Bear Creek Snorkel Survey Report 2018

Prepared by Tanielle Redman[1], Shannon Mueller[1], and Casey Horgan[1]
[1]Pacific States Marine Fisheries Commission

Abstract

From May 30 to June 6, 2018, a snorkel survey was conducted on a 1.8 mile sampled reach of Bear Creek. Data collected contributed to estimating southern California steelhead (*Oncorhynchus mykiss*) relative abundance and distribution as well as quantifying stream habitat type and trout cover types available. Stream habitat was dominated by small pools (62.0%) and shallow riffles (34.8%). On average, the surveyed habitat units contained little habitat complexity, with unit's surface area containing a mean of 41.5 ± 2.3% (mean ± SE) cover, mostly consisting of cobble/boulder (51.2 ± 2.6% [mean ± SE]) and aquatic vegetation (27.2 ± 2.6%). No inferences could be made about trout abundance or distribution trends as no *O. mykiss* were observed through the course of the survey. Changes in habitat type, cover complexity, temperature profile, and *O. mykiss* observations from surveys conducted in previous years appear to be the result of the December 2017 Thomas Fire and subsequent winter rain events. Future monitoring efforts are recommended to continue collecting data on *O. mykiss* relative abundance and habitat availability and potential anadromous *O. mykiss* repopulation in Bear Creek.

Introduction

Steelhead (*Oncorhynchus mykiss*) along the west coast of North America have been divided into Distinct Population Segments (DPS) based on discrete factors separating populations from each other. The southern California steelhead DPS comprises the southernmost extent of the specie's range (NOAA 1997). Since 1997 this DPS has been listed as endangered under the U.S. Endangered Species Act due to dramatic declines in abundance caused by habitat loss and degradation (NOAA 1997). In response, a recovery plan for the southern California DPS was released in 2012 by the National Marine Fisheries Service (NMFS). This recovery plan determined multiple factors that affect the current endangered status of southern California steelhead (SCS) and the ability for recovery. Critical to steelhead recovery is the understanding of the interactions between steelhead and their freshwater habitat (NMFS 2012).

In southern California, steelhead fresh water habitat is dominated by short streams and rivers with flashy, intermittent flows and seasonal accessibility for anadromous trout. Since 2011, Southern California has experienced persistent drought conditions (NOAA 2018) further limiting the freshwater habitat use and availability for steelhead. The Thomas Fire, which burned from December 2017 through January 2018, impacted 1,909 miles of stream habitat within the fire perimeter, nearly 80 miles of which are designated critical habitat for southern California steelhead (Klose 2018). Shortly after, during the winter of 2018, strong rain events caused extremely high flows and the movement of boulders, debris, and sediment through creeks impacted by the fire. Fish mortalities and extirpation of small populations have been observed as a result of flooding and debris flows following wildfires (Bozek and Young 1994; Rinne 1996; Howell 2006). Monitoring efforts following these events are important for understanding steelhead trout abundance, distribution, and habitat utilization in affected critical SCS habitat (Klose 2018).

An important aspect of understanding how trout interact with their freshwater habitat is observing how trout utilize cover within their environment. Cover types utilized by trout include overhanging and instream vegetation, woody debris, boulders, bedrock crevices, root wads, undercut banks, and surface water turbulence. Cover is recognized as one of the essential components affecting trout abundance and distribution in streams (Raleigh et al. 1984). For individual fish, cover functions as protection from predators, reduction of competition, and shelter from water flow (Allouche 2002). In addition to providing instream shelter for fish, certain cover types (e.g. large woody debris and boulders) aid in the creation of scours and pools which trout can utilize as habitat (Fausch and Northcote 1992; Allouche 2002).

A snorkel survey was conducted on Bear Creek between May 30, 2018 and June 6, 2018 by Pacific States Marine Fisheries Commission (PSMFC). The purpose of this study was to estimate the relative abundance, distribution, cover availability, and cover use of *O. mykiss* within the survey reach.

