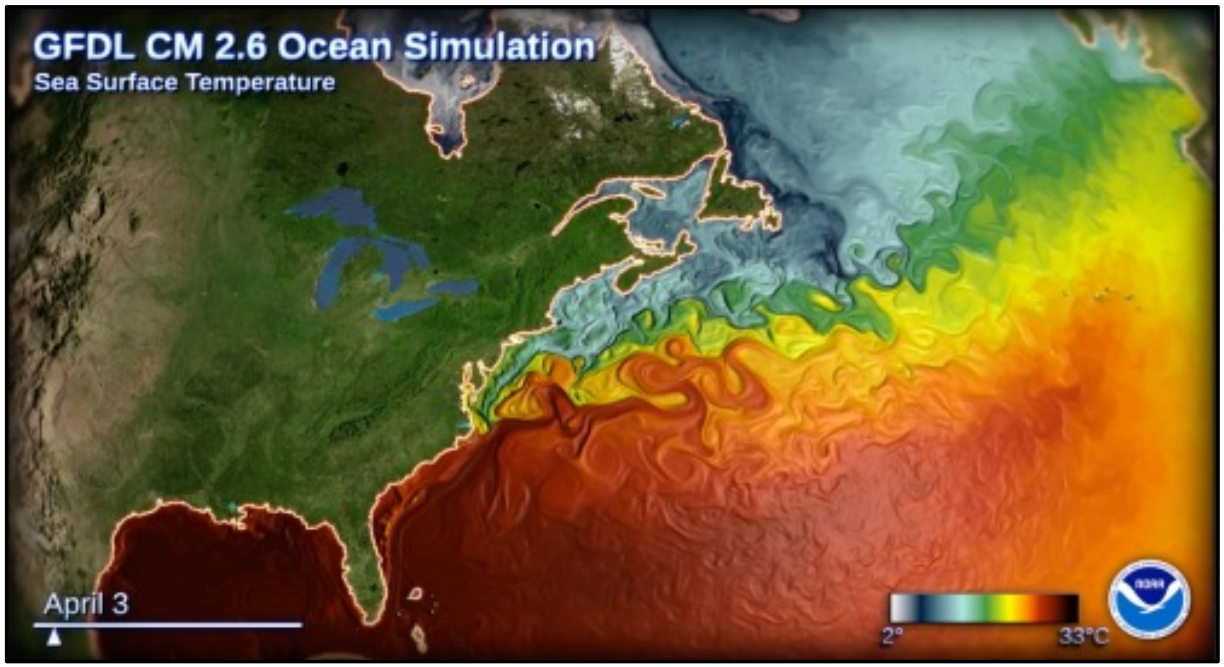
# Climate Science at the Northeast Fisheries Science Center

Vincent Saba

NOAA Northeast Fisheries Science Center / Geophysical Fluid Dynamics Laboratory



# Presentation Outline

1) Observed change in the U.S. Northeast Shelf.

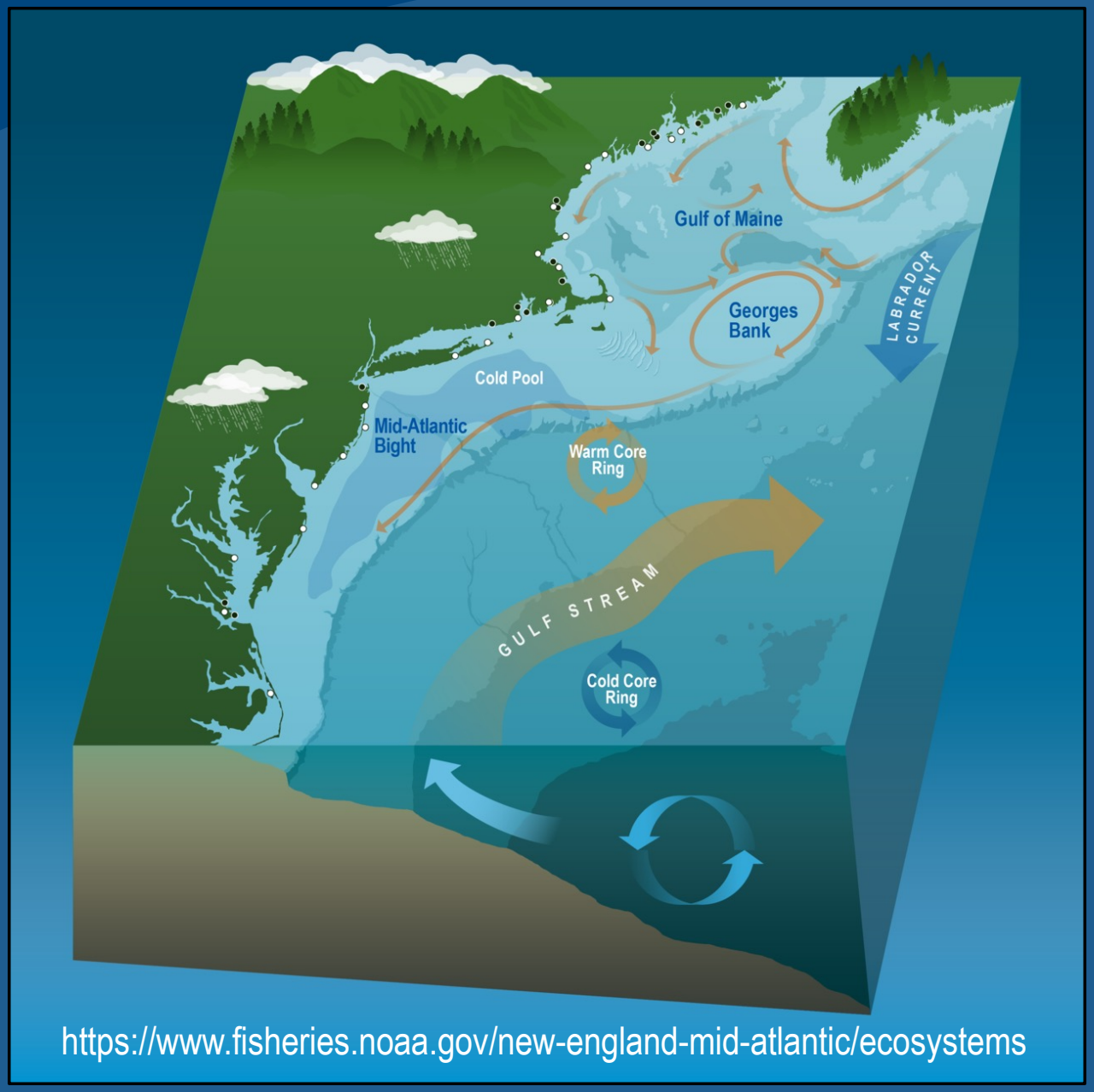
2) National Climate Science Strategy and Northeast Regional Action Plan (NERAP).

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.

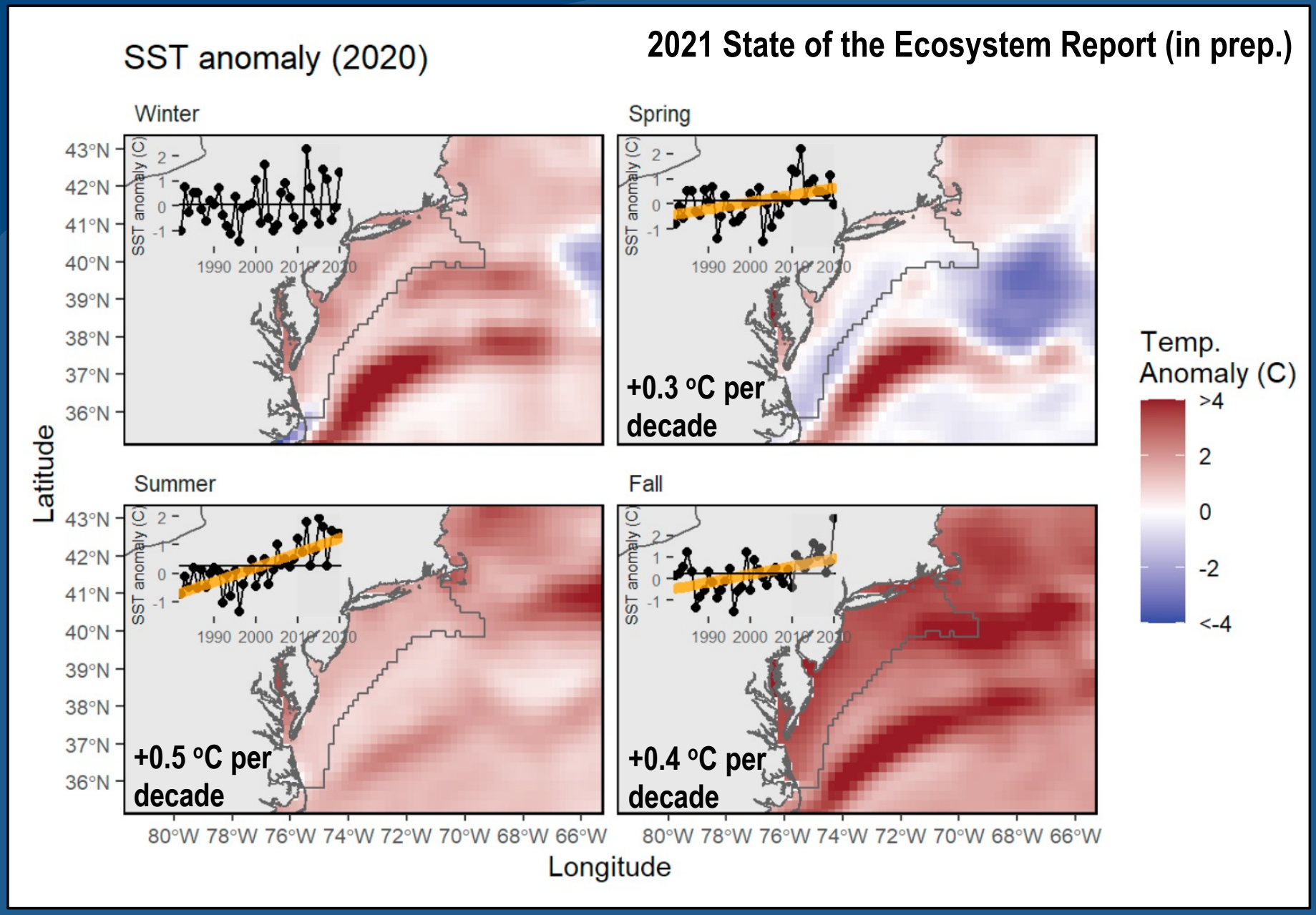
5) NOAA Climate and Fisheries Initiative.

