Long-term changes in pelagic ecosystems around the UK

Grégory Beaugrand, Philip C. Reid

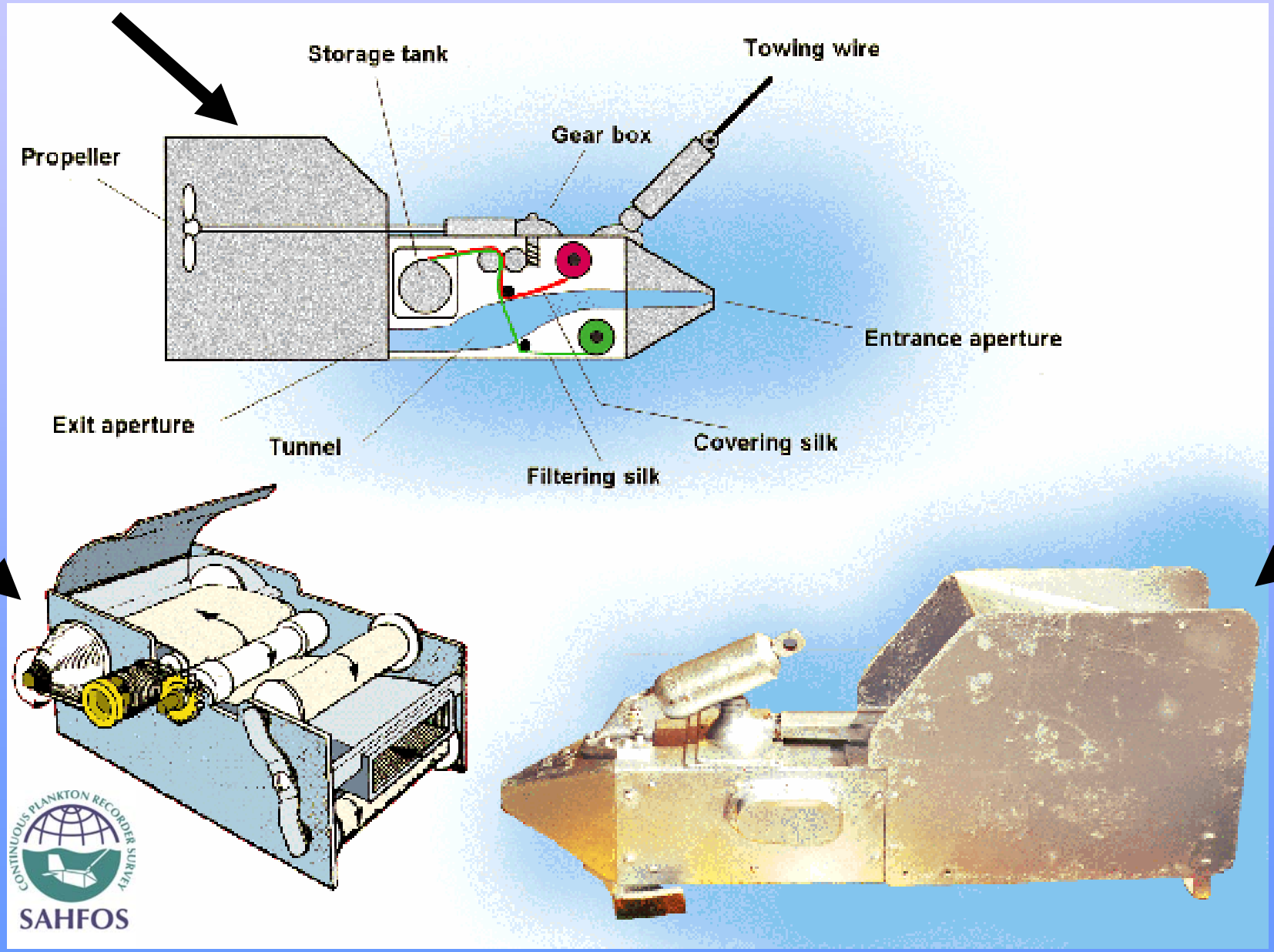
Sir Alister Hardy Foundation
for Ocean Science,
The Laboratory
Citadel Hill
Plymouth PL1 2BN
England
Email: gbea@mail.pml.ac.uk

Objectives of this talk

- **To provide evidence that climate change is already affecting marine ecosystems around the UK**

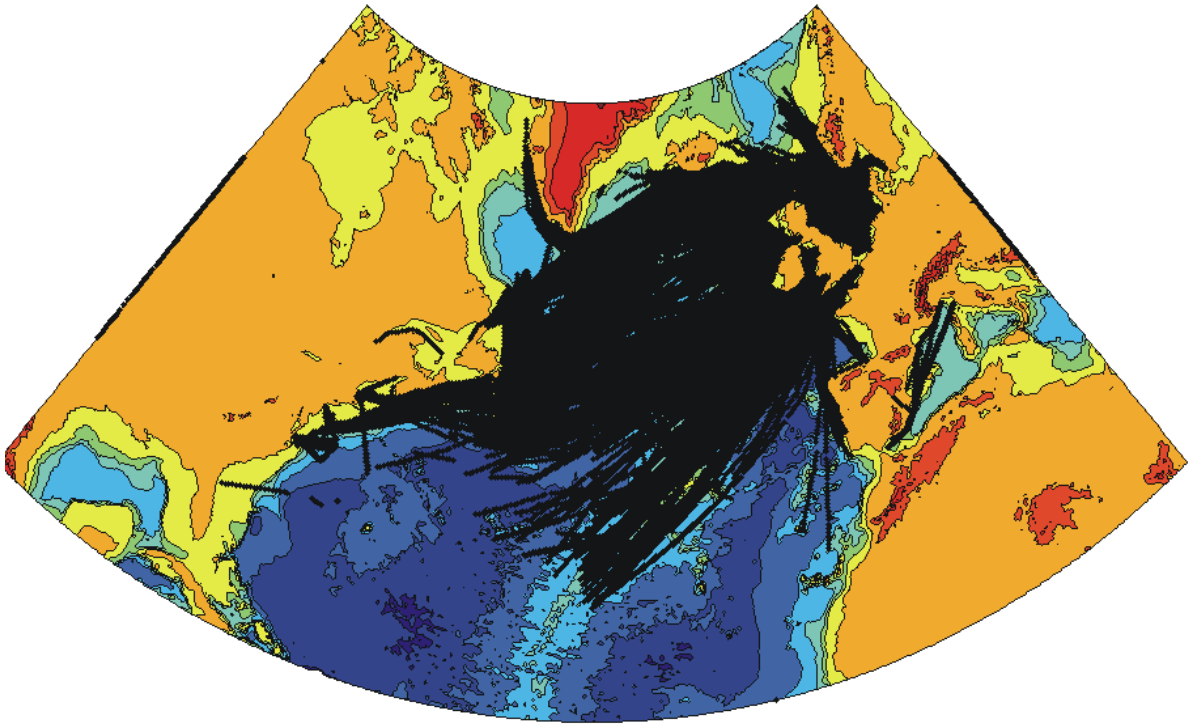
- **Consequences of plankton changes for exploited resources and biogeochemical cycles**

The CPR sampler



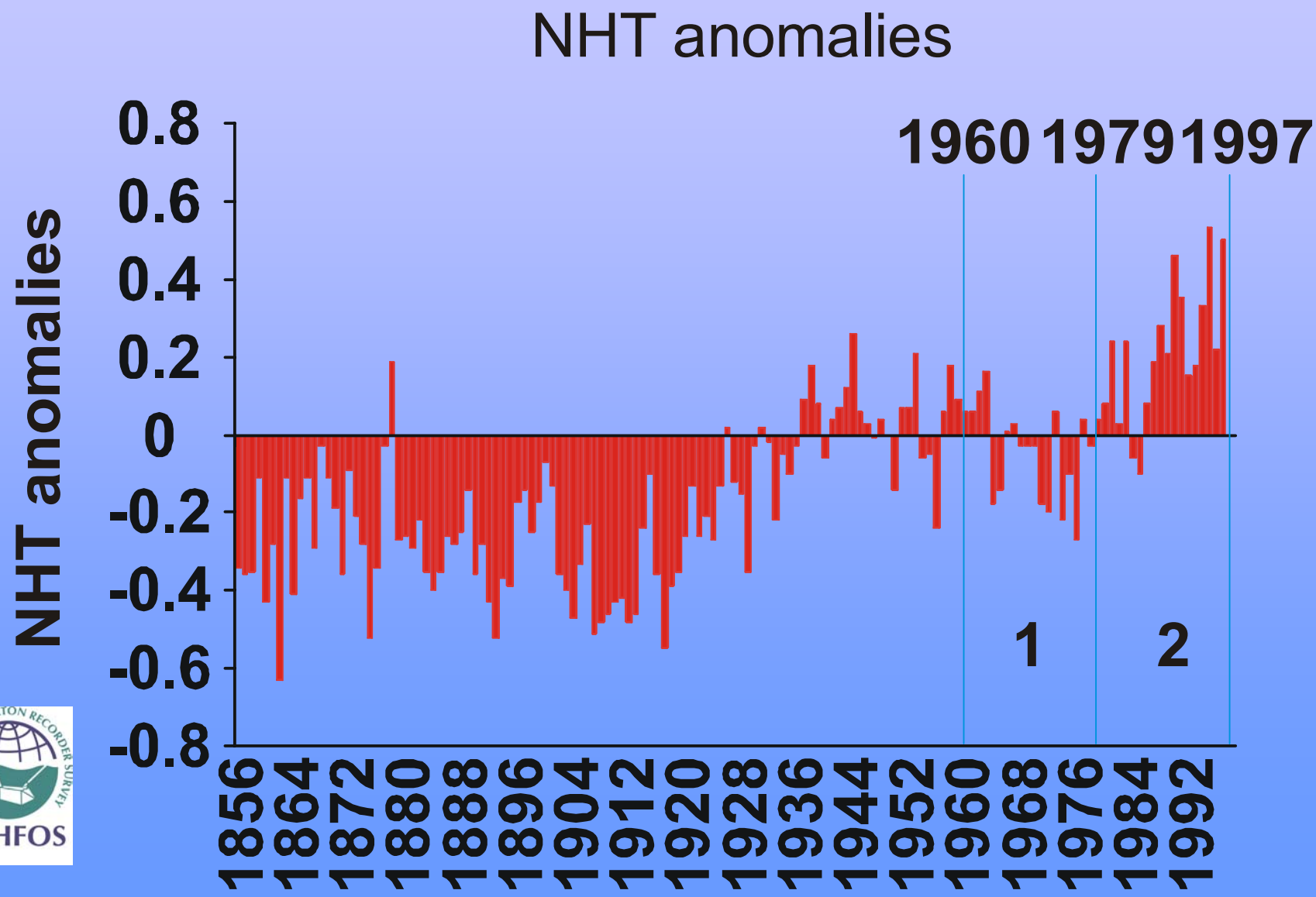
The CPR survey: use of ships of opportunity

