Zooplankton species composition is linked to ocean transport in the Northern California Current

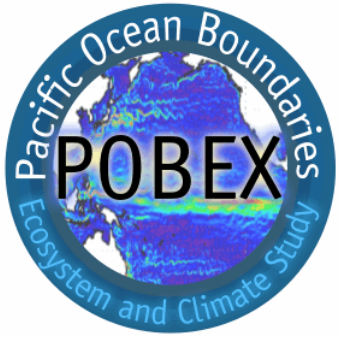
Julie Keister
University of Washington

Cheryl Morgan
Oregon State University

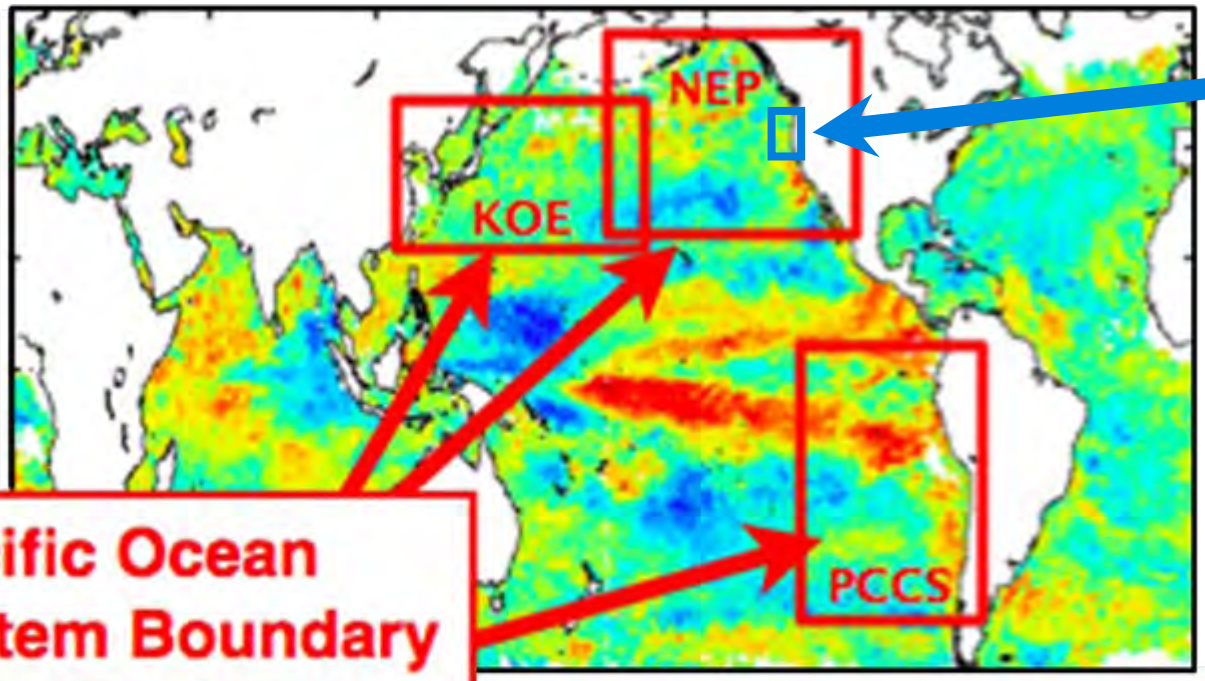
Bill Peterson
NOAA/NWFSC

Emanuele Di Lorenzo
Georgia Tech.

Neri Mariani
Vincent Combes
formerly of Georgia Tech.



U.S. GLOBEC:
Pacific Ocean Boundary Ecosystems and Climate



Regional domain

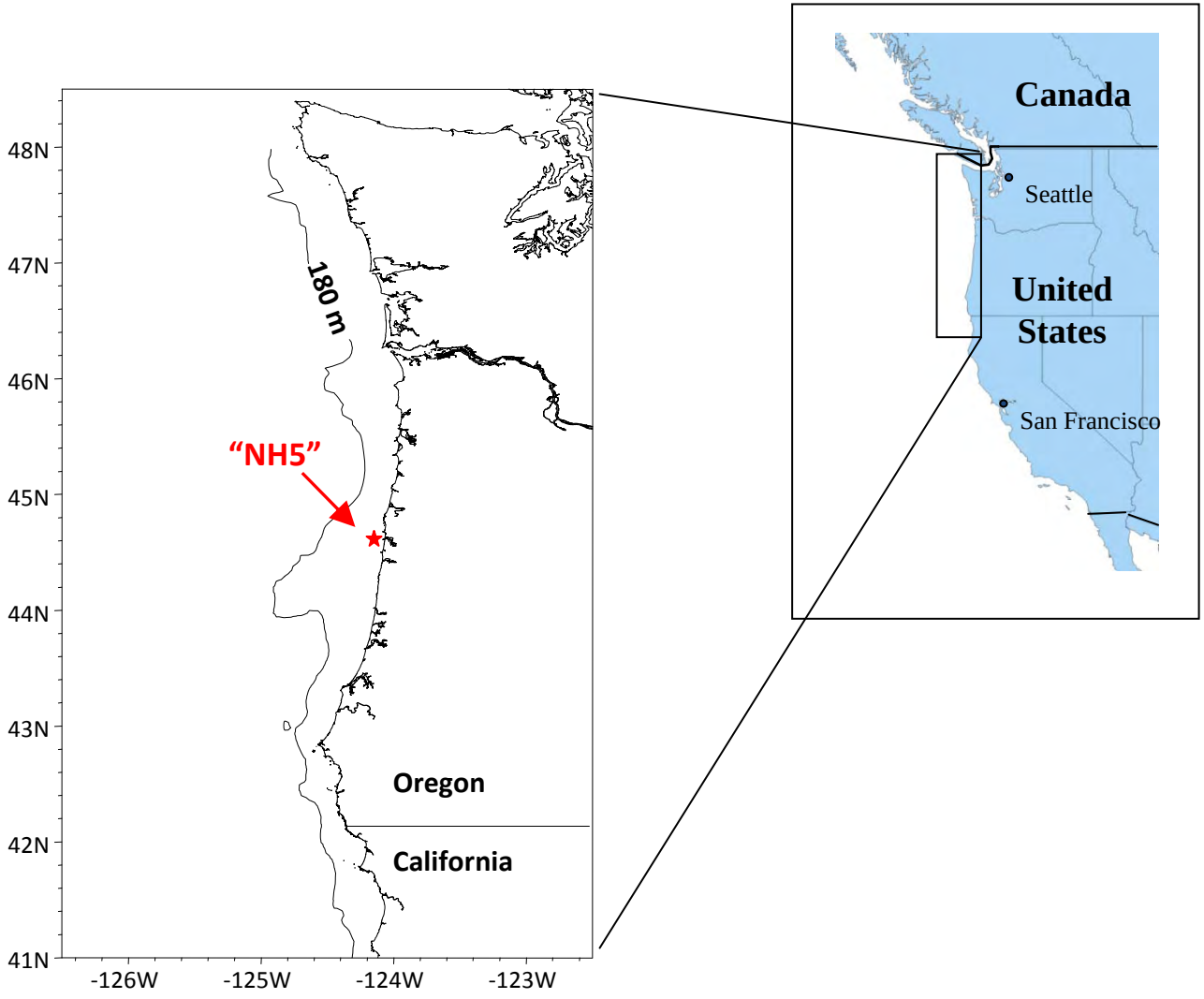
Pacific Ocean Ecosystem Boundary Study Regions

Objectives

- Assess to what extent, and by what mechanisms, large-scale climate modes drive changes across Pacific boundary ecosystems.

