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Assemblage structure of nektonic fauna in the Meghna estuary of Bangladesh: relationship with environmental variables

Md. Mostafa Shamsuzzaman[1], Md. Rashed-Un-Nabi[2], Mohammad Muslem Uddin[2], Nayan Mallick[2] & Ahmed Harun-Al-Rashid[3]

[1]Department of Coastal and Marine Fisheries, Sylhet Agricultural University, Sylhet 3100, Bangladesh
[2]Institute of Marine Sciences and Fisheries, University of Chittagong, Chittagong 4331, Bangladesh
[3]Department of Aquatic Resource Management, Sylhet Agricultural University, Sylhet 3100, Bangladesh

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

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In this study, the assemblage structure of nektonic fauna were studied in relation to some important environmental variables in the Meghna Estuary, the largest estuarine ecosystem of Bangladesh. Silica, nitrite, phosphate, and total suspended solids (TSS) were found to be positively correlated with fish species abundance. Nitrite and TSS showed significant difference, and water pH, salinity, transparency, water temperature, and dissolved oxygen were found to be negatively correlated. The results of similarity analysis showed a significant difference between different sampling stations and seasons, and revealed that finfish species like *Trypauchen vagina, Polynemus paradiseus, Johnius dussumieri, Harpodon nehereus* contributed significantly (>10.0%) to the fish abundance structure of each sampling station. Cluster analysis shows 53% similarity level in the abundance of fish in different seasons and sampling stations. Significant effect of water transparency and salinity was observed through Canonical Correspondence Analysis (CCA) in shaping assemblage structure and species distribution.

[Keywords: Estuarine set bag net, the Meghna river estuary, analysis of similarity, canonical correspondence analysis, species assemblage]

Introduction

Estuaries are nearshore coastal ecosystem features where freshwater carried by rivers meets with seawater[1]. Estuaries have ecological significance as these unique ecosystems provide support as sheltering, feeding, breeding and nursery ground for a wide range of marine and brackish water species which migrate to estuaries to complete part(s) of their life cycle[2]. Consequently, fish assemblage structures of estuaries are often characterized by rich biodiversity and species abundance, especially for juveniles[3], thus provide high fisheries yield and subsequent economic opportunities[4]. The Meghna Estuary is located at the end of Ganges-Brahmaputra river system, one of the large river system in the world, have global significance. This estuary serves as breeding ground and migratory route of most important commercially important fish species, Hilsa (*Tenualosa Ilisha*), in Bangladesh that contribute about 11% of the total national fish production[5]. The livelihoods implication is also large since thousands of small-scale fishers both from inland and island toil on estuarine waterbody of the Meghna to subsist their livelihoods. Therefore, it is necessary to examine the environmental parameter that affects the fish assemblages in that estuary.

Further, in the context of global climate change, an estuarine region of different deltaic plain (particularly Bengal Delta) is a focal point for the study of ecological and environmental changes. Thus, scientific interests also increasingly focusing on the effects of major environmental changes and human perturbations on estuarine ecosystems and how these changes interplay in a continuously changing environment of estuaries. Gray (2001) mentioned "… assessment is urgently needed of the spatial scales and dynamic of species richness from point samples to assemblages, habitat, and landscapes, especially in coastal areas and in the tropics where threats to diversity are greatest[6].” As mentioned above in the coastal areas estuarine habitats are highly productive which are well-documented in the case of temperate regions. There are about 20 major estuaries throughout the coastal areas of Bangladesh as well as some complex estuarine, islands, and mangrove ecosystems, but relatively few are known[7]. Studies on nekton assemblage in the estuaries of Bangladesh have not been well studied[8].

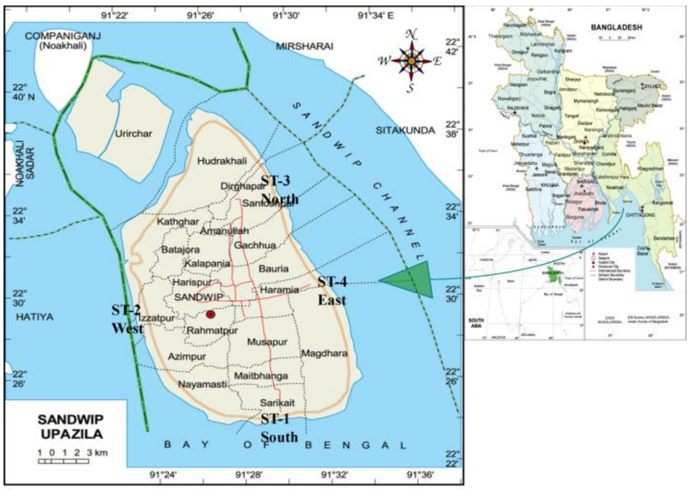

Fig.1-Location of the study area and sampling station in Sandwip Island, Bangladesh

However, two recent studies (Nabi *et al.*, 2011, and Chowdhury *et al.*, 2011) on nekton assemblages are notable[8,7]. Occurrence and habitat of nekton fauna in estuaries are highly affected by several biotic and abiotic factors such as salinity, temperature, water transparency, dissolved oxygen (DO), freshwater inflow etc. Changes in diversity and fish assemblages are continuous depending on the reproductive season of respective species and fluctuation of environmental parameters[9]. Though a number of researches have conducted research works on fish composition, taxonomy, abundance, distribution and many other aspects of the freshwater as well as marine and estuarine fisheries of Bangladesh, in respect of the Meghna Estuary, only a few works were done on the aforementioned topics, especially, in the relationship between fish assemblages and different environmental variables. The present study was designed to fulfill the gap by providing an account of nekton assemblage structure of the Meghna River estuary around Sandwip island.

Materials and Methods

Sandwip island is located between 22º11′N and 22º23′N latitudes and between 91º17′E and 91º37′E longitudes. The island occupies an area of 762.42 km^2 including 434.55 km^2 of river area and 10.13 km^2 of forest area[10]. Four sampling stations were selected around the island (Figure 1) where Estuarine Set Beg Net (ESBN) gear operation was extensive. In the Figure 1 St is used to indicate a station selected for this study; thus St-3 indicates the north part of Sandwip channel, and St-4 is at the east which isolates this island form Chittagong mainland. St-1 is located at the south end of the island which facing the Bay of Bengal (BoB) directly, and St-2 was selected near the main jetty of Sandwip island which is located in the west part of the island facing the BoB.

Fig.2-Operational view of an Estuarine Set Beg Net (ESBN)

Fish and shellfish samples were collected using barrier nets known as ESBN, locally known as ‘*behundi jal’*. The set bag net is a fixed, tapering net, resembling a trawl net, set in the tidal stream by attaching it to holdfasts (Figure 2). The mesh size decreases from 140-20 mm at the mouth to 22-5 mm at the cod end. Length of these nets vary from 8.5 m to 41 m and the height of the mouth opening is 2-7 m, and during high tide the nets are submerged under 1.5-3 m of the water surface level[11].

Fish samples were collected from the mentioned four stations in each of four selected seasons *viz.* winter (December to February), pre-monsoon (March to May), monsoon (June to September) and post-monsoon (October to November)[12]. Samples were identified following the procedures as described in Siddiqui and Zafar 2002, Siddiqui *et al.*, 2007, and Rahman *et al.*, 2009[13, 14, 15]. During sampling, some environmental parameters were measured at *in situ* condition, and the rest were determined in the laboratory.

The diversity of the fish abundance was determined by using Shannon-Wiener diversity index (H') [16, 17], Margalef index (d'), and the equabilities were measured by Pielou's evenness index (J') [18, 17]. A one-way analysis of variance (ANOVA) was used to test for significant differences in environmental variables, Shannon-Wiener diversity index, Pielou's evenness index, and Margalef index. One way analysis of Similarity (ANOSIM) [19] was used to conclude the significance of spatial and temporal variation in the structure of fish assemblage. Similarity percentages analyzes (SIMPER)[20] were used to observe the percentage contribution of each taxon to the average dissimilarity between samples of the various season and stations pair combinations. For descriptive statistics and ANOVA test SPSS software, V11.5 (Statistical Package for Social Sciences) was used. All the multivariate analyzes were performed using the software PRIMER V6 (Plymouth Routines Multivariate Ecological Research)[19]. Canonical correspondence analysis (CCA), a unimodal model for non-linear multivariate analysis were used for studying the relationship between most abundant taxa and environmental samples[21].

Results

According to Figure 3, the silicate-silicon concentration attained maxima in monsoon (81.94 µg/l at St-4) and minima in winter (52.44µg/l at St-1) with a mean of 67.72±6.416µg/l. A significant difference was observed in silicate-silicon throughout the stations $\left(F_{1,3} = 1352.211, p = 0.000\right)$ also among seasons $\left(F_{1,3} = 268.609, p = 0.000\right)$. Nitrite-nitrogen varied from 0.17 µg/l (winter at St-2) to 1.13 µg/l (monsoon at St-4) with a mean of 0.503±0.079µg/l. A significant difference was observed in nitrate-nitrogen throughout the stations $\left(F_{1,3} = 180.731, p = 0.000\right)$ and seasons $\left(F_{1,3} = 2909.502, p = 0.000\right)$.

Phosphate-phosphorus values ranged from 0.14 µg/l (winter at St-4) to 2.31 µg/l (monsoon at St-3) with a mean of 1.180±0.344 µg/l. A significant difference was observed in phosphate-phosphorus throughout the stations $\left(F_{1,3} = 44.943, p = 0.000\right)$ and seasons $\left(F_{1,3} = 4674.305, p = 0.000\right)$. Mean total suspended solid value was observed 643.479±130.022 mg/l. The total suspended solids (TSS) contents varied from 344 mg/l (winter at St- 2) to 932 mg/l (monsoon at St-3).

A significant difference was observed in total suspended solid throughout the stations $\left(F_{1,3} = 7051.403, p = 0.000\right)$ and seasons $\left(F_{1,3} = 1973.093, p = 0.000\right)$.

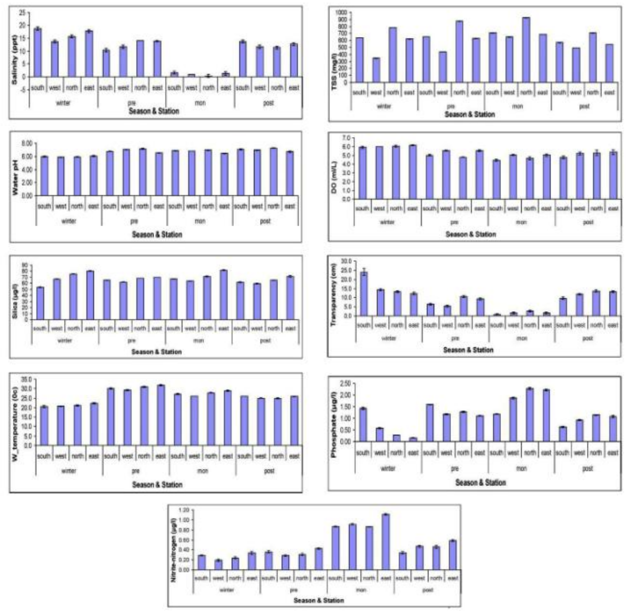

Fig.3-Temporal and Spatial variations in mean environmental parameters in the study area (season & station)

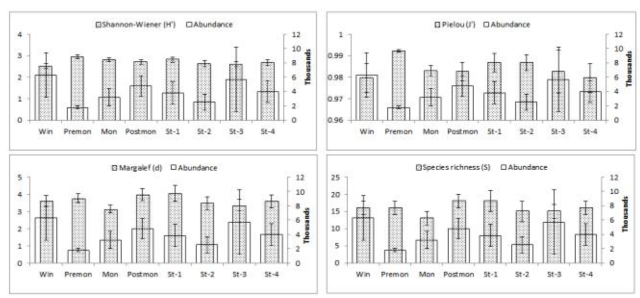

Fig.4-Spatial and temporal variation of different diversity indices

The water pH varied from 5.8 (winter at St-2) to 7.3 (post monsoon at St-3) with a mean of 6.654±0.195. A significant difference was observed in water pH throughout the stations $\left(F_{1,3} = 78.667, p = 0.000\right)$ among seasons $\left(F_{1,3} = 662.526, p = 0.000\right)$. Salinity ranged between 0.5 ppt (monsoon at St-3) and 19 ppt (winter at St-1) with a mean of 10.572±1.362 ppt. a significant difference was observed in salinity throughout the stations $\left(F_{1,3} = 30.610, p = 0.000\right)$ and seasons $\left(F_{1,3} = 1896.170, p = 0.000\right)$.

Table 1-Species composition around Sandwip Island

Name of the species	Total indv.	(%)	Station				Season			
			Win (%)	Prem (%)	Mon (%)	Postm (%)	St1 (%)	St2 (%)	St3 (%)	St4 (%)
Acetes indicus	19618	30.61	18.52	0.00	0.00	12.10	7.11	3.48	15.95	4.08
Parapenaeopsis sculptilis	8641	13.48	4.07	2.75	1.03	5.64	1.53	1.12	7.81	3.02
Johnius amblycephalus	4799	7.49	4.99	0.47	0.37	1.66	2.10	0.65	1.13	3.60
Harpadon nehereus	4697	7.33	3.35	0.44	0.17	3.37	1.02	3.06	1.25	2.00
Trypauchen vagina	4135	6.45	0.97	1.81	2.75	0.92	4.51	0.50	0.72	0.73
Fenneropenaeus merguiensis	2809	4.38	2.51	0.84	0.76	0.28	0.33	0.99	0.54	2.52
Exopalaemon styliferus	2536	3.96	0.59	0.00	2.82	0.55	0.00	0.90	1.26	1.80
Sillaginopsis panijus	2471	3.86	0.19	0.53	2.93	0.21	0.35	0.93	1.51	1.06
Mystus gulio	2397	3.74	0.39	0.23	2.71	0.42	1.07	0.48	0.17	2.02
Scylla sp.	1899	2.96	1.09	0.05	0.18	1.64	0.35	0.48	1.79	0.34
Odontamblyopus rubicundus	1553	2.42	0.00	0.11	2.31	0.00	1.80	0.00	0.22	0.40
Polynemus paradiseus	1291	2.01	0.35	0.56	0.75	0.35	0.40	0.79	0.44	0.38
Cynoglossus cynoglossus	1263	1.97	0.16	0.60	0.86	0.35	0.43	0.30	0.77	0.47
Coilia ramcarati	873	1.36	0.54	0.14	0.19	0.49	0.63	0.09	0.31	0.33
Thryssa dussumieri	706	1.10	0.24	0.16	0.39	0.30	0.31	0.23	0.25	0.31
Rhinomugil corsula	704	1.10	0.07	0.39	0.55	0.08	0.24	0.29	0.39	0.18
Lepturacanthus savala	685	1.07	0.28	0.12	0.28	0.39	0.18	0.30	0.42	0.16
Charybdis natator	389	0.61	0.00	0.27	0.34	0.00	0.22	0.00	0.22	0.17
Coilia dussumieri	346	0.54	0.28	0.12	0.00	0.15	0.13	0.29	0.00	0.12
Tenualosa ilisha	309	0.48	0.00	0.00	0.38	0.10	0.19	0.30	0.00	0.00
Arius sp.	260	0.41	0.14	0.06	0.03	0.17	0.08	0.22	0.11	0.00
Chelon planiceps	217	0.34	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.34
Mugil sp.	202	0.32	0.08	0.08	0.12	0.04	0.32	0.00	0.00	0.00
Chelonodon patoca	198	0.31	0.00	0.31	0.00	0.00	0.00	0.00	0.15	0.16
Metapenaeus brevicornis	194	0.30	0.16	0.00	0.00	0.14	0.30	0.00	0.00	0.00
Terapon jarbua	192	0.30	0.00	0.30	0.00	0.00	0.00	0.07	0.13	0.10
Glossogobius giuris	138	0.22	0.06	0.00	0.00	0.15	0.00	0.00	0.05	0.16
Rhynchorhamphus georgii	112	0.17	0.07	0.00	0.00	0.11	0.12	0.05	0.00	0.00
Pomadasys argenteus	112	0.17	0.00	0.17	0.00	0.00	0.00	0.11	0.00	0.07
Platycephalus indicus	94	0.15	0.00	0.15	0.00	0.00	0.09	0.00	0.00	0.05
Eleutheronema tetradactylum	78	0.12	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.12
Mene maculata	63	0.10	0.10	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Valamugil speigleri	53	0.08	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.08
Cynoglossus lingua	49	0.08	0.00	0.00	0.00	0.08	0.08	0.00	0.00	0.00

Mean water transparency was observed as 9.427±2.470. Water transparency varied from 1 cm (monsoon at St-1) to 26 cm (winter at St-1). A significant difference was observed in transparency throughout the stations $\left(F_{1,3} = 17.076, p = 0.000\right)$ also seasons $\left(F_{1,3} = 826.422, p = 0.000\right)$. The water temperature attained maxima in pre-monsoon (32ºC at St-4) and minima in winter (20ºC at St-1) with a mean of 26.156 ±0.875ºC. A significant difference was observed in water temperature throughout the stations $\left(F_{1,3} = 114.299, p = 0.000\right)$ also seasons $\left(F_{1,3} = 2475.319, p = 0.000\right)$.

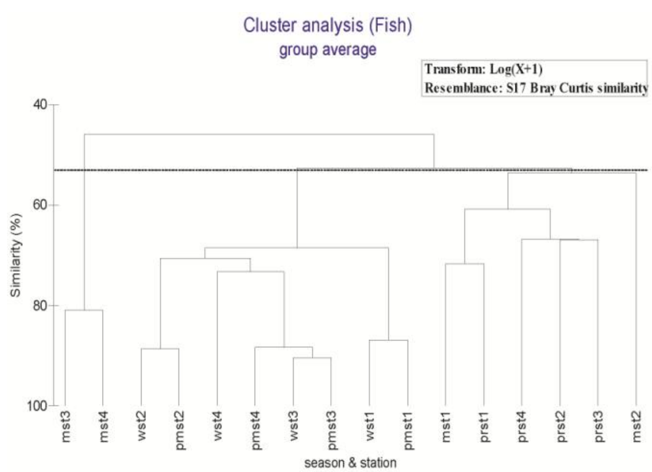

Fig.5-Dendrogram showing clusters based on Bray- Cartis similarity matrix of different seasons & stations

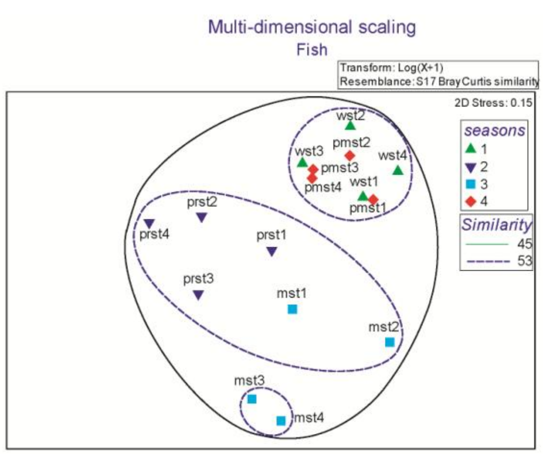

Fig.6-Using non-metric multidimensional scaling (NMDS) on the similarity matrix. Clusters 1 to 3 were superimposed on the ordination, represented by circles

In Sandwip island, a total number of 34 species, of which 27 of finfish, 2 crabs and 5 species of shrimp, were identified in the catch of ESBN. A maximum of 25 species were found in the catches of pre-monsoon and the lowest of 21 species in monsoon. Finfish comprised of the highest 73.94% followed by the shrimp 20.52% and crab 5.405%, respectively, in the proportion of catches seasonally. The highest percentage of fin fish was found in the catch of St-1, shrimp were found in St-4, and crabs were found in St-1. All species are tabulated in Table 1.

Spatial and temporal variation in fish diversity, evenness and richness are shown in Figure 4. Shannon-Wiener diversity index ranged between 2.44 (St-2, monsoon) and 2.96 (St-1, post monsoon. Significant difference was observed among the stations ($F_{3,44}$ = 8.192, *P* = 0.000) and seasons ($F_{3,44}$ = 17.370, *P* = 0.000). The minimum Pielou's evenness value (0.97) was observed at St-3 during winter while the maximum (0.99) found at St-1 during pre-monsoon. Significant difference was observed evenness diversity values among the stations ($F_{3,44}$ = 2.272, *P* = 0.000) and seasons ($F_{3,44}$ = 16.615, *P* = 0.000). The minimum Margalef's species richness value (2.92) was observed at St-3 during monsoon whereas the maximum value (4.58) found at St-1 during post-monsoon. Significant difference was observed ($F_{3,44}$ = 16.676, *P* = 0.000) in the mean values of Margalef's species richness between seasons and also stations ($F_{3,44}$ = 8.681, *P* = 0.000).

The analysis of similarity (ANOSIM) showed significant difference among different stations. Species assemblage was highly diverse in all the stations (Table 2). *Trypauchen vagina* (10.52%), *Polynemus paradiseus* (10.65%), *Johnius amblycephalus* (9.88%), and *Harpadon nehereus* (10.40%) contributed the highest percentage in assemblage structure of St-1, St-2, St-3 and St-4, respectively.

Seasonal assemblage structures of winter, pre-monsoon, monsoon and post-monsoon were contributed by a high percentage of *Acetes indicus* (12.73%), *Parapenaeopsis sculptilis* (11.64%), *Sillaginopsis panijus* (14.78%) and *Acetes indicus* (12.92%) respectively (Table 3).

Cluster analysis represents three separate groups where similarity level was formed 53%. First cluster group contained St-3 and St-4 of the monsoon season.

Table 2-Average similarity and discriminating fish and shrimp in each station using SIMPER analysis

Station 1 (72.64%)		Station 2 (63.46%)		Station 3 (64.22%)		Station 4 (58.38%)	
Contributory species		Contributory species		Contributory species		Contributory species	
Species	%	Species	%	Species	%	Species	%
Trypauchen vagina	10.52	*Polynemus paradiseus*	10.65	*Johnius amblycephalus*	9.88	*Harpadon nehereus*	10.40
Johnius amblycephalus	8.20	*Johnius amblycephalus*	10.05	*Parapenaeopsis sculptilis*	8.96	*Johnius amblycephalus*	10.27
Parapenaeopsis sculptilis	8.12	*Fenneropenaeus merguiensis*	9.52	*Cynoglossus cynoglossus*	8.88	*Sillaginopsis panijus*	10.03
Harpadon nehereus	7.29	*Harpodon nehereus*	8.92	*Harpodon nehereus*	8.61	*Polynemus paradiseus*	8.87
Coilia ramcarati	7.05	*Mystus guilo*	7.56	*Polynemus paradiseus*	8.52	*Mystus guilo*	8.28

Table 3-Average similarity and discriminating fish and shrimp in each season using SIMPER analysis

Winter (72.97%)		Pre-monsoon (71.97%)		Monsoon (63.84%)		Post-monsoon (78.46%)	
Contributory species		Contributory species		Contributory species		Contributory species	
Species	%	Species	%	Species	%	Species	%
Acetes indicus	12.73	*Parapenaeopsis sculptilis*	11.64	*Sillaginopsis panijus*	14.78	*Acetes indicus*	12.92
Harpodon nehereus	11.92	*Trypauchen vagina*	10.05	*Polynemus paradiseus*	10.55	*Harpodon nehereus*	9.44
Johnius amblycephalus	11.10	*Fenneropenaeus merguiensis*	9.32	*Cynoglossus cynoglossus*	10.34	*Parapenaeopsis sculptilis*	8.90
Trypauchen vagina	8.19	*Polynemus paradiseus*	8.74	*Johnius amblycephalus*	9.35	*Johnius amblycephalus*	8.31
Scylla sp.	7.07	*Cynoglossus cynoglossus*	8.67	*Harpodon nehereus*	6.98	*Scylla* sp.	7.55

Second cluster group controlled all four stations of winter and post monsoon season and third cluster group symbolized St-1 and St-2 of monsoon season and all four stations of the pre-monsoon season (Figures 5 and 6).

The Canonical Correspondence Analysis (CCA) axes explained 46.53% of the variation in species abundance. The first CCA axis explained 29.19% of species abundance variation and was strongly ($r \geq 0.5$) positively correlated with transparency and salinity. Axis 2 explained 7.56% and no variables were strongly correlated (positively or negatively) with this axis (Figure 7). The most abundant species was identified as *Acetes indicus* which was associated with high transparency, high DO level, high salinity, and low water temperature. *Exopalaemon styliferus* and *Sillaginopsis panijus* were found strongly associated with high turbidity and low salinity. *Johnius amblycephalus* has a strong affinity to high salinity. *Parapenaeopsis sculptilis* and *Harpadon nehereus* have a weak association with low turbidity values. *Trypauchen vagina* and *Fenneropenaeus merguiensis* were typical of high water temperature, low DO, and low transparency samples.

Discussion

The physicochemical parameters of the selected four stations around the Sandwip island were within the relatively desirable ranges for coastal fisheries. During the investigation period, the maximum and minimum water temperature at Sandwip island were 32ºC (in pre-monsoon at the st-4), and 20ºC (in winter at the St-1), respectively. Das (2005) found the range of water temperature[22] at Bandhkhali as 23 to 30.6ºC. Kamal (1992) observed some variation in DO content of Moheskhali channel[23] water at the range of 4 to 7.63 ml/l. In the present investigation, the concentration of DO showed a wide range of variation from 4.3 ml/l (monsoon at St-1) to 6.21 ml/l (winter at St-4). Lowest and the highest water pH were recorded 5.8 (winter at St-2) to 7.3 (post monsoon at St-3) respectively. Ahmed (2004) recorded the range of pH value 6 more or less constant in the Moheskhali channel[24]. So, the range of pH was in the favorable condition in the present study at Sandwip island. Mamun (2004) recorded 9 to 18.5 ppt salinity in the Halishahar coast of Chittagong[25]. In the present investigation, the salinity at Sandwip island ranged between 0.5 ppt (St-3 in monsoon) and 19 ppt (St-1 in winter), which is similar to that of Mamun (2004). In the present investigation transparency varied from 1 cm (St-1 in monsoon) to 26 cm (St-1 in winter) and coincides[25] with the study of Mamun (2004). During the study period, phosphate-phosphorus value ranged from 0.14 µg/l (St-4 in winter) to 2.31 µg/l (St-3 in monsoon) respectively. On the other hand, Noori (1999) recorded Phosphate-phosphorus level as 0.075 to 2.33 µg/l in the neritic waters off the southeast coast of Bangladesh[26]. The result of the present work coincides with their observations. The value of nitrite-nitrogen varied from 0.17 µg/l (St-2 in winter) to 1.13 µg/l (St-4 in monsoon) which are almost similar to the result of Noori (1999) (nitrite-nitrogen level 0.02 to 1.198 µg/l in the neritic waters off the southeast coast of Bangladesh)[26]. Present results are harmonious with their results. In the present study, the silicate-silicon concentration attained maxima in monsoon (81.94 µg/l at St-4) and minima in winter (52.44µg/l at St-1), respectively. Velencar and Dhargalkar (1992) recorded its concentration ranged between 26.5 and 54.1 µg/l in the south Indian coast[27]. The present work shows more or less similarity with their works.

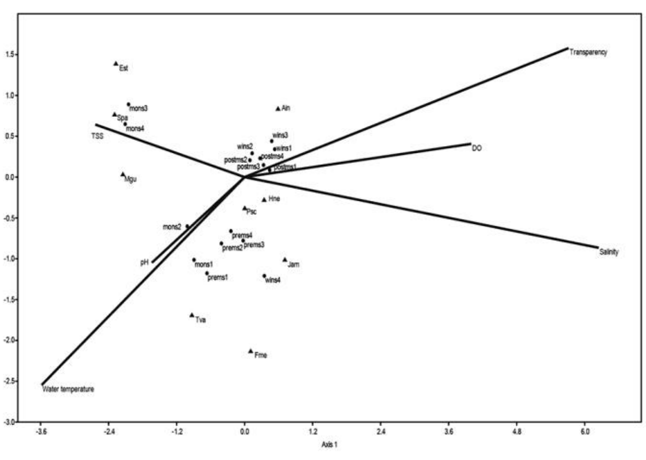

Fig.7-Ordination plot showing canonical correspondence analysis

The abundance of few species in large number and lesser contribution of a large number of species is a noticeable feature of fish assemblage structure around Sandwip island. This phenomenon was common for the most estuarine environment around the world[28,8]. The study of Hossain *et al.* (2012) at the Meghna estuary resulted in a catch of 53 species of fish species which is higher than the findings of the present study[29]. This variation is mainly due to two reasons: a) use of multiple gear and sampling methodology; and b) spatial coverage and habitat heterogeneity. Structure and composition of fish samples varied greatly due to the choice of different gear type[30,8] emphasized on target organisms, habitat type and geographic variation in designing sampling methodologies. ESBN catch study by Chowdhury *et al.*~~,~~ (2011) in a different location also varied with the present finding was also for the above-mentioned reasons[7]. Year-round influx of freshwater from Meghna estuary plays the key role in controlling hydrological variables around Sandwip island, and abundance of estuarine dependent taxa in this area support the above statement.

