Tracking ecosystem change in the northern California Current

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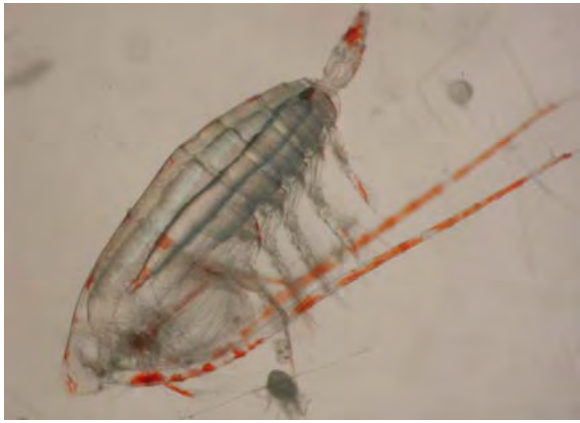
<www.nwfsc.noaa.gov/oceanconditions>



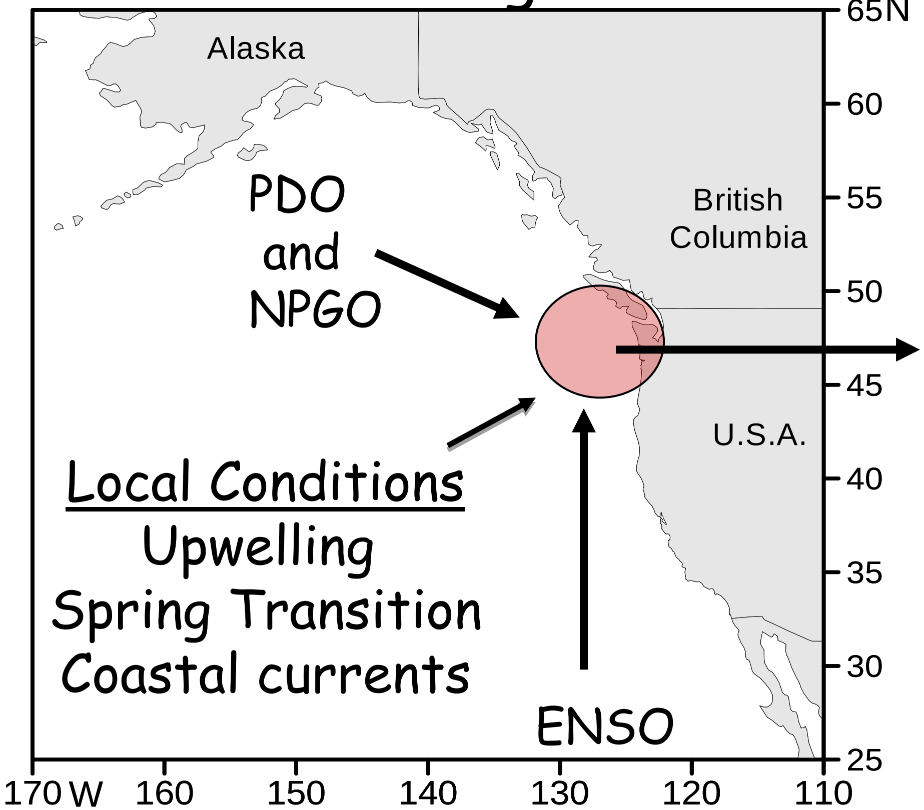
Goals of Session S3

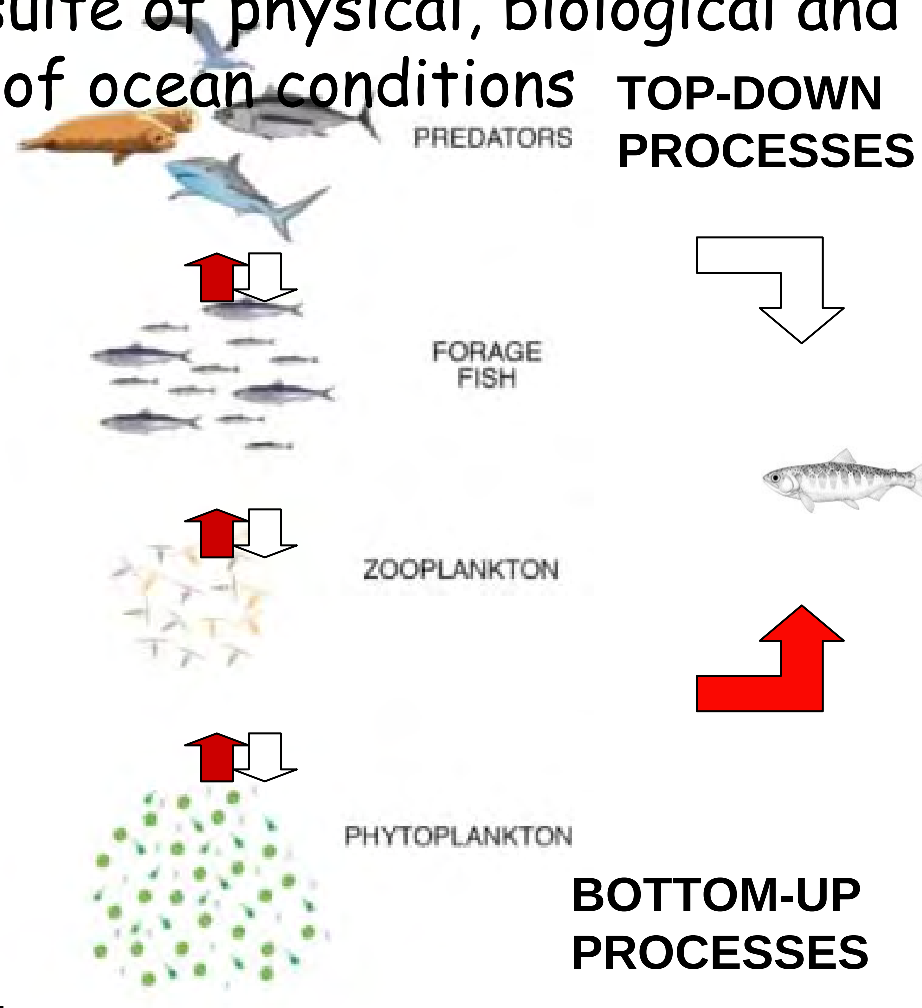
- …to share ideas about what physical parameters and processes are important in understanding and predicting the response of ***specific marine ecosystems*** to climate forcing"
- "…important developments…in **linkages** between physical conditions and marine ecosystems"
- Talk today about the basin-scale forcing of the coastal upwelling ecosystem off Newport OR (44.6° N).

