Effects of the warm Blob on phytoplankton and zooplankton off central Oregon

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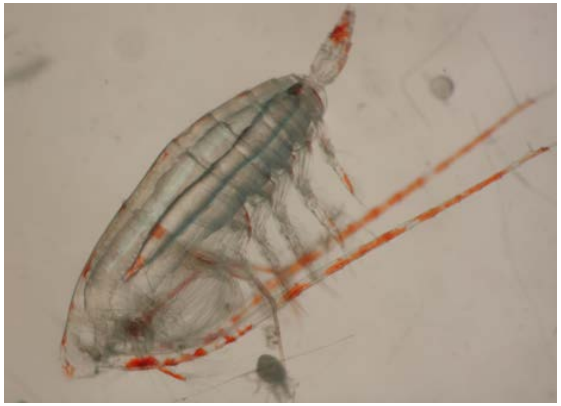
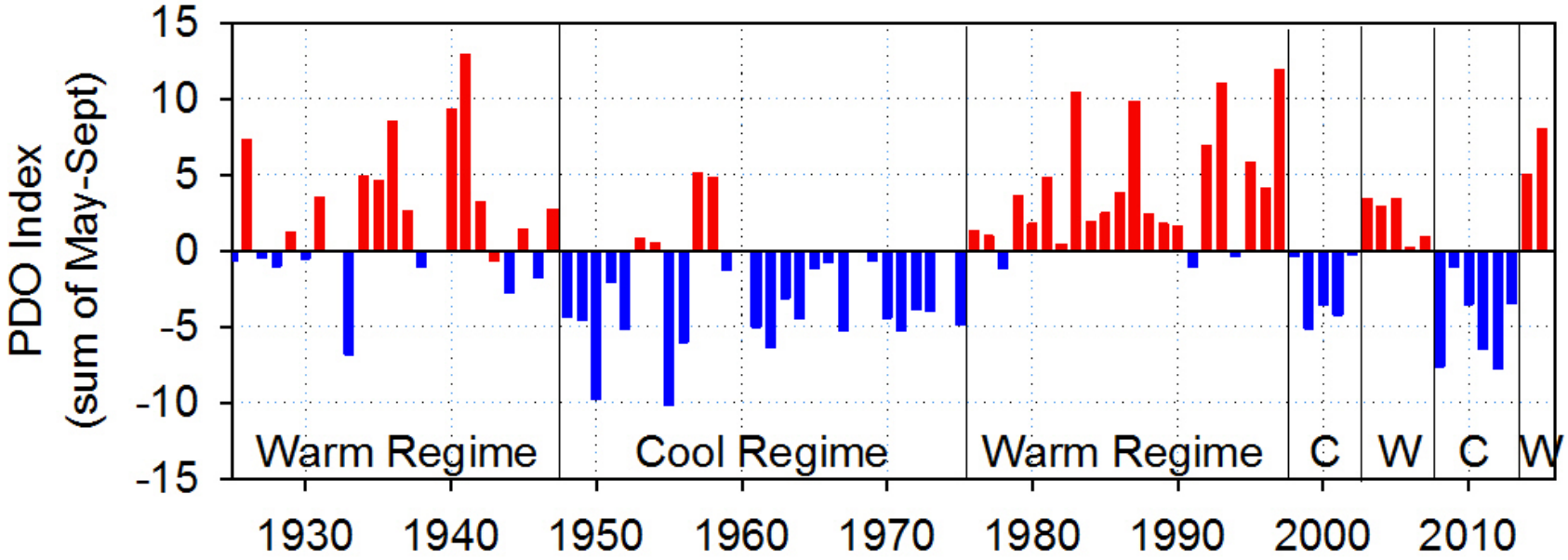
Presented by Tracy Shaw



In the 25 years since PICES was established, there have been many unusual oceanographic events in the eastern North Pacific (especially the California Current) that have affected the physics, plankton, and fisheries

