# Effects of ocean acidification on the photosynthetic performance, carbonic anhydrase activity and growth of the giant kelp *Macrocystis pyrifera**


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## BACKGROUND

•*M. pyrifera* underwater forests (Fig. 1) play an important ecological role in coastal marine ecosystems, providing habitat, protection and food for other species.

•Elevated $CO_2$ might down-regulate the carbon concentrating mechanisms (CCMs) and enhance growth rates of macroalgae.

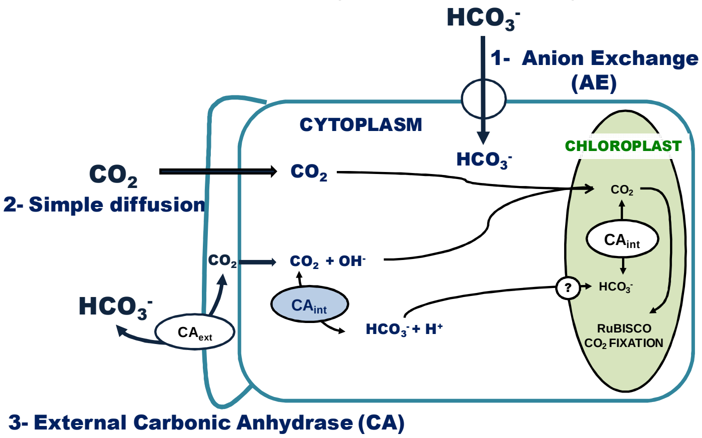


**Fig. 2:** Illustration of the main (1) and secondary (2-3) inorganic carbon (Ci) acquisition mechanisms described for *M. pyrifera* (Fernández et al. 2014).

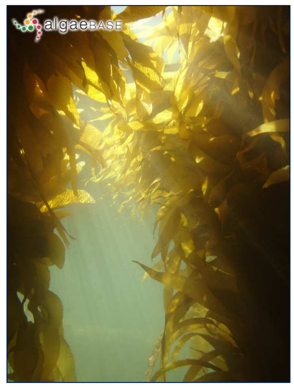


**Fig. 1:** *M. pyrifera* underwater forests, Wellington, New Zealand. Copyright Erasmo Macaya Horta.

**HYPOTHESIS:** CCMs (direct $HCO_3^-$ uptake and CA activities) of *M. pyrifera* will be down-regulated by elevated $CO_2$, whereas growth rates and photosynthesis will be enhanced.

## METHODS

•Excised discs from apical blades of 24 individuals of *M. pyrifera*
•Cultured at 12°C under 100 µmol m$^{-2}$ s$^{-1}$, nutrient-enriched SW (20 µM $NO_3^-$)
•$CO_2$ ambient (400 µatm; pH=8.1) *vs.* OA (1200 µatm; pH=7.6)
•Discs cultured for 7 d in an automated pH culture system (McGraw et al. 2010)
•Parameters measured: Photosynthetic and growth rates, external and internal carbonic anhydrase (CA), and $HCO_3^-$ vs $CO_2$ use.

## RESULTS

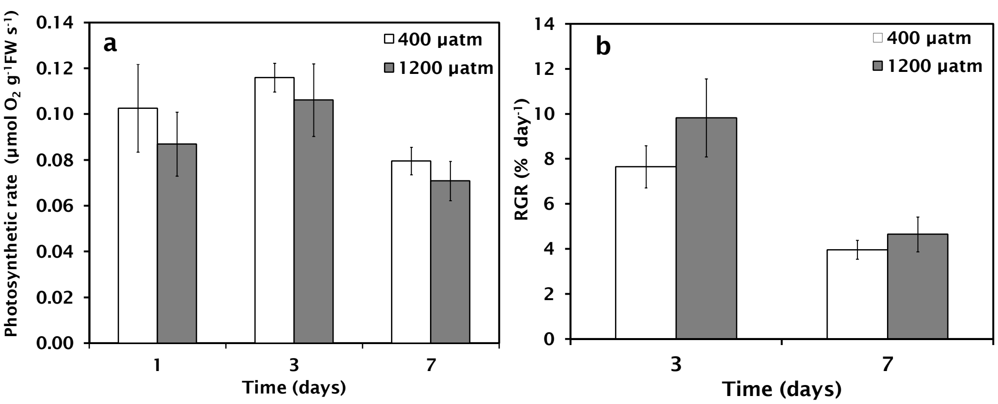


**Fig. 3:** No significant effect of $pCO_2$ treatments on (a) photosynthetic rate (Student's *t* test, P > 0.05) and (b) relative growth rate (ANOVA, P > 0.05) of *M. pyrifera*). Values represent (a) mean (n=4) ± SE and (b) (n=8) ± SE.

