J. Mar. Biol. Ass. India, **49** (2) : 213 - 218, July - December 2007

Mortality of farmed pearl oyster *Pinctada fucata* (Gould, 1850) due to the blooming of *Noctiluca scintillans* and *Cochlodinium* sp. at Kollam Bay, Kerala

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Abstract

Blooming of the dinoflagellates *Noctiluca scintillans* was observed at Kollam Bay, Kerala during September 2003 (bloom-1) and *Cochlodinium* sp. in September 2004 (bloom-2) with cell densities of 9.8×10^4 and 1.4×10^5 cells l^{-1} respectively. These caused 27% and 100% mortality of the farmed pearl oyster *Pinctada fucata* in the raft farms of Central Marine Fisheries Research Institute moored in the Bay. The mortality of the pearl oysters can be attributed to the high dissolved ammonia 14.9 µmol l^{-1} during bloom-1 and high dissolved ammonia (14.7 µmol l^{-1}) and total suspended solids (154.8 mg l^{-1}) during bloom-2. These instances of harmful algal blooms (HAB) indicate that precautionary management protocols should be developed to relocate the farm stock to overcome such natural causes to prevent economic loss to farmers.

Key words: *Noctiluca scintillans*, *Cochlodinium* sp., harmful algal blooms (HAB), farmed pearl oysters

Introduction

Though algal blooms in coastal waters are a natural phenomenon, recent studies indicate that they have increased in frequency and geographic distribution over the past few decades. Ho and Hodgkiss (1991) in a review on the red tides in subtropical coastal waters from 1928 to 1989 showed that the number of blooms increased from 1 or 2 every 10 year at the beginning of the period to over 220 between 1980 and 1989. Of the harmful algae, the species most often reported (Jugnu, 2006) from Indian waters is the dinoflagellate *Noctiluca* species which is a large (200 µm to >1 mm) unarmoured dinoflagellate widely distributed in the subtropical and tropical waters. *Noctiluca* blooms have been reported and studied in the coastal waters along the southwest coast of India (Bhimachar and George, 1950; Devassy and Nair, 1987; Katti *et al.,* 1988; Mathew *et al.,* 1988; Nayak *et al*., 2000; Eashwar *et al.,* 2001; Mohammed, 2003).

The naked flagellate *Cochlodinium* sp. is also known to form blooms and cause fish kills (Whyte *et al.,* 2001; Vicente *et al*., 2002). The present investigation reports on the occurrence of *Noctiluca scintillans* and *Cochlodinium* sp. blooms at Kollam Bay in the central Kerala coast and the associated mortality of pearl oysters stocked in a raft farm. This is the first instance of large scale mortality of farmed pearl oysters due to harmful algal bloom (HAB) along the west coast of India.

Material and Methods

The pearl oyster farm of Central Marine Fisheries Research Institute (CMFRI) is located in the Kollam Bay, an artificially created semi-enclosed bay in central Kerala. As a part of the demonstration and improvement of pearl culture technology under the National Agriculture Technology Project (NATP), wooden rafts (5 x 5m) were moored in the bay since 2001 and pearl oysters were suspended from the raft in net and plastic cages. The monthly variations in hydrological parameters at the farm site were studied by taking water samples from the farm site at a depth of 1.5 m using 10 l Niskin bottles. Water temperature was recorded by a thermometer with 0.5°C precision and salinity by a refractometer. The total suspended solids (TSS) estimation was carried out gravimetrically after desiccation (105°C, 24 h) using an electronic balance (accuracy ± 0.1 mg). Chlorophyll pigments, ammonia and nutrients *viz*., nitrate, nitrite, and phosphate were measured using a spectrophotometer (Strickland and Parsons, 1972).

In the third week of September 2003, a deep orange colouration, indicative of an algal bloom (bloom 1), was observed at Kollam bay with the intensity of the colouration increasing towards the shore line. On 10th September 2004 also a discolouration in the seawater (dirty yellow colour) with higher intensity occurred at the same site (bloom-2). To study the causative organism and the intensity of the bloom, water samples (10 l) were collected from the site on the bloom day and fixed with 4% formalin and brought to the laboratory for enumeration. Quantitative estimation of phytoplankton was done by sedimentation method (Utermohl, 1958). Enumeration was done in triplicates and the average count of phytoplankton was expressed in cells l^{-1}. The second bloom persisted and spread southward along the southwest coast.