Background and Methods

We are contributing to salmon management by studying the ocean phase of their life history and by developing management advice based on a suite of physical, biological and ecological indicators of ocean conditions

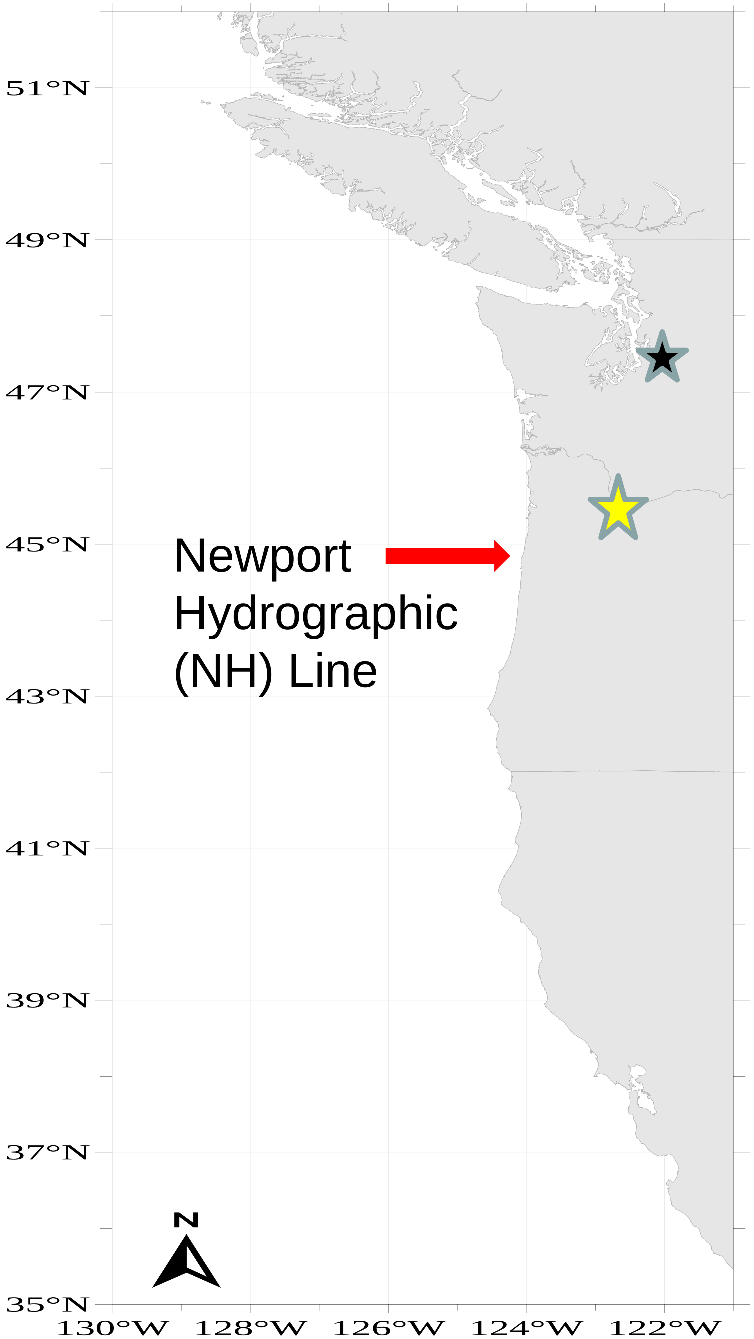
Large scale forces acting at the local scale can influence biological process important for salmon





We are working on “zooplankton”, “basin-scale forcing” and “local conditions”.

Local Biological Conditions



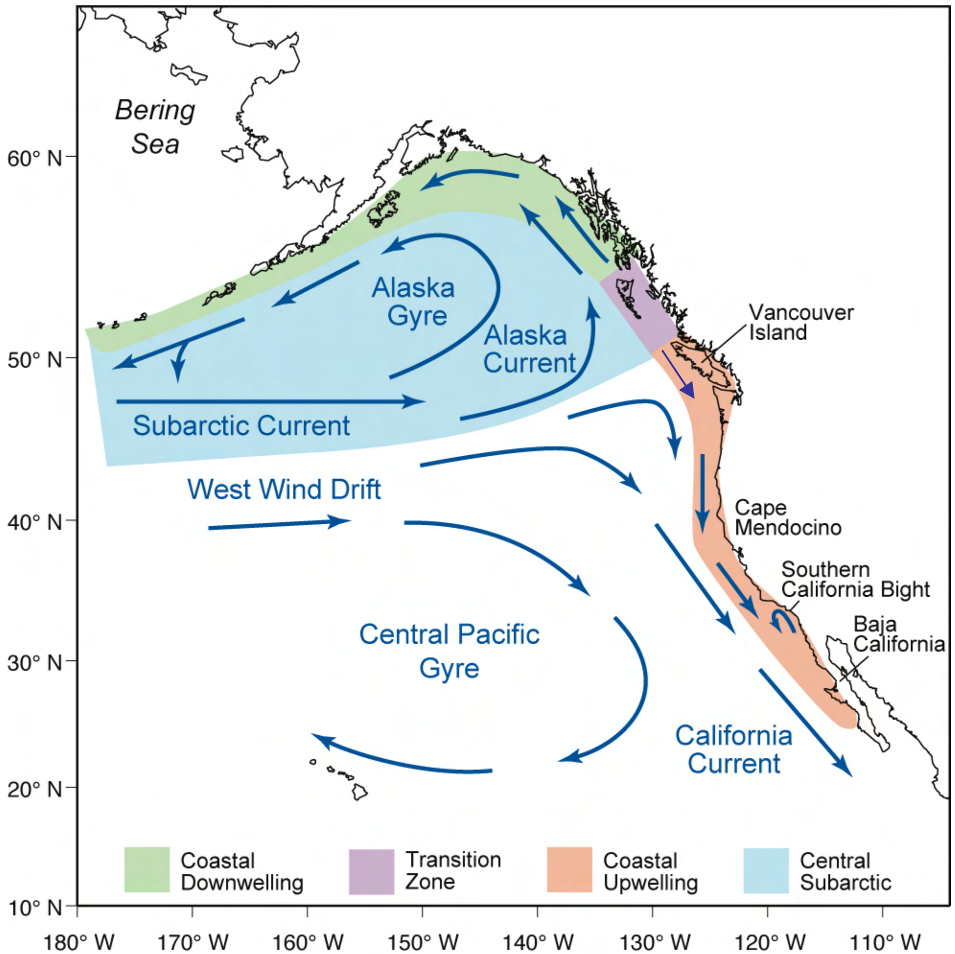
Observations

- Newport Line sampled biweekly since 1996 (17th year) with CTD and plankton nets; water samples for nutrients and chlorophyll

- Sample seven stations across the shelf and slope

- Temperature, salinity and copepods at a station five miles offshore (NH 05; in 60 m of water) is the focus of todays talk.

Circulation off the Pacific Northwest



Transport is a key part of our results and is important for three reasons:

1. Subarctic Current brings cold water and **northern copepod** species to the N. California Current;

2. The West Wind Drift brings subtropical water and **subtropical copepod** species to the NCC

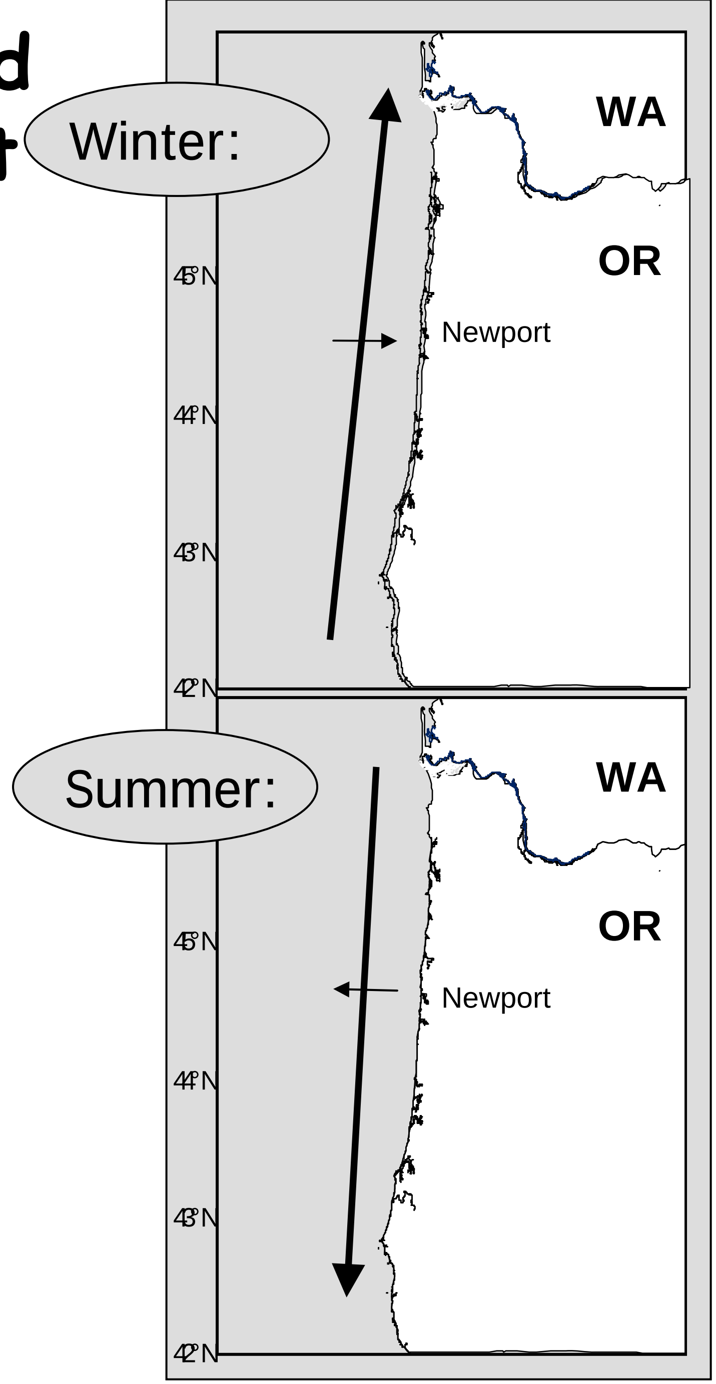
3. Therefore, ecosystem structure is affected by the source waters which feed the California Current.

Seasonal changes in winds and current structure also affect ecosystem structure in the Oregon upwelling zone:

- Winter:
  - Winds from the South
  - Downwelling
  - Poleward-flowing Davidson Current
  - Subtropical and **southern species** transported northward & onshore
- **Spring Transition in April/May**

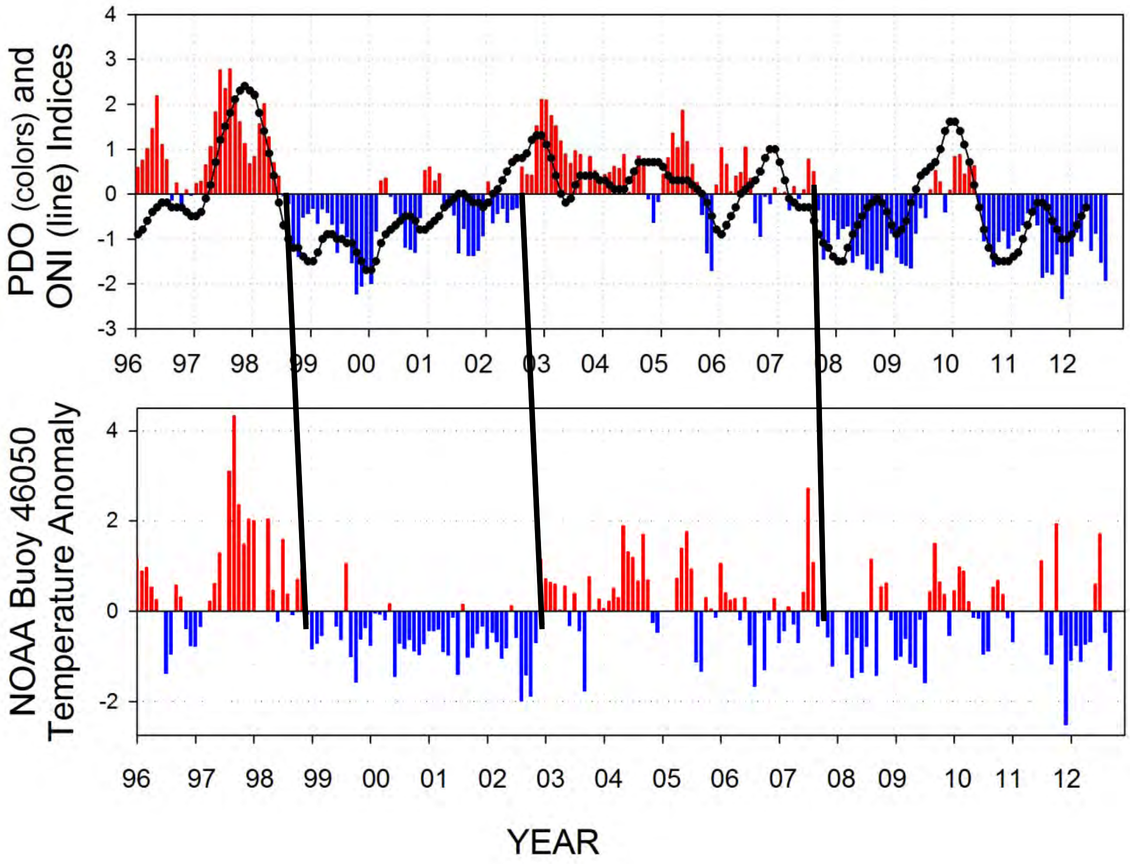
- Summer:
  - Strong winds from the North
  - Coastal upwelling
  - Equatorward alongshore transport
  - **Northern species** transported southward

- **Fall Transition in October**



Results

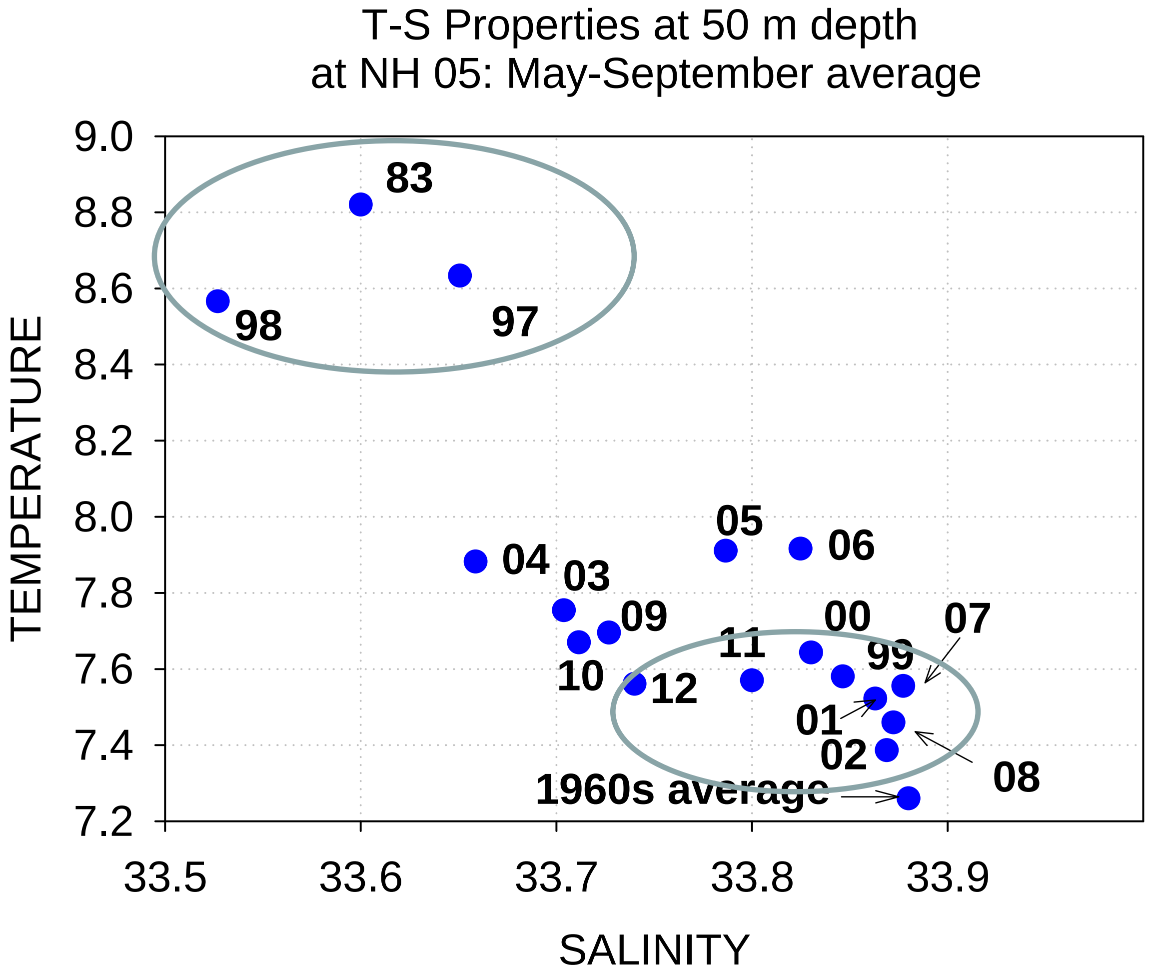
17 year time series of SST anomalies off Newport shows that PDO downscales to local SST



