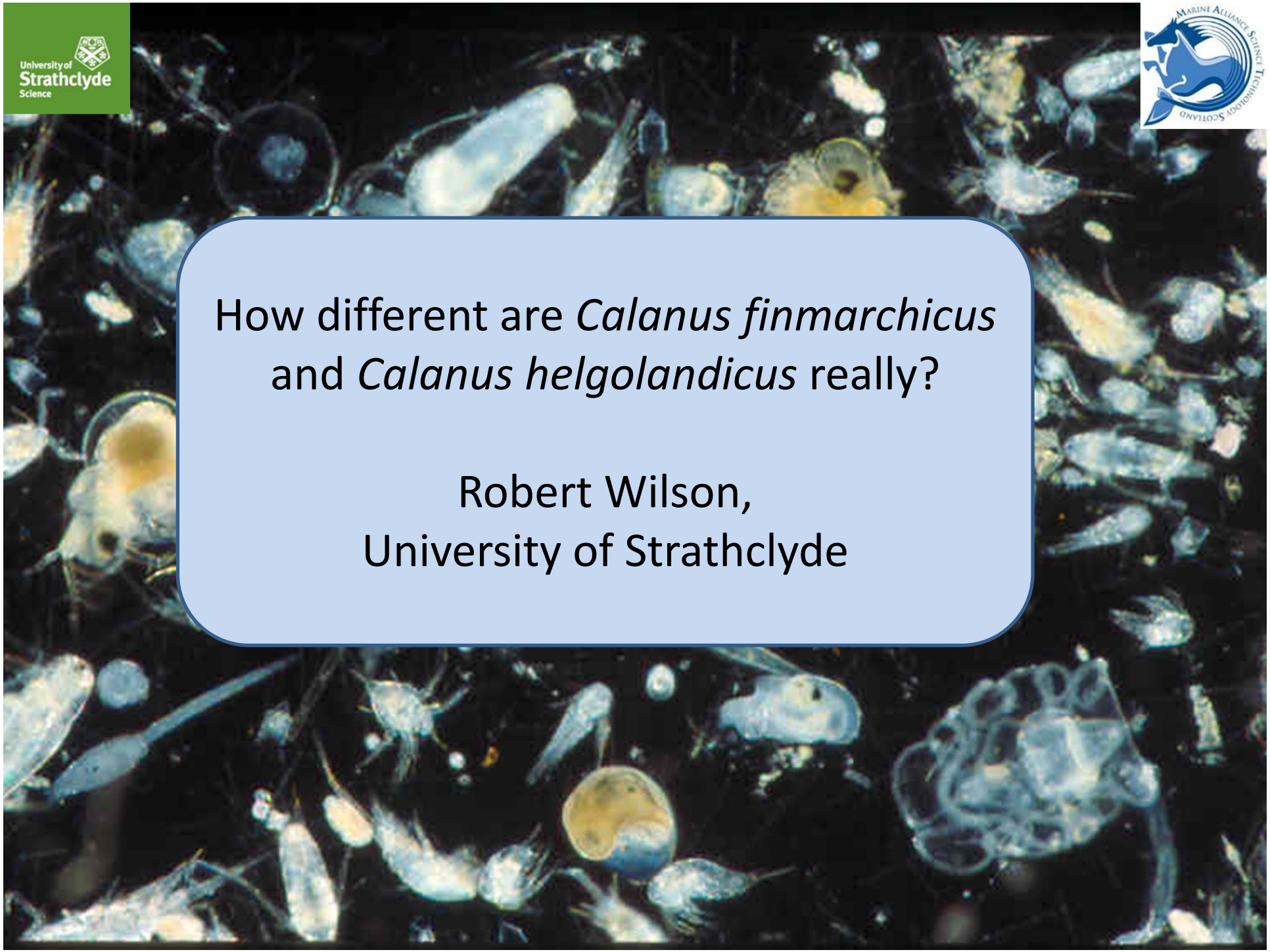


How different are *Calanus finmarchicus* and *Calanus helgolandicus* really?

