SOUTH-CENTRAL CALIFORNIA COAST STEELHEAD

Oncorhynchus mykiss irideus

Critical Concern. Status Score = 1.9 out of 5.0. South-Central California Coast steelhead are in long-term decline across their range, despite recent recovery actions taken in core watersheds. Without widespread efforts to restore stream flows and improve access to historical habitat, steelhead will be extinct in southern California within fifty years.

Description: South-Central California Coast (SCCC) steelhead are similar to other steelhead in their meristics and morphology (see North Coast steelhead for full description). This Distinct Population Segment (DPS) is distinguished from other steelhead DPSs by their distribution and ecological/zoological differences between regions (Boughton, unpubl. data). The most recent genetic information suggests that these fish could be grouped with the southern steelhead DPS, but to remain consistent with the management agencies, we treat the south-central California coast steelhead as a distinct entity. Recognizing this DPS separately provides a reason to focus on steelhead conservation in the watersheds of south-central California.

Taxonomic Relationships: Broad taxonomic relationships and a discussion of the nature of ESUs and DPSs can be found in the Northern California Coastal winter steelhead account. In California, steelhead are observed to generally follow a genetic pattern of geographic isolation with distance, which is evident within the SCCC steelhead DPS. Across the West Coast, steelhead diversity generally declines with latitude; south-central California Coastal steelhead and southern steelhead have lower allelic richness (and smaller populations) than those in the North (Garza et al. 2014). As currently designated, the Pajaro River (Monterey and Santa Clara counties) marks the boundary watershed between the Central California Coastal steelhead DPS and the SCCC DPS. Garza et al. (2004) found that clear genetic differences between south-central Coast steelhead and southern steelhead were not apparent. While other steelhead DPSs can be distinguished genetically, the SCCC DPS and the southern steelhead DPS are genetically intermixed (Girman and Garza 2006). These two DPSs are more similar to each other than to steelhead DPSs further north, with little justification for separation (Clemento et al. 2009). The SCCC DPS therefore seems to continue to exist mainly for management convenience, existing between the historical boundaries of the original ESU (Evolutionarily Significant Unit) used to describe the form. More recently, Garza and colleagues (2014) suggest that the DPS boundaries should be updated to reflect barriers on the coast to migration; they suggest that steelhead from Morro Bay north to San Francisco Bay should be grouped together for conservation and management based on similar genetics. According to the study, the current DPS boundaries do not accurately represent the biological structure of steelhead in the region. However, the five-year status review did not recommend any changes, citing lack of necessary information.

Aguilar and Garza (2006) used a molecular marker to determine that a genomic region associated with thermal tolerance and spawning time may have been under positive selection pressure in the population in Chorro Creek (SCCC DPS). Boughton et al. (2006) reported that rainbow trout are found above artificial barriers in 17 of 22 basins in the range of the South-Central/Southern and California Coast steelhead DPSs. In the Salinas and Arroyo Grande watersheds, a genetic comparison of trout above barriers with juvenile steelhead below barriers demonstrated these populations were closely related (Girman and Garza 2006). These findings have been replicated for both SCCC and Southern steelhead (Clemento et al. 2009).

Based on this genetic information and distributional information, Boughton et al (2006) identified 41 historically independent populations of SCCC steelhead in the DPS, including three populations in the large Salinas River watershed. These latter three populations each use spawning areas separated by the mainstem Salinas River; one grouping includes steelhead found in the Nacimiento, San Antonio, and upper Salinas rivers. The 41 populations are divided into four biogeographical regions including (from north to south): Interior coast range, Carmel Basin, Big Sur Coast, and San Luis Obispo Terrace (Boughton et al. 2007).

Life History: Very few biological studies have been done on SCCC steelhead, although they appear to express a diversity of life history patterns similar to other steelhead (see Southern steelhead account). SCCC steelhead complete their life history cycle in freshwater or spend 1 to 3 years in fresh water before migrating into the ocean for 2 to 4 years and returning to natal rivers to spawn. SCCC steelhead and CCC steelhead encounter similar physical habitat features that bound the trajectories of their juvenile life history, including principally small, steep coastal watersheds with flashy flows that reduce juvenile growth, and age at outmigration, as well as seasonally open estuaries, which control smoltification, marine survival, and migration patterns.

Besides exhibiting the three categories of juvenile steelhead life history strategies discussed in the CCC steelhead account (anadromous, freshwater resident, lagoon-anadromous, and variations of these), SCCC steelhead may use fine-scale movements among habitats such as making intra-seasonal movements between lagoons and fresh water and within fresh water movements between reservoirs and tributaries (Boughton et al. 2006, Hayes 2016). Immature steelhead spend several weeks to months in estuaries before entering the ocean. In larger basins (e.g. Pajaro, Salinas Rivers), juvenile life history patterns are limited by desiccation of tributary streams in dry years, which eliminates low elevation reaches as over-summering habitat. Fish may be forced to move upstream into headwater areas with perennial flows, remain in reaches supported by reservoir releases, or to emigrate downstream to the estuary. While the mainstem Carmel, Big, and Little Sur rivers provide decent rearing habitat year-round, the interior rivers (Pajaro, Salinas) are too warm for steelhead from late spring through summer, and are primarily used as migration corridors (J. Casagrande, NMFS, pers. comm. 2016). However, warm temperatures can create thermal barriers to migration. Juvenile steelhead in Southern California grow mostly during the winter in fresh water when temperatures are optimal (Krug et al. 2012).

Adult steelhead return from feeding in the ocean to enter watersheds to spawn in SCCC streams between January and May, and as lagoon bars breach or there is sufficient flow to allow passage (Boughton et al. 2006). SCCC steelhead embryos likely have accelerated hatching rates due to warmer stream water temperatures. In years with low rainfall, lagoon barriers may not breach during the rainy season and migratory access between the ocean and fresh is impossible. Presumably under such circumstances, adults spend another year in the ocean before returning to try again and older juveniles suffer high mortality.

SCCC steelhead display a high degree of life history plasticity that is likely determined based on the interaction of genetics, environment, and other factors. According to recent genetic work, Chromosomes Omy5 and Omy12 in rainbow trout have been found to be associated with aspects of sexual maturity and run-timing (NMFS 2016, Pearse et al. *in review*), suggesting a genetic basis for this life history flexibility. Traits with a genetic basis can be inherited such as expression of anadromy, smoltification, and various run timings (Kendall et al. 2015). Pearse et al. (2014) found that rainbow trout in anadromous waters had one kind of Omy5, while those in waters formerly available to anadromous fish upstream of impassable dams, had an inverted region of the Omy5 gene locus on the same chromosome. Interestingly, the notable exception to this pattern was found in the adfluvial population in Upper Arroyo Grande Creek above Lopez Dam, which has predominantly anadromous Omy5 genes. The potential for steelhead to make life history switches between adult life histories has been demonstrated for anadromous and resident fish (Zimmerman and Reeves 2000). Adding to this complexity, inland resident juvenile trout may exhibit smolt characteristics, and populations without anadromous adults can give rise to smolts that emigrate to sea (Boughton et al. 2007). Rundio and colleagues (2012) found that despite genetics, female juvenile rainbow trout were more likely to emigrate to sea than males; this could be because their fecundity is more closely tied to body size, which increases significantly with time spent at sea, than their male counterparts. In addition, Pearse and others (*in prep*.) found that in the Big Sur River, emigration to the ocean in age-0 juveniles was associated with chromosomes, sex, and juvenile body size, rather than a single factor.

