Lower trophic level ecosystem indicators from Continuous Plankton Recorder data

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***FUTURE* - *F*orecasting and *U*nderstanding *T*rends, *U*ncertainty and *R*esponses of North Pacific Marine *E*cosystems**

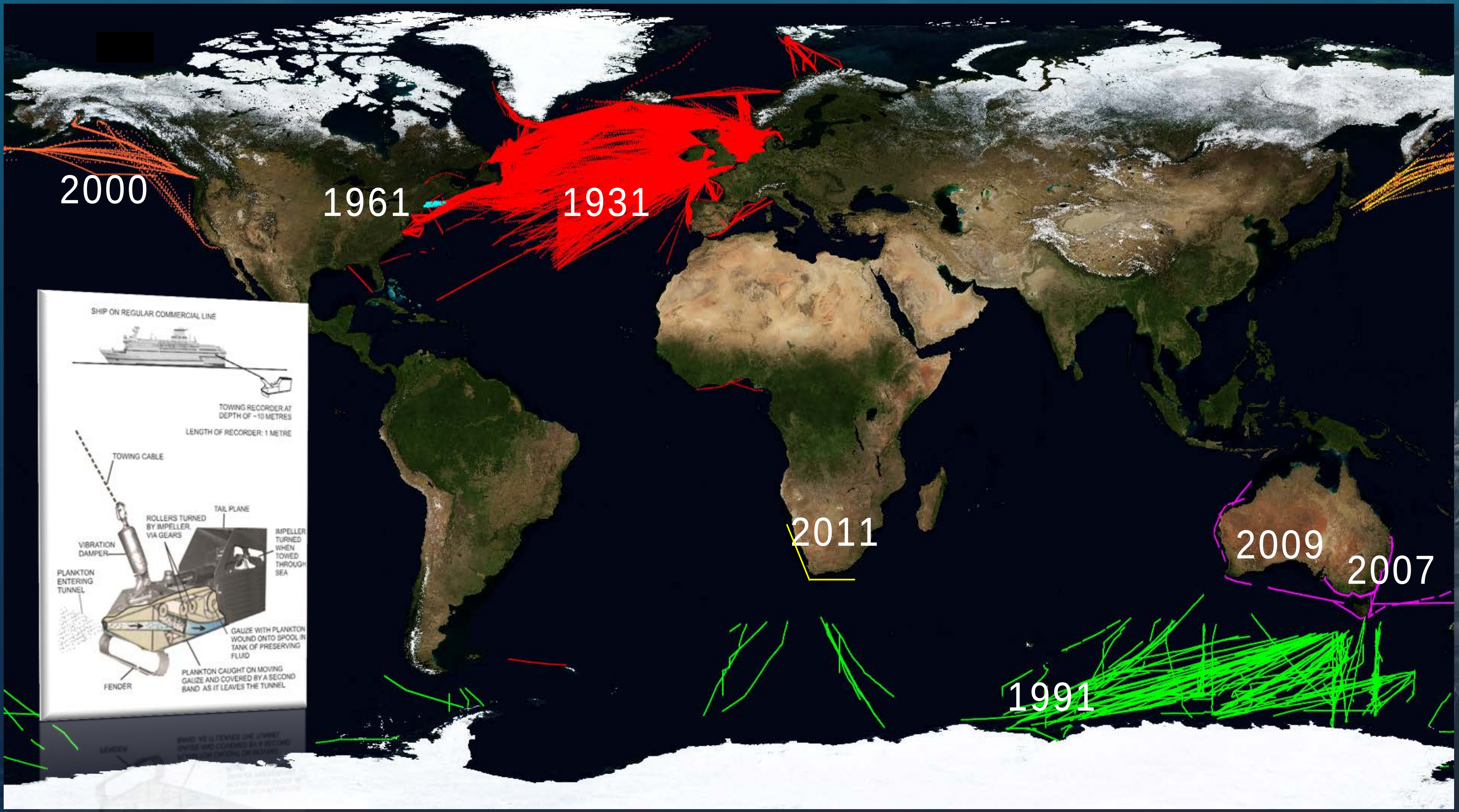
Why measure plankton?




Plankton support all societally-valued living marine resources, they link physical climate variability (through primary production then zooplankton) to fish, marine birds and mammals.

With short generation times, limited mobility and mostly non-fished, they act as indicators of ecosystem “health” in their own right.

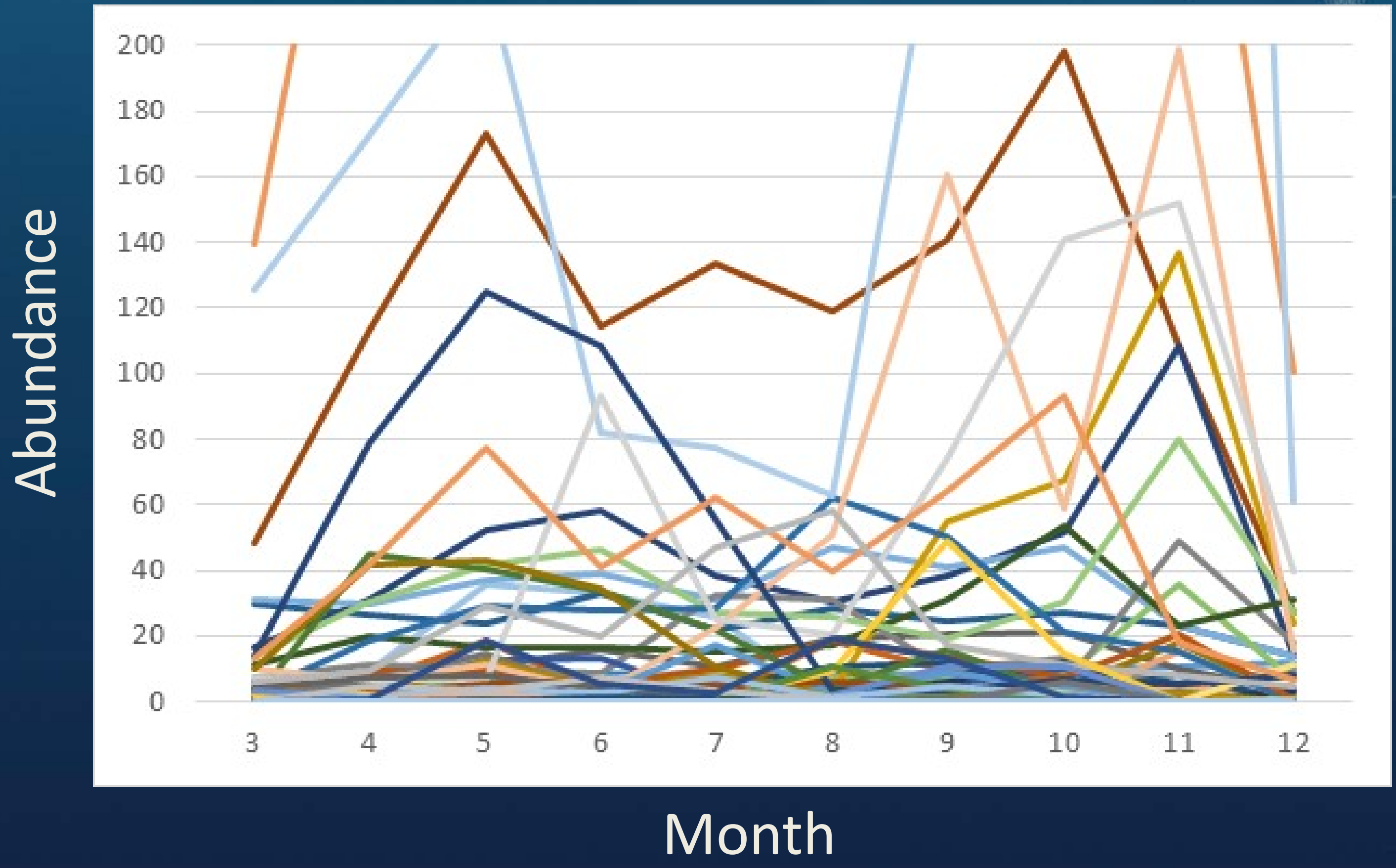
Continuous Plankton Recorder Surveys and sampling locations



