Environmental controls on pteropod metabolism along the Western Antarctic Peninsula

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Objective & Significance

To determine the effects of shifting food availability and seawater temperature on pteropod (pelagic snail) metabolism. Respiration and excretion rates are important for describing pteropod contributions to biogeochemical cycling. These results increase our understanding of metabolic responses of zooplankton to natural system dynamics and potential future responses to climate change.

Introduction

The pteropod (pelagic snail), *Limacina helicina antarctica*, is one of the most abundant zooplankton taxa in the WAP and is an important grazer of phytoplankton and prey for higher trophic levels (Fig. 1) (Thibodeau et al. 2019). However, little is known about long-term and regional environmental impacts on *L. antarctica* metabolism (respiration & excretion).

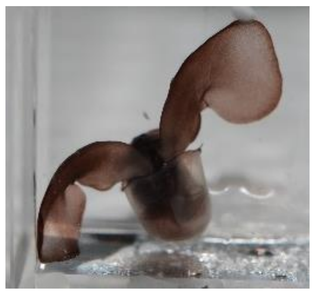


Figure 1. Live *Limacina helicina antarctica* collected onboard the PAL LTER annual January cruise.

The Western Antarctic Peninsula (WAP) is a highly dynamic and productive region of the Southern Ocean that has undergone rapid warming and significant change in the past half century (Fig. 2). A consequence of this regional warming is a latitudinal climate gradient along the length of the WAP, with a wet and warmer subpolar climate in the north, and a dry and colder polar climate in the south (Ducklow et al., 2013).

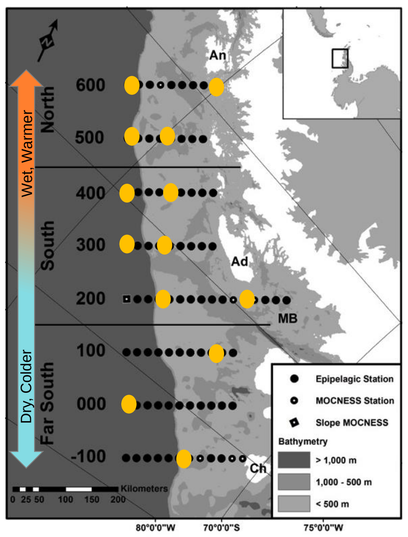
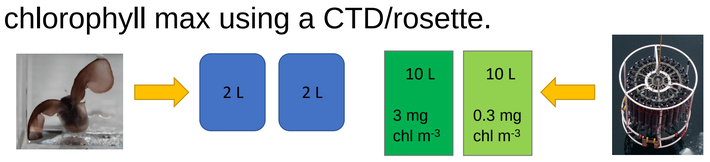


Figure 2. The Palmer LTER sampling grid along the Western Antarctic Peninsula (WAP). Filled circles indicate locations of metabolism experiments along the N-S climate gradient.

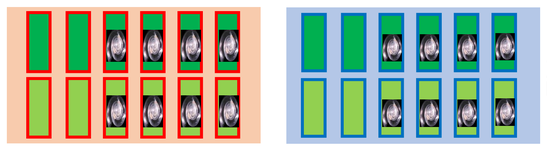
Effects of shifting food availability and seawater temperature on *L. antarctica* metabolism were determined with shipboard experiments exposing pteropods to decreased phytoplankton and elevated temperature compared to in situ conditions. These pteropods were collected with 2-m net tows during annual Palmer Antarctica Long-Term Ecological Research (PAL LTER) cruises during the austral summers 2017-2019.

Methods

- Healthy, swimming *L. antarctica* gently transferred with a wide-bore pipette into 2L jars filled with whole seawater.
- Phytoplankton (food) for experiments collected at chlorophyll max using a CTD/rosette.



- Seawater collected in 10L carboys. One carboy diluted to 10% of original phytoplankton concentration.
- Pteropods acclimated to experimental temperature and food conditions (2 hrs).
- Pteropods placed into 300ml gas-tight bottles (Fig. 3).



12 hour incubations

- Respiration (oxygen uptake) measured every 2 hrs. Samples taken for excretion measurements at end of experiment, filtered, frozen (100ml), and nutrients analyzed at VIMS.

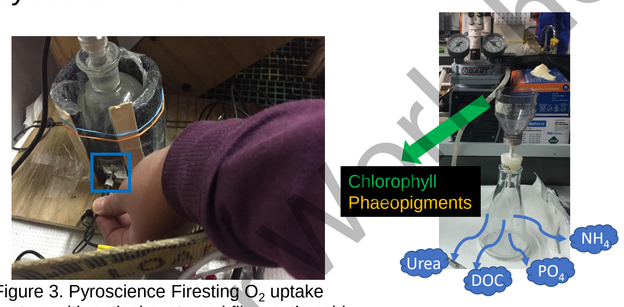
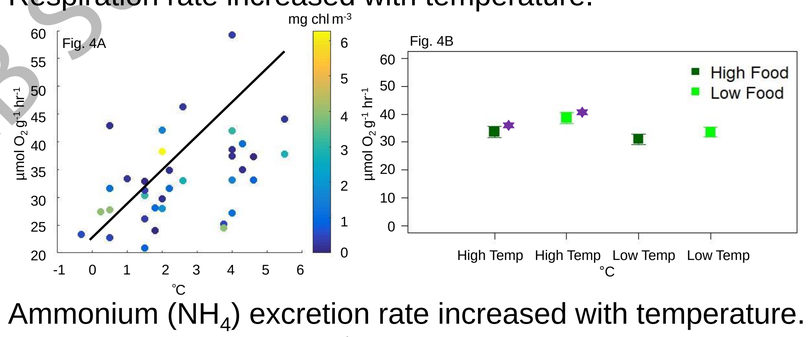


