Pink salmon − *Oncorhynchus gorbuscha*

Overall Vulnerability Rank = Low

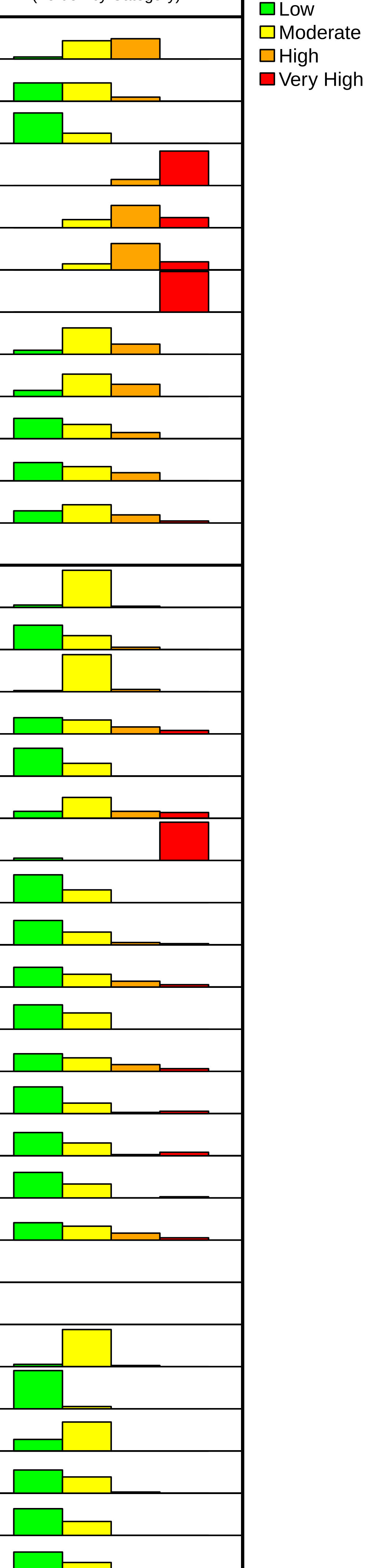
Biological Sensitivity = High

Climate Exposure = Low

Sensitivity Data Quality = 75% of scores ≥ 2

Exposure Data Quality = 64% of scores ≥ 2

	Oncorhynchus gorbuscha	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.4	2.2	
	Prey Specificity	1.6	2.8	
	Adult Mobility	1.2	2.5	
	Dispersal of Early Life Stages	3.8	2.2	
	Early Life History Survival and Settlement Requirements	3.0	2.0	
	Complexity in Reproductive Strategy	3.0	2.5	
	Spawning Cycle	4.0	2.8	
	Sensitivity to Temperature	2.1	2.2	
	Sensitivity to Ocean Acidification	2.1	1.8	
	Population Growth Rate	1.6	2.2	
	Stock Size/Status	1.8	1.8	
	Other Stressors	2.0	1.8	
	Sensitivity Score	High		
Exposure factors	Sea Surface Temperature	2.0	2.5	
	Sea Surface Temperature (variance)	1.5	2.5	
	Bottom Temperature	2.0	2.5	
	Bottom Temperature (variance)	1.9	2.5	
	Salinity	1.3	2.0	
	Salinity (variance)	2.3	2.0	
	Ocean Acidification	3.8	2.5	
	Ocean Acidification (variance)	1.3	2.5	
	Phytoplankton Biomass	1.5	1.2	
	Phytoplankton Biomass (variance)	1.8	1.2	
	Plankton Bloom Timing	1.4	1.0	
	Plankton Bloom Timing (variance)	1.9	1.0	
	Large Zooplankton Biomass	1.5	1.0	
	Large Zooplanton Biomass (variance)	1.6	1.0	
	Mixed Layer Depth	1.4	1.0	
	Mixed Layer Depth (variance)	1.9	1.0	
	Currents	NA	NA	
	Currents (variance)	NA	NA	
	Air Temperature	2.0	2.5	
	Air Temperature (variance)	1.1	2.5	
	Precipitation	1.7	2.0	
	Precipitation (variance)	1.5	2.0	
	Sea Surface Height	1.3	2.5	
	Sea Surface Height (variance)	1.4	2.5	
	Exposure Score	Low		
Overall Vulnerability Rank		Low		



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Pink salmon (*Oncorhynchus gorbuscha*)

Overall Climate Vulnerability Rank: **Low**. (91% certainty from bootstrap analysis).

Climate Exposure: **Low**. With the exception of ocean acidification (3.8), all exposure factors had scores less than 2.5.

Biological Sensitivity: **High**. Spawning cycle (4.0) and dispersal of early life stages (3.9) were ranked as "very high" sensitivity, and complexity in reproductive strategy (3.1) and early life history survival (3.1) were ranked as "high" sensitivity.

Potential for Distribution Change: **Moderate** (70% certainty from bootstrap analysis). Adult mobility indicated very high potential for distribution change, whereas habitat specificity indicated moderate potential for distribution change.

Directional Effect in the Eastern Bering Sea: Projected climate change in the eastern Bering Sea is expected to have a neutral effect on pink salmon, with an 86% certainty in expert scores.

Data Quality: 75% of the sensitivity attributes and 64% of the exposure factors had average data quality scores of 2 or greater (indicating at least "moderate" data quality).

