Lower trophic level transitions determined from Continuous Plankton Recorder surveys.

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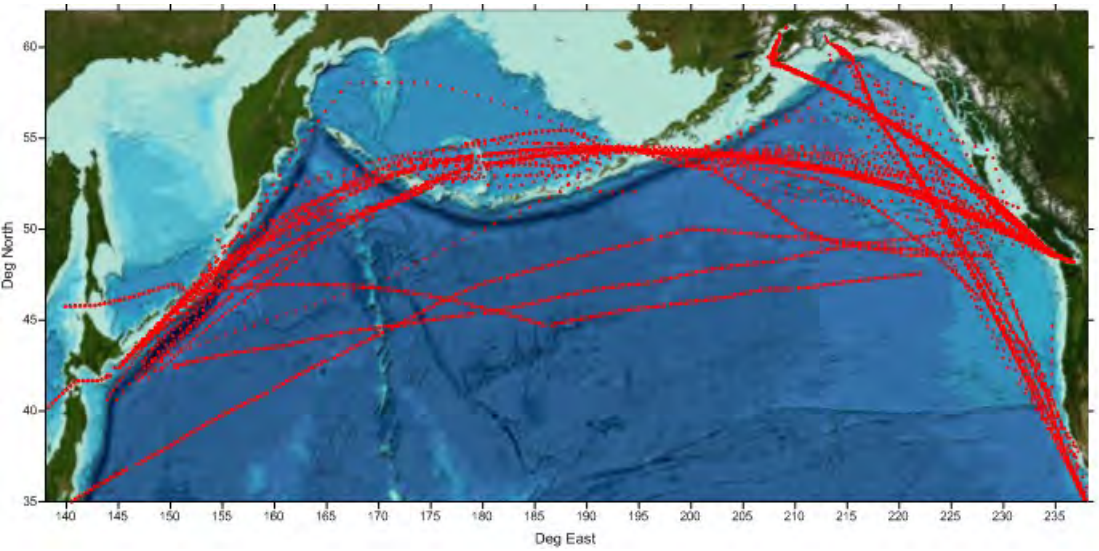
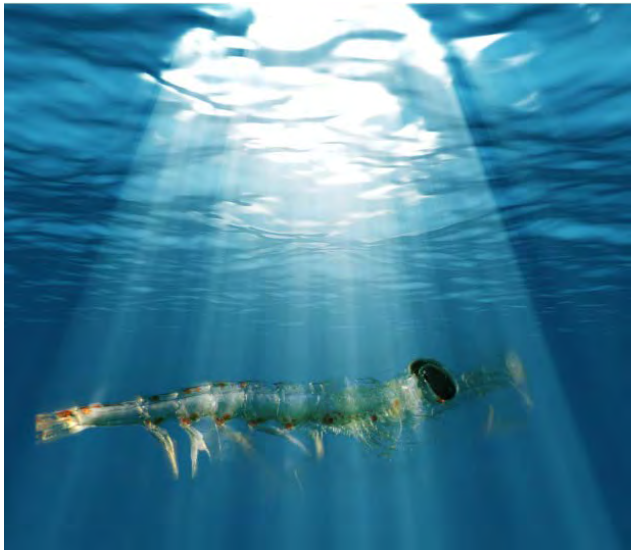
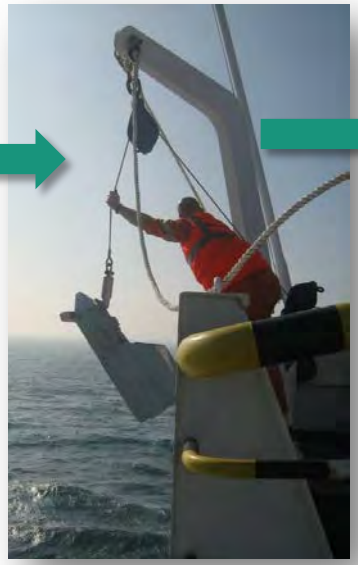


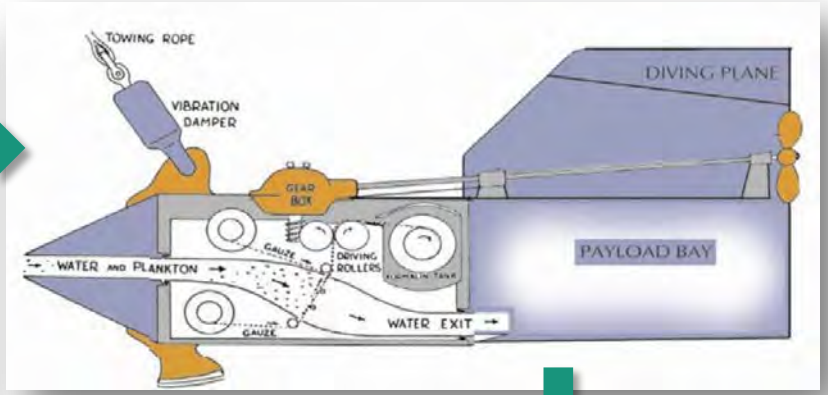


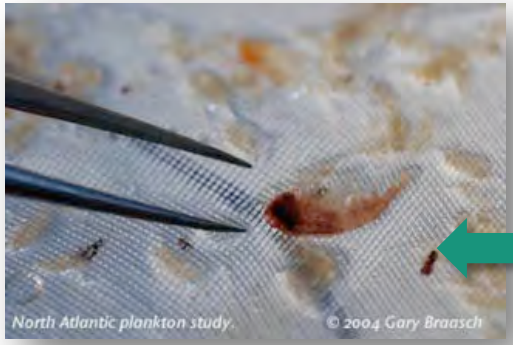
Structure of the presentation

- Introduction to the CPR Survey and the data it has collected from the North Pacific.
- Examples of mesoscale transitional areas
- Examples of basin scale transitional areas and the influence of ocean climate.

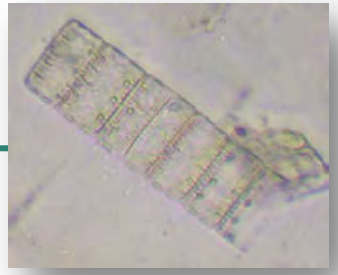
CPR survey operation

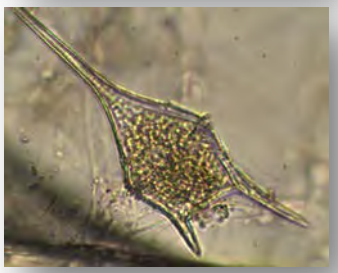






The plankton sampled consist of ~300 taxa:





Phytoplankton Taxa

- Larger diatoms, hard-shelled dinoflagellates ☺
- Small, single cells 😐
  - *Naked flagellates* ☹

