POPULATION PARAMETERS OF ASIATIC HARD CLAM, *MERETRIX MERETRIX* (LINNAEUS, 1758) IN YE ESTUARY, SOUTHERN MON COASTAL AREA

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Abstract

The population parameters, growth, mortality, and exploitation rates of Asiatic hard clam *Meretrix meretrix* were investigated in Ye estuary between May 2022 and January 2023. Monthly shell length frequency data of *M. meretrix* were analyzed for estimation of population parameters such as asymptotic length (L_∞,), growth coefficient (K), and recruitment pattern to calculate the status of the stock. The asymptotic length (L_∞) was 40.95 mm and the growth coefficient (K) was 3.51 per year. The growth performance index (ϕ') was 2.68. The total mortality rate (Z) was estimated by length-converted catch curve at 6.71 per year, fishing mortality (F) at 3.79 per year, and natural mortality (M) at 2.92 per year. The recruitment pattern was continuous with one major peak event per year. The exploitation level E of *M. meretrix* was 0.56. Virtual population analysis estimated that the maximum fishing mortality of *M. meretrix* is collected between the mid-length 36 mm and 39 mm with the maximum F value (5.84 per year). The value of exploitation level E = 0.56 which pointed slightly overfishing condition (E > 0.50) for *M. meretrix* in Ye estuary during the present study.

Keywords: Growth and mortality, exploitation and recruitment, *Meretrix meretrix,* Ye estuary, Southern Mon Coastal Area.

Introduction

Many bivalve species have important economic roles including fisheries. Bivalves provide humans with food and decoration. A large number of different species of molluscs are eaten worldwide, either cooked or raw. Clams are commercially exploited and shipped as part of the international trade in shellfish, other species are harvested, sold, and consumed locally in tropical countries (Babaei *et al.,* 2010).

Mon coastal area is one of the most densely populated states in Myanmar. Fish and fish products are an important part of the diet in Myanmar and Mon coastal area is the main role of the fishery sector for local and export for earning foreign currency. In the Mon coastal area, Ye estuary areas such as Zeephyuthaung and Asin villages support a rich fishery in varied intensities, constituting Bombay duck, anchovy, mackerel, threadfin, and clam.

The Asiatic hard clam *(*Meretrix *meretrix)* was widely distributed in the Indo-Pacific region. This clam species was an active burrower and a suspension-feeding species that grew well in intertidal areas with muddy or silty substrate types such as mangroves and estuaries, making it easily accessible to glean. The clam is a commercially important species in coastal areas of South and Southeast Asia collected by artisanal fishermen either for consumption or direct selling in markets (Sienes *et al*.,2022).

The most commonly utilized bivalves for food include clams (Veneridae), sea mussels (Mytilidae), and edible oysters (Ostreidae) in the present day. Clams are considered to be nutritious and delicious and are fished in considerable quantities in some coastal areas. They are exploited in large quantities by traditional methods and sold live and dried in markets for human consumption in Ye estuary. Clams and other bivalves of their kind are usually handpicked in shallow waters at low tides in the Ye estuary area. In the present study area, most of the villagers depend on clam fishery for their livelihood. This fishery is the main job for the villagers, especially women whose incomes depend on those fisheries.

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The bivalve fisheries have been studied near Myeik coastal areas such as Nat-eain-kan, Pyin-bu-nge, and Ma-san-pa (Phyu *et al*., 2019). However, there were no studies on the population dynamics of the hard clams in the Mon coastal area. In the present investigation, 741 specimens of the hard clams were recorded. The hard clams were recorded as ranging from 17.6 mm to 39.8 mm in shell length. Asiatic hard clam *(Meretrix meretrix)* was one of the most important bivalve species in the present study area. Therefore, the population dynamics were estimated to manage the hard clams' biomass in the present study.

Materials and Methods

Study site and Sample Collection

The study was conducted in Ye Estuary area, Mon State with coordinate 15°13'N 97°34'E during the period from May 2022 to January 2023 (Figure 1).

Monthly sample collection was conducted from May 2022 to January 2023 in the intertidal and subtidal zone of Ye estuary which has a sandy-muddy substrate. Shell length (the maximum distance between the anterior and posterior margins of the shell) was measured to the nearest 0.1mm using Vernier callipers in field trips.

