NORTHERN CALIFORNIA SUMMER STEELHEAD
Oncorhynchus mykiss irideus

Critical Concern. Status Score = 1.9 out of 5.0. Northern California (NC) summer steelhead are in long-term decline and this trend will continue without substantial human intervention on a broad scale. Due to their reliance on cold water to over summer during the warmest months in freshwater and critical susceptibility to climate change, NC summer steelhead are vulnerable to extinction by 2050.

Description: Summer steelhead are anadromous rainbow trout which return to freshwater from the ocean as large, silvery, immature trout with numerous black spots radiating outward on their tail, adipose and dorsal fins, and are nearly identical in appearance to winter steelhead. Their backs are an iridescent blue to olive or nearly brown. Their sides and belly appear silver, white, or yellowish with an iridescent pink to red lateral band. The mouth is large, with the maxillary bone usually extending beyond the eyes, which are above pinkish cheeks (opercula). Teeth are well developed on the upper and lower jaws, although basibranchial teeth are absent. The dorsal fin has 10-12 rays; the anal fin, 8-12 rays; the pelvic fin, 9-10 rays; and the pectoral fins 11-17. The scales are small with 110-160 scales along the lateral line, 18-35 scale rows above the lateral line, and 14-29 scale rows below it (Moyle 2002).

The coloration of juveniles is similar to that of adults except they have 5-13 widely spaced, oval parr marks centered on the lateral line with interspaces wider than the parr marks. Juveniles also possess 5-10 dark marks on the back between the head and dorsal fin, which make the fish appear mottled. There are few to no spots on the tail of juveniles and white to orange tips on the dorsal and anal fins. There are spots on the dorsal fin, unlike Chinook and Coho salmon. Resident adult trout may retain the color patterns of parr (Moyle 2002).

The various forms in California show slight morphological differences (Bajjaliya et al. 2014), and are mainly distinguished by genetics, behavior, and life history strategies, although different populations may show some variation in the average size of returning adults. Summer steelhead are distinguishable from other steelhead by (1) time of migration (Roelofs 1983), (2) the immature state of gonads at migration (stream-maturing ecotype) (Shapovalov and Taft 1954, NMFS 2016), (3) location of spawning in higher-gradient habitats and smaller tributaries than other steelhead (Everest 1973, Roelofs 1983), and more recently, genetic variation in the Omy5 gene locus, which helps trigger migration timing in individuals (Pearse et al. 2014).

Taxonomic Relationships: Until the late 1980s, all steelhead were listed as *Salmo gairdneri gairdneri*. However, Smith and Stearley (1989) showed that steelhead are closely related to Pacific salmon (genus *Oncorhynchus*) and are conspecific with Asiatic steelhead, then called *Salmo mykiss*. As a result, the American Fisheries Society recognizes coastal rainbow trout, including steelhead, as *Oncorhynchus mykiss*. All steelhead and nonmigratory Coastal Rainbow trout are usually lumped together as *O. m. gairdneri* or, more recently, as *O. m. irideus* (Behnke 1992). However, in this report, *O. mykiss* upstream of a manmade barrier are discussed in the account with their relevant DPS downstream, and O. mykiss above natural barriers to anadromy and in inland waters are discussed in the coastal rainbow trout account.

Moyle (2002) discusses the complex systematics of California populations of steelhead. The six genetic units (ESUs and DPSs) recognized by NMFS for California have more or less discrete geographic boundaries, with genetic similarities strongest between adjacent populations across ESU boundaries. These units are used as the basis for independent steelhead accounts. Recent genetic studies of summer and winter steelhead demonstrate greater levels of differentiation between spatially isolated reproductive populations (Papa et al. 2007, Pearse et al. 2007, Prince et al. 2015). For a full description of the ESU and DPS management units, see the NC winter steelhead account.

The Northern California summer steelhead is represented by a group of distinct populations (Distinct Population Segment, DPS, Box 1) that is well adapted to persisting in California's northern coastal mountains. The genetics of steelhead along the coast of California have been recently studied with microsatellite DNA, which reveals complex interactions with other coastal population segments and the legacy of hatchery-planted fishes (Bjorkstedt et al. 2005). In general, results indicated that geographically proximate populations were most similar genetically. The northernmost populations of NC summer steelhead show a genetic influence from Klamath Mountains Province steelhead, which are the next DPS to the north. This reflects both their transitional nature with more northern populations and possibly the transfer of hatchery juveniles from the Klamath Mountain Province and Central Coast steelhead DPSs in the 1980s.

Along the Lost Coast, collections of steelhead from the Eel, Mattole, and Bear rivers cluster together, while collections of steelhead along the Mendocino Coast show genetic connectivity among these smaller basins. This may indicate higher levels of dispersal among these numerous streams or be the legacy of past transfers of fish among these basins (Bjorkstedt et al. 2005). Genetic studies on steelhead from the Eel River found that winter and summer populations were more closely related to each other than they were to winter and summer populations from other rivers (Clemento 2006). Recent genetics information indicates that early-migrating steelhead, those that make up fall- and summer-run fish, have a genetic variation that has evolved separately in populations of both steelhead and spring-run Chinook salmon (Pearse et al. 2016). Over time, positive selection and straying likely have caused this favorable mutation to radiate outward and give rise to discrete runs of steelhead and salmon along the West Coast of the United States.

The distribution of non-anadromous individuals in the NC steelhead DPS is poorly documented. It is likely that these trout historically constituted only a small component of the overall population in most coastal basins, given the limited extent of historical barriers in most northern California watersheds. In larger basins where there are more opportunities in headwater areas for non-anadromous life histories to develop in isolation, rates of gene flow between resident and anadromous rainbow trout are likely low enough for the two forms to be considered separate populations (Bjorkstedt et al. 2005). Genetic analyses among juvenile trout in upper Middle Fork Eel River tributaries showed significant genetic differences indicating isolated, small, resident populations (Clemento 2006). Despite natural barriers, such as boulder fields and waterfalls, which segregate some Eel River tributary populations from anadromous adults in the mainstem in most years, headwater populations still retain migratory alleles in their genome, indicating their potential conservation value and potential to express an anadromous life history (Kelson et al. 2016).

Larger watersheds within the DPS also support summer run steelhead in Redwood Creek and the Mad, Mattole, Eel, and Van Duzen rivers. The Northern California steelhead DPS variations have been defined as: winter and summer, with a distinctive variant known as 'half-pounder' that may be derived from any of the three DPSs. NC summer steelhead are treated separately in another account because the two runs are distinctive in their genetic makeup, behavior, and reproductive biology and require different conservation frameworks than winter-run fish (Busby et al. 1996, Prince et al. 2015, Hodge et al. 2016). Genetic analyses support two discrete, separate monophyletic units of migrating populations based primarily on timing of freshwater entry and resulting maturation (Papa et al. 2007), correlating with run timing for the ocean-maturing (winter) and stream-maturing (summer, fall) ecotypes (Prince et al. 2015).

Life History: The continuum of life history strategies and migration timing of steelhead in California is covered in detail in the Klamath Mountains Province winter steelhead account. Summer steelhead are stream-maturing ecotype fish that enter freshwater with undeveloped gonads, and then mature over several months in freshwater. This life history is uncommon compared to ocean-maturing or winter-run fish. These steelhead oversummer in typically deep, bedrock holding pools and remote canyon reaches of streams with some overhead cover and subsurface flow to keep cool until higher flows arrive in winter (Busby et al. 1996).

NC summer steelhead enter estuaries and rivers as immature fish between April and June in the northern portion of the DPS (Redwood National Park 2001). In the Mad River, summer steelhead enter the mouth in early April through July as flows allow (M. Sparkman, CDFW, pers. comm. 2016). Mattole summer steelhead enter the river between March and June (Mattole Salmon Group 2016), and further migrations upstream occur from June on, but timing depends upon rainfall and consequent suitable stream discharge for passage into upper sections of watersheds. Spawning happens primarily in the winter between December and early April in headwater reaches of streams not utilized by winter steelhead (Roelofs 1983, Busby et al. 1997), though favorably wet conditions may lengthen the spawning period into May. Infrequent observations of steelhead spawning in June have also been reported on the Mattole River (Mattole Salmon Group 2016).

Unlike salmon, steelhead can spawn several times throughout their lives (iteroparity). Steelhead utilize this strategy to maximize reproductive success, spread survival risk over cohorts, and to buffer against short-term decline and catastrophic events such as wildfires, earthquakes, or landslides (Ricker 2016). Hopelain (1998) reported that repeat spawning varies considerably among runs and populations, from 18 to 64% of spawners. Females make up the majority of repeat spawners, and potentially the majority of spawners that are successful (Busby et al. 1996). In Freshwater Creek, between 10 and 26% of steelhead are repeat spawners, though the proportion of repeat spawners may be mostly indicative of a strong cohort of first time spawners (Ricker 2003). Females lay between 200 and 12,000 eggs (Moyle 2002). Outmigration of spawned adults can occur as late as June, but typically occurs no later than May in most watersheds (Busby et al. 1997). Shapovalov and Taft (1954) noted that hundreds of spawned-out adults often schooled above Benbow Dam on the South Fork Eel River. Additionally, in years with low spring outflows, steelhead may become stranded in their natal streams for the summer (S. Harris, CDFW, pers. comm. 2007).

