Climate change in the northern California Current ecosystem: impacts on the community composition and production of zooplankton

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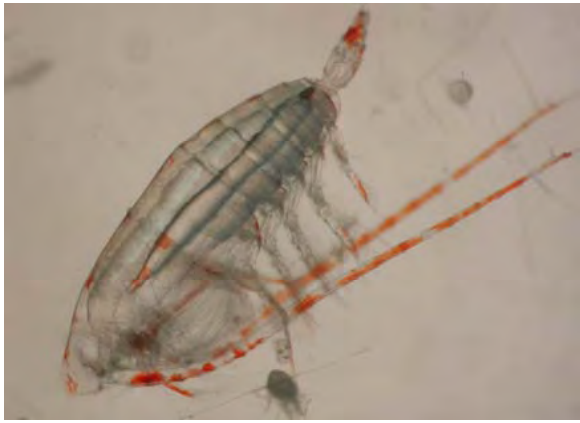
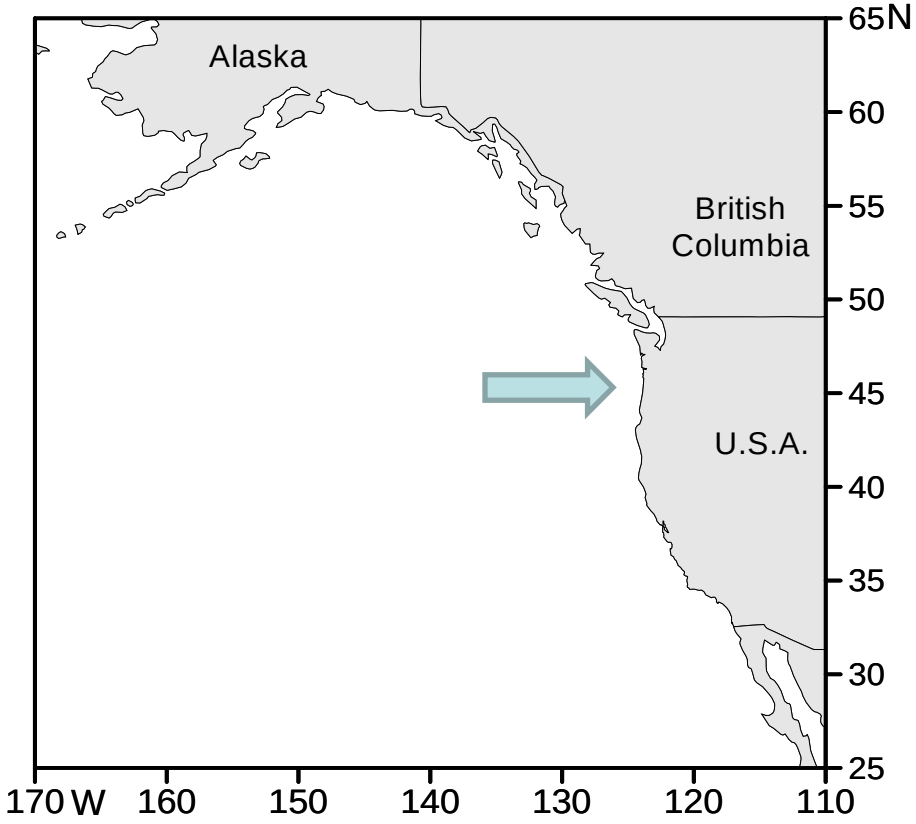


