15 years of biweekly sampling along the Newport Hydrographic Line: an update

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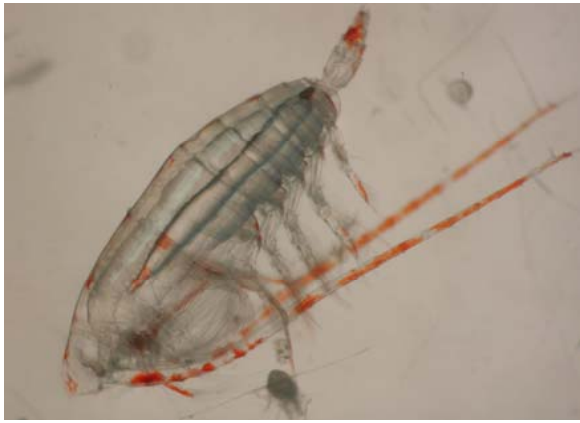
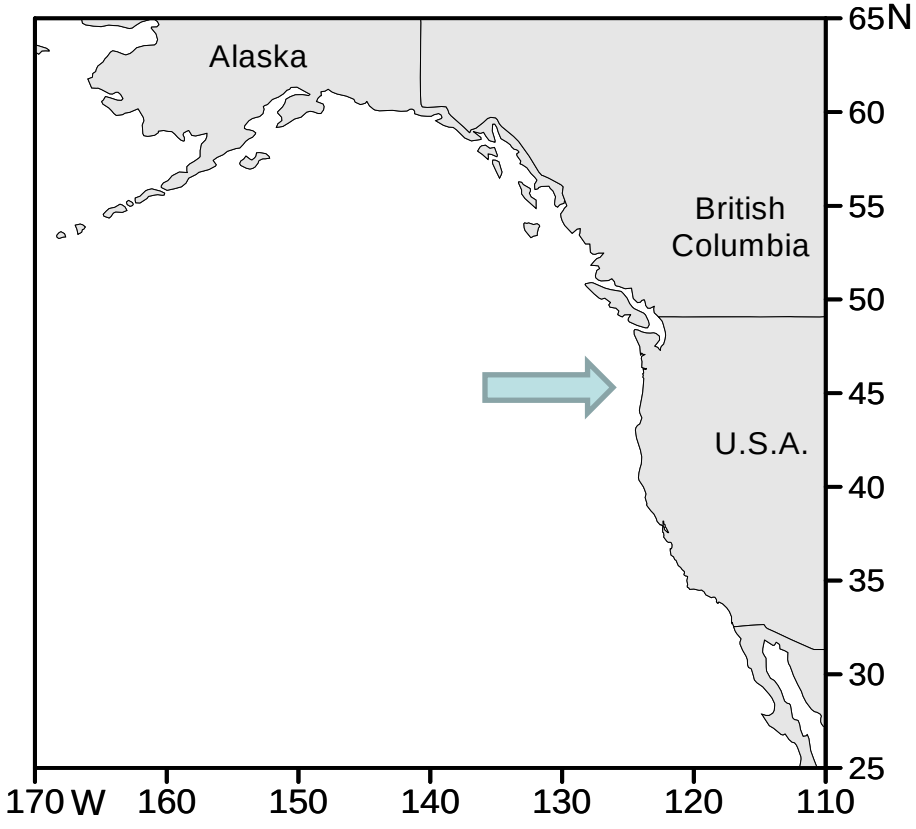


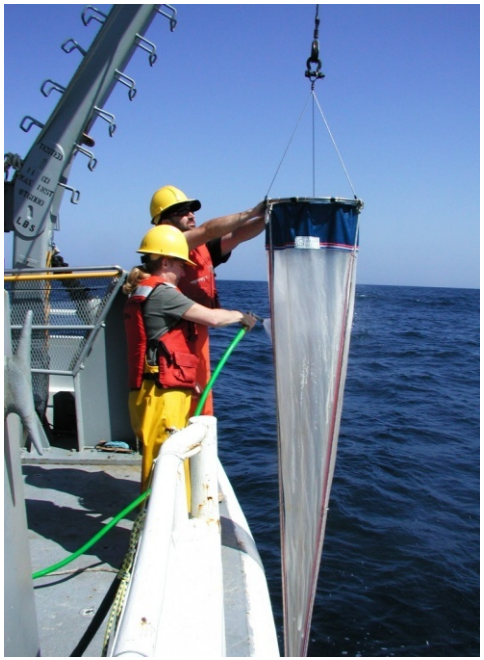
Newport Hydrographic Line

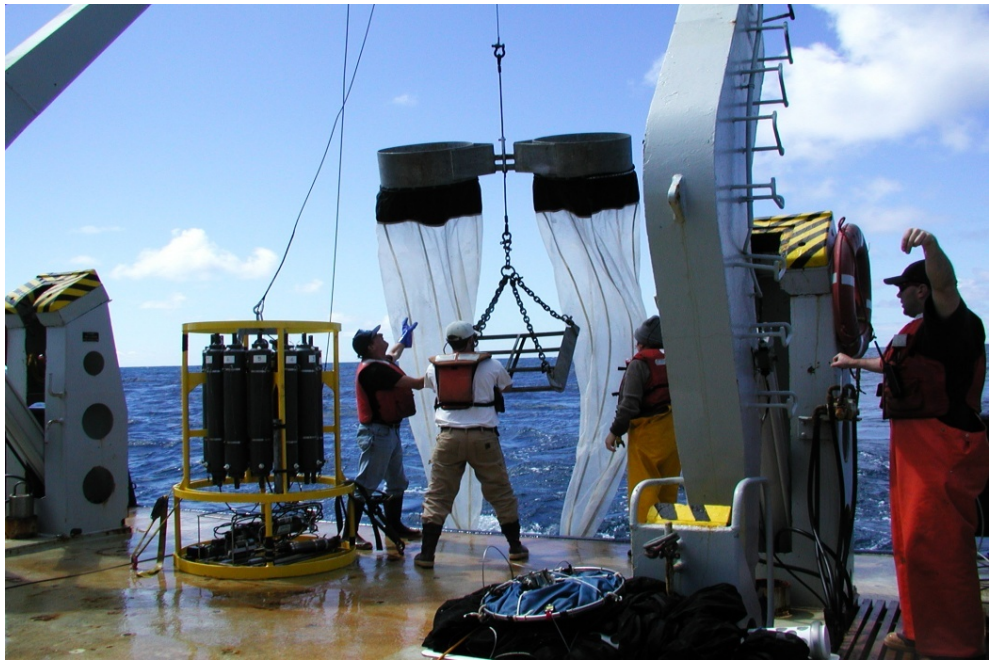


- Sampled biweekly 1996-present; historical data from 1970s, 1980s and early 1990s across the continental shelf, 7 stations, from 2 to 40 km from shore (20 m to 300 m water depth)
- CTD, secchi disc, nutrients, chl-a, zooplankton, meroplankton, krill, and ichthyoplankton
- Today: NH 05 (62 m water depth) + some offshore stuff
- Oxygen distributions

