Chapter 1

Introduction

1.1 Background

Bangladesh is one of the Bay of Bengal's marginal coastal countries, with a fertile, tidally flooded coastal territory that is suited for shrimp farming. The southern part of Bangladesh is bounded by the Bay of Bengal. Bangladesh's blue economy is centered on the coastal regions and the Bay of Bengal. The majority of ocean economic activities dependent on the Bay of Bengal, such as marine fishing, tourism, and research, affect the livelihoods and social standing of millions of people living along the coast (Sarker et al., 2018; Hossain et al., 2017). In Bangladesh, coastal shrimp aquaculture is mostly concentrated in two areas: the south-west (Khulna, Satkhira, and Bagerhat) and the south-east (Cox's Bazar). Coastal shrimp farming in Bangladesh is expanding as a result of the high demand for shrimp in both domestic and international markets. Because of its high growth, disease resistance, and market value, it is almost entirely dependent on natural tiger shrimp (*Penaeus monodon*) seed. Because of its resources and suitable agro-climatic conditions, Bangladesh is considered one of the most suited countries in the world for shrimp and prawn production. A sub-tropical temperature and a large expanse of shallow water bodies offer a unique potential for shrimp and prawn farming (Ahmed et al., 2008).

The giant tiger prawn, *P. monodon*, the largest and most economically significant species among penaeids, reaches 270 mm in body length or 260g in weight, is suitable for pond rearing and commands high market prices and is one of the world's most important and commercially cultivated species (FAO, 2016). In Bangladesh, the most common rapidly growing species are the giant freshwater prawn (*Macrobrachium rosenbergii*) and the black tiger prawn (*P. monodon*). Prawn culture in Bangladesh continues to rely on wild post larvae (PL) (Angell, 1990, 1994; Ahmed, 2000; DOF, 2002) and only 7-9 shrimp species are cultivable out of the 45 present in Bangladesh (Nuruzzaman, 1992).

According to shrimp farmers in Bangladesh, wild *P. monodon* post larvae (PL) constitute a main seed source for shrimp aquaculture. In recent years, hatchery-produced PL has partially met the growing demand of shrimp farmers, but natural PL grows and survives considerably better than hatchery PL. More than 90% of the total PL in the freshwater prawn *(M. rosenbergii*) comes from natural sources, while more than 50% of the tiger shrimp (*P. monodon*) comes from wild sources (Banks, 2003). A key element of shrimp production is capturing wild PL to stock in aquaculture facilities (Paez-osuna, 2001).Traditionally, prawn farmers preferred to stock their gher with wild PL instead of hatchery-produced fry, since hatchery PL output has been minimal and farmers regard them as being of lesser quality (Angell, 1992; Ahmed et al., 2005). In addition, the survival rate of wild PL is substantially greater than that of hatchery-produced fry (Muir, 2003). According to estimations, approximately 2 billion shrimp fries are captured from wild sources each year (Banks, 2003). Although hatchery-produced post larvae are now available in many Asian and Latin American nations, wild fry serve as an important source of seed in many regions (World Bank 2002; FAO 2007).

Bangladesh's coastal shrimp and prawn culture is an important source of revenue for the country's exporters. In 2019-20, shrimp exports reached 21,863.01 MT, valued at 1,988.56 crore BDT (Bangladesh taka) (DoF, 2020). During the early 1980s, the coastal belt continued to practice this culture in order to supply worldwide markets and make foreign money (Islam et al., 2001). Due to the expansion of the shrimp culture area and an insufficient supply of hatchery-produced seeds at the appropriate time, the collection of *P. monodon* PL has expanded considerably. Thousands of coastal landless and jobless people have been employed in shrimp seed harvesting (Angell, 1990; FAO/NACA, 1995; Islam and Wahab, 2005). More than one million people worked part-time harvesting wild sources of PL around the world (World Bank, 2002). During the Covid-19 epidemic, many persons in coastal areas switched from their original employment to PL harvesting (Bashar et al., 2021). In Bangladesh, 43 private shrimp hatcheries are registered, with a total shrimp production of 792.952 crores in 2019-20 (DoF, 2020).

According to a survey, around 0.52 million collectors were engaged in shrimp seed collection along Bangladesh's estuary and coastline. Seed collectors use a variety of nets to collect PL from various locations, including drag nets, push nets, and set bag nets. These nets are constructed from nylon materials and have a fine mesh size (0.1-0.3 mm). After each hauling, seed collectors sort out and collect only the targeted *P. monodon* PL locally known as ‘Bagda pona’ from the hauling, while the rest, which includes other species larvae, is mercilessly thrown on the dry and burning shore. Collection of wild shrimp PL is thought to have an adverse impact on coastal biodiversity (Primavera 1998, Islam et al., 1999, and Hoq et al., 2001). For collecting only one shrimp PL, around 1650 larvae of other shrimp species, 1562 fin fishes and 6787 other macro zooplankton were cruelly damaged in Mongla river, Bagerhat (Ferdousy et al., 2017). During the collection of a single shrimp PL, 37 PL of other shrimps, 11 fin fish larvae, and 31 macro-zooplankton were discarded on Kuakata beach, Patuakhali (Hasan et al., 2019). For every 100 shrimp PL harvested by collectors in Bangladesh, up to 5000 shrimp PL may be destroyed (BOBP, 1990). According to reports, 99 fin fish and other prawn species fry are destroyed in order to harvest a single prawn PL (Rashid, 2000) .In Bangladesh, due to improper handling and transportation, approximately 40% of the harvested seed died before being stocked in culture facilities (Brown, 1997).

It is critical to conduct an investigation into the catch composition of this haul in order to evaluate the loss of aquatic fauna biodiversity as a result of these actions .This study focuses on the current state of shrimp PL and other aquatic species in Cox's Bazar, as well as the loss of aquatic faunal diversity caused by wild *P. monodon* PL collection. The findings of this study show that current seed collection activities have resulted in significant damage to other valuable aquatic fauna, which has a direct impact on the biodiversity of neritic and offshore fauna, the natural productivity of tidal waters, and the ecological balance of the coastal and marine environment. Mahmood (1990) and BFRI (1996) carried out a survey on *P. monodon* PL collection and shared some information on the massive loss of crustaceans, zooplankton, and other organisms during shrimp PL collection in the tidal waters of the Chakaria Sundarbans, Satkhira, Khepupara, Khulna, Cox's Bazar, Patuakhali, Noakhali, Bhola, and Borguna. Every day, a large number of fries of various finfish and shellfish species are destroyed in this manner. According to Khan and Latif (1997), this activity has a significant impact on wild shrimp and fish stocks. To conserve fishery resources, the Bangladeshi government issued a policy in 2000 prohibiting the harvesting of shrimp seed from wild sources. The statement declares "No one shall catch or cause to be caught fry". Thousands of people, unfortunately, continue to collect PL and sell their catch. The current year-round study was conducted in four different locations of Cox's Bazar to analyze the abundance and catch composition of the set bag net used for collecting PL of *P. monodon*, as well as to quantify the destruction caused to various shrimp species, fin fishes, and zooplankton larvae while collecting PL of tiger shrimp.

1.2 Scope of the study

- The findings can be utilized as baseline information for building up a management decision to control the biodiversity loss during the collection of PL of tiger shrimp from the Cox's Bazar coasts in Bangladesh.
- It is hoped that the study will provide some valuable suggestions for taking necessary steps to stop the such massive destruction and to grow awareness among the seed collectors to release back the unwanted organisms into the water bodies without any damage.

1.3 Objectives

Objectives of the current research are as follows:

- To assess the abundance of black tiger shrimp (*P. monodon*) post larvae (PL) in Cox's Bazar Coasts
- To quantify the loss of different aquatic fauna during collection of *P. monodon* PL

Chapter 2

Review of Literature

2.1 Giant tiger shrimp

One of the largest penaeid shrimps, the black tiger shrimp, *P. monodon*, is locally referred to as "Bagda" and may grow to 260 mm in length and 250g in weight (Wyban, 1996). The most significant group of shrimp, from a commercial perspective, is without a doubt those belonging to the genus *Penaeus*. It is a crustacean and a species of the Penaeidae family. It has quite a significant commercial presence in global markets (FAO, 2016). *P. monodon* is mostly found in the waters off Southeast Asia. It is widely dispersed between latitudes of 35°N and 35°S and longitudes of 30°E to 155°E. This species of penaeid shrimp is found in the Indo- West Pacific. The species grows in warm temperate, tropical, and subtropical waters around the world (FAO, 2012).

