Recent high variability in hydrography and lower trophic levels in the upwelling region off Newport, Oregon, USA

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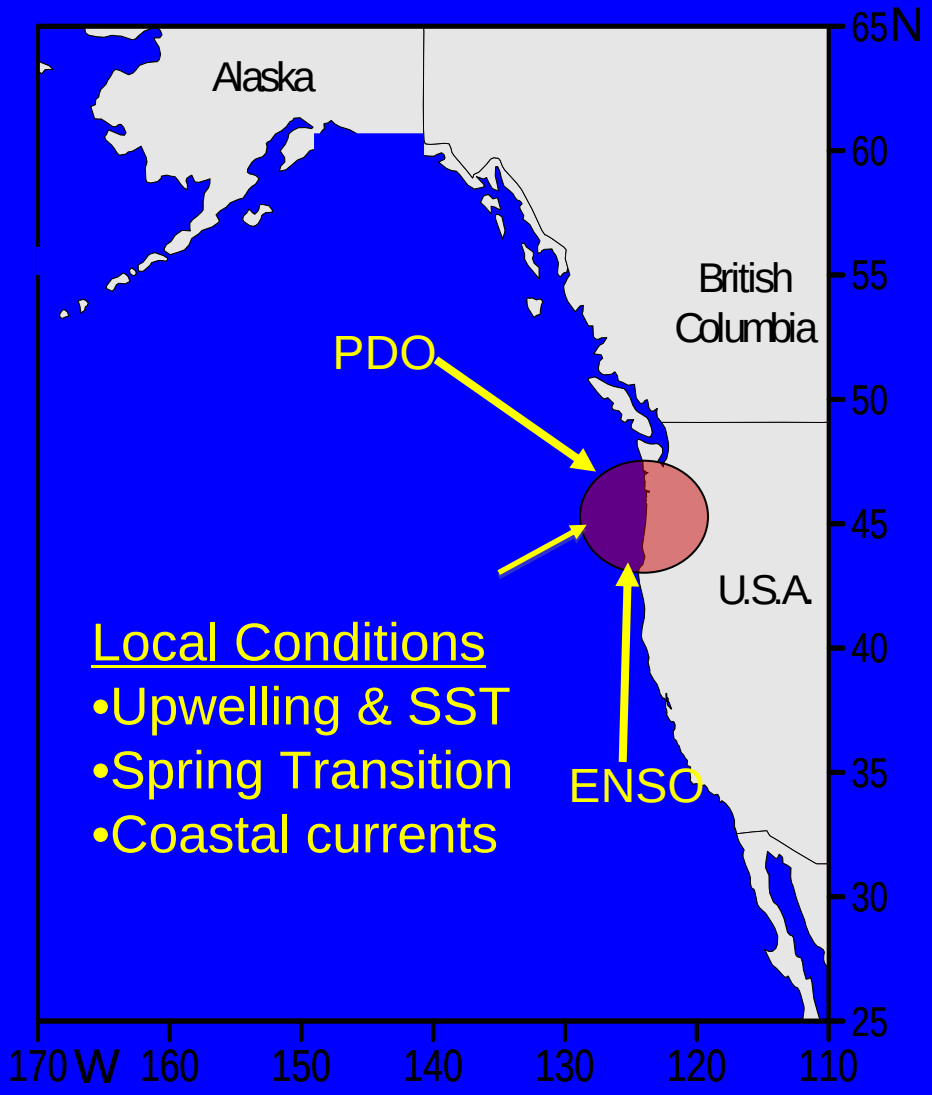
Study area



Newport Line:

Biweekly sampling since 1996 (16th year)
-CTD, chl, nut, zoop, etc.

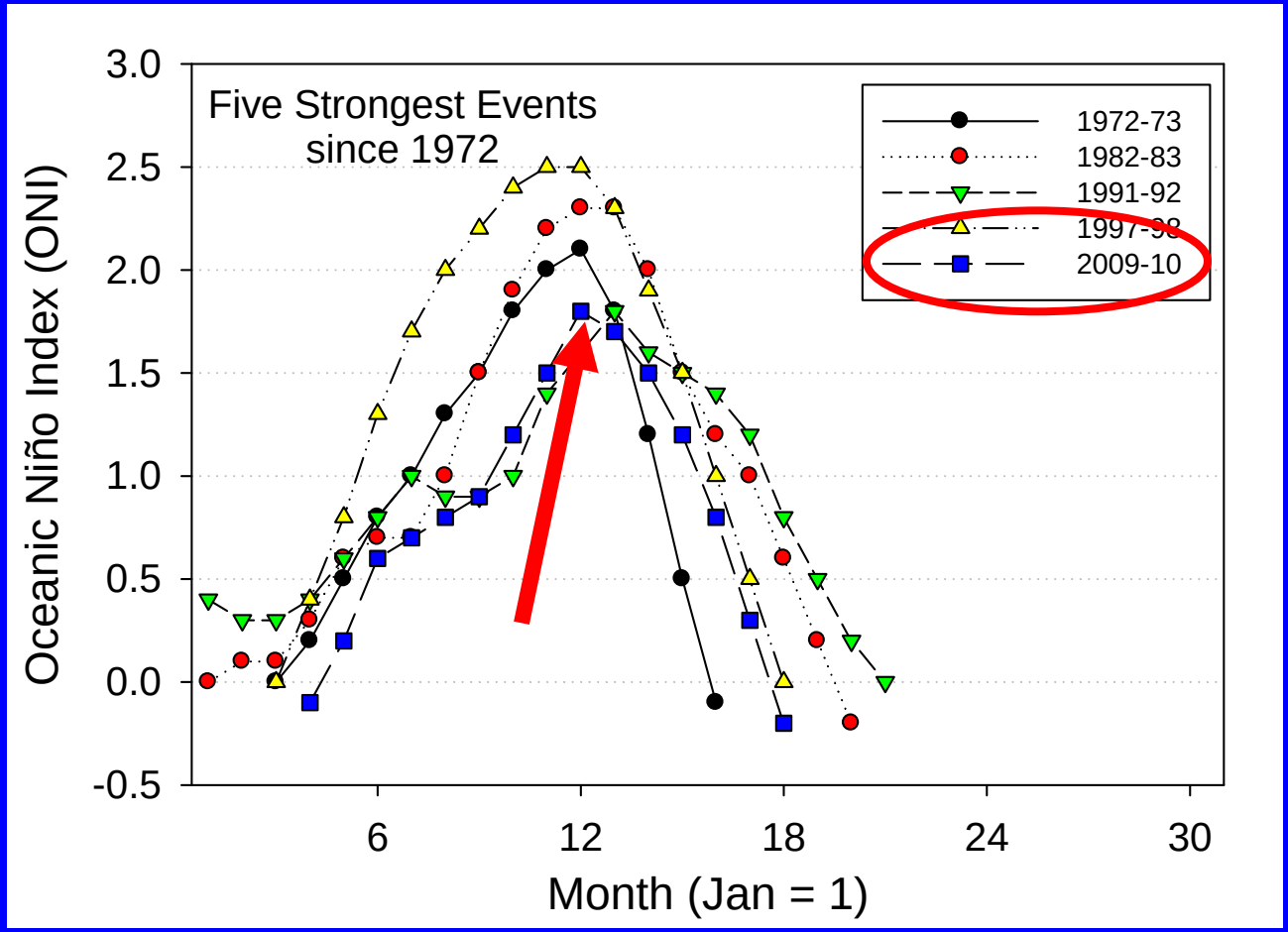
Juvenile salmon sampling:

