 pools) by dominant substrate for North Fork Santa Ana Creek. Dominant substrate categories included silt/clay, sand, gravel, small cobble, large cobble, boulder, and bedrock.

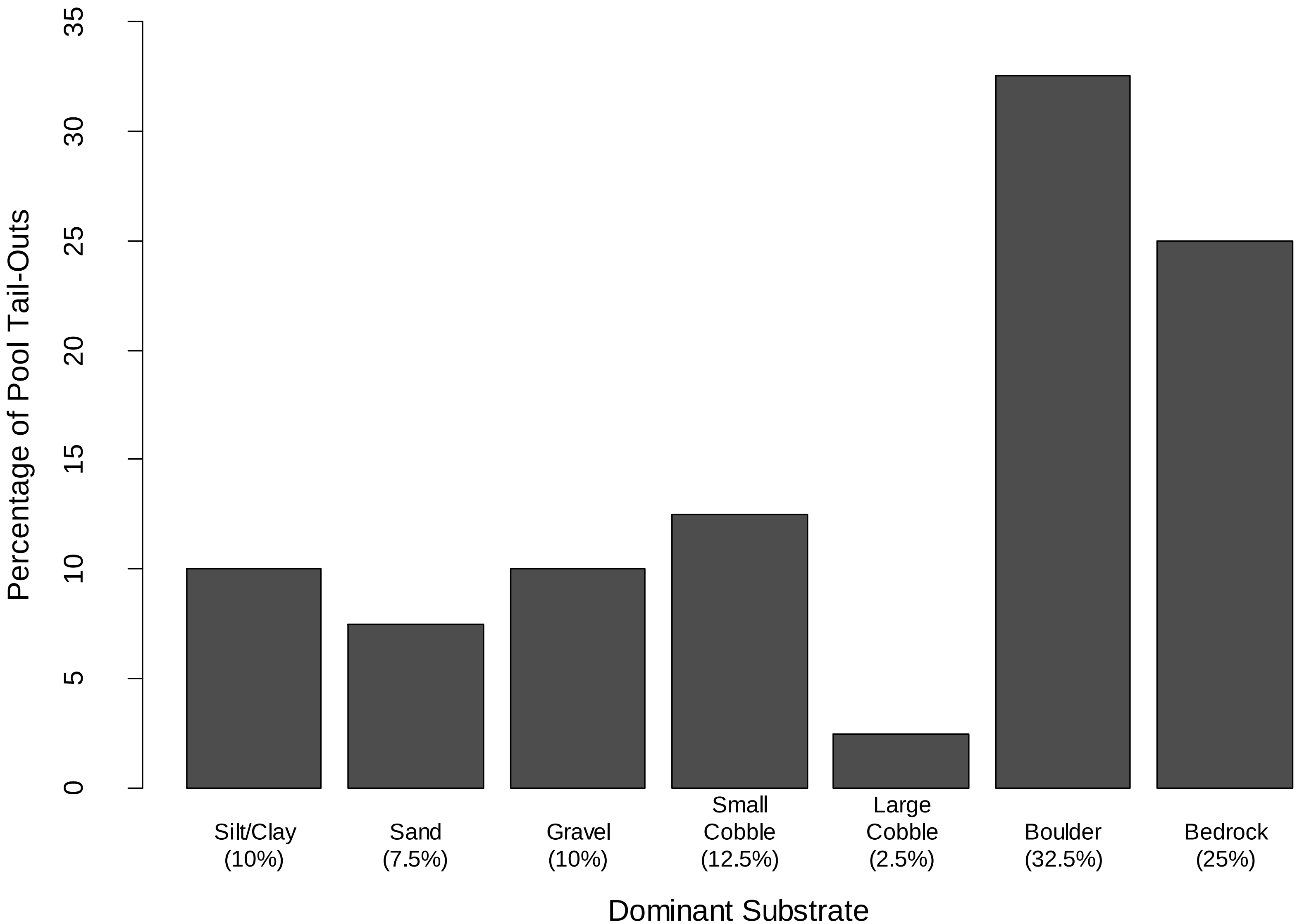


Figure 332. Percentage of all pool units (n = 42 pools) assigned a pool tail-out embeddedness value of 1 to 5 for North Fork Santa Ana Creek. Value 1 indicates 0–25% embeddedness (best for spawning), value 2 indicates 25–50% embeddedness, value 3 indicates 50–75% embeddedness, value 4 indicates 75–100% embeddedness, and value 5 indicates that the substrate was not suitable for spawning. In this survey, no pool tail-outs were assigned an embeddedness value of four.

