Predicted habitat range shifts of fishery species along the U.S. Atlantic Coast to warming bottom temperature patterns

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Background

- Bottom temperatures drive poleward shifts in species distributions
- Climate models can help project changes in species distributions under various scenarios
- Estimating species shifts is essential to anticipate changes under climate change

Goal

Use CMIP6 climate models and thermal ranges/limits of seven fisheries species off the U.S. Atlantic Coast to estimate potential distribution based on bottom temperature habitat under three climate scenarios
(SSP 2 4.5, SSP 3 7.0, & SSP 5 8.5)

Warming bottom temperatures estimate larger decreases in thermal habitat than increases, varying trends among species, and species entering new management zones under projected climate scenarios

Main Results

Species	Red Grouper	Red Snapper	Gag Grouper	Scamp Grouper	Cobia	Vermillion Snapper	Greater Amberjack
Thermal Range °C	16 – 25.7	19 – 29	18.3 – 27.1	20.7 – 27.5	16.8 – 32	18.3 – 27.2	16.9 – 29
% Change Bottom Temps in Thermal Range	-4.82 – -5.78	1.05 – 1.25	-1.63 – -5.48	-0.77 – -3.66	1.92 – 3.46	-1.25 – -4.81	1.34 – 2.21
% Change in Area by 2100	-28.63 – -35.2	0.61 – 9.07	-14.26 – -40.9	-14.1 – -41.49	12.85 – 30.36	-12.74 – -39.33	9.14 –15.13
Latitudinal Shift in Range Edge (°N)	1.35 – 2.83	0.47 – 0.7	0.52 – 0.93	0.3 – 0.48	1.08 – 1.96	0.52 – 0.93	1.03 – 1.85

Table 1 Summary table including metric ranges from three climate scenarios per species. See methods section for metric information.

Overall

- Red Grouper, Gag Grouper, Scamp Grouper, & Vermillion Snapper may experience "negative" impacts

↓ Temperatures within thermal range ↓ Thermal habitat ↑ Thermal Habitat fragmentation

- Poleward shifts of habitat for all species
- Variation in direction and magnitude of trends
- "Positive" impacts smaller in magnitude than "negative"

Bottom Temperature Habitat (Fig. 1)

\+
- Northern latitudes
- Further offshore for some species

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- Nearshore in lower latitudes
- Fragmentation in central latitudes

Management Implications (Fig.2)

- Five of seven species may move into novel management areas seeking appropriate bottom temperatures

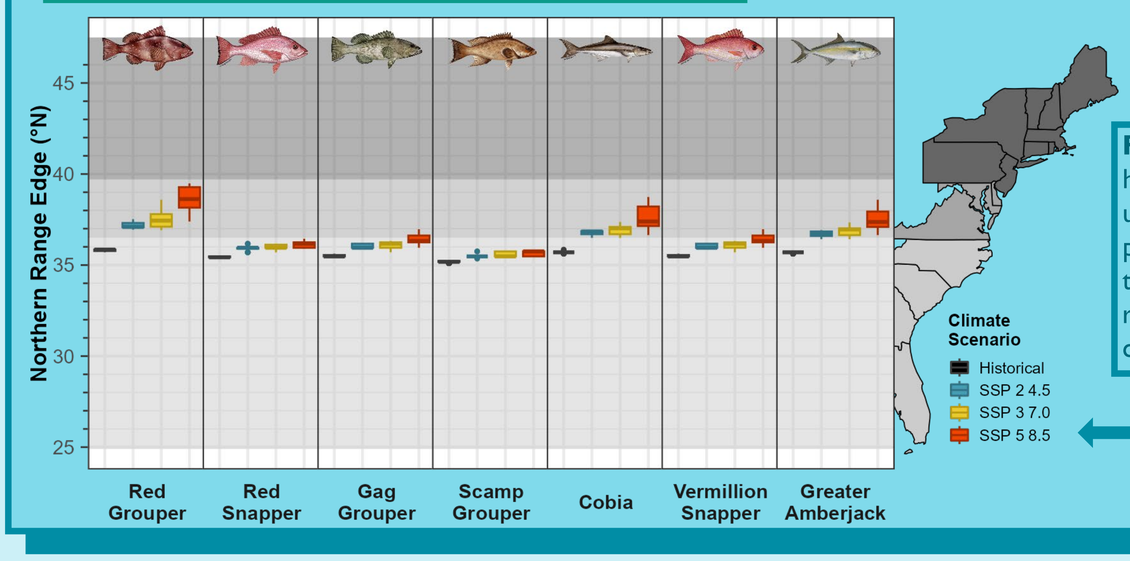

Figure 2 Northern range edge historically (1985-2014) and forecasted under climate scenarios (1971-2100) of potential habitat based on bottom temperature. Management zones represented by gray banding and corresponding map.

