Indian Journal of Geo Marine Sciences
Vol. 49 (01), January 2020, pp. 67-72

Unusual mass shoreward movement of bivalve (Mollusca) *Donax scortum* Linnaeus along the coastal waters off Calicut - South Eastern Arabian Sea

Lathika Cicily Thomas, Twinkle Sathish, I.J. Jeslin, A. Sreerag, S. Bijoy Nandan & K.B. Padmakumar*

Department of Marine Biology, Microbiology and Biochemistry, School of Marine Sciences,
Cochin University of Science and Technology (CUSAT), Kochi-16, Kerala, India

*[E-mail: kbpadmakumar@gmail.com]

Received 23 July 2018; revised 18 September 2018

Eutrophication and oxygen depletion are the major factors influencing the responses of benthic organisms in coastal ecosystems. Along the coastal waters of South Eastern Arabian Sea a mass shoreward movement of bivalve *Donax scortum* (locally referred as "*eranthu*") occurred during end phase of summer monsoon upwelling. Possible reasons for this shoreward movement points to the low dissolved oxygen (0.25 ml L^{-1}) in the bottom waters. Intense blooms of large dinoflagellate species, *Noctiluca scintillans* were observed a week prior to this event along these coastal waters and the crashing related decaying might have resulted in lower DO values in the region. The study discuss on the deleterious effects of hypoxic conditions caused by summer monsoon algal blooms on benthic fauna of South Eastern Arabian Sea.

[**Keywords*:*** Hypoxia; *Donax scortum*; Harmful algal blooms; *Noctiluca scintillans*; Arabian Sea]

Introduction

Coastal benthic ecosystems are highly influenced by alterations in physico-chemical factors of the water column and bentho-pelagic interactions are prominent in these systems. Habitat destruction by natural and anthropogenic activities such as dredging and mining, eutrophication, decrease in dissolved oxygen (DO) levels etc. are some among factors negatively affecting benthic ecosystems[1]. Dissolved oxygen is considered to be an important factor in these aspects owing to the stress caused by hypoxic and anoxic conditions[2]. Decrease in water column dissolved oxygen can result in various responses among the benthic organisms such as avoidance, growth irregularities, reproductive and behavioural changes[3,4] etc. In general the DO levels of <1.42 ml L^{-1} is considered to be hypoxic condition[3]. Hypoxia induced alteration in behavioral characteristics of benthic fauna have been documented in various coastal bays and estuarine environments around the world[5-8].

Hypoxia along the South Eastern Arabian Sea (SEAS) is directly or indirectly linked to the biannually reversing monsoons and the coastal upwelling during the summer monsoon season. High and sustained production along the coastal waters of SEAS results in higher organic matter input in the region. Coastal blooms are a regular phenomenon during the summer monsoon upwelling which can possibly reduce the dissolved oxygen concentrations during the death and decay[9]. The occurrences of intense blooms in near shore waters thus have either direct or indirect effects on the benthic fauna. The erratic movements of invertebrates and fishes were previously reported from the Alabama coast of Gulf of Mexico and were reported as Jubilee phenomenon[10] where the local fisherfolk effortlessly collected edible marine resources in huge quantities. The phenomenon repeats along the coast yearly. Along the west coast of India, bordered by eastern Arabian Sea there are several unpublished reports of such shoreward movements of benthic fishes and invertebrates. (https://www.hindustantimes.com/mumbai-news/here-s-why-dead-fish-marine-animals-are-washing-up-maharashtra-shores/story-N9RxH40FpB9G4Dcycav5TK.html). However, detailed and authentic studies regarding the causes are lacking. Oxygen minimum zones and expansion of hypoxia are the suspected causes of such shoreward movements of benthic fauna in masses. The oxygen minimum zone along the Arabian Sea is reported to be increasing with the alterations in monsoon cycles[11]. This expansion can deleteriously affect the biogeochemistry of the region in near future. A jubilee phenomenon by crabs and flatfishes were reported from the central Kerala

coast of South Eastern Arabian Sea recently[12]. The study reports a re-occurrence of such an event of mass shoreward movement of benthic fauna along the coast of South Eastern Arabian Sea during summer monsoon and the possibilities of such events in the coming years.