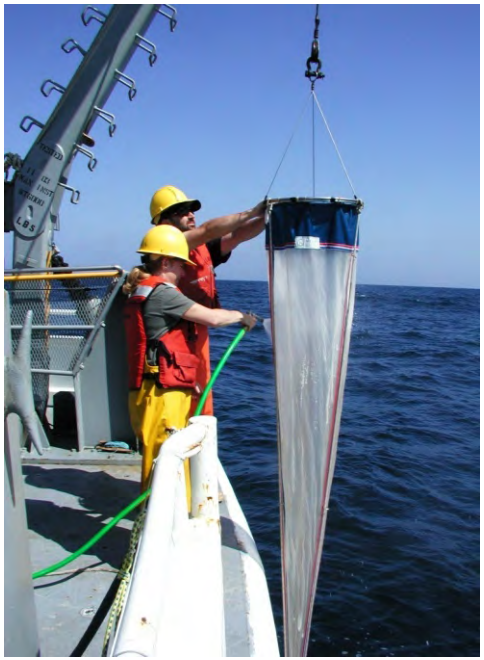
Newport Hydrographic Line

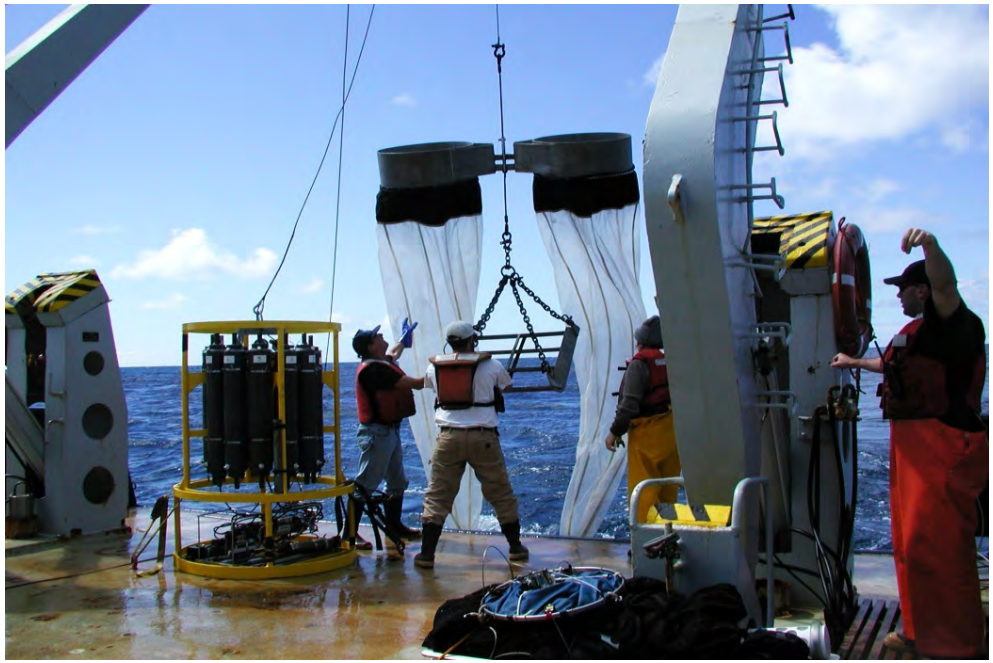


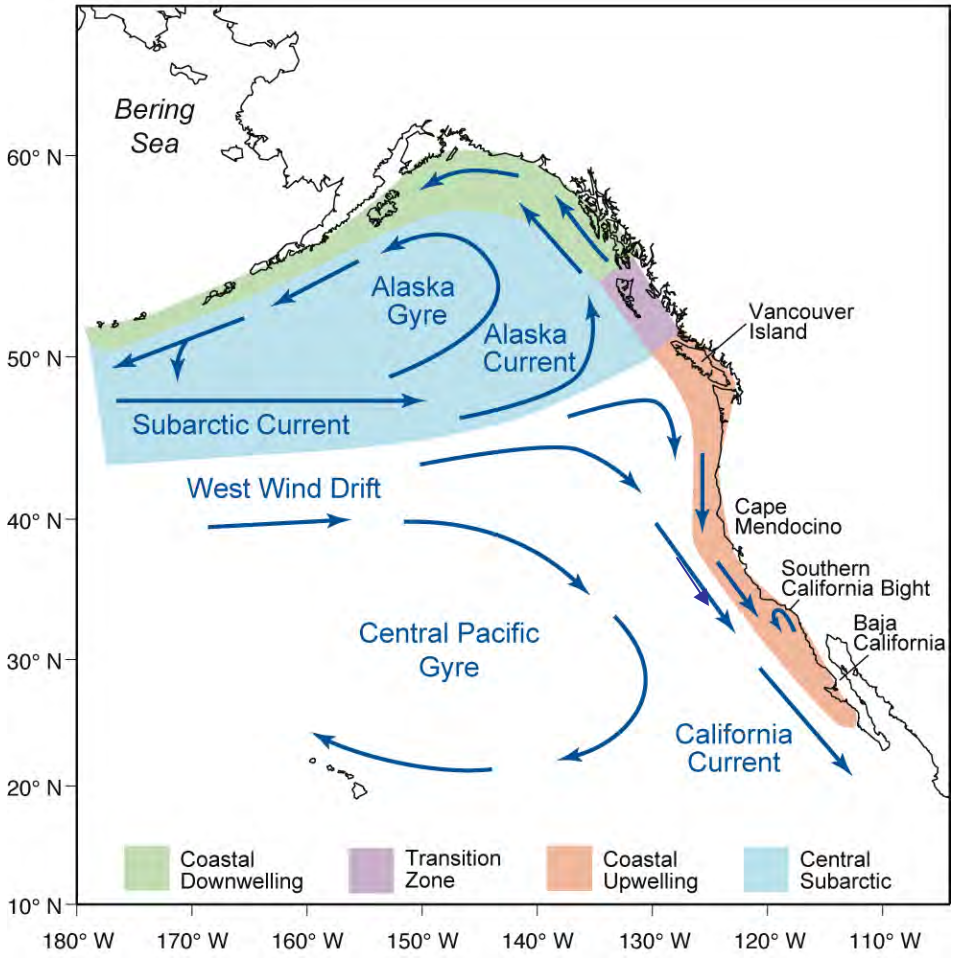
- Sampled biweekly 1996-present; 7 stations across the continental shelf, from 2 to 40 km from shore (20 m to 300 m water depth)
- CTD, secchi disc, nutrients, chl-a, holo-, mero-, ichthyo-zooplankton, and euphausiids
- Today: data from a single stations, NH 05 (62 m water depth).