Robert Wilson,
University of Strathclyde

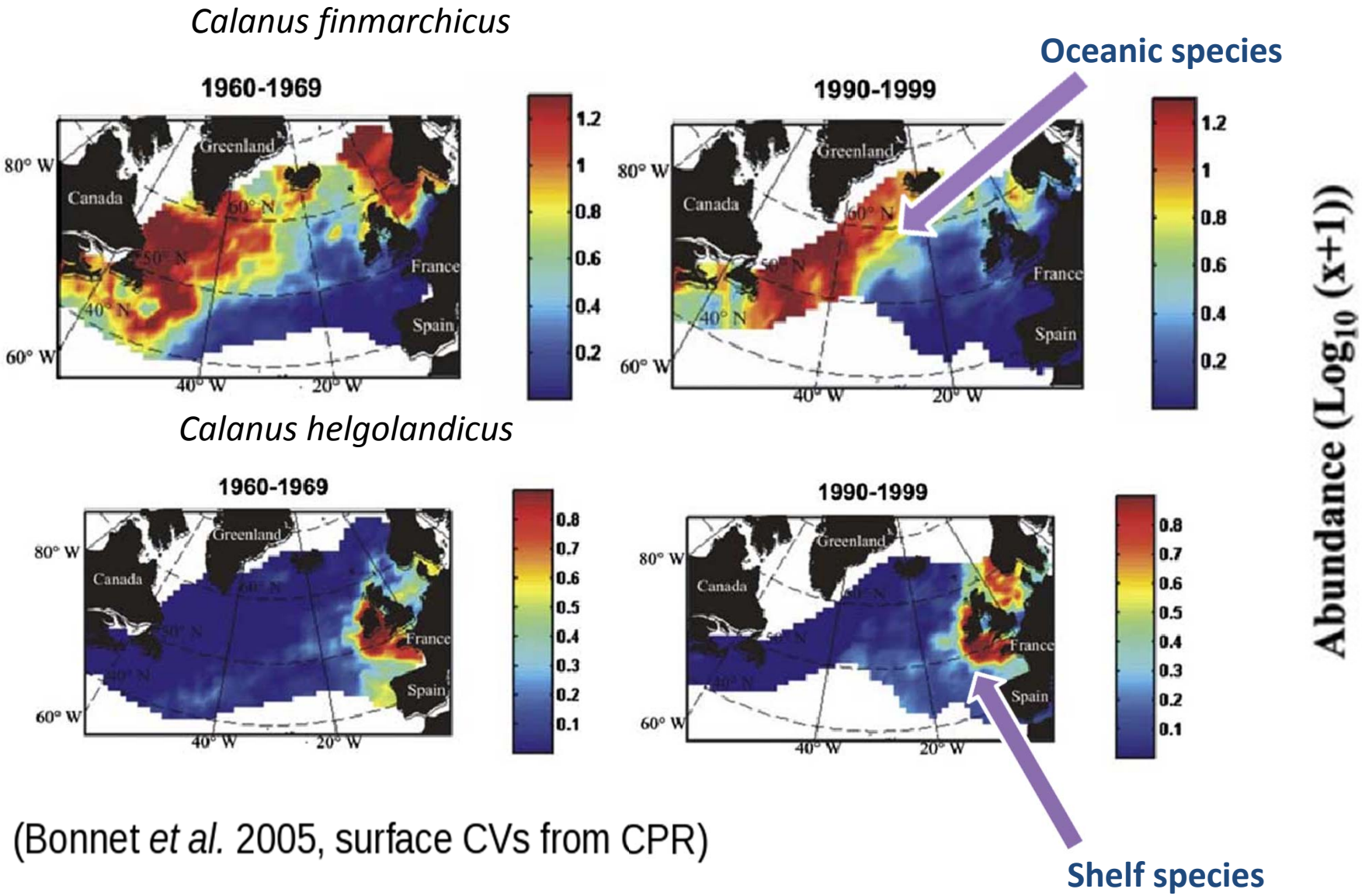
Why care about the differences between *C. finmarchicus* and *C. helgolandicus*?

- *Calanus* copepod species play a vital role transferring biomass from phytoplankton to higher trophic levels
- *C. finmarchicus* dominates the mesoplankton biomass in large parts of the North Atlantic
- However, recent biogeographic shifts are seeing it being replaced by *C. helgolandicus* in certain regions, in particular the North Sea.
- This may have significant ecosystem impacts

- AIM: synthesize differences between each species and produce new models relating development and egg production rate with temperature

