Time of exposure and light intensity modify the photosynthetic and calcification response of coralline algae to ocean acidification (OA)

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Background and objectives

It is unclear how ocean acidification (OA) will affect mäerl/ rhodolith beds in a near future. Some inconsistencies among OA experiments are related to differences in methodology, time of exposure and the synergetic effects of other stressors. The objectives of this study were; **1)** to measure the long-term effects of OA on the respiration, photosynthesis and calcification of *Phymatolithon sp*. and **2)** to study the simultaneous effect of light and OA on the photosynthesis and calcification of the algae.

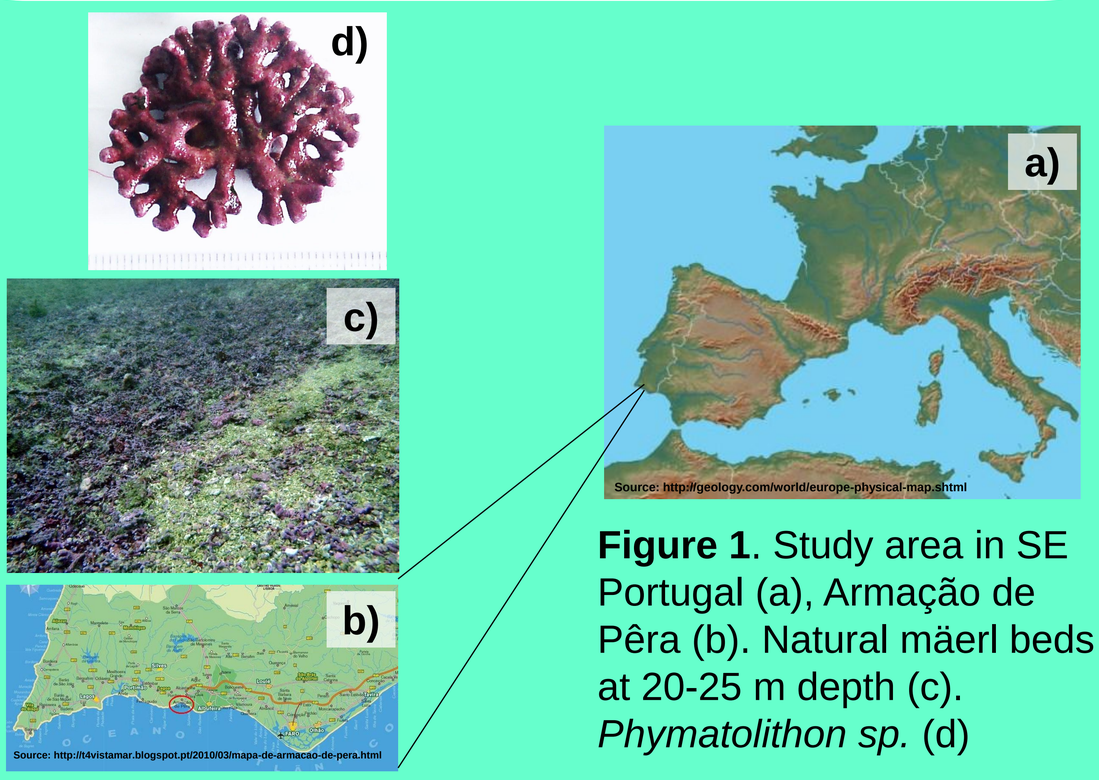

Figure 1. Study area in SE Portugal (a), Armação de Pêra (b). Natural mäerl beds at 20-25 m depth (c). *Phymatolithon sp.* (d)

Methods

Acidification effects (air-CO_2 mix bubbling) were evaluated over a **20 months period**. Three pCO_2 levels were tested: **control** (~390 ppm), **intermediate (550ppm**) and **high (750 ppm**) (Figure 2). Algae were gradually acclimatized to experimental conditions.

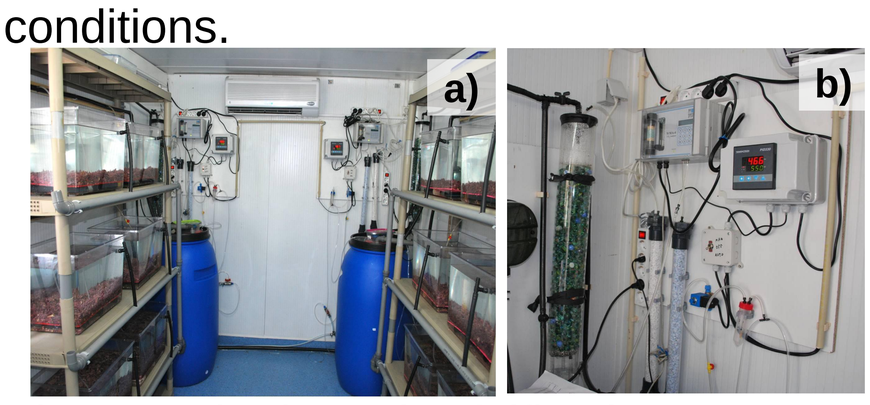

Figure 2. OA experimental system (a) and key components of CO_2 control system (b).

Photosynthetic and calcification rates were measured using chamber incubations (**dissolved oxygen evolution and alkalinity anomaly technique**) under different photosynthetically active radiation (PAR) levels (figure 3a). Calcification was also measured using the **buoyant weight technique (BW)** (figure 3b).

