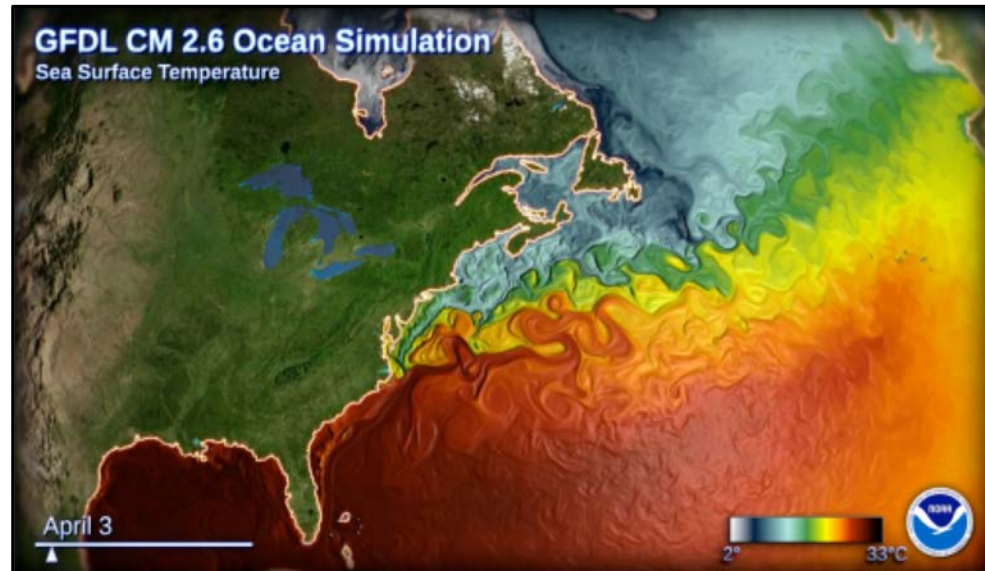


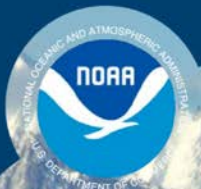


**NOAA
FISHERIES**

An Overview of NOAA Fisheries Species Distribution Research in the U.S. Northeast Shelf

Vincent Saba (with contributions from others)
NOAA Northeast Fisheries Science Center





**NOAA
FISHERIES**

NOAA Fisheries Climate Science Strategy Highlights

“The Strategy is part of a proactive approach to increase the production, delivery and use of climate-related information to fulfill NOAA Fisheries mandates in a changing climate. Implementing this Strategy will help reduce impacts and increase the resilience of our valuable living marine resources, and the people, businesses, and communities that depend on them.”

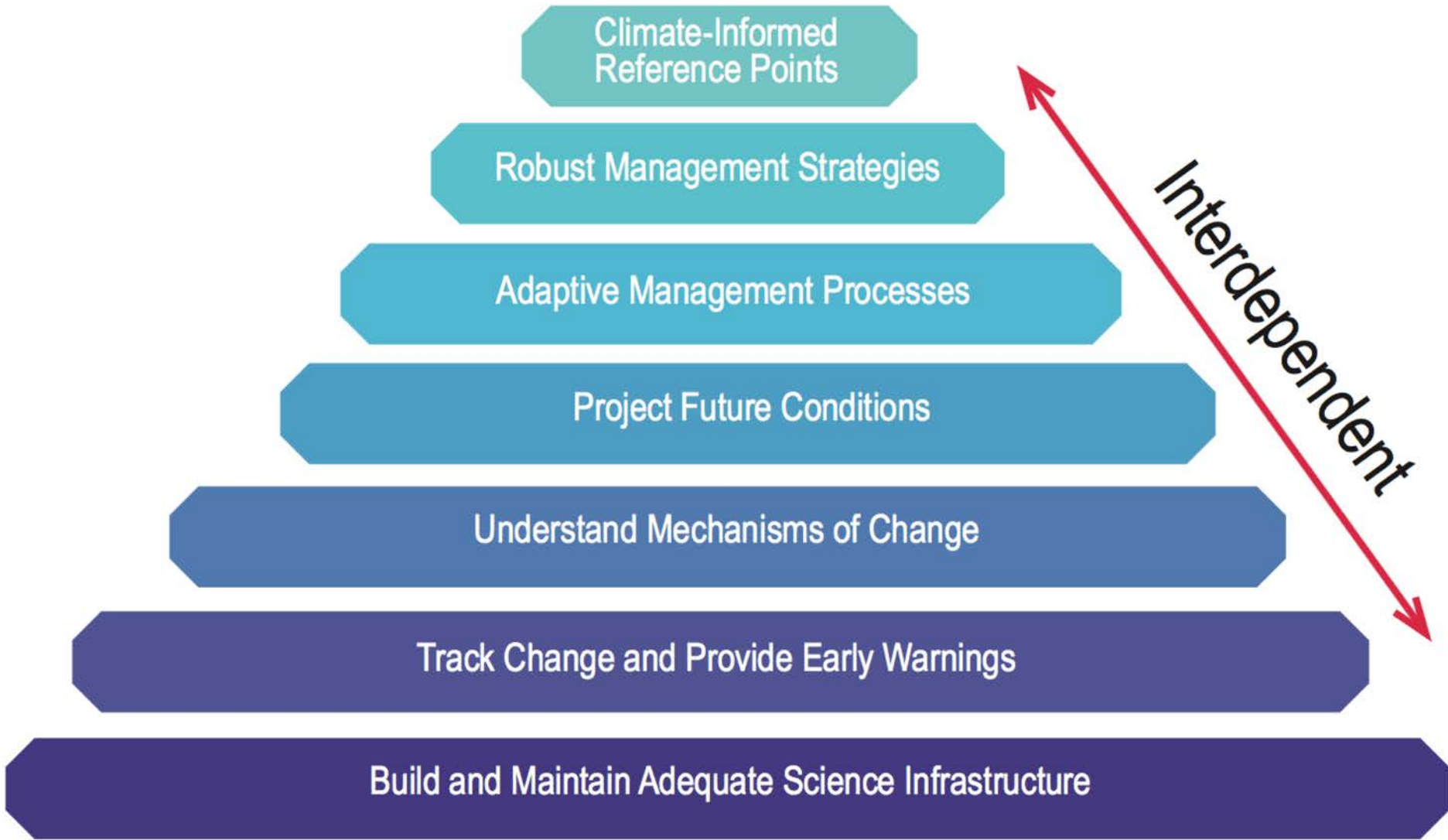
*- Eileen Sobeck
Former Fisheries
Assistant Administrator*

<https://www.st.nmfs.noaa.gov/ecosystems/climate/national-climate-strategy>



NOAA FISHERIES

Climate Science Strategy Objectives



Western
Region

NOAA Fisheries Climate Science Strategy Regional Action Plans



Northeast

Southeast



Gulf of Mexico

Alaska

Pacific Islands



Caribbean

Mouse over this icon
for more information



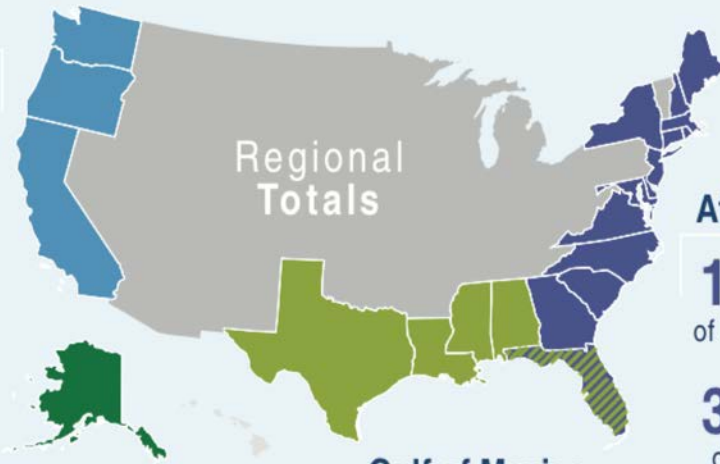
NOAA FISHERIES

U.S. Commercial Fishery Annual Value

Pacific

10%
of landings

13%
of value



Atlantic

13%
of landings

39%
of value

Gulf of Mexico

Alaska

58%
of landings

29%
of value

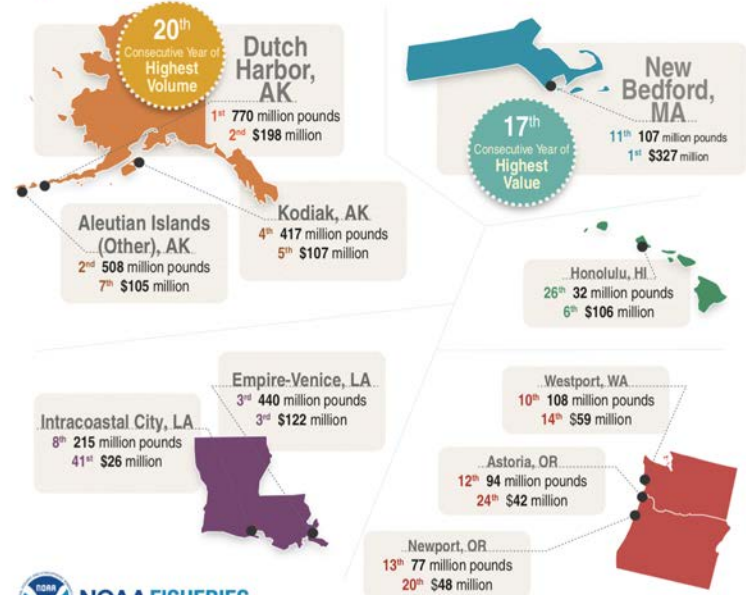
18%
of landings

16%
of value

*Hawaii contributed <1% of U.S. volume and 2% of U.S. landings value.
The Great Lakes contributed <1% of U.S. landings and landings value.

