Review of Species Distribution Modeling in the Northeast U.S. Continental Shelf Ecosystem

PICES Workshop

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Acknowledgements

This summary represents the joint work of a number of excellent people (40+)

Thank you to each one.

Outline

- Review of efforts to date

- Uncertainty

- Lessons Learned

- Next Steps

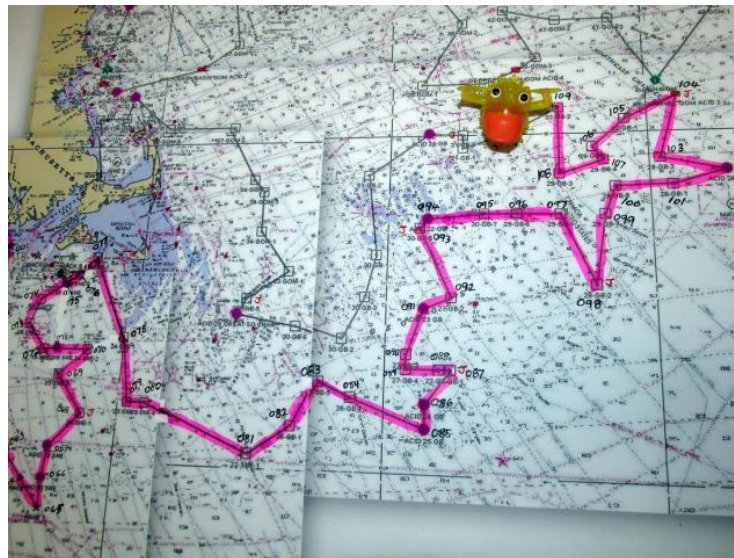
Species:

Climate Models:

Climate Scenarios:

SDM Approach:

SDM Data:

SDM Independent:

SDM Dependent:

Notes:

NOAA FISHERIES

Fogarty et al. (2008) Mitig Adapt Strat Glob Change

Species: Atlantic Cod

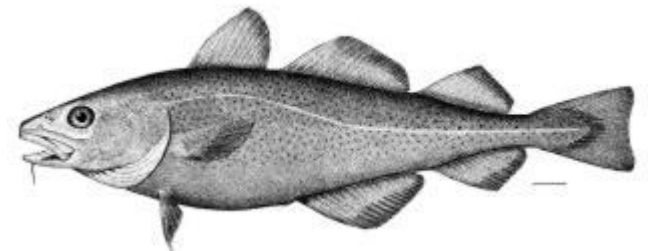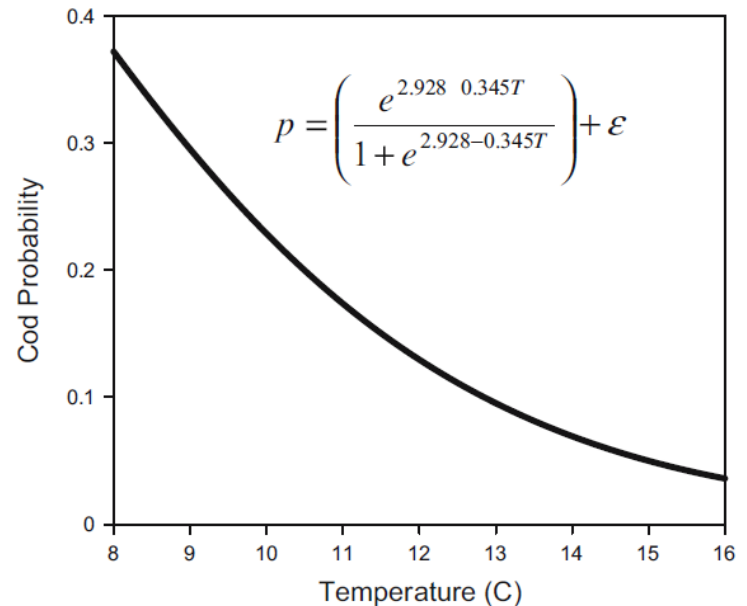# Climate Models: 3

