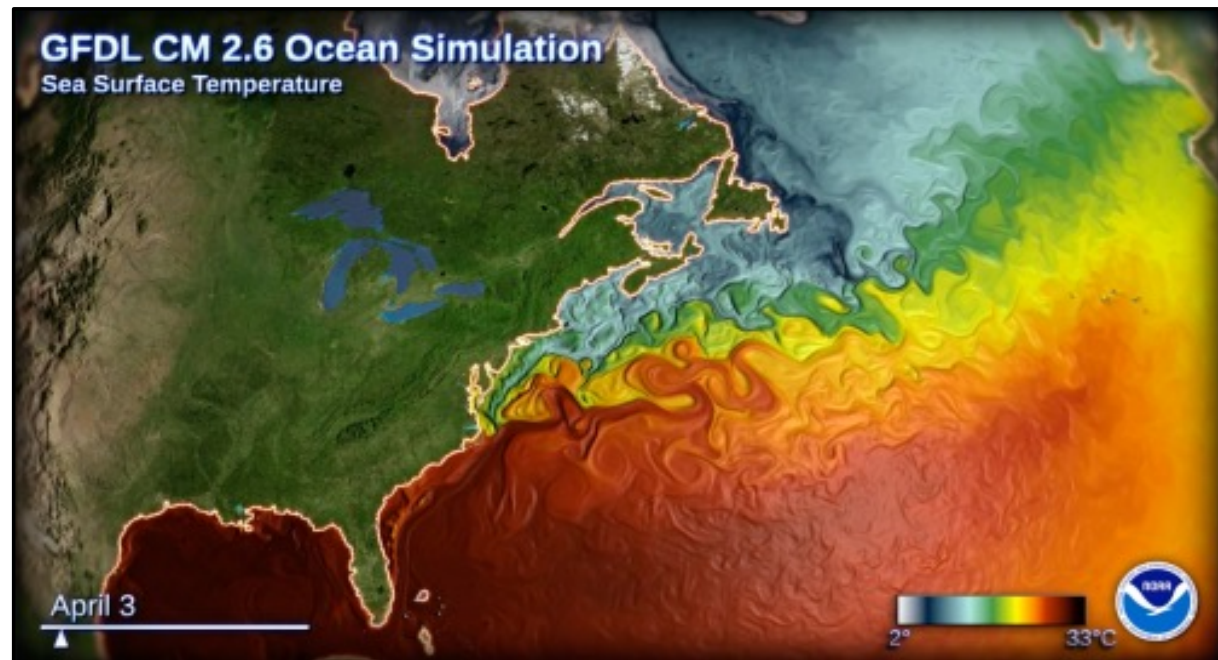


NOAA
FISHERIES

Climate Science at the Northeast Fisheries Science Center

Vincent Saba

NOAA Northeast Fisheries Science Center / Geophysical Fluid Dynamics Laboratory

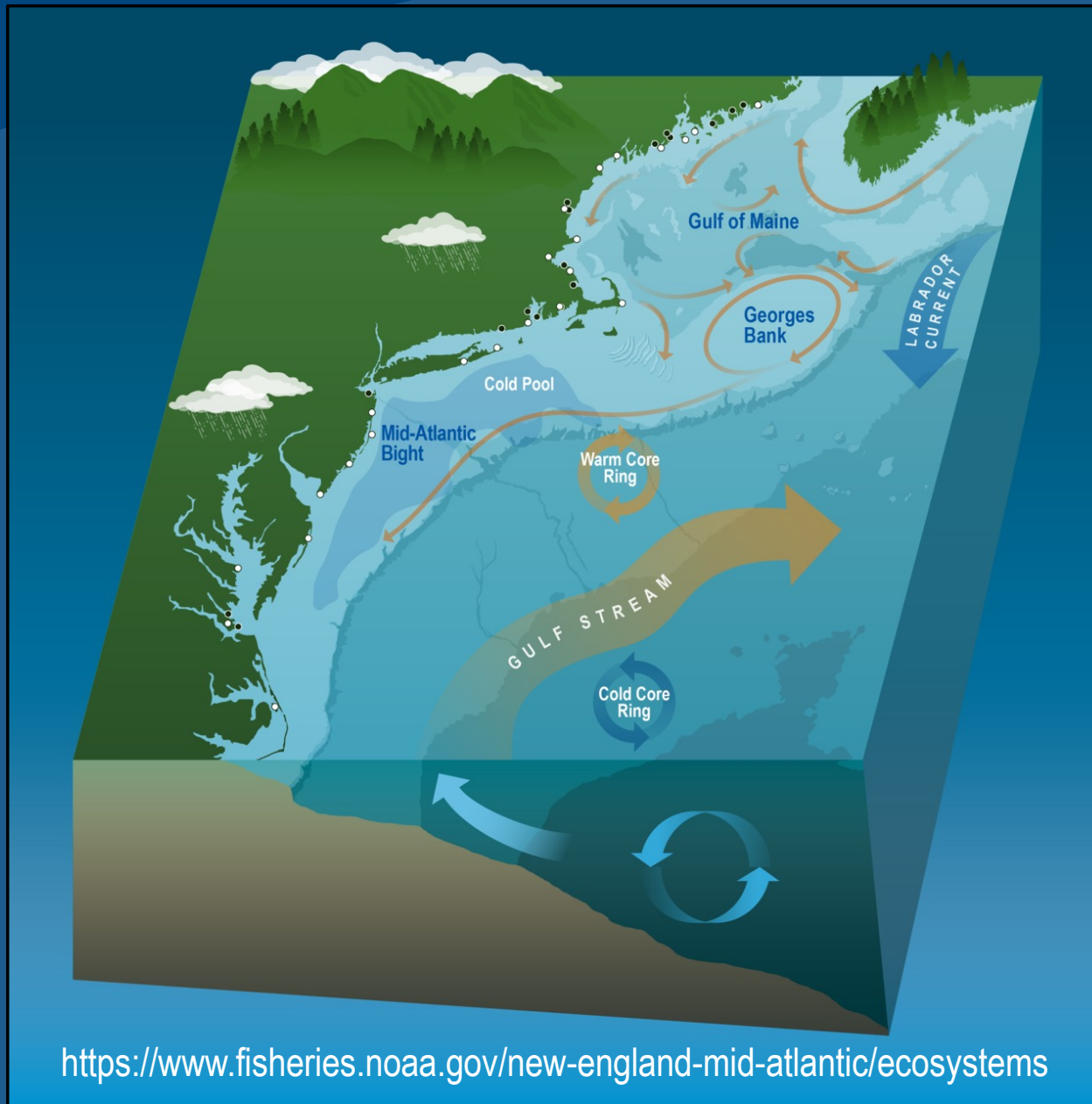


NOAA FISHERIES

Presentation Outline

- 1) Observed change in the U.S. Northeast Shelf.
- 2) National Climate Science Strategy and Northeast Regional Action Plan (NERAP).
- 3) NERAP accomplishments over the last five years.
 - Climate vulnerability assessments, scenario planning, laboratory studies, stock assessments, species distribution projections.
- 4) What's needed to achieve climate-ready fisheries management.
- 5) NOAA Climate and Fisheries Initiative.

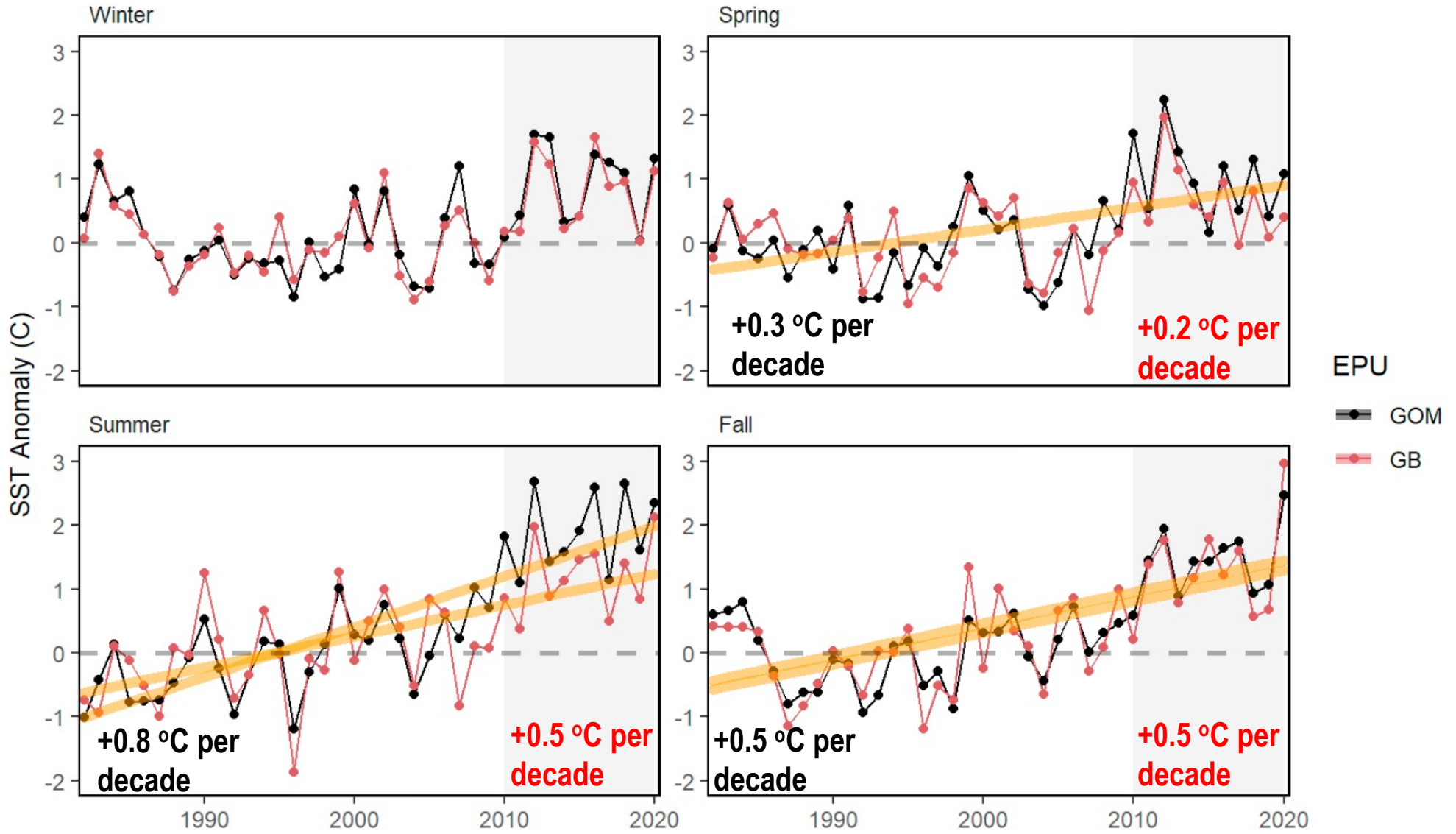
U.S. Northeast Shelf



U.S. Northeast Shelf - Ocean Warming

Gulf of Maine & Georges Bank SST Anomaly

2021 State of the Ecosystem Report

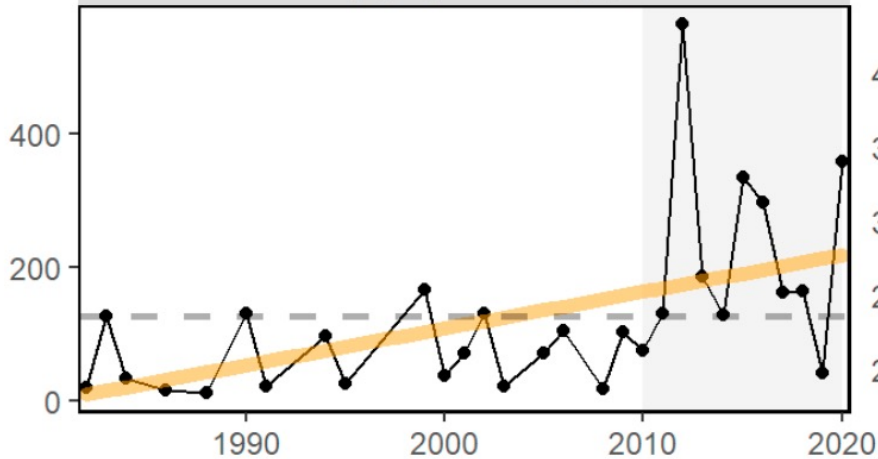


U.S. Northeast Shelf – Marine Heatwaves

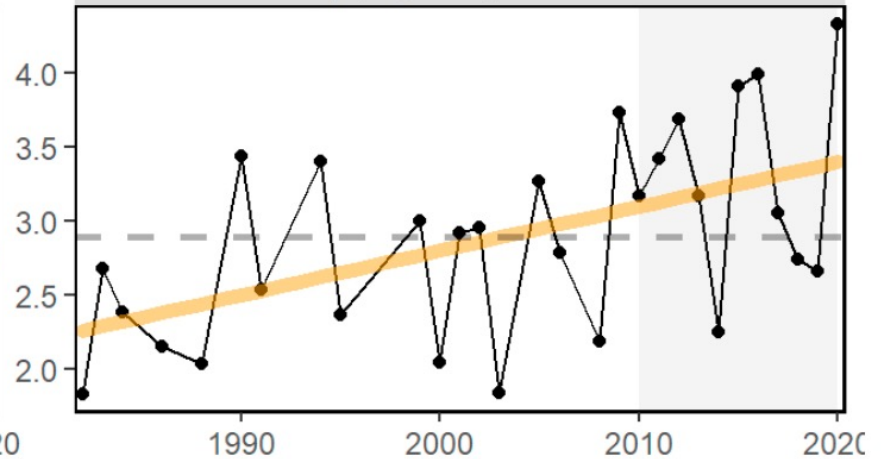
Georges Bank

2021 State of the Ecosystem Report

Cumulative Intensity (degree C x days)