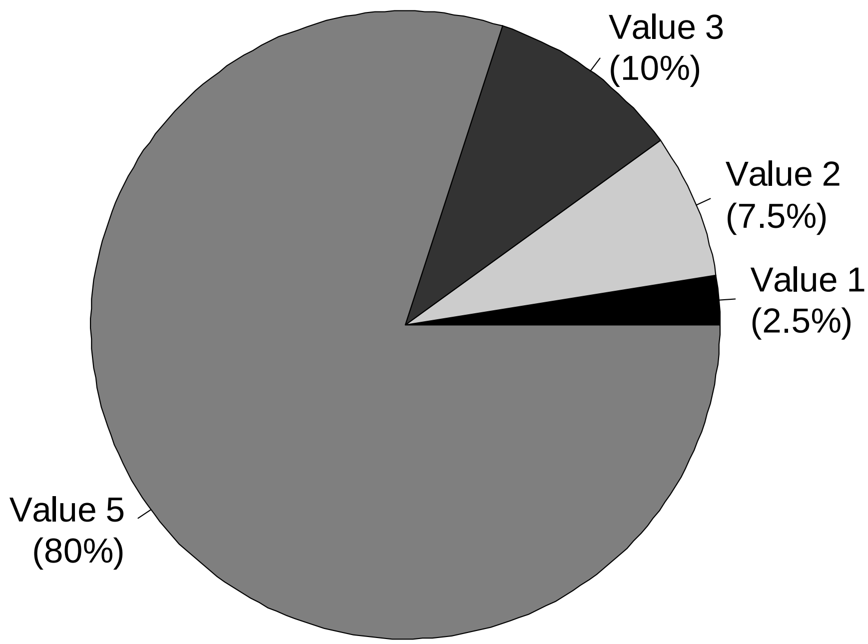


Figure 333. The percentage of instream shelter by shelter type across all units in which shelter was measured (n = 39 units) for North Fork Santa Ana Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

