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The Implications of Current Restoration Practices and Regulatory Policy for Recovery of the Federally Endangered Southern California Steelhead

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The Implications of Current Restoration Practices and Regulatory Policy for Recovery of the Federally Endangered Southern California Steelhead

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Environmental Science and Engineering

by

Stacie Michelle Fejtek

2017

ABSTRACT OF THE DISSERTATION

The Implications of Current Restoration Practices and Regulatory Policy for Recovery of the Federally Endangered Southern California Steelhead

by

Stacie Michelle Fejtek

Doctor of Environmental Science and Engineering

University of California, Los Angeles 2017

Professor Richard F. Ambrose, Co-chair

Professor Glen Michael MacDonald, Co-chair

Policy, management, and restoration practices focused on the federally endangered southern California steelhead (*Oncorhyncus mykiss*) were reviewed, tested, and compiled to provide opportunities to capitalize on already existing tools for steelhead recovery and other protected species inhabiting southern California coastal watersheds. Review of the Similarity of Appearance Clause, a rarely used portion of the Endangered Species Act, could provide southern steelhead's landlocked resident form (native rainbow trout) with greater protection from take based on the difficulty in differentiating between the two life history stages. Southern steelhead meets inclusion criteria set forth by the act, but more importantly fills the need for a precautionary approach in managing a highly endangered species. Despite being a priority recovery action small dam removal is still subject to environmental review, but recent streamlining efforts through programmatic permitting could reduce the burden on restoration partners. In the absence of examples of small dam removal monitoring data National Marine Fisheries Service programmatic

biological opinion for southern California was forced to implement precautionary thresholds on the amount of impounded sediment to avoid prolonged effects of sediment bleeding and loss of downstream habitat quality that may result under extended drought conditions. This research utilized low-cost, longstanding techniques to meet the monitoring requirements set forth in the programmatic opinion and added six small dam removal cases to support the finding of limited effects by impounded sediment on habitat quality downstream of dam removal sites. This study highlights the greater influence of upstream watershed inputs (land-use practices, roads, fires, etc.) on habitat quality rather than small dam removal impacts. Consideration of impacts and drivers on a watershed-wide scale (headwaters to ocean) is important for restoration targeting anadromous species like southern steelhead. A comparison of stream and wetland restoration issues identified common problems: climate change and process organization. Differences in permitting issues for streams and design concerns for wetlands are discussed in relation to the scale and geographical extent of habitat type in southern California. These are just a few examples of how rethinking lessons learned and reexamining already existing tools could aid in recovery of endangered species and maximize restoration dollars.

This dissertation of Stacie Michelle Fejtek is approved.

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2017

DEDICATION

This work is dedicated to my daughters Laurel and Robin Smith and Dr. Peggy Fong. The efforts and recommendations included in this thesis even if implemented today are not likely to yield results until the next generation and therefore this work is for my daughters and their daughters with the hope that they will get to see southern steelhead and other currently endangered species delisted and thriving. If it were not for Dr. Peggy Fong I would not have had the courage or support to complete this work or to embark on my life's greatest adventure, motherhood. Dr. Fong inspired me not only as a scientist, but as a mother to do more for the next generation by solving life's problems through science.

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Fejtek S., Edwards M., Kim K. (2011) Elk Kelp, Pelagophycus porra, distribution limited due to susceptibility of microscopic stages to high light. Journal of Experimental Marine Biology and Ecology 396; 194–201.

Ford T., Meux B., Fejtek, S. (2008) Kelp Forest Restoration Project Annual Progress Report. Santa Monica Baykeeper. Waterkeeper Alliance.

I. INTRODUCTION

The Endangered Species Act (ESA) of 1973 is one of the cornerstones of environmental protection. The ESA focuses on the incalculable value of diversity of species and provides for protection to ensure their existence and persistence. The ESA is placed under the authority of the Directors of the United States Fish and Wildlife Service (USFWS) for terrestrial and freshwater species and the National Marine Fisheries Service (NMFS) for marine species. Some species utilize both freshwater and marine habitats, falling between these two jurisdictions. *Oncorhynchus mykiss,* is one such species. Through the use of diverse habitats during its life history, *O.mykiss* represents a unique intersection of law, policy, and management of an endangered species.

At the southern end of its range, *O. mykiss* is incredibly adapted to cope with southern California's current and projected climate variability and the complexities associated with neighboring nearly 22 million people. *O. mykiss'* diverse habitat utilization makes it evolutionarily well suited to exist in such a seasonally unpredictable system that will become more so through climate change. Living in such a highly developed urban area as southern California poses additional threats to the species as human land and water use practices strand and cut-off migration flows for the species. *O. mykiss* in southern California, specifically Southern steelhead, was listed in 1997, but due to data gaps in species distribution and differences between NMFS and USFWS in defining the species population, this standard listing process was more complicated than most. After listing, NMFS developed recovery planning to help address the complexities of managing a highly endangered species in a volatile climate structured by environmental change and politics unique to the region.

II. BACKGROUND

A. *Oncorhynchus mykiss* Life History and Habitat Requirements

Oncorhynchus mykiss is one of six Pacific salmon in the genus *Oncorhynchus* that are native along the North American coast extending from the Aleutian Islands, Alaska to the U.S.-Mexico border. There are only two endangered *O. mykiss* populations: in southern California and in the Upper Columbia River, Washington. The southern California endangered steelhead population occurs at the southern extent of its range from the Santa Maria River, Santa Barbara, California to the U.S.-Mexico border (Figure I-1.). All members of the genus *Oncorhynchus* have the potential to exhibit anadromous life history strategies, migrating from rivers to ocean where they grow and mature before returning to their rivers to spawn. Unlike many of the other *Oncorhynchus* spp., *O. mykiss* is iteroparous, possessing the ability to spawn and then return to the ocean and repeat the cycle as many as four times (Shapovalov and Taft 1954). Also unique to *O. mykiss* is a wider range of life history strategies. This allows it to persist in a range of habitats and environmental conditions, including those found in the southern limit of the species. *O. mykiss* are known to exhibit multiple life history strategies: 1) fluvial-anadromous, 2) freshwater-residential, and 3) lagoonal-anadromous (Smith 1990, Hayes et al. 2004, Bond 2008).

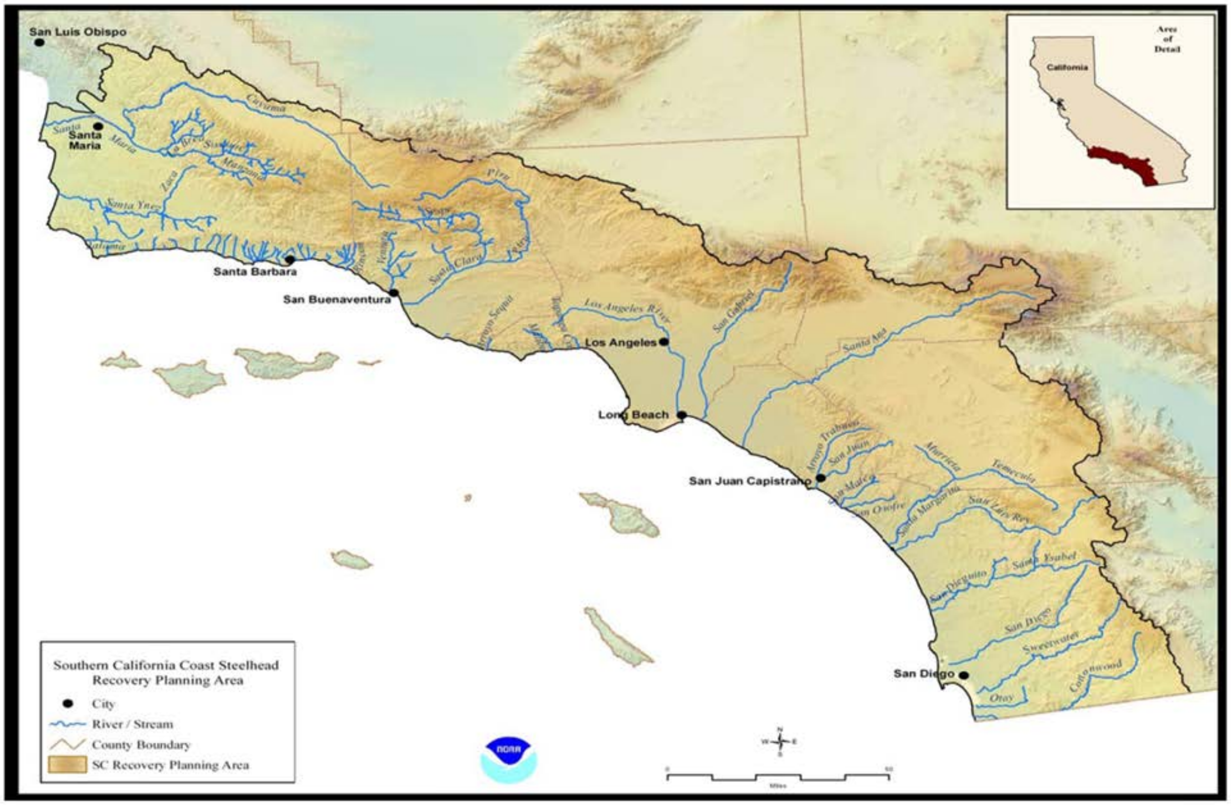


Figure I-1. Range of southern California endangered steelhead populations (NMFS 2012).

This variation in life history strategies gives rise to variation in species and habitat protection. Individuals that spend their entire lives in freshwater streams (freshwater-residential strategy) are known as “residents” and “rainbow trout” and are afforded no protection under the Endangered Species Act, while the anadromous forms are referred to as “steelhead” and are a federally-listed endangered species in southern California. *O. mykiss* has the ability to exhibit different life history strategies from one generation to the next, but the rate of this “cross-over” is poorly understood (NMFS 2007). Southern steelhead’s high variability in life history strategies gives rise to complex habitat needs, particularly during the freshwater phase, included in all *O. mykiss* egg-to-egg life cycles.

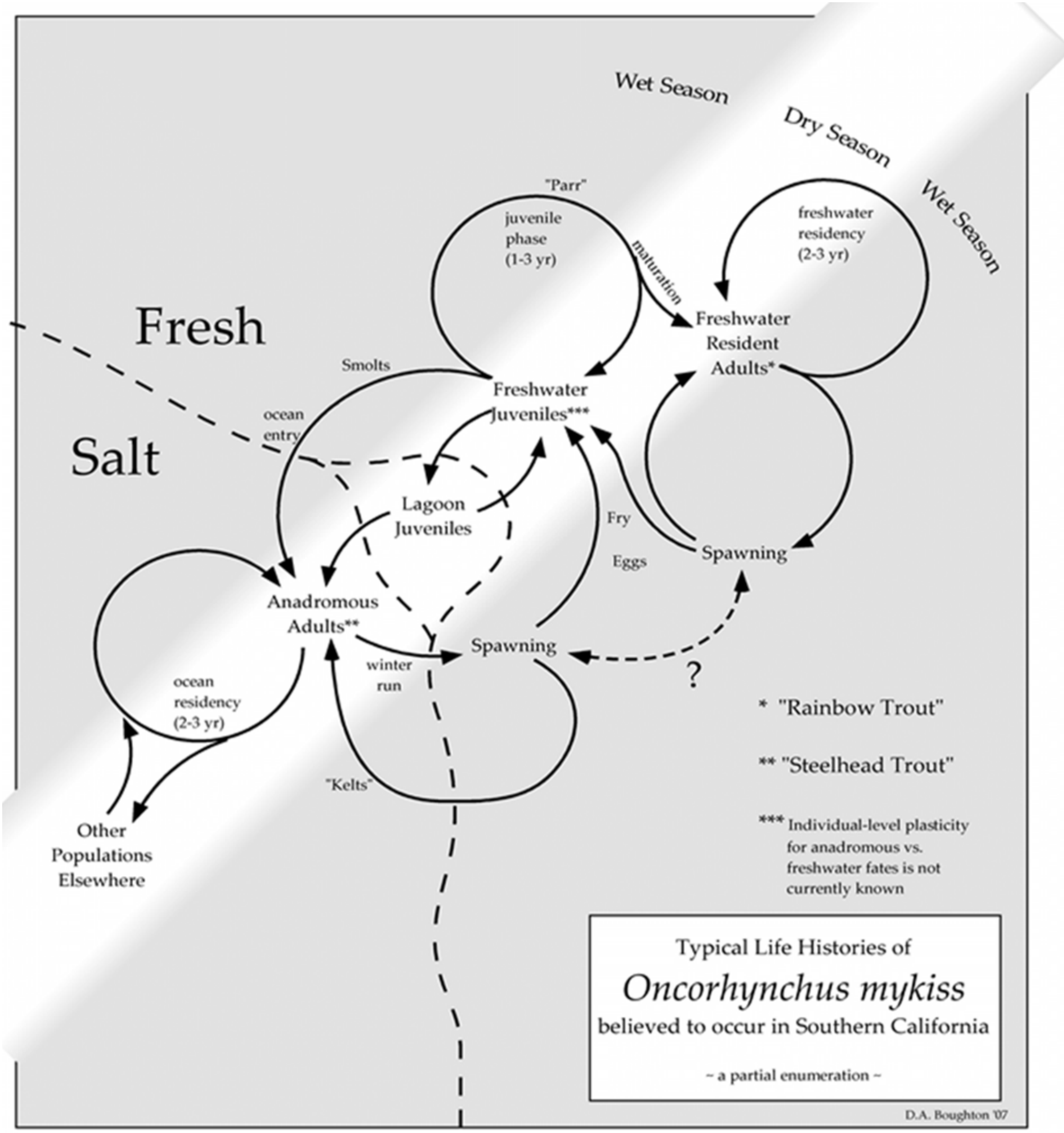


Figure I-2. Typical life histories of *Oncorhyncus mykiss* believed to occur in southern California (NMFS 2012).

The fluvial- and lagoon-anadromous strategies are the most complex and include the largest range of habitat types throughout the steelhead life cycle, with the only variation involving lagoon/estuary utilization (Figure I-2.). Developing embryos incubate in freshwater streams within gravel-cobble substrate for 3-8 weeks before hatching. Alevins, juveniles with an external yolk sac still attached, emerge from their gravel nests knows as redds 2-6 weeks later. Once the yolk sac has been consumed, the juvenile is termed a fry. Fry forage in schools along low-velocity channel margins and utilize gravel-cobble substrate and instream vegetation for cover. Once fry schools break up and the fish seek out individual territories throughout the stream they are termed parr (Shapovalov and Taft 1954).

Southern California steelhead parr utilize different seasonal habitats based on associated flows (Spina 2003, Spina et al. 2005, Boughton and Goslin 2006). Parr prefer territories commonly associated with deep pools: instream large woody debris, boulder clusters, undercut stream banks and deeper riffle/run feeding habitats for as long as the channel remains wetted. During summer and fall low-flow seasons, parr make seasonal movements in search of perennial stream reaches. Scour pools associated with boulders and large woody debris including intact rootwads are the preferred habitats where parr over-summer (Spina 2003, Spina et al. 2005, Boughton and Goslin 2006). During the winter, parr seek low velocity habitats that include off-channel/side-channel habitats (e.g. backwater pools and inundated woody vegetation) to provide refuge from high flow storm events (Solazzi et al. 2000). Parr will typically rear in freshwater for one to four years before out-migrating to the sea. Before entering the ocean physiological changes are necessary to adapt to salt water.

Smoltification is the physiological process that occurs in lagoon/estuary habitats when parr prepare for increased ocean salinity. Transformation of steelhead parr into smolts include mechanistic changes in osmoregulation (salt balance) and energy storage and well as changes in shape and color (Quinn 2005). Fluvial-anadromous steelhead only utilize lagoons for acclimation to saltwater and as a migration corridor with occasional spring-time feeding, but lagoon-anadromous steelhead spend either their first or second summer as juveniles in the seasonal lagoon at the mouth of the stream. It is worth noting that for steelhead populations within southern California lagoonal systems, the extent to which the lagoon-anadromous life history strategy is exhibited has not been investigated. However, steelhead smolts have been documented in southern California estuaries (NMFS 2011). Larger smolts will migrate to the sea in spring while smaller smolts will remain in the estuary to take advantage of the nutrient-rich feeding areas and cover from predators until they grow large enough to out-migrate. Some steelhead populations rear in estuaries for months (Bond et al. 2008). In addition to smolt size, estuarine entry and duration of use likely differ across the region based on estuary characteristics: size, habitat complexity, tidal influence, water quality and mouth breaching/opening (Jacobs et al. 2011).

Southern California is dominated by bar built estuaries that are only open to tidal exchange during a portion of the year. Smolt out-migration and adult spawning migration is only possible when fluvial outflow and/or wave energy is sufficient to break through the sand bar/ berm accumulated on the beach. When these systems are open in the Spring, smolts will out-migrate and spend 2-5 years maturing and growing in the ocean before returning to the natal rivers to spawn. Adults typically immigrate to natal streams for spawning December through May during freshets that provide sufficient flows to open-mouth rivers and estuaries (Bond 2008). Thus timing of spawning can vary among streams throughout the region due to the variation in opening and closing of mouths and sustained flows that are sufficient for adults to reach appropriate spawning habit.

Once adults approach the headwaters, females select spawning grounds based on substrate size, water velocity, depth, and temperature. Females dig redds in riffle crests with suitable gravel substrate. Egg pockets are excavated in gravel-cobble substrates at a mean depth of about 20 cm. (Sheutt-Hames et al. 1996). Once a suitable redd site is selected and constructed, one or more males will court the female. A female will select an acceptable male and release her eggs in the redd (Quinn 2005). A single spawning pair can create multiple egg pockets in the substrate, expanding the size of the redd. The female will immediately bury eggs under a layer of clean gravel after fertilization by the male, thus completing the egg-to-egg life cycle of *O. mykiss* in southern California.

