Chapter-1: Introduction

1.1 Background

Due to its resources and great agro-climatic conditions, Bangladesh is regarded as one of the world's best nations for shrimp growing. In Bangladesh, a variety of marine shrimp and prawn species can be farmed. The majority of Bangladesh's coastal aquaculture is dominated by the black tiger shrimp (*Penaeus monodon*), which is the most widely consumed due to its high value on both domestic and international markets. A vast area with shallow water bodies and a subtropical climate present a unique opportunity for the production of shrimp and prawns (Ahmed et al., 2008). Shrimp and prawn farming in the coastal area is a key source of export income for Bangladesh. Since the early 1980s, the coastal region has maintained this culture to supply international markets and generate income (Islam and Ahmad, 2001). Shrimp export and production in Bangladesh has witnessed significant increase over the previous two decades. As an export crop, Shrimp is a significant revenue and currency earner, bringing in more than $360 million annually and making up 4.9 percent of exports in 2004 (FAO, 2007). Shrimp production is Bangladesh's second-highest-earning sector after the apparel market in terms of foreign exchange production. In addition to earning significant foreign cash, this crop supports communities across a large portion of Bangladesh by employing a substantial number of rural people. Up to 1.2 million individuals may be employed directly in shrimp farming, and an additional 4.8 million household members may receive financial support from the sector. To boost export revenue from this industry, the government and private sector have stepped up their efforts (Ferdousi et al., 2017).

The wild post larvae (PL) of *P. monodon* are a key seed source for shrimp farming in Bangladesh. The capture of wild PL to stock in aquaculture plants is a major component of shrimp production (Paez-osuna, 2001). Although many Asian and Latin American countries now sell post larvae grown in hatcheries, wild fry are still a significant source of seed in many regions (FAO, 2007). A large demand for wild shrimp PL has been created by the horizontal development of the shrimp-growing region, the trend of selective stocking, and the restricted supply of needed hatchery-generated PL. Farmers feel that the quality of wild post larvae is higher than that of shrimp PL raised in hatcheries. They contend that natural PL outlives and thrives much better than hatchery-produced PL, which only partially serves the expanding need of shrimp growers. *P. monodon* post larvae enter coastal rivers, canals, and streams where they quickly develop due to the abundant biological activity in these coastal habitats. Due to the high demand, little investment, and lucrative nature of the shrimp PL, many resource-poor coastal communities are encouraged to work in the shrimp seed collection industry (Islam et al., 1999). The collecting of wild plants has opened up employment prospects for thousands of landless and unemployed coastal residents (Islam and Wahab, 2005). The estimated yearly wild shrimp harvest is expected to be around 2 billion shrimp fry (Banks, 2003). While over 50% of the overall PL for tiger shrimp originates from sources that are not cultivated, over 90% of the total PL for freshwater prawns comes from natural sources (Banks, 2003). Numerous shrimp PL are consequently taken near the coast and in tidal streams, rivers, and estuaries.

Drag nets, push nets, and set bag nets are used in the bulk of shrimp fry collection activities. After each pull, the entire catch is moved to earthen or plastic bowls by splashing on the net. The collector or another member of the family or group throws the remainder, which consists of other shrimp, macrozooplankton, and fin fish larvae, onto the hot, dry coast. Using this practice leads to the daily death of many fish and shellfish fry. This method has a major detrimental effect on the wild shrimp and fish supplies, claim Khan and Latif (1997). Wild shrimp harvesting is regarded to have a detrimental effect on coastal biodiversity (Primavera, 1997; Islam et al., 1999; Hoq et al., 2001). In addition, it has been claimed that in exchange for the collection of a single shrimp PL, 2499 more shrimp larvae, fin fish, and macro-zooplankton were dumped in the Mongla River, Bagerhat (Ferdousi et al., 2017). Up to 5000 shrimp PL may be lost for every 100 shrimp PL gathered by collectors in Bangladesh (BOBP, 1992). Nearly 40% of the harvested seed in Bangladesh perished due to poor handling and transportation before being stored in culture facilities (Brown, 1997).

Some previous investigations showed that other penaeid post larvae were ruthlessly destroyed when *P. monodon* PL was being collected (Hossain, 1984; Funegaard, 1986). However, it was unclear how many other shrimp, zooplankton, and fin-fish larvae were destroyed. While harvesting "bagda" shrimp fry in the estuary water of Bangladesh, Mahmood (1990) provided the first information on the extent of harm to zooplankton and other aquatic animals (Chakaria Sundarbans, Satkhira and

Khepupara). According to reports, 99 fin fish and other prawn species fry are thrown out in order to catch one prawn PL (Hoq et al., 2001), which poses a serious threat to biodiversity.