Climate Scenarios: 2

SDM Approach: logistic regression

SDM Dependent: presence/absence

SDM Independent: bottom temp

SDM Data: NEFSC Trawl Survey

Notes: also modeled productivity

$$p = \left(\frac{e^{2.928 \; 0.345T}}{1 + e^{2.928 - 0.345T}} \right) + \varepsilon$$

Hare et al. (2010) Ecol Appl

Species: Atlantic croaker
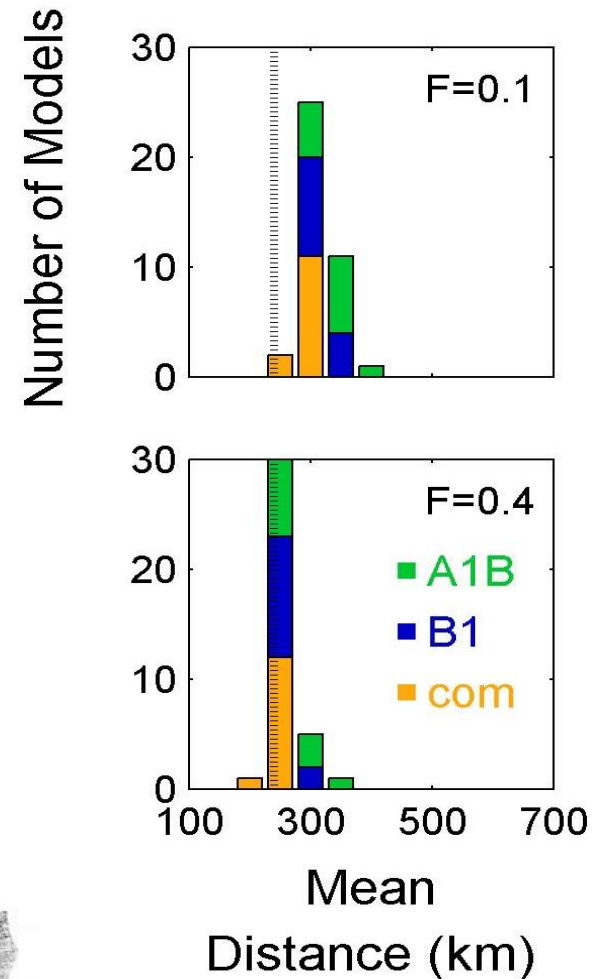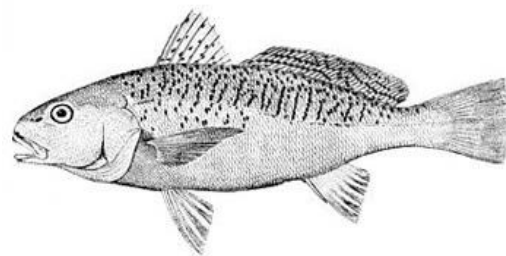
Climate Models: 15

