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Temperature and pH effects on feeding and growth of Antarctic krill

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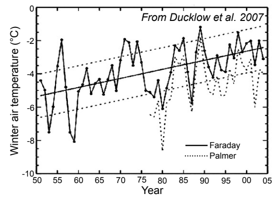
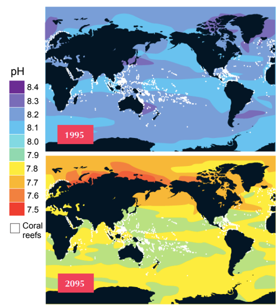
OVERVIEW

The West Antarctic Peninsula (WAP) has undergone profound warming in the past decades.



In addition to rapid warming, there are predictions that by the end of this century the Southern Ocean will be the first region to be affected by seawater chemistry changes (i.e., reduced pH) associated with enhanced CO_2.



From Feely et al. 2009

Antarctic krill, specifically *Euphausia superba*, are a key species in the food web at WAP. Thus, it is important to understand how these organisms will function in the future warmer, acidic ocean.

APPROACH

We conducted perturbation experiments to determine potential changes in feeding rates and growth of juvenile *Euphausia superba* (≈ 30 mm) due to decreased pH and elevated temperature. Target pH was reached in the experiments via CO_2 bubbling of seawater flowing through gas equilibration columns.

Treatments for Feeding Experiments and First Growth Experiment

Ambient Conditions:	Double CO_2, Ambient Temperature:	Year 2100:
0°C, pH = 8.0	0°C, pH = 7.5	3°C, pH = 7.5

The two feeding experiments differed in acclimation time. Krill in experiment 1 (Exp 1) and experiment 2 (Exp 2) were acclimated to treatment conditions for 48 hours and 21 days, respectively.

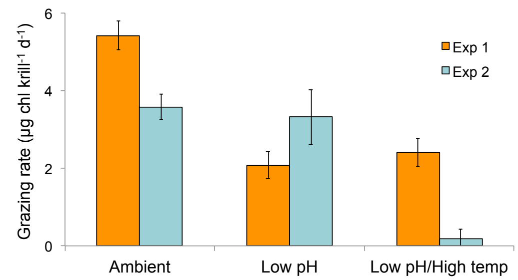
Treatments for Second Growth Experiment

0°C, pH = 8.0	0°C, pH = 7.5	0°C, pH = 7.1
3°C, pH = 8.0	3°C, pH = 7.5	3°C, pH = 7.1

We determined growth increment (GI; a step-wise percentage change in body length at molt) in both growth experiments and intermolt period (IMP; the time (days) between molts) in the second growth experiment.

FEEDING RATES

- Feeding rates of juvenile krill were affected by pH when acclimated to experimental treatments for only a short time (48 hours; Exp 1).
- After exposure to treatments for 21 days (Exp 2), feeding rates were generally lower, and significantly lower only in the low pH/high temperature treatment.

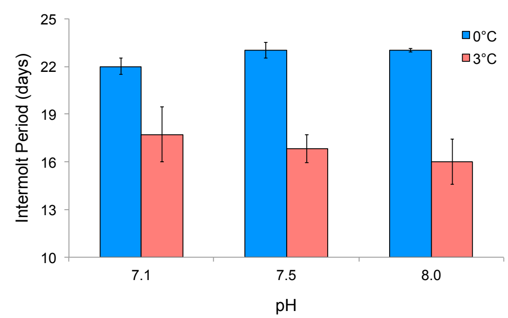


Krill may have been able to acclimate to changes in pH over the course of 21 days; however, they may still have been sensitive to high temperatures or the synergism of pH and temperature.

Juvenile krill in this study performed differently from adult krill in Saba et al. (2012). Juveniles suppressed their feeding rates under low pH and/or low pH/high temp, whereas adult krill enhanced their feeding rates and overall metabolism under low pH. This could be related to food supply in the natural seawater as chlorophyll was 50% lower in the experiments with juvenile krill.

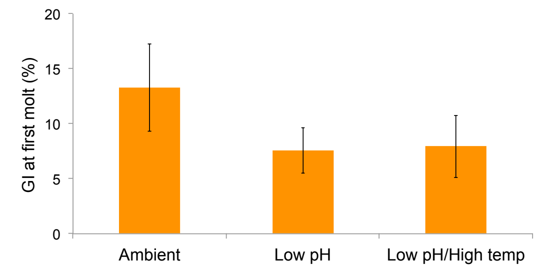
INTERMOLT PERIOD

- There was significantly less time between molts in the the high temperature treatments (16.9 compared to 22.8 days).
- pH did not significantly impact intermolt period.



GROWTH INCREMENT

First Growth Experiment



- Growth increment (GI) was lower with decreased pH at the first molt.

Second Growth Experiment

Treatment	Mean GI (%) First molt	Mean GI (%) Second molt
0°C, 8.0 pH	-1.2	-3.0
0°C, 7.5 pH	-0.8	-1.8
0°C, 7.1 pH	-0.4	-1.7
3°C, 8.0 pH	-1.7	-3.0
3°C, 7.5 pH	-1.2	-3.6
3°C, 7.1 pH	-0.8	-8.4

- All average growth rates were negative in the second growth experiment, and became more negative at the second molt. This was, again, likely related to decreasing food supply.
- There were no significant differences in GI at first molt.
- pH alone did not significantly impact GI.
- The lowest GIs occurred in the high temperature treatment and were most pronounced at reduced pH, suggesting a negative synergistic impact on krill growth.

SUMMARY AND FUTURE RESEARCH NEEDS

Food supply likely plays a large role on how krill respond to environmental stressors (i.e., metabolic suppression vs. enhanced metabolism). Low food concentration is an added stressor, while high food availability may aid Antarctic krill in acclimating to changes in temperature and pH. We would benefit greatly from determining threshold food concentrations in future studies.

High variability in experiments and individual krill response leaves an open question as to how krill populations will tolerate prolonged future climate change in the Antarctic and prompts the need for improvement of experimental design to maximize sample size.

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