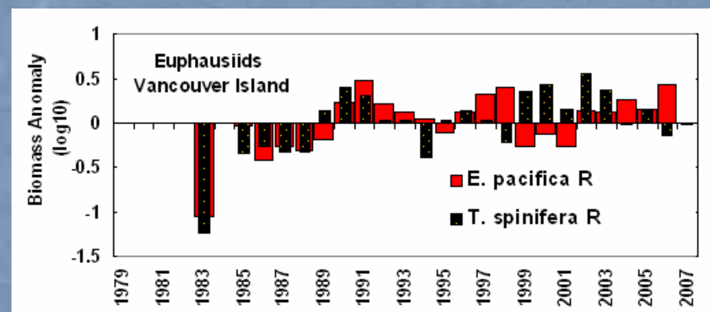
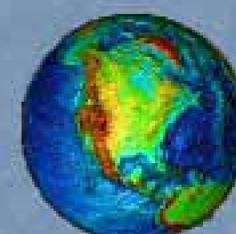
Climate-associated latitudinal shifts of zooplankton species and species assemblages





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('Data Partners')

Time series of zooplankton species abundance and community composition are expensive and laborious:

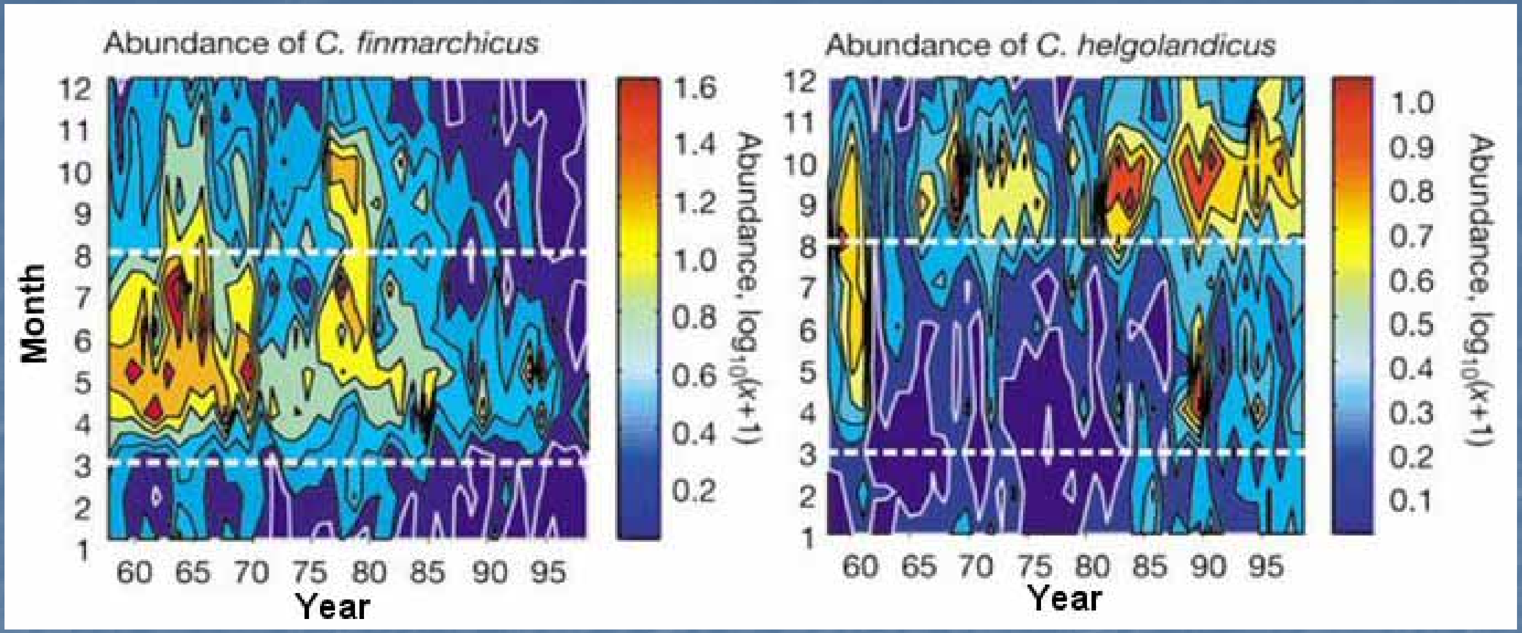
- Field work to collect & process samples
- Taxonomic ID, verification
- Species level enumeration
- Data entry and archival
- Sample archival and curation
- Data extraction and analysis
- Univariate/Multivariate interpretation

- We don’t have many long species-level time series. Are those we DO have informative?

