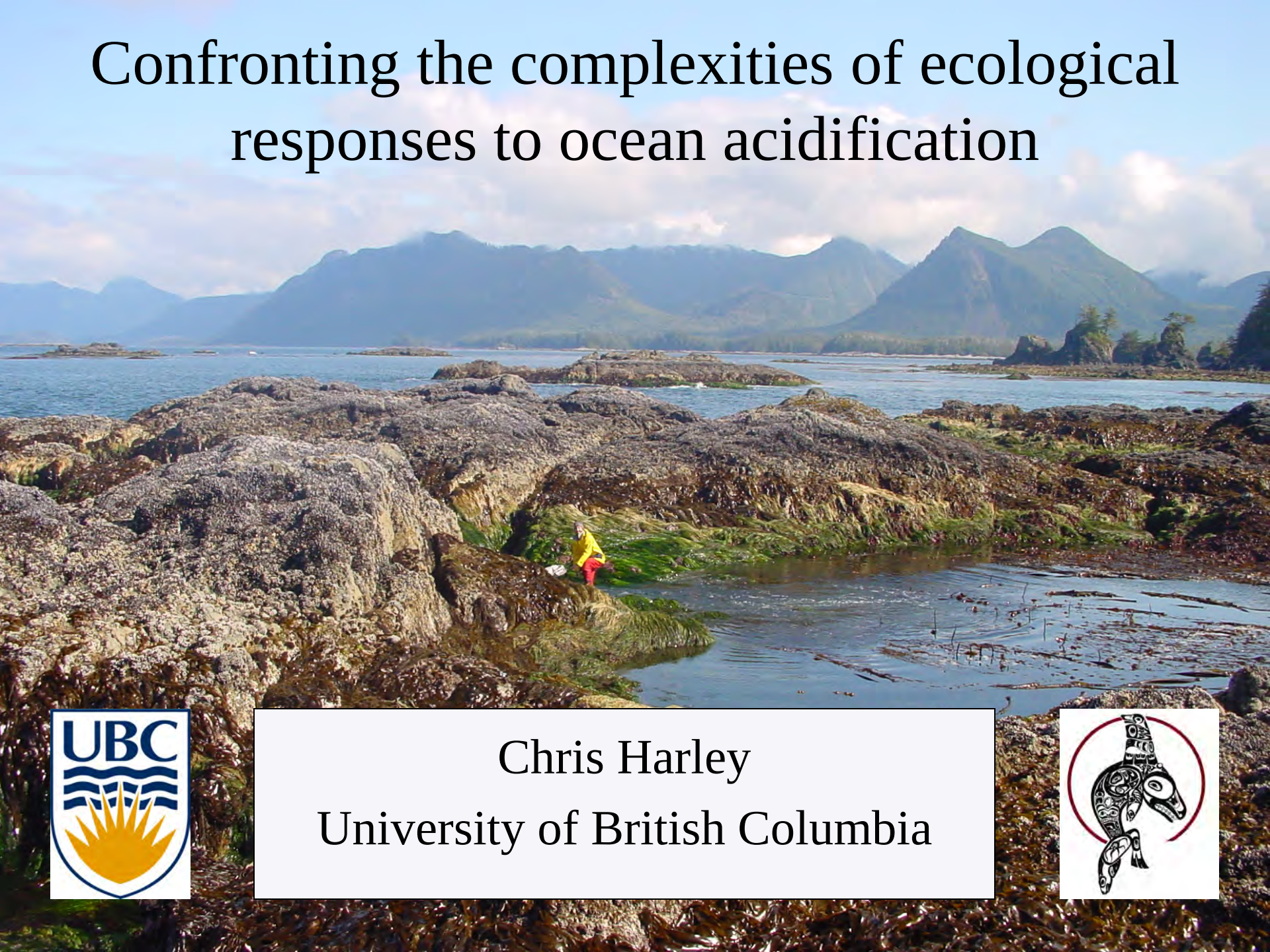
Confronting the complexities of ecological responses to ocean acidification



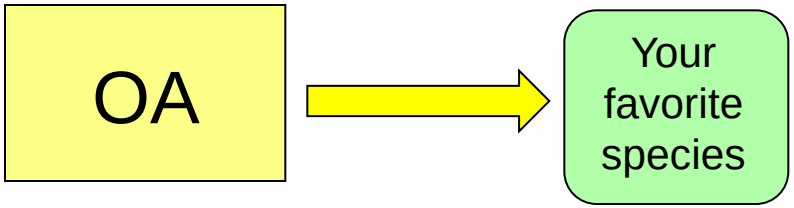
Chris Harley

University of British Columbia

“How will OA affect my favorite species?”

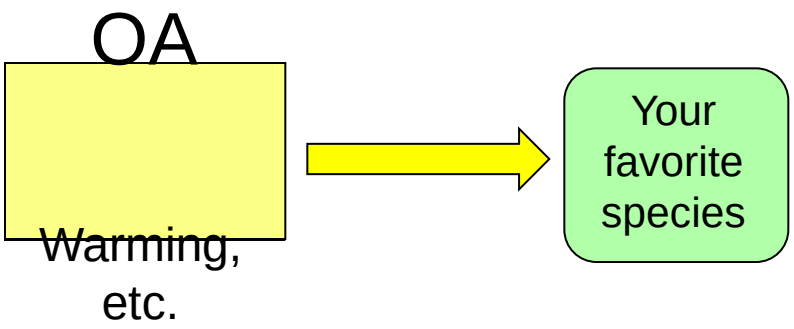
Maine Atlantic Salmon Commission

Predicting biological responses to ocean acidification



modified from Harley et al. 2006, Ecol Let

Predicting biological responses to ocean acidification



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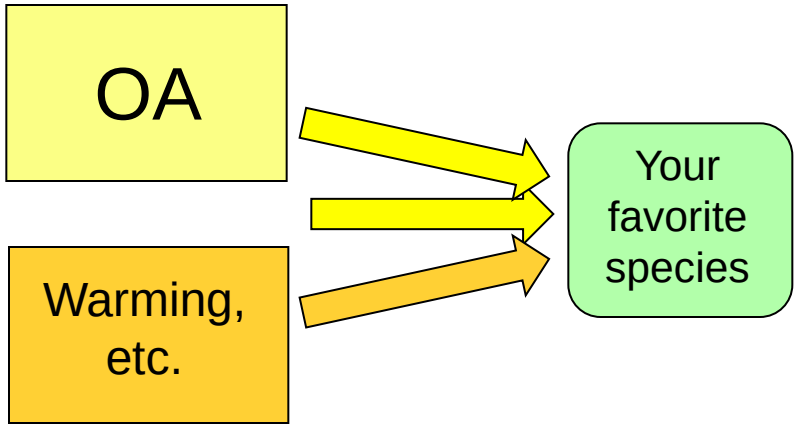
Predicting biological responses to ocean acidification



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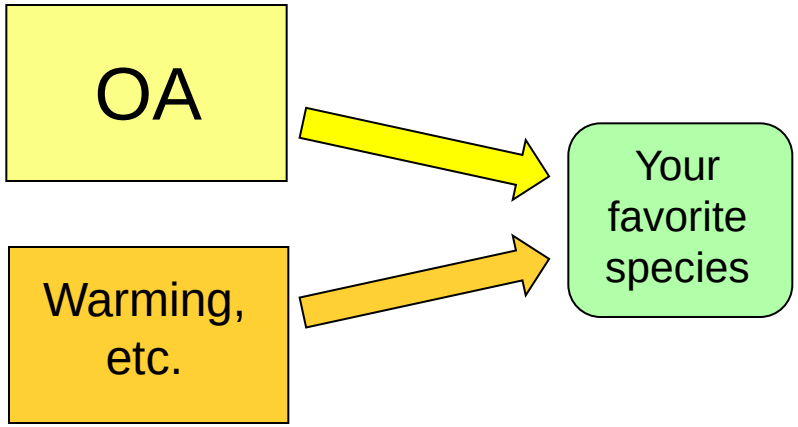
Predicting biological responses to ocean acidification



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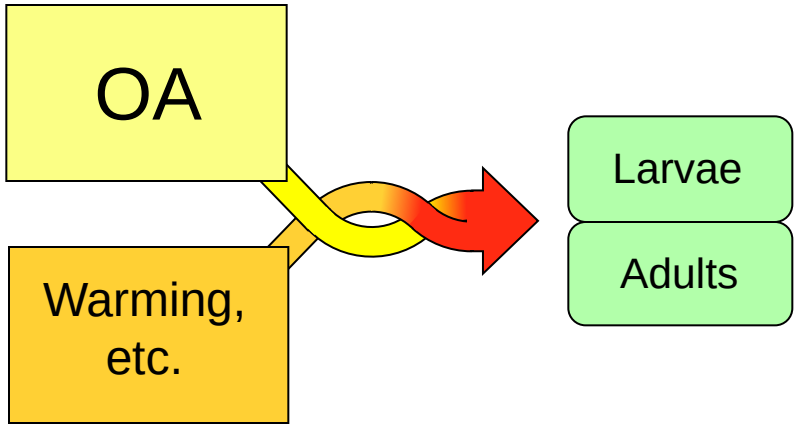
Predicting biological responses to ocean acidification



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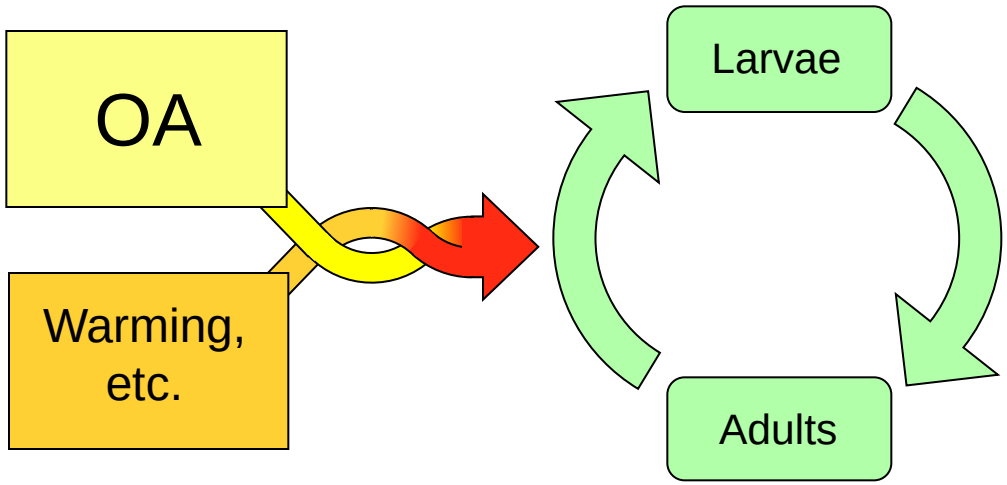
Predicting biological responses to ocean acidification



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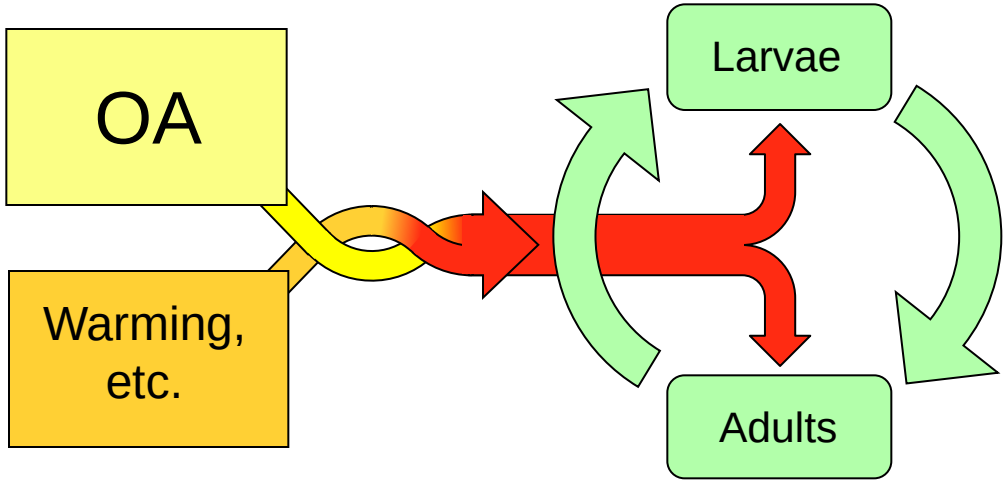
Predicting biological responses to ocean acidification



