Flat and Facing the Heat:
Biological Sensitivity of Gulf of Alaska Flatfishes

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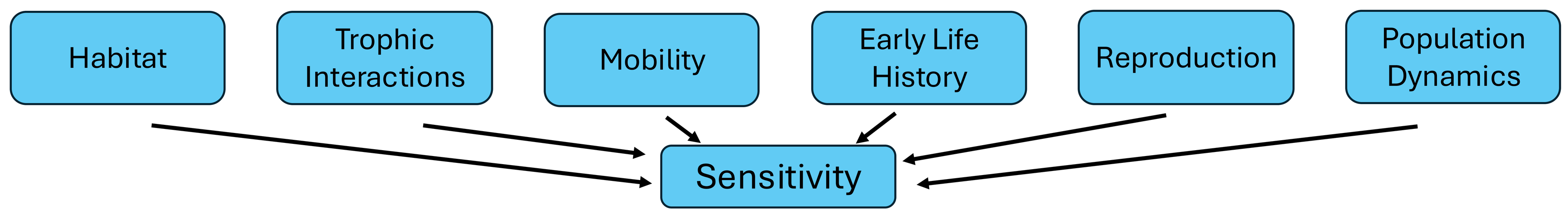
Background

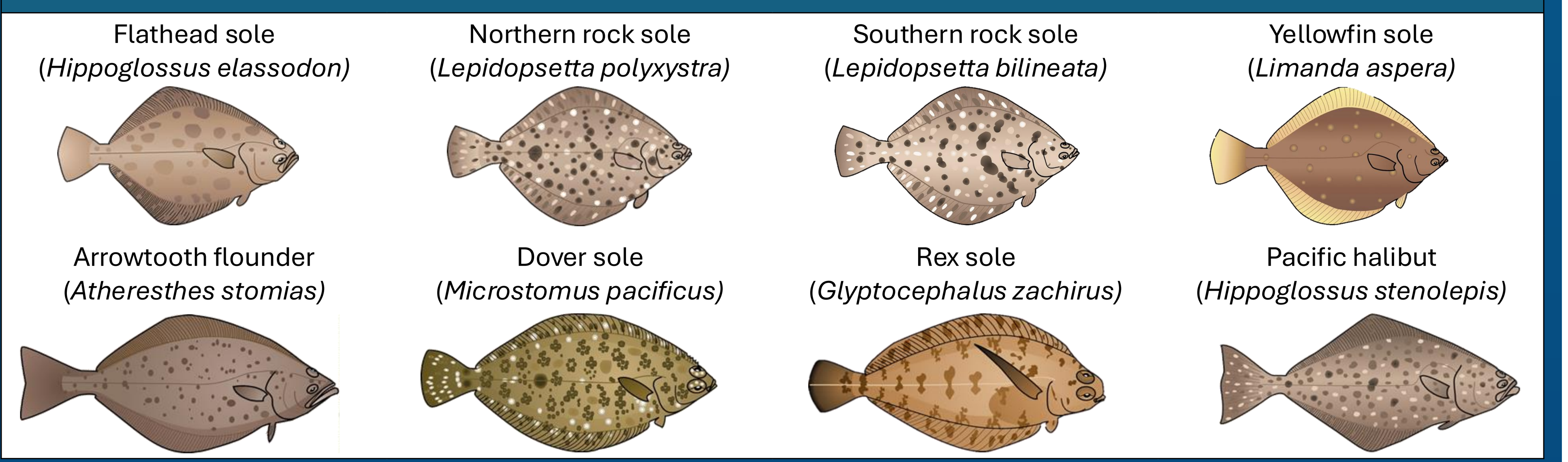
- In the Gulf of Alaska (GOA), commercially important flatfish species such as Pacific Halibut (*Hippoglossus stenolepis*), Yellowfin sole (*Limanda aspera*), and Arrowtooth flounder (*Atheresthes stomias*) collectively generate tens of millions of dollars annually.[1]
- The GOA is undergoing rapid environmental change including altered food-web dynamics, declines in key species, and climate-driven ocean warming pushing marine organisms beyond their physiological and ecological thresholds. [2]
- Climate vulnerability assessments (CVA) are informative tools that can guide resource managers, scientist, and local communities in understanding the susceptibility of individual species to climate impacts.

