Scale-dependent spatial correlation of zooplankton time series: Biomass, phenology, and species composition

SCOR Working Group 125

Members, Associate Members & Data Collaborators


WG125 members at first meeting (Nov 2005)

SCOR WG125 'Mandate'

Data: Assemble representative "long zooplankton time series".

Methods 'Toolkit': Develop & share processing, visualization & analysis software

Comparative Analyses to examine:

- Amplitudes of multi-year variability (for total biomass, size and community composition, seasonal timing...)
- Correlation structure
- Zooplankton vs. higher trophic levels
- Synchronies of major interannual fluctuations
- Likely causal mechanisms and consequences

"Cheerleading":

- Advertise existing time series
- Enable new time series, especially where there are gaps

What WG125 means by 'zooplankton':

'Mesozooplankton':

- ~1 mm – 3 cm
- Trophic level 2-4
- Swim slower than surface currents
- Life span weeks to annual
- Small enough to catch with a plankton net, big and tough enough to be retained

Why zooplankton time series?

Key link between "physics" and "fish"

Zooplankton sampling methods are (relatively) :

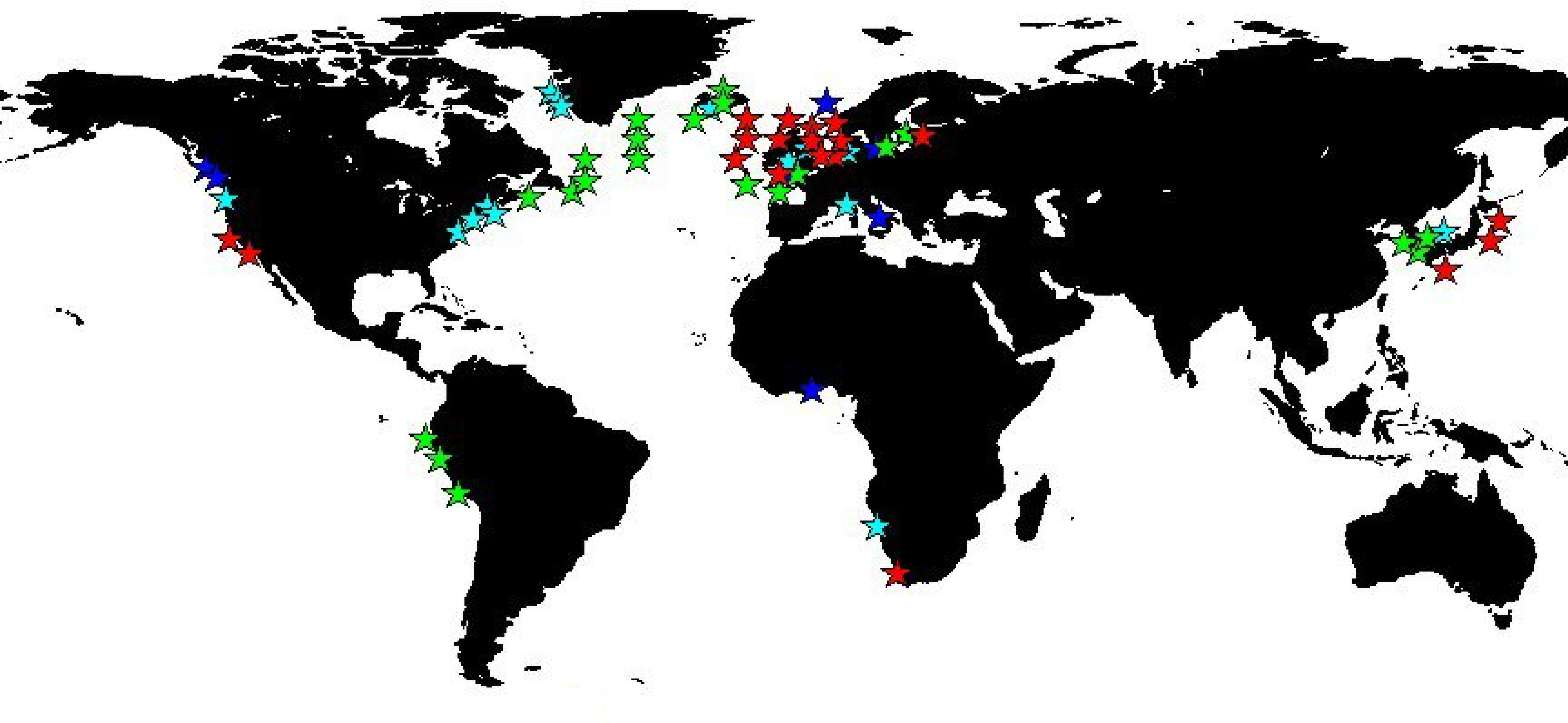
- **simple,**
- **intercomparable,**
- **fishery-independent**

Time scale of population response (~1 year or less) gives good tracking of climate forcing at interannual-decadal time scales

Topic for today: Over what separations are zooplankton time series correlated?

Within region? Within ocean basin? Global?

We now have nearly 100 'biomass' time series from 23 countries. Many are 'long' (>20 years)



Durations (years): >50 >40 >30 >20

'Methods & Indices' for biomass variability - what is needed

Separate multiyear fluctuations and trends from other intense modes of zooplankton variability (e.g. seasonal cycle; small to mesoscale patchiness)

Allow comparison across diverse sampling designs:

- Frequent (weekly to monthly) at one site
- Monthly to seasonal on a grid
- Monthly to seasonal scattered within a region
- Annual surveys at ~fixed season & locations

Allow comparison across differences in sampling gear and measurement "currency"

