Preparing the Next Generation for Climate Change: Parental Effects on Larval Thermal Tolerance in the California Mussel (*Mytilus californianus*)

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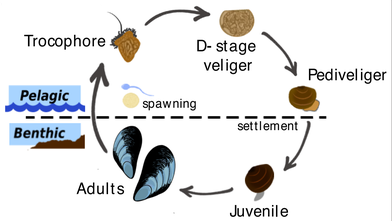
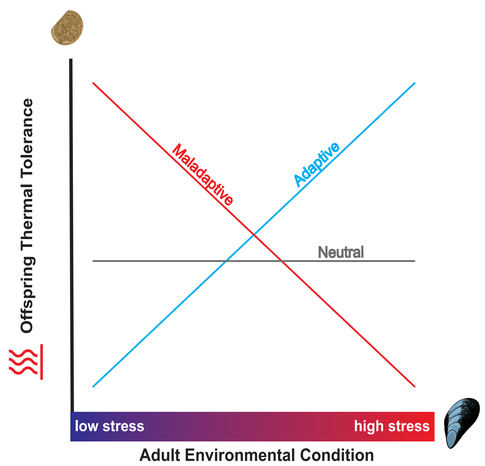
Introduction

- Oceans are warming rapidly under climate change.
- Understanding thermal tolerance is important for predicting survival & persistence of organisms.

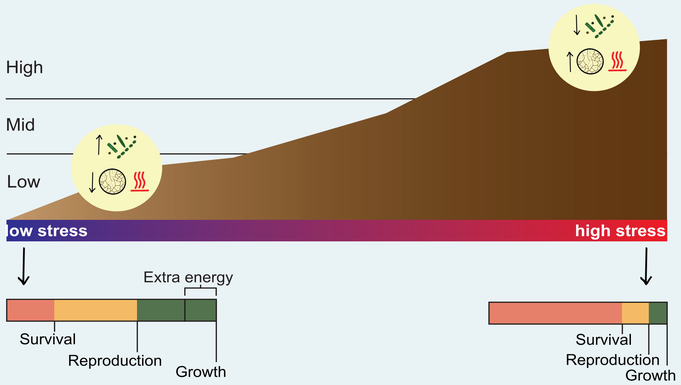




- *Mytilus californianus* has a complex life cycle.
- Parental effects (offspring responses to environmental change are influenced by parental environments) may increase survival under climate change.
- Parental effects can be adaptive, maladaptive, or neutral.

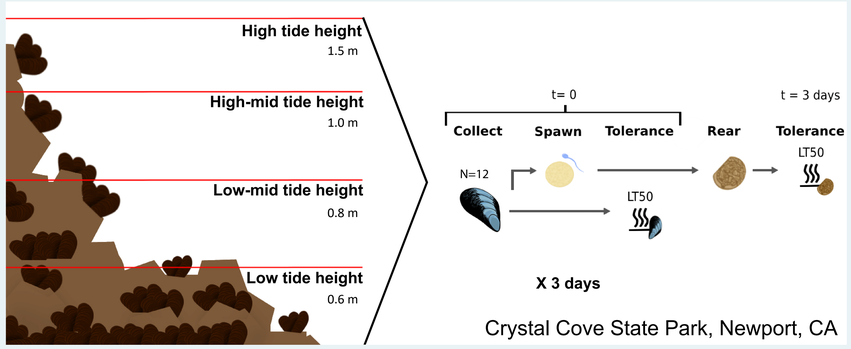
What is the role of parental effects in determining thermal tolerances of *M. californianus*?