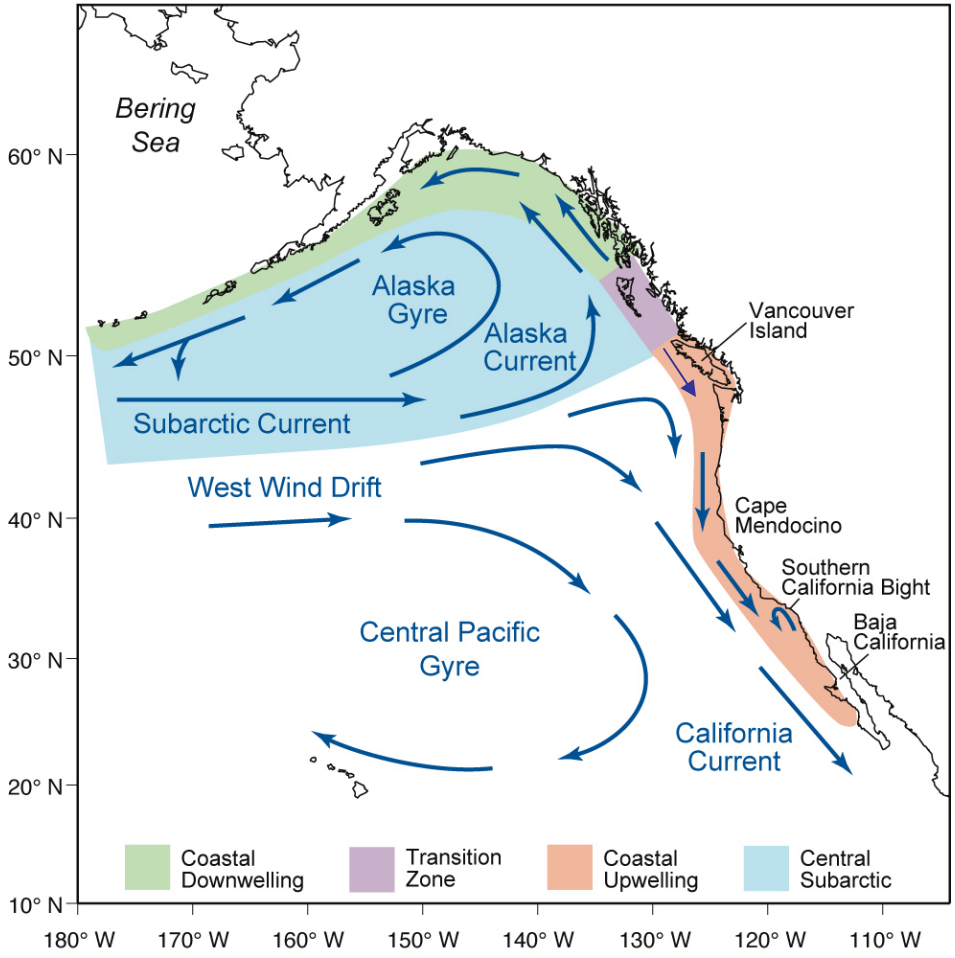
Methods

- Copepods with ½ m diameter 200 μm mesh net towed vertically from 100 m
- Krill with 70 cm 333 μm mesh Bongo net towed obliquely
- Ordination analysis of ~ 500 copepod samples collected at the station NH 05 and along the NH transect line
- Use X-axis scores





Circulation off the Pacific Northwest



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

The West Wind Drift brings subtropical water and subtropical species to the N. California Current

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

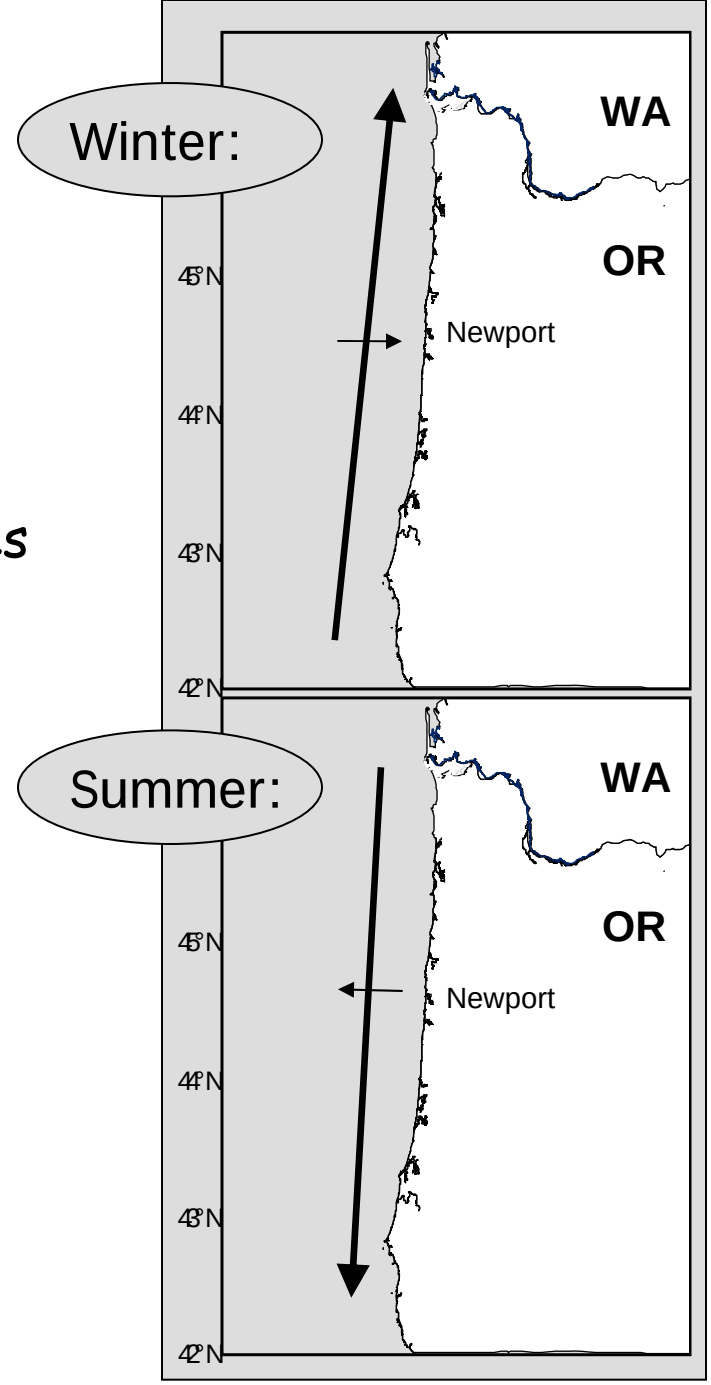
Winds and current structure off coastal Oregon:

- Winter:
  - Winds from the South
  - Downwelling
  - Poleward-flowing Davidson Current
  - Subtropical and southern plankton species transported northward & onshore
  - Many fish spawn at this time

- **Spring Transition in April/May**

- Summer:
  - Strong winds from the North
  - Coastal upwelling
  - Equatorward alongshore transport
  - Boreal/northern species transported southward

