Ocean Acidification, Warming and the Biological Carbon Pump

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11:40 Th. 26Mar
Diam. 6-7

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msi
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Global Change

Some direct and indirect changed to the abiotic environment of the surface ocean:

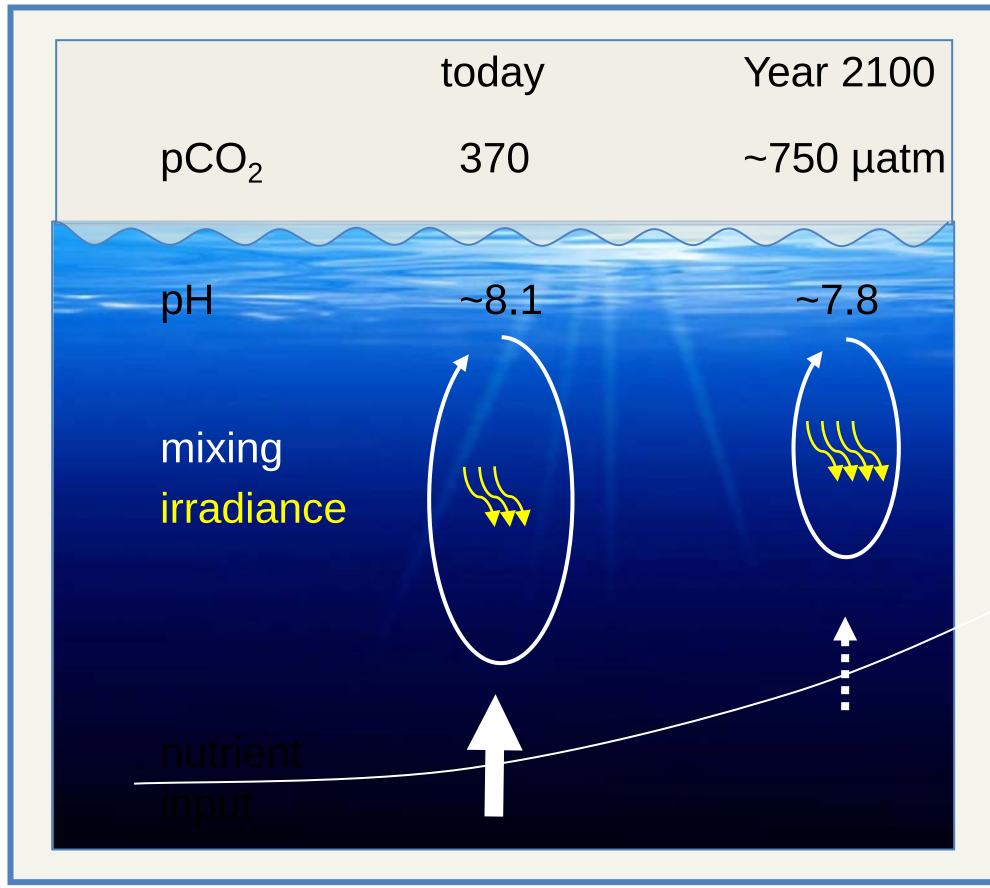
- temperature
- ocean acidification
- allochthonous inputs (N, Fe)

  - stratification/ turbulence

    - light climate
    - nutrient availability & stoichiometry

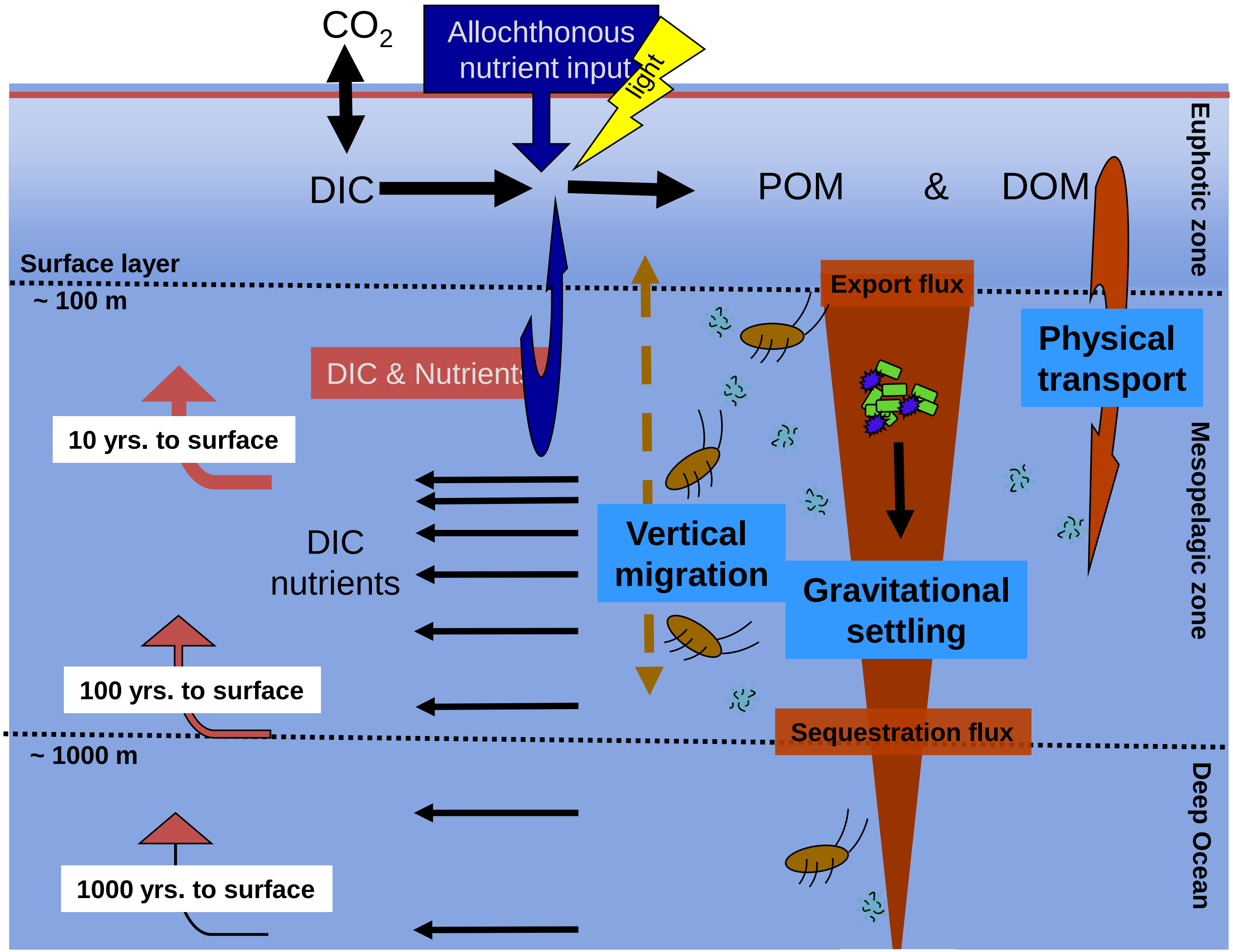
  - sea level rise
  - deoxygenation, OMZ

  - trace element availability
  - exoenzyme activity
  - saturation state of $CaCO_3$