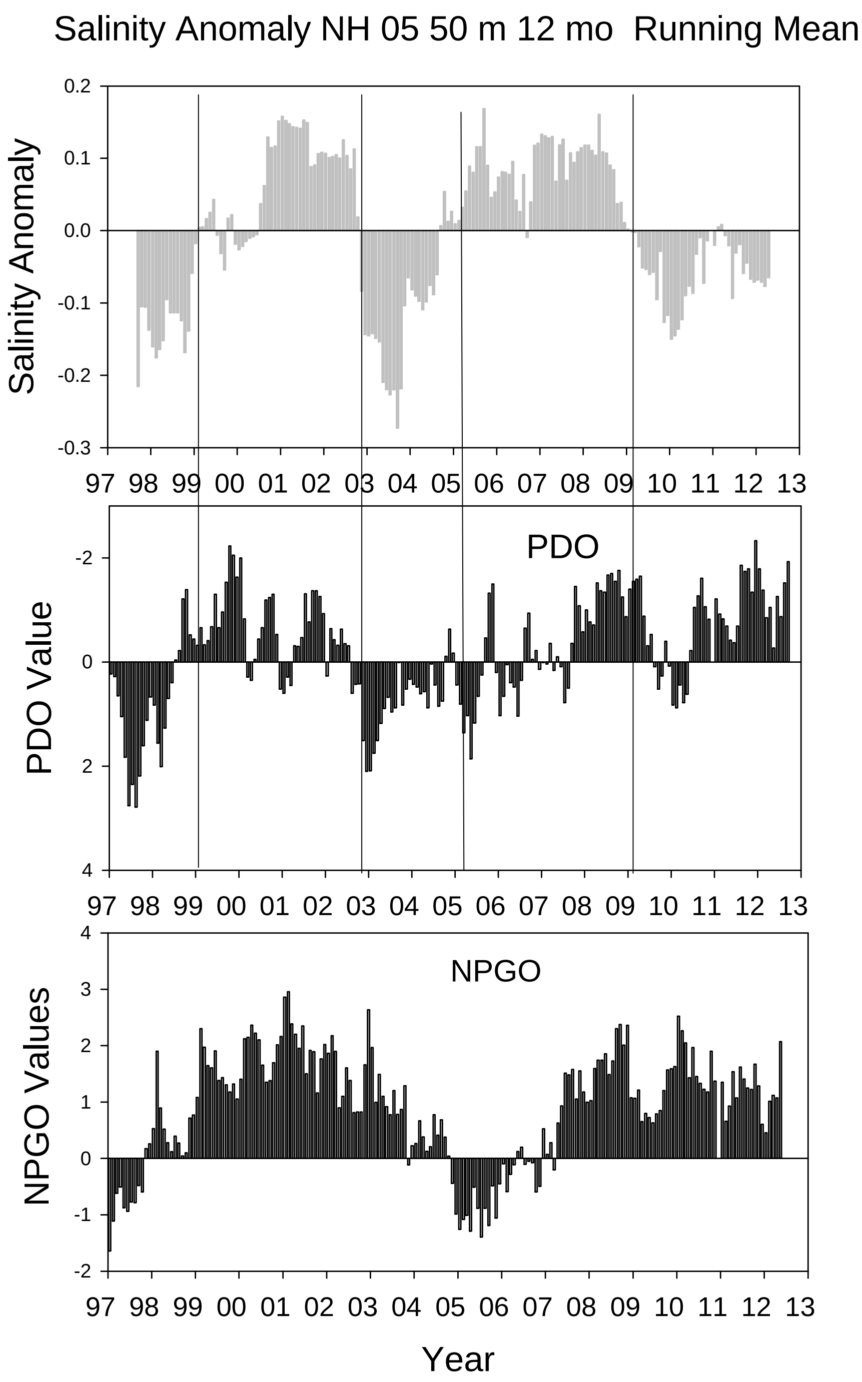
- PDO and SST correlated, (as they should be).
- Note the four recent shifts in the PDO: 1998, 2002, 2007 & 2010
- Note also the time lags between PDO sign change and SST, ~ 3-5 months, suggesting perhaps that the PDO is an advective signal along the Oregon coast

