

A meta-analysis of the interactive effects of ocean warming & acidification on marine ectotherm performance

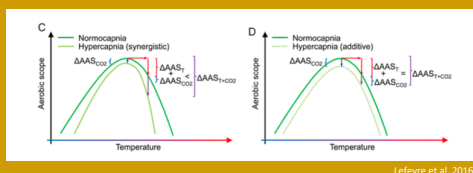
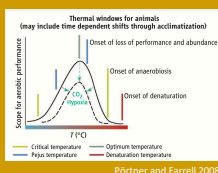


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Research questions

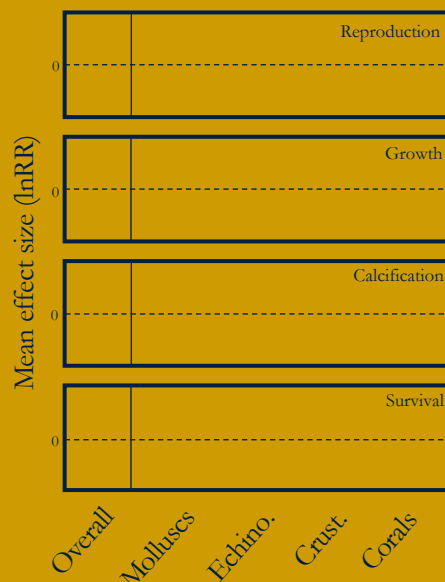
1. What are the individual and interactive effects of ocean warming (OW) and ocean acidification (OA) on marine ectotherms?
2. How do these effects vary across taxonomic groups, response variable categories, and sublethal and lethal effects?
3. Do we see consistent synergistic effects of OW & OA as proposed by the oxygen and capacity limited thermal tolerance (OCLTT) hypothesis?
4. Does OA consistently reduce the upper thermal tolerance of marine ectotherms (e.g. $C_{t_{max}}$), as per OCLTT predictions?



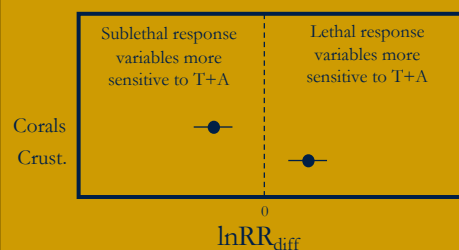
Expected results

note that these are schematics, not real data

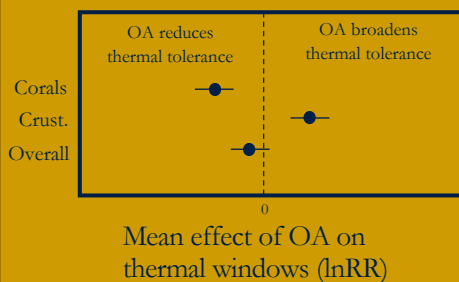
RQ 1,2,3



RQ 2



RQ 4



Methods

Inclusion criteria:

- RQ 1-3 sublethal & lethal RV sublethal RV linked w/ fitness
- RQ 4

Database formation:

- RQ 1-3 WOS AFSA 2013-2019 67 papers selected to date
- RQ 4 WOS AFSA 2013-2019 5 papers selected to date

Data analysis:

t = temperature treatment
a = acidification treatment
c = control

RQ 1,2,3

$$\ln RR_{temp} = \ln \frac{Y_t}{Y_c}$$

Indiv effects

$$v(\ln RR) = \frac{(SD_t)^2}{N_t \times (Y_t)^2} + \frac{(SD_c)^2}{N_c \times (Y_c)^2}$$

Interactive effects (factorial meta-analysis)

$$\ln RR_{int} = \frac{(Y_{ta} - Y_t) - (Y_a - Y_c)}{2s}$$

$$s_y^2(\ln RR_{int}) = \frac{1}{N_t} + \frac{1}{N_a} + \frac{1}{N_{ta}} + \frac{1}{N_c} + \frac{\ln RR_{int}^2}{2(N_t + N_a + N_{ta} + N_{ct})}$$

RQ 2

Paired analysis

$$\ln RR_{diff} = -1 * (\ln RR_{int} \text{ lethal} - \ln RR_{int} \text{ sublethal})$$

RQ 4

Indiv effects

$$\ln RR_{ta} = \ln \frac{Y_{ta}}{Y_t}$$

$$v(\ln RR) = \frac{(SD_{ta})^2}{N_{ta} \times (Y_{ta})^2} + \frac{(SD_t)^2}{N_t \times (Y_t)^2}$$

Random effects mixed-model & sensitivity analyses

Desired outcomes

- Updated understanding of the specific sensitivities of taxonomic groups and response variables to ocean warming and acidification
- Advanced clarity surrounding the evaluation of the OCLTT's predictive capacity of how climate change will impact marine ectotherms