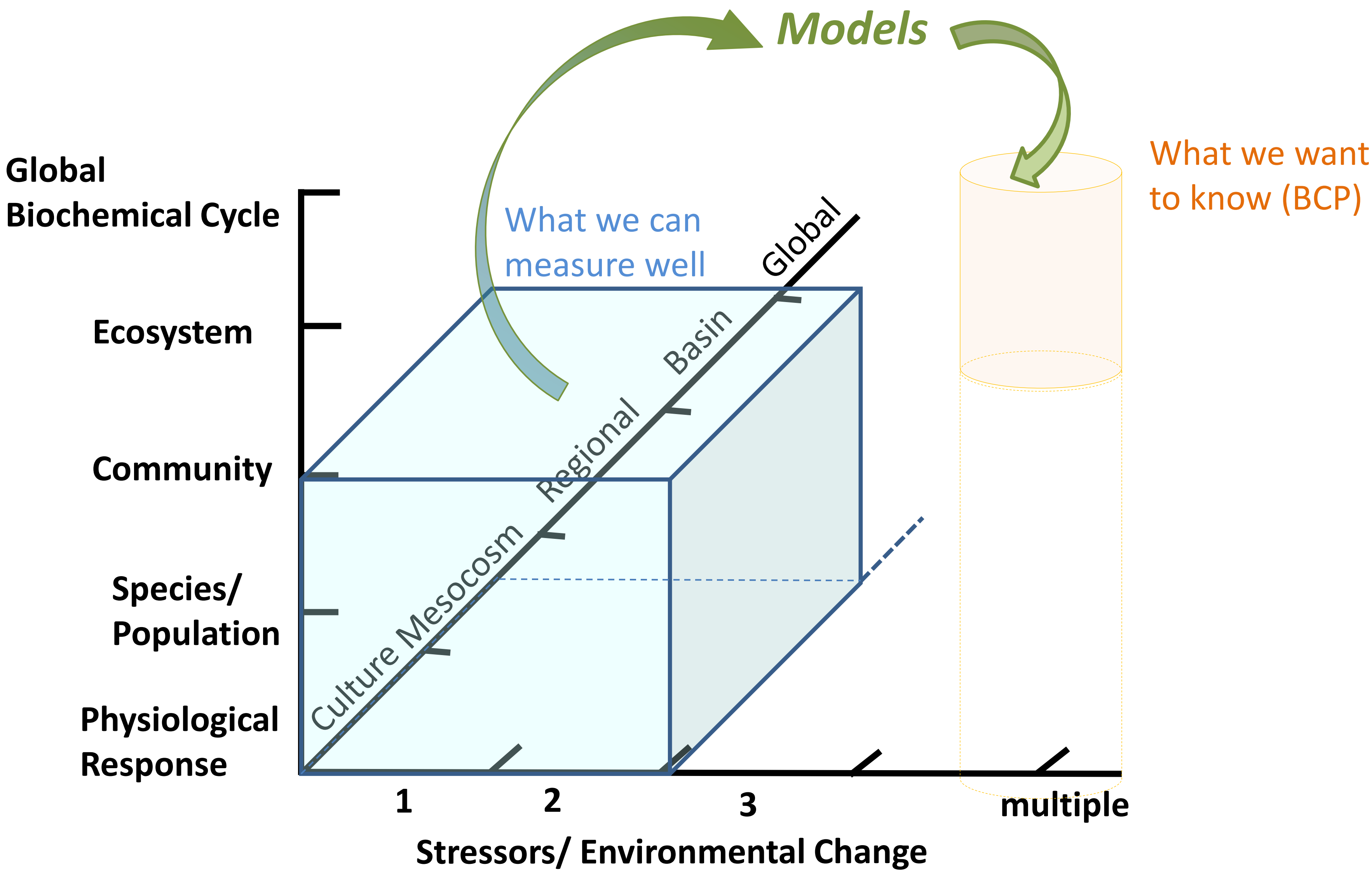
Adapted Rost et al. 2008

Carbon Sequestration by the Biological Pump

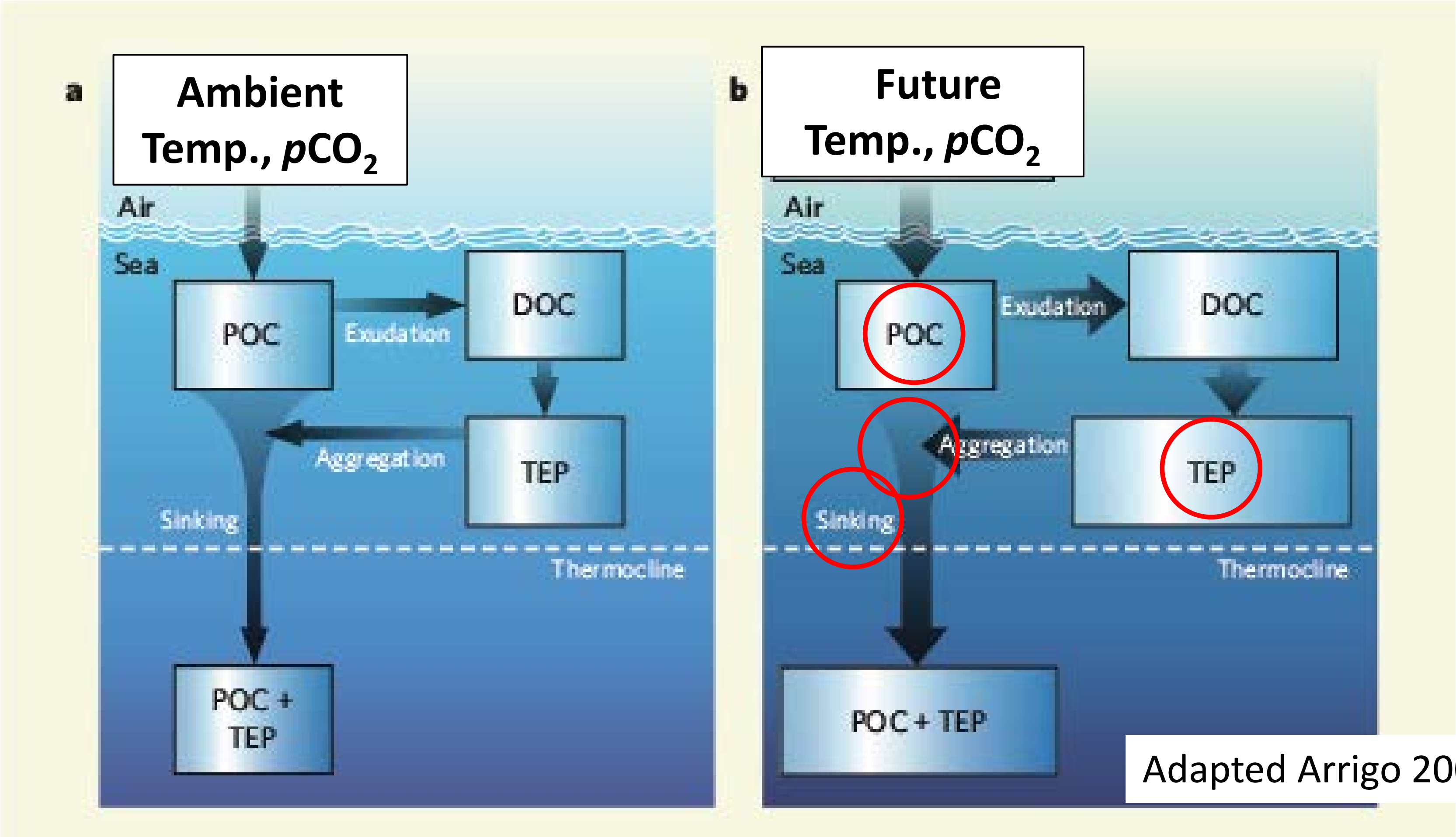


Passow & Carlson 2012

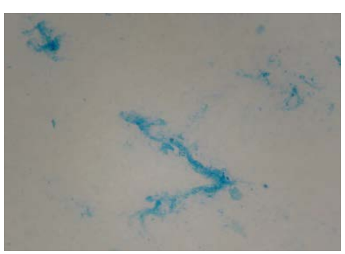
The Problem: An Analysis of Relevant Scales



