

From Light to Life: Pigment Composition, Light Absorption and Primary Production in the North Atlantic

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Key words:	Phytoplankton Ecology, Marine Biogeochemistry, Primary Production
Research theme(s):	Oceanography, Climate and Palaeoenvironment
Eligible courses for this project:	- DPhil in Earth Sciences (3-4 years) - Interdisciplinary Life and Environmental Science Landscape Award (ILES�A) - Intelligent Earth (UKRI CDT)

Overview



The RRS James Cook off the coast of

The light absorption spectrum of marine phytoplankton is an optical property that can be retrieved using ocean-colour satellites. Because the shape and magnitude of this spectrum vary with phytoplankton size and taxonomic composition (Bricaud et al. 2004, Hickman et al., 2010), it is a useful indicator of community structure in natural assemblages. Examining spectral shape could therefore allow biogeochemically significant phytoplankton groups, known as

Phytoplankton Functional Types (PFTs), to be monitored from space. This would offer a cost-effective way of mapping the distributions of key phytoplankton groups as the climate changes.

Beyond detecting shifts in community structure, phytoplankton light absorption is also used in some models of marine primary production as a proxy for photosynthetic biomass.

Phytoplankton absorption has been proposed as a better index of biomass than alternatives such as chlorophyll-a concentration, because it is directly related to the remote sensing reflectance signal. It also reflects characteristics of the phytoplankton community, such as photoacclimation state and gross taxonomic composition, that influence photosynthetic performance. In addition, light-limited photosynthesis is the product of phytoplankton absorption and the quantum yield of photosynthesis. Ocean warming is strengthening stratification, which is expected to increase the relative importance of production below the surface mixed layer, where light is limiting (Silsbe et al. 2025). Thus, understanding the factors governing phytoplankton absorption underpins both PFT retrievals at the sea surface and our estimates of primary production at depth.

Aims

This studentship will:

Examine the relative importance of cell size, pigment complement and photoacclimation in determining the shape and magnitude of the phytoplankton absorption spectrum, using in situ data (HPLC pigments, cell counts and spectrophotometry) collected by project collaborators during oceanographic expeditions in the North Atlantic.

Incorporate measurements of phytoplankton light absorption and photosynthesis-irradiance curves into a spectrally resolved model of marine primary production, to determine the significance of light limited photosynthesis for estimating primary production across the major biomes of the North Atlantic.

The successful applicant, whose first degree might be in marine, environmental or earth sciences, will have a strong interest in multidisciplinary research, good quantitative and computing skills.

Timeline

Year 1: Assemble a database of bio-optical, pigment and photosynthetic parameters, together with the associated physical, chemical and biological parameters, from existing oceanographic datasets. Begin analysis of the North Atlantic absorption, pigment and cell count data.

Years 2 and 3: Complete the database, including quality control. Use spectrally-resolved models of primary production, parameterised with the database, to quantify the role of phytoplankton light absorption in shaping the underwater light field and spectrally dependent, light-limited photosynthesis. Visit international collaborators and, where opportunities arise, participate in research cruise.

Year 4: Integrate results, complete the thesis and submit papers to journals. Present findings at UK and international conferences.

Training & Skills

The student will develop a thorough understanding of the factors that govern variability in the absorption spectra of marine phytoplankton, including cell size, pigment composition and photoacclimation. They will be trained in radiative transfer modelling and in estimating primary production with spectrally resolved models. They will also receive guidance on managing and analysing large oceanographic datasets. In addition, the student may have the opportunity to take part in a research cruise.

References & Further Reading

Bouman, H.A., Platt, T., Doblin, M. *et al.*, (2018) Photosynthesis-irradiance parameters of marine phytoplankton: synthesis of a global data set. *Earth System Science Data* 10, 251–266. doi: 10.5194/essd-10-251-2018

Bricaud, A., H. Claustre, J. Ras, & K. Oubelkheir (2004), Natural variability of phytoplanktonic absorption in oceanic waters: Influence of the size structure of algal populations, *Journal of Geophysical Research*, 109, C11010, doi:10.1029/2004JC002419.

Hickman, A.E. Dutkiewicz, S., Williams, R.G., & Follows, M.J. (2010) Modelling the effects of chromatic adaptation on phytoplankton community structure in the oligotrophic ocean. *Marine Ecology Progress Series*, 406: 1-17, doi:10.3354/meps08588

Silsbe, G.M., Fox, J., Westberry, T.K. *et al.* (2025) Global declines in net primary production in the ocean color era. *Nature Communications* **16**, 5821. <https://doi.org/10.1038/s41467-025-60906-y>

Further Information

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