Marine ecological time series and climate change

Philip C. Reid

Sir Alister Hardy Foundation for Ocean Science (SAHFOS)

University of Plymouth

Marine Biological Association of the UK

pcre@sahfos.ac.uk

« Time-series analysis in Marine science and applications for industry »

Conference in Logonna-Daoulas, France, 17-22 sept. 2012

What is a Marine Ecological Time Series?

Marine Saltmarsh, mangrove, benthic intertidal to abyssal , pelagic

Ecological Trophic and ? physico-chemical interactions between
bacteria, plankton, benthos, fish, marine mammals, seabirds
biomass, abundance, composition, biodiversity, genes, populations

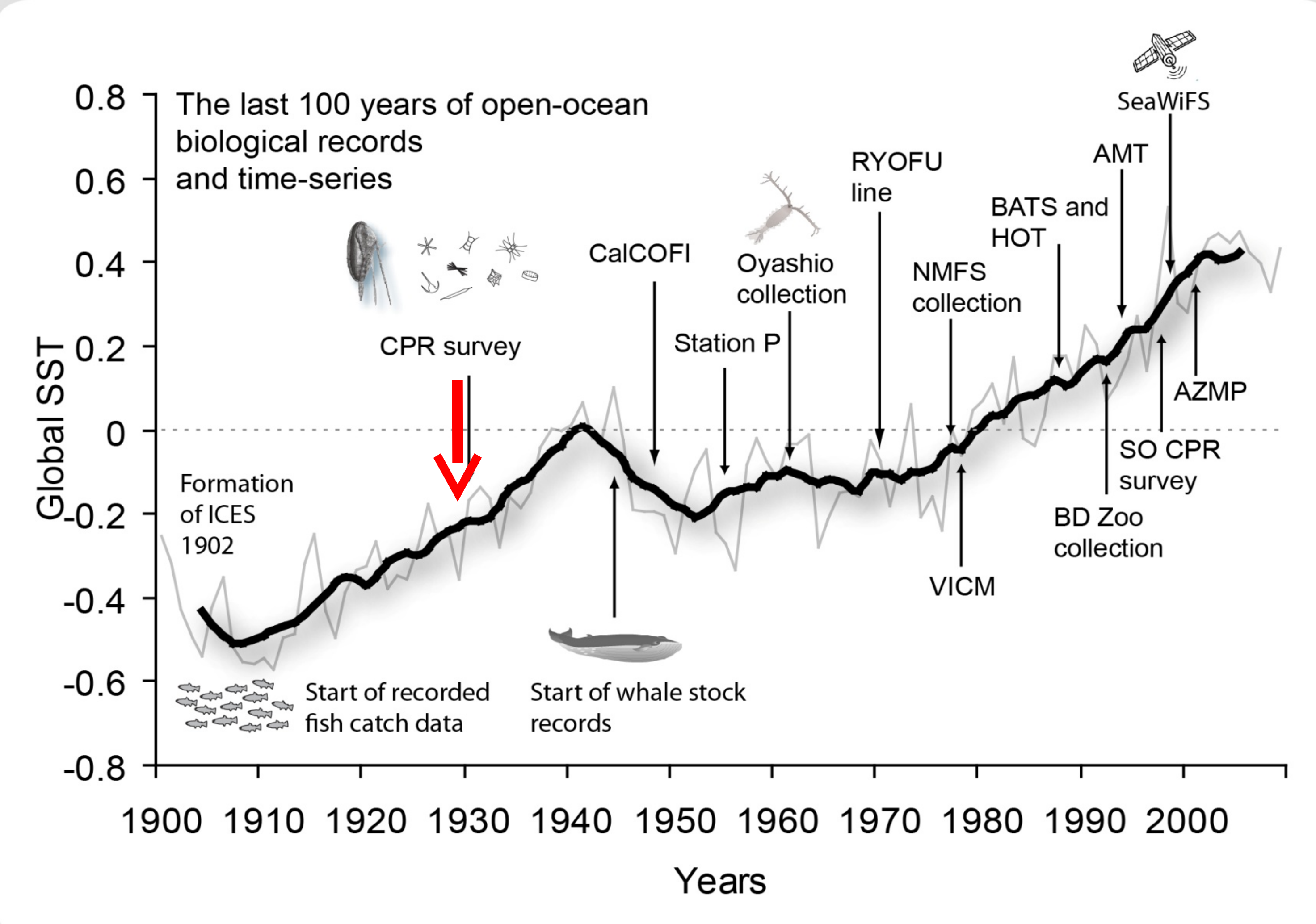
Time Palaeontological: sediment cores?
Long-term, sustained (no or minimal gaps)

Space Single point, gridded, transect, satellite, ship of opportunity (VOS)

Series Regular, systematic sampling –daily, weekly, monthly,
Standardised methodology

Survey Longer interval sampling (may not be regular)

Start of sustained open-ocean biological records and time-series



Edwards et al. 2010 TREE

Why do we need Marine Ecological Time Series?

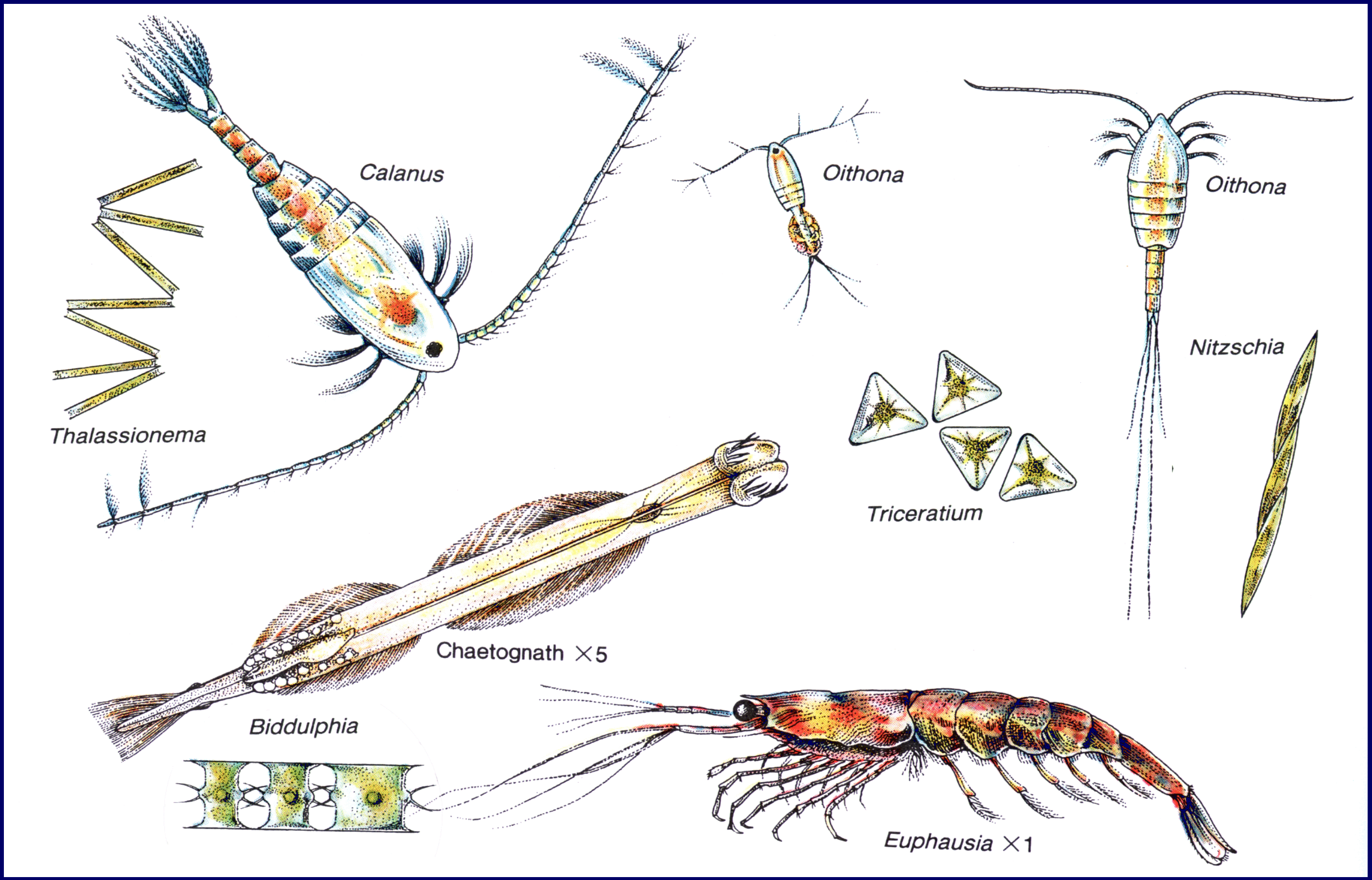
Now in the Anthropocene:

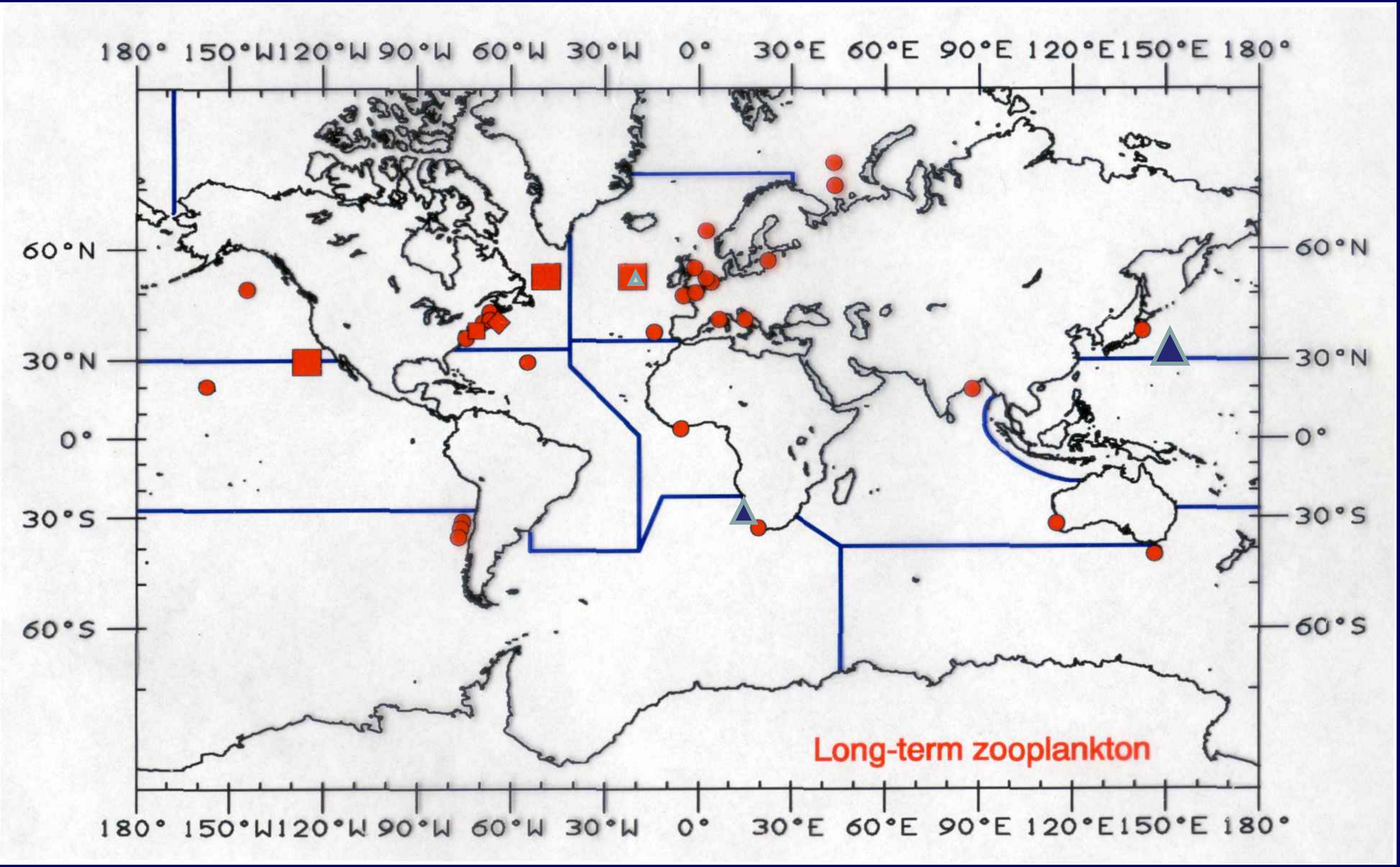
We need to evaluate human impacts on marine ecosystems (importance of baselines) and develop new ways of managing and conserving ecosystems.

“We face major challenges in understanding how ocean biology responds to global change and possibly more importantly how life in the ocean and associated biogeochemical cycles contribute to global and especially climate change. “

Reid et al. White Paper OceanObs 2009

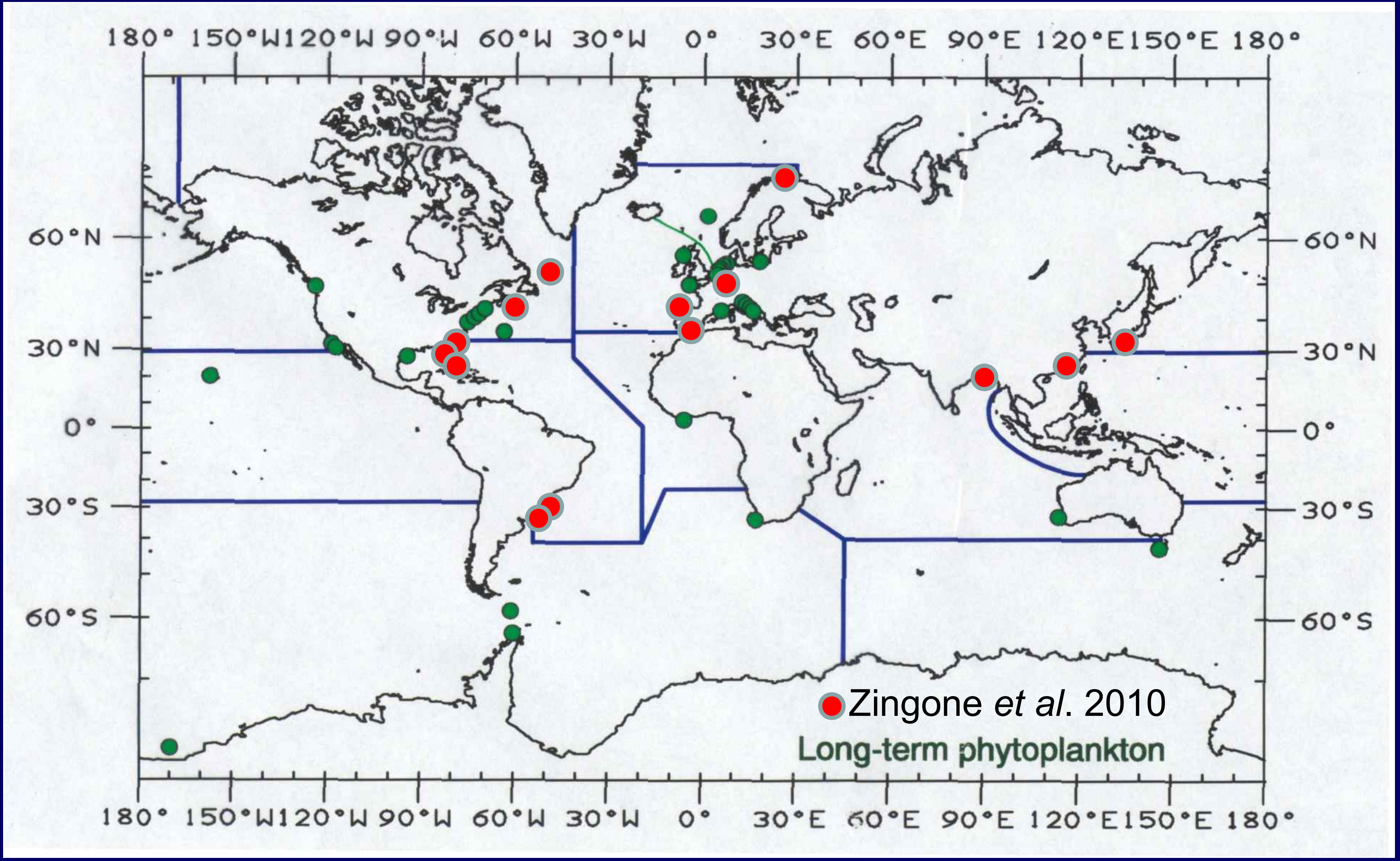
What is the location of present (and past) Marine Ecological Time Series?