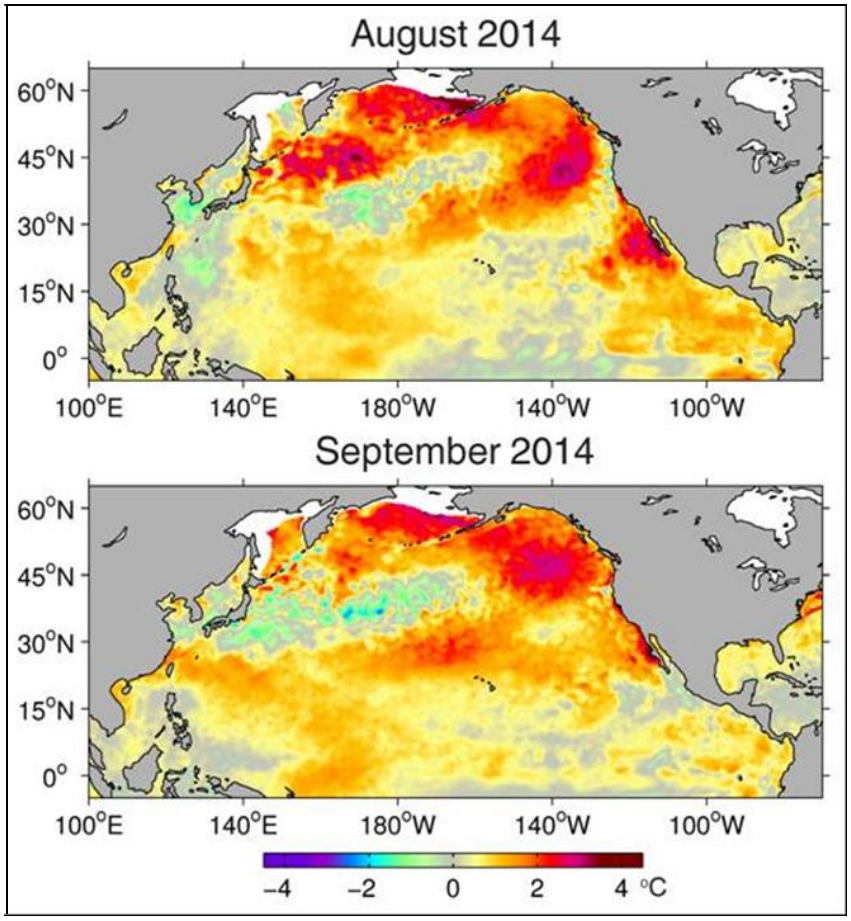
- Changes in the PDO from 20-30 year cycles to a 5-10 year cycle
- 1993-1998: extended "warm ocean" period
  (many salmon species listed as threatened or endangered)
- 1997-1998: “El Niño of the Century”
- 2002: sub-Arctic water intrusion
- 2003-2005: El Niño events
- 2005: Delayed upwelling
- 2006: Super-charged upwelling and associated anoxic/hypoxic event
- 2008: Cold North Pacific
- 2009-2010: El Niño event
- 2014-2015: The warm Blob
- 2015-2016: Another “El Niño of the Century”
  (but no apparent impact on the northern California Current)

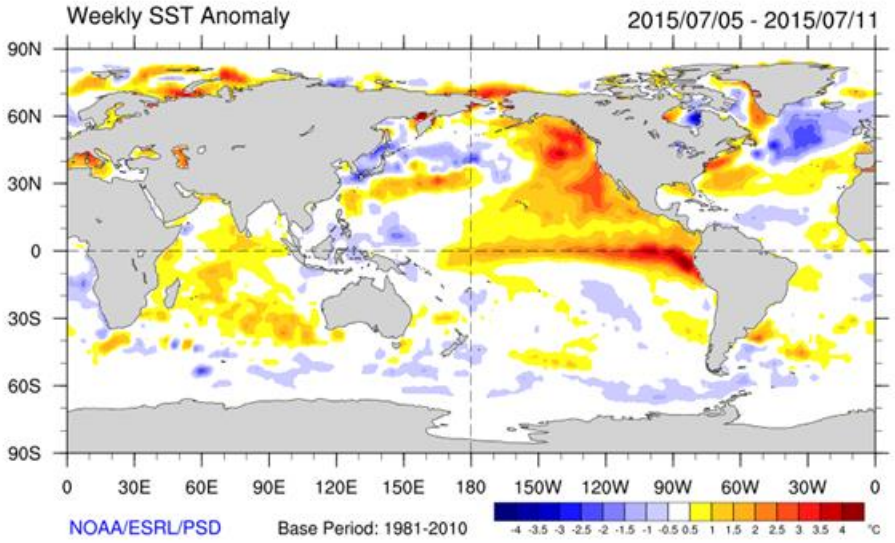
Importance of the last 25 years



- Change in PDO cycle from 20-30 years to ~5-10 years
- Recent high-frequency variability provides an interesting ‘experiment’ in assessing influence of climate variability on the ecosystem

The Blob begins: Two years ago, sea surface temperature anomalies of + 4°C in large regions of the North Pacific



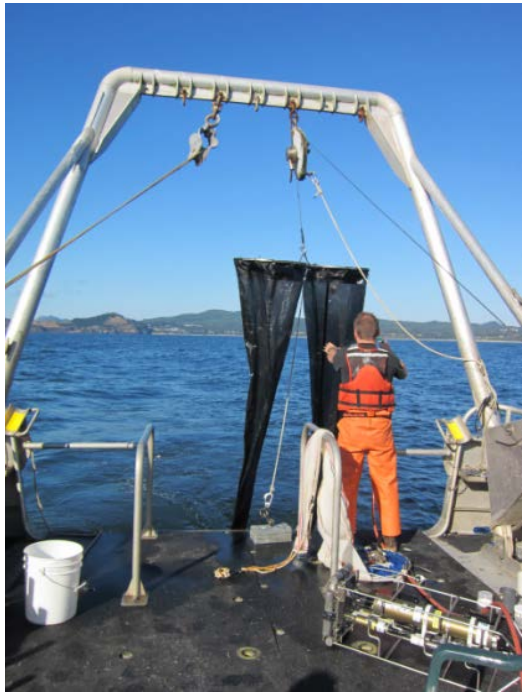


- By July 2015, an El Niño event was firmly established at the equator, but did not get to WA and OR as far as we know.

http://www.esrl.noaa.gov/psd/map/clim/sst.shtml

What we do at Newport

- **Long-term observations of ocean conditions** from ship-board surveys, twice each month, since 1996 (22 yrs).
  - CTD: Temperature, salinity, oxygen (hypoxia)
  - Water samples - Chl, nutrients, phytoplankton species composition
  - Net tows (vertical and bongo nets) - copepods, krill, other zooplankton, fish eggs and larvae



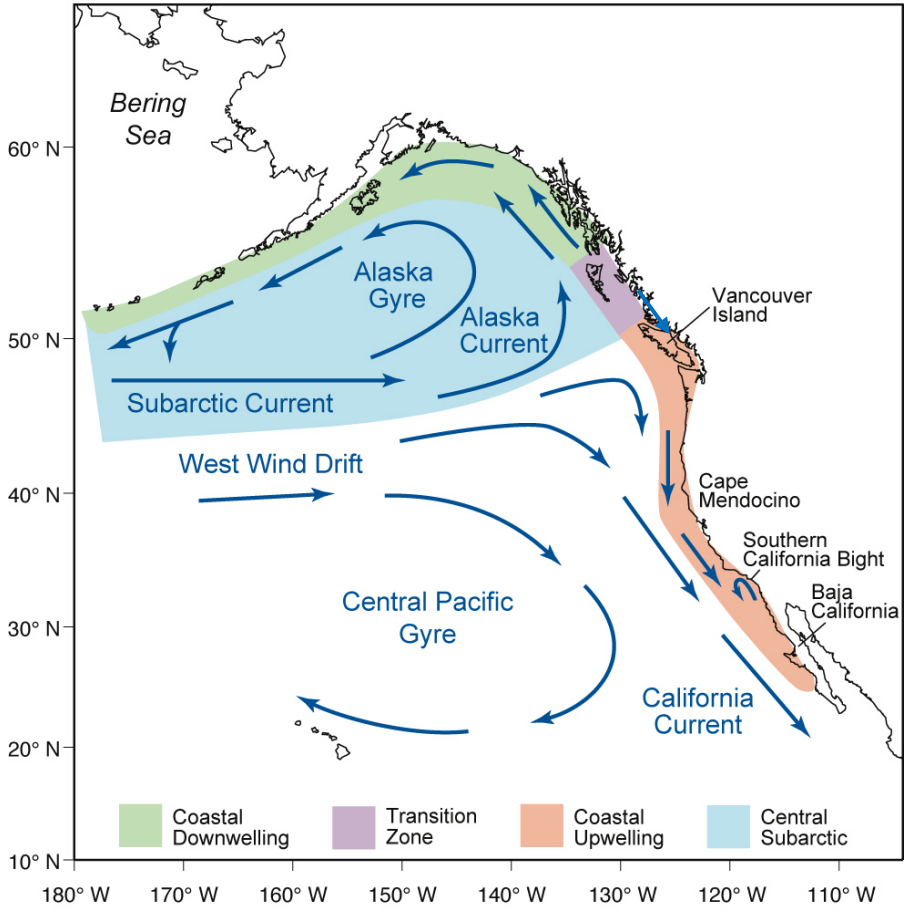
Frequent and persistent sampling allows us to track seasonal and interannual variability and unusual events (Blob, El Niño, HABs). Long-term time series provides context for how changes in ocean conditions affect our study area.

Source waters of the northern California Current

- Copepods, being planktonic, drift with the currents. Copepod species serve as indicators of particular water masses.
  - "Northern" species appear off Oregon when currents are from the north
  - "Southern" species may originate from:
    - coastal southern California through the Davidson Current in winter
    - coastal (south) and offshore (southwest) waters during positive phase of the PDO and El Niño events
- Warm Blob brought many species of copepods that are new or rare in Oregon Coast waters
    - Suggests that the source waters of the Blob were not the same as during previous warm events (El Niño or warm PDO)

Perhaps the two most important findings of our work are

- A **new view of food chain structure** and ecosystem dynamics, based on species composition (lipid content) of copepods and krill
- The importance of transport in determining food chain structure

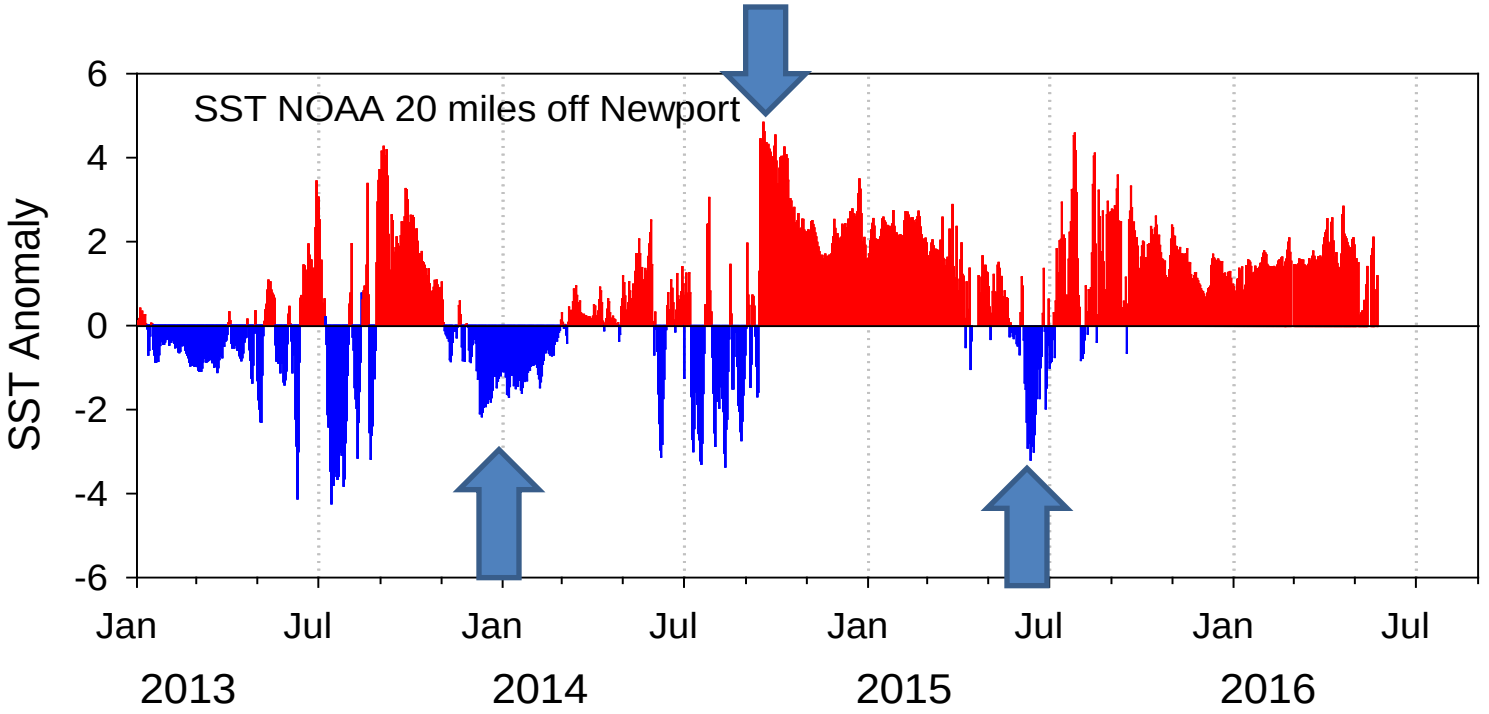


1. Subarctic Coastal Currents bring cold water and large lipid-rich **"northern" copepod** species to the N. California Current; (Cheeseburgers)

2. A weak California Current and/or onshore flow of the West Wind Drift brings warm subtropical water and small lipid-poor subtropical **"southern" copepods** to the NCC (Celery)

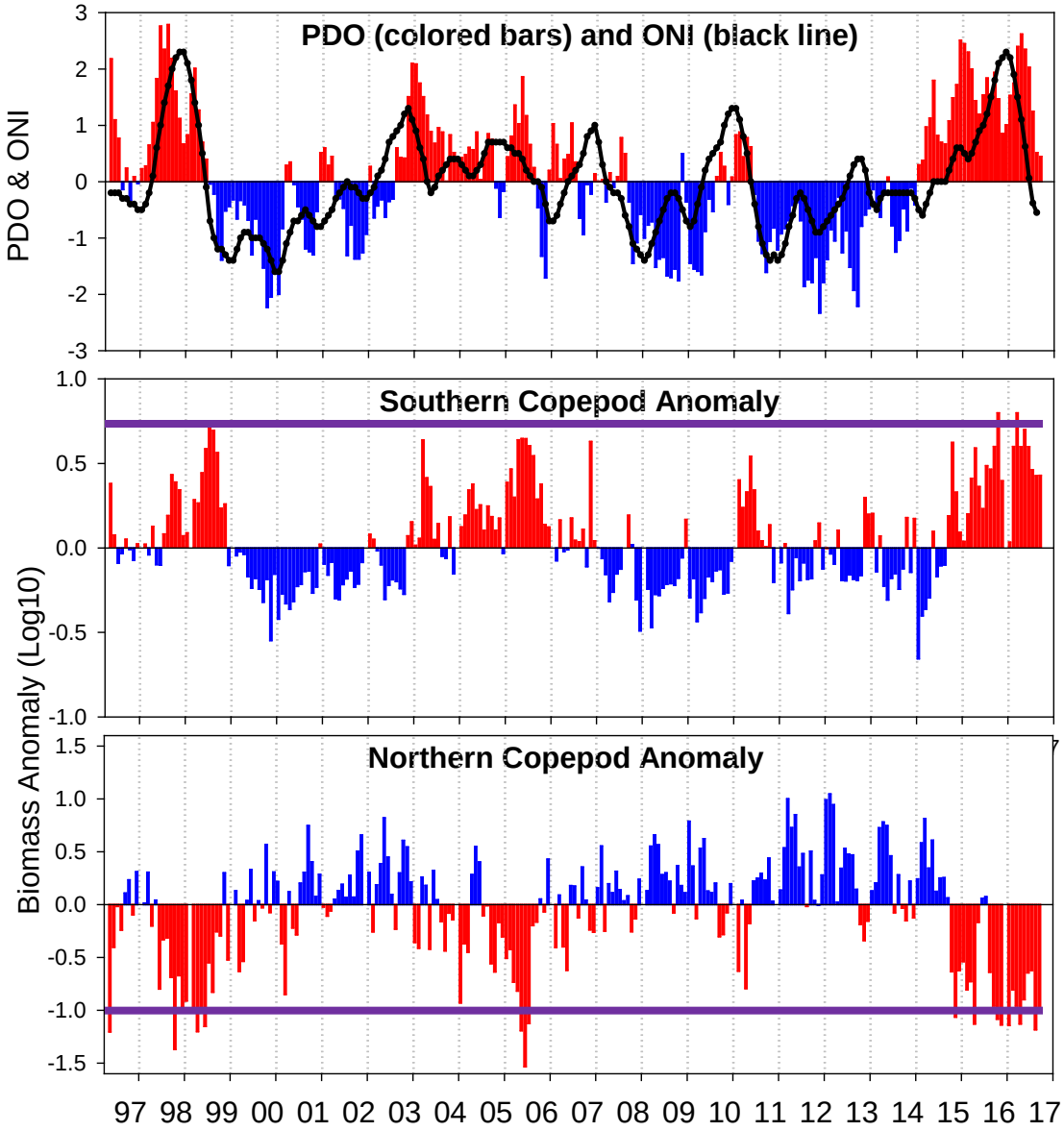
3. Therefore, bioenergetics of the food chain is affected by the source waters which feed the Calif. Current

SST anomaly off Newport Oregon: 2013-2016



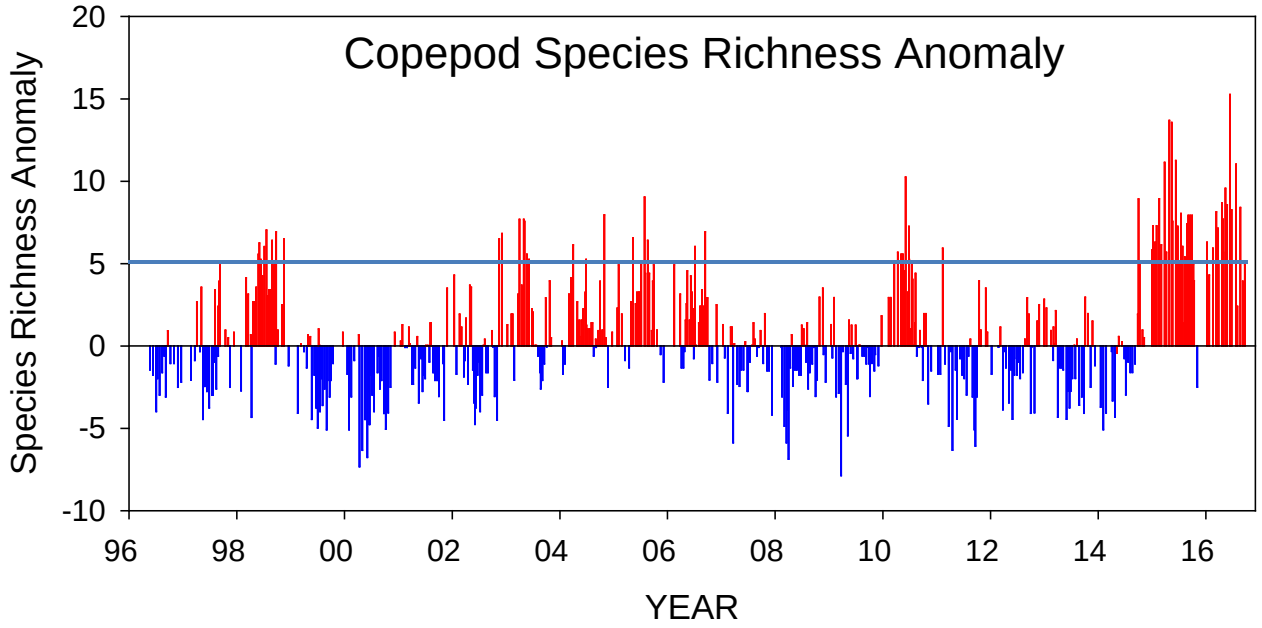
- Blob forms in winter 2013-14; winter unusually cold at Newport
- 14 Sep 2014: Northerly winds weakened, the Blob came onshore and SST jumped 6°C in a few hours, to 19.4°C
- Summer 2015: strongest Northerly winds in 20 years but minimal signature in SST – upwelling winds ineffective because the water column was so highly stratified

PDO, ONI, Southern and Northern Copepods



- N and S copepod biomass track the PDO and ONI closely, with a lag of a few months
- S anomalies during the Blob were similar to past El Niño events and positive PDO phases
- N biomass an order of magnitude lower during warm phase of PDO and during Blob

Copepod Biodiversity Anomaly



- The big difference was the increased number of copepod species – 17 more than usual, many new to the Oregon coast!
- Richness anomalies were double those observed during prior positive PDO phases and El Niño events.

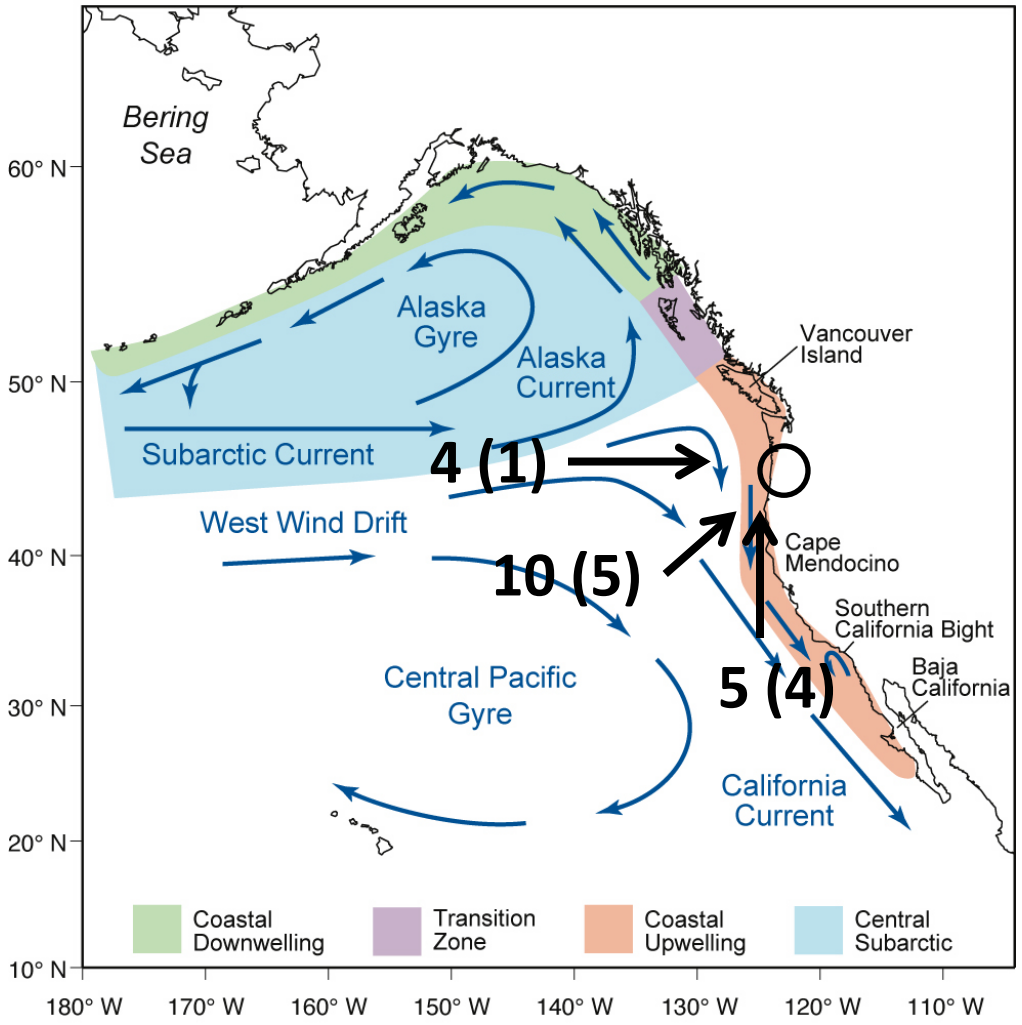
Copepod Species new to Oregon or generally rare but common during the Blob

Transition Zone – n=4 species, n=1 new

Central Pacific Gyre – n=10 species, n=5 new

Temperate Sub-tropical Coastal Neritic – n=5 species, n=4 new

Other – n=5 that aren't affiliated with a particular water mass.



Copepod species new to Oregon (*) or seen rarely, but that were seen commonly during the Blob
(note: some new species still await identification)

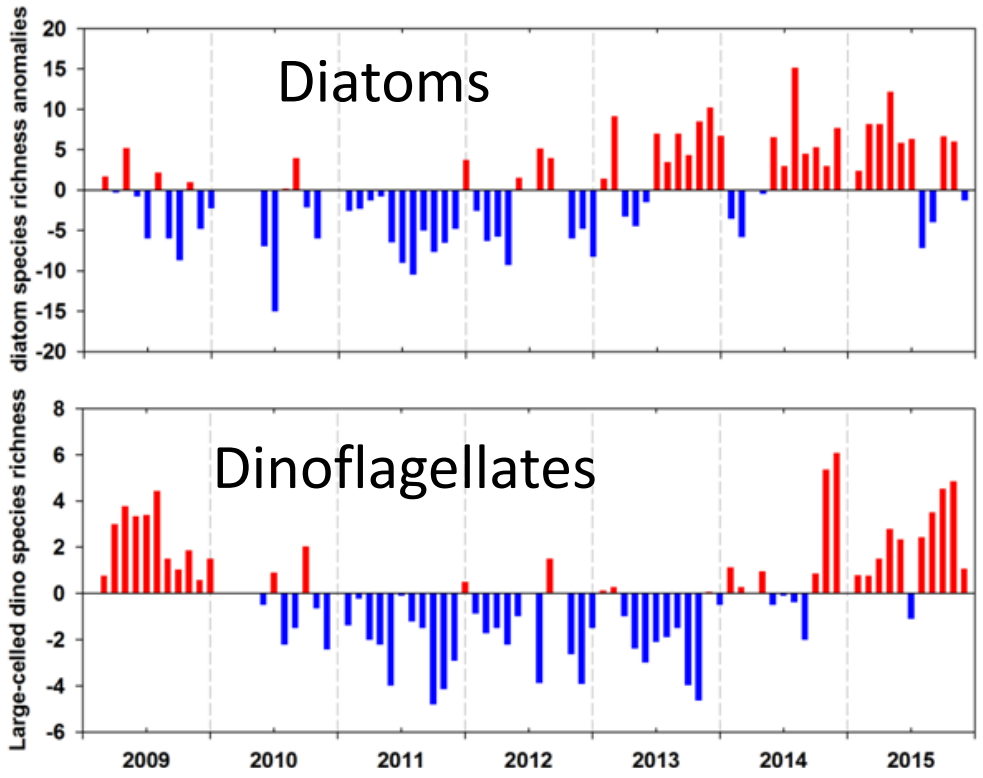
Transitional Zone species: *Pleuromamma borealis*, Heterorhabdus tanneri, Scolecithricella ovata, Centropages bradyii*

Central Gyre (North Pacific Gyre) Species: *Euchaeta media, Mecynocera clausi*, Pleuromamma xiphias*, P. abdominalis, Eucalanus hyalinus , Clausocalanus lividus, C. farrani*, C. furcatus*, Subeucalanus crassus*, Heterorhabdus papilliger*

Temperate-Subtropical Coastal Neritic Species: *Acartia negligens*, Temora discaudata*, Clausocalanus jobei, Acrocalanus* spp*, *Paracalanus* spp (not parvus) *

"Warm water species" new to Oregon which lack clearly defined water mass affinities: *Calocalanus pavo*, Calocalanus pavoninus*, Scolecithricella dentata*, Acartia pacifica*, Labidocera euchaeta**

Phytoplankton Biodiversity Anomaly



- Diatom diversity increased in late 2013, with 5-10 more species than climatology (2009-2016)
- Dinoflagellate diversity increased only when the Blob came ashore.

The most notable effect of the Blob on phytoplankton was a harmful algal bloom, initiated in spring 2015

For details see Du et al. PLOS ONE (published 12 Oct 2016)

The 2015 *Pseudo-nitzschia* (PN) bloom

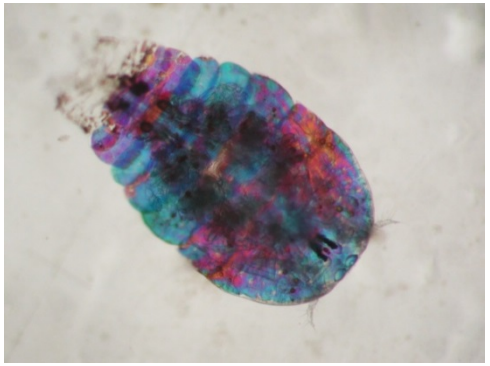
- The 2015 bloom was toxic, of long duration (April-October), and resulted in some of the highest concentrations of domoic acid ever recorded in shellfish and fish.
- **Synchronous throughout west coast, indicating it occurred in response to a common coast-wide trigger… such as the Blob ☺**
  - **Blob resulted in a highly-stratified water column and subsequent nutrient limitation**
- **P-N made up 90% of diatoms during peaks in toxcicity**
- **Passed up the food chain from diatoms →clams →Dungeness crabs**
- **For the first time**, the Dungeness Crab fishery was closed off OR and CA as a result of high levels of domoic acid. The Oregon fishery only closed for six weeks, but the CA fishery for most of the year. Total economic loss on the order of $60-70M coastwide.

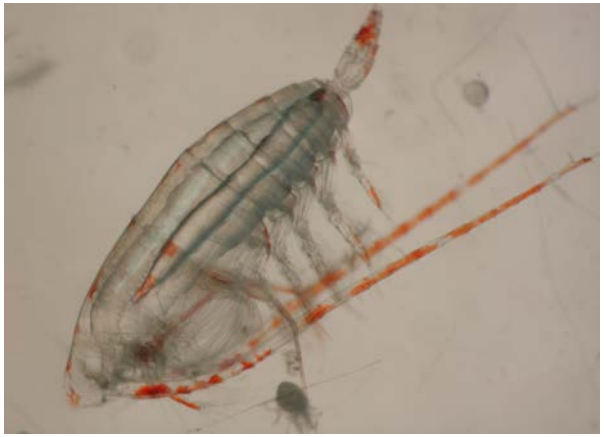
Summary

- Copepod community associated with the Blob was different from anything we've seen on the Newport Line in the past 22 years
- Water mass affiliations of the new and rare copepod species indicate that source waters of the Blob were from a more southerly and/or offshore source than it was for other warm events (El Niño or warm PDO phase)
- Toxic *Pseudo-nitzschia* bloom ~7 months duration
- Economic impacts of the Blob:
  - Poor food source for juvenile salmon; may affect salmon returns for the next several years
  - Toxic algae bloom affected seafood harvests

Expectations for 2017

- **Small, warm water, lipid-poor copepods** have been the dominant community since September 2014.
- There is a 4-6 month lag between change in sign of the PDO and a switch in the copepod community. The PDO is now neutral but trending towards negative. If this persists, the copepods should transition to a **cold-water lipid-rich** community by spring 2017.
- Have already seen marked declines in returns of coho salmon (in 2015 and 2016) and spring chinook salmon to the Columbia River in spring 2016.
- Lower salmon returns expected through at least 2017 and 2018.
- Surprisingly, The Blob returned briefly in late summer 2016 but appears to have dissipated once again. **Will it return?**





Thank you for your attention