Fisheries and Climate Change in the Gulf of Maine: Challenges and Opportunities for Fishing Communities

Coastal NH Climate Summit
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Dr. Erik Chapman – UNH Fisheries Extension Specialist
Human impacts

- Fishing
Climate Variability and Fish
(Chavez et al. 2003, Science, Vol 299)
Synergies between climate and management for Atlantic cod fisheries at high latitudes

Olav Sigurd Kjesbu\textsuperscript{a,1}, Bjarte Bogstad\textsuperscript{a}, Jennifer A. Devine\textsuperscript{a}, Harald Gjøsæter\textsuperscript{a}, Daniel Howell\textsuperscript{a}, Randi B. Ingvaldsen\textsuperscript{b}, Richard D. M. Nash\textsuperscript{a}, and Jon Egil Skjæraasen\textsuperscript{a}
Striped Bass # = fishing and Atlantic Multi-decadal Oscillation (AMO)
Shifts in distributions
(Perry et al. 2005)

Fig. 1. Examples of North Sea fish distributions that have shifted north with climatic warming. Relationships between mean latitude and 5-year running mean winter bottom temperature for (A) cod, (B) anglerfish, and (C) snake blenny are shown. In (D), ranges of shifts in mean latitude are shown for (A), (B), and (C) within the North Sea. Bars on the map illustrate only shift ranges of mean latitudes, not longitudes. Arrows indicate where shifts have been significant over time, with the direction of movement. Regression details are in Table 1.
Ocean Acidification

\[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{HCO}_3^- + \text{H}^+ \]

\[ \text{H}^+ + \text{CO}_3^{2-} \rightarrow \text{HCO}_3^- \]

\[ \text{CaCO}_3 \rightarrow \text{Ca}^{2+} + \text{CO}_3^{2-} \text{(coral)} \]
The combined effects of ocean acidification, mixing, and respiration on pH and carbonate saturation in an urbanized estuary

Richard A. Feely, Simone R. Alin, Jan Newton, Christopher L. Sabine, Mark Warner, Allan Devol, Christopher Krembs, Carol Maloy

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Pacific Northwest, Puget Sound Shellfish Industry
Example...Alaskan pink salmon and pteropods
Limacina helicina shell dissolution as an indicator of declining habitat suitability owing to ocean acidification in the California Current Ecosystem

N. Bednaršek¹, R. A. Feely¹, J. C. P. Reum², B. Peterson³, J. Menkel⁴, S. R. Alin⁷ and B. Hales⁵
Combined effects of fishing and climate change....

- Fishing
  - Reduces size and genetic variability in a population
  - Changes size and age-at-maturity
- Fish stocks are MORE vulnerable (less resilient) to effects of climate change
Mills et al. Ocean Policy, 2013
Current Situation

Sustainability requires adapting to dynamic and unpredictable......

- Markets
- Management
- Ecosystems
Changing spatial distribution of fish stocks in relation to climate and population size on the Northeast United States continental shelf

Janet A. Nye¹,* , Jason S. Link¹, Jonathan A. Hare², William J. Overholtz¹

¹National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole Laboratory, 166 Water St., Woods Hole, Massachusetts 02543, USA
²National Marine Fisheries Service, Northeast Fisheries Science Center, Narragansett Laboratory, 28 Tarzwell Drive, Narragansett, Rhode Island 02882, USA
Atlantic cod

Cod larva
Slow adaptation in the face of rapid warming leads to collapse of the Gulf of Maine cod fishery

Andrew J. Pershing,1* Michael A. Alexander,2 Christina M. Hernandez,1† Lisa A. Kerr,1 Arnault Le Bris,1 Katherine E. Mills,1 Janet A. Nye,3 Nicholas R. Record,4 Hillary A. Scannell,1,5† James D. Scott,2,6 Graham D. Sherwood,1 Andrew C. Thomas5

Several studies have documented fish populations changing in response to long-term warming. Over the past decade, sea surface temperatures in the Gulf of Maine increased faster than 99% of the global ocean. The warming, which was related to a northward shift in the Gulf Stream and to changes in the Atlantic Multidecadal Oscillation and Pacific Decadal Oscillation, led to reduced recruitment and increased mortality in the region's Atlantic cod (Gadus morhua) stock. Failure to recognize the impact of warming on cod contributed to overfishing. Recovery of this fishery depends on sound management, but the size of the stock depends on future temperature conditions. The experience in the Gulf of Maine highlights the need to incorporate environmental factors into resource management.
Gulf of Maine Cod = Fishing and climate index?

