

# Effects of ocean acidification on the coccolithophore *Emiliana huxleyi* and their modulation by light

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## Background – The other CO<sub>2</sub> problem...

Increasing atmospheric CO<sub>2</sub> partial pressures (pCO<sub>2</sub>) lead to increased CO<sub>2</sub> concentrations and higher acidity in surface waters, a phenomenon known as ocean acidification (Figure 1). As the seawater becomes more corrosive for calcium carbonate (CaCO<sub>3</sub>), researchers' focus was especially directed towards calcifying organisms, like e.g. coccolithophores. By the formation and export of organic carbon and CaCO<sub>3</sub>, these calcifying microalgae sustain vertical gradients of dissolved inorganic carbon and alkalinity. Furthermore their shells aggregate with particulate organic matter and enhance its export by ballasting. These processes affect the CO<sub>2</sub> exchange with the atmosphere and thereby also Earth's climate.

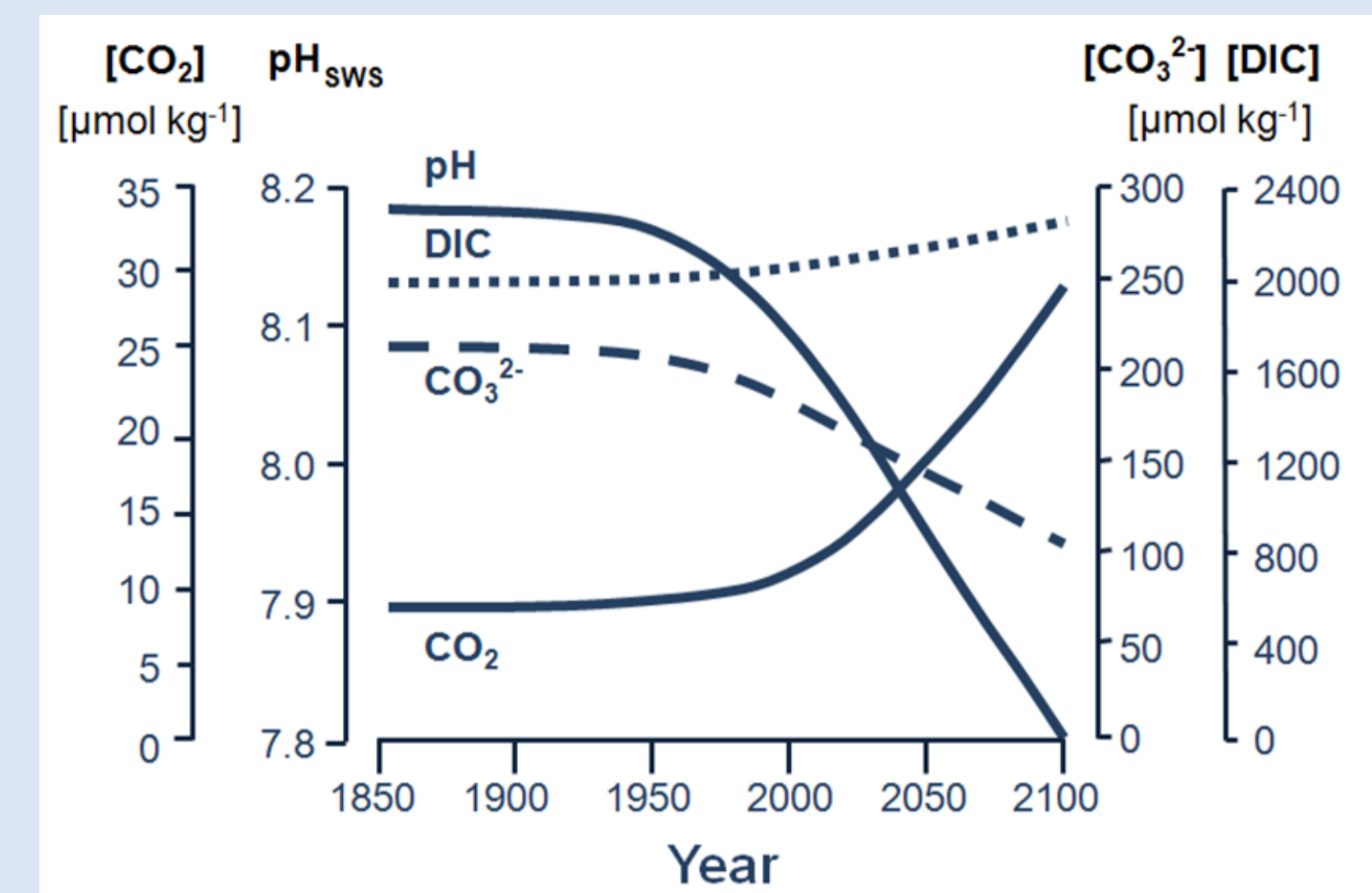


Figure 1: Ocean acidification; after Wolf-Gladrow et al. (1999)

## Past research – Diverse response patterns ...

Riebesell et al. (2000) found that in response to increased pCO<sub>2</sub>, the calcification rate was reduced in a strain of the coccolithophore *E. huxleyi*. Langer and coworkers (2006) found nonlinear response patterns or no responses at all in other coccolithophore species. Iglesias-Rodriguez et al. (2008) observed even increased calcification rates as an effect of high pCO<sub>2</sub>. Langer et al. (2009) could show that response patterns can differ between strains, i.e. within the very same species (Figure 2).

## This study – Interactive effects ...

As light is the only energy source for phototrophs and because energy supply is a crucial component in any biological system, we examined the effect of energy availability on the responses to ocean acidification. We acclimated the *E. huxleyi* strain RCC1216 to limiting and saturating light intensities (50 vs. 300 μmol photons m<sup>-2</sup> s<sup>-1</sup>; LL, HL) under ambient and high CO<sub>2</sub> levels (380 vs. 1000 ppm; LC, HC). Among other parameters, growth rates and cellular quotas of particulate organic as well as inorganic carbon (POC/PIC) were measured. Photosynthetic performance and cellular affinities to dissolved inorganic carbon (DIC) were assessed by means of membrane-inlet mass spectrometry.