What makes up sensitivity?



- Sensitivity attributes compile biological and ecological information about flatfish species.

Flatfish Species



Methods

- We identified 8 flatfish species that covered a range of locations in the GOA (continental shelf and slope).
- Information for 12 sensitivity attributes were gathered through literature reviews.
  - Habitat Specificity = HS, Thermal Tolerance = TT, Sensitivity to Ocean Acidification = OA, Foraging Strategy = FS, Adult Movement = AM, Dispersal Capability = DC, Parental Investment = PI, Reproductive Plasticity = RP, Spawning Duration = SD, Life History Strategy = LHS, Stock Status = SS, Genetic Diversity = GD
- We then compiled sensitivity information for each species in "species profiles":

Stock: Flathead sole (*Hippoglossus elassodon*)			Range: Northern California to the GOA		
Attribute	Questions	Literature Review Results	Level of Analysis	Region	Sources
Stock Status	What is the value of B/B_{MSY}?	B/B_{MSY} = 2.834	Stock	GOA	National Marine Fisheries Service 2025

Fig. 2: Example species profile section of Flathead sole.

- Each sensitivity attribute was scored from low to very high using a five-tally system (Fig. 3):

Low	Moderate	High	Very High	Total Score
I	II	I	I	2.5

Fig. 3: Example scoring for a sensitivity attribute with high uncertainty, indicated by the wide spread of tallies.

- A group of students and scientists at Hatfield scored each species.
- We compiled these scores and used a logic rule to determine the overall sensitivity for each species (Table 1).

Table 1: Breakdown of how the logic rule is used and the resulting sensitivity score.

Logic Rule	Sensitivity Score
Less than 2 attributes with mean ≥ 2.5	Low
< 2 attributes with mean ≥ 3.0 AND ≥ 2 attributes with mean ≥ 2.5	Moderate
< 3 attributes with mean ≥ 3.5 AND ≥ 2 attributes with mean ≥ 3.0	High
3+ attributes with mean ≥ 3.5	Very High

Discussion

- Pacific halibut scored as "high" sensitivity because their parental investment and life history strategy scores were above 3.5, making them the most sensitive flatfish among the studied species.
- Northern rock sole and Rex sole scored as "low" sensitivity because of their low overall scores on each sensitivity attribute, with the exception of parental investment.
- CVAs present only a snapshot in time of a species sensitivity. Looking at time series trends of attributes allow for a better understanding of the compounding impacts of fishing and changing climate on stocks sensitivity.
- This work is contributing to the first wider GOA CVA.
- We plan to refine both the literature review and sensitivity scoring process.

