Emiliania huxleyi biometry and calcification response to the Indian sector of the Southern Ocean environmental gradients

Shramik Patil, Rahul Mohan

National Centre for Polar and Ocean Research, Goa, 403804, India. shramikpatil@gmail.com

Suhas Shetye

National Institute of Oceanography, Goa, 403804, India

Vailancy Vaz, Sahina Gazi

National Centre for Polar and Ocean Research, Goa, 403804, India

Pallavi Choudhari

Centre for Marine Living Resources and Ecology, Kerala, 682508, India

Syed Jafar

National Centre for Polar and Ocean Research, Goa, 403804, India

An increase in the atmospheric pCO_2 and temperature is expected to reduce ocean $[CO_3^{2-}]$ concentration, make oceans warmer and alter ocean circulation patterns. This will also affect the production and biogeographic distribution of marine calcifying organisms including coccolithophores. The lowering of oceanic $[CO_3^{2-}]$ is expected to interfere with the coccolithophore calcification process and cause malformation of coccoliths, whereas changes in the oceanic temperature and circulation patterns may shift their biogeographic boundaries. In this study, we have investigated *Emiliania huxleyi* coccolith and coccosphere size response to the wide-ranging physico-chemical conditions of the Indian sector of the Southern Ocean between latitudes 38°S and 58°S during the austral summer of 2010 (January-February). This study helps to understand the response of *E. huxleyi* coccolith/coccosphere morphometry and mass changes to the fluctuating temperature, salinity, $[CO_3^{2-}]$, pCO_2, and nutrient values. Our results show that in the Indian sector of the Southern Ocean, *E. huxleyi* coccoliths are larger and coccospheres are smaller in the Subtropical Zone (STZ). In contrast, coccoliths size is smaller and coccospheres size is larger in the Subantarctic Zone (SAZ), which is due to the decrease in sea surface temperature, sea surface salinity and increase in nutrient concentrations. In the Indian sector of the Southern Ocean, *E. huxleyi* shows a north-to-south morphotype shift from the heavily calcified 'Group A' (*E. huxleyi* morphotype A) to the weakly calcified 'Group B' (*E. huxleyi* morphotypes B/C, C) forms. We demonstrate that although weakly calcified *E. huxleyi* morphotypes (morphotypes B/C and C) comprise less mass than that of the *E. huxleyi* morphotype A, due to the large-sized coccospheres and numerous coccoliths per coccosphere, 'Group B' coccospheres precipitate large amount of $CaCO_3$ in the SAZ compared to 'Group A' coccospheres located in the STZ. We have documented the presence of large *E. huxleyi* overcalcified coccospheres with large-sized coccoliths in the southernmost cold, high pCO_2, and nutrient-rich waters which show extracellular calcite precipitation. The energy dispersive spectrometry analysis indicates the presence of a large amount of Mg in the overcalcified *E. huxleyi* specimens. We suspect that *E. huxleyi* in the colder nutrient-rich waters, with future projected changes

in the carbonate chemistry, may adapt to low pH, high pCO_2 conditions through extracellular Ca and Mg mineralization.