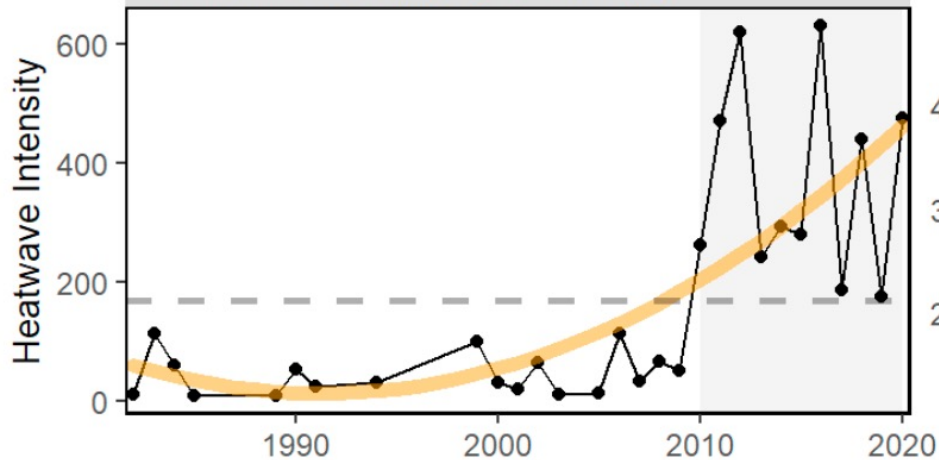


Maximum Intensity (degree C)

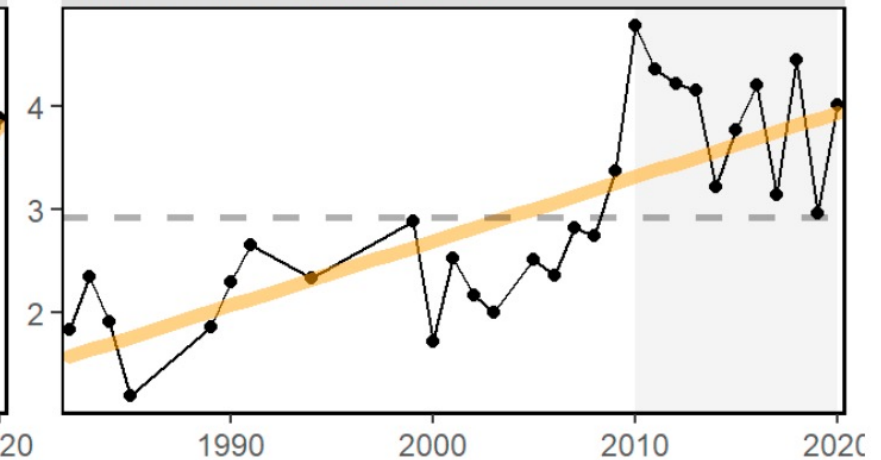


Gulf of Maine

Cumulative Intensity (degree C x days)



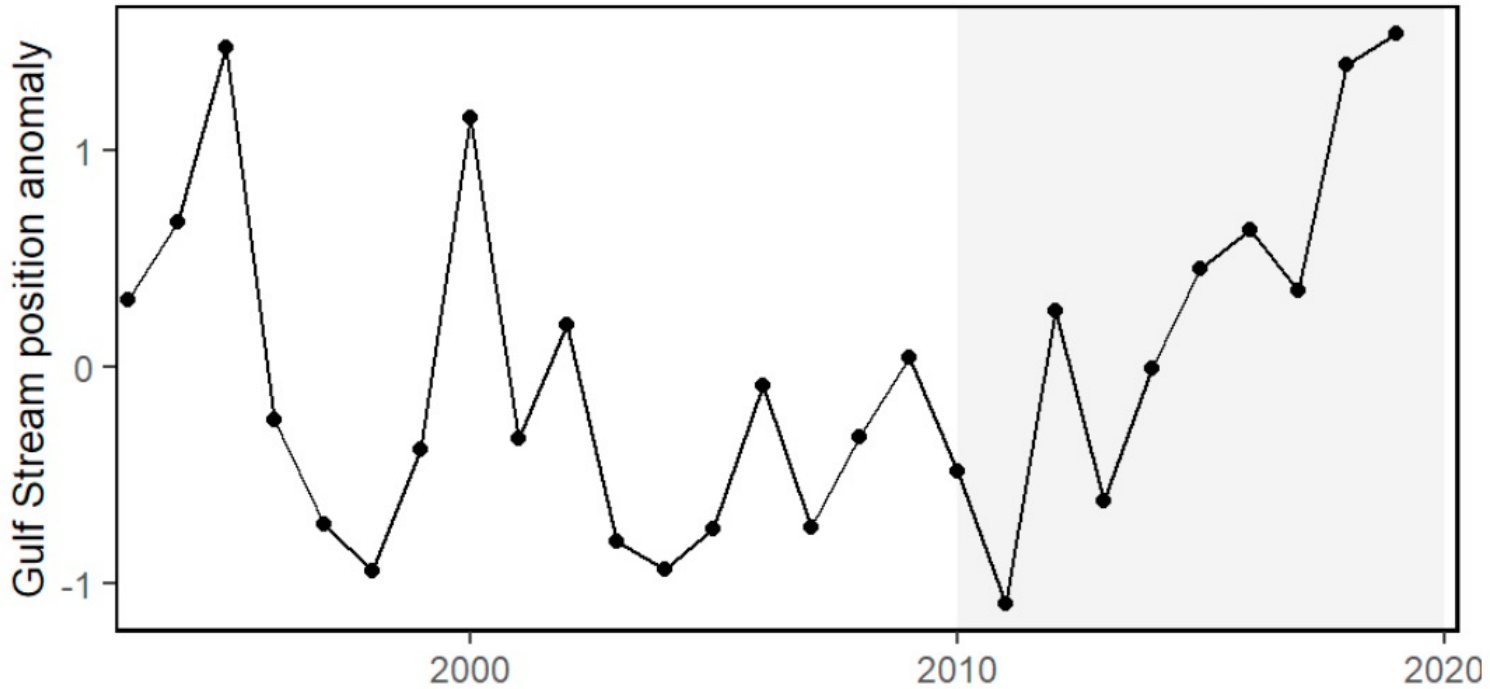
Maximum Intensity (degree C)