B. Southern California Watersheds and Southern Steelhead Decline

There are 49 river systems included in the southern steelhead range. Southern California watersheds are characterized by short coastal drainages adjacent to the coast (e.g. Gaviota Coast streams and tributaries to Santa Monica Bay), and larger river systems that extend inland through the coastal ranges (e.g., Santa Maria River, Santa Ynez River, Ventura River, Santa Clara River, San Gabriel River, Santa Ana River, San Luis Rey River, and San Diego River). Major inland watersheds currently occupied by steelhead in the southern California include the Santa Maria, Santa Ynez, Ventura and Santa Clara River systems (Good et al. 2005, Boughton et al. 2009). Significant portions of the upper watersheds are contained within four National Forests (Los Padres, Angeles, San Bernardino, and Cleveland National Forests) where resources are managed and limited development has occurred, preserving high quality habitat, but are frequently disconnected from anadromy in the lower watershed and therefore are only inhabited by resident rainbow trout.

Survey data from Boughton et al. (2005) estimates that 58-65 percent of the historical steelhead basins currently harbor *O. mykiss* populations, but 2015 data indicates that only 33% (16 of the 49 river systems) are occupied by naturally spawning *O. mykiss* in southern California (Dagit 2015). Smaller coastal streams in Santa Barbara County (Arroyo Hondo Creek, Mission Creek, Montecito Creek and others), Ventura County (Rincon Creek), and northern Los Angeles County

(Malibu Creek, Topanga Creek and others) still support steelhead despite the intense coastal development. Three watersheds in southern Orange County and northern San Diego County (San Juan Creek, San Luis Rey River, and San Mateo Creek) have also had recent observations of steelhead. While endangered southern steelhead populations span all coastal counties from Santa Barbara to San Diego, but their numbers are far below viable self-sustaining populations (NMFS 2016).

A viable population is defined by the NMFS Recovery plan as a population having a negligible risk (< 5%) of extinction due to threats from demographic variation, natural environmental variation, and genetic diversity changes over a 100-year time frame. Using this definition, a viable population of *O. mykiss* requires an annual run size of an estimated 4,150 spawning individuals. The largest run size recorded since 1997 in southern California is estimated at 16 spawning individuals in Santa Ynez (Dagit 2015).

Steelhead were once abundant enough in southern California to support a recreational steelhead fishery; this declined drastically after World War II. With the increase in population, dams and water diversion projects dominated the landscape. Urban development concentrated in coastal areas and inland valleys, with the most extensive and densest urban development located within the Los Angeles Basin. More than 22 million people, over half the population of the State of California, live in southern California. Some coastal valleys and foothills, such as the Santa Ynez, Santa Clara, and San Luis Rey watersheds, are extensively developed with agriculture – principally row crops, orchards, and vineyards (NMFS 2012). The extensive loss and degradation of habitat is one of the leading causes for the decline of steelhead abundance in southern California and listing of the species as endangered (NMFS 1997, 2006).

C. Listing History of Steelhead

Southern Steelhead were first listed August 18, 1997 (62 FR 43937) under NMFS jurisdiction. Evolutionary Significant Unit (ESU) boundaries used during the first listing were from the Santa Maria River south to Malibu Creek. An ESU is composed of a group of conspecific populations that are substantially reproductively isolated from other conspecific populations, and that possess important elements of the evolutionary legacy of the species expressed genetically and phenotypically that have adaptive value (56 FR 224, Waples 1998). After discovery and genetic identification of steelhead in Topanga Creek in Los Angeles County and San Mateo Creek in Riverside, Orange and San Diego Counties, the ESU was extended south to the U.S.-Mexico border on May 1, 2002 (67 FR 21586).

In 2006, NMFS adopted the Distinct Population Segment (DPS) designation for steelhead to replace the ESU designation, consistent with the listing policies and practices of the U. S. Fish and Wildlife Service. A DPS is a population or group of populations that is discrete from other populations of the same taxon, and significant to its taxon. A group of organisms is discrete if it is "markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, and behavioral factors.'' Therefore a DPS differs from an ESU most importantly that a DPS does not need to be reproductively isolated. For steelhead this discrete significance can be observed as physical (e.g. dams and road crossings) or the physiological, ecological, or behavioral factors that are reflected by life history strategies.

The final designation for the southern California steelhead DPS encompasses all naturally spawned steelhead between the Santa Maria River (inclusive) and the U.S.-Mexico border (hereafter referred to as the southern steelhead DPS. See Figure I-1.) was adopted on January 5, 2006 (71 FR 834). Consequently, this DPS includes only those *O.mykiss* whose freshwater habitat occurs below impassible barriers, whether artificial or natural, and which exhibit an anadromous life history. If individuals that have originated in freshwater above impassible barriers are capable of anadromy, they are also considered part of the DPS when they are within waters below the most downstream impassible barriers. Therefore *O. mykiss* that are above impassible barriers and do not display anadromous life history characteristics are not granted any protection under the ESA.

D. Recovery Planning for Southern Steelhead DPS

The ESA as amended (16 U.S.C. 1531 et seq.) mandates that NMFS develop and implement recovery plans for the conservation of listed species. ESA envisions recovery plans as the central organizing tools for guiding the recovery of listed species rather than as implementation plans. The NMFS Southern California Steelhead Recovery Plan (2012a) provides guidance for achieving recovery goals by describing the biological criteria needed for delisting, limiting factors, and priority recovery actions that must be taken to recover the species. The recovery plan is not a regulatory document; it leaves latitude for implementation of recovery actions. The framework set forth by the NMFS recovery plan provides a durable implementation strategy with two key principles: 1) solutions that focus on fundamental causes for watershed and river degradation, rather than short-term remedies; and 2) solutions that emphasize resilience in the face of projected climate change to ensure a sustainable future for both human communities and steelhead (Beechie et al. 2013; Naiman 2005, Lubchenco 1998).

The southern steelhead recovery planning area, the exact same delineation of the southern steelhead DPS, is divided into five Biological Population Groups (BPGs): Monte Arido Highlands, Conception Coast, Santa Monica Mountains, Mojave Rim, and Santa Catalina Gulf Coast (Figure I-3**.**). Each BPG is characterized by differing physical and ecological characteristics that create a palate of natural selective regimes for steelhead population. Multiple watersheds comprise each

BPG and are generally considered different populations (i.e. one watershed = one steelhead population). Not every watershed in the BPG is included in the Recovery Plan. The Recovery Plan only includes core 1, 2, and 3 watersheds with core 1 receiving the highest priority for recovery actions. A number of factors determine the core rankings for watershed prioritization, including: 1) the intrinsic potential of the population in an unimpaired condition, 2) the role of the population in meeting the spatial and/or redundancy viability criteria, 3) the current condition of the populations, 4) the severity of the threats facing the populations, 5) the potential ecological or genetic diversity the watershed and population could provide to the species, and 6) the capacity of the watershed and population to respond to the critical recovery actions needed to abate those threats.

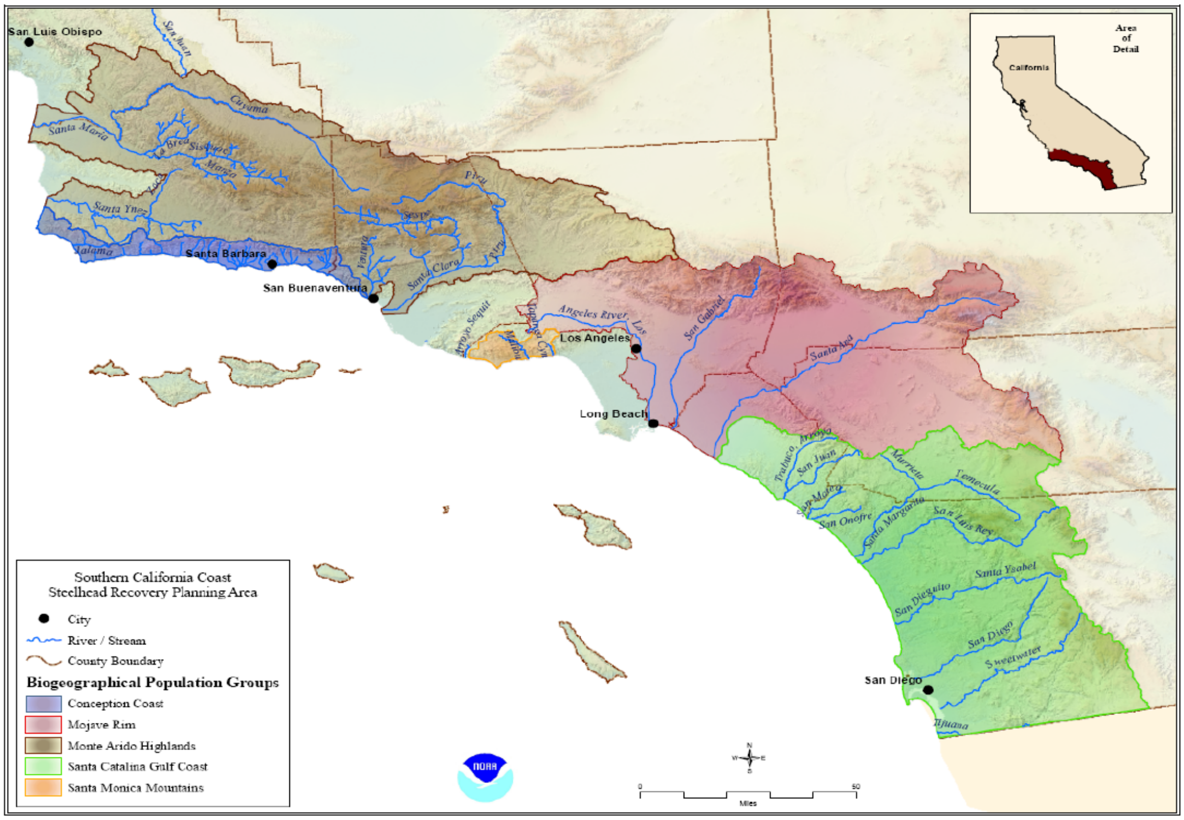


Figure I-3. The southern steelhead recovery planning area divided into Biological Population Groups (BPGs): Monte Arido Highlands, Conception Coast, Santa Monica Mountains, Mojave Rim and Santa Catalina Gulf Coast.

A threat assessment for each core watershed was developed throughout all five BPGs to assess the multiple threats to the species as well as the relative importance of each. The threat assessment allows for a further understanding of prioritization of recovery actions in each core watershed. Threats include: Dams and surface water diversions, wildfires, groundwater extraction, urban development, levees and channelization, other passage issues, flood control basins, roads, agricultural development, recreational facilities, non-native species, and estuarine loss. The threat sources ranked highest in the largest percentage of watersheds within in the recovery planning area were: dams and surface water diversions, wildfires, and groundwater extraction. Urban development, levees and channelization, and other passage barriers also affect a large percentage of steelhead watersheds in the southern steelhead DPS. Threats not quantified within the threat assessment include environmental variability of projected climatic change such as change in precipitation, sea level rise, or increase in wildfire across the region. The overarching strategy utilized by the recovery plan is to enhance the resiliency of steelhead metapopulations to respond to ecosystem changes by forecasting and managing thresholds of the species as climate science builds (Boughton et al 2009).

E. Dissertation Overview

O. mykiss in the southern California offer a unique opportunity to investigate and evaluate specific sub-sections of the ESA and how restoration practices can be maximized to recover a highly endangered species in the face of climate change, meeting the true intent of the ESA.

The rarely used portion of the ESA, Section 4(e): Similarity of Appearance clause, provides that a species not listed as endangered or threatened can gain de facto endangered or threatened status. Due to *O. mykiss* life history habitat utilization the species is divided in common name and ESA jurisdiction. Steelhead trout are the anadromous form with the ability to migrate to the ocean and therefore under NMFS jurisdiction while rainbow trout are land-locked and therefore under the jurisdiction of USFWS. Steelhead trout and rainbow trout are not similar species, but the same species with varying life history traits that are indistinguishable without lethal methods. Management decisions made by one agency can inadvertently affect the other species especially if those two species share difference in listing status like steelhead (endangered) and rainbow trout (afforded no protection). Chapter 1 examines ESA sec. 4(e) and what the section means for the resident rainbow trout including potential pros and cons of implementing this section for southern steelhead recovery.

The most commonly used section of the ESA is the section 7 consultation requirement, directing all Federal agencies to insure that any action they authorize, fund, or carry-out does not jeopardize the continued existence of an endangered/threatened species or designated/proposed critical habitat. Even highly-prioritized southern steelhead restoration practices, such as small dam removal, still trigger the environmental review process and are subject to section 7 consultations. Many steelhead restoration activities and projects have streamlined the section 7 process through regional programmatic review. Small dam removal has only recently been incorporated into programmatic review, but still creates a heavy burden of data collection for restoration partners due to NMFS concern that small dam removal may impose prolonged negative effects under extended drought conditions. Chapter 2 will evaluate how the prioritized practice of small dam removal influences stream morphology under extended drought conditions using low-cost restoration monitoring.

To meet the primary goal of the ESA, species recovery, restoration practitioners must maximize their restoration efforts while considering species habitat utilization and the complexities that climate change adds. Steelhead restoration is largely undertaken by small regionally focused non-profit restoration partners who are reliant on highly competitive grant programs for restoration funding. Due to southern steelhead utilization of stream and wetland habitats, restoration partners must work in multiple habitats, varying in scale and scope of restoration problems. Best management practices (BMPs) build on local and regional knowledge to help maximize restoration success by incorporating lesson learned from past restoration failures and successes. Chapter 3 will develop a comparison of stream and wetland restoration issues and BMPs in the face of climate change, assisting restoration partners to maximize their efforts towards steelhead recovery.

III. APPLICATION OF THE ENDANGERED SPECIES ACT'S SIMILARITY OF APPEARANCE CLAUSE FOR THE RECOVERY OF SOUTHERN STEELHEAD

A. Abstract

A rarely-used portion of the Endangered Species Act, Section 4(e): Similarity of Appearance Clause, provides that a species not listed as endangered or threatened can gain de facto endangered or threatened status if the agency with jurisdiction determines the listing is necessary because the species identity is not easily distinguishable. Some species are not just similar, but are genetically identical and only differentiated by life history. Even the most scientifically-certain methods of distinguishing steelhead trout (the anadromous, endangered form of *Oncorhynchus mykiss*) from rainbow trout (the landlocked, unprotected form) may be insufficient for enforcement personnel to prove take. Listing of rainbow trout due to similarity of appearance to steelhead would provide increased enforcement capacity as well as protection for native rainbow trout which potentially provides the capacity for genetic rescue. Review of previously listed §4(e) species revealed that the National Marine Fisheries Service has never implemented this sub-section and that to date it has only been implemented 12 times by the United States Fish and Wildlife Service. The Dolly Varden trout and Sonoran desert tortoise offer models for advancing a §4(e) listing of rainbow trout for the benefit of southern steelhead recovery.

B. Introduction

The purpose of the Endangered Species Act (ESA) is to protect species biodiversity. In recognition of the complexity of that task, the Act includes numerous clauses. The Similarity of Appearance Clause (hereafter §4e), provides that a species not listed as endangered or threatened can gain de facto endangered or threatened status if the agency with jurisdiction determines the species identity is not easily distinguishable by law enforcement or even a trained biologist (16

U.S.C. §§ 1531-1543 (1994). Exclusion of similar lookalike species complicates enforcement, monitoring used to inform recovery planning, and overall recovery potential of the species. Critically endangered species with extremely low population numbers are likely to benefit most from §4e because take of even one individual may represent a loss of potentially significant genetic contribution. Preventing even hypothetical take (undocumented due to rarity of species and therefore rare occurrences of take) is important for highly endangered species. Rare species have a greater likelihood of misidentification due to infrequent opportunities for both the public and enforcement individuals to hone their identification skills, therefore increasing potential take due to misidentification (Haas and McPhail 2000). To execute full intent of the Act, §4e is a needed component for listed species with lookalikes that complicate recovery objectives.

The federally listed endangered southern steelhead trout (*Oncorhynchus mykiss*) represents a species likely to benefit from implementation of §4e. It is also a unique and somewhat complex intersection of law, policy, and management for endangered species due to its rarity and similarity to a non-listed species. Steelhead trout are the anadromous form with the ability to migrate to the ocean, under National Marine Fisheries Service (NMFS) jurisdiction. The southern steelhead Distinct Population Segment (DPS) encompasses all naturally spawned steelhead between the Santa Maria River, California (inclusive) and the U.S.-M exico border (hereafter referred to as the southern steelhead DPS ((71 FR 834, See Figure I-1(NMFS 2012)). At the time of listing, only 500 individuals were thought to exist throughout the DPS (Williams et al. 2011). *O. mykiss* utilizes both freshwater (managed by United States Fish and Wildlife Service (USFWS)) and marine habitats (managed by NMFS) throughout its life history. Thus, management responsibilities are shared by two federal agencies, effectively bifurcating the population at the same boundary where *O. mykiss* are recognized as “different” species (steelhead vs. rainbow trout) (Gulesserian 1998).

Consequently, this southern steelhead DPS includes only those *O. mykiss* whose freshwater habitat occurs below impassible barriers, whether artificial or natural, and which exhibit an anadromous life history (71 FR 834. 2006). Therefore *O. mykiss* that are above impassible barriers and do not display anadromous life history characteristics are recognized as resident rainbow trout and currently not granted any protection under the ESA, complicating effective management of the species.

Protection of native rainbow trout, those ancestral trout populations likely cut off from the gene pool through the creation of fish passage barriers such as dams, can lower the extinction risk for steelhead for the same reasons that dispersal between separate steelhead populations reduces risk: 1) the existence of a "rescue effect" and 2) the possibility of recolonization (NMFS 2012). The rescue effect occurs when steelhead abundance is low and input from the trout population prevents their complete disappearance (NMFS 2012). Recolonization occurs when steelhead disappear completely, but are repopulated by the trout population (possibly due to fish passage barrier removal or through conservation hatcheries) (Hendry et al. 2004). It is thought that these processes are responsible for the maintenance of the steelhead population in Santa Clara River system and possibly other southern California watersheds in recent times, since modern steelhead runs appear far too small to be self-sustaining (Boughton et al. 2005). Unfortunately, lack of data prevents reliable estimates for the magnitude of the rescue effect that rainbow trout may play for steelhead recovery (NMFS 2012).

