

# Population Dynamics of Venus Clam *Meretrix meretrix* from the Moheshkali Island in the Cox's Bazar Coast of Bangladesh

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## Abstract

The population structure, growth, mortality and exploitation status of Venus clam *Meretrix meretrix* were examined in the Moheshkali channel of Bangladesh coast between June 2003 and May 2004. Monthly length frequency data of *M. meretrix* were analyzed by FiSAT software for estimation of population parameters like asymptotic length ( $L_{\infty}$ ), growth co-efficient (K) and recruitment pattern to evaluate the status of the stock. Asymptotic length ( $L_{\infty}$ ) was 8.14 cm and growth co-efficient (K) was  $0.97 \text{ yr}^{-1}$ . The growth performance index ( $\phi'$ ) was 2.07. The growth pattern showed negative allometric growth with an asymptotic weight ( $W_{\infty}$ ) of 129.69 g obtained. This Venus clam attained 5.05 cm at the end of one year. Total mortality (Z) was estimated by length-converted catch curve at  $2.63 \text{ yr}^{-1}$ , fishing mortality (F) at  $0.02 \text{ yr}^{-1}$ , and natural mortality (M) at  $2.61 \text{ yr}^{-1}$ . The exploitation level (E) of *M. meretrix* was 0.01 and the maximum allowable limit of exploitation ( $E_{\text{max}}$ ) was 0.58. The recruitment pattern was continuous with one major peak event per year. Habitat temperature, dissolved oxygen and salinity range of Venus clam were  $25.5\text{-}31^{\circ}\text{C}$ ,  $4.02\text{-}6.50 \text{ mg}\cdot\text{L}^{-1}$  and 12.36 to 26 ppt, respectively. The exploitation rate (E = 0.01) indicated that the fishing pressure on *M. meretrix* was very low and the stock condition might be unexploited in the Moheshkali channel of Bangladesh.

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## Introduction

The Venus clam, *Meretrix meretrix* occurs in shallow waters all around the Moheshkhal Island of Bangladesh (Wahab and Amin 2004). The tribal community of the Cox's Bazar coastal region of Bangladesh exploits the mollusc fishery specially oyster (*Crassostrea* spp.) and green mussel (*Perna viridis*) for consumption and local sale. These species have been extensively studied and are recognized as a valuable food resource in many parts of Asia (Choncheunchob et al. 1980; Angell 1986; McCoy and Chongpeepien 1988; Vakily 1989). Throughout the world, bivalves play an important role in the national economy of many countries (Vakily 1992).

The coastal water of Bangladesh is one of the most productive zones in the world and rich in fish and shellfishes including mollusc (Ahmed 1990). It is suitable for molluscan habitats like sandy, muddy and rocky grounds, mangrove areas and coral reefs, and thus, are suitable for the development of shellfish fishery. Several surveys were conducted for the identification of mollusc species available and their abundance in the coast of Bangladesh (Ali 1975; Ali and Aziz 1976; Ahmed et al. 1978). A total of 301 mollusc species under 151 genera and 79 families of 16 orders under 4 classes were recorded from Cox's Bazar, Moheshkhal Channel, St. Martin's Island, Sundarban reserve forest, Teknaf and also from the off shore waters of the Bay of Bengal (Ahmed 1990). However, there is no report regarding the population dynamics and exploitation status of mollusc fishery in Bangladesh. Therefore, a study on the population dynamics of the *M. meretrix* from the Moheshkhal Channel has been undertaken.

For planning and management of mollusc resources, knowledge of various population parameters and exploitation level (E) of that population is necessary. There are many tools for stock assessment. Of these, FiSAT (FAO-ICLARM Stock Assessment Tools) has been used most frequently in estimating the population parameters of finfish and shell-fish (Amin et al. 2001a; 2002; Mancera and Mendo 1996) because it only requires length-frequency data. The advantage of this technique is that within a year it is possible to assess for any fish stock whether you have sufficient length-frequency data. The objective of the present study was to estimate the population parameters and exploitation level of *M. meretrix* so as to assess the stock position of the species from the Moheshkhal Island of Cox's Bazar coast of Bangladesh, using FiSAT.

## Materials and Methods

The study was conducted at the Moheshkhali Channel (N21° 28' and N21° 46', E91° 57' and E92° 03'), south-eastern coast of Bangladesh (Fig. 1). Random samplings were done monthly between June 2003 and May 2004. Specimens of *M. meretrix* were collected from the inter-tidal zone of the Moheshkhali Channel areas of Cox's Bazar, Bangladesh. Samples were preserved with 10% formalin at field level immediately after collection. In the laboratory, a total shell length of 1366 from specimens was measured using a meter scale to the nearest millimeter and total weight was taken by an electronic balance of 0.001 g accuracy. Data from the two stations were then pooled month-wise and subsequently grouped into length classes by 0.5 cm interval. Then the data were analyzed using the FiSAT software as explained in detail by Gayanilo et al. (1996).

Asymptotic length ( $L_{\infty}$ ) and growth co-efficient (K) of the Von Bertalanffy Growth Formula (VBGF) were estimated by means of ELEFAN-1 (Pauly and David 1981; Pauly 1982; Pauly and Morgan 1987). The estimates of  $L_{\infty}$  and K were used to estimate the growth performance indeces ( $\phi'$ ) (Pauly 1981; Munro and Pauly 1983; Pauly and Munro 1984) of *M. meretrix* using the equation:

$$\phi' = 2 \log_{10}L_{\infty} + \log_{10}K$$

To establish the length-weight relationship, the commonly used relationship  $W = a L^b$  was applied (Ricker 1975; Quinn and Deriso 1999), where W is the weight (g), L is the total length (cm), 'a' is intercept (condition factor), and 'b' is the slope (growth coefficient, i.e., fish relative growth rate).

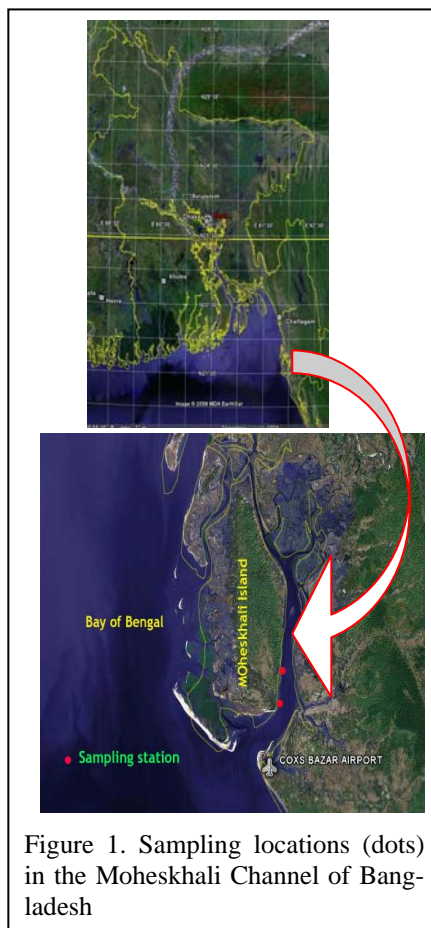


Figure 1. Sampling locations (dots) in the Moheshkhali Channel of Bangladesh

The parameters a and b were estimated by least squares linear regression on log-log transformed data:

$$\text{Log}_{10} W = \text{Log}_{10} a + b \text{Log}_{10} L.$$

The coefficient of determination ( $r^2$ ) was used as an indicator of the quality of the linear regression (Scherrer 1984). Additionally, 95% confidence limits of the parameters a and b and the statistical significance level of  $r^2$  were estimated.

The inverse von Bertalanffy growth equation (Sparre and Venema 1992) was used to find the lengths of the *M. meretrix* at various ages. Then VBGF was fitted to estimates of length-at-age curve using non-linear squares estimation procedures (Pauly et al. 1992). The VBGF is defined by the equation:

$$L_t = L_\infty [1 - e^{-k(t-t_0)}]$$

where  $L_t$  = mean length at age t,  $L_\infty$  = asymptotic length,  $K$  = growth coefficient,  $t$  = age of the *M. meretrix*, and  $t_0$  = the hypothetical age at which the length is zero (Pauly and David 1981; Newman 2002).

The total mortality (Z) was estimated by length converted catch curve method (Pauly 1983; 1984; 1990). Natural mortality rate (M) was estimated using the empirical relationship of Pauly (1980):

$$\text{Log}_{10} M = -0.0066 - 0.279 \text{Log}_{10} L_\infty + 0.6543 \cdot \text{Log}_{10} K + 0.4634 \text{Log}_{10} T$$

where M is the natural mortality,  $L_\infty$  is the asymptotic length, K refers to the growth co-efficient of the VBGF, and T is the mean annual habitat temperature  $^{\circ}\text{C}$  of the water in which the stocks live.

Once Z and M were obtained, then fishing mortality (F) was estimated using the relationship:  $F = Z - M$ , where Z is the total mortality, F is fishing mortality, and M is natural mortality.

The exploitation rate (E) was obtained by the relationship of Gulland (1971):  $E = F/Z = F / (F+M)$ .

The routine in FiSAT reconstructs the recruitment pulse from a time series of length-frequency data to determine the number of pulses per year and the relative strength of each pulse, using the VBGF parameters (Pauly 1982; 1983; Moreau and Cuende 1991) where  $L_\infty$ , K and  $t_0$  ( $t_0 = 0$ ). Normal distribution of the recruitment pattern was determined by NORMSEP (Pauly and Caddy 1985) in FiSAT.

Physical variables such as water temperature, salinity, dissolved oxygen, hydrogen ion concentration (pH) and transparency were measured monthly for one year (June 2003-May 2004). Water temperature ( $^{\circ}\text{C}$ ) and salinity were estimated by SCT meter (YSI model 33). Dissolved oxygen ( $\text{mg O}_2 \text{ L}^{-1}$ ) was measured by a DO meter (YSI model 57). Water pH was recorded by pH meter (EDT model FE 253). Transparency of water was determined by a Secchi disc to the nearest cm.

## Results

### Growth parameters

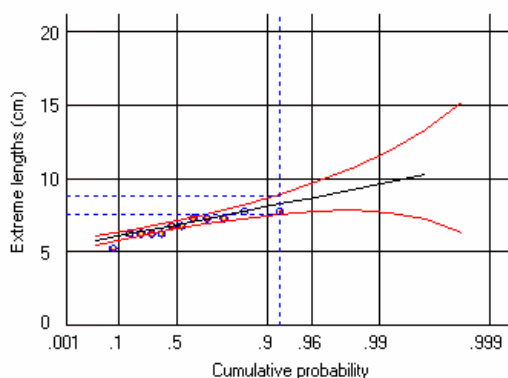


Figure 2. Predicted extreme length of *M. meretrix*

The observed extreme length was 7.75 cm and the predicted extreme length was 8.20 cm respectively (Fig. 2). The length range of 95% confidence interval was 7.55-8.86 cm. The ELEFAN-I program estimated asymptotic length ( $L_{\infty}$ ) and growth coefficient ( $K$ ) of the Von Bertalanffy Growth Formula (VBGF) were 8.14 cm and  $0.97 \text{ yr}^{-1}$  respectively, for *M. meretrix*. For these estimates

through ELEFAN-I the response surface (Rn) used for the curves were 0.271. Figure 3 shows the corresponding growth curve, superimposed on the restructured length-frequency data from table 1. Growth performance index ( $\phi'$ ) was 2.07.

### Length-weight relationship

The length of individuals ranged from 2.25 cm to 8.25 cm and the weight from 8.89 to 107.32 g. The length-weight equation calculated was:

$$\text{Log } W = 0.2725 + 2.021 \text{ Log } L,$$

in exponential form the equation is

$$W = 1.873 L^{2.021} (r^2 = 0.99; P < 0.01).$$

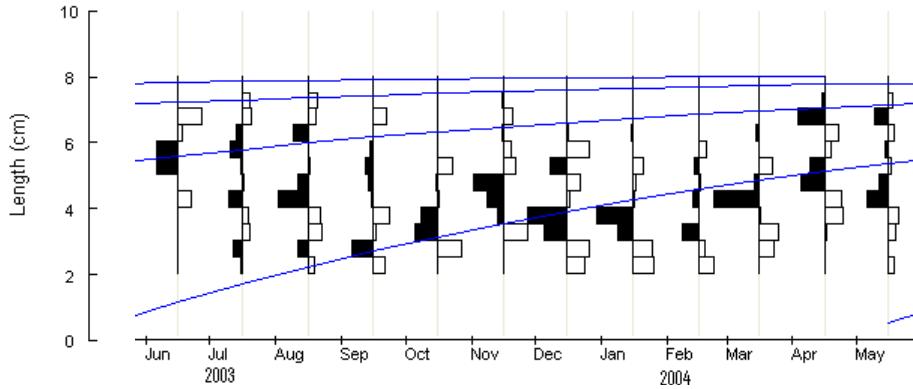


Figure 3. Restructured length-frequency distribution and the estimated growth curves for *M. meretrix*, using ELEFAN 1 ( $L_{\infty} = 8.14$  cm and  $K = 0.97$  yr<sup>-1</sup>)

Table 1. Length frequency data of *Meretris meretrix* from the Moheshkhali channel of Bangladesh

ML (cm)	2003							2004					Total
	15 Jun	15 Jul	15 Aug	15 Sept	15 Oct	15 Nov	15 Dec	15 Jan	15 Feb	15 Mar	15 Apr	15 May	
2.25		5	2				3	1	3			2	
2.75		9	7	7	1		4	3	8	2		4	
3.25		6	5	4	17	1	37	25	24	4	2	7	
3.75		8	8	1	18	20	52	42	17	22	3	8	
4.25	4	19	39	8	11	28	22	18	23	64	6	26	
4.75	12	14	29	10	9	39	9	14	14	30	37	22	
5.25	24	17	21	12	2	9	14	5	15	11	33	15	
5.75	23	19	16	9		8	1	5	6	11	22	16	
6.25	9	13	17	6		5	3	3	6	7	12	9	
6.75	1	4	5	1		2					38	13	
7.25		1	1			2					18	4	
7.75											10	3	
	73	115	150	59	58	73	145	116	116	151	181	129	1,366

The length-weight relationship curve is presented in figure 4. The computed growth coefficient (b) was 2.021 ( $\pm 0.041$ ). The b values ranged from 1.93 to 2.114 at 95% confidence limit.

**Age and growth**

It was assumed in the ELEFAN-I analysis that the value of the third parameter of the von Bertalanffy growth function  $t_0$  was zero (Pauly and David 1981). Therefore, the sizes attained by *M. meretrix* were 3.13, 5.05,

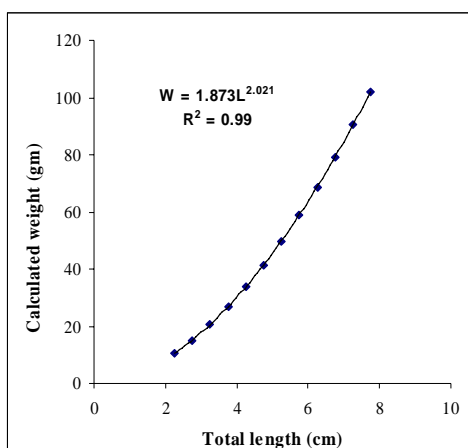


Figure 4. Length-weight relationship of *Meretrix meretrix*

6.24, 6.97, 7.42 and 7.70 cm at the end of 0.5, 1, 1.5, 2, 2.5 and 3 years of age, respectively. The absolute increase is presented in figure 5. The growth of *M. meretrix* was 2.50 cm from one to six months of age.

### ***Mortality rates and exploitation level***

Length-converted catch curve analysis produced total mortality (Z) for *M. meretrix* was 2.63 yr<sup>-1</sup> (Fig. 6). Natural mortality (M) and fishing mortality (F) were 2.61 and 0.02 yr<sup>-1</sup>, respectively (Table 2).

Exploitation level (E) was 0.01 and the maximum allowable limit of exploitation (E<sub>max</sub>) was 0.58 for maximum relative yield-per-recruit (Table 1).

### ***Recruitment pattern***

The recruitment pattern was continuous throughout the year with one major peak in the month of August. The highest peak pulse produced 21.21% recruitment during the month of August (Fig. 7).

### ***Environmental variables***

The ranges and annual averages of temperature, salinity, dissolved oxygen, hydrogen ion concentration (P<sup>H</sup>) and transparency in the investigated area where *M. meretrix* occur are shown in table 3. Salinities varied between 12.36 and 26 ppt (mean, 19.57 ppt ± 4.71), water temperature was relatively constant between 25.5 and 31°C (mean, 29°C ± 1.62) and dissolved oxygen was lowest (4.02 mg O<sub>2</sub>·L<sup>-1</sup>) in June and

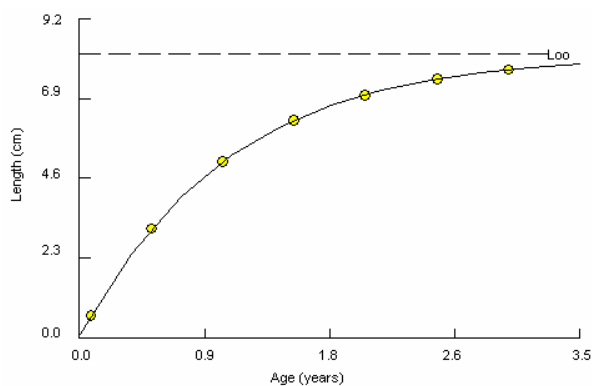


Figure 5. Plot of age and growth of *M. meretrix* based on computed growth parameters

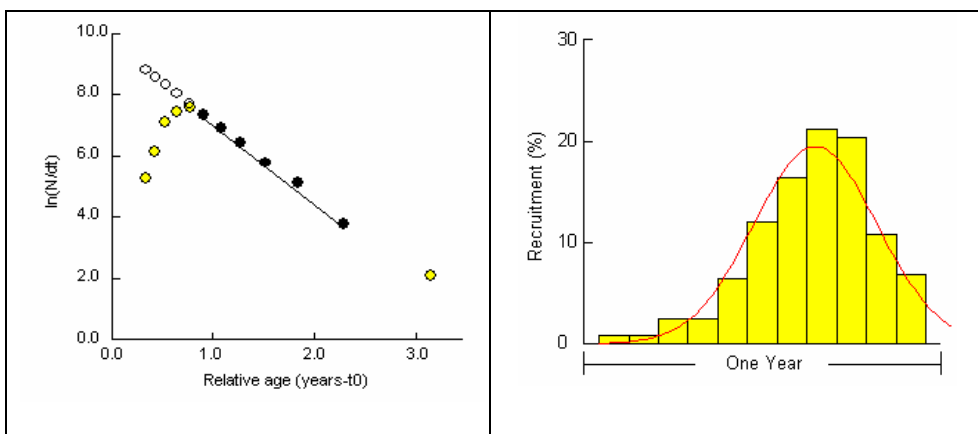


Figure 6. Length converted catch curve of *Meretrix meretrix*

Figure 7. Recruitment pattern of *Meretrix meretrix*

Table 2. Population parameters of *Meretrix meretrix*

Population parameters	<i>Meretrix meretrix</i>
Asymptotic length ( $L_{\infty}$ ) in cm	8.14
Growth co-efficient (K) $\text{yr}^{-1}$	0.97
Growth performance index ( $\phi'$ )	2.07
Natural mortality (M) $\text{yr}^{-1}$	2.61
Fishing mortality (F) $\text{yr}^{-1}$	0.02
Total mortality (Z) $\text{yr}^{-1}$	2.63
Exploitation level (E)	0.01
Allowable limit of exploitation ( $E_{\max}$ )	0.58
Length range (cm)	2.25-7.75
Sample number (N)	1366

Table 3. Physical parameters of Moheshkhali channel of Bangladesh

Parameter	Lowest	Highest	Average
Water temperature ( $^{\circ}\text{C}$ )	25.5	31	$29.0 \pm 1.62$
Salinity (ppt)	12.36	26	$19.57 \pm 4.71$
Dissolved oxygen ( $\text{mgL}^{-1}$ )	4.02	9.71	$6.19 \pm 1.96$
PH	7.1	7.7	$7.38 \pm 0.18$
Transparency (cm)	25	40	$32.58 \pm 4.87$

highest ( $9.71 \text{ mg O}_2 \cdot \text{L}^{-1}$ ) in April during the study period (Fig. 8). Hydrogen ion concentration varied from 7.1 (April) to 7.7 (September). The minimum values of water transparency (Secchi disc visibility) was recorded in October (25 cm) and the maximum in January (40 cm) during the study period (Fig. 9).



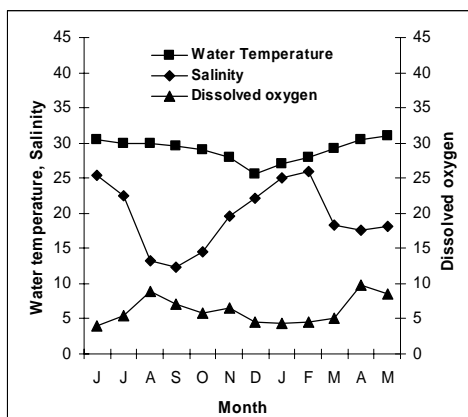


Figure 8. Monthly variation of water temperature ( $^{\circ}\text{C}$ ), salinity (ppt) and dissolved oxygen ( $\text{mg}^{-1}$ ) in the Moheshkhali Channel of Bangladesh

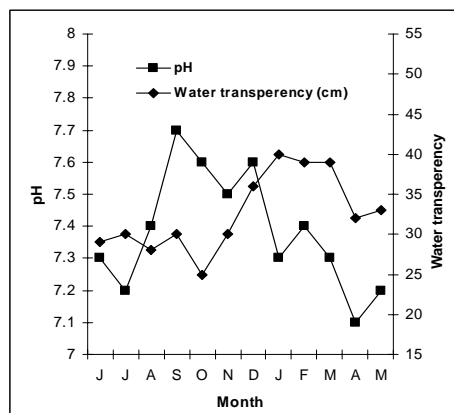


Figure 9. Monthly variation of pH and water transparency (cm) in the Moheshkhali Channel of Bangladesh

## Discussion

The results showed estimates of asymptotic length ( $L_{\infty}$ ) for Venus clam, which are very similar with surf clam (Laudien et al. 2003) but growth co-efficient ( $k$ ) is higher than surf clam (Table 4). The growth coefficient  $b$  generally lies between 2.5 and 3.5 and the relation is said to be isometric when it is equal to 3 reported for most fish (Carlander 1977). In the present case, estimated  $b$  (2.021) does not lie between the values mentioned by Carlander (1977) and significantly smaller than the isometric value (3) at 5% level. This indicates the negative allometric nature of growth for *M. meretrix* in the Moheshkhali Island of Bangladesh.

Table 4. Growth and related parameters of the other bivalves as reported in other countries

Location	Species	$L_{\infty}$ (cm)	$K \text{ yr}^{-1}$	$\phi'$	$T (^{\circ}\text{C})$	Source
Bangladesh	<i>M. meretrix</i> (Venus Clam)	8.14	0.97	1.80	28.93	Present study
Germany	<i>Donax serra</i> (Surf clam)	8.20	0.27	-	-	Laudien et. al. (2003)
USA	<i>Crassostrea virginica</i>	12.58	0.50	3.90	11.0	Vakily (1992)
India	<i>C. madrasensis</i>	11.90	0.77	4.04	28.0	Vakily (1992)
Colombia	<i>C. rhizophorae</i>	14.90	0.90	4.30	30.0	Mancera and Mendo (1996)
Venezuela	<i>C. rhizophorae</i>	76.0	3.96	4.34	-	Angell (1986)
Korea	<i>C. gigas</i>	10.37	2.35	4.40	16.0	Vakily (1992)

The growth of *M. meretrix* showed 2.50 cm from one to six months of age and at the end of 1 year, it attained around 5.05 cm. This indicates that *M. meretrix* culture could be done due to its better growth rate than what is usually obtained for other bivalve species (Mendo and Jurado 1993). Similar studies have been reported by Blaber et al. (1998), Amin et al. (2001b) and Amin and Zafar (2004) and on fish species through length converted age method which was also followed in this study.

The higher natural mortality ( $2.63 \text{ yr}^{-1}$ ) compared to the fishing mortality ( $0.02 \text{ yr}^{-1}$ ) of *M. meretrix* observed in the present study indicates the unbalance position in the stock. Fishing mortality is primarily caused by sampling, as there is no fishery for *M. meretrix* in the Moheskhali Island. The exploitation ratio (E), therefore, is minor (0.01), demonstrating that natural mortality (M) is the major cause of death of the clam.

The recruitment pattern suggests that annual recruitment consists of one seasonal pulse (Fig. 5), i.e. one cohort is produced per year; the highest peak occurs in July-September. However, studies on larval abundance and spat collections in the Cox's Bazar coast of Bangladesh (Hossain et al. 2004) showed that clam larvae settle through the year but the highest peak was found in March and the second highest in October. The recruitment peak detected in this study should correspond to the first larval settlement. It is observed that major spawning of *M. meretrix* occurs in the month of May in the Moheskhali channel of Bangladesh (Fig. 3). During the major spawning period, salinity was lower (18.15 ppt) and dissolved oxygen was higher ( $8.53 \text{ mg O}_2 \cdot \text{L}^{-1}$ ) than in other months (Fig. 8). So it may be concluded that *M. meretrix* prefers low salinity and high dissolved oxygen for spawning. Further studies are recommended to explain recruitment using environment variables. The major recruitment peak (July-September) detected in this study should correspond to major spawning season.

## Conclusion

Higher natural mortality ( $2.55 \text{ yr}^{-1}$ ) was observed compared to fishing mortality ( $0.03 \text{ yr}^{-1}$ ) and the stock of *M. meretrix* is still unexploited in the study area. From the present study, it could be concluded that the stock of Venus clam is a potential resource in the Moheskhali channel of Bangladesh. This potential resource could be an option for the livelihood of poor coastal communities in the Moheskhali Island of Bangladesh.

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