Gulf Stream Index

Gulf Stream Index

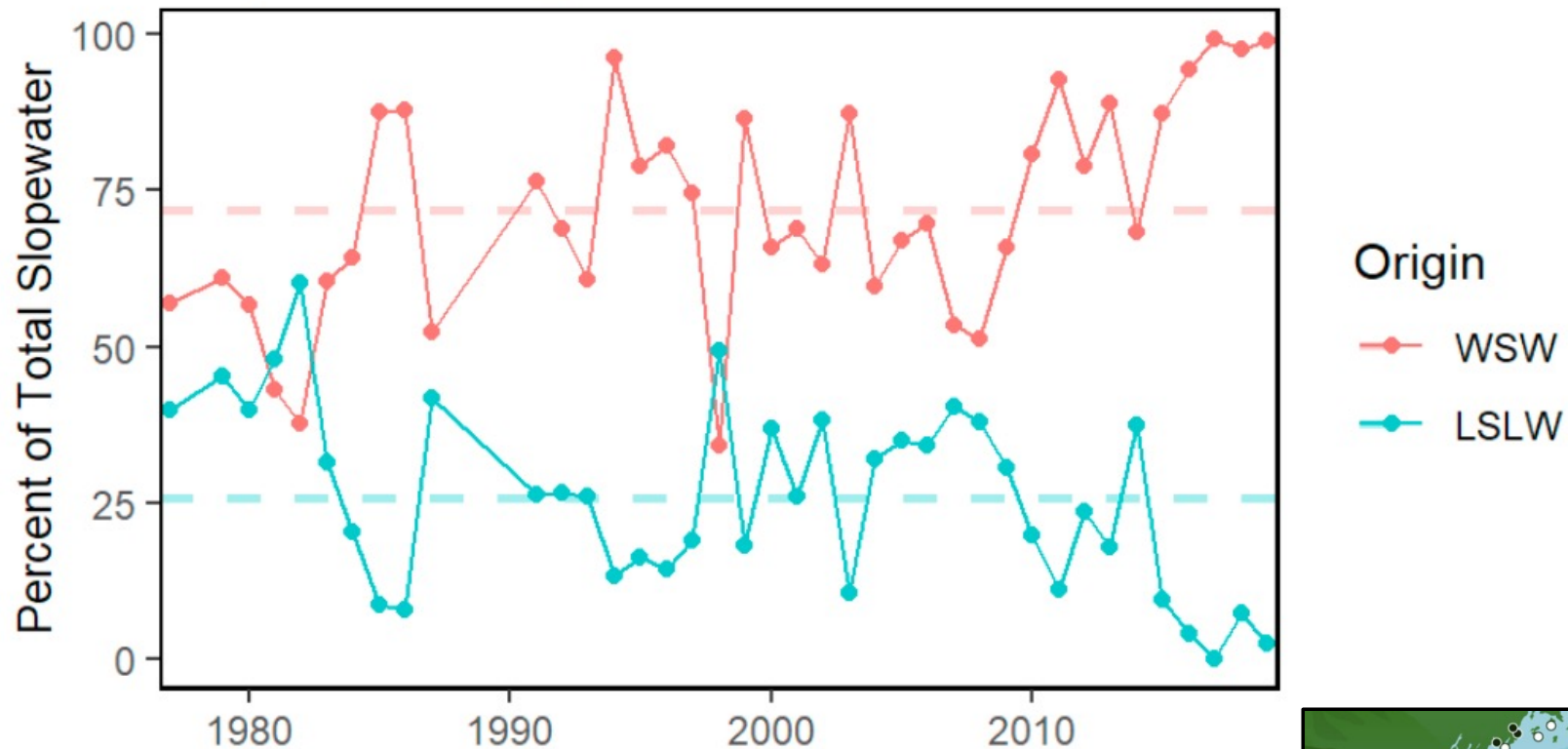
2021 State of the Ecosystem Report



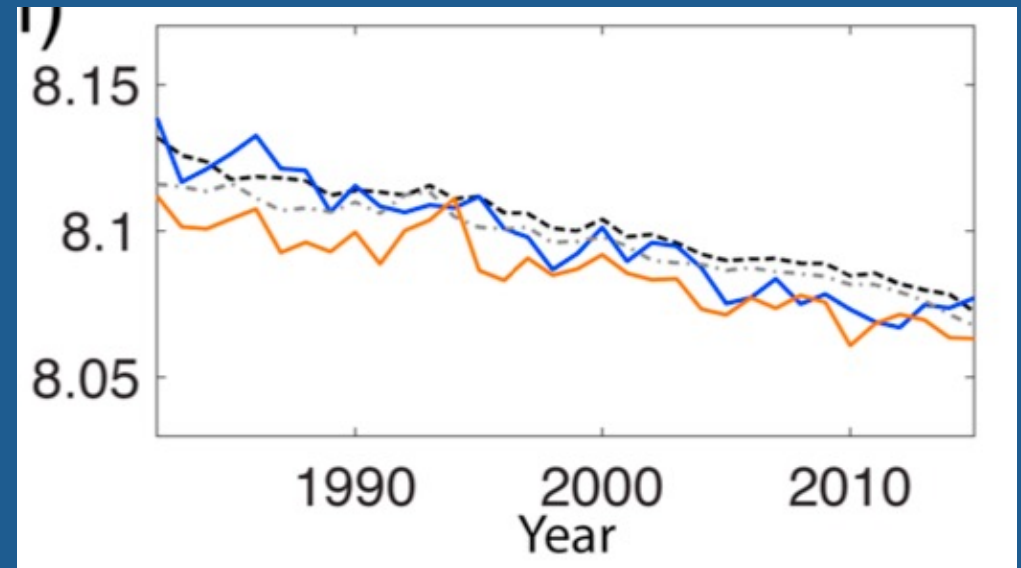
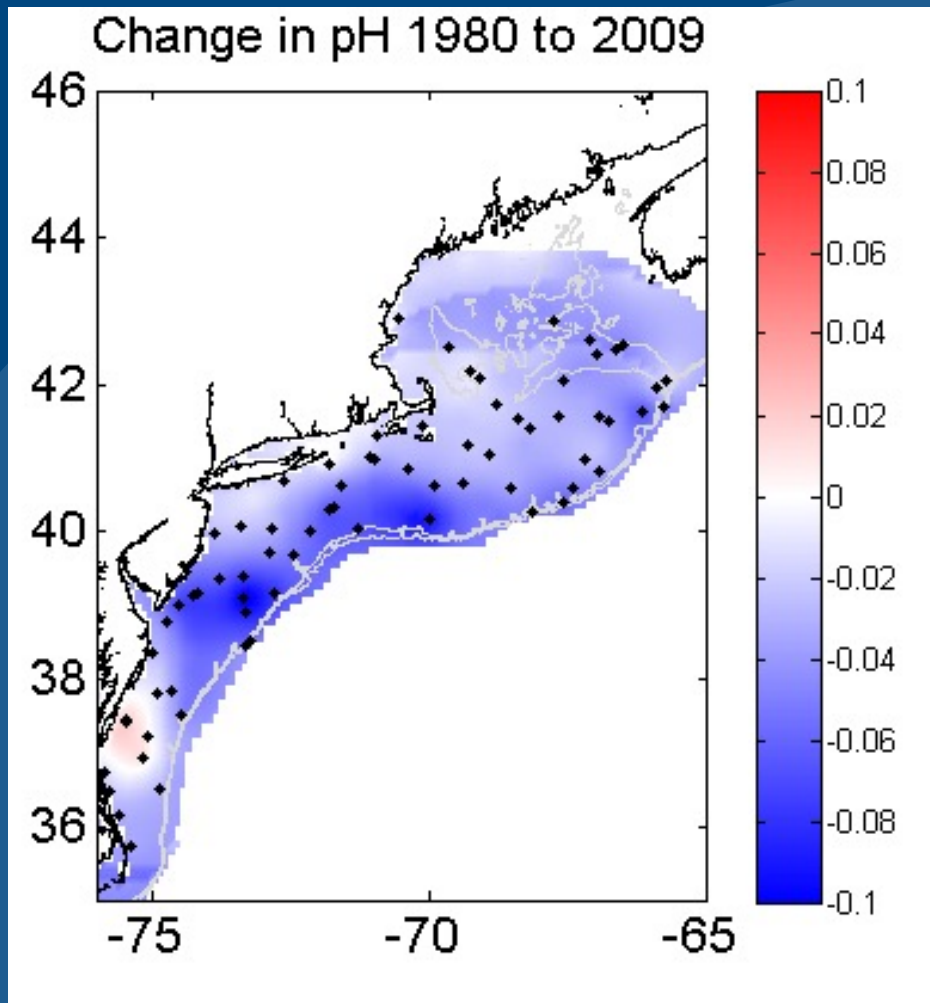
Regional Ocean Circulation

2021 State of the Ecosystem Report

Slopewater Proportions in NE Channel



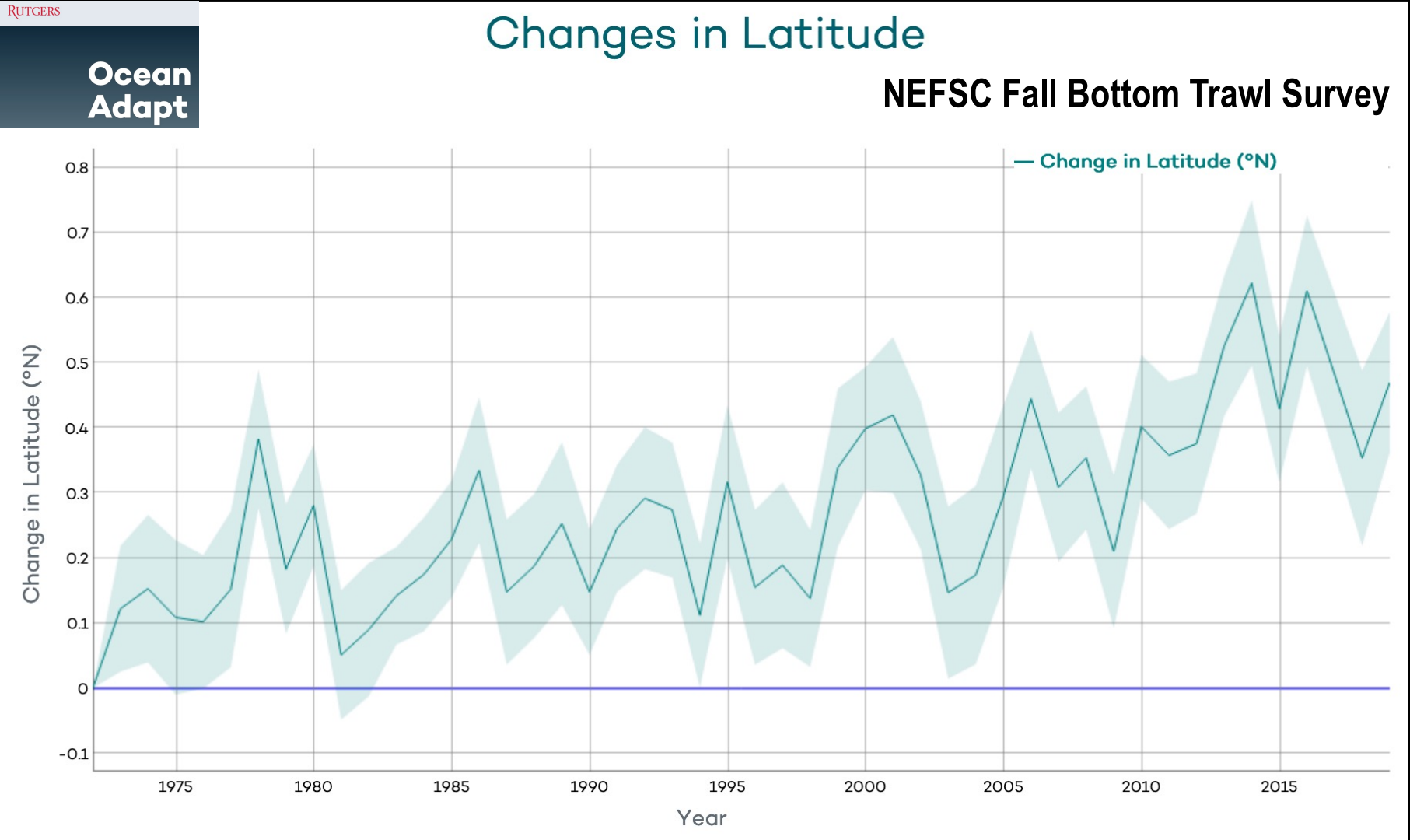
Surface pH – U.S. NES



Xu et al. 2020



Warming ocean, fish on the move



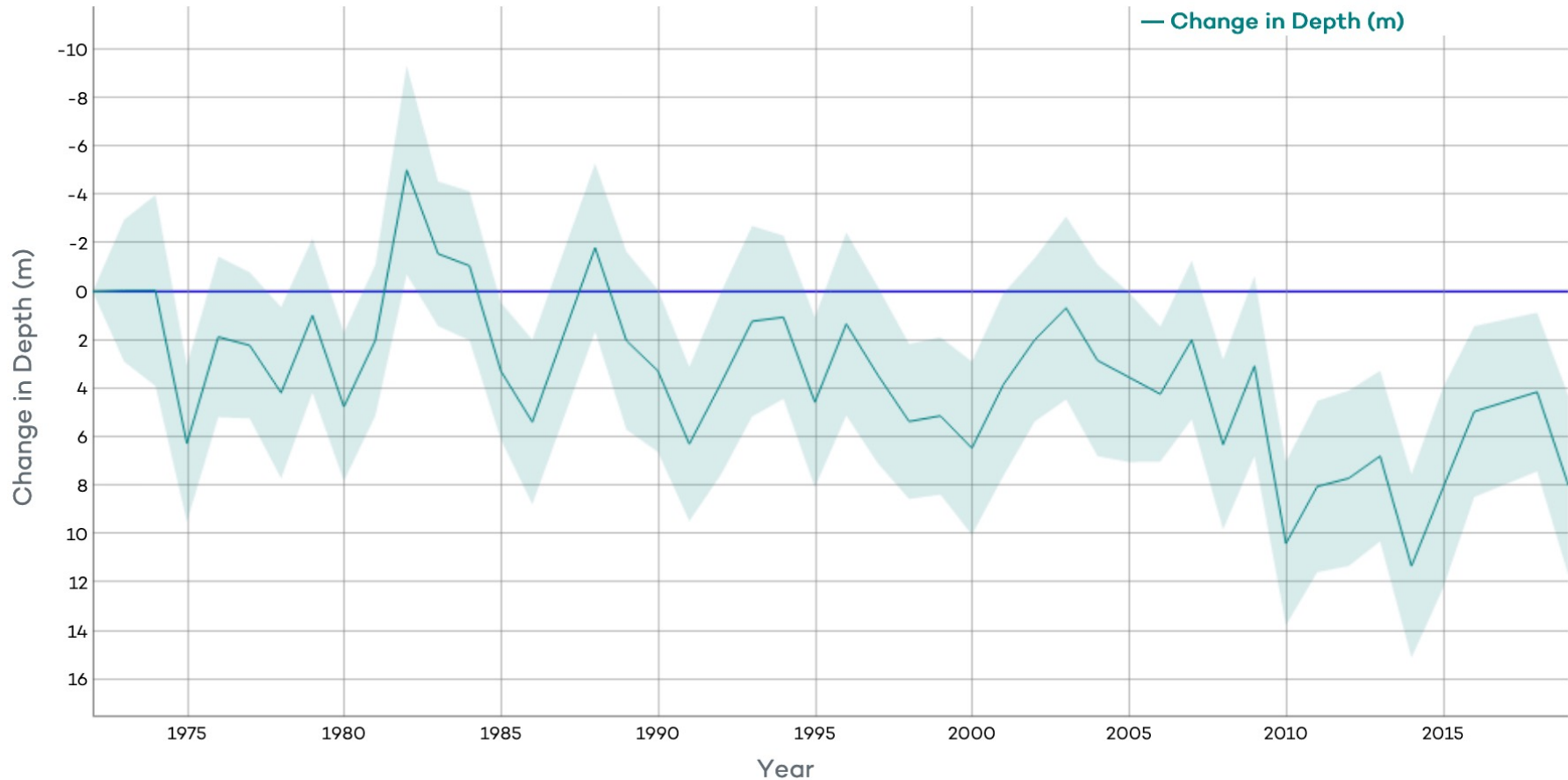
Warming ocean, fish on the move

RUTGERS

Ocean
Adapt

Changes in Depth

NEFSC Fall Bottom Trawl Survey



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**NOAA
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NOAA Fisheries Climate Science Strategy Highlights



