Modelling the Microbial Carbon Pump in a changing ocean: current state and future directions

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Circa 624 gigatons of carbon are locked in the ocean as dissolved organic matter (DOM), an amount comparable with the entire CO$_2$ content of the extant atmosphere. This DOM is operationally defined as refractory, meaning that it is resistant to bacterial degradation and persists in the ocean for millennia. Refractory DOM is considered primarily a residual product of heterotrophic bacterial activity after the bacterial consumption of more labile (i.e. easily degradable) DOM produced by marine autotrophs through photosynthesis. The process through which bacteria form refractory-DOM is termed the 'Microbial Carbon Pump' (MCP). Abiotic degradation (e.g. photo-degradation) is thought to balance refractory DOM production, thus maintaining its current pool in steady state. However, recent studies suggest that changes in surface ocean inorganic nutrient availability, due to climate change related increases in thermal stratification, could modify MCP activity, increasing refractory-DOM production with respect to its consumption. Marine bacteria thus have the potential to mitigate increases in atmospheric CO$_2$ by shunting more photosynthesised carbon into refractory-DOM. This hypothesis can only be tested by including the MCP in numerical models used for climate prediction. However, the lack of mechanistic understanding of the process (due, in turn, to the lack of experimental data) has hitherto prevented the development of adequate model formulations. In this talk, I will discuss the potential (and limitations) of existing process models to simulate (at least partially) the MCP and highlight future research directions (and related challenges) to develop new model formulations describing this process.