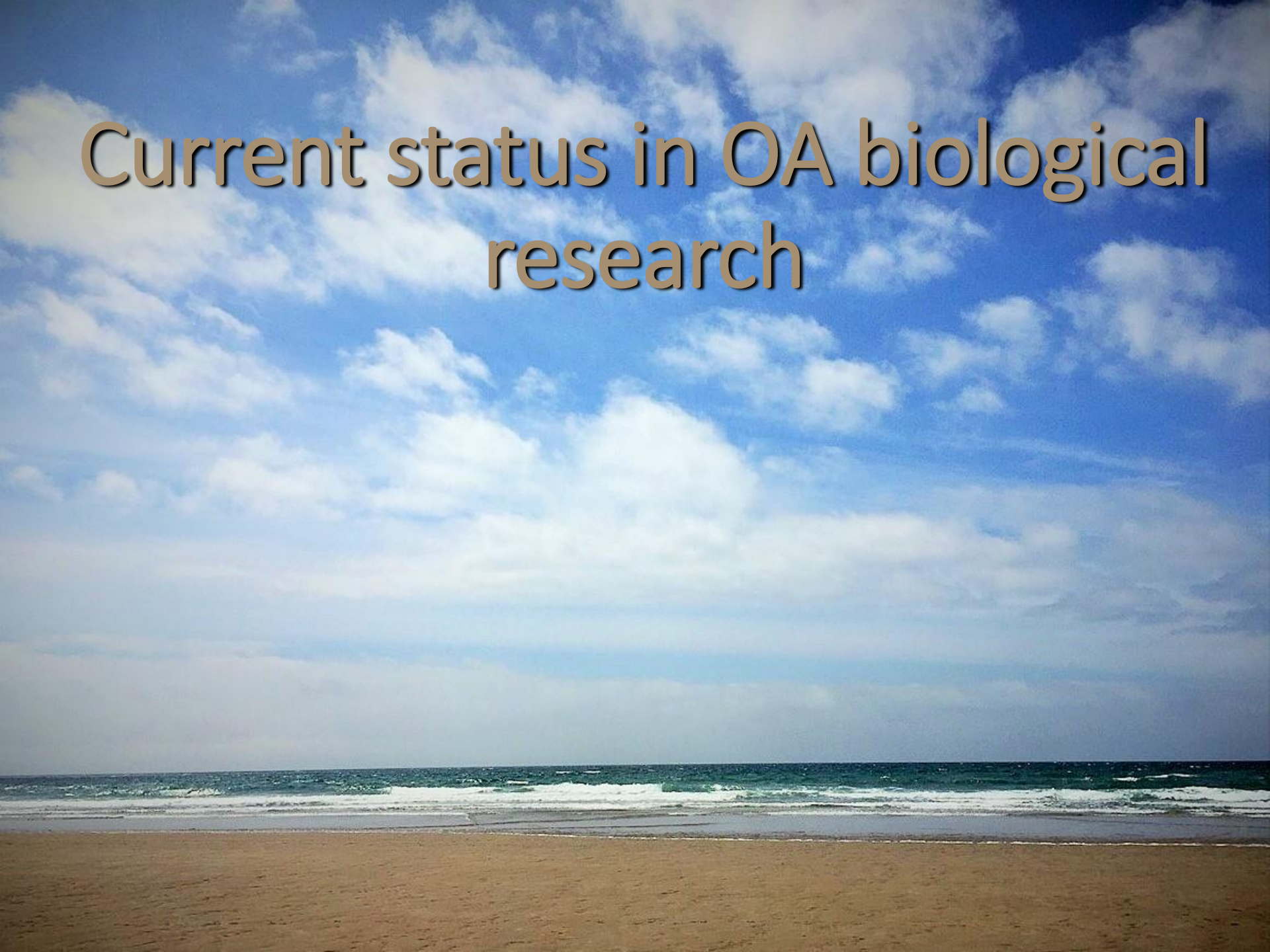
# Current status in OA biological research



# OA impacts

PML | Plymouth Marine Laboratory

**Summary of effects of acidification among selected taxonomic groups. Effects are either a mean percent increase or decrease in a given response, or as no overall positive or negative response.** After Kroeker et al. 2013.

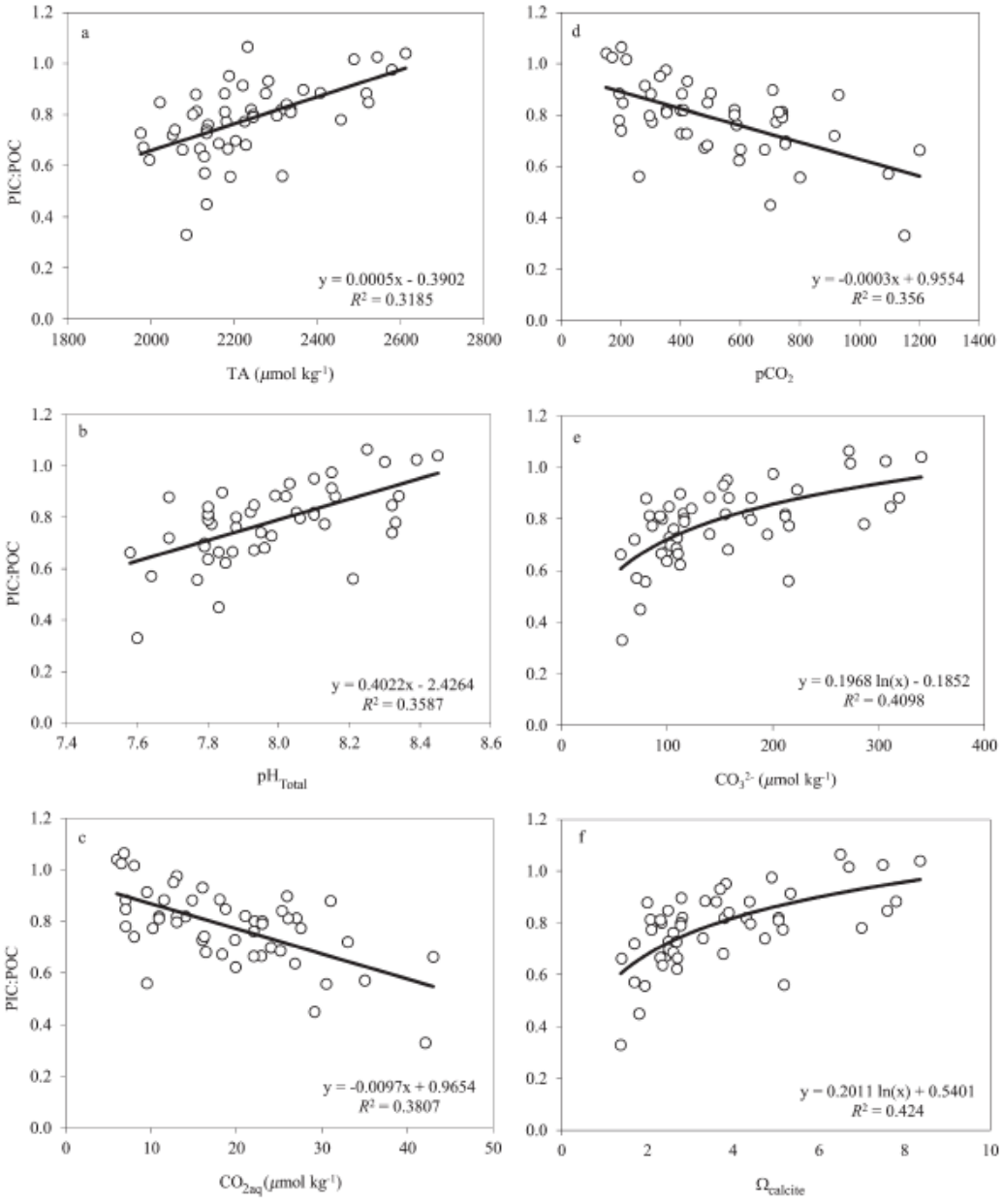
| TAXA | RESPONSE | MEAN EFFECT |
|---|---|---|
|  Calcifying algae | Survival | |
| | **Calcification** | |
| | Growth | |
| | Photosynthesis | −28% |
| | Abundance | −80% |
|  Corals | Survival | |
| | **Calcification** | −32% |
| | Growth | |
| | Development | |
| | Abundance | −47% |
|  Coccolithophores | Survival | |
| | **Calcification** | −23% |
| | Growth | |
| | Photosynthesis | |
| | Abundance | |
|  Molluscs | Survival | −34% |
| | **Calcification** | −40% |
| | Growth | −17% |
| | Development | −25% |
| | Abundance | |
|  Echinoderms | Survival | |
| | **Calcification** | |
| | Growth | −10% |
| | Development | −11% |
| | Abundance | |

| TAXA | RESPONSE | MEAN EFFECT |
|---|---|---|
|  Crustaceans | Survival | |
| | **Calcification** | |
| | Growth | |
| | Development | |
| | Abundance | |
|  Fish | Survival | |
| | **Calcification** | |
| | Growth | |
| | Development | |
| | Abundance | |
|  Fleshy algae | Survival | |
| | **Calcification** | |
| | Growth | +22% |
| | Photosynthesis | |
| | Abundance | |
|  Seagrasses | Survival | |
| | **Calcification** | |
| | Growth | |
| | Photosynthesis | |
| | Abundance | |
|  Diatoms | Survival | |
| | **Calcification** | |
| | Growth | +17% |
| | Photosynthesis | +12% |
| | Abundance | |

- Single-species experiments
- Big focus on calcification

Not tested or too few studies
Enhanced <25%
No overall +ve or -ve response
Reduced <25%
Reduced >25%

