Marine Ecosystem Experimental Chamber System
PART II: Scientific Needs

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Preface

The large-scale manipulative experiments conducted with MECS will include controls and replicates, and will have the advantage (1) over usual, small-scale laboratory experiments of including realistic environmental characteristics (e.g. density stratification and water depth), and (2) over in-situ mesocosm experiments of better control of key physiological parameters (e.g. temperature, light cycle). For example, it is possible to conduct simulated scenario studies on major geological events in earth's history, including global warming, glacial environment, ocean acidification, ocean sulfidation, ocean hypoxia, CH_4 production, and thus further collect a large-scale spatio-temporal environmental variables and ecological parameters. Such goals can not be achieved solely with experiments under contemporary natural environment.

BP / MCP Partitioning in a Changing Ocean

Global warming would change the contribution of Biological Pump (BP) and Microbial Carbon Pump (MCP) to carbon storage in the ocean. It would influence the physical processes such as stratification, mixing and ocean currents. Increasing stratification should restrict nutrient supply from deep water to the euphotic zone, and therefore impact primary production which in turn impact the export of POC. Thus the contribution of the BP to carbon storage could be expected to be relatively low in the warming ocean. Furthermore, the contribution of the Microbial Carbon Pump (MCP) to carbon storage could be expected to be relatively high in the oligotrophic ocean. A similar transition from dominance of the Biological Pump (BP) to dominance of the MCP might be expected along a latitudinal gradient from polar regions to the tropics and from surface waters to the mesopelagic (Figure 1). Such scenario would be simulated within MECS, and the hypothesis would be tested out.

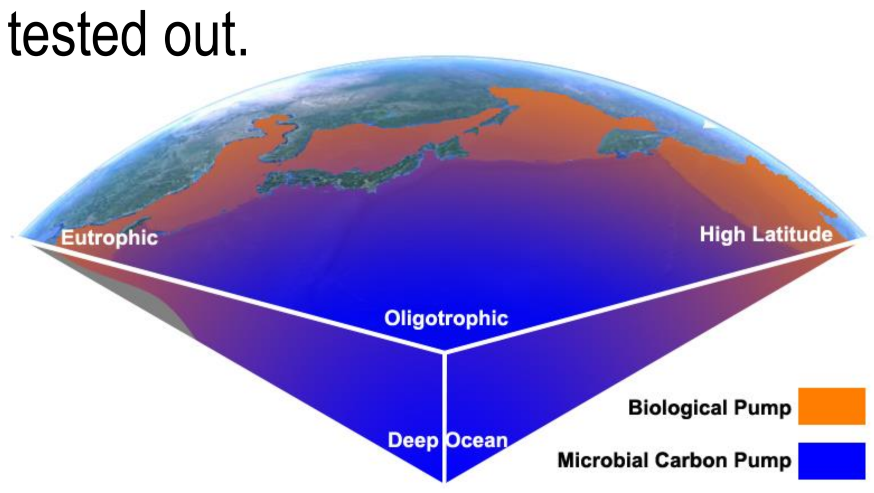

Figure 1 | A demonstration of trends in the relative dominance of the BP and the MCP along environmental gradients

(Jiao et al., Biogeosciences, 2014)

Processes affecting the flux of particles in the ocean

Autotrophic picoplankton dominate primary production over large oceanic regions but are believed to contribute relatively little to carbon export from surface layers. Recent studies show that the contribution of picoplankton to export is proportional to their total net primary production, despite their small size (Figure 2). More evidences would be test out in MECS.

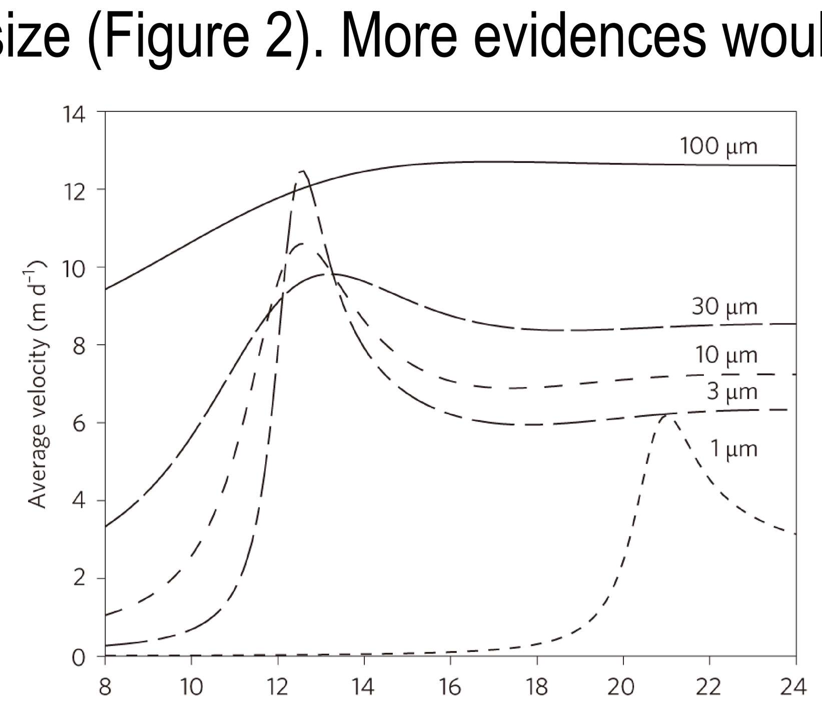

Figure 2 | Sinking velocity of different phytoplankton size classes

Richardson & Jackson, Science, 2007;
Herndl & Reinthaler, Nature Geoscience, 2013

