Projections of the eastern Bering Sea food web to support climate-informed ecosystem-based fisheries management

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Background

The eastern Bering Sea is a productive marine ecosystem that supports several commercial fish and crab fisheries and subsistence harvests. Climate change is impacting the eastern Bering Sea by altering physical and chemical conditions, which have implications for the food web and production that supports commercial fisheries. Thus, there is a need to develop climate-enhanced projections of the eastern Bering Sea food web to identify risks to the Bering Sea ecosystem, its fisheries and to assess climate-resilient fisheries management strategies. To address this need, we simulated future climate impacts to the eastern Bering Sea ecosystem through 2099 using a dynamic end-to-end food web model (Rpath, Lucey et al. (2020)).

Methods

Climate Change

- We represent primary and secondary production in the Rpath model with outputs from a regional ocean and biogeochemical model driven by three earth system models (GFDL, CESM, and MIROC), run under two contrasting climate scenarios (Cheng et al. 2021, Hermann et al. 2021). Shared Socioeconomic Pathway (SSP) 585 is a pathway with high carbon emissions, warming temperatures, and little mitigation. SSP 126 is a pathway with lower carbon emissions and high levels of mitigation.

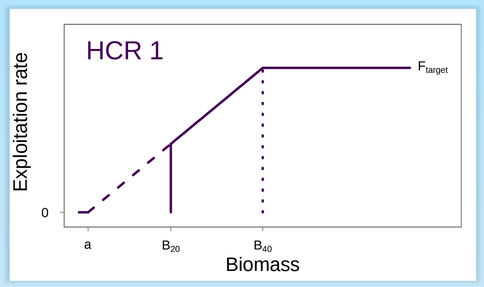
Groundfish Bioenergetics

- We directly incorporate the physiological effects of climate change on groundfish with a bioenergetics module that represents changing metabolic demands in response to changing temperatures (Heinichen et al. 2022). The projected bottom temperatures from the oceanographic modeling are used to scale consumption and respiration of all 20 federally managed groundfish stocks and pelagic forage fish, including Pacific herring, capelin, and sandlance.

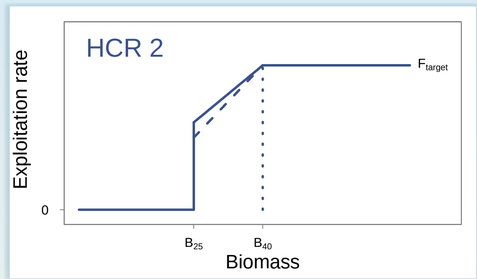
Fisheries Scenarios

- *Status Quo* - All federally managed groundfish fisheries are projected with a fisheries sub-model that incorporates social and economic tradeoffs into dynamic predictions of groundfish catch quotas under the existing fisheries management paradigm, including the two million ton cap on total groundfish removals (Faig and Haynie 2019).
- Constant exploitation rate equal to the mean of 2015–2019.
- No fishing

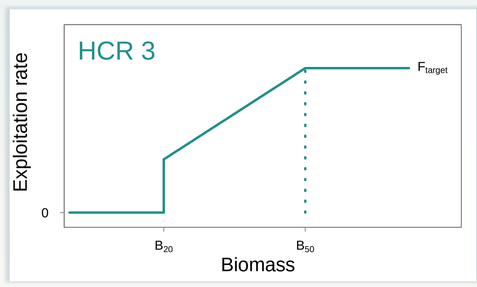
Harvest Control Rules



HCR 1 mimics the sloping HCRs currently used for Federally managed groundfish stocks in the eastern Bering Sea. The target biomass is 40% (B40) of the unfished biomass. Groundfish stocks designated as critical prey of Steller sea lions (walleye pollock, Pacific cod, Atka mackerel) have cutoff biomass of B20, below which the respective fishery is ceased.



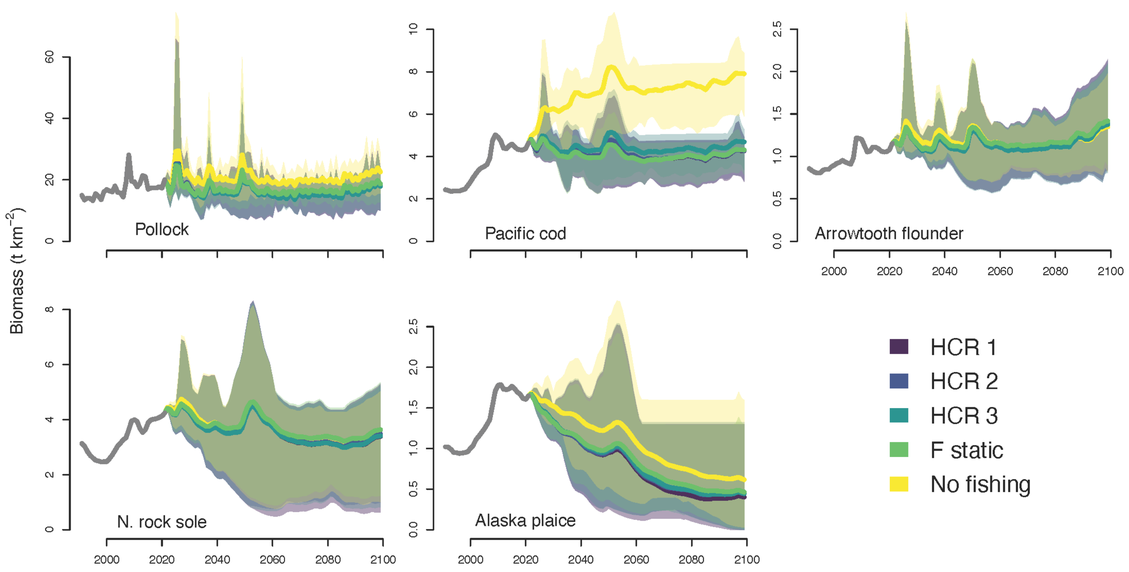
HCR 2 – All groundfish stocks have a target biomass of B40 and a more conservative cutoff biomass of B25. If a population reaches B25 and fishing ceases, the alpha (HCR slope) is increased from 0.05 to 0.25 until the population reaches B40 (dashed line), after which the original alpha (0.05) is reinstated.



