Spatial-scales

Natural Climate Variability & Ocean Ecosystems

An important ocean scales:
Decadal Oscillations & Fish Regimes
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**Decadal Time Scales:**
Basin Wide Variability

1. Pacific Decadal Oscillation
2. North Atlantic Oscillation
NAO Index = SLP_{(Azores High)} – SLP_{(Iceland Low)}

measured November through March
The North Atlantic Oscillation Index

The North Atlantic Oscillation (NAO) index, 1864–2001 (Hurrell)

The NAO index shows large variations from year to year. This interannual signal was especially strong during the end of the 19th century.

measured December through March
The North Atlantic Oscillation (NAO) index shows large variations from year to year. This interannual signal was especially strong during the end of the 19th century. Sometimes the NAO index stays in one phase for several years in a row. This decadal variability was quite strong in the second half of the 20th century.
The positive NAO index phase shows a stronger than usual subtropical high pressure center and a deeper than normal Icelandic low.

The increased pressure difference results in more and stronger winter storms crossing the Atlantic Ocean on a more northerly track.

This results in warm and wet winters in Northern Europe and in cold and dry winters in Mediterranean region.

The eastern US experiences mild and wet winter conditions.
The negative NAO index phase shows a weak subtropical high and weak Icelandic low.

The reduced pressure gradient results in fewer and weaker winter storms crossing on a more west-east pathway.

They bring moist air into the Mediterranean and cold weather to northern Europe.

The US east cost experiences more cold air outbreaks and hence snowy winter conditions.
Positive Phase

Negative Phase

SST Anomalies
The North Atlantic Oscillation

As we now know, this east-west temperature seesaw was due to changes in the north-south contrast in sea level pressure over the North Atlantic Ocean, with low pressure in the north and high pressure in the south near the Azores. The pressure gradient drives surface winds and wintertime storms from west to east across the North Atlantic. Variations in this pressure gradient affect the winds and storms tracks, thereby altering sea surface temperature, air temperature and precipitation. The impacts of this climate phenomenon reach as far as the eastern Mediterranean, southward to West Africa, westward to North America and extend throughout the entire Arctic region. These changes in atmospheric pressure and its associated impacts are known as the North Atlantic Oscillation (NAO).
The North Atlantic Oscillation

**Negative Phase**

- ✓ Less winter outberaks --> Reduced snow cover
- ✓ Warmer temperature --> Red Tides
- ✓ Colder SST --> reduced Hurricanes
- ✓ Colder SST --> less Cod reproduction (Grand Banks)
The North Atlantic Oscillation

Positive Phase

- Mild Winter N Europe --> reduced hydroelectric power
- Less rain SE Europe --> reduced drinking water & reduced stream flow in Middle East
- Increased length of growing season
- Impact on harvest of grapes and olives
The North Atlantic Oscillation

The Sensitivity of Significant Wave Height in the Wintertime (DJFM) to the NAO
NAO and fish catch in the North Atlantic

Topliss, BIO, Canada

Each time series shows a comparison between (coloured lines) historic fish catch records and (black lines) MONACLE, with its zero axis (horizontal black line) indicating positive and negative feedback in all regions. The autocorrelation time was 7 or 9 years, seasonality months are those as in world map and season lengths were 3 months except 2 months for the Norway subplot.

Northern Norway Cod

UK - Larvae (Russell Cycle) & Gadoids

New England - Mackerel

Portugal - Sardines

B.J. Topliss, Bedford Institute of Oceanography 23/11/00
Ecological effects of the North Atlantic Oscillation

Geir Ottersen, Benjamin Planque, Andrea Belgrano, Eric Post, Philip C. Reid, Nils C. Stenseth

*Posted on class website (12 pages)*

...more than 100 documented correlation between NAO and marine ecosystems.

How to make sense?
Ecological effects of the North Atlantic Oscillation

The response to NAO is classified into 3 types:

**DIRECT** - A direct ecological response to one of the environmental parameters synchronised with the NAO.

**INDIRECT** - The indirect effects of the NAO are non-trivial mechanisms that either involve several physical or biological intermediary steps between the NAO and the ecological trait and/or have no direct impact on the biology of the population.

**INTEGRATED** - The integrated effects of the NAO involve simple ecological responses that can occur during and after the year of an NAO extreme. This is the case when a population has to be repeatedly affected by a particular environmental situation before the ecological change can be perceived (biological inertia). or when the environmental parameter affecting the population is itself modulated over a number of years (physical inertia).
Ecological effects of the North Atlantic Oscillation

**Direct Effects**

**Temperature Mediated Response**
Length of active growing season, Individual growth (size), growth rate, eggs variability, timing of reproduction, spawning, time of food availability, larval growth and mortality,

**Indirect Effects**

**Physically induced by changes in oceanic transport**
Changes in spatial distribution of phytoplankton and larvae, alteration in competition between different levels of the trophic chain and alteration in food web

**Effects on Predator-Prey**
Through changes/alteration in the food
Fig 4.1 shows a schematic diagram of the impact of the North Atlantic Oscillation (±) on ungulate populations in northern Europe. The thick green line beneath the circles is a rough graph of ungulate abundance over time, with time along the x-axis, and abundance along the y-axis.
NAO and Copepods (*Calanus Finmarchicus*)

Difficult to identify causes of observed relationships

**Hypotheses:**

1) Changes in food availability

2) Alteration of competition balance

3) Variations in transport of individuals from North Atlantic
The North Atlantic Oscillation

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★ The dynamics of the NAO are not fully understood and in particular its sensitivity to ocean, land or changes in the sea-ice conditions need more study.

★ Some scientists argue that the NAO is strongly coupled to the stratosphere and will be significantly influenced by "global warming".

★ Other scientists see evidence for coupling with the North Atlantic Ocean.

★ It has also been suggested that tropical ocean temperatures can influence the phase of the NAO.
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