Bangladesh J. Fish. Res., 6(2), 2002: 173-181

Seasonal dynamics of phytoplankton in relation to environmental factors in the Maheshkhali channel, Cox's Bazar, Bangladesh

M.A.S. Jewel, M.M. Haque*, M.S. Haq and S. Khan
Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh
*Corresponding author

Abstract
In total 68 phytoplankton species were identified at the mouth of the Maheshkhali channel with the Bay of Bengal, among them 41 belong to Bacillariophyceae, 17 Dinophyceae, 7 Cyanophyceae and 3 to Chlorophyceae. The highest phytoplankton production was observed in November (578.0 x 10^5 cells/L) and the lowest in June (37.5 x 10^5 cells/L). Some hydrographic parameters e.g., surface water temperature, salinity and nutrients (NO_3-N and PO_4-P) were recorded and their relationship with the occurrence and abundance of phytoplankton population were also studied. Nutrient concentration was higher during the autumn months, when rain water provided the maximum outflow of rivers discharging into the channel. During the nutrient peak period, the total phytoplankton production was maximum. Bacillariophyceae was the dominant group of phytoplankton throughout the study period except in June and September, when Dinophyceae was dominant. Cyanophyceae was abundant in spring months when temperature began to rise.
Key words: Phytoplankton, Hydrographic parameters, Maheshkhali channel

Introduction

The Bakkhali river and Maheshkhali channel coalesced together at their extreme downstream and opened with the Bay of Bengal forming a typical estuarine ecosystem. Different traditional capture fisheries and a few commercial shrimp farms have developed around the estuary. Mariculture operations in this area have received greater attention as they are considered to be very important for the national economy and export earnings. Despite its innumerable importance, attempt has not been made previously for scientific study of species composition and abundance of phytoplankton and their seasonal dynamics in relation to environmental factors of the estuary.

Temporal dynamics of estuarine phytoplankton exhibit a wide range of seasonal pattern, such as, winter diatom blooms in Narragansett Bay (Pratt 1965) and the Peel-Harvey estuary (McComb *et al.* 1981) and winter bloom of dinoflagellates in the Pamlico River (Hobbie *et al.* 1975). Spring diatom blooms have been reported to be common seasonal events in the Wadden Sea (Cadee and Hegeman 1979), Columbia River (Small and Frey 1984) and Bristol Channel (Joint and Pomroy 1981). Phytoplankton biomass

was found to be seasonally maximal during autumn in the Patuxint river (Stross and Stottlemeyer 1965). These diversity of temporal patterns suggest that different mechanisms may control phytoplankton dynamics and productivity among estuaries, a fact that complicates the development of paradigms of estuarine phytoplankton ecology (Boynton *et al.* 1982). Seasonal variation of phytoplankton biomass, species composition and productivity differ markedly among the estuarine habitat types (Cloern *et al.* 1985).

The main objective of this work was to describe seasonal dynamics of phytoplankton communities in the Maheshkhali channel, namely phytoplankton species composition, abundance, seasonal variation and its relationship to nutrients and physical parameters.

Materials and methods

Monthly plankton samples were collected for 12 months from June 2000 to May 2001 using a 25 μm mesh plankton net from one selected station at the mouth of the Maheshkhali channel of the Bay of Bengal, Cox's Bazar, Bangladesh. The sampling were made in during daytime at high tide. For qualitative plankton study a plankton net was towed just under the water surface for one minute at a speed of approximately 1 m/s. From the net the collected samples were drained in a polyethylene bottle and was preserved with 5% buffered formalin in sea water. For quantitative study a known volume (100 litres) of sub-surface water was passed through a plankton net (mesh 25 μm) and the concentrate was collected from the bucket and preserved in 5% buffered formalin in sea water. The quantitative estimation of phytoplankton was done by Sedgewick-Rafter counting chamber (S-R cell) method using an Olympus binocular microscope.

During sampling surface water temperature and salinity were determined using a Celsius thermometer and a Hand Refractometer, respectively. Nitrate-nitrogen (NO_3-N) and phosphate-phosphorus (PO_4-P) concentrations were measured in the laboratory by HACH kit (DR 2010).

For species identification, a sample was gently shaken to resuspend all materials. It was allowed to settle for one minute, then four drops were removed from the middle of the sample and placed on a glass slide. A cover slip was placed on the slide and the entire slide was scanned for the species present. Taxonomic identifications were based on Bellinger (1992), Hasle and Fryxell (1995) and Hasle and Syvertsen (1996).

Results

Total phytoplankton

Seasonal fluctuation of phytoplankton cell density during the study period is shown in Figs. 1-2. The highest phytoplankton production was found in November (578.0×10^5 cells/L) and the lowest in June (37.5×10^5 cells/L). During the study period, about 68 species of phytoplankton belonging to Bacillariophyceae, Dinophyceae, Cyanophyceae and Chlorophyceae were recorded. Among the different phytoplankton species recorded,

41 belong to Bacillariophyceae, 17 to Dinophyceae, 7 to Cyanophyceae and 3 to Chlorophyceae (Table 1). The phytoplankton occurrence and distribution did not show any uniform trend or pattern during the study period.

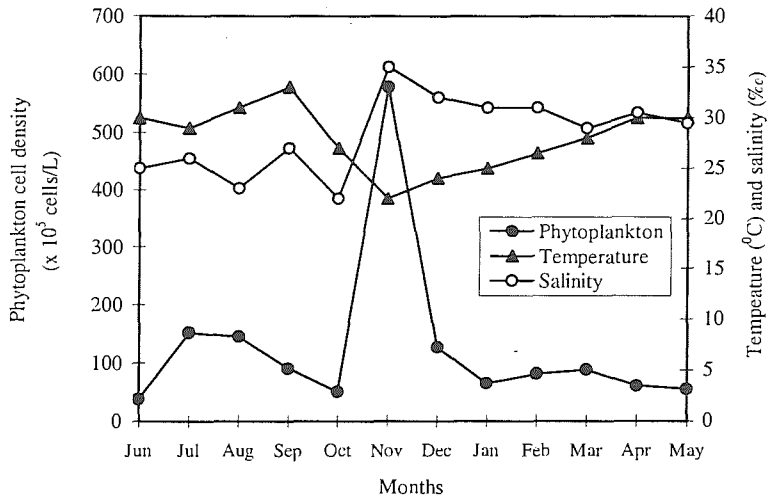

Fig. 1. Effects of temperature and salinity on the seasonal abundance of total phytoplankton population at the mouth of the Maheshkhali channel.

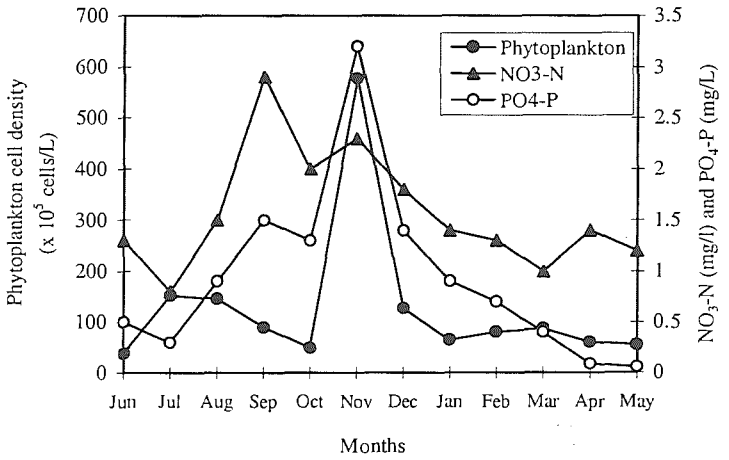

Fig. 2. Effects of NO_3-N and PO_4-P concentrations on the seasonal abundance of total phytoplankton population at the mouth of the Maheshkhali channel.

Table 1. Phytoplankton species recorded at the mouth of the Maheshkhali channel

BACILLARIOPHYCEAE		CYANOPHYCEAE
Odontella aurita	*Bacteriastrum elongatum*	*Anabaena circinalis*
O. mobiliensis	*B. furcatum*	*Aphanizomenon flos-aquae*
O. sinensis	*Chaetoceros aequatorialis*	*Trichodesmium erythraeam*
Asterionellopsis glacialis	*C. affins*	*Anabaenopsis sp.*
Pleurosigma normanii	*C. compressus*	*Aphanocapsa sp.*

Gyrosigma attenuatum
Coscinodiscus radiatus
C. lineatus
Fragilariopsis doliolus
Amphiprora alata
Planktoniella sol
Cyclotella litoralis
Amphora laevis
Melosira sulcata
Ditylum brightwellii
Nitzschia longissima
Thalassiosira mala
T. punctigera
Rhizosolenia alata
Hemiaulus indicus
Skeletonema costatum
Nitaschia closterium
Thalassionema nitzschiodes
T. bacillare
T. frauenfeldii
Pseudo-nitzschia delicatissima
P. pseudodelicatissima
P. australis
P. pungens
Thalassiothrix sp.
C. decipiens
C. danicus
C. simplex
C. curvisetus
C. lorenzianus
C. diversus

DINOPHYCEAE
Dinophysis caudata
Gonayulax spinifera
G. polygramma
Prorocentrum micans
P. sigmoides
Ornithocercus steinii
Phyrophacus steinii
Protoperidinium depressum
P. divergens
P. claudicans
Ceratium tripos
C. fusus
C. azoricum
C. furca
C. trichoceros
C. hircus
C. inflatum
Oscillatoria agardii
Nodularia spumigena

CHLOROPHYCEAE
Ulothrix aequalis
U. zonota
Dunaliella tertiolecta

Physical conditions

The water temperature varied from 22.0 °C-33.0 °C. The temperature was highest (33 °C) in September and lowest (22 °C) in December (Fig. 1). Salinity showed an irregular pattern fluctuating between 22 to 35‰. The maximum (35‰) salinity was recorded in November and the minimum (22‰) in October (Fig. 1).

Nutrients

During the study period, PO_4-P concentrations fluctuated widely from 0.06 to 3.2 mg/l. The maximum PO_4-P concentration (3.2 mg/l) was recorded in November when the cell density of phytoplankton population was found to be peak (Fig. 2). Fluctuation of NO_3-N concentration was ranging from 0.8 to 3.0 mg/l with the maximum in September and minimum in July (Fig. 2).

Variations in abundance among differentphytoplankton groups

Bacillariophyceae

Bacillariophyceae was the dominant group of phytoplankton with large number of species throughout the study period except in June and September when Dinophyceae was dominant (Table 1, Figs. 3 and 5). Bacillariophytes were most abundant ($539.0x10^5$ cells/L) in November and least abundant ($16.5x10^5$ cells/L) in June (Fig. 3). Among bacillariophytes, the different species in order of abundance were *Chaetoceros curvisetus, Pseudo-nitzschia delicatissima, P. pseudodelicatissima, P. pungens, Asterionellopsis glacialis, Odontella sinensis, O. aurita, Coscinodiscus wailesii, Rhizosolenia alata* and *Thalassionema.*

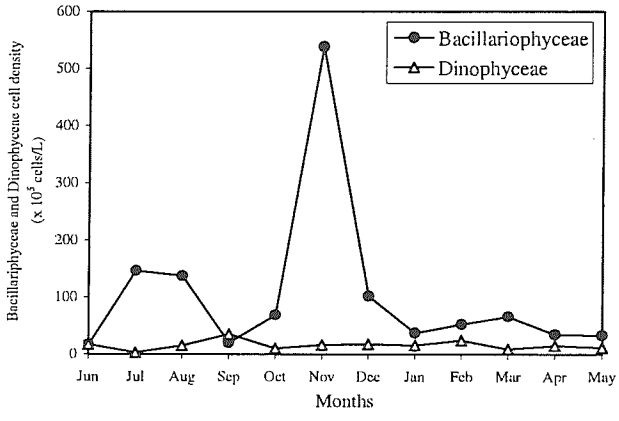

Fig. 3. Seasonal fluctuation of Bacillariophyceae and Dinophyceae cell density at the mouth of the Maheshkhali channel, during the study period.

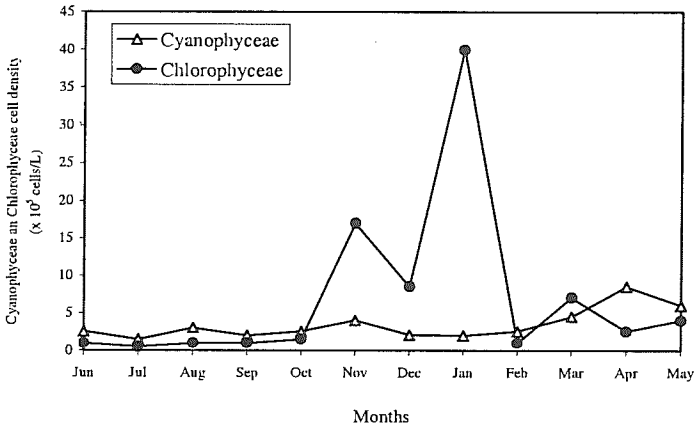

Fig. 4. Seasonal fluctuation of Cyanophyceae and Chlorophyceae cell density at the mouth of the Maheshkhali channel.

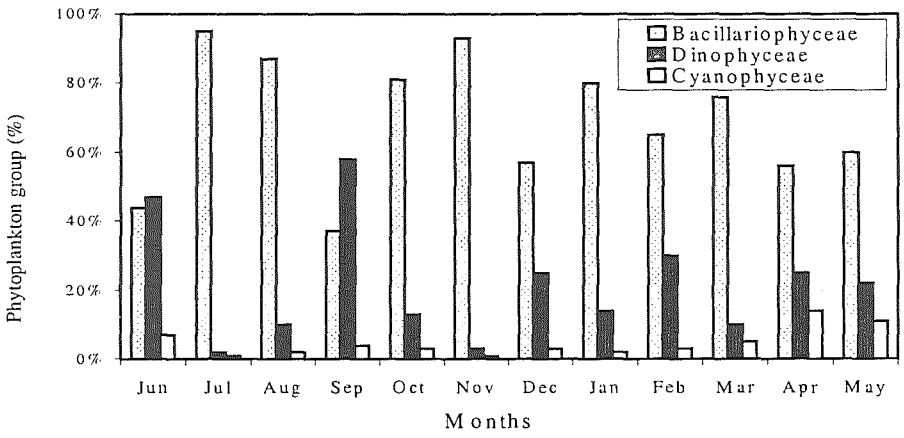

Fig. 5. Monthly fluctuation of dominant phytoplankton groups (Bacillariophyceae, Dinophyceae and Cyanophyceae) at the mouth of the Maheshkhali channel.

Dinophyceae

Dinophyceae ranked second among all phytoplankton groups in respect of both abundance and number of species. Dinophytes was most abundant (42.0×10^5 cells/L) in September and least abundant (3.50×10^5 cells/L) in July (Fig. 3). Among the dinophytes, the different species in order of abundance were *Ceratium furca, C. tripos, C. fusus, Dinophysis caudata, Prorocentrum micans* and *Gonyaulax polygramma. Ceratium furca* was abundant in September when the cell density of this species reached to 36×10^5 cells/L.

Cyanophyceae

Cell density of cyanophytes were found to be highest (6.0×10^5 cells/L) in April and lowest (1.5×10^5 cells/L) in July (Fig. 4). The most dominant species were *Aphanizomenon flos-aquae, Trichodesmium erythraeam, Oscillatoria agardii,* and *Anabaenopsis* spp.

Chlorophyceae

Chlorophytes were most abundant (40.0×10^5 cells/L) in January and least abundant (0.5×10^5 cells/L) in July (Fig. 4). The most abundant species were *Ulothrix aequalis* and *U. zonata.*

Phytoplankton species composition

In the Maheshkhali channel, phytoplankton species number was the highest (42) in November and lowest (14) in January. In winter months (December-February) the species number was relatively low. Maximum species number was recorded in November

when salinity and PO_4-P concentration were found to be highest and NO_3-N was moderate. The monthly variation in phytoplankton species number is shown in Fig. 6