RED = positive PDO + warm water; **BLUE = negative PDO + cold water**

T-S at 50 m depth at NH 05 averaged from May-September

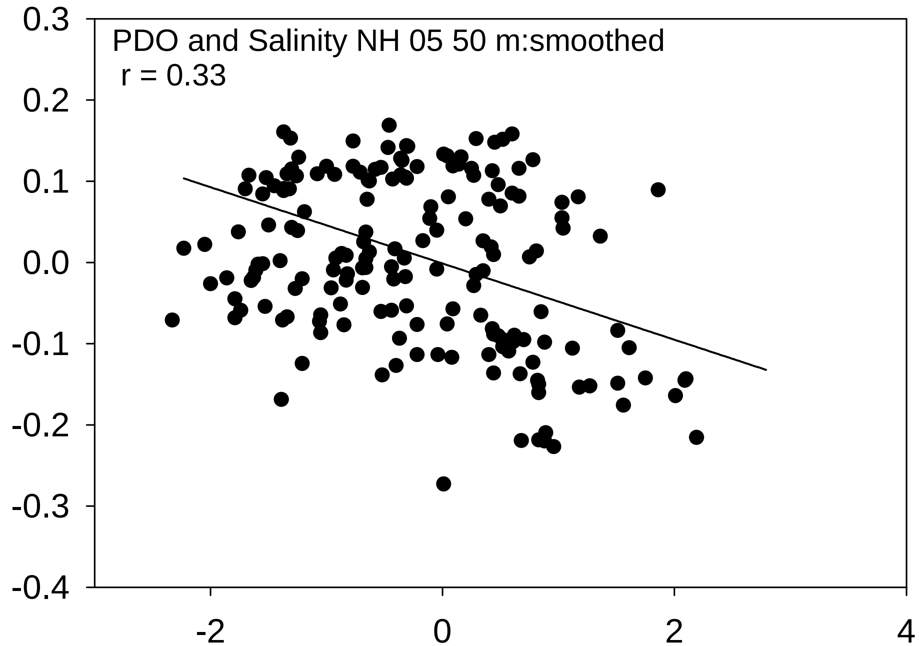


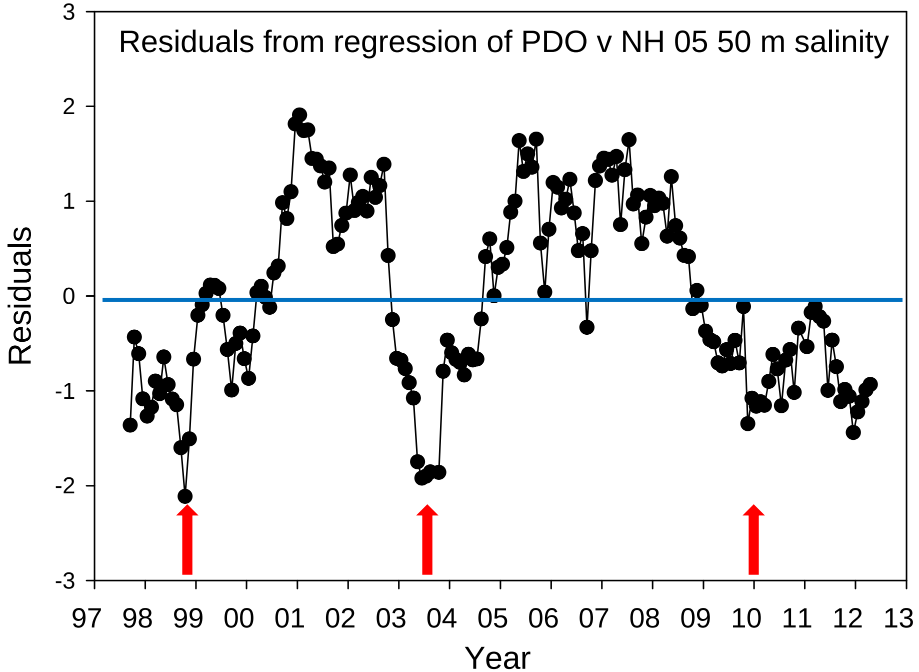
- El Niño events warm and fresh
- Negative PDO are cool and salty
- Positive PDO ~ warm and fresh



Deep salinity (50 m) on shelf vs PDO and NPGO

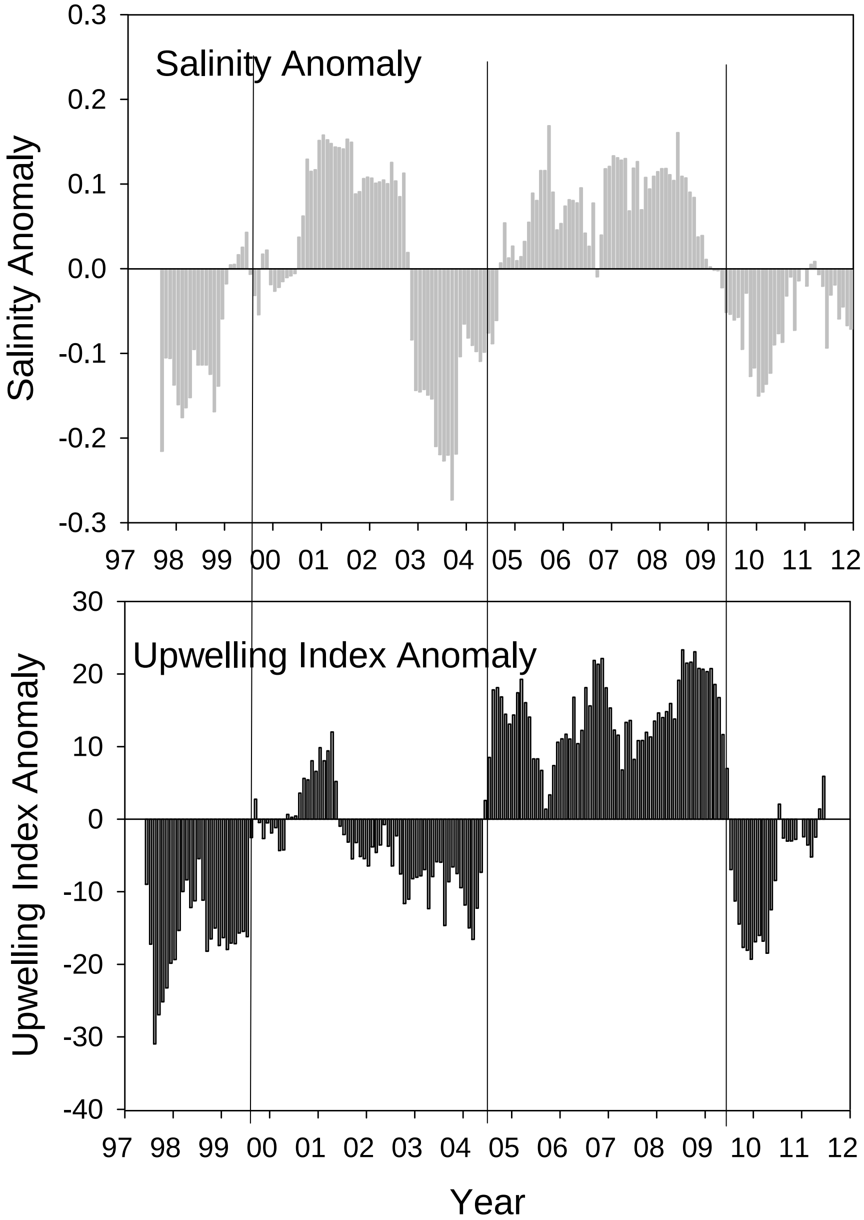
- From 1997 through 2004: + PDO associated with fresher water and – PDO with saltier water.
- 2005-2007: nothing
- 2010-2012: – PDO associated with fresher water
- NPGO has no relationship with salinity