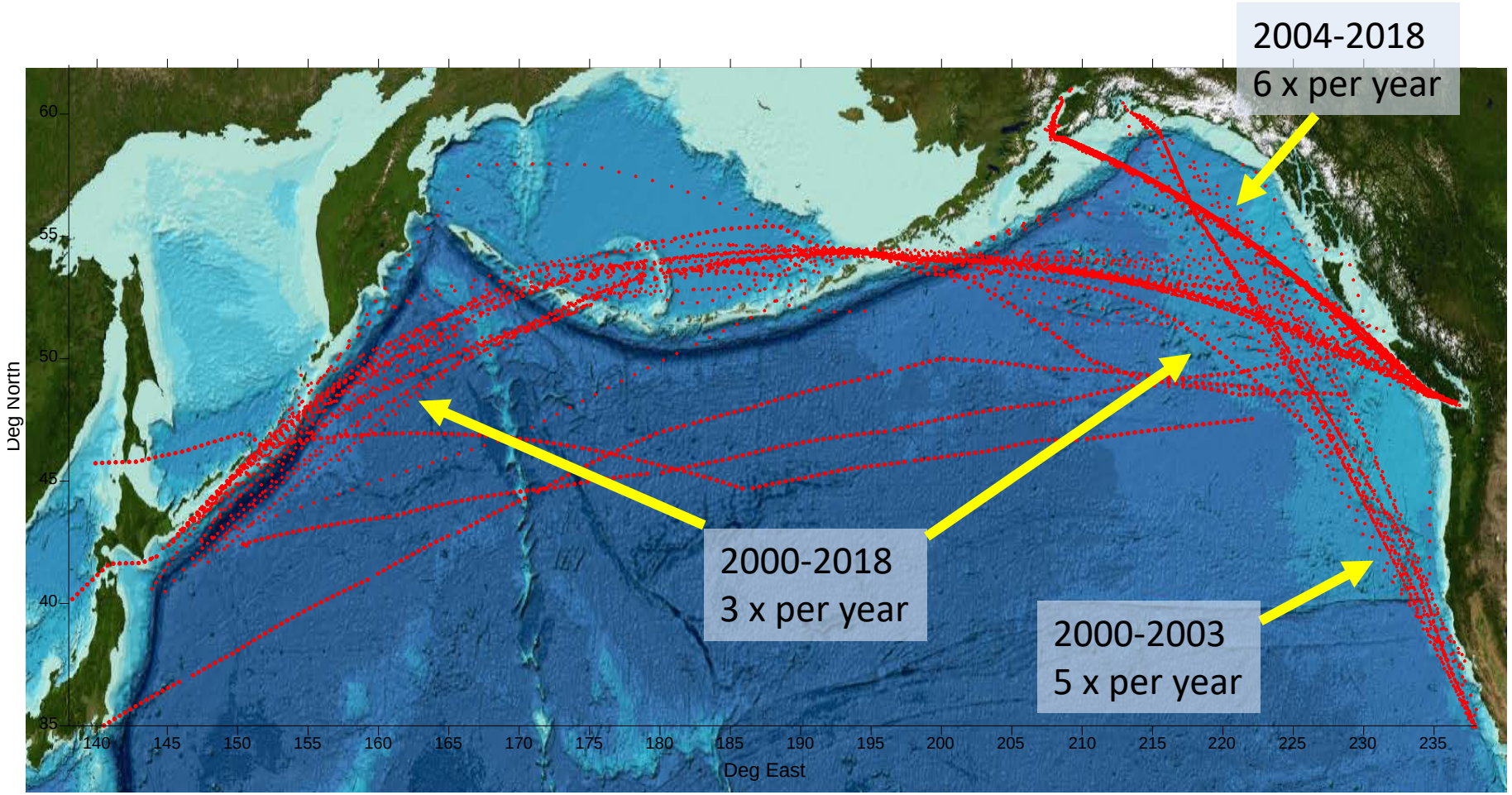
Zooplankton Taxa

- Crustacean plankton ☺
- Organisms 200µm-1cm ☺
- Organisms < 200µm, > 1cm or fragile 😐
  - *Gelatinous plankton* ☹

Additional caveat:

- Abundances are semi-quantitative
- Surface ~0-15m mixed sample

North Pacific CPR transects



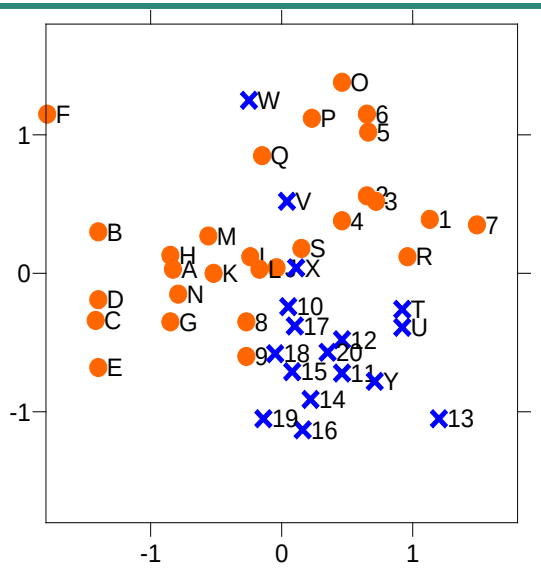
27,500 samples collected to date, 7,500 have been processed, the rest archived.

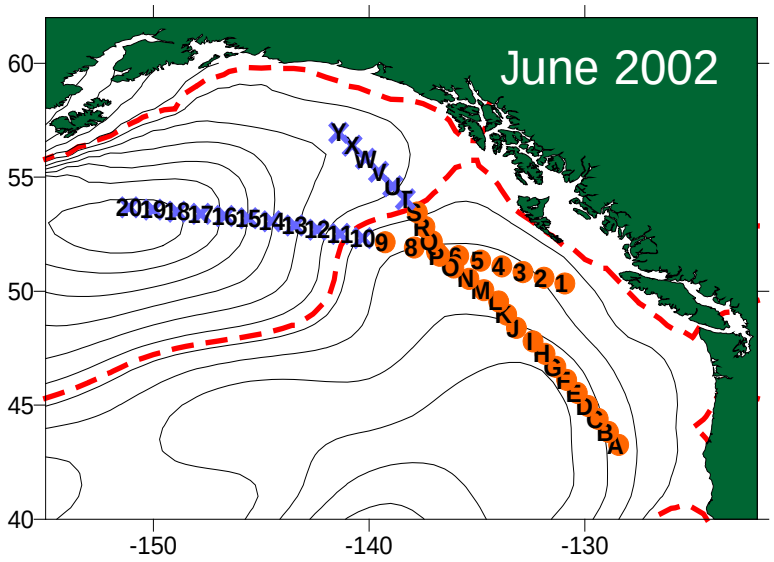
Meso-scale: Fronts

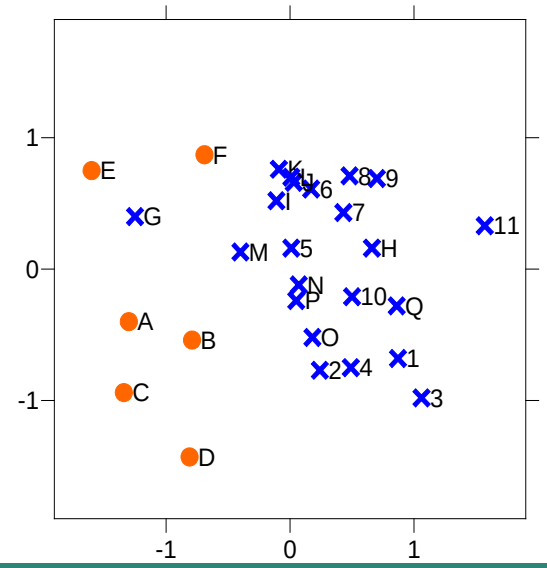
The position of the North Pacific Current was tracked from Argo data.

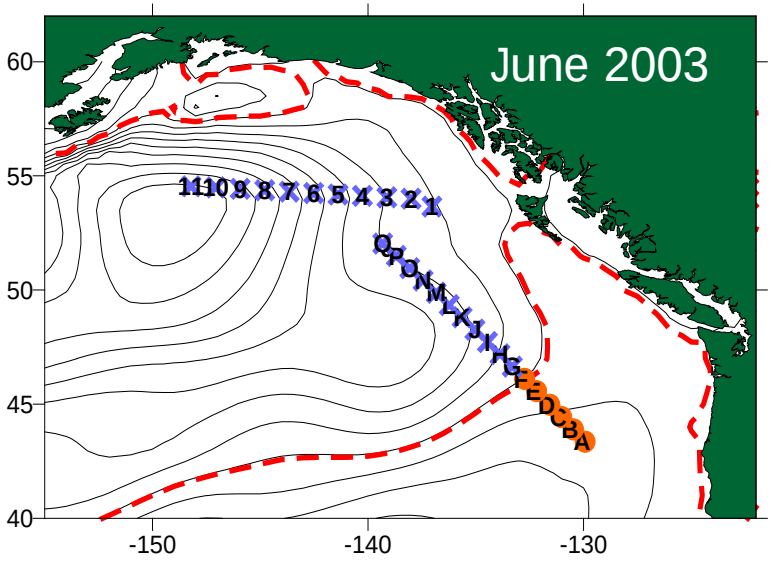
Community composition changed at the dividing line.

This divide was much further north in 2002.





