Carbonate chemistry control on coccolithophore calcification: New findings and future directions

Lennart Bach

UNIVERSITY of TASMANIA

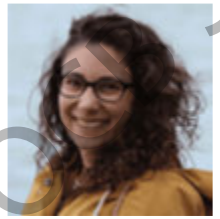
IMAS INSTITUTE FOR MARINE & ANTARCTIC STUDIES

Phil Boyd

Iron fertilization and climate intervention

IMAS INSTITUTE FOR MARINE & ANTARCTIC STUDIES

Kai Schulz



Allanah Paul

Scarlett Sett

Luisa Federwisch

Ulf Riebesell

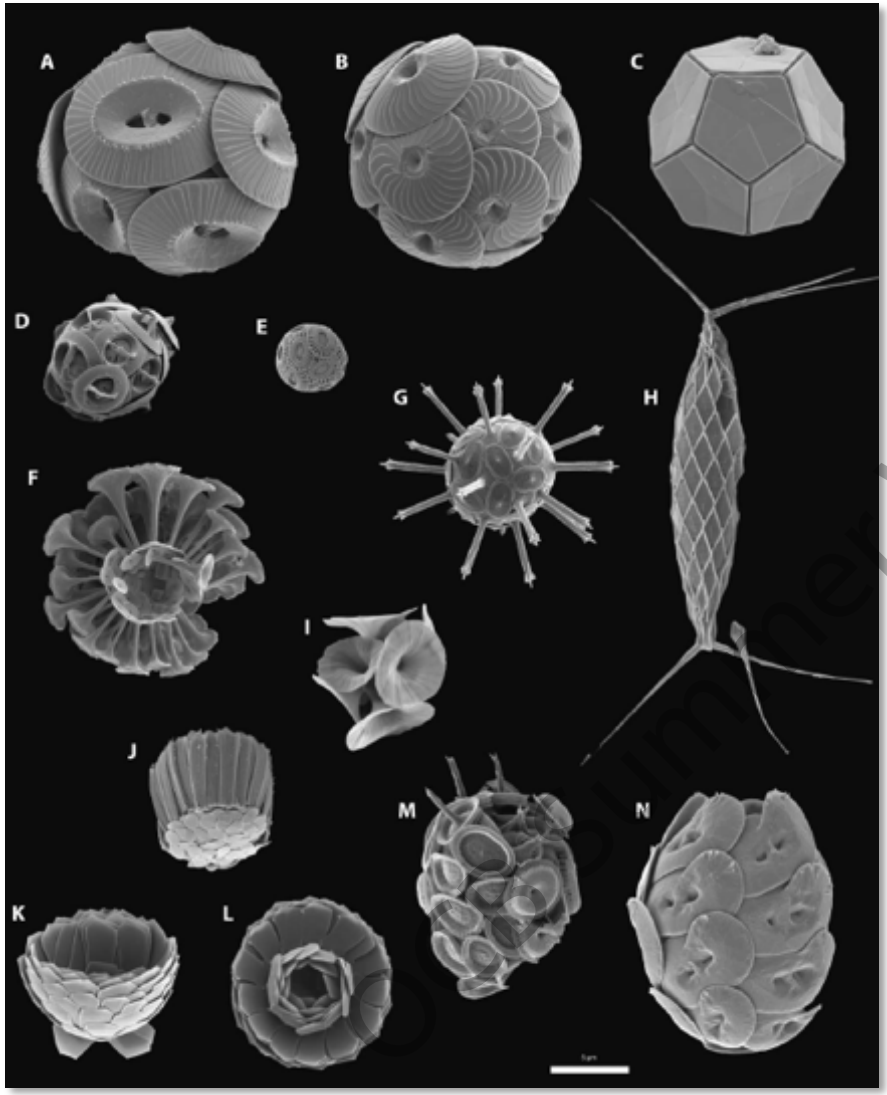
Mathias Haunost

Calcification in coccolithophores

GEOMAR Helmholtz Centre for Ocean Research Kiel

Introduction

Beginning — End



Monteiro et al., 2016, Sci. Adv.

Coccolithophores, calcifying phytoplankton (~200 species):

1) 1 – 10 % to marine primary production

1) ~50 % to pelagic $CaCO_3$ sediments

Introduction

Beginning End

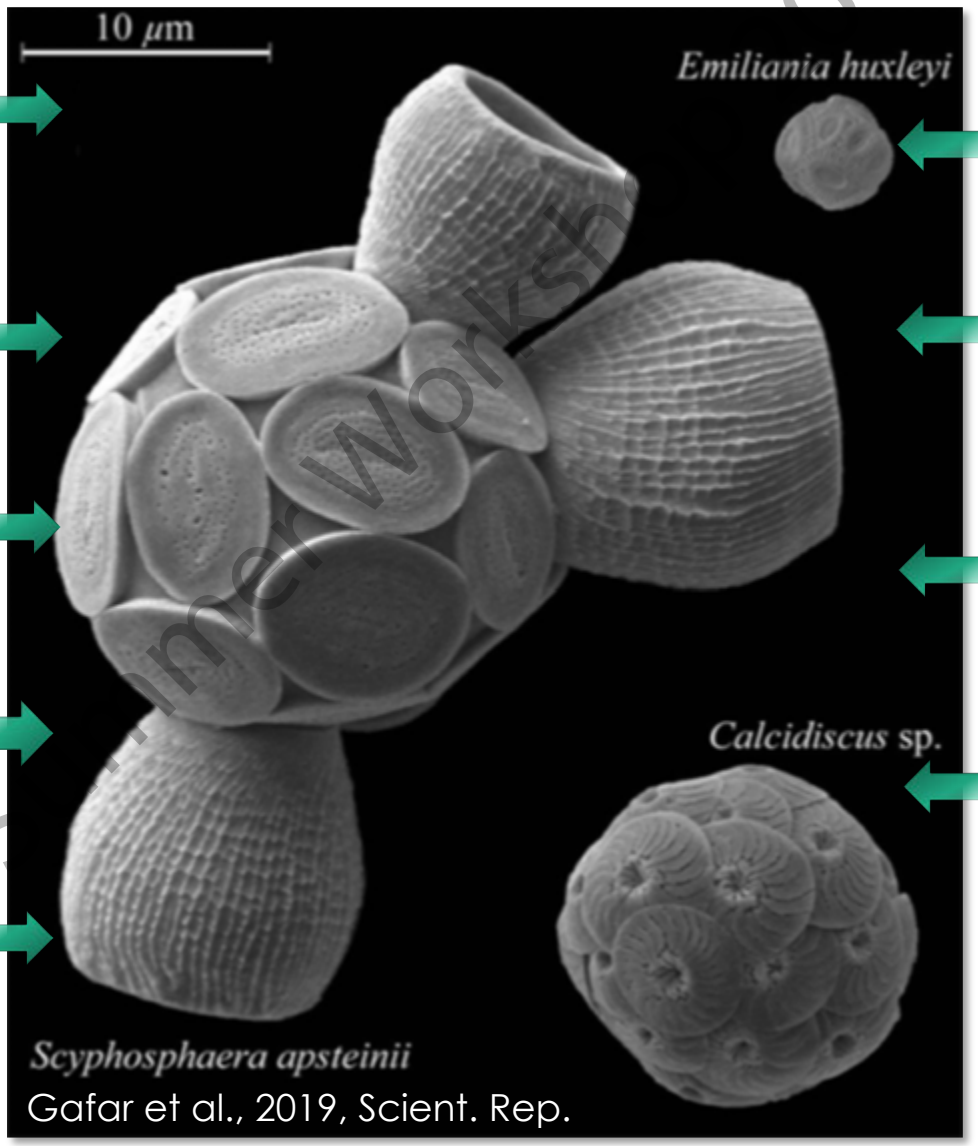
Temperature

Nutrients

Turbulence

Carbonate chemistry

"ecology"



Gafar et al., 2019, Scient. Rep.

Light

Salinity

Trace metals

others

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Beginning — End

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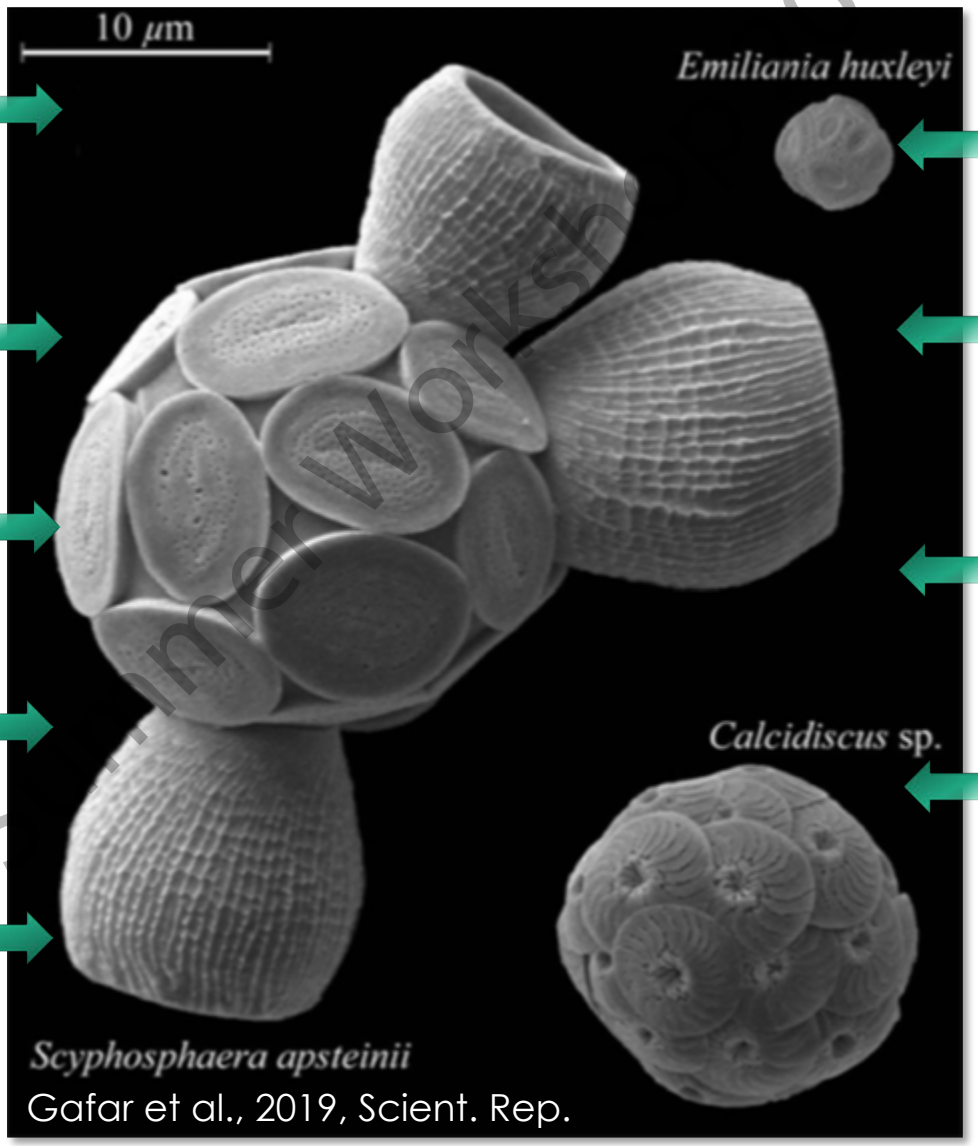
"ecology"



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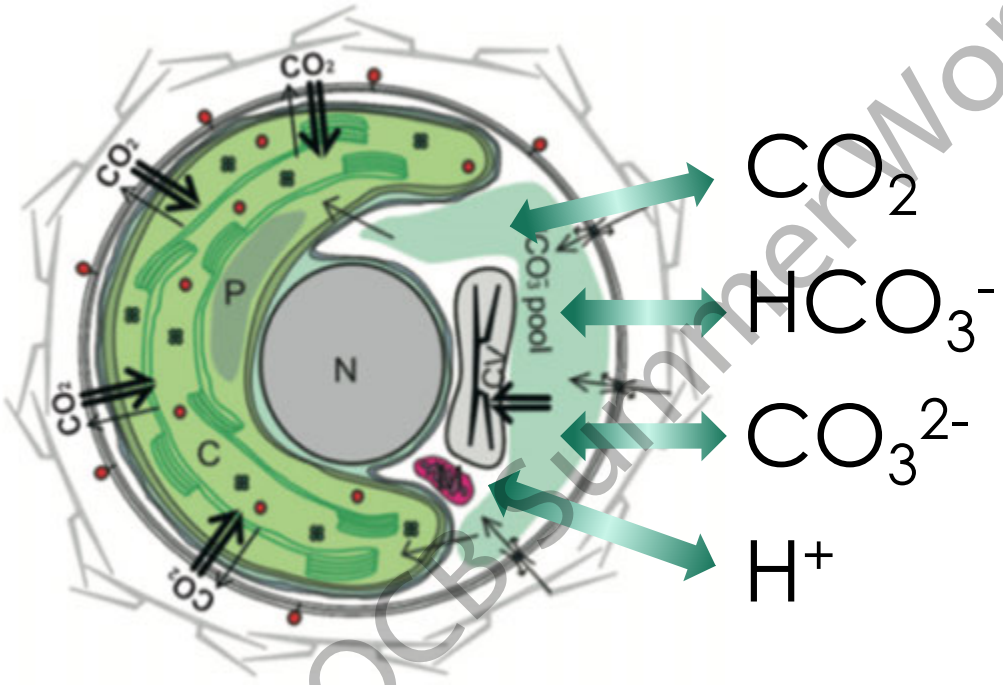
Carbonate chemistry control of calcification

What is carbonate chemistry from an organism perspective?