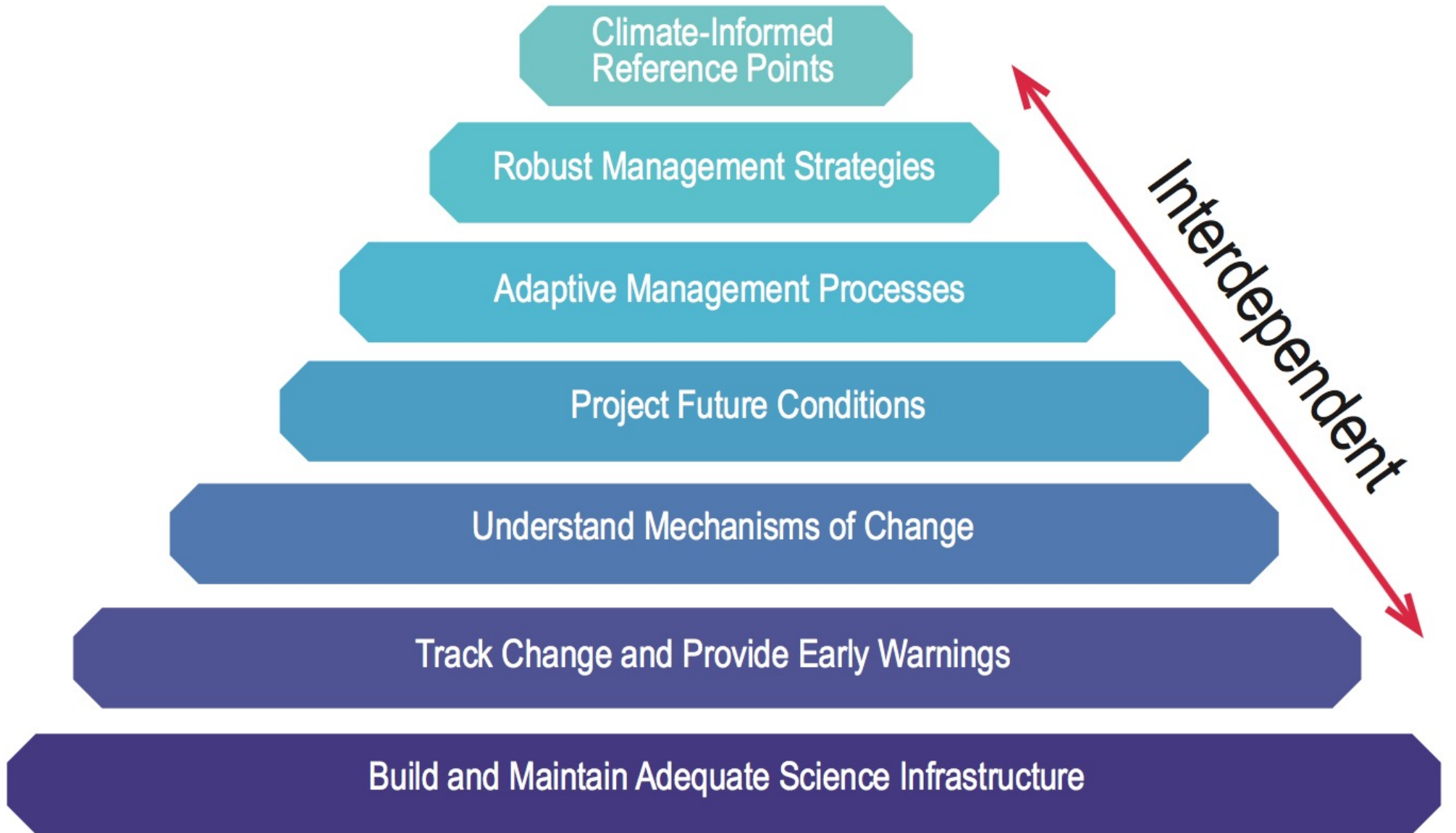
“The Strategy is part of a proactive approach to increase the production, delivery and use of climate-related information to fulfill NOAA Fisheries mandates in a changing climate. Implementing this Strategy will help reduce impacts and increase the resilience of our valuable living marine resources,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

*- Eileen Sobeck
Former Fisheries
Assistant Administrator*



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Climate Science Strategy Objectives





**NOAA
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Northeast Fisheries
Science Center

Greater Atlantic
Regional Fisheries
Office

**Highlights of the
Climate Science Strategy**

Northeast Regional Action Plan



Contents



The Need for Action	1
What's at Risk?	2
Recommended Actions	3
Moving Forward	5
More Information	6

The Northeast Regional Action Plan identifies 15 NERAP Actions of highest priority. Actions are prioritized for No New Resources and New Resources scenarios.

NERAP 2.0 development underway.



Climate vulnerability

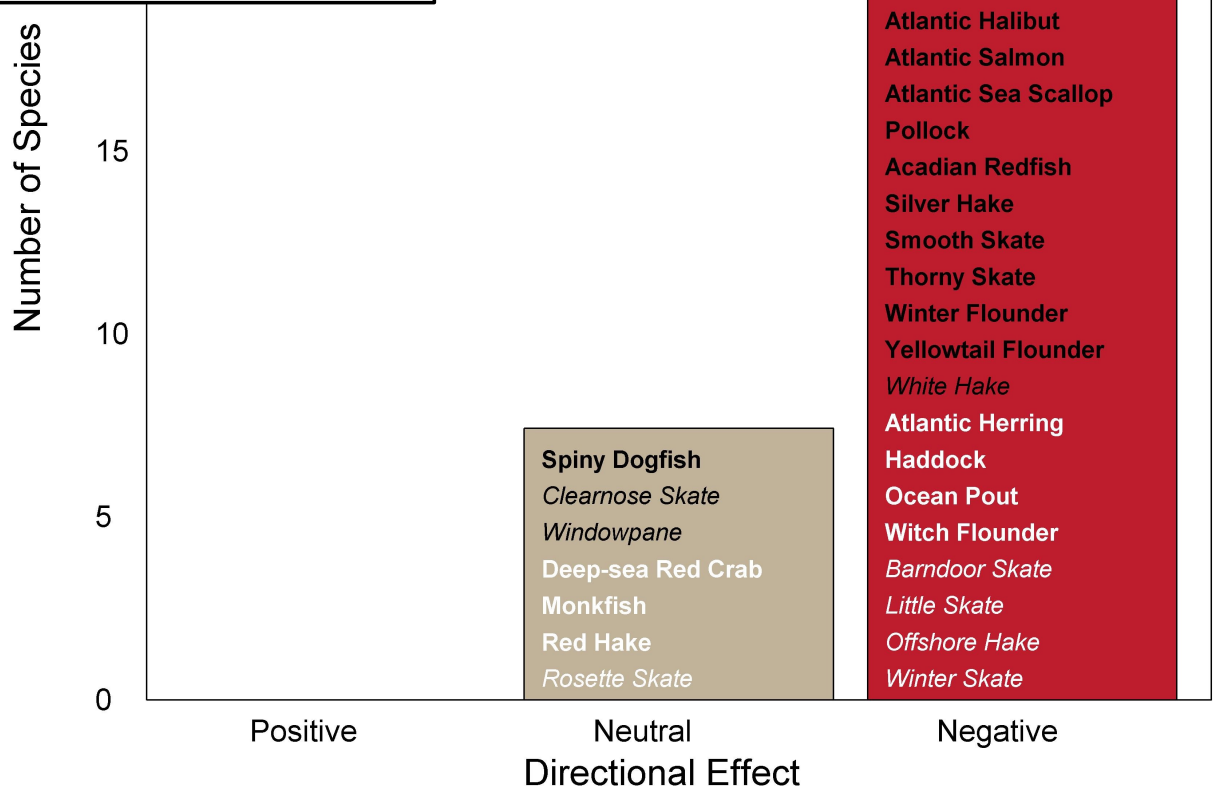
RESEARCH ARTICLE

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

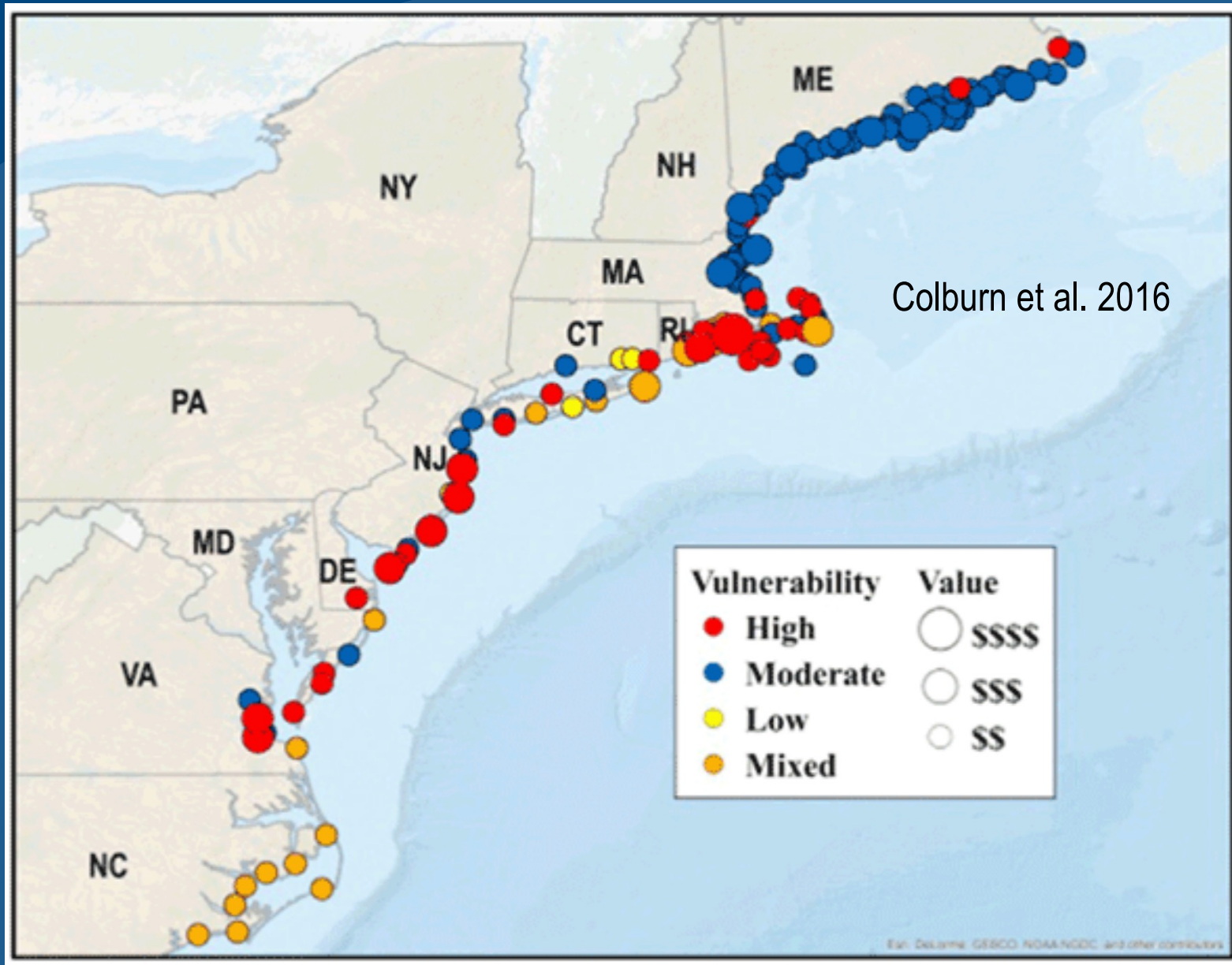
Jonathan A. Hare^{1*}, Wendy E. Morrison², Mark W. Nelson², Megan M. Stachura^{3aa}, Eric J. Teeters², Roger B. Griffis⁴, Michael A. Alexander⁵, James D. Scott⁵, Larry Alade⁶, Richard J. Bell^{1ab}, Antonie S. Chute⁶, Kiersten L. Curti⁶, Tobey H. Curtis⁷, Daniel Kircheis⁸, John F. Kocik⁸, Sean M. Lucey⁶, 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 climate vulnerability assessment (*Lettrich et al.*)