Southern steelhead recovery has remained stagnant despite the large investments in restoration activities throughout the region and further complicated by five years of drought (2011-2016) (NMFS 2016). The most recent 5-year status review concluded that "Native lineages have been nearly extirpated from this far southern region of the native range of *O. mykiss*, with only a few relict populations persisting in the headwaters of the San Gabriel, Santa Ana, and San Luis Rey rivers" (see also Abadia-Cardoso et al. 2016). Providing native trout populations with protection could be vital to steelhead recovery. Currently these individuals are afforded no protection and could be lost due to ignorance by only a few fishermen. These native trout populations may be the key for the ability to initiate conservations hatcheries in southern California (Jacobson 2016). These current pocket populations exist based on their innate ability to survive, but their luck could easily run out. Native populations face mounting climate change pressures including decreased flows, drought, elevated water temperatures, and increased wildfire incidence.

Currently §4e is not being implemented in the case of southern steelhead and rainbow trout. The resulting gap in protection has yielded three key problems to steelhead recovery: 1) Enforcement of take is complicated by the inability to definitively distinguish between steelhead and rainbow trout during the freshwater life history stages; 2) Monitoring that informs recovery planning is affected by the identity confusion and arbitrary designations used to discern rainbow trout and steelhead trout; and 3) The overall recovery potential of the species is jeopardized by excluding a segment of the population with genetic rescue potential. This research focuses on exploring a currently existing mechanism within the ESA, §4e, to provide these critical native trout populations with some protection for the benefit of southern steelhead recovery.

The primary goal of this research is to aid in southern steelhead trout recovery by compiling information to facilitate NMFS and USFWS to confidently move forward with an ESA §4(e) listing for rainbow trout within coastal streams to the natural limits of anadromy with support from state and local resource entities. This research will provide a foundation of support by answering the following questions:

1) Does §4(e) make sense for southern steelhead and resident rainbow trout?

2) How have NMFS and USFWS applied §4(e) in the past?

3) What lessons can be learned from past uses of §4(e) to benefit southern steelhead?

C. Does §4(e) Make Sense for Southern Steelhead and Resident Rainbow Trout?

> *§4(e): SIMILARITY OF APPEARANCE CASES – The Secretary may, by regulation of commerce or taking, and to the extent he deems advisable, treat any species as an endangered species or threatened species even though it is not listed pursuant to section 4 of this Act if he finds that— (A) such species so closely resembles in appearance, at the point in question, a species which has been listed pursuant to such section that enforcement personnel would have substantial difficulty in attempting to differentiate between the listed and unlisted species; (B) the effect of this substantial difficulty is an additional threat to an endangered or threatened species; and (C) such treatment of an unlisted species will substantially facilitate the enforcement and further the policy of this Act.* (16 U.S.C. 1533(e))

1. The problem with enforcement of take for similar species

There are three inclusion decision criteria set forth in the Act for applying §4(e):

1. Substantial difficulty in attempting to differentiate between listed and unlisted species.
2. The effect of this substantial difficulty creates an additional threat.
3. Treatment of an unlisted species as endangered will substantially facilitate enforcement of take for the listed species.

These criteria all revolve around providing increased enforcement capability and reduction in take. The discussion that follows utilizes each criterion to elaborate on the problems that currently exist for steelhead identification and enforcement as evidence for applicability for utilization for steelhead recovery benefit.

Criteria 1: Substantial difficulty in attempting to differentiate between listed and unlisted species

During the initial listing of steelhead, commenters reminded NMFS that its own proposed rule stated that “no suite of morphological or genetic characteristics has been found that consistently distinguishes between the two life-history forms." (69 FR 33102). There are several potential methods to determine if the *O. mykiss* in question is a steelhead or resident rainbow trout, but none provide the ability to consistently enforce the ESA. Some of these methods include color and size, specific size rules, and postmortem otolith testing. Identification of steelhead relies on the behavior of anadromy and it is therefore difficult if not impossible for enforcement personnel to differentiate in the field where enforcement of take is initiated.

Color and size can be an indicator of smoltification in which steelhead undergo physiological changes rooted in their ability to regulate salinity, but smoltification does not indicate anadromy and therefore does not provide the ability to differentiate steelhead and resident rainbow trout (Quinn 2005). It is worth noting that for steelhead populations within southern California lagoonal systems, the extent to which the lagoon-anadromous life history strategy is exhibited has not been investigated. However, steelhead smolts have been documented in southern California estuaries (NMFS 2012). Identification as steelhead relies on connectivity of estuaries to the ocean and because southern California is dominated by bar built estuaries tidal exchange, and thus smolt out-migration and adult spawning migration, are limited to a portion of the year in years of sufficient flow (NMFS 2015). Connectivity relies on fluvial outflow and/or wave energy large enough to break through the sand bar/berm accumulated on the beach (Jacobs et al. 2010). Thus, timing of spawning can vary among streams throughout the region due to the variation in opening and closing of mouths and sustained flows that are sufficient for adults to reach appropriate spawning habitat (Bond 2008). Under extended drought such as southern California experienced 2011-2016 (and is predicted to occur more often under climate change scenarios), many of these systems remained closed (NMFS 2016). Until a fish has made the journey to the ocean it is considered a resident rainbow trout in the eyes of the regulatory agencies.

California Department of Fish and Wildlife (CDFW) the primary enforcement entity for potential take of southern steelhead uses size rules (fish with fork lengths greater than 16 inches/40.46 cm) to differentiate between rainbow trout and steelhead in anadromous waters within coastal streams within the southern steelhead DPS (CDFW 2017). This 16-inch size distinction is utilized for determining the identity of steelhead and rainbow trout, but leaves all juveniles (alevin through smolt stages), even those below barriers, vulnerable to take as they would almost always be identified as rainbow trout due to their small size. While this 16-inch threshold does allow for an easy enforcement it leaves the entire fresh-water rearing stage of steelhead's life cycle vulnerable to take.

The most definitive technique currently available for differentiating between rainbow and steelhead trout is through the chemical analysis of the fish's otoliths, a lethal or postmortem process. Otoliths are ear bone structures in which sediment rings are deposited, similar to the way a tree builds rings as it grows. These bones can be analyzed for chemical signatures associated with specific locations in both freshwater and marine habitats. A resident rainbow trout will lack the signature associated with marine habitats. However even the most definitive currently available technique is vulnerable to incorrectly differentiating a functional steelhead juvenile. The otolith technique identifies maternal anadromy. Therefore, if the mother (which was offspring of ocean-run steelhead and therefore functionally a steelhead) is never able to journey to the sea due to lack of connectivity (below barriers to anadromy even as close as within estuaries) her offspring would lack that otolith signature needed to be definitively identified as functional steelhead (Zimmerman and Reeves 2000, Berejikian et al. 2013). Further, during extended droughts a generation of potential steelhead can be cut-off from the sea and even otolith testing would likely be inconclusive and incapable of differentiating steelhead and rainbow trout.

Criteria 2: The effect of this substantial difficulty creates an additional threat

After two decades of implementing steelhead-only listings, to the authors' knowledge there has only been one ESA civil fine ever assessed for take of California steelhead, and none in the southern steelhead DPS. A breach of the San Lorenzo River Lagoon (Santa Cruz, CA) in 2014 resulted in rapid dewatering and significant habitat changes leading to the deaths of "one or more" threatened steelhead (York and Sentinel 2015). While it is likely that many more steelhead were impacted by the breach, an attempt to enforce such take would be near impossible because proving take would require a trained biologist to meet the burden of proof legal standard without possessing a carcass. This has never been done (to the authors' knowledge) for southern steelhead.

To enforce take there must be certainty in species identification. Enforcement relies heavily on the location of the fish, whether it is up- or downstream of barriers to anadromy. The geographic distinction of species defines NMFS jurisdiction and the ability to enforce the ESA. CDFW fishing regulations enforce NMFS southern steelhead DPS distinction by prohibiting the take of fish downstream of barriers to anadromy in coastal streams throughout the region (CDFW 2017).

However, CDFW still operates “put-and-take” fisheries using hatchery-reared rainbow trout above many of these barriers with no protection afforded to the native trout. This requires the public to distinguish the limits of anadromy and where they can and cannot fish. This ultimately increases the likelihood of steelhead take. The limits of anadromy are constantly changing. Man-made barriers (dams, culverts, bridges) are being removed via recovery-plan-guided (and highly prioritized) restoration activities (NMFS 2012). This contributes to greater confusion on public fishing boundaries. Even in the case of take occurring downstream of barriers to anadromy (even as close as an estuary), enforcing take would require more definitive evidence (certainty of species identity) to meet the current burden of proof.

Criteria 3: Treatment of an unlisted species as endangered will substantially facilitate enforcement of take for the listed species

A §4(e) listing would remove the onerous need for field enforcement officers and NMFS legal and regulatory personnel to differentiate between a steelhead and rainbow trout to prove take within southern California coastal drainages up to the point of natural anadromy. Providing rainbow trout with a §4(e) listing would end “put-and-take” fisheries and recreational fishing within southern California coastal drainages up to the point of natural anadromy. Therefore, any person fishing within the natural limits of anadromy (below a natural barrier such as a waterfall) would be subject to take. Any action which results in take would not be subject to the current burden of proof (actually retaining the carcass and undergoing genetic or otolith analysis which may still be inconclusive). §4(e) would substantially facilitate enforcement and therefore the strength of the Act by removing this question of species identity and the constantly changing boundary of the DPS.

There are additional benefits to ending put-and-take fisheries beyond the value of enforcement. Ending put-and-take fisheries would free the ecological niche that hatchery fish are currently utilizing for native trout and steelhead resources. In coastal mountain drainages this is likely a small increase in fisheries closures while in others systems such as Santa Margarita or San Juan/Trabuco this could include additional miles of stream not currently protected. Current southern California hatcheries could turn their attention to needed conservation hatcheries, a tool not currently utilized for steelhead recovery, but recognized by NMFS Southern Steelhead Recovery Plan (NMFS 2012). Steelhead recovery work to establish and connect metapopulations using fish produced through conservation hatcheries in high priority watersheds is already underway by the South Coast Steelhead Coalition in accordance with the NMFS Recovery Plan, but the sub-population expansion is at early conceptual stages (Jacobson 2016).

2. The problem with monitoring only steelhead as it pertains to informing recovery criteria and recovery planning.

CDFW (in conjunction with the Pacific States Marine Fisheries Commission) and southern California local partnerships including the Santa Monica Mountains Resource Conservation District and the Cachuma Maintenance and Operation Board provide run size data from a small number of watersheds where such data is regularly collected using dual-frequency identification sonar (DIDSON) monitoring. DIDSON monitoring creates sonar images of fish which can reliably determine the difference between species, but all of these entities rely on size dependent classifications (fish with fork lengths greater than 16 inches/40.46 cm (CDFW 2017) and 20 inches/50 cm (personal communication Dagit, R., 2015) to differentiate between steelhead and rainbow trout despite the fact these monitoring locations exist in anadromous waters. Therefore three out of the four watersheds in which the current best available technology is utilized are potentially misidentifying steelhead (functional or actual) as rainbow trout (**s**ee Table III-1. Adapted from Atkinson et al. 2016). Classification of steelhead based on size alone potentially excludes all freshwater rearing stages (especially juveniles) which affects status reviews for the species as well as future recovery planning as well.

Table III-1. Run size data from a small number of watersheds where such data is regularly collected using Dual-Frequency Identification Sonar (DIDSON) monitoring (adapted from Adapted from Atkinson et al. 2016)

DIDSON Watershed Location	DIDSON Summary
Arroyo Hondo	During the deployment, four steelhead trout (total length ranged from 21 to 35 cm) were recorded milling at the site by the DIDSON. All four fish were believed to be residents based on their lengths.
Ventura River	During the first deployment, Department (unpublished data)captured footage of two steelhead trout (17cm and 30 cm TL). Both fish were believed to be resident fish based on length. During both the second and third deployments, one 23 cm TL steelhead trout was observed and it was suspected to be the one of the previously observed fish based on size
Topanga	During the deployment in April 2012, no adult anadromous steelhead trout were observed although several out-migrating steelhead trout smolts were recorded. Additionally, a total of five observations of "resident trout" (ranging from 19 to 23 cm TL) were documented from DIDSON. Both fish were believed to be resident fish based on length.
Salsipuedes Creek (tributary to Santa Ynez River)	Two steelhead trout (15 and 19 cm total length) were recorded by the DIDSON at this site, and both were believed to be residents by Department (unpublished data) based on their total lengths (15cm and 19cm) and the believed lack of access to the site from ocean (low stream flows and the presence of recently constructed beaver dams).

D. Previous Applications of §4(e)

1. How have NMFS and USFWS applied §4(e) in the past?

To understand past instances where the provision has been invoked, the USFWS Environmental Conservation Online System (ECOS) database was queried. To date, 2,392 species have been listed as threatened or endangered under the Endangered Species Act, with 1,653 of those in the United States (ECOS 2017). §4(e) has only been invoked by USFWS in 12 instances (9 for species in the US) and never by NMFS. Species listed under §4(e) include American alligator (*Alligator mississippiensis*), common caiman (*Caiman crocodilus crocodilus*), brown caiman

(*Caiman crocodilus fuscus* and *Caiman crocodilus chiapasius*), southern white rhinoceros (*Ceratotherium simum* ssp. *simum*), bog "Muhlenberg" turtle (*Clemmys muhlenbergii*), nickerbean blue butterfly (*Cyclargus ammon*), desert tortoise (*Gopherus agassizii*), ceraunus blue butterfly (*Hemiargus ceraunus antibubastus*), Cassius blue butterfly (*Leptotes cassius theonus*), puma/mountain lion (*Felis concolor* and all subsp. except *coryi*), shovelnose sturgeon (*Scaphirhynchus platorynchus*), and American black bear (*Ursus americanus*) (Table III-2. and Table III-3.*).*

Investigations into the motivation for listing species under §4(e) are primarily in recognition that the Section could reduce the risk of take. For example, the *Puma concolor* was listed as a §4(e) species to provide protection from illegal shooting/hunting of the Florida panther so no one could claim it had escaped from a zoo where other *P. concolor* subspecies are held in captivity (Scott 2006, USFWS 2008). The Sonoran desert tortoise was protected to prevent take of the Mojave desert tortoise as part of the pet trade (55 FR 12178). These are just two instances in which the act was used to reduce potential (hypothetical take since no case law exists for either to this end) take by removing the need for the public or authorities to distinguish between the species. It should be noted that every existing §4(e) listing occurred at the time of initial focal species listing. By pursuing §4(e) listing concurrent with §4(a) focal species listing, overall time and cost investment is reduced and protection to the listed focal species is maximized.

Table III-2. Query results for species listed under 4(e) from USFWS Environmental Conservation Online System (ECOS) database. **The American black bear and Louisiana Black bear were delisted in 2016. No distribution included in query for Southern White

Rhinoceros.

Scientific Name	Common Name	Similar to	Current Distribution
Alligator mississippiensis	American alligator	American Crocdile (*Crocodylus acutus)*	AL, AR, FL, GA, LA, MS, NC, OK, SC, TX; Southeastern U.S.A.
***Ursus americanus*	American black bear	Louisiana black bear (Ursus americanus luteolus)	LA, MS, TX; U.S.A. (LA, all counties; MS, TX, only within the historic county range of the Louisiana black bear)
Caiman crocodilus fuscus (includes *Caiman crocodilus chiapasius)*	Brown Caiman	Yacare caiman (*Caiman yacare;* also known as *Caiman crocodilus yacare)*	Venezuela, Peru, Mexico, Ecuador, Central America, Colombia
Leptotes cassius theonus	Cassius Blue Butterfly	Miami blue butterfly *(Cyclargus thomasi bethunebakeri)*	U.S.A. (FL), Bahamas, Greater Antilles, Cayman Islands
Hemiargus ceraunus antibubastus	Ceraunus Blue Butterfly	Miami blue butterfly *(Cyclargus thomasi bethunebakeri)*	U.S.A. (FL), Bahamas
Caiman crocodilus crocodilus	Common caiman	Yacare caiman (*Caiman yacare;* also known as *Caiman crocodilus yacare*	Venezuela, Suriname, Peru, Guyana, French Guiana, Ecuador, Colombia, Brazil, Bolivia
Cyclargus ammon	Nickerbean Blue Butterfly	Miami blue butterfly *(Cyclargus thomasi bethunebakeri)*	U.S.A. (FL), Bahamas, Cuba
Puma (Felis) concolor (all subsp. except *coryi)*	Puma (mountain lion)	Florida panther (*Puma concolor*)	FL; Canada to South America
Scaphirhynchus platorynchus	Shovelnose Sturgeon	Pallid sturgeon (*Scaphirhynchus albus*)	U.S.A. (AL, AR, IA, IL, IN, KS, KY, LA, MN, MO, MS, MT, ND, NE, NM, OH, OK, PA, SD, TN, TX, WI, WV, WY)
Gopherus agassizii	Sonoran Desert tortoise	Mojave dessert tortoise (Gopherus agassizii)	U.S.A. (UT, NV, CA, AZ), Mexico
Clemmys muhlenbergii	Southern Bog turtle	Northern Bog turtle (*Clemmys muhlenbergii*)	GA, NC, SC, VA; U.S.A. (VA, TN, SC, PA, NY, NJ, NC, MD, MA, GA, DE, CT)
Ceratotherium simum ssp. simum	Southern white rhinoceros	Javan (*Rhinoceros sondaicus*), Sumatran (*Dicerorhinos sumatrensis*), Indian (*Rhinoceros unicornis*), black (*Diceros bicornis*) and northern white rhino (*Ceratotherium simum cottoni*)	

Personal communication with both NMFS and USFWS indicated the concern of a §4(e) listing may trigger other sections of the Act leading to increased cost and staff time involved in such processes. Current interpretation and implementation of §4(e) has not extended to other protections of the Act that apply to species listed under §4(a). These would include consultation requirements for Federal agencies under §7 and the recovery planning provisions under §4(f) that apply to species listed as endangered or threatened under §4(a) (Scott 2006, Kilbourne 1991). However, it is less clear if scientific collection (§10(a)1(a)) would be affected under research scenarios that include take.

