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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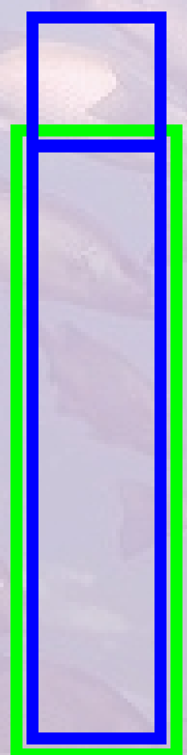
Outline

- 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

niche
species range

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

Introduction

Western Boundary Currents

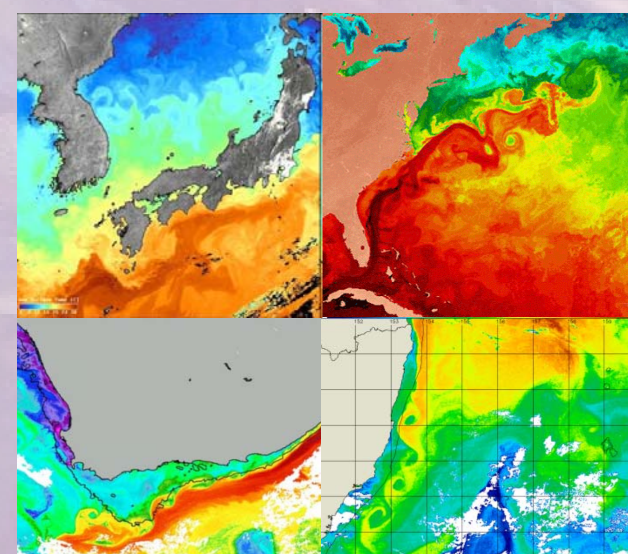
carry larvae well poleward of adult range (>1000 km)

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

Ecological Applications, 20(2), 2010, pp. 452–464

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

Jonathan A. Hare,[1,5] Michael A. Alexander,[2] Michael J. Fogarty,[3] Erik H. Williams,[4] and James D. Scott[2]

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

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Species and System

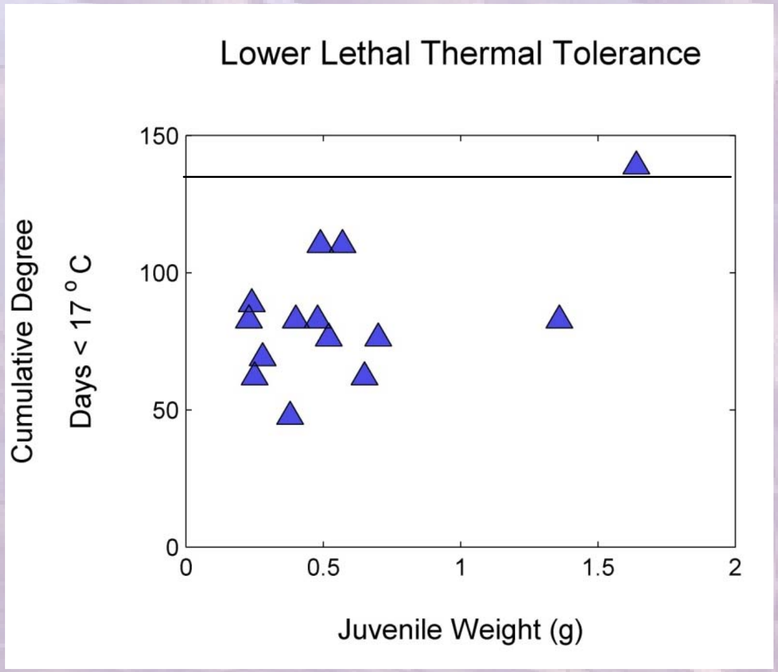
Gray snapper (*Lutjanus griseus*)