Indicators are needed to:

Reduce the complexity:

~20 phyla alone in the CPR records, hundreds of taxa:



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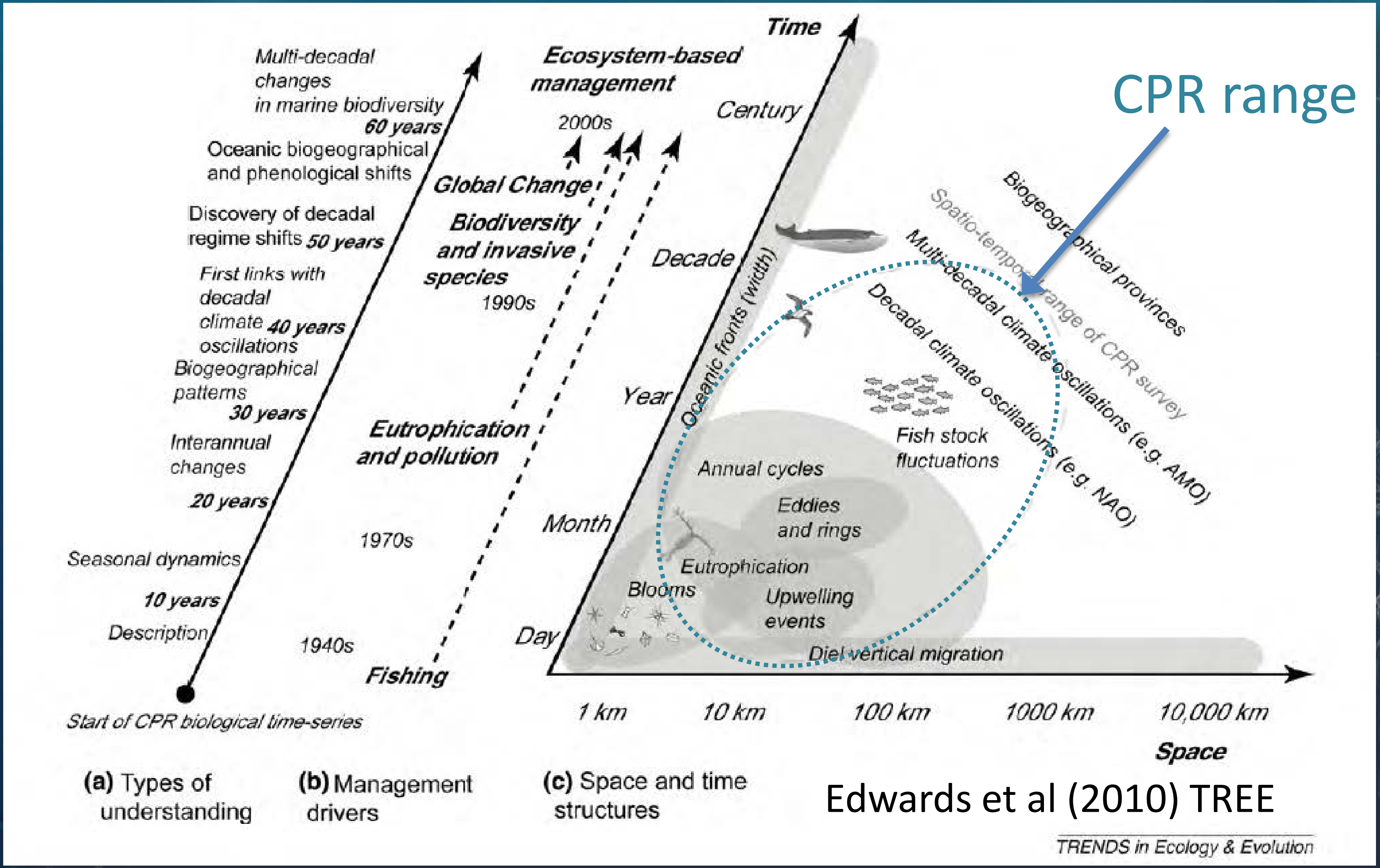
Clarify the signal:

- Enabling us to understand changes that may be sudden and unpredictable (regime shifts) or more trend-like (climate change)

With the aim of:

- setting targets which may trigger a management response.