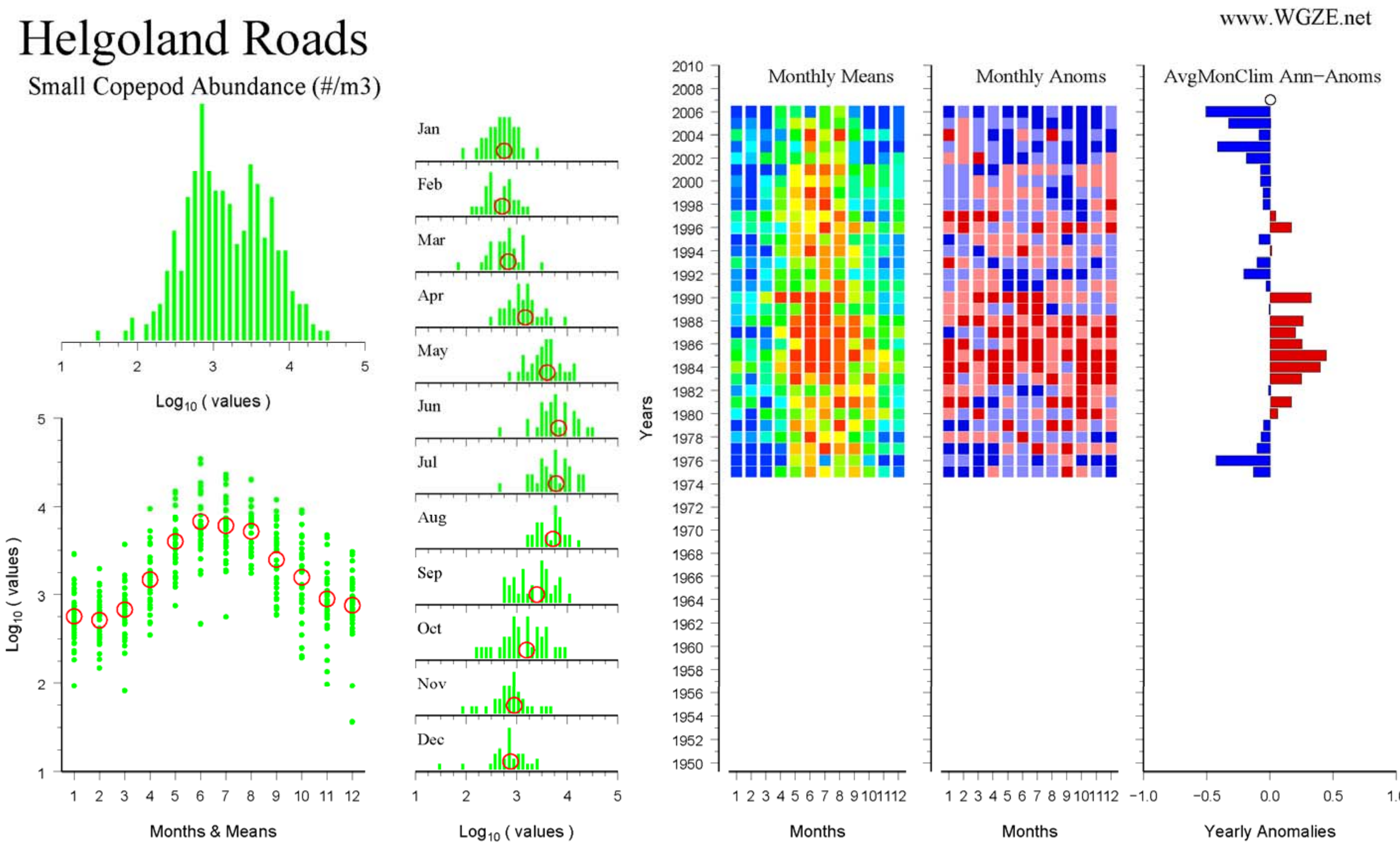
Our eventual choice as WG125 'standard' :

(summary from OBrien et al 2007, 2008 and in prep.)

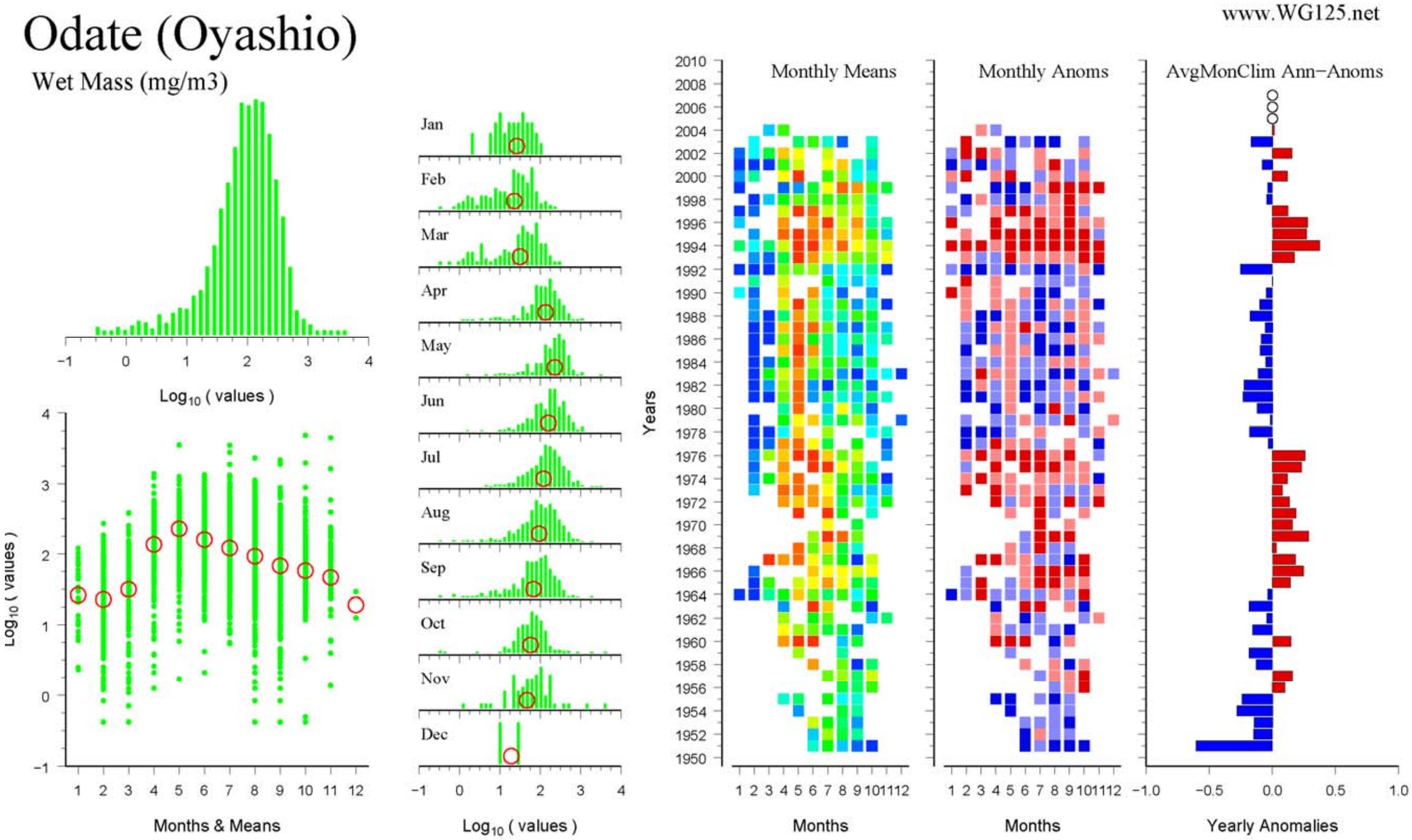
1. **Log transform data and calculate monthly means ($B_{m,y}$) For each calendar month, calculate a monthly resolution seasonal climatology B_{clim}**
2. **For each month in each year, calculate a log scale monthly anomaly $A_{m,y} = B_{m,y} - B_{clim}$**
3. **For each year, calculate an annual anomaly A_y by averaging the available monthly anomalies. Examine both $A_{m,y}$ and A_y**

N.B: log scale anomalies measure multiplicative change (1.5x, 3x, 10x). They are dimensionless (blind to measurement currency) AND also cancel out any sampling bias shared by data and climatology baseline.