Bear Creek is located in the Los Padres National Forest north of the city of Ojai in Ventura County, California. With headwaters in the Topatopa Mountains of the Traverse Range, Bear Creek flows to a confluence with North Fork Matilija Creek, which in turn is a tributary to the Ventura River. The survey reach began at the confluence of Bear Creek and North Fork Matilija (34.51256, -119.27419) and extended 1.8 miles ending at a large waterfall total barrier (34.50996, -119.24998).

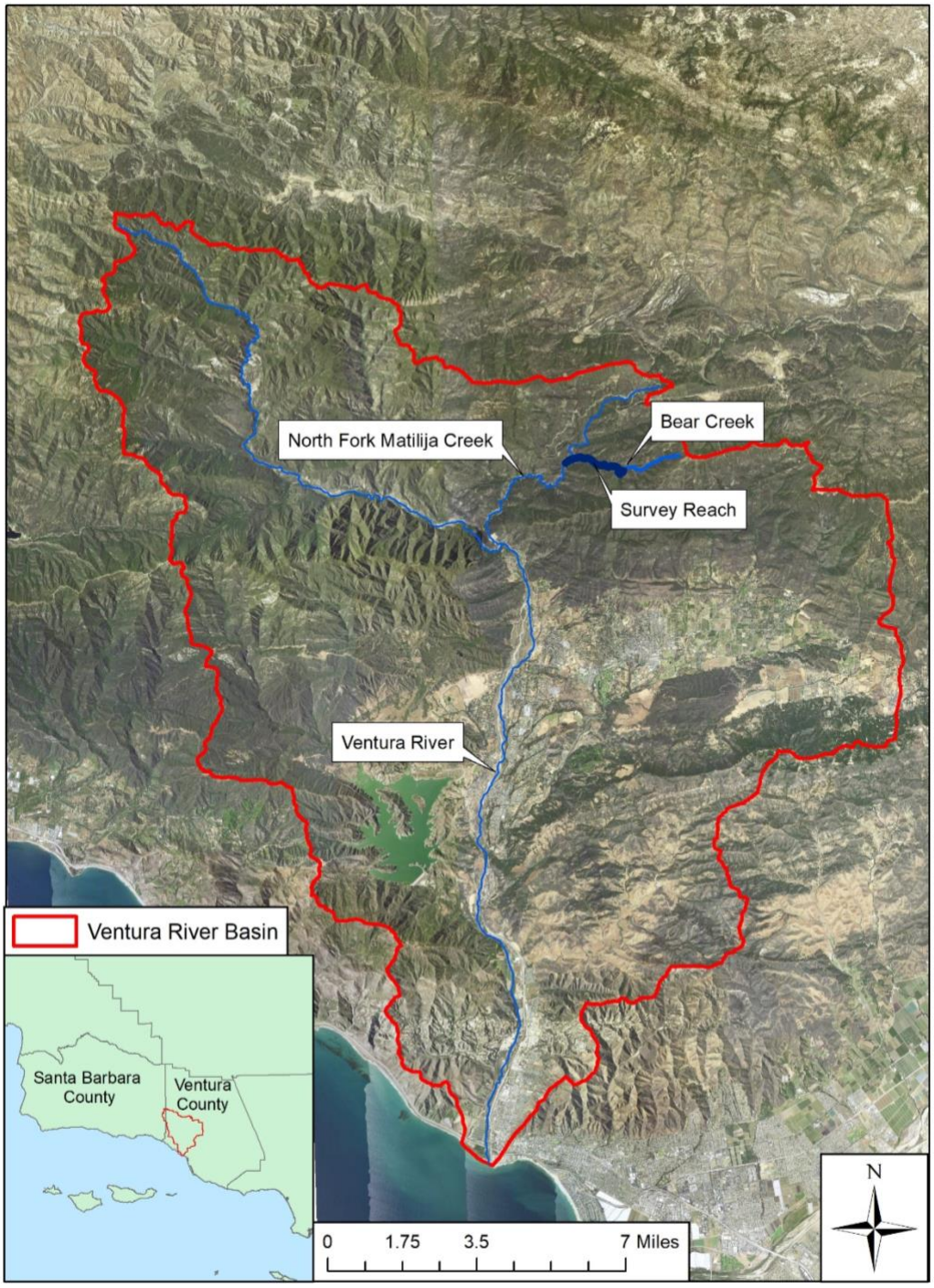
Methods

This study was conducted using elements of a snorkel survey protocol written by Tsai & Van Meeuwen (2016, unpublished). This protocol was adapted from the Salmonid Field Protocol Handbook (O'Neil 2007) and the Underwater Methods for the study of Salmonids in the Intermountain West (Thurow 1994). Snorkel surveys were used to gather relative abundance estimates of trout and quantify the available trout habitat and cover usage.

Snorkel surveys were conducted in teams of two to three, which included at least one data recorder and one snorkeler. During surveys, the wetted stream channel was delineated into discrete, natural units of similar habitat (Hankin 1984). Units were classified as either riffles (R), pools (P), or flatwaters (F) according to certain defining characteristics. These habitat types are adopted from definitions outlined in Flosi et al. (1998).

For this study, all snorkelable units with a maximum depth of 0.7 ft or greater were snorkeled once. The snorkeler entered the water at the downstream end of each habitat unit while being careful to minimize disturbance to the water and sediment. Once in the water, the snorkeler moved in a zig-zag pattern towards the upstream end of the unit making sure to visually search the entire area of the unit. The snorkeler searched the margins of the unit, boulder crevices, and other areas of potential fish cover. Cover was defined as any natural or artificial stream feature capable of hiding a 3-inch trout from the surface. To avoid duplicate counts, trout were counted as the snorkeler moved past them.