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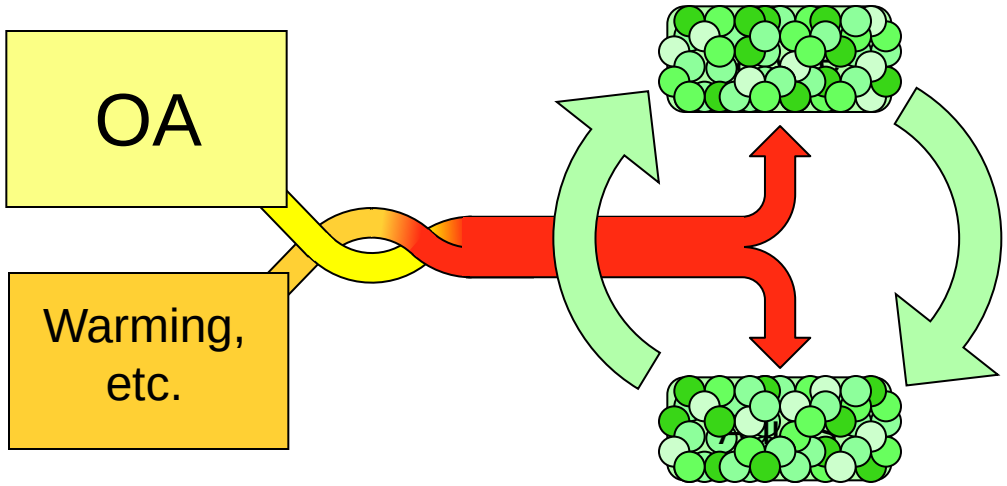
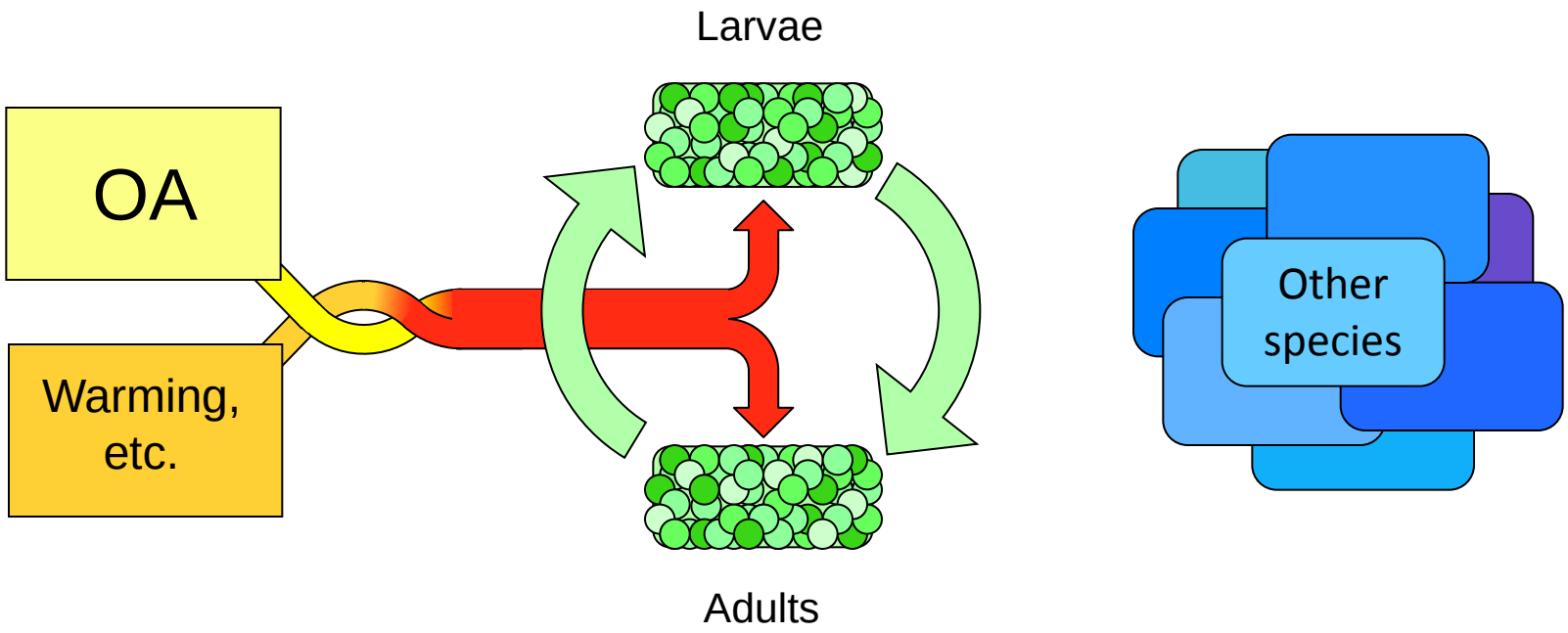
Predicting biological responses to ocean acidification



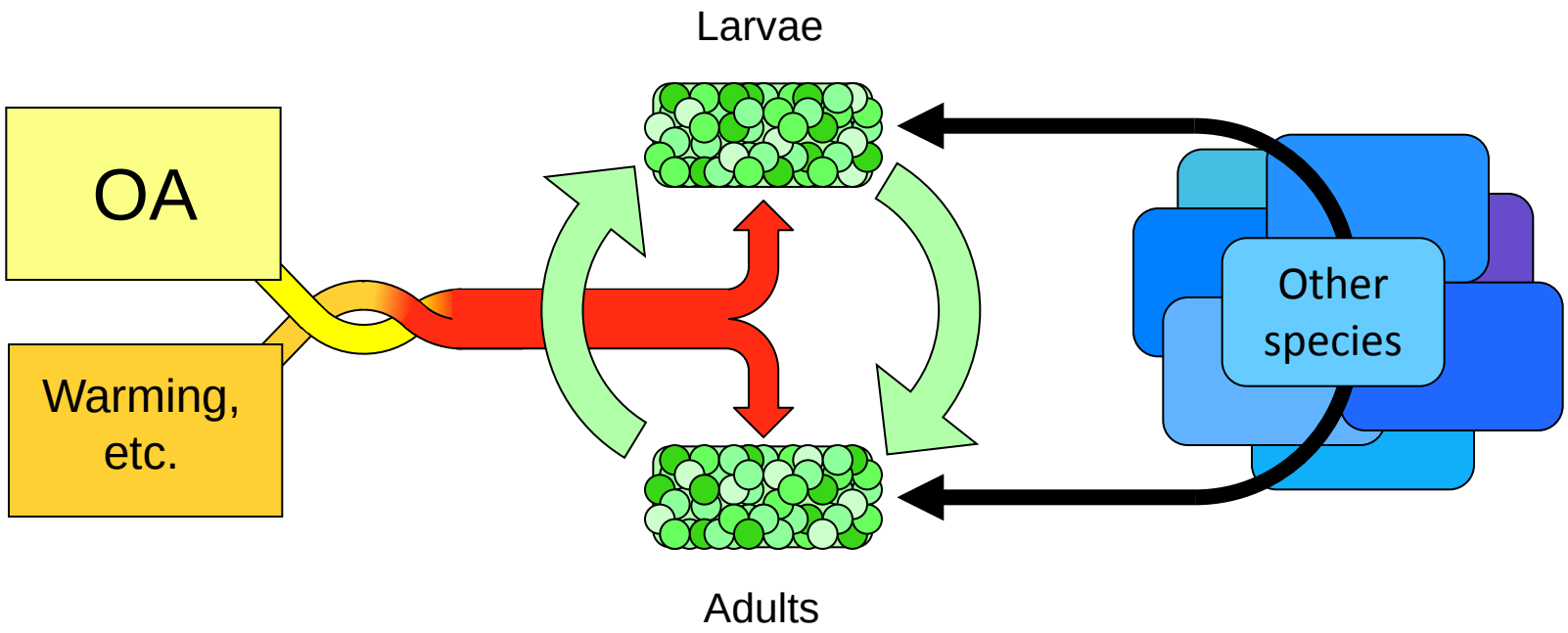
modified from Harley et al. 2006, Ecol Let

Predicting biological responses to ocean acidification



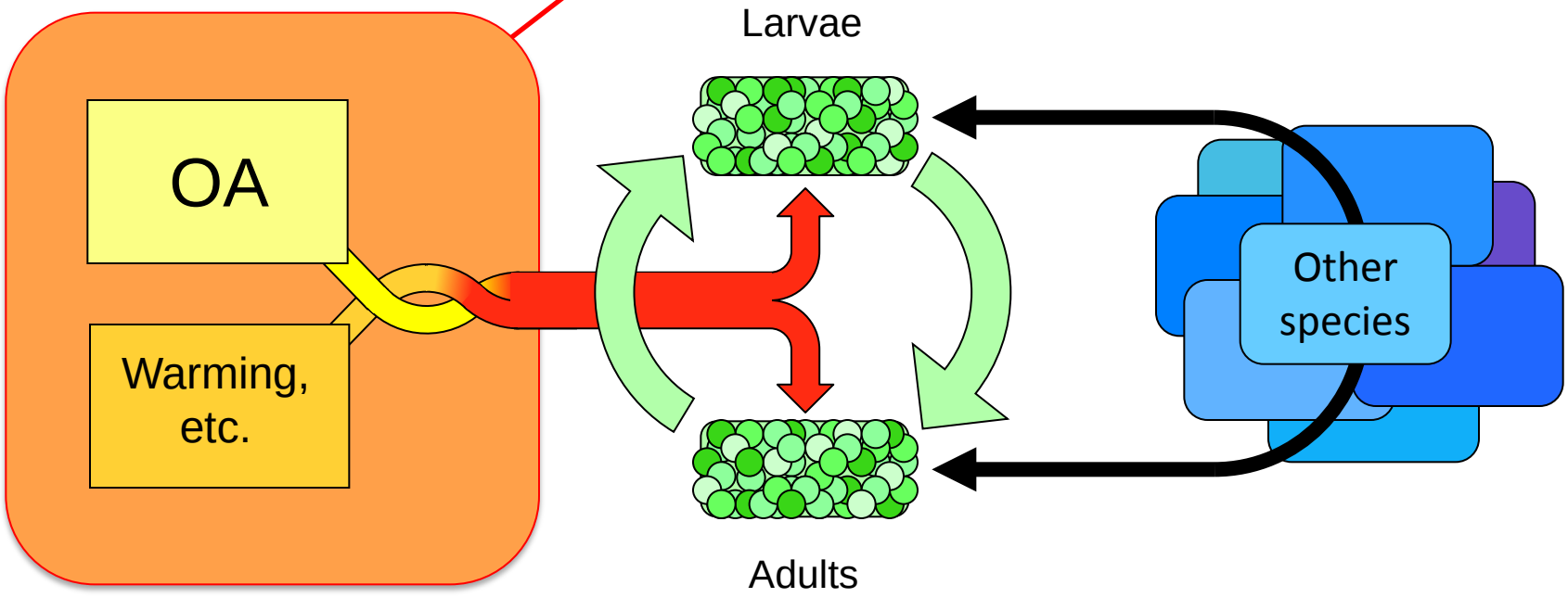
modified from Harley et al. 2006, Ecol Let

