Flathead sole − *Hippoglossoides elassodon*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = High

Climate Exposure = Moderate

Sensitivity Data Quality = 92% of scores ≥ 2

Exposure Data Quality = 56% of scores ≥ 2

	Hippoglossoides elassodon	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.8	3.0	
	Prey Specificity	1.4	2.5	
	Adult Mobility	1.8	3.0	
	Dispersal of Early Life Stages	1.4	2.5	
	Early Life History Survival and Settlement Requirements	2.5	1.8	
	Complexity in Reproductive Strategy	1.9	2.8	
	Spawning Cycle	3.0	3.0	
	Sensitivity to Temperature	1.6	2.8	
	Sensitivity to Ocean Acidification	1.6	2.5	
	Population Growth Rate	3.5	3.0	
	Stock Size/Status	1.0	3.0	
	Other Stressors	1.3	2.5	
	Sensitivity Score	High		
Exposure factors	Sea Surface Temperature	2.0	2.5	
	Sea Surface Temperature (variance)	1.7	2.5	
	Bottom Temperature	2.1	3.0	
	Bottom Temperature (variance)	2.0	3.0	
	Salinity	1.2	2.0	
	Salinity (variance)	2.6	2.0	
	Ocean Acidification	4.0	3.0	
	Ocean Acidification (variance)	1.4	3.0	
	Phytoplankton Biomass	1.3	1.2	
	Phytoplankton Biomass (variance)	1.3	1.2	
	Plankton Bloom Timing	1.4	1.0	
	Plankton Bloom Timing (variance)	2.2	1.0	
	Large Zooplankton Biomass	1.2	1.0	
	Large Zooplanton Biomass (variance)	1.3	1.0	
	Mixed Layer Depth	1.6	1.0	
	Mixed Layer Depth (variance)	2.3	1.0	
	Currents	1.3	2.0	
	Currents (variance)	1.7	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	Moderate		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

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Flathead sole (*Hippoglossoides elassodon*)

Overall Climate Vulnerability Rank: **Moderate**. (73% certainty from bootstrap analysis).

Climate Exposure: **Moderate**. Exposure to ocean acidification (4.0) was ranked as "very high", and exposure to variability to salinity (2.6) was ranked as "moderate".

Biological Sensitivity: **High**. Population growth rate (3.5) was ranked as "very high" sensitivity, and spawning cycle (3.0) was ranked as "high" sensitivity.

Potential for distribution change: **High** (99% certainty from bootstrap analysis). Dispersal of early life stages indicated very high potential for distribution change, whereas adult mobility and habitat specificity 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 neutral effect on flathead sole, with 89% certainty in expert scores.

Data Quality: 92% 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: Flathead sole catchability appears to vary with temperature and with the extent of the cold pool and therefore could be influenced by climate effects on the size of the cold pool from year to year (McGilliard et al. 2016, Rooper et al. 2005, Spencer 2008). The stock is dependent on ophiuroids, euphausiids, pandalidae, shrimp, mysids, bivalves, snails, and hermit crabs, all of which have calcareous exosketetons. The degree to which ocean acidification affects the reproduction and survival of these prey species, and the degree to which flathead sole could switch to other prey species if these species were in decline is unknown. However, although flathead sole are generalists, most prey items have calcareous exoskeletons, suggesting that if all of these species were to decline, there may be a negative effect on flathead sole (Aydin et al. 2007, Pacunski et al. 1998).

Life History Synopsis: Flathead sole are distributed from northern California, off Point Reyes, northward along the west coast of North America, and throughout the Gulf of Alaska and the Bering Sea, the Kuril Islands and possibly the Okhotsk Sea (Hart 1973).

Adults exhibit a benthic lifestyle and occupy separate winter spawning and summertime feeding distributions on the eastern Bering Sea shelf and in the Gulf of Alaska. From over-winter grounds near the shelf margins, adults begin a migration onto the mid- and outer continental shelf in April or May each year for feeding. The spawning period may start as early as January but is known to occur in March and April, primarily in deeper waters near the margins of the continental shelf. Eggs are large (2.75 to 3.75 mm) and females have egg counts ranging from about 72,000 (20 cm fish) to almost 600,000 (38 cm fish). Eggs hatch in 9 to 20 days depending on incubation temperatures within the range of 2.4 to 9.8°C (Forrester and Alderdice 1967) and have been found in ichthyoplankton sampling on the southern portion of the Bering Sea shelf in April and May (Waldron 1981). Larvae absorb the yolk sac in 6 to 17 days but the extent of their distribution is unknown. Size at metamorphosis is 18 to 35 mm (Matarese et al. 2003). Juveniles less than age 2 have not been found with the adult population, remaining in shallow areas. Late juveniles and adults occur on the shelf (0 to 200 m) wherever there are softer substrates consisting of sand and mud. Age at 50 percent maturity is 9.7 years (Stark 2004). Flathead sole catchability appears to vary with temperature and with the extent of the cold pool. Further studies on the linkage between temperature and flathead sole habitat preferences are needed.

Flathead sole feed mainly on ophiuroids, tanner crab, osmerids, bivalves, and polychaete (Pacunski 1990). Groundfish predators include Pacific cod, Pacific halibut, arrowtooth flounder, and cannibalism by large flathead sole, mostly on fish less than 20 cm standard length (Aydin et al. 2007, Livingston and DeReynier 1996).

The natural mortality rate used in recent stock assessments is 0.2 yr^{-1}. Flathead sole reach a maximum length of 47 cm and 39 cm for females and males, respectively, and start to reach maximum size around age 20 for females and age 15 for males (von Bertalanffy K is estimated to be 0.13 and 0.17 for females and males, respectively. Fifty percent of flathead sole are mature by age 10 and 95% are mature at age 13 (McGilliard et al. 2016).

Flathead sole in Alaska are managed as a two stocks, one that includes the Bering Sea and Aleutian Islands (BSAI) and a second that covers the Gulf of Alaska. In addition, the BSAI flathead sole stock is managed as a complex with a morphologically similar congener Bering flounder (*H. robustus*). Bering flounder are found in the northern part of the range that extends north to the Chukchi Sea and into the western Bering Sea. Bering flounder typically represent less than 3% of the combined biomass of the two species in annual groundfish surveys conducted by the Alaska Fisheries Science Center (AFSC) in the eastern Bering Sea (EBS). In the most recent assessment, BSAI flathead sole was not overfished or subject to overfishing (McGilliard et al. 2017). Catches of flathead sole are far below the ABC and the TAC is set far below the ABC. For example, the ABC for BSAI flathead sole was 68,278 t, the TAC for BSAI flathead sole was 14,500 t and the total catches were 4,128 t in 2017.

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