Results and Discussion

The water samples collected from the site during bloom-1 showed the presence of the toxic dinoflagellate *N. scintillans* (Fig. 1A) at a density of 9.8 x 10^4 cells l^{-1}. Apart from this, the diatom *Coscinodiscus* sp. and *Gyrosigma balticum* at densities of 5 and 3 cells l^{-1} respectively were recorded. A complete absence of other phytoplankton in the bloom area was noted in the samples taken. During bloom-2, the density of *Cochlodinium sp*. (Fig. 1B) was much higher at 1.4 x 10^5 cells l^{-1}. A few cells of the toxic dinoflagellate, *Gymnodinium* sp. were also observed. While the first bloom subsided within a day, the second bloom lasted for nearly three weeks. Bloom-2 spread to regions further south of Kollam and species such as the holococcolithophore, *Helladosphaera* sp. (Ramaiah, *et al*., 2005) bloomed during the later stages. During 23-26 September 2004, a study (Ramaiah *et al*., 2005) in this region showed that the abundance of *Helladosphaera* sp. was in excess of 1.8 x 10^6 cells l^{-1}. During bloom-2 an unusual and strong stench was reported from the coast off Kollam and Vizhinjam and several children complained of nausea, chest pain and bouts of breathlessness. However, there were no human fatalities.

The pearl oysters (*Pinctada fucata*, n = 5000) suspended in the plastic and lantern cages in the wooden raft of CMFRI in the bay were affected by bloom-1 and a mortality of 27% of oysters of length range 48-80 mm was recorded. Mortality of a few farmed green mussels, *Perna viridis*, was observed in the adjacent raft. The intensity of bloom-2 was much more severe and it was observed that the mantles of the oysters were shrunken and the meat was flaccid (Fig.1C). Complete mortality of the stock (n= 5500) of pearl oysters of length range 40 to 80 mm was noted within 24 hours of the bloom (Fig. 1D). The pearl oysters were highly susceptible to *Cochlodinium* sp. unlike *N. scintillans*. Mortality of farmed pearl oysters due to the blooms of *N. scintillans* and *Cochlodinium* sp. were not observed previously in the Indian waters but similar mortality of farmed pearl oysters due to the bloom of *Trichodesmium* sp. was reported in the pearl farm of CMFRI at Veppalodai along the southeast coast (Alagarswami, 1991). Jugnu (2006) reported on the large scale mortality of green mussels along Calicut coast due to the bloom of the raphidophyte *Chatonella marina* and on the mortality of farmed shrimps and fishes along Vypin Island in central Kerala due to the bloom of *Gymnodinium* sp. Along the British Columbia coast, bloom of *Cochlodinium polykrikoides* at a density of 6 x 10^4 cells ml^{-1} caused substantial mortality to the farmed salmon with losses estimated at Canadian $2 million (Whyte *et al*., 2001). They observed that the fishes stopped feeding when cell counts exceeded 500 cells ml^{-1}. Recently blooms of *Cochlodinium* sp. also led to fish kills at Iligan bay, Philippines (Vicente *et al*., 2002).

Both the present HABs were observed during September and instances of similar *Noctiluca*