Materials and Methods

An unusual mass aggregation of molluscs was reported by local fisher folk and in newspaper from the coastal waters off Nainamvalappu, Calicut- South Eastern Arabian Sea (Lat. 11º 13.8 N, Long. 75º 46.65 E, Fig. 1) on 24th September 2017. Prior to the event, coastal waters off Calicut were sampled for various physico-chemical parameters as a part of regular monitoring programme to study the eco-physiology of coastal algal blooms. Water samples were collected from discrete depths by using Niskin water sampler for measuring various water quality parameters. Hydrographic parameters such as temperature, salinity and dissolved oxygen (DO) were measured immediately after the collection of water samples during the field survey. Temperature was measured using an alcohol thermometer with on accuracy ± 0.01ºC. Salinity was measured using a hand held refractometer (*ATAGO-Smill-E, Japan*). Dissolved oxygen was estimated by Winkler method[13]. Chlorophyll *a* was measured spectrophotometrically using UV-Visible spectrophotometer following acetone extraction method[14]. Phytoplankton samples were collected by filtering ~50 litres of surface water through 20 µm bolting silk, and the filtrates were preserved in 1–3 % neutralized formaldehyde-lugol's iodine solution. Qualitative and quantitative analysis of phytoplankton samples were carried out using a Sedgewick Rafter counting cell under a Nikon Eclipse microscope following standard identification keys[15]. Similar measurements of physico-chemical characteristics were carried out during the present phenomenon along the coast. The bivalve samples were collected, cleaned and immediately fixed in the field with 90-100 % ethanol and were taken to the laboratory. Species level identification was carried out under stereomicroscope by using standard identification keys[16].

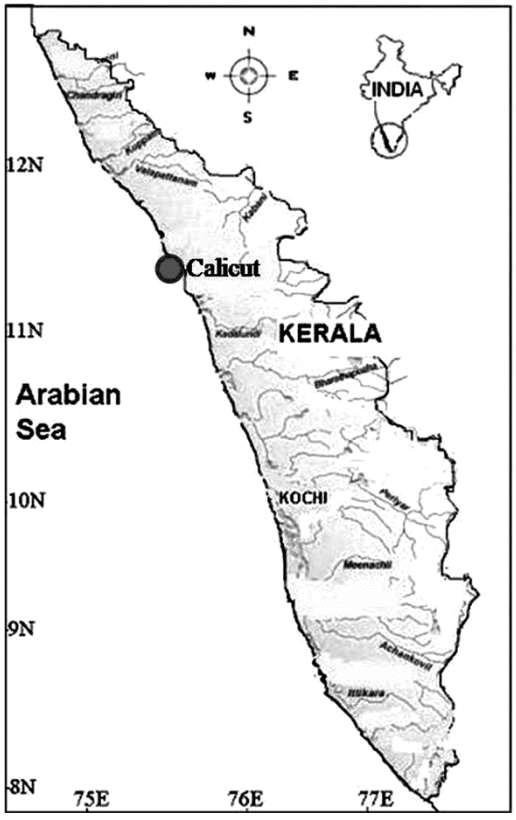

Fig. 1 — Study area. Black dot represents the area where the mass shoreward movement of *Donax scortum* was observed along the South Eastern Arabian Sea.

Results

An unusual mass aggregation of molluscs along coastal waters off Nainamvalappu Calicut was found to be as a result of large scale shoreward movement of bivalve mollusc *Donax scortum* (locally referred as "eranthu") (Fig 2). The bivalves accumulated along the shore were handpicked by fishermen as well as local people for their consumption. The meat of *Donax* is locally referred to as *eranthu* along the Malabar coast and is usually considered as culinary delicacy. No toxic effects on humans were reported following the consumption of *Donax* that moved shoreward because of this phenomenon.

