CENTRAL CALIFORNIA COAST STEELHEAD
Oncorhynchus mykiss irideus

High Concern. Status Score = 2.0 out of 5.0. Central California Coast steelhead DPS populations are in long-term decline, and face extinction in the next 100 years without significant investments in monitoring, habitat restoration, and water management.

Description: Central California Coast steelhead are anadromous coastal rainbow trout, and are made up of populations downstream of manmade or natural barriers throughout their range. A description of juveniles and adults is similar to that of steelhead in the Northern California winter steelhead account.

Taxonomic Relationships: The Central California Coast (CCC) steelhead DPS is a complex group of populations inhabiting a region that has been the recipient of hundreds of thousands of out-of-basin juvenile steelhead releases over decades. CCC steelhead have also been used as a source for numerous transfers into the neighboring South-Central Coast steelhead DPS (Bjorkstedt et al. 2005). Using microsatellite markers Garza et al. (2014) found that juvenile steelhead from CCC streams were distinct from those from other northern California DPSs, with a closer relationship to more southerly steelhead populations. Within the Russian River, samples of steelhead show two genetic patterns: mainstem river and headwaters. In the mainstem, steelhead below natural barriers are not different from each other or from fish found above recently constructed dams. However, six steelhead populations above natural barriers were significantly different genetically from other populations, suggesting long term isolation and limited genetic diversity (Deiner et al. 2007).

More recently, Garza and colleagues (Garza et al. 2014) studied microsatellite DNA in coastal California steelhead and found five distinct groups delineated by major geographic features along the shore. The five groups include: 1) Big Sur creeks to the mouth of San Francisco Bay, 2) San Francisco Bay tributaries to the Russian River, 3) Gualala River to Usal Creek, 4) Big Creek to Mad River (except Freshwater Creek), and 5) Freshwater Creek to the Oregon border. They also found that geographic distance among populations was directly related to genetic similarity, providing evidence that populations in smaller streams are reliant on migrants from nearby basins for persistence. Finally, more northerly populations had larger populations and more genetic diversity than southern populations (Garza et al. 2014).

Life History: CCC steelhead trout show a tremendous amount of juvenile and adult life history variation to match the varied systems they inhabit, though all adult runs occur during the winter. Shapovalov and Taft (1954) identified 32 different combinations in the amount of time steelhead spent in fresh and salt water, although most of the fish were of four types (freshwater years/saltwater years): 2/1 (30%), 2/2 (27%), 3/1 (11%), and 1/2 (8%). The remaining 28 life history combinations comprised less than 5% of the run. Shapovalov and Taft (1954) observed steelhead entering Waddell Creek as early as late October following the opening of the lagoon three to six weeks earlier. However, the majority of CCC steelhead enter rivers later in the season, typically between late December and February when flows are highest. CCC steelhead are mostly ocean-maturing ecotype fish, and enter rivers in reproductive condition (Hodge et al. 2014). Most spawning typically occurs during late spring (February to April) to which reduces the negative effects of winter scouring flows that are common to the small, short streams along

California's central coast. This late spawning strategy also permits CCC steelhead to spawn in upper portions of seasonally flowing watersheds, which are encountered in the southern portion of their range. On the Russian River, steelhead enter freshwater between November and February (Fry 1973). Shapovalov and Taft (1954) observed that 3+ year old fish (35%) and 4+ fish (46%) comprised the majority of spawners. The opposite seems to be true at the more northern end of the DPS range, where younger fish predominate. Typically in late-December through February, following moderate to large storms and subsequent lagoon breaching in small, flashy coastal streams (e.g., Mendocino coastal streams), female adult steelhead will often complete their spawning cycle rapidly and migrate back to sea in as little as two weeks if flow conditions allow. Male adult steelhead tend to have a much longer spawning cycle, as they attempt to maximize their spawning opportunities (J. Fuller, NMFS, pers. comm. 2016). Steelhead are iteroparous, but only 17% of Waddell Creek spawners spawned more than a single time (Shapovalov and Taft 1954).

Development of steelhead eggs is dependent upon water temperature. Shapovalov and Taft (1954) estimated hatch time to be 25-35 days, with emergence of fry after 2 to 3 weeks for alevin development. Hayes et al. (2008) found juvenile growth rates were influenced by variables including flow, temperature, young-of-year (YOY) coho salmon and YOY steelhead densities. Age 0+ steelhead move into deeper water as they grow. Juvenile steelhead and coho salmon often use similar habitats, mostly pools, to oversummer in coastal streams with abundant riparian vegetation, woody debris, and other instream shade and cover. As a result, they often get trapped together in pools as flows in riffles become subsurface in fall.

On Waddell Creek, Shapovalov and Taft (1954) observed a bimodal juvenile emigration pattern, with peaks in early January and mid-March, although they moved downstream during all seasons of the year. In general, older age classes of juveniles migrated earlier. For example, on Scott Creek, Hayes et al. (2011) found that larger smolts moved downstream from February to March and emigrated to the ocean, while smolts moving in April through June were smaller and tended to rear in the estuary. CCC steelhead smolts quickly adopt a saltwater tolerant physiology (Satterthwaite et al. 2012). Hayes (2008) described three life history pathways prior to ocean entry. Some juvenile steelhead emigrated to the estuary after spending only a few months in the upper watershed, while a second group spent one to two years rearing in the upper watershed before emigration. A third group reared for at least a year in the upper watershed, followed by downstream migration and immediate ocean entry without estuarine occupancy. These life history pathways are not discrete, however, and represent a continuum of opportunistic strategies based on a variety of factors including smolt density, prey abundance, temperature, and streamflow. Hayes and colleagues (2011) also recently described a fourth life history strategy, called "double-smolting," whereby summer recruits to estuaries migrated back upstream as water quality conditions declined in the estuary through the summer and fall months, adjusting their osmoregulation physiology as needed to allow them to rear in either fresh or brackish water.

Smoltification of juvenile steelhead seems to occur after a size threshold (100-110mm FL) has been reached, and is accompanied by physiological changes such as increased levels of Sodium-Potassium-ATPase processing enzymes in the bloodstream (Hayes et al. 2011). In Waddell Creek and the San Lorenzo River, steelhead typically reach age 1+ before they are large enough to undergo smoltification. In the Napa River, smolts are very large, and are capable of changing their average size at smolting over time to adapt to changing environmental conditions. From 2010-2016, median steelhead smolt length decreased noticeably from an average of 186mm to 170mm (J. Koehler, NRCD, pers. comm. 2016). Due to potentially restrictive summer habitat availability, age 1+ and 2+ steelhead juveniles are not as common in the CCC steelhead streams as in streams further north (Smith 2002). Limited growth during the summer was observed in age 1+ steelhead in the upper Scott Creek watershed, and most emigrated to exploit rapid growth opportunities in estuaries prior to reaching age 2 (150mm, Hayes et al. 2008).

