How living cyst studies contribute "bio" to dinoflagellate biostratigraphy

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Outline: Emphasis on ecological signals

- Quick overview based largely on our earlier work on global cyst modeling, but with updates from work since

Methods used

- Document recent cyst assemblages in region with known variation in important ecological parameters: SST, SSS, disolved nutrients, coastal-neritic.

- Compare cyst data with ecol. parameters

- Statistical treatments: CA, CCA (SMES – methods are published)

- **Model ecological signals FOR USE IN PALEO-ENVIRONMENTAL INTERPRETATIONS**


Ecologic signals from living
cysts: global distributions

Ecological change: a main driver for biostrat.

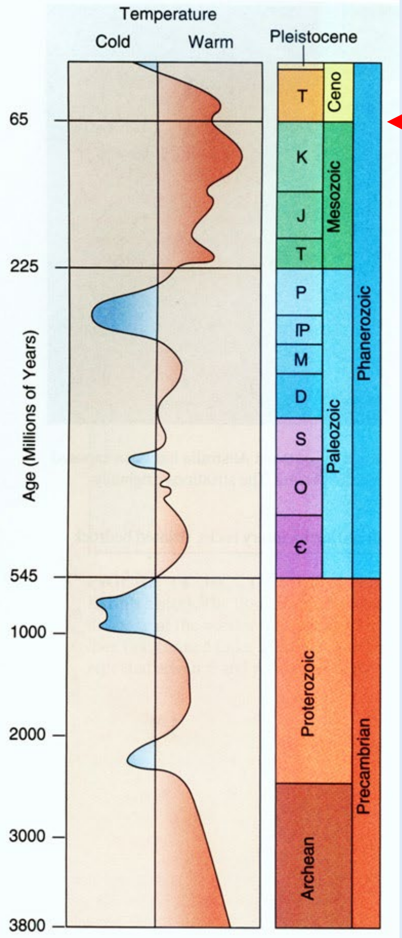


FIGURE 14.38 **Several periods of glaciation** have been identified in Earth's long history that may record changes in the surface temperature. The graph shows one estimate of relative temperature changes with time. The curve shows when temperatures were higher (to the right) or lower (to the left) than today.

NB Other plankton much more affected than Dinoflagellates

e.g. K-Pg Boundary. Probably explains why some most common genera today are ancient cyst-formers - *Gonyaulax* and *Protoperidinium*

Sometimes very quickly!

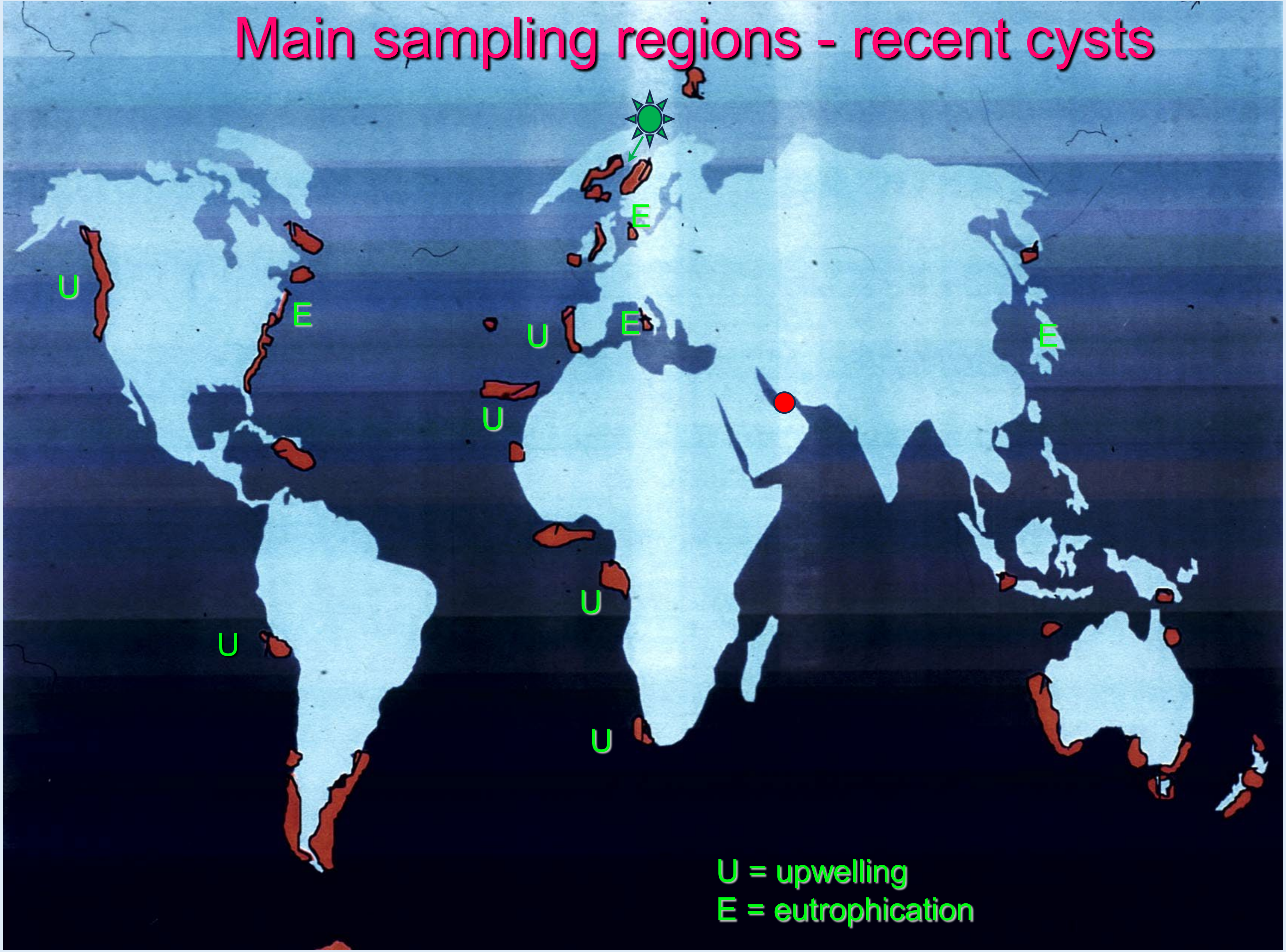
Ecological signals important in biostrat.

- **Water temperature – climate change – paleoclimate**
- **Coastal/oceanic – picking shelf edge in basin modeling**
- Salinity – climate change/SL change/ oceanic influence
- Dissolved nutrients – paleoproductivity

2 most important in statistical database

All are potential influences on LOCAL **palynology boundaries:**
First/last occurrence of species and relative species proportions in assemblages

Main sampling regions - recent cysts



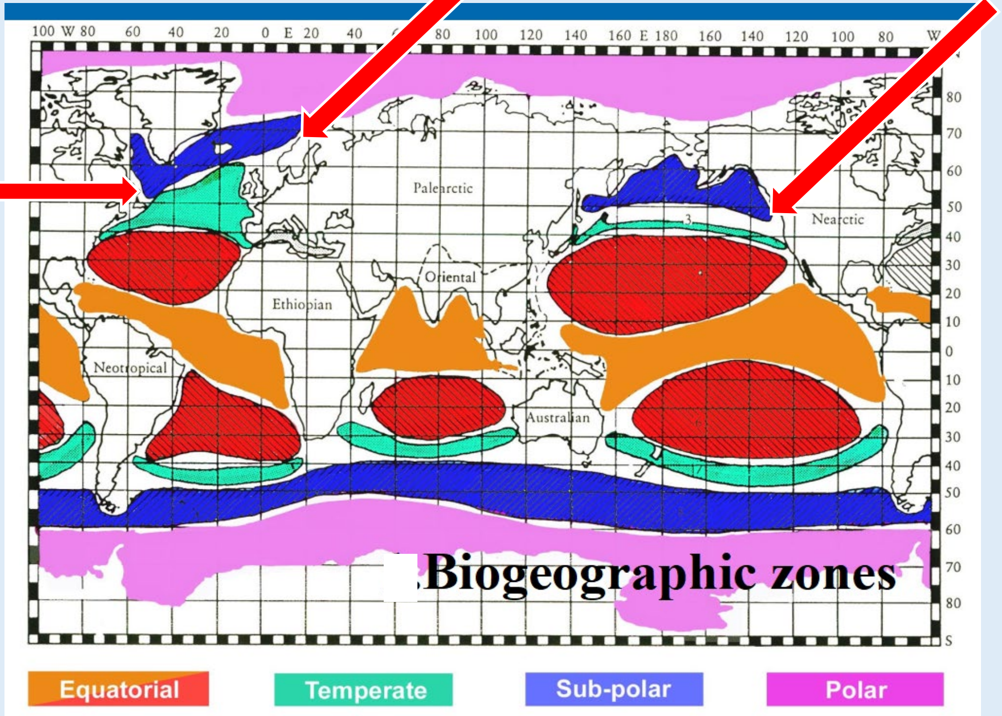
Regions sampled

Deep-sea sediment traps Nordic Seas (9)

Abu Dhabi: “living Paleocene”

Temperature signal

cysts reflect the standard biogeographic zones (benthic & plankton stages like molluscs) so excellent climate indicators!

