Ecosystem variability in the Northern California Current

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Cooperative Institute for Marine Resources Studies

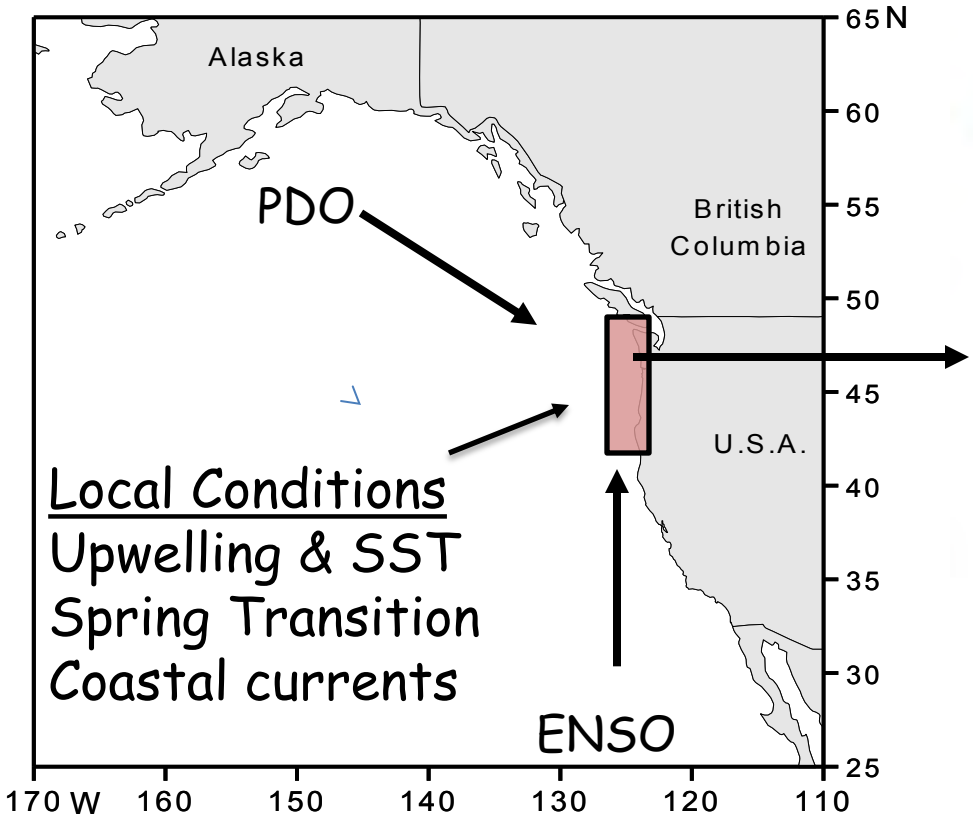
Background/Acknowledgements

- Data presented here are a product of several important programs.
  - GLOBEC-NEP
  - NOAA Stock Assessment Improvement Program (SAIP)
  - Bonneville Power Administration Ocean Salmon Survival program (1998 – present)

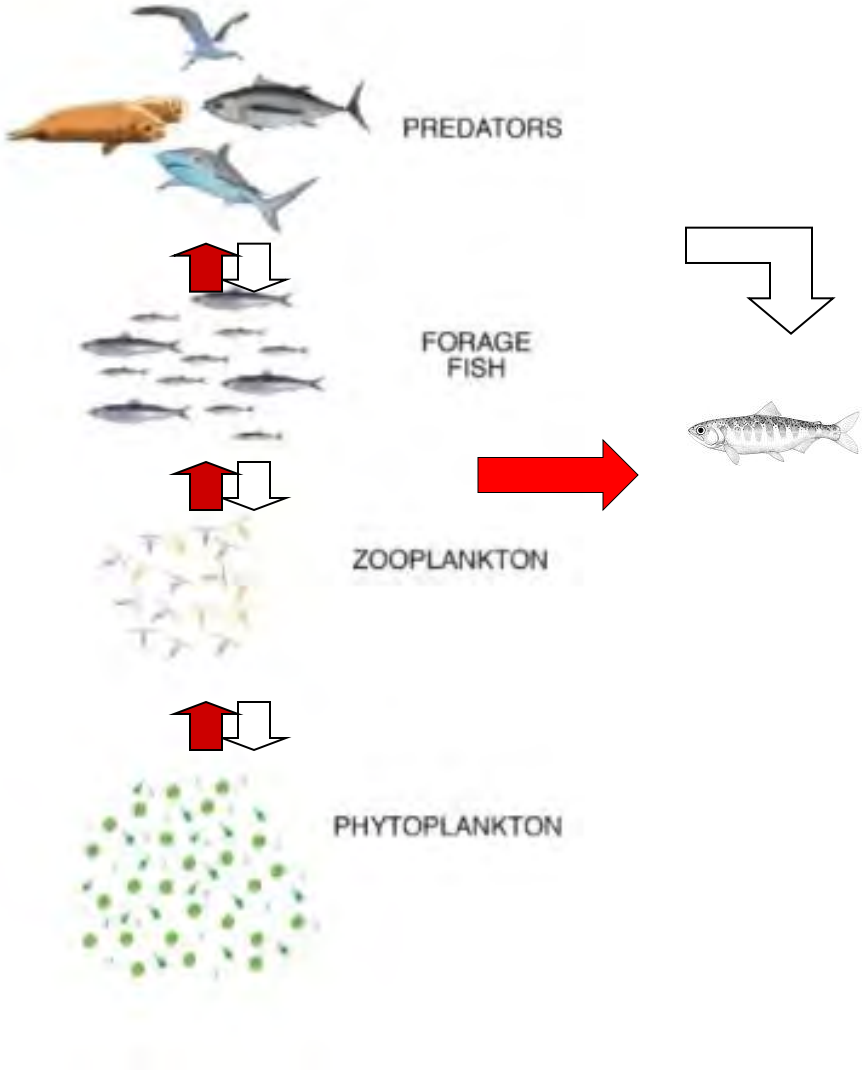
GOAL: Better understand ocean ecosystem dynamics (variability) and the relationship to salmon survival.

