

Distinct physiological responses of *Coccolithus braarudii* life cycle phases to light intensity and nutrient availability

Gerald Langer

Institute of Environmental Science and Technology (ICTA), Universitat Autònoma de Barcelona (UAB), 08193, Bellaterra, Spain.
Gerald.Langer@uab.cat

Vun Wen Jie

The Marine Biological Association of the United Kingdom, The Laboratory, Citadel Hill, Plymouth PL1 2PB, UK

Dorothee Kottmeier

The Marine Biological Association of the United Kingdom, The Laboratory, Citadel Hill, Plymouth PL1 2PB, UK

Serena Flori

The Marine Biological Association of the United Kingdom, The Laboratory, Citadel Hill, Plymouth PL1 2PB, UK

Daniela Sturm

The Marine Biological Association of the United Kingdom, The Laboratory, Citadel Hill, Plymouth PL1 2PB, UK

Joost de Vries

The Marine Biological Association of the United Kingdom, The Laboratory, Citadel Hill, Plymouth PL1 2PB, UK

Glenn M. Harper

Plymouth Electron Microscopy Centre, Brunel, Drake Circus, Plymouth PL4 8AA, UK

Colin Brownlee

The Marine Biological Association of the United Kingdom, The Laboratory, Citadel Hill, Plymouth PL1 2PB, UK

Glen Wheeler

The Marine Biological Association of the United Kingdom, The Laboratory, Citadel Hill, Plymouth PL1 2PB, UK

Coccolithophores feature a haplo-diplontic life cycle comprised of diploid cells producing heterococcoliths and haploid cells producing morphologically different holococcoliths. These life cycle phases of each species appear to have distinct spatial and temporal distributions in the oceans, with the heavily calcified heterococcolithophores (HET) often more prevalent in winter and at greater depths, whilst the lightly calcified holococcolithophores (HOL) are more abundant in summer and in shallower waters. The haplo-diplontic life cycle may therefore allow coccolithophores to expand their ecological niche, switching between life cycle phases to exploit conditions that are more favourable. However, coccolithophore life cycles remain poorly understood and fundamental information on the physiological differences between life cycle phases is required if we are to better understand the ecophysiology of coccolithophores.

In this study, we have examined the physiology of HET and HOL phases of the coccolithophore *Coccolithus braarudii* in response to changes in light and nutrient availability. We found that the HOL phase was more tolerant to high light than the HET phase, which exhibited defects in calcification at high irradiances. The HET phase exhibited defects in coccolith formation under both nitrate (N) and phosphate (P) limitation, whilst no defects in calcification were detected in the HOL phase. The HOL phase grew to a higher cell density under P-limitation

than N-limitation, whereas no difference was observed in the maximum cell density reached by the HET phase at these nutrient concentrations. HET cells grown under a light:dark cycle divided primarily in the dark and early part of the light phase, whereas HOL cells continued to divide throughout the 24 h period. The physiological differences may contribute to the distinct biogeographic distributions observed between life cycle phases, with the HOL phase potentially better adapted to high light, low nutrient regimes, such as those found in seasonally stratified surface waters.