Population Growth Parameters

The parameters of the von Bertalanffy Growth Function (VBGF), the asymptotic length (L_∞), and growth curvature (K) were analyzed by the method of ELEFAN-I and FAO-ICLARM Stock Assessment Tools-II (FiSAT-II) (Pauly, 1984).

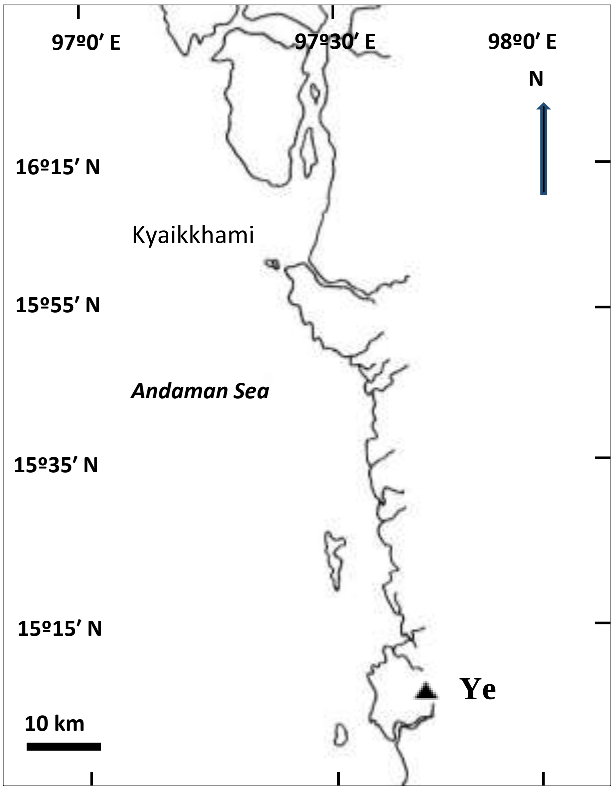

Figure 1. Map showing the present study site of the Ye Estuary area.

The resultant values of growth parameters (L_∞, K, t_0) were substituted in the von Bertalanffy growth equation: $\mathbf{L_t = L_\infty (1-e^{-K(t-t_0)})}$

Where L_t is the length at age t, L_∞ is the asymptotic length that is the mean length fish would reach if they were to grow indefinitely; K is the growth coefficient or the rate at which L_∞ is approached and t_0 is the age of the fish at zero length.

The resultant L_∞ and K were used to calculate the growth performance index (ø′) using Pauly and Munro, 1984's equation: $\mathbf{ø' = 2 \log L_\infty + \log K}$

Mortality Parameters and Exploitation Rates

The length-converted catch curve was utilized for the calculation of the instantaneous annual mortality rate (Z) (Pauly, 1984). The natural mortality (M) was calculated by Pauly's empirical equation: $\mathbf{\log M = -0.0066 - 0.279 \log L_\infty + 0.6543 \log K + 0.4634 \log T}$

where T = the mean annual water temperature °C, which is assumed to reflect the sea surface temperature in the survey area (Pauly, 1984). In this study, the mean annual temperature of the sea surface was considered as 16.6°C.

The fishing mortality (F) was calculated by subtracting the natural mortality from the instantaneous annual mortality: $\mathbf{F = Z - M}$ (Appeldoom, 1984) (as cited in Pauly, 1984). The exploitation rate (E) was calculated using the following formula (Gulland, 1985): $\mathbf{E = F/Z}$ (as cited in Pauly, 1984).

Recruitment Pattern and Virtual Population Analysis

Recruitment patterns were obtained by projecting the length frequency data on the time axis using the estimated values of the growth parameters using the ELEFAN I programme. The length frequency data were used to carry out virtual population analysis (VPA) using the FiSAT (FAO-ICLARM Stock Assessment Tools) as explained in detail in the software computer package. The values of L_∞, K, and F, a (constant) and b (exponent) for the species were used as inputs to VPA analysis (Pauly, 1984).

Results

Length Frequency Distribution

The shell length frequencies of 741 *Meretrix meretrix* which ranged from 17.6 mm- 39.8 mm were analyzed. The maximum number of clams was found distributed in the 29 to 31 mm size group (22.7 %) followed by the 32 to 34 mm size group (19.3 %). Therefore, the clam's distribution indicated that the size group of 29 to 31 mm was predominant in the natural habitat during the present study period. The remaining clams were distributed from 26 to 28 mm (18.8 %), 23 to 25 mm (11.9 %), and 35 to 37 mm (11.6 %) in Table. 1 and Figure. 2.