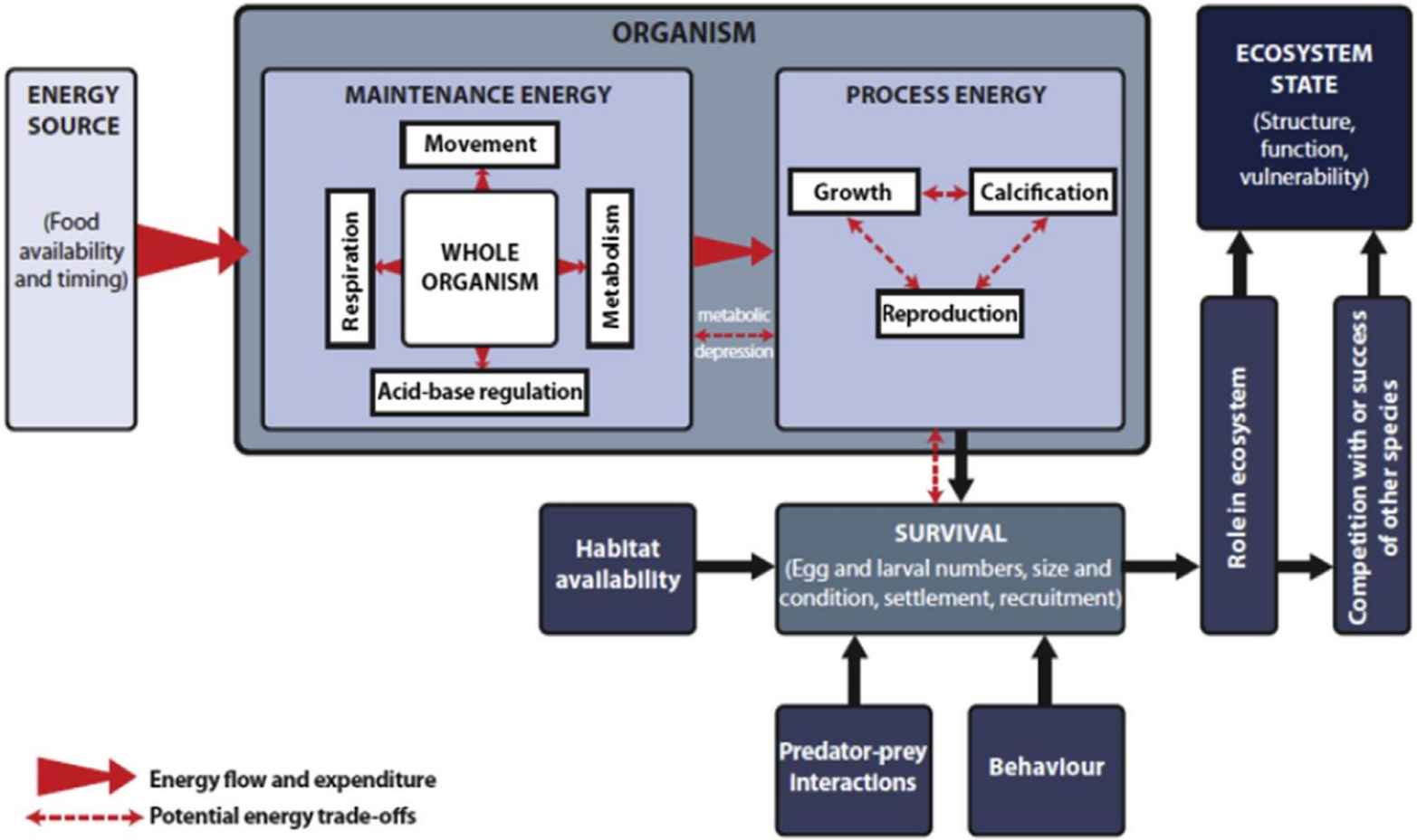
# What is driving the response?




- What are the underlying mechanisms that control the response?

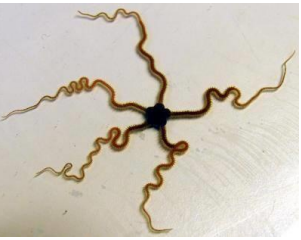
# Energetics

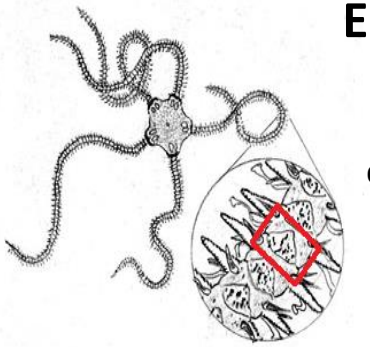
- Trade-offs between processes if energy limited

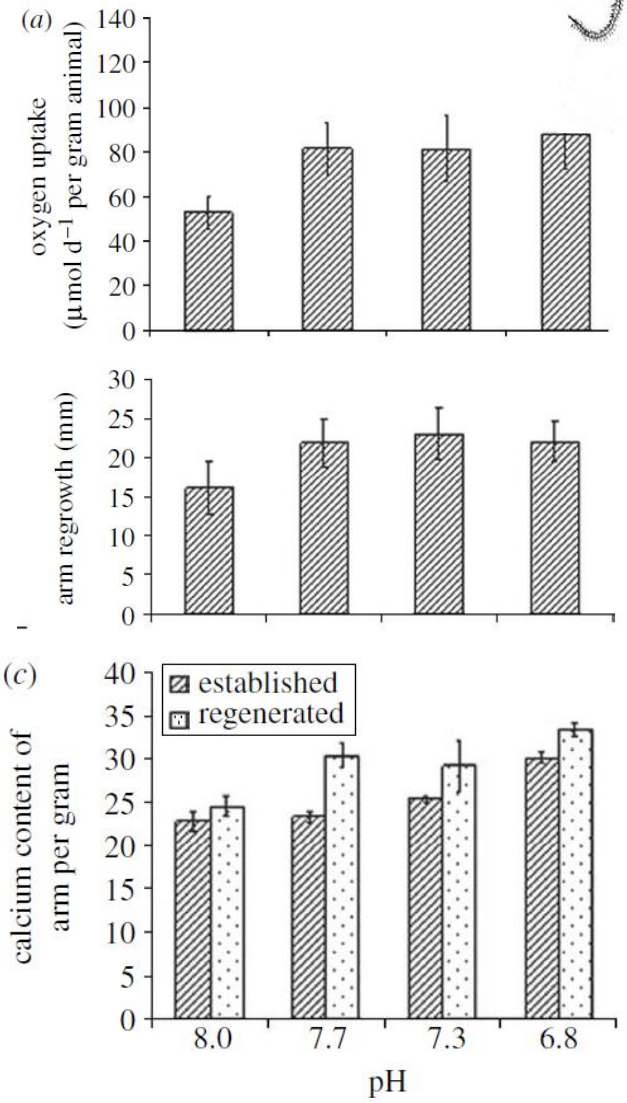



*Adapted from* Turley, in press

# Energetics & whole organism approach

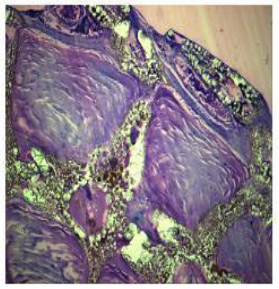


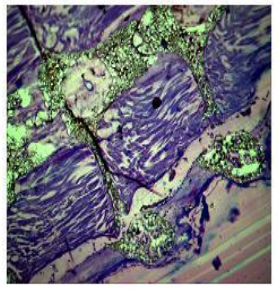





## Established arms

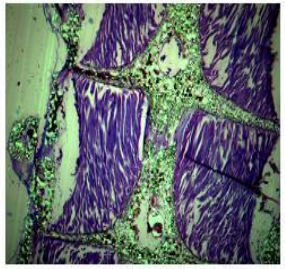
control

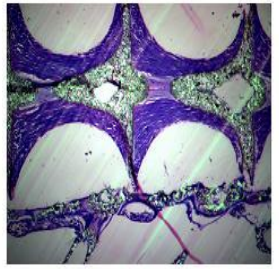




7.7

7.3

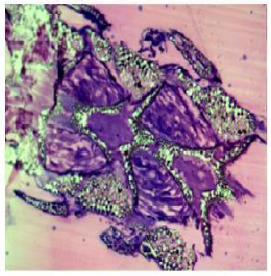


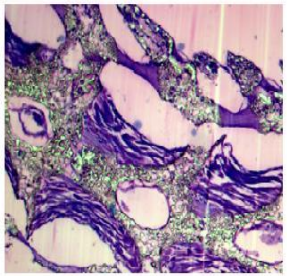


6.8

## Regenerating arms

control





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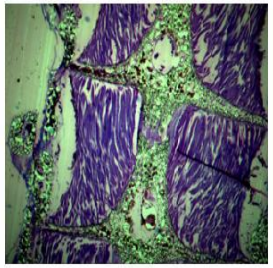
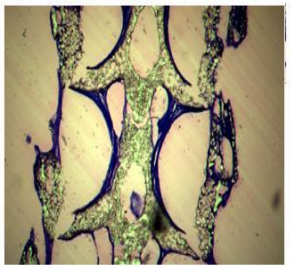
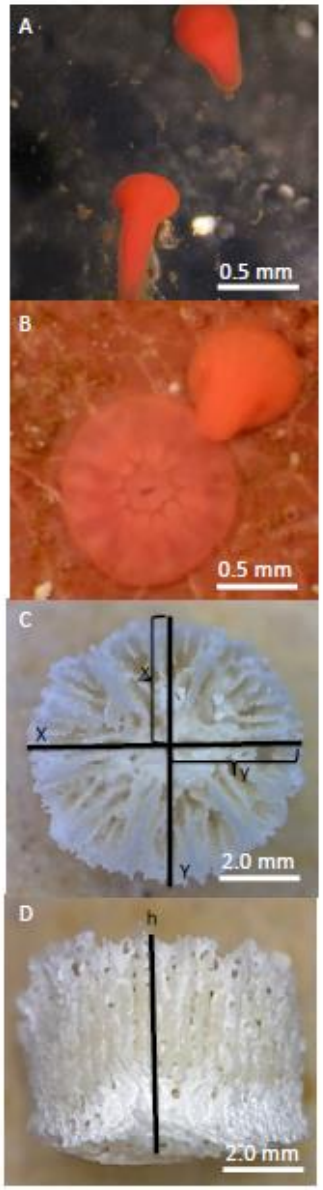




