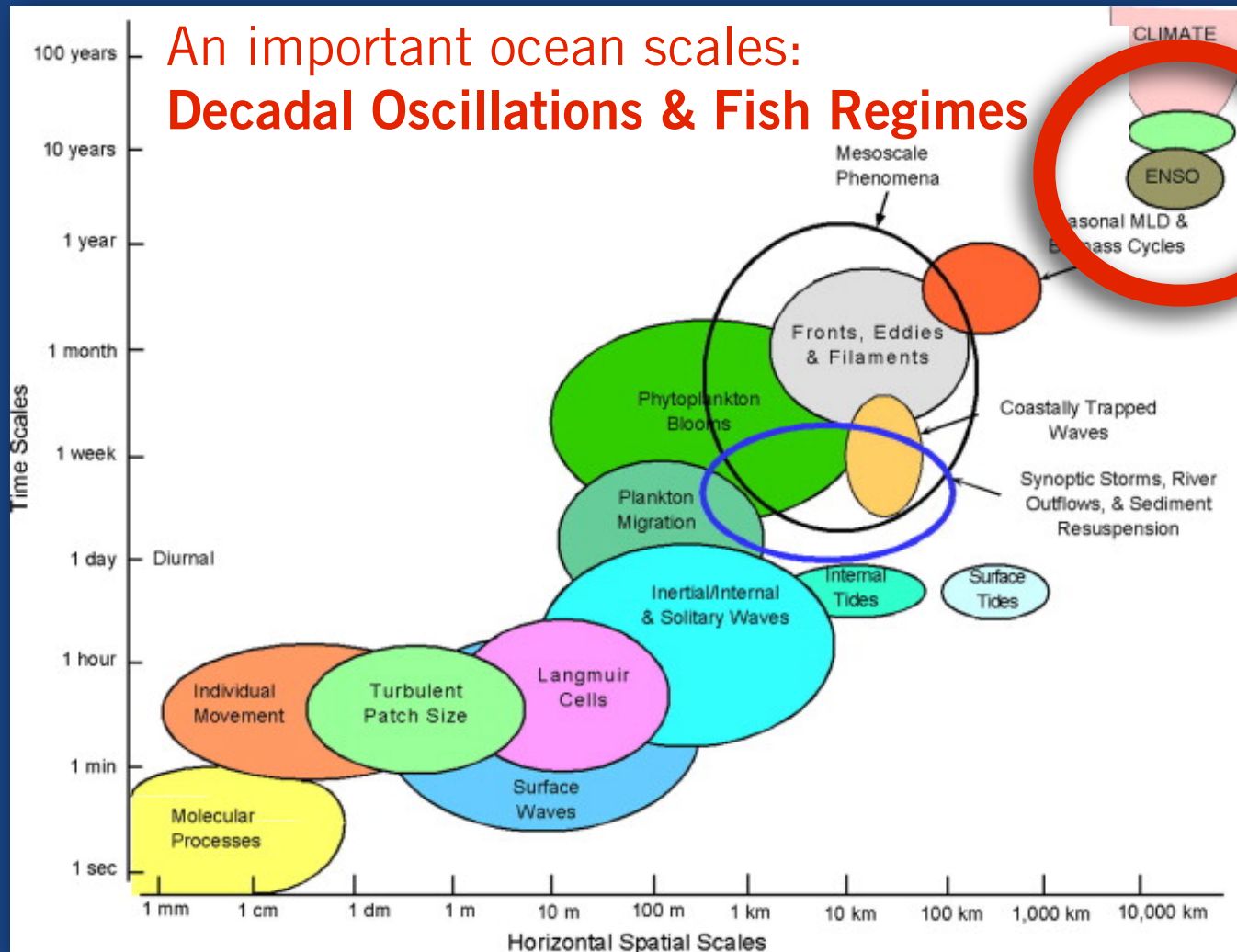


Natural Climate Variability & Ocean Ecosystems

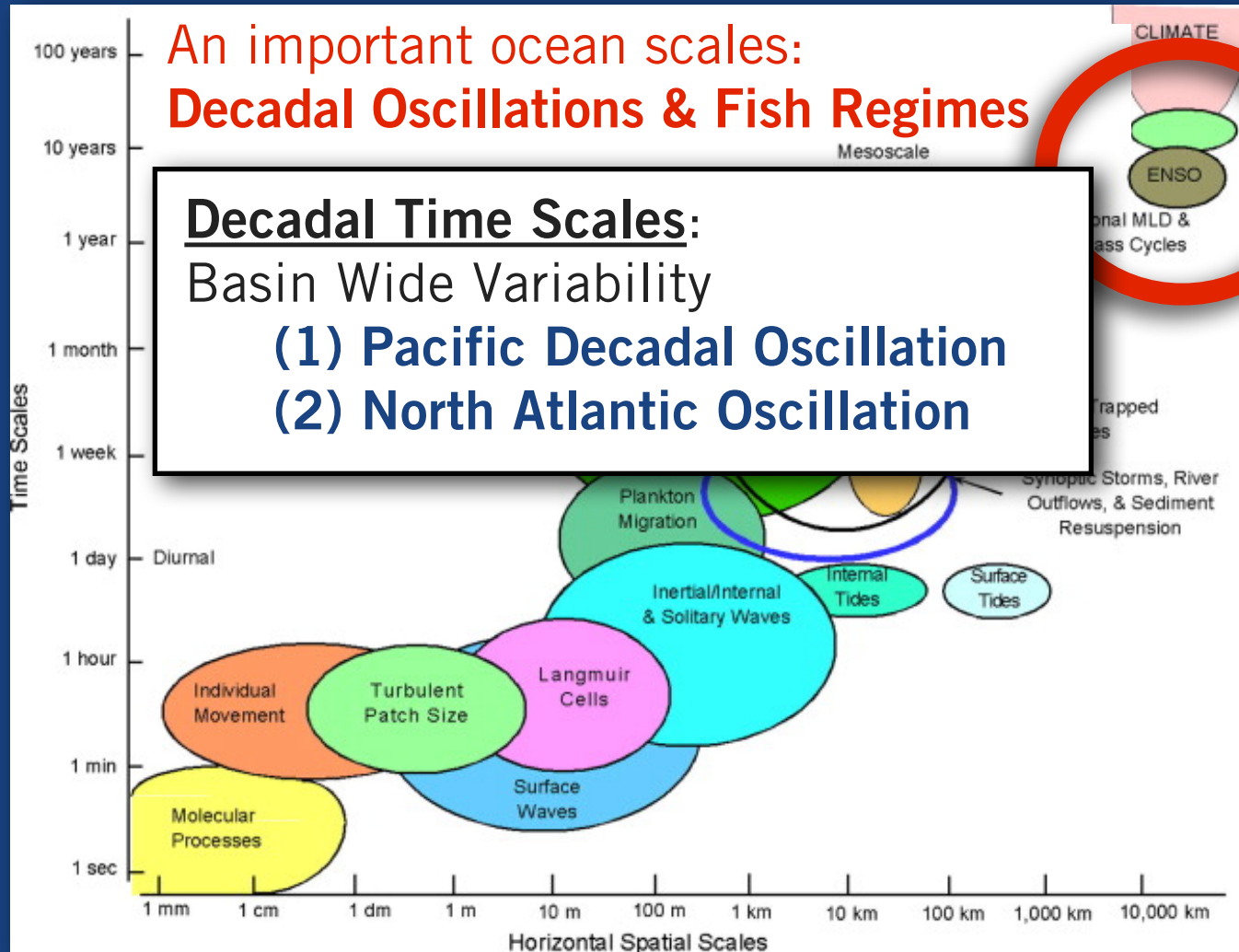
Time-scales



Spatial-scales

Natural Climate Variability & Ocean Ecosystems

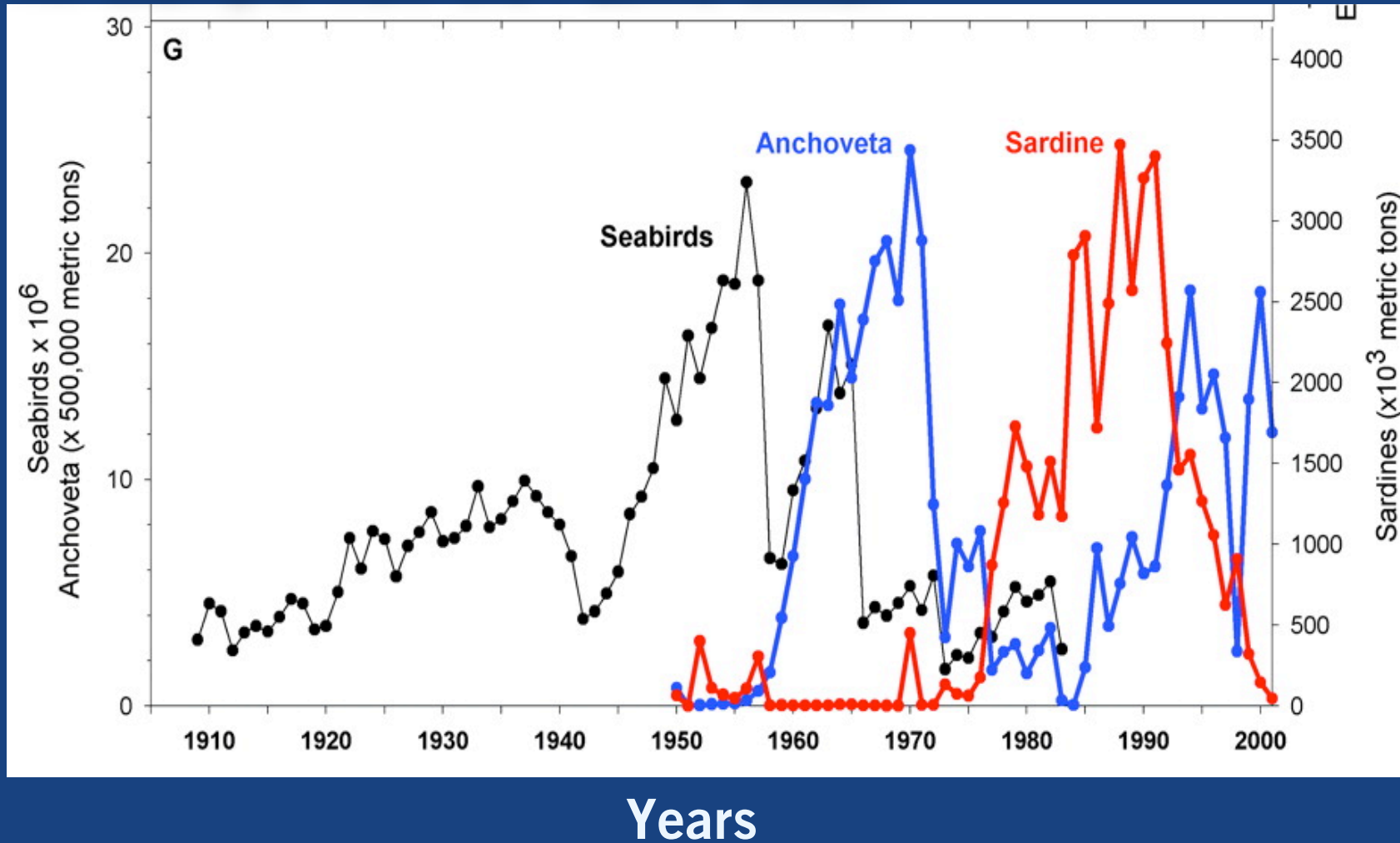
Time-scales



Spatial-scales

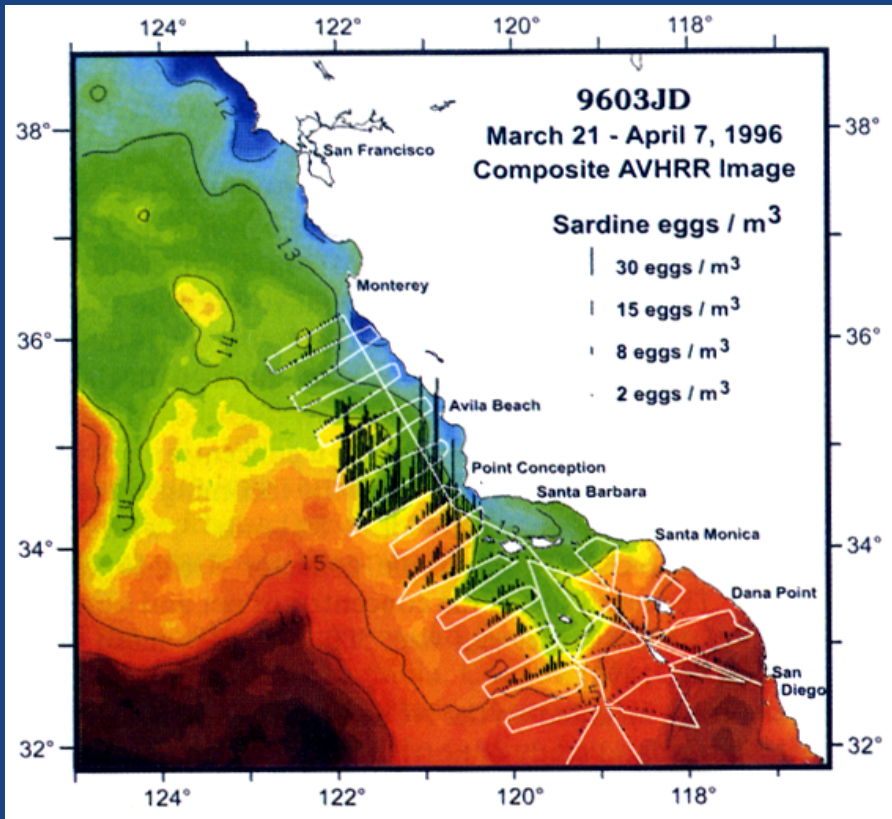
Long-term fluctuations in Fish Stocks

An example from the Pacific Ocean

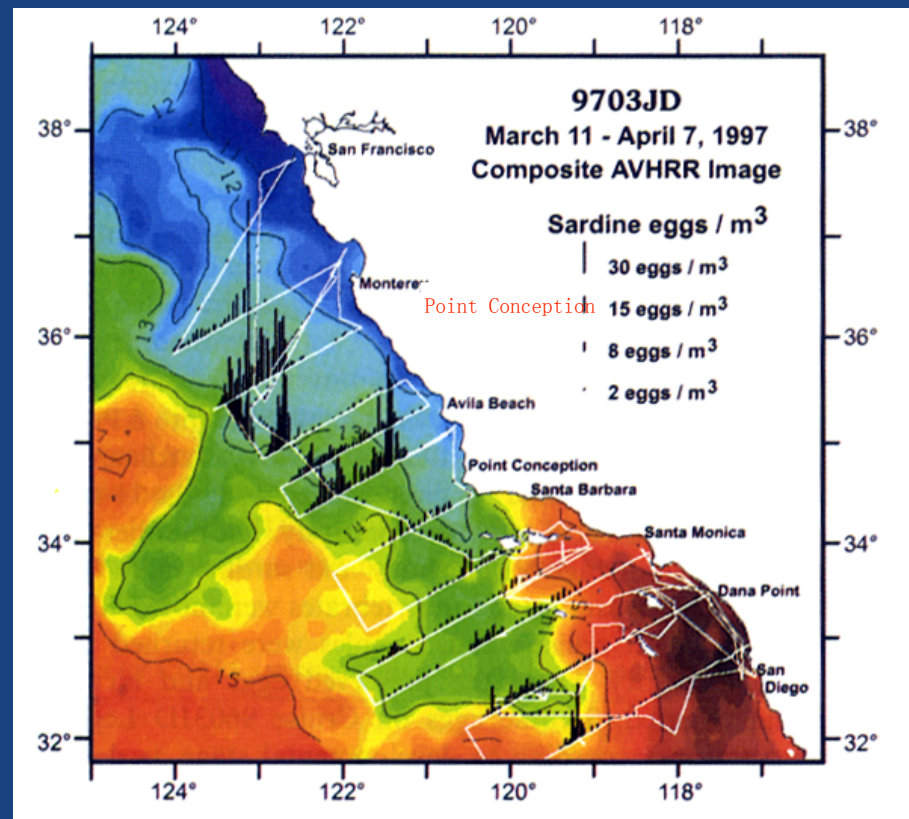


Sardine Eggs Distribution & Ocean Temperatures

1996



1997



