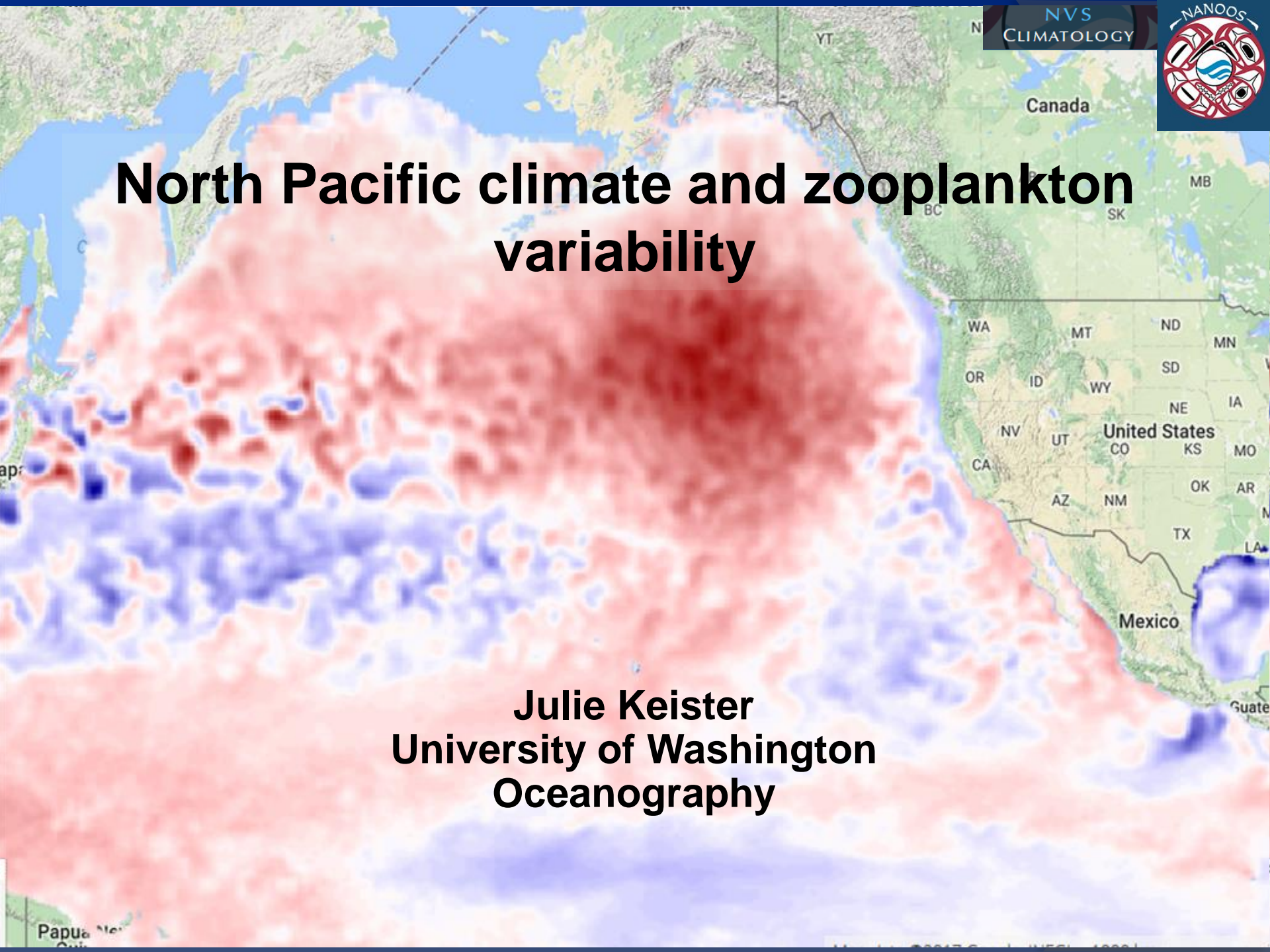


North Pacific climate and zooplankton variability

Julie Keister
University of Washington
Oceanography



The Play'ahs:

- Decadal Cycles
- Periodic Events
- Interannual Anomalies/
Extreme Events



Observed responses:

Local changes in abundance/biomass or species composition

Via what mechanisms?

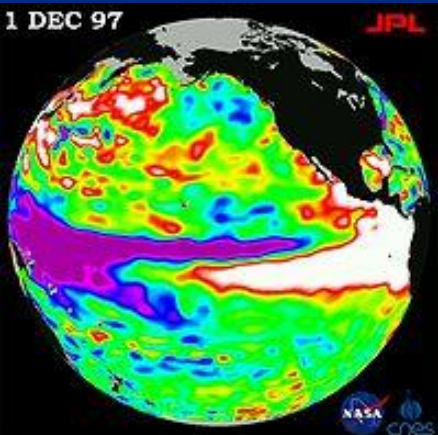
Movement

- Advective (horizontal)
- Behavioral (vertical)

Changes in population structure

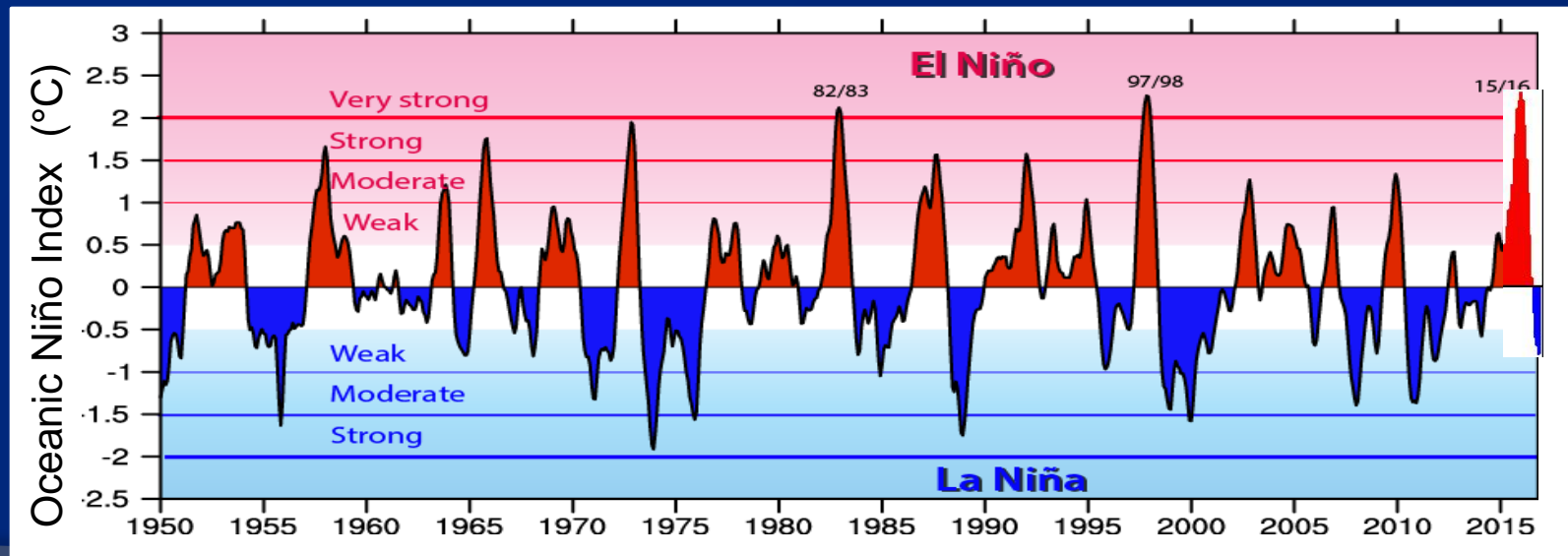
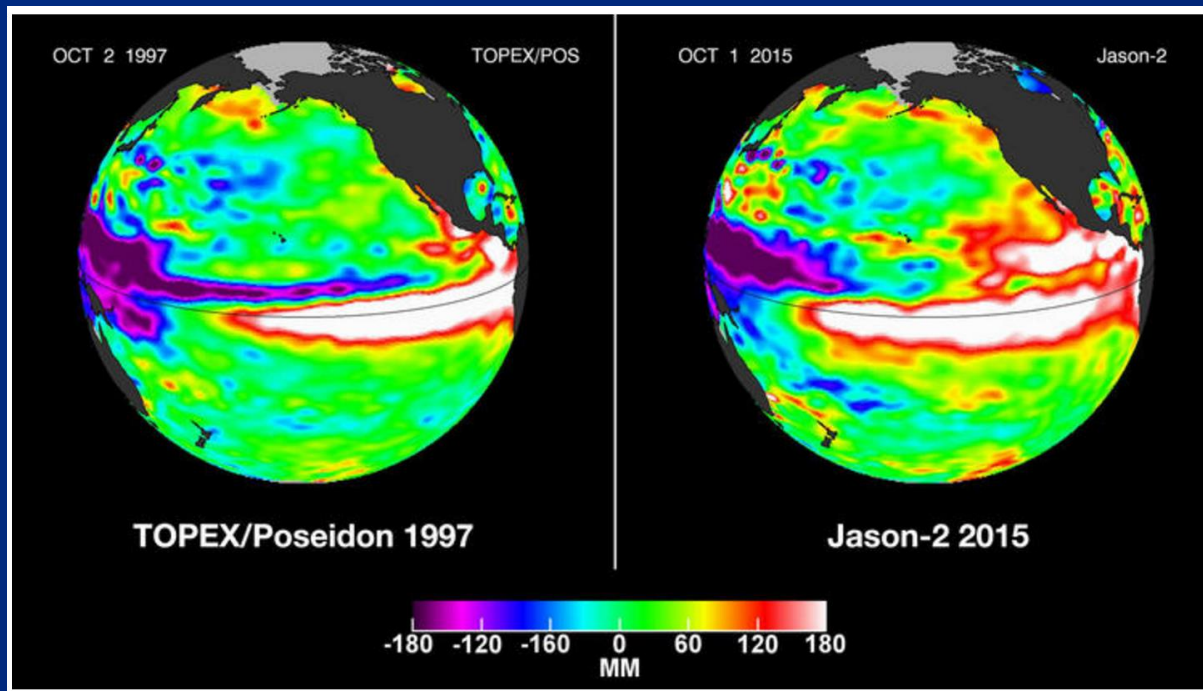
- Growth dynamics
- Predation

