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Dinoflagellate cyst composition, abundance and horizontal distribution in Bolinao, Pangasinan, Northern Philippines

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ABSTRACT

This paper constitutes the first cyst record of a eutrophic tropical mariculture area with harmful algal blooms since 2002 and provides contribution to the global record on dinoflagellate cysts, specifically from Northern part of Southeast Asia. Surface sediment samples from 54 stations in October 2006 and 5 stations from 2004 to 2006 Bolinao, Pangasinan were processed palynologically and by fluorescent techniques. Exploratory data analysis using Two-Way Indicator Species Analysis (TWINSPAN) to identify major patterns of distribution and Canonical Correspondence Analysis (CCA) ordinated stations and species along sediment and environmental variables have been done to determine spatial variations in community structure. Thirty-six cyst types have been identified which include the toxic species, *Alexandrium minutum*. Species richness and diversity correlated with silt, mud, carbonates and depth but have been observed to be generally low in the area ($p < 0.05$). Multivariate analysis shows that sediment grain size, nutrients and water depth are important variables related to cyst distribution. Two accumulation points that can be source and sinks of blooms have been identified. The decrease in species richness and diversity of dinoflagellate cysts from 2005 to 2006 has been attributed to intensive mussel farming. Heterotrophs have dominated during the northeast and southwest monsoon seasons while autotrophs which included *A. minutum*, have dominated during tradewinds. Results indicate that the cysts accumulation points could possibly seed blooms particularly during the tradewinds season and thus should be monitored effectively to prevent negative public health impacts.

1. Introduction

Among the harmful dinoflagellates, 10% form resting cysts as part of their life cycle (Dale, 1983). The importance of life cycles in the ecology of harmful algae has been discussed and reviewed by Steidinger and Garcés (2006). The motile forms, called "vegetative cells" are the ones observed in water samples during routine microscopy. These haploid vegetative cells may divide to form more vegetative cells or in some cases, gametes. The gametes fuse to form the diploid generation – the cyst that sinks into the sediments and, after a period of quiescence, germinates and eventually divides to form haploid vegetative cells once again.

Dinoflagellate cysts are important in initiating and terminating blooms (Fukuyo, 1982, 2003; Azanza et al., 2004; Anderson et al., 2005). Some studies have implicated them as the source of toxins (Cembella et al., 1988; Yentsch and Mague, 1979) whereas others have focused on their role in species distribution expansion (Hallegraeff, 1998; Hallegraeff and Bolch, 1991). Wall et al. (1977) studied cyst associations from 168 samples across world oceans and compared cyst distribution patterns of dinoflagellate cysts with environmental conditions using the ordination technique of Q-mode factor analysis. Marret and Zonneveld (2003) summarized the global distribution of extant organic-walled dinoflagellate cysts showing the relationship between distribution pattern of cyst species and surface water parameters using ordination techniques. Studies in the tropical pacific have been notably lacking.

In the Philippines, dinoflagellate cyst studies have been done in Manila Bay and Palawan (Azanza et al., 2004; Siringan et al., 2008a). These studies have been instrumental in modeling *Pyrodinium* blooms for its management (Villanoy et al., 2006). However, no such studies have been done in Bolinao, Pangasinan where HABs with accompanying fish kills and/or toxicity have been recurring since 2002. A baseline of what and where dinoflagellate cyst species exist will be helpful in designing models for prediction, control and mitigation of HABs as has been done in Manila Bay.

This paper presents the dinoflagellate cyst species in recent marine sediments from mariculture areas in Bolinao, Pangasinan; abundance and distribution pattern of dinoflagellate cyst species

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and possible environmental and sedimentological factors that control the distribution patterns. Results constitute the first records in Northern, Philippines and for the study site where harmful algal blooms have been recorded since 2002.

2. Materials and methods

2.1. Field sampling

In order to determine distribution pattern of dinoflagellate cysts and possible cyst beds of harmful microalgal species, 55 sampling stations in mariculture areas in Bolinao were sampled in October 2006 (Fig. 1). A Van Veen grab sampler was used for this purpose. The lid of the sampler was opened and by using a rubber pipette bulb to gently siphon sediment through a centimeter-marked polycarbonate transparent tube (1.5 cm diameter), the upper 2 cm of the sediment was collected in triplicates. Sediments were placed in black polyethylene bag and stored at 4 °C until processing. Sediment samples from stations 2, 38, 39, 15 and 24 collected monthly from 2004 to 2006 were also analyzed for the determination of seasonal (i.e. every Northeast, Tradewinds and Southwest monsoons of each year) distribution pattern of dinoflagellate cysts. For this, a TFO gravity corer with a polycarbonate transparent tube (1.1 cm diameter) was used and the upper 2 cm sediment collected for processing and analysis.

Environmental variables that may influence abundance and distribution of dinoflagellate cysts were considered. Temperature and salinity were measured using a thermometer and refractometer.