CPR sampling: 1946-2002



CONTINUOUS PLANKTON RECORDER SURVEY
SAHFOS

Influence of climatic warming on marine ecosystems



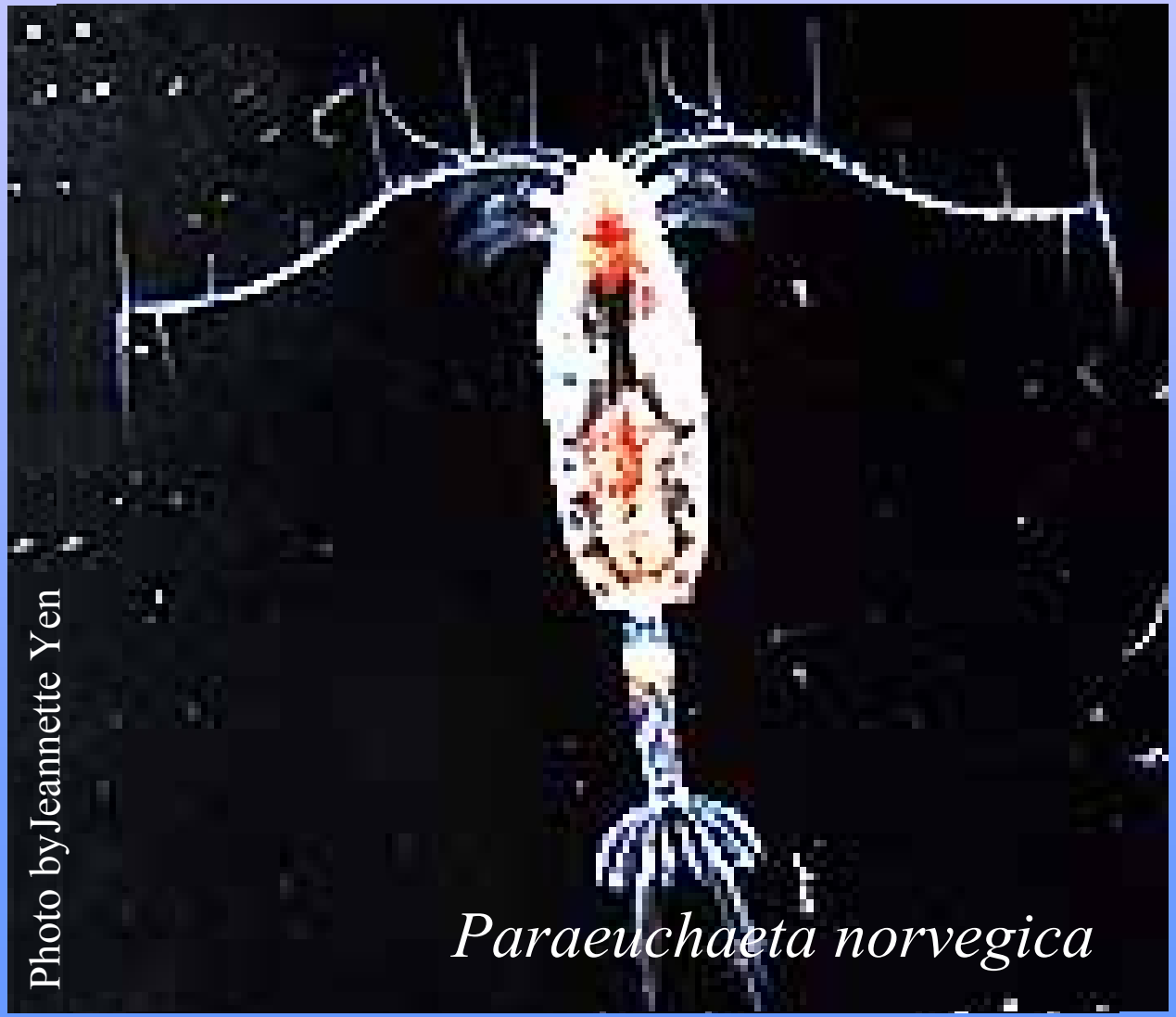
SAHFOS

What kind of biological consequences are expected under climatic warming?

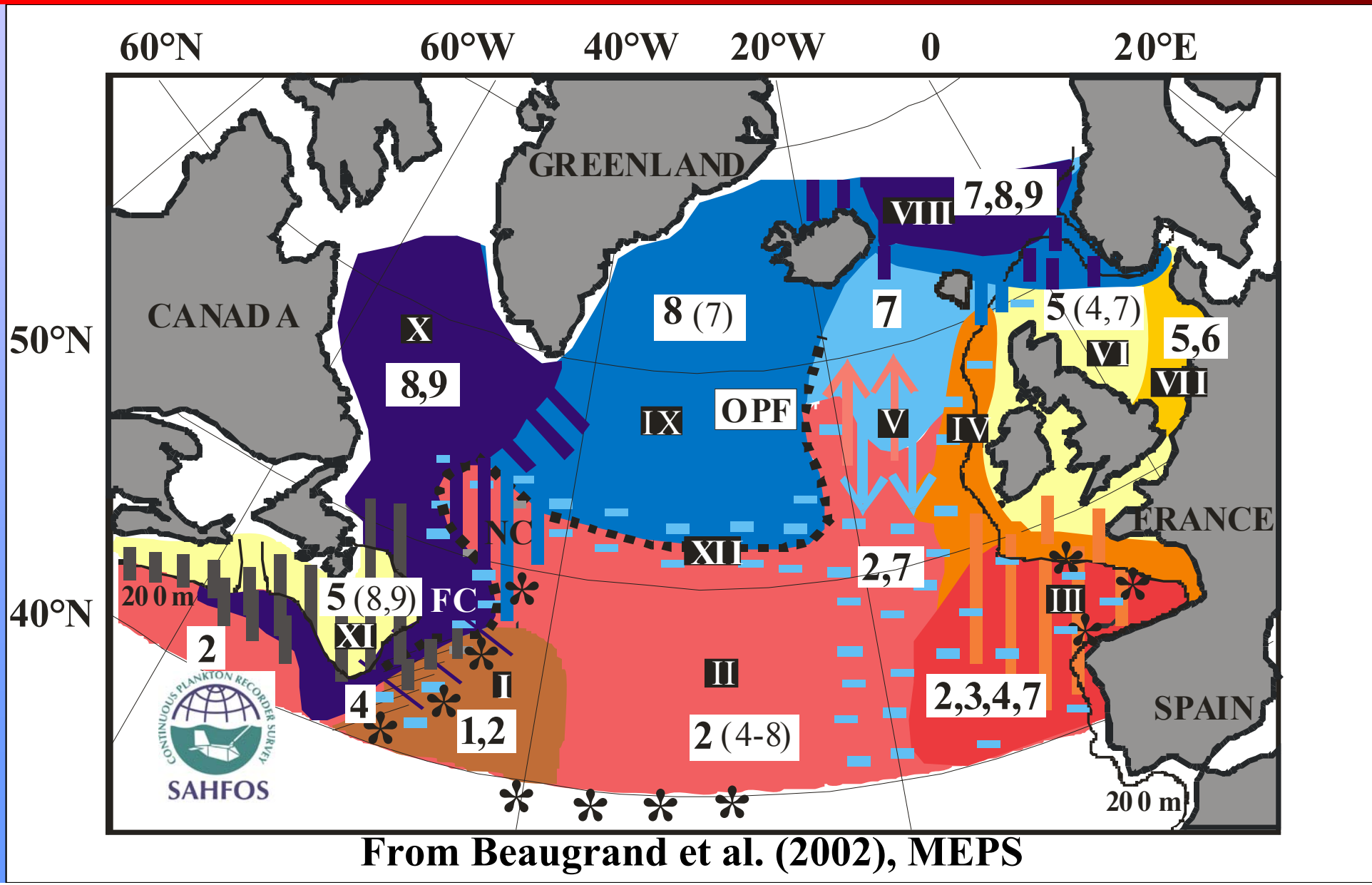
- Changes in the range and spatial distribution of species
- Shifts in the location of biogeographical boundaries, provinces and biomes
- Change in the phenology of species (e.g. earlier reproductive season)
- Modification in dominance (e.g. a key species can be replaced by another one)
- Change in diversity
- Change in other key functional attributes for marine ecosystems
- Change in structure and dynamics of ecosystems with possible regime shifts

→ **Major impact for marine exploited resources and biogeo-chemical processes (e.g. sequestration of CO_2 by the ocean)**