Hypothesis on TEP, aggregation and carbon flux

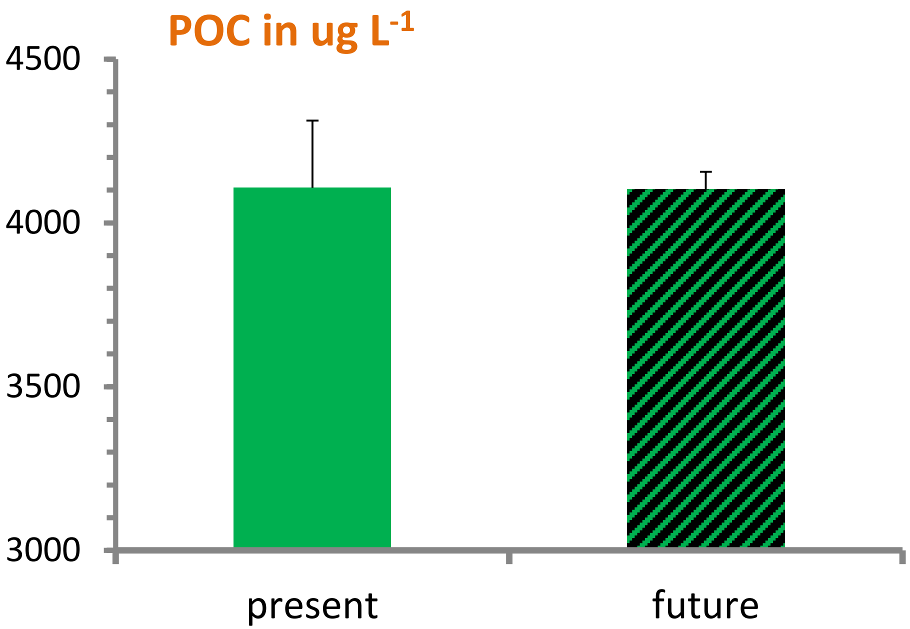


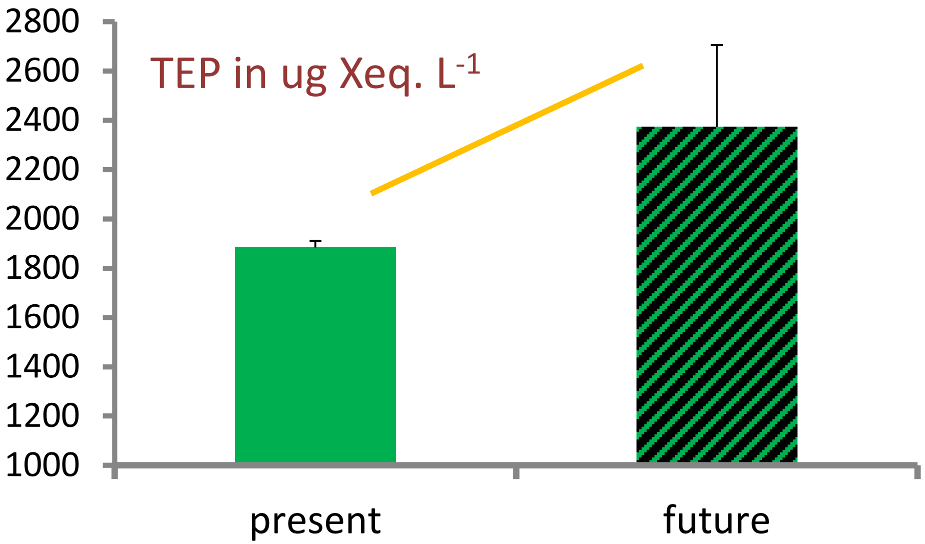
Adapted Arrigo 2007

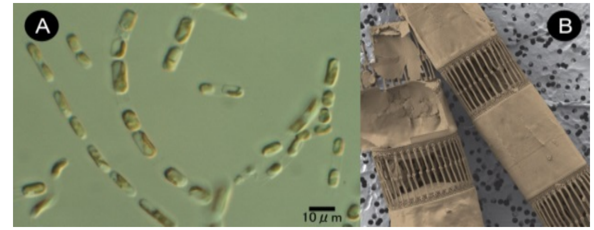


TEP = Transparent Exopolymer Particles: Sticky exopolysaccharides that form the matrix of most sinking marine snow

POC & TEP production as a function of pCO_2 (exp. 1)







Skeletonema costatum

Note:

Population level:

Higher pCO_2

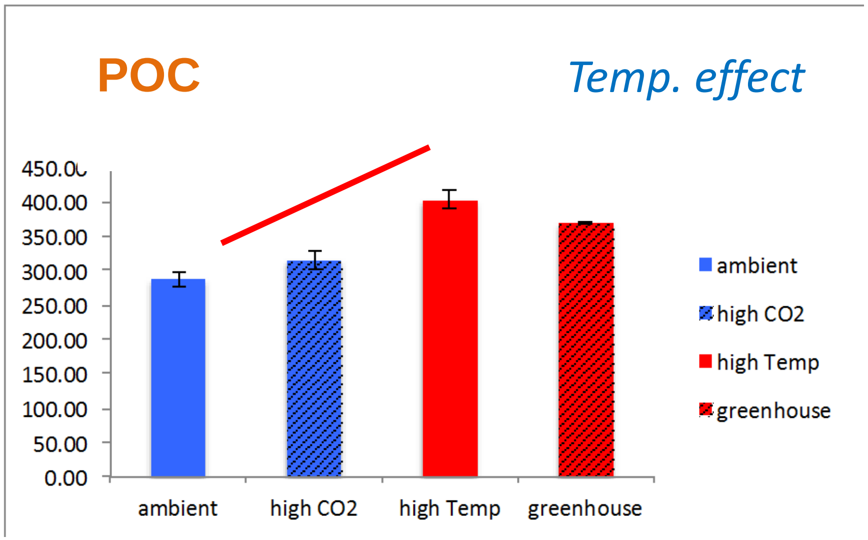
- has no impact on POC
- leads to increased TEP