Habitat Requirements: SCCC steelhead have habitat requirements similar to those of steelhead populations further north, but presumably share thermal tolerances with southern steelhead (NMFS 2016). In general, they need cool, flowing waters, a diversity of spawning, rearing, and feeding habitats, access to the ocean, and available prey. These requirements can be difficult for SCCC steelhead to find, especially in dry years. Optimal mean monthly temperatures in potential rearing areas with limited food supplies are considered to be 6-10ºC, with temperatures over 13ºC being unfavorable for growth and survival (NMFS 2007, see southern steelhead account for more details on temperature requirements). A recent study of the mainstem Big Sur River (Holmes et al. 2014), however, found average water temperatures of 16º C during summer that dropping to 14º C in the fall, with juvenile steelhead of multiple age classes using different habitat types opportunistically. Near the mouth of the Big Sur River stream temperatures in reaches containing steelhead were recorded as high as 17.2º C in 2014 and 15.8º C in 2015. The fact that this river is coastal and influenced by cooling from marine fog suggests that other rivers in the watershed are regularly above the 13ºC temperature threshold. In Uvas Creek, Casagrande (2010) found that juvenile steelhead grew rapidly in reaches where peak summer daytime temperatures were in excess of 20º C, because areas receiving more sunlight were associated with higher invertebrate production (food); these areas also cooled down to less than 16º C at night, providing temperature relief. In addition, juvenile steelhead rearing in waters with temperatures >16º C were almost exclusively found in high velocity habitats, such as runs and riffles, where invertebrate drift was higher to help them offset energy expended in greater than optimal temperatures (J. Casagrande, NMFS, pers. comm. 2016). Consistent with this study, Thompson et al. (2012) found no steelhead at sites in tributaries to the Salinas River where the maximum temperature exceeded 26ºC or where the mean temperature exceeded 21.5º C.

In addition, juveniles and adults require access to a diversity of habitats. In general, CDFW passage guidelines suggest that adult steelhead require depths > 24cm, while juveniles > 15cm in length require depths > 15cm, and juveniles < 15cm require depths > 9.1 cm (CDFW 2010, pg. 42). These depths must be maintained across > 25% of the channel width, and must be > 10% of the continuous channel width. Finally, pool depth must be at least 1.25 times the necessary jump height for steelhead to leap over a waterfall or obstruction to allow at least partial passage (CDFW 2010). Holmes and colleagues (2014) found differential habitat use in juvenile steelhead based on their size in a study spanning 2010-2012 on the Big Sur River (Table 1).

Juvenile Size	Preferred Depth	Preferred Velocity	Preferred Cover Type	Notes
< 6 cm	< .25 m	< 15 cm/s	95% used hard substrates	70% in pools or runs; size class stayed closest to bank
6 – 9 cm	.5 m	40 cm/s	65% used cobbles or boulders	65% in riffles or runs; 95% in areas with no overhead cover; middle distances from bank
10 –15 cm	$\geq$ .5 m	45 cm/s	Most used wood and hard substrates	Found furthest from bank with almost no overhead cover

Table 1. Characteristics of habitat used by different size classes of steelhead in the Big Sur River, based on data in Holmes et al. 2014.

Juvenile steelhead use deeper, faster water as they grow to access more food to meet higher metabolic demand; all size classes strongly to avoid water < 10 cm deep (Holmes et al. 2014).

Often, mainstem river and lower reaches of tributary creeks are seasonally dry and are primarily used as migratory corridors. In cases when large wood provides over-summering habitat, SCCC juvenile steelhead will use mainstem creeks and rivers with perennial flows (Thompson et al. 2012), especially in watersheds where headwater streams are dry during this period (Boughton et al. 2006). On San Luis Obispo Creek, Spina et al. (2005) observed juvenile steelhead using essentially every pool. Boughton et al (2006) presented a similar result and found that that shortly following rains that created flow in streams, juvenile steelhead were observed utilizing newly-wetted stream segments. Thus, sufficient habitat with perennial flows and cover are critical requirements for juvenile rearing and full expression of life history variation. For cover, SCCC steelhead depend on instream wood often made up of hardwood trees and root wads (Thompson et al. 2008, 2012). Thus their populations are particularly susceptible to wildfires that that remove wood (sources of habitat complexity and pool scour), which are important for juvenile overwintering survival (J. Casagrande, NMFS, pers. comm. 2016) and cause sedimentation, especially in conjunction with drought and climate change.

In addition, lagoons at the mouths of coastal streams are important for juvenile feeding, rearing, and saltwater acclimation prior to ocean entry (Hayes et al. 2008). Lagoons offer juvenile steelhead of various sizes opportunities to grow more quickly than they can in small, intermittent or ephemeral tributaries. Juvenile steelhead rearing in lagoons can grow fast enough to smolt and migrate to the ocean at age 1+. Juvenile survival at sea has been linked to greater size at ocean entry, so the more rapid growth associated with a lagoon-rearing life history is likely important for maintaining runs. In addition, fish that spent time rearing in estuaries are disproportionately represented in adults returning to coastal watersheds (Hayes et al. 2008).

Distribution: SCCC steelhead are distributed between the Pajaro River (Santa Clara/San Benito counties) south to, but excluding, the Santa Maria River (San Luis Obispo/Santa Barbara counties, Figure 1). Although habitat quality is low and population sizes in most coastal basins seem too small for persistence, prior to the 2012-2016 drought, steelhead were still found in almost all SCCC DPS coastal watersheds in which they were historically present (Boughton et al. 2007). Steelhead have also been found in basins in the DPS range with no recent historical records of steelhead, including Los Osos, Vincente, and Villa creeks, illustrating the opportunistic nature of the species (Boughton et al. 2005) and the importance of protecting such watersheds for recovery (Garza et al. 2014). Becker and Reining (2008) provide a comprehensive guide to SCCC steelhead distribution and status prior to 2008.

Watersheds in this DPS are separated into four biogeographic population groups (BPGs) that are categorized by migration connectivity and reliability, summer cool-water refuges, intermittence of streamflow, and winter precipitation (Boughton et al. 2007). In the Big Sur Coast and San Luis Obispo Terrace BPGs, 37 streams contain steelhead and bear more ecological resemblance to steelhead streams in northern California (J. Smith, SJSU, pers. comm. 2008) than to streams in the interior regions of the DPS. These watersheds are kept cool and moist by marine-based weather patterns and fog layers. The Big Sur River, unlike the Pajaro, Salinas, and Carmel rivers, remains undammed and provides high quality habitat that likely supports migrants to other watersheds (Holmes et al. 2014). With its unimpeded flow, the Big Sur River is considered a steelhead stronghold by the California Stronghold Team (2012).

Other BPGs include rivers that cut across the coastal ranges and extend inland through long valleys dominated by agriculture. These include the Pajaro River, Gabilan Creek, Arroyo Seco, Salinas River, and Carmel River in the Interior Coast Range and Carmel River BPGs, and have warmer climates that alter the timing and delivery of water for steelhead habitat.