Climate Scenarios: 3

SDM Approach: multiple regression

SDM Dependent: center of mass

SDM Independent: winter temp

SDM Data: NEFSC Trawl Survey

Notes: also modeled productivity

Hare et al. (2012) ICES JMS

<u>Species</u>: Cusk

<u># Climate Models</u>: 8

<u># Climate Scenarios</u>: 3
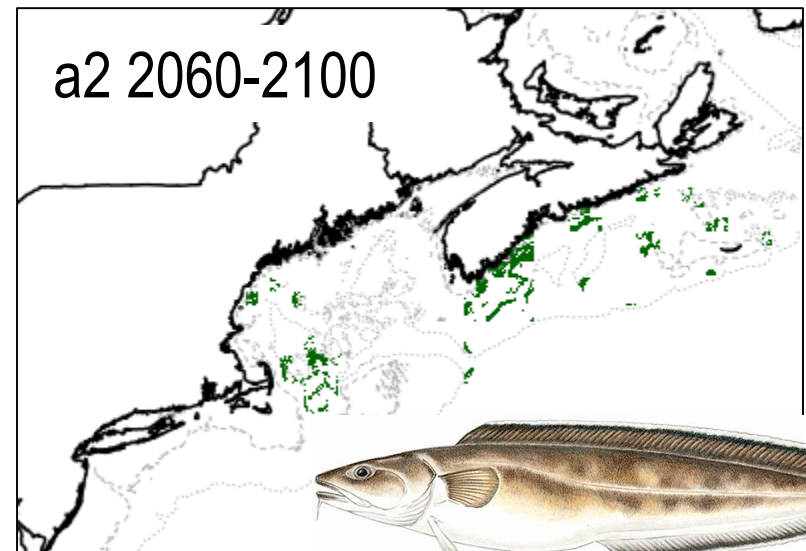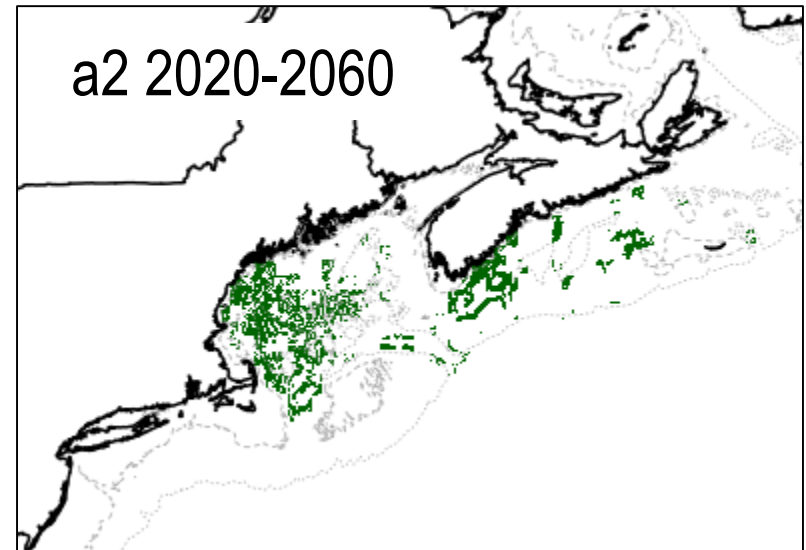
<u>SDM Approach</u>: GAM

<u>SDM Dependent</u>: presence/absence

<u>SDM Independent</u>: bottom temp & bottom roughness

<u>SDM Data</u>: NEFSC & DFO Trawl Survey

<u>Notes</u>: evaluated other distribution metrics (e.g., patchiness)