Figure 1. Map of the Ventura River Basin (outlined in red) which drains into the Pacific Ocean and is located approximately 60 miles north of Los Angeles, California. Snorkel surveys were conducted from May 30, 2018 to June 6, 2018 along a 1.8 mile reach of Bear Creek (highlighted in dark blue) which serves as a tributary to North Fork Matilija Creek (highlighted in blue). Data collected contributed to *Oncorhynchus mykiss* relative abundance, stream habitat availability and use.



Once each unit was surveyed, all observations were reported to the bankside data recorder. For each trout observed, the associated cover and estimated length were given. Trout sizes were estimated by 2-inch size bins (0-1.99 inches, 2-3.99 inches, 4-5.99 inches, etc.). Counts were also made for special status species of amphibians and reptiles including Southern Western Pond Turtle (*Actinemys pallida*), Two-striped Gartersnakes (*Thamnophis hammondii*), and California Red-legged Frog (*Rana draytonii*). Additionally, presence and visual estimates of other native fish species were recorded including Arroyo Chub (*Gila orcutti*) and Three-spined Stickleback (*Gasterosteus aculeatus*). For trout cover, snorkelers noted the type of cover used by each trout when first observed. Cover types included open (no cover used), boulder, small woody debris, large woody debris, root mass, terrestrial vegetation, aquatic vegetation, bubble curtain, bedrock ledge, undercut bank, and other/artificial cover (Table A.1). Other/artificial cover consisted of any manmade products, such as plastic or mesh netting, sandbags, and plywood that potentially provided cover for fish within a habitat unit.

The snorkeler assessed the total trout cover available in each unit by estimating the percent of surface area containing trout cover and surface area containing no cover. The snorkeler also estimated the percentage of total cover each cover type in the unit comprised.

Water visibility was recorded on a scale of zero to three. A value of zero indicates the snorkeler was unable to perform the survey due to a lack of visibility, one was poor visibility, two was adequate visibility, and three was clear visibility.