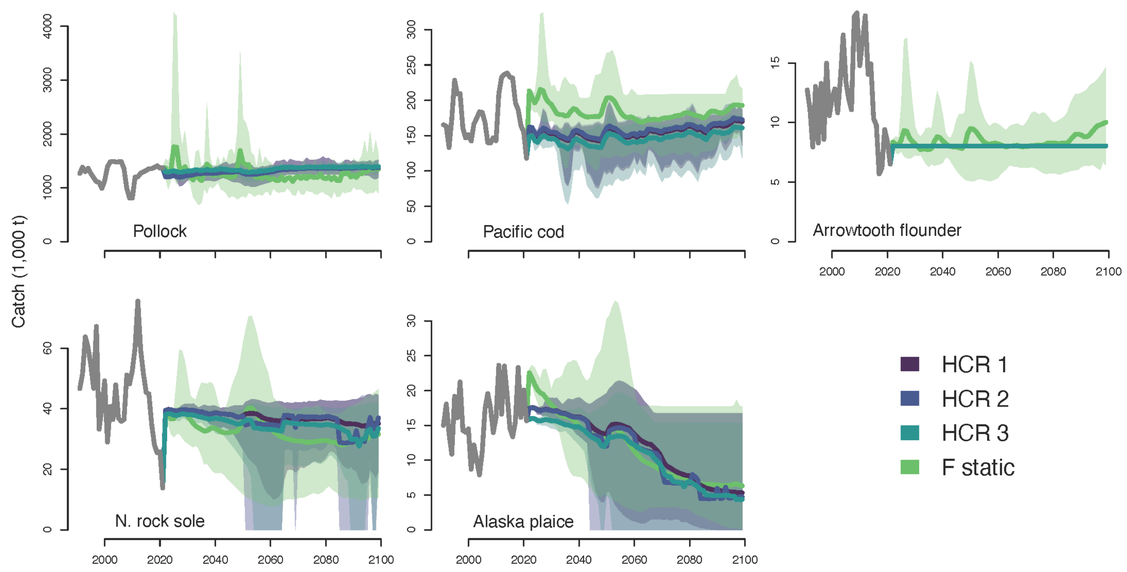
HCR 3 – All stocks have a target biomass of B50 instead of B40. Additionally, all stocks have a biomass cutoff of B20.

Results

Biomass projections for selected commercial species under forecasted climate change and fisheries management scenarios. The gray line represents the hindcast period (1991–2021). The projections (2022–2099) are represented by the different colored polygons and the lines are the mean trajectories across all climate scenarios.



Catch projections for selected commercial species under forecasted climate change and the fisheries management scenarios. The gray line represents the historical observed catch (1991–2021). The projections (2022–2099) are represented by the different colored polygons and the colored lines are the mean trajectories across all climate scenarios.



Conclusions

- The Bering Sea is at the northern margin of distribution for several groundfish stocks. For some of those stocks the present thermal conditions in the Bering Sea are on the colder end of their thermal habitat spectrum, such as arrowtooth flounder, and may benefit from the projected warmer temperatures, providing improved conditions for growth.
- In contrast, other groundfish groups may respond negatively to increasing temperatures and/or be sensitive to projected declines in invertebrate prey at lower trophic levels, resulting in negative biomass trends through the end of the century.
- The direction of climate change impacts across species may be mixed and will challenge fisheries managers. One tool that may be useful to fisheries managers in the face of ongoing climate change are alternative harvest control rules.
- Alternative harvest control rules designed to manage the risks posed by climate change can help maintain and restore commercial groundfish stocks and support sustainable fisheries harvests.

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The scientific views, opinions, and conclusions expressed herein are solely those of the authors and do not represent the views, opinions, or conclusions of the Department of Commerce, the National Oceanic and Atmospheric Administration, or the National Marine Fisheries Service

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