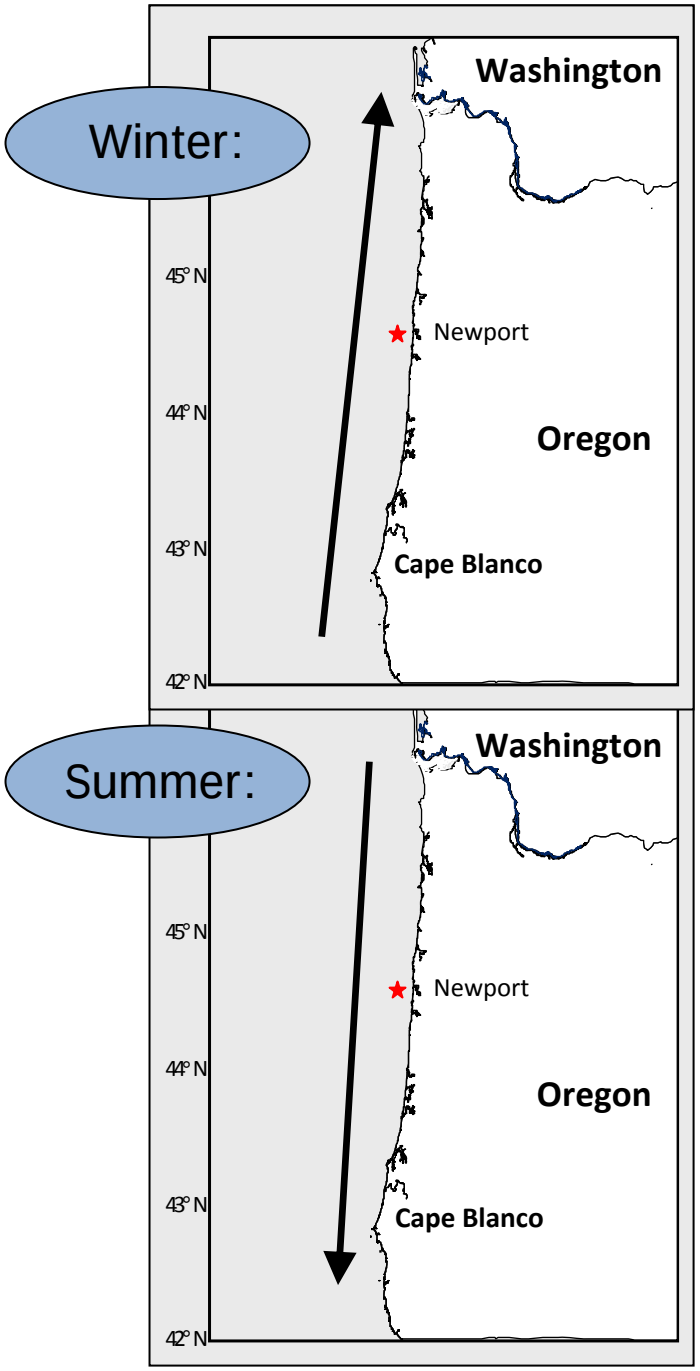
- Quantify and explain how changes in regional ocean processes (e.g. upwelling, mixing and mesoscale structure) at each boundary control phytoplankton and zooplankton dynamics.

Location of zooplankton time series data:



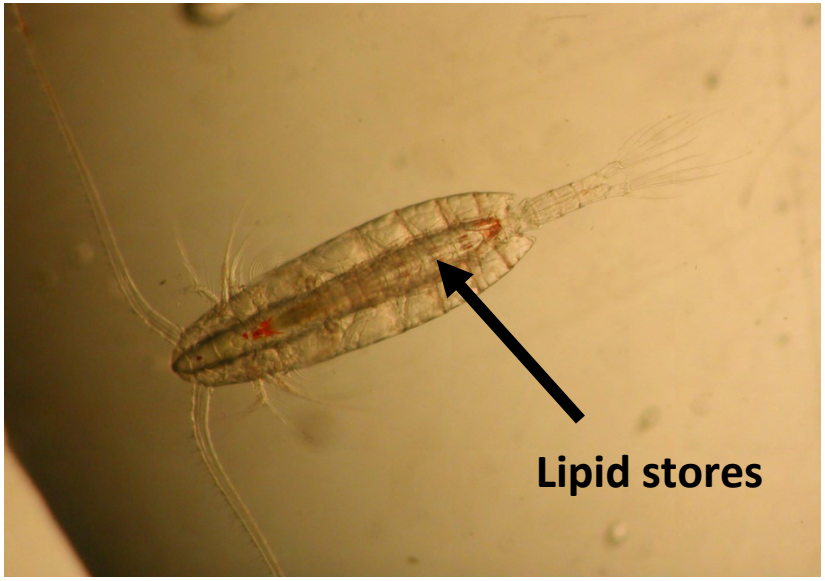
Seasonal upwelling

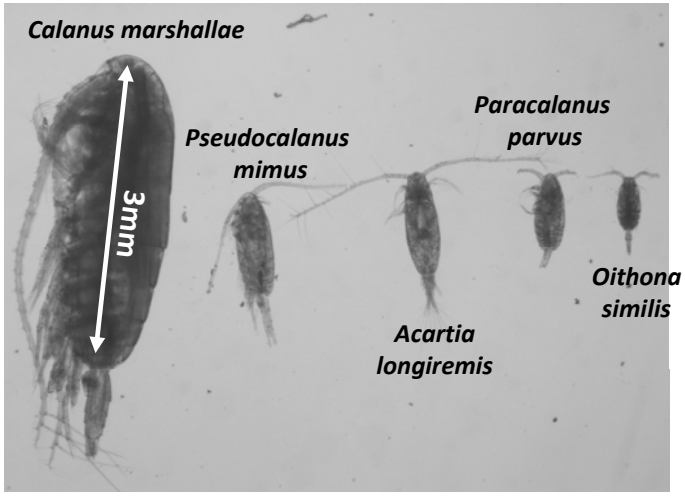
- Winter:
  - Poleward downwelling winds
  - Poleward alongshore currents
- Spring Transition
  - in March/April
- Summer:
  - Equatorward (upwelling) winds
  - Equatorward alongshore transport
- Fall Transition
  - in September/October