# U.S. Northeast Shelf

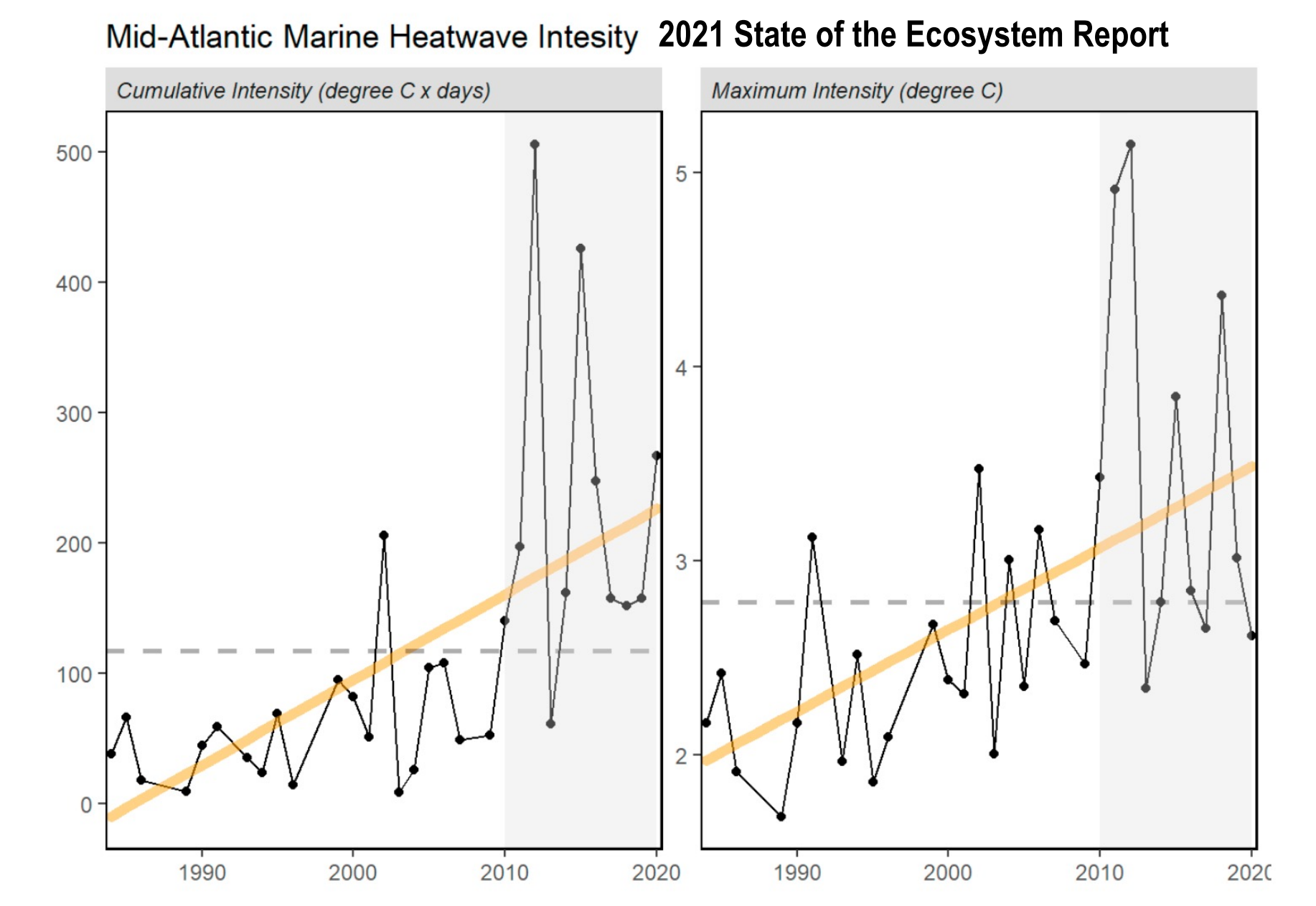



https://www.fisheries.noaa.gov/new-england-mid-atlantic/ecosystems

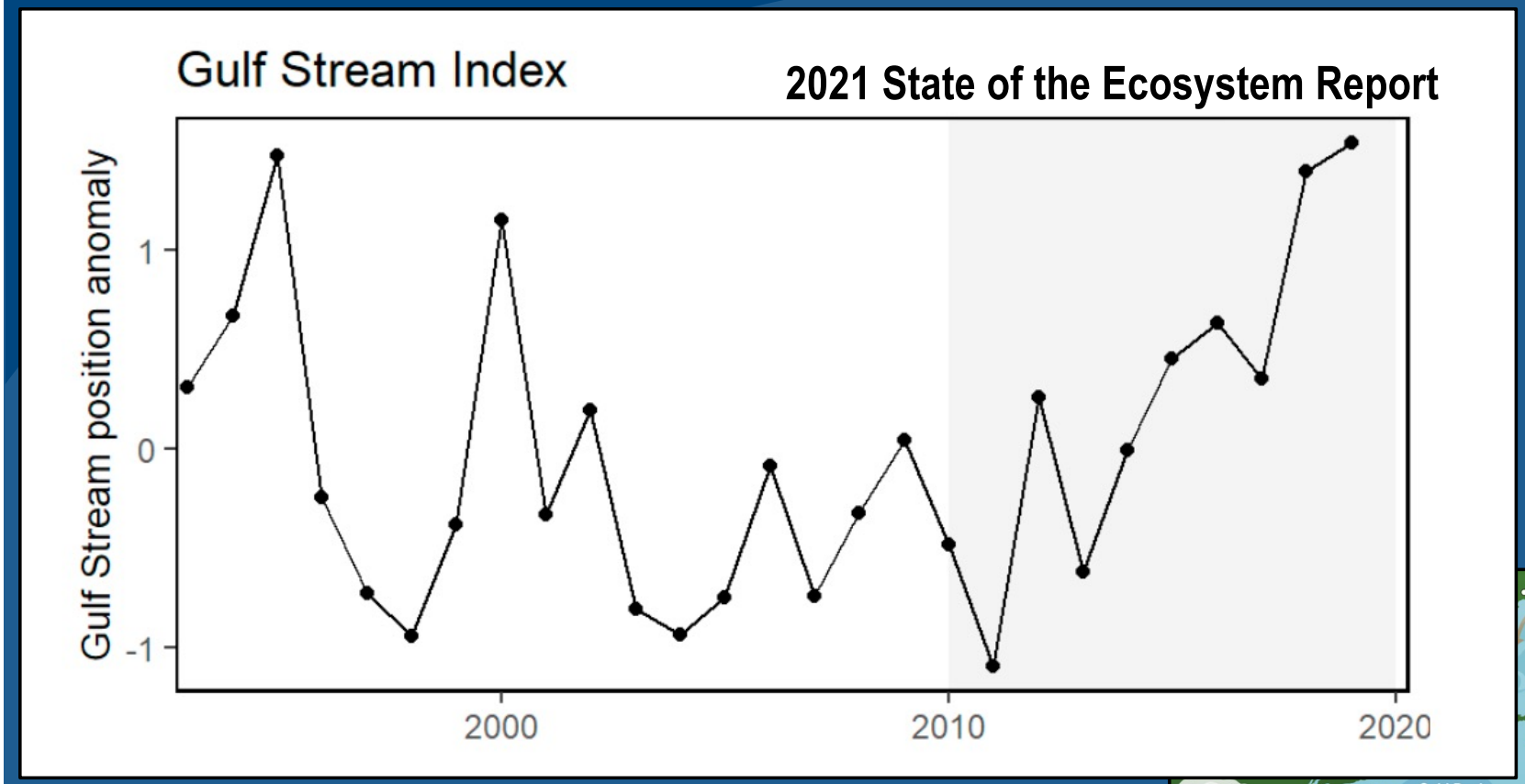
# U.S. Northeast Shelf - Warming

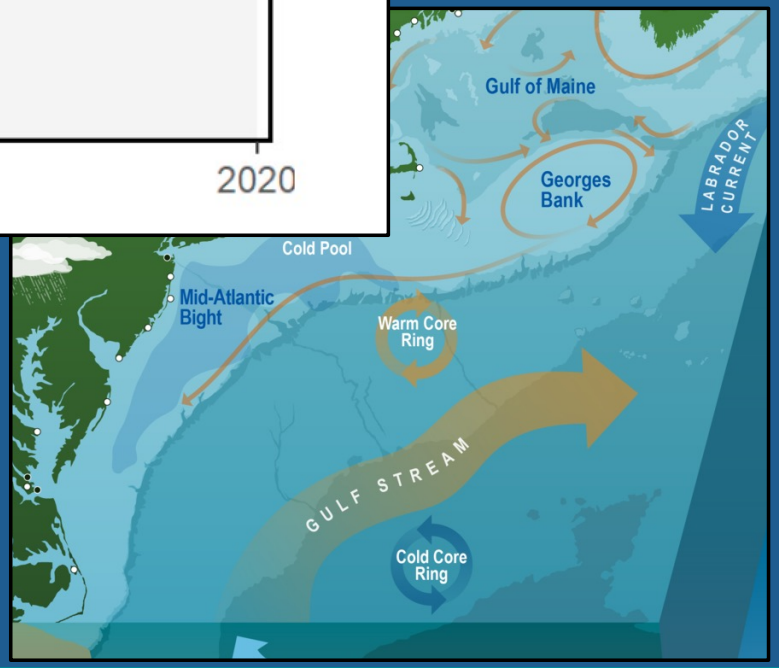


# U.S. Northeast Shelf – Marine Heatwaves

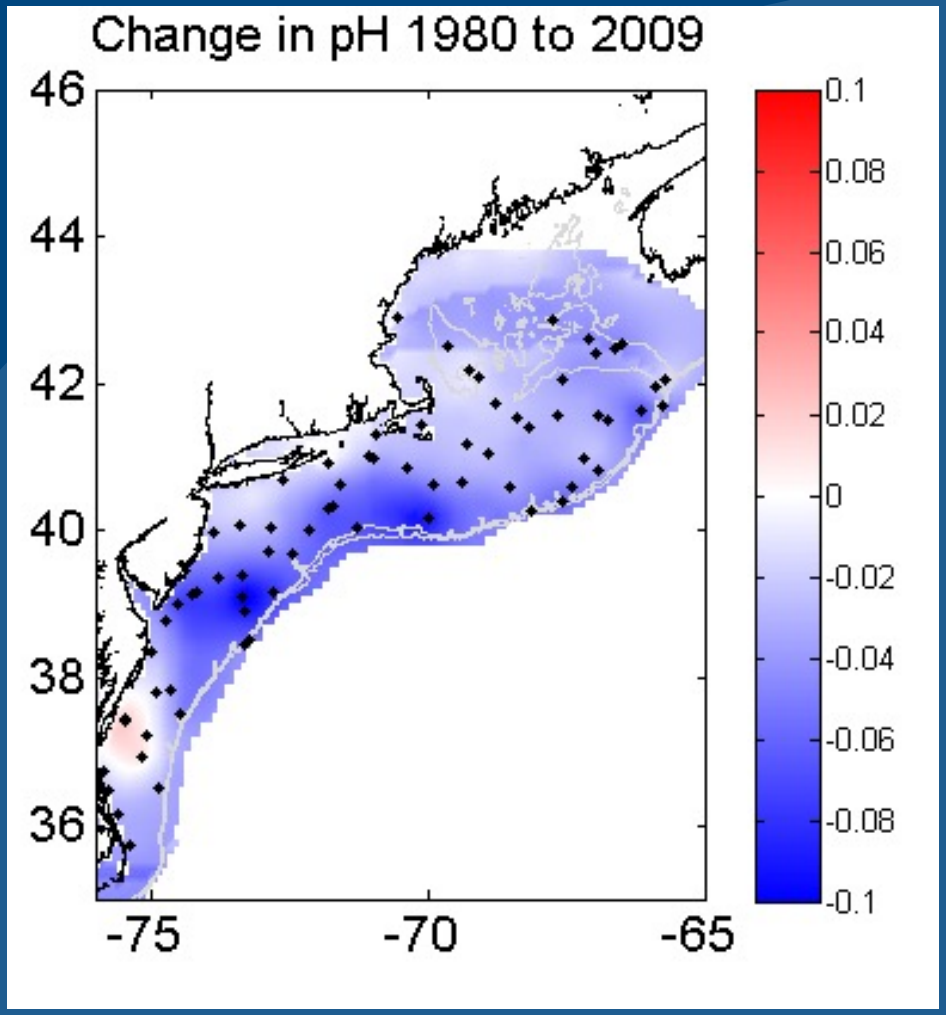


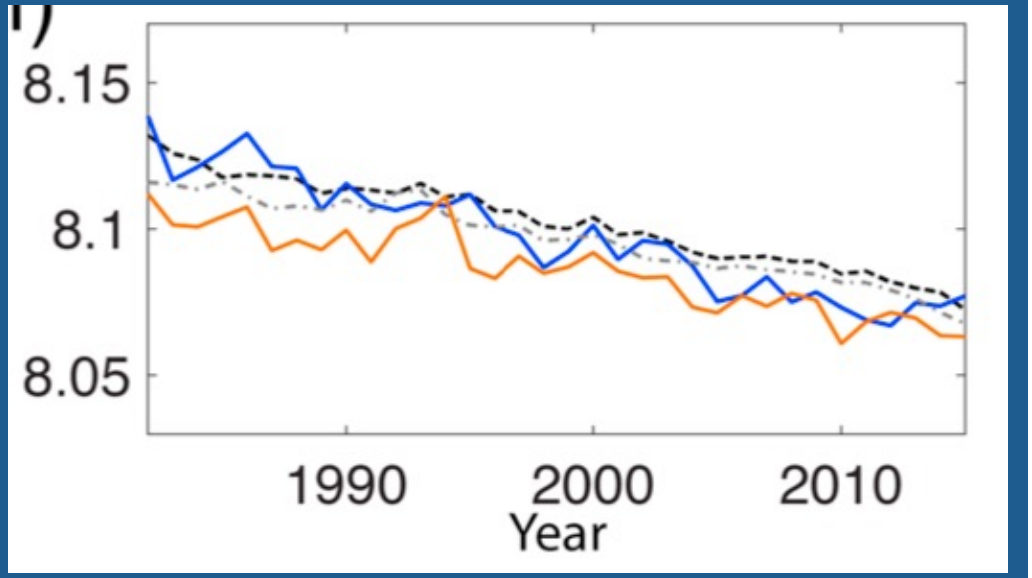