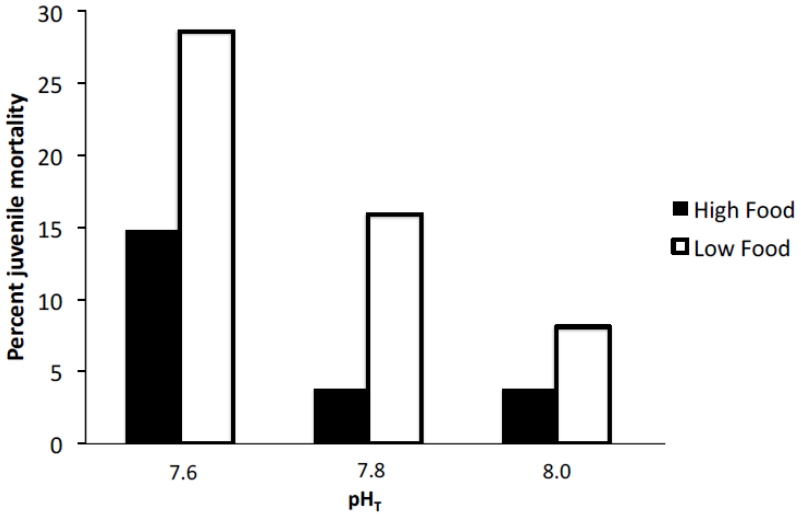
6.8

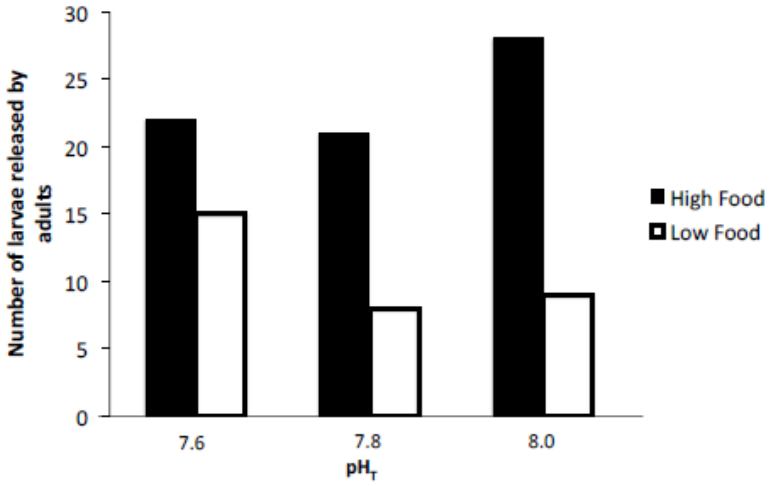
Wood et al. (2008)

# Energetics & whole organism approach




- The addition of food can counter impacts of OA

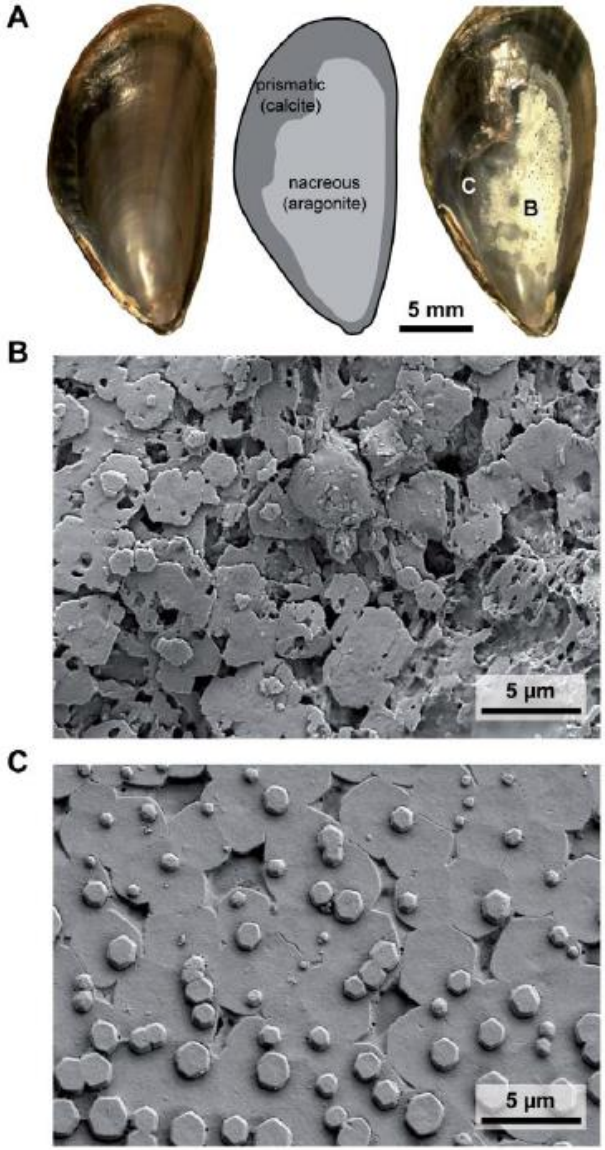


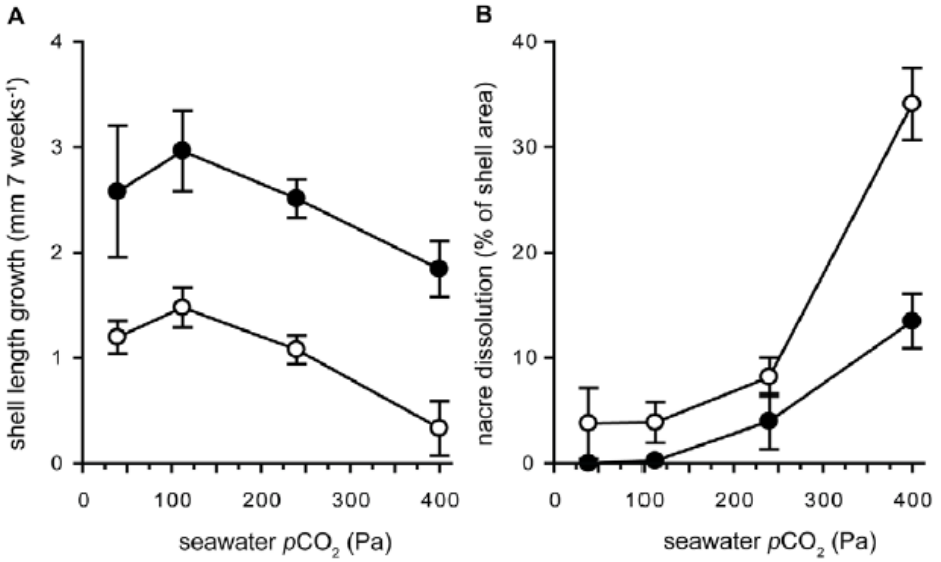

Crook et al. (2013)