Basin and local scale forces influence biological process important for salmon

Physical/Hydrographic



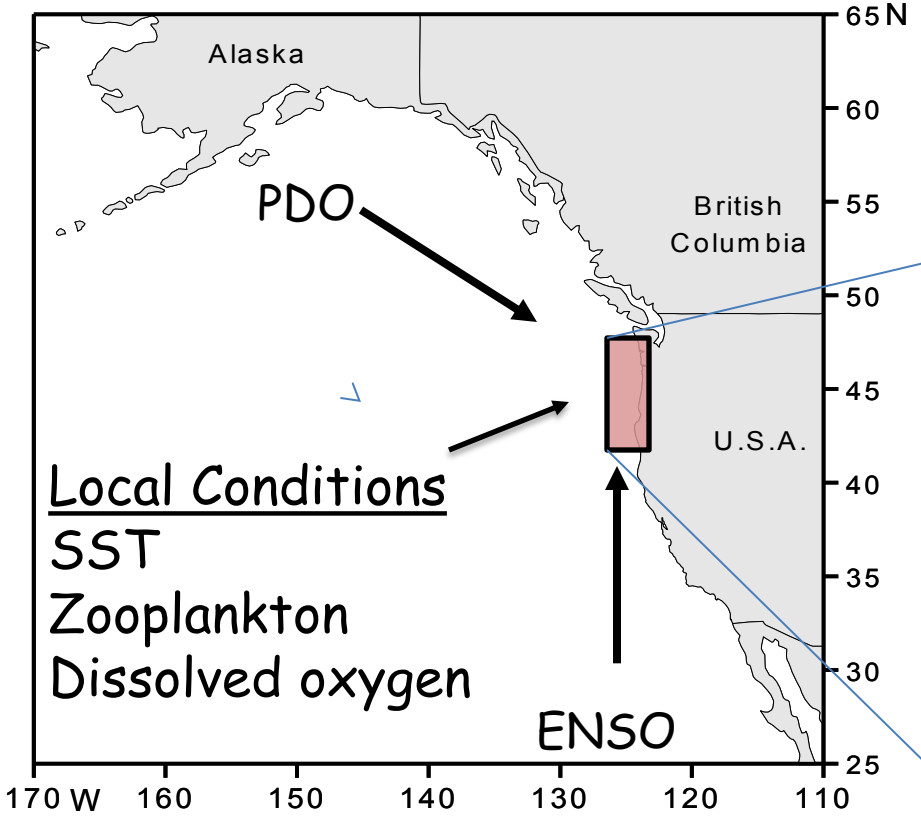
Local Biological Conditions



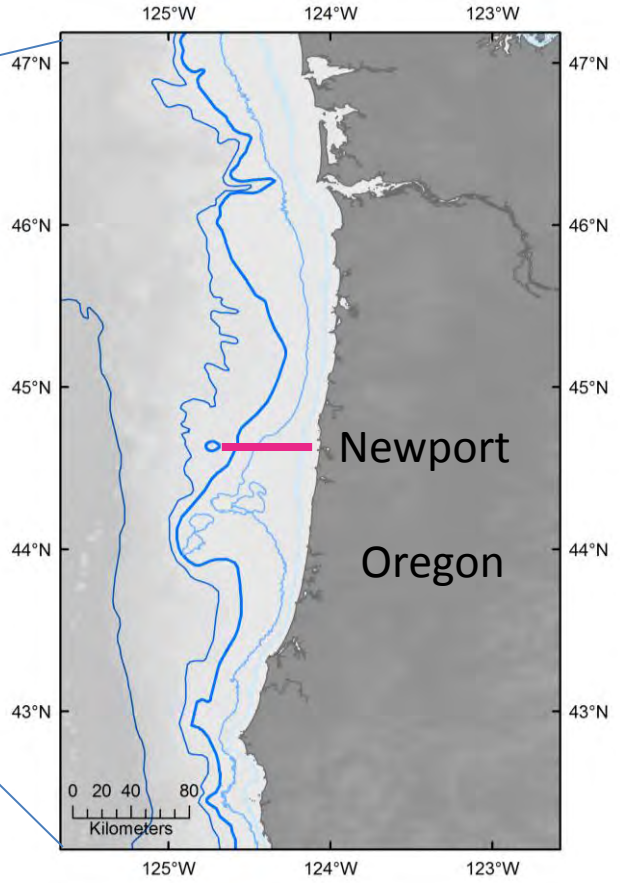
Ecosystem-based approach

Much of the biological and hydrographic information comes from sampling on the NH Line.

Climate indices are from the web.



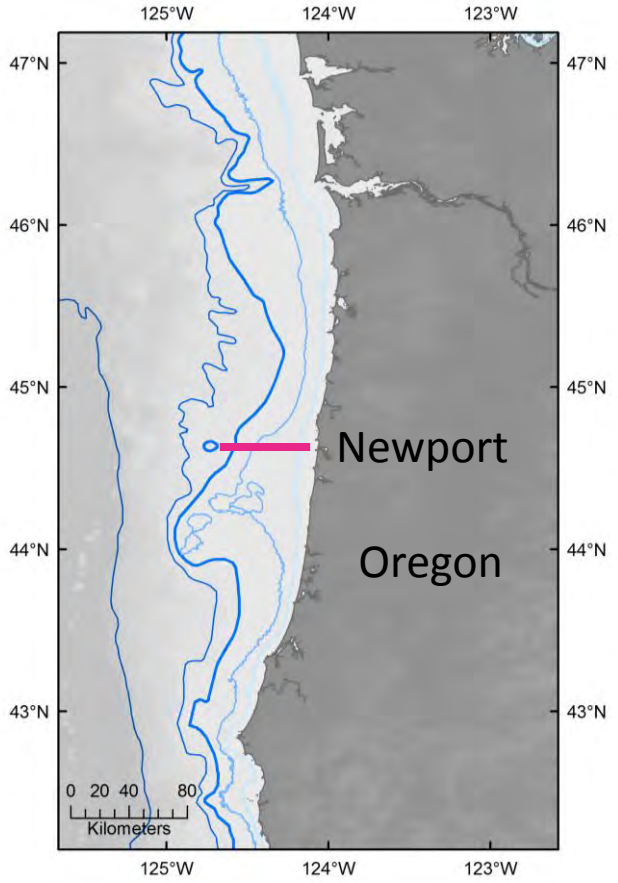
Newport Hydrographic (NH) Line



- Sampled biweekly for 18 years
  - **1996 - present**
  - 7 stations (1 – 25 nm)
- Hydrography
  - CTD
  - Nutrients
  - Dissolved oxygen
- Biology
  - Phytoplankton
  - Zooplankton
  - Ichthyoplankton

- Combine with basin and regional scale indicators
  - Upwelling index
  - PDO, ENSO

Newport Hydrographic (NH) Line



http://www.nwfsc.noaa.gov/oceanconditions

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Ocean Ecosystem Indicators

- Home
  - 2013 Mid-year Update
  - 2013 Salmon Forecast
    - Ecosystem Indicators 'stop-light charts'
  - 2012 Indicator Summary
  - 2012 Annual Report (pdf)
  - Adult Return Data
  - Past Reports
- Large-scale Ocean and Atmospheric Indicators
  - Pacific Decadal Oscillation (PDO)
  - Oceanic Niño Index (ONI)
- Local and Regional Physical Indicators
  - Temperature anomalies
  - Coastal upwelling
  - Hypoxia
  - Physical spring transition
  - Deep-water temperature and salinity
- Local Biological Indicators
  - Copepod biodiversity
  - Northern and Southern Copepods
  - Copepod community structure

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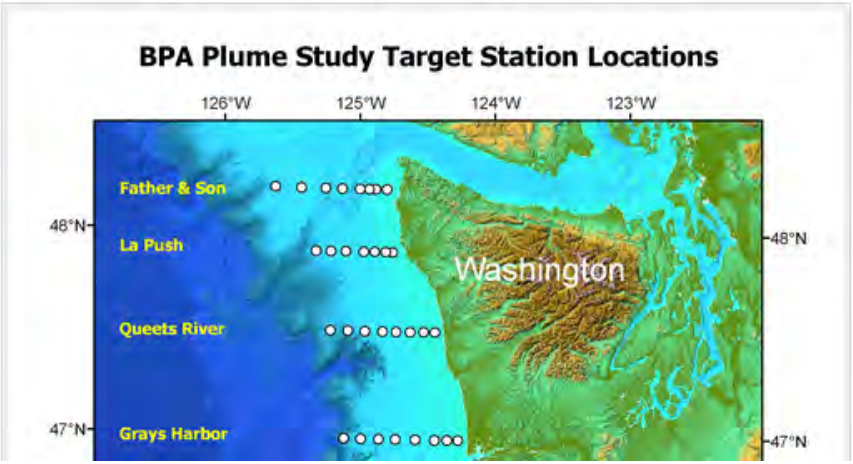
Ocean ecosystem indicators of salmon marine survival in the Northern California Current

As many scientists and salmon managers have noted, variations in marine survival of salmon often correspond with periods of alternating cold and warm ocean conditions. For example, cold conditions are generally good for Chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon, whereas warm conditions are not.

These pages are based on our annual report of how physical and biological ocean conditions may affect the growth and survival of juvenile salmon in the northern California Current off Oregon and Washington. We present a number of physical, biological, and ecosystem indicators to specifically define the term "ocean conditions." More importantly, these metrics can be used to forecast the survival of salmon 1-2 years in advance, as shown in Table 1. This information is presented for the non-specialist; additional detail is provided via links when possible.