Donax scortum belongs to order Veneroida. It is a marine species, which usually burrows in the sand in the surf line along sandy beaches. It has a length of 23-79 mm, the colour dirty white and violet in the posterior region. The shells are triangularly oblong and gibbous. Umbos posterior, elevated and pointed. Shell ovate with fine concentric striae; keel between the umbo and posterior margin are absent. Breeding period in India extends from November-June, with two spawning peaks, in November- December and May- June. The species is considered abundant along the Malabar coast (North Kerala) of South Eastern Arabian Sea.

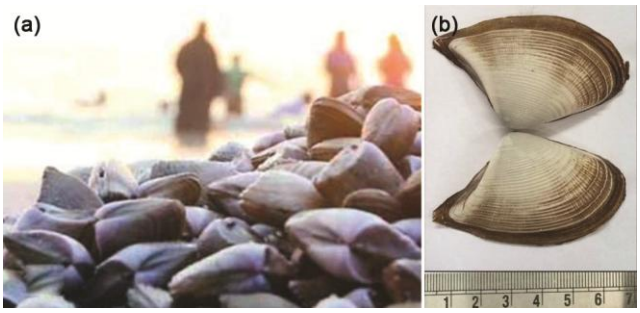

Fig. 2 — **(a)** Aggregation of *Donax scortum* along the shore (Photo courtesy: www.mathrubhumi.com **(b)** *Donax scortum*

Hydrobiological observations of the region showed a low bottom water dissolved oxygen (0.25 ml L^{-1}) which falls in the range of hypoxic conditions (Fig. 3). The sea surface temperature (SST) in the region was 27.6º C with a bottom water temperature of 22.3º C. Surface salinity of the region was 32.48 psu. Prior to this shoreward movement event, an extensive bloom of *Noctiluca scintillans* was observed along the coastal waters of Calicut two weeks ago. The blooms were found to be nearly monospecific with cell density of 3×10^5 cells L^{-1} and occupied an area of 12 km along the coast. The bloom was by red coloured *N. scintillans*, which fed upon diatoms following heterotrophic mode of nutrition. The prasinophyte photosynthetic endosymbiont *Pedinomonas noctilucae* was absent inside the dinoflagellate cells unlike green *Noctiluca scintillans* (Fig. 4). Satellite imagery of the surface chlorophyll *a* distribution of the region also observed intense surface algal blooms (Fig. 5). The surface chlorophyll *a* was observed to be 20 mg m^{-3}. At the time of mass shoreward movement event the bloom of *Noctiluca scintillans* almost decayed with remnants of decaying cells in the water column. Oxygen consumption during the decay of this large dinoflagellate might have resulted in the hypoxia of the water column in the region.

Discussion

Coastal ecosystems are regions of higher biodiversity and is characterised by heterogeneous habitats. Environmental factors undergo frequent alterations in accordance with the natural and anthropogenic influences along the coastal waters than the open water ecosystems[17]. Depletion of oxygen due to eutrophication and high biomass production is one among the major factor influencing the coastal ecosystems function and sustainability[1].