Methods and Outline

- 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 390 copepod samples collected at the station NH 05
- Use X-axis scores
- Compare to Upwelling and Pacific Decadal Oscillation







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.

Climate-driven changes in circulation will affect the kinds of zooplankton species that are transported to the California Current

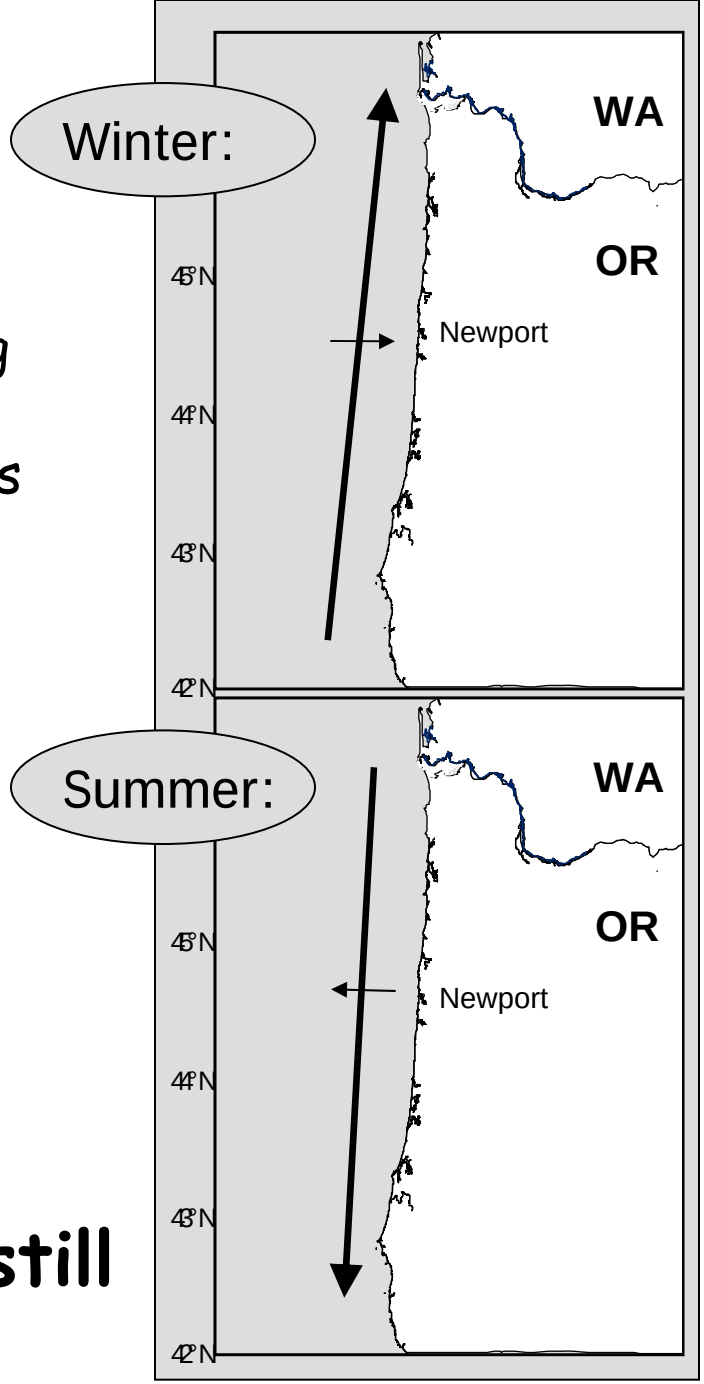
Winds and current structure off coastal Oregon:

- **Winter**:
  - Winds from the South causes downwelling
  - Poleward-flowing Davidson Current
  - Subtropical and southern plankton species transported northward & onshore

- **Spring Transition in April/May**

- **Summer**:
  - Strong winds from the north causes coastal upwelling
  - Alongshore transport is equatorward
  - Boreal/northern species transported southward

