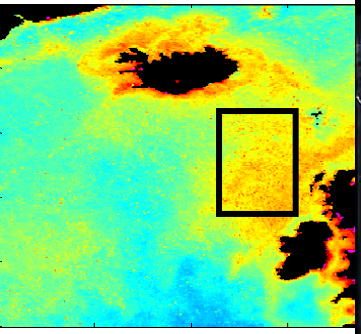
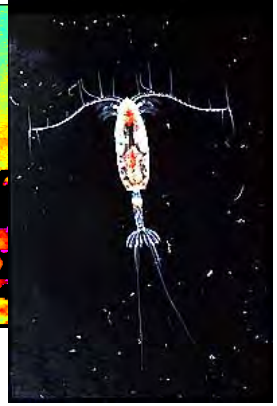




Large-scale shifts in the North Atlantic bio-geography

forced by the subpolar gyre

Hjálmar Hátún

Co-authors: M. R. Payne, G, Beaugrand, P. C. Reid, A. Sandø, H. Drange, B. Hansen, J. A. Jacobsen, D. Bloch, Heubeck, M. and Frederiksen, M.

NERSC

HAVSTOVAN
FAROE MARINE RESEARCH INSTITUTE

SAHFOS Sir Alister Hardy Foundation for Ocean Science

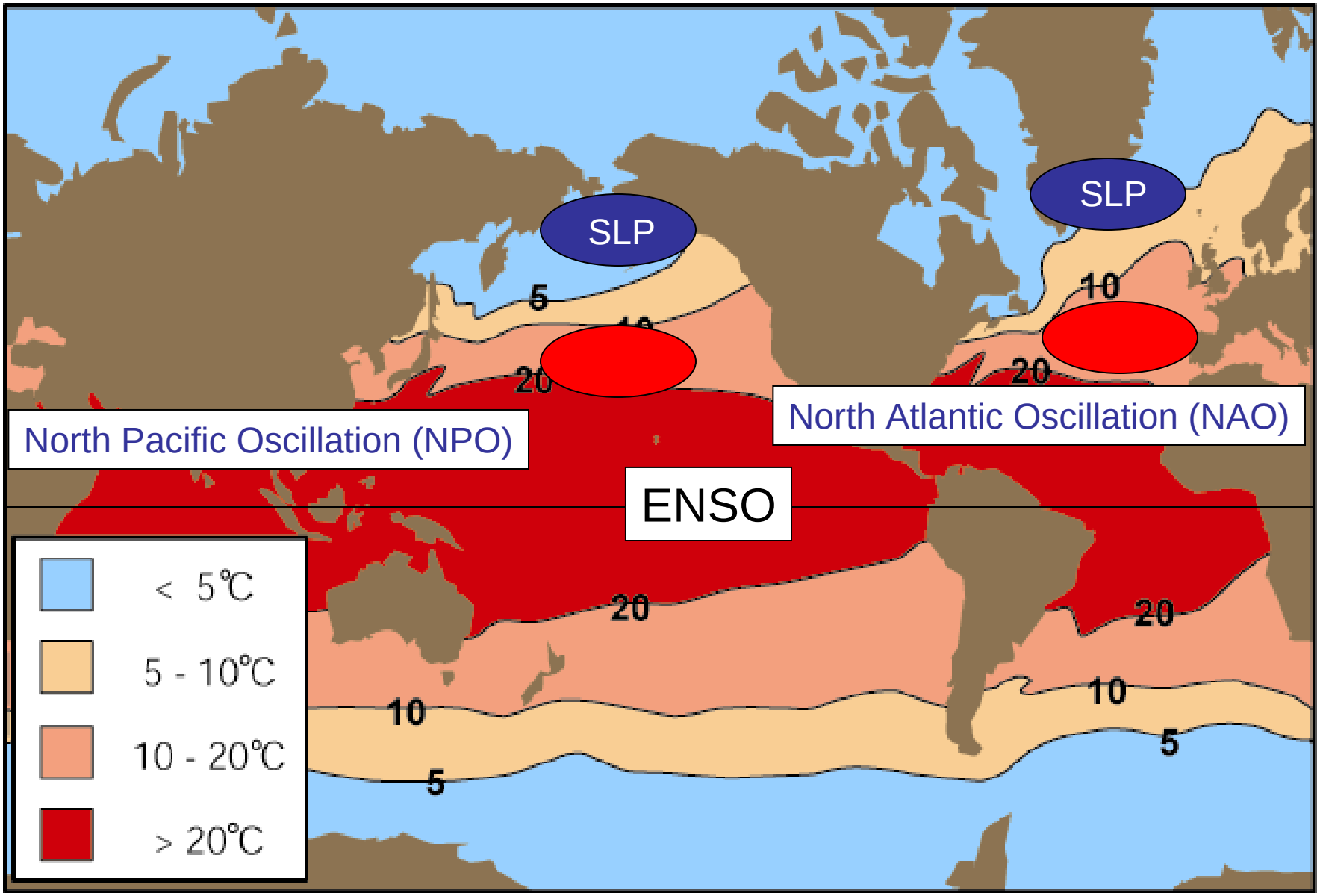
PICES - 2010

Overview

1. Recent oceanic indices – Pacific and Atlantic
2. The North Atlantic subpolar gyre
   a. Marine climate
   b. Plankton
   c. Pelagic gadoid (blue whiting)
   d. Pilot whales
3. Sub-decadal ocillations
   a. Impact on on-shelf ecosystems (kittiwake breeding succes).
   b. Potential predictability
4. A possible Pacific-Atlantic Teleconnection

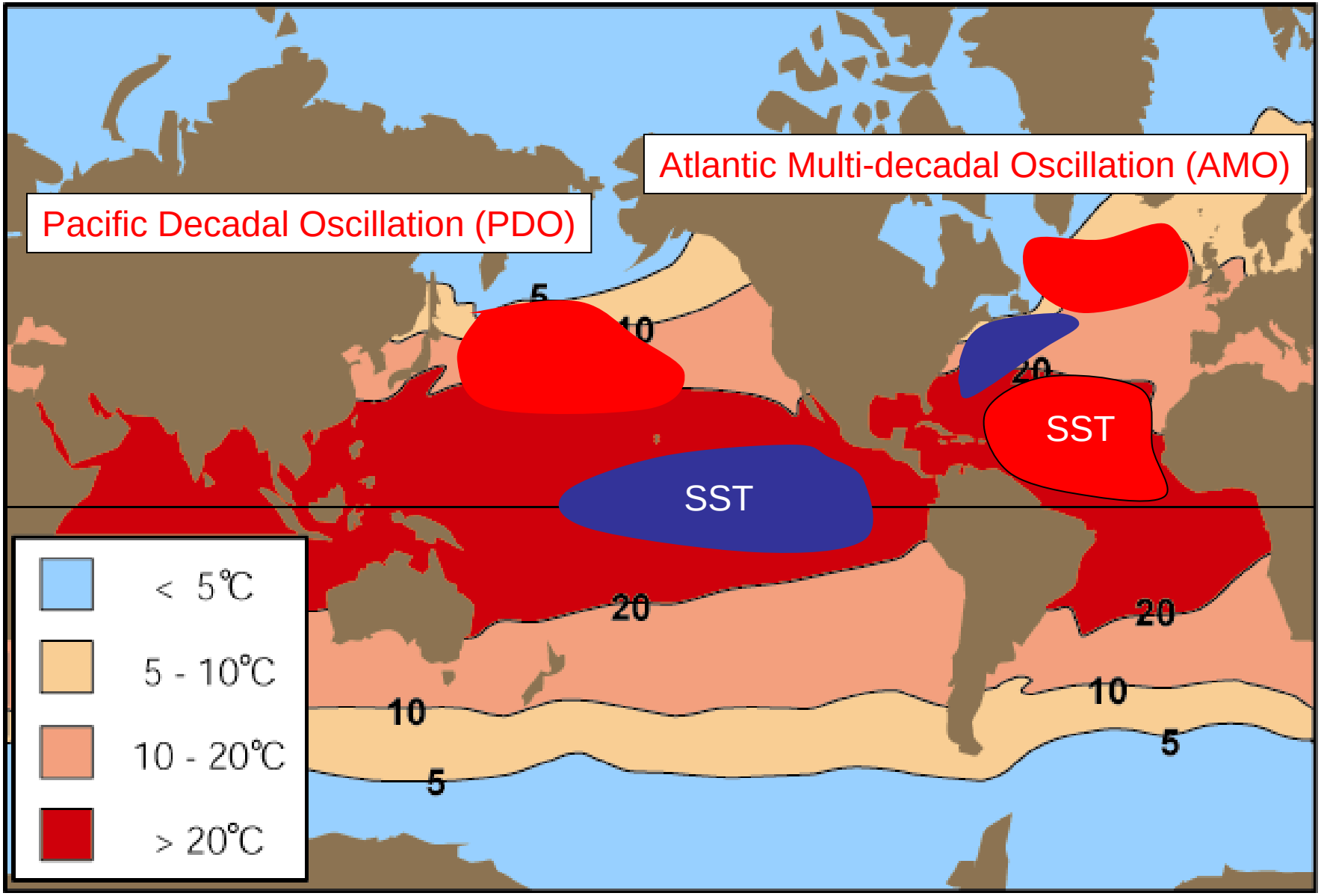
1. Popular Climate Indices:

Atmospheric (SLP) patterns



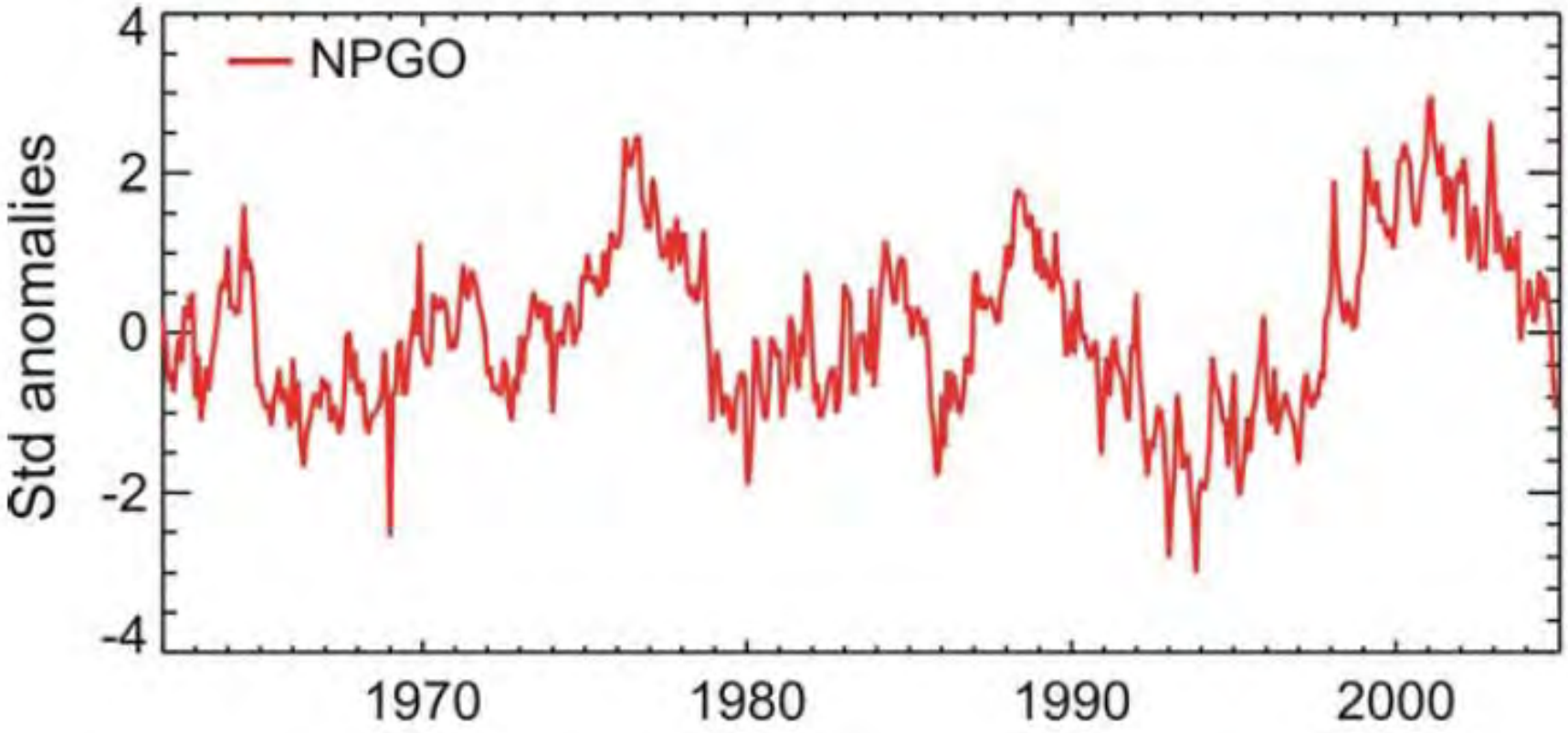
1. Popular Climate Indices:

Sea Surface Temperature (SST) patterns



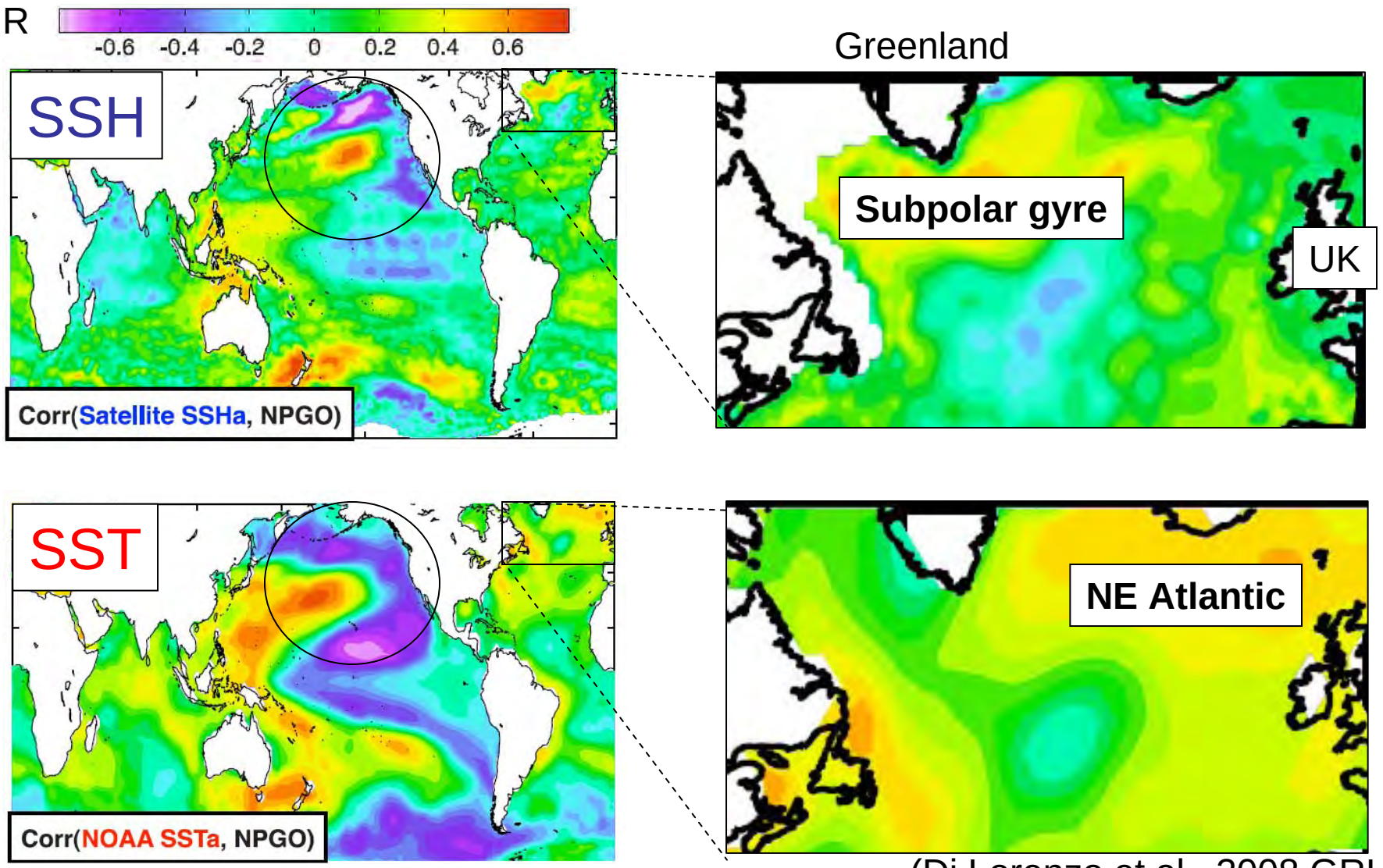
North Pacific Gyre Oscillation (NPGO)

(Based on sea surface height, SSH)



(Di Lorenzo et al., 2008 GRL)

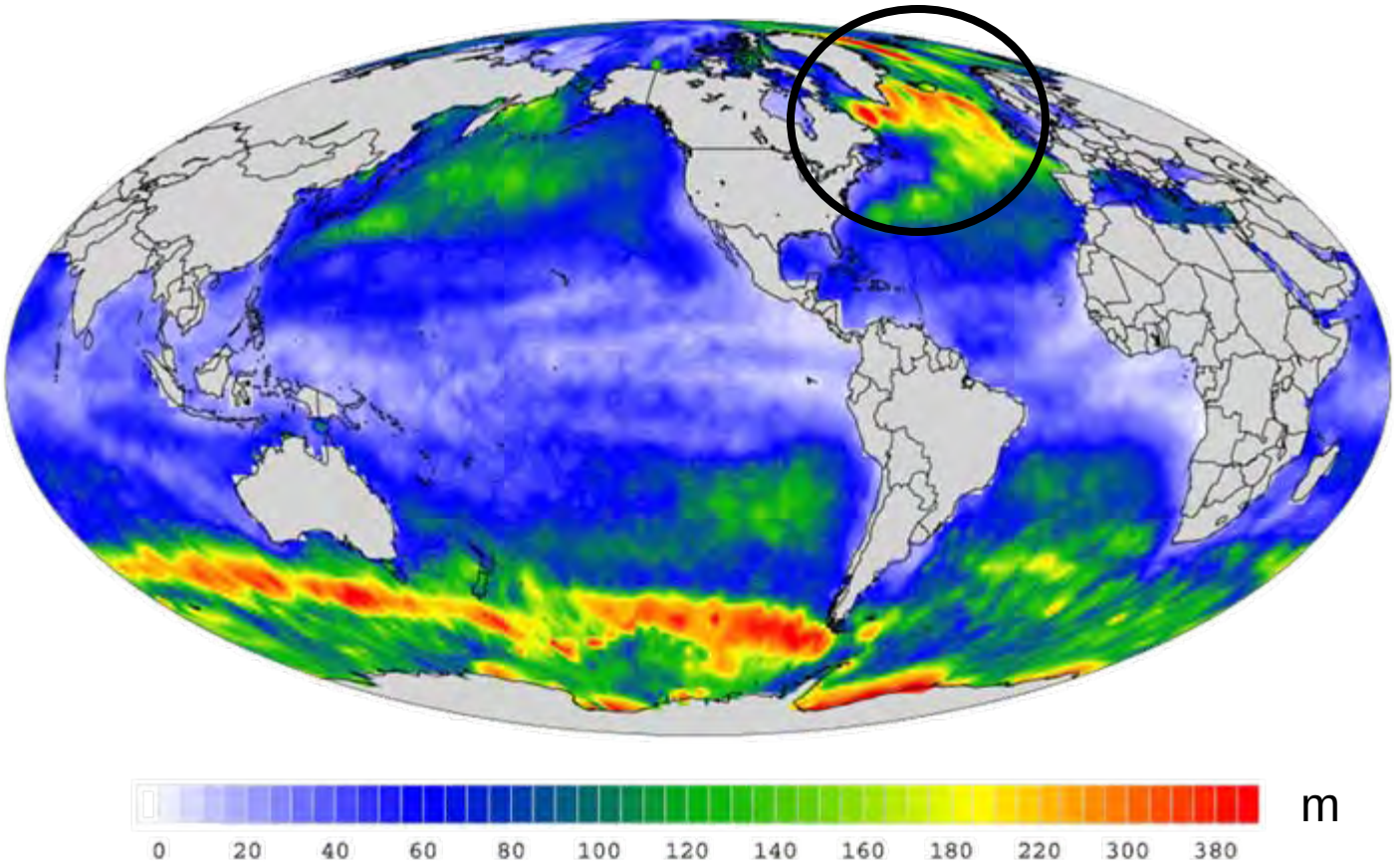
The NPGO and the North Atlantic



(Di Lorenzo et al., 2008 GRL)

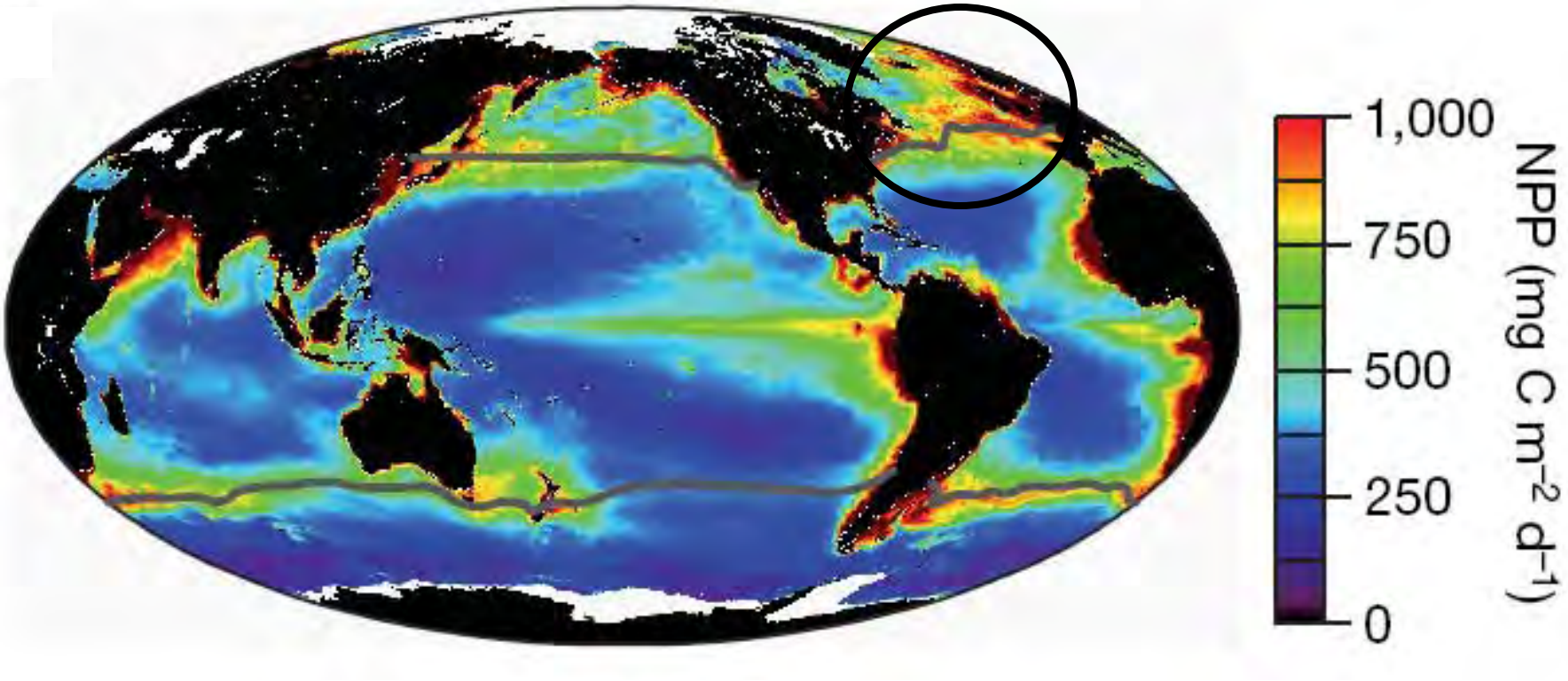
The energetic and productive North Atlantic Ocean