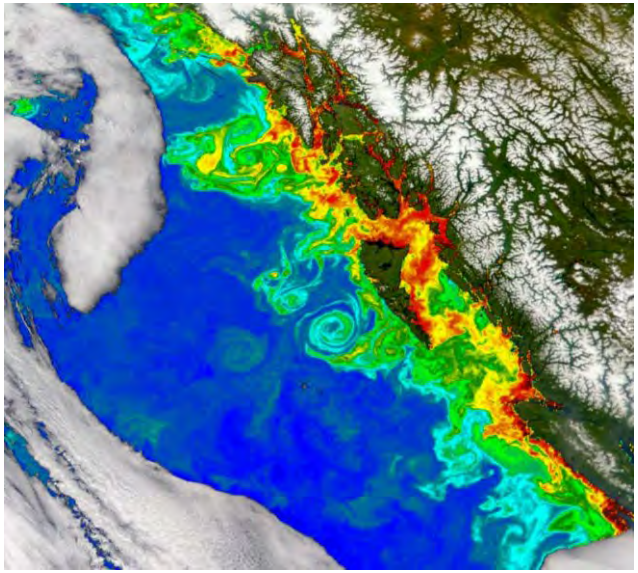


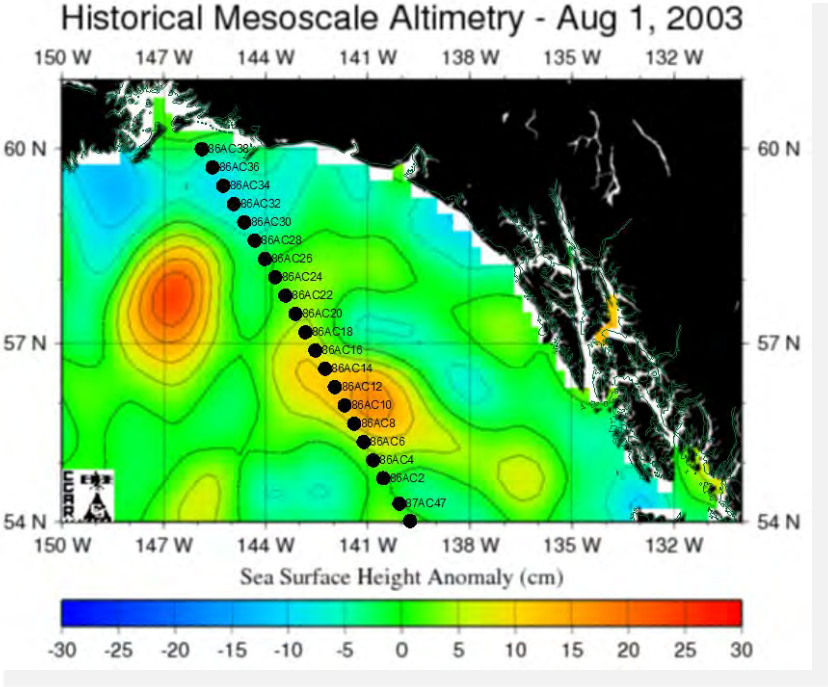


Batten, S.D. and Freeland, H.J. (2007). Fisheries Oceanography, 16, 536-646.

Meso-scale: Eddies

Anticyclonic eddies spin off the shelf at a number of places around the rim of the NE Pacific, mixing shelf and offshore water.

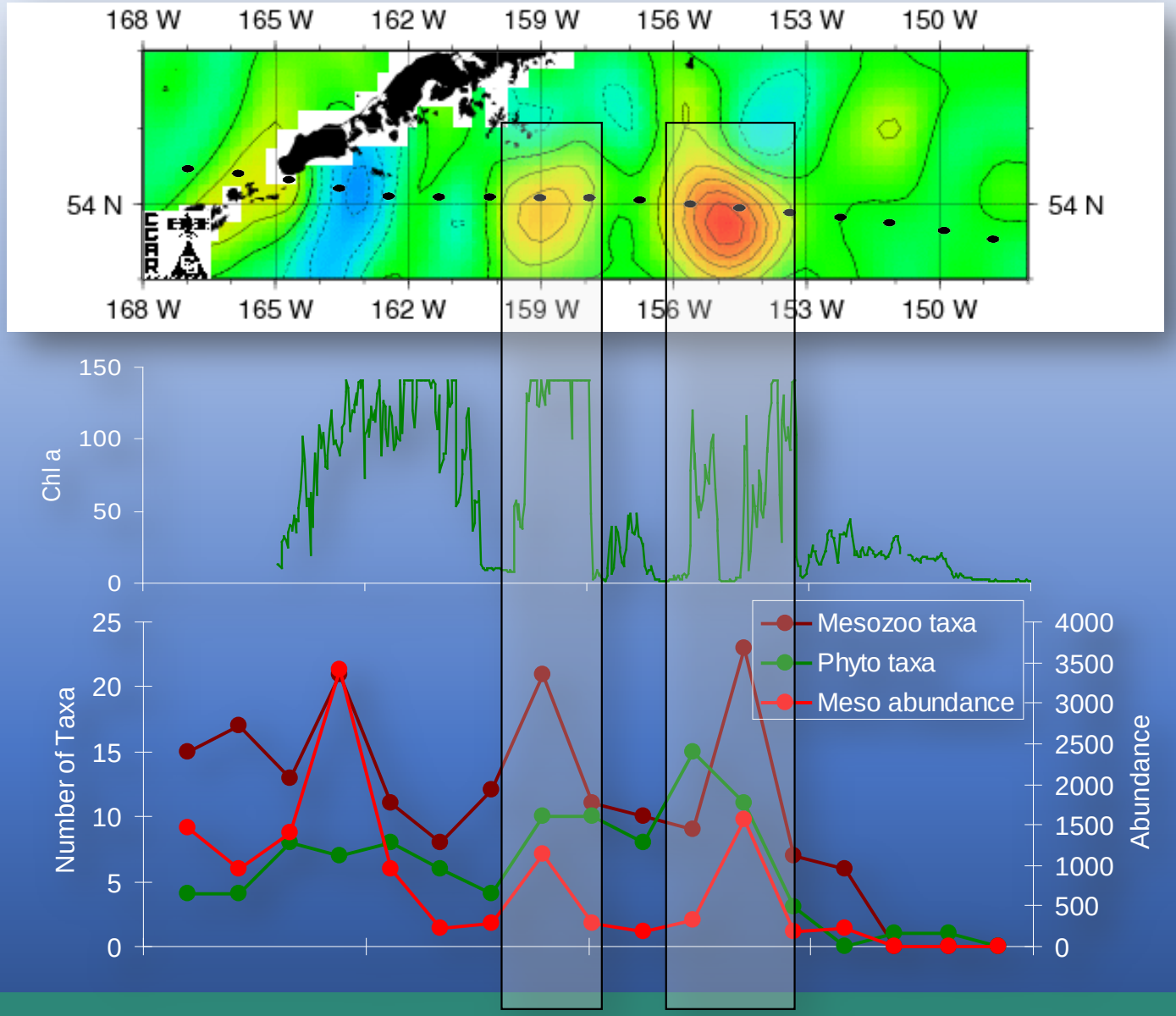




Visible from Altimetry images as elevated sea surface heights, even when cloudy!