U.S. Northeast Habitat climate vulnerability assessment (*final phase*)



Climate vulnerability



Scenario Planning – Atlantic Salmon and NA Right Whales

Scenario Planning

- Helps manage risk & prioritize management actions
- Identifies data gaps & science priorities
- Outcomes contribute to data modeling/management strategy evaluations

Pilot Purpose

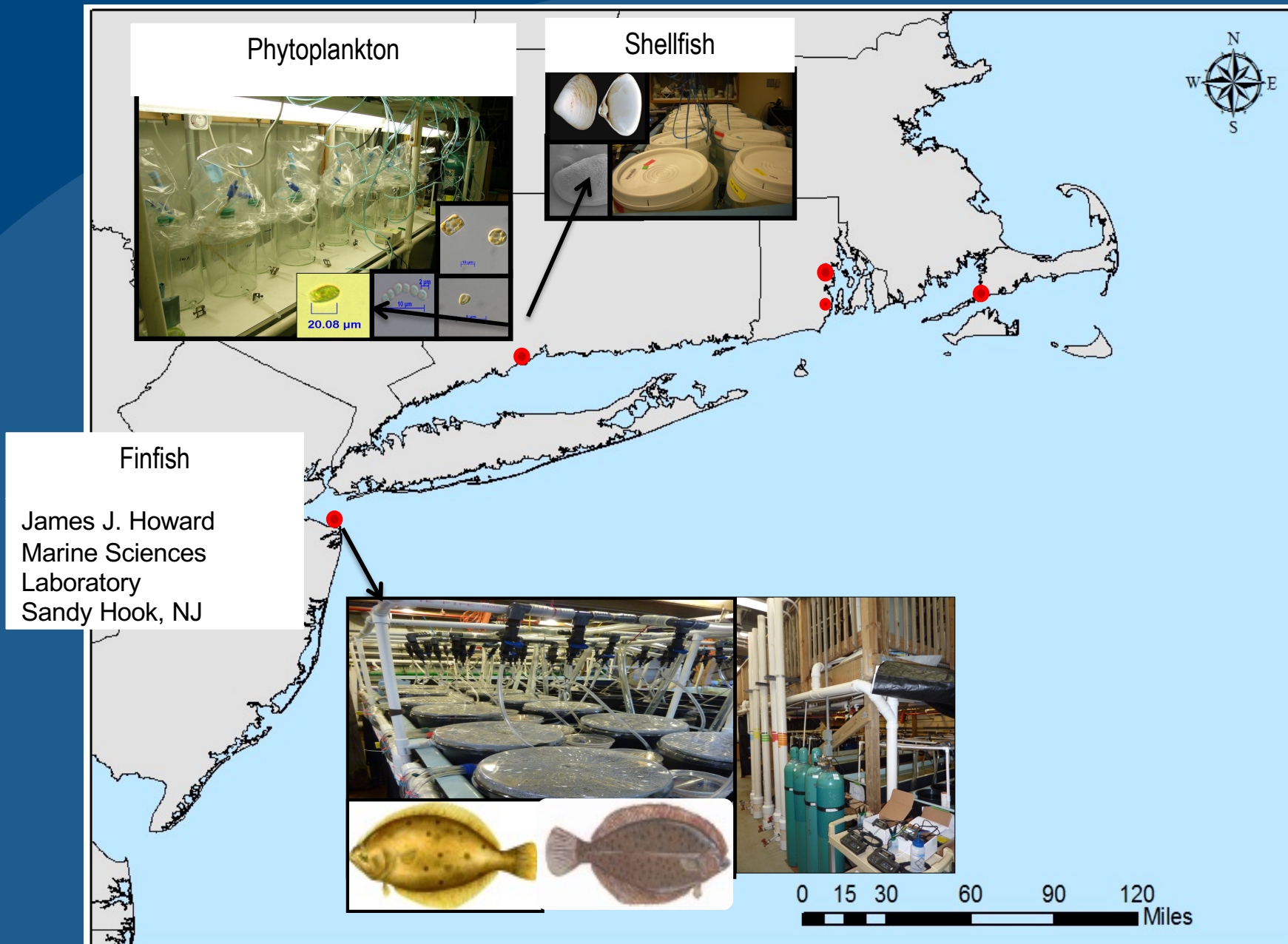
- Apply scenario planning within NMFS
- Explore what NMFS can do to improve species resilience in the face of climate change.

Successful Outcome Examples

- Identification of high priority actions
- NMFS considering additional training & applications of scenario planning



Laboratory Studies



Incorporating climate into population models

ORIGINAL ARTICLE

WILEY FISHERIES OCEANOGRAPHY

Evaluating the utility of the Gulf Stream Index for predicting recruitment of Southern New England-Mid Atlantic yellowtail flounder

Haikun Xu¹ | Timothy J. Miller² | Sultan Hameed¹ | Larry A. Alade² | Janet A. Nye¹



1405

ARTICLE

Rebuilding in the face of climate change

Richard J. Bell, Anthony Wood, Jonathan Hare, David Richardson, John Manderson, and Timothy Miller



2159

ARTICLE

Temporal and environmental variation in growth and maturity and effects on management reference points of Georges Bank Atlantic cod

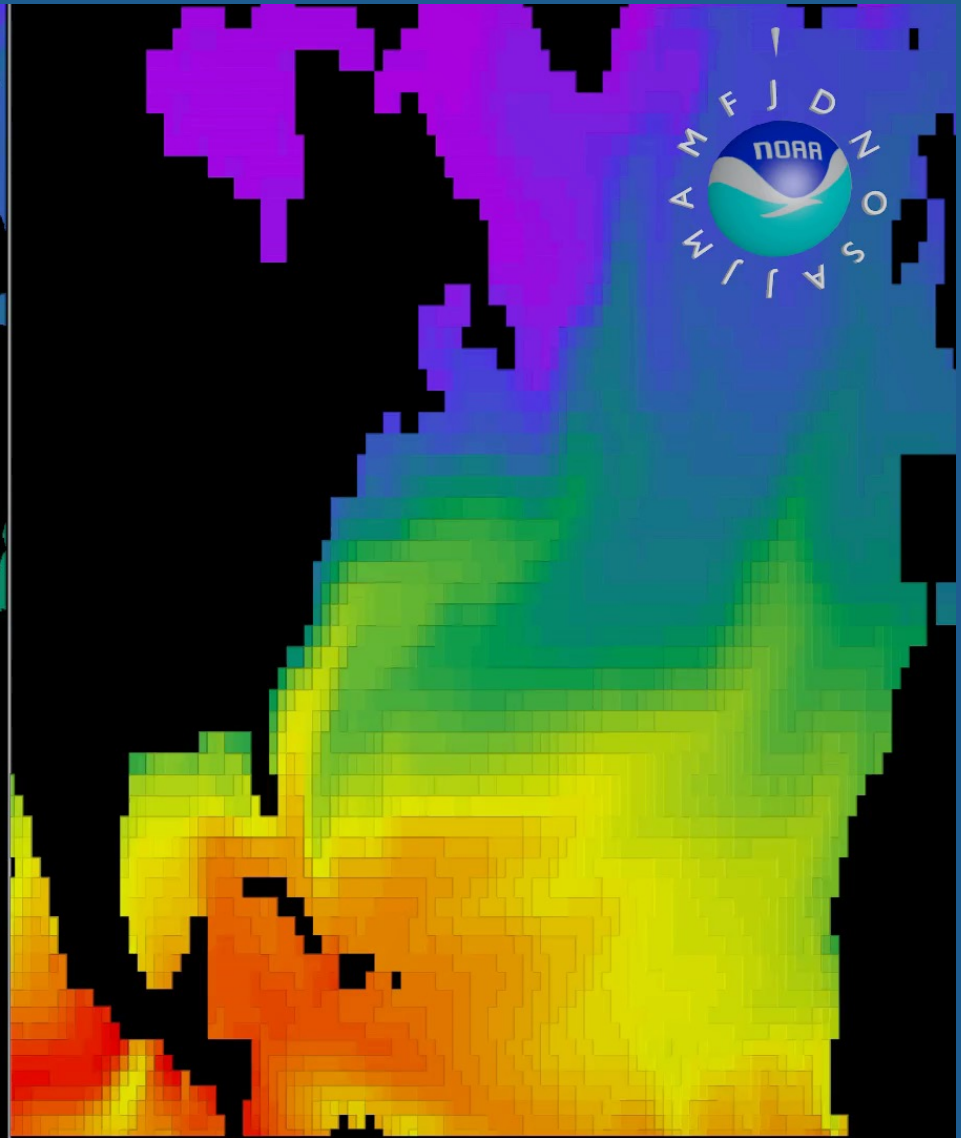
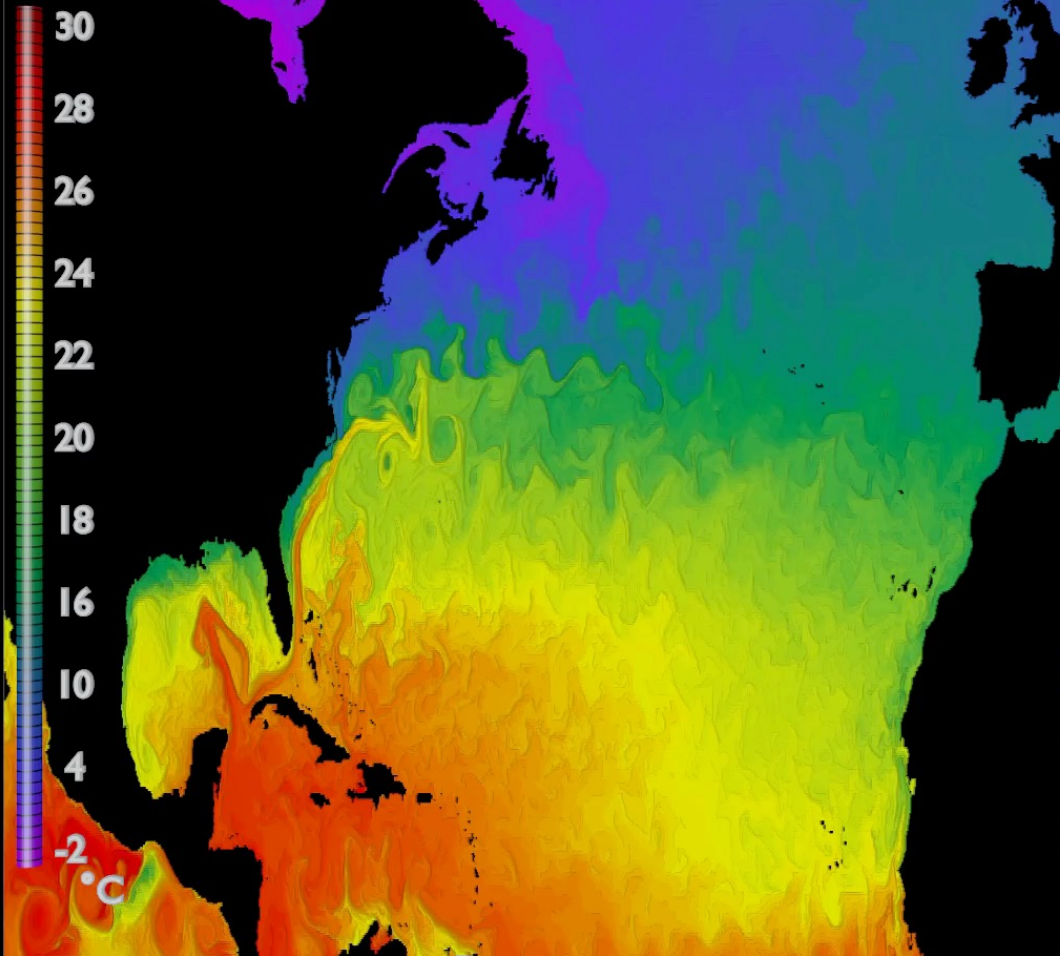
Timothy J. Miller, Loretta O'Brien, and Paula S. Fratantoni