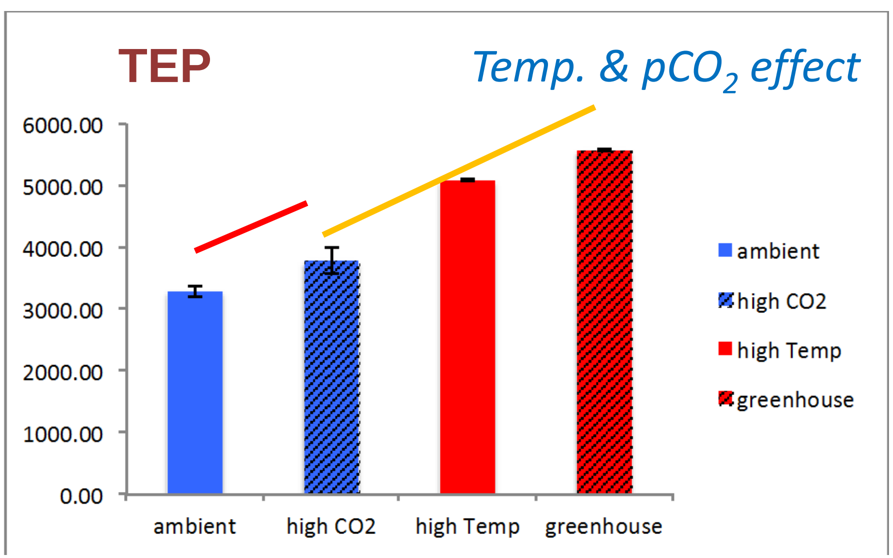
Batch growth till nutrient limitation

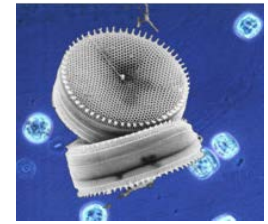
Rossi et al. in prep.

Carbon Fixation

POC & TEP production as a function of pCO_2 & temperature (exp. 3)







T. weissflogii: (CCMP 1336)

Note:

Population level:

Higher pCO_2

- no impact on POC
- increased TEP

Higher temperature

- increased POC
- Increased TEP

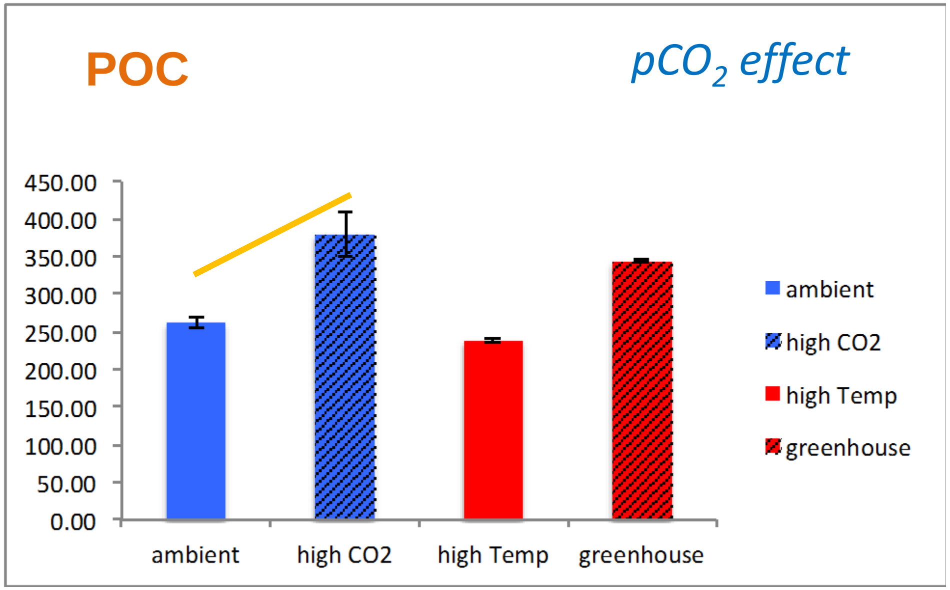
Batch growth after N-limitation

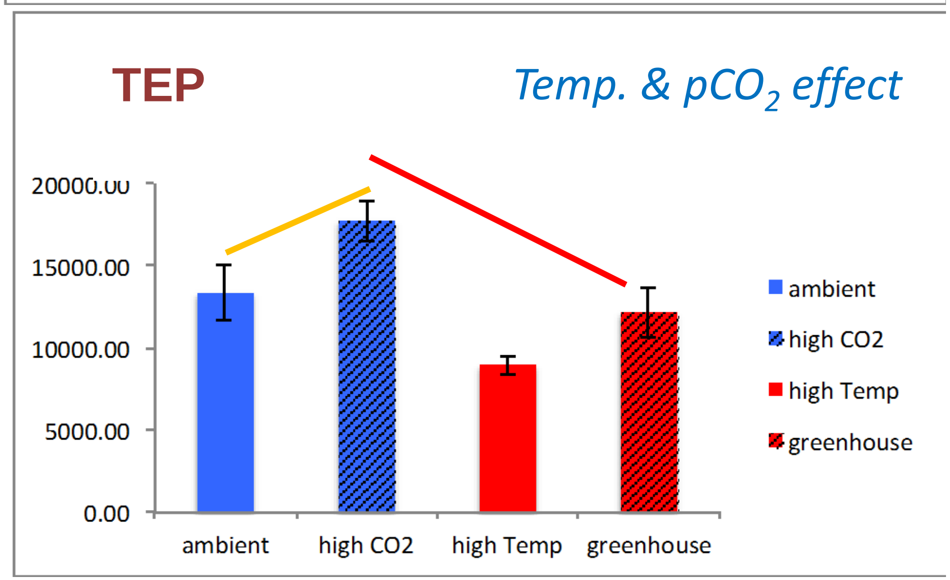
Taucher *et al*. L&O 2015

Carbon Fixation

POC & TEP production as a function of $p\mathrm{CO_2}$ & temperature (exp. 3)

Dactyliosolen fragilissimus





Note:

Population level:

Higher $p\mathrm{CO_2}$

- increased POC !!!
- increased TEP

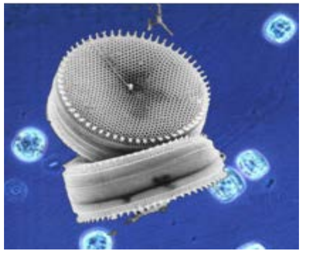
Higher temperature

- unchanged POC !!!
- decreased TEP !!!

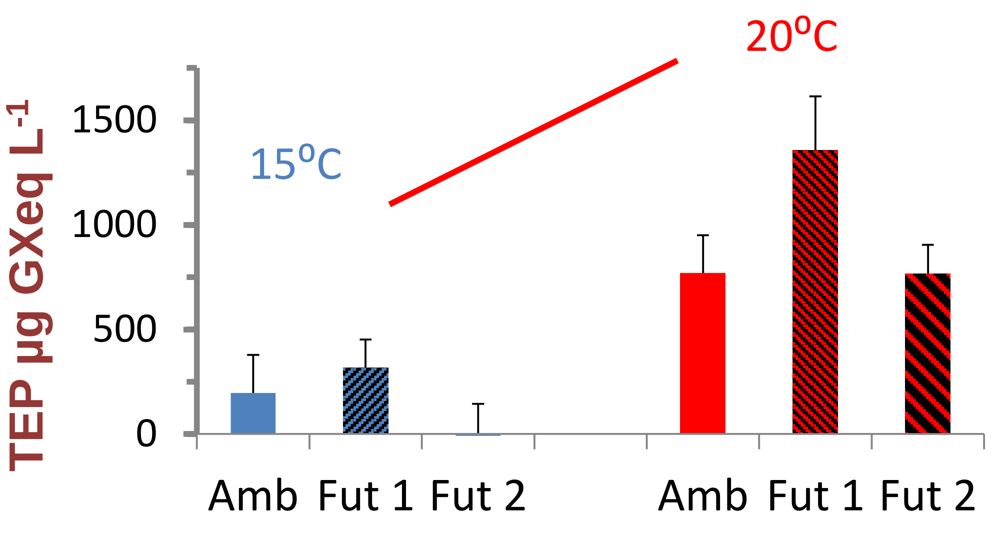
Batch growth after N-limitation

Taucher *et al*. L&O 2015

TEP Production as a function of $p\mathrm{CO_2}$ & temperature
(exp. 6)



T. weissflogii: (CCMP1336)



Note:

Population level:

Higher $p\mathrm{CO_2}$:

- No consistent effect on TEP!!!

