Ocean Warming and Marine Fisheries in the Northeast U. S.

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Northeast Monthly Climate Update
November 30, 2017
Outline

• Warming on the Northeast Shelf
• Impacts on species and fisheries
• Resilience and adaptation in fisheries

Acknowledgements:
Outline

- Warming on the Northeast Shelf
- Impacts on species and fisheries
- Resilience and adaptation in fisheries
Rapid warming trend

Gulf of Maine Sea Surface Temperature

Source: NOAA OISST
Rapid warming trend

Gulf of Maine Sea Surface Temperature

Source: NOAA OISST

GOM: 0.04 °C / yr
Rapid warming trend
Rapid warming trend

Gulf of Maine Sea Surface Temperature

GOM 10-yr: 0.18 °C / yr
GOM: 0.04 °C / yr
Global: 0.01 °C / yr

Source: NOAA OISST
Rapid warming trend

(Pershing et al. 2015)
Rapid warming trend

(Pershing et al. 2015)
Rapid warming trend

(Thomas et al. 2017)
Warm events—2012 heat wave

- Largest, most intense SST anomaly ever in the North Atlantic
- Comparable in scale to El Nino
- Warming comparable to predictions for end of century

(Mills et al. 2013)
Warm events—2012 heat wave

• Largest, most intense SST anomaly ever in the North Atlantic
• Comparable in scale to El Nino
• Warming comparable to predictions for end of century
Changing seasonality

- Length of “summer” increasing
- 2 days/yr in Gulf of Maine since 1982

(Thomas et al. 2017)
Changing seasonality

- Difference between end of summer and start of summer
  - “summer” lengthening due to later end for most of region
  - “summer” lengthening due to earlier start in mid-Atlantic

(Thomas et al. 2017)
Outline

• Warming on the Northeast Shelf
• Impacts on species and fisheries
• Resilience and adaptation in fisheries
Ecological effects

• Changes in ecosystem and populations
  • Distribution
  • Productivity
  • Timing
  • Interactions
Spatial distribution

Many stocks moving poleward and to deeper depths

(Nye et al. 2009)

(NEFSC 2015)
Spatial distribution

Mid-Atlantic species moving into the Gulf of Maine
Spatial distribution

Center of Latitude

Change in Summer Flounder Kept Catch from (1996-1998) to (2011-2013)

Change in percentage
- decrease
- increase

Latitude (degrees N)

Year


38 39 40 41 42 43
Population productivity

Many mechanisms and pathways:
- e.g., temperature, pH, disease, predator-prey interactions
- e.g., individual growth, reproduction, recruitment, mortality

(Fogarty et al. 2008)

Atlantic cod

(Fogarty et al. 2008)

Atlantic croaker

(Hare et al. 2010)
Population productivity

- Effects on commercially-targeted species
Population productivity

- Effects on protected species

(Mills et al. 2013)
Phenology

New England’s lobster fishery

• Valued at over $617 M in 2015

• Most valuable species fished in U.S. since 2014

• Accounts for 88% of NH’s landed value and 80% of Maine’s
Phenology

(Mills et al. 2013)
Phenology

(Mills et al. 2013)
Phenology

(Mills et al. 2013)
Outline

• Warming on the Northeast Shelf
• Impacts on species and fisheries
• Resilience and adaptation in fisheries
Climate resilience and adaptation

Challenges:

- Moving beyond historical analogues
- Differential response rates (biological and human)
- Changing social, economic, institutional contexts
Climate resilience and adaptation

(a) Global average surface temperature change

- Black: historical
- Blue: RCP2.6
- Red: RCP8.5

(IPCC 2014)
Climate resilience and adaptation

2002-2016

Predicted

(Saba et al. 2016)
Climate resilience and adaptation

- Account for Trends
- Manage for Resilience
- Forecasts
- Stay or Go?
- Infrastructure

Space
- Individual
- Community
- Fishery
- Management

Time
- Seasonal
- Annual
- Decadal

(Mills et al., in prep.)
Climate resilience and adaptation

Challenges:

• Moving beyond historical analogues
• Differential response rates (biological and human)
• Changing social, economic, institutional contexts

Responses:

• Assess vulnerabilities and opportunities
• Build industry and community capacity for adaptation
• New climate-relevant information streams
Climate resilience and adaptation

Evaluating Social-Ecological Vulnerability and Climate Adaptation Strategies for Northeast U. S. Fishing Communities

- Assess vulnerability of fishing communities to climate impacts
- Evaluate social and economic outcomes of climate-driven changes in species availability
- Quantify benefits of potential adaptation strategies
- Identify factors that facilitate or hinder adaptation
Social-ecological vulnerability assessment

Adapted from Cinner et al. 2013; Johnson and Welch 2010
In-depth analyses in four communities

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<th>Low diversity</th>
<th>North</th>
<th>South</th>
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<tbody>
<tr>
<td>Stonington, ME</td>
<td>New Bedford, MA</td>
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| High diversity | Portland, ME    | Point Judith, RI |

- Model social and economic outcomes
- Identify and evaluate adaptation strategies of interest
- Assess factors that facilitate or hinder adaptation
New information streams: forecasts
New information streams: forecasts

Piecewise Regression Example: 2009

Cumulative Landings (millions of pounds)
Month

Cumulative Landings (10^3 metric tons)
Day of Year

Combined $R^2=0.98$
New information streams: forecasts
New information streams: forecasts

Piecewise Regression Example: 2009

Cumulative Landings (10^6 metric tons)

Combined $R^2 = 0.98$

Start Day

Day of Year

Relationship between Start Day and April 1 temperature anomaly

$2012$ as out-of-sample

$R^2 = 0.85$

April 1 Temperature Anomaly, degC

Start Day, day of year


2004 2009
New information streams: forecasts

### April 13 Forecast

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<th>Extremely Early</th>
<th>Very Early</th>
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<th>Normal</th>
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Photo: Curt Brown, Ready Seafood
Forecast development with industry

- What decisions do participants face that would be supported by forecasts?
- How do they currently use information?
- In what form is information most useful?
  - Access
  - Format
  - Communication
  - Training
Conclusions

• Warming on Northeast Shelf:
  • Rapid rate, extreme events, seasonal timing
• Effects on species in the region
• Impacts communities and management systems
• Northeast communities are at forefront of building readiness for climate adaptation
  • New efforts to support adaptation—assessments, information, strategies
  • Opportunities to learn globally-relevant lessons here
• Consider future conditions when making decisions
Questions?

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