Figure 1. SCCC DPS boundaries and core watersheds. From: NMFS 2016 Figure 4, pg. 15.

At sea, SCCC steelhead are likely found as far south as northwestern Mexico and appear to be more solitary than other salmonids (Busby et al. 1996; Good et al. 2005). It has been hypothesized that more northern populations of steelhead migrate to a cool water patch far offshore of the Klamath-Trinidad coastline before migrating to the North Pacific feeding grounds, but more study on this subject is necessary. Steelhead that are captured in trawl surveys are generally encountered much farther offshore, and in fewer numbers, than Chinook or coho salmon (Harding 2015). But there is no specific information on marine habitats of SCCC steelhead.

Trends in Abundance: Historically, annual runs of SCCC steelhead seem to have been around 27,000 adults (NMFS 2007) in wetter years. CDFG (1965) suggests that the DPS-wide run size was as high as 17,750 adults in 1965, after much of the South-Central California coast had been developed following World War II (NMFS 2013). CDFG (1965) optimistically estimated that the main watersheds in the DPS, the Pajaro, Salinas, Carmel, Big Sur and Little Sur rivers supported a run of about 4,750 adults annually during the 1960s. Good et al. (2005) estimated less than 500 adults returned annually to each of these rivers in 1996 (<2,500 total). By these rough estimates, the SCCC steelhead DPS experienced declines in run sizes of about 90% by 1996 (Boughton et al 2007). NMFS has set a target of 4,150 total anadromous adults in the DPS per year to attain recovery, which is only about 20% of presumed historical numbers. However, very little population monitoring exists for SCCC steelhead. All signs point to lower abundances across the DPS during the 2011-2016 years of drought (CDFW 2014, 2016). Given the information presented below, we estimate there are now an average of about 500 (200-800) spawners returning each year, total, to all streams in the DPS region, although our confidence in this estimate is low because the data is so poor.

Estimating adult steelhead returns in the DPS from redd surveys, spawner surveys, cameras, or other means has remained a challenge. Sampling the mostly inaccessible mountain tributaries on private lands during the rainy winter months to obtain spawner estimates has not been adequately addressed. While imperfect, redd counts have been made for several years in the Carmel River, but are not comprehensive due to high flows and turbidity. On the Carmel River, DISON sonar has been used to estimate steelhead abundance in turbid flows, but has been shown to be unreliable as individual fish may move back and forth in front of the camera several times in one migration (NMFS 2016). Other attempts to estimate adult abundance in the DPS include visual imaging (Cuthbert et al. 2014) and a counter on a fish ladder (MCWRA 2013) on the Salinas River, but these have issues with reliability due to their specific implementation.

Opportunistic spot-check sampling has remained the best source of information on steelhead presence/absence and juvenile abundance during California's ongoing drought. Estimating relative juvenile abundance and documenting distribution occurs in some locations as well, such as electrofishing on Uvas and Llagas creeks (Pajaro River), and seine surveys in the estuary of the Pajaro River. Although flows were improved for adult access and smolt outmigration, no adults were observed, and only one potential redd was found in lower Carnadero Creek (lower Uvas Creek) in 2016. Young-of-year (YOY) abundance was the lowest since sampling began in 2005, marking the first time that no YOY were found following a winter when anadromous access was possible. Five juvenile *O. mykiss* (age 2+) were captured, however. The extremely low juvenile abundance in 2014 and 2015 also likely resulted in very few smolts produced in spring 2016 (Casagrande 2016).

Annual electrofishing surveys have also been conducted in Corralitos Creek (Pajaro River) since 2008. Further south, intermittent sampling of juveniles occurs on the Big Sur River (Holmes et al. 2014) and Big Creek (Monterey Co.), and Chorro, San Luis Obispo, Pismo, and Arroyo Grande creeks (San Luis Obispo Co., CDFW 2014, 2016). In 2014, the Salinas, Carmel, and Big Sur rivers in Monterey County and Santa Rosa, Chorro, San Luis Obispo, and Pismo creeks in San Luis Obispo were all cut off from the ocean due to low rainfall associated with the drought, and intermittent flow blocked adult and juvenile access to and from lagoons (CDFW 2014). Habitat connectivity and availability was greatly reduced through significant dry-back of stream reaches, resulting in mortality and loss of recruitment, as seen in electrofishing data from Chorro and San Luis Obispo creeks (CDFW 2014, Figure 2).

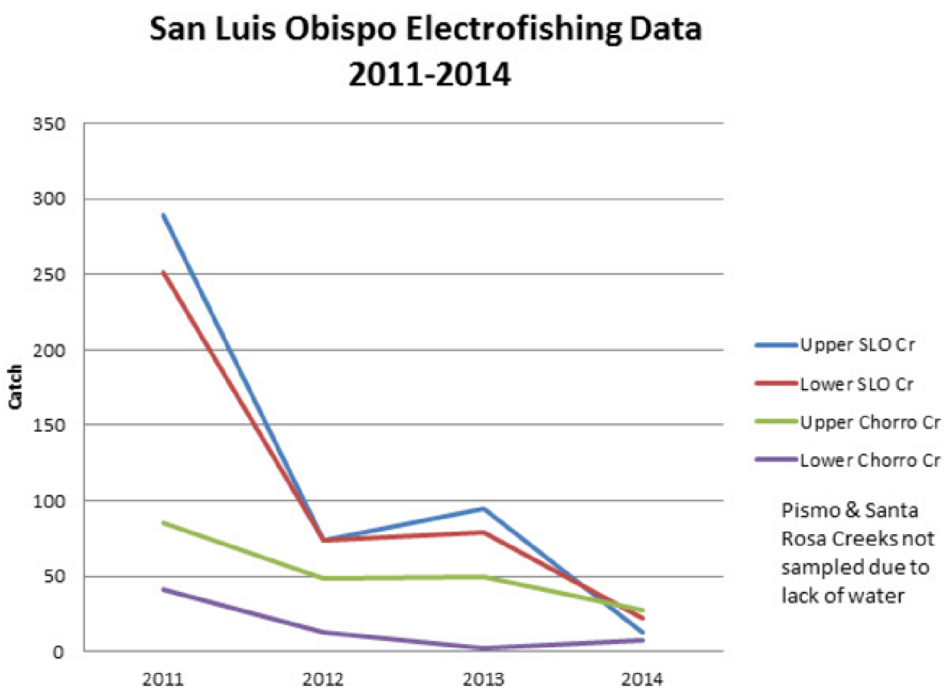

Figure 2. Juvenile steelhead abundance from electrofishing data in Chorro and San Luis Obispo Creeks, 2011-2014. From CDFW 2014, Fig. 3.

