The effects of climate on fisheries resources of the New England region

Jonathan Hare
NOAA / NMFS / NEFSC
Narragansett Laboratory
jon.hare@noaa.gov

Introduction

- Jon Hare, NEFSC
- Oversee operational oceanography programs
- Lead for NEFSC Climate Research Program
- Director of the NOAA Narragansett Laboratory
- Research is fisheries oceanography

This presentation reflects papers, projects and ideas developed with numerous collaborators and colleagues

Mike Fogarty (NEFSC)
Mike Alexander (ESRL)
Charlie Stock (GFDL)
Anne Hollowed (AFSC)
Erik Williams (SEFSC)
Cisco Werner (Rutgers)
Ken Able (Rutgers)
Janet Nye (NEFSC)
Jason Link (NEFSC)
Bill Overholtz (NEFSC)
Mark Wuenschel (NEFSC)
Matt Kimball (NERR)
Harvey Walsh (NEFSC)
Chris Legault (NEFSC)
Nathan Rebuck (NEFSC)

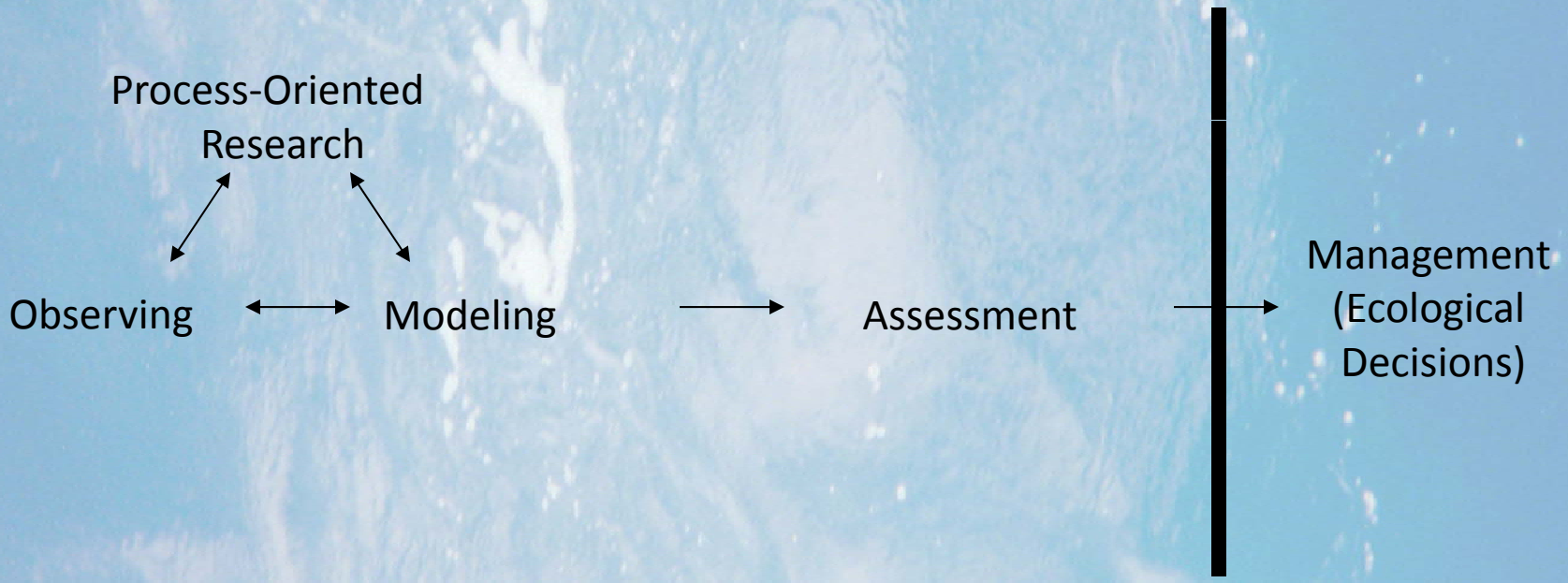
Diane Borgaard (NERO)
Kimberly Damon-Randall (NERO)
Ivan Mateo (NERO)
Sarah Thompson (NERO)
John Manderson (NEFSC)
Loretta O'Brien (NEFSC)
David Richardson (NEFSC)
Antoinetta Capatondi (ESRL)
Peter Auster (UConn)
Eric Huepel (UConn)
Bob Cowen (RSMAS)
Liz Brooks (NEFSC)
Tim Miller (NEFSC)
Megan O'Connor (NEFSC)
Many others……

Outline

- Background
- Past work
- Current activities
- Future directions
- Discussion with NEFMC

