From one gastropod to another: extended exposure to ocean acidification and warming reveals species-specific shifts in thermal performance curves

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Abstract.

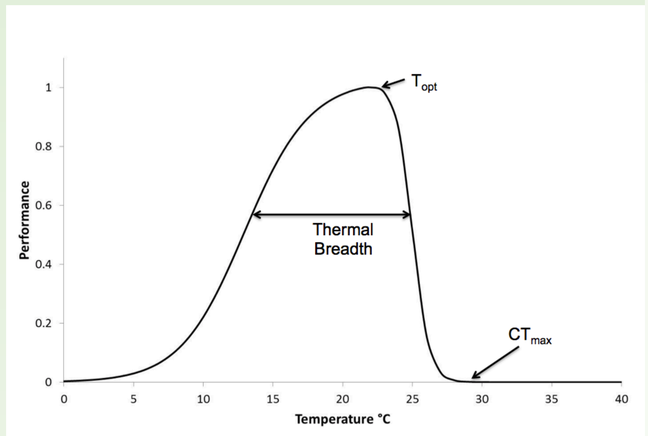
- Impacts of warmer ocean temperatures and increased pCO_2 on marine organisms are modulated by an organism's energetics: while higher temperatures increase metabolic rates, acidification increases the amount of energy needed for calcification, and consequently the amount of energetic resources required.
- *Turbo undulatus* (Turbinidae) and *Austrocochlea odontis* (Trochidae), temperate herbivorous gastropods, were exposed to crossed combinations of temperature (21°C vs. 24°C) and pCO_2 (400ppm vs. 1000ppm). Thermal performance curves (TPCs), metabolic rates, and growth rates were quantified after eight weeks exposure.
- Depending on the species, warming and OA acted either additively or antagonistically, reducing physiological performance in some but increasing it in others

Turbo undulatus

Austrocochlea odontis

What can thermal performance curves (TPCs) tell us?

- Predicts impacts of rapid environmental change on individual organisms.
- Measures physiological performance for an organism at any given temperature
- Provides clues regarding relative vulnerability or resilience of different species to warming and ocean acidification (Schulte, 2015; Stoffels et al, 2015).

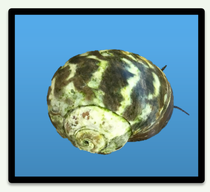


T_{opt} = Temperature of optimal performance

CT_{max} = Critical thermal maximum

45 minute trial-period at designated temperature

Initial O_2 reading



Final O_2 reading

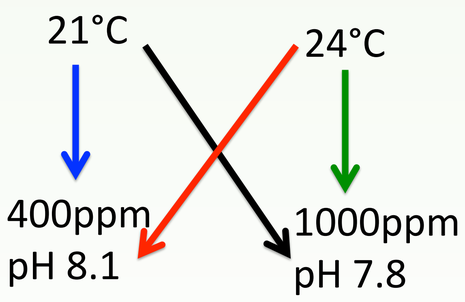
Refresh H_2O at new temperature

Repeat process until <u>mortality</u> is reached

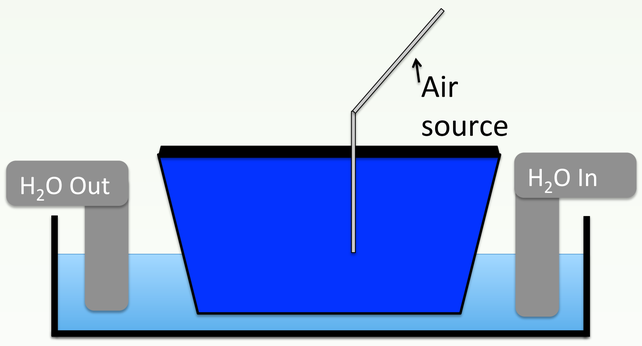
+2°C / hour

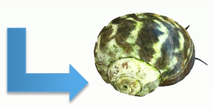
Experimental Design.