NOAA, 2016

2016 U.S. Commercial Fisheries and the Seafood Industry Top Ports by Volume and Value of Seafood Landed



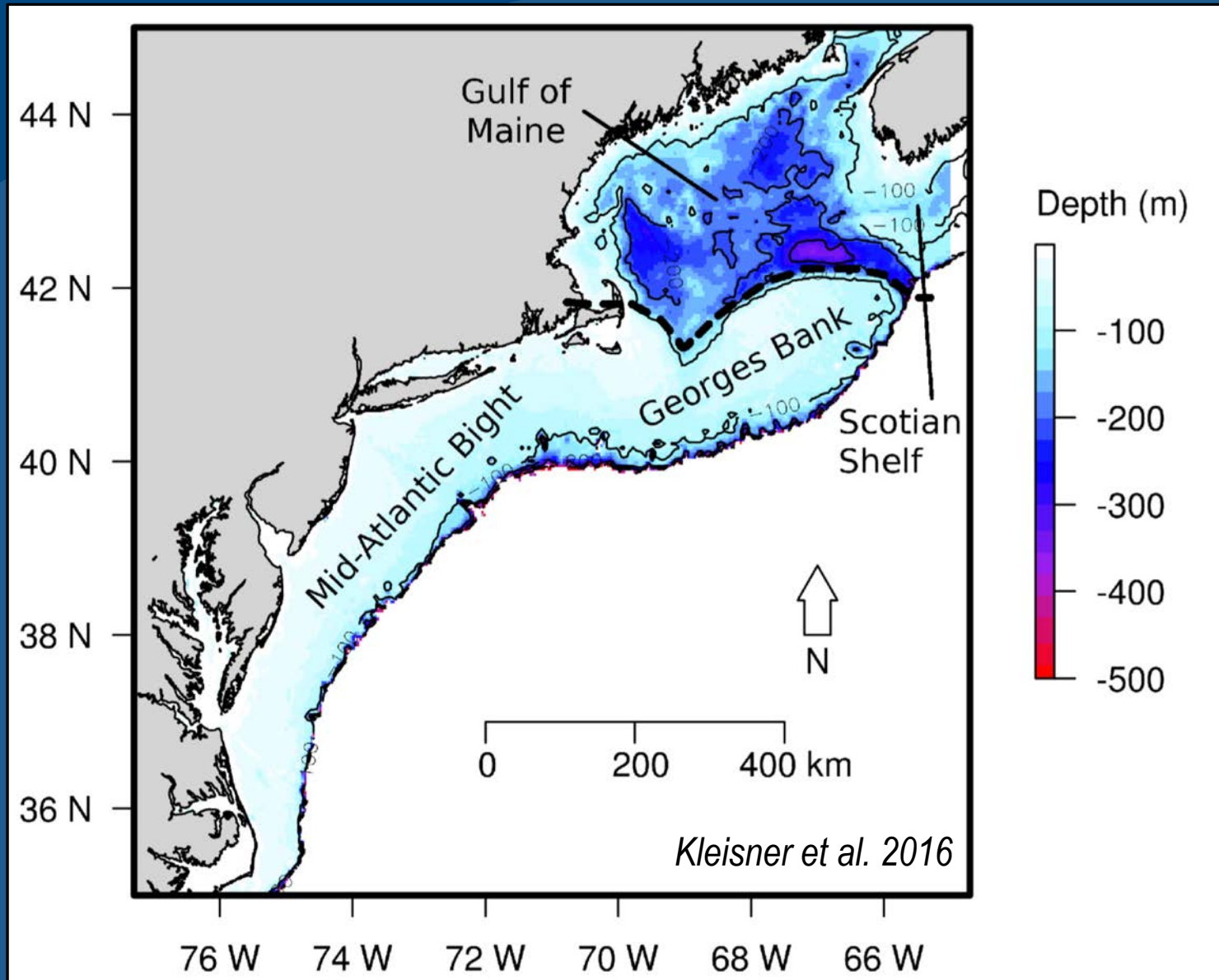
NW Atlantic - Outline

- 1) Observed change in the Northeast U.S. Shelf Ecosystem
- 2) Vulnerability analyses
- 3) Projected change (thermal habitat)
- 4) Process studies (laboratory research)

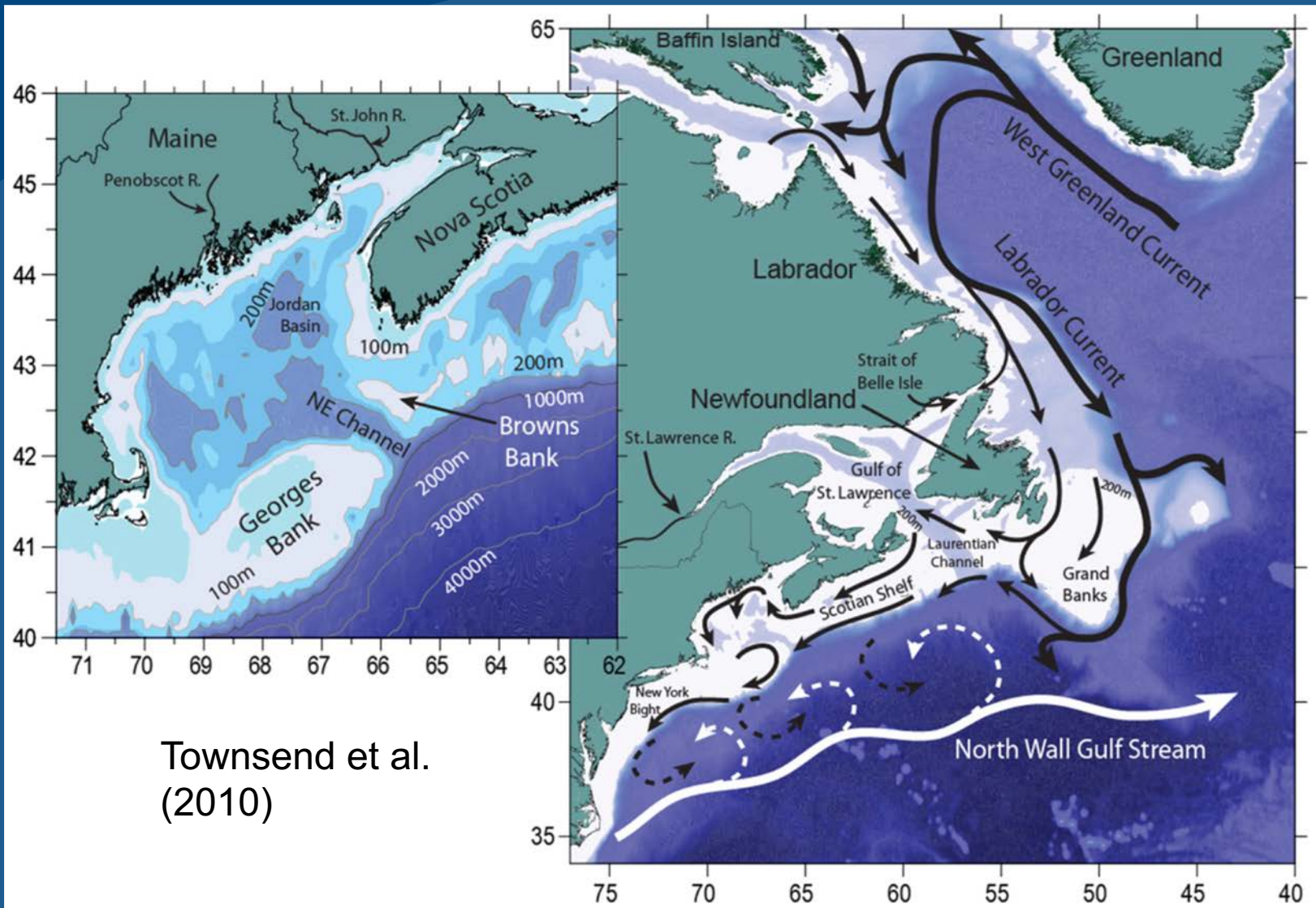
NEFSC Climate Change Website

<https://www.nefsc.noaa.gov/ecosys/climate-change>

U.S. Northeast Continental Shelf

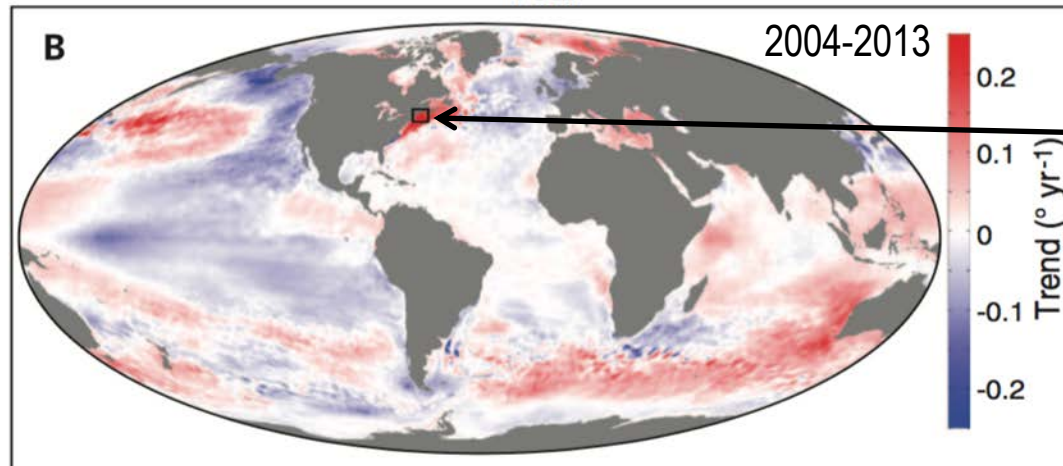
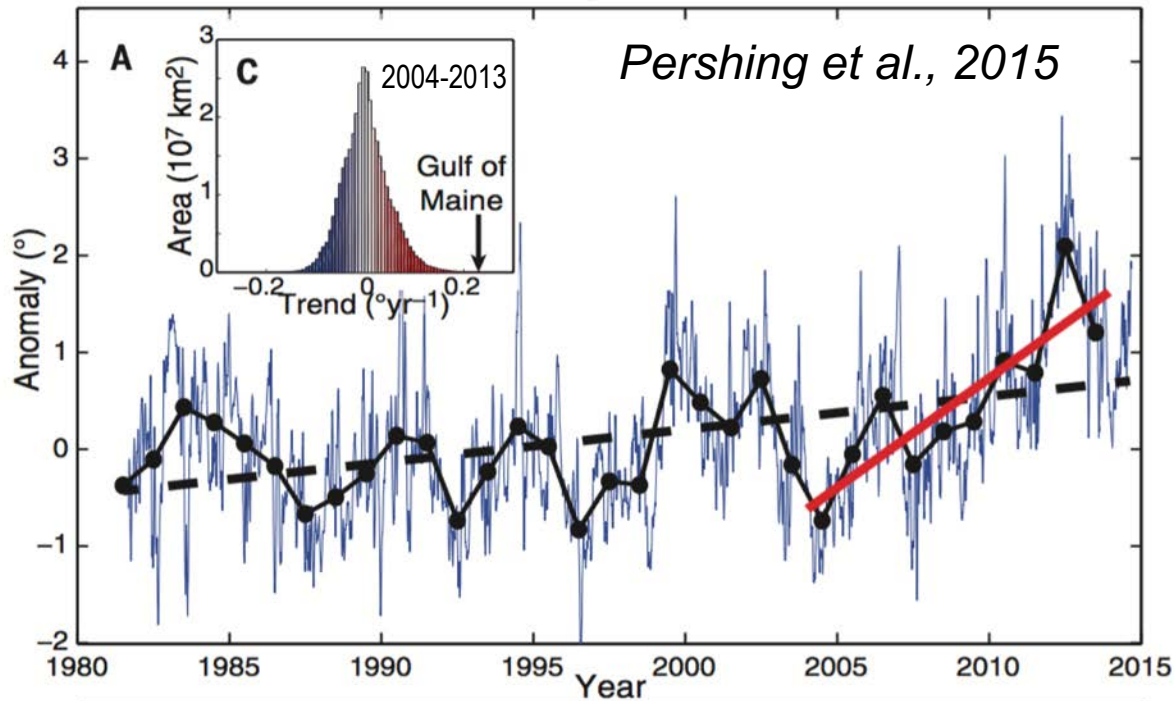


Northwest Atlantic Oceanography



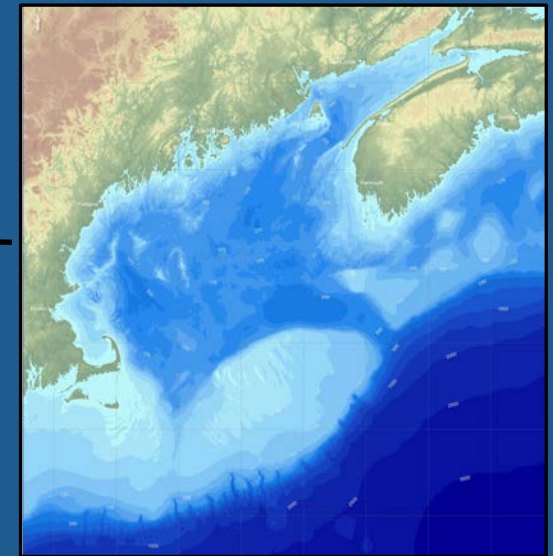
Townsend et al.
(2010)

