The Effects of Climate Change on Fisheries

Presented by: Jon Hare

Thursday, May 6, 2010
Introduction

- Jon Hare
- NOAA Fisheries
- Narragansett, Rhode Island
- Oversee operational oceanography programs for NOAA Fisheries in the Northeast
Outline

● Recent Developments
● Climate
● Northeast U.S. Climate
● Fisheries
● Northeast U.S. Fisheries
● Conclusions
● For More Information

Recent Developments

- Climate Change and Fisheries Meeting in Sendai, Japan
- ~400 scientists from around the world
- Climate change already affecting fisheries
- In a region (e.g., northeast U.S.), there will be winners and losers
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http://www.eeb.ucla.edu/test/faculty/nezlin/Lecture6/Global1.jpg
Climate

- Definition: the long-term statistics of the atmosphere-ocean-land system

http://www.usgcrp.gov/usgcrp/Library/nationalassessment/overviewtools.htm
Climate

- Important difference “climate change” vs “climate variability”
- **Climate variability** – natural variability within the climate system
- **Climate change** – change in the climate system
Climate

Variability: El niño

- Warm and cold periods in the Pacific Ocean
- Global affects
  - Storms along the west coast
  - Rain in the southeast
  - Numerous species responses

http://en.wikipedia.org/wiki/El_Ni%C3%B1o-Southern_Oscillation#cite_note-0
Climate

Variability: North Atlantic Oscillation
- Changes in patterns of atmospheric highs and lows over the Atlantic
- Basin effects
  - Winter severity
  - Wind patterns
  - Numerous species responses

http://en.wikipedia.org/wiki/North_Atlantic_oscillation
Climate

**Change:** Greenhouse gases (from fossil fuels) increase atmospheric heat adsorption

- ~90% of increased heat in ocean
- Remainder melting ice and warming land and atmosphere

Climate - Question

Do you understand the difference between climate change and climate variability?

A) Yes
B) Sort of
C) No
Climate

- General Circulation Models (climate models)
- Simulate climate system with and without addition of greenhouse gases
- Separates natural climate variability from greenhouse gas forced change

Climate - Question

- Do you feel the scientific evidence supporting greenhouse gas driven climate change is strong or weak?

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<th>Strong</th>
<th>Weak</th>
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Climate

IPCC Consensus Statement

- “[M]ost of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations”.

http://www.ipcc.ch/
http://www.sciencemag.org/cgi/content/full/306/5702/1686
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Northeast U.S. Climate

- Coastal water temperatures are warming
- Example from Woods Hole, MA
Northeast U.S. Climate

- Maximum surface ocean temperatures are increasing
- Annual range of surface ocean temperatures is increasing

Long-term trends and regime shifts in sea surface temperature on the continental shelf of the northeast United States

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National Marine Fisheries Service, 28 Tarzwell Dr., Narragansett, RI 02882, USA

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Available online 13 June 2007
Northeast U.S. Climate

- Salinity on shelf is variable
- Possibly decreasing over the past 30 years
- Linked to freshwater input from the north
Northeast U.S. Climate

- Changes in North Atlantic circulation
- Demonstrated by surface drifter tracks since the 1991
Northeast U.S. Climate - Question

Do you think climate change in the northeast is driven more by local warming of Arctic ice melt?

A) Local Warming
B) Arctic Ice Melt
C) Neither
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http://seattletimes.nwsource.com/ABPub/2008/07/17/2004014234.jpg
Fisheries

- Fish contribute ~15-20% of animal protein to the human diets worldwide.

- Asian and developing countries much more reliant on fish protein.

Fisheries

- Fish population dynamics related to number of deaths and births into the population
- A gross simplification, but useful

Fisheries

- Births are measured as recruitment (R): the number of young fish joining (recruiting) to the adult population.
Fisheries

• Deaths are measured as natural mortality (M; predation, disease, old-age) and fishing mortality (F; capture in a fishery)

http://www.bigmarinefish.com/photos8.jpg
http://i.telegraph.co.uk/telegraph/multimedia/archive/01120/bluefin-tuna-460_1120394c.jpg
Fisheries

- Fish population dynamics related to number of deaths and births into the population
- Births = Recruitment (R)
- Deaths = Fishing (F) and Natural (M) Mortality

\[ N_{y+1} = N_y + R - F - M \]
Fisheries

- Most fisheries management assumes:
  - \( M \) is constant
  - \( R \) is a function of \( N_y \)
  - Targets \( (N_{y+1}) \) are achieved by changing \( F \)

- No role of climate change or variability

\[ N_{y+1} = N_y + R - F - M \]
Fisheries Question

- Which factor is most influenced by climate variability and climate change?