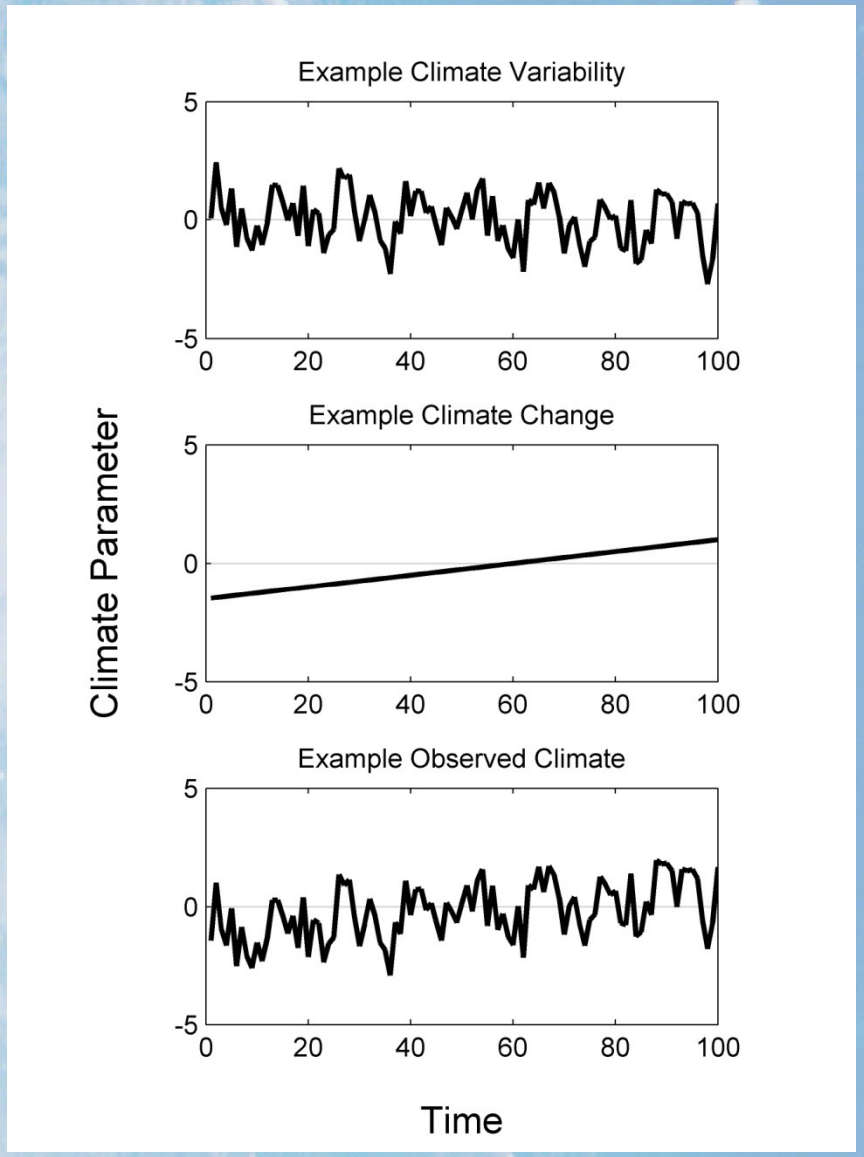
Background

Research – Assessment – Management



Background

- Important difference "climate change" vs "climate variability"
- Climate variability – natural variability within the climate system
- Climate change – change in the climate system



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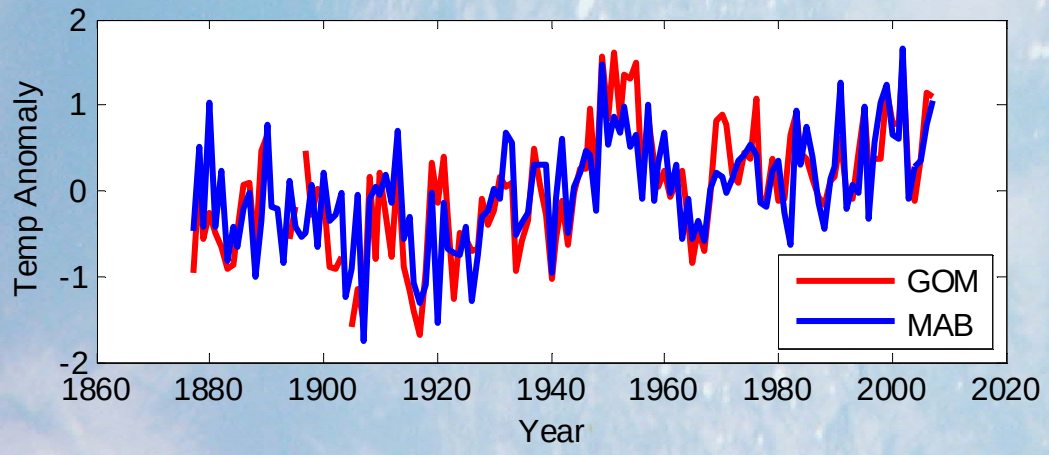
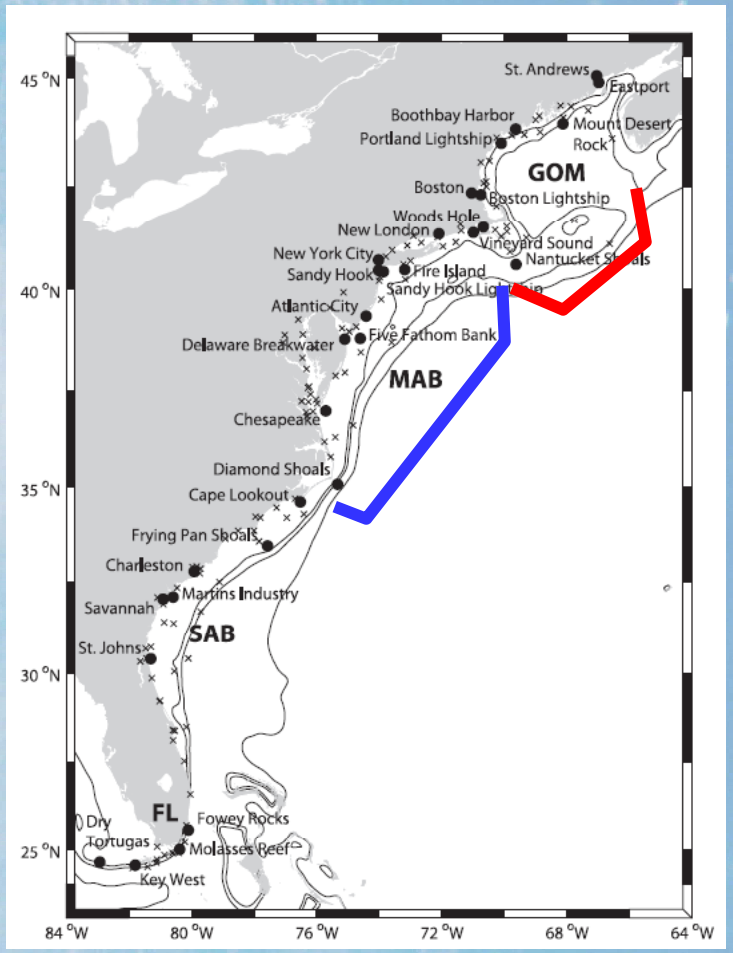
Review of climate and fisheries

Northeast US Shelf temperature

- Evidence for variability
- Evidence for change (~ 1-2 °C increase since 1920)