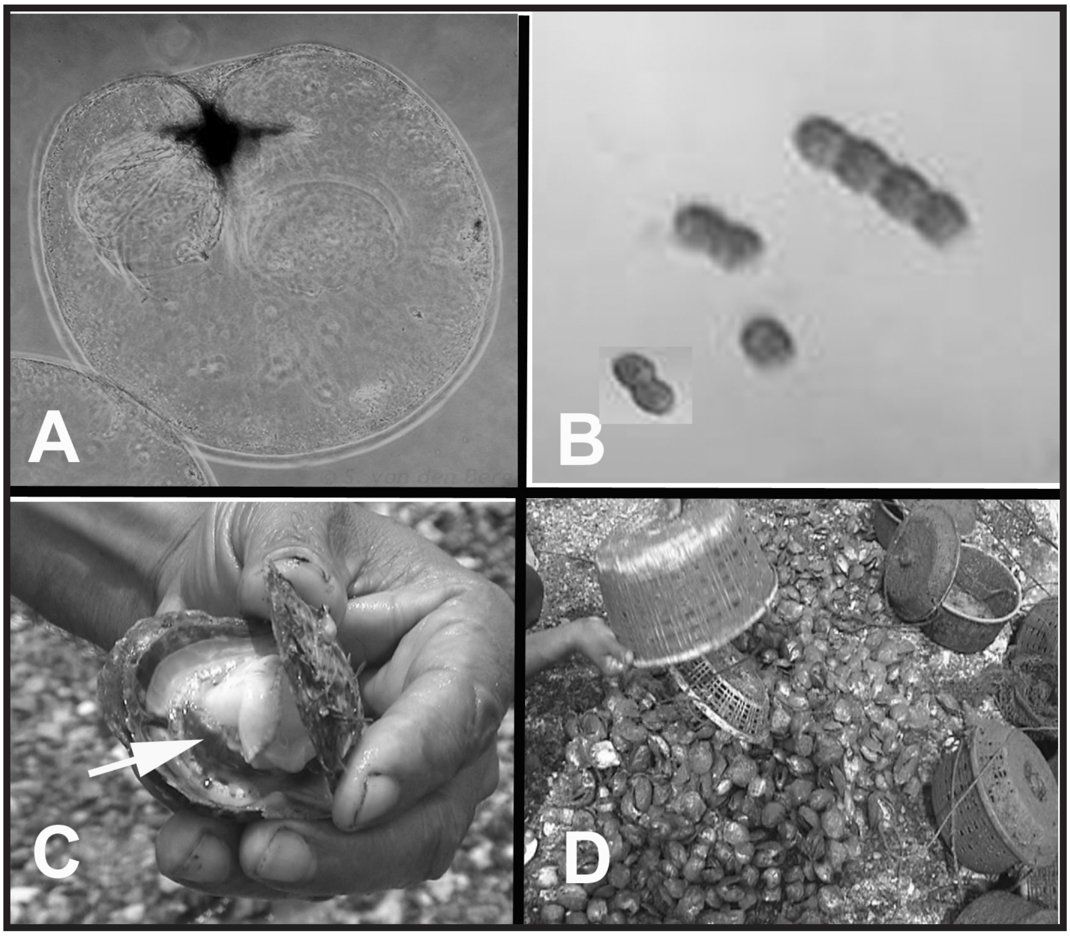

Fig. 1. (A) *Noctiluca scintillans* cell from bloom-1; (B) Cochlodinium cells in chain and pairs from bloom-2; (C) A view of the clogged gills, shrunken mantle and flaccid meat of the farmed pearl oyster *Pinctada fucata* killed by bloom-2 of *Cochlodinium sp*; (D) A view of the dead shells of pearl oysters stocked in cages in the raft farm of CMFRI at Kollam bay.

blooms along the west coast of India were reported between August and November (Mathew *et al.,* 1988) which marked the end of upwelling along the coast. Sreekumaran *et al.* (1992) observed that along the west coast of India regular blooms of *Noctiluca* sp. occur during or immediately after the onset of the monsoon following an increase in phytoplankton population. Jugnu (2006) also found that blooms of *Noctiluca* sp. occurred at Chombala in north Kerala and Vizhinjam in south Kerala in the monsoon months preceded by rains and diatom maxima. During the blooms of *N. scintillans* in August 2003 at Vizhinjam, the seawater was golden yellow colour near the shore with a frothy appearance along the shoreline. *Noctiluca* was present at a density of 1.02 x 10^5 cells l^{-1} in the sea and at a lesser density of 5.5 x 10^4 cells l^{-1} in the Vizhinjam bay (Jugnu, 2006). Shetty *et al.* (1988) observed a cell density of 8.2 x 10^9 cells m^{-3}, Venugopal *et al.* (1979) accounted for a cell density of 3-7.7 x10^5 cells m^{-3} whereas, Nayak *et al.* (2000) recorded a cell density of 1.56 x 10^6 cells m^{-3} of the same species at different centres along the west coast of India. Rich food supply is basically necessary for the species to reproduce massively, but suitable temperature and stable weather without heavy rain also appear to be favourable factors.

In Kollam Bay during bloom-1, the pigments chlorophyll *a* and *c* content of the seawater were estimated as 1.14 and 0.019 mg m^{-3} while chl *b* was absent. Chl *a* and *c* values were lower in the preceding and succeeding months with values of 0.05 and 0.04 mg m^{-3} in August and 0.65 and 0.07 mg m^{-3} in October (Table 1). Compared to the pre-bloom-2 period (August 2004), the concentration of chlorophyll pigments was low during bloom period and post-bloom period of September and October (Table 1) indicating a departure from the normal. The major physicochemical and biological parameters measured before, during and after the bloom are given in Table 1.