Example 1: a long, dense time series



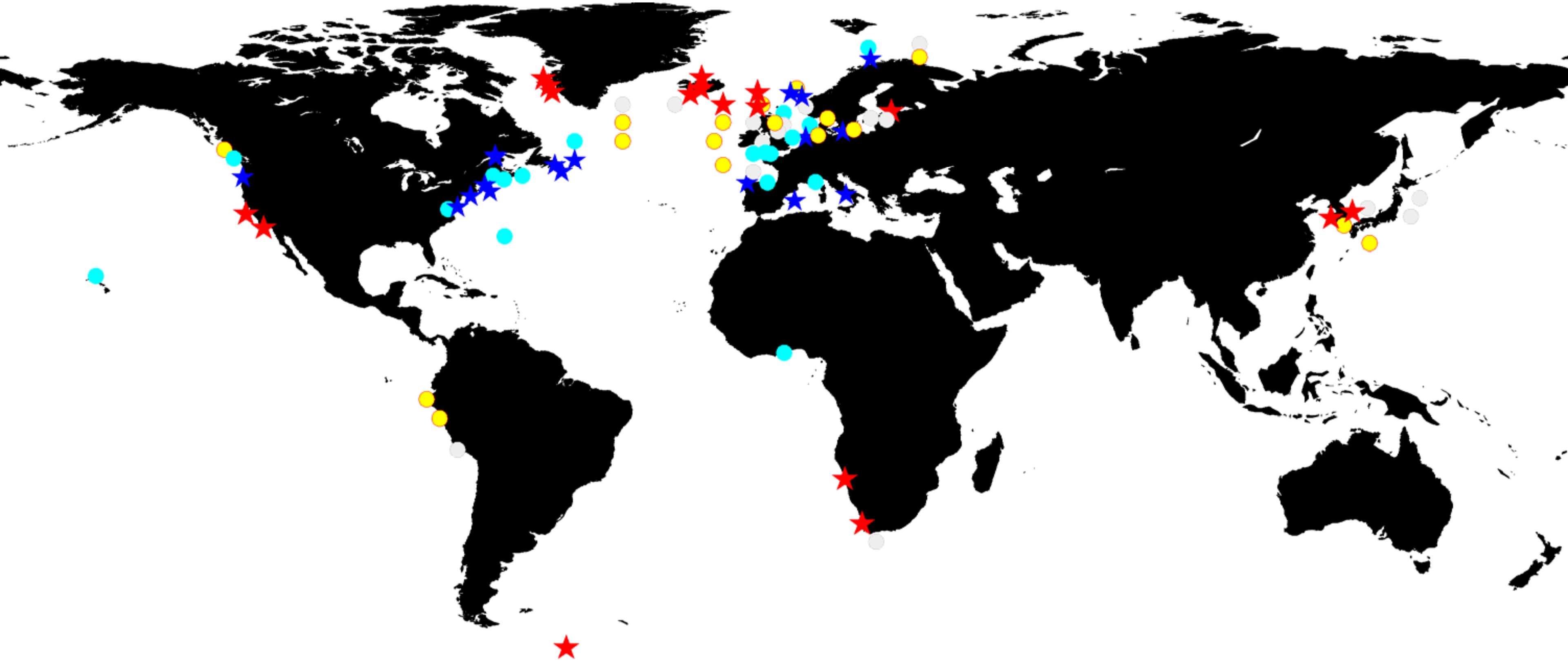
Example 2: a long time series but with 'holes'



Global comparison of biomass time series (~ complete):

1. Relative intensity of variation (how large are the anomalies?)
2. Correlation/Synchrony vs spatial separation

Relative intensity = 'span'

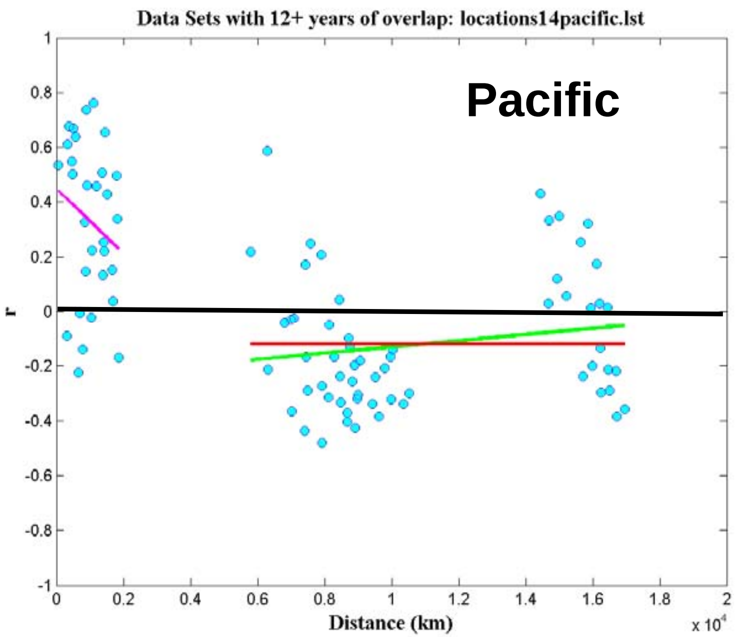


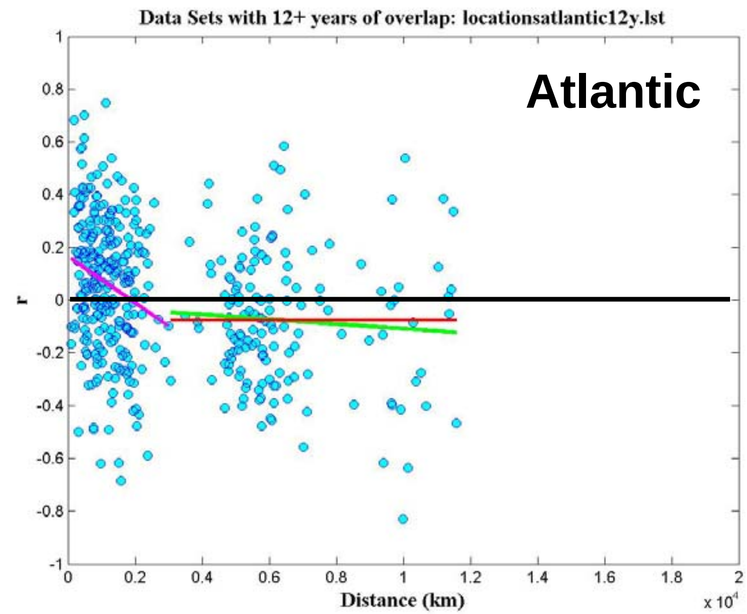
The most intense multiyear variation (red-yellow symbols) has been at subpolar-polar latitudes, in EBC upwelling regions, and around Korea-Japan

The weakest (light to dark blue) has been in the subtropical gyres and mid-latitude shelf seas

Note: Short time series may not yet have showed their full 'span'

Correlation declines RAPIDLY with spatial separation: NO global scale synchrony for biomass some correlation/synchrony <u>within</u> basin (at separations <2000-4000 km)





Pacific: Spatial autocorrelation averages ~0.3 (stronger than Atlantic) at separations <2000 km.

