Bristol Bay red king crab − *Paralithodes camtschaticus*

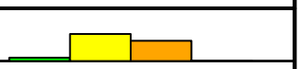
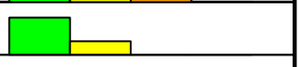
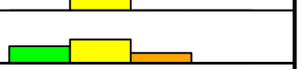
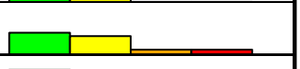
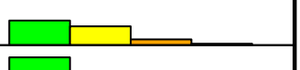
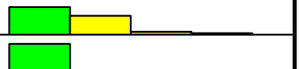
Overall Vulnerability Rank = Low

Biological Sensitivity = High

Climate Exposure = Low

Sensitivity Data Quality = 100% of scores ≥ 2

Exposure Data Quality = 56% of scores ≥ 2

	Paralithodes camtschaticus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.3	2.7	
	Prey Specificity	1.3	3.0	
	Adult Mobility	2.6	3.0	
	Dispersal of Early Life Stages	1.2	3.0	
	Early Life History Survival and Settlement Requirements	2.8	2.3	
	Complexity in Reproductive Strategy	2.5	2.3	
	Spawning Cycle	3.2	3.0	
	Sensitivity to Temperature	3.0	2.3	
	Sensitivity to Ocean Acidification	3.6	3.0	
	Population Growth Rate	3.7	2.7	
	Stock Size/Status	2.0	3.0	
	Other Stressors	1.9	2.0	
	Sensitivity Score	High		
Exposure factors	Sea Surface Temperature	2.0	2.5	
	Sea Surface Temperature (variance)	1.5	2.5	
	Bottom Temperature	2.0	3.0	
	Bottom Temperature (variance)	1.3	3.0	
	Salinity	1.5	2.0	
	Salinity (variance)	2.5	2.0	
	Ocean Acidification	4.0	3.0	
	Ocean Acidification (variance)	1.4	3.0	
	Phytoplankton Biomass	1.8	1.2	
	Phytoplankton Biomass (variance)	1.7	1.2	
	Plankton Bloom Timing	1.3	1.0	
	Plankton Bloom Timing (variance)	1.9	1.0	
	Large Zooplankton Biomass	1.5	1.0	
	Large Zooplanton Biomass (variance)	1.7	1.0	
	Mixed Layer Depth	1.3	1.0	
	Mixed Layer Depth (variance)	1.6	1.0	
	Currents	1.1	2.0	
	Currents (variance)	1.3	2.0	
	Air Temperature	NA	NA	
	Air Temperature (variance)	NA	NA	
	Precipitation	NA	NA	
	Precipitation (variance)	NA	NA	
	Sea Surface Height	NA	NA	
	Sea Surface Height (variance)	NA	NA	
	Exposure Score	Low		
Overall Vulnerability Rank		Low		

Low
Moderate
High
Very High

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Bristol Bay red king crab (*Paralithodes camtschaticus*)

Overall Climate Vulnerability Rank: **Low**. (54% certainty from bootstrap analysis).

Climate Exposure: **Low**. With the exception of ocean acidification (4.0), all exposure factors had scores less than 2.5.

Biological Sensitivity: **High**. Population growth rate (3.7) and sensitivity to ocean acidification (3.6) were ranked as "very high" sensitivity, whereas spawning cycle (3.2) and sensitivity to temperature (3.0) were ranked as "high" sensitivity.

Potential for distribution change: **High** (61% certainty from bootstrap analysis). Dispersal of early life stages indicated very high potential for distribution change, whereas sensitivity to temperature indicated a high potential for distribution change.

Directional Effect in the Eastern Bering Sea: Projected climate change in the eastern Bering Sea is expected to have a negative effect on Bristol Bay red king crab, with 57% certainty in expert scores.