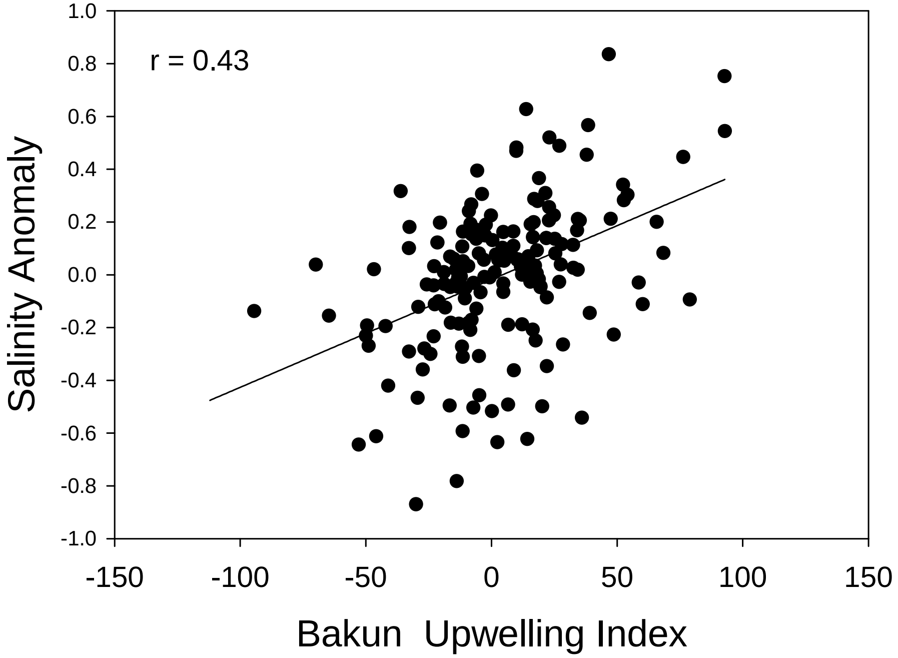
PDO v deep (50 m) salinity on shelf

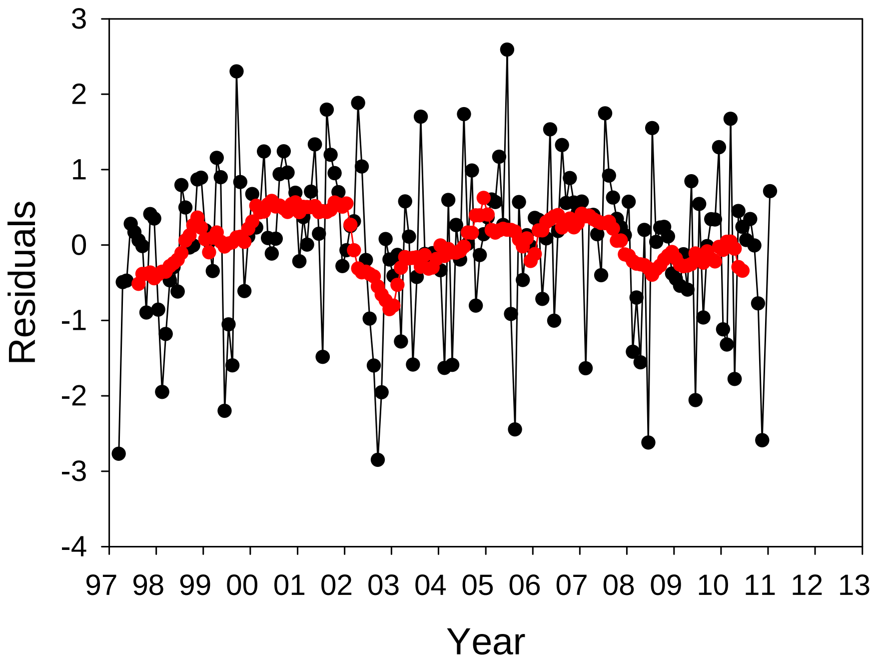
- Correlation coefficient 0.33
- Residuals not randomly distributed, rather show strongly negative values at the end of El Niño events
  - 1998, 2003, 2009
- Residuals have remained negative into 2011 and 2012: fresher water over the past two years despite the negative PDO – Jack Barth mentioned this on Tuesday in S-14



Upwelling Index and deep salinity on shelf

- 12 month running mean
- Salinity on shelf tracks upwelling strength
  - Strong upwelling brings water from a deeper depth that is saltier



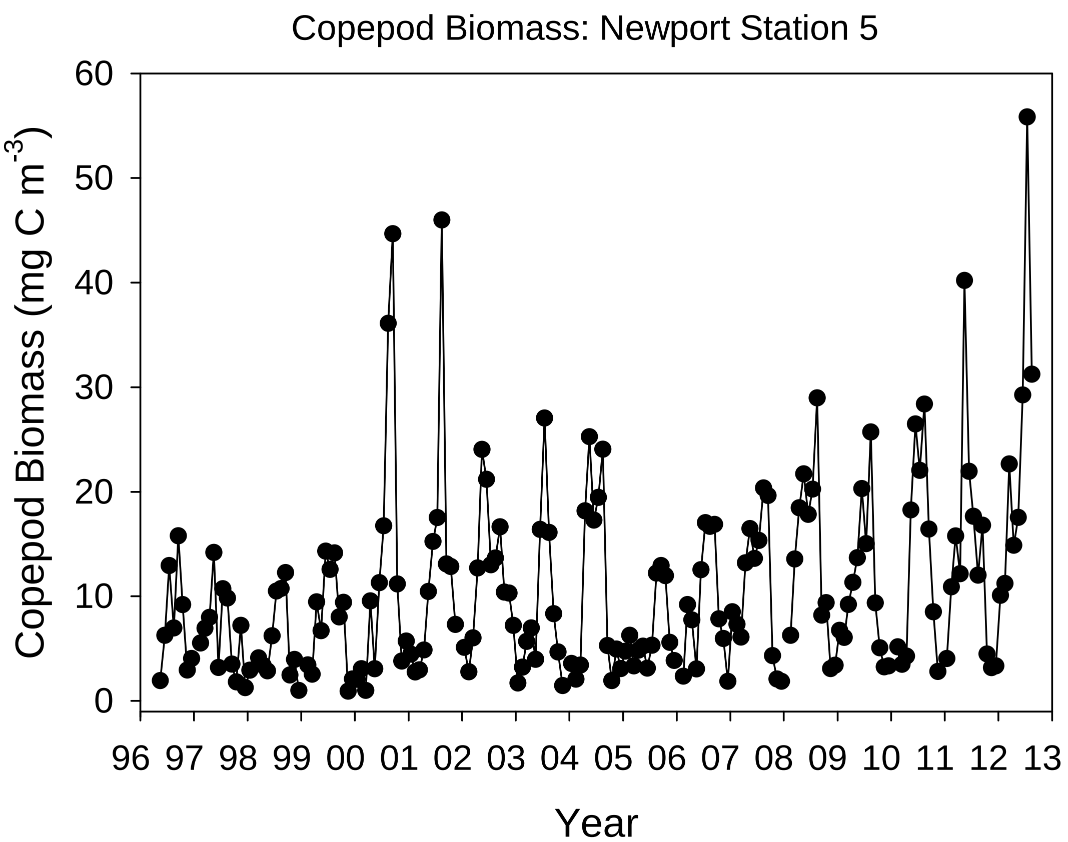


Upwelling vs deep salinity on shelf

- Upwelling index has a slightly higher correlation coefficient than PDO
- Residuals have no pattern

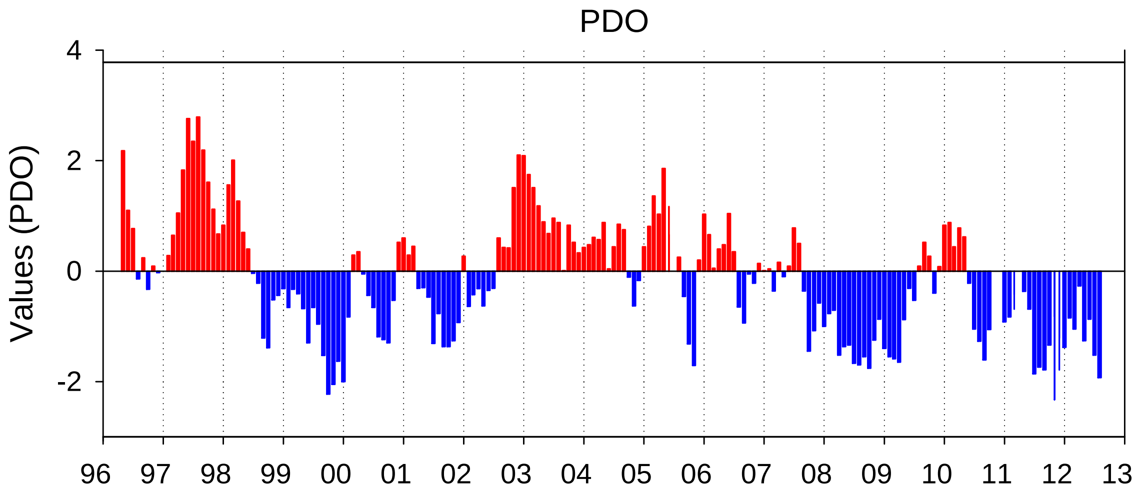
What about those copepods?