Climate Effects on Abundance and Distribution:

Stock productivity of western Alaska pink salmon is primarily from Bristol Bay with very few pink salmon returning to the Kotzebue, Yukon, and Kuskokwim river systems (Irvine and Ruggerone 2016). Survival of western Alaska pink salmon was positively correlated to coastal surface water temperatures during the first year of residence at sea (Mueter et al. 2002). Recent changes in the abundance of juvenile pink salmon during late summer in the eastern Bering Sea did not correlate significantly with summer sea temperatures (2002-2016; Yasumiishi et al. 2017).

Body size at maturity of adult pink salmon is the smallest of anadromous salmon and they tend to be smaller in the northern extent of their range (Arctic) than in the southern extent of their range in California (Heard et al. 1991). Juvenile pink salmon had higher whole body energy densities when consuming lipid-rich large zooplankton during cold years and lower whole body energy densities when consuming lower lipid prey of mostly pollock during warm years in the eastern Bering Sea (Andrews et al. 2009, Coyle et al. 2011). However, juvenile pink salmon had higher growth rate in length during warm years relative to cold years (Farley and et al. 2009). Warmer sea temperatures during the juvenile life stage of pink salmon favors growth in length but reduces body condition.

Time of upstream migration depends upon light, winds, tides, water levels, and temperature (Heard et al. 1991). Overwintering stream flows from the time of adult spawning and fry outmigration is an important physical variable regulating the survival of pink salmon in fresh water (Wickett 1958). Warming was associated with earlier upstream migration of adult pink salmon and earlier fry outmigration from fresh water to salt water for an increase in creek temperatures from 6° to 8° C (1972-2005; Taylor et al. 2007).

Juvenile pink salmon display a tolerance for some of the warmest surface temperatures, 6.9 – 15 °C (8.1 °C range) (Echave et al. 2012). Sea surface temperature preferences were 7.4-14.8 °C (7.4 °C range) for maturing pink salmon (Echave et al. 2012, NPFMC 2010). Upstream spawning migration normally occurs at water temperatures in the range of 7.2-15.6 °C for pink salmon (Reiser and Bjornn 1979). Spawning is tolerated from 1 to 26 °C but is greatly reduced at temperatures >16 °C (Smirnov 1975, NPFMC 2010). Juvenile pink salmon did not express range expansions or shifts in the center of their distribution with warming in the eastern Bering Sea (2002-2016; Yasumiishi et al. 2017).

Life History Synopsis:

Pink salmon general distribute from 44° to 66 °N latitude in the Pacific Ocean (Tagaki et al. 1981). North American chum salmon originate in rivers from as far south as the Sacramento and San Joaquin rivers that drain into San Francisco Bay, California, and in the north to the Mackenzie River into the Arctic Ocean from Canada's Northwest Territories (Heard 1991). Asian chum salmon originate from as far north and west as the Yakutsk River in central Siberia Arctic, and along the eastern Eurasian coast to as far south as North Korea (Heard 1991). The eastern Bering Sea is used as a rearing habitat for juvenile pink salmon and maturing pink salmon on their way back to fresh water to spawn (Farley et al. 2005). Juvenile pink salmon were distributed farther offshore along with sockeye and chum salmon while juvenile coho and Chinook salmon distributed near shore during late summer in the eastern Bering Sea (Farley et al. 2005).

Pink salmon is a short-lived (2 years old), anadromous, and semelparous species. Adult salmon spawn and incubate eggs in fresh water. Alevin occupy interstitial spaces within stream bed gravel where water temperatures range from about 1-10 °C. The alevin emerge from the gravel 125 days post-hatching (see NPFMC 2010). After fry emerge from the gravel in spring, pink salmon head directly to salt water to rear. In the eastern Bering Sea, pink salmon fry outmigration from fresh water to salt water occurs during early June in the Kuskokwim River (Raymond et al. 1984).

Adult spawning migration of Bristol Bay pink salmon occurs from July to September (http://www.adfg.alaska.gov/index.cfm?adfg=fishingsportfishinginforuntiming.main). Straying rates of adult pink salmon to non-natal streams were higher than 10% (Keefer and Caudill 2014). Straying rates of hatchery salmon in Prince William Sound, Alaska, were 0-98% for pink salmon (Brenner et al. 2012).

Pink salmon have an obligatory 2-year life cycle and two separate spawning populations. A strong alternating year pattern of higher returns in even-numbered years has occurred in Western Alaska pink salmon population from the mid-1970s to mid-1990s.

Prey preferences of juvenile pink salmon include crab megalopa and other zooplankton (Moss et al. 2009). Adult pink salmon prey preferences include zooplankton, squid, and fish (Davis et al. 2009).

Natural mortality rates are high for pink salmon. Freshwater mortality ranges from 80% to 99% (Heard et al. 1991). Fry to adult mortality ranges from 82.5% to 99.8% (Heard et al. 1991).

Pink salmon are managed in-season at local area levels by the Alaska Department of Fish and Game. http://www.adfg.alaska.gov/index.cfm?adfg=fishingCommercialByArea.main&_ga=2.207693394.172348407.1523379747-1353484536.1523379747 From 1996 to 2015, the commercial harvest of pink salmon increased in Bristol Bay and decreased in Norton Sound, and Kuskokwim management areas (ADFG 2017, Poetter, A. D., and A. Tiernan. 2017, Salomone et al. 2017). Total commercial harvest of pink salmon increased from 1996 to 2015.

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