Bringing light to life: a global study of the photophysiology of marine phytoplankton

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Key Words
biological oceanography, marine phytoplankton, primary production, ocean optics

Overview
Marine phytoplankton are responsible for half of the photosynthesis on our planet and form the base of the marine food chain. These photosynthetic cells are the conduit through which energy in the form of sunlight enters ocean ecosystems. Seasonal fluctuations in phytoplankton biomass and diversity are intimately linked to the flux of organic carbon out of the surface ocean into the mesopelagic where it can remain locked away for decades to millennia.

Historically, oceanographers have used the pigment chlorophyll-a as the primary currency of photosynthetic biomass because it is relatively simple to measure in seawater and is found in all marine phytoplankton. Yet, both the light reactions of photosynthesis that ultimately fuels the metabolism of marine photoautotrophs and the colour of the ocean used to map phytoplankton biomass over global scales are related to the absorption of photons by photosynthetic cells and not to a single pigment molecule.

The launch of NASA's Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission in 2024 will provide global hyperspectral data of ocean colour. The data stream from the PACE mission combined with the rapidly growing number of measurements of light absorption by phytoplankton cells using in-situ spectrophotometers presents us with the opportunity to move beyond chlorophyll-a and develop a deeper understanding of how energy across the visible spectrum is processed by the ocean’s microflora and thereby how much energy is available to support the rest of marine life.

Methodology
This project will reframe the estimation of marine primary production around the key step that drives the photochemistry of marine phytoplankton – the absorption of photons.

Variability in the light absorption properties of marine phytoplankton will be examined across ocean biomes using global bio-optical datasets covering a wide range of oceanographic settings, from productive polar seas to oligotrophic gyres. The taxonomic structure and photo-acclimatory status of phytoplankton that together are responsible for changes in the spectral shape and efficiency of phytoplankton absorption across the global ocean will be investigated. The development of photon absorption budgets across a range of ocean provinces will lead to a biophysical understanding of the fraction of solar energy that can be channelled into marine photosynthesis and ultimately used to fix carbon. A spectrally resolved model of primary production will be used to obtain an improved representation of light and photosynthesis over a range of marine ecosystems covering polar to subtropical biomes.
The project will improve our global estimates of marine primary production and the retrieval of phytoplankton groups from satellite, both of which are critical to understand the gross synthesis and net storage of organic carbon in the global ocean. The research will also determine the significance of the underwater light environment in driving the global macroecology of marine primary producers.

**Timeline**

**Year 1:** The student will join the diverse cohort of students from Oxford’s Doctoral Training Partnership in Environmental Research (DTP; https://www.environmental-research.ox.ac.uk/) and will spend the first six months engaged in training (run by the DTP); reading and reviewing the wider literature, and preparing a detailed research proposal.

Preliminary work would include exploratory investigations of previously-collected data from international repositories to develop an understanding of factors regulating the optical properties and photosynthetic response of phytoplankton in the global ocean.

**Years 2 and 3:** Continue database assembly. Examine the seasonal and latitudinal variability in community structure in relation to indices of resource (light and nutrient) supply. Refined parameterisation of the photosynthetic response using information on light absorption properties and quantum yields. Visit collaborators. Potential opportunity to participate in a research cruise if this student wishes.

**Year 4:** Write publications and present work at UK and international conferences.

**Training & Skills**

The successful applicant, whose first degree might be in marine, environmental or earth sciences, will have an aptitude for multidisciplinary research and good quantitative and computing skills. The student will receive guidance in working with large oceanographic datasets including phytoplankton diagnostic pigments, flow cytometric cell counts, light absorption coefficients, and photosynthesis-irradiance response curves. They will acquire a thorough grounding in the modelling of marine primary production.

**References & Further Reading**


**Further Information**

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