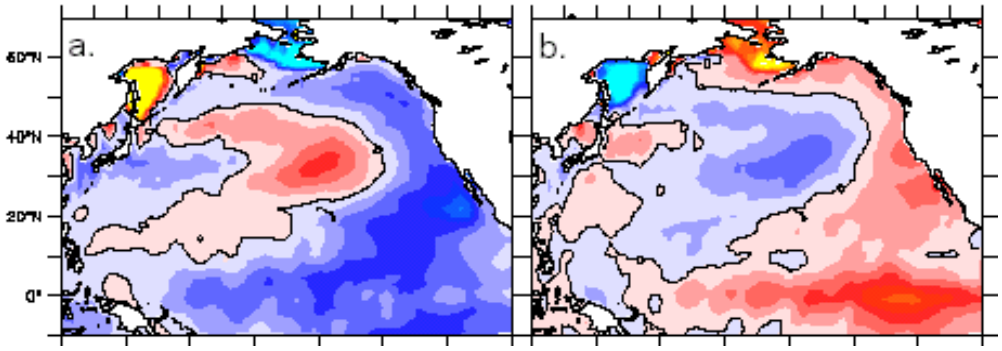
- **Fall Transition in October**



The PDO has two phases, resulting from the direction from which winds blow in winter. The oscillation is in the pattern of SST from EOF analysis.

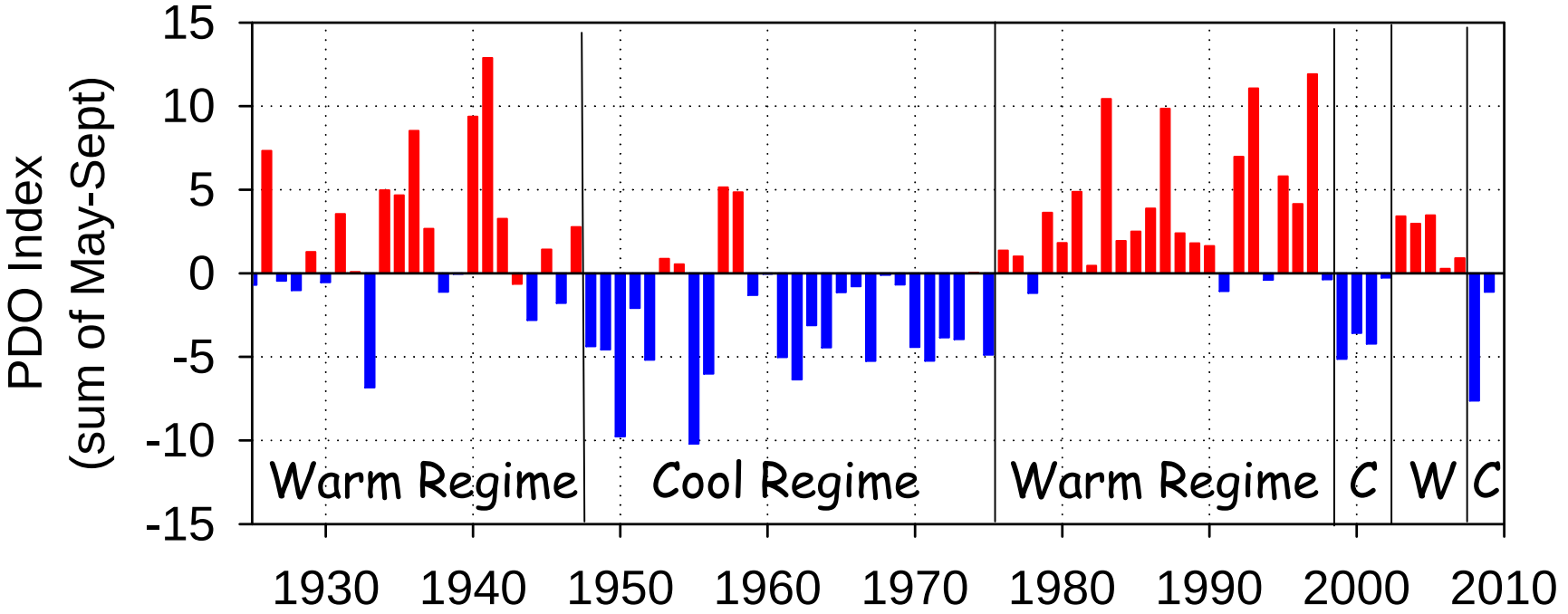
The SST anomaly patterns shown on the right results from basin scale winds: W'ly and NW'ly [negative phase] and SW'ly [positive phase]

PDO & SST



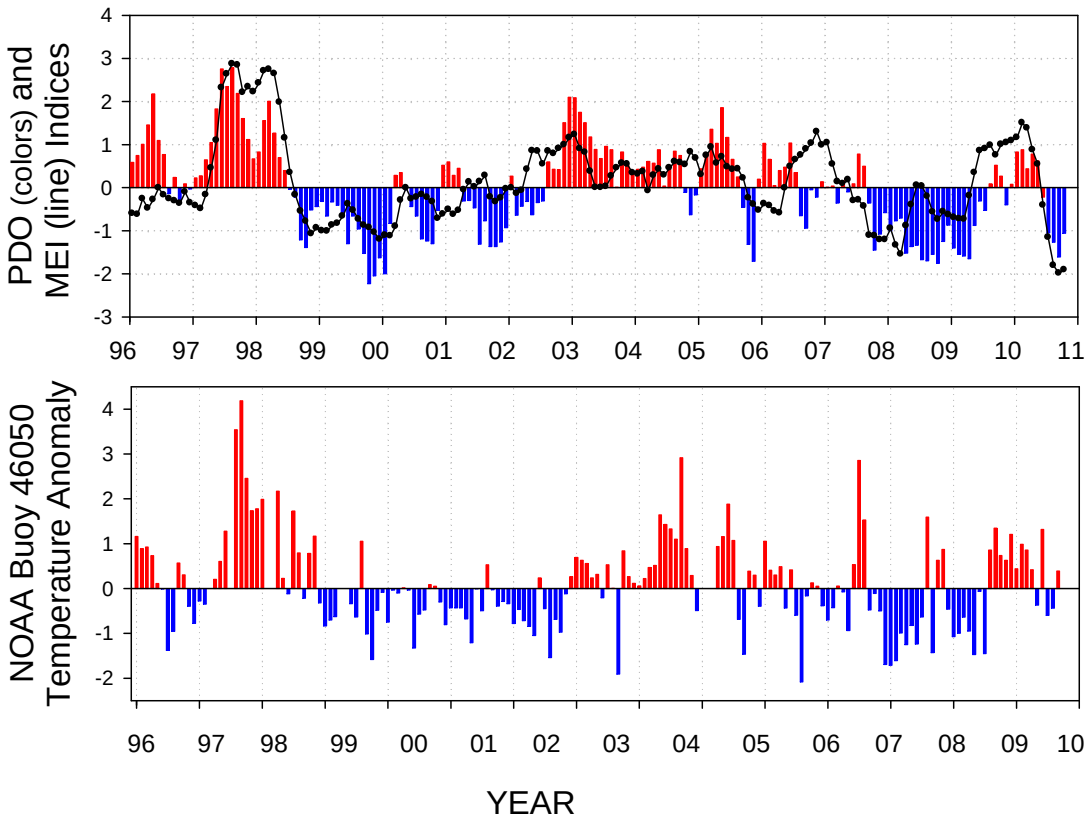
Blue is anomalously cold
Red is anomalously warm