Steelhead spawning occurs over a protracted period, and thus fry emergence may also take place over a long period, which influences young-of-the-year redistribution and potentially result in emigration into estuaries (Day 1996). Based on their occupancy of headwater streams with relatively low (< 50 CFS) winter flows (Roelofs 1983), newly emerged fry move out of these smaller natal streams into larger tributaries soon after emerging. Juvenile steelhead school together and seek shallow waters along riffle margins or pool edges, while older juveniles maintain territories in faster and deeper locations in pool and run habitats (M. Sparkman, CDFW, pers. comm. 2016). Where steelhead coexist with larger coho salmon juveniles, they prefer pool habitats for faster growth, although young-of-year steelhead can be competitively displaced to riffle habitats (Smith and Li 1983). Yearling steelhead occasionally emigrate from their natal rivers and recent studies have shown that some one-year-old smolts return as adults (M. Sparkman, CDFW, pers. comm. 2007). Typically successful juveniles rear in streams for two years.

Juvenile steelhead favor areas with cool, clear, fast-flowing riffles, ample riparian cover and undercut banks, and diverse and abundant invertebrate life (Moyle 2002). Growth rates vary with environmental conditions. NC steelhead in Redwood Creek can grow from 0.26 to 0.73 mm/day (M. Sparkman, CDFW, pers. comm. 2007). NC summer steelhead juveniles of all sizes move within their natal streams, and typically individuals leave during higher spring flows with movement peaking during late April or May. Young-of-year steelhead will emigrate to estuaries as late as June or July in Redwood Creek (M. Sparkman, CDFW, pers. comm. 2007). Very small emergent fry have been observed by divers in July and even August in the Mattole River, suggesting either a very late or very early spawning period (Mattole Salmon Group 2016). In Freshwater Creek, out-migrating steelhead averaged 156 mm FL, while the back-calculated ocean entry check for migrating spawners was at 194 mm FL, suggesting that additional rearing takes place in the estuary (Ricker 2003). Minimum growth in the estuary appears to occur when the river mouth is closing and a shift from estuarine to lagoon conditions occurs, typically between mid-August and mid-September (Cannata 1998). In the Mattole lagoon, juveniles display benthic feeding strategies. In the lower lagoon, they primarily eat amphipods (*Corophium* spp.), while in the upper lagoon they eat primarily caddisfly larvae (Zedonis 1990).

Smoltification (the physiological process of adapting to survive in saline ocean conditions) occurs in early spring. Scale studies suggest the majority of juvenile fish from the Middle Fork Eel River become smolts at two years old and return to freshwater at age 3 and 4 (Puckett 1975). Smolts typically emigrate from the river to the estuary or ocean between March and June, but prevailing habitat conditions may prevent exit from the estuary until late fall. A common process in small estuaries supporting NC summer steelhead is the formation of a summer lagoon, where beach sands form a bar across the mouth of the river. Strong salinity stratification in lagoons without sufficient inflow or very strong winds can lead to poor water quality, causing steelhead to seek refuge near the surface, in near-shore waters where more mixing occurs, or upstream beyond the seasonally stratified zone. Lagoon habitats offer juvenile steelhead flexibility in life history strategies to display a “double-smolting” strategy, whereby they enter an estuary or lagoon habitat for a short time before migrating back upstream to freshwater to grow and then before outmigrating to the lagoon and ocean once the lagoon breaches the following winter (FishBio 2016). This life history expression results in tradeoffs between carrying capacity, food availability, and likelihood of survival at different sizes between freshwater, brackish, and saltwater habitats available to them as juveniles. The prevalence and quality of these estuary and lagoon habitats are crucial for expression of the full spectrum of life history diversity of the DPS and the species, and are necessary for population resilience and recovery (FishBio 2016).

Some NC summer steelhead enter the ocean as they begin their third year of life after spending at least one year in the estuary (Cannata 1998). NC steelhead were captured in August during trawl surveys north and south of Cape Blanco (Brodeur, Fisher et al. 2004, Harding 2015), suggesting much of their time in the ocean is spent close to their natal streams. Steelhead grow rapidly at sea, feeding on fish, squid, and crustaceans in surface waters (Barnhart 1986, Harding 2015). Steelhead use their strong homing sense to return to natal areas where they were born to spawn (Moyle 2002). While California steelhead can spend several years in the ocean, many steelhead returning to Freshwater Creek, a small coastal tributary of Humboldt Bay, spend just two years in the sea (e.g., Ricker 2003). In coastal California basins, the most common life history patterns for first time spawners are 2/1 (years in fresh water/ocean), 2/2, and 1/2 (Busby et al. 1996). The majority of returning steelhead in the Mad River were three years old (Zuspan and Sparkman 2002; Sparkman 2003).

In Redwood Creek and the Mad, Eel, and Mattole Rivers, a small number of small, mostly immature “half pounder” steelhead (Snyder, 1925) are observed annually. In the Mad River, these smaller steelhead have been documented following the fall-run Chinook salmon as they migrate upstream (M. Sparkman, CDFW, pers. comm. 2016). Frequently, half-pounders outnumber adult steelhead during these surveys. However, the presence of half-pounders over-summering with adult summer steelhead is not typically characterized in the literature (Kesner and Barnhardt 1972, Hopelain 1998). While half-pounders are stream-maturing fish like summer steelhead, they are not traditionally considered to be part of summer steelhead life history because they do not mature or reproduce while in the river. (Lee 2016). The relative contribution of winter-run and summer-run steelhead to offspring that exhibit the half-pounder life history is unknown, but seems to be more common to summer-run fish (Lee, 2016). Half pounders along the Northern California coast are likely distinct from half pounder steelhead in the Klamath Mountain Province, which are reported to enter and leave the river as immature, subadult fish and spend up to 4 months at sea (Kesner and Barnhart 1972, Lee 2015, FishBio 2016). The NC steelhead half pounders are generally larger (25-35 cm FL or larger) than Klamath fish, but they are not well documented. High phenotypic plasticity in juvenile and adult life histories, demonstrated by NC summer steelhead, warrants further study. For a thorough discussion of the half-pounder life history, see the Klamath Mountains Province winter steelhead account.

Habitat Requirements: Steelhead require distinct habitats for each stage of life. The abundance of summer steelhead in a particular location is influenced by the quantity and quality of suitable coldwater habitat during low flow summer and fall months, food availability, and interactions with other species. Over-summering habitat for adult summer steelhead is critical for survival of this life history. In general, suitable habitats are often distributed farther inland than those for winter steelhead in the same watersheds (Moyle 2002).

Adult steelhead have a body form adapted for holding in faster water than most other salmonids with which they co-occur can tolerate. Within California, Bajjaliya et al. (2014) found important differences in steelhead morphology based on flow regimes and habitats occupied. Northern California steelhead had the largest individuals, on average, than populations of steelhead from elsewhere in the state. In general, coastal steelhead that occupied smaller, slower coastal rivers were deeper bodied, longer, and more robust than steelhead from larger inland rivers with higher velocities. Low flows associated with more inland rivers and tributaries do not facilitate passage of larger bodied adults, and therefore select for smaller, more streamlined fish. Adult summer steelhead require water depths of at least 18 cm for passage (Bjorn and Reiser 1991), however, this may not take into account the deep-bodied, robust physiology of coastal steelhead in the NC steelhead DPS, which would require slightly more flow to allow passage (Bajjaliya et al. 2014). Reiser and Peacock (1985 in Spence et al. 1996) reported the maximum leaping ability of adult steelhead to be 3.4 m. Hawkins and Quinn (1996) found that the critical swimming velocity for juvenile steelhead was 7.7 body lengths/sec compared to juvenile cutthroat trout that moved between 5.6 and 6.7 body lengths/sec. Adult steelhead swimming ability is hindered at water velocities above 3 m/sec (Reiser and Bjornn 1979). Preferred holding velocities are much slower, and range from 0.19 m/sec for juveniles and 0.28 m/sec for adults (Moyle and Baltz 1985). Physical structures such as boulders, large woody debris, and undercut banks create hydraulic heterogeneity that increases availability of preferred habitat in the form of cover from predators, visual separation of juvenile territories, and refuge during high flows.

