State of the Salmonids:
Status of California's Emblematic Fishes 2017

A report commissioned by California Trout

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SOUTHERN CALIFORNIA STEELHEAD
Oncorhynchus mykiss irideus

Critical Concern. Status Score = 1.9 out of 5.0. Southern steelhead populations are in danger of extinction within the next 25-50 years, due to anthropogenic and environmental impacts that threaten recovery. Since its listing as an Endangered Species in 1997, southern steelhead abundance remains precariously low.

Description: Southern steelhead are similar to other steelhead and are distinguished primarily by genetic and physiological differences that reflect their evolutionary history. They also exhibit morphometric differences that distinguish them from other coastal steelhead in California such as longer, more streamlined bodies that facilitate passage more easily in Southern California's characteristic low flow, flashy streams (Bajjaliya et al. 2014).

Taxonomic Relationships: Rainbow trout (*Oncorhynchus mykiss*) historically populated all coastal streams of Southern California with permanent flows, as either resident or anadromous trout, or both. Due to natural events such as fire and debris flows, and more recently due to anthropogenic forces such as urbanization and dam construction, many rainbow trout populations are isolated in remote headwaters of their native basins and exhibit a resident life history. In streams with access to the ocean, anadromous forms are present, which have a complex relationship with the resident forms (see Life History section). Southern California steelhead, or southern steelhead, is our informal name for the anadromous form of the formally designated Southern California Coast Steelhead Distinct Population Segment (DPS). Southern steelhead occurring below man-made or natural barriers were distinguished from resident trout in the Endangered Species Act (ESA) listing, and are under different jurisdictions for purposes of fisheries management although the two forms typically constitute one interbreeding population. Genetic analyses indicate that Southern California steelhead and upstream resident trout form a cluster of related fish from the Santa Maria River south to Baja California. Their distinctiveness presumably relates to their adaptations to the unique environment of Southern California. Similar adaptations are present in south-central California coast steelhead which do not have clear genetic differences from southern steelhead, but there are important ecological and zoological differences between the two regions (Boughton *unpubl. obs.*).

A large-scale population genetics study of rainbow trout in Southern California revealed that some of the resident trout in the southernmost portion of the DPS have hybridized with hatchery fish (Jacobson et al. 2014; Abadia-Cardoso et al. 2016). These wild self-sustaining hybrid trout populations persist above barriers in headwaters of the Los Angeles, San Gabriel, Santa Ana, San Juan, San Diego, and Sweetwater rivers. However, pure native rainbow trout populations of steelhead ancestry still exist at least three locations: 1) the San Luis Rey River in San Diego County, 2) Coldwater Canyon Creek of the Santa Ana River in Riverside County, and 3) San Gabriel River system in Los Angeles County, with the exception of the Iron Fork and Devil's Canyon Creek populations which are mixed lineage. In contrast to the southern DPS, populations in the larger watersheds in the northern part of the DPS (Santa Clara, Ventura, Santa Ynez and Santa Maria rivers) have remained largely un-hybridized.

The extent to which hybrid rainbow trout will reproduce in the wild with steelhead from neighboring watersheds once barriers are removed is unknown, but may increase population viability (Jacobson et al. 2014). Two of these southern-most populations have strikingly low genetic diversity compared to other Southern California populations, suggesting long-term genetic isolation and susceptibility to extirpation (Abadia-Cardoso 2016). These authors proposed that hybrid populations derived from "....hatchery rainbow trout are members of the same species, so some introgression does not necessarily render such small populations less viable than purely native populations . . . In fact, the introduction of some novel genetic diversity from hatchery trout into these small, isolated populations will likely increase heterozygosity, providing more variation to adapt to changing environmental conditions and reduce inbreeding." Therefore, isolated native and hybrid populations should be considered cautiously for use in programs designed to perpetuate the persistence of rainbow trout populations in Southern California (Abadia-Cardoso et al. 2016).

Life History: The ecology of southern California steelhead has not been as thoroughly studied as more northern populations (see Upper Klamath Trinity River winter steelhead account). Distinctive life history patterns of southern steelhead mainly relate to the variable environment in which they evolved and to their opportunistic life history strategies (Sloat and Reeves 2014, Kendall et al. 2015). Southern steelhead are dependent on winter rains to provide upstream passage through seasonally opened estuaries and mainstem river flows providing hydrologic connectivity to upstream tributaries. The reliance on rainstorms for permitting passage through lower portions of watersheds suggests a restricted spawning period for steelhead, with considerable flexibility in timing. Spawning typically occurs between January and May, with a peak in February through mid-April (NMFS 2012), although variation may occur across diverse geographies (M. Capelli, NMFS, pers. comm. 2017).

Three predominant life history patterns have been described for south-central coastal steelhead which are also likely important for southern steelhead: fluvial anadromous, freshwater resident, and lagoon-anadromous (Boughton et al. 2007; Kendall et al. 2015). Juvenile steelhead usually remain in freshwater for one to three years before emigrating to the ocean (Shapovalov and Taft 1954, Moore 1980a, Quinn 2005). Southern steelhead, however, probably spend less time in freshwater during migrations because of inhospitable conditions (low flows, warm temperatures, poor water quality) in the lower reaches of their streams.

Juvenile and adult life history plasticity is characteristic of southern steelhead populations (Kendall et al. 2015). In fluvial anadromous life history, southern steelhead outmigration is dictated by the breaching of lagoon sandbars (physical barriers of sand at the mouth of lagoons), typically between January and June, with a peak from late March through mid-May (NMFS 2012). Ocean swells and high tides can lead to temporary bar breaching during the summer and fall, draining lagoons and allowing juvenile trout to emigrate to the ocean. Observations of adult steelhead appearing in the lower Ventura River following a temporary mouth bar breach from large swells and high tides suggests that movement into fresh water is extremely opportunistic. While barriers may limit access to upstream areas, out-migrating juveniles often originate upstream of such barriers. In below-barrier reaches they can mature and interbreed with anadromous individuals. Perennial habitats are limited in lowland reaches, however, amplifying the significance of lagoons as rearing habitat (Kelley 2008, Hayes and Kocik 2014).

Channel connectivity is critical for steelhead to access spawning areas. It is likely that during dry years the largest steelhead populations historically occurred in streams where upstream spawning and rearing habitats were close to the ocean, such as the short coastal streams along the Santa Barbara coast, the Ventura River, Santa Monica Mountains watersheds, and San Mateo Creek, San Diego County (USFWS 1998). Different size classes of juvenile steelhead use different parts of the available habitat. For example, in one stream, Spina (2003) found young-of-year steelhead preferred water less than 40 cm deep, while age one and two fish preferred deeper water. All three sizes were found mainly at velocities of < 10 cm/sec but this largely reflected habitat availability. In a survey of resident trout in Pauma Creek in San Luis Rey River in San Diego County, trout were proportionally captured most frequently in the complex cascade-pool habitats and to a lesser extent in pools, flatwater and riffles (Barabe, 2013; Barabe and O'Brien, 2013).

