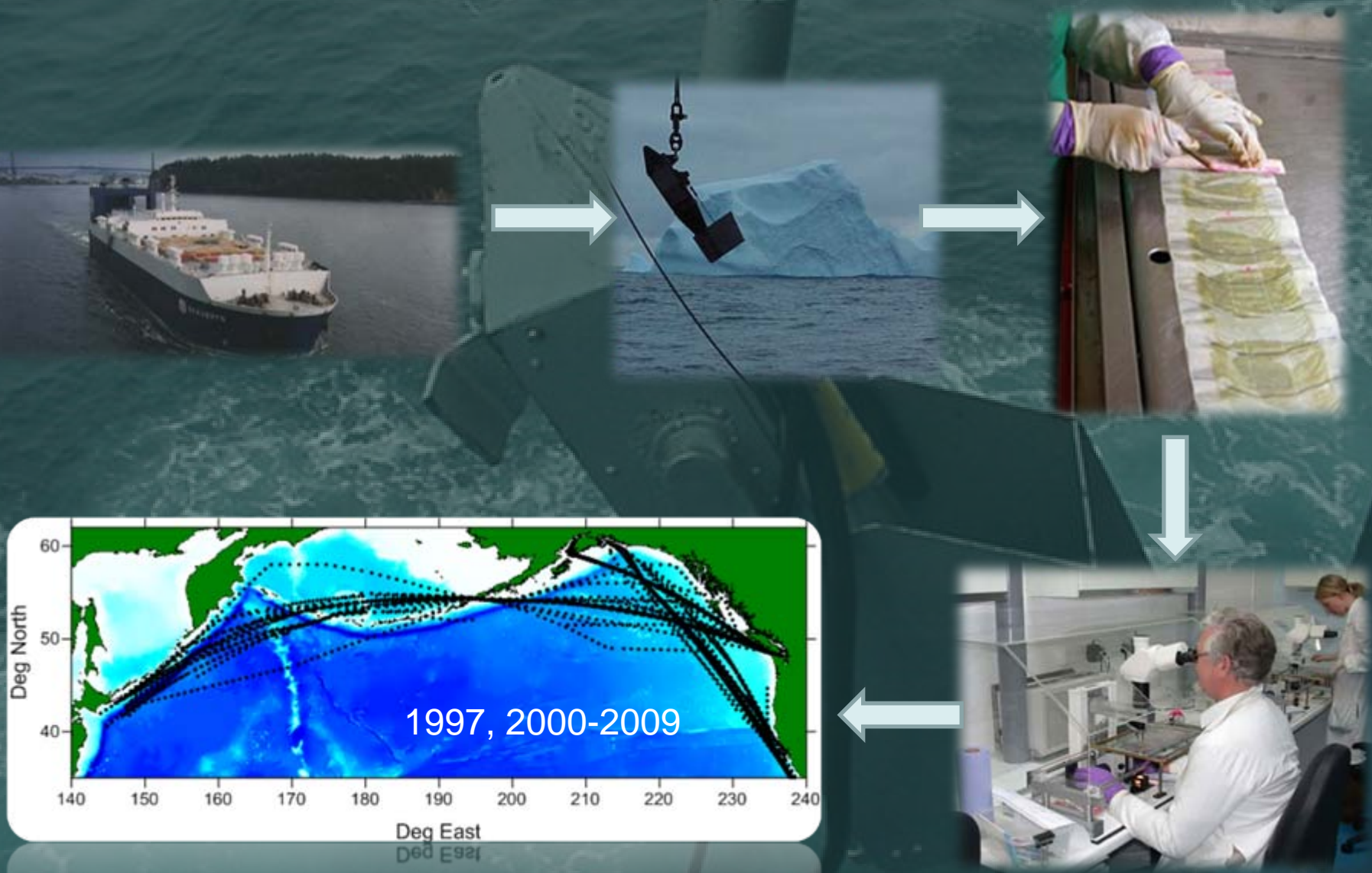


Variability in northwards extension of warm water copepods in the Northeast Pacific

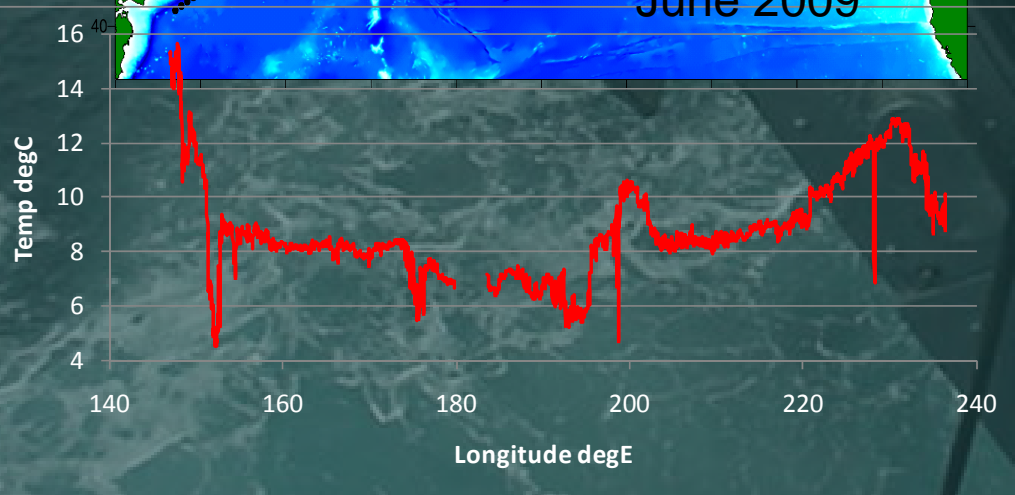
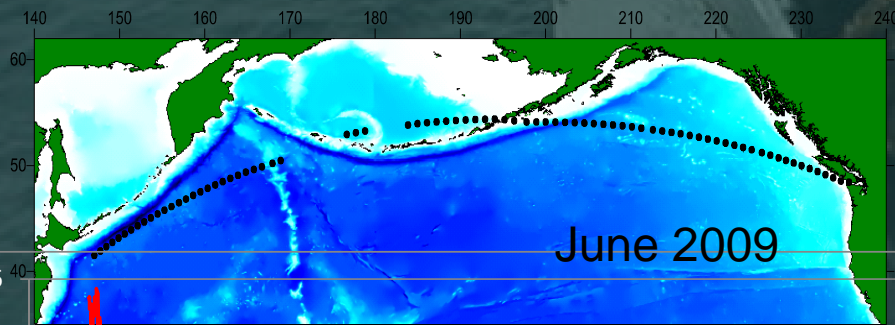
Sonia Batten and Tony Walne