Aquatic Sciences and Fisheries Abstracts: 13 Areas

Reid 2003 Guijon presentation, see also Perry et al. 2004 IJMS


180° 150°W 120°W 90°W 60°W 30°W 0° 30°E 60°E 90°E 120°E 150°E 180°
60°N
30°N
0°
30°S
60°S
Zingone et al. 2010
Long-term phytoplankton

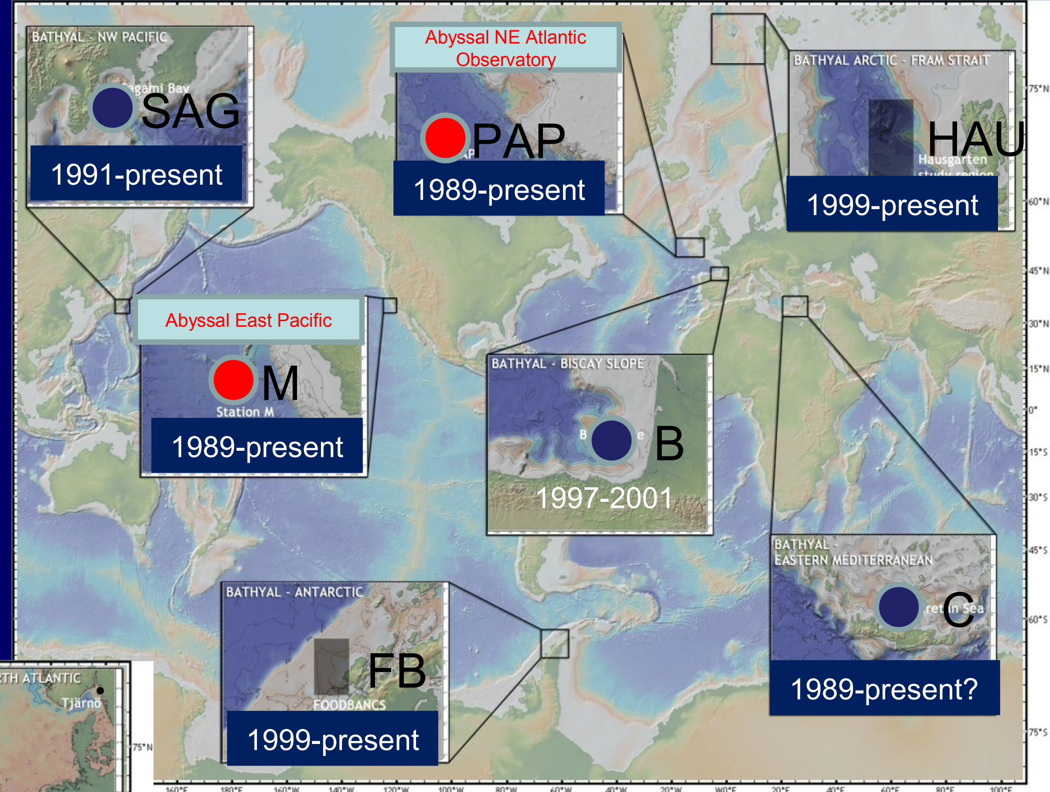
Increasing interest in long-term datasets

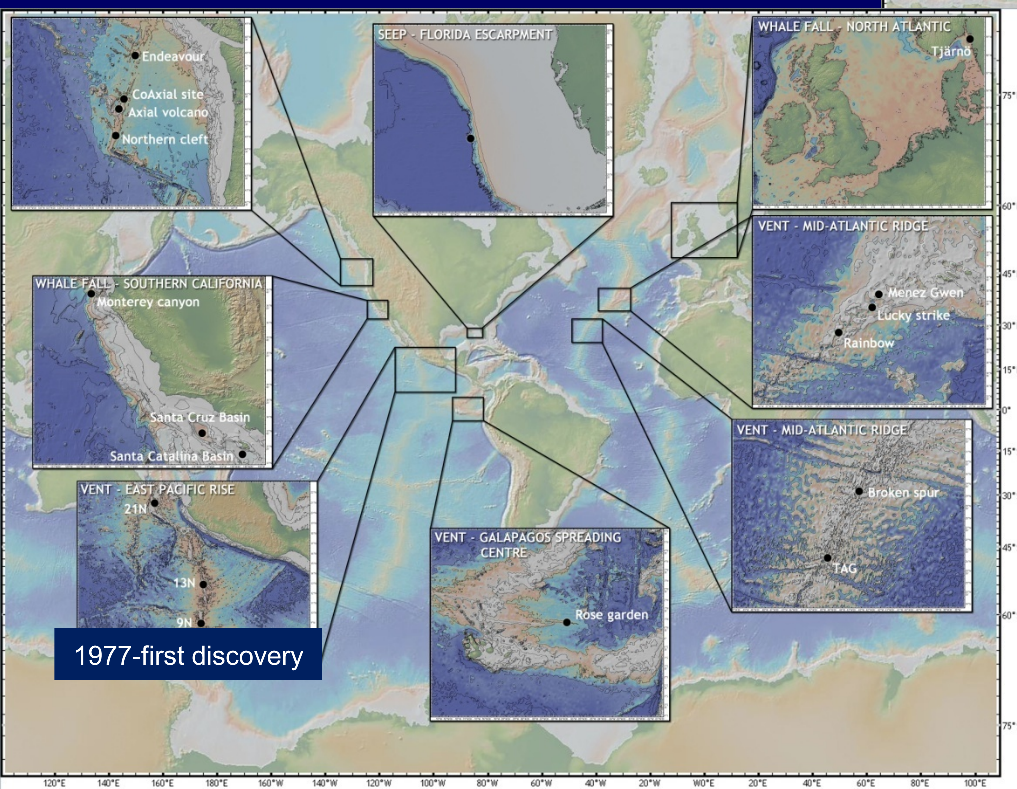
Literature expanding rapidly
Special journal editions: TREE 2010
E&C 2010
Focus of recent work by:
ICES Working Group on zooplankton ecology
SCOR Working Group on phytoplankton
Royal Statistical Society:Ecosystem Change Panel

AGU-Chapman Conference Croatia 2007
Cloern and Jassby 2010 Chlorophyll 84 time series sites
Zingone et al. 2010 E&C Phytoplankton 22 coast sites
Europole Mer Gordon-like Conference Brest Sept 2012
Helgoland Roads Time Series celebration Sept 2012

Hadal trenches: nothing

Chemosynthetic ecosystems
Hydrocarbon vents

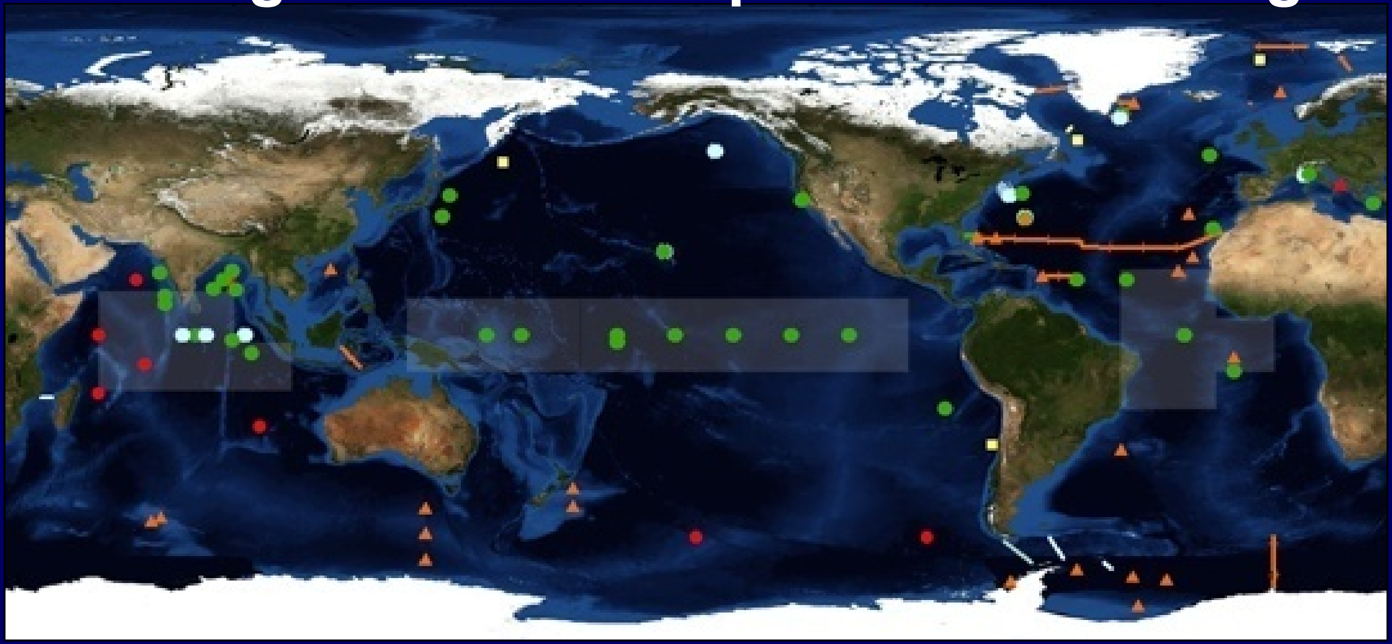




Deepsea Benthic time series

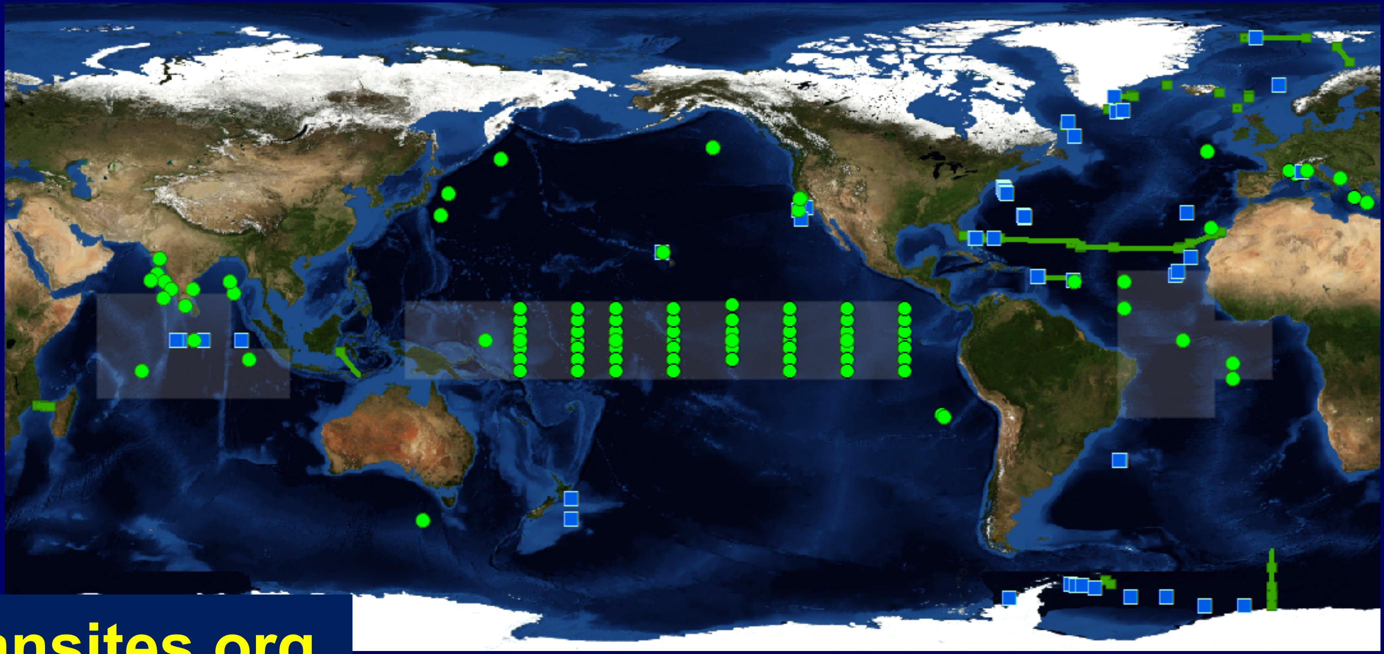
Glover et al. 2010
Advances in Marine Biology
Benthic time series sites
Review