Study Area

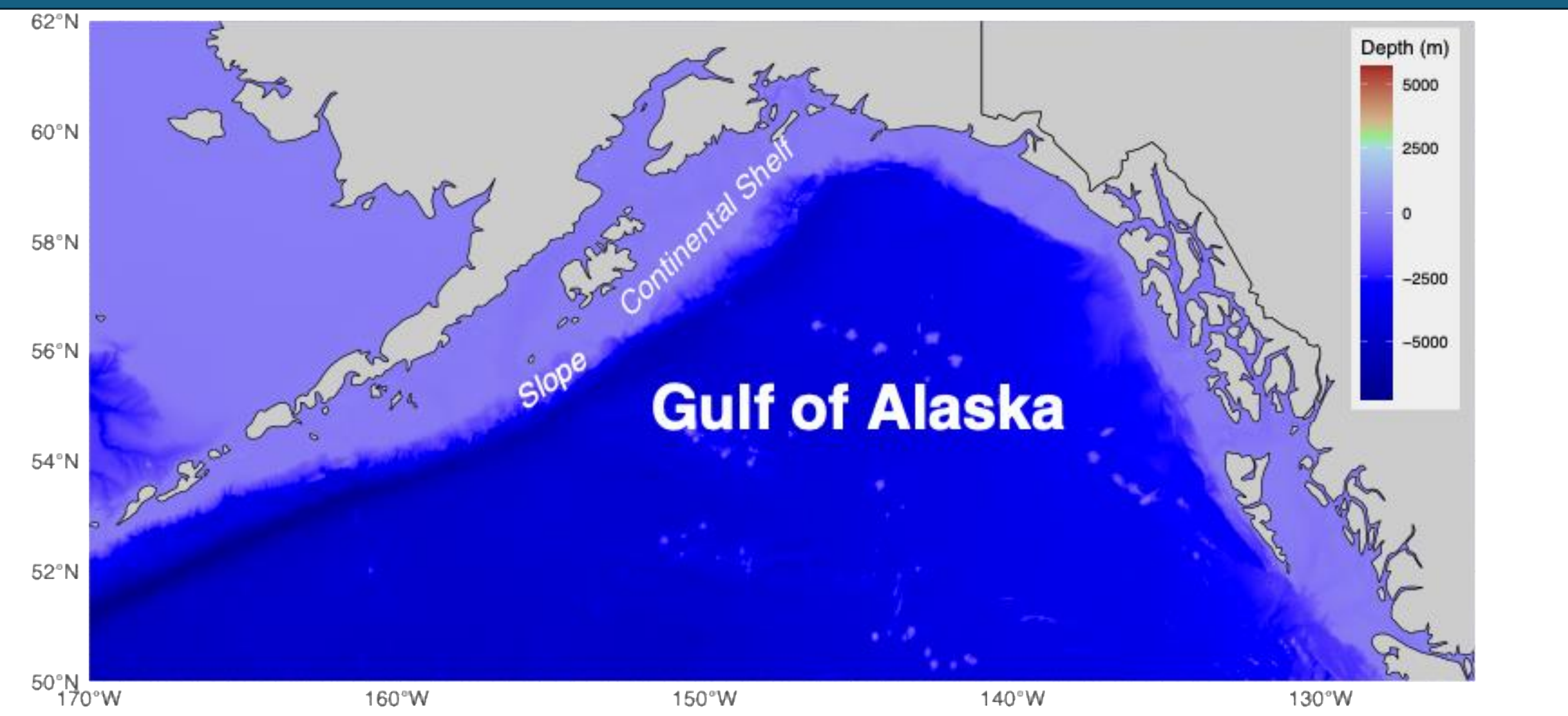


Fig. 1: Bathymetric map of the Gulf of Alaska showing focus areas of the continental shelf and slope.