All habitat units were measured for length, mean width, mean depth, and maximum depth. Length was measured along the thalweg (line of lowest elevation within a valley or watercourse) and mean unit width was measured perpendicular to the length (thalweg) line. The percentage of surface area that contained exposed substrate, usually comprised of gravel, boulders, or bedrock, was estimated for each unit. Exposed substrate included areas of dry exposed substrate not accounted for in measurements of unit length or mean width. This allowed for a more accurate surface area calculation of the available wetted trout habitat.

Snorkelers' trout size estimations were calibrated after snorkeling the first habitat unit and subsequently every tenth unit. Three randomly chosen PVC pipes of known lengths were tossed into the unit, after snorkeling was completed, and sampled by the snorkeler. The snorkeler estimated the size bin of each pipe and then confirmed with the data recorder. If an incorrect estimate was given, calibration was repeated until the snorkeler accurately estimated the sizes of all three pipes.

Water and air temperatures were measured with a thermometer at the beginning of each survey day and subsequently after every tenth unit surveyed. Additionally, a HOBO Water Temperature Pro v2 Data Logger was deployed within the survey reach to continuously record water temperature.

All data was entered into a computer database and analyzed using R (version 3.4.1, R Core Team 2017) and R Studio (version 1.0153, RStudio, Inc 2016). To examine trout relative abundances, trout density was calculated in three ways, including mean number of trout per unit, mean number of trout per foot, and mean number of trout per square foot. To evaluate trout life stage diversity, the total number of trout per size class was calculated. To examine wetted habitat the total length surveyed,

mean unit length, total unit area, mean unit area, mean unit depth, mean unit maximum depth, total unit volume, and mean unit volume were calculated. To quantify available trout cover, the mean percent of habitat units containing trout cover and the mean percent each cover type comprised was calculated. Trout cover use was examined by calculating the total number of trout observed using each cover type. For each mean the standard error was calculated.

Results

Bear Creek was surveyed from May 20 to June 6, 2018, for 1.75 miles (9,240 ft). At the time of the survey, 1.54 miles (88%) of the survey reach were wetted, with the remaining 0.21 miles dry. A total of 1,272.6 ft of stream length was snorkeled with a mean unit length of 13.8 ± 1.5 ft (mean ± SE) and a mean unit width of 4.0 ± 0.2 ft. The total unit area snorkeled was 4,057.3 ft^2, with a mean unit area of 46.8 ± 0.4 ft^2 (mean ± SE). A total of 92 habitat units were snorkeled. Of the snorkeled units, 62.0% were classified as pools (n=57), 34.8% as riffles (n=32), and 3.2% as flatwaters (n=3). The mean depth of units surveyed was 0.42 ± 0.0 ft (mean ± SE) and units had a mean maximum depth of 0.9 ± 0.0 ft (mean ± SE). The total volume snorkeled through the course of the survey was 1,596.1 ft^3, with a mean unit volume of 17.4 ± 1.3 ft^3 (mean ± SE).

The mean percentage of available trout cover by surface area in units surveyed was 41.5 ± 2.3% (mean ± SE), with 58.5 ± 2.3% open. The predominant cover types observed consisted of cobble/boulder (51.2 ± 2.6% [mean ± SE]) and aquatic vegetation (27.2 ± 2.6%). Bubble curtain made up 13.4 ± 1.1% (mean ± SE) and small woody debris made up 4.8 ± 0.8%. Root mass, bedrock ledge, soil undercut, and terrestrial vegetation each made up less than two percent of the total mean cover (Table 1).

Table 1. Mean Percent and standard error of habitat unit cover types recorded during the Bear Creek snorkel survey.