The freshwater growth rate of rainbow trout may determine whether juvenile fish out-migrate and become steelhead, or whether they remain as year-round residents. A higher growth rate seems to be necessary for fish to reach sufficient size to undergo smoltification and survive in the marine environment, but may not be the only factor that determines outmigration to the ocean (Ward et al. 1989, Bond 2008, Satterthwaite et al. 2010, Sloat and Osterback 2013); however, the mechanisms for controlling anadromy and residency are in the early stages of investigation (Phillis et al 2016; Pearse et al 2014). For example, juvenile growth rates in Topanga Creek in the Santa Monica Mountains are high enough to produce smolts in one or two years (Dagit et al. 2015) and yield juveniles of sufficient size (> 170 mm) for high marine survival (~ 10%) (Ward et al. 1989). A combination of environmental factors (e.g. growth rate, lipid storage) and genetic factors (*e.g.,* chromosomal structure and DNA sequence heterogeneity) likely co-operate to shift the resident vs. migratory life history behavior in steelhead (Kendall et al. 2015; Pearse et al. 2014; Pearse 2016; Satterthwaite 2012; Beakes 2010). They also alter gene expression profiles and tissue structure while acclimating to saltwater conditions. Partial anadromy is an active area of research to gain insight into underlying environmental and genetic influences. This multigenic trait has important implications for endangered steelhead recovery and fisheries management strategies.

Headwater streams may have limited food resources, resulting in slow growth for juvenile summer steelhead (Boughton et al. 2009) Higher water temperature and lower dissolved oxygen levels may be tolerated for short periods of time if nearby cool refuge areas are available (Boughton, et al. 2015, Sloat and Osterback 2013, Sloat and Reeves 2013). Estuaries are important rearing and gateway environments for steelhead that seasonally migrate between fresh water and the ocean. During winter and spring rains, some steelhead juveniles utilize high river flows to emigrate to the ocean. If conditions permit, they may stay in the lagoon/estuary for further rearing and smoltification for several weeks. River flows sufficient to breach bars on the mouths of lagoons allow steelhead to move into the ocean while adult steelhead use this transient access and flow surge to migrate upstream to spawning areas.

Although steelhead typically use estuaries to acclimate to salt and fresh water and to grow, some steelhead may remain in the estuary or lagoon year-round, then return upstream to spawn. This lagoon-anadromous life history has been observed in South-Central Coast steelhead and provides an alternative for juvenile steelhead to increase their size without exposure to ocean predators. In one reported case in Scott Creek in Central California, estuary-reared steelhead comprised between approximately 85-95 % of returning adults despite being a much lower percentage of the juvenile population (Bond et al. 2008). This hybrid life-history scenario observed in more northern steelhead populations may accelerate steelhead recovery in Southern California.

Because of periodic droughts in Southern California, streams may be inaccessible from the ocean during some years, such that adult steelhead may spend additional years in the ocean before having an opportunity to spawn. The increased growing time in the ocean, plus richer food sources in southern coastal waters, may account for the large size (9+ kg) attained by steelhead in some southern California streams (e.g., the Santa Ynez River). These fish may be 5-6 years old, compared to the typical 4-year old spawners in more northern areas in California. When droughts last multiple years and anadromous steelhead are unable to spawn, the freshwater-resident populations are presumably essential for the long-term viability of populations within some watersheds. Likewise, when catastrophic events (i.e., fires, debris flows) extirpate resident trout from a watershed, the anadromous fish are important for recolonization of the streams. Therefore, the ability to migrate to new habitat patches is key to the species survival, and removal of fish passage barriers and dams in Southern California is a high priority for conservation. See Climate Change section below for further discussion.

Habitat Requirements: Southern steelhead require cool, clear, well-oxygenated water with sufficient food, but they have adapted to living under highly variable environmental conditions. Thus, their physiological tolerances may be broader than other steelhead. In general, southern steelhead seem to tolerate warmer water temperatures than their northern counterparts. Their body temperature and metabolic rate fluctuate with the temperature of the surrounding environment. As temperature increases, their metabolic and feeding rate increases until the temperature approaches an upper threshold of about 25˚C where they stop feeding and/or move to a refuge area, but this response depends on proximity of refuge areas, cover and food availability (Boughton, et al. 2015, Sloat and Osterback 2013, Sloat and Reeves 2013).

Important aquatic environmental factors for steelhead include temperature, dissolved oxygen, salinity and water depth. Temperature and dissolved oxygen levels are two critical parameters which can vary diurnally and seasonally to a significant degree. Estimation of ranges for these parameters (Figure 1) comes from studies in the Santa Monica Mountains (Bell et al. 2011, Bell et al. 2012, Dagit et al. 2015), the Santa Clara River in Ventura County (Sloat and Osterback 2013), Moyle et al. 2008, Myrick and Cech 2000; and others cited below. The ranges have uncertainty because they are based on synthesis of data from diverse studies where upper limits of temperature and dissolved oxygen vary with age, food availability, thermal acclimation status, available refuge areas, and waterbody type.

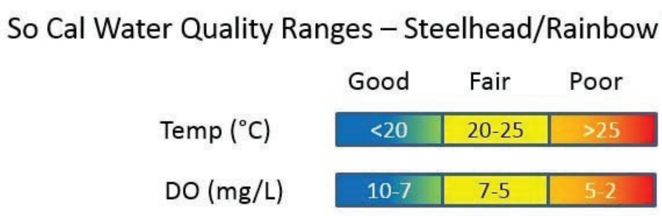

Figure 1. Southern California steelhead/ rainbow trout water quality tolerance range estimates. Data compilation by S. Jacobson, CalTrout, pers. comm. 2016.

Preferred temperatures of juvenile steelhead are reported as 10-17ºC, but southern steelhead seem to persist in environments that regularly reach temperatures outside this range. For example, Carpanzano (1996) found steelhead juveniles in the Ventura River persisted where temperatures peaked daily at 28ºC. Santa Ynez steelhead trout have been observed at temperatures of 25ºC (SYRTAC 2000). In Sespe Creek, Matthews and Berg (1997) found that trout selected cool seeps in flowing water or areas of pools that had lower temperatures despite associated low oxygen levels. Spina (2007), in contrast, found that thermal refuges were often not available to juvenile southern steelhead but they consistently were able to survive daily temperatures of 17.4-24.8°C. These fish maintained higher body temperatures than reported elsewhere and actively foraged during the day, presumably as a means to support their higher metabolic rates. Dissolved oxygen levels above 5 mg/L are generally regarded as sufficient for survival, and the incipient lethal level of dissolved oxygen for adult and juvenile rainbow trout is approximately 3 mg/L (Matthews and Berg 1997). In other California coastal streams, it seems that a period of rapid growth during spring is sufficient to compensate for slower growth at high temperatures during summer and low temperatures during fall and winter (Hayes et al. 2008, Sogard et al. 2009). In upper reaches of Pauma Creek in the San Luis Rey watershed, temperatures ranged from 6°C in winter to 22°C in summer (Jacobson et al. 2010), with a diurnal swing of 10°C during spring and summer months. This temperature fluctuation in Pauma Creek is noteworthy considering the robust trout population there.