Smith (2002) found favorable conditions for rapid growth in productive lagoons and estuaries at the mouths of streams with high summer flow, although these can be tempered by elevated mortality risks and density dependent growth variables (NMFS 2016). Estuaries along the Central California Coast are variable in size, but sandbar formation typically occurs in the early summer and they become seasonal freshwater lagoons during low flow conditions. These areas constitute relatively small portions of steelhead habitat, but seem to be a critical nursery area for juvenile steelhead in spring and summer months. In the Russian River estuary, which does not always close at its bar, steelhead preferred middle and upper portions of this habitat and were almost exclusively captured at confluences with tributaries (Cook 2005). More recent study (Fuller 2011) found more widespread usage of estuaries depending on season and water quality conditions such as temperature and dissolved oxygen content. In this habitat, juvenile steelhead increase in average size until mid-summer, then decrease in size, suggesting YOY continue to enter the estuary while larger smolts either emigrate or move upstream (Cook et al. 2005). In Scott Creek, Bond (2006) found juveniles emigrated into the estuary at all sizes, but larger smolts had a higher survival rate at sea based on mark-recapture studies. YOY juveniles remained in the estuary until it became a closed freshwater lagoon, and experienced high growth rates and a doubling of fork length (206mm mean FL). The growth rates of juveniles in the estuary varied among years and also appeared to be density-dependent (Hayes 2008). Residence times in the Russian River for a relatively small sample size of juvenile *O. mykiss* ranged from 4 to 121 days, which significant growth observed as residence time increased (Fuller 2011). In addition, upstream movements of acoustic tagged wild steelhead and captures of untagged estuary steelhead in fall suggest that long estuarine residency and accelerated growth resulted in half-pounder-like life history traits similar to those of more northern populations (Fuller 2011, see Northern California winter steelhead account). Bond (2006) found that juvenile steelhead in Scott Creek larger than 150mm FL, while comprising less than 50% of the juvenile population of the estuary, have a significant survival advantage in the ocean, and accounted for 85% of returning adults.

Tradeoffs, such as those between mortality and growth rates, likely drive life history variation in steelhead. Similar-sized juvenile steelhead engage in potentially-inherited bet-hedging behavior to avoid the high-risk (increased predation)-high-reward (faster growth) closed lagoon habitats in spring and summer months (Satterthwaite et al. 2012). Faster freshwater growth can increase marine survival, but larger size can decrease survival in fresh water. By measuring growth and survival in Central California Coast streams, Satterthwaite (2012) could predict the most frequent age of smoltification in steelhead (age 2+). Smaller fish reared in the lagoon temporarily before migrating back upstream to rear, whereas larger fish mostly went out to sea or stayed in the lagoon before eventually undertaking an ocean migration. Recent work (Boughton et al. 2017) discusses the important tradeoffs of growth opportunities with challenges (predation, poor water quality, etc.) in detail and frames the topic in terms of bioenergetics costs and rewards.

Habitat Requirements: CCC Steelhead require similar freshwater spawning and rearing sites as described in the Northern California winter steelhead account. Leidy (2007) found the abundance of CCC steelhead juveniles in the San Francisco Bay Area was positively correlated with elevation, stream gradient, and percent native species, but negatively correlated with average and maximum depth, wetted channel width, water temperature, open canopy cover, and the total number of fish species (Leidy 2007). This indicates that steelhead were mainly found in small, coldwater streams with few pools, which may be partially an artifact of the urbanization of the lower reaches of the streams. The most apparent limiting factor in streams supporting steelhead throughout the DPS is over-summering habitat for yearlings. These fish require deep water with overhead cover for protection from predators. In the Napa River watershed, steelhead were found to mostly use transitional gradient habitats from 1-6% slope in Redwood, Dry, Milliken, Sulphur, Napa, and York creeks, (J. Koehler, NRCD, pers. comm. 2016). Mainstem river habitats, such as the Napa River and Sonoma Creek, are capable of supporting spawning and rearing steelhead opportunistically, if flows are sufficient to provide cover from predators. Juvenile steelhead have been sampled in mainstem rivers near tributaries in the spring while feasting on Sacramento sucker (*Catostomus occidentalis*) eggs (J. Koehler, NRCD, pers. comm. 2016).

CCC steelhead require cool water, though these fish manage to grow and even thrive in warmer waters than their Northern counterparts. The optimal temperature range for juvenile steelhead growth is 15-18ºC (Moyle 2002). While cool water is typically found in headwaters and marine-influenced coastal regions of the DPS range, these steelhead will tolerate warmer temperatures if food is abundant. Smith and Li (1983) observed juvenile CCC steelhead moving into riffles when temperatures became stressful because of increased feeding success, despite higher energetic costs. Lagoon habitats, which become closed off from the ocean in spring and summer in most locations, provides heterogeneous thermal habitats, where steelhead can easily move between stratified cooler and warmer habitats. Inflows in these habitats must be sufficient to breach lagoon bars at least every few years to allow migration of adults and smolts. Generally, CCC steelhead juveniles are absent from waters that exceed 25-26°C for even short periods. For adult steelhead, lethal temperatures are 23-24°C (Moyle 2002).

Distribution: The CCC steelhead DPS includes all populations below natural and manmade barriers from the Russian River (Sonoma Co.) south to Aptos Creek (Santa Cruz Co.), although this delineation may change based on new genetic data (Garza et al. 2014, Figure 1). The most recent status review from the National Marine Fisheries Service (NMFS) identified watersheds that harbor essential populations (those that have physical or biological features essential to conservation of the species) that must be bolstered to stabilize for recovery, including (from North to South): Russian River, Salmon, Stemple, Walker, and Lagunitas creeks North of San Francisco Bay; Corte Madera, Novato, Sonoma, Suisun creeks, Petaluma and Napa rivers, Alameda, Coyote, and San Francisquito creeks, and Guadaulupe River within the boundaries of San Francisco Bay; and Pilarcitos, San Gregorio, Pescadero, Waddell, Scott, Soquel, and Aptos creeks, and San Lorenzo River, South of San Francisco Bay (NMFS 2016).

Figure 1: Map of Central California Coast steelhead with diversity strata boundaries.

Figure 1. Watershed regions supporting different populations (diversity strata) of Central California Coast steelhead From NMFS 2016, Fig. 1, pg. 12.

Despite new insights into their distribution, NMFS has not changed the DPS' geographic boundaries, pending further review of additional information (NMFS 2016). The CCC steelhead DPS remains centered on populations in the Russian River and San Francisco Bay (Spence et al. 2007). In the Interior Region, the upper Russian River mainstem reaches upstream of Big Sulphur Creek provide sufficient habitat and isolation to support an independent population, while tributaries such as Mark West, Dry, and Macamas Creeks historically had potentially independent steelhead populations. Lower Russian River tributaries with potentially viable populations such as Austin Creek and Green Valley Creek are included in the North Coastal Region, with tributaries around Tomales Bay. These populations were all historically dependent upon dispersal from Russian River and San Francisco Bay populations, although some contain sufficient habitat to be designated potentially independent populations (Spence et al. 2007).