The atmospheric temperature, sea surface temperature, salinity and pH did not show much difference. However, considerable differences of physicochemical parameters were observed. The total suspended solids increased from 24.8 in August to 27.2 mg l^{-1} during bloom-1 and again decreased to 23.9 mg l^{-1} in the following month. During bloom-2 the TSS level reached 154.8 mg l^{-1} and decreased to 16.8 mg l^{-1}subsequently. Ammonia concentrations were also comparatively very high during both the blooms. Ammonia which was nil in August 2003 increased to 14.9 µmol l^{-1} during bloom-1. During bloom-2 also a hike in ammonia level was noted. A high value of ammonia of 82 µg at.l^{-1} was observed by Nayak *et al.* (2000) during *N. scintillans* bloom off Mangalore. Dissolved phosphate, nitrite and nitrate values showed a marginal increase during bloom-1 while the increase was considerably higher during bloom-2 of 2004. According to Della-Cruz *et al.* (2000), *N. scintillans* is an indicator of coastal eutrophication, in New South Wales coastal waters where the frequency of occurrence has increased in recent years with increasing nutrient load. They also observed that extensive red tides of *Noctiluca* often succeeded diatom blooms, specifically *Thalassiosira* sp.

Table 1. *Environmental parameters and cell densities during the blooms of the dinoflagellates* Noctiluca scintillans *and* Cochlodinium *sp. at Kollam Bay, Kerala*

Parameters	Bloom-1			Bloom-2		
	Pre-bloom August 03	Bloom September 03	Post-bloom October 03	Pre-bloom August 04	Bloom September 04	Post-bloom October 04
Noctiluca scintillans (cells l^{-1})	0	9.8 x 10^4	0	0	0	0
Cocholdinium sp. count (cells l^{-1})	0	0	0	0	1.2 x 10^5	0
Atmospheric temperature (° C)	27	28	29	27	28	29
Sea surface temperature (° C)	28	29	29	25	27	27
Salinity (ppt)	32	33	34	35	33	33
pH	8.1	8.1	8.1	7.9	7.4	7.8
Dissolved oxygen (mg l^{-1})	5.8	4.8	4.9	3.8	*	6.5
Total suspended solids (mg l^{-1})	24.8	27.2	23.9	31	154.82	16.8
Ammonia (µmol l^{-1})	negligible	14.9	5.7	7.18	14.72	5.03
Phosphate (µmol l^{-1})	1.24	1.7	0.93	negligible	15.95	12.62
Nitrate (µmol l^{-1})	0.06	0.08	0.06	0.7	2.4	0.55
Nitrite (µmol l^{-1})	2.1	0.24	0.93	8.37	24.52	14.89
Chlorophyll *a* (mg m^{-3})	0.05	1.14	.65	2.4	1.2	0.2
Chlorophyll *b* (mg m^{-3})	0.03	0	0	0	0.21	0.05
Chlorophyll *c* (mg m^{-3})	0.04	0.019	0.07	0.27	0.47	0.06

*could not be estimated due to discoloration of sample water

Ramaiah *et al*. (2005) who made a detailed study of bloom-2 about two weeks after the bloom occurred in Kollam found the holococcolithophore, *Helladosphaera* sp. as the main species in the bloom, besides a dozen other species of diatoms. However, they did not record *Cochlodinium* sp. Species successions are common in long-duration algal blooms (Smayda and Reynolds, 2001). Ramaiah *et al*. (2005) also suggested that occurrence of such blooms during September indicates that several physical processes must have helped the holococcolithophores to bloom. They reported that the minimum de-tided sea level (i.e. sea level from which tidal variations have been removed) was recorded by the tide gauge in Cochin Port area on September 6, 2004, and from this they concluded that when the thermocline is shallow the region becomes vulnerable to events that can bring high quantities of nutrients to the surface. This would have resulted in the right conditions for the algal blooms to develop.

The large scale mortality of pearl oysters is a warning that precautionary management measures must be taken to protect the farmed stock. When aquaculture programs are planned, facilities must be developed to relocate the pearl oyster stock in shore based collapsible pools with good aeration in clean filtered seawater for 2 to 3 days in such exigencies so that the mortality of high valued farm stock and economic losses can be avoided.

Acknowledgements

The authors are thankful to the Director, CMFRI and to Dr. K. K. Appukuttan, Head, Molluscan Fisheries Division for facilities and encouragement. Dr. C. P. Gopinathan, former Principal Scientist, CMFRI helped to confirm plankton species identity. They are grateful to the fishermen of Kollam Bay for the timely alert on the bloom in the farm area.

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Received: 12 March 2008
Accepted: 28 March 2008