Detection and study of blooms of *Trichodesmium erythraeum* and *Noctiluca miliaris* in NE Arabian Sea

S. G. Prabhu Matondkar[1*], R.M. Dwivedi[2], J. I. Goes[3], H.do.R. Gomes[3], S.G. Parab[1] and S.M.Pednekar[1]

[1]*National Institute of Oceanography, Dona-Paula 403 004, Goa, INDIA*

[2]*Space Application Centre, Ahmedabad, Gujarat, INDIA*

[3]*Bigelow Laboratory for Ocean Sciences, West Boothbay Harbor, Maine, 04575, USA*

Abstract

The Arabian Sea is subject to semi-annual wind reversals associated with the monsoon cycle that result in two periods of elevated phytoplankton productivity, one during the northeast (NE) monsoon (November-February) and the other during the southwest (SW) monsoon (June-September). Although the seasonality of phytoplankton biomass in these offshore waters is well known, the abundance and composition of phytoplankton associated with this distinct seasonal cycle is poorly understood. Monthly samples were collected from the NE Arabian Sea (offshore) from November to May. Phytoplankton were studied microscopically up to the species level. Phytoplankton counts are supported by Chl *a* estimations and chemotaxonomic studies using HPLC. Surface phytoplankton cell counts varied from 0.1912 (Mar) to 15.83 cell x104L-1 (Nov). In Nov *Trichodesmium thiebautii* was the dominant species. It was replaced by diatom and dinoflagellates in the following month. Increased cell counts during Jan were predominantly due to dinoflagellates *Gymnodinium breve*, *Gonyaulax schilleri* and *Amphidinium carteare*. Large blooms of *Noctiluca miliaris* were observed in Feb a direct consequence of the large populations of *G. schilleri* upon which *N. miliaris* is known to graze. In Mar and April, *N. miliaris* was replaced by blooms of *Trichodesmium erythraeum*. This succession of species was distinctly reflected in the phytoplankton pigments measured by HPLC. In Nov high concentrations of zeaxanthin (0.5 mgm-3) and β-carotene (0.52 mgm-3) were mainly due to *T. thiebautii* while high concentrations of peridinin (0.4 mgm-3) were due to the large populations of dinoflagellates observed in Jan. During the *N. miliaris* bloom both Chl *b* (3.76 mgm-3) and prasinoxanthin (0.11 mgm-3) were reasonably high. The large amount of organic matter produced by these blooms export organic matter in subeuphotic depths. The monitoring of this export production is done with the help of OCM (IRS-P4I) during present study.

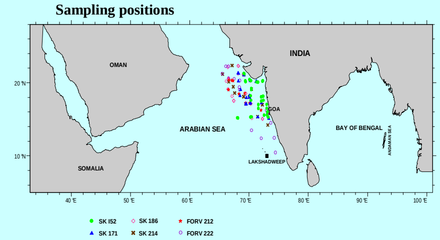
Introduction

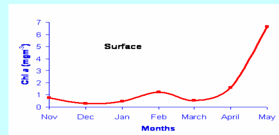
Arabian Sea is well known for its distinct and predictable oscillations in phytoplankton biomass which are strongly linked to monsoonal wind driven forcing during NE and SW monsoons. However very little information is available on the variations in phytoplankton composition associated with the blooms that appear during the NE and SW monsoons. The launching of the OCEAN-SAT (1) in1999 afforded us an opportunity to identify the phytoplankton species associated with the large scale blooms observed in the ocean colour data. The NE winter bloom was sampled periodically from Nov-April and the seasonality of phytoplankton in the Arabian Sea was established by microscopy and chemotaxonomy.

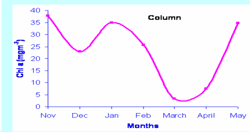
Material and Methods

Six cruises were undertaken on board the ORV *Sagar Kanya* and FORV *Sagar Sampada*. Water samples were collected and analyzed for phytoplankton taxonomy (Inverted Microscope), chemotaxonomy (HPLC), Chlorophyll *a* by HPLC and fluorometry as a part of the validation of the Indian ocean colour sensor, Ocean Colour Monitor (OCM). OCM derived chlorophyll *a* data was processed during cruises and validated using the ship board data.