Some research have been done on the abundance of fish and shrimp larvae in Bangladesh's nearby coastal and estuarine waterways. However, in the lack of proper qualitative and quantitative biological data, it is challenging to determine the impact of shrimp fry collection on the wild stock. In recent years, biologists have grown increasingly concerned about a potential threat to the sustenance of shrimp stock post-fry-collection. As a result, this study was conducted in Kumira, an estuary in the Chattogram district of Bangladesh, to determine the abundance and catch composition of the set bag net used for collecting *P. monodon*'s PL and to calculate the damage done to various shrimp species, fin fishes, and zooplankton larvae during the collection of P. monodon's PL.

1.2 Significance of the study

- The data from this experiment 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 in Kumira region, Chattogram
- It is hoped that the study will offer some insightful advice on how to stop such widespread destruction and raise seed collectors' consciousness of how to safely release undesirable creatures back into water bodies.

1.3 Objectives

- To measure and quantify the extensive harm done to various shrimp species, fin-fish larvae, and macrozooplankton during *P. monodon* collection (PL)
- To assess the abundance and catch composition of *P. monodon* PL in Kumira, Chattogram, Bangladesh

Chapter-2: Review of literature

It is essential to look at the existing research activity on connected themes before starting any research under a specific experimental approach. Below is a survey of the literature that is pertinent to the current study project.

2.1 Giant Tiger Shrimp *(Penaeus monodon)*

Giant tiger shrimp (*Penaeus monodon*) is one of the most important and commercially-cultured species in several countries of the world. It is a crustacean and belongs to the family Penaeidae. It has great commercial importance in international markets (FAO, 2016). Adult shrimps reside on the sandy floor of offshore waters at depths of 20–40 meter (m). The larvae migrate to the shore and find nursery grounds in estuaries and mangrove swamps. When they reach adolescence, they travel to deeper water again (Kungvankij et al., 1986). *P. monodon* occurs mainly in Southeast Asian waters. It has a wide distribution from longitude 30°E to 155°E and latitude 35°N to 35°S. This penaeid shrimp species is native to the Indo-West Pacific region. The species inhabits tropical, subtropical and warm temperate waters of 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 Present situation of world shrimp aquaculture

Over the past few decades, the global shrimp farming industry has grown exponentially, making it one of the most significant sectors of the seafood industry. In terms of volume (6.4 million tonnes), farmed crustaceans made up 22.4 percent ($30.9 billion) of the food fish aquaculture production in 2012. 15% of the value of all fishery products traded abroad in 2012 came from shrimp aquaculture (FAO, 2012). The volume of shrimp traded internationally increased during the first half of 2014 by 5-6% compared to the same period in 2013, primarily due to an increase in imports into the US and East Asian markets (Globefish, 2014). Shrimp culture has spread throughout the world due to its high productivity and potential to generate foreign cash, drawing both domestic and foreign private firms (Primavera, 1998). Early in the 1980s, significant advancements in hatchery production and feed processing enabled for quick advancements in shrimp farming practices, resulting in considerably higher yields (Shang et al., 1998).

However, viral illness outbreaks in the main producing nations had caused its production to slow down in 1991. Thailand, Vietnam, and Indonesia are the world's second, third, and fourth-largest shrimp-producing countries, respectively, behind China (FAO, 2012). These top nations for shrimp production have some significant disparities in terms of marketing. China produces most of its shrimp for domestic use. Contrarily, the majority of the shrimp produced in Thailand, Vietnam, and Indonesia is sold to significant markets in the United States, Japan, and the European Union (EU). The largest exporter of shrimp in the world is Thailand. However, current shrimp farming methods are linked to a number of environmental problems, disease outbreaks, overuse of antibiotics and pesticides, and price and quality instability (GOAL, 2013). White spot disease and early mortality syndrome are the two persistent diseases that have led to lower farm shrimp production in Asia and Latin America in 2012–2013.