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

Species and System

Gray snapper

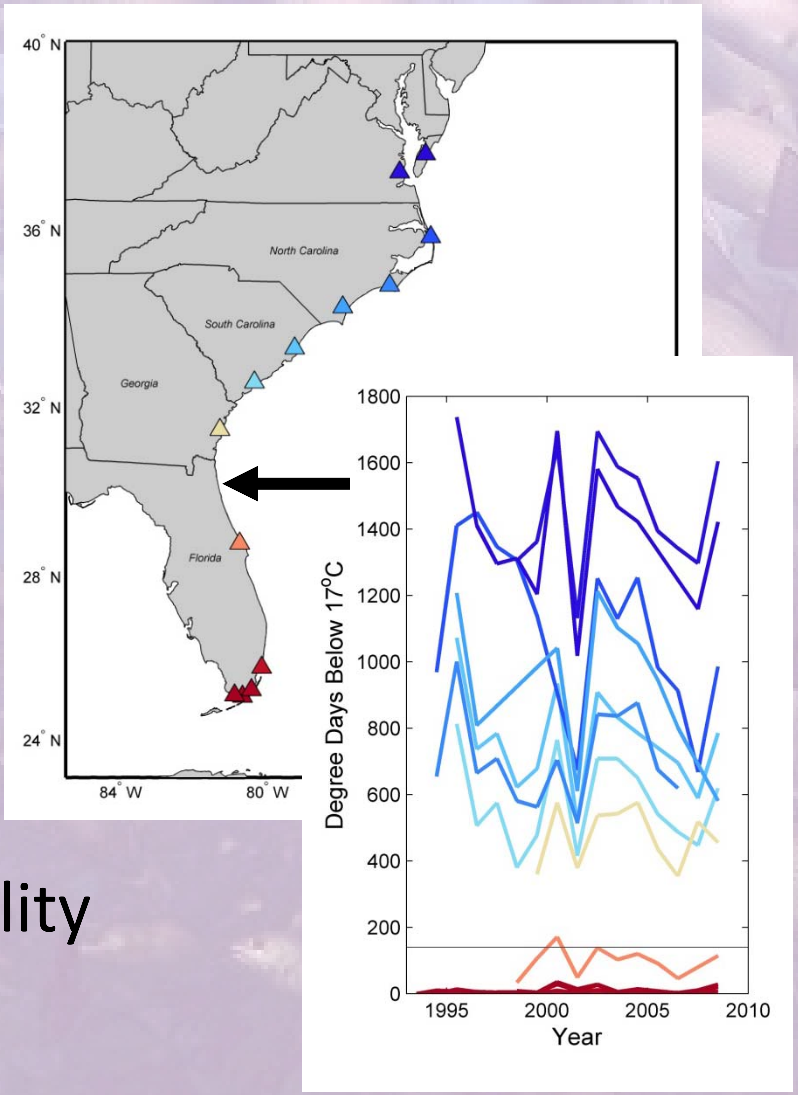
- Laboratory-based lower lethal limit ~140 degree days <17^{o}C



Species and System

Gray snapper

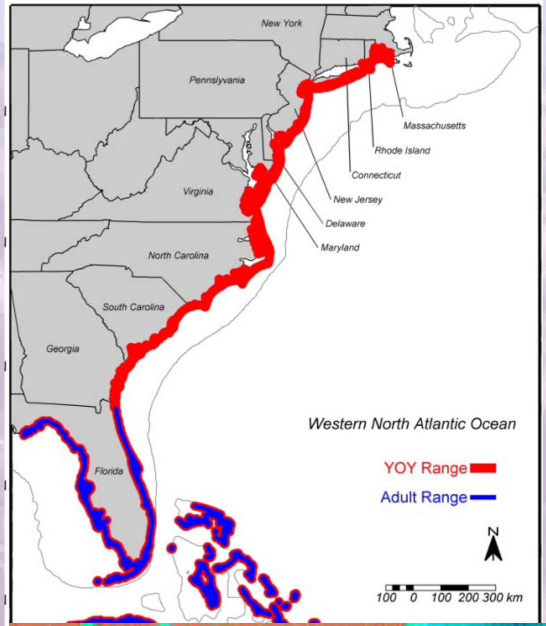
- Laboratory-based lower lethal limit ~140 degree days <17^{o}C
- Limit agrees with field observations in estuarine nurseries
- Supports hypothesis: juvenile overwinter mortality controls northern range