# Energetics & whole organism approach





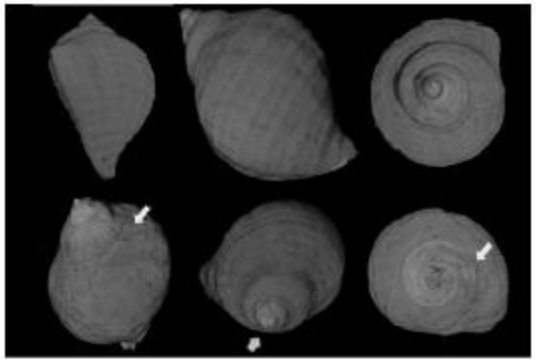

- Increased energy (food supply) can overcome dissolution

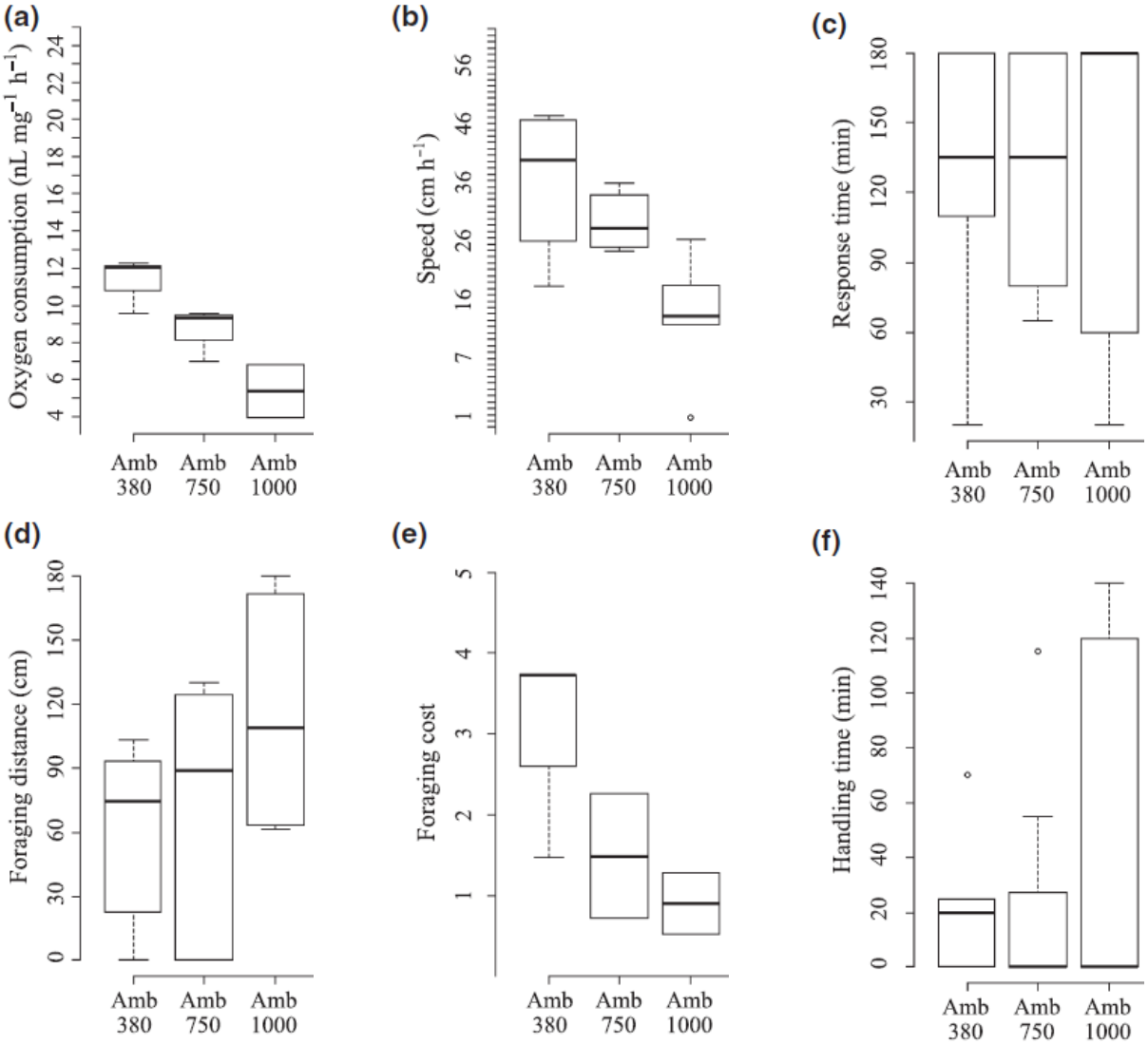



Melzner et al. (2011)

# Interactions – feeding & predation

- Foraging and feeding can themselves be impacted by OA

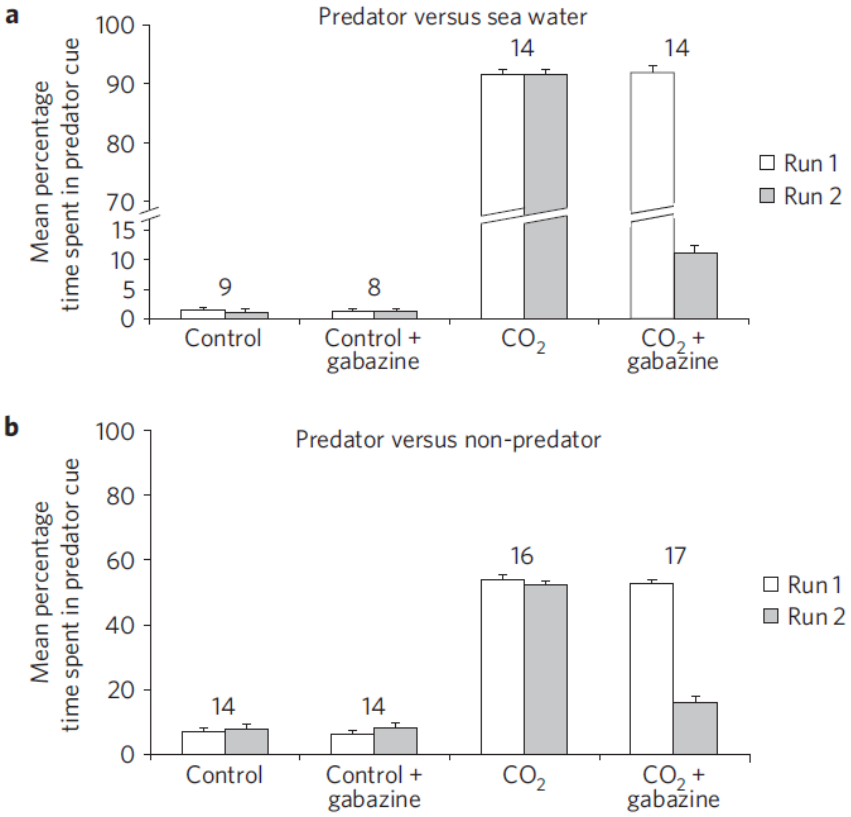




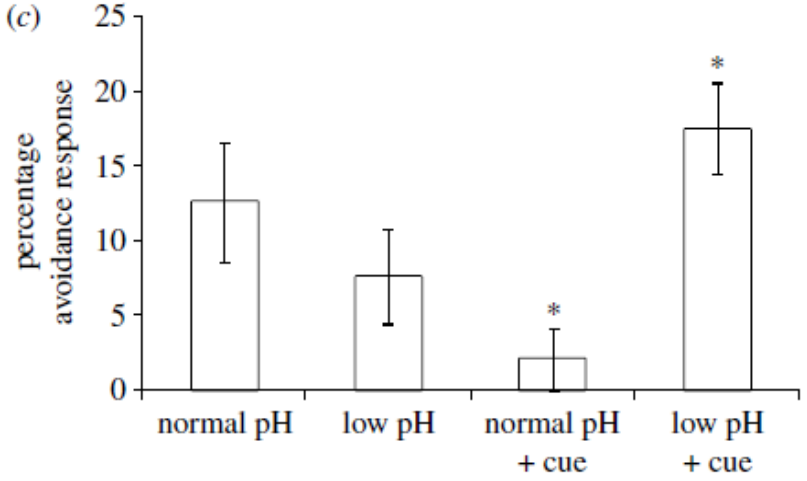

Queiros et al. (2014)

# Interactions – Predator – prey

- Chemical cues can be impacted



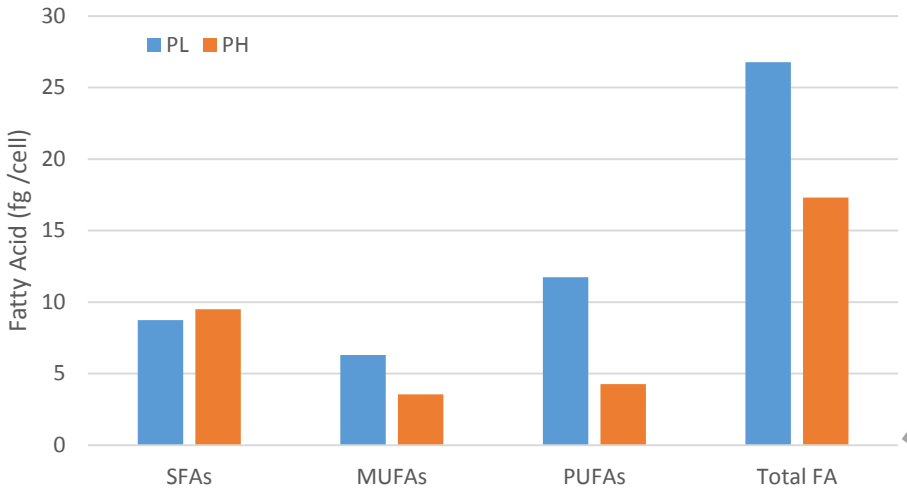

Nilsson et al. (2012)




Bibby et al. (2007)

# Interactions - Food quality feedbacks

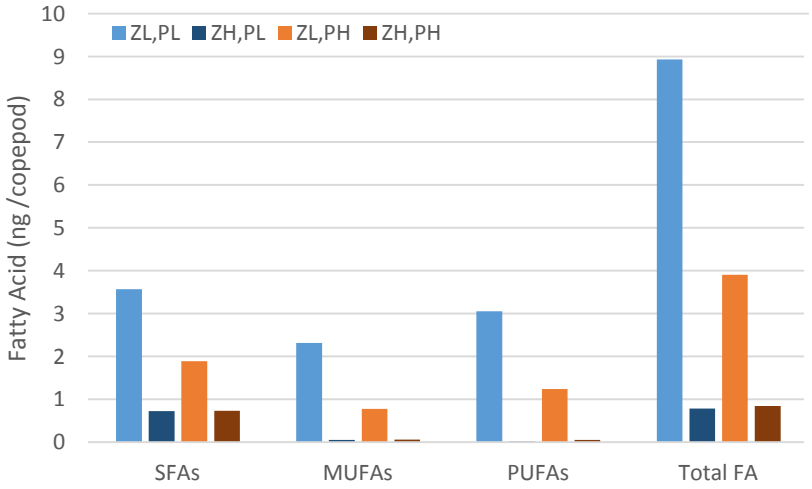
Phytoplankton – *Thalassiosira pseudonana*