Steelhead require cool water and holding habitat to withstand the higher temperatures and lower flows of summer and fall while they mature. Important factors influencing summer steelhead habitat use are pool size, low substrate embeddedness (< 35%), presence of riparian habitat shading, and instream cover associated with increased velocity through the occupied pools (Nakamoto 1994, Baigun 2003). Temperatures of 23-24°C can be lethal for the adults (Moyle 2002), which can limit abundance and spatial distribution. Subsurface, or hyporheic, flows can be important to providing cool, flowing water in habitats separated by thermal or other barriers. In August 2015 on the upper Middle Fork Eel River, adult summer steelhead were observed in pools of varying depth, but only with maximum temperatures of less than 23°C (CDFW 2015, Table 1). For a full description of steelhead thermal tolerances, see the Northern California winter steelhead account.

Pools with fish	**Mean (°C)**	**Max. (°C)**	**Min. (°C)**
Surface temp.	19.9	22.7	15.5
Bottom temp.	18.7	21.1	15.0
Pools without fish	**Mean**	**Max.**	**Min.**
Surface temp.	20.2	25.0	16.1
Bottom temp.	19.5	25.0	15.5

Table 1. Preferred summer steelhead temperatures, adapted from CDFW 2015, Table 3, pg. 9.

For spawning, adult steelhead require loose gravels at pool tails for optimal conditions for redd construction. Redds are usually built in water depths of 0.1 to 1.5 m where velocities are between 0.2 and 1.6 m/sec. Steelhead use a smaller substrate size than most other coastal California salmonids (0.6 to 12.7 cm diameter). Spawning habitat for summer steelhead can be variable, but their temporal and spatial isolation from other steelhead runs maintain low levels of genetic differentiation from winter steelhead in the same watershed (Barnhart 1986, Papa 2007, Prince et al. 2015). Summer steelhead can spawn in intermittent streams, from which the juveniles emigrate into perennial streams soon after hatching (Everest 1973). Roelofs (1983) suggested that use of small streams for spawning may reduce egg and juvenile mortality because embryos may be less susceptible to scouring by high flows and predation on juveniles by adults.

After spawning, adult steelhead, called “kelts” at this life stage, are capable of rapidly making their way back out to sea; the entire migration and spawning cycle of an adult fish can be completed in less than ten days (J. Fuller, NMFS, pers. comm. 2016). In contrast, in Redwood Creek, relatively large numbers of kelts migrate downstream through the lower watershed in March (M. Sparkman, CDFW, pers. comm. 2016). Due to the relatively short distances these fish must travel in small coastal watersheds to spawn, their survival rates and incidence of repeat spawning are higher than steelhead in the much larger Eel River, which reach dozens of kilometers inland.

Embryos incubate for 18 to 80 days, depending on water temperatures, which are optimal in the range of 5 to 13° C. Hatchery steelhead take 30 days to hatch at 11°C (Leitritz and Lewis, 1980 in McEwan and Jackson, 1996), and emergence from the gravel occurs after two to six weeks (Moyle 2002; McEwan and Jackson 1996). High levels of sedimentation (> 5% sand and silt) can reduce redd survival and emergence due to decreased permeability of the substrate and dissolved oxygen concentrations available for the incubating eggs (McEwan and Jackson 1996). When fine sediments (< 2.0 mm) compose > 26% of the total volume of substrate, poor embryo survival is observed (Barnhart 1986). Emerging fry can survive at a greater range of temperatures than embryos, but they have difficulty obtaining oxygen from the water at temperatures above 21.1°C (McEwan and Jackson 1996).

During the first couple years of freshwater residence, steelhead fry and parr require cool, clear, fast-flowing water (Moyle 2002). Exposure to higher temperatures increases the energetic costs of living for steelhead and can lead to reduced growth and increased mortality. As temperatures become stressful, juvenile steelhead will move into faster riffles to feed on more abundant prey (Moyle 2002 and bioenergetic box in SONCC coho account) and seek out cool-water refuges associated with cold-water tributary confluences and gravel seeps. In Redwood Creek, young-of-year (YOY) steelhead may travel 46 km downstream during summer months in search of rearing areas (M. Sparkman, CDFW, pers. comm. 2016). In the Mattole River, juvenile steelhead are found over-summering throughout the basin, although water temperatures often restrict their presence in the estuary. Cool water areas, including some restoration sites, provide refuge from temperatures that can rise above 19°C in the Mattole (Mattole Salmon Group 2005). However, juvenile steelhead can live in streams that regularly exceed 24°C for a few hours each day with high food availability and temperatures that drop to more favorable levels at night (Moyle 2002, M. Sparkman, CDFW, pers. comm. 2016).

Juvenile steelhead rear in the estuaries of Redwood and Freshwater creeks, Humboldt Bay, and the Eel, Navarro, Garcia, Gualala rivers. Lagoon habitats are critical for steelhead for rearing, feeding, and growth before and during smoltification (FishBio 2016). Estuary ecotones serve as important transitional habitat for both juvenile and adult salmonids, allowing feeding, resting, and acclimation to changing salinity before migration (Wallace et al. 2015). Juveniles that rear in ponds, sloughs, and other inundated estuary habitat grow more quickly than juveniles rearing in streams or tidally influenced freshwater habitats (CDFW and PSMFC 2014). As freshwater inflows decline during late spring, many of these estuaries become closed with sand bars, forming lagoons. Algal mats may then form, which reduce dissolved oxygen (DO) levels, eliminating much of this productive habitat from use by juvenile steelhead. Dissolved oxygen levels below 4.5 mg/L negatively affect juvenile steelhead trout (Barnhart 1986), although they can survive DO levels as low as 1.5-2.0 mg/L for short periods of time (Moyle 2002).

In saltwater, many age-0 California steelhead juveniles spend a year feeding in the cold California Current off the Klamath-Trinidad region, then move northwest to the North Pacific (Mantua et al. 2015, Hayes et al. 2016). Recent trawl surveys by NOAA Fisheries indicate that steelhead feed on pelagic organisms such as krill, fish, and amphipods in surface waters for several years in a narrow range of sea surface temperatures (apparently 8-14°C), then return to their natal rivers for spawning (Harding 2015, Hayes et al. 2016).

Distribution: Along the eastern Pacific, rainbow trout, including steelhead, are distributed from Southern California north to Alaska and west to Siberia (Sheppard 1972). In California, the NC summer steelhead DPS includes all naturally spawning populations of steelhead in California coastal river basins below upstream barriers to migration from Redwood Creek in the North, to the Mattole River in the South (NMFS 2016). While NC summer steelhead are present wherever streams are accessible to anadromous fishes and there are sufficient flows in the DPS geographic area, (J. Fuller, NMFS, pers. comm. 2016), summer steelhead are only present in a few select watersheds, including Redwood Creek and the Mad, Eel, and Mattole rivers. Summer steelhead were noted in local Humboldt County papers, including the Blue Lake Advocate, since at least 1908. Reports note large steelhead entering the North Fork Mad and Eel rivers in April and May (S. Van Kirk, 2013).

According to the National Marine Fisheries Service (NMFS), NC summer steelhead are divided into two geographic diversity strata: North Mountain Interior and Northern Coastal (Figure 1). Within these diversity strata, there are 10 essential independent populations that comprise the summer run portion of the Distinct Population Segment (DPS) based on environmental and ecological similarities (NMFS 2016). These populations include: Redwood Creek, Mad River, Van Duzen River, North, Middle, and South forks of the Eel River, Larabee Creek, Upper Middle and Upper Mainstem of the Eel River, and the Mattole River.