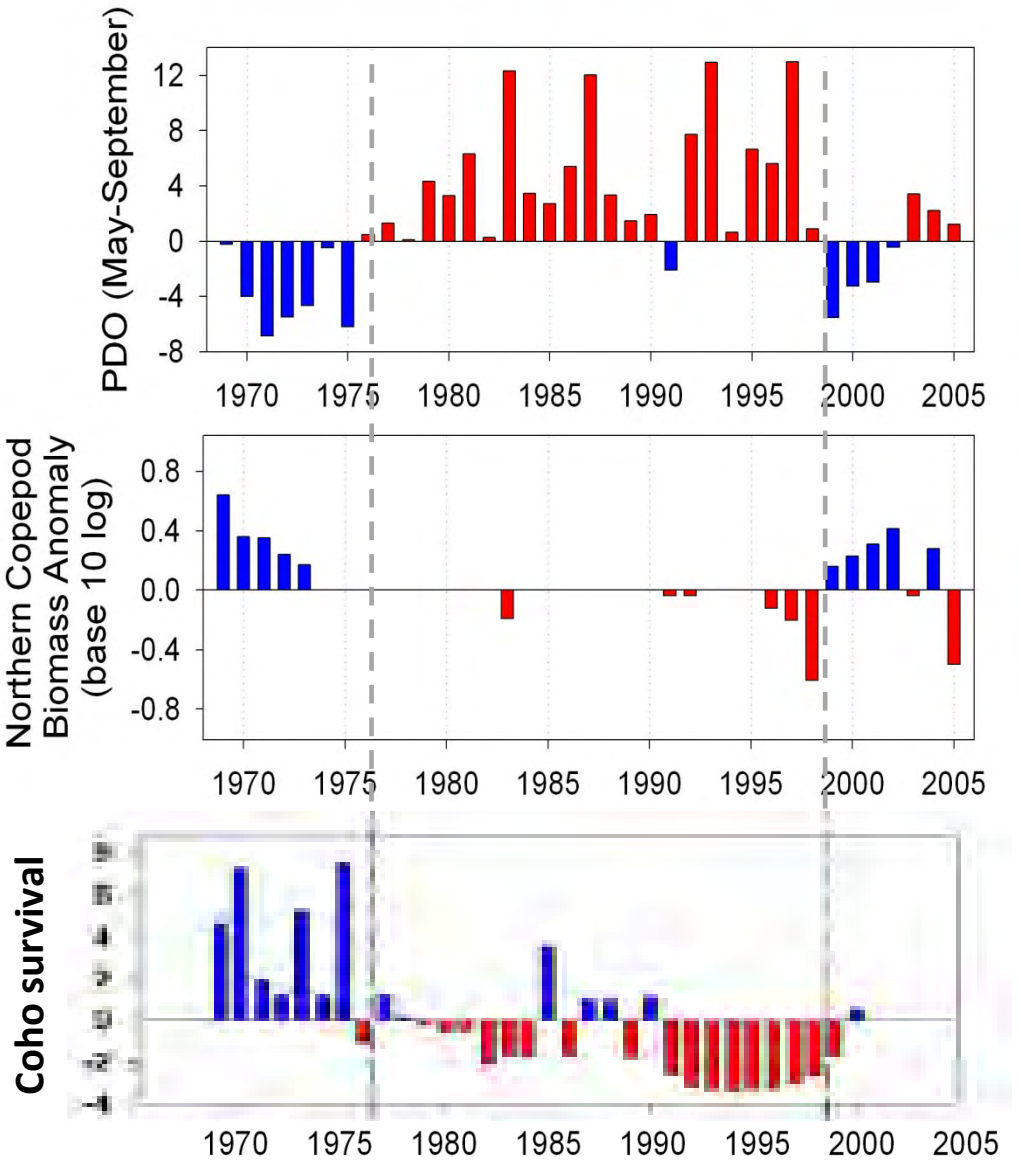
Not all copepods are created equal!

Higher lipid content in cold-water, northern species.





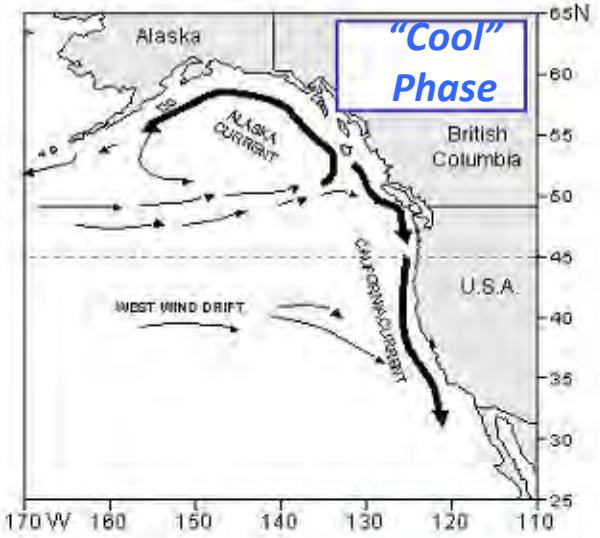
Large-scale climate indices relate to zooplankton and salmon survival:



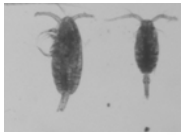
Based on Peterson and Schwing, 2003

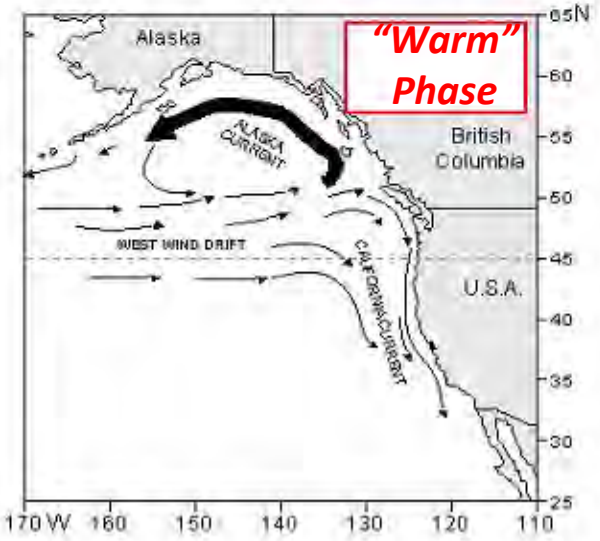
***A working mechanistic hypothesis*: source waters change:**