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Global Climate Models: Resolution

GFDL CM2.6 & CM2.5 FLOR
sea surface temperature

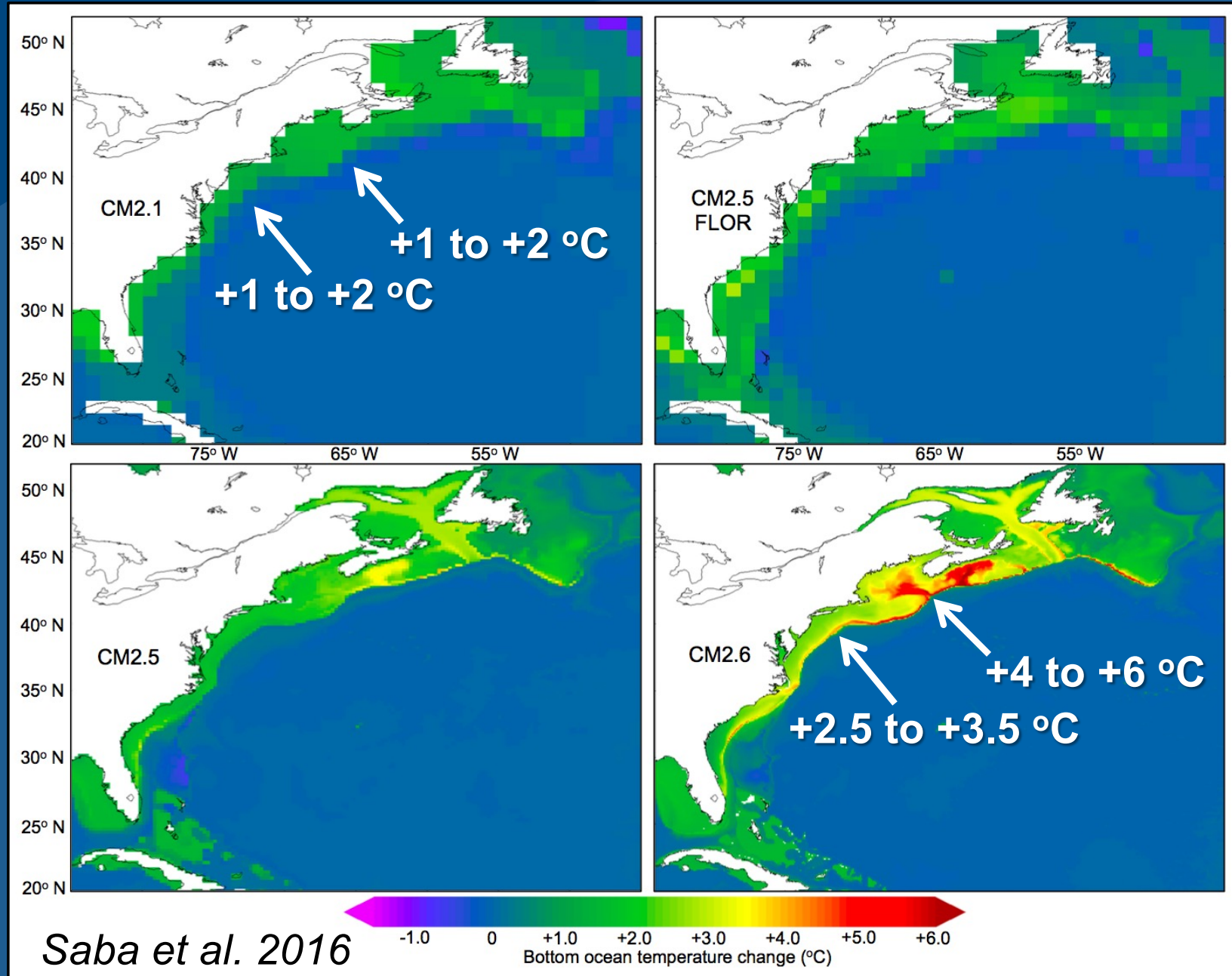


High-Resolution Ocean (10-km)

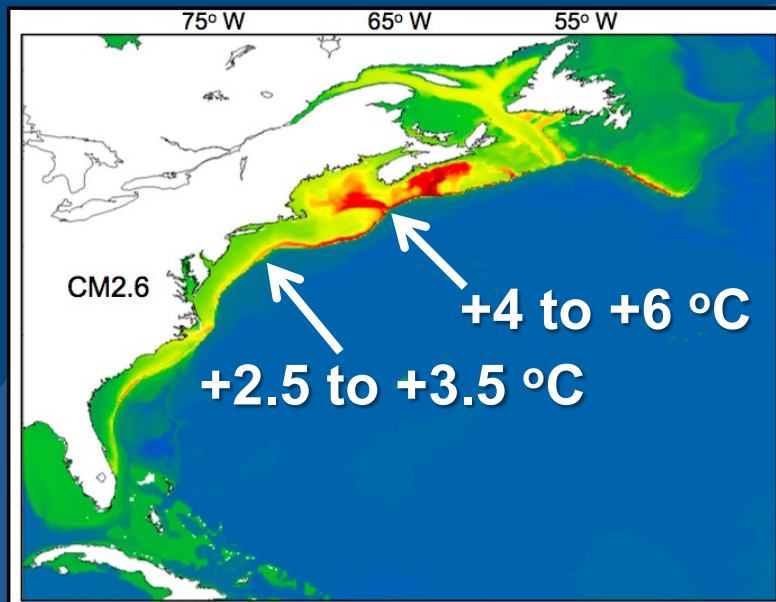
Low-Resolution Ocean (100-km)



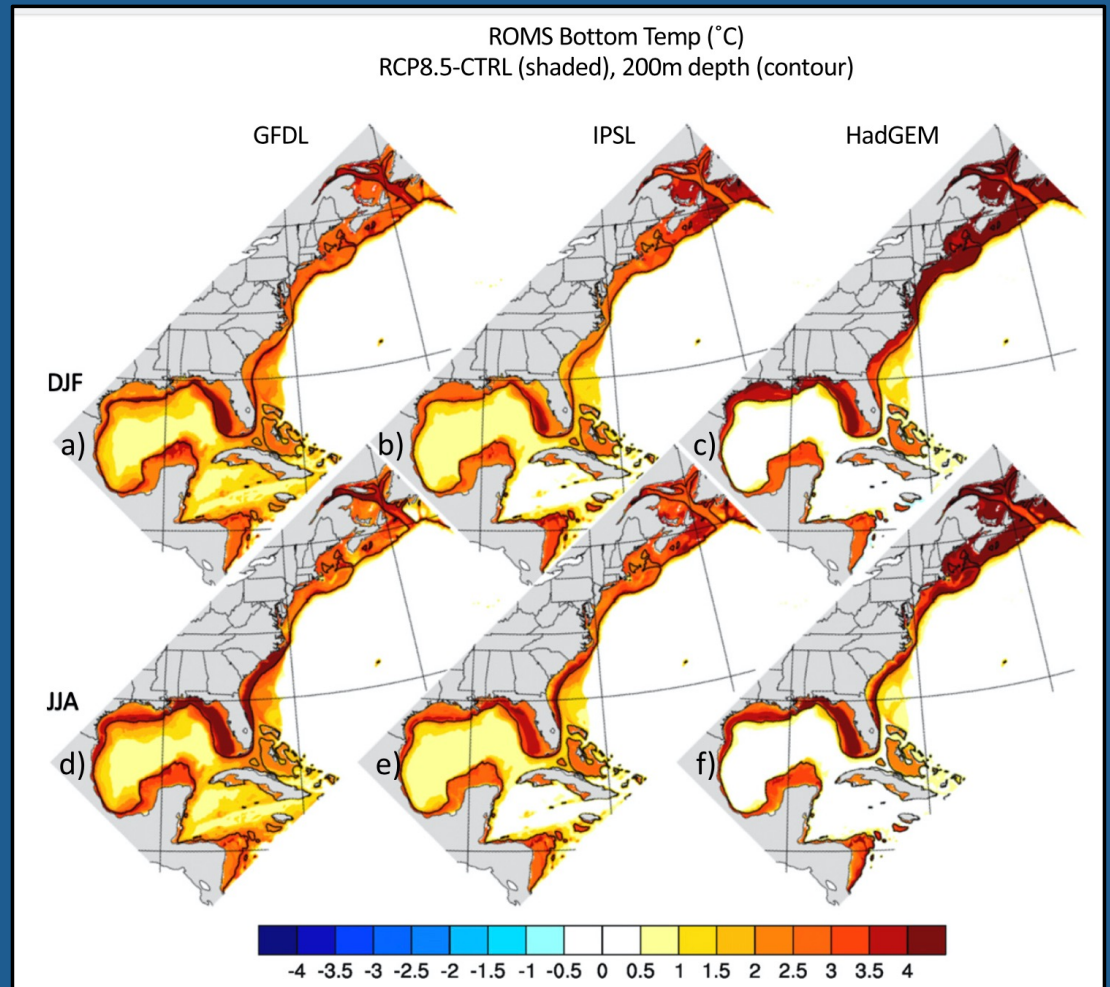
Northwest Atlantic – Projected ocean warming (2xCO₂)



Northwest Atlantic – CM2.6 vs ROMS



Saba et al. 2016



Alexander et al. 2019



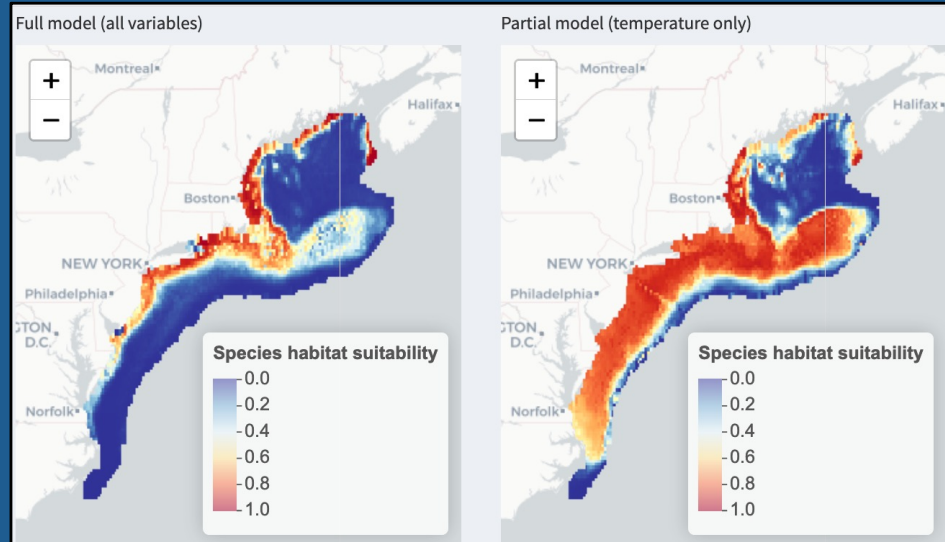
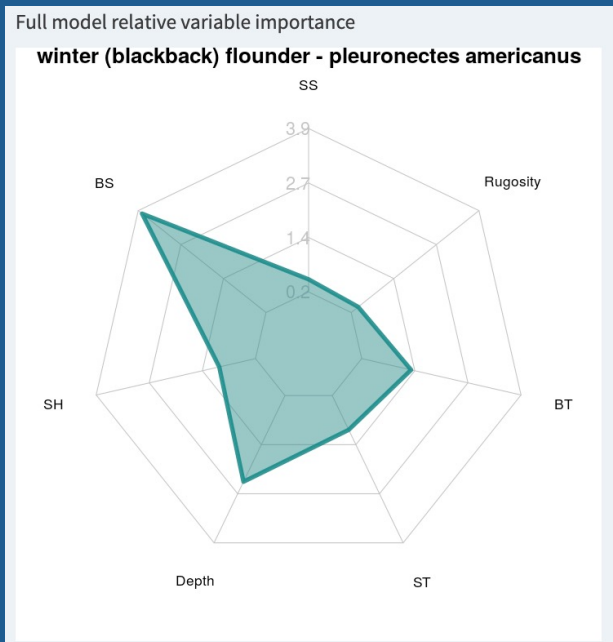
Projected impacts of ocean warming

PRIMARY RESEARCH ARTICLE

Global Change Biology WILEY

Projecting marine species range shifts from only temperature can mask climate vulnerability

Jennifer McHenry¹  | Heather Welch^{2,3}  | Sarah E. Lester¹  | Vincent Saba⁴ 



McHenry et al. 2019, Glob. Ch. Bio.