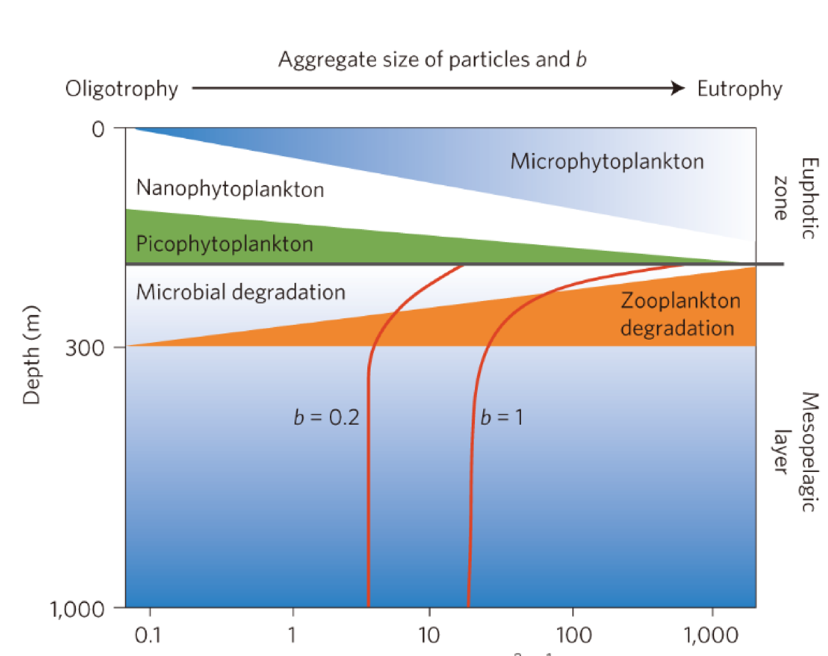

Figure 3 | Processes affecting the flux of particles in the ocean.

Guidi et al., Limnol. Oceanogr., 2009;
Herndl & Reinthaler, Nature Geoscience, 2013

Maximum output of BP+MCP for carbon sequestration

Increasing nutrient supply to coastal waters is expected to lead to an increase in primary production, and consequently an increase of the BP. However, excess nutrients from river discharge cause eutrophication, harmful algal blooms and hypoxia, which in turn influence overall carbon sequestration efficiency. Using MECS, appropriate ranges of nutrients to accommodate the maximum BP+MCP should be explored under representative environmental conditions.

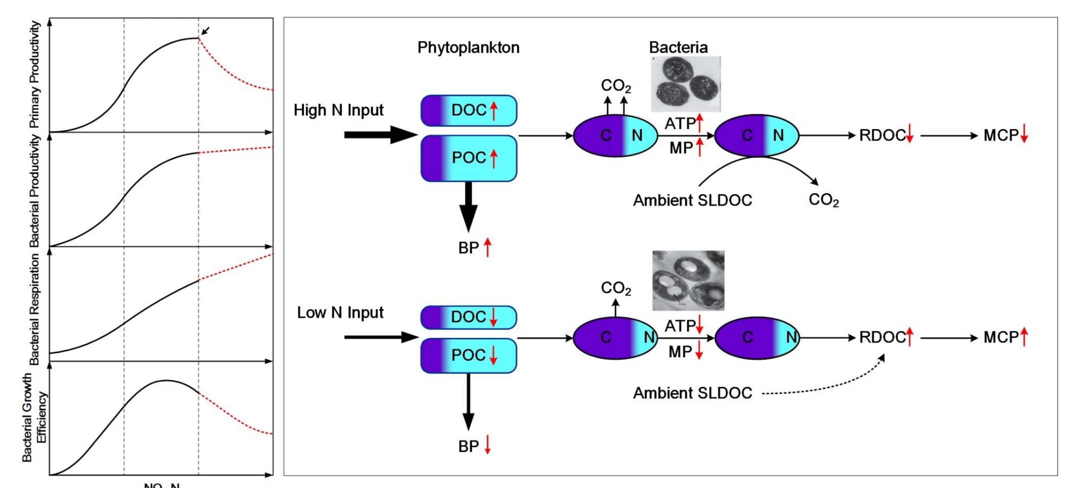

Figure 4 | The impact of nutrient supply on the sequestration of carbon via the BP and the MCP (Left panel: Primary production, bacterial respiration and bacterial growth efficiency as functions of nutrients; **Right panel**: Responses of the BP and the MCP to nutrient inputs) (Jiao et al., Biogeosciences, 2014)

Microbial ecology of expanding oxygen minimum zones

Dissolved O_2 is a critical factor in shaping the structure and function of marine ecosystems. As O_2 levels decline, energy is diverted away from higher trophic levels into microbial metabolism, leading to loss of nutrients and production of greenhouse gases, including N_2O and CH_4. This hypothesis may be easily tested with experiments using MECS.

