EARTHSCIENCES

The impact of ocean warming on nutrient and carbon acquisition of marine plankton

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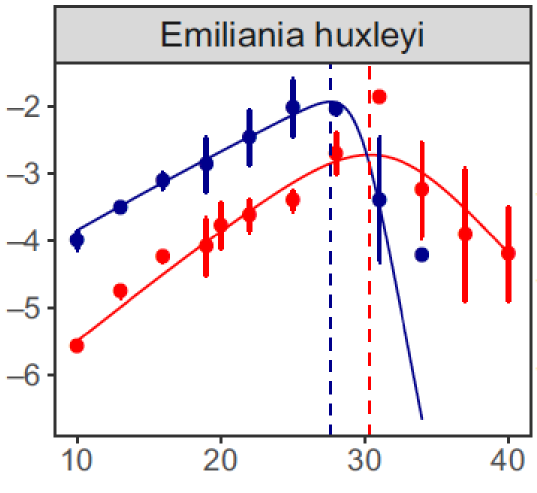
Key words:	Autotrophy, mixotrophy, heterotrophy, cyanobacteria, haptophytes
Research theme(s):	• Oceanography, Climate and Palaeoenvironment • Palaeobiology and Evolution
Eligible courses for this project:	• DPhil in Earth Sciences • Environmental Research (NERC DTP) • Interdisciplinary Bioscience (BBSRC DTP)

Overview

In the evolution of complex life, the uptake of and development of the primary endosymbiotic plastid by the ancestral heterotroph represents a singularity i.e. it was an event that only happened once. This singularity means that all extant marine algae have some remnant heterotrophic or mixotrophic capacity which may be expressed to differing degrees in the environment. The prevalence of mixotrophy has been attributed to decreased nutrient availability and even very high light availability. Of current interest as to the future efficiency of the ocean biological pump of carbon from the atmosphere to the ocean, is whether mixotrophy will increase in prevalence in the future warming ocean.



At the scale of a single cell, the temperature dependence of photosynthesis and respiration suggests that once the lower temperature optimum of photosynthesis (blue) has been breached by rising temperatures, respiration (red) (Figure 1) will become increasingly important to the cell as it has a higher thermal optima. Carbon fixation efficiency will start to decrese with increasing temperature. Whether cells may become additionally more mixotrophic as temperatures rise is not yet known.

Figure 1: The Rate of photosynthesis (blue) and rate of respiration (red) in the coccolithophore, Emiliania huxleyi versus temperature.

The primary aim of this project is to experimentally assess whether marine algae and cyanobacteria become more mixo-heterotrophic with increasing marine temperatures, to assess the impacts on the carbon balance and function of the cell using an O2-electrode, and to mechanistically interrogate such trophic mode changes on the expression of proteins and lipids within the cell. A secondary aim is to investigate the implications of such findings for the photosynthesis:respiration ratio of marine productivity over the course of the Phanerozoic, the source flux of oxygen from the marine environment, and for curious consistency of C isotopic fractionation within the fossil record. We also aim to develop methods for analysis of the prevalence of mixotrophy, via lipidomics or isotopes, in the field with attendance on research cruises or field sampling.

Methodology

Laboratory batch culture of marine algae and cyanobacteria known to be capable of mixotrophy under a range of conditions to induce altered trophic modes of marine algae at different temperatures with parallel assessment of expressed trophic mode. Physiological interrogation of cells with O2-electrode, Fv/Fm, proteomics and lipidomics. Measurement of stable isotopes in the cells, and sources.

Timeline

Year 1: Initial batch experiments in mixo-, hetero-, and autotrophic modes for eukaryotic algae and cyanobacteria at different temperatures. Set up of O2 electrode assays. Harvesting of cell material for “omics” analysis and isotopes. Field plan.

Years 2 and 3: Analysis of “omics” data and refining of experiments where trophic mode shifts have been successfully achieved.

Year 4: Data integration, thesis completion, papers for international journals/conference presentation.

Training & Skills

The student will be trained in laboratory culture of marine algae, the derivation and analysis of omics datasets, and the analysis and interrogation of stable isotope fractionation data. The student will work in an interdisciplinary way with both the Earth Science Department and the Biological Science Department. Through group meetings, the student will be training in oral presentation skills and over the course of the PhD will also acquire writing skills.

References & Further Reading

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Further Information

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