Predicting biological responses to ocean acidification

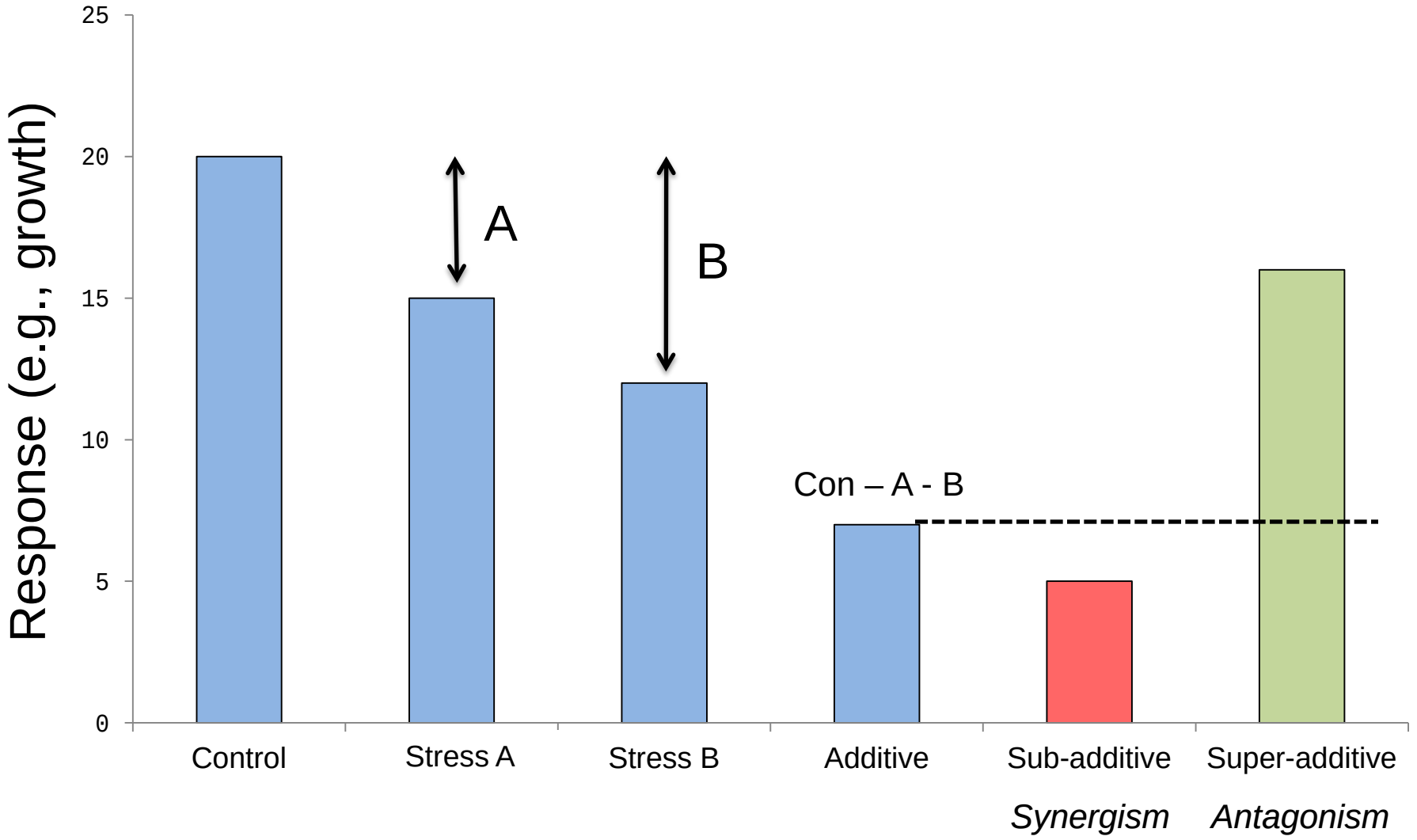


modified from Harley et al. 2006, Ecol Let

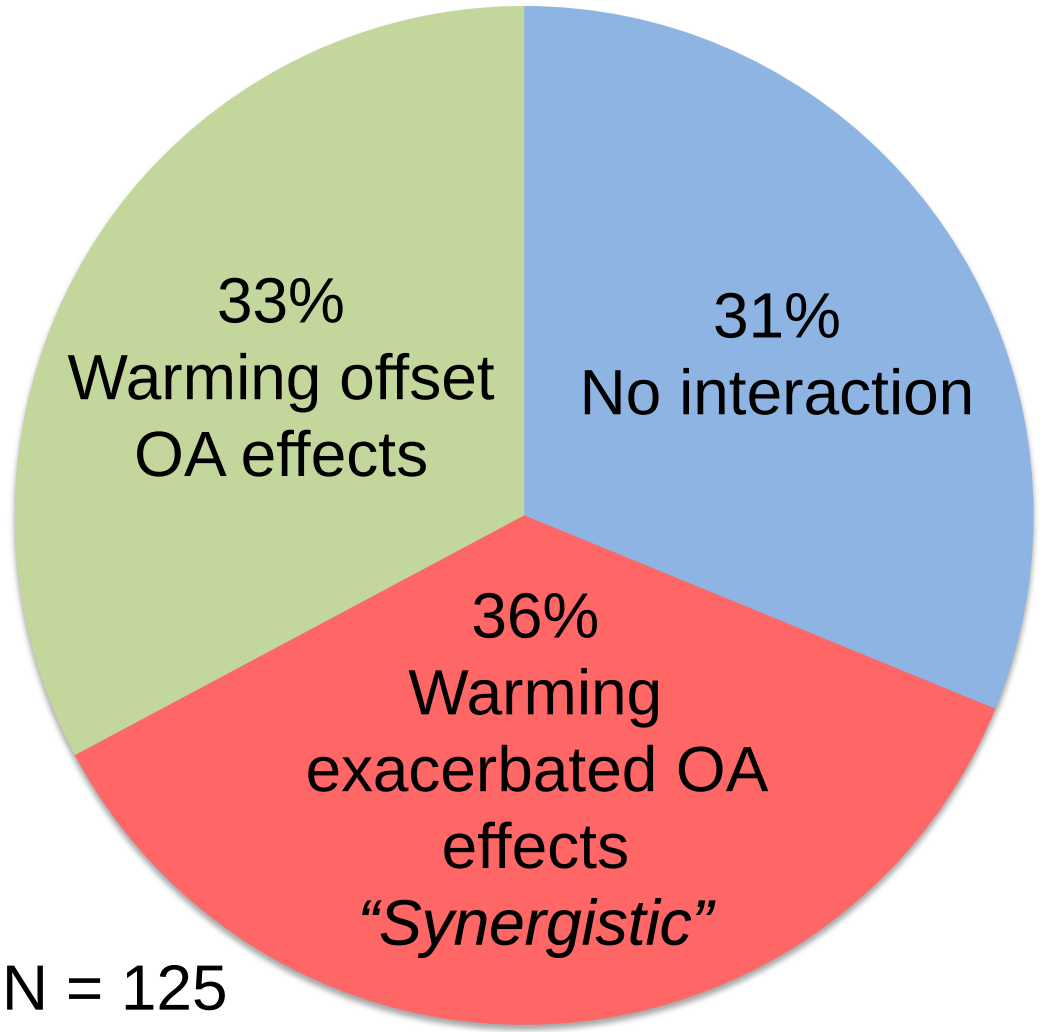
Multiple stressor and cumulative effects



3 fundamental cumulative effects



Cumulative effects of near-future warming + OA



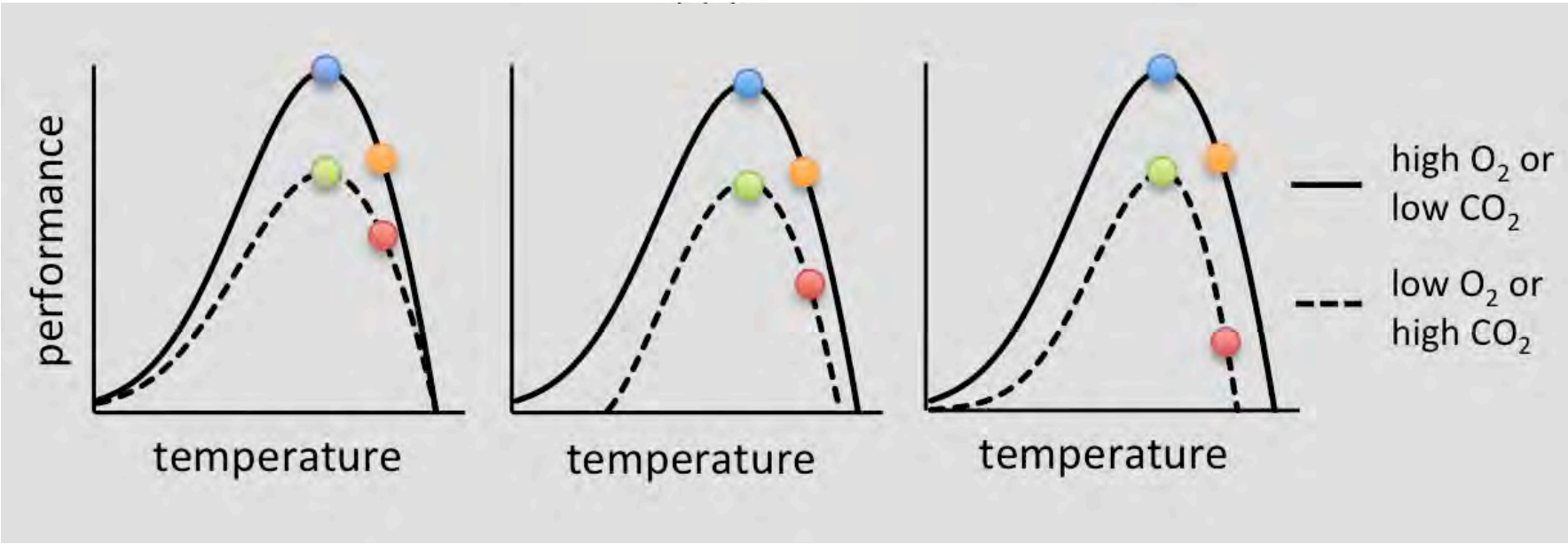
Additive

"Antagonistic"

"Synergistic"

Kroeker *et al.* in prep

OA and temperature interaction may be predictable using existing physiological theory, e.g., the oxygen and capacity limited thermal tolerance hypothesis

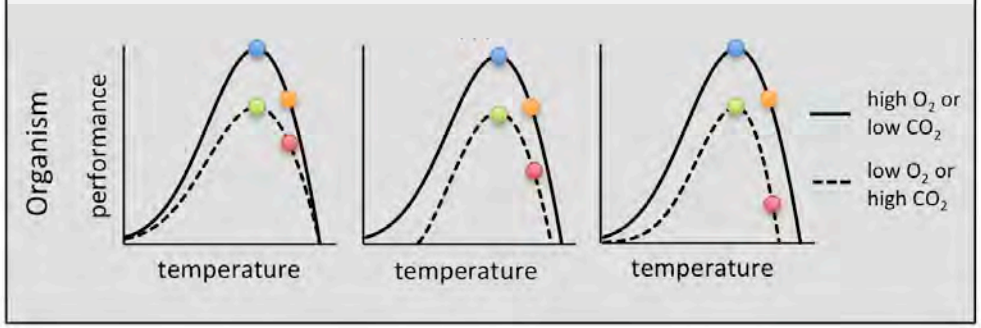


antagonistic

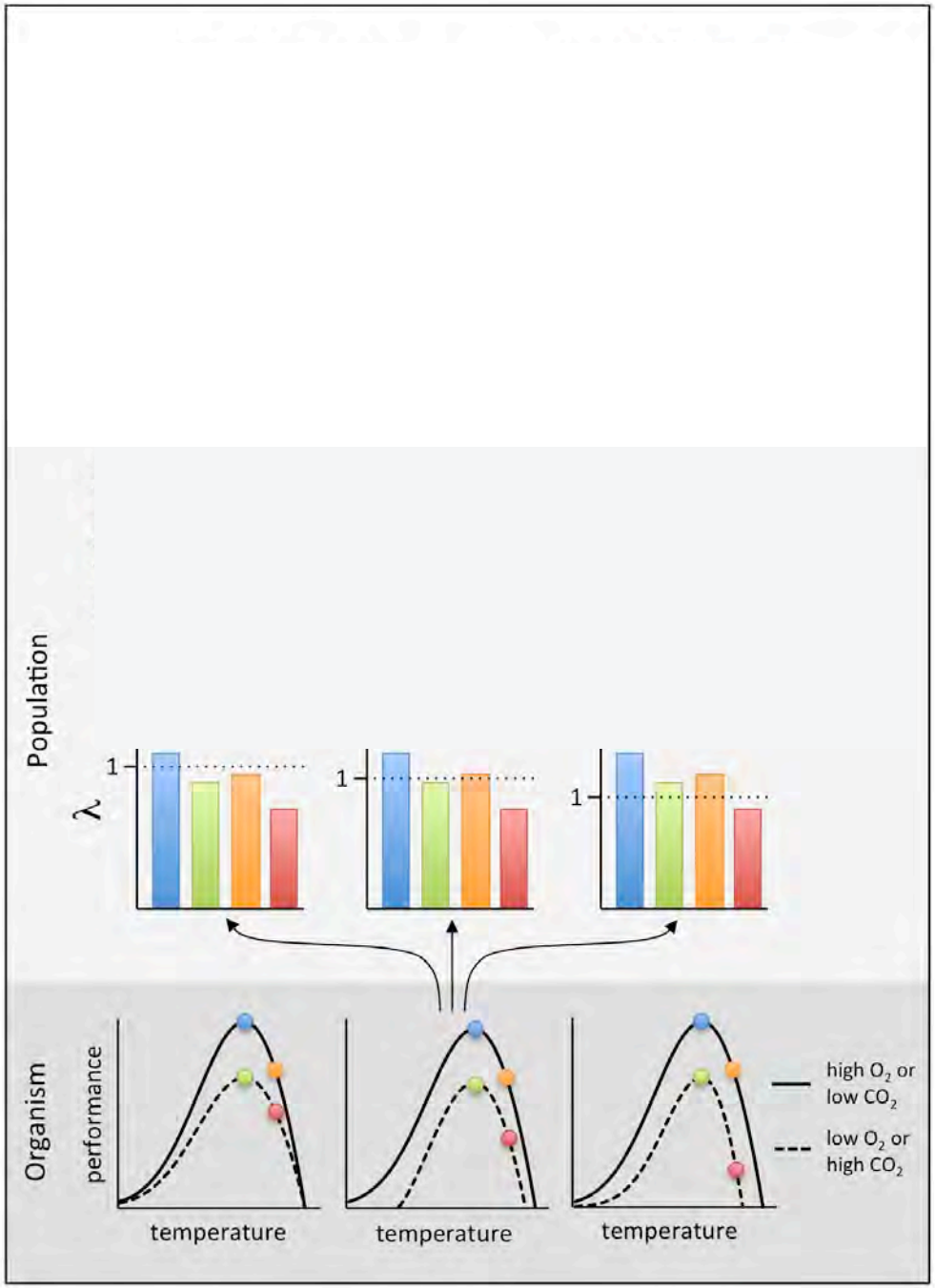
non-interactive

synergistic (OCCLT)

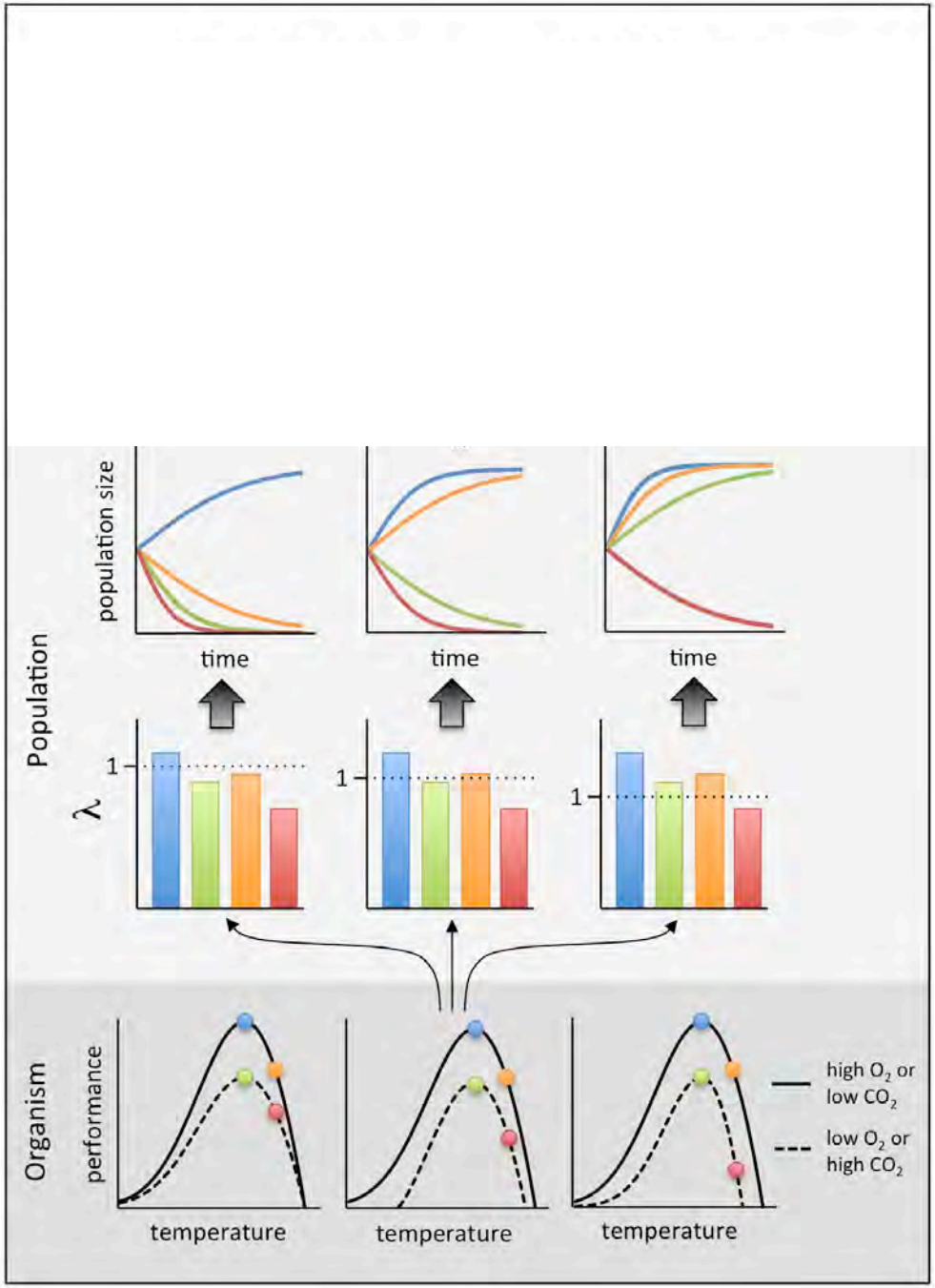
Note that patterns at one level of biological organization don't necessarily translate to similar patterns at other levels