Egg sampling in the California Current (Pacific Ocean)
Checkley et al. 2000

Regional Climate Indices track Fish Stocks

Warm/Cold Phases
may be linked to Fish

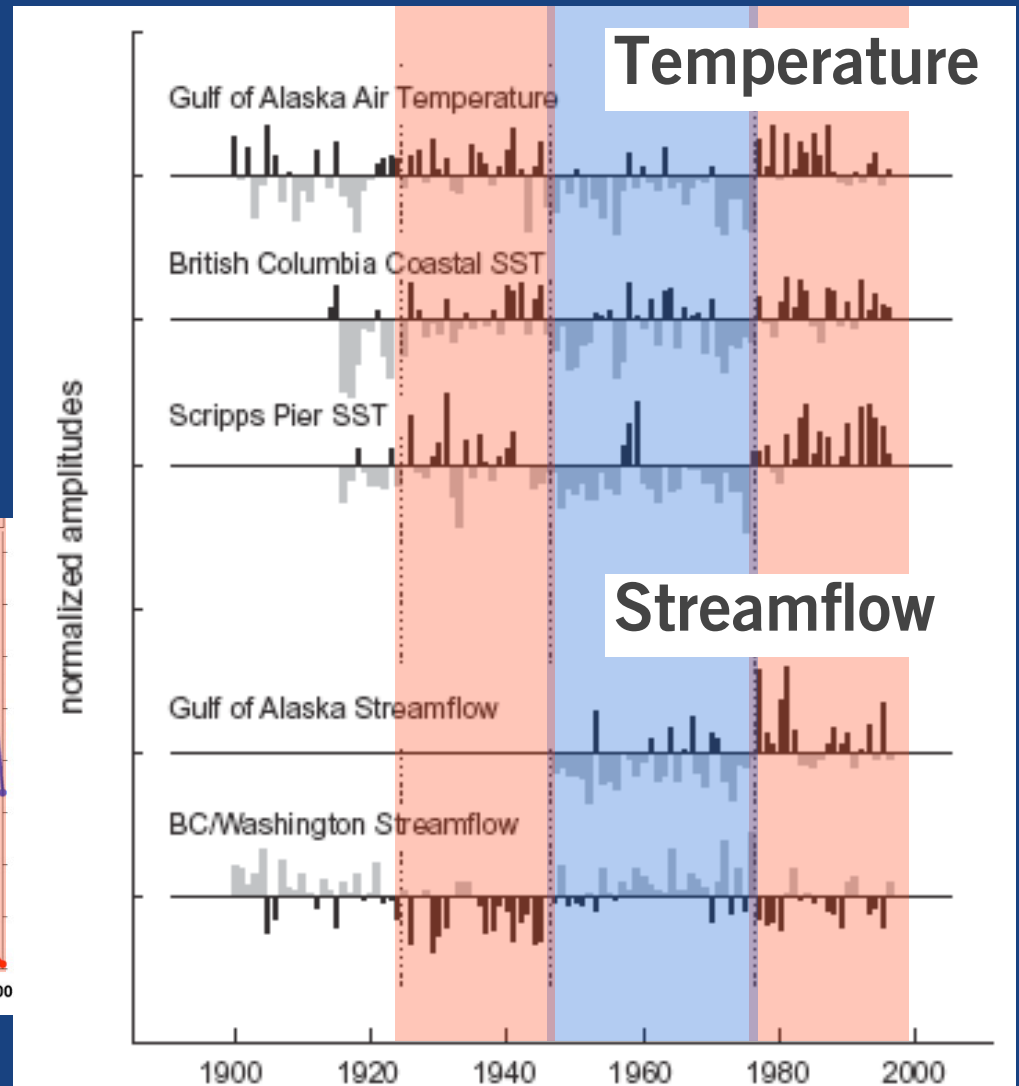
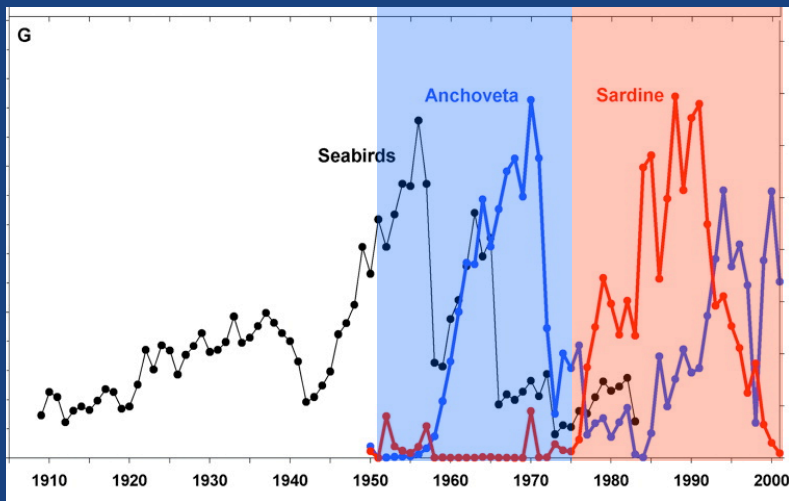


FIG. 5. Selected regional climate time series with PDO signatures. Dotted vertical lines are drawn to mark the PDO polarity reversal times in 1925, 1947, and 1977. Bars are shaded as in Fig. 1, with the shading convention reversed for the BC/Washington streamflow index.