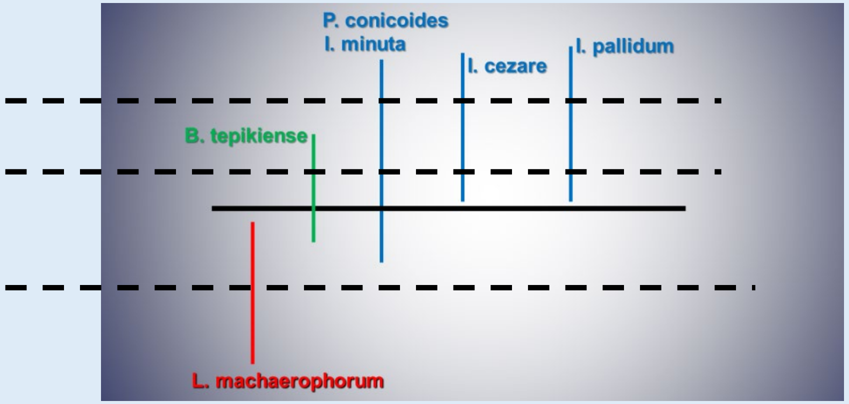


Standard biogeographic zones in the ocean from mollusks, fish etc.

Environmental change

sub-polar/temporate Biogeographic boundary

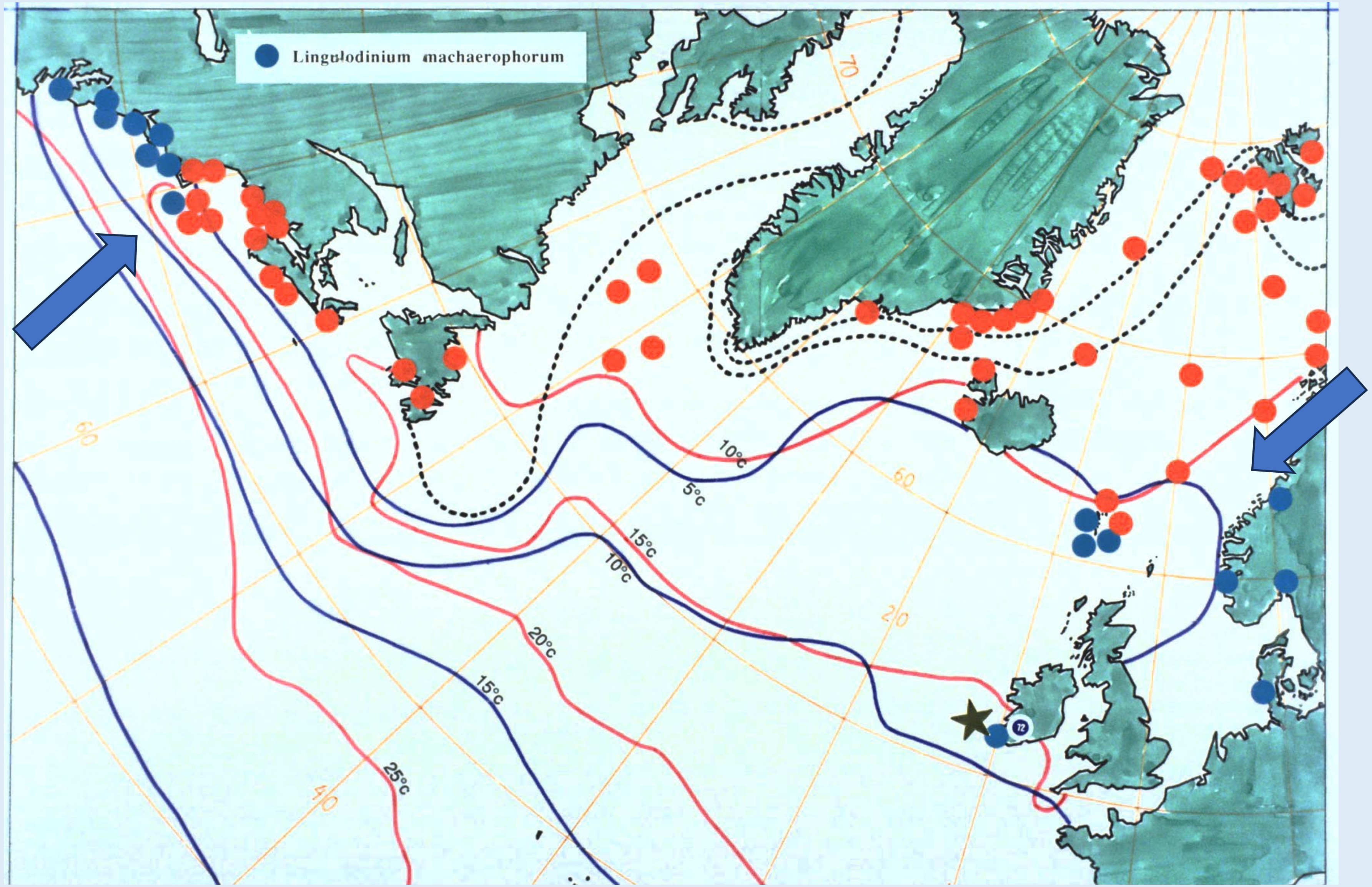
Cooling



warming

Cf range charts in biostratigraphy

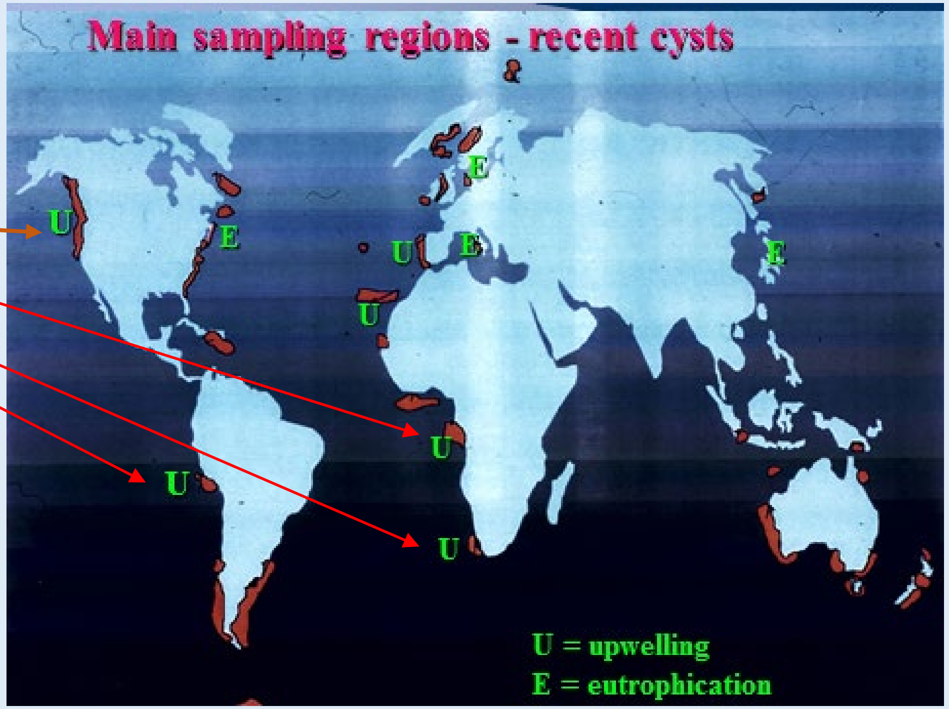
Sub-polar/temporate biogeographic boundary: data



Nutrient signals – Upwelling and Eutrophication

2 main signals – 1) upwelling and 2) eutrophication (later →)