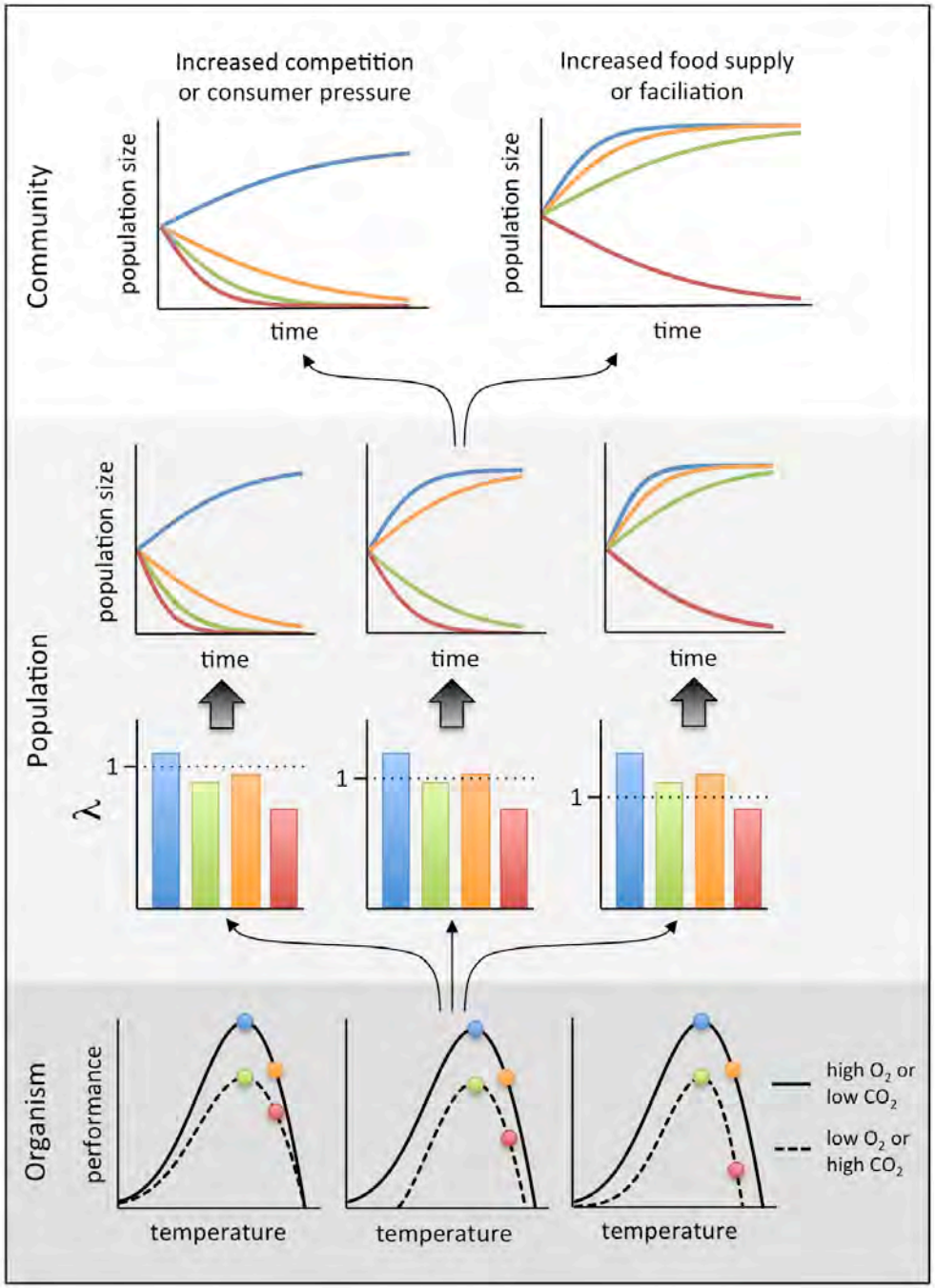
Kroeker et al. 2017 *Biology Letters*



Kroeker et al. 2017 *Biology Letters*

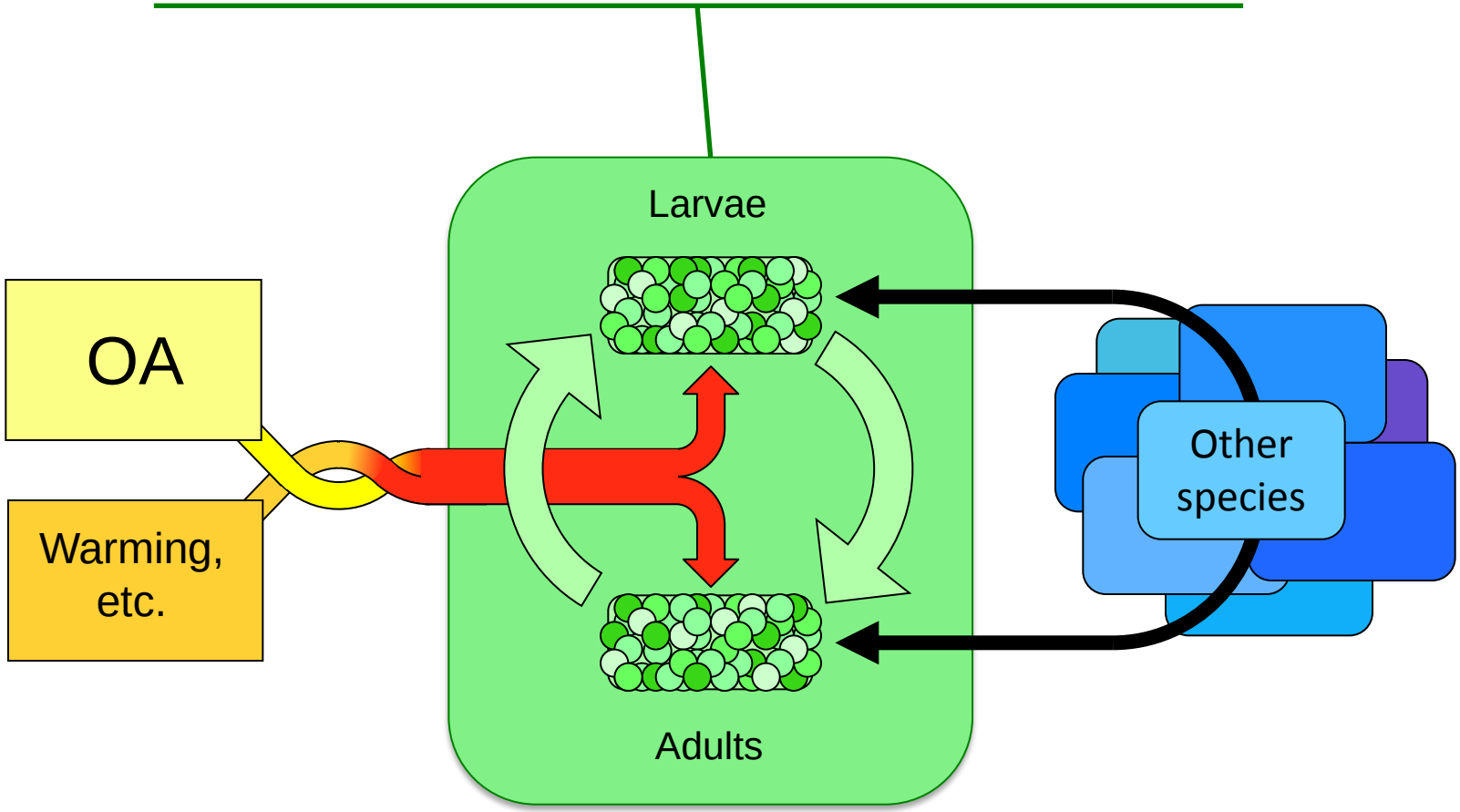


Kroeker et al. 2017 *Biology Letters*

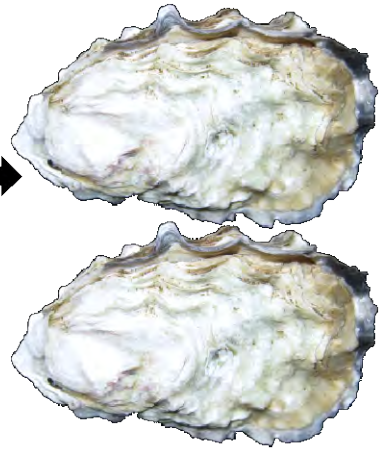


Kroeker et al. 2017 *Biology Letters*

Ontogenetic and inter-generational effects

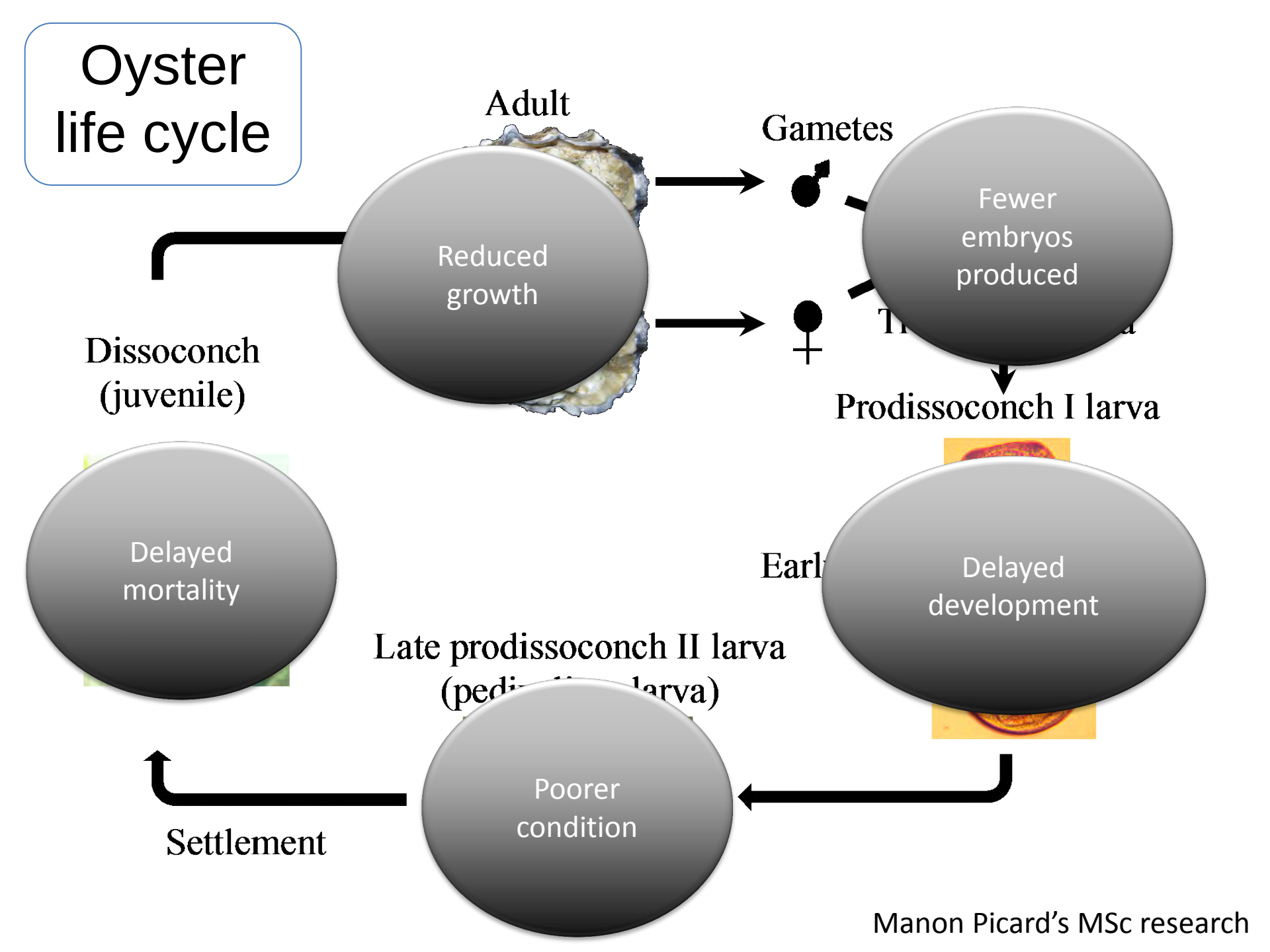


Oyster life cycle



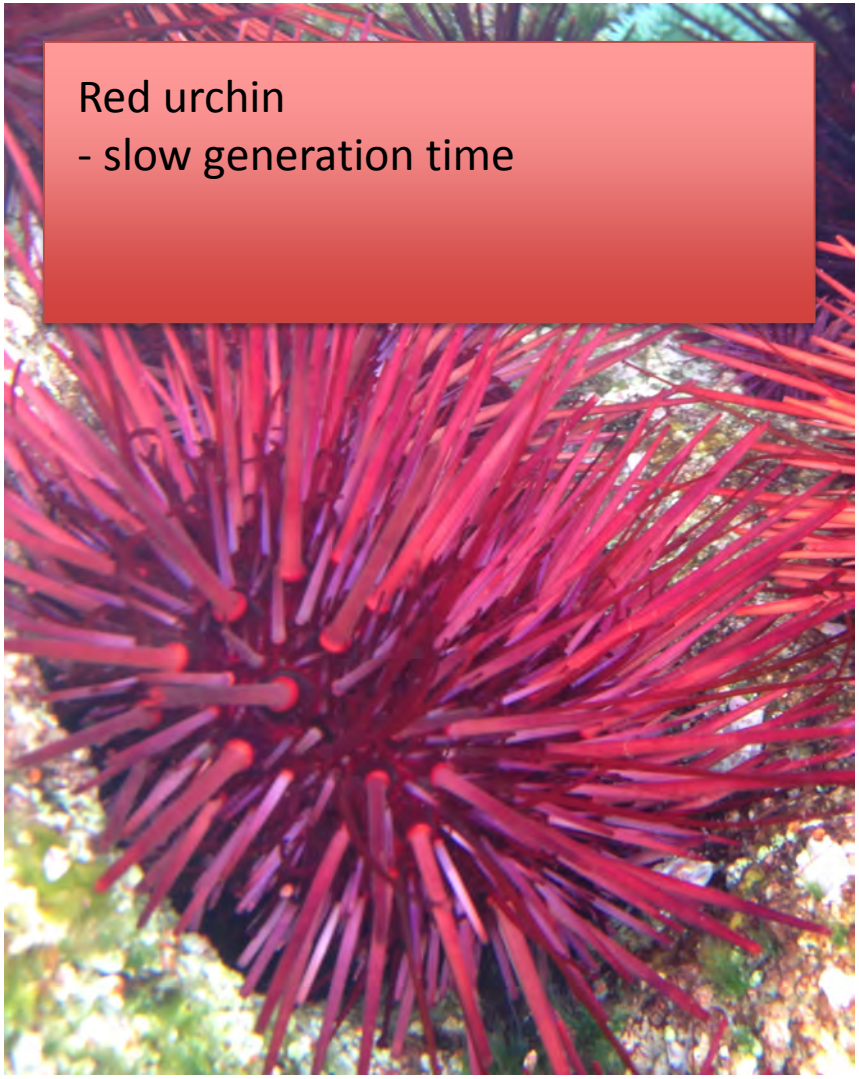