Upper lethal temperatures for salmonids tend to be higher when they have been gradually acclimated to warmer temperatures (Threader and Houston 1983) as would occur in streams in Southern California where water temperatures are warm most of the year. The ability to move into different aquatic microenvironments is likely important for juveniles to survive poor habitat conditions. Topanga Creek is an informative example of a trout stream in the southern DPS where warm-season peak daytime water temperatures regularly exceed 21ºC, and trout seek habitats associated with cooler ground water, although these habitats made up only 16% of the total available habitat (Tobias 2006). Bell et al. (2012) reported daily maximum water temperatures in Topanga Creek were generally less than 22ºC during most of the fall, winter, and spring, but usually exceeded 23ºC for nearly a week each summer in late July and early August. Despite these high summer water temperatures, trout in Topanga Creek grew quickly and adults over 270 mm FL were not uncommon (Bell et al. 2011). Another study (Krug et al. 2012) observed that growth rates of Southern steelhead are similar to those in central coast streams during fall and spring, but are significantly higher in winter, suggesting that increased food availability, reduced thermal stress, or other factors make these flashy productive streams conducive to juvenile growth.

In streams without cold-water refuges, steelhead persist by adopting different strategies. Tobias (2006) found groundwater discharge areas typically had greater surface area, greater depth, and more shelter than other nearby areas. Spina (2007) observed that steelhead preferred such areas even without cool groundwater discharges. Trout densities were inversely correlated with aquatic macrophyte densities, likely due to low dissolved oxygen concentrations in these areas at night and the presence of non-salmonid fish species (Douglas 1995). Headwater areas that are continually fed by spring water may be best locations for long-term survival of juvenile steelhead, especially during extended drought.

Distribution: The southern California steelhead DPS includes all naturally spawned anadromous *O. mykiss* populations below natural and human-made barriers in streams from the Santa Maria River, San Luis Obispo County, California (inclusive) to the Tijuana River on the U.S. - Mexico border. Steelhead are most abundant in the four largest watersheds (Santa Maria, Santa Ynez, Ventura, and Santa Clara rivers) in the northern portion of the DPS. Recent observations and genetic analyses indicate that steelhead are sporadically present in the southernmost watersheds. Adult steelhead have been documented in San Juan Creek, Santa Margarita River, San Luis Rey, and San Mateo Creek in Orange and San Diego counties (Hovey 2004; CDM 2007; Cardno TU, 2013 and references therein; NOAA 2012; Kajtaniak and Downie 2010 and references therein).

The entire range of the DPS spans over 30,000 km^2, has over 41,500 km of stream, a significant amount of which has intermittent flow, and contains more than 22 million people (NMFS 2012).

In contrast to often sporadic presence of steelhead, resident rainbow trout occupy the upper watersheds of most river systems in the southern steelhead DPS range and may be largely responsible for maintaining steelhead runs. Resident rainbow trout may be offspring of either anadromous steelhead or resident trout, although many basins have barriers restricting anadromous adults from reaching headwaters that contain resident trout. Anadromous offspring of resident parents occur with sufficient frequency that landlocked fish derived from steelhead should be considered integral components of steelhead recovery, particularly in Southern California (Courter et al. 2013, Kendall et al. 2015, Abadia-Cardoso 2016).

The southernmost rainbow trout in North America reside in headwaters of the Rio Santo Domingo in Baja California, Mexico and in several watersheds of north-central Mexico (Behnke 2002, Miller 2005; Nielson et al. 1996; Nielsen et al, 1998; Abadia-Cardoso et al. 2014, 2015, 2016). These trout, recognized as *O. m. nelsoni*, are quite distinct genetically but originated from steelhead. The southernmost native rainbow trout population known in the United States resides in the San Luis Rey River watershed (San Diego Co.) (Jacobson et al. 2014; Abadia-Cardoso et al. 2016).

The Southern California Steelhead Recovery Plan distinguishes populations in the Southern California DPS based on their relative intrinsic potential to support an independently viable populations:

> "population viability is more likely achievable by focusing recovery efforts on larger watersheds in each Biogeographic Population Group (BPG) capable of sustaining larger populations, and DPS viability is more likely achievable by focusing on the most widely-dispersed set of such core populations capable of maintaining dispersal connectivity" (NMFS 2012, pg. 7).

The five BPGs recognized by NMFS (2012) are, from north to south: *Conception Coast* (surrounding Santa Barbara), *Monte Arido Highlands* (watersheds including Santa Maria River, Santa Ynez River, Ventura River and Santa Clara River), *Santa Monica Mountains* (coastal creeks surrounding Santa Monica such as Arroyo Sequit, Malibu Creek and Topanga Creek), *Mojave Rim* (coastal rivers surrounding Long Beach containing Los Angeles River, San Gabriel River, and Santa Ana River systems) and *Santa Catalina Gulf Coast* (watersheds in Orange County and San Diego County containing San Juan Creek, San Mateo Creek, Santa Margarita River, San Luis Rey River, San Diego River, Sweetwater River and Tijuana River). Within the five BPGs, 46 southern steelhead populations have been identified (Boughton et al 2007), although over half of the populations have been extirpated (Boughton et al. 2005).

In the Santa Catalina Gulf Coast BPG, resident trout occur in a majority of streams above barriers including Trabuco Creek, San Luis Rey River, San Diego River, Pine Valley Creek and Sweetwater River (Boughton et al. 2007; R. Barabe, CDFW, pers. comm. 2016). There are numerous high country habitats that support wild rainbow trout, although fish passage barriers and modified flows impede or block upstream migration from the ocean to headwater spawning and rearing habitats.

The adjacent Mojave Rim BPG watersheds have dispersed populations of resident trout upstream of barriers in the Los Angeles, San Gabriel, and Santa Ana rivers. Populations in the Mojave Rim in the Upper West Fork, East Fork and North Fork San Gabriel River, as well as

Bear Creek, Iron Fork, Fish Fork and Cattle Canyon tributaries and Coldwater Canyon Creek are native trout of coastal steelhead descent. Significant hatchery introgression is present in Devil's Canyon, Santa Anita Creek and lower Iron Fork tributaries of San Gabriel River; and San Antonio Creek, Fuller Mill and North Fork San Jacinto of the Santa Ana River watershed (Abadia-Cardoso et al 2016).

The northern BPG, Conception Coast, has had steelhead observations in numerous watersheds (Boughton 2005) that are connected seasonally to the ocean. These included populations on Santa Anita Creek, Gaviota Creek, Arroyo Hondo, Goleta Slough Complex, Mission Creek, Montecito Creek, San Ysidro Creek, Romero Creek, Arroyo Paredon, and Carpinteria Creek. Resident trout are present in a number of Conception Coast basins above barriers including Jalama Creek, Tajiguas Creek, Dos Pueblos Canyon, Tecolote Creek, and Rincon Creek (Stoecker and Project 2002).

Trends in Abundance: Southern steelhead have been either significantly depleted or extirpated from rivers and streams in which they historically occurred. There are still remnants of self-sustaining populations in the Santa Ynez, Ventura, Santa Maria, and Santa Clara rivers and Topanga Creek. Episodic runs occur in some watersheds of all BPGs, including Gaviota, Arroyo Honda, Goleta Slough Complex, Mission, Malibu, San Gabriel, and San Mateo creeks and Santa Margarita and San Luis Rey Rivers. Historical runs in this DPS that numbered in the thousands are now reduced to single digits over the past 20 years for the Santa Clara, Ventura, and Santa Ynez rivers and Malibu and Topanga creeks (NMFS 2016). However, accurate counts of annual runs are difficult to quantify in most watersheds (M. Capelli, NMFS, pers. comm. 2017). Indeed, run size estimates made without using standard protocols in Southern California watersheds are likely to be highly subjective and based on sparse and potentially misleading data (Good et al. 2005). For the most part, estimates should be not be viewed as absolute population estimates, but, rather multiple year trends.