Cod Catch

North Atlantic Oscillation (NAO)
SNE lobster stock in ‘recruitment failure’; TC calls for five-year fishing moratorium

by Janice M. Plante

The Southern New England lobster stock area is shown in green. Note that several management areas would be affected by a lobster fishing moratorium for the SNE stock.
Stage I
8 mm = 0.3 in

Stage II
9 mm = 0.35 in

Stage III
11 mm = 0.43 in

Stage IV
15 mm = 0.6 in
Total Days above 20° c in Southern New England

Woods Hole, MA sea-surface temperature from 1945 to 2009. From 1999 on, temperatures often rose above 20°C. Lobsters avoid water greater than 19°C.

Millstone Power Station, Long Island Sound bottom temperature from 1976 through 2009.
The Southern New England lobster stock area is shown in green. Note that several management areas would be affected by a lobster fishing moratorium for the SNE stock.
Northern Shrimp
Invasive green crab
Expanding ranges...
Expanding ranges...
Expanded period of occupation by predators

Spiny dogfish
2012 – Historic warm year
Fisheries Management in a Changing Climate
Lessons from the 2012 Ocean Heat Wave in the Northwest Atlantic

BY KATHERINE E. MILLS, ANDREW J. PERSHING, CURTIS J. BROWN, YONG CHEN, FU-SUNG CHIANG, DANIEL S. HOLLAND, SIGRID LEHUTA, JANET A. NYE, JENNY C. SUN, ANDREW C. THOMAS, AND RICHARD A. WAHLE
Longfin squid
Sea Surface Temperature Anomalies for April 6-13, 2016

Gulf of Maine Research Institute
Science. Education. Community.
Gulf of Maine Lobster Forecasting

2016 Forecast

April 13 Forecast

- Extremely Early: 41%
- Very Early: 56%
- Early: 3%
- Normal: 0%
- Late: 0%
- Very Late: 0%
- Extremely Late: 0%
Ocean acidification effects in the Northeast?

- Cold water and freshwater input increase vulnerability to ocean acidification
- Remarkably little is know about effects on finfish, lobster and their prey

www.neracoos.org/necan
Challenges....

- Access determined by historic distributions
  - Black sea bass permits and markets don’t migrate with stocks
  - Groundfish allocations determined by historical catches: 1997 to 2006
- Target stock levels (baselines) determined by historic distribution/abundances
- Fishing technology and knowledge is focused on a small number of stocks
- Single-species management dominates
- We are operating at the limits of science
Is adaptation possible?

- Diversify fisheries
  - Diversify, increase value of markets of abundant species (be flexible!)
- Adaptive management
  - Move from single-species to ecosystem-based management
  - Acknowledge lack of precision in science
  - Support flexibility in fishing access
  - Empower fishing communities
- Fishermen, scientists and managers must look at these problems together
NH Community-Based Ocean/Fish Habitat Observing Program

NH lobstermen, NH groundfishermen (Sectors), NERACOOS, The Nature Conservancy, NOAA Cooperative Research Program, NOAA Northeast Regional Science Center, UNH
Species assemblage is shifting
- Conditions moving away from optimal for some species
- Conditions moving toward optimal for others
- New species moving in (opportunities!)

Phenology is shifting

Ecology is Changing!

Ocean acidification is having an effect

Species are more vulnerable due to combination of fishing and climate change

We will continue to be at the limits of science

Fishermen can adapt, but they need our help – and we need theirs...