Long-term over deep water monitoring: OceanSITES



May 2009

Operating
May 2012

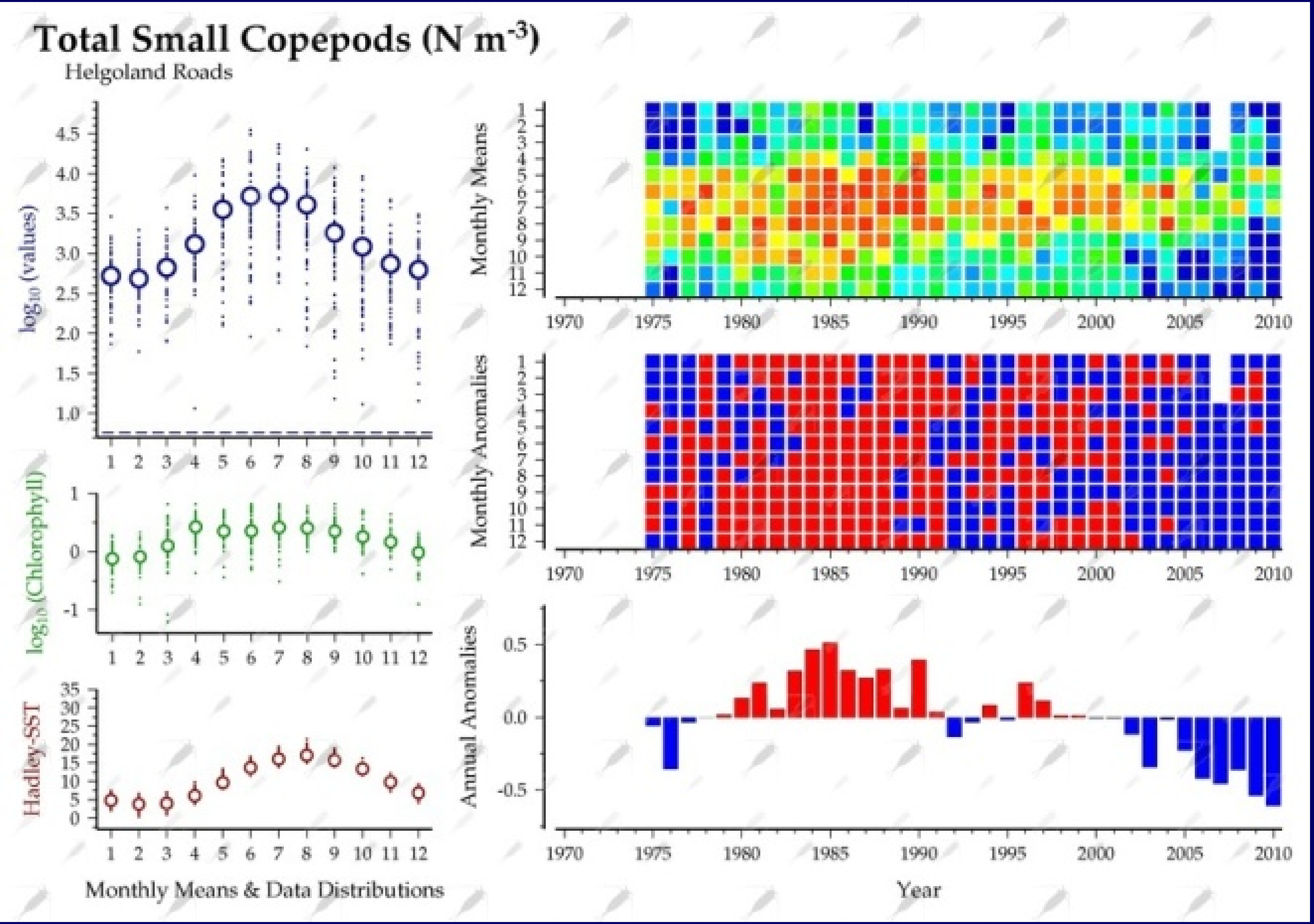


Real time

Delayed mode

http://www.oceansites.org

Helgoland

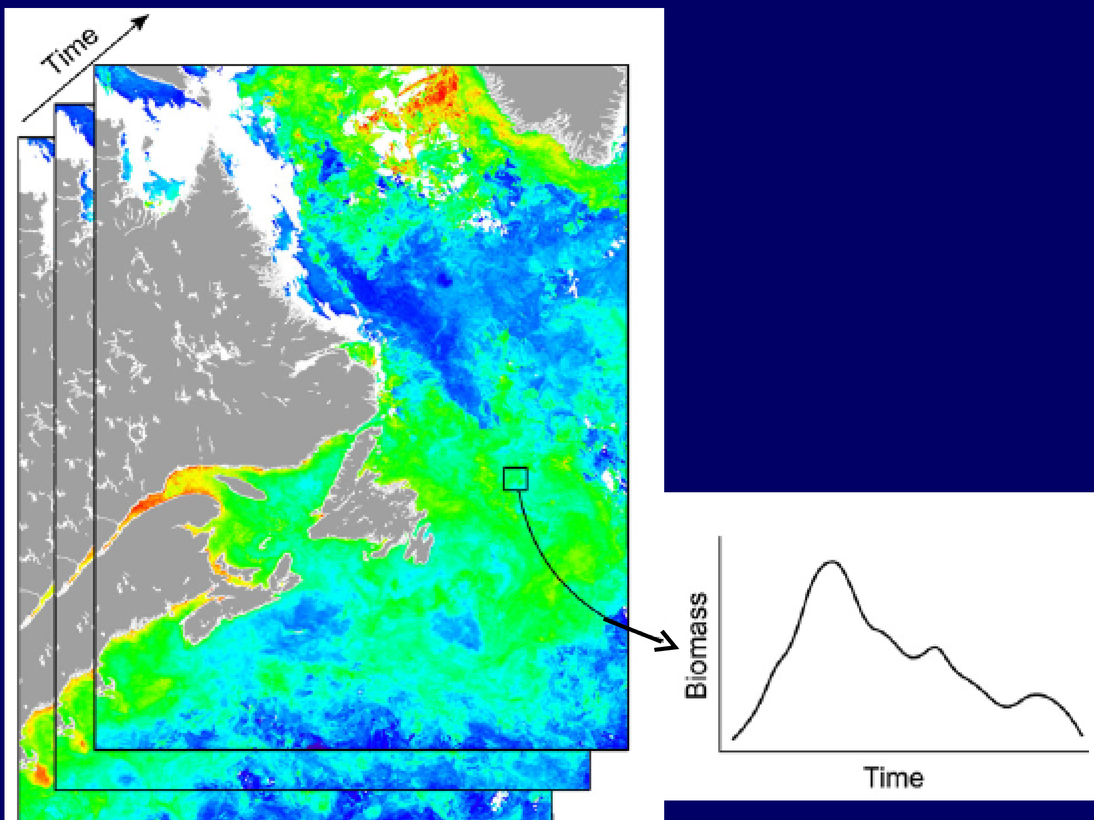


Thanks to Wulf Greve and Todd O'Brien

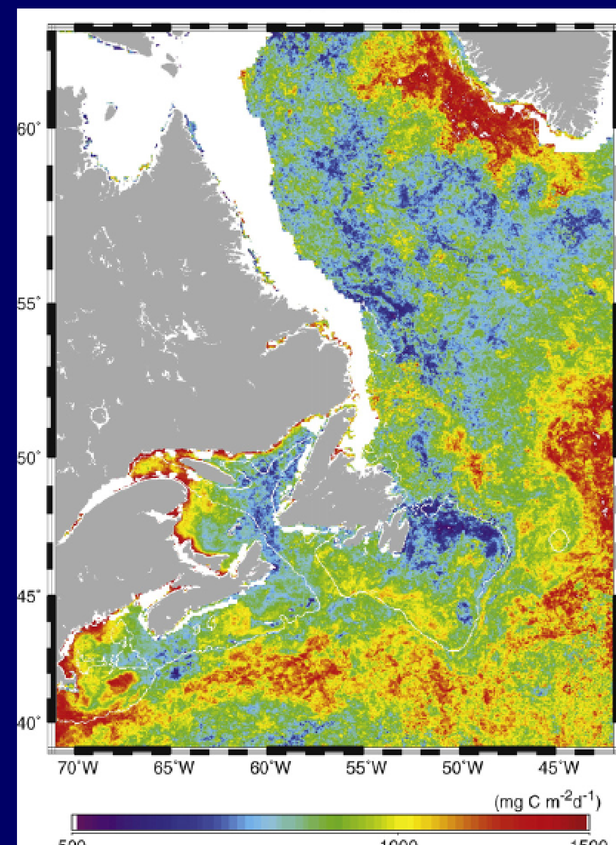
Satellite remote sensed chlorophyll time series and indicators

CZCS 1978 -1986 – SeaWiFS 1997 - present

Chlorophyll

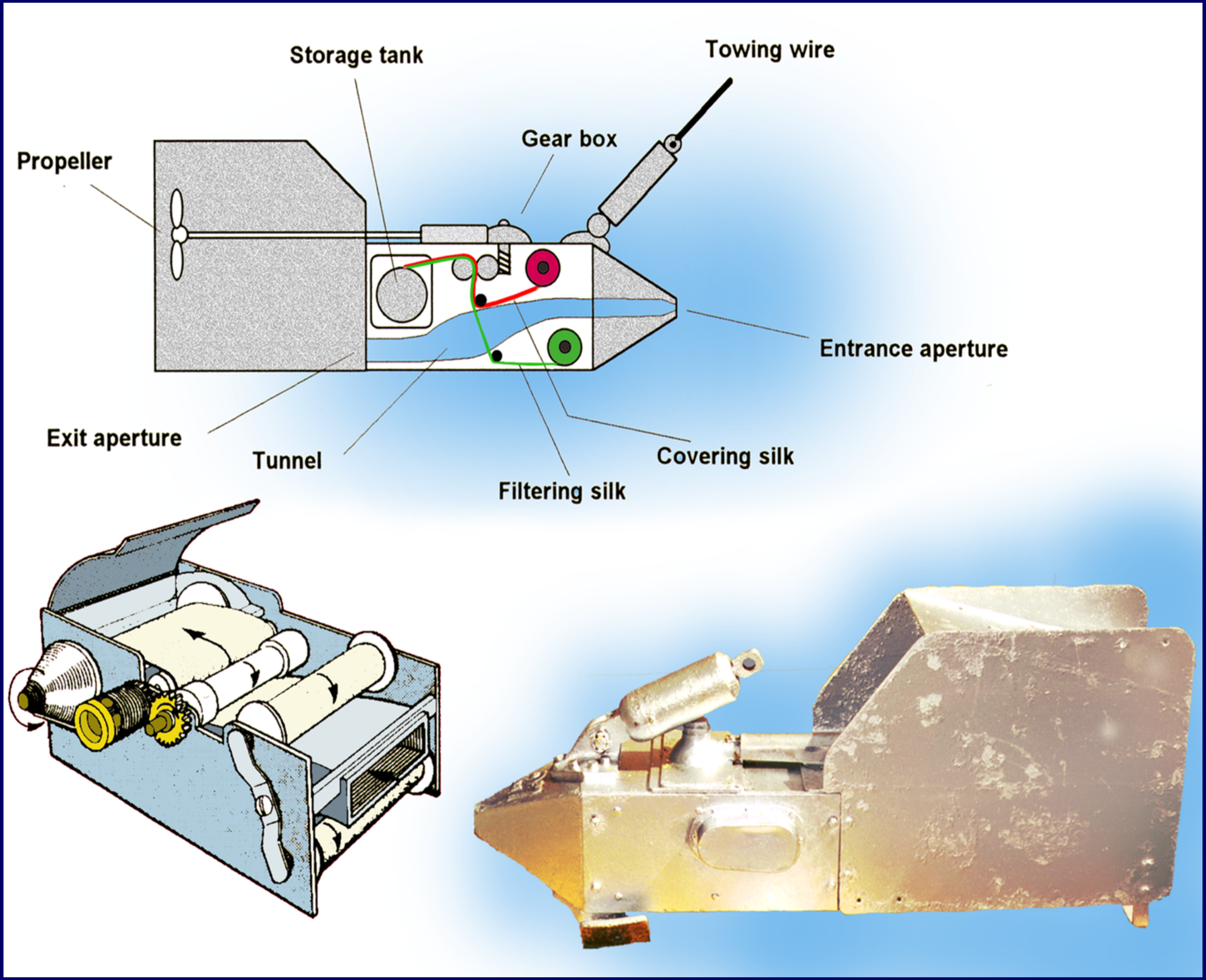


Primary Production

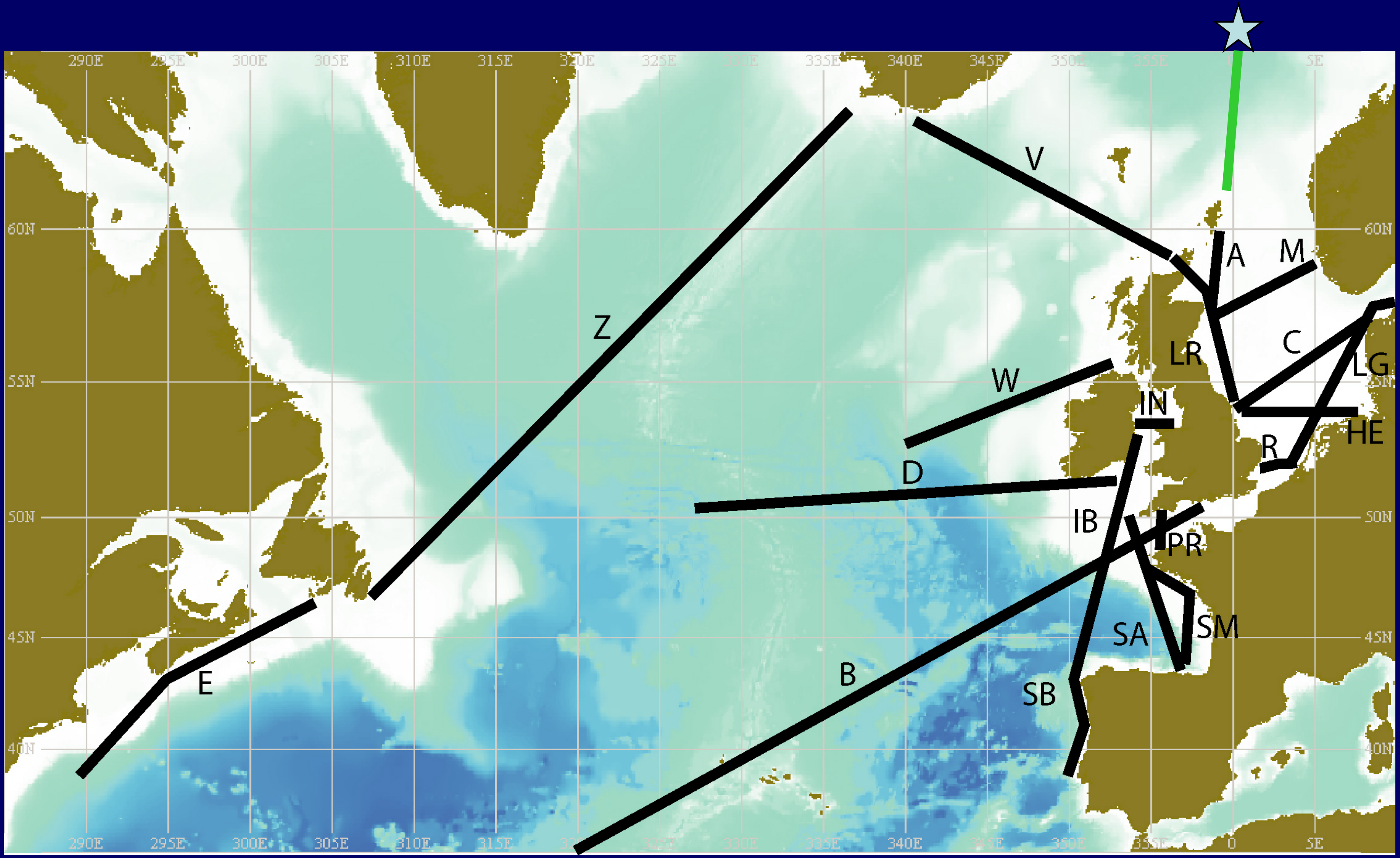


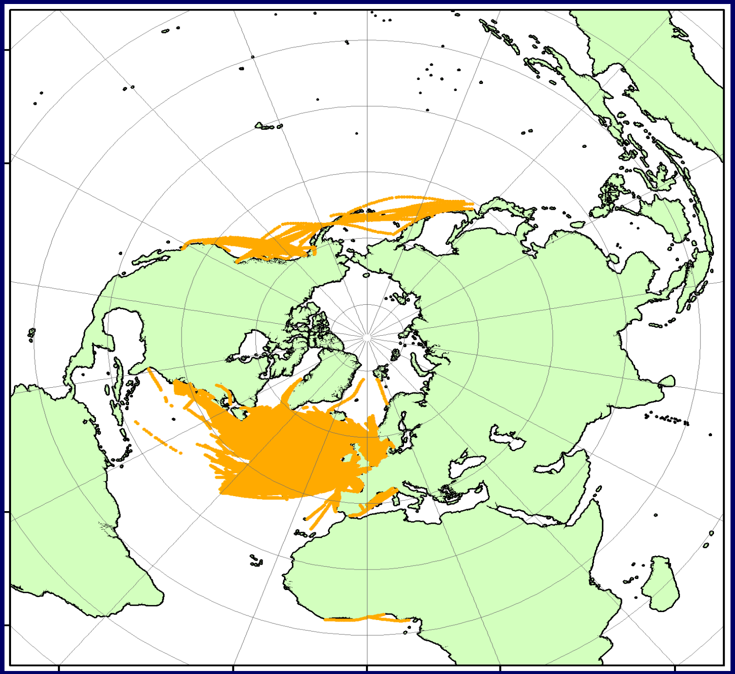
Platt et al. 2007 MEPS & Sathyendranath ICES JMS, 2009 E&C