Steelhead numbers are naturally highly variable in all Southern California streams. Some of the key factors underlying population dynamics include life-history variability in resident and anadromous individuals, population spatial structure that connects streams with other watersheds, a robust rainbow trout population in the watershed, ocean conditions, estuary integrity, unblocked migratory pathways, and high-quality summer and winter rearing habitats.

In the Santa Maria River, estimates of historical numbers are lacking but southern steelhead have been observed in the mainstem and also in Sisquoc River, one of the Santa Maria's major tributaries (Stoecker 2005). Stoecker (2005) found densities of steelhead to be highest in the South Fork Sisquoc River and lowest in the Lower Sisquoc River. Within the Sisquoc, Stoecker (2005) observed the overall age class distribution from 841 juvenile steelhead to be have 52% 0+ fish, 24% 1+ fish, 17% 2+fish, and 7% 3+fish. In May 1991, 14-25 adult steelhead were observed in the Ventura River (R. Leidy, USEPA, memorandum to B. Harper, USFWS, May 8, 1991), but no steelhead were reported in 1992, and only one pair was reported in 1993 (F. Reynolds, memo. to B. Bolster, October 13, 1993).

In the Santa Ynez River, which probably supported the largest historical runs of southern steelhead, runs may have been as large as 20,000 to 30,000 spawners in the 19th and early 20th centuries (Busby et al. 1996). In 1944, the minimum number of steelhead in the Santa Ynez River was estimated to be 13,000-14,500 fish following a favorable wet period (Good et al. 2005). While 1944 estimates of abundance are the best available for the system, a significant portion of rearing and spawning habitat was already blocked by dams on the Santa Ynez by then.

In 1940, CDFG personnel salvaged more than 525,000 young steelhead trout from pools in the Santa Ynez River as it dried in summer (Shapovalov 1940) which is indicative of the productivity of southern steelhead watersheds during wet periods.

Historical run size estimates on the Ventura River were 4,000-5,000 steelhead; while these estimates were made by CDFW personnel with extensive experience in the watershed, and when the fishery was closely regulated, with daily bag limits (Good et al. 2005). Steelhead runs in the Matilija Creek basin (Ventura River) were around 2,000 fish (Good et al. 2005), though this included hatchery raised rainbow trout that were intended to support a put-and-take summer fishery, not to enhance the steelhead fishery (M. Capelli, NMFS, pers. comm. 2017). In the Santa Clara River, historical runs have been estimated at 7,000-9,000 adult fish (Moore, 1980b, Good et al. 2005).

The Santa Clara River is one of the largest watersheds in Southern California (*ca.* 4,100 km^2) so it was presumably once capable of supporting large numbers of steelhead. Anecdotal accounts chronicle a precipitous decline in run sizes during the 1940s and 1950s, presumably due to the combination of drought, angling, urbanization and associated water use, and dam construction. The Santa Clara River drainage now also supports only a small fraction of its historical steelhead populations, the result of 129 natural and human-made fish migration barriers (Good et al. 2005). The Vern Freeman (VF) Diversion Dam alone blocks access to 99% of the watershed (Good et al. 2005). The VF Diversion Dam is downstream of the major southern steelhead spawning tributaries Piru and Sespe Creeks. Sespe Creek provides a large amount of high quality habitat. Although smaller than the above drainages, Santa Paula Creek provides some of the highest quality habitat in the watershed (NMFS 2008, Stoecker and Kelley 2005). Fish passage barrier removal efforts are underway in the Santa Clara River and Santa Paula Creek tributaries and are in the design discussion stages.

Further south, Topanga Creek in the Santa Monica Mountains offers an example of high population variability, and the value of persistence in monitoring to document and understand population dynamics through time. Some streams where steelhead had been extirpated in the Santa Monica Mountains were re-colonized in the late 1990s, and have persisted to date in low numbers (Dagit et al. 2015). In 2006, there was an observed die-off of both native and alien species in Malibu Creek, followed by re-colonization in 2007 and record numbers of adult steelhead (five fish > 50cm) and over 2,200 young-of-year (YOY) fish < 10 cm observed in 2008 (Dagit et al. 2009). Population monitoring was established by Santa Monica Mountains RCD (SMMRCD) and includes population and size surveys, redd counts, a Life Cycle Monitoring Station, and DIDSON sonar detection since 2001 (Topanga Creek) and 2005 (Malibu Creek). In 2015, SMMRCD performed mark-recapture studies and PIT tagged 104 fish to track movement. The highly variable abundance of such streams is reflected in estimates of YOY observed recently, with only 11 observed in 2005, and a peak of 590 observed in 2008, 92 in 2013, 25 in 2014, and 112 in 2015 during extended drought (Dagit et al. 2016). Monthly population surveys performed in SM Bay by snorkel survey over the past 10 years showed distinct population fluctuations in Topanga and Malibu Creeks (Figure 2).

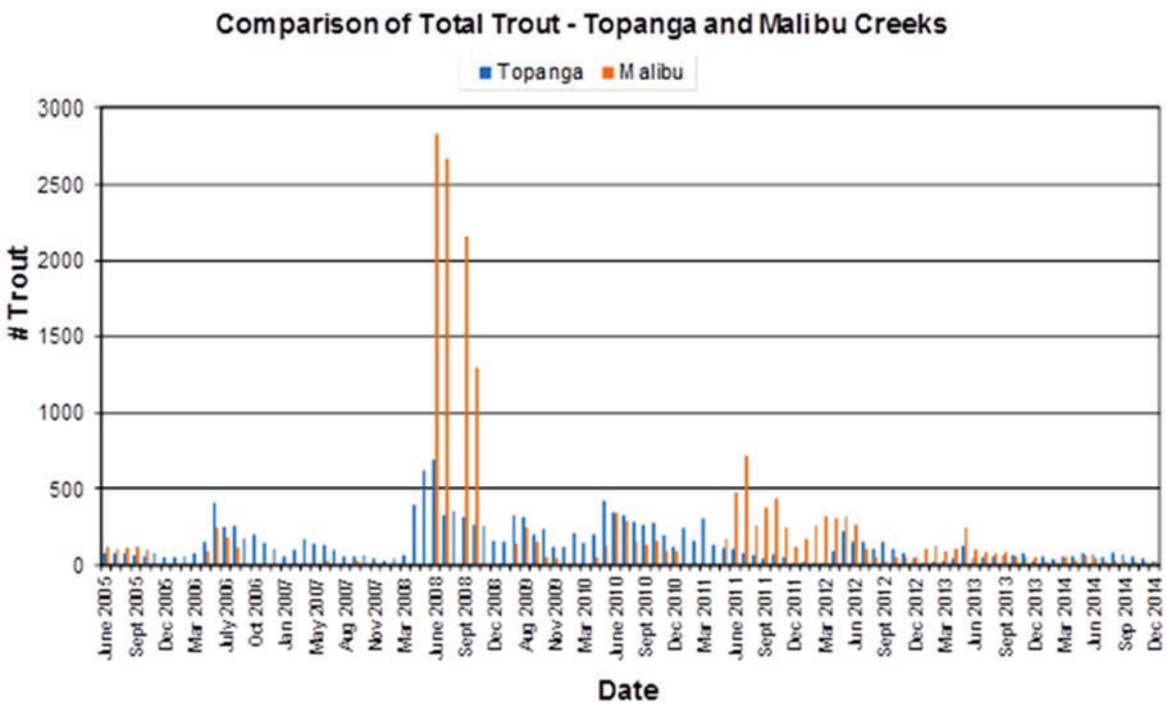

Figure 2. Rainbow trout population estimates from snorkel surveys in Topanga and Malibu creeks (SMMRCD 2015, Figure 3, pg. 8).