Fish rescue efforts have provided some information on adult occupancy in select watersheds. For example, in the Pajaro River watershed, a local citizens group, the Coastal Habitat Education and Environmental Restoration (CHEER) conducted fish rescues annually from 2006 through 2013. During that time, CHEER rescued an average of 12 adult steelhead from isolated pools and drying habitat from 2006-2013. Since historic drought took hold in California in 2012, juvenile steelhead produced in the Uvas Creek subbasin have dropped sharply (J. Casagrande, NMFS, pers. comm. 2016). Even when winter storms arrived, sufficient flow for passage was unavailable, as water tables were so low that water soaked into parched ground without running off (CDFW 2016b). As a result, there has been no documented spawning in Uvas Creek since 2013, because adults could not reach spawning areas before drying events occurred (Casagrande 2015). Before the drought, reasonable densities of juvenile steelhead or rainbow trout (20-30 fish/30m) were documented in the Uvas Creek watershed in some years (Casagrande 2013, 2014), but these densities have plummeted. In 2013, 39 adults and 260 juveniles were counted in Uvas Creek and its tributaries (Casagrande 2014); in 2014, only one adult and seven age 1+ or 2+ juveniles were captured (Casagrande 2015). On January 31, 2014, after years of reduced releases from the upstream Uvas Reservoir and significant drying of the stream, NMFS and San Jose State University biologists captured 180 juvenile steelhead from reaches subject to drying and relocated them to downstream areas with sufficient habitat (CDFW 2014b, Casagrande 2014). In 2015, no adults and 51 age 0+ juveniles were captured during electrofishing efforts in summer and fall (Casagrande 2016). In 2016, no YOY juveniles were detected in Uvas Creek or its tributaries for the first time since surveys began in 2005 (Casagrande 2017). In the nearby Salsipuedes Creek, steelhead smolts have been documented emigrating through College Lake (Podlech 2011).

On the Salinas River, monitoring of adult returns occurred in 2011, 2012, and 2013, with a mean of 22 adults returning per year, with the largest recent count of migrating adults topping out at 46 upstream of the lagoon, but the weir was taken down during high flows and some adults could have passed undetected. From 2014-2015, the Salinas River did not reach the ocean, so no upstream migrants were detected. At the upper reaches of the Salinas, juvenile *O. mykiss* were present in the Nacimiento River (below Nacimiento Dam) as of summer 2015, but were last documented in the San Antonio River in 2012/2013. Arroyo Seco retains juvenile rainbow trout but has not supported any anadromous fish in the last several years due to lack of sufficient flows for passage (J. Casagrande, NMFS, pers. comm. 2016). Redd surveys were conducted in the Big Sur River in 2012, 2014, and 2015, while annual redd surveys began in San Luis Obispo Creek in 2015. Juvenile abundance surveys have been conducted in other watersheds in San Luis Obispo County, but have not used the Coastal Monitoring Plan techniques for population estimates; however, they do provide distribution and trend information over time (NMFS 2016).

The one time series of abundance greater than twenty years in duration in the DPS is from the Carmel River (Monterey Co.). Adult steelhead counts on the Carmel River at the former San Clemente Dam ranged from 0 to 1,350 between 1962 and 2002, with an average run size of 821 adults (Good et al 2005, MPWMD 2007). Steelhead in the Carmel River underwent a drastic decline that lasted into the late 1980s (Good et al. 2005), and saw a rebound in the early 2000s due to habitat restoration and hatchery releases (NMFS 2016). The Carmel River population has continued on a downward trajectory until removal of San Clemente Dam in 2015 (Figure 3).

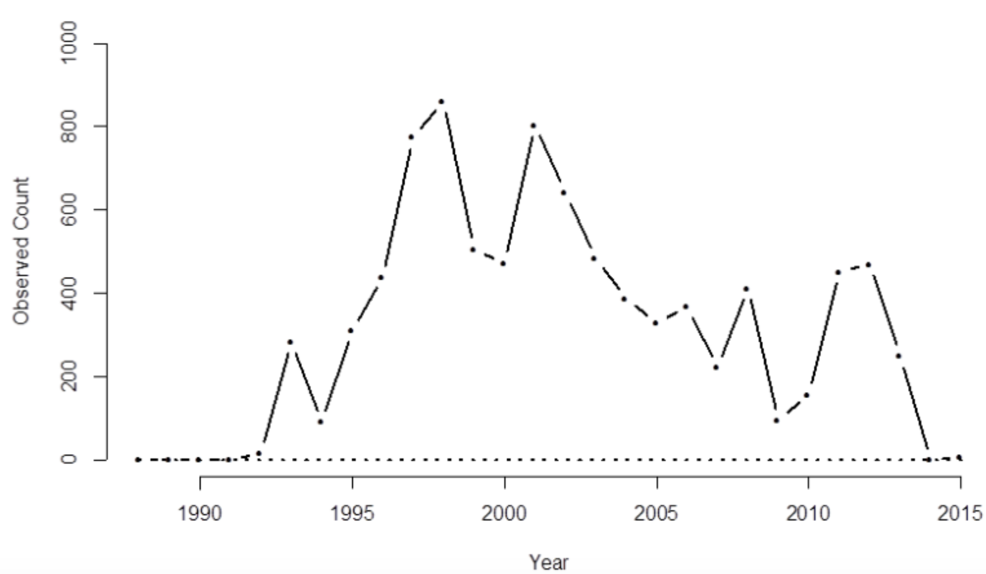

Figure 3. Adult steelhead at San Clemente Dam, 1990-2015. From NMFS 2016, Fig. 8, pg. 29.

This decline of nearly 17% per year coincides with considerable effort to release thousands of smolts per year from Sleepy Hollow Steelhead Rearing Facility (SHSRF, Figure 4). During the 1988-91 drought, the Carmel River Steelhead Association used a seawater facility to raise and release hundreds of thousands of steelhead smolts per year, which could have contributed to a spike in adult returns after 1991 (NMFS 2016). Most returning adults since 2000 are from the captive breeding program. In the river, wild young-of-year (YOY) steelhead size and numbers are also declining (Boughton 2016). Arriaza (in review) suggests that a decline in smolt growth rates may be reducing survival to adulthood.

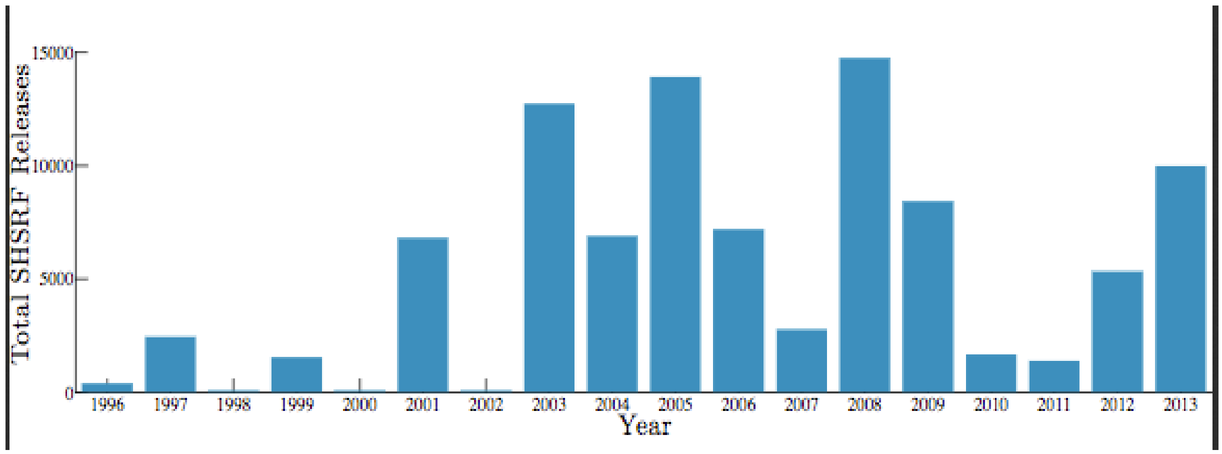

Figure 4. Sleepy Hollow Steelhead Rearing Facility smolt releases, 1996-2013. From Boughton, 2016, Fig. 3, pg. 9.