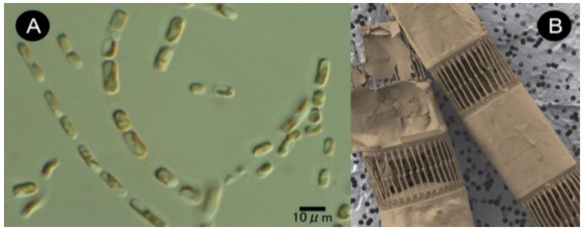
Higher temperature:

- increased TEP

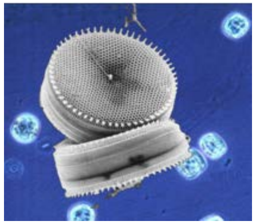
Seebah *et al.* PLOS ONE 2014

Why is there no consistent response pattern of POC and TEP to increased temperature and pCO_2?

Three coastal diatoms, all bloom forming



Skeletonema costatum



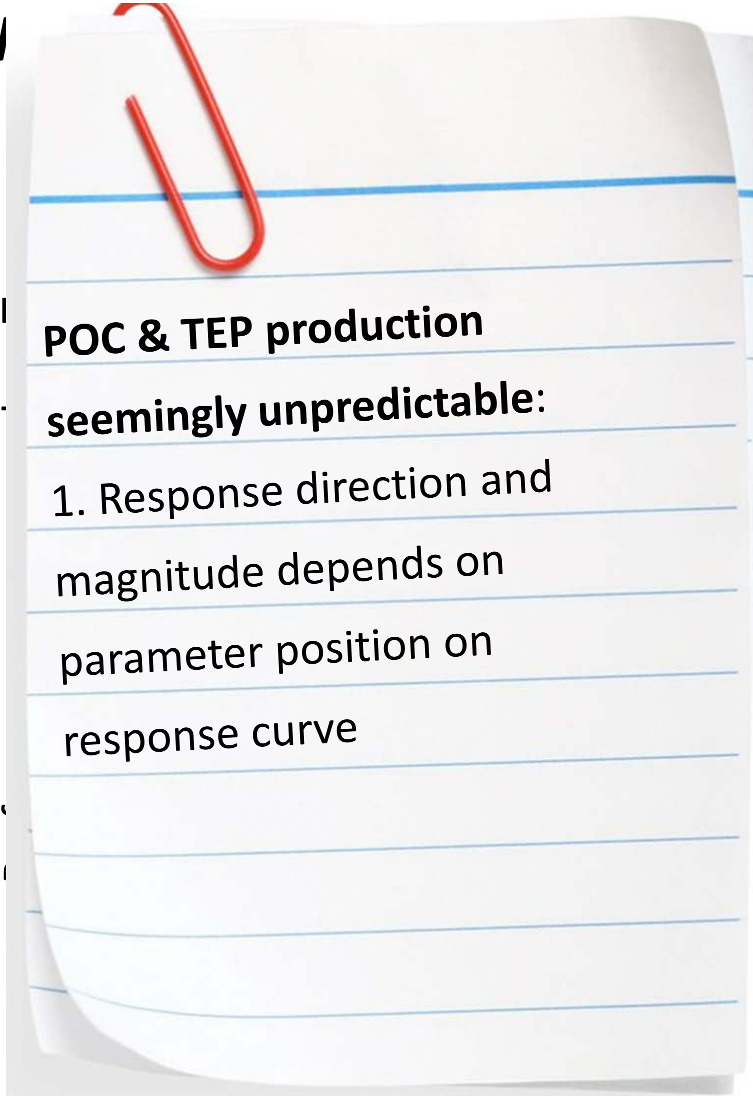
T. weissflogii:

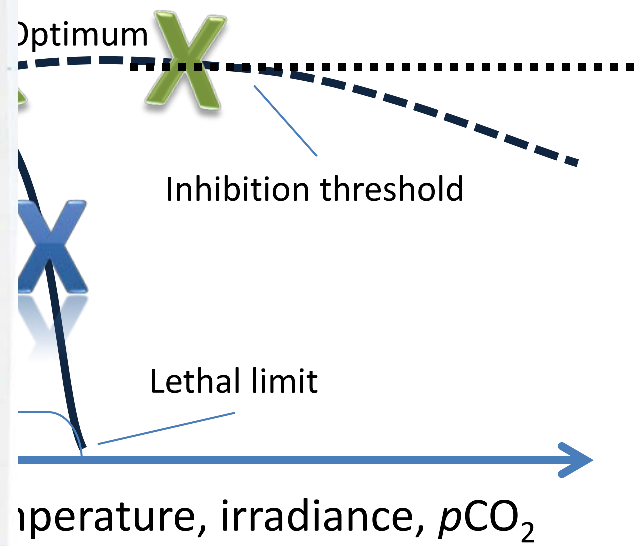
Dactyliosolen fragilissimus

1. Keeping Perspective

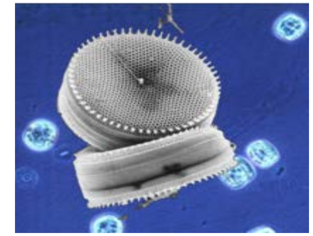
Singl ***ts:*** *A fixed change in stressor may* *ers*

Pe urves



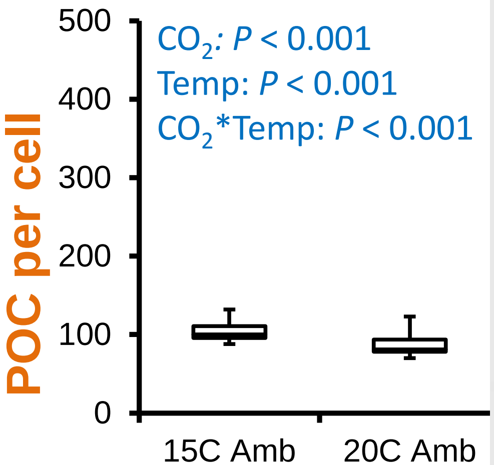


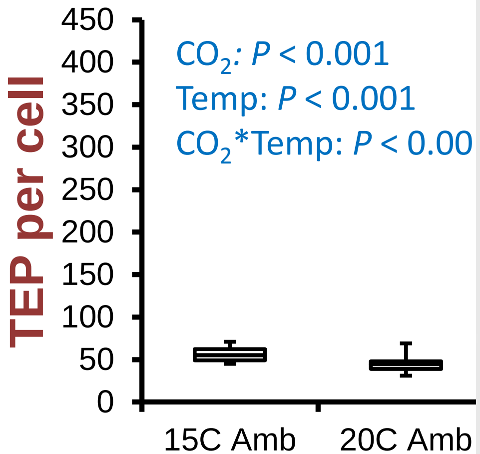
2. Interactive effects of multiple stressors (exp. 2)