CO_2

HCO_3^-

CO_3^{2-}

H^+

Carbonate chemistry control of calcification

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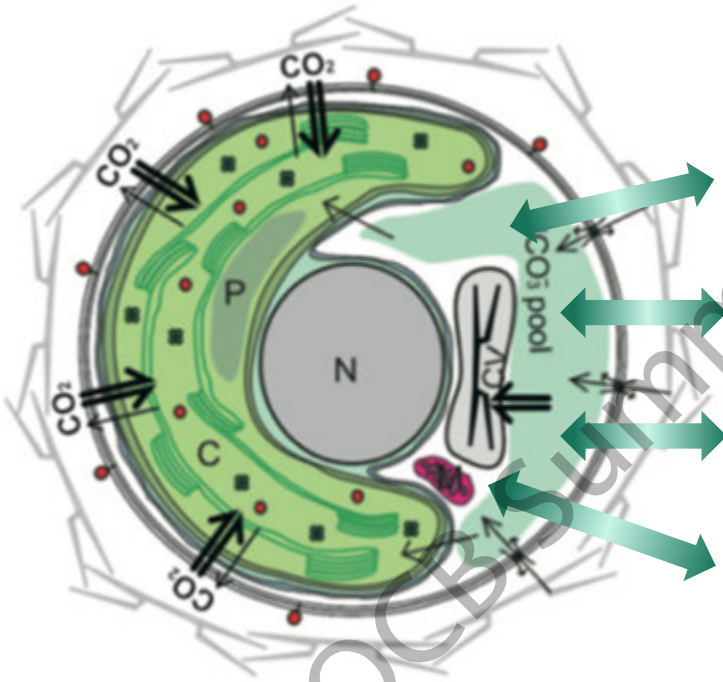

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Ocean acidification

Carbonate chemistry control of calcification

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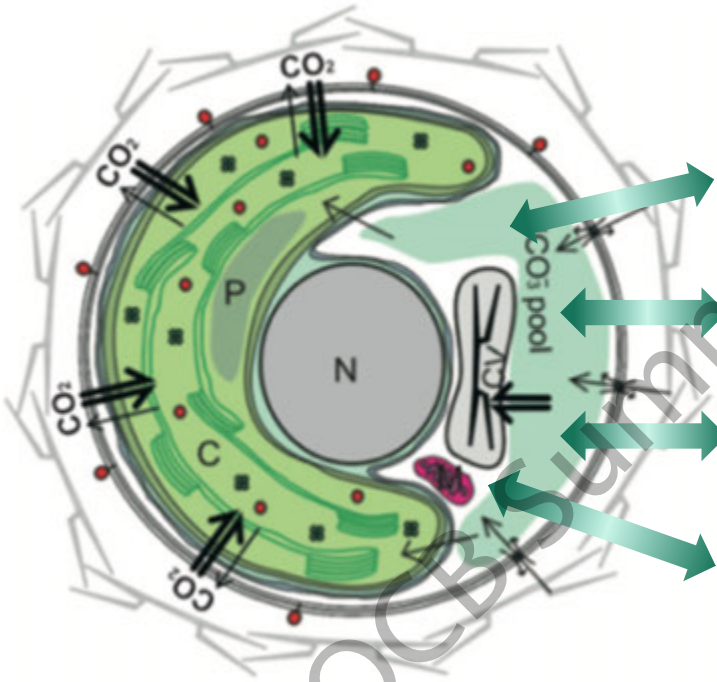

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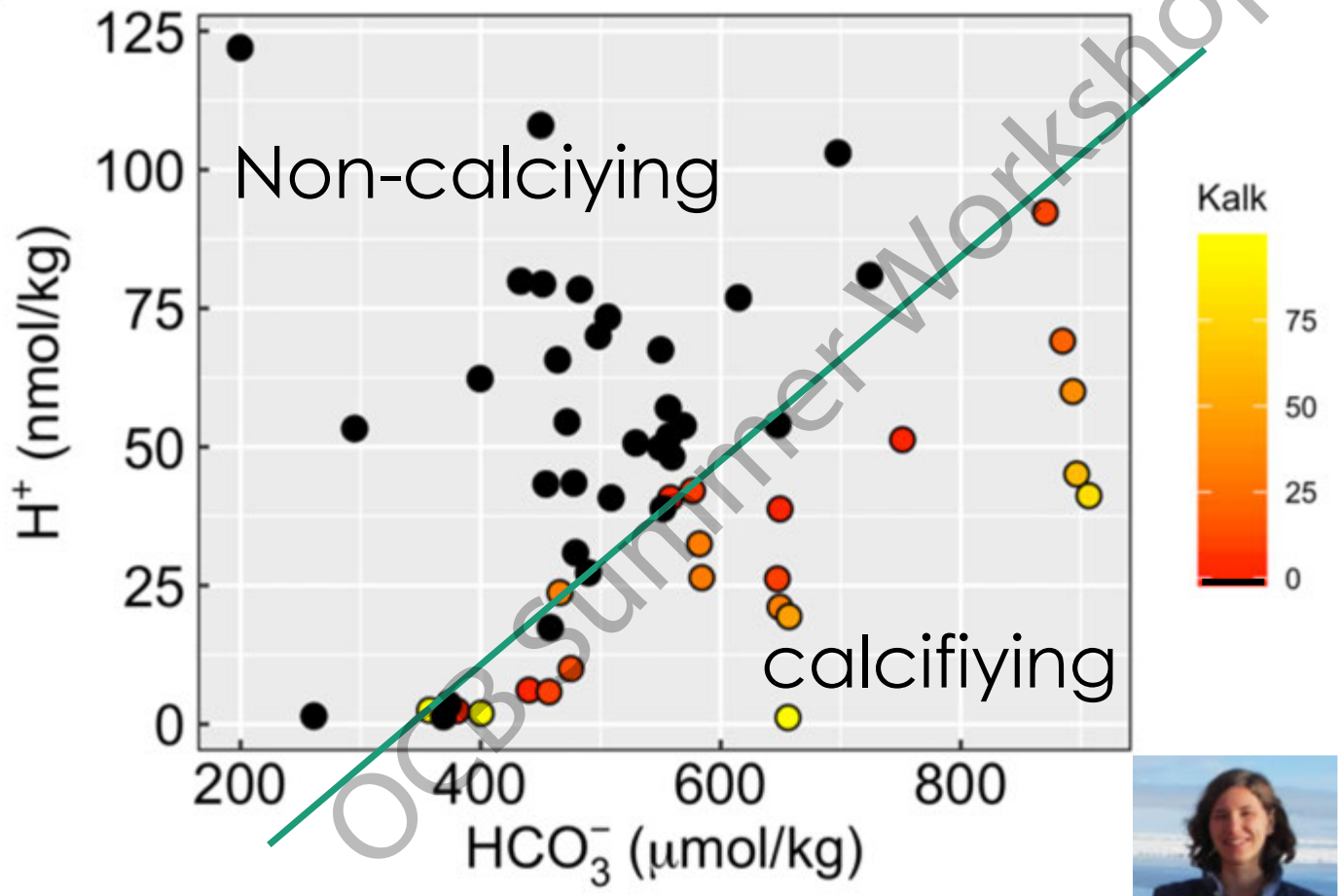
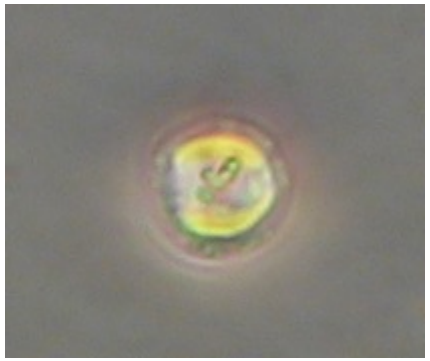
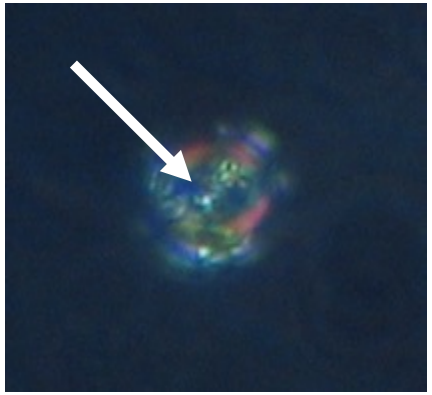
Ocean acidification

"Multiple stressor"

Carbonate chemistry control of calcification



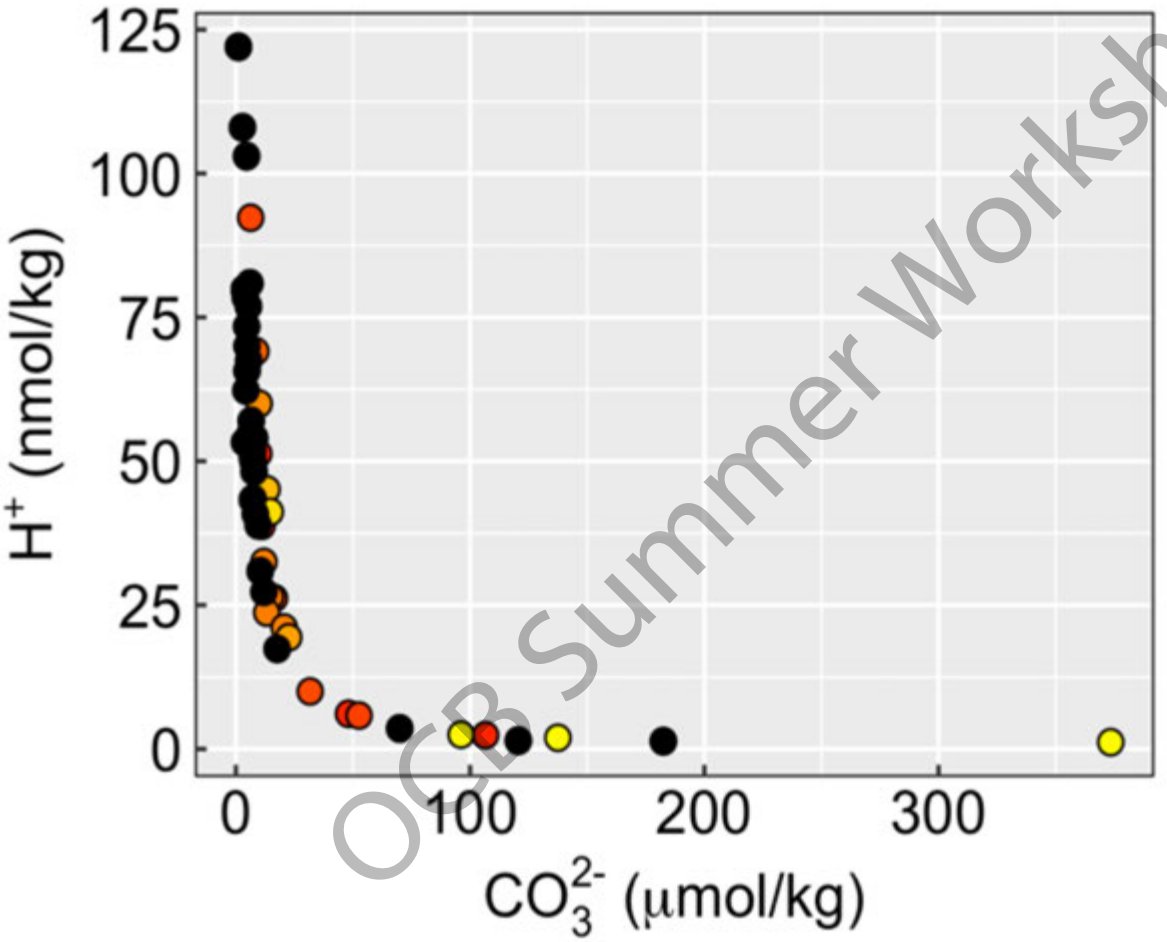




Interaction between HCO_3^- and H^+

Bach et al., 2015, Progr. Oceanogr.