Within the San Francisco Bay Coastal and Interior Region, independent populations are/were found in the Guadalupe and Napa rivers, as well as in far inland San Leandro, San Lorenzo, Coyote, and Alameda creeks. Populations of non-hybridized *O. mykiss* still reside in the upper reaches of streams that feed storage reservoirs, such as Upper San Leandro Reservoir upstream of Chabot Dam (EBMUD 2008) and are included in the DPS. Steelhead in drainages of San Francisco, San Pablo, and Suisun bays eastward to Chipps Island at the confluence of the Sacramento and San Joaquin Rivers are also part of this DPS. This region includes coastal temperate habitats dominated by redwood forests as well interior Mediterranean habitats covered by chaparral and oak woodlands. Numerous San Francisco Bay tributaries historically harbored small populations, but most currently lack sufficient habitat for self-sustaining populations. In general, the most important San Francisco Bay steelhead tributaries were Suisun Creek (Solano Co.), Napa River (Napa Co.), Sonoma Creek (Sonoma Co.), Corte Madera Creek (Marin Co.), San Francisquito Creek (San Mateo Co.), Guadalupe River and Coyote Creek (Santa Clara Co.), and Alameda Creek (Alameda Co.), and most continue to harbor populations of resident *O. mykiss* that can give rise to anadromous offspring (Leidy et al. 2007, M. Leicester, CDFW, pers. comm. 2016). Historically, fish in the headwaters of these systems could re-colonize downstream areas, but are now largely cut off by dams (e.g., Warm Springs-Russian River, Calaveras-Alameda Creek, and Guadalupe-Guadalupe River). One notable exception, coastal Scott Creek (Santa Cruz Co.) offers 23km of accessible, suitable stream habitat (Satterthwaite et al. 2012) and its fish populations have been studied for decades (Shapovalov and Taft 1954).

In the ocean, little is known about CCC steelhead habitat usage, as only a few CCC steelhead have been captured in trawl surveys along the California coast (Brodeur et al. 2004). It is hypothesized that California steelhead migrate to cool water offshore of the Klamath-Trinidad coastline before migrating to the North Pacific feeding grounds, similar to Northern California steelhead; they are generally encountered in trawl surveys much farther offshore, and in fewer numbers, than Chinook or coho salmon (Harding 2015).

Trends in Abundance: CCC steelhead abundance data is very limited due to the large number and diversity of watersheds across the DPS, but numbers appear to be less than 10% of historical estimates throughout the region. During the early 1960s, CDFW (CDFG 1965) estimated that about 94,000 steelhead spawned in this DPS, with most spawning occurring in the Russian (50,000) and San Lorenzo rivers (19,000). In 2006, NMFS estimated that only 14,100 annual spawners remain. Trend analysis is difficult because little empirical data is available. Most sampling efforts are conducted by municipal utilities per mitigation mandates for operating water storage reservoirs. Juvenile sampling, while highly variable annually and geographically, often represent the only data for abundance estimates throughout the DPS. Information on available habitat also provides insight into population status; most streams in the DPS are listed as impaired under the Clean Water Act. There is little sign of major habitat improvement, despite many local efforts, so CCC steelhead populations are still assumed to be declining.

The Russian River probably once supported the third largest steelhead run in California, and was historically the most important for CCC steelhead. Steelhead abundance in the Russian River has declined from an estimated 50,000 in the 1960s to less than 7,000 in the 1990s (Busby et al. 1996; Good et al. 2005), and is likely lower now. To mitigate for lost habitat above Lake Sonoma, the U.S. Army Corps of Engineers uses Warm Springs Fish Hatchery (Sonoma Co.) to release about 50,000 smolts per year; these hatchery fish account for nearly 95% of returning adults each year (NFMS 2016). CDFW also operates Coyote Valley Hatchery at Lake

Mendocino (Mendocino Co.), which releases approximately 200,000 yearling steelhead into the East Branch of the Russian River each year to meet a compensation goal of 4,000 returning adults. However, this goal has only been attained once since operations began in 1992 (CDFW 2016). The private Bill Townsend Conservation Hatchery raises fish from approximately 30,000 fertilized eggs from the Coyote Valley facility for release every year (CDFW 2016). Their effectiveness in boosting steelhead abundance in the Russian River is unclear (Figure 2).

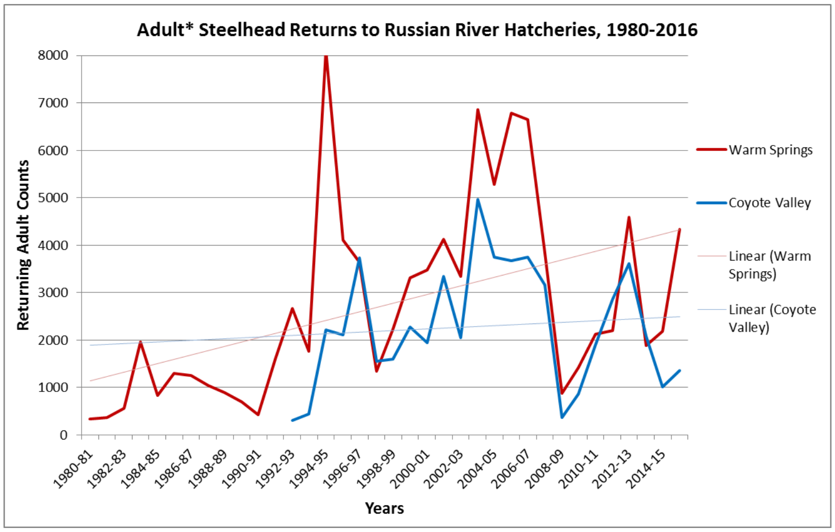

Figure 2. Adult steelhead returns to Warm Springs and Coyote Valley Hatcheries. From R. Watanabe, CDFW 2016. *Half-pounders are not included on this graphic.

Historically, tributaries in Sonoma and Marin Counties were estimated to contain a combined 12,000 adults annually. The annual run in Lagunitas Creek was about 500 fish during the 1990s (McEwan and Jackson 1996), and has remained so (Figure 3).

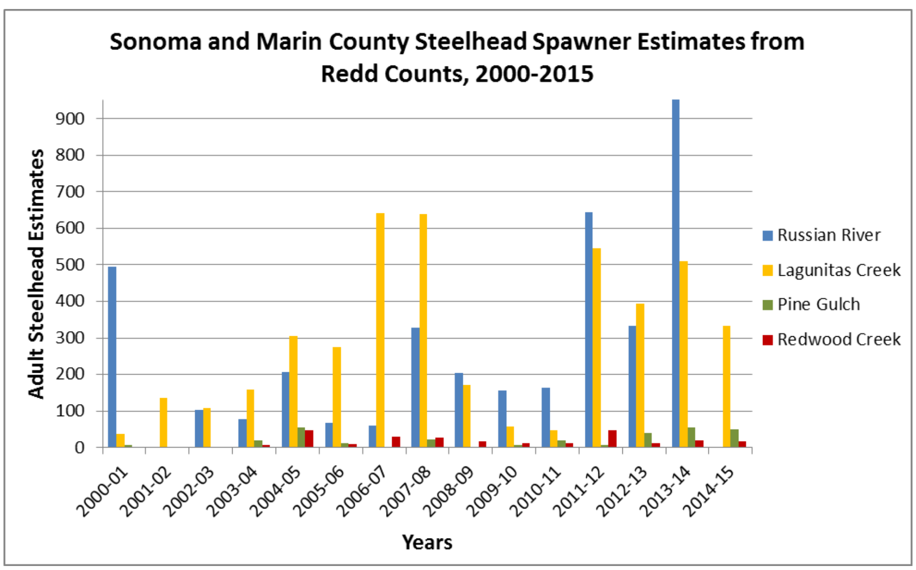

Figure 3. Numbers of spawning adult steelhead in Sonoma and Marin County streams, as estimated from redd surveys. Redd surveys conducted by CDFW; data compiled by The Nature Conservancy and NMFS. Data from D. Logan, NMFS 2016.

Redd counts provide one indicator of adult steelhead abundance in the Lagunitas watershed (Figure 4). Reintroduction of coho salmon (*Oncorhynchus kisutch*) and restoration efforts in the nearby Walker Creek basin since 2003 have increased monitoring and effort in the region to restore populations; over 1,700 steelhead juveniles and several dozen adult redds were observed in mainstem Walker Creek in 2013 (Garcia and Associates 2013).