Results

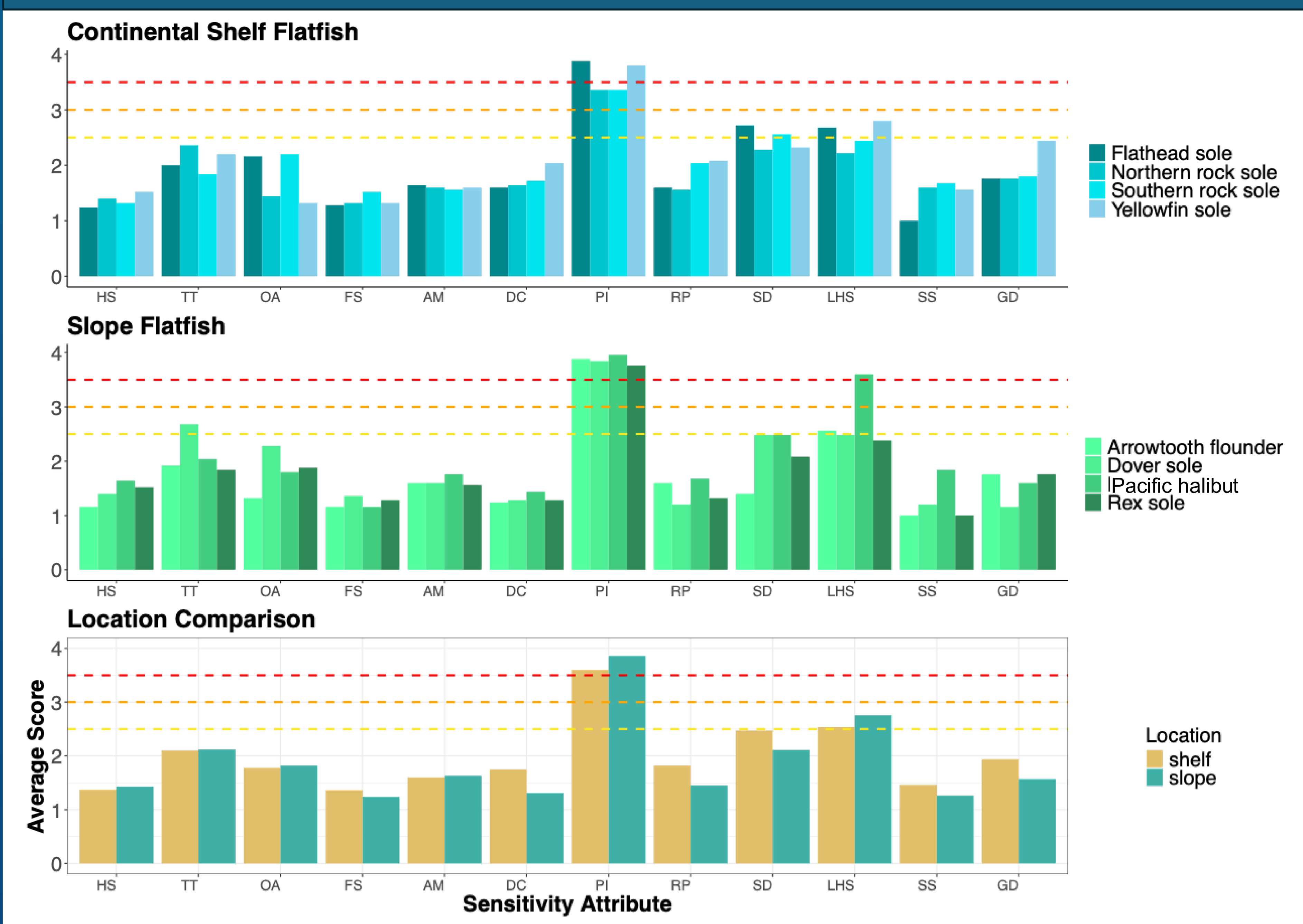
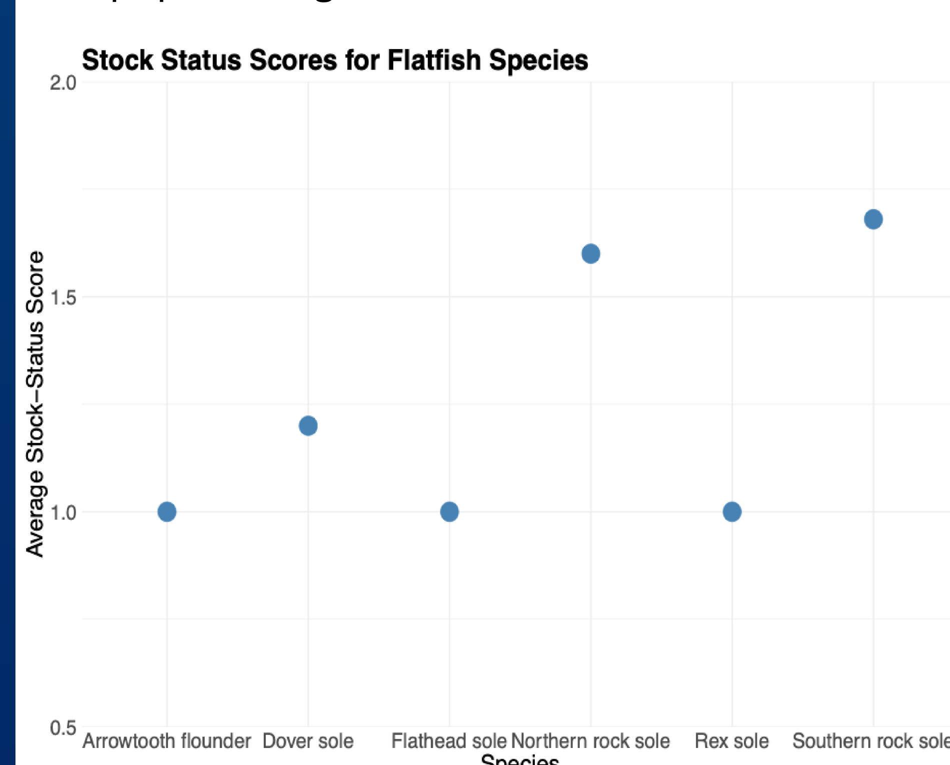