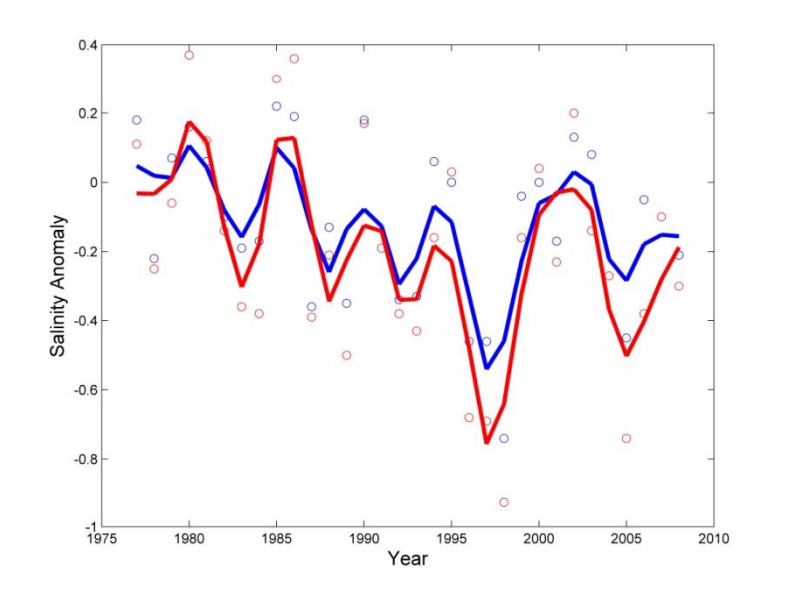


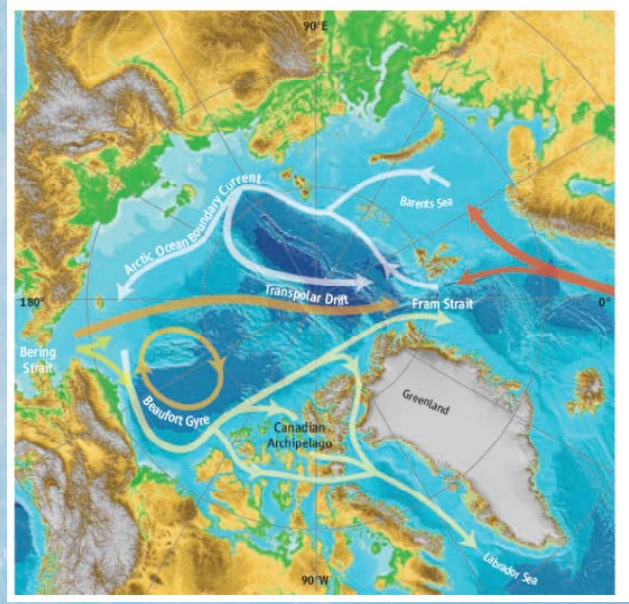
Shearman K, Lentz S (2009) Journal of Physical Oceanography 40: 1004-1017

Review of climate and fisheries

Northeast US Shelf salinity

- Evidence for variability and change (~0.3 decrease since 1977)
- Linked to freshwater input from the north



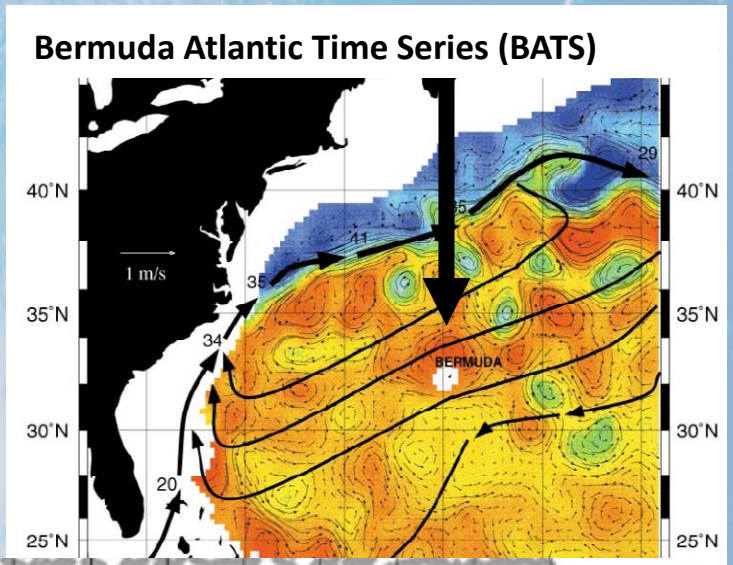


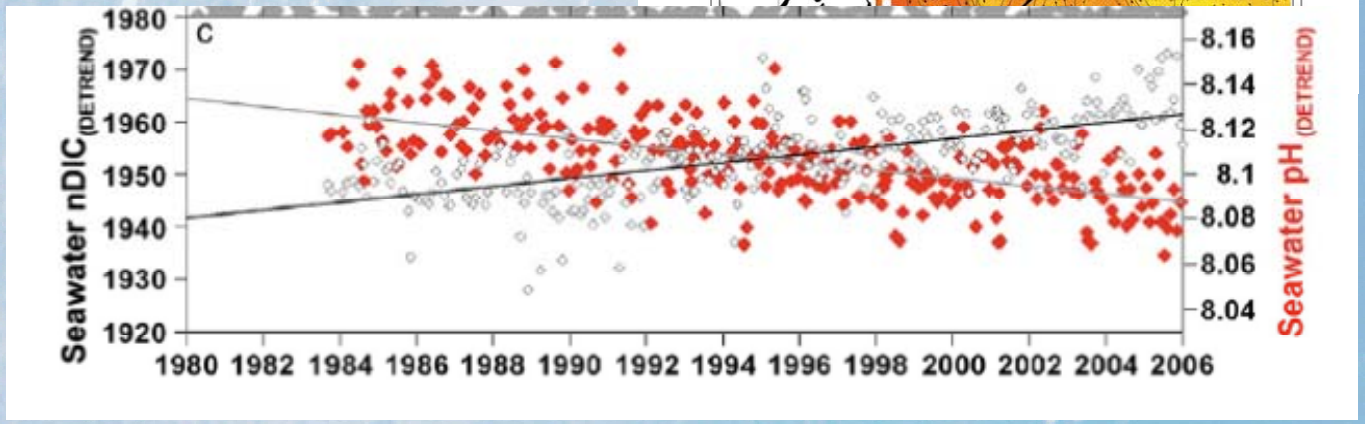
Mountain 2004 & http://www.nefsc.noaa.gov/publications/crd/crd0911/
Greene CH, Pershing AJ 2007 Science 315: 5815

Review of climate and fisheries

Northeast US Shelf acidification

- Dissolved inorganic carbon is increasing
- pH is decreasing
- Observations similar on-shelf





Bates NR, Peters AJ (2007) Marine Chemistry 107:547-558
Rebuck N (in prep)

Review of climate and fisheries

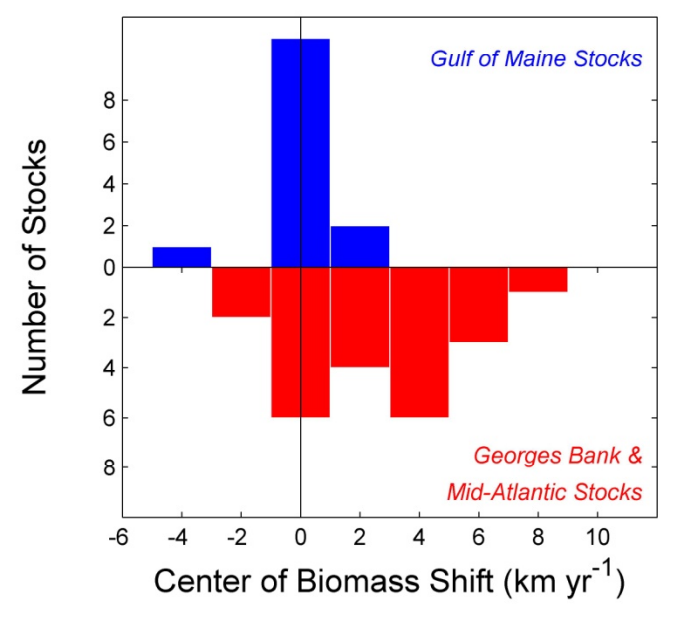
Northeast US Shelf environment

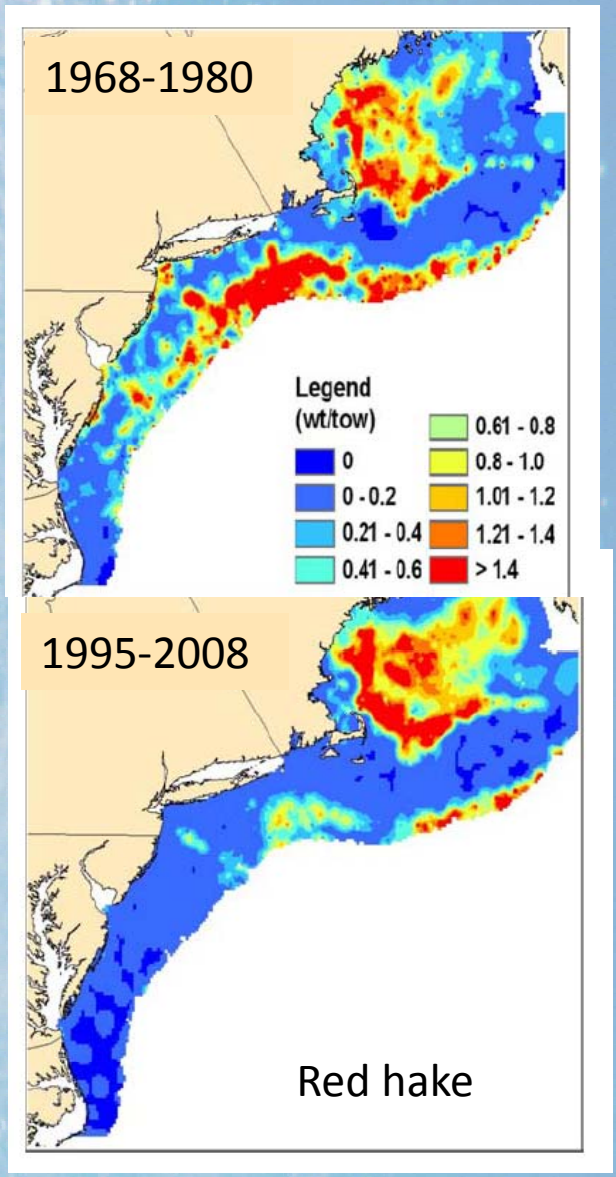
- Wind patterns – Archer and Calderia (2008)
- Precipitation and streamflow – Hayhoe et al. (2007)
- Nutrients – Townsend et al (2010)
- Large-scale circulation – Hakkinen and Rhines (2009)
- Sea-level rise – Yin et al 2009
- And more ….

Review of climate and fisheries

Shifting distributions

- 24 of 36 stocks have shifted poleward and/or deeper
- 1.6 km yr^{-1} and 0.25 m yr^{-1}