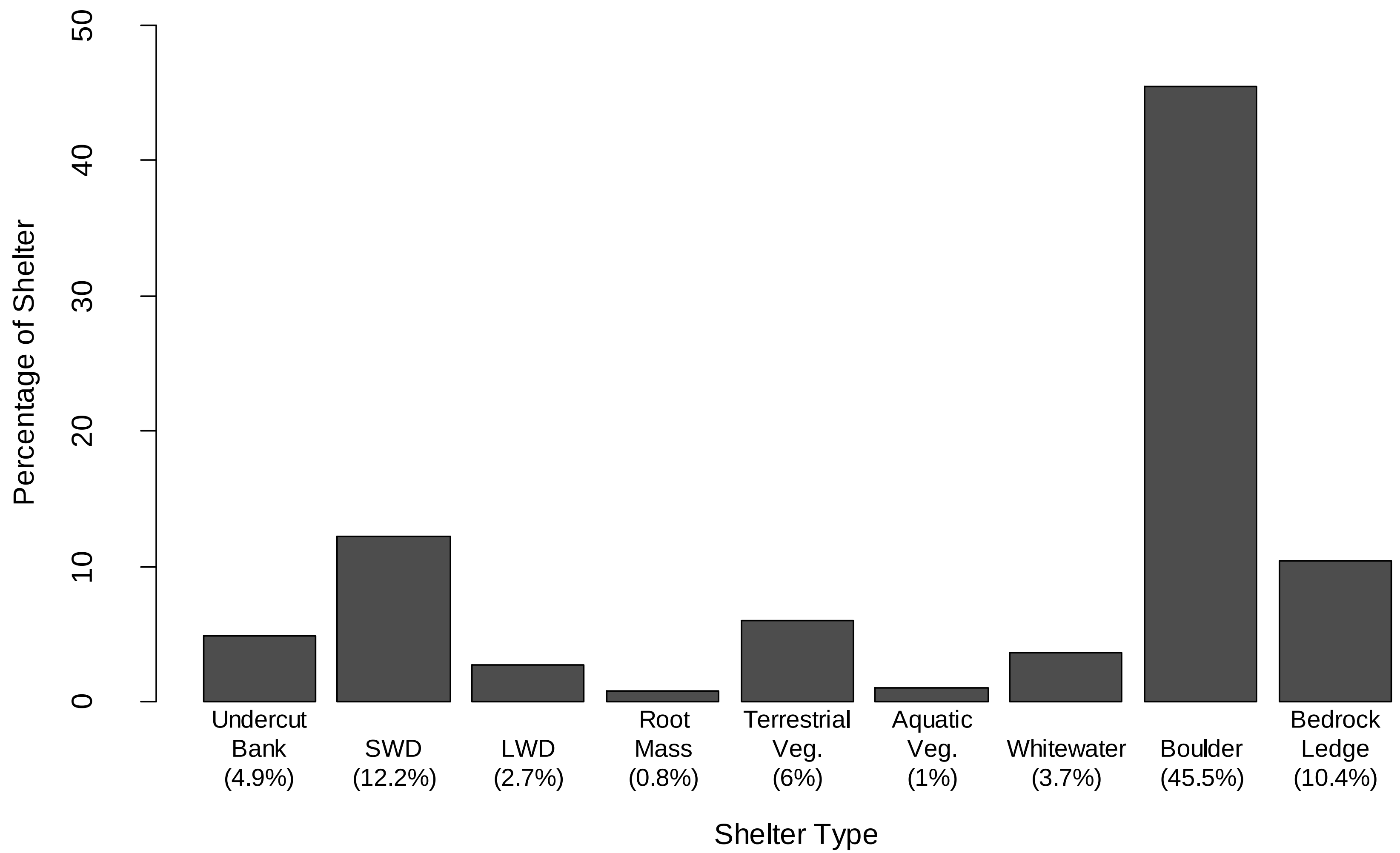


Figure 334. The percentage of instream shelter by shelter type across all pool units in which shelter was measured (n = 19 pools) for North Fork Santa Ana Creek. Percent shelter was visually estimated as the portion of wetted unit covered by shelter. Shelter types included undercut bank, small woody debris (SWD), large woody debris (LWD), root mass, terrestrial vegetation, aquatic vegetation, whitewater, boulder, and bedrock ledge.

