Pacific sleeper shark − *Somniosus pacificus*

Overall Vulnerability Rank = Low

Biological Sensitivity = Moderate

Climate Exposure = Low

Sensitivity Data Quality = 42% of scores ≥ 2

Exposure Data Quality = 50% of scores ≥ 2

	Somniosus pacificus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.4	1.7	
	Prey Specificity	1.2	2.3	
	Adult Mobility	1.3	2.7	
	Dispersal of Early Life Stages	1.1	1.7	
	Early Life History Survival and Settlement Requirements	1.0	1.7	
	Complexity in Reproductive Strategy	2.3	0.7	
	Spawning Cycle	1.3	1.0	
	Sensitivity to Temperature	1.3	2.7	
	Sensitivity to Ocean Acidification	1.1	2.7	
	Population Growth Rate	3.7	1.0	
	Stock Size/Status	2.9	1.0	
	Other Stressors	1.1	2.0	
	Sensitivity Score	Moderate		
Exposure factors	Sea Surface Temperature	2.0	2.0	
	Sea Surface Temperature (variance)	1.5	2.0	
	Bottom Temperature	1.9	2.0	
	Bottom Temperature (variance)	1.9	2.0	
	Salinity	1.2	2.0	
	Salinity (variance)	2.3	2.0	
	Ocean Acidification	4.0	2.0	
	Ocean Acidification (variance)	1.4	2.0	
	Phytoplankton Biomass	1.5	1.2	
	Phytoplankton Biomass (variance)	1.3	1.2	
	Plankton Bloom Timing	1.5	1.0	
	Plankton Bloom Timing (variance)	2.2	1.0	
	Large Zooplankton Biomass	1.3	1.0	
	Large Zooplanton 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	NA	NA	
	Sea Surface Height (variance)	NA	NA	
	Exposure Score	Low		
	Overall Vulnerability Rank	Low		

Low
Moderate
High
Very High

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Pacific sleeper shark (*Somniosus pacificus*)

Overall Climate Vulnerability Rank: **Low**. (76% 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: **Moderate**. Population growth rate (3.7) was ranked as "very high" sensitivity, and stock size/status was ranked as "moderate" sensitivity.

Potential for distribution change: **Very High** (76% 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 Pacific sleeper shark, with 92% certainty in expert scores.

Data Quality: 42% of the sensitivity attributes, and 50% 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 given the presumed longevity and fully formed offspring (i.e., no larval stage), recruitment is likely less vulnerable to climate variability.

Life History Synopsis:

Pacific sleeper shark (PSS) 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.

PSS range as far north as the Arctic Circle in the Chukchi Sea (Benz et al. 2004), west off the Asian coast and the western Bering Sea (Orlov and Moiseev 1999), and south along the Alaska and Pacific coast and possibly as far south as the coast of South America (de Astarloa et al. 1999). They have been documented at a wide range of depths, from surface waters (Hulbert et al. 2006) to 1,750 m (seen on a planted grey whale carcass off Santa Barbara, CA, www.nurp.noaa.gov/Spotlight/Whales.htm), but are found in relatively shallow waters at higher latitudes and in deeper habitats in temperate waters (Yano et al. 2007).

Age determination is difficult and growth rates and unknown for PSS and other members of the sleeper shark group (*Somniosus* spp.). However, the species in the group attain large sizes, most likely possess a slow growth rate and are likely long lived (Fisk et al. 2002). Using a method of age approximation, a Greenland shark (*Somniosus microcephalus*), the North Atlantic congener of the Pacific sleeper shark, sampled in 1999 was determined to have been alive during the 1950's - 1970's because it had high levels of DDT (Fisk et al. 2002). Additionally, a recent study

found a Greenland shark that was 220 cm total length (*TL*, tip of the snout to the upper lobe of the caudal fin) and estimated to be 49 years old, using bomb radiocarbon isotopes in the eye lens, and was still immature (Nielson et al. 2016).

