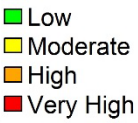
# Steelhead (*Oncorhynchus mykiss*)

## Southern California Coast steelhead

Overall vulnerability—High (99% High, 1% Very high)
Biological sensitivity—High (100% High)
Climate exposure—High (99% High, 1% Very high)
Adaptive capacity—Low (1.56)
Data quality—63% of scores ≥ 2

| | Southern California Steelhead | Expert Scores | Data Quality | Expert Scores Plots (Portion by Category) |
|---|---|---|---|---|
| Sensitivity attributes | Early life history | 1.8 | 2.3 | |
| | Juvenile freshwater stage | 2.8 | 2.5 | |
| | Estuary stage | 2.8 | 1.8 | |
| | Marine stage | 2.5 | 1.5 | |
| | Adult freshwater stage | 2.3 | 2.5 | |
| | Cumulative life-cycle effects | 2.6 | 2.3 | |
| | Hatchery influence | 1.4 | 1.8 | |
| | Other stressors | 3.5 | 2 | |
| | Population viability | 3.4 | 2.3 | |
| | Ocean acidification sensitivity | 1.9 | 0.5 | |
| | Sensitivity Score | High | | |
| Exposure variables | Stream temperature | 2.7 | 2.3 | |
| | Summer water deficit | 2.7 | 2.3 | |
| | Flooding | 3.3 | 1.8 | |
| | Hydrologic regime | 1.3 | 2.3 | |
| | Sea level rise | 3.1 | 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 | High | | |




### *Life History Synopsis*

For Southern California Coast steelhead, spawning primarily occurs from January through April and incubation from January through May. Juveniles probably migrate as mix of ages 1 and 2, but juvenile age class is poorly known. These populations are likely highly opportunistic in their movement patterns due to the natural uncertainty of rainfall and migration flows in the region. Small estuaries of numerous coastal streams provide key rearing habitat for the important "lagoon anadromous" life-history, especially in summer and early fall (Boughton et al. 2007a, Hayes et al. 2008). In addition to the anadromous life-history, depending on local environmental conditions varying proportions of populations may also pursue the

freshwater-resident life history, reaching sexual maturity without migrating to the ocean.

Ocean migrations are poorly understood, but limited data indicate that fish from this DPS travel to the central subarctic North Pacific Ocean (Burgner 1992, Hayes and Kocik 2014). In general, North American steelhead undergo extensive ocean migrations into the Gulf of Alaska and subarctic North Pacific Ocean, with an absolute thermal range of 2.8-15.8°C for all seasons and a frequently observed range of 6-12.5°C from spring to fall and 5-11°C during winter (Abdul-Aziz et al. 2011, Myers 2018). Typical age at maturity is thought to vary between 2 and 4 years, but among-year variation in age class is not well understood.

## *Climate Effects on Abundance and Distribution*

The Southern California Coast steelhead DPS encompasses the southern range limit of the species, inhabiting coastal stream systems down to the Tijuana River at the U.S. border with Mexico, and with scattered outlying populations on the Pacific coast of the Baja California peninsula. Migration and life history patterns are strongly constrained by geographic patterns of rainfall and surface flow in this arid region. Rainfall is substantially lower and more variable than in regions to the north, and very rarely occurs in summer, resulting in a natural pattern of disconnected surface flows during the dry season and in dry years. Disconnections are structured by geomorphic processes, typically occurring in low-gradient alluvial channels, tributary junctions, and estuary mouths where sediment tends to accumulate. Thus, some of the most secure habitats are steep highland creeks, which are both cool and well-watered, but frequently disconnected from the ocean. The species appears to be locally adapted to this challenging landscape, primarily by exhibiting resilient physiology and by retaining life-history plasticity that allows individuals to opportunistically pursue either a freshwater-resident or anadromous life history.

A critical limit seems to be the ability of parr to grow rapidly and attain the smolt stage at a large size, since large smolts have significantly higher rates of survival to adulthood (Boughton et al. 2015). Sensitivity scores for the juvenile freshwater and estuary stage were ranked ***moderate***, while other life stages were ranked low. Exposure to sea level rise was ranked ***high*** due to the risk of losing critical lagoon rearing habitat.