Overall, southern steelhead numbers have declined dramatically from estimated annual runs totaling a minimum of 30,000 adults in most years to significantly less than 500 returning adult fish combined annually in the past 50-75 years. There have been few comprehensive surveys conducted in recent years to provide a reliable estimate of total population size for southern steelhead. However, a recent compilation of monitoring data revealed strikingly low number of anadromous adults on several river systems. The data, however, are incomplete because sampling was conducted in small portions of respective watersheds and/or because of the difficulties associated with sampling during high discharge events, or because of other technical or environmental constraints. As such, the numbers represent raw counts or observations during certain periods and are not adjusted for observational errors or biases. Between 2001 and 2011, sampling on two primary tributaries to the Santa Ynez River and part of the mainstem below Bradbury dam showed an average annual adult return of 3.4 adults (SD = 5.2, Figure 3) and a mean smolt capture of 146 (SD = 116) (NMFS 2016). On the Ventura River, a mean return of 2.5 adults was observed at the fish passage facility at the Robles Diversion Dam between 2006 and 2009 and 0-2 adults were observed annually at the Freeman diversion dam fish ladder on the Santa Clara River between 1995 and 2009 (NMFS 2016). On Topanga Creek, observations ranged from 0 and 4 adults per year from 2001-2010, suggesting that the largest annual run would have been approximately 40 individuals under an assumption of a 10% observation probability (NMFS 2016). Finally, on Malibu Creek, a total of 11 anadromous adults were observed by snorkel survey between 2012 and 2015 (Dagit 2016 from NMFS 2016).

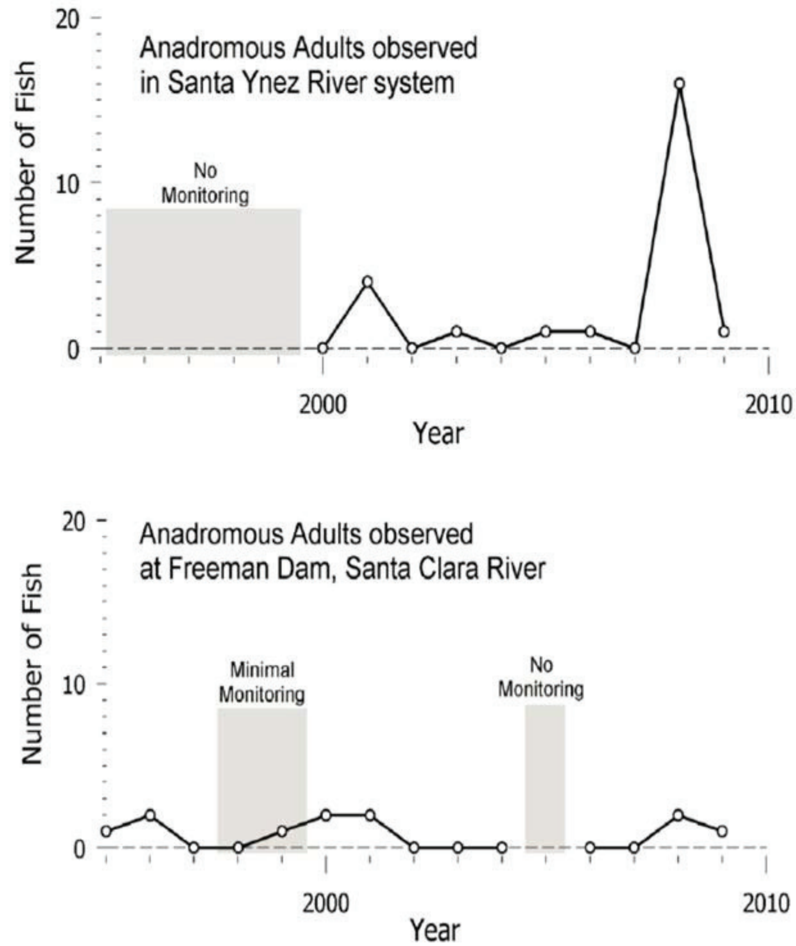

Figure 3. Anadromous adult *O. mykiss* in the Santa Ynez and Santa Clara Rivers, 1995-2010. Observations are incomplete counts unadjusted for observation probability. Williams 2011, Fig. 15, p. 74).

With steelhead abundance in Southern California extremely low, monitoring is critical to assess progress towards recovery goals. Monitoring is difficult due to patchy spawner distribution and large stretches of uninhabited water. With the recent focus statewide on protocol consistency, sample frame approaches and technology development, the Coastal Salmonid Monitoring Program (CMP) led by California Department of Fish and Wildlife should increasingly yield meaningful steelhead abundance data. Fish Bulletin 180 lays out the Viable Salmonid Population (VSP) conceptual framework designed to gain information on diversity of steelhead life history traits including abundance, productivity, spatial structure, diversity, and movement (Adams et al. 2011, HDR Engineering 2013). In contrast to Northern California with more easily measureable annual steelhead runs, the Southern California VSP analysis focuses on fixed counting stations and in-stream counting. As of 2016, there are currently weirs/dams and/or sonar cameras to quantify adult escapement on the Santa Ynez River, Arroyo Hondo, Ventura and Santa Clara rivers, as well as Topanga and Malibu creeks (D. McCanne, CDFW, pers. comm. 2016; NMFS 2016). Some of these include Fixed Life Cycle Monitoring Stations at Santa Ynez River, Topanga Creek and Malibu Creek.

Factors Affecting Status: The Southern California Steelhead Recovery Plan identified primary threats to southern steelhead viability, as summarized below (NMFS 2012).

Dams. The majority of spawning and rearing habitat for steelhead within the major river systems has been rendered inaccessible as a result of dams, debris basins, road crossings, and other in-stream structures which block or impede migration of adult steelhead to headwater spawning and rearing tributaries, as well as restricting the emigration of juveniles to the ocean (Stoecker and Project 2002, NMFS 2012). For example, Twitchell Dam eliminates access to half of the Santa Maria River's historically accessible habitat and dries up the river below it; water diversions further reduce connectivity among critical lower watershed tributaries (i.e., Sisquoc River) and the estuary. Bradbury Dam, which creates Cachuma Reservoir, is the largest barrier on the Santa Ynez River and operations restrict flows necessary to support suitable steelhead habitat (NMFS 2016). On the Ventura River, access to most upstream habitat is blocked by Matilija Dam on Matilija Creek and Casitas Dam on Coyote Creek. Rindge Dam on Malibu Creek blocks access to most upstream habitat. Diversion dams and poorly functioning fish ladders on the Santa Clara River have blocked steelhead access to spawning habitats and reduced available rearing habitat for steelhead offspring. Overall, fish passage barriers are also common in Southern California watersheds from bridge crossings with concrete and rock stabilization structures that create impassible drop structures for in-migrating steelhead.