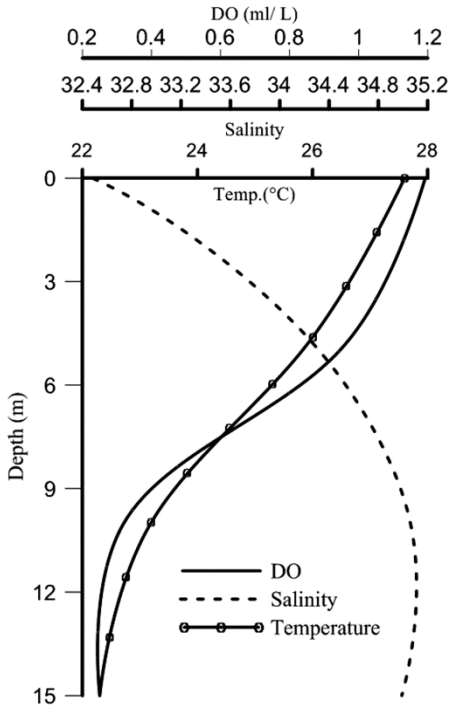

Fig. 3 — Vertical profile of Temperature, Salinity and Dissolved oxygen along the inshore waters during mass shore ward movement phenomenon of *D. scortum*.

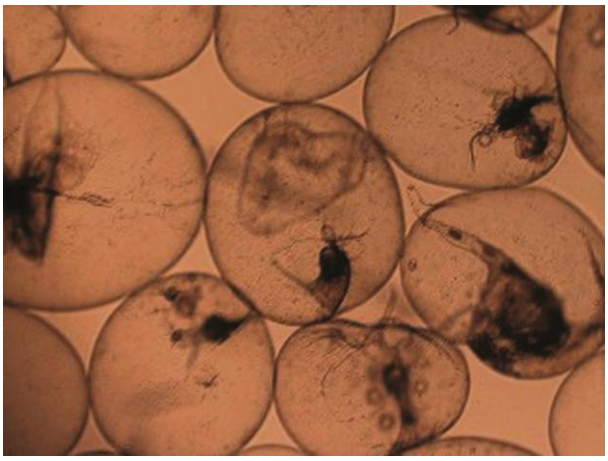

Fig. 4 — Microphotographs of Red *Noctiluca scintillans* without endosymbiont *Pedinomonas noctilucae* (x40)

Benthic fauna experiences habitat loss and food web disruption as a consequence of hypoxic conditions[18]. In responses to such alterations these organisms tends to move off from their habitat or express variabilities in their physiological responses. In extreme cases mortalities are also observed resulting in change in benthic community composition and diversities[19]. The mass shoreward movement of bivalve *Donax scortum* can be attributed mainly towards the hypoxic condition of the coastal bottom

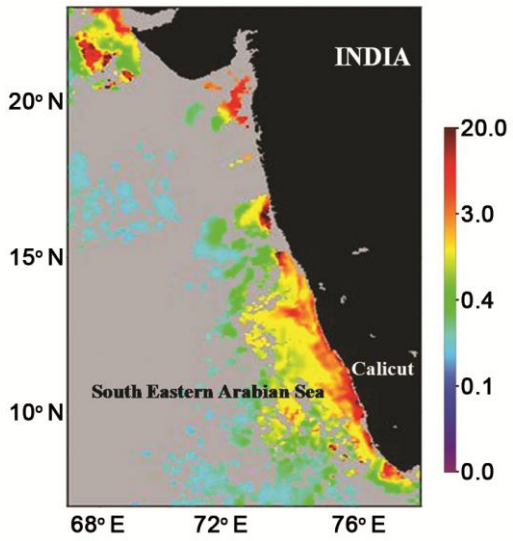

Fig. 5 — Satellite imagery of surface chlorophyll *a* distribution along the SEAS during the bloom event prior to mass shoreward movement of *D. scortum*.

waters. During summer monsoon season extensive short term blooms occur along SEAS among which the bloom of *Noctiluca scintillans* forms a major causative organism especially during the relaxation periods of summer monsoon upwelling[20]. The intense bloom and crash of this large size dinoflagellate demands dissolved oxygen. Since the biomass that sinks is of a larger quantity, consumption of oxygen will be much higher. This might have resulted in the hypoxia of shallow coastal waters.