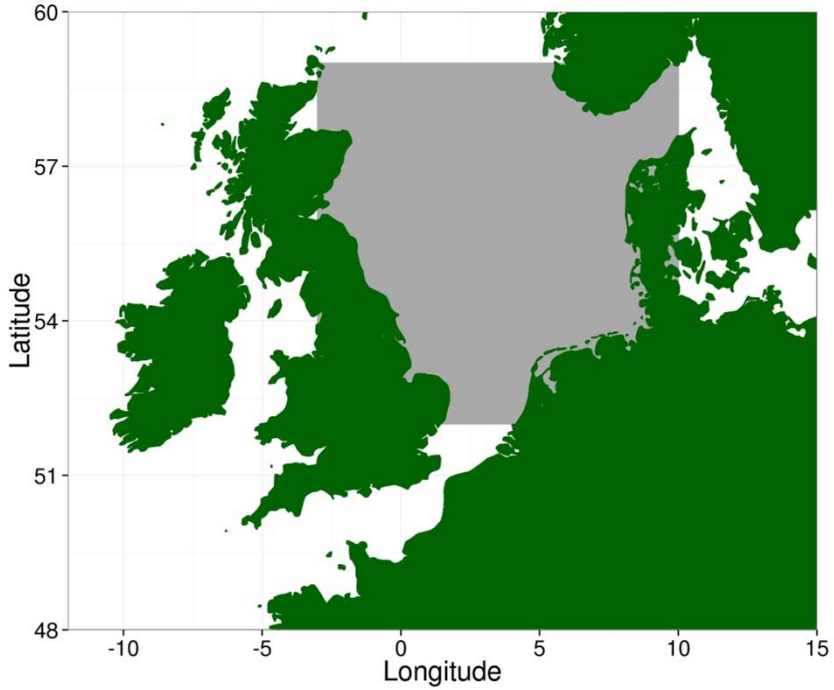
Top/bottom: *C. finmarchicus* and *C. helgolandicus* females.
Picture reference:
http://www.zooplankton.no/

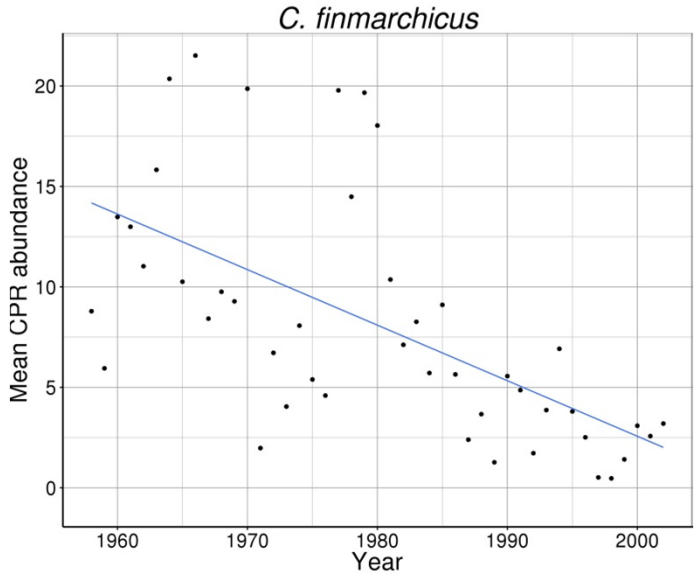
Biogeographic shifts: climate change implicated. What inter-species differences drive this?

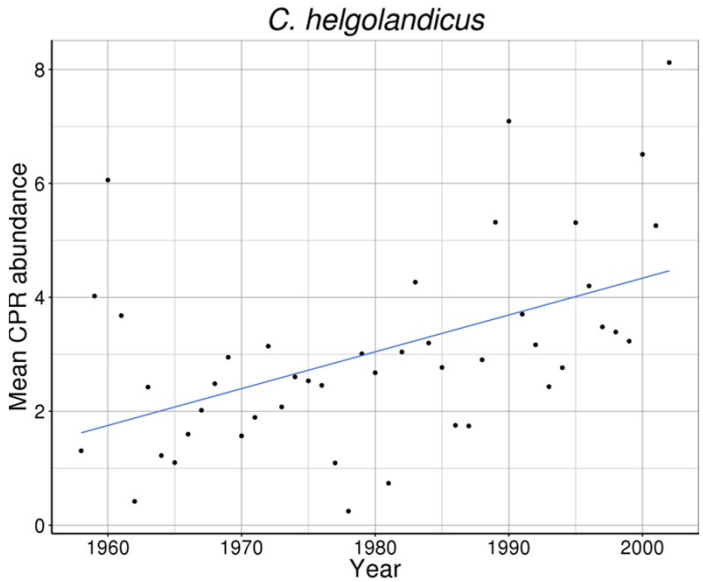


(Bonnet *et al.* 2005, surface CVs from CPR)

The North Sea: Changing *Calanus* composition revealed by the Continuous Plankton Recorder