Agriculture. Agriculture is a diminishing problem as farmland continues to be overtaken by urban development. Nevertheless, much of the early development of water in the region was to support irrigated agriculture for high value crops such as orchards of citrus and avocado and row crops of strawberries and vegetables. Agriculture continues to be important in some areas such as the lower Santa Maria and Santa Ynez Rivers, the small coastal watersheds along the Santa Barbara coast, the upper Ventura River and Ojai Basin tributaries, and portions of the San Mateo, Creek, San Luis Rey and San Dieguito River in the southernmost portion of the DPS. Agricultural water demands in the Santa Clara watershed have also had a significant impact on mainstem flows and fish passage (NMFS 2016). Agricultural development impacted steelhead habitat in the past by reducing habitat complexity, competing for water to irrigate crops, and producing runoff with nutrients that decrease water quality. The nutrients can also accumulate in estuaries that limit their utility as a growth and acclimation area for steelhead. Current efforts are focused on working with agricultural operations to stagger water consumption (both daily and seasonally) to promote steelhead viability, and implement Best Management Practices to reduce nutrient run-off and meet quantitative water quality objectives set by regional water quality control boards. Further initiatives to upgrade irrigation efficiency infrastructure will provide a foundation for community based water quality awareness and water conservation.

Urbanization. Over 20 million people live in Southern California, in a semi-arid environment where water is a limiting resource. Not surprisingly, most watersheds containing southern steelhead are urbanized. In particular, the four largest watersheds are heavily impacted by water diversions (both surface and subsurface), which reduce stream flows, and development of the floodplain and associated riparian corridor for agricultural, residential, industrial, and sand and gravel extraction uses. There has been extensive loss of steelhead populations, especially south of Malibu Creek, due to dewatering and channelization of rivers and creeks. Urban and rural waste discharges are also widespread, which degrades water quality and creates habitat conditions that favor alien aquatic organisms. However, the single biggest impact remains the demand on surface water and groundwater resources, and related water supply infrastructures such as dams, diversions, and groundwater wells. In some parts of watersheds with shallow aquifers, groundwater and surface water systems are tightly linked, such that depleted groundwater resources decrease surface flow, which can have immediate negative impacts on steelhead populations.

The Southern California population boom has led to increasing demand on surface water and groundwater resources which has depleted natural water storage. Typically 80-90% of water in Southern California is imported from Northern California, Owens River or the Colorado River (SDIRWMP 2013). To better meet the increasing demands for water, a robust effort to diversify and conserve regional water supplies is underway. However, altered river hydrology and stream flow is a widespread concern by decreasing natural flow or creating perennial flow in ephemeral streams. Due to the naturally ephemeral and flashy nature of Southern California streams, it is difficult to re-establish natural hydrologic regimes that benefit steelhead. Diversion of water and increases in non-permeable surfaces (e.g., roads, parking lots) have made the hydrograph show broader extremes in many streams, with flashier winter flows and lower summer flows, greatly reducing habitat quality and quantity. The problem is further exacerbated by upstream dams which inhibit sediment transport. Lack of flushing flows encourages sediment accumulation and can negatively affect spawning gravels and food sources.

Another major impact of urbanization is stream alteration through channelization, road crossings construction, stream bank stabilization, and flood-control levee maintenance. Floodplain development and construction of flood control structures and activities have also altered natural fluvial processes and reduced instream and riparian habitat. Increases in residential structures (and associated roads) on steep-sided slopes have accelerated erosion and sedimentation of some river and stream channels.

Mining. The principal ongoing mining in the region is drilling for and pumping of oil; the region is still a major oil producer. Waste from drilling and oil spills from pipelines are common problems but there is no evidence of direct impacts on steelhead. Hardrock mines, for gold, gems, and other minerals are common in the mountains along the coast but mostly abandoned. Aggregate mining in stream beds still occurs in Southern California, especially in the Santa Maria, Santa Ynez, Santa Clara Rives, Tujunga Wash, and streams that flow out of the San Bernardino and San Gabriel mountains; some of the mining operations have been limited or modified to provide better instream habitat protection, but many operate under old, outdated permits (Mount 1995). Removal of sediment disrupts river processes which presumably affects steelhead migration, spawning, and rearing habitat.

Fire. Periodic wildfires are an integral ecological feature of Southern California and helped shape the landscape and life history strategies of southern steelhead. Wildfires can increase wet-season runoff, reduce summertime surface flows, and increase stream temperatures (Boughton et al. 2007). When wildfires are followed by heavy rains in areas which are geomorphically unstable, high flows may cause an increase in sediment delivery to streams via debris torrents (Spina and Tormey 2000, Keeley 2006), that cover habitats and fish alike. Following a wildfire, if winter rains do not mobilize sediment but increase runoff, then favorable characteristics such as increased scour and nutrients may benefit steelhead. Because of increased frequency of drought, the severity and presumably frequency of wildfires is increasing in Southern California, making it more difficult for steelhead to persist in some watersheds. Emergency plans are either in place or under development by fisheries resource managers to react quickly to protect sensitive populations that are threatened by drought and fire.

Estuarine alteration. Southern steelhead are likely similar to South-Central Coast steelhead in their use of estuaries, which are essential for juvenile rearing, adult migration, and occasionally adult over summering (Kelley 2008, Bond et al. 2008, NMFS 2012). Many Southern California estuaries/ lagoons have disappeared due to human activities, while others are functionally degraded (Ferren et al. 1995; Lafferty 2005). Many are shallower, warmer, and more saline than they were originally, due to urbanization, channelization, and altered stream and sediment flows. Southern California estuaries also suffer from pollution, invasive riparian and aquatic vegetation, and filling to create uplands. Smaller lagoons along the rugged Gaviota Coast and Santa Monica Mountains are less disturbed than the estuaries associated with larger rivers, due to less upstream development. The degradation of remaining estuarine habitat as a result of both point- and non-point sources of pollution and artificial breaching of sandbars has reduced the suitability of these habitats for steelhead rearing and as transition zones between marine and freshwater environments.

Recreation. Southern California's streams are magnets for recreational use, especially at higher elevations where natural flows are maintained. The effects of aquatic recreation on steelhead are not well documented, but if it is fairly localized they may not be great. Recreational users could be an additional source of stress to juvenile steelhead that are living in water close their upper temperature tolerances, potentially resulting in sublethal impacts such as changes in behavior or even mortality.

Harvest. The once popular fishery for southern California steelhead closed as fish numbers were depleted and prohibited once the fish was declared an endangered species. However, adult steelhead in streams are highly vulnerable to poaching and removal of even a few individuals in some years can be a threat to the population.