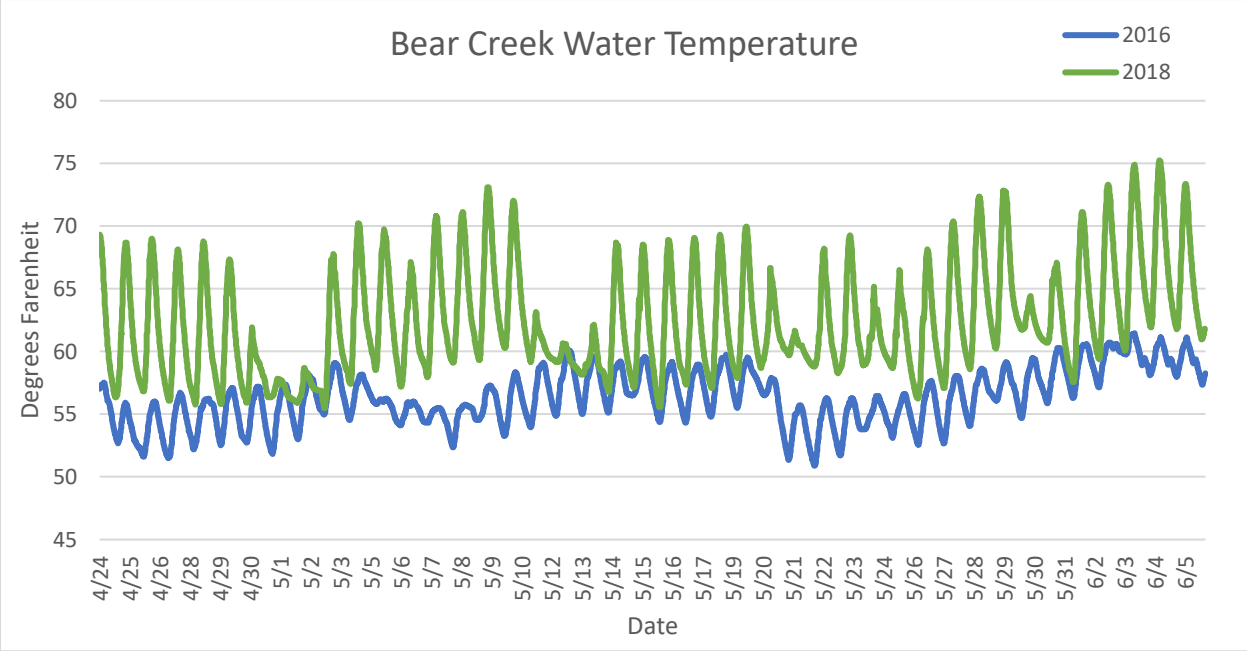
Cover Type	Mean Percentage (%)	Standard Error (±%)
Open	58.48	2.27
Covered	41.52	2.27
Cobble/Boulder	51.20	2.64
Aquatic Vegetation	27.17	2.56
Bubble Curtain	13.37	1.08
Small Woody Debris	4.84	0.81
Root Mass	1.52	0.61
Bedrock	1.25	0.59
Soil Undercut	0.38	0.25
Terrestrial Vegetation	0.27	0.18
Large Woody Debris	0.00	0.00
Other / Artificial Cover	0.00	0.00

Water temperatures recorded using thermometers ranged from 59°F at the beginning of surveys to 80°F by midafternoon. A HOBO temperature logger was deployed on April 24, 2018, near the same location as a temperature logger deployed in previous years, approximately 0.3 miles upstream of

the start of the survey reach. Water temperatures recorded from the time of deployment through the end of the snorkel survey on June 6 ranged from a low of 55.5°F to a high of 75.2°F with a daily mean temperature of 62.3 ± 0.1°F (mean ± SE) (Figure 2). Water temperatures recorded by the logger during the same dates in 2016 show a low of 50.9°F to a high of 61.5°F with a daily mean of 56.3 ± 0.0°F (mean ± SE).

Zero *O. mykiss* were observed through the course of this snorkel survey. Additionally, zero fish of any species were observed within the Bear Creek survey reach. Only two species of concern were recorded, one two-striped garter snake (*Thamnophis hammondii*) and one western pond turtle (*Actinemys pallida*).

Figure 2. Bear Creek water temperatures recorded by continuously recording HOBO loggers from 4/24-6/6 in 2016 and 2018.