- Of special interest: Timing, causes & consequences of major shifts in zooplankton species composition

1. The 50+ year Continuous Plankton Recorder program:

Beaugrand et al (2003a, 2004)

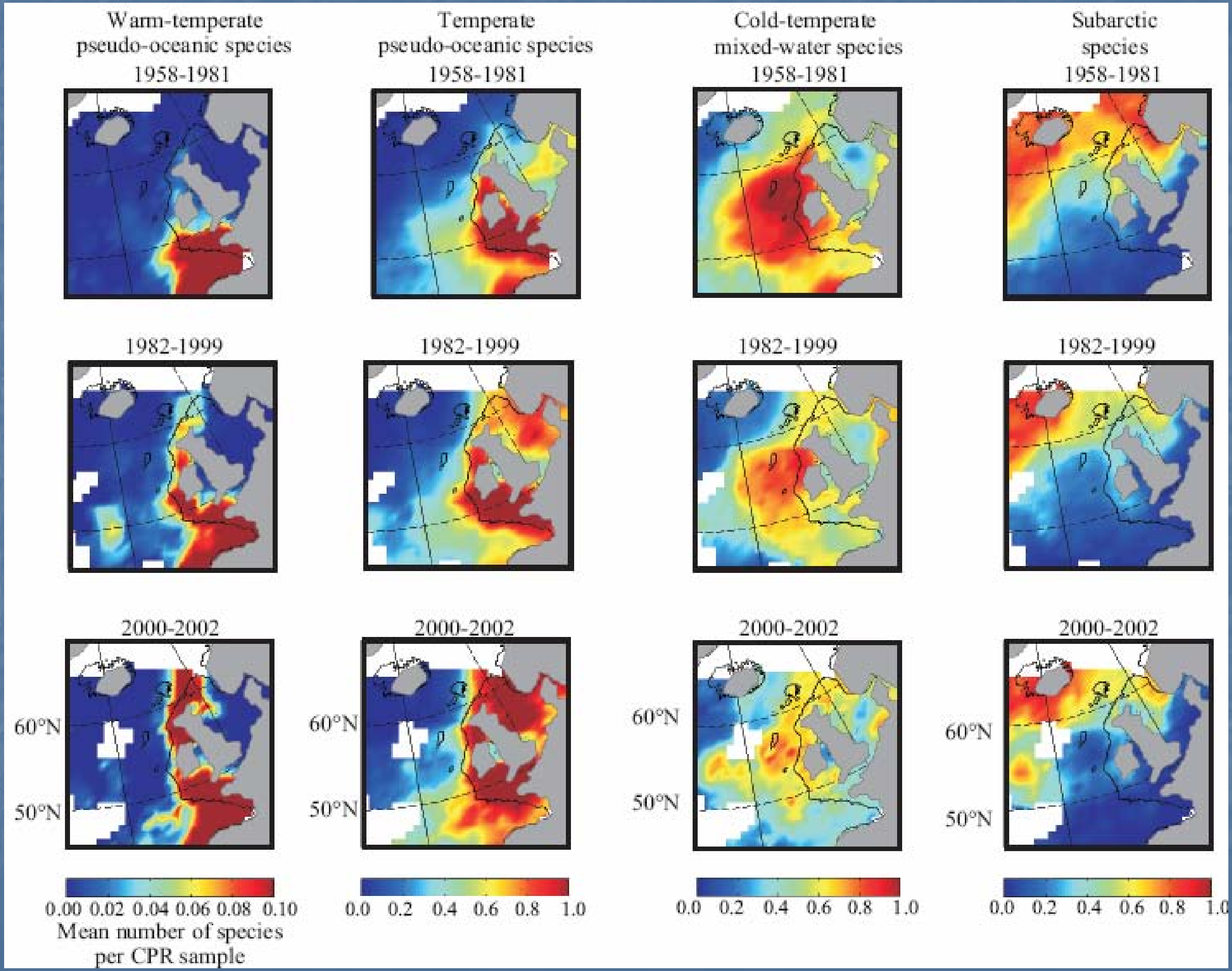


During the 1980s, *Calanus helgolandicus* rapidly replaced *Calanus finmarchicus* in the northern North Sea. Other concurrent changes :

- Ocean warming
- Changes in overall zooplankton seasonality
- Changes in zooplankton size structure & total biomass
- Very low cod recruitment

All appear to be connected to each other AND to:

Broader shifts of zoogeographic boundaries documented by presence/absence of 'indicator' taxa