# Gulf Stream Index



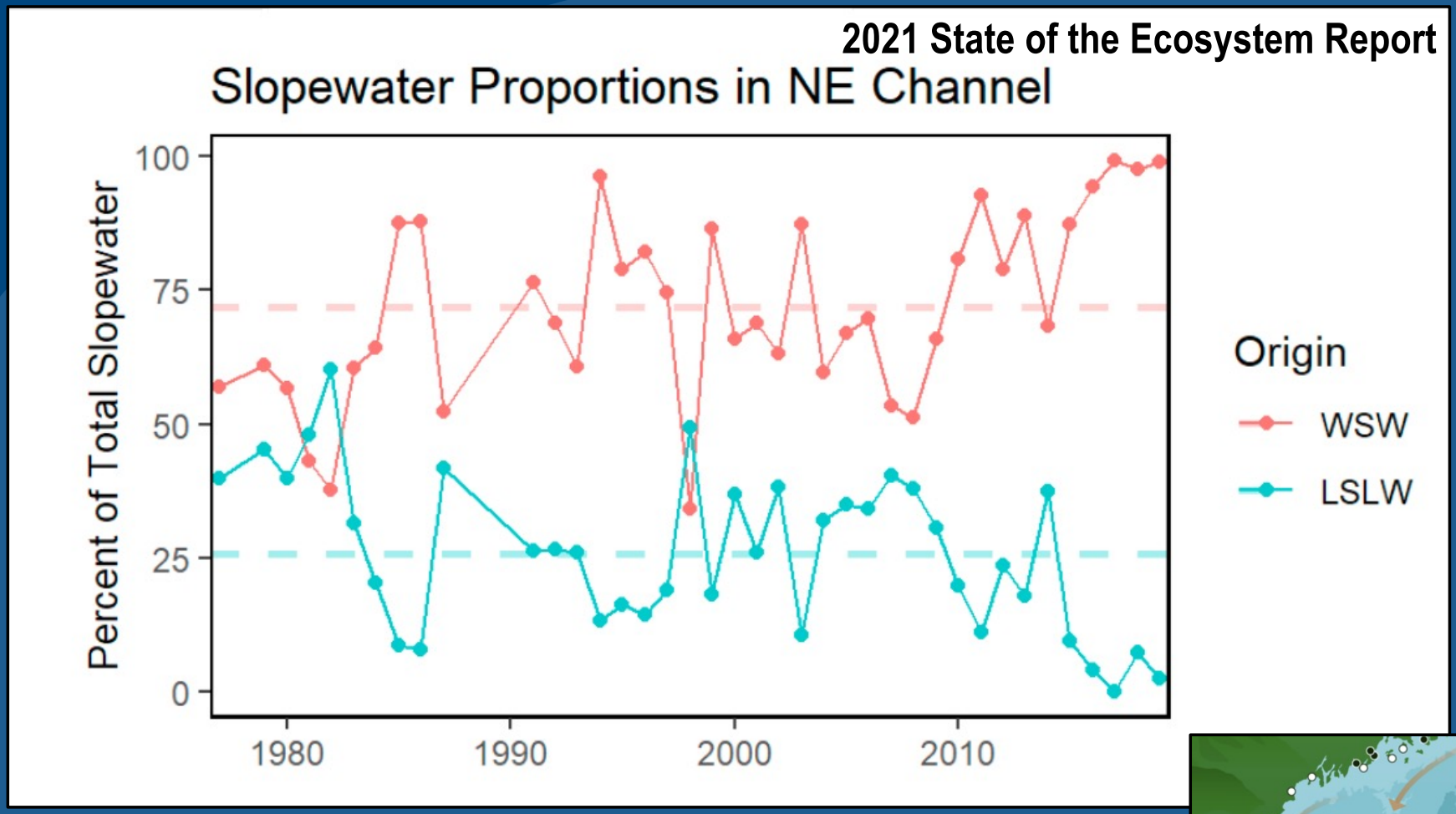
# Surface pH – U.S. NES

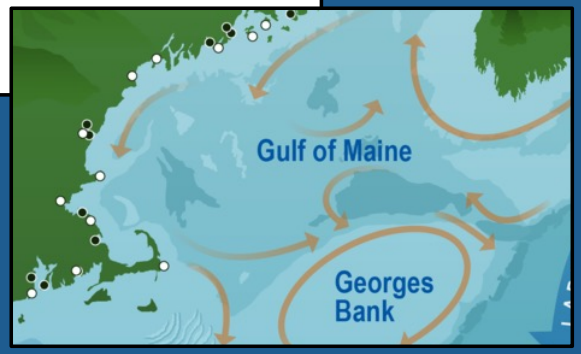


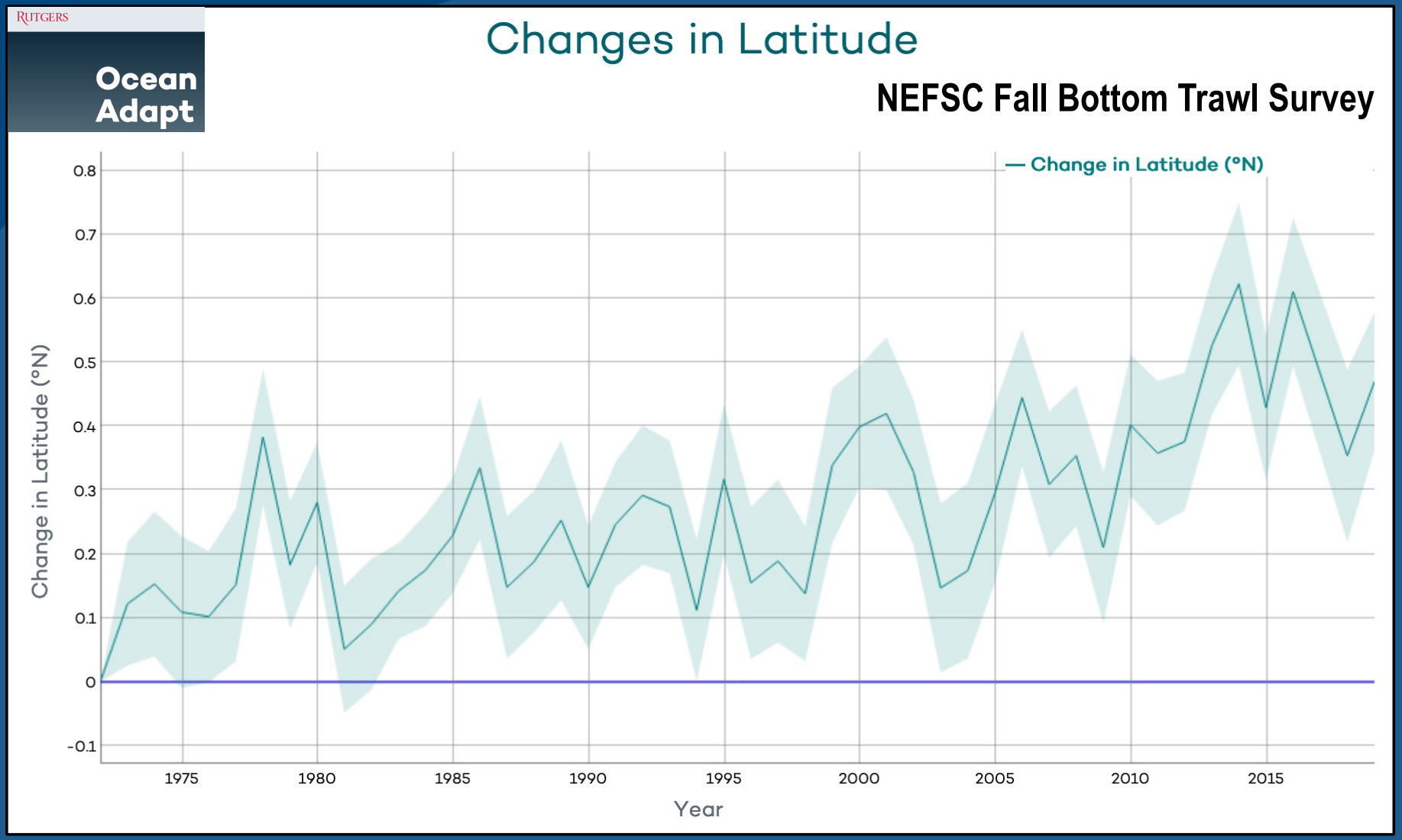

Xu et al. 2020

# Regional Ocean Circulation



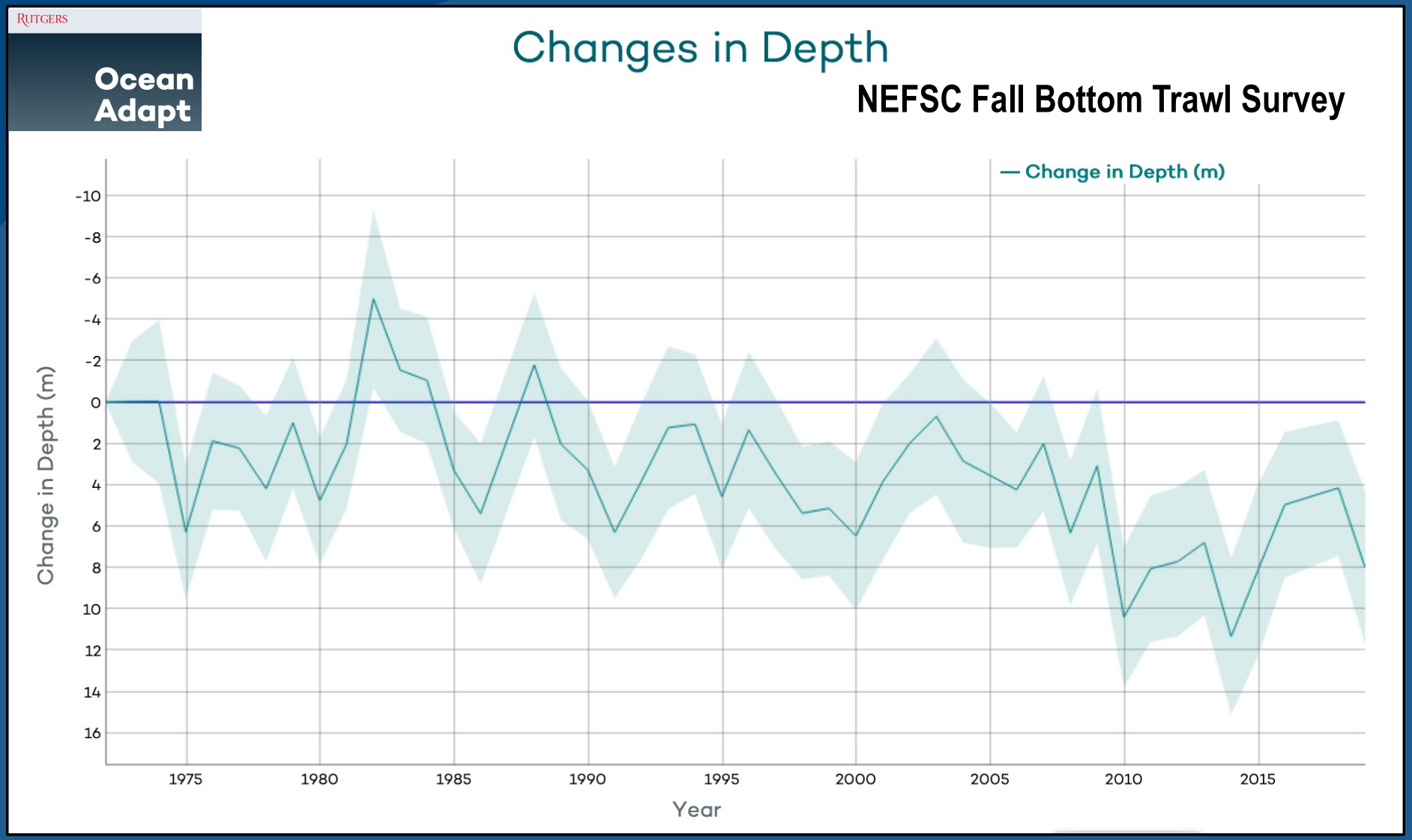
# Warming ocean, fish on the move

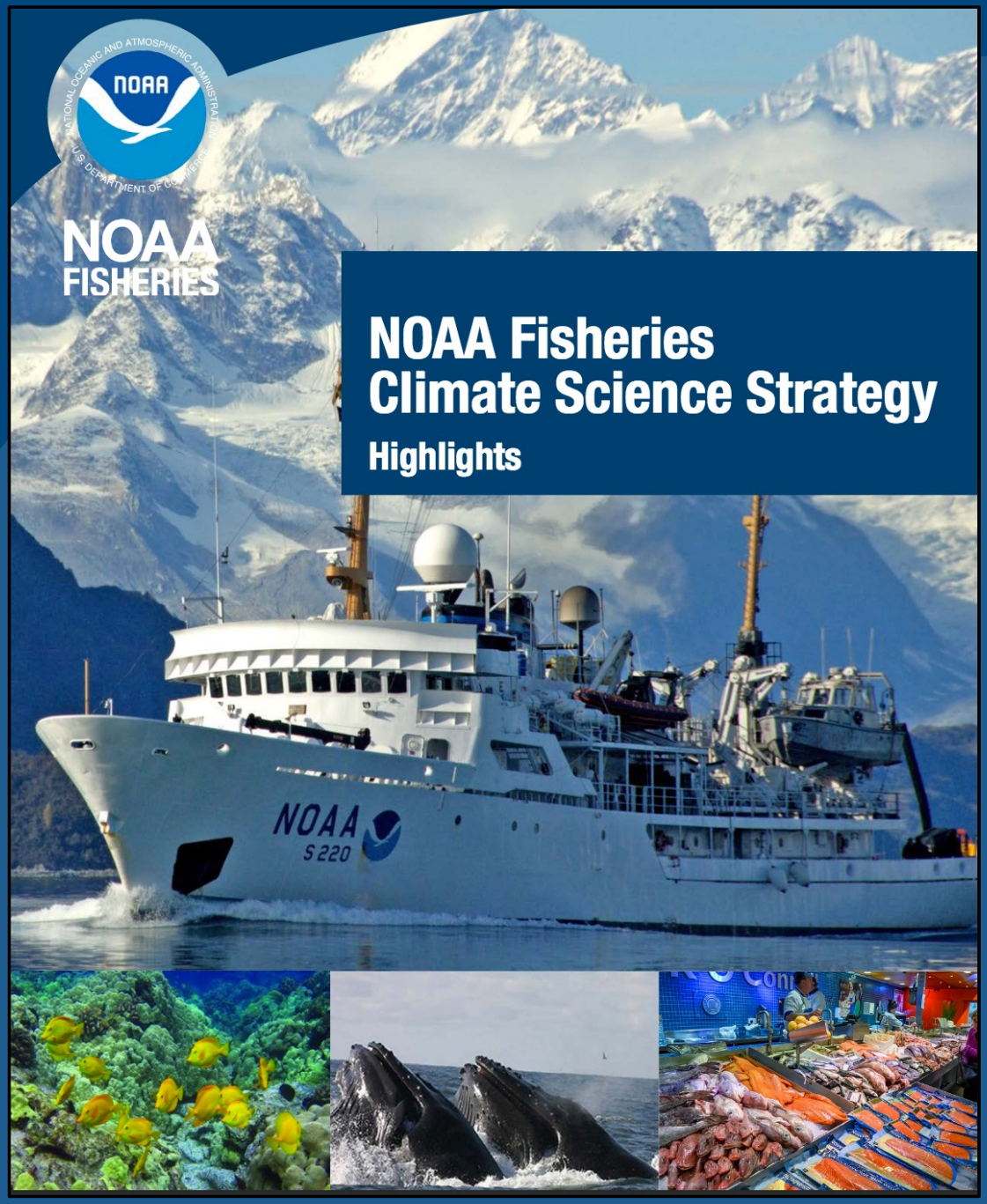


# Warming ocean, fish on the move

RUTGERS

Ocean Adapt

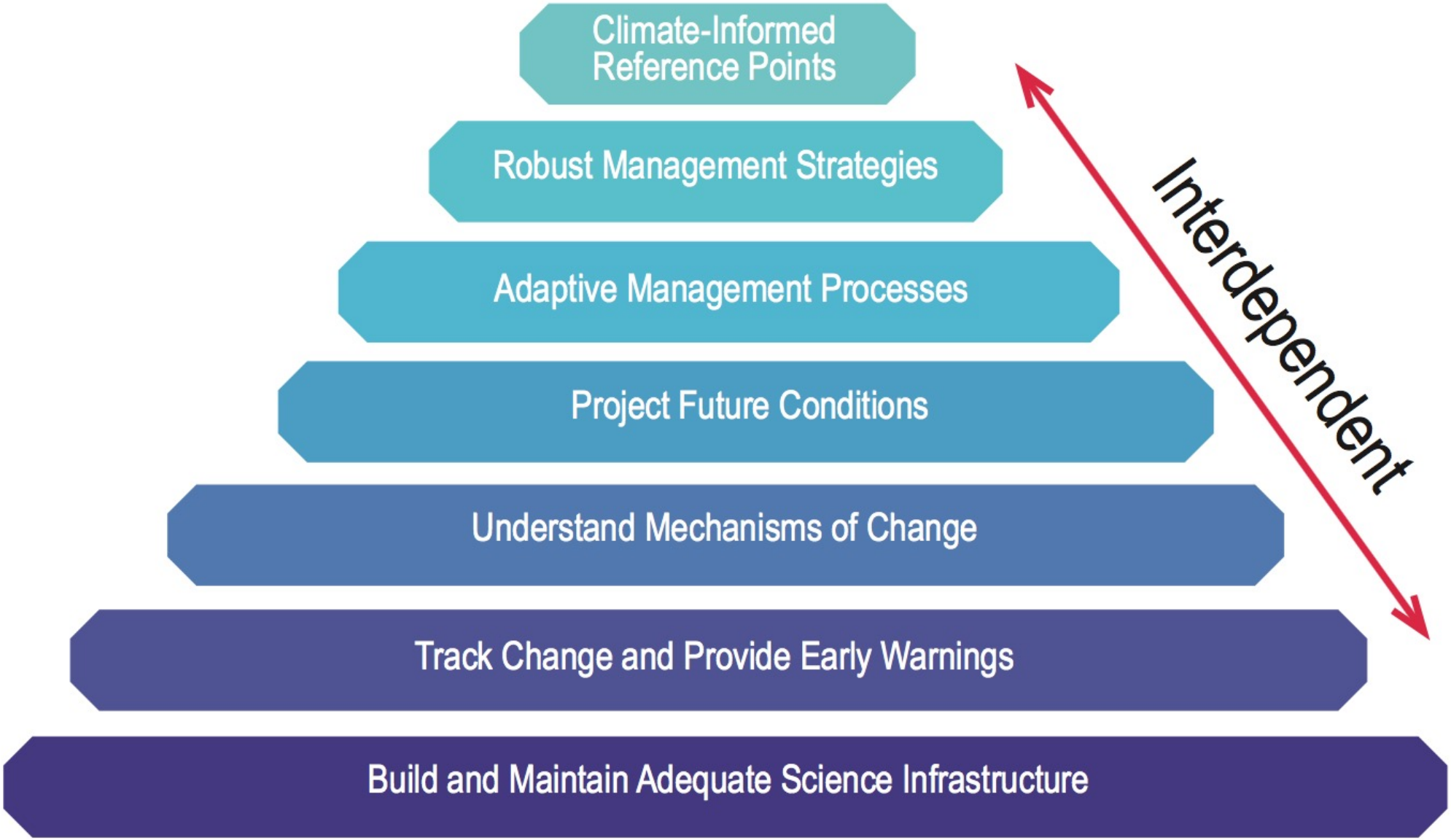