Manon Picard's MSc research

Oyster life cycle



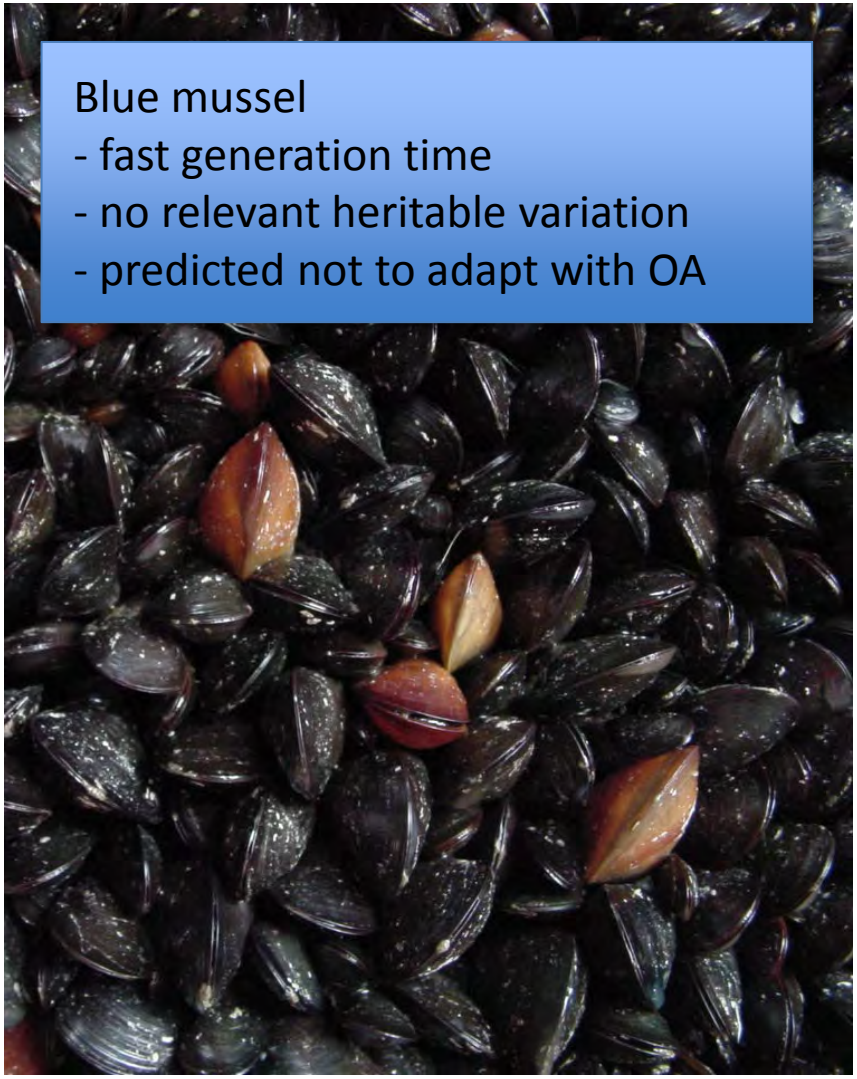
Manon Picard's MSc research

(Natural) selection to the rescue?

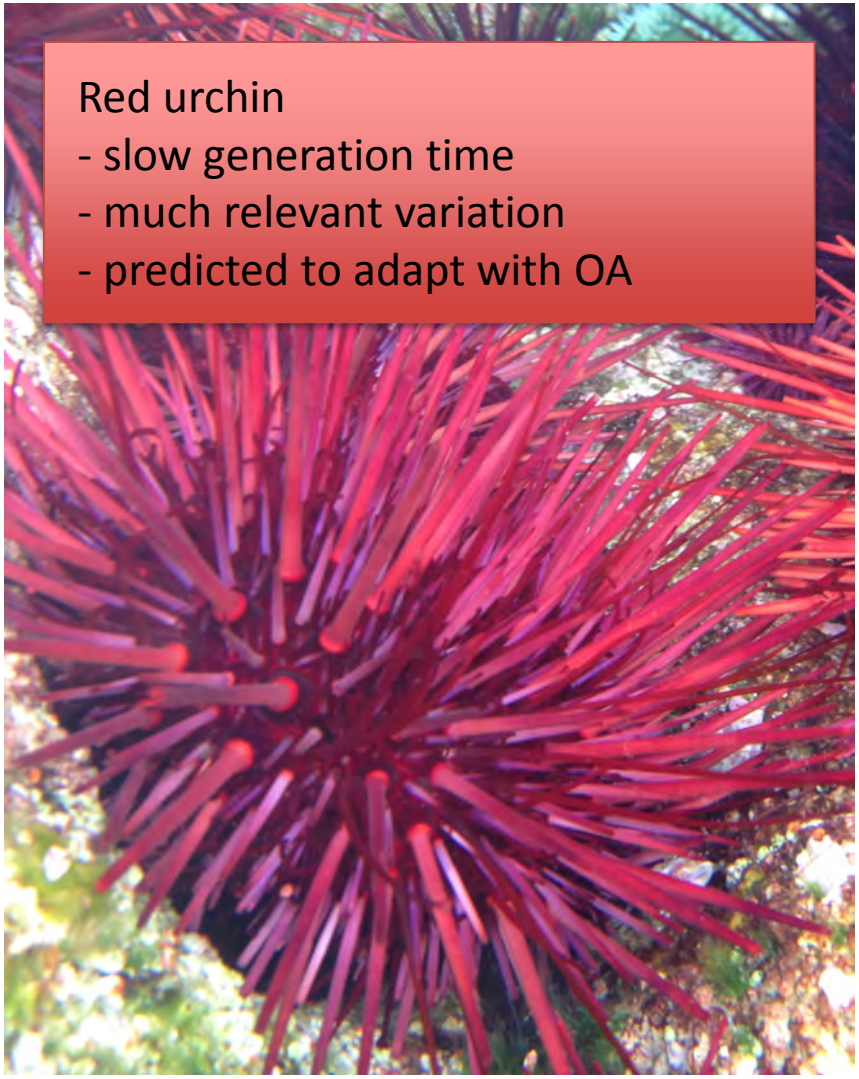


Sunday et al. 2011 PLOS ONE

(Natural) selection to the rescue?



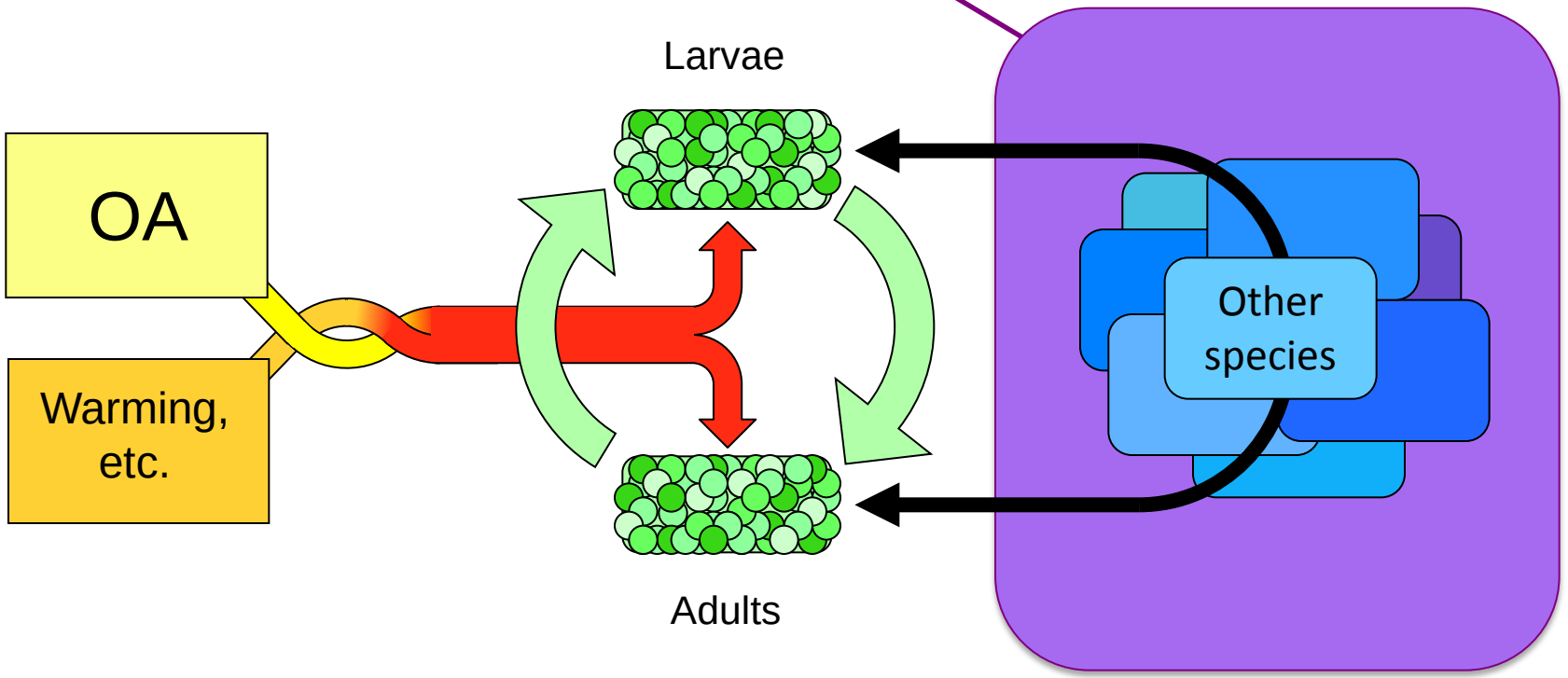
Blue mussel
- fast generation time
- no relevant heritable variation
- predicted not to adapt with OA



