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Ecosystem Effects of Recent Poor Ocean Conditions: the Blob and El Niño

Bill Peterson
Oceanographer and Senior Scientist
Northwest Fisheries Science Center
Newport OR

What we do at Newport

- Long-term ocean observations from ship-board surveys, fortnightly, since 1996.
- Track oceanographic and ecosystem conditions
  - Temperature, salinity, oxygen, nutrients, aragonite saturation
  - Collect samples and enumerate to species phytoplankton, zooplankton (copepods and krill) and fish eggs/larvae
- With such data, we can follow the development of unusual events (Blob, El Niño, HABs) before, during and after such events.
- From these data we provide (among other things) outlooks of the number of adult salmon returning to the Columbia River, 1-2 years in advance

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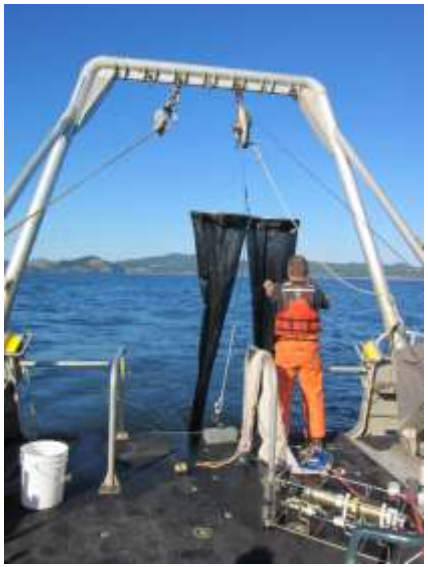

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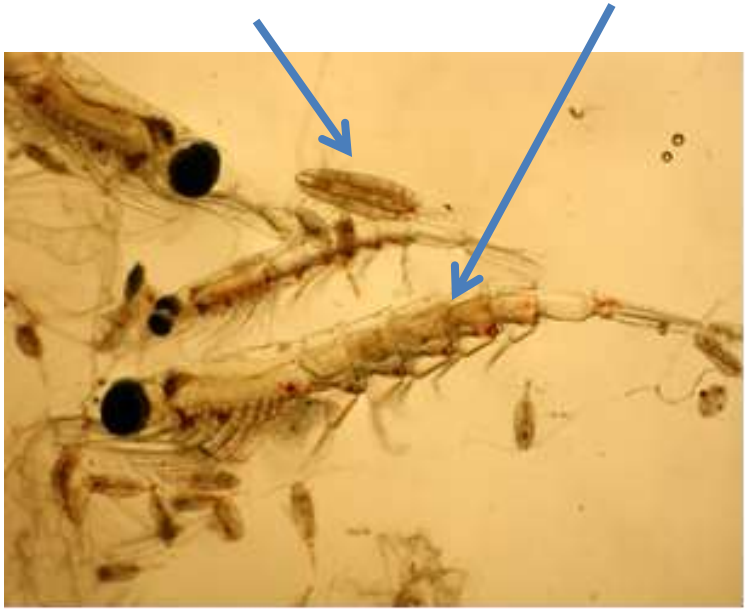
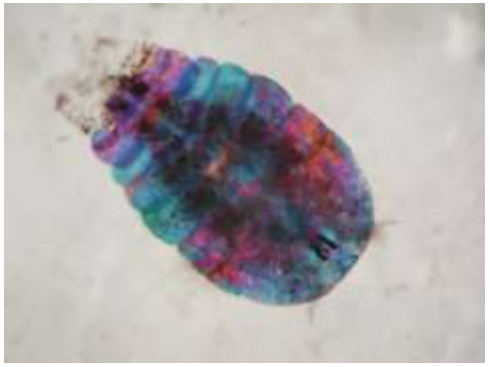
- We focus on copepods and krill because (1) they are the chief link between the tiny phyto-plankton and fishes, seabirds and some whales, but also because (2) copepods are also the most abundant metazoans on the planet.

Copepods and Krill





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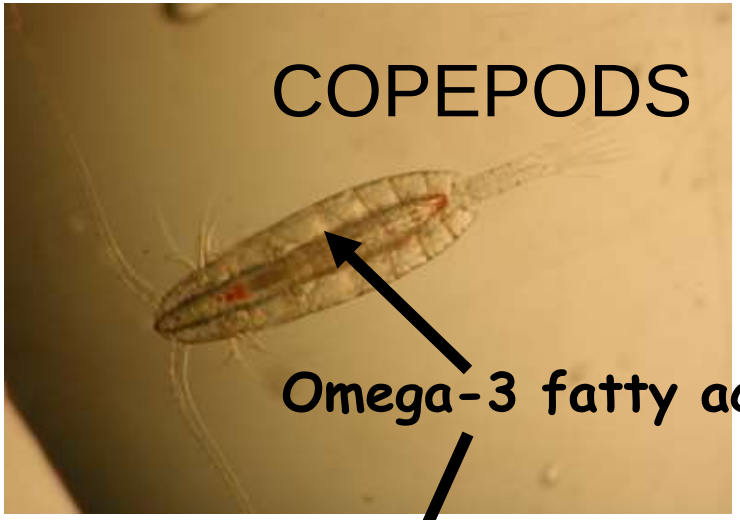
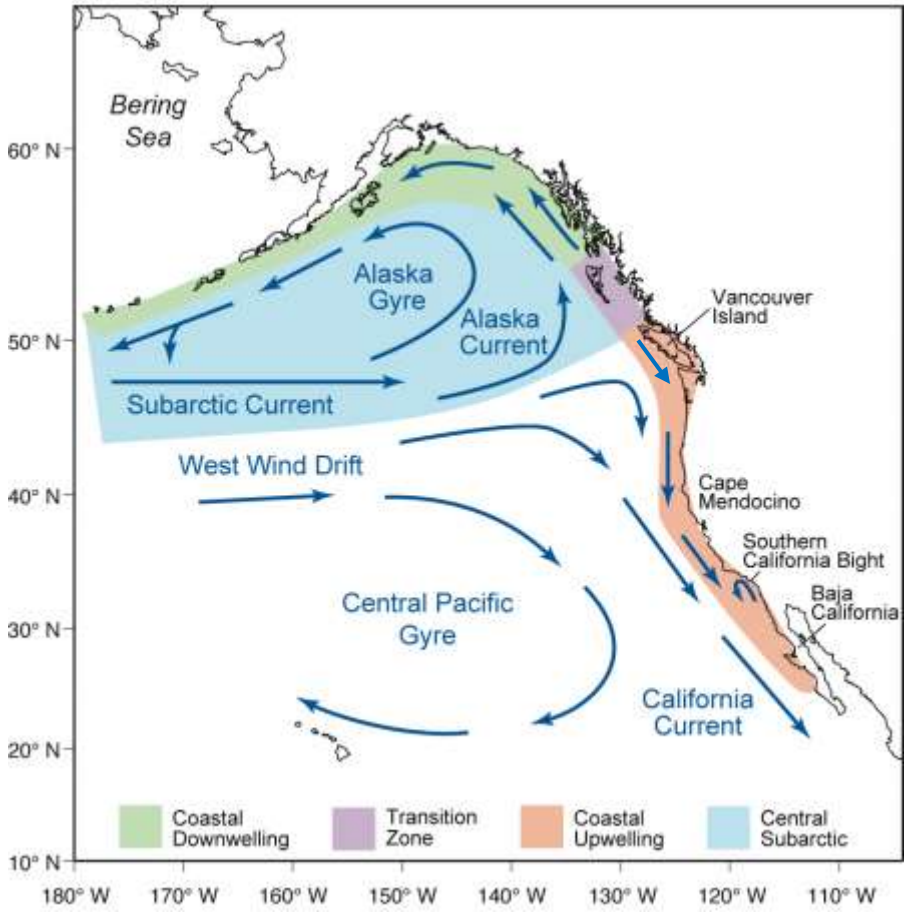
Lipid content is perhaps the most important attribute of copepods and krill



Omega-3 fatty acids

To understand copepod ecology, you need to know about ocean circulation because:

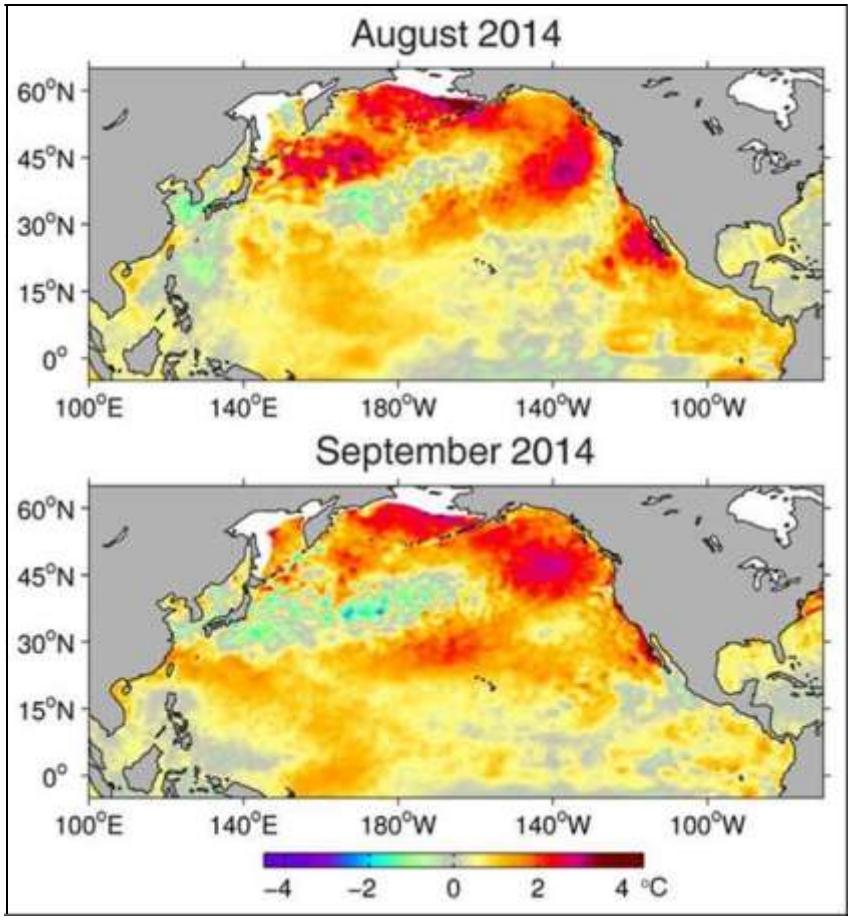


1. Subarctic Coastal Currents bring cold water and large lipid-rich **"northern" copepod** species to the N. California Current; (*Cheeseburgers*)

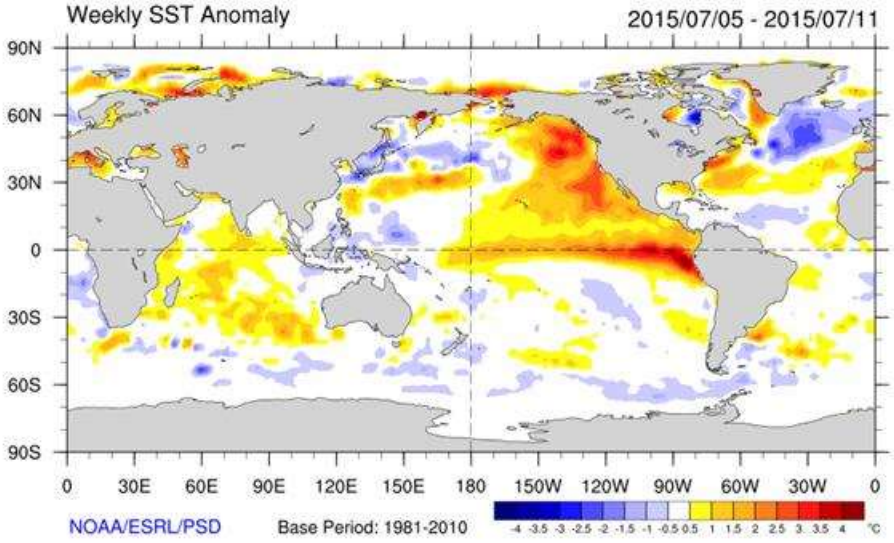
2. A weak California Current and/or onshore flow of the West Wind Drift brings warm subtropical water and small lipid-poor **subtropical "southern" copepods** to the NCC (*Celery*)

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

What has been going on over the past three years?



- Blob begins to form in Nov 2013
- 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 what is that warm water off Oregon all about?

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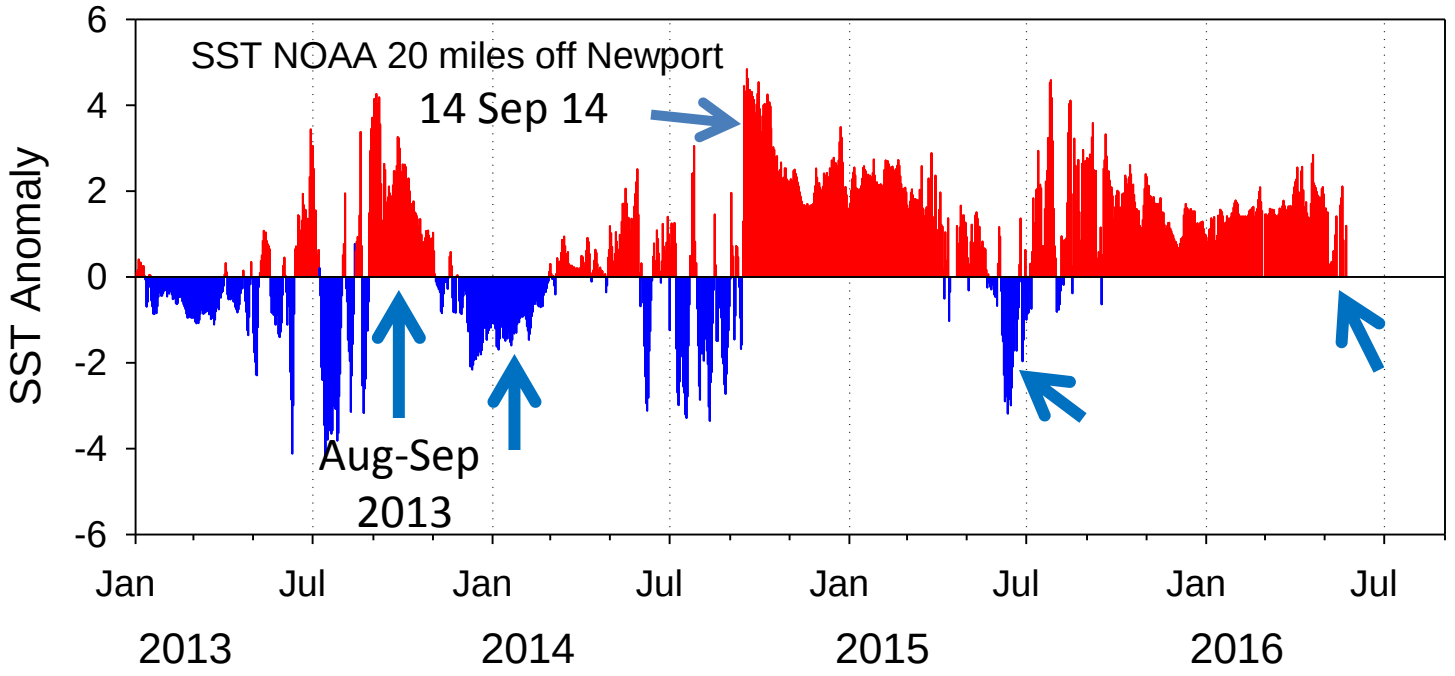
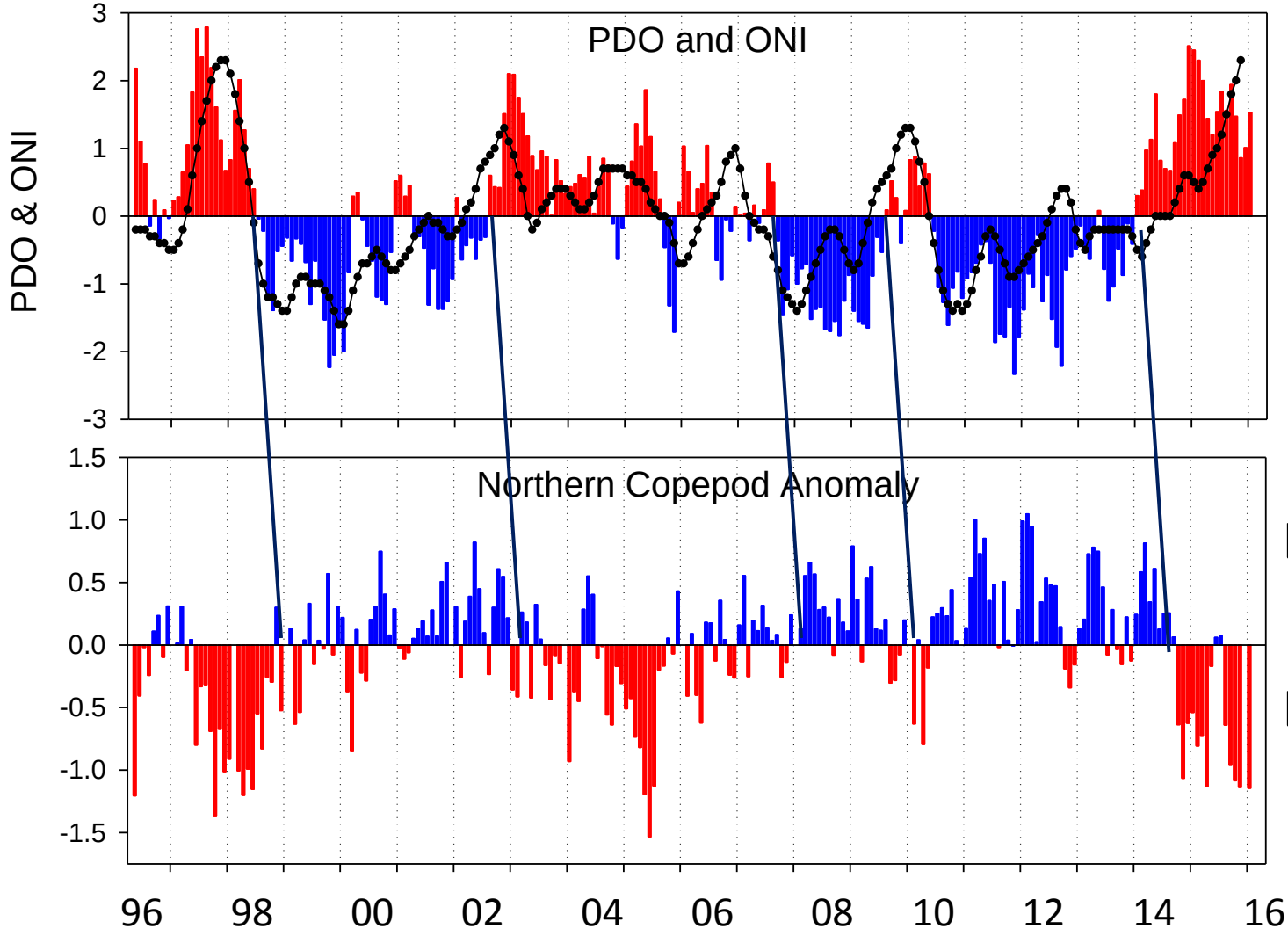
Daily sea surface temperatures anomalies at the NOAA Buoy 20 miles off Newport: Jan 2014 – May 2016