PDO: May-Sep Average, 1925-2010



- From 1925-1998, PDO shifted every 20-30 years. Some refer to these as "salmon" regimes (cool) and "sardine" regimes (warm).
- However, we have had two shifts of four years duration recently: 1999-2002 and 2003-2006, and another shift in late 2007, thus *we have a natural experiment to test the affects of PDO on marine food chains.*
- **Will a "decadal" temperature pattern persist into the future?**

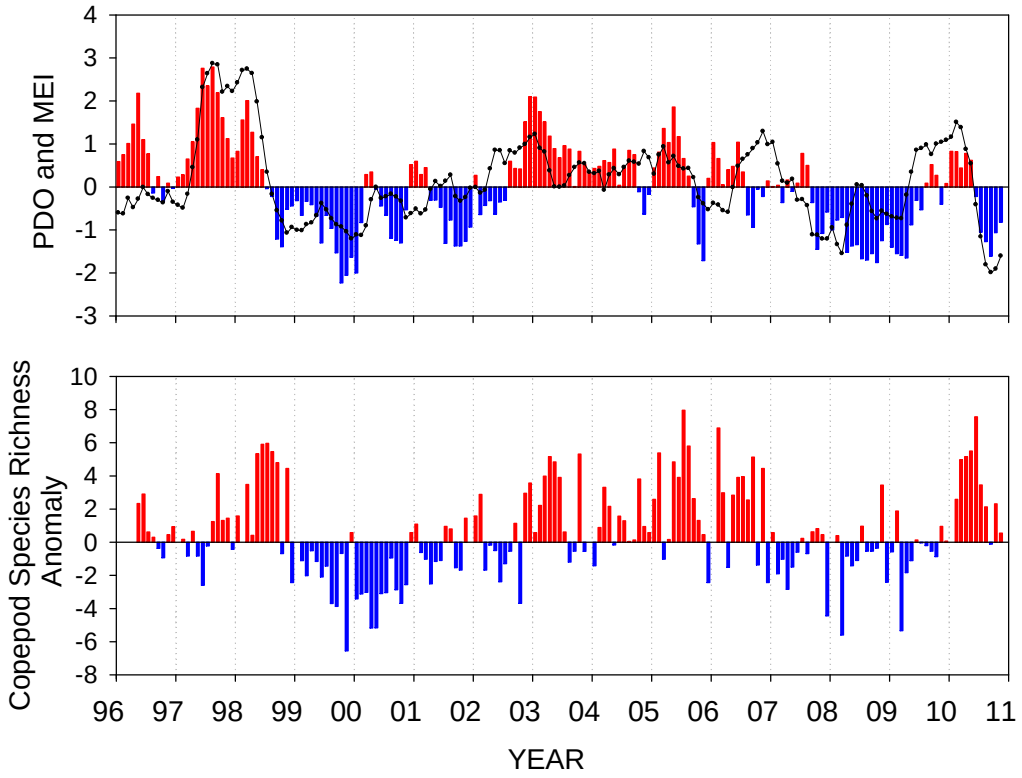
14 year time series of SST off Newport shows that PDO downscales to local SST



- PDO and SST correlated, as they should be.
- Note the three recent periods of persistent sign changes: mid-1999, mid-2003,mid-2007 and mid-2009
- There can be time lags between PDO sign change and SST response of ~ 3-5 months, suggesting perhaps that the PDO is an advective signal along the Oregon coast

