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Holocene calcareous nannoplanktons from western continental shelf of Bay of Bengal

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ABSTRACT

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Sixty-six surface sediment samples from the northern and western Bay of Bengal were analysed for the study of calcareous nannoplanktons. The samples were also studied for the nannoplankton assemblage composition with regional differences. The sediment samples from northern Bay of Bengal showed very low abundances of *Emiliania huxleyi* and *Gephyrocapsa oceanica* indicating very low productivity of nannoplanktons. The sediment samples from the western Bay of Bengal is composed of high species diversity with the dominance of *Gephyrocapsa oceanica* and sub dominance of *Emiliania huxleyi* indicating high productivity and the river discharge effect on the assemblage. The ratio between the *Gephyrocapsa oceanica* and *Emiliania huxleyi* can be used as a proxy to decipher the monsoonal fluctuations and associated runoff fluctuations.

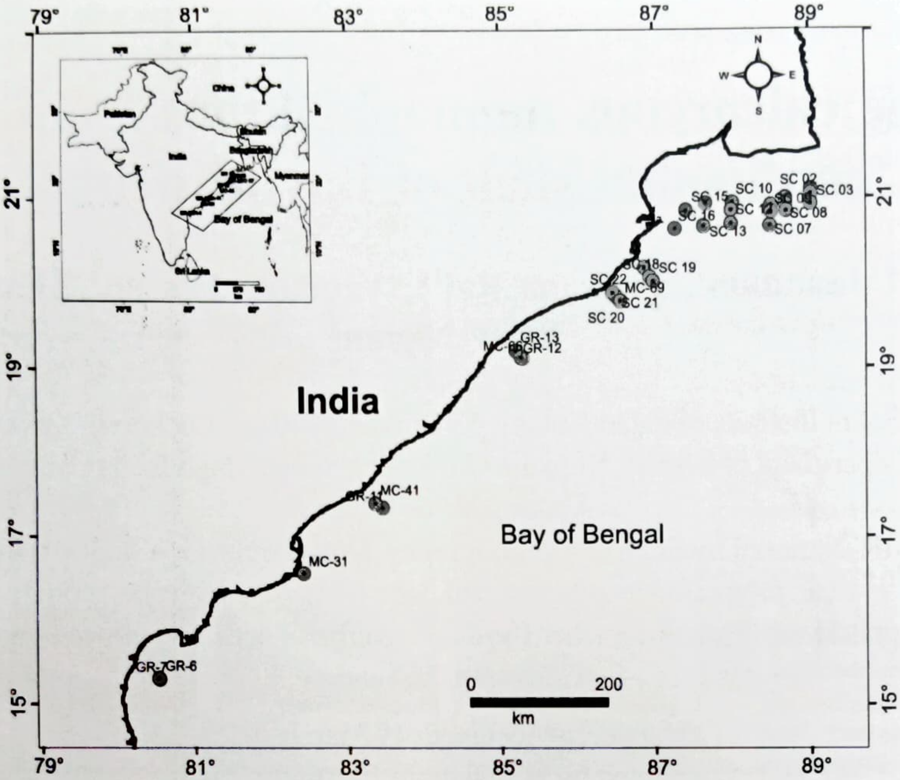
Key-words: Nannoplanktons, proxy, primary productivity, Bay of Bengal.

INTRODUCTION

Calcareous nannoplanktons are frequently abundant in the tropical oceans. They are marine phytoplankton, unicellular, tiny (2-10 μm), photosynthetic, belong to golden brown algae Chrysophyceae, biomineralise calcium carbonate dissolved in the oceans and are major primary producers of the marine system. They have been used as sensitive indicators to decipher the climatic variability, oceanographic changes and primary productivity mercurialness from the different parts of the world oceans (Rogalla & Andruleit 2005, Krammer et al. 2006). There is only one report of nannoplankton assemblage from the shelf region of Bay of Bengal (Mergulhao et al. 2013). The present study determines the assemblage composition from the shelf region of the Bay of Bengal. The knowledge of regional assemblage's composition is useful as a framework for the climatic fluctuations in the past from the Bay of Bengal.