- 14 Sep 14 N'ly winds weakened, the Blob came onshore and SST jumped 6°C in 5 hr
- Summer 2015: strongest N'ly winds in 20 years but minimal signature in SST ;
- May 2016: Still warm although N'ly winds starting to cool the coastal waters a bit

PDO, ONI (upper) and Northern Copepods (lower)



Think of the PDO and ONI as measures of temperature anomalies:

Blue is cold water; **Red** is warm water.

When the ocean is cold, cold-water/lipid rich copepods dominate.

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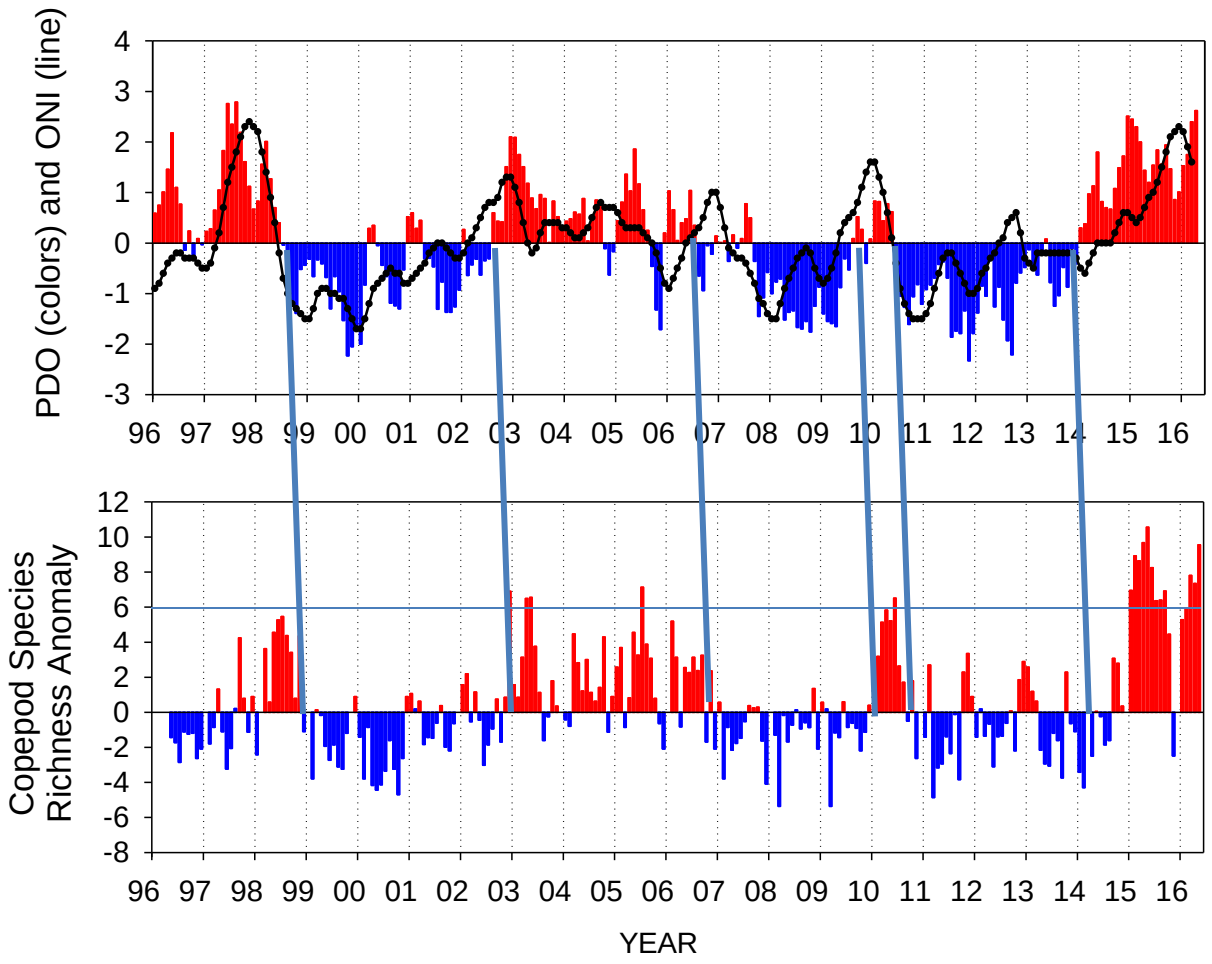
PDO & ONI (upper) and Copepod Species Richness (lower)



- Copepods track PDO with ~ 4-6 mo lag
- Greater species diversity when PDO is positive because subtropical water is transported to coastal waters off Oregon at such times --diversity is naturally higher in these waters
- Twice as many species in 2015 suggesting different origin of warm source waters

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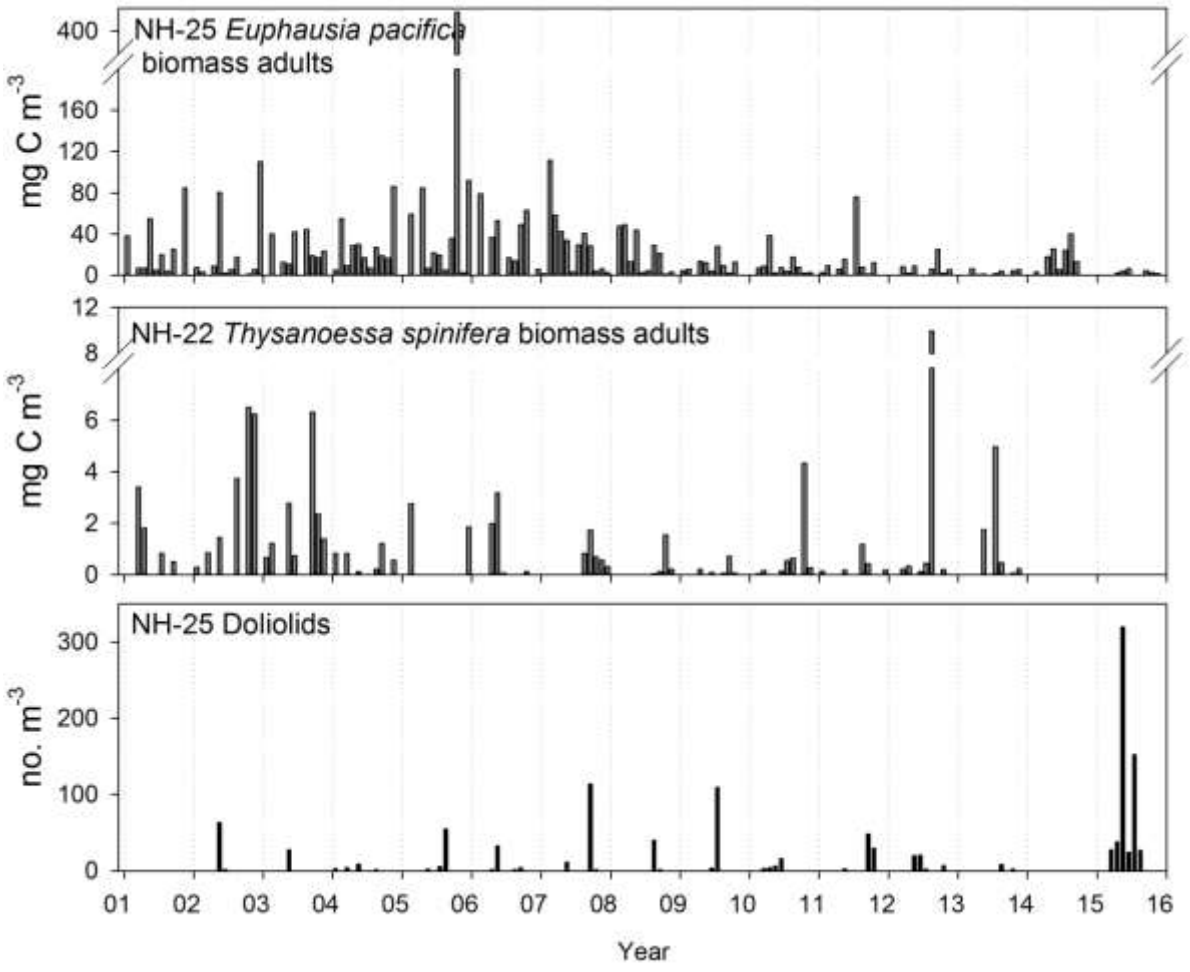


