Climate Change and Subarctic Fisheries

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- “The close link between climate and fisheries is best illustrated by the effect of ‘unexpected’ events – i.e. non-seasonal and sometimes catastrophic….”

- Due to “the complex nature of biological systems and their ability to evolve with their changing environment…non-stationarity seems to be the rule, and this will prevent simple linear empirical models from being used as predictive tools”
NAO: North Atlantic Oscillation
North Atlantic Cod
world’s most-studied fish

- **North Sea**: _NAO/warm_ … unfavorable
  (increase metabolic rates, decrease food).

- **Barents Sea**: _NAO/warm_ … favorable
  (higher primary production, zooplankton influx, more food, higher growth).

- **Newfoundland_Labrador**: _NAO/cold_ … unfavorable
  (slow growth, low food).
Atlanto-Scandian herring

- Abundance increased during warm periods, or low ice around Iceland, at the extreme north of their range. Decreased in –NAO/icy periods.
- +NAO/warm periods in NE Atlantic favorable (opposite for North Sea herring and others towards southern limit of range).
Generalizations from N. Atlantic

- Warmer conditions tend to benefit fish populations at the northern extreme of the species’ range, harm populations at the southern extreme; colder conditions have opposite effect.

- But, “warm” or “cold” conditions typically involve other changes besides temperature, some of which might be more important – e.g., stratification, primary production, larval drift, storminess, hatching of prey species.
Evolutionary aspects

- Small pelagic species w/ short lifespans (e.g. herring, capelin, shrimp) tend to be immediately sensitive to ocean climate.

- Longer-lived species (e.g. cod) adapted by “integrating” across decadal-scale variations; older individuals are reproductively robust.

- Fisheries remove large and old fish first, eliminating this climatic adaptation.
PDO: Pacific Decadal Oscillation

monthly values for the PDO index: January 1900–December 2003
Northern Pacific fisheries
“regime shift,” _PDO to +PDO, 1976-77

- **Alaska salmon**: +PDO/wet NE Pacific … favorable to abundance (water column vertically stable, more biological productivity, more food) but not size.

- **Groundfish**: (~50% US fisheries value) +PDO … favorable to some species’ abundance, but not all (increased productivity). Again, abundance might be negatively related to size-at-age.

- Zooplankton timing favors some species over others.

- Intra- and inter-species interactions filter climate impacts.
Regime change in the Bering Sea  (Policansky 2004)
Great ice/salinity anomaly of 1966-78

Propagation of the “Great Salinity Anomaly” of the 1970s
(simplified after Dickson et al., 1988)
Late-1960s herring collapse coincided with arrival of an Arctic-origin Great Salinity Anomaly – GSA’70s.
Integrating time series across disciplines: Newfoundland’s Northern Peninsula and the northern Gulf of St. Lawrence
The “other” teleconnection ... Humans

The diagram shows time series data for BC herring catch and Iceland herring catch, both measured in 1000 metric tons. The data spans from 1900 to 2000. There is a high correlation between the two catch rates, indicated by the correlation coefficient $r = 0.70$. The peak around 1960 suggests a significant event or factor affecting both catches.

Key points:
- The BC herring catch (blue line) and Iceland herring catch (red line) are depicted.
- The years range from 1900 to 2000, with notable peaks around 1960.
- The correlation coefficient ($r = 0.70$) indicates a strong positive relationship between the two catch rates.
The “other” teleconnection ... Humans
Regime change in the Bering Sea – a second look