Synchrony in climate and biological response within and between the Benguela and California Current Ecosystems

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Rob Crawford
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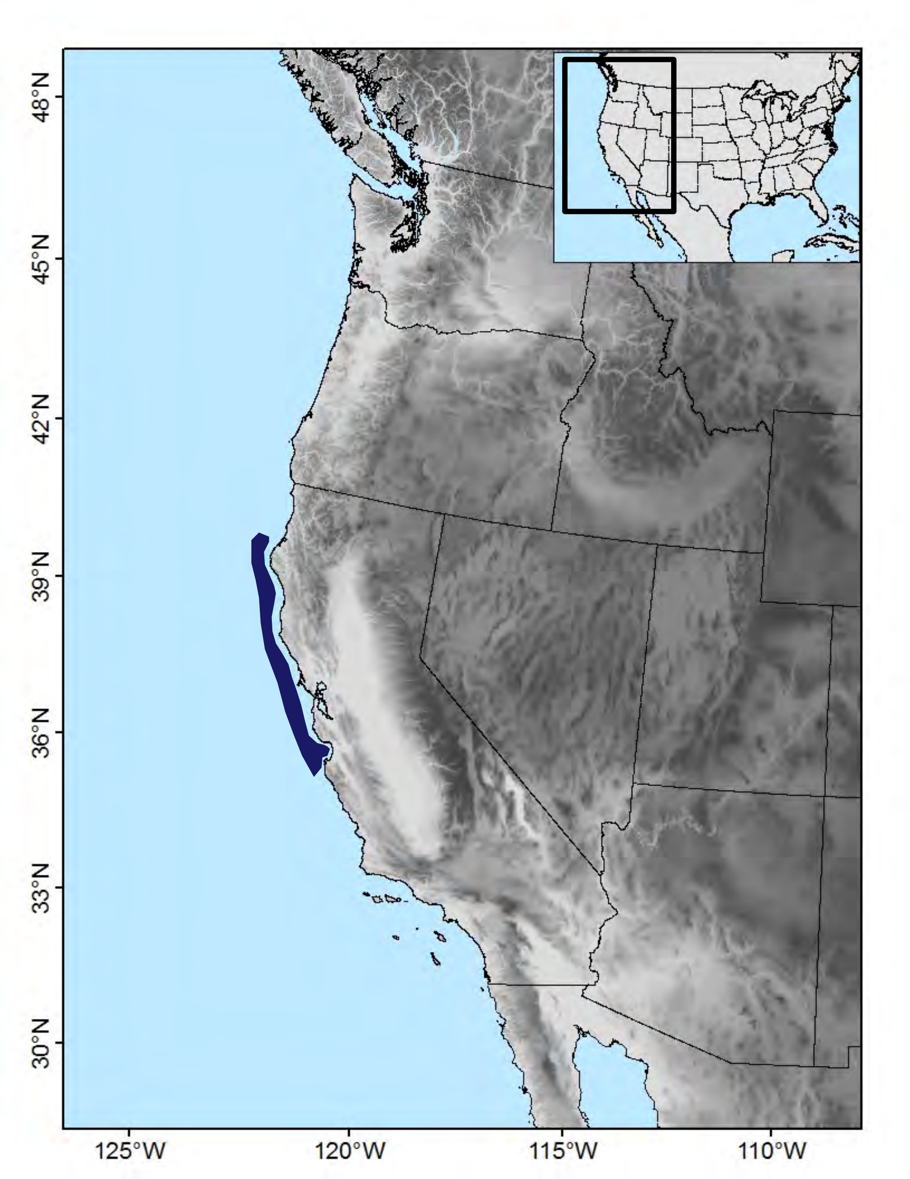
National Science Foundation
South African Dept. of Environmental Affairs

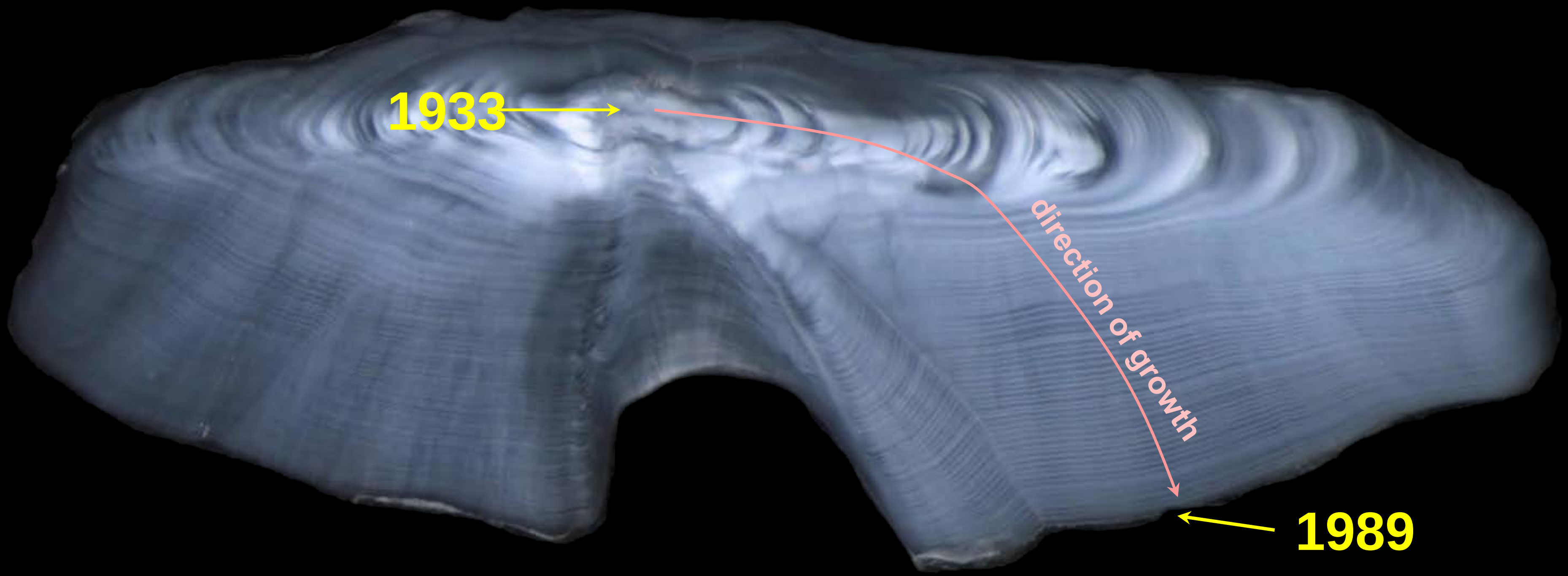
Splitnose rockfish (*Sebastes diploproa*)

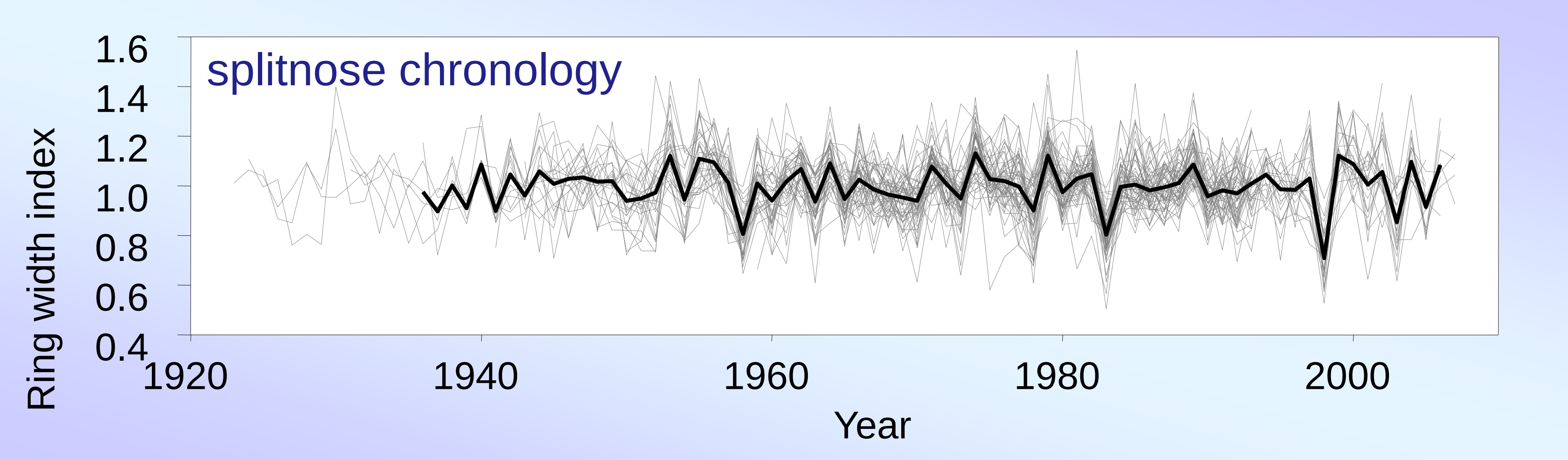
80+ yrs old
300 m depth
Live-collected 1980 - 2008

Photo credit:Lifted from M. Love's webpage



Splitnose chronology: 72 otoliths





Seven time series

Growth-increment chronologies

splitnose rockfish
planktivorous

yelloweye rockfish
piscivorous

Chinook salmon
piscivorous

Egg lay date and survivorship

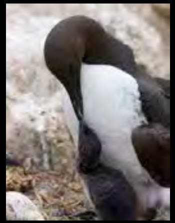
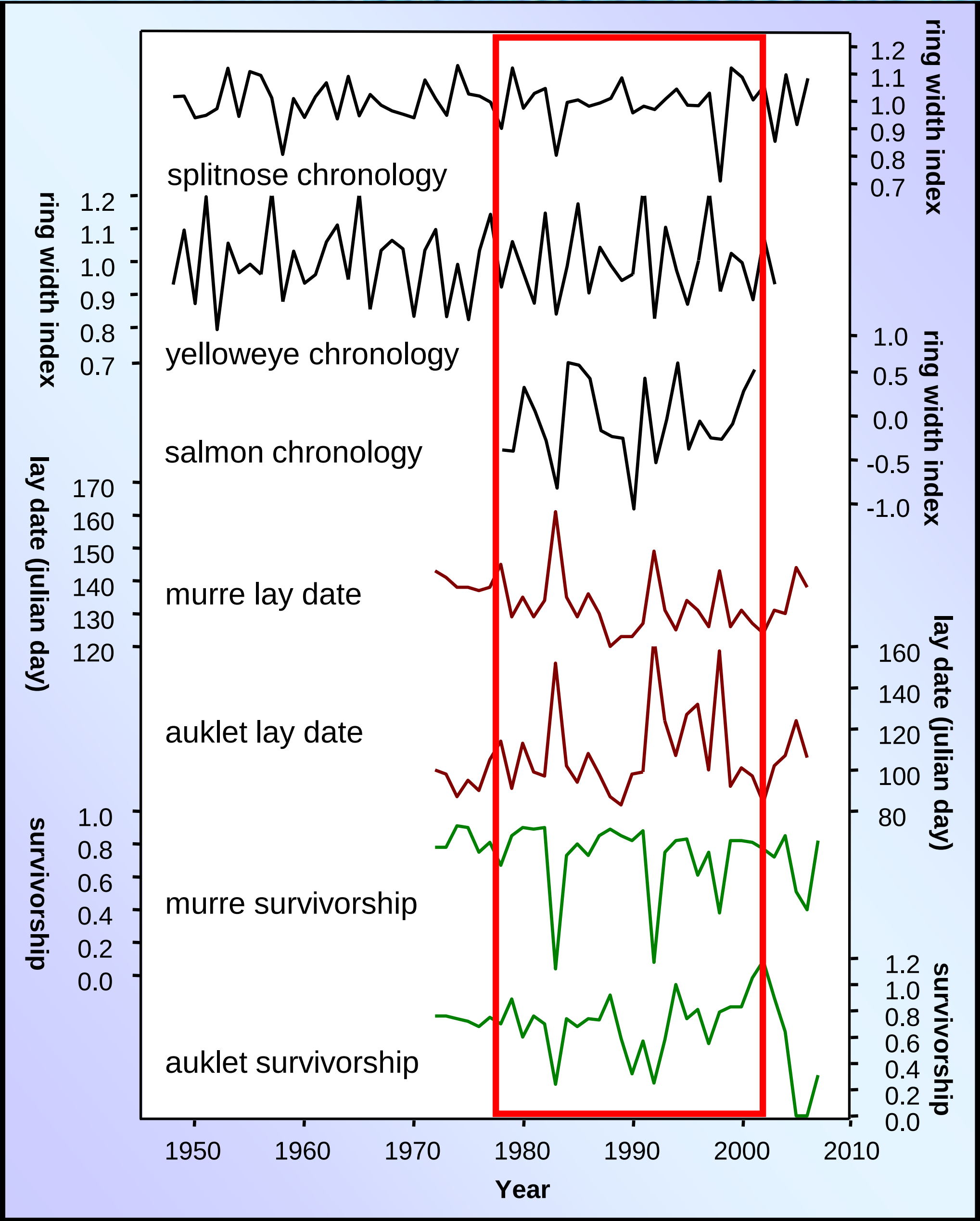