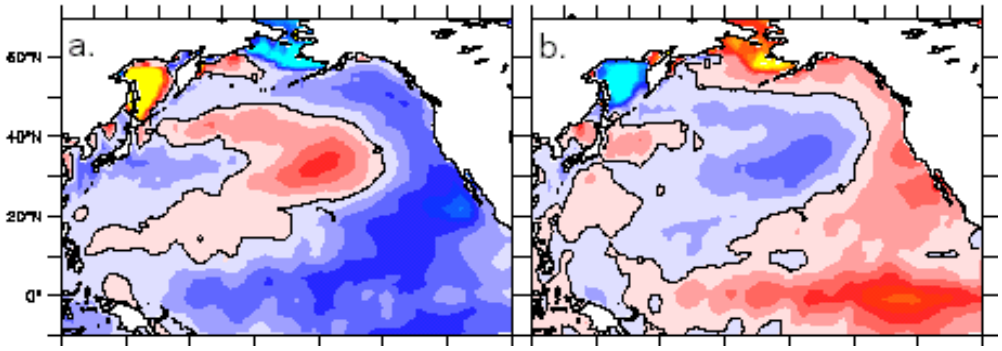
Climate change may result in greater or lesser upwelling – still being debated



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.

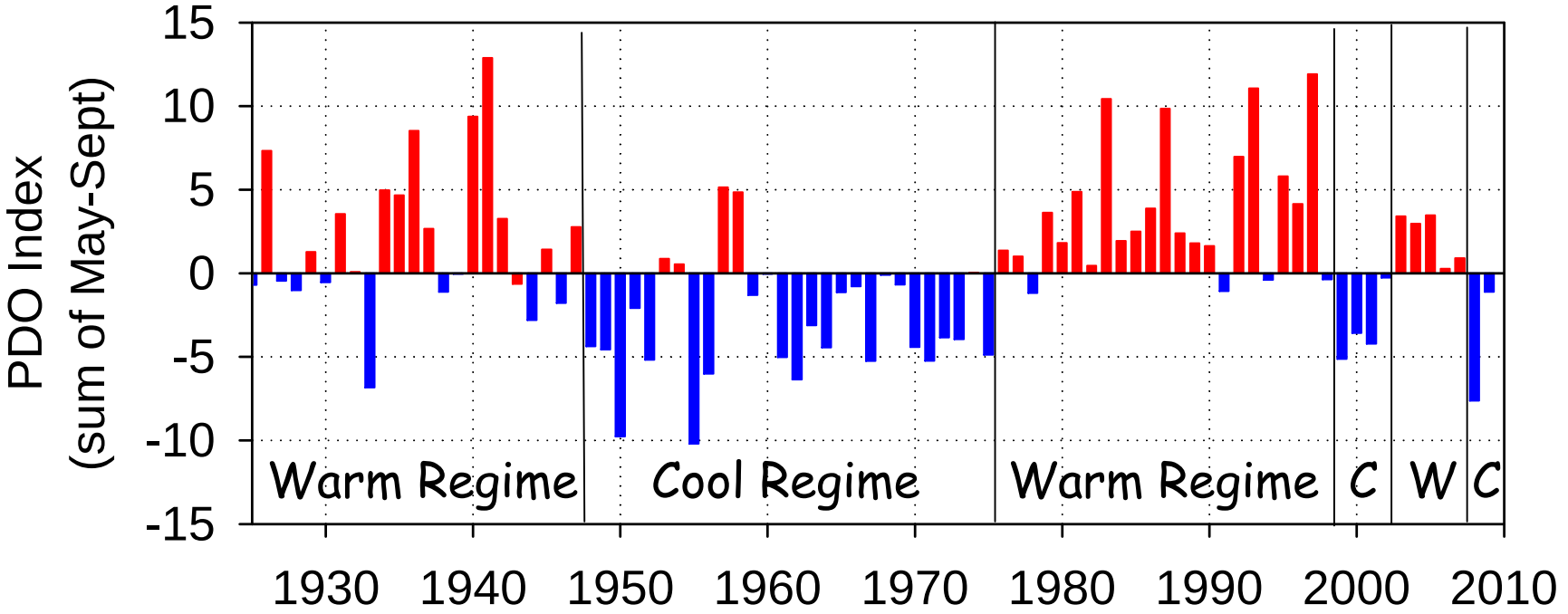
The SST anomaly patterns shown on the right results from basin scale winds: W'ly and NW'ly [negative phase] and SW'ly [positive phase]