While data from surveys of juvenile steelhead are difficult to evaluate in the context of run size and viability, this is the principal data available from a number of watersheds and is at least an indication of habitat integrity and presence/absence rainbow trout. Although steelhead numbers within the SCCC steelhead DPS have declined dramatically, about 90% of historical habitat continues to be occupied (NMFS 2016). In Big Creek, a spring-fed watershed along the Big Sur coast, a fair number of age 1+ and 2+ steelhead (NMFS 2016) inhabit the lower reaches during summer. It is possible that higher rainfall, lower air and water temperatures, perennial flows, and relatively few anthropogenic stressors in watersheds of the Big Sur Coast Region allow populations in this region to persist, despite limited habitat area. The resilience of SCCC steelhead depends on favorable over-summering conditions that benefit age 1+ and 2+ steelhead.

As indicated previously, it is reasonable to assume that the average number of SCCC steelhead spawners throughout their range in a wet year is probably on the order of 1,000 fish. According to the most recent National Marine Fisheries Service (NMFS) five-year status summary review, there are currently less than 500 spawning adults across the DPS each year (NMFS 2016), although previous assessments likely underestimated this number in some watersheds, such as Uvas and Carralitos creeks, which had adult returns of perhaps 60 or more adults in 2008 alone (J. Casagrande, NMFS, pers. comm. 2016). Recent and reliable data is notably absent from the primary core-1 populations in Little Sur River and San Jose, San Simeon, Santa Rosa, Pismo, and Arroyo Grande creeks (NMFS 2016). Williams et al. (2016) suggest that there are very small (<10 adults) but persistent runs in most streams at the southern edge of the SCCC DPS range each year, except in years when there has been insufficient winter flows to breach bars at the mouths of lagoons. This persistence could be due to migrants from source populations elsewhere or contributions of smolts from non-anadromous fish in these basins. The drought years of 2012-16 resulted in limited spawning and rearing throughout the DPS. This drought, coupled with above-average sea surface temperatures and poor productivity in the ocean (Mantua 2015), has presumably sharply reduced abundance of SCCC steelhead.

Factors Affecting Status: NMFS (2013) identified several principal natural threats to SCCC steelhead in their Recovery Plan for the DPS, including: (1) land management practices that alter natural stream flow patterns, (2) estuarine degradation, (3) alteration of floodplains and channels from agricultural development, (4) dams and diversions, (5) shifts in climate and ocean productivity, (6) urban and rural development, and (7) catastrophic fire.

The threats posed by alteration of streams and lagoons are principally associated with land use practices in the Pajaro, Carmel, Salinas (including Arroyo Seco, San Antonio, and Nacimiento Rivers). Surface water diversion and groundwater pumping associated with agriculture and urbanization have resulted in the dewatering of streams, modification of river and creeks channels, and addition of toxic materials and nutrients that degrade water quantity and quality. These activities have reduced the frequency, duration, timing, and magnitude of flows available for rearing and migrating steelhead. Due to the geography of the landscape, high winter and spring flows are critical for breaching lagoon mouths to allow adult steelhead spawning migration, and juvenile steelhead emigration to the ocean. The encroachment of agricultural, industrial, and residential developments into riparian and floodplain channels of SCCC steelhead rivers and creeks has caused loss of riparian cover to maintain suitable stream temperatures, instream cover, food resources, and over-summering habitats for juveniles. In addition, dams have blocked a significant portion of spawning and rearing habitat, and have reduced flows, altered downstream habitats, and blocked or impeded migration. Many Big Sur watersheds are on public lands or in areas with less human development, and are more able to maintain populations of steelhead.

Dams. Dams and diversions throughout the SCCC DPS range alter the amount and timing of flows throughout the Pajaro, Salinas, and Carmel river basins, block migration corridors for spawning and rearing steelhead, and alter natural flow regimes that are essential for maintaining habitat accessibility and connectivity (NMFS 2013). Major water supply and flood control facilities tend to threaten the larger rivers in the DPS, though smaller diversions reduce available steelhead habitat and alter flow regimes as well (NMFS 2016). In general, impacts of dams on steelhead are negative and are most pronounced on the main stems of rivers, blocking access to generally high-quality habitat in upstream reaches and tributaries, increasing temperatures of downstream water, altering fish communities, and reducing gravel and sediment transport from the upper watershed to the coast. These projects have increased direct mortality of steelhead, altered stream banks and channel morphology, and increased erosion, sedimentation, loss of channel complexity, pool habitat, and large wood inputs to steelhead streams (NMFS 2013).

Although impoundments and dams such as Uvas Dam (Pajaro River) have blocked access to historical spawning and rearing habitat in the headwater reaches and disrupted natural hydrologic processes, management of flow releases for aquifer recharge and flood prevention provide opportunities for successful rearing and both inland and seaward migrations of steelhead in some populations. In addition to actions seeking fish passage past these dams (or dam removal where feasible), improved adaptive management of these reservoir operations could yield benefits to steelhead production (J. Casagrande, NMFS, pers. comm. 2016).

In 2015, San Clemente Dam was removed from the lower Carmel River, and significant habitat restoration began to restore and enhance access and habitat for spawning adults and rearing juveniles. In addition to re-routing the river channel around sediment left after dam removal and step-pool creation throughout the project site, a feasibility study for removal of Los Padres Dam upstream of the project site has begun. This project could serve as an example for future dam removal projects throughout the DPS range.

Agriculture. Extensive agricultural development for row crops and orchards in the Pajaro, Salinas, Pismo, San Luis Obispo, and Arroyo Grande basins has significantly degraded mainstem river habitats, floodplains, and estuaries in the SCCC DPS (NMFS 2013). Agricultural diversions (a) reduce surface flows, especially in critical summer and fall months, (b) reduce groundwater recharge, thus lowering the water table, and (c) often degrade water quality in the streams. Agricultural return water flows off the fields and into streams at higher temperatures and with increased levels of nutrients and pesticides, making much of the habitat unsuitable for steelhead.

Estuarine alteration. Estuaries and lagoons are critical to rearing steelhead, especially in the small, coastal watersheds throughout the SCCC DPS range (Boughton et al. 2007). Much of this estuarine habitat has been lost, especially in northern portions of the range (NMFS 2013). Urban encroachment and associated water diversions alter estuary dynamics by reducing water quantity and quality, shrinking the habitat juvenile steelhead have available for rearing, especially in summer and fall months. Not only are these habitats important for increasing size at smolting and ocean entry for juvenile steelhead, they represent choke points through which all migrating juveniles and adults must pass. Reductions in their size and function impact all life history stages of steelhead.

