Growth and Functional Analyses of Photosynthetic Strategies of *Prochlorococcus* Strains Under Varying Oxygen

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Introduction

Prochlorococcus:

- Photosynthetic unicellular cyanobacterium [1]
- Contributes most primary production in the open oceans. [2]
- Different strains occupy a wide range of habitats, including Oxygen Minimum Zones. [3]
- With climate change, ocean warming will benefit *Prochlorococcus*, but also cause decreased oxygen solubility.[2]

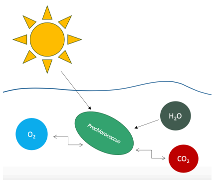

Figure 1: The biological interactions of *Prochlorococcus* with oxygen and light.

Objectives

1. Determine whether *Prochlorococcus* strains are constitutively able to accomodate changes in oxygen, or whether they acclimate over a period of time to different levels of oxygen.
2. Provide insights into the potential ecological niches of *Prochlorococcus* strains.

Methods

Biooptical Analysis of Growth Rates

Using a Multi-Cultivator, two strains of *Prochlorococcus* (MED4, MIT9313) were monitored for OD680 (Chlorophyll and scattering) and OD720 (cell scattering). Under 22°C, 12h photoperiod of blue light (450 ± 45 nm), and combinations of dissolved O_2 (250, 25, 2 μM) and light levels (30, 90, 180 μmol photons m-2 s-1).

Biooptical Functional Measurements

Exposed samples under 250, 25, 2 μM O_2, and a series of increasing light levels to track 'light response' curves of Photosystem II electron transport, using Solisense FRRf Instrument. Photosystem I and Photosystem II electron transport in parallel, using Dual-PAM-100 Instrument.

Results & Discussion

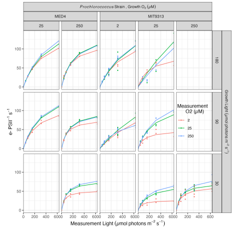

Figure 2: Light Response Curves of PSII electron transport (e- $PSII^{-1}$ s^{-1}) vs measurement light (μmol photons m^{-2} s^{-1}) for *Prochlorococcus* strains MED4 and MIT9313, after growth under combinations of light level (rows, 30, 90, 180 μmol photons m^{-2} s^{-1}) and oxygen concentration (columns, 2, 25, 250 μM). The curves were measured under 2 (red), 25 (green), or 250 (blue) μM O_2. Lines show Platt curve fits.

- Both strains show significant short term responses of electron transport to decreasing oxygen. Growth under 2 μM O_2 diminishes the short term effects of changing measurement oxygen, indicating growth acclimation to oxygen status.

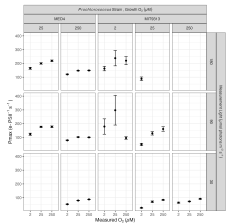

Figure 3: Maximum PSII Electron Transport Rate (Pmax) for *Prochlorococcus* MED4 and MIT9313, derived from light response curve fits, vs. measurement oxygen concentrations (error bars = SE). Data is grouped by strain and growth oxygen concentration (columns), and by growth light levels (rows).

- Strain MED4 shows increasing Pmax values across increasing measurement oxygen concentrations, indicating short term responses to varying oxygen levels. Pmax also incresses with increasing light levels and with growth at 25 μM O_2.
- Strain MIT9313 shows interactive effects of measurement oxygen, growth oxygen concentration and growth light on Pmax values. Particularly, between the lowest (2 μM) and highest (250 μM) oxygen concentrations, indicating acclimating adaptation to varying oxygen levels.

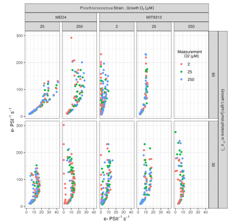

Figure 4: PSI electron transport (e- PSI^{-1} s^{-1}) vs PSII electron transport (e- $PSII^{-1}$ s^{-1}) for *Prochlorococcus* strains MED4 and MIT9313 after growth under different combinations of light level (30, 90 μmol photons m^{-2} s^{-1}) and oxygen concentration (2, 25, 250 μM). Mesurement under 2.5 (red), 25 (blue), or 250 (green) μM O_2.

- Directly comparing PSI to PSII electron transport shows that in MED4 growth under 25 μM O_2 decreases PSI electron transport.
- In contrast, in MIT9313, PSI electron transport remains more consistent across growth O_2 concentration.

Conclusion & Next Steps

Prochlorococcus shows both long and short term responses to oxygen.

- Cell pellets for future transcriptomic analyses.
- Monitoring electron carrier reduction status through Whole Cell Absorbance Spectra.

References

1. Worden AZ, Chisholm SW, Binder BJ. In Situ Hybridization of Prochlorococcus and Synechococcus (Marine Cyanobacteria) spp. With rRNA-Targeted Peptide Nucleic Acid Probes. Applied and Environmental Microbiology. 2000;66: 284–289.
2. Flombaum P, Gallegos JL, Gordillo RA, Rincón J, Zabala LL, Jiao N, et al. Present and future global distributions of the marine Cyanobacteria *Prochlorococcus* and *Synechococcus*. Proceedings of the National Academy of Sciences. 2013;110: 9824–9829.
3. Paul S, Dutta A, Bag SK, Das S, Dutta C. Distinct, ecotype-specific genome and proteome signatures in the marine cyanobacteria Prochlorococcus. BMC Genomics. 2010;11: 103.