Predictability of species distributions deteriorates under novel environmental conditions in the California Current System

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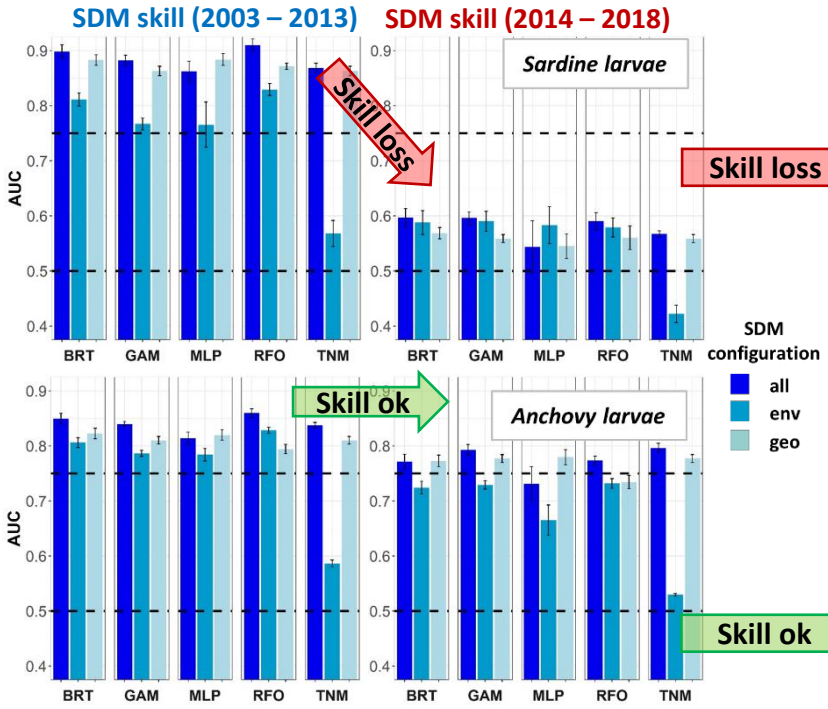
The problem

- **Species Distribution Models** (SDMs) can show how environmental variability impacts the distribution of marine organisms
- SDMs can also predict range shifts under future climate change
- But how might these models perform under novel environmental conditions? Recent marine heatwaves can provide a test case

Our approach

- In this study, we assessed the ability of 5 different SDMs to predict species distributions during a recent marine heatwave:
  - Generalized Additive Models (**GAM**)
  - Boosted Regression Trees (**BRT**)
  - Multilayer Perceptron Artificial Neural Network (**MLP**)
  - Random Forest (**RFO**)
  - Thermal Niche Model (**TNM**)
- Our test species were **Pacific sardine**, and **northern anchovy**
  - Adults from trawl surveys, larvae from plankton surveys
- We trained the SDMs using data from 2003 - 2013, and validated them on the heatwave years (2014 - 2018)



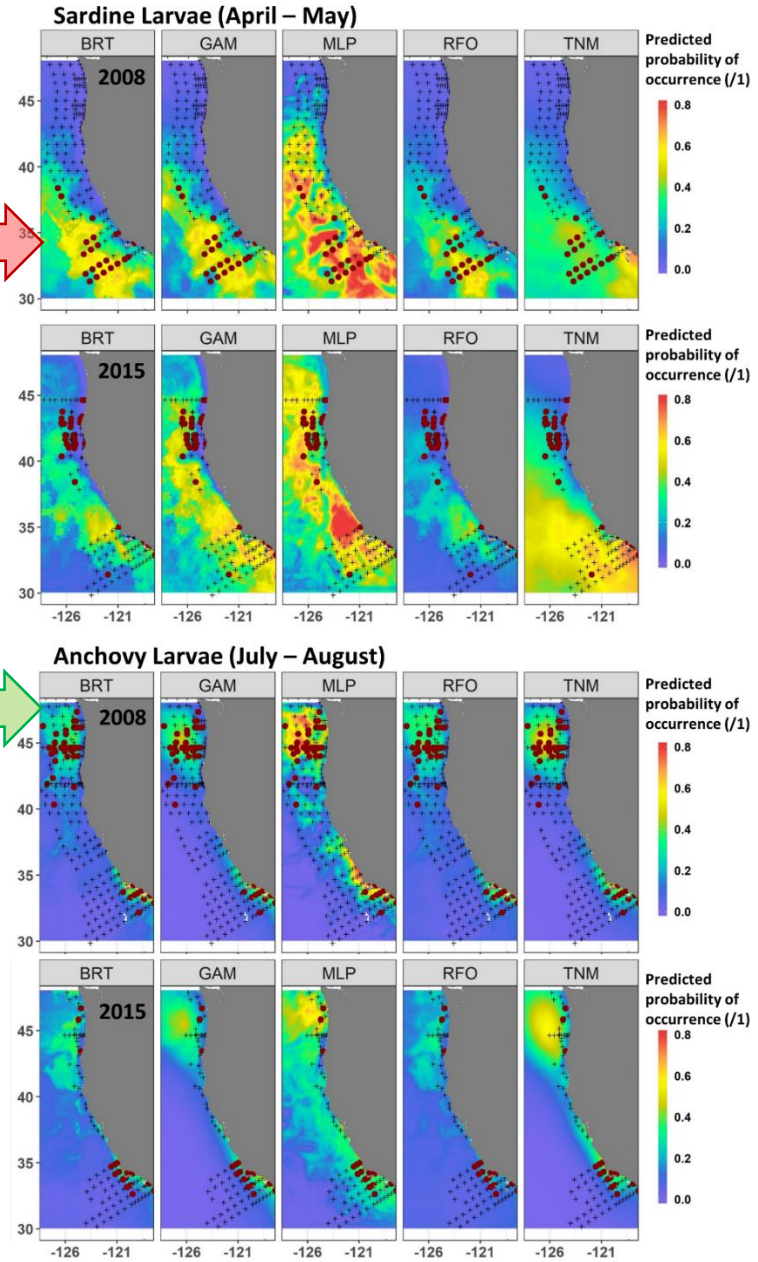
Model skill (AUC) for "average" training years (left), and heatwave validation years (right), for larval sardine and anchovy SDMs. Bar colors show whether SDMs contained only environmental predictors ("env"), only geographic predictors ("geo"), or both ("all"). Sardine larvae SDMs lost most of their skill, but anchovy larvae SDMs retained skill

What we found

- We found that the SDM predictive skill **declined substantially** when applied to the marine heatwave years
- Relationships between species and environmental predictors were non-stationary, especially for adult sardine
- The larval anchovy SDMs retained some skill, mostly because spawning areas did not change substantially during the heatwave

What does this mean?

- We need to be very careful running SDMs into the future, or extrapolating them into novel conditions in time or space
- We need to better understand the physiological basis behind the statistical correlations in SDMs
- Marine species can respond to extreme events in unexpected ways, especially those with separate subpopulations



Example SDM predictions (colors) and sample observations (dots) for an "average" year (2008) vs. a heatwave year (2015). Sardine larvae moved strongly north, which was not captured by any of the SDMs. Anchovy larvae did not shift as strongly

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