Assessing the Reliability of Species Distribution Models (SDMs) in the Face of Climate and Ecosystem Regime Shifts: How Common is Non-Stationarity?

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Introduction

- Species distribution models (SDMs) are a common tool for projecting how climate change impacts living marine resources.
- SDMs assume stationary relationships between organisms and the environment.
- This assumption was violated during the 2014-2016 marine heat wave affecting the California Current System (Muhling *et al.*, 2020).

How frequently has non-stationarity been observed during previous climate and ecosystem regime shifts?

Methods

Target Species

Environmental variables

Temperature (T), Salinity (S), Dissolved oxygen (O), Zoo-plankton displacement volume (Z)

Types of SDMs: Generalized Additive Models (GAMs; max. 4 knots), Non-Parametric Probabilistic Ecological Niche (NPPEN) models (Beaugrand *et al.*, 2011)

Types of Regime Shifts: 1) Pacific Decadal Oscillation (PDO); 2) Change points in detected in time series of environmental variables and fish spawning stock biomass (SSB) with Ruggieri (2013) algorithm

Results

Change Point Detection: Change points were detected in the time series of: 1) Zooplankton volume in 1968 and 1983; 2) Anchovy SSB in 1963; 3) Sardine SSB in 1963 and 1997.

Assessment of Non-Stationarity: Incidents of non-stationarity associated with regime shift were assessed with six metrics. White = stationary relationship; Purple = non-stationarity; Grey = N/A

Metric 1: Variables included in model

	Anchovy T S O Z	Sardine T S O Z	Chub mackerel T S O Z	Jack mackerel T S O Z
PDO				
Zooplankton				
SSB				

Metric 2: Linearity

	Anchovy T S O Z	Sardine T S O Z	Chub mackerel T S O Z	Jack mackerel T S O Z
PDO				
Zooplankton				
SSB				

Metric 3: Rank order of deviance explained

	Anchovy T S O Z	Sardine T S O Z	Chub mackerel T S O Z	Jack mackerel T S O Z
PDO				
Zooplankton				
SSB				

Metric 4: Response curve shape

	Anchovy T S O Z	Sardine T S O Z	Chub mackerel T S O Z	Jack mackerel T S O Z
PDO				
Zooplankton				
SSB				

Metric 5: Degree of responsiveness

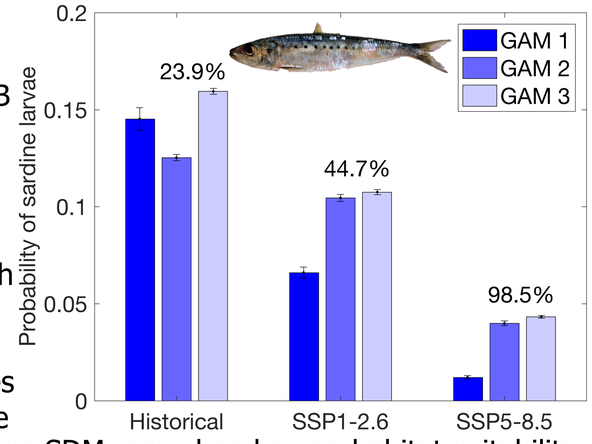
	Anchovy T S O Z	Sardine T S O Z	Chub mackerel T S O Z	Jack mackerel T S O Z
PDO				
Zooplankton				
SSB				

Metric 6: Preferred environmental range

	Anchovy T S O Z	Sardine T S O Z	Chub mackerel T S O Z	Jack mackerel T S O Z
PDO				
Zooplankton				
SSB				

How could this affect projections of future climate change impacts?

Projections are for sardine SSB regime shifts and are based on the CNRM Earth System Model. Percentages indicate the ratio between SDM spread and mean habitat suitability. ***This ratio increases as climate change impacts increase, indicating that non-stationarity has a greater effect on projections as environmental conditions exceed previous limits.***



References

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