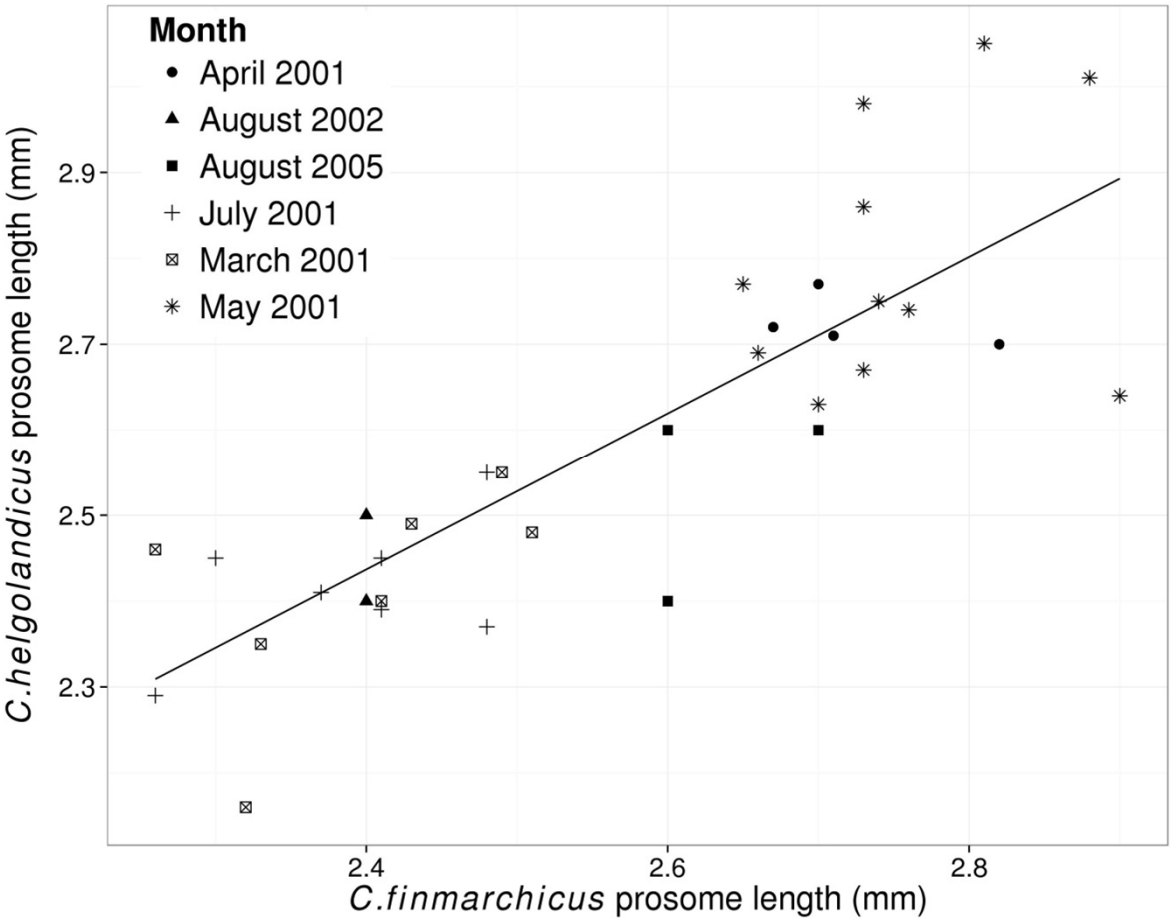




C. finmarchicus and *C. helgolandicus*: more similar than thought

- Conventional wisdom: *C. helgolandicus* is smaller and has lower lipid content, a poor replacement for *C. finmarchicus*
- We performed a quantitative review of the published literature finding fewer inter-species differences than expected
- Evidence is consistent with no interspecies differences in body size and lipid content
- Review of published literature suggests the relationship between development time, ingestion rate and temperature is the only concrete difference between each species