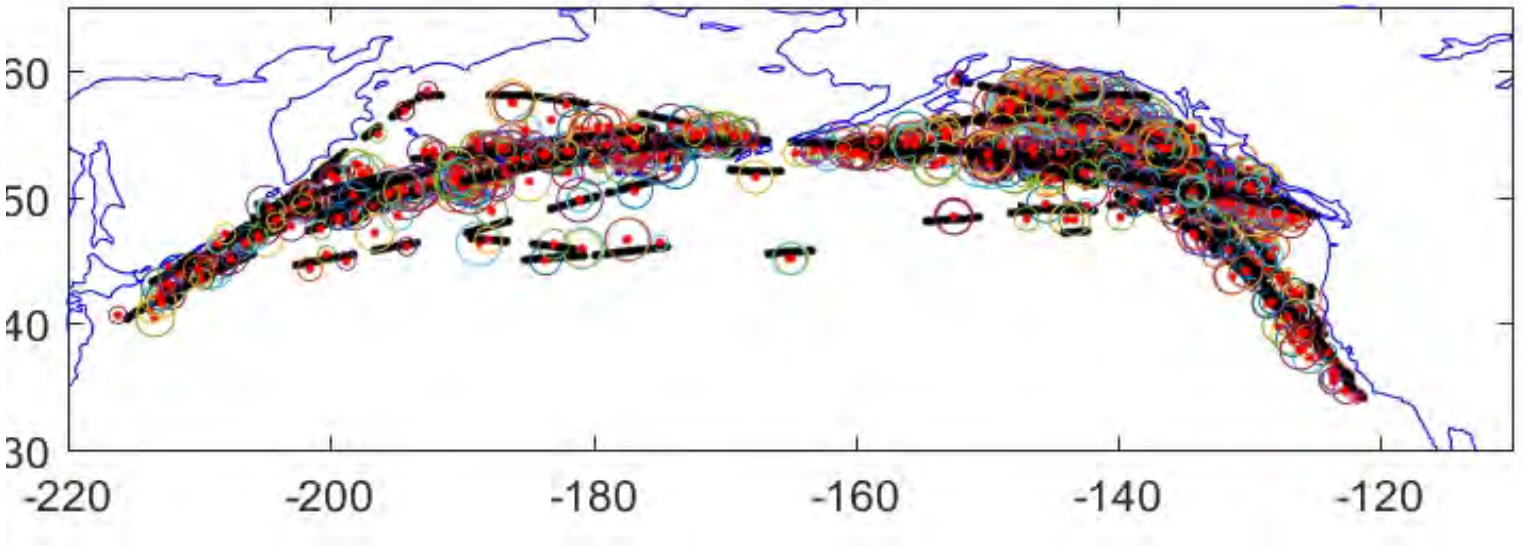
Mesoscale: Eddies

- June 2005 in the western Gulf of Alaska.
- The CPR was fitted with a fluorometer.
- The ship passed through 2 eddies, and Chl-a, species richness and zooplankton abundance were all elevated within the eddy.



New Project *"East Meets West: Dynamic Biogeography of the Subarctic North Pacific"*

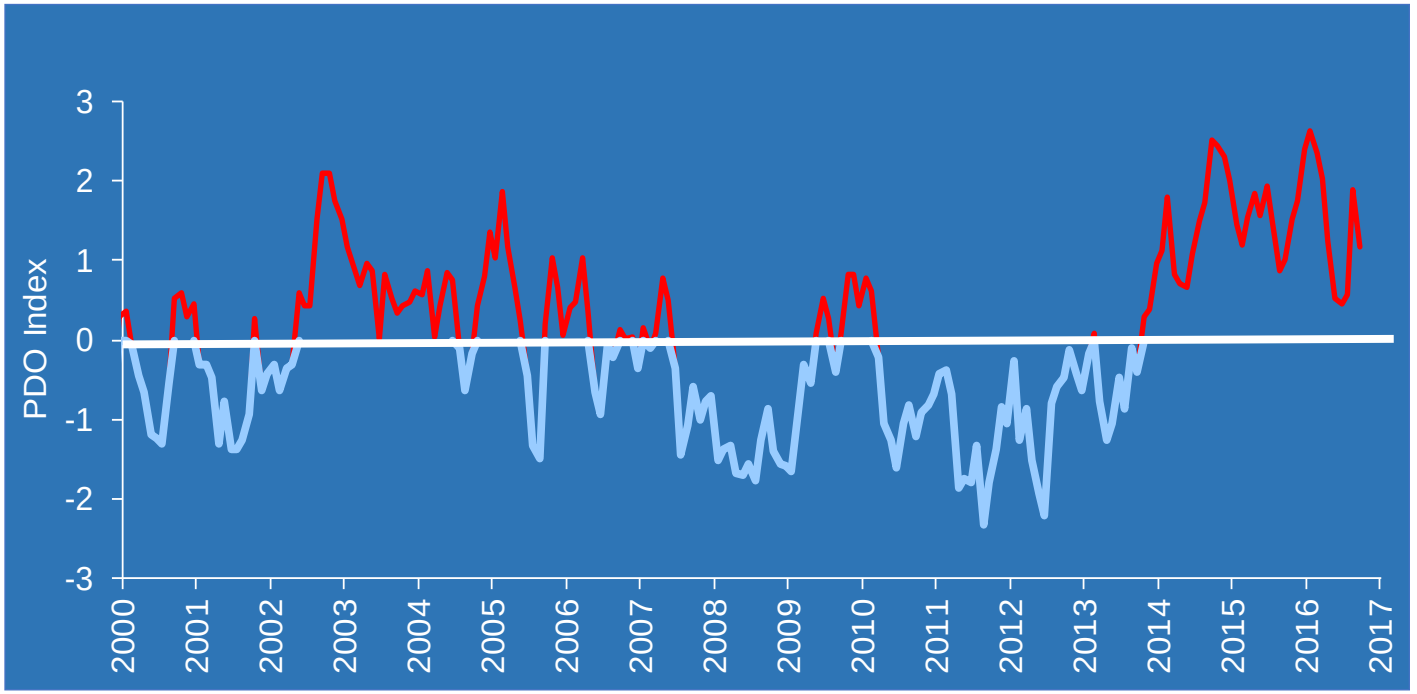
To use CPR data to define the Meso-Marine Ecosystem boundaries in the sub-arctic North Pacific and investigate the effects of variation in the North Pacific Current and related eddy fields.



There are 765 unique eddies that collocate with CPR data. Of those, 31 eddies have more than 30 CPR samples collocated with them.

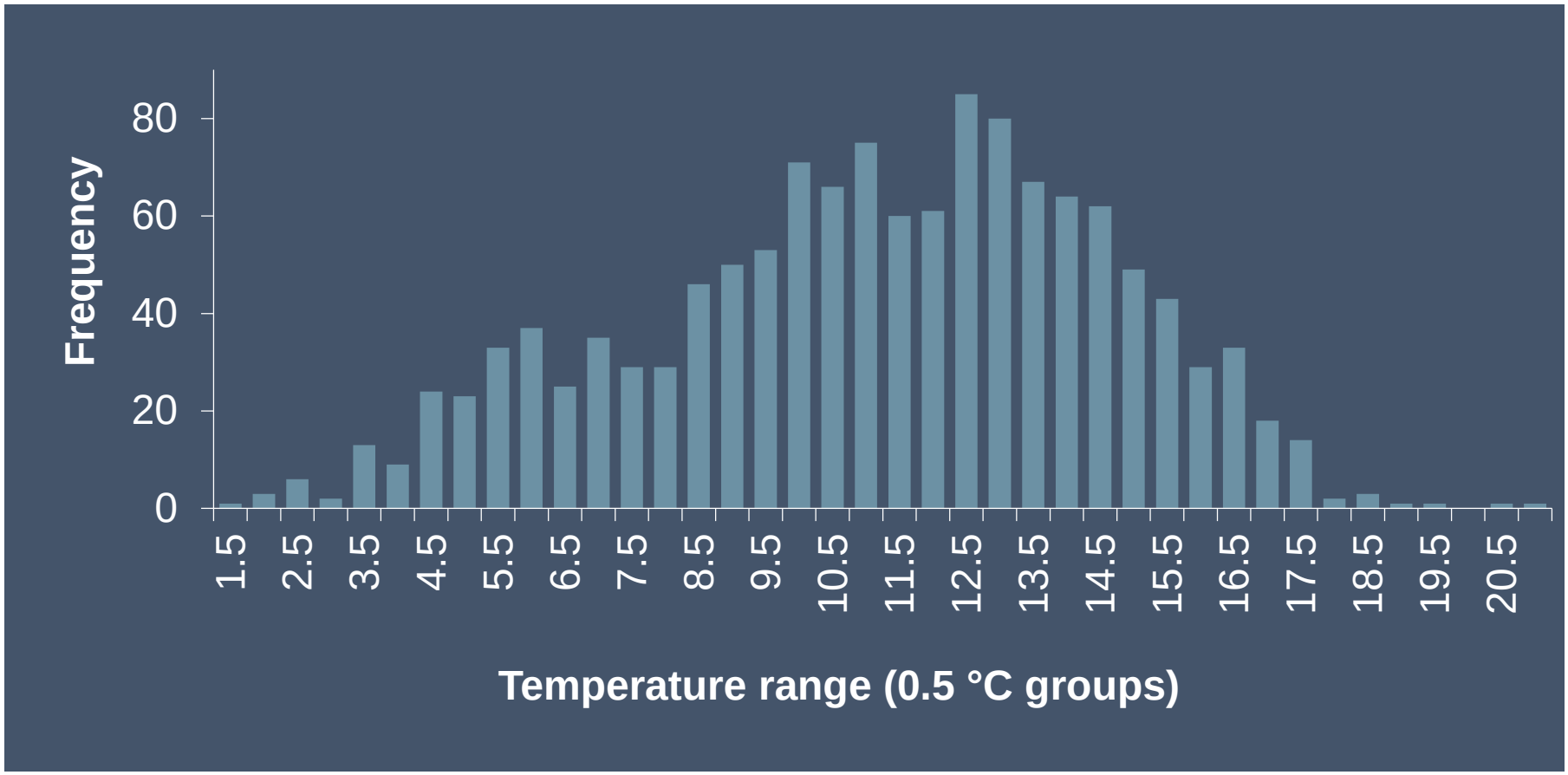
Climate variability during the CPR timeseries

- Historically, the Pacific Decadal Oscillation (PDO) has been a dominant mode of climate variability in the N Pacific.
- Higher frequency variability during CPR sampling years.
- 2014-2016 known as a “marine heatwave” affecting the east – the Blob plus El Niño.