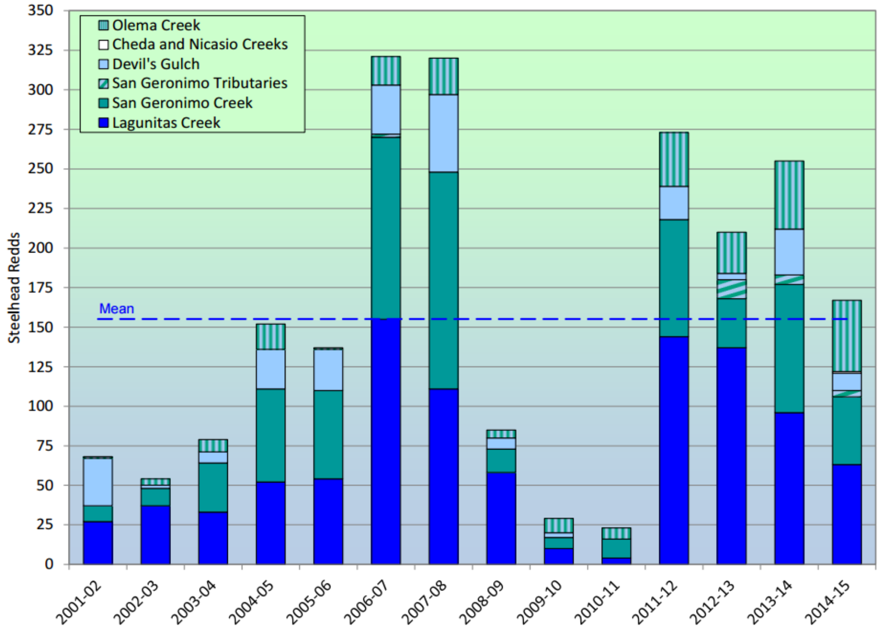

Figure 4. Steelhead redds, Lagunitas Creek watershed 2001-15. MMWD 2015, Fig. 3, pg. 17.

For San Francisco Bay tributaries, information on steelhead numbers is largely lacking, and these small, isolated populations are at a high risk of extinction due to the prevalence of impassable dams and barriers, reduced flows, and degraded water quality from runoff and pollution (NMFS 2016). Most existing information comes from opportunistic sampling or observations. For example, a public sighting of two adult steelhead was confirmed below an impassable public transportation weir in Alameda Creek, the first confirmed sighting in that watershed since 2008 (*East Bay Express* 2016). CDFW has not documented spawning or rearing of steelhead in southern San Francisco Bay tributaries since the drought began in 2012 (M. Leicester, CDFW, pers. comm. 2016). In the northern portion of the bay, the Napa Resource Conservation District has used rotary screw trap data to estimate that between 100 and 1000 juvenile steelhead exit the Napa River watershed each year (J. Koehler, NRCD, pers. comm. 2016). However, 2014 smolt totals trapped per day dropped significantly, possibly due to the ongoing drought and reduced trapping efficiency at lower flows (Figure 5).

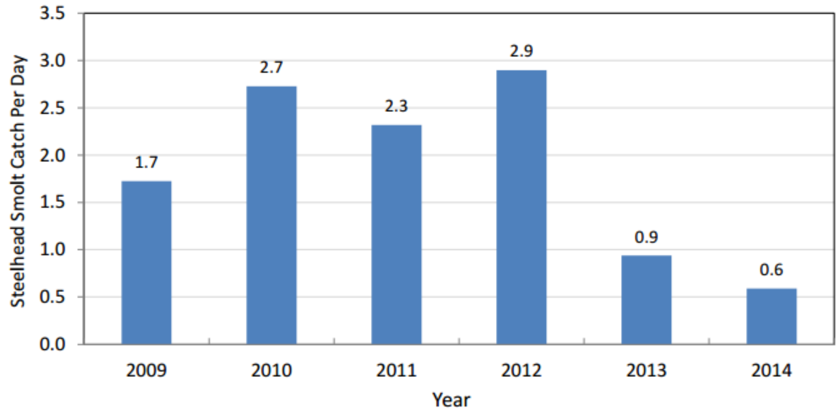

Figure 2. Steelhead smolt catch-per-unit-effort (CPUE) in the Napa River RST from 2009-2014.

Figure 5. Rotary screw trap catch per unit effort of steelhead smolts in the Napa River, 2009-2014. From: NRCD 2016 Figure 2, pg. 4.

In San Mateo County, Pescadero Lagoon provides important wetland habitat for juvenile steelhead, including larger smolts that contribute disproportionately to the number of returning adult spawners. However, since 1995 this habitat has become the site of nearly annual fish kills when the lagoon breaches in late fall or early winter each year (CDFW 2014). With historic drought in California from 2012-2016, the lagoon has either not breached at all or breached for such a short time that passage of adult and juvenile steelhead to the ocean was not possible. In 2013, state, federal, and public partners gathered to rescue 54 adult steelhead trapped in the closed lagoon, and transported them over the sandbar into the ocean (NMFS 2013). In 2014, biologists estimated that all of the 170 mostly two-year-old steelhead smolts in the lagoon perished that summer (CDFW 2014). These conditions were similar to those observed in nearby San Gregorio and San Lorenzo (Santa Cruz Co.) lagoons. Drought may compound poor water quality conditions by trapping juveniles and post-spawn adults in lagoon habitats throughout the region. In 2015, biologists counted dozens of dead juvenile steelhead smolts in anoxic water in Pescadero Lagoon, prompting calls for further restoration study (*San Jose Mercury News* 2016).

CCC steelhead have also steadily declined in abundance south of the mouth of San Francisco Bay. YOY sampling on Gazos Creek in Half Moon Bay has revealed a downward trend since 2000 (Smith 2016). Waddell Creek, a potentially independent population in Santa Cruz County, averaged about 500 adults between 1933 and 1942 (Shapovalov and Taft 1954). In the San Lorenzo River in downtown Santa Cruz, creel surveys in 1953-54 ranged from 1,895-5,645 steelhead caught by anglers to between 1,035-1,816 captured between 1970 and 1973 (Johansen 1975). The most recent estimates for Waddell Creek are less than 100 adults per year, with recorded YOY densities less than 50% of 1995-1998 averages (93 YOY/30m) every year since 1999 (Smith 2016). In the San Lorenzo River, the recent average hovers around 500. San Vincente, Scott, Soquel, and Aptos Creeks all average below 200 fish annually, but sampling efforts are few and far between. Only Scott Creek currently has a full life cycle monitoring station in place to collect data on steelhead and coho salmon. Juvenile sampling of YOY juveniles since 2002 (Smith 2016) and recent adult returns (TNC and NMFS 2016) show a continuing downward trend, which is due in part to the ongoing drought (Smith 2016, Figure 6).