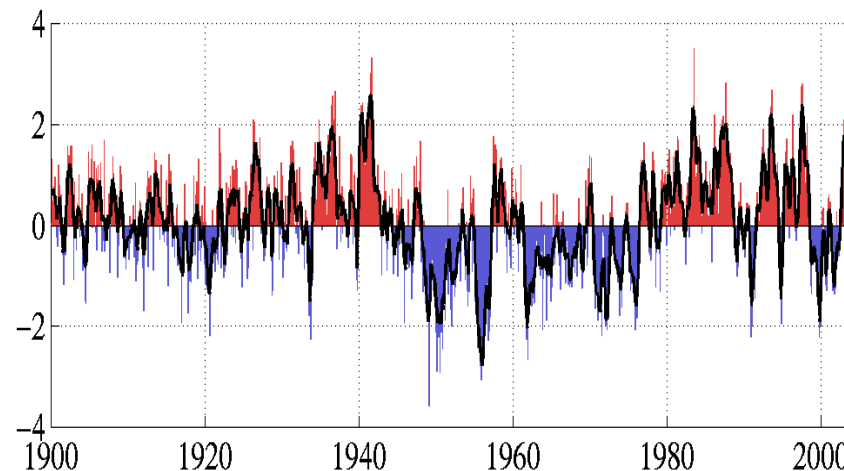
Regional Indices & Basin-scale Climate

Most of the regional indices reflect large-scale climate variations

in the North Pacific they can be summarized

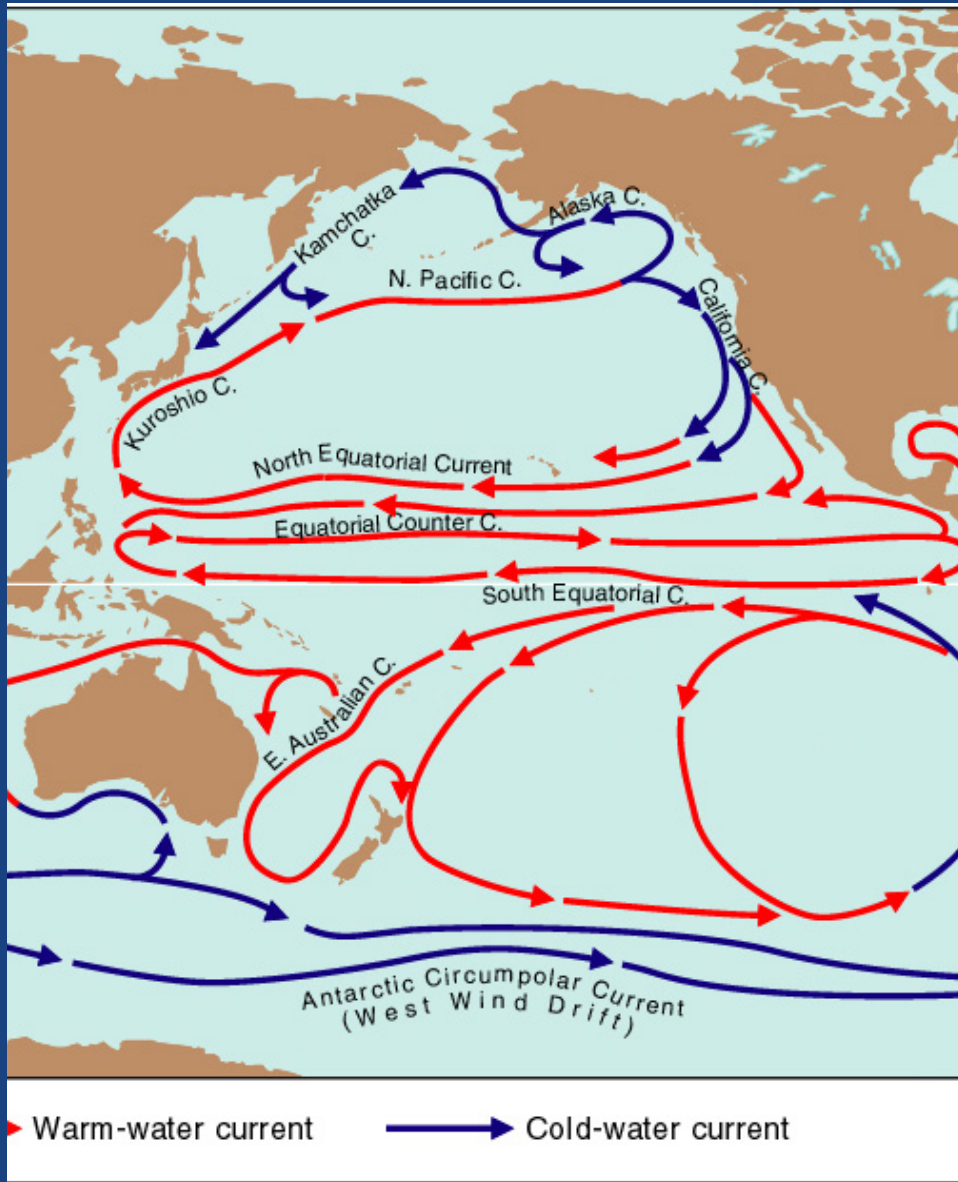


Pacific Decadal Oscillation Index

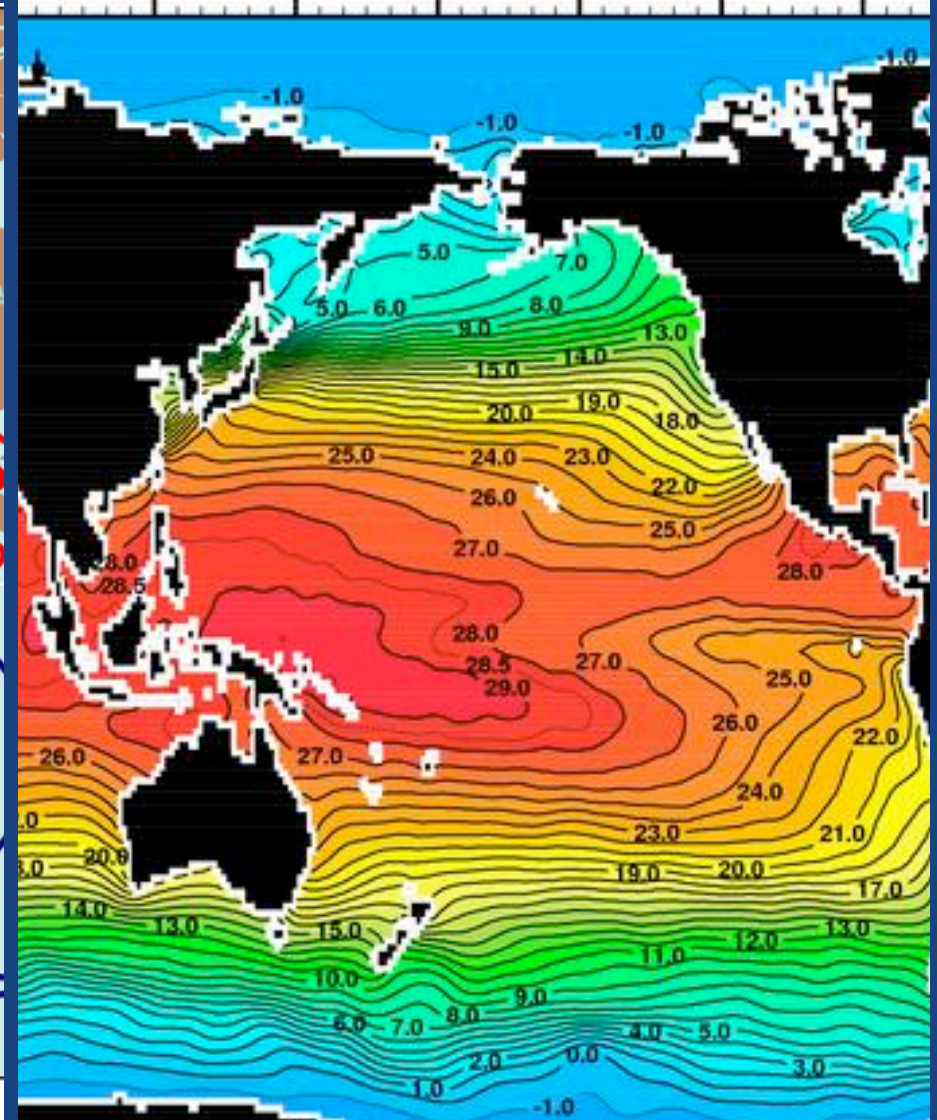


Mean Ocean Climate

Currents

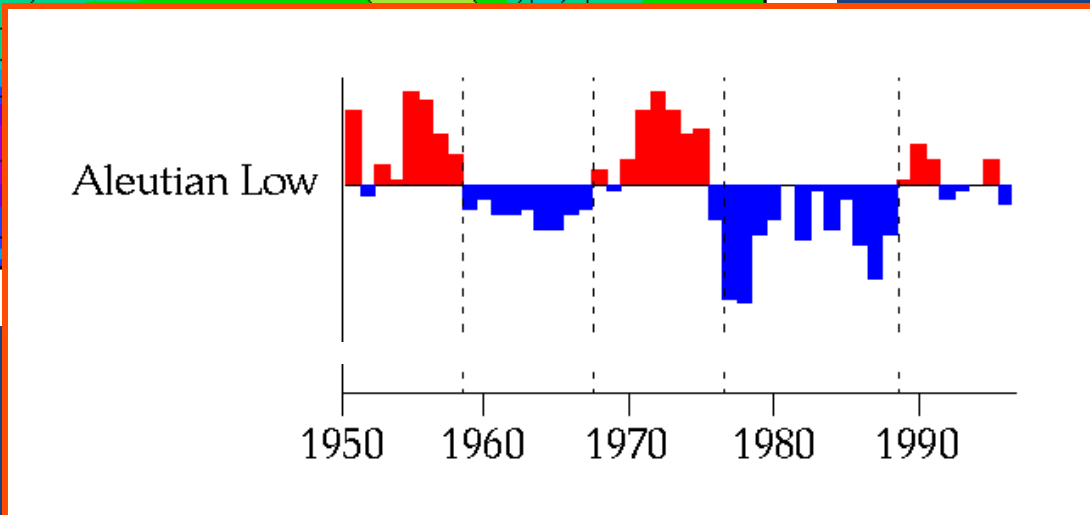
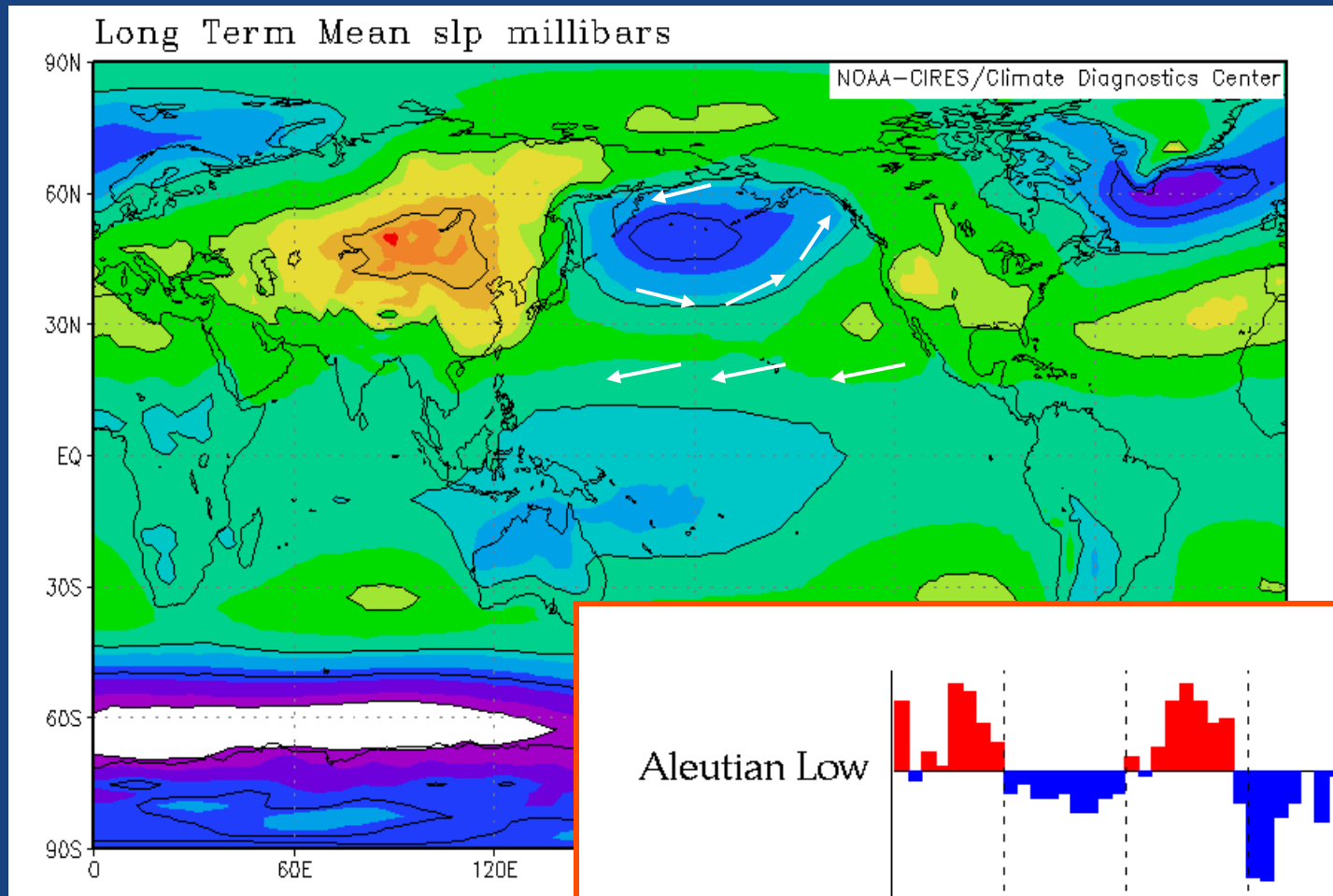


SST



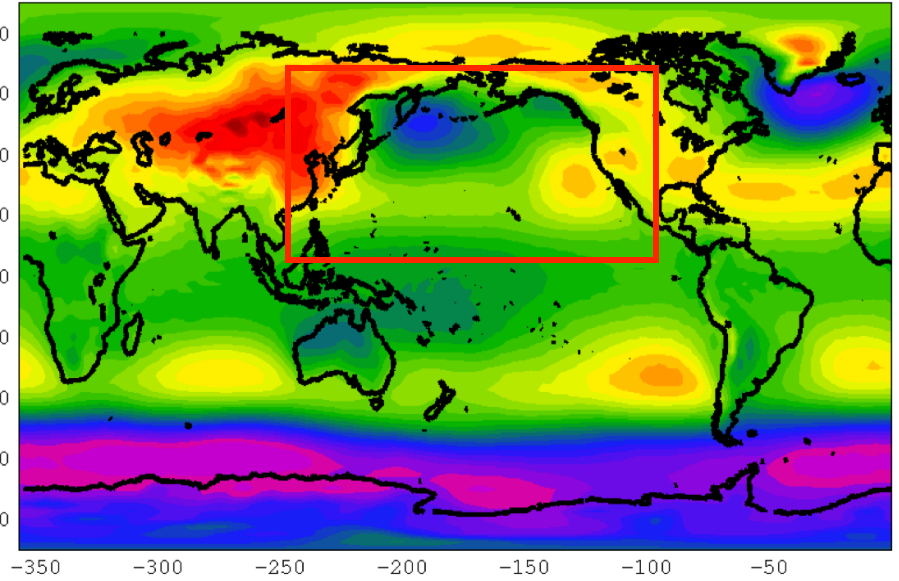
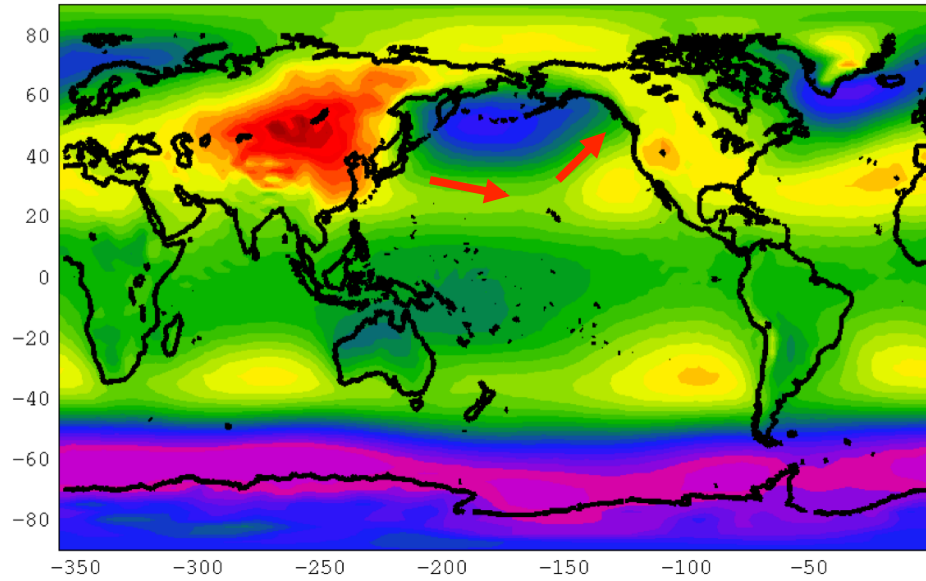
Atmospheric Driver of Mean Climate (not steady)

January Mean Sea Level Pressure



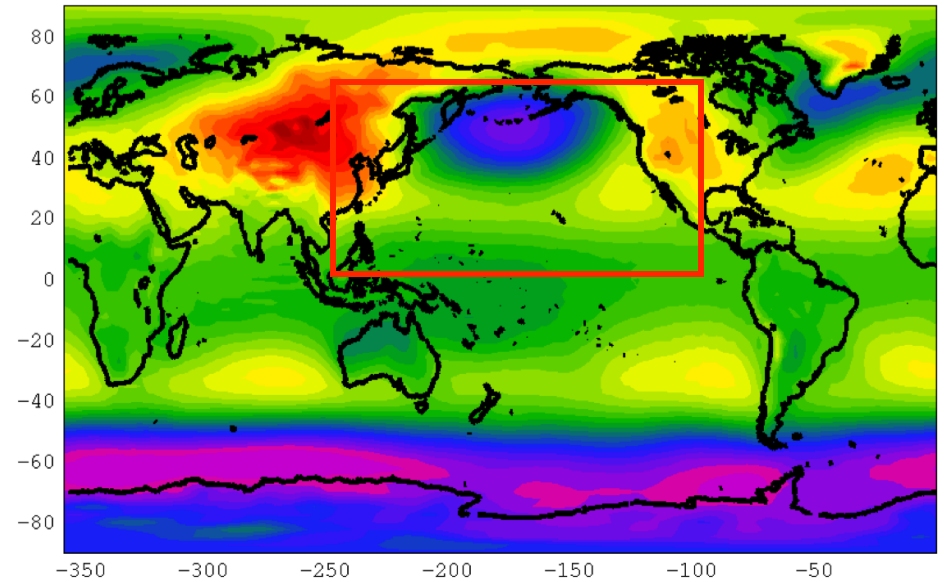
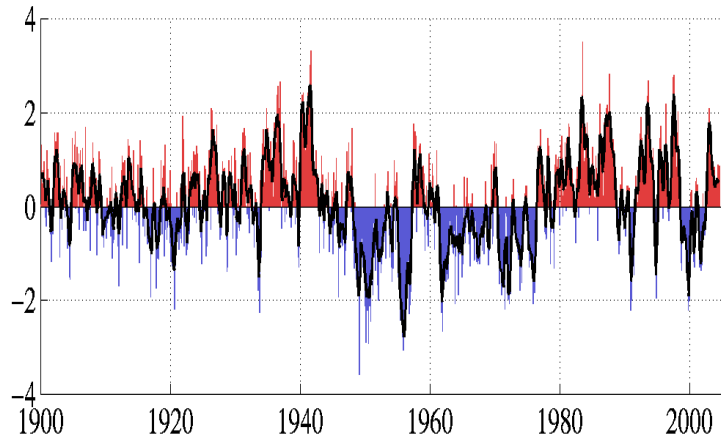
Mean Sea Level Pressure