eissflogii (CCMP 1053)

pCO$_2$ & Temper

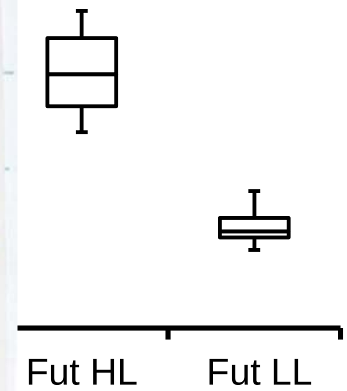


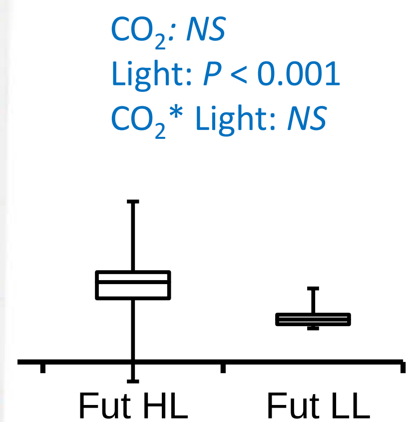


POC & TEP production seemingly unpredictable:

2. Multi-stressor effects are not the sum of the individual stressors. (Cellular response to pCO$_2$ depends on light climate or temperature)

3. Physiological responses complex and species specific



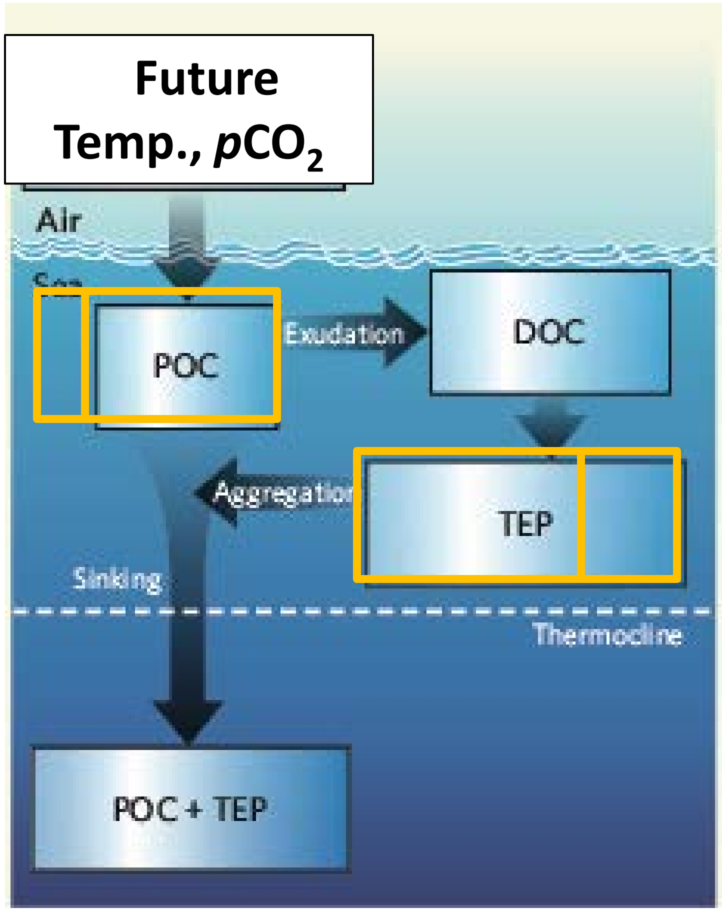


sow & Laws subm.

Partitioning: POC, DOC & TEP:

1. Response direction and magnitude depends on parameter position on response curve
2. And on interactive effects between potential stressors (light, temp, nutrients,…)
3. Species specific physiology

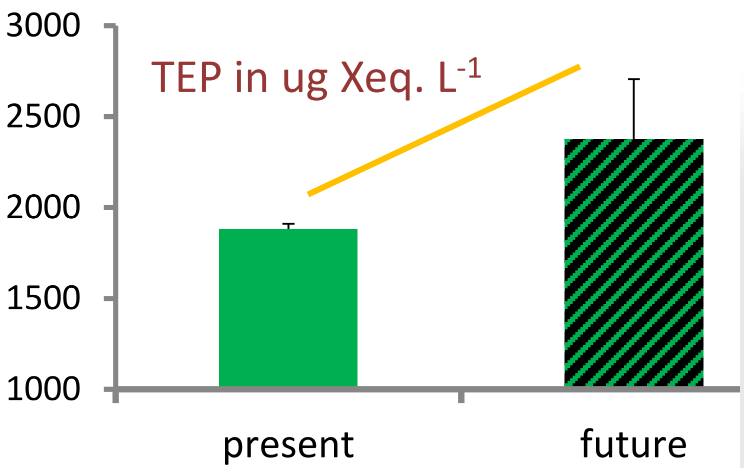
Hypothesis on POC and TEP production

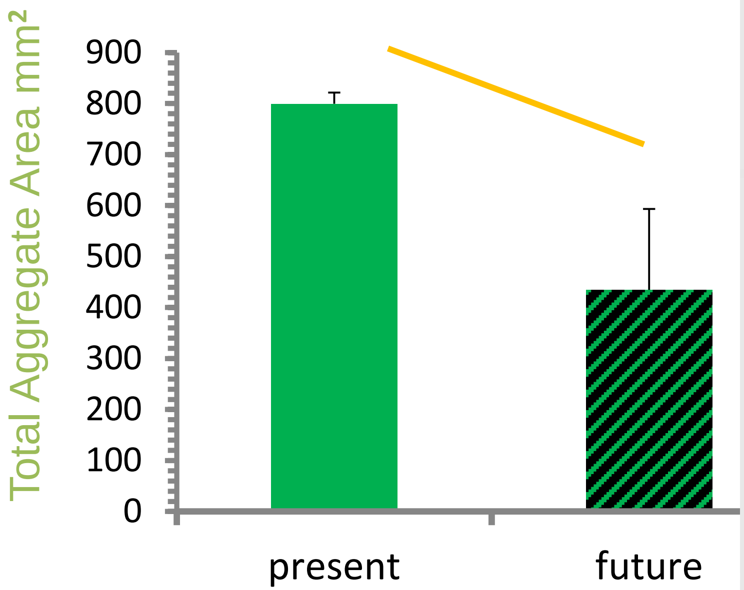


No *a priori* predictions on the net effect of increased temperature and pCO_2 for POC & TEP productions can be made at this time.

However, a predictive understanding may be possible.