During the present event of bivalve shoreward movement in large numbers, hypoxic conditions caused by extensive bloom of *Noctiluca scintillans* might have played a crucial role. Generally, *Noctiluca scintillans* is unpalatable and are often avoided by predators, due to its large size, nature of bioluminescence and the external metabolites produced[21]. As a result, the accumulated large algal biomass consumes oxygen during their death and decay resulting in dissolved oxygen depletion (hypoxia). Such hypoxic conditions are discussed to alter the structure and function of benthic communities[22]. Coastal systems are highly vulnerable to environmental alterations and are a region where strong bentho-pelagic coupling occurs. Faunal variabilities in the benthic communities take place in accordance with the fluctuations in environmental parameters such as temperature, salinity, oxygen, nutrient supply and animal interactions[23,24]. These variabilities can be either due to natural processes or due to anthropogenic influences. Algal blooms occur partly due to natural nutrient enrichment and other due to eutrophication from anthropogenic sources. Upwelling induced nutrient input along with runoff from the anthropogenic sources supports the coastal production along SEAS during summer monsoon[25,26]. Algal blooms often results from the alterations in the nutrient stoichiometry[27] that occurs during these productive period. On the instance of extensive blooms of large *N. scintillans* blooms, which are characterized by huge algal biomass, the tendency to develop hypoxia occurs[28].

Lowering of dissolved oxygen levels affects the benthic organisms[3] when the dissolved oxygen (DO) concentrations comes to as low as <1.45 ml L^{-1}. During the present phenomenon, DO of the bottom water reached to 0.25 ml L^{-1}. In such situations, benthic fauna tends to shift away from the stressed waters. The shoreward movement of Scorteem *Donax* scortum can be attributed to the hypoxic conditions created by *N. scintillans* blooms. The usual response of benthic macro fauna towards oxygen depletion is either avoidance or mortalities[4]. This anomalous shoreward movement of fishes, crustaceans and shellfishes in great numbers is called as "Jubilee"[10]. This type of event was first reported from the Mobile Bay (Gulf of Mexico) during which irregular movement of bottom dwelling marine fauna moved towards the shore[10]. A similar event was observed from the coastal waters off Chavakkad along the South-West coast of India that resulted in the mass shoreward movement of crabs and flatfishes[12]. The reoccurrence of these phenomenona might be due to the increased and frequent occurrence of *Noctiluca scintillans* blooms along the Arabian Sea during monsoon seasons. The food web disruptions and oxygen depletion caused by *N. scintillans* blooms thus influence both pelagic as well as benthic ecosystems which is a serious matter of concern.

The Arabian Sea is experiencing variabilities in the production patterns due to the bi-annually reversing monsoon winds as well as climate change. The basin also observes an increase in the intensity and expanse of oxygen minimum zones (OMZ)[11]. Various processes have been suggested for this expanse and algal blooms are one among them. Indian EEZ reports an increase in algal bloom events in the recent decades[29]. Among the bloom forming algae *Noctiluca scintillans* is found to be a major species. With the increase in the frequency of algal blooms that can lead to oxygen depleted condition, both pelagic and benthic fauna may observe stressed conditions and Jubilee like phenomenon can re-occur.

Conclusion

Algal blooms are considered as a frequent outcome of upwelling ecosystems mainly in the coastal and shallow near shore waters. Even then intense blooms of large sized algae such as *Noctiluca scintillans* seriously affects the stability of coastal systems. Hypoxia, one among the major consequence of these extensive blooms negatively influences both the pelagic and benthic ecosystems. The avoidance of *Donax scrotum* from its habitat and shift to shore due to oxygen depletion indicates the stressful conditions prevailed in the coastal waters during summer *Noctiluca* blooms. The frequency and occurrence of *Noctiluca* blooms are reported to be on an increasing scale along the west coast of India. Along with this the increased occurrence of Jubilee like phenomenon points towards the possible ecological threats of *Noctiluca* blooms along the South Eastern Arabian Sea.