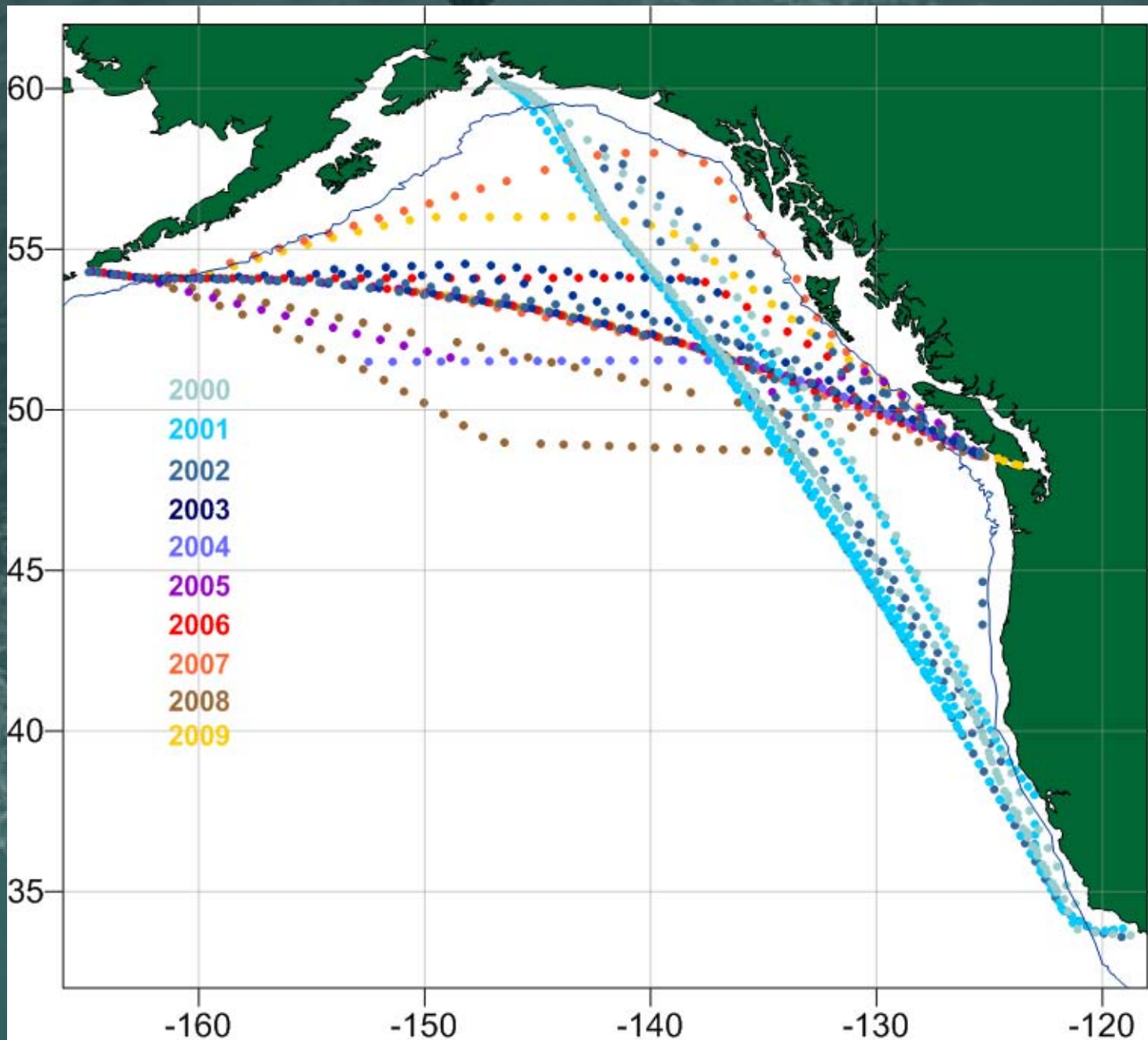
Plankton were sampled by the Continuous Plankton Recorder