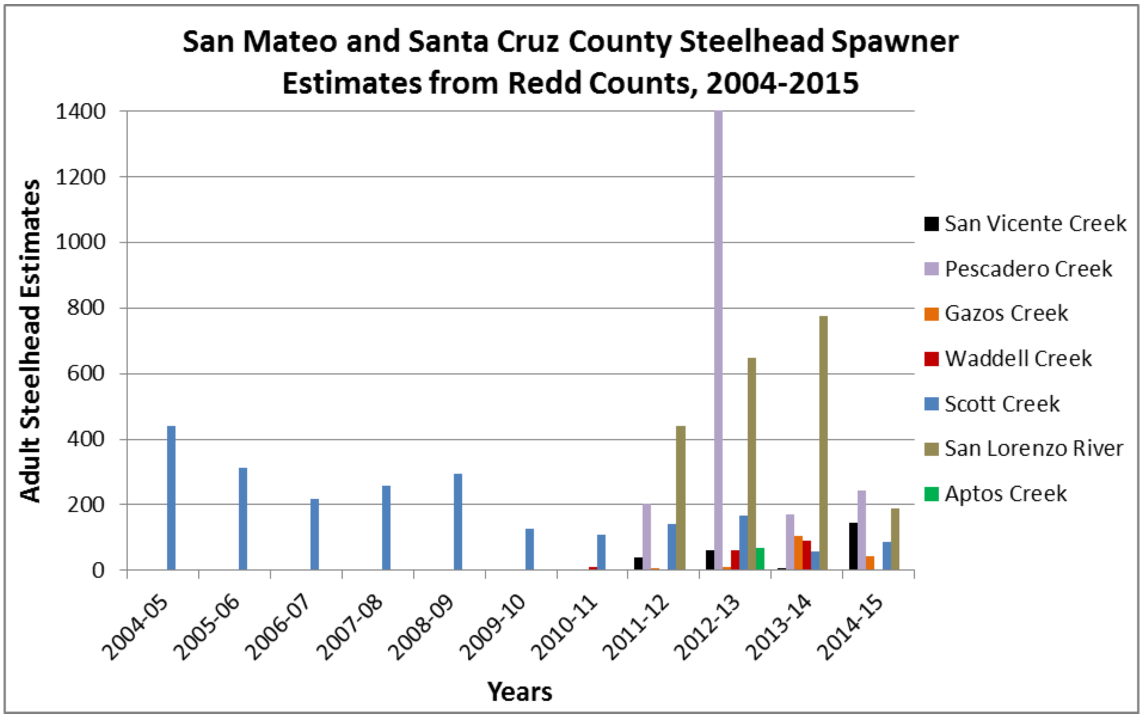

Figure 6. Steelhead spawner estimates based on redd surveys conducted by CDFW; data compiled by The Nature Conservancy and NMFS. From: D. Logan, NMFS 2016.

From 1999 to 2013, students on the Monterey Bay Salmon and Trout Project (Santa Cruz Co.) at Kingfisher Flat Hatchery on a tributary to Scott Creek released 33,840 steelhead smolts to supplement low populations. This program has been shuttered since 2013/2014 (NMFS 2016).

Factors Affecting Status: Small populations of steelhead still occur in watersheds throughout the DPS range, but they are limited by dams and other barriers, degradation of existing habitat through land use practices, hatcheries, and other factors. The cumulative and synergistic effects of these threats make it difficult for CCC steelhead populations to contend with ongoing drought and fluctuating ocean conditions, and limit their ability to recover in the face of climate change.

Dams. Across the CCC steelhead DPS, dams have significantly reduced the amount of accessible habitat for juveniles and adults and reduced streamflows. For the DPS as a whole, 22% of historical habitat is estimated to be blocked by human-made barriers (Good et al. 2005). In the Russian River, Coyote and Warm Spring dams both block historical spawning and rearing habitat. Dry Creek has lost 56% of its habitat, Mark West Creek (7%), and the upper Russian River (21%) (Spence et al. 2007). In the San Francisco Estuary, approximately 58% of historically occupied streams no longer support anadromy, although presumably related resident populations do exist in many headwaters (Leidy et al. 2005). Watersheds around San Francisco Bay that have lost habitat include: Novato Creek (22%), Napa River (17%), Walnut Creek (96%), San Pablo Creek (72%), San Leandro Creek (80%), San Lorenzo Creek (48%), Alameda Creek (95%), Coyote Creek (49%), Guadalupe River (21%), Stevens Creek (54%), San Francisquito Creek (33%), and San Mateo Creek (83%). In Tomales Bay, accessibility is also a problem in Lagunitas Creek (49%) and Walker Creek (26%).

Steelhead tend to rear and spawn in smaller headwater tributaries in upper portions of watersheds, and so regaining access to this habitat is critical for recovery of the DPS (Bjorkstedt et al. 2005). None of these dams allow passage, and what water is allowed to flow through them is often reduced in quantity and quality from what it would be without dams in place (NMFS 2016). Whether for flood control, water storage, or hydropower generation, dams trap sediment and lead to loss of instream/riparian habitat for steelhead (NMFS 2016). Dams also dramatically change the hydrograph of the streams on which they occur, with larger dams especially removing peak flows that bring steelhead in from the ocean to spawn and help propel juveniles downstream in spring. Related diversions typically reduce summer flows, reducing habitat and increasing water temperatures, and make it more difficult for steelhead to survive through the warmer summer months.

Dams also play a major role in sustaining remaining downstream habitat for steelhead. For example, in the Russian River, releases from the Eel River and Mendocino Reservoir for downstream urban and agricultural diversion may actually increase summer flows in places. While dam operations perpetuate extinction risk in many CCC steelhead populations by restricting access to habitats, they may also regulate flow and water temperature in summer and fall months and offer suitable rearing habitat immediately downstream (M. Leicester, CDFW, pers. comm. 2016, NMFS 2016). The Russian River is the first National Oceanic and Atmospheric Administration (NOAA) Habitat Focus Area to coordinate restoration efforts among federal, state, and private entities for the benefit of all salmonids, and incorporates adaptive management to allow flushing flows to benefit ESA-listed coho and Chinook salmon as well as steelhead (NMFS 2016). Downstream of the San Francisco Bay rim dams, tributaries such as Alameda, Coyote, and San Francisquito creeks have some flow directly downstream of dams, dry middle reaches in urban areas, and accreted flow in lower sections. These disturbed watersheds offer very small windows of opportunity to allow adult passage, but little opportunity for rearing or getting smolts back into ocean through dry-back zones. Even with adjusted dam operations to allow strategic adult attraction flows in the fall and pulse flow releases to benefit juvenile outmigration in the spring, recovery of CCC steelhead in San Francisco Bay tributaries is daunting with so many dams in place (M. Leicester, CDFW, pers. comm. 2016).

Urbanization. Degradation of habitat in most watersheds is a significant threat to CCC steelhead through urbanization, expansion of vineyards and other agriculture, road building, logging, mining, sewage discharge, and other actions. For instance, numerous tributaries and the mainstem Russian River are currently listed as impaired water bodies under the Clean Water Act due to high levels of sedimentation, aggravated water temperatures, presence of pathogens, and poor water quality. Urban development throughout the DPS, especially in San Francisco Bay tributaries, intrudes on floodplains and destroys riparian habitat, especially on estuarine wetlands and riparian corridors, which contribute to reductions in water quantity and quality. Without societal efforts to reduce water usage in urban and agricultural areas, critical over-summering habitats will not be available for juvenile steelhead. This will reduce the life history diversity expressed by juveniles in the CCC steelhead DPS and increase their susceptibility to climate change. In the San Francisco Bay area, CWA-listed impaired watersheds include the Guadalupe River, San Francisquito, Stevens, and Sonoma creeks as well as the Petaluma and Napa Rivers.