a2 2020-2060

a2 2060-2100

Lynch et al. (2014) ICES JMS

Species: 2 species of river herring

Climate Models: 8
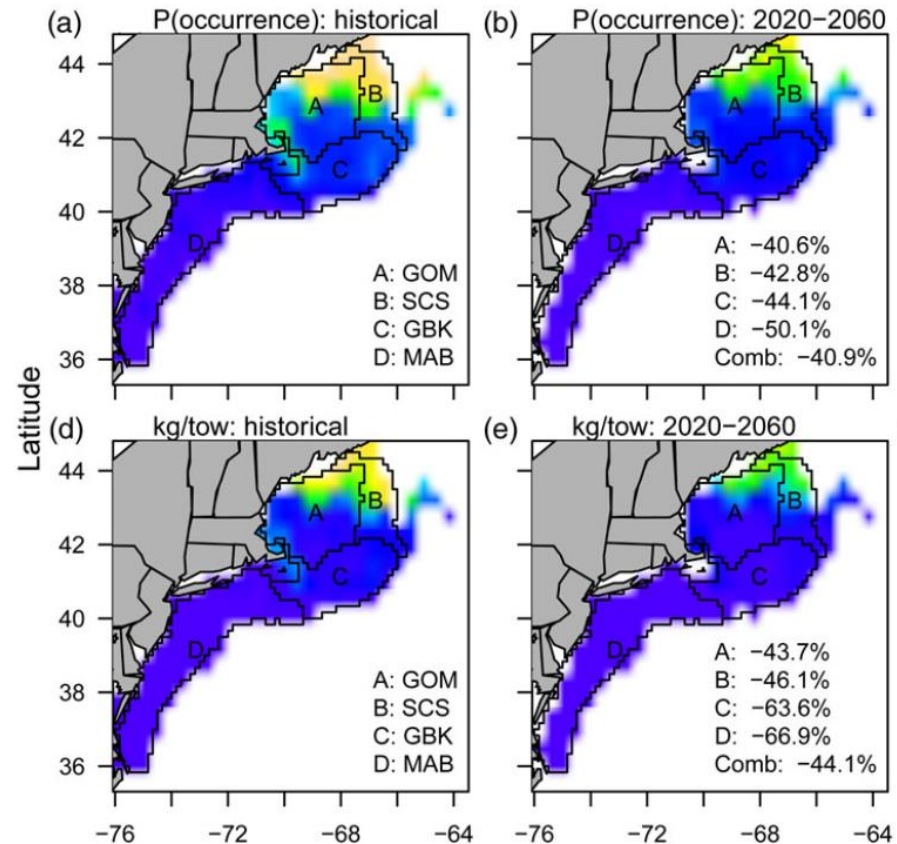
Climate Scenarios: 3

SDM Approach: delta GAM

SDM Dependent: presence/absence & abundance

SDM Independent: bottom temp & surface temperature

SDM Data: NEFSC Trawl Survey

Notes: included abundance as covariate

Kleisner et al. (in review) Prog. Oceanogr.

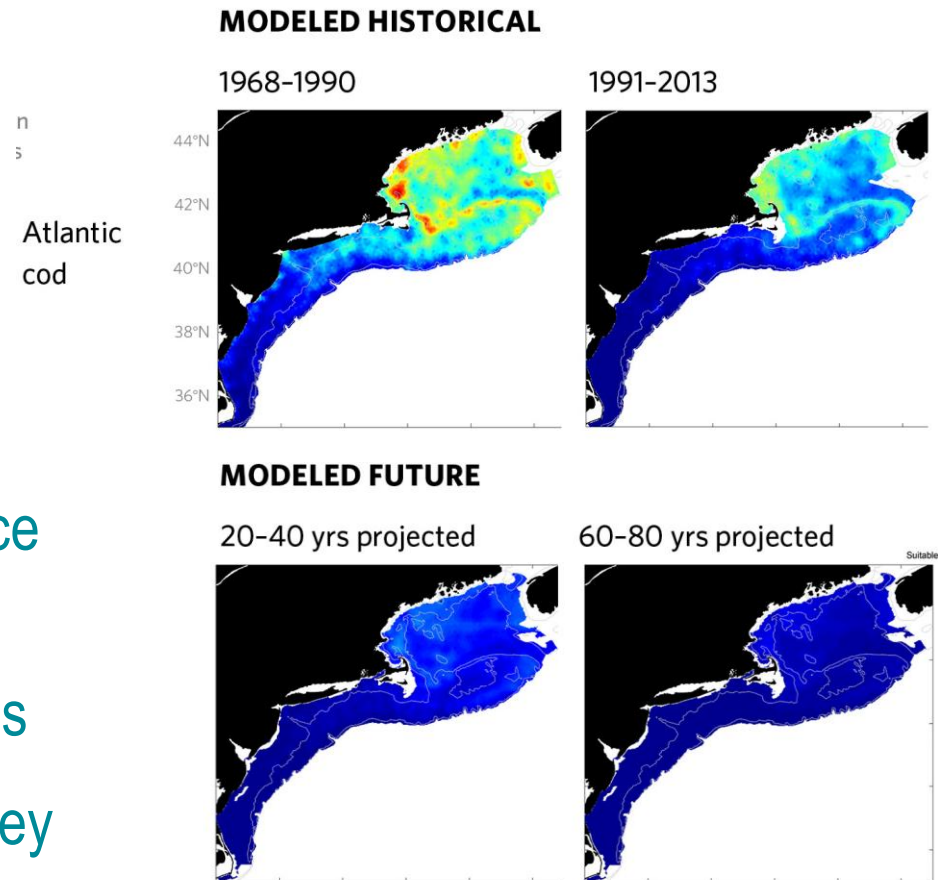Species: ~70

Climate Models: 1

Climate Scenarios: 1

SDM Approach: delta GAM

SDM Dependent: presence/absence & abundance

SDM Independent: surface & bottom temp, bottom roughness

SDM Data: NEFSC Trawl Survey

Notes: included abundance as covariate

MODELED HISTORICAL

1968–1990   1991–2013

Atlantic cod

MODELED FUTURE

20–40 yrs projected   60–80 yrs projected

Saba et al. (2015) JGR Oceans

- Kleisner et al. (in review) used GFDL high resolution global model

- Previous studies used standard global models downscaled as a delta relative to a climatology