Negative Phase

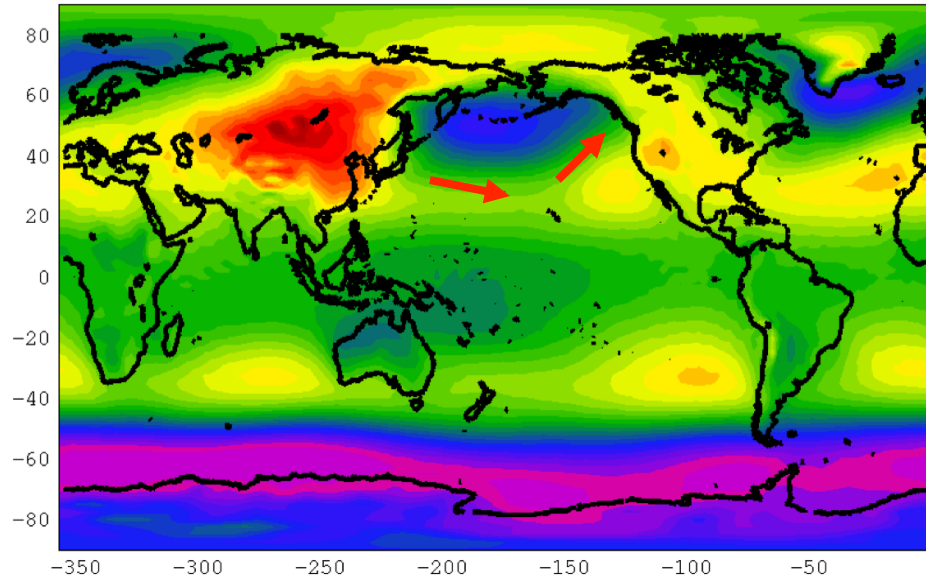


Positive Phase

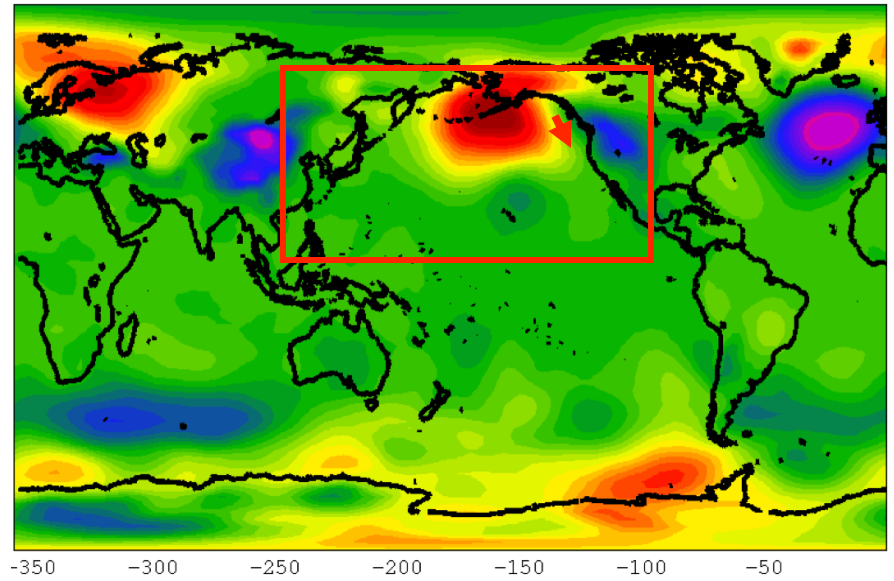
monthly values for the PDO index: January 1900–August 2004



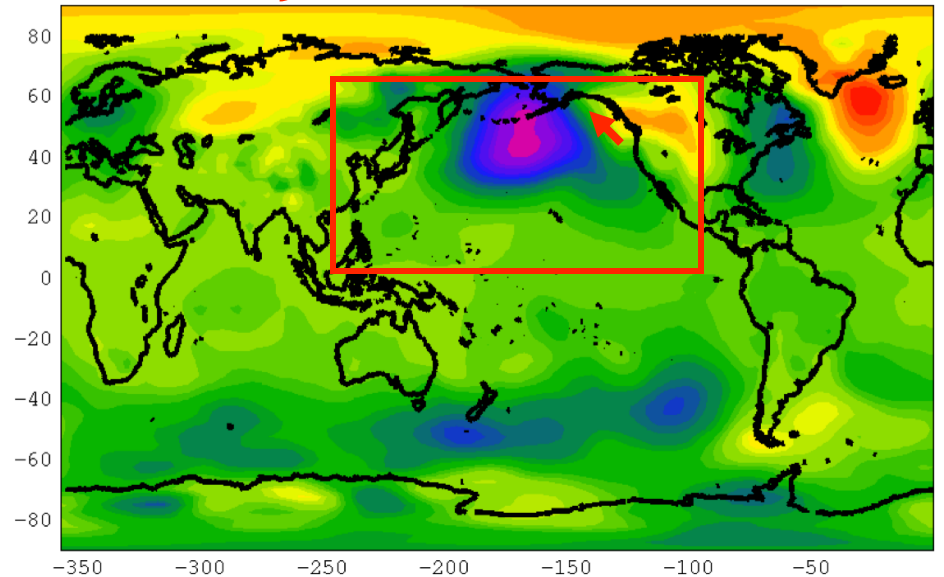
Mean Sea Level Pressure



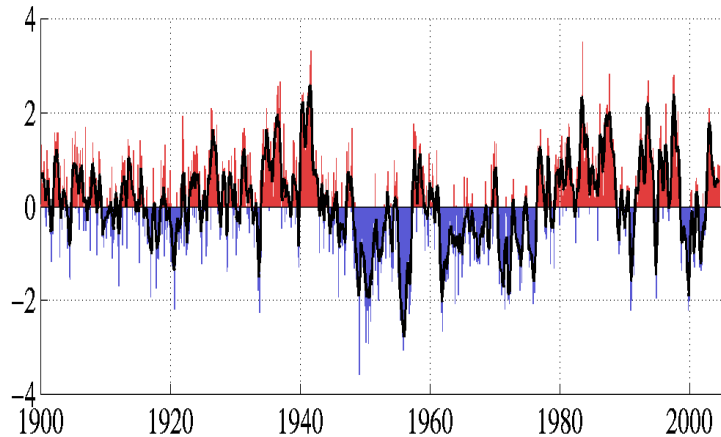
Anomaly PDO Negative Phase



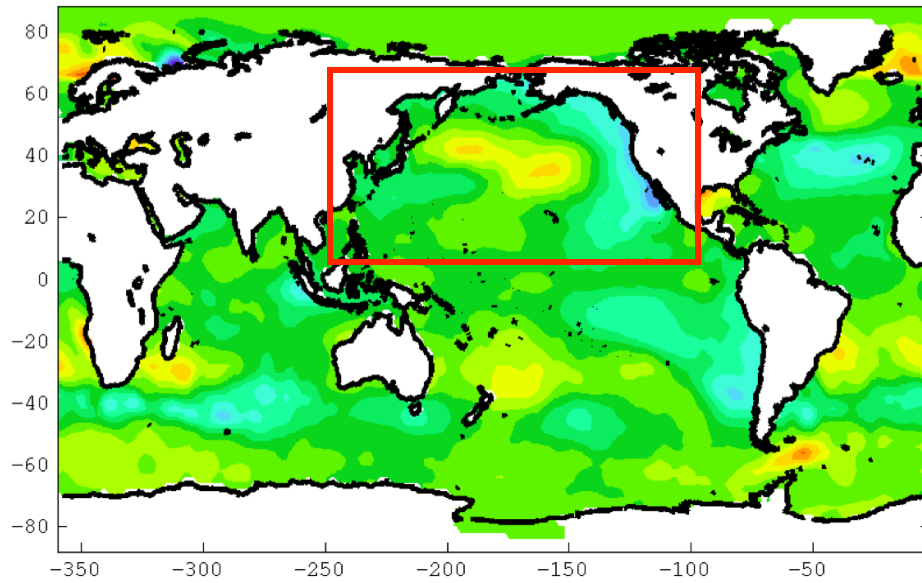
Anomaly PDO Positive Phase



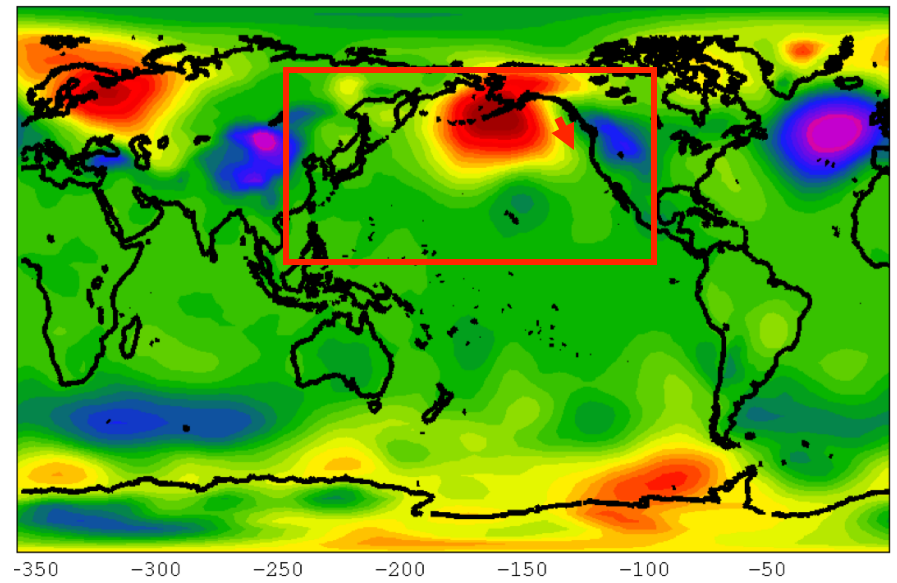
monthly values for the PDO index: January 1900–August 2004