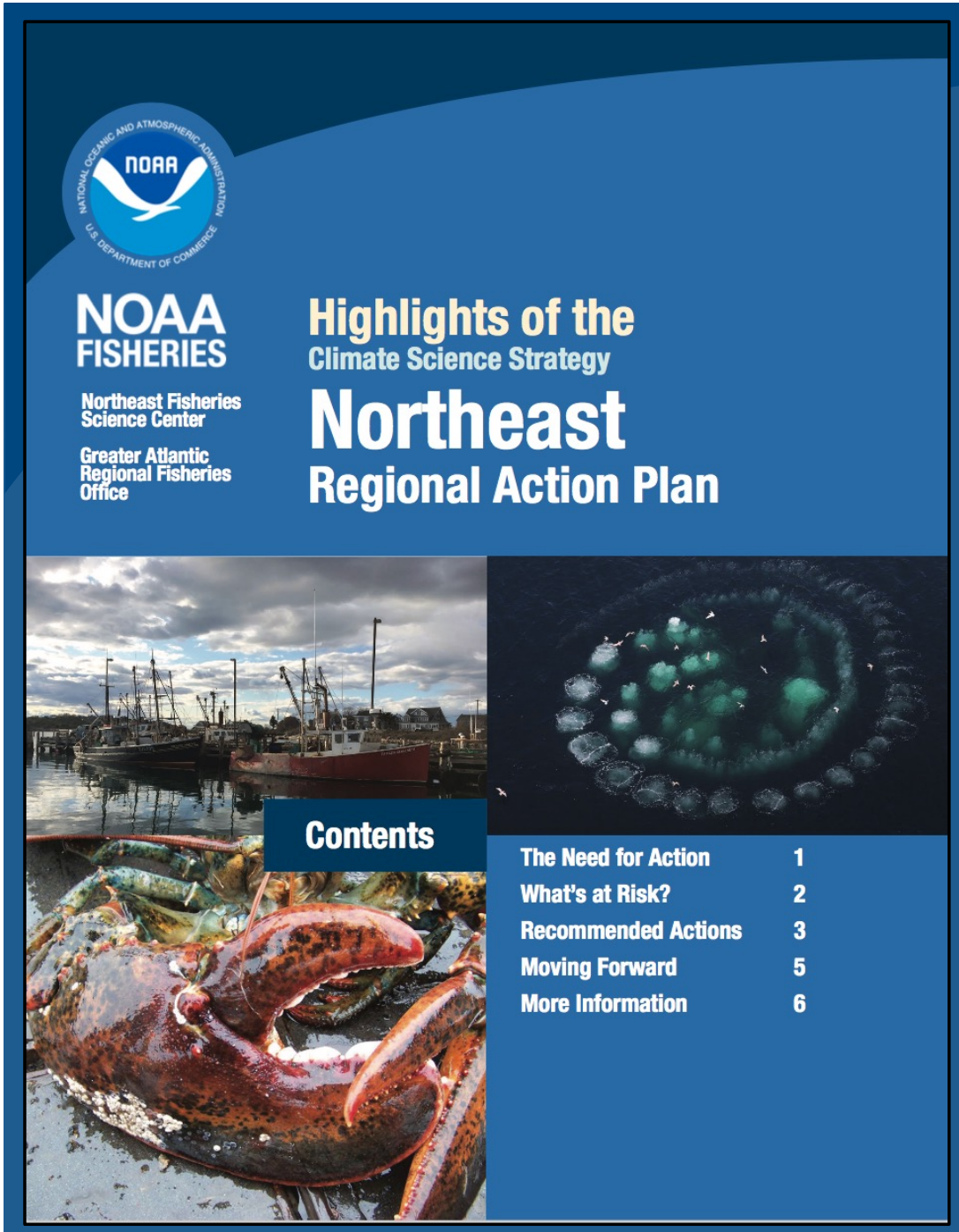



*"The Strategy is part of a proactive approach to increase the production, delivery and use of climate-related information to fulfill NOAA Fisheries mandates in a changing climate. Implementing this Strategy will help reduce impacts and increase the resilience of our valuable living marine resources,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