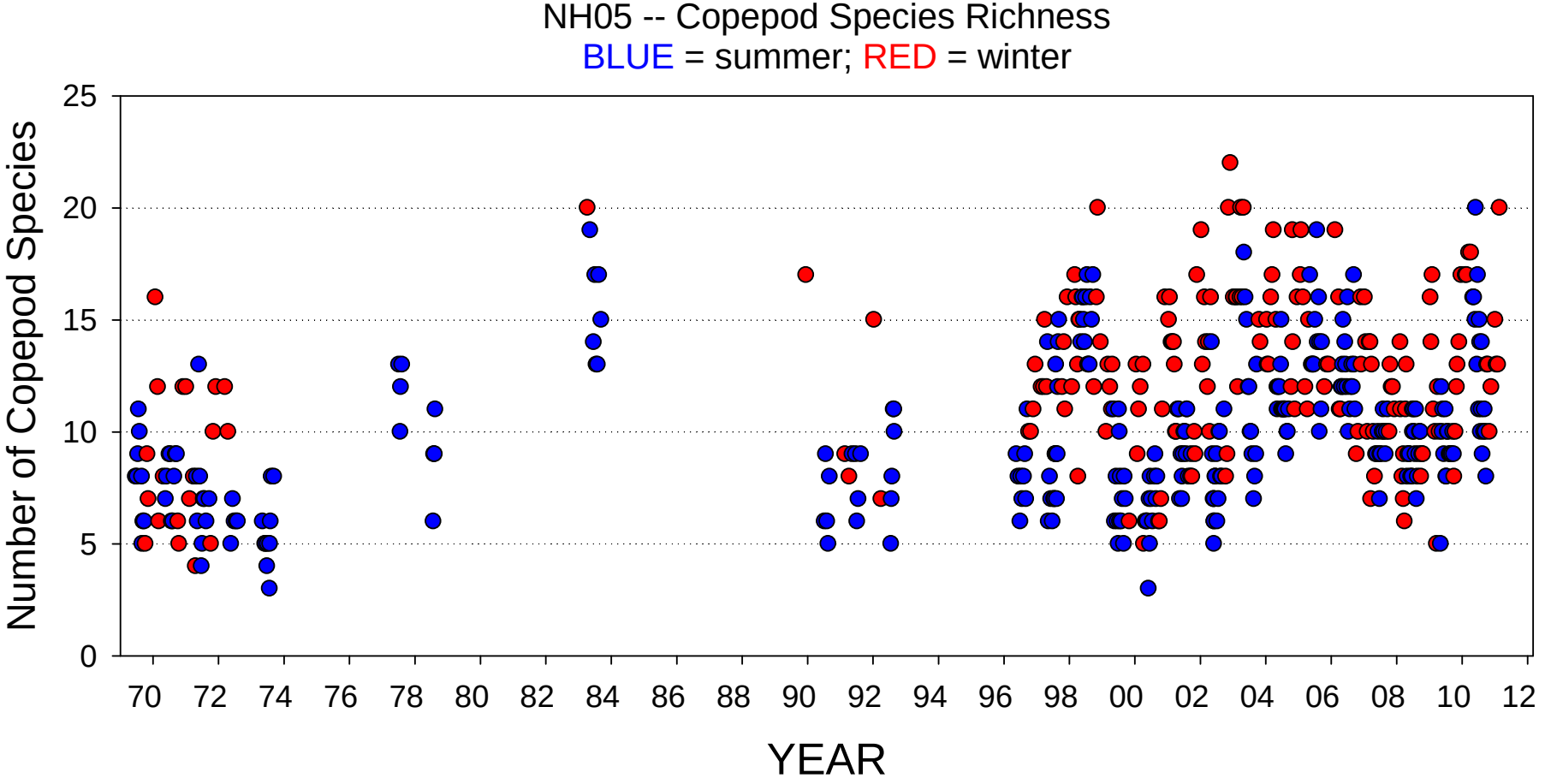
Temperature differences usually ± 1° C

PDO, MEI and Copepod Species Richness



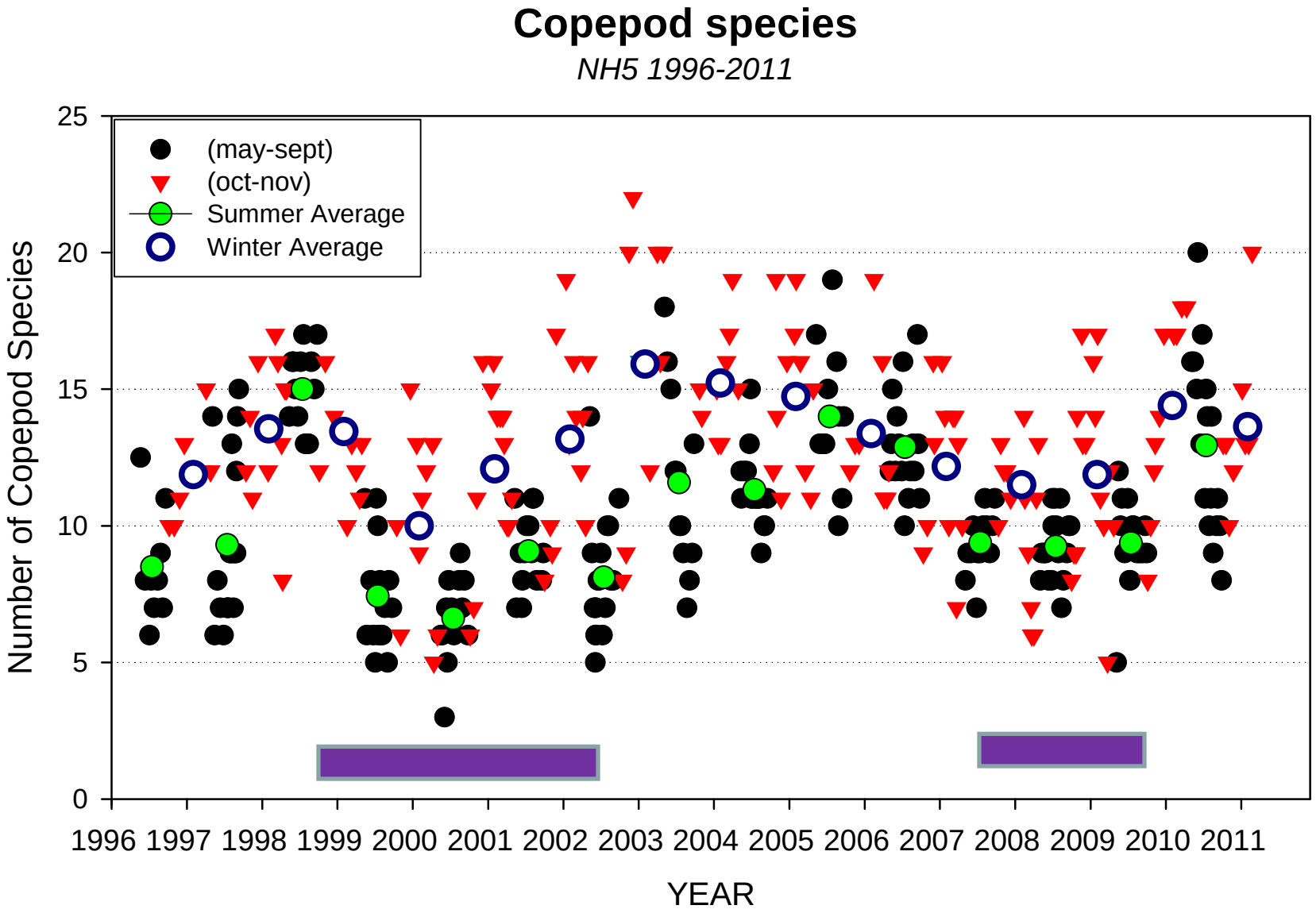
- PDO not showing a strong "decadal" pattern since the regime shift of 1999
- Higher species richness associated with warm phase of PDO and vice versa

COPEPOD BIODIVERSITY

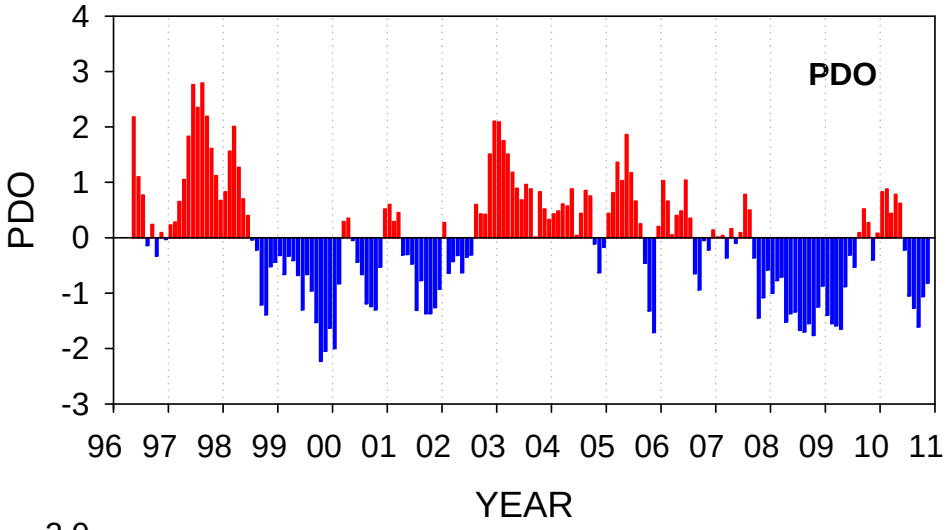


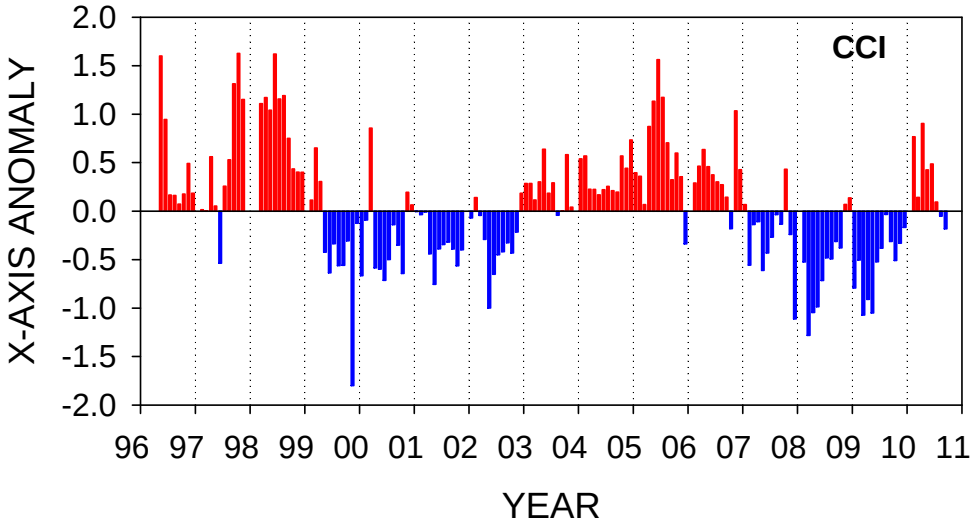
- Increased species richness since 1969; rate is 3.3 spp (summer) and 5.3 (winter) over 40 years
- SST = 0.31 deg C in 40 years; global SST = 0.72; Line P = 0.76 in 40 years
- Deep T at mid shelf is 0.43 in 40 years (summer) but – 0.011 in 14 years