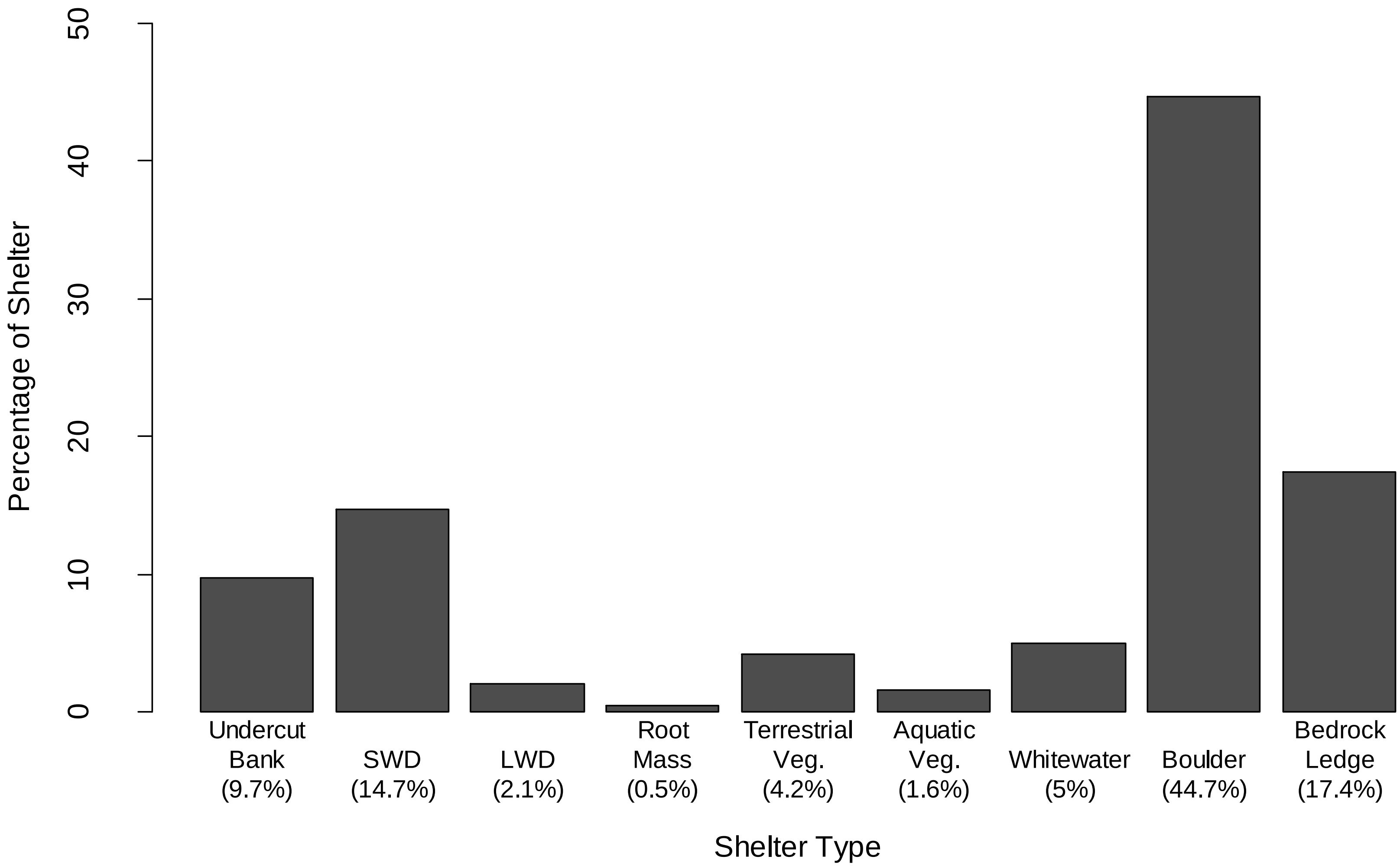


Figure 335. Percentage of banks by dominant substrate composition for North Fork Santa Ana Creek. Substrate types included sand/silt/clay, cobble/gravel, boulder, and bedrock.

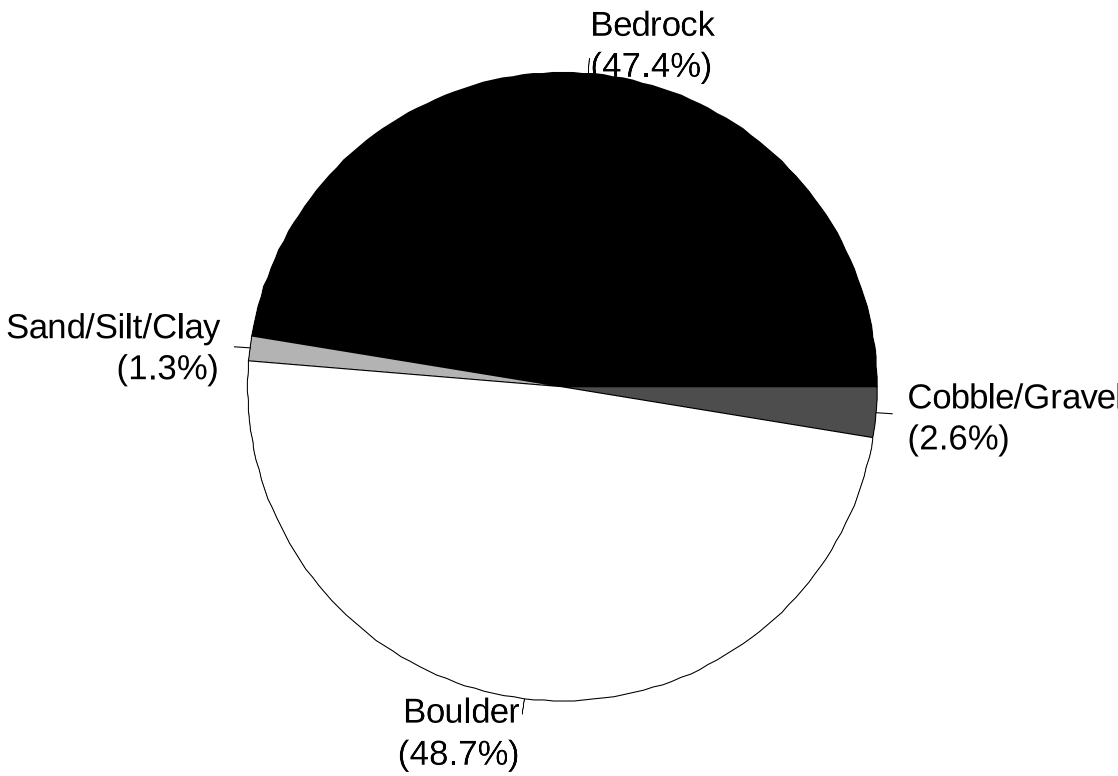
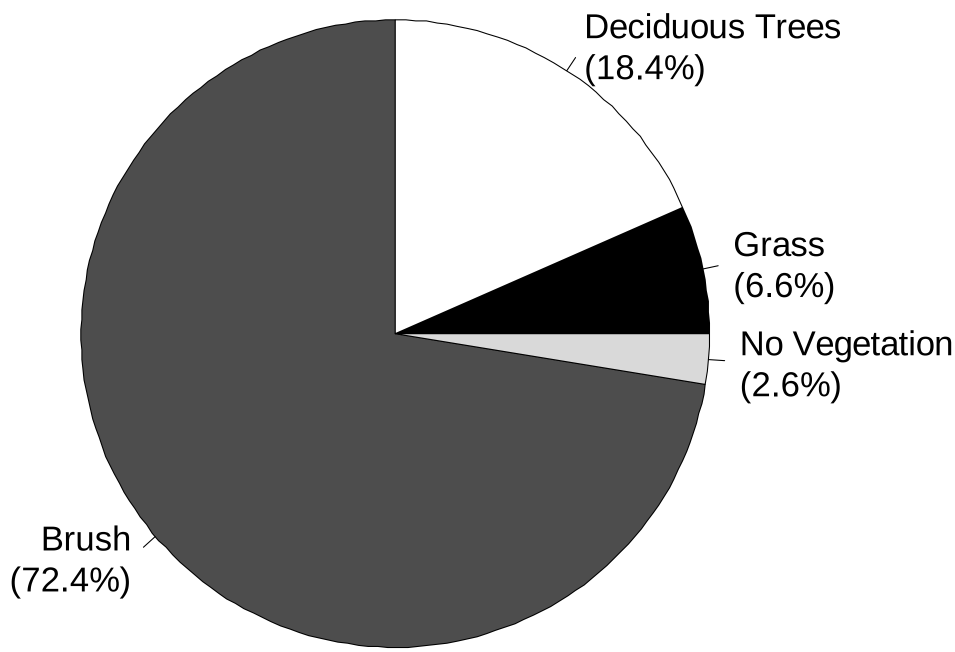