PDO & SST



Blue is anomalously cold
Red is anomalously warm

PDO: May-Sep Average, 1925-2010

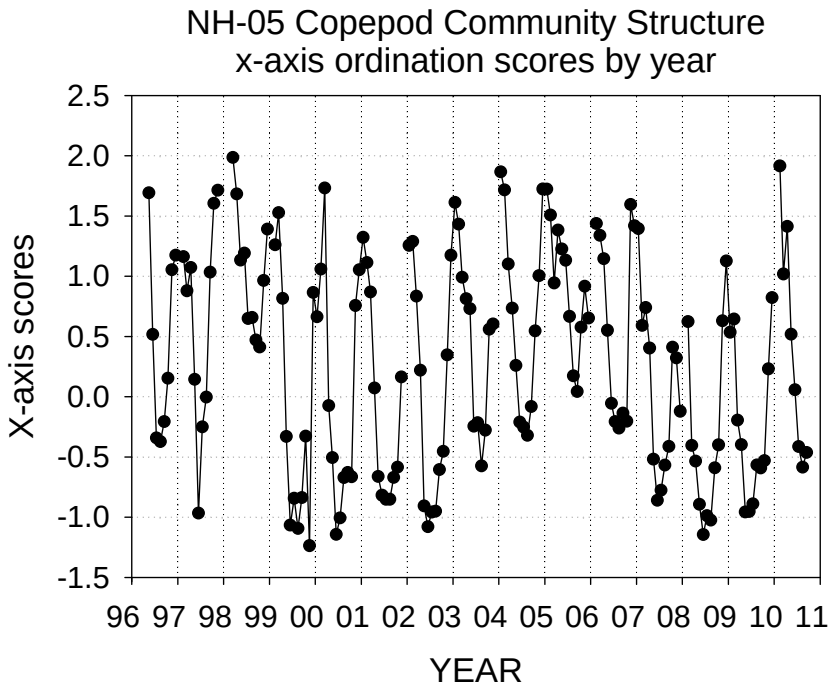


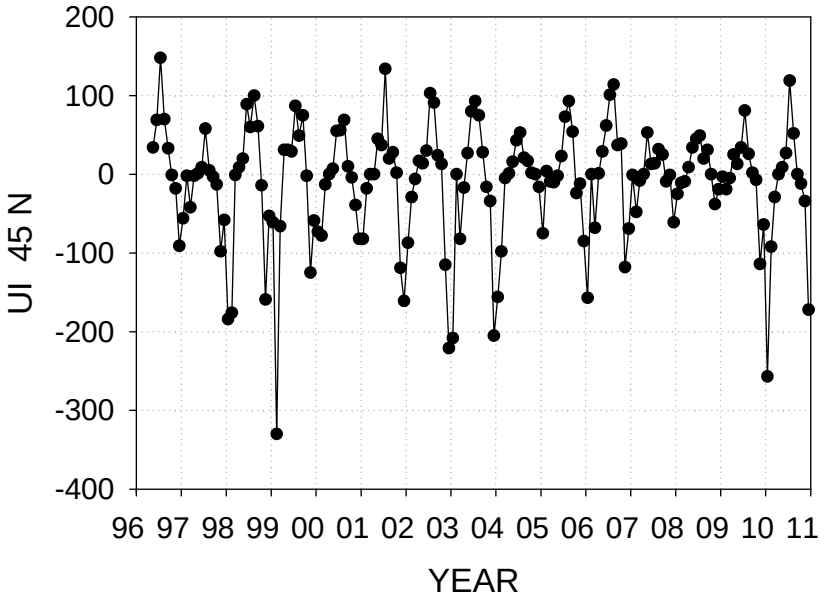
- From 1925-1998, PDO shifted every 20-30 years. Some refer to these as "salmon" regimes (cool) and "sardine" regimes (warm).
- However, we have had two shifts of four years duration recently: 1999-2002 and 2003-2006, and another shift in late 2007, thus *we have a natural experiment to test the affects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

Seasonal Cycles in Copepod Community Composition

Strong seasonality due to the seasonal cycle of upwelling and seasonal cycle of coastal currents

1. Cold water (and a cold water copepood community) in summer
2. Warm water (and a warm water copepod community) in winter