Sediment grain size, and nutrient data were acquired from the Marine Geology Laboratory of Prof. F.P. Siringan at the University of the Philippines Marine Science Institute (Siringan et al., 2008b). For sampling of sediment, the technique of David et al. (2009) was followed. Cores were extruded on site. The samples were also kept in polyethylene bags and transported at 4 °C. Phosphorus and nitrogen content were analyzed by the Bureau of Soils and Water Management, Department of Agriculture.

2.2. Sediment processing for dinoflagellate cyst analysis

In the laboratory, one part of the sediments (2–5 g) was dried overnight at 70 °C to measure water content and the other was processed palynologically as adopted from Matsuoka and Fukuyo (2000). Water content was calculated by dividing the difference of the dry from wet sediment weight by the wet weight sediment and multiplying the quotient by 100. Another part, approximately 1–2 g sediments were treated with 10% hydrochloric acid and 38% hydrofluoric acid to remove calcium carbonate and silicate materials, respectively. After a series of washing, sediments were passed through 125 μm then 20 μm mesh sieves and residues from the 20 μm mesh sieves were collected and concentrated to 10 mL distilled water. One mL duplicate samples were withdrawn for cell counting using Sedgewick Rafter Chamber and analyzed under a bright field microscope from 100× to 400× magnification.

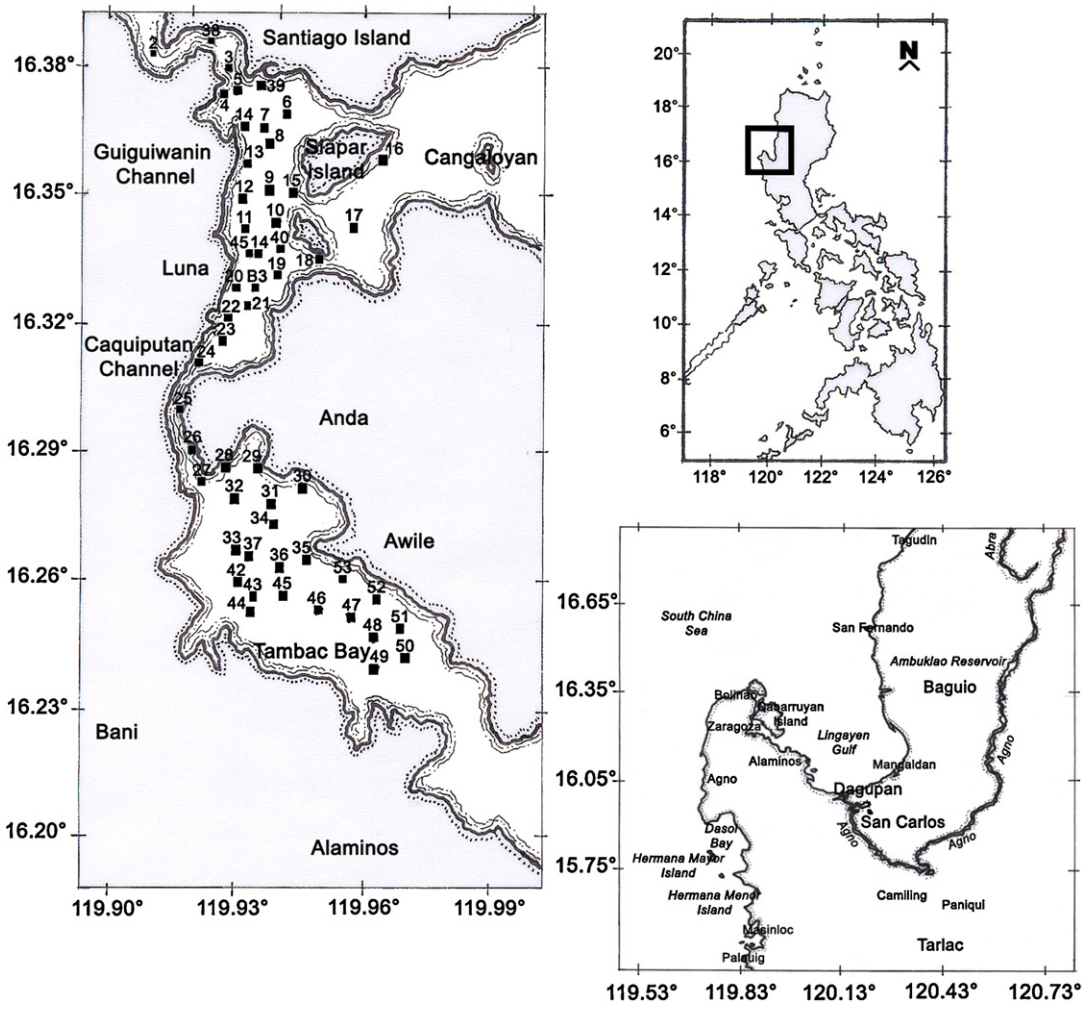

Fig. 1. Location of sampling stations for dinoflagellate cysts in Bolinao, Pangasinan.