Prochlorococcus wild – Appetite for Light!
Light effects on the uptake of amino acids and phosphate in natural microbial populations at Station ALOHA

Introduction
In the oligotrophic North Pacific subtropical gyre (NPSG) the availability of essential bio-elements, such as nitrogen or phosphorus, may be limiting microbial production. The presence of high-affinity uptake systems for inorganic nutrients, or the ability to utilize organic compounds, which are present in relatively higher concentrations, may constitute an ecological advantage. However, the acquisition and transport of select compounds are often energy requiring processes, which may lead to evolutionary trade-offs and act as a selective force shaping the microbial community composition.

We are interested in furthering our understanding of group specific rates of production, nutrient acquisition and energy allocation within the microbial community, and the mechanism by which groups of organisms compete for limited resources in the sun lit oligotrophic environments of the subtropical oceans.

Using radio-labeling techniques coupled with cell sorting by flow cytometry, we investigated the cell specific amino acid (3H-leucine) and inorganic phosphate (32P-PO4) uptake by Prochlorococcus and non-pigmented bacteria in field collected samples at Station ALOHA in the North Pacific subtropical gyre (NPSG).

Results

Figure 2. Cytograms of A: unstained sample showing the Prochlorococcus (PRO) population and fluorescent reference beads (1.0 µm) and B: SYBR Green I stained sample showing low nucleic acid (LNA) cells as defined by relative green fluorescence.

Figure 3. Leucine assimilation (pmol L⁻¹ h⁻¹) in the light (L) and dark (D)
A: whole water populations L=yellow, D=black. B: Prochlorococcus L= light green, D=dark green; LNA L=light brown, D=dark brown. C: L:D ratios – whole water = red, Prochlorococcus = green, LNA=black

Figure 4. Phosphate uptake (pmol L⁻¹ d⁻¹) in the light (L) and dark (D)
A: whole water populations L=yellow, D=black. B: Prochlorococcus L= light green, D=dark green; LNA L=light brown, D=dark brown. C: L:D ratios – whole water = red, Prochlorococcus = green, LNA=black

Photosynthesron experiments

Figure 5. ³H-leucine uptake (dpm cell⁻¹) at different light intensities in natural populations of Prochlorococcus collected at 45 m and 125 m.

- Prochlorococcus leucine L:D assimilation ratios was a factor of ~6 (Figure 3 B,C)
- In the LNA subpopulation of the SYBR Green I stained cells, the Light:Dark assimilation was approximately equal (Figure 3 B,C)
- Phosphate uptake rates by Prochlorococcus were increased in the light, but uptake in the LNA bacterial population appeared unaffected (Figure 4).
- Photosynthesron results revealed a rapid response in the 125 m population of Prochlorococcus with enhanced leucine uptake, as well as signs of photo-inhibition at high light intensities. The 45 m sample appeared to be saturated at all light intensities tested. (Figure 5).

Summary
- Light has fundamental effects on many processes in the metabolism of Prochlorococcus, beyond the quintessential photosynthesis process.
- Culture studies by C-MORE investigators at MIT, suggest that Prochlorococcus, on a gene expression level, leads a “highly choreographed” life governed by the daily light cycle.
- We show here that Prochlorococcus utilizes light energy to drive uptake and assimilation processes of both essential inorganic nutrients and organic compounds (here P and leucine). These light enhanced processes may allow Prochlorococcus to allocate its energy resources more efficiently and provide Prochlorococcus its competitive edge in these oligotrophic environments.