Carbonate chemistry control of calcification



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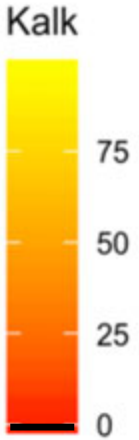

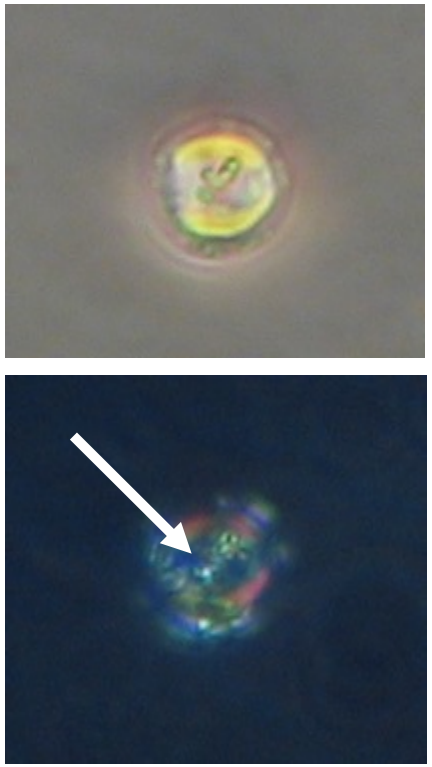

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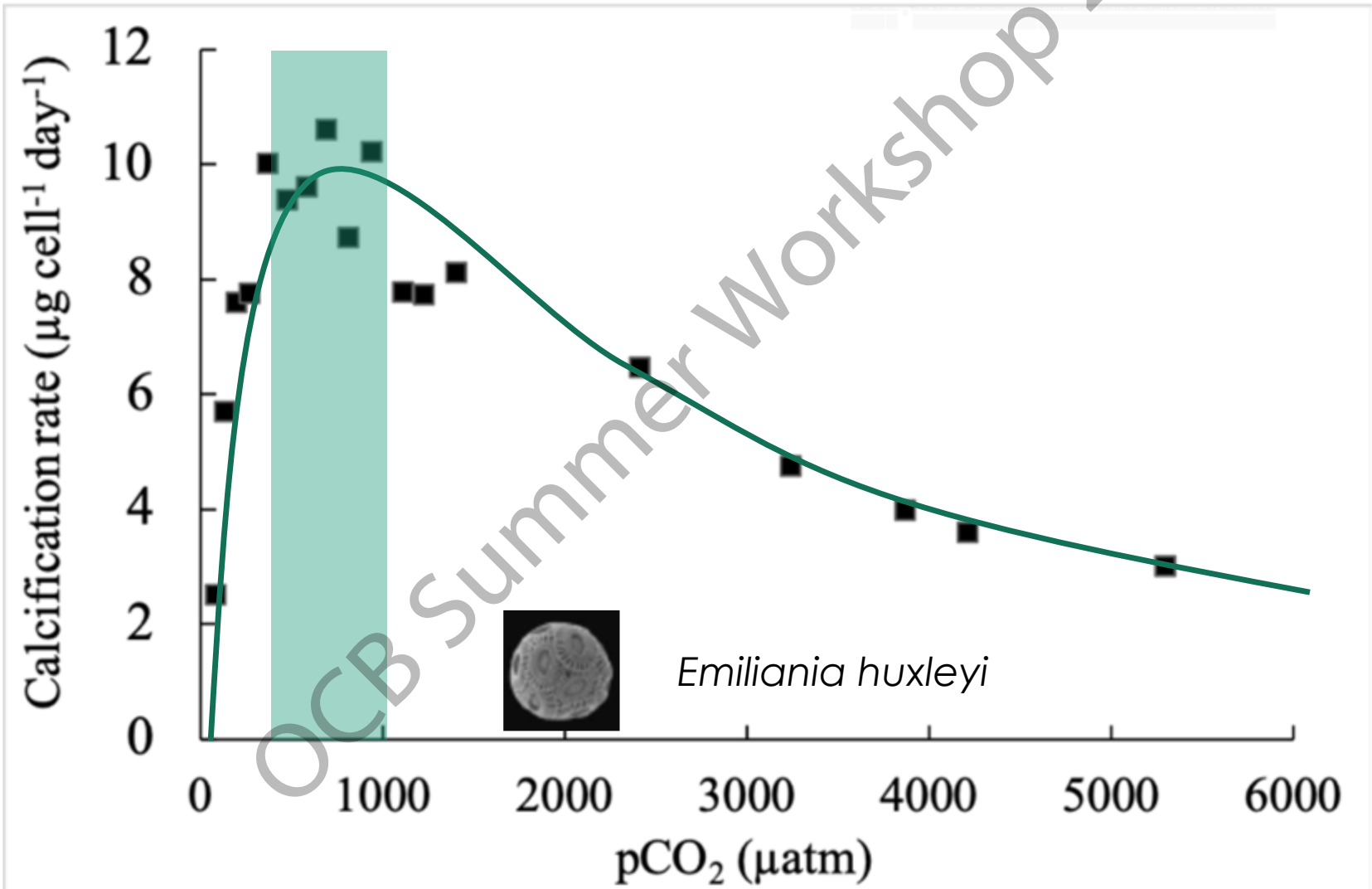
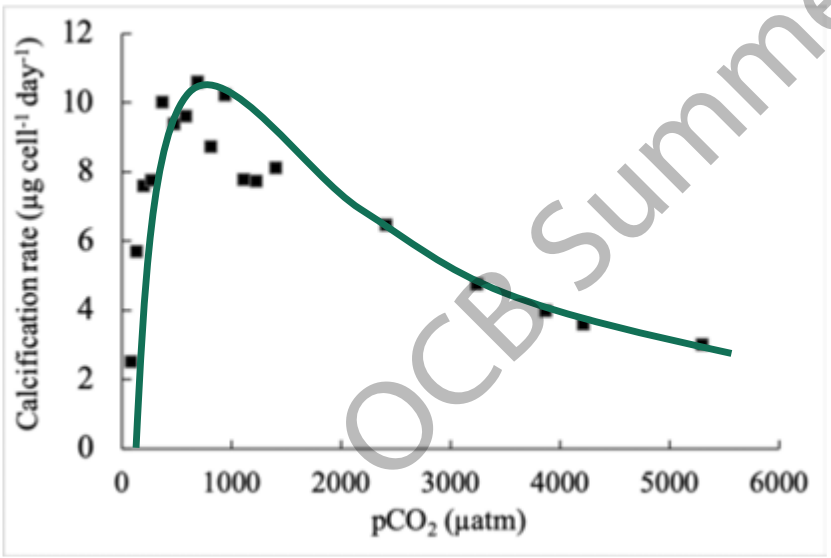


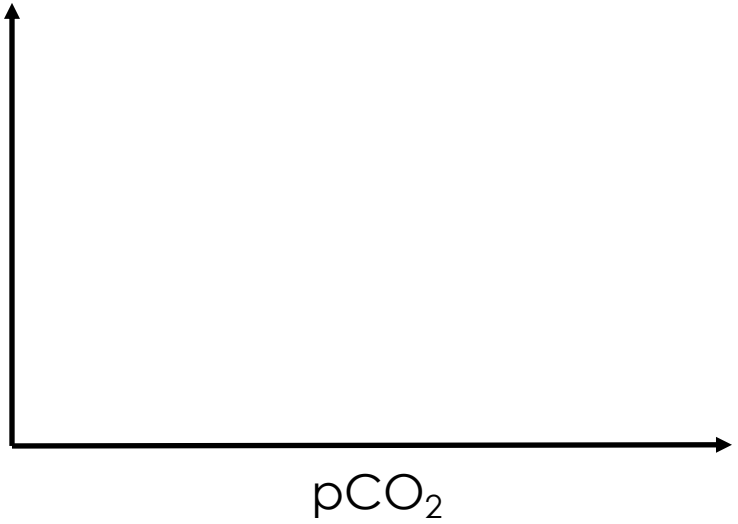
Carbonate chemistry control of calcification

$$Calcification\ rate = $$

Data



Concept



Bach et al., 2015, Progr. Oceanogr.

Carbonate chemistry control of calcification

$$Calcification\ rate = \frac{a[HCO_3^-]}{b + [HCO_3^-]}$$

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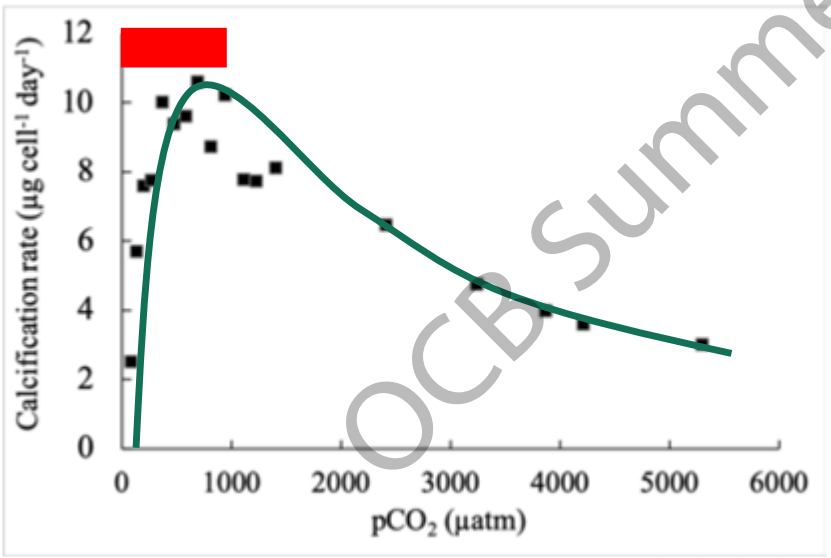

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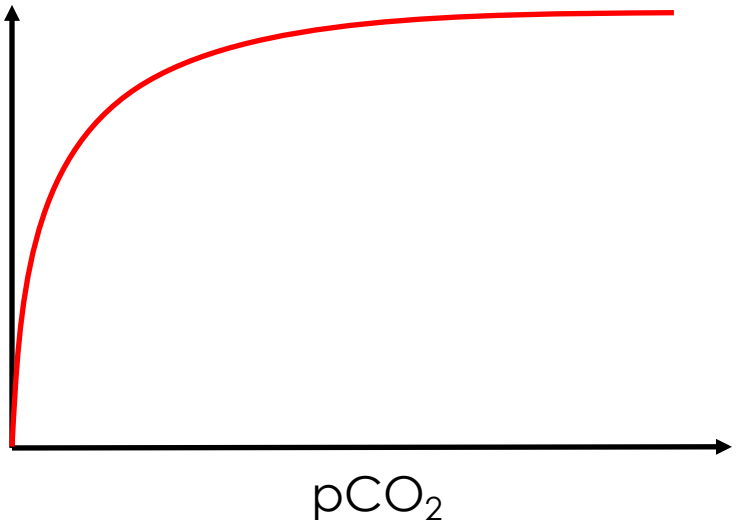

Bach et al., 2015, Progr. Oceanogr.

Carbonate chemistry control of calcification

Modified Monod model

$$Calcification\ rate = \frac{a[HCO_3^-]}{b + [HCO_3^-]} - e^{-c[CO_2]}$$

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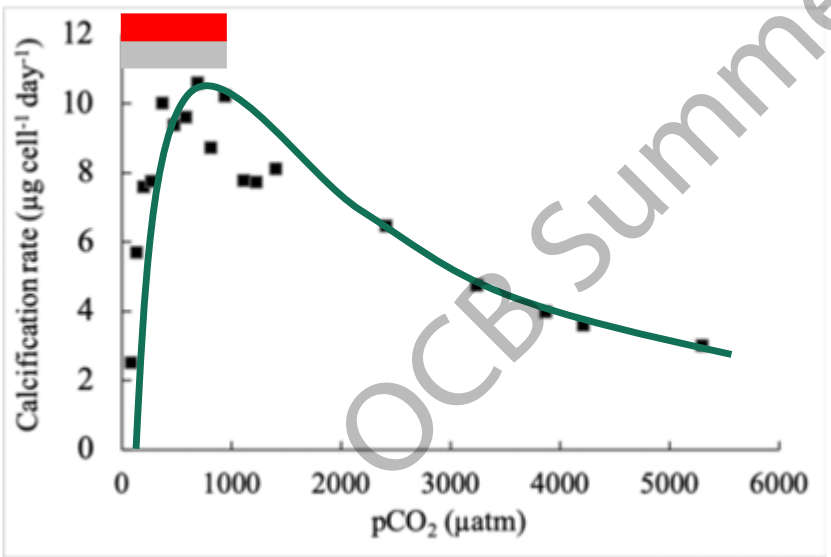

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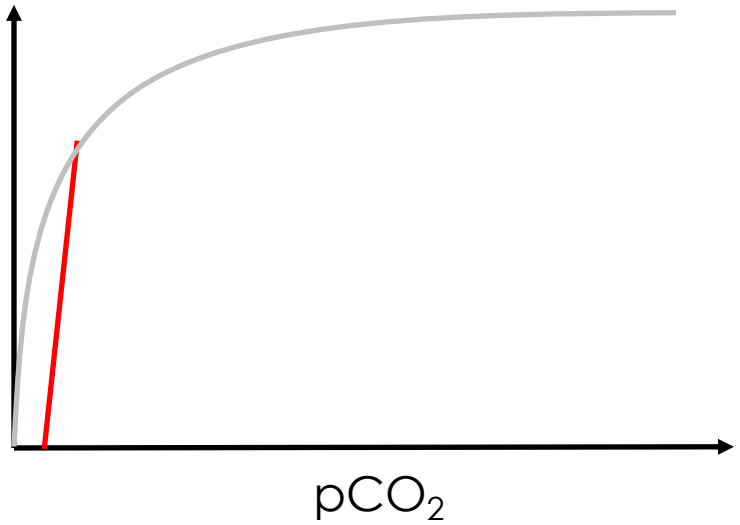

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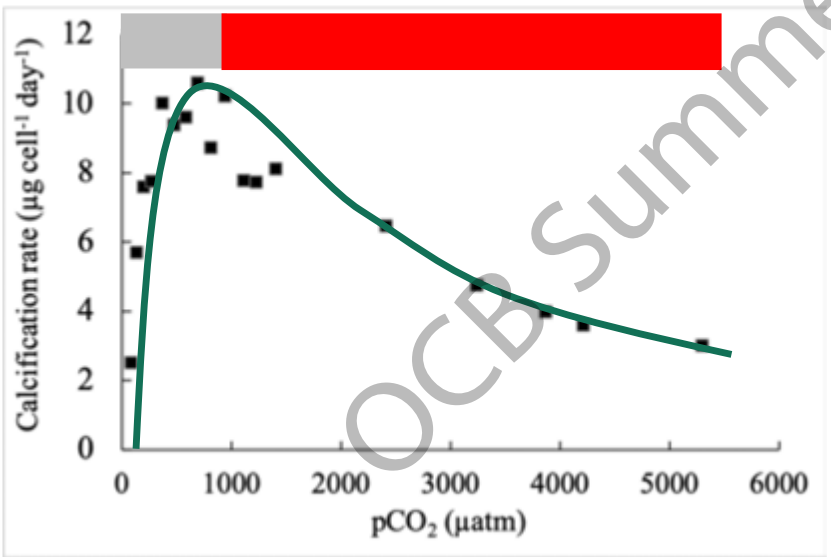

