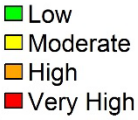
Central California Coast steelhead

Overall vulnerability—Moderate (65% Moderate, 35% High)
Biological Sensitivity Moderate (65% Moderate, 35% High)
Climate exposure—High (100% High)
Adaptive capacity—Moderate (2.0)
Data quality—58% of scores ≥ 2

	Central California Coast Steelhead	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Early life history	1.7	2.3	
	Juvenile freshwater stage	2.5	2.3	
	Estuary stage	2.9	1.8	
	Marine stage	2.1	1.8	
	Adult freshwater stage	1.8	2.5	
	Cumulative life-cycle effects	1.9	1.8	
	Hatchery influence	2.4	2	
	Other stressors	3	1.8	
	Population viability	2.9	2	
	Ocean acidification sensitivity	1.9	0.5	
	Sensitivity Score	Moderate		
Exposure variables	Stream temperature	2.7	2.3	
	Summer water deficit	2.7	2	
	Flooding	3.1	1.8	
	Hydrologic regime	1.3	2.3	
	Sea level rise	3	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		



Life History Synopsis

The Central California Coast steelhead DPS exhibits considerable life history variation, though all adult migrations occur during winter (Moyle et al. 2017). Populations are found in streams below natural and man-made barriers from the Russian River south to Aptos Creek. Adults from this DPS enter rivers from October to May, depending on the system (Shapovalov and Taft 1954, Busby et al. 1996, Osterback et al. 2018), and can spawn soon after reaching spawning grounds. However, most spawning occurs during late spring, and thus avoids the damaging effect on redds of winter floods common to Central California Coast watersheds. In Waddell Creek, the majority of spawners are comprised of 3+ and 4+ year-old fish (35 and 46%, respectively); only 17% of Waddell Creek spawners spawned more than a single time

(Shapovalov and Taft 1954). Shapovalov and Taft (1954) identified 32 different combinations of freshwater/saltwater year type, although most were among the following four combinations: 2/1 (30%), 2/2 (27%), 3/1 (11%), and 1/2 (8%).

Central California Coast steelhead eggs hatch in 25-35 days, depending on temperature, and alevins emerge from the gravel as fry after 2-3 weeks. Fry move to the stream edges but switch to deeper water as they grow larger. The abundance of juveniles in tributaries to San Francisco Bay is positively correlated with elevation, stream gradient, dominant substrate size, and percent native species. Conversely, juvenile abundance is negatively correlated with stream order, average and maximum depth, wetted channel width, water temperature, water clarity, percent open canopy, conductivity, percent pool habitat, and total number of fish species (Leidy 2007).

Juveniles move downstream during all seasons of the year, though in smaller coastal systems, movement is limited during the low-flow periods of late summer and fall. Often, significant numbers of age-0 fish move downstream with the onset of fall rains, though it is likely that most take up residence in lagoons, rather than moving out to sea. The smolt migration typically takes place from February to May, with older age classes tending to migrate somewhat earlier in this window (Shapovalov and Taft 1954, Osterback et al. 2018). Some juveniles migrate to the estuary after spending only a few months in the upper watershed, while others spend 1-2 years rearing in the upper watershed. Both types of fish typically spend 1-10 months rearing in the estuary prior to ocean entry, although some smolts also migrate immediately to the ocean without estuarine occupancy. Juveniles undergo smoltification at sizes ranging from 90-150 mm FL or more.

Favorable conditions for rapid growth in occur in lagoons at the mouths of streams and in stream reaches with high summer flow. Juveniles often remain in such lagoons after they close, foregoing ocean access (Hayes et al. 2008, Bond et al. 2017). These fish experience high growth rates, often doubling in length; the mean FL of fall lagoon residents can be over 200 mm. Juvenile steelhead that are larger than 150 mm FL have a significant survival advantage in the ocean; they comprised 85% of the returning adult population in Scott Creek, although they comprised less than 50% of the population in the estuary.

Reconstructions from Central California Coast steelhead tagged with archival tags have indicated that these fish move rapidly offshore and are widely distributed across the subarctic North Pacific (Hayes et al. 2012). This pattern is consistent with high seas distributions of other West Coast steelhead populations (Myers 2018).

Climate Effects on Abundance and Distribution

Exposure scores ranked high due to ***high*** scores for *sea surface temperature*, *sea level rise*, and *flooding*, in addition to *ocean acidification*. Increased variability in winter flows may lead to increased risk of redd scour in flood years and lack of attraction flows in drought years. Sea level rise is an important threat because of heavy reliance on lagoon habitat for juvenile

rearing. Other predicted exposure problems faced by this DPS included increases in *stream temperature* and *summer water deficit*, both of which were ranked ***moderate***.