The CPR survey has monitored more than 100 calanoid copepods since 1946

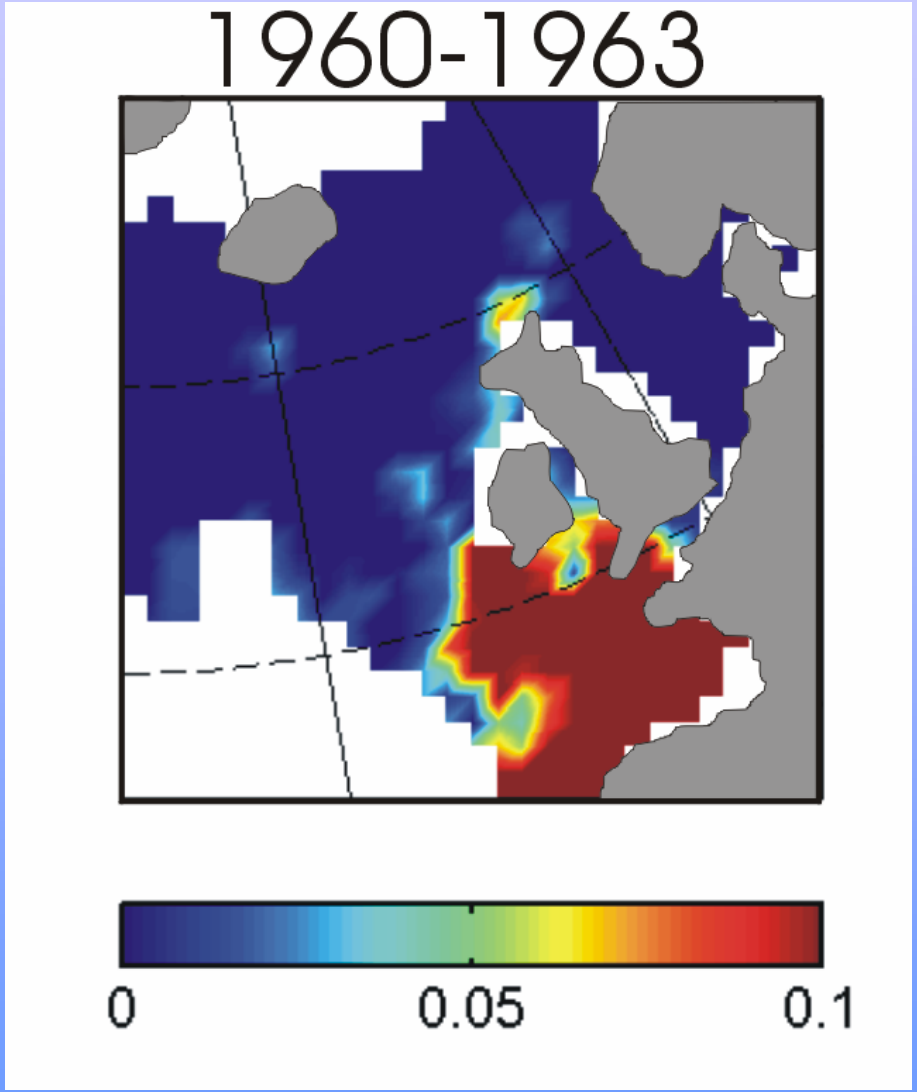


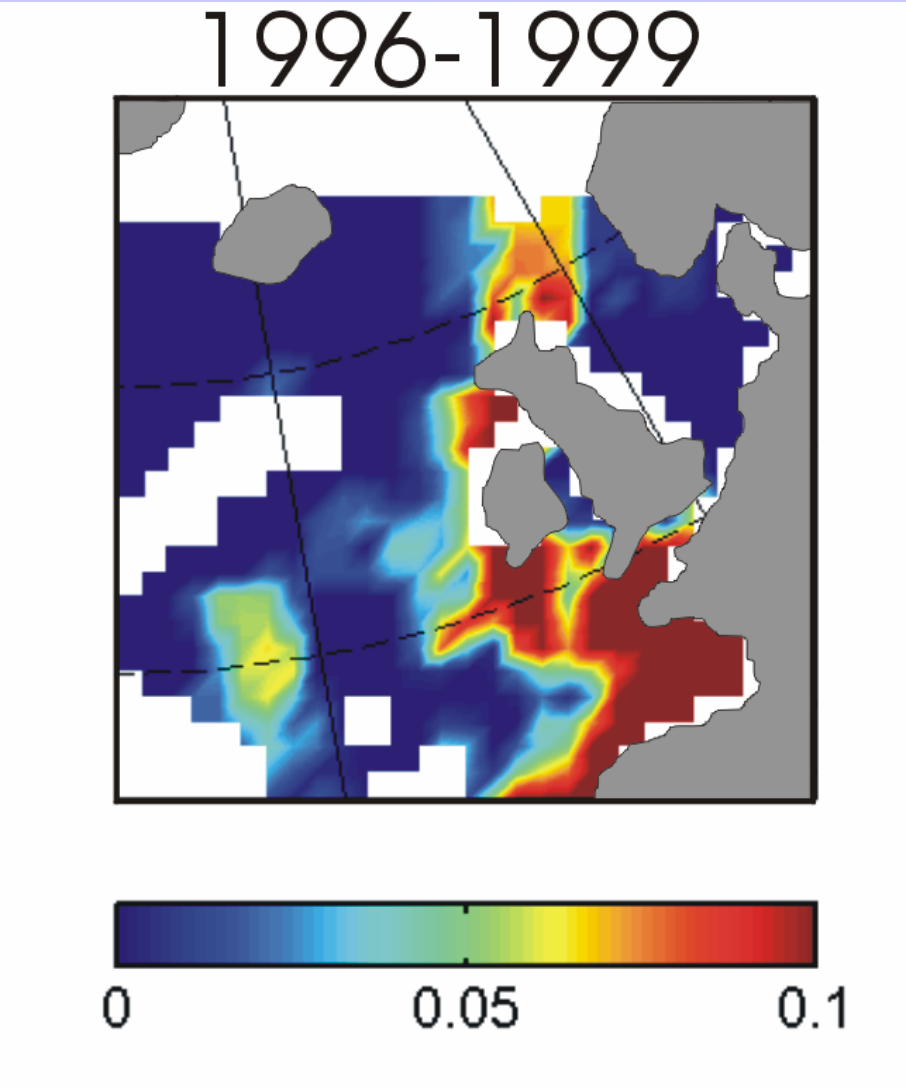
Synthesis: mean spatial distribution of species associations and location of ecosystems and ecotones



From Beaugrand et al. (2002), MEPS

Biogeographic Changes in the Northeast Atlantic

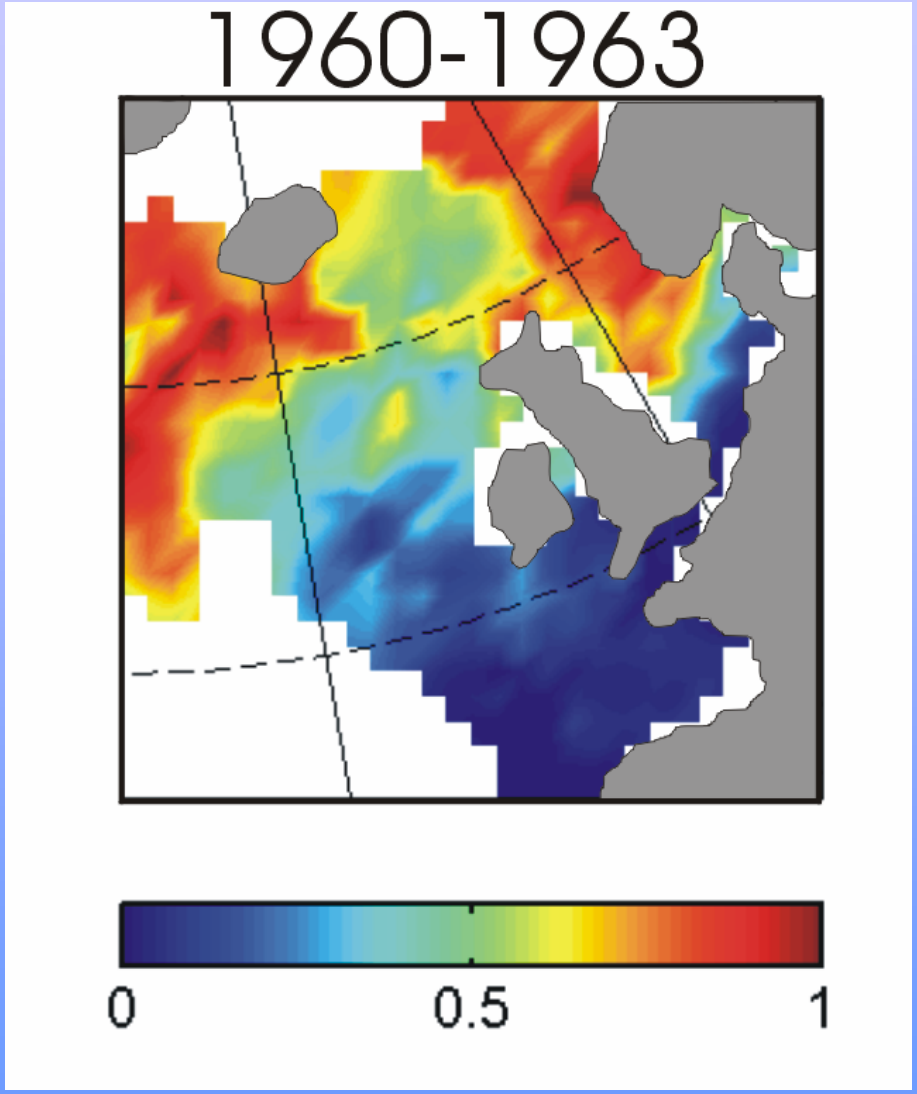


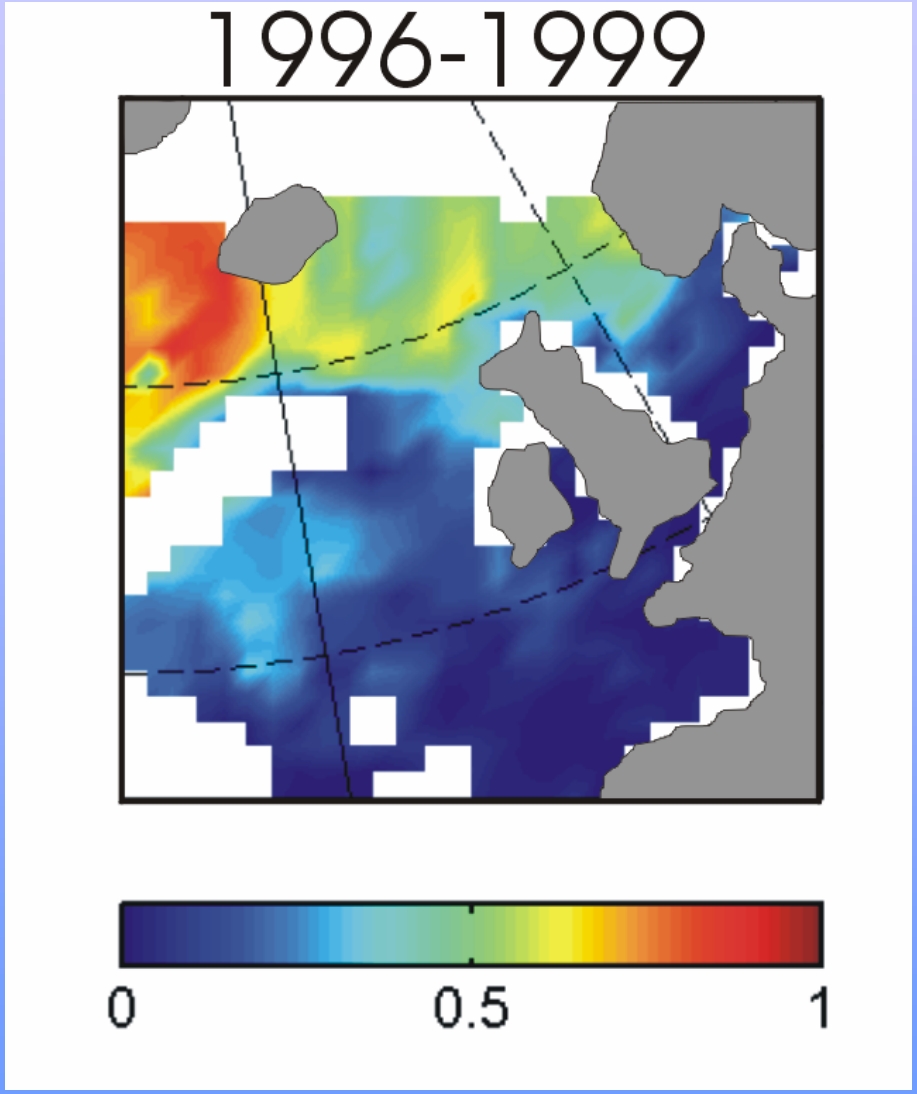


Warm temperate slope species

Beaugrand et al. 2002. Science. 296: 1692-1694.