Fire. Wildfires are a natural occurrence and are important to the chaparral plant community that dominates much of the SCCC DPS range. However, after decades of suppression practices by federal and state agencies, NMFS (2013) considered catastrophic fire events, such as the recent Pfeiffer and Soberanes fires along the Big Sur coast, as “very high” threats to the recovery of SCCC steelhead throughout their range. Fire removes large wood that can provide shading and instream cover for all life stages of steelhead, and cause extensive sedimentation and smothering of substrates after precipitation events (Thompson et al. 2008, 2012). Because many SCCC steelhead-bearing coastal streams are small in size and area, and bounded by rugged mountainous canyons, extensive fires can threaten entire core populations.

Hatcheries. Despite decades of stocking out-of-basin rainbow trout throughout the SCCC DPS region, Garza et al. (2014) found that this practice has not altered the genetics of steelhead in coastal basins, with a few exceptions. For several years, no hatchery rainbow trout have been stocked in anadromous waters and CDFW only plants unviable triploid fish in waters that are inaccessible to the ocean (NMFS 2016). More recent investigation (Abadia-Cardoso et al. 2016) has documented limited genetic introgression between wild and hatchery fish, even in the Carmel River watershed, even with continuing operation of a captive breeding program at Sleepy Hollow Steelhead Rearing Facility on the lower mainstem. While only limited introgression has been documented due to the use of natural-origin, rescued adult steelhead from the Carmel River, evaluation of selection pressures on remaining wild fish have not been fully evaluated.

Harvest. It is illegal to harvest (take) SCCC steelhead. There is very low catch of steelhead at sea and such fish are not retained. Legal catch-and-release fishing is permitted for steelhead and is monitored by CDFW through steelhead report cards. Records indicate extremely low levels of fishing effort from recreational anglers in the DPS during 1993-2014 (CDFW 2014). Despite this low effort, Good et al. (2005) concluded that recreational angling is a limiting factor on SCCC abundance; as a result, CDFW has restricted legal fishing access in the region to certain days of the week and downstream of major road crossings in recent years to protect migrating adults. Due to extremely low levels of abundance in most watersheds and reduced flows during ongoing drought, legal catch-and-release fishing likely results in some mortality or sublethal impacts on wild fish. In the absence of widespread monitoring, fishers provide valuable data on adult presence through catch reporting and anonymous tips regarding illegal activities and poaching. Poaching remains a major issue in the Pajaro and Salinas watersheds, with considerable documented effort to trap fish illegally (Casagrande 2014).

Alien species. Alien species play a role in limiting expansion of some populations in the SCCC DPS. Efforts have been undertaken on Chorro Creek to remove invasive Sacramento (*Ptychocheilus grandis*), a known predator of juvenile salmonids. In San Luis Obispo Creek, efforts are being made to control invasive, water-thirsty giant reed (*Arundo donax*) that can take over riparian habitat. On the mainstem Salinas River, Monterey County Resource Conservation District has removed significant stands of Arundo to reduce water use and flood potential (J. Casagrande, NMFS, pers. comm. 2016). In Santa Rosa Creek, projects aimed at removing invasive eucalyptus trees have helped reduce water demand in the watershed. Riparian restoration efforts that include reducing invasive plants are ongoing in Pismo and Walters creeks near Morro Bay. Cucherousset and Olden (2011) showed that predation on juvenile steelhead by American bullfrogs (*Lithobates catesbeianus*) and basses (*Micropterus* spp. and *Morone saxatilis*), can be significant and both bass and frogs may compete for resources with juvenile steelhead. Striped bass have been documented in the Pajaro, Salinas, and Carmel rivers; CDFW has been trying to remove them from the Carmel Lagoon for a decade (J. Casagrande, NMFS, pers. comm. 2016). In the Pajaro River drainage, striped bass and several other species of nonnative predatory fishes have been captured far inland in Miller Canal and Carnadero Creek; this is noteworthy because of the potential threat they pose to out-migrating steelhead smolts in spring (Casagrande 2011). Striped bass are known to occur in the Pajaro River Lagoon, and have recently been documented in low numbers in San Felipe Lake in the upper reaches of the watershed (Casagrande 2010). In the both the upper and mainstem Pajaro River watershed, shading due to nonnative evergreen acacia trees (*Acacia auriculiformis*) is potentially limiting productivity and feeding opportunities for juvenile steelhead, while Himalayan blackberry (*Rubus armeniacus*) is holding potential gravel and cobble at stream edges, which need to be mobilized in the river to provide rearing and spawning habitat (Casagrande 2017).

In addition to the factors described above, synergistic effects of disease, predation, and other factors likely have minimal consequences in healthy watersheds with large steelhead populations, but may negatively impact the small remaining populations of SCCC steelhead, especially when considered in concert with the low flows and high temperatures. These conditions are strongly associated with drought in degraded lower watersheds such as the Salinas River. Miller et al. (2014) found that diseases likely reduce already low salmonid populations when remaining fish are exposed to warmer waters than are preferable for the species. Osterback et al. (2015) determined that western gulls (*Larus occidentalis*) predation on juvenile steelhead could be as much as 2.5 times higher than historically due to the increased abundance of gulls due to artificial feeding opportunities. Taken together, these impacts are likely to reduce small populations of SCCC steelhead even further.

Factor	Rating	Explanation
Major dams	High	Major and minor dams in the Pajaro, Salinas, and Carmel watersheds block or alter spawning and rearing habitat.
Agriculture	High	Extensive water diversions for agriculture, especially in the Pajaro and Salinas basins, limit populations and reduce water quantity and quality; water often present at wrong time for steelhead.
Grazing	Low	Livestock grazing is not widespread in the SCCC range.
Rural /residential development	Medium	Diversions for rural residential use likely impact rearing and over-summering habitat for juveniles, especially in watersheds bordered by mostly private land.
Urbanization	Medium	The region is relatively rural, though urbanization in the Pajaro, Salinas, and Carmel River basins is increasing demands for limited water and degrading its quantity and quality. The City of Salinas is the largest city in the DPS >170,000 people and relies on groundwater pumping from the over drafted Salinas aquifer.
Instream mining	Low	Gravel mining not widespread and regulated.
Mining	Low	Heavy metal contaminants from historical mining may settle in lagoons and reduce suitability for juvenile rearing.
Transportation	Low	Highway 1 bisects every watershed, and most have several bridge crossings with only short stretches of habitat altered.
Logging	Low	Mostly legacy impacts of timber removal that reduce large wood input into streams and reduce cover.
Fire	High	While uncommon, recent large fires have closed access to several Big Sur watersheds, reduced recruitment of logs to streams, and increased sedimentation.
Estuarine alteration	High	With the exception of the Big Sur BPG populations, most estuary and lagoon habitats in the DPS have been altered by encroachment of developments, agriculture, and water resource development.
Recreation	Low	Recreation may negatively impact behavior of steelhead.
Harvest	Low	Harvest of wild steelhead is prohibited, and catch-and-release fishin effort is extremely low.
Hatcheries	Low	Decades of stocking hatchery trout has had little genetic impact.
Alien species	n/a	Predation by alien species, such as striped bass and catfish, may be problem in the Pajaro and Salinas estuaries, and alien plants alter stream habitats. Impact on steelhead smolts is unknown.