Discussion

The 1.8 mile reach of Bear Creek was snorkeled from May 30 to June 6, 2018. At the time of the survey, 88% of the reach was wetted, with 0.2 miles of creek dry and thus not snorkeled. A total of 92 habitat units comprising 1,272.6 ft were snorkeled within the stream reach. Of the habitat units surveyed, pools were the most abundant, comprising 62.0% (n=57) of the total habitat units. Riffles made up 34.8% (n=32) of habitat units while flatwaters made up only 3.2% (n=3). Although pools were the most numerous habitat type, in terms of surface area surveyed Bear Creek was dominated by riffles, comprising 2,676.8 ft² of the total snorkeled area of 4,057.3 ft². Water depth was limited throughout the survey reach, with a mean unit depth of 0.4 ± 0.0 ft (mean ± SE) and a mean maximum unit depth of 0.9 ± 0.0 ft (mean ± SE). The deepest point measured throughout the survey reach was only 1.6 ft. While shallow riffles are suitable habitat for *O. mykiss* fry and small juveniles due to the protection they

provide from aquatic predation and competition, larger adults require pool habitat in order to thrive as pools have lower velocities contributing to energy conservation and provide refuge from terrestrial predation (Raleigh et al. 1984; Rosenfeld and Boss 2001). The reduced stream depth and small size of pools limits the available habitat for adults to access in future spawning seasons and seek refuge in throughout the year.

Zero *O. mykiss* were observed through the course of this survey. As a result, no inferences could be made about trout habitat type and cover utilization. The data collected through this survey show that Bear Creek contained cover that could be utilized by trout, although it lacked complexity. Our results show habitat units contained slightly less covered area than open area, with 41.5 ± 2.3% (mean ± SE) covered and 58.5 ± 2.3% open. Of the cover available, the majority consisted of cobble/boulder (51.2 ± 2.6% [mean ± SE]). Aquatic vegetation and bubble curtain made up 27.2 ± 2.6% (mean ± SE) and 13.4 ± 1.1% of the available cover respectively, while all other cover types made up a combined 8.2% of the available cover. The low percentage of cover availability and lack of cover type complexity suggest that fish within the survey reach have limited protection from predation, competition, and high flow events (Allouche 2002).

Since zero trout were observed in Bear Creek during this survey, no inferences could be made about trout densities or distribution trends. No snorkel surveys had been conducted in Bear Creek prior to this survey, so we have no *O. mykiss* relative abundance estimations within this survey reach to use as comparison. There have been bankside observations of individual *O. mykiss*, redds, and young of the year recorded in Bear Creek from 2014 through 2017 by California Department of Fish and Wildlife and Pacific States Marine Fisheries Commission (CDFW, unpublished data). However, zero *O. mykiss* observations have been recorded by CDFW and PSMFC staff following the Thomas Fire and 2018 winter storm flows. These results indicate the lowest *O. mykiss* abundance since monitoring efforts began in Bear Creek. The lack of trout observations could be attributed to impacts to stream habitat due to the persisting drought conditions combined with the impacts of the Thomas Fire and subsequent rain events. These events have led to significant changes observed within Bear Creek, resulting in reduced and degraded available *O. mykiss* habitat. Specifically, changes to the creek's thermal profile indicate limited survival of *O. mykiss* during the time of snorkel data collection

Water temperature data recorded by the HOBO logger in Bear Creek in 2018 show higher temperatures and greater fluctuations than recorded in previous years. Daily temperature fluctuations measured before and during this survey were much greater than measured in previous years, with temperatures fluctuating as much as 14.8^{o}F throughout a single 24-hour period, compared to a maximum daily fluctuation of 5.5^{o}F during the same date range in 2016 (Figure 2). From April 24 through the end of the survey on June 6, 2018, the highest temperature recorded was 75.2^{o}F with a daily mean temperature of 62.3 ± 0.1^{o}F (mean ± SE). Maximum temperatures recorded by thermometers exceeded 80^{o}F in exposed, sunny portions of the reach. Maximum temperatures recorded by the logger reached 75.2^{o}F (24^{o}C), the accepted lethal temperature for *O. mykiss* (Spina 2007). Although southern California *O. mykiss* strains have shown the ability to survive higher maximum temperatures (Spina 2007), a warming trend observed through the temperature logger data suggest water temperatures continued to peak above 75.2^{o}F following the data collection period. These changes in the temperature profile of Bear Creek may be attributed to factors such as the loss of riparian canopy burned by the fire and/or