June and September since 1998 (14th year)

Historical data:

- Hydrography: 1960s;
- Plankton: 1969-1973; 1983, 1990-1992
- Juvenile salmon: 1981-1985

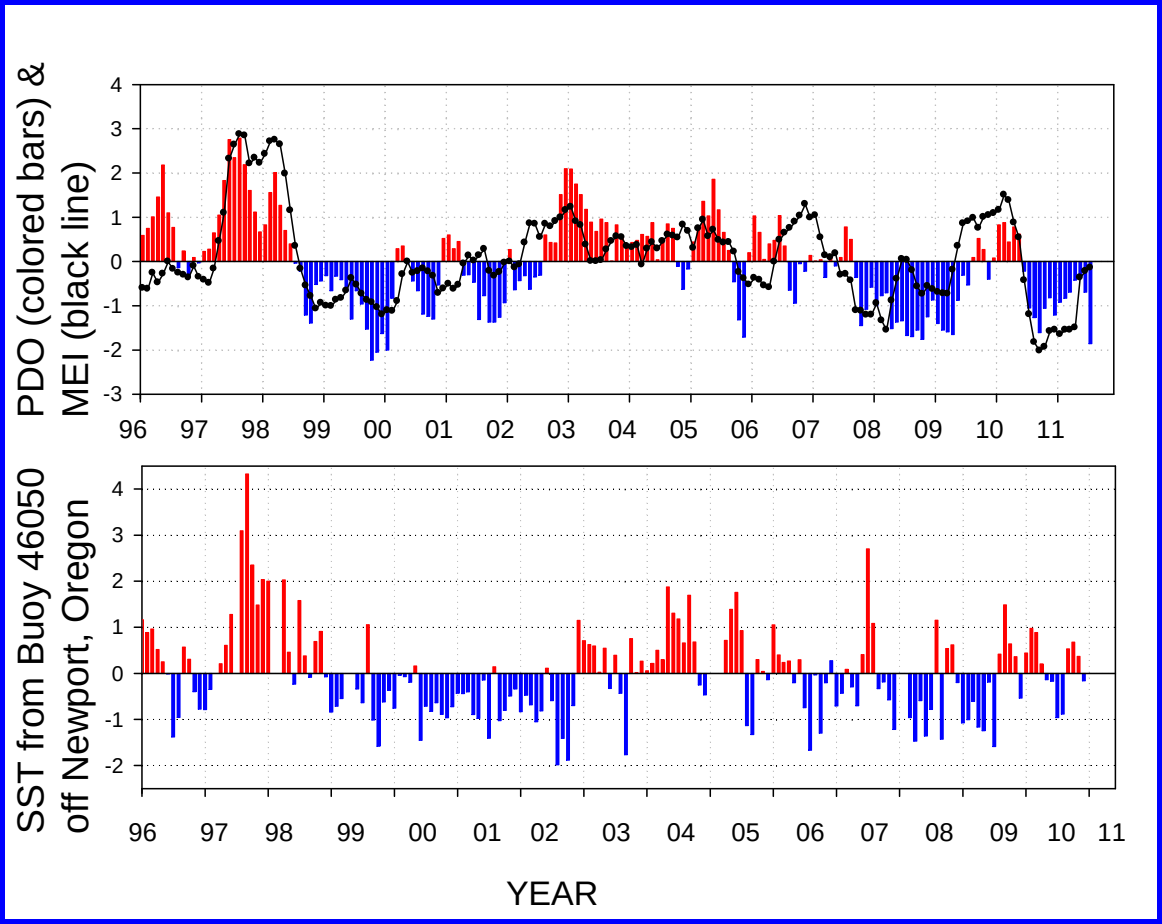
Recent variability is in relation to the 2009-2010 El Niño



