Species distribution model predictability doesn’t always decline under novel temperature conditions

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Abstract

Despite the rapid development and application of species distribution models (SDMs) to predict species responses to climate-driven ecosystem changes, we have a limited understanding of model predictive performance under novel environmental conditions. We aimed to address this gap using a simulation experiment to evaluate how novel ecosystem conditions and species movement influence SDM predictability. We leveraged observed sea surface temperature responses in the California Current and Northeast U.S. Shelf large marine ecosystems (LMEs) and prescribed species-response curves to simulate the distribution of a resident but mobile ectotherm, and a seasonally migrating ectotherm in each LME. For each LME and species archetype, we fitted boosted regression tree SDMs using data from 1985-2004 and then predicted the monthly probability of presence from 2005-2020 and calculated the environmental novelty of prediction month conditions. Generally, climate-driven ocean warming resulted in increasing environmental novelty over time, though patterns varied seasonally as warming caused novel conditions to increase over time in the summer and fall and decrease in the winter and spring as novel, cool conditions became more rare. Overall, predictive performance declined as novelty increased and occurred before prediction conditions became distinguishable from observation conditions. There were also unexpected increases in performance under novel environmental conditions when these novel conditions occurred at optimum species-response curve temperatures. These results highlight that environmental novelty may not always pose prediction challenges and will depend on where novel conditions map onto species-response curves. As SDM applications expand, there will be an ongoing need to maximize data quantity and quality to more fully characterize a species’ fundamental niche, explore environmental novelty relative to species-response curves, and continue to improve methods for quantifying and communicating model uncertainty. These efforts will open opportunities for model improvement and support stakeholders’ capacity to understand and integrate predictions into decision-making processes.

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1. Select focal large marine ecosystems (LMEs), leveraging recent SST patterns as a natural experiment.

2. Define species-response curves for a resident-mobile (solid line) and seasonally migrating (dashed line) species archetypes.

3. Simulate monthly species' habitat suitability for each archetype/LME.


5. Calculate environmental novelty of prediction target conditions.


Results: Prediction performance relative to environmental novelty.

Resident-mobile species archetype

Seasonally-migrating warm water species archetype