There is at least one known instance in which USFWS proposed a listing of an anadromous fish species, the Dolly Varden trout (*Salvelinus malma*), due to similarity of appearance with bull trout (*Salvelinus confluentus*), but never actually listed the species (66 FR 1628. 2001). Personal communication with USFWS staff involved in the process indicated that the reason for never pursuing the listing was due to mandated timing of recovery planning associated with the focal listed species, bull trout, rather than jurisdictional concerns. Thus, the importance of seeking §4(e) listing at the time of listing the focal species is further highlighted.

There are at least two instances (smooth/scalloped hammerhead shark and African/Indonesian coelacanth) in which NMFS was petitioned by outside entities to list species under §4(e), but never listed (81 FR 41934, 81 FR 17398). In both cases the request for §4(e) listing was subject to the three decision criteria set forth in the Act. Neither candidate species met all three criteria for listing under §4(e). While the African and Indonesian species exhibit morphological similarities, they are clearly geographically and genetically separated. Enforcement personnel would have no difficulty in differentiating between the Tanzanian DPS of the African coelacanth and the Indonesian coelacanth (fails criteria 1) because their geographic separation (in the Western Indian Ocean and Indo-Pacific, respectively) should already facilitate regulation of take (81 FR 17398). The take and trade of scalloped hammerhead sharks by persons under U.S. jurisdiction was not identified as a significant threat to the listed DPSs (failing criteria 2). In fact, for the threatened scalloped hammerhead shark DPSs (i.e., the Central and Southwest Atlantic DPS and Indo-West Pacific DPS), it was determined that prohibiting these activities would not have a significant effect on the extinction risk of those DPSs (79 FR 38213).

2. What lessons can be learned from past uses of §4(e) to benefit southern steelhead?

Of the species previously listed as §4(e) species, the Sonoran desert tortoise draws several parallels with rainbow and steelhead trout. One of the most unique characteristics about the steelhead listing is the bifurcation of the DPS based on behavioral traits (71 FR 834). This creates a geographic division between rainbow trout and steelhead even though they are essentially genetically identical and share a scientific name (Gulesserian 1998). The Sonoran desert tortoise is the only previously §4(e) listed species that splits the extent of protection, only protecting those south and east of the Colorado River (Table III-3.). Like *O. mykiss*, the Sonoran desert tortoise and the Mojave desert tortoise were genetically indistinguishable and shared the same name *Gopherus agassizii* at the time of listing. Today the Mojave and Sonoran desert tortoises have been distinguished as genetically unique species (*Gopherus agassizii* and *Gopherus morafkai*, respectively), but the §4(e) listing still stands regardless of their genetic differences because there is still difficulty identifying the differences in the field for enforcement purposes of preventing illegal pet trade (Murphy et al. 2011, Scott 2006).

Table III-3. Query results for species listed under 4(e) from USFWS Environmental Conservation Online System (ECOS) database. **The American black bear and Louisiana black bear were delisted in 2016.

Common Name	First Listed	Lead Region	Regions of Occurrence	Special Rules	U.S. or Foreign	Where Listed
**American black bear	01/07/92	4	2, 4	17.40(i)	US	Entire
American alligator	07/27/79	4	2, 4	17.42(a), 23.57	US	Entire
Brown caiman	05/04/00	Foreign	NA	17.42(g)	Foreign	Entire
Cassius blue butterfly	04/06/12	4	NA	N/A	US	Entire
Ceraunus blue butterfly	04/06/12	4	NA	N/A	US	Entire
Common caiman	05/04/00	Foreign	NA	17.42(g)	Foreign	Entire
Nickerbean blue butterfly	04/06/12	4	NA	N/A	US	Entire
Puma (mountain lion)	08/14/91	5	4	17.40(h)	US	U.S.A. (FL)
Shovelnose sturgeon	10/01/10	6	NA	N/A	US	Entire
Sonoran desert tortoise	04/02/90	8	2, 6, 8	17.42(e)	US/Foreign	AZ south and east of Colorado River, and Mexico, when found outside of Mexico or said range in AZ
Southern bog turtle	11/04/97	5	4, 5	17.42(f)	US	U.S.A. (GA, NC, SC, TN, VA)
Southern white rhinoceros	09/11/13	9	NA	N/A	Foreign	Entire

The proposed listing of the anadromous Dolly Varden trout also provides a great example of what a proposed rule might look like for rainbow trout and how to approach using such a unique portion of the ESA. Bull trout and the Dolly Varden trout are virtually impossible to differentiate visually, and misidentifications occur even using an established morphometric field identification procedure (Leary and Allendorf 1997). In a study of the errors associated with species identification, bull trout were misidentified as Dolly Varden trout 48 percent of the time while the error rate was only 2.5 percent for Dolly Varden trout misidentified as bull trout (Haas and McPhail 2000). Therefore, there is a clear line of enforcement value in listing Dolly Varden trout to prevent take of bull trout. As yet, no such study has been attempted to identify error rates in distinguishing rainbow trout and steelhead although it is reasonable to believe that a species as rare as the endangered southern steelhead would easily be misidentified as rainbow trout simply due to the rarity of the species and lack of opportunities to compare confirmed individuals.

The rarity of use for §4(e) has resulted in lack of agency familiarity especially for the Southwest Region. The Sonoran tortoise is also the only species with a distribution in California (or for that matter in all of the Southwest Region) to which §4(e) has been applied by USFWS (Table III-3.). The only instance of an attempted listing of an anadromous fish species (Dolly Varden trout) was undertaken by USFWS, indicating lack of organizational understanding by NMFS. The research in this article has already sparked interest from both agencies within the region, but identifying the next steps in implementing a §4(e) listing of rainbow trout are urgently needed considering rising threats (specifically extended drought conditions) to native rainbow trout populations if they are to offer any potential genetic rescue for steelhead.

Despite the rarity implementation, there appears to be little ambiguity in when to apply the rule based on the three inclusion criteria described in the act itself. There is case law that supports that this three-criteria test can provide sufficient affirmation in the court of law (867 F.Supp.2d 108). In 2012 a United States district court upheld the §4(e) listing of shovelnose sturgeon in a suit brought by the Illinois Commercial Fishing Association, who argued that the §4(e) listing was "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with the law." (5

U.S.C. § 706(2)(A), (C)). A similar such concern or civil suit may arise from recreational rainbow trout anglers in southern California. NMFS could bolster and possibly prevent such a suit by presenting clarity and specificity to meeting the three inclusion criteria during the listing process

E. Conclusion

The ability to enact §4(e) will require coordination between federal (NMFS and USFWS) and state agencies (CDFW). The coordination between federal agencies will primarily focus on developing and publishing the §4(e) listing, which is no small task. The rigorous rulemaking process requires publishing the proposed rule in the Federal Registry, a 60-day public comment period, and a public hearing before a final rule is reached. This process can take more than a year to complete under favorable conditions. A key aspect of creating those favorable conditions includes coordinating with CDFW in advance as to how CDFW would balance protection of steelhead and recreational fishing in southern California.

Ending put-and-take fisheries to the limit of natural anadromy would end all recreational fishing within potentially anadromous waters regardless of manmade barriers. CDFW's Mission is "to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public." Ending put-and-take fisheries and extending the range of protecting of steelhead to include all waters to the point of natural anadromy would reduce recreational fishing opportunities in southern California in the near term. However, if native rainbow trout are in fact able to provide a rescue effect, we could see a quicker recovery and increased fishing opportunities for future generations. Since CDFW wardens have the primary enforcement presence in the field, coordination between CDFW and NMFS would be required to ensure the added benefits of §4(e) through reduction of take are realized.

There exist two major logistical questions in implementing §4(e) for federal entities: 1) Which agency will pursue the listing process; and 2) What needs to be done between agencies to trigger a take case and provide the full enforcement value §4(e) offers? It makes a great deal of sense for the agency with the listed species to take the lead in advancing a §4(e) listing. NMFS has a greater familiarity with southern steelhead management and native rainbow trout's role in potential recovery, especially since a status review has never been conducted (nor does it need to be conducted per §4(e)) for rainbow trout. Additionally, NMFS has biologists and staff devoted to steelhead recovery whereas there is no such counterpart represented at USFWS for rainbow trout (because rainbow trout is not listed). Therefore, NMFS should take the lead by providing technical support and drafting the proposed rule, but allow for USFWS comments and legal review before initiating the rulemaking process. Coordination between the two agencies would be vital in successfully designating a cross-agency §4(e) listing, but that coordination does not end with the §4(e) listing. It must also include operational understanding about what to do when take occurs. It could be possible for the agency who manages the actual ESA listed species (e.g. steelhead or bull trout) to be able to act without consulting the agency who manages §4(e) species (rainbow trout or Dolly Varden trout). Asking these types of operational questions is an important aspect of actually implementing the sub-section of the Act. A memorandum of understanding (MOU) should be developed between the two agencies that addresses how each exercises its authority, undertakes the listing process, and future enforces take.

Applying §4(e) to rainbow trout for the benefit of southern steelhead could provide the following benefits: 1) the ability for NMFS to more effectively prove take; 2) protection to a segment of the population currently excluded that offers genetic diversity and potential rescue effect; and 3) encouraging California Department of Fish and Wildlife to end the practice of put-and-take fisheries in southern California coastal streams below the natural limits of anadromy. Implementing §4(e) for rainbow trout to benefit steelhead recovery would mark not only the first time NMFS used this sub-section, but it would act as a landmark in cross-agency coordination to implement the act. The groundwork set by both of these notable achievements could benefit not only southern steelhead, but other threatened and endangered species over which NMFS has authority, such as the recently delisted DPS of humpback whales.

IV. INVESTIGATING COST-EFFECTIVE APPROACHES TO SMALL DAM REMOVAL FOCUSED ON RECOVERY OF SOUTHERN STEELHEAD UNDER EXTENDED DROUGHT CONDITIONS

A. Abstract

Small dam removal carries certain inherent risks. These risks vary based on removal goals, unique hydrologic characteristics that exist naturally within the region, and anticipated climate change. To ensure dam removal elicits a net beneficial response for endangered species, such as southern steelhead (*Oncorhynchus mykiss*), environmental review is necessary. In many cases this review can be streamlined through programmatic permitting. This study examines three high priority steelhead streams in southern California where six dams were removed under extended drought conditions (2012-2016). The feasibility of applying the constraints and monitoring requirements set forth in the National Marine Fisheries Service southern California programmatic biological opinion are explored. This study aims to understand how sediment released by small dam removal influences streambed morphology under extended drought conditions in southern California, employing cost-effective long-standing methodologies in order to: 1) Understand the hydrologic context southern California streams face under extended drought conditions; 2) Examine elevation change in streambeds after dam removal to understand its influence in changing habitat features; and 3) Evaluate stream substrate quality in response to dam removal. Even under extended drought conditions, small dam removal efforts guided by biological opinions had clear benefits to fish passage and habitat quality. Scenarios with sequential dam removal and those operating with limited permit constraints were able to alleviate fish passage constraints, but have more complex impact on habitat quality. This study highlights the importance of regional sediment

flux and the value of programmatic environmental review when undertaking dam removal with the goal of aiding steelhead recovery.

B. Introduction

Twenty-eight salmonid and other anadromous species populations (e.g. green sturgeon), have become depleted to the point of listing as threatened or endangered under the Endangered Species Act (ESA) (NMFS 2016). These depletions are due in large part to the inability of species to migrate freely up and down watersheds to complete their life cycles (Whol 2012, Moyle et al. 2017). The National Marine Fisheries Service (NMFS) Southern California Steelhead Recovery Plan (NMFS 2012) identifies fish passage barrier removal as a critical recovery action to assist the highly endangered southern steelhead (*Oncorhynchus mykiss*). Sixty-eight percent of steelhead losses are associated with anthropogenic barriers to migration (e.g. dams, flood-control structures, culverts, etc.) (Boughten et al. 2006), yet a critical gap in dam removal understanding still exists in scientific literature. Of the 1,594 dams in California, less than 100 have been removed statewide and only four of those dams have one or more scientific publication associated with them (Bellmore 2017). Dam removal monitoring that does exist is often short term (1-2yrs) and often includes little or no data prior to dam removal (Major et al. 2017). The United States Geological Survey (USGS) Dam Removal Information Portal (DRIP) identifies a complete gap in studies for the Southern California Bight (USGS 2017).

Dam removal in southern California has the potential to provide both upstream and downstream benefits for steelhead recovery. Most importantly dam removal allows for access of additional habitat upstream of the dam that may include more ideal spawning and rearing habitat than was previously available. Downstream benefits include gravel transport that improves habitat quality. Monitoring of over 400 redds in the Ventura and Malibu watersheds identified preferred particle sizes of 10-140mm for spawning by southern steelhead (Per comm. R. Bush 2014). Logically this is the grain size that restoration practitioners hope to release and see transported downstream post dam removal. Understanding the impacts of dam removal in the context of unique drivers of the region such as hydrology and geomorphology are vital in understanding the influence of this restoration technique (Graf 2005). The potential benefits of releasing impounded gravel are not without risks, and there remains concern for both short- and long-term impacts following dam removal.

Sediment quantity and quality ("caliber," or grain size) are concerns for small dam removal in steelhead-bearing streams. Importantly, these factors are influenced in part by the hydrology of the region (Graf 2005, Skalak et al. 2009, Major et al. 2017). Southern California hydrology can be highly variable and could be even more so under the extended drought conditions anticipated in climate change scenarios. This variability in hydrology has the potential for small dam removal to result in sediment fouling (fine particles <6.4mm inundating covering areas of more optimal grain size) of stream reaches extending up to 100-meters downstream of dam removal sites. This fouling could continue for 1 to 2 years or longer under drought conditions as exhibited between 2011-2016 (NMFS 2015). This type of sediment fouling is likely to negatively impact steelhead habitat and fry emergence times (Bjorn and Reiser et al.1991). However, negative impacts from dam removal may be temporary and potentially outweighed by better quality upstream made accessible by dam removal. Of course, there are still major considerations when permitting such an activity (NMFS 2015). To make an informed decision, it is important to understand the quantity and quality of impounded sediment and the role that region-specific hydrology may play in permitting dam removal to ensure restoration activities yield net-positive benefits for target protected species.

Due to the potential risks, small dam removal is subject to environmental review despite the potential recovery benefits it may yield. The ESA Section 7 biological consultation process can be costly and time consuming, resulting in permitting delays or making restoration projects financially infeasible. Programmatic biological opinions (BOs) are one method that restoration projects can be prioritized and the Section 7 process can be streamlined while still providing necessary protections to threatened and endangered resources. This reduces the time and cost involved in the formal Section 7 consultation process for the applicant, reviewing agency, and other permitting entities (Pagliuco and Samonte 2015). A review of consultations for restoration actions completed in Oregon in 2011 showed that the average time for restoration projects covered by a programmatic consultation was 6 days or less—as compared to 132 days or longer for restoration projects that required individual consultation (NMFS 2014). On December 23, 2015, a biologic opinion covering southern California was approved by NMFS. These programmatic documents are powerful permit and design tools for restoration practitioners who can leverage them.

Three conditions preclude a small dam removal project from eligibility for coverage under the southern California BO: 1) sediments stored behind dam have a reasonable potential to contain environmental contaminants (dioxins, chlorinated pesticides, polychlorinated biphenyls, or mercury); 2) the risk of significant loss or degradation of downstream spawning or rearing areas by sediment deposition is considered to be such that the project requires more detailed analysis; or 3) impoundment of more than 900-cubic yards of sediment (regardless of quality/grain size). Therefore, this study aims to explore the feasibility of applying the constraints and monitoring requirements set forth in the NMFS southern California programmatic biological opinion to understand how sediment released by small dam removal influences streambed morphology under extended drought conditions in southern California.

Table IV-1. Comparison of dam removal site characteristics.*Dam remnants did not impound sediment, but constricted flows.

Dam Site Name	Lattitude	Longitude	Barrier Serverity	Sediment Storage (Yrds³)	Dam Height (ft)	Thick (ft)	Width (ft)	Valley Form	NMFS Biological Opinion	Road Adjacent	Removal Method
Trabuco 7	33.67437	-117.52586	Total	631	6	5.5 base, 2.5 cap	31	Constrained	No	Yes	Excavator and pneumatics
Trabuco 9	33.67426	-117.52536	None	0*	4.5 - 9 at thalweg	4.5	25	Constrained	No	Yes	Excavator and pneumatics
Trabuco 10	33.67432	-117.52521	Total	74	2.5	2.5	2.5	Constrained	No	Yes	Excavator and pneumatics
Trabuco 11	33.67436	-117.52507	Partial	281	6.5	2	40	Constrained	No	Yes	Excavator and pneumatics
Arroyo Sequit	34.05788	-118.93298	Partial	185	5	4	40	Constrained	Yes	No	Pneumatic hand tools
Lion Creek	34.54345	-119.16380	Partial	182	3.1	1.5	26.5	Constrained	Yes	No	Pneumatic hand tools

C. Study Setting

During 2014 several small dams were removed throughout southern California (Table IV-1.): 1) One small check dam structure from Lion Creek in the Sespe Wilderness, Los Padres National Forest. Project implementation began October 13 and was completed November 17; 2) One small check dam structure from Arroyo Sequit Creek. Project implementation began August 18 and was completed September 4; and 3) Four small dams (only dams 7, 10, and 11 impounded sediment) within Cleveland National Forest in Trabuco Creek were removed in December. Trabuco Creek is the only site in which multiple dams were removed simultaneously.

Figure IV-1. shows locations of 2014 small dam removal projects overlaid on southern California steelhead DPS (adapted from NMFS 2012). Physical and land-use characteristics are compiled in Table IV-2. to provide context of watershed characteristic across the region (adapted from NMFS 2012). None of these dams had reasonable potential to contain environmental contaminants; therefore contamination was not examined in this study.

