Climate-related changes in ocean transport control zooplankton biogeography around the North Pacific basin

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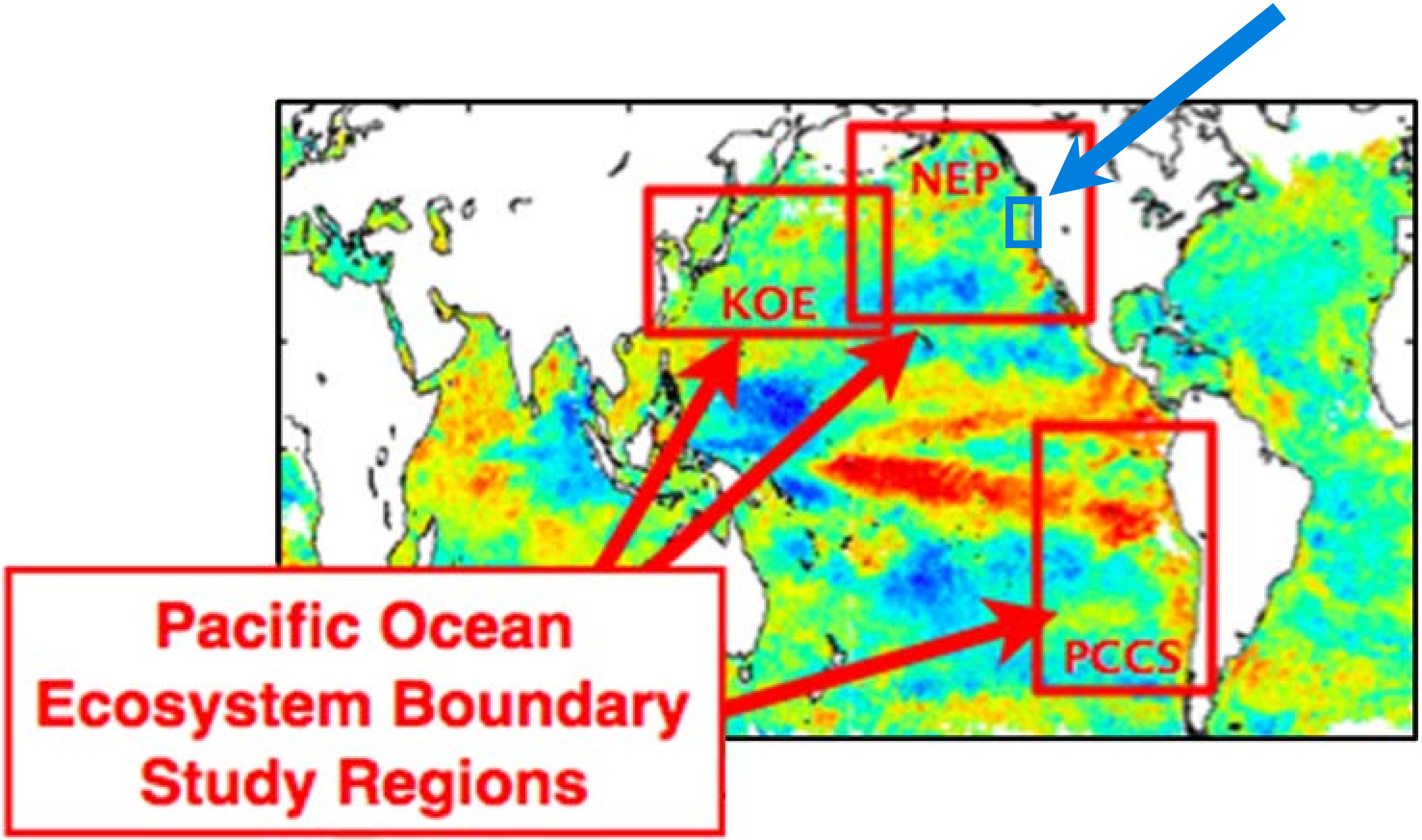
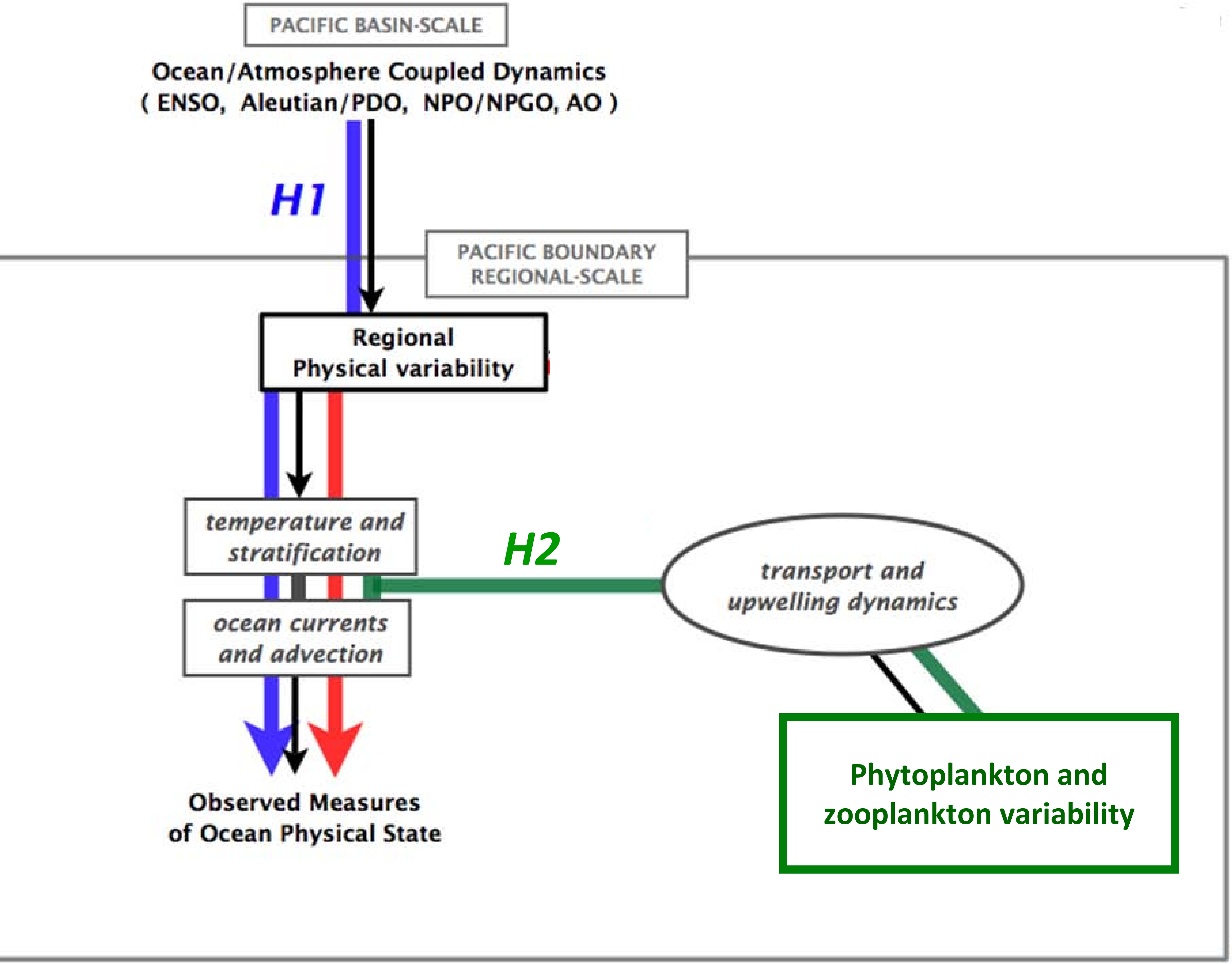
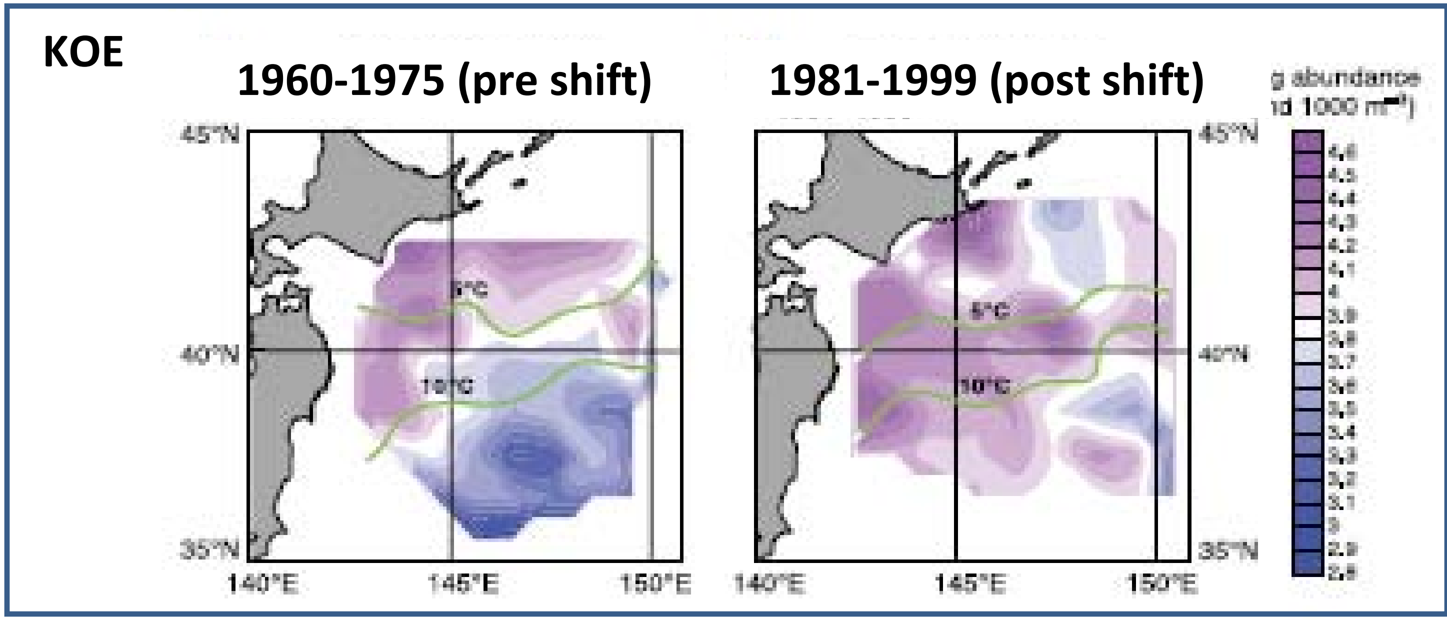
Climate-control of ecosystems?