U.S. Northeast Shelf - Warming



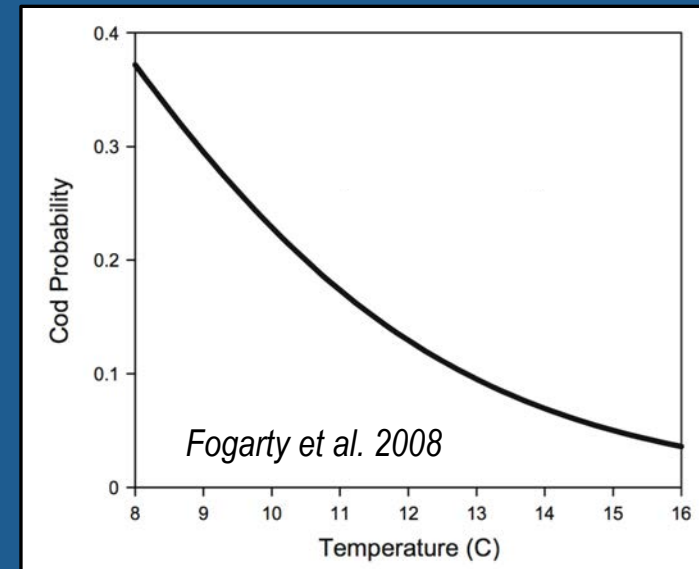
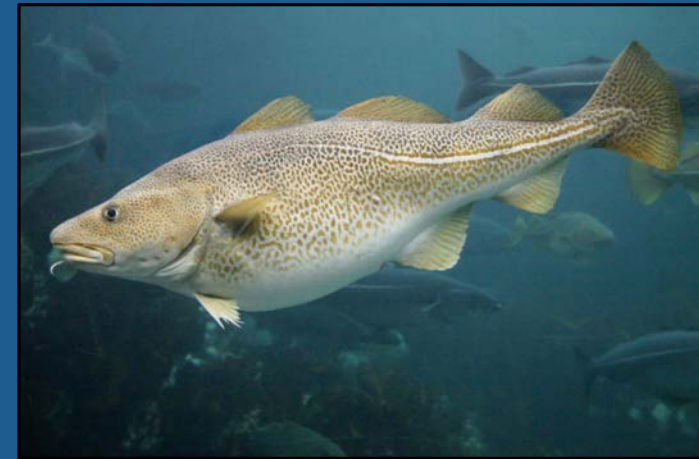
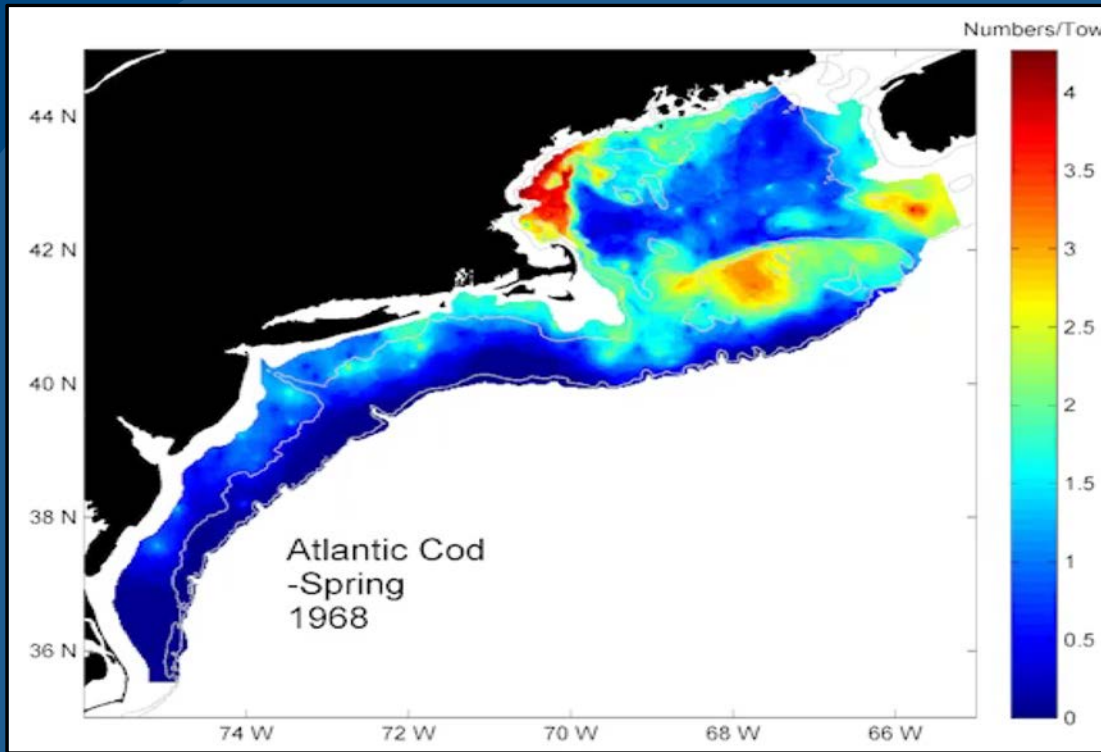
Gulf of Maine

Ocean surface temperature has warmed faster than 99% of the global ocean (*Pershing et al. 2015*).



Warming ocean, fish on the move

Atlantic cod

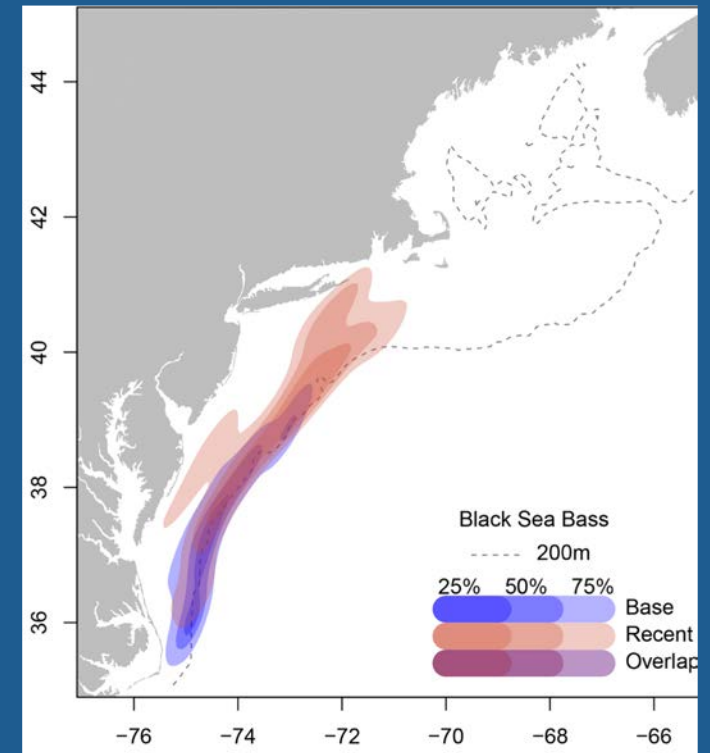
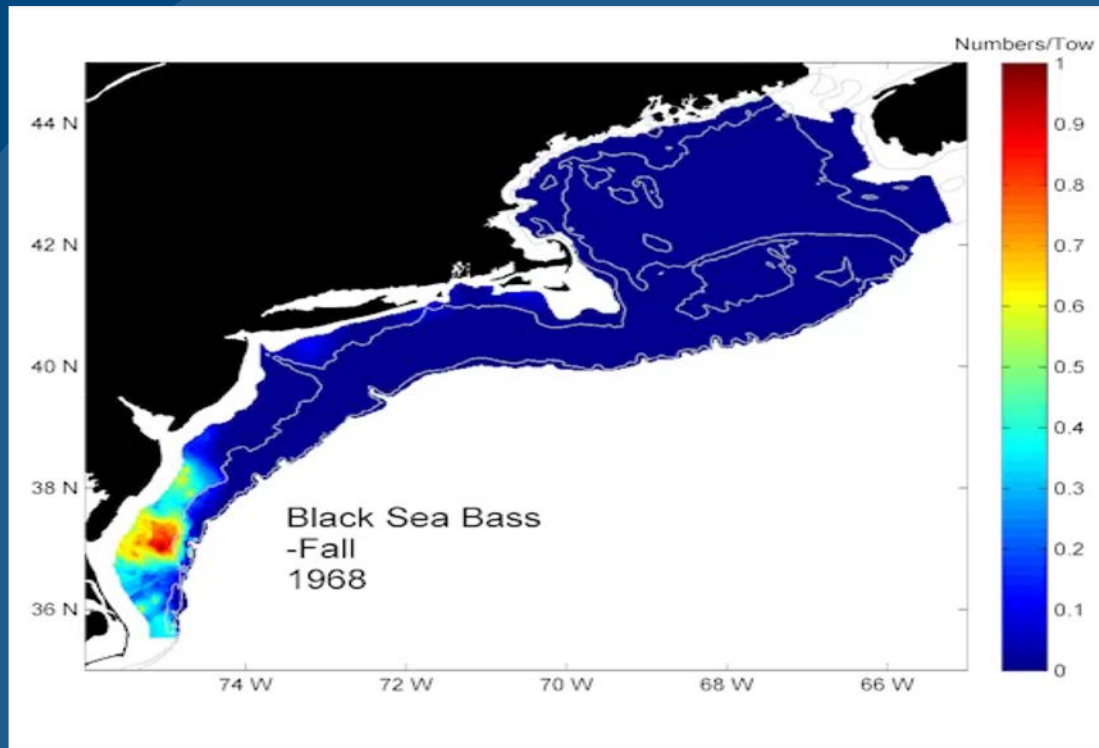