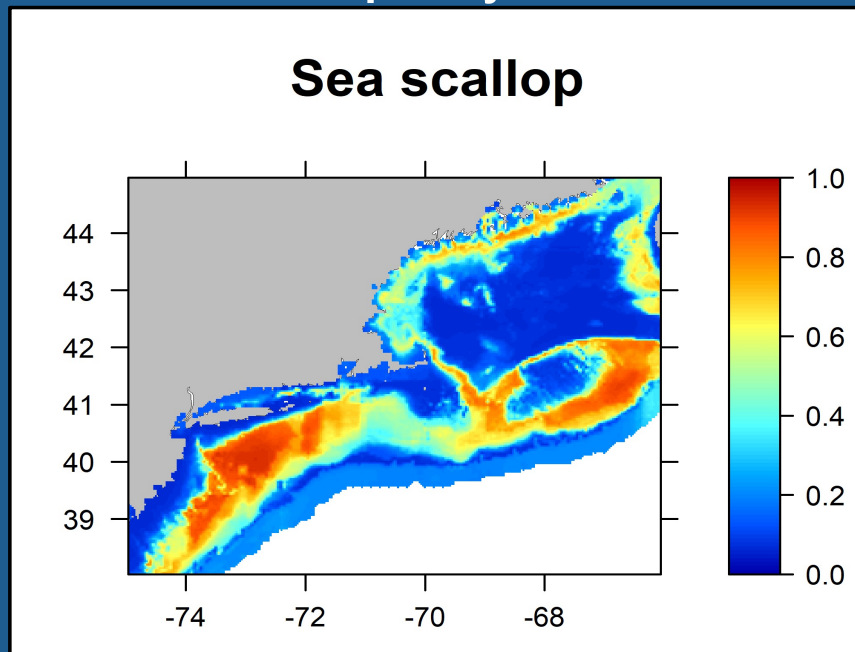


https://heatherwelch.shinyapps.io/beyond_temperature/

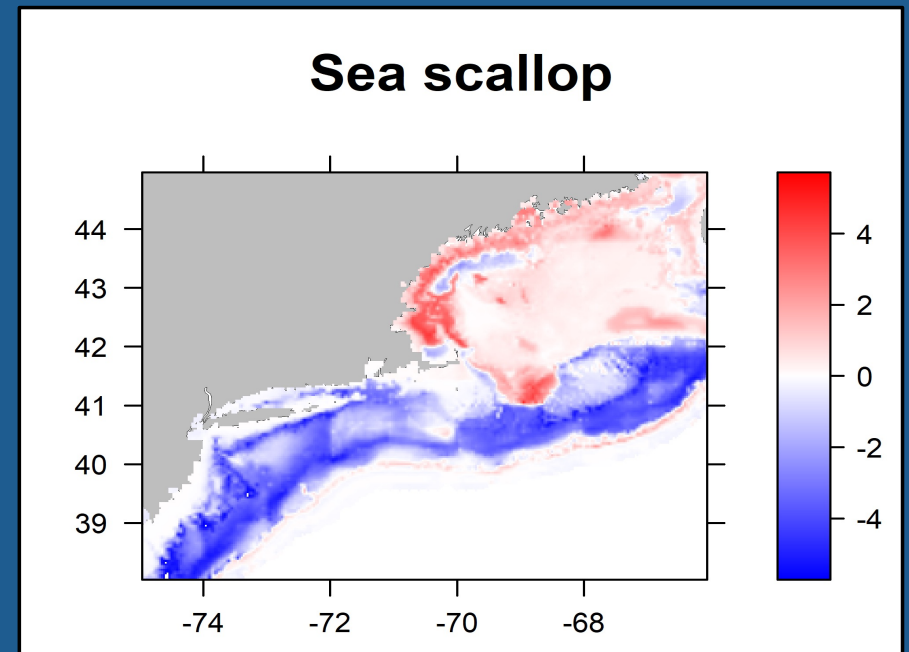
High-resolution ensemble habitat modeling of lobster and sea scallop

Kisei R. Tanaka, Vincent S. Saba, et al.
Diversity and Distributions, 2020

Contemporary habitat



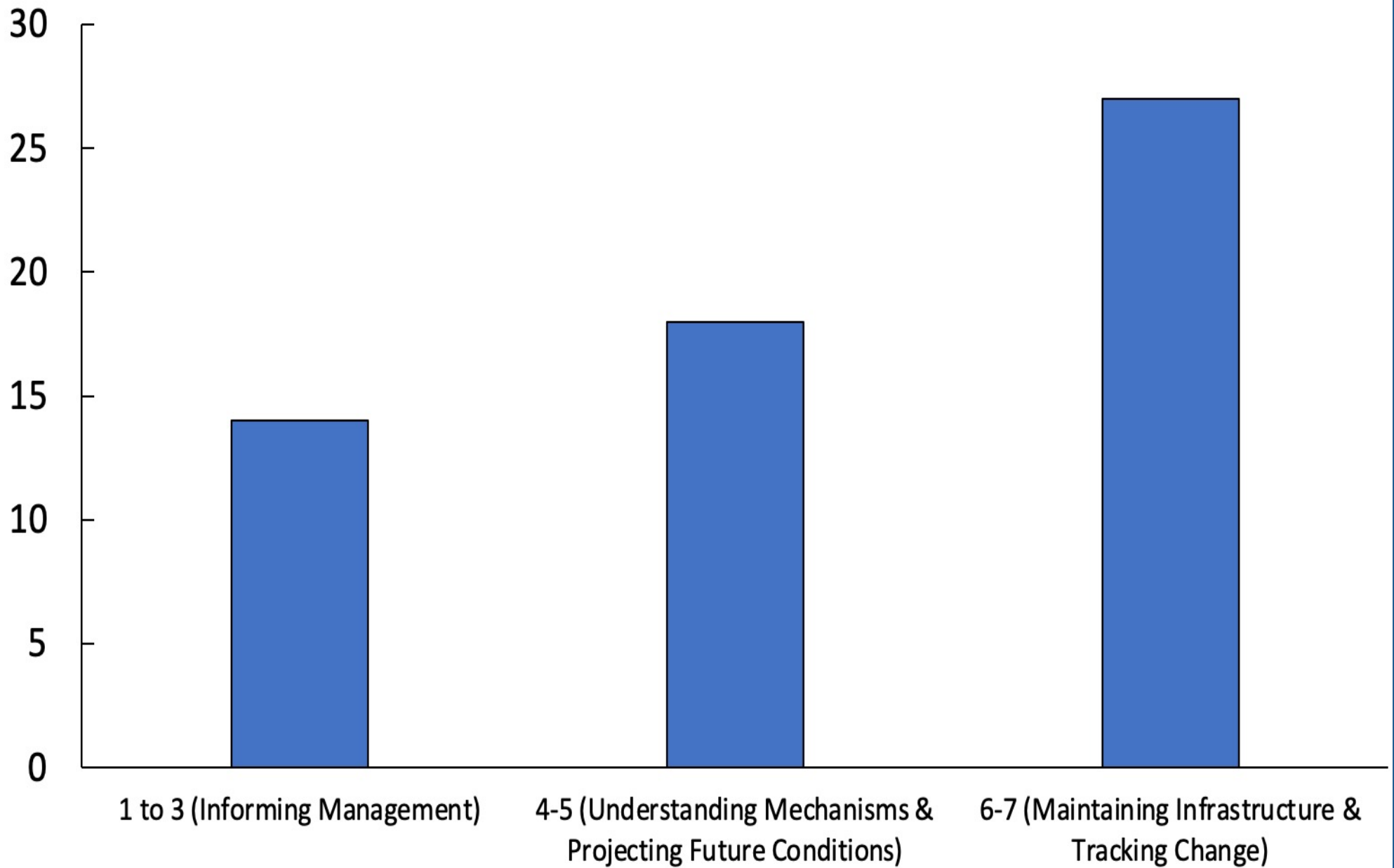
Future habitat GFDL's CM2.6 2xCO2

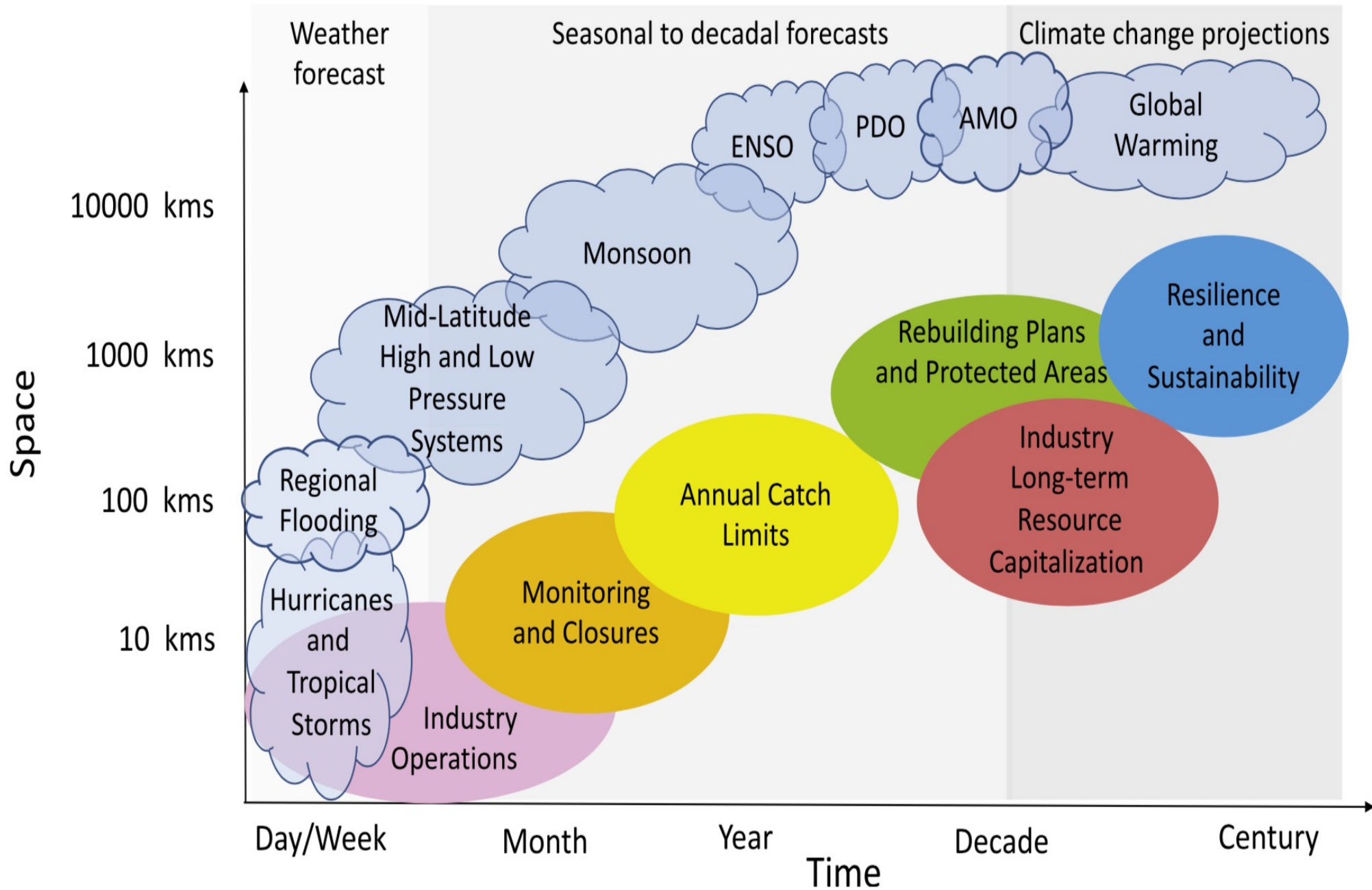


- 1) Considers variables beyond temperature
- 2) Uses BIOMOD2 ensemble habitat modeling.