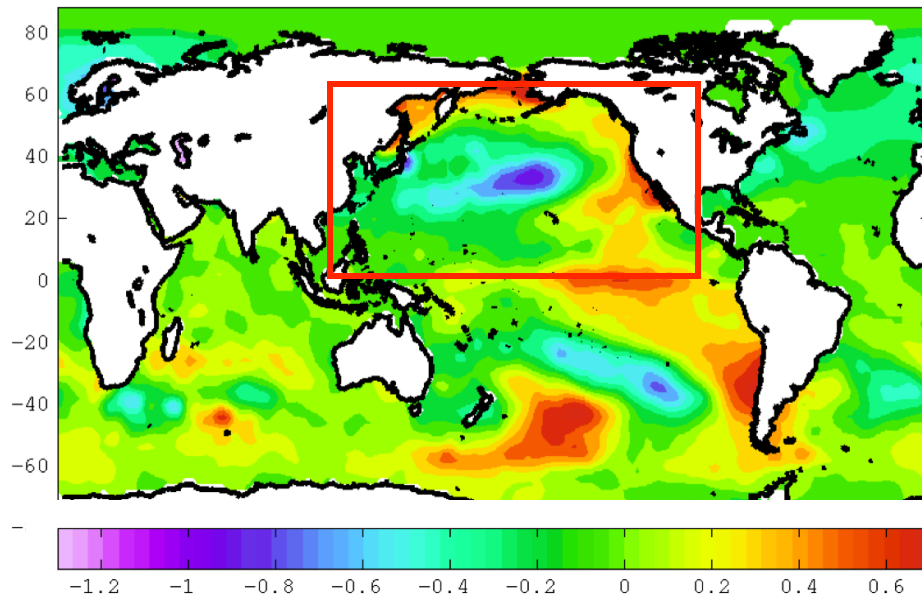
SST Anomalies



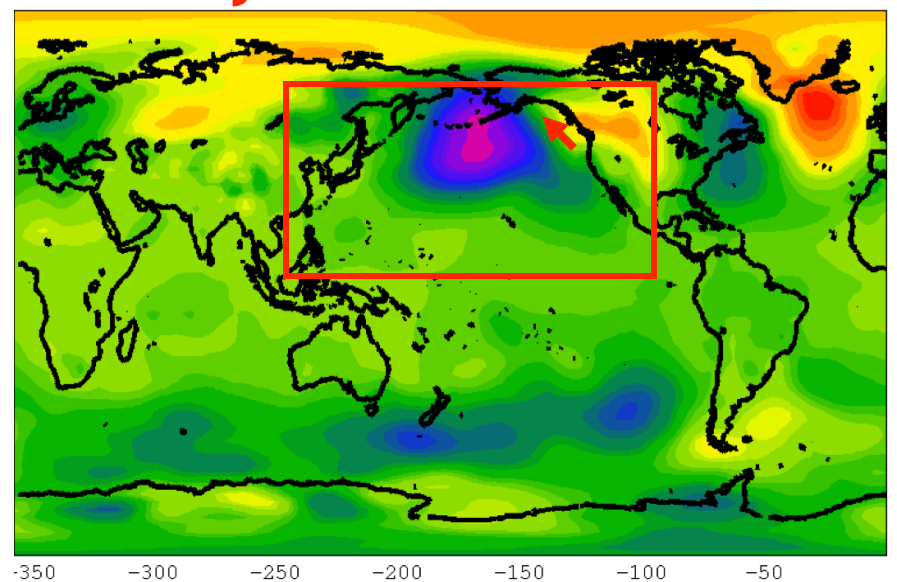
Anomaly PDO Negative Phase



SST Anomalies

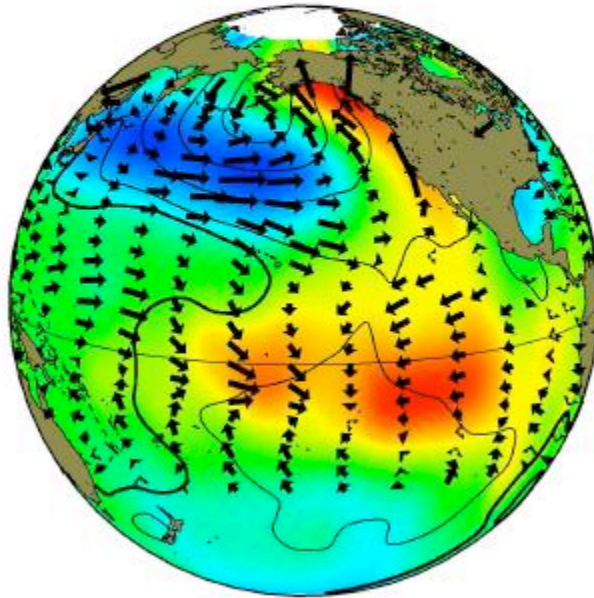


Anomaly PDO Positive Phase

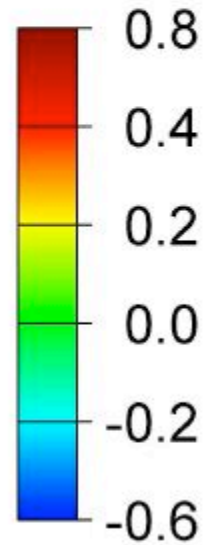
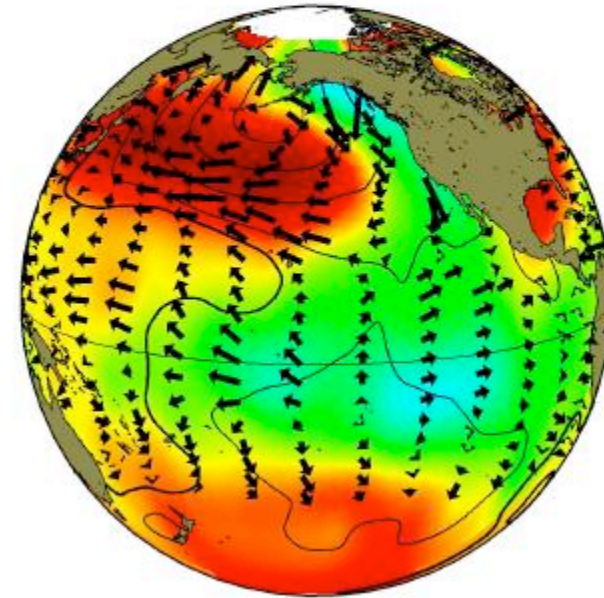


Pacific Decadal Oscillation

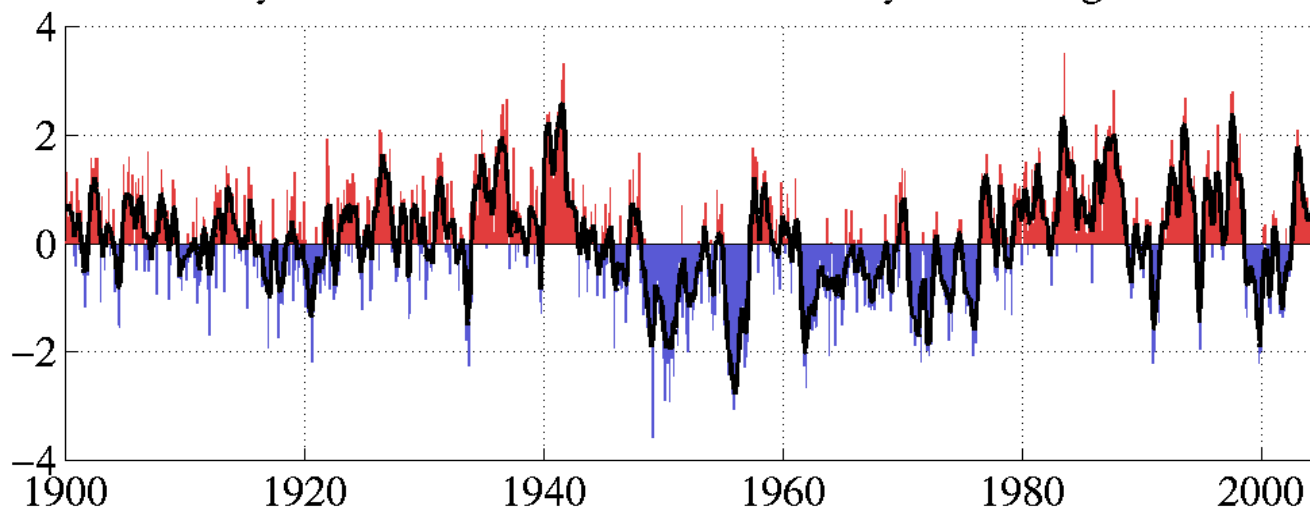
positive phase



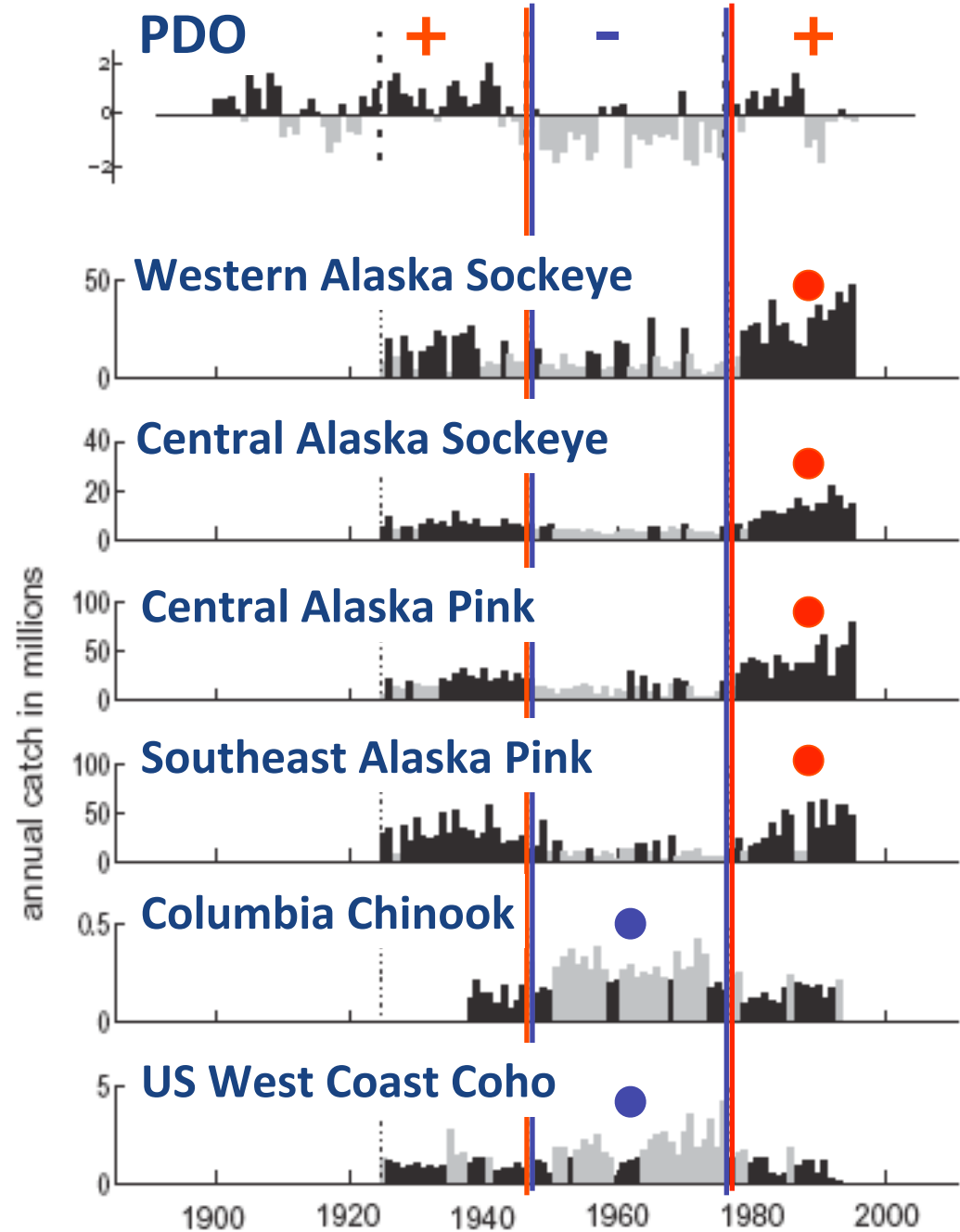
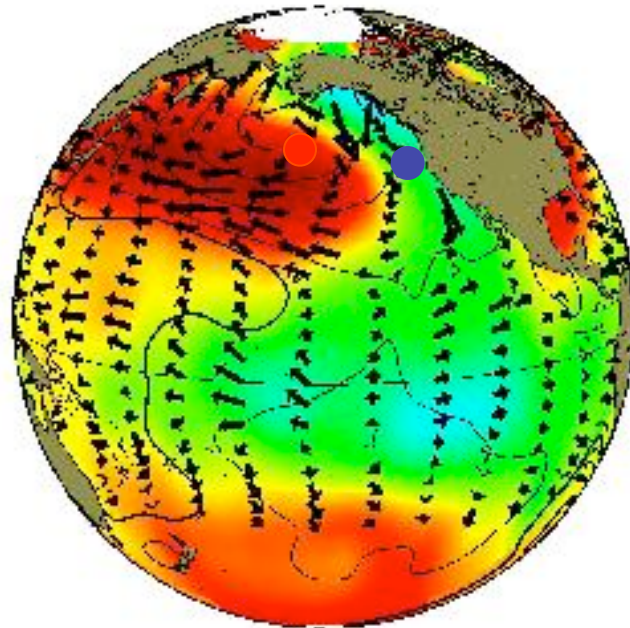
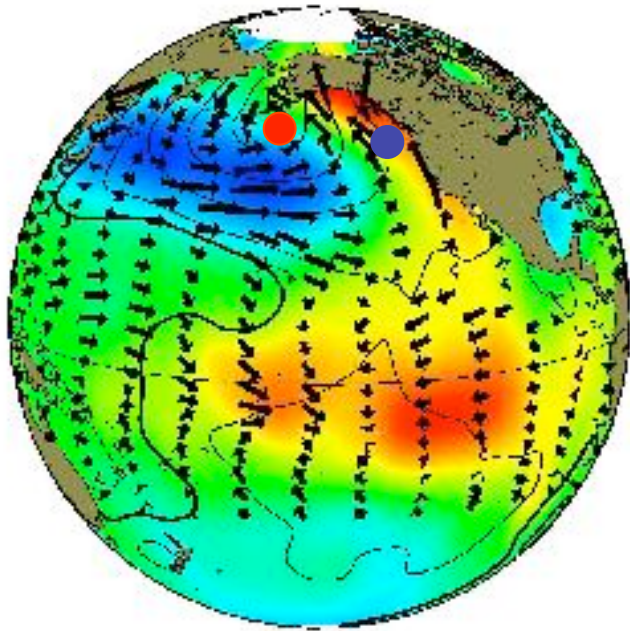
negative phase



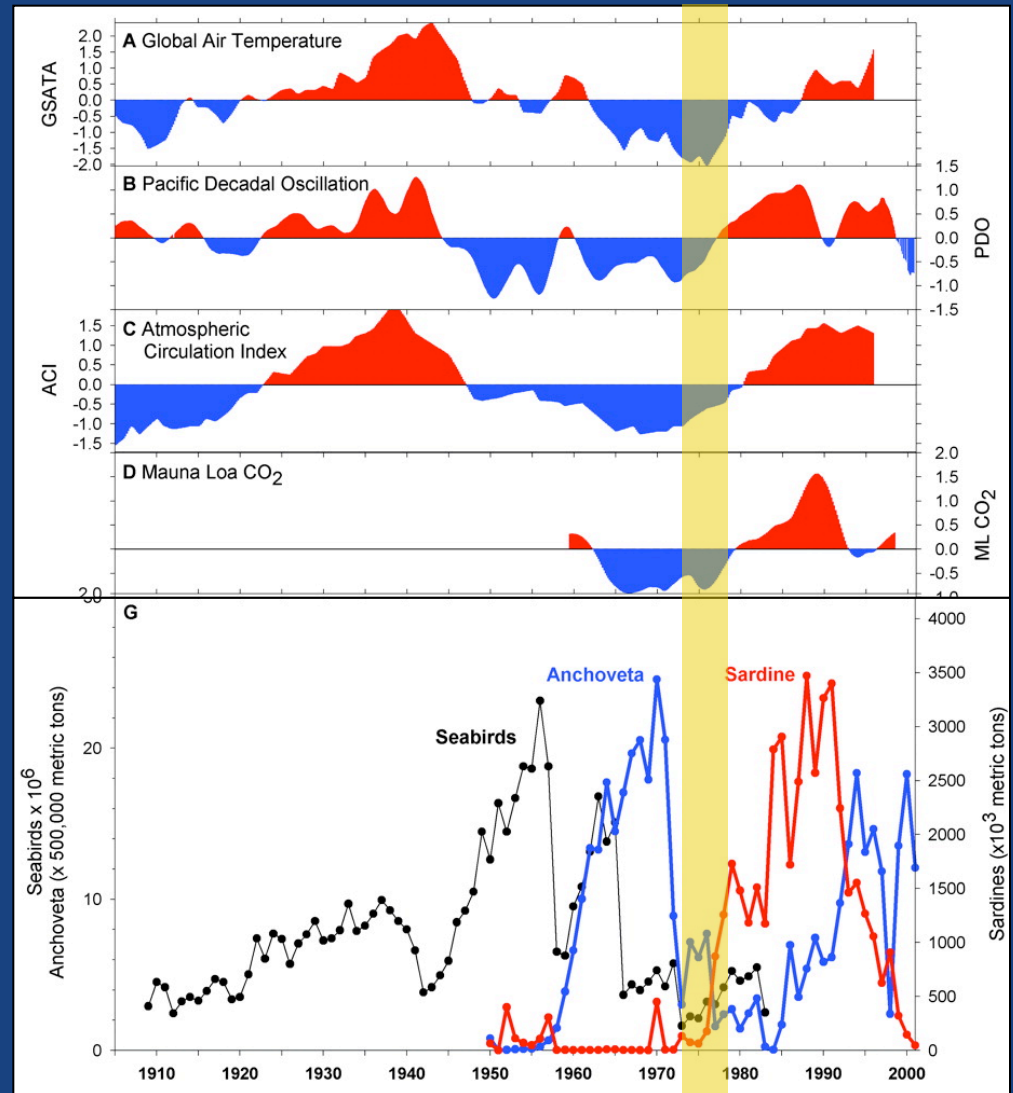
monthly values for the PDO index: January 1900–August 2004