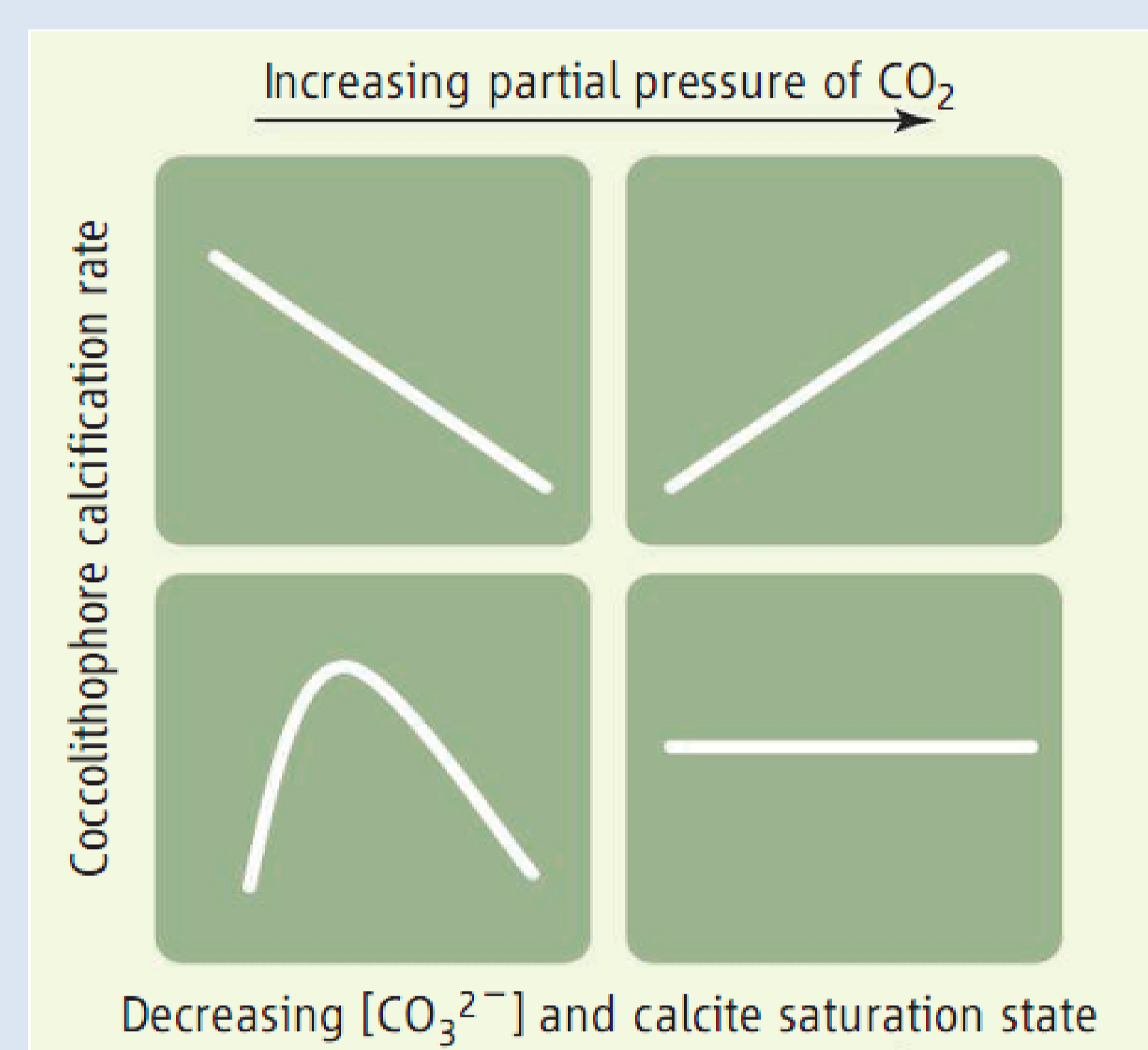


Figure 2: Results of different studies, compiled by Fabry (2008)

## Results – Mutual influence of effectors...

- POC production (Fig. 3A) increased as an effect of high pCO<sub>2</sub>, but this relative stimulation was more pronounced under low-light conditions.
- PIC production (Fig. 3B) declined due to increased pCO<sub>2</sub>, but the relative effect was stronger under low-light conditions.
- Cellular DIC-affinities as well as chlorophyll contents (Fig. 3C and D) did not significantly change in response to high pCO<sub>2</sub>.
- The rates of light saturated O<sub>2</sub> evolution (V<sub>max</sub>; Fig. 3E) and those that apply to acclimation conditions (V<sub>in-situ</sub>; Fig. 3F) decreased as an effect of high pCO<sub>2</sub>. These relative effects were more pronounced under low-light conditions.