Correlogram 'range' poorly determined because few site pairs at separations between 2-6x10^3 km)

Atlantic: Autocorrelation declines from ~0.2 to 0 as spatial separation increases to 3000 km.

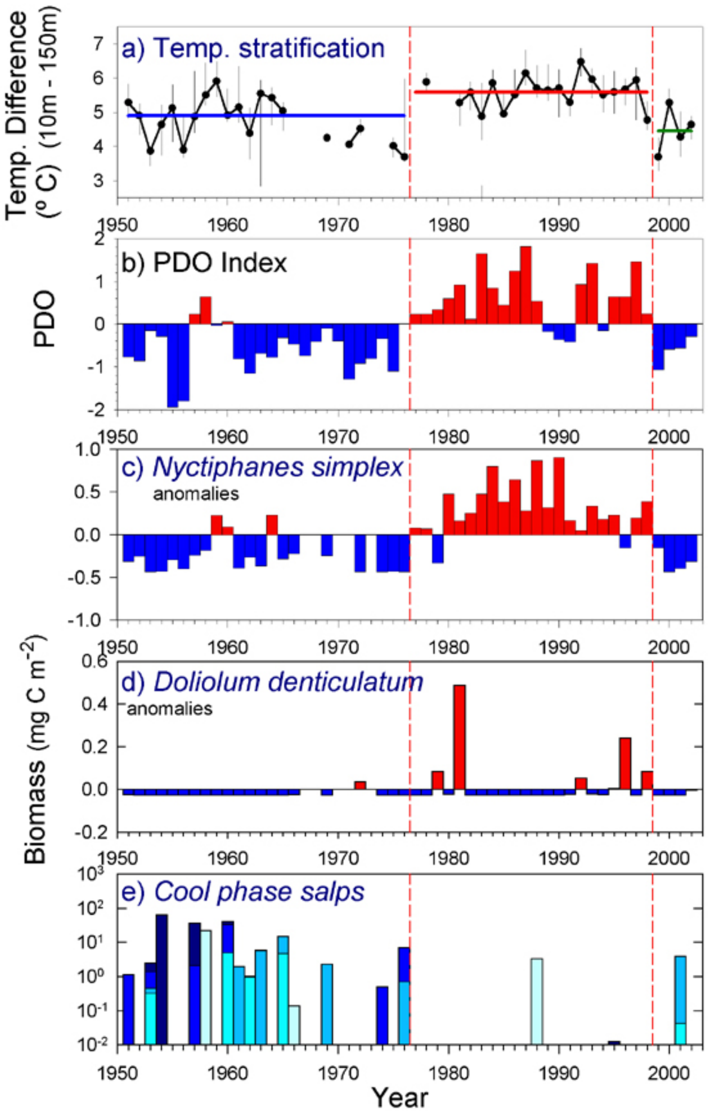
Correlogram 'range' ~3000 km

(from Batchelder et al. 2008 presentation & in prep)

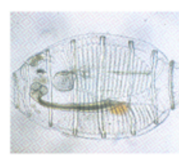
There are other important (perhaps more important!) modes of zooplankton variability: (e.g. community composition, phenology).

Our results so far (based on comparisons between 2-5 regions):

"Composition Regimes"
(e.g. California Current and North Sea)



CalCOFI

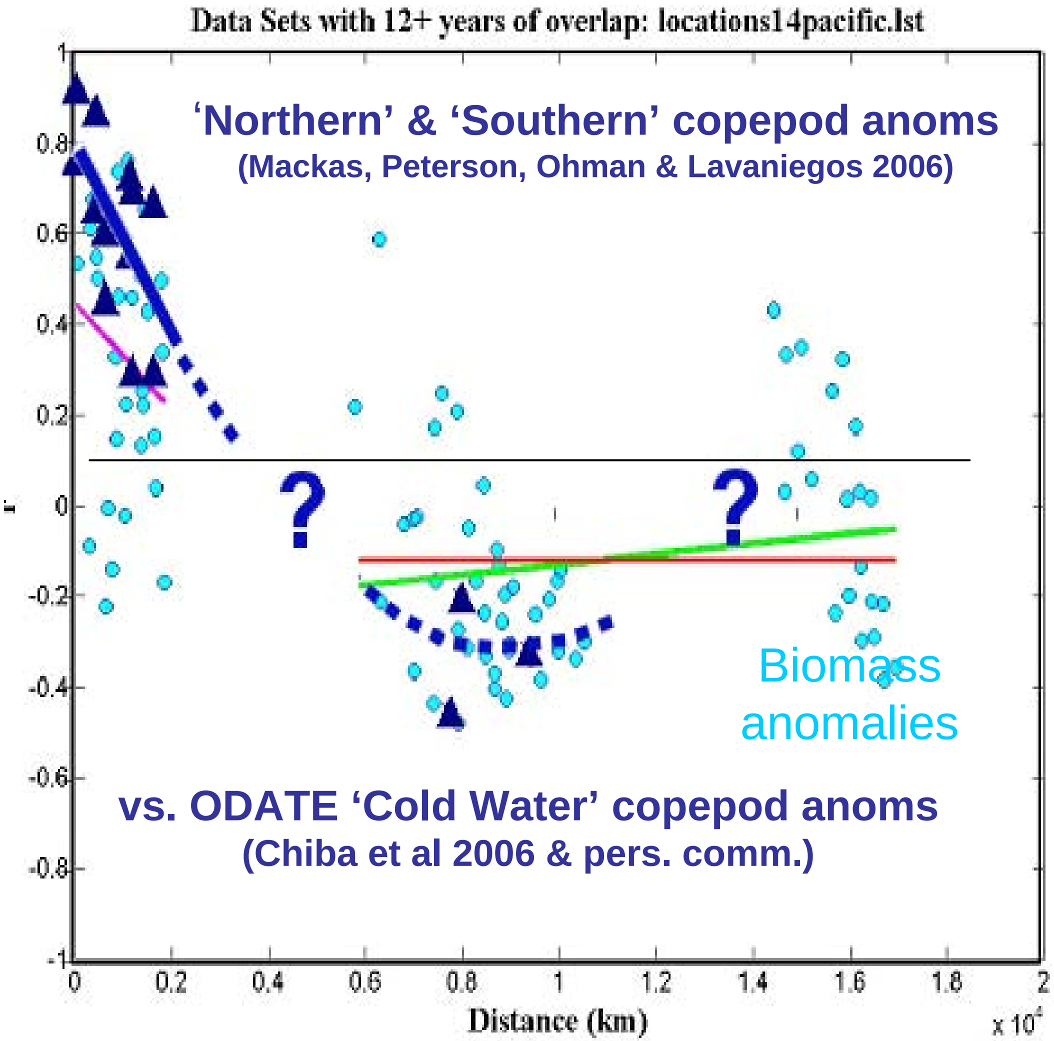


Ohman and Venrick 2003

Community variability can be indexed by biomass or abundance anomalies of individual species (or by averages within 'species group')

Community anomalies at any given site typically have larger amplitudes (by 3-10x) and are less 'noisy' than corresponding biomass anomalies.