Beaugrand et al. 2003b

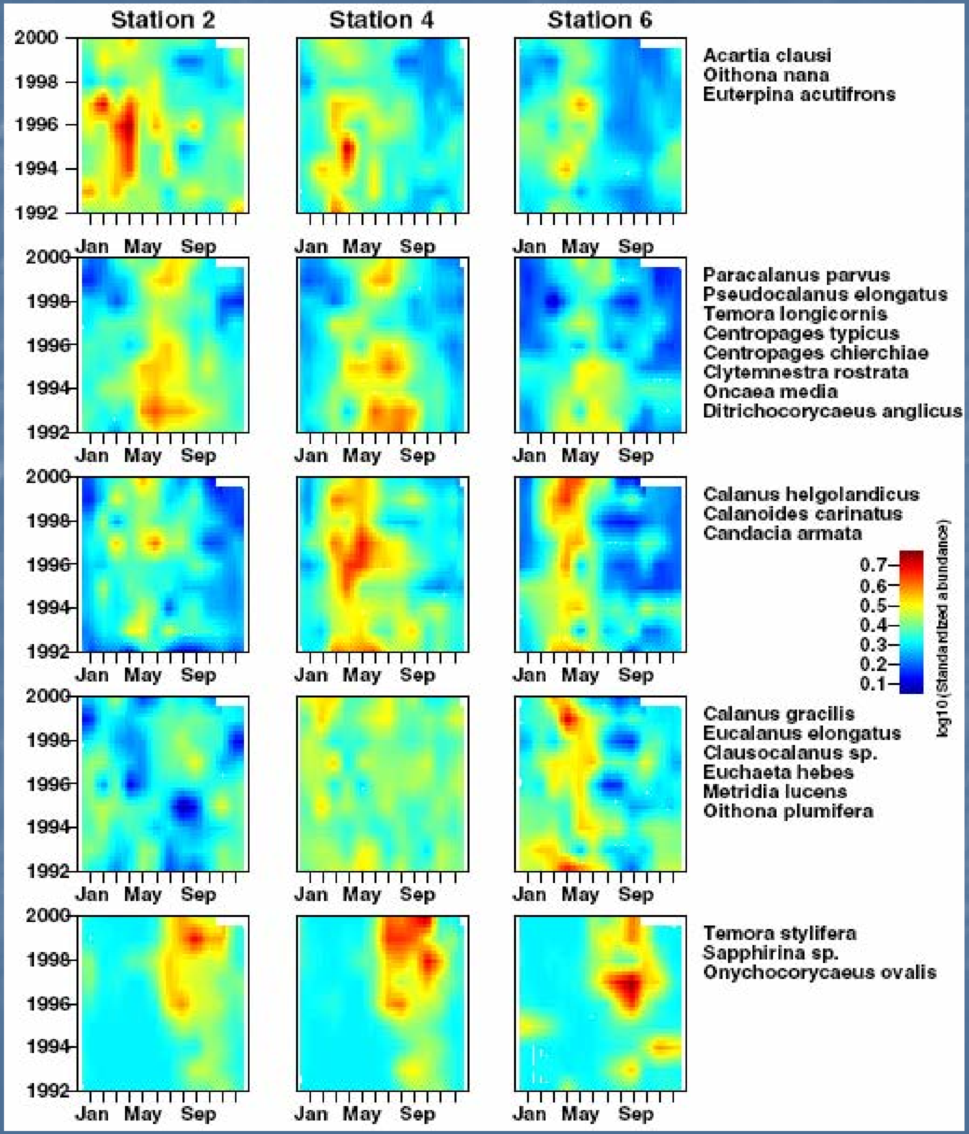
In Iberian waters, the Project Radiales time series (1991-present) has found similar linked trends:

Physics:
(not shown)

↑ T° C in summer,
↓ T° C in winter

↓ upwelling wind stress τ

↑ density stratification



Valdés et al 2007

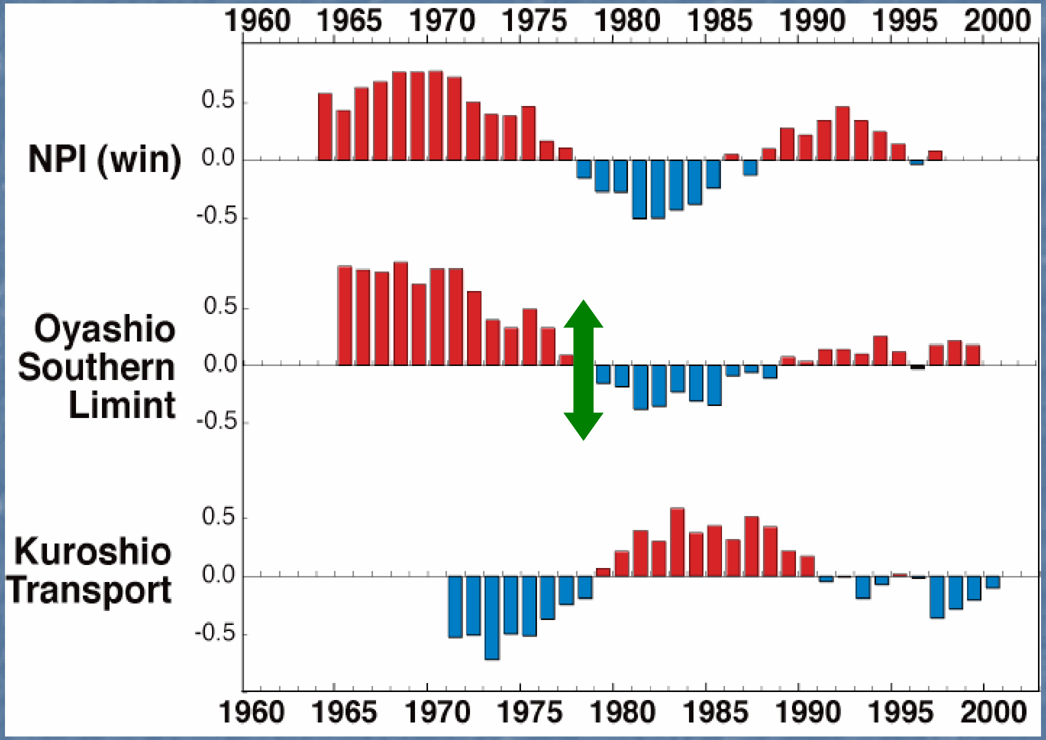
Zooplankton:

~ to ↑ total biomass

Appearance & persistence of subtropical species

Declines of several temperate species

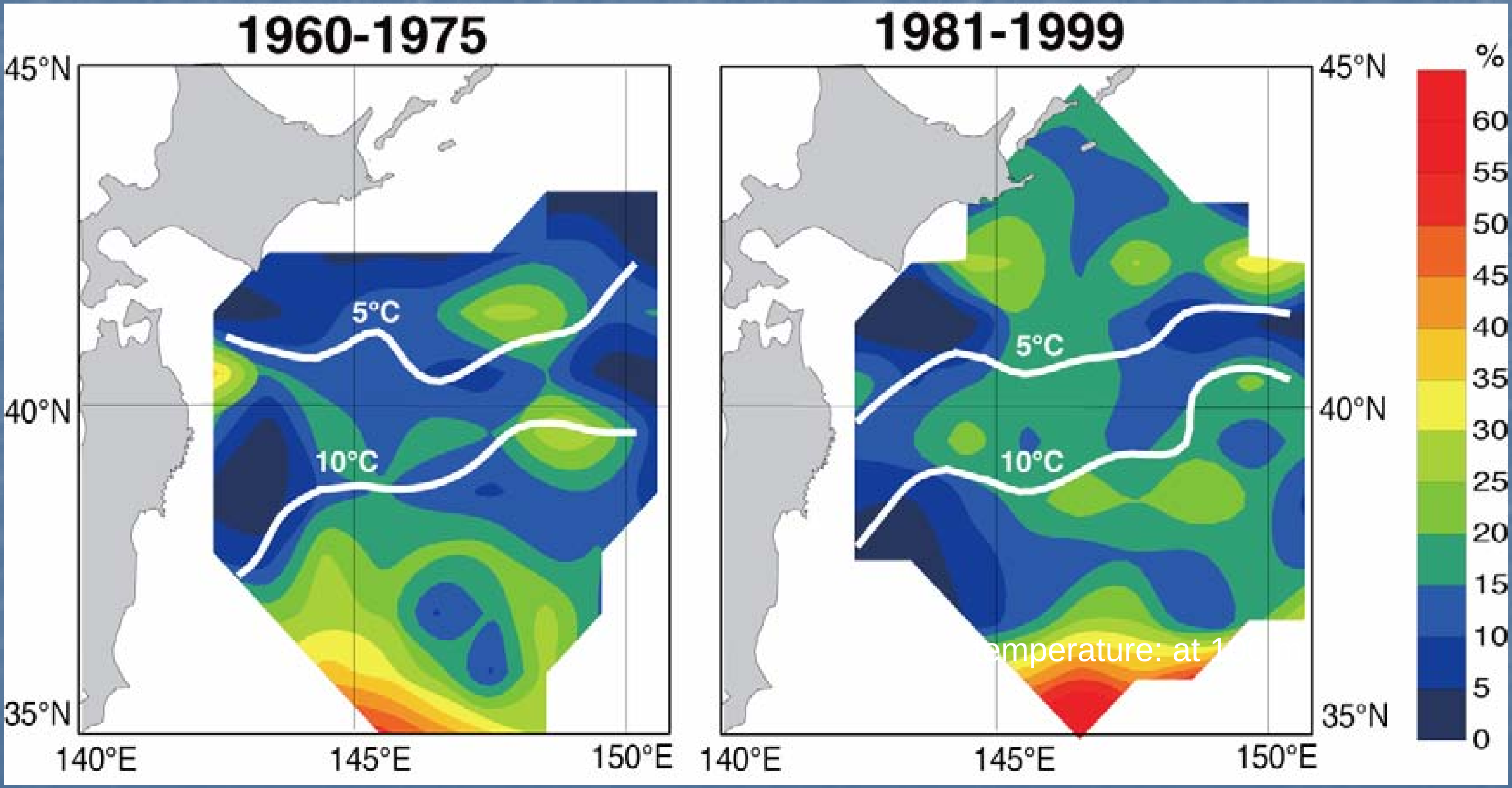
Meanwhile, in the NW Pacific : Large decadal changes in atmospheric (Aleutian Low) & Kuroshio-Oyashio Dynamics



- Big 'climate' index trends late 1960s-mid 1980s,
- Zero crossing by 3 indices occurred ~1976.
- Ongoing physical fluctuations though the early 2000s have been associated with changes in biological productivity