*- Eileen Sobeck*
*Former Fisheries*
*Assistant Administrator*

# Climate Science Strategy Objectives






*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

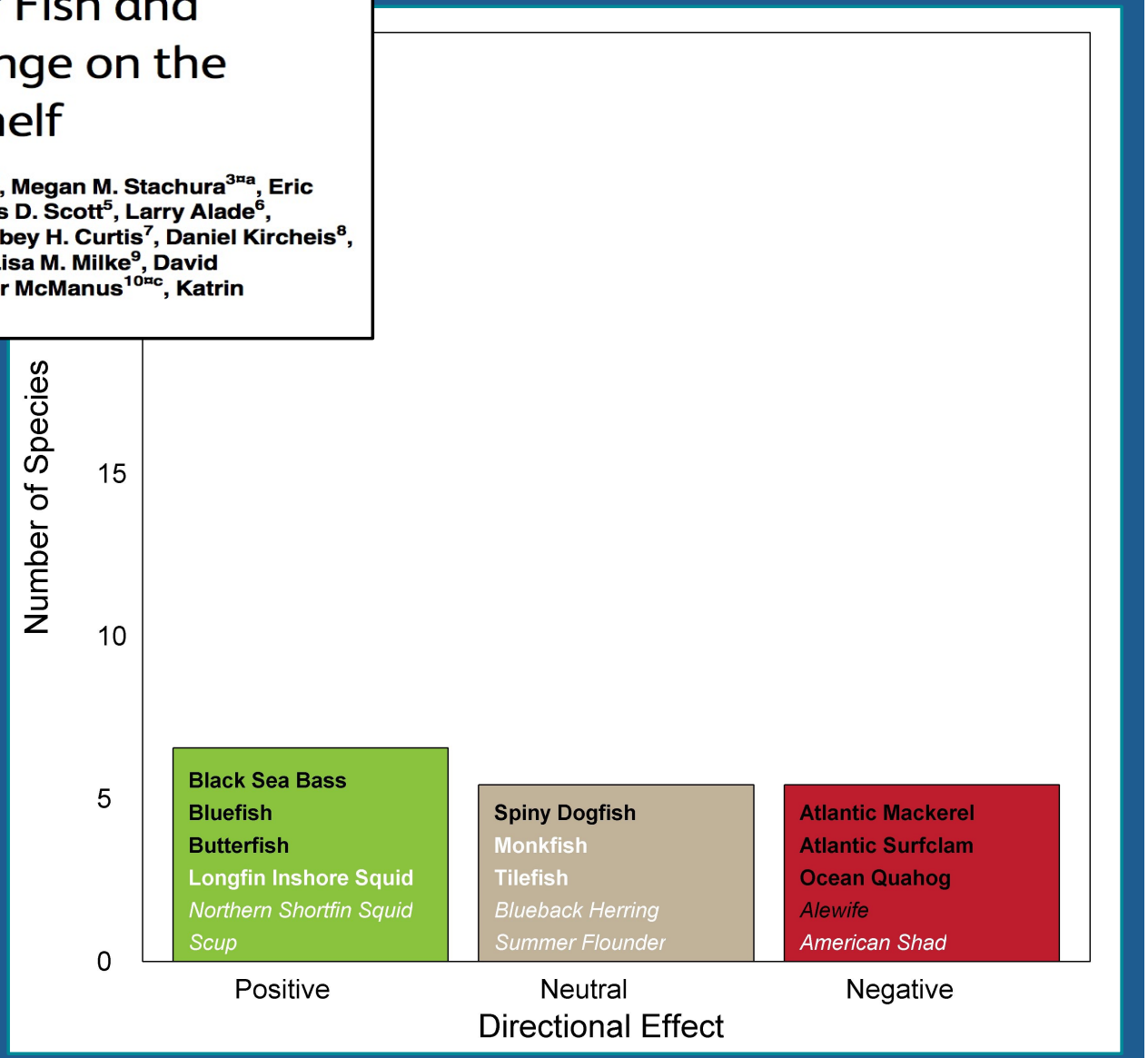
RESEARCH ARTICLE

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

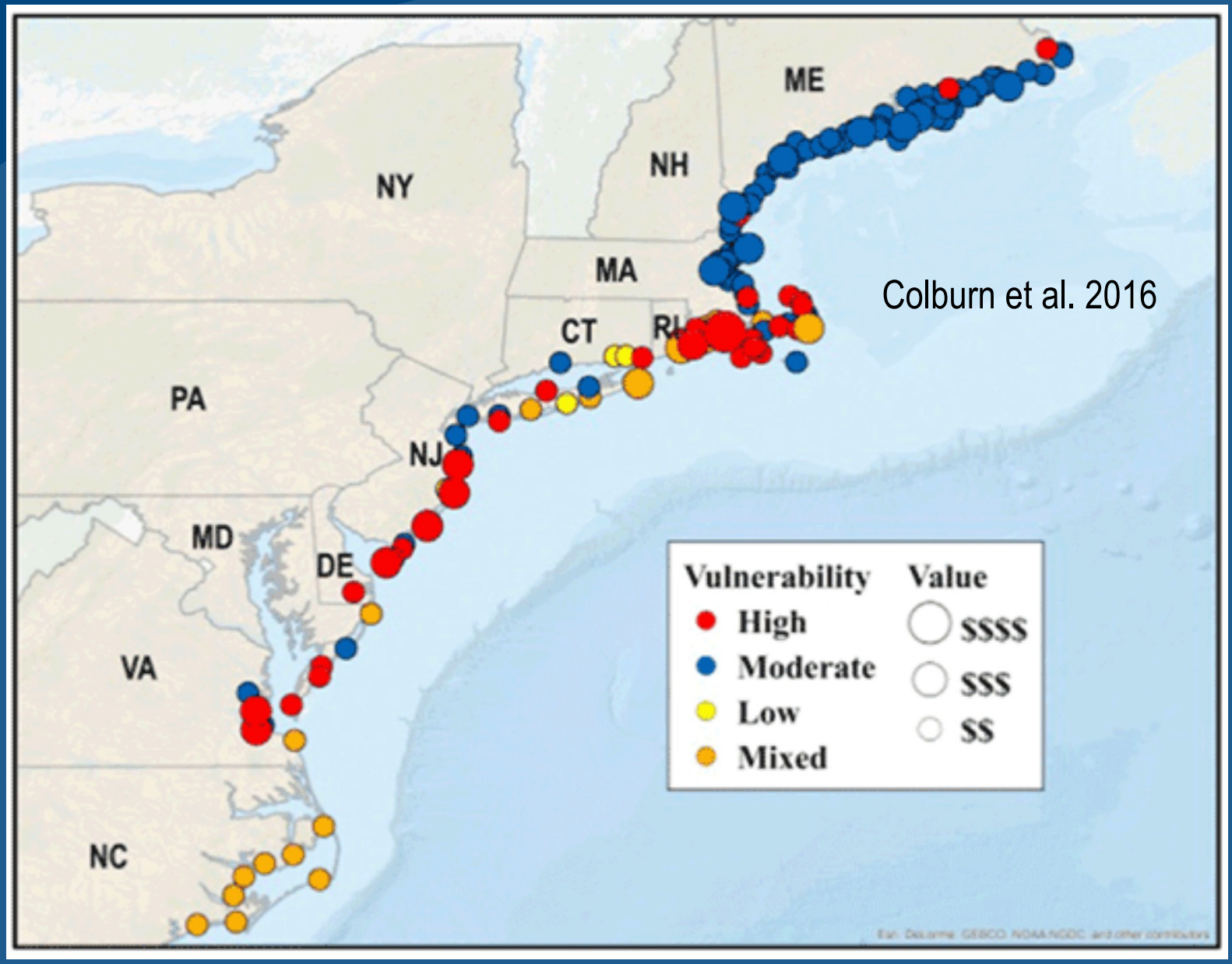
Jonathan A. Hare[1]*, Wendy E. Morrison[2], Mark W. Nelson[2], Megan M. Stachura[3¤a], Eric J. Teeters[2], Roger B. Griffis[4], Michael A. Alexander[5], James D. Scott[5], Larry Alade[6], Richard J. Bell[1¤b], Antonie S. Chute[6], Kiersten L. Curti[6], Tobey H. Curtis[7], Daniel Kircheis[8], John F. Kocik[8], Sean M. Lucey[6], Camilla T. McCandless[1], Lisa M. Milke[9], David E. Richardson[1], Eric Robillard[6], Harvey J. Walsh[1], M. Conor McManus[10¤c], Katrin E. Marancik[10], Carolyn A. Griswold[1]

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

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



# Climate vulnerability




Colburn et al. 2016

# 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

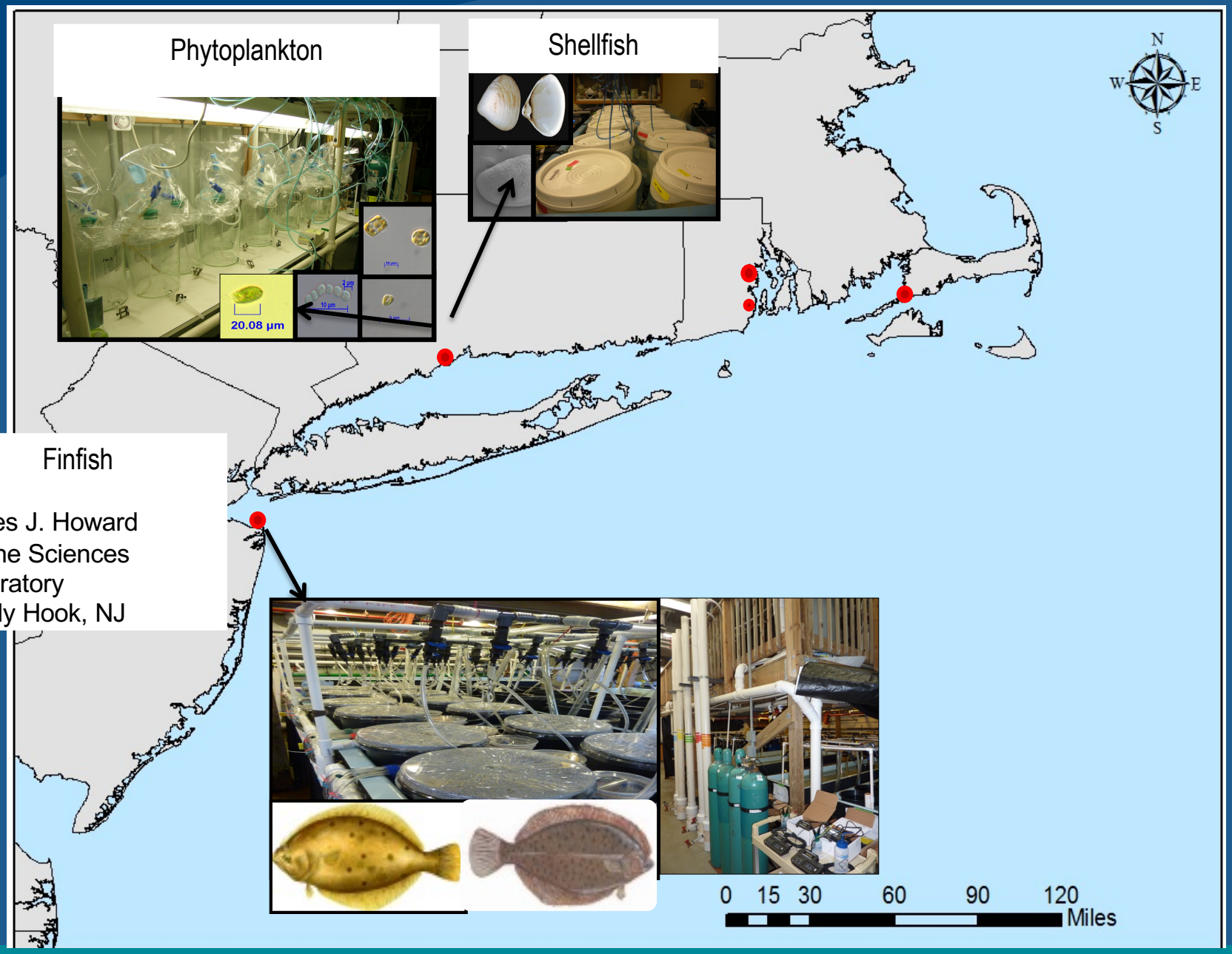

## Pilot Purpose

- 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**

**Comparison of multiple approaches to calculate time-varying biological reference points in climate-linked population-dynamics models**

Cecilia A. O'Leary [1]*, James T. Thorson[2], Timothy J. Miller[3] and Janet A. Nye[4]



NRC Research Press

ARTICLE

Understanding historical summer flounder (*Paralichthys dentatus*) abundance patterns through the incorporation of oceanography-dependent vital rates in Bayesian hierarchical models

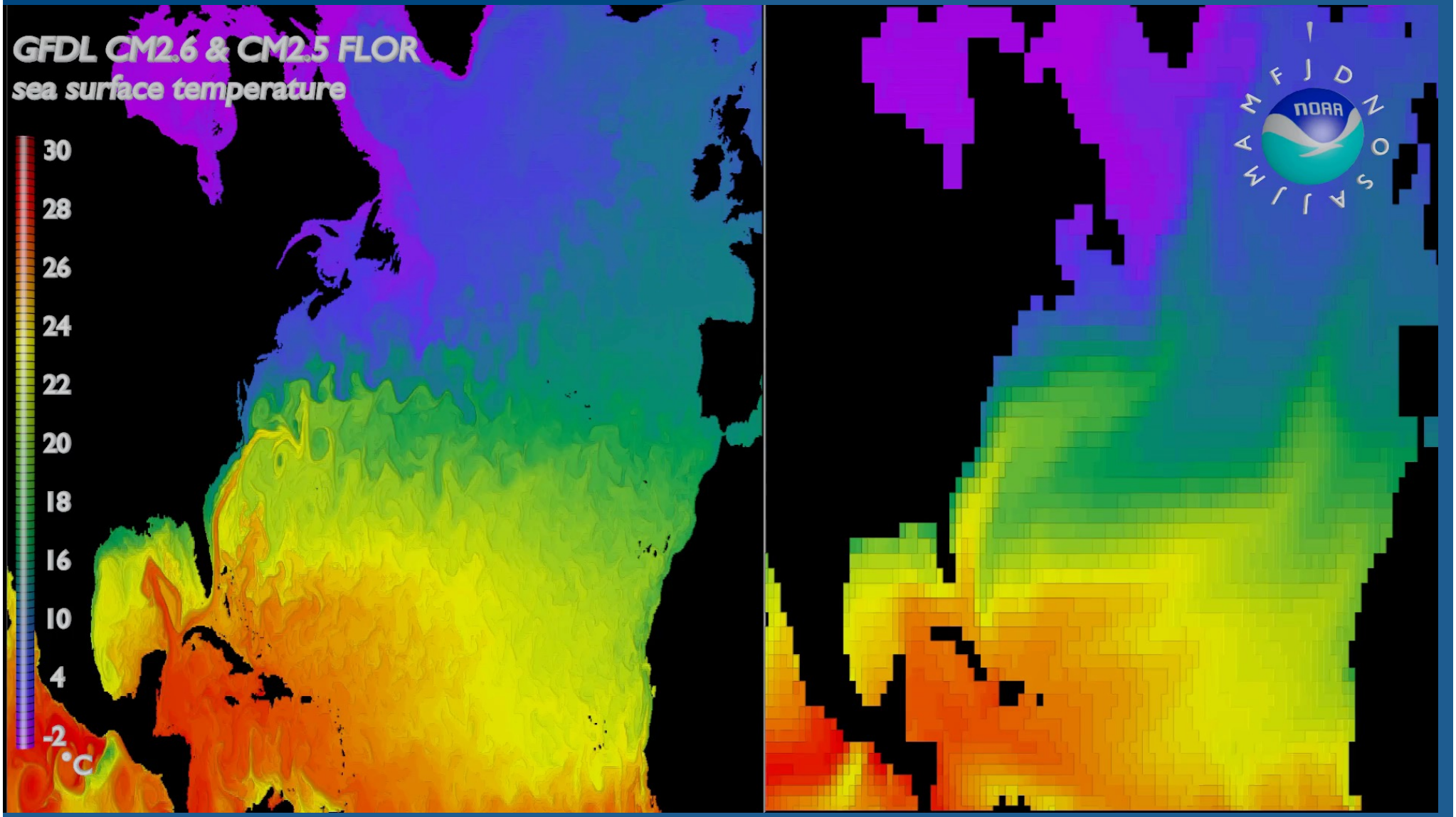
Cecilia A. O'Leary, Timothy J. Miller, James T. Thorson, and Janet A. Nye

RESEARCH ARTICLE

Offshore Habitat Preference of Overwintering Juvenile and Adult Black Sea Bass, *Centropristis striata*, and the Relationship to Year-Class Success

**Alicia S. Miller*, Gary R. Shepherd, Paula S. Fratantoni**

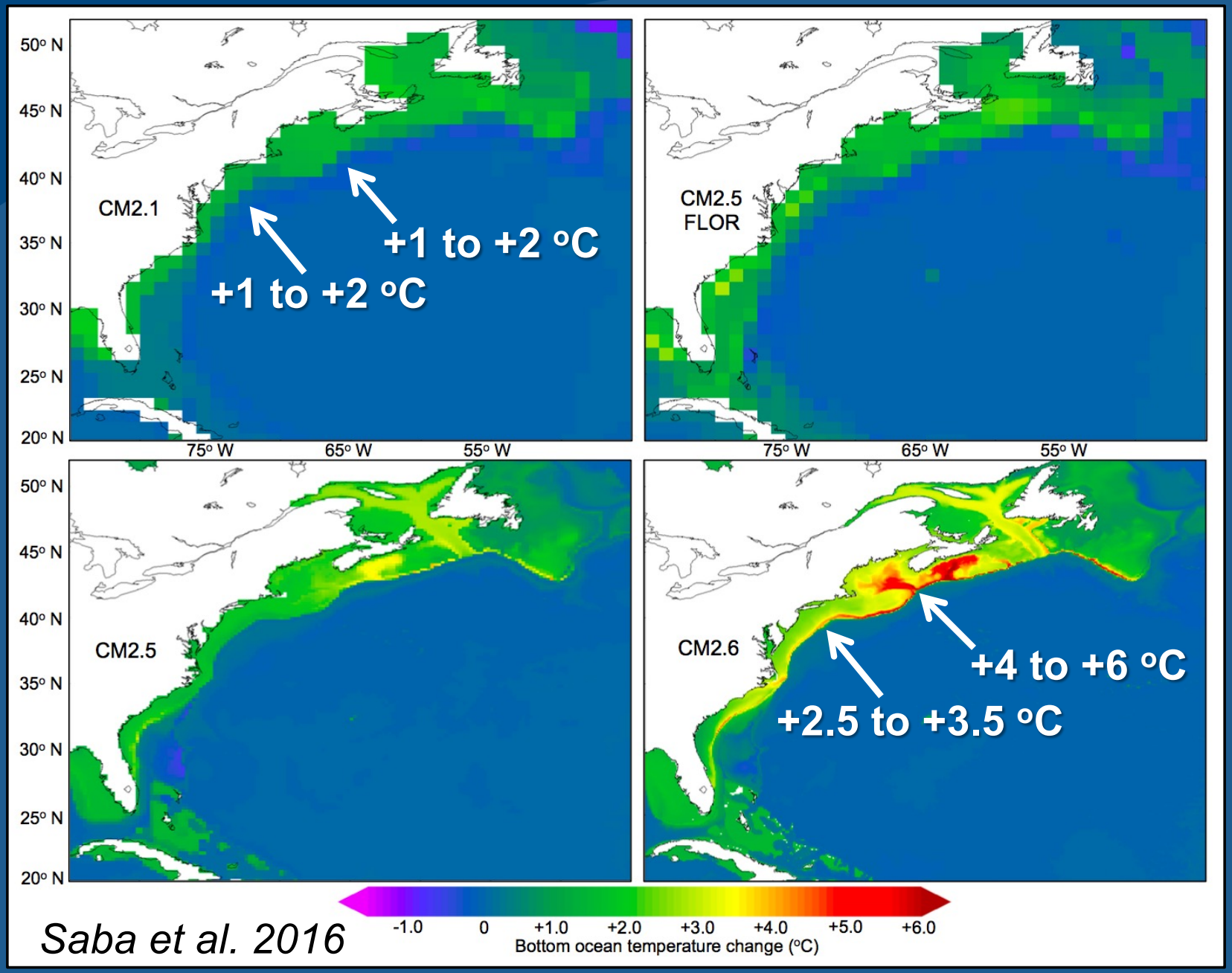
# Global Climate Models: Resolution




High-Resolution Ocean (10-km)

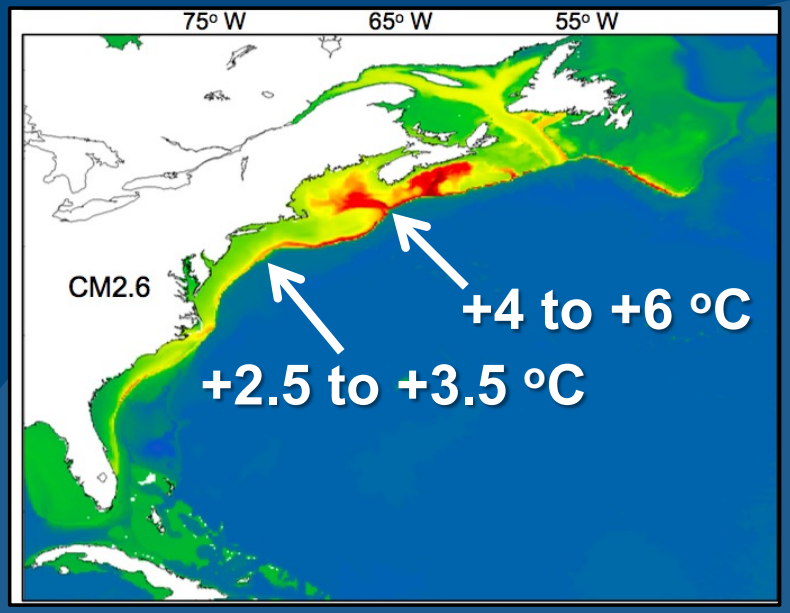
Low-Resolution Ocean (100-km)