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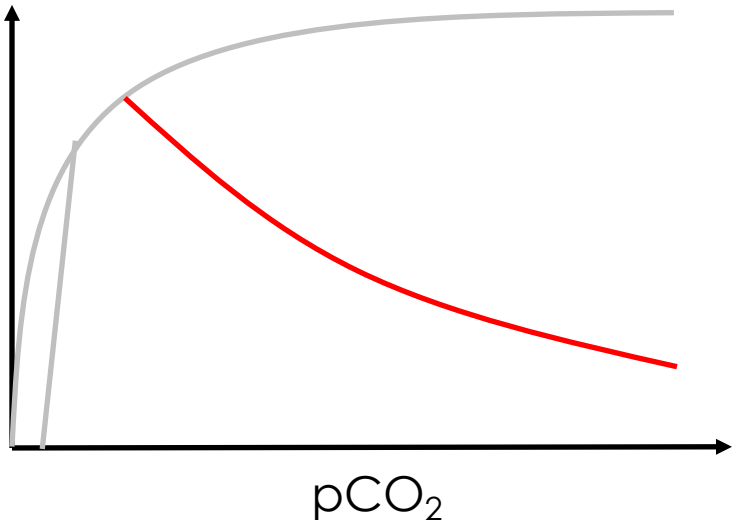

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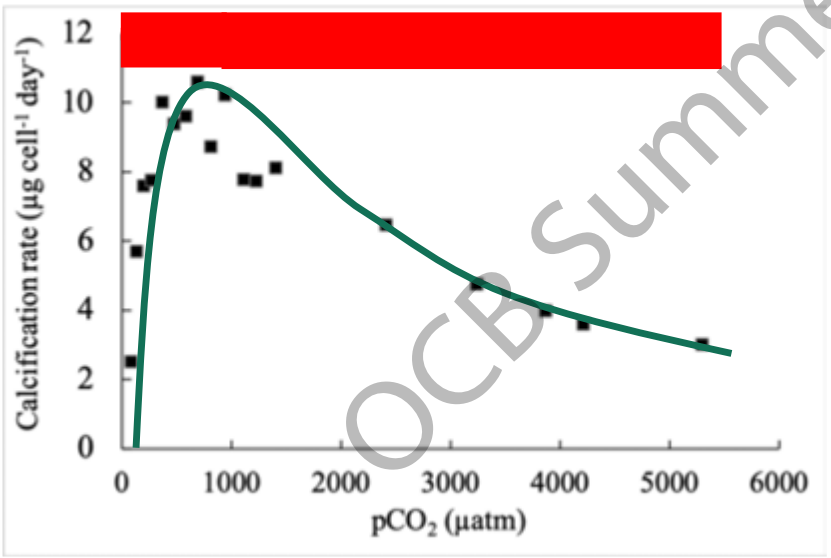

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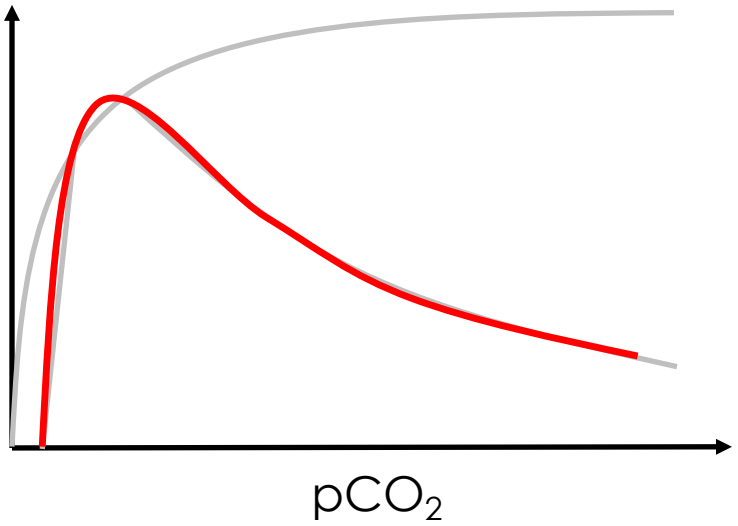
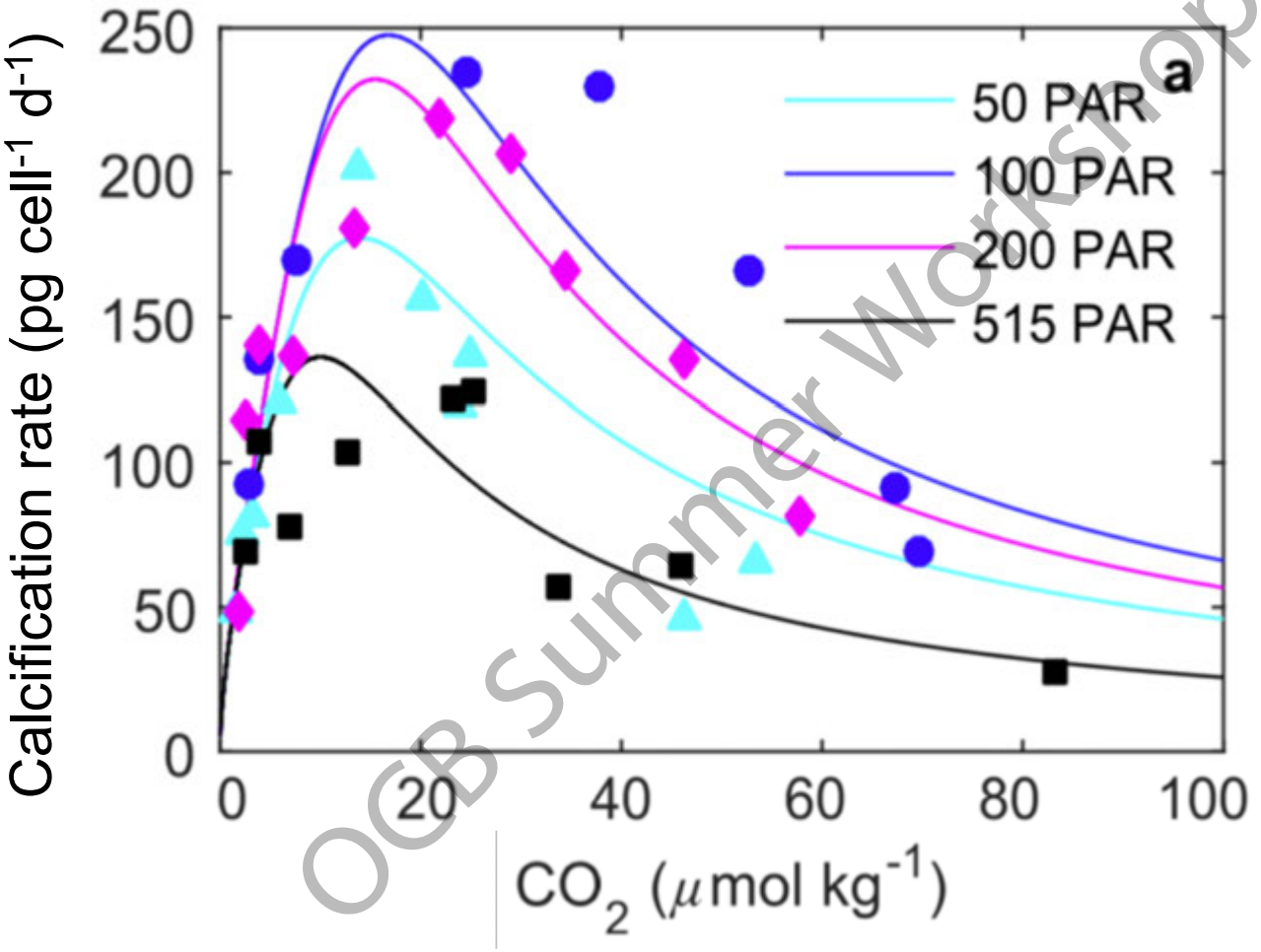


Bach et al., 2015, Progr. Oceanogr.

What about other environmental drivers?



Light

Modifies the shape of the reaction norm

Gafar et al., 2019, Sci. Rep.

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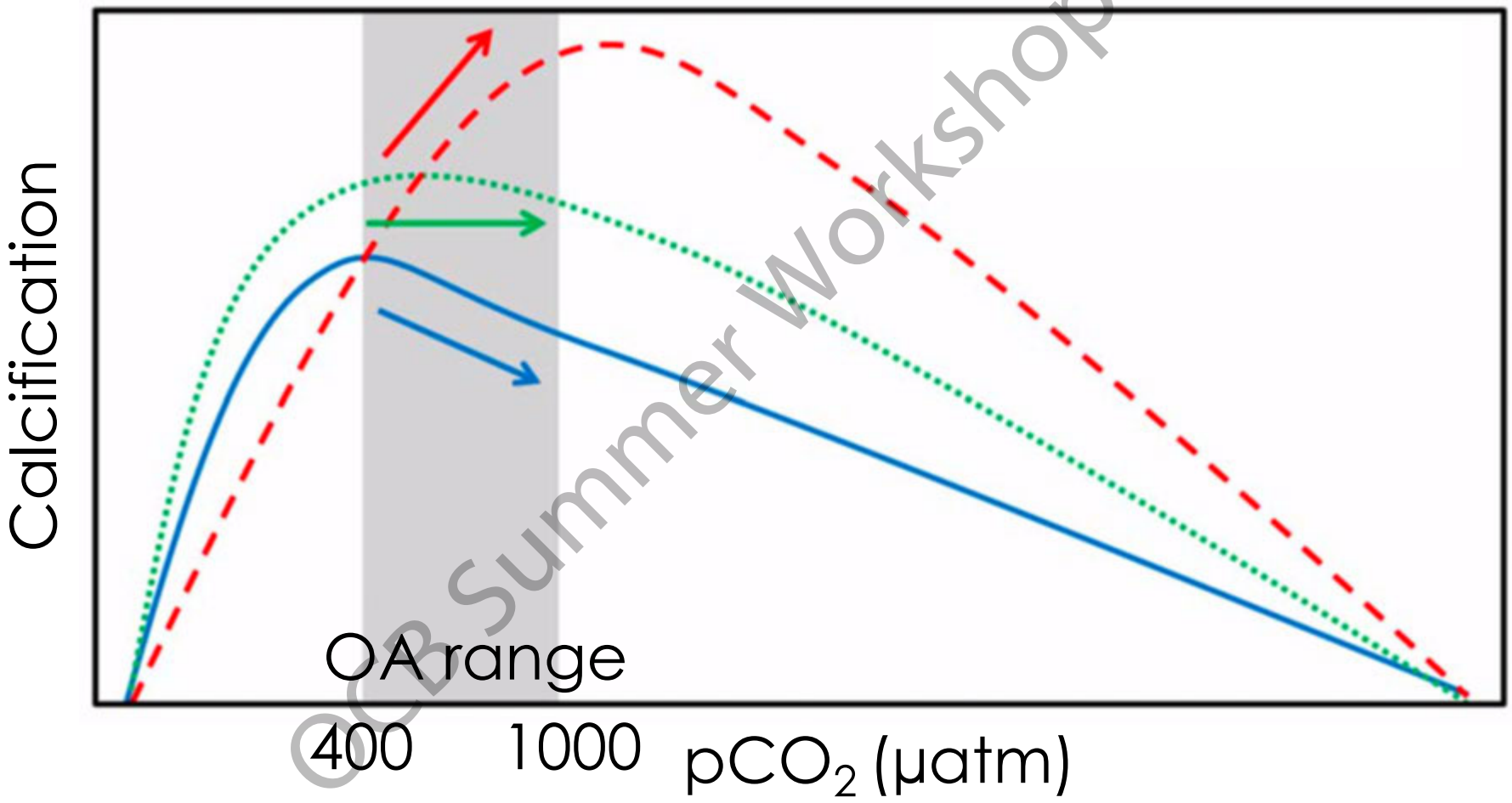
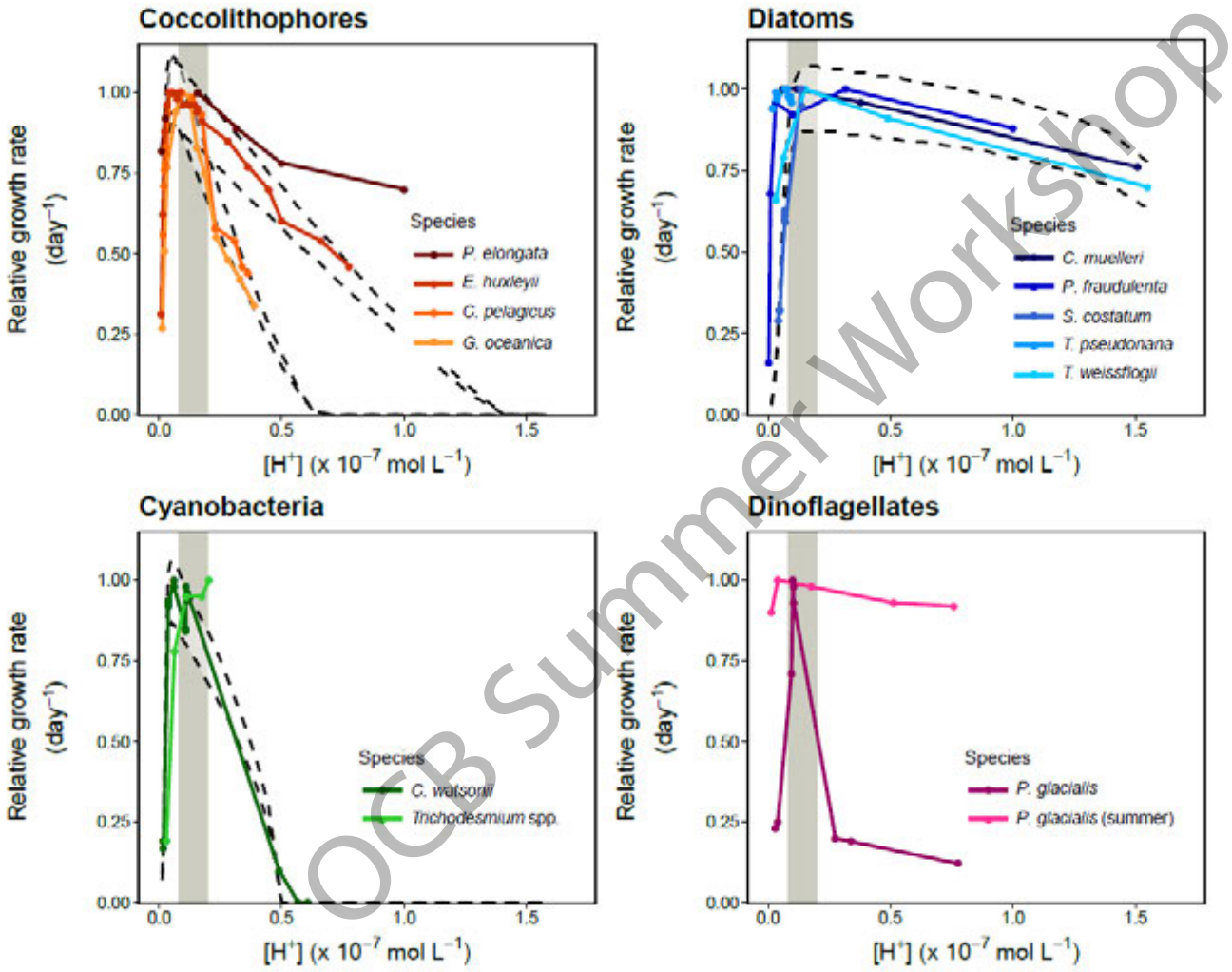


Sett et al., 2014, Plos One

What about other taxa?