Increased species richness trend only seen using historical data



PDO and zooplankton: copepod community composition





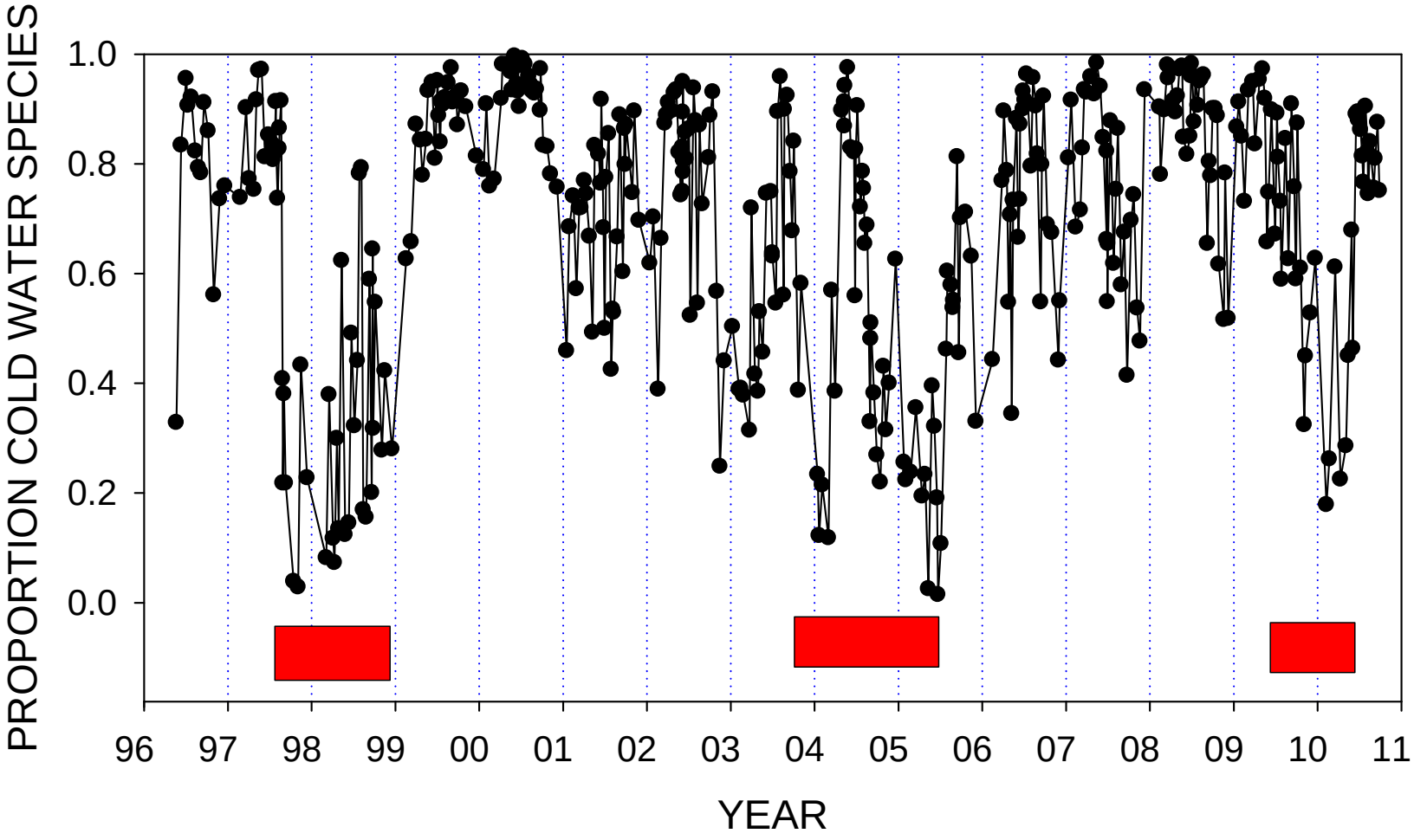
As I said earlier, the sign of the PDO is associated with either warm or cold water being advected to the coast

As a consequence you get "warm" and "cold" water zooplankton communities in coastal waters in association with positive or negative phase of the PDO, but with a few months lag.