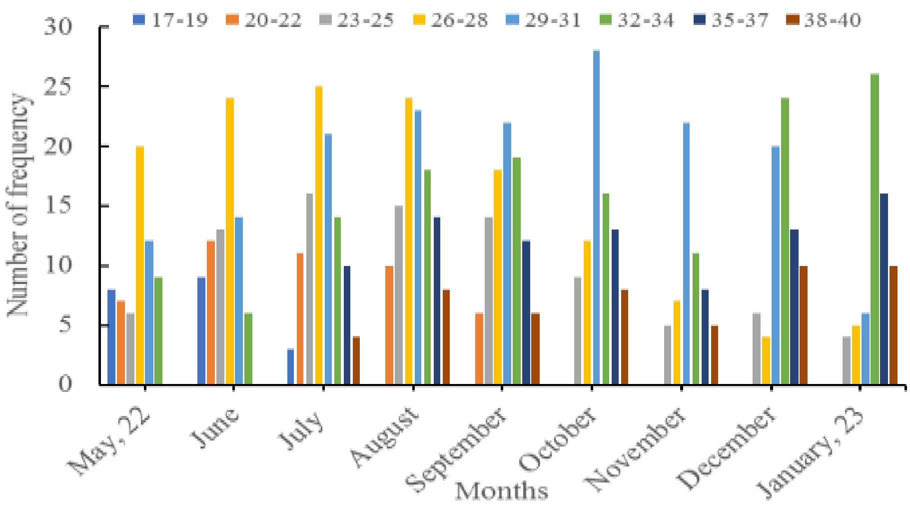

Figure 2. Monthly shell length frequency distribution of *Meretrix meretrix* during the present study.

Table 1.Monthly shell length frequency distribution of *Meretrix meretrix* during the present study.

Shell length (mm)	May, 22	June	July	Aug	Sept	Oct	Nov	Dec	Jan, 23
17-19	8	9	3						
20-22	7	12	11	10	6				
23-25	6	13	16	15	14	9	5	6	4
26-28	20	24	25	24	18	12	7	4	5
29-31	12	14	21	23	22	28	22	20	6
32-34	9	6	14	18	19	16	11	24	26
35-37			10	14	12	13	8	13	16
38-40			4	8	6	8	5	10	10
Total	62	78	104	112	97	86	58	77	67

Growth Parameters and Age

Based on shell length-frequency data, ELEFAN-I estimated growth parameters such as asymptotic length (L_∞) and annual growth coefficient (K) for *Meretrix meretrix* were 40.95 mm and 3.51 per year, respectively (Figure 1 (A and B)). The growth performance index or phi prime value (ø′) for *M. meretrix* recorded from Ye estuary was 2.68 (Table 2). In the present, it was estimated that *M. meretrix* attains a length of 33.87 mm, 39.73 mm, 40.74 mm and 40.91 mm at the end of 0.5, 1.0, 1.5, and 2 years of life its lifespan, respectively (Figure 1 (C)).

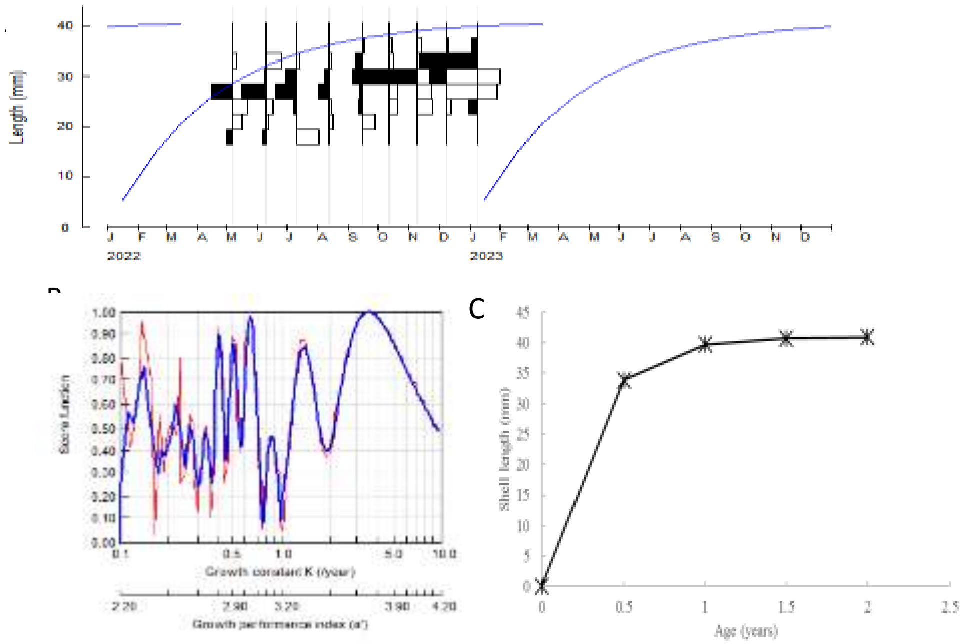

Figure 3 (A-C). A) Restructed length frequency distribution with growth curves superimposed (L_∞ = 40.95 mm and K = 3.51per year) of *M. meretrix*, B) Estimation of K of *M. meretrix* and C) Plot of age and growth of *M. meretrix* based on computed growth parameters during the present study.

Mortality parameters and Exploitation rate

The estimated value of the total mortality coefficient (Z) was found as 6.71 per year using the length-converted catch curve method (Figure 4). The value of natural mortality (M) and fishing mortality (F) was estimated as 2.92 per year and 3.79 per year, respectively (Table 2). The estimated value of exploitation rate E was 0.56 which indicated the overexploitation conditions (E>0.5) (Table 2).

Recruitment Pattern and Virtual Population Analysis

The recruitment pattern of *Meretrix meretrix* was continuous throughout the year with one major peak. The percentage of the recruitment varied from 1.97% to 17.77% during the study period. It showed that the species peaked in August (Figure 5). The structured population analysis indicated the maximum and minimum fishing mortality was estimated as 5.8400 per year and 0.3289 per year for the mid-lengths of 36 mm and 18 mm, respectively. The fishing mortality was relatively higher over the mid-length size of 33 mm (Figure 6).

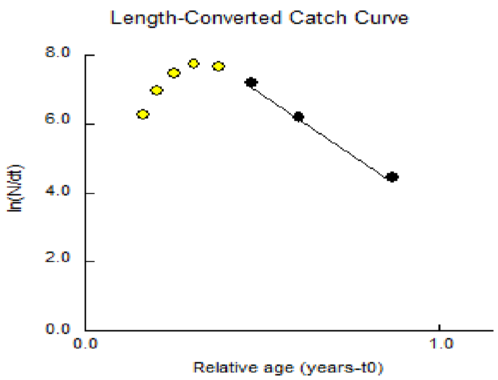

Figure 4. Length converted catch curve of *M. meretrix* during the present study.

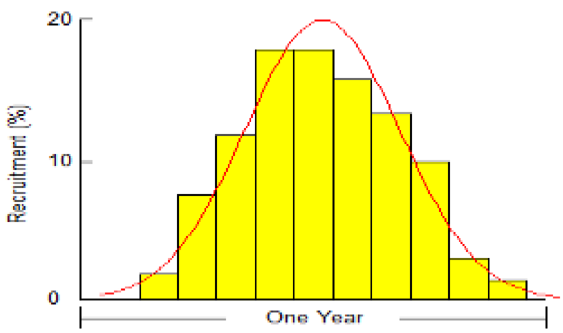

Figure 5. Recruitment pattern of *M. meretrix* during the present study.

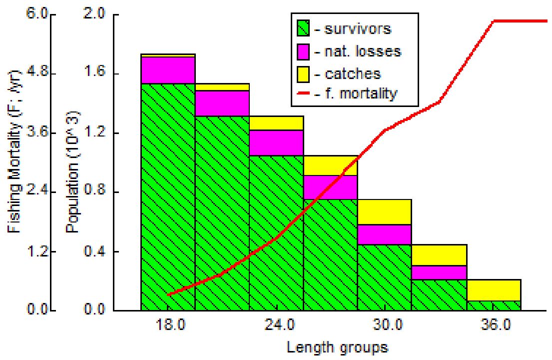

Figure 6. Virtual population analysis of *M. meretrix* during the present study.

Table 2. Growth, mortality and exploitation parameters of *Meretrix meretrix* in Ye estuary

Parameters	L_∞ (mm)	K (yr^{-1})	ø′	Z (yr^{-1})	M (yr^{-1})	F (yr^{-1})	E	Recruitment
Results	40.95	3.51	2.68	6.71	2.92	3.79	0.56	Unimodal

Discussion

The present investigation was carried out on the population dynamics of *Meretrix meretrix*, which is a commercially important bivalve species along the Ye estuary, Mon coastal area. The present observed shell length (17.6 mm- 39.8 mm) of *M. meretrix* was higher than the previous results; 24.15- 37.29 mm (Sienes *et al*., 2019) and 17.2- 39.1 mm (Sienes *et al*., 2022). The length of *M. meretrix* ranges from 11 to 46 mm recorded from Tanjung Balai, North Sumatera (Desrita *et al*., 2019) and 20 to 46 mm from Bancaran village waters, Bangkalan (Rohmah and Muhsoni, 2020). Few areas recorded higher lengths of *M. meretrix*, such as the southwest coast of Maharashtra, 21 to 55 mm (Sawant and Mohite, 2013); Mumbai waters, 38 to 57 mm (Sharma *et al*., 2005); and Kandleru Estuary, 39 to 63 mm (Thangavelu *et al*., 2008). The high length ranges of *M. meretrix* were recorded as 22.5 to 82.5 mm from the Moheskhali channel of Bangladesh (Amin *et al*., 2009) and 14.6 to 91 mm from Korampallam Creek, Tuticorin (Narasimham *et al*., 1988). The maximum size range of *M. meretrix* recorded from Telik Marudu, Malaysia was 18.3 to 101.7 mm (Admodisastro *et al*., 2021). The variation in *M. meretrix* size range might be due to the changes in biotic-abiotic factors, availability of food, geographical distribution, climate changes, and fishing efforts (Jayawiekrma and Wijeyaratne, 2009).

The estimated asymptotic length (L_∞) of 40.95 mm recorded in the present study was similar to the previous result from Panguil Bay (Sienes *et al*., 2022). The present L_∞ value was higher than the Asahen river (36.76 mm) and Batubara (39.90 mm) in the Tanjung Balai region, North Sumatra (Desrita *et al*., 2019). In the present estimation, the L_∞ value was obtained as 40.95 mm, which is lower than the earlier reported from Panguil Bay, 44.5 mm (Jimenez *et al*., 2009); from Tanjung Balai, 45.15 mm (Desrita *et al*., 2019); from Bancaran village water, 51.1 mm (Rohmah and Muhsoni, 2020); from the southwest coast of Maharashtra, 58.80 mm (Sawant and Mohite, 2013); from Kambu River estuary, 58.91 mm (Bahtiar *et al*., 2022); from Moheskhali channel of Bangladesh, 81.4 mm (Amin *et al*., 2009); from Korampallam Creek, 99.1 mm (Narasimham *et al*., 1988); and Telik Marudu, 107.63 mm (Admodisastro *et al*., 2021). The asymptotic length must be varied due to the variation in geographic distributions, fishing pressure, and local environmental situations (Gurjar *et al*., 2021). Similarly, the high fishing pressure and environmental conditions change found in the present study area. Therefore, the L_∞ value of the present study was different from the previous results.

In the present estimation, the K value was obtained as 3.51 per year, which was higher than earlier reports from different areas of the world (Table 3). The value of the growth coefficient (K) was associated with the mortality rates (as cited in Takar *et al*., 2022). Therefore, the K value was found that the high value was due to the high fishing activity in the present study area. Moreover, the present recorded growth performance index (ø′) for *Meretrix meretrix* was 2.68. It was higher than the earlier reported from the Moheskhali channel of Bangladesh (Amin *et al*., 2009) while lower than from Telik Marudu (Admodisastro *et al*., 2021) and from Panguil Bay (Sienes *et al*., 2022) (Table 3). The growth performance index indicated that high growth values showed a better and faster growth curve (Nadeem *et al*., 2017). Therefore, the present result showed that the growth rate of *M. meretrix* was good and fast.

The present estimation showed growth attained by *M. meretrix* of 33.87, 39.73, 40.74, and 40.91 mm at the end of 0.5, 1.0, 1.5, and 2.0 years respectively. From the southwest coast of Maharashtra, India, *M. meretrix* attained the length of 30, 42, and 45 mm at the end of one, two, and three years (Sawant and Mohite, 2013) and from Panguil Bay, Philippines, the species attained the length of 24.45, 32.84, 38.99, and 40.47 mm at the end of one, two, four and six years, respectively (Sienes *et al*., 2022). The present result was more similar to the study conducted on Panguil Bay than on the southwest coast of Maharashtra, India, which might be attributed to the study area.