Hatcheries. Hatchery rainbow trout have been planted in virtually all Southern California streams. These plantings were comprised predominantly of hatchery raised rainbow trout, and were intended to support a put-and-take summer fishery, not to enhance expression of the anadromous steelhead life history (M. Capelli, NMFS, pers. comm. 2017). Genetic studies show that fish of hatchery origin dominate rainbow trout populations in the more urbanized southernmost part of their range where the expression of anadromy may have been less frequently expressed because of the restricted hydrological connection between the ocean and upstream spawning and rearing habitats, although several substantial wild native populations still exist (Abadia-Cardoso et al. 2016). Stocking of hatchery rainbow trout has presumably resulted in the displacement or hybridization of native trout and steelhead from most of these waters. Where the expression of anadromy is most frequently observed in the northernmost populations of steelhead and trout (e.g. Santa Clara, Ventura, and Santa Inez rivers), populations show minimal introgression with hatchery fish, maintaining both native resident and steelhead life histories.

Alien species. The presence of invasive vegetation such as giant reed (*Arundo donax*), tamarisk, and Pampas grass have disrupted river morphology, creating monotypic riparian habitats that consume more water. These aggressive growers are highly disruptive and expensive to eradicate. However, the past ten years has seen a concerted effort to control them. The presence of non-native aquatic species such as bass, catfish, shiners, carp, bullfrogs and crayfish is pervasive in Southern California streams. These competitors thrive in warmer, slow moving water and can withstand lower water quality, dissolved oxygen levels and high sediment. Once non-native aquatic species are dominant, depletion and eradication requires long-term control programs. Although habitat may exist for southern steelhead in some watersheds from which they are currently missing, the presence of non-native fishes makes reestablishment of steelhead in these basins difficult. Designated wild trout streams such as Sespe Creek have in recent years been colonized by a host of non-native species, which have significantly degraded this wild trout fishery and impacted the important refugia habitat for rearing juvenile steelhead within the Santa Clara River watershed (M. Capelli, NMFS, pers. comm. 2017).

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of Southern 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. Certainty of these judgments is moderate. See methods for explanation.

Factor	Rating	Explanation
Major dams	High	Many rivers in the DPS have major dams blocking passage.
Agriculture	Medium	Irrigation diversions in many streams reduce flows, especially during drought.
Grazing	Low	Some grazing on public lands, often for fire or weed control.
Rural /residential development	Medium	Many homes along streams throughout basins, outside of major urban areas. Effects included in urbanization.
Urbanization	High	Many important streams flow though highly urbanized areas across Southern California, which may overdraw water from surface and groundwater sources.
Instream mining	Medium	Gravel mining in some watersheds reduces habitat.
Mining	Low	Gold mining and dredging may increase siltation and negatively impact eggs and juveniles, but impacts largely unknown.
Transportation	Medium	Roads and railroads line streams, creating sediment and erosion throughout most basins, and highway crossings create migration barriers. Effects included in urbanization.
Logging	Low	Impacts are likely due mainly to legacy effects.
Fire	High	Fires in Southern California are very common and can cause siltation of streams, loss of riparian habitat, and increased water temperatures.
Estuarine alteration	High	Nearly all estuaries and lagoons highly altered with reduced rearing habitat.
Recreation	Medium	Recreational use common in streams; effects on steelhead unknown.
Harvest	Medium	Poaching may impact small populations.
Hatcheries	Low	Many populations introgressed with hatchery-origin rainbow trout in the southern portion of the DPS, but stocking has been curtailed in anadromous waters.
Alien species	High	Most watersheds significantly invaded by alien aquatic species.

Effects of Climate Change: Moyle et al. (2013) rated southern steelhead "critically vulnerable" to climate change, likely to go extinct by 2100 without strong conservation measures. Climate change is predicted to increase variability in rainfall, stream flow, and temperatures, reducing suitable stretches of stream, even when flowing, for steelhead/rainbow trout. 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 southern steelhead DPS, which lies at the southern edge of the species' range, is on the front line of climate impacts. As a result, southern steelhead will be exposed to periods of higher water temperature and flow variability, possibly outpacing their ability to avoid such exposure (Wade et al. 2013).

Longer and more severe droughts are also predicted in the future due to climate change, enhancing competition for water between a large and growing human population and a small and shrinking trout population in Southern California. Drought has increased temperatures and natural variability in precipitation (Williams et al. 2015; NMFS 2016), and reduced natural spawning, rearing, and migration habitat for already small populations. The ongoing "hot drought" in California has been characterized by several of the hottest years on record in the last five years (2012-2016) alone. No part of the state was impacted more by drought than Southern California, with significant reductions in precipitation over the last five years compared to long term averages and much of the region remaining in critical drought. For example, Lake Cachuma, which provides drinking and irrigation water to the City of Santa Barbara, holds less than 9% of its capacity as of this writing (January 2017, Santa Barbara County Flood Control District 2017). A hotter, drier climate regime in Southern California is expected in the future, and is likely to increase the frequency and magnitude of catastrophic wildfires in California. In their five year status review, NMFS (2016) 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. Another potential impact of climate change is sea level rise, which may lead to inundation and displacement of estuaries/lagoons. Reduction in these important rearing habitats will likely reduce smolt survival and further strain populations of southern steelhead.

Given the precarious position of the southern steelhead life history, there will be an increase in dependence on resident rainbow trout above manmade barriers to produce out-migrants that become steelhead. Unfortunately, climate change will likely create conditions that will select against the steelhead life history in Southern California. Maintenance of steelhead runs may therefore require artificial means from enhancing flows during critical periods, to fish rescues, to employing conservation hatcheries. Williams et al. (2016) found that 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 DPSs (NMFS 2016). Providing access and connectivity among populations, 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. Southern steelhead populations are in danger of extinction within the next 25-50 years due to stresses associated with the growing human population of Southern California and climate change (Table 2). They were listed as an endangered species under the Endangered Species Act (ESA) in 1997 (62 FR43937), and abundance remains precariously low. Southern steelhead initially included steelhead populations from the Santa Maria River (Ventura Co.) system south to Malibu Creek (Los Angeles Co.). The range of the listed steelhead was extended southward to the U.S. – Mexico Border in 2002 (67 FR21586). A final listing determination was issued in 2006 for the Southern California Coastal Steelhead Distinct Population Segment (DPS), which encompasses all naturally-spawned anadromous rainbow trout in the listing area whose freshwater habitat occurs below artificial or natural impassible upstream barriers, as well as rainbow trout above impassable barriers that can emigrate into water below barriers and exhibit an anadromous life-history. The National Marine Fisheries Service (5-Year Status Review) summarizes recovery progress to date and recommends that the Southern California Coastal Steelhead DPS remain listed as an endangered species with no changes to the geographic boundaries of the recovery area (NMFS 2016).

NMFS (2012) concluded there is moderate potential for recovery of southern steelhead. If resident rainbow trout populations are considered part of the southern steelhead complex, then the extinction threat of the overall population is somewhat less. Reconnecting the anadromous and resident forms of the native *O. mykiss* populations, however, is essential for maintaining both the anadromous and resident trout populations in the future.

Table 2. Metrics for determining the status of southern steelhead. The range is as follows: 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.