Biogeographic Changes in the Northeast Atlantic

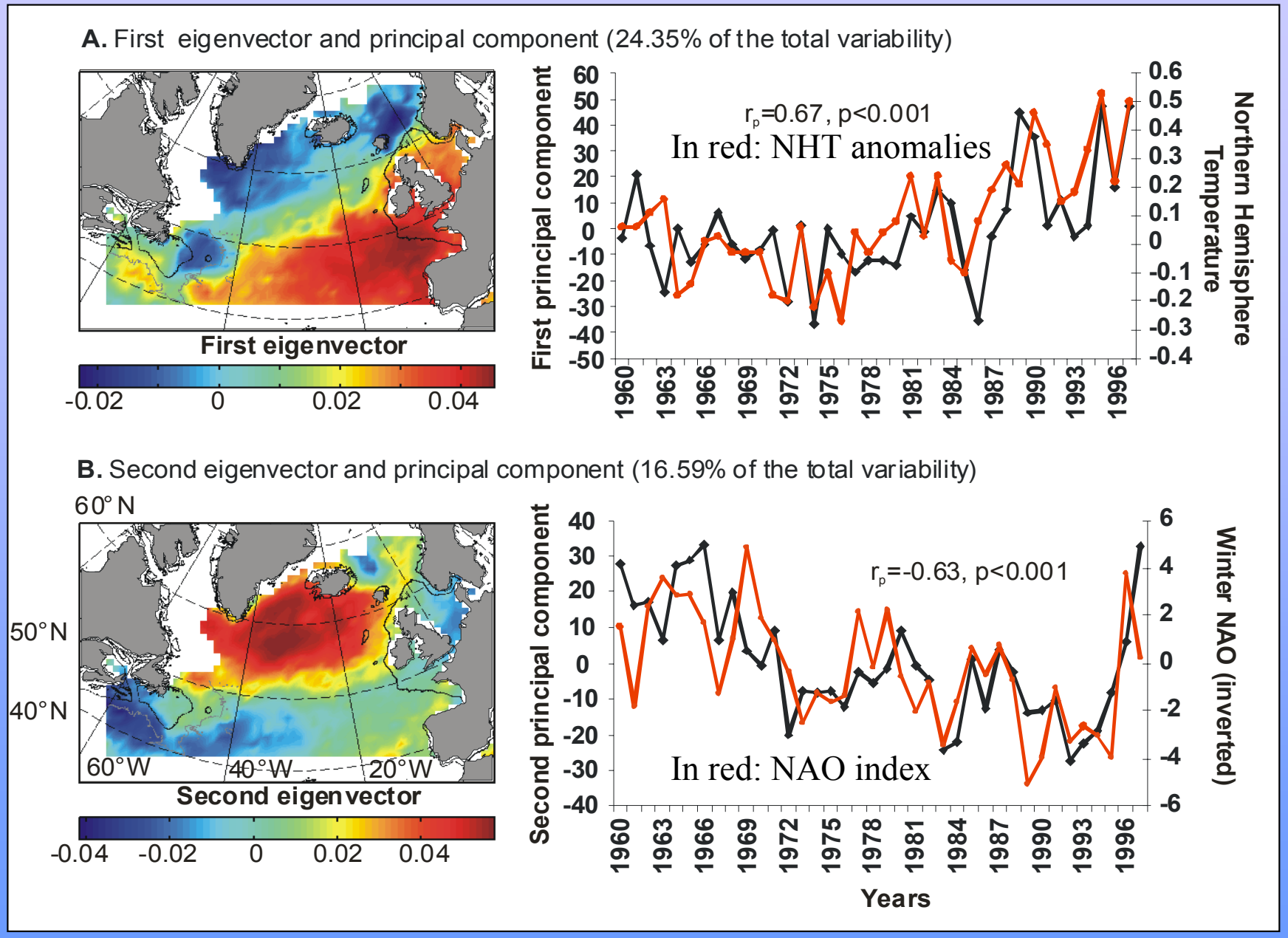




Subarctic species

Beaugrand et al. 2002. Science. 296: 1692-1694.

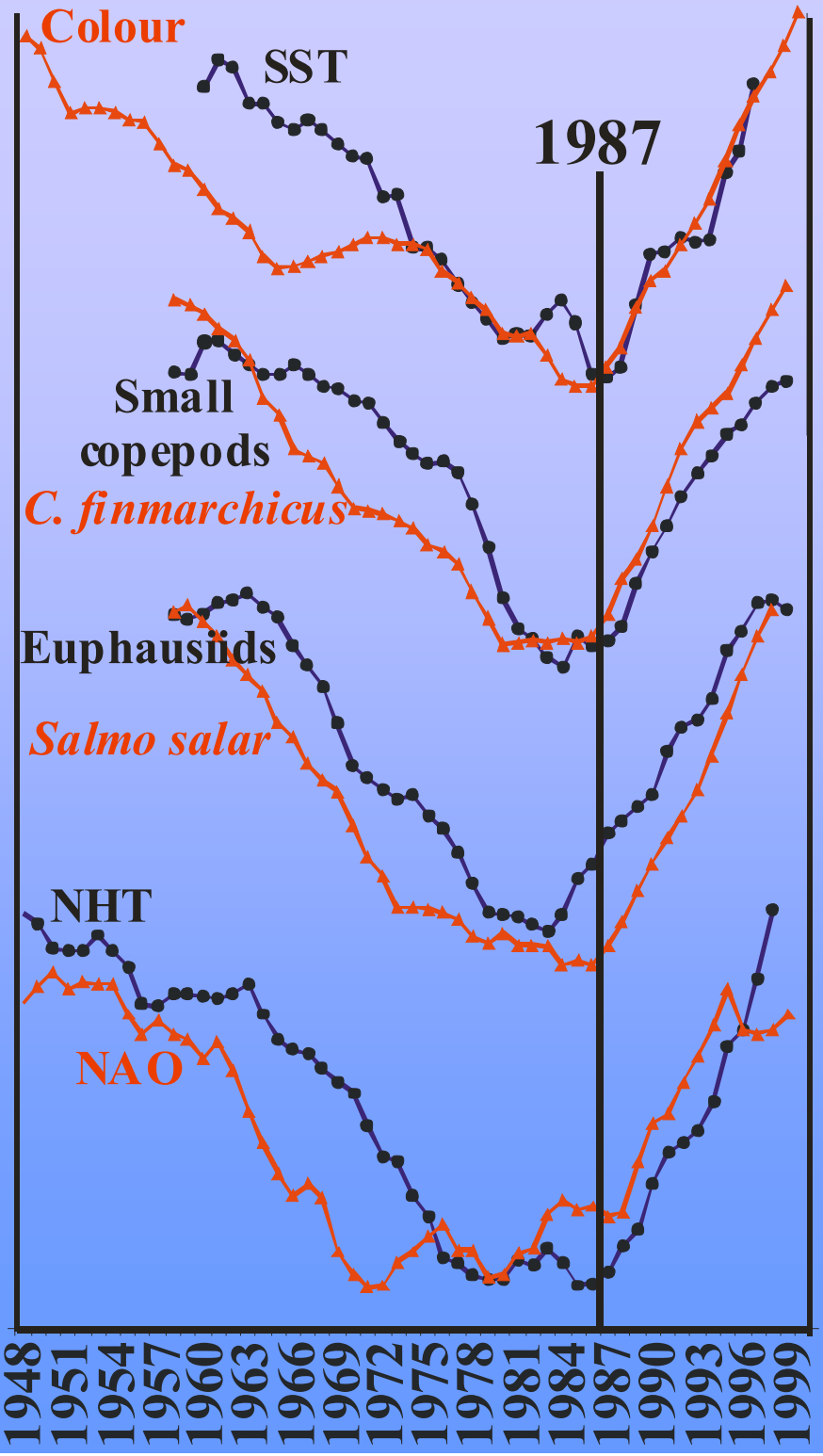
Long-term changes in sea surface temperature (1960-1997)



From Beaugrand et al. (2002). Science. 296: 1692-1694.