2 types of upwelling: permanent
and periodic

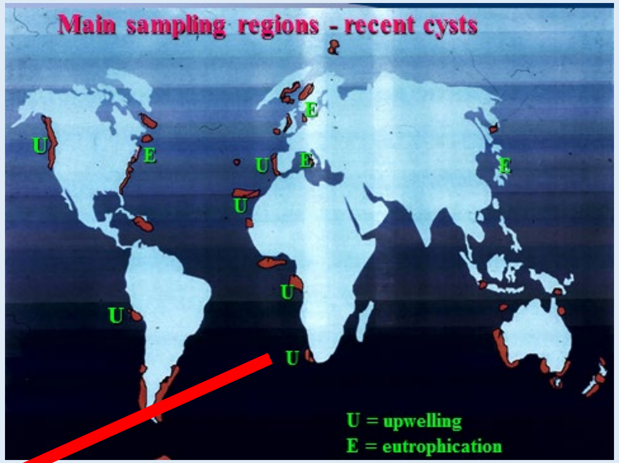


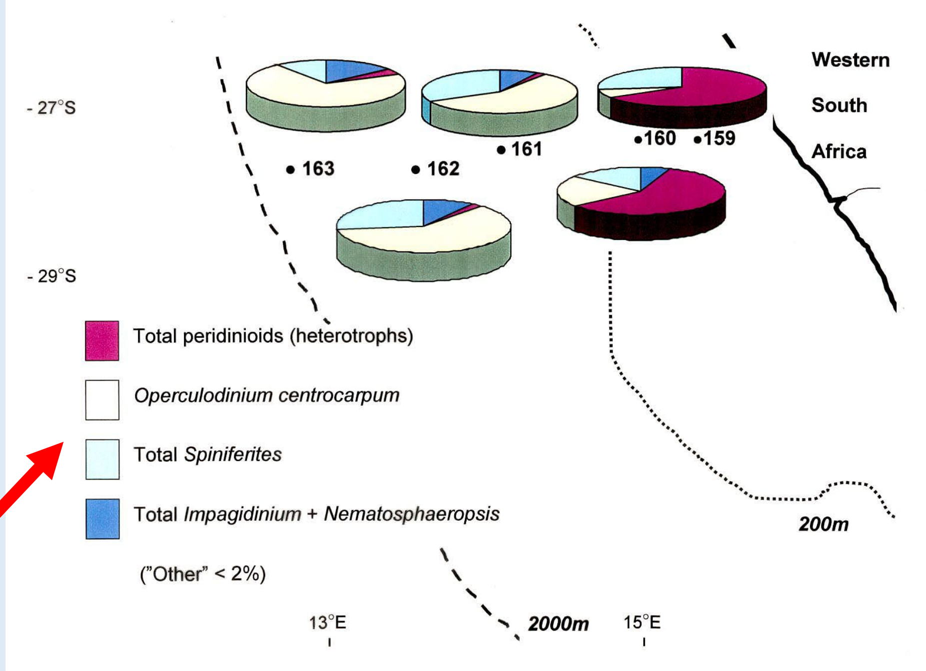
Permanent upwelling – increased heterotroph cysts

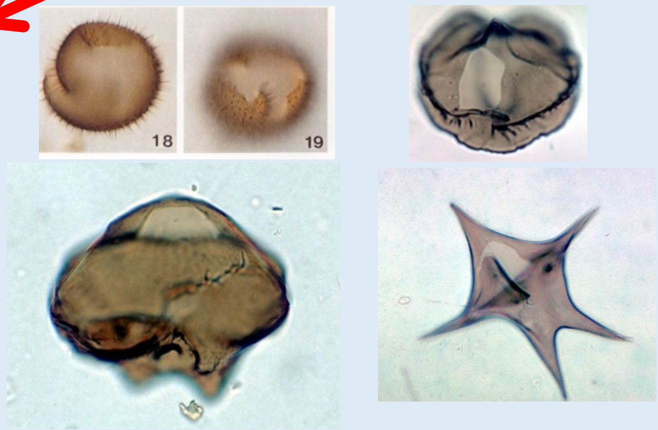
Periodic upwelling more like eutrophication signals

Permanent upwelling signal

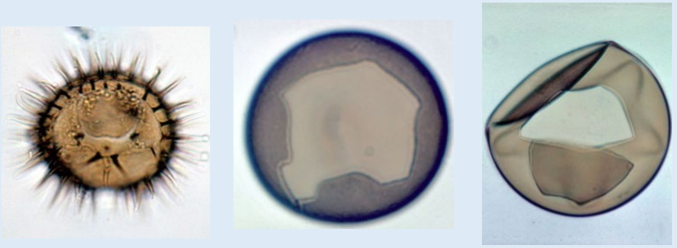
High % heterotrophs in permanent upwelling and many other high-nutrient systems







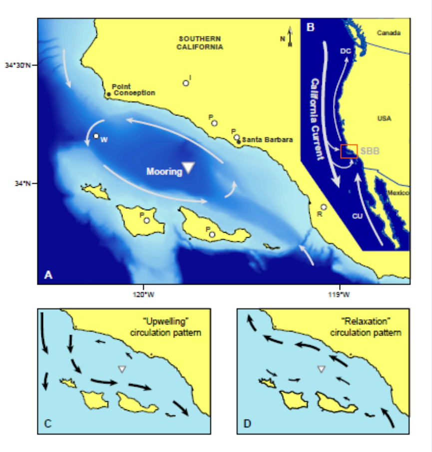
Mainly *Protoperidinium*

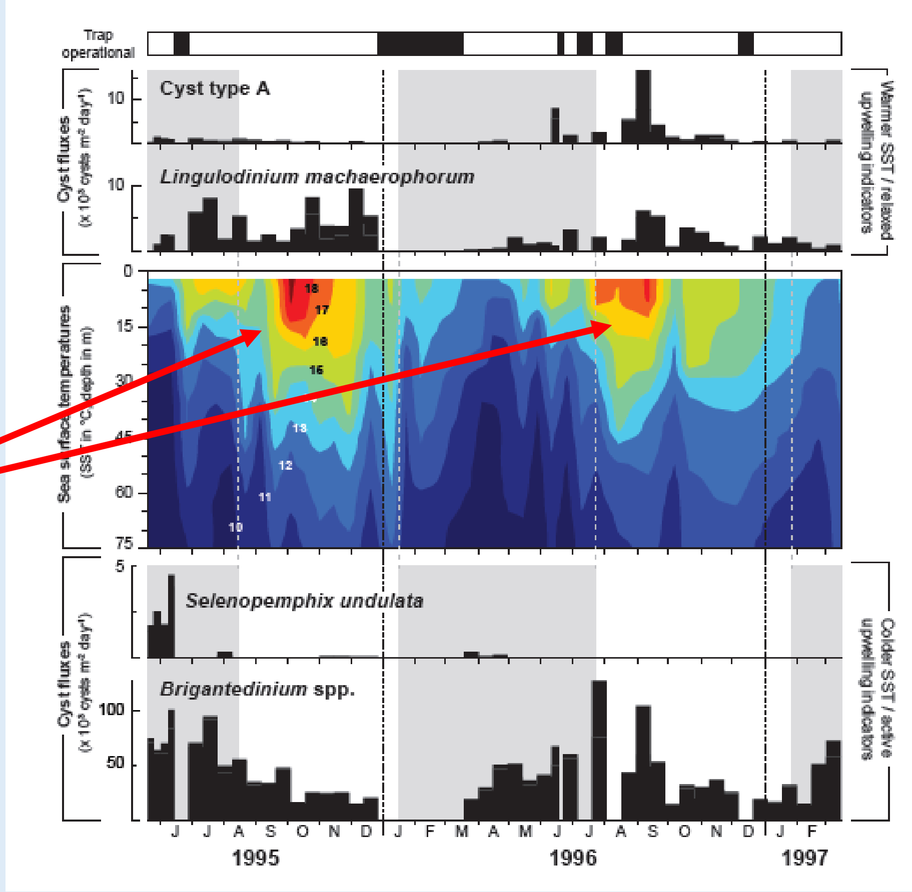


But note – associated dominance of cosmopolitans as nutrients less

Temporary upwelling is weaker - signal reflects this

Example - sediment trap from California:





Bringué, Pospelova and Pak, 2013

Blooms of *L. machaerophorum*
In areas of upwelling relaxation

NB: Relaxation phase other regions – other bloom species

e.g. ***O. centrocarpum*** – S. Africa;
G. catenatum - Portugal

Eutrophication signals - the Oslofjord

- **Ideal example to study pre/during and post-eutrophication**

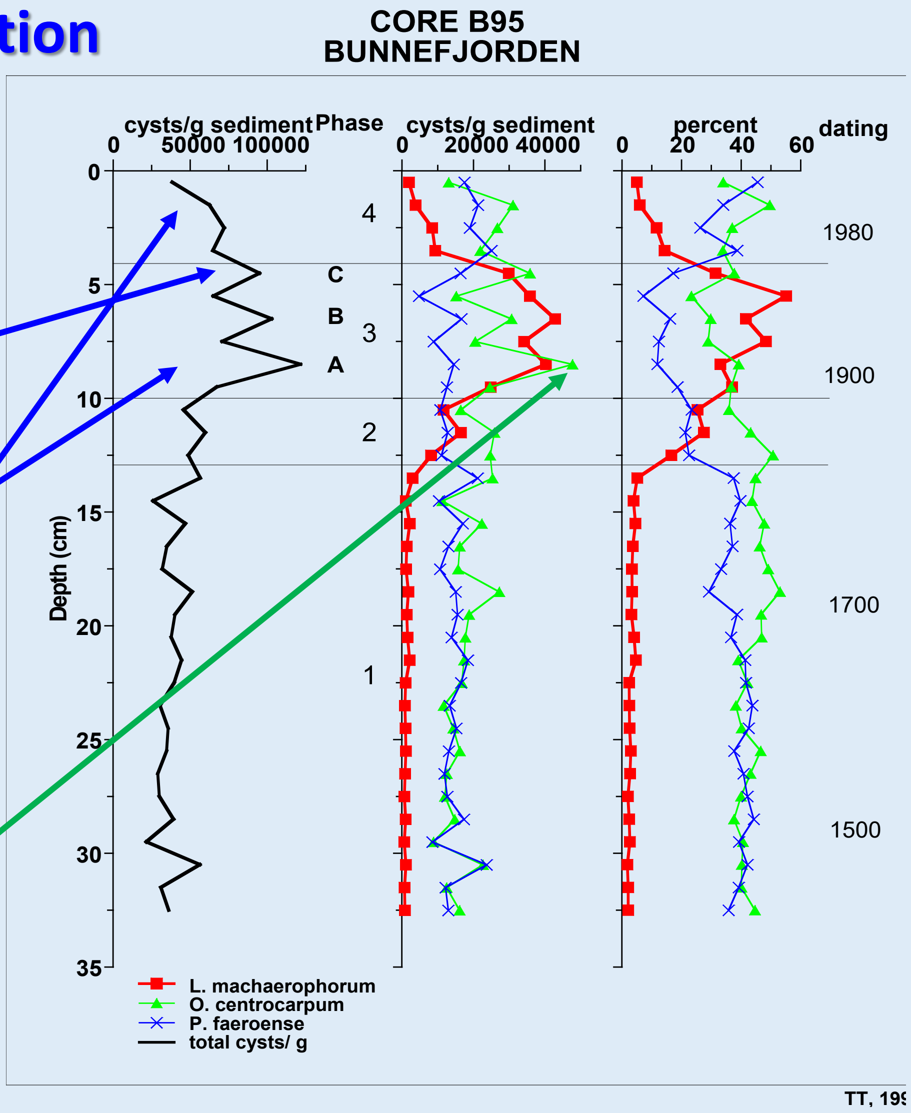
- **Mid-1800s** - **First large industry in Oslo area**
  - Rapid population increase

- **Early 1900s** - **First sewage disposal outlets to Oslofjord**
  - Widespread during 1930s (WC)

- **1950s** - **worst eutrophication - collapse of local fishery**

- **1960s-1970s** - **gradually more treatment**

- **1982** - **large new treatment plant in outer fjord**
  - > 20 years recovery until today



Increased *O. centrocarpum* - opportunistic species- signals environmental change

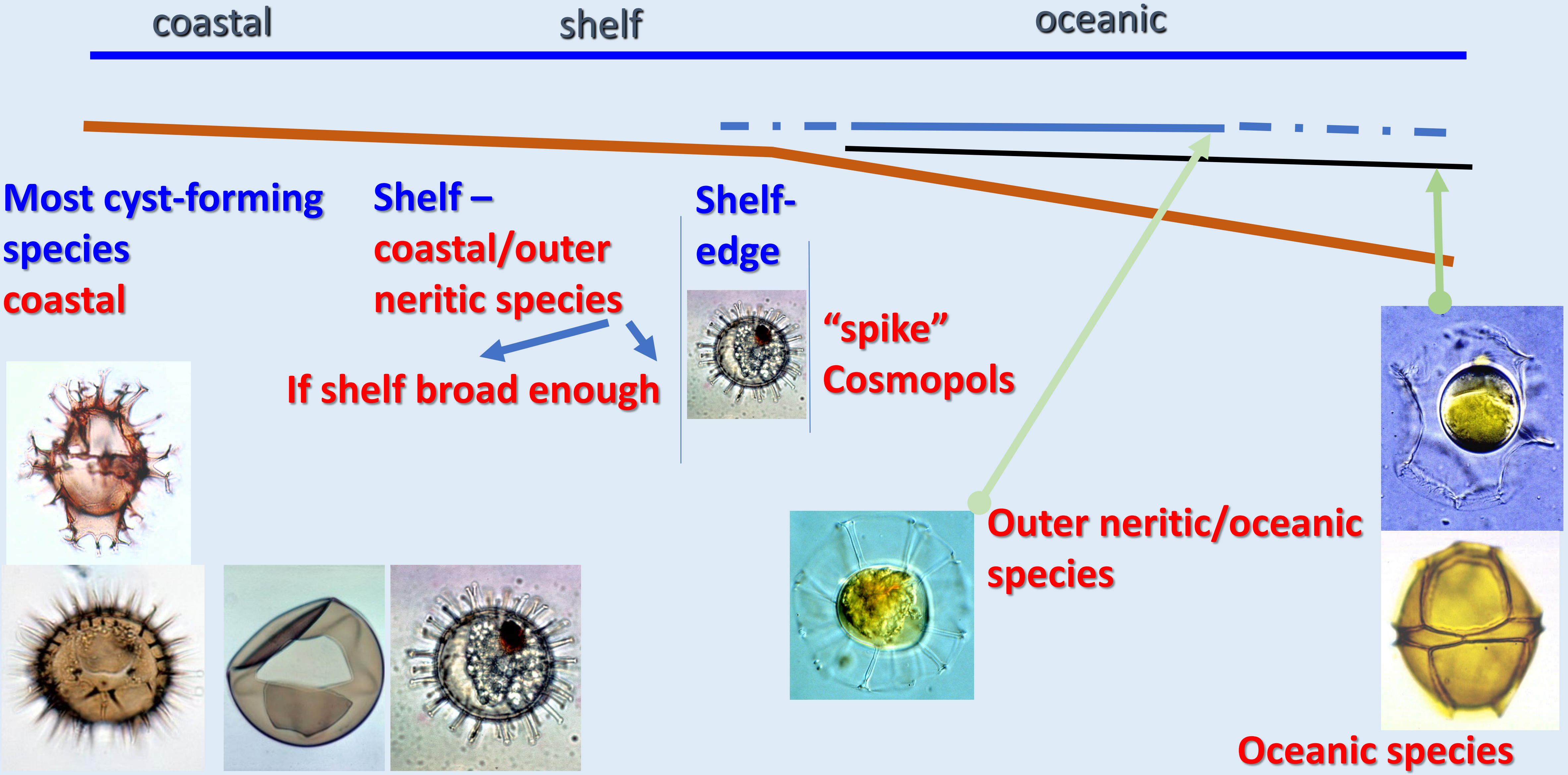
New insight into nutrient signals for palynology

- Increase/dominance of heterotrophs is only one indicator of increased nutrients
- Temporary upwelling and eutrophication include increased opportunistic species as main signal.

For palynology:

Now recognize general range of signals – cosmopolitans to heterotrophs - with nutrient increase . Not just increase in heterotrophs.
And remember not all brown cysts are heterotrophs
and not all protoperidiods are brown.

Coastal/oceanic signal



Salinity signal

Species: Reduced processes in *Lingulodinium*, *Operculodinium* and *Spiniferites*

Assemblage: Reduction in diversity to just most cosmopolitan (opportunistic) species.

In extremes, even towards indigenous species, e.g. in Baltic Sea

Sorting out the signals: a job for biostratigraphers

- **Overlapping signals may need sorting out**

Examples from our work

Using SMES we were able to separate signals:

1. **in living cysts**
2. **in the interplay of sea-level rise, salinity and nutrients in the Paleocene-Eocene thermal maximum (PETM) dinoflagellate cyst assemblages from Spitzbergen - part of an interdisciplinary project organized by Ian Harding, and**
3. **in industrial projects.**

