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SHORT COMMUNICATION

Estimation of diatom and dinoflagellate cell volumes from surface waters of the Northern Indian Ocean

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Summary Phytoplankton samples collected from the Northern Indian Ocean (Bay of Bengal, northern Arabian Sea, and Dona Paula Bay Goa, west coast of India), were utilized to quantify changes in cell size, cell volume and carbon per cell of diatoms and dinoflagellates. The dataset from the Bay of Bengal also provides inter- and intra-annual variations (April 2008 to March 2010). The variations in cell size and volume were large in regions influenced by the riverine influx or terrigenous inputs. An interregional comparison of commonly available forms (8 species) points out that cell volumes are highest in the North Atlantic and lowest in the Mediterranean. The information provided will be useful in estimation of carbon biomass and biogeochemical studies.

1. Introduction

Trait-based characteristics are increasingly used to predict the phytoplankton community distribution along the environmental gradient (Margalef, 1978; Reynolds, 1988). They are not necessarily taxonomy related but determined based on size and the physiological processes such as growth (light and nutrient assimilation) and loss (sinking and grazing) (Morabito et al., 2007). The cell size is referred as a master trait which places important constraints on many key organismal characteristics and biotic interactions (Barton et al.,

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2013 and references therein). Smaller organisms have several advantages over large ones for e.g. a lower sinking rate, which is proportional to cell radius squared (Stokes law) (Smayda, 1970). Higher surface to volume ratio that helps efficient acquisition of limiting nutrients (Ploug et al., 1999; Sherwood et al., 1975) and higher maximum growth rates (Banse, 1976). In contrast, the large size organisms carry the advantage of motility, access nutrient resources unavailable to other organisms; avoid grazing and higher possibility of survival (Reynolds, 2006). The trade-off between these traits represents an ecological strategy to exploit better the available resources (Litchman et al., 2010). Since micro-phytoplankton exhibit a wide range in their size (20–200 μm) and shape, quantification of cell numbers only will not provide accurate information on carbon biomass. Hence, there is a need to convert cell count to cell volume since a large number of small cells are equivalent to few larger cells in terms of carbon biomass (Harrison et al., 2015). Cell size and its carbon content evaluations from cell volume can provide useful inputs to ecosystem applications, modeling and biogeochemistry studies. Phytoplankton cell volume and its associated parameters have been reported from Chinese Sea, Baltic Sea, Mediterranean Sea, Beagle Channel and North of Atlantic (Almandoz et al., 2011; Barton et al., 2013; Olenina et al., 2006; Sarno et al., 1993; Stanca et al., 2013; Sun et al., 2000). However, a similar kind of work from the waters surrounding the Indian subcontinent is lacking. Although Harrison (Harrison et al., 2015) has cited some of the references in this context, published literature is meager. In the Indian waters, the phytoplankton cell volume is measured in a few cases from the mangrove habitat and near coastal sites (Biswas et al., 2010; Mitra et al., 2012; Munir et al., 2015). This study provides information on cell volume and carbon per cell of diatoms and dinoflagellates from coastal and open ocean stations. The dataset is further compared for inter bioregional variations.

2. Material and methods

2.1. Study area

Surface water samples from the Bay of Bengal hereafter referred as "BoB" (XBT program using ships of opportunity) were collected from April 2008 to March 2010 on seven occasions along the Chennai – Port Blair; 81°00′E, 13°00′N to 92°00′E, 11°23′N, and on six occasions (April 2008 to March 2010) along Port Blair to Kolkata; 12°00′N, 93°14′E to 21°00′N, 88°23′E at 22 different stations. The stations are categorized into C-P open ocean (CPOS), Andaman Region (AR), P-K Open Ocean (PKOS) and River Mouth (RM) regions as shown in Fig. 1. From the northern Arabian Sea the surface water samples were collected while on a cruise SSK60 from 25th January 2014 to 1st February 2014 (40 stations covering 6 transects; 20°13′E, 68°90′N to 18°50′E, 69°99′N) and one coastal station located off Goa, Dona Paula Bay (15°27′N, 73°48′E), weekly twice from 1st September to 24th December 2015 with a total 34 samples.

2.2. Hydrological parameters

From the BoB, vertical temperature profile of the water column was recorded by launching XBT-MK21-T7 probes (Sippican Inc.) at one-degree intervals. From the northern Arabian Sea, the temperature was recorded using CTD (Sea - Bird Electronics, Inc.). In the Dona Paula Bay, surface water temperature was measured in situ. The conductivity of surface seawater from the Bay of Bengal and Dona Paula Bay was measured using Autosal and later converted into salinity (Guildline Autosal 8400B). From the northern Arabian Sea, the conductivity was measured using dual conductivity (SBE4) sensor fitted to CTD.

In all regions, for nutrients, 10 ml of seawater samples were collected into 10 ml cryovials, immediately frozen in

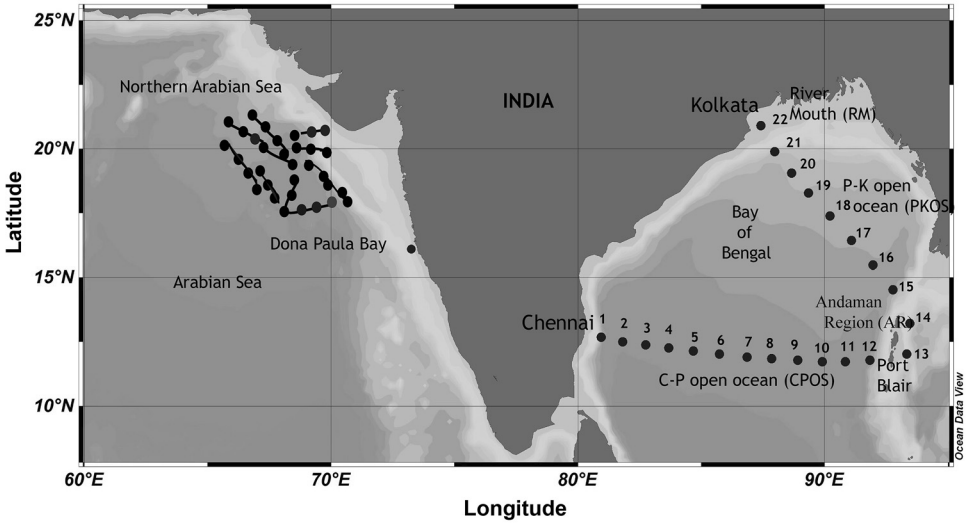

Figure 1 Locations of sample collection from the northern Indian Ocean (Bay of Bengal, northern Arabian Sea, and Dona Paula Bay). In the Bay of Bengal, samples were collected from four different tracks (Chennai to Port Blair open ocean – CPOS; Andaman Region – AR; Port Blair to Kolkata open ocean – PKOS; and River Mouth – RM). From the northern Arabian Sea samples were collected from 40 stations and in the Dona Paula Bay from one station.