Synchrony of 'Composition Regimes' (California Current & Oyashio regions)

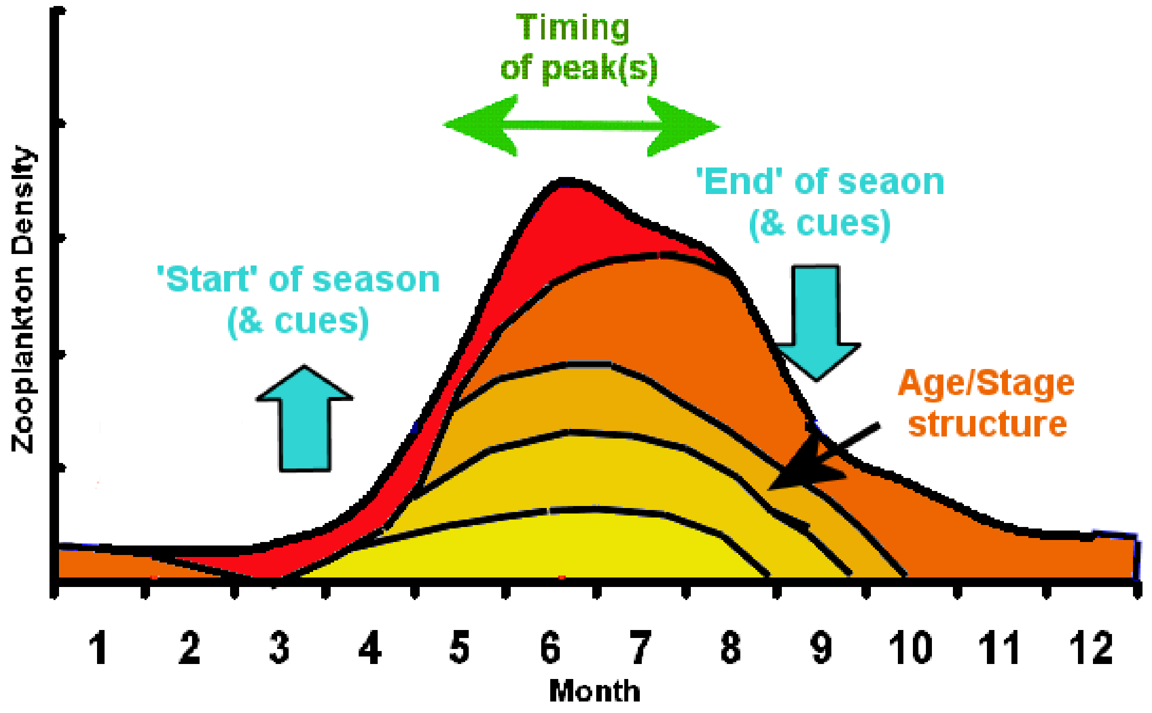


At separations <2000 km, spatial correlation of 'community' anomalies is much higher than correlation among biomass anomalies. Covariance with climate and predator time series is also stronger.

Negative trans-NPacific correlation (8000-10000km) consistent with PDO pattern.

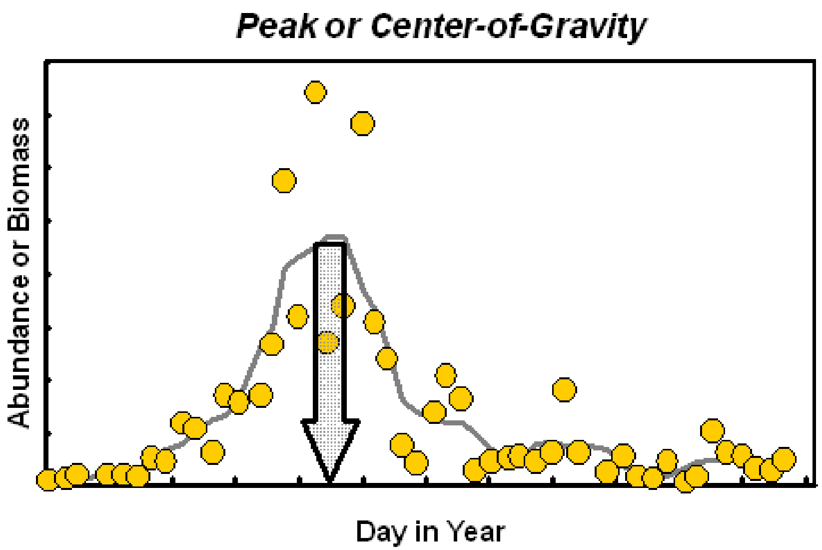
NEED MORE EXAMPLES & BROADER RANGE OF SPATIAL SEPARATIONS!!!

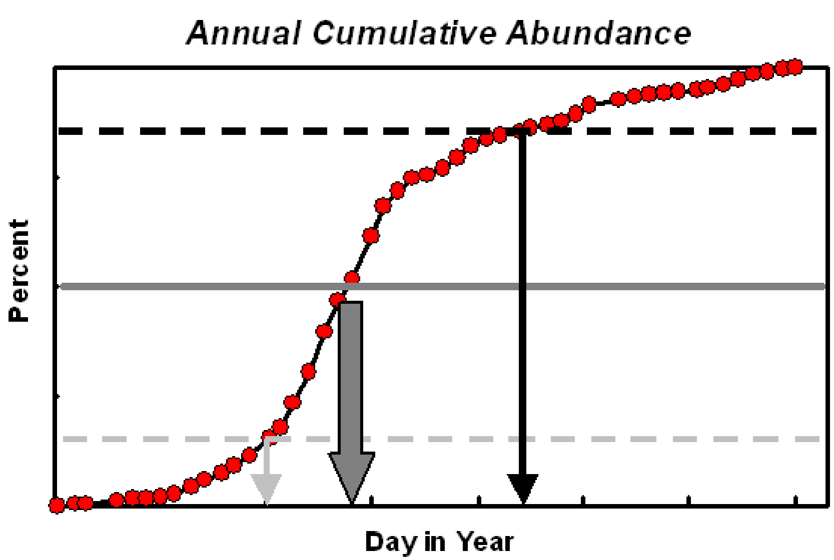
Variability of seasonal timing (a.k.a. phenology) has several interesting components