Approach



- Used intertidal elevation as natural thermal gradient
- Sharp stress gradient: low stress at low tide heights, high at high tide heights
- Stresses: **heat**, desiccation and food
- To test for parental effects, quantified and compared thermal tolerances of adults and their larval

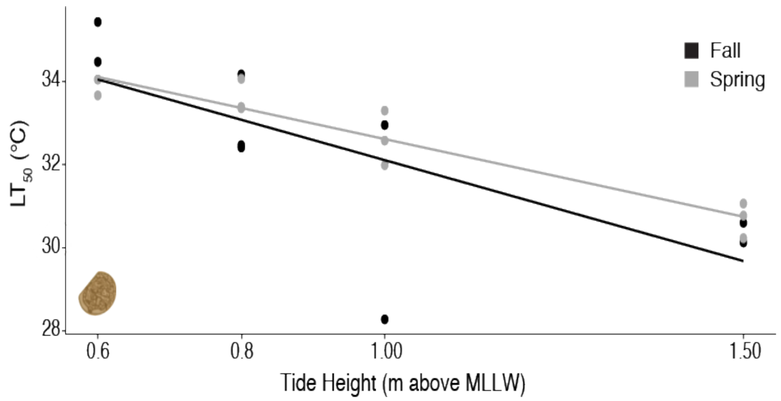
Methods



- Sampled & spawned mussels at 4 tide heights in Nov '19 & Jun '20
- Quantified adult LT_{50} thermal tolerances (temperature lethal to 50% of individuals)
- After 3 days of rearing, tested larval LT_{50} thermal tolerances
- Temporally replicated over 3 days
- Measured adult GSI (reproductive capacity) and egg size
- Compared adult and larval tolerances, GSI, and egg size across tide heights using GLMs

Results

Question 1: Do parental thermal environments impact the thermal tolerance of larval offspring?



- **Mussel larvae from parents exposed to warmer habitats (higher tide heights) yielded less tolerant offspring.**
- Tide height (P<0.001), adult LT_{50} (P=0.0108), season (P=0.0134), and adult LT_{50}: season interaction (P=0.0125) significantly affected larval tolerances.
- No clear effects of tide height on adult tolerances (P=0.274)

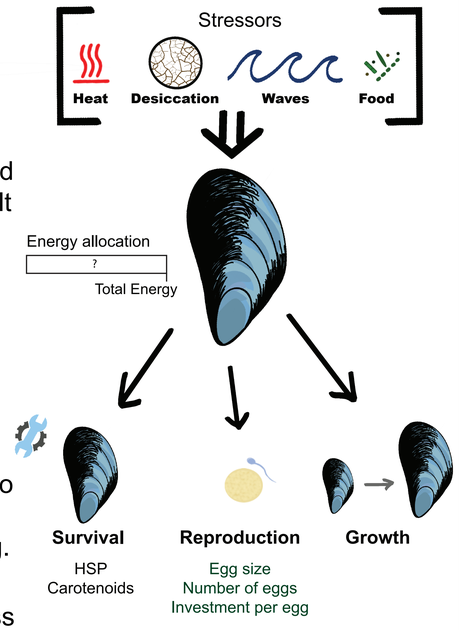
Results continued

Question 2: Do indicators of condition (adult reproductive capacity & egg size) differ across tide heights?

- From low to high tide heights, both GSI (P=0.0494) and egg size (P<0.001) decreased.

Discussion

- Parental effects were maladaptive for thermal tolerance & indicate negative effects of stress.
- Yet, thermal stress had no clear effect on adult tolerances. Adult mussels may invest more in own survival (e.g. heat shock proteins) that buffer their own thermal tolerances but reduce investment in reproduction leading to lower thermal tolerances in offspring.



- Both GSI and egg diameters suggest less investment in reproduction in the high thermal stress than in the low thermal stress environment.
- Though parental effects may be adaptive for some organisms and traits as several studies suggest, physiological tradeoffs may limit the effectiveness of this strategy.
- Maladaptive parental effects could leave larvae more vulnerable to thermal stress and impact the survival of the mussel under climate change.
- Future directions: How long do parental effects last? What effects do parental effects have on subsequent life stages?

Acknowledgements

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