Taxonomic classification of *P. monodon* is as follows (Holthuis, 1949):

Kingdom: Animalia

Phylum: Arthropoda

Subphylum: Crustacea

Class: Malacostraca

Order: Decapoda

Family: Penaeidae

Genus: *Penaeus*

Species: *Penaeus monodon*

2.2 Wild PL Collection in Bangladesh

Although many countries in Asia and Latin America now sell PL grown in, PL from the wild continues to be a key supply (Primavera, 2006). Over 50% of the time, shrimp PL is harvested from the wild. In Bangladesh, an estimated 2 billion wild shrimp are caught each year (Banks, 2003).Prior to the 1980s, shrimp growers used to capture natural tidewater and shrimp PL flows into their farm or gher. Since 1980, shrimp farming has increased. Since then, farmers have shifted to selective wild PL stocking. The demand for shrimp PL surged as a result, and considerable amounts of natural PL were harvested from coastal locations (Hossain and Hasan, 2017). Children, women, and adults from coastal communities participate in the gathering of wild PL. They are drawn to this occupation by the minimal skill and capital requirements. Approximately 4,00,000 people in Bangladesh's coastal regions depend on the PL collecting for their livelihood (USAID, 2006). Every year, more than 2,000 million wild PL are collected, valued at USD 30 million (EJF, 2004). In order to prevent the collecting of wild PL, the Government of Bangladesh (GoB) created a rule in 2000. Due to the unsustainable form of the alternative means of PL collectors' income, the efficacy of this rule has not yet been clearly stated (Alam, 2001). When the COVID-19 epidemic struck, many people in coastal regions lost their means of income. Thus, in coastal locations like Cox's Bazar, the transition from other occupations may be considerable. On the other hand, compared to earlier in the decade, shrimp farming has grown. The rate of wild PL collecting has grown as a result of both the profession-shifting and increased shrimp farming (Bashar et al., 2021).

2.3 Causes of Wild PL Collection

Due to a lack of hatchery-produced postlarvae (PL) compared to demand, prawn aquaculture in Bangladesh is dependent on wild PL. Currently, Bangladesh's hatchery supply can only meet approximately 20% of the overall demand for prawn PL seed (Ahamed et al., 2012). Farmers also like wild PL since it is said that its survival rate is substantially greater than that of PL grown in hatcheries. For many of poor, landless, and coastal dwellers in Bangladesh, wild prawn PL fishing has provided an option for work. For the poor communities of coastal areas, wild PL gathering is a significant income source and subsistence. In the coastal zones, more over 40% of landless households engage in wild PL gathering (Frankenberger, 2002). In Cox's Bazar, there were 7512 total members of the PL collectors' families, out of a population of 62200. Of these, 16794 were males, 17416 were females, and 27990 were children who are (under 18 years old) (Mostafa et al., 2007).

For PL collectors, there are no viable alternatives to their current means of subsistence. Consequently, wild PL collection is continuing at a good pace as before with its negative impacts. Farmers prefer wild PL over PL produced in hatcheries. They claim that wild PL has a higher chance of surviving and is more readily available locally year-round. With this in mind, the demand for wild PL continues to grow every year (Hossain and Hasan, 2017). The demand for *P. monodon* fry multiplied as more and more places were subjected to intense *P. monodon* cultivation as a result of the high market rate in the global market for shrimp farming. The lack of excellent quality seeds was one of the main obstacles to shrimp cultivation. Due to their low mortality rate, the majority of shrimp farmers choose to use wild caught shrimp. According to reports, wild PL have a much greater rate of survival than hatchery-raised fry (Muir, 2003).

2.4 Use of Gears for Wild PL Collection

Due to a lack of available hatcheries in the nation that can produce enough shrimp fry to meet demand, thousands of individuals engage in the destructive collection of shrimp fry from coastal and estuary areas using fine-mesh fixed bag nets, push nets, and drag nets. Various nets, including drag nets, push nets, and set bag nets, are frequently used in activities to capture shrimp fry. These nets are constructed from nylon materials and have a fine mesh size (0.1-0.3 mm). The most often utilized equipment for harvesting shrimp is the set bag net (Behundijaal), dragnet (Bakshojaal), and push net (Thelajaal). Price, mesh size, and degree of damage are all variable in the gears (Azad et al., 2007). Along the Chattogram and Cox's Bazar seacoasts, bag nets (Behundijal) are frequently used to collect shrimp. Due to the significant bycatch, they are the most destructive (Hossain and Hasan, 2017). Fry collectors in West Bengal, India, utilize very fine-meshed nets in the Hooghly-Matlah Estuary (Ramesan et al., 2009). They catch fish of all sizes, including species that are not targeted. The set bag net, which has been identified as the most harmful gear used in PL collection, is among the destructive PL fishing gear with very fine mesh sizes. As a result, in order to decrease the effects of PL harvesting, fishing gear used in this activity must be restricted, with the set bag net and similar gear being prohibited.

2.5 Impact of Indiscriminate Wild PL Collection on Aquatic Biodiversity

Shrimp PL harvesting in the wild is a destructive fishing method. It has an impact on the biodiversity and distribution of various shrimp and finfish species in marine and coastal waters (Hossain and Hasan, 2017). Collection of wild shrimp is considered to have a detrimental effect on the coastal biodiversity (Primavera, 1998; Hoq et al., 2001). The amount of bycatch for wild PL collecting is higher than any other fishery in the world. Approximately 98 billion larvae and zooplankton are discarded each year for PL collecting worldwide (Latif et al., 2002). Loss of biodiversity is caused by the practice of stocking wild PL for shrimp farming (Primavera, 2006). According to Mahmood (1990), the capture of a single wild PL results in the extinction of 1631 zooplankton species, 21 finfish species, and 14 other shrimp.

The capture of a single shrimp PL on Kuakata Beach Patuakhali resulted in the waste of around 37 PL of further shrimp, 11 fin fish larvae, and 31 macro-zooplankton (Hasan et al., 2019). According to Rahman et al. (1997), in the estuaries of the Barguna area, shrimp seed collecting results in the destruction of around 37 shrimp larvae of other species, 12 finfish, and 10 macrozooplankters for every *P. monodon* postlarvae (PL). In a research by Toufique (2002), for every PL collection, 1341 juvenile stages of other species were lost off as bycatch. According to Islam et al., (1999) findings, for every PL harvest, collectors damage 530 more macro-zooplankton, 12 additional finfish, and 45 additional shrimp. For a single PL harvest, PL collectors discard the young of roughly 99 different species of fish and shrimp (Rashid, 2000). During PL collection, bycatch includes tiny cyprinids, eels, anchovies, crabs, snails, mussels, bivalves, bombay ducks, marine and coastal catfish, gobies, eel gobies, and several more unidentified species in their fry and post-larval stages (Toufique, 2002). Several economically significant species are collected as bycatch during PL collecting in Bangladesh's coastal regions. *Penaeus indicus, Penaeus merguiensis, Metapenaeus monoceros, Tenualosa ilisha, Gadusia chapra, Lates calcarifer, Macrobrachium malcolmsonii, Macrobrachium villosimanus, Macrobrachium mirabilis, Macrobrachium birmanicus, Macrobrachium rude, and Macrobrachium dayanus* are a few of the more prevalent species among them (Ahmed et al., 2010). Additionally, it has been stated that 2499 more shrimp larvae, fin fish, and macro- zooplankton were wasted in the Mongla River, Bagerhat, in order to capture a single shrimp PL (Ferdousy et al., 2017). For every 100 shrimp PL collected by collectors in Bangladesh, up to 5000 shrimp PL may be lost (BOBP, 1990). Due to inadequate handling and transportation in Bangladesh, almost 40% of the harvested seed was lost before being stocked in culture facilities (Brown, 1997).

2.6 Impact on Coastal and Marine Fish Stock

Overfishing in the wild PL reduces fish availability and hinders the recruitment of several fish species. For most people, fish serves as their primary protein source. People's nutritional status may be impacted by the decrease in fish supply caused by wild PL harvest (Islam et al., 2001). Non-targeted species are sold to fish meal producers for less money after being dried or discarded in huge quantities. The potential for future fisheries might be seriously harmed by the removal of young fish before they reach maturity (Ramesan et al., 2009). Collecting of wild prawns without consideration fisheries resources and fish ecology are threatened by PL (Ahamed et al., 2012). The loss of many juvenile stages of finfish, shellfish, and macro-zooplankton species poses a danger to biodiversity. It interferes with strategies for resource conservation and sustainable use. These species are extremely important in terms of economy, ecology, and biomedicine. Continued eradication of this biota might dramatically decrease stock and degrade the ecosystem (Brown, 1997).

