Arctic copepod *Calanus glacialis* larvae are tolerant to lowered pH

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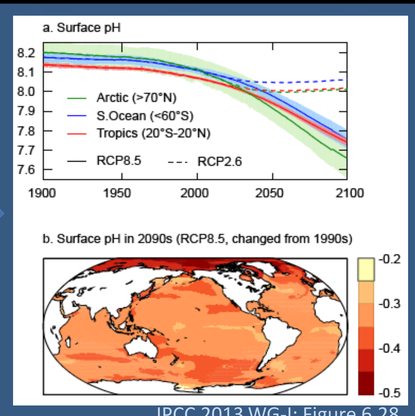
Image:Calanus.no

The ISSUE: Arctic Ocean acidification (OA)

- Anthropogenic CO_2 is absorbed by the world's oceans, where it decreases the pH of seawater. This is observed in the last 150 years and is projected for the next 300 years (IPCC 2013).
- **The Arctic Ocean is expected to experience the largest changes**: 185% increase in H+, ΔpH -0.45 (Steinacher et al. 2009)
- Potential ΔpH -0.77 by 2300 (Caldeira and Wickett 2003)
- OA has been shown to be deleterious to some marine species, with increased energetic costs of homeostasis as one effect



IPCC 2013,WG-I: Figure 6.28

The SPECIES: *Calanus glacialis*

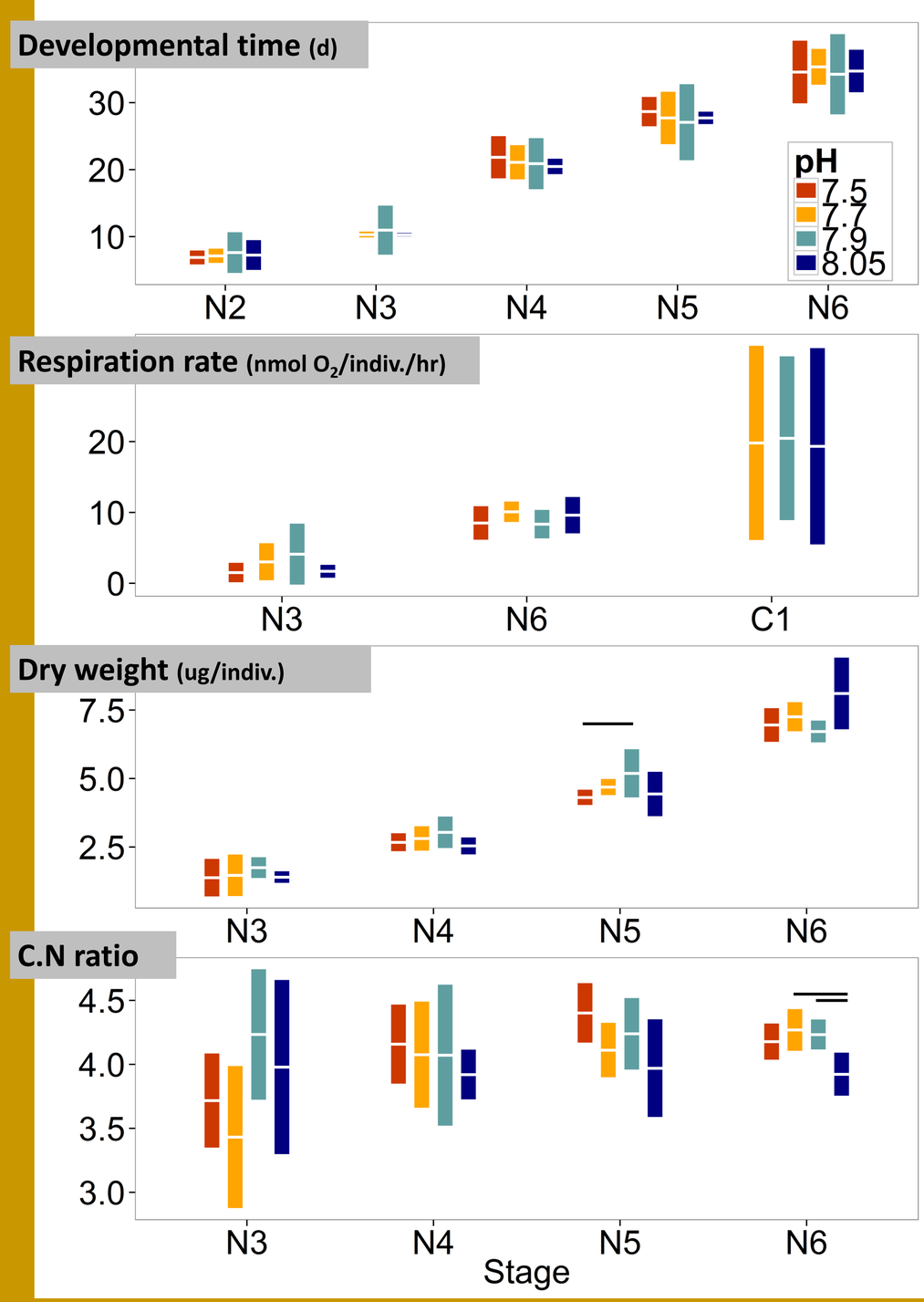
- Calanoid copepod, 2-4mm, non-calcifying
- 70–80% of the zooplankton biomass in Arctic shelf seas
- Important prey item in Arctic (fish, seabirds, whales)

The QUESTIONS: Will projected ocean acidification affect this key species? Will low pH be an energetic cost, resulting in slower development, higher respiration, and lower body mass?