Transport of boreal coastal copepods into NCC



Transport of sub-tropical copepods into NCC





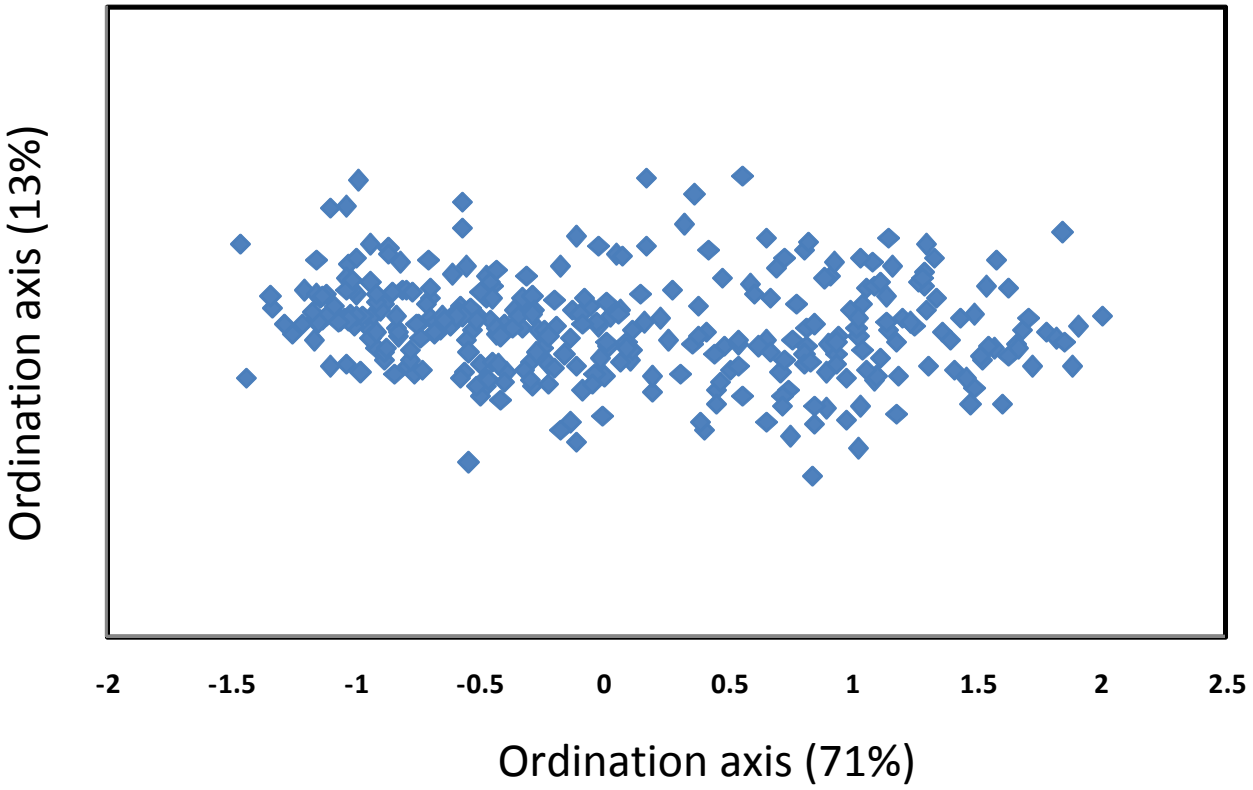
Zooplankton sampling since 1996:

- **Bi-weekly net tows:**
  Vertical tows from near bottom
  (½-m diameter, 202-µm mesh)

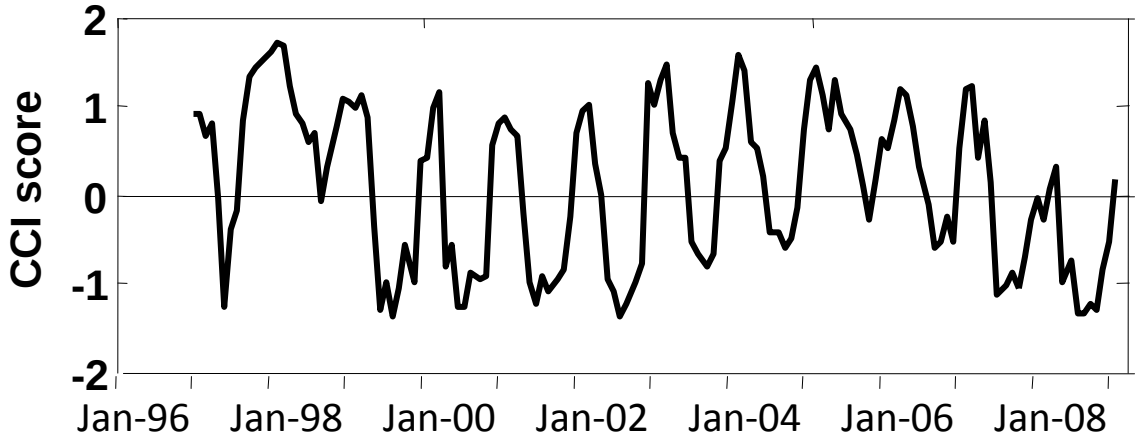
Laboratory/Statistical Methods:

- **Microscope identification of zooplankton to species**
- **Non-metric Multidimensional Scaling (NMS) ordination of copepods**
- **“Rigidly-rotated” variance to load on Axis 1**

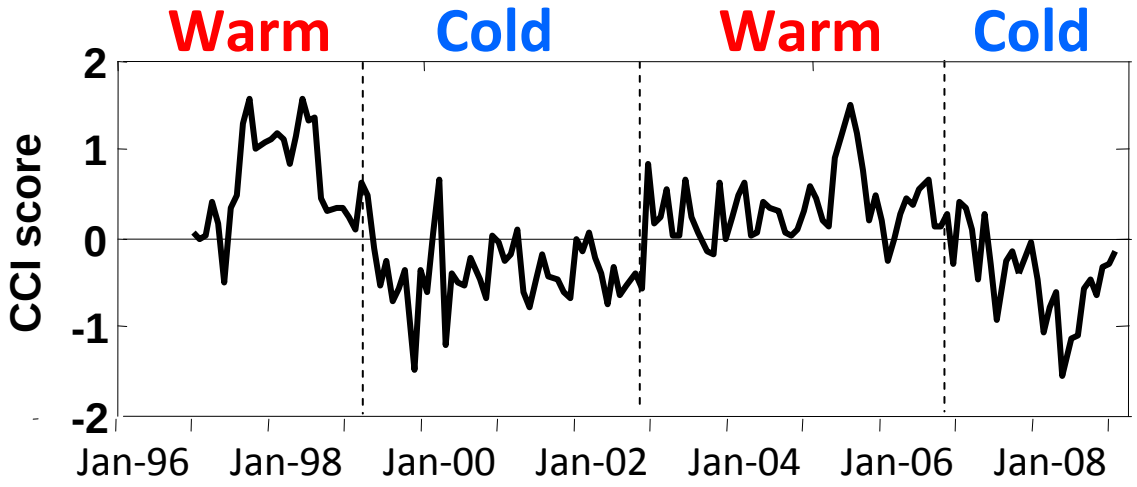
Ordination of zooplankton time series data



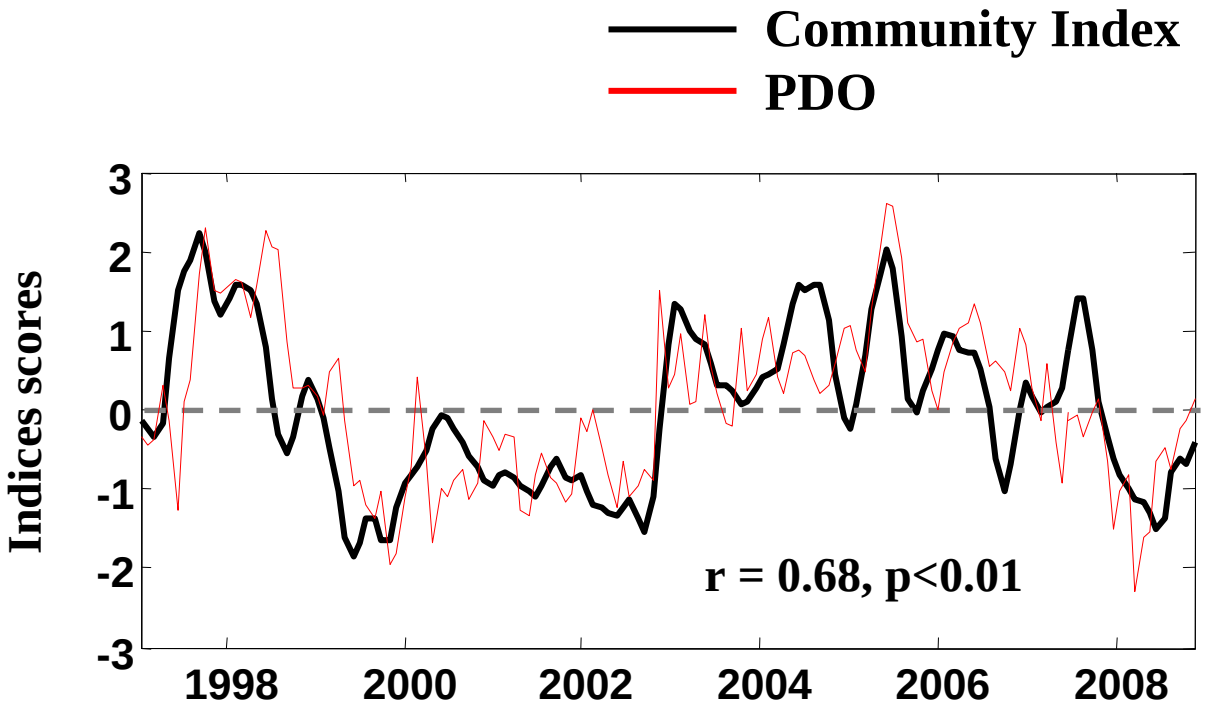
Time series of ordination scores = the “Copepod Community Index”