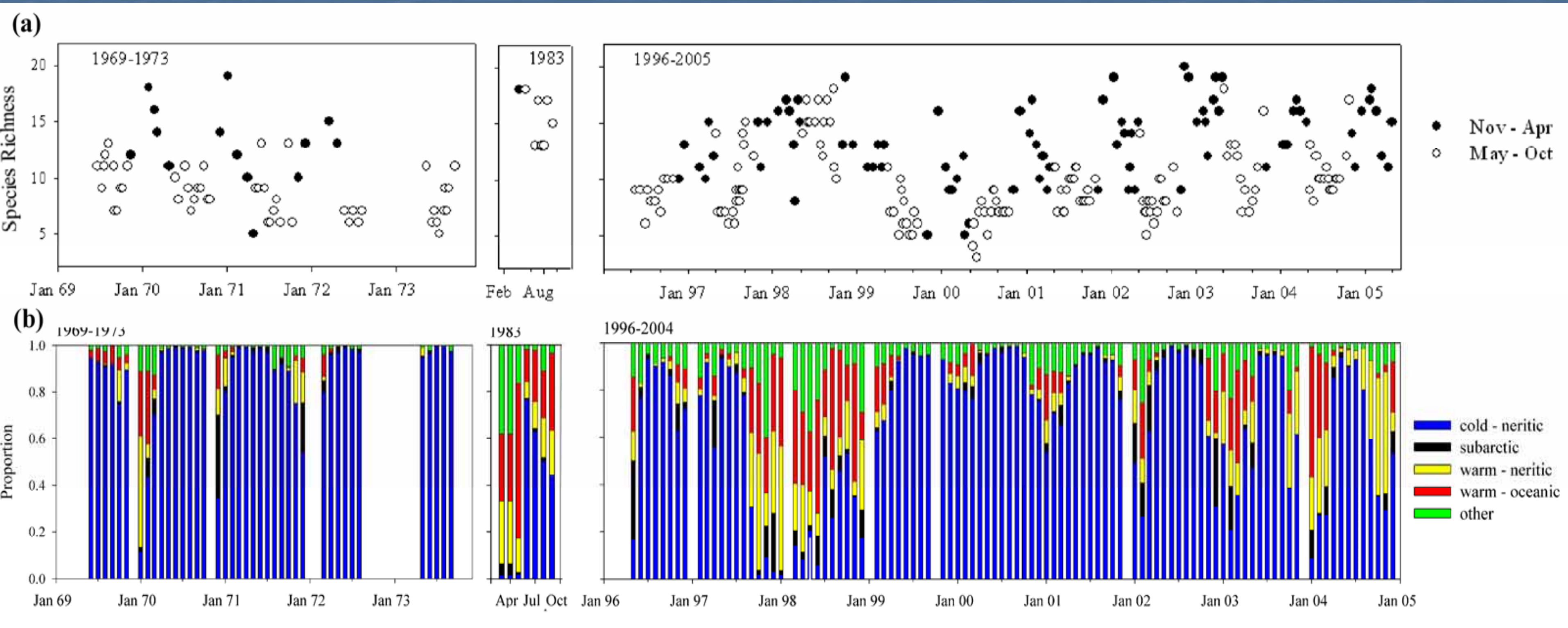
Be sure to see Sanae Chiba's talk on Thursday morning!

Subtropical copepods are increasing north of the Oyashio/Transition front



Occurrence rate before & after 1976

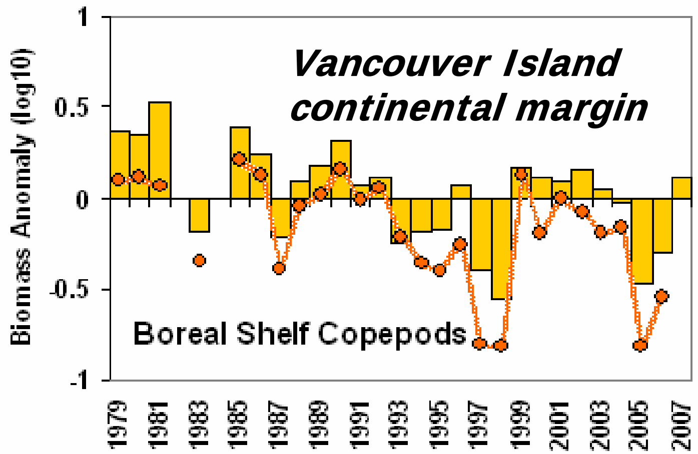
Latitudinal displacements in the California Current

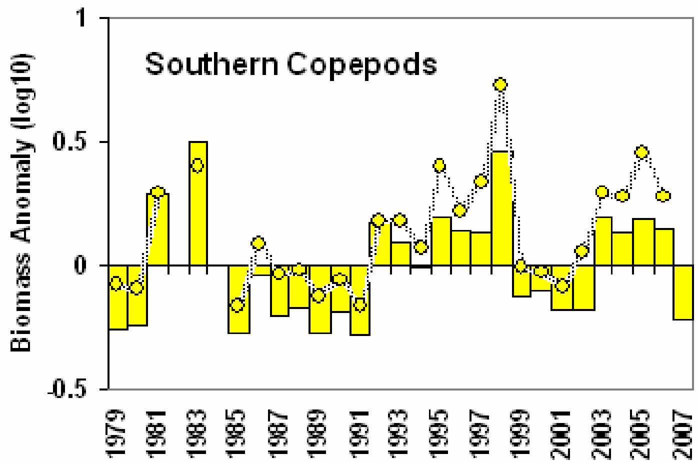


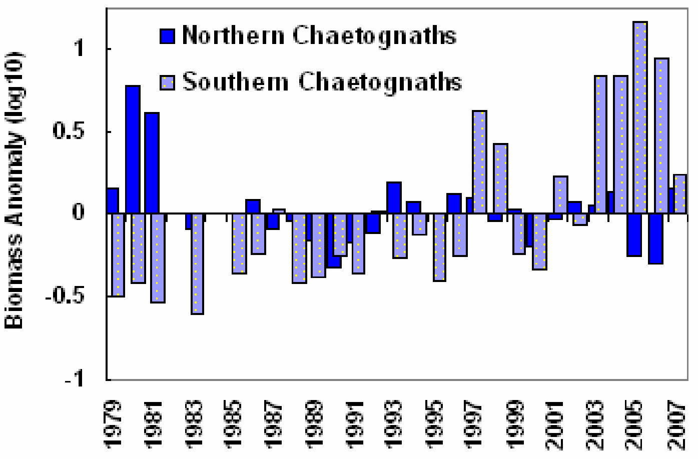
Seasonal currents transport ‘warm water’ taxa poleward each winter.