MATERIAL AND METHODS

Surface samples studied in the present study (0-1 and 1-2 cm) were collected during the cruises of SSK-



Text figure 1. Study area and the locations of the present studied samples.

35 (northern Bay of Bengal) and SK-308 (western Bay of Bengal) with spade corer (SC), Multicorer (MC) and Grab (GR). Permanent duplicate slides, one containing comparatively coarser and the other having finer fraction of the samples for nannoplankton productivity and study, were prepared using the usual preparation technique described in Bown (1998). These slides were examined under Leica DM 2500P polarizing microscope (LM) with 10x (magnification) or 10x oculars and microphotographs were taken under 100x oil immersion objective both under normal and crossed polarized illumination at times using gypsum plates also. Frequency of individual species is plotted against sample numbers to decipher the productivity variation in the surface samples (Figure 2).

NANNOPLANKTON ASSEMBLAGE

The following nannoplankton taxa have been recorded (in alphabetical order): *Calcidiscus leptoporus* (Murray & Blackman 1898) Loeblich & Tappan 1978, *Ceratolithus simplex* Bukry 1979, *C. telesmus* Norris 1965, *Emiliania huxleyi* (Lohmann 1902) Hay & Mohler 1967 in Hay et al. 1967, *Gephyrocapsa caribbeanica* Boudreaux & Hay in Hay et al. 1967, *G. oceanica* Kamptner 1943, *Helicosphaera carteri* (Wallich 1877) Kamptner 1954, *H. carteri* var. *hyalina* (Gaarder 1970) Jordan & Young 1990, *H. carteri* var. *wallichii* (Lohmann 1902) Theodoridis 1984, *Neosphaera coccolithomorpha* Lecal-Schlauder 1950, *Pontosphaera jonesii* (Boudreauax & Hay 1969) Proto Decima 1974, *P.*

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Plate 1

1a-c. *Emiliania huxleyi* (Lohmann 1902) Hay & Mohler 1967, Slide no. MC-69. **2a-c.** *Calcidiscus leptoporus* (Murray & Blackman 1898) Loeblich & Tappan 1978, Slide no. MC-69. **3a-c.** *Ceratolithus simplex* Bukry 1979, Slide no. MC-41. **4a-c.** *Ceratolithus telesmus* (Norris 1965) Jordan & Young 1990, Slide no.GR-13. **5a-c.** *Gephyrocapasa oceanica* Kamptner 1943, Slide no. MC-31. **6a-c.** *Helicosphaera carteri* Kamptner 1954, Slide no. MC-31. **7a-c.** *Helicosphaera carteri* var. *wallichil*, Slide no. MC-41. **8a-c.** *Helicosphaera carteri* var. *hyalina* (Gaarder 1970) Jordan & Young 1990, Slide no. MC-69. **9a-c.** *Pontosphaera jonesii* Boudreauax & Hay 1969, Slide no MC-41. **10a-c.** *Pontosphaera* sp. Slide no. MC-69. **11a-c.** *Reticulofenestra asanoi* Sato & Takayama 1992, Slide no. MC-69. **12a-c.** *Neosphaera coccolithomorpha* Lecal-Schlauder 1950, Slide no. MC-69. a, b: cross nicols; c- normal light.

multipora (Kamptner 1948) Roth 1970, *Pontosphaera* sp., *Pseudoemiliania lacunosa* (Kamptner 1963) Gartner 1968, *Reticulofenestra asanoi* Sato & Takayama 1992 and *Syracosphaera pulchra* Lohmann 1992 (Plate 1).