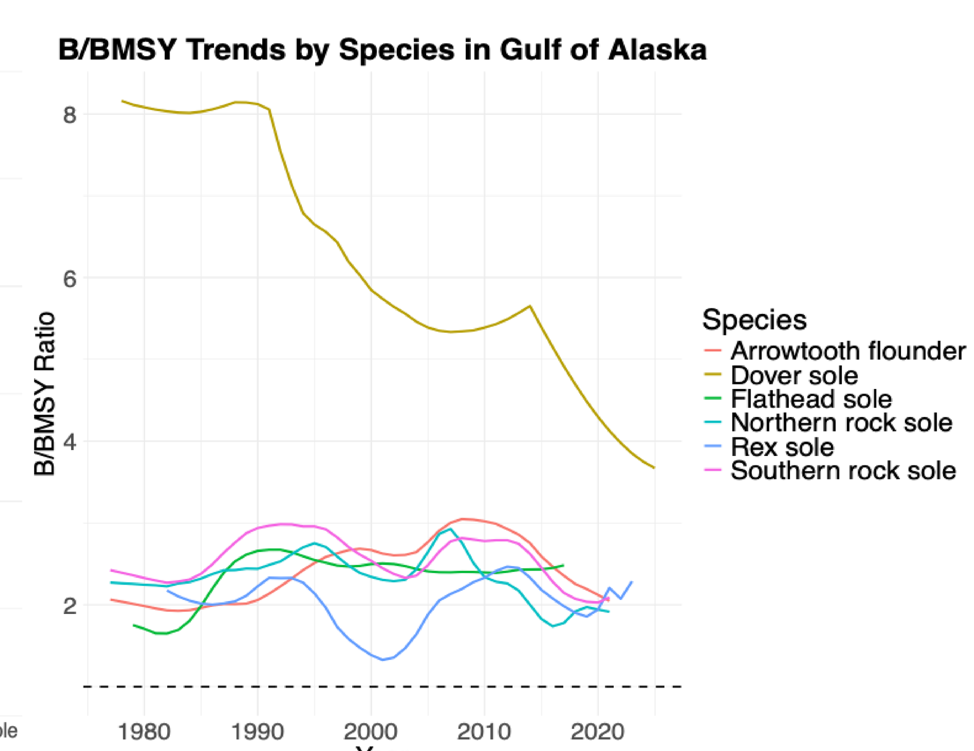
Fig 4: Mean sensitivity attribute scores for flatfishes on the continental shelf (top panel), slope flatfishes (middle panel), and a combined comparison between the two groups (bottom panel).

Overall Sensitivity

Low	Moderate			High
Northern rock sole	Southern rock sole	Yellowfin sole	Flathead sole	Pacific halibut
Rex sole	Arrowtooth flounder		Dover sole	

- Overall, all flatfish showed some similar trends in sensitivity due to limited spawning cycles and low population growth rates.





- We did a deeper analysis of stock status changes for flatfishes because their attribute score was low, however, a time series of their B/BMSY can provide deeper insights.

Acknowledgments and References

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References: