Northern California steelhead

Overall vulnerability—Moderate (94% Moderate, 6% High)
Biological sensitivity—Moderate (94% Moderate, 6% High)
Climate exposure—High (100% High)
Adaptive capacity—High (2.4)
Data quality—58% of scores ≥ 2

	Northern California Steelhead	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Early life history	1.9	2.3	
	Juvenile freshwater stage	2.7	2.3	
	Estuary stage	2.7	1.8	
	Marine stage	2.4	1.8	
	Adult freshwater stage	2.2	2.3	
	Cumulative life-cycle effects	1.9	2	
	Hatchery influence	2.7	1.8	
	Other stressors	2.9	1.8	
	Population viability	2.6	2.3	
	Ocean acidification sensitivity	1.9	0.5	
	Sensitivity Score	Moderate		
Exposure variables	Stream temperature	2.7	2.3	
	Summer water deficit	2.5	2	
	Flooding	3.1	1.8	
	Hydrologic regime	1.5	2.3	
	Sea level rise	2.8	2	
	Sea surface temperature	3.4	2	
	Ocean acidification exposure	4	3	
	Upwelling	2.5	1.5	
	Ocean currents	1.9	1	
	Exposure Score	High		
	Overall Vulnerability Rank	Moderate		

Low
Moderate
High
Very High

Life History Synopsis

Northern California Coast steelhead adults exhibit both summer- and winter-run migration timing. In larger watersheds such as the Mad and Eel River, freshwater entry for winter-run fish can occur as early as September or October, whereas in smaller watersheds (some subject to bar formation), entry typically begins in December and continues into April or May (Busby et al. 1996). Neither flow nor temperature is generally problematic for winter-run adults. Summer-run populations migrate primarily from April to June or July (Moyle et al. 2008). Migration distances range from a few kilometers in systems such as Redwood Creek to more than 250 km in the Middle Fork Eel River, and distances were even longer prior to dam

construction. Summer-run adults depend on cold-water refuges that often occur at tributary junctions or in thermally stratified pools (Nielsen et al. 1994, Moyle et al. 2008).

Age at maturity varies considerably within and among populations of Northern California steelhead. The predominate life history of winter-run spawners includes 2 years in fresh water and 1-2 years at sea; however, fish may spend anywhere from 1-3 years in fresh water and up to 3 years at sea (Busby et al. 1996). Additionally, adults may survive to spawn a second or third time. Progeny of summer-run adults remain in fresh water 1-3 years, with 2 years being most common, and spend 1-3 years at sea, with 1-2 years being most common.

Non-anadromous individuals add to the suite of life histories in this DPS. Additionally, the DPS includes a "half-pounder" life history where fish migrate to sea for 2-4 months, return to fresh water to overwinter in non-reproductive condition, and then return back to sea. The "half-pounder" type is found in the Eel and (possibly) Mattole Basins (Snyder 1925, Moyle et al. 2008). During the marine residence period, steelhead moves rapidly offshore and is widely distributed across the subarctic North Pacific (Myers 2018). Juvenile steelhead typically move rapidly through estuarine habitats (Hayes and Kocik 2014, Myers 2018). However, for rivers in this DPS, ocean access can be intermittently blocked by barrier sandbars, forcing fish to inhabit lagoons until ocean access is restored (Hayes and Kocik 2014).

Climate Effects on Abundance and Distribution

In general, flood risk exposure was higher for DPSs in California than for those in the Pacific Northwest. Climate-related concerns from flooding include redd scour during high flows and deposition of fine sediments in spawning gravels. Risk of redd scour is exacerbated when large wood and other structural elements are lacking, and both concerns will be affected by rainfall intensity and frequency and shifts in the timing of peak flows. Despite these potential risks, Northern California steelhead ranked ***low*** in sensitivity during *early life history* (egg stage), likely due to spawn timing being somewhat after peak flooding.

Present low flow conditions during spring can result from low snowpack or low spring precipitation. Such conditions can hinder migration of adult summer steelhead, causing them to over-summer in suboptimal (i.e., warmer) habitats lower in the watershed. Such behavior has been observed in Northern California steelhead in the Van Duzen and Middle Fork Eel Rivers (S. Thompson and S. Harris, CDFW, pers. commun.). Summer-run steelhead were considered to have higher vulnerability to climate change in the California multi-species recovery plan because of additional exposure over summer to high stream temperatures.