Plate 1

Table 1. A = Abundant (10-40 per field of view; F = Frequent (2-3 per 5 fields of view; R = Rare (1-2 per 20 fields of view; - = Absent

Sample number	*Emiliania huxleyi*	*Calcidiscus leptoporus*	*Ceratolithus simplex*	*Ceratolithus telesmus*	*Gephyrocapsa caribbeanica*	*Gephyrocapsa oceanica*	*Helicosphaera carteri*	*Helicosphaera carteri* var. *wallichii*	*Helicosphaera carteri* var. *hyalina*	*Pontosphaera jonesii*	*Pontosphaera multipora*	*Pontosphaera* sp.	*Pseudoemiliania lacunosa*	*Reticulofenestra asanoi*	*Syracosphaera pulchra*	*Neosphaera coccolithomorpha*
SC-01 (0-1&1-2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SC-02 (0-1&1-2)	R	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
SC-03 (0-1&1-2)	F	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-
SC-04 (0-1&1-2)	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
SC-05 (0-1&1-2)	R	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
SC-06 (0-1&1-2)	R	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-
SC-07 (0-1&1-2)	F	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-
SC-08 (0-1&1-2)	R	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
SC-09 (0-1&1-2)	R	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
SC-10 (0-1&1-2)	-	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-
SC-11 (0-1&1-2)	F	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
SC-12 (0-1&1-2)	R	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
SC-13 (0-1&1-2)	R	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
SC-14 (0-1&1-2)	R	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
SC-15 (0-1&1-2)	R	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
SC-16 (0-1&1-2)	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
SC-17 (0-1&1-2)	R	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
SC-18 (0-1&1-2)	R	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
SC-19 (0-1&1-2)	F	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-
SC-20 (0-1&1-2)	F	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-
SC-21 (0-1&1-2)	F	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-
SC-22 (0-1&1-2)	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GR-7	A	F	F	F	R	A	F	F	F	R	R	R	F	R	R	F
MC-31(0-1&1-2)	A	F	F	F	R	A	F	F	F	R	R	R	F	R	R	F
GR-11	A	F	F	F	R	A	F	F	F	R	R	R	F	R	R	F
GR-12	A	F	F	F	R	A	F	F	F	R	R	R	F	R	R	F
MC-66(0-1&1-2)	A	F	F	F	R	A	F	F	F	R	R	R	F	R	R	F
GR-13	A	F	F	F	R	A	F	F	F	R	R	R	F	R	R	F
MC-69(0-1&1-2)	A	F	F	F	R	A	F	F	F	R	R	R	F	R	R	F
GR-6	A	F	F	F	R	A	F	F	F	R	R	R	F	R	R	F
MC-41(0-1&1-2)	A	F	F	F	R	A	F	F	F	R	R	R	F	R	R	F

DISCUSSION

Northern Bay of Bengal and western Bay of Bengal exhibit differences in the physical processes such as rivers discharge and upwelling. Northern region is bordered by the huge Ganga-Brahmaputra delta and western region is bordered by the Krishna, Godavari, Mahanadi and Penner river deltaic systems (Varkey et al. 1996). With regard to river discharge and associated stratification, nutrients are high in the northern region and comparatively low in the western region. Additionally, the pronounced upwelling turns the upper waters, enriched with nutrients, confined to the western region of the Bay of Bengal (Shetye et al. 1991, Vinayachandran et al. 2002, Prasanna Kumar et al. 2002, 2010).

Altogether, sixteen nannoplanktons taxa were recorded. The recovery of nannoplanktons from the northern shelf samples was very depauperate showing occurrence of *Emiliania huxleyi* and *Gephyrocapsa oceanica* only in very low abundances (2-3 specimens per five fields of view).

The recovery of nannoplanktons from the western Bay of Bengal was higher both in diversity and abundance in comparison to the northern region. The assemblage is dominated by the small and medium sized coccoliths of *Gephyrocapsa oceanica* and *Emiliania huxleyi*. Other nannoplankton taxa are *Calcidiscus leptoporus, Ceratolithus simplex, Ceratolithus telesmus, Gephyrocapasa caribbeanica, Helicosphaera carteri, Helicosphaera carteri* var. *wallichii, Helicosphaera carteri* var. *hyalina, Neosphaera coccolithomorpha, Pontosphaera jonesii, Pontosphaera multipora, Pontosphaera* sp., *Pseudoemiliania lacunosa, Reticulofenestra asanoi,* are moderately abundant in the assemblage.