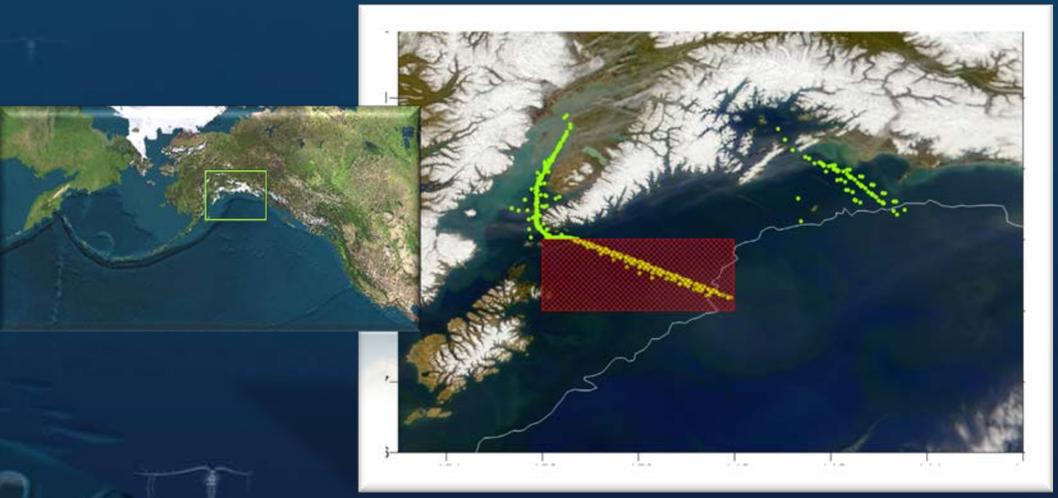
Conceptual approach

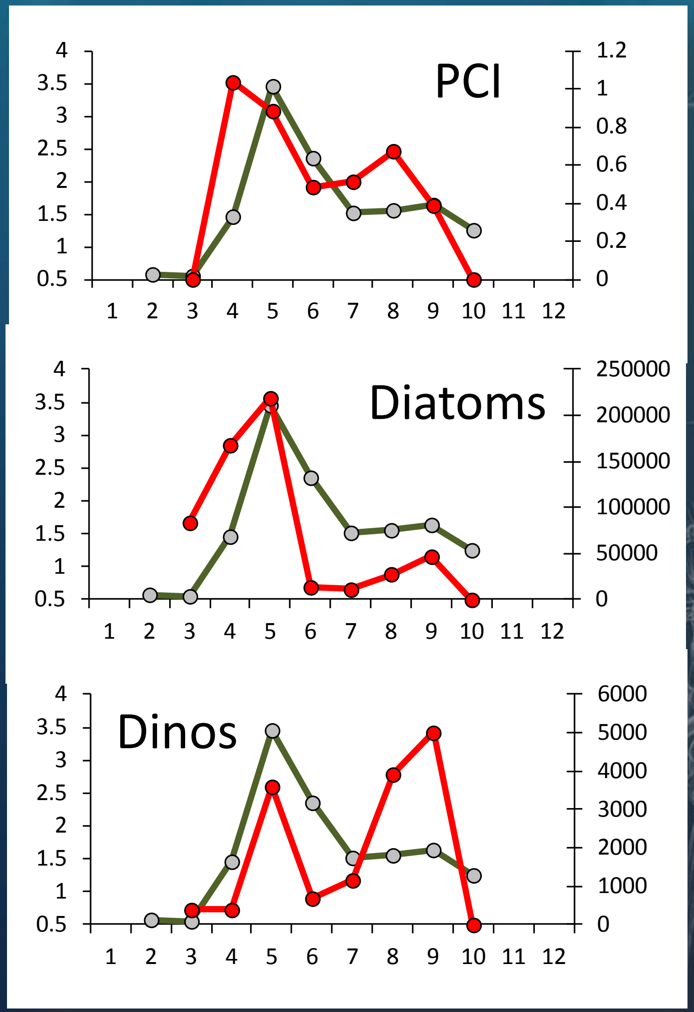


Examples - the Phytoplankton Colour Index (PCI)

Category	Value	Equivalent Chl
0	No colour	0
1	Very Pale Green	1
2	Pale Green	2
3	Green	6.5

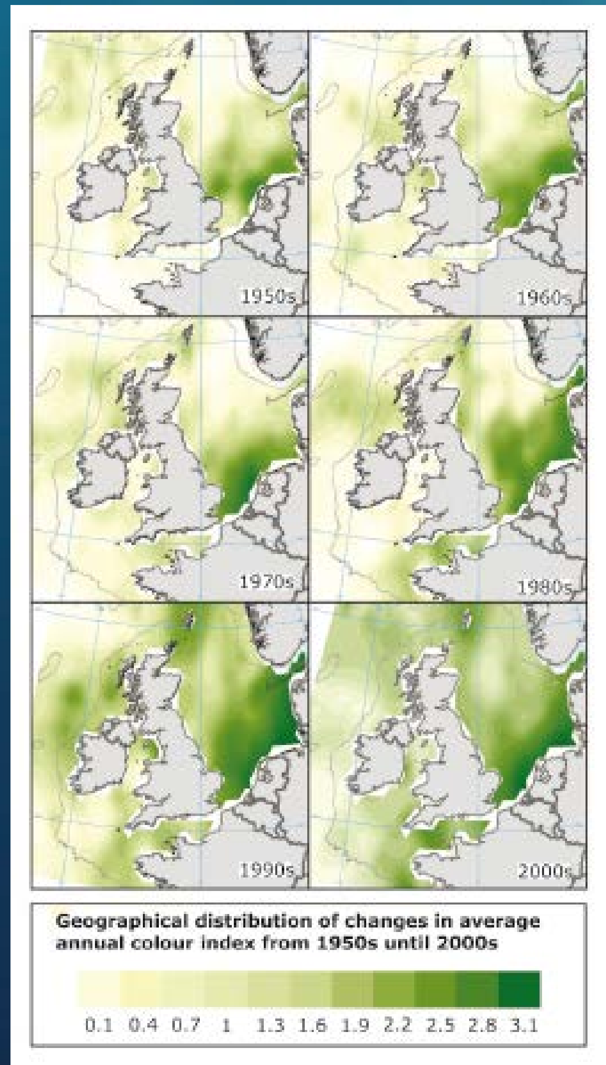
Satellite data (Modis) v CPR
for the shelf region:

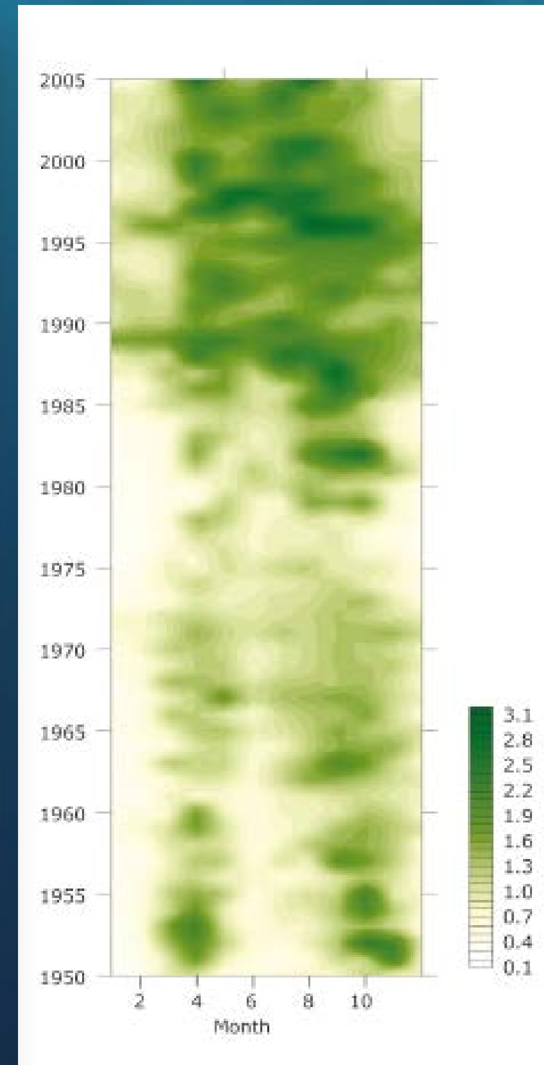




Courtesy D. Raitsos

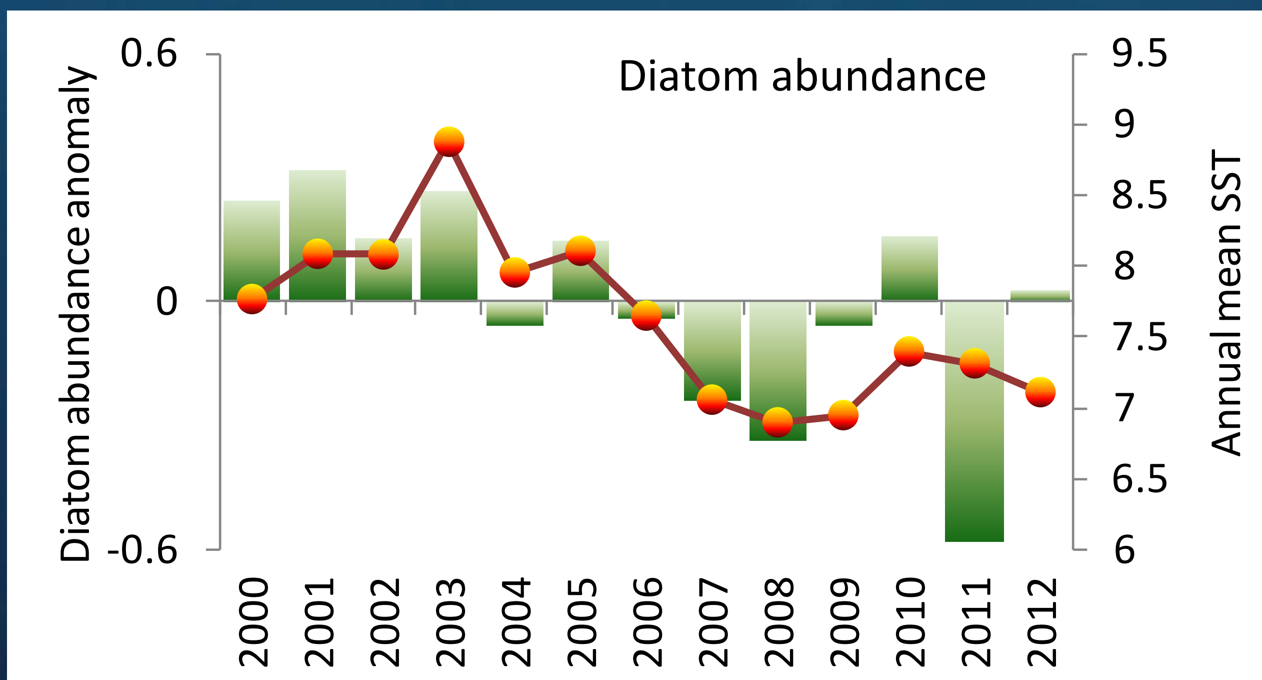
Phytoplankton Colour Index in the North Sea, Regime shift and change in seasonality.





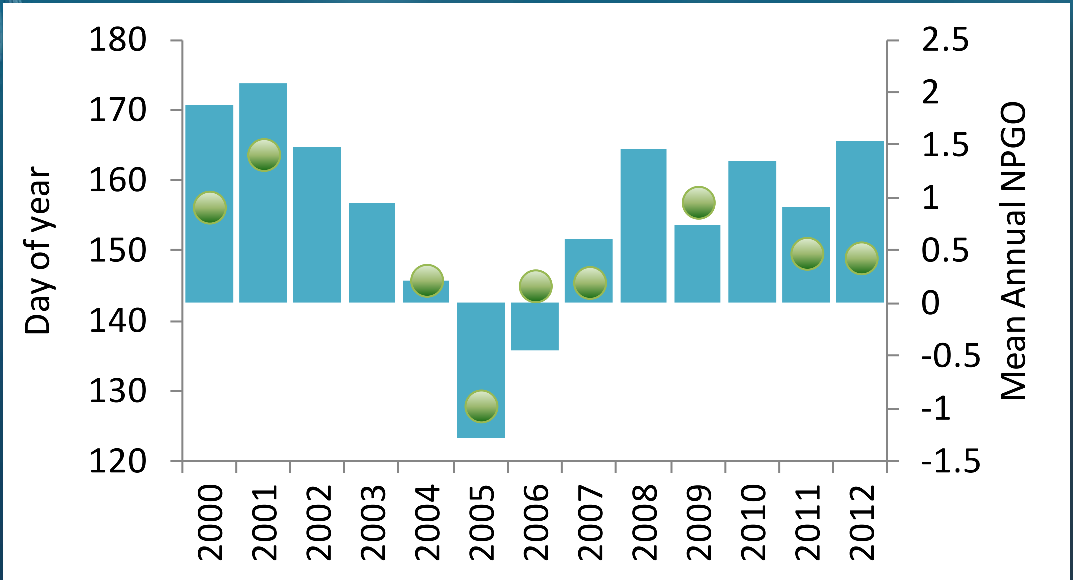
Updated from Edwards et al (2001) ICES Journal of Marine Science

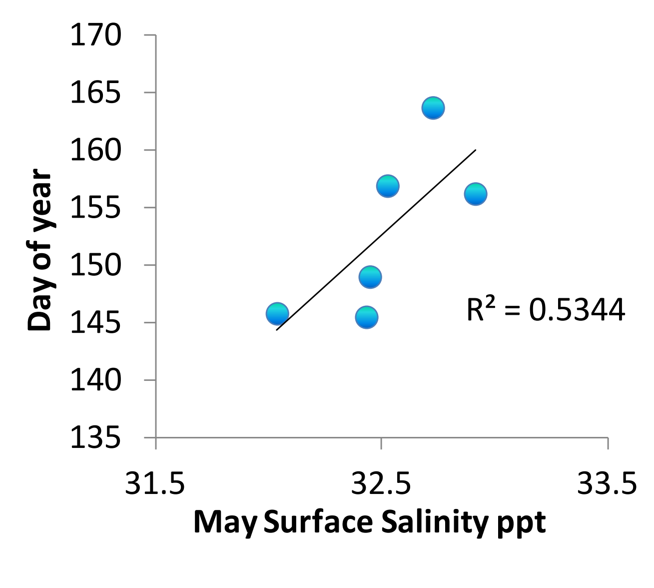
“Total Diatoms” – typically larger taxa,
Best represent shelf populations
Show clear relationships with climate forcing,
e.g. Abundance anomalies v SST



positive correlation (r^2=0.42, p<0.02)

And, spring diatom timing related to large scale circulation/salinity variability





Early years coincide with lower values of the NPGO (r^2=0.77, p<0.001)

Early years coincide with reduced salinity in May (r^2=0.53, p<0.05)