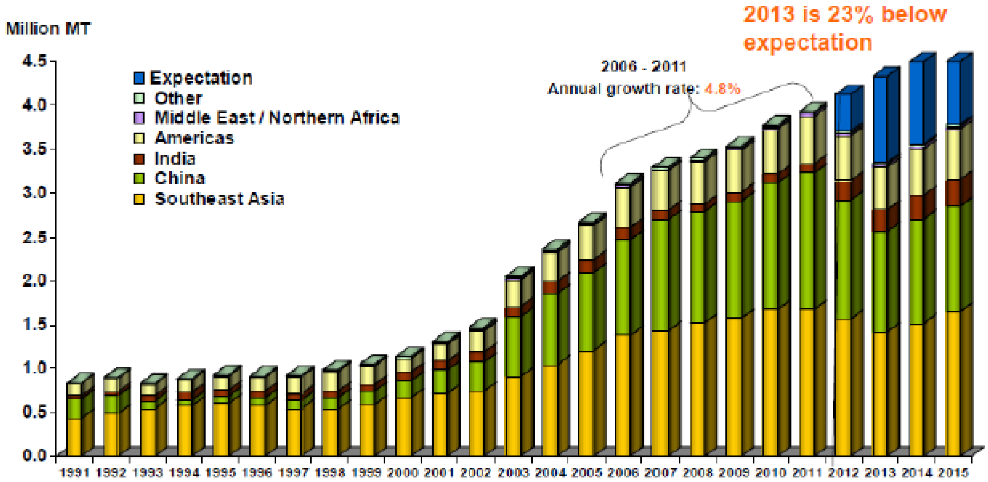


Figure 2.2: World shrimp aquaculture production by region

2.3 Overview of shrimp aquaculture in Bangladesh

2.3.1 Economic status

With the largest flooded wetland and the third-largest aquatic biodiversity in Asia after China and India, Bangladesh's fisheries industry is one of the most dynamic food-producing industries. About two-thirds of Bangladesh's agro-based commodities' value was made up of shrimp (Muir, 2003). Shrimp made almost 85% of the overall exports from the fishing industry. Bangladesh is watered by rivers and inland bodies of water, which are important habitats for wild shrimp resources and prospective supplies for shrimp farming. Bangladesh's advantageous geographic location and environment give a large habitat for shrimp species and a lot of support for the prospective fisheries (Paez-Osuna, 2001). Rivers, culture farms, and flood plain areas are Bangladesh's primary sources of shrimp production besides the ocean. Black tiger shrimp (P. monodon) and freshwater prawn (M. rogenbergii) culture farms account for the majority of Bangladesh's coastal region's production. Khulna (80.44%) and Chattogram (17.23%) are the two biggest divisions (Yearbook of Fisheries Statistics of Bangladesh, 2017-18).

According to certain research findings, Bangladesh's aquaculture subsector's recent status as a producer of shrimp and its economic impact are described for the years 2017–2018. Although the export of frozen shrimp products fell from 51,599 MT to 36,167.77 MT between 2010 and 2018, the overall value climbed from $340.48 MT to

$416.22 MT. Shrimp output has gradually increased over the past ten years, and from 2015 to 2016, it climbed by 3.23%. (Paez-Osuna, 2001).

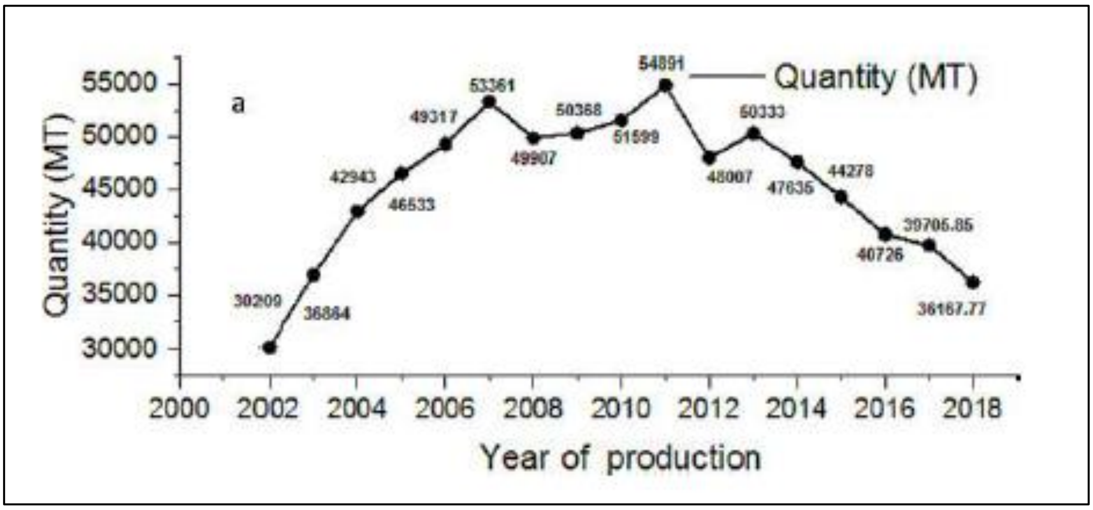


Figure 2.3.1: Value of shrimp fiscal year 2002 to 2018 (Hossain et al., 2021)

2.3.2 Hatchery PL Production and Supply

Since 1997, the number of new hatcheries and quantity of PL production increased with the increase in shrimp exports and technical assistance from overseas. Shrimp PL production capacity of hatcheries surpasses the current demand now (Hossain and Hasan, 2017). There are a total of 43 registered private shrimp hatcheries in Bangladesh but no government shrimp hatchery till now. In 2019-20, hatchery production of shrimp PL was 792.952 crores (DoF, 2020).

Most of the shrimp-hatcheries of Bangladesh are located in Cox’s Bazar district. About 60 shrimp hatcheries (registered and unregistered) operate in Cox’s Bazar in three zones named Kolatoli Hatchery Zone, Sonarpara Hatchery Zone, and Teknaf Hatchery Zone (Debnath et al., 2016).PL produced in hatcheries is often transported from Cox's Bazar to Jessore. Then the PLsare distributed to the major shrimp-producing areas by road or by air. Road transportation costs BDT 30 per 1000 PL and air freight costs BDT 50 per 1000 PL (Hossain and Hasan, 2017).