The Continuous Plankton Recorder

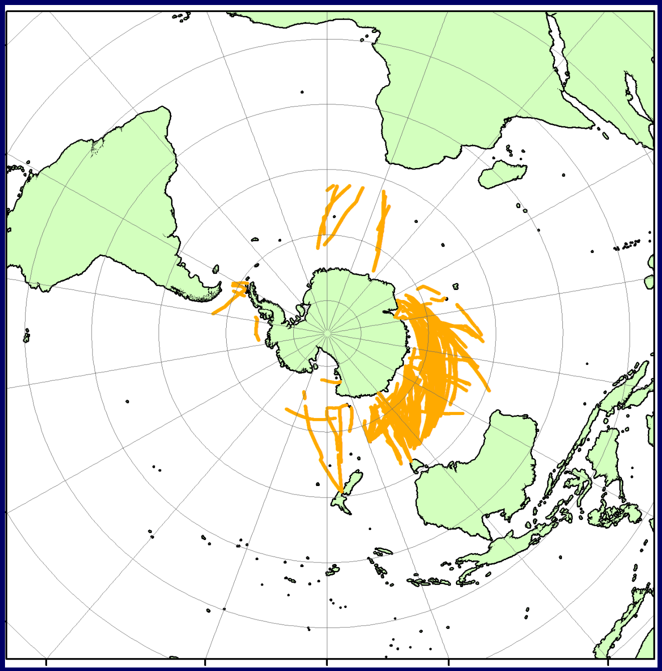


Standard monthly Continuous Plankton Recorder routes in the North Atlantic





1931
to
2008



Lessons from the Continuous Plankton Recorder survey

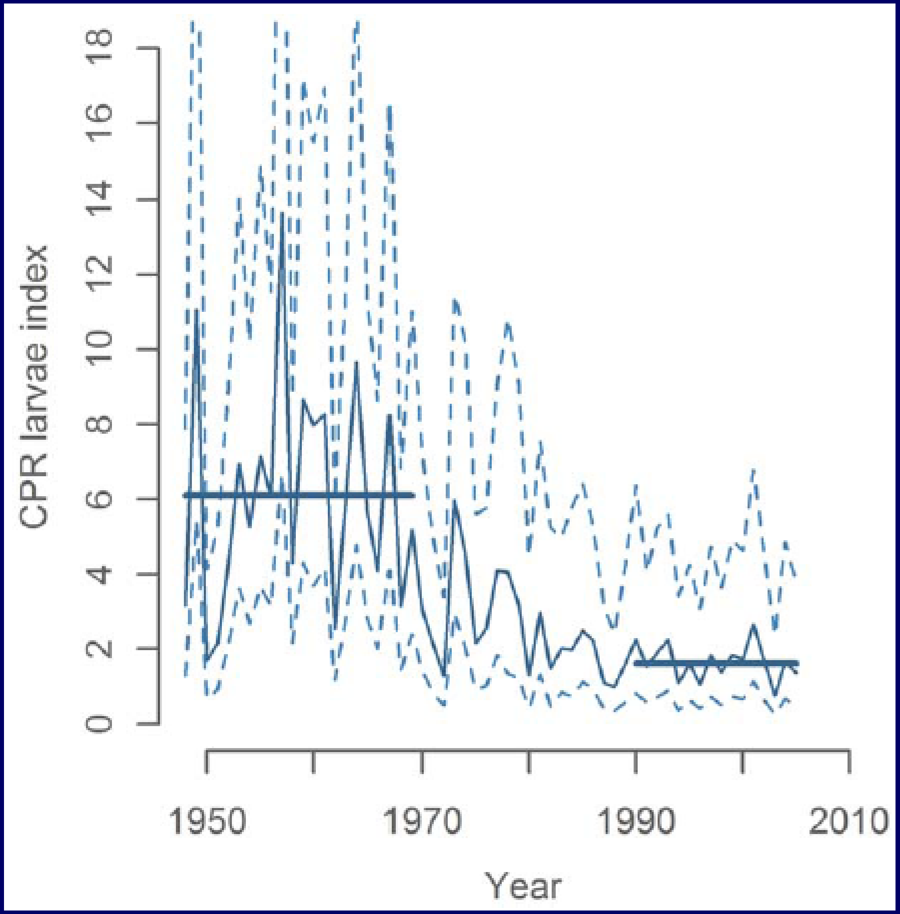
Uses voluntary merchant ships to tow machines

>500 taxa (50% to species) identified

>200,000 samples analysed

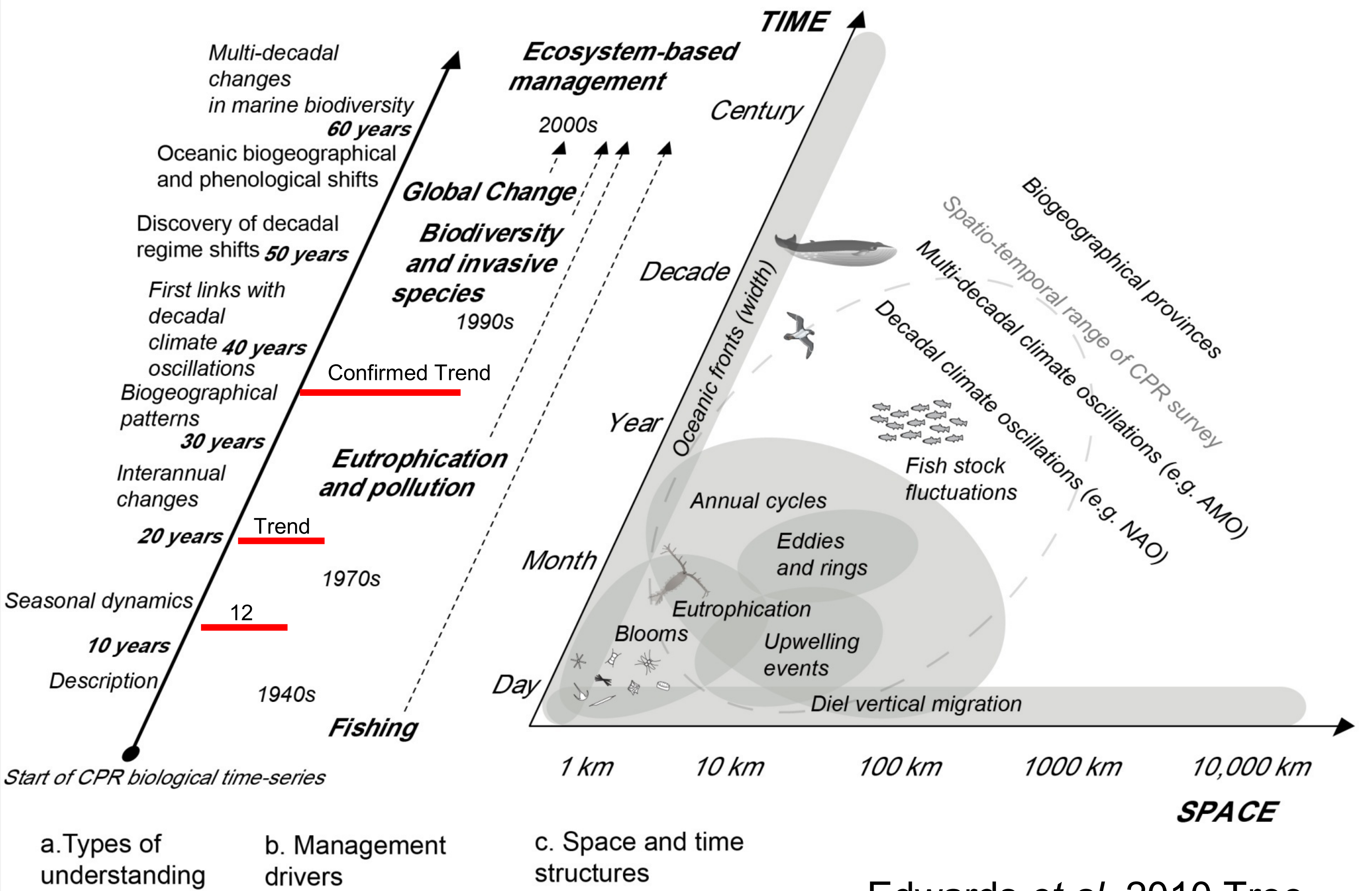
This summer passed 6 million Nmiles of tow

Modelling North Sea Mackerel Stocks



Jansen et al. 2012 PLOS1

Co-evolution of a biological time-series and marine management



Edwards *et al.* 2010 Tree

Reasons for success?

Luck?

People are important (funding and research)

Strong advocates

Government support

Link to policy

Publication output

Standardised methods

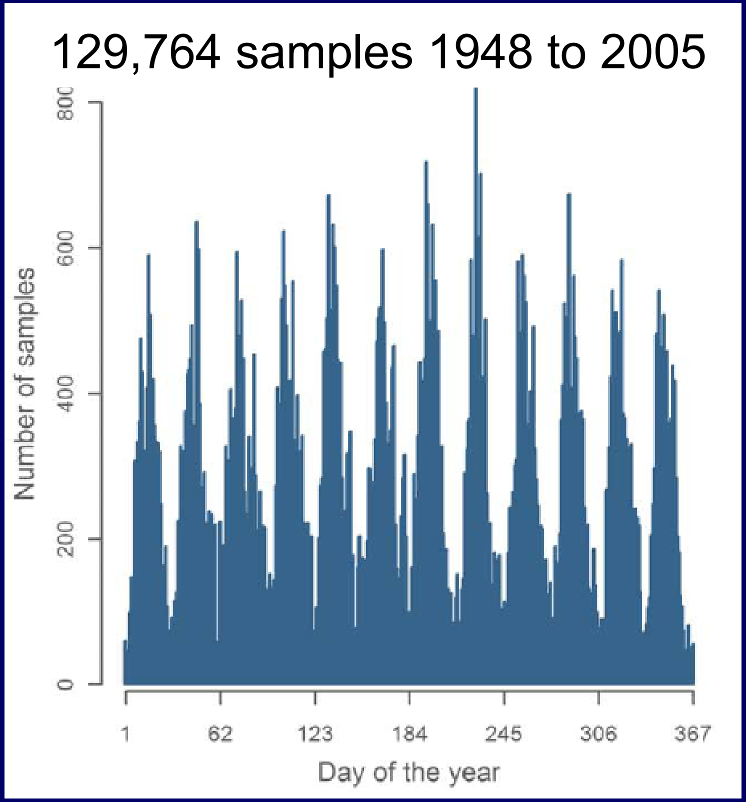
Deployment, sampling, analysis

Associated Instrumentation

Relationship with SOOPs

Silk story.

CPR box tail story



Jansen et al. 2012 PLOS1: CPR sampling

Huge gaps in sampling globally

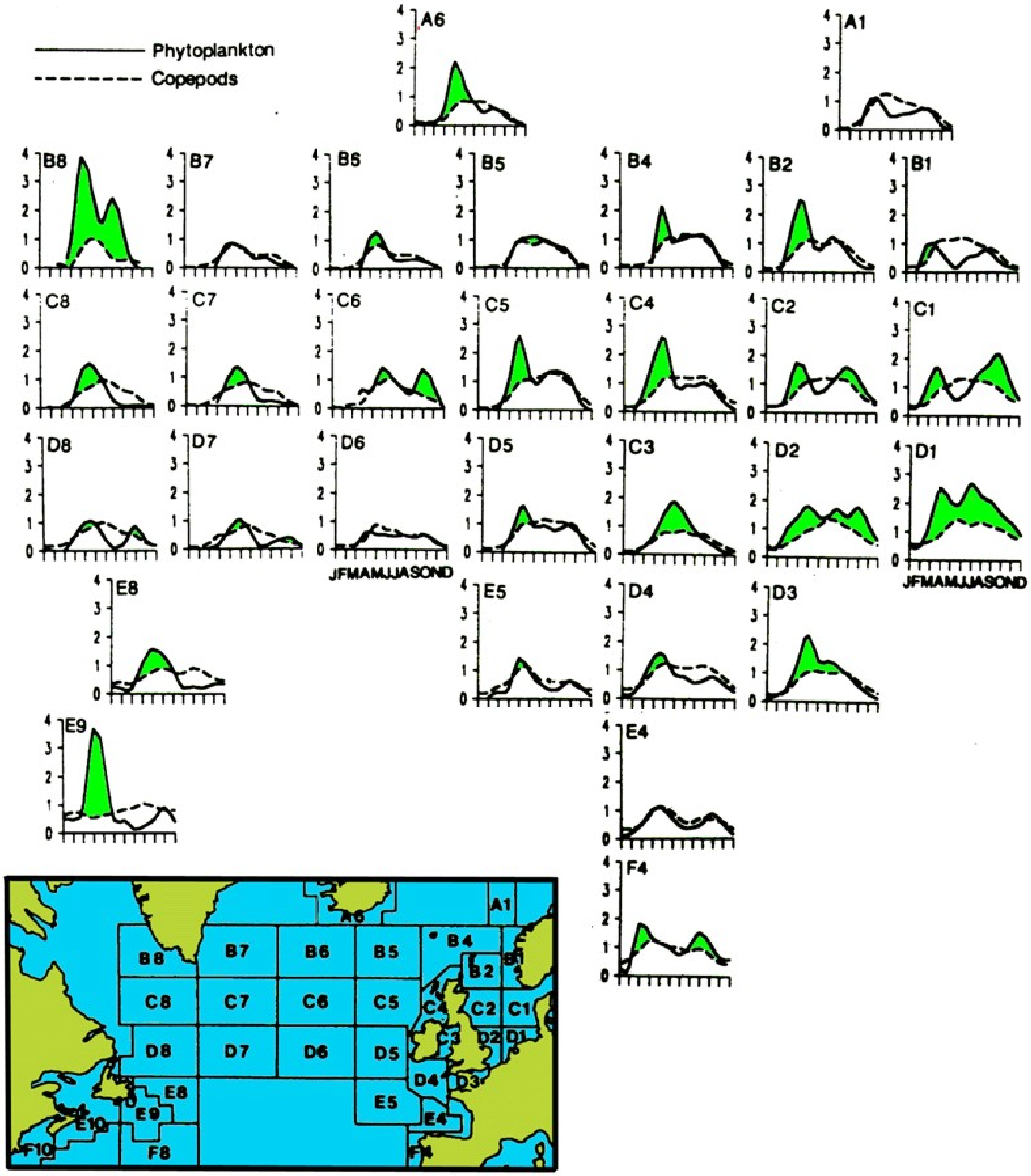
No information from the tropics

Parallel to terrestrial
but much fewer time series

The First 70 years

Year 70 2002 Biogeographic range shift (1000km)
Year 69 2001 DNA sequencing of formalin preserved samples breakthrough
Year 68 2000 Biodiversity patterns established XX
Year 65 1997 North Sea circa 1987 regime shift identified. First modelling application
Year 64 1996 Link between plankton and the North Atlantic Oscillation established XX
Year 61 1993 Contributions to North Sea Task Force: Quality Status Report on the NS.
Year 60 1992 Plankton and climate change link suggested
Year 59 1991 The phoenix rises. Establishment of SAHFOS
Year 56 1988 to 91 closure and redundancy. Loss of archive
Year 55 1987 Importance of winter plankton production
Year 44 1976 Move of laboratory, failure of tows FLEX Value of multiple species
Year 43 1975 Phytoplankton change. Chlorophyll, diatoms, dinoflagellates differ
Year 40 1972 Long-term trend (20 years data 1948 to 1968)
Year 38 1970 Phytoplankton linked to stratification and temperature
Year 34 1965 Basin scale interannual abundance, timing and season length
Year 27 1958 Introduction of computers
Year 26 1957 Mean distribution atlas, water mass associations (indicators)
Year 17 1948 Streamlining methods (alternate samples)
Year 9 to 15 Interuption during World War II for 8 years (1939 to 46)
Year 9 Patchyness in the plankton
Year 8 Pioneer years. Logistics, geography, methods standardisation
Year 1 September 1931 official start of the CPR survey