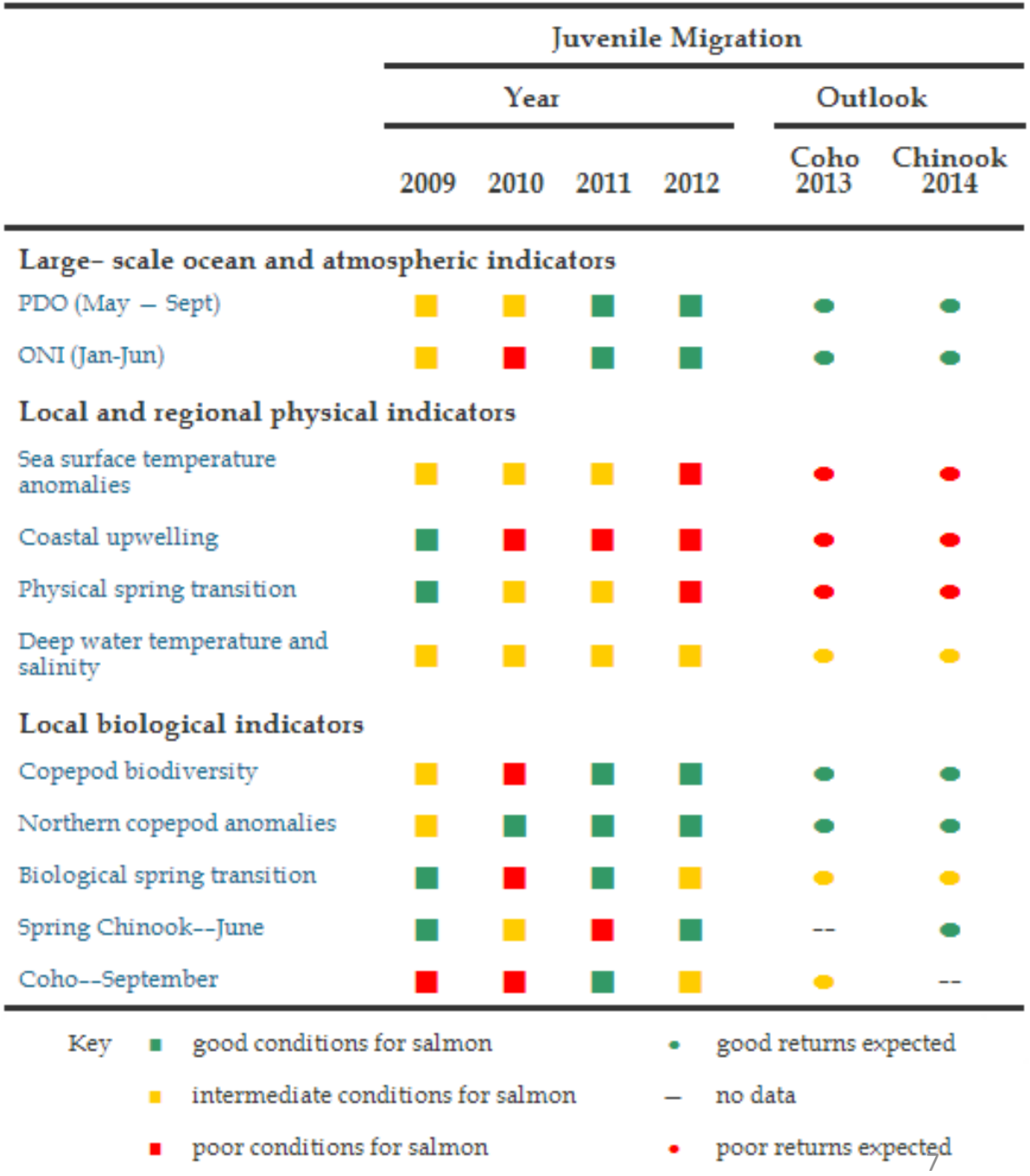


Array of indicators spanning a range of spatial scales and processes.

Large scale physical
- PDO
- ONI

Local scale physical
- Temperature
- Salinity

Local biological
- Copepods
- Dissolved Oxygen

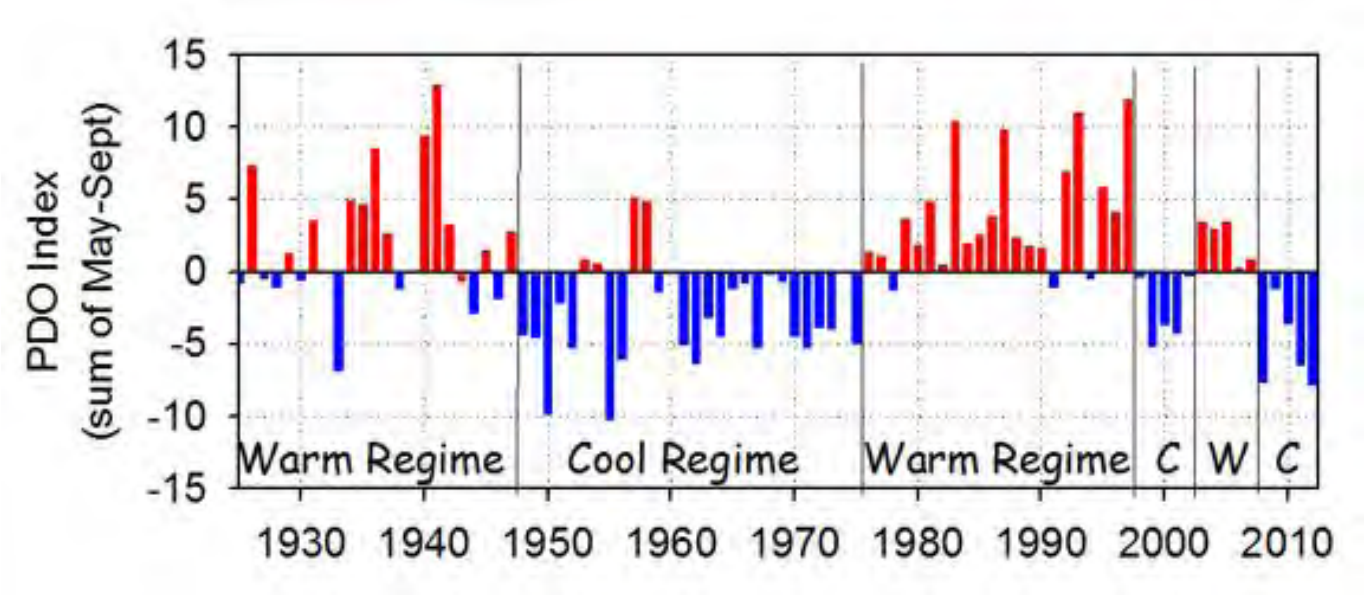


	Juvenile Migration					
	Year				Outlook	
	2009	2010	2011	2012	Coho 2013	Chinook 2014
Large– scale ocean and atmospheric indicators						
PDO (May – Sept)	■	■	■	■	●	●
ONI (Jan-Jun)	■	■	■	■	●	●
Local and regional physical indicators						
Sea surface temperature anomalies	■	■	■	■	●	●
Coastal upwelling	■	■	■	■	●	●
Physical spring transition	■	■	■	■	●	●
Deep water temperature and salinity	■	■	■	■	●	●
Local biological indicators						
Copepod biodiversity	■	■	■	■	●	●
Northern copepod anomalies	■	■	■	■	●	●
Biological spring transition	■	■	■	■	●	●
Spring Chinook--June	■	■	■	■	--	●
Coho--September	■	■	■	■	●	--

Key
- ■ good conditions for salmon
- ■ intermediate conditions for salmon
- ■ poor conditions for salmon
- ● good returns expected
- – no data
- ● poor returns expected

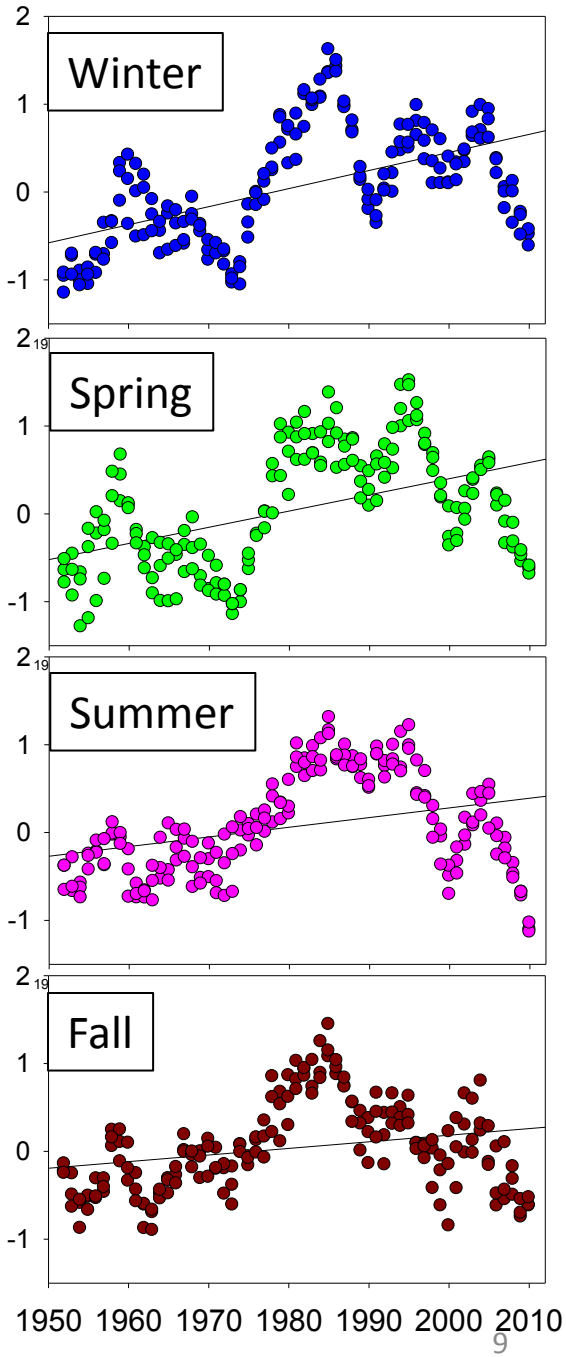
Pacific Decadal Oscillation (PDO)

- Generally multi-decadal
- Short term variability in recent 16 years
  - Coincident with ecosystem monitoring efforts in NCC
  - Interesting opportunity/experiment

