New Approaches to Understanding Ecosystem Dynamics in the Southern Ocean Involving Phytoplankton Using FTIR Spectroscopy

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Photosynthetic carbon assimilation by microalgae produces organic carbon biomass in the form of macromolecules (carbohydrates, proteins and lipids) which ultimately fuel the entire marine ecosystem. The quality of the microalgal biomass, in terms of the relative proportions of proteins, lipids and carbohydrates, is variable, affecting trophic transfer efficiency and thus the amount of carbon, nutrition and energy available to the ecosystem. Despite long being recognised as a critical driver of marine ecosystems, models which accurately relate primary production to ecosystem production continue to elude marine scientists [1]. Major challenges faced by carbon and ecosystem modelers relate to limited field data availability and understanding of the interaction of microalgal physiology, assemblage composition and environmental factors. Improving our ability to efficiently and robustly measure microalgal physiological and macromolecular parameters will lead to more robust models and subsequently more accurate predictions of ecosystem responses to stimuli (such as harvesting quotas and environmental change).

Currently, sample analysis is a bottleneck in data collection, since available methods such as isotopic incubations can be time-consuming and expensive. Thus, an opportunity exists to innovate marine microbiology through the application of high-throughput, rapid and inexpensive spectroscopic approaches [2]. Traditionally, physiological parameters such as growth rate and productivity have been determined over time (typically 12-24 hours) using isotopic incubation techniques. The number of samples which can be analysed is limited by cost and turn-around times. Spectroscopy offers substantial advantages over traditional methods, being inexpensive, quantitative, objective, rapid, high throughput, sensitive and inherently multivariate. It has the potential to revolutionise the way we collect data on marine microorganisms and thereby facilitate a leap in our understanding of their contributions to marine ecosystems.

In this context we will discuss analyses using FTIR microspectroscopy of phytoplankton samples obtained recently from the Kerguelen Plateau, an upwelling of iron-rich waters that promotes the growth of the largest phytoplankton bloom in the Southern Ocean starting in November and continuing until February each year. We demonstrate that the spectroscopic approach could provide both taxonomic identification and information about macromolecular composition related to changes in environmental factors such as nutrients at the single cell level.

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[2] Heraud P., Wood B. R, Beardall J. and McNaughton D. in Kneipp K., Aroca, R., Kneipp H., and Wentrup-Byrne E. (eds.) "New approaches in biomedical spectroscopy", p. 85-106, American Chemical Society (2007).