Figure 336. Percentage of banks by dominant bank vegetation type for North Fork Santa Ana Creek. Vegetation types included deciduous trees, evergreen trees, grass, brush, and no vegetation. In this survey, grass was not recorded as a dominant bankside vegetation type.



Literature Cited

Allen, M. A. 2015. Steelhead population and habitat assessment in the Ventura River/ Matilija Creek Basin 2006–2012. Final Report. Normandeau Associates, Inc.

Bankston, S., and Block, H. 2015. DIDSON Steelhead Population Viability Monitoring in Santa Barbara and Ventura County, California 2012-2014. Pacific States Marine Fisheries Commission, California Department of Fish and Wildlife Fisheries Restoration Grant Program, Grant Number P1250012, Santa Barbara, California.

Boughton, D. A., H. Fish, J. Pope, and G. Holt. 2009. Spatial patterning of habitat for *Oncorhynchus mykiss* in a system of intermittent and perennial streams. Ecology of Freshwater Fish 18: 92–106.

Boughton, D.A., P.B. Adams, E. Anderson, C. Fusaro, E. Keller, E. Kelley, L. Lentsch, J. Nielsen, K. Perry, H. Regan, J. Smith, C. Swift, L. Thompson, and F. Watson. 2006. Steelhead of the south-central/southern California coast: Population characterization for recovery planning. NOAA Technical Memorandum NMFS. NOAA-TM-NMFS-SWFSC-394.

California Passage Assessment Database (PAD). California Department of Fish and Wildlife. Available: https://nrm.dfg.ca.gov/PAD/. (January 2016).

California Streams and Hydrography. California Department of Fish and Wildlife. Available: http://www.calfish.org/ProgramsData/ReferenceLayersHydrography/CaliforniaHydrography.aspx. (January 2016).

Classification and Assessment with LANDSAT of Visible Ecological Groupings (CALVEG). U.S. Forest Service. Available: http://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5365219. (November 2015).

Clemento, A. J., E. C. Anderson, D. Boughton, D. Girman, and J. C. Garza. 2008. Population genetic structure and ancestry of *Oncorhynchus mykiss* populations above and below dams in south-central California. Conservation Genetics 10: 1321–1336.