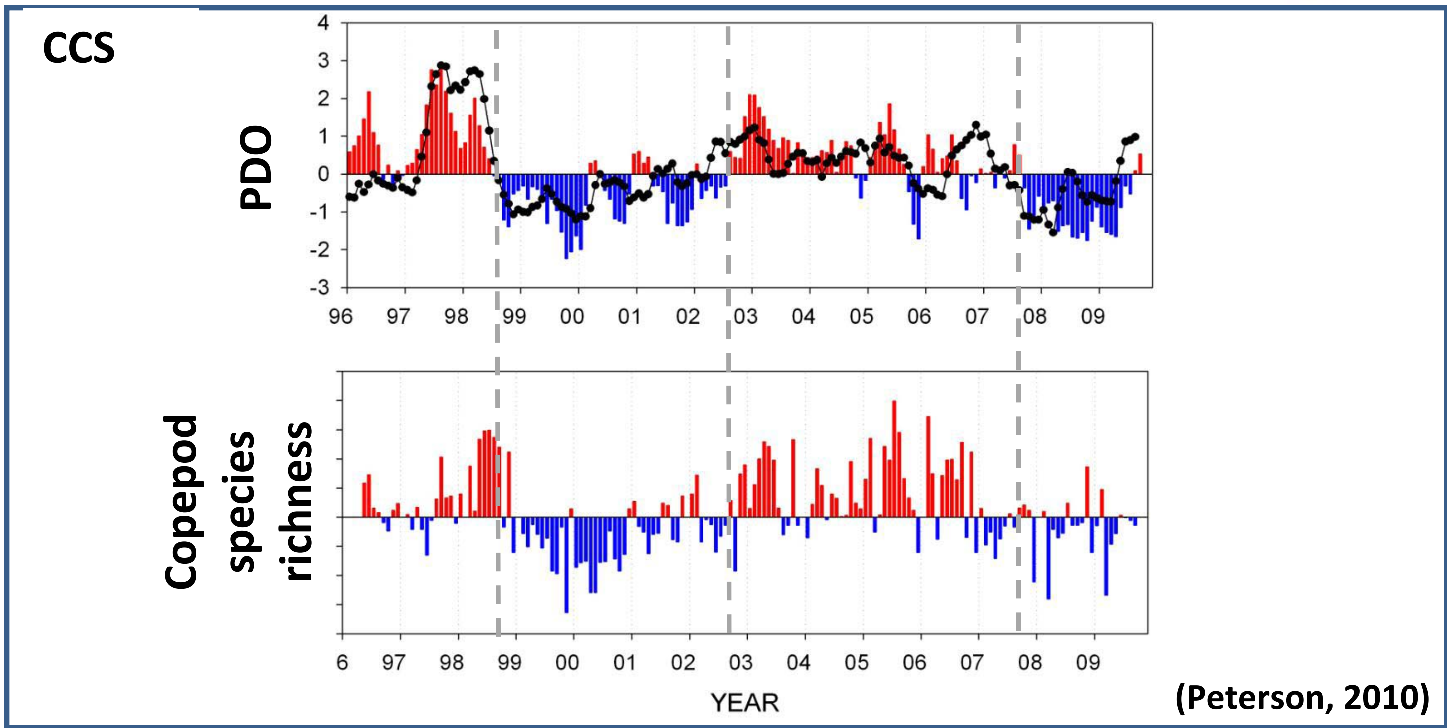



PACIFIC BASIN-SCALE
Ocean/Atmosphere Coupled Dynamics
(ENSO, Aleutian/PDO, NPO/NPGO, AO)
H1
PACIFIC BOUNDARY
REGIONAL-SCALE
Regional
Physical variability
temperature and
stratification
H2
transport and
upwelling dynamics
ocean currents
and advection
Observed Measures
of Ocean Physical State
Phytoplankton and
zooplankton variability

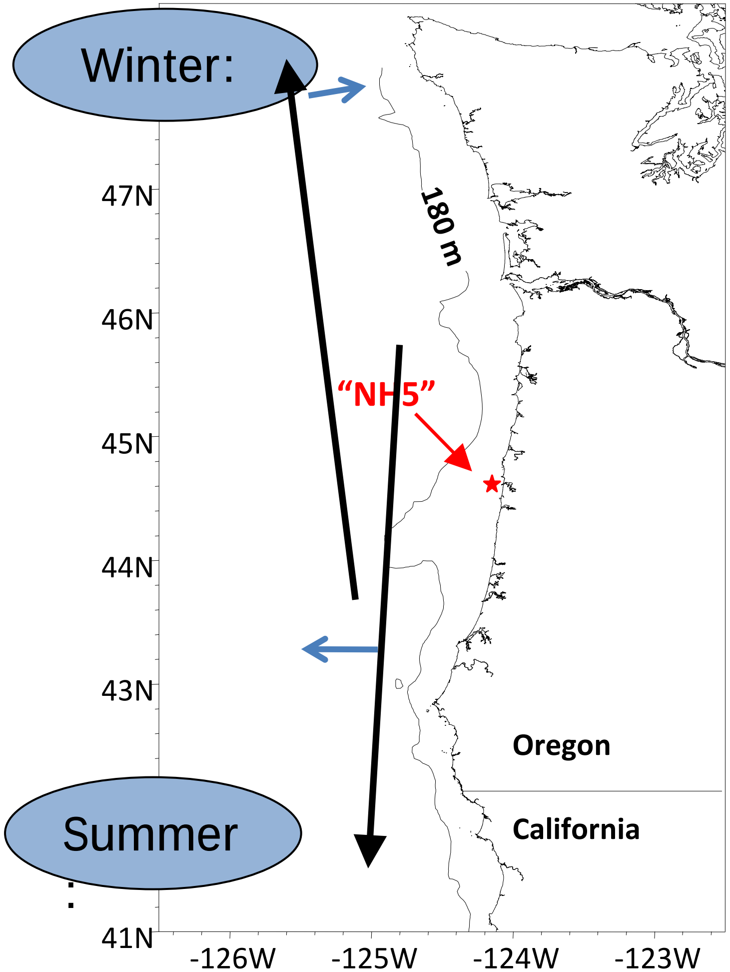
Large-scale climate indices correlate with zooplankton diversity and biogeography:

Chiba et al., 2009





(Peterson, 2010)

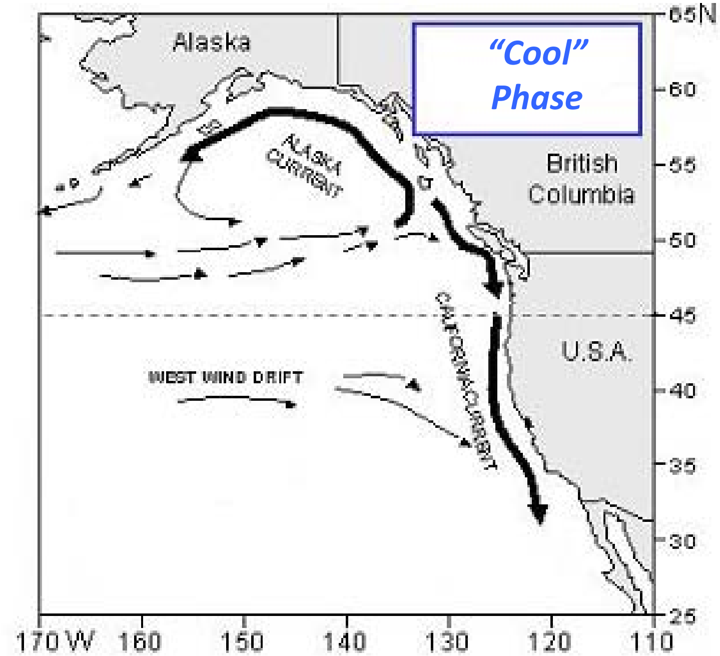


Winter:
Summer
180 m
"NH5"
Oregon
California
47N
46N
45N
44N
43N
41N
-126W
-125W
-124W
-123W

<u>Working hypothesis:</u>
Transport of organisms,
Source waters differ

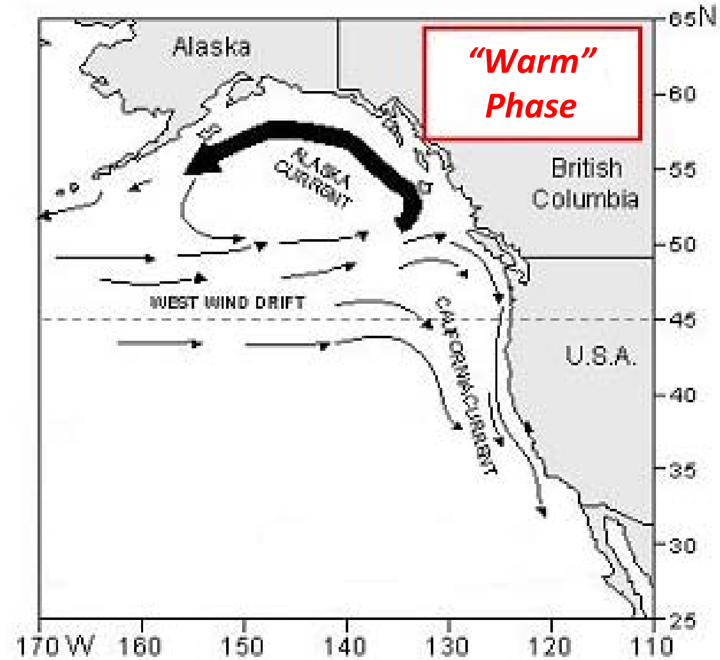
PDO "Cool phase"

Transport of boreal coastal copepods into NCC



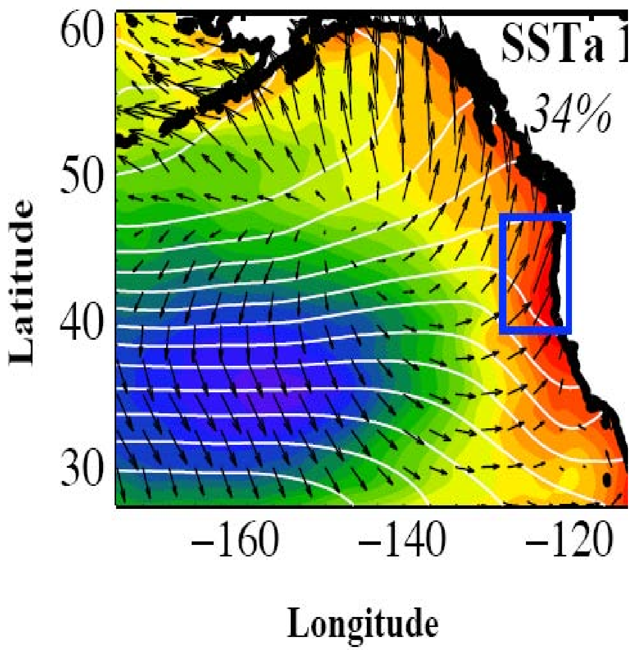
PDO "Warm phase"

Transport of sub-tropical copepods into NCC



The test?

Compare modeled transport to zooplankton observations



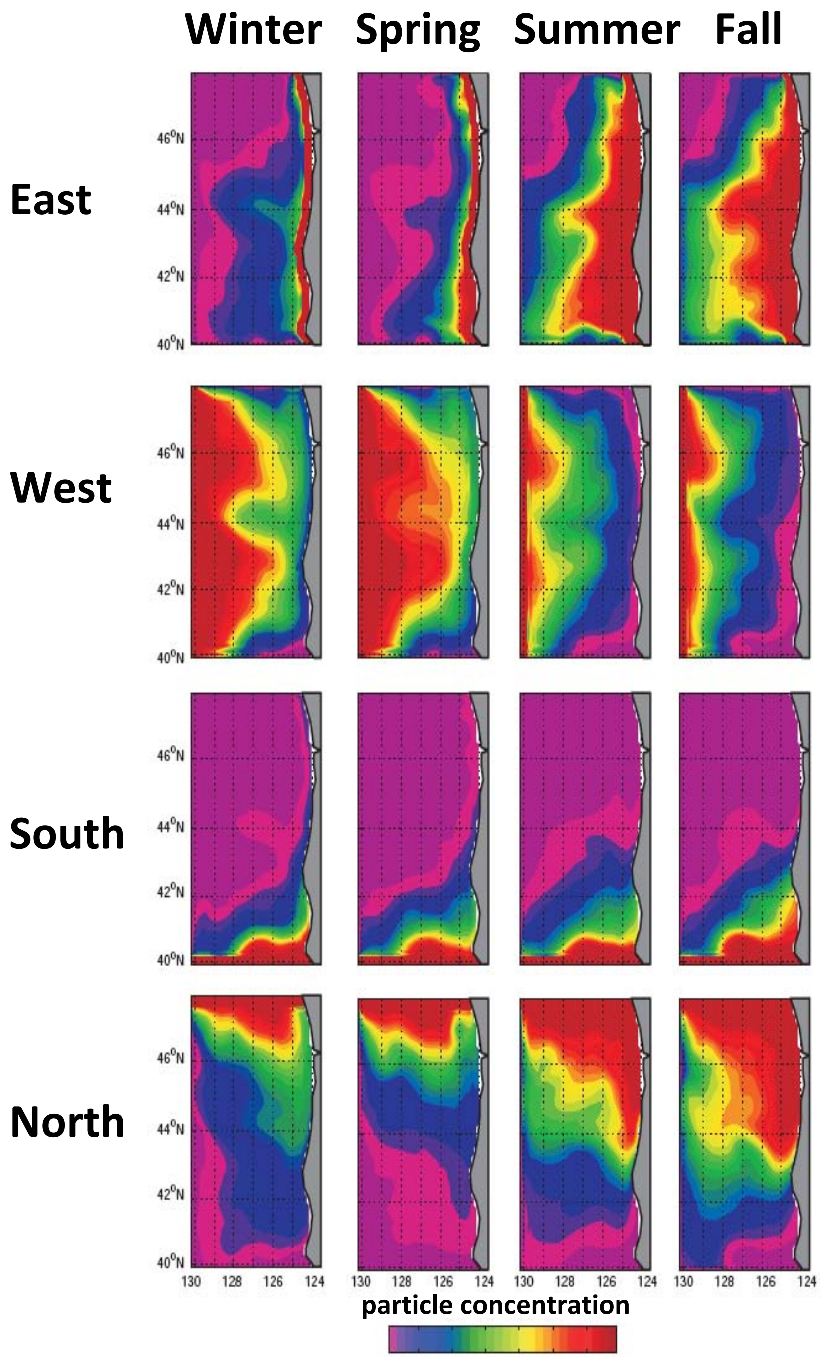
Nested ROMS model http://www.myroms.org/)