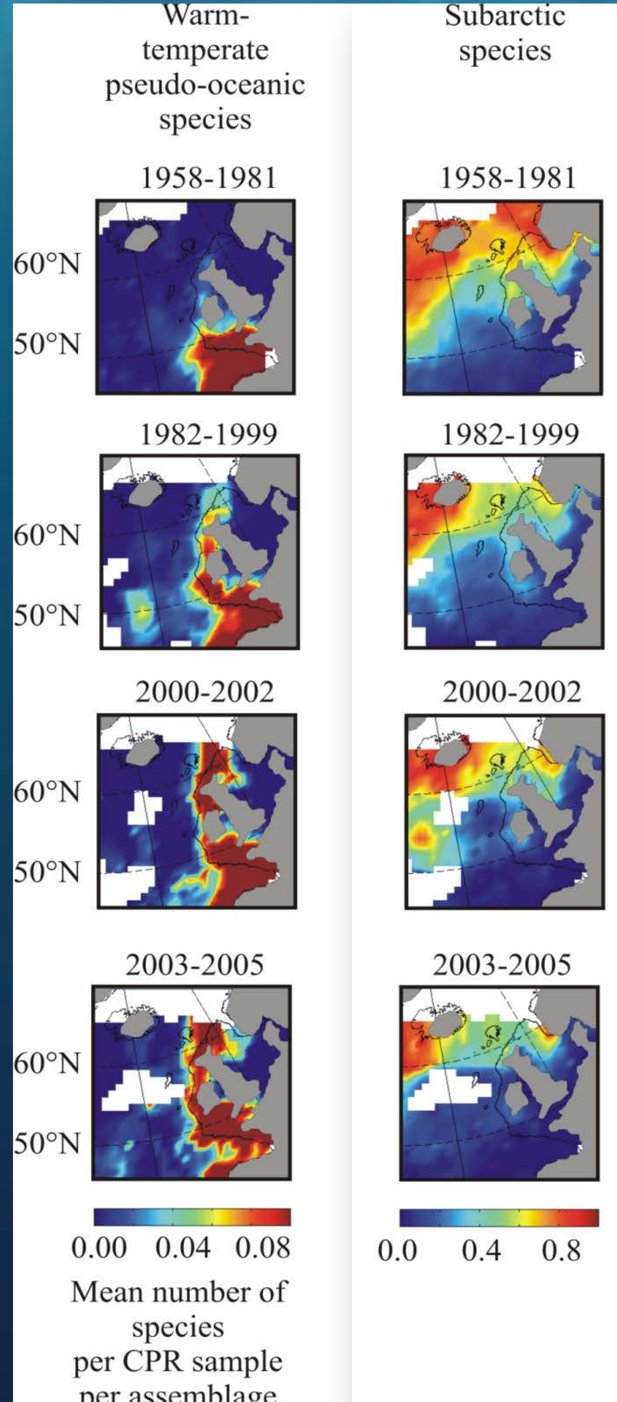
NPGO index, DiLorenzo et al., 2008, http://www.o3d.org/npgo/

Salinity data courtesy of Russ Hopcroft and the Seward Line program.

Examples – Zooplankton

Suites of zooplankton species showing climate related gradual change

A northwards shift of about 1000km

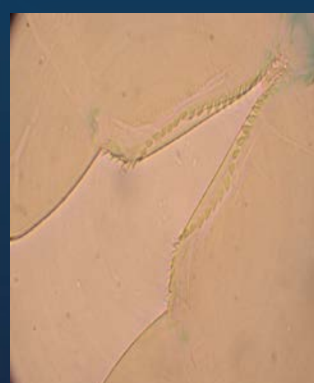


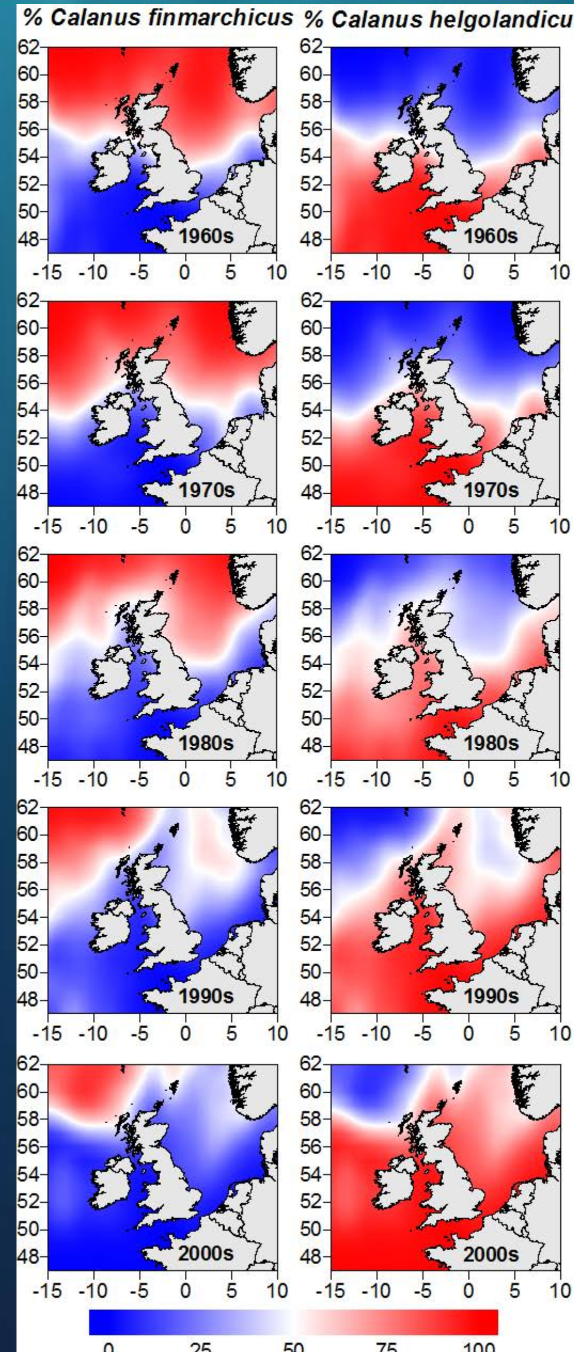
Updated from Beaugrand et al, Science, 2002.