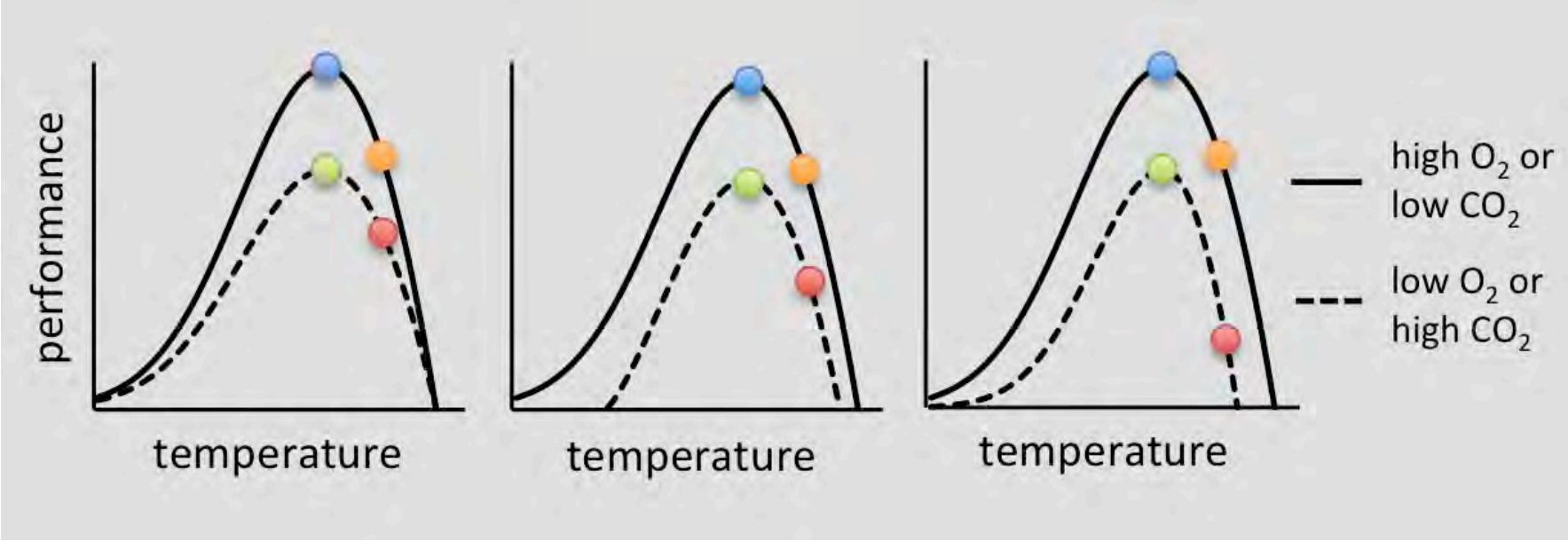
Red urchin
- slow generation time
- much relevant variation
- predicted to adapt with OA

Sunday et al. 2011 PLOS ONE

Food web and biogenic habitat effects

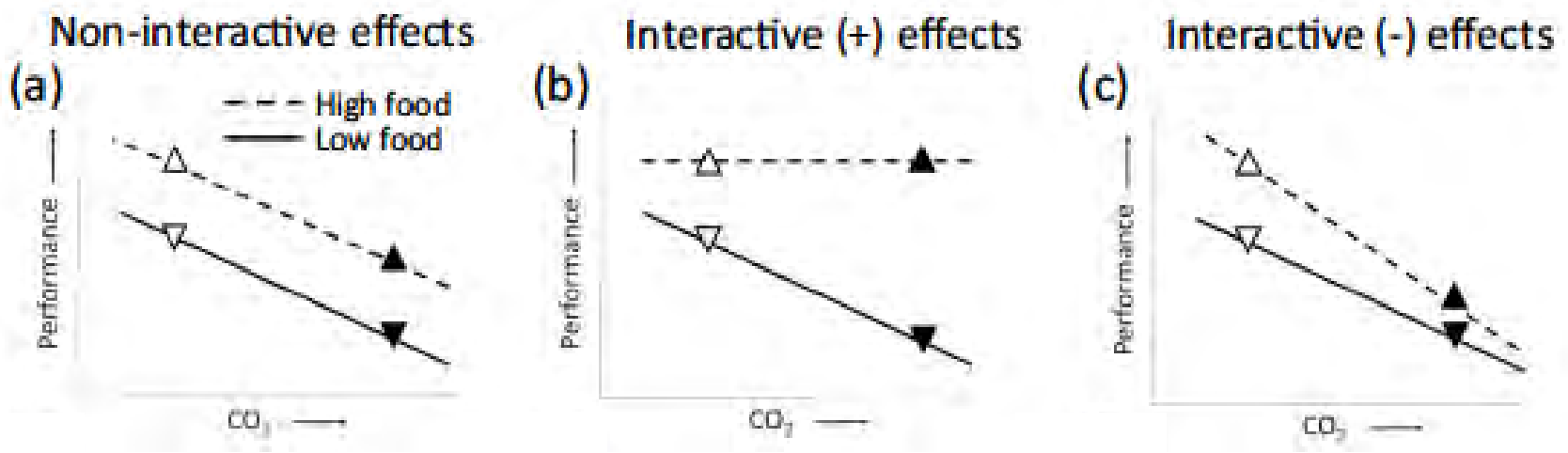


If OA is fundamentally an energetics problem…



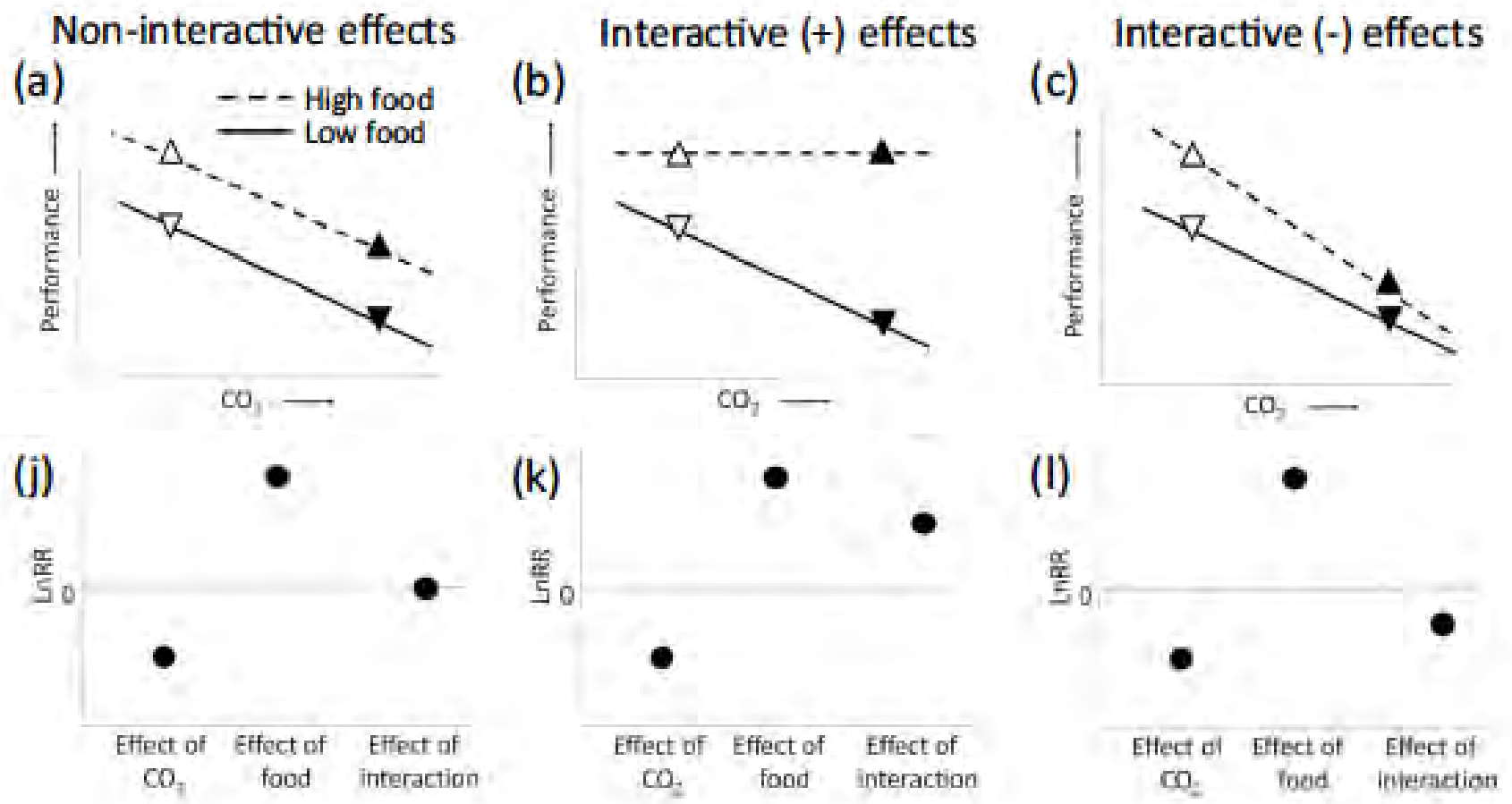
…could increasing food supply solve the problem?

OA effects vs. food supply – possible outcomes of a factorial meta-analysis



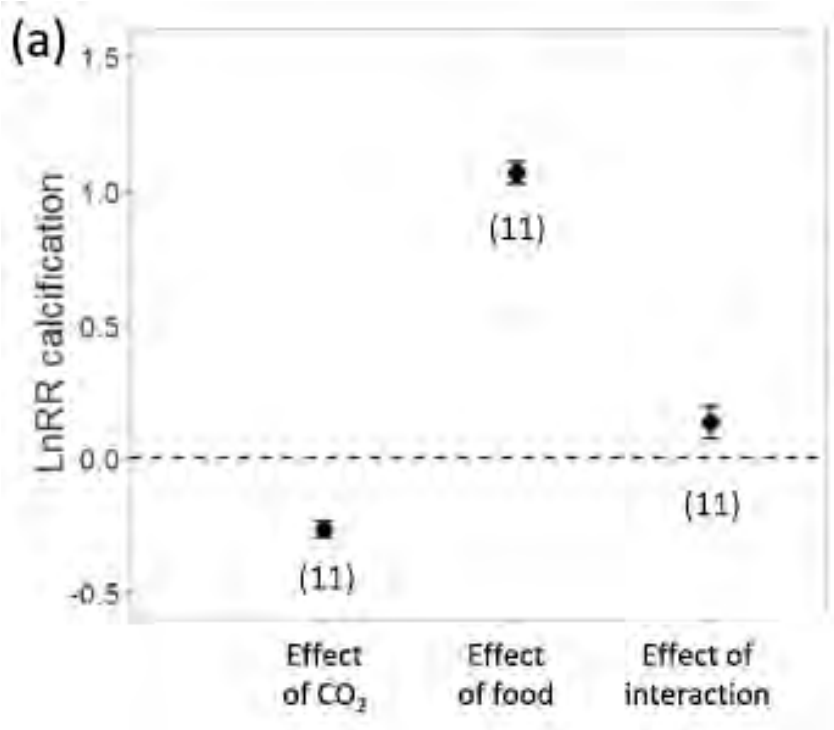
Brown et al. 2018 Sci. Rep.

OA effects vs. food supply – possible outcomes of a factorial meta-analysis



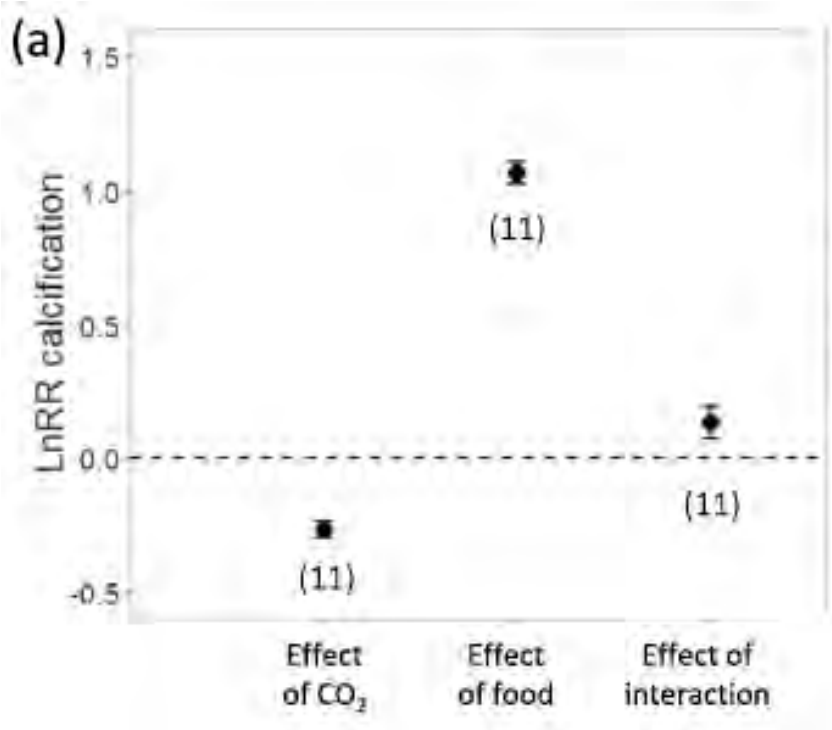
Brown et al. 2018 Sci. Rep.

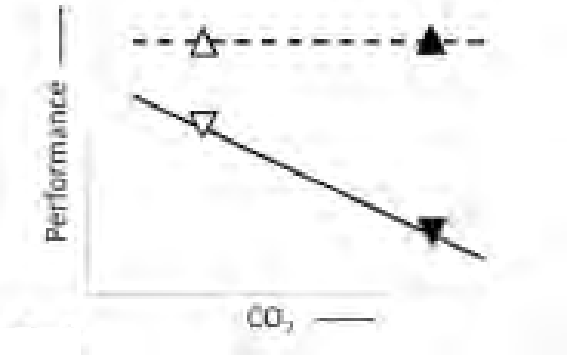
Observed influence of food on OA effects (factorial meta-analysis)



Brown et al. 2018 Sci. Rep.