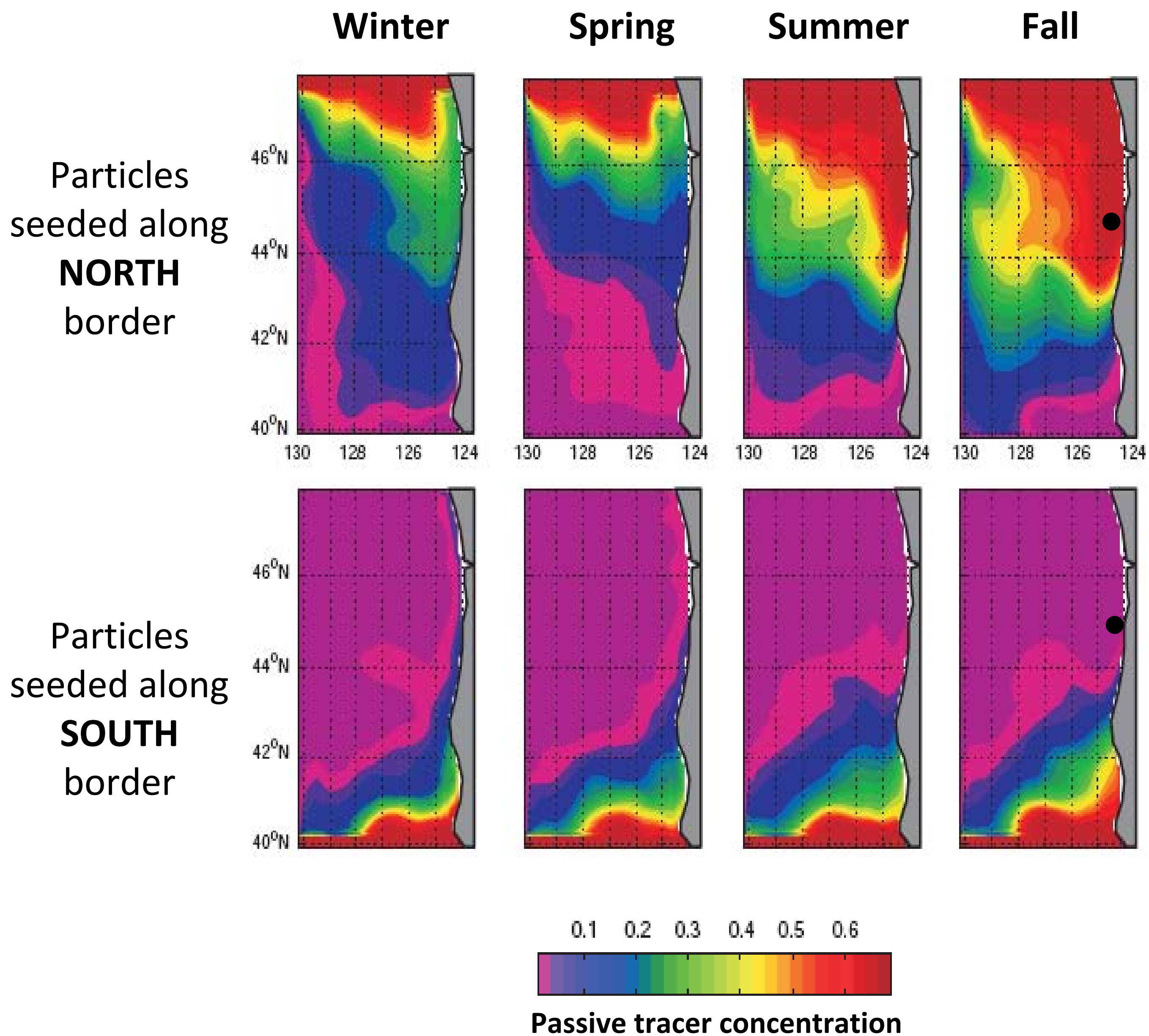
- 10 km resolution
- 30 vertical layers
- boundary conditions from World Ocean Atlas climatology
- nudged at open boundaries
- forced by NCEP winds and SST
- 1950-2008

Passive tracers released continuously along the 4 regional domain boundaries (NORTH, SOUTH, EAST, WEST) with 12-month decay scales.

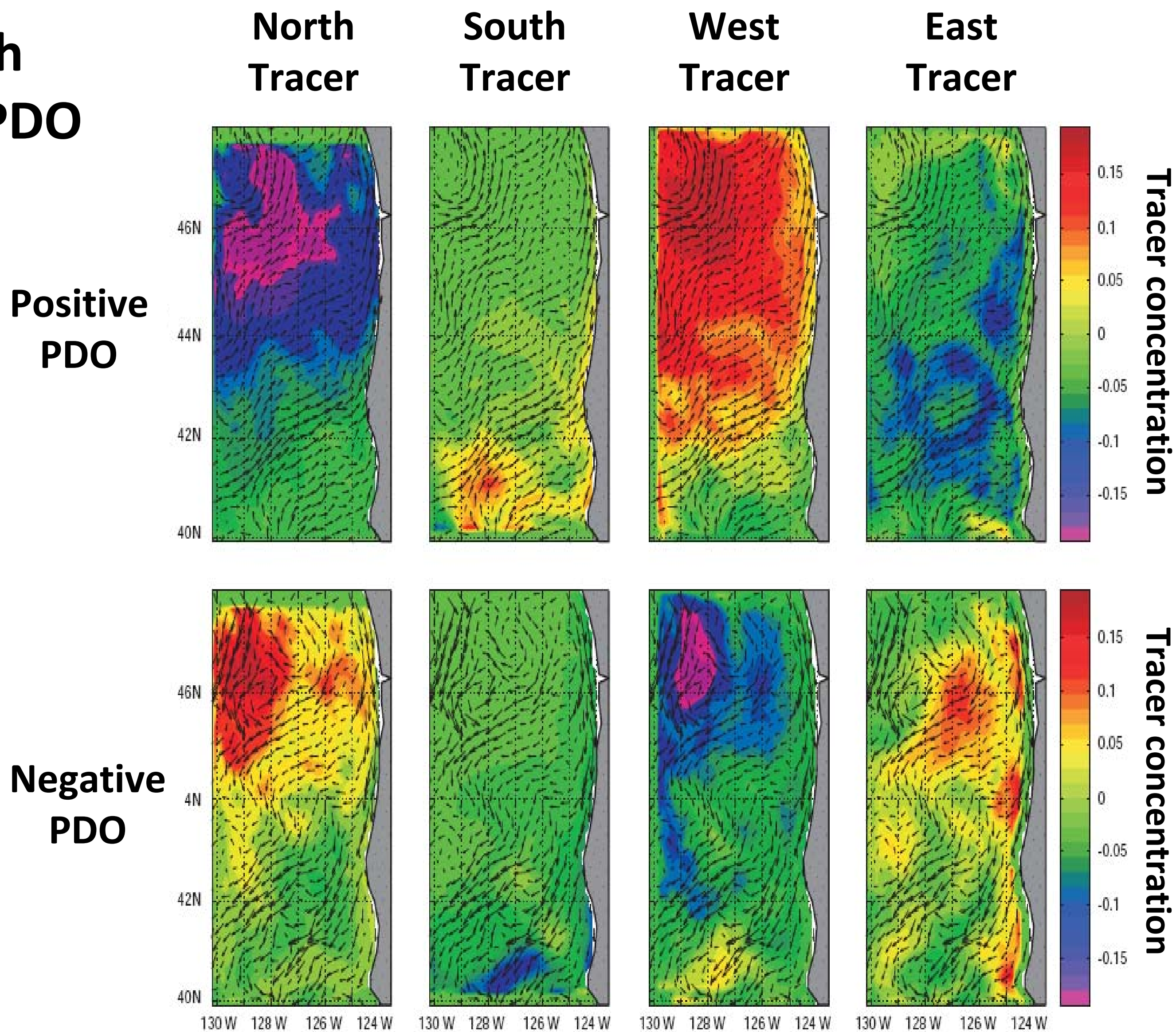
Time series integrated over 1x2 degree region centered on zooplankton observations.