2.7 Abundance and Seasonal variation

The major wild PL harvesting season runs from November to June, with March and April being the peak months (Hossain and Hasan, 2017). Primavera (1998) and Basu et al., (1998) noted two peaks for penaeid recruitment and settlement during the pre monsoon and winter seasons at average salinity and high temperatures. Zafar & Mahmood (1994) found that penaeid post larvae were most abundant in July at high salinity and least abundant in March in estuary waters near the Sundarbans. *P. monodon* PL was often prevalent from October to February and was correlated to moderate salinity (Hoq et al., 2001). During post monsoon period, comparatively higher quantity of fin fishes were observed than the other part of the year (Rahman *et al*., 1997 and Islam et al., 1999a). Houque (1992) noted that bagda shrimp fry were available in the Satkhira and Khulna area mostly from January to April/May. Karim (1998) stated that during the peak season (March and April), around 200 seeds/net/day were gathered, while shrimp fry harvesting was done mostly from

November to July. Additionally, he stated that the majority of the seeds were harvested each month's new and full moons. According to Banerjee and Singh (1993), *P. monodon* PL were available year-round in the Muriganga estuary, West Bengal, with maxima in April-May and August-September. Funegaard (1986) found that *P. monodon* exhibits abundance during the new moon fortnight.

Chapter 3

Methodology

3.1 Study area

The post-larvae of tiger shrimp (*Penaeus monodon*) were captured from the wild along the Ukhiya-Teknalf Peninsula of Cox's Bazar. It is one of the most important wild tiger shrimp fries collecting areas in Bangladesh. For this research purpose, "Rajarchora" along with "Marishbuniya" of the Teknaf coast and "Rezu estuary" along with "Sonarpara" of the Ukhiya coast were considered as 4 hotspots along the Ukhiya-Teknaf peninsula for sample collection. Among the selected four stations, Rezukhal and Sonarpara were located in an estuary, and Rajarchora and Marishbuniya were located in marine water bodies. The coordinates of the sampling station were at 'Rajarchora' (20°54'1.63"N & 92°14'10.38"E) 'Marishbuniya' (20°58'25.17"N & 92°11'58.86"E) of Teknaf coast and, 'Rezu estuary' (21°17'43.13"N & 92°3'1.35"E) 'Sonarpara' (21°17'25.12"N & 92°2'43.004"E) of Ukhiya coast. Samples were drawn from four different selected spots of the Cox's Bazar, with monthly sampling from January to December 2021. Geographical coordinates of the sampling area were recorded with "GPS coordinates" software. The map (Figure 1) of study sites was constructed with "QGIS" (Version – 3.4.5).

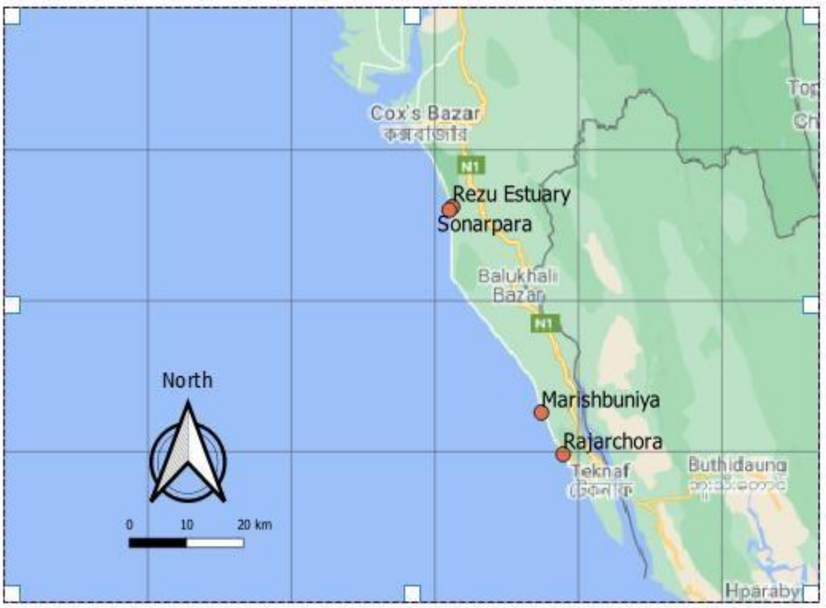


Figure 1. Study sites of the Ukhiya-Teknaf Peninsula of Cox's Bazar

3.2 Sampling Procedure

Post-larvae of Tiger Shrimp (*P. monodon*) were collected with monthly sampling from wild (estuary and marine waterbody) using small sized marine set bag net (MSBN). The MSBNs were structurally funnel-shaped net of 18-22ft long body with 7-9ft mouth opening. The PL collection process was commenced during high tide along the coast and PL collectors assemble samples from the cod end of MSBN at half an hour (30 minutes) interval commonly for separating PL of desired species. The research team collected samples of one haul (30 minutes operation of MSBN) and soon after trouping, samples were preserved.

3.3 Sample Transportation

After each catch, samples were immediately stored in plastic pot and preserved with 96% ethanol at 2:1 ratio (sample: ethanol). Assorted samples were fetched to 'Aquatic ecology lab' of 'Fisheries Resource Management Department' of 'Chattogram Veterinary and Animal Science University' for further analysis and record keeping.

3.4 Sorting and grouping

Samples were brought into laboratory for analysis. For taxonomic identification, samples were sorted out visually. The first step of sorting was to discard ethanol from the sample. To do this, samples were sieved through meshes of 0.1 mm and thoroughly washed with distilled water so that sand particles, plastics, leaves, and other unwanted matters could easily be removed. Then the samples were grouped primarily according to their general appearance. Washed samples were again placed into a jar with fresh ethanol and each sample was placed in a petri dish one by one to be identified under a stereo microscope at low magnification (10x) and several pictures were taken. Each picture was given a specific code so that it can be easily found later.

3.5 Identification of Shrimp PL, Crustacean and Finfish

The samples were identified up to the family level by using stereo microscope (OPTIKA Microscope Italy C-B3) at low magnification (10x). Samples were segregated and penaeid shrimp larvae were identified up to the species level

following Muthu (1978) and Motoh and Buri (1980). According to Muthu (1978) and Motoh and Buri (1980), the body of the postlarvae of *P. monodon* was transparent with a dark brown streak from the tip of the antennular flagellum to the tip of the telson (Fig. 2). The 6th abdominal segment is relatively longer than the carapace length. The carapace length of the post larvae varies between 1.2 to
2.2 mm. *P. monodon* enters nursery grounds during the last substage of the megalopa. Macrozooplankton including other shrimp and fin fishes were identified as major taxonomic groups following George (1969) and Fischer and Witchead (1974). Morphological aspects described by Scotton et al., (1973) Huda et al., (2003); Rodriguez et al., (2017) and Singha et al., (2019) and were used for identification. The number of shrimp PL and individuals of other families was counted .The total number of major taxa of shrimp PL, finfish and crustacean were determined and their abundance was expressed as number of individuals per each catch and as a percentage.

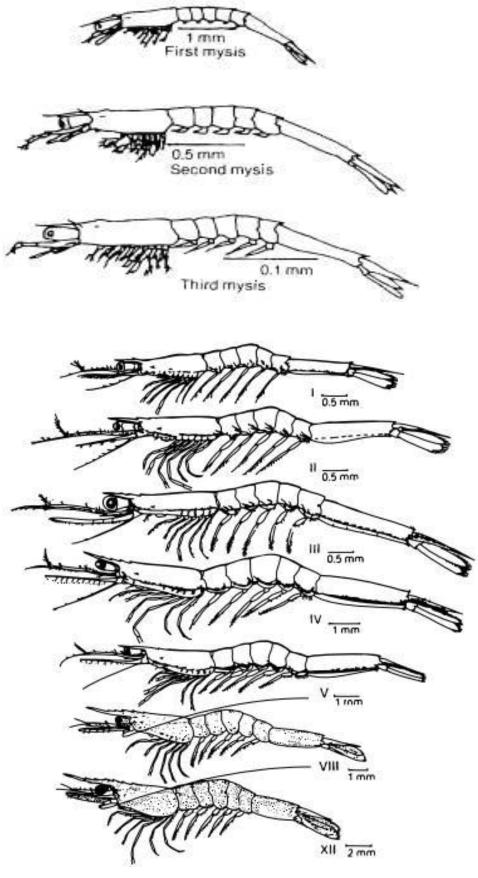


Figure 2. Morphological development of mysis, megalopa (I-III) and juvenile (IXII) of *P. monodon* (Motoh and Buri ,1980)

3.6 Preservation

The identified samples were preserved with 90% ethanol in plastic pots. The pots were labeled with sampling number, sampling station name, date of sampling, family name and the number of individuals in each family. The identification records were used later to determine the catch composition, bycatch level, bycatch types, family composition and impact on coastal fisheries.