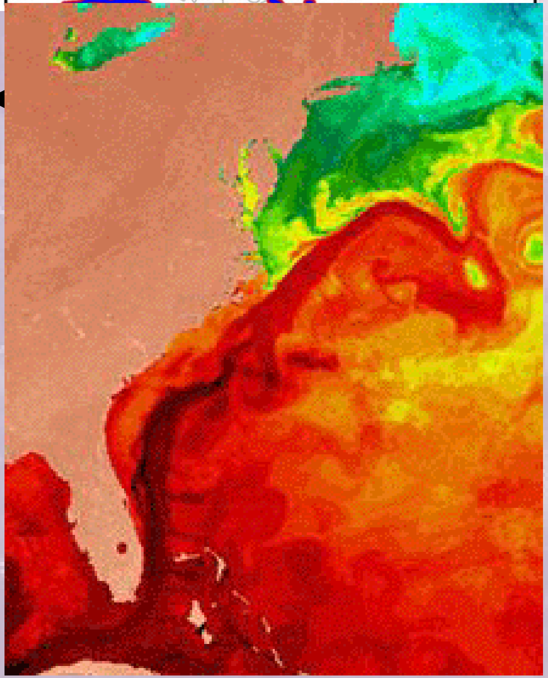


Species and System

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

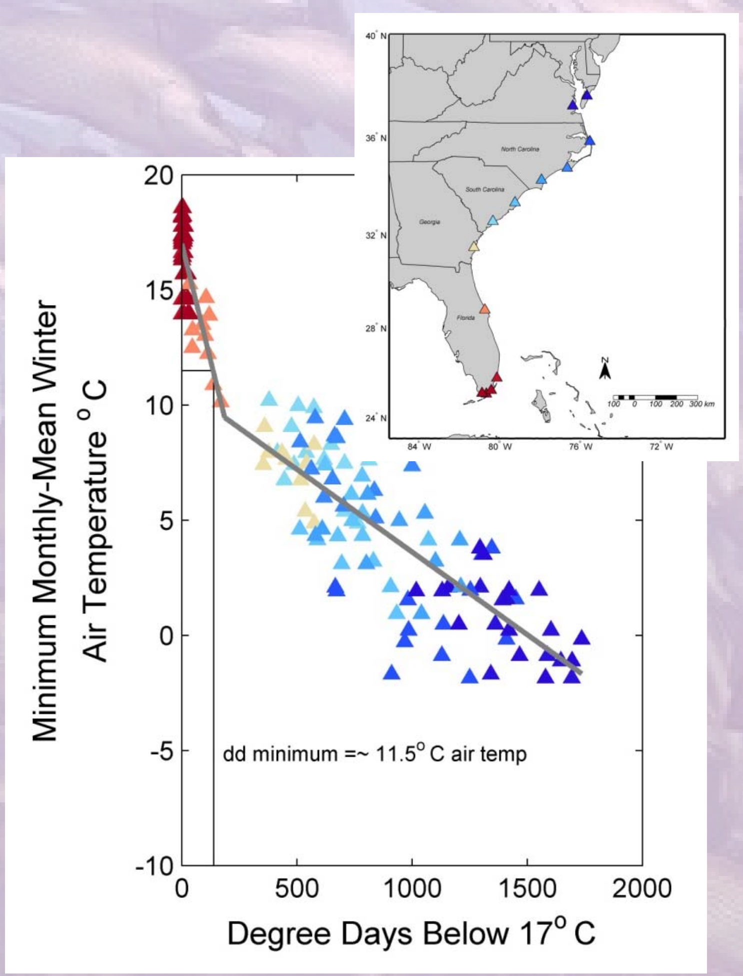




Species and System

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

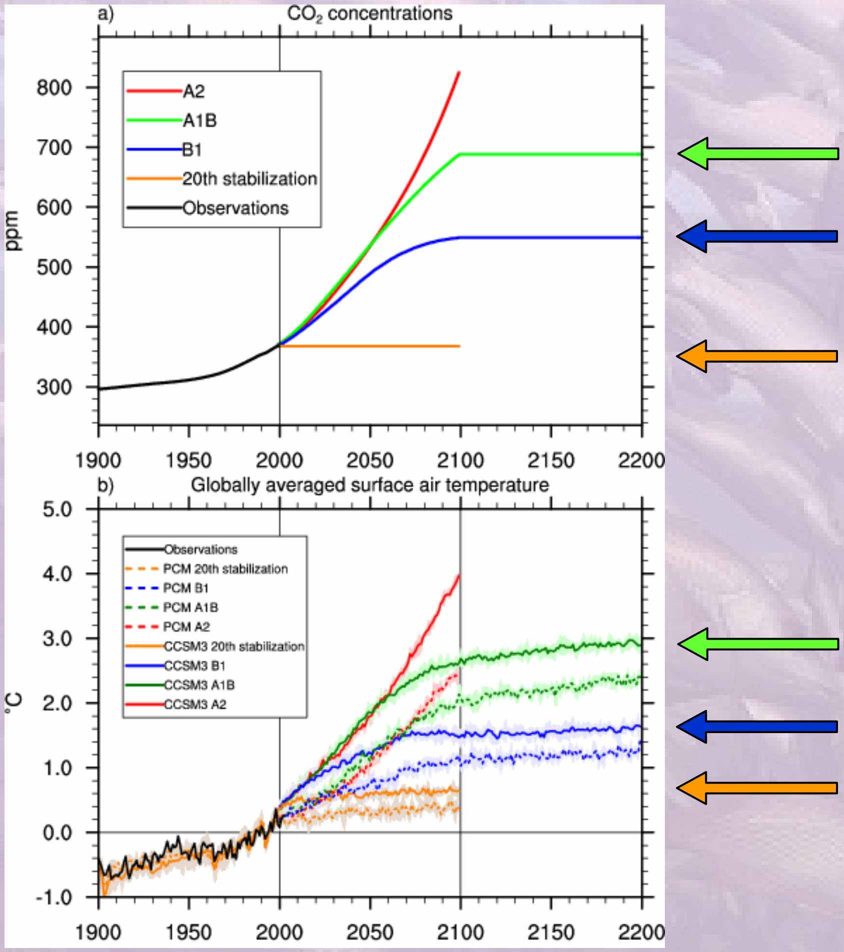
- Minimum monthly winter air temperature from 14 GCM's

Modeling center
Bjerknes Centre for Climate Research, Norway
Canadian Centre for Climate Modelling and Analysis, Canada
Centre National de Recherches Meteorologiques, France
Australia's Commonwealth Scientific and Industrial Research Organisation, Australia
Meteorological Institute, University of Bonn, Germany, Meteorological Research Institute of Korea Meteorological Administration, Korea, Model and Data Group at MPI-M, Germany
Institute of Atmospheric Physics, China
Geophysical Fluid Dynamics Laboratory, USA
Goddard Institute for Space Studies, USA
Institute for Numerical Mathematics, Russia
Institut Pierre Simon Laplace, France
National Institute for Environmental Studies, Japan
Meteorological Research Institute, Japan
National Center for Atmospheric Research, USA
Met Office, UK

World Data Center for Climate, IPCC Data Distribution Centre (http://www.mad.zmaw.de/IPCC_DDC/html/SRES_AR4/index.html)

