COMMENTARY

National Science Review
12: nwaf415, 2025
https://doi.org/10.1093/nsr/nwaf415
Advance access publication 25 September 2025

EARTH SCIENCES

Awaited paradigm shift in marine N_2 fixing ecology

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Crocosphaera watsonii (hereafter, *Crocosphaera*—note that, nowadays, this term technically includes broader taxa [1], but here it is used for UCYN-B and *Crocosphaera watsonii*, Fig. 1) has been thought of as one of the key nitrogen fixers in the surface ocean. However, its global impact has been overshadowed by other N_2 fixers, including *Trichodesmium*, *Richelia* and UCYN-A. For example, a recent review shows a map with limited *Crocosphaera* habitats [2], following earlier data compilation [3]. A machine-learning approach shows relatively small areas of *Crocosphaera* domination [4] and a recent metagenomic analysis shows that *Crocosphaera* did not dominate in any size classes [5].

At the same time, predictions and evidence for the high abundance of *Crocosphaera* did exist. An ecological simulation showed *Crocosphaera* analogue dominating in the North Pacific Ocean with effective iron utilization [6]. Although not genomically confirmed as *Crocosphaera*, a high abundance of nanoplanktonic cyanobacteria and their close correlation with the rate of N_2 fixation were observed in the North Pacific gyre [7] with a subsequent study having shown an even bigger niche of nanoplanktonic cyanobacteria, likely *Crocosphaera* [8]. The biomass of *Crocosphaera* was estimated to be substantially larger than those of even major non-N_2-fixing cyanobacteria, such as *Prochlorococcus* and *Synechococcus*, at a sampling point in the North Western Pacific [9]. However, deterministic evidence that demonstrated a wide area of *Crocosphaera* dominance was still missing.

Jiang *et al.* [10], together with a previous work from a similar region [11], convincingly shows that *Crocosphaera* dominates in an extended region in the Subtropical North Pacific, with measurements of the *nifH* gene abundance of major cyanobacterial diazotrophs. The results show that *Crocosphaera* dominates across a range of 10 degrees in latitude and 30 degrees in longitude—arguably the widest region of *Crocosphaera* domination observed to date in genomics studies. Jiang *et al.* [10] added these new data to the global dataset of N_2 fixers and ran a statistical model that showed a *Crocosphaera* niche beyond the observed area in the present study. These areas include the Southern Hemispheric Indian Ocean and the Central South Pacific Subtropical gyre. These predictions guarantee the importance of observations in these regions to test the dominance of *Crocosphaera* and the rate of N_2 fixation.

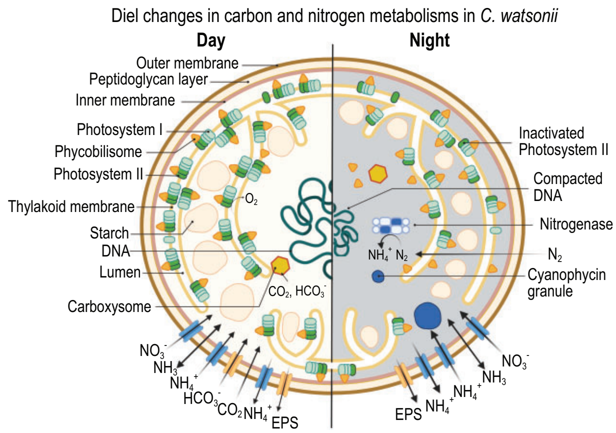

Figure 1. Schematics of UCYN-B or *Crocosphaera watsonii* cell and its day–night metabolic shift. Figure is adapted from Masuda *et al.* (2022) [12] under license number CC BY 4.0.

However, the mechanics of *Crocosphaera* domination still remain elusive. Useful information has been provided by the present study [10], in which the abundance of different N_2 fixers is related to three key factors: temperature, Fe and phosphate. Yet, challenges still remain because (i) there are overlapping relationships across taxa and (ii) these relationships provide limited ecophysiological interpretation. For example, regarding (i), there is an overlapping abundance–Fe relationship between *Crocosphaera* and *Trichodesmium*. Regarding (ii), an increasing abundance of *Crocosphaera* is associated with decreasing Fe above a certain threshold, but why is that the case? How does the unique diurnal metabolic cycle (Fig. 1 and [6,12]) support their niche? How does the heterogeneous metabolic population (i.e. mixture of N_2-fixing and non-N_2-fixing cells [13]) contribute to their regional dominance? A multi-methodological approach [14], synthesizing modeling and experiments, is essential in addressing such mechanistic uncertainties.

Conflict of interest statement. None declared.

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