NOAA Survey Data

<https://www.nefsc.noaa.gov/ecosys>

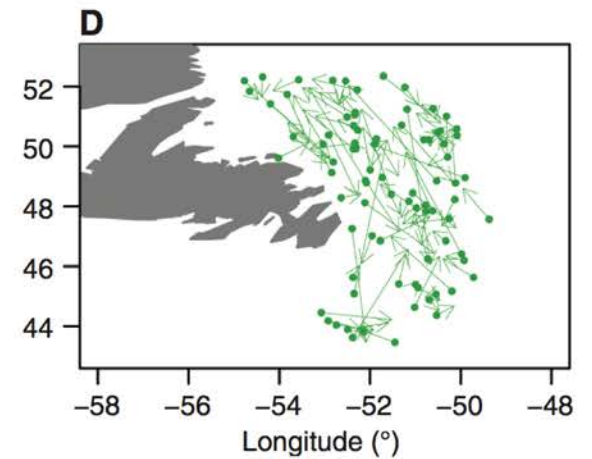
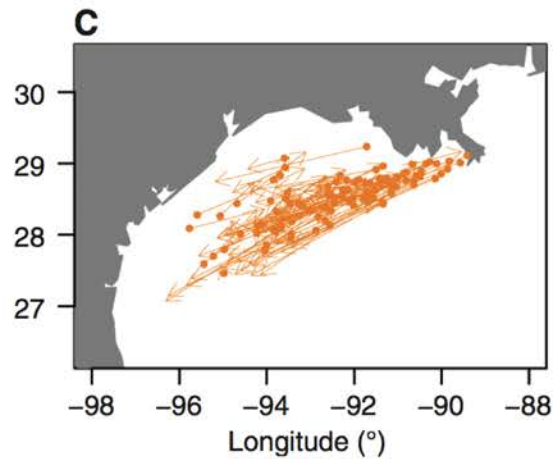
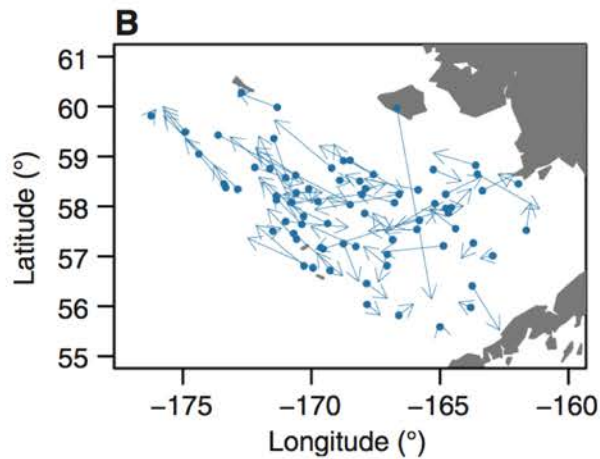
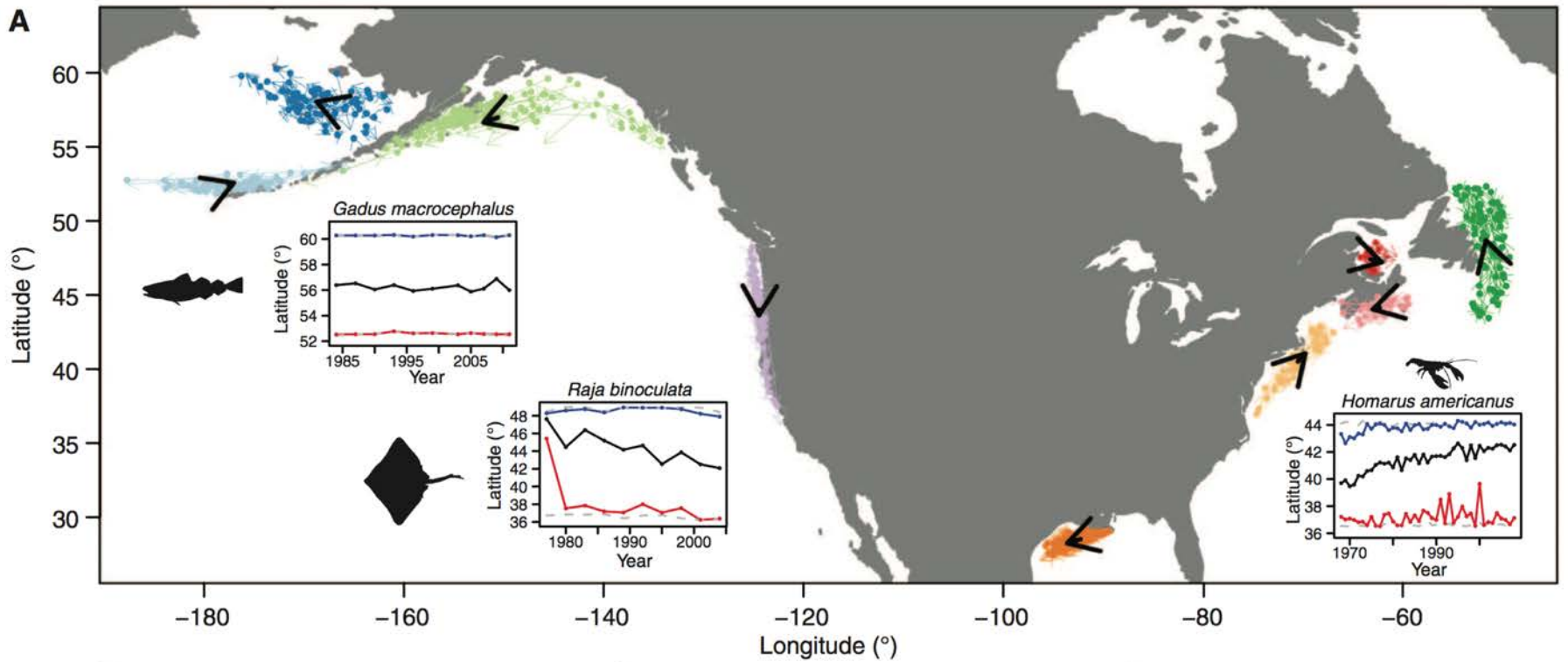
Warming ocean, fish on the move

Black sea bass



NOAA Survey Data

<https://www.nefsc.noaa.gov/ecosys>

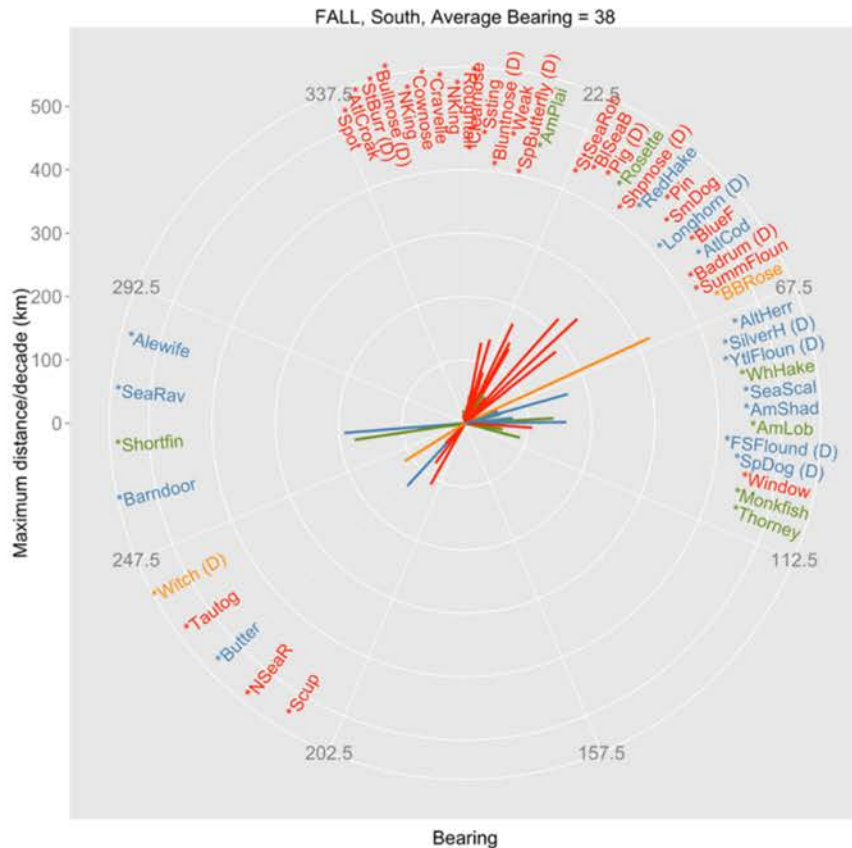


Pinsky et al., 2013

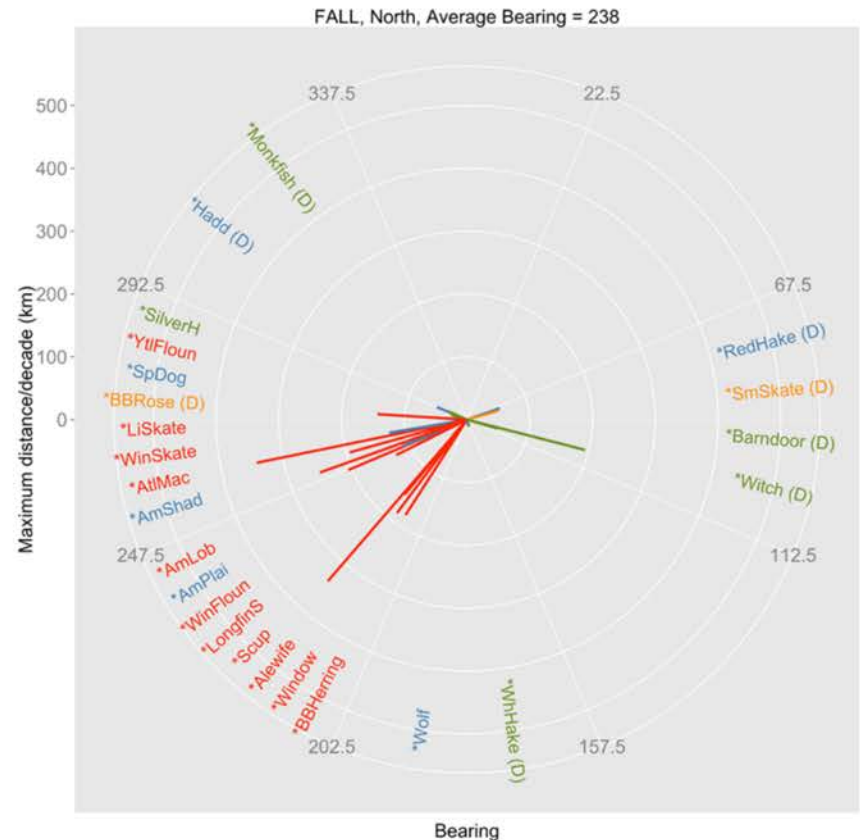
The effects of sub-regional climate velocity on the distribution and spatial extent of marine species assemblages

Kristin M. Kleisner^{1*}, Michael J. Fogarty¹, Sally McGee², Analie Barnett², Paula Fratantoni¹, Jennifer Greene², Jonathan A. Hare³, Sean Lucey¹, Christopher McGuire², Jay Odell², Vincent S. Saba⁴, Laurel Smith¹, Katherine J. Weaver², Malin L. Pinsky⁵

a.



b.



