Larval dispersal, overwinter mortality, and climate change: forecasting range shifts of a sub-tropical fish species in a western boundary current system.

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Outline

• Introduction (Range Shifts)
• Species and System
• Species Range Forecast – Methods
• Species Range Forecast – Results
• Conclusions
Introduction

Species range limited by distribution of niche

Climate change causes change in distribution of niche

Dispersal determines speed of response in new niche area
Introduction

Complex Life Histories
egg, larvae, juveniles, adults

Dispersive Early Life History Stages
eggs and larvae disperse beyond adult range

Overwinter mortality
juvenile mortality restrict range

Climate change
new adult niches can be rapidly occupied

- niche
- species range
Introduction

Western Boundary Currents carry larvae well poleward of adult range (>1000 km)

Overwinter mortality
juvenile mortality restrict range

Climate change
new adult niches can be rapidly occupied
Introduction

Objectives

• Quantify overwinter mortality
• Link to General Circulations Models
• Forecast Changes in Range in a Western Boundary Current System
Introduction

Builds upon recently published study

Forecasting the dynamics of a coastal fishery species using a coupled climate–population model

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Hare et al. 2010 Ecological Applications 20(2); 452-464
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Species and System

Gray snapper (*Lutjanus griseus*)

- Sub-tropical species
- Pelagic eggs and larvae (~45 days)
- Juveniles dependent on nearshore habitats
- Adults reef-associated
Species and System

Gray snapper

- Laboratory-based lower lethal limit $\sim 140$ degree days $< 17^\circ C$
Species and System

Gray snapper

- Laboratory-based lower lethal limit $\sim 140$ degree days $< 17^\circ C$
- Limit agrees with field observations in estuarine nurseries
- Supports hypothesis: juvenile overwinter mortality controls northern range
Species and System

Gray snapper

• Larvae dispersed poleward in association with Gulf Stream

• Juvenile die in winter owing to low temperatures

• Northern limit of adult population determined by overwinter juvenile survival
Species and System

System

• Winter estuarine temp. (observed) linked to winter air temp. (NCEP)

• Shallow systems with efficient heat exchange

• Use winter air temp. as proxy for winter estuarine water temp.
Forecasts – Methods

• Minimum monthly winter air temperature from 14 GCM’s

World Data Center for Climate, IPCC Data Distribution Centre
Forecasts – Methods

- Minimum monthly winter air temperature from 14 GCM’s
- Three scenarios considered: commit, B1, and A1B
Forecasts – Methods

- Minimum monthly winter air temperature from 14 GCM’s
- Three scenarios considered: commit, B1, and A1B
- Simple mean bias correct using 20th century GCM runs for each estuary
Forecasts – Results

- Estuarine winter temp. rise with increased CO₂
Forecasts – Results

- Estuarine winter temp. rise with increased CO₂
- Range forecast to expand poleward (modest distance ~2 km yr⁻¹)
Forecasts – Results

- Estuarine winter temp. rise with increased CO₂
- Range forecast to expand poleward (modest distance ~2 km yr⁻¹)
- Forecast can be generalized for similar species
Conclusions

• Hypothesis: poleward spread in WBC not dispersal limited

• Hypothesis: overwinter mortality important mechanism at poleward edge of ranges

• Can use air temperature as proxy for ocean temperature in shallow systems

• Minimum winter temperature variability strongly coherent over 1000 km’s

• Ensemble forecasts northward spread of 50-100 km in 30-40 years
Conclusions

- For gray snapper need to include statistical uncertainty in overwinter mortality and in relationship between air and water temperature

- Forecast rates of change are low relative to general patterns in marine systems (Chueng et al. 2009, Nye et al. 2009, others) – species/system? Or forecasts?