Metric	Score	Justification
Area occupied	3	Found in most of native range, if scattered; mainly in 4 northernmost rivers, but also in a number of short coastal watersheds in the central and southern portion of the DPS
Estimated adult abundance	1	Highly variable but with general downward trend and very low abundance in all populations.
Intervention dependence	2	Intensive efforts such as barrier modification, habitat restoration, and restoration of instream flows are essential.
Environmental tolerance	3	Moderate physiological tolerance to existing conditions, although limits are being reached.
Genetic risk	2	Limited gene flow among populations; some hatchery hybridization. Populations very small and geographically isolated.
Climate change	1	Climate change impacts likely throughout their range, exacerbating other factors.
Anthropogenic threats	1	5 High, 6 Medium, 4 Low factors.
Average	1.9	13/7.
Certainty (1-4)	3	Moderate.

Management Recommendations: The NMFS Recovery Plan for southern steelhead defines biological viability criteria for individual populations and for the DPS as a whole, providing quantitative benchmarks for recovery. A viable population is defined as a population having a negligible (< 5%) risk of extinction over a 100-year time frame. Therefore, a viable DPS must be comprised of a number of viable populations widely distributed throughout the DPS but sufficiently well-connected through ocean and freshwater dispersal to maintain long-term persistence and evolutionary potential. Population-level viability criteria apply to core populations in all of the geographic regions. These criteria include population characteristics such as mean annual run-size, persistence during varying ocean conditions, spawner density, and the anadromous fraction of the individual populations. For the entire DPS, viability criteria identify a minimum number of populations which must be restored to viability and the minimum spatial distribution between populations in each BPG: Monte Arido (4), Conception Coast (3), Santa Monica Mountains (2), Mojave River (3), and Santa Catalina Gulf Coast (8). Recovery efforts are further supported by designated critical habitat which encompasses 1,133 km (708 miles) of stream habitat within 32 watersheds.

To achieve the overarching goals of preventing extinction of the Southern California steelhead and ultimately de-listing this species, the Southern California Steelhead Recovery Plan outlines the following six objectives:

1. Protect existing populations and habitats.
2. Maintain and restore distribution to previously occupied areas that are essential for recovery.
3. Increase abundance of steelhead to viable population levels, including the expression of all life history forms and strategies.
4. Conserve existing genetic diversity and provide opportunities for interchange of genetic material between and within meta-populations.
5. Maintain and restore suitable habitat conditions and characteristics for all life history stages so that viable populations can be sustained.
6. Conduct research and monitoring necessary to refine and demonstrate attainment of recovery criteria.

Additional actions could be added to further help recovery: i) declare native resident rainbow trout populations part of the DPS and then manage them with steelhead as a threatened/endangered species, and ii) continue to utilize triploid (sterile) hatchery rainbow trout in Southern California streams where such fish can reach anadromous waters.

Successfully meeting these objectives will require protection and expansion of habitat for steelhead within each of the five biogeographic regions and reestablishment of large runs in streams that historically were highly productive for steelhead (i.e., Santa Maria, Santa Ynez, Ventura, Santa Clara River, and other rivers to the south). Restoration efforts focused at the watershed scale will ensure adequate flows and passage to historical spawning and rearing areas. It is important to provide connectivity among populations in different streams to allow exchange of genetic material. A key part of this connectivity is ensuring anadromous and resident populations in each watershed can overlap and interbreed during most years. Removal of the artificial distinction between resident rainbow trout and steelhead and manage them together in the DPS, with a special emphasis on expanding the anadromous life history would be consistent with the recovery strategy identified in NMFS Recovery Plan.

Restoration/reconciliation. Changes in water management are critical to restoring habitats and hydro-geomorphic processes important to southern steelhead. Water removal from streams now containing critically low numbers of steelhead should be restricted in order to leave minimum flows for fish in streams. The environmental impact of future development should be carefully evaluated and appropriate alternate measures reviewed by state and federal regulatory agencies (e.g., CDFW, NMFS) prior to accepting mitigation. Restoration techniques that increase habitat fairly rapidly for southern steelhead may include groundwater recharge projects, removal of barriers in watersheds with high quality habitat, and enhancement of instream and riparian habitats. Recycled water from treatment plants may provide an important means by which to recharge streams and groundwater. The effective allocation of recycled water could be instrumental for maintaining migration corridors later into the spring and rearing habitat for juveniles during the fall and early winter in lower reaches of Southern California streams.

Involvement of local citizens is crucial for steelhead recovery as well. Coalitions are already operational for Santa Clara River and San Diego/Orange County priority watersheds. These coalitions engage over 30 federal, state, and local agencies, tribal nations, resource conservation districts, and non-governmental organizations including California Trout to implement the Southern California Steelhead Recovery Plan. Many extant southern steelhead populations are on public lands, and effective management of these waters and cooperation by state and federal managers is needed to benefit these populations.

Dam removal and reoperation. Dams and fish passage facilities provide numerous opportunities for restoring southern steelhead into portions of watersheds with optimal spawning and rearing habitat. In many cases, resident trout persist upstream of these barriers. Considerable planning has gone into removal of Matilija Dam on Matilija Creek (Ventura River), and Rindge Dam on Malibu Creek, as well as construction of fish passage facilities (Robles Diversion Dam) on the Ventura River. Implementation of these projects should be more expeditious in order to benefit southern steelhead as soon as possible. Evaluation of fish passage barrier removal and remediation and associated water operation facilities in the Cuyama, Santa Ynez, Santa Margarita, San Juan Creek and San Luis Rey Rivers should be completed and implemented to reconnect freshwater and marine habitats. Dams on southern steelhead streams, such as Bradbury Dam on the Santa Ynez River and Twitchell Dam on the Cuyama River, can be operated more effectively to reestablish flows during periods critical for steelhead survival, especially during migrations and periods when fish are rearing in estuaries and lower river reaches.

Monitoring. In the short term, monitoring data will ensure that trends and restoration progress are quantifiable and understandable. Development of a baseline monitoring plan for steelhead and their habitat in Southern California watersheds is an essential task. Integration with existing Coastal Salmonid Monitoring frameworks in place in Northern California will contribute important information on steelhead biology and management, and will aid in decision making and coordinating recovery actions.

Conservation Hatcheries. The benefits and guidelines of instituting regional conservation hatcheries are presented in the NMFS (2012) Recovery Plan. Conservation hatcheries are fundamentally different in structure and purpose from large scale hatcheries designed to generate high numbers of trout for stocking waters for sport-fishing. The conservation hatchery is a limited-scope program that aims to conserve and propagate steelhead taken from the wild for conservation purposes, and return the progeny to their native habitats to mature and reproduce naturally. This type of hatchery is typically an outgrowth of an emergency translocation of trout that are facing extirpation from a catastrophic event such as drought, debris flows and/or wildfire.

The goals of operating a potential southern steelhead conservation hatchery are to preserve remaining genotypic and phenotypic characteristics, reduce short-term risk of extinction, reintroduce populations into restored watersheds, conduct research on Southern California stock relevant to species conservation, and incorporate scientific and management considerations into southern steelhead recovery. Within this context, it is imperative that protocols and rationale are in place prior to establishing a conservation hatchery.