Strong annual signal of both species composition & species richness (above, from Hooff & Peterson, 2006)

Poleward flux is greatly amplified in El Niño years (1983, 1997-98) and also during Niño-like local conditions (2004-2005)



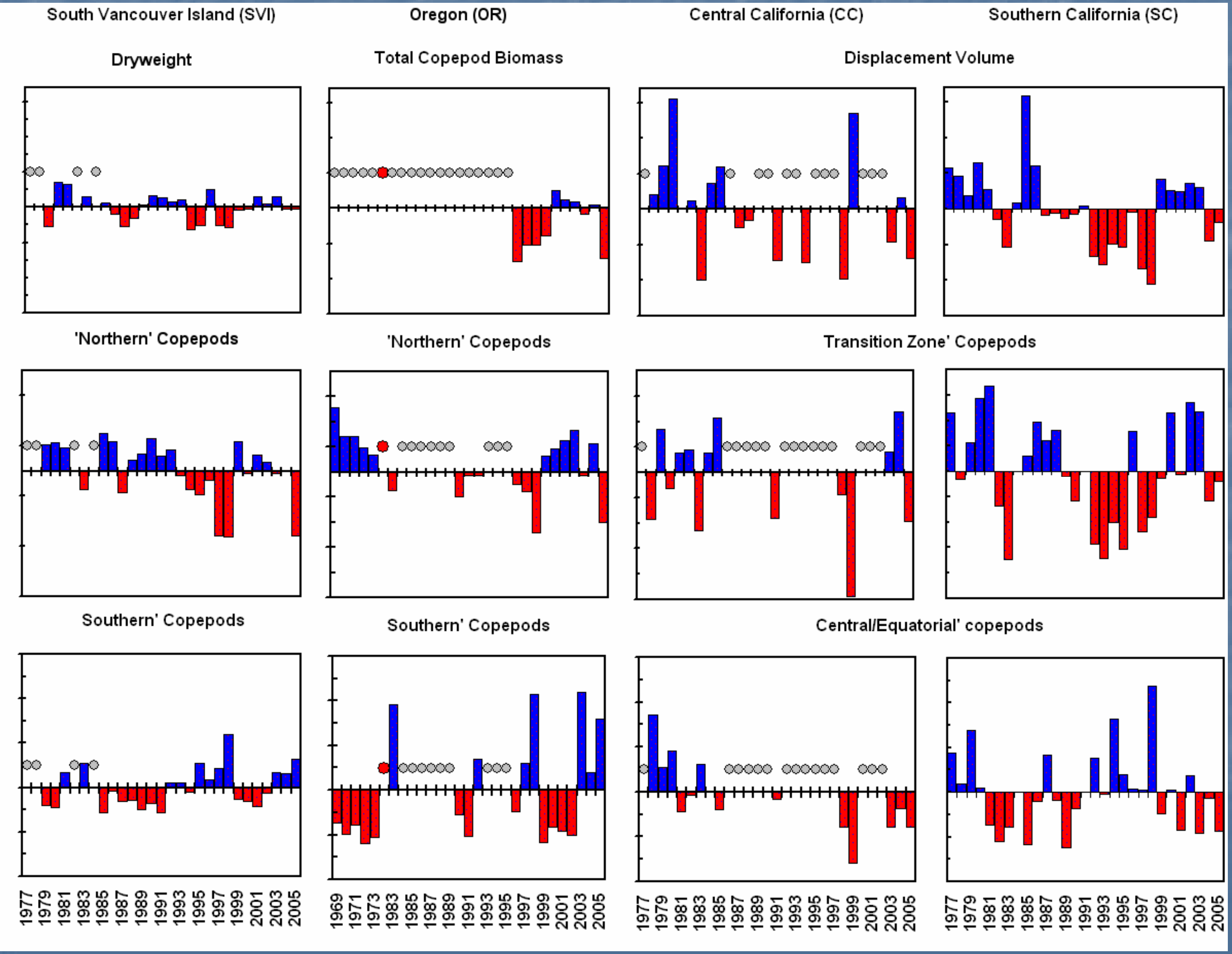




Some consequences:

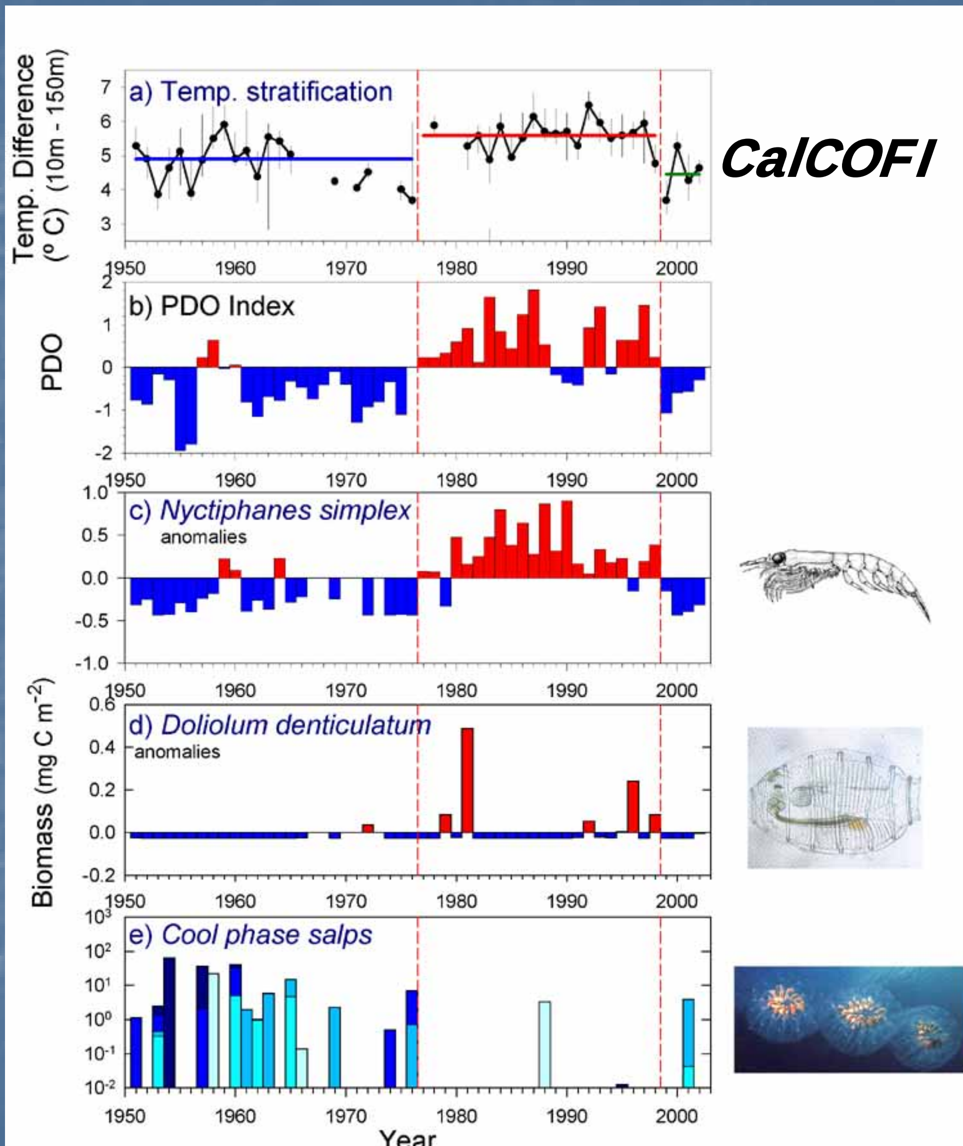
- Biomass/abundance fluctuations in the CCS become mirror images (N vs S origin , high vs low total)
- Log scale anomaly span is equivalent to 10x -50x change in abundance
- Spatially coherent throughout the CCS (see next page)
- Zooplankton anomalies lag transport anomalies by 0.5-2 years

Alongshore coherence in the CCS: Canada to Mexican border



- Anomaly time series are correlated over a 2000 km span: (| *r* | = 0.2-0.8)
- Beyond this span, the correlation decays steeply both equatorward (Baja California) and poleward (N end of Vancouver Island)