Table 2. Major anthropogenic factors limiting, or potentially limiting, viability of populations of South-Central California Coast steelhead. Factors were rated on a five-level ordinal scale where a factor rated "critical" could push a species to extinction in 3 generations or 10 years, whichever is less; a factor rated "high" could push the species to extinction in 10 generations or 50 years whichever is less; a factor rated "medium" is unlikely to drive a species to extinction by itself but contributes to increased extinction risk; a factor rated "low" may reduce populations but extinction is unlikely as a result. A factor rated "n/a" has no known negative impact. Certainty of these judgments is moderate. See methods for explanation.

Effects of Climate Change: Climate change will likely exacerbate the decline of SCCC steelhead primarily by reducing the temporal and spatial availability and accessibility of usable habitat throughout their range. As a consequence, Moyle et al. (2013) rated SCCC steelhead as "highly vulnerable" to climate change.

As temperatures rise and precipitation patterns shift to reduce rainfall in Central and Southern California, SCCC steelhead will be exposed to greater periods of higher water temperatures and more flow variability, eventually outpacing their ability to avoid such exposure (Wade et al. 2013). A changing climate will reduce freshwater inflow to rivers, streams, and estuaries, alter nutrient cycling, and reduce sediment transport (NMFS 2016). With low flows, remaining water may become too warm and oxygen-poor to support juvenile steelhead growth and survival. In general, regions with lower latitude and elevation will be subject to the greatest increase in duration and intensity of higher air and water temperatures (Wade et al. 2013). The SCCC steelhead DPS is very low in elevation and near the southern edge of the species' range. In the ocean, climate change is likely to increase sea surface temperatures and ocean acidity, reduce estuarine habitat through sea level rise, reduce upwelling currents that provide prey sources, and lower marine productivity and salmonid survival off of California's coast (NMFS 2016). For a full description of how climate change impacts steelhead at the southern edge of their range, see the Southern steelhead account.

Climate change is also likely to cause more frequent and more intense drought, and reduce usable habitat. According to Boughton et al. (2007), multi-decade droughts have occurred in the South-Central California Coast area throughout history, yet steelhead have persisted. However, the ongoing drought in California has been characterized as a "hot drought," with several of the hottest years on record coming in the last five years alone. A hotter, drier climate regime for California is expected, and is likely to increase the frequency and magnitude of catastrophic wildfires in California. In addition to above average temperatures and below average rainfall across most of California, precipitation patterns shifted as well.

The changes that took place during the 2012-2016 drought are a harbinger of things to come. For example, half of all the precipitation in 2014 fell during a few storms during a very short time period (December), causing a quick flushing of rivers to the ocean. For steelhead, ideal flows should occur throughout winter and spring to provide passage for spawning adults and smolt outmigration. In 2015, total rainfall in the region was even lower than in 2014, on 25% of average, causing drying of streams and necessitating emergency fishing closures and fish rescues (CDFW 2014) in the DPS. During this time, flows in the Big Sur River were less than the 0.6 m^3 flows needed for successful spawning and rearing in the river (Holmes and Cowan 2014), presumably negatively affecting the steelhead population. As a result of reduced flows, the lagoon to become disconnected from the ocean. These impacts culminated in two CDFW fish rescues in September 2015 that resulted in moving 105 juvenile and one adult steelhead downstream to the lagoon. That winter, only nine steelhead redds were counted in the entire river, significantly below the long-term average (CDFW 2016). Similarly, the Carmel River experienced a sharp decline in steelhead numbers during this time (NMFS 2016). In their five year status review, NMFS concluded that the ongoing hot drought and poor ocean conditions associated with reduced upwelling likely reduced salmonid survival across DPSs and ESUs for listed steelhead and salmon (NMFS 2016).

Another potential impact of climate change are rising sea levels, which may lead to inundation and displacement of estuaries/lagoons. For proper function, estuaries must have intact sandbars and sufficient inflows from the stream during the dry seasons (J. Smith, SJSU, pers.

comm. 2008). Research on CCC steelhead indicates these habitats are critically beneficial to productive steelhead runs, especially in the adjacent DPS to the north (Bond 2006; Hayes 2008. Due to the small size and coastal location of estuaries in the SCCC steelhead DPS, these areas have been subject to intense pressures from human developments, water use, and pollution.

Drought has increased temperatures and natural variability in precipitation (Williams et al. 2015), and reduced natural spawning, rearing, and migration habitat for already low populations across the SCCC steelhead DPS. Williams et al. (2016) found that about climate change impacts on salmonids are increasing over time, suggesting that building resilience in remaining populations will be essential for persistence of steelhead in Southern California. Without resilience of population size, habitat diversity and quantity, and genetic variation, climate change will reduce long-term viability of DPS (NMFS 2016). Providing access, through removal of barriers and restoration of degraded mainstem migration corridors, to a variety of habitats that allows expression of all steelhead life history strategies remains the best approach for building resiliency to climate change in steelhead populations (Wade et al. 2013).

Status Score = 1.9 out of 5.0. Critical Concern. All steelhead populations in Southern California are likely to be extinct within 50 years without serious intervention (Table 3). SCCC steelhead were listed as threatened by NMFS in 1997 and their status was recently reaffirmed (NMFS 2016). They are considered a Sensitive Species by USFS. NMFS (2016) cited threats to a few small populations by loss of accessible habitat, low abundance, degraded estuaries, and altered hydrology; they determined that recovery potential for SCCC steelhead is low to moderate. This finding has not changed since the five-year status review in 2011 (NMFS 2016).

Metric	Score	Justification
Area occupied	3	Multiple watersheds occupied in small numbers.
Estimated adult abundance	1	Most populations probably contain less than a few dozen spawners, with a total of less than 500 in the entire DPS in recent years.
Intervention dependence	2	Barrier removal, habitat restoration, and updated water management practices are critical to recovery as are restored access to historical spawning, rearing, and refuge habitat and reconnection of resident and anadromous populations.
Tolerance	3	Moderate physiological tolerance, iteroparity uncommon.
Genetic risk	2	While introgression with hatchery rainbow trout is minimal, limited gene flow among populations make them vulnerable.
Climate change	1	Rated highly vulnerable. Effects on small populations documented.
Anthropogenic threats	1	4 High and 2 Medium factors.
Average	1.9	13/7.
Certainty (1-4)	3	Little monitoring of most populations. High confidence that the DPS is in serious decline, low confidence in actual population size.

Table 3. Metrics for determining the status of South-Central California Coast steelhead, where 1 is a poor value and 5 is excellent. Each metric was scored on a 1-5 scale, where 1 is a major

negative factor contributing to status; 5 is a factor with no or positive effects on status; and 2-4 are intermediate values. Certainty of these judgments is moderate. See methods for explanation.

SCCC steelhead are threatened by loss of freshwater and estuary habitat, increasing human land and water development, poor ocean conditions, and altered hydrology, as well as climate change, wildfires, and drought. These impacts may be insurmountable without coordinated short-and long-term societal and managerial changes. Socially, municipal and county governments will need to focus on restoring aquatic habitats in estuaries and along mainstems and tributaries that flow through residential areas. Best management practices for water use and management must be implemented in cooperation with municipalities, private landowners, agricultural interests, and industrial water users to conserve and restore floodplain and riparian habitats throughout the DPS. NMFS (2013) identified extensive public education, development of cooperative relationships, and interagency collaboration as critical to recovery of SCCC steelhead. These steps are necessary to ensure that funding and strategic planning result in effective, sustained funding and implementation of SCCC steelhead recovery efforts.