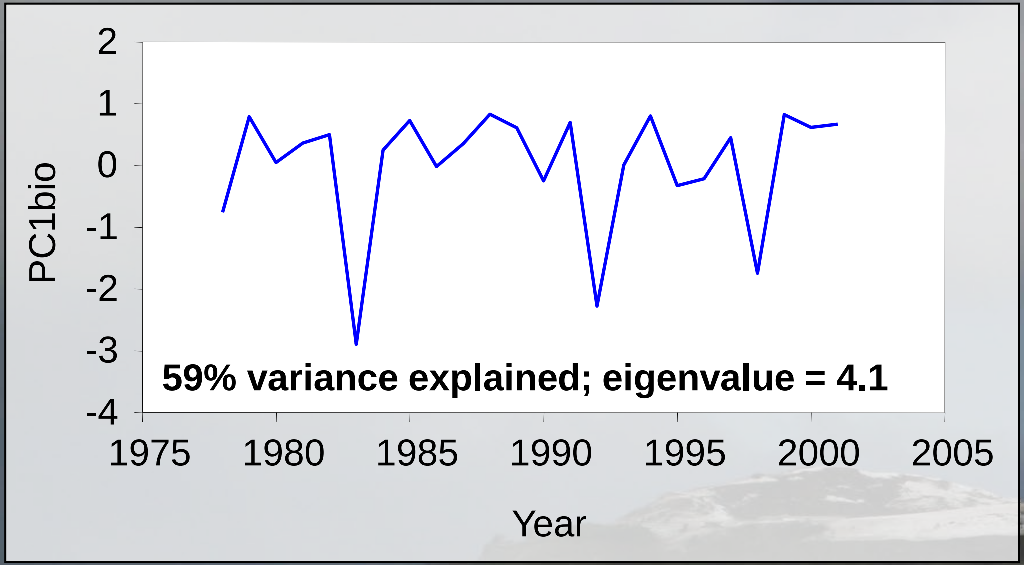
photo: Ron LeValley, PRBO

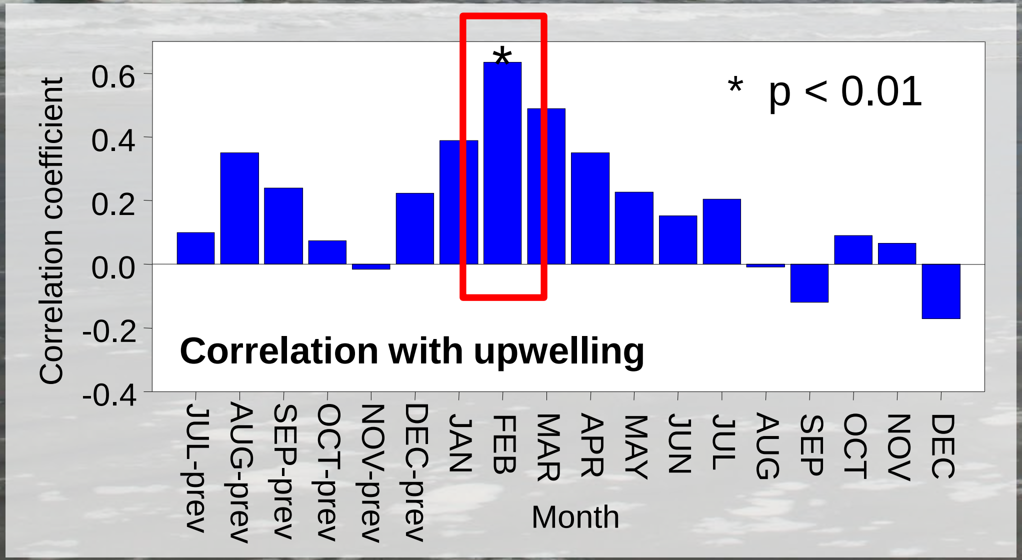
common murre
piscivorous

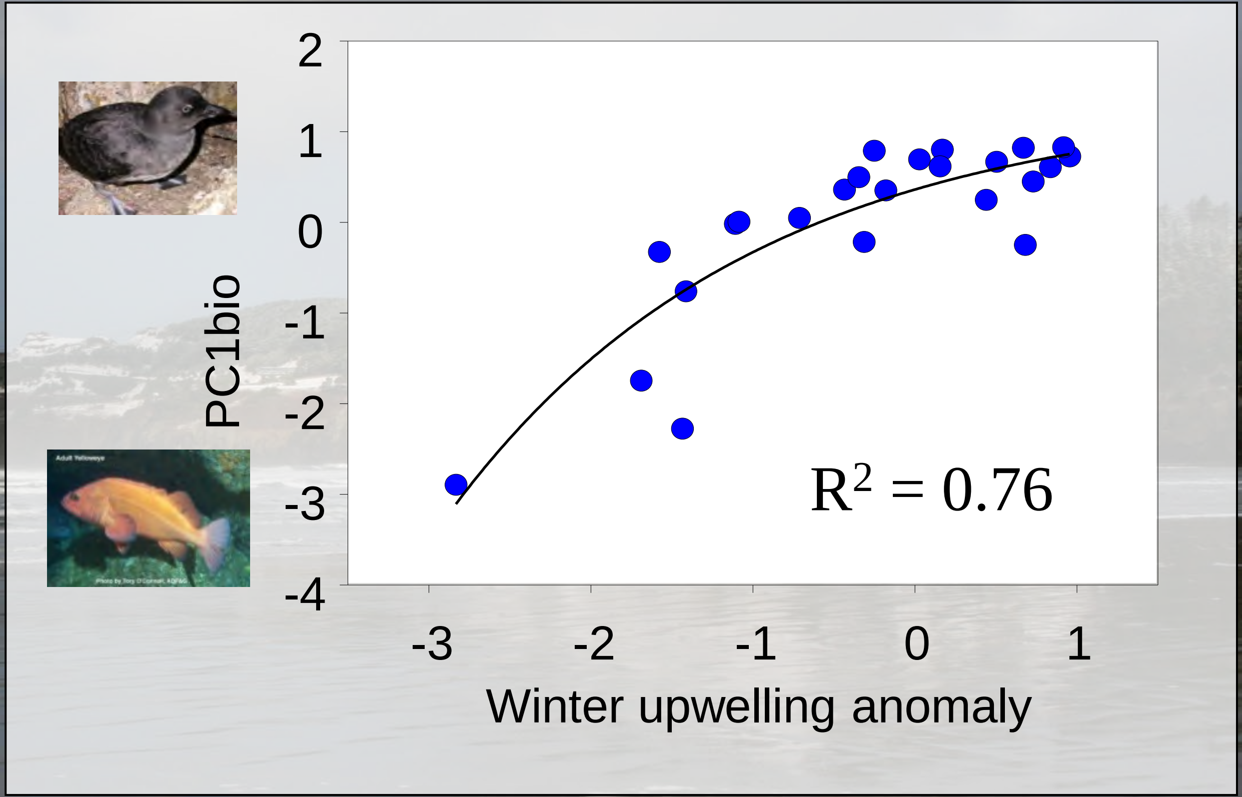
Cassin's auklet
planktivorous



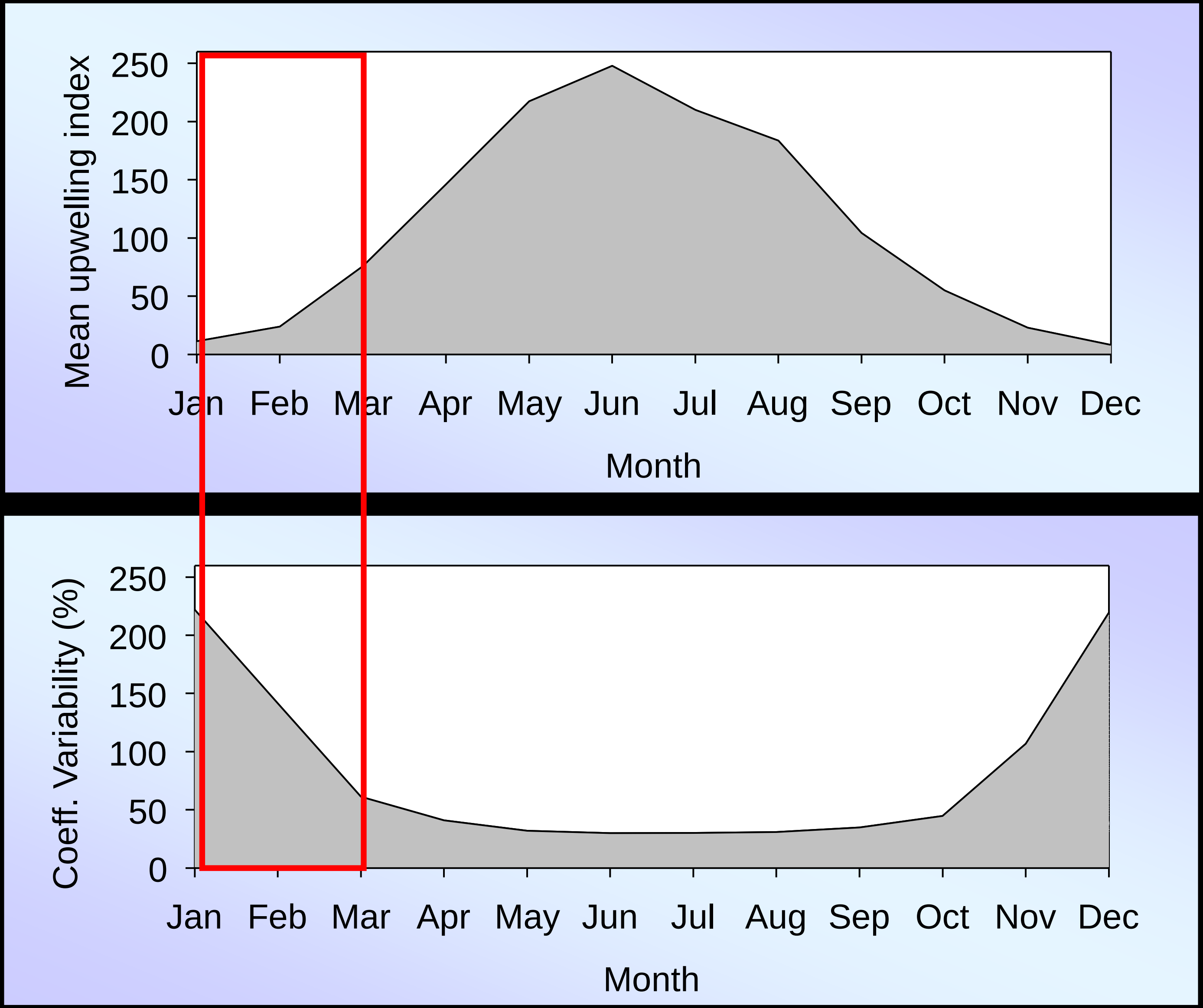
PC1 for fish and bird time series



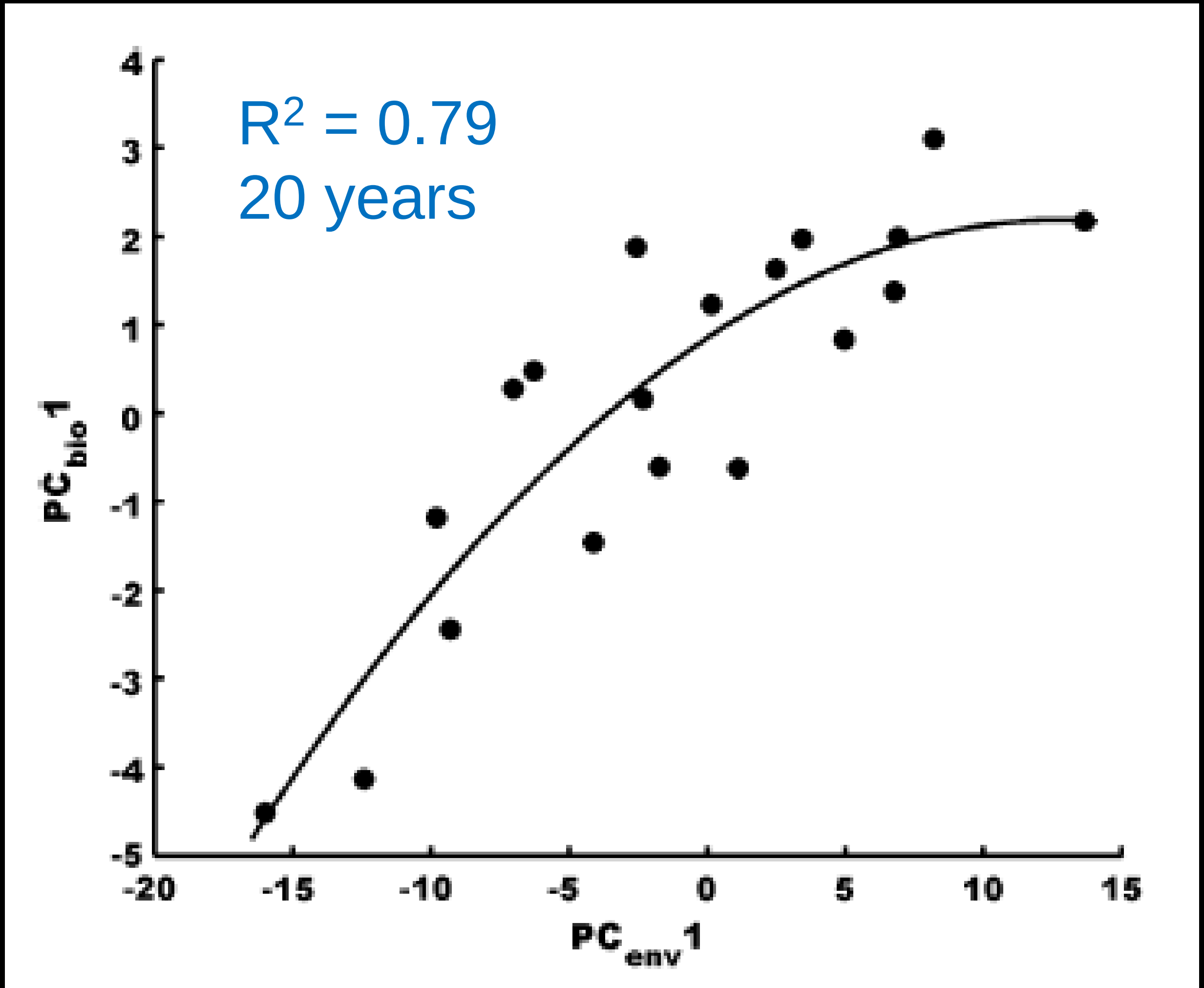




Upwelling seasonality



Early season environment explains biotic response



PC_{env} from winds, temps (winter / early spring signal)
PC_{bio} from 9 time series (56% variability explained)

CA Current – Benguela comparison

Collaborative Research: Climate Change and Upwelling – Comparative Analysis of Current & Future Responses of the California and Benguela Ecosystems (project CalBenJI)

University of TX
University of SC
Farallon Institute
NOAA SWFSC

South African Dept. of Environmental Affairs
South African Dept. of Ag., Forestry, and Fisheries
University of Cape Town

Lambert's Bay South Africa, March 2015

Physical and biological data

Upwelling indices: Lamont *et al*. in review
daily NCEP-DOE Reanalysis 2 wind vectors
monthly sums of all positive Ekman transport
southern Benguela: 29-36°S

Biological data:

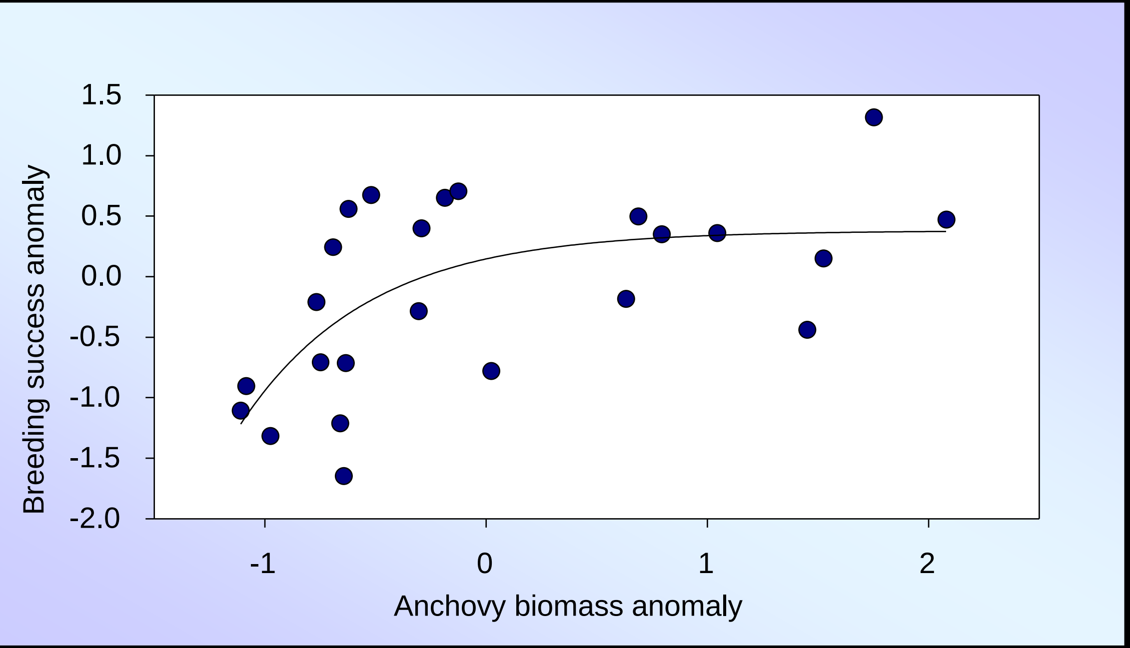
- Seabird
  - lay date
  - molt date
  - breeding success
  - survival
  - population estimates
- Fish
  - condition indices
  - population estimates

Physical and biological data

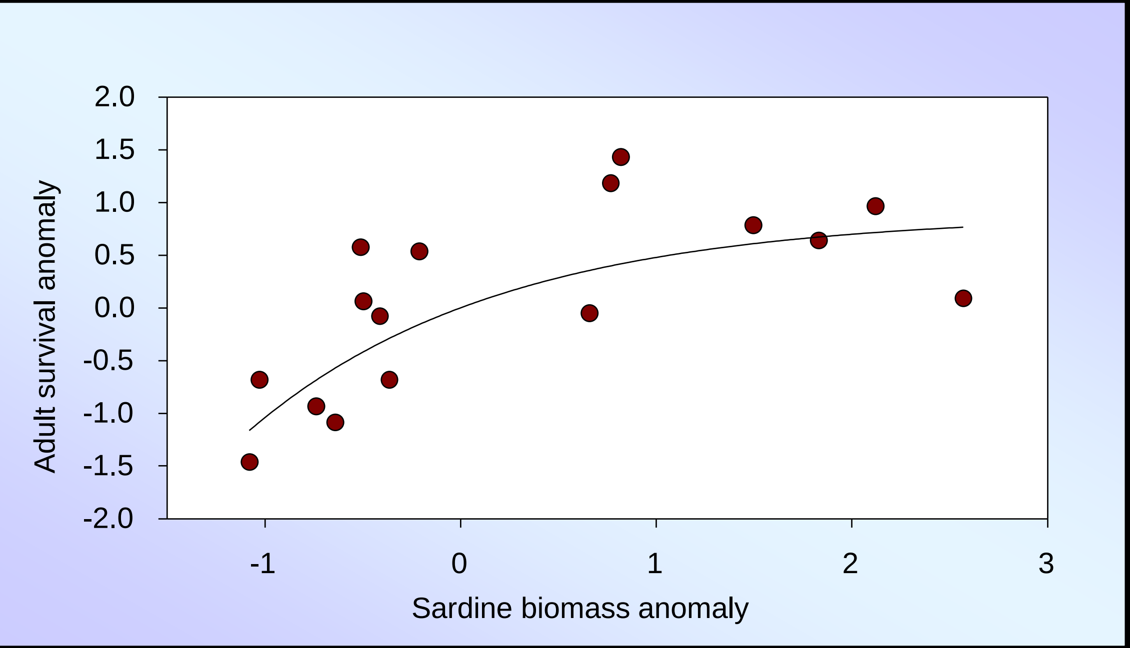
African penguin

breeding success (chicks fledged per pair)

survival (portion surviving)



Breeding success and anchovy



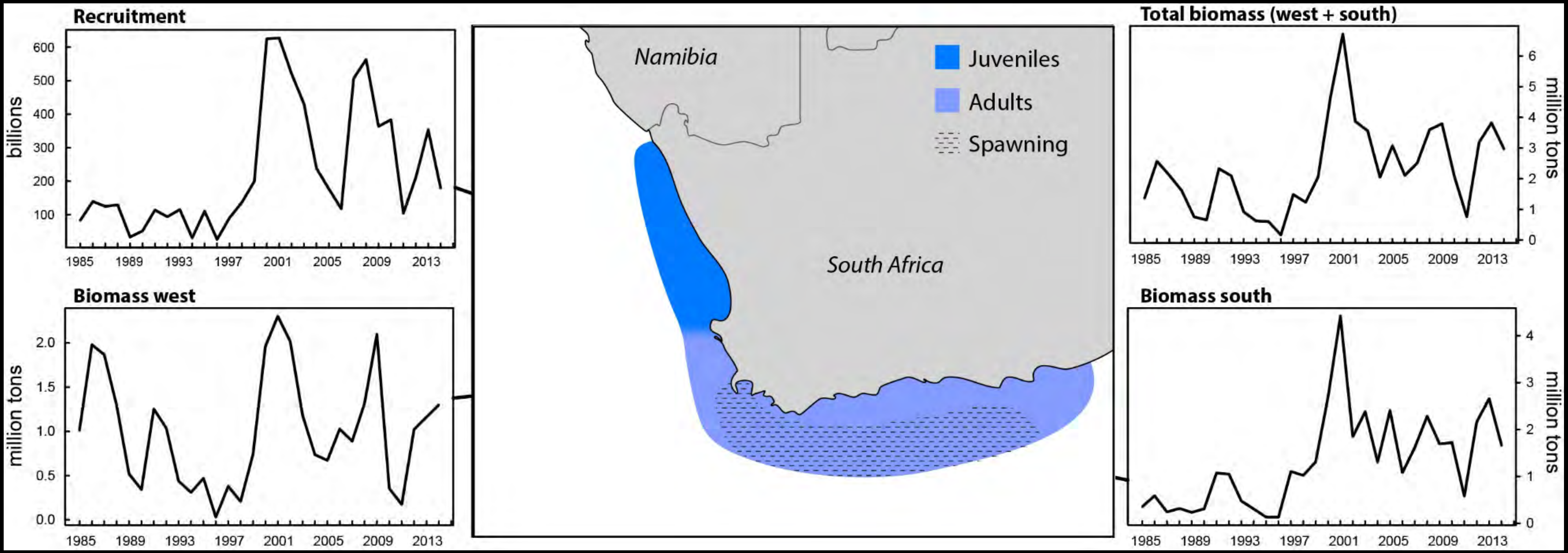
Adult survival and sardine

Benguela anchovy

Cape anchovy

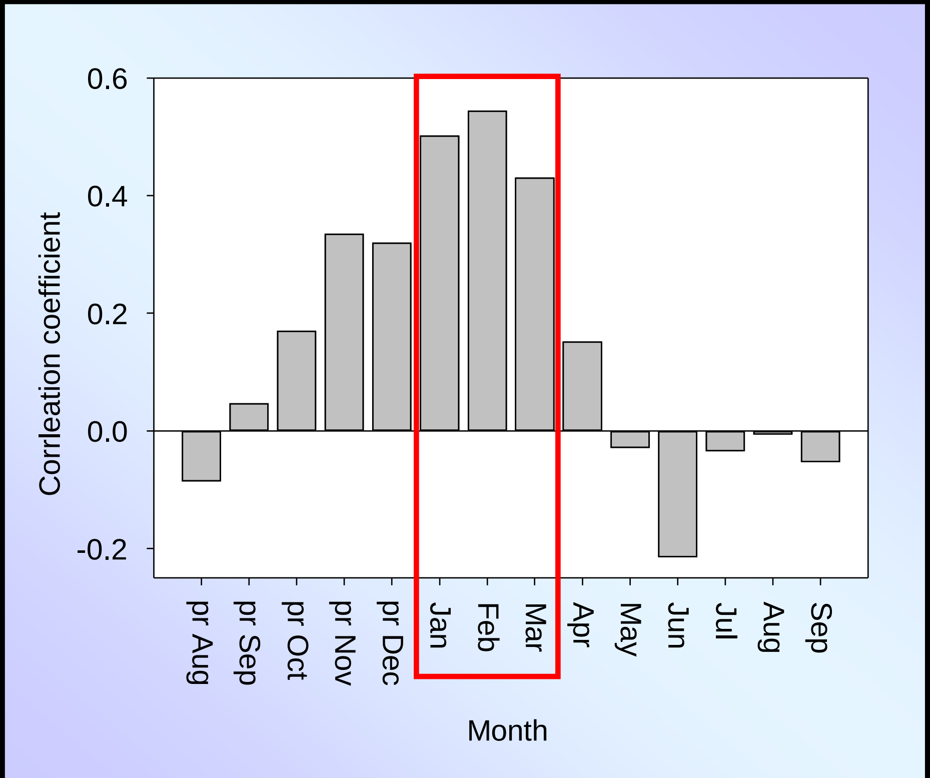
spawn Sep-Mar (peak Nov, Dec) on Agulhas Bank