Basin Scale: Northwards extent of warm water species in the eastern N Pacific

Frequency distribution of observed sample temperatures, from loggers on the CPR (2000-2010)



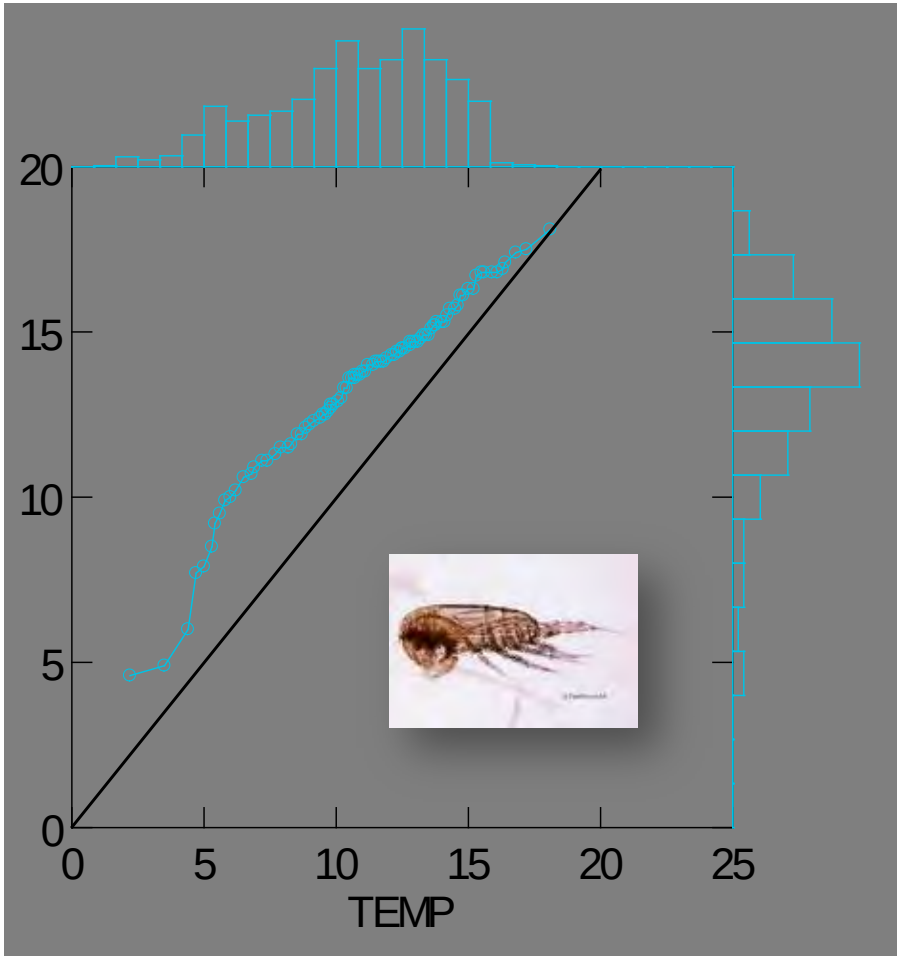
Batten and Walne , 2011. Journal of Plankton Research, 33

Basin Scale: Northwards extent

We first categorised each copepod taxon into one of 4 groups based on Q:Q plots (warm water, cold water, ubiquitous and other)

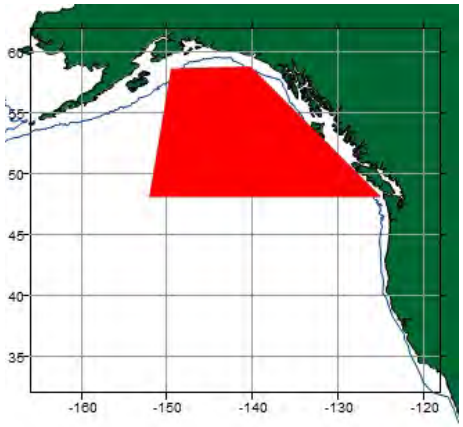
Example Q:Q plot for *Clausocalanus* spp.

Points plot to the left of a 1:1 line indicating a warmer distribution than the sample temperature distribution. A warm water group of 7 taxa (4 common) was identified.

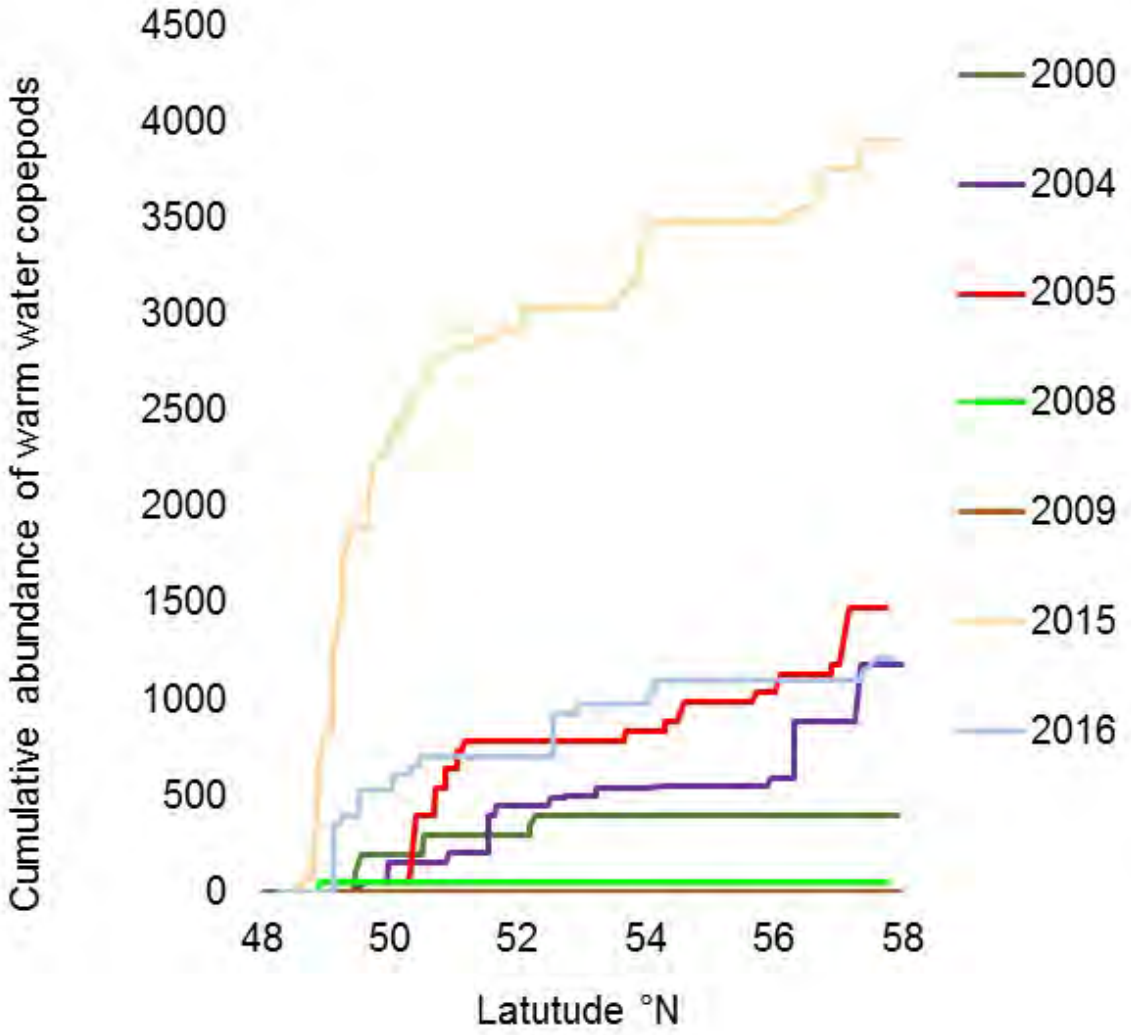


Basin Scale: Northwards extent

Updated to 2016:
Cumulative abundance of warm group (48-58°N).