3.7Analysis and visualization of collected data

All data were summarized, categorized and analyzed in Microsoft Excel (Version-2016), and statistical analysis was done using SPSS (Statistical Package for Social Science) version 25. A one- way ANOVA was conducted to evaluate their significant differences among the mean destruction and mean catch composition of different groups from four different sampling stations.

Chapter 4

Results

4.1 By-catch Composition

The by-catch of organisms was comprised of young and juveniles of finfishes, other shrimp postlarvae, larvae of crabs and lobsters. The finfish community in the bycatch composed of 22 different families (Table 1). The identified families are Dictylopteridae, Mugilidae, Gobiidae, Blenniidae, Serranidae, Sciaenidae, Megalopidae, Haemulidae, Gerridae, Ophichthidae, Clupeidae, Sillaginidae, Belonidae, Terapontidae, Lutjanidae, Siganidae, Myctophidae, Lactariidae, Loliginidae, Leiognathidae, Signanidae, Engraulidae, Muraenesocidae, Carangidae, Mullidae, Uranoscopidae, Cyanoglossidae, Paralepididae, Ambassidae, Scombridae whereas crustacean community composed of 3 different families. The identified families were Penaeidae, Portunidae, Palinuridae. Some finfish (two unidentified) larvae could not be identified. Among the identified groups of crustaceans, the highest mean number was found in the Penaeidae family (1829.58±4701.19) from Sonarpara station, whereas the mean number of the finfish group Myctophidae family were found to be higher (24.50± 55.04) from Rajarchora station**.**

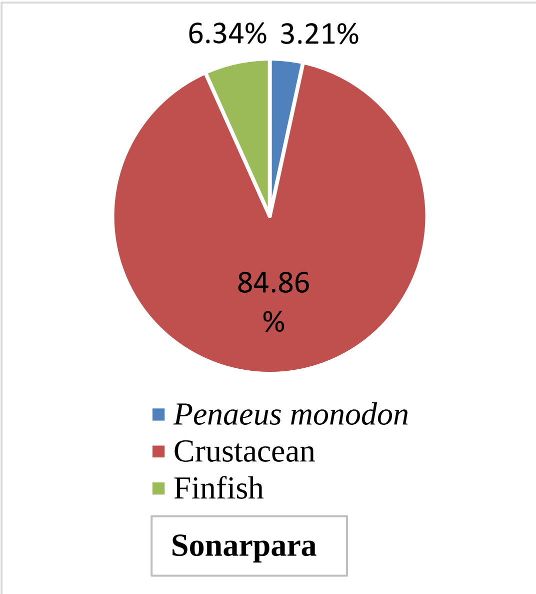
Table 1. Family composition of by-catch (Individual No.) during wild PL collection

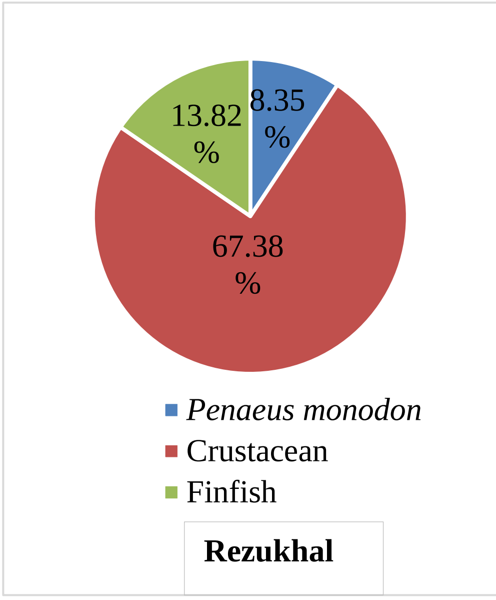
Species/Family	Sonarpara		Rezukhal		Rajarchora		Marishbuniya	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Penaeus monodon	71.50	55.48	75.92	121.43	95.58	121.82	71.48	42.12
Penaeidae	1829.58	4701.19	588.25	1423.13	650.58	2157.49	2880.5	4862.4
Portunidae	20.83	26.24	21.33	44.93	6.92	16.75	20.76	18.46
Palinuridae	38.42	113.52	2.83	5.83	1.17	2.86	26.88	45.23
Dactylopteridae	1.25	2.94	4.08	10.20	1.5	3.53	2.39	2.88
Mugilidae	0.25	0.87	5.42	18.14	12.75	39.96	6.54	12.92
Gobiidae	0.25	0.87	13	16.37	2.67	6.85	3.43	6.00
Blenniidae	2.25	4.16	10.17	34.90	1.67	3.89	6.70	10.03
Serranidae	2.42	3.25	3.58	6.52	3.58	6.80	2.65	2.26
Megalopidae	9.50	9.66	8.75	16.54	9.42	9.91	7.16	4.40
Haemulidae	14.08	23.88	6.33	8.41	3.08	3.61	13.78	19.89

Ophichthidae	0.42	1.08	1.42	3.70	0.5	1.17	0.82	1.08
Clupeidae	29.25	47.98	0.17	0.39	7.08	19.99	24.09	32.74
Terapontidae	0.67	0.98	1.25	3.44	0.67	1.37	1.00	0.95
Lutjanidae	0.08	0.29	6.58	13.57	1.5	4.30	2.22	4.44
Siganidae	1.42	3.48	0.25	0.62	1	3.46	1.76	1.92
Myctophidae	8.25	16.37	15.25	45.48	24.5	55.04	19.63	17.52
Lactariidae	0.08	0.29	0.92	2.15	0.08	0.29	0.35	0.67
Loliginidae	0.00	0	1.08	3.75	0	0	0.40	1.20
Leiognathidae	0.75	2.60	0.67	1.56	0	0	0.74	1.03
Signanidae	0.00	0	0	0	1.75	5.46	0.60	1.75
Engraulidae	34.17	114.32	25.25	56.38	4.17	12.94	32.98	43.23
Muraenesocidae	0.08	0.29	0.08	0.29	1.17	2.86	0.51	0.88
Carangidae	0.58	1.51	0	0	0	0	0.93	1.55
Mullidae	18.75	35.56	0	0	0.75	1.65	13.41	18.69
Uranoscopidae	0.92	3.18	0	0	0.58	1.67	1.79	3.33
Unidentified 1	3.75	10.48	0.08	0.29	0	0	5.40	11.17
Unidentified 2	0.08	0.29	6.67	22.47	0	0	2.57	7.11

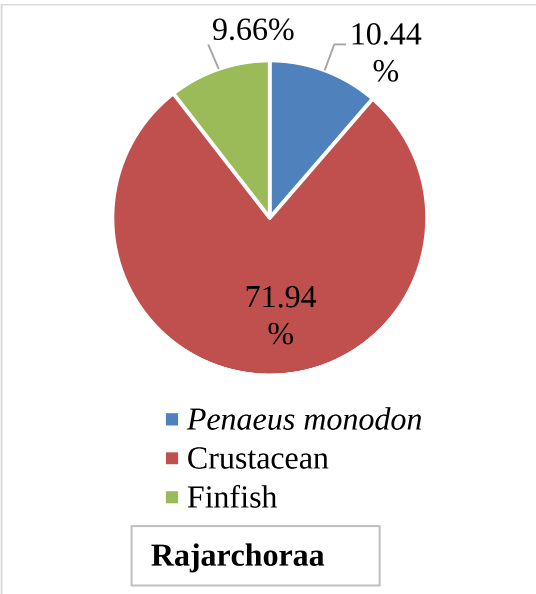
4.2 Relative abundance of different catch groups

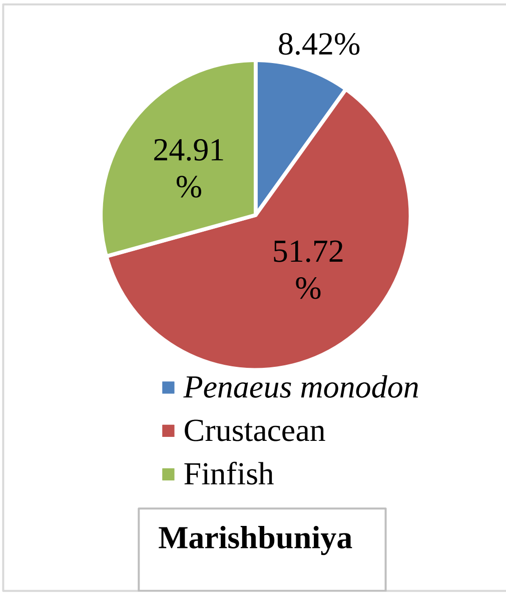
Relative abundance of different groups in the catch composition was determined for four different stations. According to the total average value for different groups of organisms (Figure 3), crustaceans (including other shrimp, lobster, and crab larvae) comprised more than half of the catch at each station, whereas the catch was higher in Sonarpara station (84.46%) (Figure 3A) and lower in Marishbuniya station (51.72%) (Figure 3D). The highest rate of *P. monodon* capture (10.44 %) was recorded at Rajarchora station (Figure 3C), while the lowest rate was recorded at Sonarpara station (3.21%). On the other hand, the percentage of finfish in the catch was highest in Marishbuniya station (24.91%) and lowest in Sonarpara station (6.31%).