NH-05 Copepod Community Structure
x-axis ordination scores by year
X-axis scores
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11
YEAR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0
-100
-200
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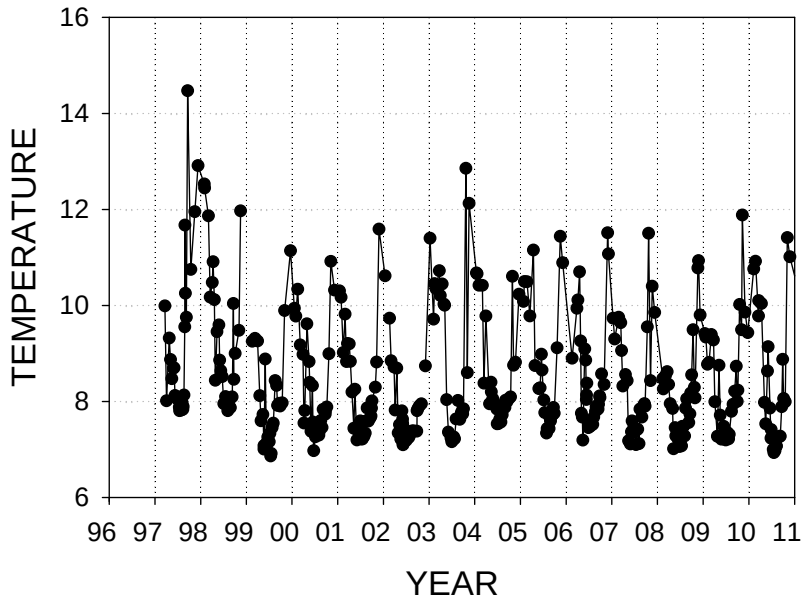
-400
96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11
YEAR