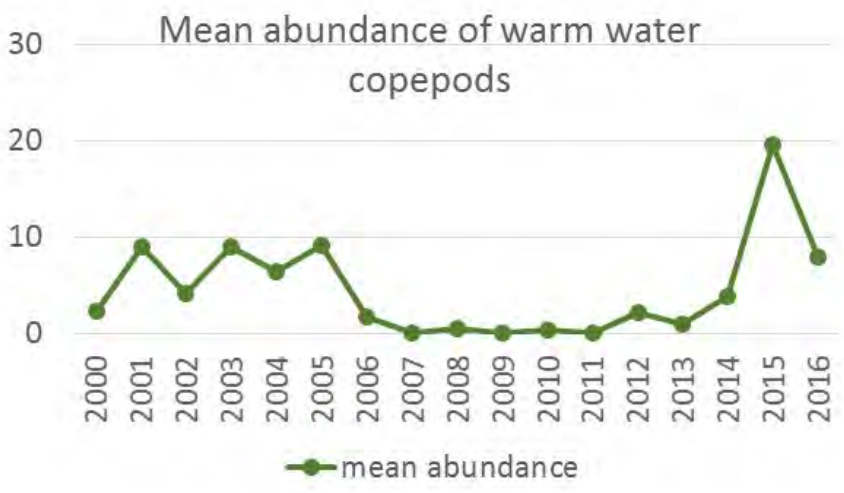


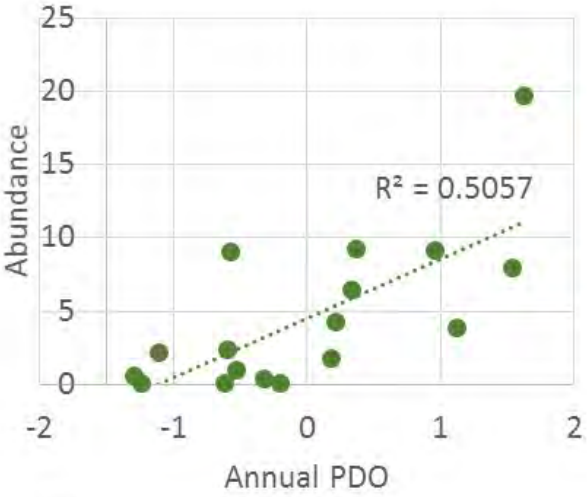
Variability in years, sometimes only found in the south, sometimes continue to occur right up to Alaska.

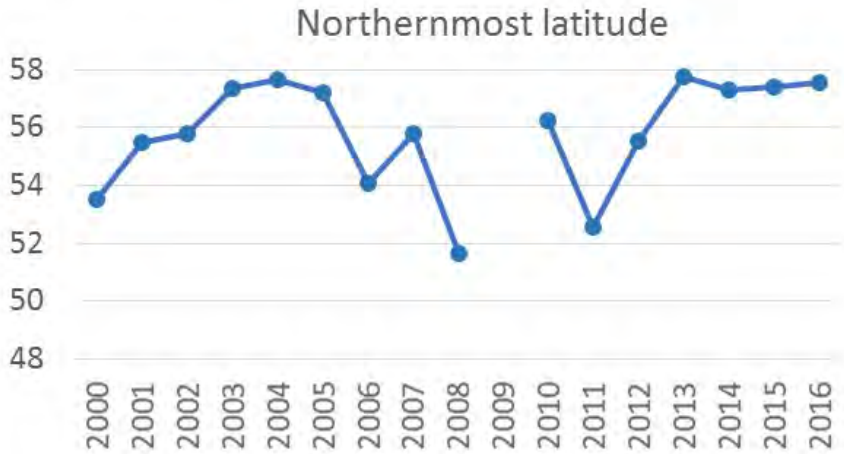


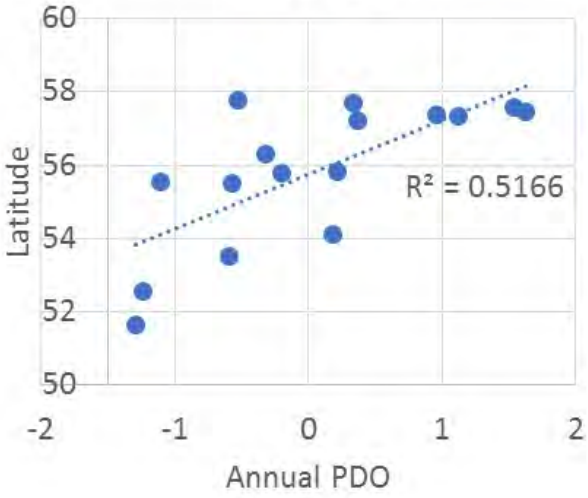
Basin Scale: Northwards extent

Highly significant relationships ($p<0.005$) between PDO index and these data:









Basin Scale: Northwards extent

- The cold-water group showed no significant relationship between abundance or latitude and PDO.

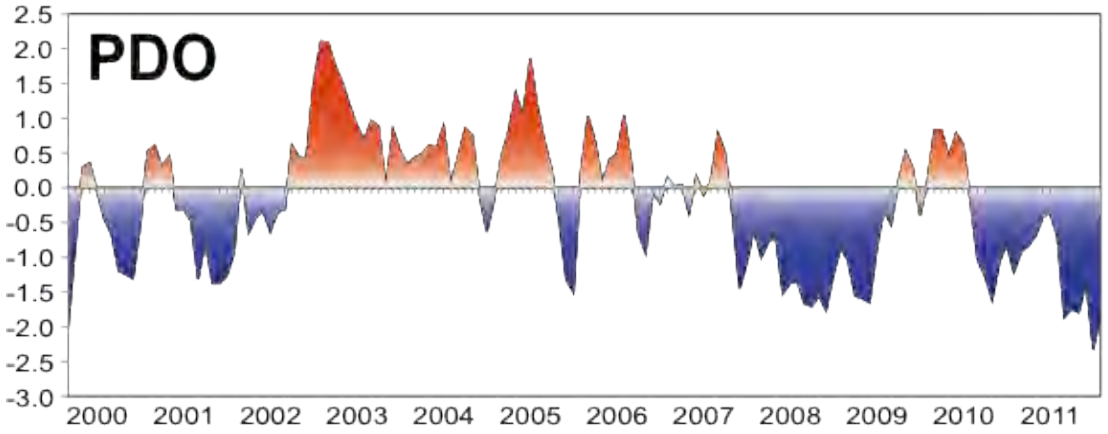
- No change in temperature distribution of warm water species between warm and cold years – follow isotherms