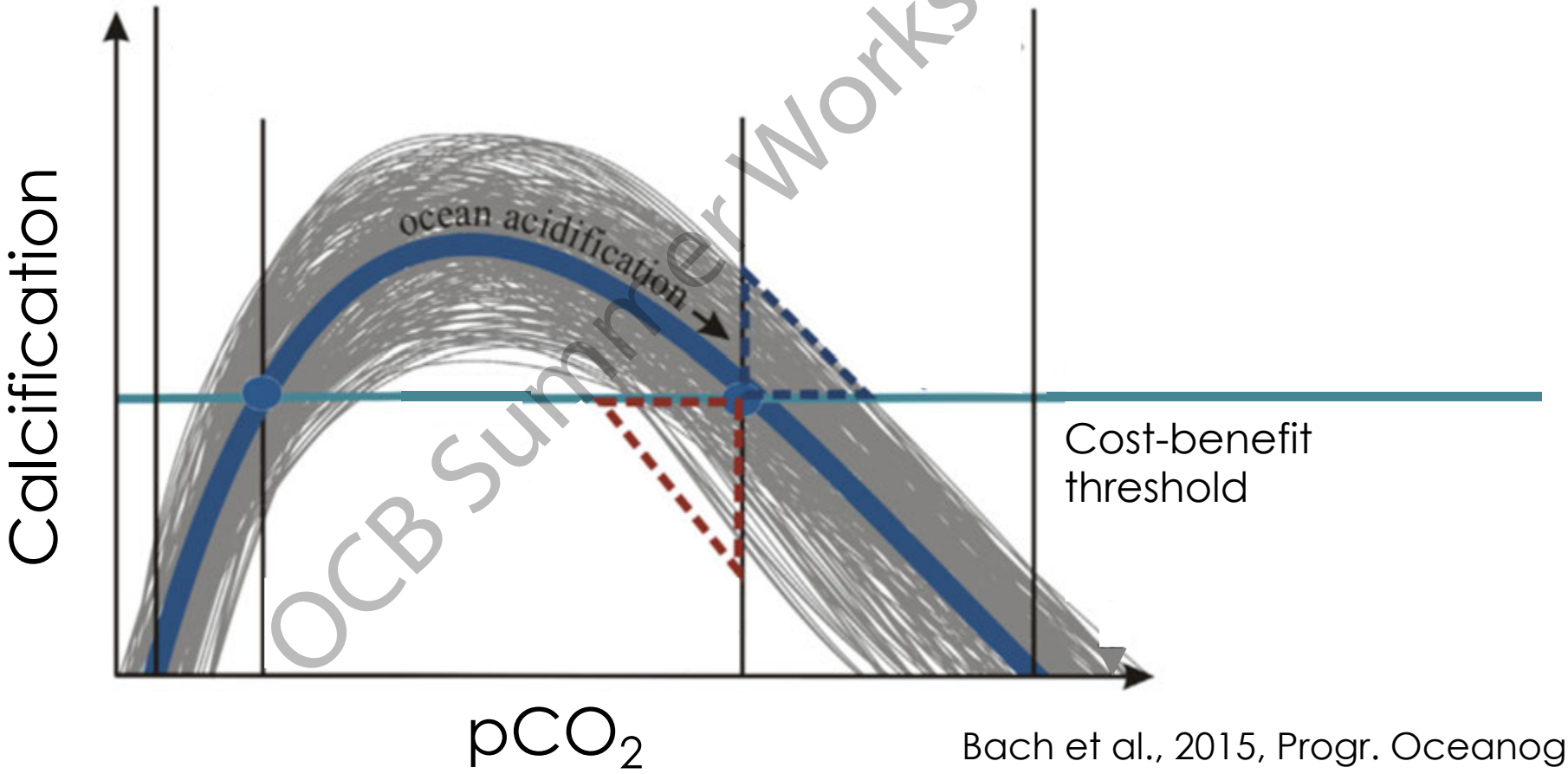


„A *default* reaction norm of **phytoplankton** to carbonate chemistry in general“

Paul and Bach, in prep.

Why do coccolithophores calcify?

Why a relevant question?



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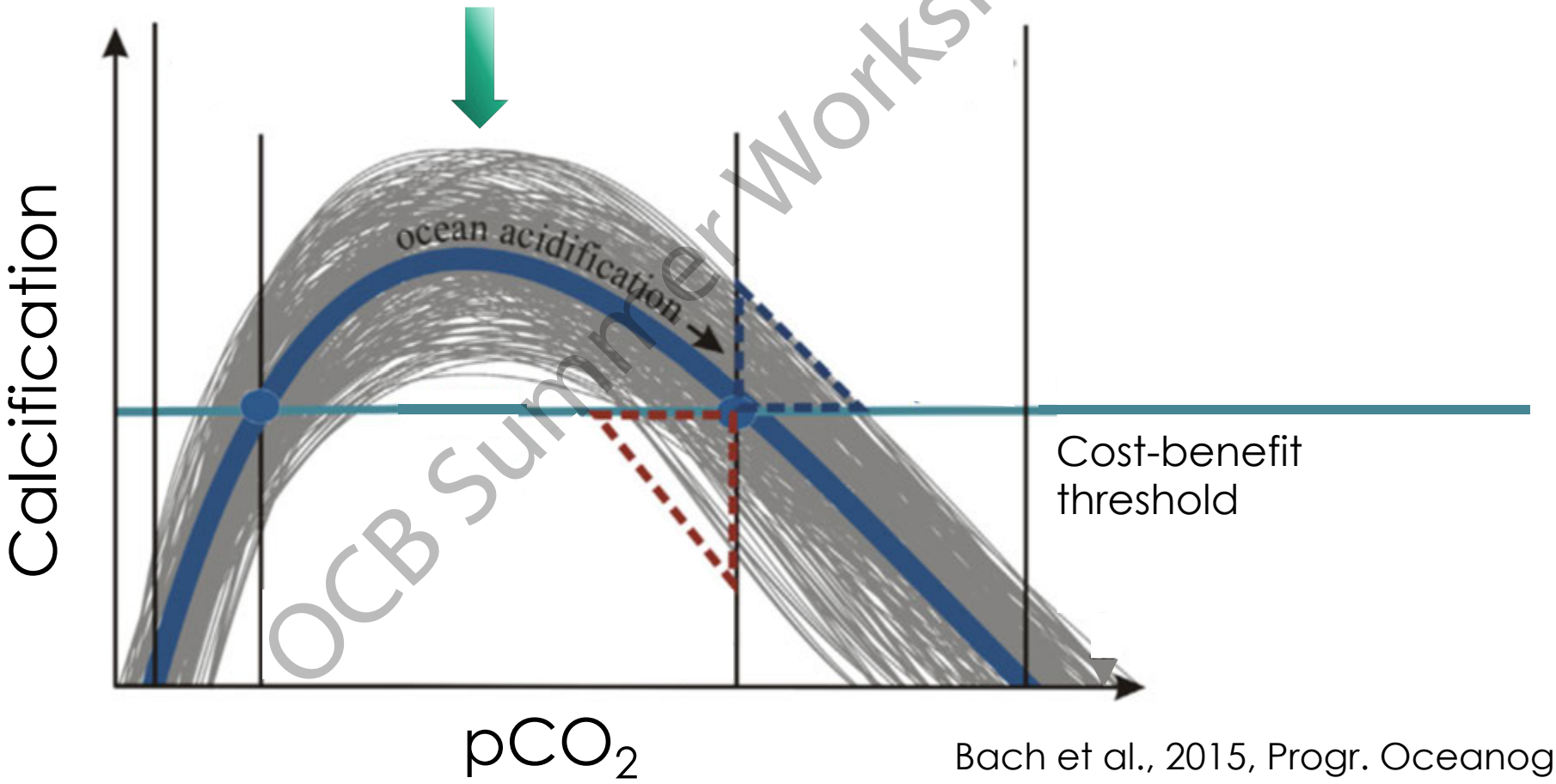

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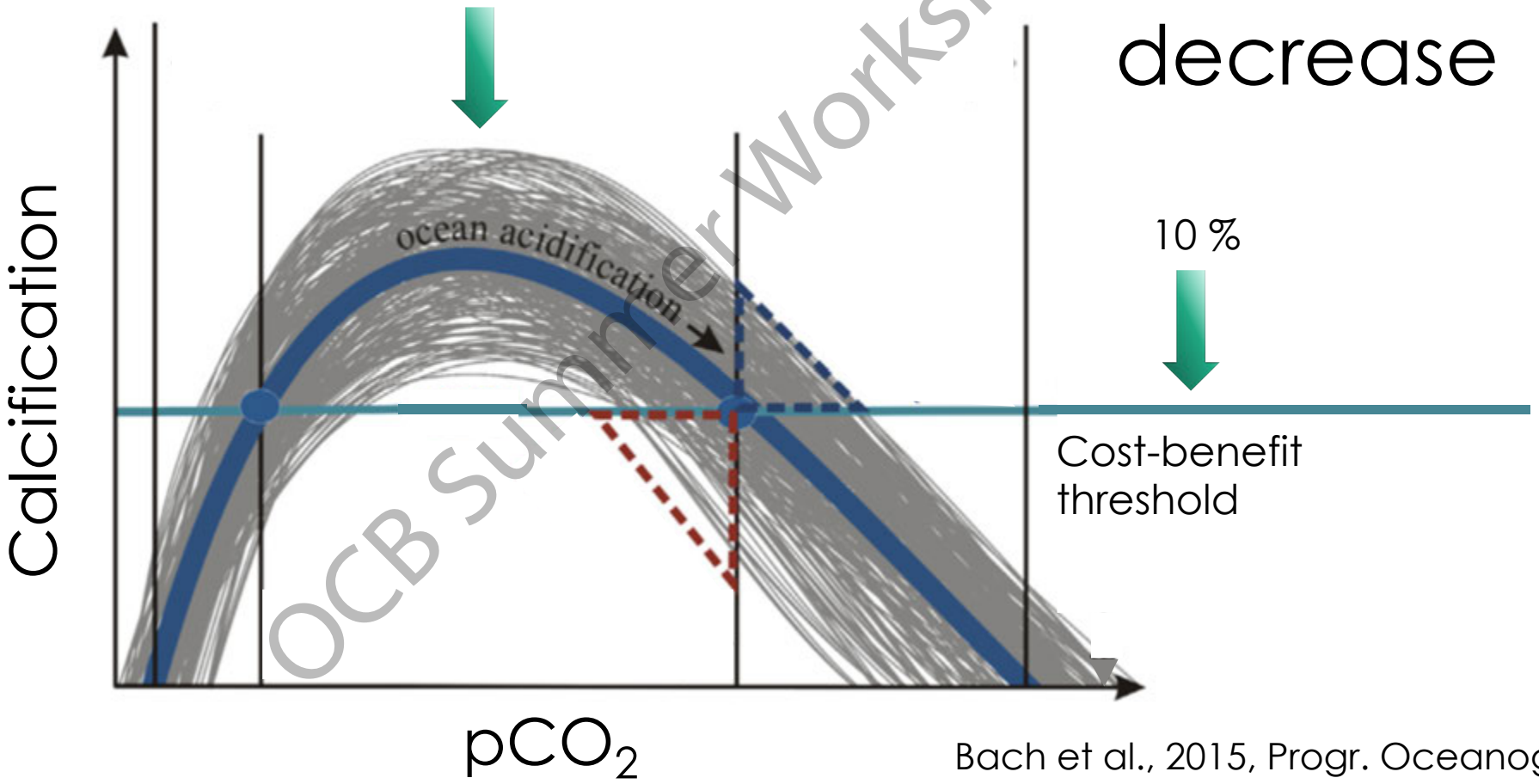

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Why do coccolithophores calcify?