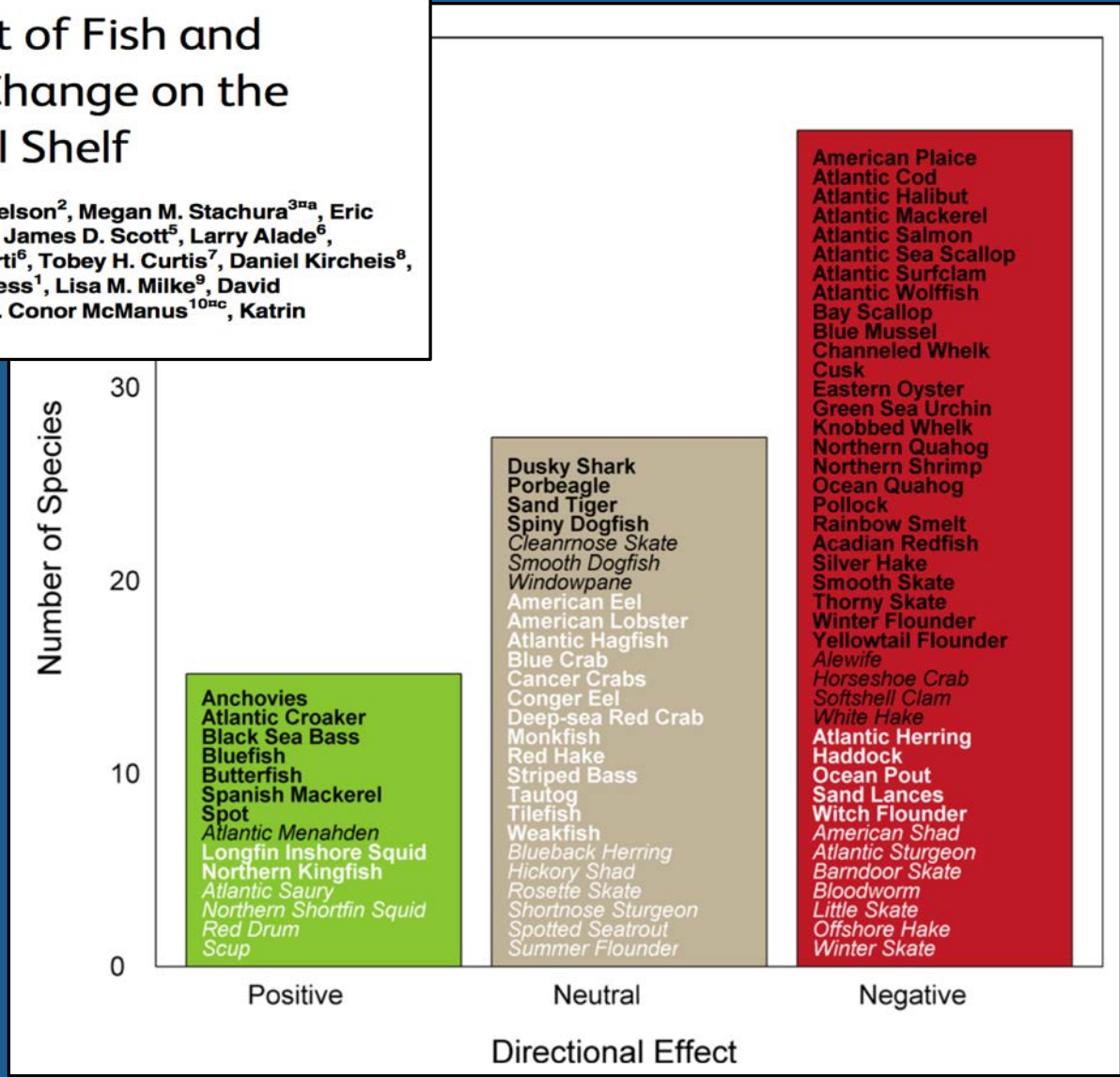
Climate vulnerability

RESEARCH ARTICLE

A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf

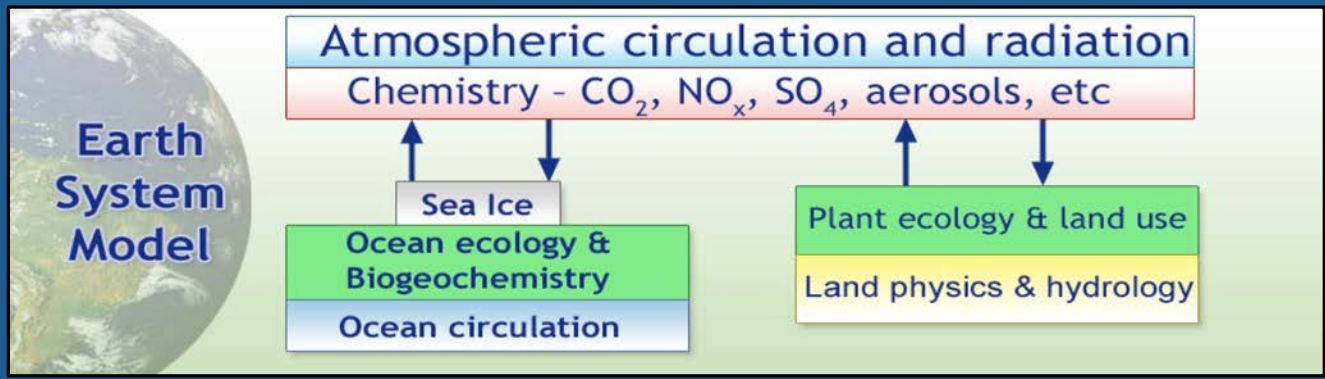
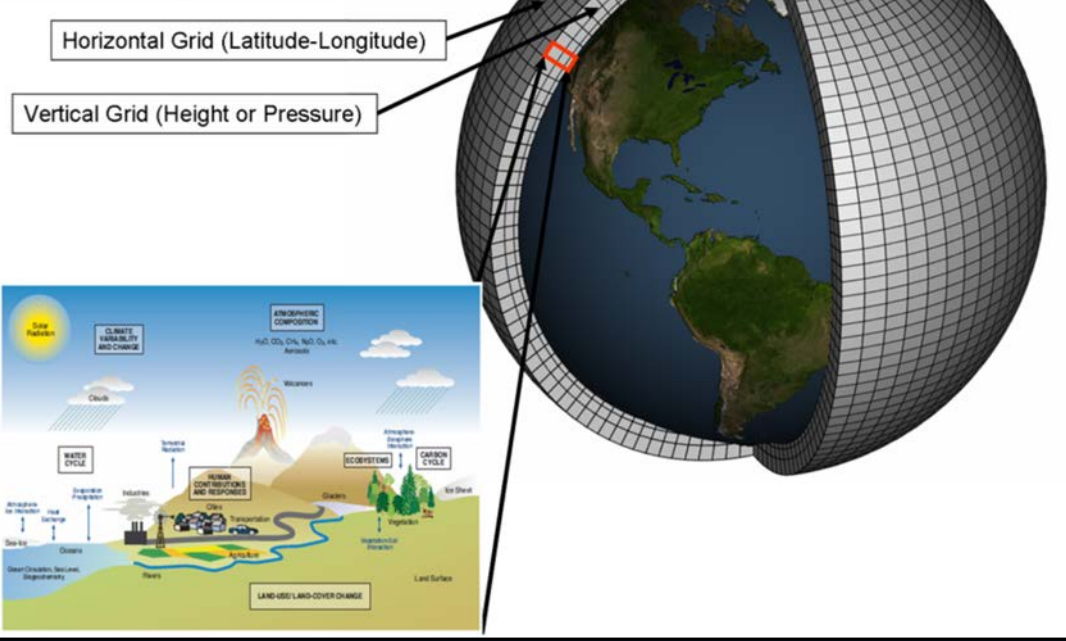
Jonathan A. Hare^{1*}, Wendy E. Morrison², Mark W. Nelson², Megan M. Stachura^{3aa}, Eric J. Teeters², Roger B. Griffis⁴, Michael A. Alexander⁵, James D. Scott⁵, Larry Alade⁶, Richard J. Bell^{1ab}, Antonie S. Chute⁶, Kiersten L. Curti⁶, Tobey H. Curtis⁷, Daniel Kircheis⁸, John F. Kocik⁸, Sean M. Lucey⁶, Camilla T. McCandless¹, Lisa M. Milke⁹, David E. Richardson¹, Eric Robillard⁶, Harvey J. Walsh¹, M. Conor McManus^{10ac}, Katrin E. Marancik¹⁰, Carolyn A. Griswold¹

Sea turtle and marine mammal vulnerability assessment (*Lettrich et al. in prep.*)

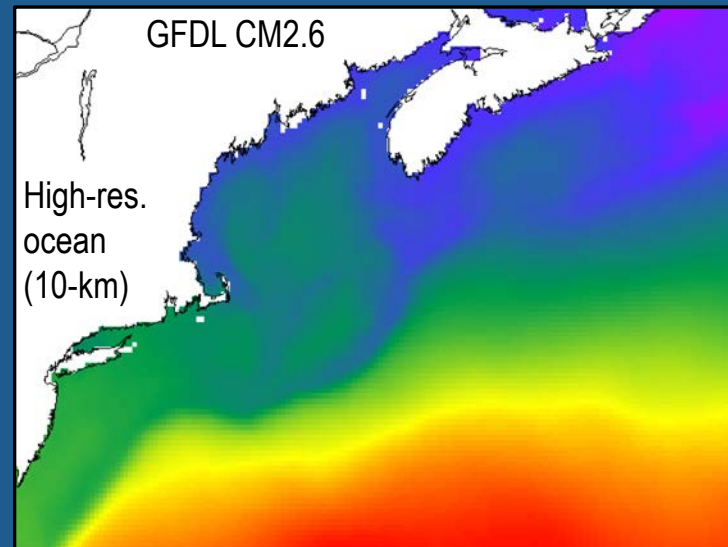
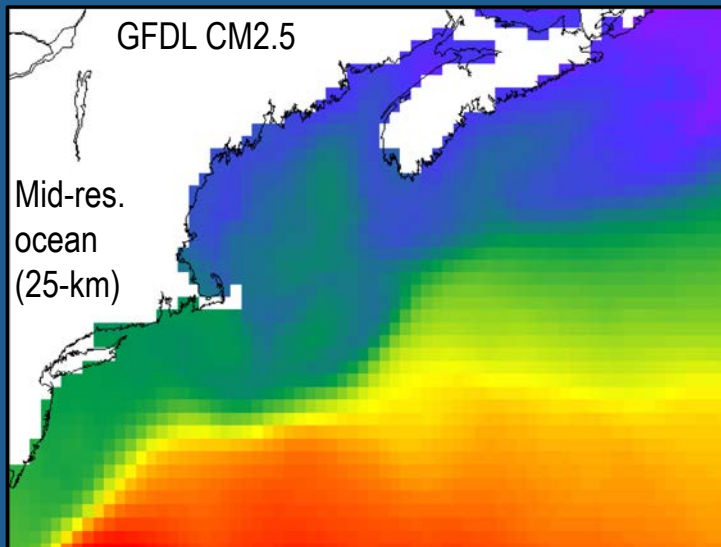
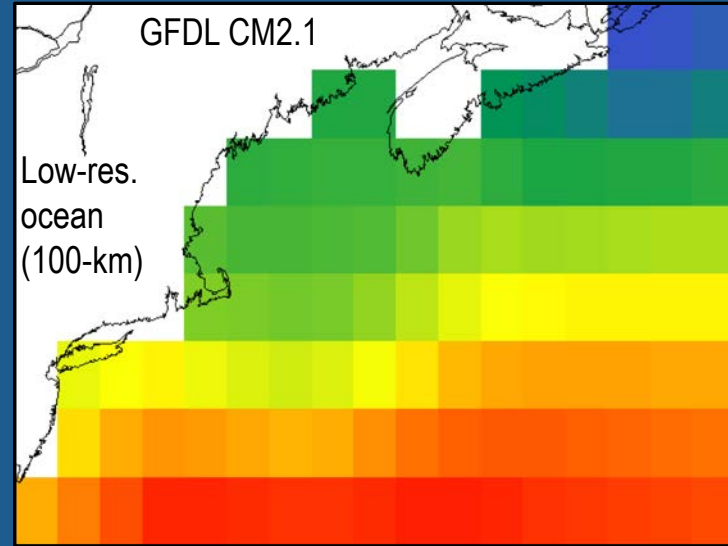
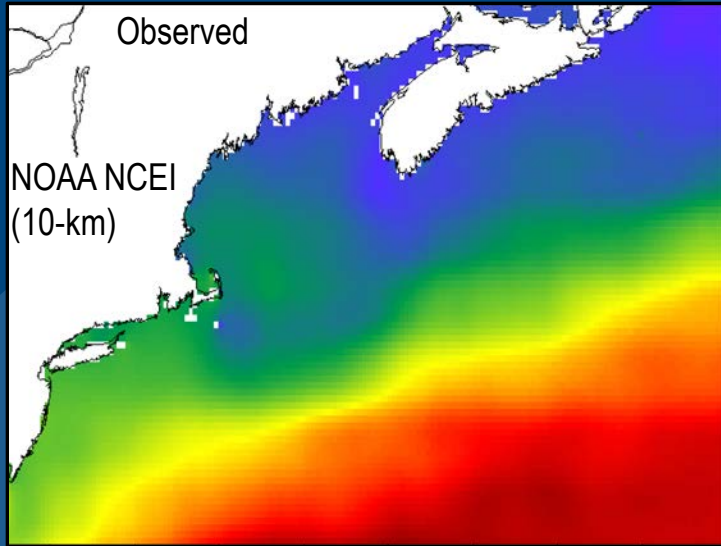


Climate Projections - Global Climate & Earth System

Schematic for Global Atmospheric Model

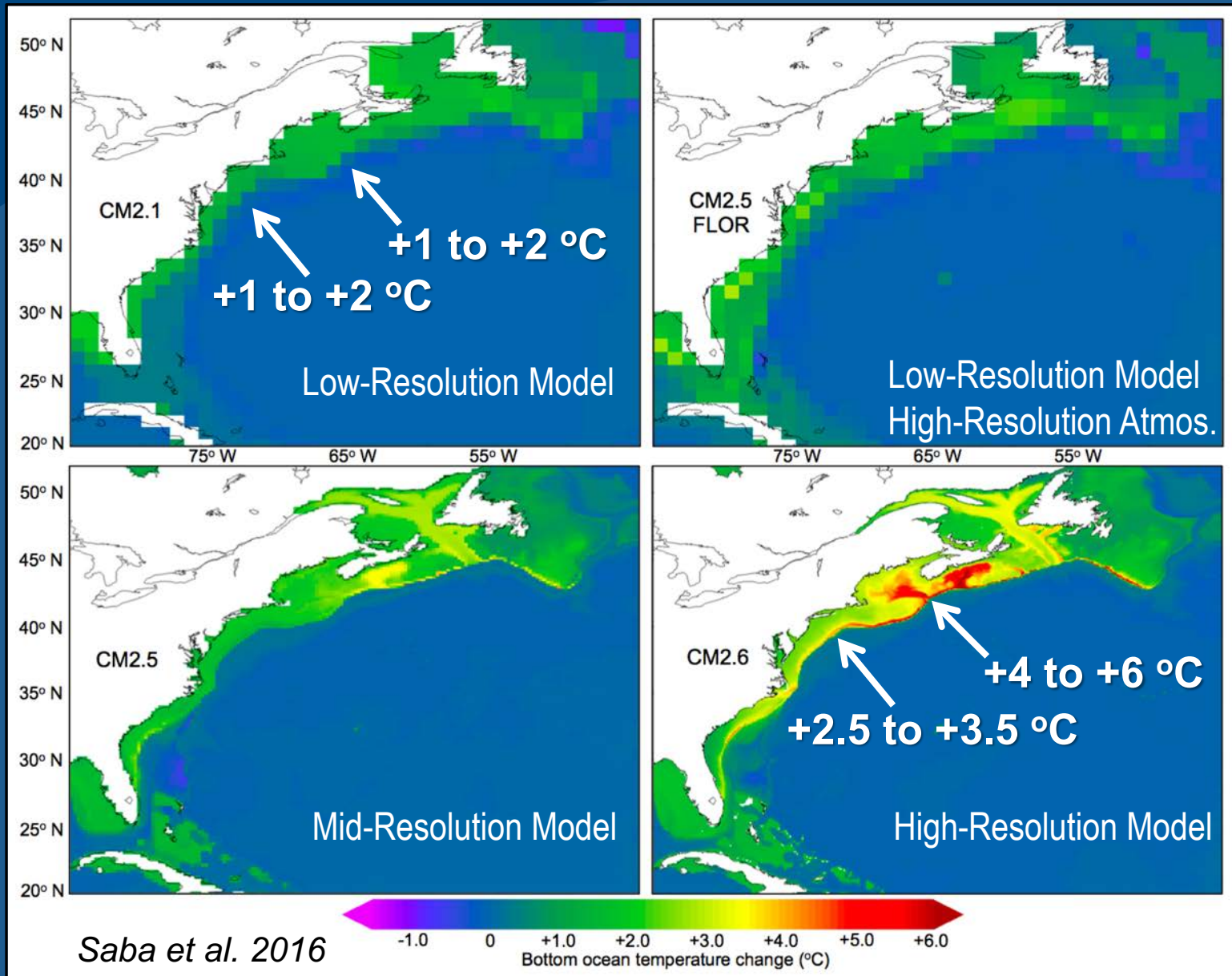


NOAA GFDL Climate Models: U.S. Northeast Shelf

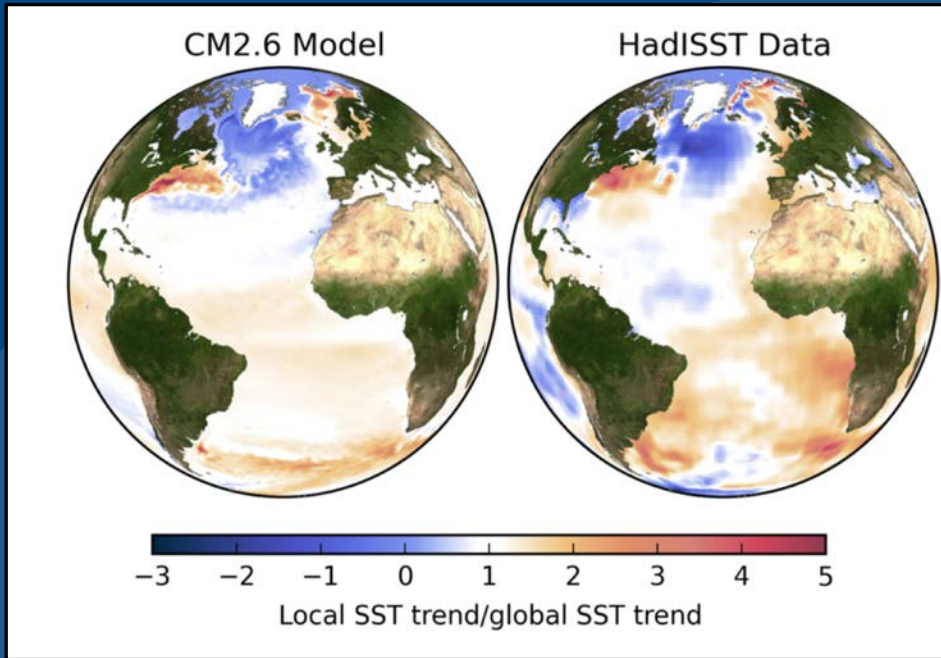


Saba et al. 2016

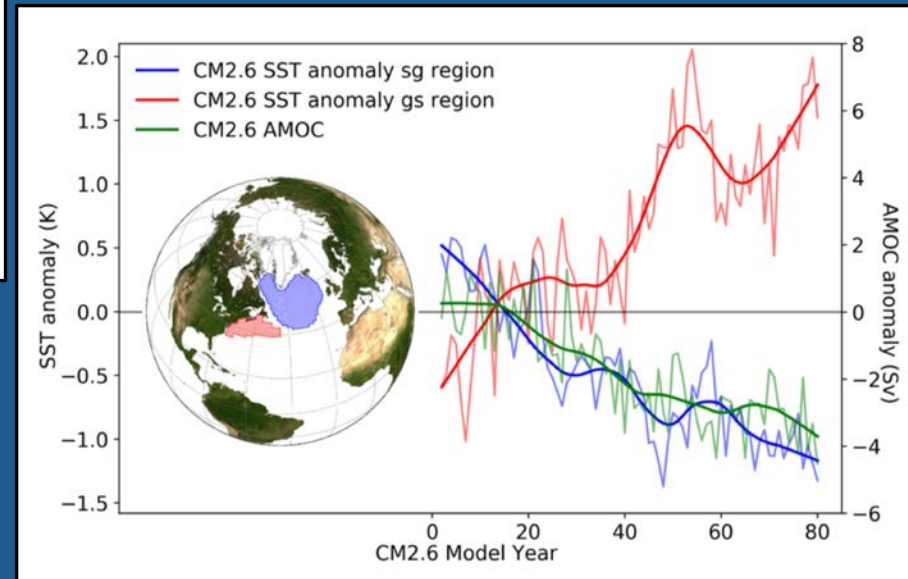
Northwest Atlantic – Projected ocean warming



Enhanced Warming linked to AMOC

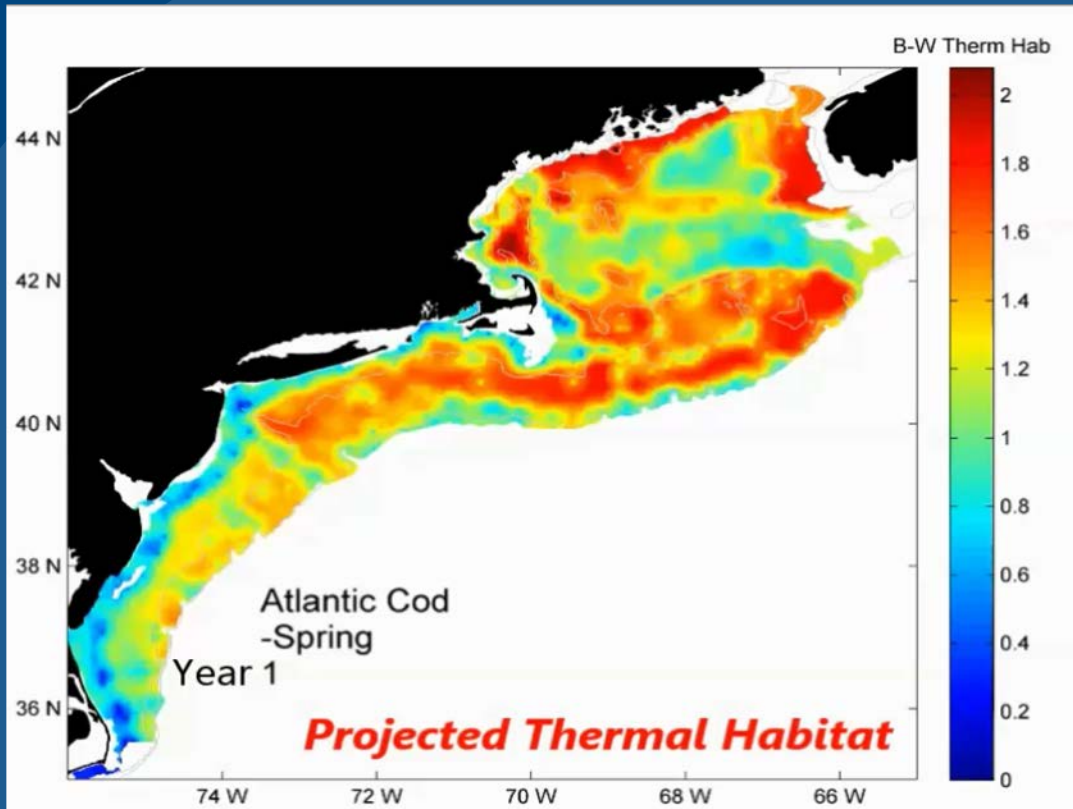
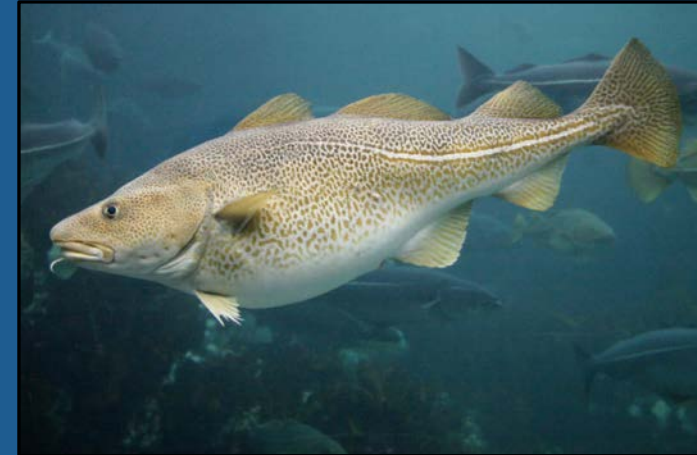


*Caesar, Saba et al. in press,
Nature*



Atlantic cod thermal habitat projection based on NOAA GFDL's high-res. climate model

Atlantic cod

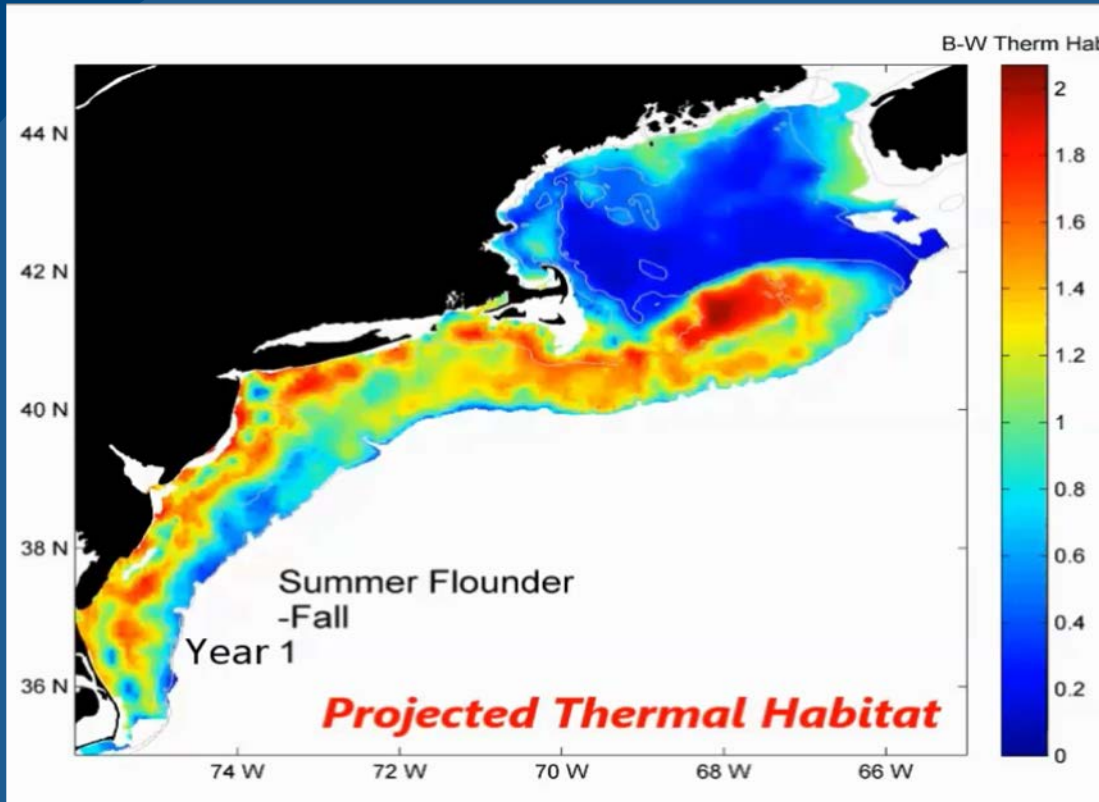
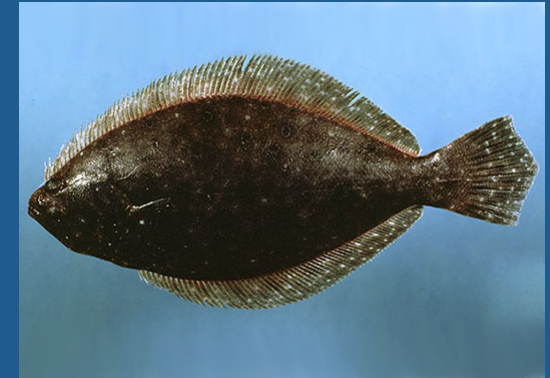


Kleisner et al. 2017

Value of Landings		
Rank	Species	Thousand Dollars
1	Lobsters	679,214
2	Crabs	678,727
3	Shrimp	488,384
4	Salmon	460,166
5	Pollock	449,198
6	Scallops	440,496
7	Cod	264,191
8	Flatfish	263,615
9	Oysters	213,773
10	Clams	206,299

Summer flounder thermal habitat projection based on NOAA GFDL's high-res. climate model

Summer flounder



Kleisner et al. 2017

Value of Landings		
Rank	Species	Thousand Dollars
1	Lobsters	679,214
2	Crabs	678,727
3	Shrimp	488,384
4	Salmon	460,166
5	Pollock	449,198
6	Scallops	440,496
7	Cod	264,191
8	Flatfish	263,615
9	Oysters	213,773
10	Clams	206,299

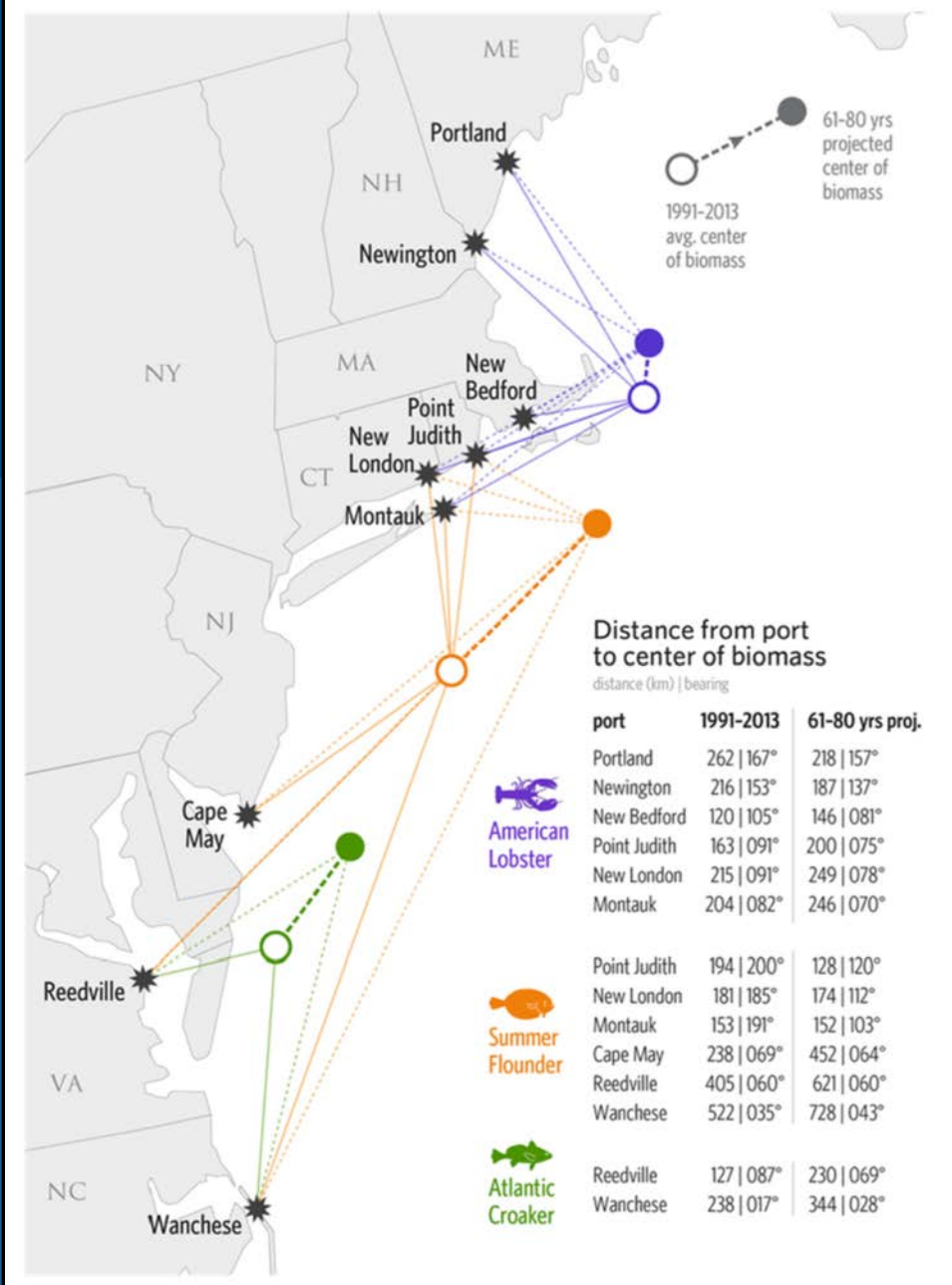
Distance from port to fishing areas

Distance to port under continued ocean warming.

Does not account for:

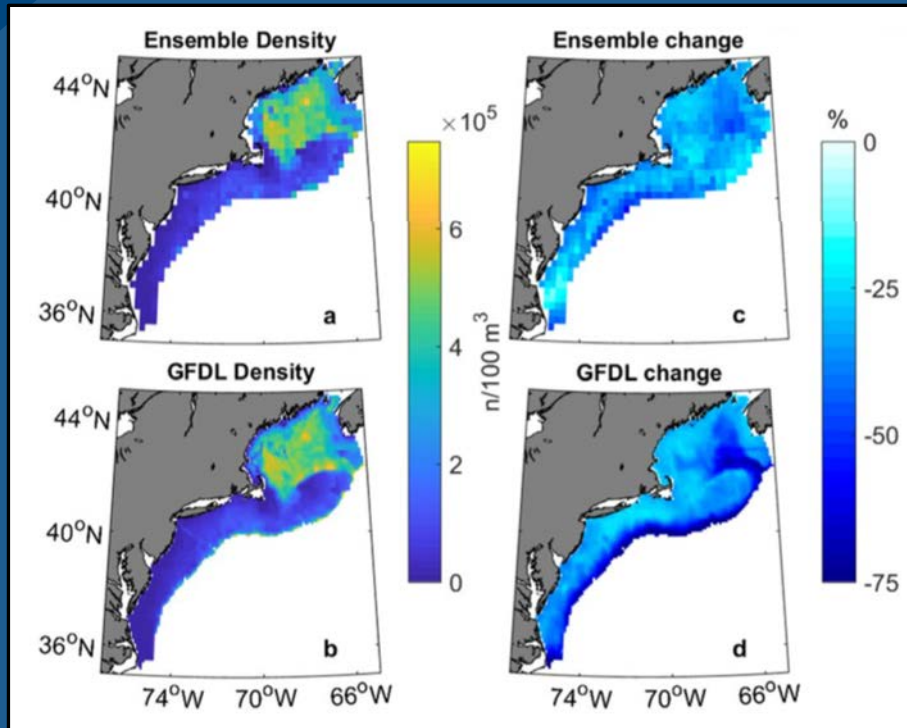
- Fishing mortality change.
- Species interactions.