washed away by the high storm flows and the overall shallowing of the reach due to sedimentation following storm events. These changes have attributed to an increase in the amount of direct sunlight reaching the creek channel and its water column thus heating the water and contributing to higher temperatures. Additionally, the lack of deep pools reduces potential thermal refuge for trout (Spina 2007).

Although snorkel surveys are an ideal method for collecting in-water data, there are limitations. One potential limiting factor is the dependency of the observational data collected on the individual snorkeler. To minimize error, each snorkeler was trained according to the protocol used. Differences in snorkeler observations are possible due to variable observation probabilities. Water depth is one such factor that can influence snorkeler observations. Due to the changes in the streambed following the fire and rain events, many units contained shallow sections that were difficult to snorkel effectively.

This study aimed to describe *O. mykiss* relative abundance and stream habitat in Bear in 2018 following the December 2017 Thomas Fire and subsequent winter rain events. Our results found a lack of habitat depth, size, and cover complexity and elevated water temperatures contributing to freshwater habitat not suitable for *O. mykiss* persistence. We attribute these changes to a loss of canopy cover and increased sedimentation which reduced water depths and increased solar thermal heating.

In order to make reliable population abundance estimates, electrofishing surveys are typically conducted to calibrate snorkel counts (Hankin 1984). However, the use of electrofishing to sample *O. mykiss* is ill-advised in high stress environments including elevated water temperatures. Therefore, future monitoring efforts will likely rely on snorkel surveys to continue collecting data on *O. mykiss* relative abundance and habitat availability. These data will serve as important indicators of anadromous *O. mykiss* repopulation in Bear Creek.

Acknowledgements

We would like to thank all PSMFC and CDFW staff who participated in the planning and implementation of this project, and recognize the field efforts of Kathryn Carmody and Sam Bankston from PSMFC. We would like to acknowledge the Fisheries Restoration Grant Program which provides funding for this project through grant P1550013.

Literature Cited

Allouche, S. 2002. Nature and functions of cover for riverine fish. Fish Bulletin 365/366: 297-324.

Bozek, M. A., and M. K. Young. 1994. Fish mortality resulting from delayed effects of fire in the greater Yellowstone ecosystem. Great Basin Naturalist 54:91–95.

Fausch, K. D., and T. G. Northcote. 1992. Large woody debris and salmonid habitat in a small coastal British Columbia stream. Canadian Journal of Fisheries and Aquatic Sciences. 49: 682-693.

Flosi, G., S. Downie, J. Hopelian, M. Bird, R. Coey, and B. Collins. 2010. *California Salmonid Stream Restoration Manual,* 4th ed. State of California, The Resources Agency, California Department Fish and Game, Inland Fisheries Branch.

Hankin, D. G. 1984. Multistage sampling designs in fisheries research: applications in small streams. Canadian Journal of Fisheries and Aquatic Sciences 41: 1575–1591.

Howell, P. J. 2006. Effects of wildfire and subsequent hydrologic events on fish distribution and abundance in tributaries of the North Fork John Day River. North American Journal of Fisheries Management 26:983–994.

Klose, K. 2018. Fisheries Resource Report Thomas Fire BAER Assessment – Santa Barbara and Ojai Ranger Districts Los Padres National Forest.

National Marine Fisheries Service. 2011. Southern California Steelhead Recovery Plan. Southwest Region, Protected Resources Division, Long Beach, California.

NOAA National Centers for Environmental Information. North American Drought Monitor. 2018. https://www.ncdc.noaa.gov/temp-and-precip/drought/nadm/maps. (accessed June 2018).