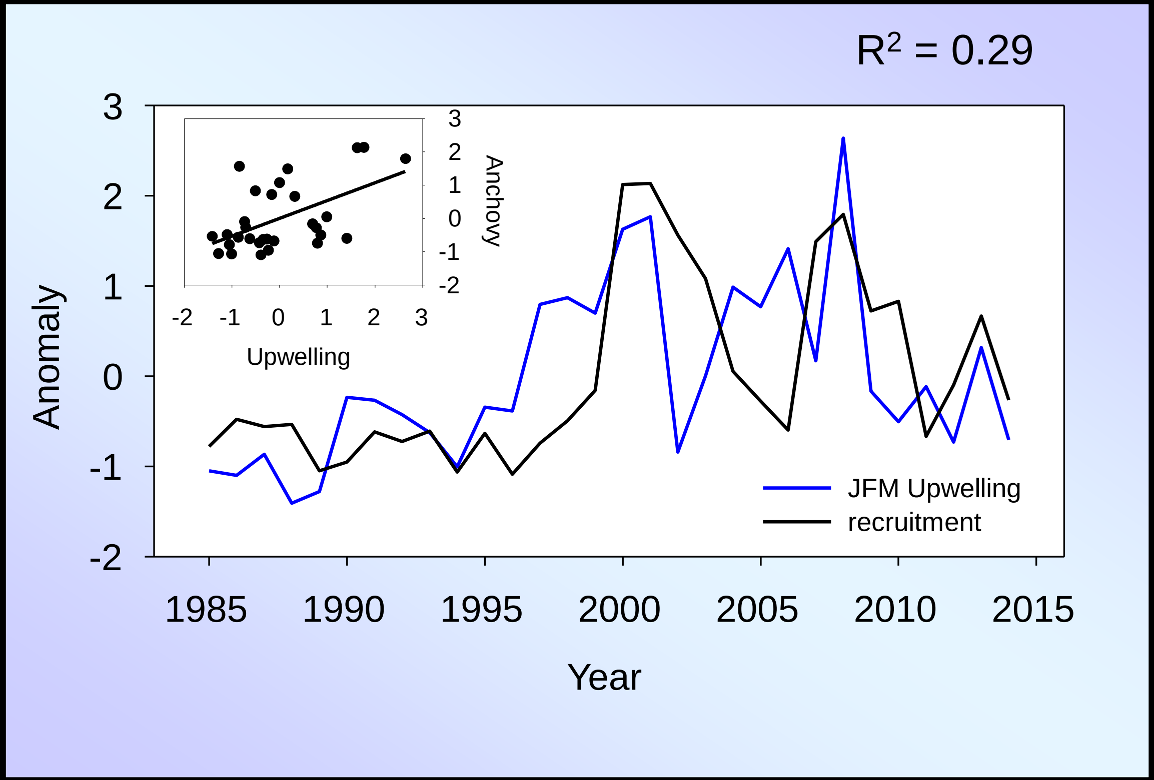
peak recruitment Jan-Mar on west coast



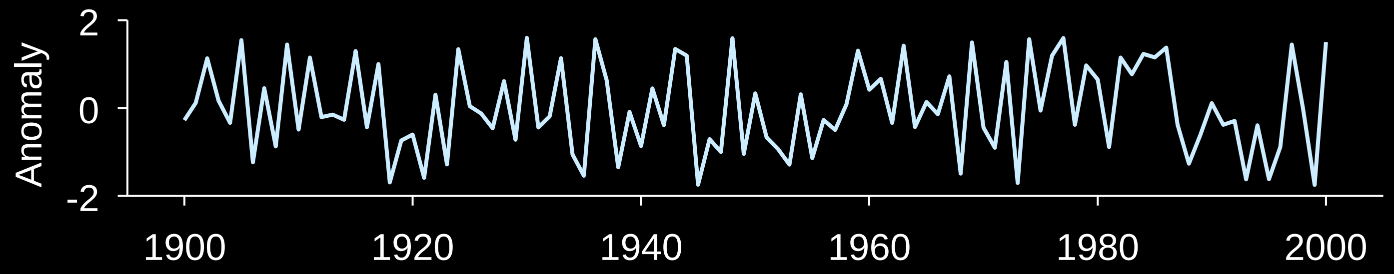
Benguela anchovy

Southern Benguela upwelling
and anchovy recruitment



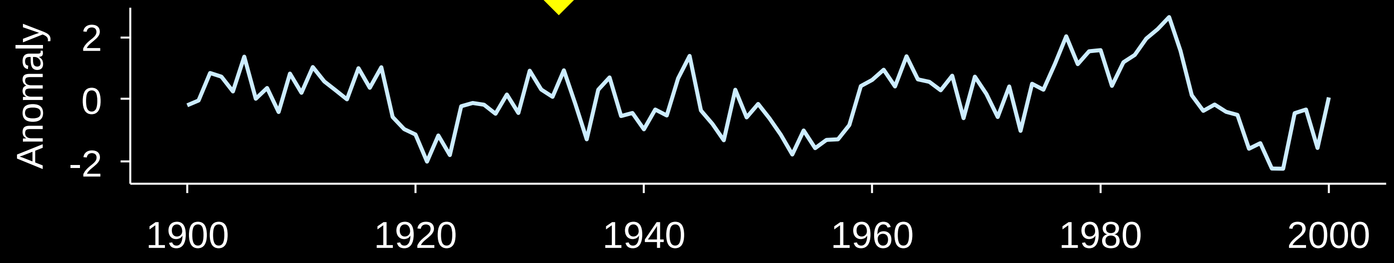


Integration: DiLorenzo and Ohman 2013 PNAS



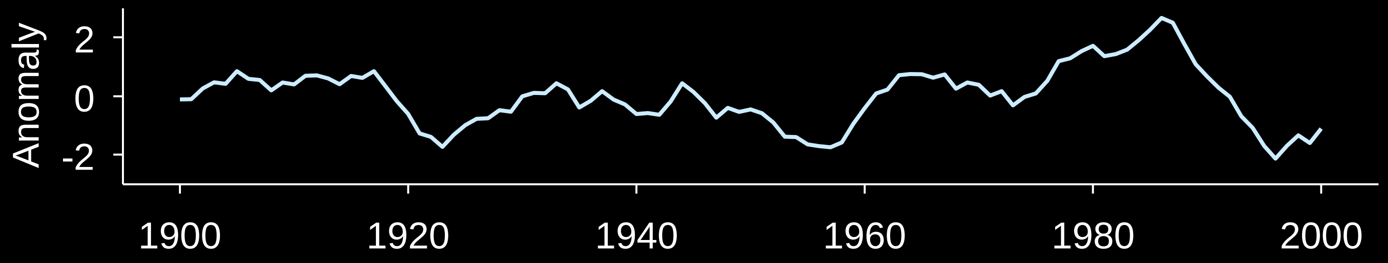
white noise
(random)

add autocorrelation



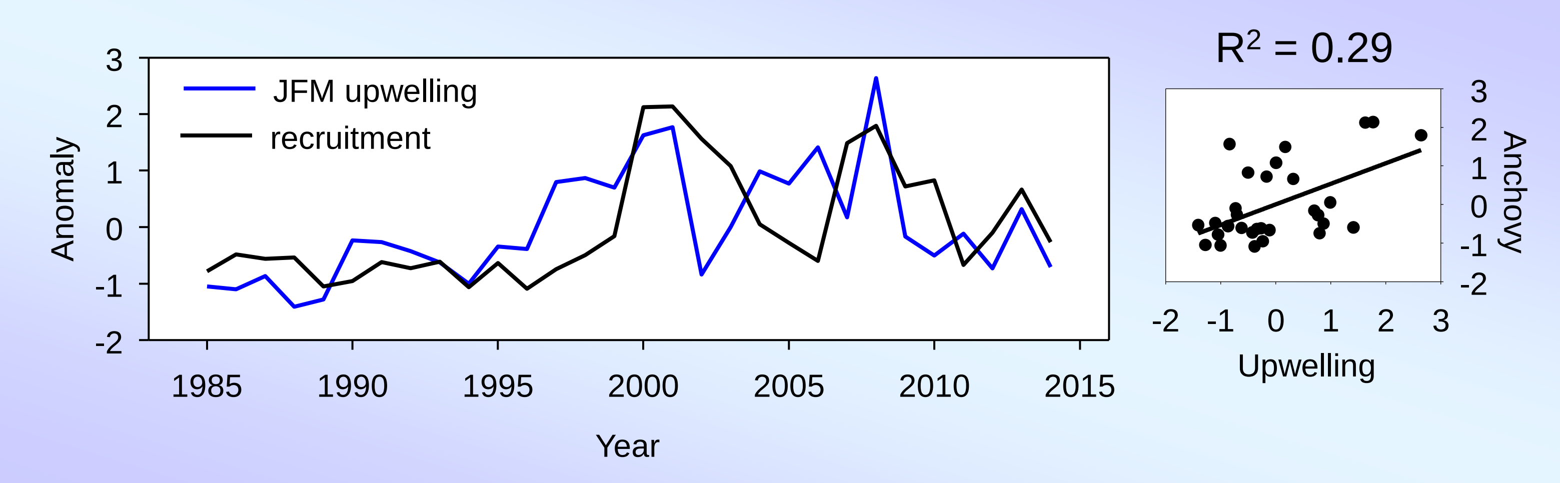
“reddened”
(autocorrelation
added)

add autocorrelation

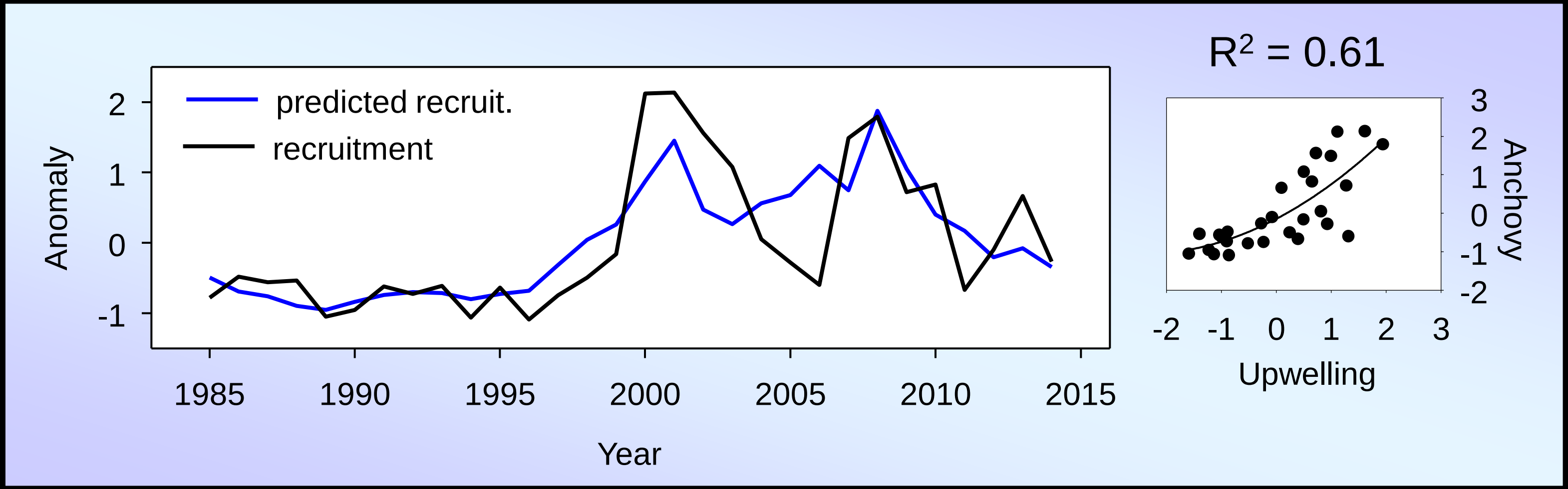


even more
autocorrelation!

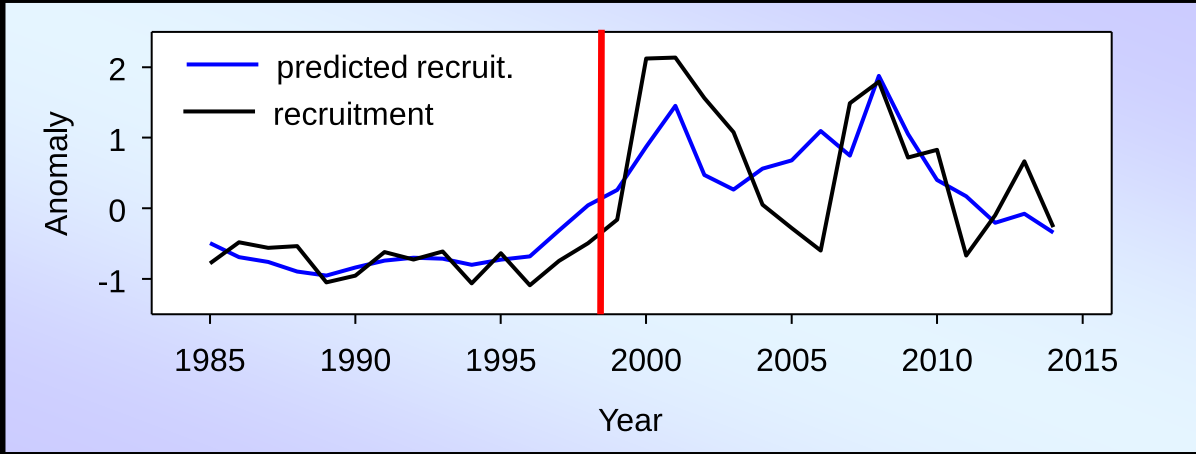
Benguela anchovy

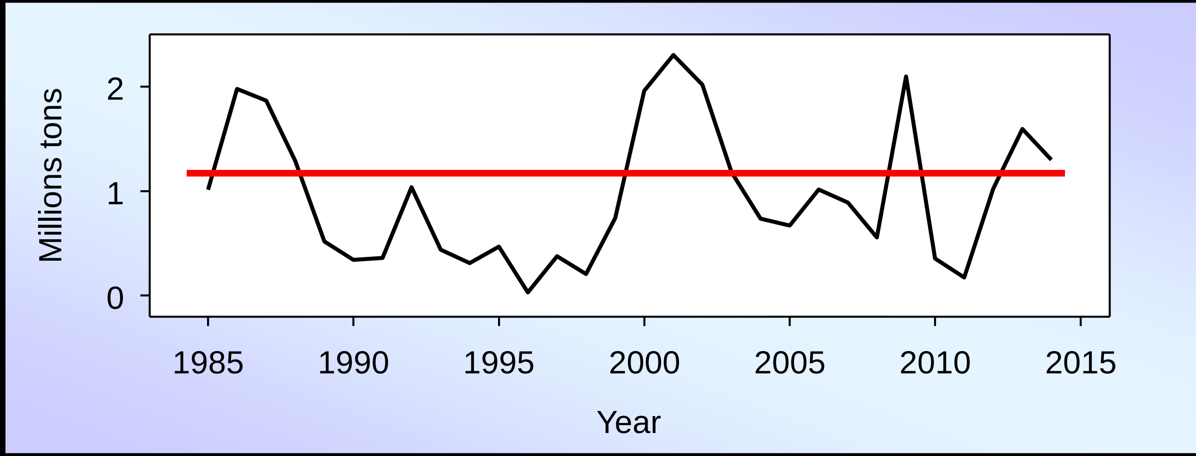


Add autocorrelation to upwelling
(“integrate”)



Threshold effects (non-stationarity)

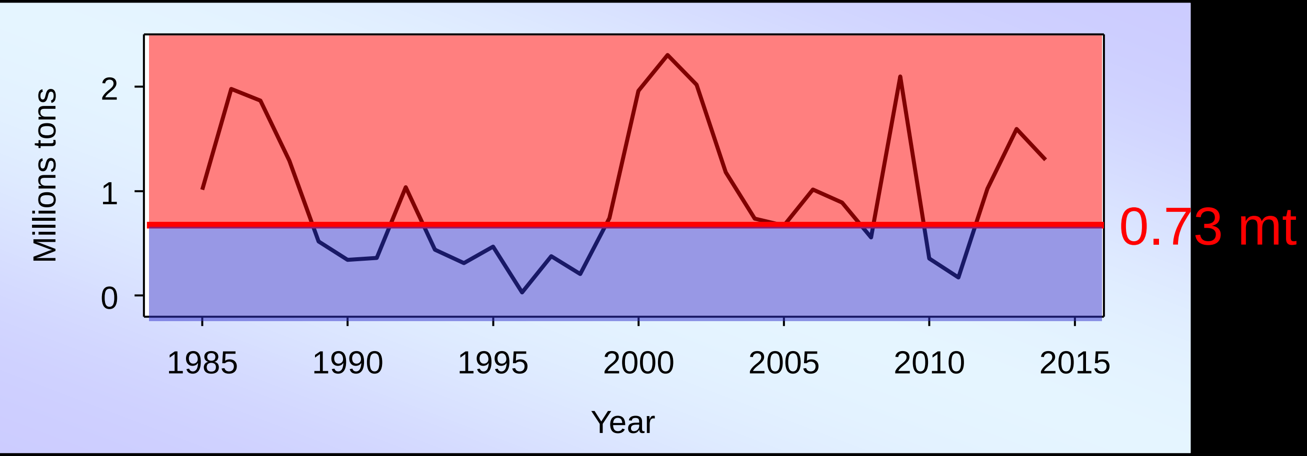




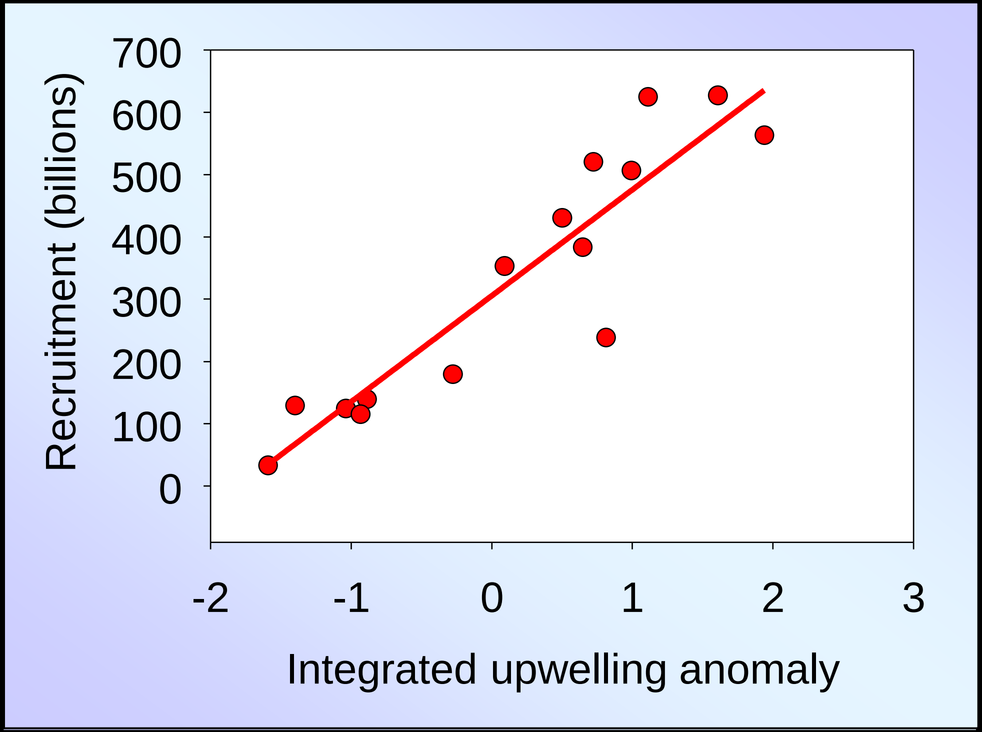
West Coast anchovy biomass

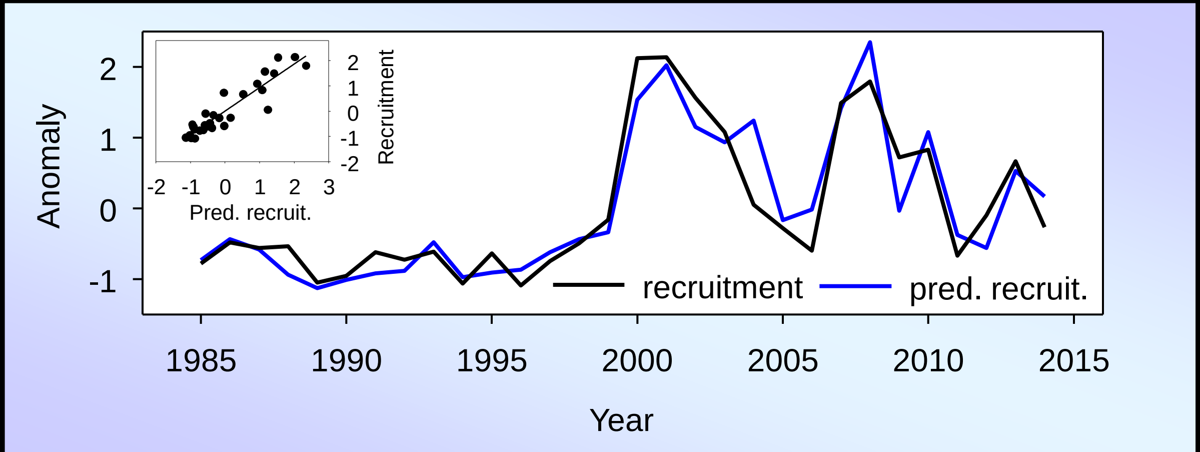
Threshold Interaction (“T”) GAMs
Ciannelli et al. 2004 *Ecology*

Threshold effects (non-stationarity)



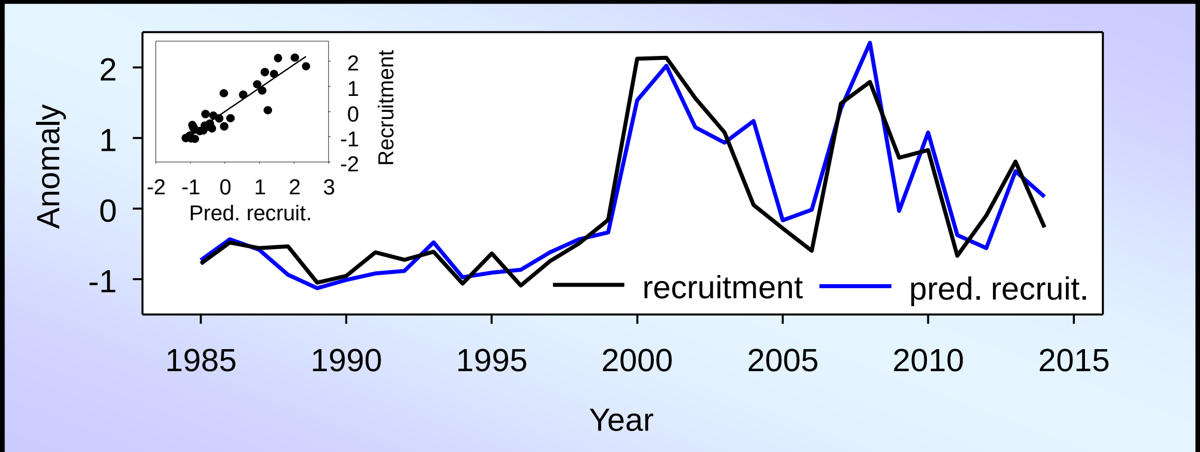
West Coast anchovy biomass



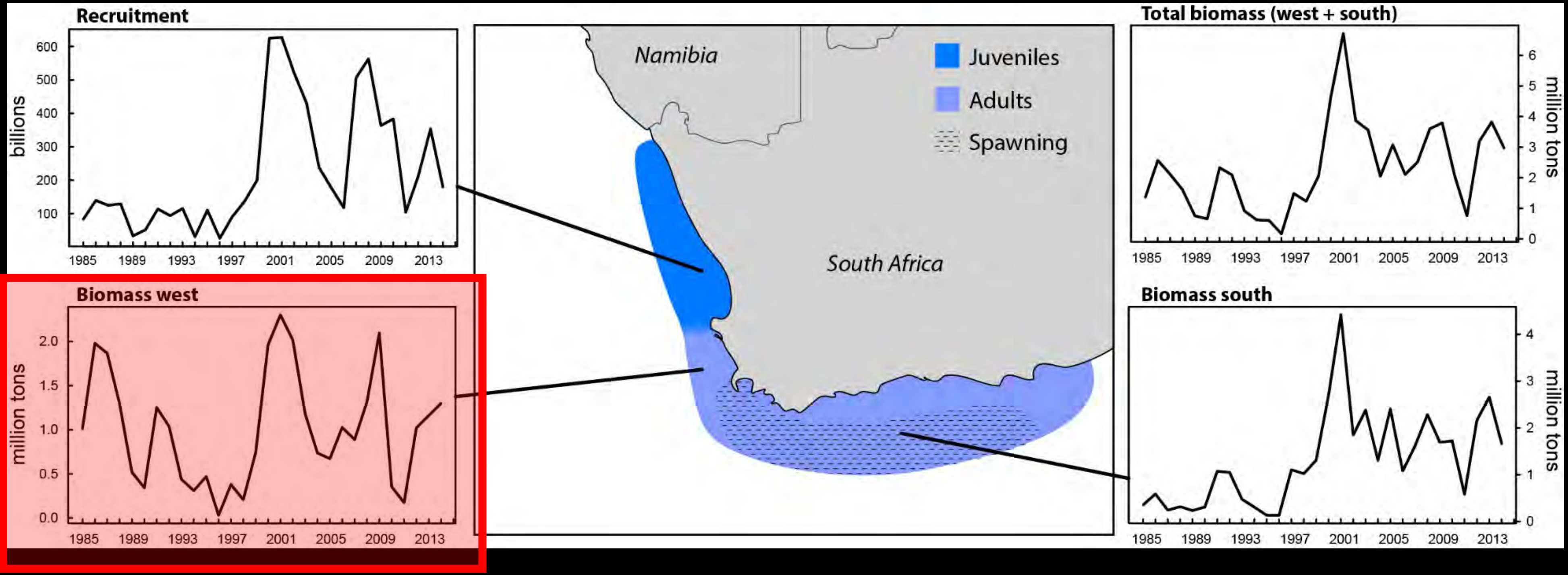


Predicted recruitment (R^2 = 0.84)

Predicted recruitment

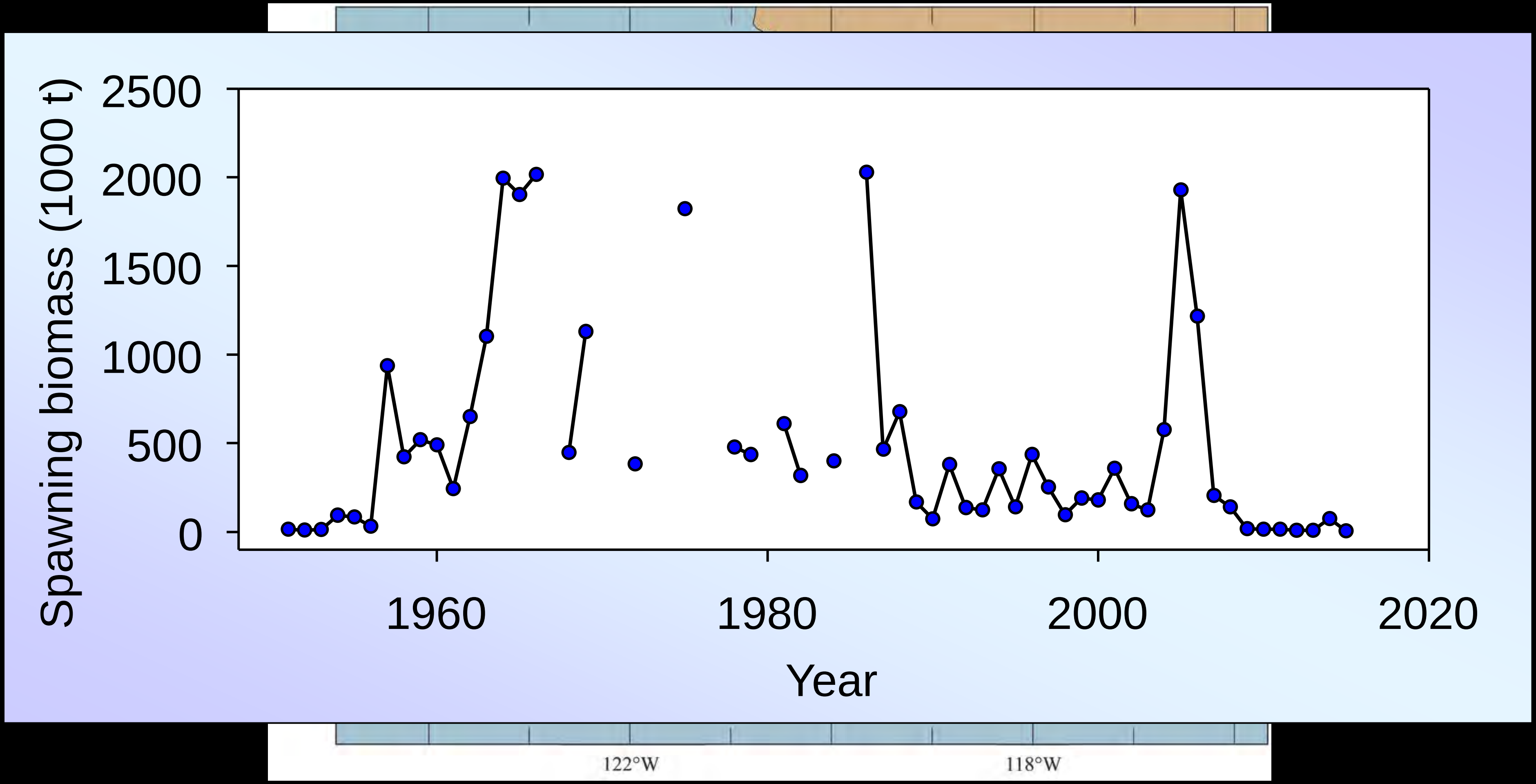


1) Integration of upwelling signals
2) Threshold response of west biomass

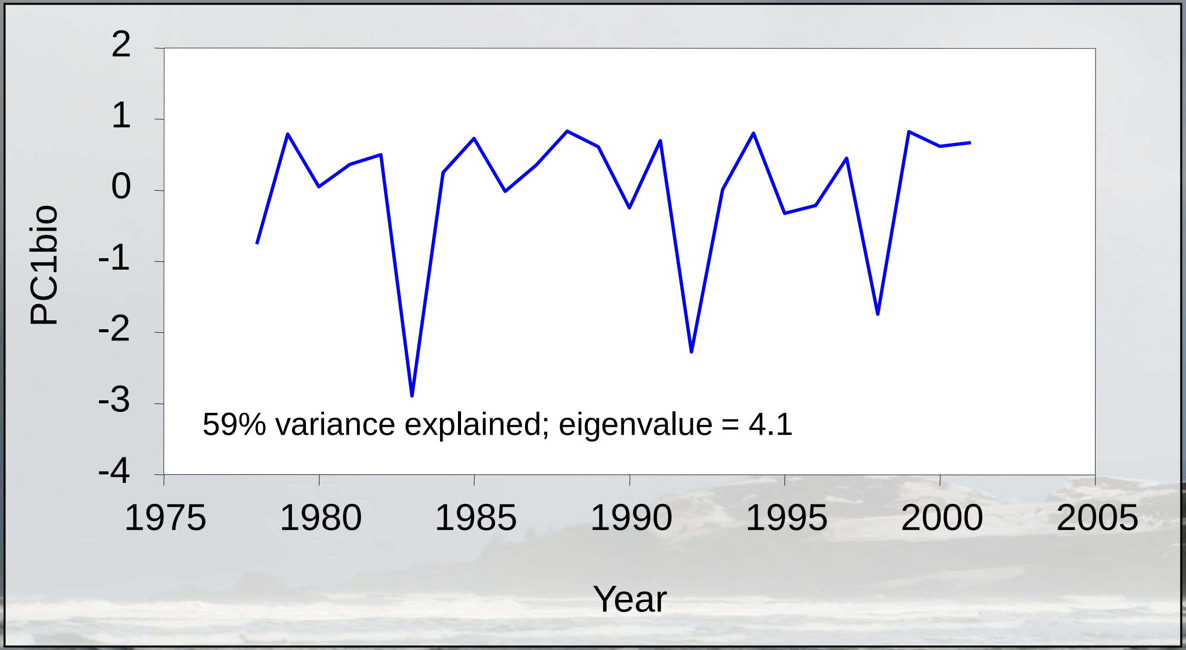


California Current anchovy biomass

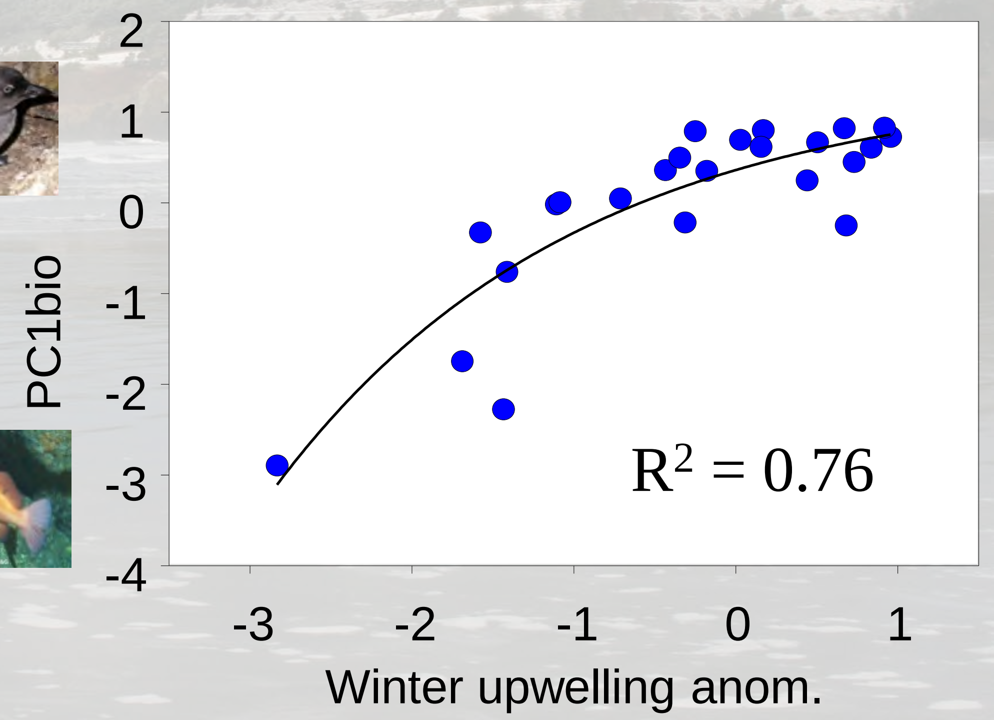
MacCall *et al*. 2016. *Fish. Res*. Recent collapse of northern anchovy off CA