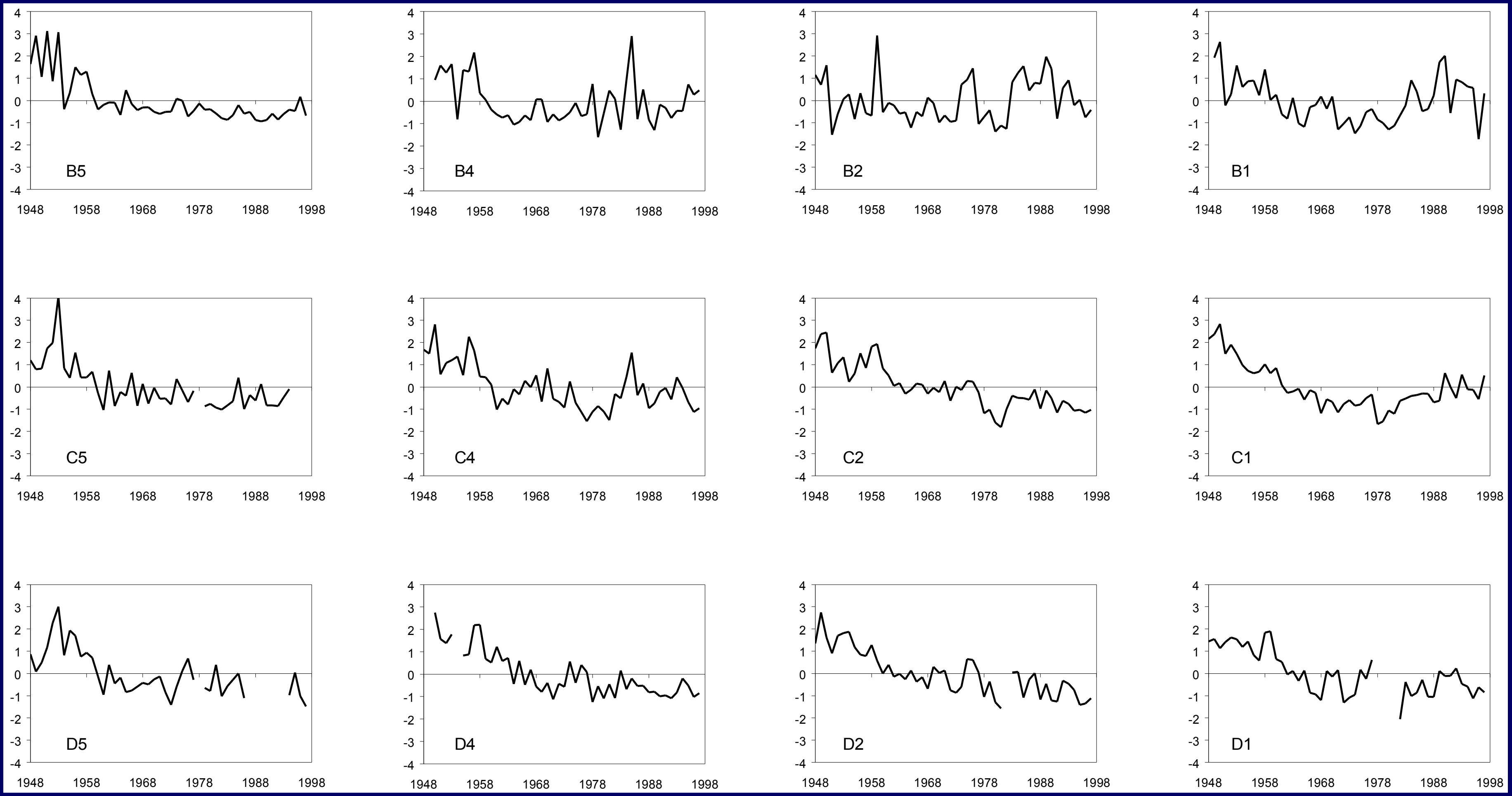
Mapping seasonal changes



CPR 'standard area' map.

Long-term seasonal patterns in the abundance of phytoplankton and zooplankton in CPR ‘standard areas’ Colebrook 1979

Trends



Para-pseudocalanus spp.

Step Changes, Regime Shifts

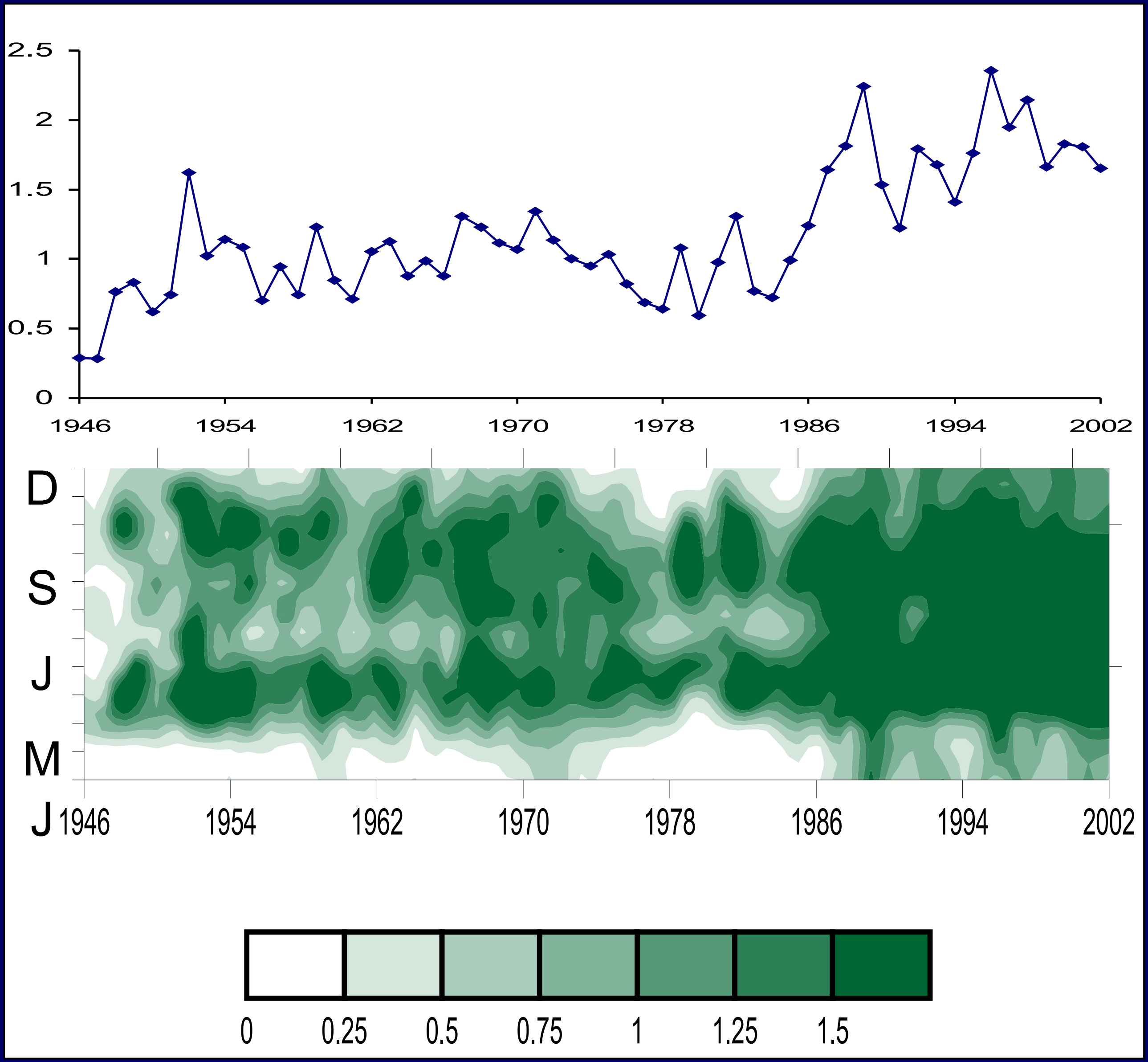
~1987
Recognised 1997 published 2001
10 years

Why so long? Fashion?
Opponents of the CPR method
= to climate deniers

First described by Reid *et al*. 2001 Fisheries Research

North Sea Phytoplankton Colour

1946

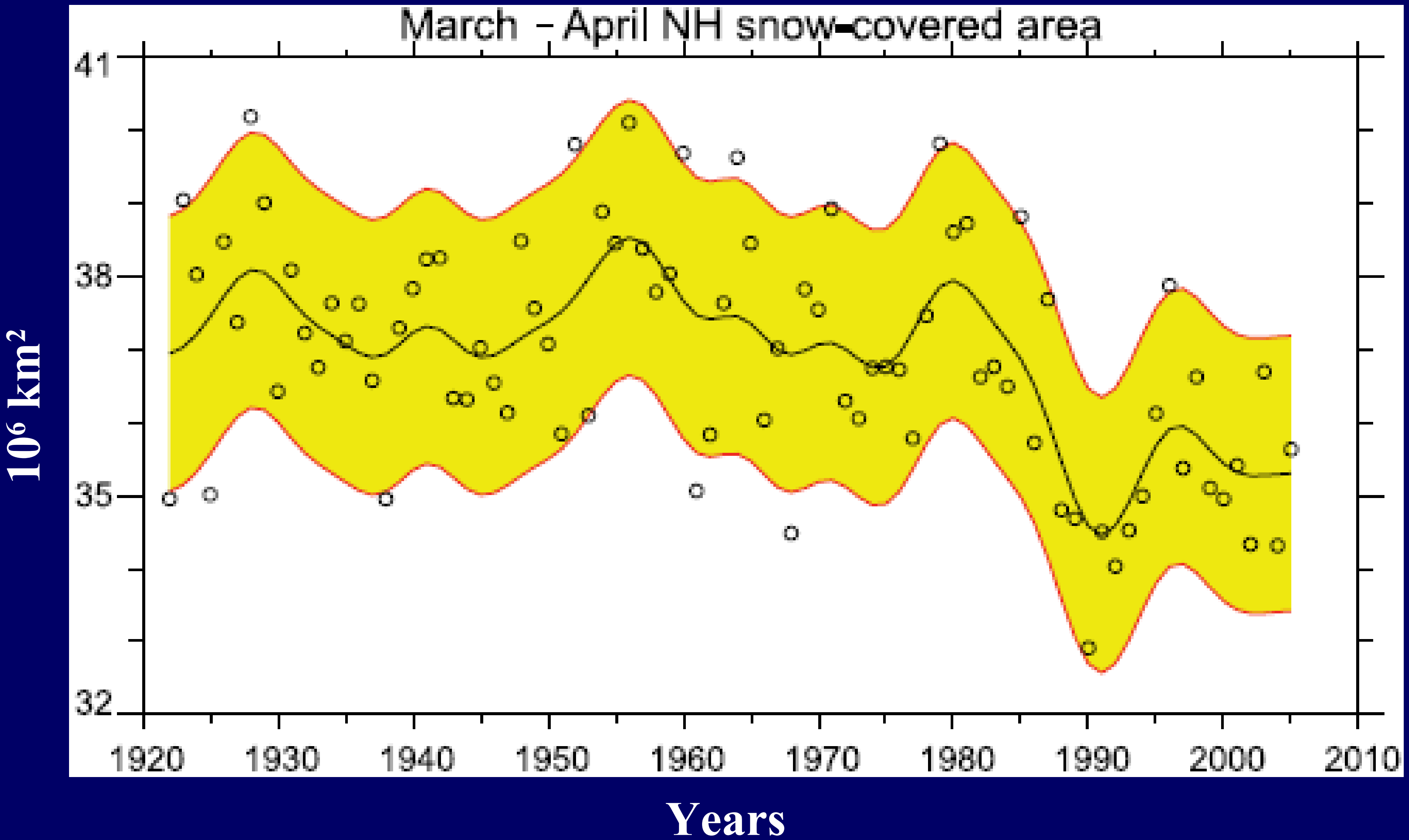


2002

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

Step changes in regional sea systems: Regime shift

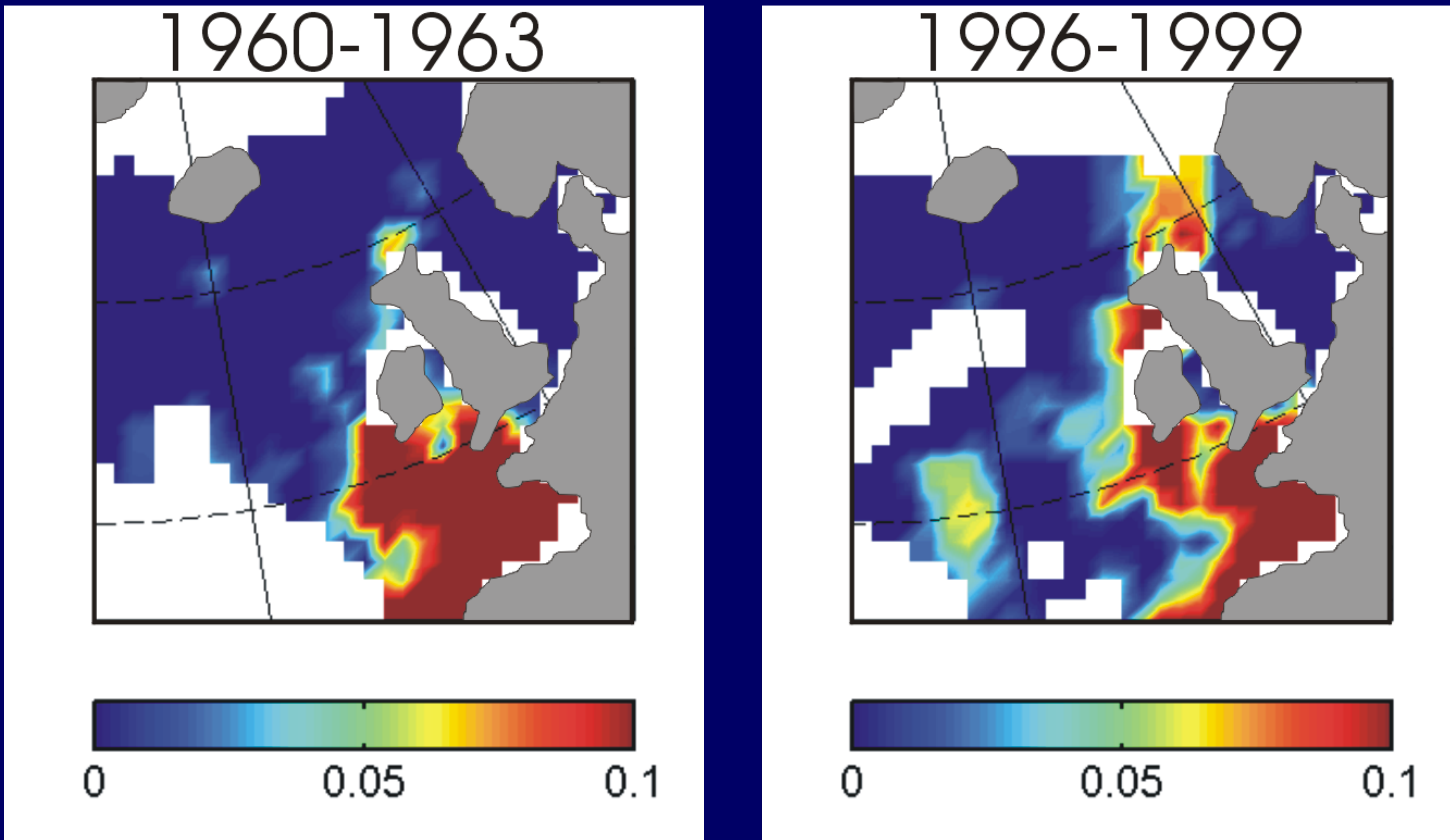
Northern Hemisphere Snow Cover Mar-Apr



Brown 2000

IPCC 2005 *WG 1*

Northerly movement of plankton and fish



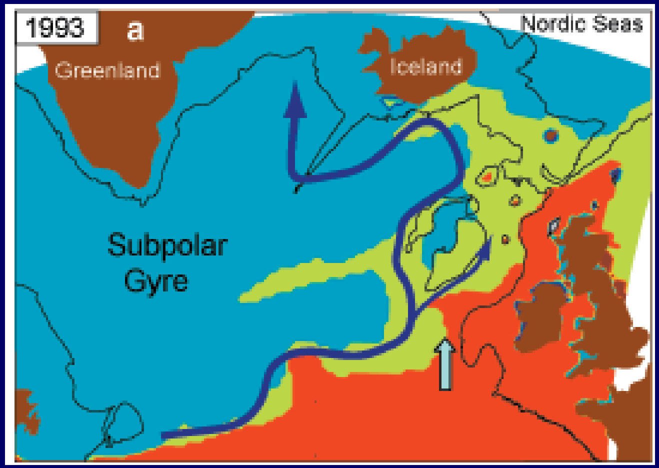
Warm temperate slope species

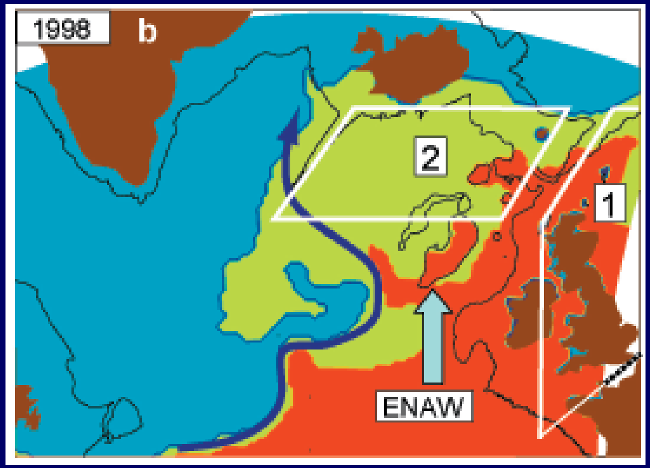
2005 Euchaeta hebes, Clausocalanus, Ceratium hexacanthum