Non-seasonal anomalies of the Index



The **Copepod Community Index** tracks the **PDO**



The Model

ROMS model

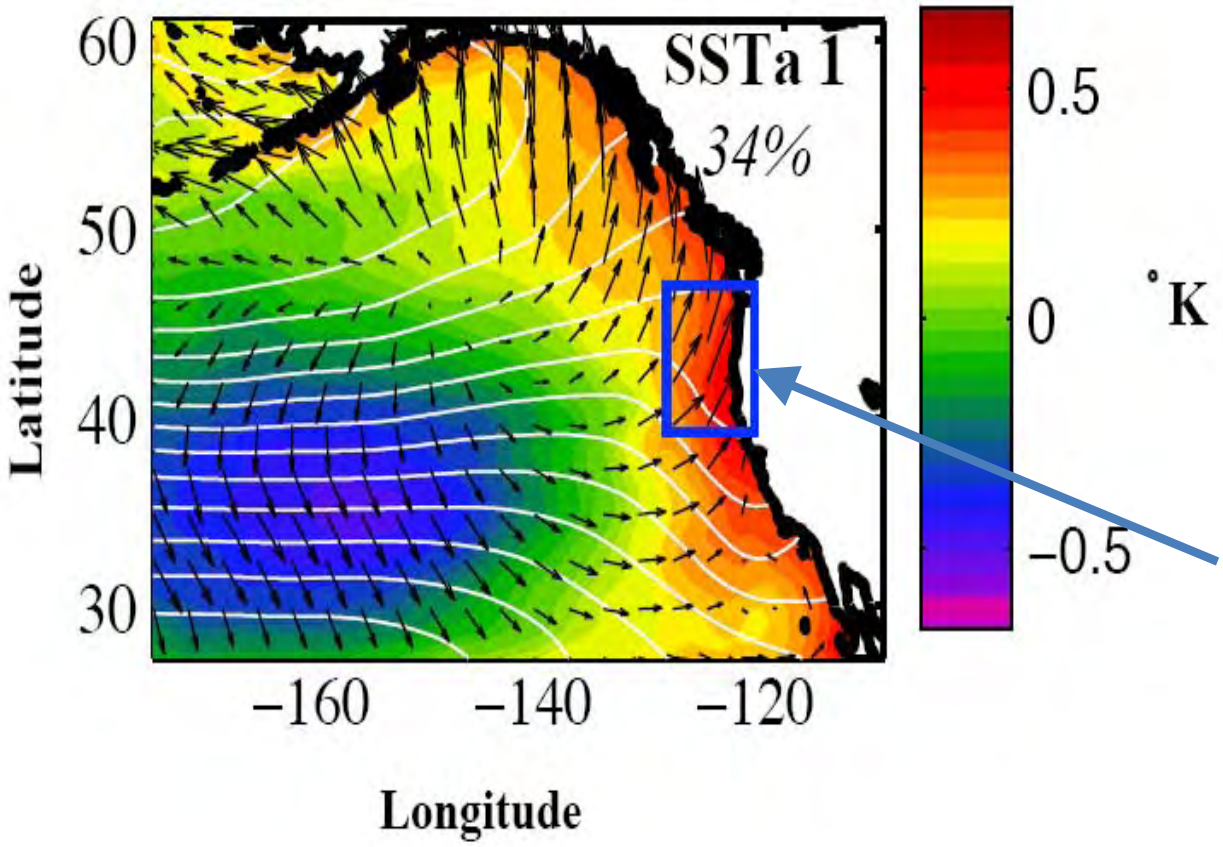
- 1950-2008
- Nested within the OFES model (global 10 km hindcast)
- 10 km resolution
- 30 vertical layers
- nudged at open boundaries
- forced by NCEP fluxes (winds and heat)

Passive tracers experiments to diagnose transport pathways.

Model representation of the Pacific Decadal Oscillation

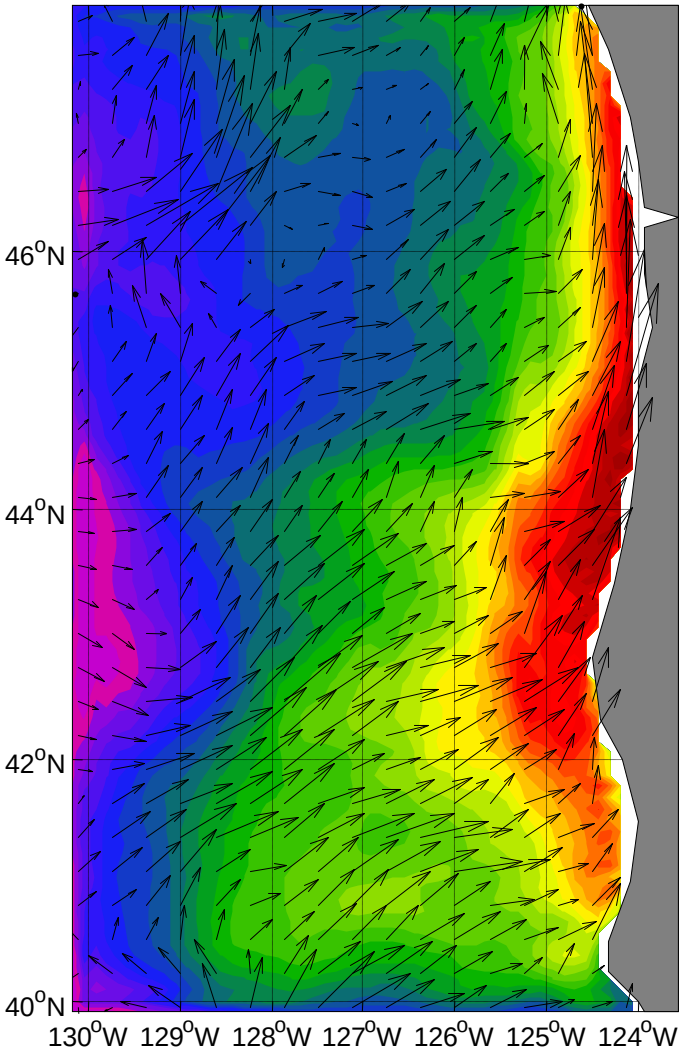
Positive (warm) phase

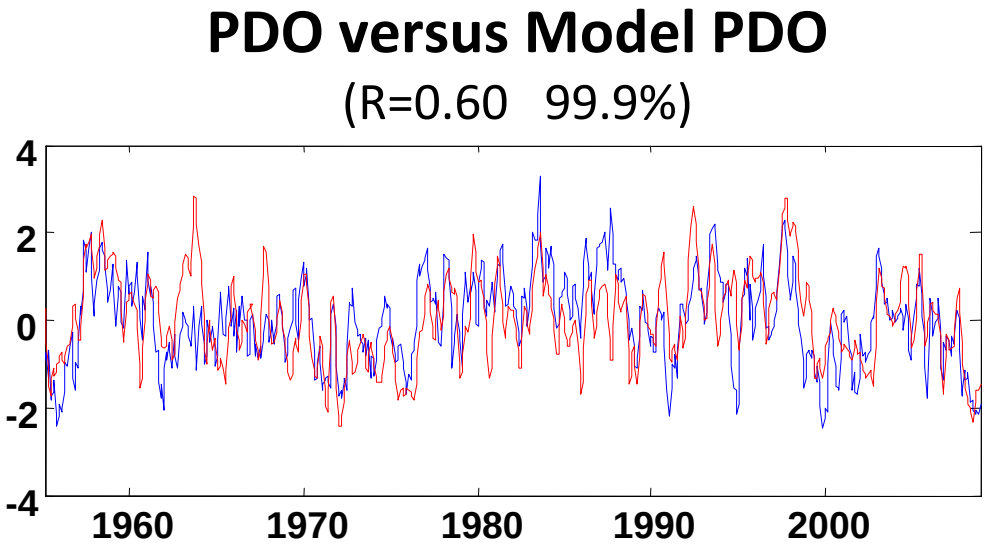
EOF of SST (color) and current anomalies (vectors) closely match the PDO pattern



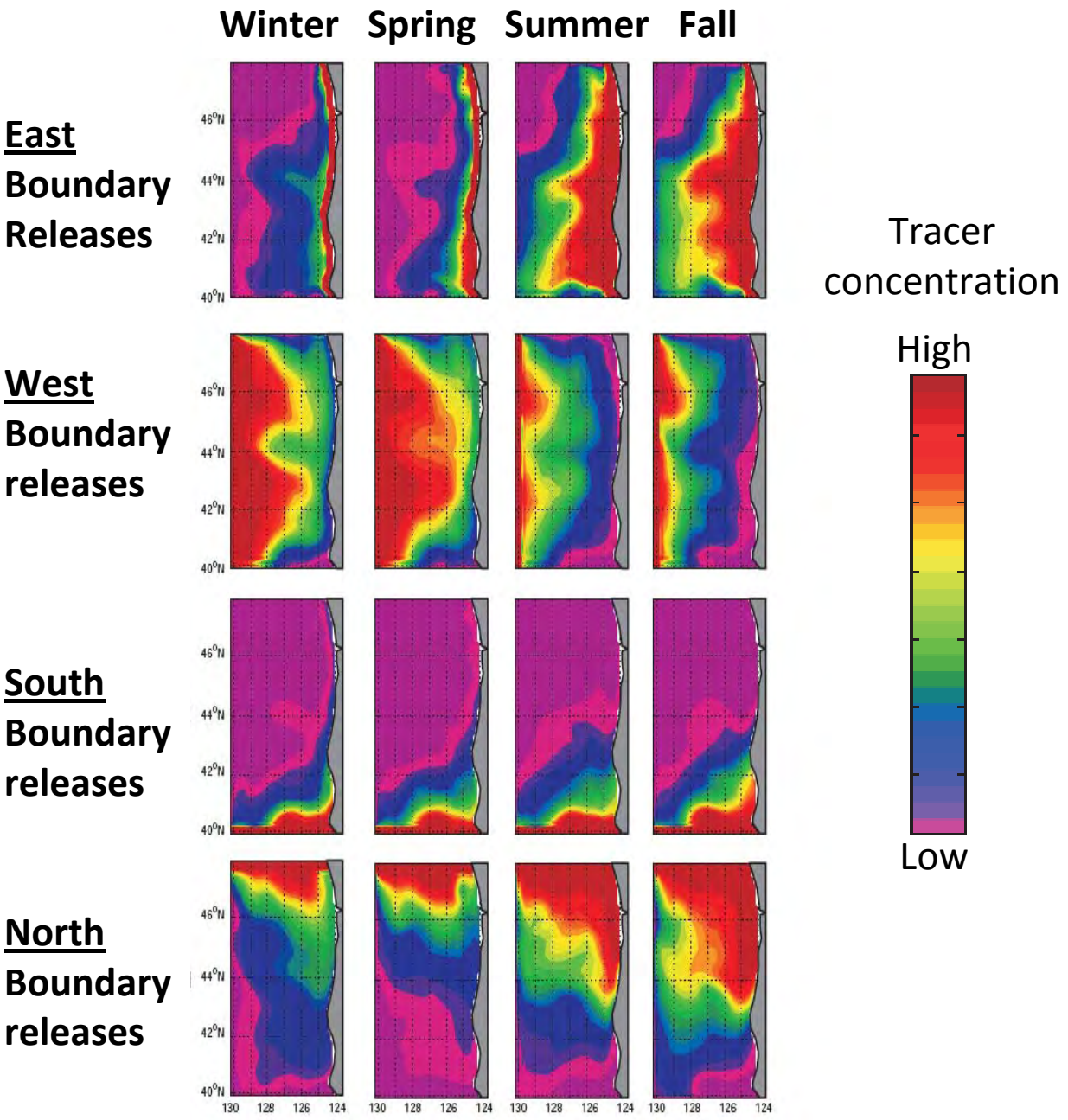
Regional model PDO dynamics match observations