"Composition Regimes" in the California Current

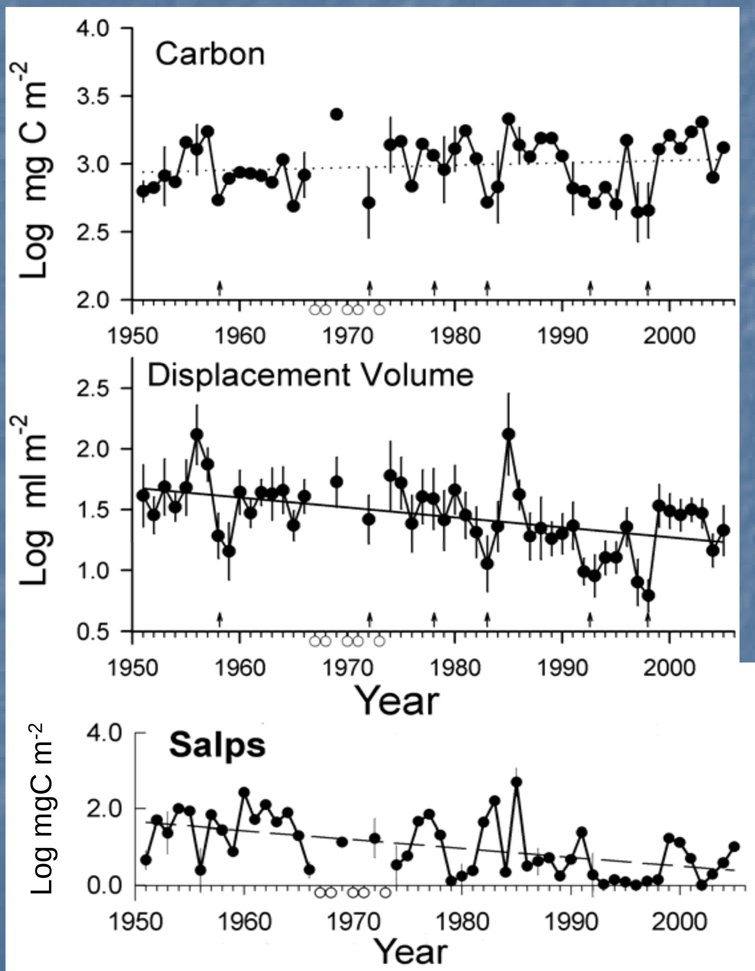


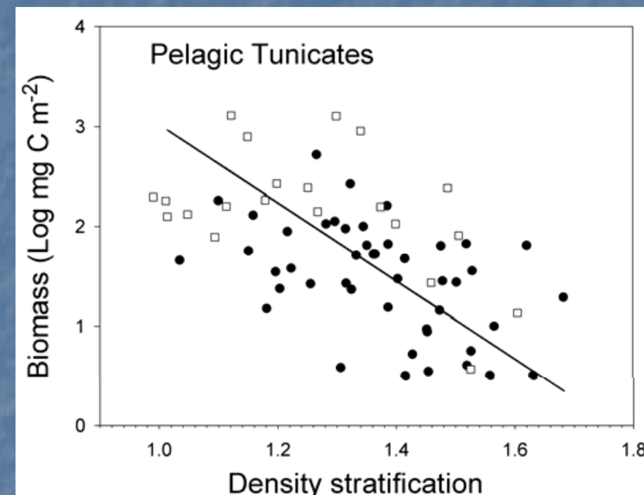
Individual species anomaly time series have larger amplitudes and are smoother (higher signal:noise?) than biomass or biovolume time series.

Covariance with climate and predator time series is also often stronger.

Ohman and Venrick 2003 Oceanography 16:76-85

But knowledge of composition can improve interpretation of biomass/biovolume time series

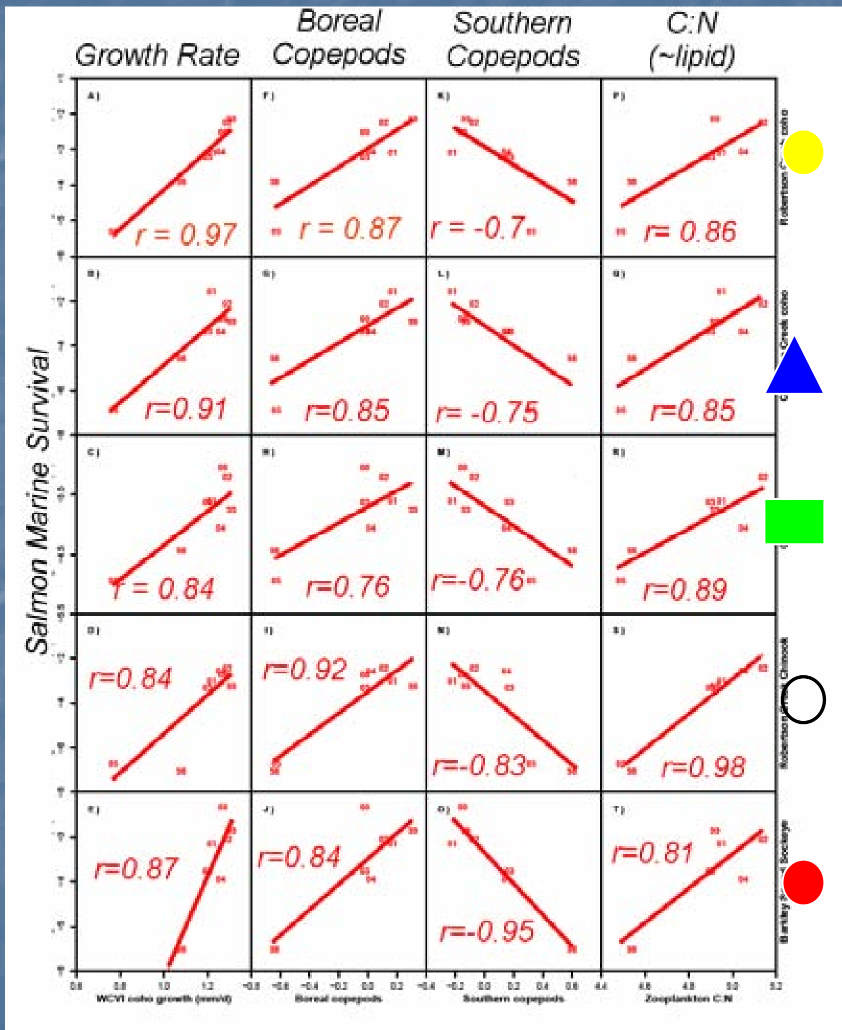




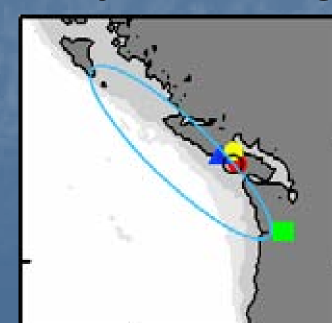
The famous downward trend of CalcOFI biovolume is mostly a decline of salp abundance. No trend in total zooplankton carbon.

(Lavaniegos and Ohman, 2007)

Zooplankton composition anomalies affect fish:
(example: marine survival and growth rate of young salmon)



- "Junk Food" hypothesis: abundant but low quality food does not support predator growth
- Predators that can't grow soon become prey
- 'Boreal' copepods are bigger & fatter than 'southern' copepods (lipid to support seasonal dormancy)
- Correlates of survival for five intensely-monitored salmon stocks that share first year foraging area



Trudel et al., this meeting

Where are we today with comparison of zooplankton community time series?

- (Not as far as I'd hoped)
- Good between-site comparisons <u>within</u> regions where sites share species (examples in this paper, plus Baltic & Mediterranean)
- Similar comparisons coming soon from within Benguela & Humboldt Currents
- But access to species level data remains a barrier (although some great web-based archives & tools are appearing)
- Also need to identify and compare time series of 'equivalent' species and species groups

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