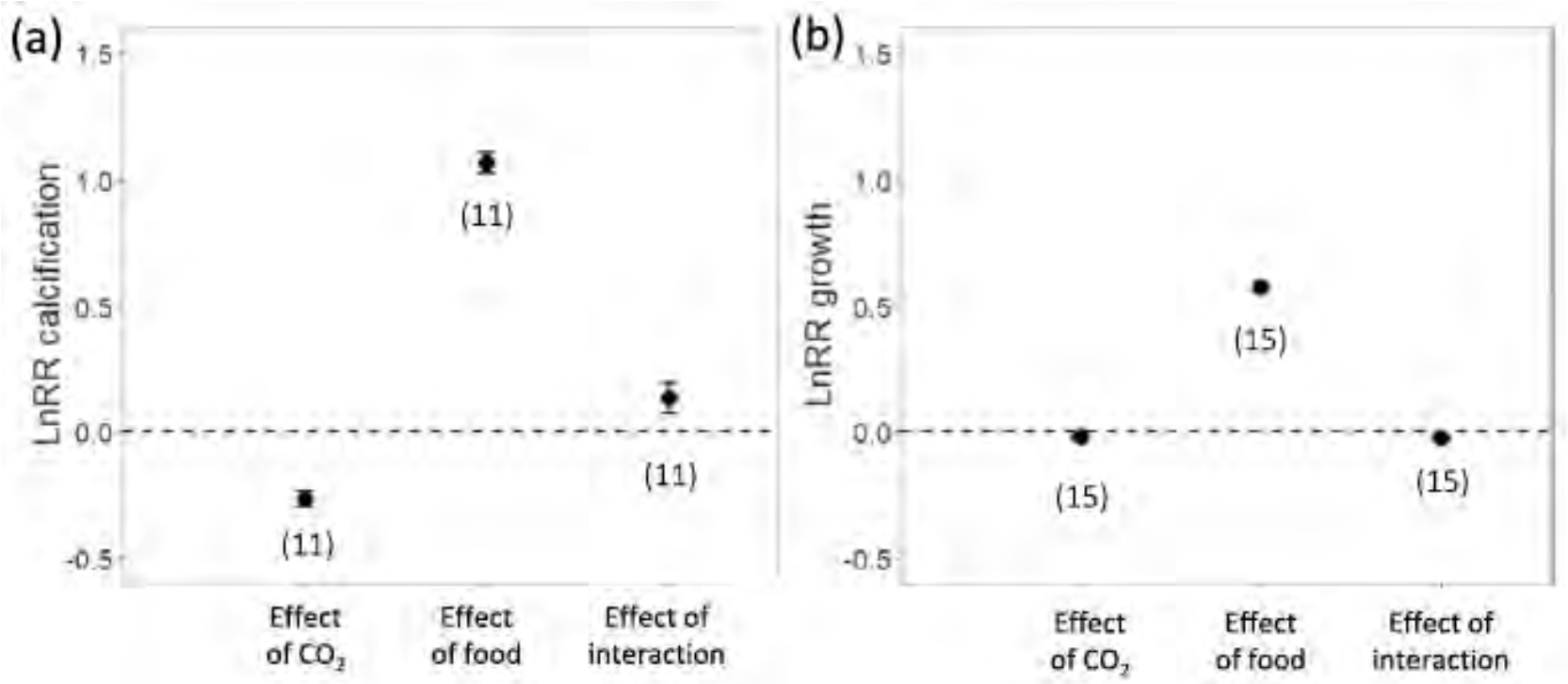
Observed influence of food on OA effects (factorial meta-analysis)

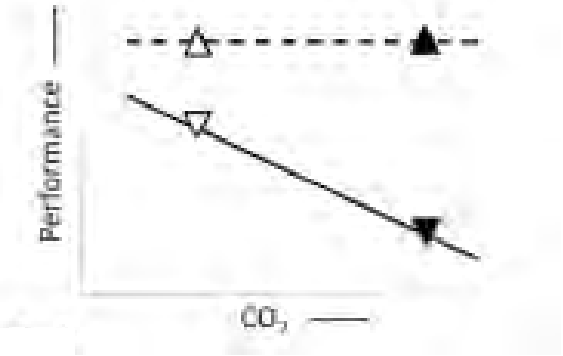




Brown et al. 2018 Sci. Rep.

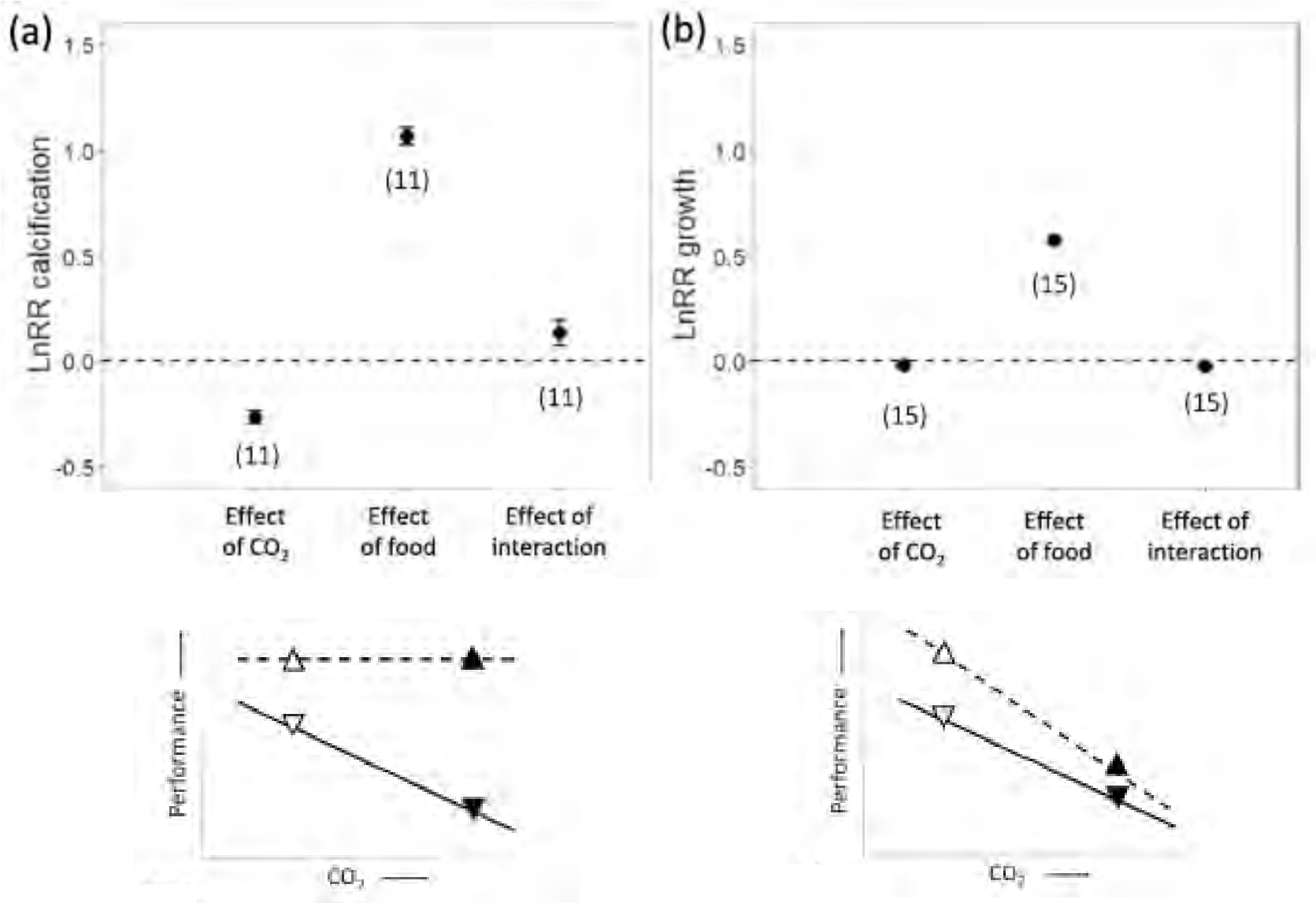
Observed influence of food on OA effects (factorial meta-analysis)





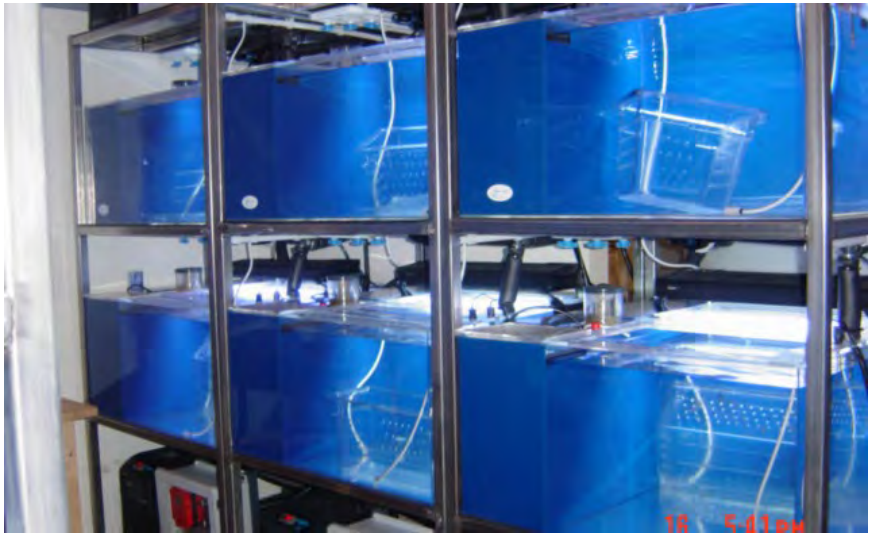
Brown et al. 2018 Sci. Rep.

Observed influence of food on OA effects (factorial meta-analysis)

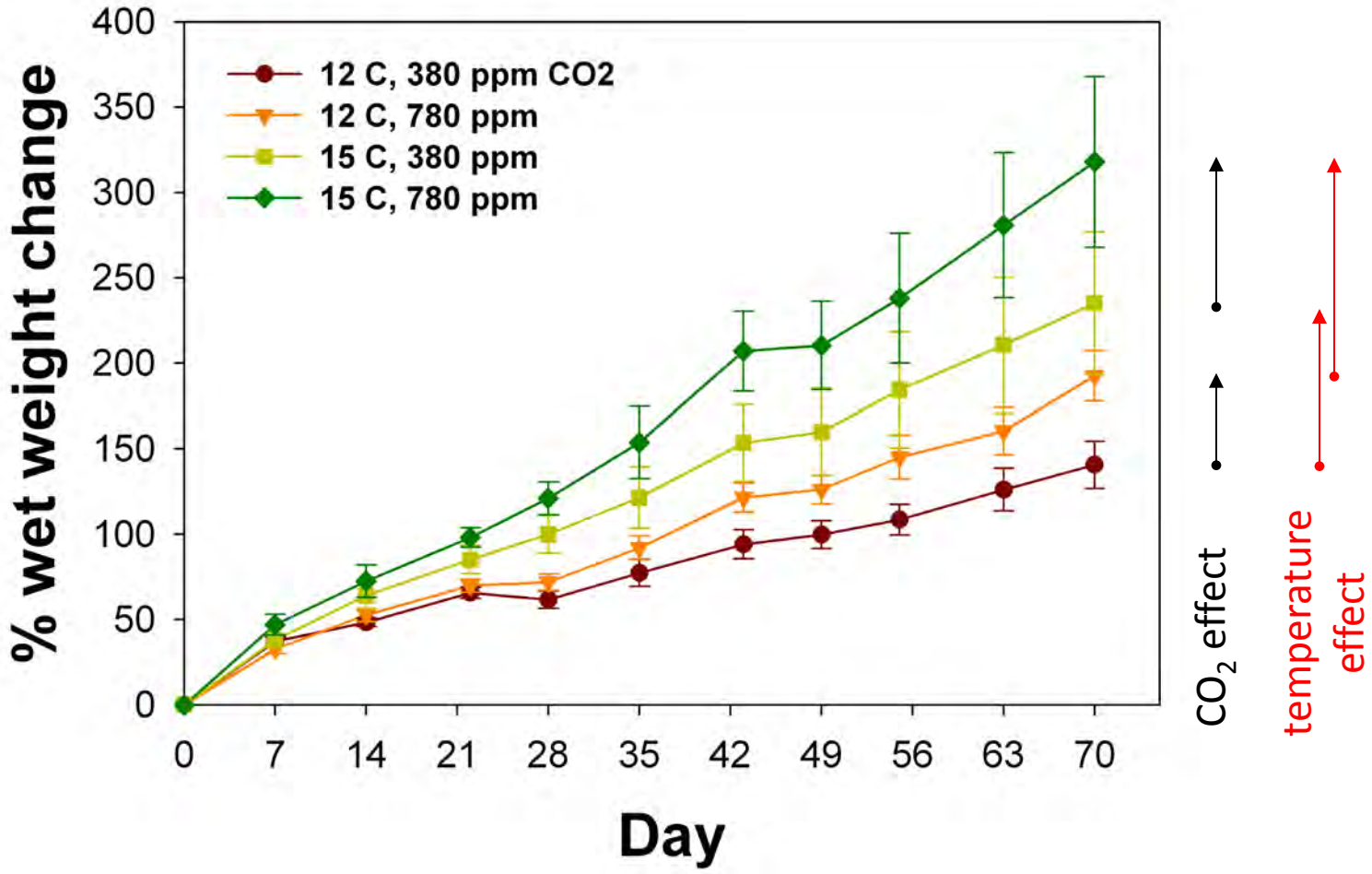


Brown et al. 2018 Sci. Rep.