TEMPERATURE
16
14
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8
6
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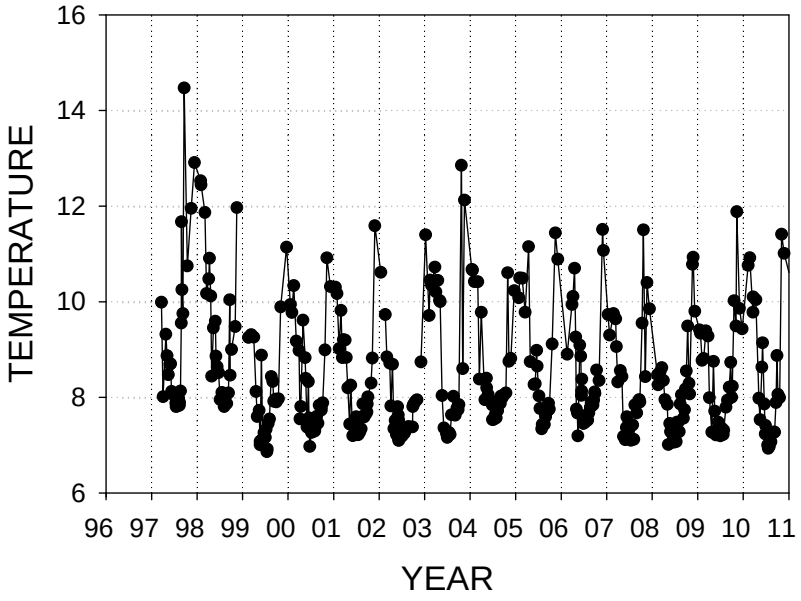
YEAR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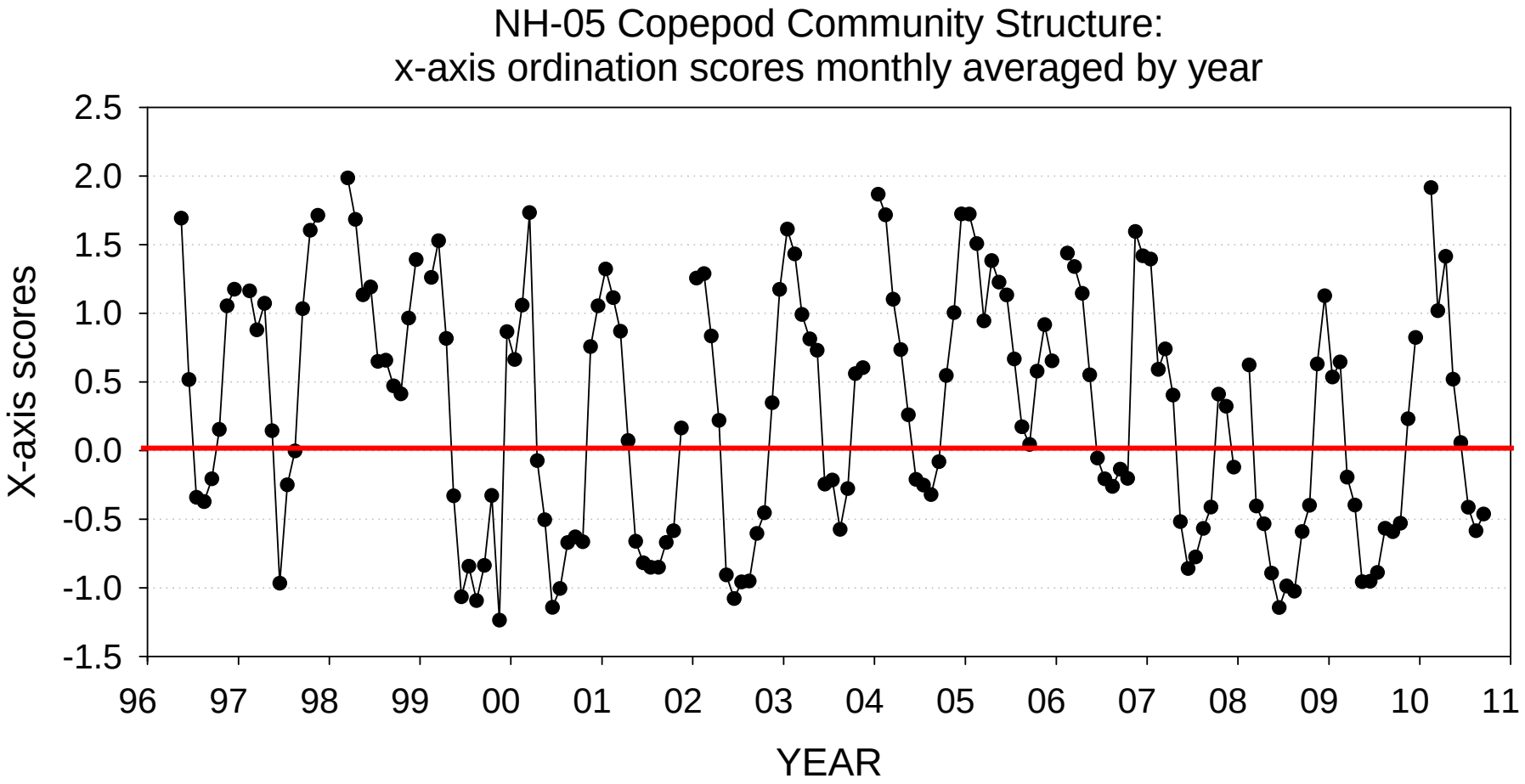
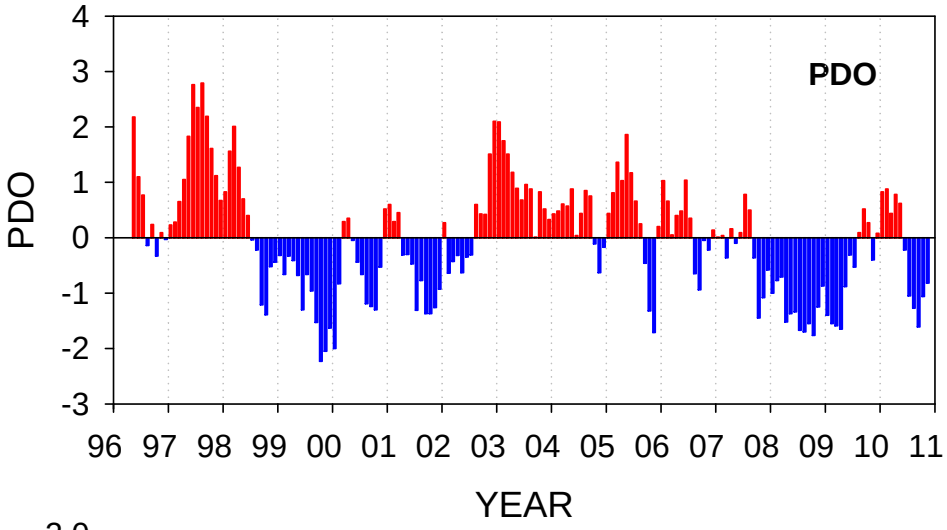
Interannual Variability in Community Structure