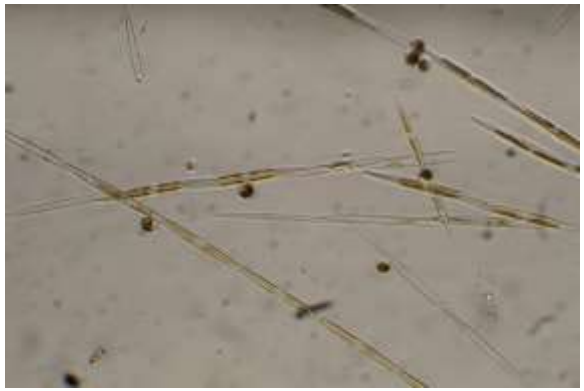
Biomass of two krill species and abundance of doliolids off Newport

- *Euphausia pacifica* have been on a downward trend since 2008, but extremely low in 2015.
- *Thysanoessa spini*fera are abundant only when the ocean is in cool phase.
- Doliolids are indicators of oligotrophic (‘blue water’) ocean conditions

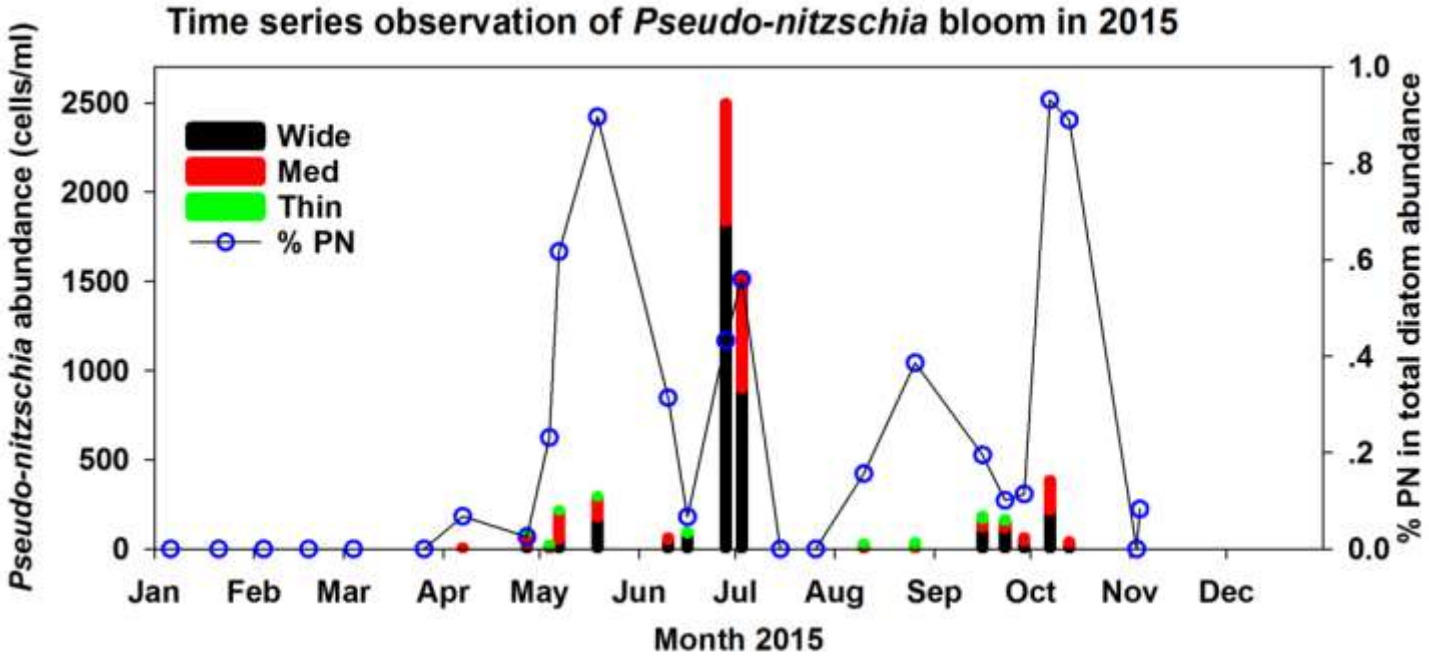
The 2015 *Pseudo-nitzschia* (PN) bloom

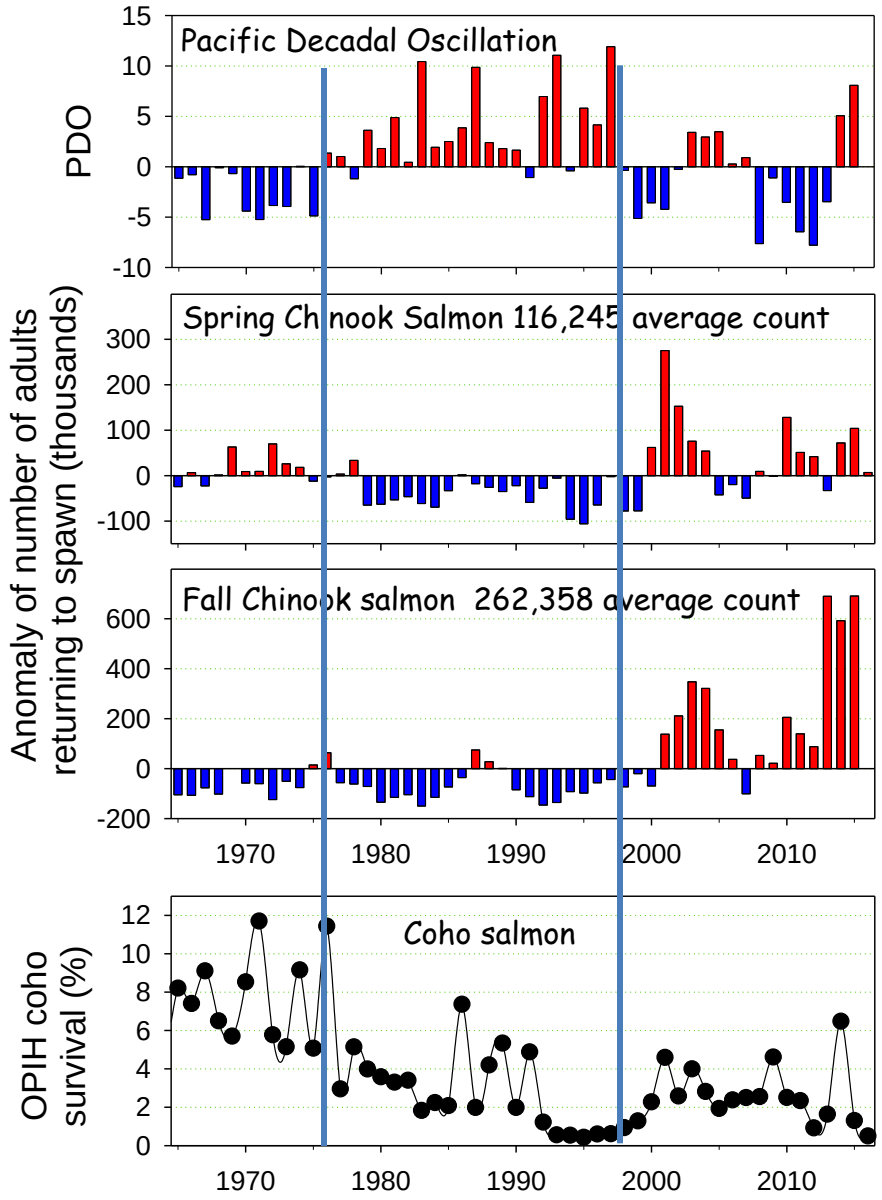
- Wide-spread: stretching from southern CA to Alaska
- Longest duration: spring/summer/fall
- The most toxic—among the highest domoic acid concentration in sea water, shellfish and fish samples
- Synchronous throughout west coast (indicating a response to a common coast-wide trigger)
  - From end of April 2015, increasing PN cells at Newport; May 14th, entire Oregon coast closed to razor clamming;
  - In early May, high levels of DA detected in Monterey Bay along with high concentrations of PN cells.
  - In early May, increasing PN cell concentration seen on Washington coastal beaches, razor clamming closed.
  - Closure of Dungeness Crab harvest in December 2015
- We usually get toxic P-n blooms when the PDO is positive; for the 2015 bloom we think that the Blob was the common trigger.

Harmful Algal Bloom



- Wide-spread from CA to Alaska suggests a common trigger (The Blob?)
- Long duration (May-November)
- Very toxic – domoic acid, a neurotoxin
- Have manuscript submitted to Proc. Natl. Acad. Sci.





Adult Chinook salmon counts at Bonneville Dam and coho OPIH compared to the PDO since 1965

- Note that from 1976 through 1997, PDO was positive. Poor salmon returns (blue bars) are related to positive PDO (red bars) but with a 1 to 3 year lag (a function of how many years they spend at sea).
- Since 1998, PDO has been oscillating every 5 years as have Chinook salmon returns.
- Coho returns have been on a downward trend since 2009.
- Spring Chinook run is average this year (as of yesterday)

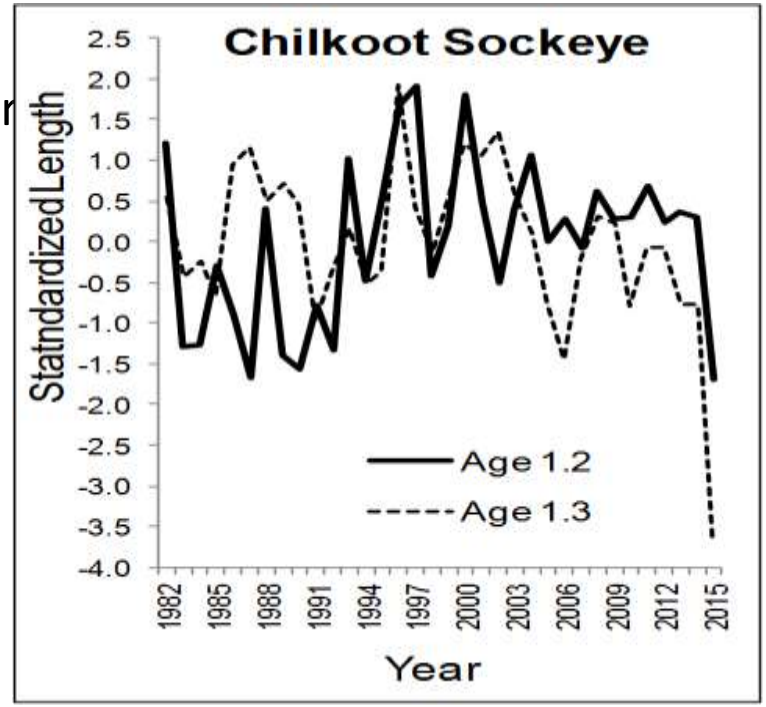
Impacts of the Blob on Fisheries

- For salmon, early indicators are not good:
  - Coho salmon that went to sea in spring 2014 returned in fall 2015 at one of the lowest rates since the 1998 El Niño
  - Spring Chinook that went to sea in spring 2014 are returning now in average numbers that are only half the size of the runs over the past two years.
- For salmon that went to sea in 2015 (the year of even worse ocean conditions), we will not know how runs were impacted until autumn 2016 for coho, spring 2017 for Columbia River spring Chinook, and fall 2018 for Columbia River and Sacramento River fall Chinook.
- Sockeye returns in summer 2015 failed due to warm Columbia River
- Hake (whiting) harvest in 2015 poor
- Opening of Dungeness Crab fishery of OR and WA delayed until Jan 2016 due to a massive harmful algal bloom which impacted local economy in December; fishery just now (in May) opening in California.
- Shrimp fishery this year doing poorly

Other effects of warm water on Pacific salmon in 2015

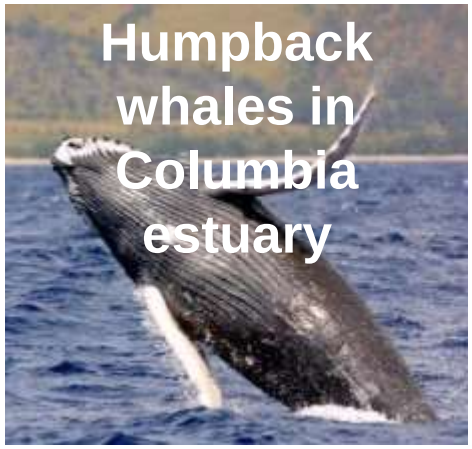
- Washington, Oregon:
  - Puget Sound coho returns extremely low, very small-bodied
- Alaska
  - Alaskan sockeye had average adult numbers but extremely small bodied (smallest in >20 yrs)
- Fraser River

  Sockeye and pink half the number
  Adult coho returns low and small
- Columbia River
  - Adult fall Chinook and sockeye returns extremely high but sockeye suffered huge in-river mortality
  Coho returns low; low returns of Chinook jacks



Unusual sightings in 2015

7 swordfish caught along Oregon coast



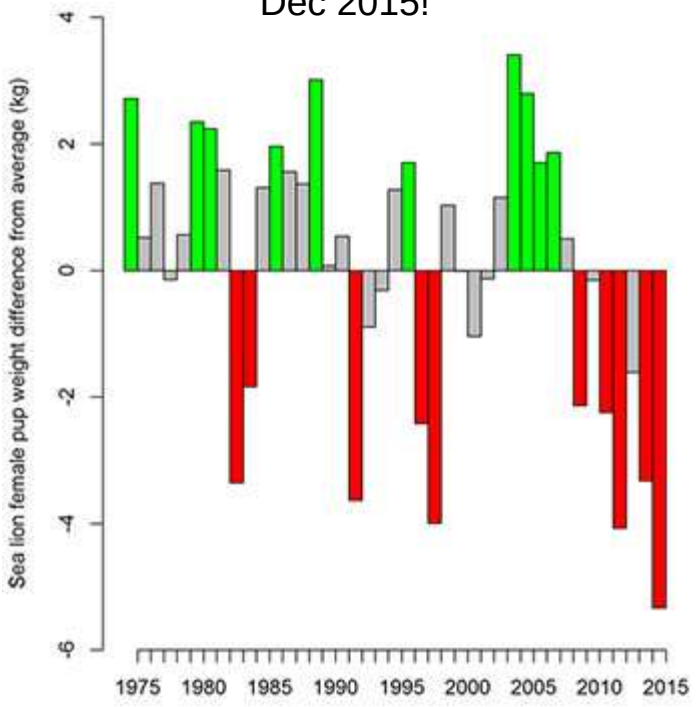
Warm water species we've seen before but earlier or unusually abundant

Opah caught off Oregon Coast

Skinny coho & Chinook in ocean

Record numbers of CA sea lions in the Columbia and along the WA/OR coast

Sea lion pups on San Miguel Island (S CA) had low weight in Dec 2014; even lower in Dec 2015!



Astoria East Mooring basin

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- Other unusual tropical critters that appeared off the OR coast:
  - Green turtles off WA, OR and CA
  - Opah caught off Depoe Bay
  - Sea snakes off Los Angeles and one spotted 14 miles off Newport August 2015
  - Giant Ocean sunfish in the Gulf of Alaska and off OR and WA
  - *Vellella* (by-the-wind sailors)
  - Mole crabs (*Emerita*) and Green crabs both had extraordinarily high recruitment

Expectations for 2016

- Copepod species richness is still very high
- The food chain is still dominated by small, warm water, lipid-poor copepods. In the past there has been a 4-6 month lag between change in sign of the PDO and the appearance of a different copepod community. Given that the PDO is now in an extremely positive state, it is highly unlikely that the food chain will transition to a cold-water lipid-rich state until next year.
- What about the Monster El Niño event? SSTs are still very warm. Will the El Niño ever get here? Was it here and now gone?
- Given that the food chain has been in a lipid-depleted state for 20 months (since September 2014) and is not showing any signs of improving, will we one day conclude that the Blob + El Niño gave rise to an environmental disaster?

Brief Summary

- To understand what is meant by the term “ocean conditions”, you need to know ocean currents: where did the water and plankton come from, and why?
  - If water comes from the north = cheeseburgers
  - If water comes from the south or offshore = celery, popcorn
  - But why the different sources?
- Important for at least reasons:
  - Local salmon go to sea to get fat in support of their migration back home
  - Many long distance migrators come up here each summer to feed: whiting (hake)m sardines, shearwaters, albatross, whales and when it is really warm, turtles and apparently sea snakes!

Funding Sources over the past 20 years

FATE
FISHERIES AND THE ENVIRONMENT

GLOBEC
Global Ocean Ecosystem Dynamics

BONNEVILLE
POWER ADMINISTRATION

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

NSF

U.S. GLOBEC
Northeast Pacific Program

Pacific Ocean Boundaries
POBEX
Ecosystem and Climate Study

NASA

CAMEO
COMPARATIVE ANALYSIS OF MARINE ECOSYSTEM ORGANIZATION

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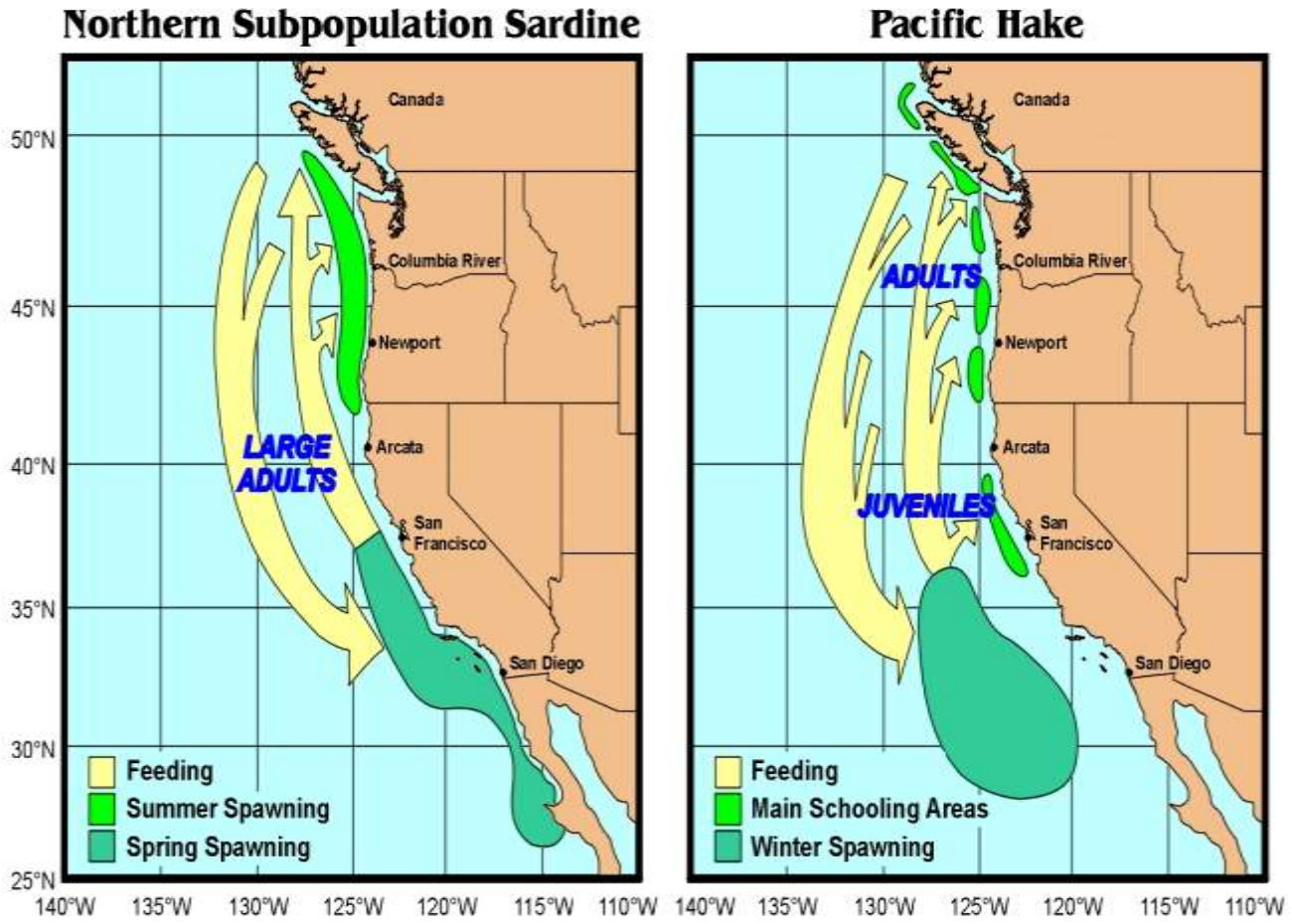
Our Center's webpage www.nwfsc.noaa.gov has two buttons that should be of interest:

- Newportal (a Blog Site)
- Salmon Forecasting

During a “normal year”, sardines and hake migrate to Oregon in spring to take advantage of the lipid-rich food chain and bountiful harvest; salmon of course migrate to the ocean at the same time for the same reasons



We also get some long distance migrants including:

- Sooty shearwaters from New Zealand
- Black Footed and Laysan Albatross from Hawaii
- Gray Whales from Mexico
- Humpback whales from Eastern Tropical Pacific
- The occasional leatherback turtle from New Guinea
- Green + Olive Ridley Turtles from central America
- Salmon from the Snake River (and from British Columbia pre-Grand Coulee)

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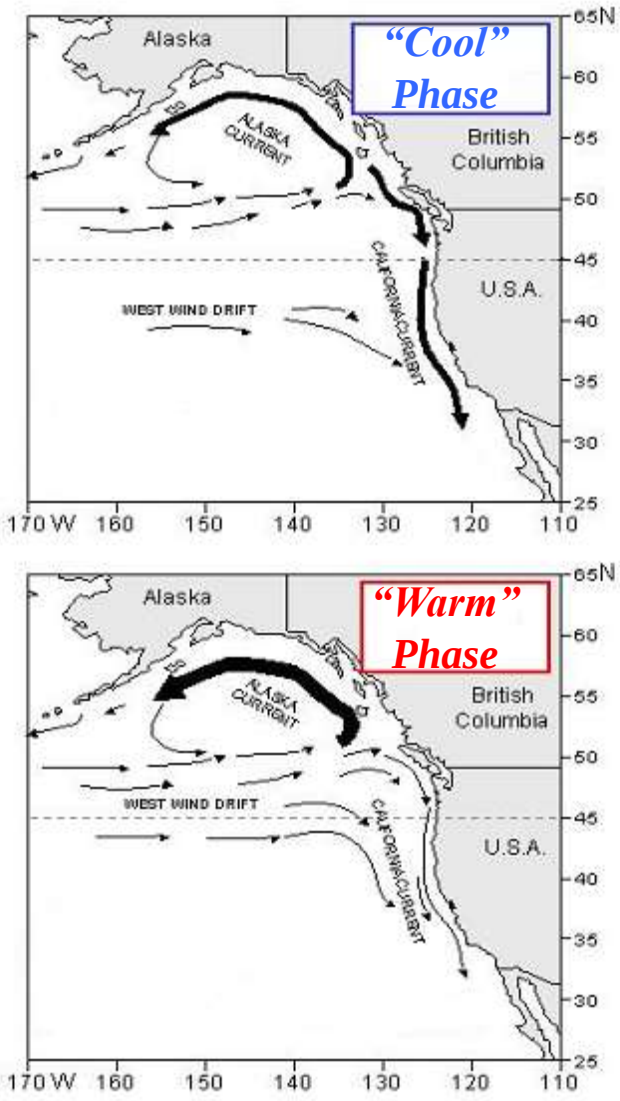

1. "Cool Phase of the California Current". Strong subarctic coastal currents bring cold water and large **lipid-rich copepod** species to the ecosystem.

2. "Warm Phase". The West Wind Drift along with seasonal reversals in coastal currents and a weak California Current bring sub-tropical water and **small lipid-poor subtropical copepod** species to the northern California Current

3. Thus the size of copepods and the nutritional value of the food chain varies with the ocean currents.

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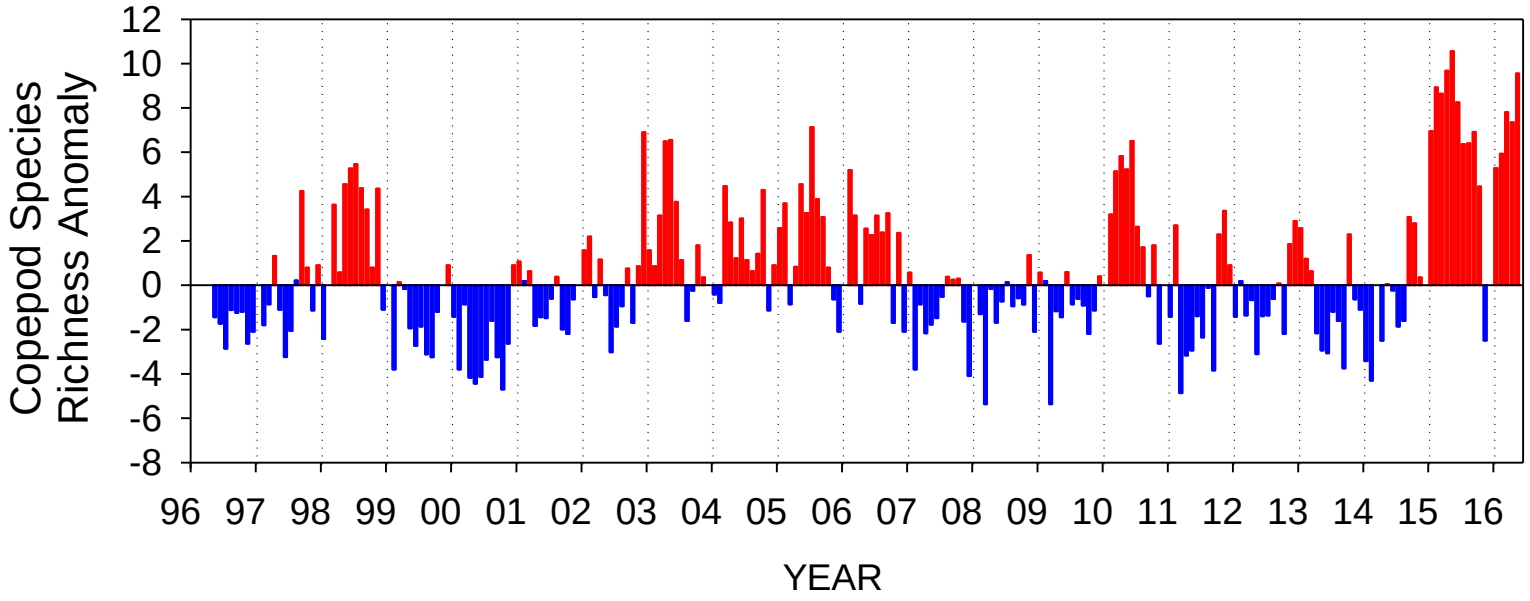
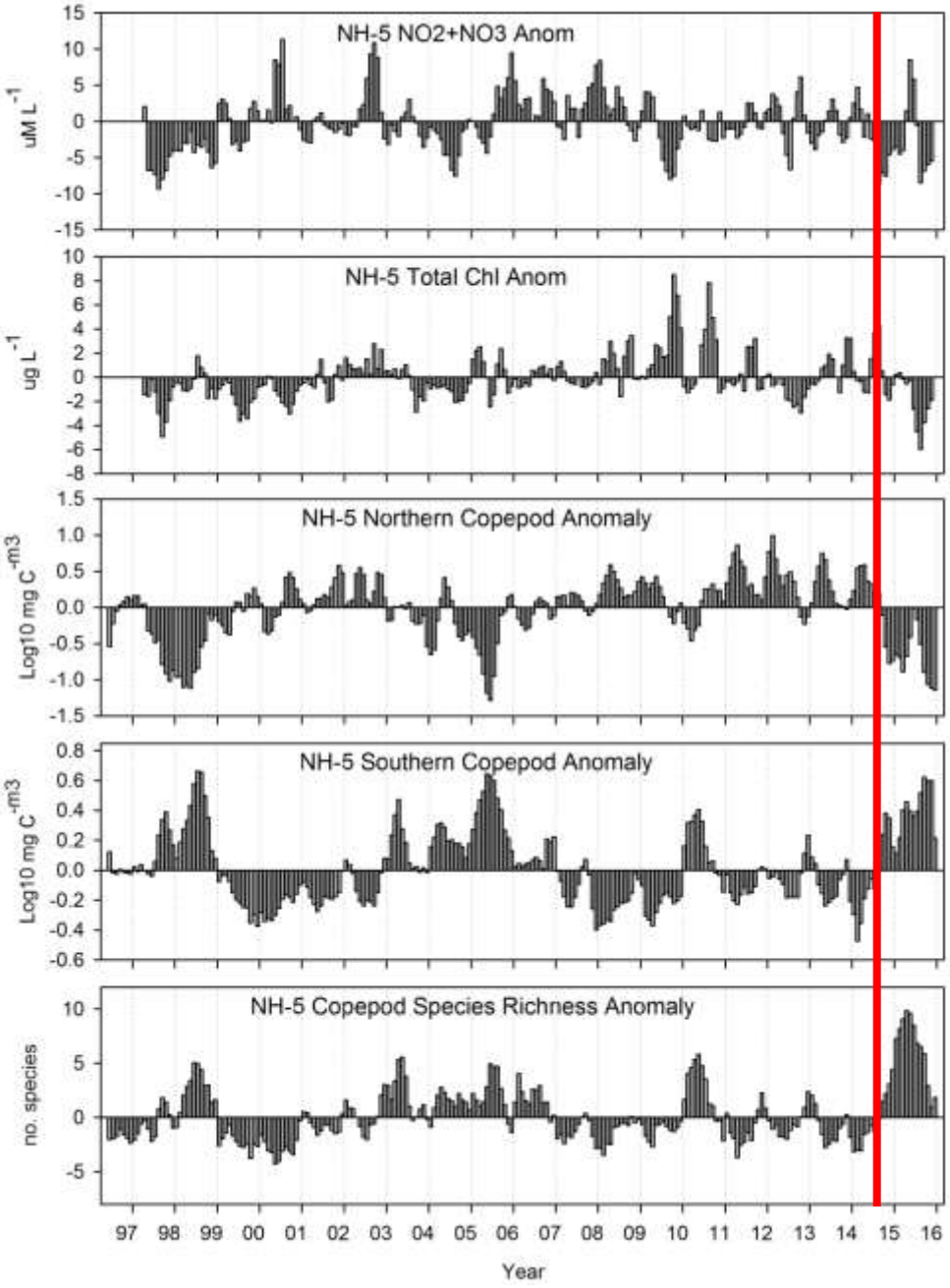
Speaking of the “Monster” El Niño event?

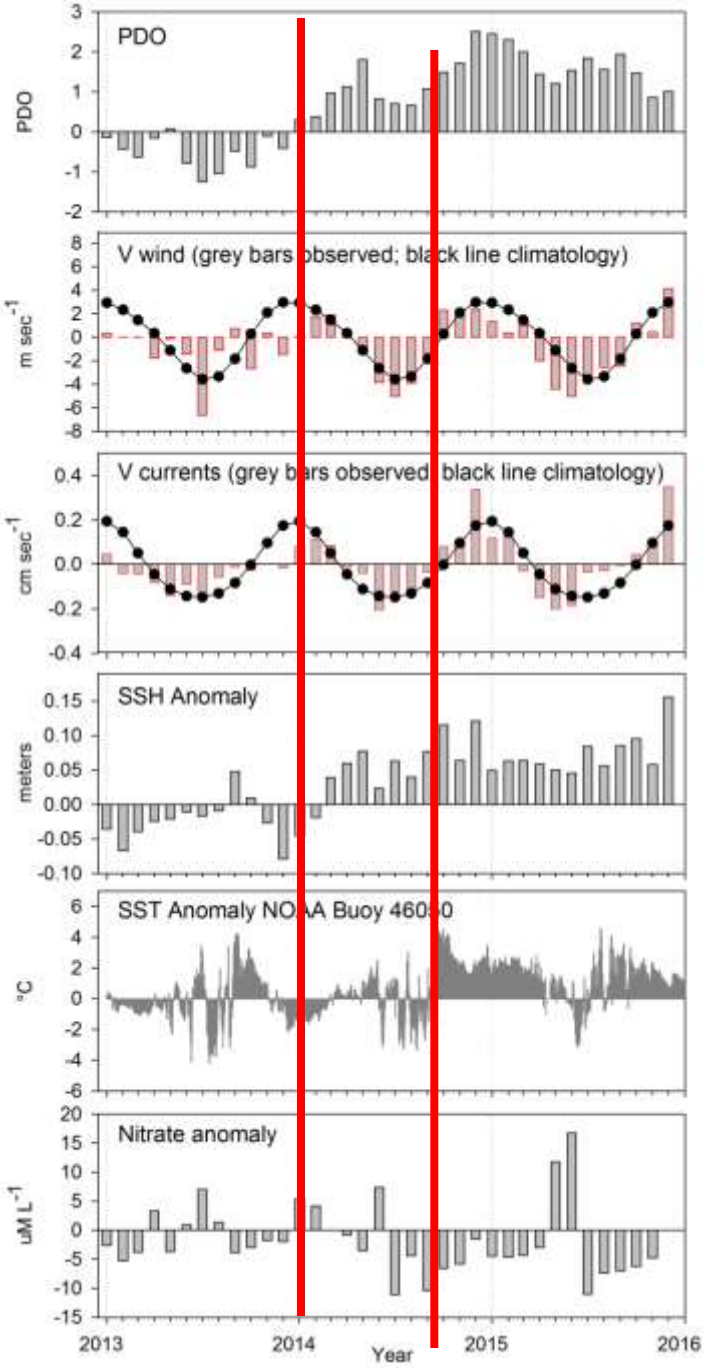
- The ‘monster’ El Niño event definitely got to California, as far north as Eureka to be sure. But did it get to Oregon? SSTs is warm…..
  - **Since the ocean is already warm, how will know if/when the** El Niño **arrives?**
- Until we get those fat copepods and fat krill back into the food chain, fish and fisheries that depend on a lipid-rich food chain are going to suffer.
  - **Especially true for those species that migrate to the northern California Current each spring to fatten-up: whiting, sardines, shearwaters, albatross, grey, humpback and blue whales**

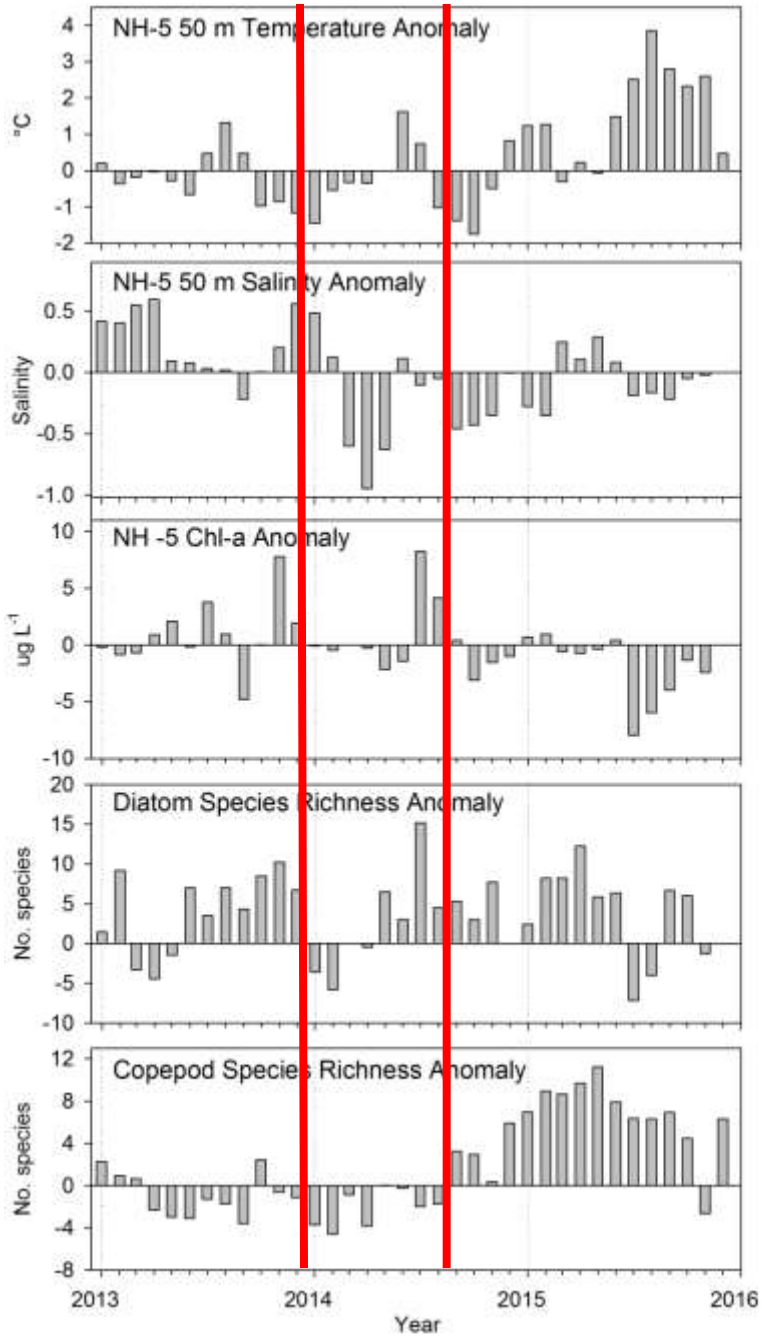
Anomaly of the number of copepod species (species richness) in plankton net samples



When the Blob came ashore, it brought ~ 20 copepod species that are new records for the northern California Current. Many are North Pacific (Subtropical) Gyre species.


NH-5 NO2+NO3 Anom
uM L-1
NH-5 Total Chl Anom
ug L-1
NH-5 Northern Copepod Anomaly
Log10 mg C-m3
NH-5 Southern Copepod Anomaly
Log10 mg C-m3
NH-5 Copepod Species Richness Anomaly
no. species
97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16
Year


PDO
PDO
V wind (grey bars observed; black line climatology)
m sec-1
V currents (grey bars observed; black line climatology)
cm sec-1
SSH Anomaly
meters
SST Anomaly NOAA Buoy 46050
°C
Nitrate anomaly
uM L-1
2013
2014
2015
2016
Year


NH-5 50 m Temperature Anomaly
°C
NH-5 50 m Salinity Anomaly
Salinity
NH -5 Chl-a Anomaly
ug L-1
Diatom Species Richness Anomaly
No. species
Copepod Species Richness Anomaly
No. species
2013
2014
2015
2016
Year

Cassin's Auklet Wreck of 2014-15 {Julia Parrish}

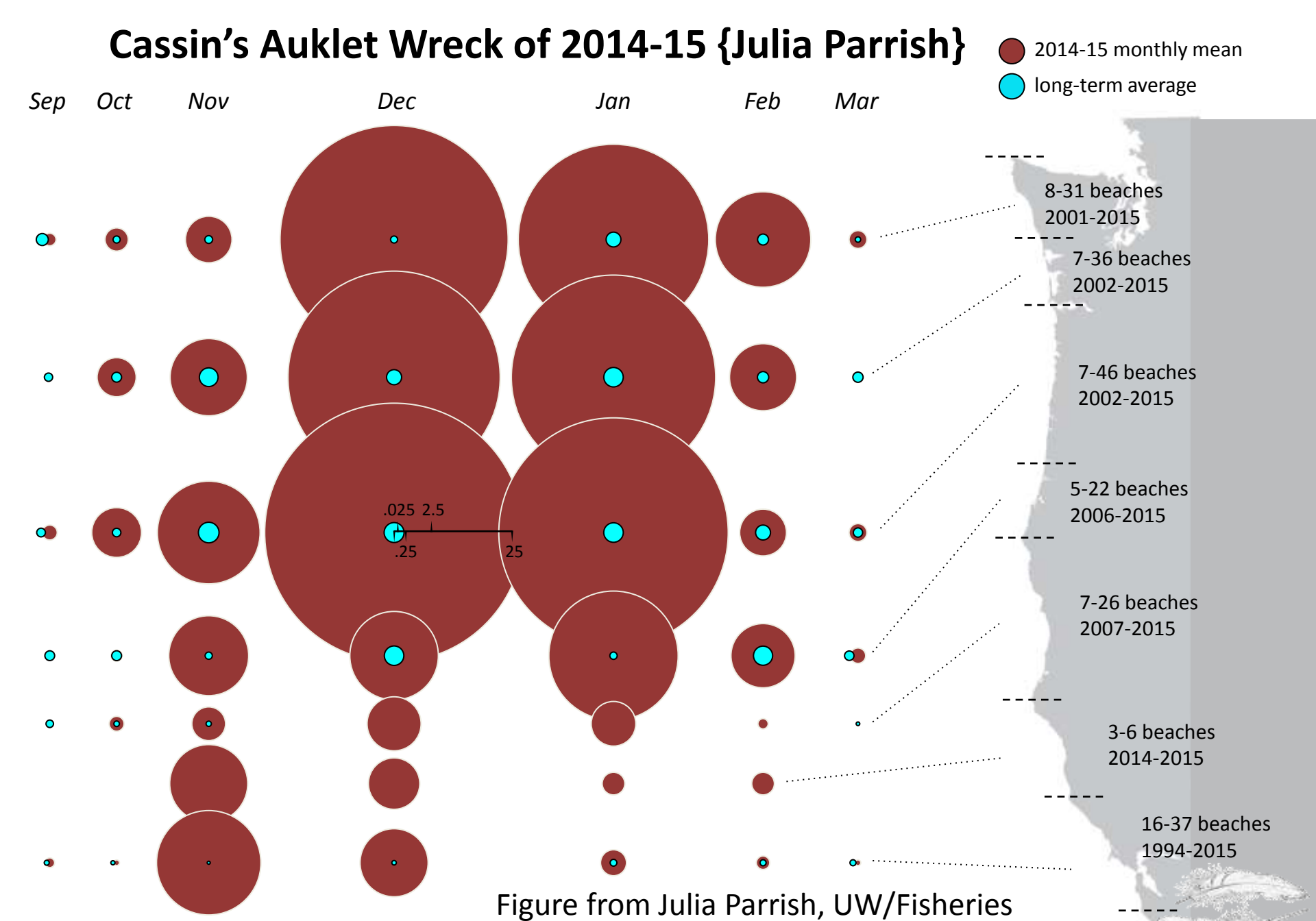


Figure from Julia Parrish, UW/Fisheries

data from: COASST - Neah Bay to Mendocino, BeachWatch – Mendocino to San Francisco