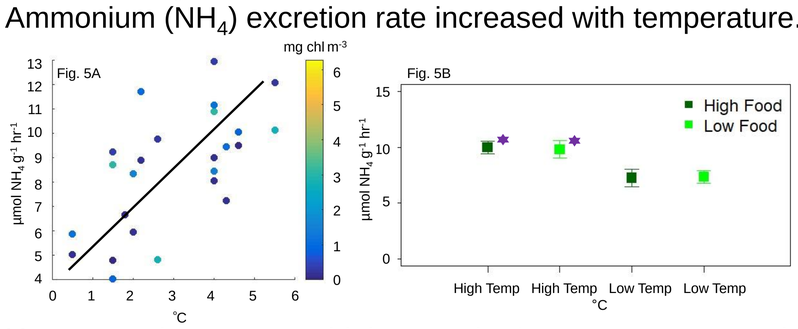
Figure 3. Pyroscience Firesting O_2 uptake system with optical spots and fiber optic cable.

Results

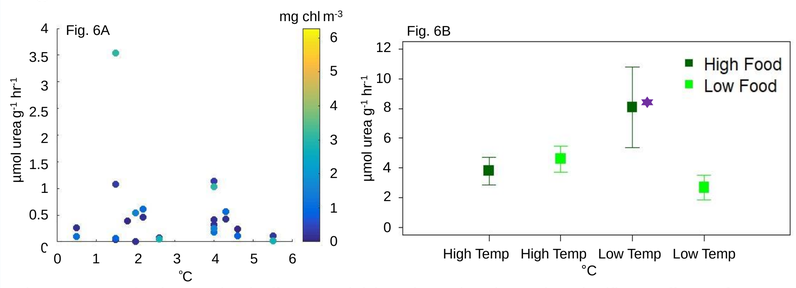
Respiration rate increased with temperature.



Ammonium (NH_4) excretion rate increased with temperature.



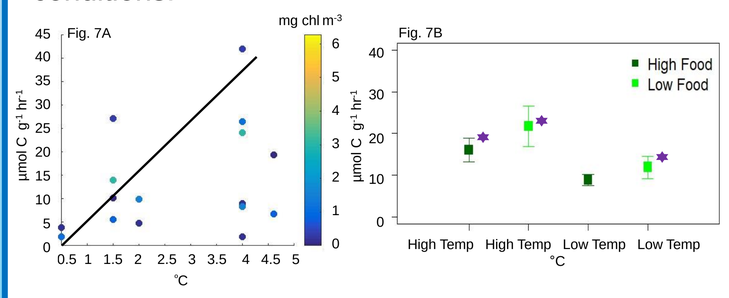
Urea excretion rate was highest under low temperature and high food conditions.



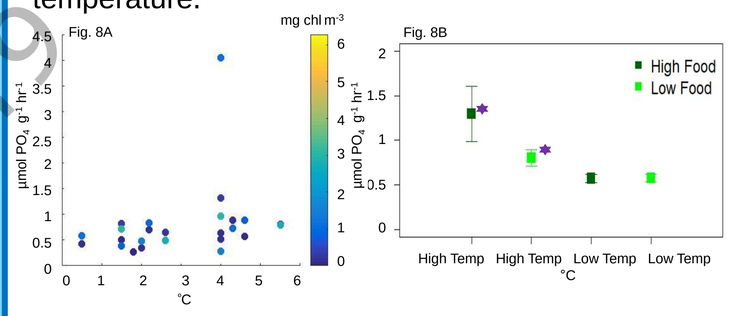
Figures 4, 5 & 6. Linear Mixed Effects Model (LME) used to determine significant effects of temperature and food on pteropod metabolism. Significance indicated by a star (*). Respiration rate was significantly affected by temperature (2017-2019) (Fig. 4; Temp: (F(df) = 4.33, p<0.05, Food: (F(df) = 0.24, p>0.05). NH_4 excretion was significantly affected by temperature (2017-2018) (Fig. 5; Temp: (F(df) = 25.16, p<0.05, Food: (F(df) = 0.65, p>0.05). Urea excretion rate significantly affected by the interaction between temperature and food (2017-2019) (Fig. 6; Temp: (F(df) = 5.92, p<0.05, Food: (F(df) = 0.72, p>0.05, Temp:Food: (F(df) = 8.63, p<0.05).

Results

Dissolved organic carbon (DOC) excretion rate was highest under high temperature and low food conditions.



Phosphate (PO_4) excretion rate increased with temperature.



Figures 7 & 8. Linear Mixed Effects Model (LME) used to determine significant effects of temperature and food on pteropod metabolism. Significance indicated by a star (*). Respiration was significantly higher under high temperature and low food (2017-2018) (Fig. 7; Temp: (F(df) = 12.18, p<0.05, Food: (F(df) = 7.82, p<0.05). Phosphate excretion was significantly higher under high temperature conditions but food had no significant effect (2017-2018) (Fig. 8; Temp: (F(df) = 30.4, p<0.05, Food: (F(df) = 0.16, p>0.05).

Conclusions

- As predicted, higher respiration and excretion rates under higher temperature.
- Food did not significantly affect respiration, but did affect DOC and urea excretion rates.
- Indicates pteropod metabolism most responsive to temperature, which is also seen as a driving factor in their long-term abundances (Thibodeau et al. 2019).
- The WAP is a natural laboratory in which environmental gradients act as analogs for predicted future zooplankton metabolic changes in Antarctica.

References

Ducklow, H., W. Fraser, M. Meredith, and others. 2013. West Antarctic Peninsula: An Ice-Dependent Coastal Marine Ecosystem in Transition. Oceanography **26**: 190–203.

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