The model captures the seasonality in advection:




Winter
Spring
Summer
Fall
Particles seeded along NORTH border
Particles seeded along SOUTH border
46°N
44°N
42°N
40°N
130
128
126
124
0.1
0.2
0.3
0.4
0.5
0.6
Passive tracer concentration

Changes in advection with phase of the PDO



Zooplankton data: from sampling off Oregon since 1996

Station NH5

60 m water depth (mid-shelf)

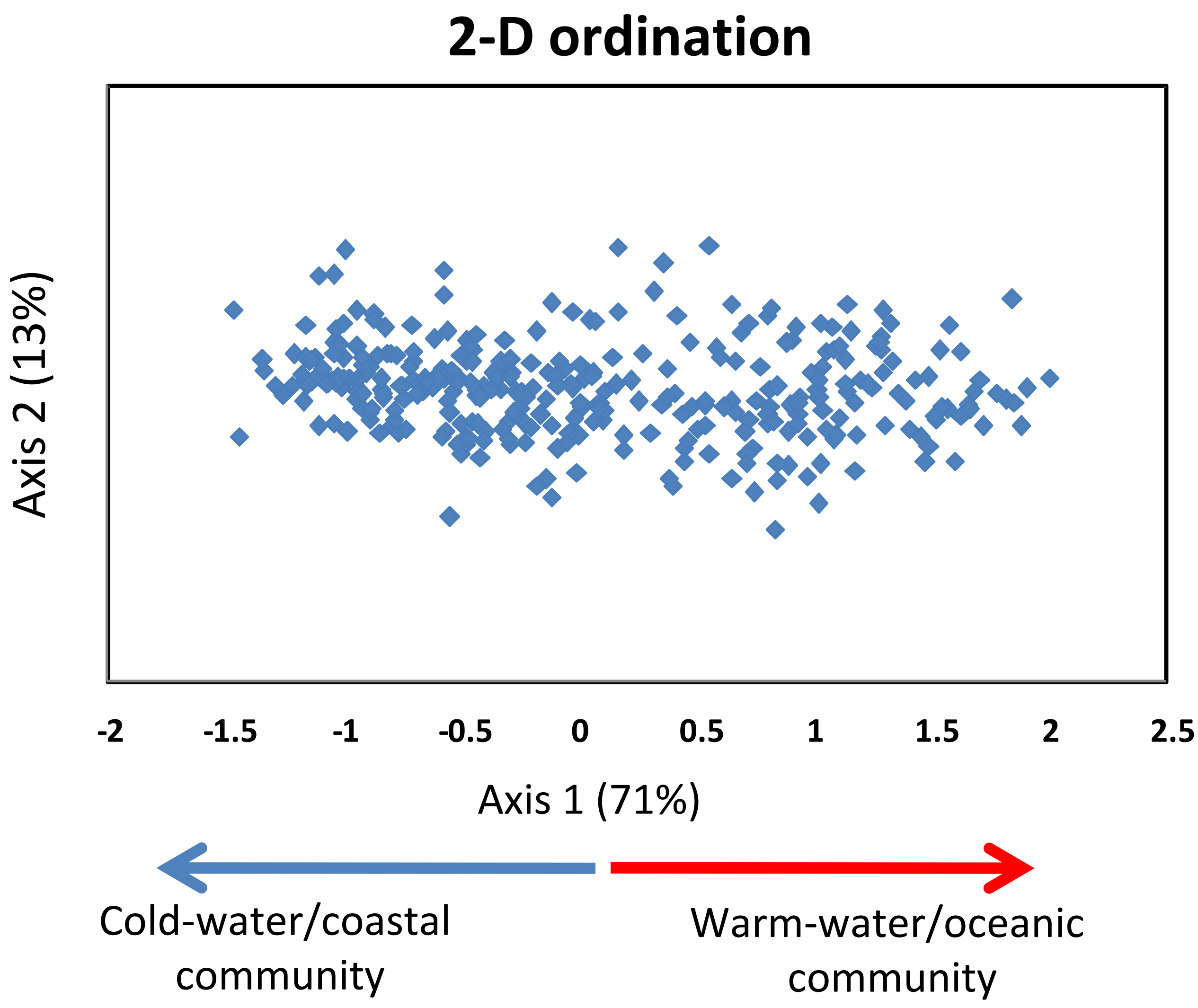
Zooplankton net tows from near bottom
(½-m diameter, 202-µm mesh)

Analyzing copepods only:
(comprise >70% of biomass; taxonomy is well known; good indicators)

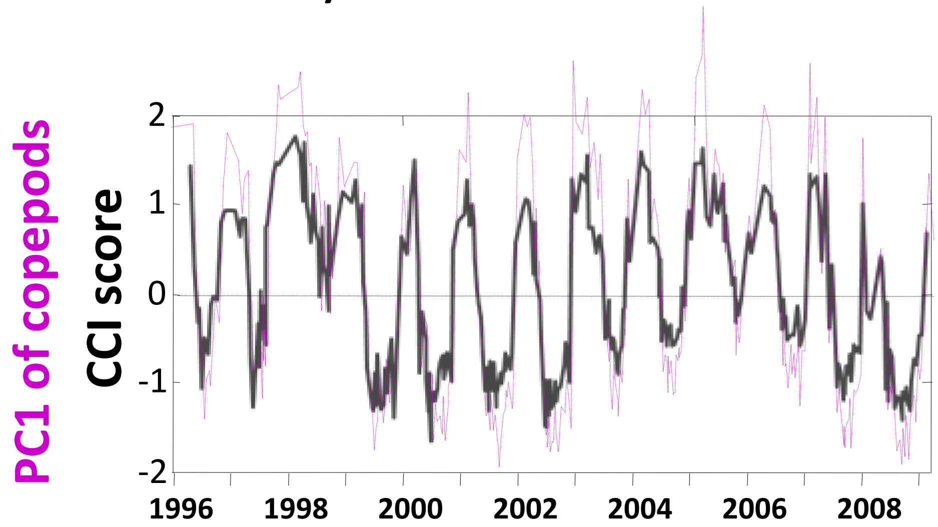
→ **343 sample dates x 29 species matrix**