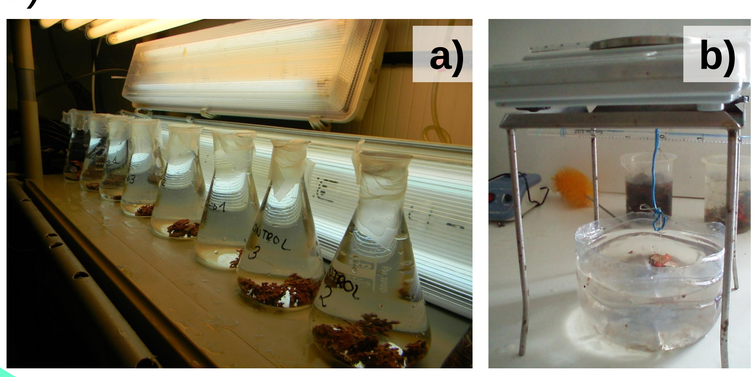

Figure 3. Incubation chambers (a) and BW measurements (b).

Results and discussion

Respiration, photosynthesis and calcification vs. PAR

The first 11 months, **respiration decreased with CO_2** and **photosynthesis** increased with CO_2 and light (figure 4). **Calcification** also **increased with CO_2 and light,** saturating at around 45 µmol $m^{-2}s^{-1}$ for acidified algae at 750 ppm, a much lower level than for photosynthesis (~200 PAR) (figure 5).

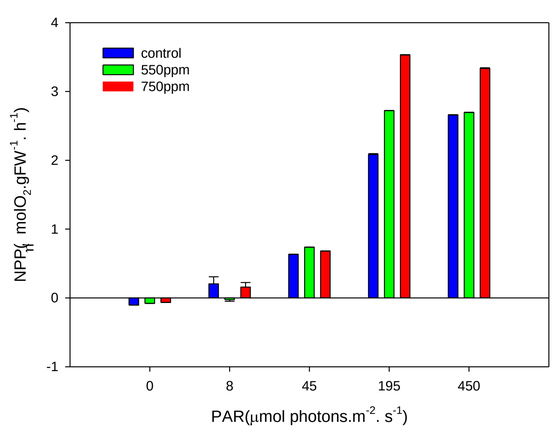

Figure 4. Photosynthetic rates (NPP) at different pCO_2 as a function of PAR. Means ± SE.

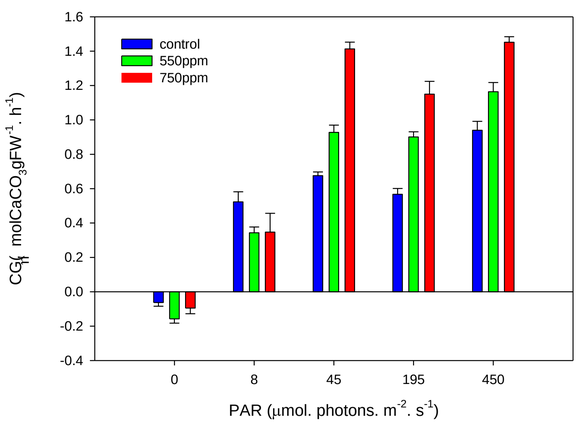

Figure 5. Calcification rates (CG) at different pCO_2 as a function of PAR after 11 months of treatment. Means ± SE.

Photosynthesis and calcification vs. time

Photosynthetic rates of acidified algae **increased** during the **first 11 months but decreased with CO_2 after 20 months of exposure** (figure 6). **Calcification/growth** rate also **decreased with time in acidified algae and proportionally to CO_2** (figure 7)**.** Control algae kept continuous rates and after 20 months of acidification presented the highest cumulative growth.

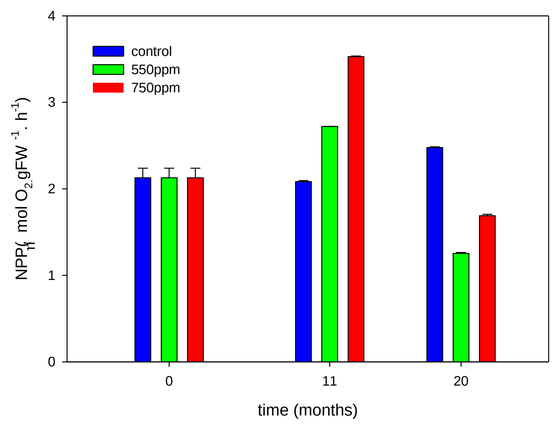

Figure 6. Photosynthetic rates (NPP) at different pCO_2 as a function of time. Means ± SE.

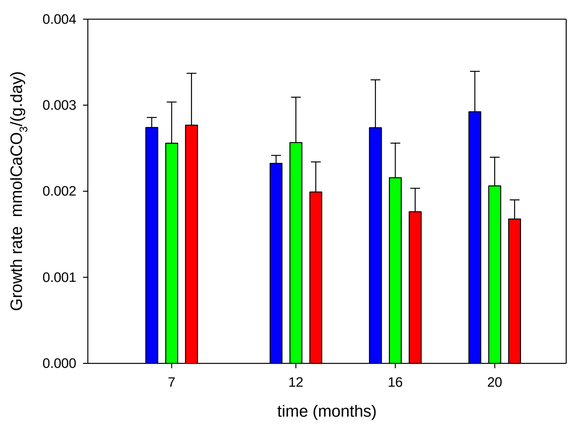

Figure 7. Calcification/growth rates at different pCO_2 as a function of time. Means ± SE.

Conclusions

We found that both the **time** of exposure and the **light** intensity **affect the predictions** of how ***Phymatolithon sp*. will respond to OA**. While in the **short-term** algae **increased their rates** to compensate the corrosive conditions of low pH, in the **long-term** both photosynthetic and calcification **rates decreased**.
Long term effects of OA, particularly at higher irradiances will be detrimental to these algae.

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