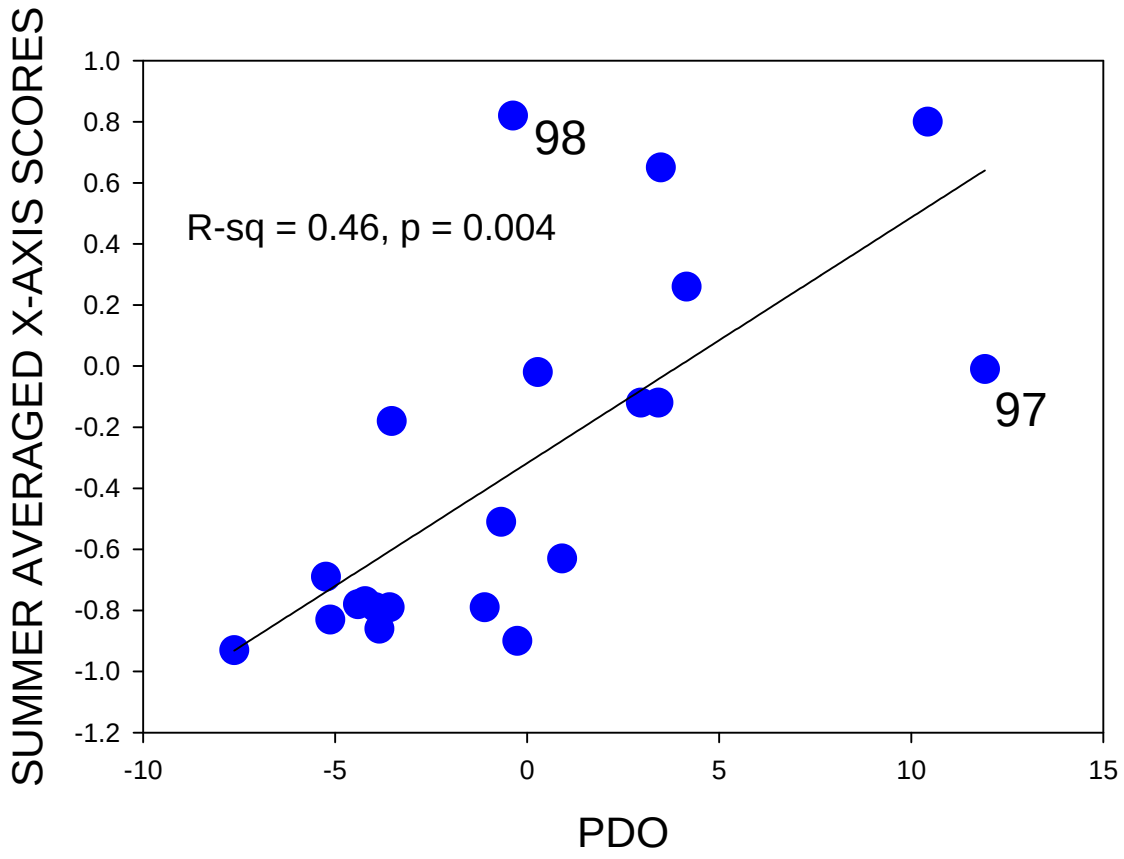
Warm water community

Cold water community

Proportion of cold water species since 1996 (*Pseudocalanus*, *Calanus marshallae* and *Acartia longiremis*



Summer-averaged PDO vs summer averaged X-axis scores: 1969-1973, 1983, 1996-2010 (n = 21 years)



4 CLUSTERS	ALL												
Sample Date	1	5	10	15	20	25	35	45	55	65	85	100	125
Jan 98	1	1	1	1		1		1		1			
Apr 98	1	1	1	1	1	1		1		1			
Jun 98	1	35	1	1		1		1		1			
Aug 98	35	35	35	1	1	1		1		1			
Sep 98	35	35	1	1	1	1		1		1			
Nov 98	35	35	1	1		1		1		1			
Feb 99		1	1	1		1							
Apr 99	1	1	1	1		1		1		1			
Jul 99	54	54	65	65		65		1		1			
Sep 99	54	65	65	65	65	65		1		65			
Feb 00		1	1		1	1		1		1			
Apr 00	1	1	1	65	1	1		1		1			
Jul 00	65	65	65	65	65	65	65	65					
Aug 00	54	65	65	65	65	65	65	65					
Sep 00	54	54	54	65	65	65	65	65		65			
Jan 01	1	1	1	1	1	1	1	1		1			
Jul 01	54	54	54	65	65	65	1	1		1			
Sep 01	54	65	65	54	54	65	65	1		1			
Feb 02	35	1	1	1	1	1	1	1		1			
Apr 02	35	35	65	65	1	1	1	1		1			
May 02		65	65	65	65	65	65	1		1			
Jul 02	54	54	54	65	65	65	65	65		1			
Jul_Aug 02	54	54	65	65	65	65	65	65	65	65			
Aug 02	54	54	65	65	65	65	65	65					
Sep 02		65	65	65	65	65	65	65		65			
Dec 02	1	1	1	1	1	1	1	1		1			
Feb 03		1	1	1	1	1	1	1		1			
Apr 03	54	35	1	1	1	1	1	1		1			
Jul 03	54	54	35	35	35	35	35	1		1			
Sep 03	54	54	54	65	65	65	1	1		1			
May 04	54	35	35		1	1	1	1		1			
Jun 04	54	54	35	35	35	35	35	1		1			
Aug 04	54	54	54	65	65	65	65	1		1			
May 05		1	1		1	1	1	1		1			
Aug 05		35	35	35	35	35	35	1		1			
May 06		35	35	1	1	1	1	1		1			
Mar 07		1	1	1	1	1		1		1	1	1	1
Apr 07		1	1	1	1	1		1		1	1	1	1
May 08		54	65	65	65	65	65			65			
Jul 08	54	54	65	65	65	65	65	65	65	65			
Aug 09	54	65	65	65	65	65	65	65		65			

1 = **PURPLE** = OFFSHORE, WARM
35 = **ORANGE** = SHELF, WARM
54 = **BLUE** = SHELF, COLD
65 = **GREEN** = OFFSHORE, COLD

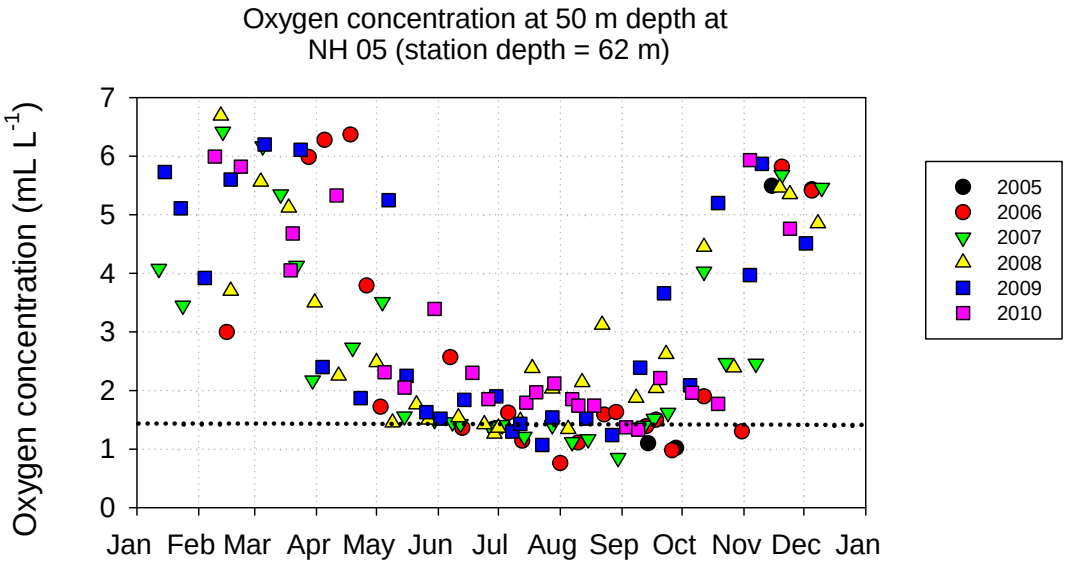
98 = El Niño
99-02 = Negative PDO
03-07 = Positive PDO
08-09 = Negative PDO