- Warm water species may also do better in warm years

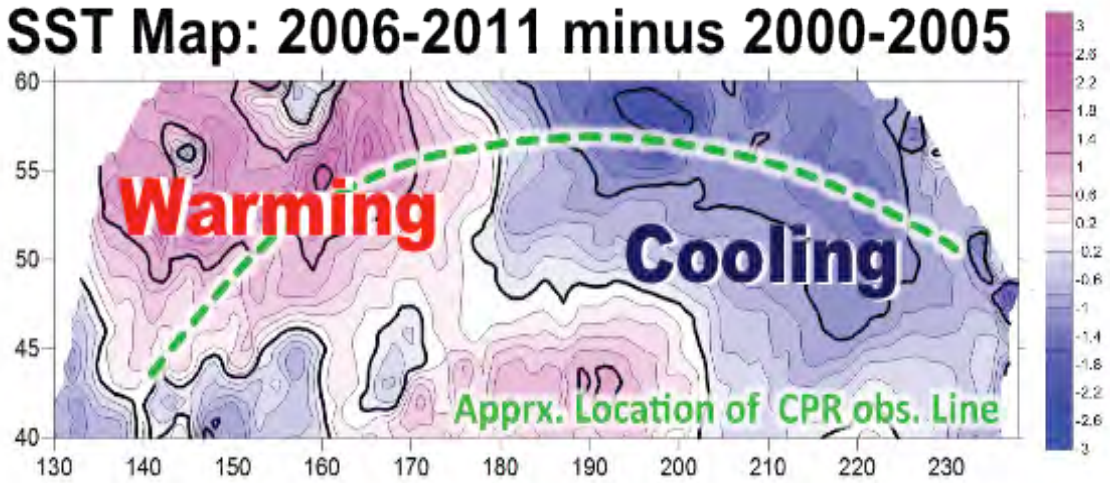
- With the predicted 1-3 °C rise in temperature, we will likely see an increase in the co-existence of these two groups in the NE Pacific, an increase in copepod diversity.

Basin Scale: West v East

The PDO was positive from 2002 to 2006 and then in 2006/07 went negative again.



From 2006-2011 the east saw cooling and the west saw warming.



East-West comparison of ZP community changes. Chiba et al. (2015) Ecology and Evolution, 5

Basin Scale: West v East

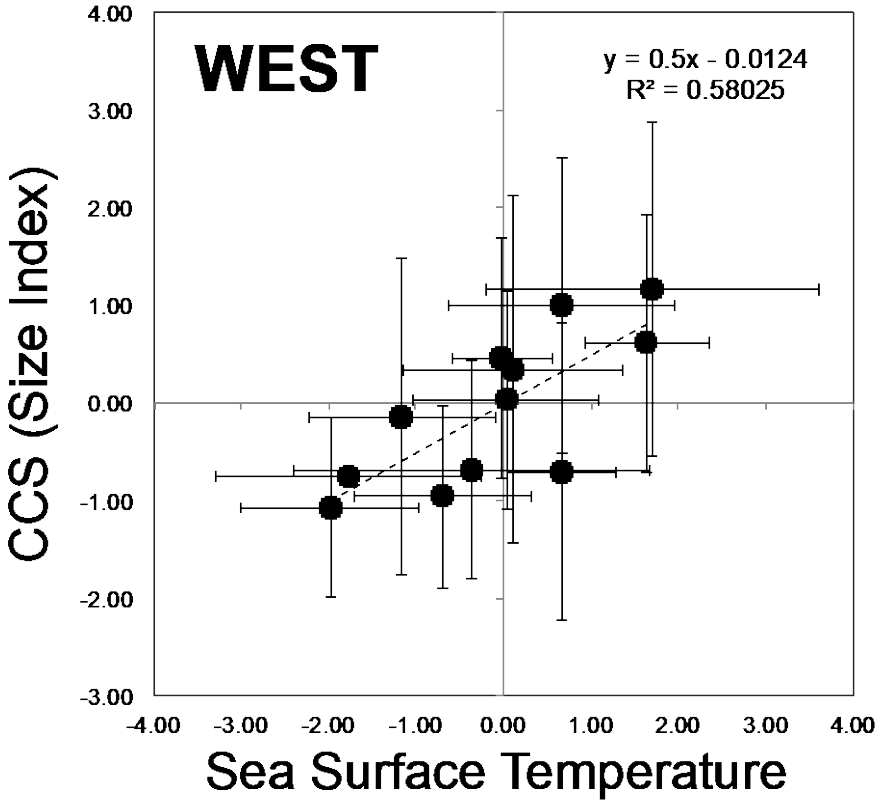
Copepod Community Size is an indicator of the community bias towards larger, typically subarctic species or smaller, typically more southern species.

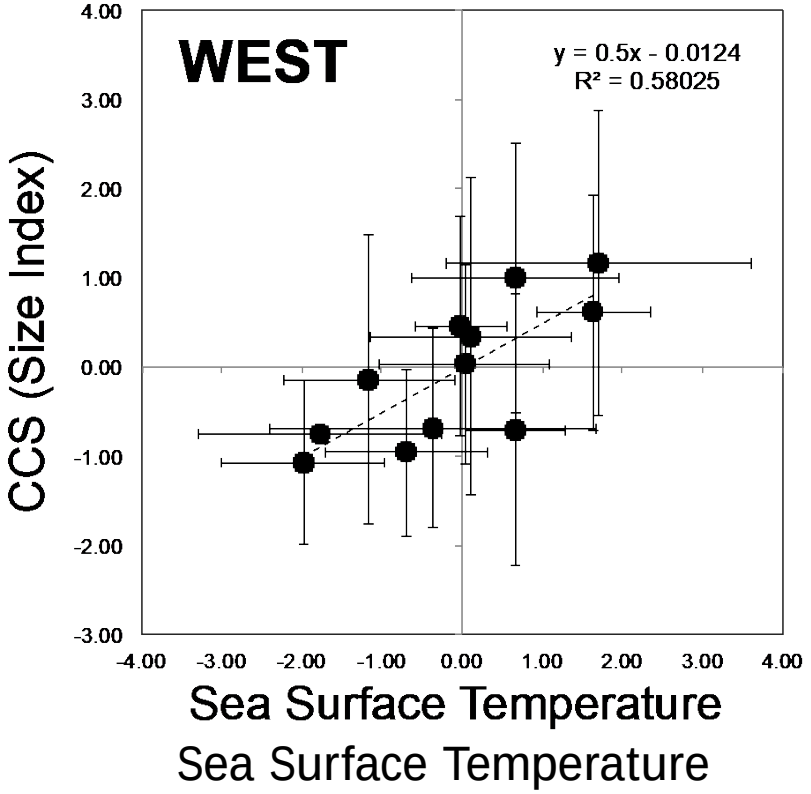
Copepod Community Size:

$$\overline{S} = \frac{\sum_{i=1}^{N}(L_i \times X_i)}{\sum_{i=1}^{N} X_i}$$

L = length L (in mm) of each copepod species i (adult female length), x by its abundance Xi, summed over all species (N) and divided by the total abundance.

Basin Scale: West v East





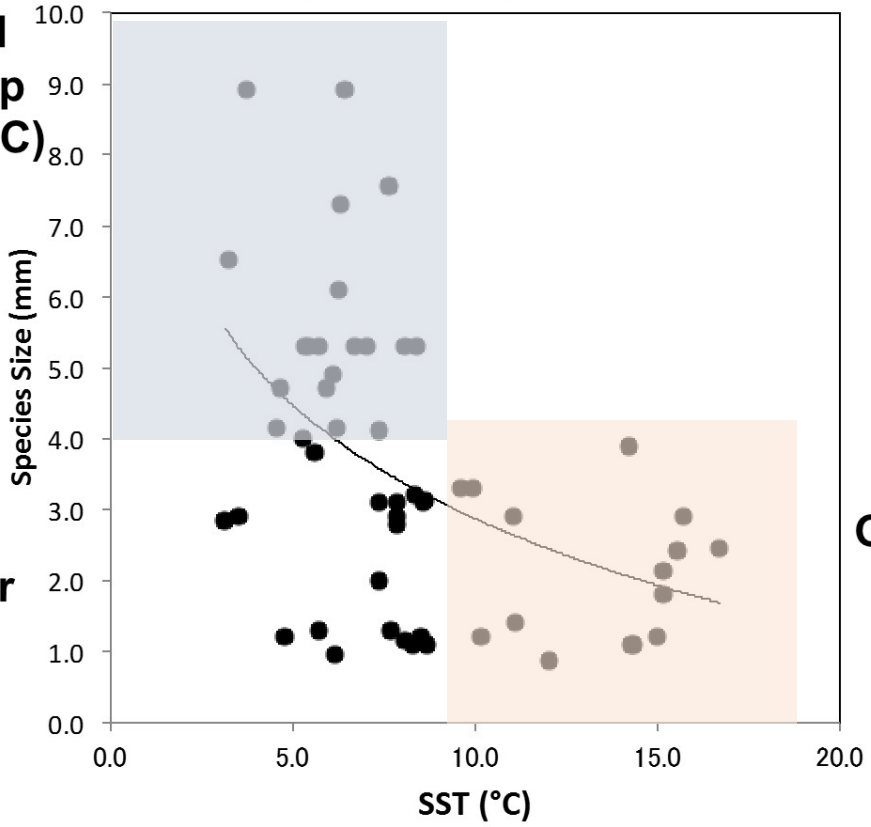
Sea Surface Temperature

These results showed the influence of the PDO cool-warm cycle on the zooplankton community structure in both regions, BUT the West did not follow the accepted "smaller when warm" result found in other studies.