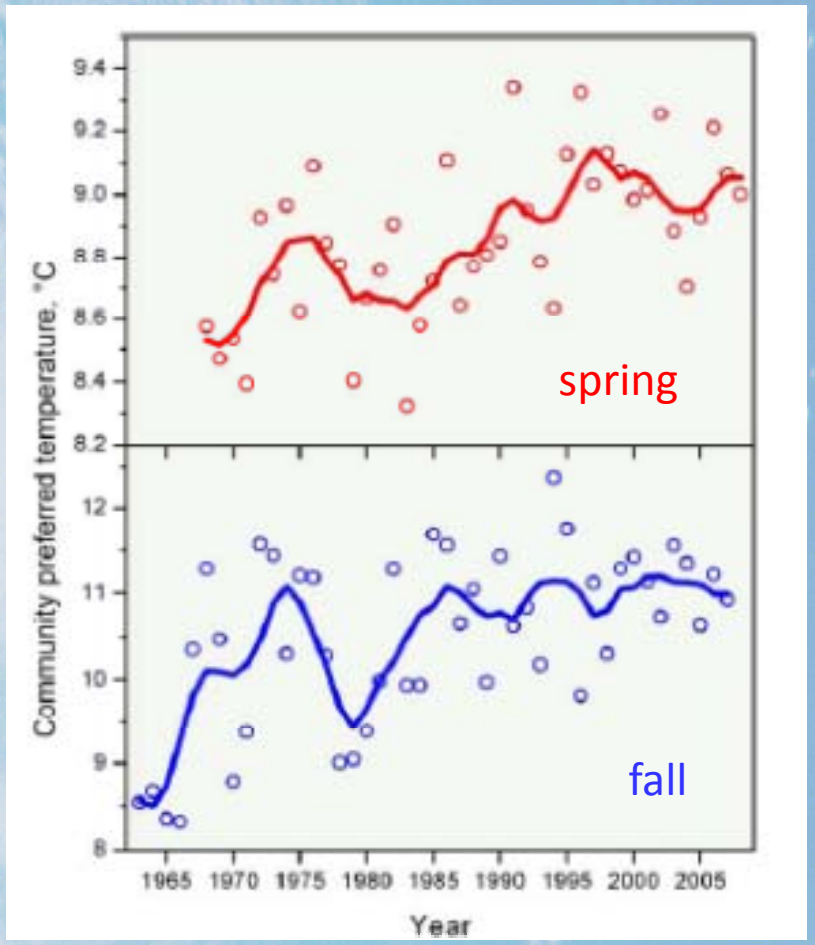


Nye JA et al. (2009) Marine Ecology Progress Series 393:111-139

Review of climate and fisheries

Shifting communities

- Fish community on northeast U.S. shelf is shifting to a warmer water fauna



Ecosystem Assessment Program (2009) NEFSC Center Reference Document 09-11

Review of climate and fisheries

Northeast US Shelf resources

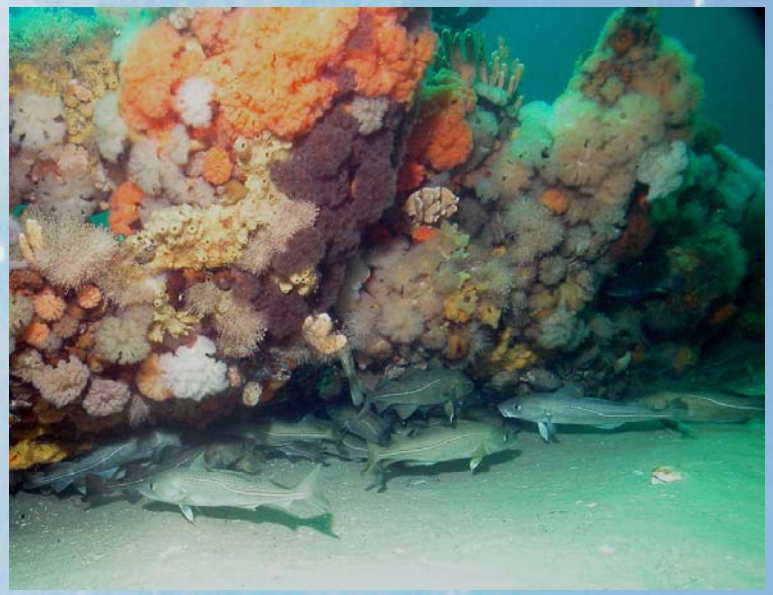
- Mackerel distribution - Overholtz et al. (2011)
- Atlantic salmon- Friedland et al. (2003)
- Shellfish – Weinberg (2005), Talmage and Gobler (2010)
- Phytoplankton – Balch et al. (2012)
- Zooplankton - Kane (2007)

Review of climate and fisheries

Fogarty et al (2008) Atlantic cod

- Examined distribution and abundance as function of temperature
- Coupled biological model to climate models
- Projections based on 2080-2084

$$R = SSBe^{(a+b\cdot SSB+c\cdot T+\varepsilon)}$$

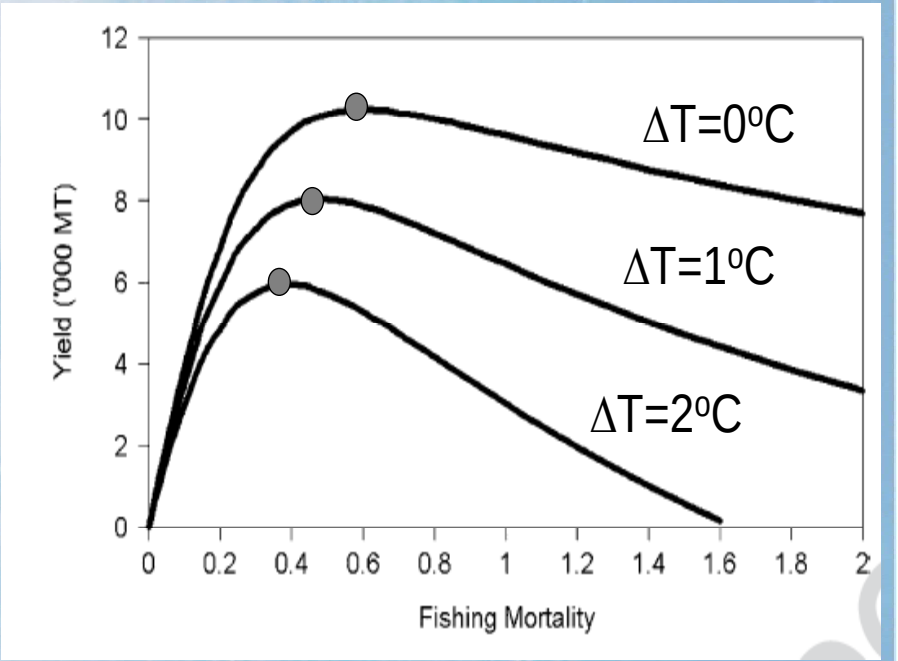


http://stellwagen.noaa.gov/management/fmp/fmp2010_media.html

Review of climate and fisheries

Fogarty et al (2008) Atlantic cod

- Extirpation from southern New England
- MSY decreases with increasing temperature
- Fishing at MSY decreases
- Climate changes fishery benchmarks!