Correlation between the PDO and the 1st EOF of model SST

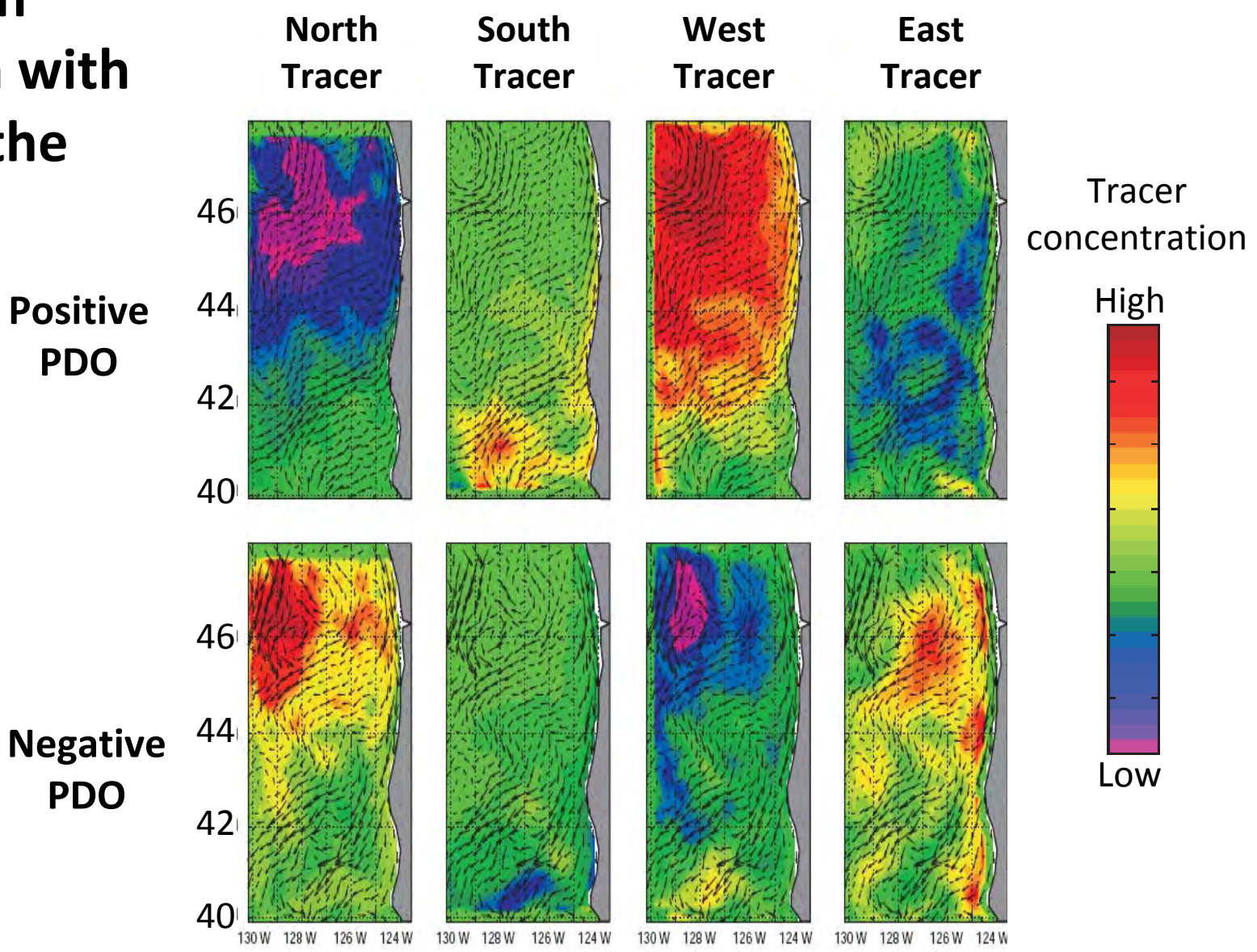




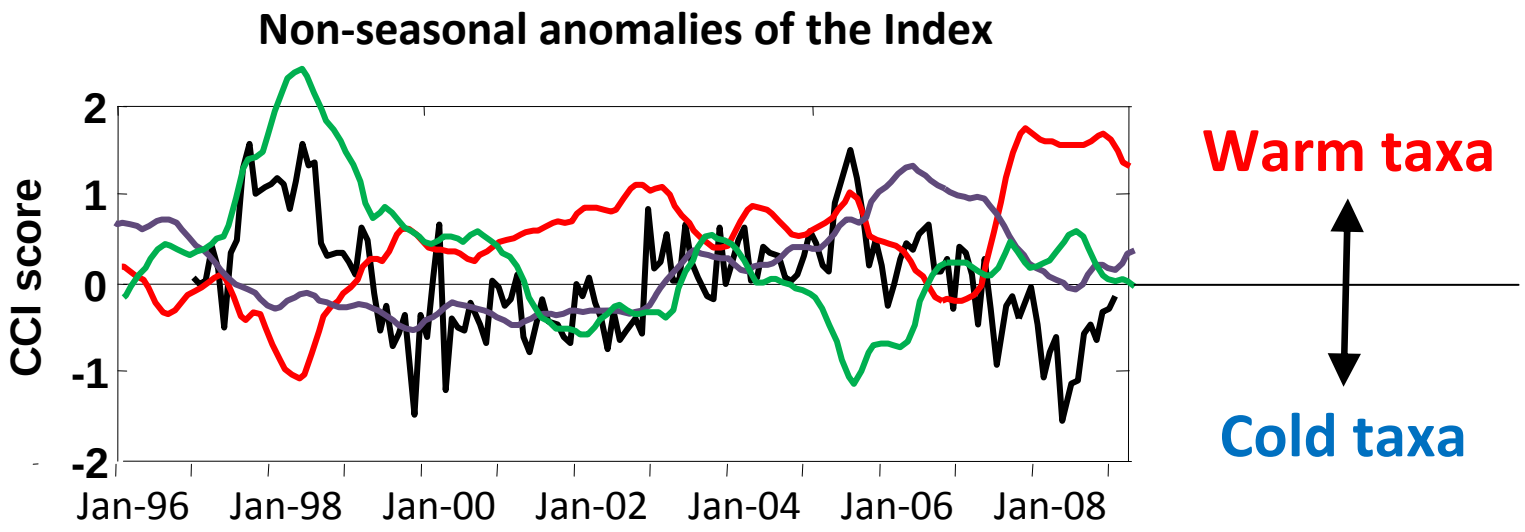
Seasonality in advection is captured by model passive tracers.



Changes in advection with phase of the PDO



The “Copepod Community Index” (CCI)



Advection from north:
R= -0.56
(99.0%)

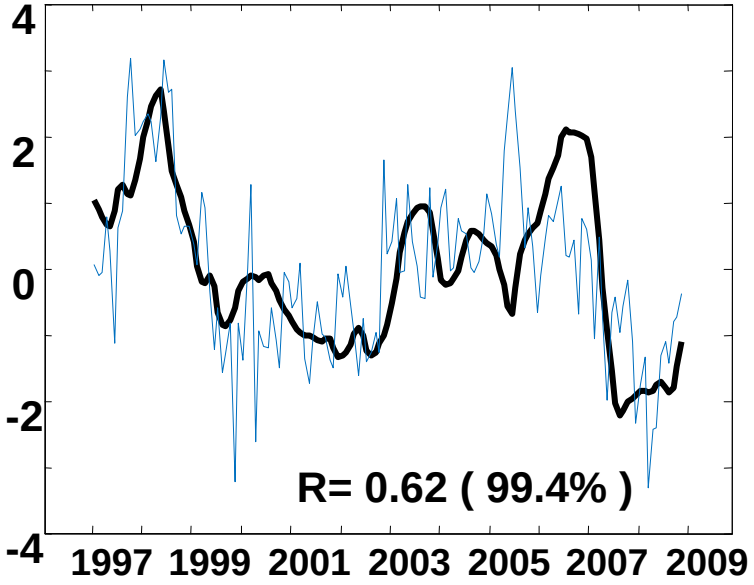
Advection from south:
R= 0.56
(99.0%)

Advection from west:
R= 0.21
(58.6%)

Reconstruction of Copepod Community Index using model passive tracers:

Modeled Copepod index

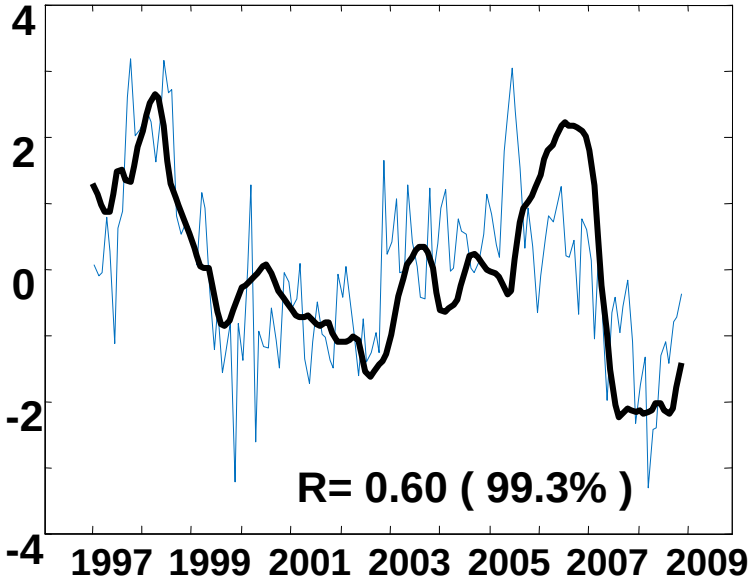
Observed Copepod index



All Tracers

$CCI = \alpha_N$ NORTH + α_S SOUTH + α_E EAST + α_W WEST+ ε

α_N =-0.59
α_S = 0.20
α_E = 0.25
α_W = 0.17

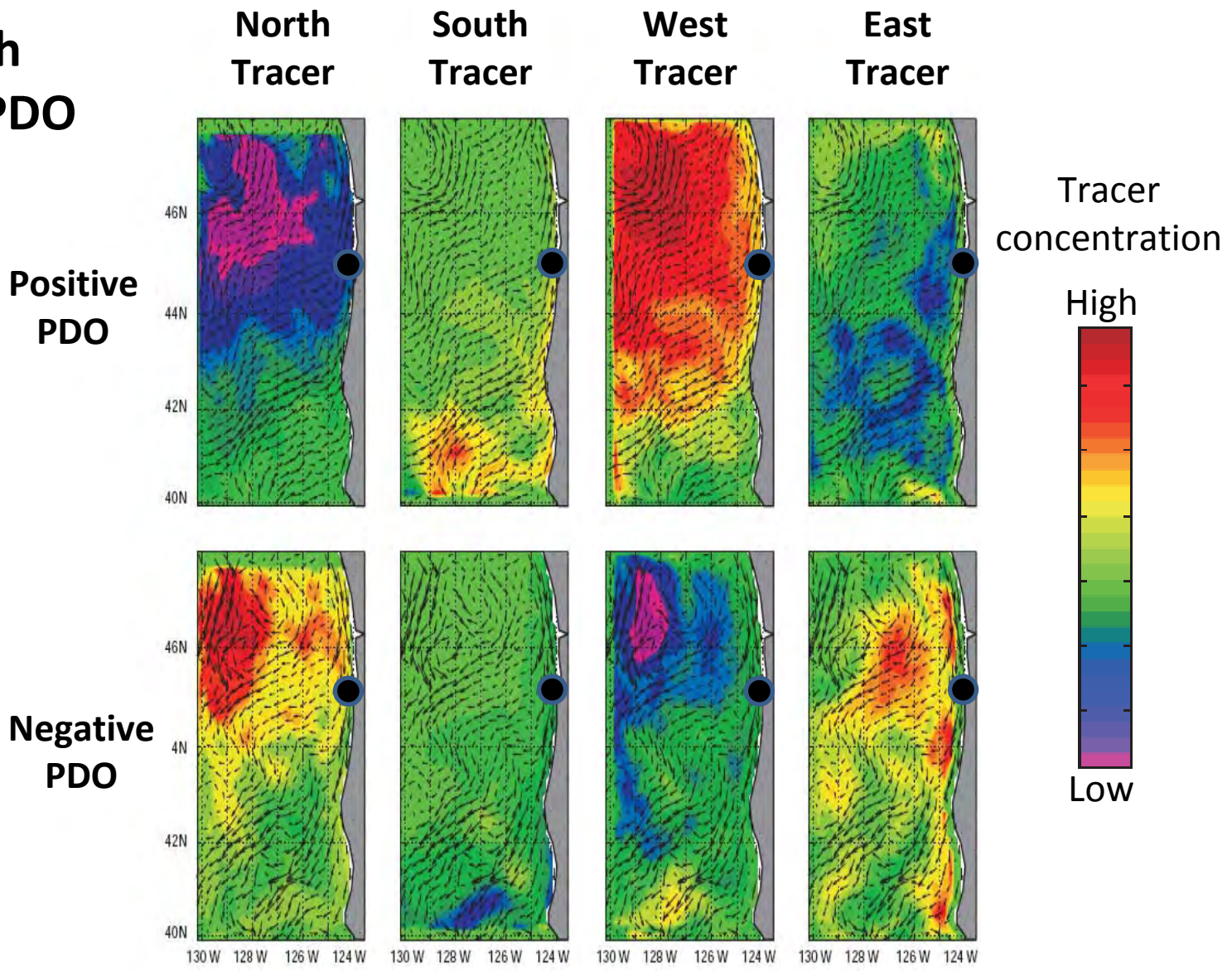


Two Tracers

$CCI = \alpha_W$ NORTH + α_S SOUTH + ε

α_N =-0.54
α_S = 0.25

Changes in advection with phase of the PDO



Conclusions

- **Model experiments confirm that a large portion of the change in zooplankton species composition at our coastal station is explained by changes in north/south (alongshore) surface transport.**

- **Farther offshore, downwelling dynamics are also important (as indexed by the WEST tracers).**

- **Advection, and therefore species composition, changes on climate scales.**

- **Changes in species composition are important to predator growth and survival.**

- **<u>Future experiments planned</u>:**

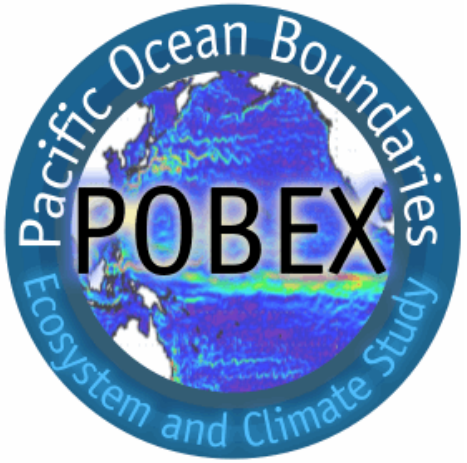
  - To explain remaining variance in NEP region:

  - **examine the role of deep advection (using passive tracer experiments)**
  - **examine the role of growth and mortality (using future NPZ model)**

  - To compare with other Pacific boundary regions

  Ultimately, aim to determine the extent to which basin-scale processes control Pacific boundary systems versus regional and local processes through the regional experiments and comparisons.

Project Participants:



Project PIs:

Emanuele Di Lorenzo
Julie Keister
Ted Strub
Andy Thomas
Steve Bograd
Frank Schwing
Bill Peterson
Peter Franks

Field crew:

Tracy Shaw
Leah Feinberg
Jay Peterson
Jesse Lamb
Jennifer Menkel
Anders Roestad
Mitch Vance
Many, many more…

Data analysts:

Cheryl Morgan
Greg Kowalke
Neri Mariani
Vincent Combes