The very low representation to absence of the nannoplanktons with a very low diversity from the northern shelf samples indicates the low productivity in the northern region. Unlike the other tropical region, light intensity appears to be a limiting factor for the phytoplankton growth in the northern Bay due to the high cloud cover during the summer monsoon despite the nutrient availability (Prasanna Kumar et al. 2010). High river discharge lowers the salinity of northern region resulting into an estuarine environment. The turbidity caused due to the river discharge further lowers the availability of light into the waters hindering phytoplankton growth particularly marine coccolithophores.

Higher abundances and diversity in the western region could be due to the high primary productivity. The western region is characterized by the upwelling phenomenon and nutrients richness by river discharge. In addition, cold core eddies in this region enhance the periodical nutrient availability which results into the high productivity of coccolithophores. *Gephyrocapsa oceanica* is the most dominant taxa in the western region. It has been documented to have a characteristic low latitude biogeography from the tropical and subtropical regions and highly abundant in the nutrient rich regions such as upwelling (McIntyre et al. 1967) and ocean margins, continental shelves (Okada & Honjo 1973, Broerse et al. 2000, Guptha et al. 2005, Mergulhao et al. 2006) and rarely observed in the oligotrophic regions. This species has been documented as characteristic taxa for the moderate saline waters in the river discharge areas from the Coast of Puerto Rico, Gulf of Panama (Smayda 1966, Jordon & Winter 2000). It is used as an indicator of warming and runoff from the Mediterranean Sea (Weaver & Pujol 1988).

Emiliania huxleyi has an extremely wide biogeographical distribution and is the most abundant living coccolithophore from the majority of the world oceans (Winter et al. 1994, Hattori et al. 2004). It thrives in broad ranges of salinity and temperatures (1-30ºC) and present in the entire photic zone (Winter 1982). It has been documented to be present in high abundances in the nutrient rich environments such as upwelling regions and river discharge areas (Smayda 1966, Berger 1976, Stoll et al. 2007).

Changes in the assemblages are inferred by assessing dominance between *E. huxleyi* and *G. oceanica* ratio and thus have been linked to changes between an upwelling dominated ecosystem to a river dominated ecosystem from the Cariaco Basin (Mertens et al. 2009). Study by Doose-Rolinski et al. (2001) from the Arabian Sea suggested the ratio between *G. oceanica* and *E. huxleyi* being indicative for warmer and fresher conditions related to higher monsoon activity. As Bay of Bengal is also situated under the same climatic forcing as Arabian Sea, the dominance of assemblage by *Gephyrocapsa* species and subdominance by *Emiliania huxleyi* and their ratio are used herein as proxy to decipher the climatic fluctuations, productivity and monsoonal fluctuations from the Bay of Bengal.

CONCLUSIONS

1. Overall nannoplankton diversity is considerably low in the Bay of Bengal region compared to the other regions of the Indian Ocean and Arabian Sea. The study shows low diversity in the northern shelf region and high diversity and abundances in the western shelf region of the Bay and Bengal.
2. The low diversity of nannoplanktons in the inner and outer neritic region of northern Bay of Bengal is due to the low saline condition and heavy river discharge in the area.
3. *Emiliania huxleyi* and *Gephyrocapsa oceanica* are considered as opportunistic taxa that can withstand the fluctuating salinity conditions in Bay of Bengal region hence dominate in the assemblages.

4. The present study of nannoplankton data from Bay of Bengal clearly points that nutrient richness does not play any role in the proliferation of nannoplankton primary productivity instead appropriate stable saline conditions are required for their growth.

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