Logging. Historical and ongoing timber harvest in Santa Cruz County watersheds continue to have legacy impacts on steelhead habitat such as sedimentation as a result of the associated roadbuilding that occurred in mountainous areas (NMFS 2016). Logging practices have led to the CWA listing of San Mateo County coastal steelhead creeks (Pomponio, Pilarcito, and Pescadero) for poor water quality. Legacy impacts of logging include removal of old-growth trees, which provide important cover for adult and juvenile salmonids. Large wood in streams provide important habitat features for steelhead, yet throughout the CCC steelhead DPS, logjams continue to be removed due to concerns over flooding and recreational hazards. Because significant portions of the CCC steelhead DPS are heavily developed and riparian areas are being lost, woody debris removals are reducing cover and pool formation, and increasing conditions unfavorable to juvenile steelhead.

Estuarine alteration. CCC steelhead are unusually dependent on the estuaries (lagoons) at the mouths of their streams for growth and survival at all life stages. These habitats are shrinking as they fill with sediment from upstream land uses and are encroached upon by urbanization and agriculture. For example, over 90% of critical wetland and estuarine habitat in the San Francisco Bay region has been drained and/or filled (NMFS 2016). This results not only in less habitat, but shallower, less complex (increased vulnerability to predators), and warmer habitat that is increasingly vulnerable to pollution events and drought. In addition, the natural summer sand barriers are frequently artificially breached, resulting in sudden draining of lagoons and large-scale reduction in habitat quantity and quality (Moyle and Smith 1995). For example, CDFW has been studying the impacts of low freshwater inflows, agricultural pollutant inputs, and reduced dissolved oxygen on the fish communities in Pescadero Lagoon for years (CDFW 2014). Agency investigators found that the duration of lagoon bar closure and marsh inundation, as well as reductions in freshwater inflows to the lagoon all play a role in contributing to the extent and duration of anoxic conditions at breaching, which have led to fish kills in most years since 1995 (CDFW 2014). These stressors have likely been exacerbated by the ongoing drought in California, which reduces inflows and leads to earlier bar closure than under average water years, trapping adults and juveniles alike. Highways impacts many estuaries in the CCC steelhead DPS through direct pollution, channelization via bridge and roadway construction, erosion, and sedimentation.

Agriculture. While mostly urbanized, CCC steelhead DPS watersheds have been heavily impacted by agricultural water diversions, especially in the northern portion of the range (Sonoma, Marin, Napa, and Solano counties). Cattle ranches, dairies, vineyards, orchards, and other agricultural users have placed high demands on limited water supplies through diversions and groundwater pumping, which have led to habitat reduction, degradation, and fragmentation, and non-point pollution. Return flows from agricultural uses to streams are often warmer and contain organic compounds that reduce the suitability of habitat for salmonid survival. Irrigated agriculture, ranches, dairies, municipalities, and other water users throughout the Napa and Sonoma Valleys have ditched, channelized, diverted and pumped water over time to support the burgeoning population and wine industry (M. Leicester, CDFW, pers. comm. 2016). South Bay municipalities draw out groundwater to support agricultural and other human uses in Santa Clara and Alameda counties, which reduces the supply of cool, subsurface flow into small, critical steelhead rearing streams such as tributaries to Coyote Creek and the Guadalupe River.

Hatcheries. There are currently two large artificial propagation programs for CCC steelhead: the Warm Springs Hatchery (Dry Creek, Russian River) and upstream Coyote Valley Hatchery (East Branch Russian River) (CDFW 2016). While the stated goals of the Warm Springs and Coyote Valley hatcheries are to contribute to future abundance and spatial structure in the CCC steelhead population. Due to the low number of wild spawners remaining in the limited available natural habitat left below dams, it is more likely that domestication selection is reducing genetic diversity and effective population size in the Russian River watershed with potentially negative effects on the remaining wild populations as well, through interbreeding with ‘stray’ hatchery fish. The influence of past frequent plants of hatchery steelhead from out-of basin is not well understood but is probably minimal. Currently, NMFS is undertaking a Hatchery Genetic Management Plan review for both active programs to try to understand and reduce these impacts on the genetic integrity of fish in the wild (NMFS 2016).

In addition, the Kingfisher Flat Hatchery, located on Scott Creek, operated during 1982-2014. This facility, which was run by a the Monterey Bay Salmon and Trout Project, collected wild coho salmon and steelhead from Scott Creek and the San Lorenzo River for spawning and rearing. It was closed down in 2014. It effects, positive or negative, on the steelhead population are not known.

Harvest. As a DPS with Threatened status under the Endangered Species Act, CCC steelhead must be kept in the water and released unharmed if accidentally caught. Therefore, harvest is low, and fishing closures on small coastal watersheds and San Francisco Bay tributaries such as Sonoma Creek helped to reduce stress on wild fish during the exceptionally dry years of 2014-2015. On the Russian River, where hatcheries support what has become a popular but essentially put-and-take fishery, anglers can harvest two hatchery-origin steelhead per day that have had their adipose fins clipped. Some inadvertent mortality on wild fish while legally fishing is likely, although poorly understood in the Russian River. Commercial fisheries rarely catch steelhead at sea (Harding 2015).

Predation. Since the CCC DPS has such low abundance, natural rates of predation may significantly impact small, fragmented populations, making recovery more difficult. For example, NMFS researchers estimated that higher numbers of sea lions at the mouth of the Russian and San Lorenzo rivers likely cause significant predation on CCC steelhead, and that western gulls or even raccoons may have higher rates of predation on juvenile steelhead in recent low water years than is typical (NMFS 2016). Degraded habitats resulting from myriad anthropogenic stressors can favor alien species over natives, which can increase predation pressures on juvenile steelhead from species such as basses (*Micropterus* and *Morone* spp.), especially in lower reaches of watersheds (Leidy 2007).

Status Score = 2.0 out of 5.0. High Concern. Most CCC steelhead populations are very low in abundance (e.g., San Francisco Bay tributaries) and far below recovery thresholds, though there is not enough information to determine if their extinction risk has changed since the last NMFS status update in 2011 (NMFS 2016). Throughout most of the DPS range, populations are now small enough to be susceptible to stochastic events, and are at risk of permanent shifts in population dynamics and genetics (NMFS 2016). Every indication is that downward trends in all populations will be accelerated by climate change. CCC steelhead were listed as a threatened species on August 18, 1997; their status was reaffirmed for fish downstream of impassable barriers in 2006 (71 *Federal Register* 834, Jan. 5, 2006, NMFS 2006). They have no special status in California except as a sport fish with limited take for hatchery-marked fish. The NMFS draft recovery plan states that CCC steelhead have a low potential for recovery due to the demands of transportation, land use practices, and urbanization, which are not likely to be reduced in the heavily-populated DPS range. The plasticity of life history strategies observed in CCC steelhead will likely guarantee their persistence in the far reaches of larger watersheds they inhabit, but it is likely extirpation of steelhead from most currently occupied watersheds will occur over the next 25-50 years unless large-scale restoration actions are coordinated and implemented.