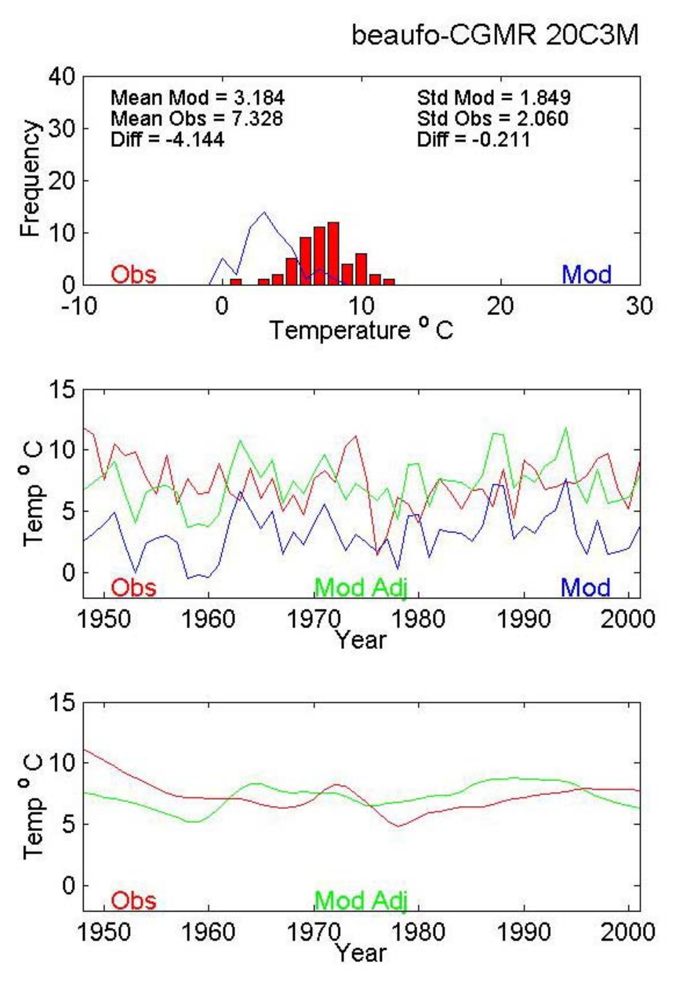
Forecasts – Methods

- Minimum monthly winter air temperature from 14 GCM's
- Three scenarios considered: commit, B1, and A1B