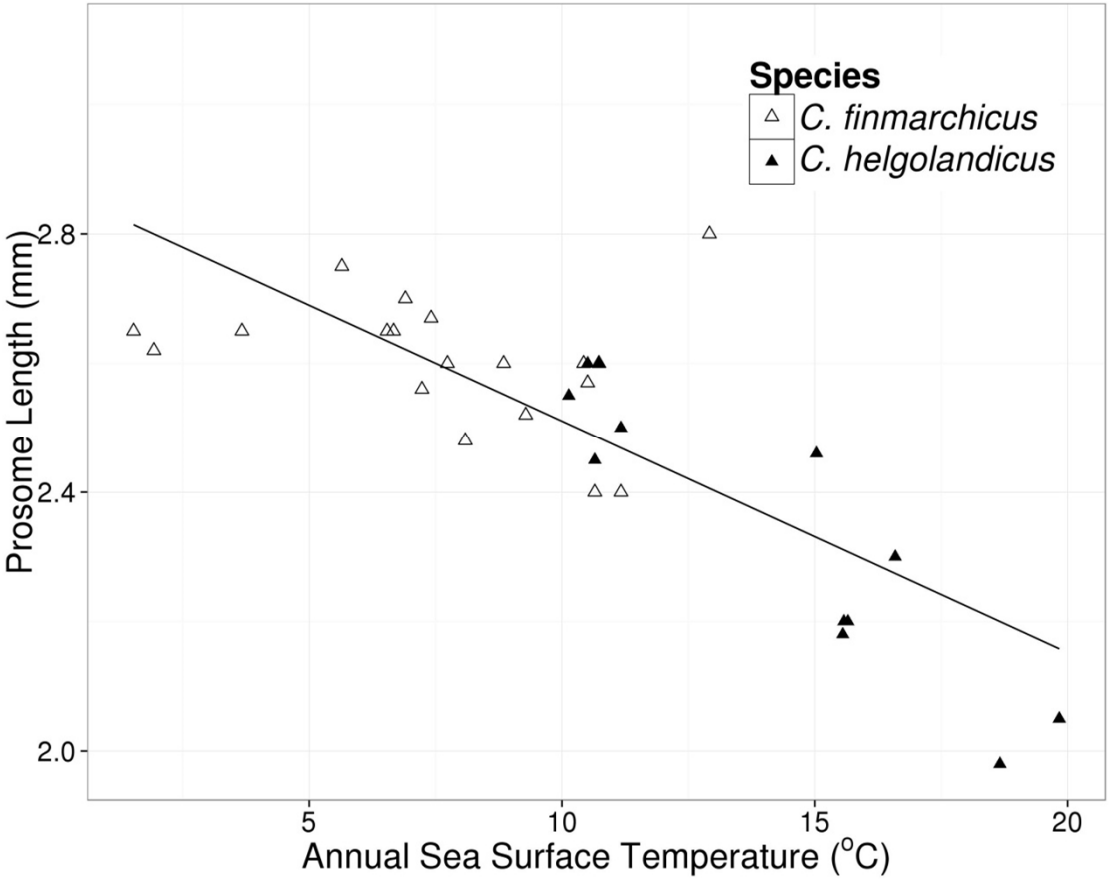
Body Size: no inter-species differences in female prosome length where the species co-exist



Location: North Sea

Data sources: Jónasdóttir et al. 2005; Jónasdóttir and Koski 2011

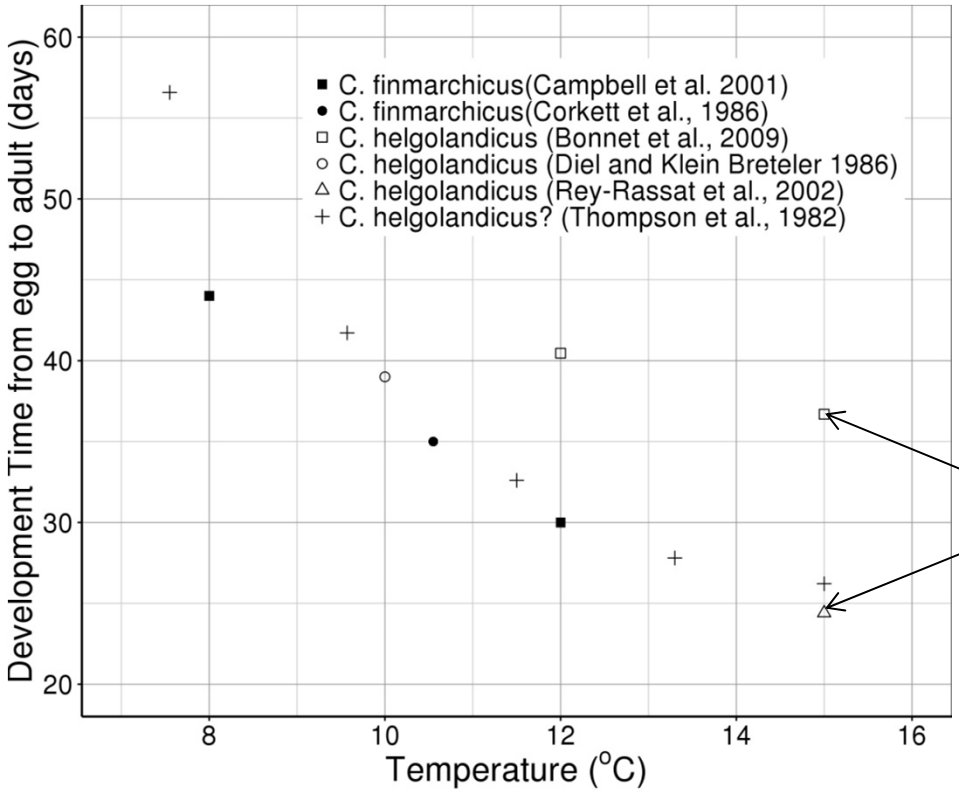
Body Size: geographic continuity



Annual average sea surface temperature explains much of the geographic variation in both species' body size