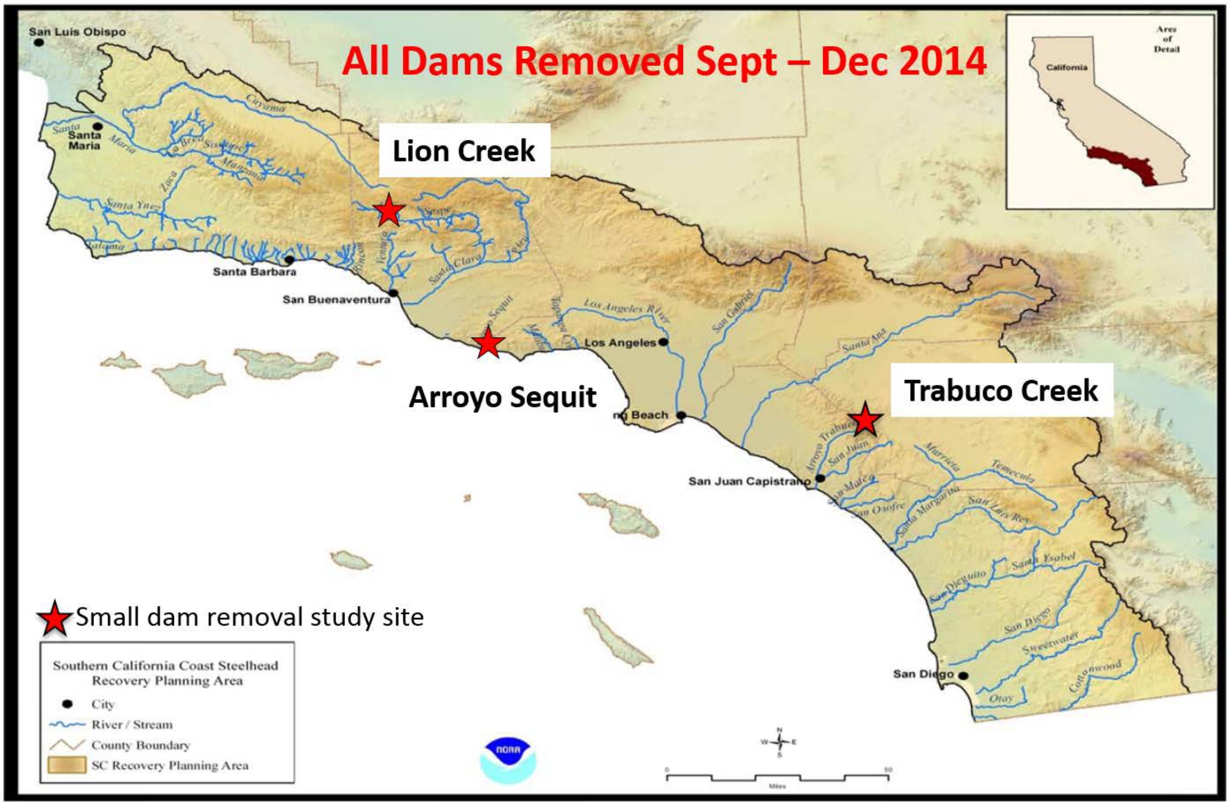


Figure IV-1. Small Dam Removal Sites

The study sites share few similarities (Table IV-1.) with the exception that all three creeks are recognized as historic southern steelhead waters and the dams served no current purpose but were barriers to fish passage. Arroyo Sequit and Trabuco Creeks are ephemeral (containing dry segments reducing connectivity some portion of the year) while Lion Creek exhibits perennial flows. The three creeks currently have varying levels of protection due to position in watershed and ability for steelhead to access the sites. Lion Creek dam and Arroyo Sequit check dam were both accessible to steelhead under certain flow conditions while Trabuco Creek has multiple total barriers (barriers that prevent fish passage under all flow conditions) in the watershed (notably Interstate 5 and Orange County Metrolink crossings). Thus, Trabuco Creek dam removal sites would only have resident rainbow trout (the landlocked life history form of steelhead), which do not receive protection under the Endangered Species Act, and therefore would not require a Section 7 consultation to engage in dam removal activities. Therefore, Trabuco Creek dams could be removed differently (not subject to a NMFS biological opinion) and under much fewer constraints than if done in areas accessible to steelhead.

Table IV-2. Physical and land use characteristics for small dam removal sites watersheds. Adapted from NMFS 2012. *Ventura Watershed includes Lion Creek dam removal study site.

Physical Charactersitics						Land-Use			
Watersheds	**Area (acres)**	**Area (sq miles)**	**Stream Legnth (miles)**	**Ave. Annual Rainfall (inches)**	**Total Human Population**	**Public Ownership**	**Urban Area**	**Agricultural /Barren**	**Open Space**
*Ventura River	144,967	227	409	18.8	44,550	48%	6%	9%	85%
Arroyo Sequit	7,572	12	17	17.9	370	43%	3%	1%	96%
San Juan Creek	113,977	178	280	12.5	191,997	37%	23%	7%	70%

D. Methods

This study employs cost-effective long-standing methodologies to achieve the following goals: 1) Understand the hydrologic context southern California streams face under extended drought conditions; 2) Examine elevation change in streambeds post dam removal to understand how dam removal may influence change in habitat features; and 3) Evaluate stream substrate quality in response to dam removal.

1. Site Conditions

To understand the hydrologic context southern California streams face under extended drought conditions, publicly available stream discharge data was reviewed (Goal #1). Stream discharge data from the nearest USGS stream gauge was used for Lion Creek (USGS 11111500- Sespe Creek near Wheeler Springs, CA) and Trabuco Creek (USGS 11047300- Arroyo Trabuco at San Juan Capistrano, CA). No gauge data is available in Arroyo Sequit Creek; therefore the nearest gauge data was reviewed (Topanga Creek – Los Angeles Department of Public Works No. F54C-R). It should be noted that Lion Creek and Trabuco gauges are further downstream (12 and

23 miles respectively), where flows are likely to be greater due to increased runoff and convergence of flows from other tributaries. Gauge data was used to understand flows that each stream experienced following dam removal (September 2014) during the study period (September 2015-June 2016). Additionally, monthly precipitation summaries (NOAA California Nevada Rover Water Forecast Center 2017) were compiled for 2014-2017 to show range of variability in precipitation. The nearest stations available were used to create water year summaries: Ojai station was used as a proxy for Lion Creek (~15 miles away), Oxnard station for Arroyo Sequit (~20 miles away), and Santa Ana for Trabuco Creek (~28 miles away).

2. Habitat Response to Dam Removal

To address Goals #2 and #3, the data on elevation and substrate changes in the streambed from September-October 2015 (representing extended drought following dam removal) were compared to data from May-June 2016 (representing low flow conditions). Longitudinal profiles (elevation and habitat type with particular focus on pools) and Wolman pebble counts (substrate assessments) followed standard protocols described in the California Department of Fish and Wildlife Salmonid Restoration Manual (Flosi et al. 1998) and the US Forest Service Field Technique Guide (Harrelson et al. 1994). Analysis of grain size followed Bevenger et al. 1995 and used Potyondy and Bunte 2002 publicly available free software. Fines likely to negatively impact steelhead habitat was defined as grain sizes ranging <2mm-6.4mm (Bjorn and Reiser et al.1991). Beneficial spawning particle sizes are considered 10-140mm (NMFS unpublished data 2014; personal communication with R. Bush, NMFS). Pre-dam-removal longitudinal profiles and pebble counts were only available for Lion Creek (U.S. Forest Service, Los Padres unpublished data). Multiple dams were removed in close proximity (less than 10 feet between the dam influence of the two dams) at Trabuco Creek and therefore Wolman pebble counts were combined for dams 10 and 11 in order to achieve sufficient sample size in the distance between the two dams (Figure IV-3a.). No pebble counts were conducted immediately downstream of dam 9 because there was no sediment impounded by the barrier.

There was no pre-dam-removal data documenting the amount of sediment stored behind any of the dams studied; therefore, sediment storage capacity was estimated using dam height, dam width, and estimates of length of impounded sediment from pre-removal photographs. No cross sections or substrate assessments were completed on impounded sediment because dams were removed prior to initiation of study.

E. Results

1. Site Conditions

When summary monthly precipitation water year records were compared to the 30-year average, Lion Creek (proxy station Ojai) ranged from 45-54%, Arroyo Sequit proxy (Oxnard) ranged from 38-67%, and Trabuco Creek proxy (Santa Ana) ranged from 26-61% (Table IV-3.). Nearest stream gauge discharge data is compared across all dam removal sites (Figure IV-2 a-c.). Sespe Creek stream gauge (12 miles downstream of the Lion Creek dam removal site) indicated that during the study only two storm events exceeded 100 CFS (Figure IV-2a.). Topanga stream gauge (Arroyo Sequit nearest gauge) exhibited intermittent flows with only one event exceeding 50 CSF (Figure IV-2c.). Although the Topanga gauge is in a different watershed than where dam removal occurred (23 miles down coast), it is more likely to represent flows near the study site because of the gauge's location in the watershed is similar to the actual location of dam removal (dam removal and gauge are less than one mile from the ocean). Trabuco Creek gauge experienced much higher flows exceeding 100 CFS on more than 20 occasions and even exceeded 1000 CFS on two occasions during the study period (Figure IV-2b.). Trabuco Creek stream gauge even exhibited flows over 100 CFS during July 2015. Due to its position in the watershed (23 miles downstream from dam removal site), Trabuco is subject to increased flow from water releases from upstream sources (e.g., private golf course pond and reservoir) and occurs in the most developed of watersheds in the study.

Table IV-3 Summary of monthly precipitation percent total water year records when compared to the 30-year average.

Location	Latitude (°N)	Longitude (°W)	Elevation (ft)	2014 Percent Total Water Year	2015 Percent Total Water Year	2016 Percent Total Water Year
OJAI	34.44	119.13	1560	45	54	50
OXNARD	34.21	119.14	63	38	67	42
SANTA ANA	33.74	117.87	135	26	61	38

2. Habitat Response to Dam Removal

Longitudinal profiles showed change in elevation of key habitat elements including pools (Figure IV-3 a-c), but direct dam removal change was only reflected at Lion Creek (Figure IV-3a.) because it was the only site which pre-dam-removal data existed. Longitudinal profiles showed that no pool loss resulted directly from dam removal at Lion Creek (large pools located at ~70-100ft and ~170-215ft) (Figure IV-3a.). At Arroyo Sequit the step pools immediately downstream (~110-125ft) and immediately upstream (~154-189ft) of dam removal site at Arroyo Sequit were maintained throughout the study. However, Arroyo Sequit lost pool depth in the uppermost pool above the dam removal site (at ~294-329ft in Figure IV-3b.) and Trabuco creek lost depth in two of three pools (Figure IV-3c).

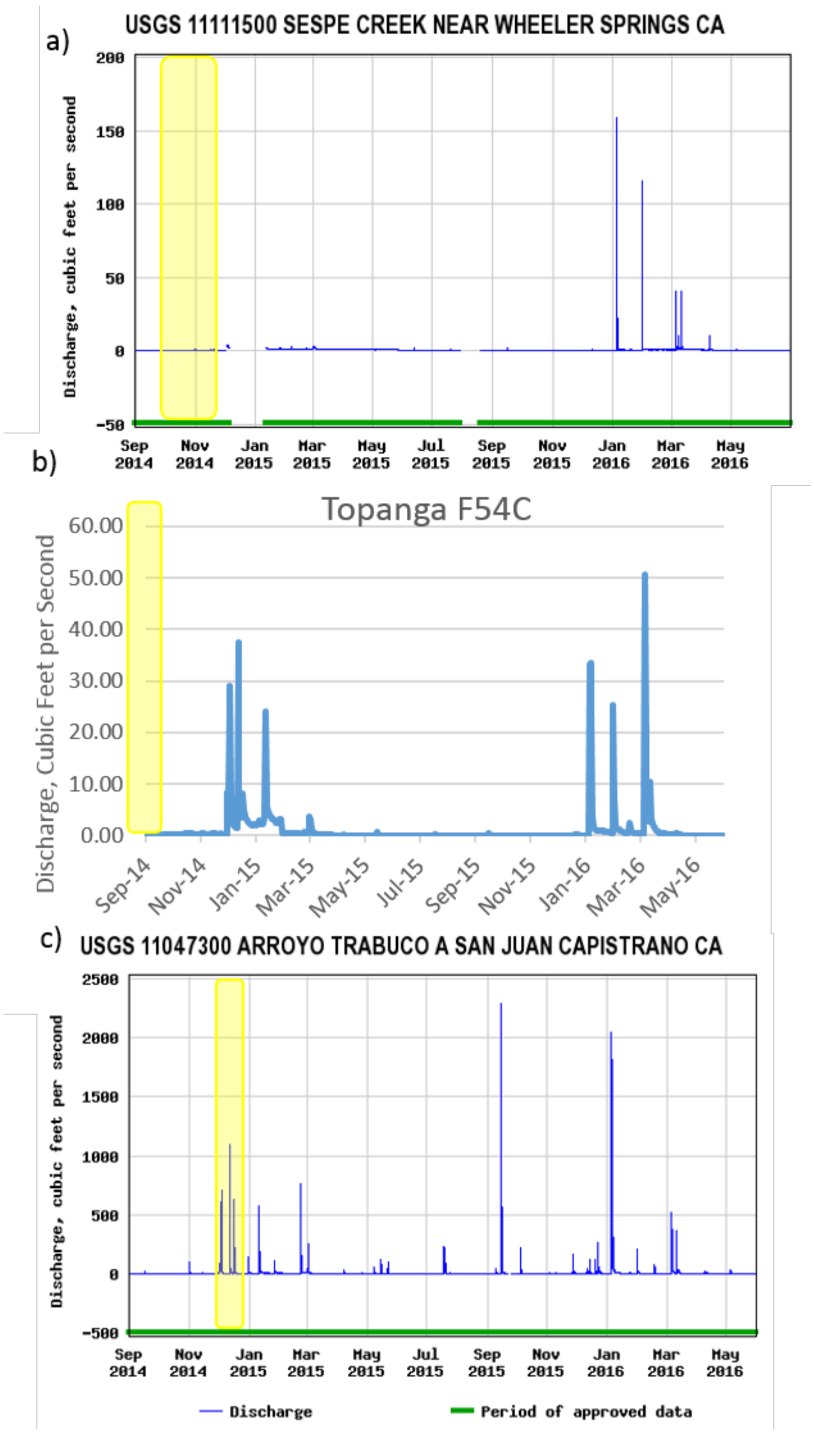
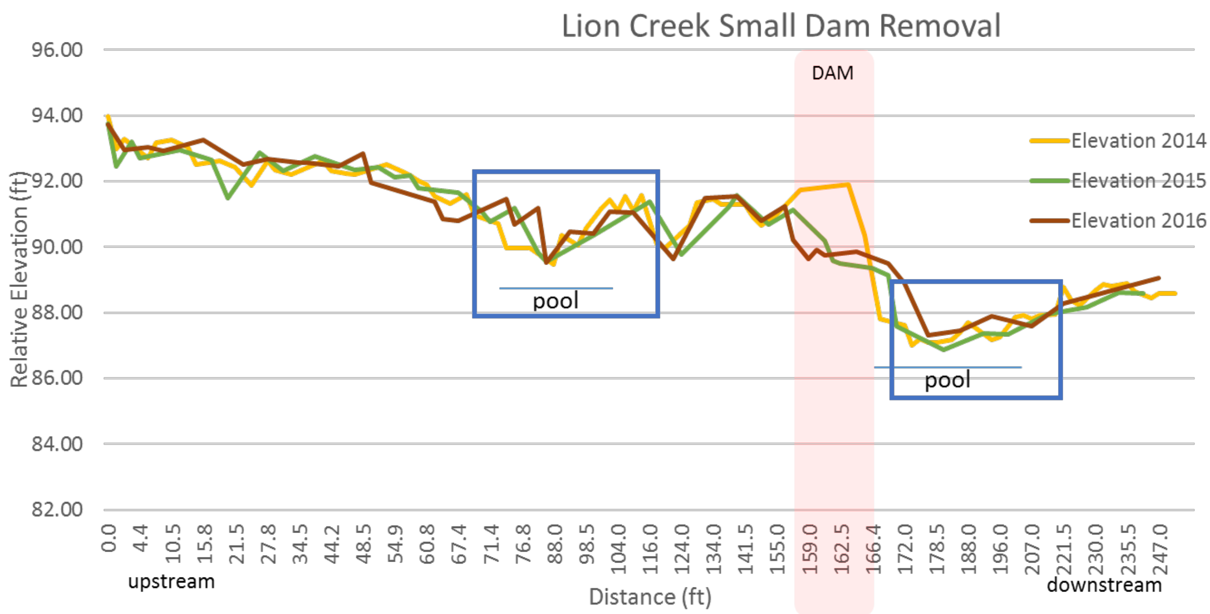
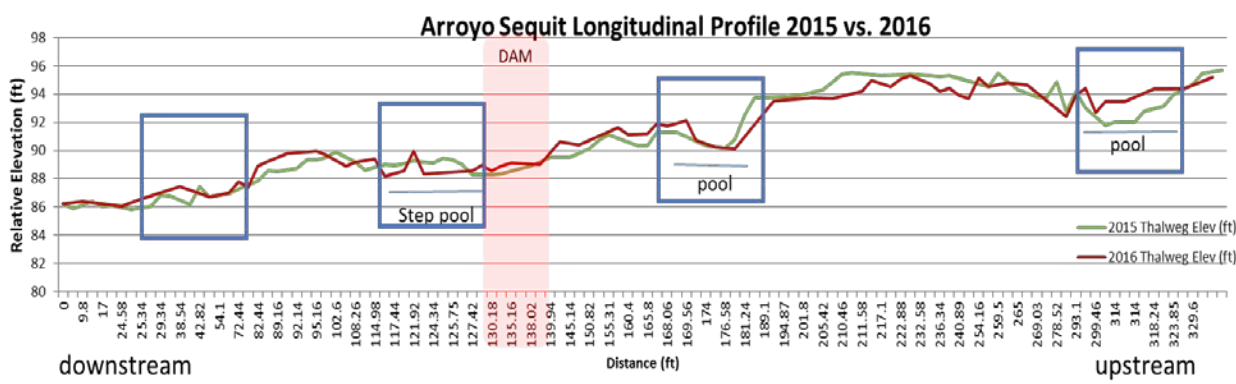


Figure IV-2 a-c. Stream discharge data at nearest stream gauge to dam removal site. Yellow bars highlight dam removal period for each site.

a)