Two sibling species

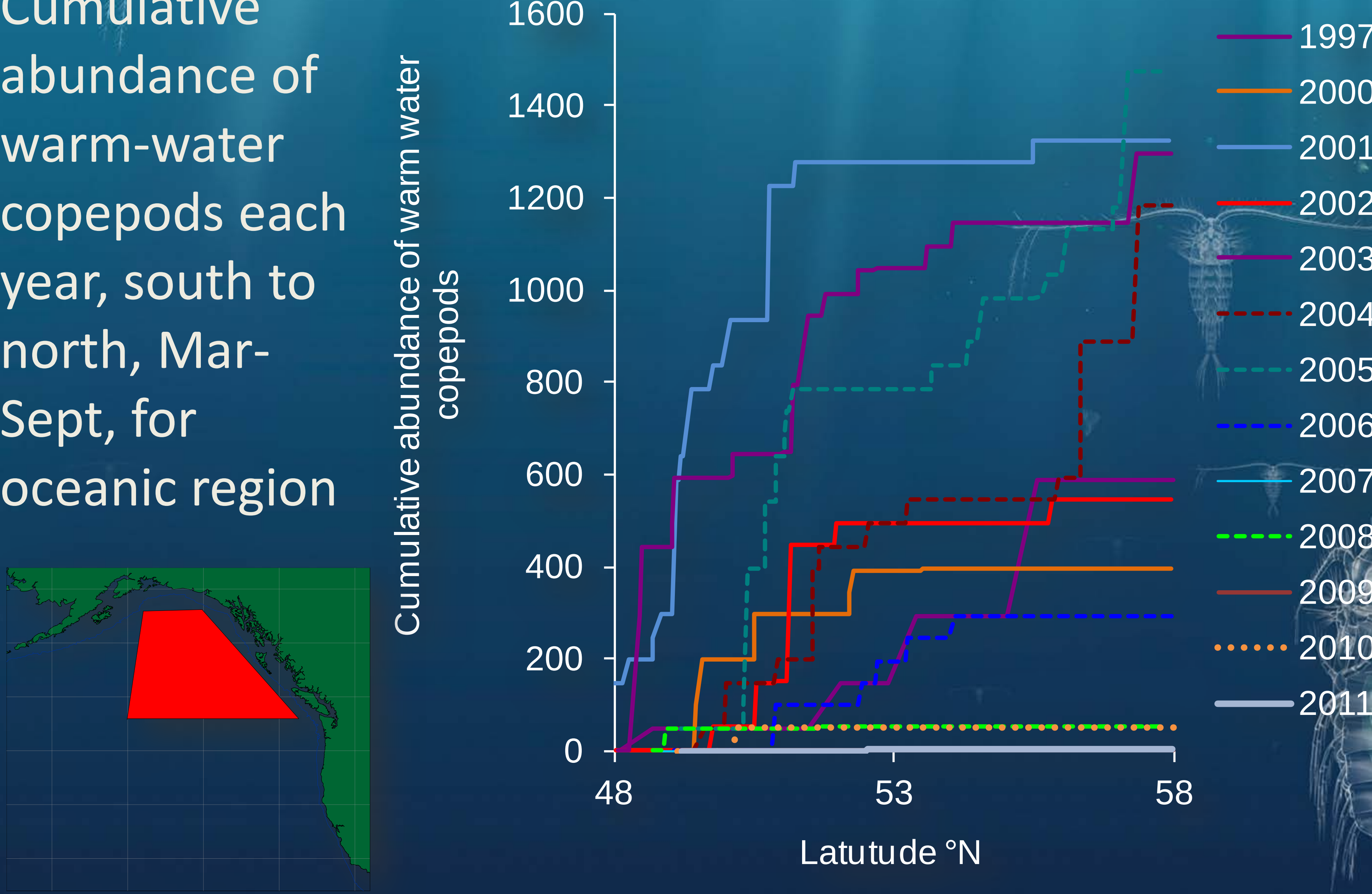
C. helgolandicus
warm

C. finmarchicus
cold





Cumulative abundance of warm-water copepods each year, south to north, Mar-Sept, for oceanic region



Updated from Batten & Walne (2011), Journal of Plankton Research

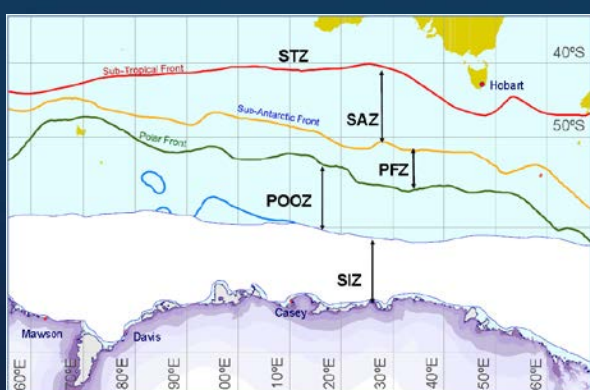
Copepod Community Size Index

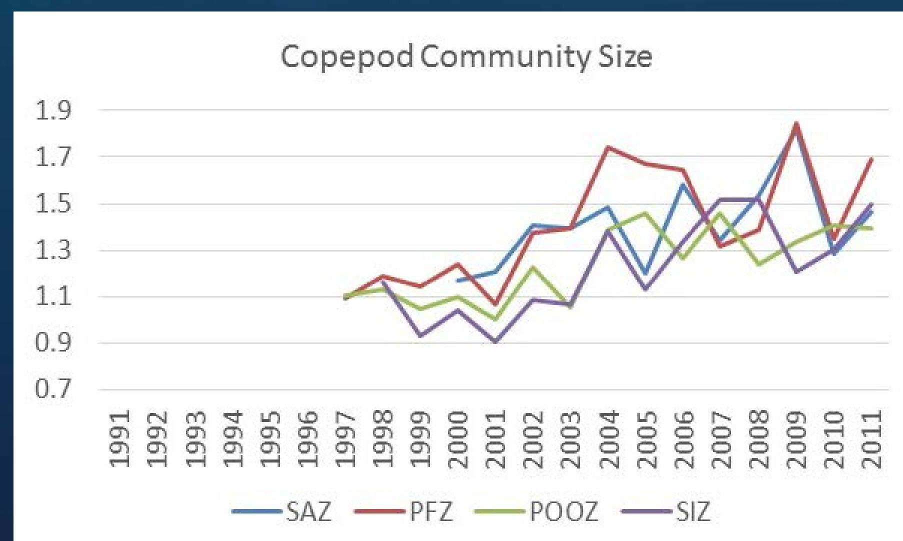
- incorporates community structure
- uses strengths of CPR sampling
- can be globally applied

$$\overline{S} = \frac{\sum_{i=1}^{N}(L_i \times X_i)}{\sum_{i=1}^{N} X_i}$$

CCS = length *L* (in mm) of each copepod species *i* (adult female length), multiplied by its abundance X_i, summed over all species (*N*) and divided by the total abundance, according to Richardson et al., 2006.

