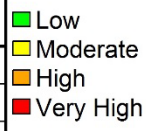
Central Valley spring-run Chinook

Overall vulnerability—Very high (100% High)
Biological sensitivity—Very high (1% High, 99% Very high)
Climate exposure—High (78% High, 22% Very high)
Adaptive capacity—Low (1.56)
Data quality—53% of scores ≥ 2

	Central Valley spring-run Chinook	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Early life history	2	1.5	
	Juvenile freshwater stage	2.8	1.8	
	Estuary stage	3.4	2	
	Marine stage	2.6	1.8	
	Adult freshwater stage	3.8	3	
	Cumulative life-cycle effects	3.8	2.8	
	Hatchery influence	3.7	3	
	Other stressors	3.6	2.3	
	Population viability	3.5	2.8	
	Ocean acidification sensitivity	1.8	1	
	Sensitivity Score	Very High		
Exposure variables	Stream temperature	3	2	
	Summer water deficit	3	1.8	
	Flooding	3.3	1.3	
	Hydrologic regime	2.9	1.8	
	Sea level rise	3.5	2.3	
	Sea surface temperature	3.4	2	
	Ocean acidification exposure	4	2.5	
	Upwelling	3.3	1	
	Ocean currents	1.9	1	
	Exposure Score	High		
	Overall Vulnerability Rank	Very High		



Life History Synopsis

Central Valley spring-run Chinook adults migrate past the Golden Gate and up the Sacramento River from late January to early February, reaching spawning areas from March through June, after which they hold in cold, deep pools to mature during summer (CDFG 2003-2012). Spawning occurs in fall, and eggs incubate from about September to the following March. Juveniles migrate downstream throughout spring of the same year they hatched, although a small portion remains through summer and enters the ocean the following spring.

Historically spring-run Chinook occurred in most river systems of the Sierra Nevada, but wild populations have been extirpated from all but three relatively small tributaries of the Sacramento River (Mill, Deer, and Butte Creek), each of which is about 500 km from the ocean.

A hatchery stock occupies the Feather River, but is assumed to be a major threat to the genetic integrity of wild spring-run Chinook due to interbreeding and hybridization in the hatchery between spring-run and fall-run fish (Johnson and Lindley 2016).

Some age-0 juveniles rear in natal creeks while others are thought to rear downstream in the Sutter and Yolo Bypasses (flood-control channels), the Sacramento River, or the Sacramento-San Joaquin Delta. The Sacramento-San Joaquin Delta is a geographically extensive, highly engineered, and decidedly altered estuary draining nearly the entire Central Valley watershed. It is not known but commonly assumed that some or even many spring-run age-0 juveniles could rear in the delta. Therefore, even though estuary rearing time is unknown, some juveniles likely forage for a month or more in the estuary while others simply migrate through (CDFG 1998, Brandes and McLain 2001, Whipple et al. 2012). The number of age-0 juveniles that rear in the delta is poorly estimated because the only method of detection (rotary-screw-trap data) to identify spring-run fish is based on length-at-date-criteria, which are inaccurate (Brandes and McLain 2001, Harvey et al. 2014).

Central Valley spring-run Chinook has a relatively broad ocean distribution from central California to Cape Falcon, Oregon, similar to that of the fall run (Satterthwaite et al. 2015). Adults return to fresh water at age 2, 3, or 4, with the majority returning at age 3 or 4. While in the ocean, these fish are subject to commercial and recreational fisheries at ages 3 and 4 (Grover et al. 2004).

In part because of its low diversity, poor spatial structure, and low abundance (Lindley et al. 2007, Williams et al. 2011), Central Valley spring-run Chinook is listed as threatened under the Endangered Species Act.

Climate Effects on Abundance and Distribution

Overall, vulnerability to climate change ranked ***very high*** for Central Valley spring-run Chinook, which is consistent with results from Moyle et al. (2017). Exposures to *stream temperature* and *summer water deficit* were ranked ***moderate*** and ***high,*** respectively. Sensitivity in the **adult freshwater stage** ranked ***very high*** due to present climate stress in freshwater habitats used by adults for pre-spawn holding. High mortality of holding adults, associated with elevated water temperatures and pathogen outbreaks, was reported in 2002 and 2003 in Butte Creek, the largest single run, where the accessible spawning areas are all below 1000 ft elevation.

The extremely vulnerable state of the Sacramento-San Joaquin Delta resulted in ***moderate*** ranks for exposure to *hydrologic regime* shift and *stream temperature*, but a ***high*** rank for exposure to *sea level rise*. Because this DPS is moderate-to-highly vulnerable to climate risks throughout its entire life cycle, sensitivity to *cumulative life-cycle effects* ranked ***very high***. (see also Herbold et al. 2018). Fish in this DPS use the Sacramento-San Joaquin Delta for migration and rearing, where mortality rates are high (Moyle et al. 2017). Sensitivity in the *estuary stage* ranked ***high***.

Although Central Valley spring-run Chinook scored relatively ***low*** in sensitivity for *early life history* (egg incubation/early fry stage), there is evidence that temperatures during incubation (Sept-Mar) sometimes exceed the critical limits for 100% mortality (CDFG 1998). Rising temperatures could also affect juvenile growth and development rates, especially for yearlings that may hold over summer in freshwater tributaries.

Climate predictors associated with marine survival or behavior are not known for Central Valley spring-run Chinook specifically, but for Pacific salmon in general, growth and survival have been correlated with large-scale indicators, such as El Nino–Southern and Pacific Decadal Oscillations. Moreover, a strong correlation has been shown between early marine survival and upwelling/sea surface temperature. Early marine links between climate indicators and survival are better understood than later marine links (Wells et al. 2007, Petrosky and Schaller 2010). Overall, sensitivity for Central Valley spring-run Chinook ranked ***moderate*** at the *marine stage*, but the exposure attributes of *sea surface temperature* and *upwelling* were ranked ***high***.

Extrinsic Factors

The California Central Valley and Sacramento-San Joaquin Delta are highly altered systems, with impassable dams on nearly every major river and a very high concentration of invasive predators in the altered waterways. These anthropogenic effects prevent the species from using high-elevation streams in the Sierra Nevada that are likely more resilient to predicted effects of climate change (higher stream temperature, smaller snowpack). Because spring-run adults need to hold over summer in headwaters of the natal river, Central Valley spring-run Chinook salmon are restricted to three small undammed streams that are relatively low elevation and thus more vulnerable. For these reasons, sensitivity to *other stressors* ranked ***very high*** for this DPS. Sensitivity to *hatchery influcence* also ranked ***very high*** due to the reliance of this DPS on the Feather River hatchery program.

This DPS is listed as threatened under the U.S. Endangered Species Act. This DPS was considered especially vulnerable in spatial structure in relation to climate change, and sensitivity for *population viability* was ranked ***very high***.

Adaptive Capacity

Adaptive capacity for Central Valley spring-run Chinook ranked ***low***. This is in large part due to highly altered freshwater and estuary ecosystems, which have reduced the number of viable life histories and created a situation where the species is highly dependent on human management of resources (design flows to queue migrating adults and keep temperatures cool).

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