EARTHSCIENCES

Hidden Ocean Forests: Understanding the Ecological and Physiological Properties of Phytoplankton in Subsurface Layers

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Key words:	Phytoplankton, Carbon Cycle, Primary Production, Satellite Oceanography, BGC-Argo, Aquatic Photosynthesis
Research theme(s):	Oceanography, Climate and Palaeoenvironment
Eligible courses for this project:	• DPhil in Earth Sciences • Environmental Research (NERC DTP) • Intelligent Earth (UKRI CDT) • Interdisciplinary Bioscience (BBSRC DTP)

Overview

Satellite sensors have provided an unprecedented view of changes in phytoplankton chlorophyll in the surface ocean. Yet in many ocean regions, from the poles to the tropics, the maximum concentration of chlorophyll occurs at depths which are invisible to earth-orbiting satellites. The formation of subsurface chlorophyll maxima is believed to be caused by the exhaustion of surface nutrients within the surface mixed layer and an increase in the intracellular pigment concentration of low-light acclimated phytoplankton at depth. Studies have shown that even though these phytoplankton assemblages are growing in dimly-lit waters, they can contribute a significant fraction of the total and new water-column production in shelf and open-ocean ecosystems. Moreover, the communities of cells that occupy these chlorophyll layers serve a pivotal role in both the ecological and biogeochemical functioning of the global ocean.

The primary aims of this project are 1) to examine the ecological, physiological and biogeochemical roles of the photosynthetic microbes that occupy subsurface and deep chlorophyll layers, 2) compare their cellular and photosynthetic properties to surface mixed-layer assemblages and 3) quantify their contribution to water-column primary production. The successful applicant, whose first degree might be in marine, environmental or earth sciences, will have an aptitude for multidisciplinary research, good quantitative and computing skills, and an interest in laboratory and field-based experimental work. There will be opportunities to spend time visiting collaborators at other institutions and to participate in an oceanographic cruise if the student wishes.

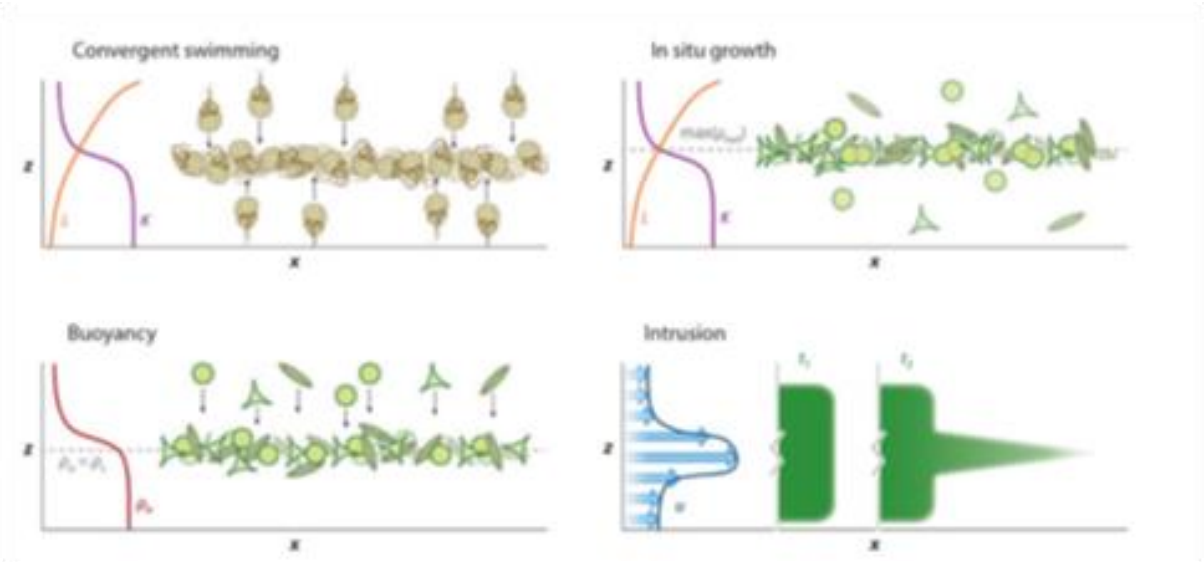

Figure illustrates various physical, chemical and biological mechanisms leading to the formation of subsurface chlorophyll layers. Profiles of depth (z) against each biological/environmental factor (x) shown in each subplot. From Durham & Stocker (Ann. Rev. Mar. Sci. 2012).

Methodology

Datasets used in this study will cover a large latitudinal gradient (polar seas to the subtropics) and a wide range of marine settings (marginal ice zones to subtropical gyres). You will determine the factors leading to the formation of these layers over a range of environmental settings through the analysis of global oceanographic datasets (ships, BGC-Argo floats) and derive a predictive model of profile shape. Using this predictive model and satellite-based observations of sea-surface chlorophyll concentration, light-driven models of marine primary production will be used to assess the global significance of these subsurface communities. We will also assess the ecological characteristics of these populations and how they vary with latitude.

Timeline

Year 1: Developing an understanding of the structure and parameterisation of marine primary production models. In situ and sensor database assembly.

Years 2 and 3: Continue database assembly. Extract physical, chemical and biological parameters from field datasets. Examine the spatial and temporal variability of SCMs for a range of biogeochemical provinces. Compute primary production using refined parameterisation and interpret results. Visit to collaborators and/or research cruise.

Year 4: Write publications characterizing the biodiversity and productivity of chlorophyll layers across the Atlantic basin and attend UK and international conferences.

Any specific training the student would undertake as part of the project and other training and skills that will be taught / developed over the period of the project.

References & Further Reading

H.A. Bouman, T. Jackson, S. Sathyendranath, T. Platt, Vertical structure in chlorophyll profiles: influence on primary production in the Arctic Ocean. Philosophical Transactions of the Royal Society A 378, (2020) http://dx.doi.org/10.1098/rsta.2019.0351

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Further Information

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