Mixed layer depth seasonal cycle



The energetic and productive North Atlantic Ocean

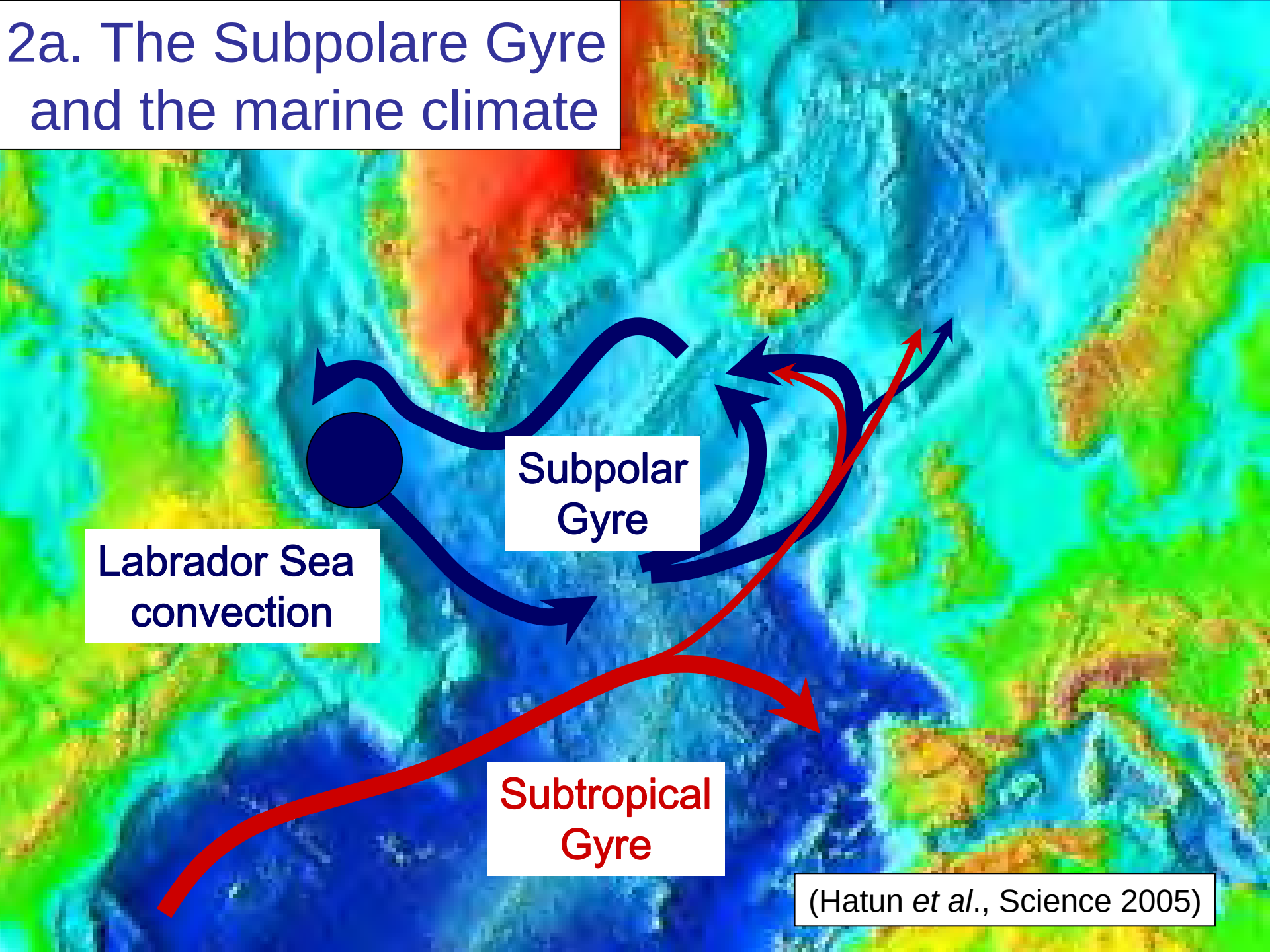
Net Primary Production (NPP)



(Behrenfeld et al., 2006 Nature)

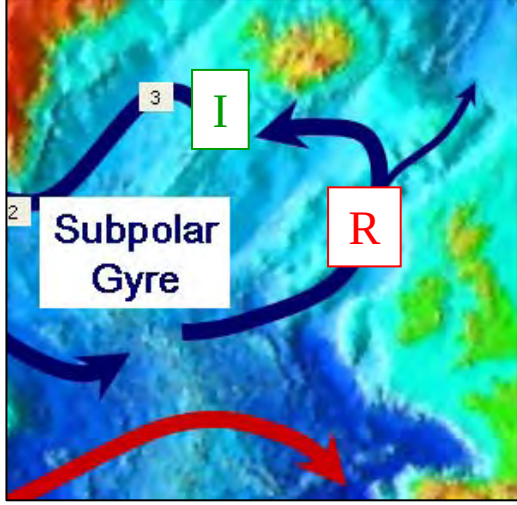
2.The North Atlantic Subpolar Gyre and Marine Ecosystems

2a. The Subpolare Gyre and the marine climate



(Hatun *et al*., Science 2005)

2a. The Subpolare Gyre and the marine climate



Record high T and S

Weak.

Salinity at Rockall (obs.)

Gyre index
(GI)

Salinity in the Irminger Current (obs.)

Strong

Salinity anomaly

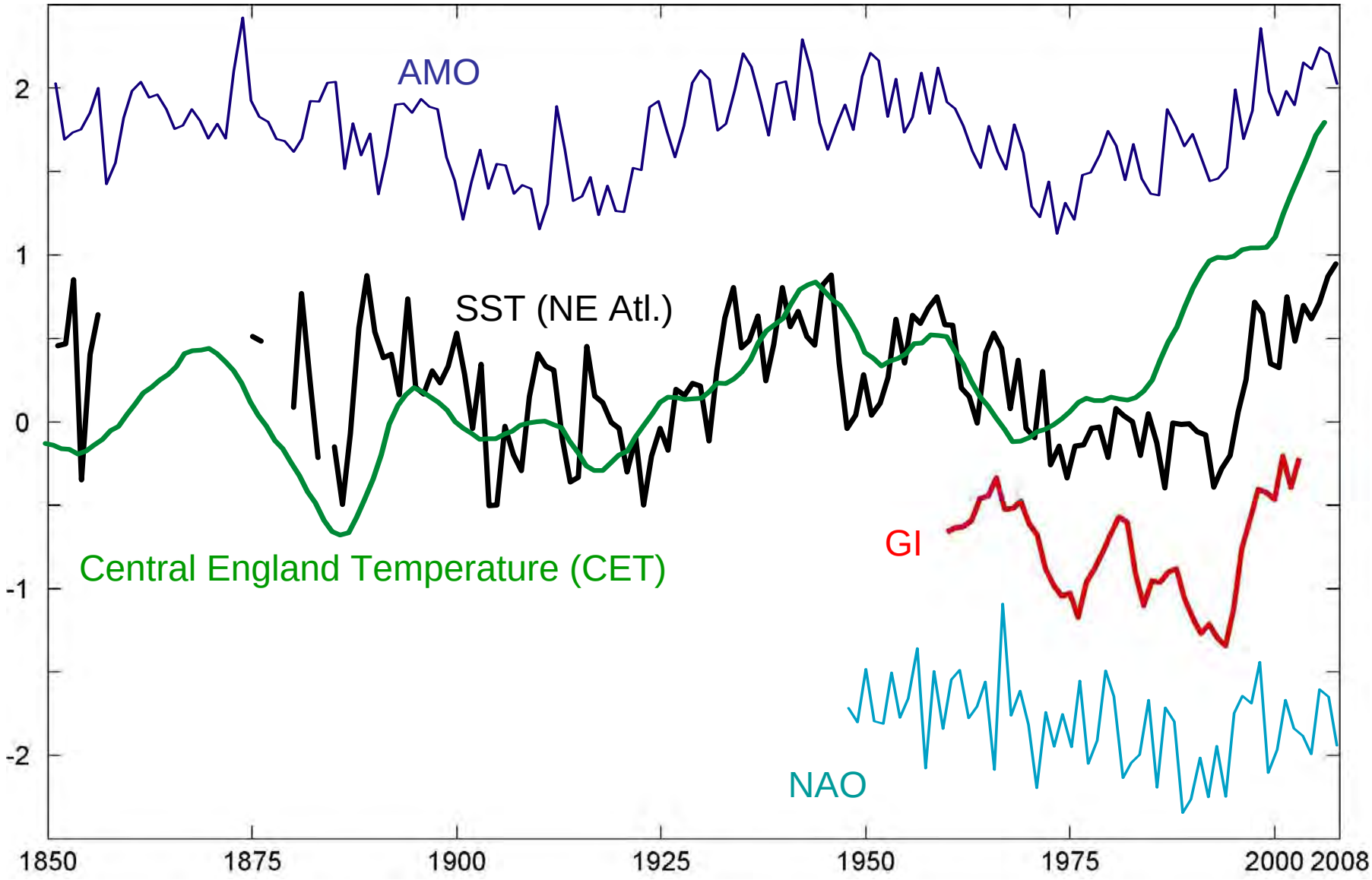
Gyre index (cm)

0.10
0.06
0.02
0
-0.02
-0.06
-0.10

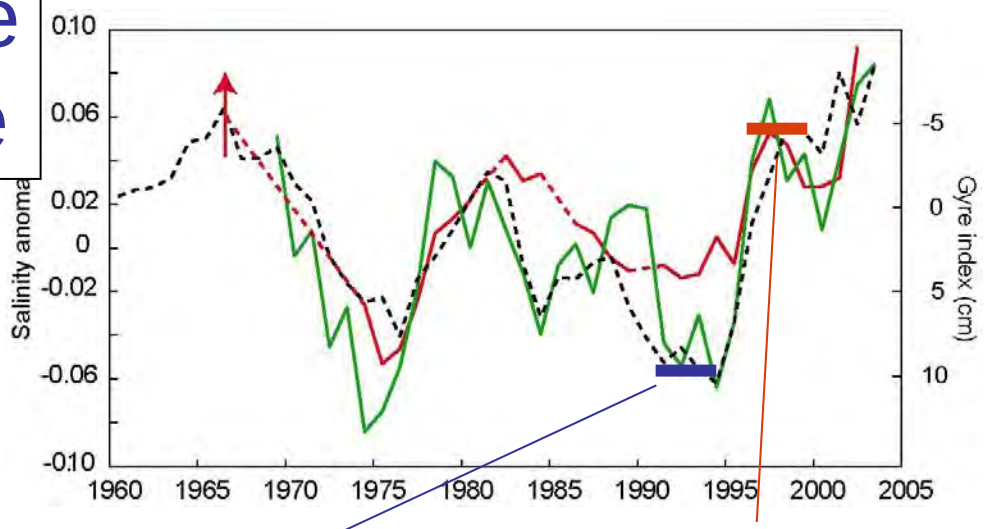
-5
0
5
10

1960 1965 1970 1975 1980 1985 1990 1995 2000 2005

Atlantic Climate Indices (and proxies)



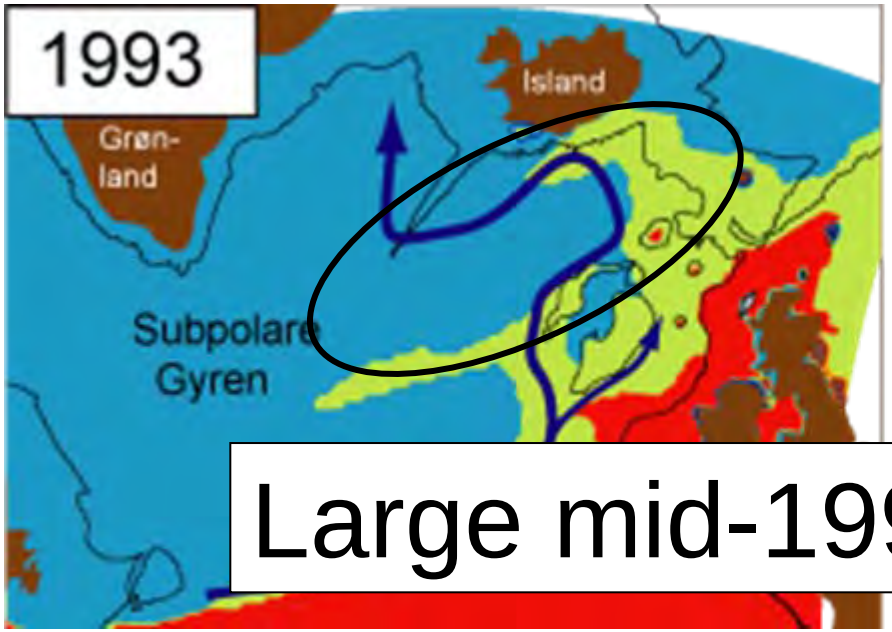
2a. The Subpolare Gyre and the marine climate

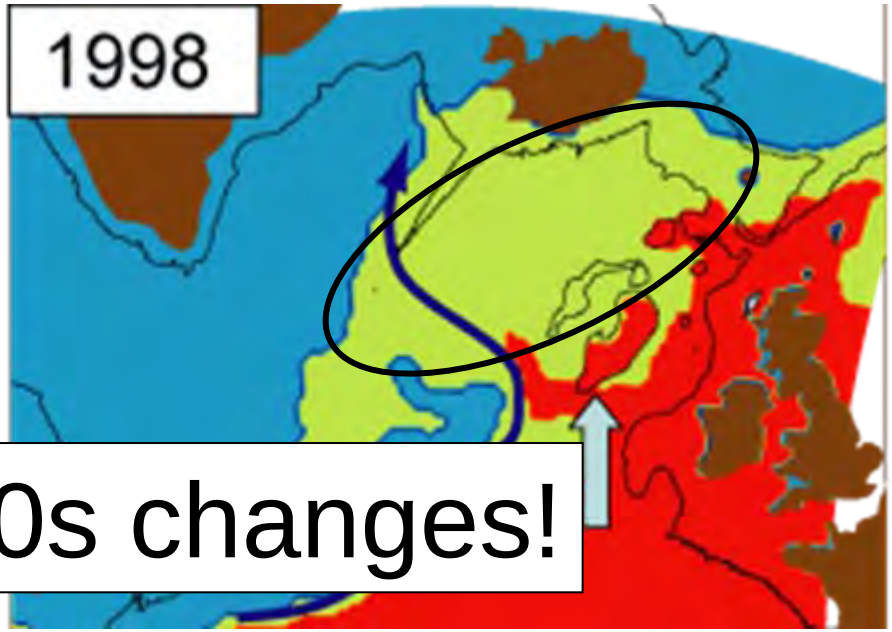


Cold

Warm

Simulated temperature



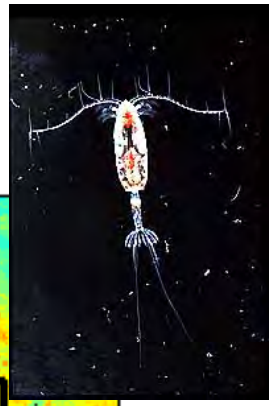


Large mid-1990s changes!

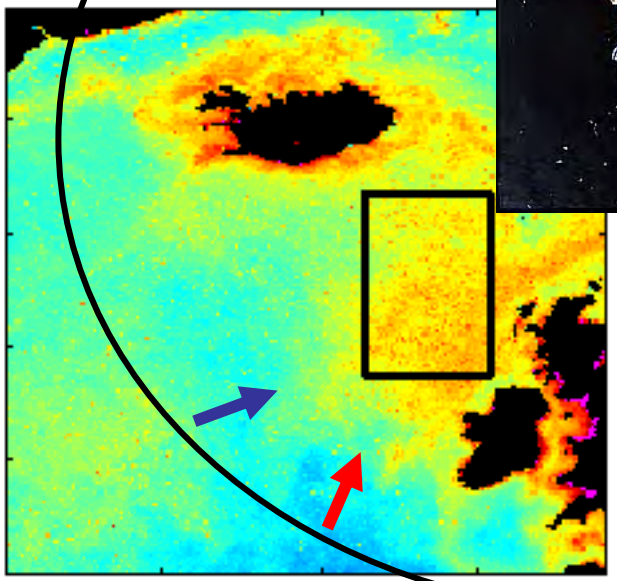
2b. The Subpolar Gyre and the marine ecosystem

Pilot whales

Blue whiting

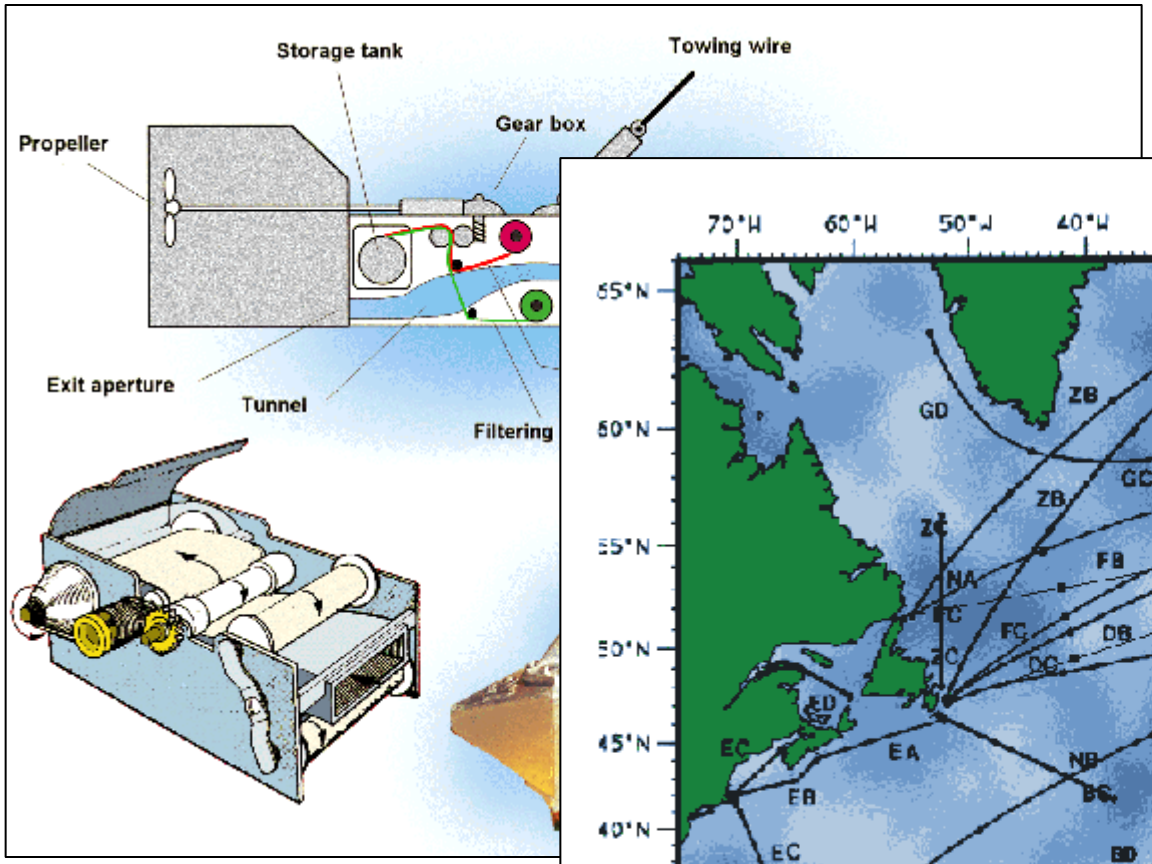


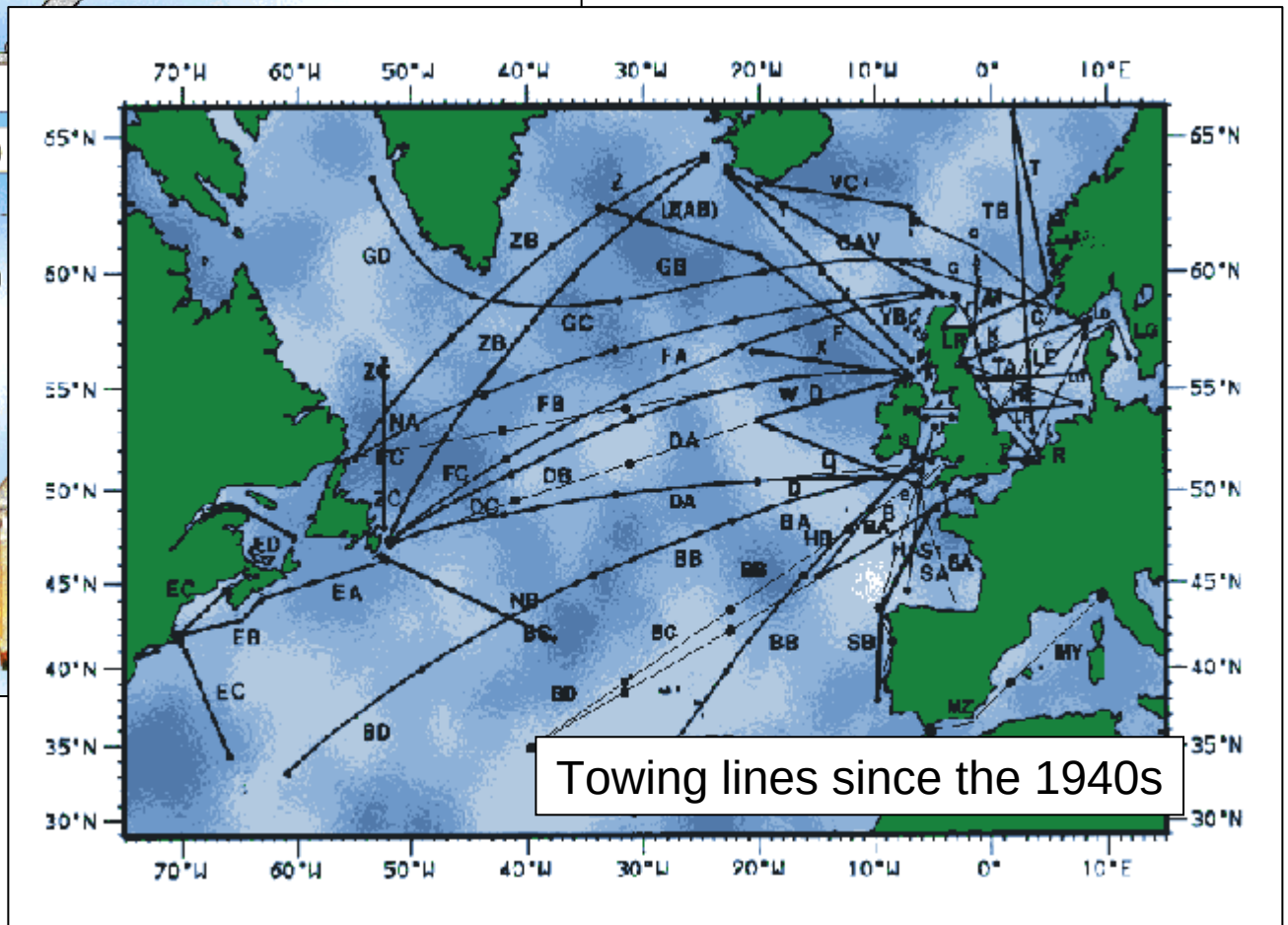
Zooplankton



Phytoplankton

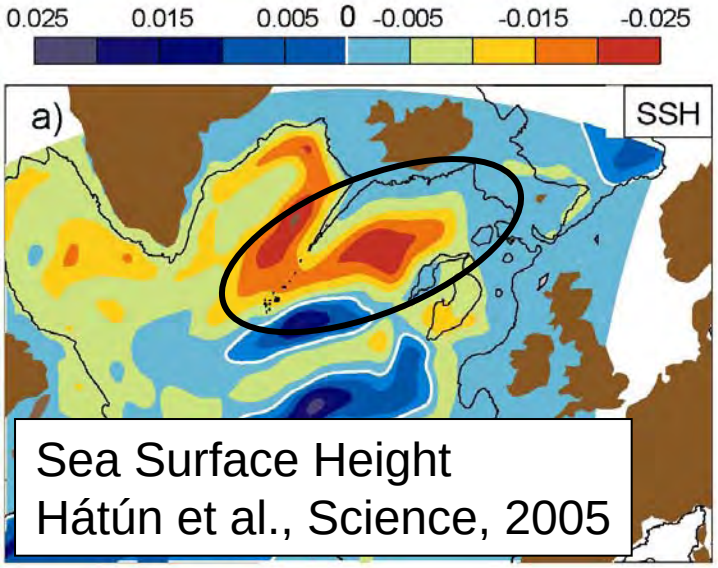
Continuous Plankton Recorder (CPR) (SAHFOS, Plymouth)

