Effects of Ocean Acidification on Growth and Development of the Planktonic Copepod, *Calanus finmarchicus*

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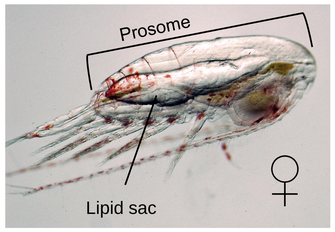
INTRODUCTION

The marine, planktonic copepod, *Calanus finmarchicus*, fulfills a key role as an intermediary in pelagic food webs across the North Atlantic. Assessment of ecosystem impacts of ocean acidification requires knowledge of the effects of increased CO_2/lower pH on *C. finmarchicus.* However, there is a lack of information on how to parameterize their population dynamics under future climate change scenarios. Here we investigate the null hypothesis that *Calanus finmarchicus* growth and development rates are not affected by increased CO_2/lower pH levels that are predicted to occur over the next century.

METHODS

- Female *C. finmarchicus* were collected using nets and light traps from waters near the Austevoll Research Station, Norway in late April, 2013. Females (500-850) were maintained on a diet of mixed algal at high concentration and then used to inoculate triplicate control and treatment tanks.
- Each of the 30L tanks were provided a constant flow of 12 ºC seawater with controlled CO_2 concentrations. Automated pumps maintained a minimum food level of 600 µg C/L from a mixed algae stock of: *Rhodomonas baltica, Isochrysis, Chaetocerous* sp*., and Skeletonema* sp .
- Temperature, pH (calibrated electrode), salinity, and food levels were measured daily. Samples for pH (spectrophotometric measurement), total alkalinity (titrated) and nutrients were taken twice a week following standard OA protocols (Dickson et al. 2007).
- Staging and size/lipid analysis were measured daily on a minimum of 25 animals from photographs of anesthetized copepods using ImageJ.
- Dry weight was measured for eggs, N6, all copepodite stages and adult females. The CO2Sys program will be used to compute inorganic carbon parameters from observed temperature, salinity, TA, and pH. This approach provides associated acidification experiment data (e.g. DIC, *p*CO2, $[CO3^{2-}]$, and calcite saturation state (i.e. $\Omega_{calcite}$)).



Calanus finmarchicus
Cultured in mid pH treatment (anesthetized to show swimming legs)

Treatment tanks in cold room
Temperature maintained at 12°C

Algal cultures(100-L)
used for food

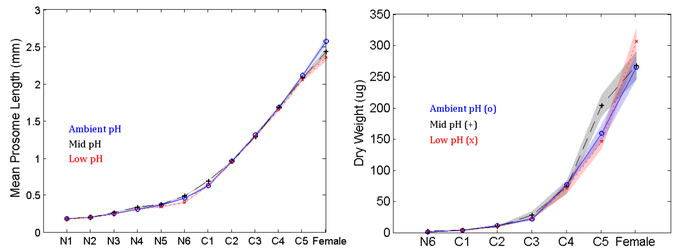
Austevoll Research Station, Norway

RESULTS

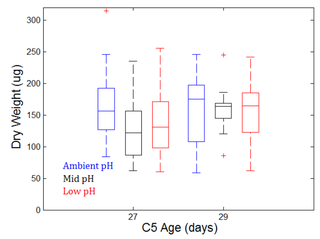
pH Spectrophotometric measurements

Treatments	Ambient (~400 ppm) (+/- STD)	Mid (~900 ppm) (+/- STD)	Low (~1200 ppm) (+/- STD)
pH	7.935 (0.007)	7.608 (0.006)	7.495 (0.019)

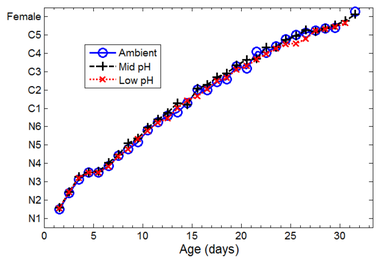
Calanus finmarchicus Growth by pH Treatment



Dry Weight Comparison

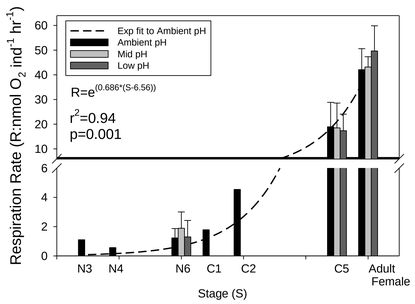


Development through Stages



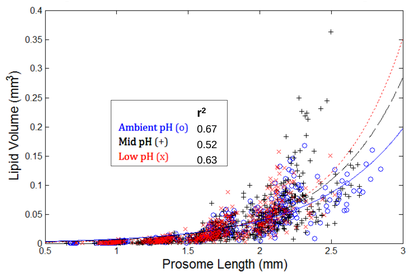
Progression through **development** stages depicted by Weighted Stage Value. The proportion in a stage at a given date was multiplied by its stage value (N1=1, C1=7, etc.) and then all weighted values were summed for that day. The results of each tank were aggregated by treatment revealing no consistent differences between them.

Measurements of **respiration rates** were made with a clark-style microelectrode (Unisense DK). Each observation used 3 animals in 4 ml vessels at 12ºC. Respiration rates at ambient pH were fit to a modified 2 parameter exponential model ($R=e^{(a*(S-S_o))}$) with stage value as N1=1, C1=7 (etc.).

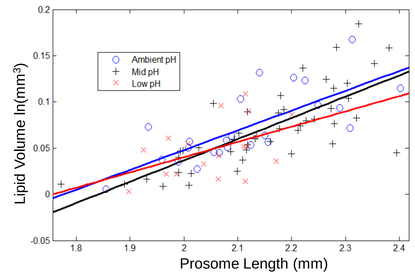


There were some differences in body mass between treatments, particularly in stage C5. However, this was influenced by variability in age at time of sampling. When restricting the ANOVA to C5's that were 27 and 29 days old, **growth** rates were not found to be significantly different ($p = 0.2513$).

Exponential Increase in Lipid



Lipid Analysis of Covariance



Lipid volume increased exponentially with prosome length as the copepods developed ($(x)=a*\exp(b*x)$, $n = 1474$). Similar to the growth rates, there were some differences between treatments, but an Analysis of Covariance for C5's that were 29 days old ($n = 88$) indicated no significant difference between the lipid volume or slope against prosome length ($p= 0.3803$ and 0.7468, respectively).

ACKNOWLEDGEMENTS

This work was supported by the Norwegian Institute for Marine Research and by an NSF awards OCE-1041081 to JR, and OCE-1220068 to DMF.

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CONCLUSIONS

We were able to culture *C. finmarchicus* in abundance in control and treatment tanks. The developmental stages appeared healthy and displayed normal respiration rates, feeding, swimming and avoidance behaviors (Fields et al., in prep). Our results are consistent with the hypothesis that growth and development rates of the species do not need to be reparameterized for ocean acidification in population dynamics models under climate change scenarios.