Cochran, W. G. 1977. Sampling Techniques, 3rd edition. John Wiley & Sons, New York.

Flosi, G., S. Downie, J. Hopelain, M. Bird, R. Coey, and B. Collins. 1998. California salmonid stream habitat restoration manual, 3rd edition. California Department of Fish and Game.

Fox, M. and S. Bolton. 2007. A regional and geomorphic reference for quantities and volumes of instream wood in unmanaged forested basins of Washington State. North American Journal of Fisheries Management 27: 342–359.

Hankin, D. G. 1984. Multistage sampling designs in fisheries research: applications in small streams. Canadian Journal of Fisheries and Aquatic Sciences 41: 1575–1591.

Hankin, D. G. and G. H. Reeve. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45: 834–844.

Keller, E. A., G. Bean, and D. Best. 2015. Fluvial geomorphology of a boulder-bed, debris-flow – dominated channel in an active tectonic environment. Geomorphology 243: 14–26.

Kier Associates and National Marine Fisheries Service. 2008. Guide to the reference values used in south-central/southern California coast steelhead conservation action planning (CAP) workbooks. 1–38.

MacKenzie, D. I., J. D. Nichols, G. B. Lackman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83: 2248–2255.

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. Arcata, CA. U.S. Forest Service 1: 1–14.

McCanne, D. M. & B. Reisberger. 2005. Regional abundance survey for the Mad River-Redwood Creek hydrologic unit. Agreement No.: CAWIP-NR-29, Final Report.

National Marine Fisheries Commission (NMFS). 2012. Southern California steelhead recovery plan. Southwest Region, Protected Resources Division, Long Beach, California.

Negishi, J. N. and J. S. Richardson. 2003. Responses of organic matter and macroinvertebrates to placements of boulder clusters in a small stream of southwestern British Columbia, Canada. Canadian Journal of Fisheries and Aquatic Sciences 60: 247–258.

O'Neal, J. S. 2007. Snorkel Surveys. Pages 325–340 *in* D. H. Johnson, B. M. Shrier, J. S. O'Neal, J. A. Knutzen, X. Augerot, T. A. O'Neil, & T. N. Pearsons, editors. Salmonid Field Protocols Handbook: Techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland.

Pollock, K. H. and M. C. Otto. 1983. Robust estimation of population size in closed animal populations from capture-recapture experiments. Biometrics 39: 1035–1049.

R Core Team. 2015. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available: https://www.R-project.org/. (December 2015).

Raleigh, R. F. and C. Short. 1981. Depletion sampling in stream ecosystems: assumptions and techniques. Progressive Fish-Culturist 43: 115–120.

Roni, P., T. Beechie, G. Pess, and K. Hanson. 2015. Wood placement in river restoration: fact, fiction, and future direction. Canadian Journal of Fisheries and Aquatic Sciences 72: 466–478.

Särndal, C.-E., B. Swensson, and J. Wretman. 1992. Model assisted survey sampling. Springer-Verlag, New York.

Sloat, M. R. and A-M. K. Osterback. 2013. Maximum stream temperature and occurrence, abundance, and behavior of steelhead trout (*Oncorhynchus mykiss*) in a southern California stream. Canadian Journal of Fisheries and Aquatic Sciences 70: 64–73.

Temple, G. M. and T. N. Pearsons. 2007. Electrofishing: Backpack and drift boat. Pages 95–132 *in* D. H. Johnson, B. M. Shrier, J. S. O'Neal, J. A. Knutzen, X. Augerot, T. A. O'Neil, & T. N. Pearsons, editors. Salmonid Field Protocols Handbook: Techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland.

Thompson, L. C., J. L. Voss, R. E. Larsen, W. D. Tietje, R. A. Cooper, and P. B. Moyle. 2008. Role of hardwood in forming habitat for southern California steelhead. USDA Forest Service General Technical Report PSW-GTR-217: 307–319.

Thompson, L. C., J. L. Voss, R. E. Larsen, W. D. Tietje, R. A Cooper, and P. B. Moyle. 2012. Southern steelhead, hard woody debris, and temperature in a California central coast watershed. Transactions of the American Fisheries Society 141: 275–284.