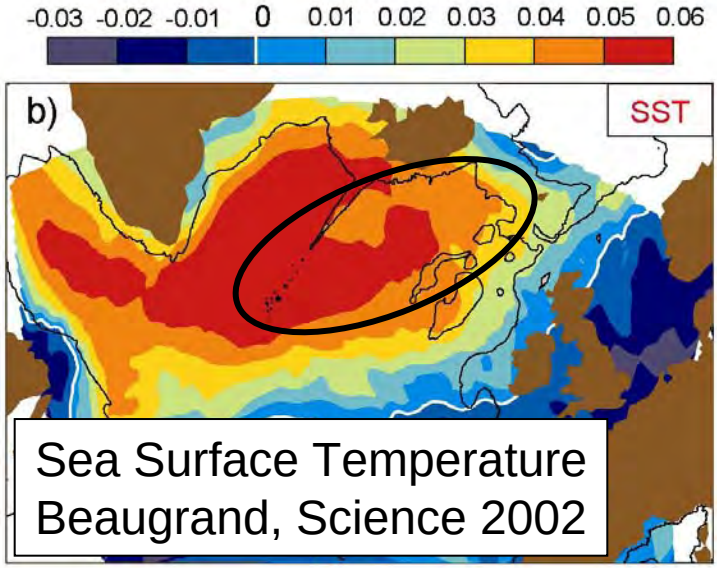


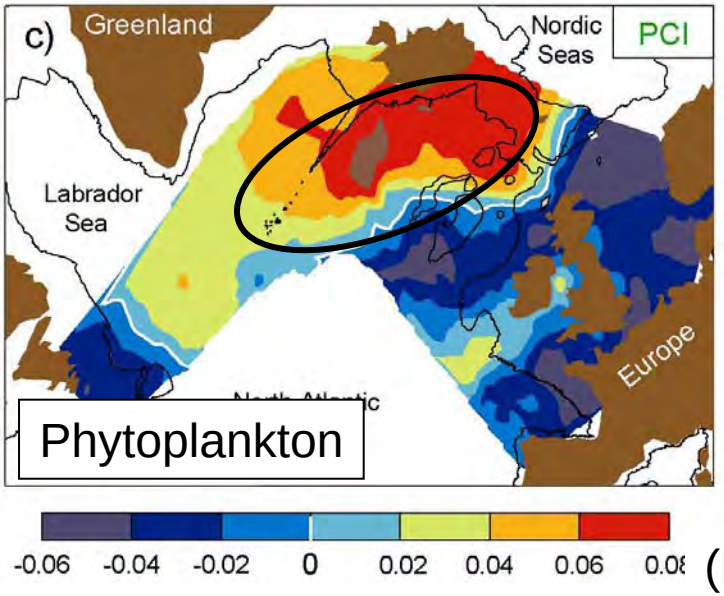


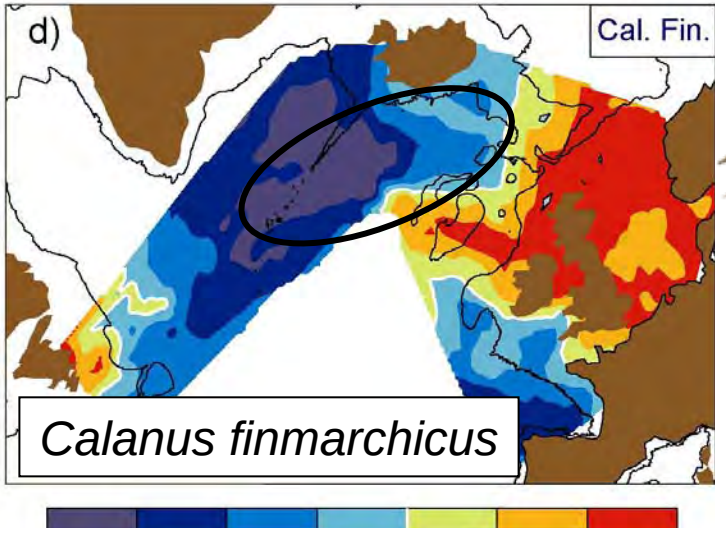
2b. The Subpolar Gyre and plankton - Space

(1955-2005)





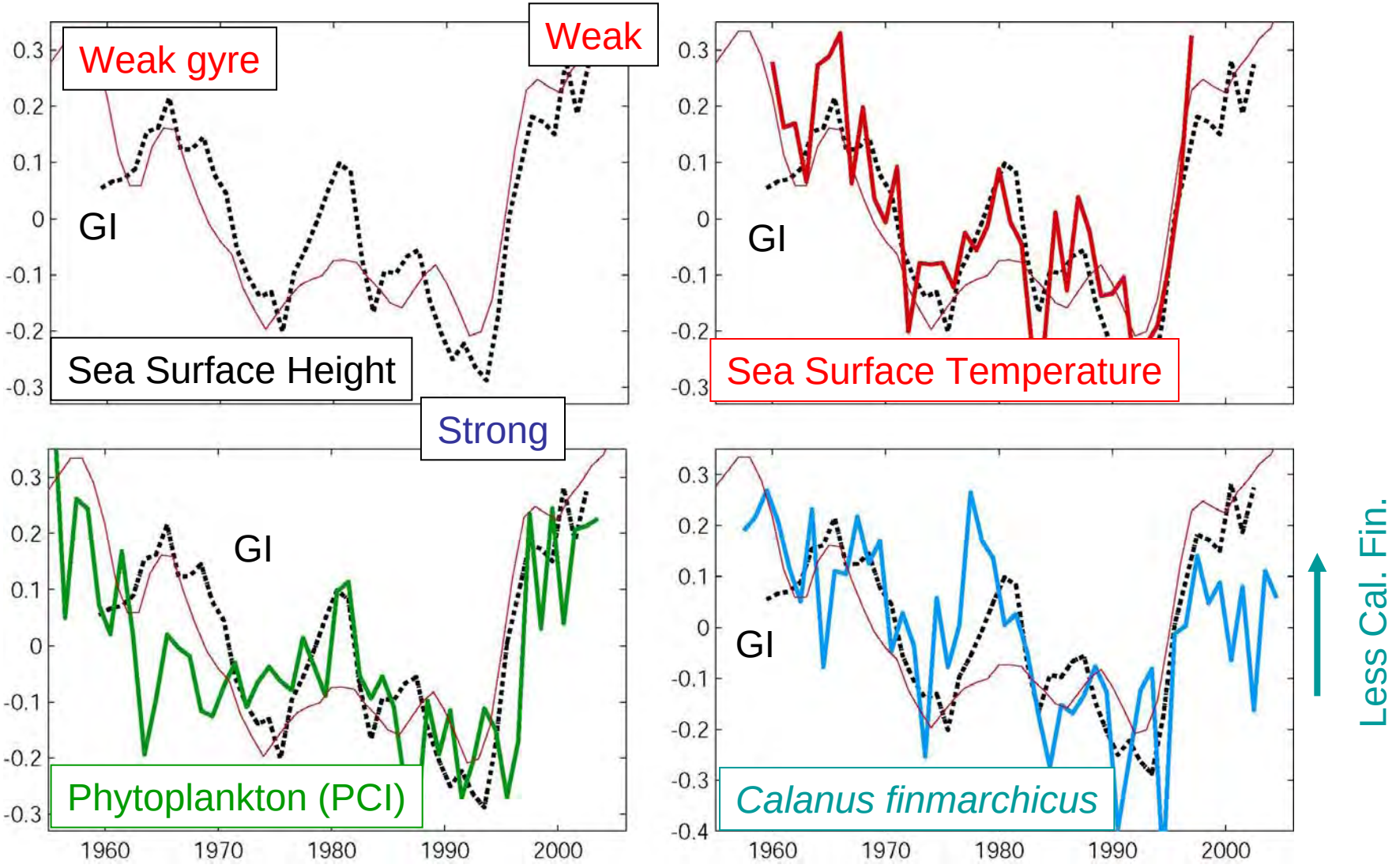




(Hátún et al., Progress in Oceanography, 2009)

2b. The Subpolar Gyre and plankton - Time

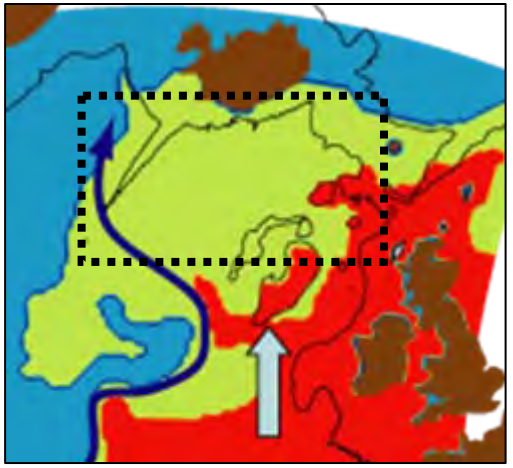
(1955-2005)



(Hátún et al., PIO, 2009)

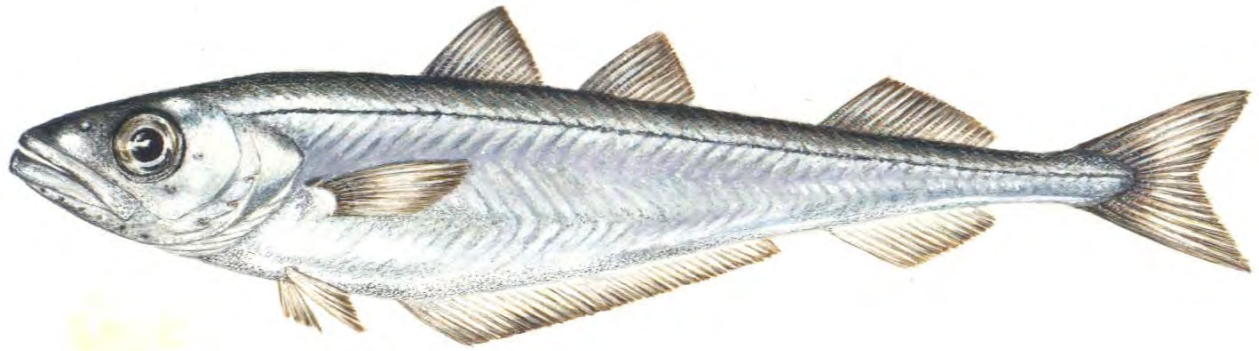
Conclusions regarding Plankton

(from Hátún et al., 2009)



- More subtropical influence after 1995
- Much more phytoplankton after 1995!
- Higher abundance of warm-water zooplankton species (not shown)
- Lower abundance of sub-arctic zooplankton species (*Calanus finmarchicus*)

2c. Blue whiting (Micromesistius poutassou)



2c.Blue whiting

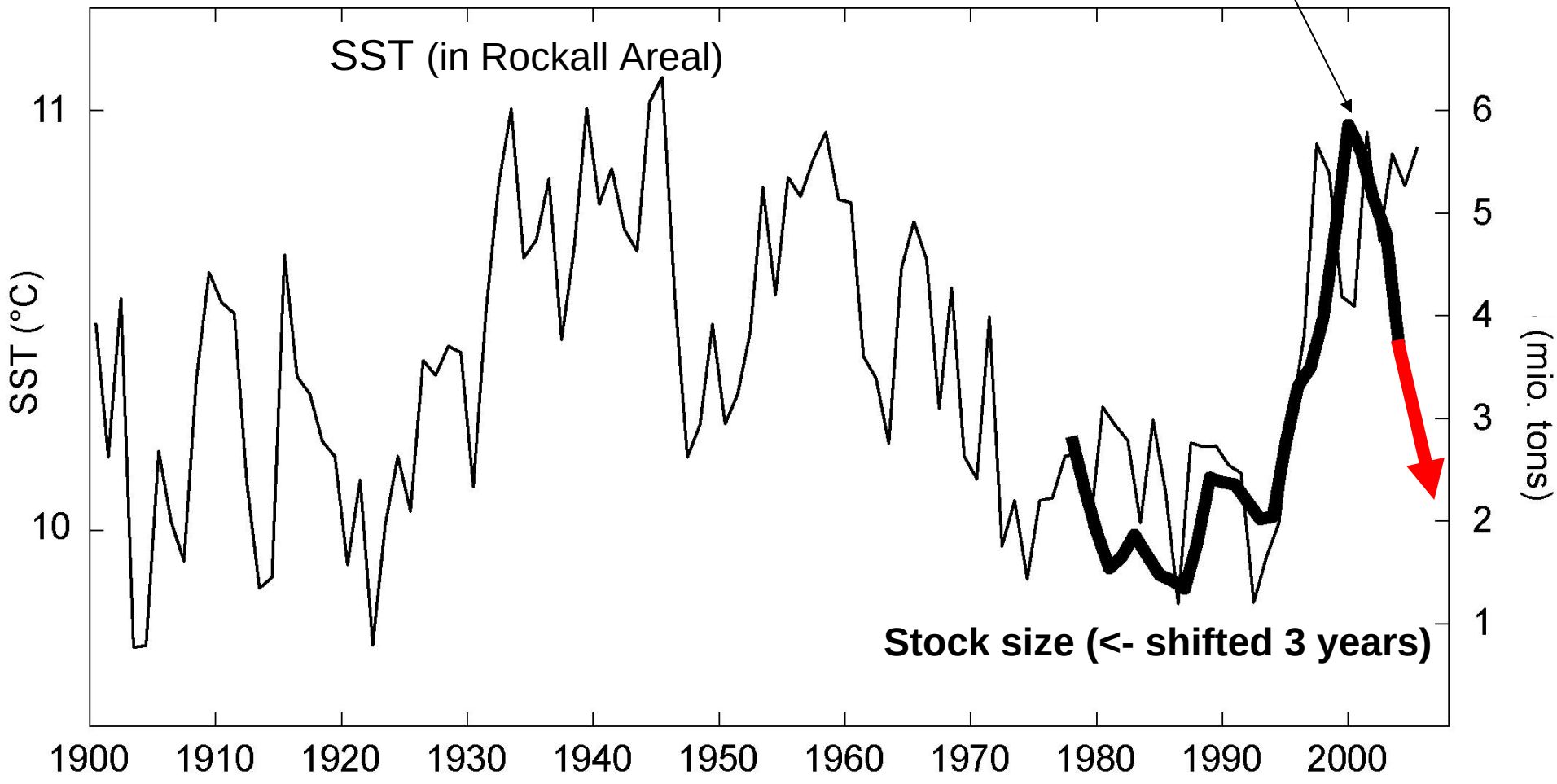
Feeding area

Spawning

(Hátún et al., PIO, 2009)

A threefold stock-size increase

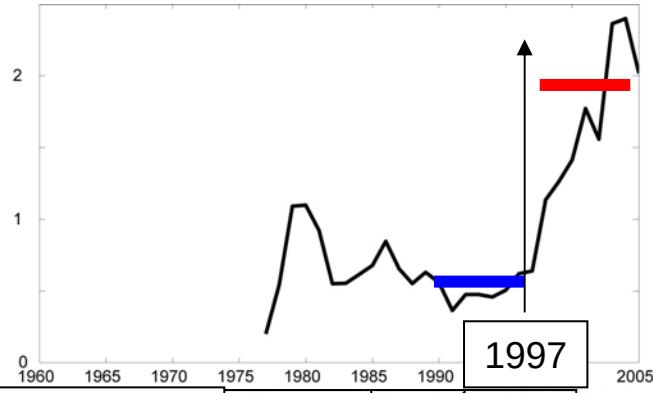
Largest fishery
in the North Atlantic!



(Hátún et al., PIO, 2009)

Spatial Shifts

(Catches – all nations)



Cold (1990-1996)

Warm (1998-2003)

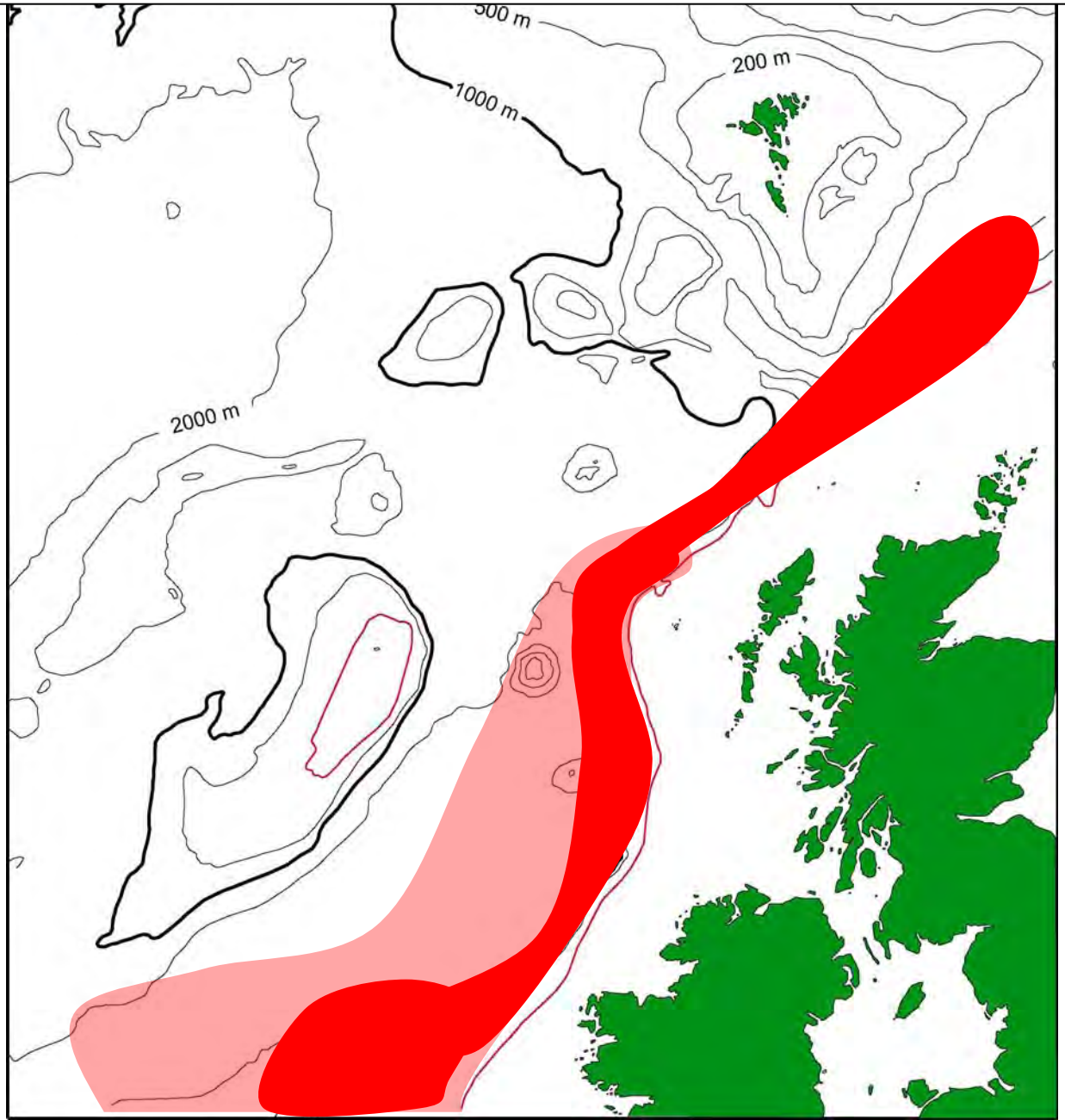
(Hátún et al., PIO, 2009)

Migration

Spawning distribution

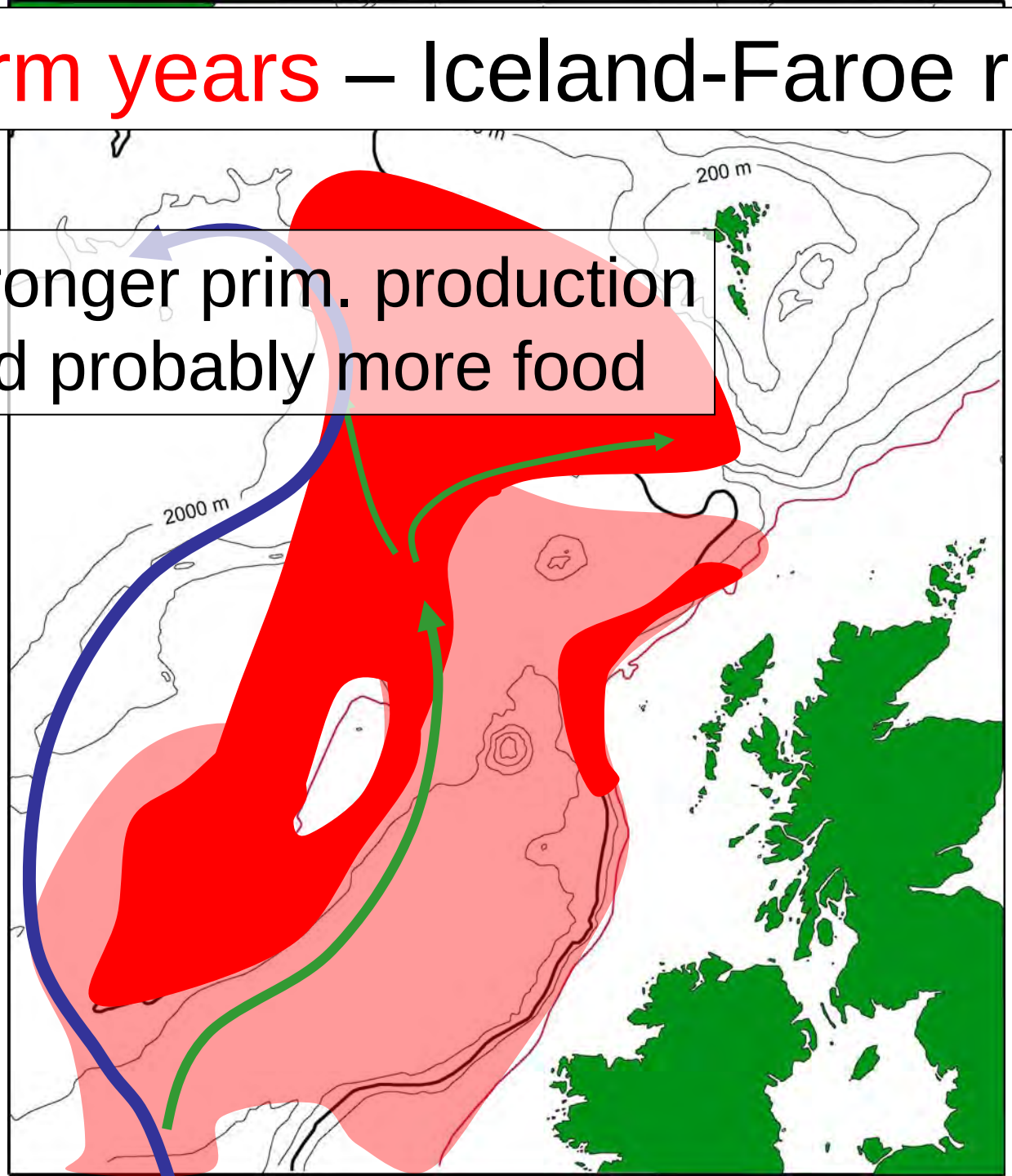
(Hátún et al., CJFAS, 2009)

Cold years – Faroe-Shetland Ch.



(PIO, 2009)

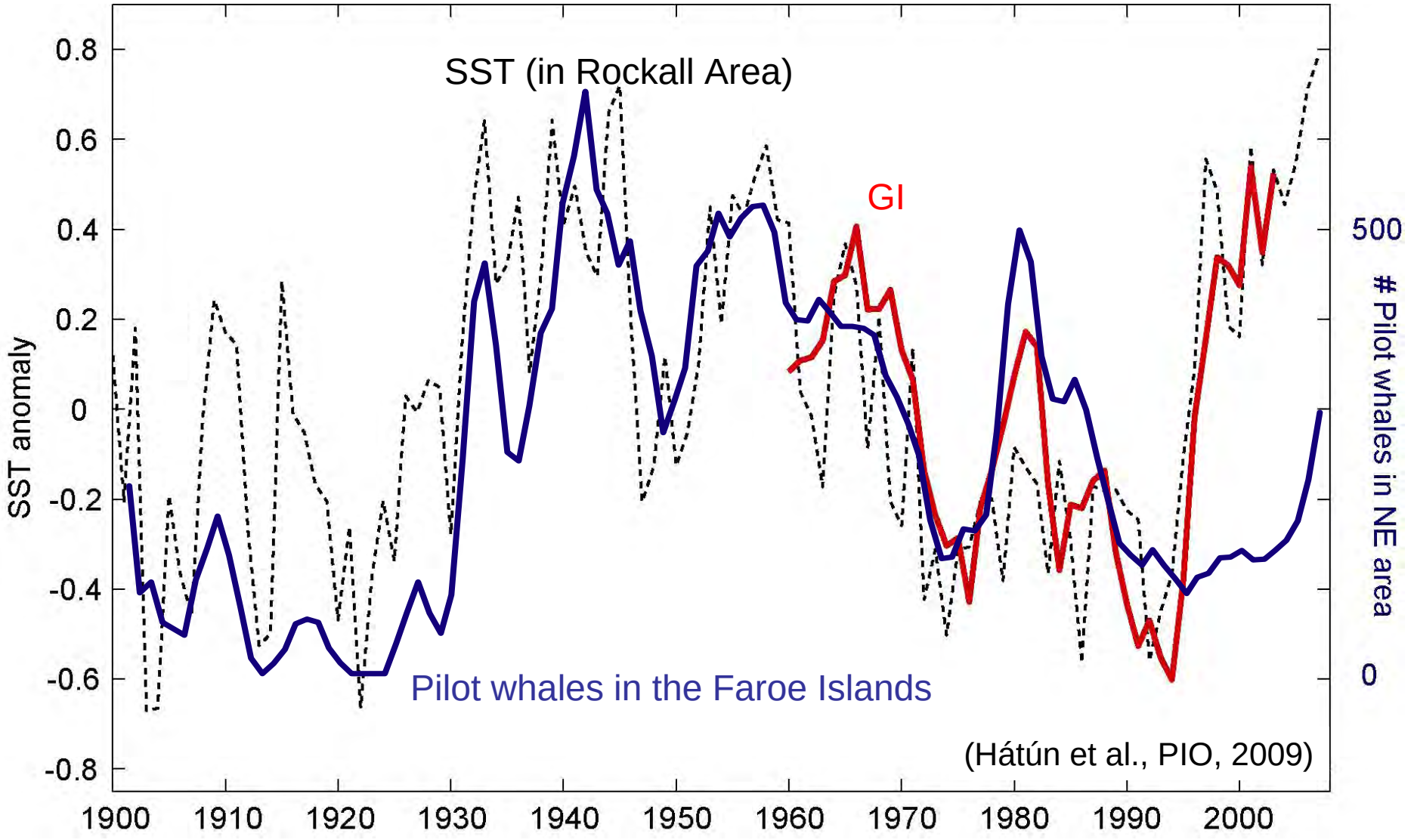
Warm years – Iceland-Faroe region



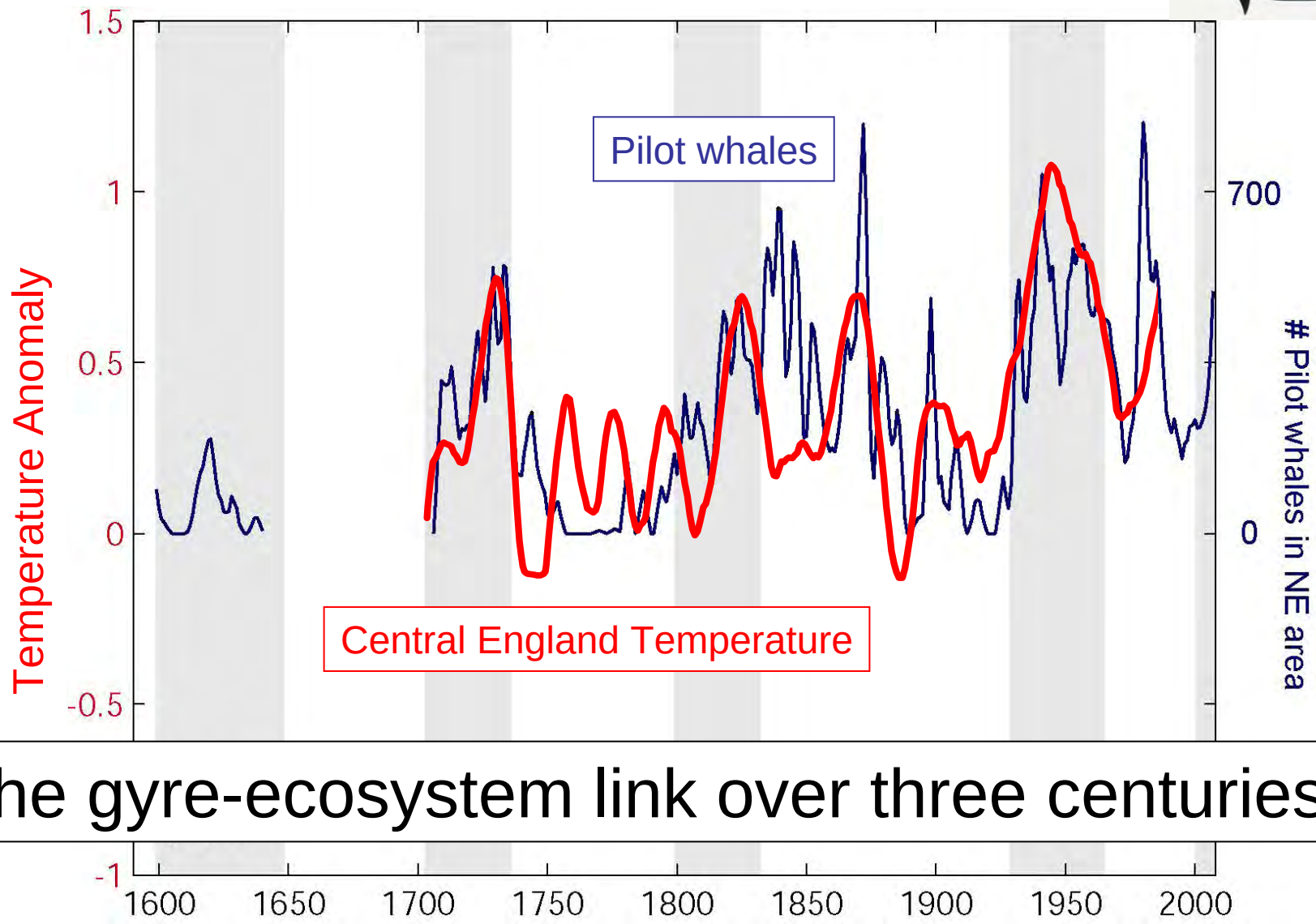
(PIO, 2009)

2d.The Subpolar Gyre and *Long-finned Pilot Whales (Globicephala melas)*

2d. Pilot Whale Migration



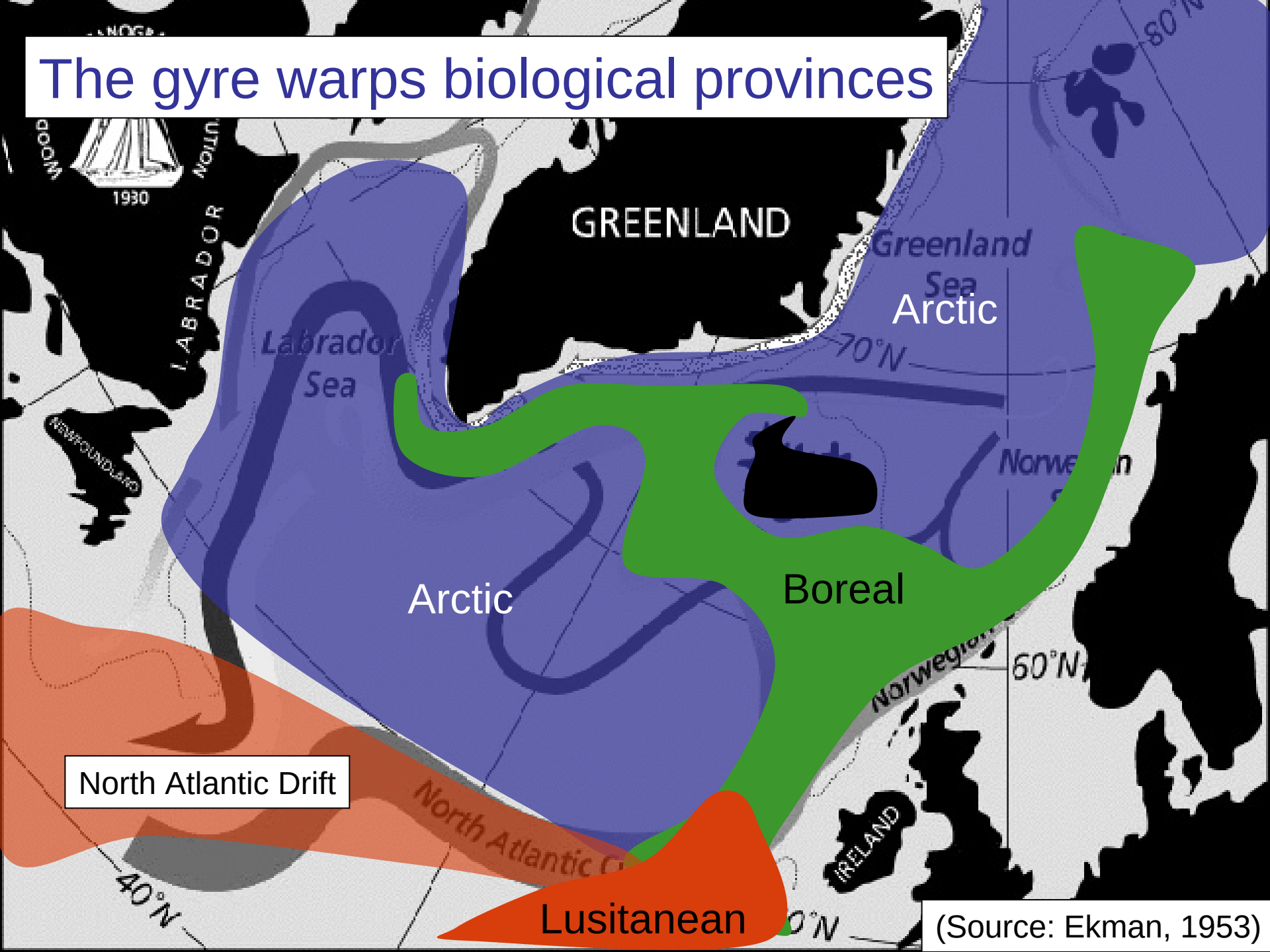
Long-term whale migration



The gyre-ecosystem link over three centuries!

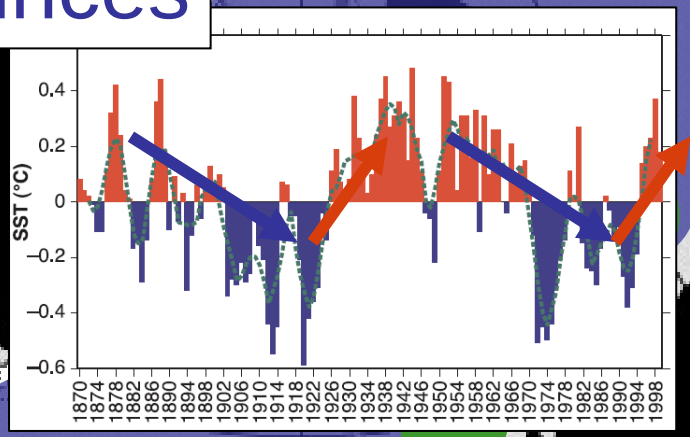
(Hátún et al., PIO, 2009)

The gyre warps biological provinces



(Source: Ekman, 1953)

The gyre warps biological provinces



GREENLAND

LABRADOR

NEWFOUNDLAND

IRELAND

Subpolar Gyre

Boreal

North Atlantic Drift

Lusitanean

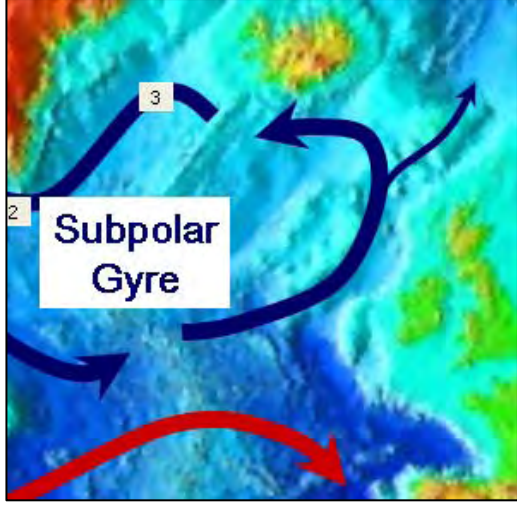
60°N

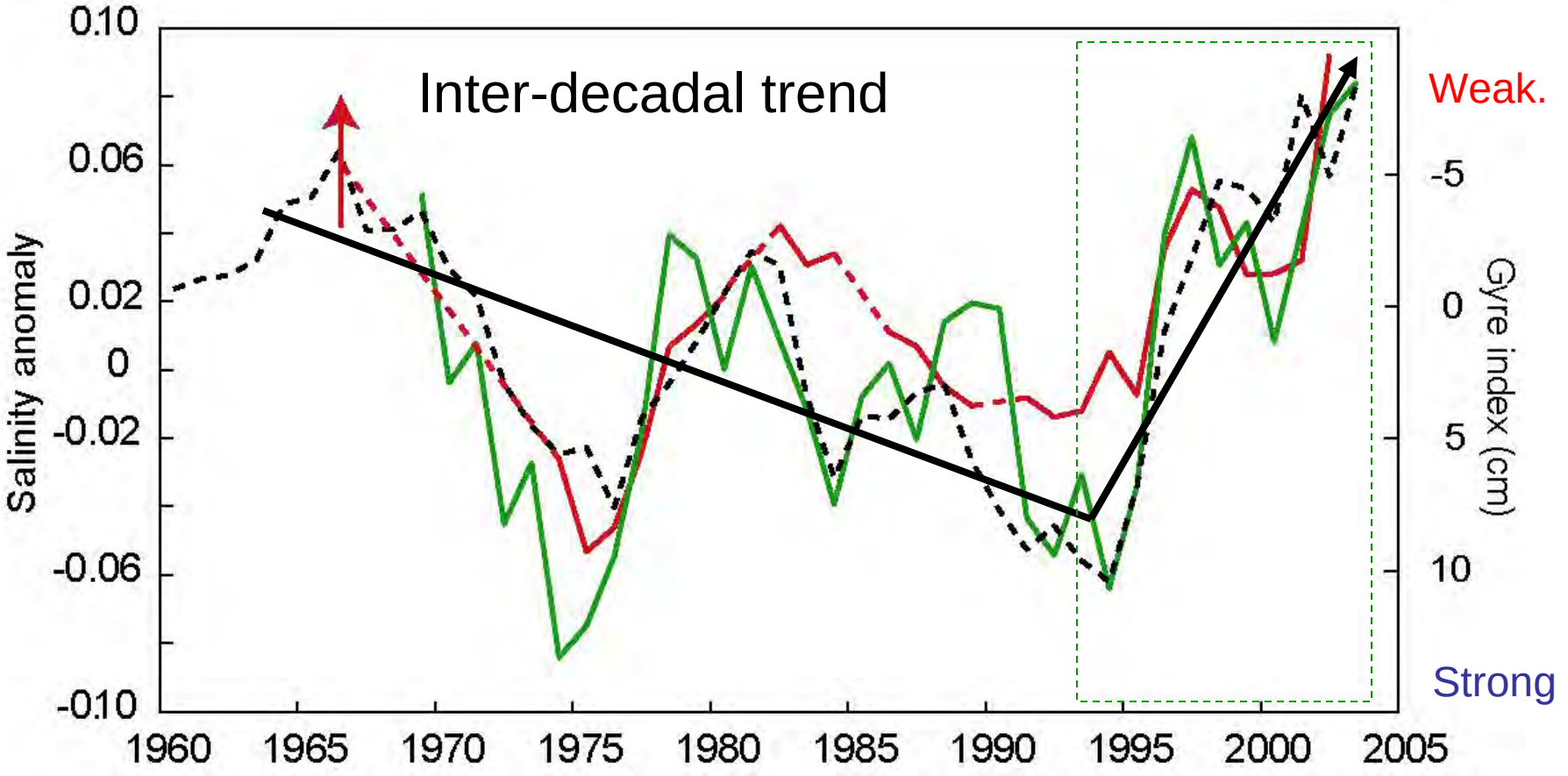
40°N

(Source: Ekman, 1953)

3. Sub-decadal Oscillations

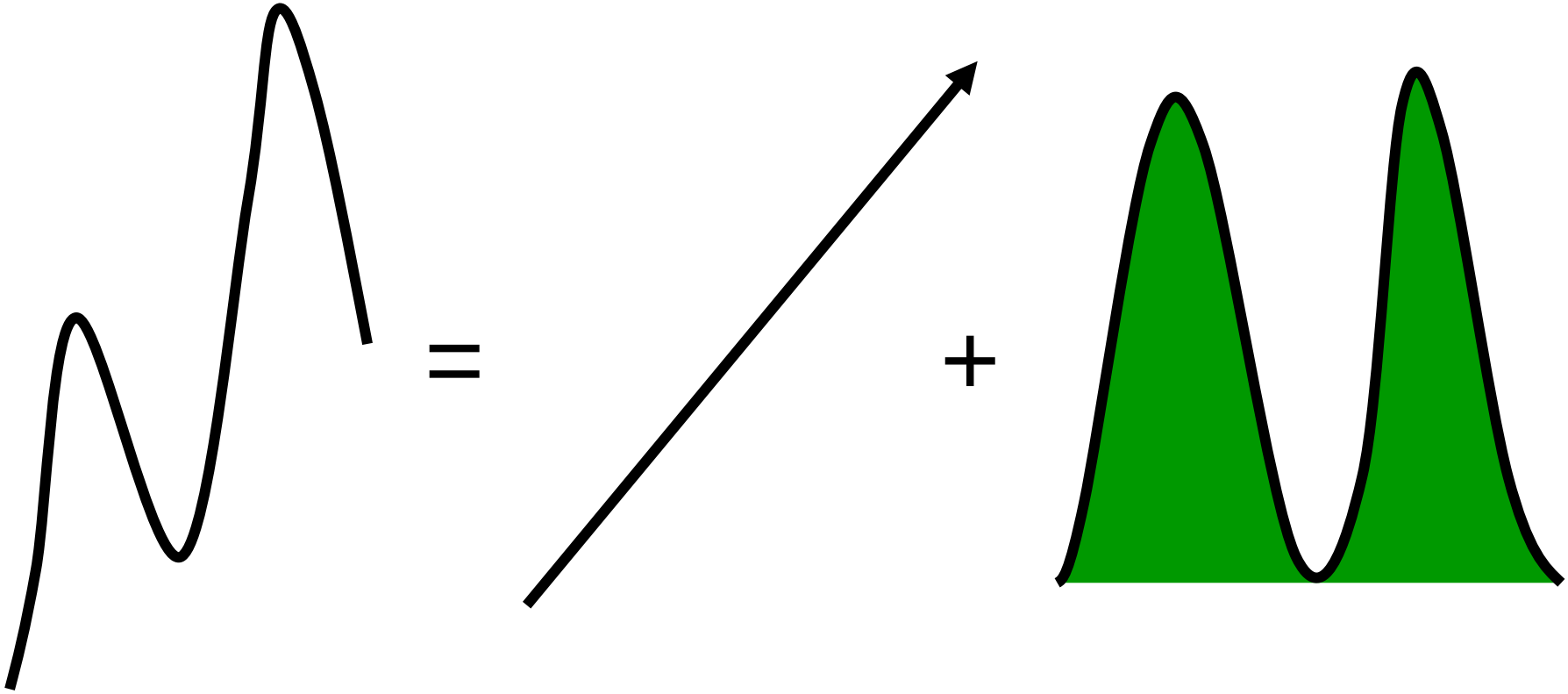
3. Sub-decadal Oscillations



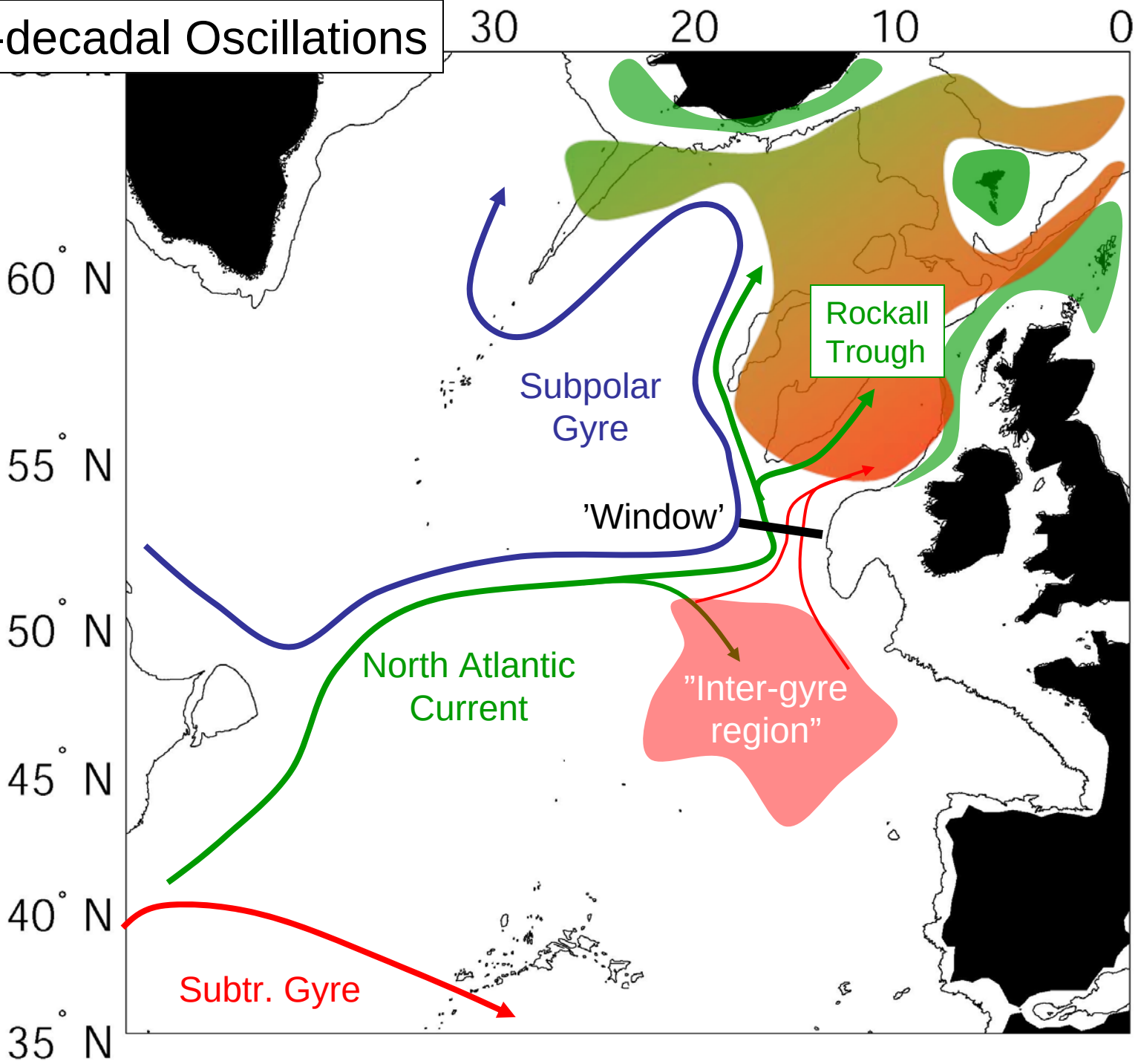


3. Sub-decadal Oscillations

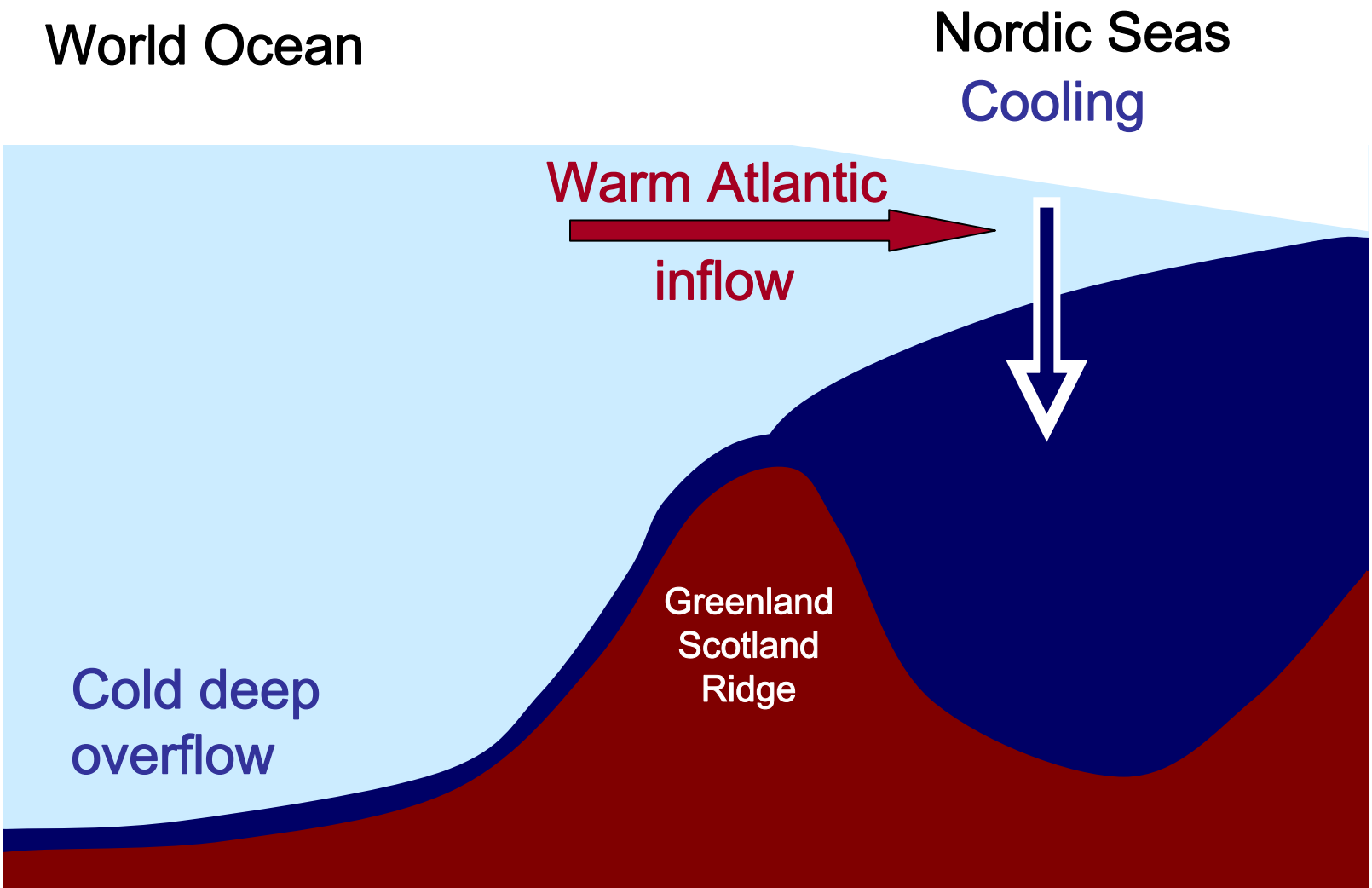
Open Ocean **Inter-decadal trend** **Sub-decadal osc.**

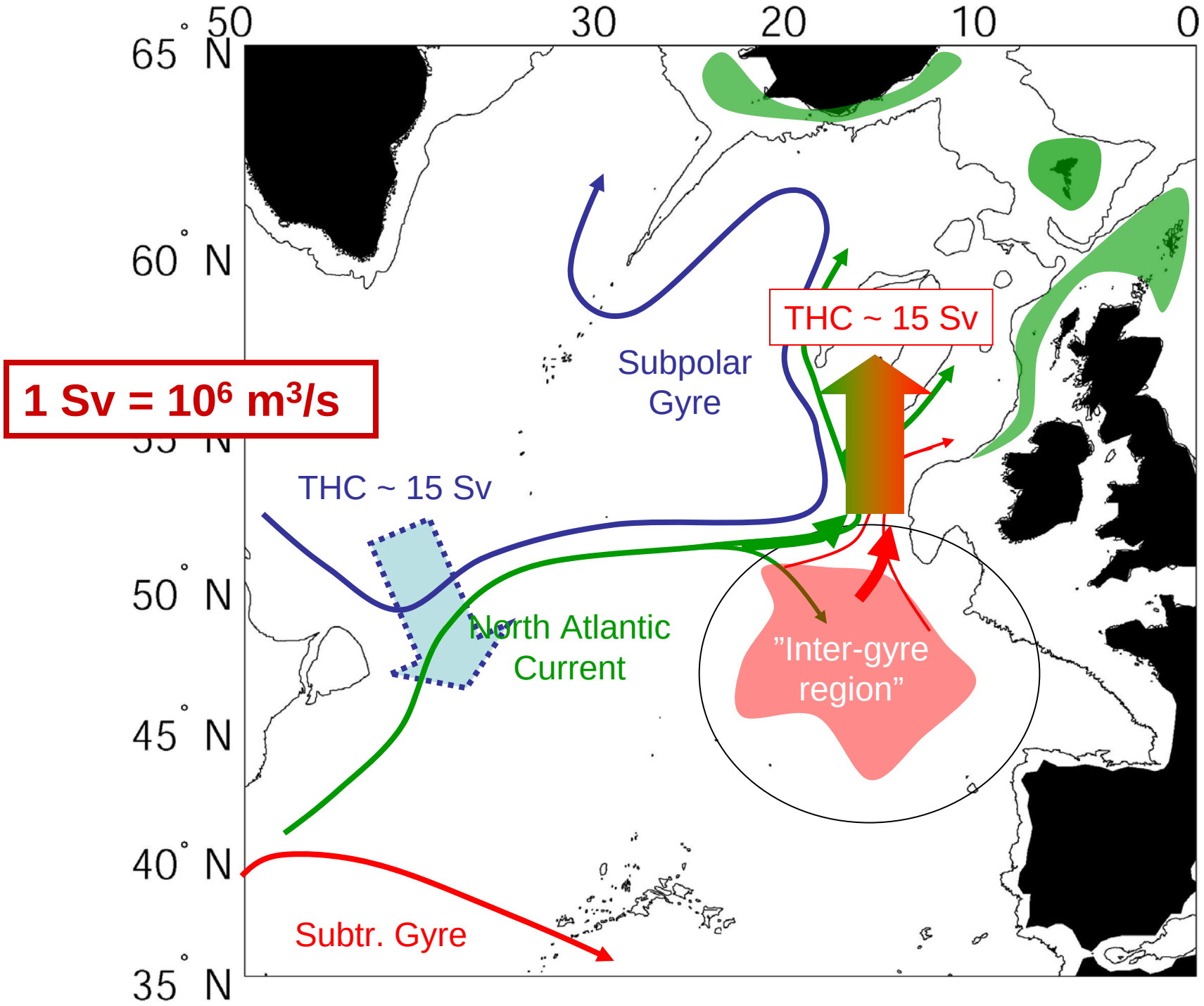


3. Sub-decadal Oscillations

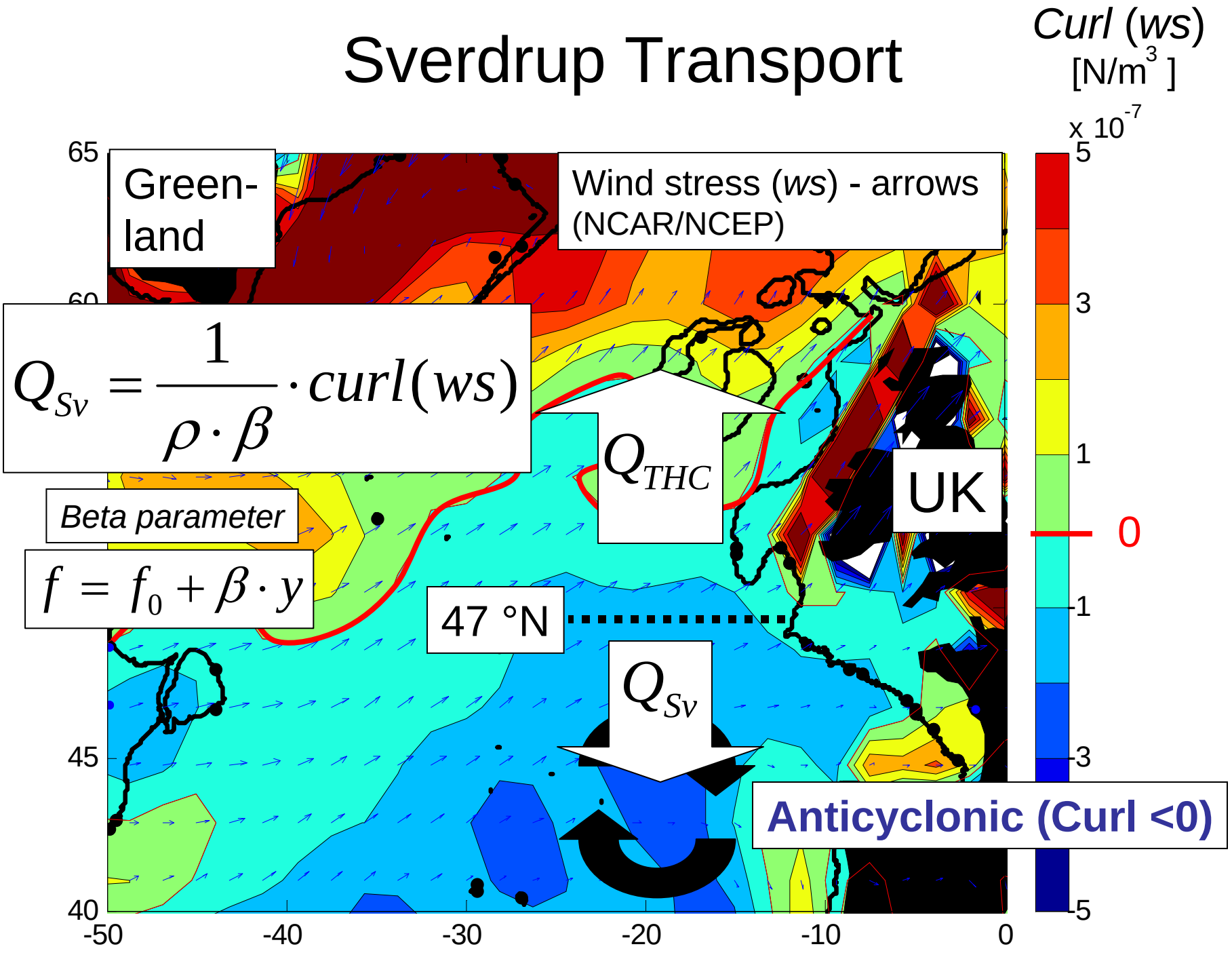


The ThermoHaline Circulation (THC)

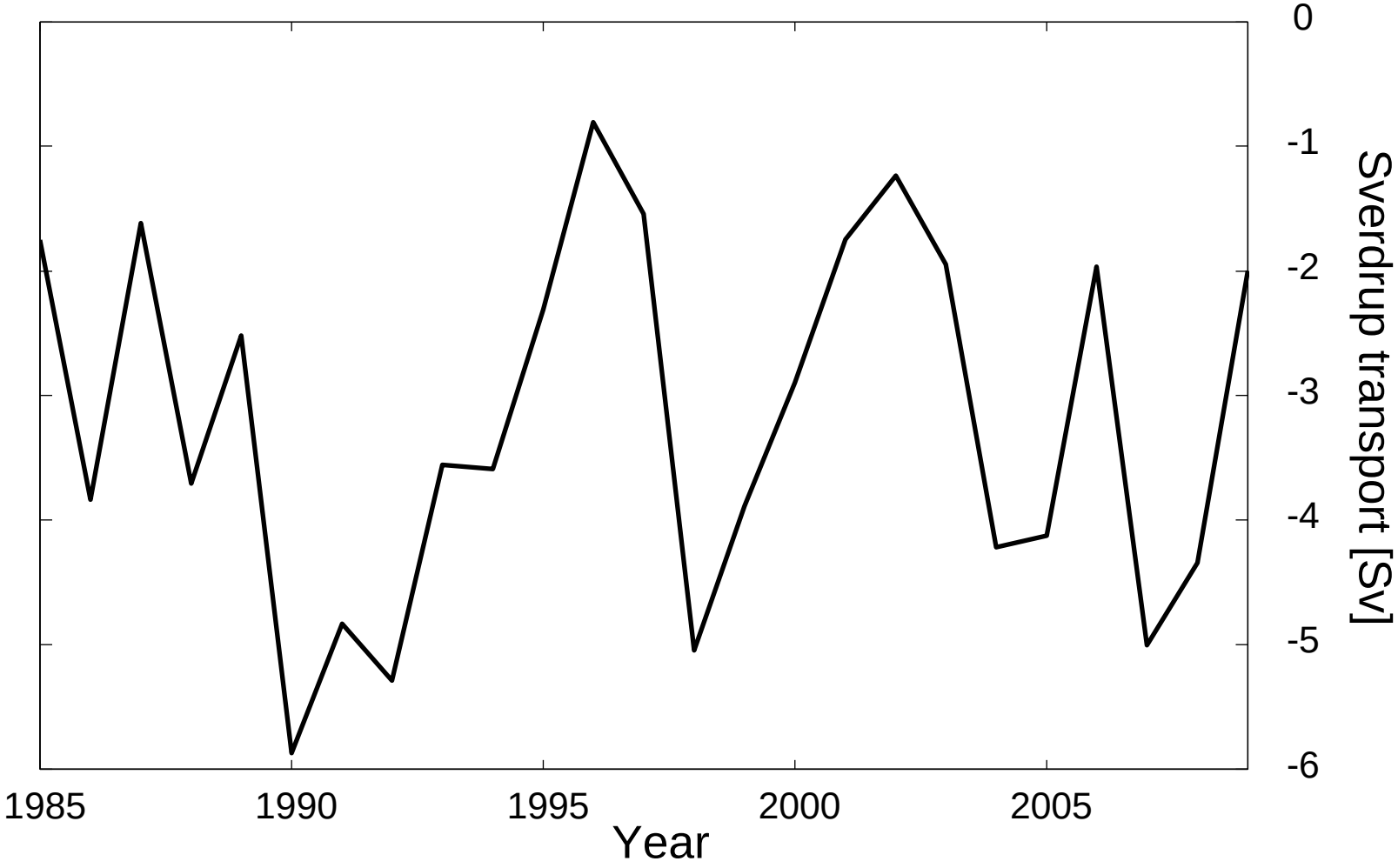



50
30
20
10
0
65° N
60° N
50° N
45° N
40° N
35° N
1 Sv = 10⁶ m³/s
THC ~ 15 Sv
Subpolar Gyre
THC ~ 15 Sv
North Atlantic Current
”Inter-gyre region”
Subtr. Gyre

Sverdrup Transport

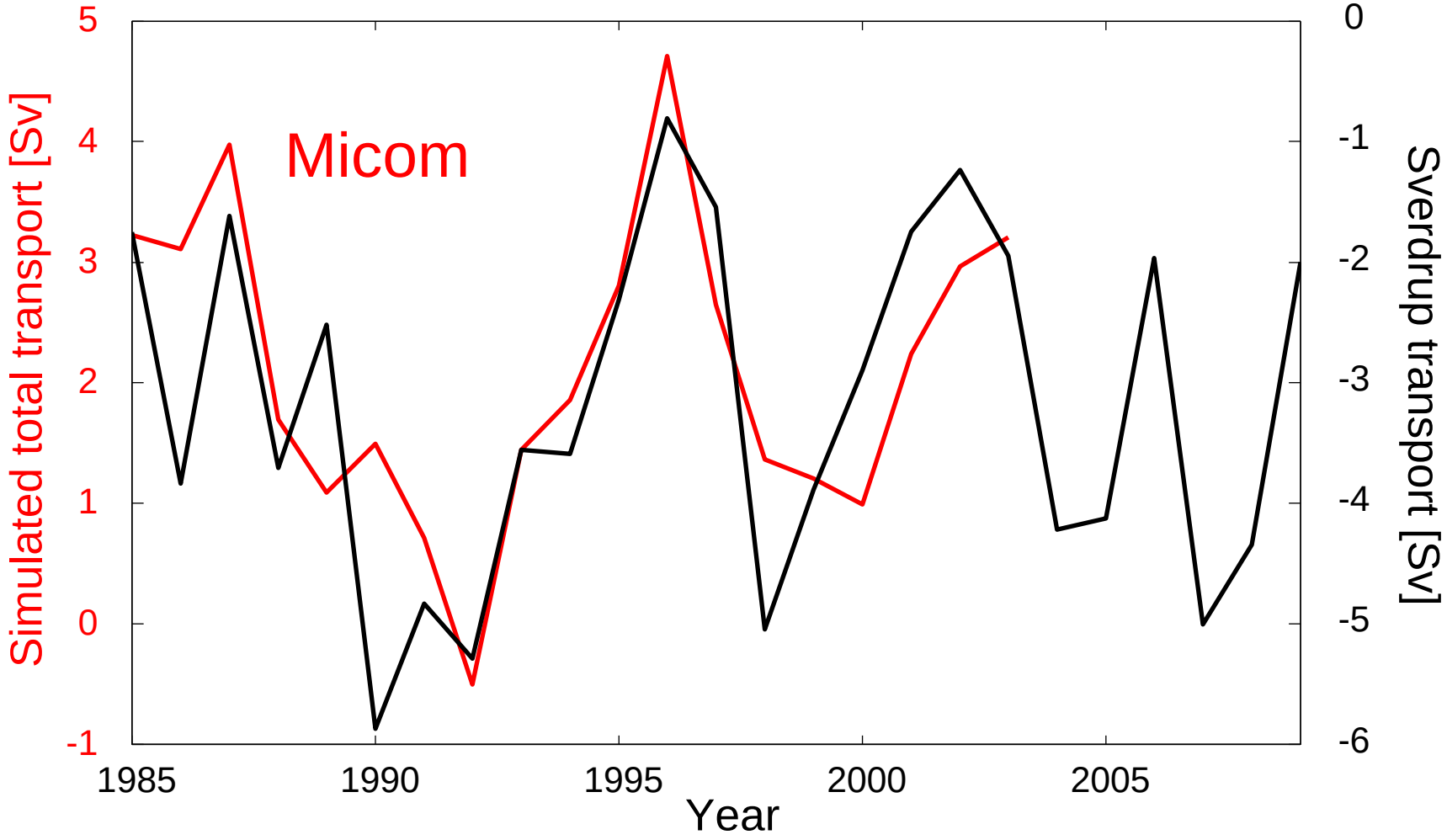


Transports
from the Inter-gyre region (47°N)



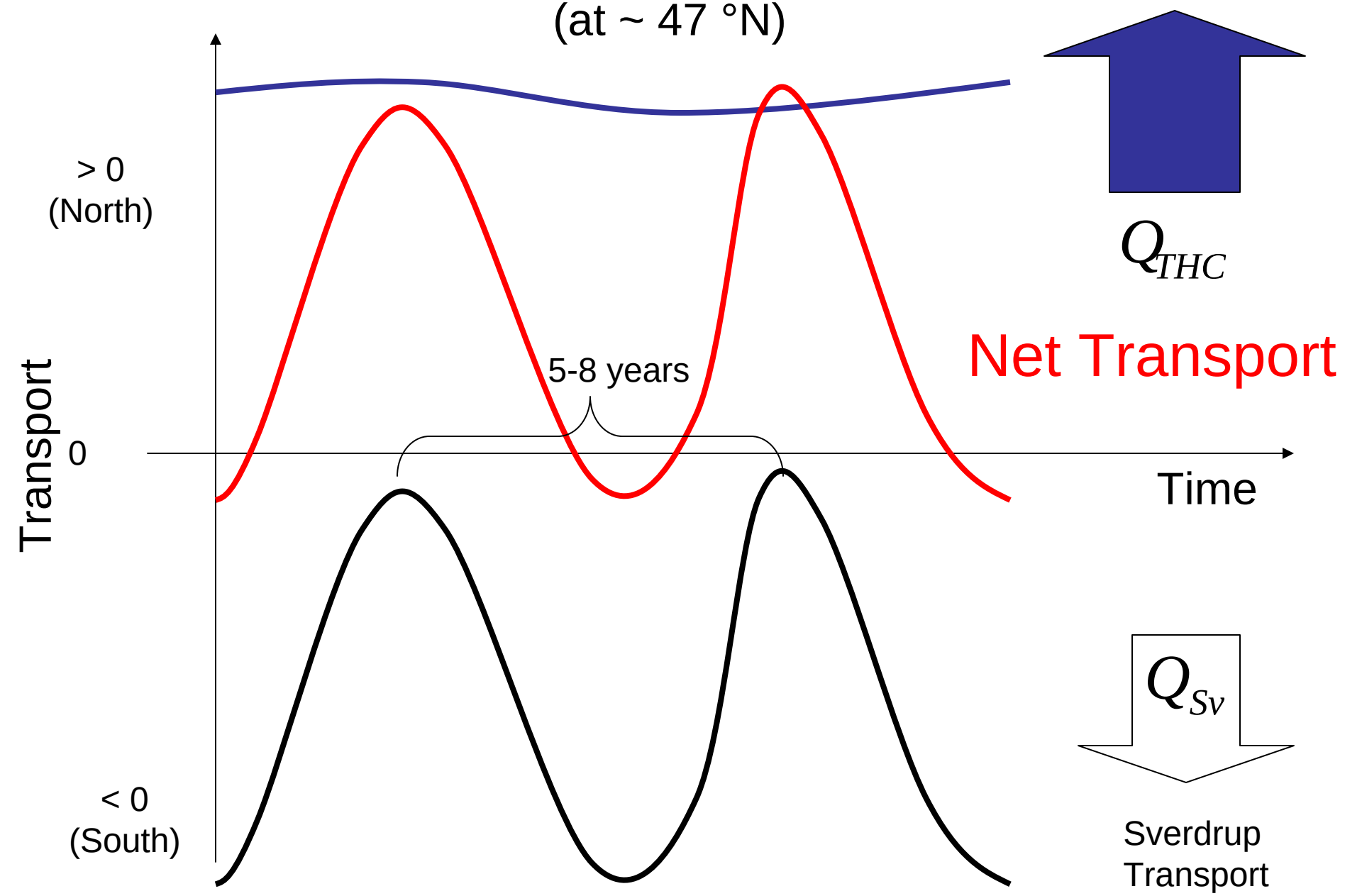
Transports

from the Inter-gyre region (47°N)



The opposing THC and Sverdrup transports

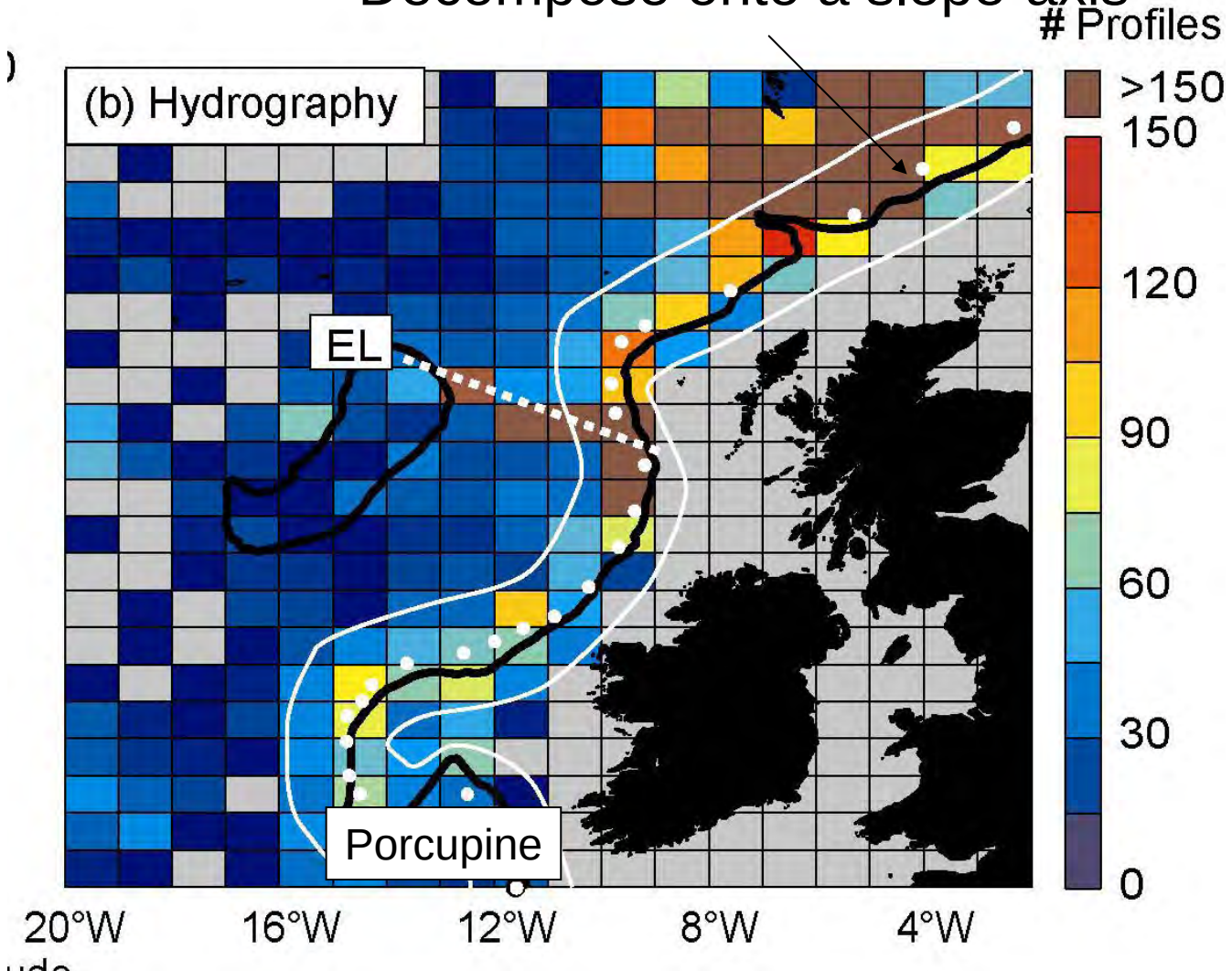
(at ~ 47 °N)



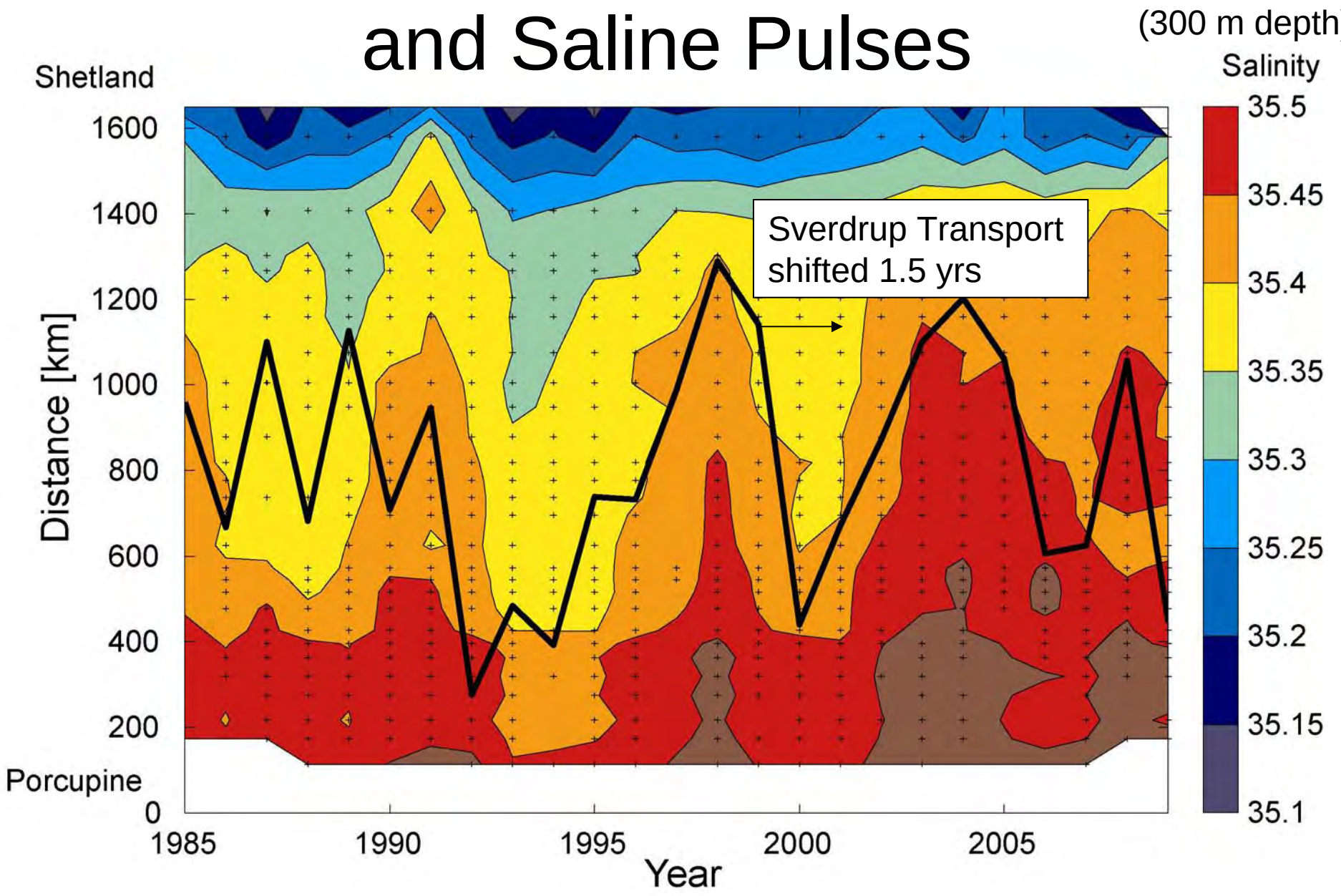
An along-Continental Slope perspective

(Data availability)

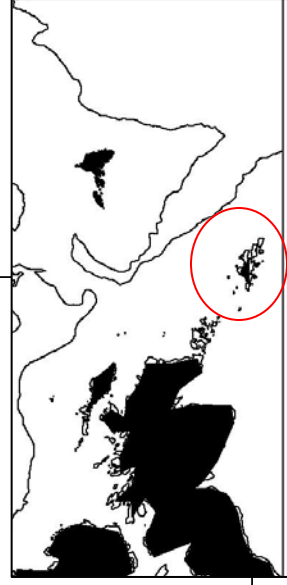
Decompose onto a slope-axis



Sverdrup Transport and Saline Pulses



Kittiwakes – Breeding Succes



Average over 15 colonies
in Shetland

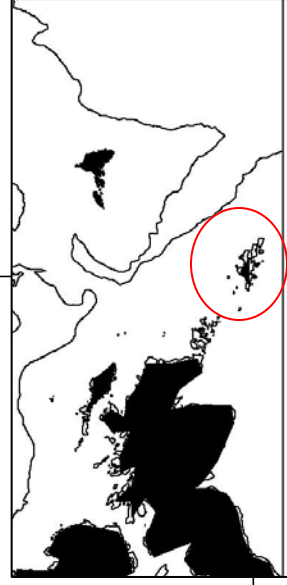
#Chicks/nest

1
0.8
0.6
0.4
0.2
0

1985 1990 1995 2000 2005 2010

Year

Kittiwakes – Breeding Succes



Sverdrup Transport (inverted)

Shifted 1.5 yrs

Potential for Prediction!

2010

2011

#Chicks/nest

0

0.2

0.4

0.6

0.8

1985

1990

1995

2000

2005

2010

Year

A Possible Pacific-Atlantic Teleconnection

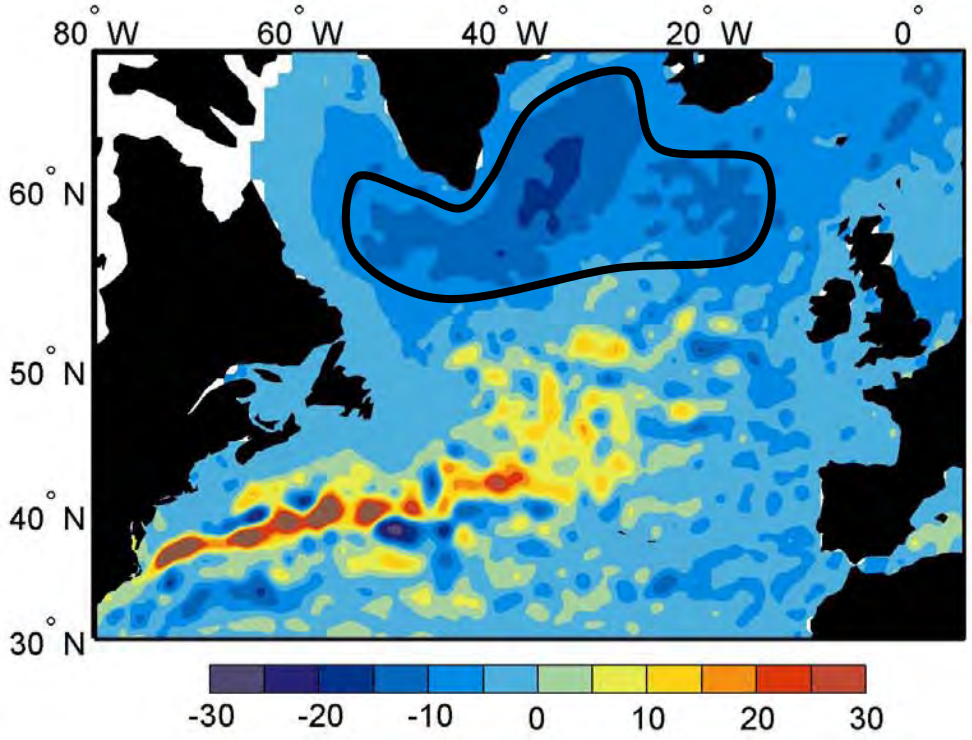
Speculation ☺

Sea surface height:

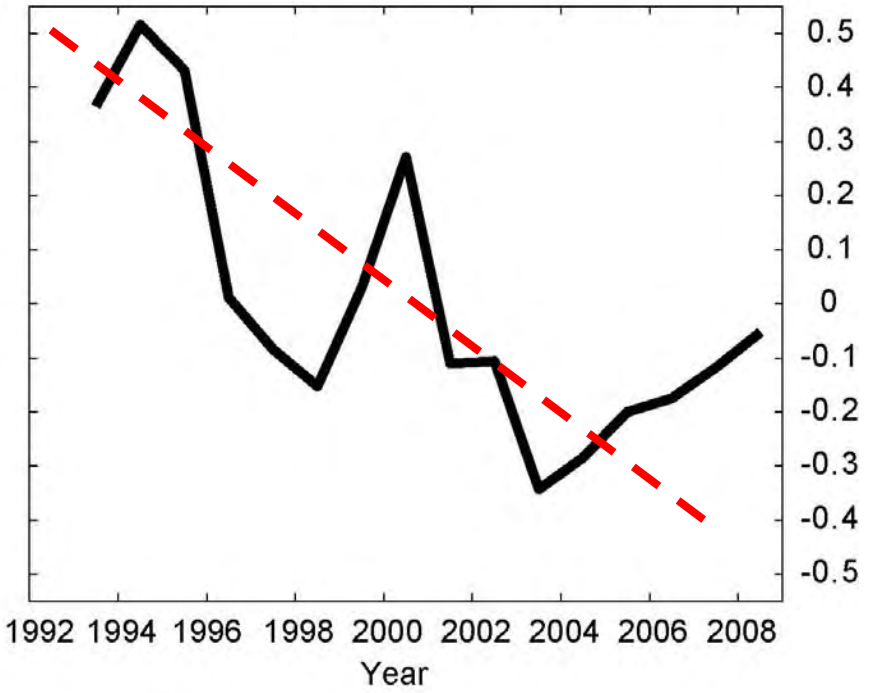
Gyre Mode

Satellite altimetry

Spatial pattern



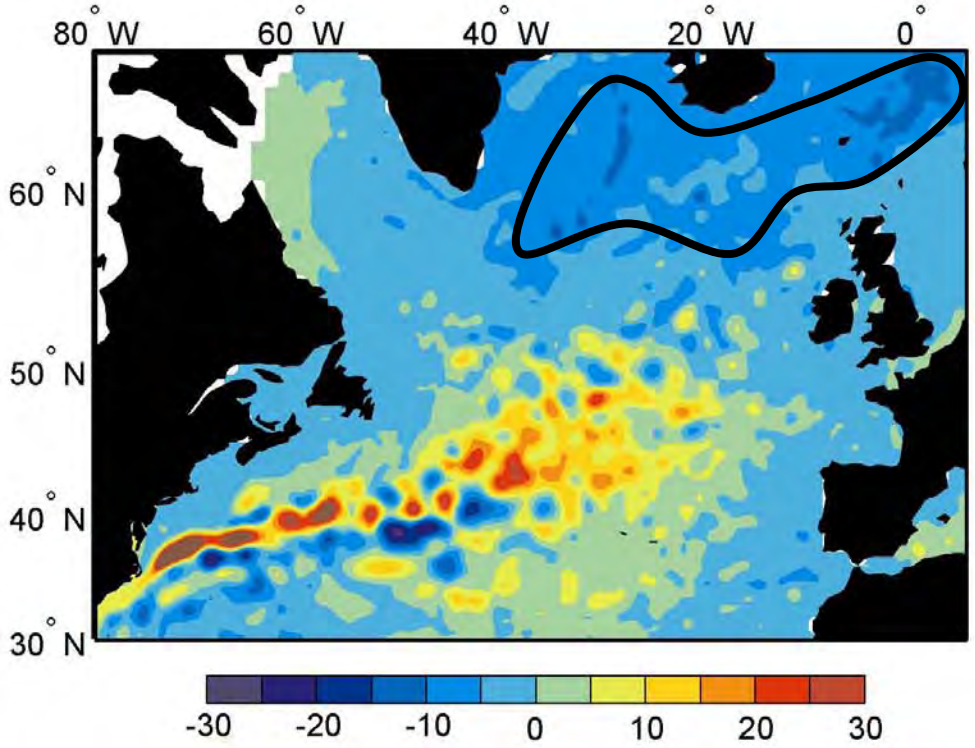
Time series
(gyre index)



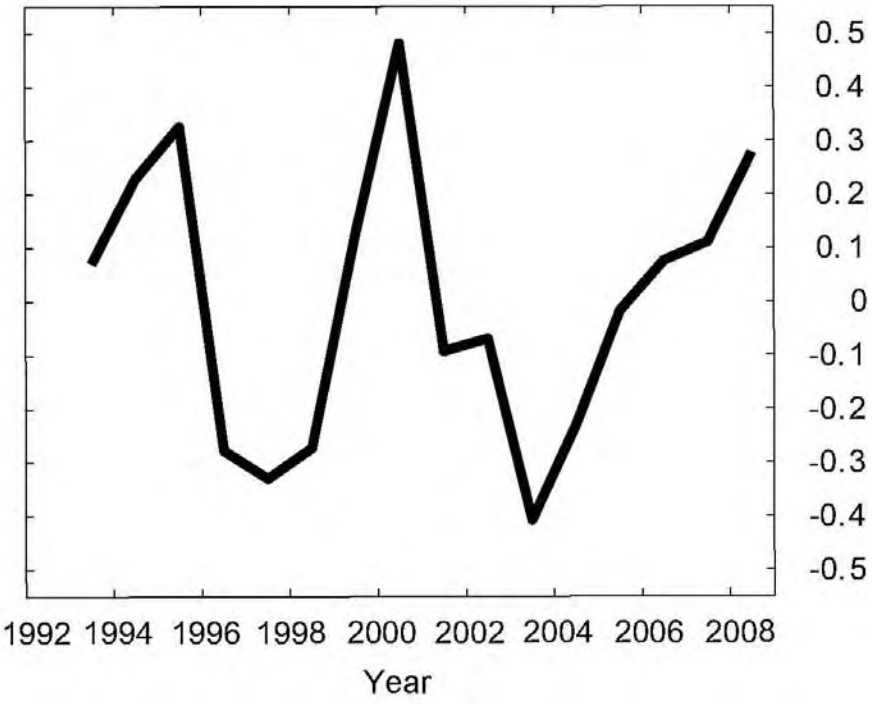
Sea surface height:

Sub-decadal oscillations (SDO)

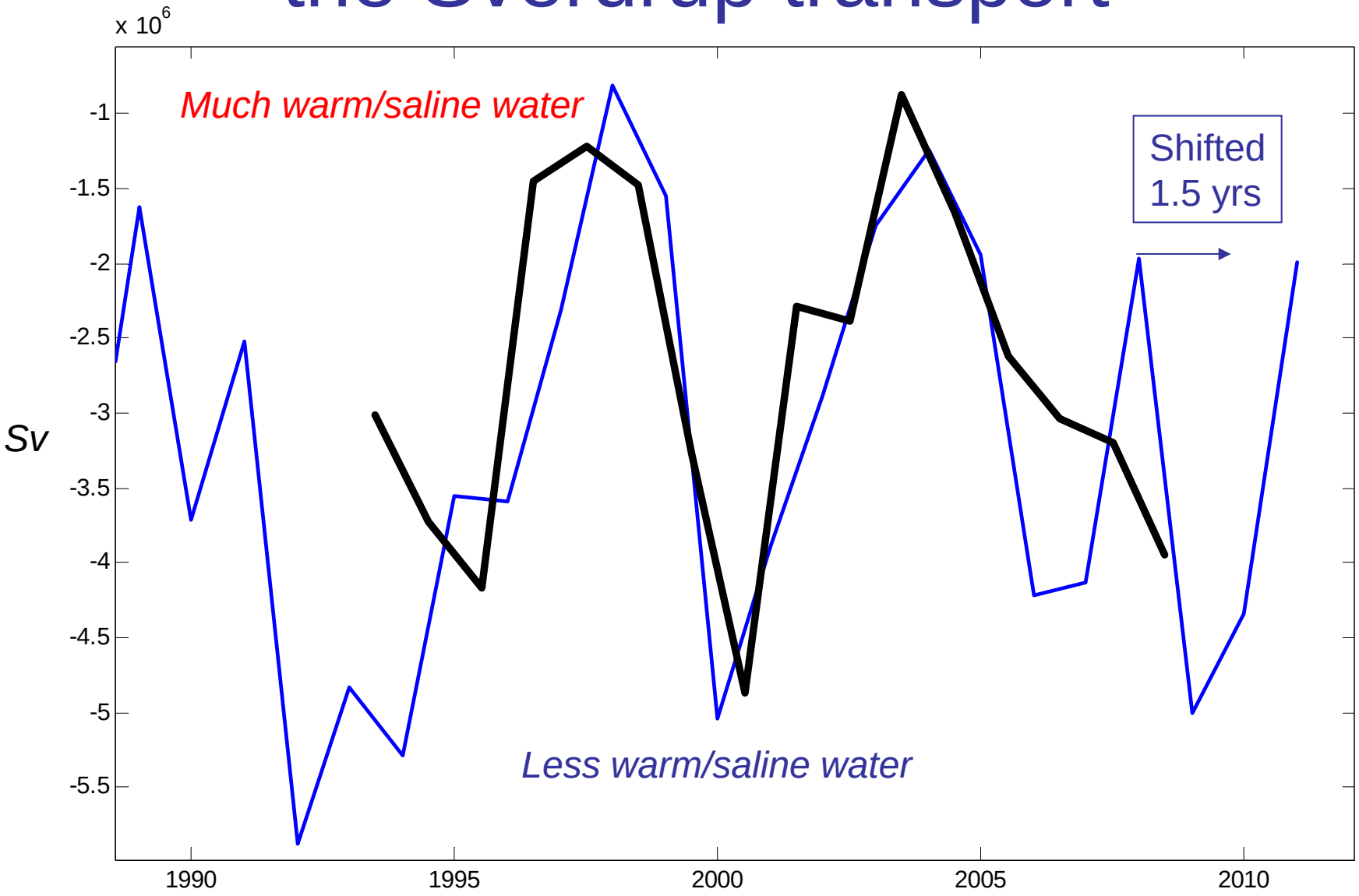
Spatial pattern



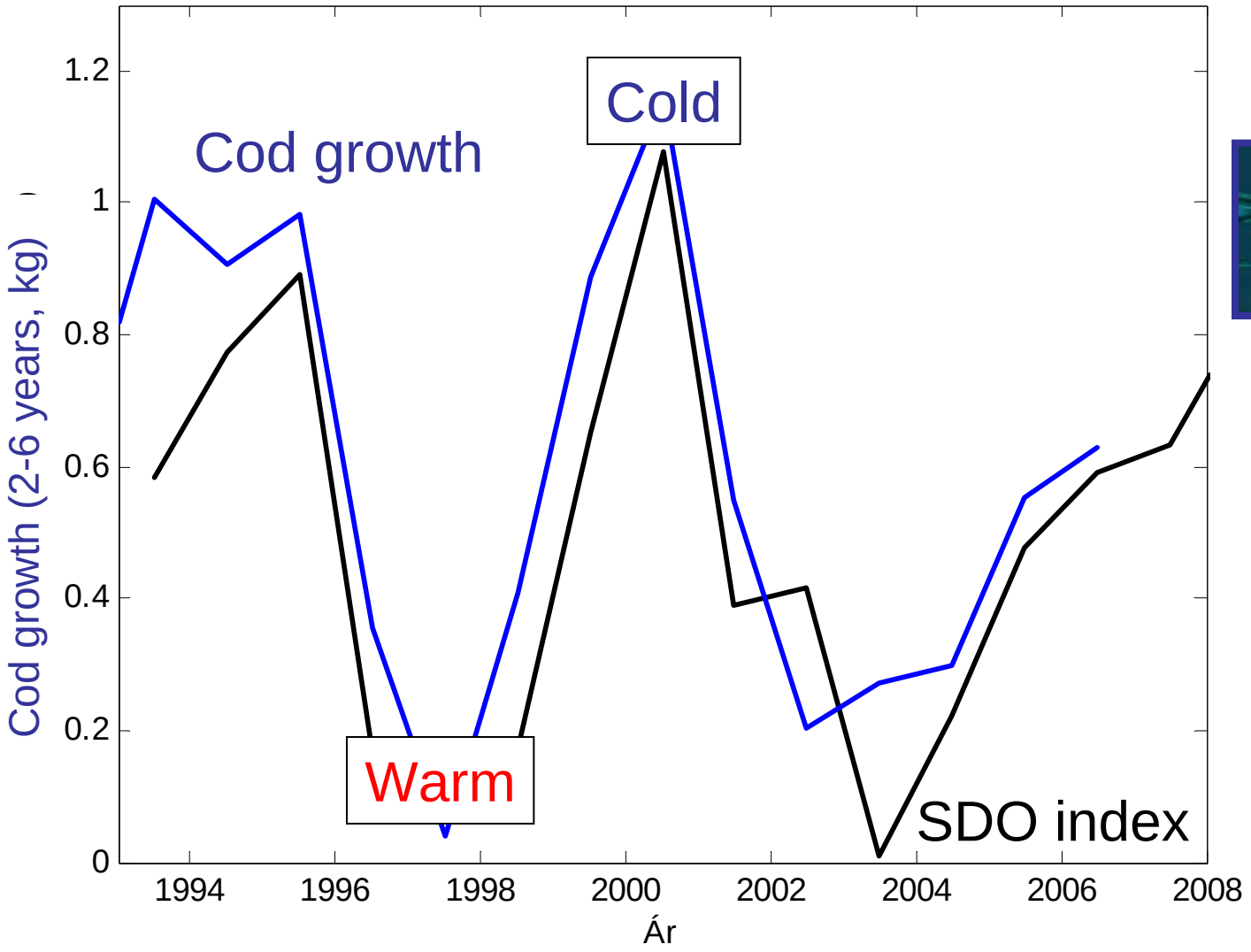
Time series
(SDO index)

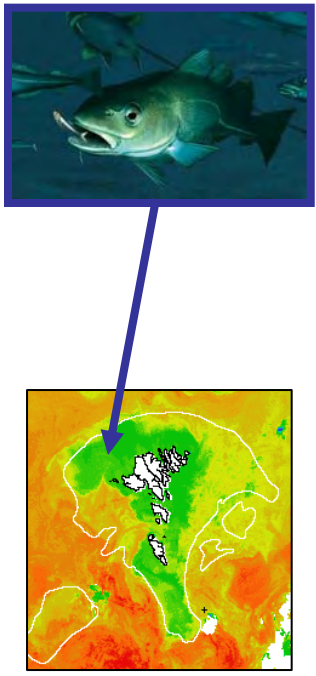


SDO index and the Sverdrup transport

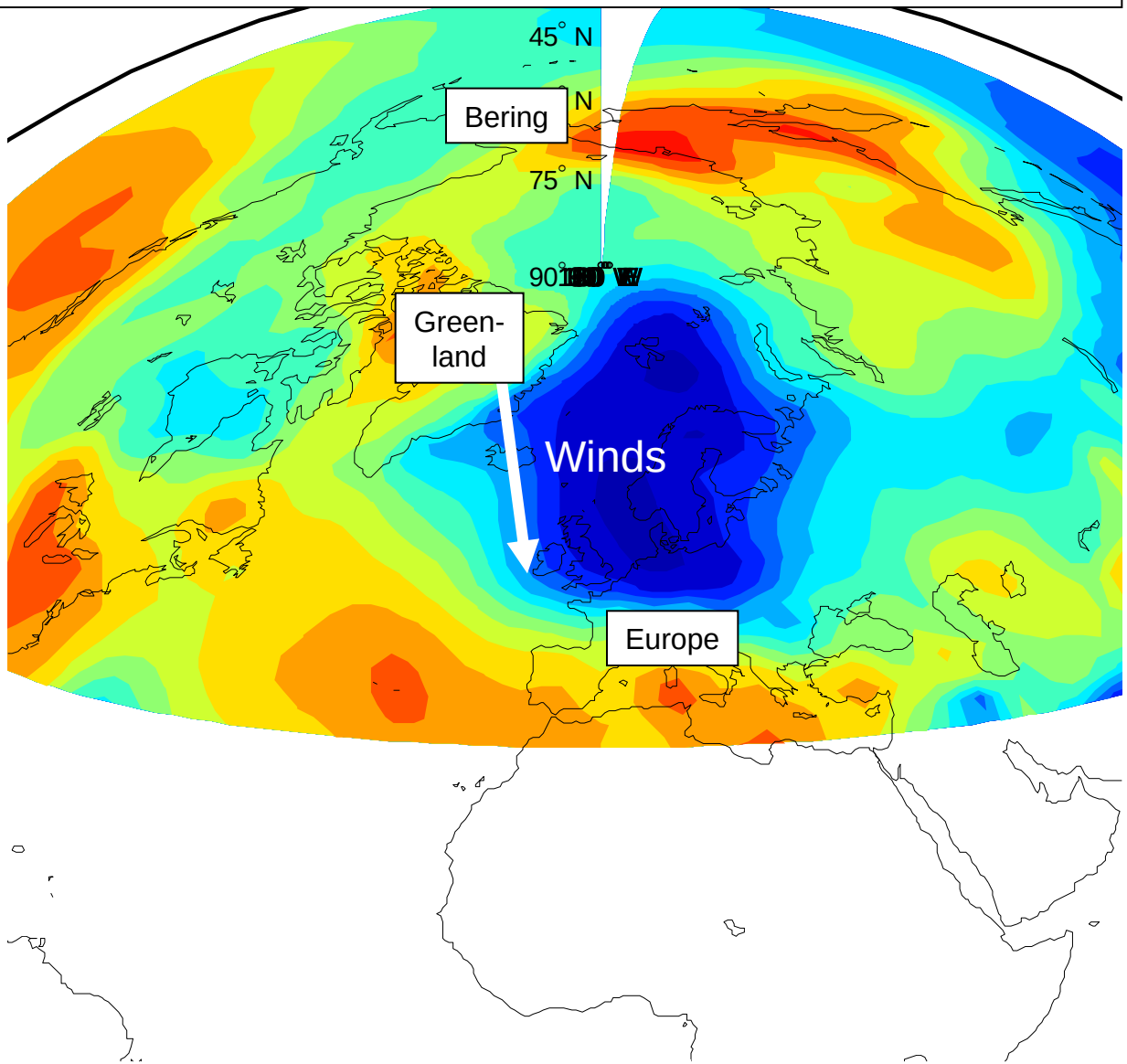


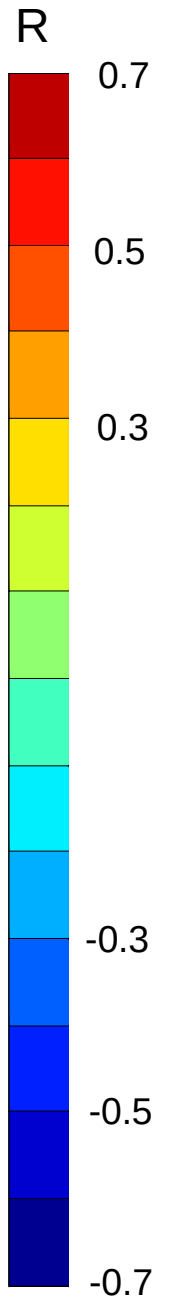
Marine climate and on-shelf Fish

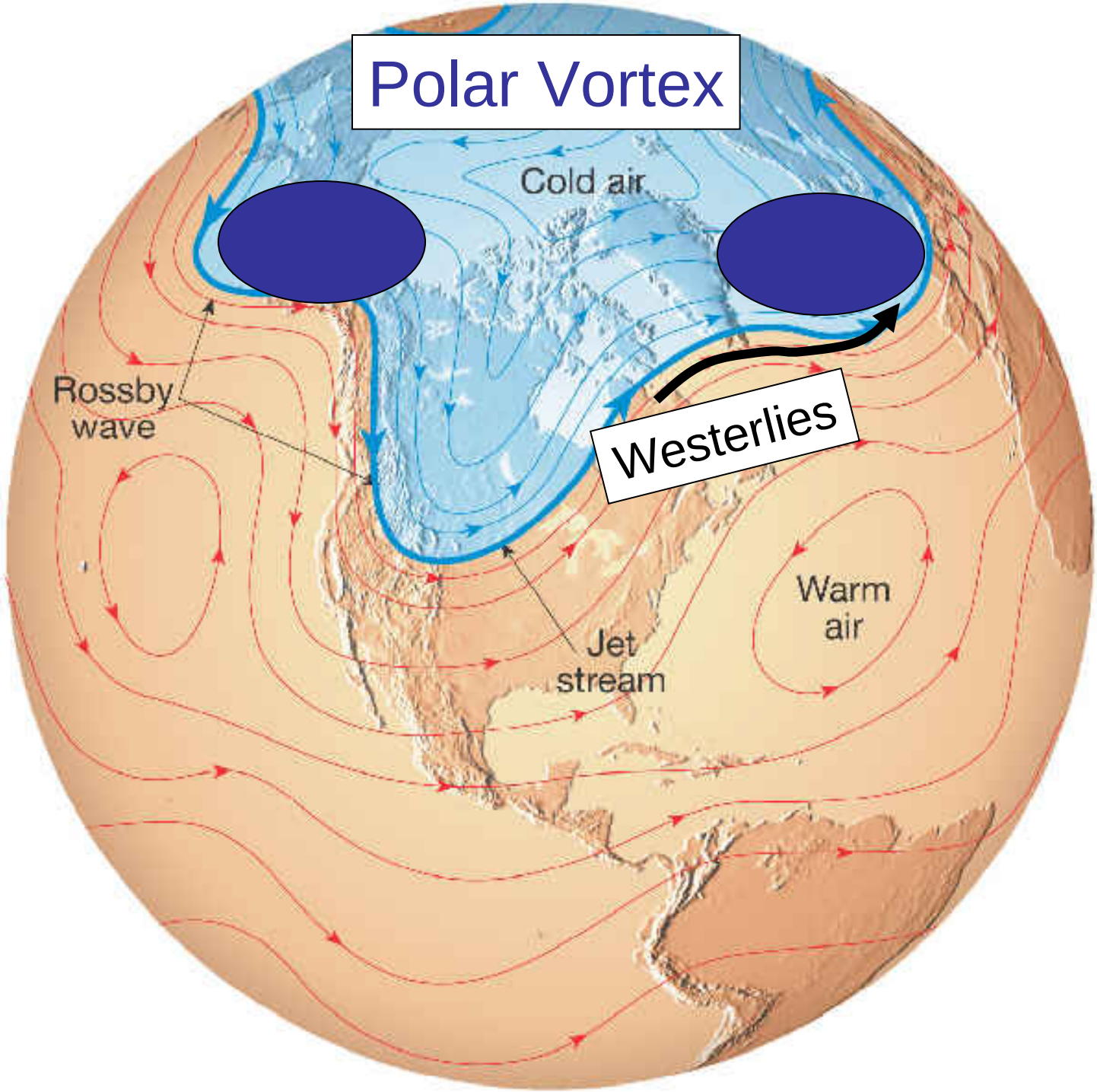




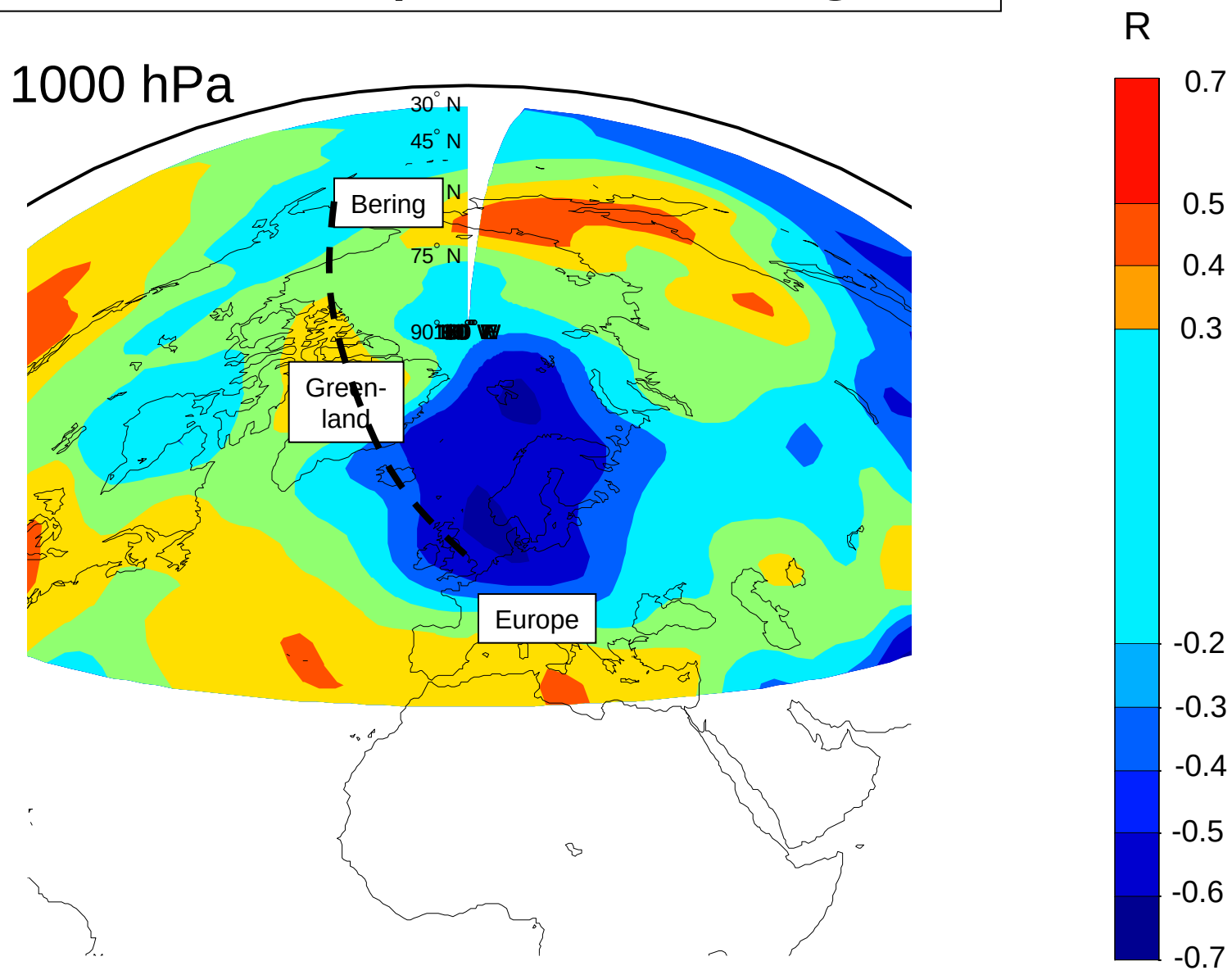
Correlation map:
SDO Index - Sea Level Pressure



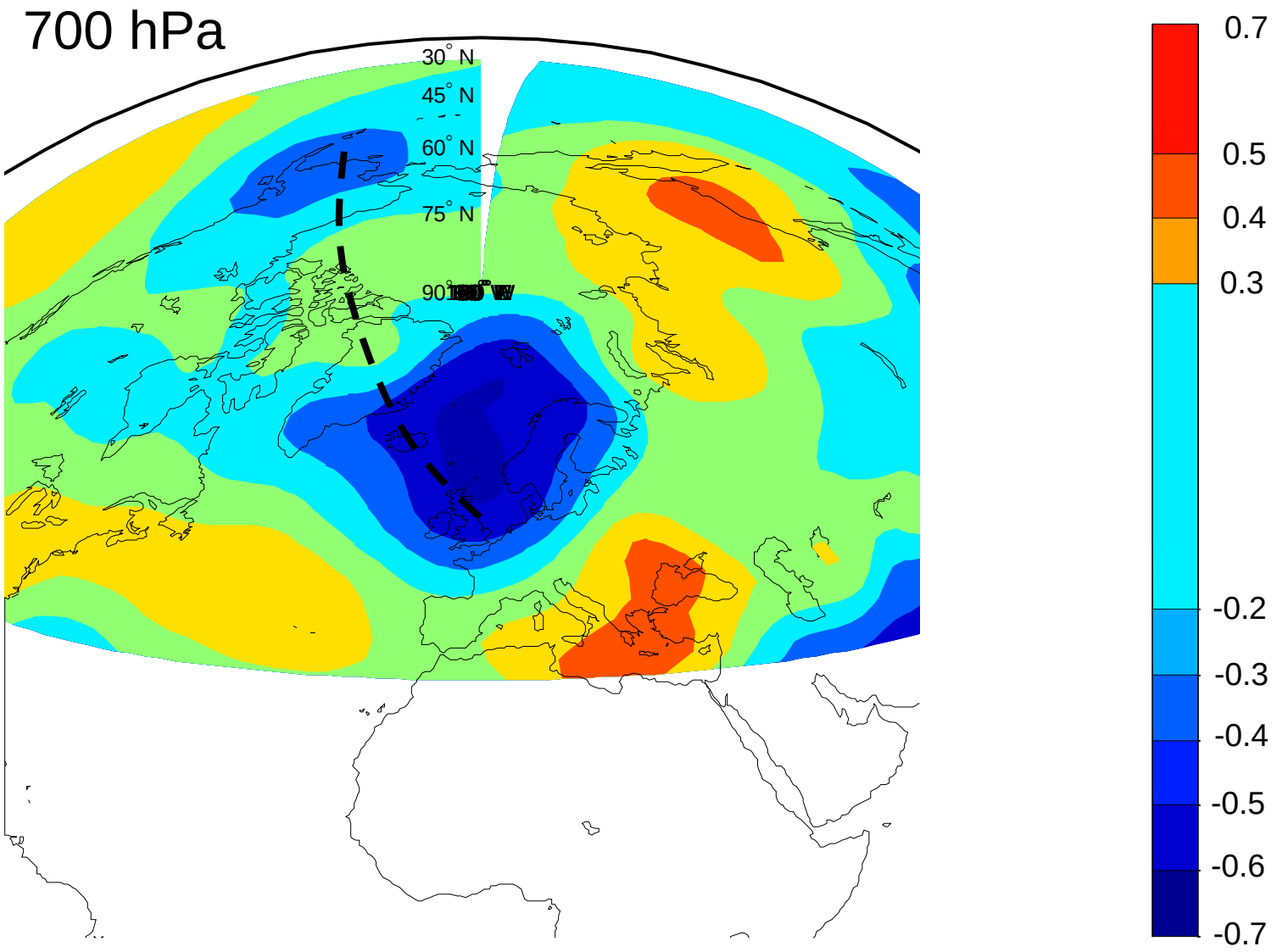



Polar Vortex
Cold air
Rossby wave
Westerlies
Warm air
Jet stream

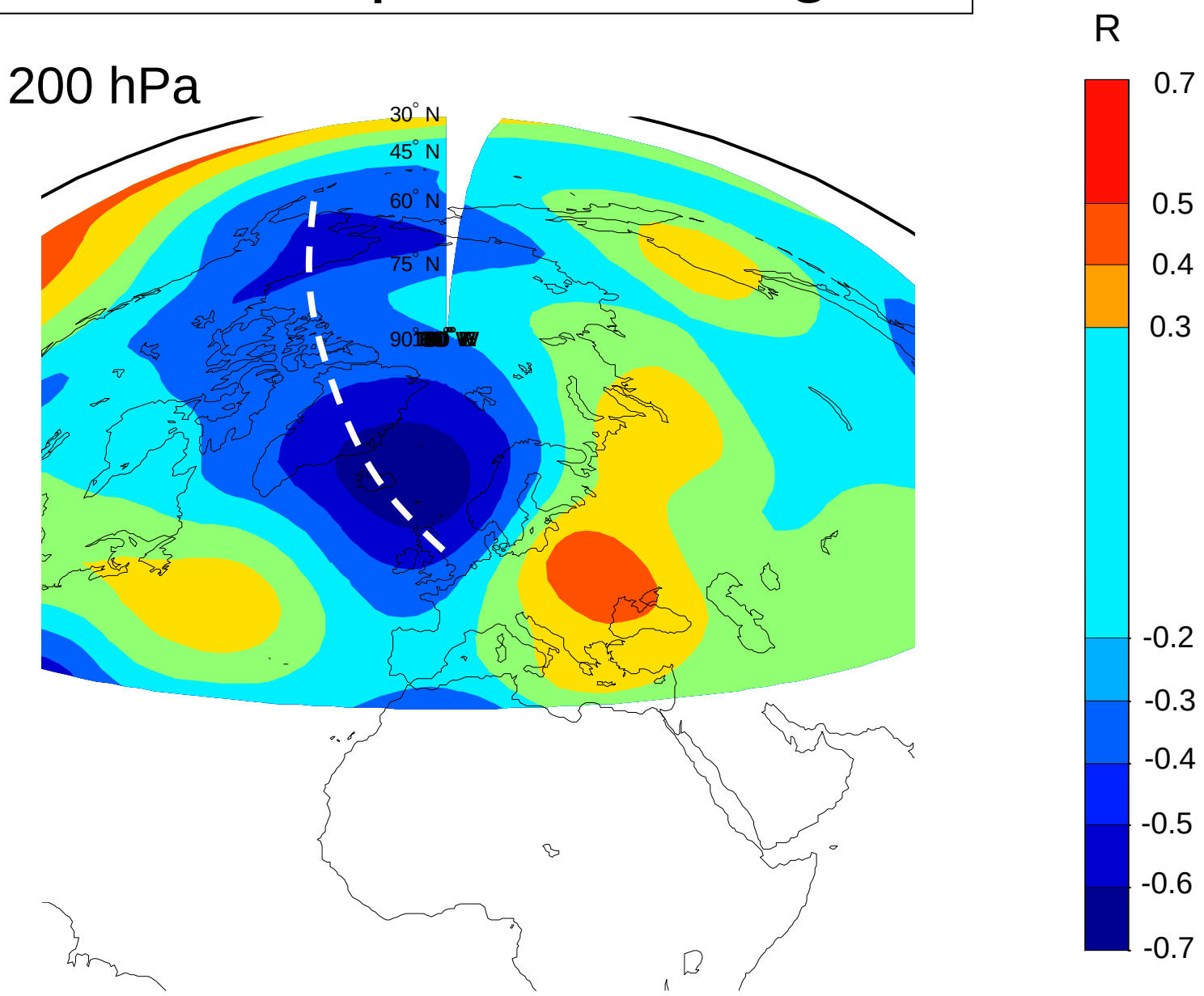
SDO Index - Geo-potential heights



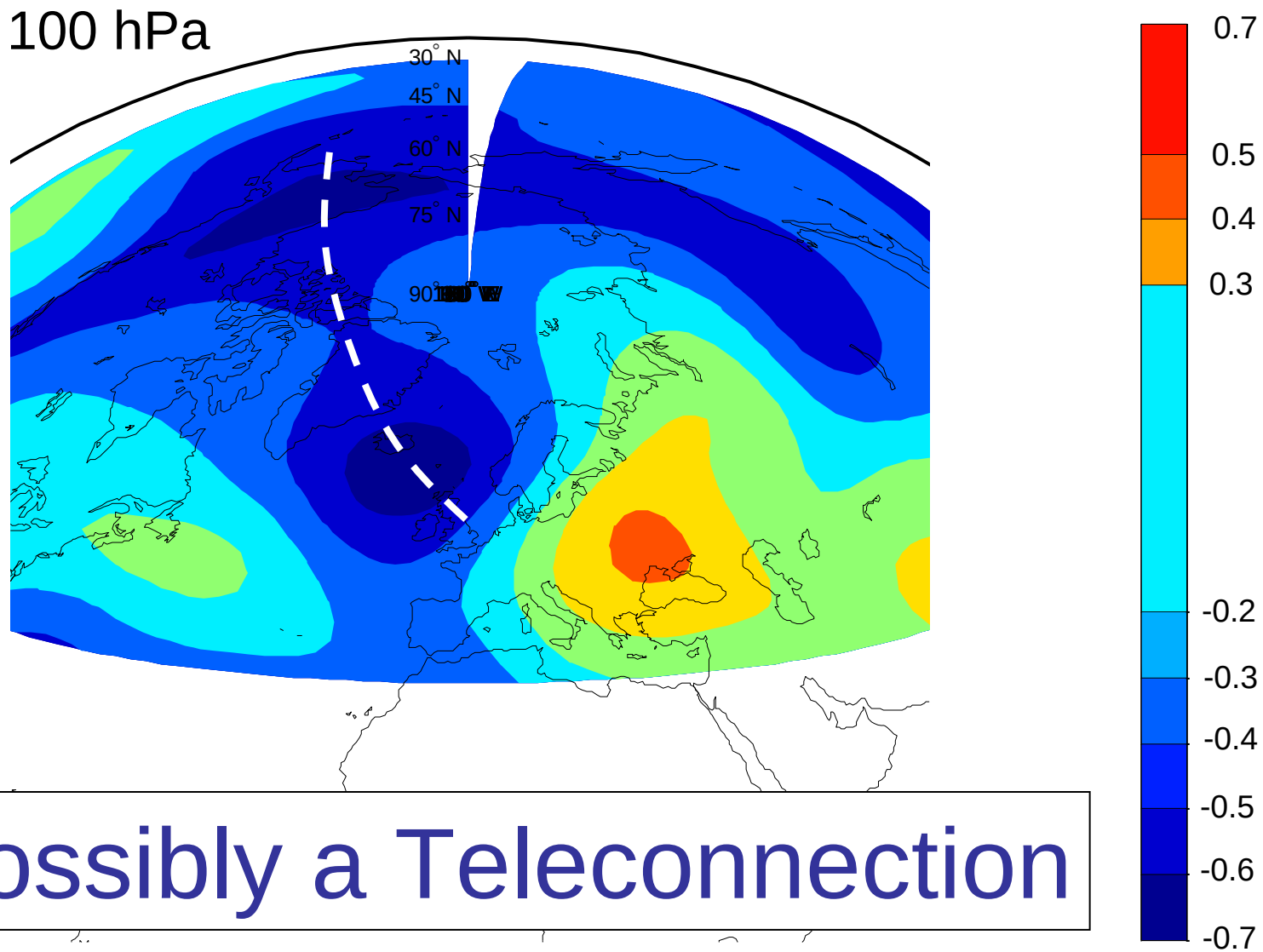
SDO Index - Geo-potential heights



SDO Index - Geo-potential heights



SDO Index - Geo-potential heights

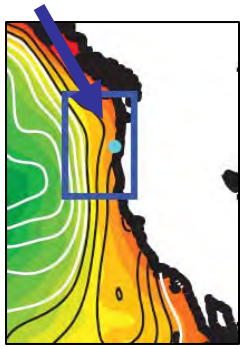


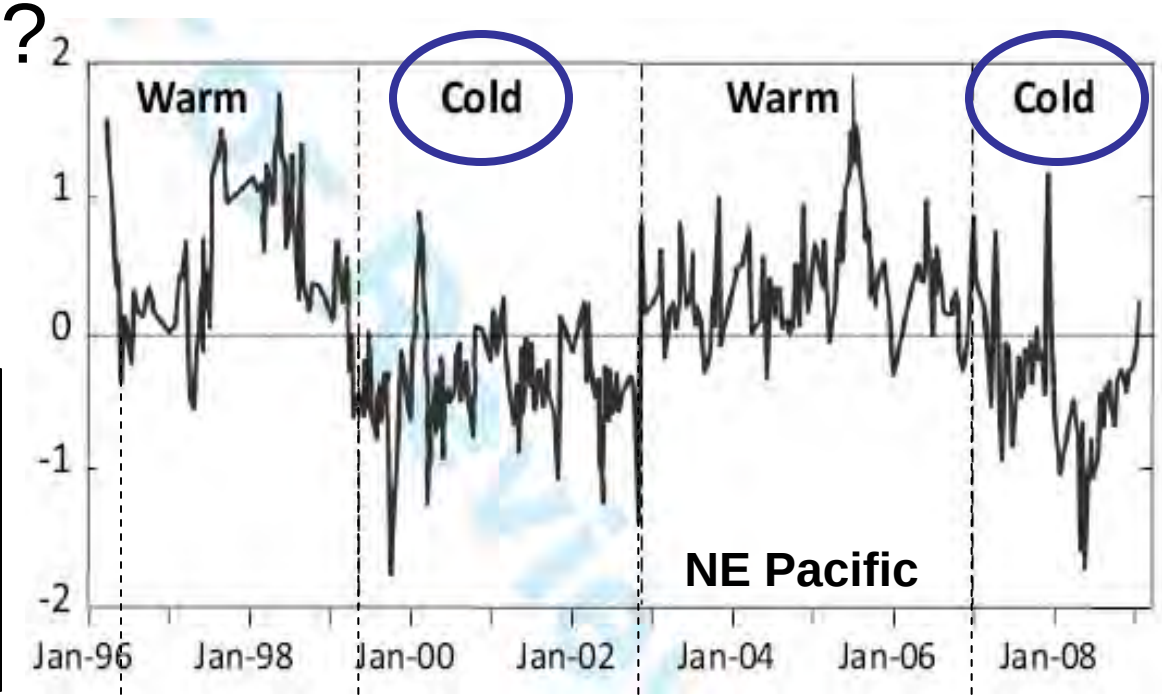
Possibly a Teleconnection

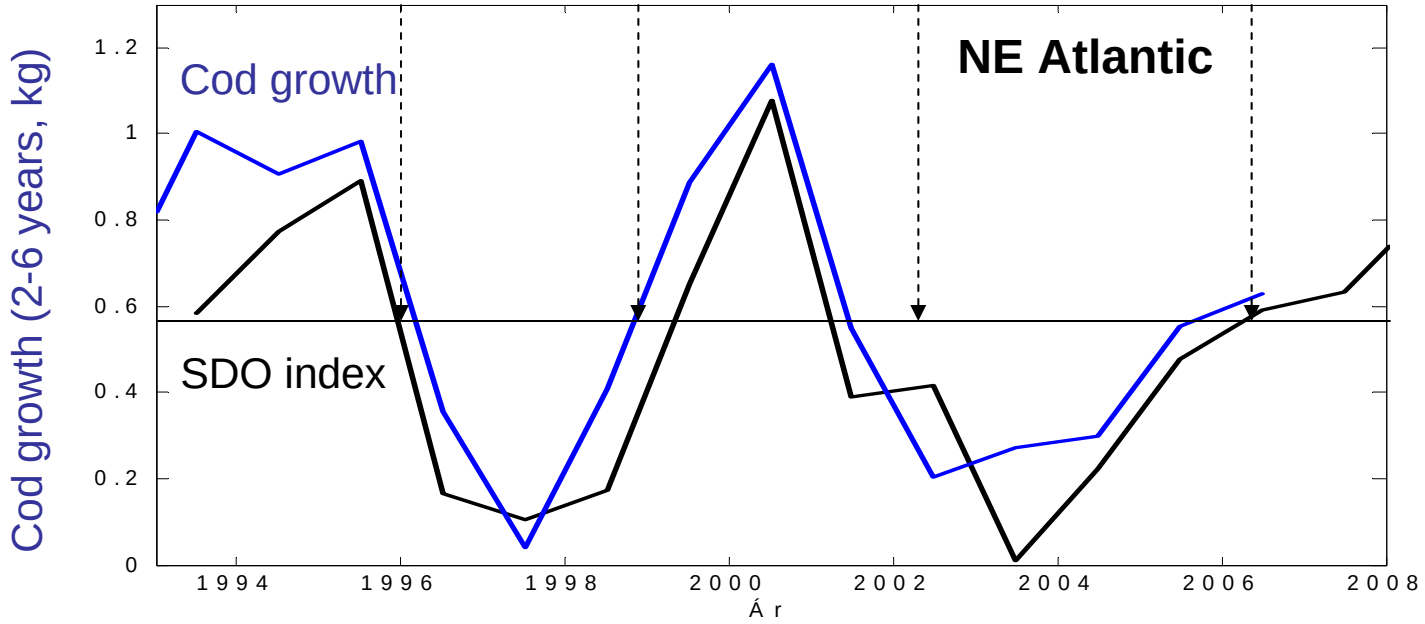
SDO in the Pacific?

Copepod Index (CCI)

Station ”NH5”, Oregon Coast (Keister et al. Global Change Biology, *In review*)





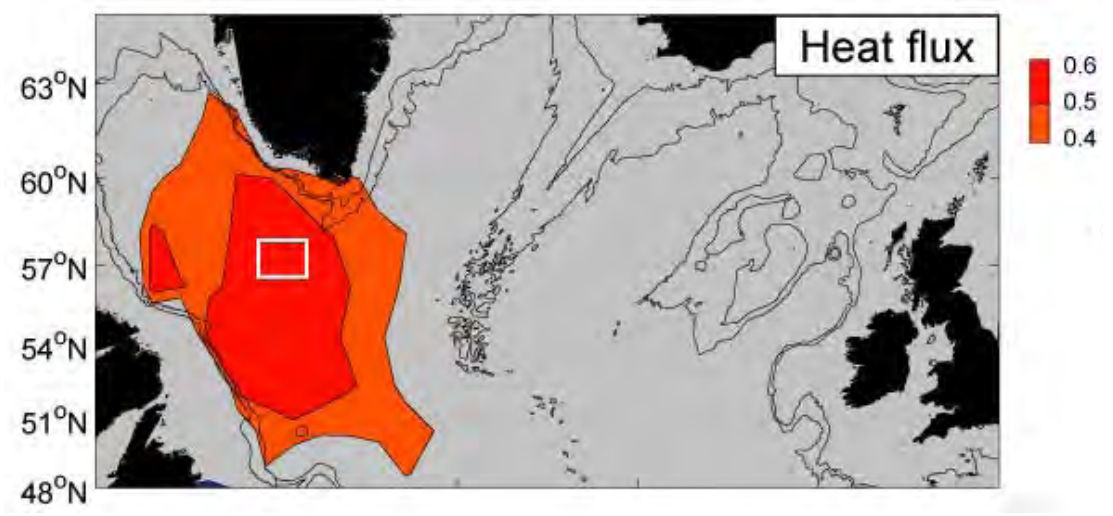


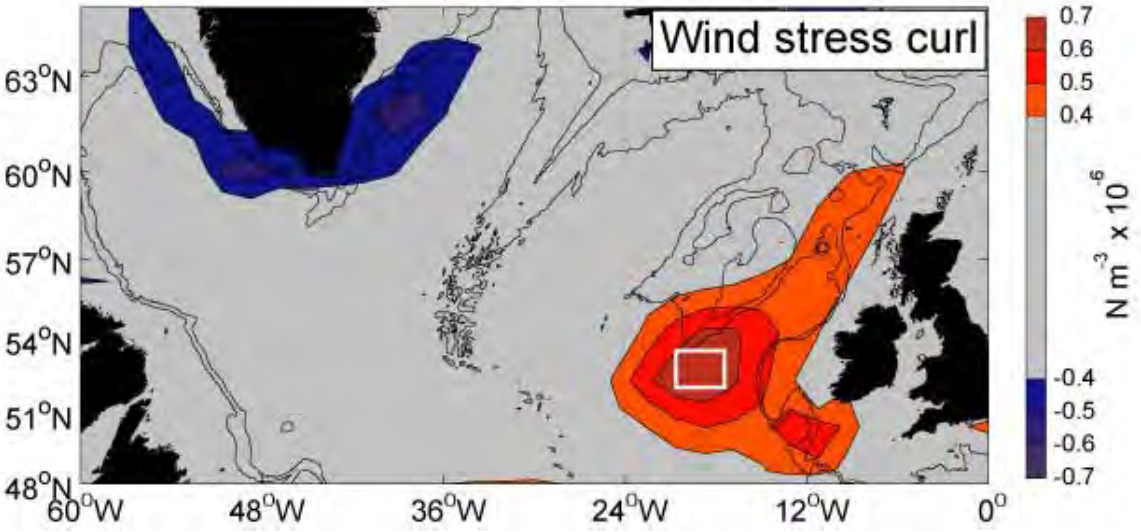
Messages

- The North Atlantic subpolar gyre regulates ecosystems in the NE Atlantic
- A mechanistic understanding
- Potential for prediction
- Possibly a Hemispheric Teleconnection

2e. Atmospheric Forcing

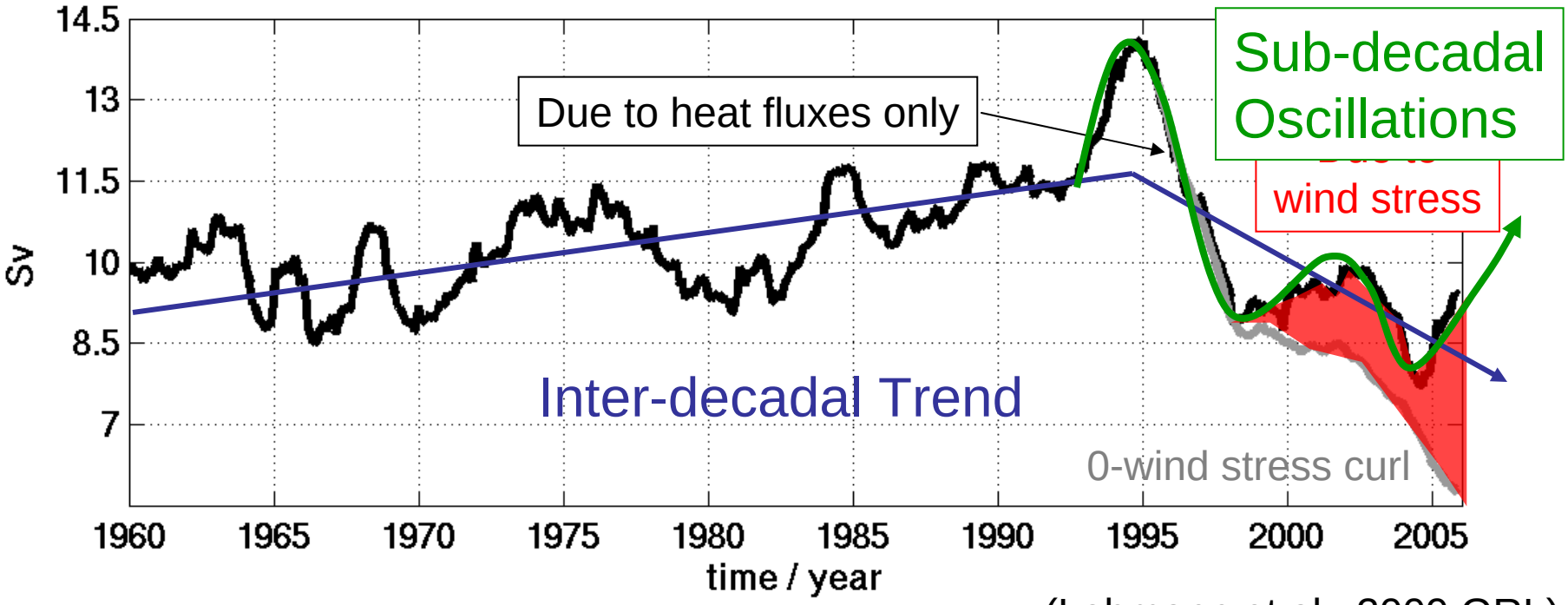
Correlations:
Gyre index and





(Hátún et al., 2007)

Post-95 Decline – Decreases Heat Fluxes



(Lohmann et al., 2009 GRL)