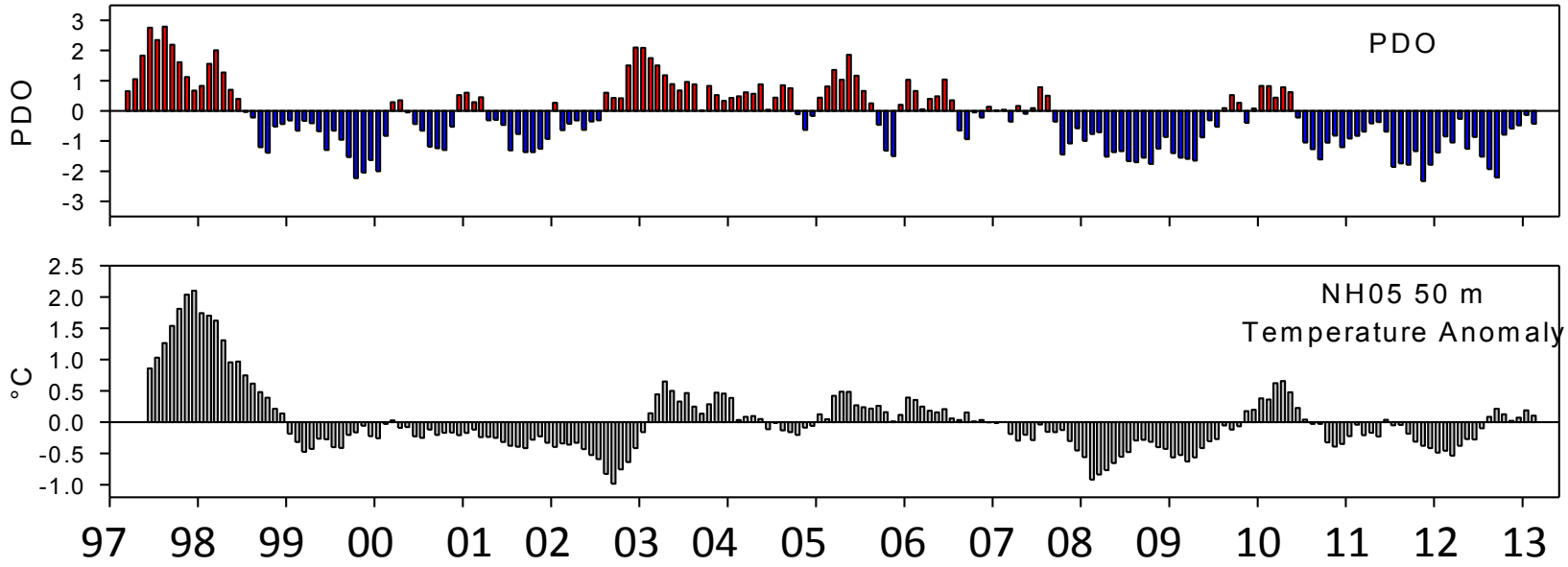


Seasonal variation in PDO anomalies

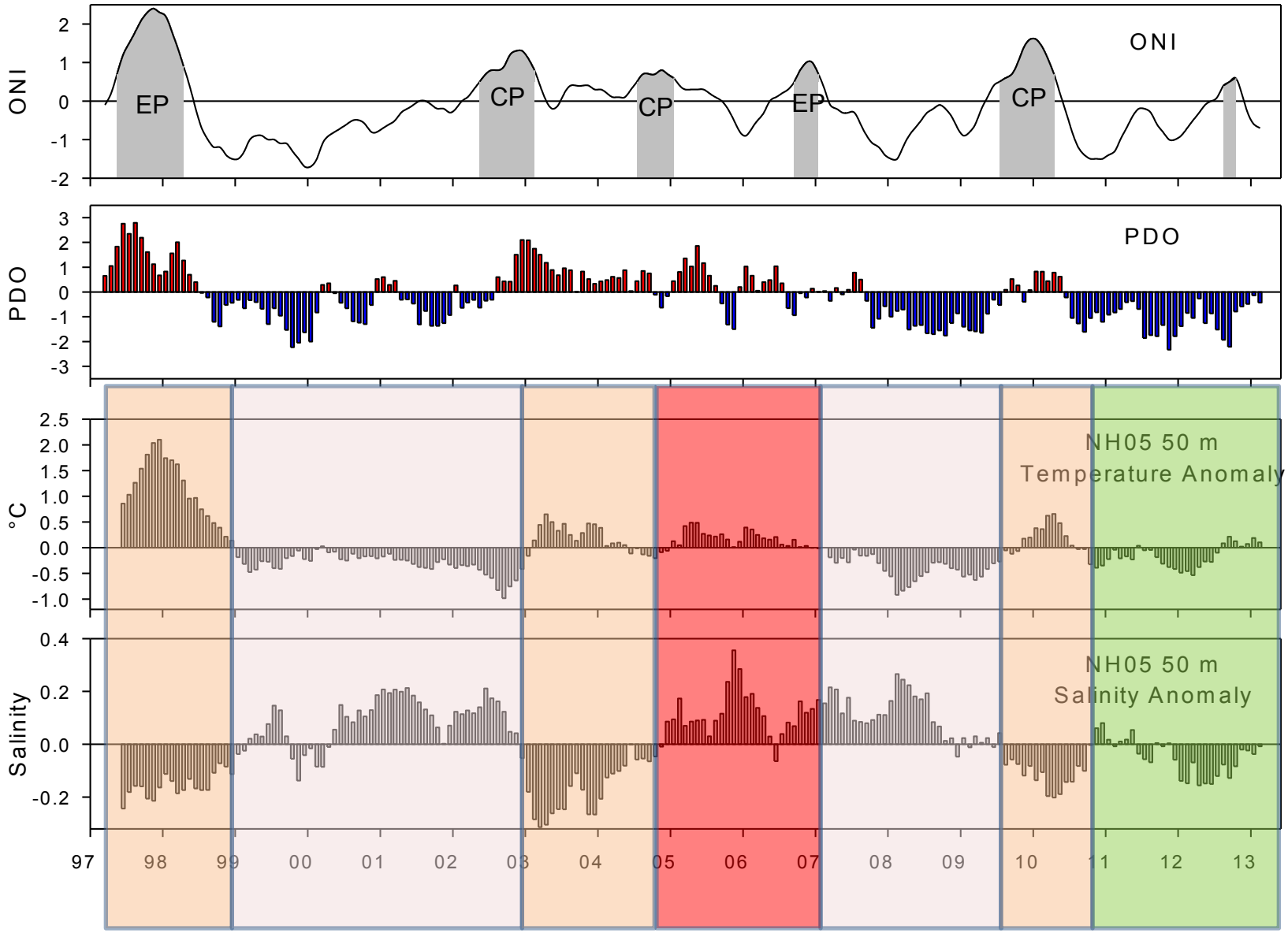
- Winter (Jan-Mar) trending towards more positive PDO values.
- Summer (July-Sept) and Fall have less of a trend and smaller anomalies



Local temperature signal (50 m NH05) in response to basin scale forcing



Local temperature and salinity signal (50 m NH05) in response to basin scale forcing



Transport

Directly impacts the composition of the lower trophic levels.

Plankton are drifting with water masses.

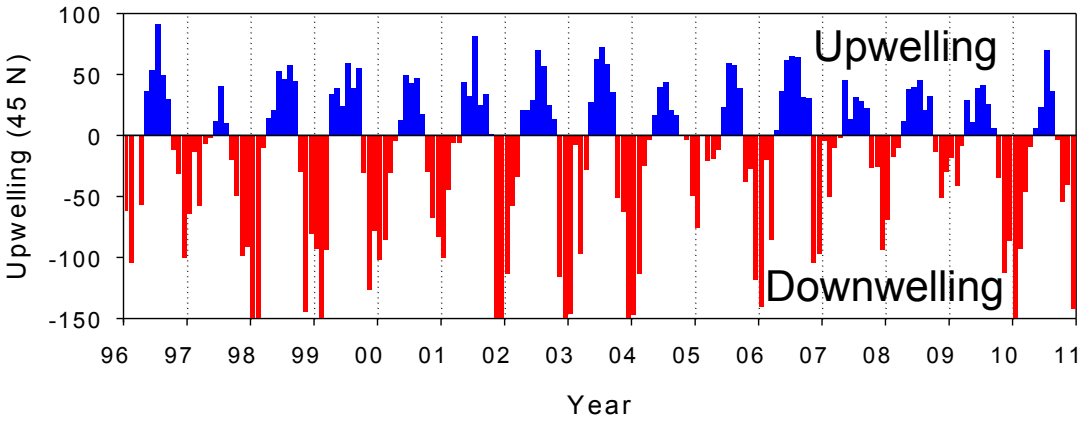
Transport from the North brings a different copepod community than transport from the South.