Acknowledgement

This investigation was carried out as a part of the *Seed Money for New Research Initiatives* (SMNRI) programme under the State Plan Grant (2017-18) of Cochin University of Science and Technology (CUSAT), Kerala, India.

References

1 Lotze, H. K., Lenihan, H. S., Bourque, B. J., Bradbury, R.H., Cooke, R. G., Kay, M. C., Kidwell, S. M., Kirby, M. X., Peterson, C. H. & Jackson, J. B. C., Depletion, degradation, and recovery potential of estuaries and coastal seas, *Science*, 312 (2006), 1806–1809.

2 Gilbert, D., Rabalais, N. N., Diaz, R. J. & Zhang, J., Evidence for greater oxygen decline rates in the coastal ocean than in the open ocean, *Biogeosciences*, 7, (2010), 2283–2296.

3 Levin, L. A., Ekau, W., Gooday, A. J., Jorissen, F., Middelburg, J. J., Naqvi, S. W. A., Neira, C., Rabalais, N. N. & Zhang, J., Effects of natural and human-induced hypoxia on coastal benthos, *Biogeo Sci.*, 6, (2009), 2063–2098.

4 Diaz, R. J. & Rosenberg, R., Marine benthic hypoxia: a review of its ecological effects and the behavioural responses of benthic macrofauna, *Oceanogr. Mar. Biol. Ann. Rev.*, 33, (1995), 245–303.

5 Rabalais, N. N. & Turner, R. E., Hypoxia in the Northern Gulf of Mexico: description, causes and change. In: N. N. Rabalais & R. E. Turner (Editors.). Coastal and estuarine studies: coastal hypoxia consequences for living resources and ecosystems, *American Geophys. Union*, Washington, DC, (2001), 1–36.

6 Sellanes, J., Neira, C. & Quiroga, E., Composition, structure and energy flux of the meiobenthos off central Chile, *Rev. Chil. Hist. Nat.*, 76, (2003), 401–415.

7 Verity, P. G., Alber, M. & Bricker, S. B., Development of hypoxia in well-mixed subtropical estuaries in the southeastern USA. *Estuar. Coast.*, 29, (2006), 665–673.

8 Tyler, R. M., Brady, D. C. & Targett, T. E., Temporal and spatial dynamics of diel-cycling hypoxia in estuarine tributaries, *Estuar. Coast.*, 32, (2009), 123–145.

9 Naqvi, S. W., Naik, H., Jayakumar, D.A., Shailaja, M. S. & Narvekar, P. V., Seasonal oxygen deficiency over the western continental shelf of India. In*:* L. N. Neretin & Dordrecht (Editors.), *Past and Present Water Column Anoxia*, The Netherlands, (2006), 195–224.

10 Loesch, H., Sporadic mass shoreward migrations of demersal fish and crustaceans in Mobile Bay, Alabama. *Ecology*, 41, (1960), 292–298.

11 Lachkar, Z., Levy, M. & Smith, S., Intensification and deepening of the Arabian Sea oxygen minimum zone in response to increase in Indian monsoon wind intensity, *Biogeosciences*, 15, (2018), 159–186.

12 Padmakumar, K. B., Lathika, C. T., Anilkumar, V. & Sudhakar, M., Crab jubilee subsequent to red tide of *Noctiluca scintillans* along the central Kerala coast (SW coast of India), *Indian J. Mar. Sci*., 45(11), (2016), 1549–1551.

13 Winkler, L. W., Die Bestimmung des im Wasser gelosten Sauerstoffes, *Chem. Ber*., 21, (1888), 2843–2855.

14 Parsons, T. R., Maita, Y. & Lalli, C. M., *A manual of chemical and biological methods for Seawater analysis*, Pergamon Press, New York, (1984), pp 173.