Outline

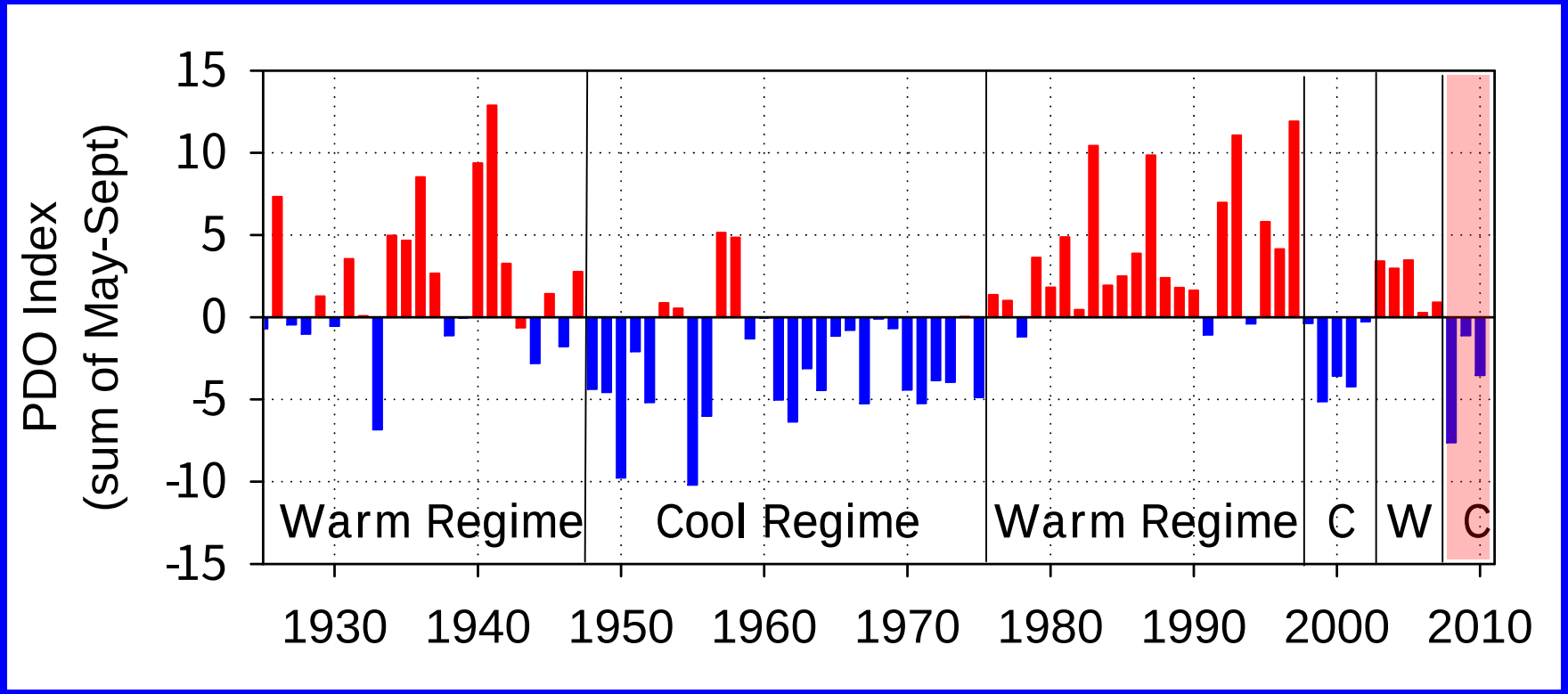
- Larger-scale environmental variability
  - PDO, MEI
- Local conditions in our study area in relation to 2009-2010 El Niño
- Association between PDO and copepod community composition
- Relationship between PDO and salmon

PDO, MEI, and local SST off Newport, OR



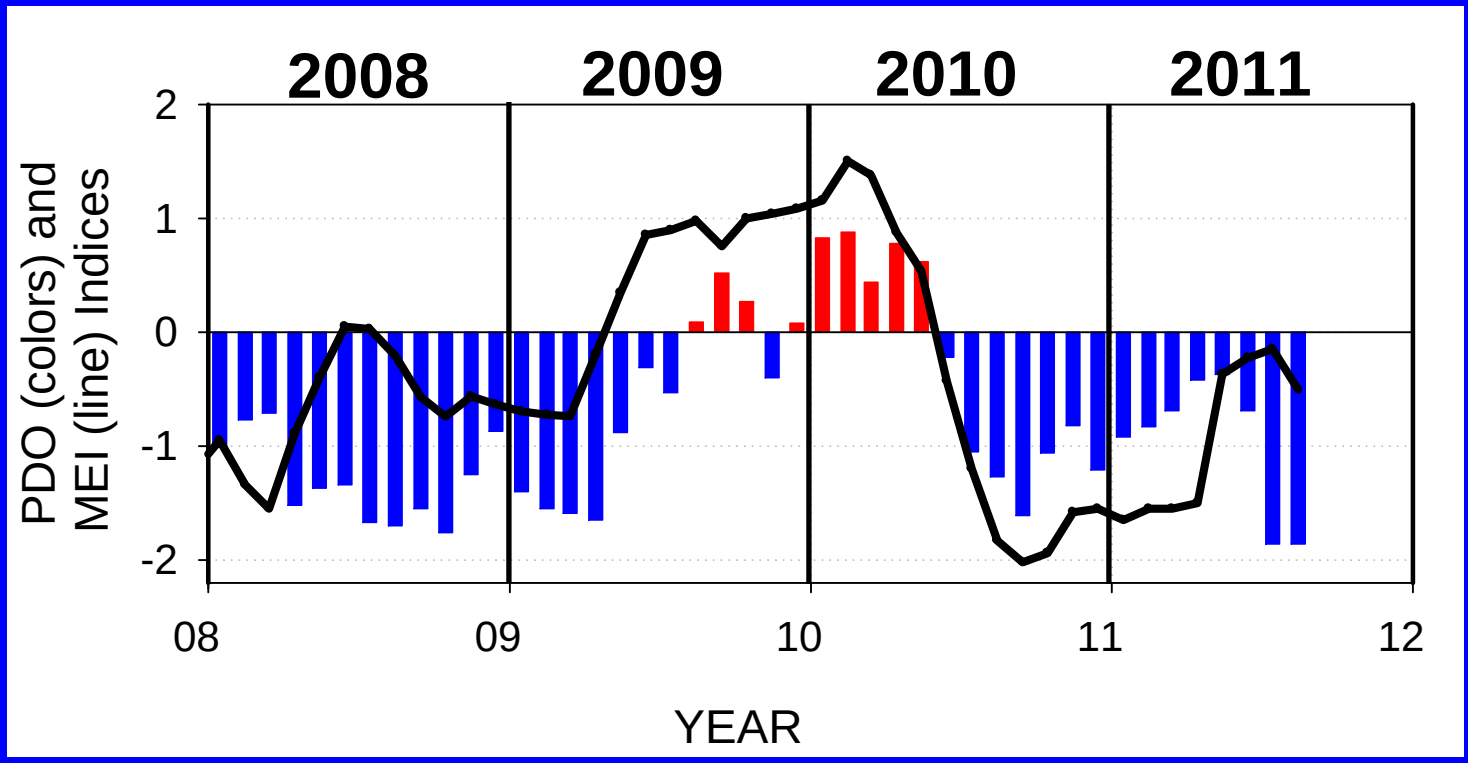
- PDO and SST correlated (as they should be)
- Time series of SST off Newport shows that PDO downscales to local SST
- Local SST may lag PDO sign change by 3-5 months