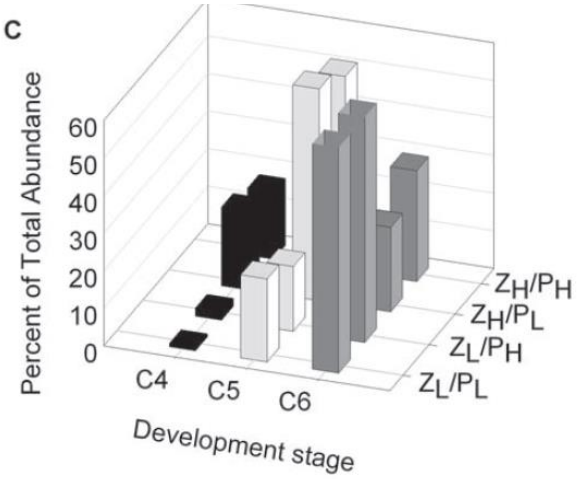


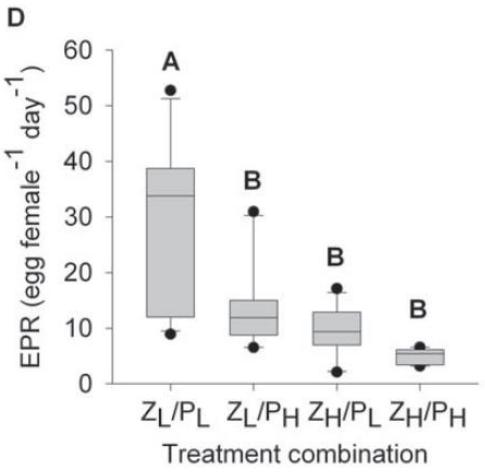

- Change in fatty acid concentration of food source directly impacts herbivores

Rossoll et al. (2012)

Copepod – *Arcatia tonsa*

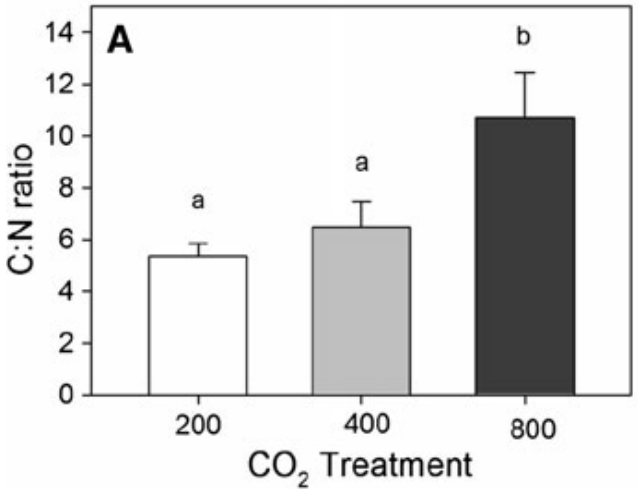


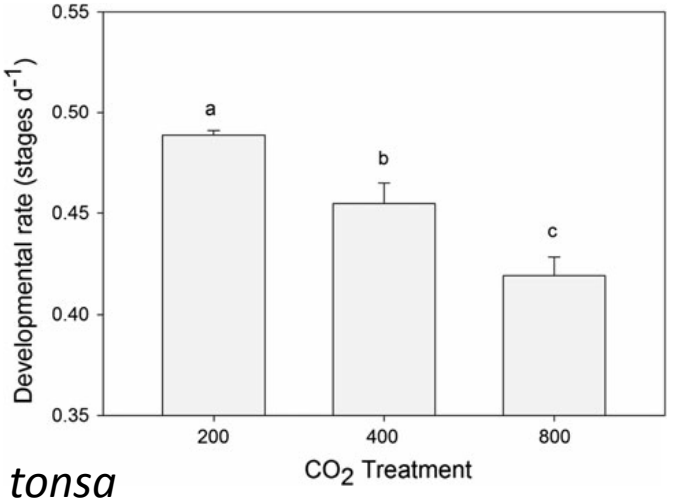
# Interactions - Food quality feedbacks

Phytoplankton - *Rhodomonas salina*

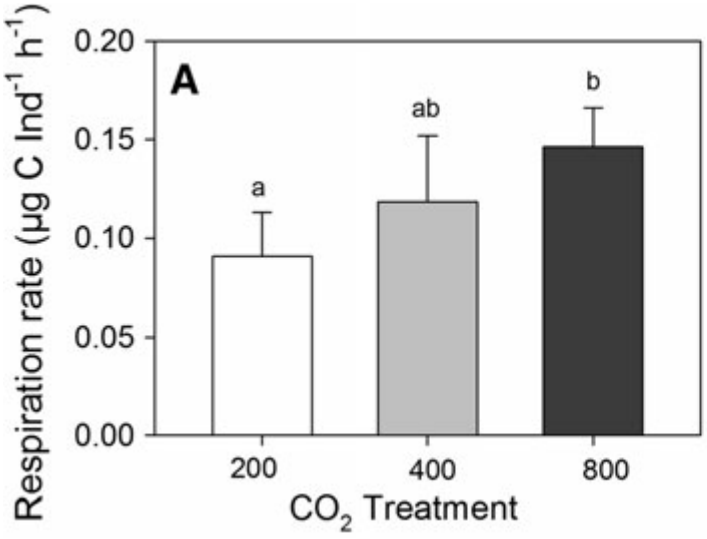


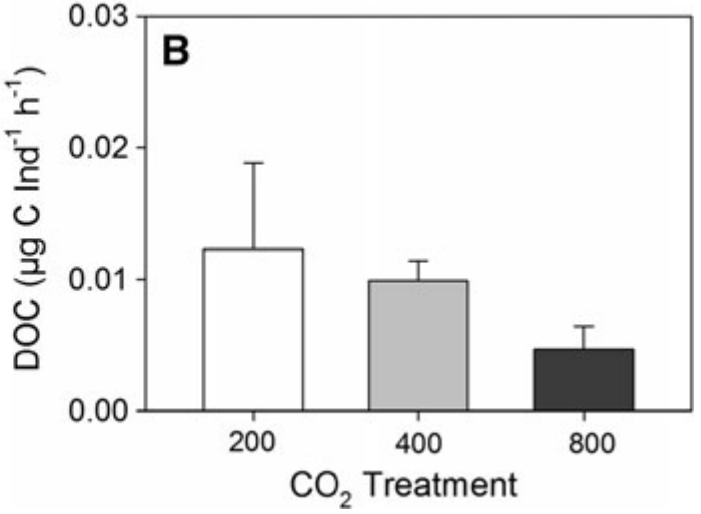

Schoo et al. (2013)