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<tr>
<th>Recruitment</th>
<th>Fishing Mortality</th>
<th>Natural Mortality</th>
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Northeast U.S. Fisheries

- The southern-end of the northeast
- More southern species of reef fish off of North Carolina
- Consistent with bottom warming
Northeast U.S. Fisheries

- On northeast shelf, 17 of 36 stocks moved poleward
- 17 of 36 stocks moved deeper
- Changes consistent with global warming
Northeast U.S. Fisheries

- Shelf fish fauna shifting to warmer water species

http://www.nefsc.noaa.gov/publications/crd/crd0911/
Northeast U.S. Fisheries

- Cod (a cold-water species) recruitment decreases with increasing temperature.
- Sustainable cod fishing rate forecasted to be lower with climate change.

\[ N_{y+1} = N_y + R - F - M \]
Northeast U.S. Fisheries

• Atlantic croaker (a warm-water species) recruitment increases with increasing temperature

• Sustainable croaker fishing rate forecasted to be higher with climate change

\[ N_{y+1} = N_y + R - F - M \]
What percentage of fish species in the northeast U.S. will be affected by climate change?

A) 47%
B) 76%
C) 100%
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http://www.gfdl.noaa.gov/pix/user_images/kd/highlights/Sea_Ice_3globes_V_314x681.png
Conclusions

- Climate variability has affected fisheries for centuries
- Climate change also affecting fisheries
Conclusions

- In a region, there will be winners and losers
- Warmer water species likely ‘winners’
- Cooler water species likely ‘losers’

http://upload.wikimedia.org/wikipedia/commons/0/08/Atlantic-cod-1.jpg
http://www.sciencedaily.com/images/2010/03/100324155407-large.jpg
Conclusions

• Need to refine projections by including:
  – Species interactions
  – More than just temperature
  – Incorporating climate variability and change into assessments
Conclusions

• Need to discuss adaptation strategies in northeast fisheries
• What are likely changes?
• What can be done to prepare / adapt?
• What about ocean acidification?

http://celebrating200years.noaa.gov/datasets/fisheries/image1_220.jpg
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For more information

- The Discovery of Global Warming (http://www.aip.org/history/climate/)
- Ecosystem Status Report for the Northeast U.S. Continental Shelf Large Marine Ecosystem (http://www.nefsc.noaa.gov/publications/crd/crd0911/)
Online Educational Resources

**Fisheries Statistics:**
Data sources for US commercial fisheries landings, fishery market information, and foreign trade information for fishery products

*Target: Intermediate elementary, Middle school, High school*

http://www.st.nmfs.noaa.gov/st1/index.html

**FishWatch - U.S. Seafood Facts**
Provides consumers with factual data to assist in decisions about sustainable seafood

Data taken from a variety of NOAA sources

*Target: Middle school, High school, College*

http://www.nmfs.noaa.gov/fishwatch/
Fisheries Science with NOAA: Fisheries:

Manage various species of fish after learning about what overfishing can do to commercial fishing.

Includes background information, data, and applications

*Target: Intermediate elementary, Middle school, High school*

http://www.oar.noaa.gov/k12/html/fisheries2.html

MARE’s Build a Fish:

Online game where students choose fish body parts best adapted to the particular environment

*Target: Elementary*

http://sv.berkeley.edu/showcase/flash/fish.html

FLOW: Fisheries Learning on the Web

FLOW is a comprehensive curriculum about the Great Lakes ecosystem

Three core units: Food Web, Water and Fish

Standards-based lesson content features hands-on activities

*Target: Upper elementary and middle school*

http://www.miseagrant.umich.edu/flow/
Project Oceanography Fish Ecology Lesson Plans

Entry-level activities
Examine the morphology of fishes, including body shape, scale and skin characteristics, coloration, mouth orientation, and fin shape.

*Target: Intermediate elementary, Middle school*


**Fishing for the Future**
Fishing simulation modeling several consecutive seasons of a commercial fishery
Explore how technology, population growth, and sustainable practices impact fish catch and fisheries management.

*Target: Middle and High school*

http://www.pbs.org/emptyoceans/educators/activities/fishing-for-the-Future.html

**C.O.O.L. Biology Project: Gone Fishing**
Online module analyzing data to predict where fish might be off the coast of New Jersey based on data collected from the Rutgers COOLroom

*Target: Middle and high school*

http://www.coolclassroom.org/cool_projects/lessons/biology/hypothesis.html
**Net Results:**

Game to investigate how decisions by watermen, recreational fishermen, and lawmakers influence and are influenced by economics and the abundance or scarcity of fish or shellfish stocks

*Target: Upper middle and high school*


**Counting FishStix**

Learn how scientists estimate the population size of different fish groups by collecting and analyzing data from surveys they conduct in the classroom.

*Target: High school*

[http://www.uncw.edu/aquarius/education/lessons/Aq%20FishStix.pdf](http://www.uncw.edu/aquarius/education/lessons/Aq%20FishStix.pdf)
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