Prosome length data compiled from the literature

Published development times: some ambiguities

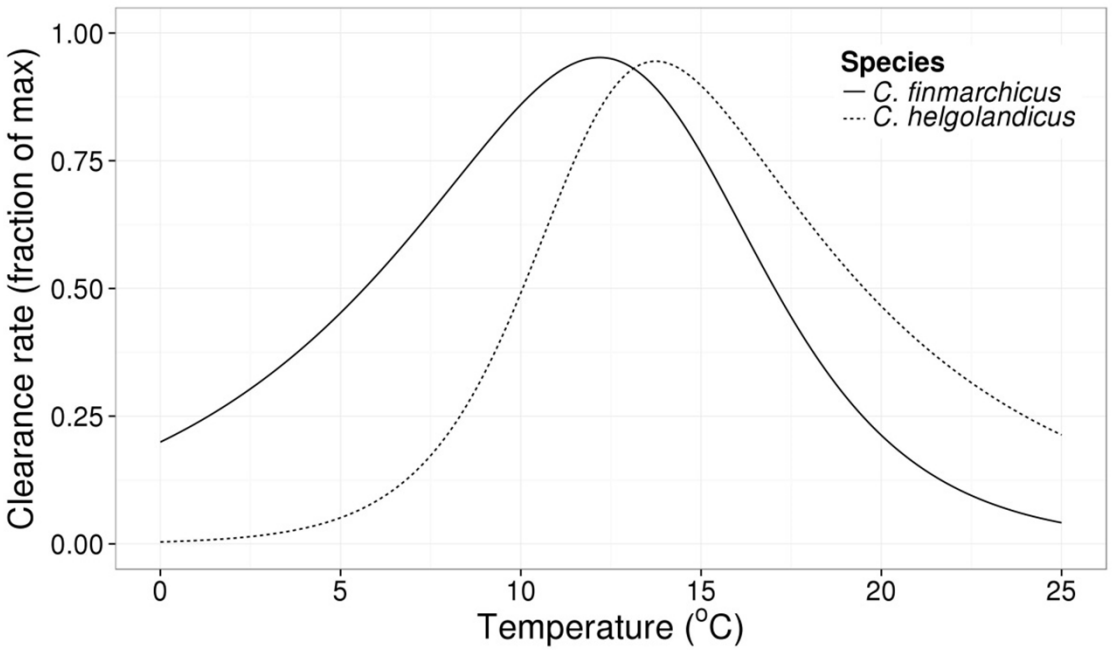


- Below 10 C, *C. finmarchicus* appears to develop more slowly
- Development time for *C. helgolandicus* are not consistent above 12 C.

Identical dietary regimes in these studies

Are there inter-species difference above 12 C?

A key difference: the response of ingestion rate to temperature



- Moller et al. (2012) estimated the response of ingestion rate to temperature
- Both species exhibit distinct dome-shaped ingestion rate-temperature curves

• Moller et al. used this relationship to model development time, assuming inter-species differences in temperature etc.
• Our review indicates that only differences in ingestion rate should be assumed a priori.
• What is the result?

How much of differences in published development times can be explained by ingestion rates?

- We modelled *C. finmarchicus* and *C. helgolandicus* development time assuming that the only inter-species difference is the response of ingestion rate to temperature
- Growth was modelled as follows