Factor	Rating	Explanation
Major dams	High	Major dams on the Russian River and many other small dams and diversions present throughout DPS.
Agriculture	Medium	Diversions for agriculture likely limit population sizes, especially at the margins of the DPS boundaries.
Grazing	Low	Some impacts in rural portions of CCC steelhead range.
Rural residential	Low	Diversions for rural residential use likely impact rearing and oversummering habitat for juveniles.
Urbanization	High	The CCC DPS range is heavily urbanized and increasing demands for limited water degrade its quantity and quality.
Instream mining	Low	Gravel mining still occurs regularly on the Russian River.
Mining	Low	Heavy metal contaminants from historical mining reduce the suitability of estuaries and lagoons for juvenile rearing.
Transportation	Medium	Nearly every watershed in the DPS is crossed by major roads and highways, often several times.
Logging	Low	Mostly legacy impacts of timber removal that leave streams devoid of valuable large wood cover.
Fire	Low	Not a major threat to coastal streams or Bay tributaries.
Estuary alteration	High	Every estuary and lagoon in the DPS has been significantly altered by urbanization and roadbuilding.
Recreation	Low	Recreation may negatively impact behavior of low numbers of steelhead but are unknown.
Harvest	Low	Harvest of wild CCC steelhead is prohibited.
Hatcheries	Medium	Effects of hatchery steelhead on wild populations is not known but probably negative.
Alien species	Low	Predation by alien species may be significant in San Francisco Bay and the lower Russian River watershed, especially during periods of drought.

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of California Central Coast steelhead. Factors were rated on an 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.

Effects of Climate Change: The impacts of a changing climate will exacerbate the decline of CCC steelhead primarily through reductions in the temporal and spatial availability and accessibility of usable habitat. Moyle et al. (2013) rated this fish as "highly vulnerable" to the effects of climate change, likely leading to extinction by 2100 if present trends continue and their range or populations decline. The reasons for this evaluation are multiple and complex.

Climate change is expected to increase demands for existing water supplies in California, as well as increase remaining water temperatures beyond lethal limits, especially during summer and fall months. As temperatures rise and precipitation patterns shift, steelhead will be exposed to greater periods of higher water temperatures and more flow variability, eventually outpacing their remarkable ability to alter the timing of life strategy transitions to avoid such exposure (Wade et al. 2013). In general, climate modeling suggests that regions in lower latitude and with lower elevation will be subject to the greatest increase in duration and intensity of high air and water temperatures (Wade et al. 2013). The CCC steelhead occur at very low elevations, near the southern edge of steelhead range; there are not many potential headwater habitats at higher elevations accessible to CCC steelhead to reduce their exposure to higher temperatures without removal of dams. Fortunately, most watersheds are coastal or tributary to San Francisco Bay, which may help moderate fluctuations in air and water temperature more than inland watersheds. Providing access to a variety of habitats to allow expression of all life history strategies remains the best approach for building resiliency to climate change in populations (Wade et al. 2013).

In saltwater, where steelhead spend a majority of their lives feeding and growing, climate change is likely to increase sea surface temperatures and ocean acidity, contribute to loss of habitat through sea level rise, change the timing and strength of upwelling currents that provide prey, and generally lower marine productivity and salmonid survival off of California's coast (NMFS 2016). The poor ocean productivity observed over the last few years off California's coast associated with El Nino events probably reduced survival of freshwater, estuary, and marine life stages across the DPS by reducing foraging success, and similar impacts are expected if sea surface temperatures rise off California (NMFS 2016). Changes in ocean productivity generally manifest themselves in low numbers of returning adult steelhead in a few years when mostly age-3 and 4 fish return to freshwater to spawn.

Where land and sea meet, a changing climate will likely reduce freshwater inflow to estuaries, which are critical nursery areas for CCC steelhead, altering nutrient cycling and sediment transport (NMFS 2016). Climate change is also likely to cause more frequent and more intense drought, and a reduction in usable estuary habitat due to sea level rise. With low flows, remaining water in estuaries becomes too warm and oxygen-poor to support juvenile steelhead growth and survival, and gives rise to algae blooms that further deplete oxygen at night. Monitoring coastal lagoons for juvenile survival and conducting adult fish rescues when they are stranded in low water years must be continued and expanded to support small and stressed populations of CCC steelhead. Recent restoration projects in San Francisco Bay, coastal lagoons in Pescadero Creek and San Lorenzo River watersheds are improving habitat conditions, but drought impacts continue to threaten these populations with extirpation (CDFW 2014).

California's historic, extreme drought (2012-2016) has highlighted poor water management across the region. In addition to providing some of the lowest precipitation on record for California, the ongoing drought has also been coupled with several of the hottest years ever recorded. The result of these combined forces has revealed that water storage systems along California's Central Coast are inadequate. As drought has continued, reservoir storage has become depleted and caused release of highly turbid, warm water downstream, which has degraded spawning and rearing habitat (NMFS 2016). As a direct result of drought, groundwater withdrawals throughout the DPS range have impaired the volume, timing, extent, and temperature of surface flows in streams, and San Francisco Bay tributaries have been lowered and even run dry due to over-drafting of aquifers (NMFS 2016). The high rates of groundwater pumping that have occurred to make up the deficit of surface water deliveries have starved watersheds of critical cooling hyporheic flows in the summer and fall months. In addition, coastal lagoon habitats have been cut off from the ocean much sooner than in average water years, subjecting juveniles and trapped post-spawn adults to lethal water quality in many areas

(CDFW 2014). Illegal water diversions for marijuana cultivation have been especially stressful to salmonid populations over the current drought, as the plants require large volumes of water to grow during the warmest months. These impacts are likely to continue until surface waters are managed differently and groundwater pumping is regulated and allows aquifers to recharge over time (NMFS 2016).

Metric	Score	Justification
Area occupied	2	Multiple watersheds occupied in California but very few viable populations still exist.
Estimated adult abundance	2	The Russian River contains > 1,000 spawners annually, with smaller contributions from other populations, but numbers are declining and supported by hatcheries.
Intervention dependence	2	Habitat restoration and barrier removal are critical to increasing habitat availability.
Tolerance	4	Able to adapt to live in freshwater and estuarine environments.
Genetic risk	3	Widespread but populations increasingly fragmented and isolated, with potential for interbreeding with hatchery fish.
Climate change	1	Extremely vulnerable due to limited access to habitat and cumulative effects of other factors (e.g. urbanization) dams, etc.).
Anthropogenic threats	1	3 High, 3 Medium factors.
Average	2.0	14/7.
Certainty (1-4)	3	Hard numbers are few but status is fairly certain.

Table 2. Metrics for determining the status of 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.

Management Recommendations: The CCC steelhead DPS continues on a downward trajectory as the result of being centered in a highly urbanized landscape, with many competing land uses and pressures on limited water resources. Impacts from dams, agriculture, urbanization, logging, hatcheries, and other factors pressure small, fragmented populations in different ways across the large and diverse DPS range. In general, most central coast watersheds are neglected and not prioritized for monitoring or restoration funding unless they also contain coho salmon (e.g., Lagunitas and Scott creeks) (M. Leicester, CDFW, pers. comm. 2016). In the face of cumulative impacts from increasing anthropogenic stressors, including climate change, providing connectivity among diverse, high-quality habitats from headwaters to sea will be critical to the persistence of the CCC steelhead DPS.

Both local and widespread habitat improvements and land use changes are needed across all scales, such as additions of large wood into streams, maintenance of adequate riparian buffers, and limitations on sediment and other pollutants flowing into streams to cumulatively benefit recovery of CCC steelhead. Restoration guidelines have been developed by NMFS and other management partners for bank stabilization, road maintenance, and instream gravel mining projects to help minimize impacts of land use in this heavily urbanized DPS range. To enhance summer and overwintering survival of CCC steelhead, improvement in stream habitat complexity, as well as recruitment and retention of large wood, is important across the DPS. The

California Forest Practices Rules are currently inadequate for protection of riparian habitat, which shades streams, limits sedimentation, and provides large wood into streams. Actions that enhance riparian and upslope habitats will increase food supplies for juvenile steelhead, decrease siltation into the stream, and reduce solar exposure of streams, especially during warmer months.