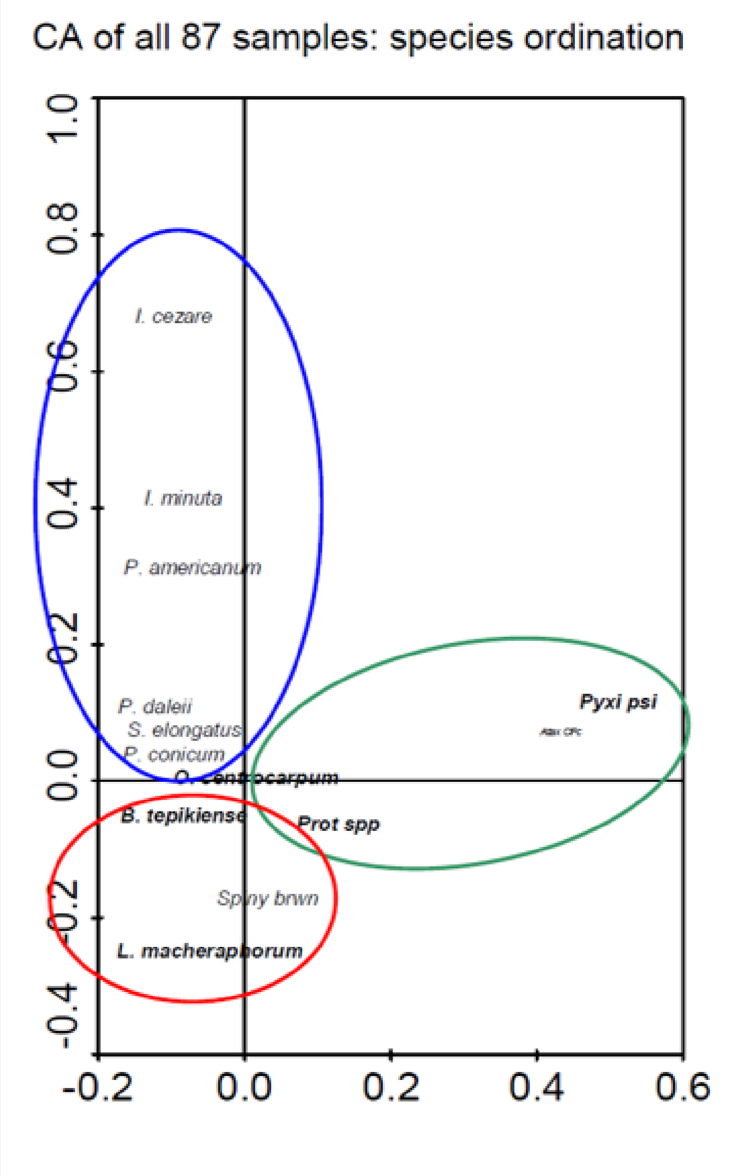
- **Despite eventual help from AI, we still need Biostratigraphers!**

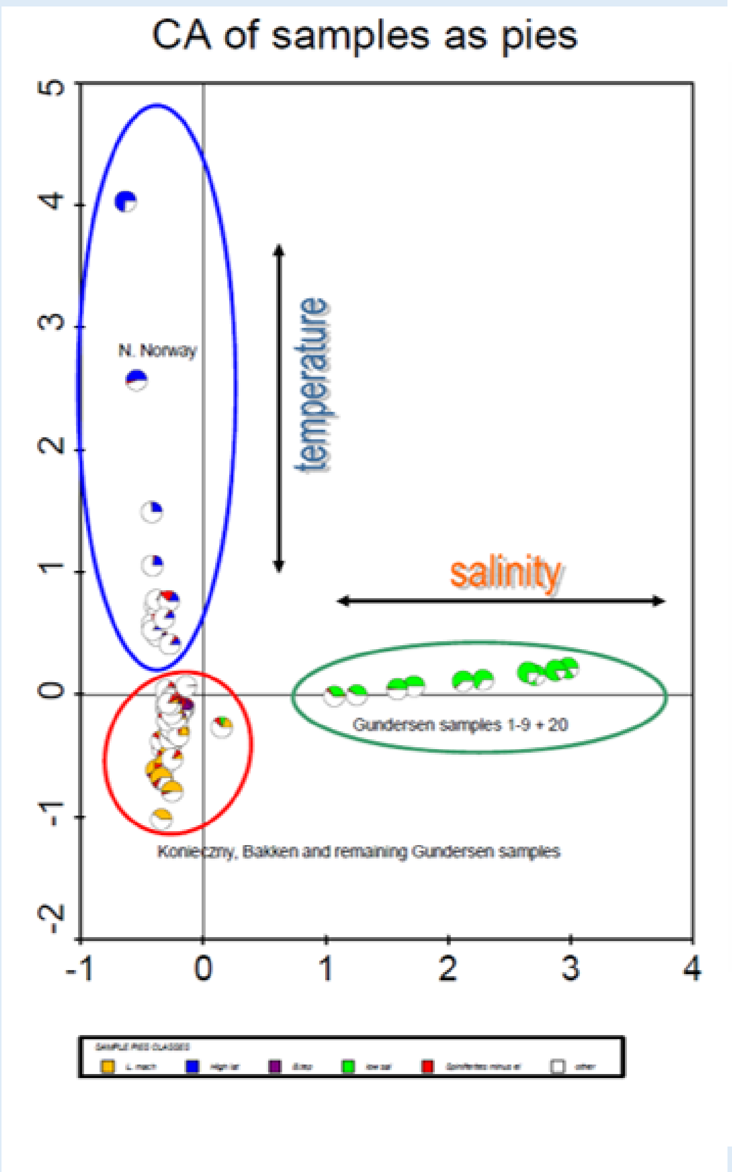
Sorting out the signals in living cysts - Norway

- **Signals often mixed in a region/basin**
- **SMES identifies different signals**

e.g. temperature signal from biogeographic boundary

Salinity signal from Baltic



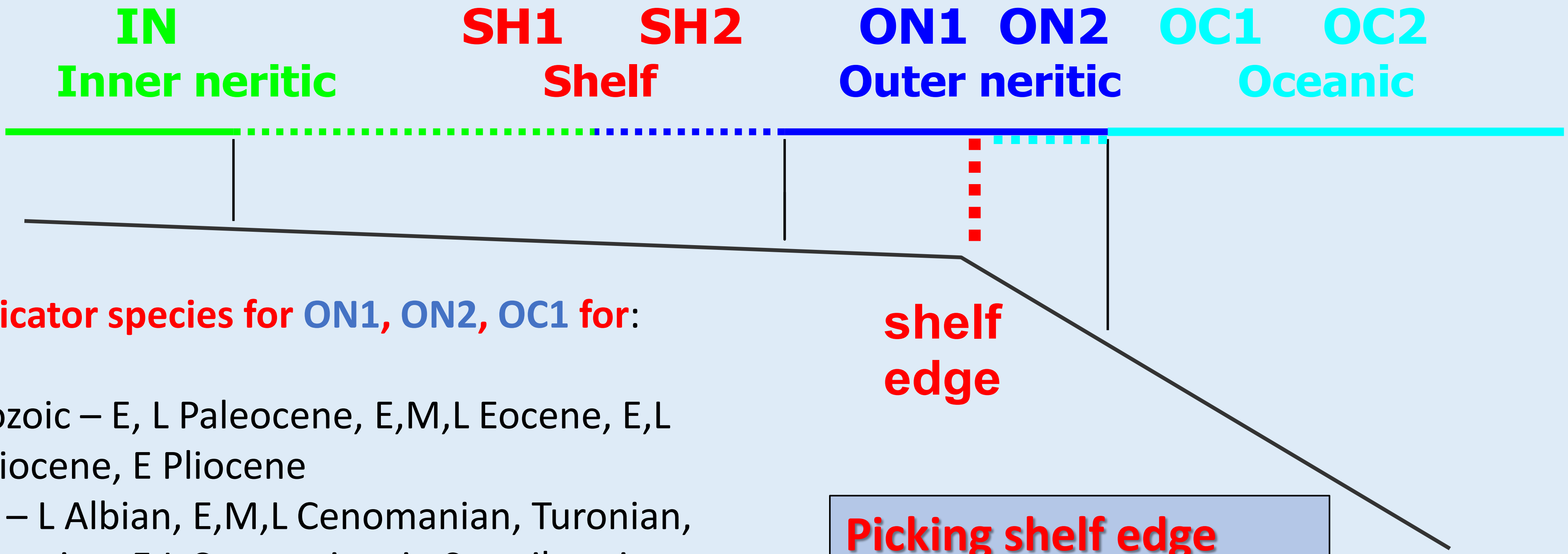


SMES Statistical treatments – CA picks out ecological signals

What SMES can do for biostrat – SL change

Identifying rel. water depths for longer geological sequences to pick flooding surfaces

Combines topographic (e.g. shelf) and hydrographic (neritic) terms



identified key indicator species for ON1, ON2, OC1 for:

9 time-slices Cenozoic – E, L Paleocene, E,M,L Eocene, E,L Oligocene, M-L Miocene, E Pliocene
+12 L. Cretaceous – L Albian, E,M,L Cenomanian, Turonian, Coniacian, E,L Santonian, E,L Campanian, in Statoil project.

Picking shelf edge may be useful info. for basin modelling?