Management Recommendations: NMFS (2016) gives the SCCC steelhead DPS only a moderate-to low potential for recovery as a result of the myriad threats that the low numbers of steelhead face throughout their range. Recovery of these populations hinges upon restoring access to high quality habitats throughout their range so they can use their flexible life history strategies to build sustainable populations. Such a strategy should be coordinated among resource management partners and citizens, and be based on promoting sustainable land and water uses, restoring natural river and estuary processes, and building resilience to climate change impacts (NMFS 2013). The most important aspect of such a strategy relates to securing adequate streamflows for all steelhead life stages. Programs that address and expand water conservation, efficiency, and re-use throughout South-Central California will be essential to establishing necessary flows throughout the DPS range. Toward that end, a recent effort to use residential storage tanks in periods of low flow rather than groundwater pumping is gaining traction among private landowners and water users in the Upper Pajaro and Salinas watersheds (Clifford 2016). In order for such programs to function efficiently, there is a need for alternative sources of water in the dry season, incentives for landowners to change their practices, water rights exchanges or purchases, and ease of permitting, funding, and enforcement.

Next, fish passage must be addressed on a broad and coordinated scale to allow juvenile outmigration and adult steelhead to access high quality habitat in the upper main stems and tributaries of core watersheds (NMFS 2013). Because viability of a population increases with population size, restoring habitat access in key watersheds is most likely to help populations meet viability criteria (Boughton et al. 2006, NMFS 2016). The limited number of fish returning to streams within the Interior Coast Range and Carmel Basin regions indicates that mainstem restoration may be necessary for maintaining viability in the DPS. However, habitat for smaller populations is also needed for aid in dispersal and connectivity across the landscape; long-term viability of the DPS depends upon migrants from neighboring basins to maintain metapopulation dynamics and genetic diversity (Garza et al. 2014).

Toward this end, significant habitat restoration has been undertaken in the Carmel River watershed. In 2013, river channel re-routing began, and San Clemente Dam was removed in 2015. Significant habitat restoration, including construction of step-pools to aid adult steelhead migration, has been conducted downstream of the old dam site, restoring access to over 40km of historical spawning and rearing habitat and sediment transport from the upper watershed. Thus, populations of resident rainbow trout currently above the dam will be reconnected to steelhead, creating stability and resilience in this population. In addition, the smaller Old Carmel River Dam will be removed in coming years, opening further habitat for spawning and rearing steelhead (Alberola and Kirschenman 2015). Continued monitoring of sediment and steelhead populations will be critical to adaptively managing the newly accessible habitat. In addition, feasibility studies to remove Los Padres Dam, located 40km further upstream, have begun. Long-term monitoring resources will be required to assess habitat changes after removal of several dams in the watershed and to determine effects on the population (Alberola and Kirschenman 2015).

Downstream, in the Carmel Lagoon, restoration has been ongoing in the past decade to battle poor water quality associated with overdraft of surface and ground water in the basin, which has led to improvements in fish habitat. The California American Water District has been discharging advance-treated wastewater near the lagoon to replenish the groundwater table during the dry season, likely adding 250,000m^3 of water per year to the lagoon for fish habitat. However, a study of CAWD's wastewater found concentrations of chemicals associated with pharmaceuticals and personal care products. Research is ongoing to determine if this well-meaning practice is having a negative impact on steelhead juveniles or lagoon habitat (Alberola and Kirschenman 2015).

In a display common in Southern California, manual breaching of the Carmel River lagoon bar is currently required every year to protect infrastructure and housing encroaching on its margins. A proposed Ecosystem Protective Barrier study is currently being funded by Proposition 84 funds to determine the best way to manage the lagoon to avoid further reduction in habitat quantity and quality for juvenile steelhead and federally-listed California red-legged frog (*Rana draytonii*), western snowy plover (*Charadrius nivosus*), and Smith's blue butterfly (*Euphilotes enoptes smithi*) in the lagoon (Alberola and Kirschenman 2015).

The actions taken on the Carmel River are indicative of the numerous beneficial actions that can be taken now to reduce the threats to SCCC steelhead, including:

- Completing fish barrier removal or passage projects in smaller coastal streams (i.e. Arroyo Grande Creek) and larger interior rivers (Carmel, San Antonio, Nacimiento Rivers) to provide access to historical habitat and increase connectivity among anadromous and resident populations. Management partners can leverage CDFW Code 5937 to maintain fish populations below impoundments in good condition.
- Establishing low flow regimes in the Pajaro, Salinas, and Carmel river systems to support functioning riparian corridors and floodplain habitats to increase the spatial distribution and productivity of SCCC steelhead. Uvas, Pacheco, and Corralitos creeks on the Pajaro River have reservoir or diversion bypass flows to protect steelhead (J. Casagrande, NMFS, pers. comm. 2016). On the Salinas River, adequate flows for steelhead protection have been developed but are currently undergoing re-examination. Last, SWRCB has ordered California-American Water to reduce its overdraft on the Carmel River. A new project, Pure Water Monterey Groundwater Replenishment Project, is nearly approved and will recycle and re-use up to 3,500 acre-feet annually from agricultural or industrial return flows in the Salinas Basin in exchange for a reduction of an equal amount of water from the Carmel Basin. SWRCB currently lacks the oversight and regulatory authority to effectively manage groundwater development, especially on private properties on small tributary streams throughout the DPS. Trout Unlimited's water storage tank programs,

which reduce groundwater pumping and surface diversions from critical tributaries during low flow months of summer and fall are a program that warrants expansion to benefit rearing steelhead (J. Casagrande, NMFS, pers. comm. 2016). This is essential and complementary to the need for SWRCB to establish and enforce minimum instream flow requirements for Monterey and San Luis Obispo County streams for SCCC steelhead, and closely monitor flows throughout the entire DPS (CDFW 2014).

- Training regulatory agencies and biologists to protect stream corridors, facilitate assessment of waste discharges (sediment, pesticides, and other non-point source pollutants), and reduce the filling in, artificial breaching, and draining of estuaries.
- Improving estuarine/lagoon habitat function through regulation of land use practices that degrade water quantity and quality that eventually settles out in lagoons.
- Initiating life cycle monitoring in the Pajaro, Salinas, and Carmel rivers to prioritize and implement recovery actions to support SCCC steelhead. Data collection should be amended and streamlined across Southern California so that the data may be used to reliably estimate adult abundance, smolt production, and survival at sea.
- Capitalizing on ongoing drought to identify and prioritize cool water refugia throughout core watersheds in the DPS for cataloging and protection, and re-thinking core-1/2/3 watersheds throughout the range.
- Updating, funding, and implementing the California Coastal Monitoring Plan (CMP) protocols throughout all core-1 watersheds in the SCCC DPS.
- Completing a Fishery Management and Evaluation Plan (FMEP) that CDFW can implement with NMFS and other management partners.

The continuing increase in human populations in the region, coupled with climate change changing rainfall patterns and increasing water temperatures, means that long term (> 50 years) persistence of SCCC steelhead in most watersheds is not likely without large-scale intervention. Possible exceptions may exist in the larger streams that parallel the Big Sur Coast (e.g., Big Creek, Big Sur River), which still benefit from the summertime cooling effect of ocean proximity.

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