Kleisner et al. 2017



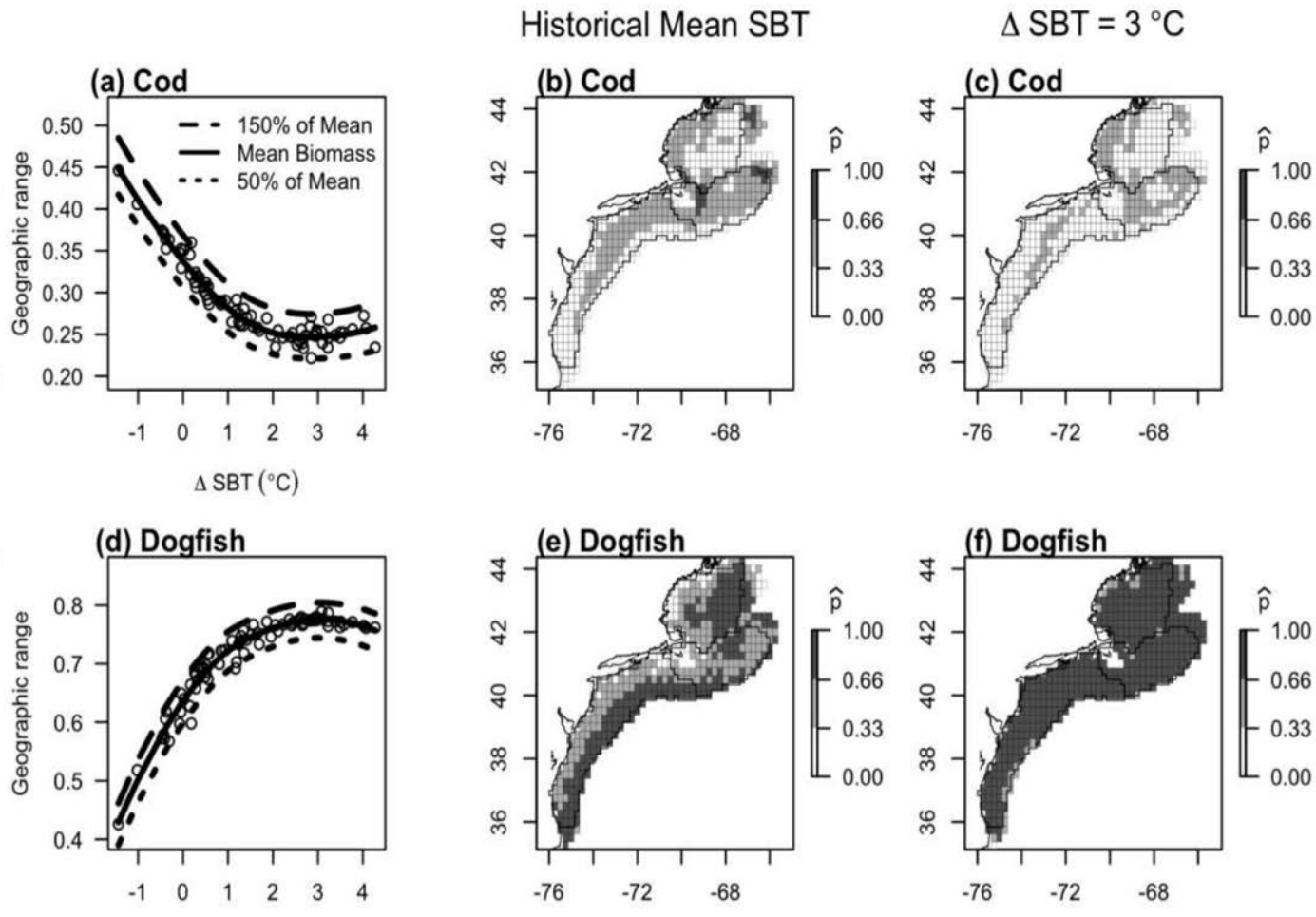
Calanus finmarchicus projection based on NOAA GFDL's high-res. climate model

Calanus finmarchicus habitat climate change projection based on NOAA GFDL's high-res. CM2.6.



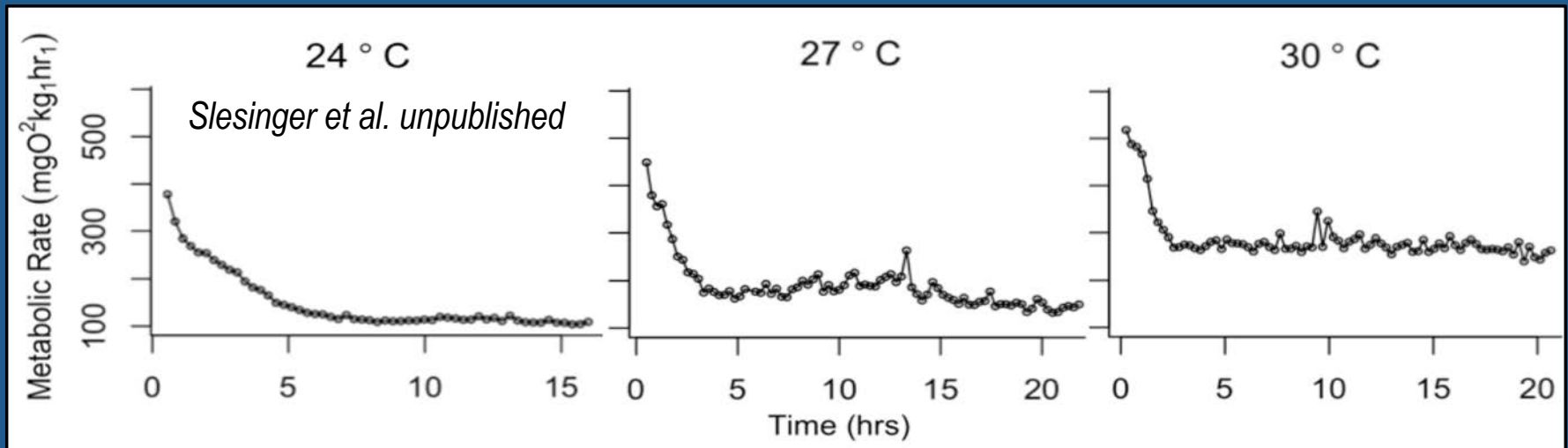
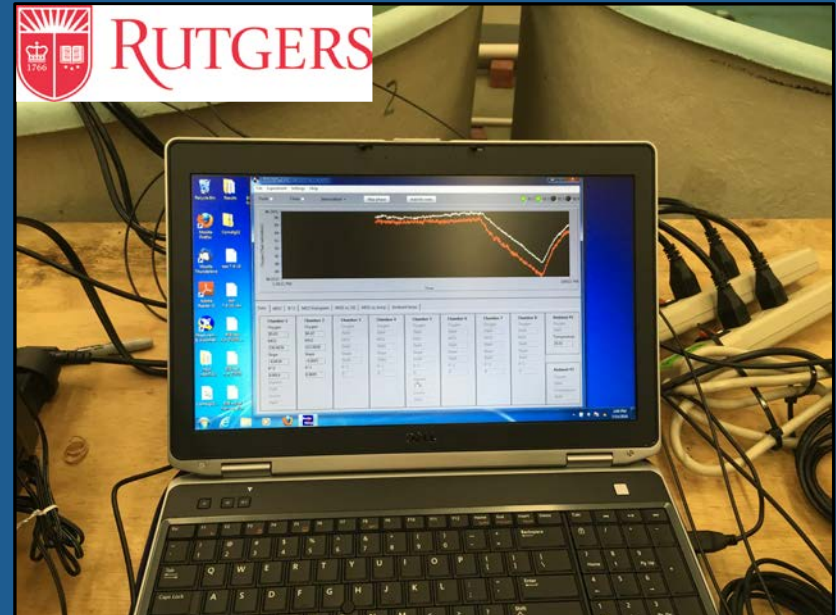
Grieve et al. 2017

Piscivore overlap projections based on NOAA GFDL's high-res. climate model



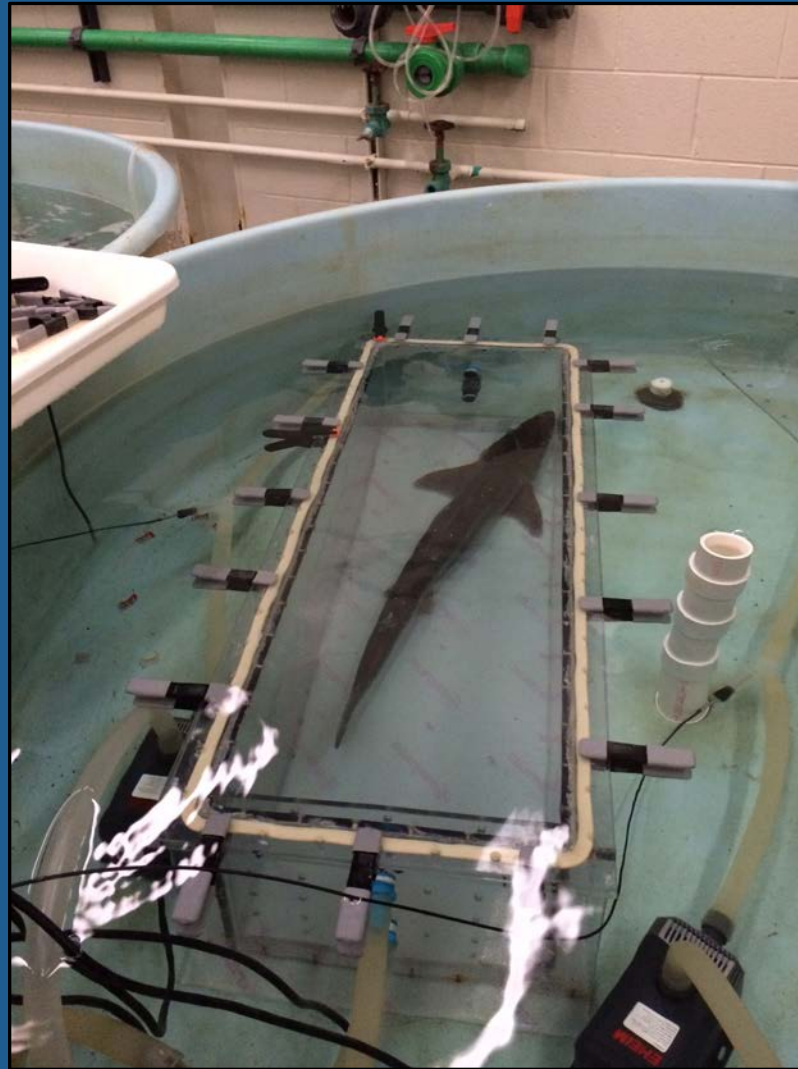
Selden et al. 2017

Laboratory Studies



Laboratory Studies

NOAA Sandy Hook Lab



Andres et al. unpublished



NOAA FISHERIES

Other ongoing research

- Habitat vulnerability analysis; Scenario Planning
- Fine-scale modeling of lobster and scallop habitat
- Sea turtle nesting and habitat analyses
- Beyond temperature: Habitat modeling using biological and physical variables

Contact: vincent.saba@noaa.gov

Summary

- U.S. Northeast Shelf > 1/3 U.S. annual value of commercial fish.
- Last decade: U.S. Northeast Shelf has warmed faster than most other coastal waters globally.
- Continued distribution shifts of valuable commercial and rec. species are highly likely under climate change.
- Need to move beyond temperature impacts. More laboratory process studies!
- Climate impacts research – inform assessments and management.
- Goal – climate ready fisheries management. Requires EBFM.