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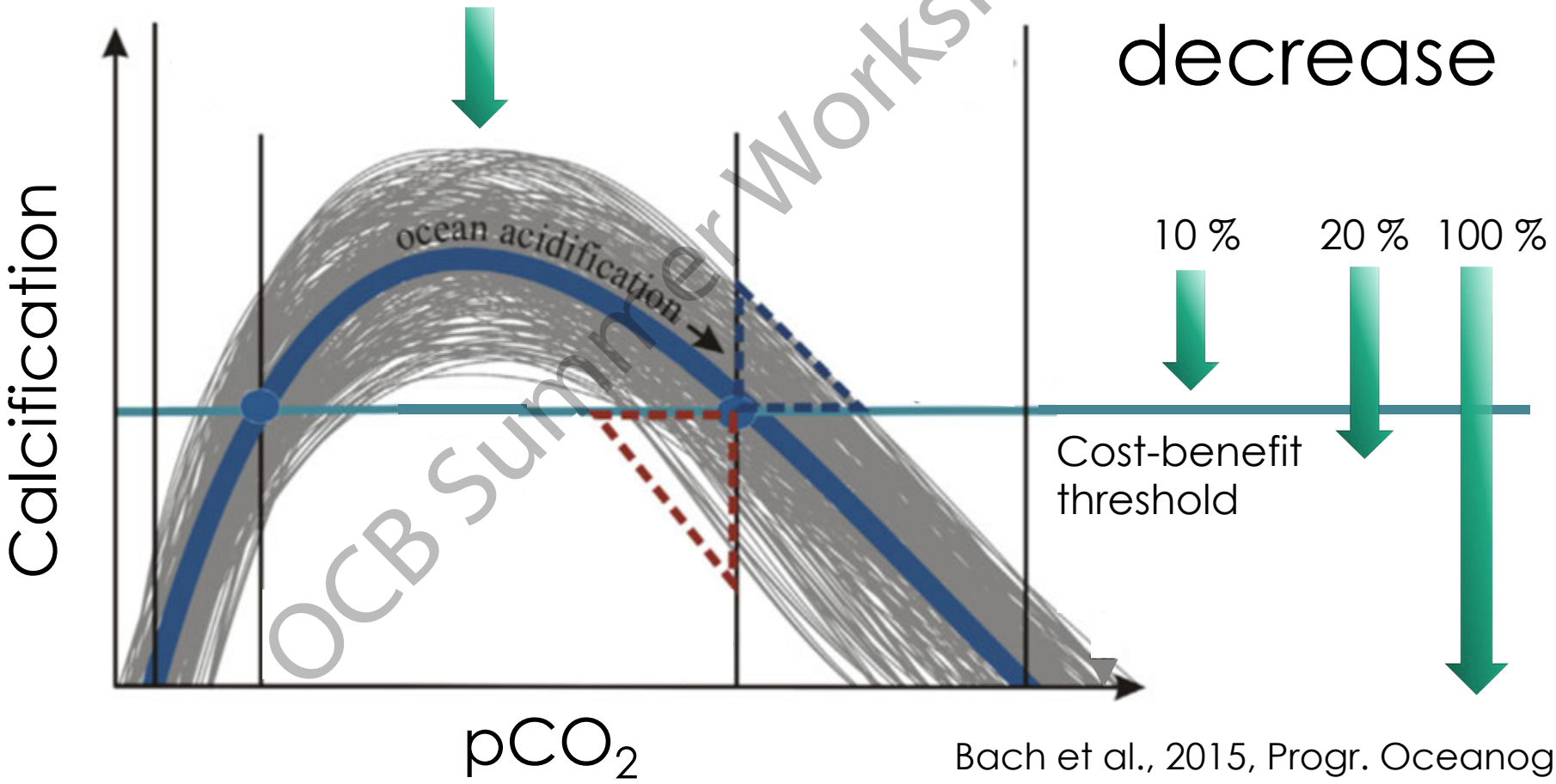

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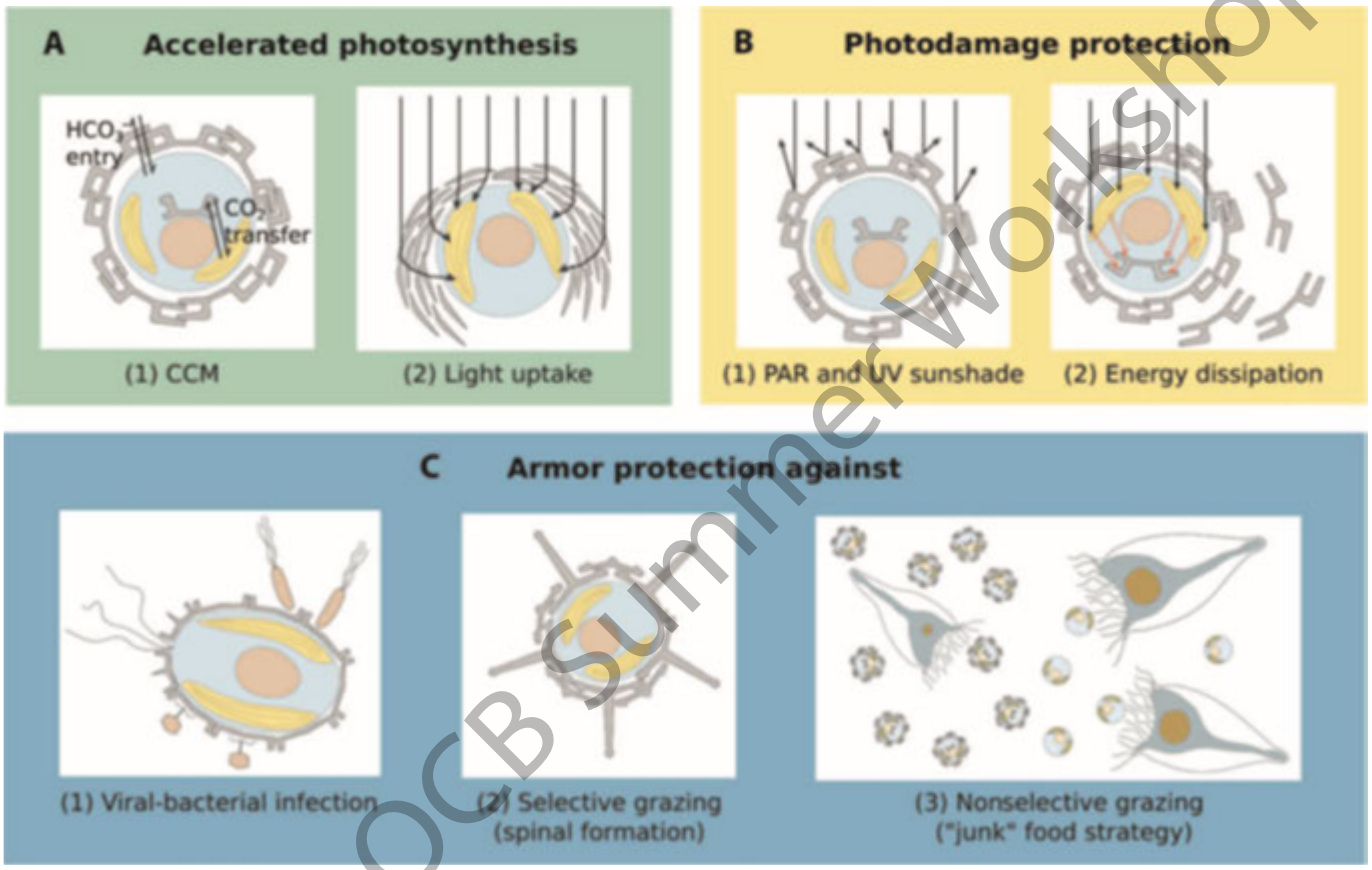
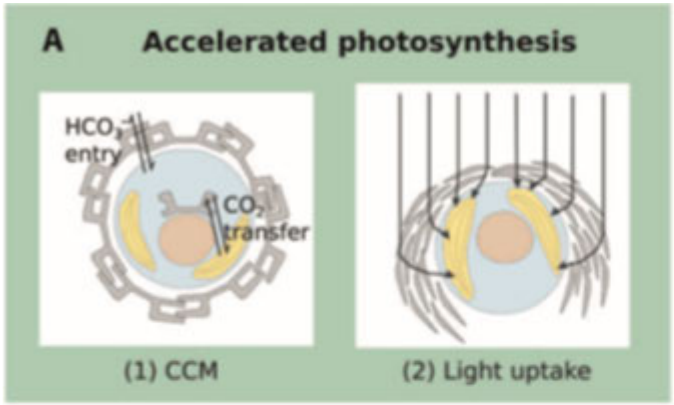


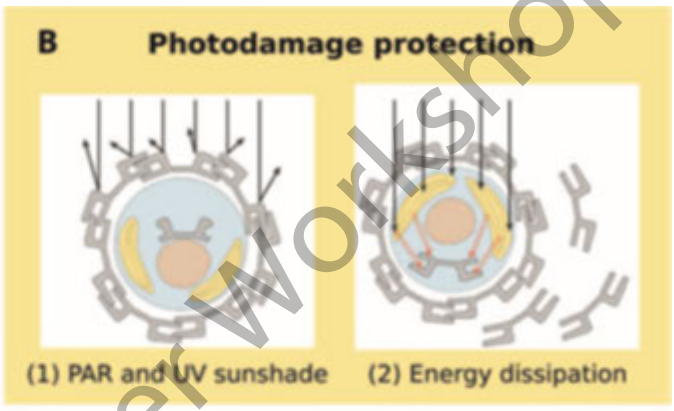
„Probably an armor against grazers“

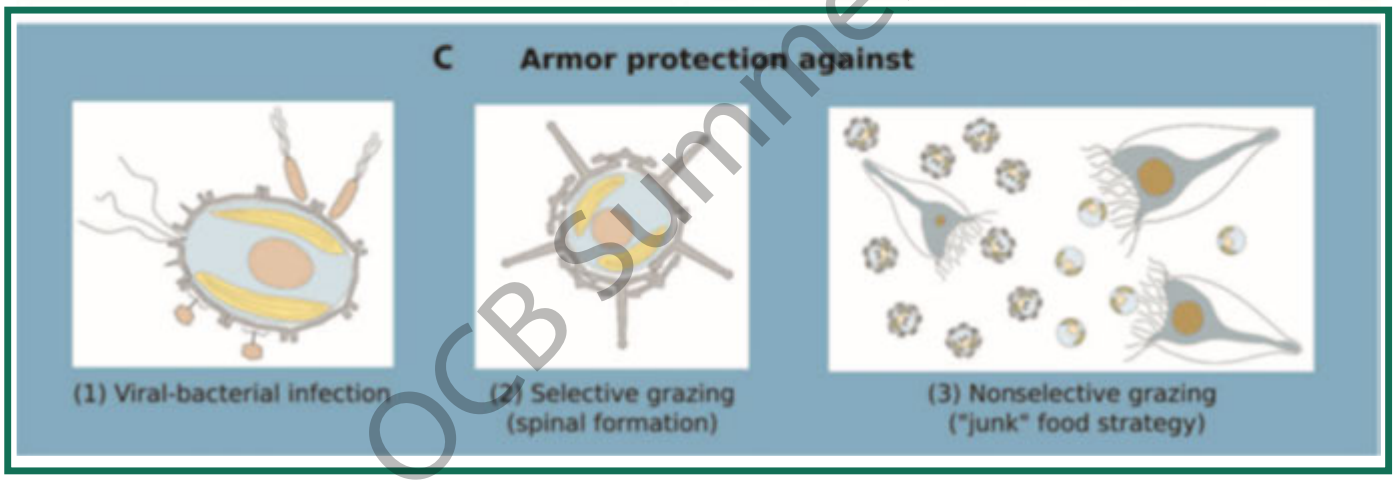
Monteiro et al., 2016, Sci. Adv.

Ecology of Calcification

Why do coccolithophores calcify?







Monteiro et al., 2015, Sci. Adv.

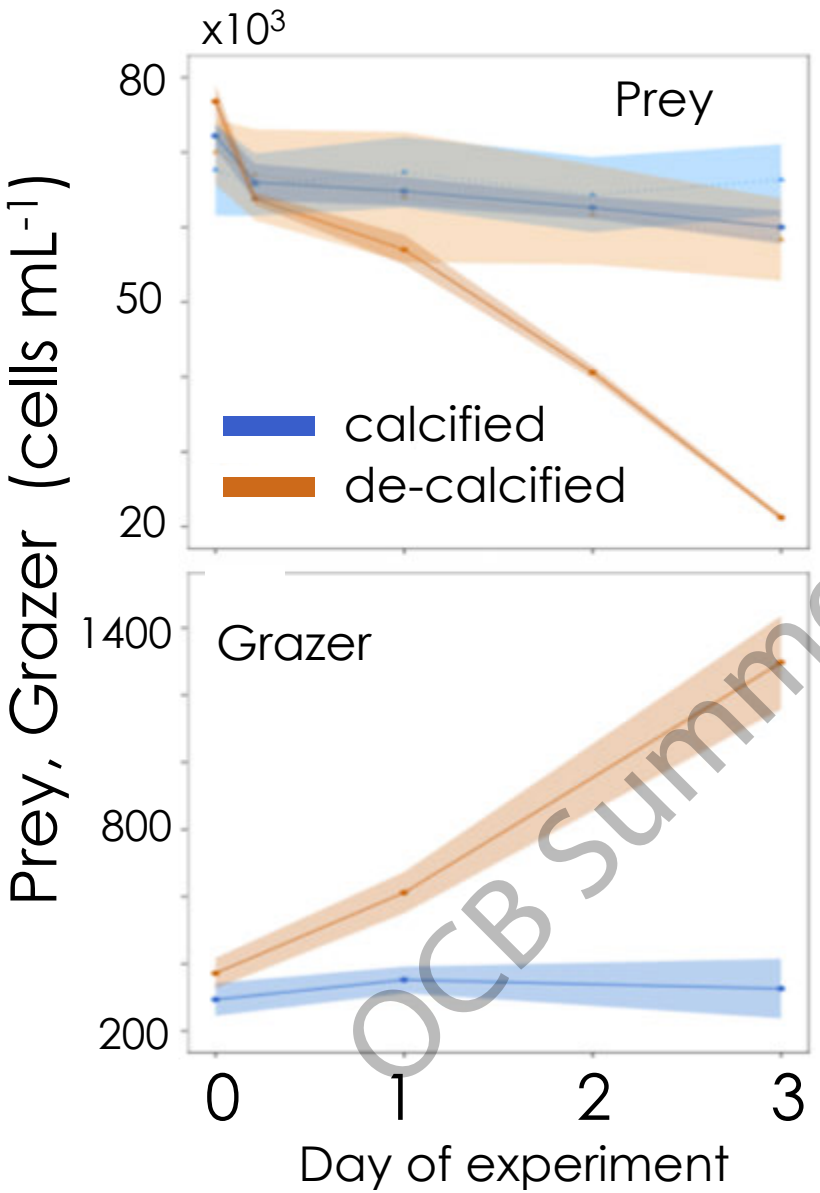
DFG

calciWHY?