PC1 for fish and bird time series



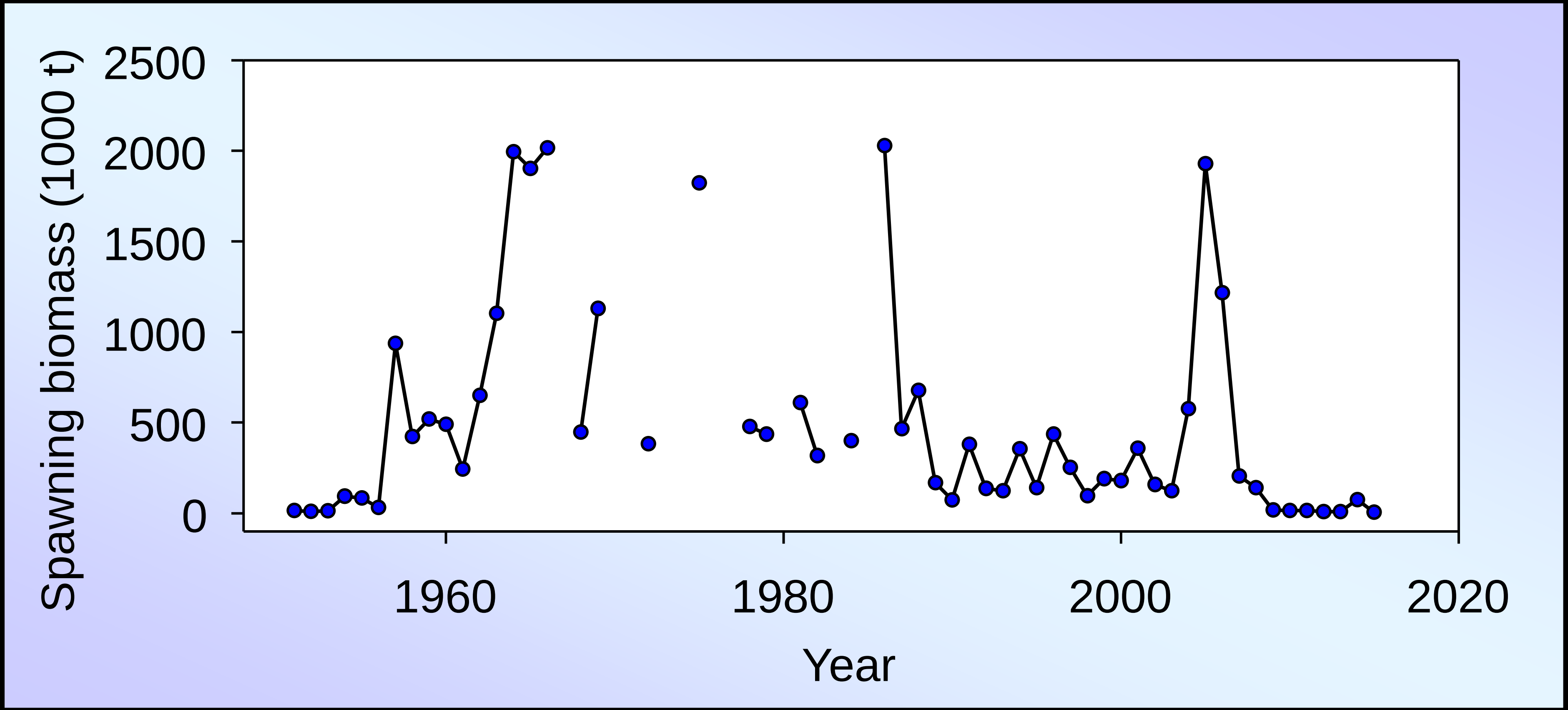
PC1 of 7 bird and fish series



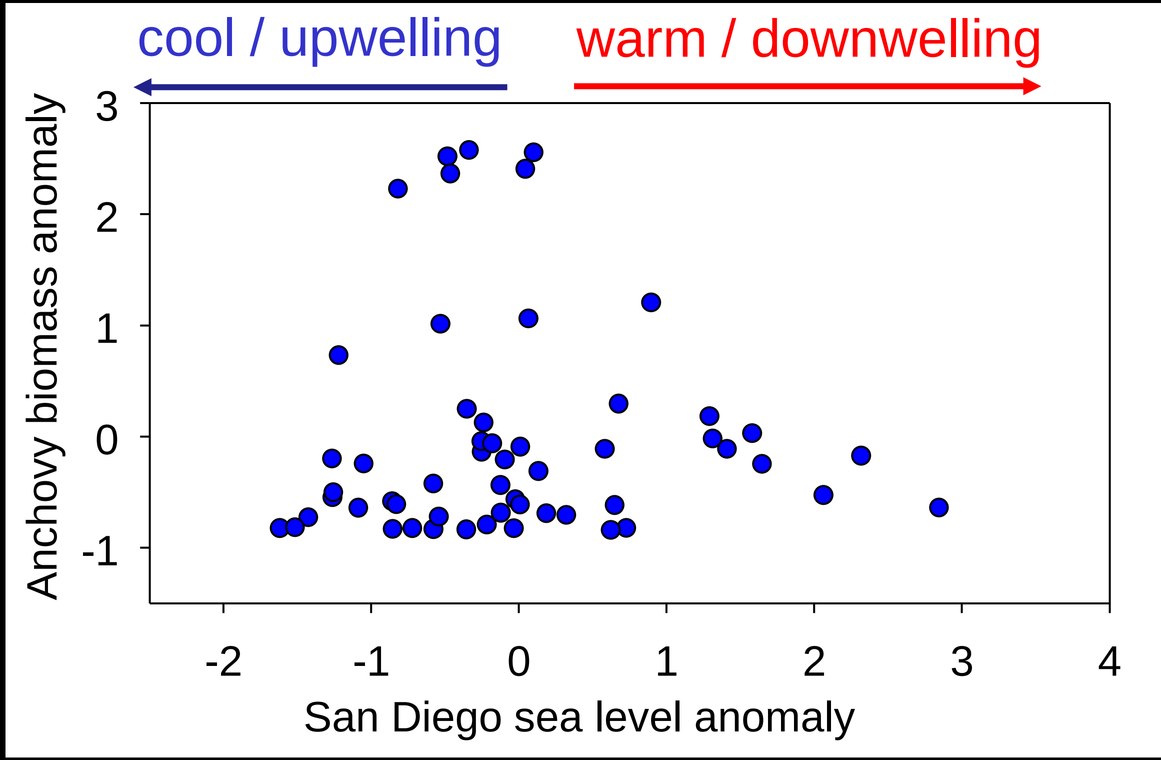
California Current anchovy biomass

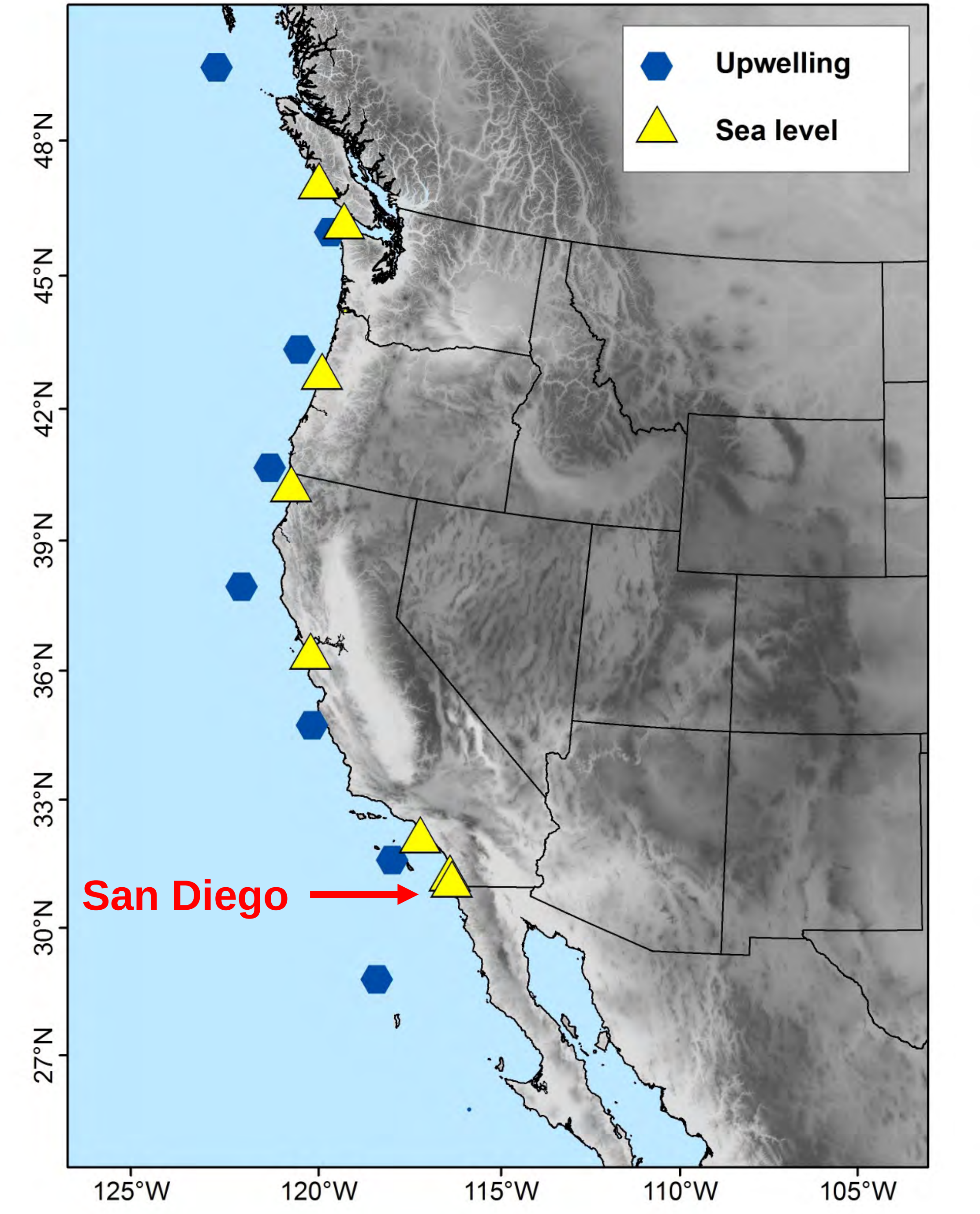
Does integrating upwelling / winter pattern (or any month of upwelling) help explain anchovy?