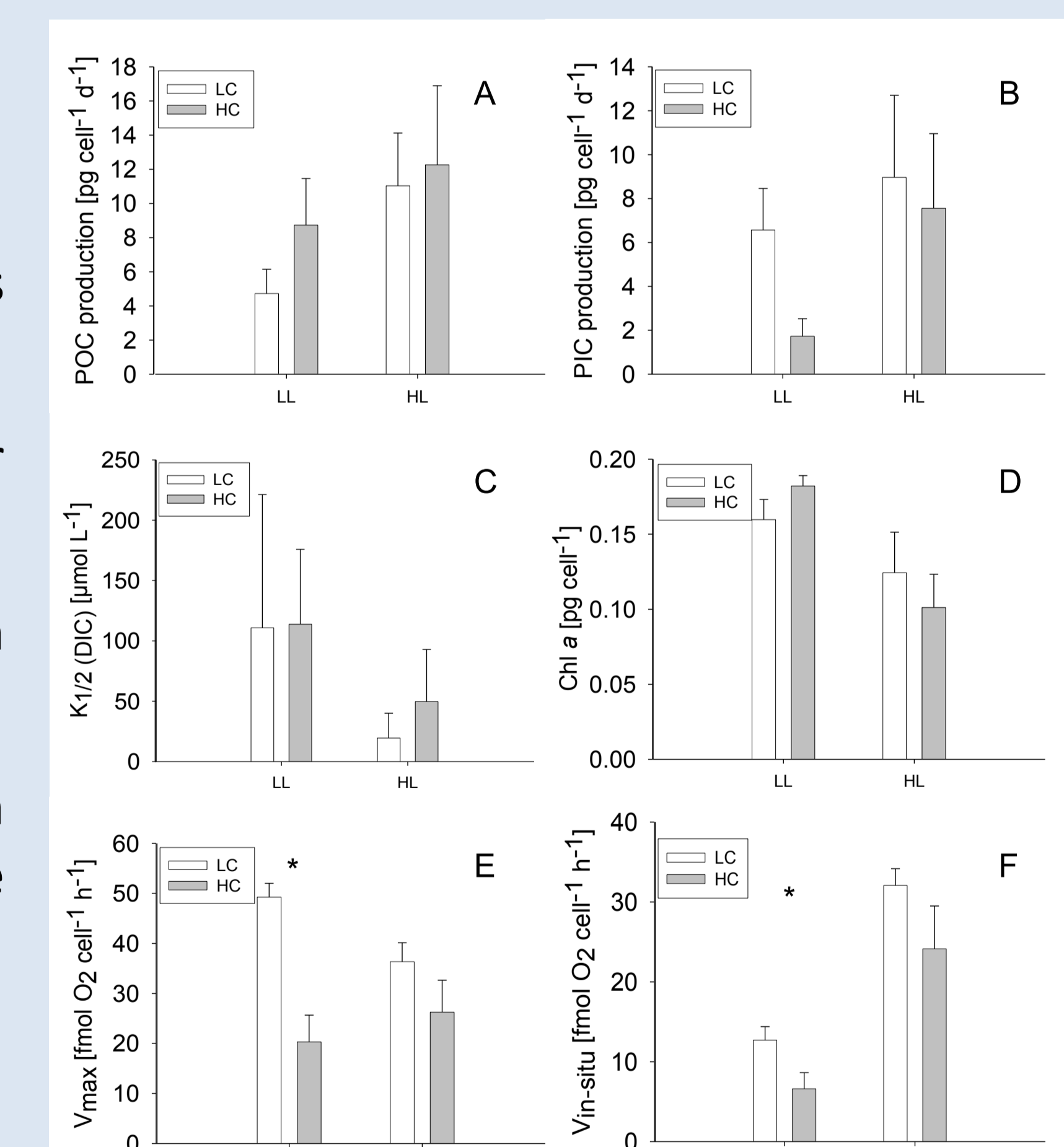


Figure 3: Physiological responses to pCO<sub>2</sub> and light intensity

## Conclusion – From response patterns to response landscapes...

- Ocean acidification response patterns are strongly modulated by energy availability, changing the amplitude or even inverting the observed trends (Fig. 3 A-F).
- Effects of ocean acidification were typically more pronounced under limiting light. Consequently *E. huxleyi* RCC1216 might cope (better) with future increased acidity, when energy availability is high.
- Despite a decreased energy generation which cannot be attributed to altered DIC-affinity or light harvesting properties, cells build up more biomass. This increased energy use efficiency may derive from either a reduced need for active DIC uptake and/or a reallocation of energy due to impaired calcification.