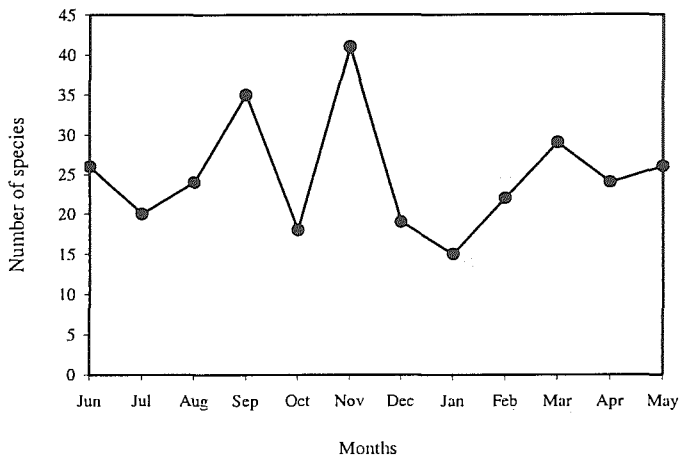

Fig. 6. Monthly variation in number of phytoplankton species at the mouth of the Maheshkhali channel during the study period.

Discussion

Phytoplankton population indicates the productive status of a water body, because they are the direct and basic sources of food for most of the organisms in an aquatic habitat. The results of seasonal variation in environmental parameters and plankton population suggest that the favorable period for primary production in the Maheshkhali channel is from July to November when nutrients accumulate from freshwater run-off due to monsoon rainfall and more sewage pollution in this month. Similar phytoplankton growth due to nutrient accumulation during rainy season from September to November was observed in Maputo Bay (Paula *et al.* 1998). In the Maheshkhali channel the availability of high nutrients was found to be related to rain and connected river discharge similar to the findings of Kitheka *et al.* (1995) for Gazi Bay, Kenya.

In Maheshkhali channel of the Bay of Bengal a number of pollutant materials from different sources have led to nutrient enrichment which induced phytoplankton bloom. Nuruddin *et al.* (1994) reported that 480 tons of solid wastes and 2.5 million people's excreta were being dumped into the Karnofully river estuary each year which directly entered into the Bay of Bengal, especially during the rainy season. In the present study, the highest cell density (578.0×10^5 cells/L) of phytoplankton was found during the late rainy season, agreeing with the findings of Santhanam and Srinivasan (1996), who reported highest phytoplankton cell density (11×10^5 cells/L) during monsoon months in the Tuticorin Bay of India which was supposed to be caused by continuous discharge of sewage water during the rainy periods. Lugomela (1995) also found higher primary

productivity in different estuarine and coastal waters during rainy season. The rain cycle thus seems to be the main factor controlling the seasonality of plankton assemblages in the Maheshkhali channel.

Phytoplankton abundance and taxonomic diversity depend upon the supply of nutrients in natural waters. In the present study, the highest cell density and species diversity of phytoplankton was found in November, when salinity and phosphate-phosphorus concentration (3.2 mg/l) were found to be highest. So, it can be assumed that high salinity and phosphate-phosphorus concentration may be important factors for maximum cell density and taxonomic diversity of phytoplankton at the Maheshkhali channel in November. Santhanam and Srinivasan (1996) recorded the highest PO_4-P concentration (1.65 to 5.23 μg/l) in Tuticorin Bay of India, during the bloom of *Dinophysis caudata.*

Diatom was the dominant group of phytoplankton with large number of species throughout the study period except in June and September when dinoflagellates was dominant, agreeing with the findings of Santhanam and Srinivasan (1996), who reported diatom as a dominant group round the year except in August and September when dinoflagellates formed blooms. Seasonal succession of phytoplankton population indicate that, dinoflagellates mainly *Ceratium furca, Prorocentrum micans, Gonyaulux polygramma, Dinophysis caudata* were dominant in the summer and in early autumn and diatoms especially *Chaetoceros* and *Pseudo-nitzschia* were dominant in late autumn and some other diatoms, *Skeletonema costatum, Asterionellopsis glacialis, Thalassionema* spp. appeared regularly round the year.

References

Bellinger, E.G., 1992. A Key to Common Algae: Freshwater, Estuarine and some Coastal Species. The Institution of Water and Environmental Management, London. 138 pp.