3A **3B**





3C **3D**

Figure 3. Percentage of different catch groups in different sampling stations

4.3 Destruction of other individuals during collection of *P. monodon* PL

At the end of data collection, the catch composition and the extent of damage caused to crustacean and finfish as a result of harvesting wild *P. monodon* PL have been presented in (Table 2) along with a comparative study of the mean number of by-catch individuals destruction calculated per 100 individual shrimp PL collection (Figure 4). Other shrimp seed and crab larvae from crustacean groups was estimated to be destroyed maximally for each 100 *P. monodon* PL collection across all sampling stations, whereas finfish individuals were estimated to be destroyed minimally. Statistical analysis showed that there was no significant difference ($P > 0.05$) among the mean destruction of different groups from four different sampling stations.

Table 2. Number of individuals of different groups destroyed for each 100 *P. monodon* PL collecttion

Major groups/ Station	Total catch (No.)	Mean	Std. Deviation	Relative abundance (%)	Number of other individuals destroyed for each 100 *P. monodon* PL collection
Sonarpara					
P. monodon	858	100	0.00	3.42	-
Crustacean	22660	2633	182.43	90.24	2641
Finfish	1593	183	100.41	6.34	186
Total	25111			100	2927
Rezu Khal					
P. monodon	911	100	0.00	9.5	-
Crustacean	7354	832	875.40	76.68	807
Finfish	1325	143	22.63	13.82	145
Total	9590			100	1053
Rajarchora					
P. monodon	1147	100	0.00	11.45	-
Crustacean	7904	765	245.37	78.89	689
Finfish	968	95	34.65	9.66	84
Total	10019			100	873
Marishbuniya					
P. monodon	252	100	0.00	10.51	-
Crustacean	1548	508	548.71	64.58	614
Finfish	597	237	12.02	24.91	237
Total	2397			100	951

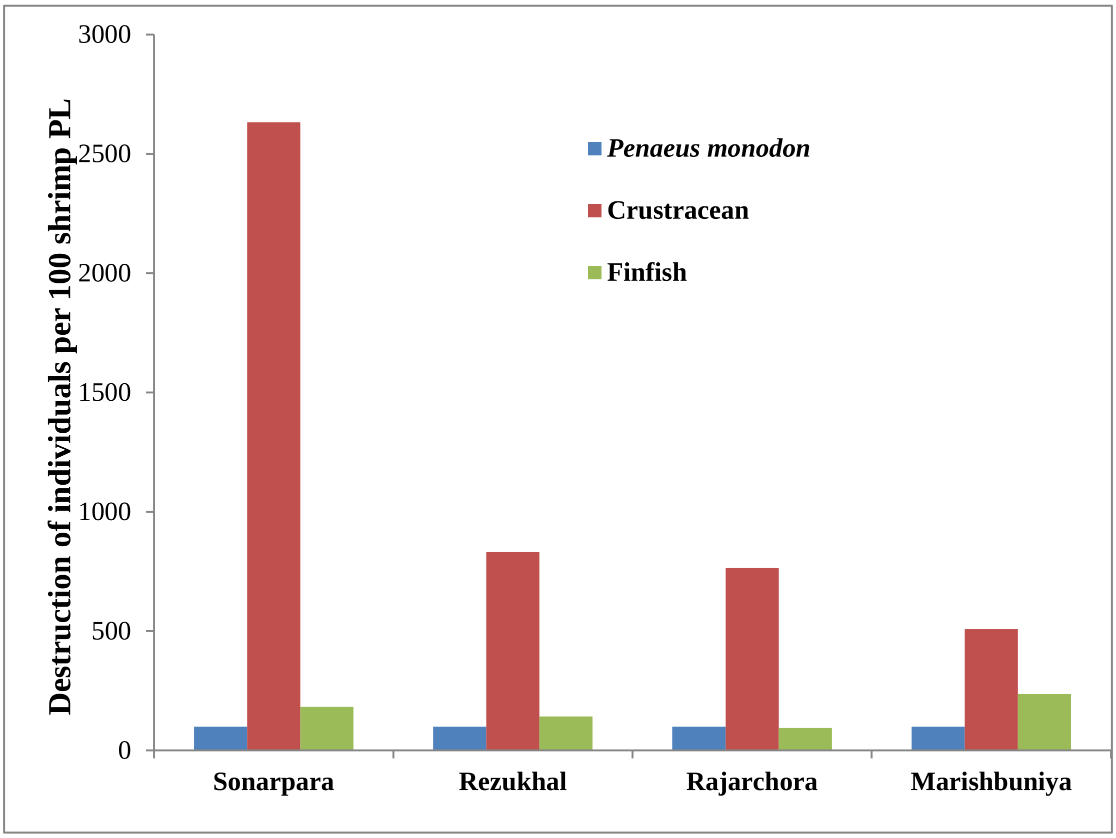


Figure 4. Destruction of other individuals per 100 *P. monodon* PL collection from four different sampling stations

4.4 Seasonal variation of different catch groups

The seasonal variation (winter, summer and rainy season) of catch composition from four sampling station were compared and showed in Figure 5. *P. monodon* PL, larvae of crustacean and finfish were found year-round. Data (Table 3) revealed that in the rainy season (July, August, September and October), larvae of *P. monodon* were found to be higher compared with the other seasons in all stations. Whereas, the abundance of *P. monodon* reduced during winter season (November, December, January and February).There was no uniform pattern in abundance and distribution of both finfish and crustacean. The statistical analysis showed that, there was no significant difference (P > 0.05) among mean catch composition of *P. monodon* from different sampling stations.

Table 3. Abundance and seasonal distribution of different catch groups

Major groups/ Station	**Season**		
	Winter	**Summer**	**Rainy Season**
Sonarpara			
Penaeus monodon	225	302	331
Crustacean	16839	3381	2440
Finfish	626	302	665
Total	17690	3985	3436
Rezu Khal			
Penaeus monodon	213	196	502
Crustacean	412	5206	1736
Finfish	422	678	225
Total	1047	6080	2463
Rajarchora			
Penaeus monodon	63	420	664
Crustacean	143	7515	246
Finfish	372	450	146
Total	578	8385	1056
Marishbuniya			
Penaeus monodon	56	97	99
Crustacean	8	36	1476
Finfish	290	226	81
Total	354	359	1656