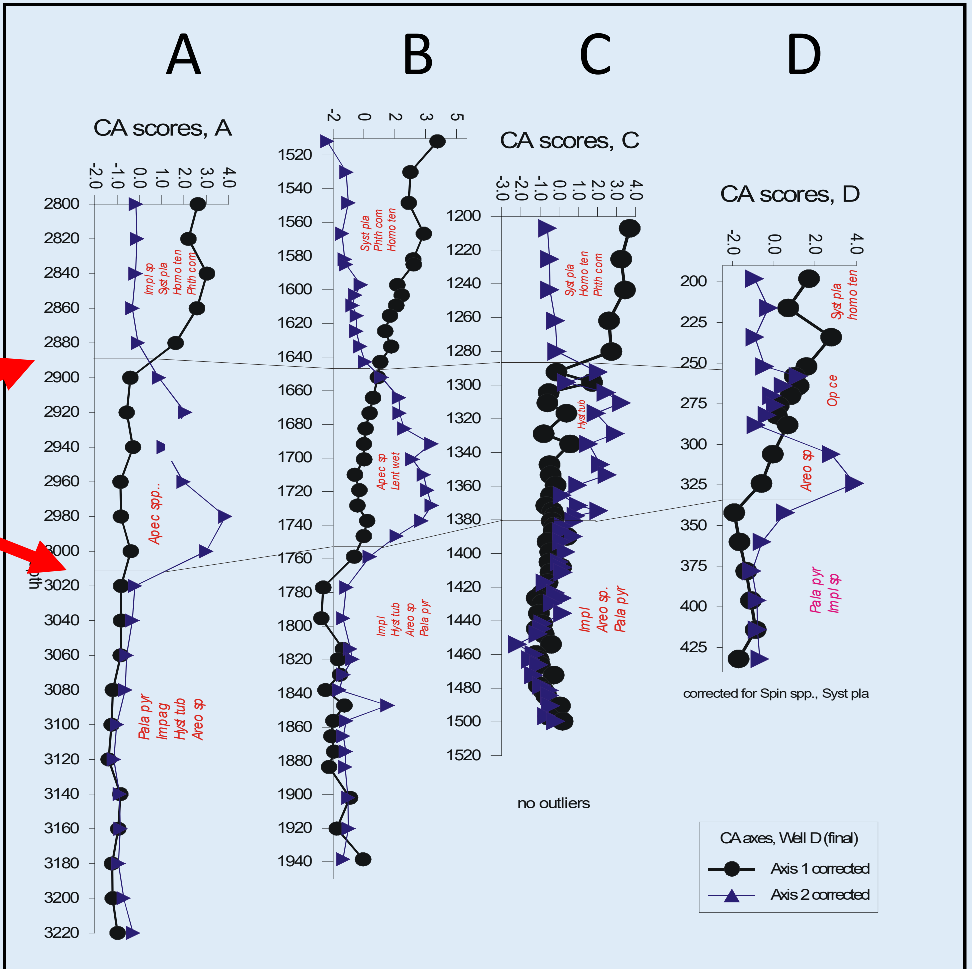
Example: picking flooding surfaces in Paleocene

Key species - % downcore

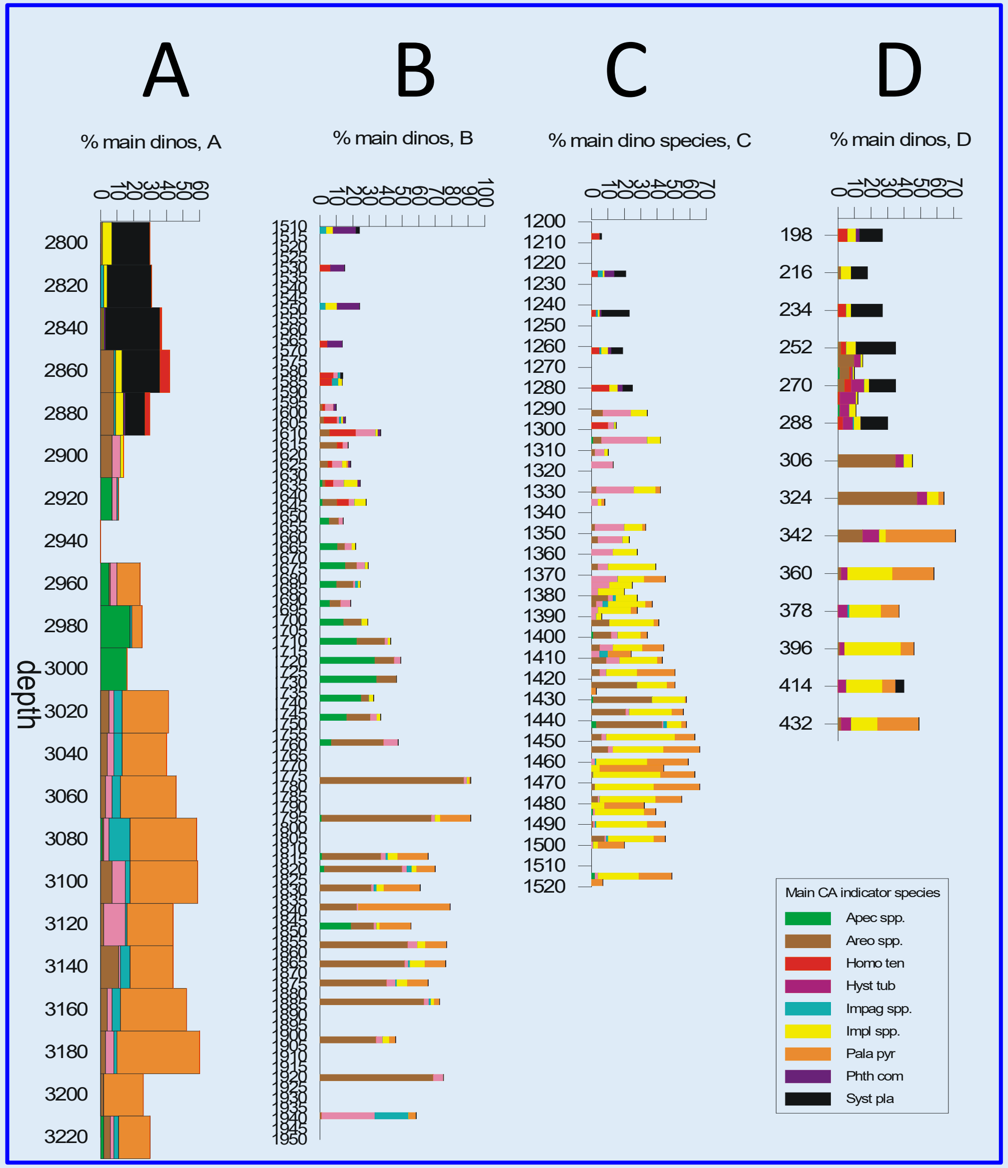
(high wts. / high scores) = **Indicator species**

