# Ocean acidification effects on productivity in a coastal Antarctic marine microbial community

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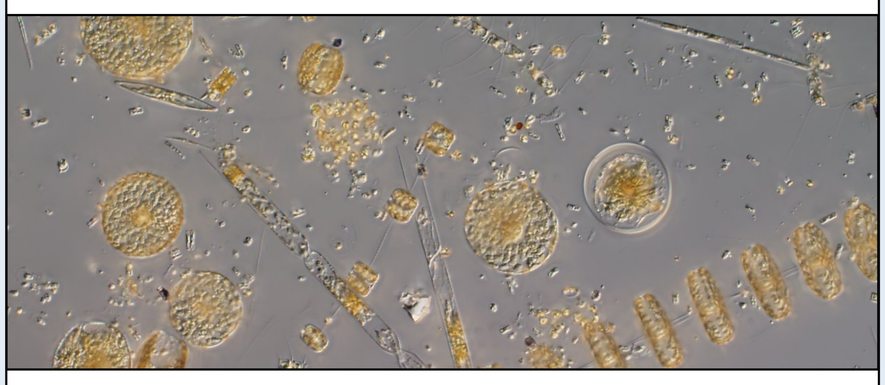
## Introduction

The oceans have absorbed approximately 30% of the anthropogenic $CO_2$ released to the atmosphere, of which approximately 40% has been absorbed by the Southern Ocean[1,2]. Marine microbes (phytoplankton, protozoa and bacteria) are critical drivers of the biological pump and the cycling of carbon in the ocean[3]. Despite their importance, little is known of the effects of increased $CO_2$ on marine microbes in Antarctic waters.

## Methods

### Minicosms

- Six 650 L minicosm tanks were filled with a natural community of Antarctic marine microbes from near-shore waters off Davis Station, Antarctica.
- Each tank was acclimated to $CO_2$ concentrations between ambient (343 ppm) and 1641 ppm over 5 days at low light.
- Light was increased to saturating intensity between days 5 and 7.
- Tanks were incubated until the nutrients were exhausted (day 18).
- Samples were obtained every two days.



### Primary & Bacterial Productivity

- Primary productivity was measured through the uptake of $^{14}$C-bicarbonate[4] over 21 light intensities.
- P vs. I curves were modelled from productivity data.
- Bacterial productivity was measured through the uptake of $^{14}$C-Leucine[5] in the dark.

### Cell Abundance

- Phytoplankton abundance was estimated using Chlorophyll *a* (Chl *a*) concentration via High Performance Liquid Chromatography[6].
- Bacterial counts were determined by flow cytometry[7].

## Primary Productivity

- Chl *a* concentration and gross primary production decreased with increasing $CO_2$ concentration (Fig. 1a-b).
- Chl *a*-specific primary productivity decreased with high $CO_2$ (Fig. 1c).

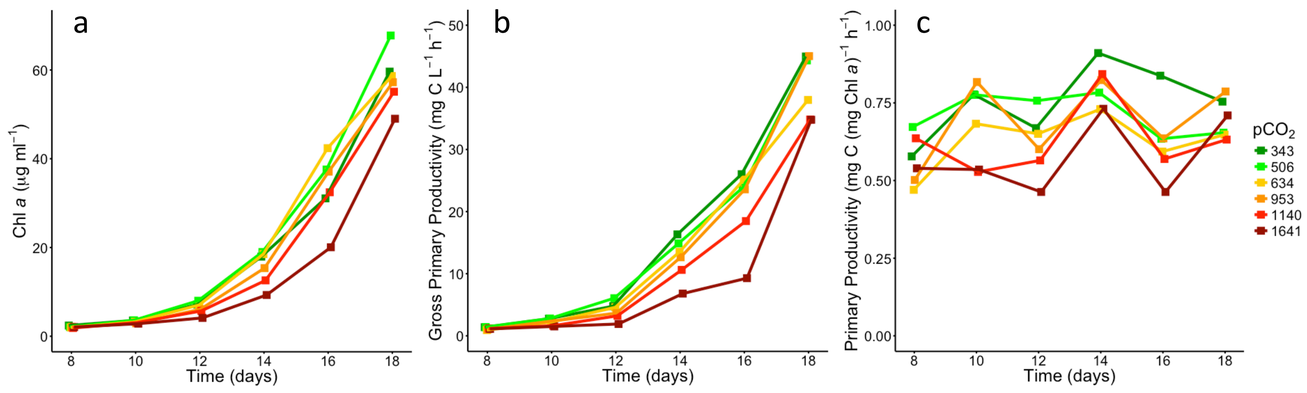



Figure 1. a) Chlorophyll *a* abundance, b) gross primary productivity, and c) Chl *a*-specific primary productivity in all $CO_2$ treatments. Results for incubation period shown (days 8-18).