O'Neal, J. S. 2007. Snorkel Surveys. Pages 325-340 in Salmonid Field Protocols Handbook – Techniques for Assessing Status and Trends in Salmon and Trout Populations. American Fisheries Society, Bethesda, Maryland and State of the Salmon, Portland, Oregon.

R Core Team. 2017. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Raleigh, R. F., T. Hickman, R. C. Solomon, and P. C. Nelson. 1984. Habitat suitability information: Rainbow trout. United States Fish and Wildlife Service FWS/OBS-82/10.60. 64pp.

Rinne, J. N. 1996. Short-term effects of wildfire on fishes and aquatic macroinvertebrates in the southwestern United States. North American Journal of Fisheries Management 16:653–658.

Rosenfeld, J. S. and S. Boss. 2001. Fitness consequences of habitat use for juvenile cutthroat trout: energetic costs and benefits in pools and riffles. Canadian Journal of Fisheries and Aquatic Sciences. 58(3): 585–593.

RStudio Team. 2016. RStudio: Integrated Development for R. RStudio, Inc., Boston, MA. http://www.rstudio.com/.

Spina, A. P. 2007. Thermal ecology of juvenile steelhead in a warm-water environment. Environmental Biology of Fish 80:23-34.

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.

Tsai, Y. and T. Van Meeuwen. 2016. Snorkel Survey Protocol for Drought. Pacific States Marine Fisheries Commission. Unpublished.

Appendix

Figure A.1. Tanielle Redman, a Fisheries Technician with Pacific States Marine Fisheries Commission (PSMFC) conducts a snorkel survey of a small pool in Bear Creek.

Figure A.2. A portion of the Bear Creek survey reach photographed by CDFW and PSMFC staff during a redd survey conducted in April 2017 showing average habitat units and riparian vegetation.

Figure A.3. A portion of the Bear Creek survey reach photographed by CDFW and PSMFC staff during a redd survey conducted in February 2018 following the Thomas Fire and subsequent winter rain events.

Table A.1. Table of the cover types used to quantify the amount of trout cover available within a unit (percentage) and the type of cover being used by trout observed during snorkeling.

Cover Type	Description
Open/No cover	Percentage of the unit that is open and without trout cover. Trout are not hiding, instead milling or swimming in an open area of the unit.
Cobble/Boulder	Rocks less than the size of a Volkswagen Beetle. This category includes instances in which a 3-inch trout could hide in the crevices of a boulder cluster and underneath the ledge of the boulder.
SWD	Small Woody Debris. Fallen (dead) twigs, leaves, tree-related debris, loose roots (“free-wheeling”), and logs less than 12 inches in diameter or less than 6 feet long that is in the water and capable of providing cover to at least a 3-inch fish.
LWD	Large Woody Debris. Logs at least 12 inches in diameter and at least 6 feet long touching the water and capable of providing cover to at least a 3-inch fish.
Bedrock ledge	Rocks larger than a Volkswagen Beetle that overhang the water such that a 3 inch trout could hide underneath (approximately 6 inches deep or greater).
Terrestrial vegetation	Any live, terrestrial vegetation touching or overhanging within 1-foot of the water's surface that is large or complex enough to hide a 3-inch trout.
Aquatic vegetation	Any live, aquatic vegetation that is large or complex enough to hide a 3-inch trout.
Bubble curtain	Bubbles or agitated water created by flow that could provide cover a 3-inch trout.
Root mass	A mat or cluster of live roots (e.g. willow mats) that could provide cover to a 3 inch trout.
Soil Undercut	An area along the margins of the unit comprised mostly of soil that has eroded only underneath the surface to create a ledge. This undercut should be able to hide a 3 inch trout (approximately 6 inches deep or greater).
Other	Snorkeler could not identify the cover type used by the trout, or the cover type used did not fit into the above categories. Details should be included in the comments section. This category should very rarely be used.