Sampling positions







Monthly variations in surface Chl *a* (mg m^{-3}) and column Chl *a* (mg m^{-2}) in the Northeastern Arabian Sea

Months	Dominant phytoplankton species					
	Surface			Column		
Nov	***Trichodesmium thiebautii***	*Nitzschia closterium*	*Ampphora hyalina*	*Chaetoceros socilalis*	*Melosira moniliformis*	*Chaetoceros danicus*
Dec	*Gymnodinium gracile*	*Prorocentrum minimus*	*Rhizosolenia alata*	***Trichodesmium thiebautii***	*Nitzschia longissima*	*Actinoptychus senarius*
Jan	***Gymnodinium breve***	*Gonyaulax schilleri*	*Amphidinium carteare*	*Amphidinium carteare*	*Coscinodiscus radiatus*	*Gyrodinium spirale*
Feb	***Noctiluca miliaris***	*Navicula sp. I*	*Nitzschia closterium*	***Noctiluca miliaris***	*Rhizosolenia shrubsolei*	*Coscinodiscus occulus*
March	***Trichodesmium erythraeum***	*Noctiluca miliaris*	*Hemiaulus sinensis*	*Rhizosolenia shrubsolei*	*Pyrophacus horologium*	*Cocconeis scutellum*
April	***Trichodesmium erythraeum***	*Coscinodiscus marginatus*	*Peridinium elegans*	*Navicula delicatula*	*Trichodesmium erythraeum*	*Rhizosolenia stolterfothii*
May	***Trichodesmium erythraeum***	***Trichodesmium thiebautii***	*Scripsiella trochoidea*	*Trichodesmium erythraeum*	*Nitzschia accuminata*	*Thalassiothrix frauenfeldii*

Months	Phytoplankton cell counts		Surface phytoplankton group %			
	Surface (nos.x10^{4}l^{-1})	Column (nos.x10^{6}m^{-2})	Dia	Dinf	Cyano	Other
Nov	15.831	180.690	30.39	0.40	69.21	0.00
Dec	0.4352	19.4238*	75.00	23.44	0.78	0.00
Jan	0.2324	4.2638	7.14	89.29	0.00	3.57
Feb	0.53	4.479	20	20	0.00	60.00
March	0.1912	14.553	30.71	23.08	38.96	7.69
April	1.6682	20.2165	3.64	16.63	79.73	0.00
May	4.1626	10.1084	1.94	3.94	94.07	0.00

(Dia-diatom; Dinf- dinoflagellates; Cyano-cyanobacteria.; Other- *Noctiluca*)
*Sub-surface bloom of *Trichodesmium* was observed

Results

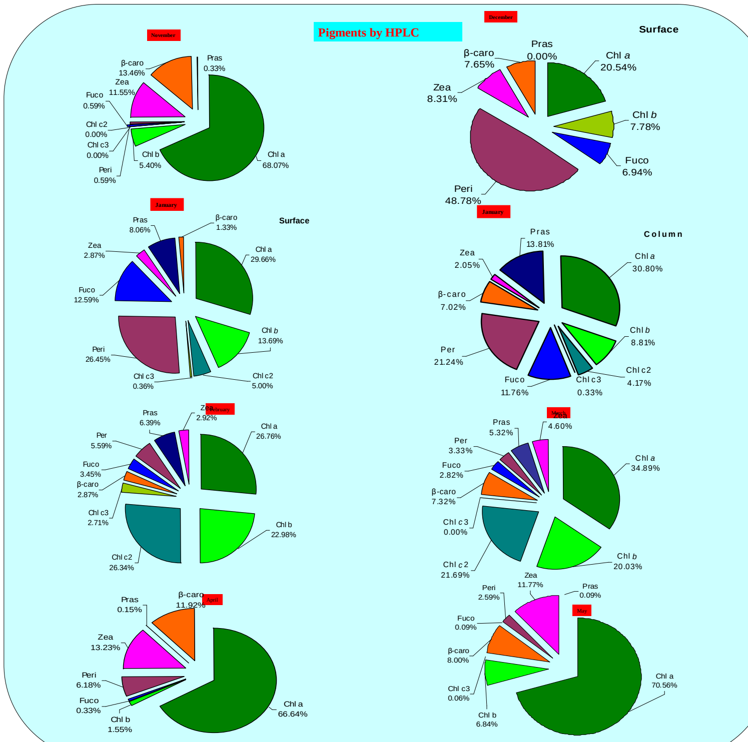
Taxonomy

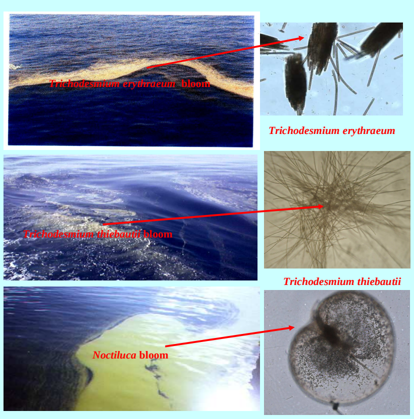
- ❖Phytoplankton cell counts ranged from 0.2 to 15.83 x10^{4}l^{-1} at the surface and 4.5 to 180.7 x10^{6}m^{-2} in the water column.
- ❖Highest surface cell counts were observed in Nov and lowest in Jan and Mar. The month of Feb saw the presence of an intense *N. miliaris* bloom.
- ❖In the Nov, cyanobacteria (69%) dominated the phytoplankton populations.
- ❖In the following month, diatoms dominated followed by dinoflagellates and cyanobacteria.
- ❖In Jan, diatoms were replaced by dinoflagellates (89%) followed by diatoms and other algae.
- ❖In the Feb the large bloom of *N. miliaris* dominated the phytoplankton population (60%) followed by diatoms and dinoflagellates.
- ❖In March cyanobacteria was the dominant (38%) group followed by diatoms and dinoflagellates.
- ❖In the months of April and May cyanobacterial populations increased dramatically to 80-94 %.