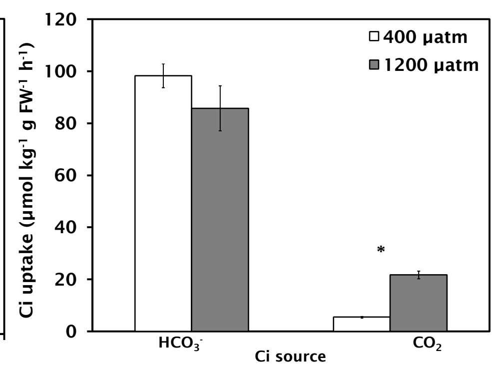


**Fig. 4:** $HCO_3^-$ uptake by *M. pyrifera* did not significantly vary between $pCO_2$ treatments (Student's *t* test, P=0.269), and was higher than $CO_2$ uptake, irrespective of the $pCO_2$ concentration in the medium (Student's *t* test, P<0.001). $CO_2$ uptake was significantly higher at 1200 µatm (Student's *t* test, P<0.001). Values represent mean (n=3) ± SE.

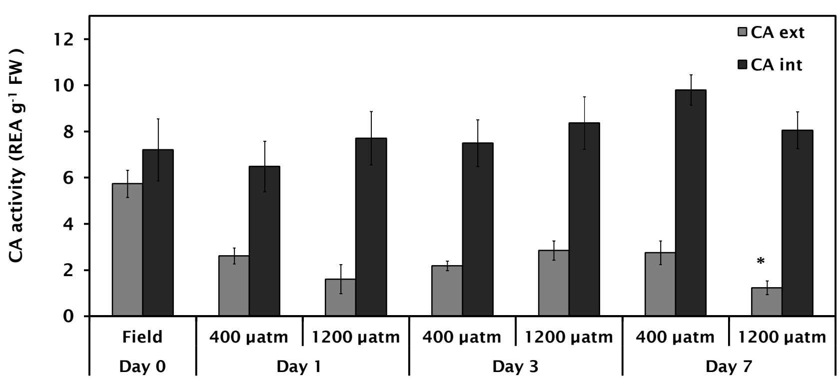


**Fig. 5:** The internal CA ($CA_{int}$) was consistently 4-times higher than external CA ($CA_{ext}$) activity in both $pCO_2$ treatments across all sampling days. On day 7, $CA_{ext}$ was reduced under the OA treatment (Student's *t* test, p=0.028). $CA_{int}$ remained high and active under both $pCO_2$/pH treatments (Student's *t* test, p=0.121). Values represent mean (n=8) ± SE.

## CONCLUSIONS

•Opposite to our hypothesis, CCMs (direct $HCO_3^-$ uptake and CA activities) of this species **WILL NOT BE** down-regulated by elevated $pCO_2$/low pH predicted for the future.

•Photosynthetic and growth rates of *M. pyrifera* **WILL NOT BE** enhanced under an OA scenario.


REFERENCES

•Fernández PA, Hurd CL, Roleda MY (2014) Bicarbonate uptake via an anion exchange protein is the main mechanism of inorganic carbon acquisition by the giant kelp *Macrocystis pyrifera* (Laminariales, Phaeophyceae) under variable pH. J Phycol 50: 998-1008.
*Fernández PA, Roleda MY, Hurd, CL (2015) Effects of ocean acidification on the photosynthetic performance, carbonic anhydrase activity and growth of the giant kelp *Macrocystis pyrifera*. Photosynth Res 124: 293-304.
•McGraw CM, Cornwall CE, Reid MR, Currie KI, Hepburn CD, Hurd CL, Hunter KA (2010) An automated pH-controlled culture system for laboratory-based ocean acidification experiments. Limnol Oceanogr Methods 8: 686-94.