- High resolution model projects changes in circulation warming
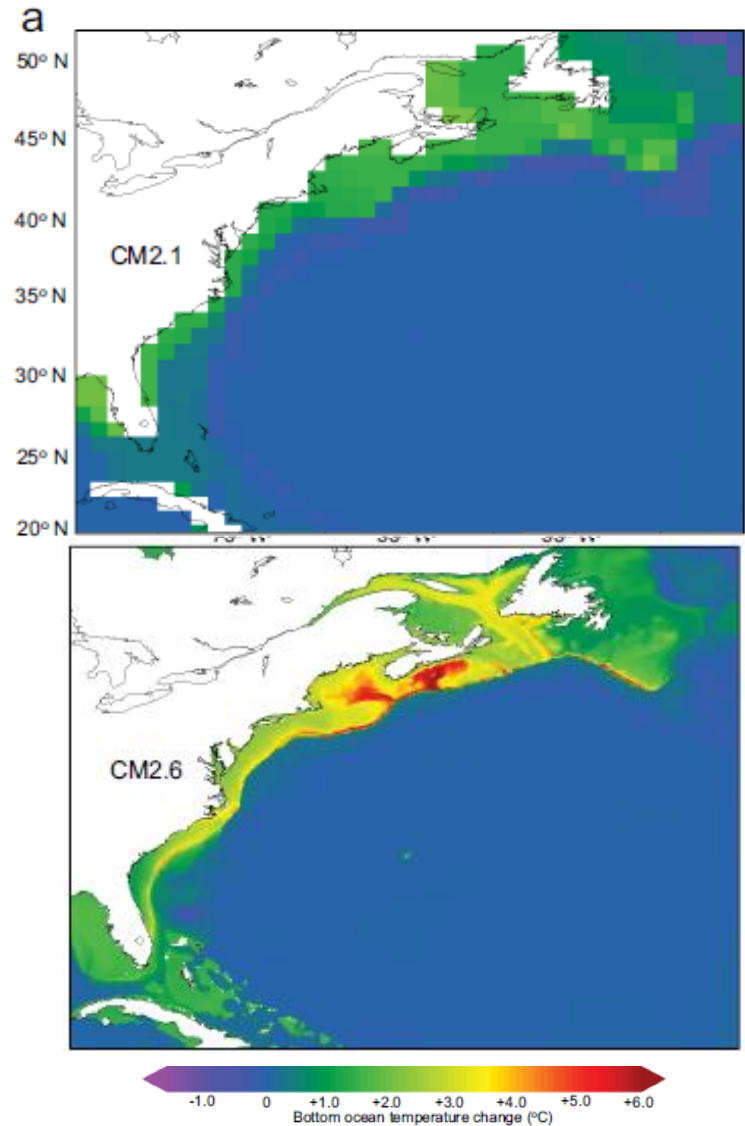
Hare et al. (2016) PLoS ONE