Aggregation & sinking velocity as a function of pCO$_2$ (& TEP)(exp. 1)





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Aggregation & Sinking:

Higher pCO$_2$:

- Decreased aggregation (more TEP)
- no impact on sinking

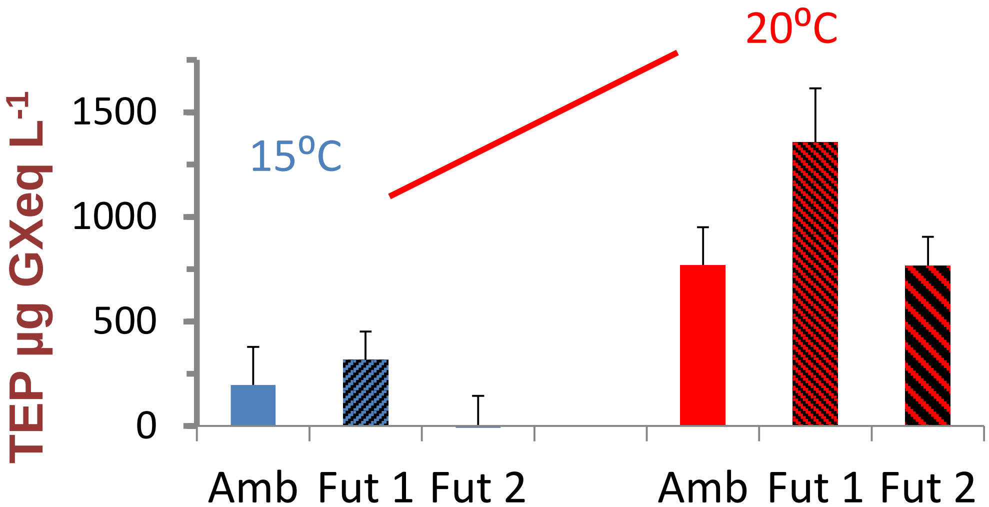
re

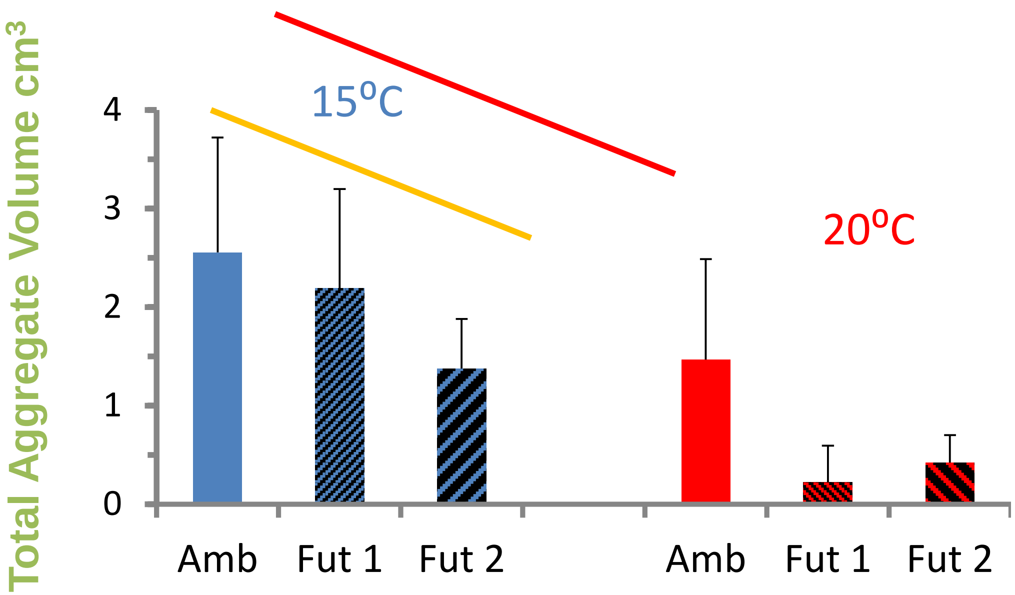
Rossi et al. in prep.

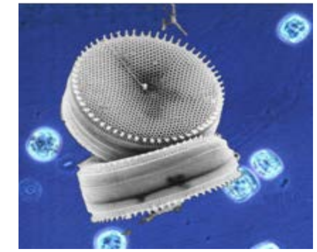
Aggregation

Sinking Velocity

Aggregation as a function of *p*CO_2 & temperature (and TEP)(exp. 6)







T. weissflogii:

Aggregation:

Higher *p*CO_2:

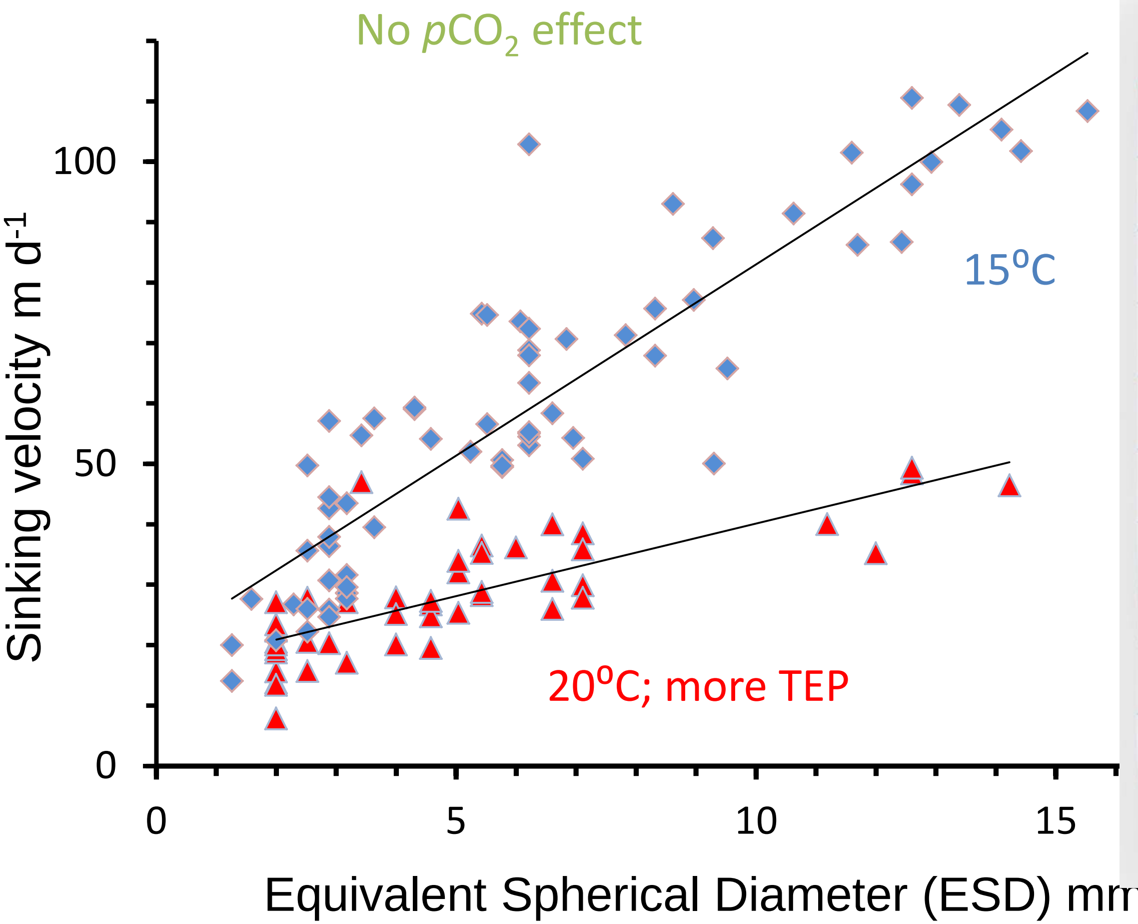
- decreased aggregation (independent of TEP)