- Changes in food quality impacts herbivores



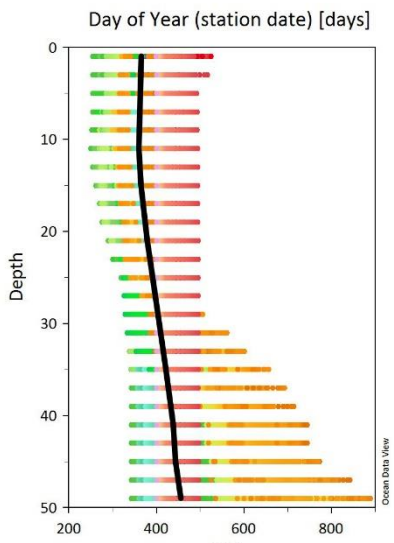

Copepod - *Acartia tonsa*

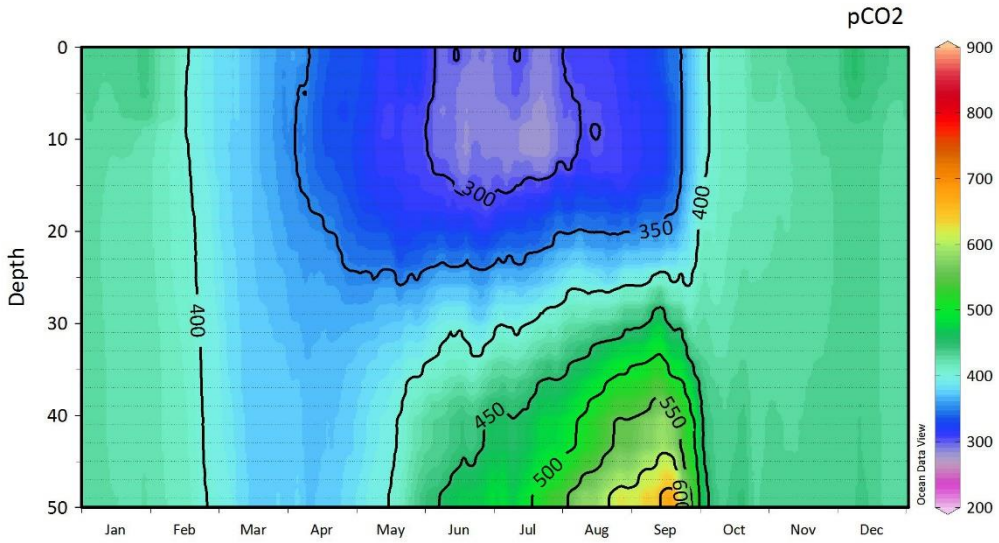


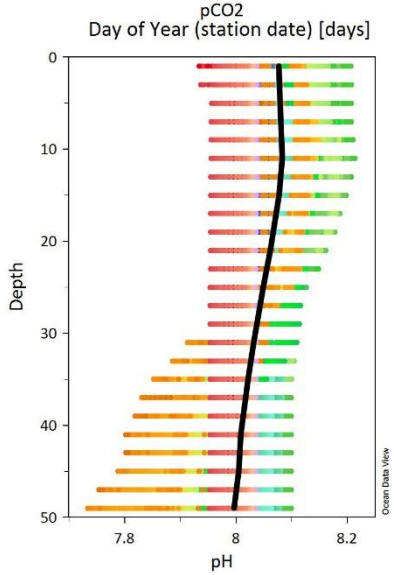



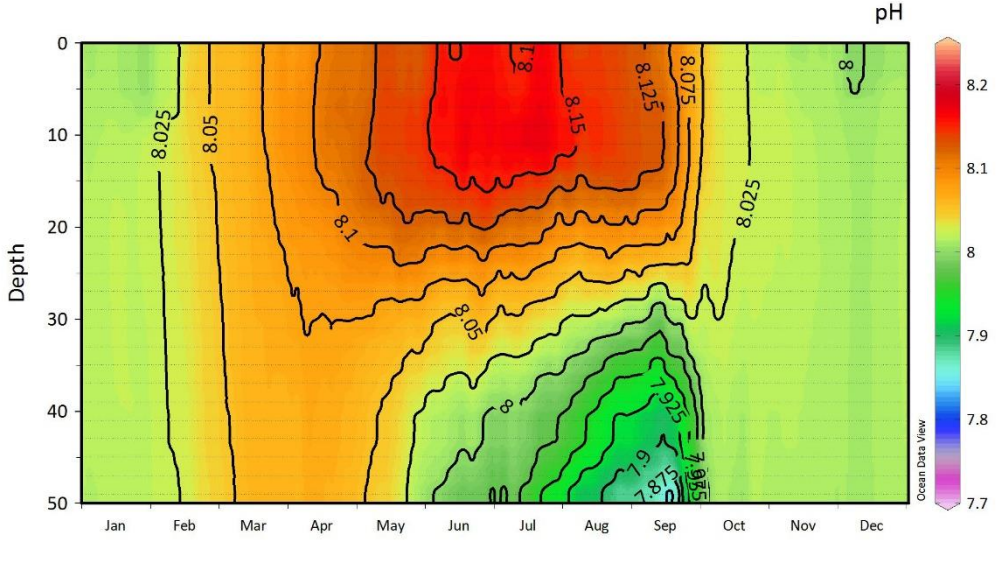
# Natural variability – benthic vs pelagic

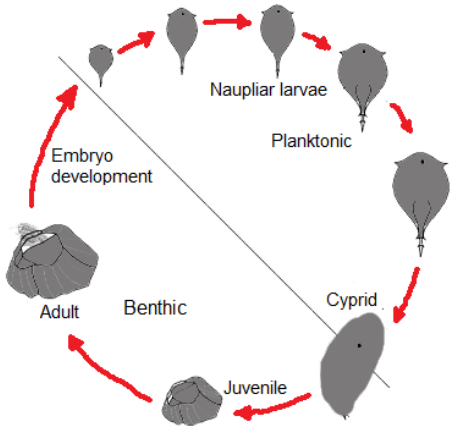
- The environment is dynamic and organisms live in different regions; different life stages…



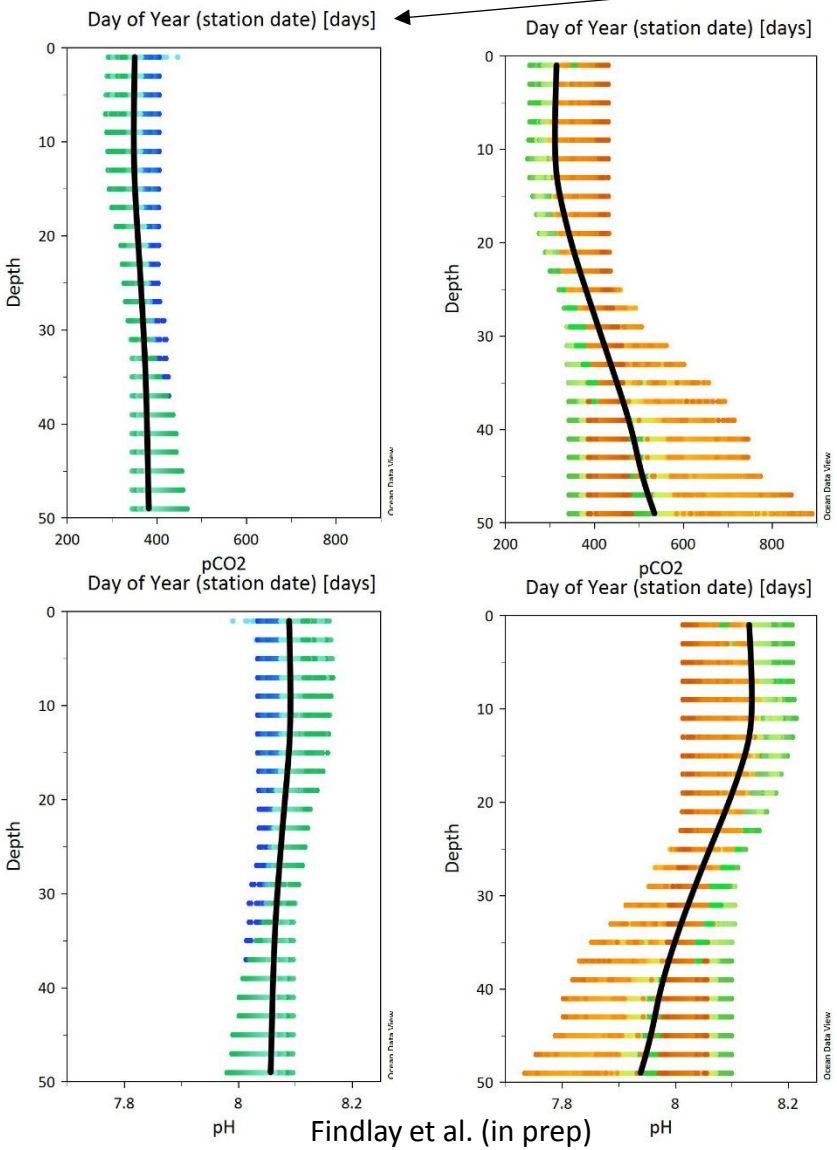



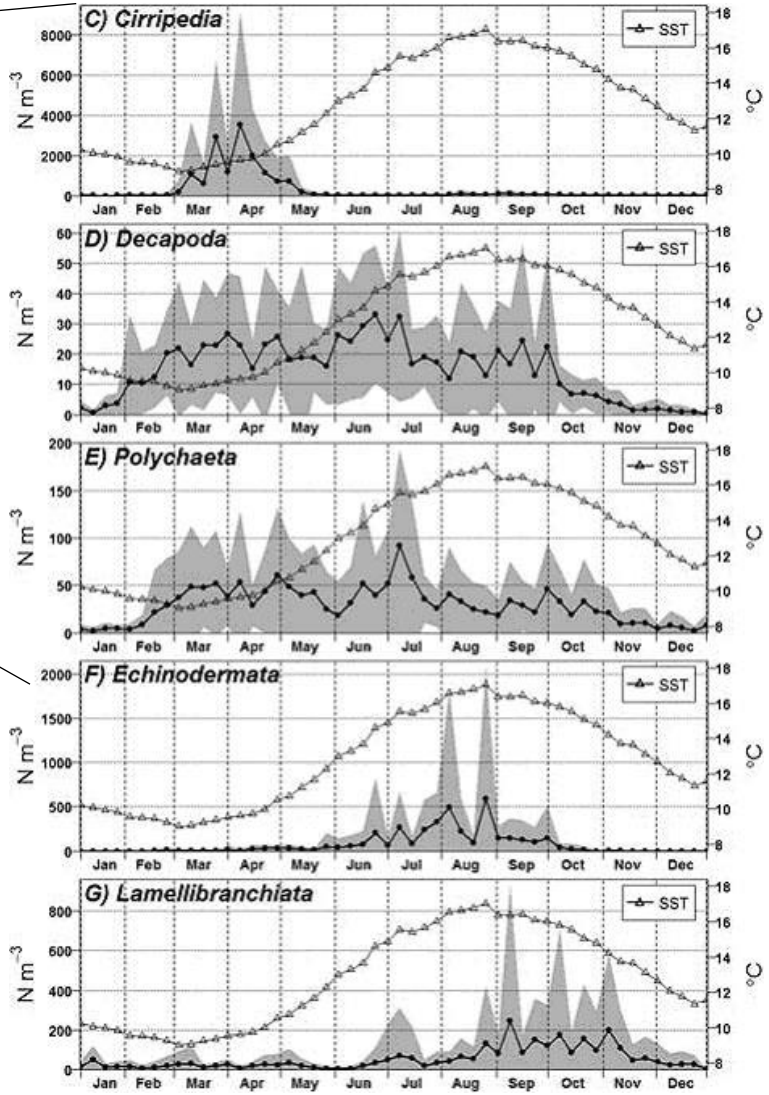

Findlay et al. (in prep)

# Natural variability – life cycle specific

- The environment is dynamic and organisms live in different regions; different life stages…