Species: 82

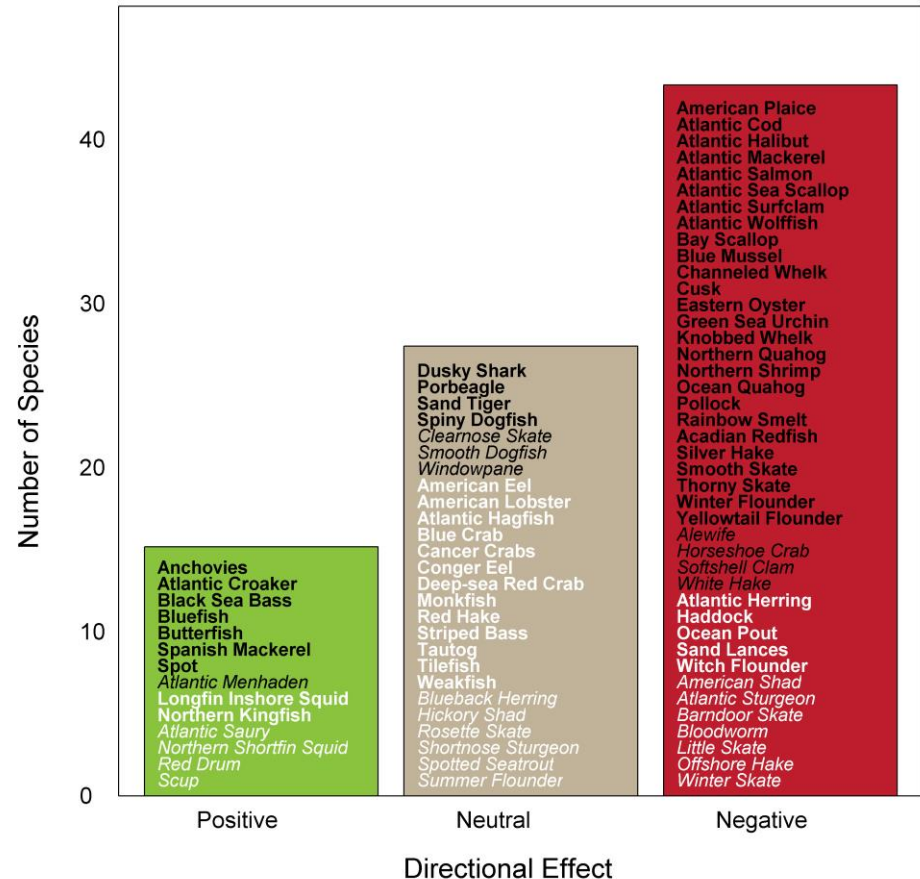# Climate Models: 27

Climate Scenarios: 1

Approach: expert opinion

SDM Dependent: positive or negative effect

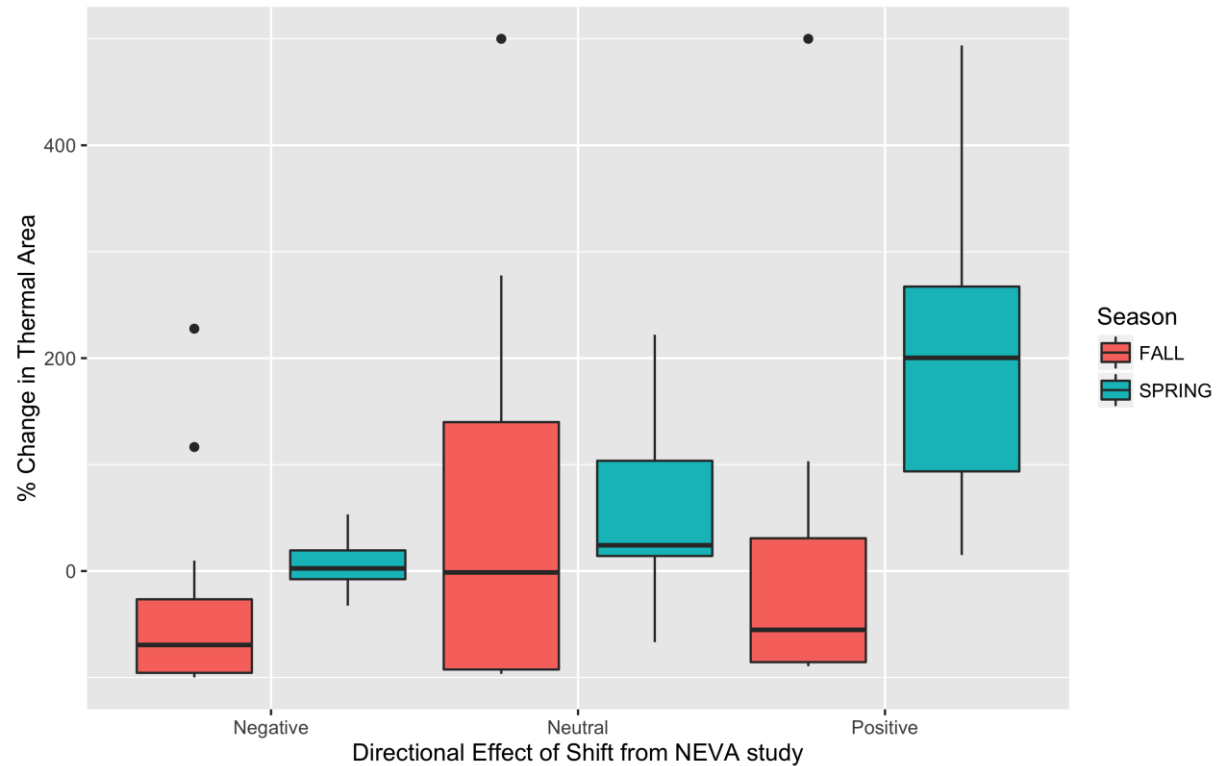SDM Independent: 14 climate variables

Data: all available

Notes: vulnerability assessment framework

SDM v Expert Opinion

- SDM approaches and expert opinion agreed for spring not fall

- Seasonal dynamics important

Shackell et al. (2014) PLoS One

Species: ~46