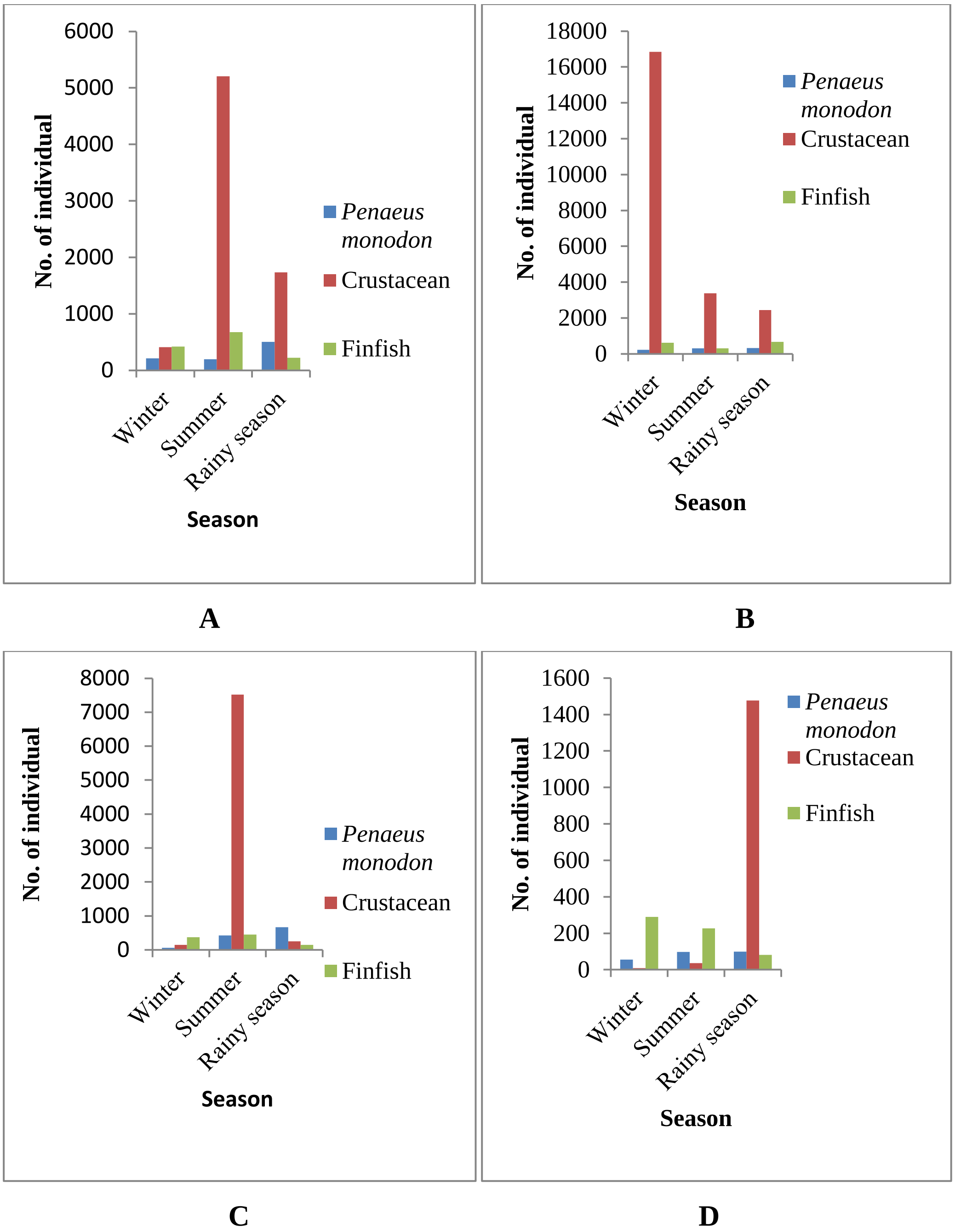


Figure 5. Seasonal variation of catch composition (mean) in four different stations (A=Sonarpara, B=Rezukhal, C=Rajarchora, D=Marishbuniya)

4.5 Temporal variation of different taxa in four different sampling stations

Monthly quantitative distribution of *P. monodon* postlarvae, larvae of finfish and crustacean in four sampling stations of Cox's Bazar coast have shown in Table 4. *P. monodon* PL, larvae of crustacean and finfish were found year-round. The highest number of *P. monodon* PL was found in the months of October and March in all stations. In Sonapara Station (Figure 4), the highest number of crustaceans was recorded in November, and the largest number of finfish was observed in September. A higher number of crustaceans was found in the month of March at both Rezukhal and Rajarchora stations. A higher number of finfish were found in March such as 487, 327, 164 at three sites in Rezukhal (Figure 5), Rajarchora (Figure 6), and Marishbuniya (Figure 7), respectively.

Table 4. Temporal distribution of different taxa in four sampling stations of Cox's Bazar coast

Major Groups/ Station	**Months**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Sonarpara												
P. monodon	9	27	102	91	88	21	50	30	81	170	168	21
Crustacean	0	89	424	132	2772	53	35	1	629	1775	16615	135
Finfish	90	147	29	160	95	18	52	21	422	170	312	77
Total	99	263	555	383	2955	92	137	52	1132	2115	1705	233
Rezu Khal												
P. monodon	50	16	128	40	7	21	15	11	31	445	75	72
Crustacean	60	77	4955	141	26	84	23	17	81	1615	179	96
Finfish	75	11	487	50	128	13	58	100	67	0	95	241
Total	185	104	5570	231	161	118	96	128	179	2060	349	409
Rajarchora												
P. monodon	15	17	124	35	51	210	293	9	12	350	15	16
Crustacean	89	23	7500	15	0	0	21	14	39	172	30	1
Finfish	83	69	307	63	66	14	35	18	17	76	184	36
Total	187	109	7931	113	117	224	349	41	68	598	229	53
Marishbuniya												
P. monodon	7	9	25	27	28	17	35	11	12	41	17	23
Crustacean	0	8	0	24	10	2	1388	13	13	62	0	0
Finfish	100	30	164	32	30	0	14	22	15	30	121	39
Total	107	47	189	83	68	19	1437	46	40	133	138	62

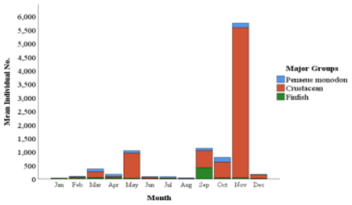


Figure 6. Temporal variation of Different Groups (*P. monodon*, Crustacean and Finfish) at Sonarpara Staion

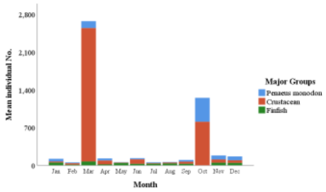


Figure 7. Temporal variation of Different Groups (*P. monodon*, Crustacean and Finfish) at Rezukhal Station

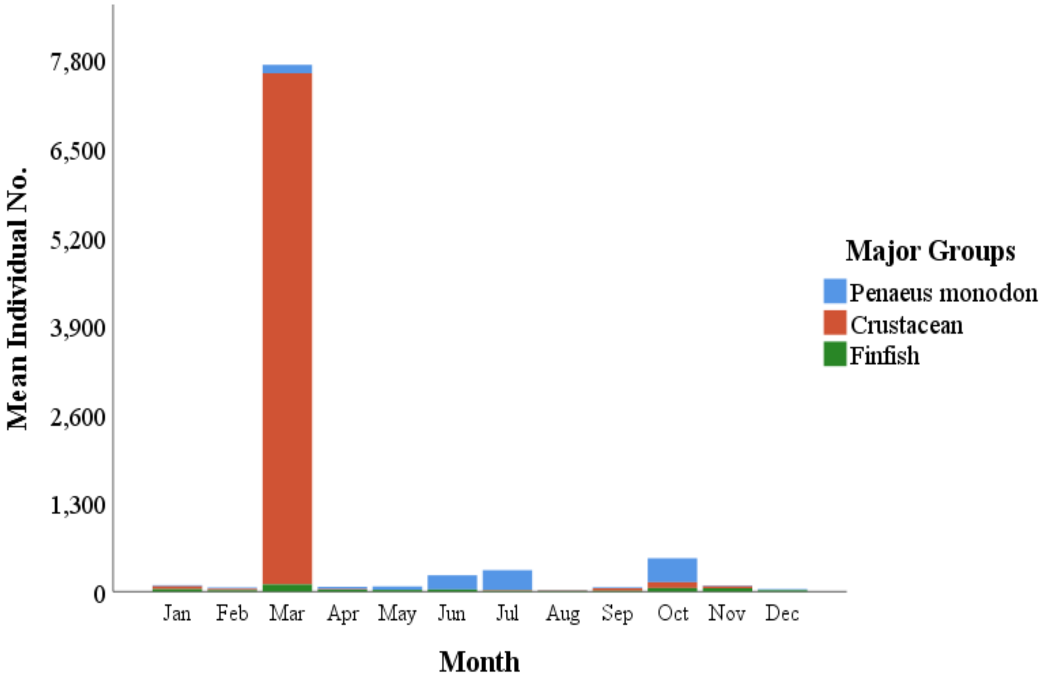


Figure 8. Temporal variation of Different Groups (*P. monodon*, Crustacean and Finfish) at Rajarchora Station

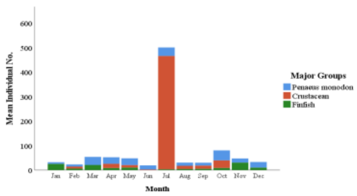


Figure 9. Temporal variation of Different Groups (*P. monodon*, Crustacean and Finfish) at Marishbuniya Station

Chapter 5

Discussion

5.1 Catch composition of different groups

The catch composition was comprised of *Penaeus monodon* PL, young and juvenile finfishes, and larvae of crutacaeans. Total of 22 different families of fish and crustacean were identified and 2 families were unidentified in bycatch samples (Table 1). The composition of bycatch of this study resembled that by-catch composed of finfish, crustaceans and other invertebrates by Das and Sarkar (2009). Das and Sarkar (2009) found a total of 24 families of finfish and crustaceans in the Indian Sundarbans. The bycatch status in this study is similar to the findings of Ekka et al., (2020).