2.3.3. Collection of Wild PL in Bangladesh

A crucial aspect of shrimp farming is the acquisition of wild post larvae to stock in aquaculture facilities (Paez-osuna, 2001). Although many nations in Asia and Latin America now sell PL grown in hatcheries, PL from the wild continues to be a key supply (Primavera, 2006). More than 50% of shrimp PL is obtained from the wild.

There is an annual collection of approximately 2 billion shrimp PL from the wild in Bangladesh (Banks, 2003).

Before the 1980s, shrimp farmers used to trap shrimp PL flowing naturally with tidal water into their farm or gher. Growth of shrimp farming startedsince 1980.Farmers moved towards selective stocking of wild PL from then. As a result, the demand for shrimp PL increased and led to the wild PL collection in large numbers from coastal areas (Hossain and Hasan, 2017).

Men, women and children of coastal areas are involved in wild PL collection. The requirement of low skills and low investment attracts them to engage in this occupation. PL collection supports the livelihoods of about 4, 00,000 people in coastal areas of Bangladesh (USAID, 2006). The amount of wild PL collection is more than 2,000 million every year with a value of USD 30 million (FAO, 2007). In order to prevent the gathering of wild PL, the Government of Bangladesh (GoB) created a regulation in 2000. Due to the unsustainable nature of the alternative means of PL collectors' income, the significance of this rule has not yet been made clear (Alam, 2001). Many peoples in the coastal areas lost their income sources during the adverse situation ofCovid-19 pandemic. Thus, the shift from other professions may be significant in coastal areas like Cox’s Bazar. On the other side, shrimp farming has been increased in the last decade than before. Both the profession-shifting and increased shrimp farming increased the rate of wild PL collection (Ahmed et al., 2005).

2.4 Causes of Wild PL Collection

Wild PL collection is an important source of income and livelihood for the poor peoples of the coastal areas. More than 40% of the landless households of the coastal areas are involved in wild PL collection (Frankenberger, 2002).

The alternative livelihood options for PL collectors are not sustainable. Consequently, wild PL collection is continuing at a good pace as before with its’ negative impacts. Farmers prefer wild PL to hatchery-produced PL. They perceive that wild PL has better survival and local availability on-demand around the year. Bearing this perspective in mind, the demand for wild PL is prevailing year after year (Hossain and Hasan, 2017).

2.5 Seasonality of PL collection

Between November and June is the primary fishing season for bagda post-larvae (PL), with March and April being the peak months. The seasons vary slightly from one region to another. The most PL gear is used in Satkhira, especially in January and March. Although it continues through October at considerably lesser levels, collection in Cox's Bazar begins later in February and peaks in April. Some of the current methods that lower bycatch and fry survival rates include dumping bycatch on riverbanks or beaches, sorting PL in direct sunlight, using behundi nets for prolonged periods of time that result in mortalities in the cod end, and storing bycatch in unclean, anerated water at high concentrations. Additionally, inadequate shipping circumstances, prolonged storage times at buying and selling stations, failure to acclimate PL to local temperature and salinity conditions, and a lack of nursing PL before to stocking in shrimp ghers all lower the survival rates. We are concerned about biodiversity loss in coastal rivers owing to PL collection activity, thus we return the non-target catch to the water during collection, PL harvesters stated in the focus group discussions (FGD). However, the authors' observations show that PL collectors actually throw non-target captures onto the ground, where they quickly perish and are not returned to the water as claimed. Many different types of coastal fish, shrimp, crabs, and mollusks' eggs, spawns, and fry were involved in this. Even when a small percentage of PL collectors return non-target catches (albeit this proved to be a very low amount), other factors still have an impact on non-target species survival. The hauling process, which takes 30 to 45 minutes, is laborious for many species and deadly for many organisms, especially for those caught at the start of the haul. The FGD participants responded that biodiversity is in a dire situation and that many once-abundant and valuable fish, shrimp, and crab species have now become rare or even locally extinct. This statement was made in response to a question about the current biodiversity status of the river from which they catch the PL. The PL collectors, however, claimed that the decline in biodiversity in the river was caused by a variety of factors, including an increase in fishing activity, the use of harmful gear (such as fine-mesh nets), and other variables in addition to PL collection. Although many PL collectors were aware of the negative effects of PL collecting, the majority of them were unable to find another way to support themselves. As a result, hundreds of men, women, and children from the coastal poor still participate in PL collection.

Additionally, it has been noted that gher owners currently favor natural PL over those bred in hatcheries since they think the latter are weaker and don't grow as well as wild PL. Poor people are more tempted to continue catching PL from the wild due to the shrimp grower high demand for wild-caught PL (FAO, 2005).

2.6 Use of Gears for Wild PL Collection

Set bag net (Behundijaal), dragnet (Bakshojaal) and push net (Thelajaal) are the commonly used gears to harvest shrimp PL. The gears vary in price, mesh size and destruction level (Azad et al., 2007). Bag nets (Behundijal) are commonly used to harvest shrimp PL along the Cox's Bazar seacoast and Chattogram. These are most damaging because of high amount of bycatch (Hossain and Hasan, 2017).

2.7 Challenges in PL Production and Supply

Availability of PL is a key factor in shrimp aquaculture. Hatchery operators often experience lower hatching and survival rates of shrimp PL. Bacterial, fungal and viral infection results in mass mortality of *P. monodon* larvae in the hatchery tank (Iqbal et al., 2011).

Higher production cost in hatcheries, requirement of foreign technicians, high feed cost, antibiotic use, competition between hatchery and wild PL supply, transport-related mortality, too many intermediaries in the supply chain, cumulative increase in price, poor governance and traceability, limited care of brood stock, selling under aged PL, poor acclimatization, mixed supply of wild and hatchery PL and information gap to the farmers are some of the major challenges in shrimp PL production and supply chain. Moreover, very few researches, lack of extension efforts are the constraints as well (Hossain and Hasan, 2017).

Hatchery supply of shrimp PL now surpasses the demand but the demand of wild PL remains significant yet. The perspective of the farmers regarding better survival, growth and tolerance of wild PL is not justified by any scientific means. On the other side, relevant literature, statistics and documents show that the negative impacts of wild PL collection are severe for coastal and marine fisheries. However, there are no recent studies on the detrimental effects of wild PL collection on aquatic biodiversity in Cox's Bazar. There is a need for scientific information to prevent wild PL collection as well as improving quality of hatchery PL. Considering the abovementioned situation, the present study was aimed to assess the impacts of wild PL collection and scientifically justify the quality differences between wild PL and hatchery PL (Paez-Osuna, 2001).

2.8 By-catch from post-larvae collection

A significant amount of "bycatch" is related to extensive PL fishing. In a study of the collection method in the Pasur river, the "bycatch" is at least 1 341 fry of another species for every PL caught (Toufique, 2002). Numerous kinds of fry and post-larvae, including small cyprinids, eels, anchovies, crabs, snails, mussels, bivalves, Bombay ducks, marine and coastal catfish, gobies, eel gobies, as well as numerous other unidentified species, made up the bycatch (Figure 16). The fishermen in the village upstream saw that there were less fish available since PL was being overfished. As a result, the current levels of PL fishing for shrimp/prawn farms may have a severe impact on the recruitment of numerous other riverine and coastal species throughout Bangladesh. Given that fish is the primary source of protein for the majority of people, especially the impoverished, who live upstream, the practice may have additional effects on their nutritional health (Islam et al., 2001), Hossain et al(2015b) , summarized of how PL harvest affects aquatic biodiversity along the shore reads as follows;

- Due to the shrimp PL collection, the variety of marine and freshwater fish/shellfish is significantly reduced, with substantially smaller individual sizes in the coastal rivers and estuaries
- Catch per unit effort significantly declined. Just five years ago, when using a cast net, it was fairly simple to catch 2-3 kg of fish in an hour. A person may now only catch fish weighing less than 1 kg in 4–6 hours. 36 An evaluation of the negative effects of shrimp farming in Bangladesh and the potential for improvement
- Fifteen freshwater fish, primarily, have gone extinct locally, and many more are under threat of disappearing as well.

2.9 Impact of Wild PL Collection on Aquatic Biodiversity

The by-catch amount for wild PL collection is highest among any other fishery worldwide. There is an estimated amount of discarding 98 billion larvae and zooplankton per year for PL collection globally (Latif et al., 2002). The trend of stocking wild PL for shrimp culture results in biodiversity loss (Primavera, 2006). Harvesting shrimp PL from the wild is a destructive fishing technique. It affects the biodiversity and abundance of different finfish and shrimp species of coastal and marine waters (Hossain and Hasan, 2017). According to Mahmood (1990), collection of single wild PL destroys 14 other shrimp, 21 fin-fishes and 1631 zooplanktons.

In a study by Toufique (2002), 1,341 early stages of other species were destroyed as bycatchfor every PL collection. The results obtained byIslam et al. (1999) revealed that PL collectors destroy about 45 other shrimp, 12 finfish and 530 other macro-zooplankton for one PL collection. PL collectors discard fry of about 99 finfish and other shrimp species for harvesting single PL (Rashid, 2000).

Bycatch during PL collection includes fry and post-larval stages of small cyprinids, eels, anchovies, crabs, snails, mussels, bivalves, bombay duck, marine and coastal catfish, gobies, eel gobies and many other unidentified species (Toufique, 2002). During PL collection, several commercially important species are caught as bycatch in the coastal areas of Bangladesh. Some of the most common species among them are *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* (Ahmed et al., 2010).

2.10 Impact on Coastal and Marine Fish Stock

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). Fry collectors use very small-meshed nets in the Hooghly-matlah estuary in West Bengal, India. They catch fish of various sizes, including non-targeted species. Non-targeted species are dumped in large quantities or dried and sold to fish meal manufacturers at a lower price. The removal of juveniles before they reach maturity may have a severe influence on fish diversity and may undermine future fisheries potential (Ramesan et al., 2009).