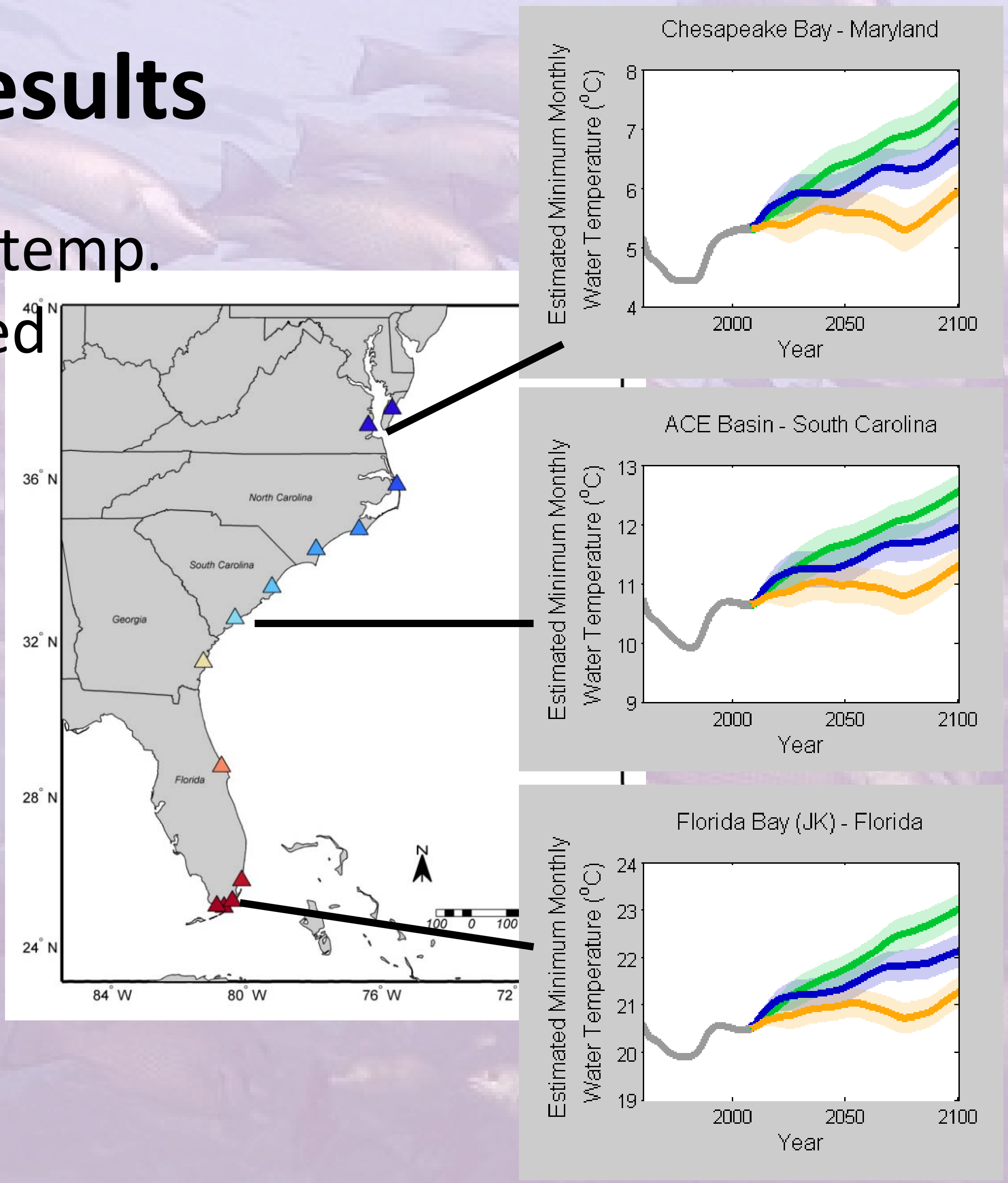
Forecasts – Methods

- 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



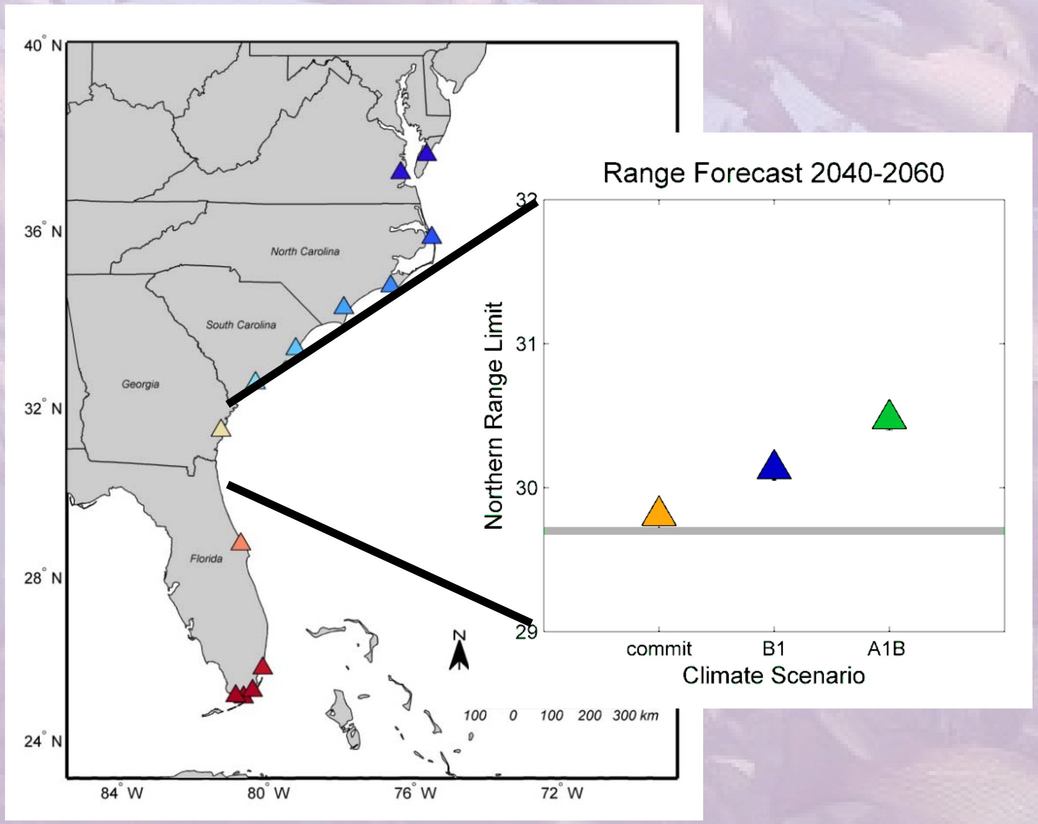
Forecasts – Results

- Estuarine winter temp. rise with increased CO_2



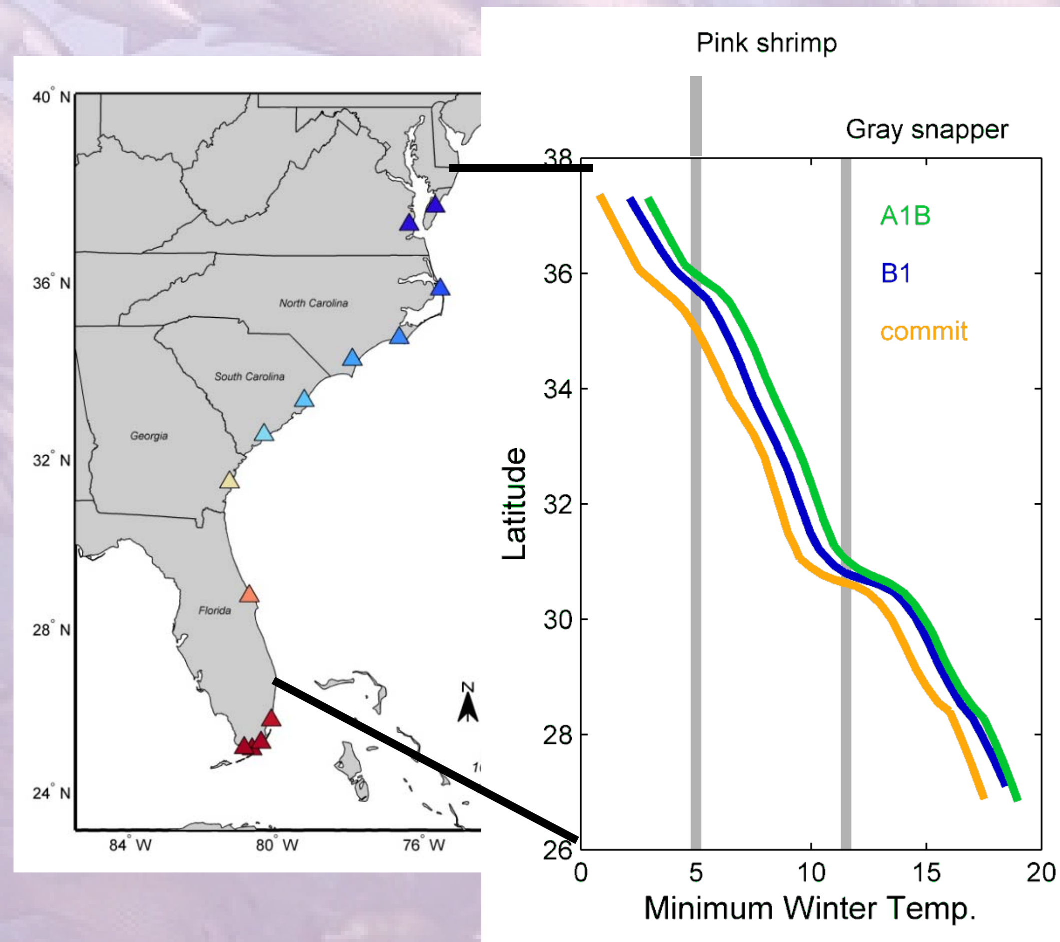
Forecasts – Results

- Estuarine winter temp. rise with increased CO_2
- Range forecast to expand poleward (modest distance ~2 km yr^{-1})



Forecasts – Results

- Estuarine winter temp. rise with increased CO_2
- 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?