P. monodon larvae were found to occupy a small portion of the total annual catch composition, such as 3.42%, 9.50%, 11.45%, and 10.51% at four sites in Sonarpara, Rezukhal, Rajarchora, and Marishbuniya, respectively. The highest rate of *P. monodon* capture (10.44%) was recorded at Rajarchora station, while the lowest rate was recorded at Sonarpara station (3.21%). According to Hasan et al. (2019), post larvae of shrimp were found to occupy a very small portion in the total annual catch composition in Kuakata sea beach which was not similar but followed the same trend as the current findings. In comparison to the current findings, Ferdousy et al., (2017) reported very much lower proportions of *P. monodon* post larvae in the overall yearly catch composition in the Mongla river.

Larvae of crustacean (other shrimp, crab and lobster) exerted 84.86%, 71.94%, 67.38% and 51.72% at four sites in Sonarpara, Rezukhal, Rajarchora, and Marishbuniya, respectively. Crustaceans comprised more than half of the catch at each station, whereas the catch was higher in Sonarpara station (84.46%) and lower in Marishbuniya station (51.72%). The number of individuals of Penaeid shrimps other than *P. monodon* was higher than the findings of Islam et al., (1999) in Kuakata but close to the findings of Das and Sarkar (2009) in Sundarbans Biosphere, West Bengal, India. Larvae of fin fishes (Dictylopteridae, Mugilidae, Gobiidae, Blenniidae, Serranidae, Sciaenidae, Megalopidae, Haemulidae, Gerridae, Ophichthidae, Clupeidae, Sillaginidae, Belonidae, Terapontidae, Lutjanidae, Siganidae, Myctophidae, Lactariidae, Loliginidae, Leiognathidae, Signanidae, Engraulidae, Muraenesocidae, Carangidae, Mullidae, Uranoscopidae, Cyanoglossidae, Paralepididae, Ambassidae, Scombridae) shared 6.34%, 9.66%, 13.82% and 24.91% of the total catch in Sonarpara, Rezukhal, Rajarchora, and Marishbuniya, respectively . The percentage of finfish in the catch is highest in Marishbiniya station (24.91%) and lowest in Sonarpara station (6.31%). The individuals of the finfish group Myctophidae family were found to be higher in each station. Islam et al., (1999) revealed that the number of individual of finfish larvae was found to be 105 and 99 at the Meghna river in 1997 and 1998, which was lower than in the present study and lower than the findings from Ahmed et al., (1998). This difference could be attributed due to different locations, sampling methods, seasonal variation, water quality and environmental conditions. Due to their seasonal breeding patterns parallel to those of the penaeid shrimps, non-penaeid shrimps dominated the bycatch. Additionally, factors affecting water quality, such as salinity, temperature and dissolved nutrients, were in the larvae's favor due to environmental circumstances.

According to the findings of this study, massive shrimp PL collection will impede the recruitment of other shrimp and finfish, potentially resulting in a drop in their stocks in the coming years. So, the findings of the above studies and the present study reveal that there has been a trend of a gradual reduction in the abundance of different kinds of PL of crustacean and fin-fish larvae in neritic and inshore waters which may be due to over harvesting and indiscriminate fishing that hinder the usual recruitment pattern to the original mother stock, and it is a great threat to the natural biodiversity protection mechanism.

5.2 Destruction of other individuals during the collection of *P. monodon* PL

The number of shrimp fry collectors expanded significantly in the coastal region of this country as a result of the increasing demand for *P. monodon* PL. They use fine-mesh nylon nets to harvest shrimp fry from all suitable locations along the coastal rivers. The early stages of the life cycles of other aquatic organisms are severely harmed by this. According to the current effort (Table 2) to quantify the damage caused by such exploitation, approximately 2641 PL of crustacean, 186 fin fish larvae in Sonapara station, 807 PL of crustacean, 145 fin fish larvae in Rezukhal station, 689 PL of crustacean, 84 fin fish larvae in Rajarchora station, and 614 PL of crustacean, 237 fin fish larvae in Marishbuniya station were cruelly damaged at the time of collection for every 100 PL of *P. monodon.* According to Mahmood (1990) for catching only one PL of *P. monodon*, 14 other shrimp spp., 21 fin fishes and 1631 zooplanktons were destroyed in the Chakaria Sundarbans, Satkhira and Khepupara estuaries. BFRI (1996) reported that one PL of *P. monodon* was collected at the cost of 356 larvae of other shrimp species, fin fishes and macrozooplankton in the Bagerhat region in 1996. Islam et al. (1999a) stated that for catching a single PL of *P. monodon*, the fry collectors destroyed 587 larvae of other shrimps, fin fishes and macro zooplankton in the Satkhira region. The tremendous loss of valuable different aquatic organisms was also reported by BOBP (1992) and Khan et al. (1988). It has also been reported that around 1650 larvae of other shrimp species, 1562 finfish and 6787 other macro zooplankton were discarded for collecting a single shrimp PL in the Mongla river, Bagerhat (Ferdousy et al., 2017), which was close to the present study. In addition, 37 PL of other shrimps, 11 fin fish larvae and 31 macro –zooplankton were discarded for collecting a single shrimp PL in Kuakata beach, Patuakhali (Hasan et al., 2019). The present study did not obtain zooplanktons during bycatch analysis and thus differs from the findings of Mahmood (1990) and (Hasan et al., 2019). The bycatch estimation was higher than the earlier studies by Islam et al. (1999a) in estuaries of the Satkhira and Islam et al. (1999b) in estuaries of the Bhola district. The cause of great variation was possibly due to different locations, sampling methods, different mesh sizes of the net, seasonal variation, water quality, and environmental conditions.

Shrimp PL harvesting in the wild is a destructive fishing method. It has an impact on the biodiversity and quantity of many shrimp and finfish species in marine and coastal waters (Hossain and Hasan, 2017). The collection of wild shrimp is thought to have a negative influence on coastal biodiversity (Primavera 1998; Islam et al., 1999 and Hoq et al., 2001). The potential for future fisheries might be seriously harmed by the removal of young fish before they reach maturity (Ramesan et al., 2009). Indiscriminate collecting of wild shrimp PL endangers fisheries resources and fish ecology (Ahamed et al., 2012).

The extinction of many immature finfish, shellfish, and macrozooplankton species threatens biodiversity. It hinders conservation and sustainable resource utilization practices. These species have great economical, ecological and biomedical significance. The ongoing destruction of this biota can dramatically decrease supplies and render the ecosystem extremely vulnerable (Brown, 1997).

According to Khan and Latif (1997), this activity has a significant impact on wild shrimp and fish stocks. Excess harvesting of wild PL causes the reduction of fish availability and hampers the recruitment of different fish species. Fish is the major source of protein for most people. The reduction of fish availability due to wild PL collection can affect the nutritional status of people (Islam et al., 2001).

Shrimp seed harvesting operations had a serious negative influence on the availability of *P. monodon*, which fell from 2,000 shrimp fry per net per day (Funegaard, 1986) to barely 200 fries per net per day (Alam, 1990) in the Satkhira area. Therefore, the results of the research stated above as well as the current study show that there has been a progressive decrease in the number of other shrimp, fin fish, and zooplankton larvae in neritic and offshore waters.

