Is *Emiliania huxleyi* expanding its presence in polar waters? Evidence from multi-year observations

Shramik M. Patil
ESSO-National Centre for Antarctic and Ocean Research, Vasco-da-Gama, Goa 403804, India; shramikantsci@gmail.com

Rahul Mohan
ESSO-National Centre for Antarctic and Ocean Research, Vasco-da-Gama, Goa 403804, India; rahulmohan@ncaor.gov.in

Sahina Gazi
ESSO-National Centre for Antarctic and Ocean Research, Vasco-da-Gama, Goa-403804, India; sahina@ncaor.gov.in

Suhas S. Shetye
National Institute of Oceanography, Dona Paula, Goa 403004, India; suhasshetye@gmail.com

Syed A. Jafar
Flat 5-B, Whispering Meadows, Haralur Road, Bangalore 560102, India; syeda_jafar@yahoo.com

Coccolithophores, one of the most abundant eukaryotic phytoplankton in the oceans that almost always possess calcite scales, play a pivotal role in the oceanic biological pump. Increasing levels of atmospheric carbon dioxide lead to the lowering of oceanic pH, which affects calcifiers and therefore the calcification ability of coccolithophores, including the abundant and widespread species *Emiliania huxleyi*. Recent investigations in southern polar waters indicate an expansion of *E. huxleyi* in the extreme southern latitudes. Our investigation in the southern Indian Ocean sector also showed evidence of a poleward expansion of *E. huxleyi*. Any change in *E. huxleyi* abundance relative to the non-calcifiers (i.e., diatoms) could affect the biogeochemical cycling of carbon and climatic feedback.

We tested the poleward expansion hypothesis of *E. huxleyi* with the use of our six-year cruise data and samples collected during austral summers of 2009–2016. Our findings show that: (1) *Emiliania huxleyi* does not show consistent year by year poleward expansion throughout the austral summer period, (2) the uneven poleward expansion suggests influence from intra-seasonal biogeochemical changes, (3) the decline in the abundance of non-calcifiers (i.e., diatoms) during late summer (low light and low SiO_4) and the increase in grazing by heterotrophs could affect the latitudinal expansion of coccolithophores, (4) *E. huxleyi* is climatically sensitive, and any changes in the environmental conditions are reflected in its morphological variations, and (5) *E. huxleyi* does show overcalcification in polar waters south of 55°S by replacing calcium with magnesium to form magnesium calcite. Coccolithophores probably overcalcify because magnesium calcite is more soluble in acidified water than any other forms of calcite, and thus this extra calcite allows them to exist in the extreme southern latitude waters, which in turn affects the pCO_2 in those surface waters.