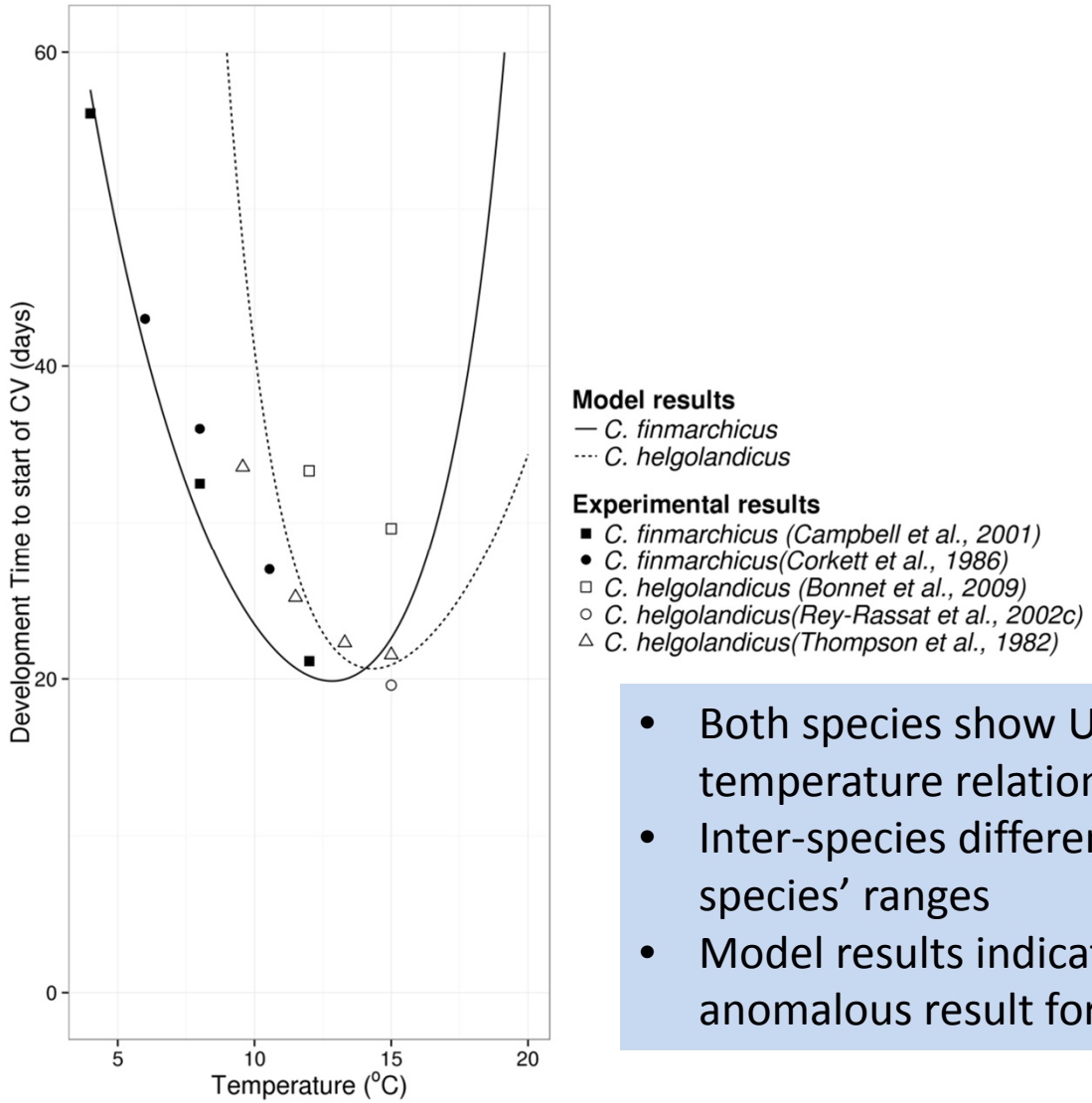
$$\frac{dw}{dt} = i(T)AE\mu w^{0.75} - Q10^{T/10}\lambda w^{0.75}$$

- where
- *w* - carbon weight
- *i(T)* the response of ingestion rate to temperature, scaled to 1
- AE – assimilation efficiency
- μ - maximum ingestion rate for a given body size
- Q10 – increase in respiration rate for 10 C increase in temperature
- λ – respiration rate at 0 C.
- Development terminates when an individual reaches a terminal body size, determined
- from the literature.

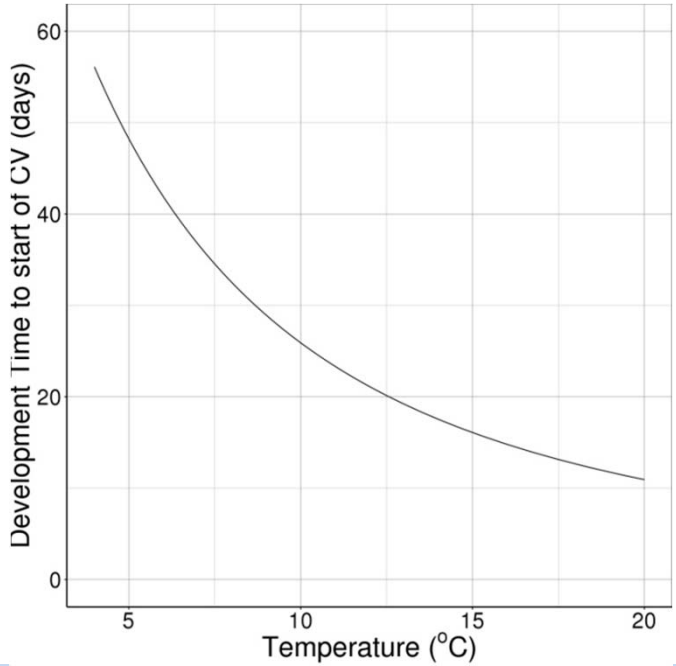
Model was parameterised using *C. finmarchicus* development times from Campbell et al. 2001