Thurow, R. F. 1994. Underwater methods for study of salmonids in the Intermountain West. U.S. Forest Service, Intermountain Research Station, General Technical Report INT-GTR-307, Odgen, Utah.

White, G. C., D. R. Anderson, K. P. Burnham, and D. L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos National Laboratory, LA-8787-NERP, Los Alamos, New Mexico.

Appendices

Appendix I. Landowner Access

To survey 24 previously-unstudied streams in the Conception Coast BPG and the Ventura River Basin, landowner agreements were needed to access to privately-held surrounding land.. We therefore sent mailings to all private landowners requesting access (Figure 337). Some areas within these streams were excluded from mailings because they were either above a total barrier to fish passage, made up of too many individual residential landowners for mailings to be practical, or lacked owner information allowing for contact.

Of 480 letters that were mailed, only 153 (31%) landowners responded, with 98 landowners granting access and 55 refusing access. Thirteen responses indicated that the wrong landowner had been contacted or could not be interpreted as either granting or refusing access.

Due to time constraints during the reporting period, we could not analyze the responses from landowners occupying both main stems and tributaries. However, we were able to examine main stem landowners and found that we gained access to 95,847 meters of stream length (45% of total length), were refused from 36,368 meters (17%), and could not sample 68,221 meters (32%) due to a lack of response (Figure 339). However, these percentages must be interpreted with some caution given that some areas in which landowners granted access remained inaccessible due to downstream landowners denying entry. This resulted in a number of systems where were granted access to non-contiguous parcels, making survey logistics impractical. Furthermore, any potential data obtained would be spatially fragmented to a point where its utility would be questionable. Federal, state, county, and city-owned land were categorized as consenting to access, as we had previous agreements allowing for access.

Figure 337. Example of the letters mailed to a landowner requesting access to their property.

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
South Coast Region - Field Office
1933 Cliff Drive, Suite 9
Santa Barbara, CA 93109
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

Date

Owner Information

As California enters the fourth consecutive dry year and water availability is drastically limited, California Department of Fish and Wildlife (DFW) is taking a number of crucial actions to preserve and protect the state's fish and wildlife resources. We are actively monitoring stream conditions around the state. The California Steelhead Monitoring Program, consisting of Pacific States Marine Fisheries Commission (PSMFC) and DFW staff, is tasked with monitoring Southern California steelhead in the region during the drought.

We are asking for permission to survey the length of stream that is on your property. Any additional assistance will be gladly accepted whether it is information on the basin or volunteering your time.

These surveys involve a field crew of two or three surveyors walking through the stream channel to make physical and biological observations and measurements of the stream. Our presence in the stream for any survey will take no more than two days to collect the data we need and, depending on the stream length within your parcel, can take less than an hour to traverse through your property. If field crews determine the presence of pools with fish that are in danger of drying up, we will inform you and determine whether continued monitoring will be possible.

All activities occur within the stream channel; surveyors will not enter the surrounding property except with owner permission at designated locations to enter and exit the stream. We realize that working on or traveling through your land is a privilege and the field crew will respect your rights as a landowner at all times. The crew will consider any special conditions that you want to impose concerning access to the sampling site. If you wish, you may accompany the field crew and observe the surveying activities.

The State of California is self-insured. Enclosed you will find an access agreement. Please sign the agreement and return in the addressed stamped envelope. If your property does not contain the creek, please check the appropriate box on the agreement and return it to us.

We want to assure you that this is a research effort and is not connected to any specific regulatory action or activity. Data collected during these surveys will be used only to protect endangered fish species threatened by drought conditions.

If you have questions or concerns, please contact me at (*xxx*) *xxx-xxxx* or by e-mail at *xxxx*@wildlife.ca.gov.

Sincerely,

Conserving California's Wildlife Since 1870

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
South Coast Region - Field Office
1933 Cliff Drive, Suite 9
Santa Barbara, CA 93109
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

ACCESS PERMISSION FORM
CALIFORNIA STEELHEAD MONITORING PROGRAM

The California Steelhead Monitoring Program staff requests permission to travel through the streambed on or near your property up to the high water mark in order to sample the physical and biological characteristics of the stream and banks of:

Stream:

APN:

Owner(s) Name(s):

☐ I grant property access to employees of the California Steelhead Monitoring Program from **January 1 through December 31, 2015** for the purpose of conducting stream surveys to evaluate trout habitat and abundance, with the expectation that these representatives will respect landowner's privacy.

or

☐ I **DO NOT** grant property access to employees of the California Steelhead Monitoring Program. Field personnel shall NOT, under any circumstances, enter the property.

or

☐ My property has been incorrectly identified as containing or being adjacent to the stream listed above.