Data Quality: 100% of the sensitivity attributes, and 56% 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:

Different life stages of red king crab vary in their degree of thermal tolerance. Embryos are the most sensitive to higher temperatures, with mortality increasing at temperatures greater than 8°C (Nakanishi 1987). Mature females exhibit reduced, but sub-lethal, growth at 12°C (Shirley et al. 1989). In contrast, larvae and juveniles exhibit higher thermal tolerances and do not experience higher mortality (larvae, Kurata 1960) or reduced growth (juveniles, Rice et al. 1985, Stoner et al. 2010) until 15°C.

Red king crab are sensitive to changes in ocean acidification (Swiney et al. 2017). Larvae exhibited decreased time-to-starvation at a pH of 7.7 (Long et al. 2013a) while juveniles exhibited increased mortality and decreased growth at pH 7.8 (Long et al. 2013b). Swiney et al. (2017) found synergistic effects on mortality at pH 7.8 and temperature increased 4°C above ambient for early juveniles. Lower pH and increased temperatures also affected intermoult duration (Swiney et al. 2017).

Life History Synopsis:

Red king crab inhabit intertidal waters to depths >200 m of the North Pacific Ocean from British Columbia, Canada, to the Bering Sea, and south to Hokkaido, Japan, and are found in several areas of the Aleutian Islands, eastern Bering Sea, and the Gulf of Alaska. The State of Alaska divides the Aleutian Islands and eastern Bering Sea into three management registration areas to manage red king crab fisheries: Aleutian Islands, Bristol Bay, and Bering Sea (Alaska Department of Fish and Game [ADFG] 2012). The Bristol Bay area includes all waters north of the latitude of Cape Sarichef (54°36' N lat.), east of 168°00' W long., and south of the latitude of Cape Newenham (58°39' N lat.) and the fishery for red king crab in this area is managed

separately from fisheries for red king crab outside of this area; i.e., the red king crab in the Bristol Bay area are assumed to be a separate stock from red king crab outside of this area. The stock is currently not overfished nor is overfishing occurring.

Red king crab have a complex life history. Fecundity is a function of female size, ranging from several tens of thousands to a few hundreds of thousands (Haynes 1968; Swiney et al. 2012). The eggs are extruded by females, fertilized in the spring, and held by females for about 11 months (Powell and Nickerson 1965). Fertilized eggs are hatched in the spring, most during April-June (Weber 1967). Primiparous (first clutch) females are bred a few weeks earlier in the season than multiparous females.

Larval duration and juvenile crab growth depend on temperature (Stevens 1990; Stevens and Swiney 2007). Red king crab spend 2- 3 months in larval stages before settling to the benthic life stage. Young-of-the-year crab occur at depths of 50 m or less. They are solitary and need high relief habitat or coarse substrate such as boulders, cobble, shell hash, and living substrates such as bryozoans and stalked ascidians. King crab molt multiple times per year through age 3 after which molting is annual. At larger sizes, king crab may skip molting as growth slows. Females grow slower and do not get as large as males. Between the ages of two and four years, there is a decreasing reliance on habitat and a tendency for the crab to form pods consisting of thousands of crabs. Podding generally continues until four years of age (about 65 mm), when the crab move to deeper water and join adults in the spring migration to shallow water for spawning and deep water for the remainder of the year. Mean age at recruitment to the fishery is 8-9 years. Male and female red king crab mature at 5–12 years old, depending on stock and temperature (Loher et al. 2001; Stevens 1990) and may live >20 years (Matsuura and Takeshita 1990). Males and females attain a maximum size of 227 and 195 mm carapace length (CL), respectively (Powell and Nickerson 1965). Female maturity is evaluated by the size at which females are observed to carry egg clutches. Male maturity can be defined by multiple criteria including spermataphore production and size, chelae vs. carapace allometry, and participation in mating in situ (reviewed by Webb 2014). For management purposes, females >89 mm CL and males >119 mm CL are assumed to be mature for Bristol Bay red king crab.

Pacific cod is the main predator on red king crabs. Walleye pollock, yellowfin sole, and Pacific halibut are minor consumers of pelagic larvae, settling larvae, and larger crabs, respectively. Juvenile crab may be cannibalistic during molting.

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