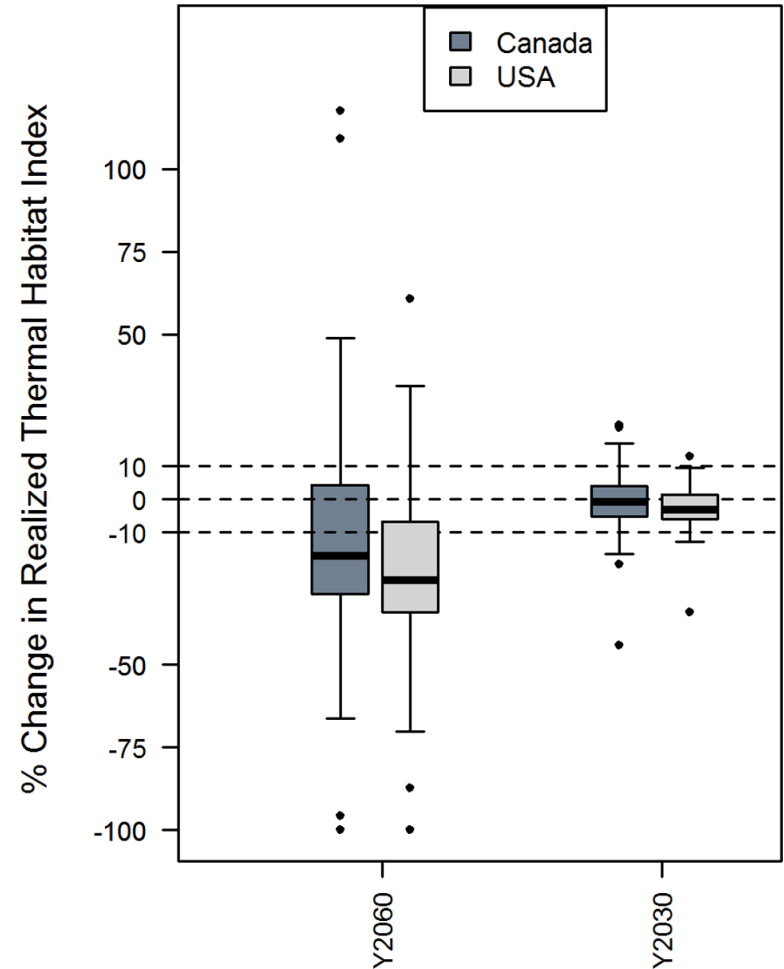# Climate Models: not direct

Climate Scenarios: 2

SDM Approach: binomial GAM

SDM Dependent: presence/absence

SDM Independent: surface & bottom temp

SDM Data: DFO & NEFSC Trawl Survey

Notes:

Hare et al. (2012) PLoS ONE

Parameter x SDM x 14 models x 3 scenarios x 3 time periods

Uncertainty is in biological models

Table 3. Percent variance in estimate of gray snapper northern range attributable to different factors.