Bi et al. 2011
Keister et al. 2011

Southern copepods – small, lipid poor

Northern copepods – large, lipid rich

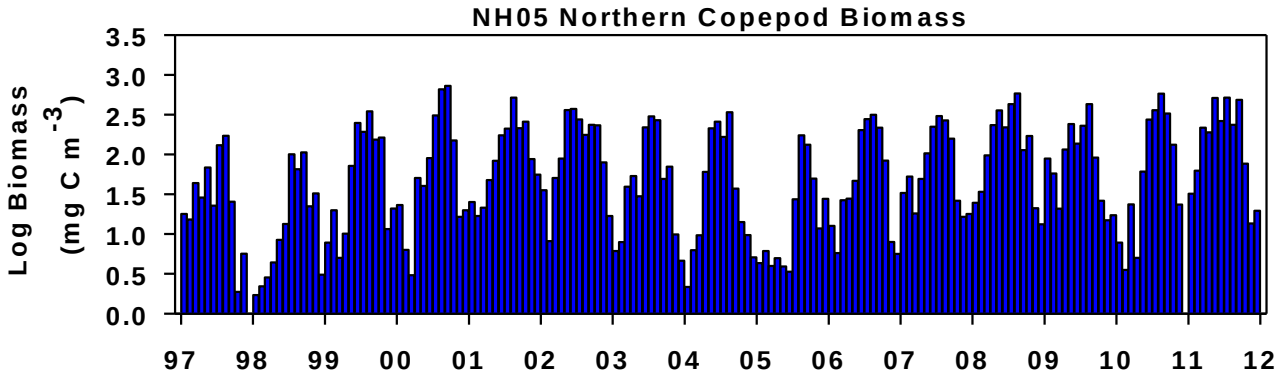
Two main sources of transport variability forcing copepod communities

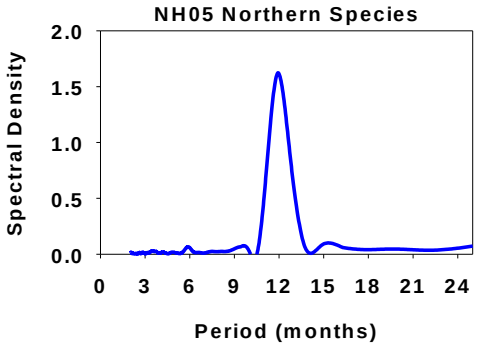


Seasonal structure of coastal upwelling

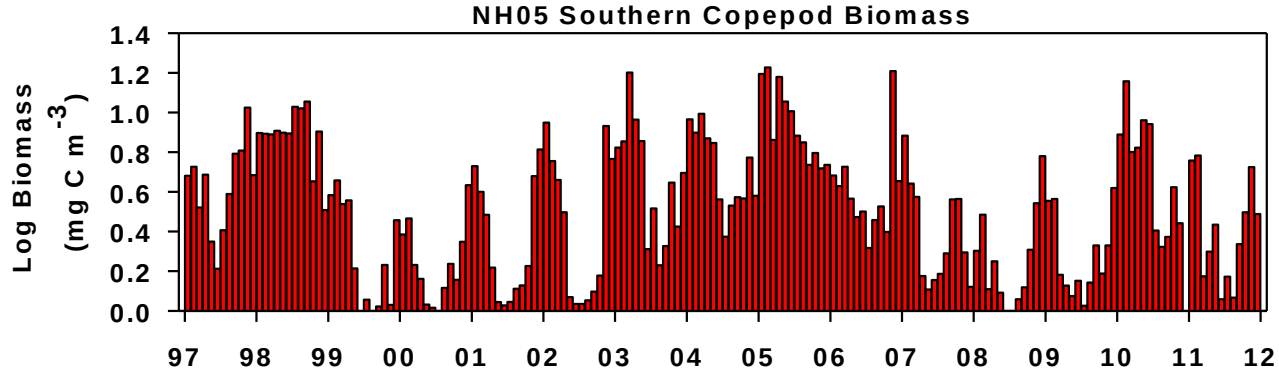
- Spring/summer- Upwelling
  - 'cold water' shelf copepods
  - Boreal/Northern spp.
- Winter- Downwelling
  - 'warm water' shelf copepods
  - Sub-tropical/Southern spp.

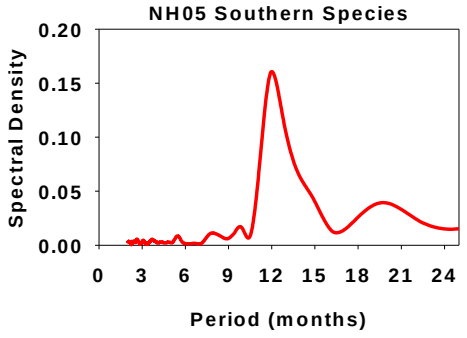
Strong seasonality of Northern and Southern copepods at NH05 - northerns appear more seasonal while southerns have more residuals





Peak in Jul - Aug

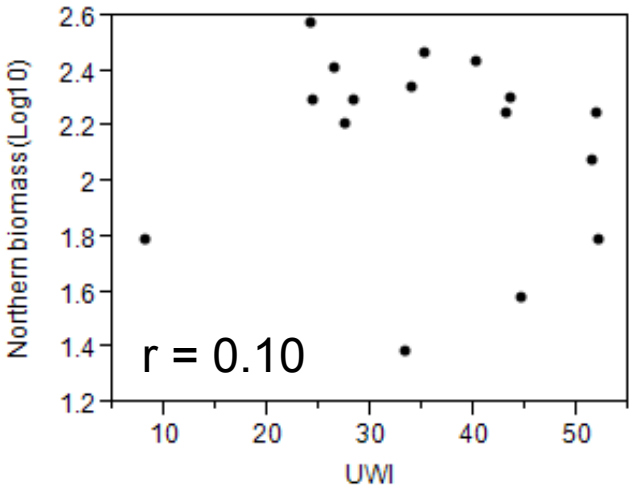




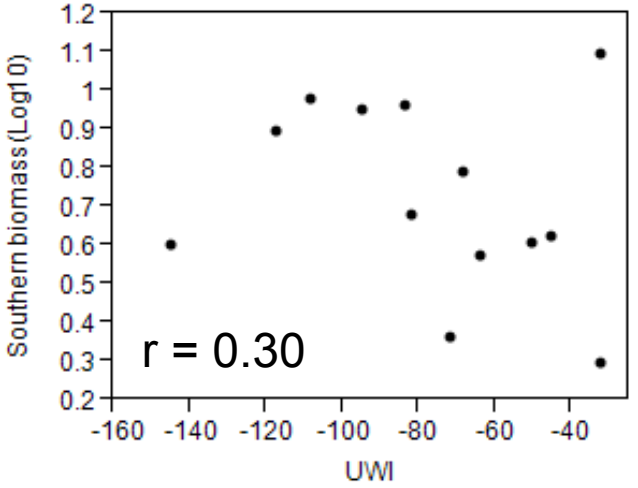
Peak in Jan - Feb

Poor relationship between upwelling and the biomass of the copepod community.

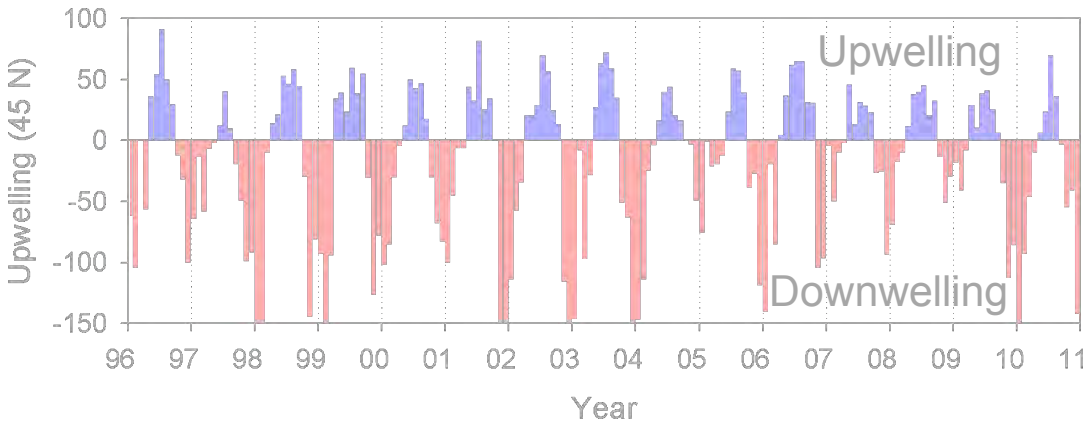
Northern copepods v. UWI

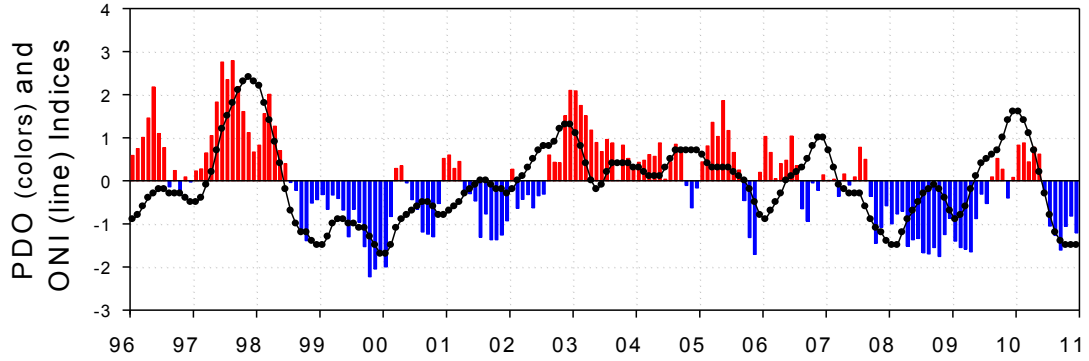


Southern copepods v. UWI



Two main sources of transport variability forcing copepod communities





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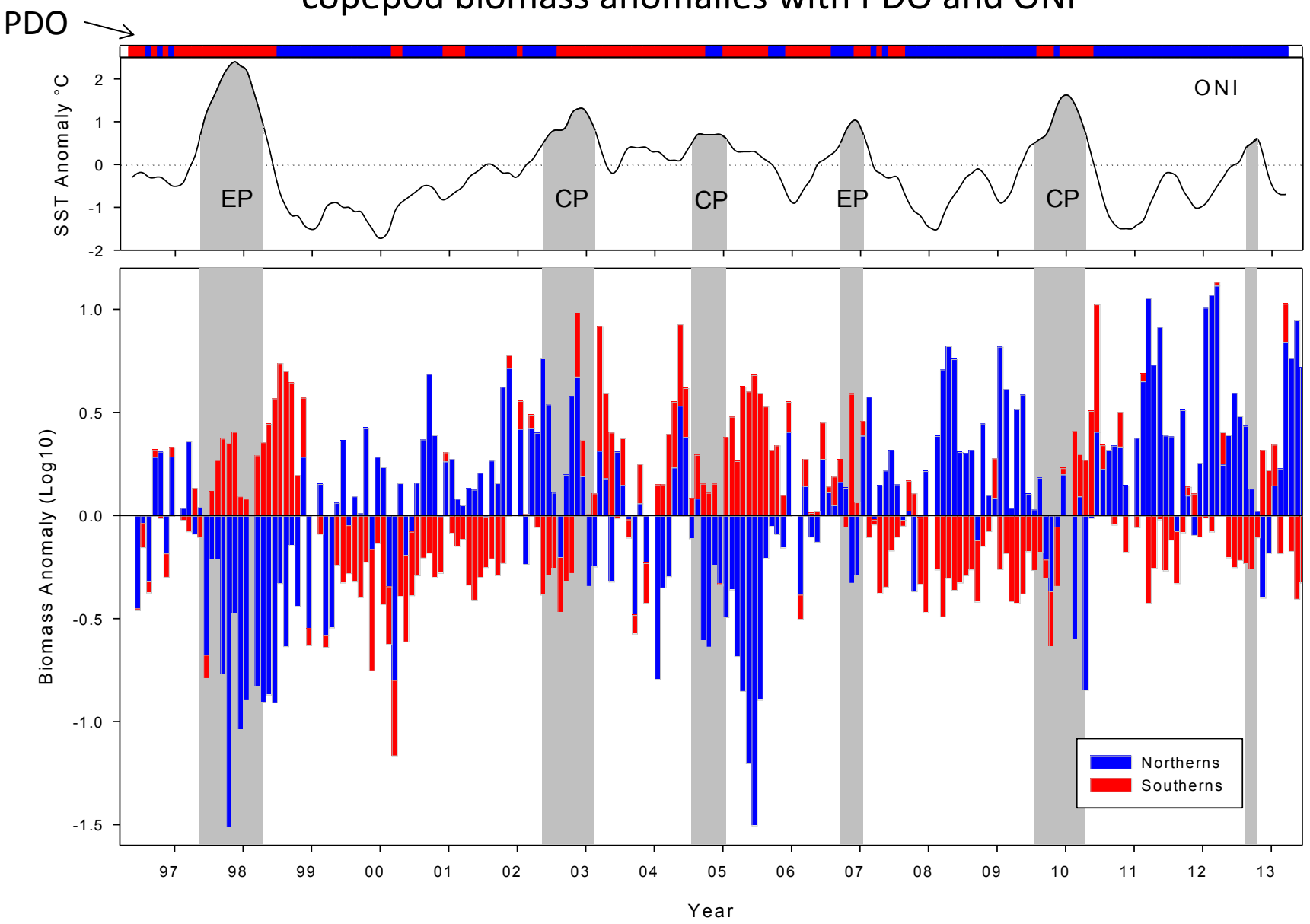
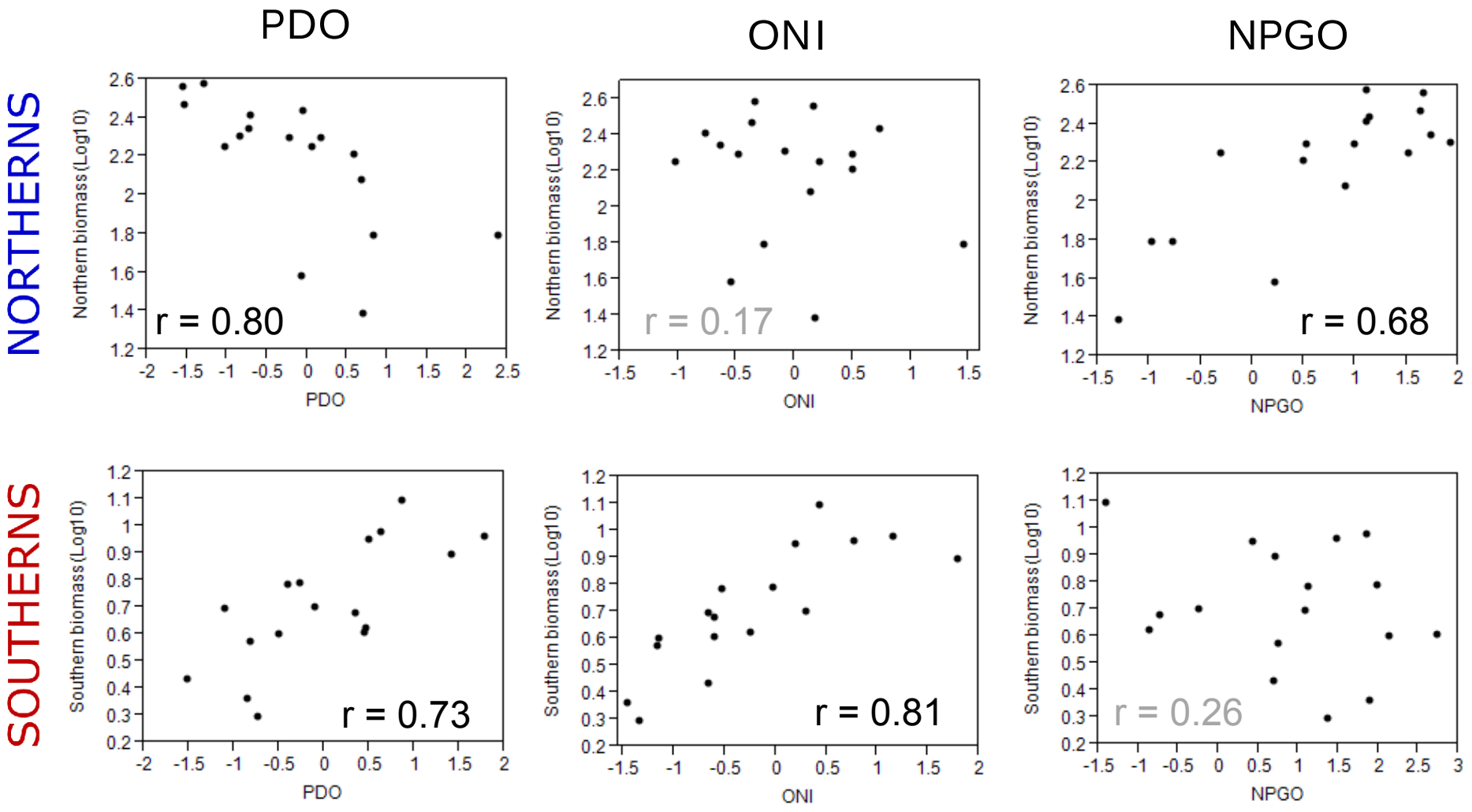
Basin-scale forcing- Advection

- PDO
- ONI

Inter-annual variability of the Northern and Southern copepod biomass anomalies with PDO and ONI

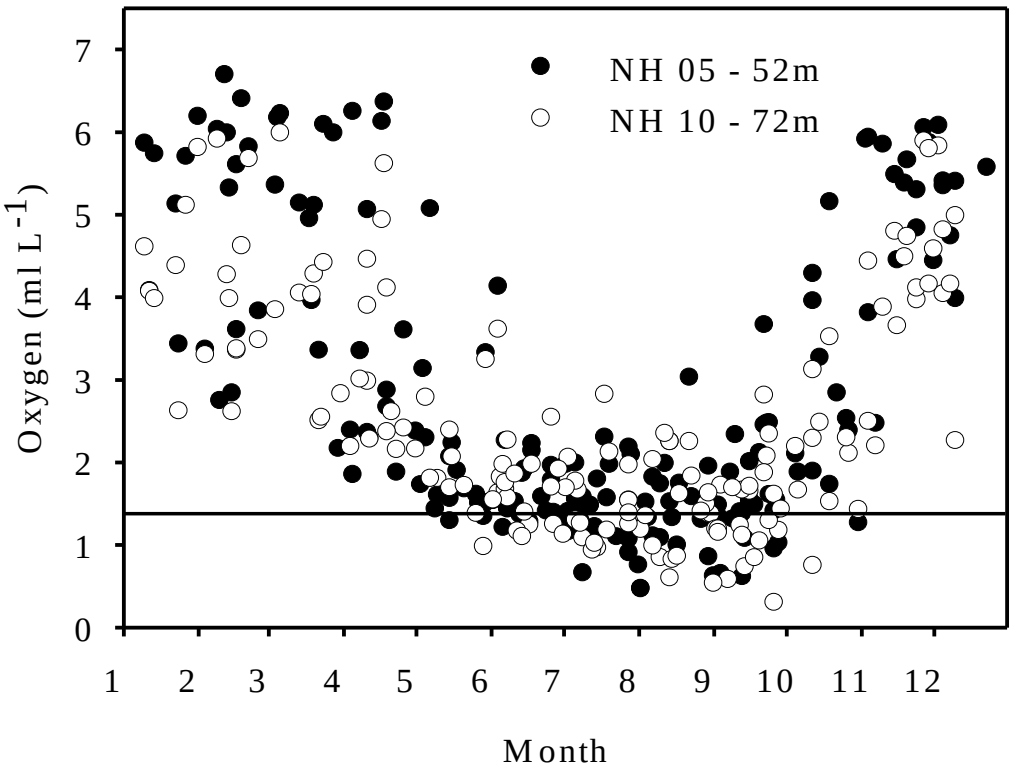


Copepod community response to basin-scale forcing



Hypoxia

- Dissolved oxygen < 1.4 ml L^{-1}
- Seasonal
- Occurs during the upwelling period.
- Most severe in August-September

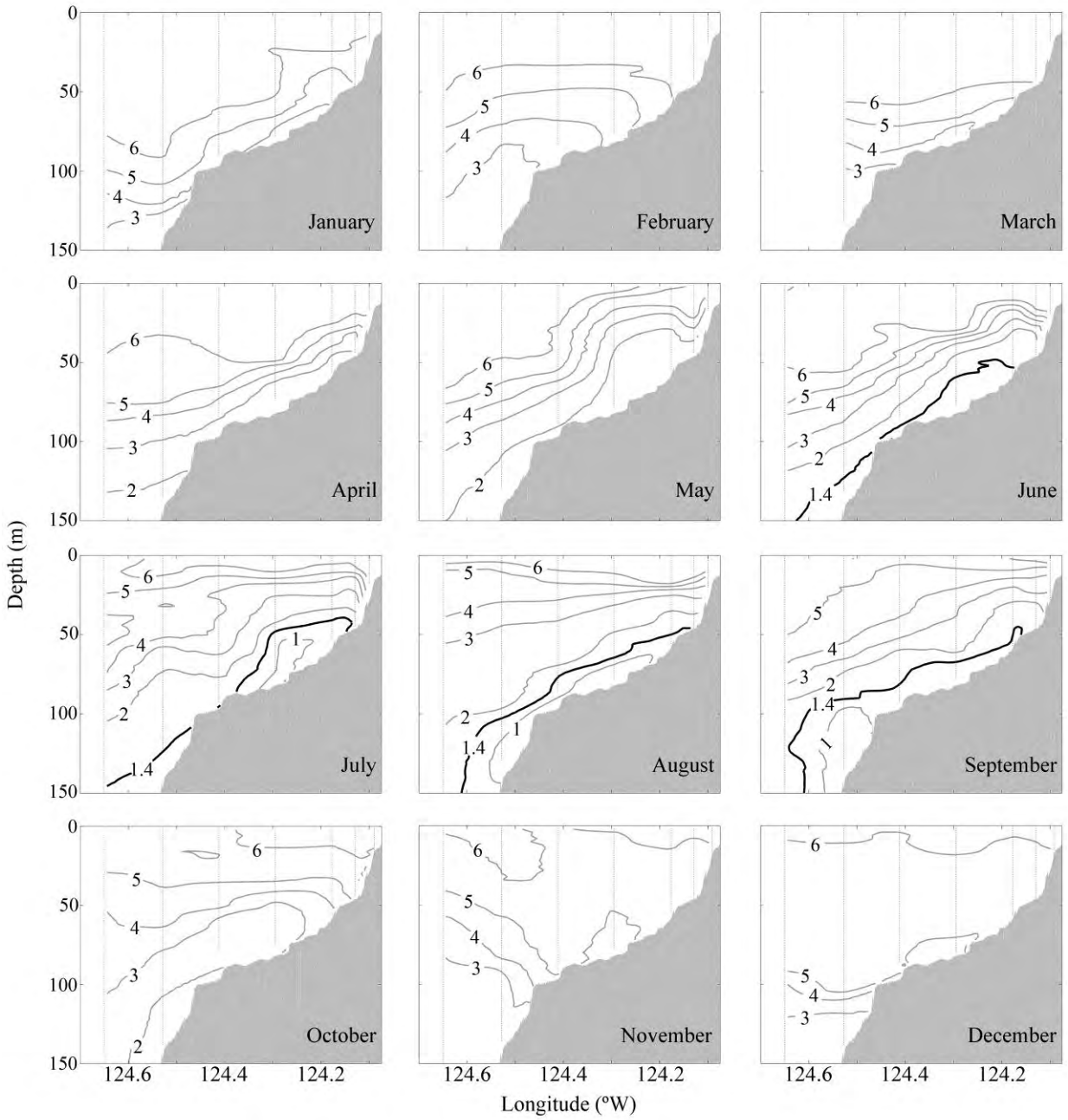


Peterson et al. 2013

Hypoxia

- Seasonal variation in the position of oxygen isopleths over the shelf.

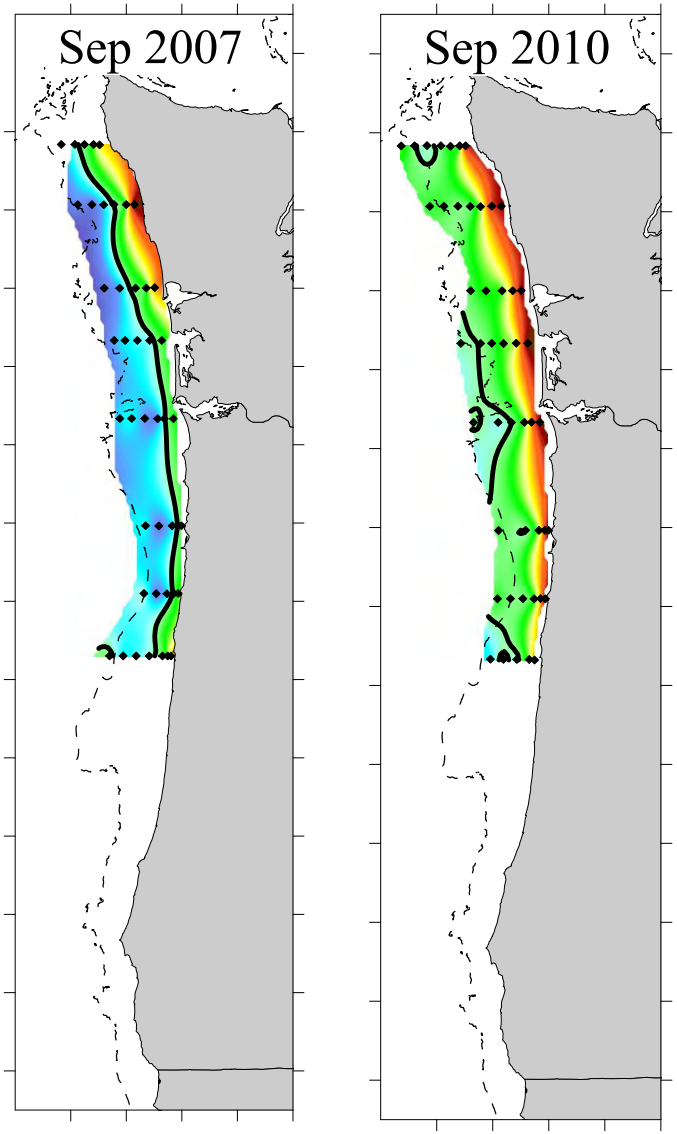
- Upwelling moves low oxygen water onto the shelf.
- Further oxygen drawdown during productive summer season.
- Low oxygen waters typically in the lower 30m of the water column.



Hypoxia

Most severe, and covered the greatest area (>60%) of the shelf in 2002, 2006-2007

Least severe years were 2003, 2009-10.



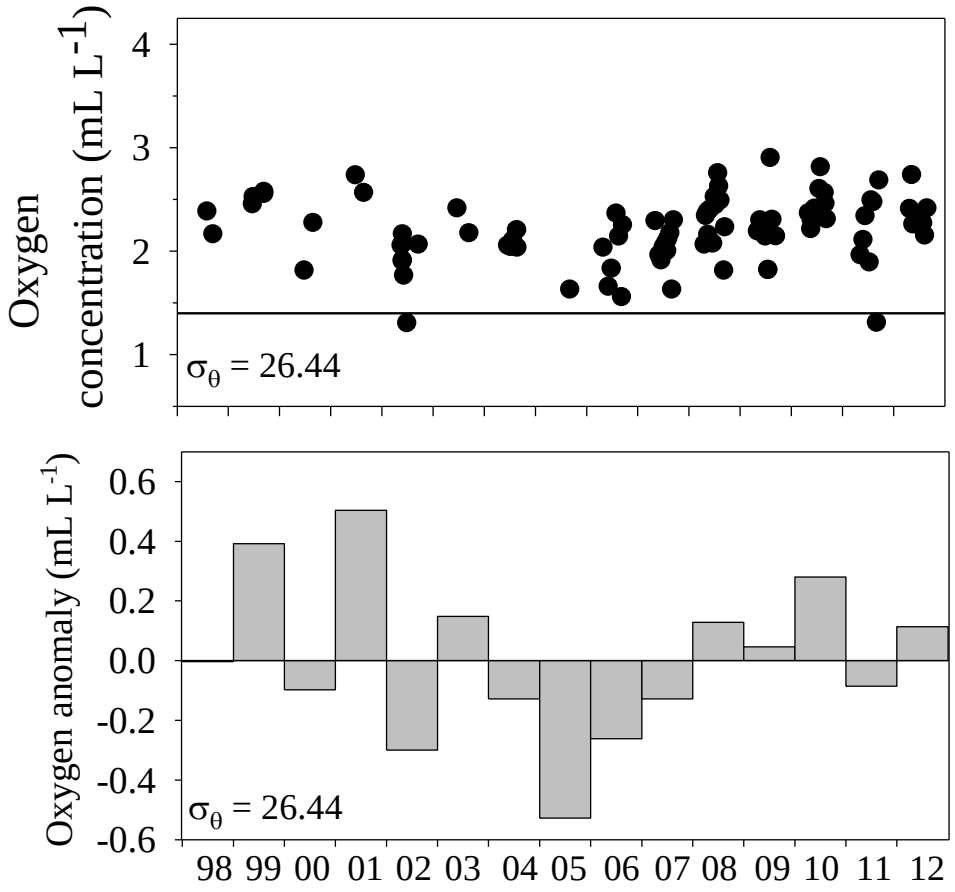
Source water oxygen anomaly

Dissolved oxygen (DO)

The DO concentration in upwelled water varies annually.

General trends:

Decreasing DO: 2001 – 2005
Increasing DO: 2006 - 2010



Peterson et al. *in press* Limnol. Ocean.

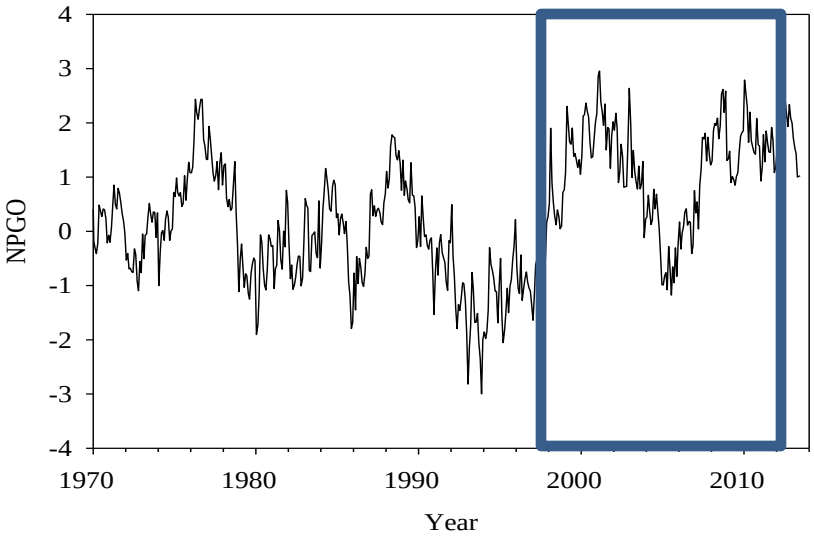
Hypoxia

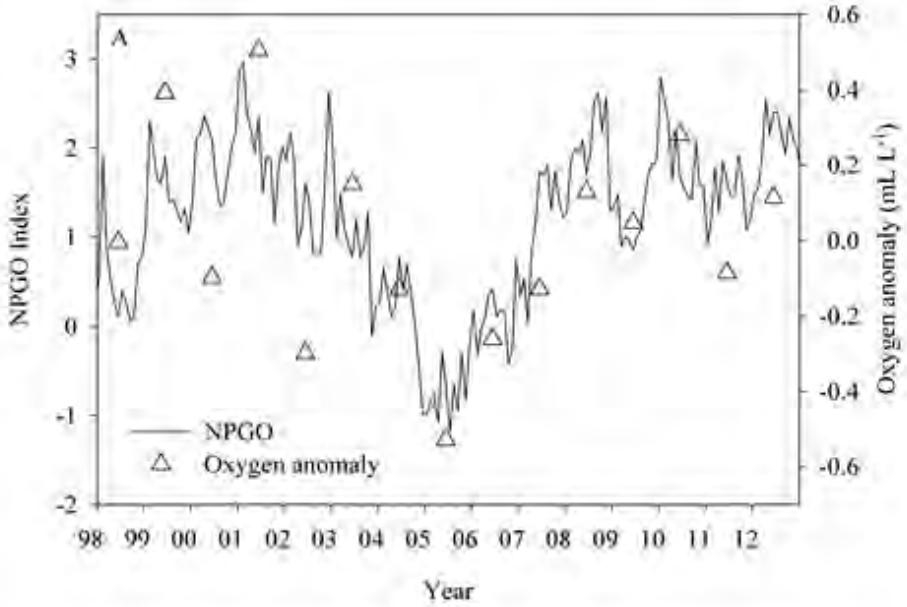
Intriguing relationship between the amount of oxygen in upwelled water and

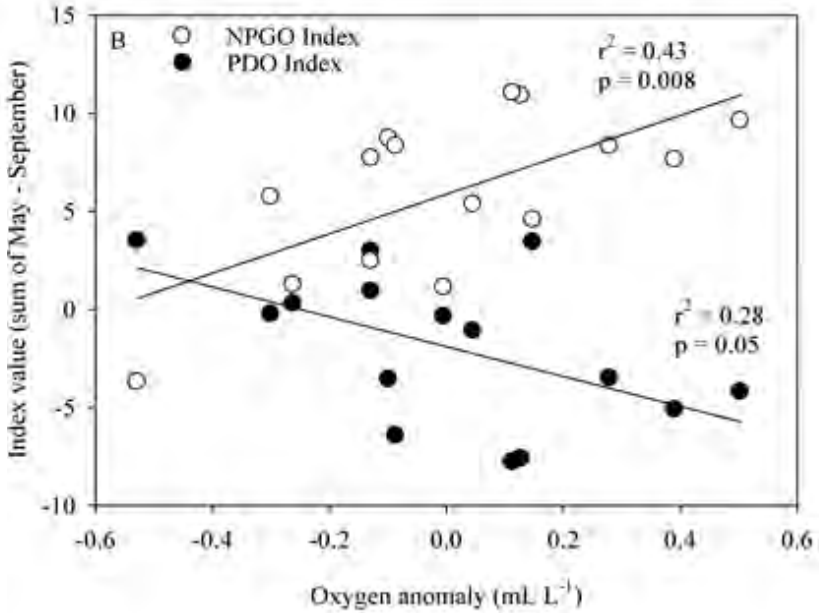
NPGO

PDO

…..though time scales are a bit short (one oscillation) for a robust comparison.







Peterson et al. *in press* Limnol. Ocean.

Summary

- NCC has strong seasonal cycles in biology and hydrography.
- Basin-scale processes are driving local hydrography and copepod variability.
  - Northern copepods (PDO, NPGO); Southern (PDO, ONI)
  - Mechanisms and time-lags are less well understood
- Importance of circulation/transport continues to be recognized, but a better understanding is needed

Acknowledgements

W.T. Peterson Group:

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Captains and Crew of R/V Elakha, F/V Frosti, R/V Wecoma

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