Session: Modeling and Analysis

Ecosystem Modeling and Analysis: Exploration of climate-induced shifts in historical and future distributions of marine species on the U.S. Northeast Shelf

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The overarching goal of this project is to advance ecosystem-based management and ocean use planning in the Northeast and Mid-Atlantic regions through modeling and analyzing historical and future distribution shifts of demersal marine species. As opposed to studies that examine shifts in distribution of individual species, this project took an ecosystem approach and measured historical shifts of groups of species that have similar depth and temperature preferences using trawl survey data on the U.S. Northeast Shelf (NES). Future changes in suitable thermal habitat availability on the NES were also evaluated using cutting-edge high-resolution climate model temperature outputs. The products include a time series of 'movies' and static maps that illustrate the temporal changes in distributions of individual species and species groups for past, contemporary, and future time periods. These results are designed to be useful to fisheries managers, spatial planners, and the wider community of stakeholders in understanding and planning for potential climate-induced changes to valuable fisheries and the ecosystem in this region.

The project was completed in two phases. The first phase examined historical changes on the NES. The authors classified almost 70 demersal species into 4 distinct assemblages based on oceanographic characteristics from the spring and fall Northeast Fisheries Science Center bottom trawl surveys. Because the oceanographic and habitat characteristics are so different between the Gulf of Maine (the 'northern' NES) and the Mid-Atlantic Bight and Georges Bank (the 'southern' NES), the species groups were examined separately in these two regions. Depth and surface and bottom temperature data were key to distinguishing the groups in each region. Observed shifts in species distributions were compared with shifts in temperature to determine whether consistent responses to climate change were visible within the species groups.

There were distinct differences in shifts in the assemblages of species in each region. Species associated with warmer, shallower waters in the Mid-Atlantic Bight and Georges Bank exhibited a strong northward shift, tracking shifts in temperature bands along the shelf. In contrast, species in the Gulf of Maine were shifting to the southwest, possibly tracking the cooler bottom waters on the shelf and in deeper basins in this area of the Gulf. Species in the Gulf of Maine associated with cooler and deeper waters tended to shift deeper, taking advantage of the variable bottom topography in this region. The results from this phase of the project were published in Plos One (Kleisner *et al.* 2016).

In the second phase of the project, a high-resolution climate model was used to model species distribution shifts over the next 80 years. In general, species that are currently distributed in the south of the U.S. NES in the Mid-Atlantic Bight and Georges Bank were found to shift northward and many species currently found in the Gulf of Maine did not have access to habitat with a suitable temperature in the future. This may have important impacts on the viability of species currently inhabiting the Gulf of Maine and their ability to maintain robust populations in the future. This will also translate into impacts on the commercial fisheries in this region.

Overall, it is understood that, given climate change, some species will be 'winners' and others will be 'losers'. It is harder to predict how these dynamics will unfold on the U.S.NES, especially given the extreme warming predicted by global climate models. Combining our understanding of how species have shifted in the past, with predictions of future temperature from climate models can help identify the potential climate change impacts on vulnerable fish species. Additionally, current and potential biomass hotspots and areas of high fish biodiversity can be identified to help highlight implications for fishermen and communities that depend on fishery resources. Together these results provide critical information for developing spatial management strategies in response to climate change.

Major findings

Using a combination of temperature and habitat variables sampled on the U.S. NES we defined four groups of species based on temperature and depth.

- Exploring distribution shifts between the species groups on a regional basis illustrated different patterns between the Gulf of Maine, a northern region with variable bottom topography and complex currents, and the Mid-Atlantic Bight and Georges Bank in the south, a region with more uniform depths.
- In the Gulf of Maine, the centers of distribution of many species shifted to the southwest, possibly tracking cooler bottom temperatures in the southwestern Gulf. Species associated with cooler and deeper waters tended to shift to even deeper waters.
- Along the Mid-Atlantic Bight and Georges Bank, the centers of biomass of many species shifted to the northeast, tracking shifts in temperature bands. Species associated with shallow, warmer waters shifted northward at the greatest rates, generally staying in shallower waters.
- Species with current centers of distribution on the Mid-Atlantic Bight or Georges Bank may be future climate winners because they can shift northward or deeper.
- Species that are currently distributed in the Gulf of Maine are climate losers on the Shelf because areas with suitable temperatures in the future may not be available.
- Potential future shifts will mean major changes in species composition along the U.S. NES. Fishing communities will need to adapt to new conditions by switching their targeted species or traveling further to maintain viable fisheries.

References

Kleisner, K.M., Fogarty, M.J., McGee, S., Barnett, A., Fratantoni, P.S., Greene, J., Hare, J.A., Lucey, S., McGuire, C., Odell, J., Saba, V.S., Smith, L., Weaver, K.J., Pinsky, M.L., 2016. The effects of sub-regional climate velocity on the distribution and spatial extent of marine species assemblages. *Plos One*, 11, e0149220.

Relevant posters:

Northeast Coastal and Ocean Climate Applications Program, Jon Hare and Vince Saba, NEFSC Ecosystems Processes Division

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