Maybe something with sea level at San Diego



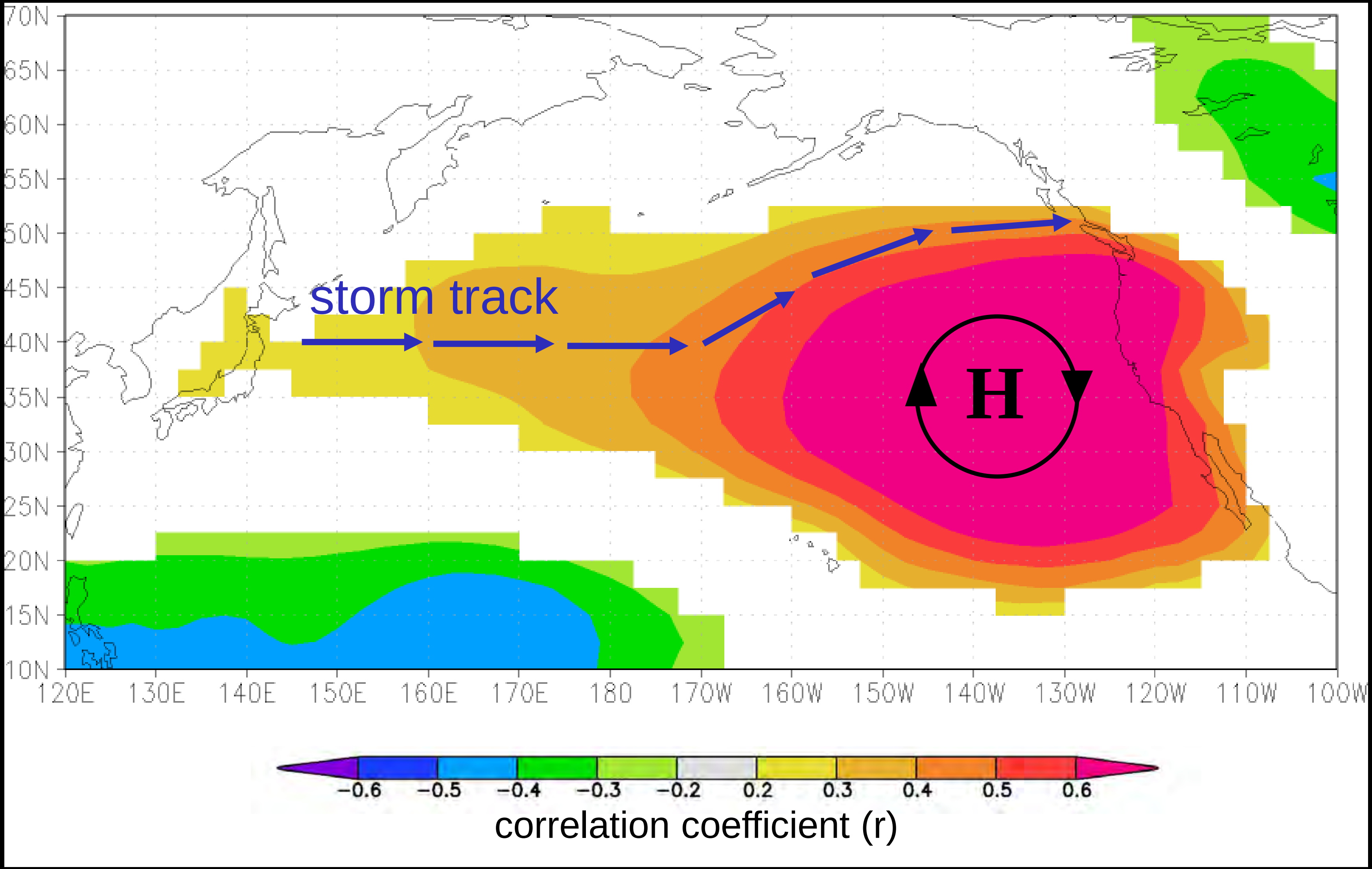
Anchovy and winter sea level



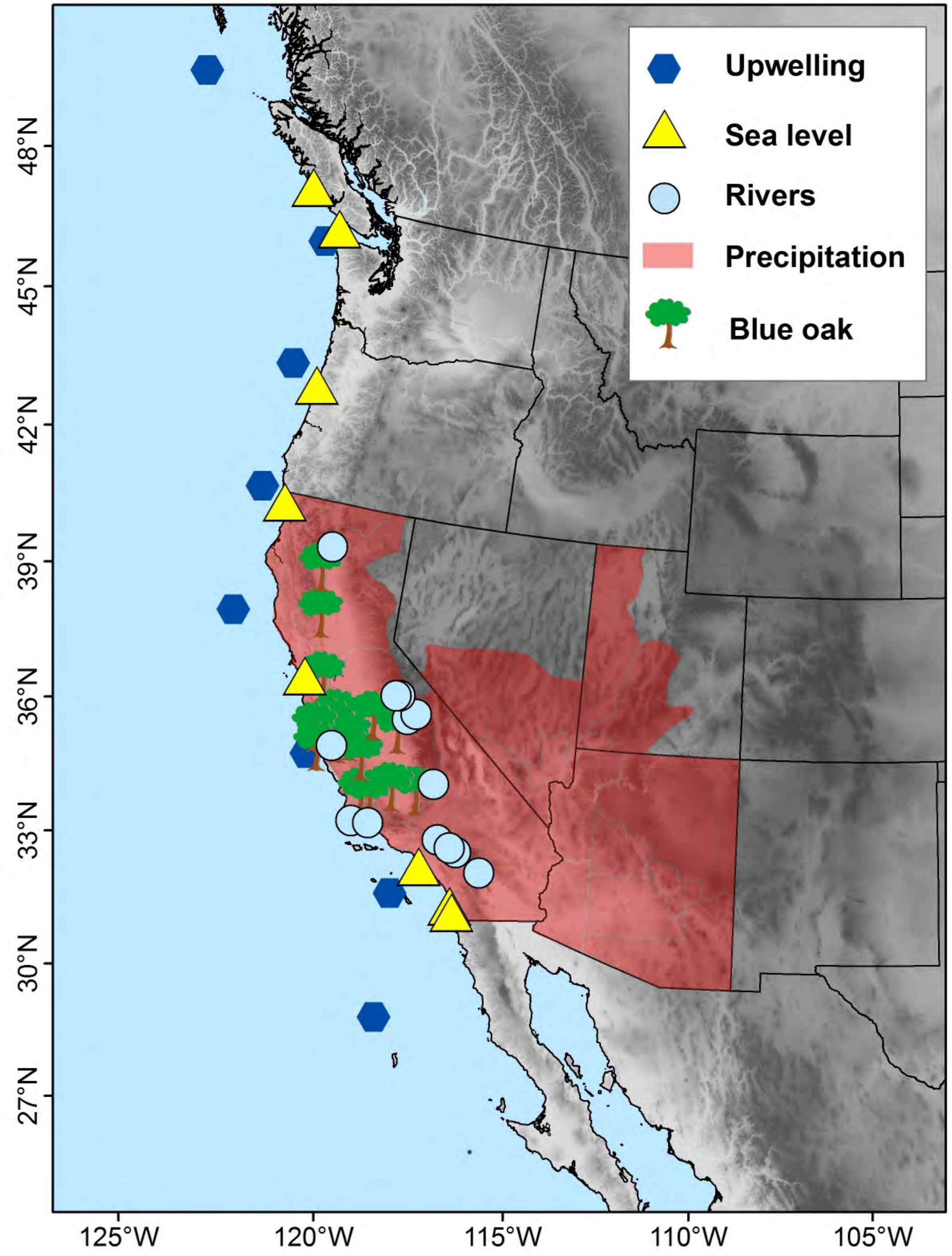


Winter blocking high

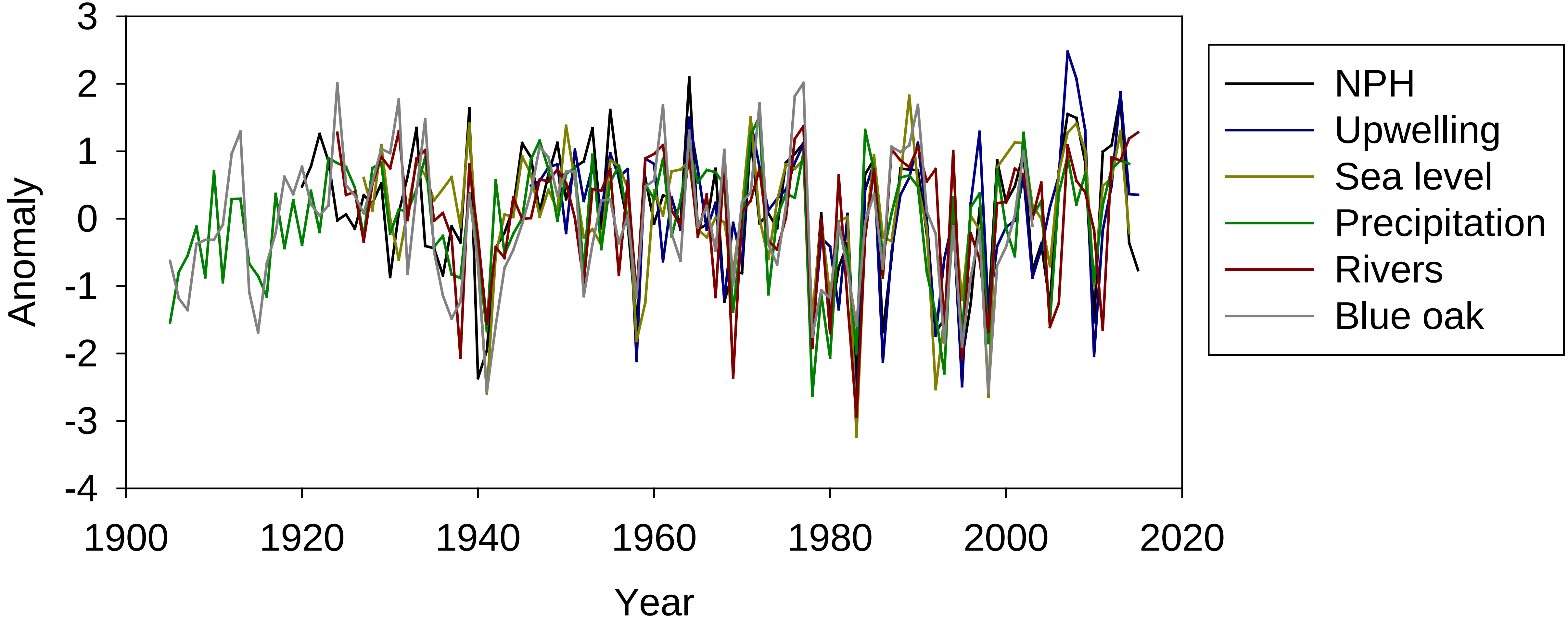
Correlation between winter upwelling and sea level pressure



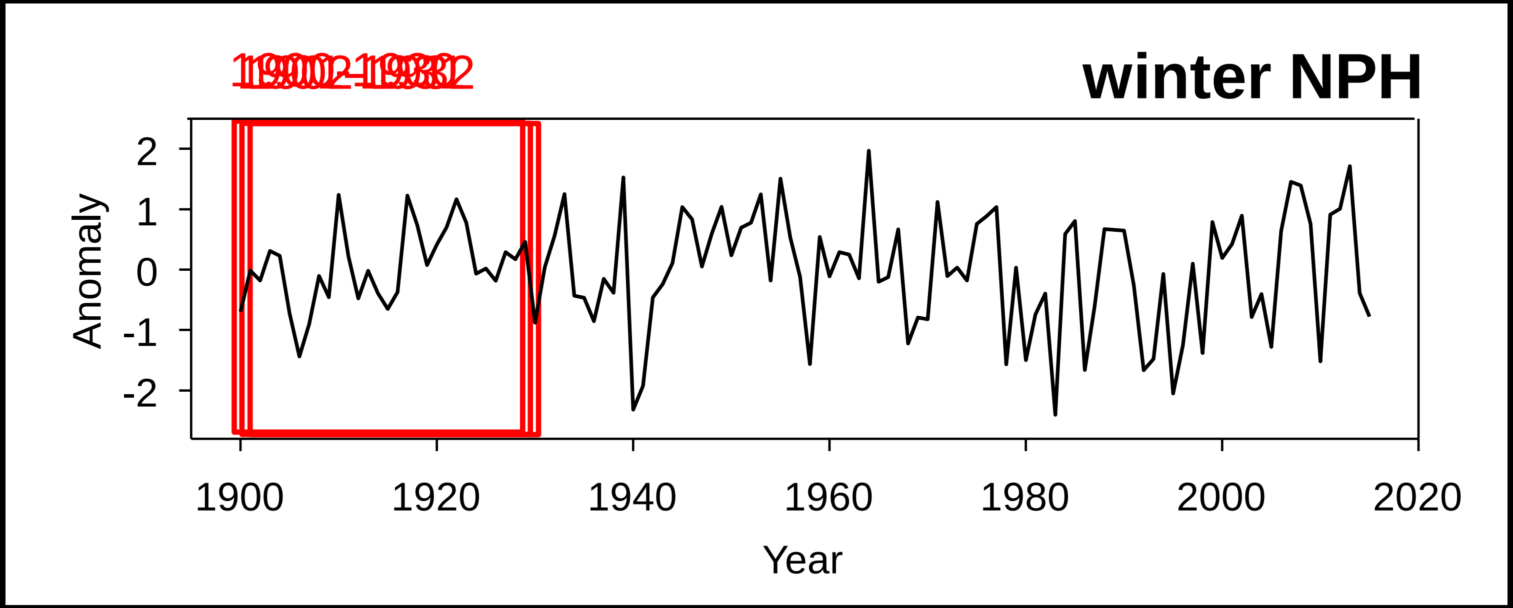
Winter North Pacific High correlates to…