In addition, headwaters must be protected and connected to downstream areas subject to summertime dry-back, and managed in a coordinated way to maximize benefits of conservation and restoration activities that increase resiliency to climate change (Wade et al. 2013). Regulating releases from existing dams to mimic natural flow regimes must be instituted where possible to benefit all life stages of salmonids. At a broad scale, public education and engagement should be prioritized so citizens are made aware of the plight and distribution of CCC steelhead near where they live and work. For example, along Adobe Creek, tributary to the Petaluma River, a local school works with CDFW to incorporate an egg rearing and juvenile stocking program into their curriculum. Where practicable, these programs have the potential to help connect citizens better understand their impacts on fish species and help protect them.

Across all populations in the DPS, more monitoring will be essential to understanding baseline population dynamics and how recovery actions can be implemented to support CCC steelhead. Stalling implementation of CDFW's statewide coastal salmonid monitoring program prevents collection and use of comprehensive abundance and trend information for management. Reliable assessments of steelhead-bearing streams and estuaries are severely lacking throughout the DPS currently, and hinder recovery efforts. Toward that end, CDFW should continue to integrate data collection with partners to streamline statewide data collection and management, obtain reliable information on core and peripheral populations, and help managers understand how and when specific habitats are used that allow expression of diverse life histories. This information could inform creation of an adaptive Fisheries Management and Evaluation Plan (FMEP) that prioritizes and defines criteria for taking specific actions to benefit recovery of the DPS. For example, at the northern edge of their range in the Tomales Bay Watershed (Walker, Lagunitas, Olema creeks), there is documented steelhead usage of main-stream habitat, but they probably use smaller tributaries opportunistically in wet years. Likewise, interior bay watersheds such as Suisun, Corte Madera, and Novato creeks are not monitored at all currently. These peripheral habitats require protection because they can play important role in providing habitat in the future (R. Watanabe, CDFW, pers. comm. 2016). Basic stream gaging, and stream connectivity studies should be undertaken to help understand the habitats available to these populations. Until more basic monitoring is carried through, several important questions with management implications, such as abundance trends in priority watersheds, how and when steelhead use San Francisco Bay habitats, where, when, and why do steelhead and coho salmon co-occur in the DPS, how hatchery operations and stocking practices impacting wild steelhead, and which barriers to migration should be removed, will be left unanswered (NMFS 2016).

CDFW, National Parks Service, NMFS, other management agencies, and private citizens have identified specific actions that will benefit CCC steelhead but need to be coordinated and implemented. The reality in Central California is that ESA-Endangered coho salmon are the number one priority for funding and projects, but there is potential to get piggyback benefits for steelhead through coho restoration projects. Wherever possible, monitoring and restoration that benefits all native salmonids, and not only coho, should be prioritized. For starters, management partners can work together to ensure that there is enough water left in streams during critical oversummering periods: there are several tools available to accomplish this. First, AB 2121 minimum flow requirements can protect flows for salmonids downstream of dams. Second, Fish and Game Code 1537, which mandates that dam operators keep fish in good condition downstream, is being wielded currently in court on water operations on the Guadalupe River in San Jose, and shows promise for setting precedent for flow restoration on other San Francisco Bay rim dams. Third, the recent Sustainable Groundwater Management Act (SGMA), which requires creation of groundwater management plans that account for and ensure recharge of aquifers, should also be aggressively implemented. Currently, several CDFW-funded projects statewide are focused on promoting voluntary options storage on private property, switching from direct diversion in summer/fall months to using storage tanks to collect water during wet seasons. NMFS and CDFW developed the Voluntary Drought Initiative Program (VDI) to help incentivize water conservation, fish rescue, and flow augmentation in Green Valley Creek, Dutch Bill Creek, Mill Creek, Mark West Creek, and Porter Creek over 1,900 acres of vineyards in the Russian River Valley, reducing water demand by 25% over 2013 levels (NMFS 2016). The 2014 Russian River Frost Protection Regulation controls harmful stream stage changes during low-flow fall periods for frost control over 3 years, and will likely improve fry survival across watersheds in Napa and Sonoma Counties. Other projects focus on providing subsistence flows in streams, and while they are mostly voluntary, they have seen some success and should be replicated wherever possible. Recovery of the CCC steelhead DPS depends upon such partnerships between agencies, municipalities, and private landowners to coordinate conservation activities.

Restoration of headwaters, active channels and floodplains, and estuaries/lagoons that encourage life history diversity yield resiliency to threats such as climate change can be supported in populations by providing habitat complexity (NMFS 2016). Replacement of the Highway 1 bridges over Scott and Waddell creeks offers the potential to restore residual lagoon depth, which can enhance rearing habitat and increase juvenile survival (Smith 2016). Illegal lagoon breaching, which has occurred on several CCC watersheds since 2008, should be fiercely prosecuted. Barrier removal projects that benefit native species should also be expedited where possible. The town of Saint Helena is slated to remove a long-standing earthen dam that has blocked passage for many adult steelhead each year from valuable spawning and juvenile rearing habitat. The U.S. Forest Service's Forest Practice Rules need to be updated to reduce impacts of decommissioned and active logging roads to reduce sedimentation and siltation and help contribute large wood to streams to benefit all salmonid life stages. In addition to re-introducing wood to watersheds, snags and logjams must be monitored so they do not turn into passage barriers themselves, as has happened on Gazos and Scott creeks recently (Smith 2016).

Next, CDFW can implement the new Hatchery and Genetics Management Plan for the Warm Springs/Coyote Valley hatcheries using the best available science. The most recent findings suggest that the current DPS boundaries are not sufficient for conservation or management of coastal steelhead in California; they should be updated to account for gene flow, population dynamics, and opportunities for future adaptation and persistence (Garza et al. 2014). In addition to minimizing the impacts of hatchery fish on the genetic integrity of wild steelhead within the DPS, NMFS and CDFW can enforce low-flow fishing closures and regulation changes throughout the DPS to minimize fishing impacts during times when juveniles and adults are highly susceptible. Last, all management partners can work with law enforcement to implement provisions in Proposition 64 to minimize impacts of marijuana cultivation on fish.

Finally, the heavily altered San Francisco Bay lies at the heart of the DPS and remains integral to efforts to meaningful recovery. Restoration of Bay salt ponds and tidal marshes has increased recently, with massive projects such as the South Bay Salt Pond Restoration Project currently underway in Alviso, Ravenswood, and Eden Landing, and myriad projects to benefit wildlife, such as migratory birds, surrounding San Pablo Bay. In the South Bay, biologists have been tagging and tracking juvenile steelhead in the Guadalupe River watershed since 2013 to assess former salt pond habitat functionality. In an effort to reduce toxicity associated with methyl mercury creation and entrainment in former salt ponds and degraded marsh habitats that can be lethal to wildlife, researchers have breached tide gates for extended periods of time to allow steelhead and other species volitional passage between brackish waters of the bay and more freshwater environments further upland in the watershed. As large-scale restoration of San Francisco Bay continues and expands to benefit native species, passage and habitat suitability for juvenile and adult CCC steelhead should be incorporated and prioritized.

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