Boynton, W.R., W.M. Kemp and C.W. Keefe, 1982. A comparative analysis of nutrients and other factors influencing estuarine phytoplankton production. *In:* Estuarine Comparisons (ed. V.S. Kennedy). Academic Press, New York. pp. 69-90.

Cadee, G.C. and J. Hegeman, 1979. Phytoplankton primary production, chlorophyll and nutrients composition in an inlet of the western Wadden Sea (Marsdiep). *Neth. J. Sea Res.*, 13: 224-241.

Cloern, J.E., B.E. Cole, L. Raymond, J. Wong and A.E. Alpine, 1985. Temporal dynamics of estuarine phytoplankton: A case study of San Francisco Bay. *Hydrobiologia*, 129: 153-176.

Hasle, G.R. and G.A. Fryxell, 1995. Taxonomy of Diatoms. *In:* Manual on harmful marine microalgae (eds. G.M. Hallegraeff, D.M. Anderson and A.D. Cembella). IOC Manuals and Guides No. 33. UNESCO. pp. 339-364.

Hasle, G.R. and E.E. Syvertsen, 1996. Marine Diatoms. *In:* Identifying marine phytoplankton (ed. C. R. Tomas). Academic Press, San Diego. pp. 5-385.

Hobbie, J.E., B.J. Copeland and W.G. Harrison, 1975. Sources and fates of nutrients of the Pamlico river estuary, North Carolina. *In:* Estuarine Research (ed. L.E. Cronin). Academic Press, New York, 1: 287-302.

Joint, E.R. and A.J. Pomroy, 1981. Primary production in a turbid estuary. *Estuar. Coast. Shelf Sci.*, 13: 303-316.

Kitheka, J.V., B.O. Ohowa, B.M. Mwashote, W.S. Shimbira, J.M. Mwaluma and J.M. Kazungu, 1995. Water circulation dynamics, water column nutrients and plankton productivity in Gazi Bay (Kenya). *In:* Interlinkages between Eastern African Coastal Ecosystems (ed. M. Hemminga). Report EU TS3-CT 92-0114, N 100, Yerseke. pp. 95-121.

Lugomela, C.V., 1995. Spatial and temporal dynamics of phytoplankton biomass and species composition in Chwaka Bay, Zanzibar. *In:* Interlinkages between Eastern African Coastal Ecosystems (ed. M. Hemminga). Report EU TS3-CT 92-0114, N 100, Yerseke. pp. 166-172.

McComb, A.J., R.P. Atkins, P.B. Birch, D.M. Gordon and R.J. Lukatelich, 1981. Eutrophication in the Peel-Harvey estuarine system, western Australia. *In:* Estuaries and Nutrients (eds. B.J. Neilson and L.E. Cronin). Humana Press, Clifton, N. J. pp. 323-343.

Nuruddin, M., M.J.U. Chowdhury, M.M. Hossain, S.M.B. Haider and S.R. Chowdhury, 1994. Bangladesh. *In:* An Environmental Assessment of the Bay of Bengal Region (ed. S. Holgren). BOBP/REP/67. Bay of Bengal Programme, Madras, India. pp. 75-129.

Paula, J., I. Pinto, I. Guambe, S. Montaro, D. Gove and J. Guerreiro, 1998. Seasonal cycle of planktonic communities at Inhaca Island, Southern Mozambique. *J. Plankton Res.*, 20 (11): 2165-2178.

Pratt, D.M., 1965. The winter-spring diatom flowering in Narragansett Bay. *Limnol. Oceanogr.*, 10: 173-184.

Santhanam, R. and A. Srinivasan, 1996. Impact of dinoflagellates *Dinophysis caudata* bloom on the hydrographic and fishery potentials of Tuticorin Bay, South India. *In:* Harmful and toxic algal blooms (eds. T. Yasumoto, Y. Oshima and Y. Fukuyo). Intergovernmental Oceanographic Commission of UNESCO. pp. 41-44.

Small, L. F. and B.E. Frey, 1984. Water column primary production in the Columbia River estuary. Final Report, Columbia River Estuary Data Development Program, Astoria, Oregon. 133 pp.

Stross, R.G. and J.R. Stottlemeyer, 1965. Primary production in the Patuxent River. *Ches. Sci.*, 6: 125-140.

(Manuscript received 20 November 2001)