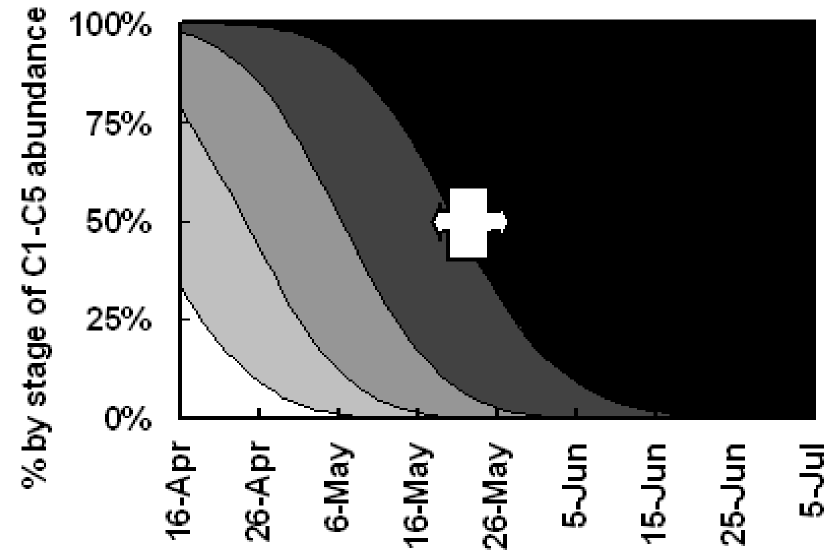
Potential Timing Indices:

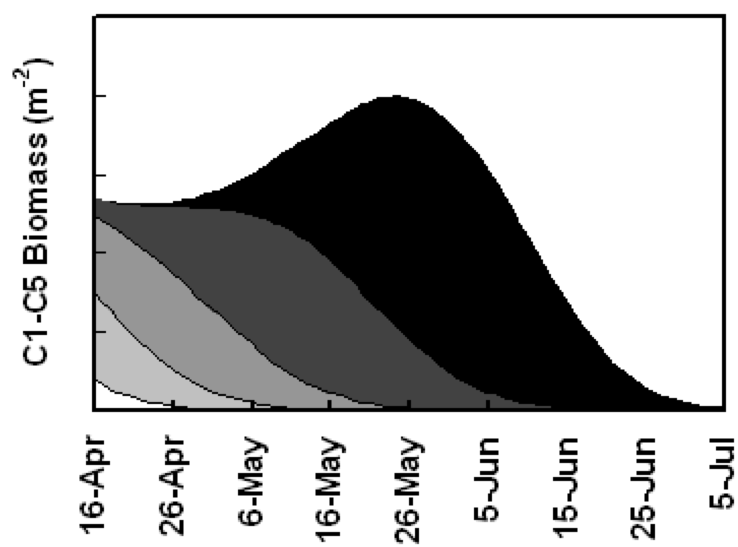
Amount-based





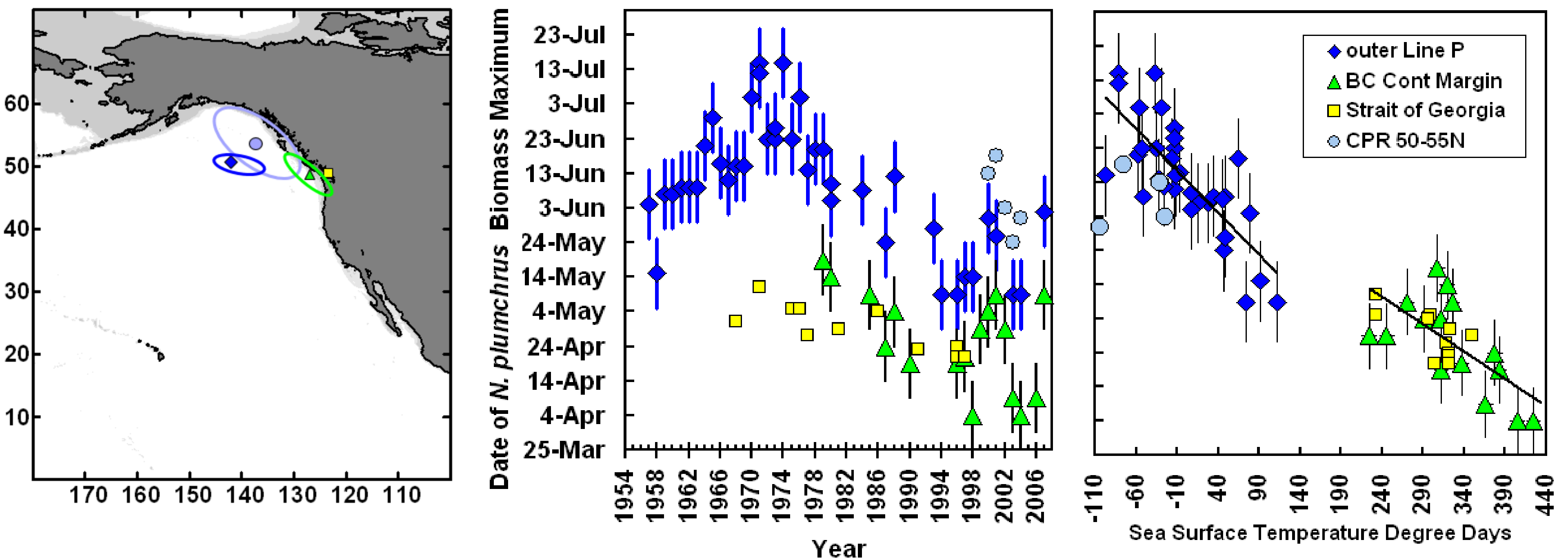
Age-structure-based



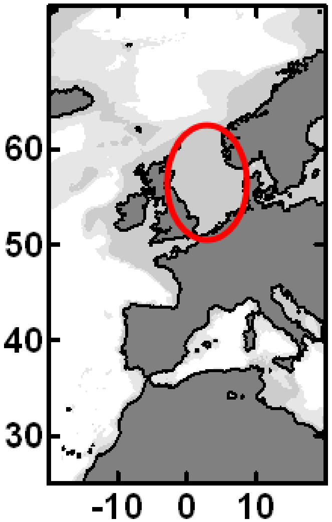


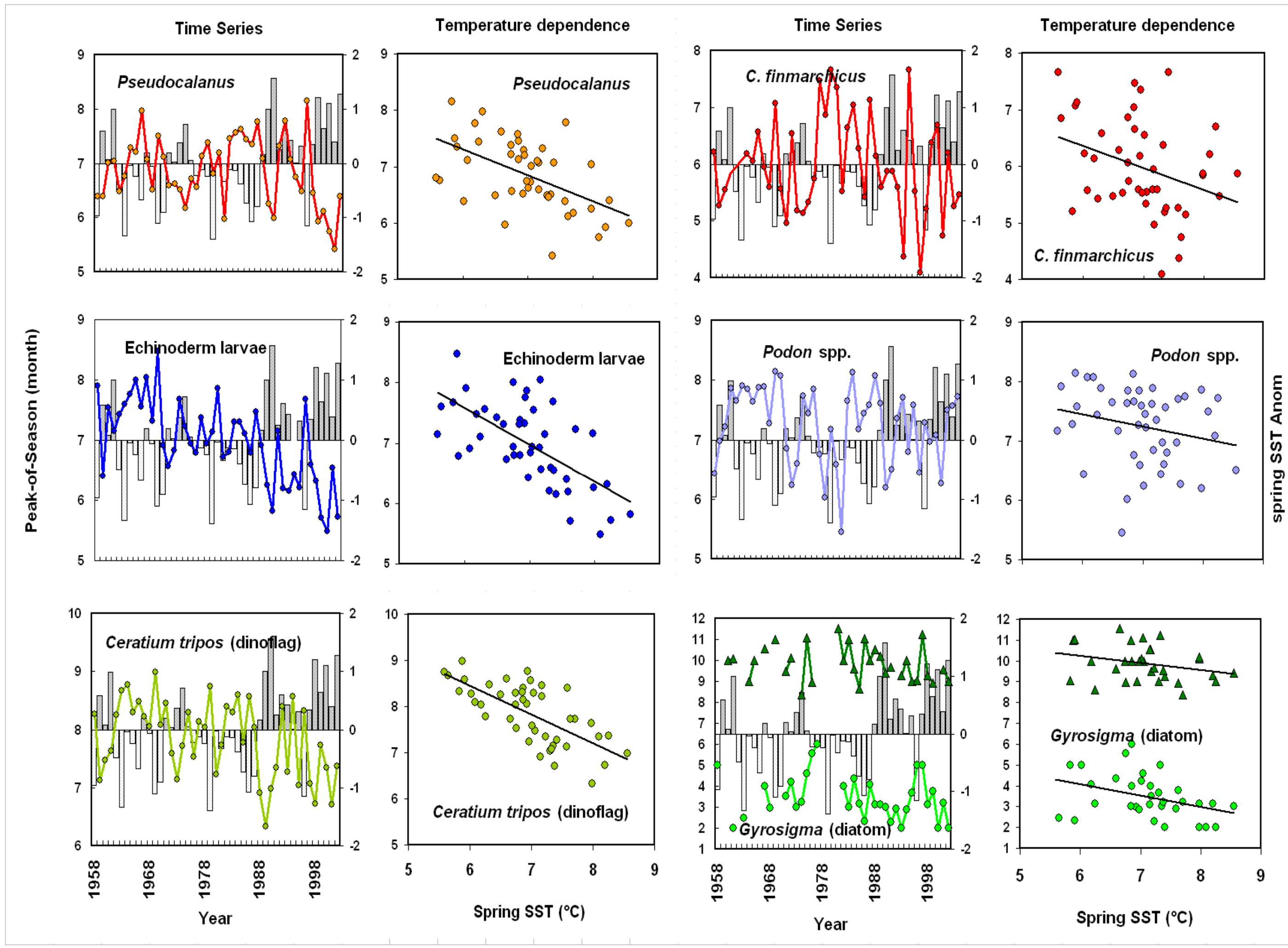
For many species phenologic variability is strongly correlated with temperature anomalies:

Example #1 *Neocalanus plumchrus,* Alaska Gyre, BC coast, Oyashio



Example #2: North Sea CPR surveys



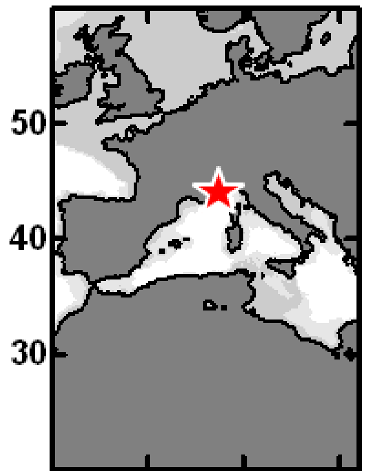


50+ years

Many species exhibit trend to earlier timing

Many species have timing correlated with sea surface temperature

Plots for individual taxa from supplementary data provided by Edwards and Richardson (2004)

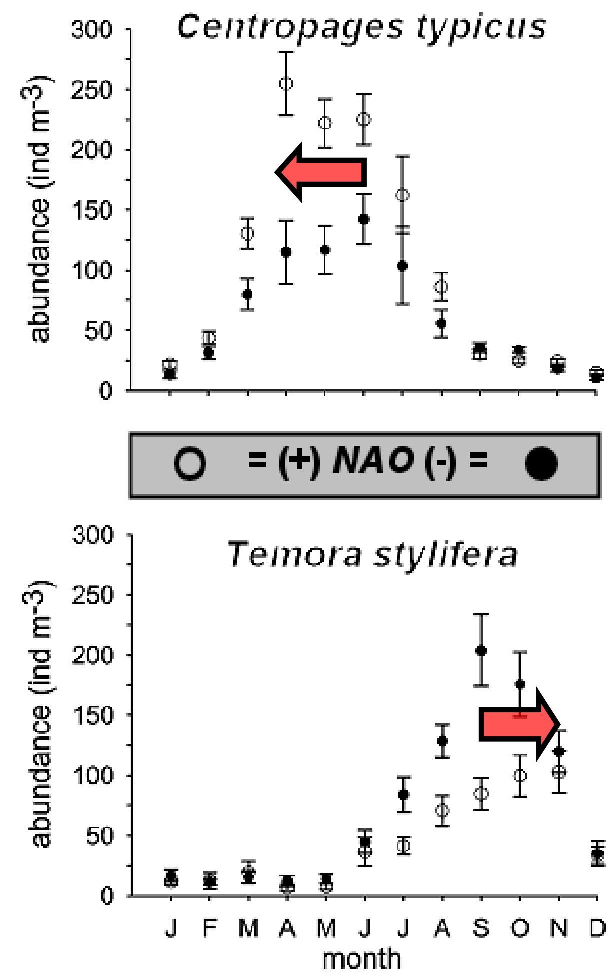


Example #3 (Ville-Franche, Western Mediterranean). Timing vs. T°C dependence can be either (+) or (-), depending on species and season

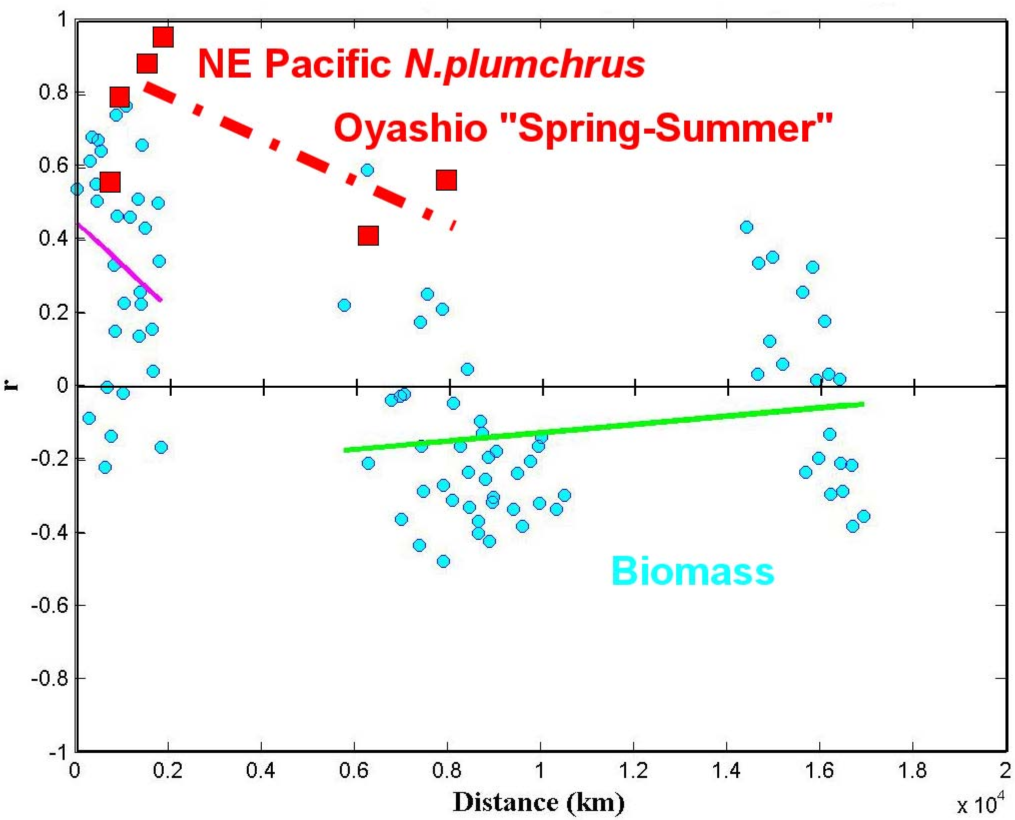
When NAO swung from negative phase (moist, cool) to positive phase (dry, warm) in the late 1980s:

- *Centropages typicus* (a spring dominant) became earlier and more abundant but
- *Temora stylifera* (a fall dominant) became later and less abundant.

(Molinero et al. 2005)

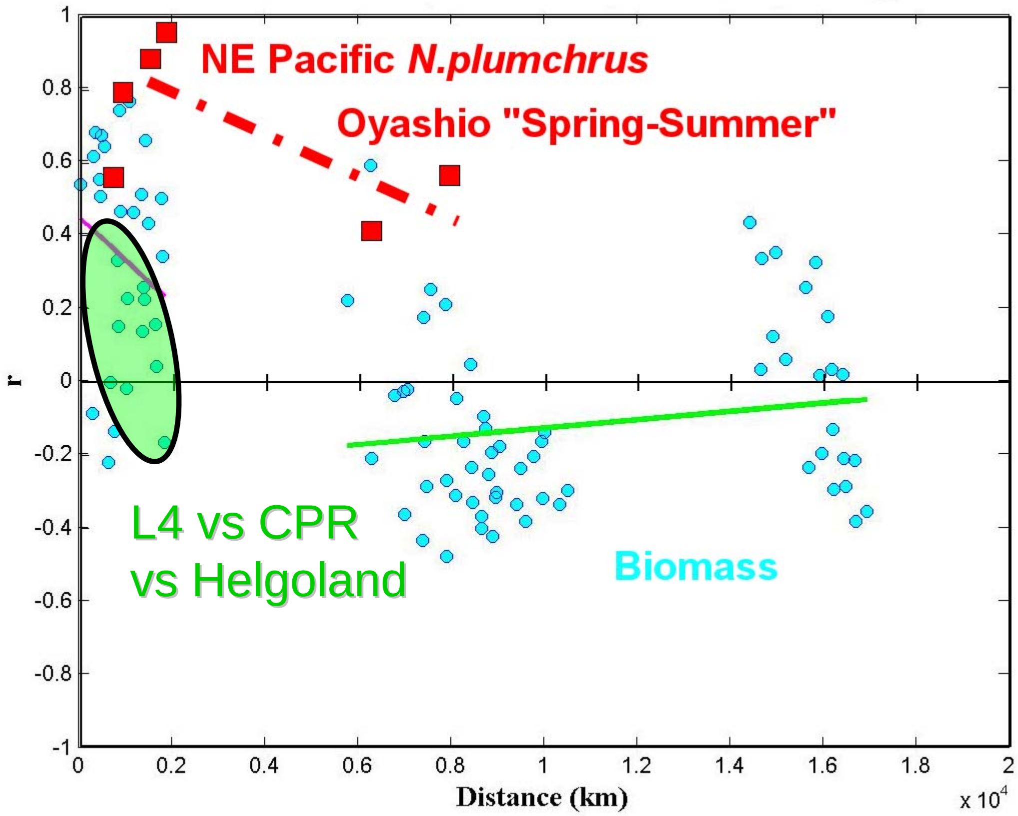


Spatial correlation of 'Phenology' (Subarctic NE Pacific & Oyashio regions)



Seasonal timing can be correlated at basin scale (e.g. *Neocalanus plumchrus* across the entire North Pacific). This may primarily reflect shared response to an upward trend of spring summer SST late 1960s-late 1990s).

Spatial correlation of 'Phenology' (Subarctic NE Pacific & Oyashio regions)



Conversely, correlation can also be weak at relatively close separations (e.g. Plymouth, North Sea CPR, and Helgoland time series sites around the North Sea).

Here, weak correlation probably reflects different controls on temperature at tidally-mixed vs stratified sites. Sites share similar temperature vs timing regressions for many species

AGAIN, NEED MORE EXAMPLES & BROADER RANGE OF SPATIAL SEPARATIONS!!!

Summary

- Spatial coherence scale for zooplankton depends on what mode of variability we are examining.
- Biomass correlation is relatively weak and mostly 'within 'region' (<3000 km)
- Variability of community composition and zoogeography is coherent at up to basin scale (matches atmospheric forcing?)
- Variability of phenology can be very broad or quite local (matches locally dominant process for T°C control?)

MORE EXAMPLES WOULD BE VERY USEFUL!!

If you have a zooplankton time series you are willing to include in this comparison, please contact us.

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