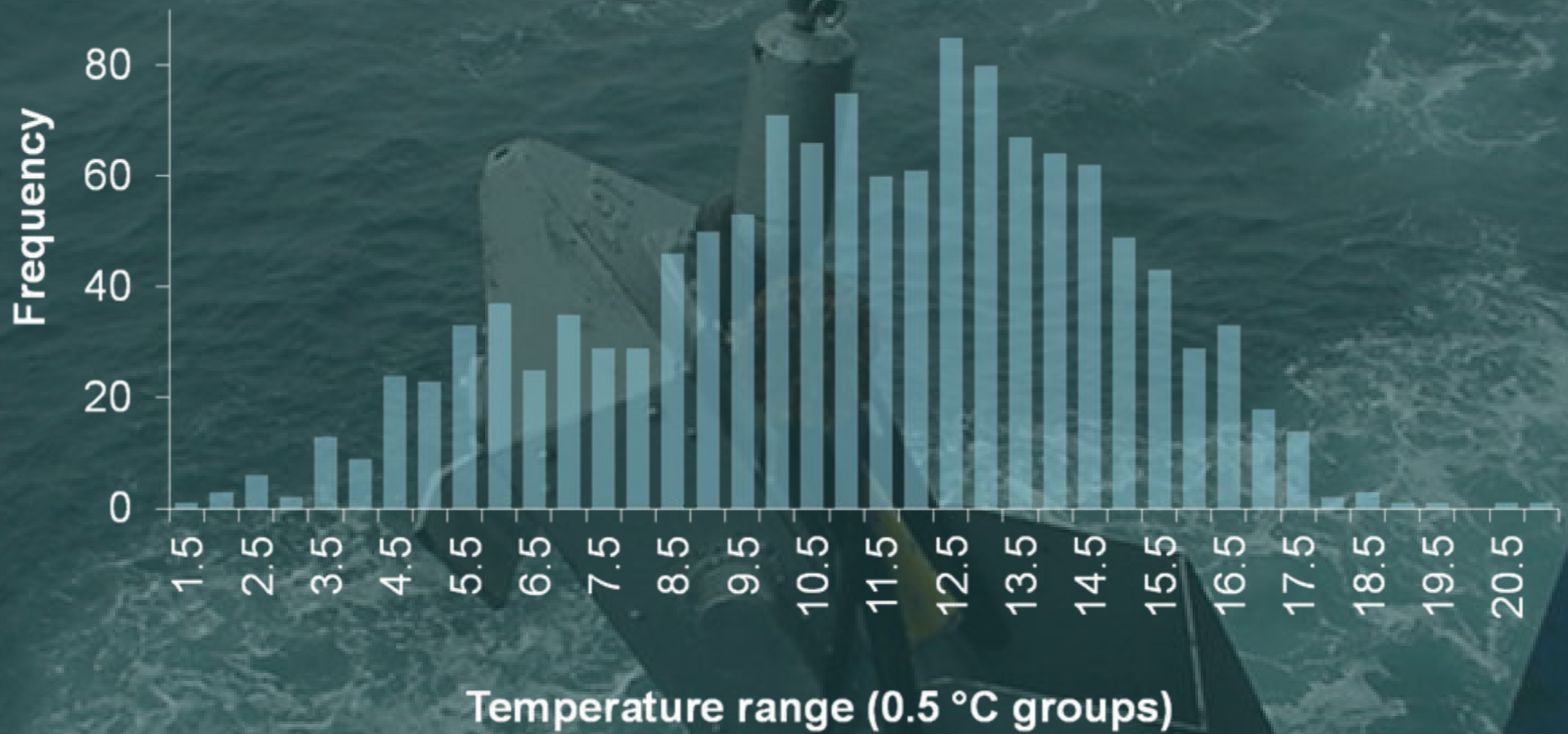


Instrumentation was also added to some transects by attaching temperature loggers or self-logging CTDs to the CPR



Samples with associated in situ temperature in the NE Pacific (1,304)