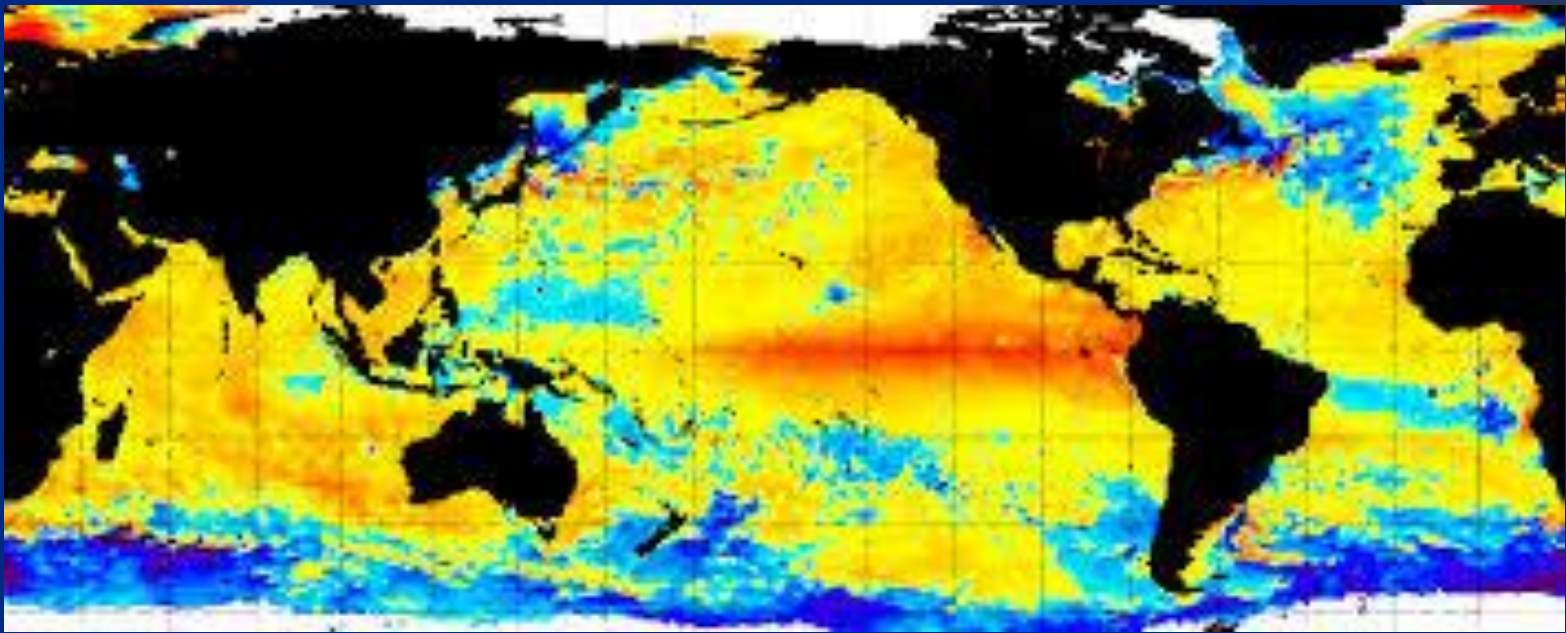
1 DEC 97



Periodic Events: El Niño



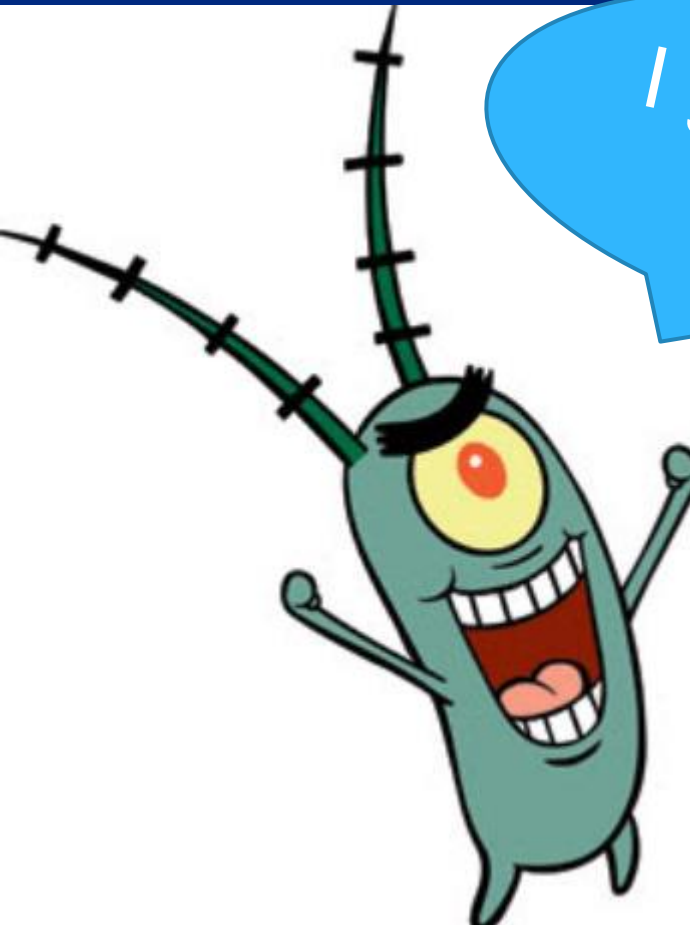




Environmental changes during El Niño events:

- Warming – stratified, lowered nutrient delivery
- Wave propagation - advection pathways
- Changes in storm tracks – mixing and precipitation

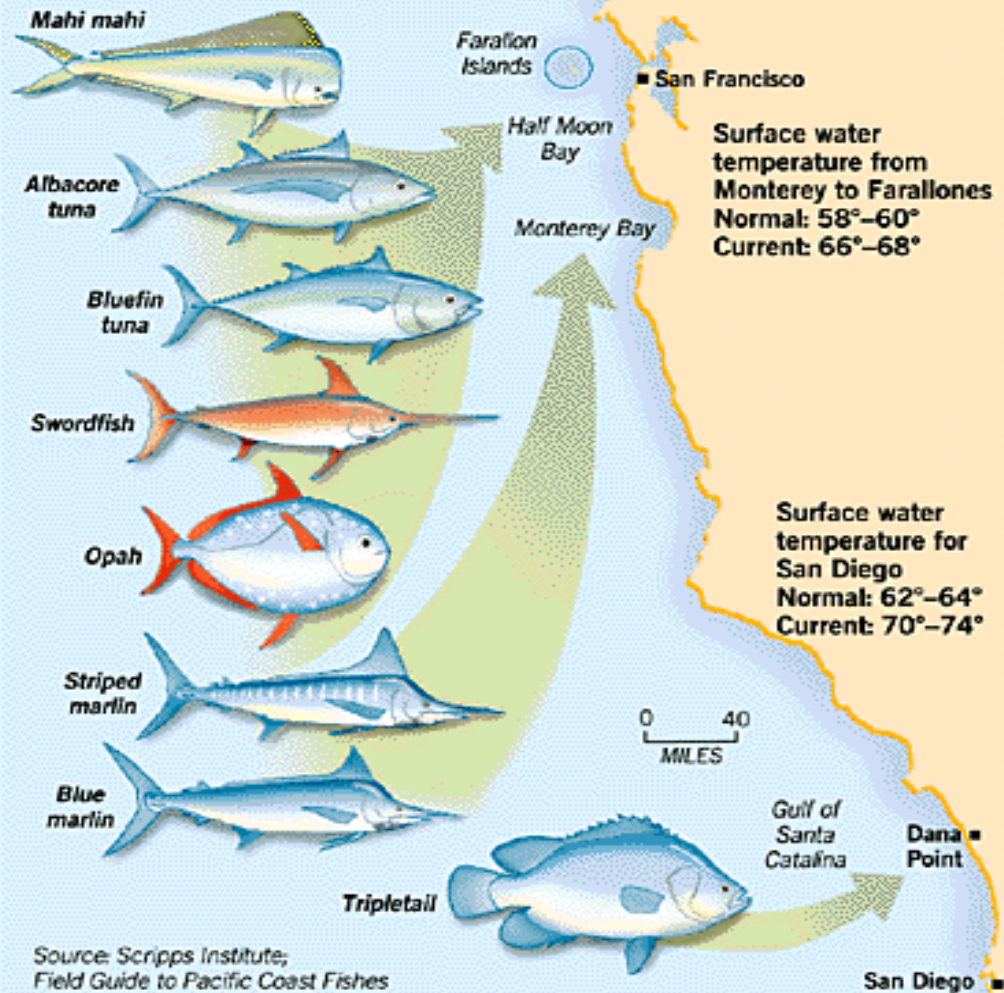
Strong evidence for advection-driven changes in California Current communities



El Niño

OUT-OF-TOWN VISITORS

Warm currents from a growing El Niño have brought tropical and subtropical fish to Northern California waters. Below are examples of fish that have been either caught or sighted within 20 miles of shore.

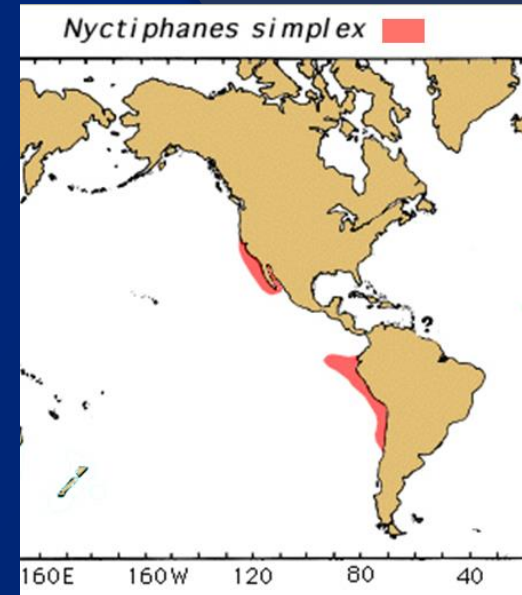
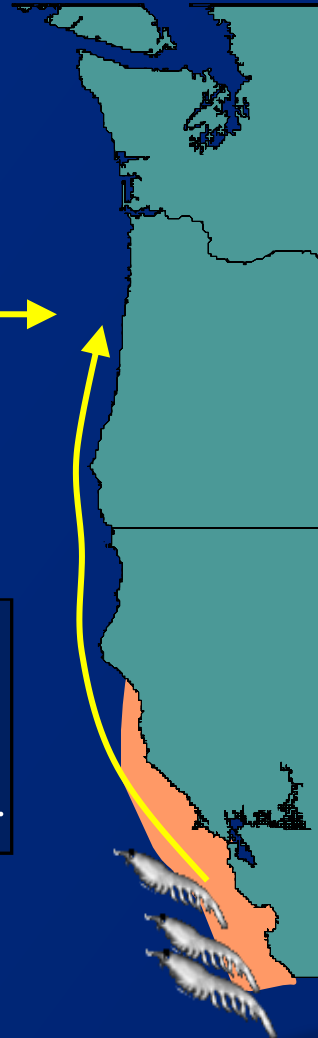
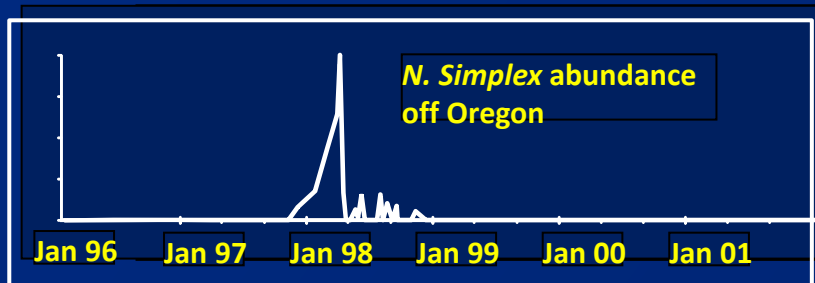
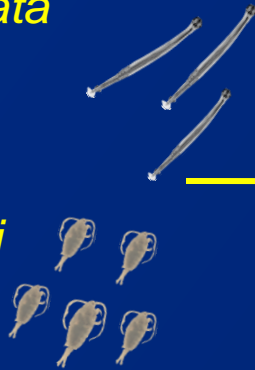


JOHN BLANCHARD / The Chronicle

El Niño distributional shifts:

Sagitta
pseudoserratodentata
Sagitta hexaptera
(chaetognaths)

Centropages bradyi
(copepod)



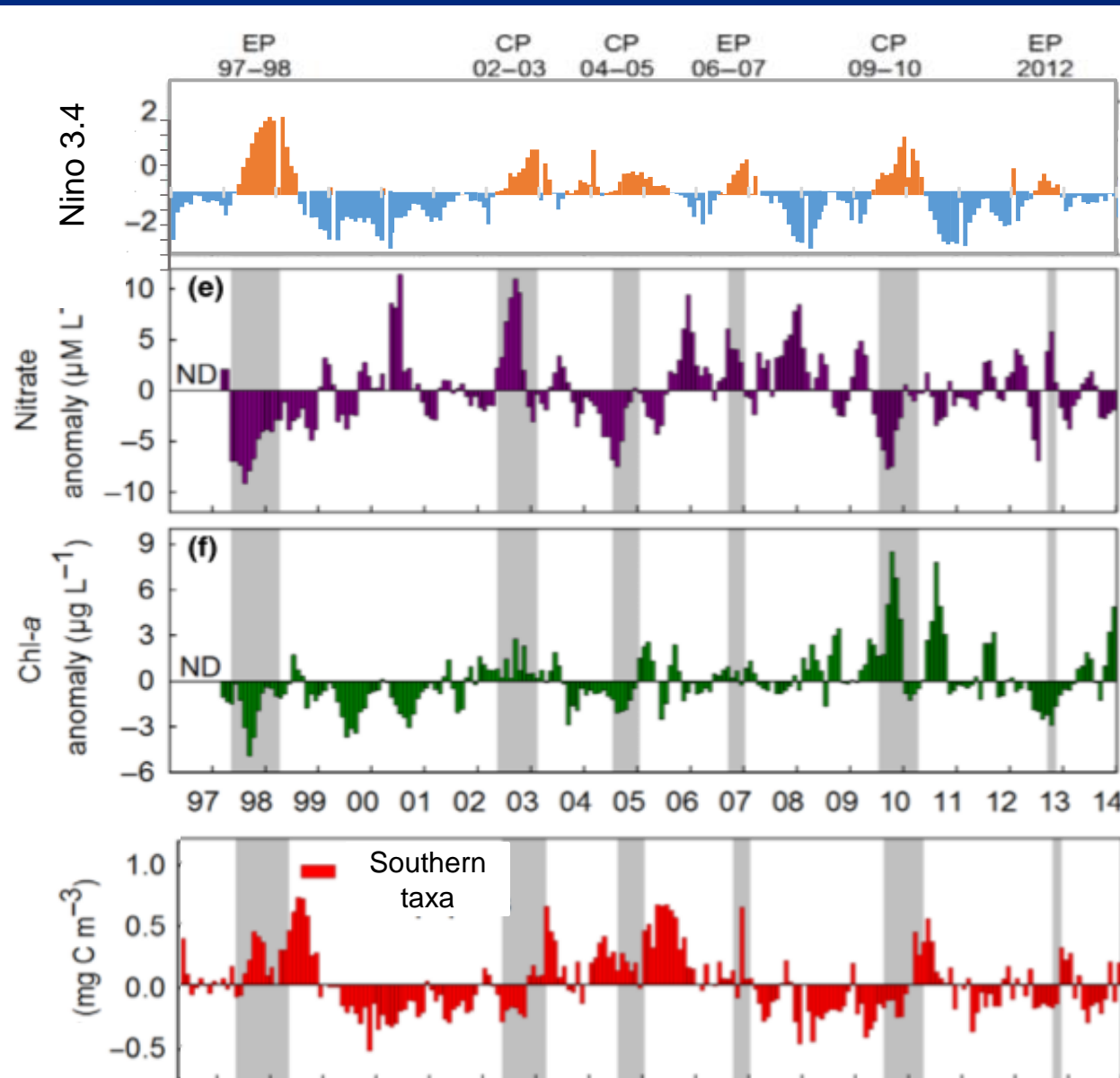
Nyctiphanes simplex

- Coastal euphausiid
- Typically found south of Pt. Conception

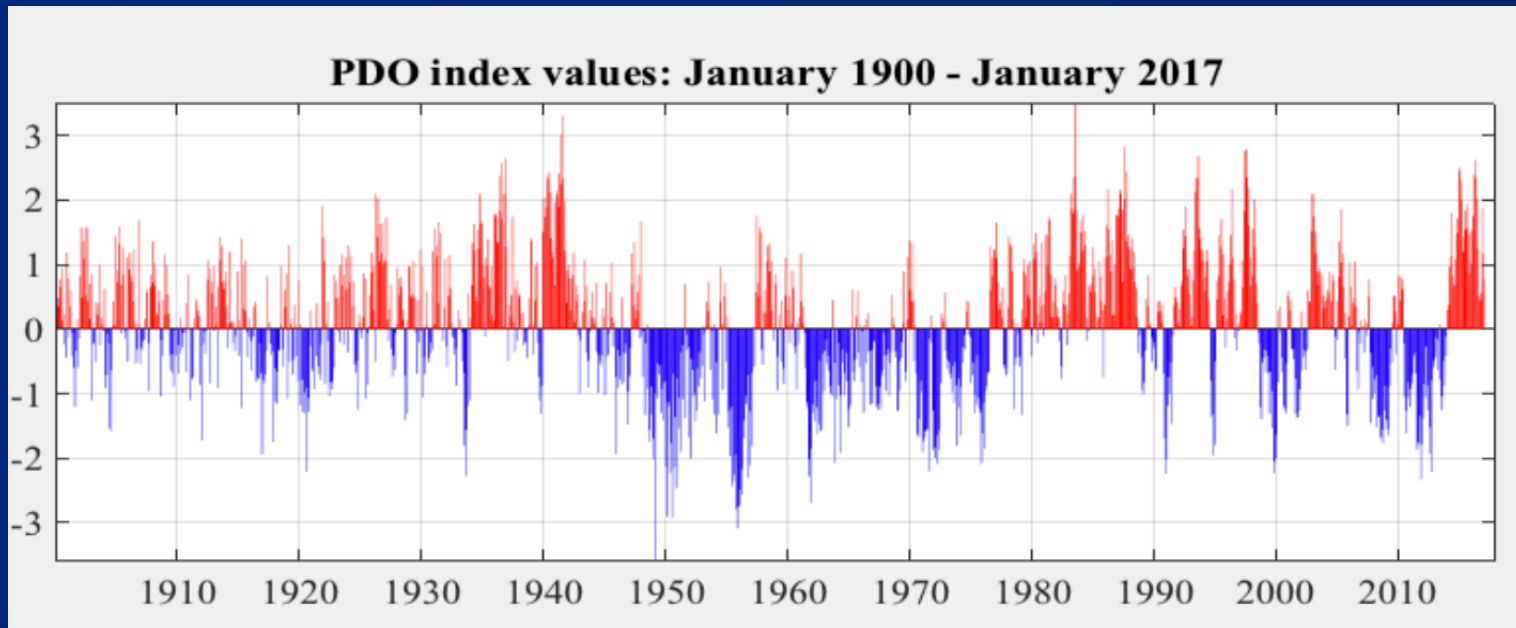
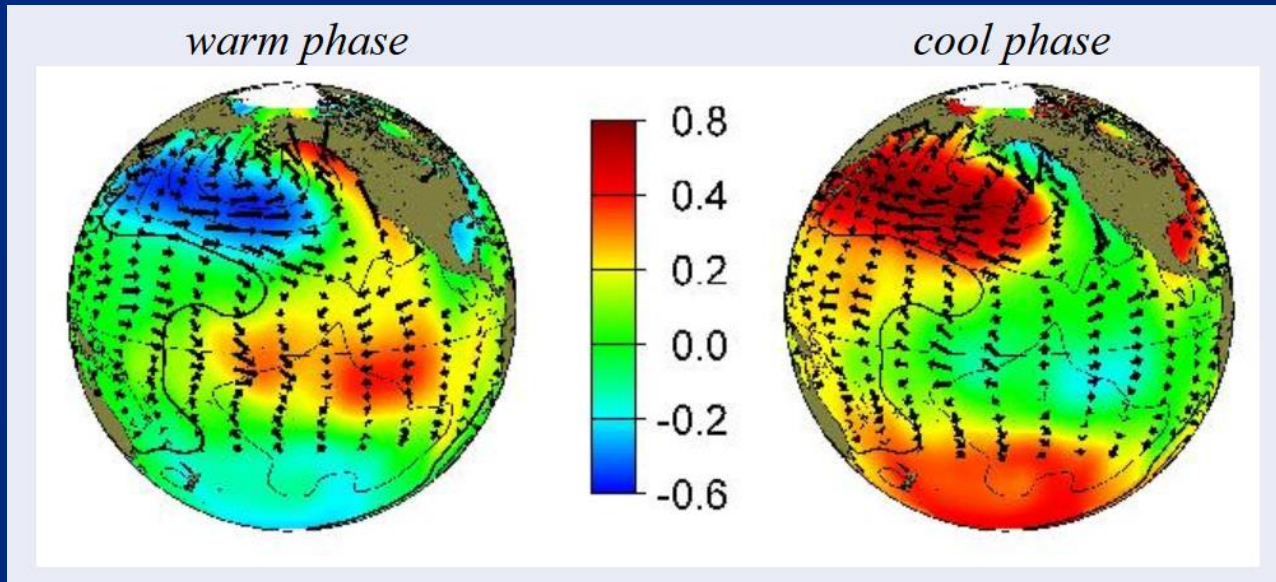
(Brinton, CalCOFI Atlases)

- Is advected north along coast during strong El Niños
- (Keister et al. 2005; Brodeur 1986)

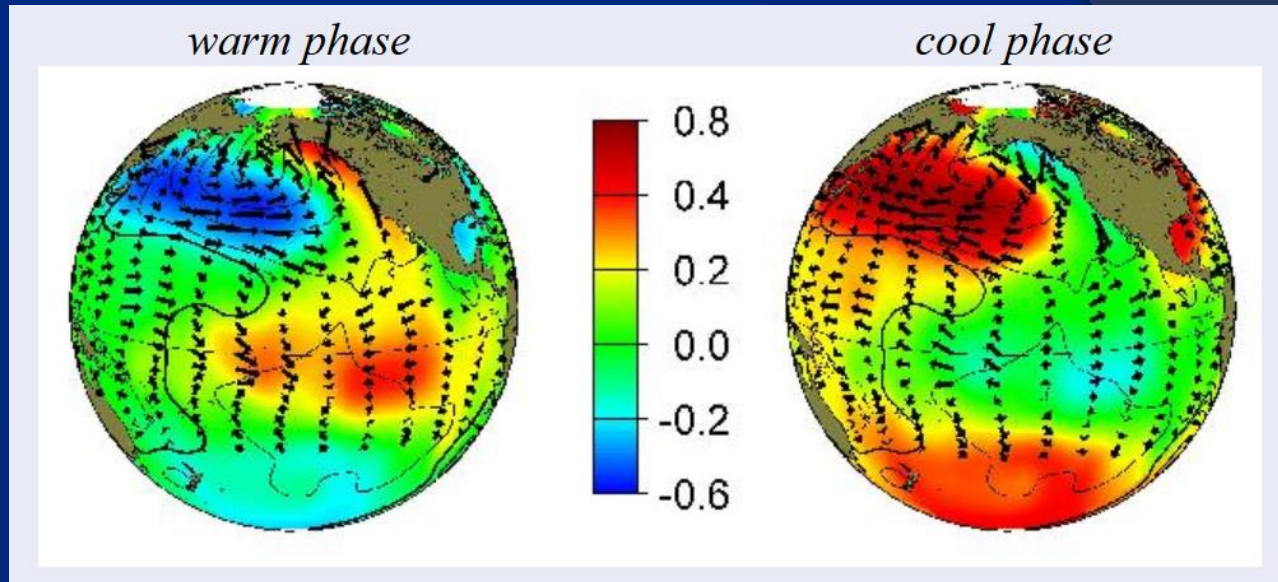
Weaker predictability in NO_3 and Chl-a changes in NEP:



Cycles: The Pacific Decadal Oscillation



Pacific Decadal Oscillation



California Current:

- Strong Aleutian Low
 - Enhanced gyre circulation
 - Weaker upwelling*
 - Higher SST
 - Higher Stratification*
 - Lower nutrients*
- Weak Aleutian Low
 - Weaker gyre circulation
 - Stronger upwelling*
 - Lower SST
 - Lower stratification*
 - Higher nutrients*

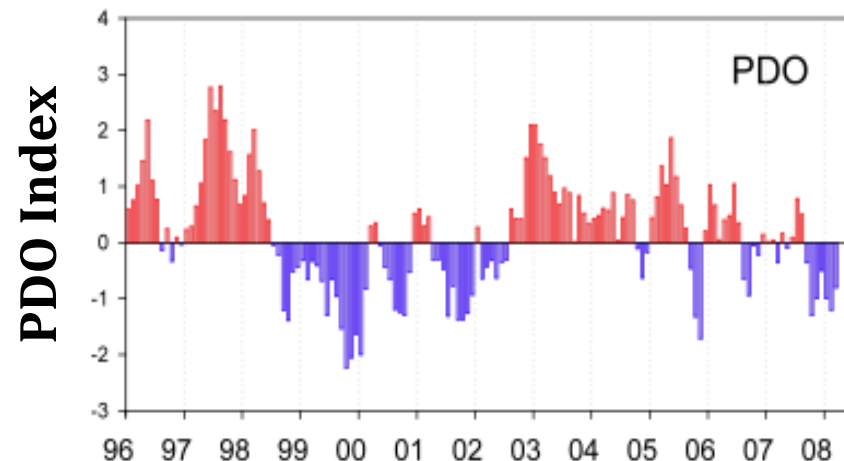
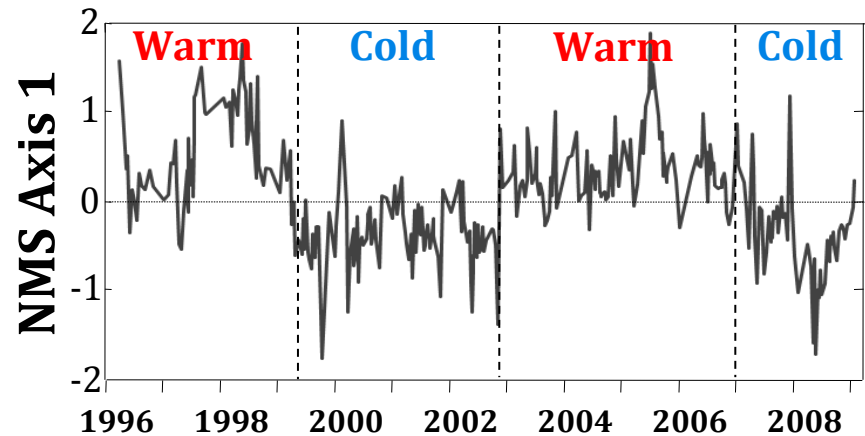
* Lower predictability

NMS Ordination Axis 1 scores

Copepod Community Index (CCI)

Oregon data

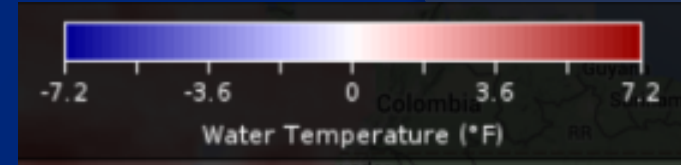
CON Time series
anomalies



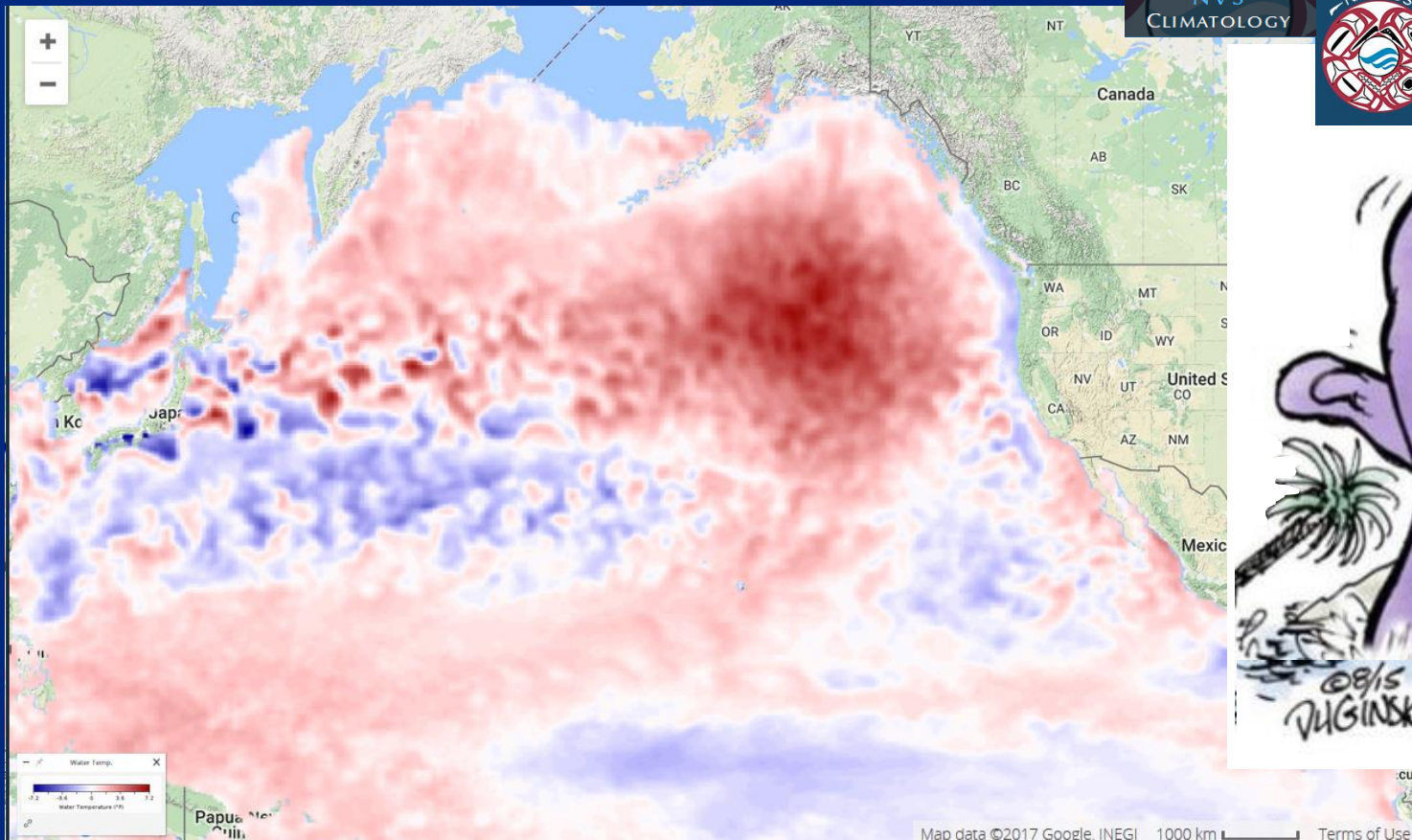
Pacific Decadal Oscillation

Extreme events: The Blob

SST anomalies



January 2014



NVS
CLIMATOLOGY



Map data ©2017 Google, INEGI 1000 km Terms of Use



NANOOS Visualization System:

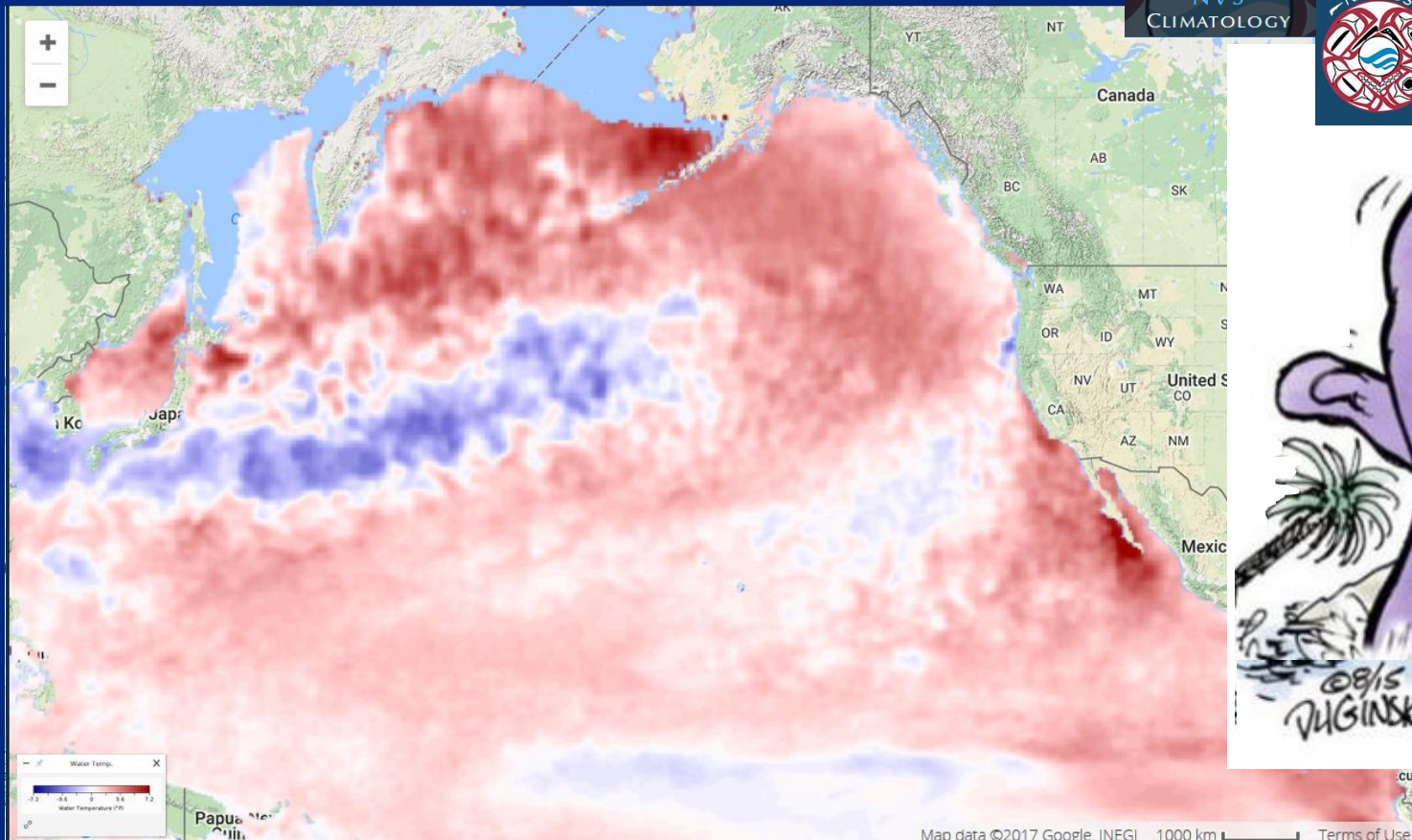
<http://www.nanoos.org/>



SST anomalies



July 2014

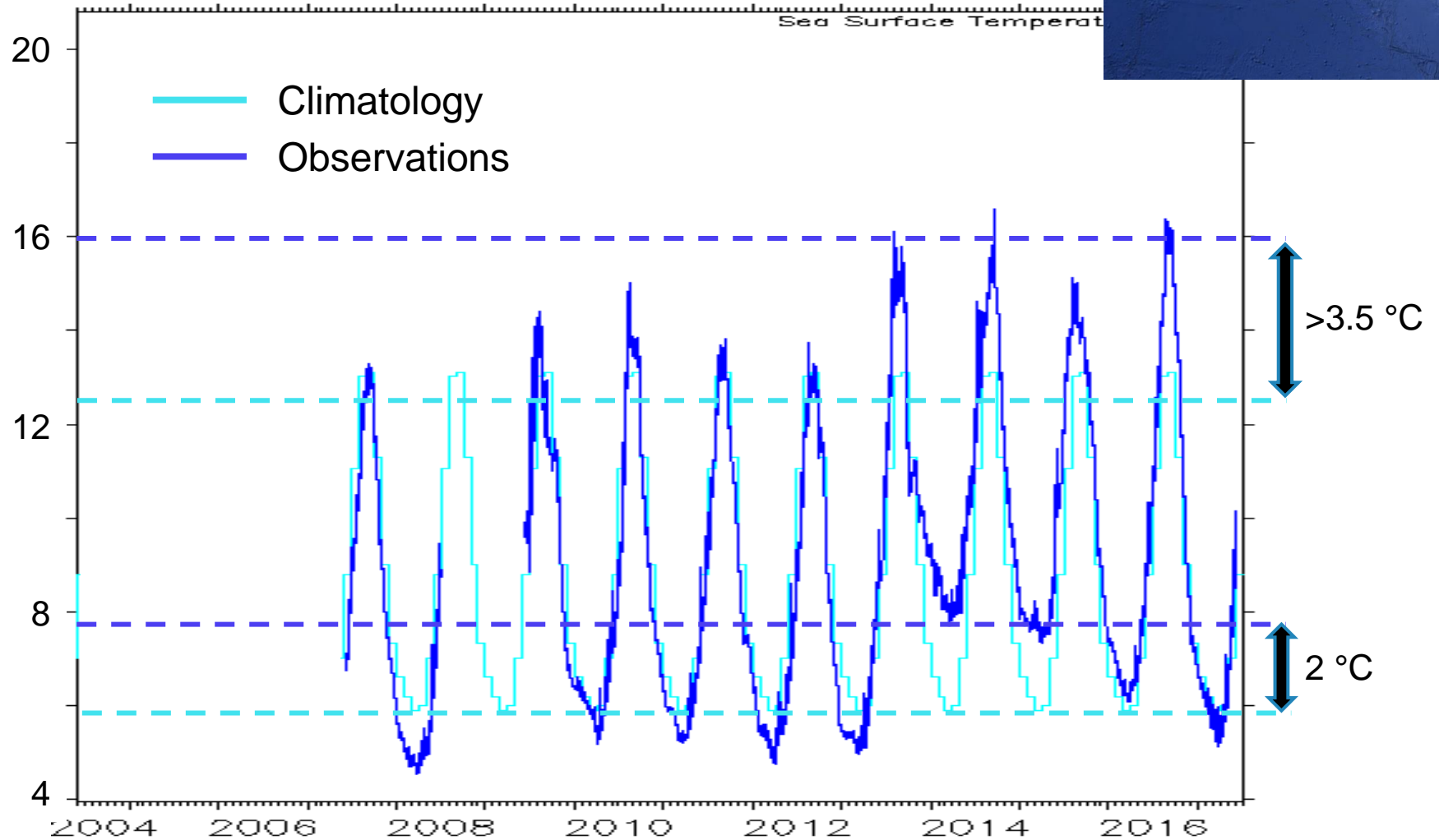


NVS
CLIMATOLOGY

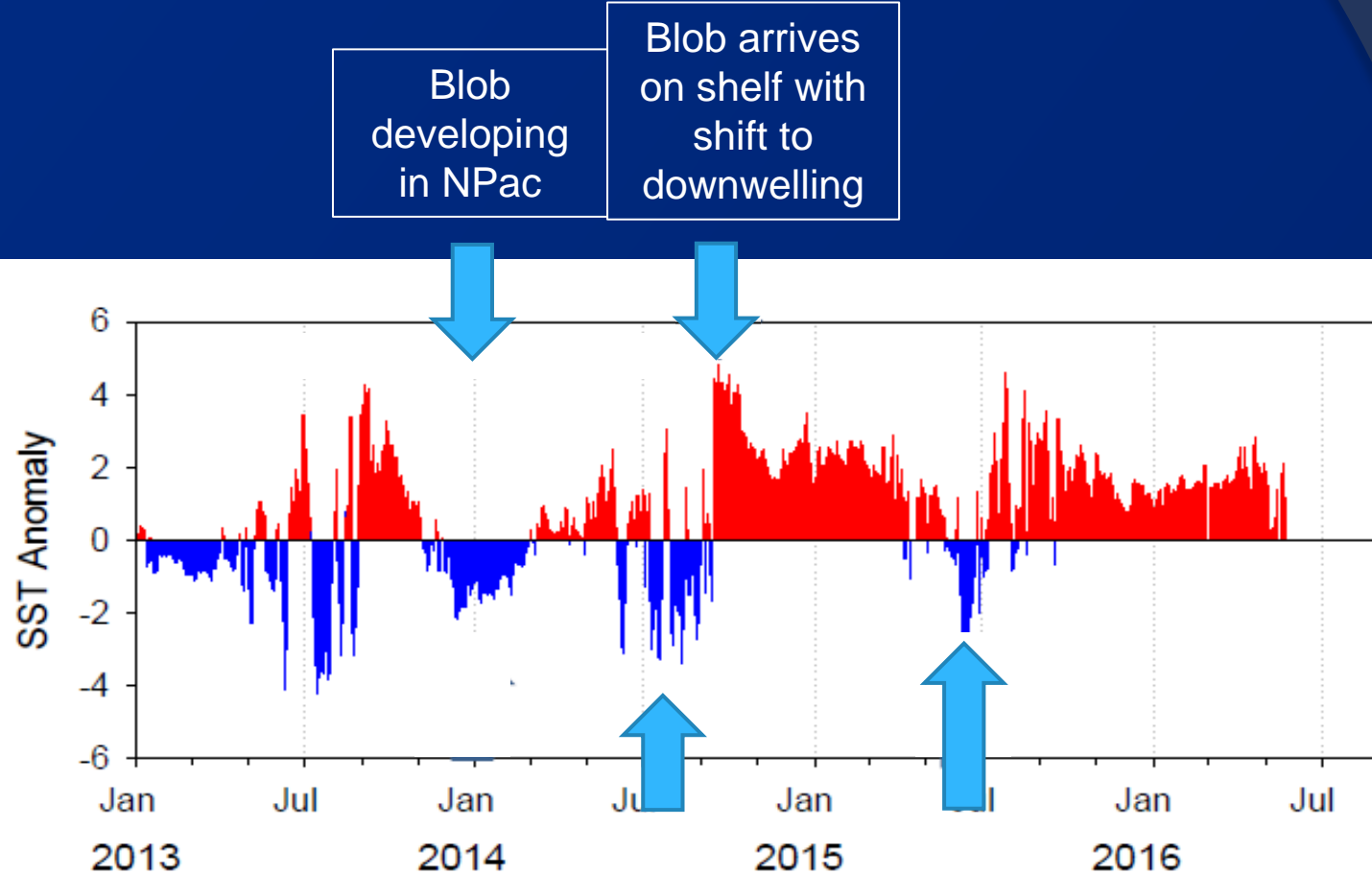




SST at Station P



Oregon shelf SST anomalies



Blob developing in NPac

Blob arrives on shelf with shift to downwelling

Summer upwelling holds Blob water off shelf

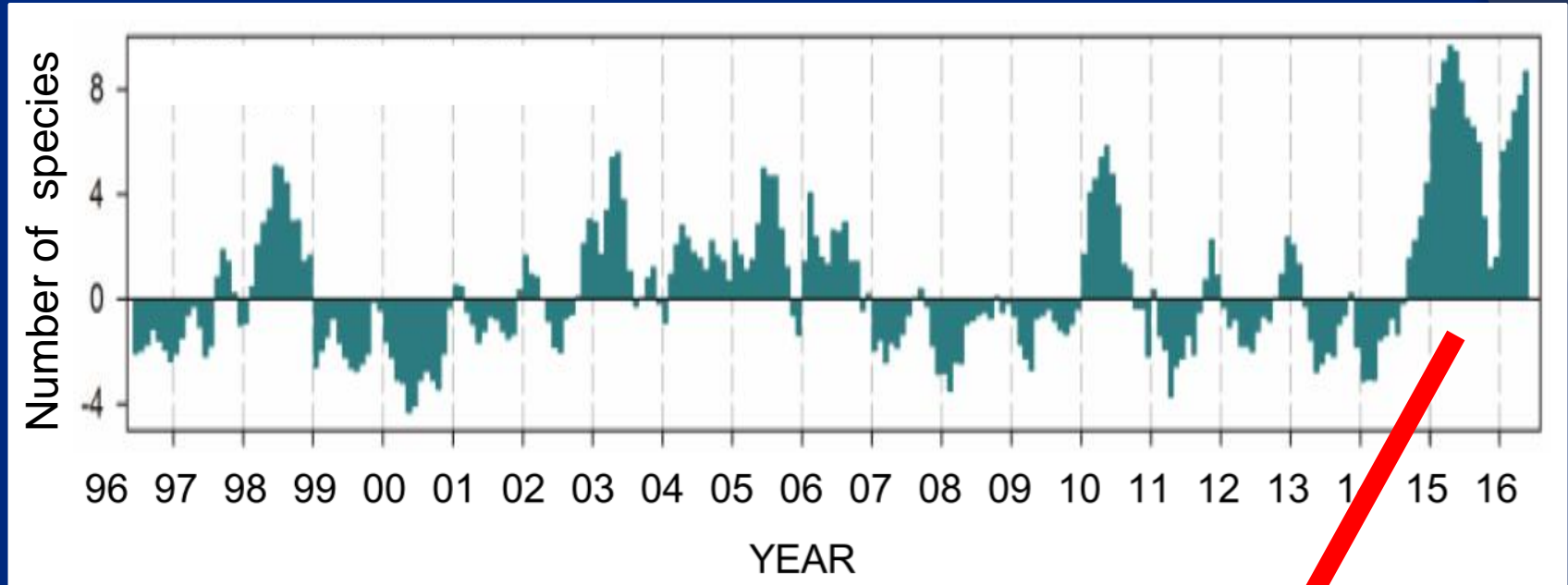
2015: Very strong upwelling winds, but weak upwelling signal in SST

Reported biological impacts during the Blob:

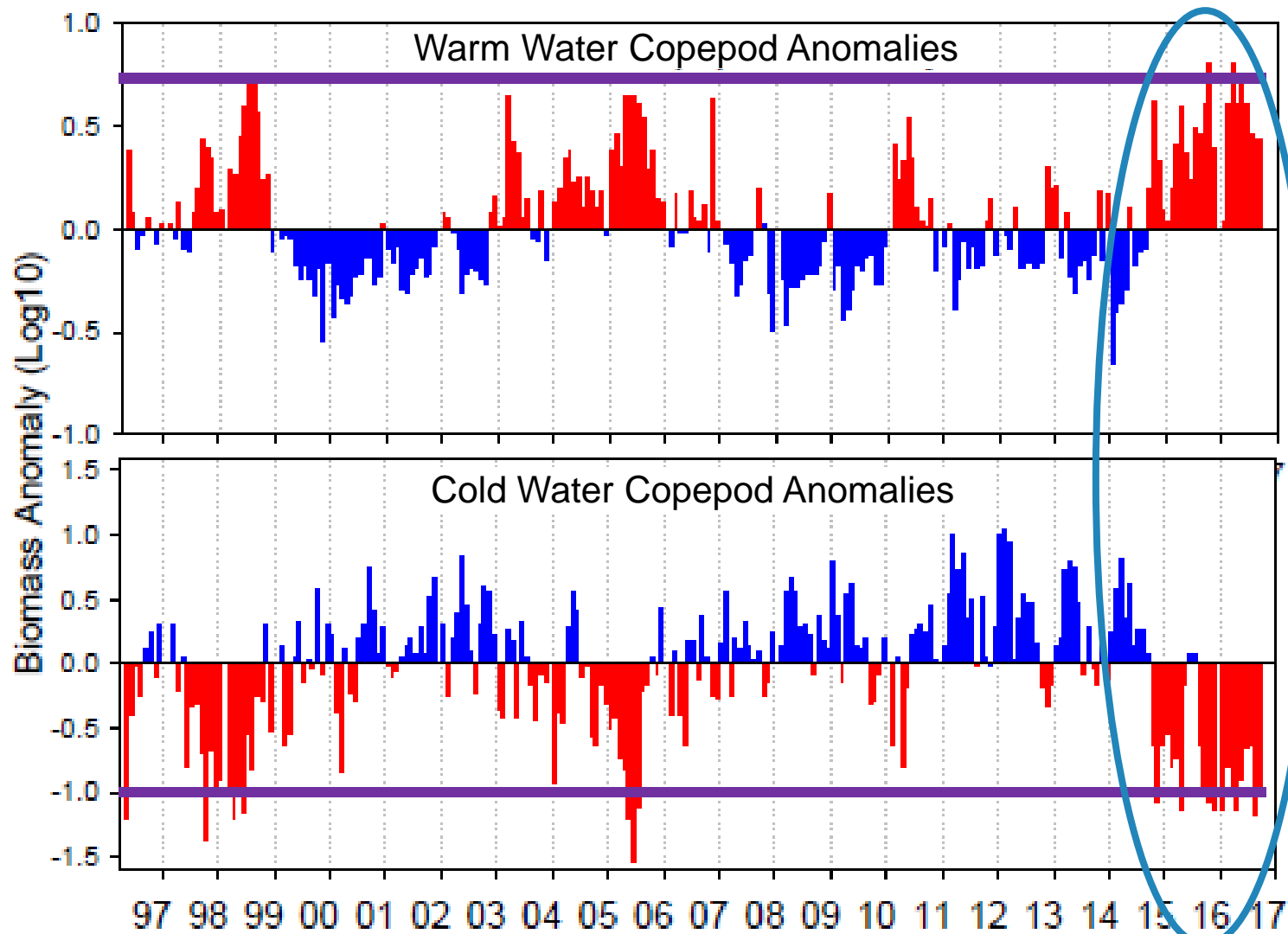
- Extremely low euphausiid biomass (C.T. Shaw)
- Massive Cassin's auklet die offs (J. Parrish)
- Abandoned and starved sea lion pups
- Unprecedented, wide-spread toxic *Pseudo-nitzschia* bloom (Du et al. 2016)
- Extremely low coho salmon returns
- Unusual species sightings of turtles, fish, sharks and whales



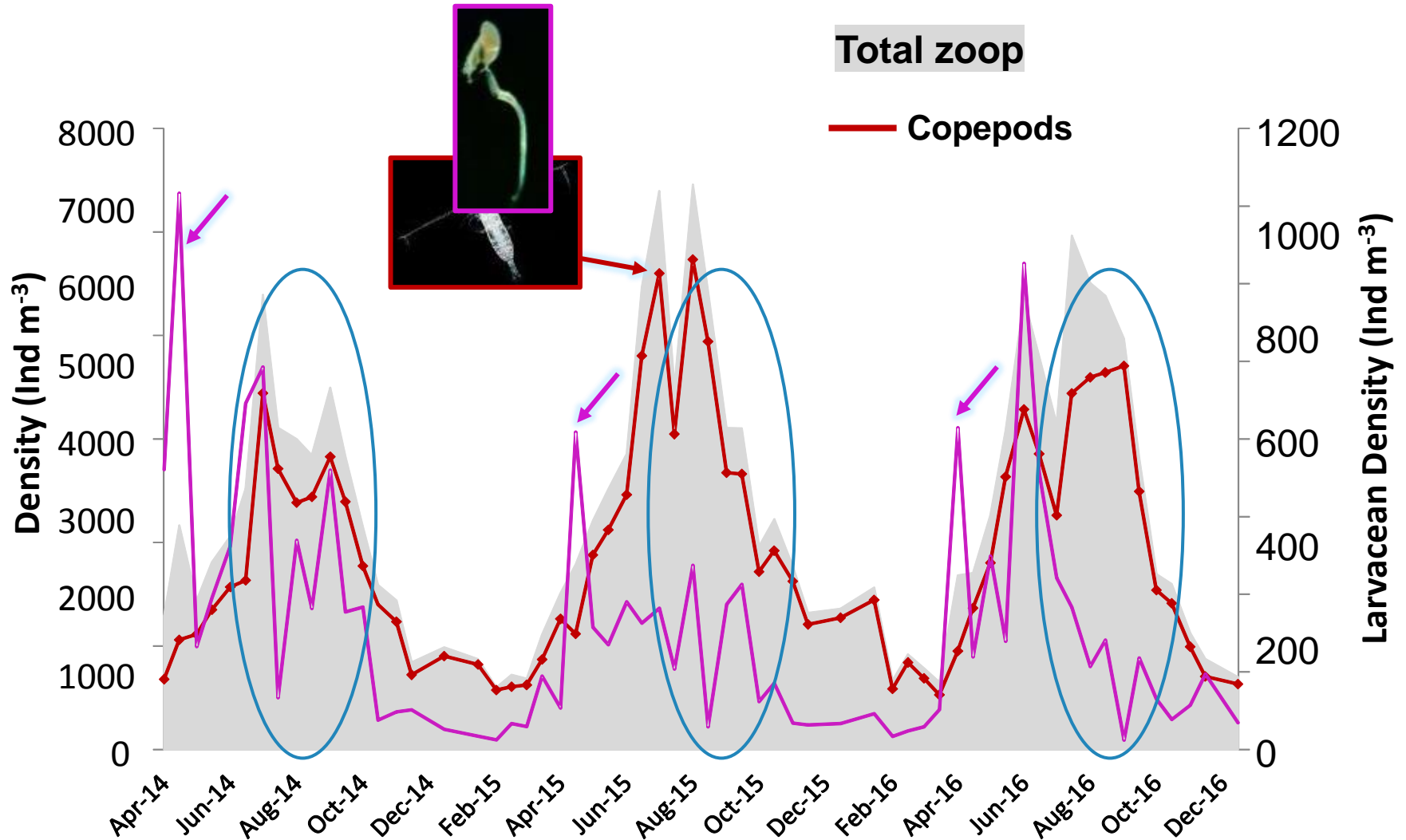
Copepod Species Richness highest on record during the Blob



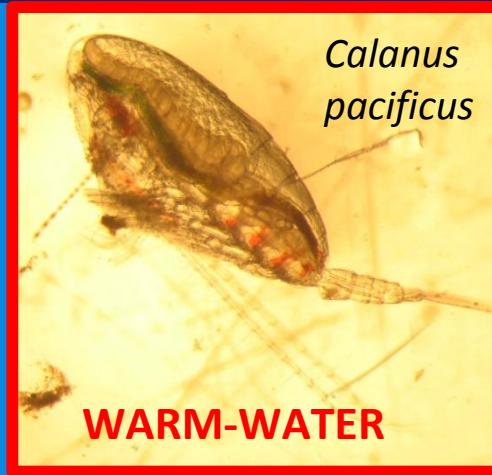
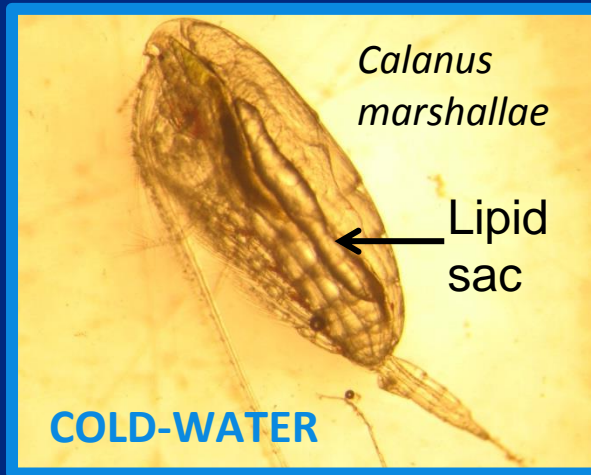
17 new copepod species observed on Oregon shelf in 2014-2015, many with Transition Zone/North Pacific Current associations.



Unexpected shifts in zooplankton abundances: Puget Sound 2014-2016



Implications of community shifts?

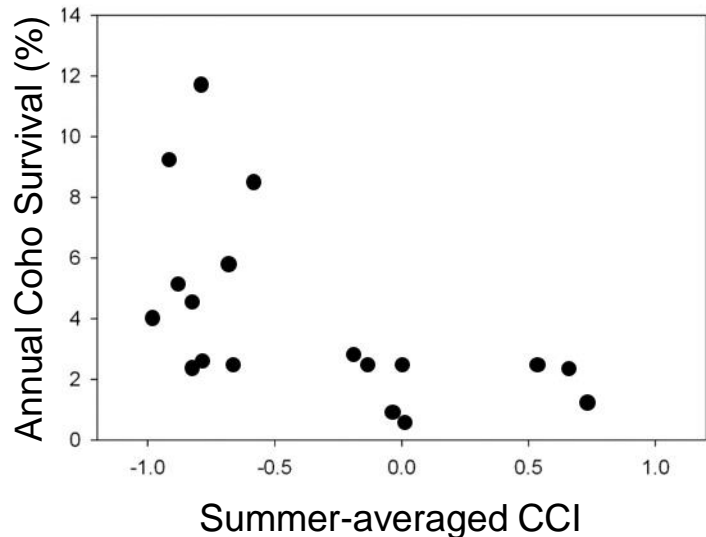


Boreal cold-water species =
larger and lipid filled



*Copepod
oil*

And....the copepod community index relates to salmon survival:

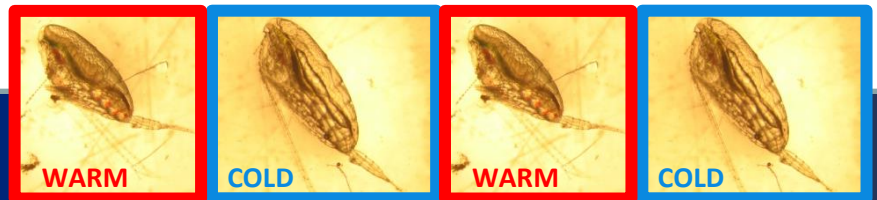
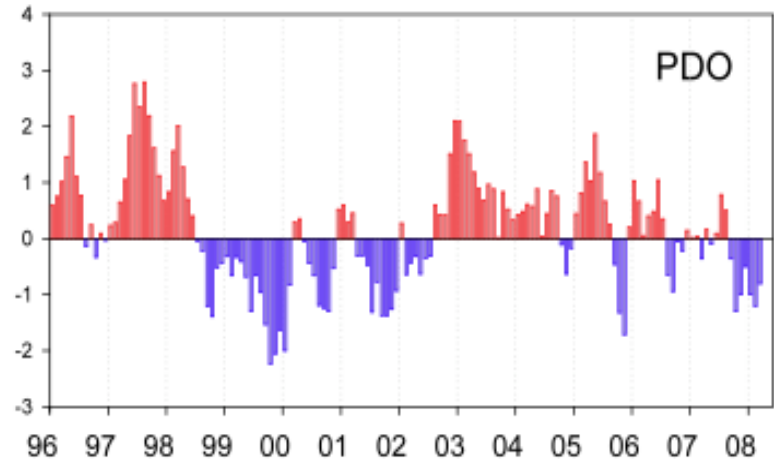


Cold water community

Warm water community



PDO Index



Lipids
EPA
EPA:DHA



Miller et al., 2017;
Trudel et al., PICES 2011
Keister, unpub. data

Peterson 2009

Keister et al., GCB 2011

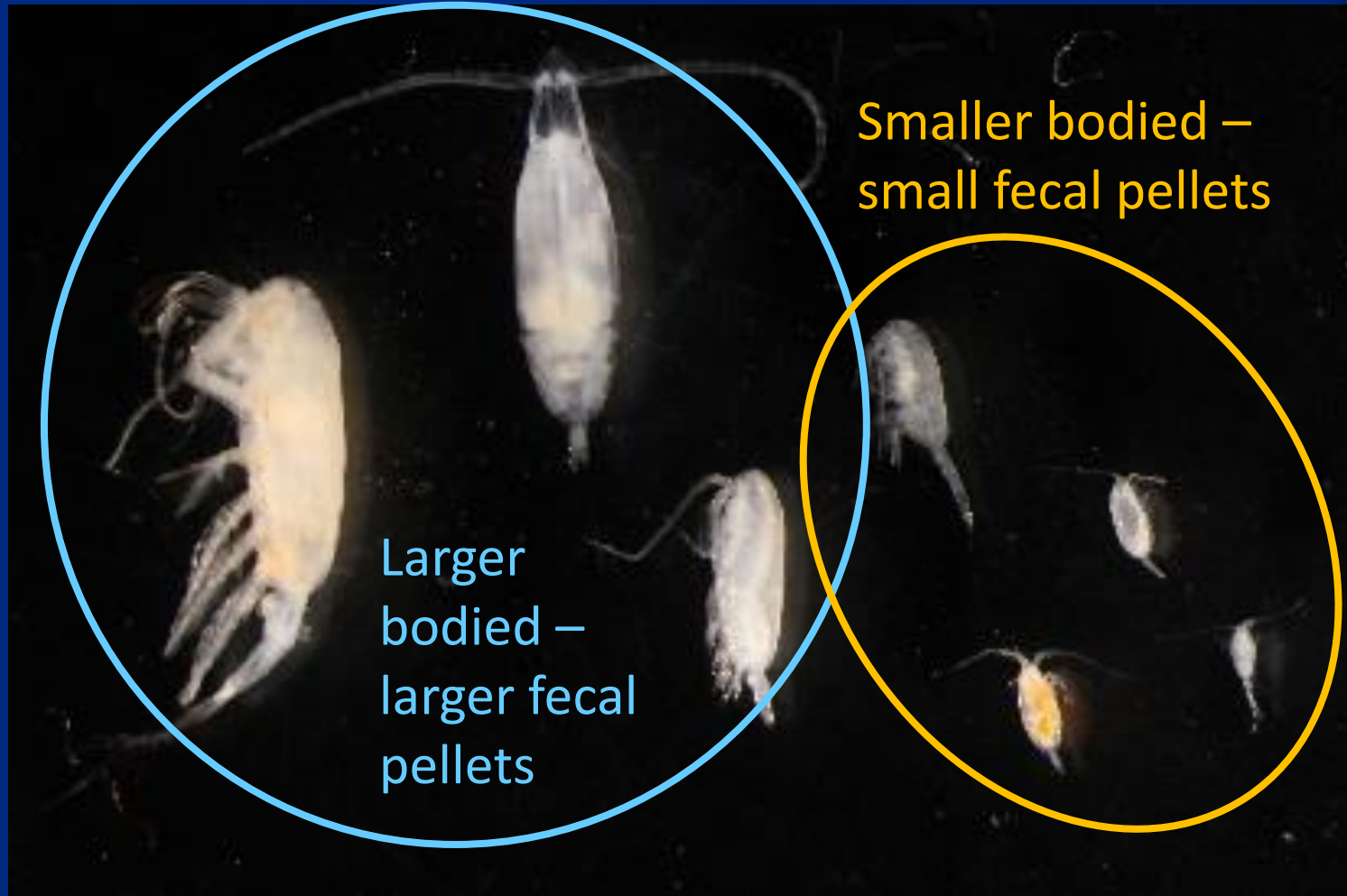
More differences among species: (Example: more copepods)

(Very speciose. The most numerous metazoans on the planet !)

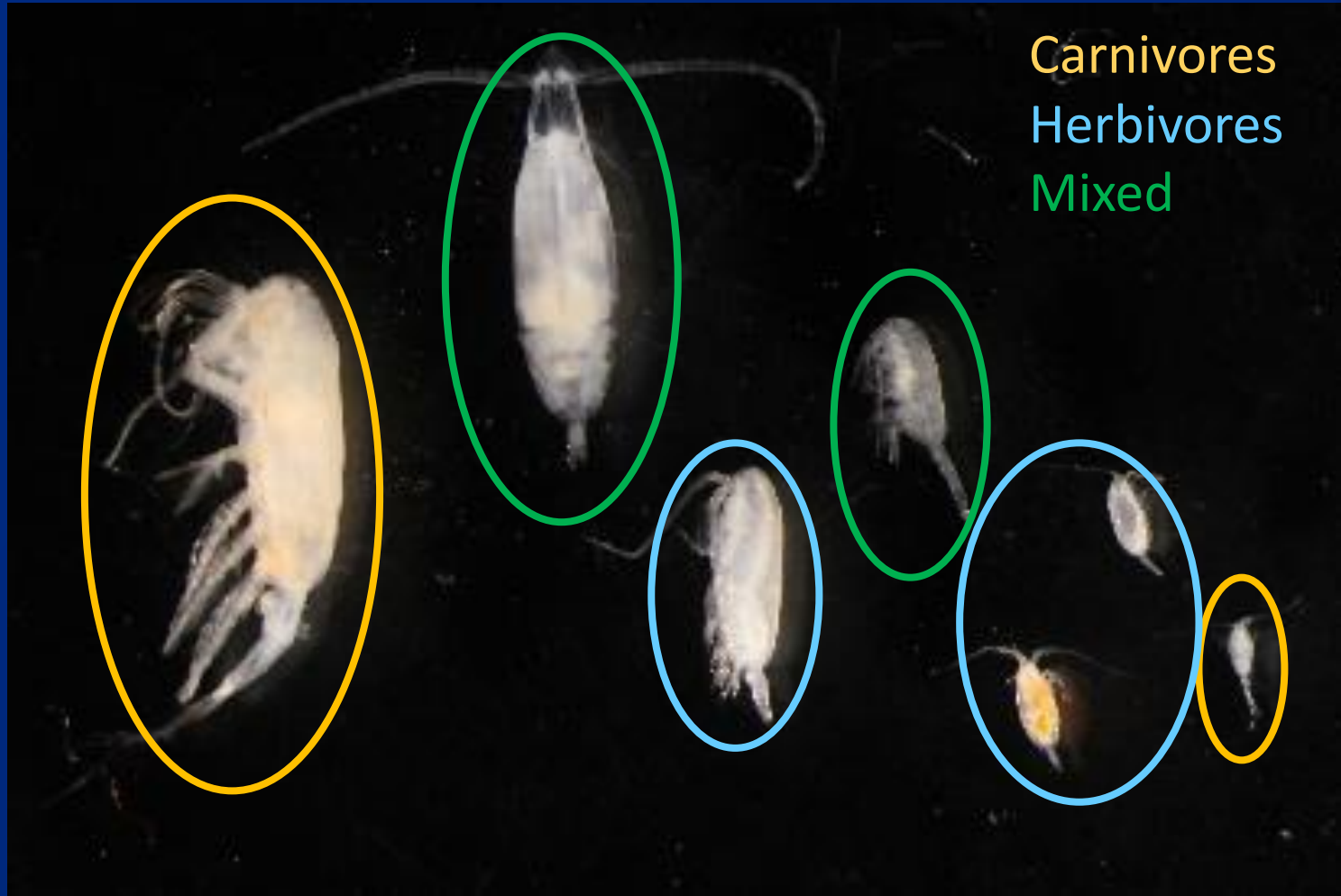
Boxshall and Halsey, 2004



Body size:



Trophic roles:



Migration differences:

Large
DVM

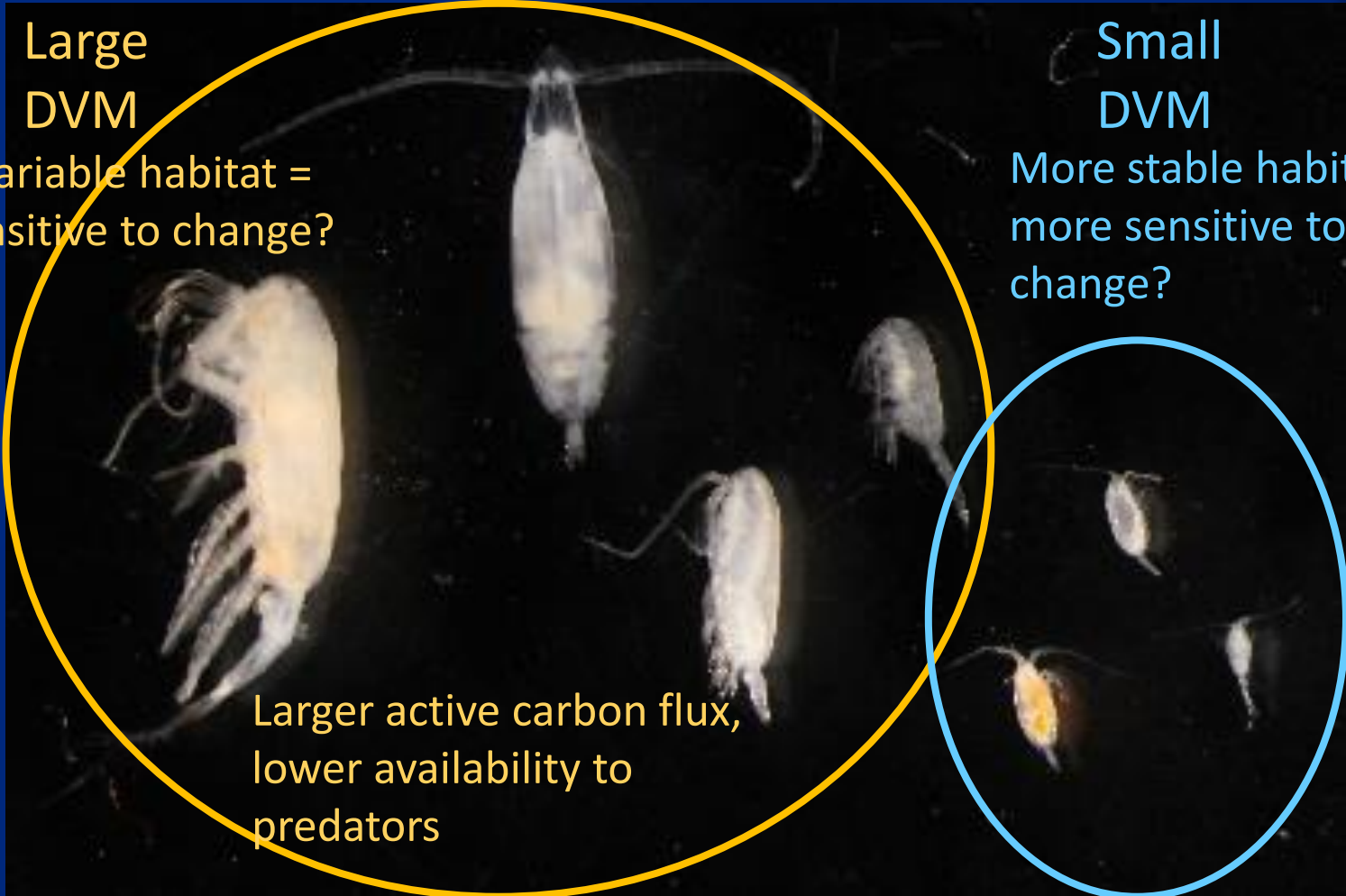
More variable habitat =
less sensitive to change?

Larger active carbon flux,
lower availability to
predators

Small
DVM

More stable habitat,
more sensitive to
change?

Lower carbon export, more
available to visual predators



With-in group food web effects:
Multiple trophic levels, even just within the copepods!



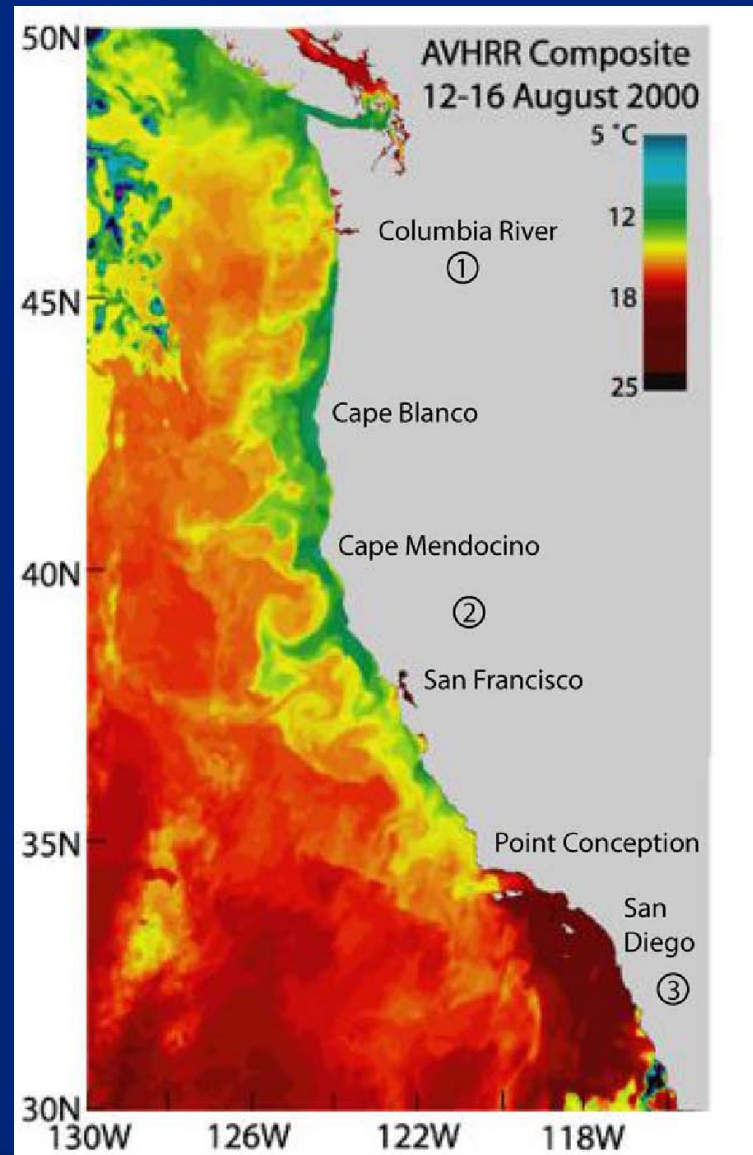
Conclusions:

- Big changes in zooplankton with climate variability
- Signals of advection are clearest and best demonstrated.

Biggest Remaining Challenge?

- Separating advection from population growth dynamics

Future Change



Funding:



Data Acknowledgments:

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N. Bond

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