Overall sensitivity was ranked ***moderate*** for Central California Coast steelhead, but 35% of bootstrapped samples ranked ***high***. Both the *estuary* and *freshwater juvenile stage* were ranked ***moderate*** because these fish spend extended periods in both environments, residing 1-3 years in fresh water and often an entire year in lagoons. During these life stages, fish from this DPS are very sensitive to water quality and habitat access.

Extrinsic Factors

For Central California Coast steelhead, risk attributes related to climate change are superimposed on existing threats, such as dams and other impassable barriers, water diversions, agricultural development, urbanization, logging practices, and hatchery influence (Busby et al. 1996). These combined risk factors increase the likelihood of rapid extirpation as time passes without dramatic action to protect and enhance habitats. There is no directed commercial or recreational fishing for Central California Coast steelhead in the ocean. However, recreational fishing for steelhead occurs in several rivers within the range of this DPS. Regulations prohibit retention of natural-origin Central California Coast steelhead in these fisheries; however, retention of up to two hatchery-origin steelhead per day is allowed. Incidental mortality from these recreational fisheries is not well documented (Spence 2016). For these reasons, the *other stressors* attribute was ranked ***high***.

Central California Coast steelhead is listed as threatened under the U.S. Endangered Species Act. Quiñones and Moyle (2014) rated this DPS as "highly vulnerable" to climate change. This rating was a result of low population abundance, greatly reduced and fragmented stream flows, and highly altered watersheds.

Adaptive Capacity

Adaptive capacity was ranked ***moderate*** because Central California Coast steelhead presumably benefit from some buffering by resident rainbow trout populations in headwaters. These populations can produce individuals that go out to sea, and present a potential source of extensive life history variation. If conditions become unfavorable for the anadromous type, it is likely this DPS would shift towards a higher proportion of resident fish.

Literature Cited

Bond, M. H., P. A. H. Westley, A. H. Dittman, D. Holecek, T. Marsh, and T. P. Quinn. 2017. Combined effects of barge transportation, river environment, and rearing location on straying and migration of adult Snake River fall-run Chinook salmon. Trans Am Fish Soc **146**:60-73.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dep Commerce NOAA Tech Memo NMFS-NWFSC-27, Seattle, WA.

Hayes, S. A., M. H. Bond, C. V. Hanson, E. V. Freund, J. J. Smith, E. C. Anderson, A. J. Ammann, and R. B. MacFarlane. 2008. Steelhead growth in a small central California watershed: upstream and estuarine rearing patterns. Trans Am Fish Soc **137**:114-128.

Hayes, S. A., M. H. Bond, B. K. Wells, C. V. Hanson, A. W. Jones, and R. B. MacFarlane. 2012. Using archival tags in infer habitat use of central California steelhead and coho salmon. Pages 471-492 *in* J. McKenzie, B. Parsons, A. Seitz, R. Kopf, M. Mesa, and Q. Phelps, editors. Advances in fish tagging and marking technology. American Fisheries Society Symposium 76.

Leidy, R. A. 2007. Ecology, assemblage structure, distribution, and status of fishes in streams tributary to the San Francisco estuary, California. 530, San Francisco Estuary Institute Contribution No. 530, Richmond, CA.

Moyle, P. B., R. Lusardi, P. Samuel, and J. Katz. 2017. State of the salmonids: Status of California's emblematic fishes 2017. Center for Watershed Sciences, University of California, Davis and California Trout, San Francisco, CA. Available at http://caltrout.org/sos/.

Myers, K. W. 2018. Ocean ecology of steelhead. Page 1090 *in* R. J. Beamish, editor. The ocean ecology of Pacific salmon and trout. American Fisheries Society, Bethesda, MD.

Osterback, A.-M. K., C. H. Kern, E. A. Kanawi, J. M. Perez, and J. D. Kiernan. 2018. The effects of early sandbar formation on the abundance and ecology of coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Oncorhynchus mykiss)* in a central California coastal lagoon. Can J Fish Aquat Sci **75**:2184-2197.

Quiñones, R. M., and P. B. Moyle. 2014. Climate change vulnerability of freshwater fishes in the San Francisco Bay Area. San Fran Est Wat Sci **12**.

Shapovalov, L., and A. C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California and recommendations regarding their management. Calif Dep Fish Game Fish Bull **98**:275 pp.

Spence, B. C. 2016. North-Central California Coast Recovery Domain.*in* B. C. Williams, D. A. Spence, D. Boughton, R. C. Johnson, N. Crozier, M. Mantua, M. R. O'Farrell, and S. Lindley, editors. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. U.S. Dep of Commerce NOAA Tech Memo NMFS SWFSC 564, Santa Cruz, CA.