ISSN: 1511-3701
Pertanika J. Trop. Agric. Sci. **28** (**2**): 103-109 (2005)

Population Dynamics and Exploitation Level of Green-Lipped Mussel (*Perna viridis*) Using FiSAT from the Offshore Island of the Cox's Bazar Coast of Bangladesh

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Keywords: Population dynamics, exploitation, *Perna viridis*, Bangladesh

ABSTRAK

Perancangan dan pengurusan sumber moluska memerlukan pengetahuan pelbagai parameter populasi dan tahap eksploitasi (E) populasi tersebut dalam lokasi khusus yang tertentu. Aggaran parameter populasi seperti kepanjangan asimptot (L∞), pekali pertumbuhan (K), kematian, tahap eksploitasi (E) dan corak rekruitmen kupang Perna viridis *di luar pesisir pantai Pulau Cox's Bazar Bangladesh telah dikaji dengan menggunakan frekuensi kepanjangan berdasarkan analisis perisian FiSAT. Kepanjangan asimptot (L∞) adalah 19.43 cm dan pekali pertumbuhan (K) dianggarkan 0.56 setahun. Jumlah kematian (Z) adalah 1.44 setahun untuk* P. viridis. *Kematian semula jadi (M) dan kematian penangkapan (F) masing-masing adalah 1.38 setahun dan 0.06 setahun. Tahap eksploitasi (E)* P. viridis *adalah 0.04 manakala nilai had eksploitasi maksimum yang dibenarkan (E_{max}) adalah 0.68. Tahap eksploitasi (<0.50) menunjukkan bahawa stok* P. viridis *mungkin kurang dieksploitasi di luar pesisir pantai Pulau Cox's Bazar Bangladesh.*

ABSTRACT

*Planning and management of molluscan resources require knowledge of various population parameters and exploitation level (E) of the population in a particular location. Estimation of population parameters like asymptotic length (L∞), growth co-efficient (K), mortalities, exploitation level (E) and recruitment pattern of green-lipped mussel (*Perna viridis*) in the offshore Island of Cox's Bazar coast of Bangladesh were studied by using the length frequency based analysis of FiSAT software. Asymptotic length (L∞) was 19.43 cm and growth co-efficient (K) was estimated at 0.56/yr. Total mortality (Z) was 1.44/yr. Natural mortality (M) and fishing mortality (F) were 1.38/yr and 0.06/yr, respectively. Exploitation level (E) of* P. viridis *was 0.04 while the maximum allowable limit of exploitation value(E_{max}) was 0.68. The exploitation level (< 0.50) indicates that the stock of* P. viridis *might underexploited in the offshore Island of the Cox's Bazar coast of Bangladesh.*

INTRODUCTION

The majority of fishermen in coastal communities of Bangladesh are poor and do not own or have access to any land. Many of them are engaged in the fishing industry as temporary labour. Women and children particularly are involved in the collection of shrimp post larvae (PL) by push net in the shallow coast. Their livelihood options are limited and unstable and some are currently being threatened with the recommended bans on PL collection and shallow water fishing using bag nets. Alternative income generating activities are also limited. Recent surveys, reviews and workshops (TAANGO 2002; Luu 2002; Frankenberger 2002) have identified a number of potential alternative livelihood options that could have a considerable and

positive impact to the poor as well as enhancing foreign earnings. One of these options is the development of a molluscan fishery, in particular the bivalves. The coastal water of Bangladesh is one of the most productive zones in the world and rich in fish and shell-fishes including molluscs (Ahmed *et al.* 1978). Along the coastal area, varieties of marine habitats such as sandy, muddy and rocky grounds, mangrove areas and coral reefs are inhabited by the bivalves, and thus are potentially viable for the development of shellfish fishery. Commans (1940) was the first to report the presence of some species of molluscs in the St. Martin's Island from the Bay of Bengal. Ali (1975) later reported that several taxa including 33 species exist within the St. Martin's Island. Ali and Aziz (1976) later described 33 species under three different taxa from the same Island. Ahmed (1990) subsequently identified 301 molluscs species belonging to 151 genera, 79 families, 16 orders and 4 classes from the Cox's Bazar, Moheskhali Channel, Teknaf, St. Martin's Island, Sundarban reserve forest and deep water of the Bay. This survey was conducted mainly to identify the marine molluscs available in the Bay of Bengal. But there is no report regarding the status of exploitation levels despite a market demand from foreign countries such as Japan, Thailand and China.

