Puget Sound Chinook

Overall vulnerability—High (96% High, 4% Very high)
Biological sensitivity—High (100% High)
Climate exposure—High (96% High, 4% Very high)
Adaptive capacity—High (2.3)
Data quality—79% of scores ≥ 2

Life History Synopsis

Puget Sound Chinook salmon is notable for its large adult size and life history variation. Adults migrate into Puget Sound rivers in two-to-three seasonal runs. Spring-run Chinook returns in May-July during snowmelt from the Cascade and Olympic Mountains and spawns primarily in higher-elevation tributaries. Summer/fall-run Chinook returns from July to October during low-flow periods and spawns in lower-elevation mainstem and large tributary reaches. The 19 Chinook spawning populations in Puget Sound span population groups in both the Olympic and Cascade watersheds, providing broad spatial diversity across the region. Migration corridors in these watersheds are no greater than 100 miles from river mouth to spawning grounds, so upstream migration can be quite rapid. Upstream migrations can be delayed by stream temperatures, which vary dramatically across the Puget Sound region in part due to the
presence or absence of headwater glaciers. Adults spawn in large gravel beds, depositing 2500-7500 eggs. Eggs hatch in 4–7 months, and length of incubation is temperature-dependent. For most spawning populations, incubation occurs during the transition from low summer flows to high fall and winter flows, and the ratio of high incubation flow to low summer flow is a very good predictor of productivity (Ward et al. 2015).

After emergence from redds, these Chinook salmon exhibit highly variable juvenile life history strategies. Most migrate to Puget Sound as subyearling fry that rear extensively in natal or nearby non-natal estuaries, coastal creek mouths, or other coastal habitats for up to 4 months (Healey 1991, Beamer et al. 2005). Accordingly, Puget Sound Chinook salmon may be regarded as highly dependent upon estuary environments during early life history. Nevertheless, other subyearlings develop as parr that rear an equivalent time in riverine habitats before migrating. A smaller proportion of individuals migrate as yearlings, but this life history type has decreased in recent years (Beechie et al. 2006).

After migration into Puget Sound in spring or summer, individuals may exhibit extended residence within the Salish Sea before migrating to the Pacific Ocean, and some individuals (termed blackmouth) remain for the rest of their lives as residents within the Salish Sea. Ocean-going individuals tend to remain near the continental shelf and reside from coastal British Columbia to southeast Alaska (Myers et al. 1998). In the Puget Sound Chinook DPS, most adults return to spawn after 3–6 years in marine waters (the dominant year class is age 4), although a minority may return after 2 years as jacks.

**Climate Effects on Abundance and Distribution**

Puget Sound Chinook salmon are subject to a wide variety of climate impacts. The greatest risks likely occur during egg incubation, when they are vulnerable to high mortality due to increased flooding and variability in seasonal flow (Ward et al. 2015). This was reflected in a high sensitivity score for early life history (egg incubation). A high exposure score for hydrologic regime resulted from the expectation from our analysis that 8% of spawning habitat will change from snow-dominated to transitional, and 16% will change from transitional to rain-dominated (Appendix S2). These projections suggest that winter flooding will become more common, directly affecting incubating eggs. Stream temperature was ranked high in the extent of change expected, which could increase pre-spawn mortality in low-elevation tributaries (Cristea and Burges 2010).

Rising temperatures during late spring and summer may also impact Chinook juveniles in estuary and riverine habitats. Most Puget Sound estuaries already surpass optimal rearing temperatures in summer, and the expectation of additional habitat warming for this DPS was reflected in its high exposure score to sea surface temperature. Thus Puget Sound Chinook is likely to face increased vulnerability, despite its moderate score for estuary stage. Estuary rearing habitat in Puget Sound has already been greatly impaired due to agriculture and urbanization. Estuary habitat may be further degraded as a consequence of sea level rise, although Puget Sound generally is expected to experience less sea level rise than other regions.
Chinook salmon is a notable predator of crab larvae, including Dungeness crab which is thought to be sensitive to direct (Busch and McElhany 2016) as well as indirect effects of ocean acidification on the benthic food web (Marshall et al. 2017, Hodgson et al. 2018). However, such food web effects remain highly uncertain (Busch et al. 2013). Chinook salmon appears sensitive to a variety of ocean conditions, so upwelling and ocean currents have potential to impact abundance of adult returns. Compared to other DPSs, Puget Sound Chinook will likely have lower exposure to adverse temperature impacts during spawning, although stream temperature effects are likely for summer/fall-run adult migrants.

Extrinsic Factors

Hatcheries play a large role in Puget Sound, with the percentage of hatchery fish migrating through the sound surpassing 70% in some areas (Rice et al. 2011). Rates of disease prevalence and intensity are correlated with local abundance of hatchery fish (Rhodes et al. 2011). Many hatcheries within the Puget Sound recovery domain are production hatcheries. Genetic diversity of the Puget Sound Chinook DPS has been greatly impacted by fish from the Green River, which has historically dominated the broodstock of all regional hatcheries (Hard et al. 2015, Myers et al. 2015). Nonetheless, this DPS scored moderate in vulnerability to hatchery influence, reflecting the perception by scorers that other DPSs experience relatively higher impacts from hatcheries.

Puget Sound Chinook was ranked high in adaptive capacity because of its high expression of life history variation. This DPS is expected to be somewhat resilient to temperature extremes and to high mortality events associated with changes in flow. Subyearlings exhibit great flexibility in residence among freshwater, estuarine, and marine habitats. Relative habitat usage was considered likely to change based on local conditions and growth opportunities, as a consequence of changes in both temperature and rearing habitat capacity. Furthermore, some large rivers within Puget Sound are expected to increase in growth.
opportunity for salmon as a consequence of warming (Beer and Anderson 2011); thus, not all climate changes may result in negative impacts to salmon populations.

**Literature Cited**