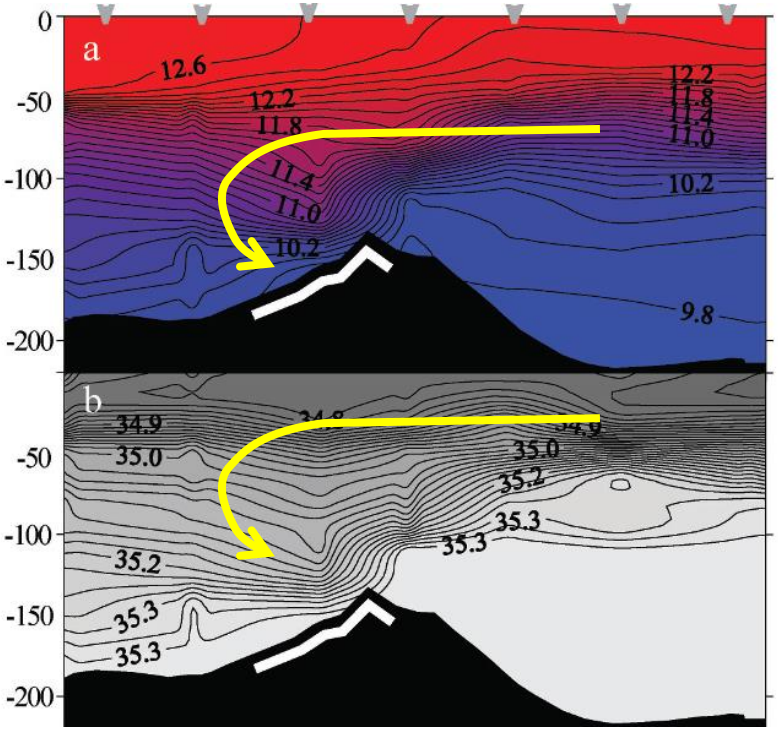



Findlay et al. (in prep)

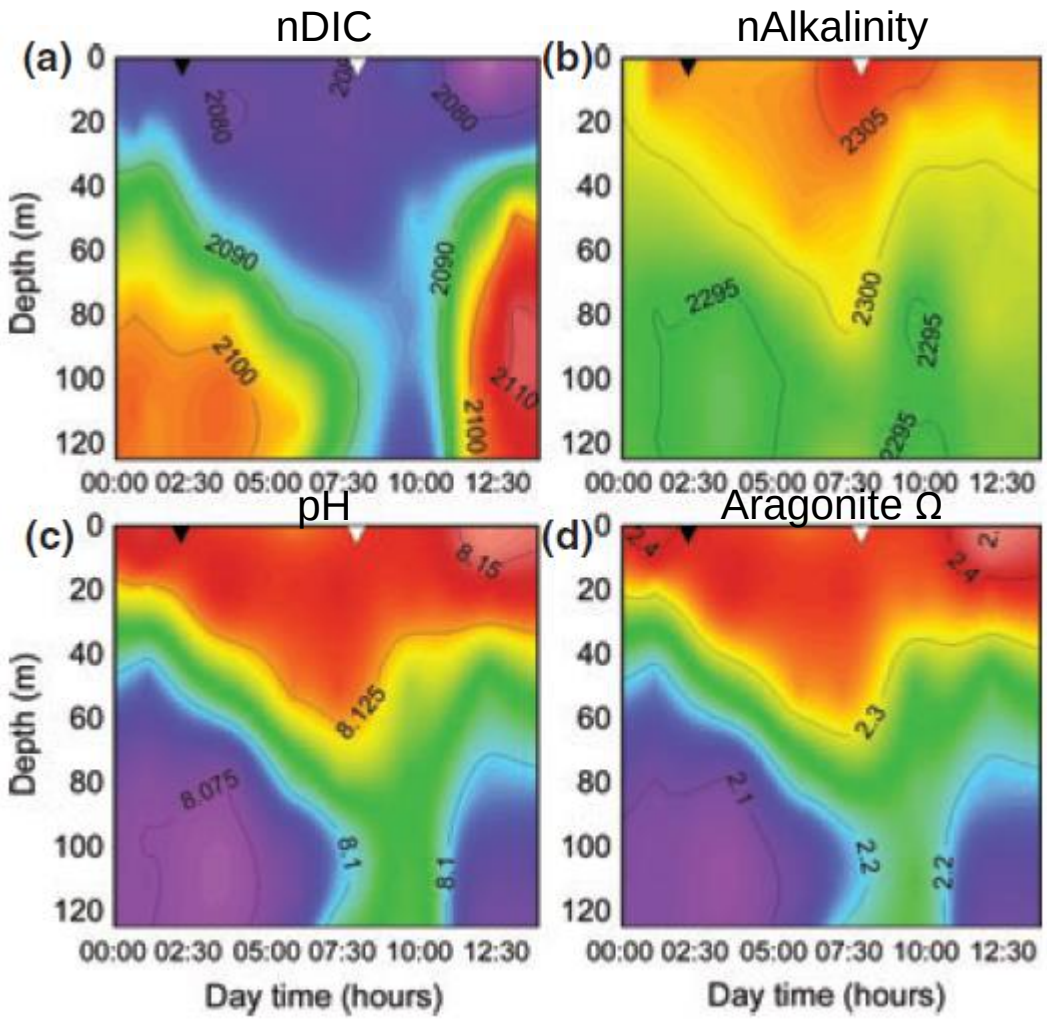



Highfield et al. (2010)

# Natural variability – tidal influence

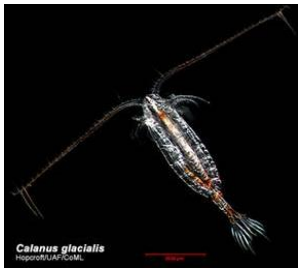



- Tidal variability – even at 120 m!



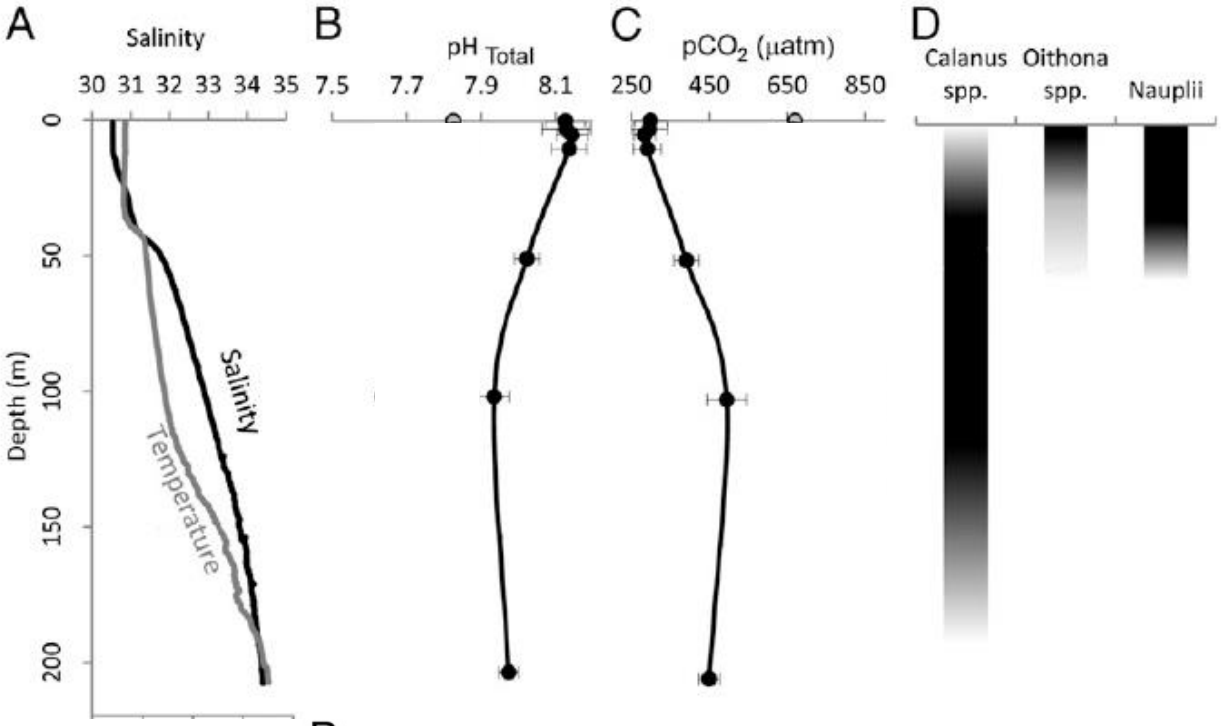

Findlay et al. (2013)

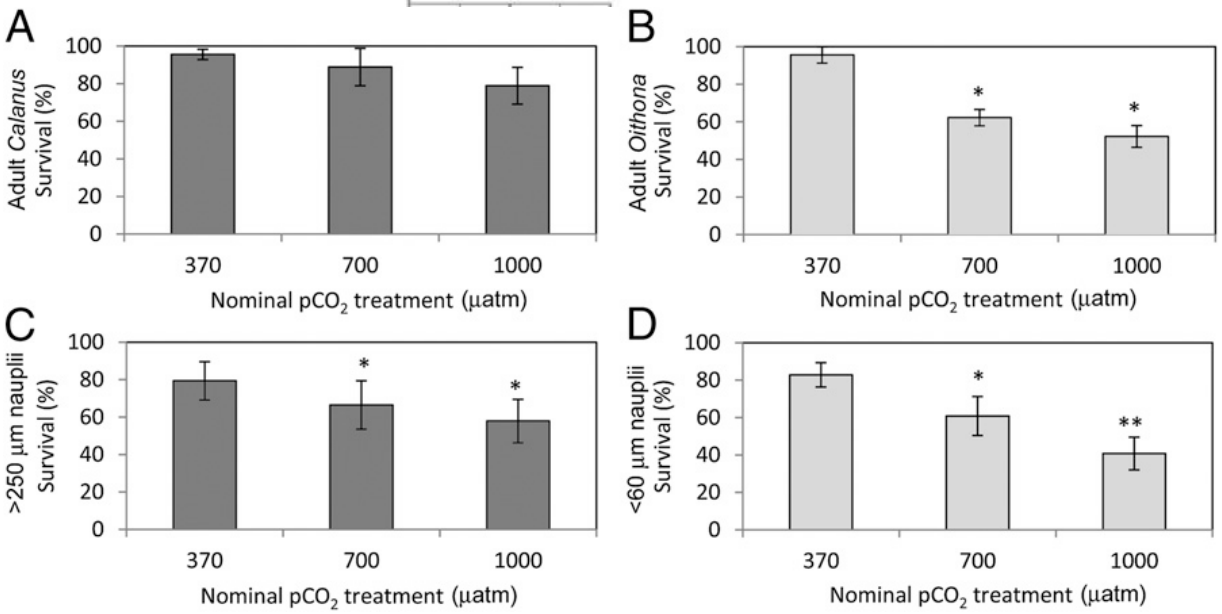
# Natural variability – organism behaviour