Pacific Decadal Oscillation and Salmon Stocks



Basin-scale Climate Indices and Global Climate

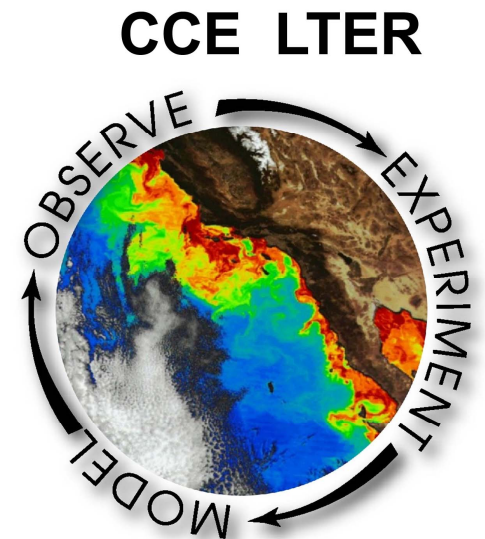
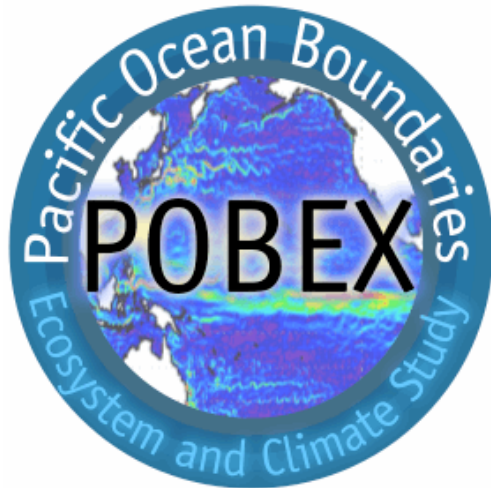


1976 Regime Shift ?

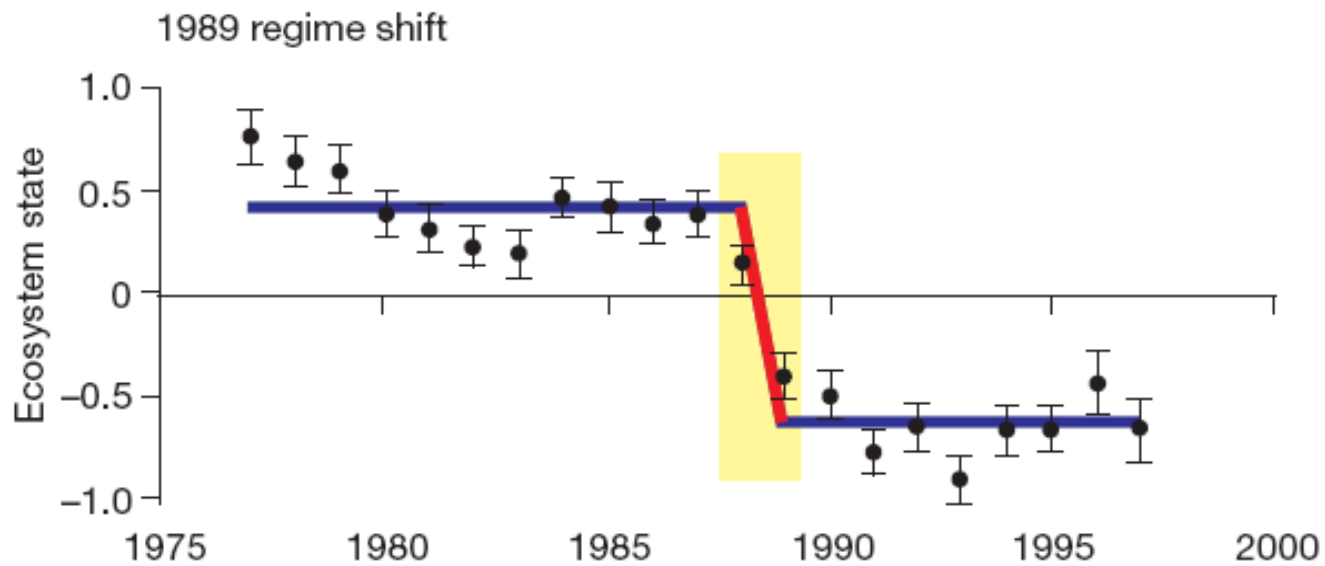
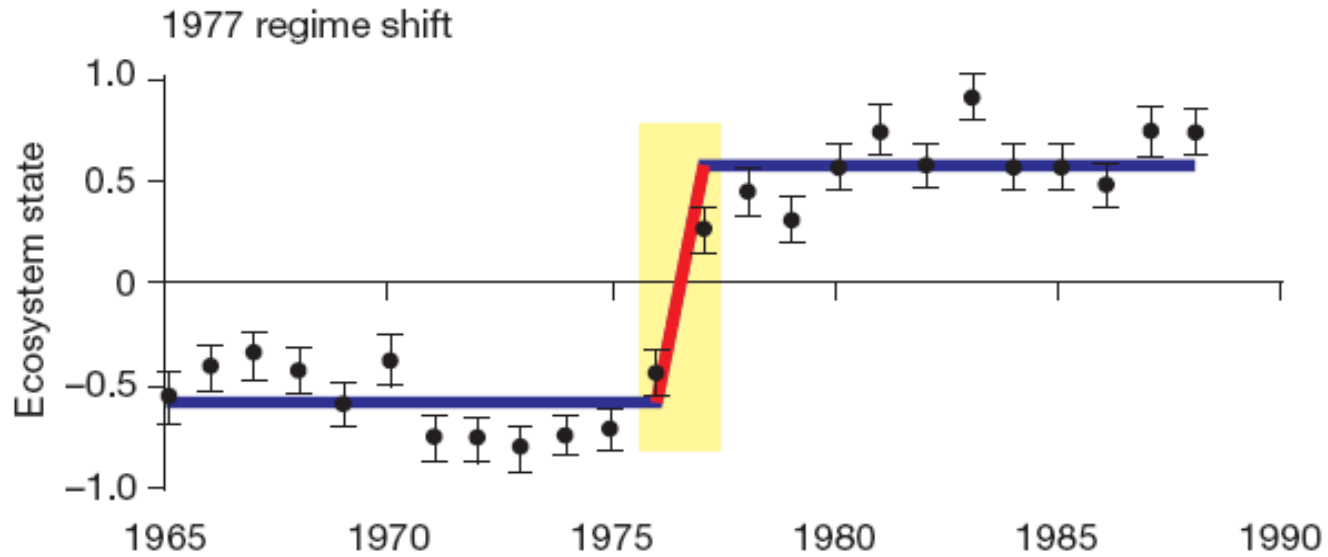
A *null hypothesis* to explain climate driven “*regime-like*” transitions in ecosystem species

Examples from instructors research:

E. Di Lorenzo and M. D. Ohman

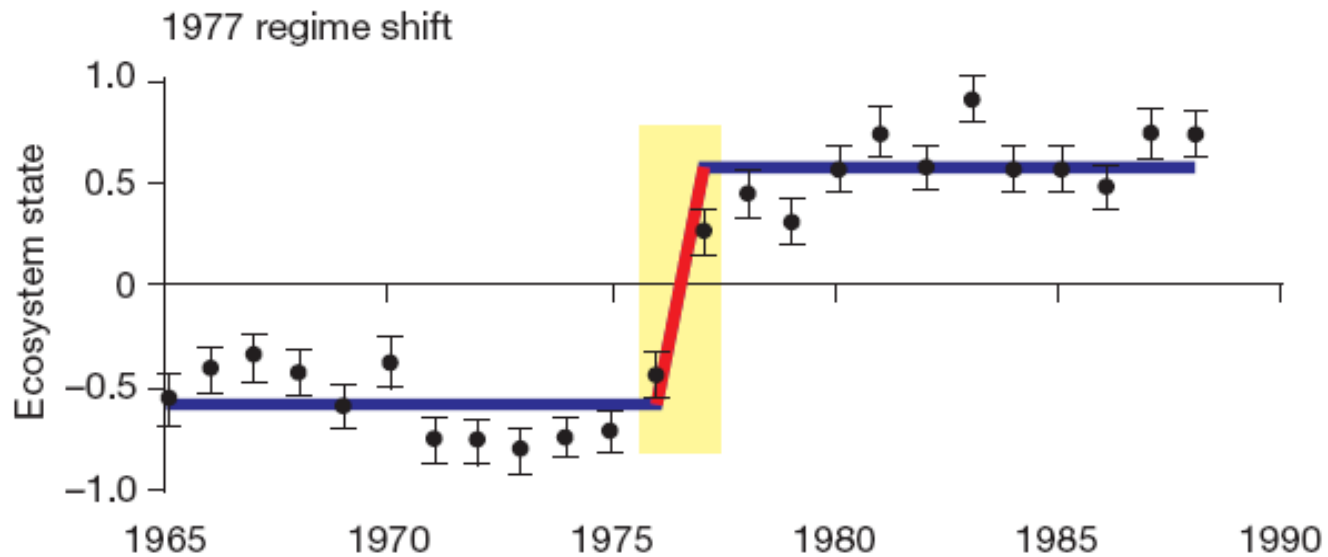


Ecosystem exhibit “regime-like” behavior



(from Hare and Mantua 2000, modified by Sheffer et al. 2009)

Ecosystem exhibit “regime-like” behavior



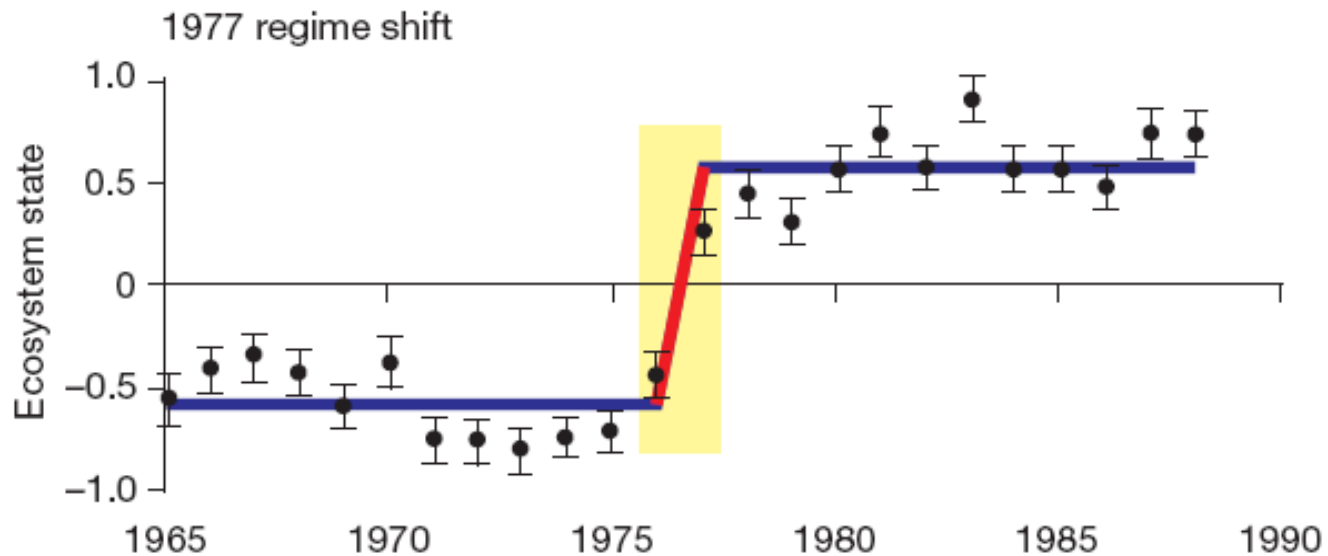
QUESTION:

Are these real regime shifts?

1975 1980 1985 1990 1995 2000

(from Hare and Mantua 2000, modified by Sheffer et al. 2009)

Ecosystem exhibit “regime-like” behavior



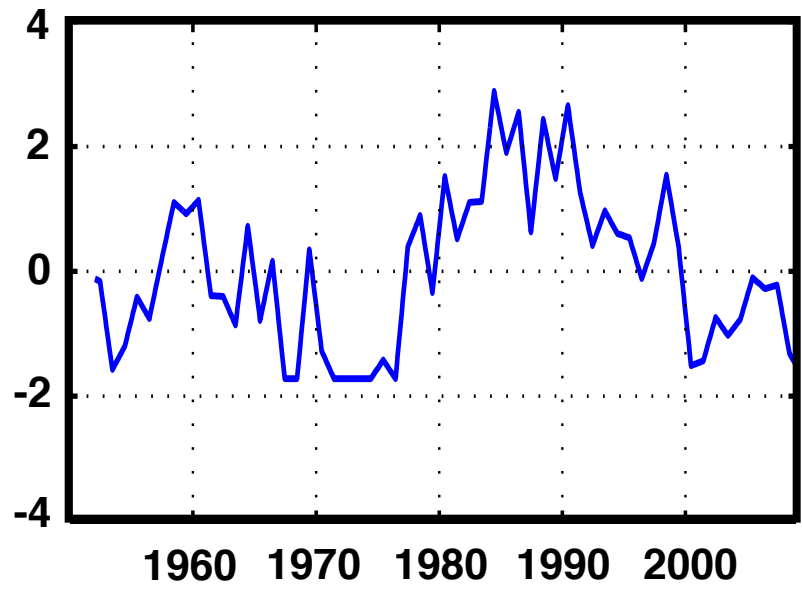
QUESTION:

What do these regime-like changes tell us about the dynamics of ecosystem variability?