Indiscriminate collection of wild shrimp PL brings threats to the fisheries resource and ecology of fishes (Ahamed et al., 2010). Loss of a broad range of younger stages of finfish, shellfish and macro-zooplankton species threatens biodiversity. It hinders the conservation and sustainable resource utilization practices. These species have great economical, ecological and biomedical significance. The continued destruction of this biota can lead to deplete stock severely and make the environment very fragile (Brown, 1997).

2.11 Impacts on the species recruitment and capture fishery production

The destruction of vital habitats, such as feeding and nursery grounds for many species that use these areas during part of their life cycles and have an impact on recruitment, as a result of the vast and widespread collection of wild prawns poses a threat to the coastal environment (Saikat, 1992). Postlarvae, juveniles, and pre-adults of finfish and shellfish species are indiscriminately gathered in the coastal region of Bangladesh, with some species already reaching critical levels of overexploitation as a result of the harmful PL collection techniques. Table 4 provides information on the estimated loss of non-target shellfish, fish, and macro-zooplankton over the previous ten years associated with the harvesting of wild PL in Bangladesh's coastal zones. Additionally, as a result of intensive PL collection in these coastal environments, the recruitment of shell and finfishes, as well as macro-zooplanktons, which serve as a basis for the food webs for many aquatic creatures, is also badly harmed. These destructive fishing methods, which kill the juveniles and larvae at the intertidal and estuarine nursery and feeding grounds, have a significant negative impact on the recruitment of the prawn population as well as that of other shellfish, finfish, and numerous other species discarded as by-catch. The harvest is therefore only comparable to industrial and commercial non-selective fishing techniques like bottom prawn trawling. Nevertheless, due to its direct effects on species recruitment as well as fisheries output, the loss of the nursery and the habitats associated with it continues to be the most ecological obstacle to the conservation of biodiversity. Aside from that, Bangladesh's coastal population is expanding quickly due to a lack of arable land, rising competition for few natural resources, and dwindling prospects for employment. As a result, the indiscriminate harvesting of wild prawns and the increase of prawn farming practices will negatively affect the ecosystems, current conservation efforts, and the existing fishery stocks. The coastal fishermen whose livelihood depends on the very resources currently subject to non-sustainable exploitation methods would undoubtedly be severely impacted by this circumstance.

According to Paez-Osuna (2001), overfishing—both in terms of the harvesting of food fish and shellfish and the effects of fishing methods on aquatic ecosystems—is to blame for the diminishing catches of wild prawns and fishes in many coastal environments. It should be emphasized that as prawn culture methods have grown and intensified, less agricultural land is now available for the cultivation of rice, the main staple food for the majority of coastal Bangladesh's population. Statistics from Bangladesh demonstrate that over the previous ten years, the rate of depletion of aquatic and fishery resources from rivers and estuaries has been, on average, 10%. (DOF,2009).

2.12 Mitigation strategy the impacts of wild PL harvesting

In order to assess the socioeconomic and environmental effects of these livelihood activities and ensure responsible resource use practices for development, institutional intervention is required due to the localized and wider effects of harvesting wild PL on Bangladesh's already vulnerable and impoverished coastal population. Only by conducting effective information transfer through institutional adjustments and sufficient monitoring of compliance with environmental and social standards will the negative effects of this indiscriminate harvesting of wild PL be lessened (Primavera, 1997; Hein, 2002). In order to lessen greater livelihood conflicts over scarce and diminishing resources, social discrimination, and to protect the natural ecosystems, good governance remains a prerequisite (Samarakoon, 2004; Costa- Pierce, 2008). The functions of the several institutions in Bangladesh's fisheries sector, which include a number of ministries, divisions, and departments as well as government and non-governmental organizations, must be drastically restructured (Maniruzzaman, 2006). Additionally, a number of organisations and groups are essential to this industry, including the donor community, cooperatives for fishing and prawn farming, and local union councils (also known as parishads) (Pokrant and Bhuiyan, 2001). In order to protect the integrity of the coastal ecology, several policies, laws, government acts, rules, and ordinances have been passed in Bangladesh to regulate prawn farming activities, including the wild harvesting of PL, as shown in Table 5. Under the administrative supervision of the Ministry of Fisheries and Livestock, the department of fisheries (DOF) is designated as the primary implementing agency for the policies controlling the fisheries and aquaculture industry. The sustainability of this industry and the long-term preservation of the marine, coastal, and estuarine ecosystems on which the livelihoods of Bangladesh's larger coastal populations depend remain, however, largely dependent on the implementation of the policies, laws, and regulations governing the fisheries sector. Despite a ban on wild PL harvesting being enforced in September 2000, Department of Fisheries (DOF) implementation of the restriction was not closely implemented due to several institutional flaws, including a lack of sufficient people and assertiveness (Hein, 2002; Alam, 2007). The FAO Code of Conduct for Responsible Fisheries, the National Water Policy, the National Agricultural Policy, the National Rural Development Policy, the National Land Use Policy, the National Environmental Policy, and the Coastal Zone Policy are just a few of the other policies that are relevant to this industry (DOF, 2006). The biggest obstacle to the implementation and enforcement of these policies, laws, and regulations governing the wise-use of Bangladesh's fisheries and aquatic resources, however, continues to be the absence of alternative sources of prawn seed for the extensive prawn farming activities in coastal Bangladesh.

