Puget Sound chum

Overall vulnerability—Moderate (32% Low, 68% Moderate)
Biological sensitivity—Moderate (32% Low, 68% Moderate)
Climate exposure—Moderate (47% Moderate, 53% High)
Adaptive capacity—Moderate (1.9)
Data quality—84% of scores ≥ 2

	Puget Sound Chum	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Early life history	1.7	2.8	
	Juvenile freshwater stage	1.4	2.8	
	Estuary stage	2.5	2.8	
	Marine stage	2.2	1.8	
	Adult freshwater stage	1.6	3	
	Cumulative life-cycle effects	2.3	2.3	
	Hatchery influence	1.8	2.3	
	Other stressors	3	2.5	
	Population viability	1.8	3	
	Ocean acidification sensitivity	1.9	1	
	Sensitivity Score	Moderate		
Exposure variables	Stream temperature	2	2.8	
	Summer water deficit	1.6	2	
	Flooding	1.8	2	
	Hydrologic regime	2.9	2.8	
	Sea level rise	2.8	2	
	Sea surface temperature	2.9	2.5	
	Ocean acidification exposure	3.9	3	
	Upwelling	1.5	2	
	Ocean currents	1.8	1	
	Exposure Score	Moderate		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Life History Synopsis

Adult Puget Sound chum migrate relatively short distances to spawning grounds (1-60 km). Migration begins in late summer, when adults may encounter low flows and relatively high stream temperatures. Puget Sound chum spawns in both large and small river systems, and therefore has a broad array of systems that support spawning. Chum typically spawns in the lower reaches of rivers and in side-channels and riffles. Incubation occurs in the cool, wet months of fall and winter, when temperatures are generally unlikely to approach stressful thresholds for eggs. Juveniles enter the ocean during their first spring as fry or subyearlings, spending up to a month in fresh water. This short period of freshwater rearing occurs during winter months when temperature variation is low. Juvenile chum can spend up to one month in estuarine shallow waters (all salinity zones) in late winter before moving to the ocean. After leaving estuaries, juveniles may exhibit extended residency within Puget Sound before migrating, and may even overwinter in the sound. In the ocean, juveniles move northward along nearshore areas to Alaska (Johnson et al. 1997). Age at maturity is highly variable (typically 3, 4, or 5 years).

In general, West Coast chum salmon undergo extensive ocean migrations into the Gulf of Alaska and subarctic North Pacific Ocean (Urawa et al. 2018). West Coast chum have an absolute thermal range of 0-15.6°C for all seasons, and a frequently observed range of 1-13°C during spring-fall and 1.5-10°C during winter (Abdul-Aziz et al. 2011). In marine environments juvenile chum consume crustaceans, including amphipods and copepods, which may be impacted by ocean acidification. Chum salmon eat a wider variety of prey than other salmon species (Davis et al. 2009), including gelatinous zooplankton (Arai et al. 2003).

Climate Effects on Abundance and Distribution

Chum salmon adults may aggregate in estuaries near river mouths for up to one month prior to upstream migration, and warm temperatures or hypoxia at this time may be stressful.

A relatively small number of studies have examined the effect of climate factors on the abundance, distribution, or productivity of West Coast chum salmon. Eaton and Scheller (1996) found that the maximum weekly average upper thermal tolerance for chum salmon was 21°C. Exposure to summer *stream temperature* and *hydrologic regime* shift is a concern largely for adults returning to rivers and hatched fry. Both of these exposure factors were ranked ***low***. Flow conditions may be highly variable, and are projected to become more extreme with climate change. High fall river flows increase bed load sediment, which may lead to scouring of redds. Sea level rise and potential storm surge risks pose the greatest climate-related stressors during estuary rearing, although sensitivity in the *estuary stage* ranked ***low***.

Early marine climate signals such as coastal sea surface temperature and PDO explain a small proportion of the variation in total productivity for Washington and West Coast Vancouver Island chum salmon, with warmer coastal SSTs (and positive PDO) a few months prior to and during the early marine period associated with increased productivity (Mueter et al. 2005).

Abdul-Aziz et al. (2011) developed spatially explicit representations of open ocean thermal habitat for North American chum salmon, using a multimodel ensemble average of climate model outputs under the A1B emissions scenario. They projected a decline in summer habitat area for chum salmon of 29% by the 2080s, with the largest habitat losses in the eastern half of the Gulf of Alaska. Wintertime habitat area losses were 19%, with reductions at the southern end of the historical range offset somewhat by habitat area gains in the southern Bering Sea.

Whether a general northward and westward displacement of the most frequently observed thermal open ocean habitat will have substantial impacts on life-cycle productivity or spawning distribution for chum salmon is unknown. However, it seems likely that West Coast chum salmon populations are vulnerable to projected displacements of high seas thermal habitat. Exposure to mean *sea surface temperature* ranked ***moderate*** while sensitivity in the *marine stage* ranked ***low***.

Jellyfish become more abundant in warmer years and may offer food sources to juvenile chum that other salmon do not take advantage of (Arai et al. 2003). Puget Sound chum appears to compete with pink salmon, so climate effects on pink will indirectly affect chum (Ruggerone and Nielsen 2004, Greene et al. 2015). There may be linkages between declining adult biomass, egg size, and juvenile size at migration, leading to life-cycle based shifts in total mortality. Size trends are negative over time for many chum populations. Some of these patterns may be the consequence of marine or incubation thermal regimes (Johnson et al. 1997).

Extrinsic Factors

Some regions of Puget Sound are experiencing losses in primary production and increases in eutrophication, possibly due to nutrient inputs. These can be exacerbated by higher temperatures and increased stratification, and could impact fish via losses in secondary production and hypoxia (Moore et al. 2008). However, sensitivity to *other stressors* (such as pollutants) was ranked ***low*** for Puget Sound chum.

Fall run Puget Sound chum is not presently listed under the U.S. Endangered Species Act. In some areas of the sound, chum run sizes are increasing, while in others runs have declined precipitously. Overall sensitivity to *population viability* was ranked ***moderate***.

Adaptive Capacity

Adaptive capacity for Puget Sound chum was ranked ***moderate***.

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