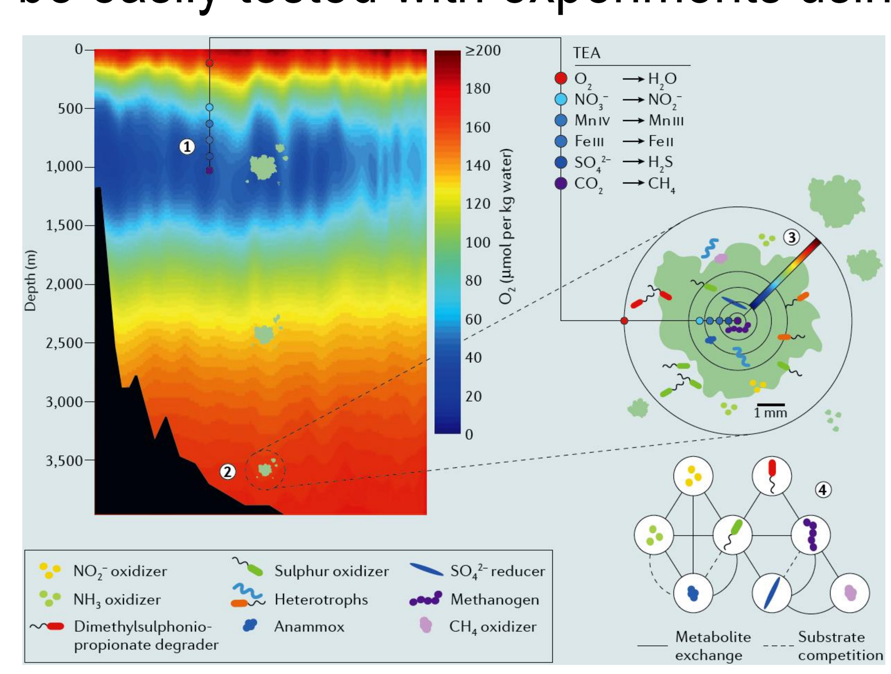

Figure 5 | Redox-driven niche partitioning Reduction–oxidation (redox)-driven niche partitioning in the molecular oxygen (O_2)-deficient water column selects for shared metabolic capabilities across different ecological scales.

(Wright et al., Nature Reviews Microbiology, 2012)

Evolution of Carbon Cycling in the Ocean

The ancient ocean can be simulated in MECS which could create conditions conducive to explore the evolution of chemistry and carbon cycling in the ocean. Improved process based understanding of the role of carbon cycling will aid the elucidation not only of the ancient world but also modern ocean may respond to future climate change.

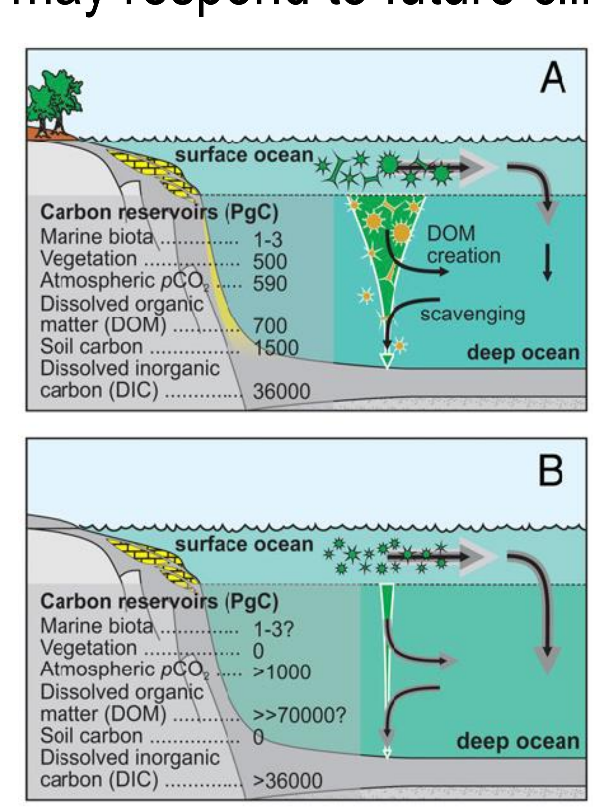

Figure 6 | Illustration of potential differences in modern vs. ancient carbon cycling
A: Modern Ocean is dominated by strong vertical settling flux of POC that decreases approximately exponentially with depth;
B: In the poorly oxygenated Neoproterozoic ocean, bacterial metabolism of organic matter would tend to proceed coupled to sulfate (SO_4^{2-}) reduction rather than using O_2.

(Ridgwell, PNAS, 2011)

Calling for more potential applications about MECS

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