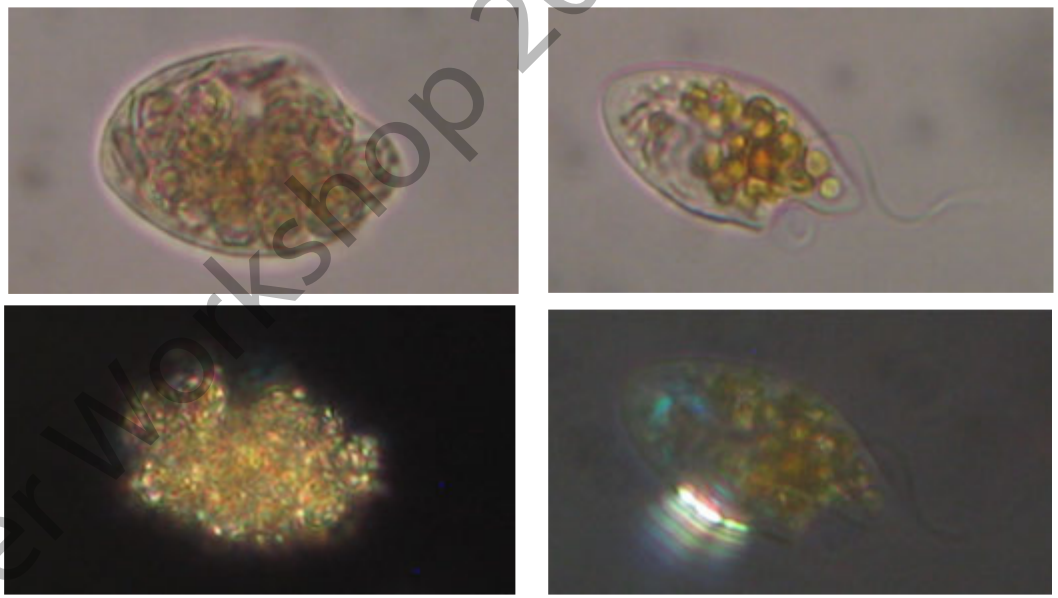
Mathias Haunost

Ecology of Calcification

Beginning End



calcified de-calcified

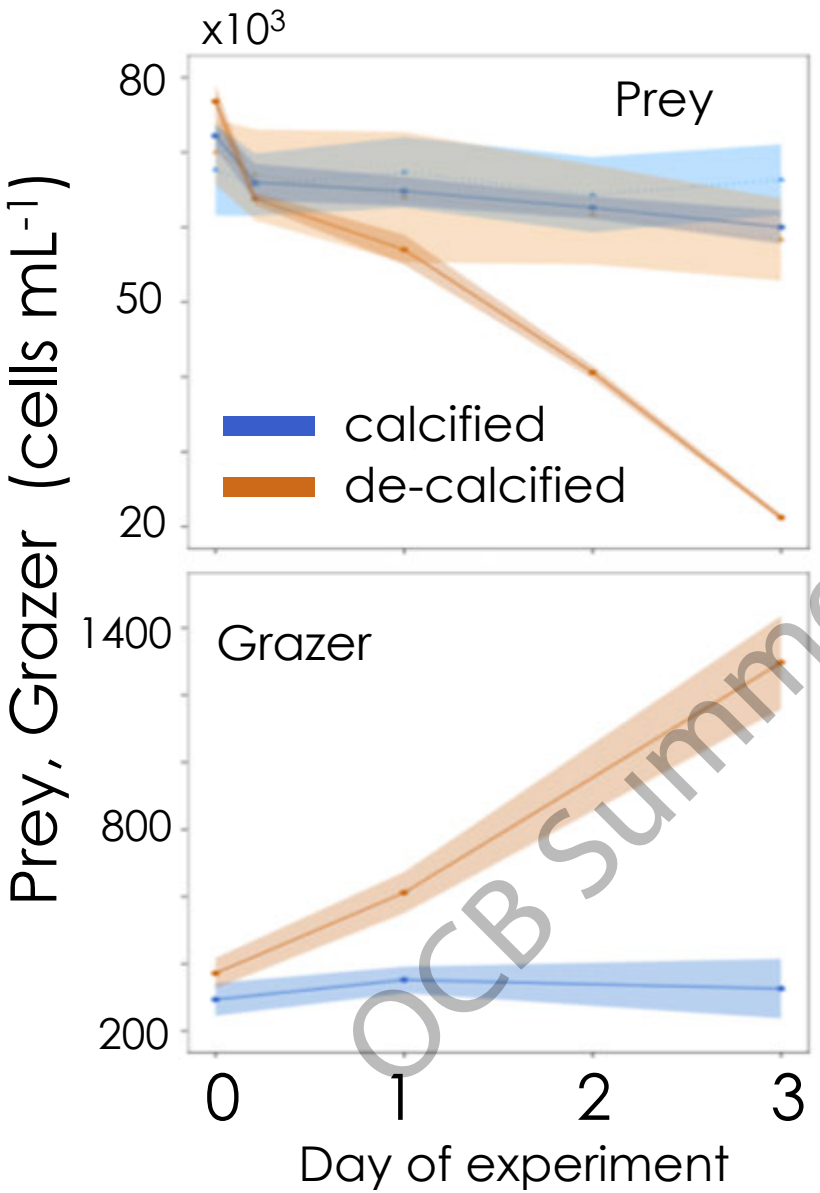


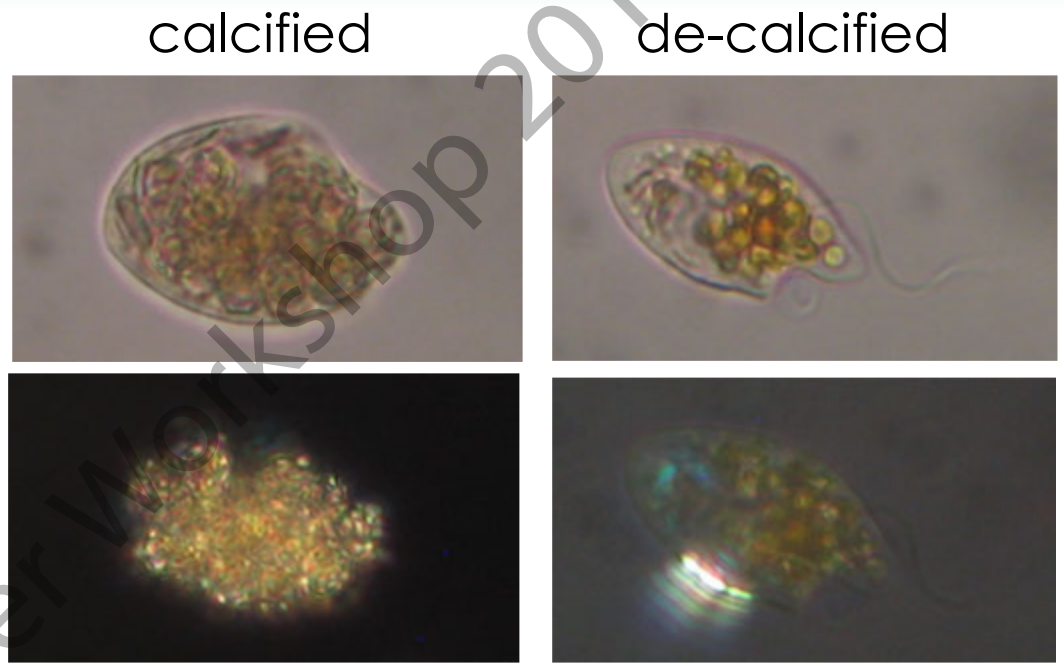
Microzooplankton defense?

Haunost et al., in prep.

Ecology of Calcification

Beginning End





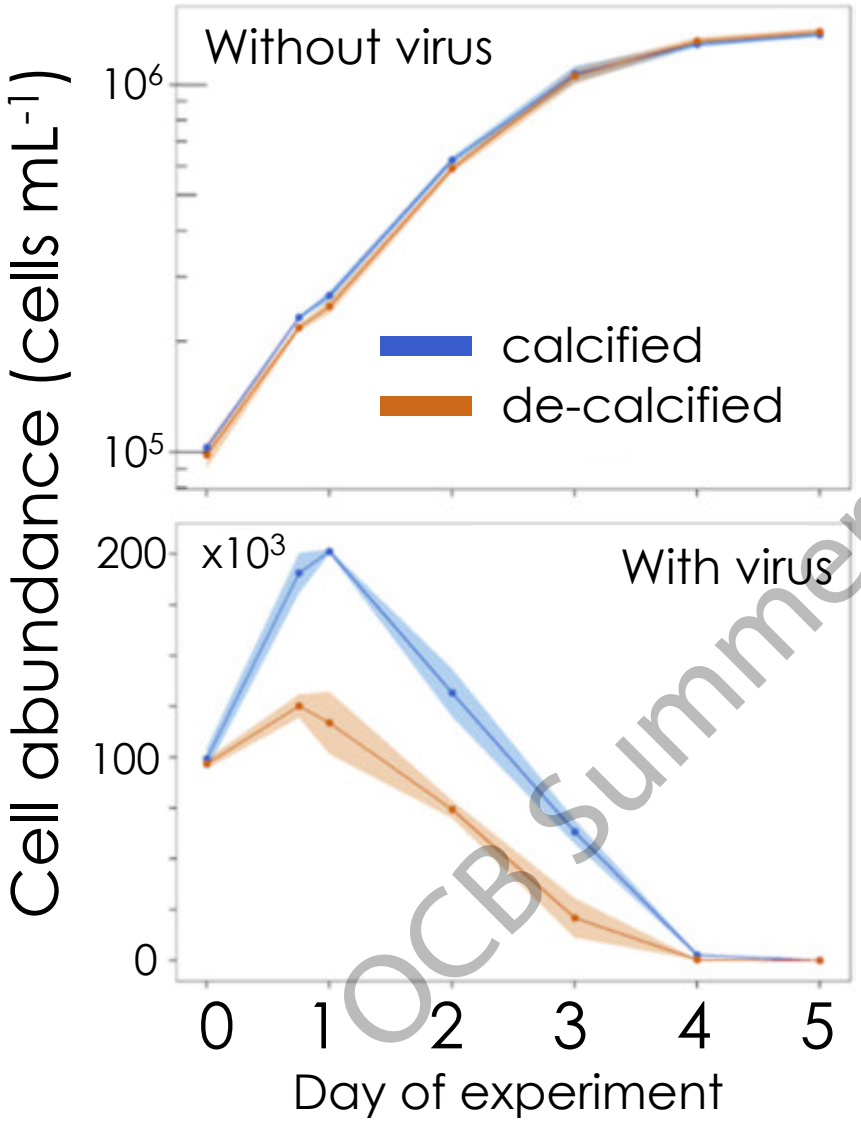
Microzooplankton defense?

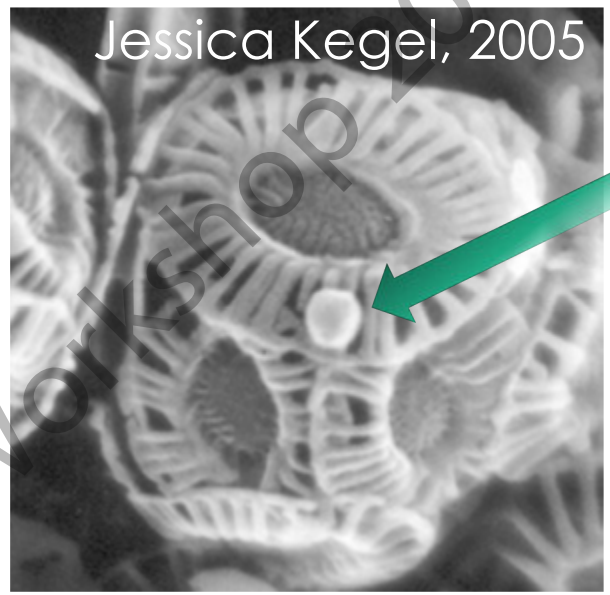
Yes.

Haunost et al., in prep.