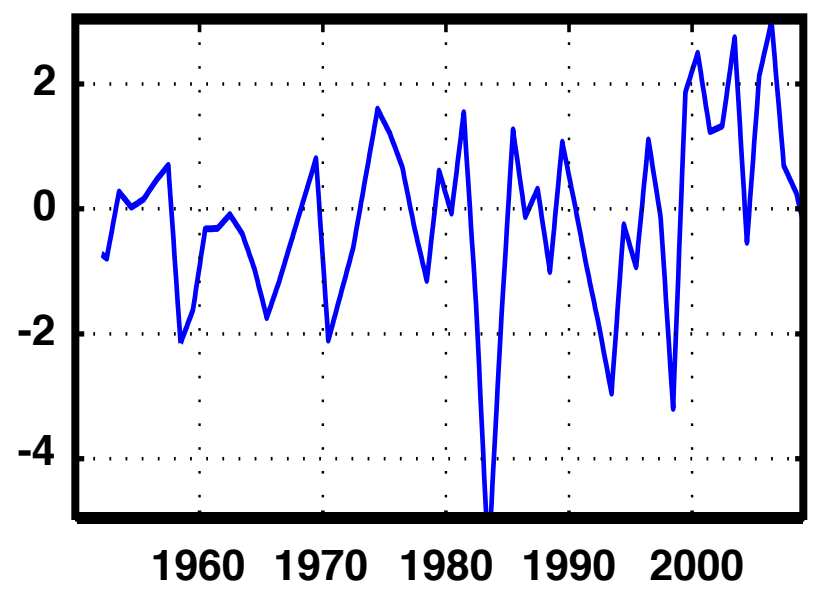
1975 1980 1985 1990 1995 2000

(from Hare and Mantua 2000, modified by Sheffer et al. 2009)

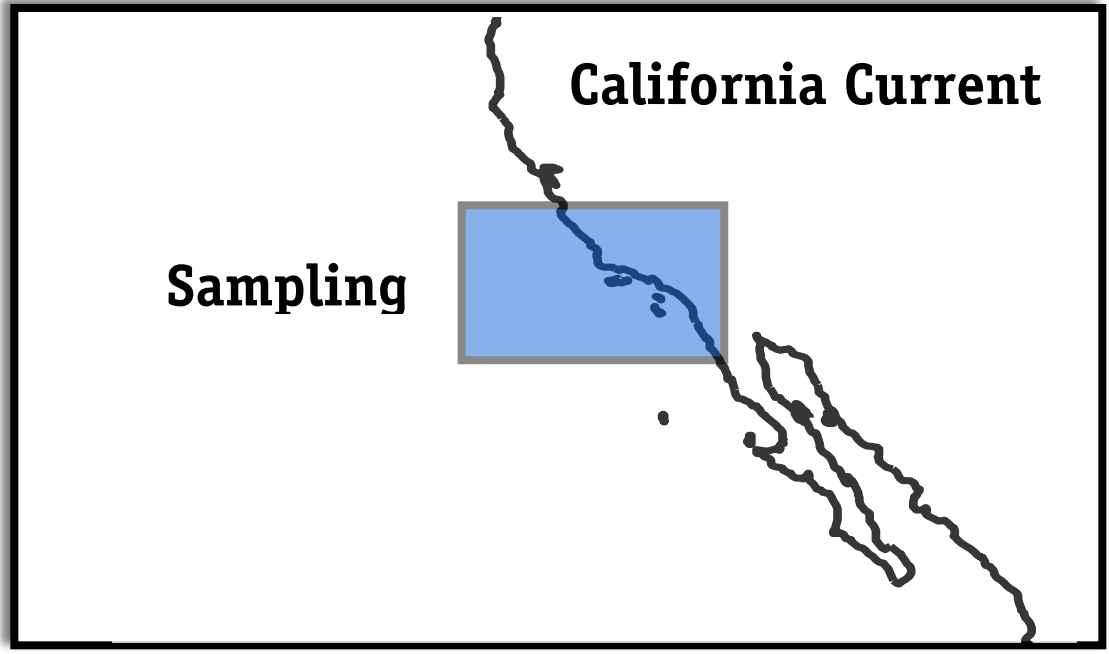
Nyctiphanes simplex



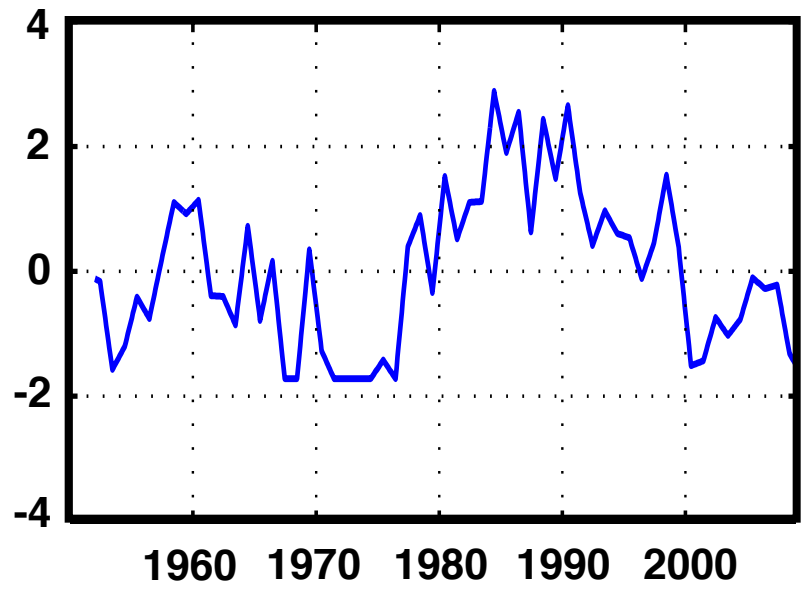
Euphausia pacifica



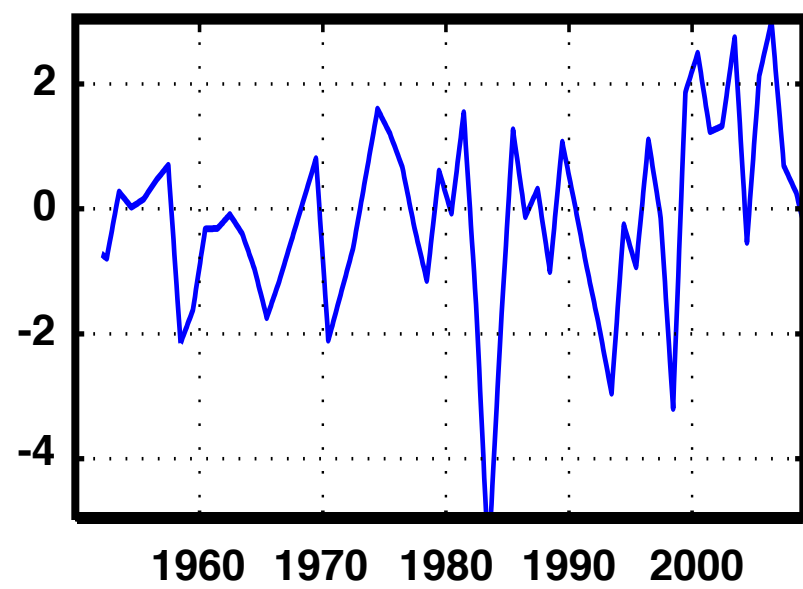
Zooplankton
observations in the
California Current



