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Seasonal changes in phytoplankton composition in an extensive fish culture area in Bolinao, Pangasinan, northern Philippines

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Abstract—The proliferation of fish cages and pens in Bolinao, Pangasinan, northern Philippines seemed to have reached its limit in 2002 when a massive fish kill coinciding with a bloom of *Prorocentrum minimum* occurred. Since then, various measures have been taken by the local government to decrease the number of fish cages to allow recovery of the waters of Bolinao. Samples collected in April, June and November 2004 representing summer, southwest and northeast monsoons, respectively, from five stations were analyzed for phytoplankton composition. Diatoms generally dominated the phytoplankton and peaked during summer which can be attributed to a very high concentration of *Thalassiosira* sp. constituting 92% of the phytoplankton in that season. The dinoflagellates constituted a small portion of the phytoplankton composition in all seasons. The flagellates represented a small fraction of the phytoplankton and followed the trend of the dinoflagellates. Cyanobacteria thrived during the wet seasons, almost co-existing with the diatoms. The results seem to suggest that the management of the fish cages or the aquaculture ponds might have resulted to changes in the present (2004) phytoplankton composition compared to previous years (1995–2002).

Key words: phytoplankton, Bolinao, fish culture area

Introduction

The potential for aquaculture in Bolinao was tapped in 1995 and since then *Chanos chanos* (milkfish) culture in the area has become one of the top producers in the country. Sumagaysay-Chavoso and San Diego-McGlone (2003) have determined the holding capacity of a semi-intensive pond to be below 1348 kg ha^{-1} or 54 kg feed ha^{-1} day^{-1} based on dissolved oxygen concentration of less than 1.0 mg l^{-1} which are conservative values. At present, the amount of feed dumped into a fish pen, 0.0030 ha in size ranges from 150 kg–800 kg per day (Yap et al. 2004), i.e. 50,000 kg of feeds in a hectare of fish pen per day. Estimates show that the number of fish cage and pens has totaled 1,100 units (Yap et al. 2004). Due to yearly occurrence of harmful algal blooms since 2001, which coincides with massive fish kills causing economic and health problems, the number of fish pens and cages has been decreased to 600 units. Most studies in Bolinao focus on water quality assessment which includes nutrient (ammonia, nitrate, nitrite and phosphate), chlorophyll *a*, total suspended solid and dissolved oxygen analyses which they found to increase with increasing structures of fish pens and fish cages (Padayao and San Diego-McGlone 2004; Sumagaysay-Chavoso and San Diego-McGlone 2003). Few studies have been done on its phytoplankton composition (Yap et al. 2004, de Castro et al. 2005) This paper is part of a continuing study that seeks to determine changes in phytoplankton composition after the reported decrease (in 2003) in the number of fish pens and cages in the area.

Methods

Bolinao, Pangasinan has a 160 km coastline, 40% of which was recorded to be occupied by fish pens and fish cages for finfish aquaculture in 2001 (Jacinto 2002). It receives an average annual rainfall of 2,500 mm and its current speed ranges from 0.005 to 0.10 m s^{-1} (Villanoy 1988). Five monitoring stations were established in 2004 (Fig. 1). Except for the first station, stations were selected in areas impacted by fish pens and cages. Station depths range from 4 to 13 m, temperature from 29 to 31°C and salinity from 32 to 34 ppt. Water samples were collected using a 1L-Kemmerer water sampler in 5 stations in April, June and November 2004. Each month is representative of the Tradewinds (summer), Southwest and Northeast monsoons. Two replicates were collected at 1 m and bottom depths. Samples were preserved

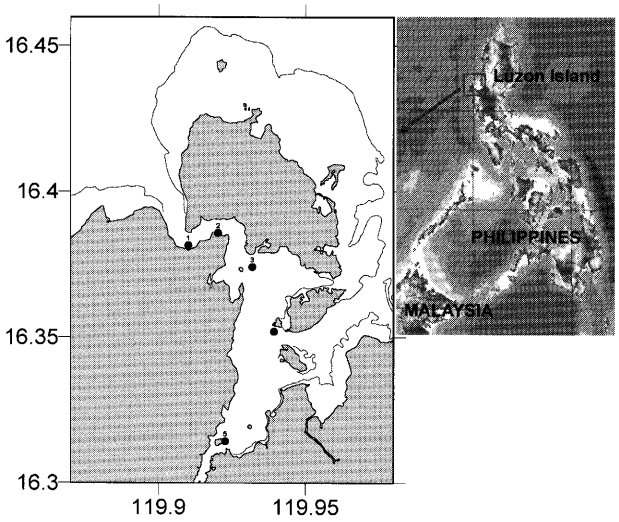

Fig. 1. Map of the monitoring stations in Bolinao, Pangasinan.

with Lugol's solution, gravimetrically settled for 24 hours for concentration from which 1mL aliquots were taken for quantitative and qualitative analysis under a Zeiss Axioskop II microscope. Tomas (1997) was used for phytoplankton identification. Cell counts (up to at least 100 cells) were made using a Sedgewick Rafter counting chamber.