Data on the length of sleeper sharks are not prevalent because of their large size, which makes handling difficult. The maximum lengths of captured PSS were 440 cm *TL* for females and 400 cm *TL* for males (Mecklenburg et al. 2002). Pacific sleeper sharks as large as 430 cm *TL* have been caught in the western North Pacific (WNP), where the species exhibits sexual dimorphism, with females being shorter and heavier (avg. length = 138.9 cm *TL*, avg. weight = 28.4 kg) than males (avg. length = 140 cm *TL*, avg. weight = 23.7 kg) (Orlov 1999).

Size at maturity is estimated based on limited reports of mature animals. Published observations suggest that mature female PSS are in excess of 365 cm *TL*, mature male PSS are in excess of 397 cm *TL*, and the size at birth is approximately 40 cm *TL* (Gotshall and Jow 1965, Yano et al. 2007). The reproductive mode of sleeper sharks is thought to be aplacental viviparity. Three mature females 370 - 430 cm *TL* were opportunistically sampled off the coast of California. One of these sharks had 372 large vascularized eggs (24 - 50 mm) present in the ovaries (Ebert et al. 1987). Another mature PSS 370 cm *TL* long was caught off Trinidad, California (Gotshall and Jow 1965) with ovaries containing 300 large ova.

Because of a lack of observations of mature and newly born sharks, and the absence of dates in literature, the spawning and pupping seasons are unknown for PSS. Two 74 cm sharks have been caught off the coast of California at depths of 1300 and 390 m; one still had an umbilical scar (Ebert et al. 1987). Unfortunately, the date of capture was not reported. A newly born shark of 41.8 cm was also caught at 35 m depth off Hiraiso, Ibaraki, Japan (Yano et al. 2007). Additionally, three small sharks, 65 - 75 cm *TL*, have been sampled in the Northwest Pacific, but the date of sampling was not reported (Orlov and Moiseev 1999). In summer 2005, an 85 cm *PCL* (pre-caudal length, measured from the tip of the snout to the dorsal pre-caudal notch, at the base of the tail) female was caught during the annual AFSC longline survey near Yakutat Bay and in spring 2009 another 85 cm *PCL* female was caught by a commercial halibut fisherman inside Chatham Strait in Southeast Alaska (Tribuzio unpublished data).

The most recent AFSC stock assessments compiled length data for PSS from standard and non-standard AFSC trawl surveys in the GOA and BSAI, the Northwest Fisheries Science Center (NWFSC) groundfish trawl survey off the U.S. west coast, and International Pacific Halibut Commission (IPHC) surveys. The length data compiled thus far show that small animals (50 – 200 cm total length) are caught coast-wide; larger fish, those >200 cm *TL*, have never been recorded in the BSAI and animals up to 400 cm *TL* have been caught, in small numbers, in all other regions (see Figure 20.2 in Tribuzio et al. 2016). One study has examined the sizes of PSS caught in the GOA, eastern Bering Sea (AFSC trawl survey data for both regions), western Bering Sea, along the Kamchatka Peninsula and in the Sea of Okhotsk (Russian survey and fishery data), and found that there were very few fish greater than 200 cm (Orlov and Baitalyuk 2014). These data indicate that the animals caught in the BSAI are all young and small, some possibly even being neonates, and are all likely immature. In all of the other regions, the animals

being caught are also primarily small, but occasionally larger, possibly mature animals are captured.

Because few large, mature PSS are found in surveys or fisheries, it is possible that adults inhabit abyssal depths and are generally not available nor susceptible to fishing or survey gear. Another possibility is that adults inhabit the nearshore environments but are not susceptible to the gear. At this time, the only evidence of the presence of large presumably adult Pacific sleeper shark in any area comes from camera footage from deep water drop cameras (e.g., Monterey Bay Research Institute) or the occasional adult that has been reported in the literature (Ebert et al. 1987, Yano et al. 2007). It is possible that the larger animals (>350 cm TL) captured in the GOA or BSAI are mature, however, maturity is generally not collected during surveys because the animals are released alive and biological information is not routinely collected from animals caught in commercial fishing activities.

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