# Northwest Atlantic – Projected ocean warming ($2xCO_2$)

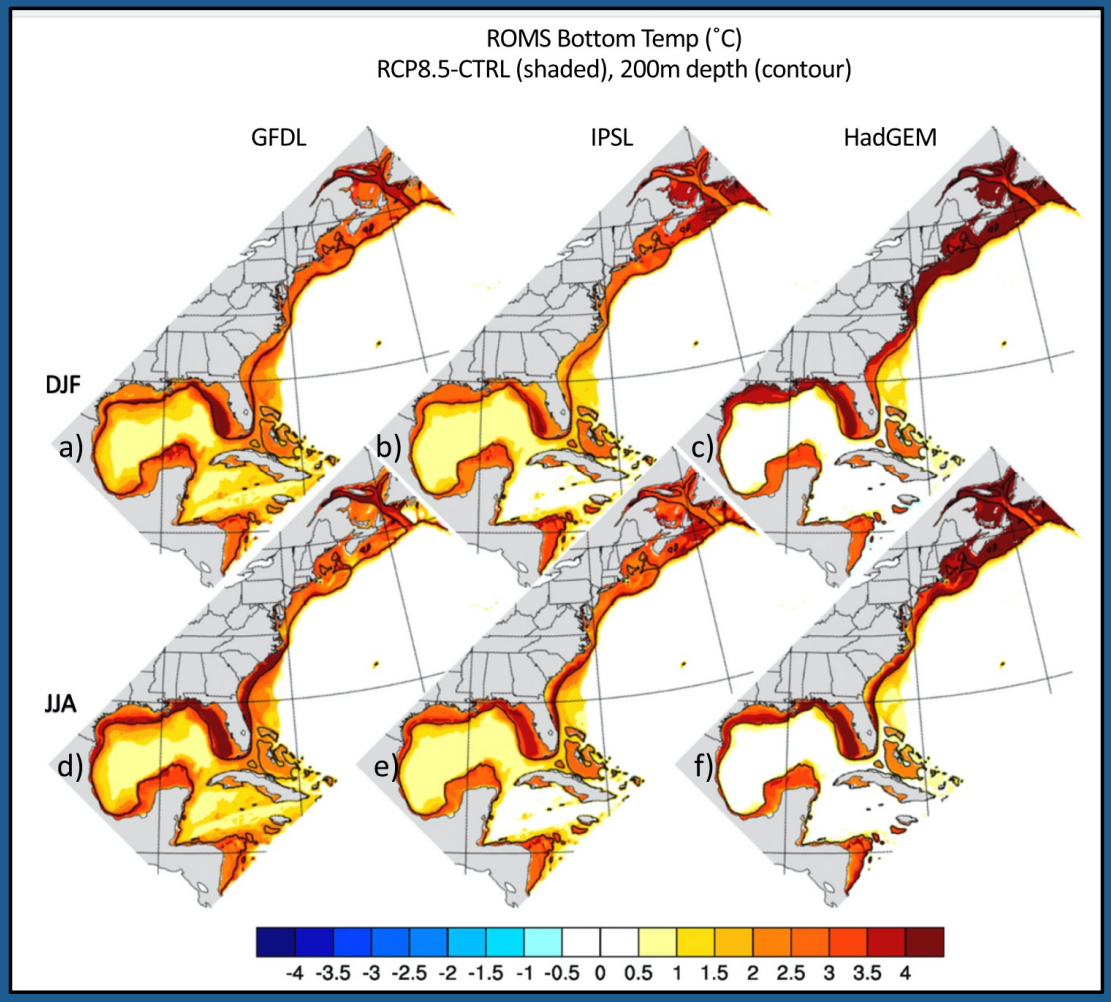



*Saba et al. 2016*

# Northwest Atlantic – CM2.6 vs ROMS




*Saba et al. 2016*




*Alexander et al. 2019*

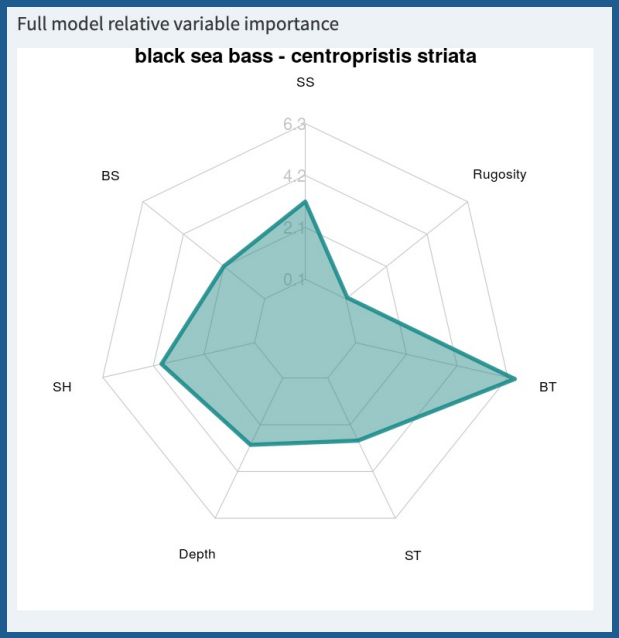
# Projected impacts of ocean warming

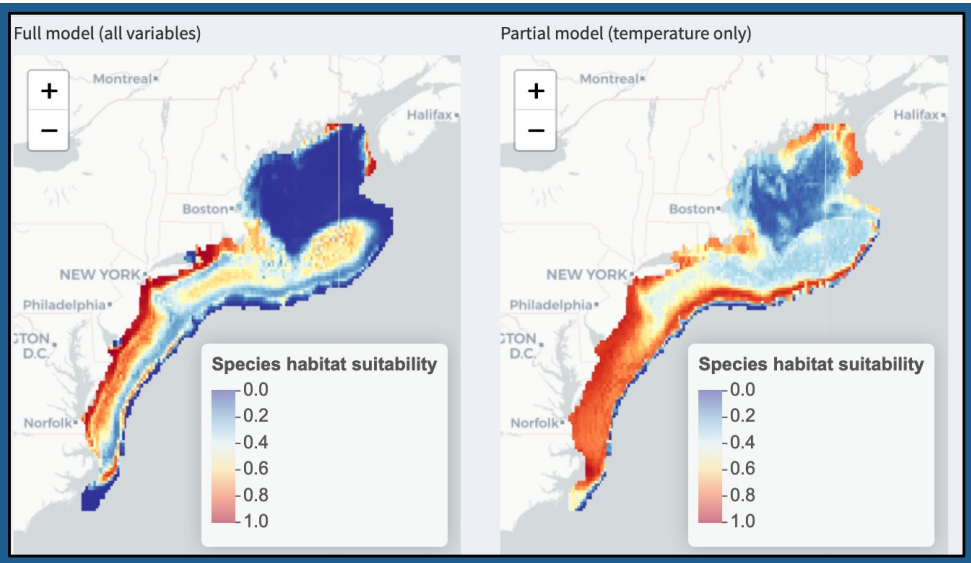
PRIMARY RESEARCH ARTICLE

Global Change Biology WILEY

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

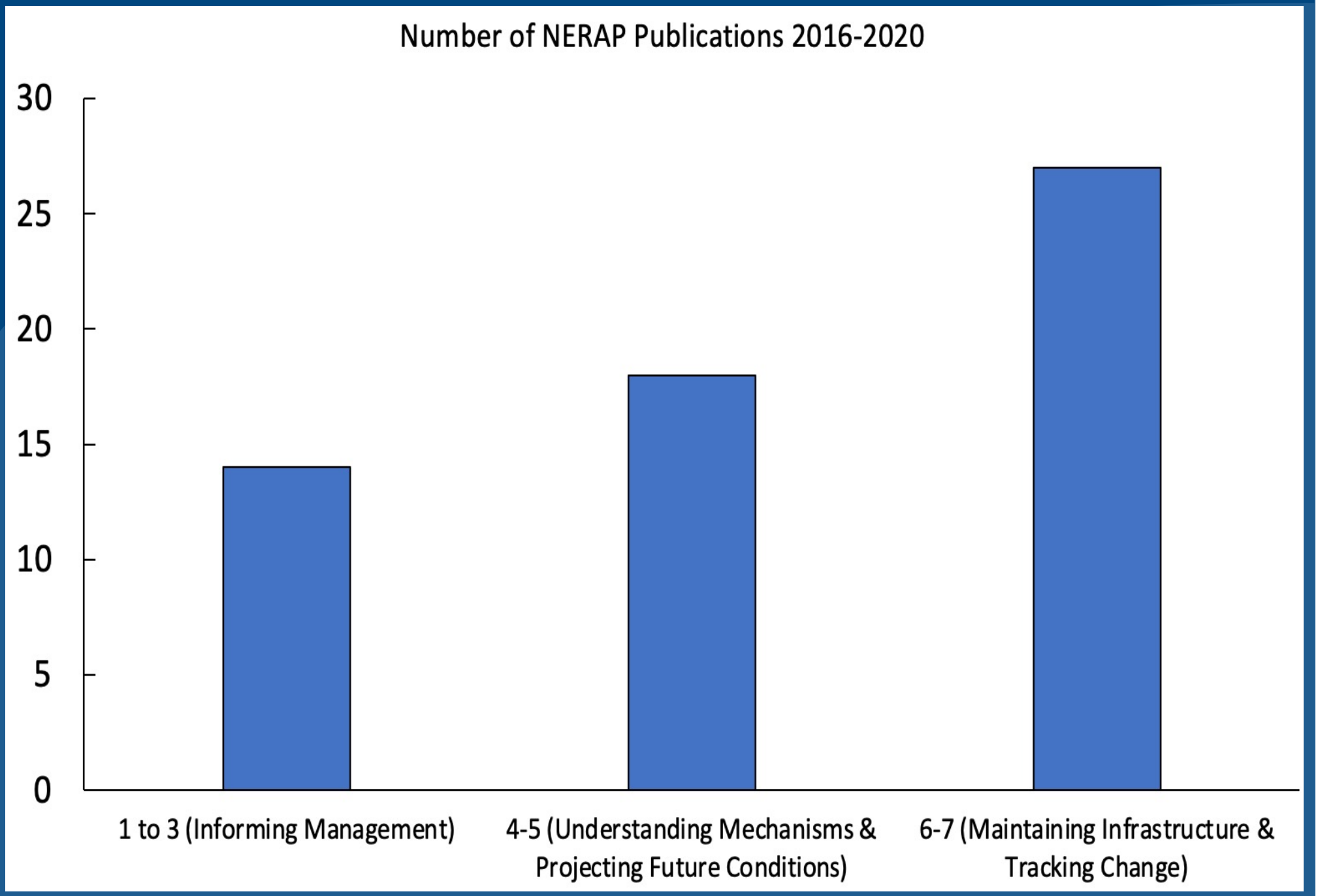
Jennifer McHenry[1] | Heather Welch[2,3] | Sarah E. Lester[1] | Vincent Saba[4]