Results

Diatoms generally dominated the phytoplankton in all seasons in 2004. It peaked during the tradewinds (summer) which can be attributed to a very high concentration of *Thalassiosira* sp. constituting 92% of the phytoplankton (Fig. 2). Dinoflagellates constituted a small portion of the phytoplankton composition in all seasons. Flagellates represented a small fraction of the phytoplankton and followed the trend of the dinoflagellates. A bloom of the raphidophyte *Chattonella marina* in May, 2004 coinciding with a massive fish kill was reported. Its presence was evident as early as April in this study. Cyanobacteria (mostly *Anabaena* spp. looking) thrived during the wet seasons, almost co-existing with the diatoms.

Discussion

The 2004 trend of seasonal phytoplankton composition in the area was similar to that reported by Yap et al. (2004) for the previous years. Except for the wet season (August) of 2001, diatoms dominated the water column from 1998 to 2001 (Fig. 3 from Yap et al. 2004). Species composition however, was different from 1998 to 2001. *Cylindrotheca closterium* (=*Nitzschia closterium*), *Skeletonema* spp. and *Pleurosigma* spp. were the dominant diatoms, whereas in 2004, *Helicotheca tamesis* (=*Streptotheca tamesis*) and *Thalassiosira* sp. predominated.

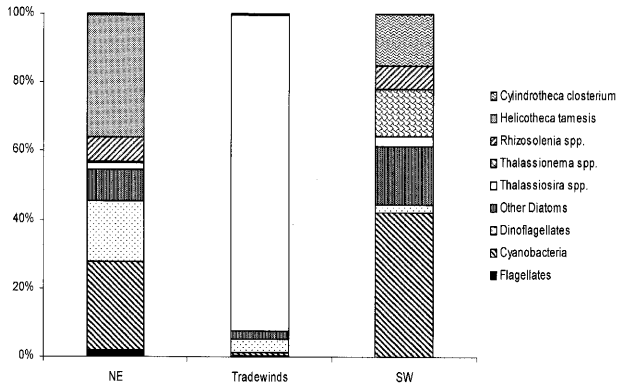

Fig. 2. Percentage composition of common diatoms and dinoflagellates during the northeast monsoon (NE), tradewinds and southwest monsoon (SW) in Bolinao, Pangasinan in 2004.

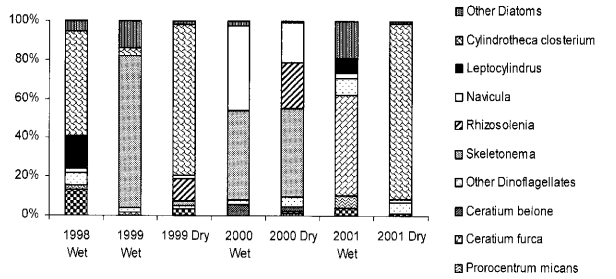

Fig. 3. Percentage composition of common diatoms and dinoflagellates during wet and dry seasons from 1998 to 2001 in Bolinao, Pangasinan (from Yap et al. 2004).

Nutrient concentration in Bolinao waters have been increasing from 1995 to 2001 which has been attributed to the >300% increase in fish pen and cages (San Diego-McGlone and Ranches 2003). Significant decrease in nitrate and nitrite, however, has been observed between 2002 and 2003 which was parallel to the decrease in fish pen and cage structures from 1,067 to 577 units (Padayao and San Diego-McGlone 2004). On the other hand, ammonia, a more reduced form of nitrogen was higher in 2003 which implicates a low oxygenated environment that favors its formation that can be attributed to continued build up of decomposing products (fish feeds) and other organic materials (Padayao and San Diego-McGlone 2004). Holmer et al. (2002) in their study of nutrient fluxes in Bolinao determined that nitrate was taken up while ammonium was released from the sediments. They further constructed a mass balance of carbon, nitrogen and phosphorus and they determined that 51–68% of carbon and nitrogen from the total input is lost to the surroundings (Holmer et al. 2002).

In Manila Bay from 1999 to 2001, diatoms dominated during the dry season while dinoflagellates dominated during the wet season (Azanza et al. in prep). However, from 1997 to 1999, diatoms were more dominant than dinoflagellates in all samples for all seasons (Azanza and Miranda 2001) much like what the trend is now in Bolinao.

The wet season is characterized by having elevated levels of nutrients, total suspended solids, chlorophyll *a*, and lower levels of dissolved oxygen and zooplankton biomass (de Castro et al. 2005, Yap et al. 2004, Padayao and San Diego-McGlone 2004). The increase in cyanobacteria could affect the decrease in zooplankton biomass. Numerous reviews have suggested the inadequacy of cyanobacteria as a food source for zooplankton (Haney 1987, Lampert 1987).

The results seem to suggest that the management of the fish cages or the aquaculture ponds might have resulted to changes in the present (2004) phytoplankton composition compared to previous years (1995–2002) towards a diatom and cyanobacteria dominated aquaculture area. Further identification of these cyanobacterial species should be done for management purposes, *e.g.* to see whether these are toxic species. Changes in the phytoplankton composition and how possibly they are affected by nutrient loading from the fish culture in this area should be continuously studied.

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