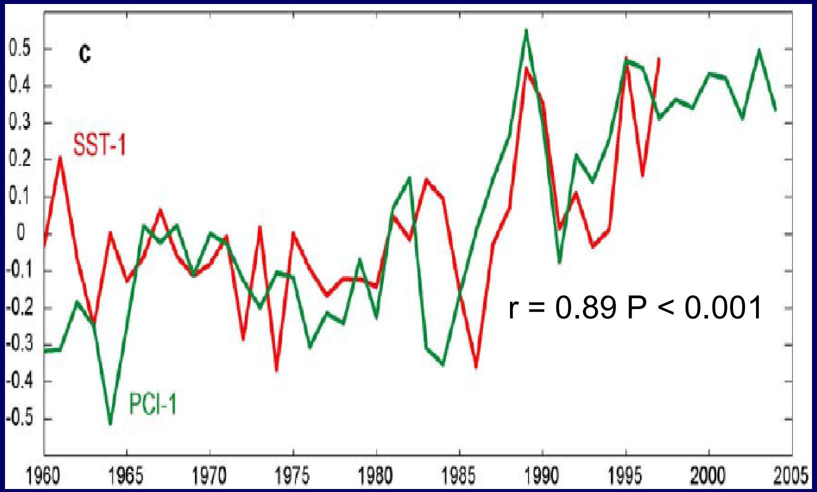
Beaugrand *et al*. 2003. Science **296**, 1692-1694

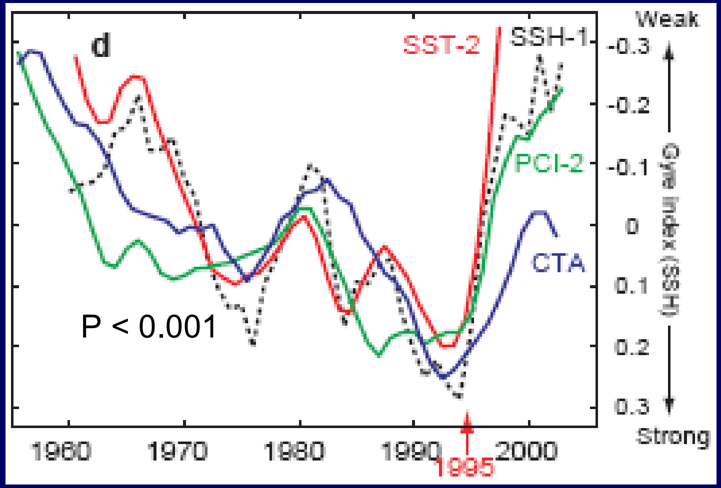
SAHFOS

Changes in the North Atlantic subpolar gyre post 1995



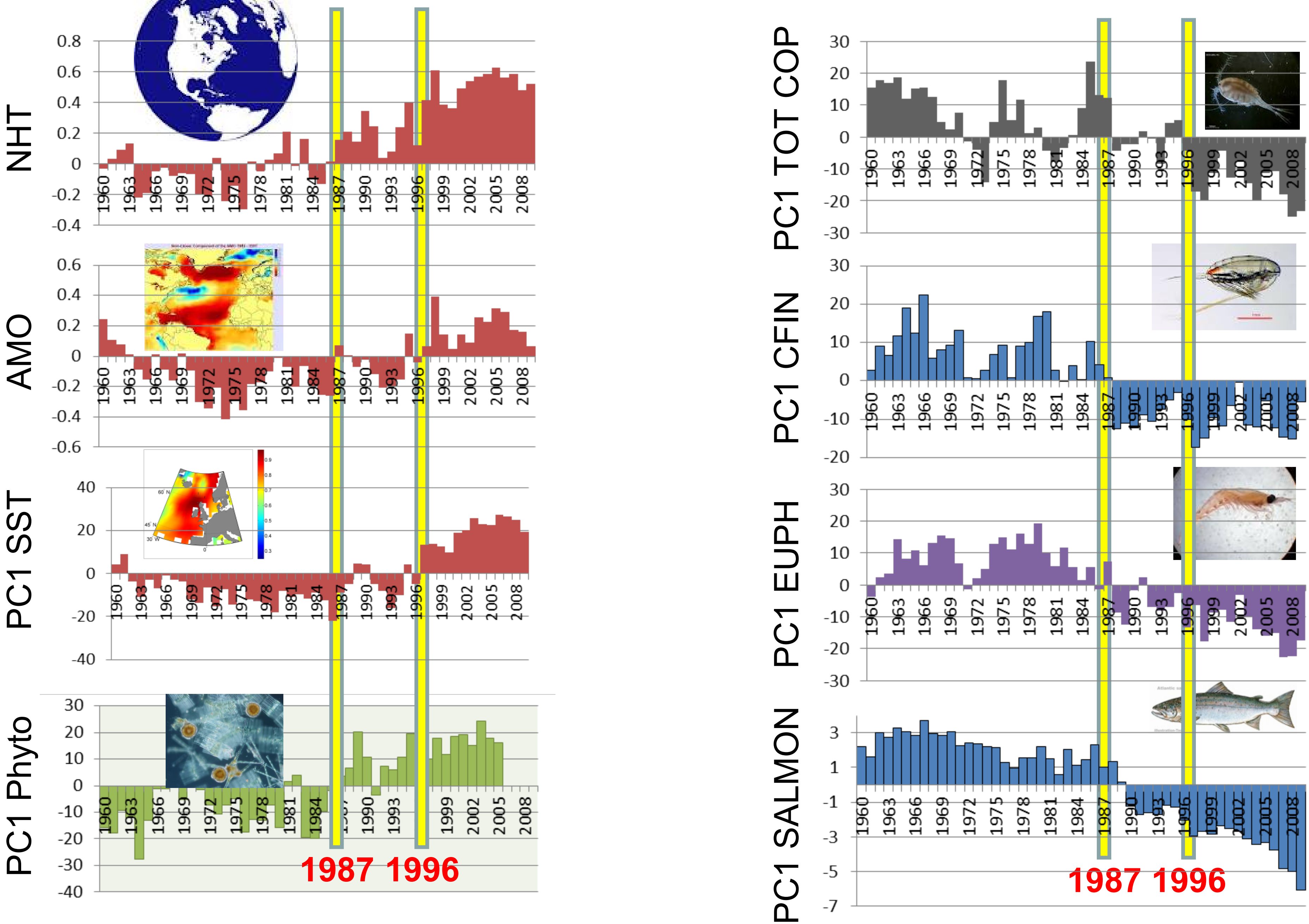




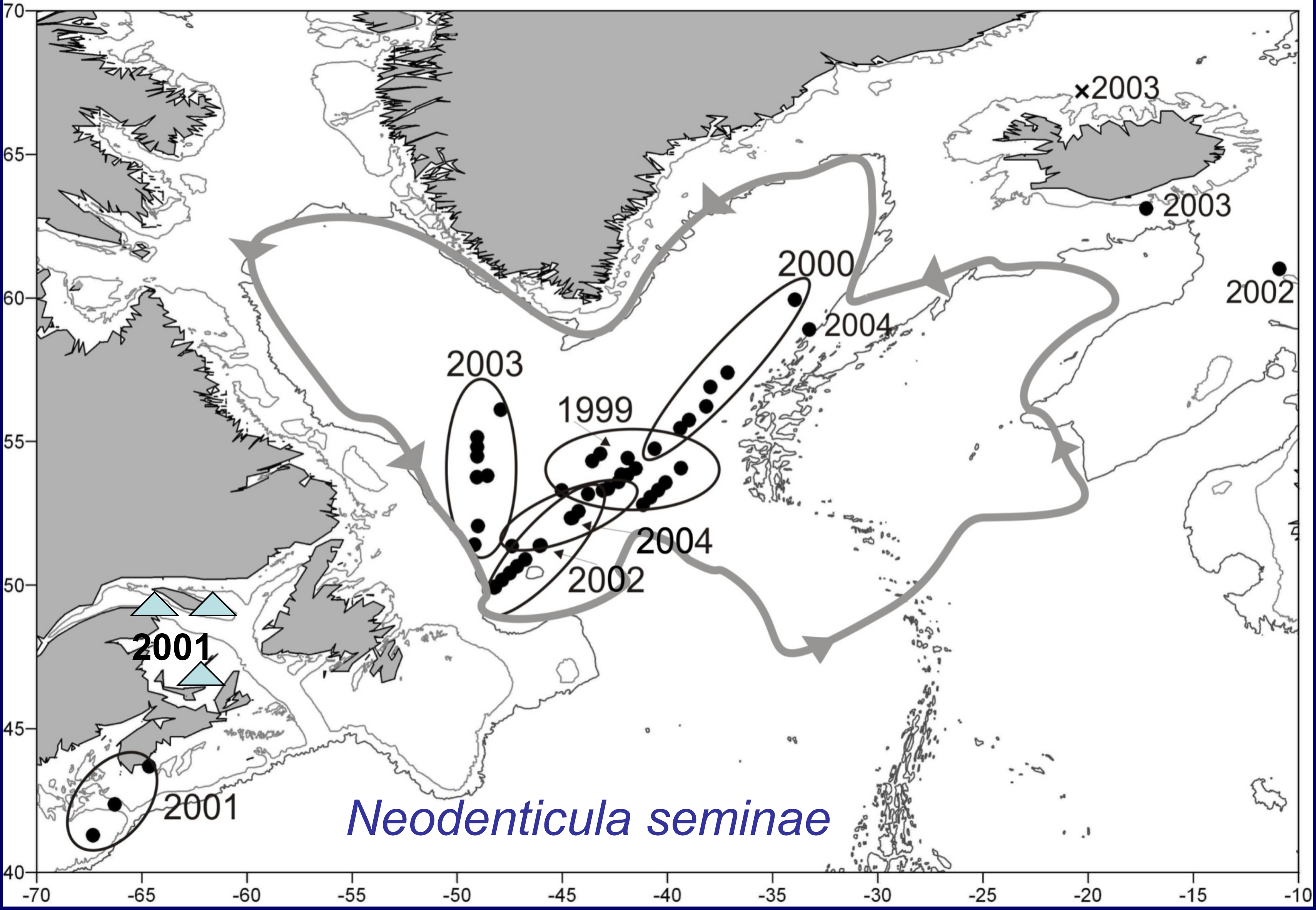


Hatun *et al*. 2009 Prog. Oceanog.

Changes in phytoplankton, zooplankton and salmon

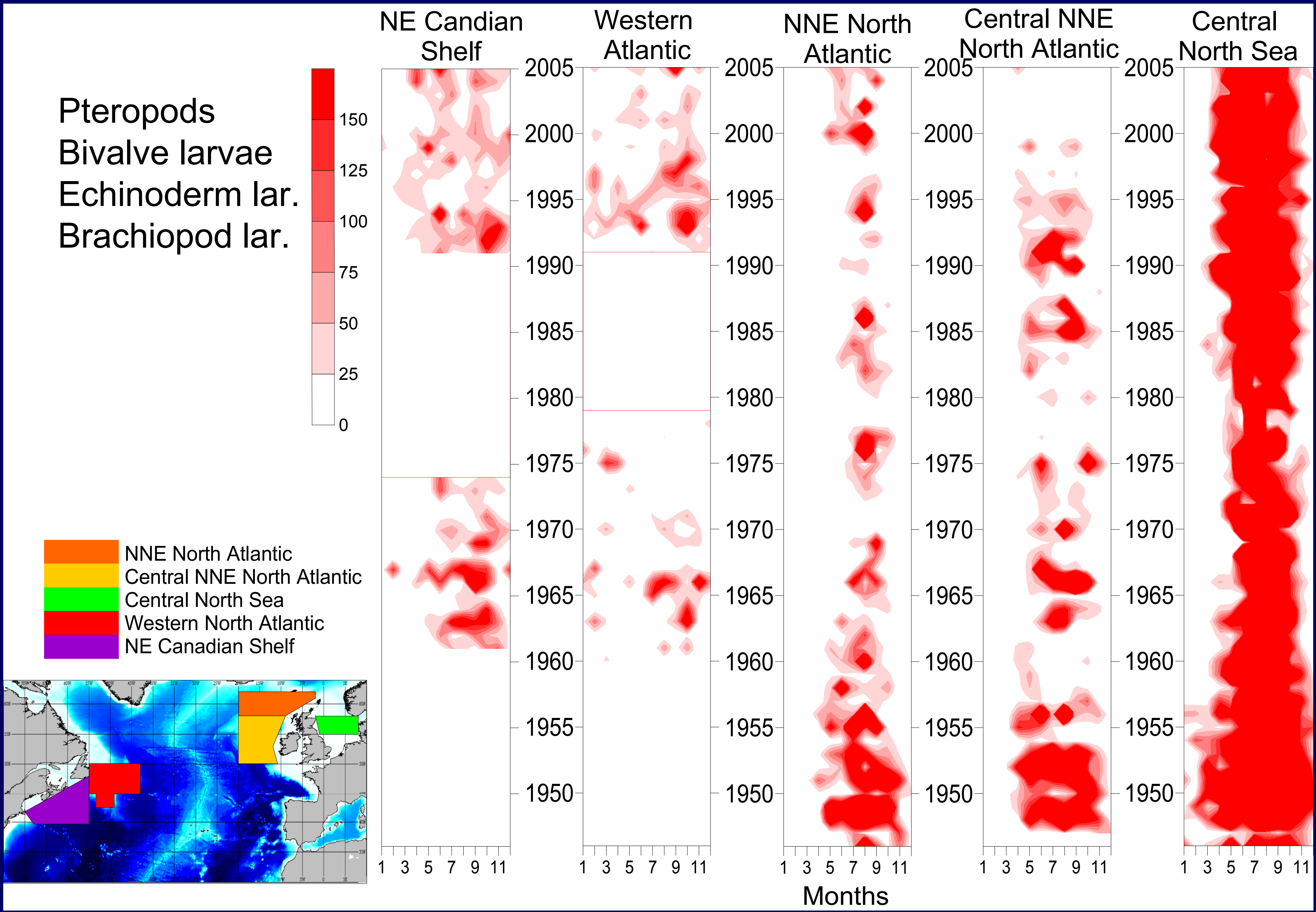


Pacific diatom in the Northwest Atlantic circa 1998



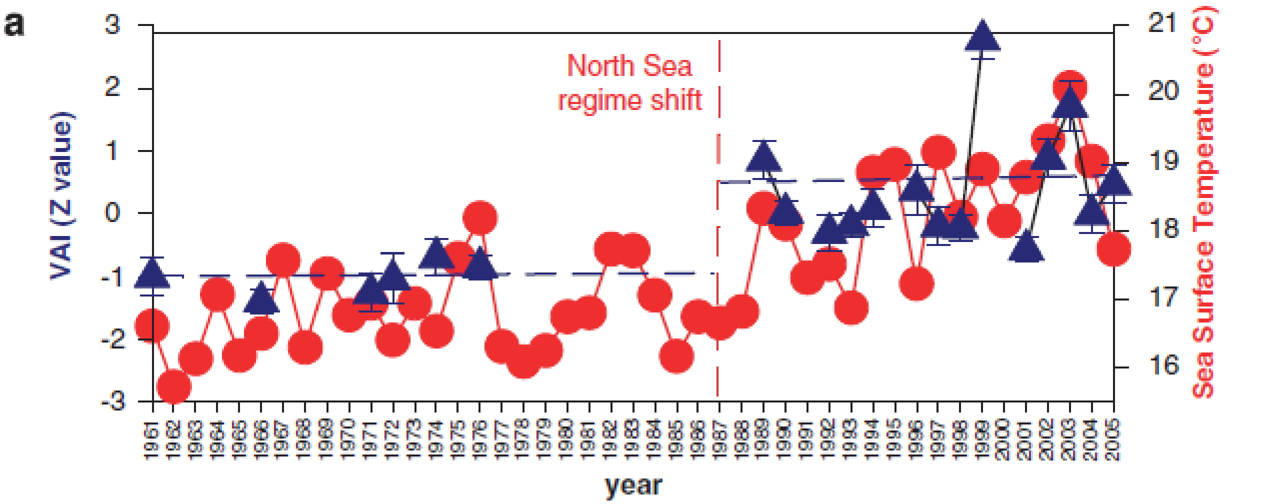
Reid *et al*. 2007. Global Change Biology 13