Frequency distribution of observed sample temperatures

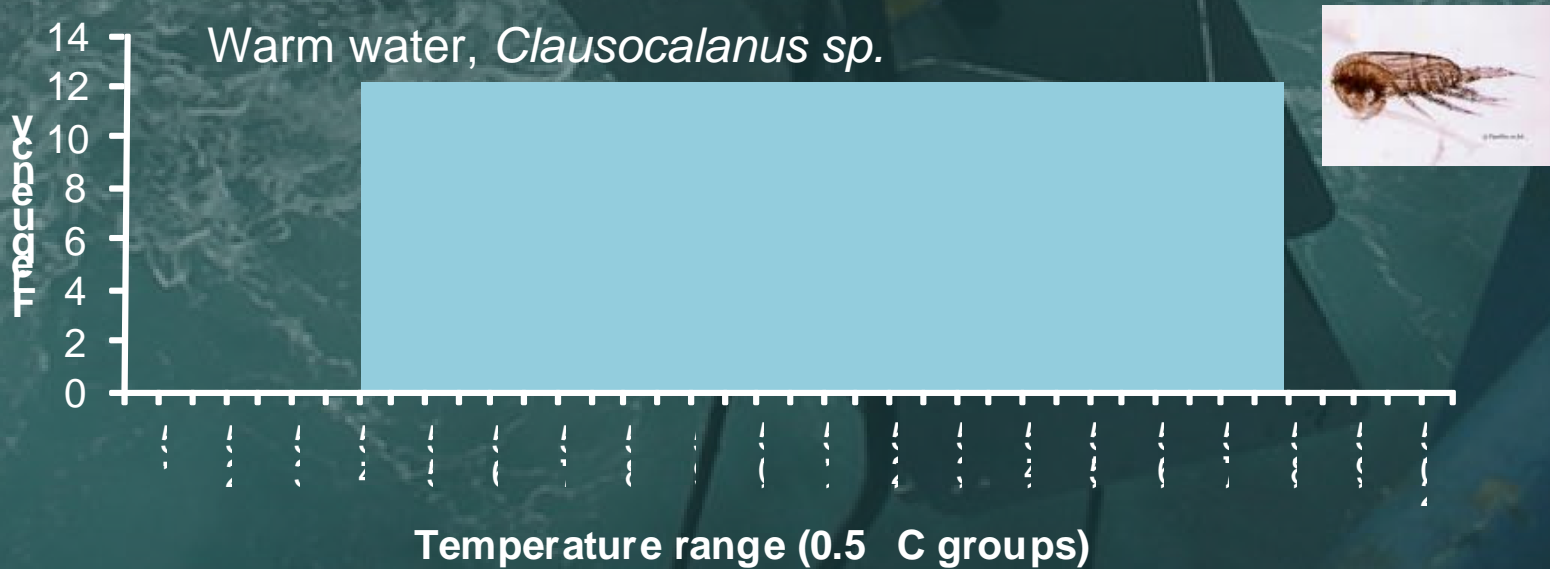
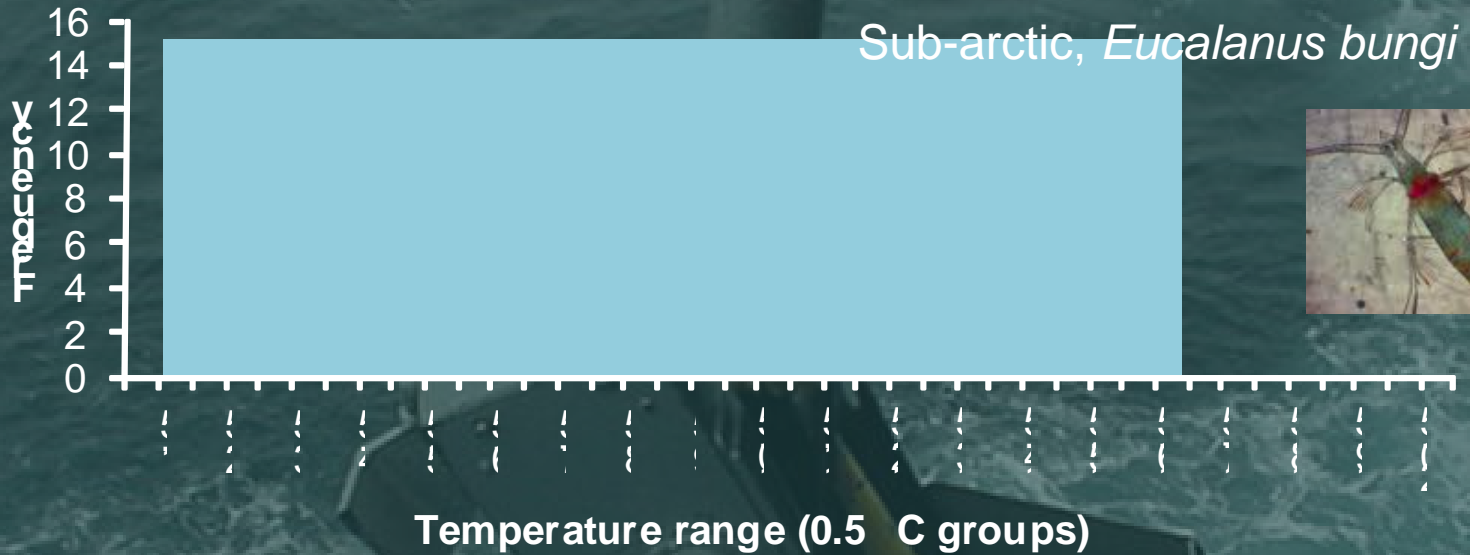
29 copepod taxa were common enough to examine their temperature distributions: median, max and min



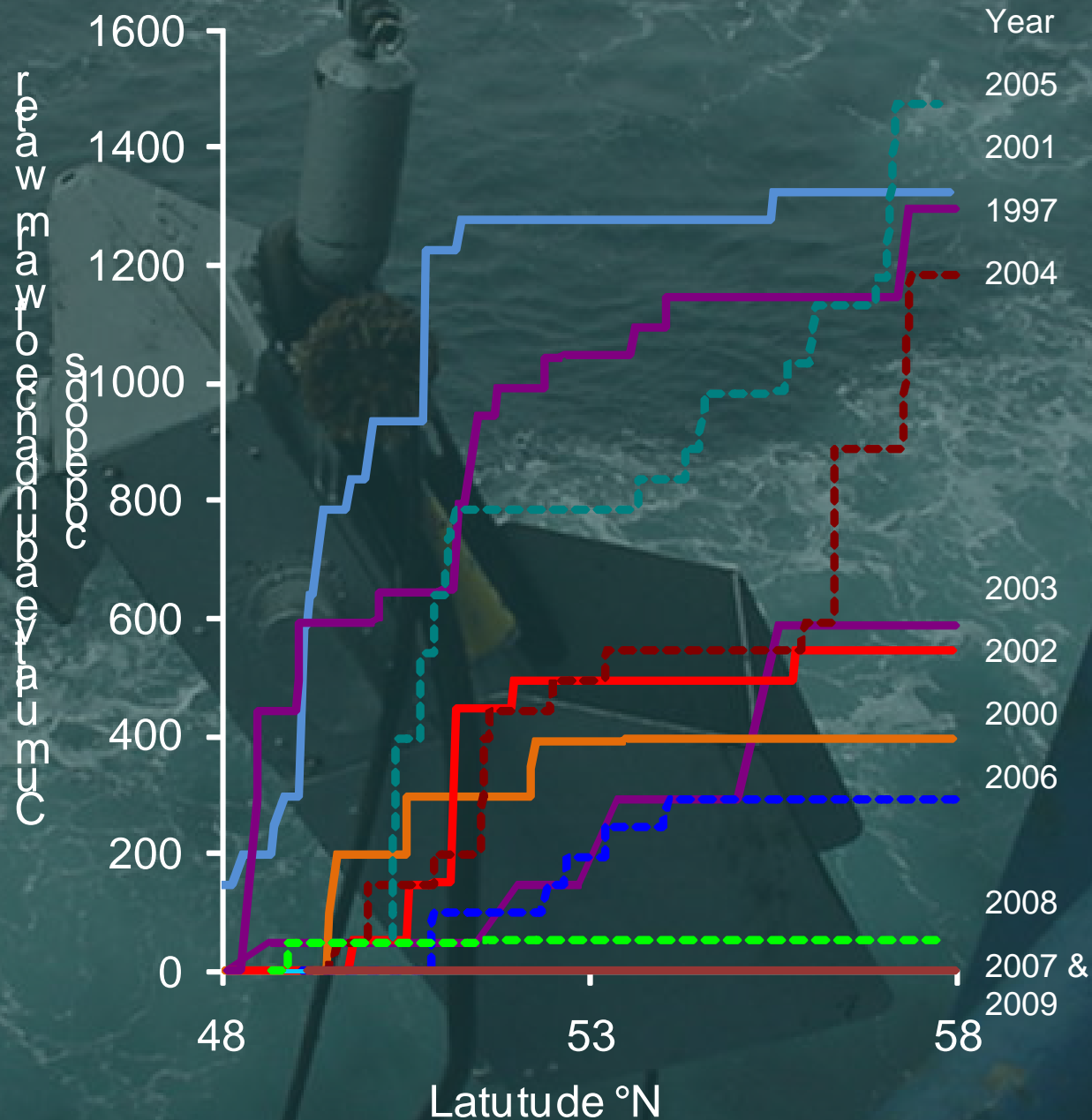
Quantile: Quantile plots were used to allocate the taxa into 4 groups:

Ubiquitous	Warm water	Cold water	Other
Calanus spp. C1-4	Acartia danae	Calanus marshallae	Acartia spp.
Metridia pacifica C5-ad.	Candacia bipinnata	Eucalanus bungi	Acartia longiremis
Metridia spp. C1-4	Clausocalanus spp.	Neocalanus cristatus C1-4, C5-adult	Calanus pacificus
Oithona spp.	Corycaeus spp.	Neocalanus plumchrus/flemingeri C2, C3, C4, N plumchrus C5, N flemingeri C5	Candacia colombiae
Para-pseudocalanus spp	Mesocalanus tenuicornis	Paraeuchaeta elongata	Centropages abdominalis
Pseudocalanus spp. C5-adult	Pleuromamma abdominalis		Euchirella rostrata
	Undeuchaeta major		

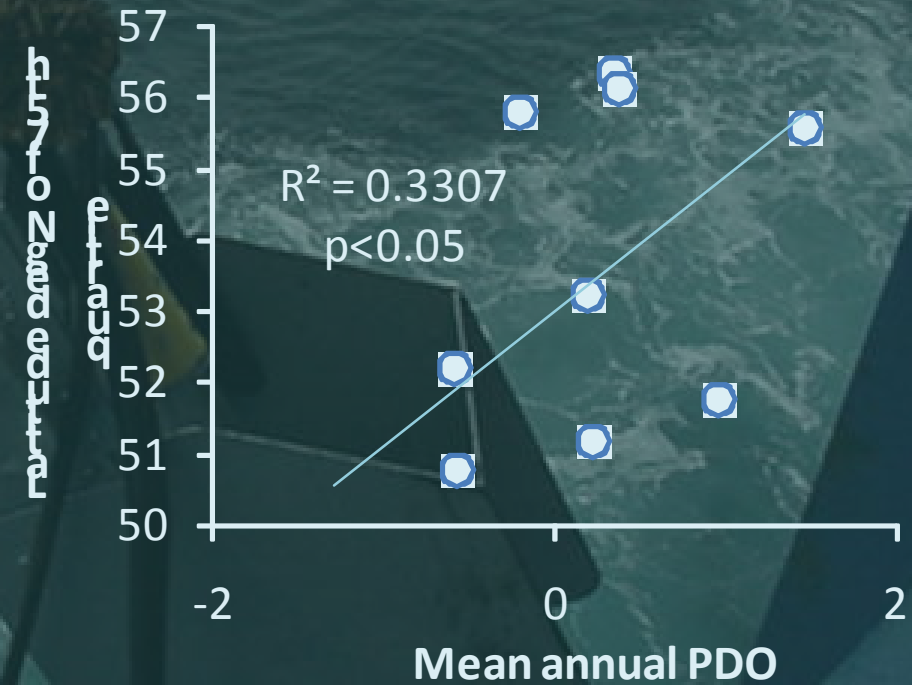
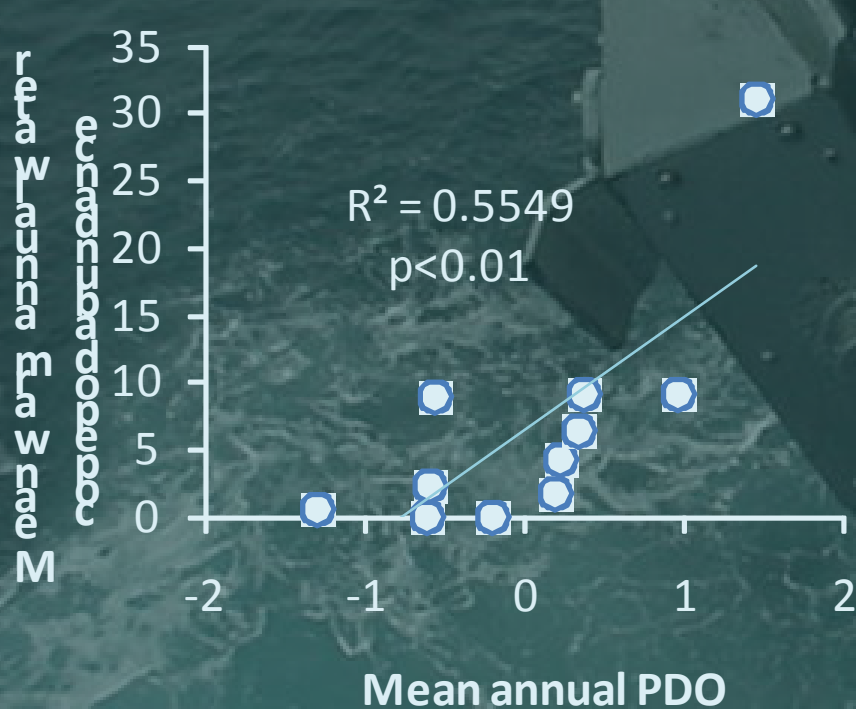
Temperature distributions of two example taxa