Seasonal Cycle of Copepod Biomass

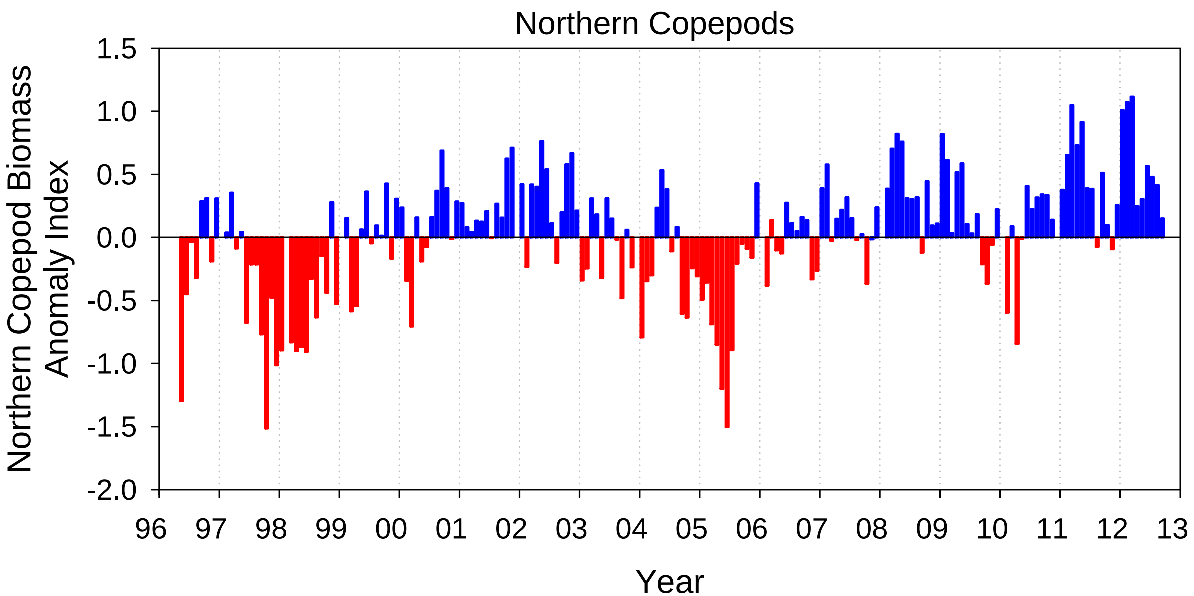


- Low in winter; high in summer
- Large differences among years
- Low 96-99; 05
- High 01, 02, 12

PDO and Northern Copepods

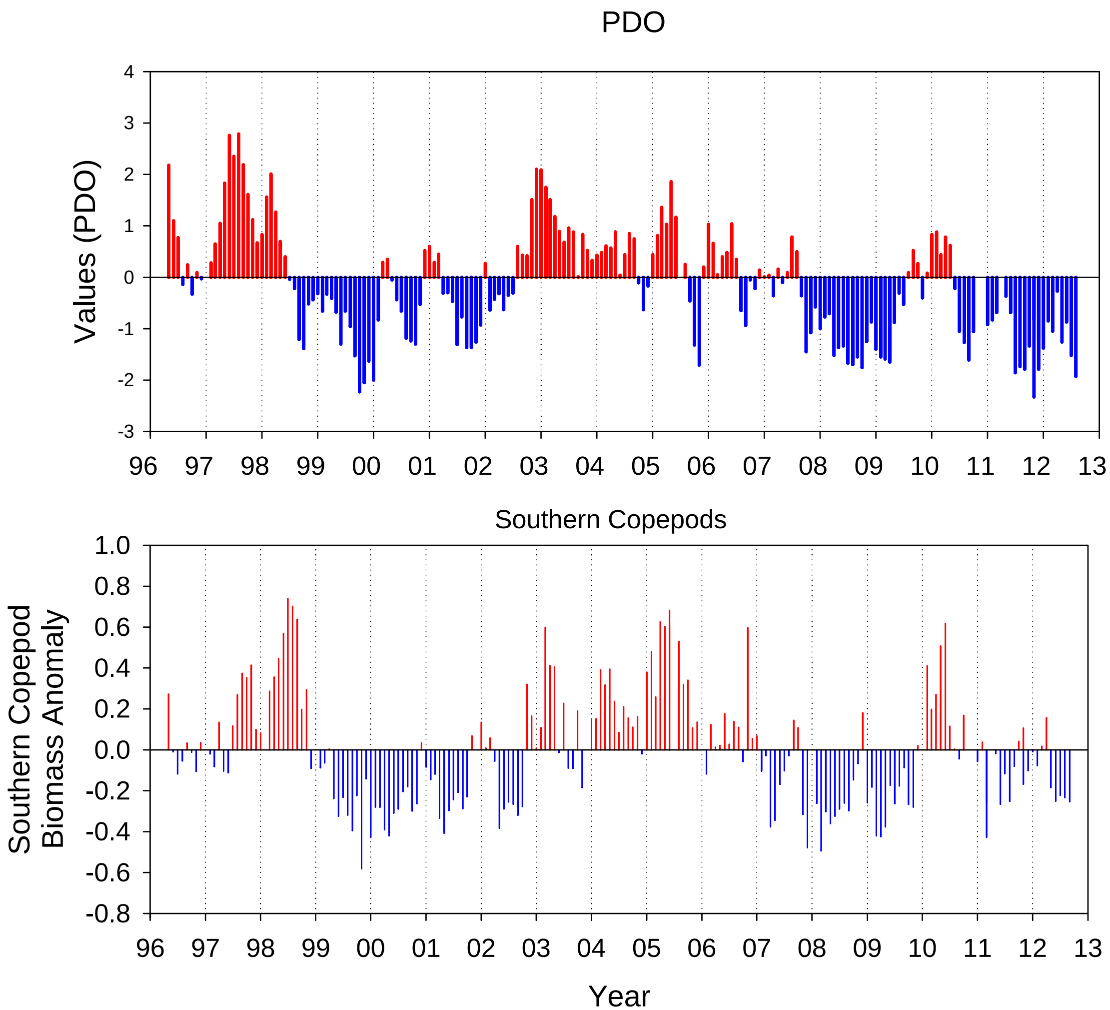


RED BARS = positive PDO, warm water and sub-tropical copepods from the south and offshore