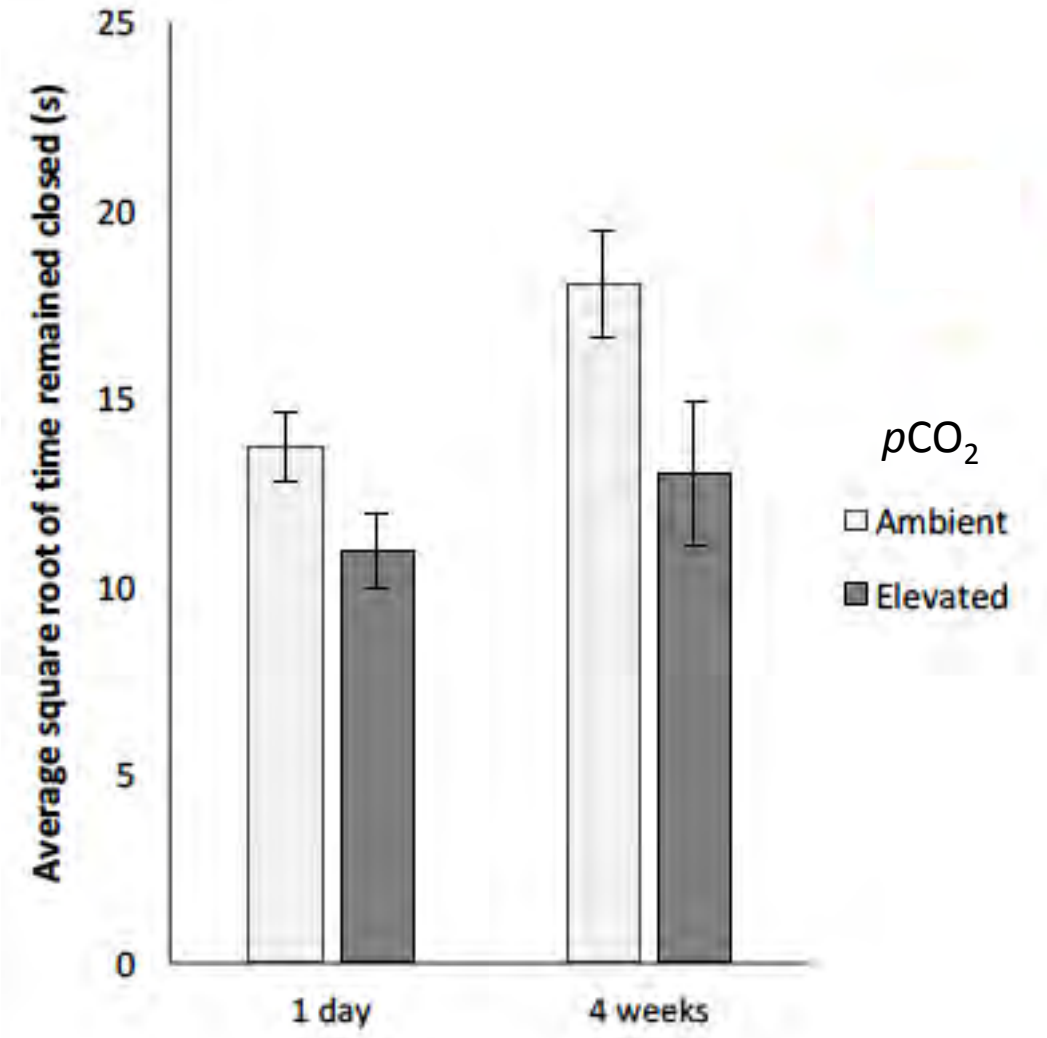
Bottom-up effects matter. What about top-down effects?



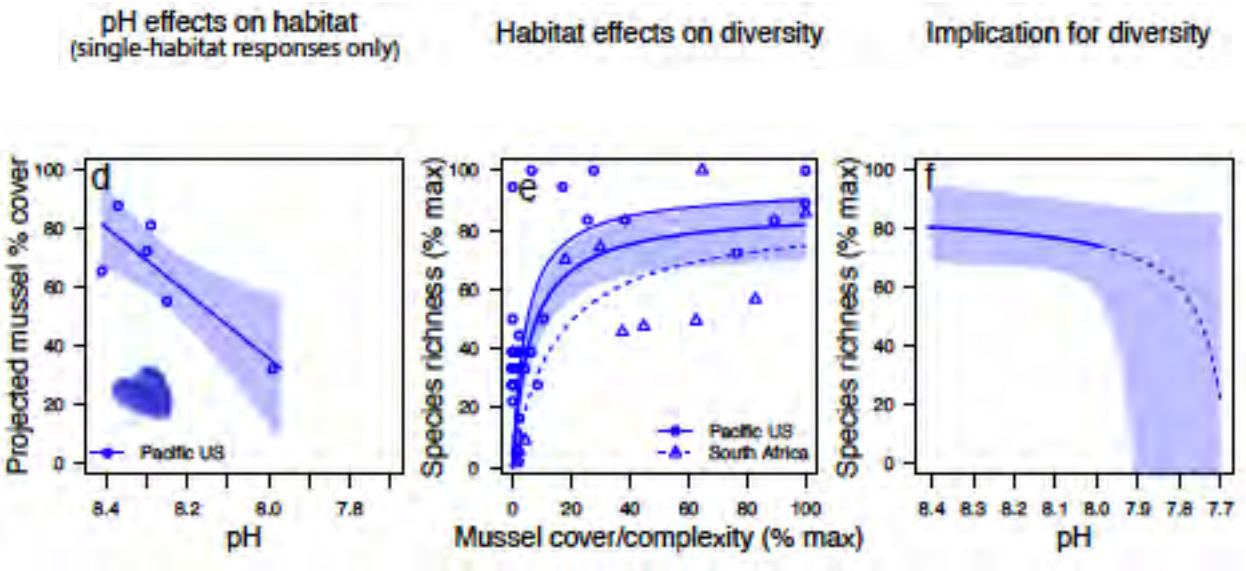
growth of *Pisaster ochraceus*



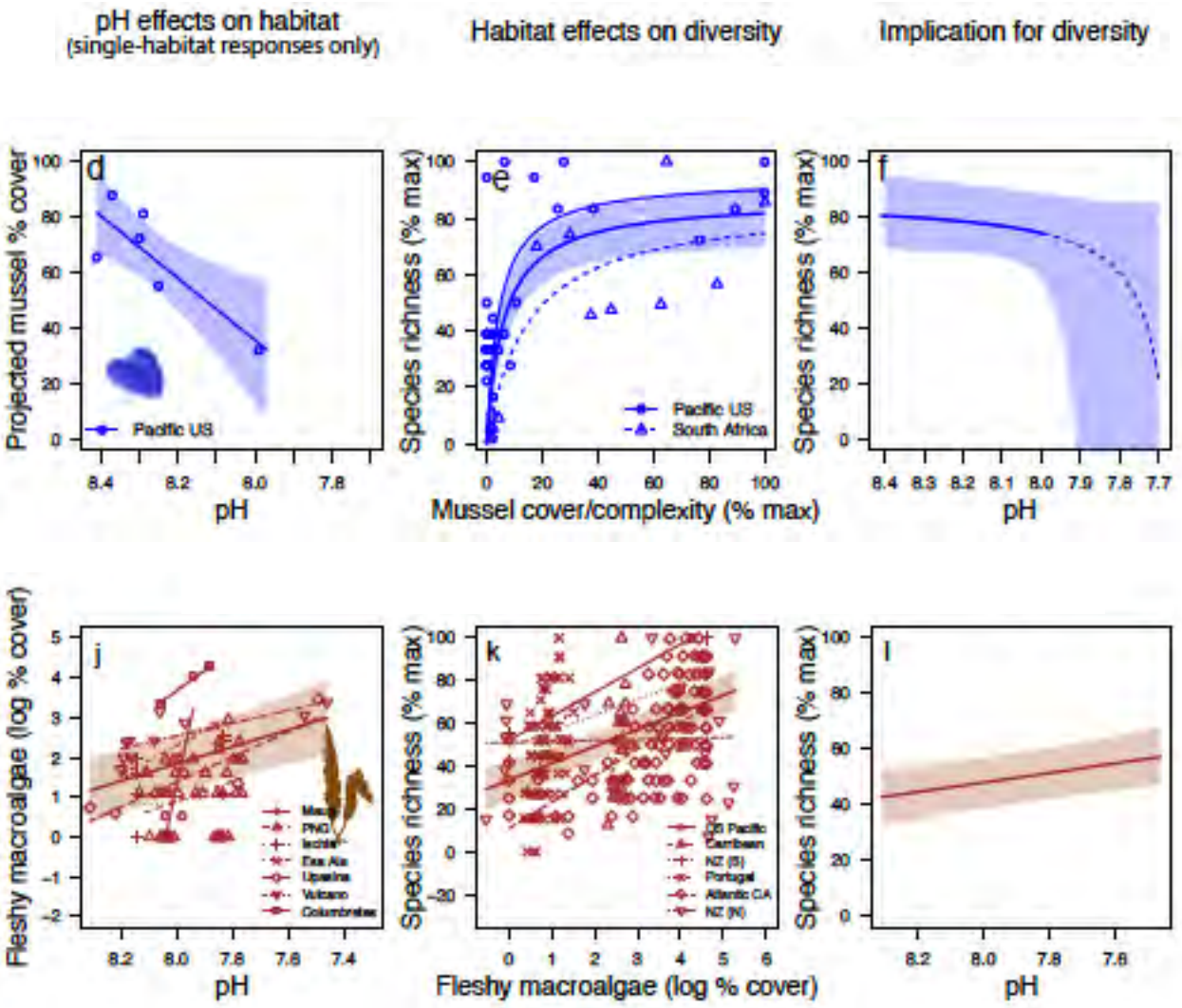
Gooding et al. 2009 *PNAS*



Flynn & Harley, unpublished



Sunday et al. 2016, NCC



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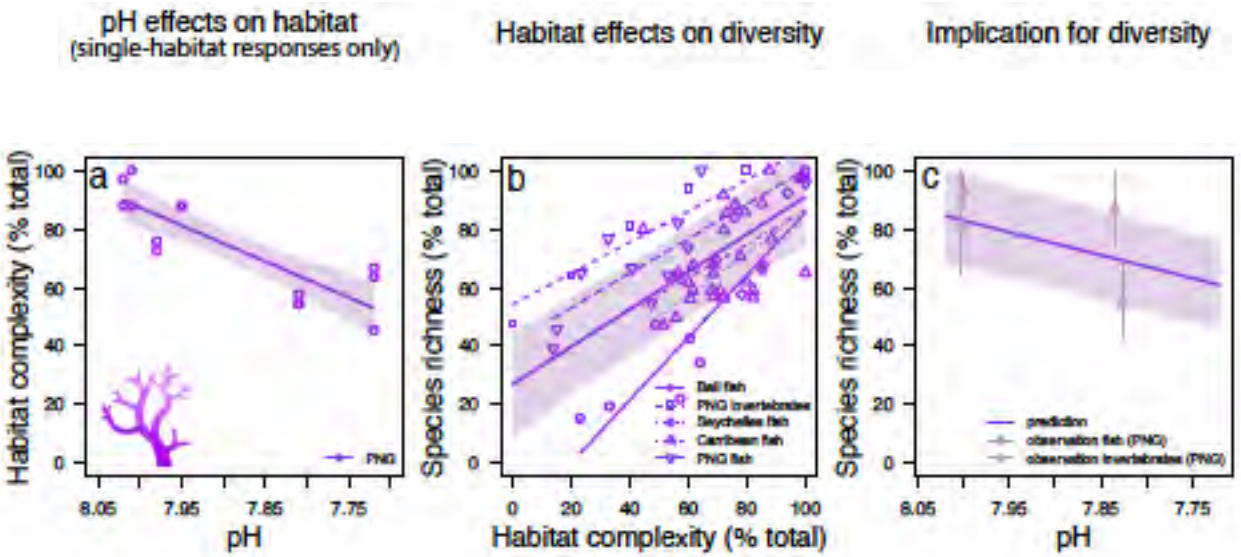


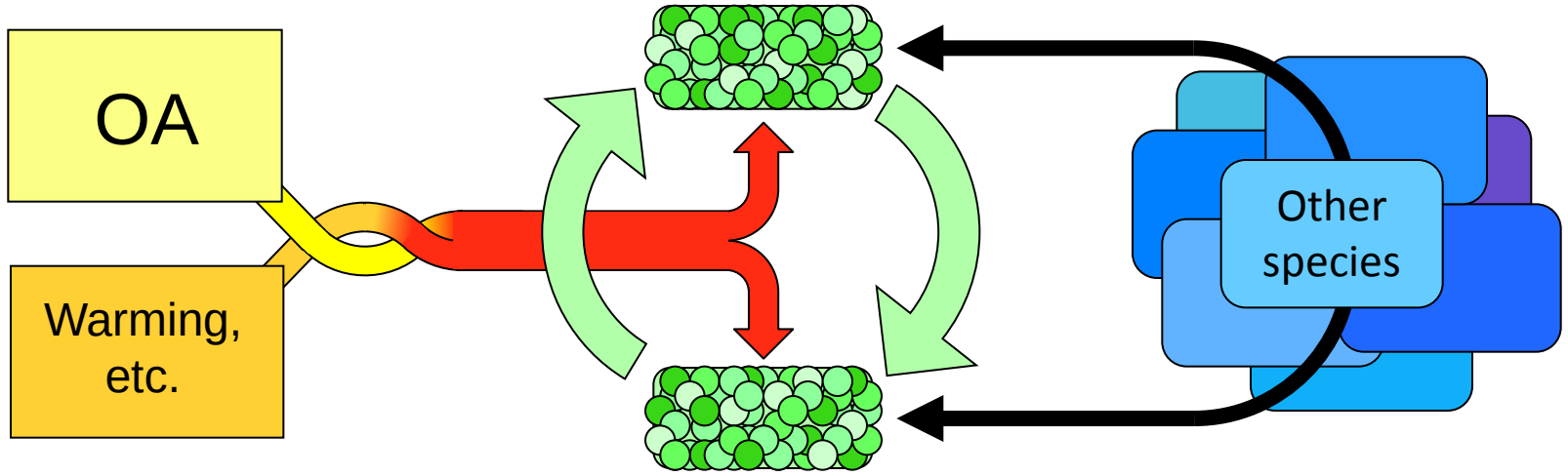
Sunday et al. 2016, NCC

Take-homes: key vulnerabilities and research priorities

"surprises" (thresholds and synergistic effects)

ontogenetic bottlenecks, lack of genetic diversity

habitat and food web effects, microbes



Integrating across levels of organization will be required to fully understand the ecological implications of ocean acidification

Special thanks to:

Students and postdocs: Norah Brown, Ryan Crim,j Kelsey Flynn, Becca Gooding, Manon Picard, Jenn Sunday, and the rest of the lab

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Intertidal adventurers: Sam, Zoe, Christina, and the dog