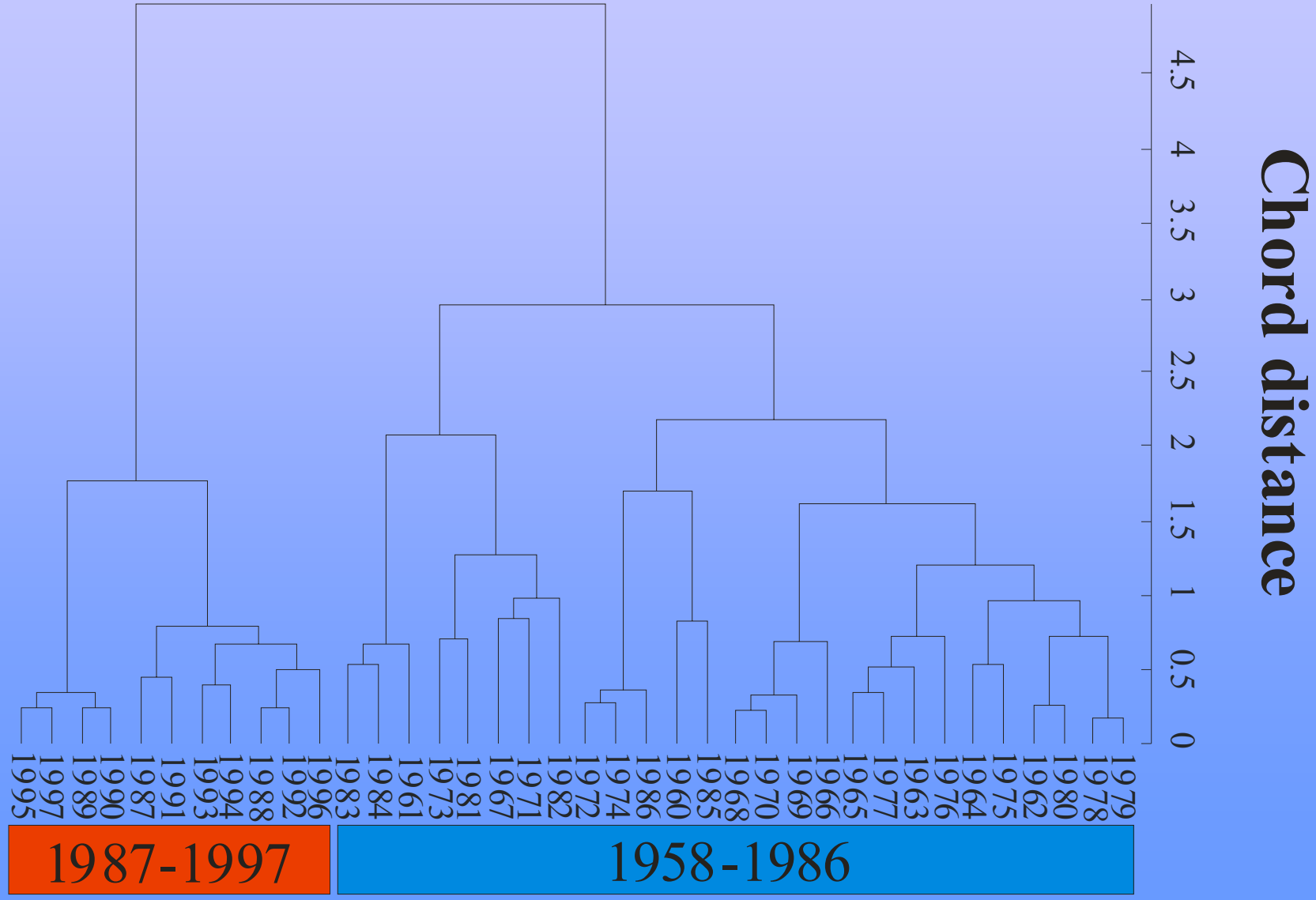
Long-term changes (1958-2000) in the abundance of some species in relation with SST, NHT and NAO

- All (original) biological variables are correlated with NHT anomalies
- *C. finmarchicus* is the only variable correlated with the NAO
- Stepwise changes after circa 1987 (earlier with euphausiids)



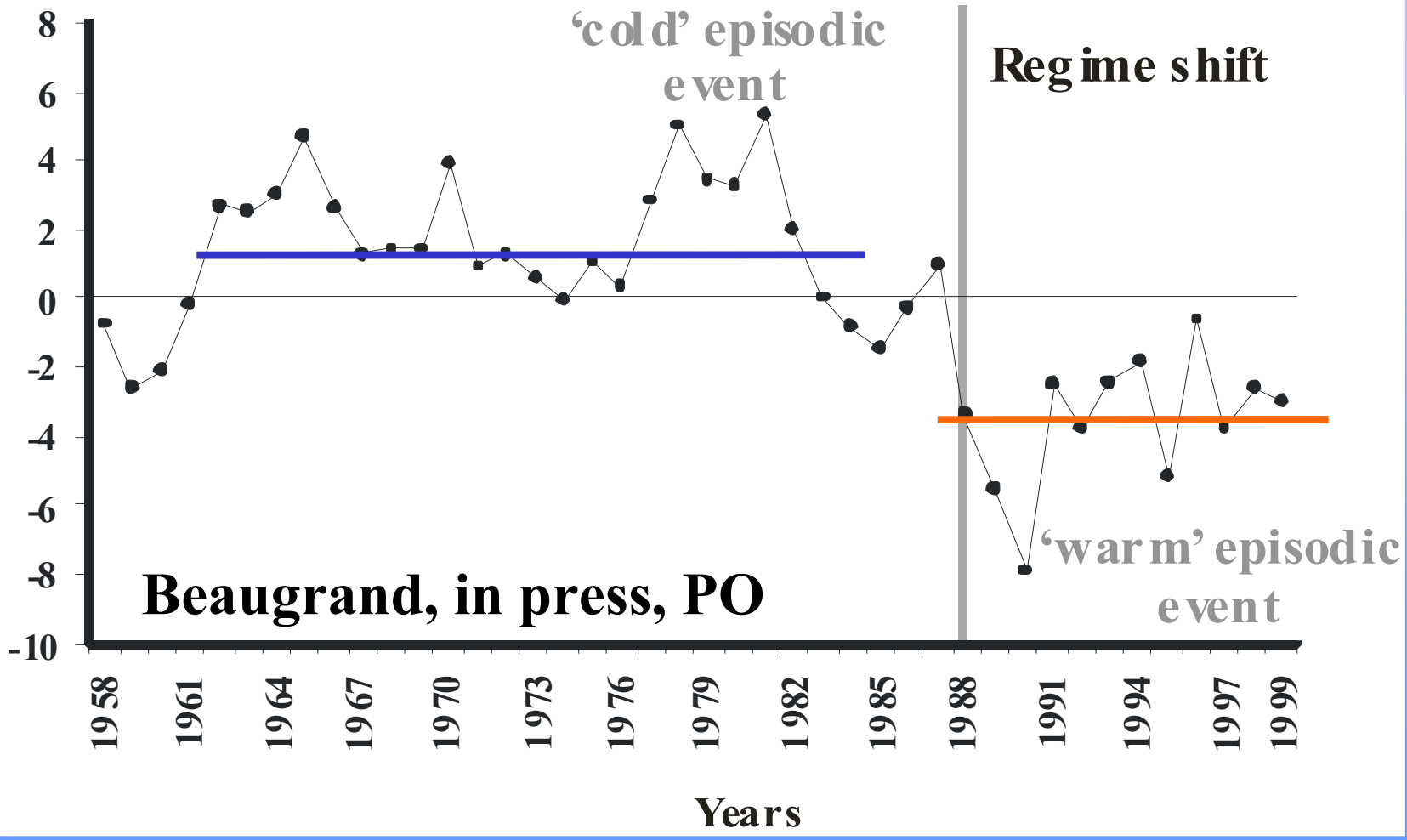
From Beaugrand & Reid (2003, GCB)