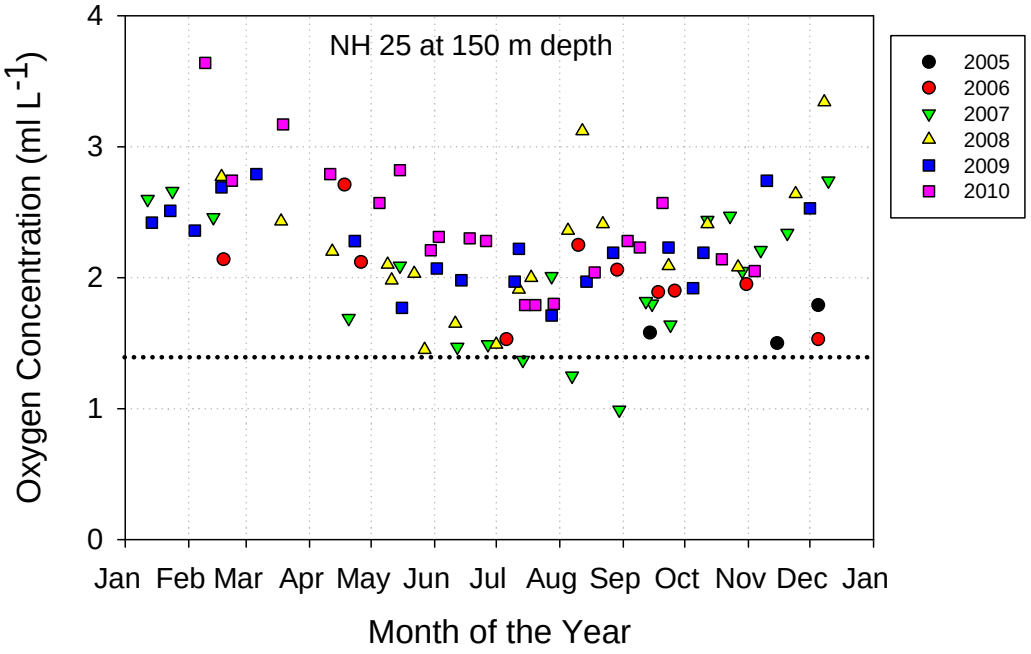
Expect “purple” during winter due to downwelling and during summer during “warm ocean conditions”

4 CLUSTERS	Stn	SUMMER								
Sample Date	1	5	10	15	20	25	35	45	55	65
Jun 98	1	2	1	1		1		1		1
Aug 98	44	2	2	1	1	1		1		1
Sep 98	2	2	1	1	1	1		1		1
Jul 99	28	28	28	28		28		1		1
Sep 99	28	28	28	28	28	28		1		44
Jul 00	28	28	28	28	28	28	28	44		
Aug 00	28	28	28	28	44	44	44	44		
Sep 00	28	28	28	28	44	44	44	44		44
Jul 01	28	28	28	28	28	28	1	1		1
Sep 01	28	28	28	28	28	44	44	44		1
Jul 02	28	28	28	28	28	28	28	44		44
Jul_Aug 02	28	28	28	28	28	28	44	44	44	44
Aug 02	28	28	28	44	28	28	44	44		
Sep 02		28	28	28	28	44	44	44		44
Jul 03	2	2	2	2	2	2	2	1		1
Sep 03	28	2	2	44	44	44	1	1		1
Jun 04	2	2	2	2	2	2	2	1		1
Aug 04	2	2	2	44	44	44	44	1		1
Aug 05		2	2	2	2	2	2	1		1
Jul 08	28	28	28	28	28	28	28	28	44	44
Aug 09	28	28	28	28	44	44	44	44		44

WARM OFFSHORE = 1
WARM SHELF = 2
COLD SHELF = 28
COLD OFFSHORE = 44

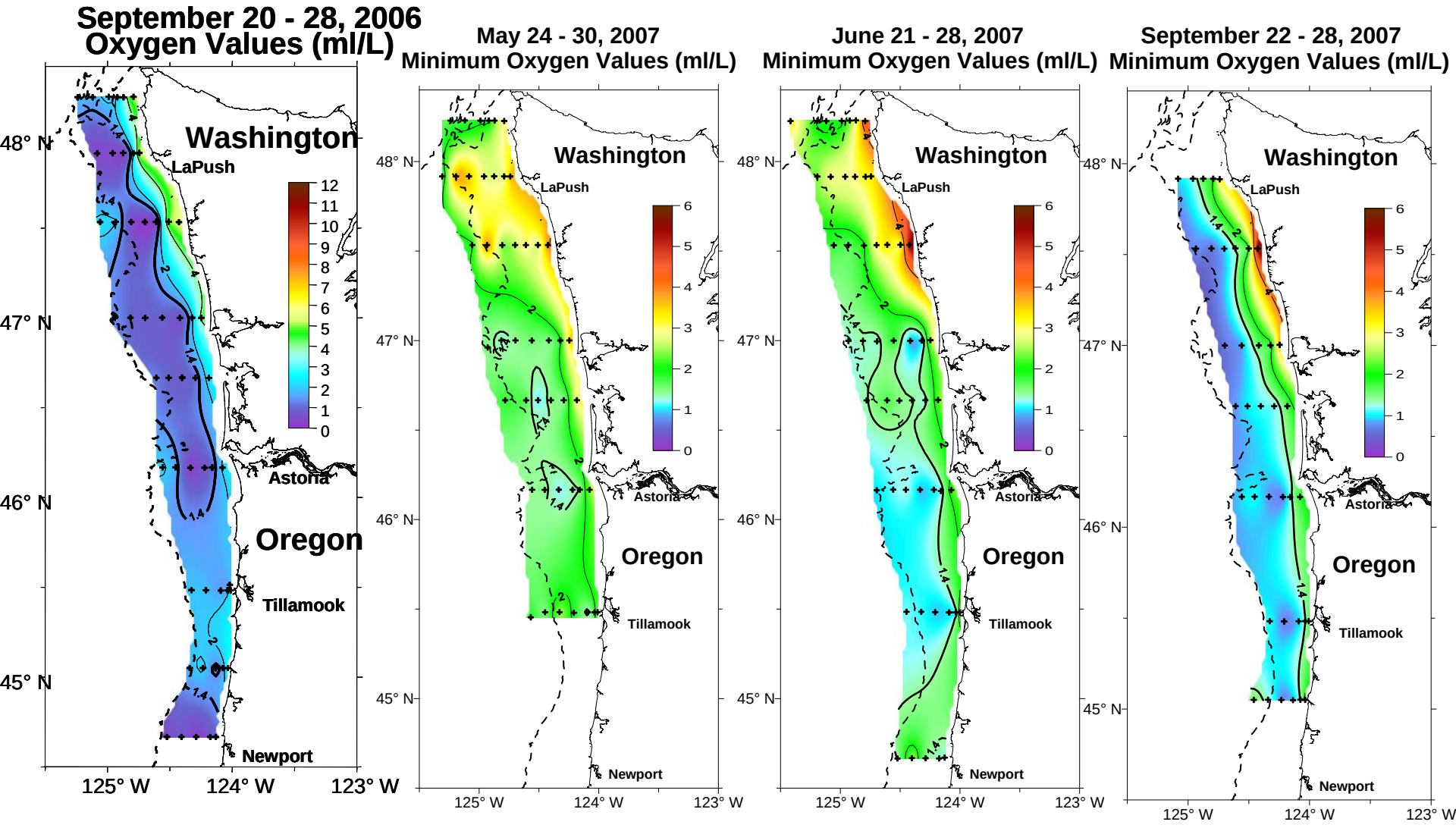
Oxygen concentrations at NH-05 and NH 25





Area of hypoxia during summer 2006 equaled that of the Gulf of Mexico

Hypoxia off WA and OR
May, June, Sept 2007



Papers of potential interest

Hooff and Peterson 2006, Limnol. Oceanogr.

Peterson 2009 CalCOFI Reports 50:73-81

Keister et al. (in press) Global Change Biology

Bi, Peterson, Strub (in review) Geophys Res Lett