Chapter-3: Materials and Methods

3.1 Study area

Samples were collected from three different sites (Station 1, 2 and 3) of Kumira coastal region of Chattogram district. From the selected three study areas, station 1 lies between latitude 22°31´53´´ N and longitude 91°40´40´´ E, station 2 between latitude 22°32´05´´ N and longitude 91°40´33´´ E and station 3 lies between latitude 22°31´49´´ N and longitude 91°40´44´´ E. These areas were selected for investigation because of intensive shrimp seed collection in that region. The samples collection period started from January, 2021 and were continued up to December, 2021. Sampling was done for once in every month. Geographical coordinates of the sampling area were recorded with "GPS coordinates" software. The map (Fig. 3.1) was constructed with “QGIS” (Version – 3.4.5).

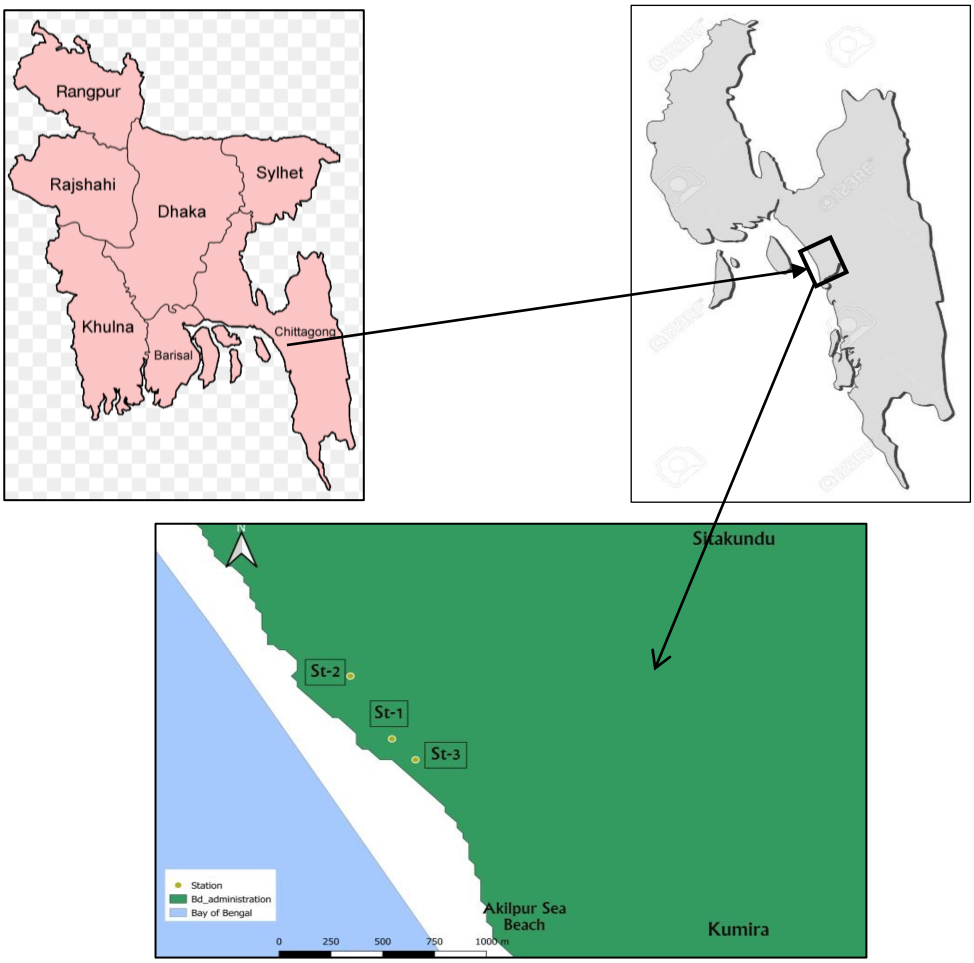


Figure 3.1: Map of Chattogram region and the sampling sites

3.2 Collection of sample

Post-larvae of Tiger Shrimp (*Penaeus monodon*) was captured from wild using small sized push and pull net along coastal region of Kumira, Chattogram. The mesh size of the net was 1mm and 3 pieces of woods (3-4ft) were used for making the net operational. The samples were collected from one haul (30 minutes operation of net) and soon after trouping, samples were conserved with 96% ethanol. Samples were generally collected in early morning depending on tidal influence.