1987-1997 : an exceptional period in the north-east Atlantic



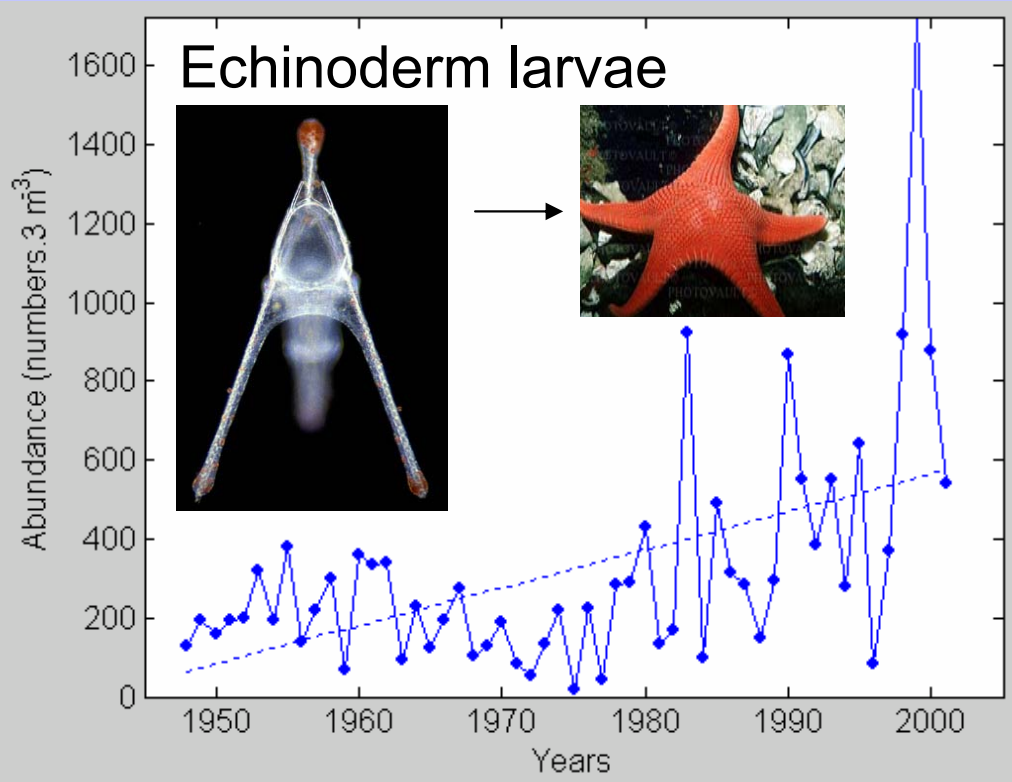
SAHFOS

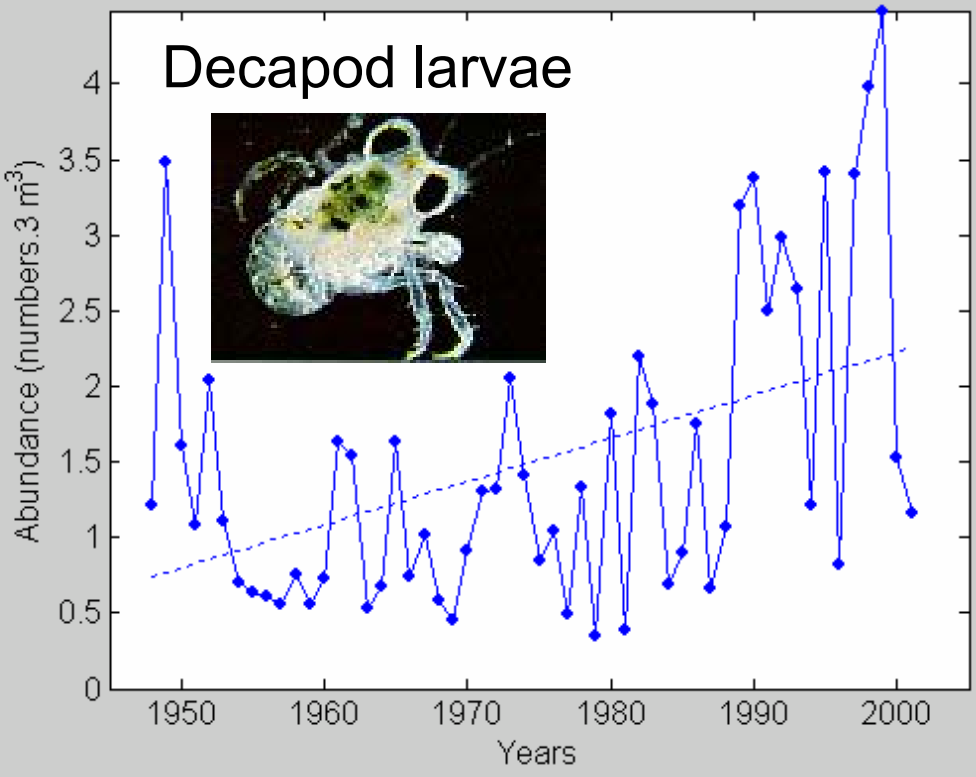
Long-term changes in the ecology (hydro-climate + biology) of the North Sea



Massive increases in meroplankton

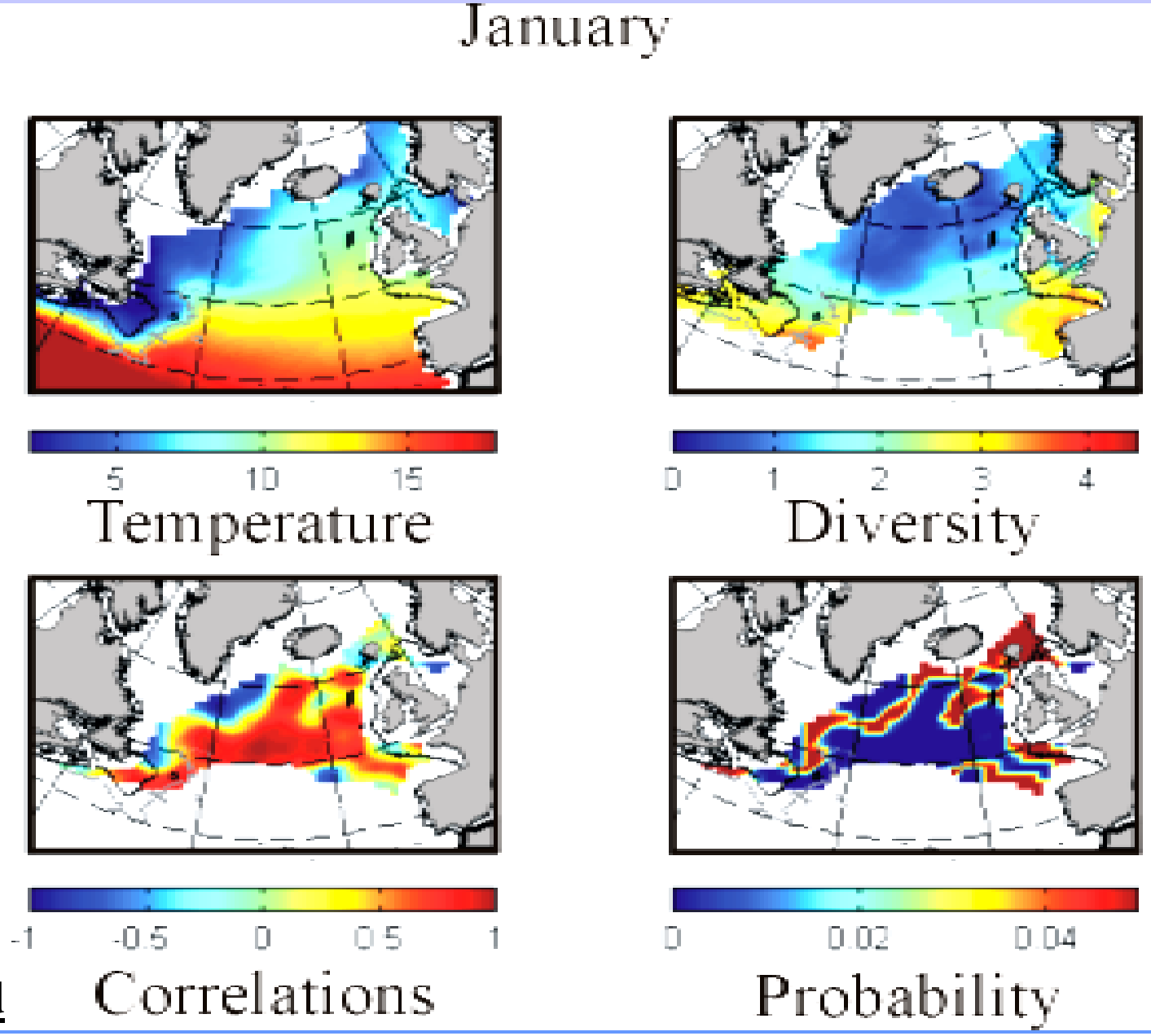
Central North Sea





see Lindley & Batten (2002) JMBA

Statistical modelling of the seasonal changes in diversity. Link with temperature

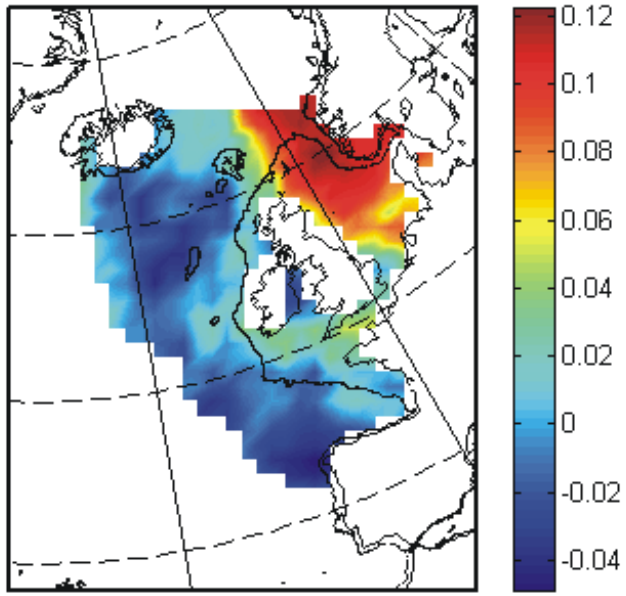


SAHFOS

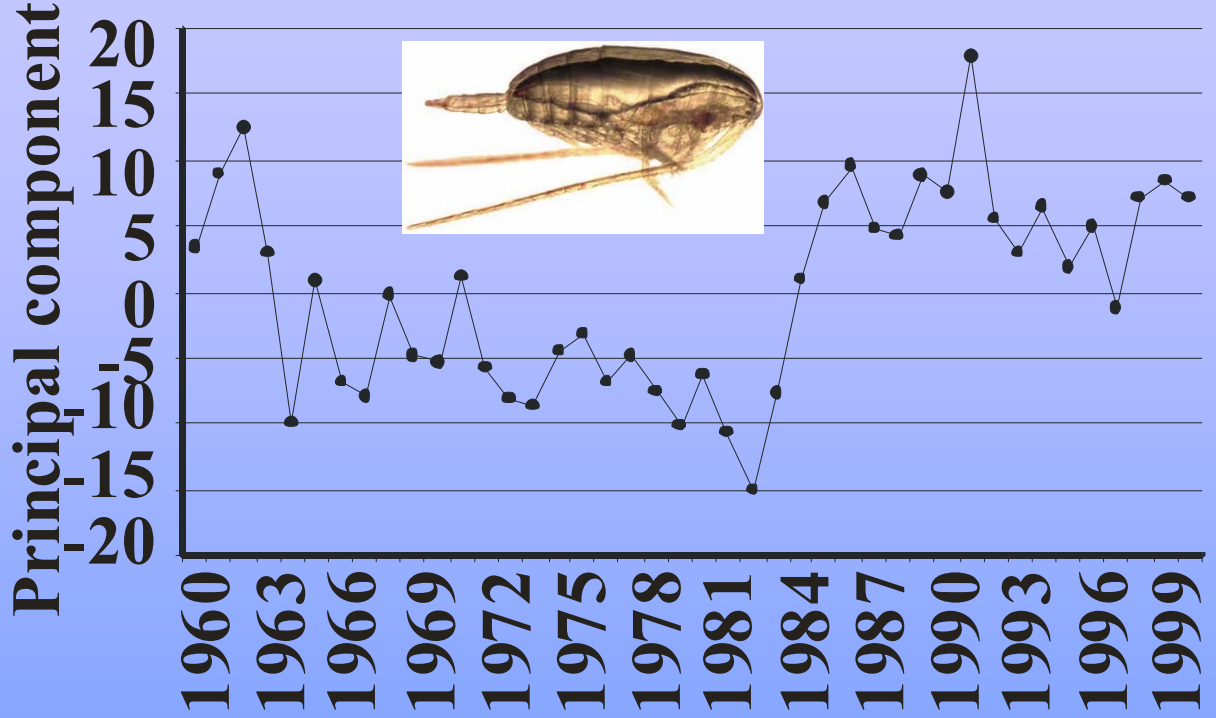
G. Beaugrand

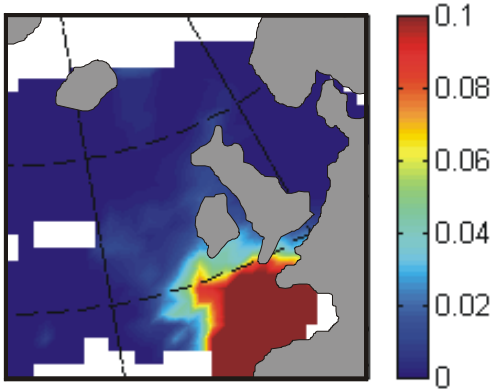
Increase in the diversity of calanoid copepods