Lion Creek Small Dam Removal
DAM
Elevation 2014
Elevation 2015
Elevation 2016
pool
pool
Relative Elevation (ft)
96.00
94.00
92.00
90.00
88.00
86.00
84.00
82.00
0.0 4.4 10.5 15.8 21.5 27.8 34.5 44.2 48.5 54.9 60.8 67.4 71.4 76.8 88.0 98.5 104.0 116.0 124.0 134.0 141.5 155.0 159.0 162.5 166.4 172.0 178.5 188.0 196.0 207.0 221.5 230.0 235.5 247.0
upstream
downstream
Distance (ft)

b)


Arroyo Sequit Longitudinal Profile 2015 vs. 2016
DAM
Step pool
pool
pool
2015 Thalweg Elev (ft)
2016 Thalweg Elev (ft)
Relative Elevation (ft)
98
96
94
92
90
88
86
84
82
80
0 9.8 17 24.58 25.34 29.34 38.54 42.82 54.1 72.44 82.44 89.16 92.14 95.16 102.6 108.26 114.98 117.44 121.92 124.34 125.75 127.42 130.18 135.16 138.02 139.94 145.14 150.82 155.31 160.4 165.8 168.06 169.56 174 176.58 181.24 189.1 194.87 201.8 205.42 210.46 211.58 217.1 222.88 232.58 236.34 240.89 254.16 259.5 265 269.03 278.52 293.1 299.46 314 314 318.24 323.85 329.6
downstream
Distance (ft)
upstream

c)

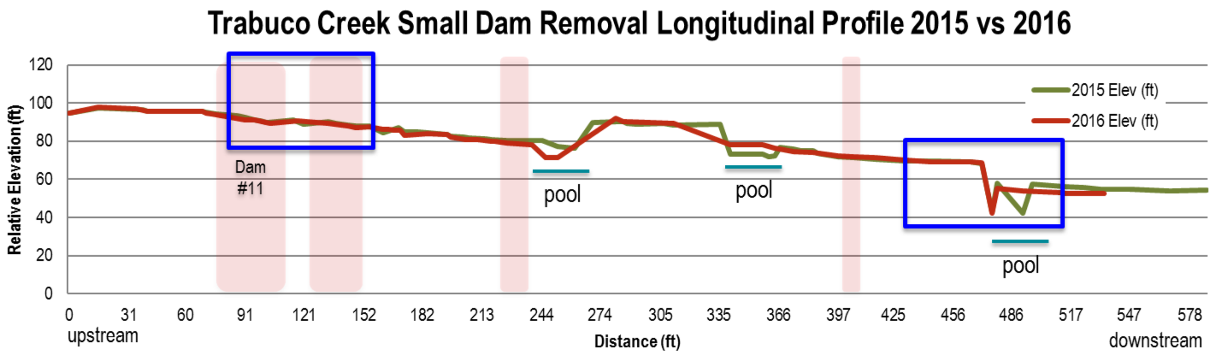


Figure IV-3 a. Longitudinal profiles showed change in elevation of key habitat elements including pools. Blue line boxes indicate location of pebble counts. Underlined portions indicate key pool habitats. Highlighted segment indicates location of dam. a) Lion Creek pre (2014) and post dam (2015) removal and under extended drought (2016). b) Arroyo Sequit post dam removal (2015) and under extended drought (2016). c) Trabuco Creek.

Wolman pebble counts tracked the change in substrate overtime (Figure IV-4 a-d.). Initial response of dam removal indicated an increase in ideal spawning gravel (grain size 10-140mm) and a decrease in fines (grain sizes <2mm-6.4mm) at Lion Creek (Figure IV-4a.). Lion Creek Wolman pebble counts showed an overall increase in ideal spawning gravel from 2014 pre-dam-removal conditions (Figure IV-4a). There was an increase in fines between 2015 and 2016, but the levels were similar to those measured before removal; this indicates watershed inputs and not dam removal (Figure IV-4a). For Arroyo Sequit, pebble counts conducted downstream of the dam removal and immediately upstream indicated no significant difference in fines or spawning gravel, but the perennial pool located upstream (watered throughout entire drought) indicated a significant increase in fines in 2016 (Figure IV-4b.). Trabuco creek lost depth in two of three pools (Figure IV-3c.), and exhibited a significant increase in fines in the lowermost pool (Figure IV-4c.). Trabuco Creek showed a significant decrease in fines between 2015-2016 in riffle habitat downstream of dam 10 and 11 removal sites, despite the fact the 2015 sampling occurred just after the largest storm event during the study period (Figure IV-4c.). Sediment storage capacity ranges from 74-631 cubic yards of impounded sediment (Table IV-1.).

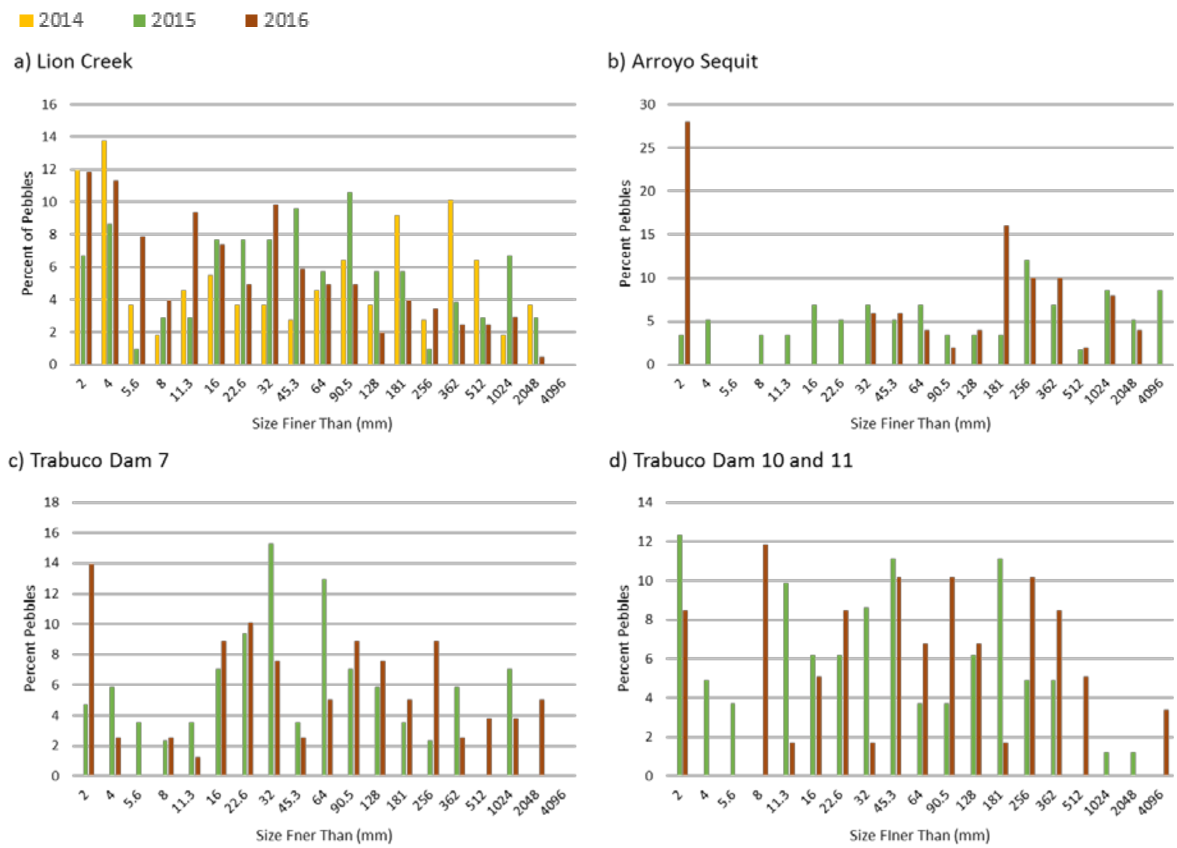


Figure IV-4 a-d. Wolman pebble counts tracked the change in substrate overtime. a) Lion Creek pool below dam removal. b) Arroyo Sequit upper pool above dam removal. c)Trabuco Creek below dams 10 and 11. d) Trabuco Creek below dam 7. Ideal spawning gravel identified as grain size 10-140mm and fines identified as grain sizes <2mm-6.4mm. Only Lion Creek had pre removal data collected in 2014.

F. Discussion and Future Research Considerations

Even under extended drought conditions, flows were sufficient to transport the majority of sediment stored by the small dams included in this study within a year of removal (if not sooner). This supports other finding in which flows below a 2-year storm event were adequate to mobilize most of the sediment previously stored behind dams (Pearson et al. 2011, Major et al. 2012, Wilcox et al. 2014, Major et al. 2017). Southern California, like much of the arid southwest is subject to flashy storm events that, even under drought conditions, appear sufficient to prevent sediment-bleeding scenarios that would create prolonged impacts to stream water quality (Garf 2005). Future studies could further investigate this specific factor by quantifying sediment caliber prior to dam removal and then directly tracking turbidity following removal along with other biologically relevant characteristics (e.g. dissolved oxygen) to provide greater insight on potential impacts of dam removals occurring in ephemeral and low-flow streams.

Numerous studies identify reservoir sediment quantity and caliber as critical pieces of information to inform dam removal decisions (Doyle et al. 2003, Sawaske and Freyburg 2012, O'Connor et al. 2015, Major et al. 2017). Sediment storage capacity was not directly measured by this study although volume of stored sediment was roughly estimated to provide insight into the scale of potential dam removal impacts in the future. None of the dams included in this study impounded more than the threshold of 900 cubic yards identified by the programmatic biological opinion, therefore it is still uncertain if 900 cubic yards is indeed a reasonable threshold for southern California or if there is opportunity for larger scale projects to be eligible for coverage under the programmatic permit to further enable this critical recovery action to be undertaken. This study echoes Bellmore et al.'s assertion that inadequate pre-dam-removal data is a critical gap in dam removal science and emphasizes the importance of capturing a better understanding of reservoir sediment quantity and caliber prior to dam removal.

While the sediment quality impounded by these dams was unknown, there was variability in what remained instream after removal based on regulatory ability. Lions Creek and Arroyo Sequit were subject to terms and conditions under their own individual biological opinions requiring that all concrete be removed from the stream because they are part of the southern steelhead DPS. Roughly 20 tons of concrete and sediment were removed by hand from Arroyo Sequit during the 11-day process (The Bay Foundation 2014). Trabuco Creek, however, was not subject to a NMFS biological opinion because of downstream barriers which exclude it from NMFS jurisdiction. The Trabuco dam removals left most of the dam debris instream. It should be noted that the concrete were locally sourced rock and mortar. Trabuco Creek exhibited the greatest impact to pools and habitat quality, but in addition to not being subject to BO requirements, it was the only dam immediately adjacent to a road and the only sequential dam removal studied, further complicating the interpretation of the results.

While Trabuco Creek creates more future research questions than answers for this study, it does offer an example of a potential cost-effective strategy for high density small dam removal by taking advantage of its location in relation to NMFS jurisdiction. Without being subject to NMFS review, the range of methodologies by which dam removal can be implemented are greater. This is key for the removal of over 80 small dams (many only a few feet away from each other) with a budget that might be insufficient to design and remove even a single barrier lower in the watershed. The value of removing these small dams is not only recognized in the cost savings of the removals (no requirement to engineer restorations to meet fish passage criteria at this time), but provides additional momentum to address downstream legacy fish passage barriers like Interstate 5, priming the upstream habitat for if and when the downstream barriers (most notable is the Interstate 5 spillway and concrete apron) are remedied.

Increased fines and loss of pool depth upstream of dam removal sites at Arroyo Sequit highlights the importance of the watershed's background sediment flux (which was not accounted for in this study or required under the programmatic opinion). Sediment input from land-use practices and watershed inputs (fires, roads, erosion from unseasonal urban freshwater inputs) and natural annual sediment flux may be more important influences on stream morphology and habitat quality under drought conditions than dam removal itself. Calculating a sediment budget for a watershed is a complex undertaking and would likely be cost-prohibitive for small dams such as these. However, it is not uncommon for small dams to be located in systems with large defunct dams (e.g. Matilija Dam, also on the Ventura River) in which case sediment budgets may already exist and have the potential to add considerable insight to projects throughout the watershed. The ability to track these large-scale watershed inputs is limited, but should not be underestimated even in these seemingly remote and less-impacted streams.

Dam removal is a complicated restoration strategy, but vital in restoring stream connectivity for anadromous species. This study fills a critical geographic gap in dam removal knowledge in a region with increasingly dynamic hydrologic variation, placing questionable doubt on the paradigm that hydrology and watershed setting are subordinate influences on initial geomorphic response to dam removal. This study also provides insight into dam removal response under a range of management strategies to help focus future small dam removal planners on key factors where monitoring is needed to best inform managers and agencies when making species-specific recommendations. Finally, while no two dams are likely to respond identically, programmatic permitting gives an opportunity to create consistency in pre- and post-dam-removal monitoring requirements and should be viewed as an opportunity to understand dam removal on a regional scale for recovery of species most at risk.

V. BEST PRACTICES FOR SOUTHERN CALIFORNIA COASTAL WATERSHED-WIDE RESTORATION AND MANAGEMENT IN THE FACE OF CLIMATE CHANGE

A. Abstract

Many coastal rivers and wetlands have been heavily altered and degraded. The degradation of upstream systems directly influences the processes of downstream coastal wetlands. Anadromous species such as the endangered southern steelhead are dependent on wetland and river systems functioning together; recovery of such species requires these systems to be restored with system connectivity in mind. Coastal watershed restoration professionals working in both coastal wetlands and coastal rivers/streams in southern California were surveyed regarding the best management practices in the face of climate change. Coastal watershed restoration professionals were asked to consider all phases of restoration (planning, construction, and post-restoration management). The planning phase had largest number of issues watershed-wide. The most frequent issues identified for coastal wetlands were: 1) Climate Change; 2) Process Organization; 3) Stakeholders; and 4) Restoration Design. Streams' most frequently-identified restoration issues were: 1) Climate Change; 2) Process Organization; 3) Permitting; and 4) Adaptive Management. In southern California from 2002-2017, 3.5 times more coastal stream restoration projects have been undertaken than wetland projects, which appears to play a key difference in the restoration issues (in particular permitting, process organization, and restoration design). In addition to comparing coastal ecosystem restoration issues, this study focuses on eight climate-change-specific best management practices with a watershed-wide perspective.

B. Introduction

Wetlands and rivers are the two key systems that comprise a watershed; climate change will affect both (IPCC 2014). Anticipated climate change effects for rivers include increased stream temperatures and altered stream flow, likely resulting in altered scour rates and reduction in forest cover (Mote et al. 2003, IPCC 2014, NMFS 2016). The most imminent threat from climate change for coastal wetlands is sea level rise (SLR), but wetlands are also predicted to undergo changes in the timing of closure and opening of the estuary mouth in addition to possible acidification impacts (IPCC 2014). The ability of coastal wetlands to naturally keep pace with projected SLR is limited by their capacity to naturally accrete sediment or transgress as sea level rises (Morris et al. 2002, Belliard et al. 2017, Roman 2017). Often coastal areas where wetlands would naturally migrate with SLR are occupied by growing populations and dense human infrastructure. Sediment accretion via fluvial processes has been reduced by dams, channelization and urbanization of rivers. Some of the most anticipated drivers in coastal wetland evolution regardless of climate change scenarios are the processes that result from fluvial inputs (Beechie et al. 2010). These systems are undeniably vulnerable to climate change and interconnected.

Anadromous species such as the endangered southern steelhead (*Oncorhynchus mykiss*) are dependent on coastal wetland and stream systems functioning together. Recovery of such species requires both systems to be restored with connectivity in mind. Anticipated climate change is likely to affect the federally listed endangered southern steelhead throughout its life cycle due to its complex life history and diverse habitat utilization (NMFS 2016). To meet the goals set forth in the Endangered Species Act (ESA) and achieve species recovery, restoration practitioners must maximize their restoration efforts while considering species habitat utilization and the complexities that climate change adds (NMFS 2012). The southern steelhead's utilization of both stream and wetland habitats requires restoration partners to work in both with varying scale and scope of restoration projects. Inherent to addressing such a wide breadth of restoration project types are the inevitable restoration issues that can delay or undermine restoration goals from being achieved. Projects have thus far been managed in isolation, essentially treating each restoration project as a different scientific, political, and social experiment (Palmer 2009).

Wetland and river restoration has evolved over the last 40 years, encountering numerous social, political, and scientific hurdles (Thayer and Kentula 2005). Climate change concerns now add more complexity. Early restoration of coastal systems during the 1970s focused on small scale mitigation, placing little importance on ecological criteria (Race and Christie 1982). Over the next 20 years, managers and scientists struggled to better understand the effects of initial site conditions, causes of degradation, impact of restoration scale, and importance of setting clearly defined restoration goals (Palmer et al. 1997, Palmer et al. 2009). Recognition of the need to incorporate resiliency in coastal systems through adaptive management strategies began to develop in the late 1990s (Thom 2000), but was not developed specifically with climate change in mind. Management of watershed-wide restoration projects for climate change differs due to site-specific characteristics: structural complexity (current and pending human infrastructure both within and surrounding a site), sediment transport/compaction/accretion/subsidence, and pumping of groundwater and/or hydrocarbons (CO-CAT 2013). Climate change has only recently entered restoration planning and policy, adding to the complicated history of problems embedded in coastal restoration.

Best management practices (BMPs) build on local and regional knowledge to help maximize restoration success by incorporating lessons learned from past restorations (Stark and Dettman 2010, LoSchiavo et al. 2013, Bellmore 2017). Structured BMPs better incorporate lessons learned from past restorations in an action-oriented, clear, and digestible form that are more accessible to those who undertake restoration. Lessons learned from one restoration could be the crux of another. Additionally, understanding similarities and differences between stream and wetland restoration issues can provide insight to general coastal restoration problems, providing pathways to solutions.

The goal of this research was to develop a watershed-wide comparison of restoration issues, sharing lessons learned through BMPs developed specifically focusing on southern California and climate change to enable practitioners to maximize benefits and success of their restoration efforts. Southern California's dense coastal populations and heavily degraded coastal rivers and wetlands make the region more susceptible to climate change (CO-CAT 2013). Comparing restoration issues that affect both system will provide a greater benefit for species that utilize multiple ecosystem (like southern steelhead). This research aims to better understand coastal restoration, specifically confronting climate change issues in restoration and management across southern California watersheds from headwaters to ocean.