Higher temperature:

- decreased aggregation (increased TEP)

Seebah *et al.* PLOS ONE 2014

Sinking velocity as a function of pCO_2 & temperature (exp. 6)



Sinking velocity:

Higher pCO_2:

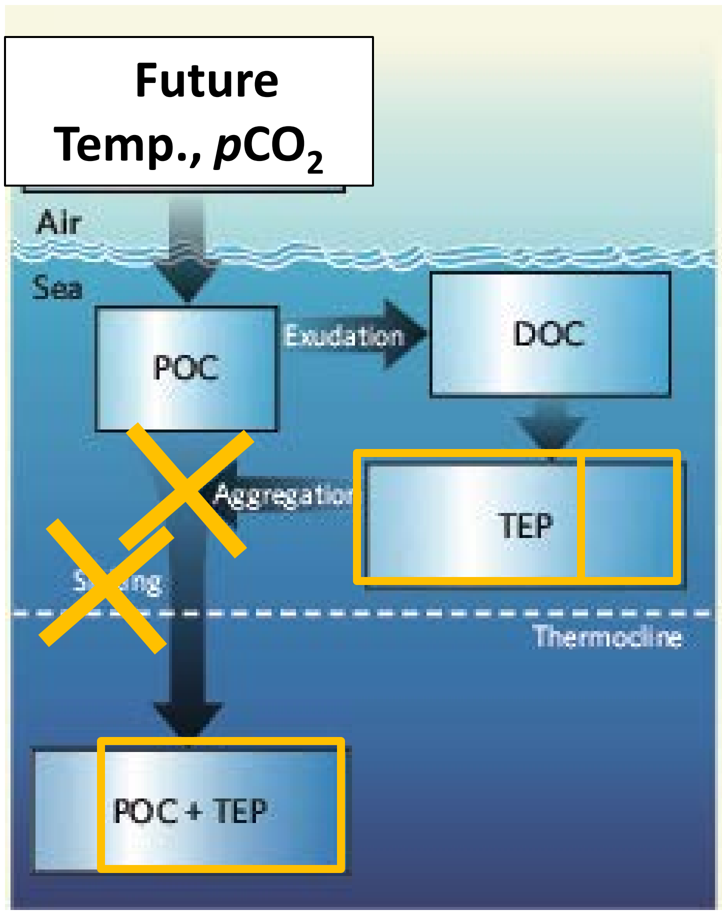
- no impact on sinking velocity

Higher temperature:

- decreased sinking velocity

Seebah *et al.* PLOS ONE 2014

Hypothesis on aggregation and sinking velocity

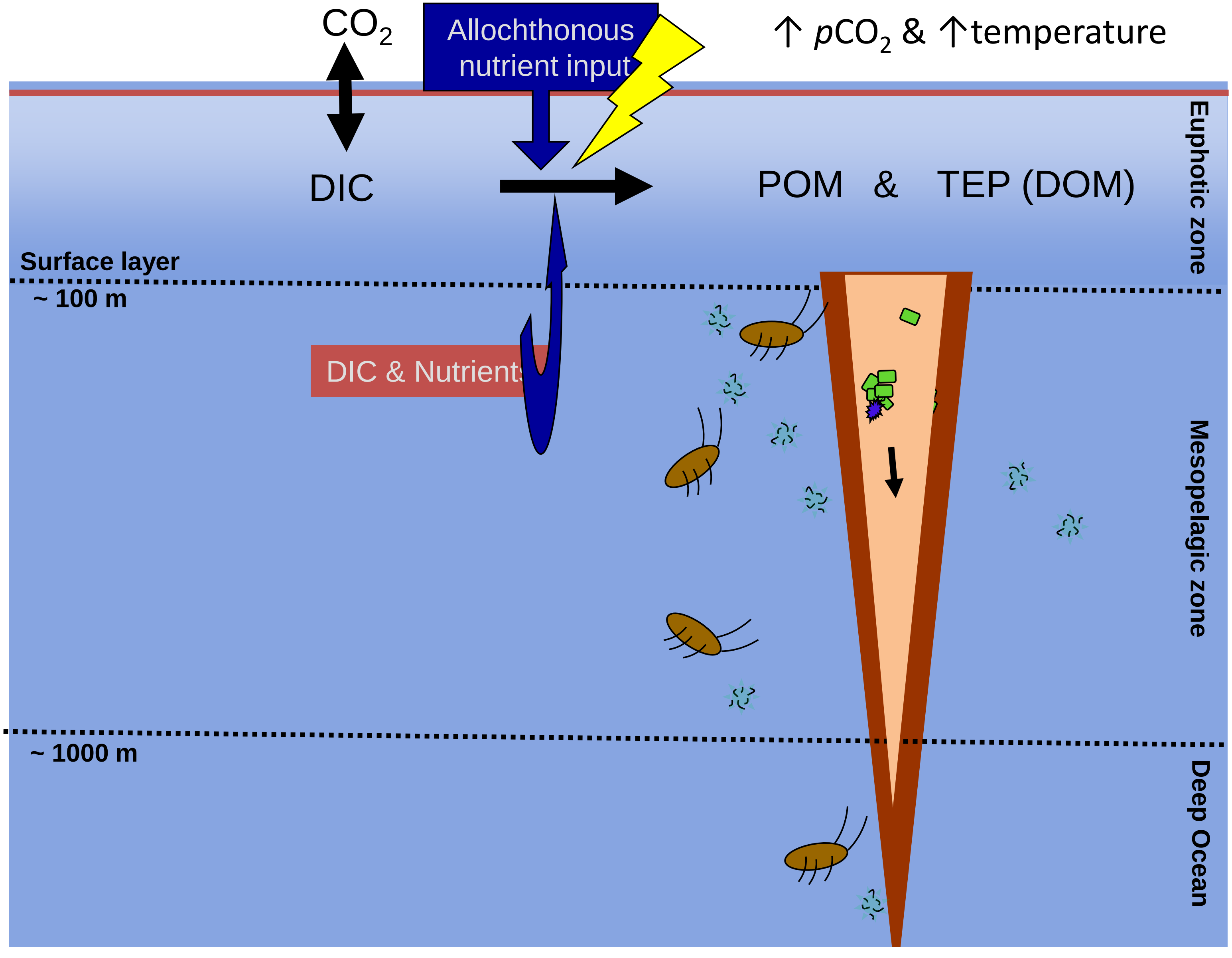


Note:

Higher TEP concentration did NOT result in more aggregation or in faster sinking

This evidence gives no reason to believe that BCP will be more efficient.

Carbon Sequestration by the Biological Pump



Conclusions

Summary & Conclusions

Carbon Fixation

- No *a priori* predictions with regards to carbon partitioning (between TEP and POC and DOC) as a function of increased temperature or pCO_2 currently possible. The response is a
  - function of stressor in relation to response curve of that species
  - function of species physiology
  - function of interactive effects of multiple environmental stressors

Aggregation & Sinking

- Aggregation rate decreased at high pCO_2 or high temperature
- Sinking velocity decreased at high temperature (more TEP), but no pCO_2 effect *per se* (or maybe a high TEP effect).

BCP

- Diatom aggregation section of the Biological Carbon Pump would suggest a weakening of carbon flux under high pCO_2 and high temperature conditions


Thank you!
Gotschalk