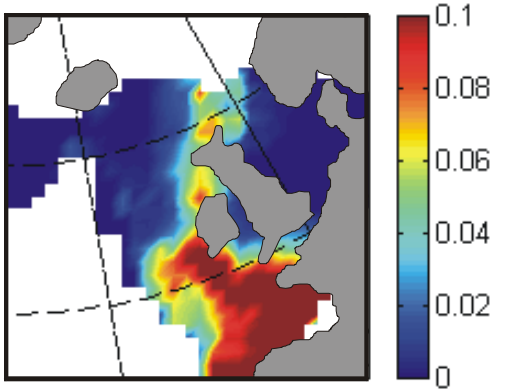
Eigenvector 2 (12.81%)



Principal component 2





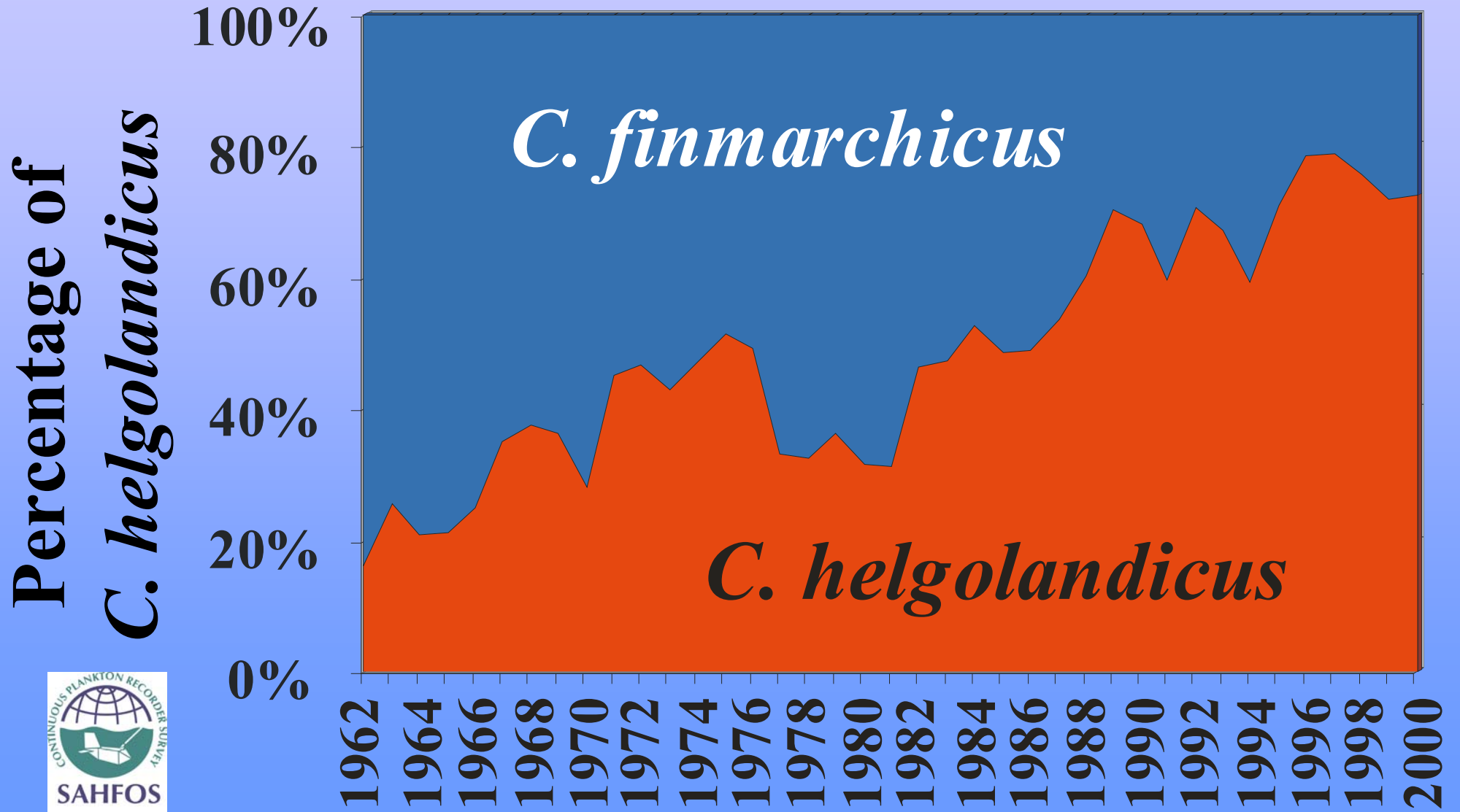


Mean number of species per CPR sample

SAHFOS

G. Beaugrand

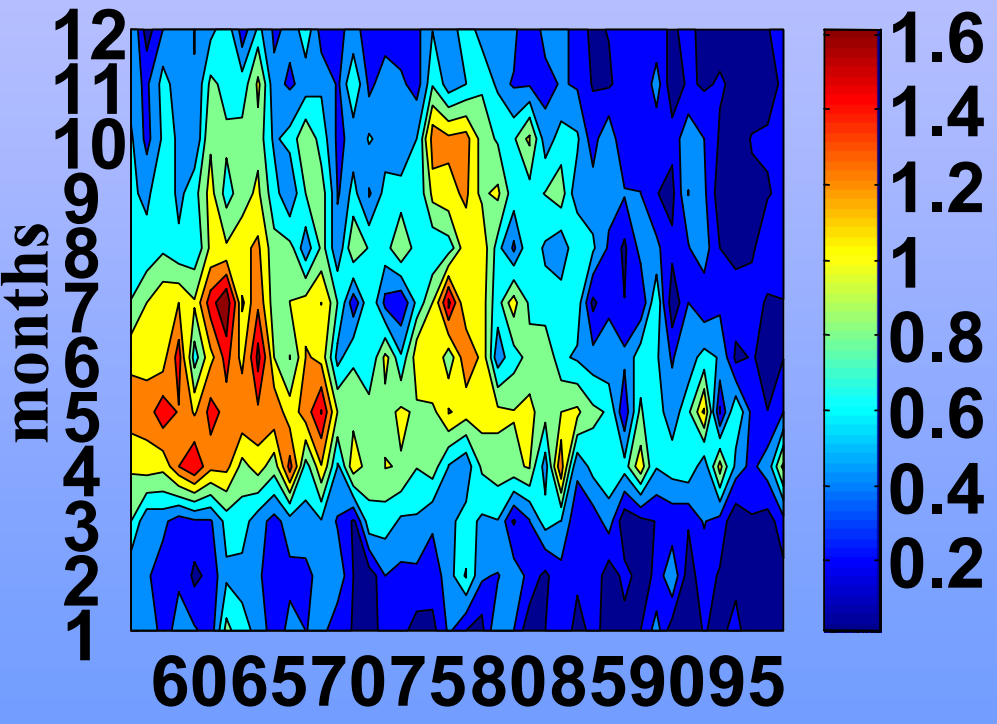
Long-term changes in the abundance of two key species in the North Sea



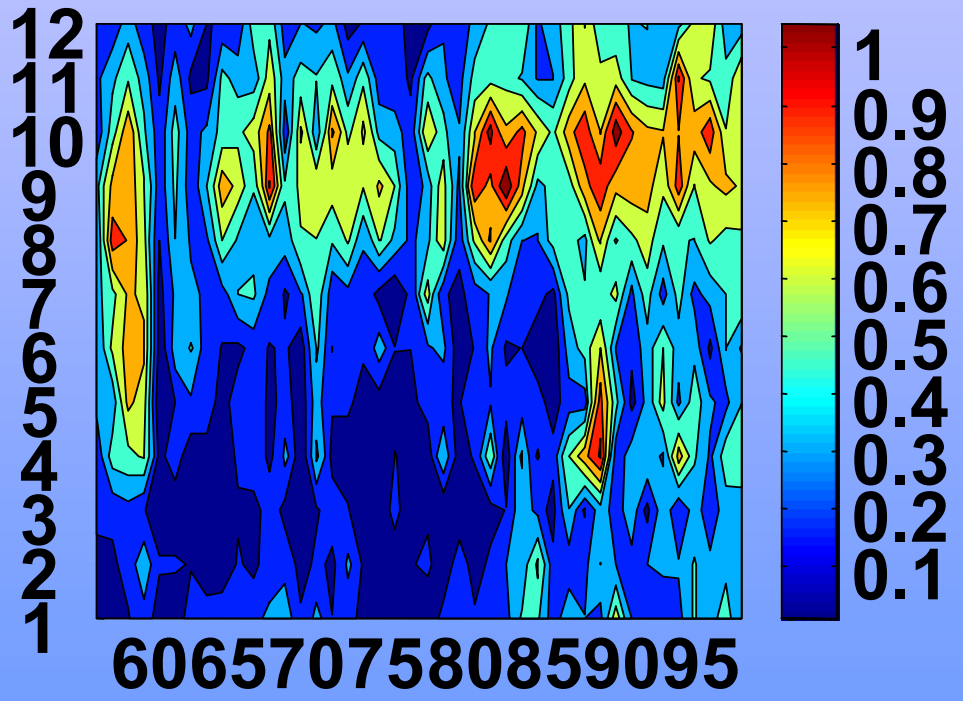
CONTINUOUS PLANKTON RECORDER SURVEY
SAHFOS

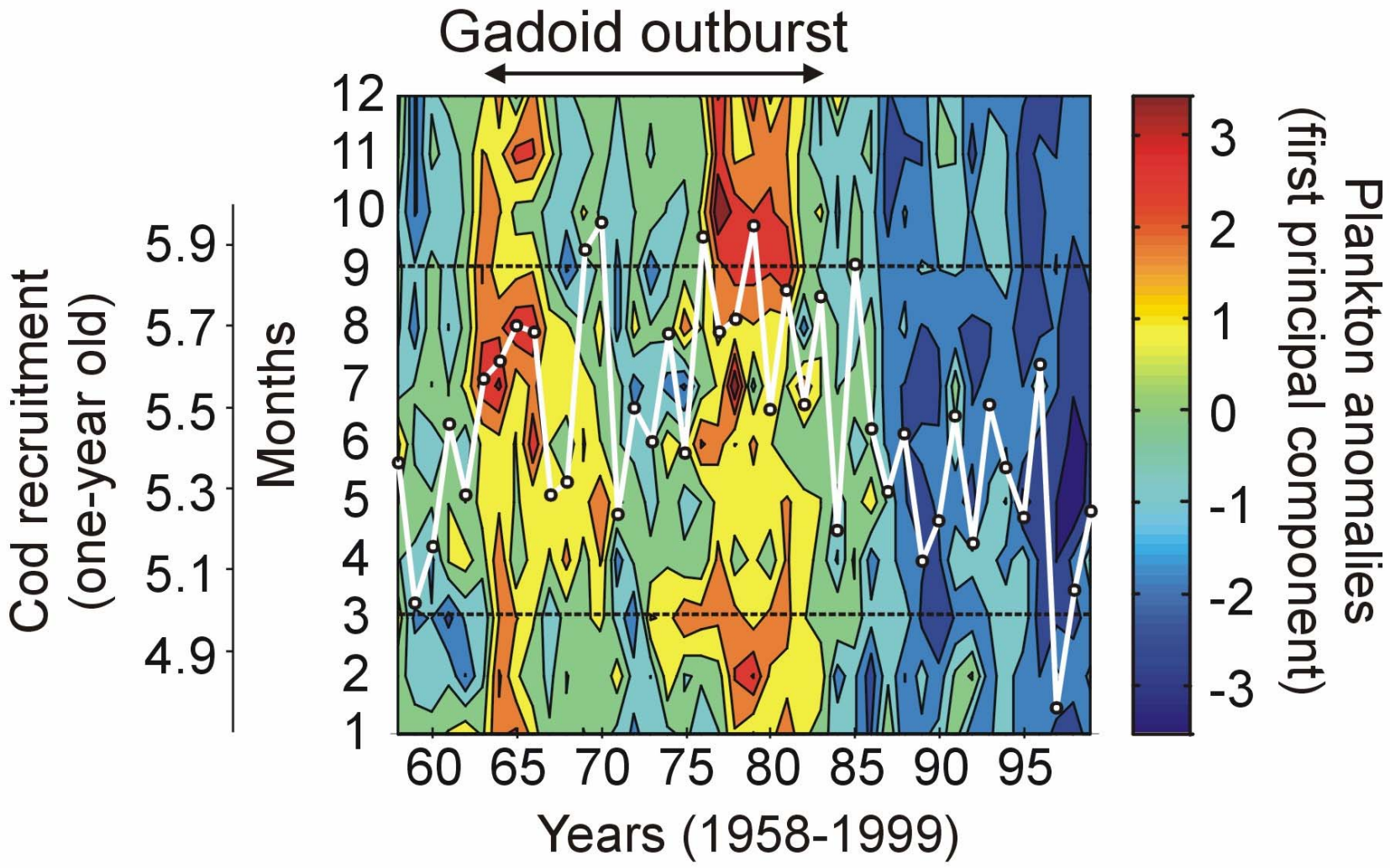
Long-term changes in the abundance of two key species in the North Sea

Calanus finmarchicus



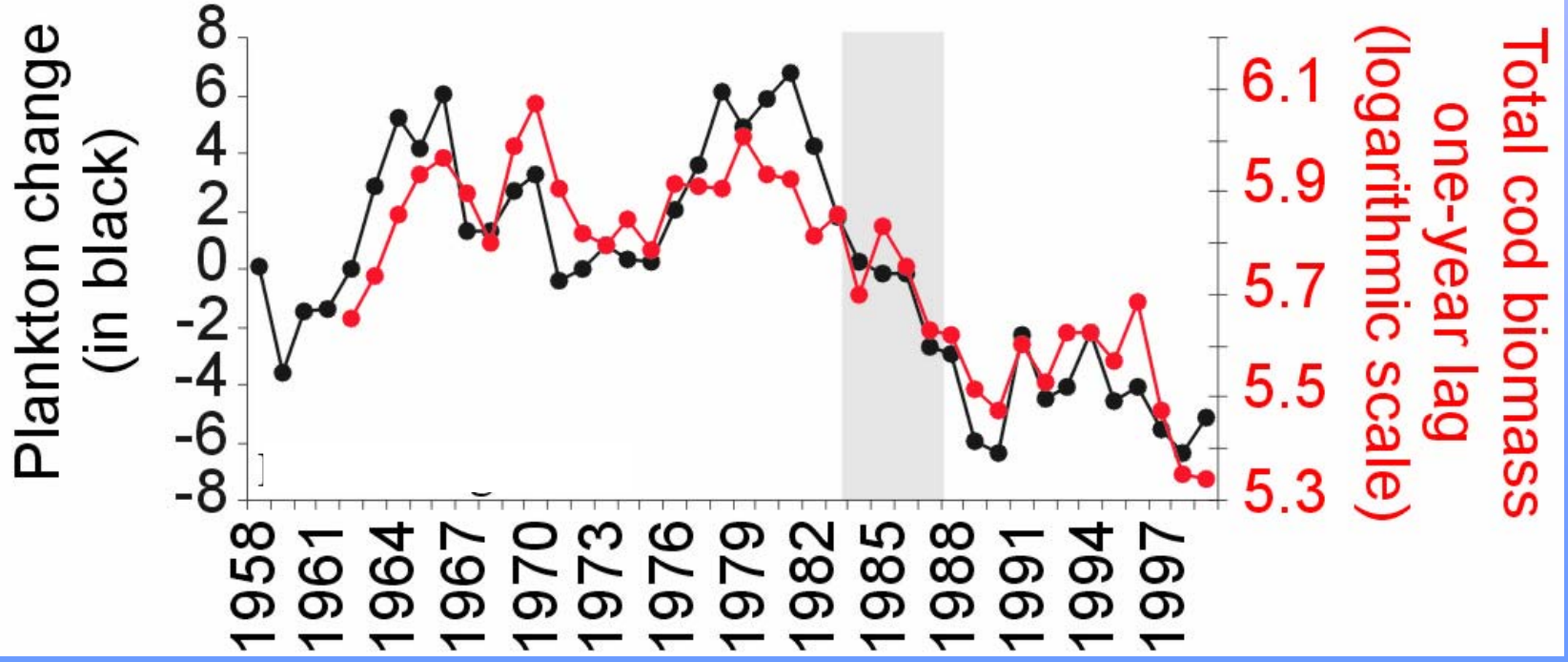
Calanus helgolandicus





Beaugrand et al 2003, Nature

Consequences of plankton changes on higher trophic level (2)



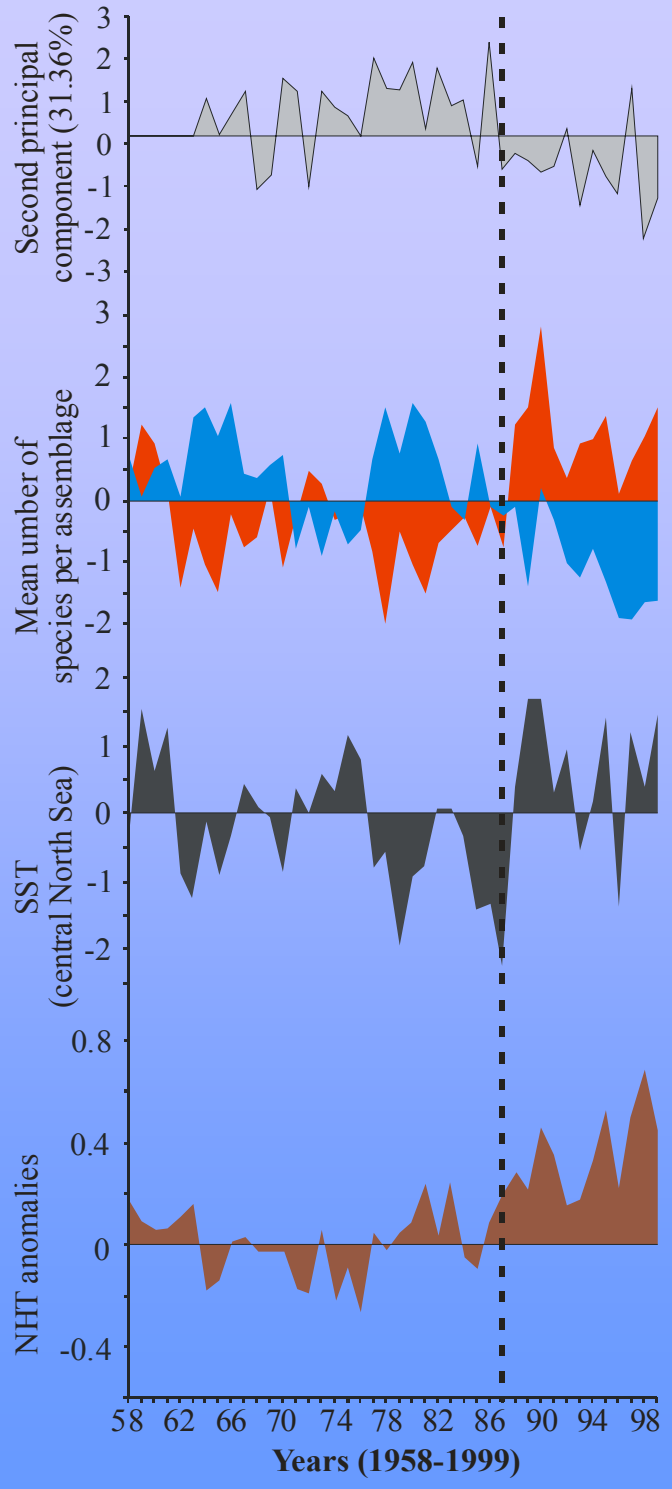
Beaugrand et al, in preparation)

Fish gadoid species (whiting, cod, haddock)

Warm-water plankton species (in red) and cold-water plankton species (in blue)

Sea surface temperature

NHT anomalies



Beaugrand (in press, PO)

Conclusions

- Many biological changes observed from a single species to important functional attributes of marine ecosystems have been detected since the beginning of the 1980s
- All biological modifications observed in the north-east Atlantic and the North Sea are in agreement with expected changes under climatic warming
- These stepwise biological modifications (called regime shift) in many functional attributes of the ecosystems of the North Sea led to an exceptional period: 1987-onwards
- These changes may have strong consequences for exploited resources in the North Sea and biogeochemical cycles