Range of Shannon–Weiner diversity index of ranged between 2.441 and 2.957 with a mean diversity value of 2.6790. Diversity index was medium at St-3 and St-4. The variation was probably due to the richness of species in the corresponding station and other unknown factors might regulate the index values. Belaluzzaman (1995) recorded $H^/$ as 1.017534–4.6494 from the Bakkhali River estuary, Cox's Bazar[31]. Nair *et al.*~~,~~ (1989) showed that the value of $H^/$ is dependent on sample size, on species richness and evenness[32]. In the present work species evenness index (J/) was observed in an overall sample of all stations and seasons of Sandwip island. Minimum Pielou evenness value (0.9697) was observed at St-3 during winter while the maximum value (0.9928) was found at St-1 during pre-monsoon. Belaluzzaman (1995) recorded $J^/$ 0.708295 from the Bakkhali muddy beach of Cox's Bazar[31]. Chandran (1997) recorded $J^/$ 0.891 from the intertidal zone of Valley estuary, Madras, India[33]. The minimum Margalef species richness value (2.92) was observed at St-3 during Monsoon while the maximum value (4.583) was found at St-1 during post-monsoon.

The CCA results showed the significant contribution of transparency and salinity in species distribution as these variables are highly correlated with the first axis. Akin *et al.*~~,~~ (2005) and Vilar *et al.*~~,~~ (2011) found the significant effect of transparency on the species distribution at Koyecegiz Lagoon-Estuary and Baía da Babitonga estuarine gradient respectively[28,34]. Salinity and transparency influenced the species distribution in Bakkhali River estuary[8]. Variation in species distribution explained of CCA was 46.53%, which indicates that there are other biotic and abiotic factors, not measured in this study, responsible for species distribution, because movement of fishes are dynamic and fish community structure can be affected by reproduction, competition, predation, and food availability[30]. The results of Nabi *et al*., (2011) for Bakkhali River estuary[8] and Hossain *et al*., (2012) for Meghna estuary are in an argument with the present study[29].

Conclusion

The shallow waters around Sandwip island serve as an important habitat for a number of commercial fish and shrimp species. Temporal and spatial scale variation of fish and shrimp species around this island provides important information on their availability, distribution, diversity and assemblage structure. Knowledge about their relationship with varying environment is very much necessary for management and conservation of this ecosystem. This research urge for initiation of further research on niche availability for fish, relationship with biotic factors and tropic structure of different aquatic biota.

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References

1. Dyer K R, *Estuaries: A physical introduction*, 2nd ed. (John Wiley and Sons, Chichester) 1997, pp. 195.
2. Mclusky D S & Elliott M, *The estuarine ecosystem*, (Oxford University Press, Oxford) 2004, pp. 214.
3. Whitfield, A.K., Ichthyofaunal assemblages in estuaries: A South African case study, *Rev. Fish Biol. Fish*., 9(1999) 151-186.
4. Houde, E., & Rutherford, E.S., Recent trends in estuarine fisheries: Predictions of fish production and yield. *Estuaries*, 16(1993) 161-176.
5. DoF, 2014, Department of Fisheries, Ministry of Fisheries and livestock, Bangladesh, at http://www.fisheries.gov.bd/.
6. Gray J.S., Marine diversity: the paradigms in patterns of species richness examined. *Sci. Mar.* 65(2) (2001) 41–56.
7. Chowdhury, M.S.N., Hossain, M.S., Das, & N.G., Barua, P., Environmental variables and fisheries diversity of the Naaf River Estuary, Bangladesh, *J. Coast. Conserv.*, 15(2011) 163- 180.
8. Nabi, M.R., M., Al-Mamun, M. Ullah, M.H. & Mustafa, M.G.,. Temporal and spatial distribution of fish and shrimp assemblage in the Bakkhali river estuary of Bangladesh in relation to some water quality parameters, *Mar. Biol. Res*,, 7(2011) 436-452.
9. Garcia A.M, Vieira J.P, & Winemiller K.O., Effects of 1997-1998 El Nino on the dynamics of the shallow-water fish assemblage of the Patos Lagoon estuary (Brazil), *Estuar. Coast. Shelf Sci.*, 57(2003) 489-500.
10. BBS, 2011. Population and Housing Census, Bangladesh Bureau of Statistics, Ministry of Planning, Bangladesh.
11. Islam, M.S., Khan, M.G., quayum, S.A., Sada, M.N., Chowdhury, Z.A., 1993. Studies on the interactive marine fisheries of Bangladesh. Working Paper 89. Bay of Bengal Program. Madras, India, 114 pp.
12. Mahmood, N., Chowdhury, M.J.U., Hossain, M.M., Haider, S.M.B., & Chowdhury, S.R., 1994. A review of the state of Environment relating to Marine Fisheries of Bangladesh. *In:* Holmgren, S. (Eds.). *An environmental assessment of the Bay of Bengal region. Report No. 67, Bay of Bengal Program*. Madras, India, pp. 74-129.
13. Siddiqui., M.Z.H., Zafar, M., Crabs in the Chakaria Sundarbans area of Bangladesh, *J. Naomi*, 19(2002) 61-77.
14. Siddiqui K U, Islam M A, Kabir, S M H, Ahmad M, Ahmed A T A, Rahman A K A, Haque E U, Ahmed Z U, Begum Z N T, Hassan M A, Khondker M & Rahman M M, *Encyclopedia of Flora and Fauna of Bangladesh. Vol. 23. Freshwater Fishes.* (Asiatic Society of Bangladesh, Dhaka) 2007, pp. 300.
15. Rahman A K A, Kabir S M H, Ahmad M, Ahmed A TA, Ahmed Z U, Begum Z N T, Hassan M A & Khondker M., *Encyclopedia of Flora and Fauna of Bangladesh. Vol. 24. Marine Fishes,* (Asiatic Society of Bangladesh, Dhaka) 2009, pp. 485.
16. Shannon, C.E. 1949. Communities in the presence of noise. *Preceding of the Institute of Radio Engineers,* 37(1):10-21.
17. Ramos, S., Cowen R. K., Re, P., & Bordalo, A.A., Temporal and spatial distributions of larval fish assemblage in the Lima estuary (Portugal), *Estuar. Coast. Shelf Sci.*, 66(2006) 303-314.
18. Pielou, E.C., The measurement of diversity in different types of biological collections, *J. Theor. Biol.*, 13(1966) 131- 144.
19. Clarke K R & Warwick R M, *Change in marine communities: An approach to statistical analysis and interpretation,* (Natural Environmental Research Council, Plymouth) 1994, pp. 144.
20. Clarke, K.R., Nonparametric multivariate analyses of changes in community structure. *Aust. J. Ecol.*, 18(1993) 117-143.
21. Rakocinski, C.F., Lyczkowski-Shulz, J., & Richardson, S.L., Ichthyoplankton assemblage structure in

Mississippi Sound as revealed by canonical correspondence analysis, *Estuar. Coast. Shelf Sci.*, 43(1996) 237-257.

22. Das, 2005. Livelihood and Resource Assessment for Aquaculture Development in Waterlogged Paddy lands: Remote Sensing, GIS, and Participatory Appraisal. A joint Application of GOB-DANIDA and IMS, CU: 122pp
23. Kamal, 1992. Studies on the intertidal Green mussel *perna viridis* L. inhibiting Moheshkhali Channel, Bay of Bengal, IMS, CU.
24. Ahammad, F., *Catch composition of estuarine set bag net in the Mosheshkhali Channal of the Bay of Bengal, Bangladesh,* M.Sc. thesis, University of Chittagong, Bangladesh, 2004.
25. Mamun. *Water quality consideration for sustainable aquaculture development in the Halishahar Coast, Chittagong*, M.Sc. thesis, University of Chittagong, Bangladesh, 2004.
26. Noori, *An investigation on seasonal variation of micronutrients and standing crop of phytoplankton in neritic waters of the southeast coast of Bangladesh*, M.Sc. thesis, University of Chittagong, Bangladesh, 1999.
27. Jegadeesan, P & Ayyakkannu, K.1992. Seasonal variation of benthic fauna in marine zone of Coleroon estuary and inshore waters, south east coast of India. *Indian J. Mar. Sci.*, (1992) 67-69.
28. Akin, S., Buhan, E., Winemiller, K.O., & Yilmaz, H., 2005. Fish assemblage structure of Koycegiz Lagoo Estuary, Turkey: Spatial and temporal distribution patterns in relation to environmental variation, *Estuar. Coast. Shelf Sci.,* 64(2005) 671-684.
29. Hossain, M.S., DAS, N.G., Sarker, S., & Rahman, M.Z., Fish diversity and habitat relationship with environmental variables at Meghna river estuary, Bangladesh, *Egypt. J. Aquat. Res.,* 38(2012) 213-216.
30. Kneib, R.T., Early life stages of resident nekton in intertidal marshes, *Estuaries,* 20(1997) 214-130.
31. Belaluzzaman, A. M., *Ecology of the intertidal Macrobentic Fauna in Cox's Bazar coast area, Bangladesh,* M.Sc. thesis, University of Chittagong, Bangladesh, 1995.
32. Nair, N.B., Arunachalam, M., Madhusoodanan Nair, K.C., & Suryanarayanan, H., Seasonal variation and species diversity of fishes in the Neyyar river of the Western Ghats, *Trop. Ecol.*, 30(1)(1989) 69-74
33. Chandran, R., Thangaraj, G.S., Sivakumar, V., Dhas, B.S., & Ramamoorthi, K., Ecology of in the Velar Estuary. *Indian J. Mar. Sci.,* 11(1997) 122-127.
34. Vilar, C.C., Spach, H.L., & Joyeux, J.C., Spatial and temporal changes in the fish assemblage of a subtropical estuary in Brazil: Environmental effects, *J. Mar. Biol. Assoc. U. K.,* 91(2011) 635-648.