For planning and management of mollusc resources, knowledge of various population parameters and exploitation level (E) of their population is required. There are many tools for assessing exploitation level and status of stock. FAO-ICLARM Stock Assessment Tools (FiSAT) is one which has been most frequently used for estimating population parameters of fin-fish and shell-fish (Amin *et al.* 2001, 2002; Angell 1986; Cha *et al.* 2002; Mancera and Mendo 1996; Tuaycharoen *et al.* 1988; Vakily 1992) because it needs only length-frequency data. The advantage of this technique is that within a year it is possible to assess of any fish stock if you have sufficient length-frequency data.

The commercially important mollusc species green-lipped muscle (*P. viridis*), is available in Cox's Bazar coast. Tribal communities are currently exploiting them for local consumption. The marine mussels are popular food items in many other countries around the globe. There has been no published report on population dynamics and status of exploitation of *P. viridis* in Bangladesh prior to this study. Hence, the estimation of population parameters and exploitation level of this species of bivalves from the coast of Bangladesh is very important.

The objective of this study was to estimate the population parameters and exploitation level of *P. viridis* to assess the stock position of the species from the offshore Island (Moheskhali) of Cox's Bazar coast of Bangladesh using FiSAT.

MATERIALS AND METHODS

The study was conducted in Moheskhali Channel (N21^0 28$^/$ and N21^0 46$^/$, E91^0 57$^/$ and E92^0 03$^/$) of south-eastern coast of Bangladesh (*Fig. 1*). Random sampling was done monthly between June 2003 and May 2004. Specimens of *P. viridis* were attached with the stone on inter-tidal zone of Moheskhali Channel and Chaufaldandi coastal area of Cox's Bazar, Bangladesh. An iron rod was utilized during sampling for separating the specimens from the stone. Samples were preserved with 10% formalin at field level immediately after collection. In the laboratory, total shell length was measured with the help of a meter scale to the nearest millimeter and total weight was taken by an electronic balance of 0.001 g accuracy. A total of 981 specimens were collected. The data from two stations were then pooled month-wise and subsequently grouped into length classes by 1 cm interval. Then the data were analyzed using FiSAT software as explained in detail by Gayanilo Jr. *et al.* (1996).

Asymptotic length (L_∞) and growth co-efficient (K) of the von Bertalanffy growth equation were estimated by means of ELEFAN-1 (Pauly and David 1981; Saeger and Gayanilo 1986). The estimates of L_∞ and K were used to estimate the growth performance index (φ') (Munro and Pauly 1983; Pauly and Munro 1984) of *P. viridis* using the equation:

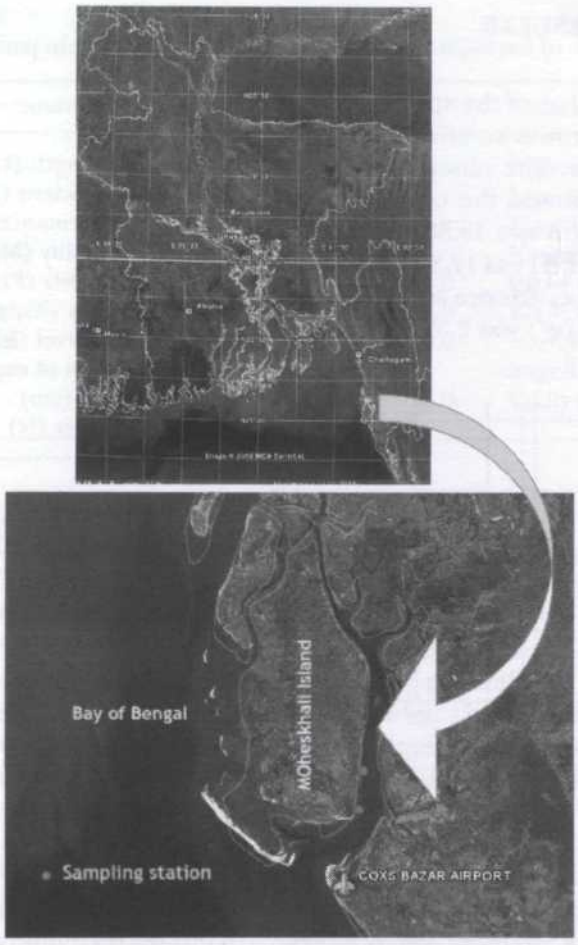

Fig. 1: Sampling stations of the study area

$$\varphi' = 2 \log_{10} L\infty + \log_{10} K$$

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

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

where T is the mean annual habitat temperature 0c of the water in which the stocks live. Once Z and M were obtained, then fishing mortality (F) was estimated using the relationship:

$$F = Z\text{-}M$$

where Z is the total mortality and F fishing mortality. The exploitation level (E) was obtained by the relationship of Gulland (1971):

$$E = F/Z = F/\ (F+M)$$

The recruitment pattern of the stock was determined by backward projection on the length axis of the available length frequency data set as described in FiSAT. This routine 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. Input parameters were L_{∞}, K and t_0 (t_0=0).

RESULTS

Growth Parameters

Asymptotic length (L_∞) of the von Berttalenfy was 19.43 cm and growth co-efficient (K) was 0.56/yr for *P. viridis*. The observed extreme length was 18.50 cm and the computer predicted extreme length was 19.38 cm (*Fig. 2*). The confidence interval was 17.35 to 21.42 cm (95% probability of occurrence and the growth performance index (φ') was 2.32.

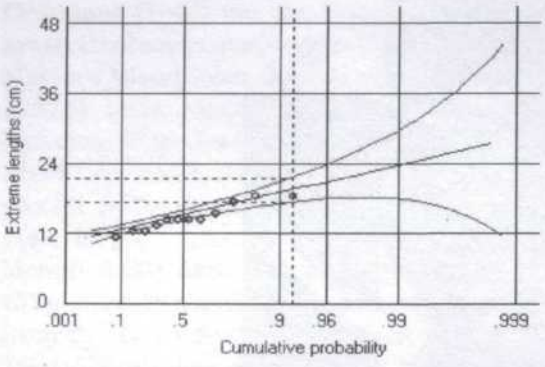

Fig. 2: Maximum size estimation of Perna viridis

Mortalities

Length converted catch curve analysis produced total mortality estimates of Z = 1.44/yr for *P. viridis* (*Fig. 3*). Natural mortality (M) was 1.38/yr and fishing mortality (F) was 0.06/yr for the species (Table 1).

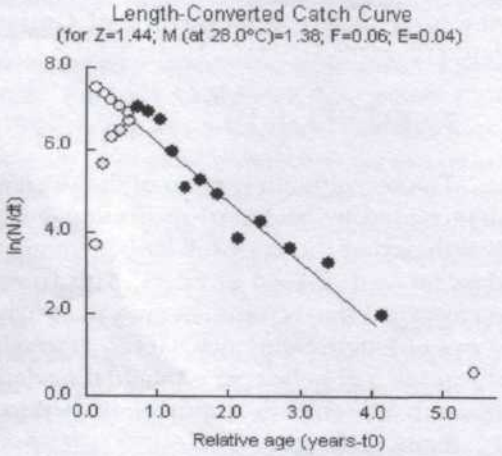

Fig. 3: Length converted catch curve of Perna viridis

TABLE 1
Population parameters of *Perna viridis*

Population parameters	*Perna viridis*
Asymptotic length (L_∞) in cm	19.43
Growth co-efficient (K)/yr	0.56
Growth performance index (φ')	2.32
Natural mortality (M)/yr	1.38
Fishing mortality (F)/yr	0.06
Total mortality (Z)/yr	1.44
Exploitation level (E)	0.04
Allowable limit of exploitation (E_{max})	0.68
Length range (cm)	1.50-18.50
Sample number (N)	981

Exploitation Level (E)

Exploitation level (E) of *P. viridis* was 0.04 and the maximum allowable limit of exploitation (E_{max}) value was 0.68 (Table 1). Results in Table 1 show that exploitation level (E) of *P. viridis* alone in comparison to its E_{max} was lower than 94%. It clearly shows that there was a definite case of under exploitation of the total stock of the species.

Recruitment Pattern

The recruitment pattern of *P. viridis* was continuous but there were two major peaks in a year; the highest peak observed in March-May and second peak occurred in August-October (*Fig. 4*).

Fig. 4: Recruitment pattern of Perna viridis

TABLE 2
Population parameters of the *P. viridis* and other bivalves as reported in other countries

Location	Species	L_∞ (cm)	K/yr	φ'	T (°c)	Source
Bangladesh	*P. viridis*	19.43	0.56	2.32	28	Present study
Hong Kong	*P. viridis*	10.19	0.30	-	-	Lee (1985)
Thailand	*P. viridis*	11.20	1.00	-	-	Tuaycharoen *et. al.*, (1988)
India	*P. viridis*	18.46	0.25	-	-	Narasimham (1981)
USA	*C. virginica*	12.58	0.50	3.90	11.0	Vakily (1992)
India	*C. madrasensis*	11.90	0.77	4.04	28.0	Vakily (1992)
Colombia	*C. rhizophorae*	14.90	0.90	4.30	30.0	Mancera and Mendo (1996)
Venezuela	*C. rhizophorae*	7.60	3.96	4.34	-	Angell (1986)
Korea	*C. gigas*	10.37	2.35	4.40	16.0	Vakily (1992)

DISCUSSION

The estimated asymptotic length (L_∞) was 19.43 cm and growth co-efficient (K) 0.56/yr for *P. viridis* in this study. The comparison with growth parameters obtained in other studies show differences for *P. viridis* from different areas of the world (Table 2). The highest value of (L_∞) (19.43 cm) was obtained from this study in Bangladesh coast waters and the lowest value (10.19 cm) was from Hong Kong (Lee 1985). The highest K value (1.0/yr) was obtained in Thailand (Tuaycharoen *et. al.* 1988) and the lowest value (0.25/yr) was reported from India (Narasimham 1981). It was observed that the L_∞ of *P. viridis* from Bangladesh coastal waters is higher than other countries (Table 2) but K is more or less very close to *P. viridis* of India and Hong Kong waters. Higher L_α indicates plenty of oyster resources in the Moheskhali Island of Bangladesh.

Higher natural mortality (1.38/yr) observed as opposed to fishing mortality (0.06/yr) of *P. viridis* observed in this study indicates an imbalance in the stock. The yield is optimized when fishing mortality (F) = natural mortality (M) (Gulland 1971).

The lower value of E indicates an 'under fishing' status during the study period. Theoretically when E= 0.50, then the stock of any aquatic species is at the optimum level. According to Gulland (1971), the yield is optimized when F = M; therefore, when E is more than 0.5, the stock is over fished. Sparre and Venema (1992) advocated the use of Beverton and Holt's E_{max} (E_{MSY}) to decide the state of under or over exploitation and suggest management measures, if necessary, because the hypothetical ideal E value of 0.5 is only possible if natural and fishing mortality is equal, and this is unsual for any exploited fish population. From this study, it could be concluded that the stock of *P. viridis* is virgin in the study area.

The recruitment pattern suggests that annual recruitment consist of two seasonal pulses (*Fig. 4*), i.e. two cohorts are produced per year; the highest peak occurs in March-May followed by a second peak occuring in August-October. However, studies on larval abundance and spat collections in the St. Martin coast of Bangladesh (Hossain *et al.* 2004) showed that green mussel larvae settle through the year but the highest peak was found in October and the second highest in March. The recruitment peaks detected in this study should correspond to the first and second larval settlement.

CONCLUSION

Higher natural mortality (1.38/yr) was observed compared to fishing mortality (0.06/yr) and the stock of *P. viridis* is underexploited in the study area. It could be concluded that the stock of green-lipped mussel has a great potential in the Cox's Bazar coast of Bangladesh. More exploitation is possible and

it could be an option for the livelihood of poor coastal communities of Bangladesh.

ACKNOWLEDGEMENTS

This work is part of a research project funded by "Support for University Fisheries Education and Research (SUFER)," and "Department for International Development (DFID)," U. K. The authors are grateful to the late Mr. Chris Morrice, Project Coordinator for his help and advice during the early stages of this study.

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(Received: 25 February 2006)
(Accepted: 13 May 2006)