Number of NERAP Publications 2016-2020





What's needed to achieve climate-ready fisheries and protected species management?

- 1) More studies that identify mechanistic relationships between stock assessment variables (recruitment, growth, natural mortality) and climate/ocean variables (temperature, circulation, pH, productivity).
- 2) More skillful ocean forecasts that operate on the time-scale of fisheries and protected species management (monthly, seasonal, annual).
- 3) A more unified NOAA ocean modeling system that produces high-resolution, regional ocean hindcasts, forecasts, and projections.
- 4) Communities of Practice: Linking resource managers and scientists to communicate best available science regarding climate information.
- 5) Cross-NOAA regional teams to support the production & application of state-of-the-art ocean models.





NOAA Climate and Fisheries Initiative

Steering Committee White Paper



March 2020

Four Actions

- 1) Enhance the utility of existing climate information.
- 2) Advance NOAA's regional modeling system.
- 3) Establish regional teams and communities of practice.
- 4) Fuel innovation and applications through targeted research.



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**FISHERIES AND CLIMATE
DECISION SUPPORT
SYSTEMS (FACSS)**
(ACTION 4)

**REGIONAL OCEAN
MODELING TEAMS**
(ACTIONS 1,3)

**REGIONAL TEAM
SUPPORT**
(ACTIONS 1-3)

**OCEAN MODEL
DEVELOPMENT**
(ACTIONS 1,2)



In Two Years

- **Communities of practice** link resource managers, researchers, & forecasters to ensure they have the best available information for resource management.
- **The new regional MOM6 ocean modeling system** is beginning to produce pilot regional climate & ocean hindcasts, predictions, & projections for coordinated assessment & evaluation.
- **Regional teams** are helping guide/test regional MOM6 products & research results.
- **NOAA has launched** new research & modeling efforts improving understanding of climate impacts on biological resources & best management strategies for reducing risks & increasing resilience.
- **NOAA is leveraging** past & future investments to make data & information available for use.
- **New investments** are driven by stakeholder needs for information & applications.



In Five Years

- **Regional MOM6 ocean modeling system is operational** & delivers next-gen hindcasts, nowcasts, forecasts, & projections for management of marine & coastal resources.
- **Cross-NOAA regional teams** support the production & application of regional MOM6 products and research results.
- **NOAA investments in research & modeling** are improving understanding of climate impacts & identifying best management strategies to reduce risks & increase resilience.
- **NOAA portals** provide easy access to climate-related information for multiple applications.
- **NOAA is leveraging** past & future investments to increase data & information availability.
- **Decision-makers** have, and respond to, robust early warnings & longer-term projections of changing climate/ocean conditions including marine heatwaves, hypoxic events, harmful algal blooms, & acidification.

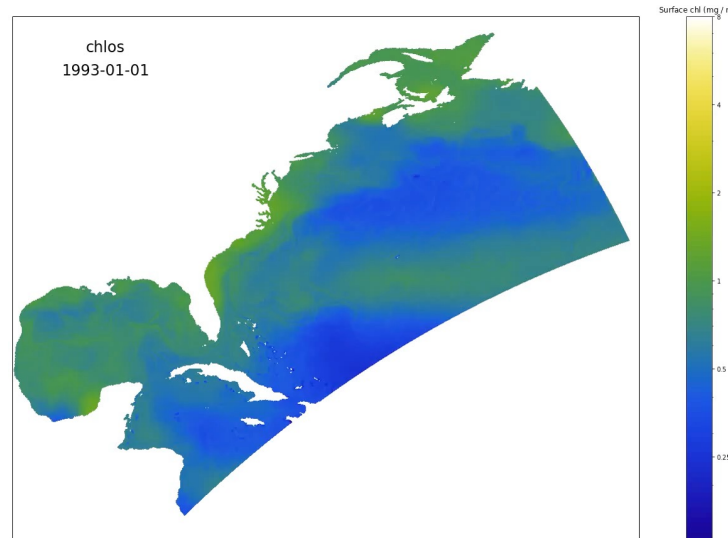
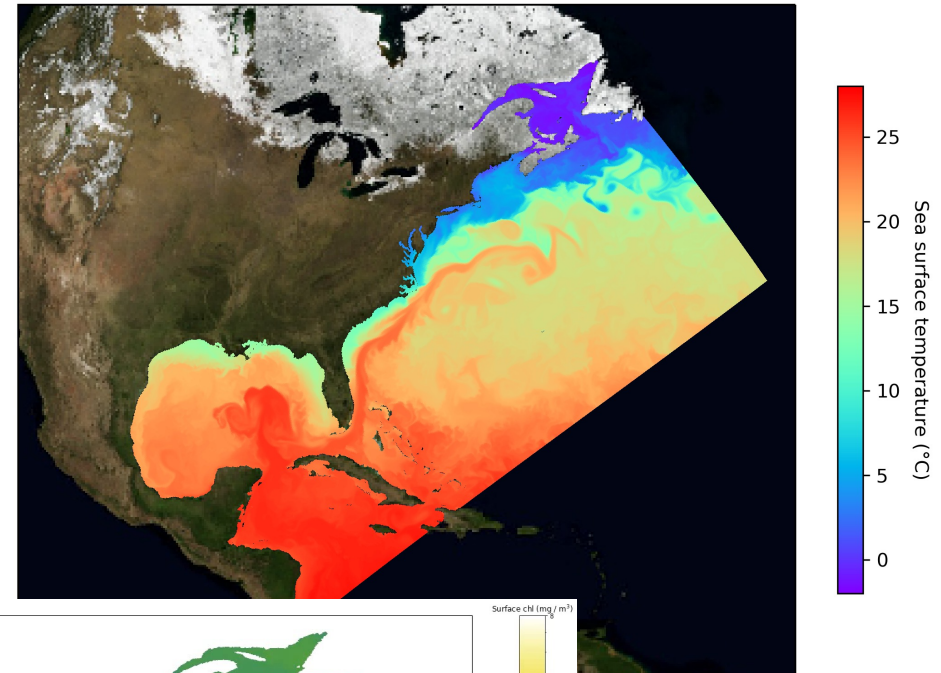




NOAA Climate and Fisheries Initiative

Steering Committee White Paper

- Regional hindcasts, forecasts, and projections using NOAA GFDL's state-of-the-art ocean model MOM6. Physics and biogeochemistry.

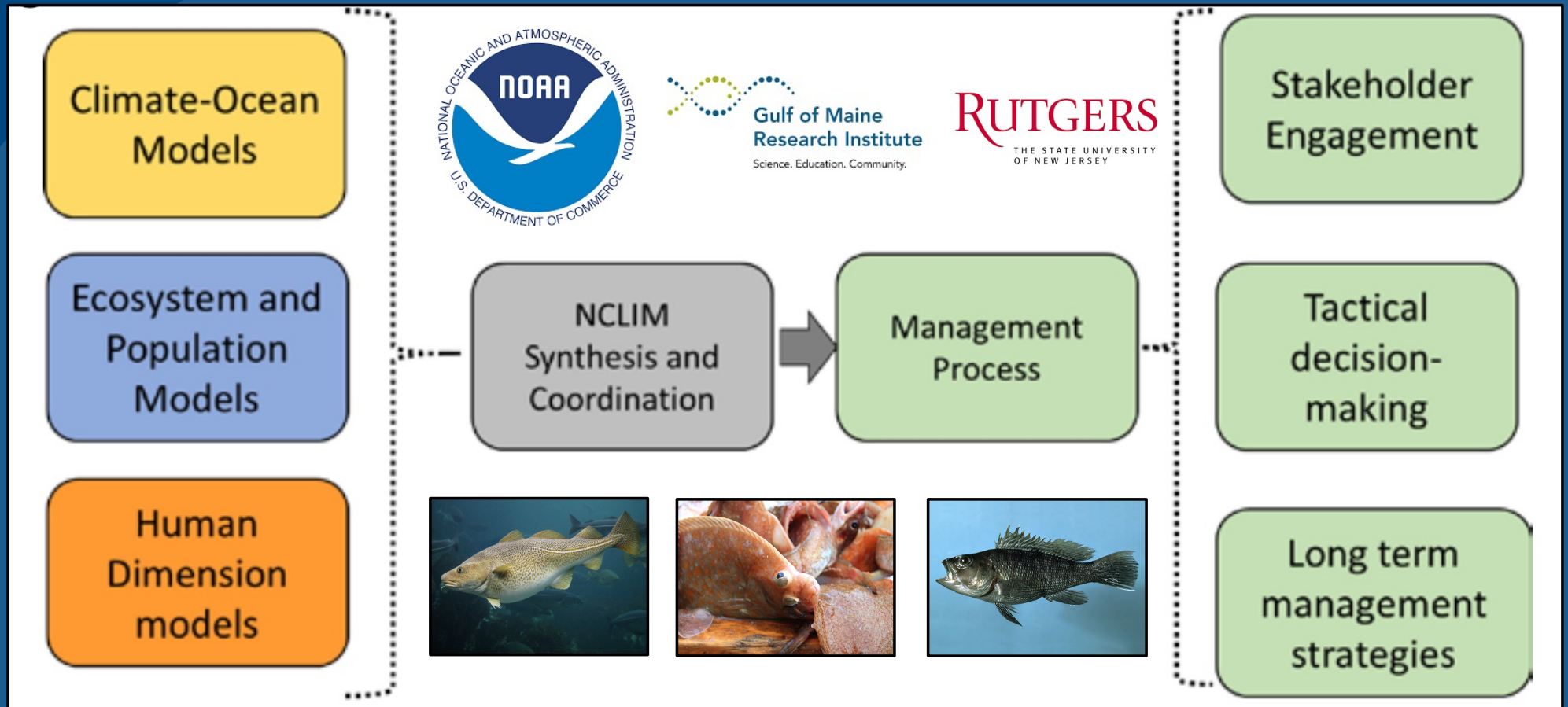


Ross et al. in prep.

Animation and figure courtesy of Andrew Ross (GFDL).



Northeast Climate Integrated Modeling (NCLIM)



U.S. Northeast Climate Fisheries Seminar Series

Date	Speaker	Title
1/28/21	Vincent Saba (NEFSC)	NOAA's high-resolution global climate model utilization in marine species distribution modeling.
2/25/21	Tori Kentner & Chris Haak (NEFSC)	Use of joint and single species distribution models for the Northeast Regional Habitat Assessment (NRHA).
3/25/21	Zhuomin Chen (WHOI)	Seasonal Prediction of Bottom Temperature on the Northeast U.S. Continental Shelf.
4/29/21	Gavin Fay (SMAST)	Integrating responses to environmental drivers of system change within ecosystem-based fishery management procedures.
5/27/21	Jaime Palter (URI GSO)	Circulation changes at the Tail of the Grand Banks cause predictable environmental change on the Northeast US and Canadian Shelf.
6/24/21	Brian Stock & Tim Miller (NEFSC)	Temperature-linked assessments for winter flounder and Gulf of Maine cod.
7/29/21	Alexa Fredston (Rutgers)	Understanding and forecasting species range dynamics in the oceans.
8/26/21	Samantha Siedlecki & Kelly McGarry (UCONN)	Regional drivers of interannual and spatial variability of OA variables on the NE shelf.
9/30/21	Shannon Meseck (NEFSC)	Ocean acidification effects on Eastern oysters, surfclams, and Atlantic sea scallops: Commonalities and differences?
10/28/21	Mackenzie Mazur & Lisa Kerr (GMRI)	Evaluating the performance of Northeast Groundfish Fisheries Management in a Changing Ocean.
11/18/21	Chris Chambers (NEFSC)	Biological consequences of a changing climate on the pre-recruit life stages of NE US finfish: effects of CO2 and thermal environments.
12/16/21	Andrew Allyn & Kathy Mills (GMRI)	Shifting species and climate adaptation pathways for Northeast U. S. fishing communities.