E.g. Coastal/ocean indicators for SL changes and flooding surfaces

N. Sea Paleocene



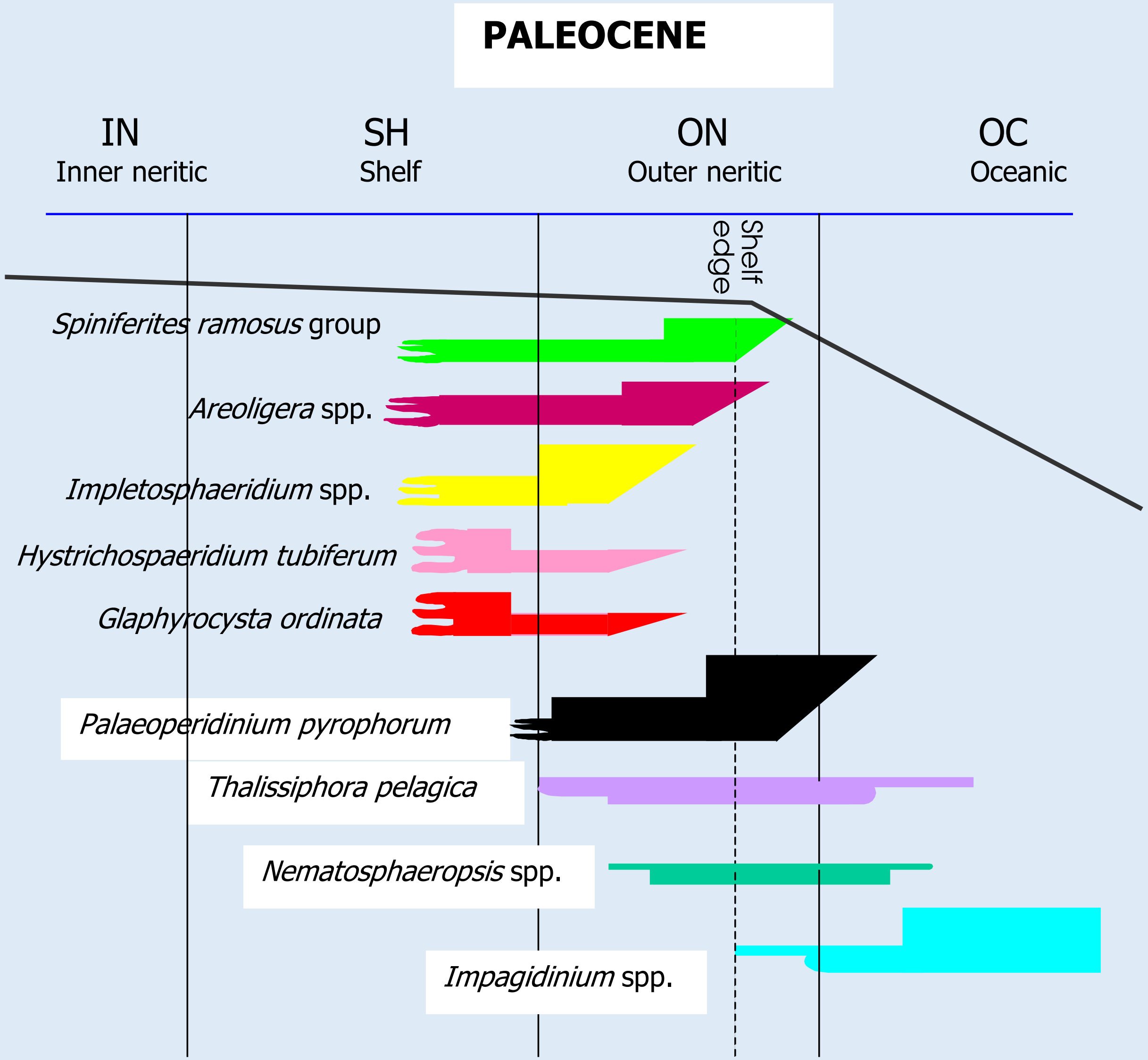
B. Dale, A.L. Dale, & I. Prince 2005



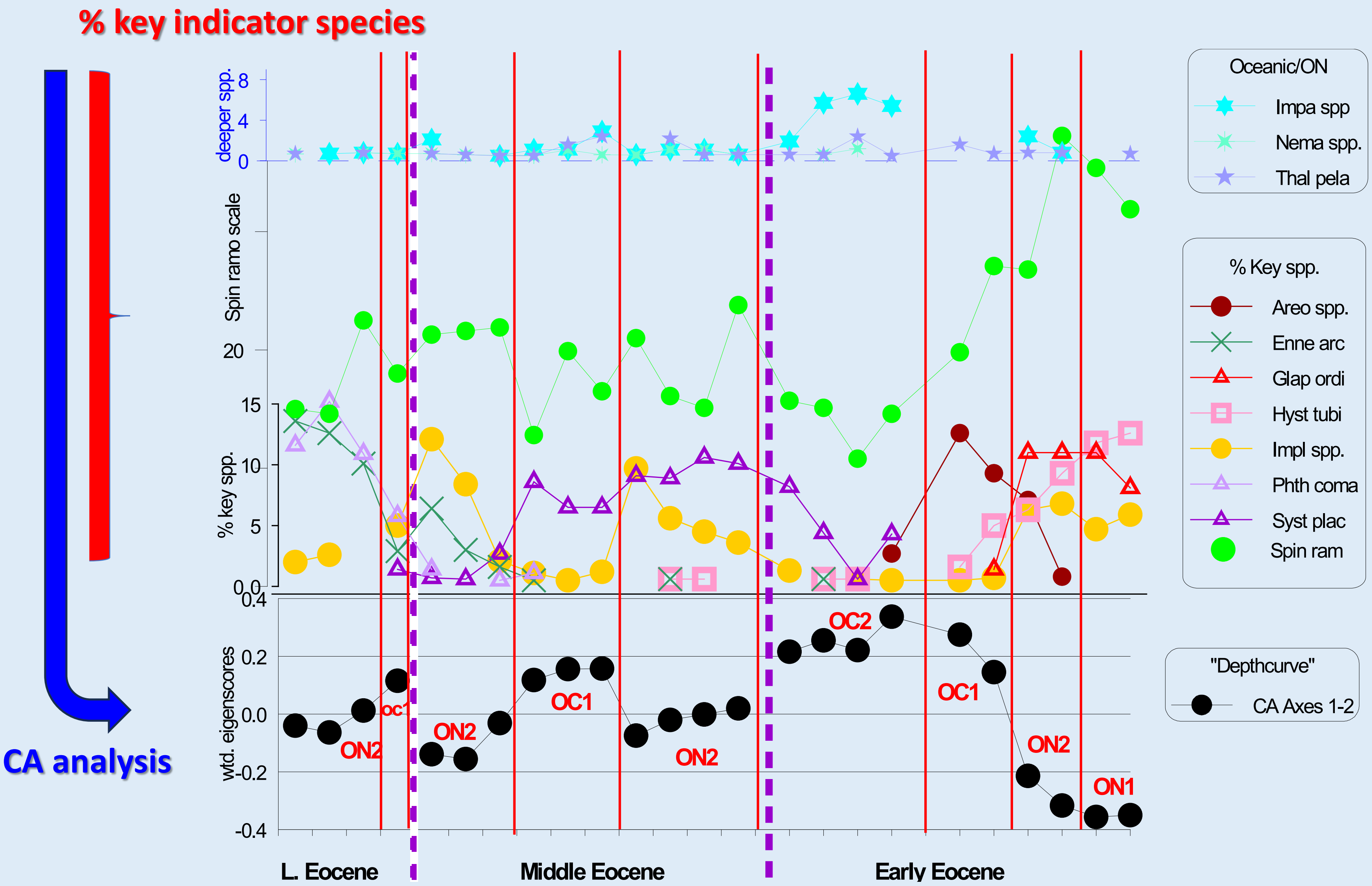
NB different assemblages – changes = signals

key indicator species Integrated from same 4 wells

Both presence and relative amounts important

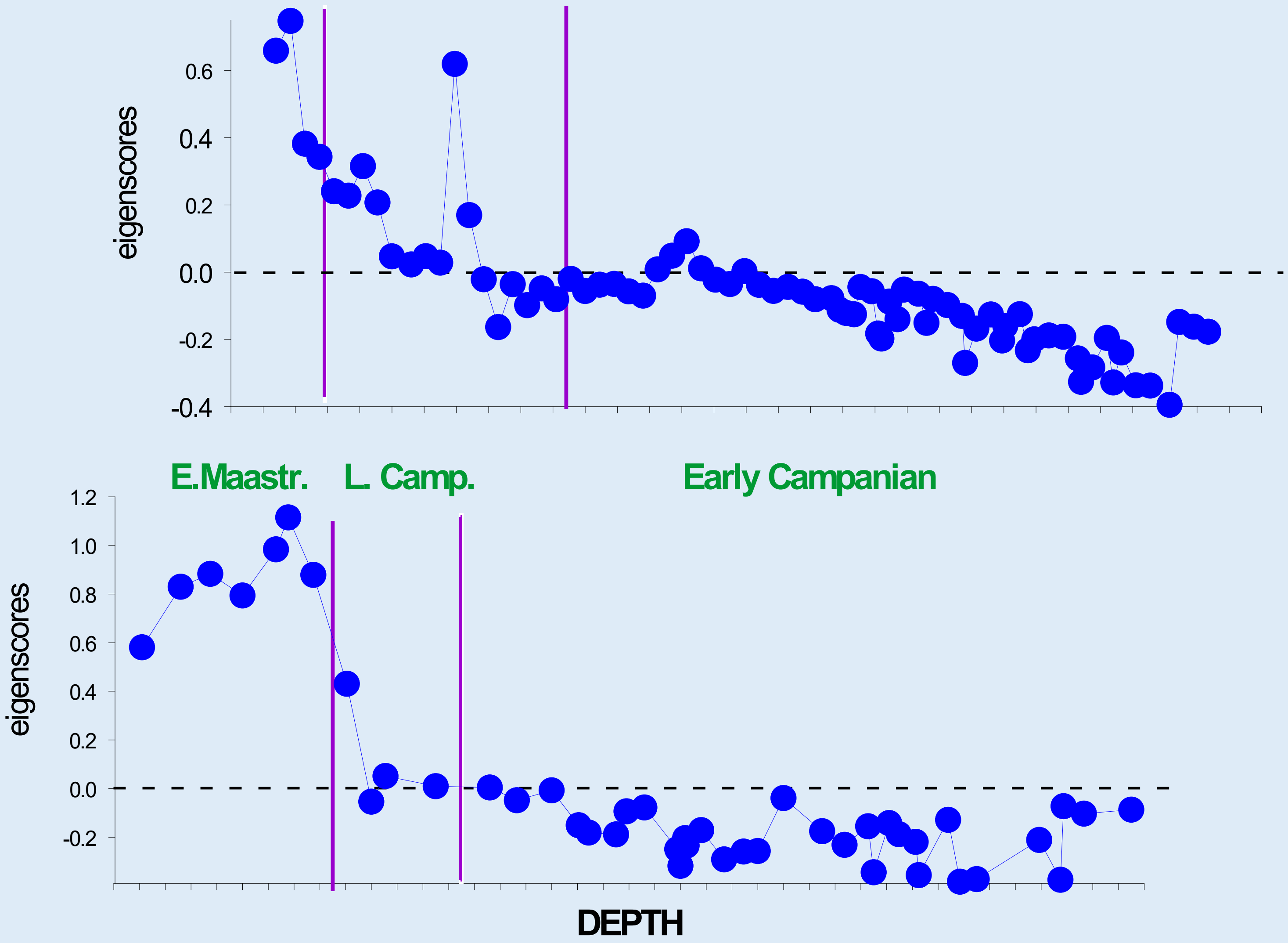


Relative «depth curves» from another well



Applications of relative "depth curves"

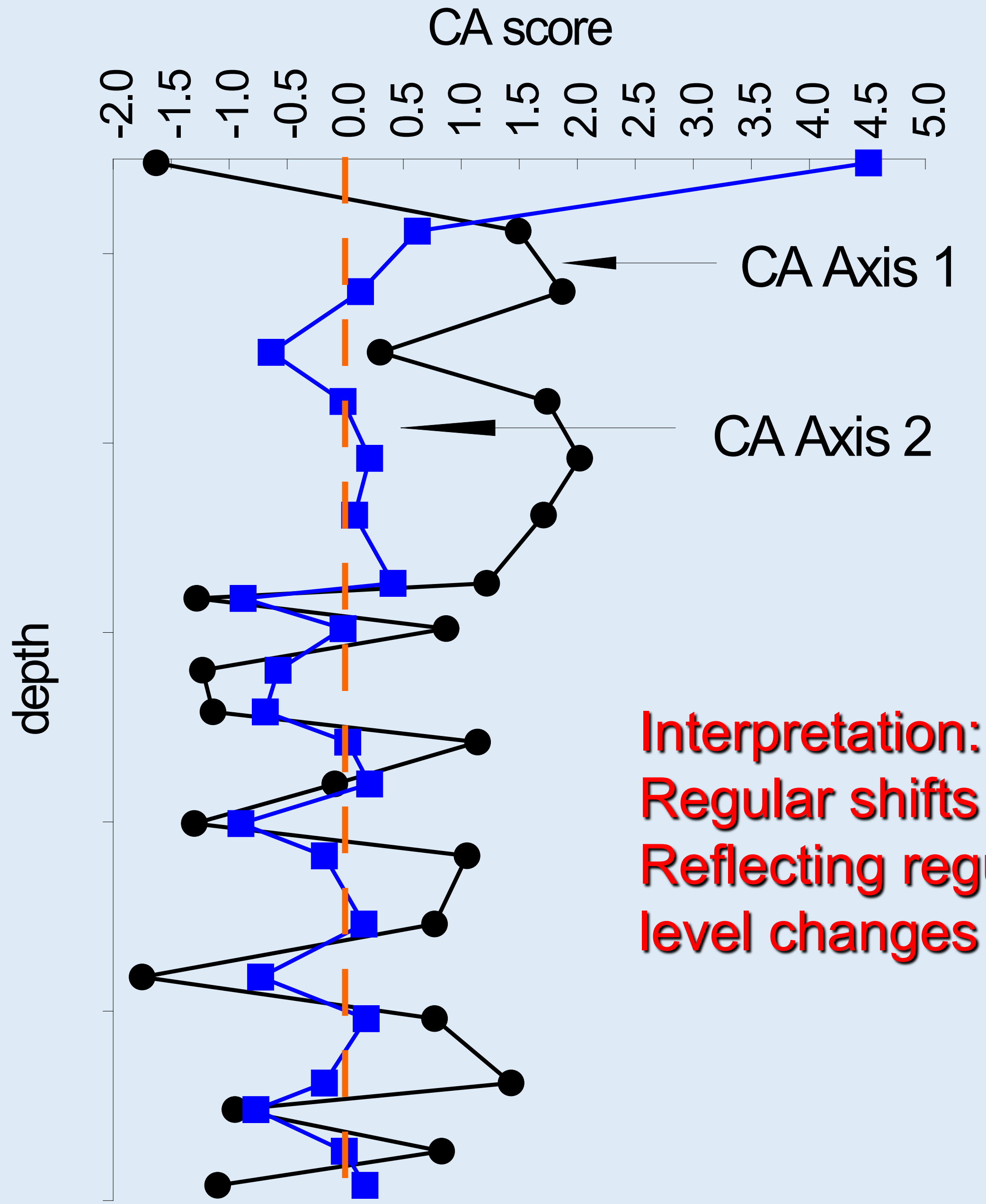
"Depthcurves" E. Maastr.-E. Campanian from CA axes 1-2 in 2 different wells



S.L. changes even at scales of 100s of thousands of years

Climatic perturbations?

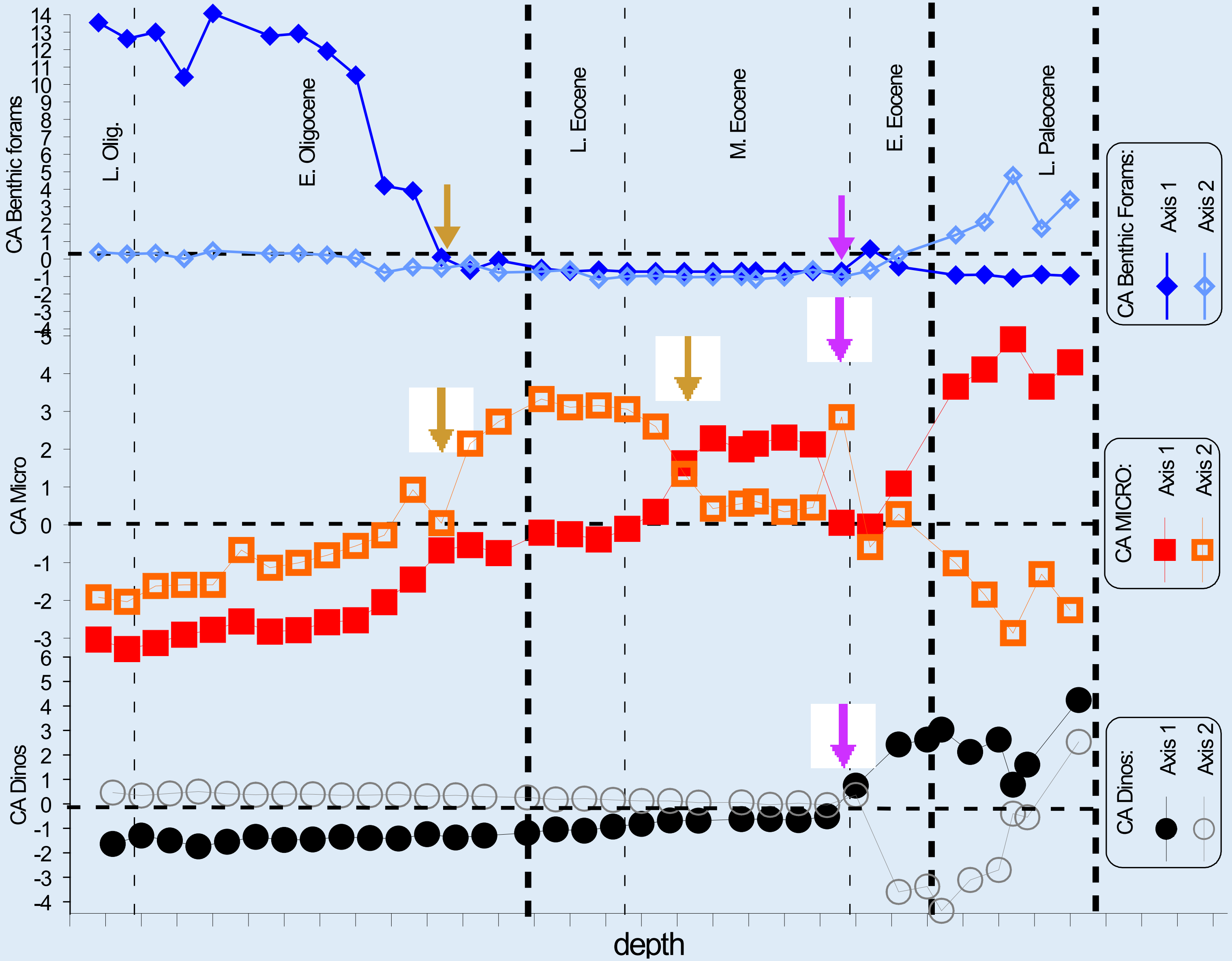
Coniacian from the Vøring Basin



Interpretation:
Regular shifts in axes
Reflecting regular sea-level changes

CA of Micro and Paly compared for Paleogene

Different microfossil groups contribute different information



Living cysts we are working on now

A serious look at the Oceanic Signal!

THANK YOU ALL

Dinoflagellate cysts in deep-sea sediment traps around the northern North Atlantic: implications for paleoceanography

Amy and Barrie Dale