The EXPERIMENT: Culture *C. glacialis* at four pHs (8.05, 7.9, 7.7, 7.5) during early development

RESULTS:

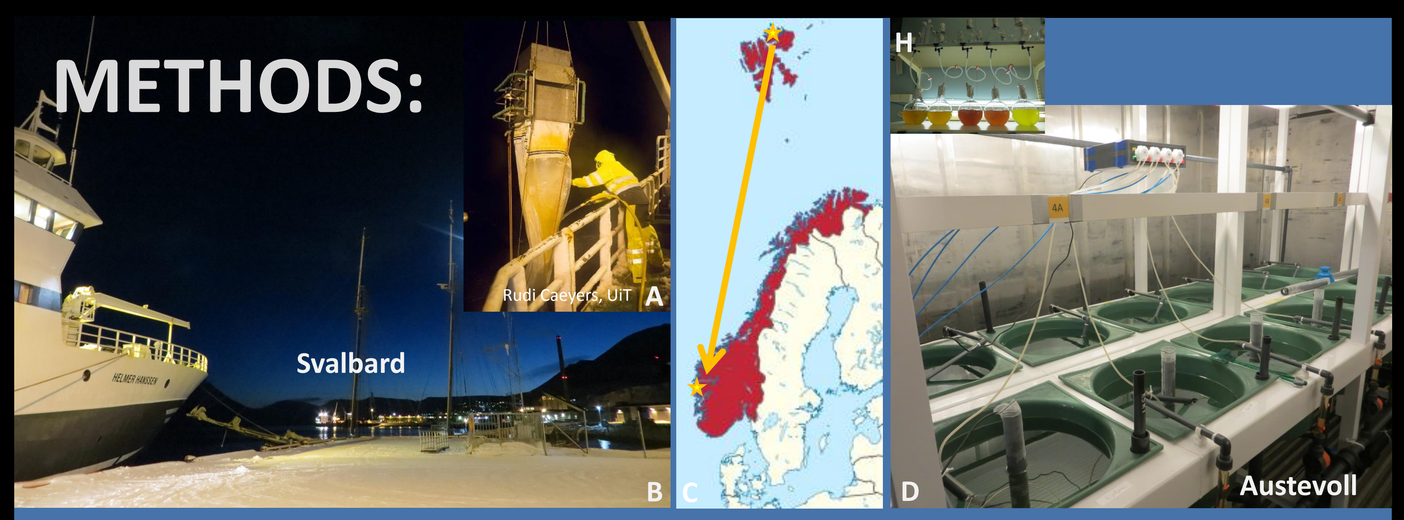
Throughout two months of naupliar development, we measured:

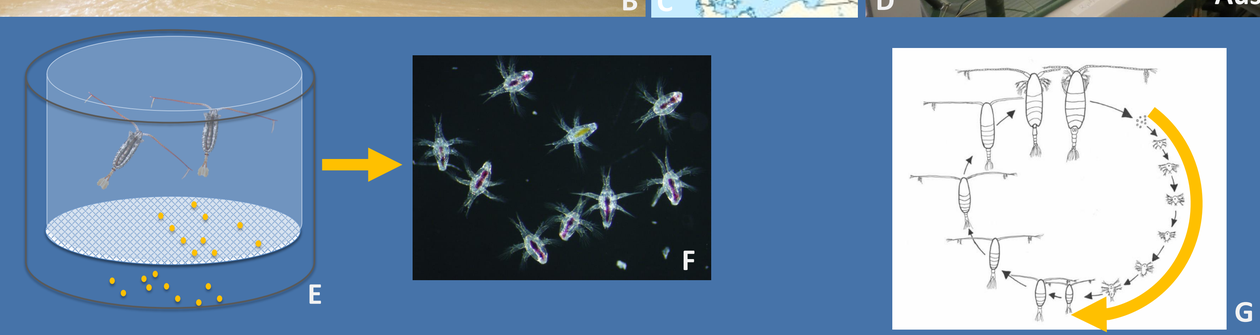


There were no consistent significant differences between pH treatments in four important parameters.

Colored bars indicate median and 95%CI. Differences were tested within each stage with a linear mixed-effects model, with pH as a fixed effect and replicate as random effect. Horizontal lines indicate pairs with significant differences (p<0.05).

METHODS:





Copepods were collected in Rijpfjorden, Svalbard January 2014 (A,B) and transported to Austevoll marine facilities (C,D). A pool of 1900 *C. glacialis* females inoculated each of 12 tanks (4 pHs x 3 replicates) (E). Eggs then developed at treatment pH for 2 months, through 6 naupliar stages (N1-N6; F,G), while being fed live algae (H) *ad libitum*.

DISCUSSION:

In seawater pH projected for 2300, *C. glacialis* naupliar development, growth, and respiration appear unaffected

Reasons for apparent tolerance

Abundant food
- Increased energy intake may have **compensated** for (and masked) an energetic cost of low pH, allowing normal growth
- If so, *C. glacialis* may be more affected by OA in the wild, where it often faces **low food availability**

Selective mortality
- OA-sensitive individuals may have died early, leaving only tolerant phenotypes to be measured
- If so, **the majority are tolerant**, and sensitive genotypes may be lost via adaptive selection

Phenotypic buffering
- Changes in other physiological processes may have allowed the maintenance of the fitness-related traits measured
- Transcriptomic samples will be analyzed for **differential gene expression**

Variable environment
- Naturally adapted to different pHs: **seasonal and vertical pH variability** is in the same range as projected OA
- **Wild-caught** populations have environmental tolerance cf. cultured lines

Increasing likelihood of tolerating future OA *in situ*

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