Indian Journal of Geo Marine Sciences
Vol. 50 (03), March 2021, pp. 258-261

Short Communication

Maximum sustainable yield estimate for Brown shrimp, *Metapenaeus monoceros* (Fabricius 1798) in marine waters of Bangladesh using trawl catch log

S Barua

Marine Fisheries Office, Department of Fisheries,
Chattogram – 4100, Bangladesh

[E-mail: sbarua123bd@gmail.com]

Received 04 September 2019; revised 24 February 2020

Brown shrimp, *Metapenaeus monoceros* is a major contributor of shrimp trawling in Bangladesh marine waters. This is a key fisheries item owing of its fast growth and short life span. Though, stock assessment is need to be conducted annually, the present study is the maiden effort on the assessment of the stock of *M. monoceros* in marine waters of Bangladesh. Catch per unit effort (CPUE), the most common pieces of information was taken from trawl catch log between 1986 and 2017 for assessing the status of brown shrimp stock using Schaefer biomass model through MS-Excel and CMSY/BSM interfaces. The standing stock and fishing mortality were assessed to be around 5960 t and 43 %, respectively. The calculated reference points of maximum sustainable yield (MSY) with 95 % confidence interval are optimum biomass B_{MSY} 5060 t (4190-6110 t) and optimum fishing mortality F_{MSY} = 61 % (51-63 %). The average annual catch of last two decades was 2793 t, below assessed MSY of 3090 t (2920-3260 t). The stock is probably going to be of satisfactory size with sustainable exploitation close to MSY. Thus, management would be well advised not let to increase catches but to maintain them at the current level.

[**Key words**: Bangladesh, Brown shrimp, Catch log, MSY, Trawl]

Introduction

The brown shrimp, *Metapenaeus monoceros* (Fabricius 1798), is one of the widely distributed species in the Indo-Pacific area[1]. It is commonly known as Brown shrimp (Fig. S1). The major contributor of shrimp trawling in Bangladesh marine waters is brown shrimp, which usually accounts for 38 to 52 % of the total shrimp catch[2]. The modal sizes in the catch varied from 26 to 80 mm. They feed on small crustaceans, algae, small mollusks, foraminiferans and on organic detritus with small crustaceans being the main food item[1]. They show diurnal behavior, preference for the muddy bottom and remained burrowed in the mud fully concealed during the day and move actively at night. The species occur in estuary round the year, but the main fishing season extends from October to January/February[1]. The estimated biomass of *M. monoceros* in Bangladesh marine waters was 551 t after reviewed survey data and the highest abundance of this was found at 51 to 80 m depth zone[2].

Maximum sustainable yield (MSY) is the most notable piece of information of any stock can be assessed by the production models, for instance, the Schaefer's model 1954[ref. 3]. Stock production models (SPM's) are well known for their simplicity. These require only two or three types of data like time series data of abundance and removals in order to calculate the carrying capacity '*K*' and the maximum rate of population increase '*r*' for a given stock of any specified ecosystem. Though the assessments of removals such as the addition of catch and discards are easy to calculate but the estimates of abundance are comparatively tough to achieve because mostly are not under consideration. However, narrow range of *r*-*k* combinations is desirable to maintain the time series so that it may remain within the expected carrying capacity. MSY can be estimated from this reasonable combination of *r*-*k*[4].

Based on stock reduction analysis, the Catch-MSY method (CMSY) was suggested by Kimura & Tagart[5] and Kimura *et al.*[6]. A time series data of removals, initial ranges of *r* and *k* and probable ranges of relative stock sizes in the initial and final years of the time series are required as input data in CMSY analysis. Annual biomasses then derive from a particular combination of *r*-*k* parameters using Schaefer production model. In most fish stocks, there are no initial combinations of *r* and *k*. Therefore, random *r*-*k* pairs are usually drawn from an evenly distributed initial distribution. Thereafter a Bernoulli distribution was used as the likelihood function for accommodating every *r*-*k* pair which can never collapse the stock or surpass the carrying capacity. In consequence, it is possible to elucidate a final relative biomass that falls within the expected limit of depletion[4].

Although, the biology and fisheries of this shrimp has been studied in Indian and other Mediterranean countries, the studies related to Bangladesh marine waters are too limited. Due to fast growth and short life span, brown shrimp is considered a key fisheries item. Therefore, stock assessment need to be conducted annually. The present study is the maiden effort on the assessment of the stock of *M. monoceros* from the Bangladesh marine waters. The aim of the study is to assess the status of the exploited stock so that management measures could be adopted.

Materials and Methods

Data sources

A series of annual catch and effort data of *Metapenaeus monoceros* of industrial catch log in Bangladesh marine waters since 1986 to 2017 (Fig. 1) were taken from logbook datasheet from Marine Fisheries Office (Table S1). The catch data were converted from headless weight to total weight using the conversion factor of 0.66 for brown shrimp[7]. Shrimp trawlers are allowed to fish in marine waters of Bangladesh beyond 40 meter depth contour. Shrimp trawlers usually have 150-250 tonnes gross tonnage capacity including main engine power of 500-900 BHP. The maximum days of fishing per trip are 30 days. In active fishing days, shrimp trawler generally completes 5-6 hauls and each haul usually takes 3-4 hours. However, the fishing days and number of hauling completely subject to condition of weather and sea worthiness of the vessel itself[8].

The catch is expressed in metric tons (t), and effort as the number of fishing days. Those data provided e.g. catch per unit effort (CPUE) which was required in the CMSY and Bayesian Schaefer Model (BSM) analysis using R studio software[9]. Data file and ID file were two core files initially constructed. Four columns *i.e.* stock, year (yt), catch (ct) and CPUE (bt) were formed in the data file. Resilience ‘r’ was the main input parameter of the ID file adapted from FishBase (www.fishbase.org) and the remaining cells were marked as default values.

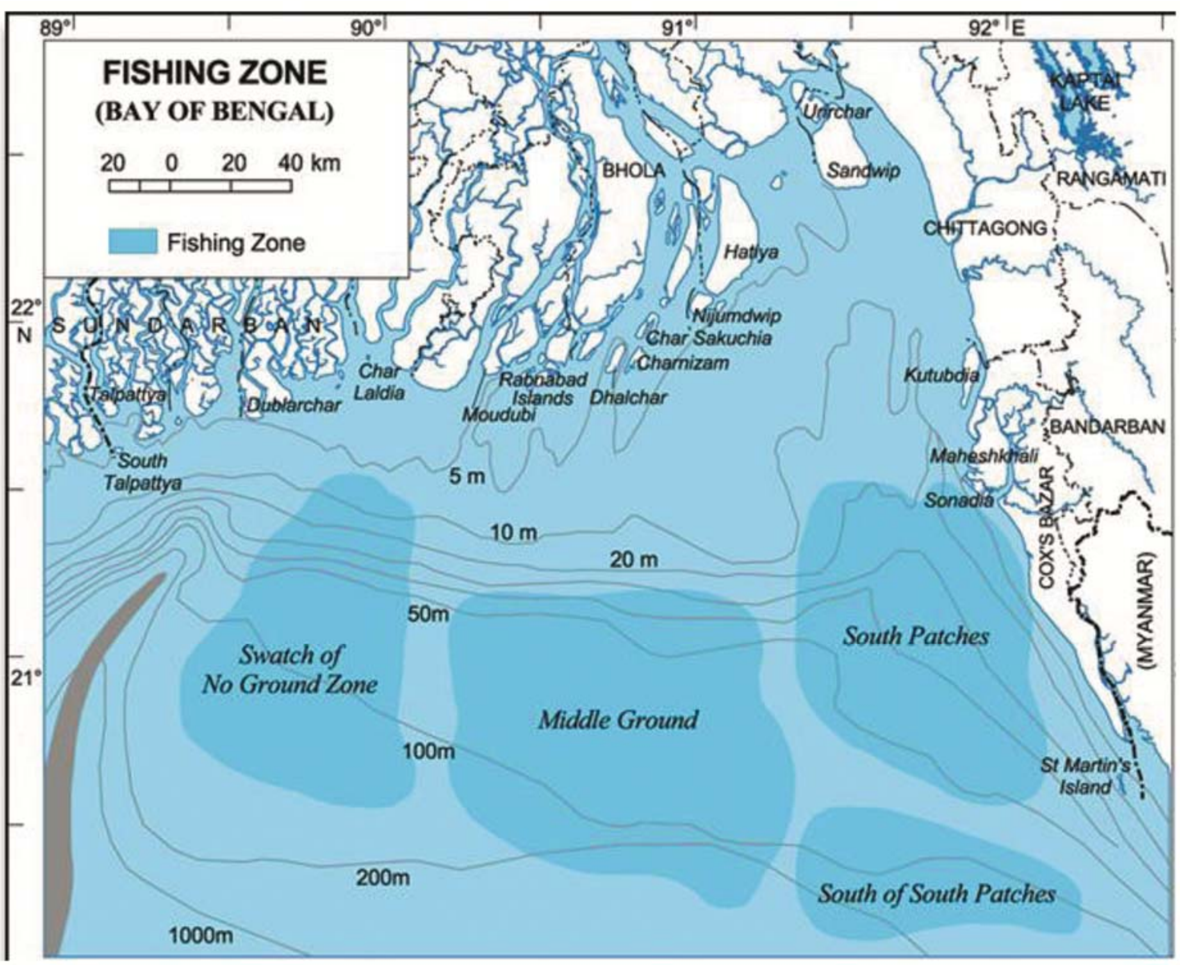

Fig. 1 — Map showing trawl fishing zone in Bangladesh EEZ[7]

Results and Discussion

For sustainable management of capture fisheries need to know the status of stock. An important method to assess the stock of capture fisheries is surplus production models (SPMs) or biomass dynamic models (BDMs). This model is beautiful for its simplicity and gives some essential information on the given stock including stock status, MSY reference points and related uncertainties[10]. In general, production models have simple equation incorporating two or three parameters. The status of population and fishing performance could easily be defined by a single variable[11]. The model fits the biomass index quite well and corresponded well to the observed data (Fig. 2).

Points estimate of parameters and key quantities are addressed in Table 1, along with 95 % confidence intervals. The *r* and *K* parameters are calculated as 1.22 and 10000, respectively. The calculated harvest rate in 2017 is 0.43 lower than u_{MSY} at 61 % while the calculated biomass is 5960 t, higher than B_{MSY} at 5060 t. The calculated MSY is 3090 t, which is close to the average catch from 1986 to 2017 was 2898 t.

Table 1 — Point estimates and 95 % confidence intervals of estimated parameters of *M. monoceros*, biomass in 2018 and reference points.

Quantity	Estimate	95 % CI
r	1.22	1.03 – 1.45
K	10000	8380 – 12200
q	0.000102	0.000088 – 0.000119
sigma	0.109	0.084 – 0.142
F_{2017}	0.43	0.38 – 0.55
B_{2018}	5960	4760 – 6830
MSY	3090	2920 – 3260
B_{MSY}	5060	4190 – 6110
F_{MSY}	0.61	0.513 – 0.725

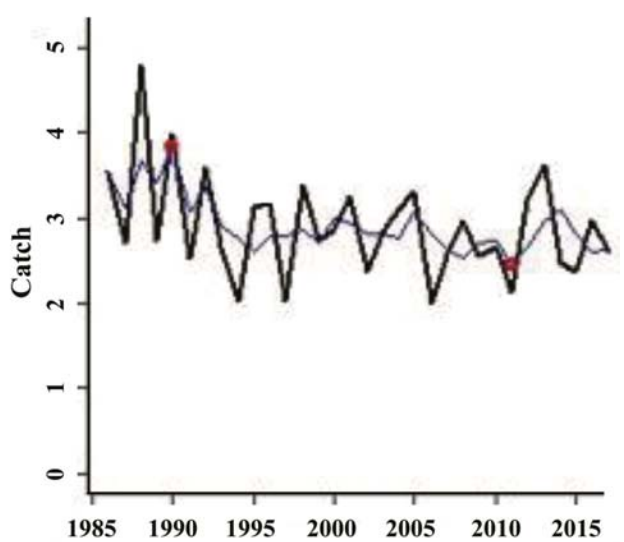

Fig. 2 — Observed (black) and fitted (grey) biomass indices

Estimates of population trajectories and exploitation rate

Initially the biomass over B_{MSY} was more than 1.0 which had declined to 0.75 and kept maintained static biomass upto the year 2007. The biomass over B_{MSY} has gradually increased to 1.2 in 2012 and maintained the same trend upto the present year of study (Fig. S2). The harvest rate over F_{MSY} calculated to have fluctuation above 1.0 in the year 1985 to 2004. Since then, the current harvest rate got reduced trend close to 0.5 in 2017 (Fig. S3).

The catch was above MSY (3020 t) during initial years of study. Then, the catch showed fluctuation below MSY scale except little mount over MSY in the year of 2012 (Fig. 3). In 2017, stock size was relatively higher than that of 1986 where more efforts had been engaged in than 2017. This indicates stability of stock in current years (Fig. 4). But, the

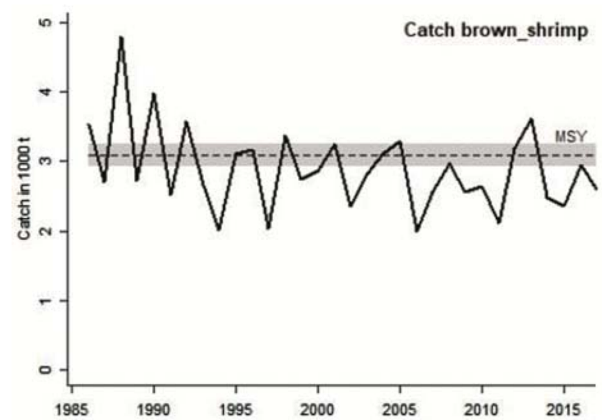

Fig. 3 — Estimates of MSY with 95 % confidence bands over catch

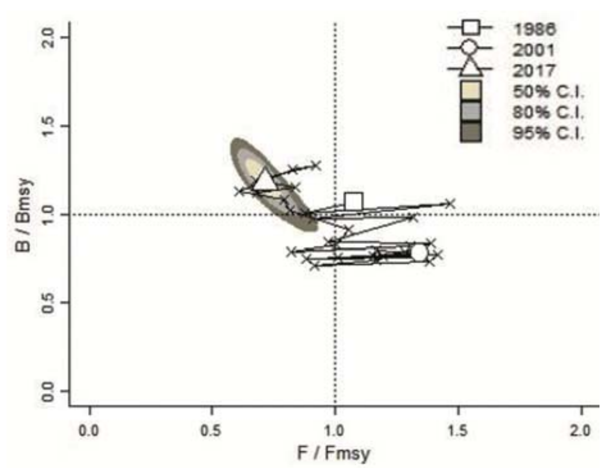

Fig. 4 — Relative stock size over relative effort

stock was in an alarming state from beginning of study to the year of 2001.

Conclusion

The stock has been overexploited in the past. But now, the stock is likely to be of good size with sustainable exploitation near MSY. The wide range of uncertainty associated with stock size and harvest rate correspond with unsustainable levels. Thus, management would be well advised not let to increase catches but to maintain them at the current level.

Supplementary Data

Supplementary data associated with this article is available in the electronic form at http://nopr.niscair.res.in/jinfo/ijms/IJMS_50(03)258-261_SupplData.pdf

Acknowledgements

The author would like to acknowledge the skipper and crews of all shrimp trawlers those were engaged in fishing in Bangladesh marine waters and made a very good catch report. Special thanks are due to my beloved family, the efficient officers and staffs of Marine Fisheries Office, Department of Fisheries, Chattogram. The author is also indebted to all brilliant reviewers and editor for their meticulous comments to improve the manuscript.

Conflict of Interest

There is no conflict of interest to carry out this research programme.

References

1 Subramanyam M, Fishery and biology of *Metapenaeus monoceros* (Fabricius) from the Godavary estuarine system, *Indian J Fish*, 20 (1) (1973) 95-107.

2 Khan M A A, Sada N U & Chowdhury Z A, Status of the demersal fishery resources of Bangladesh, In: *Assessment, Management, and Future Direction of Coastal Fisheries in Asian Countries*, edited by A Silvester, L Garces, I Stobatzki, M Ahmed, R A Valuste, *et al*., (World fish Center Conference Proceedings, 67), 2003, pp. 63-82.

3 Schaefer M B, Some aspects of the dynamics of populations important to the management of the commercial marine fisheries, *Bull Inter-Am Trop Tuna Comm*, 1 (2) (1954) 25-26.

4 Martell S & Froese R, A simple method for estimating MSY from catch and resilience, *Fish Fish*, (2012) 1-11. DOI: 10.1111/j.1467-2979.2012.00485.x

5 Kimura D & Tagart J, Stock reduction analysis, another solution to the catch equations, *Canadian J Fish Aquat Sci*, 39 (1982) 1467-1472.

6 Kimura D, Balsiger J & Ito D, Generalized stock reduction analysis, *Canadian J Fish Aquat Sci*, 41 (1984) 1325-1333.

7 Barua S, Magnuson A & Humayun N M, Assessment of offshore shrimp stocks of Bangladesh based on commercial shrimp trawl logbook data, *Indian J Fish*, 65 (1) (2018b) 1-6. DOI: 10.21077/ijf.2018.65.1.61384-01.

8 Uddin M S, Karim E, Hasan S J, Barua S & Humayun N M, Catch composition of marine shrimp species in Bangladesh, *Bangladesh Res Pub J*, 7 (2012) 91-98.

9 Froese R, Demirel N, Coro G, Kleisner K M & Winker H, Estimating fisheries reference points from catch and resilience, *Fish Fish*, 18 (2017) 506-526.

10 Cadrin S X, Overholtz W J, Neilson J D, Gavaris S & Wigley S, Stock assessment of Georges Bank yellowtail flounder for 1997, *NEFSC Ref Doc*, (1998) 98-106.

11 Laloë F, Should surplus production models be fishery description tools rather than biological models? *Aquat Living Resour*, 8 (1) (1995) 1-16.