BLUE BARS = negative PDO, cold water, and northern copepods from the north

PDO and Southern Copepods



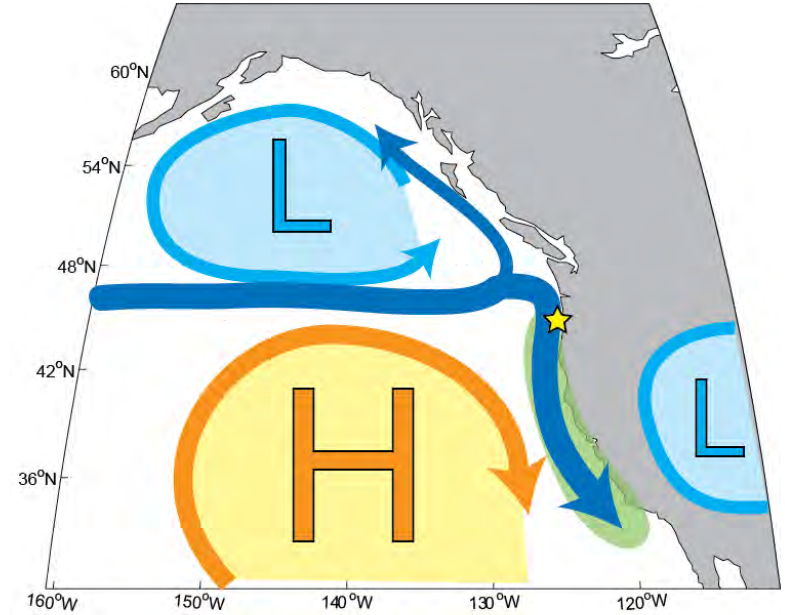
- Anomalously high biomass of "southern copepod species" under three conditions:
  - when PDO is in positive phase;
  - During strong El Niño events:1997-1998
  - During weak El Niño events of 03-06
- Jennifer's talk

		Correlation coefficient	Coefficient of determination	
PDO	**Northern Copepods**	- 0.48	0.235	
NPGO	**Northern Copepods**	0.36	0.13	
ONI	**Northern Copepods**	- 0.38	0.14	
UI	**Northern Copepods**	0.07	0.005	NS
PDO	**Southern Copepods**	0.49	0.24	
NPGO	**Southern Copepods**	- 0.44	0.196	
ONI	**Southern Copepods**	0.34	0.12	
UI	**Southern Copepods**	0.12	0.015	NS

Cartoon from Ryan Rykaczewski, modified from Chelton and Davis

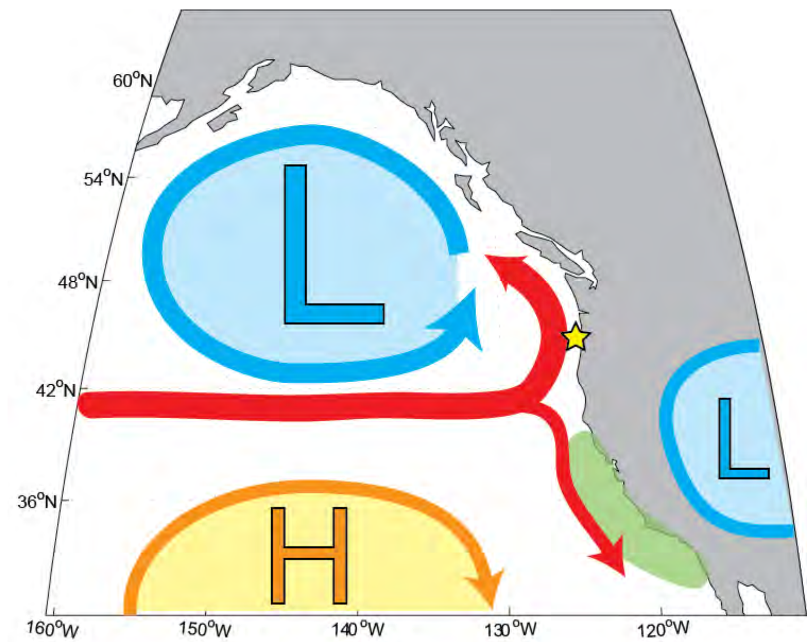
Cool Coastal Phase ➔

Weaker Aleutian Low; **more southerly flow** along the coast; lipid-rich, boreal zooplankton at Newport



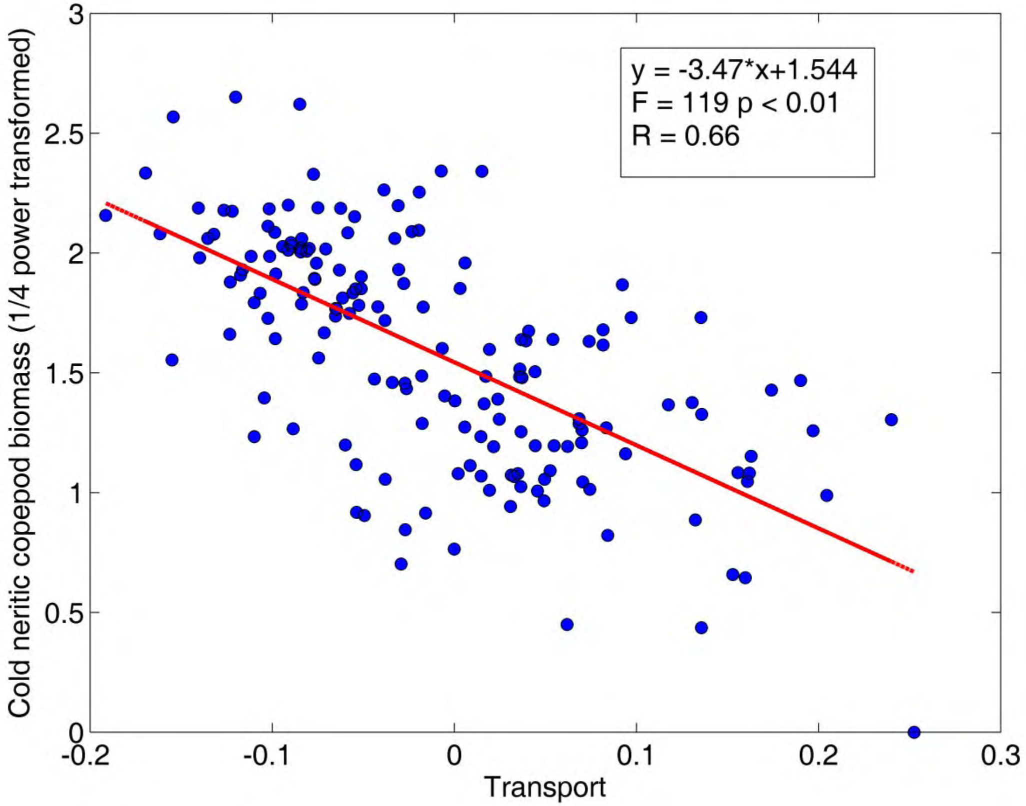
Warm Coastal Phase ➔

Stronger Aleutian Low; longer winter with stronger Davidson Current thus **more northerly flow** along the coast and more water from subtropical gyre; smaller, subtropical zooplankton at Newport



NH05: Alongshore transport and cold neritic copepods

The biomass of cold neritic copepods negatively correlated with northward transport, based on analysis of altimeter and tide gage data (Bi et al., 2011).



What physical parameters and processes are important in understanding and predicting the response of ***specific marine ecosystems*** to climate forcing”

- Transport associated with the Pacific Decadal Oscillation is what links physics with structure of the zooplankton component of coastal ecosystems;
- Latitudinal variations in the role of the North Pacific Gyre Oscillation in coastal upwelling ecosystems need to be worked out;
- Coastal upwelling seems to explain salinity differences but not differences in copepod species composition

“FUTURE” Needs

- Basin and regional-scale models need to be able to capture “decadal” scale variability associated with the PDO and NPGO;
- Models do not necessarily need to capture dynamics of “zooplankton species” but will need to produce accurate estimates of transports;
- Coastal upwelling brings nutrients (N) to the shelf (we already know this) which supports phytoplankton (P) but how it affects zooplankton (Z) is unclear. It does not seem to have a role in setting zooplankton <u>species composition</u>.

Questions?