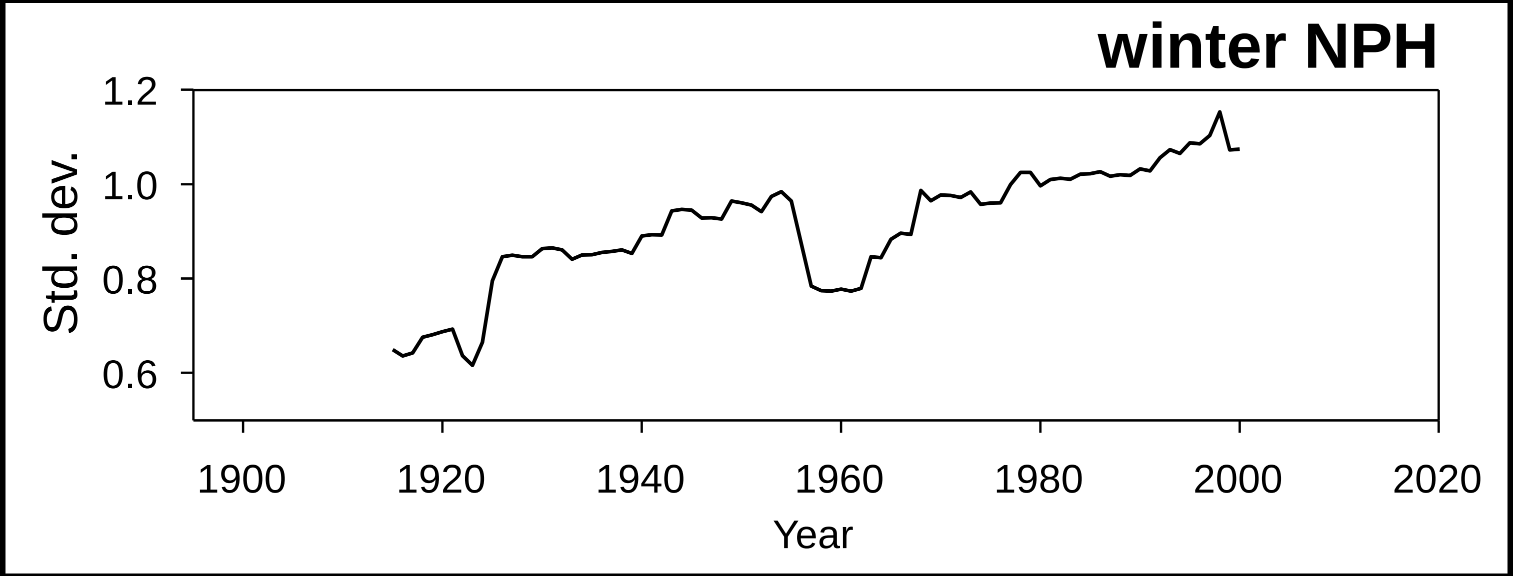


Marine-terrestrial coherence

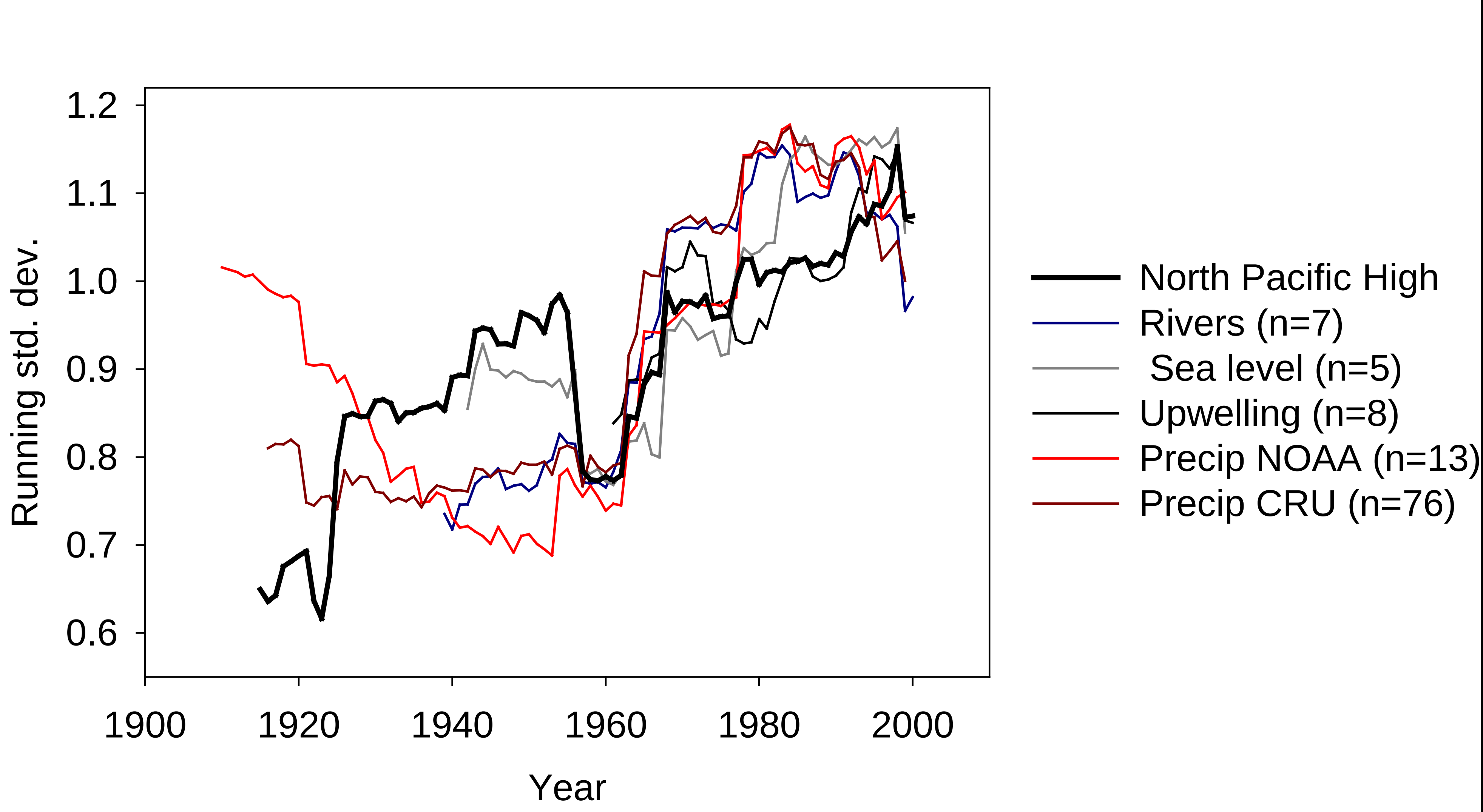


Running standard deviation

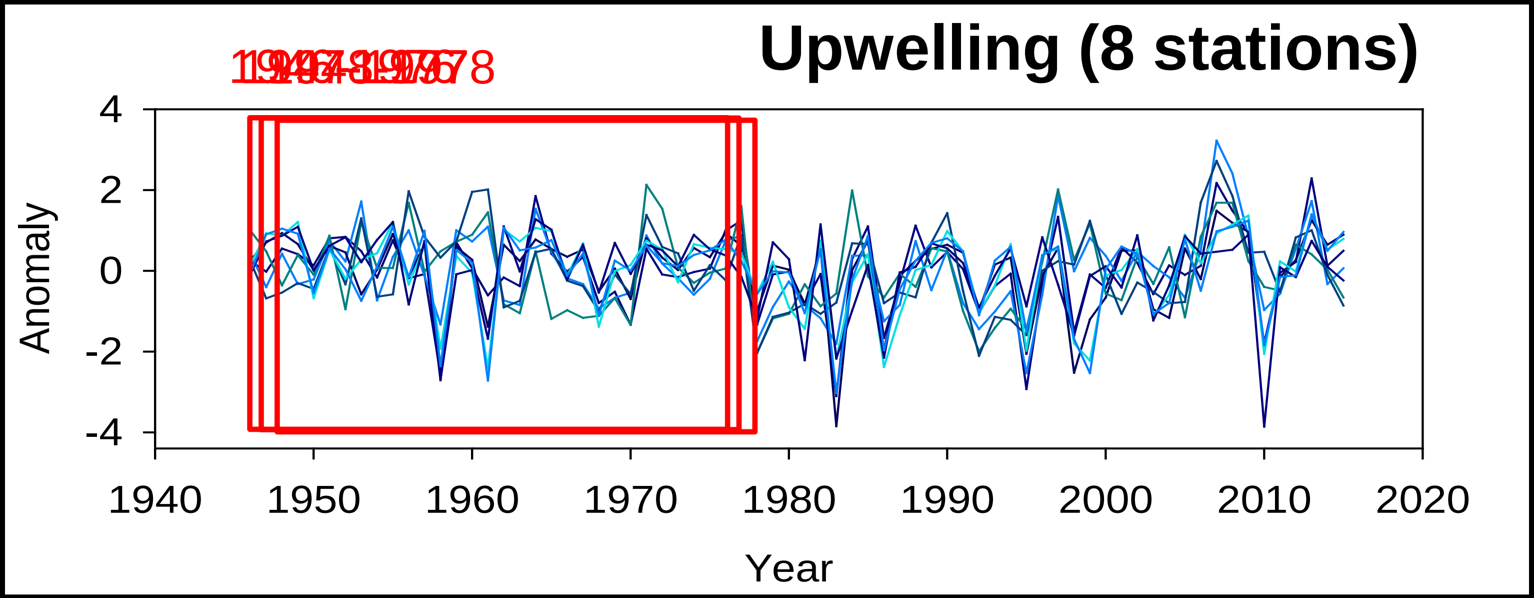


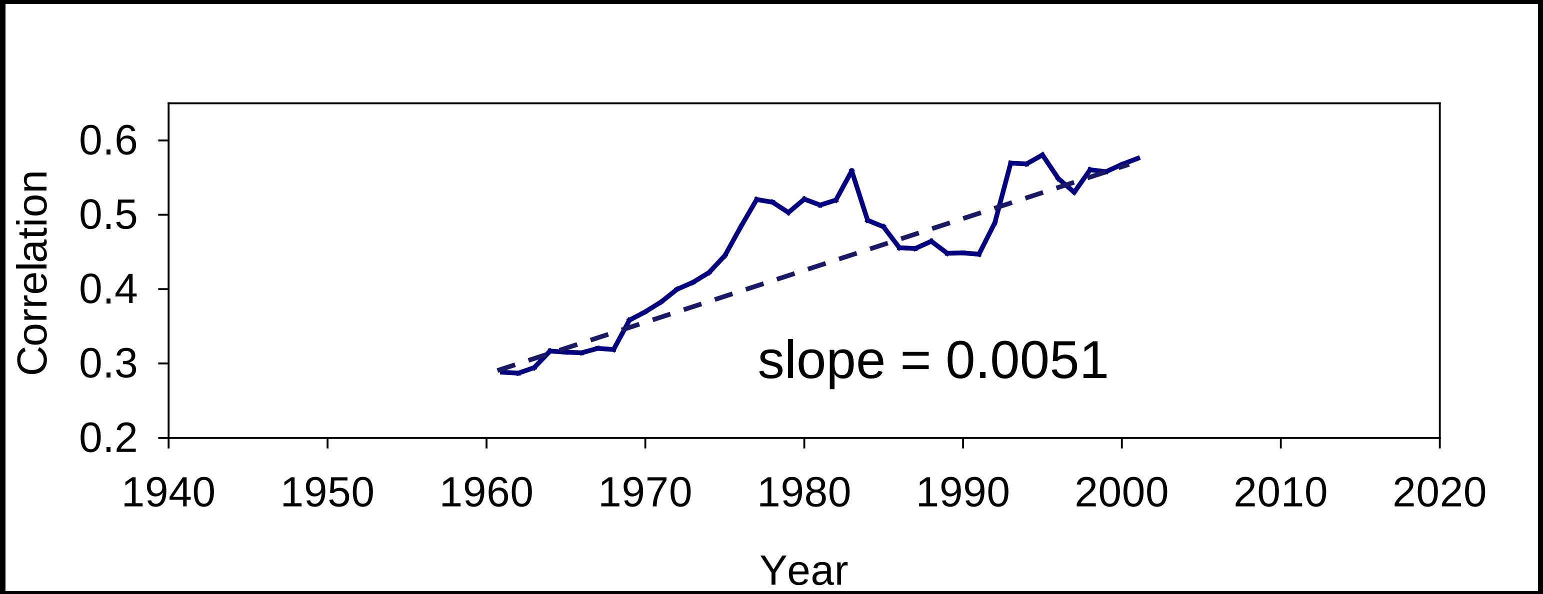


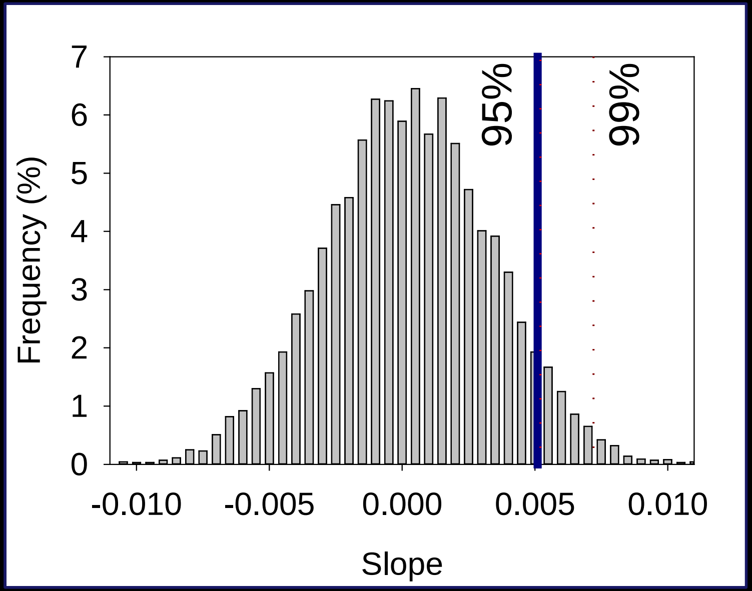
Running standard deviation



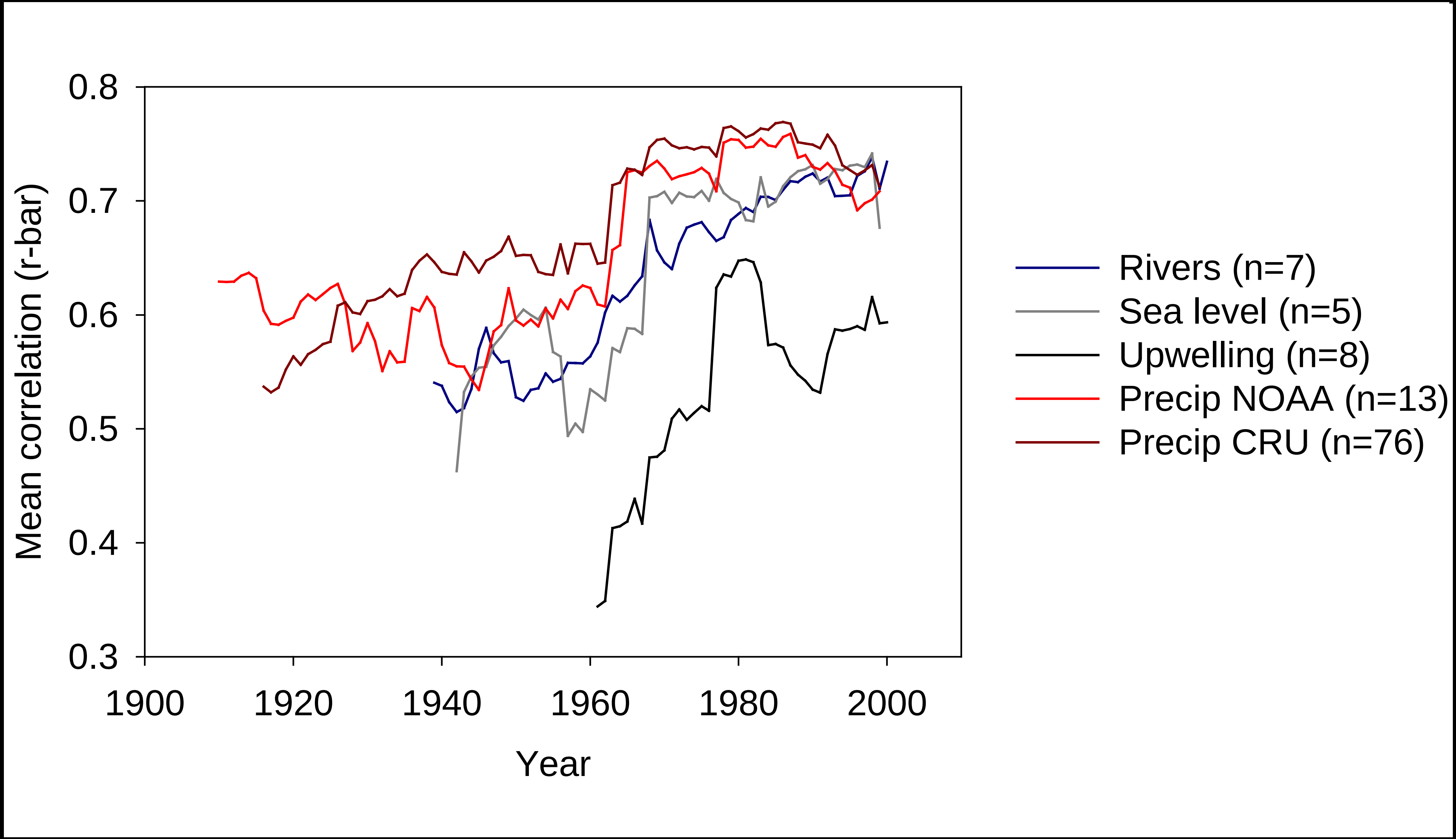
Running pairwise correlations



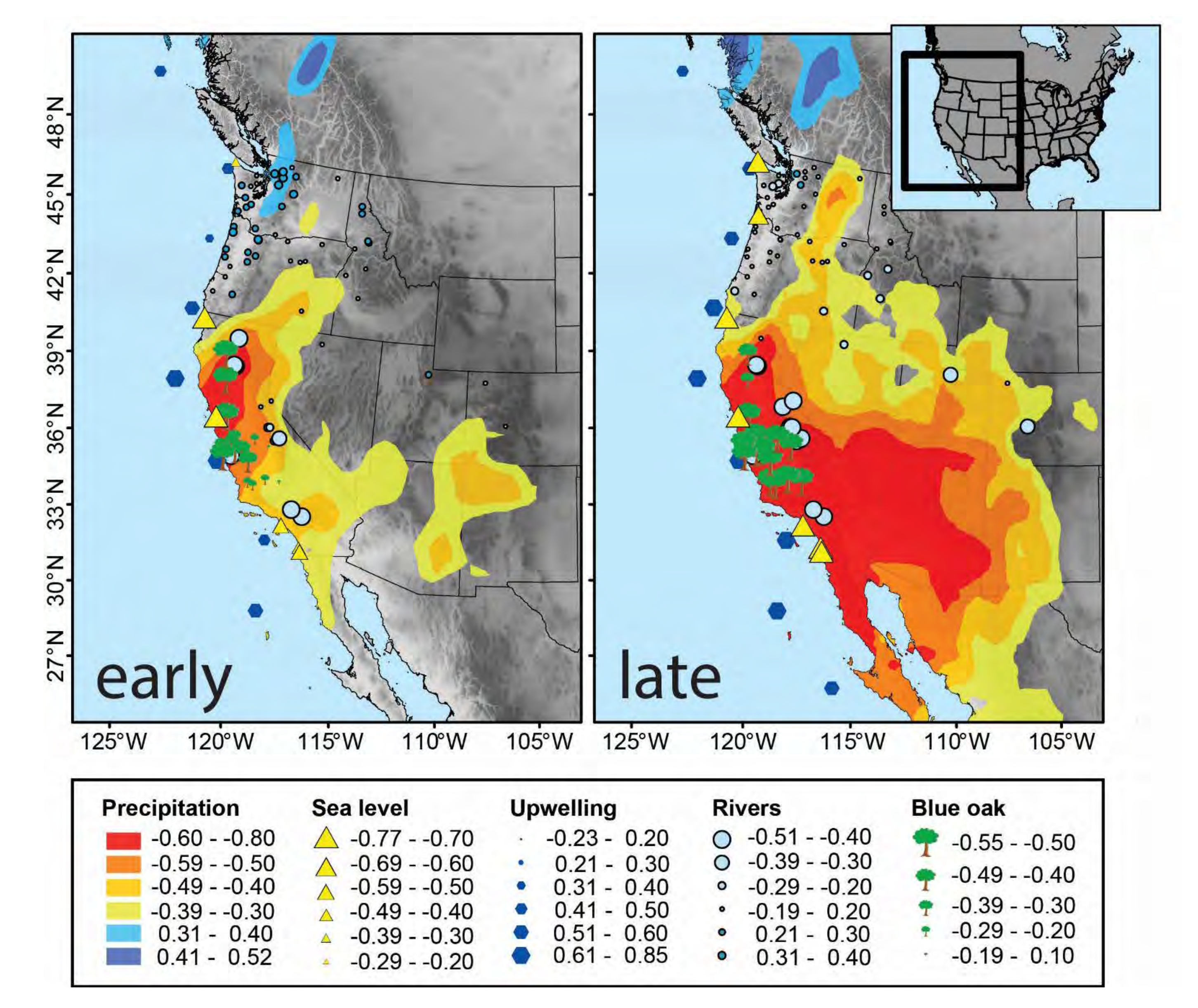




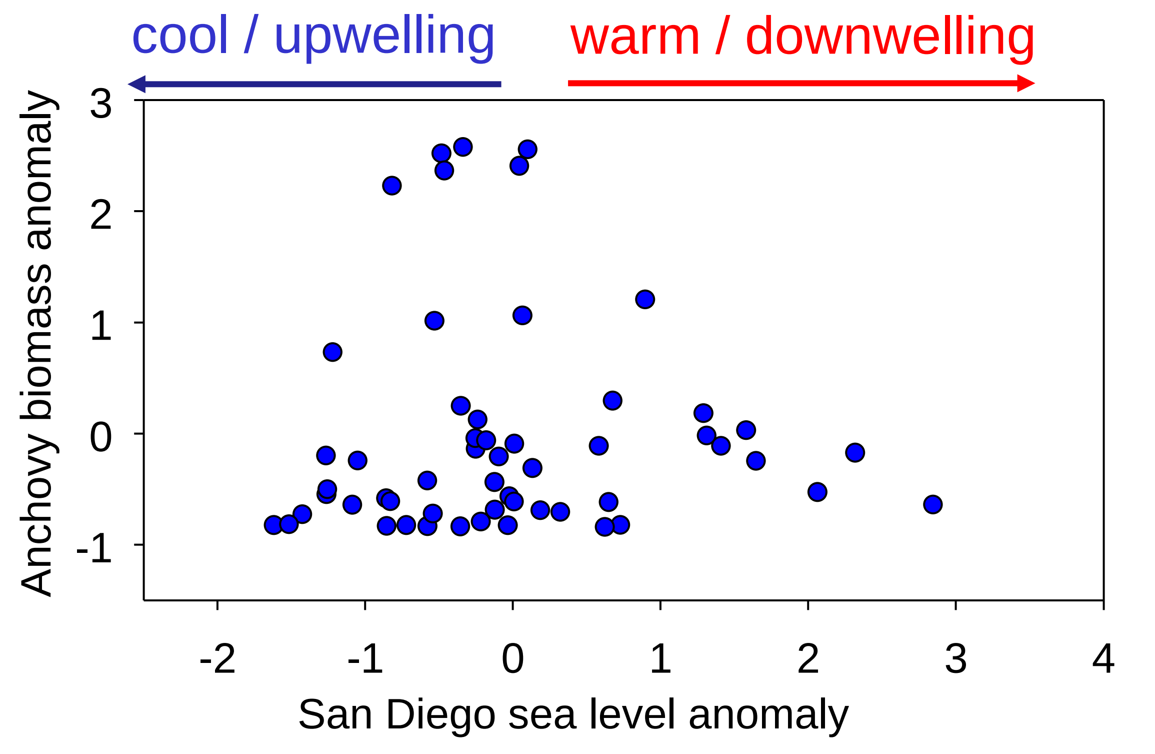
Running pairwise correlations

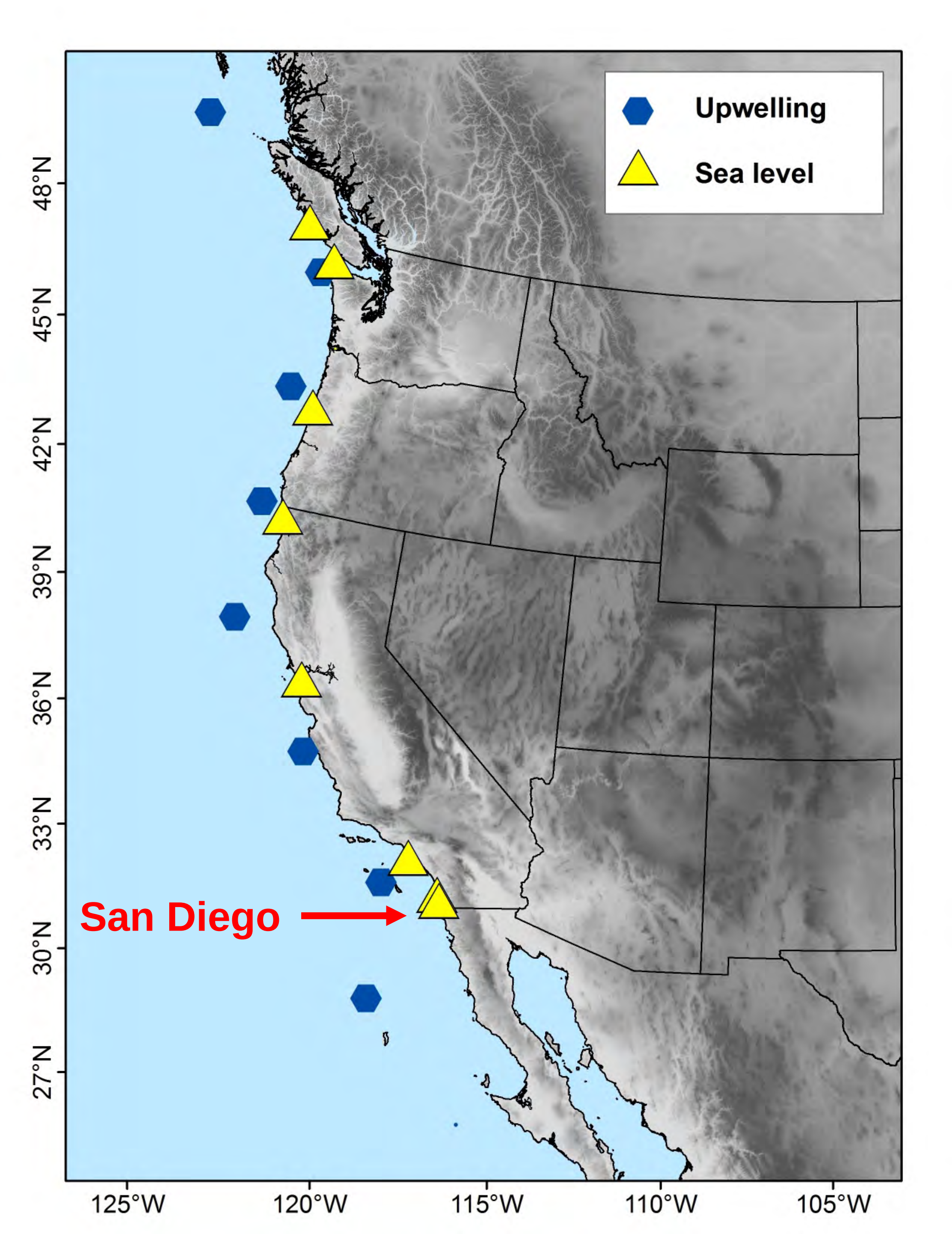


Increasing NPH “fingerprint”