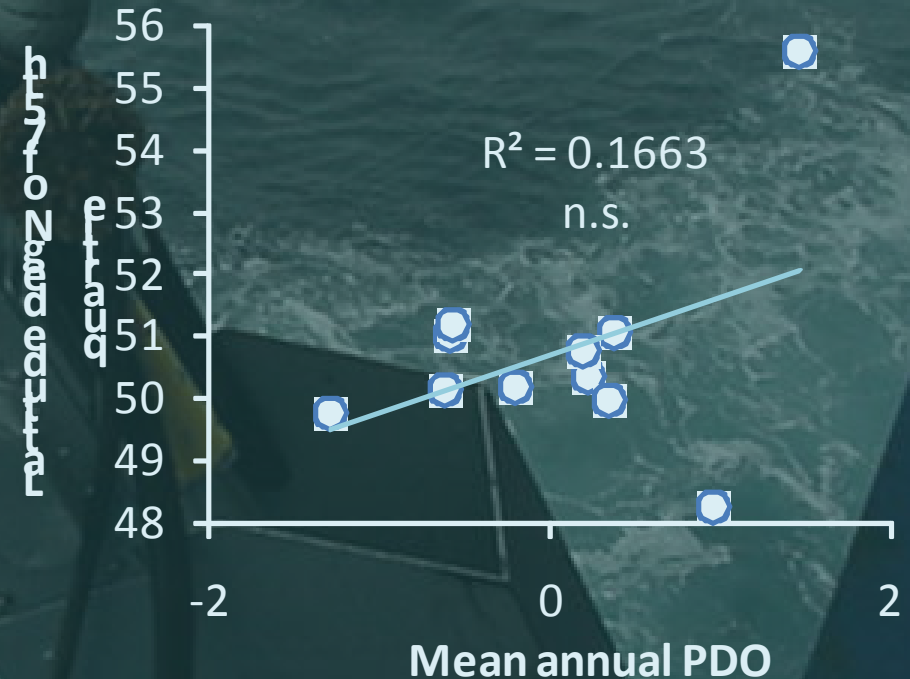
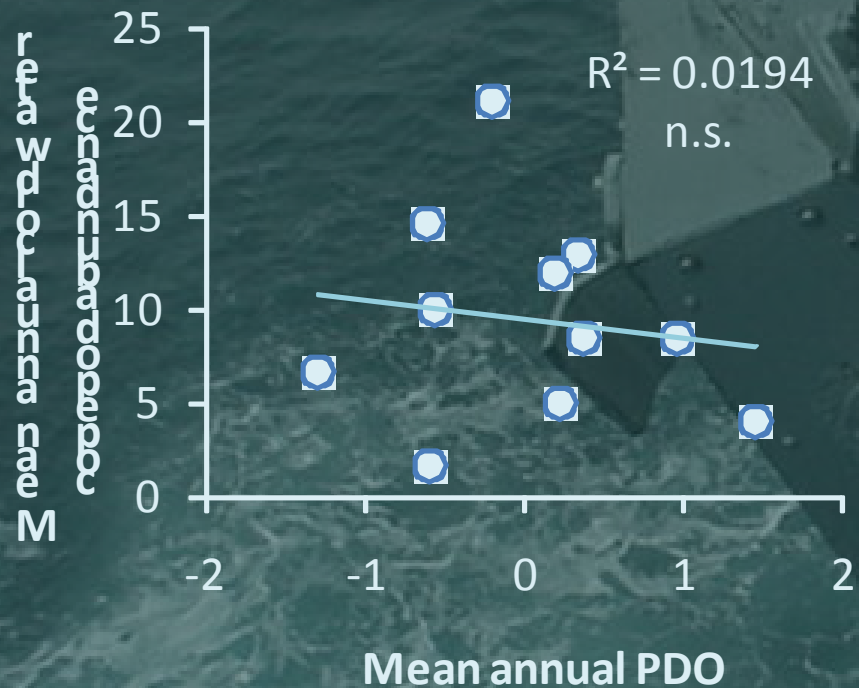
Cumulative abundance of warm-water copepods each year, south to north, Mar-Sept, for oceanic region (shelf out to 150°W)



Both the abundance and the latitude reached are significantly positively correlated with temperature/PDO