Nyctiphanes simplex

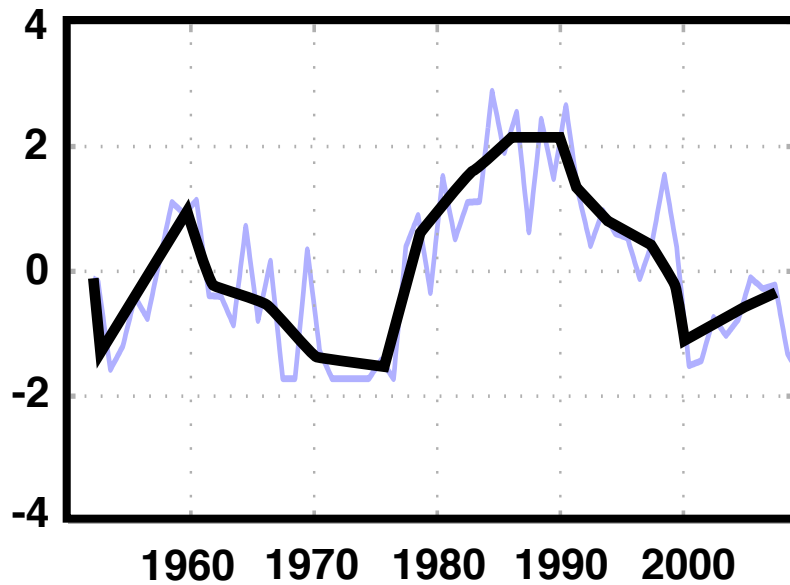


Euphausia pacifica

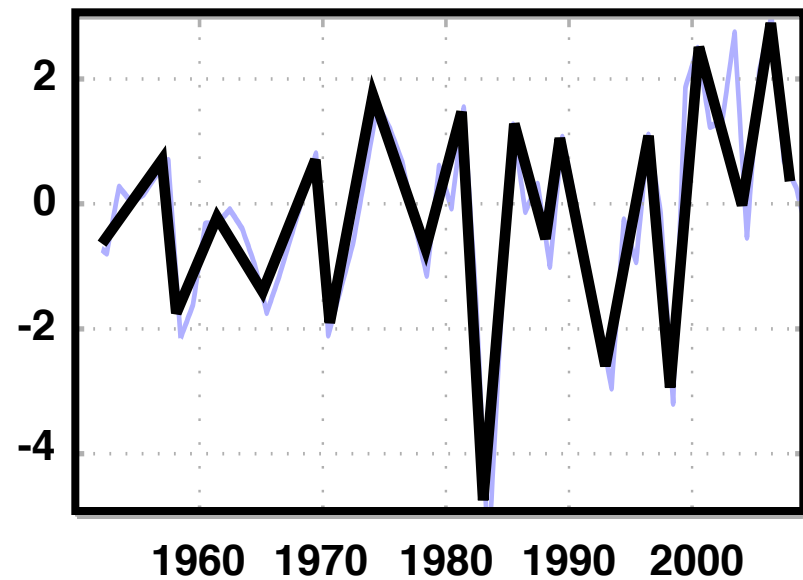


Zooplankton
observations in the
California Current

Nyctiphanes simplex

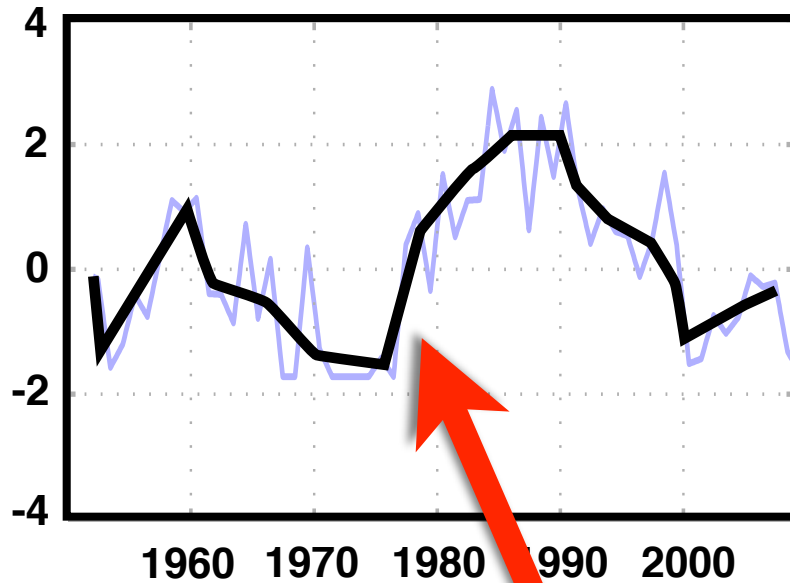


Euphausia pacifica

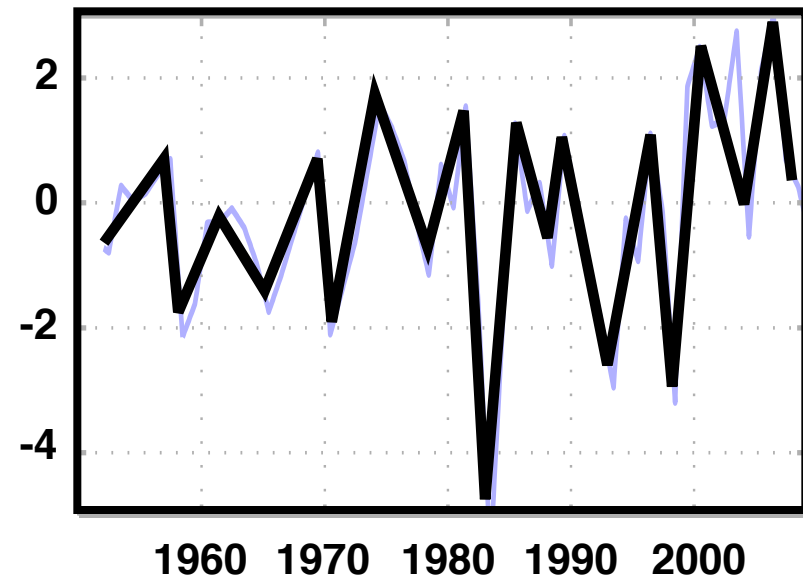


Zooplankton
observations in the
California Current

Nyctiphanes simplex



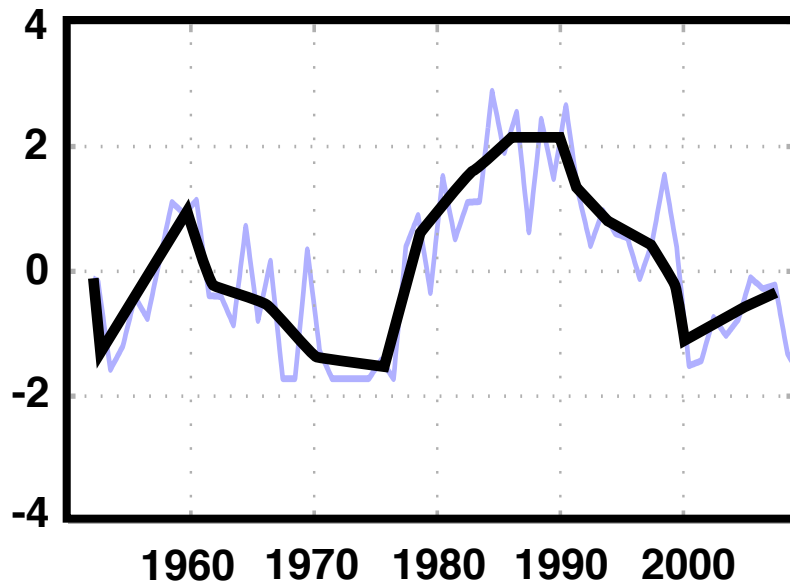
Euphausia pacifica



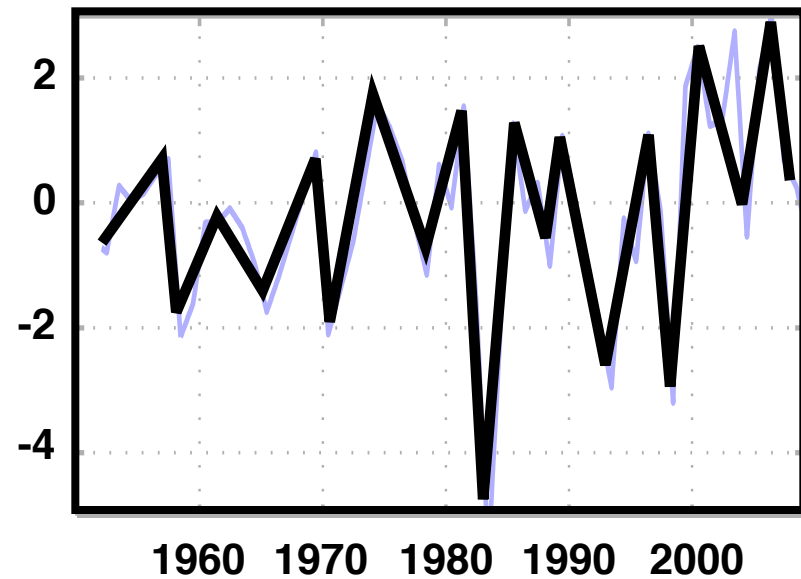
QUESTION:

Why do some zooplankton time series exhibit sudden and prolonged transitions on decadal scales?

Nyctiphanes simplex

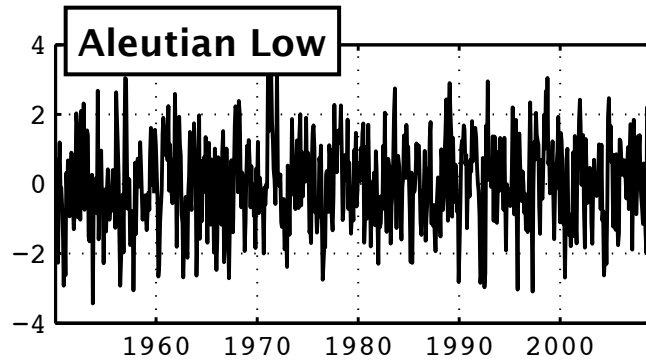


Euphausia pacifica



GOAL:

Develop a null hypothesis or conceptual model of ecosystem variability driven by climate forcing.

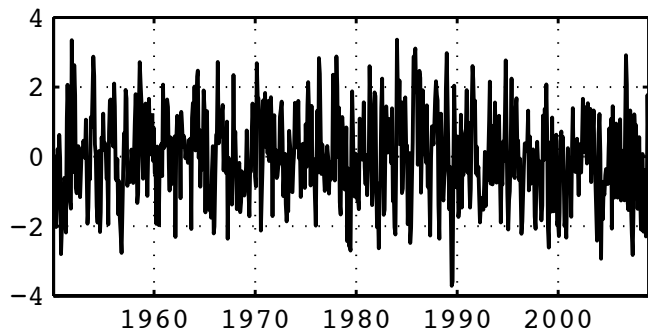
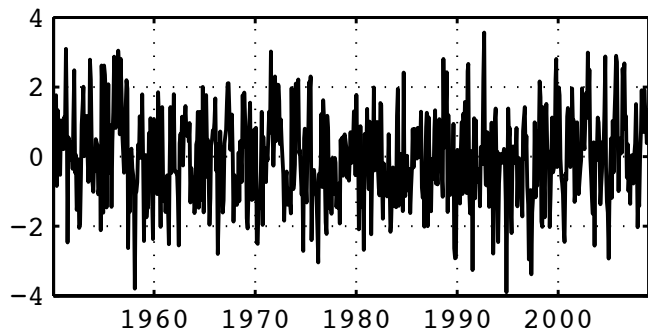
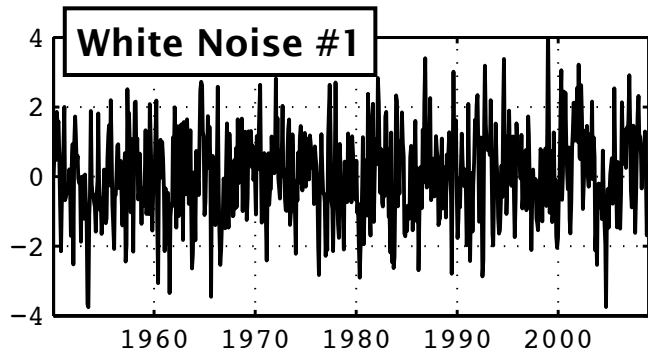
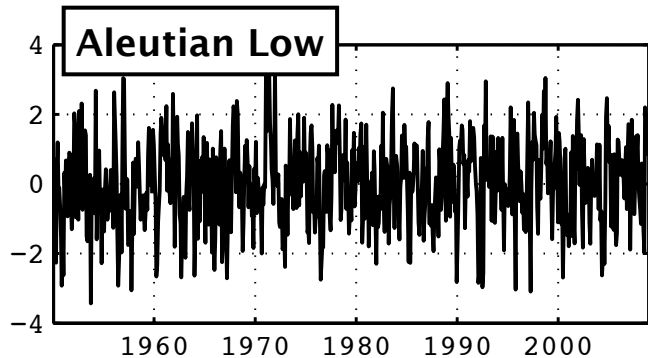


Atmosphere

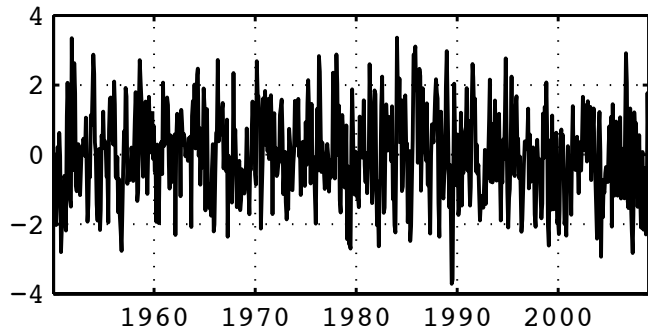
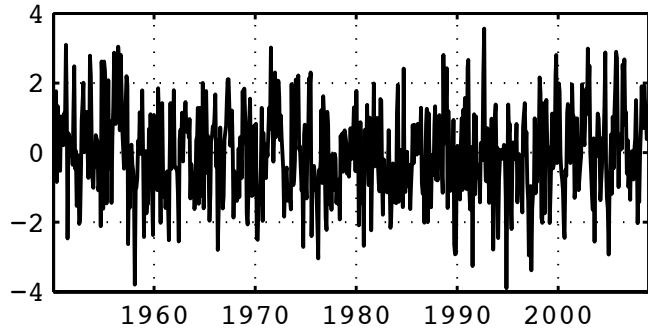
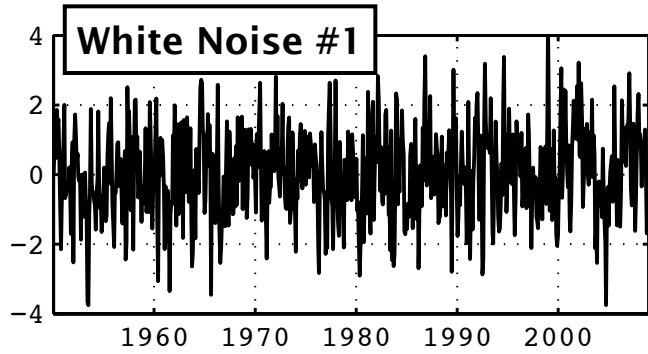
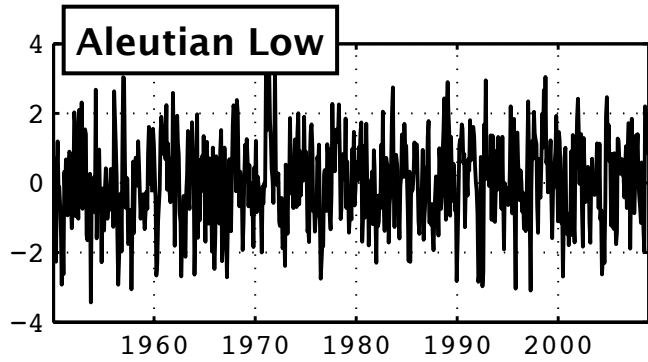
GOAL:

Develop a null hypothesis or conceptual model of ecosystem variability driven by climate forcing.

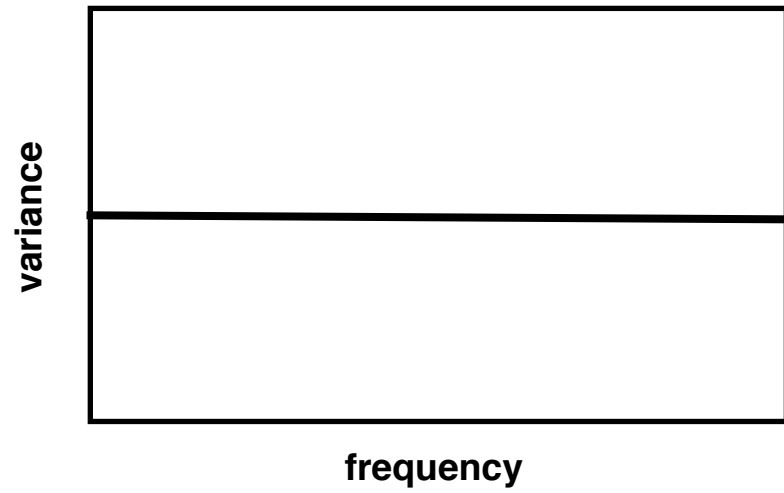
Atmosphere

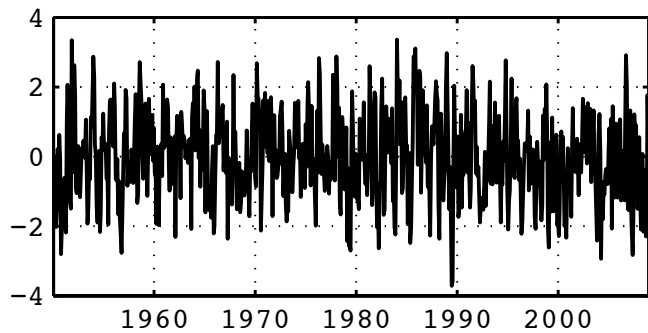
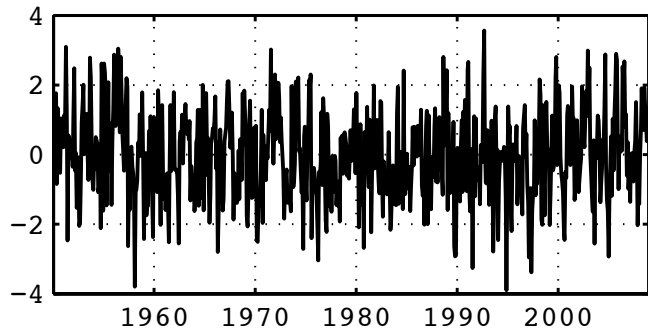
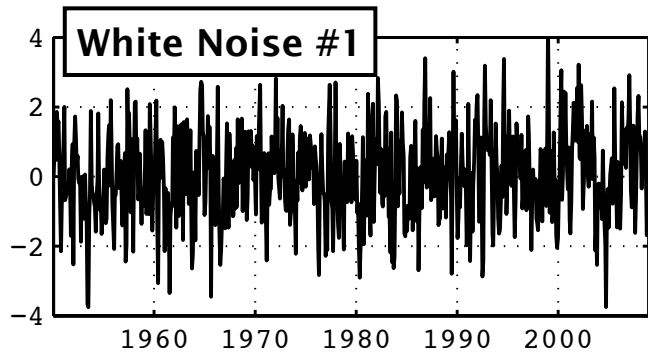
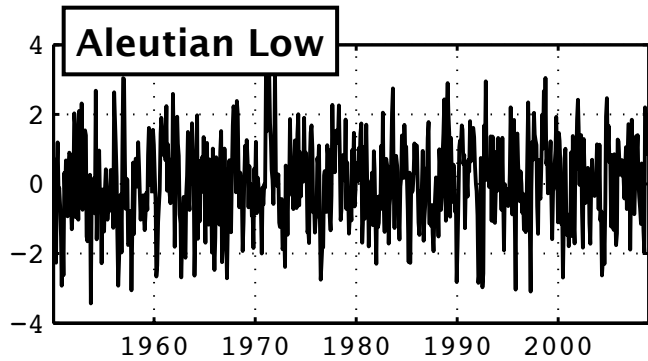


Atmosphere

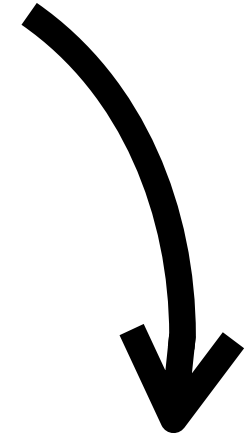


White Noise (Spectrum)





Atmosphere



Ocean