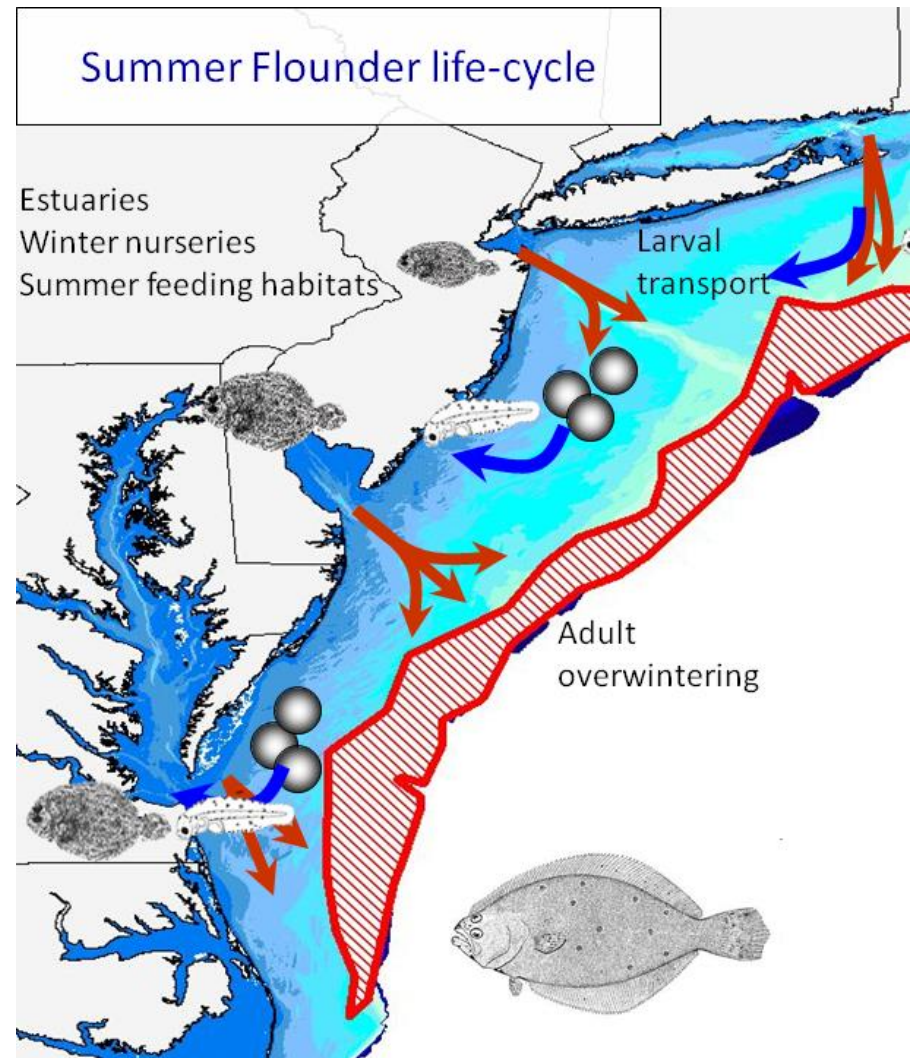| Parameter	Percent Variance
Thermal Tolerance Estimate	65.3
Mapping to Latitude	20.8
Unexplained Error	6.0
Time Period	5.6
Scenario	1.8
Model	0.5
Statistical Downscaling	0.0

Lessons

- Most SDMs focus on uncertainty resulting from climate models; yet most uncertainty is likely in statistical functions used to describe biological distribution

- Abundance and by extension fishing has a large influence on distribution

- Expert opinion can comparable to statistical SDM

- Visualization

Next Steps

- Uncertainty

- Other data

- Seasonal migration

- Life history connectivity

- Process-based models

- Species interactions

- High-resolution climate models or dynamical downscaling

Summer Flounder life-cycle

Estuaries
Winter nurseries
Summer feeding habitats

Larval transport

Adult overwintering

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Next Steps

- Social and economic effects (Cooley et al., 2015; Colburn et al., 2016; Kleisner et al., in review, others)

- Management (e.g., ESA Decisions, MAFMC EAFM Guidance, Pinsky et al. COCA)

- Fishing scenarios

  - Complicated fleet dynamics in the Northeast U.S.

ICES Theme Session

Projected impacts of climate change on marine ecosystems, wild captured and cultured fisheries, and fishery dependent communities

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18–21 September 2017
Fort Lauderdale, Florida, US