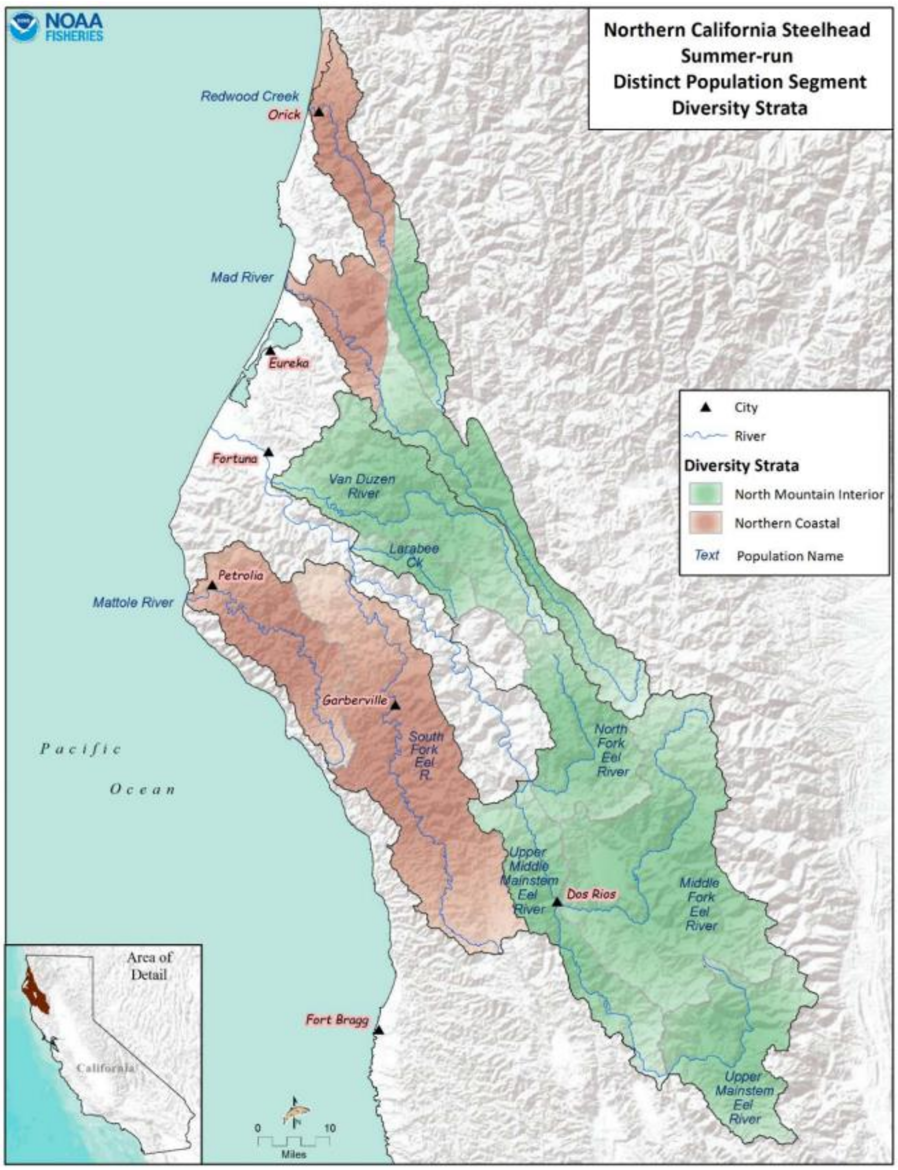

Figure 1. NC summer steelhead diversity strata. From: NMFS 2016, Fig. 2, pg. 4.

In the Mad River, upstream passage for summer steelhead is often blocked by a natural flow and velocity barrier near Humbug Creek (Mad River Alliance et al. 2016). An estimated 36% of potential habitat for summer steelhead over summering, spawning, and rearing is upstream of R.W. Matthews Dam and Ruth Lake. Flows from the dam provide cool water for summer-run adult fish and juveniles (NMFS 2016). However, a potential natural landslide barrier is about 48 river km downstream of the dam, so some flushing flows or restoration of the area may be required to access upstream available habitat.

On the Eel River, summer steelhead are found in the mainstem, upper mainstem, North, Middle, and South forks. Valuable habitat for summer steelhead on the Middle Fork Eel historically existed above Rio Dell, Fly Creek (Mendocino Co., CEMAR 2009). Estimates of the potential spawning and rearing habitat upstream of Scott Dam on the Eel River differ somewhat, but are significant (over 100 km) (Eel River Forum 2016). This population has never had hatchery influence, and was considered one of the most important summer steelhead populations in the state. A 1983 study found Fossil, Morrison, and Red Chert creeks to be important spawning tributaries to the North Fork of the Middle Fork Eel (DFW 1983 in CEMAR 2009). The natural boulder roughs (> 8-12% slope) at the Asa Bean crossing on the Middle Fork Eel River is a known impediment to passage of adult summer steelhead, forming a natural dam. The roughs in this area generally go dry by the end of July, causing adult and hundreds of juvenile steelhead to perish each year (CDFW 2015). Low baseflows during summer months are limiting to summer steelhead on the North Fork Eel and the Van Duzen River (NMFS 2016). Past CDFW reports have indicated that natural falls and the Eaton Roughs, approximately 67 km from the mouth of the Van Duzen, form an upstream barrier to migration, but that significant productive capacity exists could passage be enabled upstream (CEMAR 2009).

On the Mattole, summer steelhead can access the entire length of the river and two major tributaries, making these fish the southernmost population of summer steelhead in a watershed without significant snowmelt during spring and summer (Mattole Salmon Group 2016).

Trends in Abundance: Little historical abundance information exists for naturally spawning populations of NC summer steelhead, but current abundance of this species is likely much less than historical estimates. In general, summer steelhead abundance estimates come from volunteer-organized snorkel surveys in headwater reaches of rivers. These surveys are often difficult to make consistent in their scientific rigor or replicability due to issues with skill level, training, safety concerns, and access to similar reaches year after year. In addition, resident *O. mykiss* can often be mistaken for "half-pounder" subadult steelhead, which can cloud results and total counts. For example, snorkel surveys on the Mad River that have been occurring for decades must occasionally be altered due to issues of access associated with wildfires, changes in private land ownership, and illegal proliferation of marijuana (Mad River Alliance, 2015). However, redd surveys, angler surveys, carcass surveys, and DIDSON sonar and other methods have been used to provide rough estimates of returning adult spawners throughout the DPS. In addition, the Coastal Salmonid Monitoring Protocol has been in place for several years for the North Coastal Diversity Stratum (Redwood Creek, Mad River, Humboldt Bay tributaries, and Eel River) and has helped streamline data collection and synthesis (Williams et al. 2016).

The catastrophic flood of 1964-1965 caused nearly total loss of holding pools and created barriers to migration that have contributed to decline of summer steelhead populations in the Eel River watershed, as in Woodman Creek (CEMAR 2009). Low summer flows, sedimentation, high turbidity, and poor water quality associated with rural development, diversions, forestry practices, and cattle grazing have significantly reduced summer steelhead holding habitat in the Eel River basin and contributed to their decline (CEMAR 2009).

Redwood Creek, in northern Humboldt County, historically had summer steelhead, but only numbering a few dozen fish per year from 1981-1991 due to poor water quality from land use patterns, diversions, and warm temperatures (Anderson 1961, Figure 2). A recent evaluation (Williams et al. 2016) suggests that Redwood Creek would need to support a population in the hundreds to aid recovery of the DPS. It is currently temperature-impaired under the Clean Water Act, and faces temperature threats to over summering fish (NMFS 2016).

Year	No. of Summer Steelhead	Survey Dates
1981	16	8/10 - 13
1982[a]	2	10/12 & 14
1983	5	8/22 - 25
1984	44+	8/08 - 10
1985	44+	8/20 - 22, 9/4
1986	19+	8/25 - 27
1987	14	7/14 - 16
1988	8	7/26 - 28
1989[b]	0	7/31, 8/01 - 02
1990	14	7/31, 8/01 - 03
1991	15	8/05 - 08
1992	5	8/03 - 06, 10
1993	2	8/02 - 05, 09
1994	5	8/01 - 04
1995	5	7/24 - 27
1996	1	8/05 - 08
1997	6	8/04 - 07
1998	4	7/27 - 30
1999	5	8/2-10
2000	3	8/1 - 09
2001	0	7/31, 8/01-02, 08

[a] Survey from Stover Creek to Emerald Creek, 14 miles, covering most of index section and best pool habitat.
[b] Survey from Lacks to Bridge Creek, minus Garret to Panther Creek, a total of 11.1 miles. Covered best pool habitat.

Figure 2. Redwood Creek summer steelhead estimates, 1981-2001. From National Parks Service 2001, Appendix 1.

In the Mad River, snorkel surveys and opportunistic redd surveys are used to provide trend data for summer steelhead populations (Mad River Alliance et al. 2016). From 1994 to 2002, divers observed a mean of 250 adult steelhead per year (Mad River Alliance 2016, Figure 3). In recent drought years, numbers have continued to decline and some upstream reaches were no longer accessible due to low flows. Divers also complained about headaches and rashes, symptoms often associated with exposure to toxic cyanobacteria that are known to multiply in warm waters on the Eel River (Power et al. 2015). If the sampling protocol in use since 2013 can be slightly amended, NOAA could assess viability of Mad River summer steelhead for recovery (CDFW 2016).

Table 1. Mad River summer-run steelhead dive survey results 1980 - 2015

		Adults			Half-Pounders		
Year	Miles Surveyed	Live	Dead	Total	Live	Dead	Total
1980[p]	17.9	0	0	0	0	0	0
1981[p]	17.5	2	0	2	0	0	0
1982[p]	32.4	167	0	167	0	0	0
1983[p]	22.8	31	0	31	0	0	0
1984[p]	14.1	111	0	111	0	0	0
1985[p]	14.8	52	0	52	0	0	0
1986[p]	7.8	10	0	10	0	0	0
1987[p]	20.2	18	0	18	0	0	0
1988[p]	10.6	60	0	60	0	0	0
1989[p]	10.6	20	0	20	0	0	0
1990[p]	10.6	33	0	33	0	0	0
1991[p]	14.7	59	0	59	0	0	0
1992[p]	10.6	34	0	34	0	0	0
1993[p]	10.6	48	0	48	0	0	0
1994[p]	51.6	305	0	305	166	0	166
1995[p]	66.6	541	1	542	10	0	10
1996[p]	60.7	427	1	428	19	0	19
1997[p]	66.6	292	5	297	12	0	12
1998[p]	57.0	191	0	191	20	0	20
1999[p]	46.4	82	0	82	15	0	15
2000[p]	53.5	170	0	170	62	0	62
2001[p]	12.5	194	0	194	583	0	583
2002[p]	19.7	185	0	185	80	0	80
2003[p]	18.7	483	0	483	5	0	5
2004[p]	5.8	209	0	209	9	0	9
2005[p]	5.6	211	0	211	10	0	10
2006	No Survey						
2007	No Survey						
2008[p]	5.1	110	0	110	20	0	20
2009	No Survey						
2010	No Survey						
2011	No Survey						
2012	No Survey						
2013	50.0	280	2	282	28	0	28
2014	61.0	322	0	322	92	0	92
2015	47.1	336	0	336	222	0	222

p = Provisional data

Figure 3. Mad River summer steelhead snorkel survey estimates, 1980-2015. From: Mad River Alliance 2016, pg. 19, Table 1.