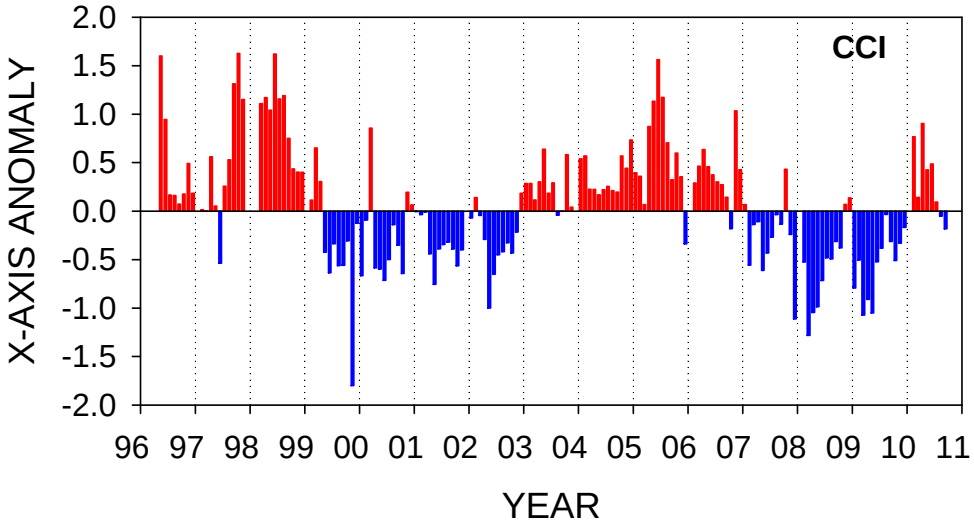


Positive scores = warm water community; usually in winter
Negative scores = cold water community; usually in summer

“Decadal” Cycles in Copepod Community Composition

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

Contrasting Communities

- **Negative PDO = "cold-water" copepod species.** These are dominants in Bering Sea, coastal GOA, coastal northern California Current
  - *Pseudocalanus mimus, Calanus marshallae, Acartia longiremis*
- **Positive PDO = "warm-water" copepods.** These are common in the Southern California Current neritic and offshore NCC waters
  - *Clausocalanus spp., Ctenocalanus vanus, Paracalanus parvus, Mesocalanus tenuicornis, Calocalanus styliremis*

Based on Peterson and Keister (2003)

Comparisons in size and chemical composition

- **Warm-water taxa** - (from offshore OR) are **small** in size and have minimal high energy wax ester lipid depots

- **Cold-water taxa** – (boreal coastal species) are **large** and store high-energy **wax esters** as an over-wintering strategy

Therefore, significantly different food chains may result from climate shifts;

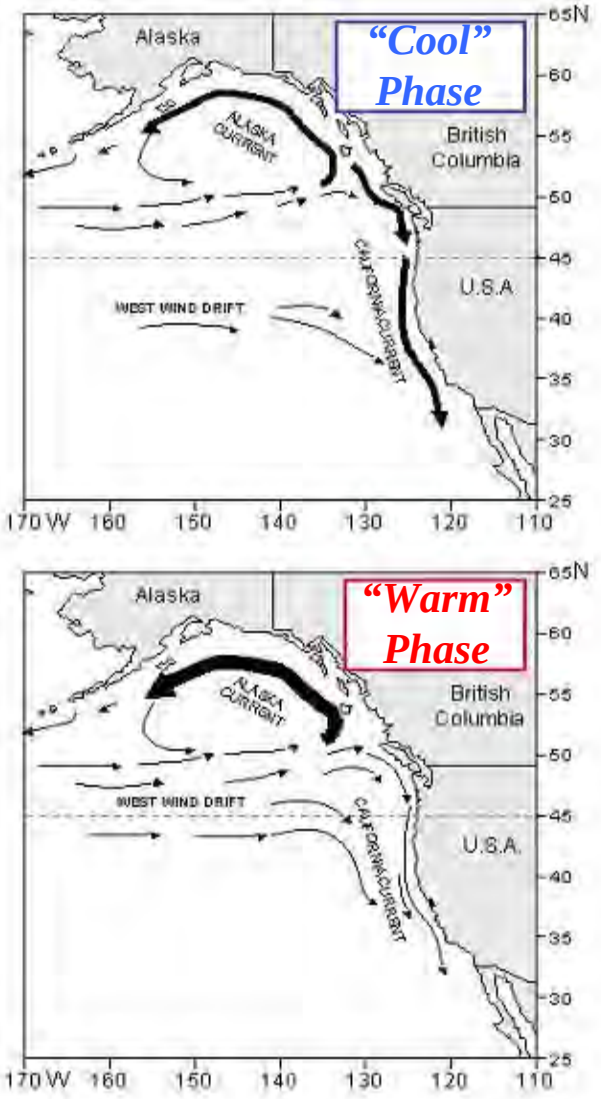
A working mechanistic hypothesis: source waters. . .

Cool Phase ➔

Transport of boreal coastal copepods into NCC from Gulf of Alaska

Warm Phase ➔

Transport of sub-tropical copepods into NCC from Transition Zone offshore



What problems lie ahead?

- Will coastal upwelling become weaker, stronger or stay the same?
- Will warming of the ocean lead to greater stratification thus reducing the effectiveness of coastal upwelling?
- Will the Pacific "Decadal" Oscillation return to "Decadal"?
- Will the central North Pacific Gyre expand northward and make the waters off Oregon more subtropical?
- Of great concern in coastal upwelling systems is the trend toward decreased oxygen concentration and of decreased pH in waters which upwell at the coast.

Acknowledgements

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- See www.nwfsc.noaa.gov, "Ocean Conditions and Salmon Forecasting"