Chemotaxonomy

- ❖The pigments zeaxanthin (11.6 %) and β-carotene (13.5%) measured in Nov were primarily due to the *T. thiebautii* bloom.
- ❖In December dinoflagellates such as *Gymnodinium gracile* and *Prorocentrum minimus* contributed substantial amounts of peridinin (48.8 %) and β-carotene (7.65%) while the zeaxanthin (8.31%) measured was due to *T. thiebutii*.
- ❖Peridinin dominated the water column in Jan (21-26%) due to the presence dinoflagellates such as *Gymnodinium breve* and *Gonyaulax schilleri*. Chl *b* (13.7%) was from the considerable fraction of green flagellates observed microscopically.
- ❖The Feb bloom of *N. miliaris* contributed Chl *b* (23%), Chl *c*2 (26.4%) and Prasinoxanthin (6.4%), the latter derived from the endosymbiont *Pedinomonas noctilucae* that the dinoflagellate harbors. *N. miliaris* blooms were observed in the open ocean while on the shelf *Trichodesmium* blooms dominated.
- ❖In Mar, the bloom of *T. erythraeum* produced the pigments such as zeaxanthin (4.6%) and β-carotene (7.3 %).
- ❖The following month, concentrations of zeaxanthin (13.2%) and β-carotene (11.9 %) increased as the bloom of *T. erythraeum* developed.
- ❖In May zeaxanthin (11.77%) and β-carotene (8 %) measured were due to the diazotrophs *T. erythraeum* and *T. thiebautii*.

Pigments by HPLC



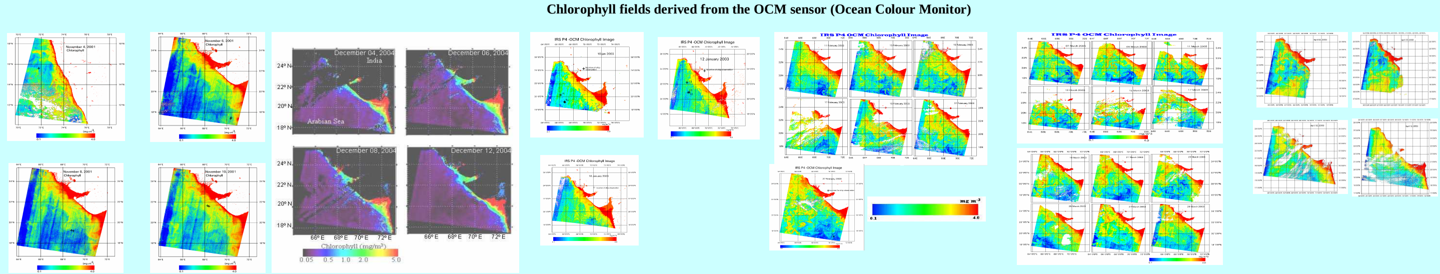


Trichodesmium erythraeum

Trichodesmium thiebautii

Noctiluca miliaris

Chlorophyll fields derived from the OCM sensor (Ocean Colour Monitor)



Conclusions

- ➢ In Nov/Dec, depletion of nutrients that had upwelled from winter convective mixing coincided with development of blooms of *T. thiebautii* at surface in Nov and at subsurface in Dec. This was confirmed by elevated zeaxanthin and β-carotene measured.
- ➢Low Chl *a* concentrations and low phytoplankton counts were seen in Dec, a situation that was mirrored in the ocean colour images.
- ➢In Jan, blooms comprising of a mixture of several species of dinoflagellates were observed which contributed to the high Chl *a* seen in the ocean color data and to the high concentrations of peridinin measured by HPLC.
- ➢This mixed dinoflagellate bloom was followed by an intense *N. miliaris* bloom in Feb. The elevated levels of Chl *b* and Chl *c* were derived from the *N. miliaris* bloom. High levels of prasinoxanthin were due to the symbiotic prasinophyte *Pedinomonas noctilucae* that the *N. miliaris* harbors as an endosymbiont.
- ➢*T. erythraeum* blooms were seen in association with the *N. miliaris* bloom as well as during the post *N. miliaris* bloom stage in Mar-April.
- ➢May was marked by an intense *T.* bloom which was associated with flagellates.

Acknowledgements

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