If you are granting access, please check:

☐ I do not require additional notification before the survey

☐ I would like to be notified in writing before survey (notification letter will mailed 3 to 5 days before survey)

☐ I would like to be notified by e-mail: ______________________
email address

☐ I would like to be notified by phone: ______________________
telephone number

Signature ______________________ ***Date*** ______________

Print Name ______________________ ***Telephone*** ______________

Conserving California's Wildlife Since 1870

Figure 338. Total number of letters mailed to landowners by response. Landowners granted access (Access Granted), denied access (Access Denied), or did not respond (No Response). Those categorized as Other were responses that did not fit the previously-listed category (e.g. response did not specify whether access had been granted or denied). Percentages were rounded to the nearest integer.

Stream	Mailed	Access Granted	Access Denied	No Response	Other
Aqua Caliente	14	3	2	7	2
Arroyo Paredon (above Foothill Rd)	10	2	3	5	0
Arroyo Quemado	2	0	1	1	0
Bell Canyon	14	1	7	6	0
Cañada de Santa Anita	12	0	6	6	0
Cañada del Corral	3	2	1	0	0
Cañada del Refugio	19	4	5	9	1
Cañada del Venadito	3	1	1	1	0
Cañada San Onofre	2	0	0	2	0
Dos Pueblos Creek	4	1	0	3	0
Eagle Canyon	9	2	5	0	2
Gato Canyon	1	0	0	1	0
Gaviota Creek	6	0	4	2	0
Las Vegas Creek	22	11	4	7	0
Maria Ygnacio	29	2	0	27	0
Rincon (above Hwy 101)	20	8	1	11	0
Romero	107	1	0	104	2
San Jose (above Hollister Rd)	25	7	3	15	0
San Pedro (above Hwy 101)	13	6	0	7	0
Tecelote Canyon	52	27	6	13	6
Oak Creek	69	0	0	69	0
Gridley Creek	9	1	5	3	0
Senior Creek	5	2	0	3	0
Thacher Creek	30	17	1	12	0
Total	***480***	***98 (20%)***	***55 (11%)***	***311 (65%)***	***13 (27%)***

Figure 339. Total and percentage of main stem stream lengths by landowner response. Landowners either granted access (Access Granted), denied access (Access Denied), or did not respond (No Response). Federal, state, county, and city-owned lands were included under Access Granted. In some cases, landowners were not or could not be contacted (No Mailing). Percentages were rounded to the nearest integer.

Stream Name	Total Stream Length (m)	Granted Access (m)	Denied Access (m)	No Response (m)	No Mailing (m)
Aqua Caliente	5,062	598	1,435	3,029	0
Aroyo Quemado	5,106	4,950	156	0	0
Arroyo Paredon (above Foothill Rd)	8,911	1,365	3,656	2,377	1,513
Bell Canyon	11,921	6,489	5,432	0	0
Canada de Santa Anita	8,201	0	2,759	5,442	0
Cañada del Corral	9,529	8,708	75	746	0
Cañada del Refugio	10,561	5,040	1,766	3,755	0
Cañada del Venadito	5,974	2,473	2,725	776	0
Cañada San Onofre	4,059	1,149	0	2,910	0
Dos Pueblos Canyon	11,592	4,244	0	7,348	0
Eagle Canyon	7,732	2,415	5,317	0	0
Gato Canyon	9,454	3,822	0	5,632	0
Gaviota Creek	11,047	5,430	3,418	2,199	0
Gridley Creek	6,717	4,954	1,388	375	0
Las Vegas	4,763	1,623	835	763	1,542
Maria Ygnacio	11,273	4,735	0	6,538	0
Oak Creek	4,433	0	0	4,433	0
Rincon Creek (above Hwy 101)	16,095	12,878	0	3217	0
Romero Canyon	8,321	2,251	0	6,070	0
San Jose (above Hollister Rd)	15,568	1,985	0	6,658	6,925
San Pedro Creek (above Hwy 101)	8,791	3,370	0	1,317	4,104
Senior Creek	7,680	4,655	2,108	917	0
Tecolote Canyon	11,093	4,555	4,909	1,629	0
Thacher Creek	10,637	8,158	389	2,090	0