Climate forcing: marine fish responses

Outline: sketches of four topics

1.) Climate forcing via NAO—altering oceanographic contexts

2.) An oceanographic/climate data source

3.) NAO influence on fish assemblages—hypothesis testing at large spatial scales

4.) Testing climate’s influence relative to others—methods and an example

Jon Fisher
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1.) Winter North Atlantic Oscillation (NAO) index

**High/Positive NAO years:**

- Strong Iceland Low; strong Azores High
- Warm, wet conditions in eastern US
- Cool, stormy conditions in northeast Canada and Greenland
- Decreased transport of cold Labrador slope water to southwest

Winter surface air pressure shown as labelled lines
Wind anomalies shown as green arrows

Low/Negative NAO years:
Weak Iceland Low; weak Azores High
Cool, dry conditions in eastern US
Warm, calm conditions in northeast Canada and Greenland
Increased transport of cold Labrador slope water to southwest

Correlation between NAO and SST

Salmon –NAO-SST relationships are well developed...focus on testing hypotheses

Visbeck et al. (2001) PNAS
How does the Gulf of Maine (and adjacent areas) respond to NAO forcing on a fine spatial scale?
2.) An oceanographic and climate data source


AZMP (20 time series)

BIOCHEM (1575 research missions; 92,560 sampling events; 2,224,000 discrete measurements; 522,500 plankton measurements)

Oceanographic Databases (Climate-Hydrography ~850,000 T,S profiles to 1920; Ocean Colour (1997-2004))

Provide data that may compliment/expand available US Sources (U. Maine chl., etc.)
Some data sources include the Gulf of Maine. How does the Gulf of Maine (and adjacent areas) respond to NAO forcing at a fine spatial scale?
Difference in bottom temperature (-NAO minus +NAO years)

NAO ‘run years’ T, S from Climate database

Warmer during –NAO years than +NAO years

Cooler during –NAO years than +NAO years

Shelf bottom water responses to the NAO

- NAO years: Minimum temperature difference between north and south
+ NAO years: Maximum temperature difference between north and south

3.) NAO influence on fish assemblages—hypothesis testing at large spatial scales

e.g. How does marine species richness respond to the NAO?

What is the mechanism driving interannual variability?

Combined trawl survey data from the northwest Atlantic

1973 to 2003; 35° to 55° N
(0-200 m to 47° N; 0-350 m ≥ 48° N)

8933 USA samples; Fall survey
4404 Scotia/Fundy samples; July survey
13887 Nfld. and Labrador samples; June-December samples
Trawl survey data—shelf bottom water temperatures

Warmer than average during +NAO years

Warmer than average during –NAO years
Are the yearly changes in the species diversity gradient related to the strength of the NAO?

Annual NAO strengths and diversity gradients are significantly negatively related ($r = -0.41$, $n = 31$ years, $P = 0.01$).
Patterns not simply due to changes in the distribution of few species

- 133 species had ≥20% difference in frequency of occurrence between +NAO and –NAO years (26 in GOM)

- As expected, at southern latitudes, more species were observed during +NAO; more northern species observed during –NAO ($r = -0.54$)

- Gulf of Maine changes were influenced by both southern and northern species
$H_a$: NAO influence on shelf productivity?

Based on rather informal analyses (correlation): No strong evidence from long-term CPR greenness time series or 1997-2004 satellite chl
Potential implications for salmon

Demonstrated NAO influence via physiological tolerance is a direct and *simple* mechanism (no species interactions, no population dynamics, single TL)

Oceanographic (productivity) allowed testing competing hypothesis

Potential salmon predators/prey shift distributions quickly (annually) with no apparent lag in NAO-temperature (shallow shelf) or NAO-species response

Positive temperature anomalies in GOM contrast high latitude—salmon climb steeper gradient (NAO+)

Additional (e.g. NMFS spring trawl) survey data are available
4.) Testing climate’s influence relative to others—methods and an example
Ecological thresholds and regime shifts: approaches to identification

Tom Andersen¹, Jacob Carstensen², Emilio Hernández-García³ and Carlos M. Duarte⁴
# Ecological thresholds and regime shifts: approaches to identification

Tom Andersen¹, Jacob Carstensen², Emilio Hernández-García³ and Carlos M. Duarte⁴

## Table 1. Software for regime shift detection

<table>
<thead>
<tr>
<th>Program</th>
<th>Methods</th>
<th>Approach</th>
<th>Availability</th>
<th>Authors</th>
<th>URL</th>
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</thead>
<tbody>
<tr>
<td>Dimensionality reduction</td>
<td>Linear (PCA, etc.) and nonlinear dimensionality reduction methods</td>
<td>Exploratory</td>
<td>Freeware, Matlab scripts, multiple OS</td>
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<td>toolbox</td>
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<td><a href="http://cran.r-project.org/web/packages/strucchange/index.html">http://cran.r-project.org/web/packages/strucchange/index.html</a></td>
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<tr>
<td>Strucchange</td>
<td>Multiple change-points, F tests, empirical fluctuation processes, etc.</td>
<td>Inferential</td>
<td>Freeware, R package, multiple OS</td>
<td>A. Zeileis et al. [39]</td>
<td><a href="http://cran.r-project.org/web/packages/strucchange/index.html">http://cran.r-project.org/web/packages/strucchange/index.html</a></td>
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</tbody>
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How do extrinsic and intrinsic factors contribute to trophic structuring?

Western Scotian Shelf 4 trophic level system

Why does top-predator biomass remain stable despite increasing potential prey biomass and other changes at low trophic levels?

Consistent with bottom-up effects or trait changes in predators affecting lower levels?

From: N.L. Shackell et al. (in prep.)
WSS Population Trends

Population Biomass (PC1 =40%)

Oceanography (PC1 =60%)

Oceanographic data from BIOCHEM

From: N.L. Shackell et al. (in prep.)

Does multivariate oceanographic or traits information provide more explanatory power?
Body size, not oceanographic conditions parallel WSS population trends and may explain lack of top-predator response.

GAM tests confirm the apparent influence of size.

From: N.L. Shackell et al. (in prep.)
Potential implications for salmon

Diverse methods, software, and data are available to test specific hypotheses about regime change.

Examining intrinsic (e.g., traits) vs. extrinsic (e.g., climate) influences on population time series may be useful.

For salmon, returns provide population time series at multiple spatial scales and climate influences (and from different areas) could be tested against each other.
End.
Correlation between NAO and SST

From: Hurrell and Dickson (2004) in Marine Ecosystems and Climate Variation
1.) The winter North Atlantic Oscillation (NAO) index

- Dec.-Feb. difference in sea level pressure between Iceland (low) and Azores (high)

- Dominant climate signal across the north Atlantic

- The NAO Influences climate from US east coast to Siberia via changing wind speeds and directions

Winter sea level pressure fields. (Ottersen et al. [2001] Oecologia)