The Eel River is the most important steelhead producing river in this DPS and once supported between 100,000 and 150,000 winter and summer steelhead, with the South and Middle forks combining to hold 70% of these spawning fish (NMFS 2016). Annual counts of steelhead in the Eel River were historically made at the Benbow Dam Fishway on the South Fork Eel River and at Van Arsdale Dam on the mainstem Eel River. The North Fork Eel River had populations of summer steelhead in the past, but that run has likely been extirpated (Higgins 1995). The Middle Fork Eel also had summer steelhead arriving as early as April 20th in some years and supported good numbers of fish (DFG 1959). It was once home to what was considered the largest run of summer steelhead left in the basin (DFG 1999). CDFW has conducted snorkel and electrofishing surveys on the Middle Fork since 1966, with survey data showing a downward trend in abundance and relatively low fluctuating numbers of fish over the last five decades (Figure 4). The majority of fish counted this past year were seen upstream of Fly Creek on the Upper Middle Fork Eel, with the majority of fish observed in pools between 3 and 6 meters in depth (S. Harris, CDFW, pers. comm. 2016). In addition, juvenile steelhead sampled near Osborn, fairly low in the Middle Fork Eel watershed, turned up abundance estimates about half of what they had been the previous two years in the area (CDFW 2015). The South Fork Eel River never supported large runs of summer steelhead, but occasionally reports of adult fish came out of this area (DFG 1992).

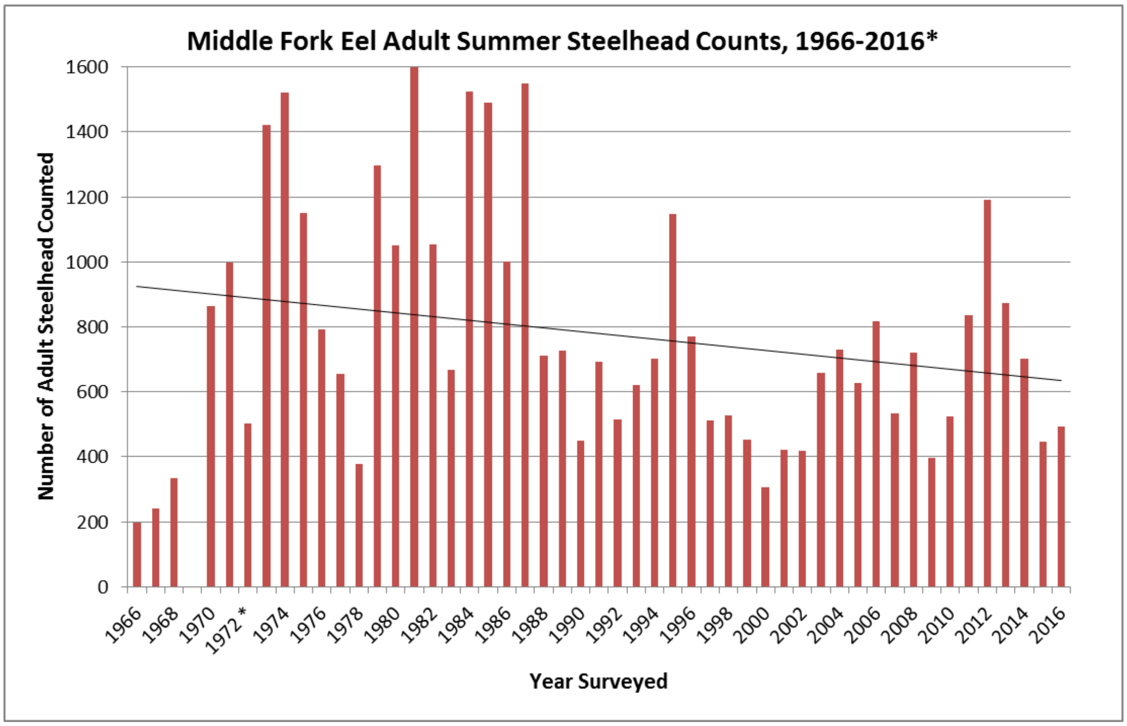

Figure 4. Middle Fork Eel River summer steelhead snorkel survey data, 1966-2016. Data from S. Harris, CDFW, pers. comm. 2016. *1972 surveys incomplete.

In the Van Duzen River, summer steelhead were likely never abundant, and were designated by the American Fisheries Society as having a high risk of extinction due to populations less than 200 adults per year (Higgins 1992). In 1995, a local biologist estimated that less than 100 adults were still present (Higgins 1995). The Little Van Duzen (South Fork Van Duzen) used to have around 100 summer steelhead adult per year in the early 1960s, but more recent surveys only found a single adult summer steelhead in 1997 (Preston 1997).

The Mattole River supports a small population of summer steelhead (Williams et al. 2016, Figure 5) at the southernmost extent of the DPS, and is not fed by snowmelt, making it even more susceptible to changes in flow and temperature (Mattole Salmon Group 2015). To sustain this population, CDFW and the Mattole Salmon Group captured and relocated as many coho and steelhead as possible from Baker Creek to Thompson Creek in August and September, 2014 as pools dried (Mattole Salmon Group 2014).

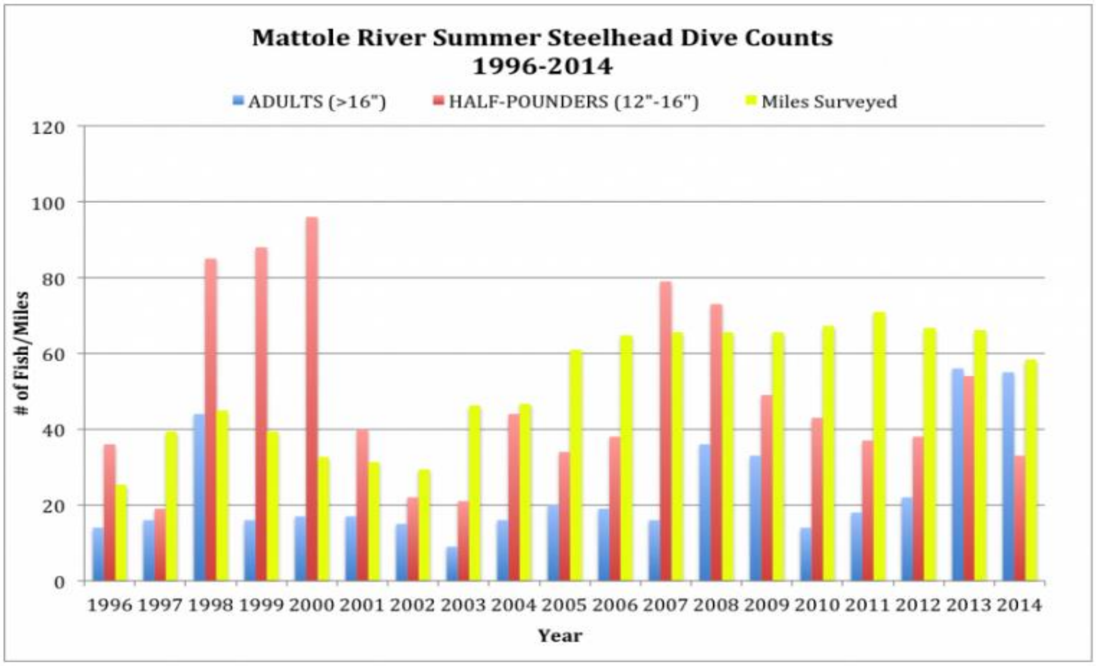

Figure 5. Mattole River summer steelhead snorkel surveys, 1996-2014. From: Mattole Salmon Group, 2015. Fig. 1, pg. 4.

Factors Affecting Status: Over the recent, historic drought (2012-2016), increasingly severe anthropogenic pressures have compounded naturally stressful conditions for steelhead in California (floods, drought, fires, poor ocean conditions, etc.), causing depleted populations to decline further. The Northern Diversity Stratum of summer steelhead lack adequate shelter, staging pools, gravel quantity, and sufficiently cool mainstem water temperatures. Reduced floodplain connectivity, low passage flows, physical barriers to migration, and low abundance are limiting recovery of the DPS (NMFS 2016). Expression of the full suite of steelhead life history diversity is at risk due to low population abundance, fishing pressure during summer months, poor water quantity and quality, and lack of complex over summering pool habitat (NMFS 2016).

Dams. Both the Eel and Mad rivers have dams that prevent access to considerable steelhead rearing and spawning habitat. Approximately 36% of potential steelhead habitat in the Mad River lies above Matthews Dam, while in the upper mainstem Eel River more than 99% of available spawning habitat upstream of Soda Creek is blocked by Scott Dam, exemplified by Gravelly Valley (NMFS 2016). Recent study (Cooper et al. *In progress*) suggests that potential steelhead habitat upstream of Scott Dam ranges from 291-463 km. In 1981, the Eel and its major tributary, the Van Duzen, were both designated as Wild and Scenic Rivers, protecting them from future dams, but not from diversions (Power et al. 2015). These barriers represent a major limiting factor on NC summer steelhead abundance: reduced gravel quantity and quality necessary for successful spawning and egg hatching in the Eel River (NMFW 2016). Blocked high gradient, small tributaries are important to summer steelhead, because these fish probably ascended higher in each watershed than any other salmonid based on their morphological adaptations to hold in lower, faster water and leap higher than other steelhead or Chinook salmon (Hodge et al. 2011). Scott Dam also reduces flows into the mainstem Eel River by delivering about 3% of its water into the neighboring Russian River watershed (NMFS 2016). This flow reduction negatively impacts mainstem water quality, especially during summer and fall, reduces stream complexity, and constricts the period of outmigration by juvenile steelhead during the spring and summer. Barrier inventories have been completed in NC summer steelhead counties, but most are still in place because considerable effort is required to eliminate even the priority barriers. Recent creation of the Eel River Action Plan may help prioritize and catalyze action to remove these barriers.

Flow releases in the reach between Scott Dam and Cape Horn Dam have improved summer temperatures. As a result, juvenile steelhead grow faster than those rearing in tributaries; some may reach over 19 cm in a single year of growth, a size which is suitable for smolting and migrating out to sea (SEC 1998). Unfortunately, the smolts leaving the interdam reach tend to migrate several weeks later than those from the tributaries, exposing them to less favorable conditions (higher temperatures, lower flows) than fish that migrate earlier (SEC 1998).

Logging. A significant proportion of the NC summer steelhead landscape is industrial timberlands, both private and public, which have already undergone intense logging in the 19^{th} century. The cumulative, synergistic effects of these operations is difficult to grasp, though direct impacts to steelhead from logging include increased sedimentation and stream temperatures, reduced canopy cover, destruction of instream habitat, lack of large woody debris, and altered flow timing and volume. The channel of the Eel River and its tributaries have become shallower, braided, and less defined (Lisle 1982). These changes have reduced the ability of adults to reproduce, juveniles to forage, and migrants to safely pass to the ocean, as well as reducing productivity of aquatic invertebrates that are the principal food for fish. Excessive fine sediments from legacy impacts of logging still clog channels in the Eel today (Power et al. 2015).

Areas subjected to logging in many steelhead watersheds also suffer from increased effects of fire, a natural phenomenon in most coastal landscapes, especially outside the coastal fog belt. The history of timber management, combined with natural variability in conditions, create a complex potential fire regime (Noss et al. 2006), but in many areas both the frequency and intensity of fires has been increased by a long history of forest management focused on tree production. An additional problem has been “salvage logging” where large dead trees are removed after a fire, enhancing the erosion following a fire by increased road building and reducing availability of trees to fall into streams and create steelhead habitat.

Logging and its associated roads and legacy effects (see Coho Salmon accounts) have increased erosion on steep hillsides, greatly increasing sediment loads in the rivers. High sediment loads cause deep holding pools to fill with gravel, embed spawning gravels in fine materials, and create shallower runs and riffles. All this decreases the amount of usable habitat and increases the vulnerability of fish to poachers and predators. Such practices may also decrease summer flows, raising water temperatures to levels that may be stressful or even lethal to summer steelhead (Lewis et al. 2004).

Agriculture. Agricultural and cattle ranching land use practices in the DPS can negatively impact adjacent streams containing steelhead and other anadromous fish. The trampling and removal of riparian vegetation by grazing livestock destabilizes and denudes stream banks, increasing sediment and stream temperatures (Spence et al. 1996). These activities can reduce canopy over stream channels and increase siltation of pools necessary for juvenile rearing (Moyle 2002). Other impacts of agriculture include stream channelization, large woody debris removal, and armoring of banks to prevent flooding of fields (Spence et al. 1996). These types of activities remain “best management practices” for agriculture, vineyards, and ranching in some parts of the NC summer steelhead range. All of these activities, in combination with diversions for irrigation, degrade aquatic habitat quality, reducing its suitability for steelhead or other native fishes, while enhancing its suitability for non-native fishes, such as Sacramento pikeminnow (*Ptychocheilus grandis*) (Harvey, White et al. 2002).

These land uses have altered floodplain hydrology, decreased bank stability, increased sediment delivery and transport of pollutants. Within river channels, these activities disrupt substrate composition, divert flows, reduce water quality, and inhibit natural processes of temperature regulation. In addition, lagoon and estuary habitats often store excess sediments, have reduced habitat complexity, and are impaired by temperature increases.

In the past few decades, illegal water diversions and subsequent habitat degradation of remote headwater streams as part of the "Green Rush" for marijuana cultivation has become the limiting factor for salmonid survival in first- and second-order streams in the DPS. The unregulated pesticide, damming, and habitat destruction that typically accompany illegal grow operations pose a serious threat to the long term persistence of steelhead in the DPS (NMFS 2016). Specifically, Mendocino and Humboldt Counties, with their sparse, rural populations and heavily forested landscape, serve as epicenters of these illegal activities. A recent CDFW-funded study (Bauer et al. 2015) found that in the headwaters of Redwood Creek, home to a key independent population of NC summer steelhead, illegal and unregulated diversions for marijuana cultivation could consume over 20% of the available water in a year. These diversions have significant consequences on habitat quantity and quality for salmonids, such as elevated temperature and sediment, increased competition, predation and disease risks, increased stranding and delayed migration, lower growth rates, and reduced survival, and are likely occurring in remote streams throughout the DPS.

Water diversions and impoundments are threats rated as "very high" by NMFS because they lead to decreased flows and increased temperatures that are often lethal to over summering fish (NMFS 2016). Water temperature is a crucial limiting factor, and can be addressed with riparian vegetation restoration, increased large woody debris in streams, and fewer water diversions that allow more groundwater recharge within watersheds (NMFS 2016). Irrigated agriculture, subdivisions of parcels in rural areas, and illegal marijuana diversions all stress water supply, especially during drought. Estuary hydrodynamics become altered with less freshwater inflow, causing hypersaline conditions to prevail. A voluntary Sanctuary Forest water forbearance program is attempting to use water tanks in place of diversion during critical months to support oversummering fish.

Degraded water quality and supply have perhaps the greatest impact on adult summer steelhead in California. Many rivers and streams in the DPS are impacted by high temperatures, low dissolved oxygen, low flows, or all of the above during summer and early fall months due to diversions and land use practices. Summer discharge in the lower Eel is often insufficient to connect pools with surface or even hyporheic flow, leading to harmful cyanobacteria blooms that disrupt food chains and kill salmonids (Power et al. 2015). In 2013, a very poor water year led to the formation of the largest cyanobacteria algal bloom in the South Fork Eel River since 1988. In the large Eel watershed, summer temperatures peak between 20-22 degrees Celsius in headwaters, 26 degrees Celsius in upper mainstem tributaries, and reach 30 degrees Celsius at sites in the lower drainages that are not protected by cooling fog. High summer baseflows fueled by groundwater recharge are more likely to provide temperatures, flows, connectivity, and support a food web favorable for juvenile fish survival during summer (Grantham et al. 2012). Flows are especially crucial for sustaining adult summer steelhead until higher flows return in the fall and winter for spawning.

Estuarine alteration. According to NMFS (2016), estuary/lagoon quality and extent of available habitat is a limiting factor on NC summer steelhead. What suitable estuary habitat remains is subject to high turbidity, poor water quality from runoff and sedimentation, and onset of hypersaline conditions by mid-summer that cause juvenile steelhead to leave these valuable rearing and feeding habitats (CDFW 2014). The estuaries of the Eel and Mad rivers and Redwood Creek have been leveed, subjected to armoring with hard structures, drained, altered by tidegates, and converted to support agricultural and rural development, robbing juvenile salmonids of valuable habitat. The essential water purification and sediment delivery functions of the Eel delta, which delivers more sediment per watershed area than any river in America, have been significantly hampered by human development (Taylor 2015).

Recreation. While sport fishing regulations require a zero take for naturally produced NC steelhead, fishing for steelhead and "trout" continues in large portions of the two largest systems, the Mad and Eel rivers. Angling is allowed on the Mad River for ten months. The fishery is directed towards hatchery winter steelhead, which are marked, and supports an angler success rate that is normally higher than other North Coast rivers (Sparkman 2003). Natural steelhead populations in the Mad River are at very low levels, reflected in the low harvest of natural produced fish (Sparkman 2003). However, recent counts using sonar are showing increases in the returns of natural adult steelhead (M. Sparkman, CDFW, pers. comm. 2016). The mainstem Eel River and its forks support catch-and-release fisheries, which are monitored through the Steelhead Report Card Program. Summer steelhead are especially vulnerable to illegal fishing and poaching, as they are often constrained to a single pool that is disconnected from other usable habitat and enforcement is inadequate (NMFS 2016). While the bag limit for hatchery-reared steelhead is 2 fish per person per day, even catch and release fishing can have an impact at times when conditions are naturally stressful to wild steelhead (NFMS 2016).

Hatcheries. Mad River Hatchery releases about 150,000 winter steelhead smolts per year since 2009 (CDFW 2016 Mad River Hatchery Plan). Competition among winter adults of hatchery origin on natural origin summer steelhead remain unknown, but broodstock for the hatchery fish originate in the basin now to reduce genetic impacts to natural populations such as outbreeding depression. Large numbers of hatchery origin fish do spawn downstream of the Mad River Hatchery each year, which increases competition for redds with natural origin fish and redd superimposition (CDFW 2016). Hatchery steelhead have also been documented to displace a large percentage of wild steelhead in some streams (McMichael et al. 1999) and they may directly prey upon smaller young-of-year wild steelhead. Other risks from hatcheries include disease transmission, alterations of migration behavior in wild fish, and genetic changes that affect subsequent fitness in wild populations such as reduced fitness and productivity of natural stocks (Waples 1991). Effects on summer steelhead should be explored.

Mining. Instream mining, especially in the leveed reach of lower Redwood Creek, has become necessary to maintain flood control conveyance as a result of inadequate levee design and increased sediment delivery to the stream. Humboldt County has mined gravel from this reach every year from 2004-2010, causing simplification of the channel, removal of pools and aquatic vegetation, and important shelter habitat (NMFS 2016). This threat was rated "high" for the most recent status review update.

Alien species. Non-native species are present in NC summer steelhead watersheds, and invasion of the Eel River system by Sacramento pikeminnow pose a threat to juvenile steelhead (Brown and Moyle 1997). Pikeminnow prey directly on and displace juvenile steelhead, pushing them from pool habitat into less desirable riffle habitat, resulting in reduced growth and survival.

In addition, reduced habitat connectivity and low water levels may increase susceptibility of summer steelhead to diseases (Power 2015) and predation, especially from river otters (*Lontra canadensis*, M. Sparkman, CDFW, pers. comm. 2016).

Factor	Rating	Explanation
Major dams	High	Major dams present on the Mad and Eel Rivers, which block access to significant important spawning and rearing habitat.
Agriculture	High	Conversion of estuarine wetlands to agricultural lands, diversions, influx of fertilizers and other pollutants into estuaries, especially for illegal marijuana cultivation.
Grazing	Medium	Some impacts in lowland areas, especially where estuary marshes have been converted to pasture.
Rural/ residential development	Medium	Effects localized, but increasingly an issue in Humboldt Bay tributaries.
Urbanization	Low	Increasingly an issue in the DPS.
Instream mining	Low	No known impact but occurs in some streams.
Mining	n/a	
Transportation	Medium	Roads are an ongoing source of sediment input, habitat fragmentation, and channel alteration.
Logging	Medium	Major activity, with dramatic historical impacts in many areas.
Fire	Low	Increased stream temperatures and sediment input may be a factor in some inland watersheds.
Estuarine alteration	High	Estuaries are vitally important rearing, feeding, and migrating habitat and have been significantly altered in most watersheds.
Recreation	Low	Mortality and sublethal impacts are likely through regulated, legal catch and release fishing.
Harvest	Low	Prohibited for all summer steelhead.
Hatcheries	Medium	Hybridization or competition with hatchery steelhead is possible but not well-studied recently.
Alien species	Low	Sacramento pikeminnow may play an increasing role in predation on juvenile salmonids in the Eel River watershed.

Table 2. Major anthropogenic factors limiting, or potentially limiting, viability of Northern California summer steelhead populations. 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 unlikely as a result. Certainty of these judgments is moderate based on peer reviewed and gray literature, direct observation, expert judgment, and anecdotal information. See methods for explanation.

Effects of Climate Change: Climate change is a major threat to the continued persistence of NC summer steelhead. In general, climate change will impact the freshwater habitat of steelhead in several important ways:

1. Increased runoff and flooding, scouring redds
2. Higher stream temperatures reducing habitat quality and survival
3. Lower stream flows reducing habitat quantity and accessibility
4. Earlier spring snowmelt reducing juvenile outmigration success
5. Altered ocean circulation and productivity reducing sub-adult growth and survival in the marine environment (decrease in smolt to adult survival)
6. Higher stream temperatures and flows creating thermal and velocity migration barriers to juveniles and adults in both marine and freshwater
7. Increased frequency and intensity of catastrophic wildfires, threatening salmonid survival with attendant erosion, mass wasting, etc.
8. Altered woody debris availability and characteristics reducing holding areas for juvenile salmonids
9. Higher temperatures shifting range of suitable habitat northward in ocean and freshwater habitats
10. Increased eutrophication of estuaries that serve as important nurseries and foraging habitat for juvenile and sub-adult salmonids

To summarize the recent NMFS findings on climate-related impacts to NC steelhead, the primary concerns focus on altered streamflows and warmer temperatures, which reduce survival and passage through reductions in suitable holding, spawning, and rearing habitat. These impacts can reduce life history diversity, further stressing low populations of summer steelhead (NMFS 2016). NMFS considered summer-run steelhead in the DPS separately from winter-run fish, due to their increased susceptibility to redd scour due to timing of spawning and necessary holding in mainstem rivers during the warmest months of the year (NMFS 2016). Summer steelhead were found to be more vulnerable to these impacts than winter fish in “most (if not nearly all) cases” (NMFS 2016, Appendix B, pg. 21). Using a threat vulnerability analysis, NOAA Fisheries forecast that NC summer steelhead populations in the Redwood Creek, Van Duzen River, North and South Fork Eel, and Mattole are all highly susceptible to climate change impacts in the near future (NMFS 2016). These impacts are already being seen throughout the DPS range, and are limiting suitable upper watershed habitat for summer steelhead. Persistence of these populations is likely only with increased protection and restoration to improve stream flows, allow accessibility to prime holding and spawning habitat, and maintain cool temperatures in headwater tributaries for both spring Chinook salmon and summer steelhead.

Modeling of high greenhouse gas emissions scenarios have forecast increasing frequency and duration of critical drought, which exacerbates and compounds these impacts by reducing overall streamflow and increasing the variability in timing of precipitation events in California (NMFS 2016). As a result, Northern California summer steelhead may experience local extinctions and range contractions since higher gradient or elevation headwater streams are inaccessible behind falls, boulder fields, or dams in the DPS. Ongoing drought in California has likely contributed to a dip in populations of summer steelhead in the DPS, as lower flows and warmer summer water temperatures likely caused increased mortality before spawning. Persistent drought is likely to exacerbate already acute problems associated with depletion of summer baseflows, reduction of coldwater refugia, or even stream dewatering during the late summer and early fall months by reducing spawning, rearing, and migration habitat. More frequent and severe droughts are likely to contribute to higher occurrences of low summer baseflows that fuel toxic cyanobacteria blooms and degrade food webs that oversummering adult steelhead and juveniles depend on (Power et al. 2015). If summer temperatures increase during summer and early fall month and precipitation and prevalence of fog decrease, as has been observed in Northern California over the last fifty years, stream temperatures will rise and further stress summer-rearing salmonids and summer steelhead holding in pools (Madej 2011).

Drought and poor ocean conditions tied to climate change and El Nino conditions likely caused some decline in salmonid populations across the state by reducing coldwater upwelling and food availability (Daly et al. 2013, Williams et al. 2016). Changes in precipitation patterns could lead to flooding, contributing sediments from highly erodible terrain that smothers valuable gravel and fills in pool habitat. As populations continue to decline and become more fragmented, stochastic events such as increased catastrophic fire may change genetic structure, breeding, and population dynamics in ways that are unrecoverable.

Status Score = 1.9 out of 5.0. NC summer steelhead have a high risk of extinction in the next 50 years without significant restoration and intervention (Table 2). The entire DPS, which includes winter steelhead, was listed as threatened under the Federal Endangered Species Act on June 7, 2000 (NMFS 2000), a status that was reaffirmed on January 5, 2006 (NMFS 2006). They are considered a Sensitive Species by the U.S. Forest Service. This status could deteriorate rapidly if restoration and protection efforts are not put into effect. NC summer steelhead currently have no special conservation status within the state of California, but should be officially recognized as threatened under the California Endangered Species Act by the Fish and Game Commission or at least declared a state Species of Special Concern.

Metric	Score	Justification
Area occupied	2	Much diminished from historical distribution.
Estimated adult abundance	2	Likely fewer than 1,000 adults across the DPS in a given year.
Intervention dependence	3	Require continuous monitoring and significant improvement of habitat and accessibility for recovery.
Environmental tolerance	2	Adults require coldwater refuges and pool habitat with cover that is free from human intervention.
Genetic risk	2	Spatial and temporal segregation between summer and winter fish make this life history susceptible to extinction.
Climate change	1	Highly vulnerable; temperatures and flows already marginal in many areas and summer steelhead require cold water in the warmest months to survive to spawn.
Anthropogenic threats	1	3 High and 5 Medium threats. Sufficient flows and temperatures are rapidly disappearing in the DPS.
Average	1.9	13/7.
Certainty	2-3	Actual numbers of fish poorly known.

Table 3. Metrics to determine the status of Northern California summer steelhead, where 1 is poor value and 5 is excellent and 2-4 are intermediate values. Certainty of these judgments is moderate. See methods for explanation.

Management Recommendations: Northern California summer steelhead are trending downward over time, and require significant action to recover from legacy impacts of road building, logging, forest fires, poor water quality, and disjointed land use throughout their range. Increasing rural development and illegal diversions and withdrawals for illegal marijuana cultivation throughout the DPS range, coupled with five years of ongoing historic drought, have significantly stressed summer steelhead populations and have driven their decline. Other threats across diversity strata include dearth of large woody debris and cover for rearing fish, abundance of roads and railroads adjacent to sensitive watersheds and associated sedimentation/erosion, illegal diversion and degradation, presence of barriers to migration, and lack of sufficient high quality spawning and rearing habitat due to uncoordinated land use practices (NMFS 2016).

To ameliorate these threats, the NMFS Coastal Multispecies Recovery Plan for the NC steelhead DPS lays out a full suite of necessary recovery actions and essential partners (NMFS 2016). CDFW is currently revising a steelhead restoration and management plan, which will help compile threats and identify specific actions to restore and manage steelhead in California (Nelson 2016). However, lack of coordination and prioritization of specific actions to protect summer-run life history steelhead in California represents a major challenge. Although designation of ESUs and DPSs are based upon distinctiveness of life-history traits and distinguishing genetic characteristics, such distinctions are not guiding conservation of steelhead life history diversity at the watershed scale, which is essential for maintaining populations of summer steelhead in the future.

CDFW and NMFS have been developing a statewide coastal salmonid monitoring program on the North Coast. Developing consistent monitoring protocols, with comprehensive abundance and trend data for all salmonids is essential for assessing the viability and recovery of NC summer steelhead. In addition, California has made significant investments in North Coast watersheds by matching federal funds from the Pacific Coast Salmon Recovery Fund to provide annual grants for restoration activities through the Fisheries Grant Restoration Program. Coordination with the State Coastal Conservancy grant programs has also leveraged funds to meet identified habitat restoration needs. To that end, a major timberlands owner along California's coast, Mendocino Redwood Company, is implementing its Habitat Conservation Plan (HCP), which will cover 6 high priority watersheds for NC summer steelhead, as well as Chinook and Coho Salmon (Williams et al. 2016). While these efforts are important, there is a need to better integrate HCPs with other watershed-based management actions and restoration activities across basins.

California's historic drought has sparked emergency drought actions to help stem declining trends in fish abundance. Law enforcement has cracked down on illegal diversions for marijuana cultivation, violations of fishing closures and poaching, and other activities that negatively impact salmonid populations, especially summer steelhead (J. Fuller, NMFS, pers. comm. 2016). Partnerships between NGOs, local landowners, and municipalities have increased utilization of real-time sensors and helped reduce water diversions voluntarily from juvenile rearing habitat during critical summer periods (Lehr 2016). In the future, California can develop innovative approaches to conservation by utilizing available legal provisions, such as AB 2121, to maintain instream flows to protect fisheries resources downstream of water diversions (Williams et al. 2016). In 2015, Governor Brown allocated over $35M in emergency funding for CDFW to monitor water quality, conduct baseline population and stressor monitoring, and carry out juvenile fish rescues across the state during the drought. CDFW teamed up with the Mattole Salmon Group to relocate juvenile steelhead and coho salmon from isolated pools on Baker Creek, near Whitethorn, (Humboldt Co.) to another tributary of the Mattole River with sufficient flow in 2014 and 2015 (Fisheries and Aquatics 2016). In 2015, over 200 juvenile SONCC Coho Salmon and 300 juvenile steelhead were successfully relocated (Fisheries and Aquatics 2016).

Emergency fishing closures under CDFW Code of Regulations Title 14 were enacted in the last three years throughout watersheds in the DPS range due to concerns over low flows and dissolved oxygen levels, high water temperatures, reduced fish passage, and increasing rates of disease and infection among already-stressed steelhead populations (Nelson 2016). Through the dedicated work of NOAA Fisheries, CDFW, the Native Fish Society, CDFW, and others, the low-flow closures for the Northern California steelhead DPS were amended by the California Fish and Game Commission to better reflect real-time changes in streamflow in the flashy systems most common in the geographic range. Now, the gages on the more representative Noyo and Navarro Rivers are used as triggers for low flow closures instead of utilizing the managed flows of the Russian River below Lake Sonoma (D. DeRoy, Native Fish Society, pers. comm. 2016). These actions have reduced poaching and targeted fishing over stressed individuals, but are not sufficient to allow these fish to recover or persist long term (J. Fuller, NMFS, pers. comm. 2016).

Perhaps the single greatest opportunity for increasing robust runs of wild salmon and steelhead in California remains large scale restoration and recovery of the Eel River through implementation of action items prioritized by the Eel River Forum. This ecosystem scale approach to managing salmonid and nonnative fish in the Eel River is essential to maintain the steelhead population in the tributaries and forks of this basin in the long term. The Eel River Forum, a partnership of resource users, landowners, managers, residents, and others, recently released its Eel River Action Plan, which will "coordinate and integrate conservation and recovery efforts in the Eel River watershed to conserve its ecological resilience, restore its native fish populations, and protect other watershed beneficial uses" (Eel River Forum 2016). Key action items identified in by the Forum include:

1. Evaluate flow releases from Potter Valley project
2. Prioritize block flow releases below the project to assist out-migrating salmon and steelhead in the spring
3. Evaluate extent of pikeminnow invasion and impacts on salmonids
4. Explore and document salmonid habitat upstream of Scott Dam
5. Determine water dynamics and quality for Lake Pillsbury
6. Evaluate potential use of PG&E lands for salmon and steelhead habitat restoration implementation
7. Understand past and future potential carrying capacity of the Eel watershed for salmonids and how proposed projects would impact it
8. Consider potential changes to operations during FERC relicensing of the Potter Valley Project, slated to begin in April 2017

Hatchery operation can also play a role in conservation of Northern California summer steelhead on the Mad River. Further monitoring, including implementation of the hatchery genetic management plan, should be undertaken to minimize the risks associated with the operation of hatcheries on naturally-produced NC summer steelhead. Implementation of the Mad River Hatchery Genetic Management Plan (2016) is essential for recovering wild winter steelhead in the DPS. Use of broodstock of Mad River basin fish and reduced numbers of fish should reduce interactions between natural origin fish and hatchery origin fish, giving wild steelhead a foothold to recover in the watershed.

Innovative, large-scale restoration activities that seek to regulate land use, manage sediment transport and input into streams, restore floodplain and estuary function as rearing habitat, and re-introduce large woody debris instream have occurred throughout the DPS range in the last several years. For example, a decades-long, multi-stakeholder project on the Salt River, in the Eel River estuary, continues to create valuable habitat for rearing fish on floodplain habitat purchased from a willing cattle rancher. Restoration of the stream-estuary ecotone of the Elk River, seasonal flooding of marginal agricultural lands, and construction of off-channel habitats on Salmon and Jacoby creeks, have created habitat that is used seasonally by over 17 species of fish (including federally threatened species like Coho Salmon and tidewater goby) and helps support a relatively intact native fish assemblage (Taylor 2015, Scheiff et al. 2016). In September 2013, over 100 whole large conifers and their intact root wads were planted strategically instream to provide scour pools, velocity refuge, and foraging and rearing cover for juvenile salmonids. By allowing large woody debris to interact with flows, the river itself can generate habitat complexity in the form of side-channels, scour pools, and meanders to provide rearing habitat for juveniles and resting areas for migrating adults (Mattole Salmon Group 2015). These types of cutting-edge projects are scaling from proof of concept to become replicable across watersheds, and are essential to recovery of NC summer steelhead. While such projects are important to test ideas and strategies, more coordinated and extensive restoration is required to bolster wild salmonid populations.

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