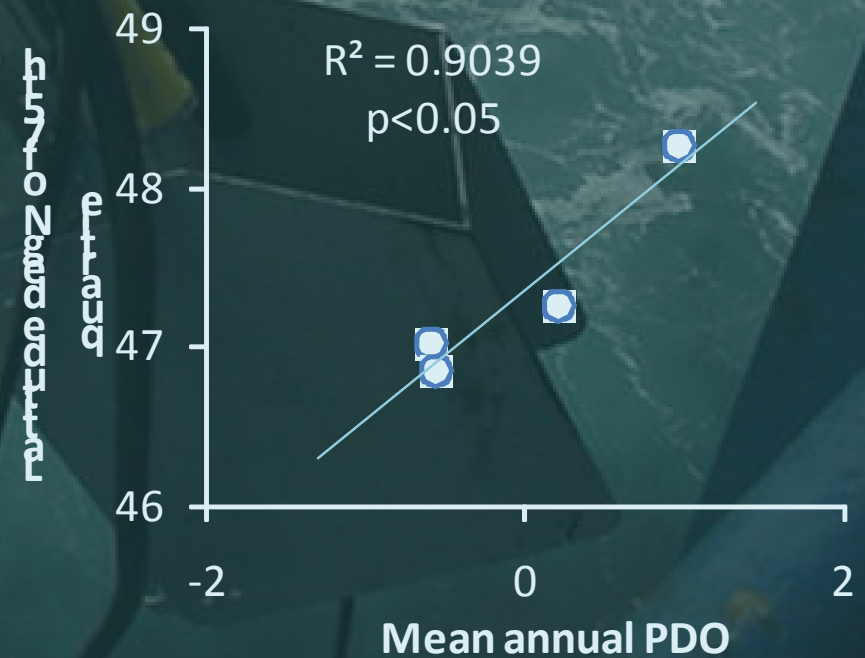
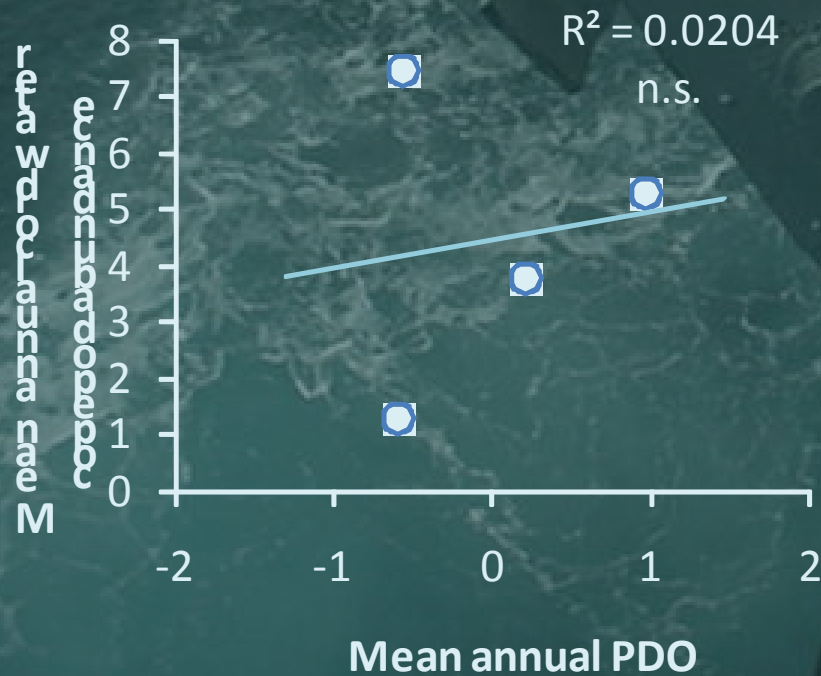
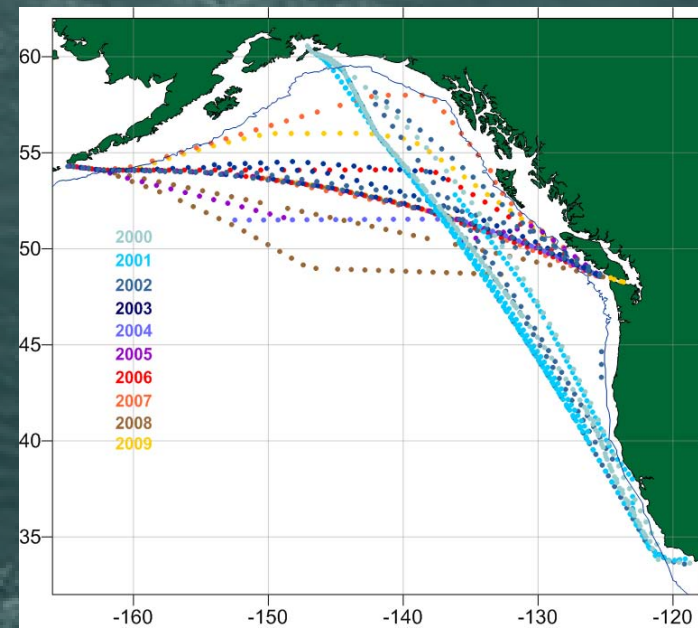


Repeated with subarctic species. But no significant relationship with abundance or latitude and PDO/Temperature



Perhaps this is because 48°N is not close to the southern distribution limit of the subarctic species?

If just the 4 years were used where the transect extended further south we do see a relationship (just latitude) perhaps the southern extent is affected by temperature/PDO?



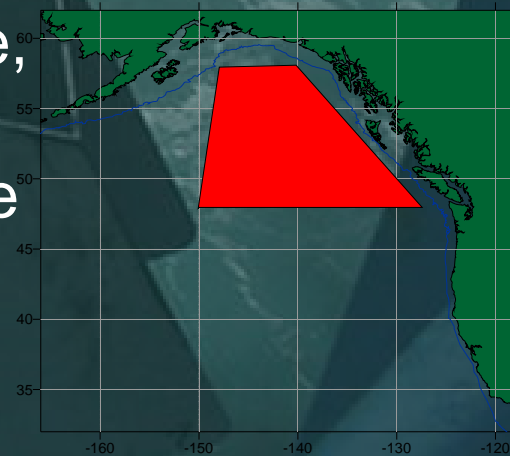
✈ Expect stronger poleward winter winds with +ve PDO to carry copepods further north but no correlations with current strength as derived from Argo floats (courtesy Howard Freeland)

✈ 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 see an increase in the co-existence of these two groups in the NE Pacific, an increase in copepod diversity

But is that a good thing?