PDO: May-Sep Average, 1925-2010



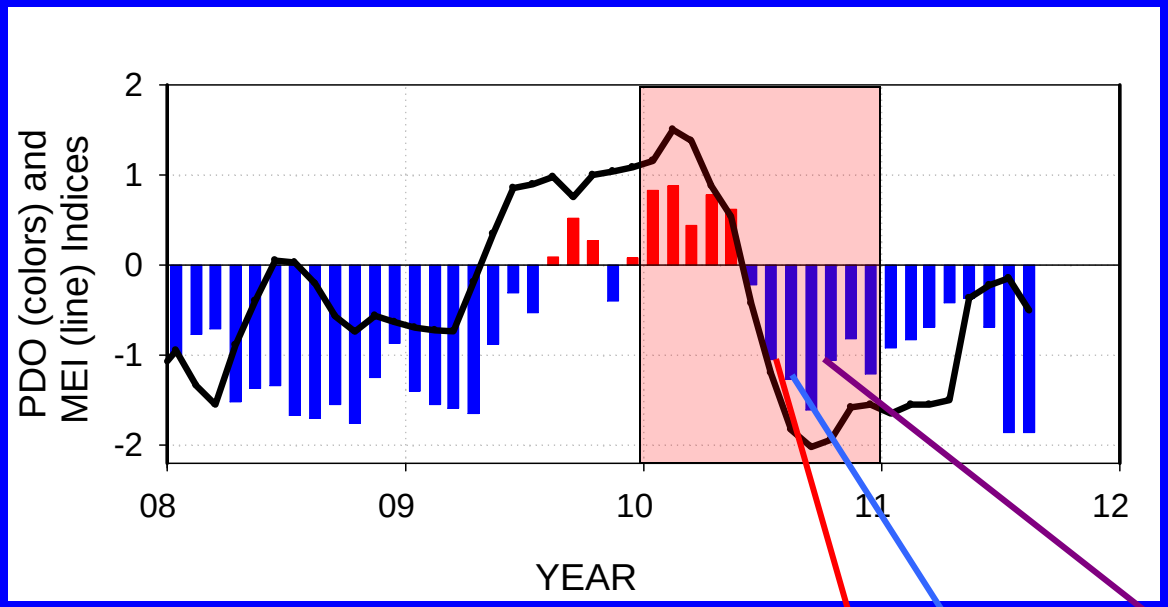
- 1925-1998: PDO shifts between warm and cool regimes every 20-30 years
- PDO has not been decadal since 1999: negative 1999-2002, positive 2003-2006, negative late 2007
- PDO negative 2008-2010 in spite of 2009-2010 El Niño

PDO & MEI 2008-2011

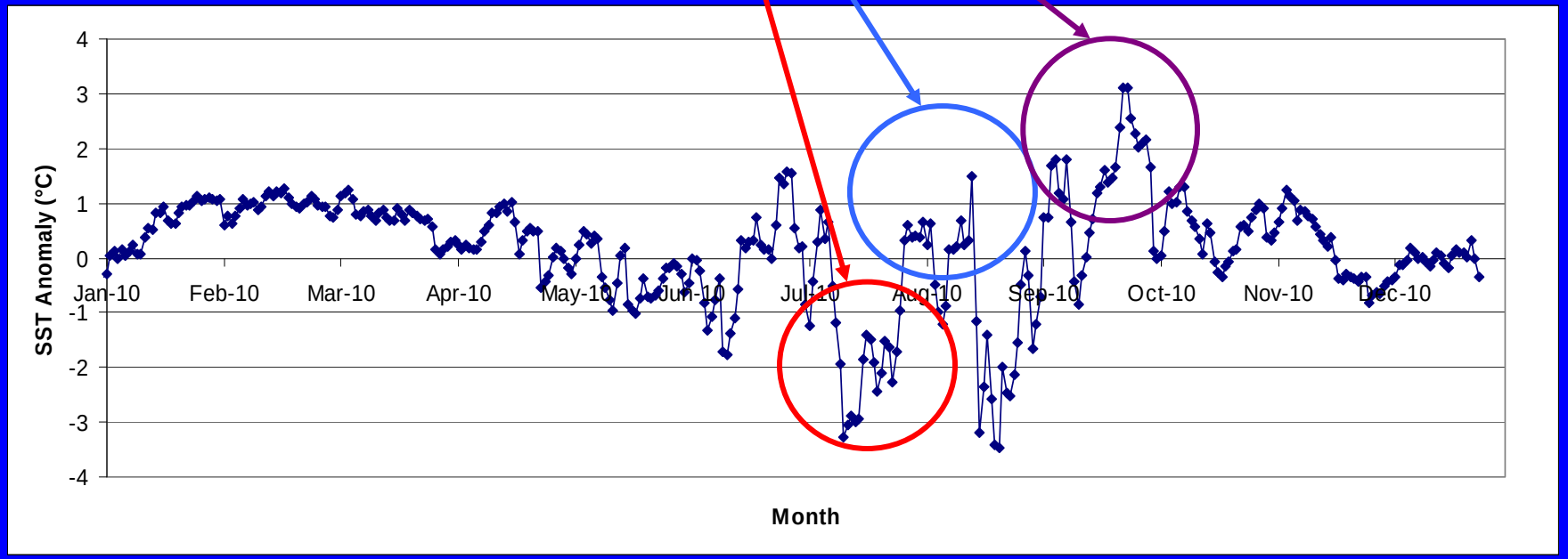


- 2008 most strongly negative PDO since the 1950s and remains strongly negative through April 2009
- Change to positive in August 2009 due to El Niño
- Changes back to negative in June 2010 when El Niño dissipates
- PDO negative from end of El Niño to the present

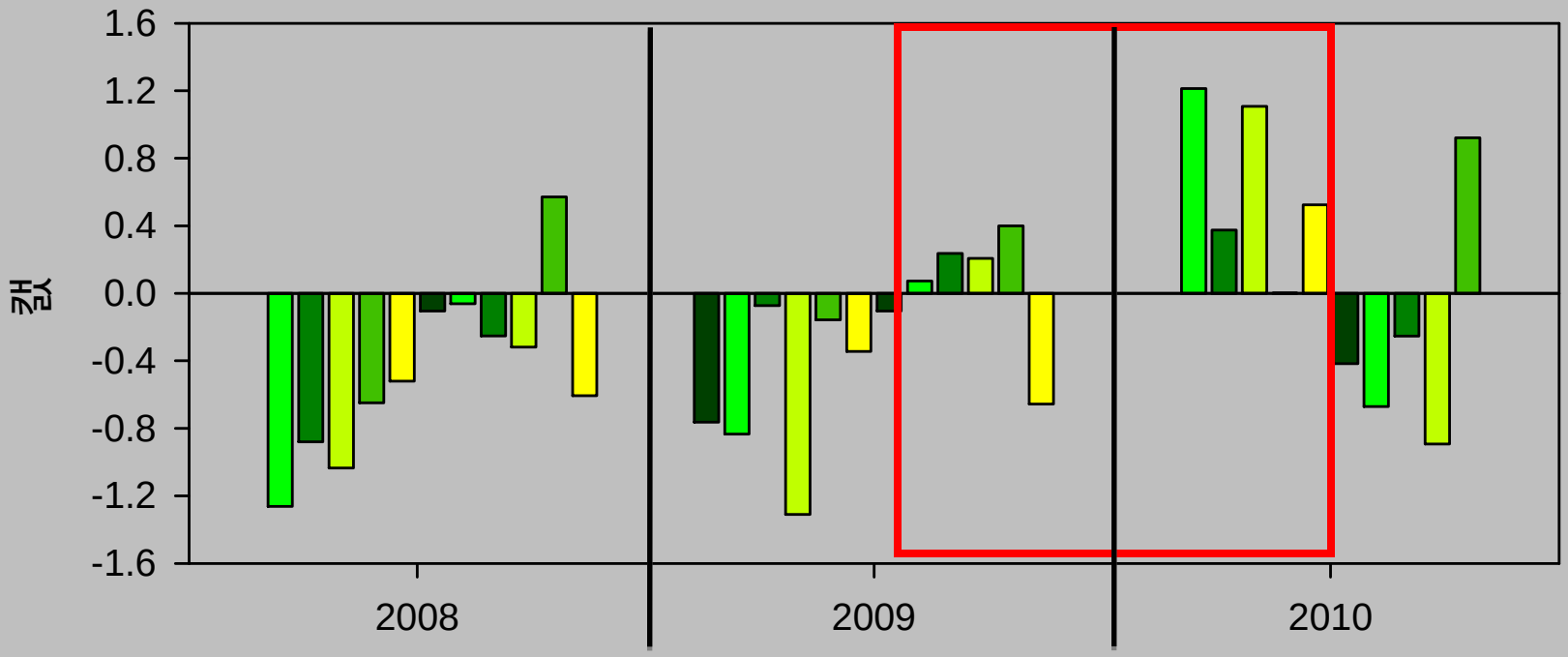
PDO & local SST



- PDO and local SST both decreased rapidly when El Niño dissipated
- Local SST anomaly has warm periods after PDO shifts to strongly negative
- Useful to know local temperatures in addition to PDO