- Elevated $pCO_2$ affected photophysiology by decreasing;
  - photosynthetic rate ($P_{max}$) (Fig. 2a),
  - maximum photosynthetic efficiency (α) (Fig. 2b),
  - photoinhibition rate (β) (not shown).
- $pCO_2$ did not affect saturating irradiance ($E_k$) (Fig. 2c).

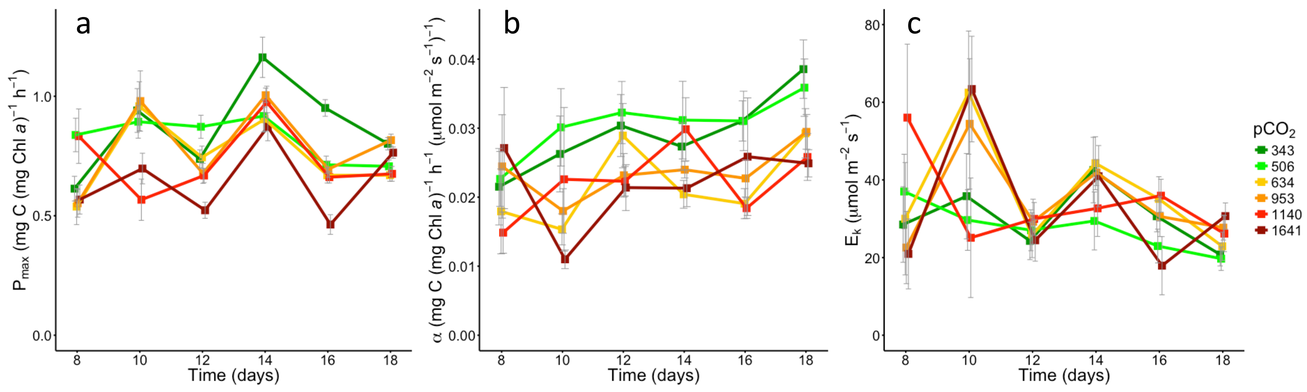



Figure 2. a) Maximum photosynthetic rate ($P_{max}$), b) maximum photosynthetic efficiency (α), and c) saturating irradiance ($E_k$) of phytoplankton in all $CO_2$ treatments. Results for incubation period shown only (days 8-18).

## Bacterial Productivity

- Bacterial abundance was commonly higher in high $CO_2$ treatments (Fig. 3a).
- Bacterial cell abundance declined through increased bacterivory, however it did not abate the exponential increase in the rate of cell-specific bacterial productivity (Fig. 3b).
- Gross bacterial production differed little amongst $CO_2$ treatments (except at 600 ppm) (Fig. 3c).
- Rates of productivity were highest at 600 ppm $CO_2$.

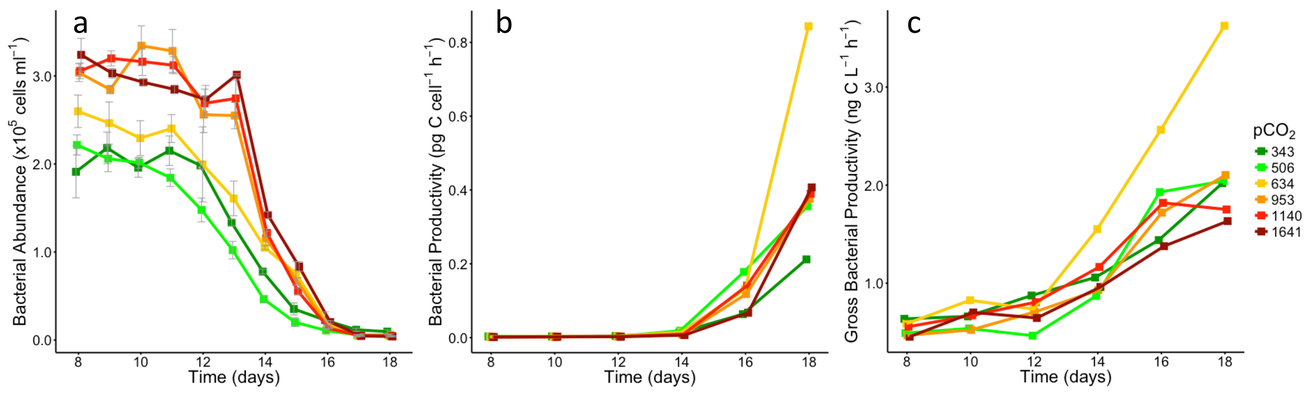



Figure 3. a) Bacterial abundance, b) cell-specific bacterial productivity, and c) gross bacterial productivity in all $CO_2$ treatments. Results for incubation period shown only (days 8-18).

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## Conclusions

- Increased $pCO_2$ negatively affected phytoplankton by decreasing phytoplankton biomass and rates of productivity.
- Bacteria appear to tolerate high $CO_2$ conditions.
- The $CO_2$-induced decrease in productivity and cell growth in Antarctic phytoplankton communities are likely to reduce the future $CO_2$ uptake by the Southern Ocean. This decrease will likely exacerbate global warming.

## References

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