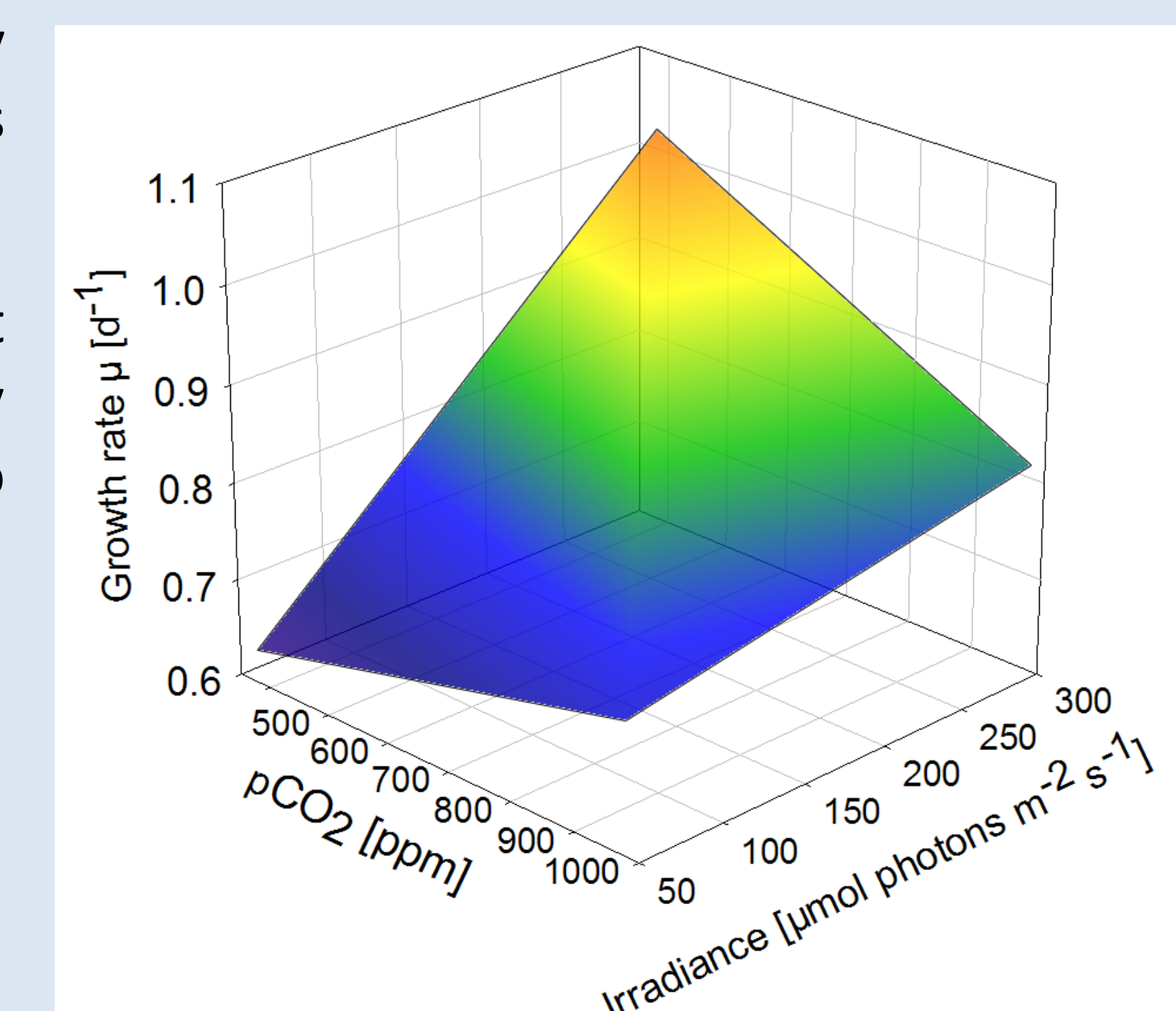


Figure 4: Growth rate in response to pCO<sub>2</sub> and light intensity

## References:

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