Review of climate and fisheries

Hare et al (2010) Atlantic croaker

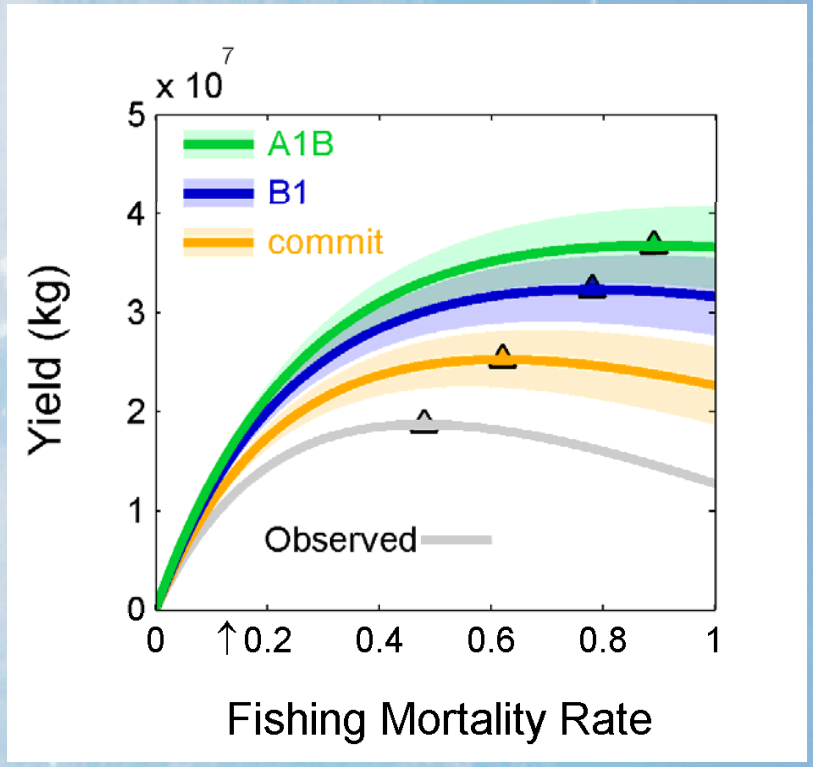
- Examined distribution and abundance as function of temperature
- Coupled biological model to climate models
- Projections based on 2050-2100

$$R = SSBe^{(a+b\cdot SSB+c\cdot T+\varepsilon)}$$

Review of climate and fisheries

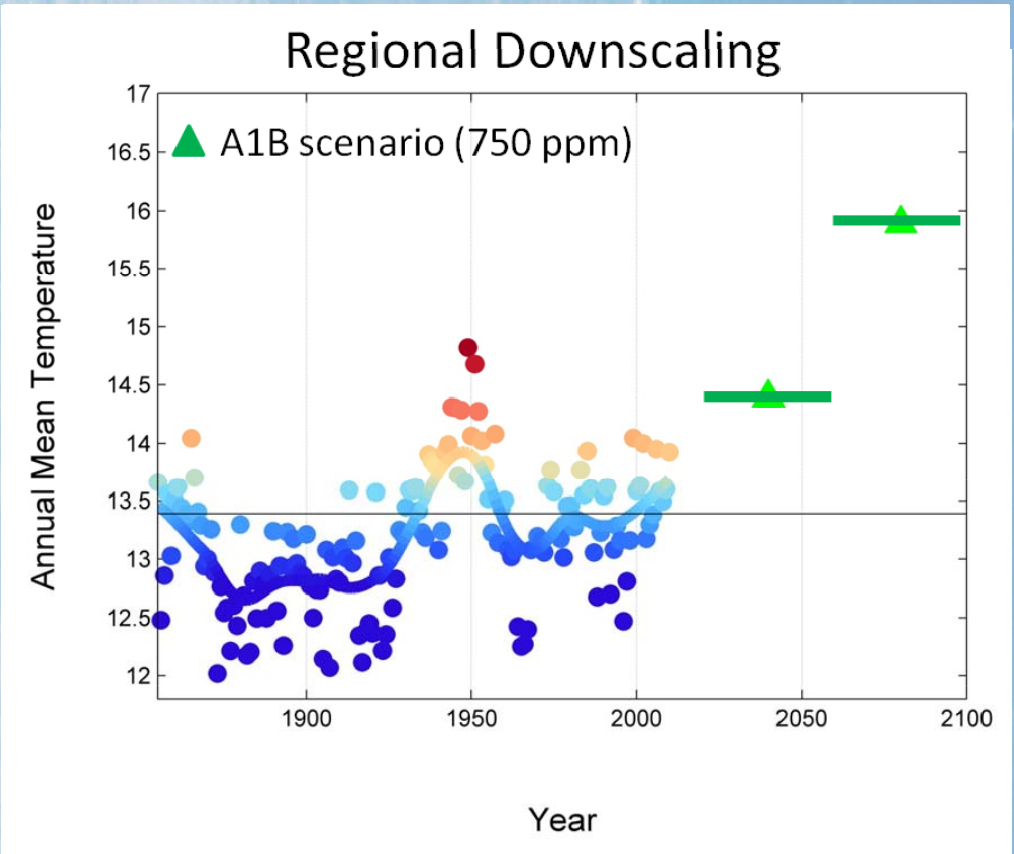
Hare et al (2010) Atlantic croaker

- Expansion throughout mid-Atlantic and into southern New England
- MSY increases with increasing temperature
- Fishing at MSY increases
- Climate changes fishery benchmarks!