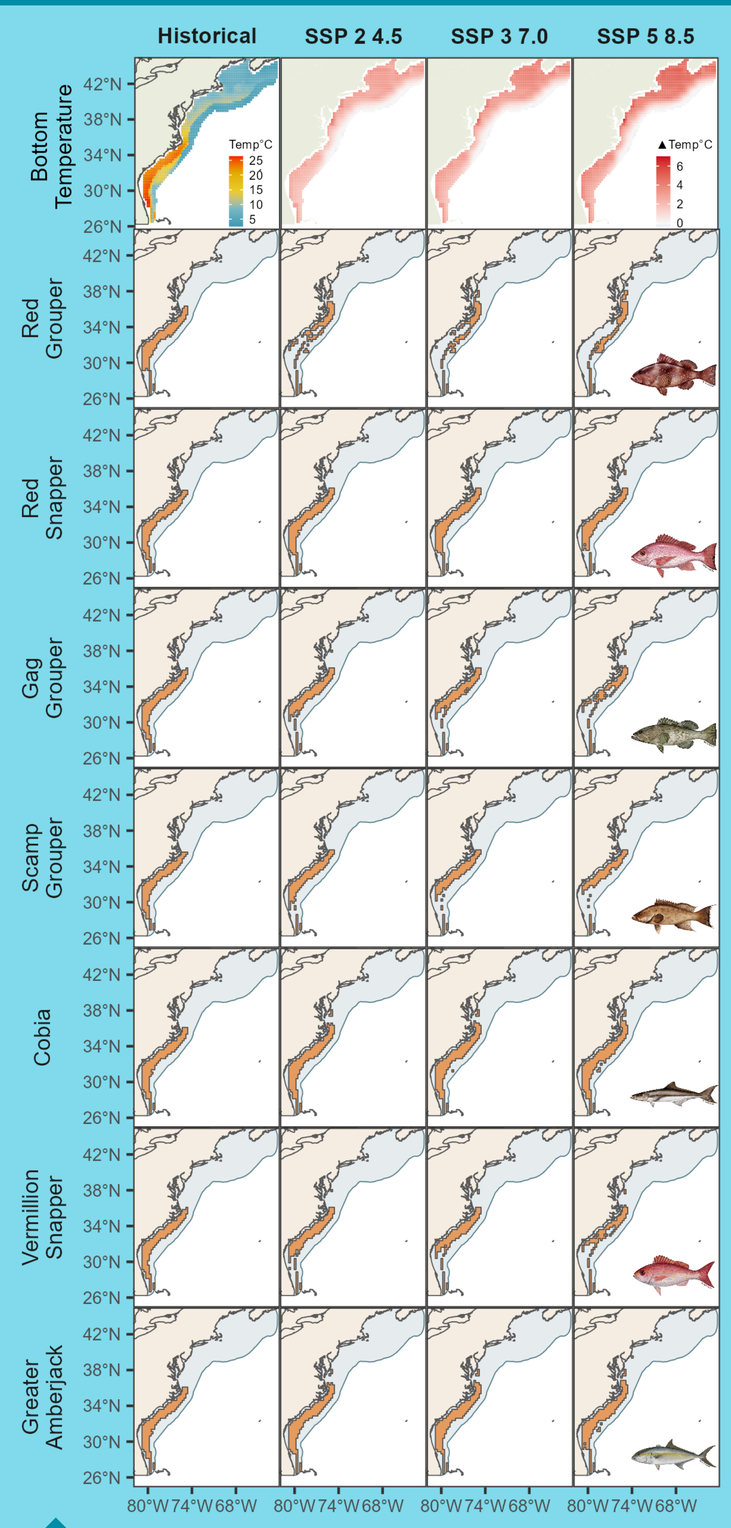

Figure 1 Top row: Historical bottom temperatures and degree change under each climate scenario (°C). Remaining rows: Possible species distribution based on bottom temperature historically and forecasted under three climate scenarios.

Methods

- **Climate Model:** Multi-model ensemble mean of six CMIP6 models for three socioeconomic climate scenarios representing "low", "medium", and 'high" radiative forcing
  - Historical time frame: 1986-2014
  - Forecasted time frame: 2071-2100
- **Thermal range:** Optimal thermal range or limit from FishBase and additional resources; based on species range or physiological limits
- **Percent change in bottom temperatures within thermal range:** Change in distribution of mean temperatures per grid cell within a species' thermal range compared to historical time frame
- **Percent change in area:** Percent difference of mean area with habitable bottom temperature compared to historical time frame
- **Latitudinal shift in range edge:** Mean latitude of ten northern most grid cells within a species' thermal range

Future Studies

- Regional differences
- Absolute vs. relative temperature change
- Temperature extremes
- Shifts in depth
- Increase model resolution
- Additional environmental covariates
- Physical bottom habitat
- Multi-species analysis for species assemblage results

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