<u>2 x 2 Factorial:</u>



Control – 21C, 400ppm
OA – 21C, 1000ppm
HT – 24C, 400ppm
HTxOA – 24C, 1000ppm





3 per species
6/container
<u>120</u> total

5/treatment
4 treatments
<u>20</u> total

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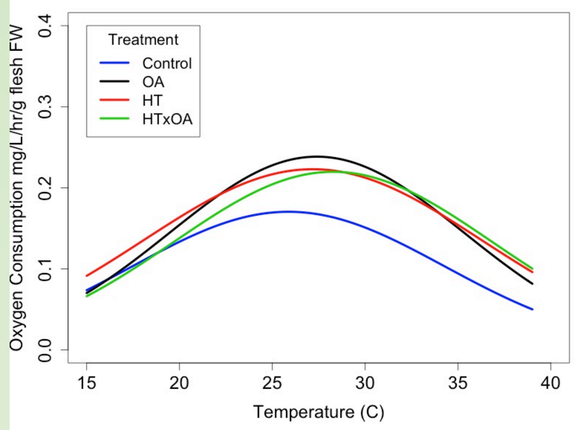
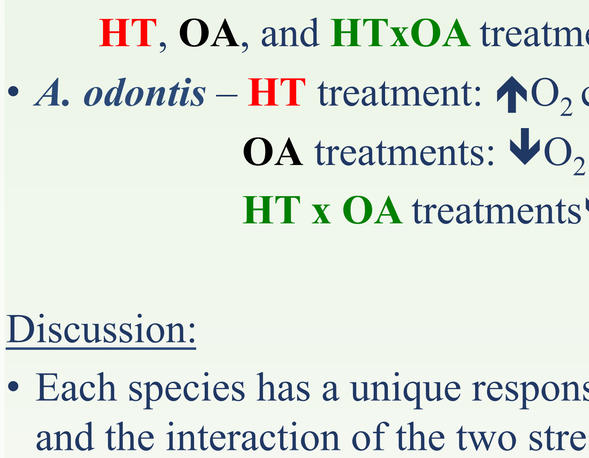
Question.

How does extended exposure to elevated temperature and *p*CO2 impact a species' thermal performance and growth?

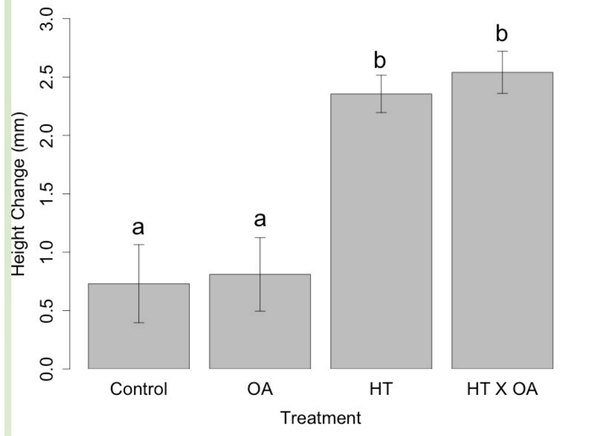
Results and Conclusions.

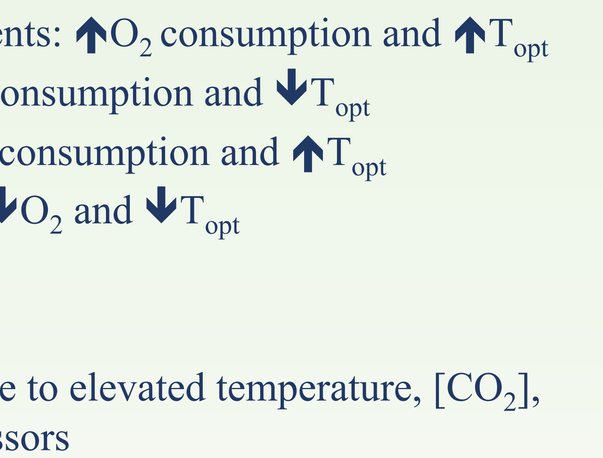
Thermal Performance





Growth response





<u>Growth Results:</u>

- ***T. undulatus*** – **HT** and **HTxOA** had <u>positive</u> effects on growth
  - **OA** did not have a strong effect
- ***A. odontis*** – **HT** and **OA** had <u>negative</u> effects on growth
  - <u>Antagonistic</u> interaction between temperature and CO_2

<u>TPC Results:</u>

- ***T. undulatus*** –
  HT, **OA**, and **HTxOA** treatments: ↑O_2 consumption and ↑T_{opt}
- ***A. odontis*** – **HT** treatment: ↑O_2 consumption and ↓T_{opt}
  OA treatments: ↓O_2 consumption and ↑T_{opt}
  HT x OA treatments ↓O_2 and ↓T_{opt}

<u>Discussion:</u>

- Each species has a unique response to elevated temperature, [CO_2], and the interaction of the two stressors
- Temperature is a more immediate threat to growth rate in *T. undulatus* than ocean acidification
- Regardless of metabolic rate changes across treatments, individuals reached CT_{max} at the same temperature (*T. undulatus* 39°C; *A. odontis* 43°C), indicating a possible species-specific temperature threshold

References.

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