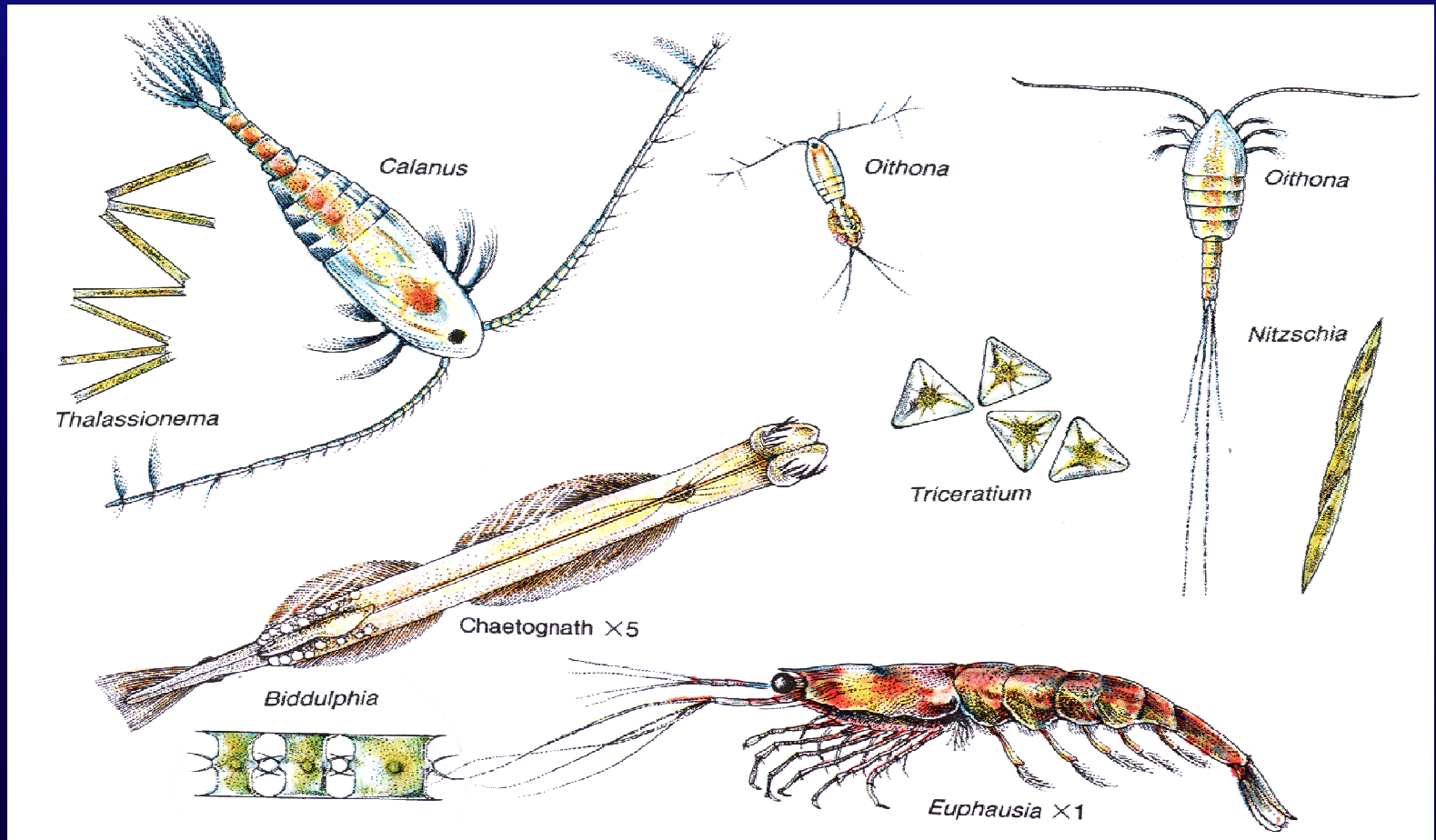


Climate & ecosystem change in the North Sea: The case for regime shift

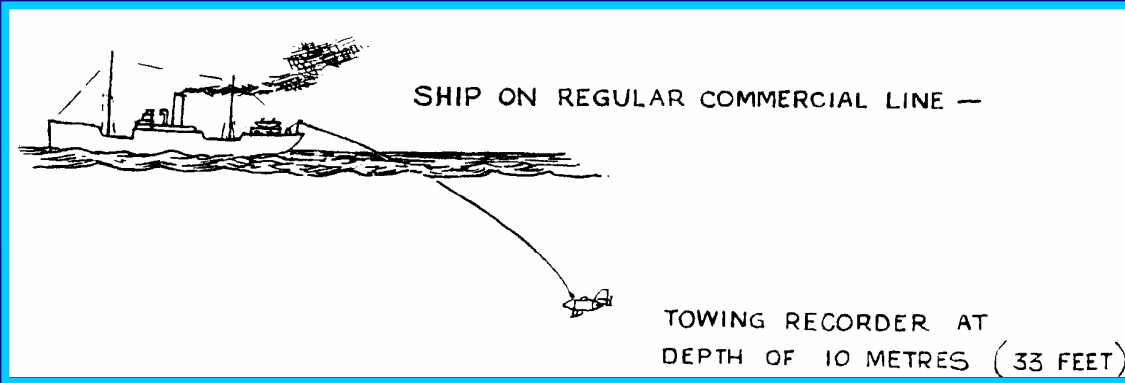
Philip C. Reid

Sir Alister Hardy Foundation for Ocean Science

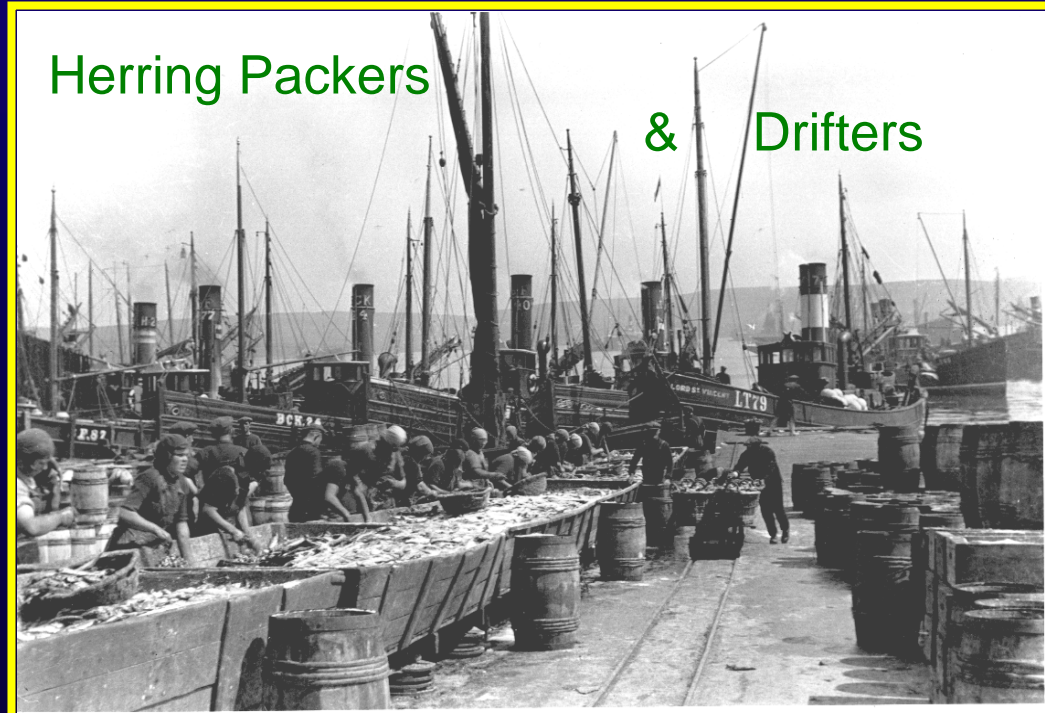


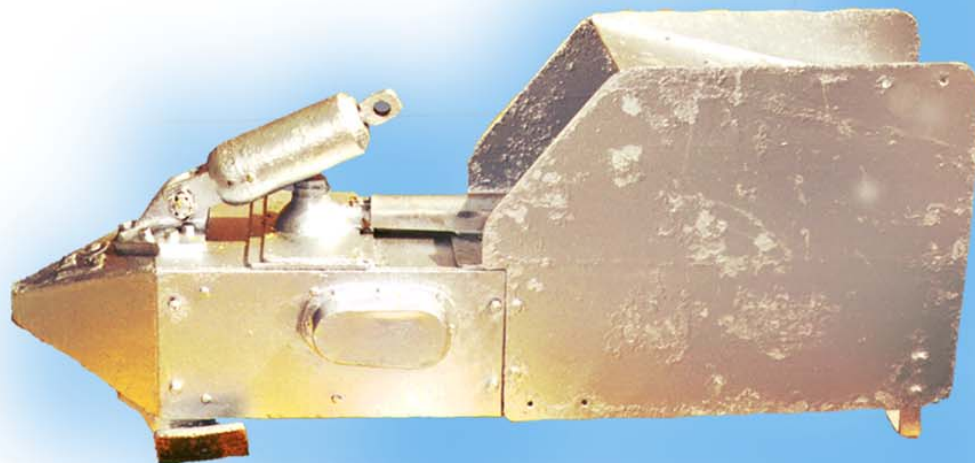
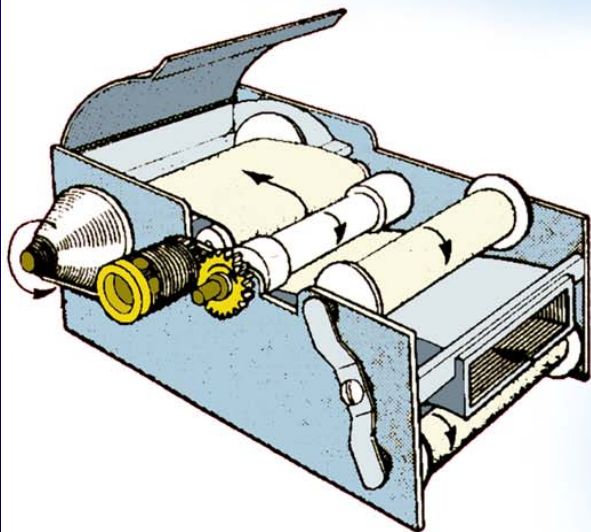
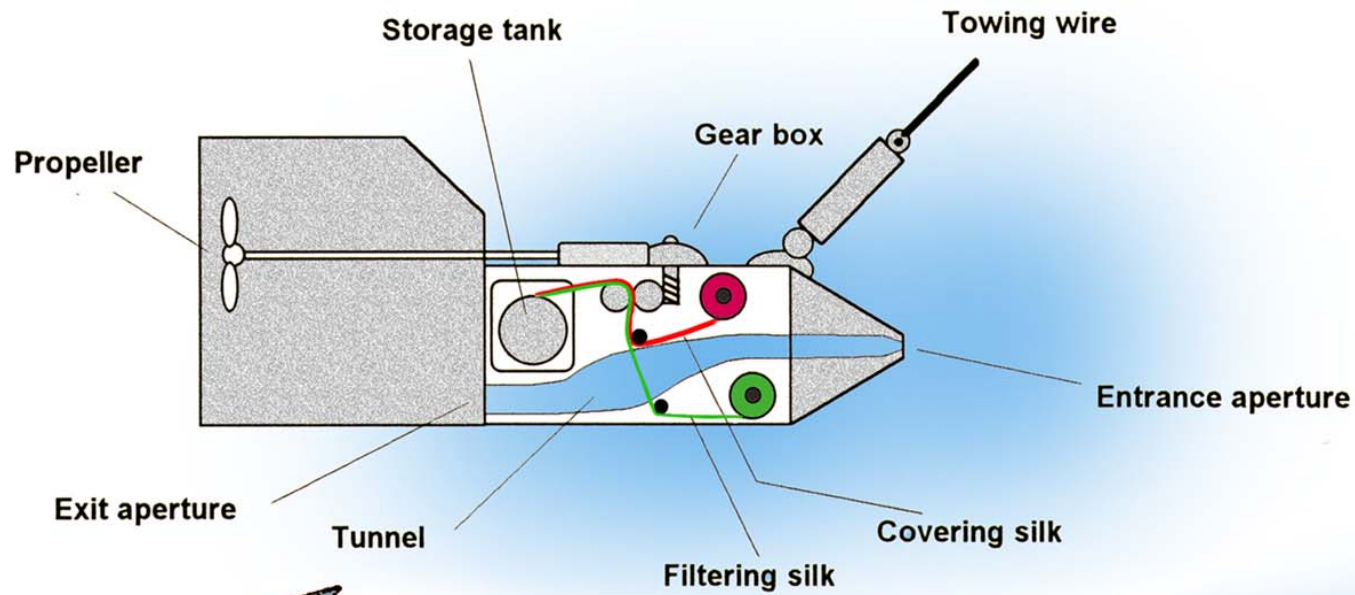
- The CPR survey

Continuous Plankton Recorder (CPR) Survey



First tow
September
1931





The Continuous Plankton Recorder (CPR)



In the lab.....

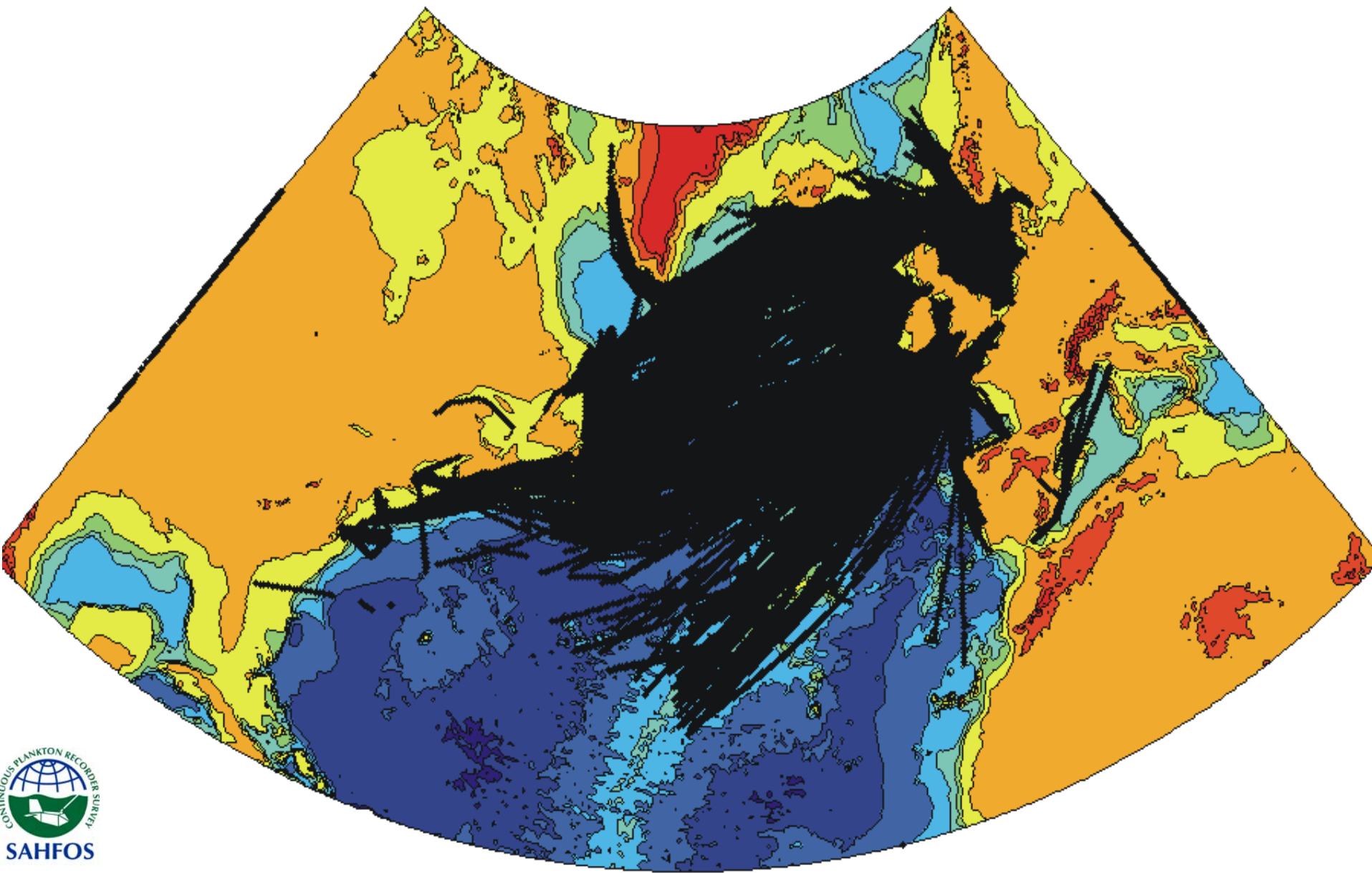


- Mesh cut into separate samples, representing 18km each

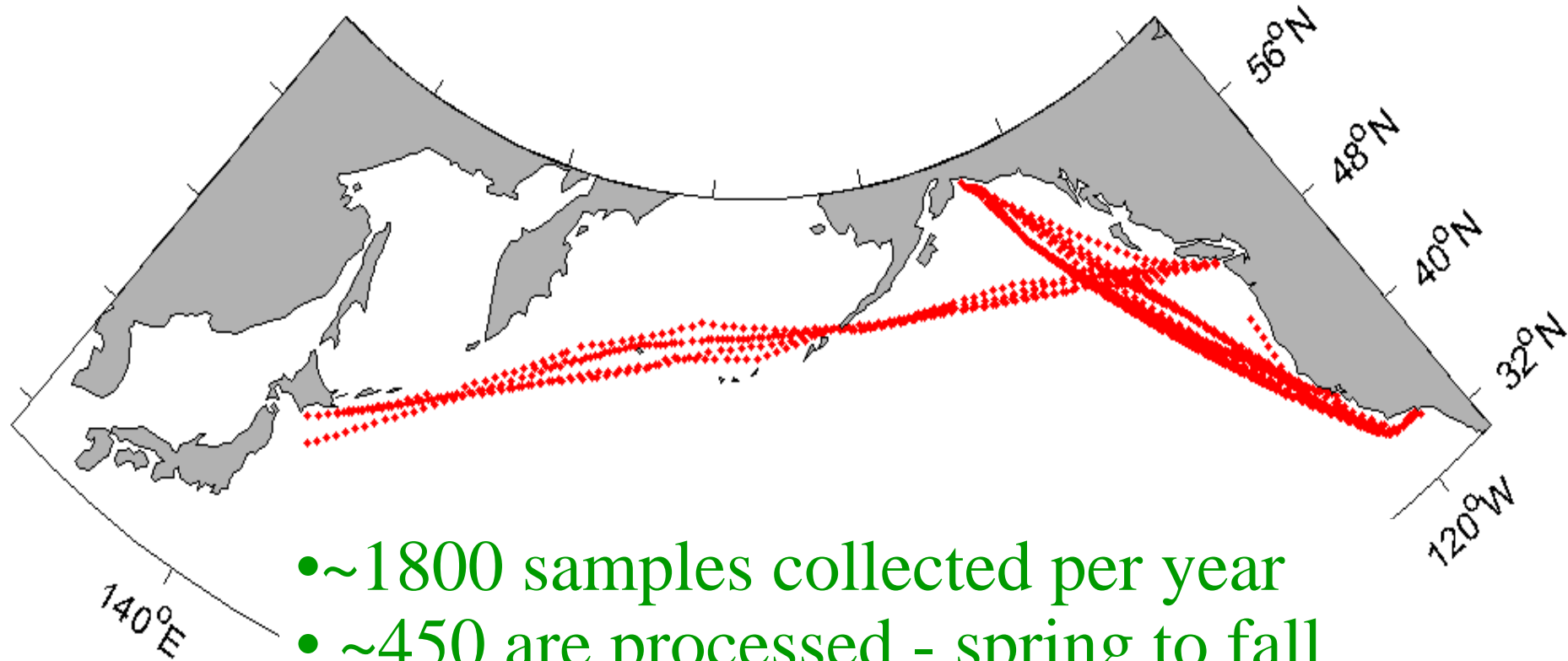
- Samples viewed under a microscope and larger phytoplankton and zooplankton identified (to a practical taxonomic level) and counted

- Data stored in database as counts of taxa together with time, date and location of sample

CPR sampling: 1946-2002



CPR sampling in the Pacific 2000-2002



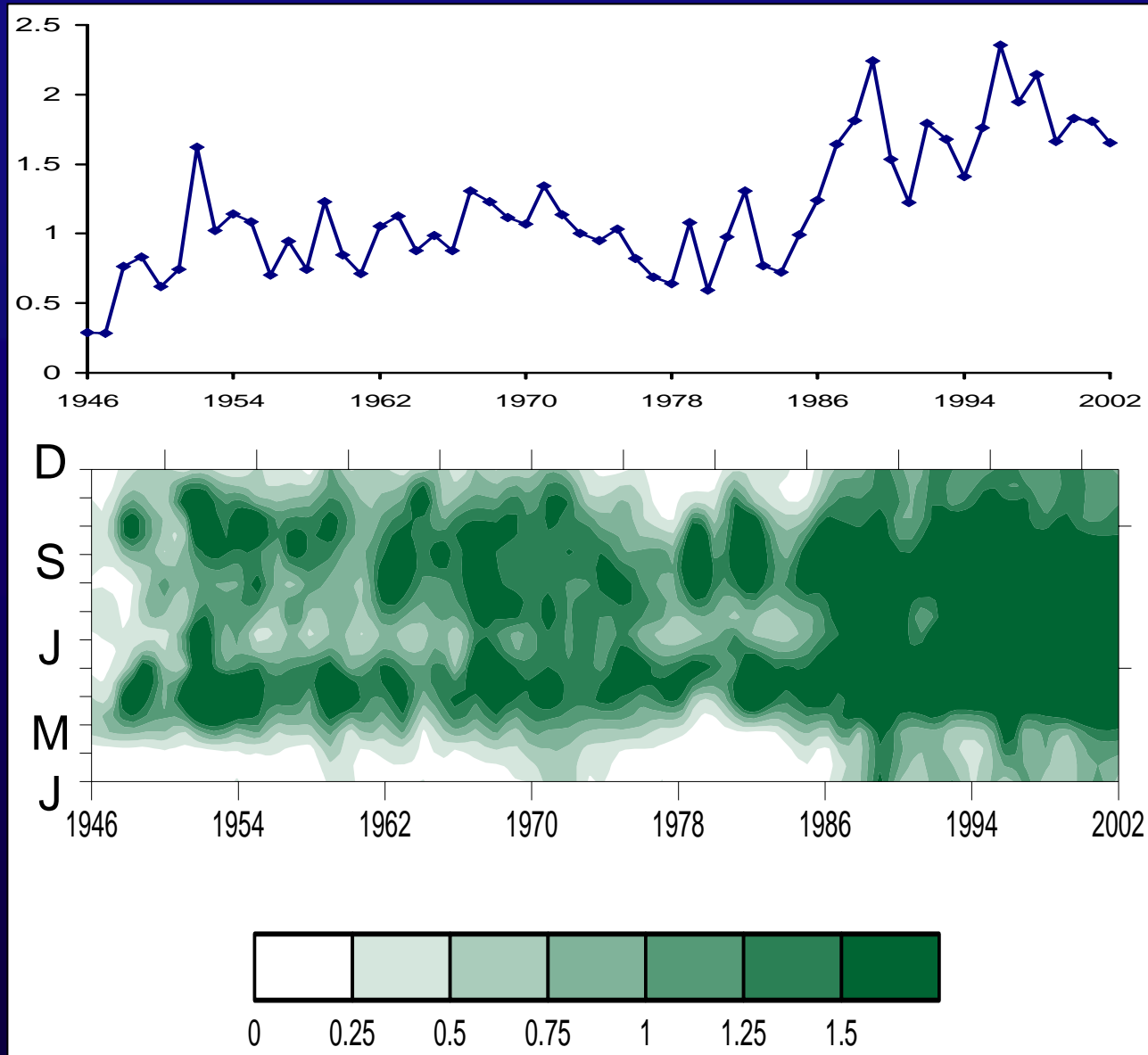
- ~1800 samples collected per year
- ~450 are processed - spring to fall
- 20% processed locally
- Results on web within 3 months

- Regime Shift

North Sea Phytoplankton Colour

1946

2002



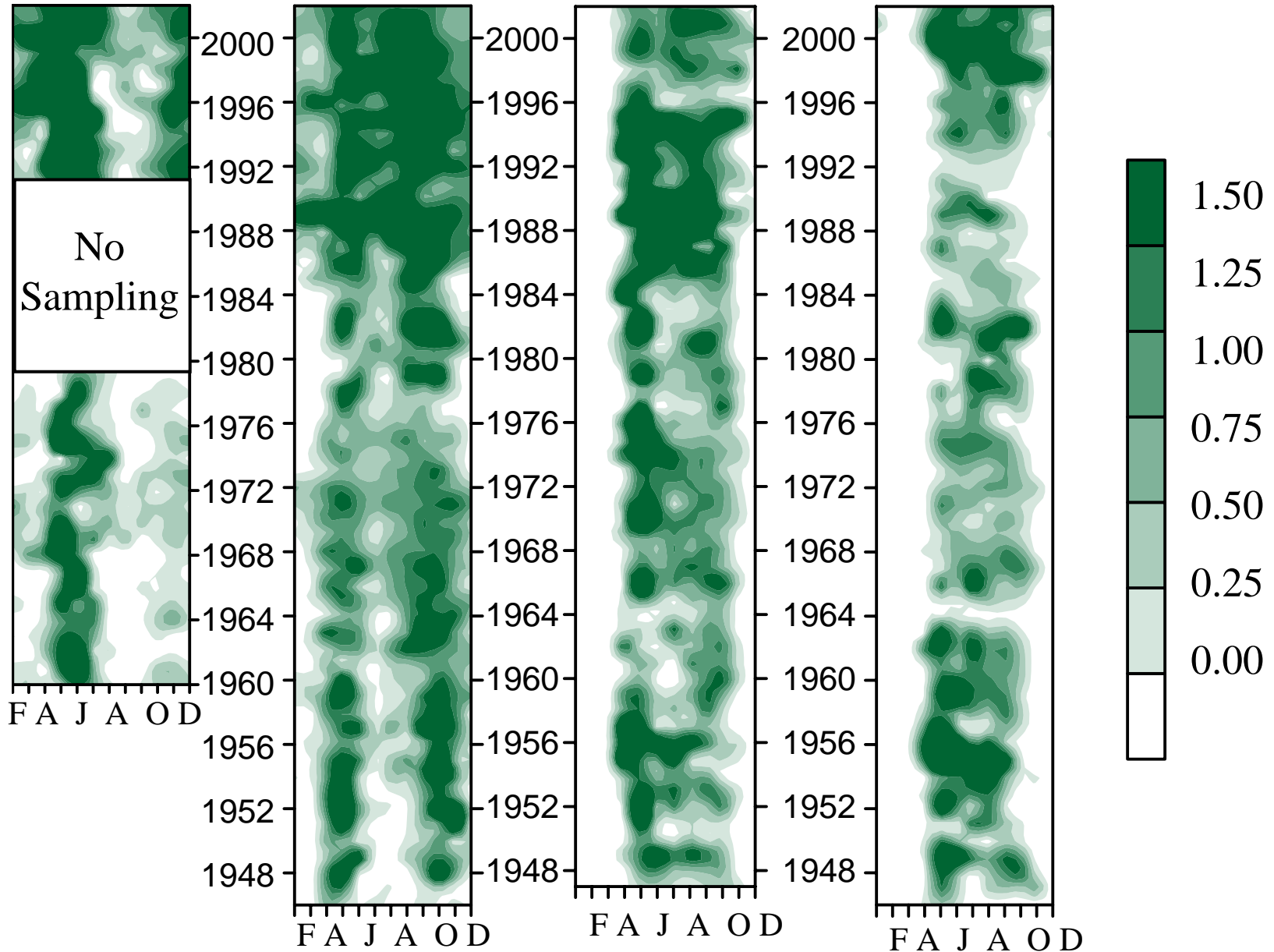
Reid et al. 1998, Nature 391, 546 (updated)

WN Atlantic

C North Sea

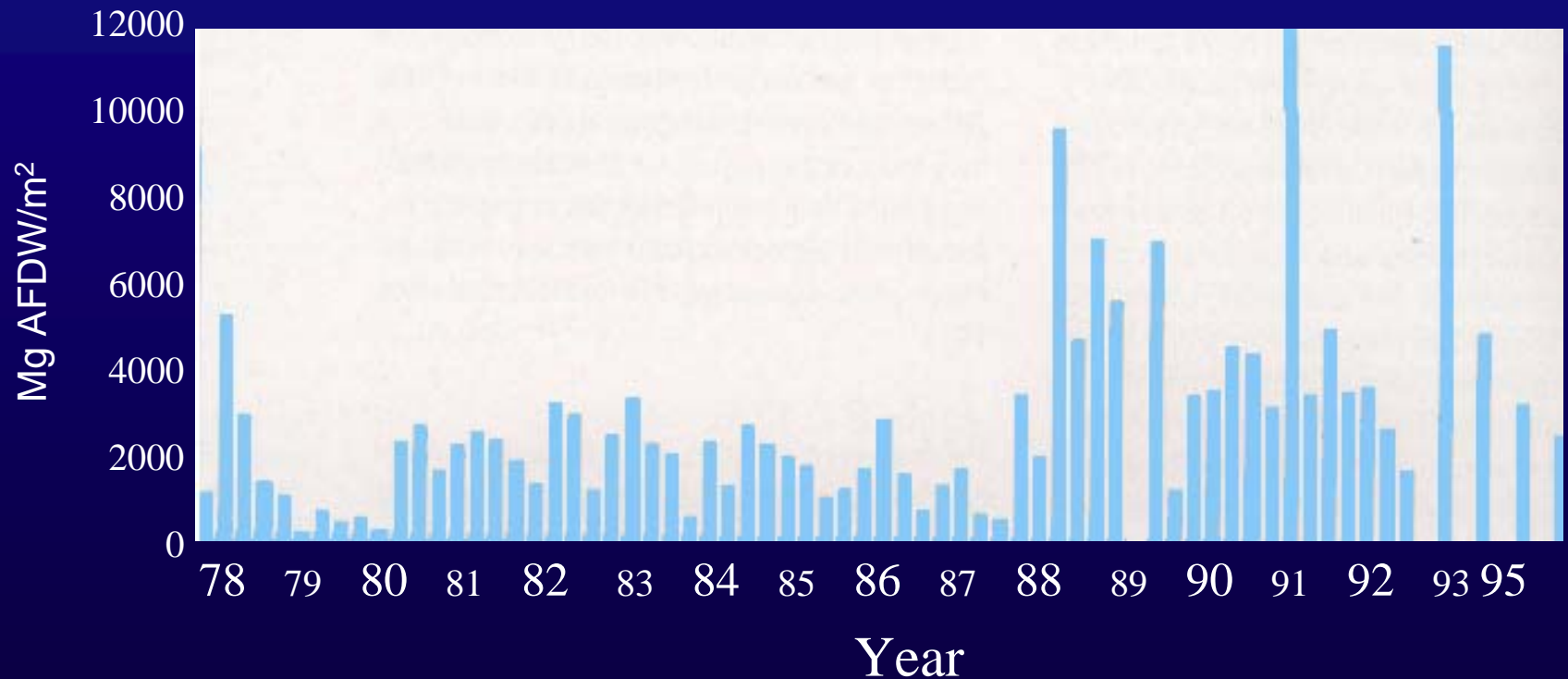
CNE Atlantic

NNE Atlantic

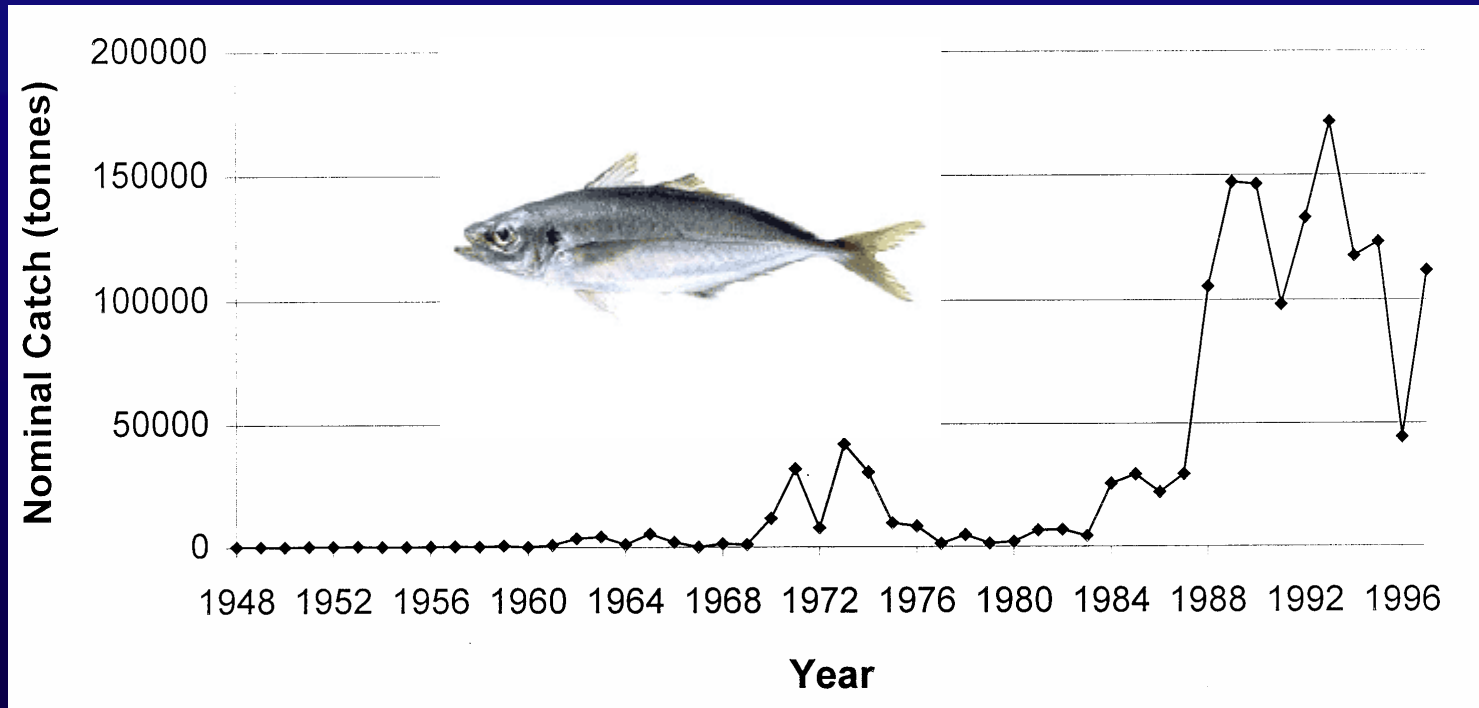


CPR sample 'greenness' showing long term and seasonal change

Quarterly Benthic biomass at Norderney (Southeast North Sea)



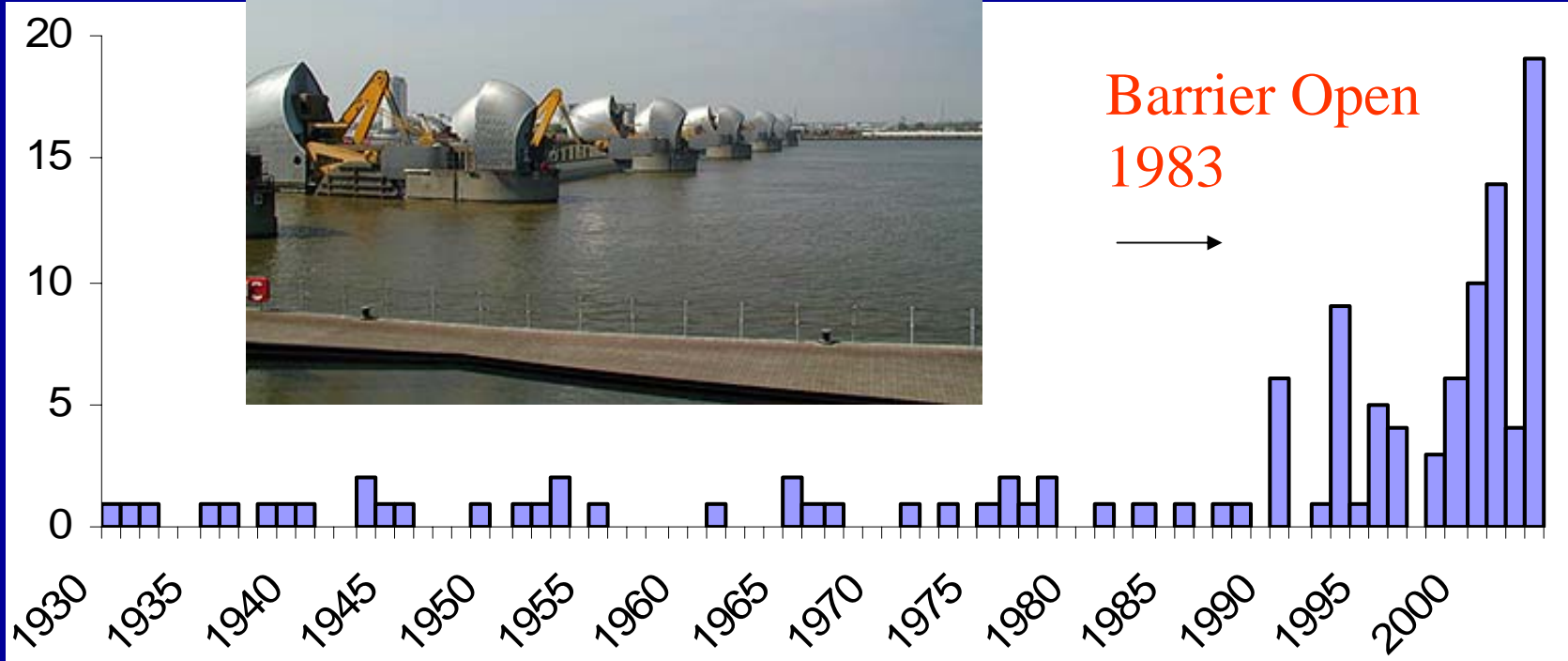
Annual landings of horse mackerel in the North Sea



Annual Closures of the Thames Barrier



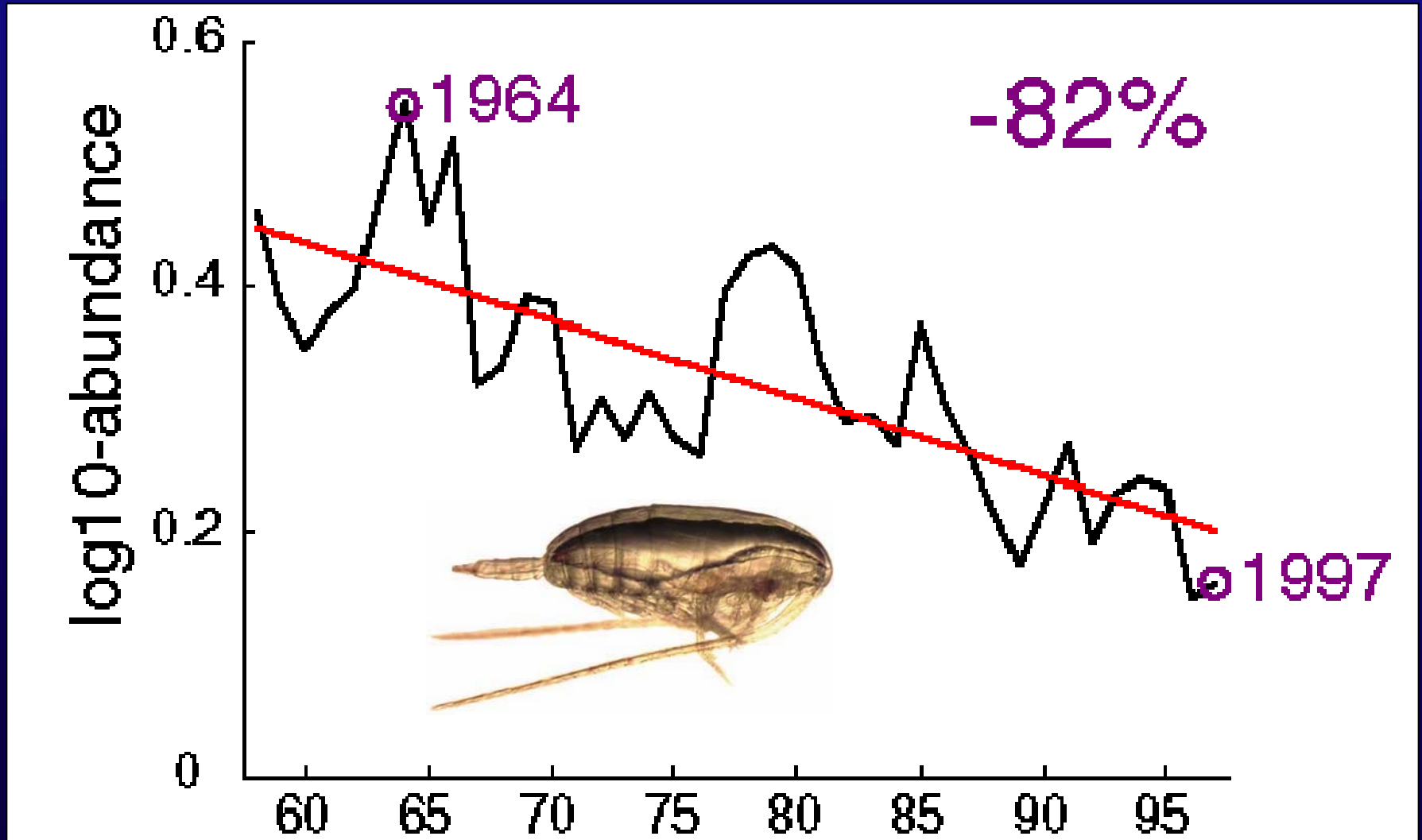
Number of closures



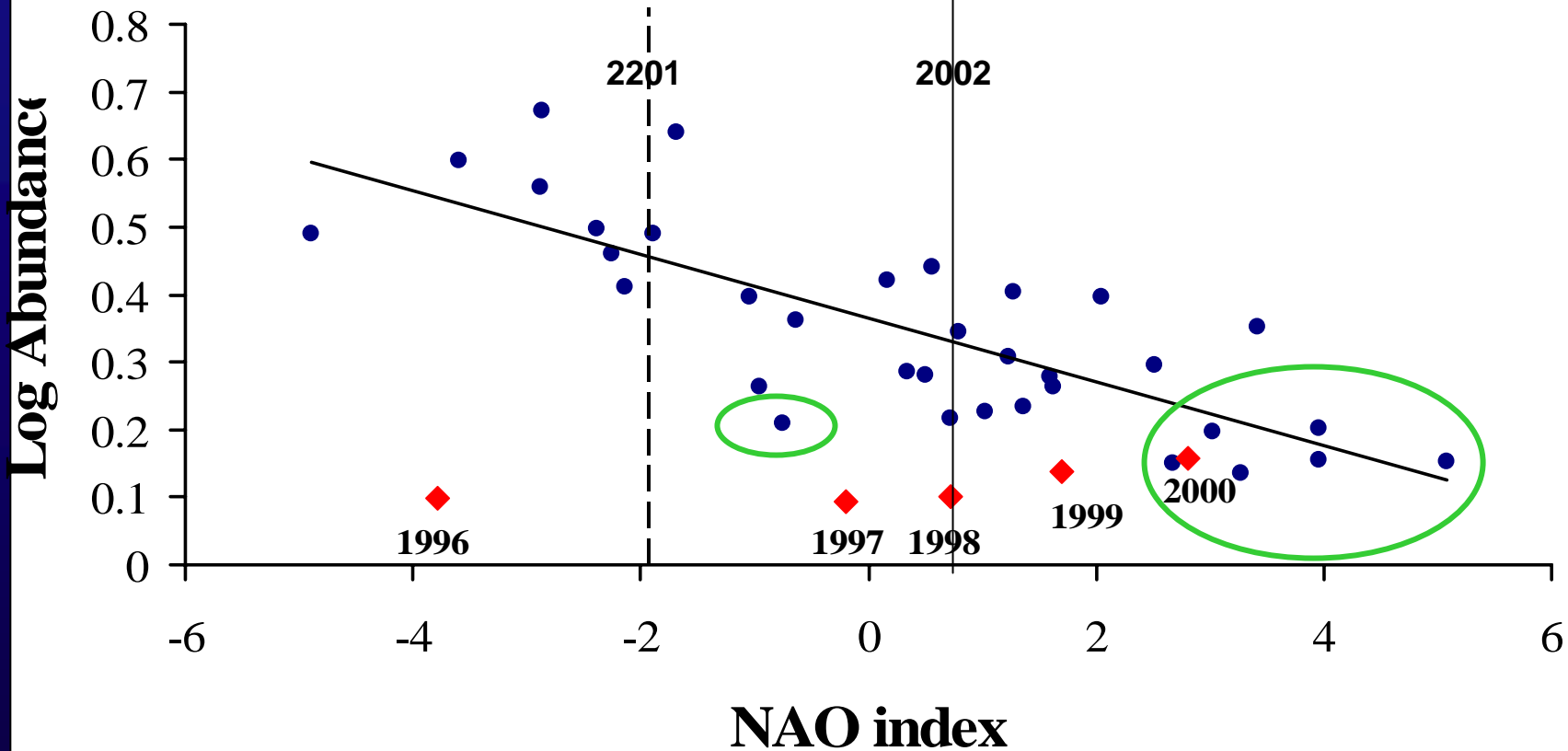
UK Environment Agency

- C. fin./NAO

Interannual variations in the abundance of *C. finmarchicus* in the Northeast Atlantic

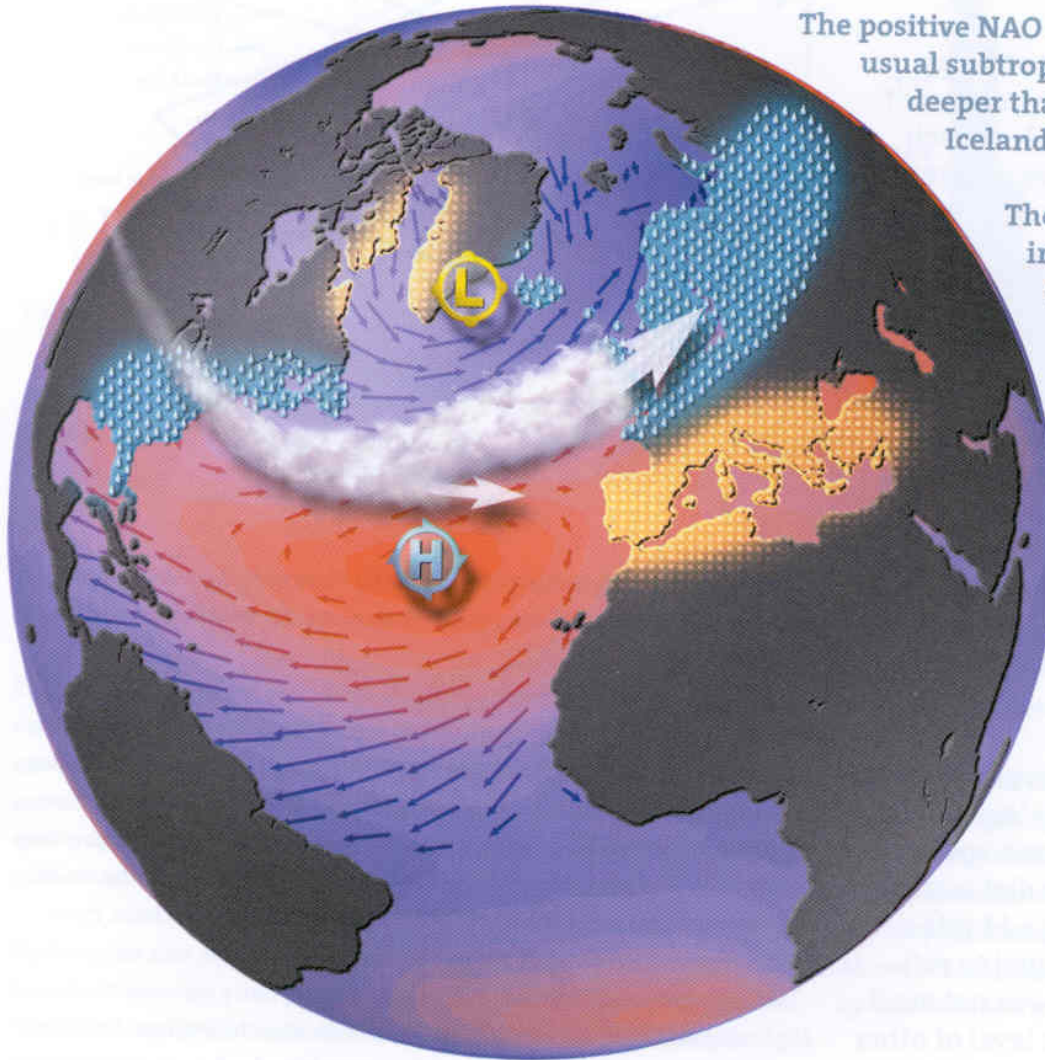


Annual Log abundance of *Calanus finmarchicus* from CPR samples plotted against the NAO index from 1962-2000



What it means for the North Atlantic

Positive NAO Index



The positive NAO index phase shows a stronger than usual subtropical high-pressure centre and a deeper than normal Icelandic low.

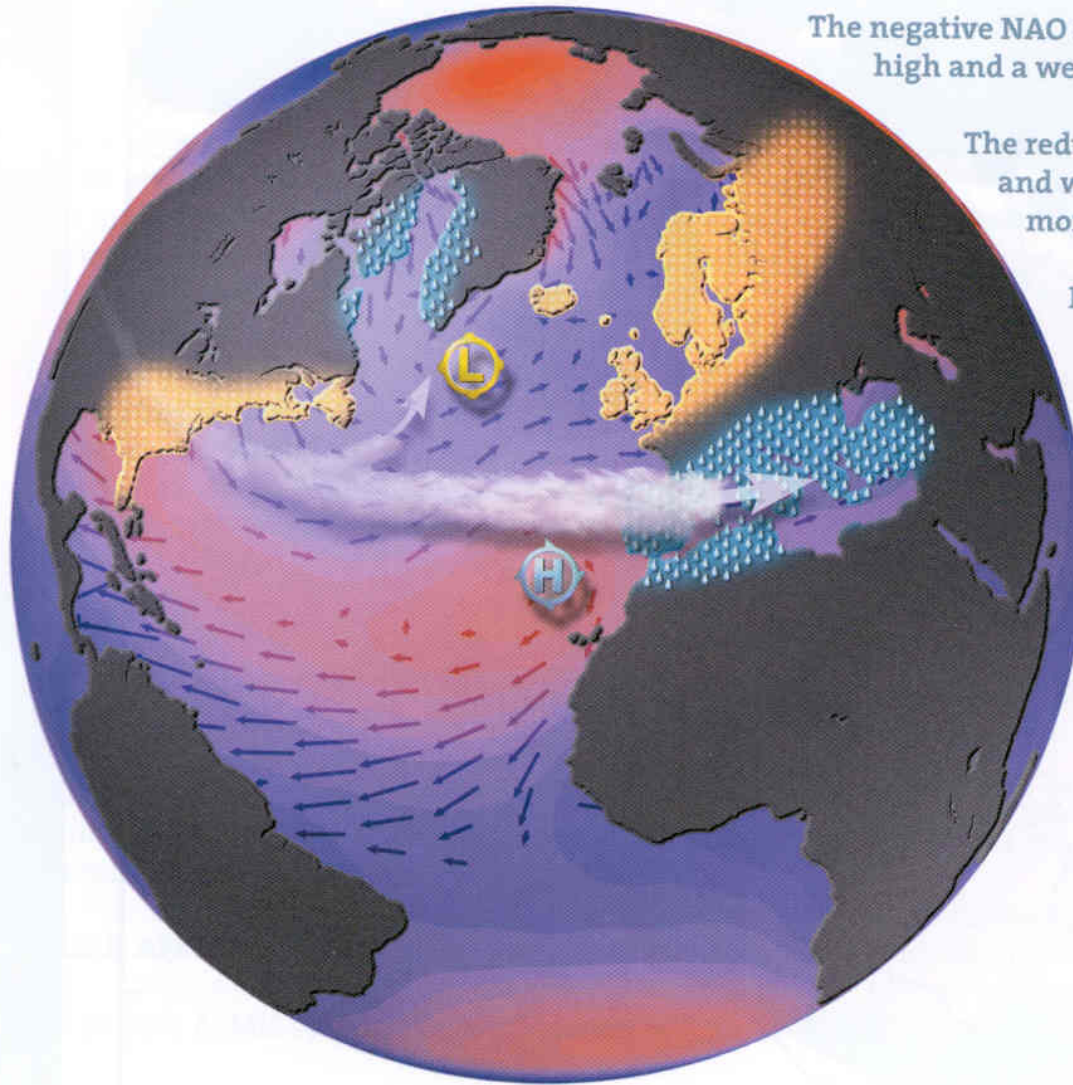
The increased pressure difference results in more and stronger winter storms crossing the Atlantic Ocean on a more northerly track.

This results in warm and wet winters in Europe and in cold and dry winters in northern Canada and Greenland.

The eastern US experiences mild and wet winter conditions.

What it means for the North Atlantic

Negative NAO Index



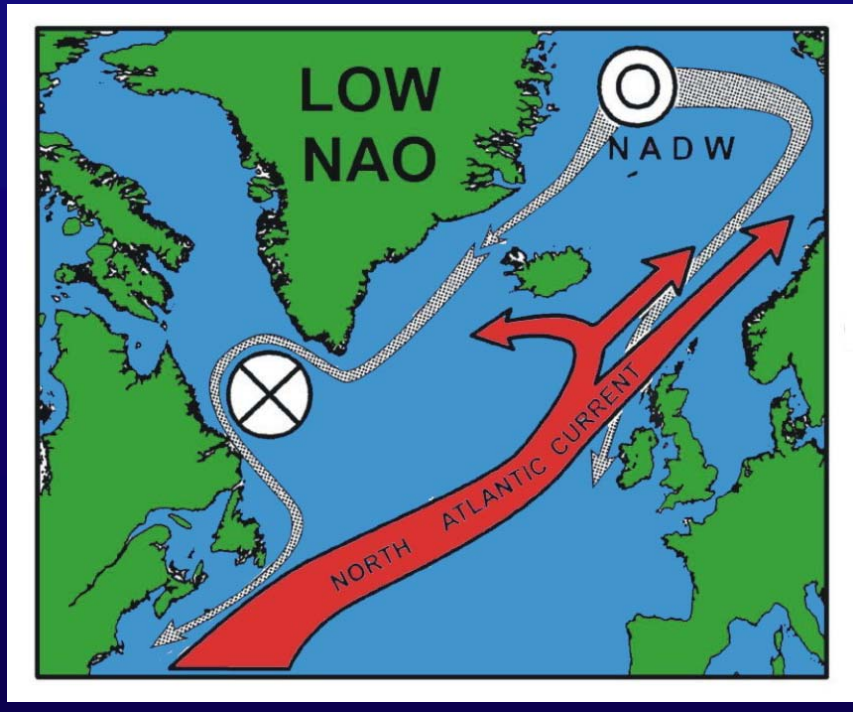
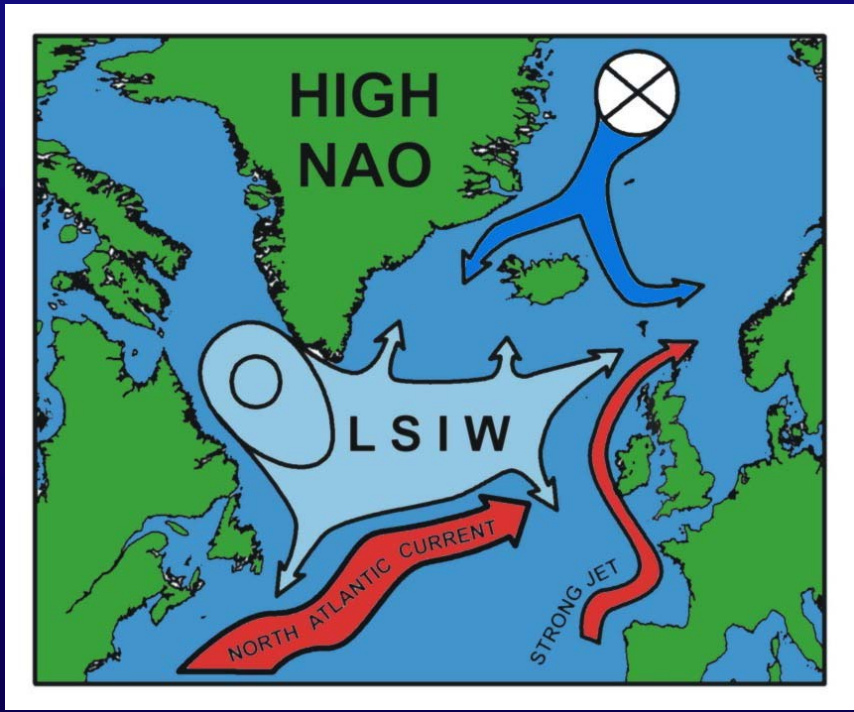
The negative NAO index phase shows a weak subtropical high and a weak Icelandic low.

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

Brings moist air into the Mediterranean and cold air to northern Europe.

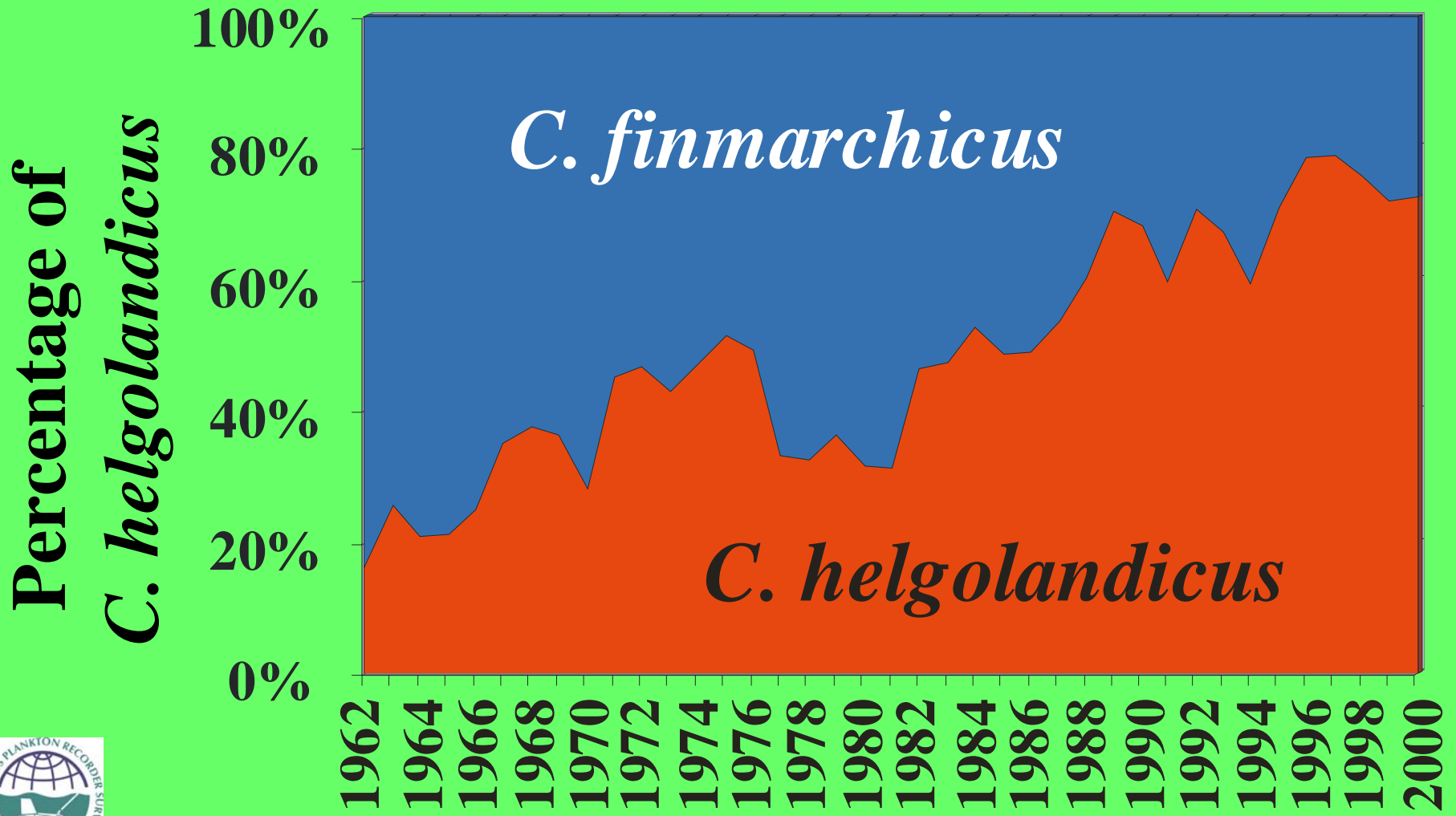
The US east coast experiences more cold air outbreaks and hence snowy weather conditions.

Greenland, however, will have milder winter temperatures.

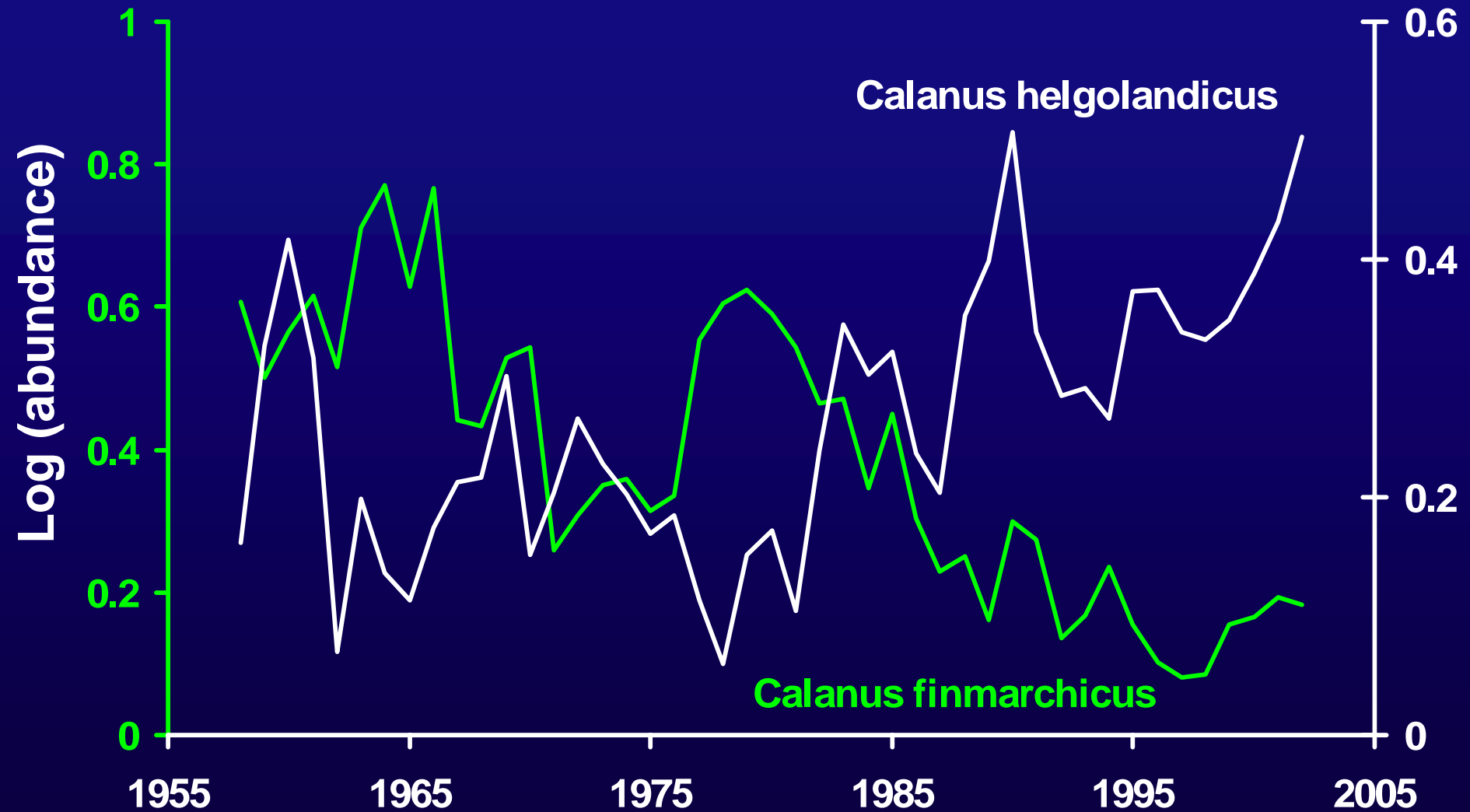


- C. fin./C. hel

Long-term changes in the abundance of two key species in the North Sea



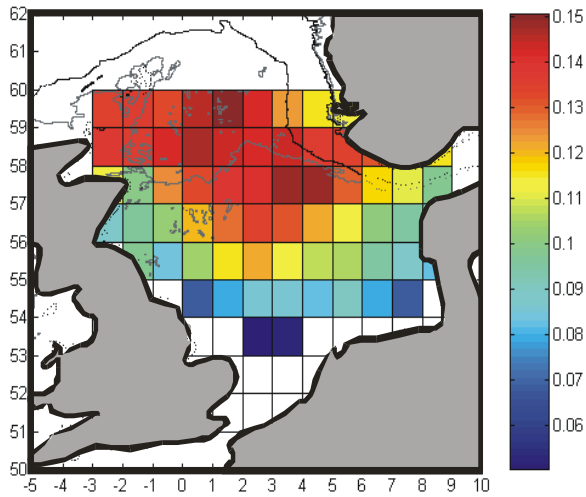
Calanus North Sea 1958-2002



Reid et al. 2003, Fisheries Oceanography 12, 260-269

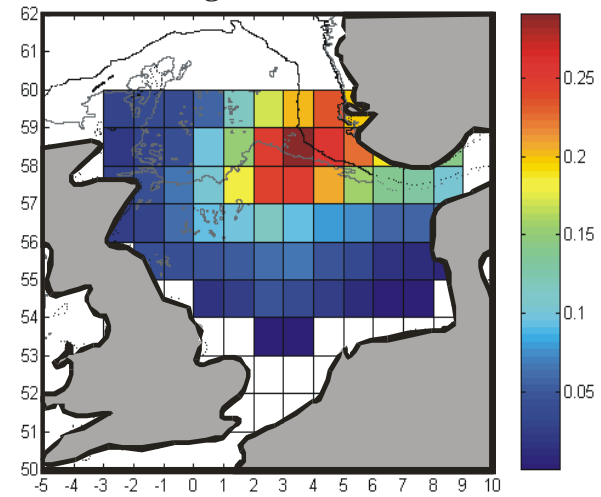
Calanus helgolandicus

Eigenvector 1

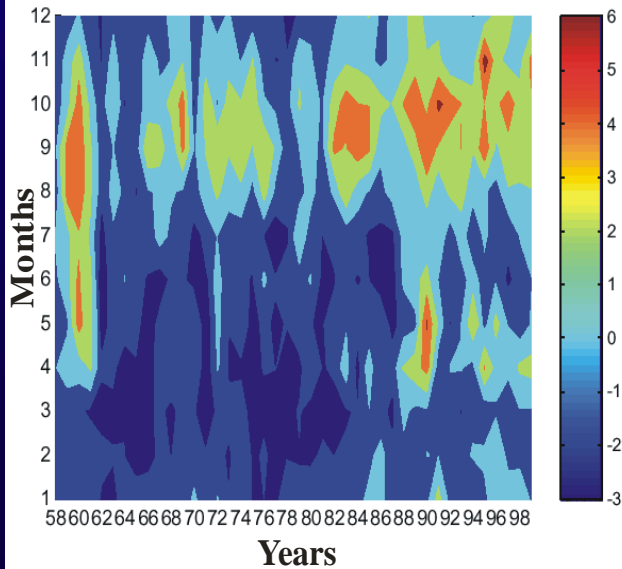


Calanus finmarchicus

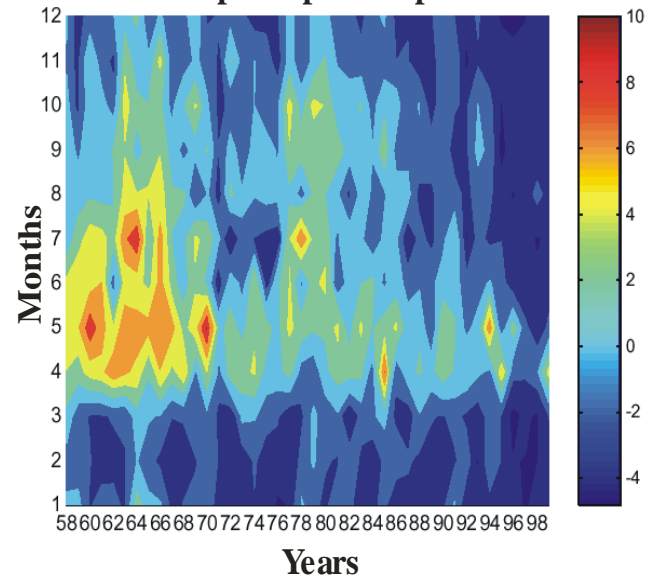
Eigenvector 1



First principal component

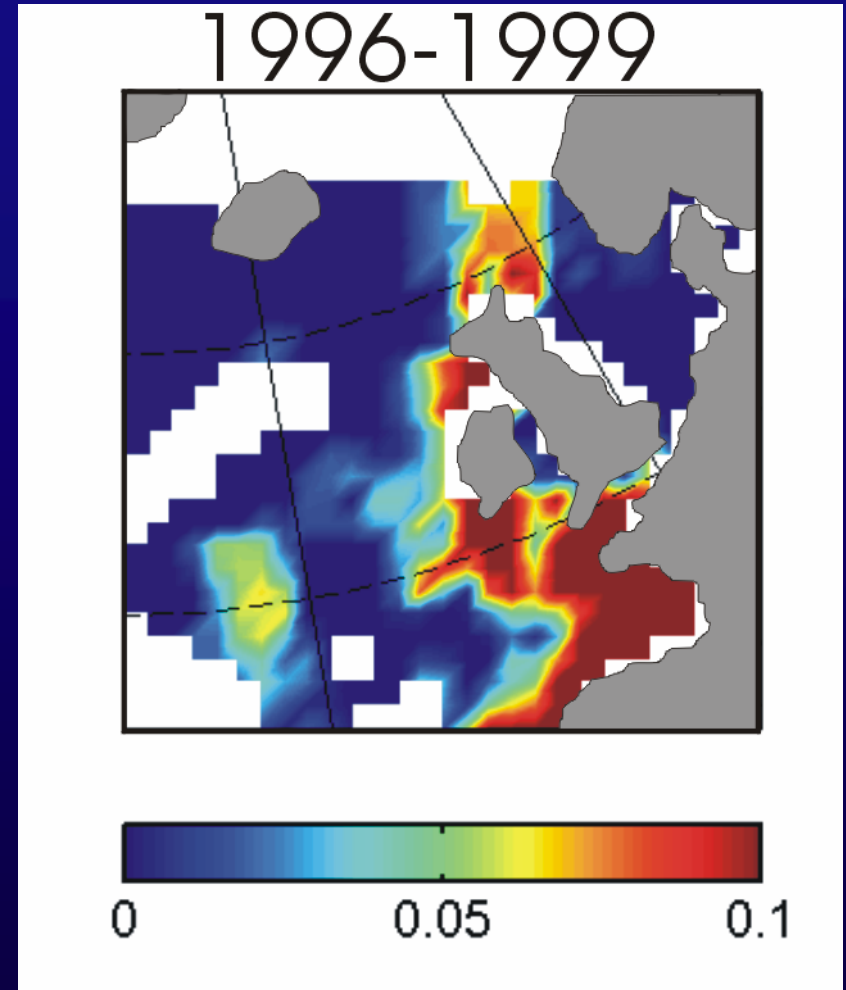
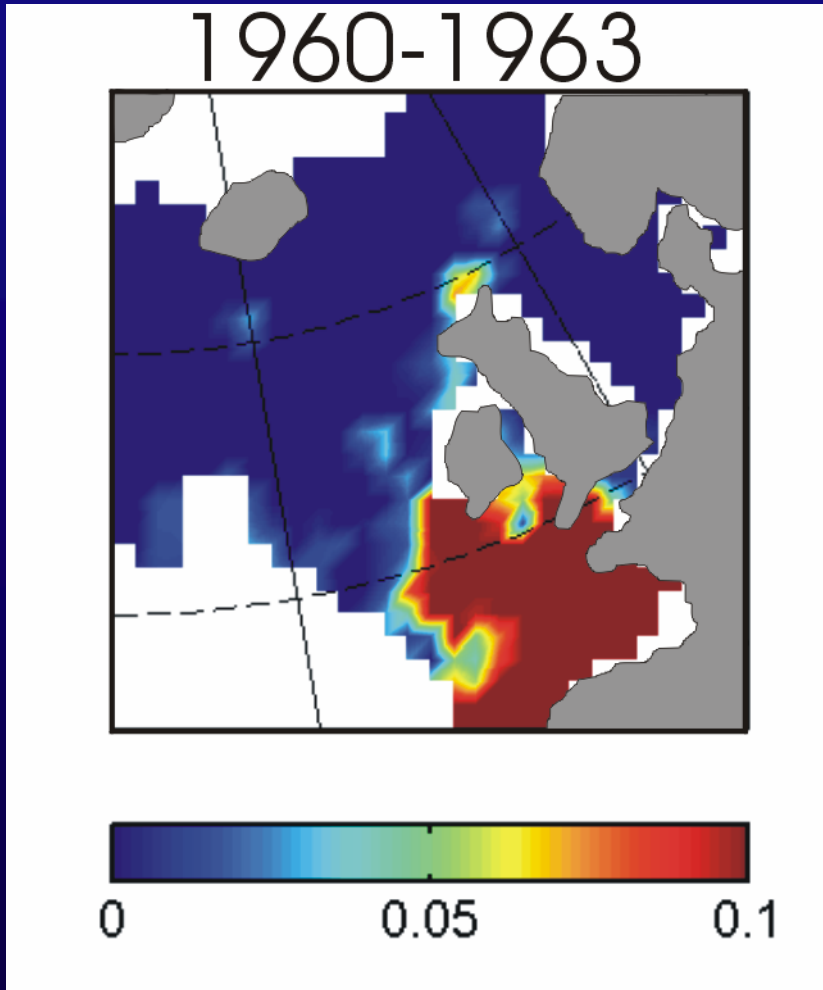


First principal component



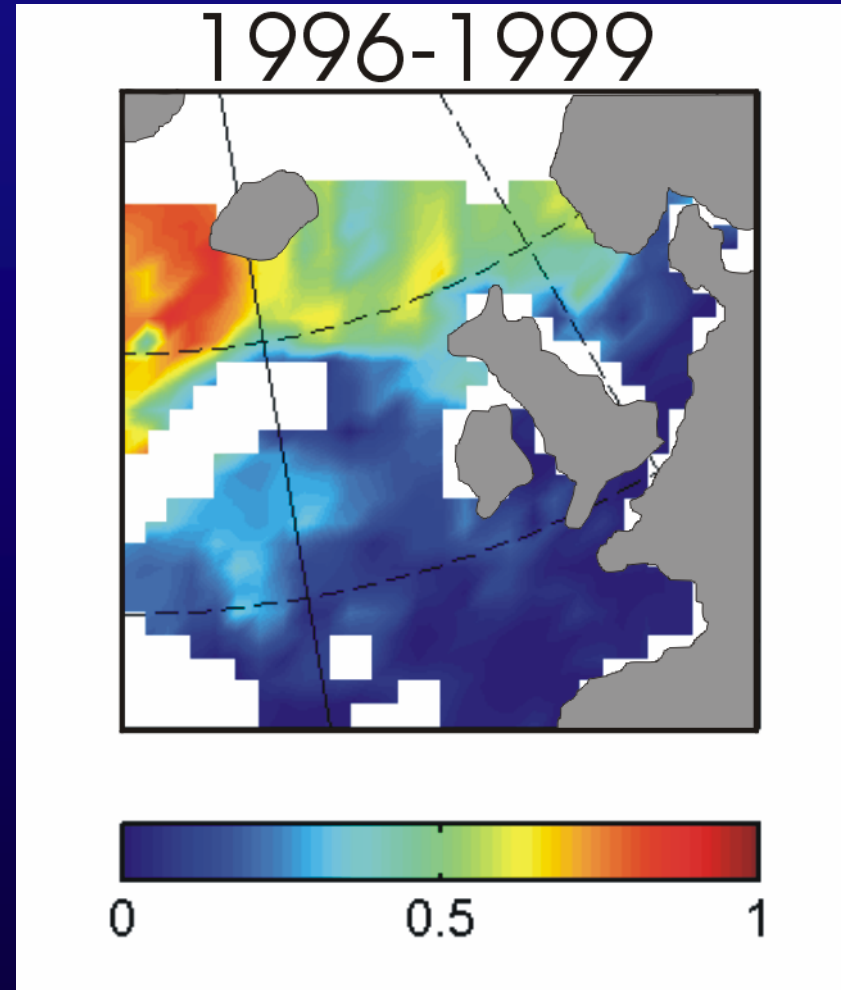
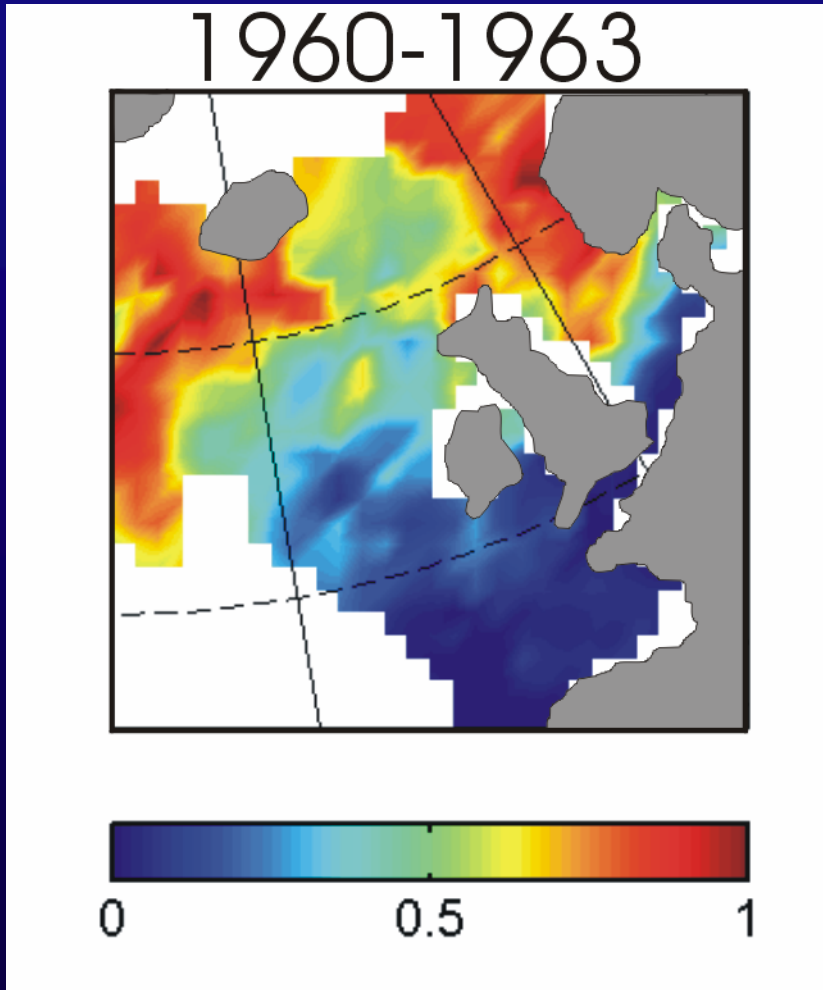
Northerly biogeographic movement of plankton

Biogeographic Changes in the Northeast Atlantic



Warm temperate slope species

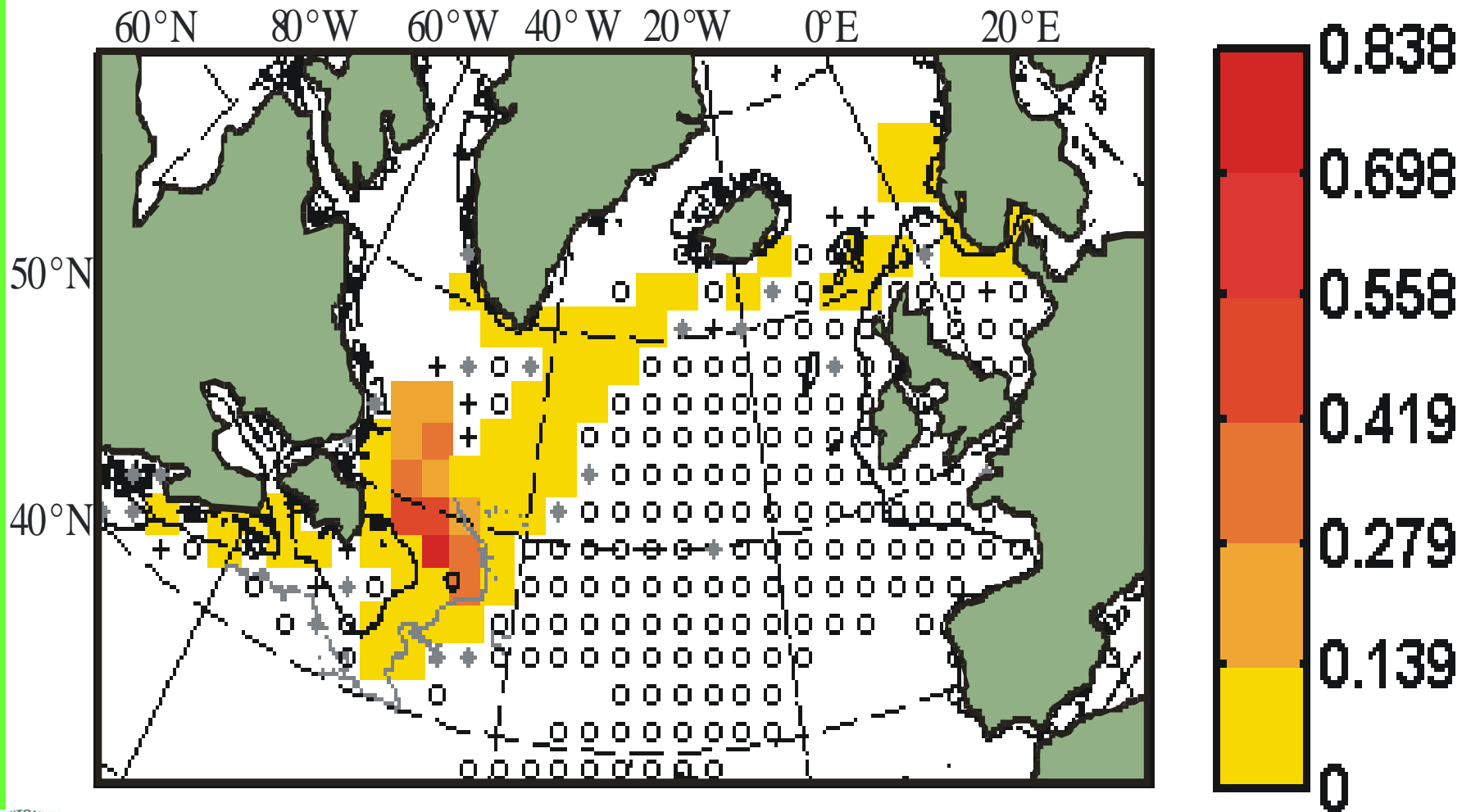
Biogeographic Changes in the Northeast Atlantic

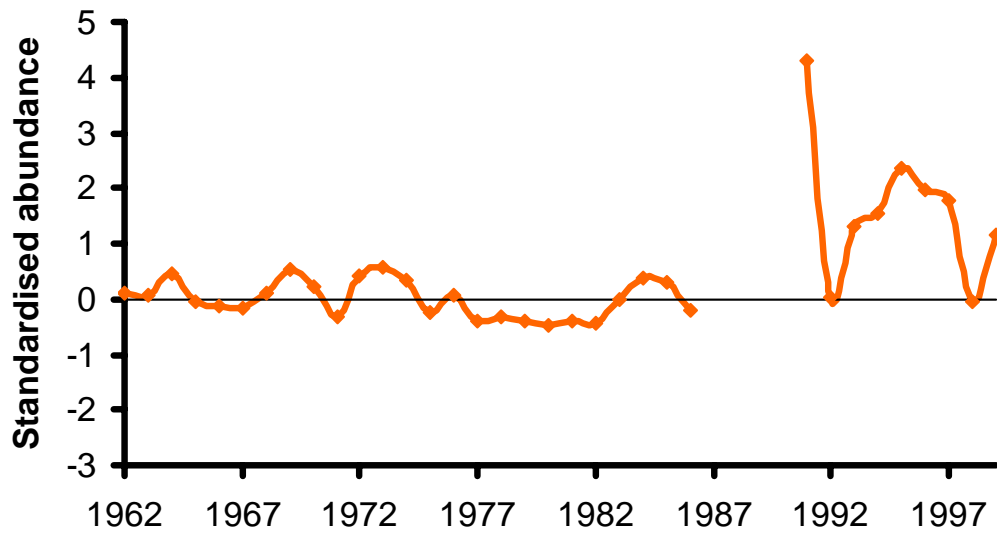


Subarctic species

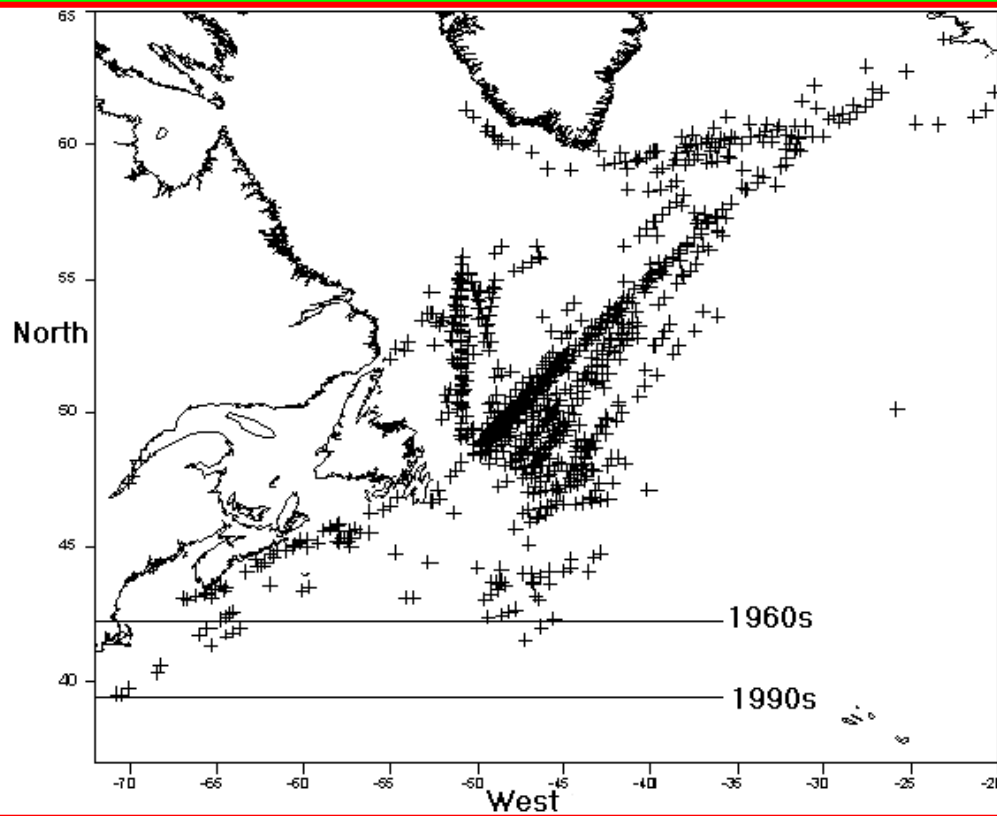
- *C. hyperboreus* NW Atlantic

Calanus hyperboreus

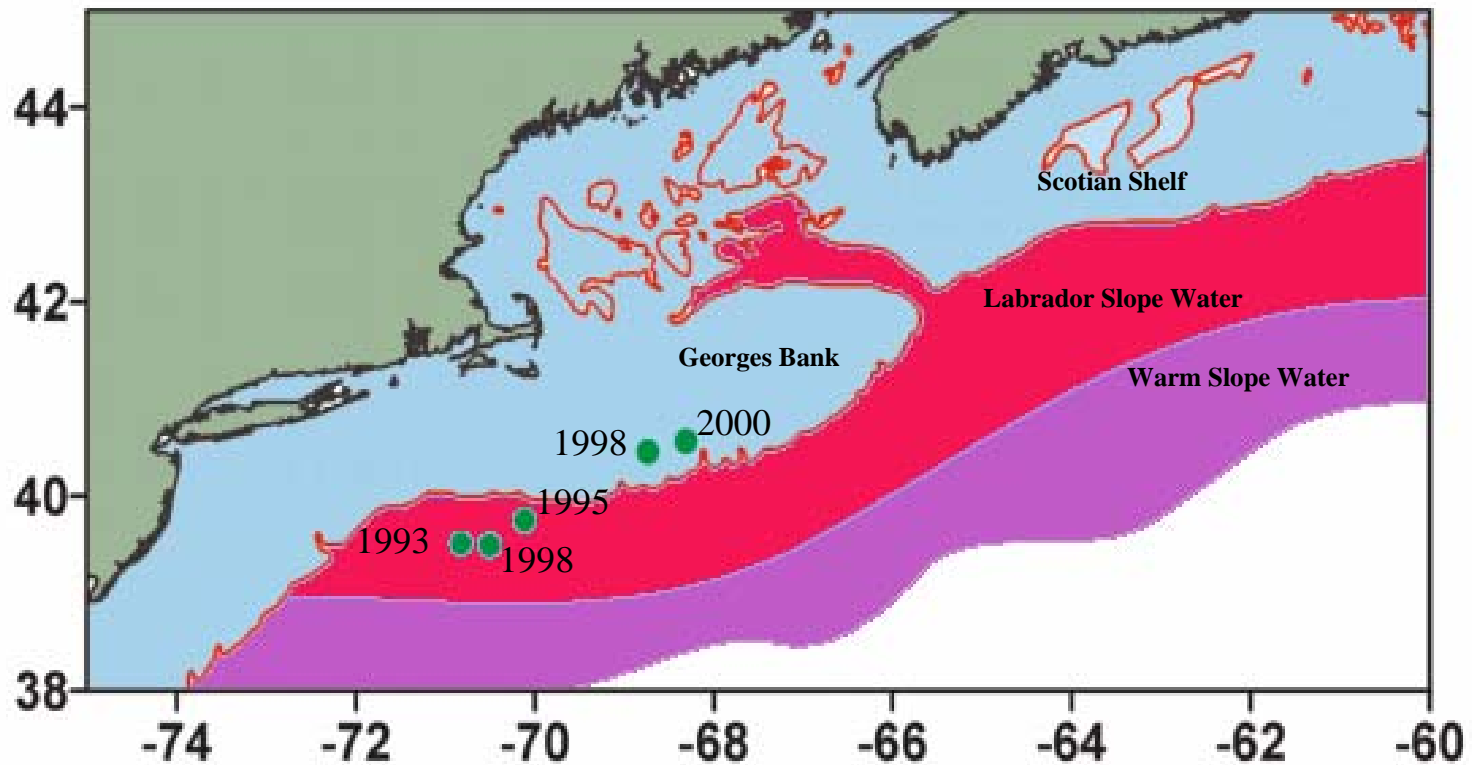




Calanus hyperboreus
in the NW Atlantic



Johns et al., 2001



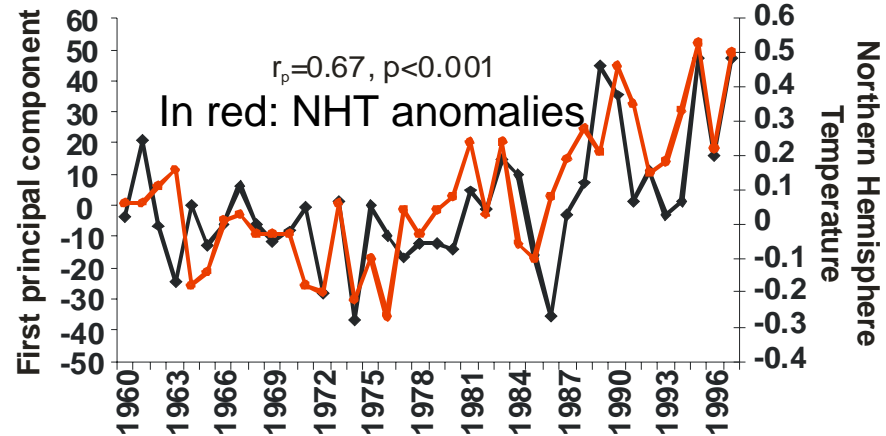
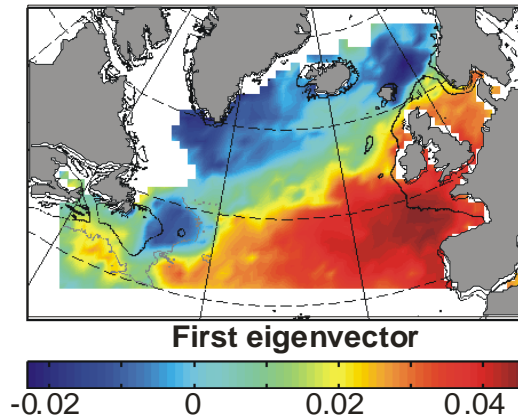
Higher Sea Surface Temperatures

Correlated with

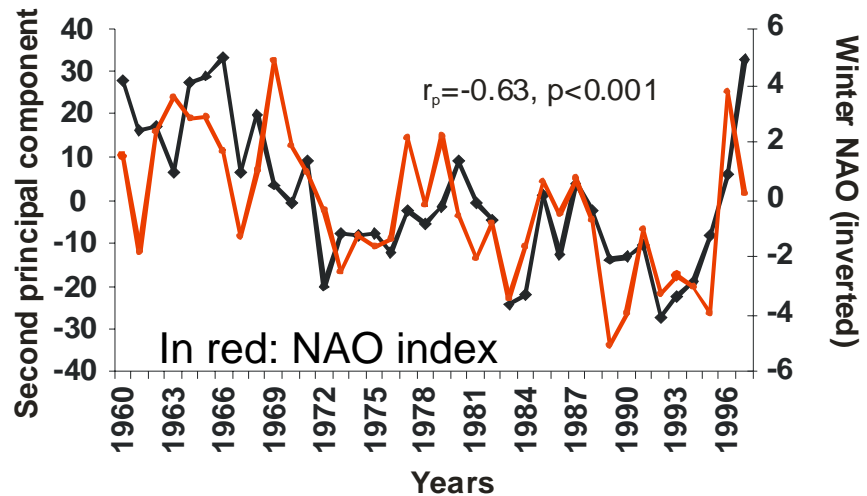
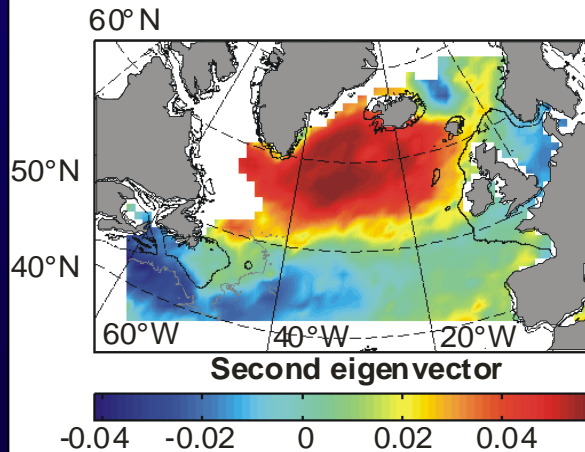
- Northern Hemisphere temperatures
 - North Atlantic Oscillation

Long-term change in North Atlantic sea surface temperature (1960-1997)

A. First eigenvector and principal component (24.35% of the total variability)



B. Second eigenvector and principal component (16.59% of the total variability)



- Plankton: salmon & cod
- Correlations NHT, NAO, SST

Cluster Analysis: grouping years as a function of physical and biological characters

Variables :

Sea Surface Temperature
NE Atlantic

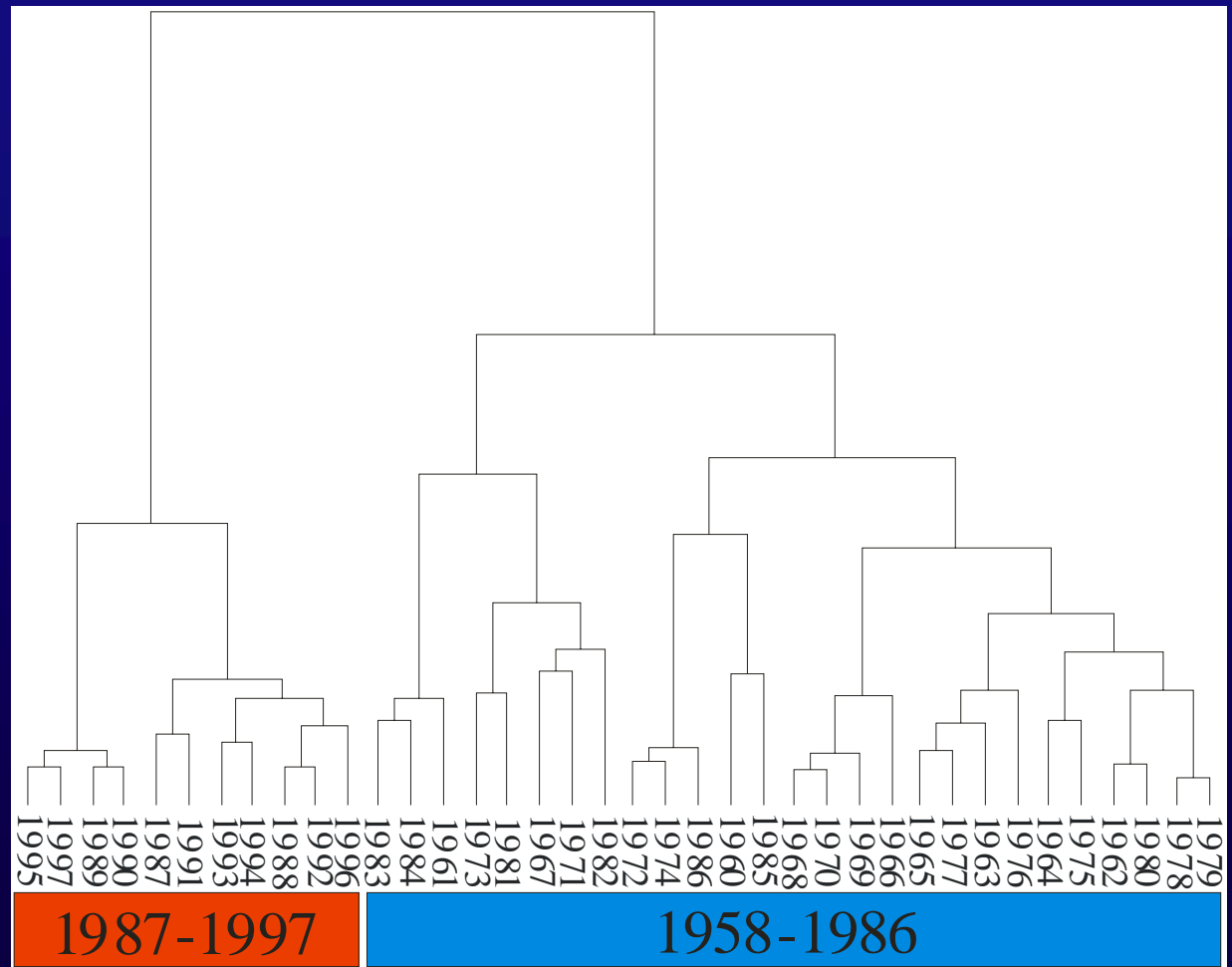
Northern Hemisphere
Temperature

North Atlantic Oscillation

Phytoplankton

Zooplankton (3 taxa)

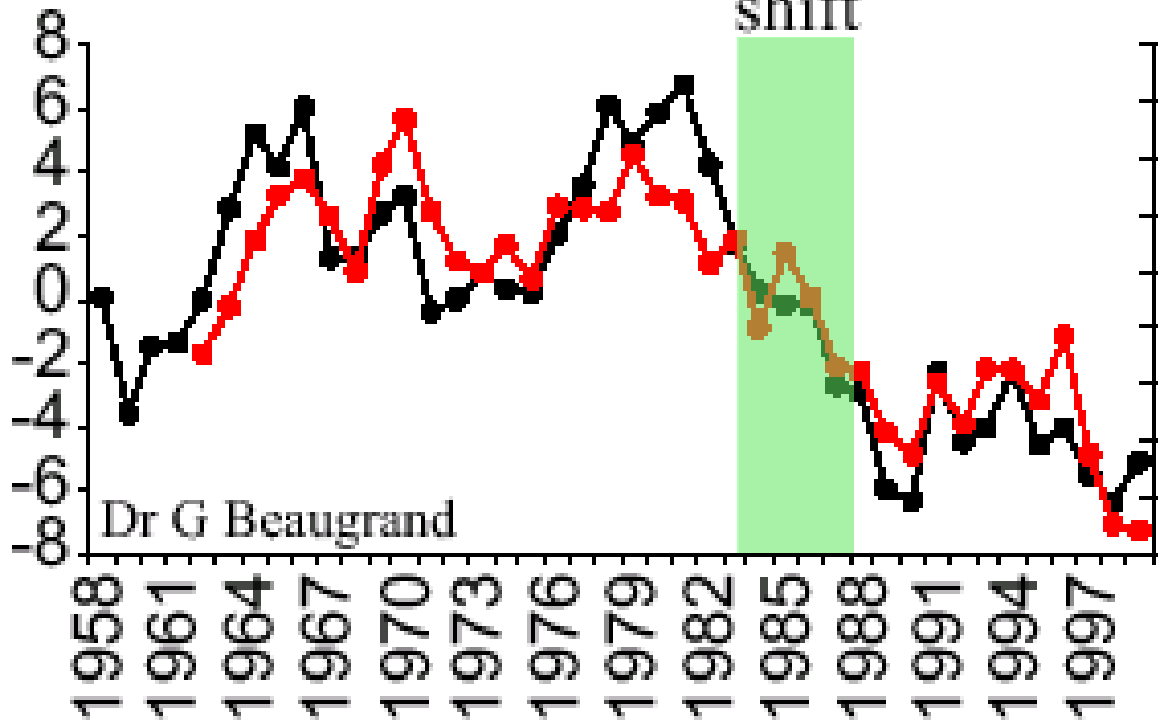
Salmon catches



Beaugrand & Reid, 2003 Global Change Biology 9, 801-807



Plankton change
(in black)



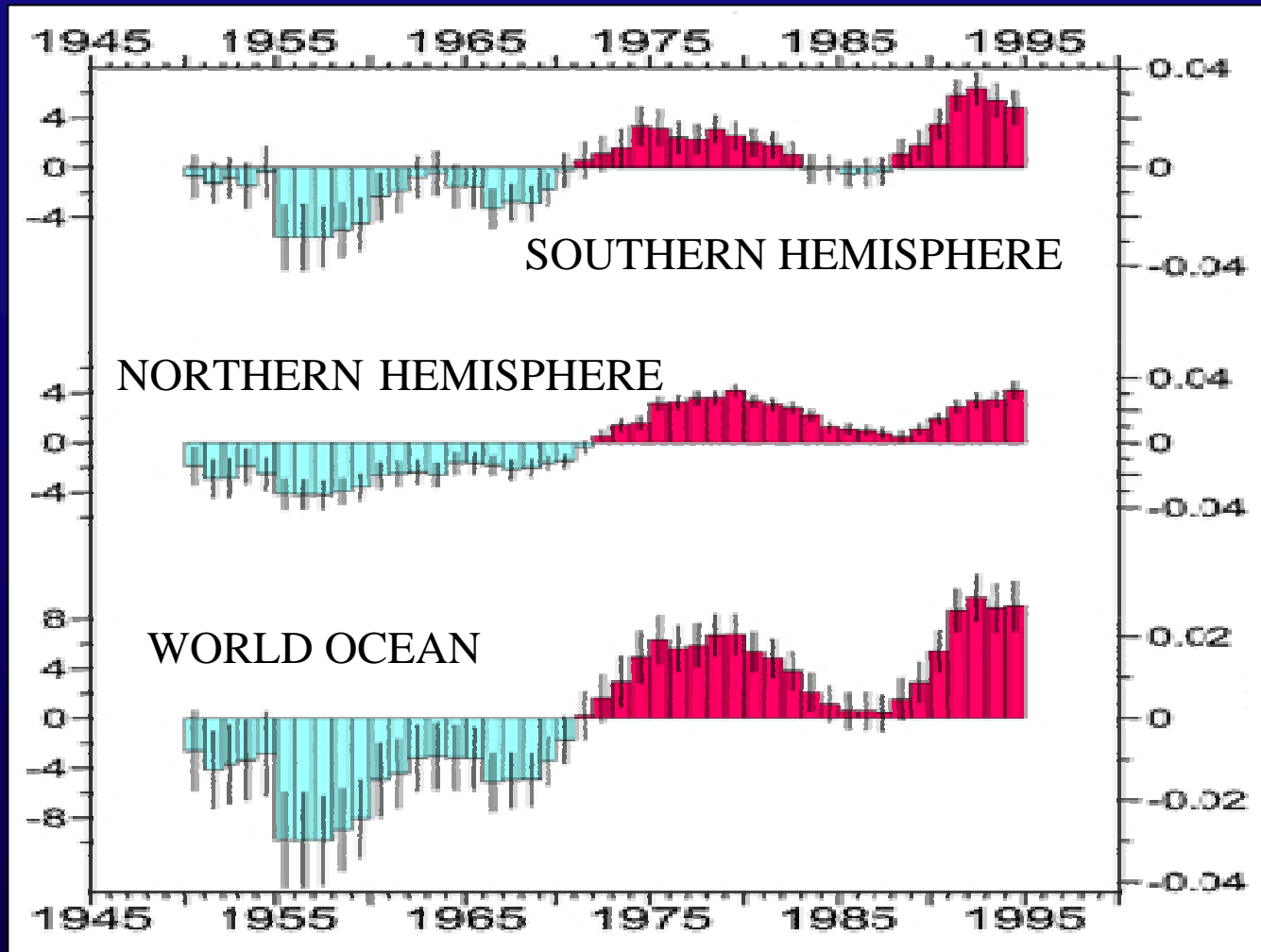
Dr G Beaugrand

Total cod biomass
one-year lag
(logarithmic scale)

Linked to global warming?