Southern Ocean CPR

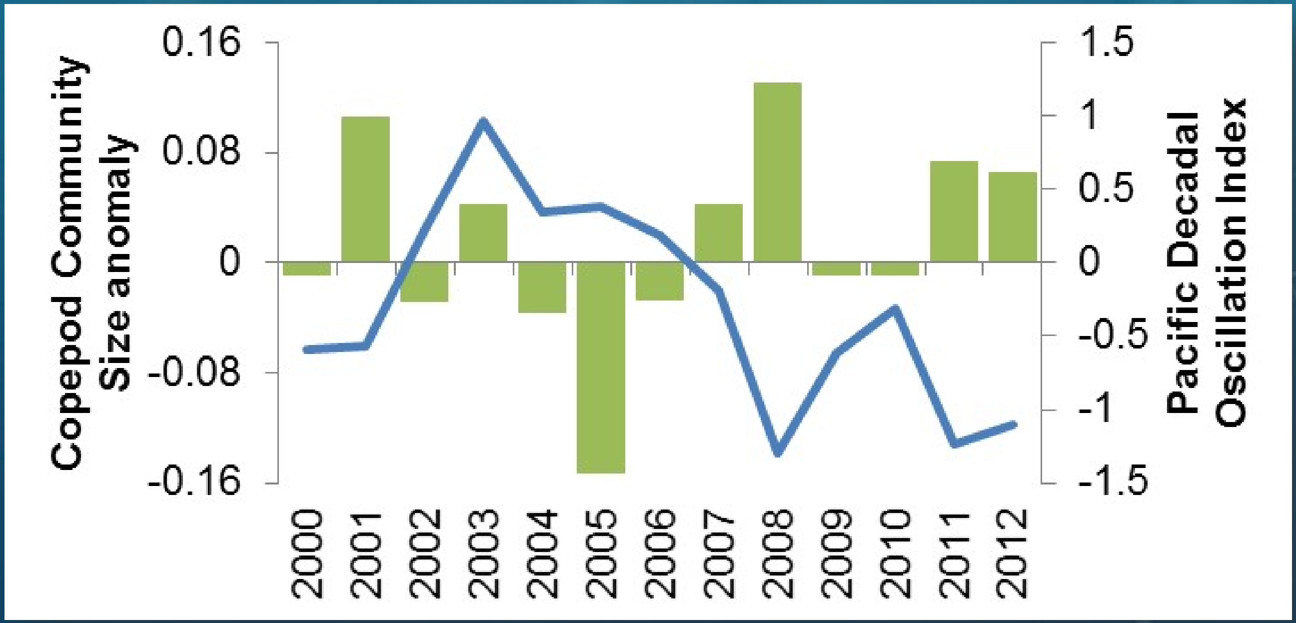


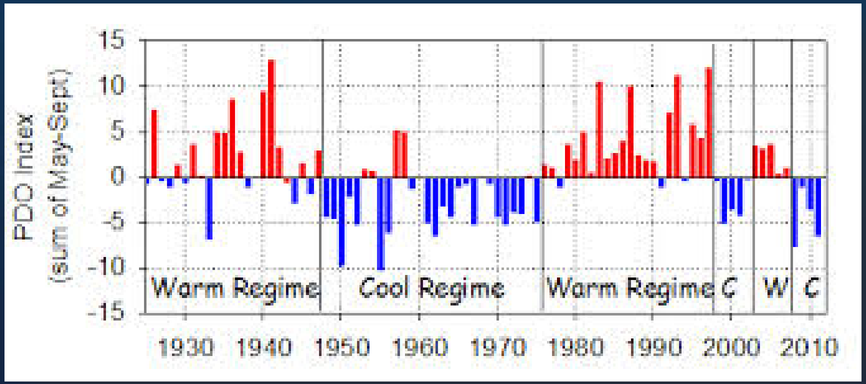


Courtesy G. Hosie

Response to high frequency climate variability (PDO). Smaller when warmer, larger when colder.