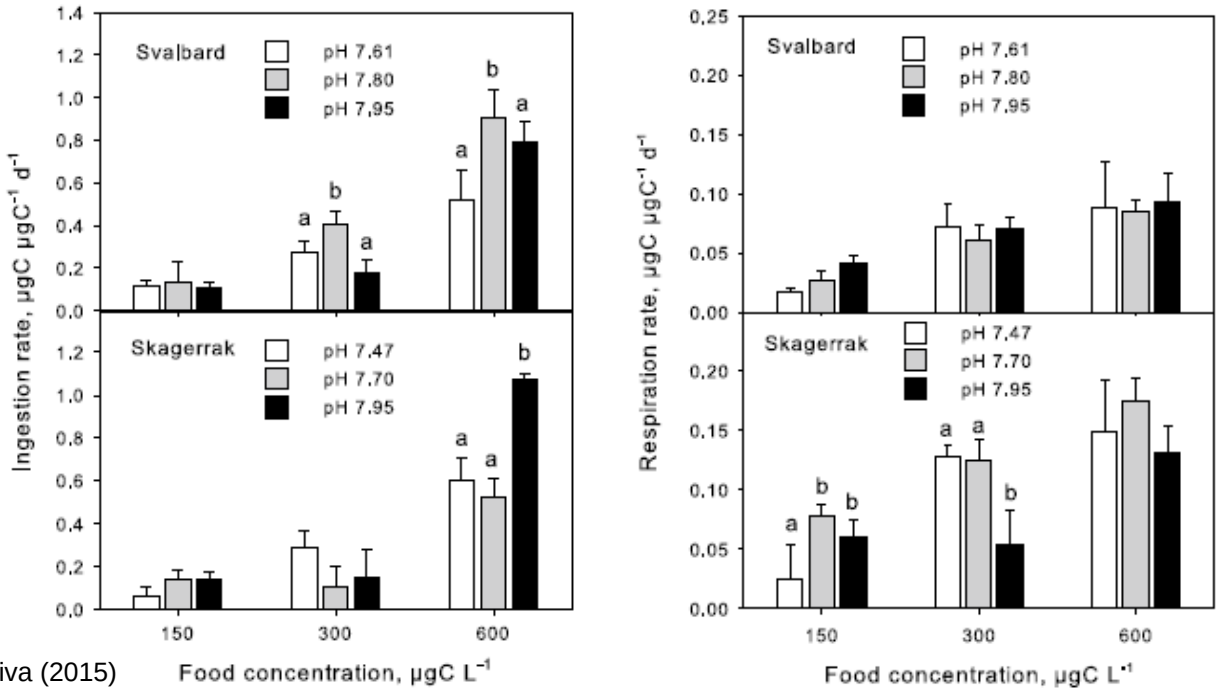
- Behaviour can dictate environmental experience



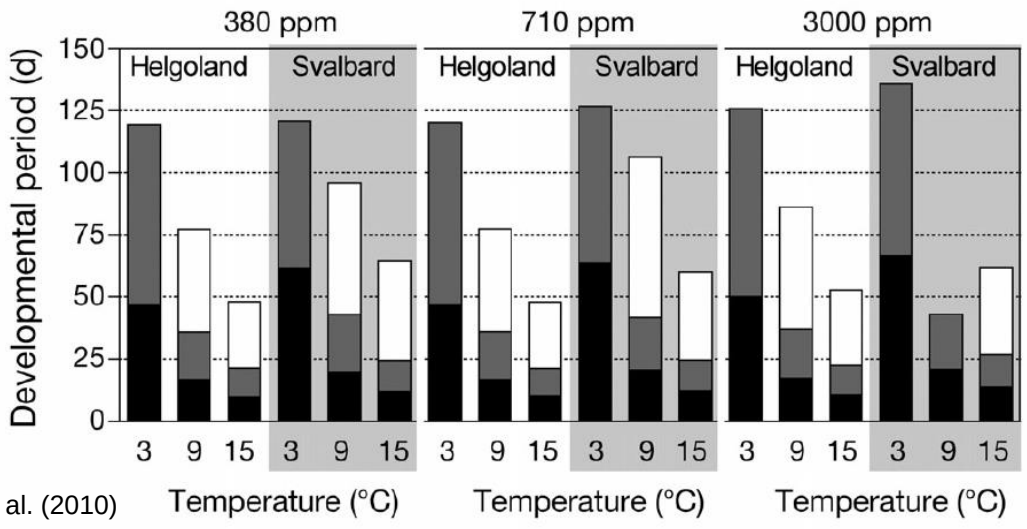




Lewis et al. (2013)

# Population differences

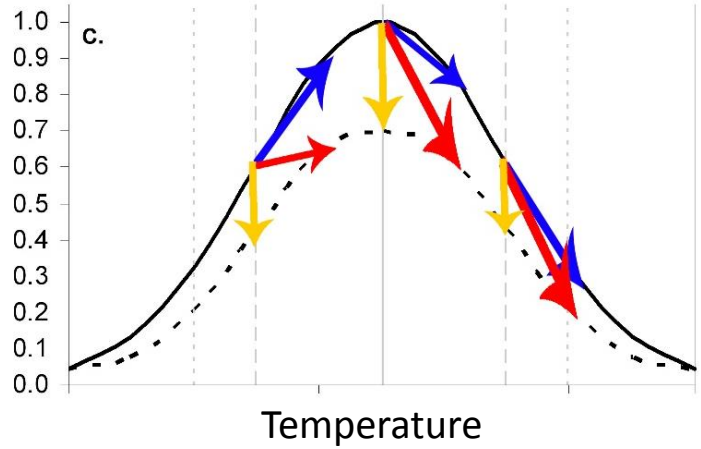



Thor & Oliva (2015)




Walther et al. (2010)

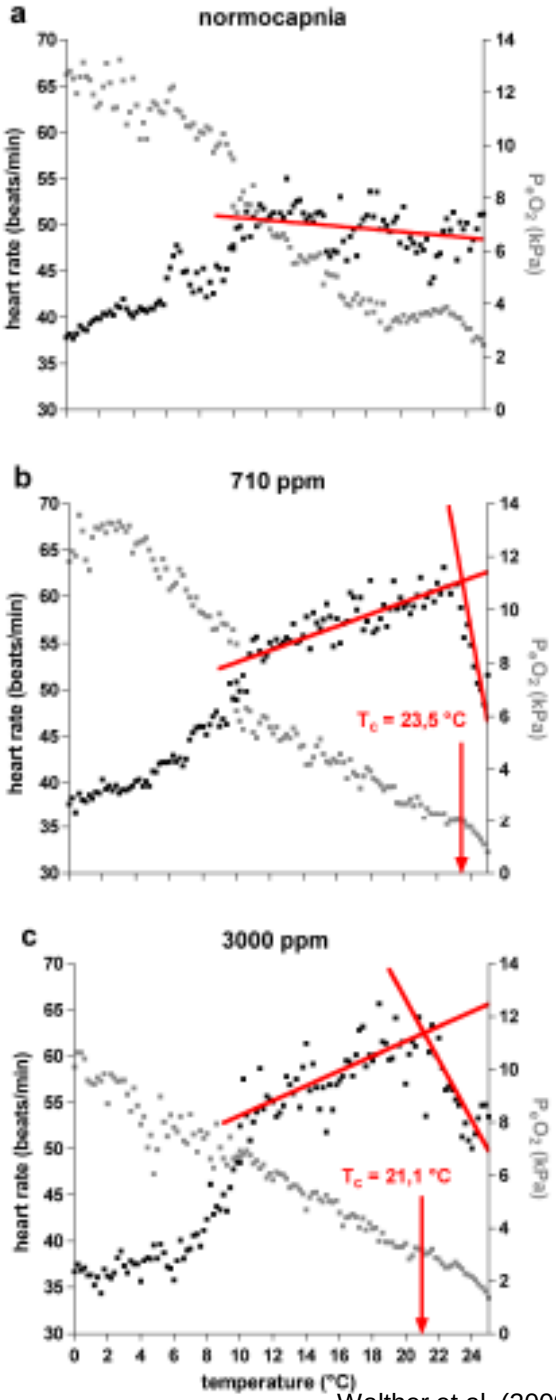
# Multiple stressor impacts




Ocean Acidifcation response only (-ve)

Temperature & acidification response (+ve & -ve)

Temperature response only (+ve & -ve)




Walther et al. (2009)

# Knowledge gaps

PML | Plymouth Marine Laboratory

- Underlying **mechanisms** behind responses? Other end-points, trade-offs, feeding?
- How will **food quantity, quality** change?
- **Natural variability** influence on sensitivity; implications for plasticity?
- Long-term **shifts in range** of variability?
- Response of **populations of the same species** in different locations?
- Understanding the **standing genetic variation**?
- Experimental assessment of **evolution**? Transgenerational effects?
- **Combined** environmental stressors?