Exposure to *stream temperature* and sensitivity at the *juvenile freshwater stage* both ranked ***moderate***. Sensitivity of steelhead was ranked lower than that of Chinook and coho because steelhead tend to use habitat over a broader range of temperatures than these other species (Myrick and Cech Jr 2001).

Steelhead use lagoons extensively (Zedonis 1992, Cannatta 1998, Wallace and Allen 2007, 2015), and thus are likely to be sensitive to changes in their dynamics. Poor water quality (high temperature, low dissolved oxygen, high salinity) can limit use of lagoons in some watersheds and at certain times of the year (J. Kiernan, NMFS SWFSC, unpub. data.). Lagoon water quality is dictated by complex interactions between stream flow, over-bar exchange of marine water, breaching dynamics of sand bars, wind, and other factors. These processes affect the relative quantity of fresh and saline waters and the degree of mixing, which in turn affects salinity-driven stratification of the water column with the potential to create anoxic conditions (Atkinson 2010). In extreme cases, mixing of anoxic waters that occurs with breaching of sand bars has been known to cause fish kills (Smith 2009). However, there was uncertainty in how climate change would affect these dynamics because of the interaction between sea level rise, air temperature rise, and a change in precipitation (see additional discussion in *Central California Coast coho, Climate Effects* section). Once they enter the ocean, steelhead smolts tend to move offshore relatively quickly, heading primarily in a northward direction (Hayes and Kocik 2014). In sum, Northern California steelhead sensitivity was ranked ***moderate*** in the *estuary stage*, with ***moderate*** exposure to *sea level rise*.

Exposure was rated ***high*** for changes in *sea surface temperature* because changes in temperature across the entire marine range of this species are projected to exceed two standard deviations. Exposure to *ocean acidification* was rated ***very high*** because it exceeded 14 standard deviations across the marine range.

Overall the ***moderate*** vulnerability score for this DPS reflected long periods of exposure to change in the freshwater and marine environments (multiple years per juvenile), tempered by moderate sensitivity via tolerance for warm conditions, reproductive timing that avoids peak temperatures, and the ability to wait for intermittent precipitation events (in winter-run steelhead). Increased summer warming would likely reduce or eliminate some populations of summer-run steelhead due to loss of over-summering habitat. Over-summering adults are likely at higher risk within this DPS.

Extrinsic Factors

Sensitivity to *hatchery influence* was ranked ***moderate***. The Mad River Hatchery is the only active hatchery program in the geographical range of Northern California Coast steelhead. However, this hatchery stock was established with out-of-basin broodstock, primarily from the Eel River, and is not considered part of the DPS. Outbreeding between hatchery and wild steelhead in the Mad River is considered a significant risk factor, as in some years hatchery-origin steelhead may constitute more than 60% of spawners in the Mad River and its tributaries (Spence 2016).

The Northern California steelhead DPS is listed as threatened under the U.S. Endangered Species Act, and was therefore ranked ***moderate*** for *population viability* (Spence 2016). Sensitivity to *other stressors*, including fisheries and invasive species, was ranked ***moderate***. There is no directed commercial or recreational ocean fishing on natural-origin stocks in this

DPS, and ocean harvest is thought to be relatively rare. Recreational fishing for steelhead occurs in many rivers within this DPS. Regulations prohibit retention of natural-origin Northern California steelhead in these fisheries; however, retention of hatchery-origin steelhead is allowed. Incidental mortality from these recreational fisheries is poorly documented (Spence 2016). Water diversion, land use practices, pesticides, invasive species (striped bass and pikeminnow), and dams on the Eel and Mad Rivers were identified as threats (Moyle et al. 2008, NMFS 2015).

The *Multispecies Recovery Plan* identified the quality and extent of juvenile rearing habitat in estuaries and lagoons as in poor condition compared to other components of their habitat for a majority of populations in this DPS, as well as in Central California Coast steelhead and California Coastal Chinook.

Adaptive Capacity

Northern California steelhead was ranked ***high*** in adaptive capacity because of its substantial life-history diversity, which includes both winter- and summer-run run types, as well as a wide age range for smolt migration and maturation. Although other coastal steelhead have similar life histories, this DPS benefits from less xeric ecosystems than other California steelhead, which might provide the Northern California steelhead DPS with a greater buffer from extreme conditions with climate change.

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