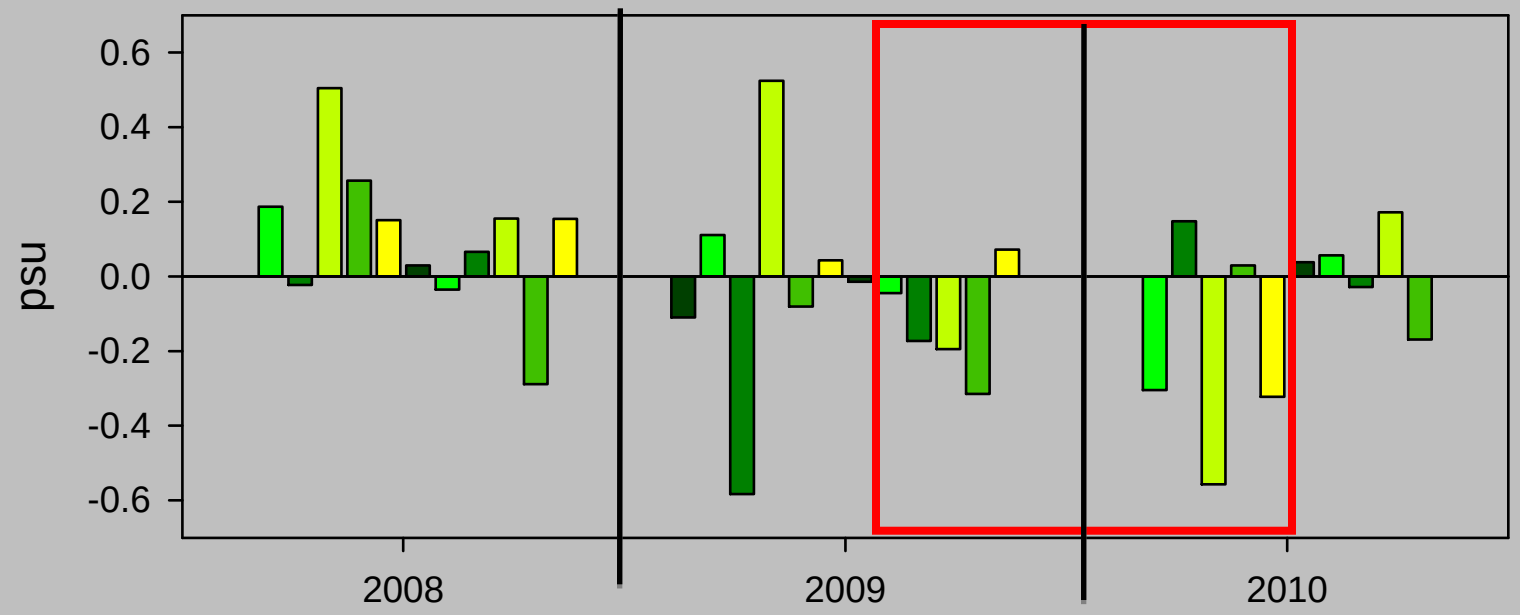


Temperature anomaly (50m) at NH05



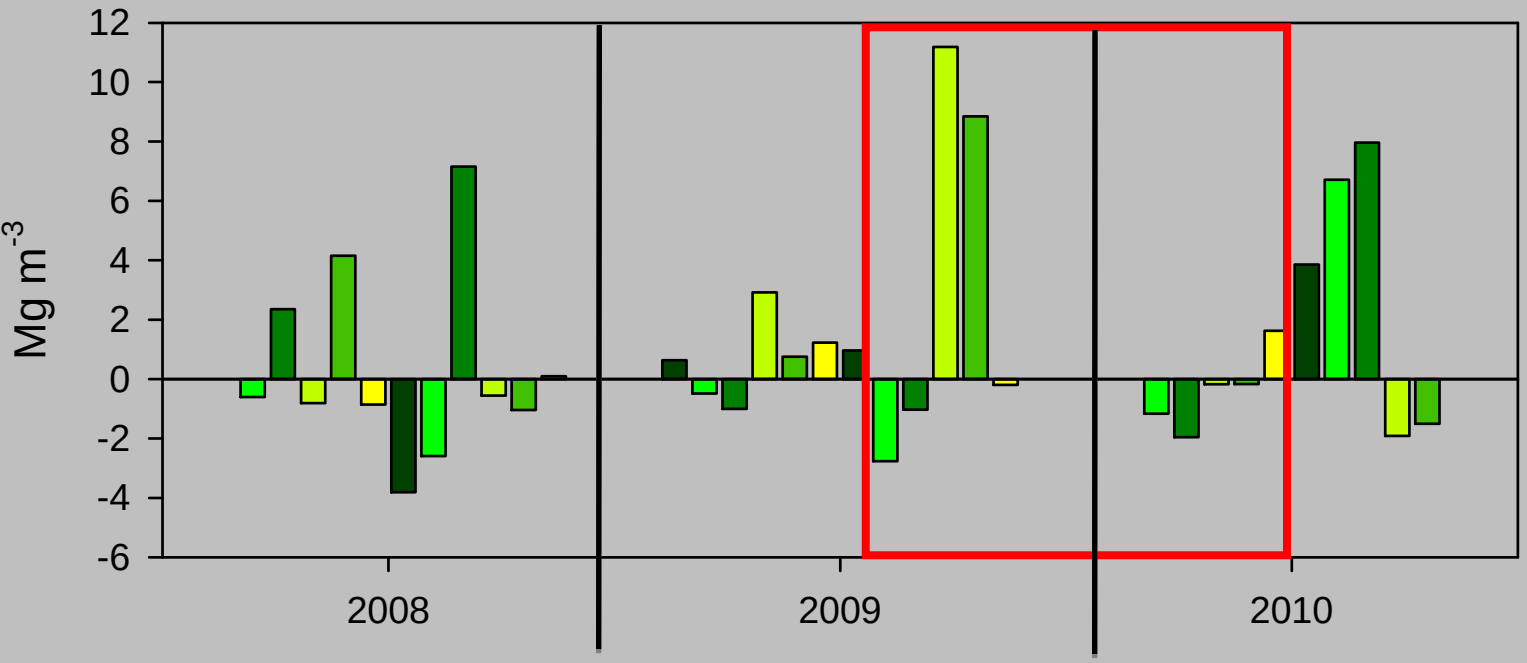
- Positive anomaly during El Niño indicates the presence of a different water mass

Salinity anomaly (50m) at NH05



- Negative anomaly during El Niño indicates the presence of a different water mass

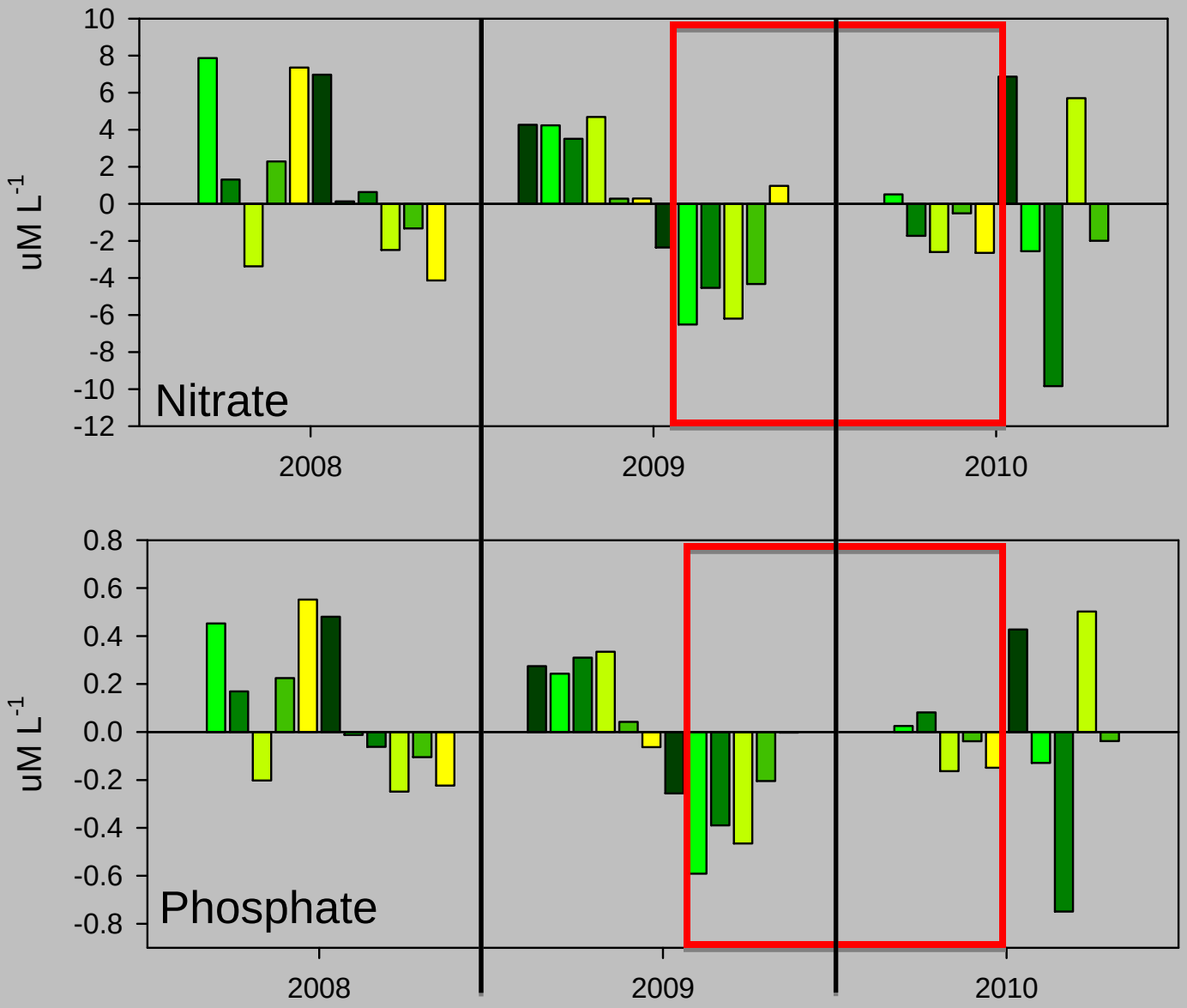
Chl-*a* anomaly at NH05



High chl-*a* anomaly late in 2009 is associated with large bloom of *Akashiwo sanguinea*, normally a rare species in our study area

(see talk by Xiuning Du in BIO @ 1405 today)

Nutrient anomalies at NH05



Nitrate & phosphate patterns similar during all three years, indicating that nutrients also track different water masses

Linkage from PDO to salmon survival

- PDO phase is associated with advection of either warm or cold water to the coast
- Warm and cold water masses are associated with distinct copepod communities
  - Negative PDO = cold water copepod community
  - Positive PDO = warm water copepod community
- The copepod community that is present when juvenile salmon enter the ocean is a good indicator of their survival, even though juvenile salmon do not feed directly on copepods.