Copepod Community ordination

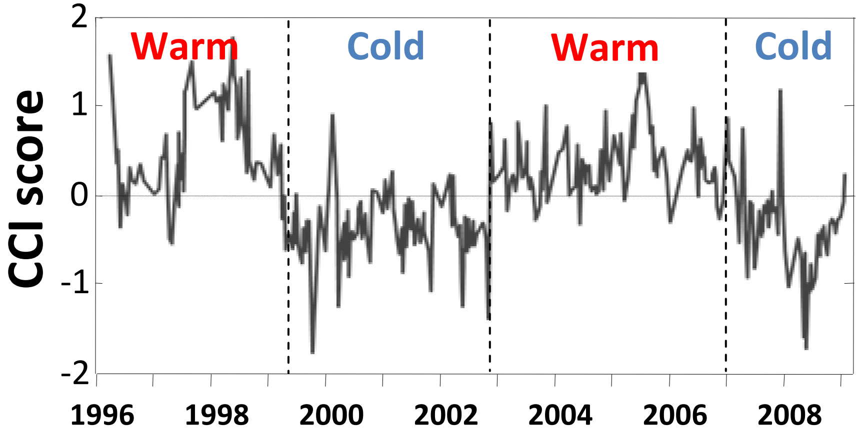
Using NMS: Non-metric Multi-dimensional Scaling



“Copepod Community Index” = CCI

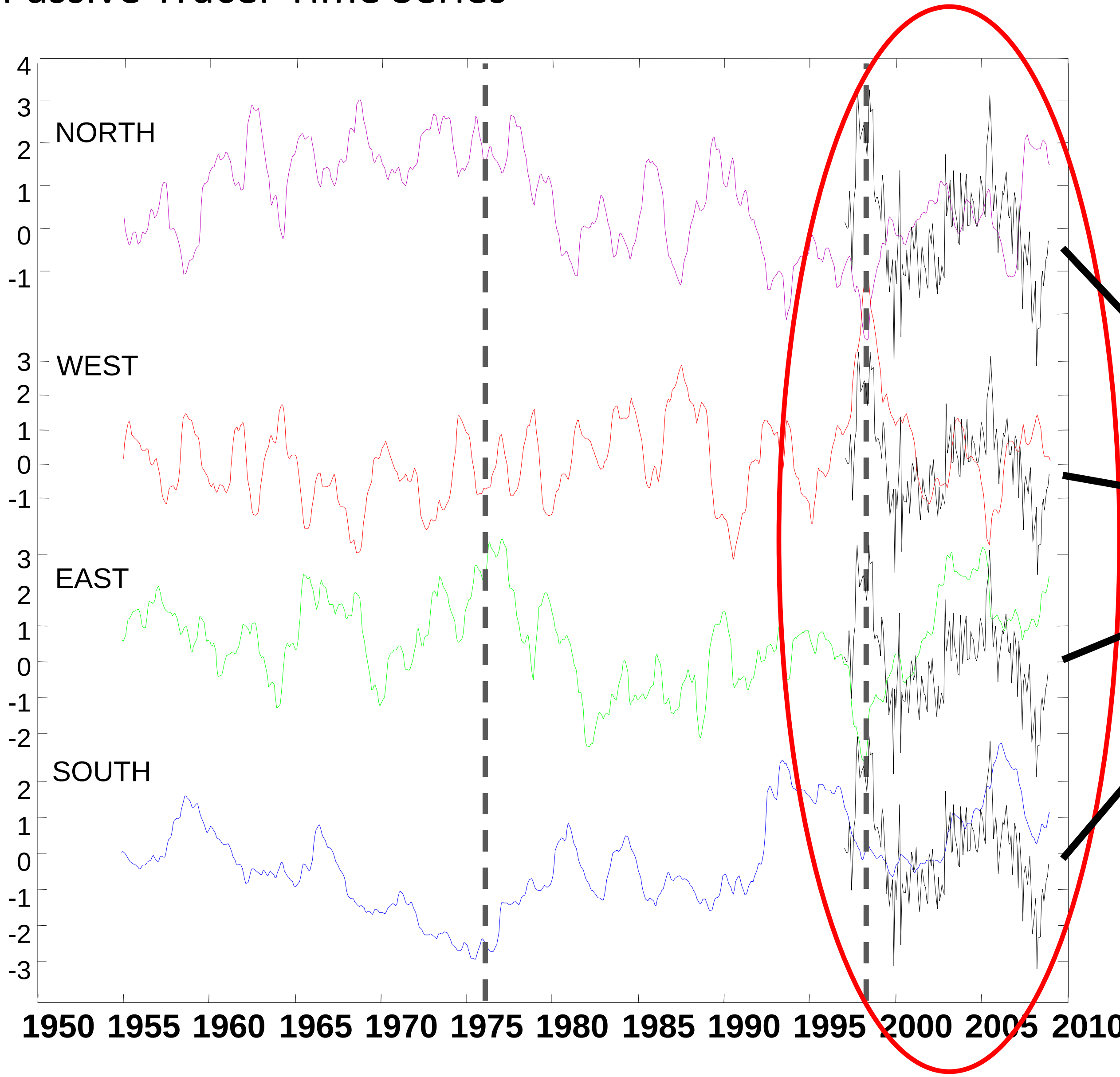


CCI Timeseries



Monthly anomalies

Passive Tracer Time Series



CCI = NORTH tracer

+

SOUTH tracer

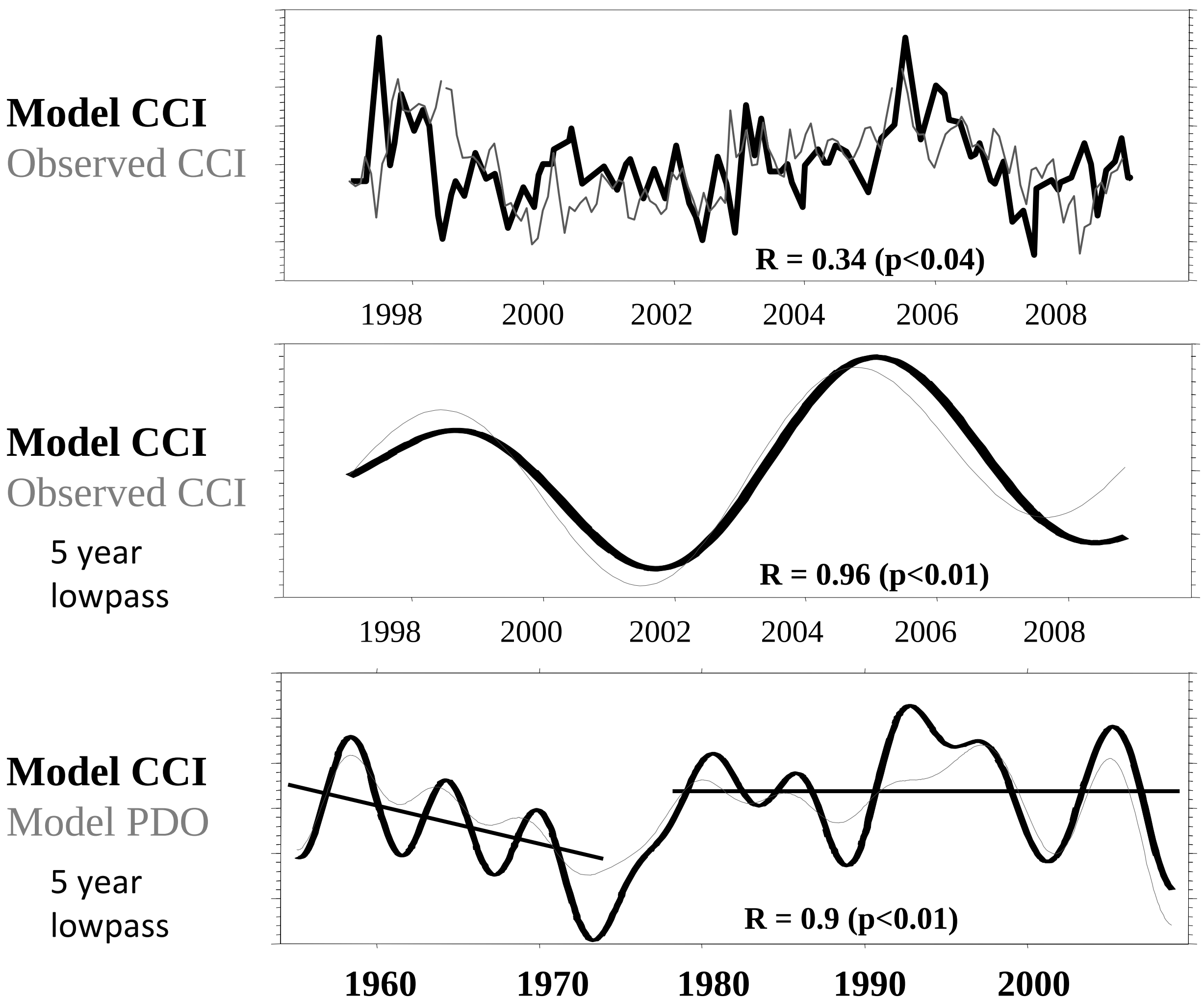
+

EAST tracer

+

WEST tracer

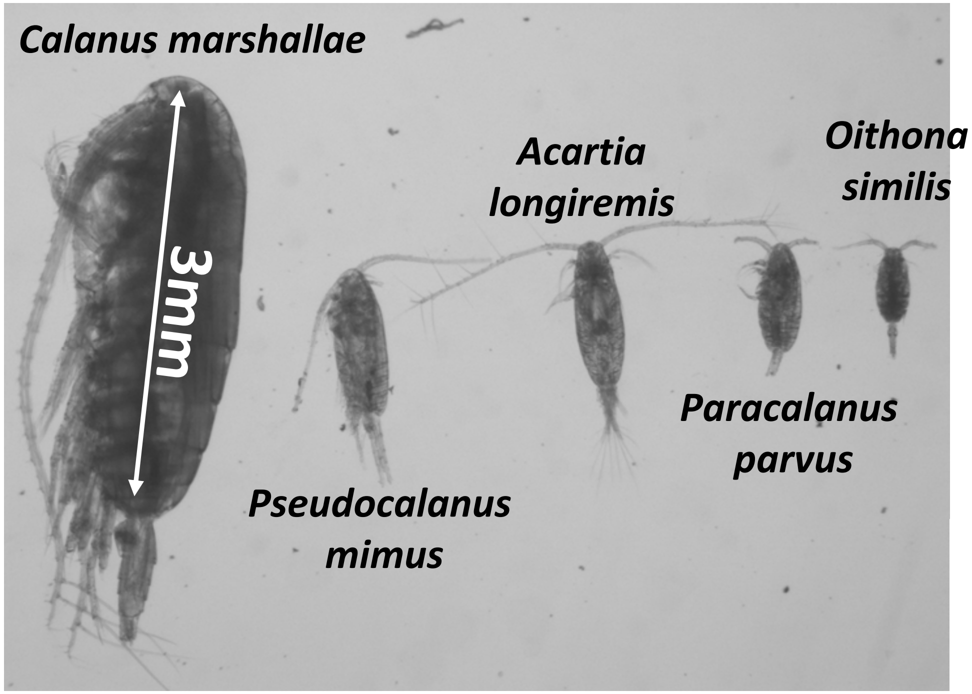
+ ε

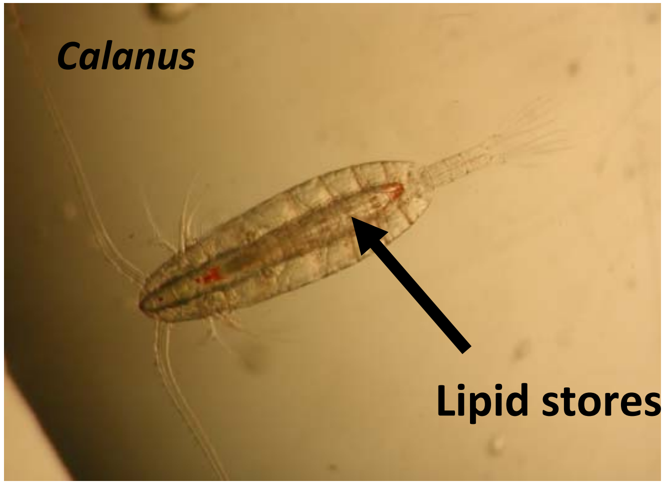


Keister et al. 2010

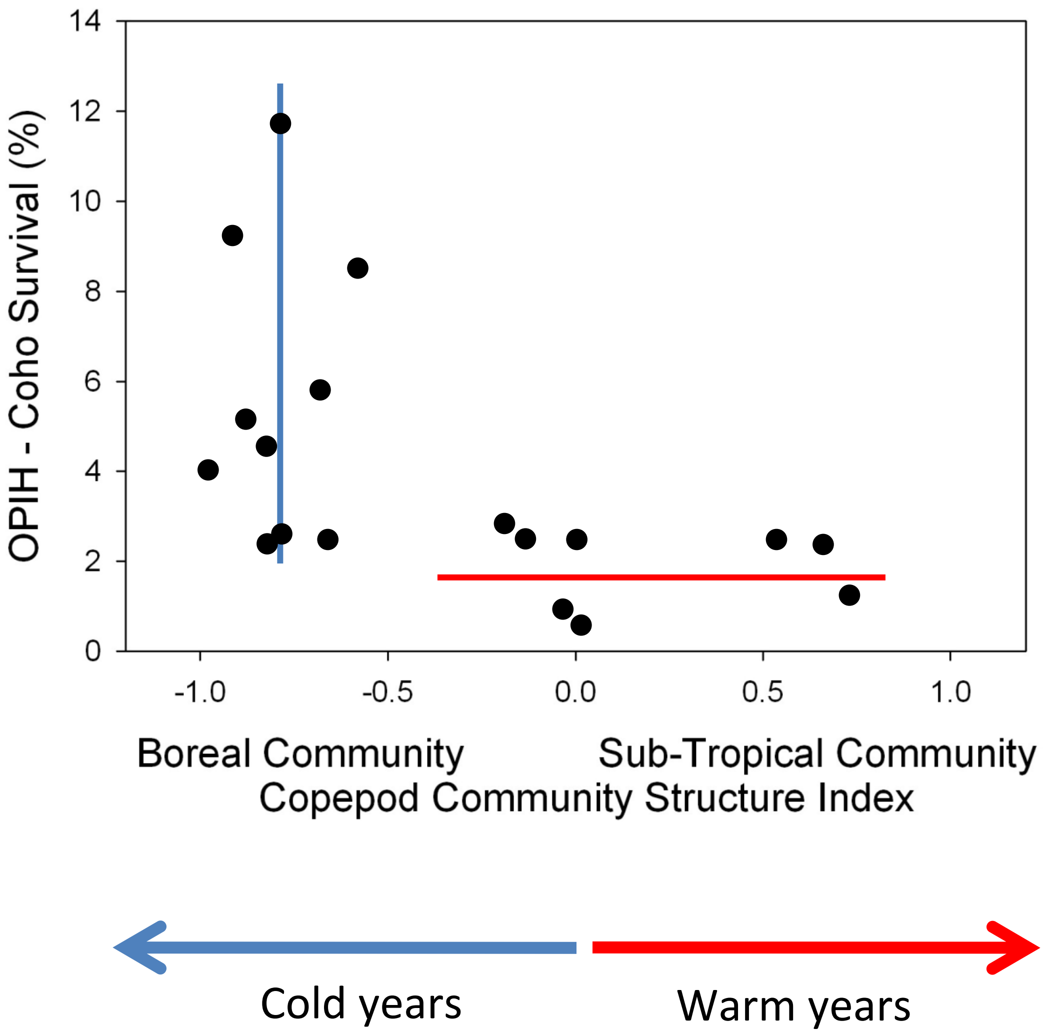
Not all copepods are created equal

Boreal species = large and lipid filled



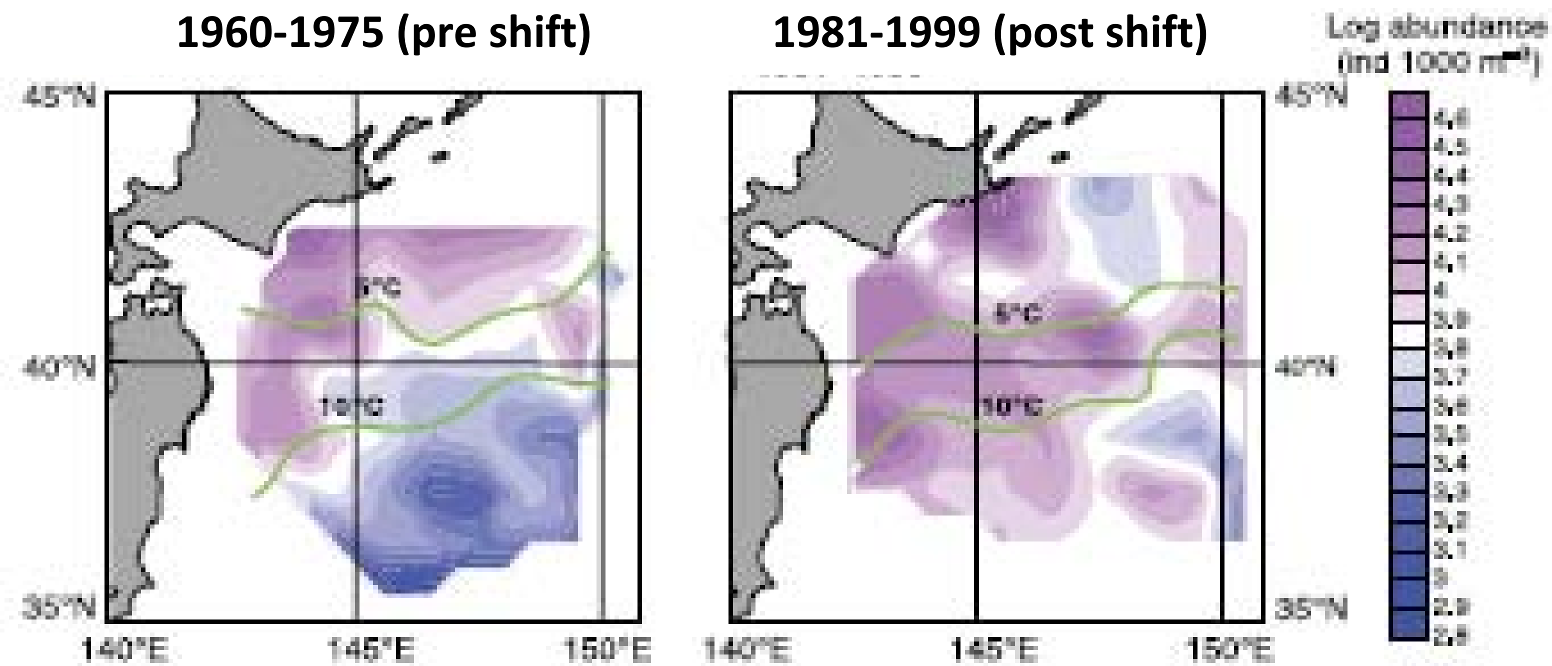


Copepod Community related to salmon survival:



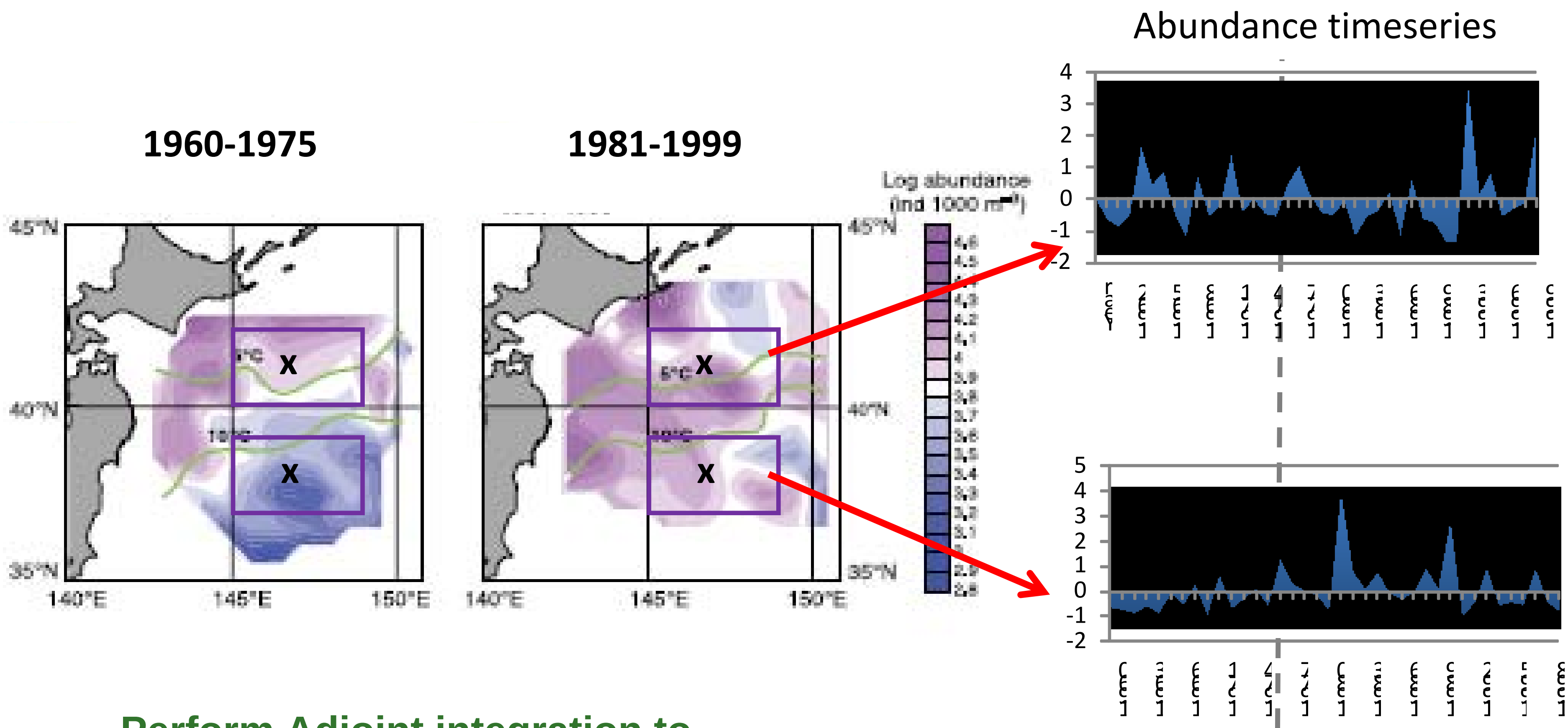
Kuroshio / Oyashio Region
zooplankton biogeography changed following the 1976 PDO regime-shift

Cold-water copepod abundances:



(**Chiba** *et al.*, 2008, GCB)

Testing the role of advection in the observed changes in the KOE:



Perform Adjoint integration to assess where water masses are coming from in regions 1 and 2

Diagnose relationship between changes in Zooplankton and source waters

Conclusions

- Model experiments confirm that a majority (>80%) of the low-frequency variability in zooplankton species composition at our coastal station is explained by changes in north/south (alongshore) transport.

- Both the eastern and western Pacific regions are influenced by PDO-indexed variability indicating that atmospheric forcings associated with the Aleutian Low downscale to influence regional ecosystem structure around the North Pacific boundaries.

- Is advection of the zooplankton populations the dominant mechanism leading to the observed community biogeographical changes?