C. Methods

Two separate and independent processes were undertaken to develop BMPs, first for coastal wetlands and then coastal stream systems to allow for comparison of restoration issues watershed-wide. These separate processes allowed for the comparison of system to better understand overlapping and unique problems. Both processes utilized a wide range of project participants that included a range of expertise: biologists/ecologists and engineers/hydrologists from federal, state, and local government agencies as well as private consulting companies and contractors. Both processes utilized the same ten questions (only variation was system identifiers "wetland" or "river/stream" to solicit restoration issues and identify potential BMPs (Appendix A). Questions consisted of multipart questions that focused on each restoration phase (planning, construction, and management).

Responses to questionnaire the interviews were compiled from the interviews into larger restoration themes, then refined by removing ambiguous recommendations, combining similar responses, and restructuring recommendations into action-oriented BMPs (i.e. if you want X, then do Y). The same 17 restoration themes were identified by both processes and therefore the basis of the watershed-wide comparison. All BMPs were structured with an action-oriented approach. BMPs were not intended to be stand-alone statements, but rather a simplified way for managers to identify a restoration issue and possible solutions based on other's previous experiences. BMPs were organized by the phase in which the identified restoration issue occurs (planning, construction, or management). Unique aspects of the BMP development processes are discussed by process.

1. Coastal Wetland BMP Process:

The wetland BMP process involved one-on-one interviews with wetland experts, a workshop meeting, and synthesis of the information by the authors. This study engaged wetland professionals who have worked on coastal wetland restoration projects within southern California (Point Conception to the United States/Mexico international border). A list of 40 potential project participants was developed based on their experience and reputation as recognized experts in the wetland restoration community. Participants were prioritized for the interview process based on the extent of involvement in the restoration process and number of projects they participated in. One-on-one interviews were utilized for the coastal wetland survey, with fifteen interviews conducted during summer 2013.

BMPs were reviewed and discussed at a full-day wetland restoration workshop held at the University of California Los Angeles on January 23, 2014. Meeting participants included 17 wetland experts (six of whom were also interview participants). The workshop provided the opportunity to bring together managers, agency persons, and academic scientists for comments on the BMP list. Additionally, attendees were asked to consider gaps in BMPs. The authors utilized the comments gathered from the wetland workshop to facilitate a review and synthesis of literature to support the wetland BMPs as well as additional prioritization of BMPs. Forty-six final BMPs were compiled with a brief discussion on each into a guidance document that covered 12 restoration issue themes. Seven climate-change-specific BMPs were discussed in the guidance document although a large majority of other restoration themes included aspects of climate change considerations.

2. Coastal Stream BMP Process

An online survey was utilized for the stream process rather than a one-on-one interview due to the large number of stream and restoration practitioners throughout southern California. Twenty-one surveys were collected during spring 2016. When developing stream restoration BMPs, rather than using a workshop approach southern California stream restoration partners were targeted through three regionally focused coalition meetings: 1) The Tri-County Fish Team Forum (May 4, 2016), which targets San Luis Obispo, Santa Barbara, and Ventura County watersheds; 2) The Santa Clara River Coalition (March 31, 2016), which focuses specifically on the Santa Clara River, but members are also engaged in nearby watersheds such as the Ventura and Santa Monica Mountains; and 3) The South Coast Steelhead Coalition (May 9, 2016), which works on Orange and San Diego County Watersheds. An additional presentation was given to stream restoration partners statewide at the 34th annual Salmonid Restoration Federation symposium (April 9, 2016). During the presentations individuals were given the option to submit a paper survey or participate via an online survey program. The survey process ran from March 31 to May 31, 2016. The Wetland Restoration BMP Guide was not shared directly with stream restoration partners prior to the surveys, but a broad overview was introduced during presentation at the regional meetings to provide a conceptual understanding of project goals.

3. Comparison of Watershed-Wide BMPs

Stream restoration issues were categorized by themes and compared to wetland restoration themes. Because the wetland process went through several rounds of prioritization to distill the final 46 BMPs included in the guidance document (Fejtek et al 2014), the climate-change-specific BMPs from that document were used to focus the development of watershed-wide climate change BMPs. To understand similarities and differences in BMPs an understanding of the number of project types that are undertaken throughout the region was needed. The National Oceanic and Atmospheric Administration (NOAA) Restoration and Conservation Data Base was queried to compare the number of stream and wetland restoration projects within the southern California bight, California wide, and nationwide.

D. Results

1. Wetland Process, Stream Process, and Watershed Wide Comparison

The 15 wetland-focused interviews resulted in 349 responses and 17 restoration issue themes. Those same 17 restoration issue themes appeared again from 21 stream-focused surveys that produced 359 responses. Most responses focused on issues occurring during the planning phase. The two BMP processes produced very similar distribution of responses over restoration phases (Figure V-1.). The restoration issue themes covered social, political, scientific, and physical restoration issues (Table V-1.). The most frequently identified restoration issues for coastal wetlands were: 1) Climate Change; 2) Process Organization; 3) Stakeholders; and 4) Restoration

Design. The most frequently identified stream restoration issues were: 1) Climate Change; 2) Process Organization; 3) Permits; and 4) Adaptive Management (Table V-1.).

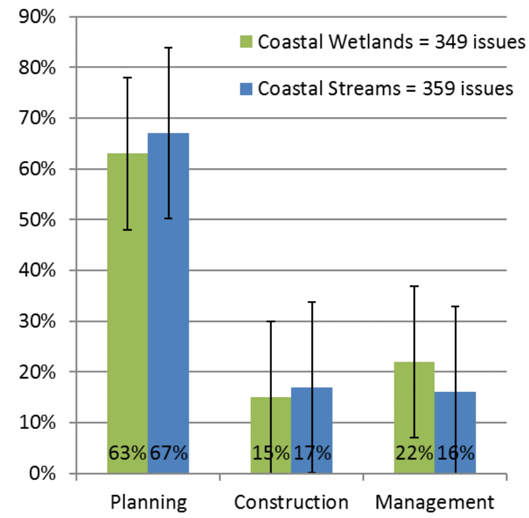


Figure V-1. Distribution of survey/interview responses by restoration phase.

Table V-1. Responses by restoration issue for both wetland and stream processes.

Watershed-Wide Restoration Issue	Coastal Stream %	Coastal Wetland %
Adaptive Management	10.58%	9.74%
Best Available Science	3.90%	1.43%
Budget/Funding	5.01%	7.45%
Climate Change	20.06%	17.48%
Design	4.74%	11.75%
Evalutating Success	3.62%	5.16%
Legal	0.56%	1.72%
Permits	11.14%	2.29%
Planting	3.34%	4.30%
Preliminary Studies	4.74%	2.29%
Process Organization	16.99%	15.76%
Public Access	1.11%	1.15%
Regional vs Local	0.84%	1.43%
Sediment Issues	1.39%	1.72%
Stakeholders	10.03%	12.89%
Water Quality	0.28%	0.86%
Work Stoppage	1.67%	2.58%

The NOAA RCDB contains detailed information on projects that receive funding or technical assistance from the NOAA Restoration Center. A query of the RCDB for the years 2002-

2017, inclusive, provided information for 758 wetland and 1560 stream projects (939 instream and 521 riparian) nationwide, including 61 wetland and 376 stream projects (246 instream and 130 riparian) throughout California and 9 wetland and 32 stream projects (20 instream & 12 riparian) in the southern California Bight.

2. Watershed-Wide Climate Change BMPs

Climate change was the most frequently identified watershed-wide restoration issues. Climate change-specific restoration issues were only identified for the planning and management stages of the restoration process watershed-wide. Seven wetland BMPs were specifically identified as climate change BMPs (three planning and four management BMPs) in Fejtek et al. 2014 and adapted to produce watershed-wide BMPs (Table V-2.). The lack of construction phase climate change restoration issues is in large part a result of the fact that the construction phase focuses heavily on following plans developed during the planning phase. Decisions and actions made during the construction phase often focus on how best to meet project plans previously developed rather than trying to consider construction action implications for climate change.

Climate-change-specific planning issues (Table V-2.) focused on: 1) Selection of key habitats that will persist and provide the greatest benefit under climate change scenarios; 2) Shortsightedness of restoration goals to incorporate climate change; and 3) Lack of region-wide and site-specific guidance for adapting climate change resiliency. Planning issues #2 and #3 can almost identically be applied to both wetlands and streams. However, selection of key habitats has system-specific ramifications yet incorporates the same underlying principle of targeting habitats that offer the greatest resiliency and sustainability into the future (Climate Change Restoration Issue #1).

Table V-2. Coastal watershed-wide restoration issues and BMPs for climate change adapted from Fejtek et al 2014.

Restoration Phase	Issue Category/#	Coastal Watershed-Wide Restoration Issue	Coastal Watershed-Wide Restoration BMP
Planning	Design #1	It will be increasingly difficult to incorporate historical data into project designs as climate change pushes conditions further away from historical conditions.	Historical knowledge is helpful to understand historical processes, but the key to watershed-wide restoration into the future will be the ability to move forward with current constraints while incorporating climate change when possible.
Planning	Climate Change #1	What habitats should be the focus of retoration? What are the key habitats that will persist and provide the greatest benefit under climate change scenarios?	In wetland systems marsh and upland restorations should be the focus. Maintaining habitats that allow for future transgression with SLR is necessary if project goals are to reflect all habitat types in the future . Stream system restorations must focus on goals and designs that provide a diversity of habitats to offer refugia to sensitive species under climate change conditions.
Planning	Climate Change #2	Shortsightedness of restoration goals; Restoration planning is generally too narrow and too short-term to meet the needs of climate change.	Use larger planning areas and longer term frameworks (accommodating for sea level rise and other aspects of climate change). Watershed plans provide long-term goals with short-term objectives and should incorporate climate change impacts from headwaters to ocean.
Planning	Climate Change #3	Lack of region -wide and site-specific guidance for adapting climate change resiliency is limited/lacking.	Managers should be encouraged to do climate scoping for projects and incorporate site-specific information into a regional profile
Management	Climate Change # 4	Older restoration projects that failed to incorporate climate change may fail to meet long-term project goals in the near future.	Adding new phases (which may increase the project footprint) to old projects to incorporate climate change may avoid reinitiating full-scale restoration in the future. Phasing projects may allow for land acquisition (to allow for transgression of wetland habitats or relocate infrastructure that may be susceptible to increased storm intensity (fluvial or littoral).
Management	Climate Change #5	Urbanization has confined and restricted coastal wetlands and streams making them more vulnerable to climate change.	Retreat when possible and invest heavily in projects that still have opportunity to transgress or access natural floodplains. Sites where land acquisition is feasible or public infrastructure could be relocated can allow for natural development of these dynamic coastal systems
Management	Climate Change #6	Management of coastal watershed is complicated due to levels of uncertainty of climate change predictions (SLR, frequency and intensity of storms) and consistency of ranges among agencies.	Models must include a range of climate change projections (change in flow, storm frequency, and SLR) in restorations efforts utilizing regionally recognized projections combined with site-specific models whenever possible.
Management	Climate Change #7	Strict habitat targets will be difficult to maintain into the future with climate change.	Evaluation of project progress (habitat area requirements) should be rethought. Establish broader targets with the understanding that coastal systems are dynamic. Avoid measuring progress based on variation from the original vision. Not only do these systems evolve over time, but habitats will shift drastically depending on SLR and availability for transgression.

Subtidal habitat in coastal wetlands is anticipated to increase with SLR, resulting in the loss of upland and transitional habitat (Craft et al. 2008). Southern California wetlands have suffered from excessive focus on subtidal “water restorations” that has artificially increased subtidal habitat within wetlands as compared to historical values (Stein et al 2014). This increase was cited by interview and survey subjects because of compensatory mitigation requirements and focus on commercial and protected fish species. Ultimately, restorations considered depth but not the hydrologic processes at play and, in some cases, have created bathtub-like systems lacking some of the ecological benefits generally provided in estuarine subtidal habitat (e.g. Malibu Lagoon; see Ambrose et al. 2000).

Marsh and upland restorations should be the focus of future wetland restoration efforts. Maintaining habitats that allow for future transgression with SLR is necessary if project goals are to reflect all habitat types in the future (Climate Change BMP #1 (wetland specific)). Wetland sites need sufficient vertical zonation for the maintenance of a diversity of habitats now and in the future (Donnelly and Bertness 2001, Feagin et al. 2010). Tailoring the 3-D geometry to a particular wetland site is challenging and requires careful design and modeling to take site-specific constraints into consideration. Thus, engineers are vital in the process, but ecological review should also be incorporated. Consideration of historical habitat ratios rather than acres in design phases will provide a more balanced approach for managing habitat types and provide increased resiliency into the future.

Similarly, stream system restorations must focus on goals and designs that provide a diversity of habitats to offer refugia to sensitive species under climate change conditions (Climate Change BMP #1 (stream specific)). Pool habitats are critical both for fish passage (resting pools) and low flow refugia (especially if the project may result in loss of scour pools when removing grade control structures) (NMFS 2015). It is critical to consider what role restoration site plays in life cycle (rearing vs. migration). Creating heterogeneity in habitat complexity in stream systems requires modeling of flow dynamics under projected climate change scenarios and generally requires hydrologists or geomorphologists to provide the best site-specific predictions (Flosi et al. 1998). Although due to range in stream restoration scale and scope modeling these complexities may make small scale projects financially infeasible. Longitudinal profiles, cross sections, and/or basic pebble counts can provide low-cost methodologies for tracking habitat changes, but lack the predictive capability (including climate change considerations) that modeling provides (Fejtek et al in prep).

Shortsighted restoration goals that omit the incorporation of climate change (Climate Change Issue #2) and a lack of region-wide and site-specific guidance for adapting climate change resiliency (Climate Change Issue #3) are restoration issues common to both wetlands and streams. BMPs for both reflect that commonality. Restoration goals are often in opposition. Short-term performance standards (especially in cases of mitigation) limit the ability to implement long-term climate change planning, but grant funding often requires 10-25 years of project sustainability (Belmore et al. 2016, CDFW 2017). Larger planning areas and longer-term frameworks (beyond the scope of a 3-5-year federal or state grant life cycle) can better accommodate for incorporating aspects of climate change (e.g. watershed plans can provide long-term goals with short-term objectives and should incorporate climate change impacts from headwaters to ocean (Climate Change BMP #2, also see Zedler 2017). Many older restoration projects that failed to incorporate climate change may fail to meet long-term project goals (Climate Change Issue #4). Adding new phases (which may increase the project footprint) to old projects to incorporate climate change may avoid reinitiating full-scale restoration in the future (Climate Change BMP #4). Additionally, phasing developing projects may allow projects to meet short-term goals while allowing for the continuation of efforts to include climate change objectives such as land acquisition (to allow for transgression of wetland habitats or relocate infrastructure that may be susceptible to increased storm intensity (fluvial or littoral) (Herzog and Hect 2013).

Urbanization has confined and restricted our coastal wetlands and streams making them more vulnerable to climate change (Climate Change Issue #5). Approximately 40% of the coastline covered by wetlands in southern California lack viable areas to transgress (Heberger et al. 2009). Urbanization results in floodplain encroachment, heightened need for flood control structures such as levees or channelization, and greater channel maintenance requirements (NMFS 2012). Retreat when possible and invest heavily in projects that still have opportunity to transgress or access natural floodplains (Climate Change BMP #5). Managed retreat limits armoring of coasts and rip-rap or similar structures along stream banks (rip-rap reduction) (Couvillion et al. 2013). Policy changes regarding local coastal plans or zoning/regulation may discourage development along the landward edge of wetlands (Titus 2000, Herzog and Hect 2013). Using larger planning areas and time scales may allow for opportunities as land owners better understand risks associated with property proximity to increasingly variable coastal system. Sites where land acquisition is feasible or public infrastructure could be relocated can allow for natural development of these dynamic coastal systems (Jenkin 2002).

Incorporating climate change aspects into restoration projects requires a regionally-defined strategy and site-specific climate change understanding which is generally lacking (Climate Change Issue #3). Climate change will require site-specific planning as well as regional strategies. Therefore, managers should be encouraged to do climate scoping for projects and incorporate site-specific information into a regional profile (Climate Change BMP #3). Examples of this include The Ballona Wetlands Restoration report which included SLR, precipitation, and hydrologic processes wetland and watershed for multiple alternatives (Bergquist et al.2012). 2-D and 3-D modeling, as prescribed by FEMA Guidance for Flood Risk Analysis and Mapping (2016), CDFW Restoration Manual (Flosi et al. 1998), and NMFS fish passage guidance (NMFS 2011), can provide an understanding of project risk to a range of climate change scenarios for both wetlands and streams. Southern California Wetland Recovery Project Regional Strategy’s pending update (in prep) and NMFS Steelhead Recovery Plan (2012) and subsequent 5-year Status Review (2016) are a few documents which integrate climate change and restoration strategies specifically for the southern California regions for wetland and streams respectively.

Management of coastal watersheds is complicated due to levels of uncertainty of climate change predictions (SLR, precipitation, frequency of storms) and consistency of ranges among agencies (Climate Change Issue #6). Models must include a range of climate change projections (change in flow, storm frequency, and SLR) in restorations efforts utilizing regionally recognized projections combined with site-specific models whenever possible (Climate Change BMP #6). California has SLR guidance mandated by Governor Schwarzenegger's 2008 (S-13-08) and Governor Brown's 2015 (B-30-15) executive orders. California initially adopted the National Research Council 2012 SLR projections to create consistency across agencies in their development of approaches to SLR (Co-CAT 2013). Five years have elapsed since the NRC study, during which time a new Intergovernmental Panel on Climate Change (IPCC 2014) report was published containing updated sea-level rise projections based on new scenarios, model simulations, and scientific advances thus the statewide guidance has been updated for a second time to reflect recent advances in ice loss science and projections of sea-level rise (Griggs et al. 2017). Selecting as a minimum moderate estimates of climate change predictions position projects to better meet guidance that is in flux while choosing higher estimates (which may be more costly) is a more precautionary approach to maintenance of coastal habitats and the diversity they represent.

