

Salmon shark – *Lamna ditropis*

Overall Vulnerability Rank = Low ■

Biological Sensitivity = Low ■

Climate Exposure = Moderate ■

Sensitivity Data Quality = 75% of scores ≥ 2

Exposure Data Quality = 56% of scores ≥ 2

<i>Lamna ditropis</i>		Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.2	3.0	
	Prey Specificity	1.2	3.0	
	Adult Mobility	1.1	3.0	
	Dispersal of Early Life Stages	1.1	2.0	
	Early Life History Survival and Settlement Requirements	1.0	1.7	
	Complexity in Reproductive Strategy	2.3	0.7	
	Spawning Cycle	1.9	2.7	
	Sensitivity to Temperature	1.1	3.0	
	Sensitivity to Ocean Acidification	1.1	3.0	
	Population Growth Rate	3.5	2.7	
	Stock Size/Status	1.8	0.7	
	Other Stressors	2.1	2.7	
	<b>Sensitivity Score</b>	<b>Low</b>		
	Exposure factors	Sea Surface Temperature	2.0	2.0
Sea Surface Temperature (variance)		1.6	2.0	
Bottom Temperature		2.0	2.0	
Bottom Temperature (variance)		2.2	2.0	
Salinity		1.1	2.0	
Salinity (variance)		2.5	2.0	
Ocean Acidification		4.0	2.0	
Ocean Acidification (variance)		1.4	2.0	
Phytoplankton Biomass		1.2	1.2	
Phytoplankton Biomass (variance)		1.2	1.2	
Plankton Bloom Timing		1.5	1.0	
Plankton Bloom Timing (variance)		2.1	1.0	
Large Zooplankton Biomass		1.1	1.0	
Large Zooplankton Biomass (variance)		1.4	1.0	
Mixed Layer Depth		1.7	1.0	
Mixed Layer Depth (variance)		2.2	1.0	
Currents		NA	NA	
Currents (variance)		NA	NA	
Air Temperature		NA	NA	
Air Temperature (variance)		NA	NA	
Precipitation		NA	NA	
Precipitation (variance)		NA	NA	
Sea Surface Height		1.9	2.0	
Sea Surface Height (variance)	1.5	2.0		
<b>Exposure Score</b>	<b>Moderate</b>			
<b>Overall Vulnerability Rank</b>	<b>Low</b>			

■ Low  
■ Moderate  
■ High  
■ Very High

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## **Salmon shark (*Lamna ditropis*)**

Overall Climate Vulnerability Rank: **Low**. (82% certainty from bootstrap analysis).

Climate Exposure: **Moderate**. Exposure to ocean acidification (4.0) was ranked as “very high”, and exposure to variability in salinity (2.5) was ranked as “moderate”.

Biological Sensitivity: **Low**. Population growth rate (3.5) was ranked as “very high” sensitivity, and all other sensitivity attributes were ranked as “low” sensitivity.

Potential for distribution change: **Very High** (99% certainty from bootstrap analysis). Three attributes (adult mobility, dispersal of early life stages, and habitat specificity) indicated 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 neutral effect on salmon shark, with 59% certainty in expert scores.

Data Quality: 75% 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: Recruitment processes are unknown for this species, but they are born fully formed (i.e., no larval stage), and thus recruitment is likely less vulnerable to climate variability. The species has homeothermic capabilities and occupy a wide range of temperatures and may be more tolerant to shifting temperatures than other species.

### Life History Synopsis:

The salmon shark are managed as part of the Shark Stock Complexes in two Fishery Management Plan (FMP) areas: the Gulf of Alaska (GOA) and the Bering Sea/Aleutian Islands (BSAI). The stock complexes are considered data-limited for all of the species within them, and management reference points are based on catch history (with the exception of spiny dogfish in the GOA). It is impossible to determine an overfished status, and overfishing is considered to not be occurring. However, the Overfishing Limit (OFL) is a proxy based on fishery behavior, not biology, and may not accurately reflect a biologically meaningful OFL.

Salmon sharks range in the North Pacific from Japan through the Bering Sea and GOA to southern California and Baja, Mexico. They are considered common in coastal littoral and epipelagic waters, both inshore and offshore. Salmon sharks tend to be more pelagic and surface oriented than the other shark species in the BSAI, spending 72% of their time in water less than 50 m depth (Weng et al. 2005). While some salmon sharks migrate south during the winter months, others remain in Alaska waters throughout the year (Hulbert et al. 2005, Weng et al. 2005).

Like other lamnid sharks, salmon sharks are active and highly mobile, maintaining body temperatures as high as 21.2°C above ambient water temperatures and appear to maintain a constant body core temperature regardless of ambient temperatures (Goldman et al. 2004). Adult salmon sharks typically range in size from 180 - 210 cm pre-caudal length (PCL, measured from the tip of the snout to the dorsal pre-caudal notch, at the base of the tail) (Goldman and Musick

2006) in the eastern North Pacific and can weigh upwards of 220 kg. Length-at-maturity in the western north Pacific (WNP) has been estimated to occur at approximately 140 cm PCL for males and 170 - 180 cm PCL for females (Tanaka 1980). These lengths correspond to ages of approximately five years and 8 - 10 years, respectively. Length-at-maturity in the eastern north Pacific (ENP) has been estimated to occur between 125 - 145 cm PCL (3 - 5 years) for males and between 160 - 180 cm PCL (6 - 9 years) for females (Goldman and Musick 2006). Tanaka (1980) (see also Nagasawa 1998) states that maximum age from vertebral analysis for WNP salmon shark is at least 25 years for males and 17 years for females and growth coefficients are 0.17 and 0.14 for males and females, respectively. Goldman and Musick (2006) gave maximum ages for ENP salmon shark (also from vertebral analysis) of 17 years for males and 30 years for females, with growth coefficients of 0.23 and 0.17 for males and females, respectively. Salmon sharks in the ENP and WNP attain the same maximum length (approximately 215 cm PCL for females and about 190 cm PCL for males). However, males past approximately 140 cm PCL and females past approximately 110 cm PCL in the ENP are of a greater weight-at-length than their same-sex counterparts in the WNP (Goldman and Musick 2006).

The reproductive mode of salmon sharks is aplacental viviparity and includes an oophagous stage when embryos feed on eggs produced by the ovary (Tanaka 1986 cited in Nagasawa 1998). Litter size in the WNP is four to five pups, and litters have been reported to be male dominated 2.2:1 (Nagasawa 1998). Gestation times throughout the North Pacific appear to be nine months, with mating occurring during the late summer and early fall and parturition occurring in the spring (Nagasawa 1998, Tribuzio 2004, Goldman and Musick 2006, Conrath et al. 2014). Salmon shark appear to have at least a two year reproductive cycle, with an extended resting period between pregnancies (Conrath et al. 2014). Size at parturition is between 60 - 65 cm PCL in both the ENP and WNP (Tanaka 1980, Goldman and Musick 2006).

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