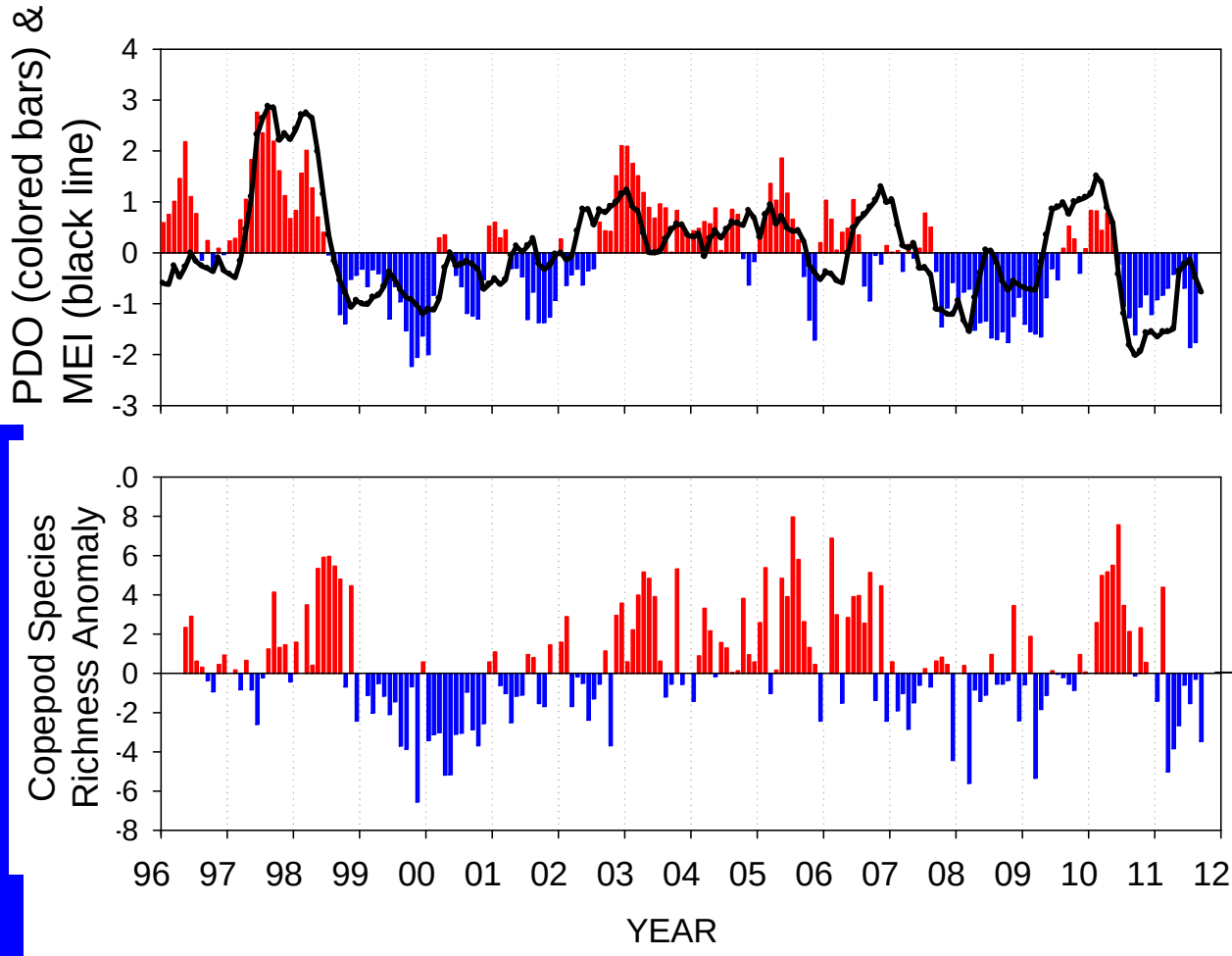
Cold and warm water copepod communities

- **Negative PDO = cold-water copepods** – (boreal coastal species) are **large** and store high-energy **wax esters** as an over-wintering strategy

- **Positive PDO = warm-water copepods** - (from offshore OR) are **small** in size and have minimal high energy wax ester lipid depots

Cold-water copepods are a richer source of energy than warm-water copepods

PDO, MEI and Copepod Species Richness Anomaly



- Species richness anomaly closely associated with PDO phase
- PDO can serve as a proxy for which copepod community is present