Development time model results

Model results



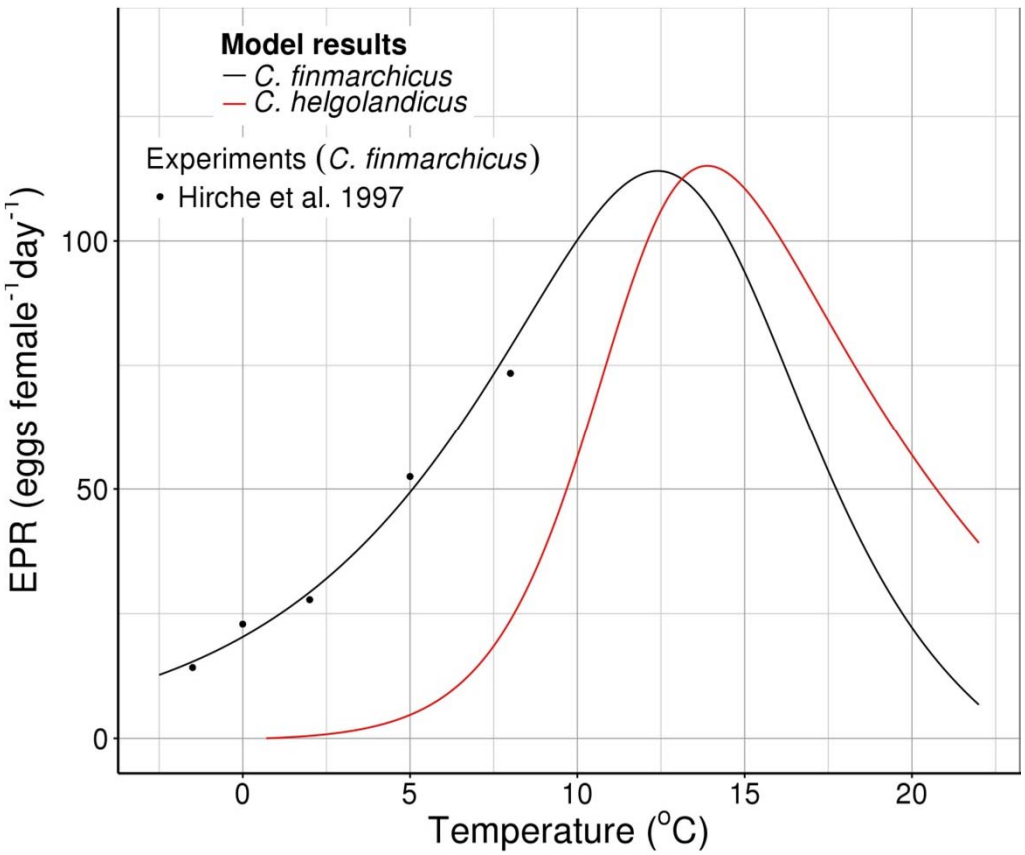
Conventional view of *C. finmarchicus* development



- Both species show U-shaped development time-temperature relationships
- Inter-species differences are reasonably consistent with species' ranges
- Model results indicate that Bonnet et al. (2009) is an anomalous result for *C. helgolandicus*.

A new egg production rate model

- Assumption: production of egg carbon assumed to be equivalent to carbon growth
- Both species show dome-shaped responses
- Model very successfully reproduces the egg production rate from only existing experimental study of *C. finmarchicus*
- Dome-shaped responses are common in zooplankton. Evidence required for *C. finmarchicus* and *C. helgolandicus*



Conclusions

- Development time and egg production rate probably do not decrease and increase monotonically respectively with temperature, as is commonly assumed

- The only known difference between *C. finmarchicus* and *C. helgolandicus* is the response of ingestion rate with temperature

- This response may play a key role in influencing their geographic distributions

- Further experimental work is required to confirm the precise form of the relationship between development, egg production and temperature. We could be proved wrong!

Thank you!

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