Time series of summed calcareous plankton from the CPR survey 1946-2005

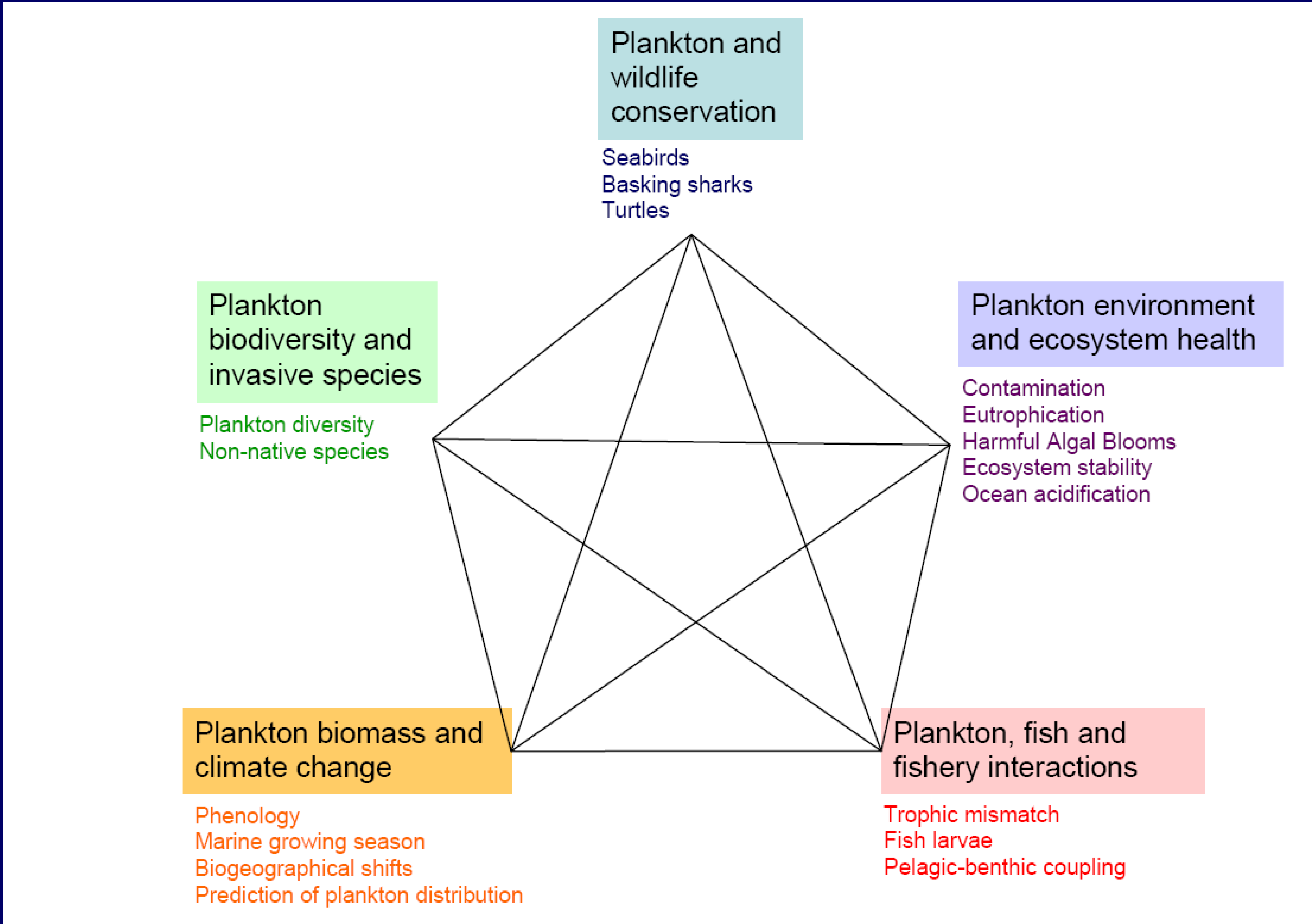


Application to policy and the European Union Marine Strategy Framework Directive

Vibrio and temperature



Vezzulli et al. 2011 ISMWJ



Reid et al. 2010 Feeder report to Charting Progress II
Downloadable from the Charting Progress website

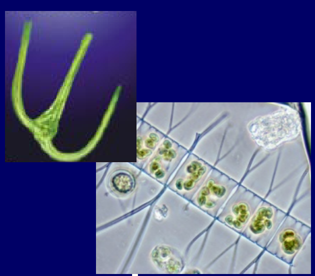
A functional group approach

"Biodiversity descriptors"

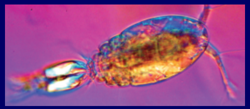
- Biodiversity (D1)
- Foodwebs (D4)
- Seafloor integrity (D6)

→ Scientific expertise informs & interprets MSFD indicators

Phytoplankton

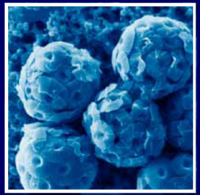


Holoplankton

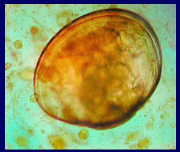


Meroplankton

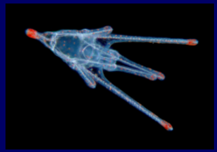
Coccolithophores



Bivalve larvae

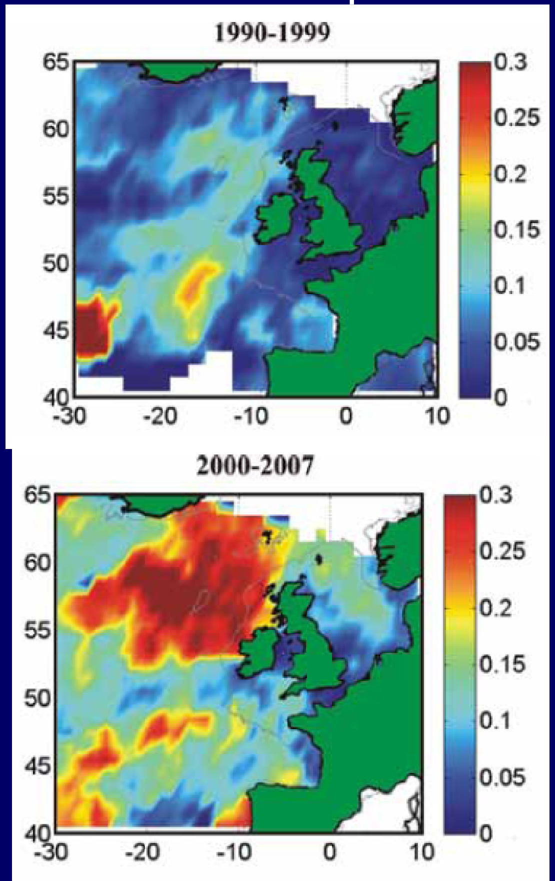


Echinoderm larvae

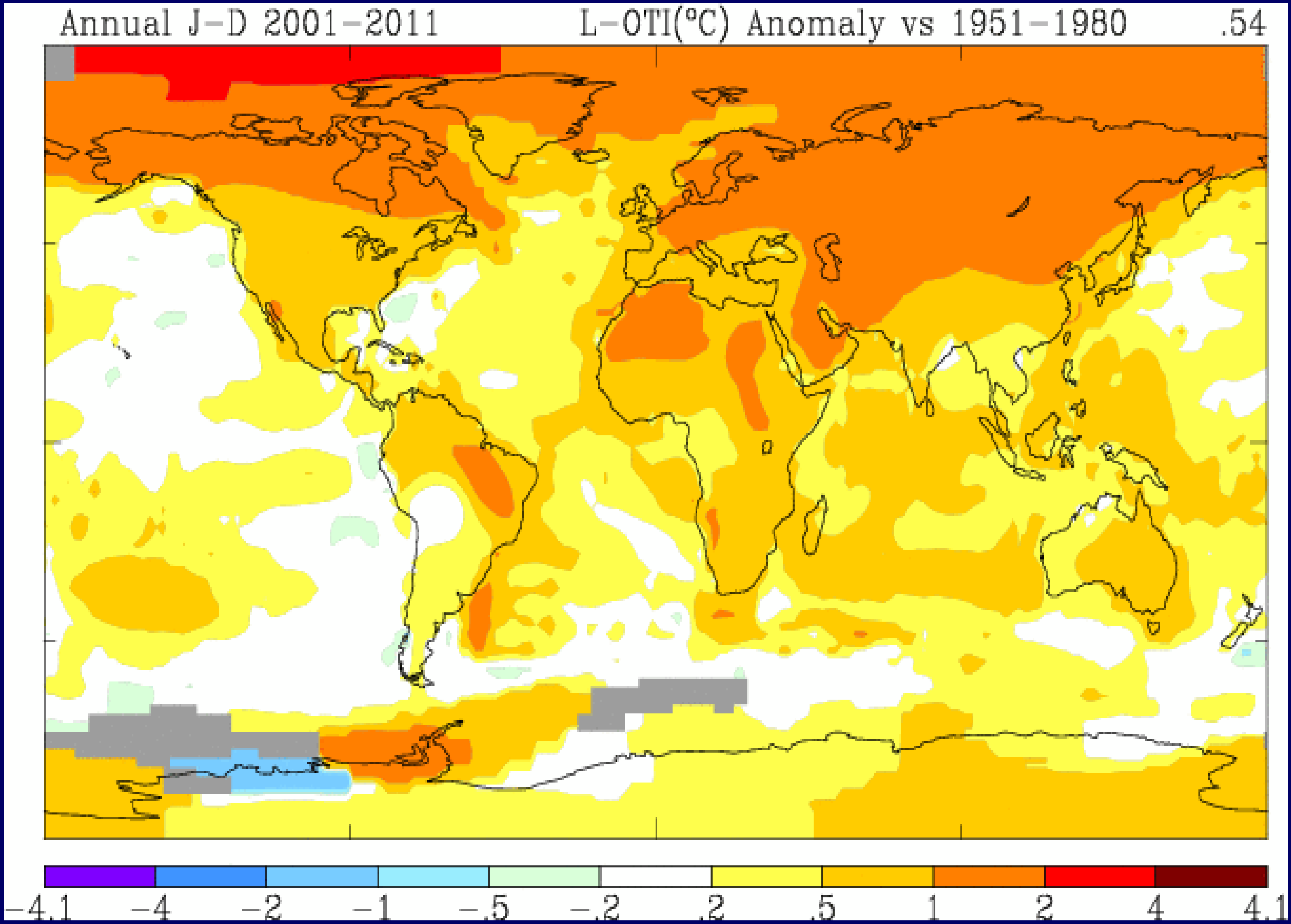


Courtesy Abby McQ-G

Coccolithophores



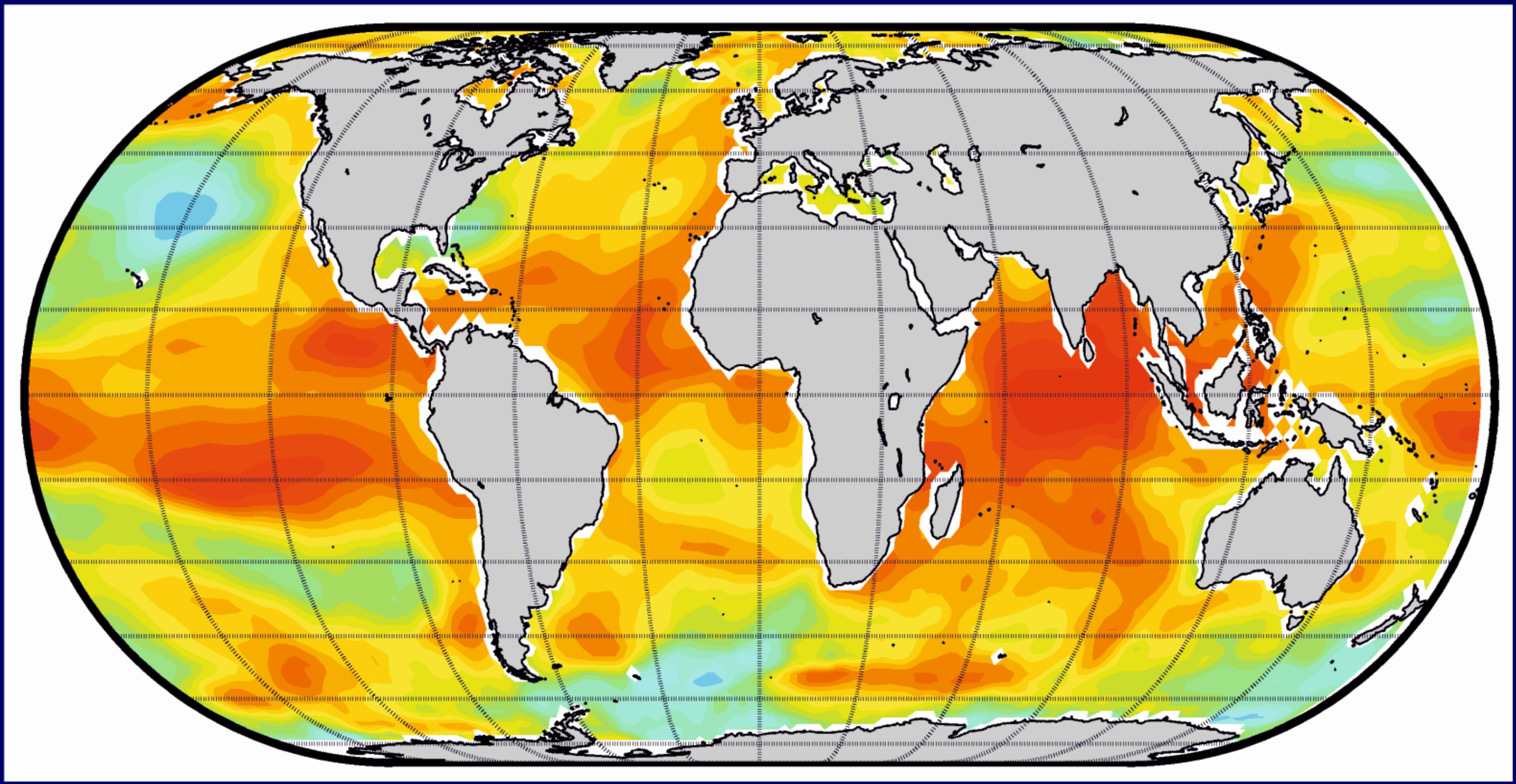
Surface temperature anomalies (°C)



