California Coastal Chinook

Overall vulnerability—High (2% Moderate, 86% High, 12% Very high)
Biological Sensitivity –High (3% Moderate, 97% High)
Climate exposure—High (88% High, 12% Very high)
Adaptive capacity—Low (1.56)
Data quality—42% of scores ≥ 2

	California Coastal Chinook	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Early life history	1.7	1.5	
	Juvenile freshwater stage	2.3	1.8	
	Estuary stage	2.8	1.8	
	Marine stage	2.6	1.8	
	Adult freshwater stage	2.5	2.8	
	Cumulative life-cycle effects	3.3	1.8	
	Hatchery influence	1.1	3	
	Other stressors	3.6	1.8	
	Population viability	3	3	
	Ocean acidification sensitivity	1.8	1.5	
	Sensitivity Score	High		
Exposure variables	Stream temperature	3.3	2	
	Summer water deficit	2.4	1.8	
	Flooding	3.5	1.3	
	Hydrologic regime	1	2.5	
	Sea level rise	3.3	2	
	Sea surface temperature	3.3	2	
	Ocean acidification exposure	4	2.5	
	Upwelling	3.3	1	
	Ocean currents	1.9	1	
	Exposure Score	High		
	Overall Vulnerability Rank	High		

Life History Synopsis

Fall-run adults of the California Coastal Chinook DPS migrate from September through December or January in larger rivers that remain open to the ocean all summer. In streams with bar-built estuaries, freshwater entry may be delayed until the onset of fall rains (Myers et al. 1998; S. Harris, CDFW, pers. commun.). Spawning generally occurs from October to December (Fukushima and Lesh 1998, Myers et al. 1998, M. Sparkman, CDFW, pers. commun.), and egg incubation from November into April.

Fall-run Chinook salmon produce primarily ocean-type juveniles that reside for less than a year in fresh water. These ocean-type juveniles migrate to estuaries or the ocean between March and August of their first year (Gallagher 2001, Chase et al. 2002, Gallagher 2003, Chase

et al. 2004, Gallagher 2004, Chase et al. 2005). Early migrants are often young fry smaller than 50 mm, whereas June and July migrants tend to be larger (~70 mm). A small fraction of juveniles reside for a full year in fresh water and migrate the following spring (Sparkman et al. 2016), probably due to variation in individual growth rates rather than to a genetically distinct life-history type.

Juvenile use of estuaries likely varies among populations of this DPS. Juvenile Chinook have been reported in Humboldt Bay throughout summer, suggesting several months of estuarine residence (Wallace and Allen 2009). Many stream systems have bar-built estuaries, with sand bars that recurrently close and open the marine connection, creating seasonal freshwater lagoons. The majority of juveniles probably enter the ocean before bar formation occurs, typically by late July, but some remain in the lagoon until connectivity to the ocean is reestablished by the return of the wet season in October or November (Madej et al. 2012).

In the ocean, California coastal Chinook remain primarily between Pt. Reyes and southern Oregon, with highest abundances in the Fort Bragg and Klamath subareas (Satterthwaite et al. 2014b, Bellinger et al. 2015, Satterthwaite et al. 2015). Most fish appear to mature at age 3 or 4, with 2-year-old jack males making up 5-11 % of returns (Myers et al. 1998). Interannual variation in the percentage of each life-history type can be substantial.

Climate Effects on Abundance and Distribution

In fresh water, the interaction between changes in precipitation and warming will likely have effects that propagate through the life cycle of California coastal Chinook. Sensitivity to *cumulative life-cycle effects* ranked ***high***. Changes in the timing and magnitude of fall storms could adversely affect the ability of migrating adults to enter streams and navigate to spawning areas. These conditions merited ranks of ***high*** exposure to *flooding* and ***moderate*** sensitivity for the *adult freshwater stage*. For the *early life history* (egg stage), likely climatic threats include redd scour during high flows (exacerbated by habitat degradation) and deposition of fine sediments in spawning gravels, both of which will be affected by rainfall intensity and frequency (NMFS 2015). Additionally, incubation rates are dependent on water temperature (Murray and McPhail 1988); thus, accelerated development and early emergence will occur in a warmer climate. *Stream temperature* and *hydrologic regime* shift could be limiting for the fraction of juveniles that migrate downstream in summer or spend a full year in fresh water, and exposure to *stream temperature* ranked ***high***. Climate change could also affect estuarine habitat quality, especially in the summer dry season, and sensitivity in the *estuarine stage* ranked ***moderate***.

The first spring and summer at sea is considered a critical period when most mortality at sea occurs (Beamish and Mahnken 2001, Wells et al. 2012). Factors affecting survival are complex and multi-scale. The state of the North Pacific High (NPH) during winter influences subsequent productivity (Schroeder et al. 2009, Black et al. 2011, Thompson et al. 2012, Schroeder et al. 2013), with a strong NPH maintaining both nutrient levels and an abundant and diverse diet portfolio (Thayer et al. 2014). Timing of the spring transition, and the intensity and consistency of upwelling (also affected by the NPH) dictate the development, maintenance, and

retention of krill populations and forage fish, as well as affecting potential predators of salmon (Fiechter et al. 2015). Because of the complexity of interactions operating at different scales, attempts to directly correlate survival to individual environmental variables have not been especially successful. However, the timing, intensity, and duration of upwelling are clearly key factors that are likely to be affected by changing climate (Satterthwaite et al. 2014a). Exposure to mean sea *surface temperature* and *upwelling* both ranked ***high***, while sensitivity in the *marine stage* ranked ***moderate***.

Extrinsic Factors

Historically, the California Coastal Chinook DPS included both spring- and fall-run stocks, but the spring-run has been extirpated. This DPS is listed as threatened under the U.S. Endangered Species Act (Spence et al. 2008, Spence 2016). Sensitivity to *population viability* ranked ***moderate*** to ***high***. Sensitivity to *other stressors* ranked ***high***. Threats include dams on the Eel and Russian Rivers that block access to habitat and incidental harvest. Incidental harvest is regulated, but its impacts remain highly uncertain (O'Farrell et al. 2012, O'Farrell et al. 2015), and indirect mortality from catch-and-release of undersized fish, as well as bycatch in non-salmon fisheries, have been identified as concerns (NMFS 2015).

In fresh water, warm-adapted invasive species are likely to gain advantage with climate change and prey on juvenile Chinook salmon or limit their use of preferred habitat. Such species include smallmouth bass, striped bass, and channel catfish (NMFS 2015), as well as Sacramento pikeminnow. Migrating adult Chinook salmon are commonly intercepted by recreational fishing in the Eel and Russian Rivers (NMFS 2015). Although caught fish must be released, capture and handling occurs during periods of thermal stress and has an impact that is likely to increase with climate change.

Adaptive Capacity

Overall, adaptive capacity ranked ***low*** for California Coastal Chinook. Increased summer warming would likely reduce opportunities for re-expression of the spring-run life history (currently extirpated), as conditions in summer holding pools would become less favorable.

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