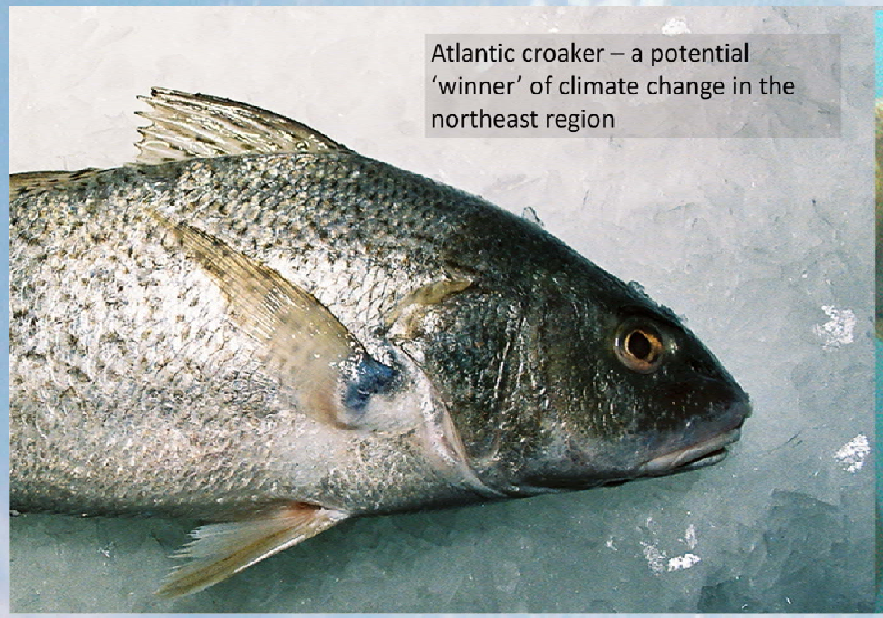
Review of climate and fisheries

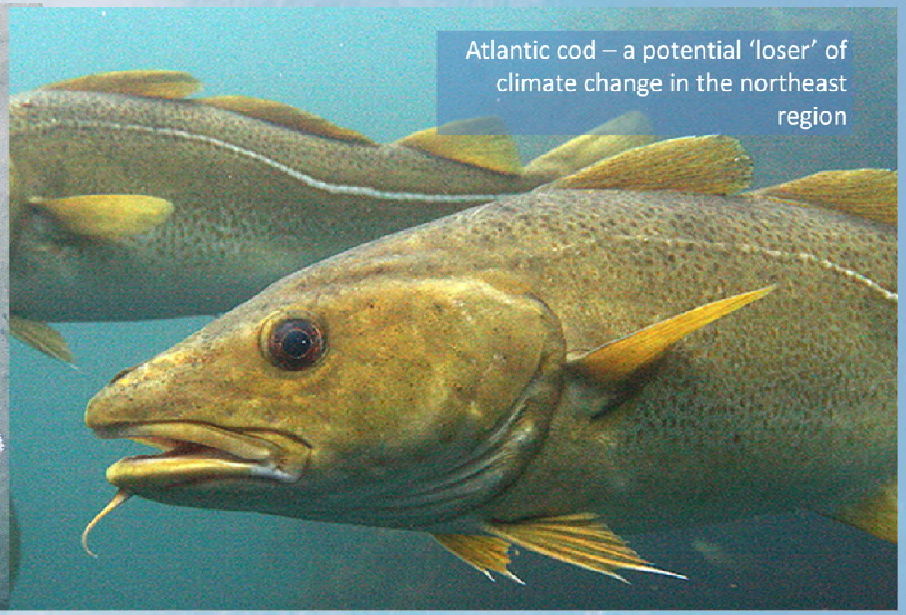
- Environment is changing
- Fish distribution and abundance is changing
- Projections indicate changes will continue



Review of climate and fisheries

- In a region (e.g., New England) there will be ‘winners’ and ‘losers’
- Need to better incorporate effects of fishing and effects of climate


Atlantic croaker – a potential ‘winner’ of climate change in the northeast region


Atlantic cod – a potential ‘loser’ of climate change in the northeast region

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- Future directions
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Current Activities

NEFSC Climate Research Program

- No dedicated funding
- Piecemeal, competitive annual funding (NMFS FATE Program)
- Distributed across programs and divisions in the NEFSC
- Integration with Ecosystem-Based Fisheries Management

Current Activities

Ecosystem Assessment Program

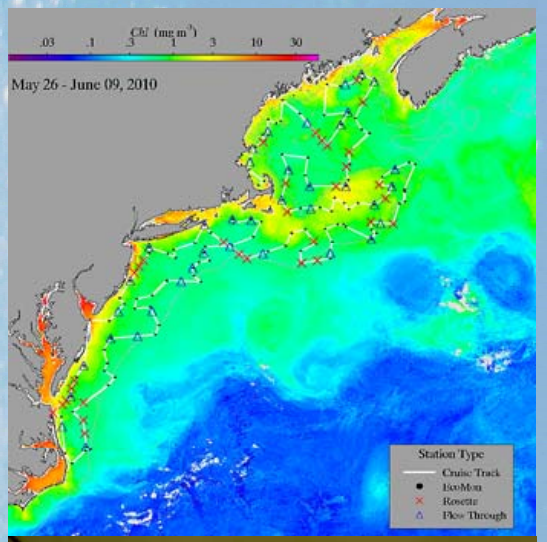
- 2009 and 2011 Ecosystem Status Reports
- Include “climate” indicators
- Progression toward developing support for Ecosystem-Based Fisheries Management

http://www.nefsc.noaa.gov/publications/crd/crd1207/crd1207.pdf

Current Activities

NEFSC Ocean Acidification Program

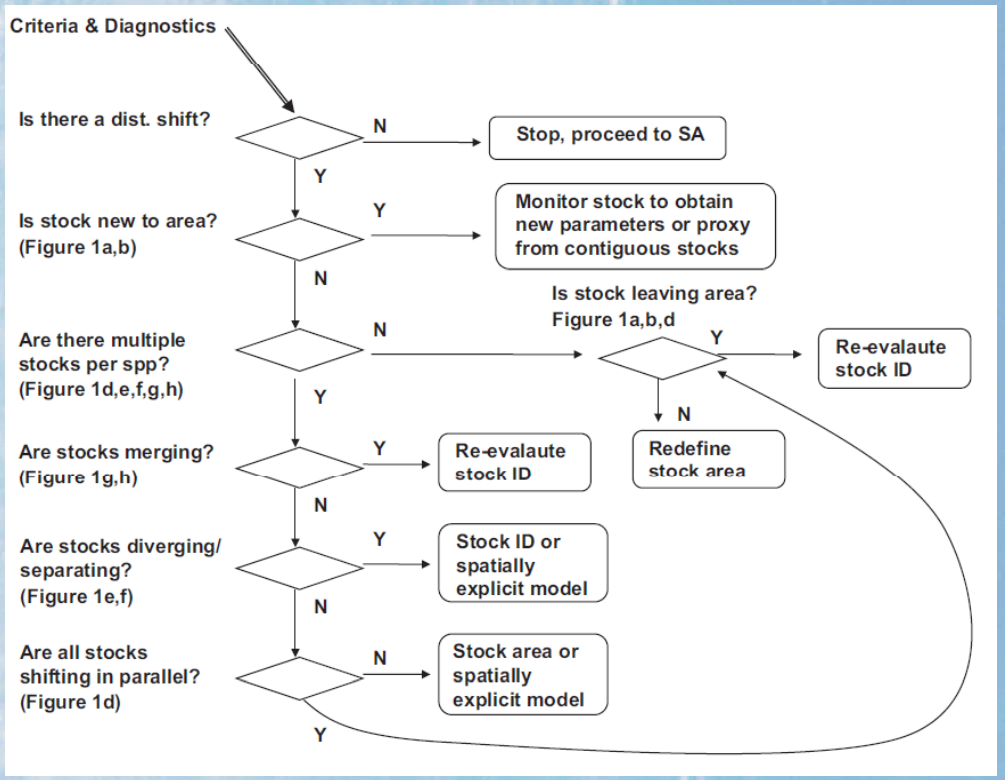
- Beth Phelan (NEFSC SH) is lead
- Funded through NOAA OA Office
- Contains process, monitoring, modeling, and assessment activities
- Distributed across programs and divisions in the NEFSC



Current Activities

Stock Boundaries and Identification

- Stock boundaries shifting
- Implications for stock assessments
- Need to consider effects in the assessment process



Link J, Nye J, and Hare J (2010) Fish and Fisheries 12: 461-469

Current Activities

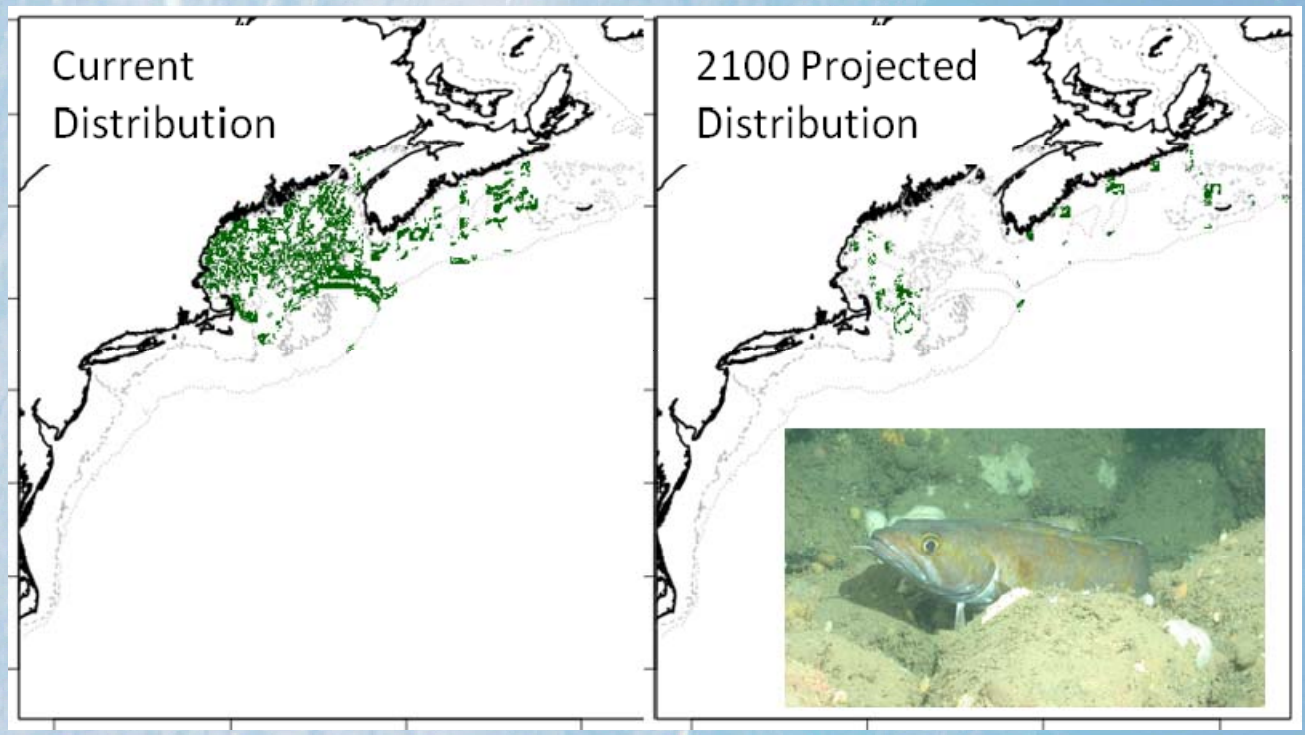
Environmentally-Explicit Stock Recruitment Relationships

- Winter flounder (all three stocks)
- Atlantic cod (Gulf of Maine)
- Yellowtail flounder (Southern New England)
- Atlantic herring
- Atlantic croaker

Current Activities

Climate and “Protected Species”

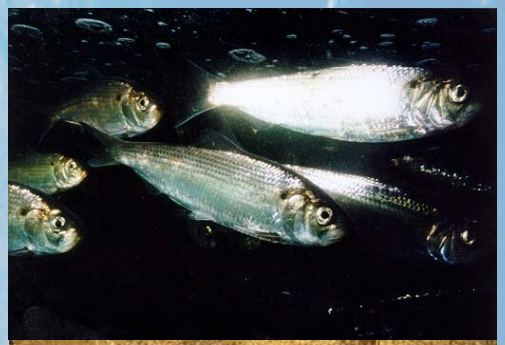
- Cusk and climate change
- River herring and climate change
- Habitat models coupled with climate models



Current Activities

Climate Vulnerability Assessment

- Quick relative assessment of species vulnerability
- Regional pilot in summer 2012 (~20 species)
- Full regional implementation in 2013 (all managed species)



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Future

Climate Research Program Goal:

To determine and understand the dynamic properties of the NEUS in response to climate variability and change, in order to provide advice on future conditions with a focus on biological productivity and fisheries sustainability

Future

- Short-term advice (1-5 years) – Environmentally-explicit stock assessment models
- Medium-term advice (5-20 years) – Rebuilding plans with environmental projections
- Long-term advice (30-100 years) – projections of long-term sustainability
- Support for EBFM (5-100 years)

Future

- Short-term advice (1-5 years) – Environmentally-explicit stock assessment models
- Medium-term advice (5-20 years) – Rebuilding plans with environmental projections
- Long-term advice (25-50 years) – projections of long-term sustainability
- Support for EBFM (5-100 years)