Mean 2001 to 2011

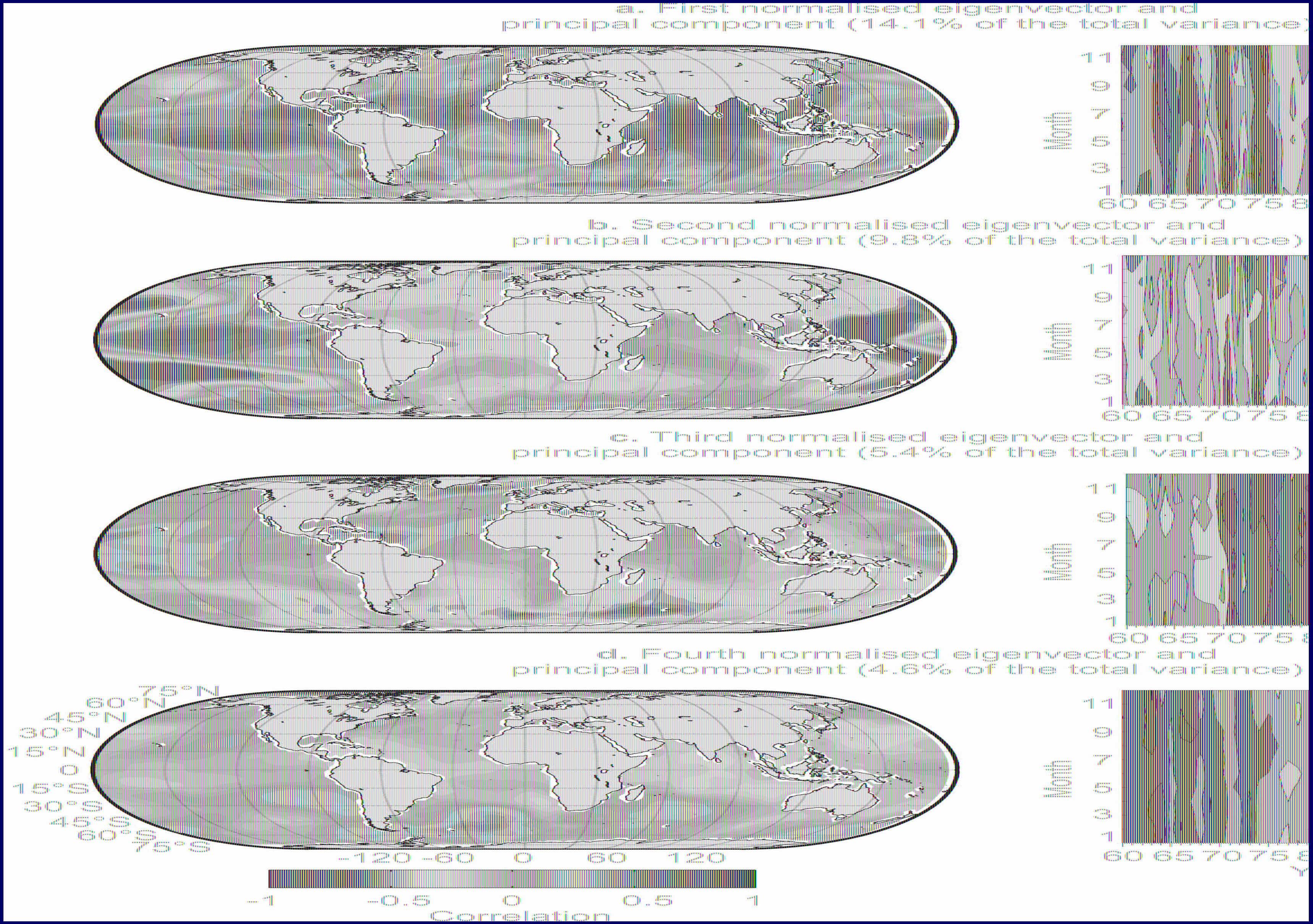
NOAA GISS

Principal Component Analysis (PCA) of global SST (Jan.1960-Dec. 2008) First normalised eigenvector



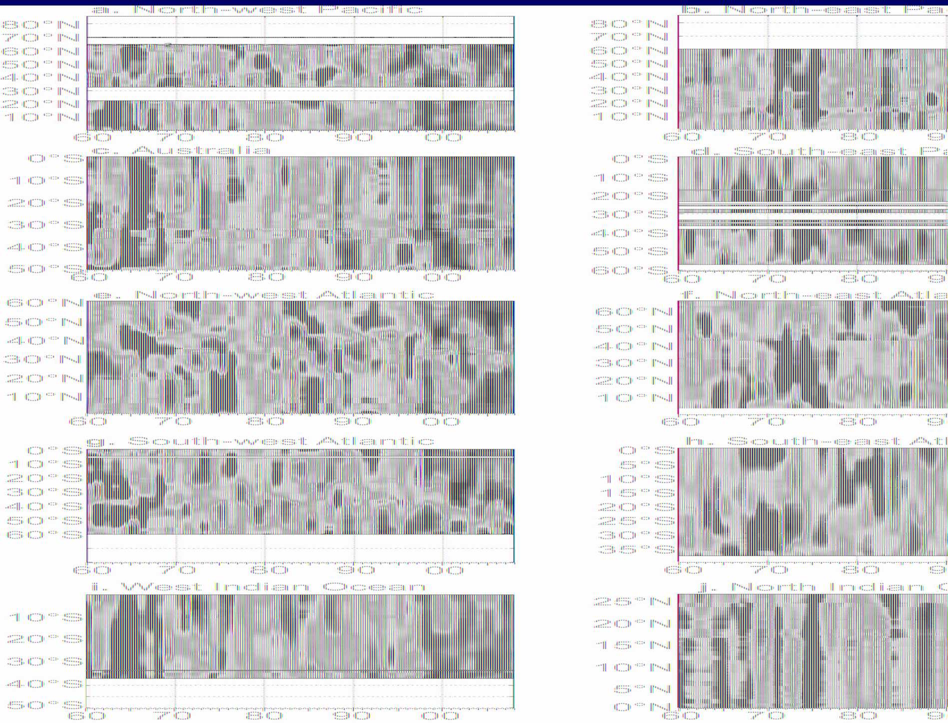
Reid and Beaugrand 2012 JMBA

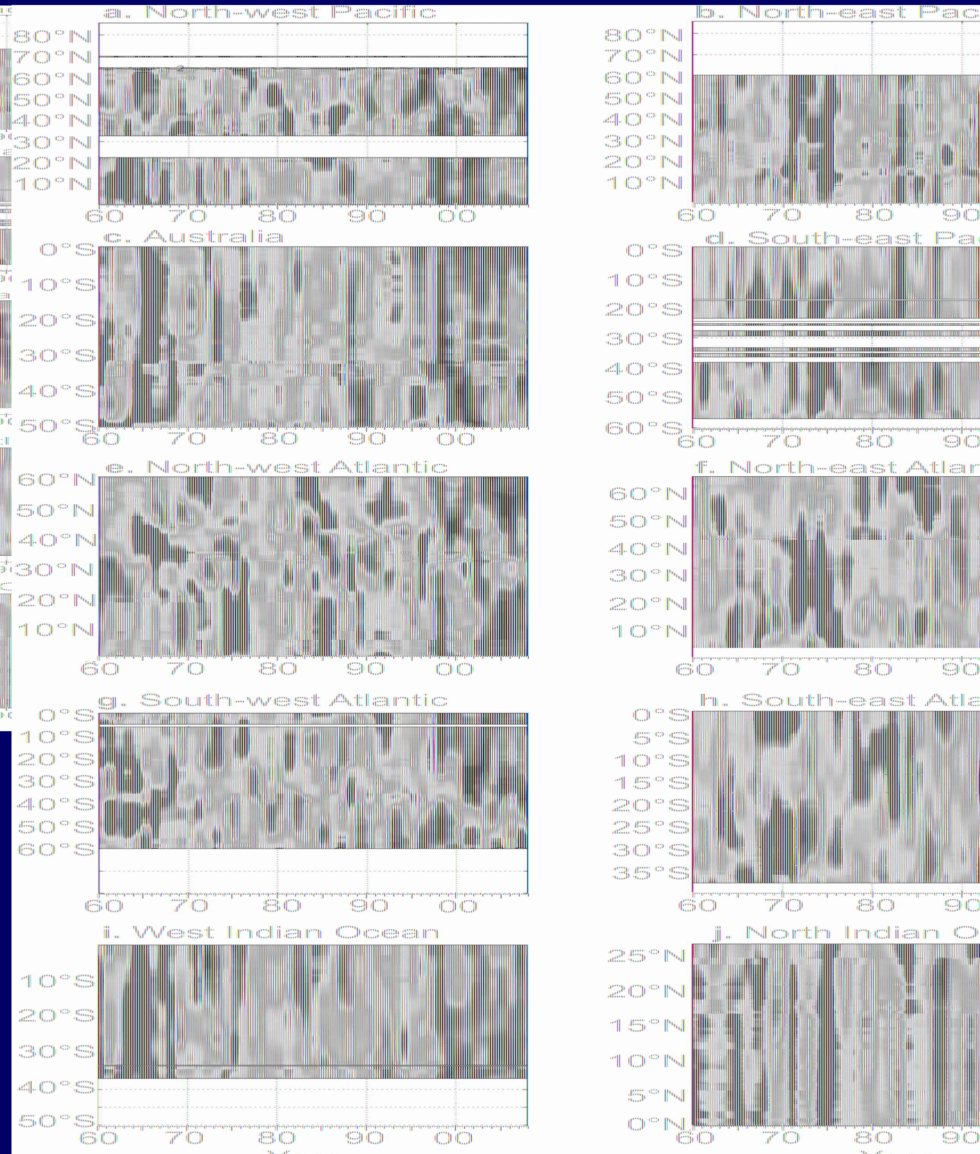
Global synchrony of sea surface temperature



Reid and Beaugrand 2012 JMBA

Global synchrony of sea surface temperature





Reid and Beaugrand 2012
JMBA

A Future Vision

A Commonwealth of regional CPR surveys across the world linked to other long-term ecological time series datasets

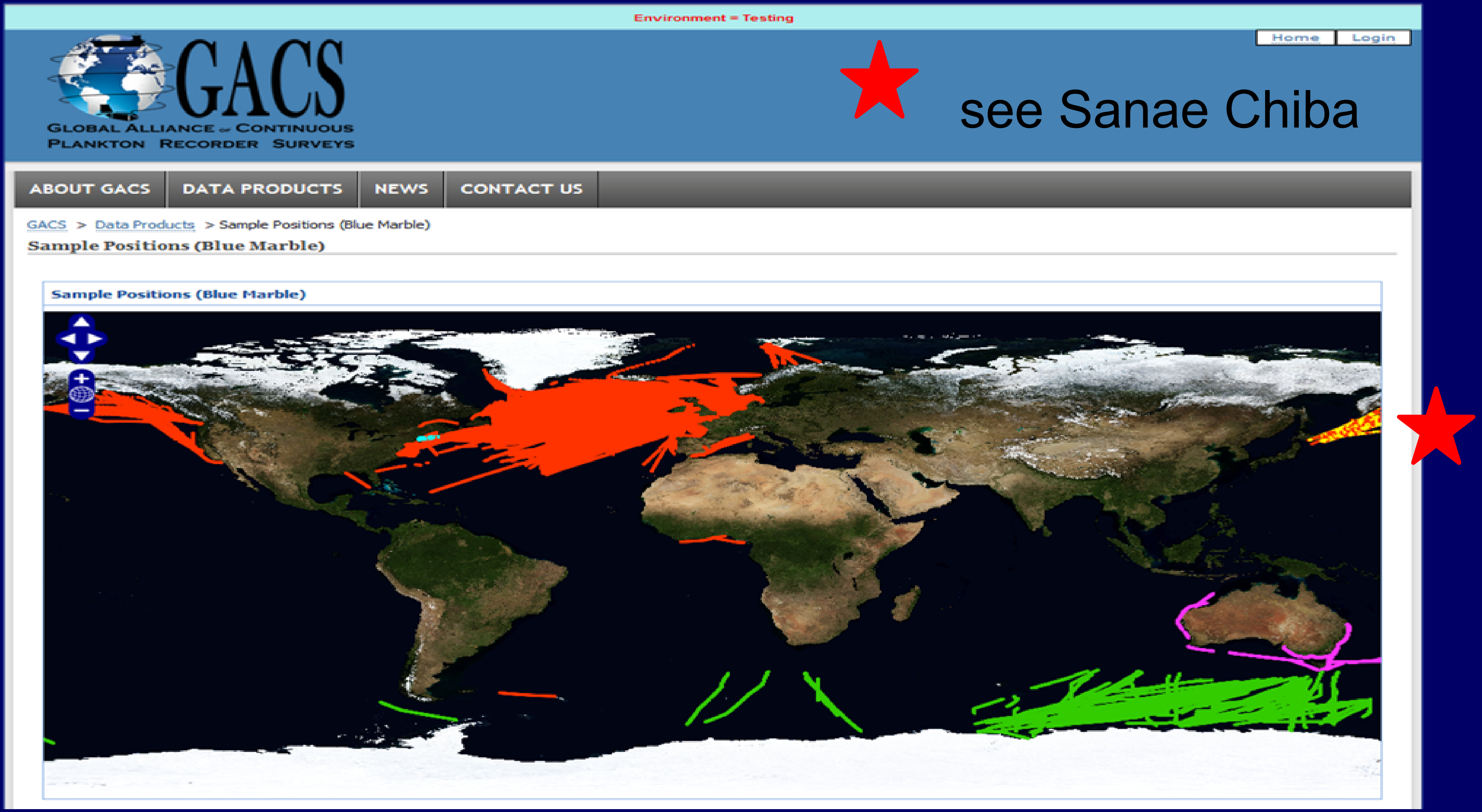
Integrated with OceanSITES
Integrated biological, molecular, physical and chemical monitoring
Include instrumented measurements and new technologies

Contributing to GOOS, GEO, IMBER
Contributing to national efforts to comply with UNCLOS

Standardisation of techniques where possible
Permanent archiving of samples
Characterising marine food webs versus carrying capacity for fish
Define Biogeochemical, Ecosystem and Socio regional areas
Identify regional hotspots?
Capacity building/training

Modelling

Biological data assimilation:
Need advice from modellers on their regional and global data requirements



New website launched and second newsletter

Conclusions / Recommendations

- Global ocean changing rapidly
- Few ecological time series in the oceans in all domains
- Strong linkage with temperature
- Evidence for rapid spatial and temporal response
- What is happening outside well sampled areas??
- Hysteresis, tipping points?
- Understanding long-term ecological change crucial to climate
- Decadal to 100 year plus prognosis worrying
- Improved ecological understanding of the oceans a high priority

NOT TACKLING ISSUES WITH URGENCY AND RESOURCES REQUIRED

- Need an integrated global ocean biological/biogeochemical observing programme NOW
  - Establish a global CPR survey