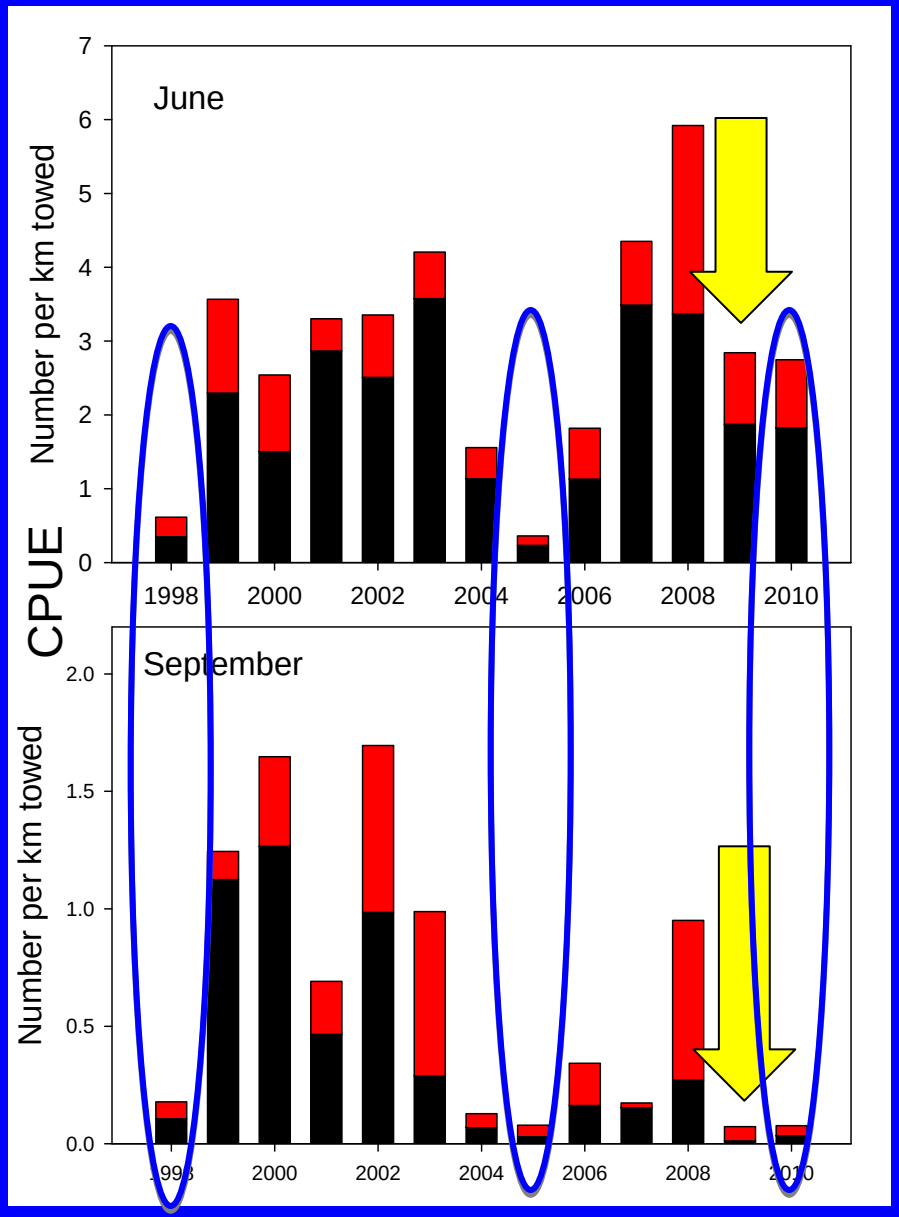
← Warm Water Species

← Cold Water Species

Meet the local salmon

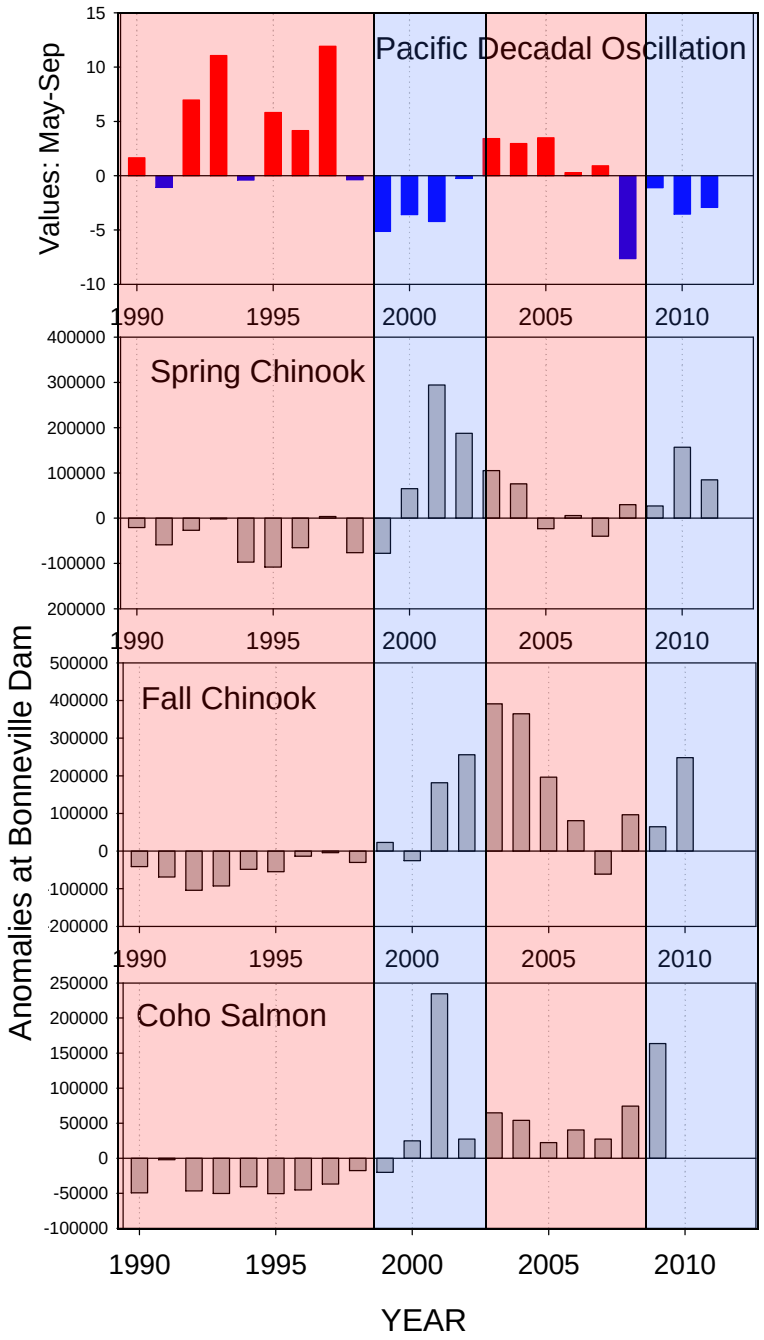
- Spring Chinook
  - Enter the ocean in May
  - Stay in study area a short time before migrating north
  - Most spend two years at sea
- Coho
  - Enter the ocean in May
  - Most stocks remain in the study area
  - Spend 1.5 years at sea
- Fall Chinook
  - Enter the ocean in summer
  - Most spend three years at sea

Catches of juvenile salmon in trawl surveys



- **Black bars** = coho
- **Red bars** = spring Chinook

- June 2009 (prior to El Niño) among the highest catches of spring Chinook (rank 5/13)
- Sept 2009 (after El Niño arrives) among the lowest catches of coho (rank 11/13)
- 2010 same pattern as 2009 which we find confusing – lingering effects of El Niño?



Salmon returns since 1990: counts at Bonneville Dam

- PDO in warm phase until 1998 & salmon survival was poor
- PDO shift to cool late in 1998 was followed by record returns
- PDO shift to warm late in 2002 – salmon stocks decline
- PDO shift to cool in 2008 and returns improve
- Salmon that went to sea in 2010 will return 2011-2013 so effects on adult returns remain to be seen

What does it mean?

- Currently, the relationship between the PDO and the copepod community is a pretty good predictor of salmon survival
- How this relationship will be affected by increased environmental variability remains to be seen
  - Similar catches of juvenile salmon in 2009 and 2010 suggest that although the PDO was negative, the environment was not favorable to salmon survival
- Increasing environmental variability is almost certain to affect salmon survival
  - Temperature = copepod community (food quality) = survival
  - Important to understand life cycle of target species in order to correlate environmental conditions with biological responses