Although this DPS occurs in relatively warm and xeric stream systems, it has never been shown to have higher thermal tolerance than the rest of the species. Instead, perennial creek habitats where the species occurs typically have peak daily temperatures lower than 18°C (Boughton et al. 2007b). These stream temperatures are buffered by evapotranspiration in the riparian tree canopy (Boughton et al. 2012) or by upwelling in the nearby Pacific Ocean. However, juvenile *O. mykiss* have been documented to withstand peak daily temperatures up to ~29-30°C in the aftermath of a canopy-replacing wildfire (Sloat and Osterback 2013), suggesting the capacity for high thermal tolerance during extreme events. Exposure scores were ranked ***moderate*** for *stream temperature* and *summer water deficit*, primarily because of the link between summer climate and the *upwelling* regime in the adjacent Pacific Ocean, which was also

ranked ***moderate***. At the same time, the spread in expert scores was relatively high, reflecting greater uncertainty about the stability of these habitats in the face of climate change.

Flood risk exposure was ranked ***high*** for this DPS. Many river channels that serve as migration routes for this DPS are dry or have sections that are dry except immediately after winter storms. Therefore, migration occurs only during the brief periods after these storms and may not occur at all in dry years due lack of surface flow. Some years see large numbers of adults trapped in fresh water before they can migrate back to the ocean (Barnett and Spence 2011). Streamflow between storms is the primary climate-driven barrier to migration. Water velocities and sedimentation during winter storms may also limit survival (Boughton et al. 2009, Boughton et al. 2015), depending on habitat conditions; particularly important in such storms are large roughness elements such as boulders and coarse wood, which provide velocity refugia.

Abdul-Aziz et al. (2011) developed spatially explicit representations of open ocean thermal habitat for steelhead. They found that under a multi-model ensemble average of climate model outputs using the A1B emissions scenario, summer habitat area for steelhead declined by 36% for the 2080s, with the largest habitat losses in the northeast Pacific Ocean. Wintertime habitat area losses were 2%, with reductions at the southern end of the historical range largely offset by gains in the Bering Sea and Sea of Okhotsk. Whether a general northward and westward displacement of thermal open-ocean habitat will have substantial impacts on the life-cycle productivity or spawning distribution of West Coast steelhead is not known. However, these populations are vulnerable to the projected displacement of high seas thermal habitat. Thus, exposure to *sea surface temperature* was ranked ***high*** and sensitivity in the *marine stage* ranked ***moderate***.

## *Extrinsic Factors*

Southern California Coast steelhead was ranked ***high*** for *other stressors*. Major threats to this DPS include water withdrawals for agriculture and domestic use. Such withdrawals reduce streamflows and can make channels shallow or dry them outright; they can lower water tables enough to kill riparian vegetation and destabilize channels. Extensive channelization in habitats occupied by this DPS has reduced vegetative shading and hyporheic exchange, in many cases, stream banks have been completely replaced with concrete. There are many invasive species, especially in the urbanized areas of Los Angeles and San Diego, and rivers such as the Santa Ynez that are managed for summer agricultural water supply (Moyle 2002, Marchetti et al. 2004, Robinson et al. 2009).

Fisheries impacts on Southern California Coast steelhead are thought to be low, with recreational fisheries limited to streams above impassable barriers. Poaching during low-flows may be a problem in some streams, particularly in the disconnected pools of urban areas during the summer low-flow season or between storms during the migration season. In addition, there are many geomorphic stressors: sea level rise interacts with coastal urban development, especially around estuaries; floodplains disconnected via levees exacerbate extreme flashiness in streamflows; dams sequester sediment in streams where arid climate and flashy storms produce

large movements of sediment. Additional habitat loss is related to the presence of an invasive plant (*Arundo*) that uses much water and traps fine sediments. There are numerous infrastructure barriers to dispersal. Finally, anthropogenic breaching of lagoon/estuary systems is an additional threat to populations in this DPS. All of these threats are exacerbated by climate change because it will reduce usable habitat throughout the range of this DPS (Moyle et al. 2017, p. 327.).

Southern California Coast steelhead is listed as endangered under the Endangered Species Act, and sensitivity to *population viability* was ranked ***high***. Abundance, productivity, spatial structure, and diversity are all at high risk for this DPS. No hatcheries are present in this DPS, but hatchery supplementation is being discussed.

## *Adaptive Capacity*

This DPS has already evolved life-history flexibility to deal with the challenges of a warm and arid climate, including coexistence of anadromous and resident forms in the same population. However, because habitat is already so limited, there is little room for future adaptation, and adaptive capacity ranked ***low***. Moyle et al. (2017) came to a similar conclusion.

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