OCEAN HEAT CONTENT (10^{22} J) INTEGRATED THROUGH 3000m DEPTH

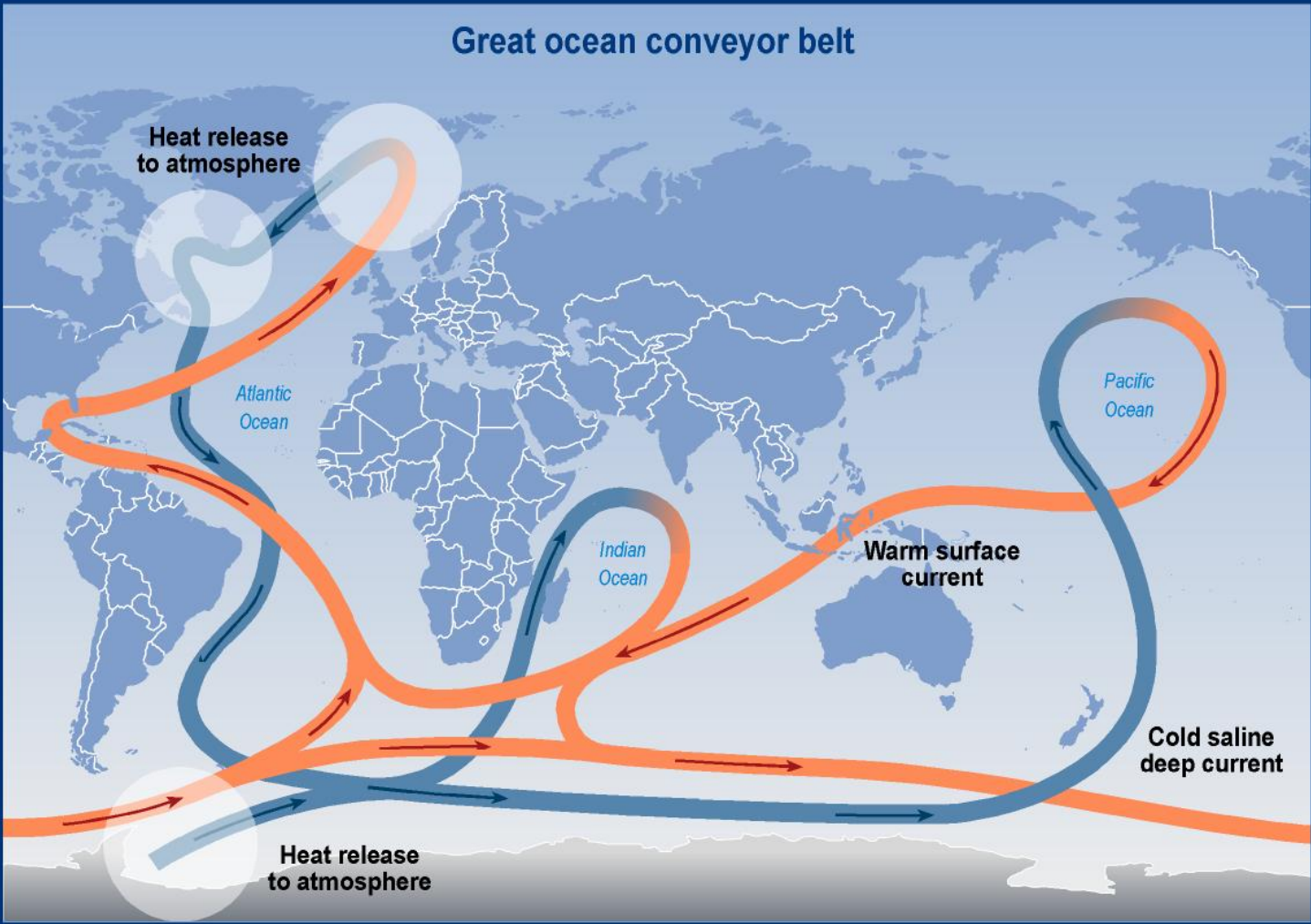
Heat Content (10^{22} J)



Volume mean temperature anomaly ($^{\circ}$ C)

YEAR

Levitus 2000 *Science* **287**, 2225-2229



SYR - FIGURE 4-2

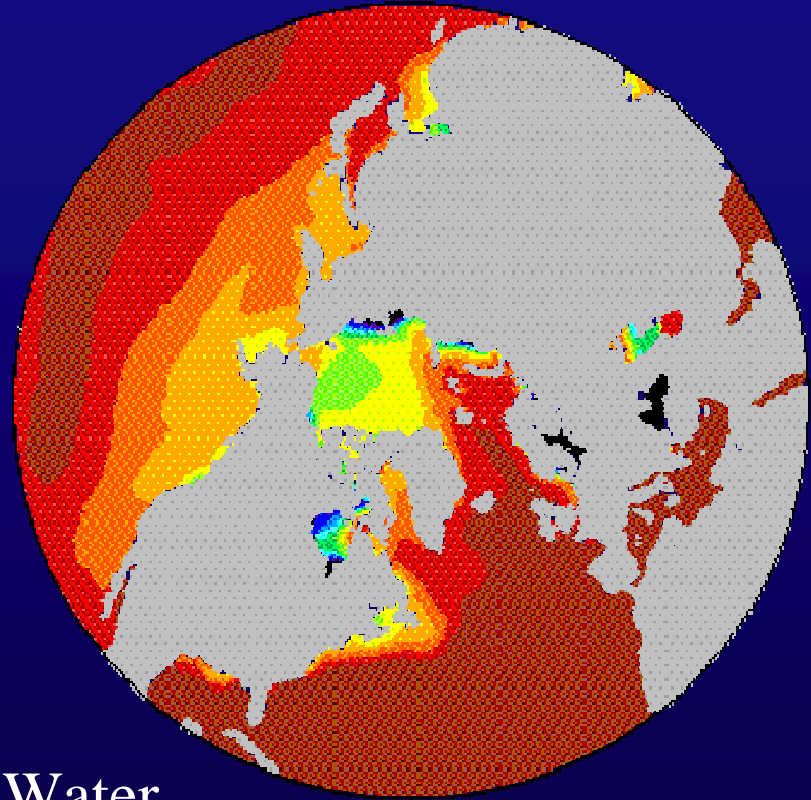
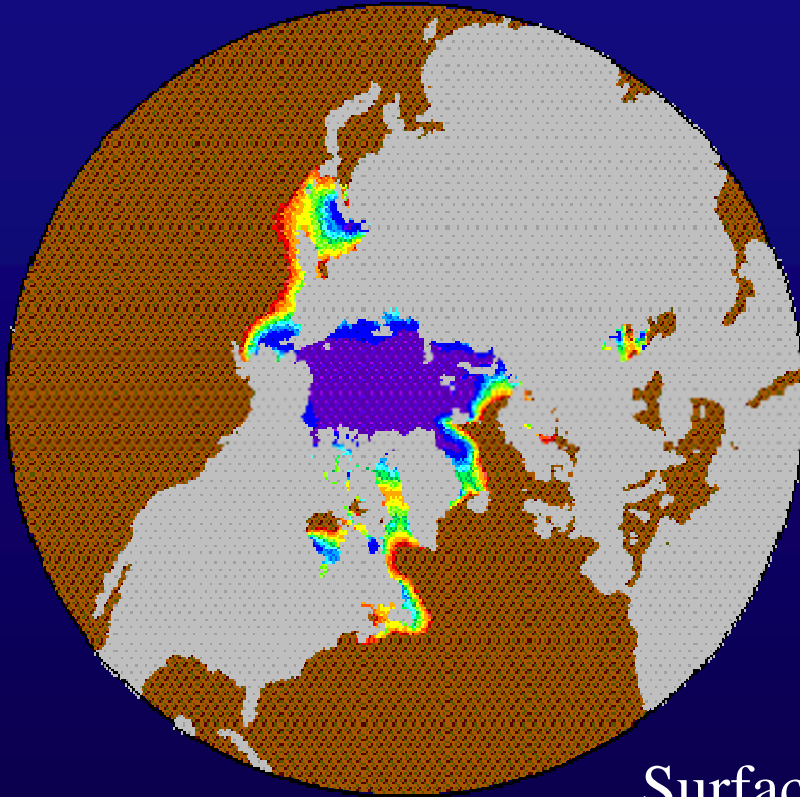
Global Ocean thermo-haline circulation

Unfortunately, our models do not yet deal adequately with many of the mechanisms believed to control the THC, and our observations cannot yet supply many of the numbers they need.

Meinke et al. 2003 in: Marine Science Frontiers for Europe,
Springer Verlag

Winter Temperature

Winter Salinity



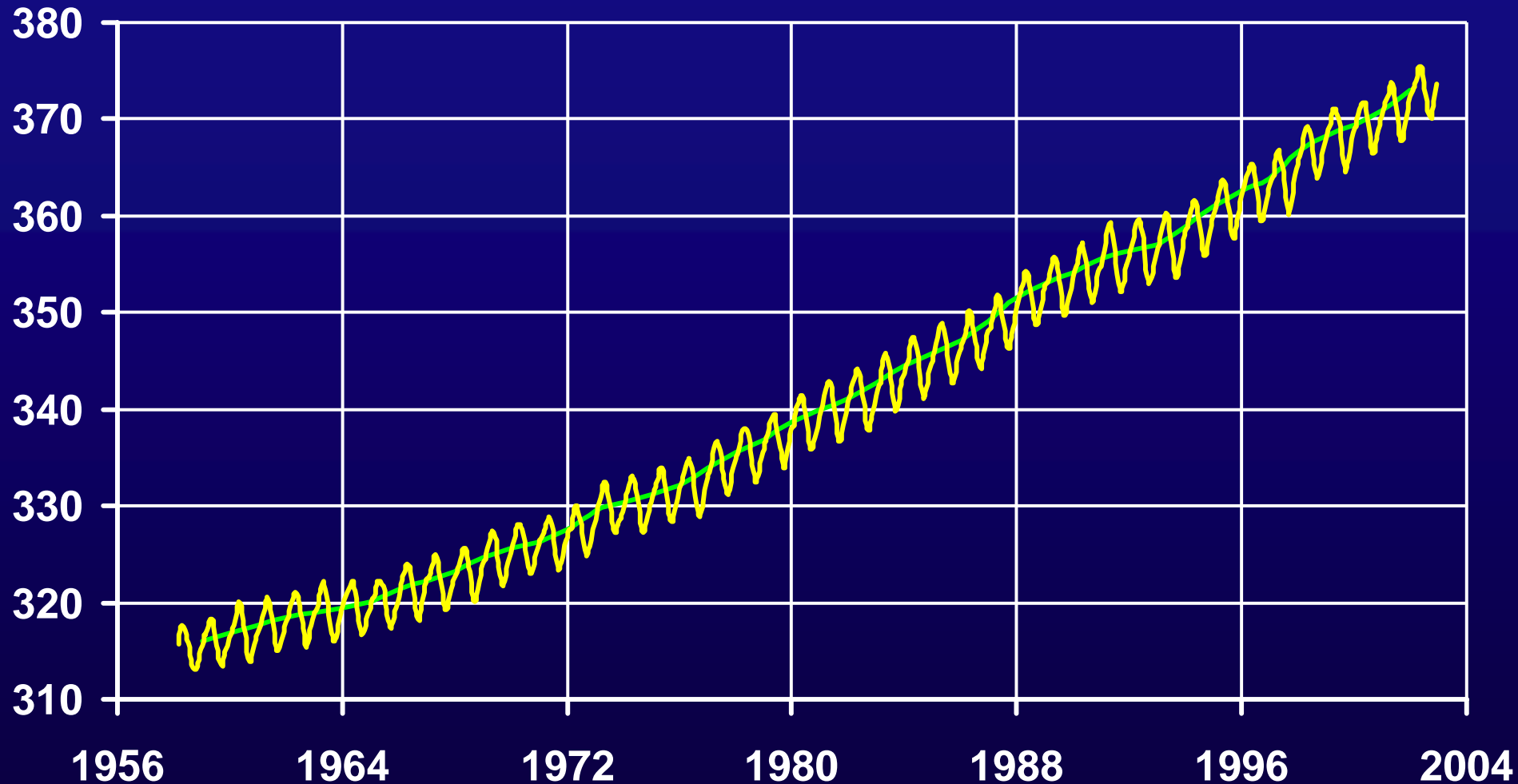
Surface Water

Steele, Morley, Ermold

psc.apl.washington.edu/POLES/RMORLEY/Climatology.html

CO₂ Mauna Loa, Hawaii

ppm



Keeling & Whorf, Scripps Inst. Univ of California



Main Sections
About Us
Education
Research
Monitoring
Data
Publications
Help Us Do More
Research efforts at SAHFOS largely depend on the public's support. Your help can aid in our research
Visitors Book
Please send us your views on the web site
Click here to read comments from people who have visited the web site

Welcome

[Site Index](#) | [Email Us](#)

Welcome to the SAHFOS Website

The Sir Alister Hardy Foundation for Ocean Science (SAHFOS) is an international charity registered in the UK, that operates the Continuous Plankton Recorder (CPR) survey. The Foundation has been collecting data from the North Atlantic and the North Sea on biogeography and ecology of plankton since 1931.

The new SAHFOS website is currently undergoing some heavy updates please be patient whilst these changes take place

Highlights



CPR survey

See how the CPR Functions and the Instrumentation involved



SAHFOS Annual Report 2001

Is now available to download



Towing Ships

SAHFOS thanks all of the shipping companies that have supported us. You can see them here



Parables of Sea and Sky

Take a journey through the life and times of Sir Alister Hardy

Press Release 19/07/02

SUB TROPICAL PLANKTON MOVING NORTH

The CPR survey Identified a major shift North of sub-tropical Plankton species, as reported recently in "SCIENCE" [More Here](#)

Focus Areas

- ▶ [New Brochure](#)
- ▶ [Standard areas maps](#)
- ▶ [Pacific Project](#)

Quality Control of website

Every effort is made to keep this website up to date. You can see when each page was last

News and Events

Oct 25:
[Phil Williamson explains the importance of Zooplankton](#)

Events:
[European Science and Technology Week](#)
[4th - 10th November](#)

Image Library



[Visit our Library of beautiful Plankton images](#)

Conclusions

- Good evidence for a regime shift in the North Atlantic
- Seen as a step-wise change centred on the mid 1980s
- Northerly movement plankton and fish in east, reverse in west
- Ocean circulation and temperature is changing rapidly
- Plankton integrate & are a sensitive indicator of climate change
- Observed and predicted climate change is possibly accelerating
- Take environmental change into account in fishery management
- North Atlantic may see large amplitude changes in the future
- Huge implications for mankind
- Understanding the oceans a high priority research issue
- Need to establish CPR type programmes in other areas (GOOS)