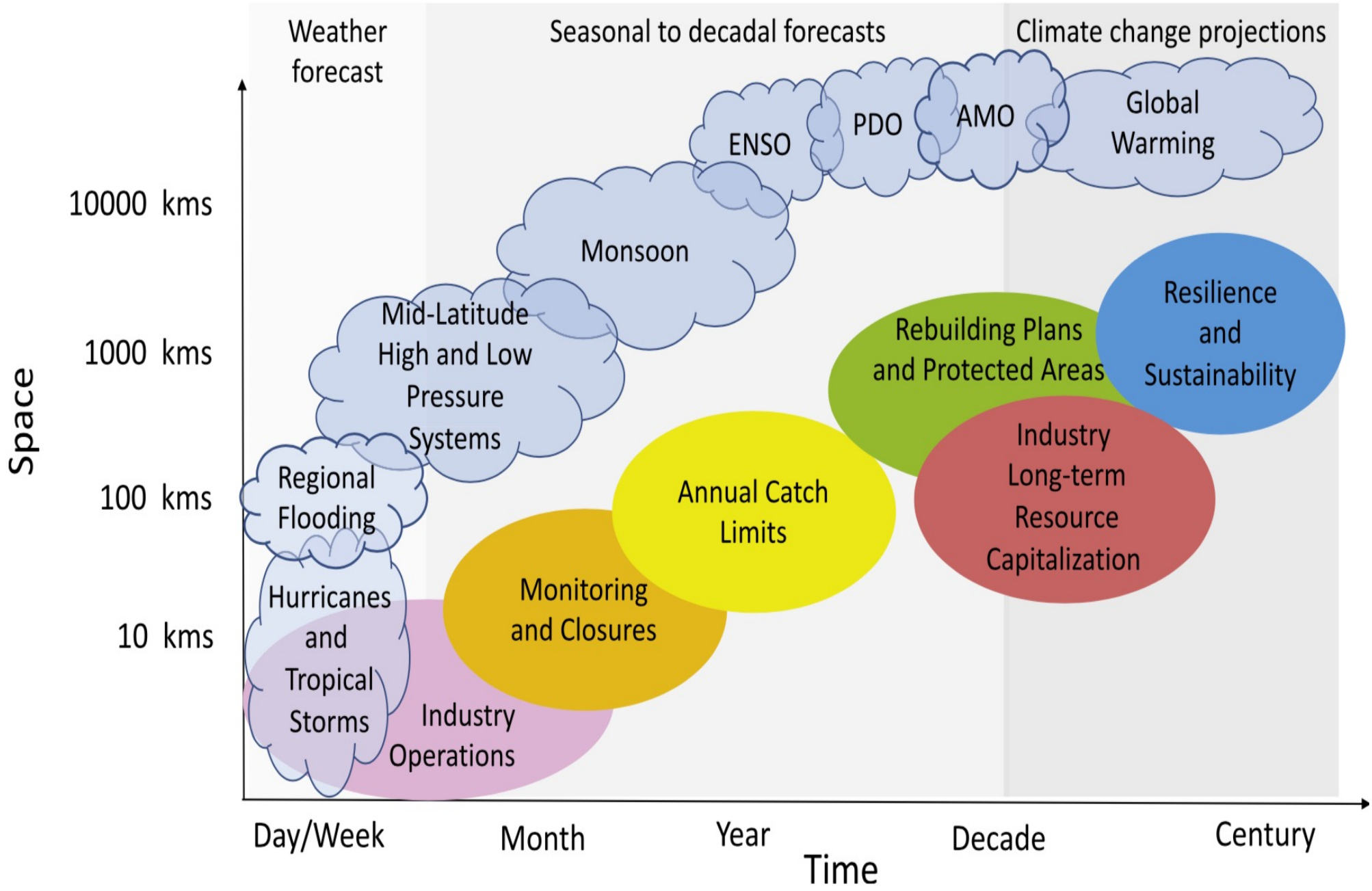



*McHenry et al. 2019, Glob. Ch. Bio.*

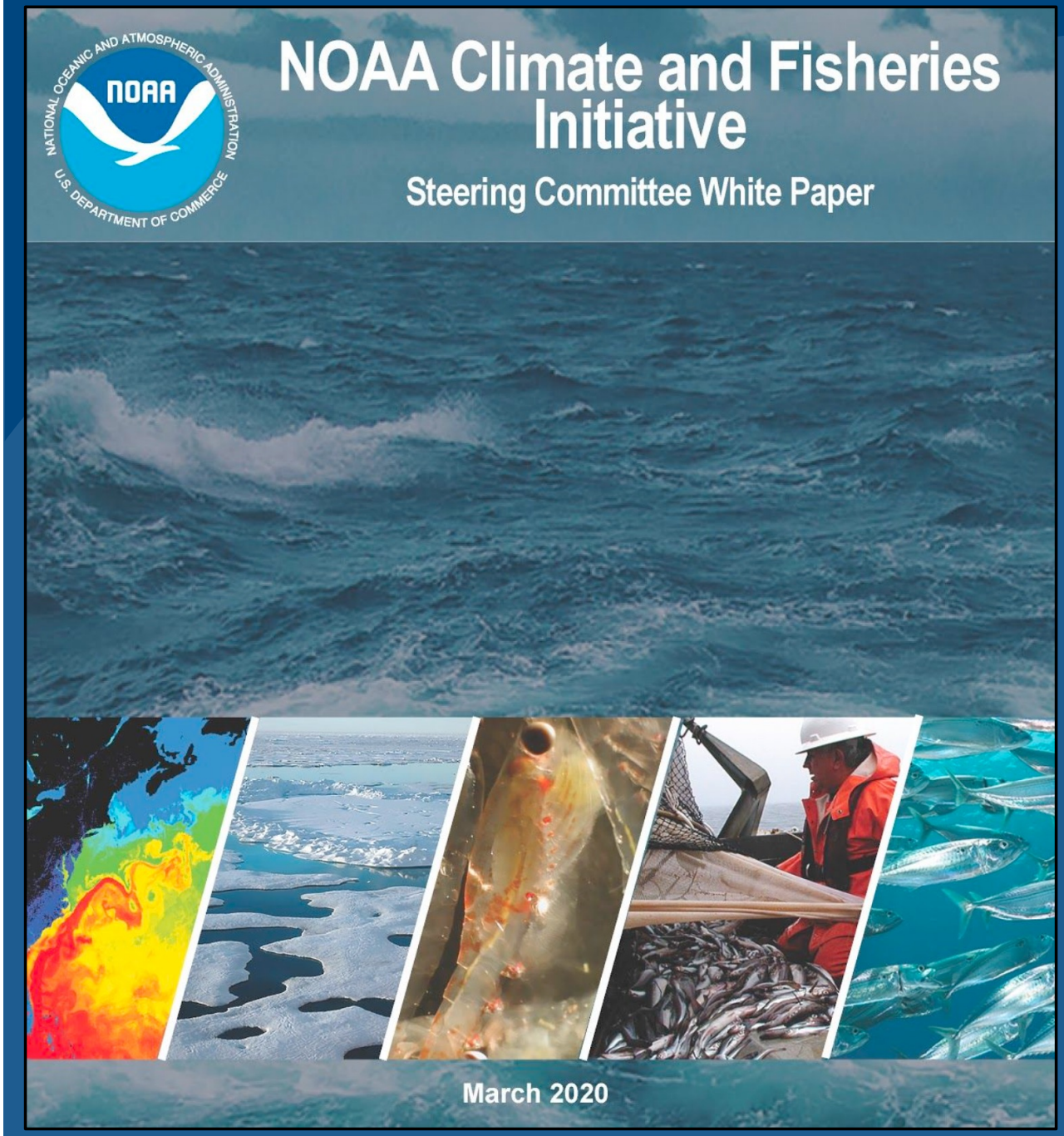
https://heatherwelch.shinyapps.io/beyond_temperature/


Number of NERAP Publications 2016-2020
30
25
20
15
10
5
0
1 to 3 (Informing Management)
4-5 (Understanding Mechanisms & Projecting Future Conditions)
6-7 (Maintaining Infrastructure & Tracking Change)


Weather forecast
Seasonal to decadal forecasts
Climate change projections
ENSO
PDO
AMO
Global Warming
Monsoon
Mid-Latitude High and Low Pressure Systems
Regional Flooding
Hurricanes and Tropical Storms
Industry Operations
Monitoring and Closures
Annual Catch Limits
Rebuilding Plans and Protected Areas
Resilience and Sustainability
Industry Long-term Resource Capitalization
10000 kms
1000 kms
100 kms
10 kms
Space
Day/Week
Month
Year
Decade
Century
Time

# 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.




## 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.


**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.

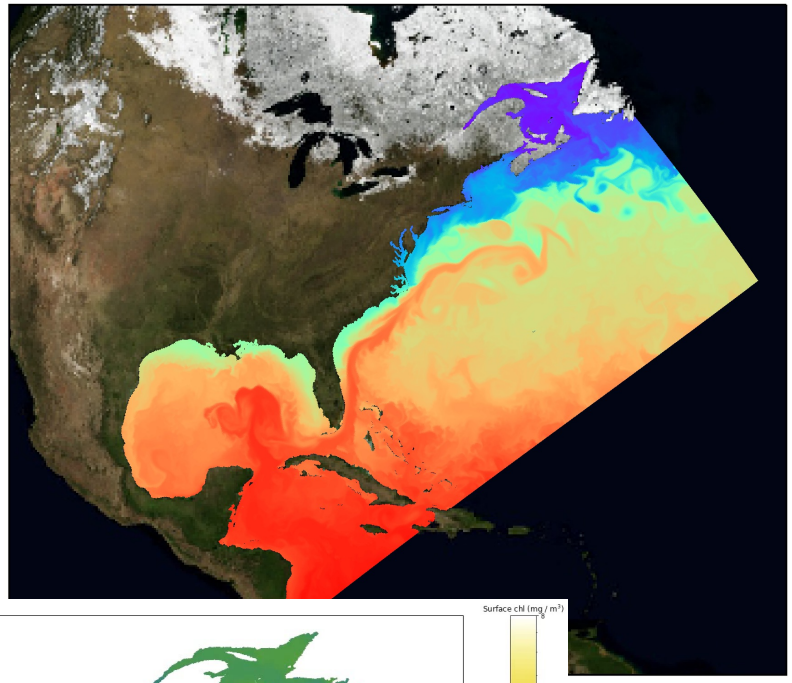
# In Five Years

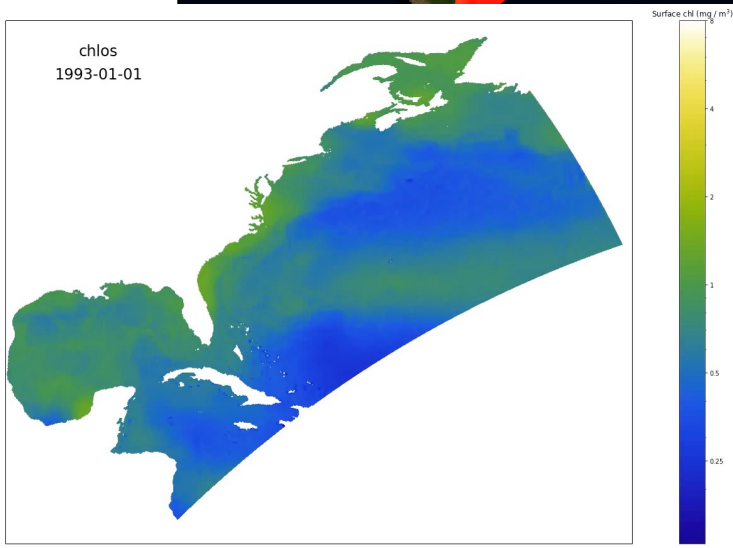
- **Regional MOM6 ocean modeling system is operational** & delivers next-gen hindcasts, nowcasts, forecasts, & projections for management of marine & coastal resources.
- **Cross-NOAA regional teams** support the production & application of regional MOM6 products and research results.
- **NOAA investments 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)

Climate-Ocean Models

Ecosystem and Population Models

Human Dimension models

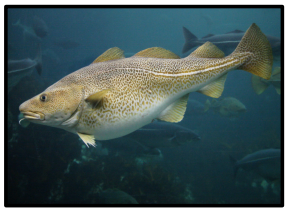
NCLIM Synthesis and Coordination

Management Process

Stakeholder Engagement

Tactical decision-making

Long term management strategies



NOAA FISHERIES

# 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. |