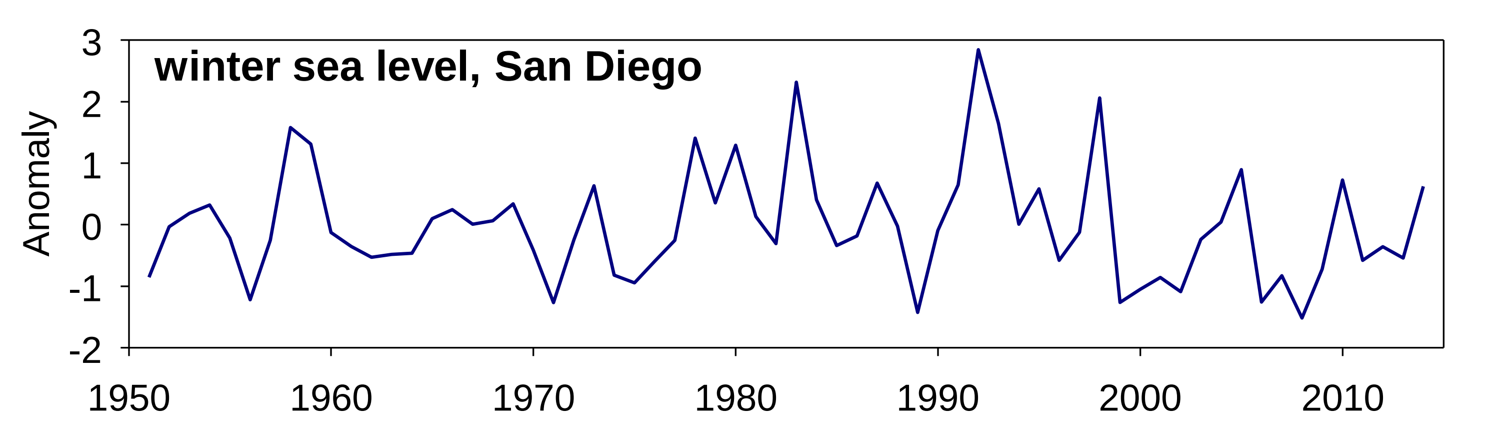


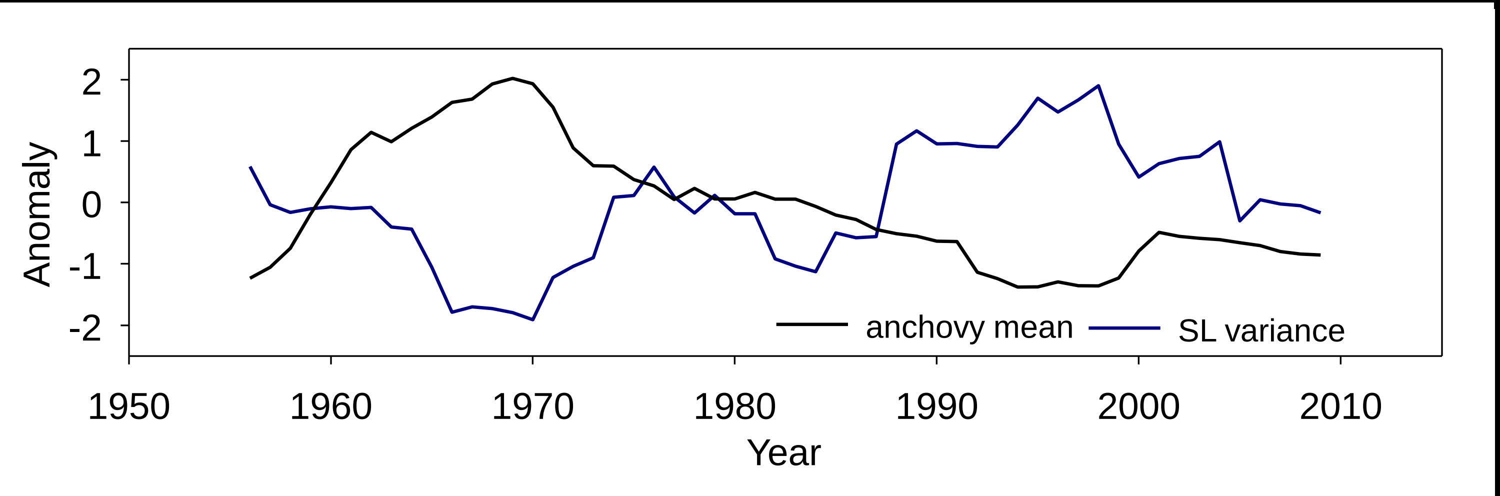
Anchovy and winter sea level

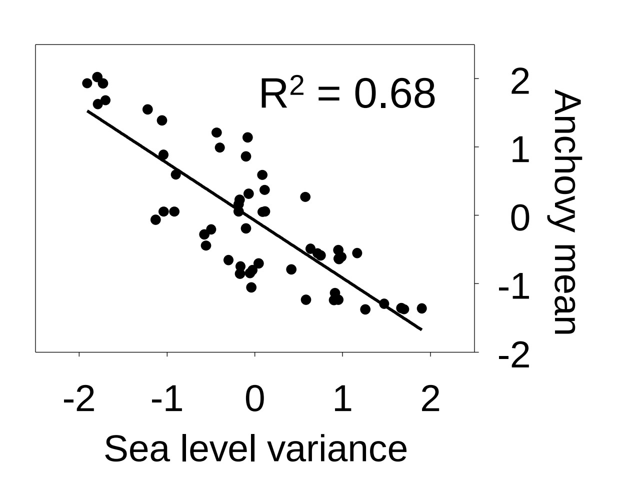




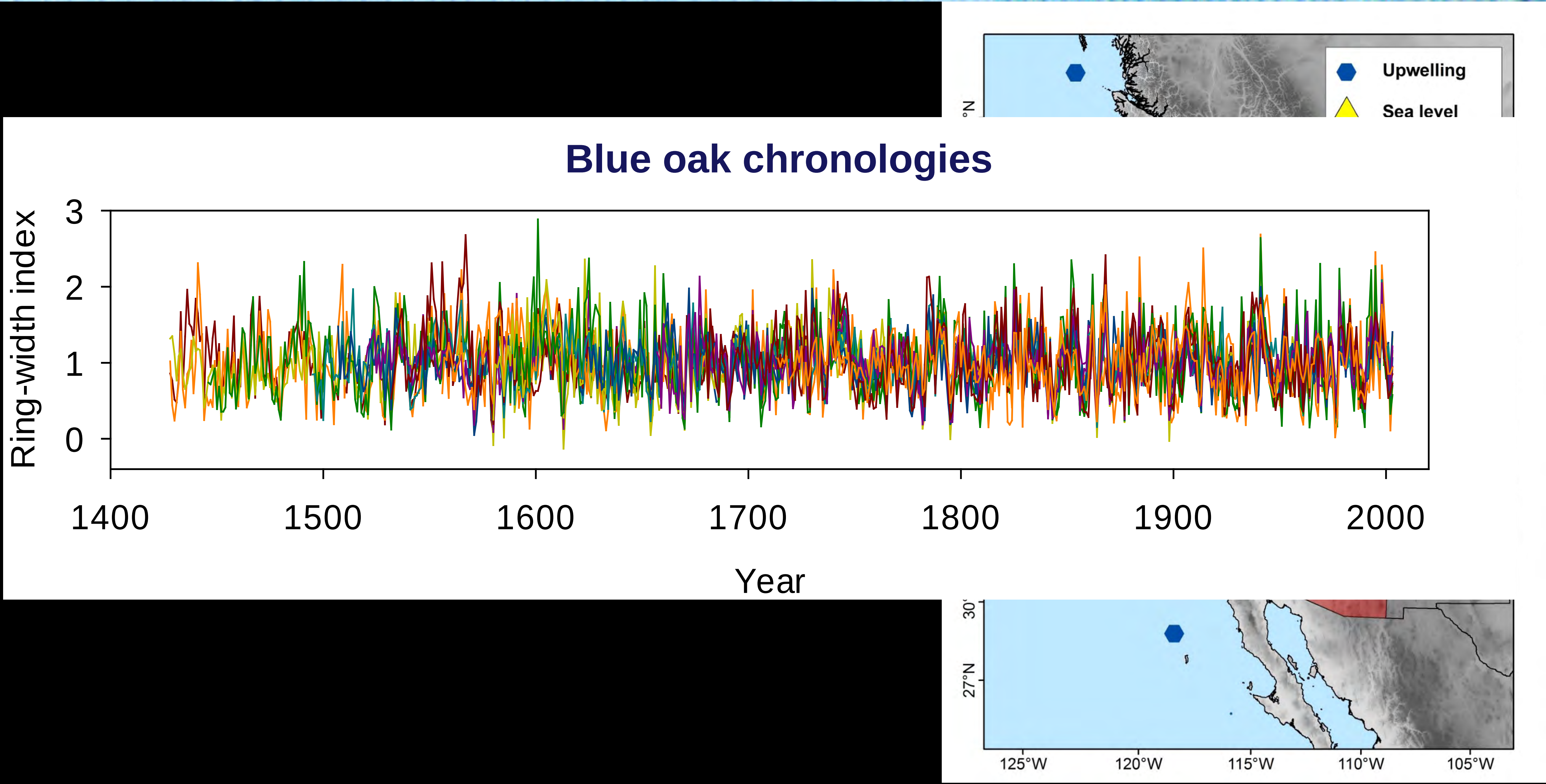
Anchovy and winter sea level variance







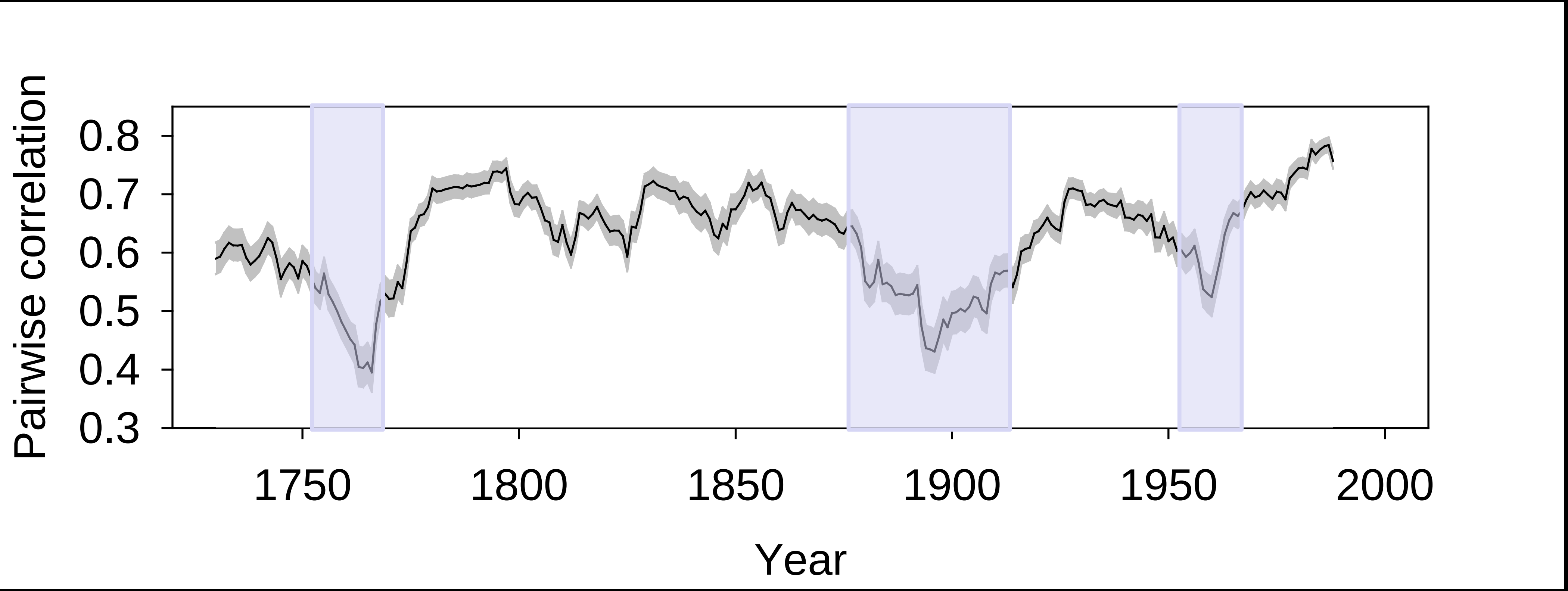
16 blue oak chronologies



Blue oak synchrony

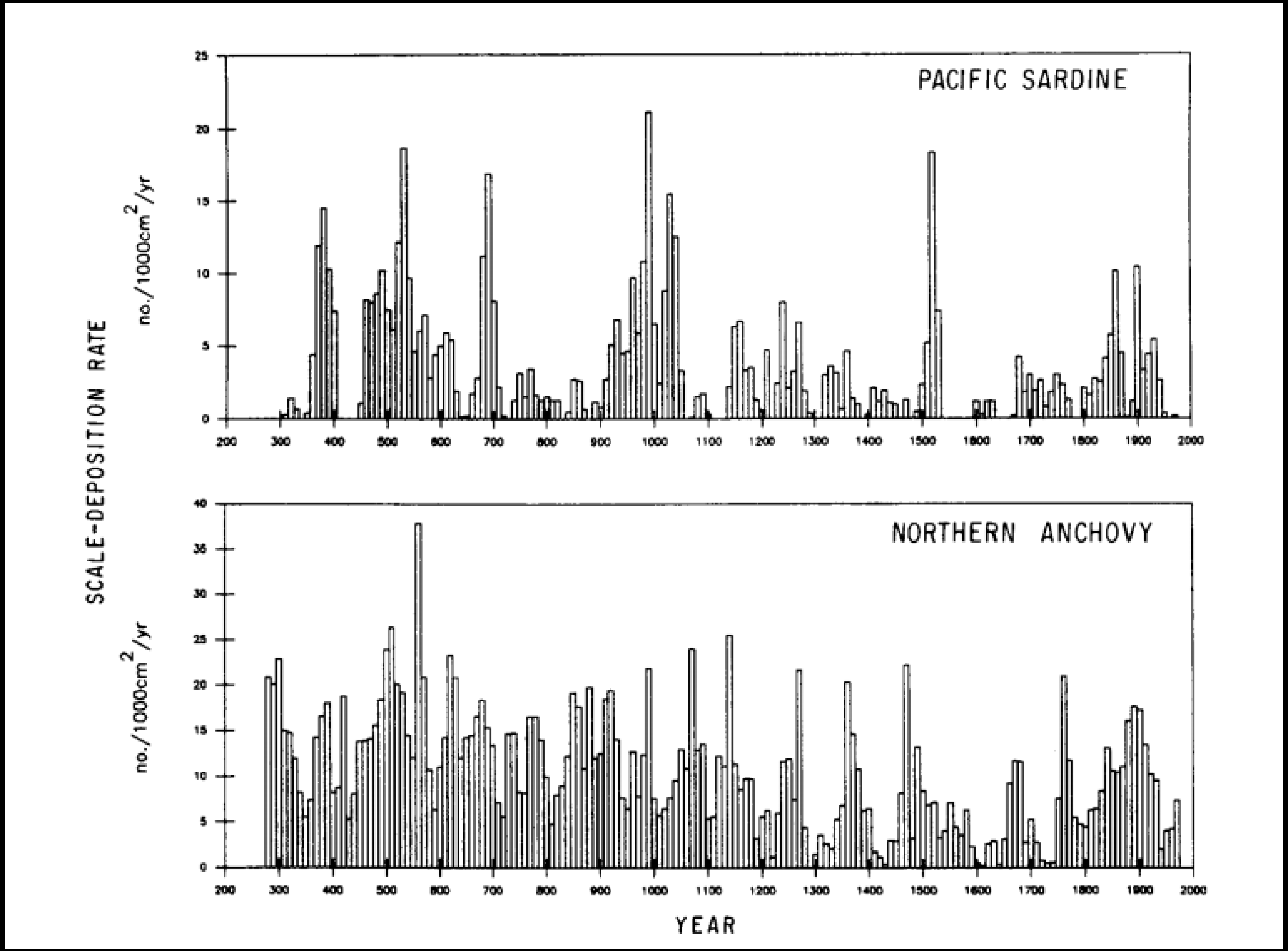
Mean pairwise correlation among chronologies (20 yr window)

Low synchrony, low variance



Anchovy: deeper time

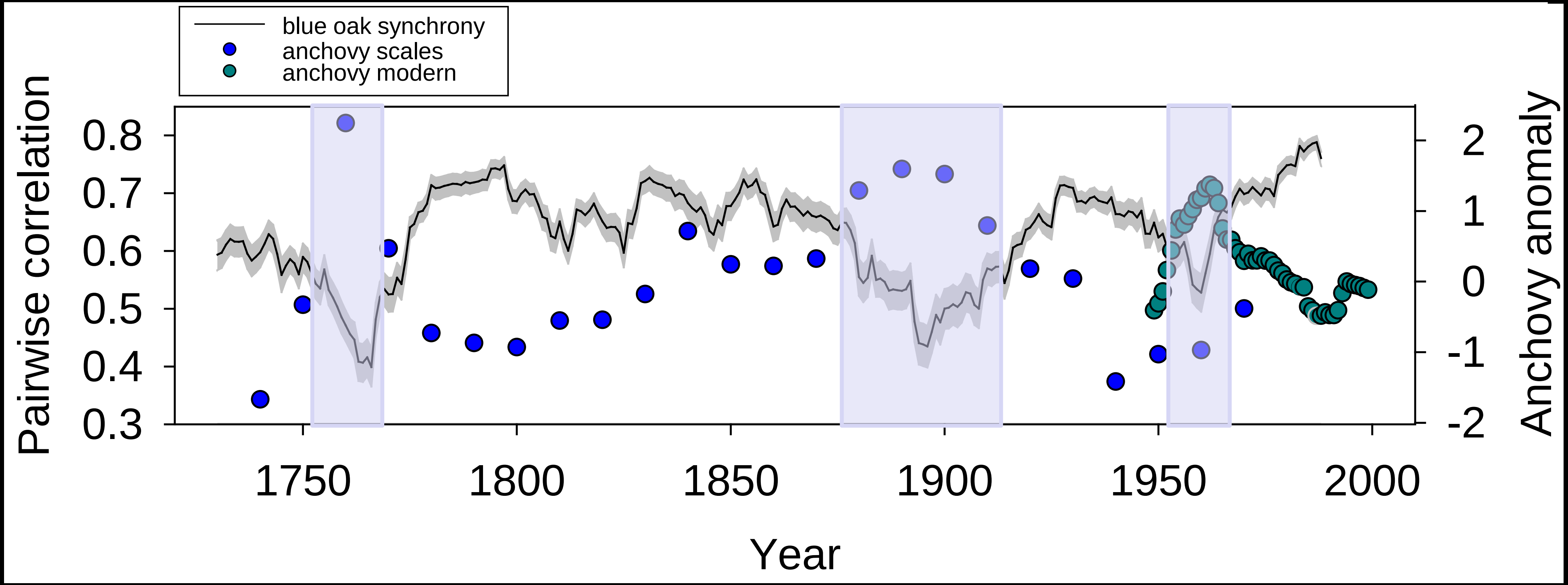
Baumgartner *et al*. 1992. *CalCOFI Rep. Vol. 33*



Blue oak synchrony

Mean pairwise correlation among chronologies (20 yr window)

Low synchrony, low variance, “calm and cool”



CA Current – Benguela comparison

Tools for environmental analysis

- "Integration"
- Thresholds
- Role of climate variability vs. mean state

Differences between Benguela and California anchovy response?

- Sampling differences
- High interannual variability of CA winter pattern
- Temporal scale of environmental analysis (daily/weekly better?)