While SLR guidance is becoming more fine scale and readily available guidance regarding precipitation variation is still largely evolving. Storm events are anticipated to decrease during the shoulder season (April-June and September-October) and southern California extreme events will become more extreme (which differs from other Mediterranean climates around the world) (Polade et al. 2014). Southern California should anticipate more time between rainfall events with increased year-to-year variability (Polade et al. 2014). Storm capacity (100-year vs. 25-year) storm event) required by FEMA for bridge infrastructure provides critical risk evaluation for projects under a range of flow regimes that while not specifically designed to address climate change speaks to the naturally flashy nature of southern California streams. Because southern California streams have long since dealt with huge amounts of variability in flows in some ways stream restoration partners may be better equipped through best practices to address climate change variability in flow.

Finally, the way in which success of a restoration is measured will be affected by climate change. Strict habitat targets will be difficult to maintain into the future with climate change (Climate Change Issue #7). Evaluation criteria must change with climate change. Evaluation of project progress (habitat area requirements) should be rethought. Establishing broader targets with the understanding that coastal system are dynamic systems is critical (Zedler 2007). Avoid measuring progress based on variation from the original vision (Climate Change BMP #7). Use of criteria that correlate with maintained process function is needed. Establishing landmarks in restoration progress, such as major changes in key functions or key species presence or population growth can provide funding entities and the public with the social fulfillment needed to justify supporting future restoration efforts. Not only will coastal systems continue to evolve over time, but habitats could shift drastically depending on climate change variables (SLR, stream scour rates and drought durations).

E. Discussion

1. Watershed-Wide Comparison of Restoration Issues

There is no single recipe for coastal watershed restoration and management, but understanding the issues is the first step in finding solutions that restore these habitats for the benefit of multiple species. Habitat restoration is complex; incorporating multiple habitats with pending climate change effects exacerbates that complexity. Solving restoration issues requires consideration of both wetland and stream issues so that coastal systems can be restored and managed as one watershed providing greater resiliency under predicted climate change. First, acknowledging that there are key differences in restoration issues between streams and wetlands can provide for linkages between the systems for larger ecosystem benefit. Second, understanding the problems that streams and wetlands share can provide for use of shared available resources (technical, financial, and biological) to better navigate the restoration process.

The two main differences between restoration issues in wetlands and streams are design and permitting. To understand why these two issues were so divergent between systems it is important to think of not only the scale and scope of restoration projects, but also the number of previous projects undertaken in each system. Over the past fifteen years 2-6 times more stream restoration projects have been undertaken than wetland restoration projects at every level: regional, state, and national (NOAA RCDB 2017). The greater frequency of stream projects means a higher permitting burden that restoration partners must undertake to achieve overall stream restoration objectives. Coastal wetland restoration projects are often large-scale projects that develop over a decade or more but are only subject to the permitting process once, while stream projects can vary drastically in scale and scope (single fish passage barrier vs. large dam removal) and significant time and money is invested in repeated permitting of stream projects to achieve restoration objectives.

Due to southern California's geography, coastal wetland restoration projects have primarily focused on large scale ecosystem strategies covering a diverse number of habitat types (i.e. subtidal, marsh, upland). As diverse as the wetland habitats being restored is the list of protected and managed species (including United States Fish and Wildlife Service (USFWS)- and NOAA-managed threatened and endangered ESA listed species, California Department of Fish and Wildlife California Endangered Species Act (CDFW CESA) species and Magnuson-Stevens Fishery Conservation and Management Act species associated with essential fish habitats (EFH)). Single-species management can greatly influence project design in wetlands and streams, but EFH requirements are limited to coastal wetland systems, considered critical nursery habitats for a larger range of species (Toft et al. 2015). What is needed for one species may vary drastically and even conflict with another (i.e. tide water goby vs. steelhead habitat needs). Coastal wetland restoration design seems to suffer more from the question "what are we restoring to?" than streams (Simenstad et al. 2006). Classically this question has been historical conditions vs. current constraints, but it has now evolved to include resilient habitats vs. historical habitats. These are not the watersheds of 200 years ago and human footprint is ever present often with the inability to completely escape human infrastructure constraints and thus a critical element of design considerations (Middleton 1999).

It will be increasingly difficult to incorporate historical data into project designs as climate change pushes conditions further away from historical conditions (Planning Design Issue #1). Historical knowledge is helpful to understand historical processes, but the key to watershed-wide restoration into the future will be the ability to move forward with current constraints while incorporating climate change when possible (Planning Design BMP #1). Consideration of current deviations from historical conditions and what processes are influenced by those differences can inform watershed-wide restoration design. Consider the baseline hydrological and topographic variability as well as hydrogeomorphic, subsurface and ecological landscape processes and then incorporate climate considerations. Opportunities to reoccupy available historical habitats such as historical channels or floodplains should be considered. Developing restoration goals that focus more on function and process rather than recreating historical habitats will build greater resiliency and sustainability in the future. Understanding past, present, and predicted future hydrologic and geomorphic processes are also important basis for determining effects of proposed projects and are critical to informing permits (especially ESA Section 7 consultation requirements).

Only 2.29% of coastal wetland responses focused on permit issues while 11.14% of stream responses identified this as one of the largest problems in stream restoration. As previously mentioned, wetland projects are far fewer and operate on longer time scales. Acquiring all necessary permits (CEQA, NEPA, Army Corps 404, USFWS and NMFS section 7 consultations, NMFS EFH consultation, state water board, coastal commission approval, CDFW 1600 and CESA permit, county and local permits), while still onerous, must only be done once for a large project (2006 County of Ventura). This is advantageous (and required) over piecemeal projects, providing a better understanding of the cumulative effects of projects on the landscape. Whereas if an organization is removing fish passage barriers in various locations throughout a stream each barrier removal would require its own set of permits. In a place like southern California where some watersheds have upwards of 90% urbanization, barriers are numerous (e.g. 11 total barriers were removed in Carpinteria Creek within less than 5 miles) (RCDB 2017). In addition to the time needed for acquiring permits (some processes can last more than a year), there is significant cost and skill associated with gathering the necessary permits. Stream restoration is largely undertaken by non-profit organizations who generally lack the capacity and often capability to compile complex permit applications and therefore are forced to rely on costly private consultants to achieve all the necessary permits. This increases the cost of small-scale restoration projects to levels which may make the projects less competitive in public grant processes.

Small-scale voluntary restoration projects may be eligible for exemptions or qualify for streamlined permit processing. In recent years several new streamlined permits have become available for California coastal watershed projects specifically through NOAA. These streamlined permit efforts include: 1) statewide programmatic biological opinions for fisheries restoration projects (with regional leads in Arcata, Santa Rosa and Long Beach); 2) a federal consistency determination with the California Coastal Commission for community-based restoration projects; and 3) a programmatic Environmental Impact Statement (EIS) for compliance with National Environmental Protection Act (NEPA) requirements (NOAA 2016). Other agencies including CDFW have recognized the need to facilitate voluntary restoration and current legislation including the Habitat Restoration and Enhancement Act of 2014 (Assembly Bill No. 2193) have also tried to ease permit compliance in recent years. Incorporating permit processes into overall project planning can guide and facilitate better process organization (the second most common restoration issue watershed-wide).

Process organization, how agencies and decision makers organize the process of restoration, has varied drastically throughout the region regardless of system. A preliminary strategy that looks at the overview of project goals and trajectory is key in understanding the flexibility needed for a single project of any scale. Incorporating concurrent permit processes and stakeholder engagement are key elements of process organization. Restoration goals must be rigid enough to provide a framework for the project, but also flexible. Goals must integrate project limitations of the site, inevitable unknowns the project will encounter, and of course climate change. There are many uncertainties in restoration planning, but the organizational structure and process should not be one of them. Clear and consistent process organization can be facilitated by strong regionally focused entities like the NOAA Restoration Center, the Southern California Wetland Recovery Project, California Department of Fish and Wildlife Region 5, and California Department of Transportation (regions 7, 11, 12 and parts of region 5). Such agencies can act as a memory bank for the decision-making process, including tracking best practices and providing process streamlining opportunities for those agencies with regulatory oversight. Process organization should provide for the input of best available climate science during restoration planning and management of coastal systems.

F. Conclusion

The restoration issues identified in this study focus on southern California, but the BMPs developed have ramifications for strategies that can potentially be utilized worldwide to increase coastal watershed-wide resilience to accommodate and adapt to climate change. Identifying similarities and differences in restoration practices across systems will provide greater connectivity not only between habitats, but between the people who undertake these efforts. Dividing ourselves and thus limiting resources for any one group of people (wetland vs. river scientist/professionals/managers) limits the likelihood of restoring fully functioning coastal systems. No one system is more important than the other when both habitats are necessary to complete species' life cycles. Restoration practitioners must share lessons learned across political and social boundaries to avoid repeating mistakes multiple times throughout the watershed. Limited restoration resources should be fully utilized (in particular permit streamlining opportunities) to ensure the greatest chance for ecosystem resilience in a warming world.

In order to manage coastal watersheds as a whole a future holistic approach is necessary not only for development of BMPs, but undertaking actual restoration planning, implementation, and management. This study took steps towards integrating coastal wetland and stream system BMPs, but still treated the systems independently with separate processes. Future BMP efforts should look at integrated system management approaches that include bringing both sets of restoration practitioners together and identifying common problems on a watershed-wide scale. More importantly restoration projects should consider the role of the project in the context of the whole watershed and how that role may further effect the entire system under climate change scenarios.

VI. CONCLUSION

Recovering endangered species and their critical habitats through restoration has been and always will be complex due to its interdisciplinary nature; climate change further increases this complexity. Restoration is an intersection of science, engineering, policy, and management from public and private entities at the local, state, and federal levels. Undertaking restoration requires managing finite resources and balancing competing interests from a wide range of experts. Facilitating recovery of endangered aquatic species that utilize habitats ranging from headwaters to ocean as southern steelhead do, requires crossing not only ecosystem boundaries, but social and political boundaries as well. Restoration needs additional tools to facilitate this increasingly complex process. Many of these tools already available, but their potential largely untapped. This research focused on utilizing these existing laws, monitoring protocols, and knowledge (in the form of best management practices) to maximize recovery efforts for one endangered species in the face of climate change.

Southern steelhead provided an ideal example species. Despite the large financial and human capital invested in recovery efforts thus far, species recovery has been stagnant. In the absence of sufficient population abundance monitoring, current population estimates rely heavily on a few observations throughout the entire Distinct Population Segment (DPS). In 2017, one of southern California's wettest winters, only eight anadromous steelhead were observed throughout the DPS (Unpublished data compiled from California Department Fish and Wildlife, Santa Monica Resource Conservation District and Pacific States Marine Fisheries Commission). Southern steelhead extinction is forecasted within 25-50 years (Moyle et al. 2017) due to in large part to anthropogenic and environmental impacts. In the face of extinction, managers may be forced to consider alternative strategies to achieve recovery (or, minimally, to postpone complete extinction for a time). Reevaluating existing tools may be the key for ensuring survival of the southern steelhead.

Of the 2,392 listed plant and animal species, only 80 have ever been delisted in more than 40 years of the Endangered Species Act. Of the 80 species delisted, 30 of these were delisted because an error in the listing; 10 have gone extinct. This leaves only 40 species that were delisted based on actual recovery (notably 8 species have distributions within California) (ECOS database 2017). Therefore, only 1.6% of listed species have actually recovered in over 40 years of implementing the Endangered Species Act. Conversely, of the only twelve species listed under Section 4(e), two (American Alligator and Louisiana Black Bear) have been delisted due to recovery. While a small subset, these success stories speak strongly for the use of Section 4(e) as a highly effective tool to move species towards recovery.

This study provides strong support for applying Section 4(e) for the recovery of steelhead trout. Specifically, listing rainbow trout within coastal streams to the natural limits of anadromy with support from state and local resource entities. Section 4(e) provides additional protection from take for the general public that could provide larger scale benefits when considering the genetic resource and potential rescue effect rainbow trout may have to offer steelhead populations. A better understanding of how effective Section 4(e) could be for southern steelhead would require internal National Marine Fisheries Service (NMFS) review of the history of potential steelhead take cases which have been dismissed or not pursued due to the inability to discern the difference between anadromous steelhead and resident rainbow trout (not done for this study). Section 4(e) can offer a precautionary approach in preventing take when every fish counts.

Section 4(e) is only one example of many potential underused legal opportunities that could provide increased protection for southern steelhead. Consideration of other federal environmental laws, like the Clean Water Act, Clean Air Act, and Harbor and Rivers Act from a 2017 perspective could potentially provide additional opportunities for listed salmonids and climate change integration. Similarly, state (California Environmental Quality Act, Porter-Cologne Water Quality Control Act, and Coastal Zone Management Act) and local laws such as zoning and ordinances could also prove to be valuable tools. Nationwide, stream protection ordinances are currently being implemented at the local level. For example, within the southern steelhead DPS the City of Carlsbad has implemented guidelines for riparian and wetland buffers (2012); the City of Los Angeles proposed a similar ordinance in 2007. The purpose of these ordinances was to establish minimal acceptable requirements for buffers to protect the streams, wetlands, and floodplains within the city boundaries; to protect the water quality of watercourses, reservoirs, lakes, and other significant water resources; and to protect the cities' riparian and aquatic ecosystems; and to provide for the environmentally sound use of the cities' land resources. While the Los Angeles ordinance failed in 2007, perhaps revisiting the option in light of the increased understanding of climate change scenarios is worthwhile.

This work highlights the value of environmental review in protection of endangered species. Even highly prioritized southern steelhead restoration practices, such as small dam removal, still trigger what is seen by some as an overly onerous environmental review process. Streamlining approaches like programmatic permitting can be used to realize more critical recovery actions sooner and at a cost savings (both for project proponents and agencies). The NOAA Restoration Center has developed three recent tools to help advance highly prioritized restoration activities while still providing appropriate environmental review: 1) statewide programmatic biological opinions for fisheries restoration projects (with regional leads in Arcata, Santa Rosa and Long Beach, and Sacramento); 2) a federal consistency determination with the California Coastal Commission for community-based restoration projects; and 3) a programmatic Environmental Impact Statement (EIS) for compliance with National Environmental Protection Act (NEPA) requirements (NOAA 2016).

While onerous, the environmental review process is critical in assessing benefits and risks of restoration efforts. Chapter 2 highlighted the value that simple protective measures (removal of dam debris from instream) may have in dam removal response. Additionally, providing case studies of small dam removals throughout southern California will help restoration partners and regulators understand monitoring elements which can best inform future dam removal under southern California's unique hydrologic and climatic conditions. These case studies suggest that even under extended drought conditions, small dam removals have a relatively small influence, while watershed-wide inputs (annual sediment flux) may be more important drivers over stream morphology and habitat quality. Chapter 2 supports the value of a watershed-wide perspective in undertaking coastal restoration in southern California.

Chapter 3 typifies the headwaters to ocean concept, developing a comparison of stream and wetland restoration issues and BMPs in the face of climate change, in order to assist restoration partners to maximize their efforts for those species that utilize the entire watershed. The notable differences in permitting issues for streams and design concerns for wetlands were discussed in relation to the scale and geographical extent of habitat type in southern California. A comparison of stream and wetland restoration issues identified common problems: climate change and process organization.

Acknowledging climate change as the primary issue facing restoration was focused on through the development of climate-specific BMPs in this study. However, the fact that process organization (the way in which we structure restoration planning and management) is the number two issue demonstrates the complexity of restoration and the critical need for a well-conceived process structure. The value of bringing all the stakeholders together from the very early stages of planning is often severely underestimated. Crucial early interactions, such as design charrettes and kick-off meetings, should include: 1) clearly identified, mutually developed and mutually agreed-upon goals; 2) a conceptual timeline that incorporates all necessary permitting and potential funding strategies; and 3) strong documentation and archiving of decision making (able to survive a decade or more to inform new planners and managers as team transition happen).

Unfortunately, social/political hurdles are just as real as scientific hurdles in resource management. Dividing ourselves and thus limiting resources for any one group of people (wetland vs. river scientists/professionals/managers) limits the likelihood of restoring fully functioning coastal systems. No one system is more important than the other when both habitats are necessary to complete species' life cycles. Restoration practitioners must share lessons learned across political and social boundaries to avoid repeating mistakes.

Reevaluation of both longstanding tools and "new" tools (those not currently being utilized in the region, but successful elsewhere) is needed to provide support sooner for species at the brink. The timing of this work comes at a crossroads for steelhead recovery in which we must either accelerate the valuable habitat restoration work being done or consider the need to take steps towards genetic banking and/or conservation hatcheries in order to avoid extinction and further loss of genetic diversity on the world. A diverse portfolio of recovery strategies is likely needed to sustain southern steelhead while habitat restoration tools are better maximized to create fully functioning ecosystem from headwaters to ocean.

VII. APPENDICES

Appendix A. Wetland and Stream Questionnaire.

*Both processes utilized the same ten questions (only variation was system identifiers “wetland” or “river/stream” to solicit restoration issues and identify potential BMPs

Name: ____

Email: ____

Contact Phone Number: ________________________

Organization: __________________________________

Organization Affiliation: (Circle one)

Private Non-private Government (Federal State Local)

<u>Overview Restoration Questions</u>

1. What southern California coastal stream/wetland restoration projects have you worked on? If numerous please give an approximate number of projects highlighting a few examples which you were involved throughout the restoration process.

2. Have you worked on projects that have utilized an adaptive management plan? Was the adaptive management plan developed as part of the planning process? If so how was it developed?

3. How was climate change considered in prior restoration projects? What climate change considerations should be taken for future projects? What do you believe are the current gaps in knowledge for coastal stream/wetland restoration planning?

<u>Planning</u>

4. How much consideration was placed on historical, current, and future conditions in development of restoration goals?

5. What technical, physical, and societal factors slowed or enhanced the planning process?

6. What recommendations would aid in the planning process and minimize conflict/frustration/failure for restoration projects?

<u>Construction</u>

7. What factors (hydrological, biological, and or engineering) have enhanced or slowed the restoration construction process?

8. What recommendations would aid in the restoration/construction process for future restorations in general and also in the light of climate change?

Post Construction Management

9. What were some of the anticipated maintenance requirements projects you have worked on have faced? Did actual maintenance requirements match the expected maintenance requirements? What were the unanticipated maintenance requirements?

10. Will climate change alter the way projects are managed in the future? How can climate change be incorporated into post construction management?

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