Ecology of Calcification

Beginning — End



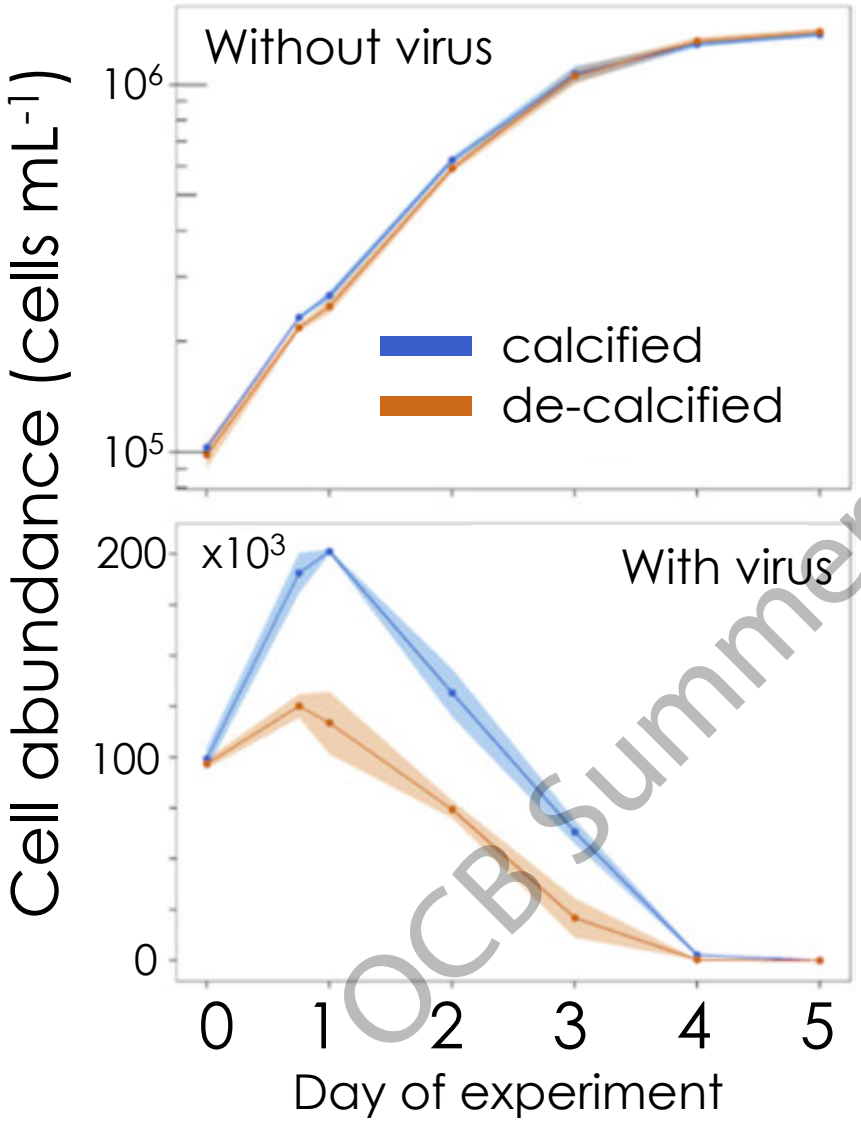


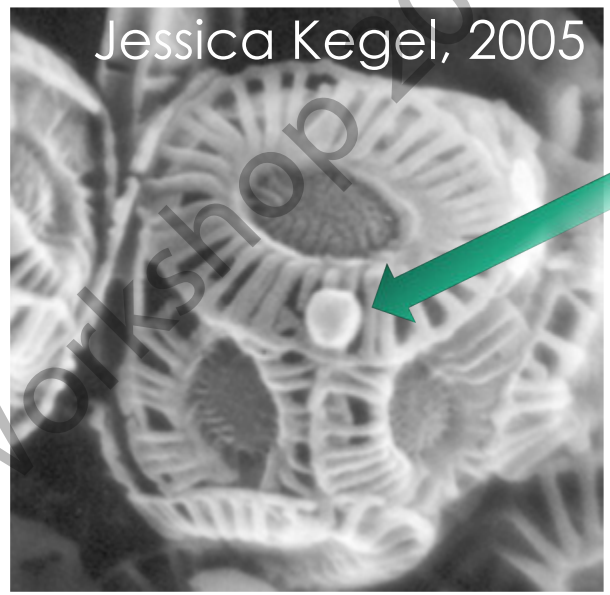
Ehux virus

Virus defense?

Ecology of Calcification

Beginning — End





Ehux virus

Virus defense?

Yes.

Physical immune system

Haunost et al., in prep.

Future research priorities

Beginning End

Future research priorities

Beyond Ehux

Future research priorities

Beginning

End

⚠ Highly opinionated ⚠

 Beyond Ehux

 Ocean acidification

Future research priorities

Beginning — End

⚠ Highly opinionated ⚠

 Beyond Ehux

 Ocean acidification

 Costs and benefits

Future research priorities

Beginning End

⚠ Highly opinionated ⚠

 Beyond Ehux

 Ocean acidification

 Costs and benefits

 Calcification in the climate engineering context

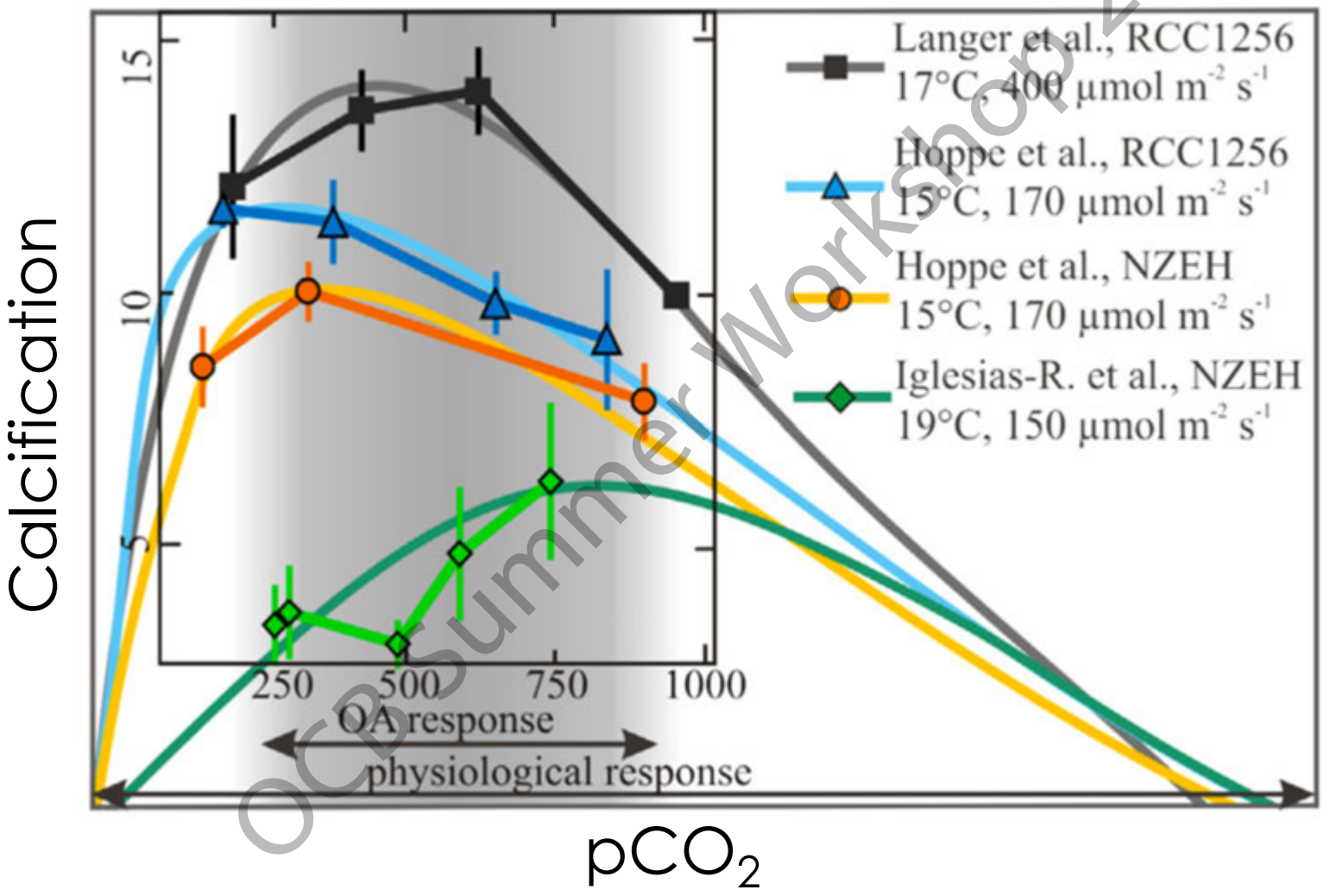
End

Thanks

Email: lennart.bach@utas.edu.au

Physiology of Calcification

What about other environmental drivers?

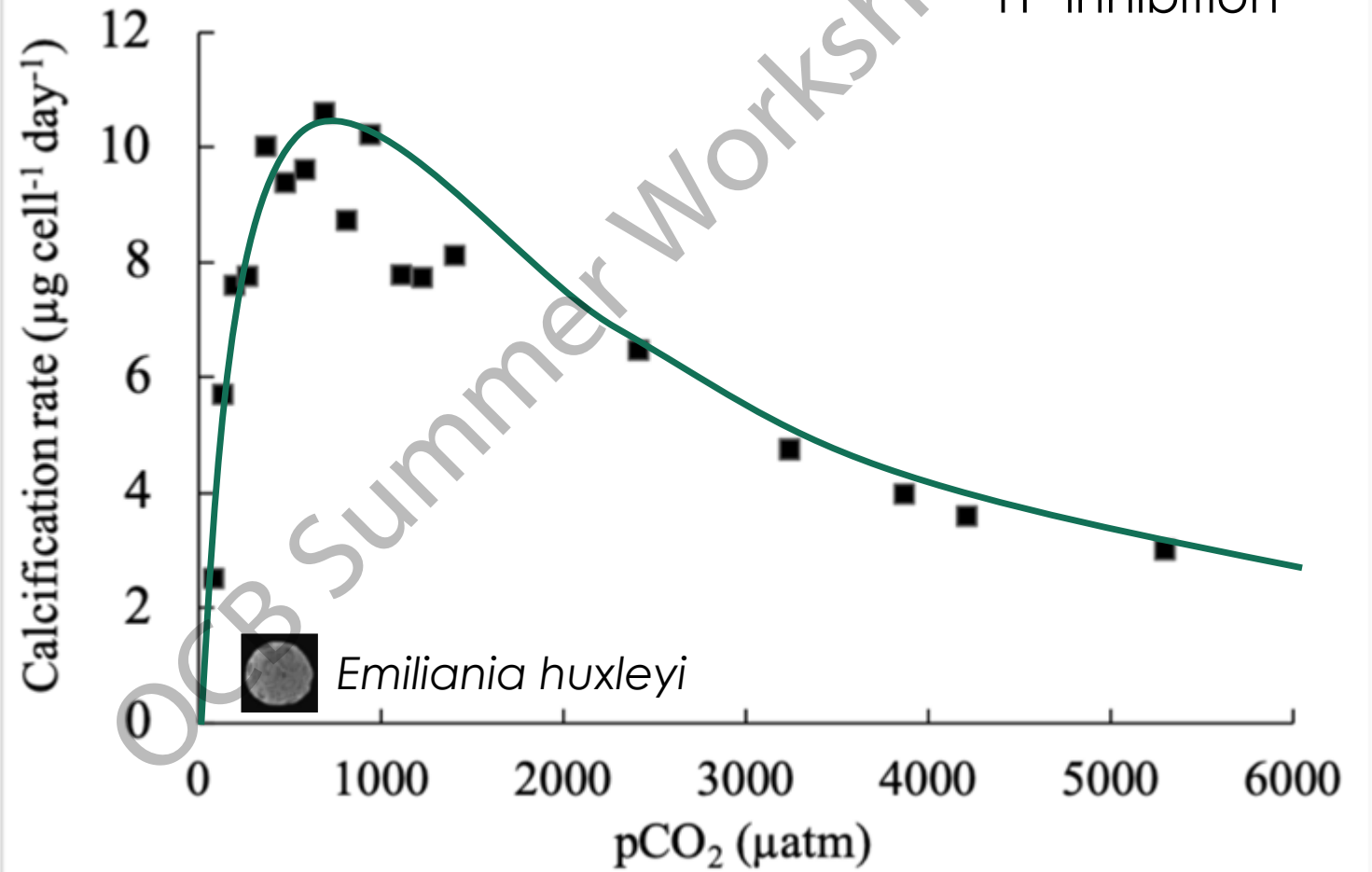


Bach et al., 2015, Progr. Oceanogr.

Carbonate chemistry control of calcification

CO_2, HCO_3^- limitation

H^+ inhibition



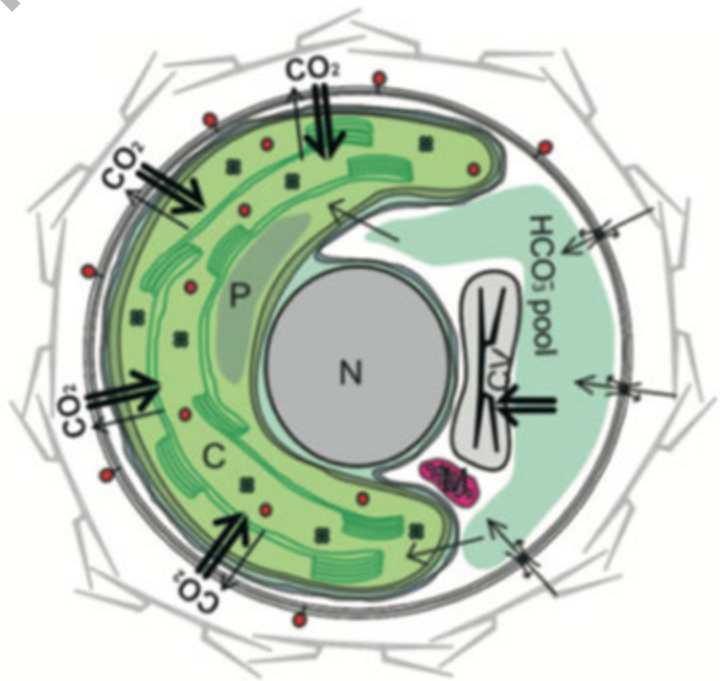
Carbonate chemistry control of calcification

What is carbonate chemistry from an organism perspective?

"Multiple stressor"

CO_2	√
HCO_3^-	√
CO_3^{2-}	√
H^+ (pH)	√

DIC	x
Total alkalinity	x
Saturation state (Ω)	x
…	



Bach et al., 2013, New Phyt.