In the tropical regions where age structure data was not easy to determine, then the length converted catch curve method was used to determine the mortality with the length frequency distribution data. In the present study, the total (Z), natural (M), and fishing (F) mortality rates were estimated at 6.71, 2.92, and 3.79 per year, respectively. The mortality parameters of *M. meretrix* from other parts of the world are shown in Table 3. It was observed that overall values were lower than the present results. When the exploitation rate was greater than 0.5 it could be assumed that the clam stock from the areas was overexploited. Therefore, the present exploitation rate (0.56) showed that the clam stock was slightly overexploited condition. Moreover, the earlier estimated results from Jimenez *et al*., (2009), Admodisastro *et al*., (2021), Sienes *et al*., (2022), and Bahtiar *et al*., (2022) were similar to the present study (Table 3). However, the previous report from Amin *et al*., (2009) and Rohmah and Muhsoni (2020), found that the clam stock was underexploited (Table 3).

Table 3. Comparison of the growth, growth performance index, mortality, and exploitation parameters with previous studies from different regions of Asia.

L_∞ (mm)	K (yr^{-1})	ø′	Z (yr^{-1})	M (yr^{-1})	F (yr^{-1})	E	Locations	Literature
81.4	0.97	2.07	2.63	2.61	0.02	0.01	Bangladesh	Amin *et al*., 2009
51.1	1.10	-	3.21	1.69	1.52	0.47	Indonesia	Rohmah and Muhsoni, 2020
58.91	1.10	-	4.75	1.59	3.16	0.67	Indonesia	Bahtiar *et al*., 2022
107.63	0.47	3.736	2.65	0.78	1.87	0.70	Malaysia	Admodisastro *et al*., 2021
44.5	0.80	-	4.13	1.60	2.53	0.61	Philippines	Jimenez *et al*., 2009
40.95	0.71	3.07	3.18	1.22	1.96	0.62	Philippines	Sienes *et al*., 2022
40.95	3.51	2.68	6.71	2.92	3.79	0.56	Ye Estuary	Present study

Like other tropical bivalves, *Meretrix meretrix* could spawn throughout the year under favourable conditions due to minimal fluctuations in environmental parameters (Admodisastro *et al*., 2021). The one recruitment peak observed in the present study coincided with the unimodal result obtained from the assessment of *M. meretrix* in Panguil Bay (Jimenez *et al*., 2009) and the southwest coast of Maharashtra (Sawant and Mohite, 2013) while contrasting the bimodal result obtained from the assessment of species in Panguil Bay (Sienes *et al*., 2022).

The virtual population analysis showed that younger individuals of snubnose emperor were more susceptible to natural mortality caused by predation, pollution, or disease than fishing mortality. In the present study, high fishing mortality was found at the mid-lengths of 33 mm. The fishing mortality began to dominate at the length ranging from 26 mm, with the maximum value at a size of 36 mm. Therefore, the dominance due to fishing operations starting at 26 mm in size was an indicator that that species was caught after starting in the spawning activities for at least one time.

Conclusion

This study was the first report on the population dynamics of *Meretrix meretrix* from Ye estuary, southern Mon coastal area. The present study showed that the high fishing mortality and exploitation rate of *M. meretrix* stock indicating that it was overfished. The current study demonstrated *M. meretrix* population in Ye estuary was fast growing and recruitment happened throughout the year with unimodal conditions. Thus, the present study was the baseline information on the population dynamics for the sustainable utilization and conservation of *M. meretrix* in the Ye estuary. Moreover, it would form the basis for the scientific community and conservation decision-makers to manage and reach a sustainable harvest of this resource with optimal exploitation.

Acknowledgements

I am indebted to Dr. Than Tun, Rector of Pathein University, Dr. Khine Lae Win, and Dr. Moe Moe Aye, Pro-Rectors of Pathein University, for their support in preparing this work. I am very grateful to Dr Soe Pa Pa Kyaw, Professor and Head of the Department of Marine Science, at Pathein University, for her suggestions and constructive criticisms on this study. I also thank my colleagues and my students, the Department of Marine Science, Mawlamyine University for their help in field trips and advising and willingness to be helpful to me. Finally, my infinite thanks are to my beloved brother and my parents for their kind and financial support throughout this study period.

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