5. 3 Abundance and seasonal variation of different catch groups

In the present study, monthly variation in abundance of *P. monodon* PL, crustacean and finfish was observed in four sampling stations along with the Cox's Bazar coast (Table 4). Although *P. monodon* PL is available throughout the year, its density was high in Razarchora station. A higher number of *P. monodon* PL was found in the months of October and March in all stations .*P. monodon* PL was often prevalent from October to February and was correlated to moderate salinity (Hoq et al., 2001). Like the present study a similar trend was found by Zafar & Mahmood (1994), they found that penaeid post larvae were most abundant in July at high salinity and least abundant in March in estuary waters near the Sundarbans. In four sample stations, there were no notable changes in the annual total catch composition of *p. monodon* and finfish. The seasonal variation (winter, summer and rainy season) (Figure 5) of catch composition from four sampling station were compared and shown in Figure 5. *P. monodon* PL, larvae of crustacean and finfish were found year-round. During post monsoon period, comparatively higher quantity of fin fishes was observed than the other part of the year (Rahman *et al*., 1997 and Islam *et* al., 1999) which was close to the present study. Data revealed that in the rainy season (July, August, September and October), larvae of *P. monodon* were found to be higher compared with the other seasons in all stations. Whereas, the abundance of *P. monodon* reduced during winter season (November, December, January and February).The present study revealed two peaks for penaeid recruitment and settlement during the pre monsoon (March, April, May) and post monsoon (November and October) . Primavera (1998) and Basu et al., (1998) noted two peaks for penaeid recruitment and settlement during the pre monsoon and winter season at average salinity and high temperatures. This difference could be attributed to several writers pointing to variable information on the same aspect owing to differences in location and season/time. The primary wild PL collecting season goes from November to June, with the peak season being in March and April (Hossain and Hasan, 2017). The current investigation discovered more or less similar pattern. Houque (1992) noted that bagda shrimp fry were available in the Satkhira and Khulna area mostly from January to April/May. Karim (1986) stated that during the peak season (March and April), around 200 seeds/net/day were gathered, while shrimp fry harvesting was done mostly from November to July. Additionally, he stated that the majority of the seeds were harvested each month's new and full moons. According to Banerjee and Singh (1993), *P. monodon* PL were available year-round in the Muriganga estuary, West Bengal, with maxima in April-May and August-September. Funegaard (1986) found that *P. monodon* exhibits abundance during the new moon fortnight. The present study contrast to Hoque (1992), this may be caused by changes in sample techniques, temporal changes in seed collecting intensity, differences in the seasonality of the research period, and most importantly, changes in water quality and other environmental factors. Although *P. monodon* PL is found year round, there is a seasonal restriction to how much of it may be stocked in coastal aquaculture ponds. Both finfish and crustacean larvae were not distributed according to a consistent pattern and their quantity changed station to station.

Chapter 6

Conclusion

The collection of wild PL for use as seed in the aquaculture and prawn farming industries is a crucial component of aquaculture endeavors and continues to do so in many nations throughout the world. In Bangladesh, wild PL is the primary source of seed for the giant freshwater prawn (*M. rosenbergii*) and black tiger prawn (*P. monodon*). It is clear that overfishing is putting many shrimp species and other aquatic life at risk. Furthermore, the gathering of wild PL employs hundreds of coastal landless and vulnerable populations of the coastal community, particularly women and children. Fishermen take only the desired *P. monodon* PL from the catch, and the rest, which includes larvae of other species that are not targeted to them, is mercilessly discarded. According to the study, collecting *P. monodon* PL by shrimp seed collectors poses a danger to aquatic biodiversity conservation and the ecology of coastal waters by indiscriminately killing shell and finfish as well as other significant aquatic organisms. Therefore, the results of this study show that there has been a trend toward a gradual decline in the abundance of shell and finfish larvae as well as other zooplanktons in the coastal waters of Bangladesh. This decline may be caused by overfishing of *P. monodon* PLs as well as the indiscriminate killing of zooplanktons and other valuable organisms that obstruct general recruitment to the natural stock. The ecology of river-estuaries may be negatively impacted by these circumstances. Therefore, urgent action should be taken to train the fry catchers so that, during the collection of *P. monodon* PL, other valuable different aquatic animal larvae caught in the net are released back into the water without causing any damage. This will help to preserve the ecological balance, aquatic biodiversity, and natural productivity of waters.

Chapter 7

Recommendation and Future Perspectives

According to this research work, the following recommendations may be done:

- Hatcheries need to be established, net mesh sizes should be strictly regulated, and undesired species must be released into the sea.
- *P. monodon* PL survivability may be enhanced by developing efficient strategies in gear operating, fry sorting, holding, transportation, and stocking.
- Only aware coastal inhabitants who use legal and proper boats and gear in a certain location and during specific months of the year should be permitted to harvest shrimp. Additionally, a seasonal prohibition need to be enforced throughout the breeding season.
- The government should look for options for alternative sources of income for the large population that depends on these resources.
- To ensure a community-based drive for sustainable resource use and ecosystem protection, awareness must be raised in the community.
- The destruction of significant organisms during the collection of desired shrimp PL should be publicized.

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Photo Gallary

Plate 1: Sampling by Marine Set Bag Net

Plate 2: Collected sample in container

Plate 3: Sample Sorting and Grouping

Plate 4: Larvae Identification under stereo microscope

Plate 5 : Identified samples were preserved with 90% ethanol

Plate 6: Labeling and Storage

Plate 7: Carangidae

Plate 8: Gerridae

Plate 9: Mugilidae

Plate 10: Haemulidae

Plate 11: Serranidae

Plate 12: Dacylopteridae

Plate 13: Engraulidae

Plate 14: Clupeidae

Plate 15: Gobiidae

Plate 16: Muraenesocidae

Plate 17: Terapontidae

Plate 18: Lutjanidae

Plate 19: Blenniidae

Plate 20: Leiognathidae

Plate 21: Megalopidae

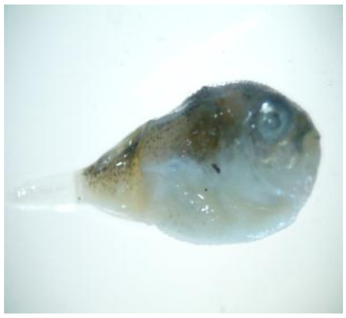

Plate 22: Uranoscopidae

Plate 23: Ophichthidae

Plate 24: Myctophidae

Plate 25: Lactariidae

Plate 26: Siganidae

Plate 27: Mullidae


Plate 28: Penaeidae

Plate 29: *p. monodon*

Plate 30: Portunidae


Plate 32: Loliginidae

Plate 31: Palinuridae


Plate 33: Unidentified 1

Plate 34: Unidentified 2

Appendices

Appendix 1. Family composition of by-catch (Individual No.) during wild PL collection

Major groups	Family	Sonarpara	Rezukhal	Rajar-chora	Marish-buniya	total
Crustacean	Penaeidae	21955	7059	7807	1439	38260
	Portunidae	250	257	93	87	687
	Palinuridae	455	38	4	20	517
Finfish	Dictylopteridae	29	49	18	17	113
	Mugilidae	3	65	153	61	282
	Gobiidae	3	146	32	5	186
	Blenniidae	27	122	20	39	208
	Serranidae	30	43	43	5	121
	Megalopidae	123	94	113	104	434
	Haemulidae	158	87	37	40	322
	Ophichthidae	5	17	6	0	28
	Clupeidae	351	2	85	75	513
	Terapontidae	8	53	8	0	69
	Lutjanidae	1	40	18	4	63
	Siganidae	17	3	19	1	40
	Myctophidae	99	183	320	94	696
	Lactariidae	1	6	1	0	7
	Loliginidae	0	13	0	0	13
	Leiognathidae	9	8	0	0	17
	Signanidae	0	0	19	0	19
	Engraulidae	410	303	50	32	795
	Muraenesocidae	1	1	14	26	42
	Carangidae	10	0	0	7	17
	Mullidae	225	0	9	87	321
	Uranoscopidae	11	0	3	0	14
	Unidentified 1	39	80	4	0	123
	Unidentified 2	28	1	0	0	29

Appendix 2. One-way Analysis of Variance Examining mean destruction of different groups (*Penaeus monodon*, Crustacean, Finfish) from four different sampling stations

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Penaeus monodon	Between Groups	0	3	0	.	.
	Within Groups	0	4	0		
	Total	0	7			
Crustacean	Between Groups	5712921	3	1904307	6.562	0.05
	Within Groups	1160897	4	290224		
	Total	6873818	7			
Finfish	Between Groups	21776.5	3	7258.83	2.432	0.205
	Within Groups	11939	4	2984.75		
	Total	33715.5	7			

Appendix 3. **One-way Analysis of Variance Examining mean catch composition of *P. monodon* from different sampling stations**

ANOVA					
P. monodon					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2242.333	2	1121.167	0.640	0.587
Within Groups	5258.500	3	1752.833		
Total	7500.833	5			