Basin Scale: West v East

AVG SST of Occurrence and Size of 54 copepod spp/taxa

Large Cold Water Group (>4mm, <9° C)



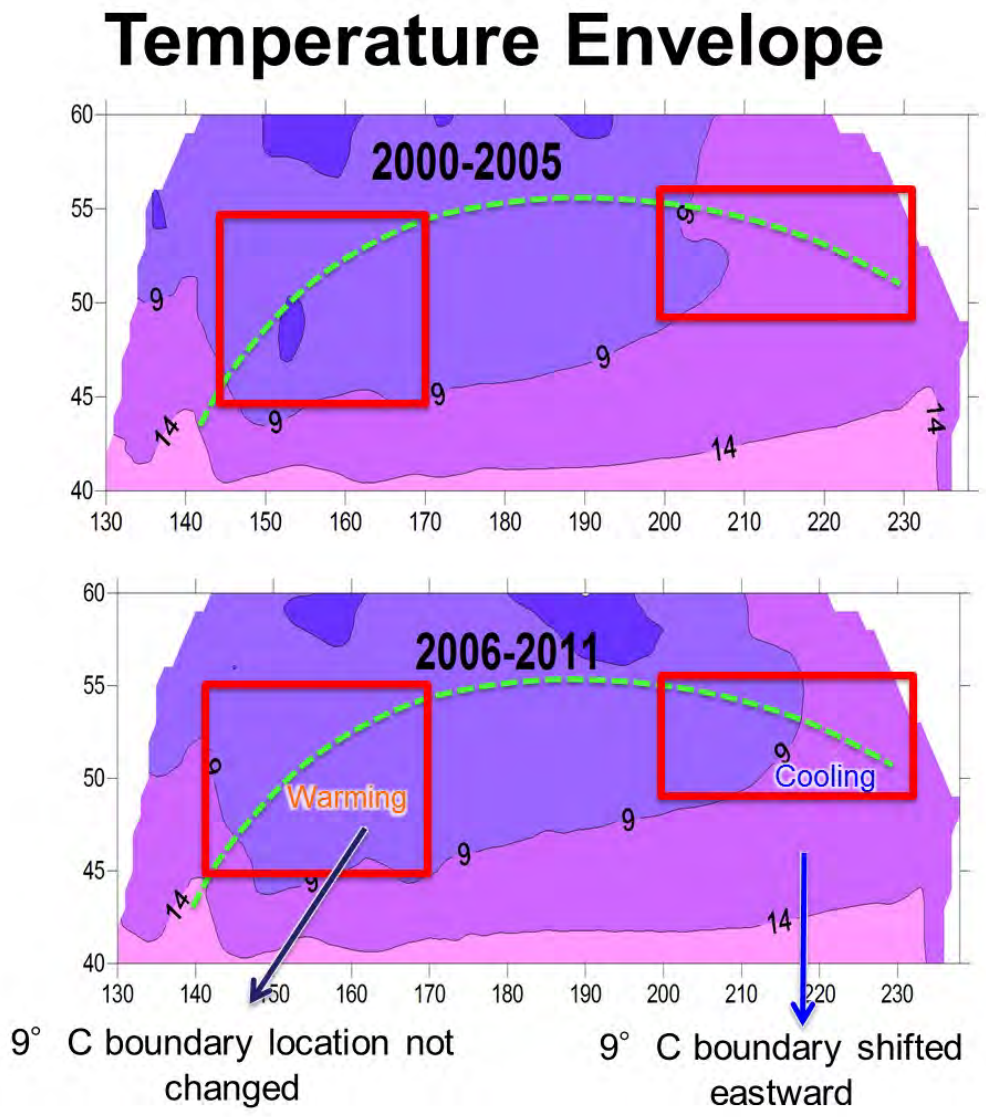
Small Cold Water Group (<4mm, <9° C)

Warm Water Group (<4mm, >9° C)

East-West comparison of ZP community changes. Chiba et al. (2015) Ecology and Evolution, 5

Basin Scale: West v East

In the West, the 9°C boundary did not change in space after 2005, but in the East the 9°C boundary moved eastwards in the sampled region.



East-West comparison of ZP community changes. Chiba et al. (2015) Ecology and Evolution, 5

Basin Scale: West v East

AL-PDO system

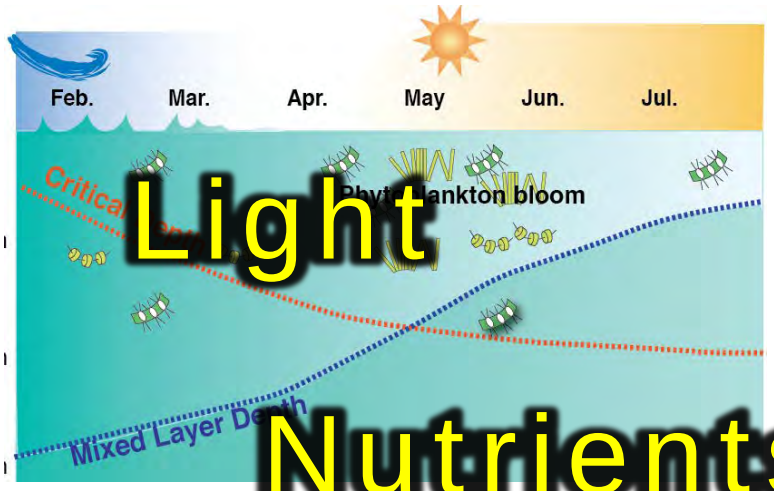
Mechanisms which drive cool-warm condition and plankton community variability differ between East and West

WEST → **Wind Stress**

EAST → **Ocean Circulation**

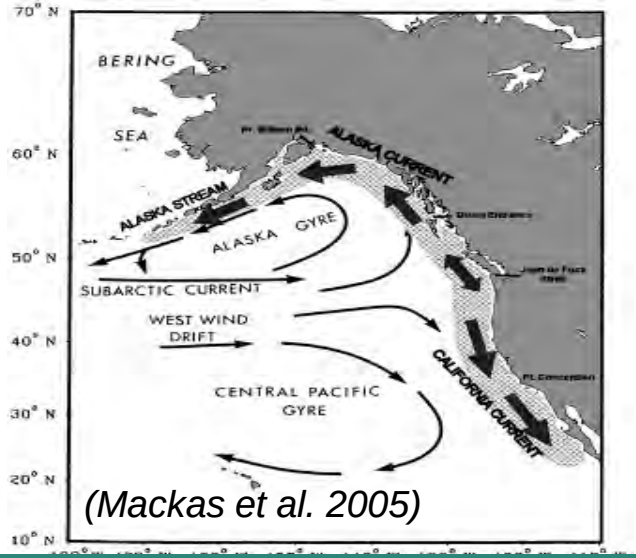
Seasonal Mixed Layer – Bottom-up Process

Within the SST-Envelope…



Advection Transport by Current Dynamics

Out of the SST-Envelope…



(Mackas et al. 2005)

East-West comparison of ZP community changes. Chiba et al. (2015) Ecology and Evolution, 5

Summary

Long-term, consistent CPR transects provide data necessary to assess:

Variability in meso-scale transitional areas (eddies, fronts, currents) and their role in the oceanic diversity.

Effects of climate on basin-scale responses in the plankton, including differing responses in the east and west oceanic gyres.

May see increased biodiversity in transitional regions.

Acknowledgements

Further information:
sonia.batten@mba.ac.uk
http://pices.int/projects/tcprsotnp/data.aspx

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And to our hosts!

Exxon Valdez Oil Spill Trustee Council

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