15 Tomas, C. R. *Identifying Marine diatoms and dinoflagellates*, New York: Academic press, (1997), 858 pages.

16 Poutiers, J. M., Bivalves FAO species identification guide for fishery purposes. The living marine resources of the western central Pacific. Volume 1: *Seaweeds, corals, bivalves and gastropods* FAO, Rome 1, (1998), 686 pp, http://www.fao.org/docrep/009/w7191e/w7191e00.htm.

17 Segar, D. A., Coastal oceans and estuaries, Chapter. 13. In: Douglas A. Segar (Editor), *Introduction to ocean sciences*, 4th edn., IInd digital edn., version 4.0, (2012), 319–346.

18 Norkko, J., Gammal, J., Hewitt, J. E, Josefson, A. B., Carstensen, J. & Norkko, A., Seafloor ecosystem function relationships: in situ patterns of change across gradients of increasing hypoxic stress, *Ecosystems*, 18, (2015), 1424–1439.

19 Zaitsev, Y. P., Recent changes in the trophic structure of the Black Sea, *Fish. Oceanogr*., 1, (1992), 180–189.

20 Padmakumar, K. B., Lathika, C. T., Sudhakar, M. & Bijoy Nandan, S., Extensive outbreaks of heterotrophic dinoflagellate *Noctiluca scintillans* blooms along coastal waters of the South Eastern Arabian Sea, *Harmful Algae News*, 52, (2016), 11–12.

21 Padmakumar, K. B., Algal blooms and Zooplankton standing crop along the South West coast of India, *Ph.D. thesis*, *Cochin University of Science and Technology*, Kerala, India, (2010).

22 Berdalet, E., Fleming, L. E., Gowen, R., Davidson, K., Hess, P., Backer, L. C, Moore, S. K., Hoagland, P. & Enevoldsen, H., Marine harmful algal blooms, human health and wellbeing: challenges and opportunities in the 21st century. *J. Mar. Biol. Assoc. U. K.*, 96(1), (2016), 61–91.

23 Dauer, D. M. & Alden, R.W., Long-term trends in the macrobenthos and water quality of the lower Chesapeake Bay (1985–1991), *Mar. Poll. Bull.*, 30(12), (1995), 840–850.

24 Jayaraj, K. A., Jayalakshmi, K. V. & Saraladevi, K., Influence of environmental properties on macro benthos in the northwest Indian shelf, *Enviro. Moni. Asses*., 127, (2007), 459–475.

25 Habeebrehman, H., Prabhakaran, M.P., Jacob, J., Sabu, P., Jayalakshmi, K. J., Achuthankutty, C. T. & Revichandran, C., Variability in biological responses influenced by upwelling events in the eastern Arabian Sea, *J. Mar. Syst*., 74(1), (2008), 545–560.

26 Lathika, C. T., Padmakumar, K. B., Smitha, B. R, Ashadevi, C. R., Bijoy Nandan, S. & Sanjeevan, V. N., Spatio-temporal variation of microphytoplankton in the upwelling system of South Eastern Arabian Sea during the summer monsoon 2009, *Oceanologia*, 55(1), (2013), 185–204.

27 Glibert, P. M. & Burkholder, J. M., Harmful algal blooms and eutrophication: Strategies for nutrient uptake and growth outside the Redfield comfort zone, *Chinese J. Oceanography*, 29, (2011), 724–738.

28 Baliarsingh, S. K., Lotliker, A. A., Trainer, V. L., Wells, M. L., Parida, C., Sahu, B. K., Srichandan, S., Sahoo, S., Sahu, K. C. & Srinivasakumar, T., Environmental dynamics of red *Noctiluca scintillans* bloom in tropical coastal waters, *Mar. Poll. Bull*., 111(1-2), (2016), 277–286.

29 Padmakumar, K. B., Menon, N. R. & Sanjeevan, V. N. Is occurrence of Harmful algal blooms in the EEZ of India on the rise? *International Journal of Oceanography*, Volume 2012, Article ID 263946, 7 pages, doi:10.1155/2012/263946.