Subarctic species

Calanus marshallae

Neocalanus plumchrus

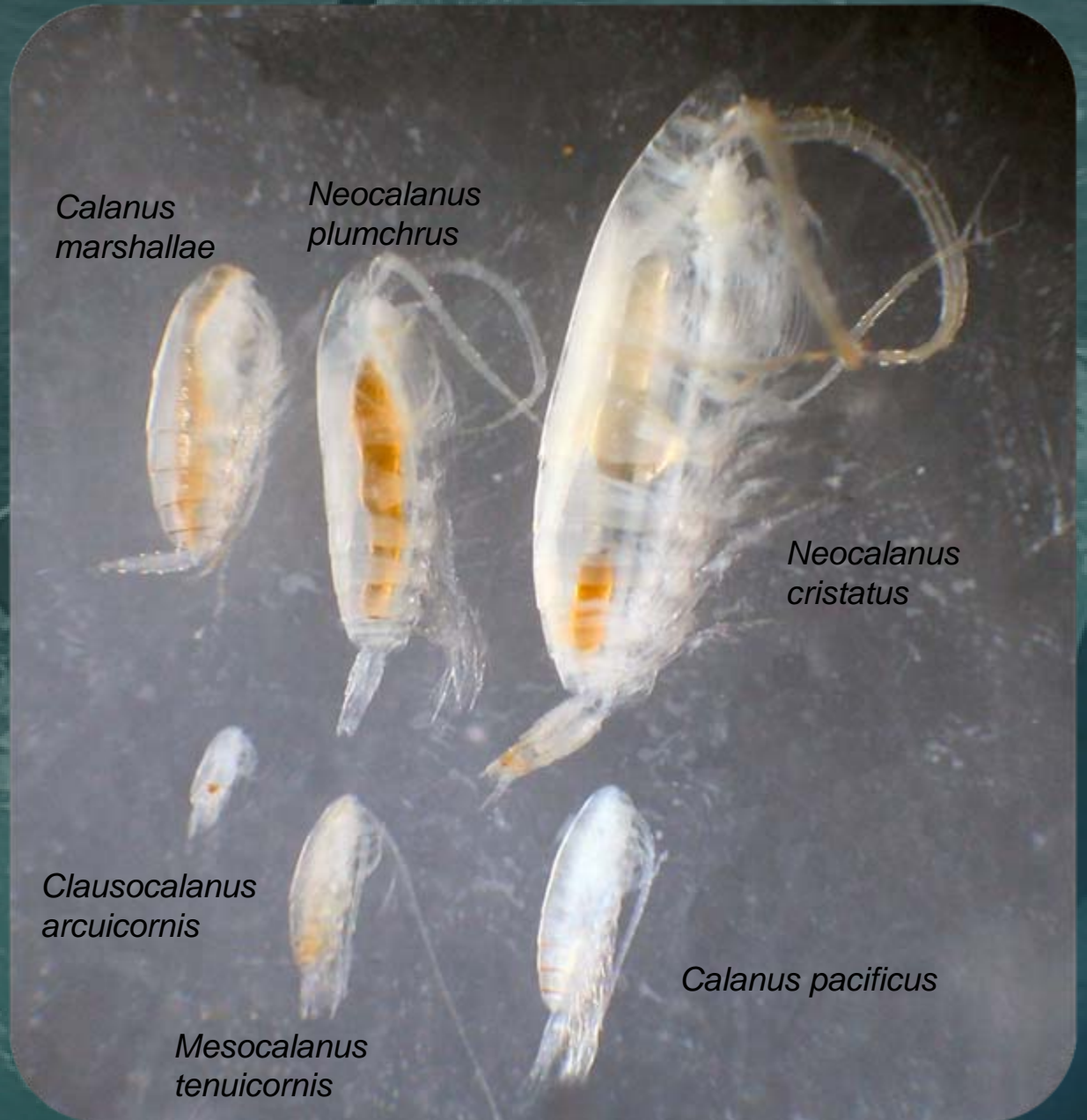
Neocalanus cristatus

Warm water species

Clausocalanus arcuicornis

Mesocalanus tenuicornis

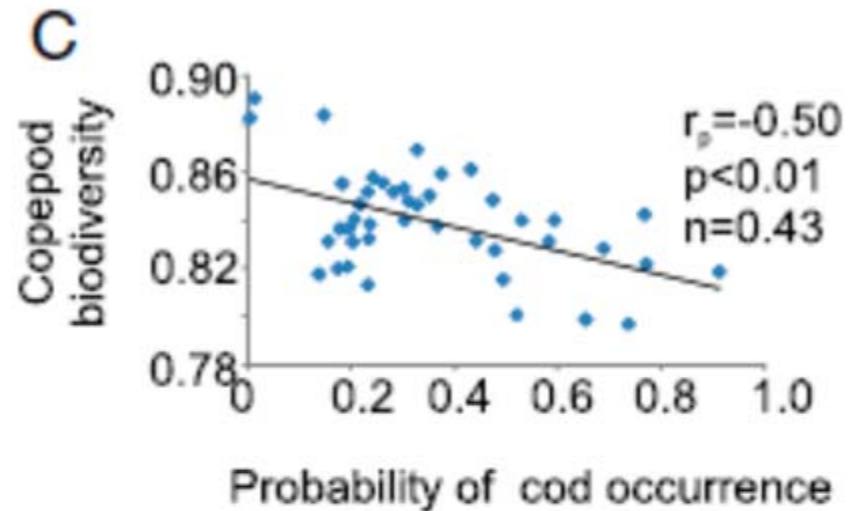
Calanus pacificus



From Beaugrand
et al. (2010)

www.pnas.org/cgi/doi/10.1073/pnas.0913855107.

“at these higher latitudes simpler food webs and lower biodiversity ecosystems have often been characterized by large populations of exploitable fish species”



Relationship between copepod biodiversity and probability of cod occurrence in the extratropical North Atlantic

Acknowledgements

Thanks to:

Officers and crews of the volunteer vessels (Skaubryn, Horizon Kodiak and Polar Alaska)

To everyone at SAHFOS east and west for time at the microscopes

To the funders and to PICES for supporting the project



Fisheries and Oceans
Canada

Pêches et Océans
Canada



EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL