Yellowfin sole – *Limanda aspera*

Overall Vulnerability Rank = Low

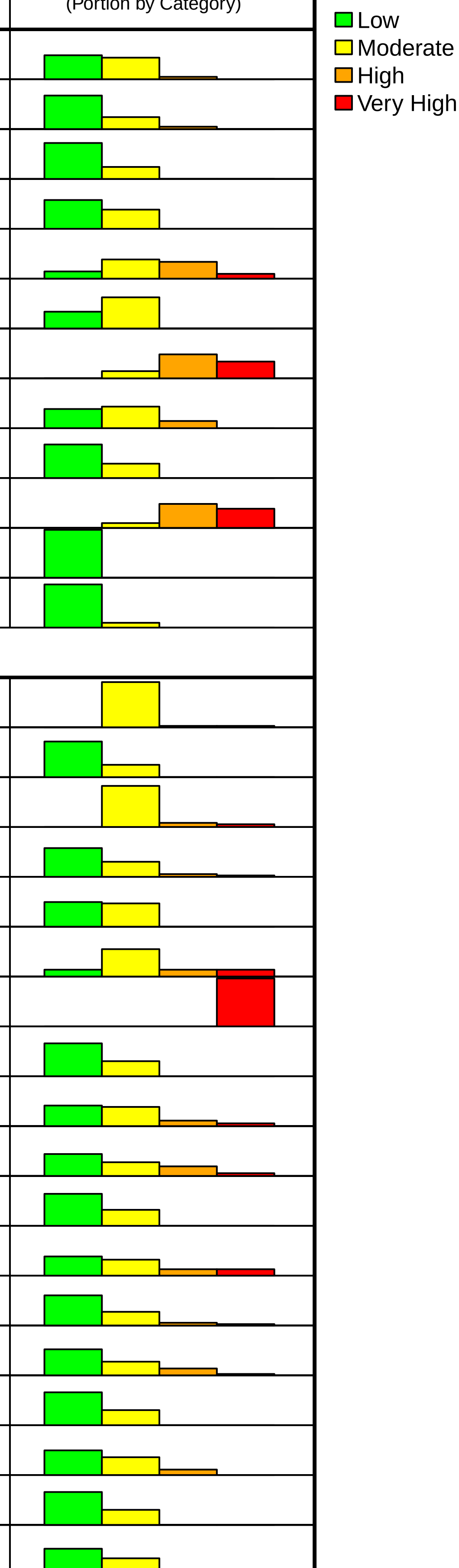
Biological Sensitivity = High

Climate Exposure = Low

Sensitivity Data Quality = 92% of scores ≥ 2

Exposure Data Quality = 56% of scores ≥ 2

	Limanda aspera	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.6	3.0	
	Prey Specificity	1.4	3.0	
	Adult Mobility	1.2	3.0	
	Dispersal of Early Life Stages	1.4	2.2	
	Early Life History Survival and Settlement Requirements	2.4	1.5	
	Complexity in Reproductive Strategy	1.6	2.8	
	Spawning Cycle	3.2	3.0	
	Sensitivity to Temperature	1.8	2.5	
	Sensitivity to Ocean Acidification	1.3	2.5	
	Population Growth Rate	3.3	3.0	
	Stock Size/Status	1.0	3.0	
	Other Stressors	1.1	2.8	
	Sensitivity Score	High		
Exposure factors	Sea Surface Temperature	2.1	2.5	
	Sea Surface Temperature (variance)	1.3	2.5	
	Bottom Temperature	2.2	3.0	
	Bottom Temperature (variance)	1.5	3.0	
	Salinity	1.5	2.0	
	Salinity (variance)	2.3	2.0	
	Ocean Acidification	4.0	3.0	
	Ocean Acidification (variance)	1.3	3.0	
	Phytoplankton Biomass	1.8	1.2	
	Phytoplankton Biomass (variance)	1.9	1.2	
	Plankton Bloom Timing	1.3	1.0	
	Plankton Bloom Timing (variance)	2.0	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	1.3	2.0	
	Currents (variance)	1.6	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		



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Yellowfin sole (*Limanda aspera*)

Overall Climate Vulnerability Rank: **Low**. (91% 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 (3.3) and spawning cycle (3.2) were ranked as "high" sensitivity.

Potential for distribution change: **High** (64% certainty from bootstrap analysis). Adult mobility and dispersal of early life stages indicated very high potential for distribution change, 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 yellowfin 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: It is not known what effect climate has on the distribution and abundance of Bering Sea yellowfin sole. Recruitment success has not been linked to any particular environmental variable although a year effect has been observed on somatic growth where temperature is positively correlated with annual bottom temperature. In addition, the timing of seasonal spawning migrations and subsequent distributions for feeding have been shown to be related to temperature, where earlier spawning has been observed to occur in warmer years and delayed spawning in cooler years. Studies on the spatial abundance from survey catches did not indicate large differences in population distributions between warm and cold years (Spencer 2008).

Life History Synopsis: The yellowfin sole (*Limanda aspera*) is one of the most abundant flatfish species in the eastern Bering Sea (EBS) and currently is the target of the largest flatfish fishery in the world. They inhabit the EBS shelf as far north as Norton Sound and are considered one stock in the Bering Sea/Aleutian Islands (Lauth 2011, Lauth and Conner 2014). Abundance in the Aleutian Islands region is negligible.

Yellowfin sole are distributed in North American waters from off British Columbia, Canada, (approx. lat. 49^{o} N) to the Chukchi Sea (about lat. 70^{o} N) and south along the Asian coast to about lat. 35^{o} N off the South Korean coast in the Sea of Japan. Adults exhibit a benthic lifestyle and occupy separate winter, spawning and summertime feeding distributions on the eastern Bering Sea shelf. From over-winter grounds near the shelf margins, adults begin a migration onto the inner shelf in April or early May each year for spawning and feeding (Wakabayashi 1986). The directed fishery has typically occurred from winter through autumn (Wilderbuer et al. 1992). Yellowfin sole are managed as a single stock in the BSAI management area as there is presently no evidence of stock structure.

Large spawning aggregations form in the near shore areas of Bristol Bay and north and westward at Nunivak Island and beyond (Nichol 1994). The age at maturity is estimated at 10.5

years (TenBrink and Wilderbuer 2015). Migrations may be as much as 100's of kilometers. The timing of the annual spawning migration and subsequent spawning appear to be temperature related as spawning may be weeks later in colder years and have a significant effect on their annual availability to the survey.

Eggs have been found to the limits of inshore ichthyoplankton sampling over a widespread area at least as far north as Nunivak Island. Larvae have been found in late August - early September. Advection may not be as important for yellowfin sole as for other flatfish, however, any kind of physical oceanographic forcing that causes larvae to be retained in near-shore areas would be beneficial. The survival of larvae is thought to be more strongly dependent upon the availability of suitable prey than on predation pressure. The age or size at metamorphosis is unknown but is assumed to be around 100 days. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and burrowing for protection. Juveniles are separate from the adult population, remaining in shallow areas until they reach approximately 15 cm. Adults consume polycheates, bivalves, amphipods and sand dollars. Diet depends on substrate type and they tend to be generalists inhabiting abundant physical habitat (Yang and Yeung 2013, Yeung and Yang 2014, Yeung et al. 2013, Livingston and DeReynier 1996). There is quite a bit of variability in recruitment success with very large-year classes spawned in 1981 and 1983 and strong year-classes in 1991, 1995 and 2003 (Wilderbuer et al. 2017).

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