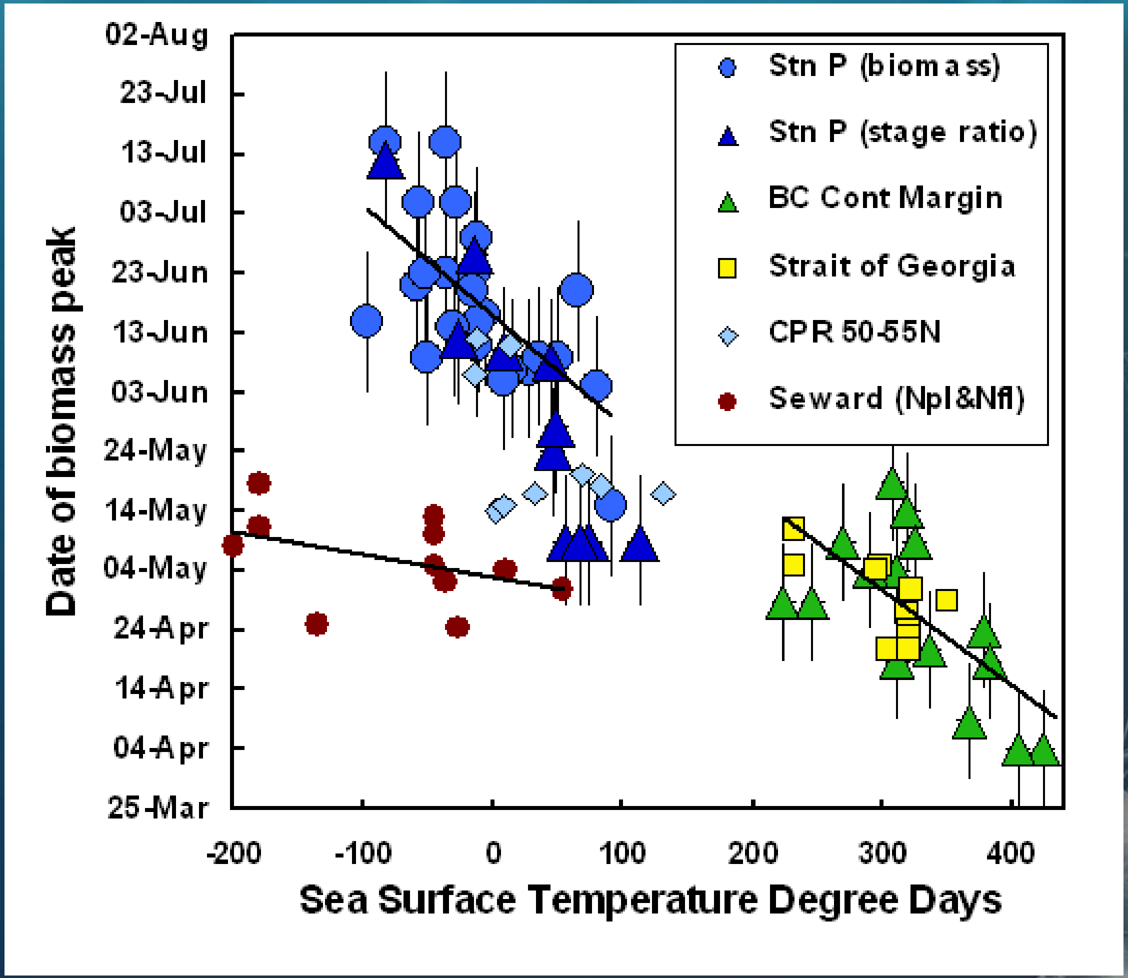
$r^2=0.37$, $p<0.02$



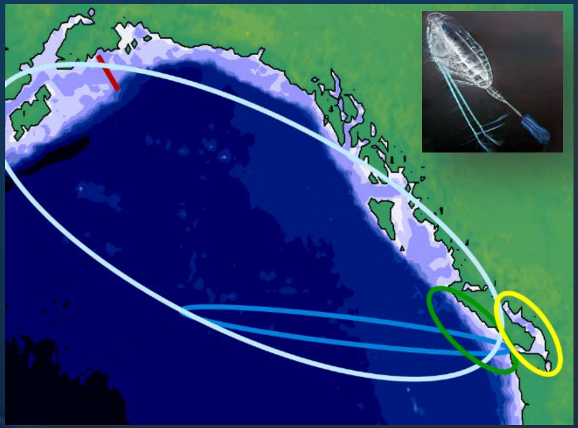


See http://jisao.washington.edu/pdo/PDO.latest

Timing - regions of the NE Pacific show similar changes in phenology, spring biomass peak in a key species is earlier in warmer years and *vice versa*.

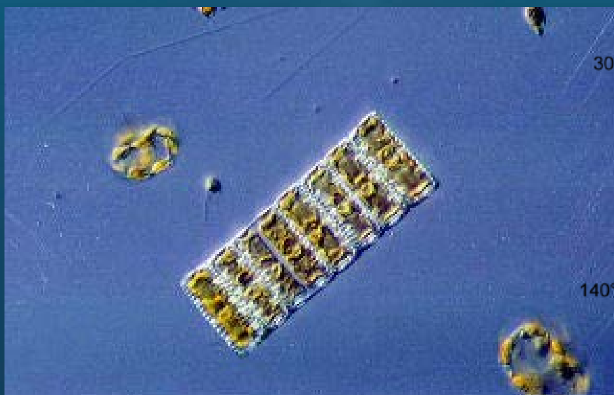


Updated from Mackas et al., Pr in Ocean, 2007

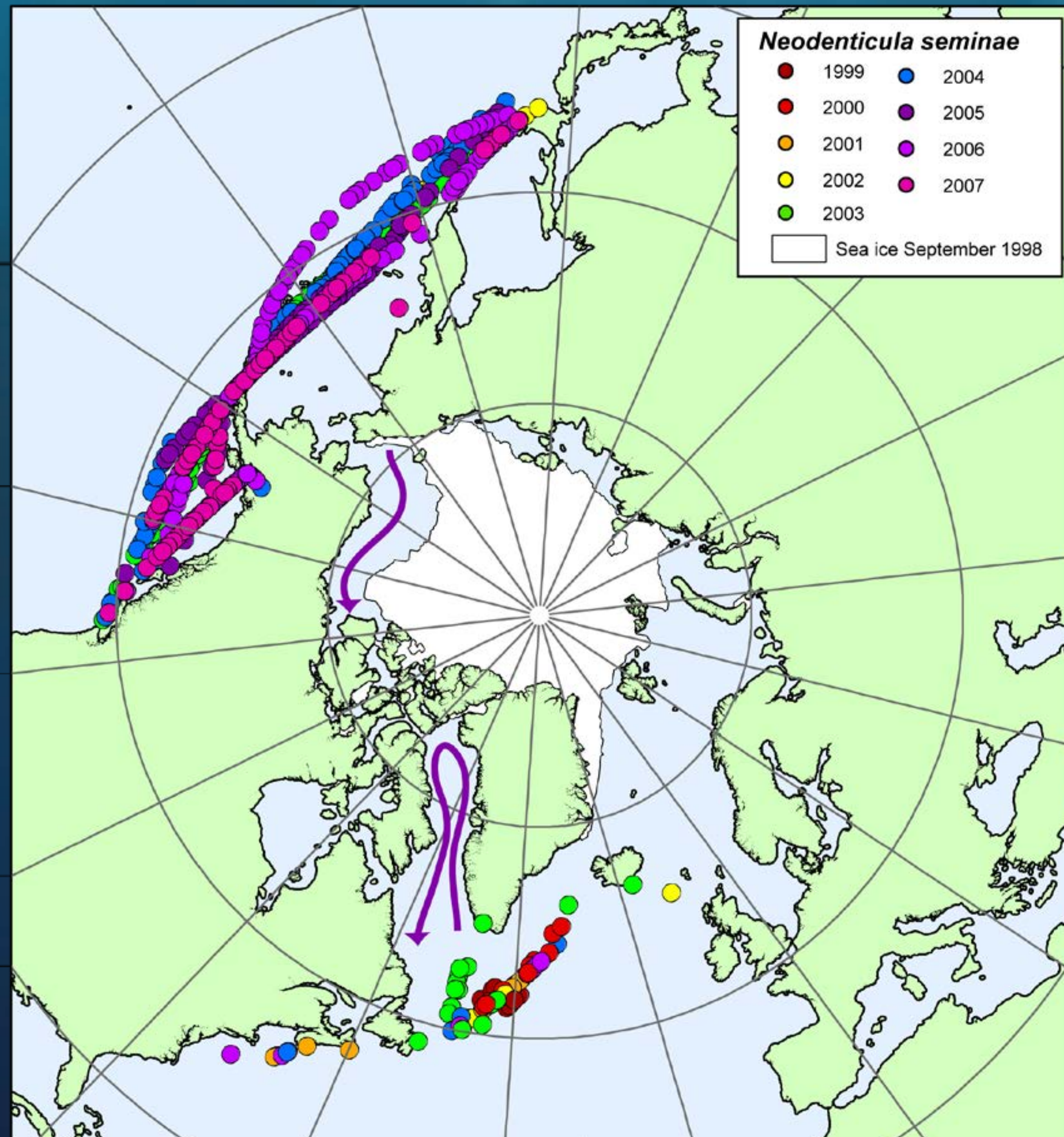


So, smaller AND earlier when warmer,
Vice versa when colder.

Monitoring changing species distributions



Neodenticula seminae



Reid et al 2007 GCB

Summary

- Monitoring of LTL by the CPR survey provides indicators which demonstrate responses to climate forcing:
  - Variability/base-lines
  - Long term trends
  - Regime shift-like changes
- These indicators summarise the extensive taxonomic data into key, relevant components of the ecosystem.
- Goal is multi-decadal, spatially extensive sampling (as in the N Atlantic), although significant progress has been made over 14 years in the N Pacific.

Thanks to the agencies and organisations for supporting the North Pacific CPR survey:

North Pacific Research Board

Exxon Valdez Oil Spill Trustee Council

Japan Society for the Promotion of Science

PICES

Continuous Plankton Recorder Survey SAHFOS

Fisheries and Oceans Canada / Pêches et Océans Canada

And to the ships, their officers and crew and all the SAHFOS technicians who are responsible for sample collection and analysis