3.3 Transportation protocol

Following each transport, samples were immediately kept in little plastic pots with a 2:1 ratio of 96% ethanol (sample: ethanol).The solution had preserved the sample in good condition during transportation for further laboratory sorting of shrimp PL, larvae of fin fishes, shell fish and other organisms. Assorted samples were subsequently carried to the 'Aquatic Ecology Laboratory' of 'Fisheries Resource Management Department' at 'Chattogram Veterinary and Animal Sciences University' for qualitative and quantitative estimation of different organisms as by-catch and record keeping.

3.4 Laboratory analysis and data collection

After the samples were brought to the laboratory, sorting and identification up to genus level of the collected samples were performed within two weeks from the date of collection. Different groups of organisms were sorted from the by-catch sample that had been preserved. The sample was collected in a petri dish, viewed through a stereo microscope (OPTIKA Microscope Italy C-B3) and different groups of organisms were counted after proper identification. After segregation, penaeid shrimp larvae were identified up to species level following Muthu (1978) and Motoh and Buri (1980). Following George (1969), Fischer and Witchead (1974), and FAO (1974), important taxonomic groups of macrozooplankton, including more shrimp and finfish, were recognized. Other shrimp, finfish, and macrozooplankton main taxonomic totals were calculated, and their abundance was expressed as the number of individuals per 10 minutes haul and as a percentage. Penaeid post-larvae of various species were treated the same way, and their percentage composition based on the overall quantity of post-larvae was calculated. Following the techniques of Ahmed et al. (2005) and Das and Sarkar (2009), various indices for the estimate of variety in the by-catch were developed. Applying the ratio of the estimated number of each group of fry in the total catch and its percentage in the species composition of the catch, the respective total numbers of all groups were estimated. The monthly catch of the study area was calculated by extrapolating the observed value. Diversity loss of the major groups (crustaceans, finfish and unidentified) were determined for each shrimp PL collection and per 100 individual PL catch of *P. monodon*. The data were subjected to statistical analyses following appropriate methodologies, where necessary.

3.5 Statistical analysis

The mean and percentage calculation of all the data were calculated in MS Excel and reported throughout the text. All statistical analyses related to the seasonal variation in total catch composition and destruction rate of by-catch species was done using SPSS (Statistical Package for Social Science) version 25. Descriptive statistics were computed for each variable, followed by a test for homogeneity of variance. A one-way Analysis of Variance (ANOVA) was used to examine the acquired data. T-test was performed to determine the correlation among different data value. Percentage data was transformed before performing ANOVA. Tukey's multiple comparison tests were used to look for significant differences among treatments at 95% confidence interval level. To distinguish between groups, a post-hoc test was performed.

Chapter-4: Results

4.1 Catch composition of finfish in different station

In this experiment, samples were collected from different station for twelve consecutive months (January to December). Mean number of individual finfish caught in the fishing net while harvesting *P. monodon* were determined at the end of the experiment (Table 4.1). Among the finfish larvae, 16 different families- Bottidae, Gonostomatidae, Phosichthyidae, Clupeidae, Channidae, Latidae, Oxudercidae, Bagridae, Terapontidae, Cyprinidae, Gobiidae, Tetraodontidae, Scatophagidae and Sciaenidae were recorded and some finfish larvae could not be identified. The number of unidentified species was more than the identified groups (station1- 185.42, station 2- 181.08 and station 3- 152.83). Among the identified groups, highest mean number was found in Oxudercidae group (6.75 and 7.58) from station 1 and 3, whereas individual from Phosichthyidae group was found to be higher (12.50) in station 2.

Table 4.1: Catch composition of different finfish groups from three different sampling station of Kumira during the period of observation

Family/Species	Station-1		Station-2		Station-3	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Penaeus monodon	62.42	89.82	78.42	126.03	68.33	114.17
Bottidae	0.67	1.36	0.42	0.88	1.83	3.78
Gonostomatidae	1.33	2.71	00	00	00	00
Phosichthyidae	6.08	6.32	12.50	14.51	7.17	6.71
Clupeidae	4.17	5.36	4.33	5.16	5.25	6.41
Channidae	0.67	1.23	1.25	1.36	0.83	0.94
Latidae	1.67	2.02	2.33	1.56	1.00	0.95
Oxudercidae	6.75	4.33	5.58	4.70	7.58	7.18
Bagridae	1.83	1.70	1.33	1.44	2.83	2.17
Tetraodontidae	2.92	2.61	1.17	1.40	3.42	3.55
Gobiidae	2.42	1.93	2.25	2.42	2.33	3.17
Terapontidae	0.58	0.67	1.17	1.47	0.83	0.94
Cyprinidae	2.08	1.78	2.08	1.56	1.08	1.73
Scatophagidae	0.08	0.29	0.00	0.00	0.00	0.00

Sciaenidae	2.00	1.71	2.33	1.30	1.67	1.44
Unidentified	185.42	133.40	181.08	109.86	152.83	93.00

4.2 Relative abundance of different by-catch groups

Relative abundance of different groups in the by-catch composition was determined for three different stations. In station 1, the overall average value for different groups of organisms (Figure 4.2) indicated that almost half of the by-catch was comprised of 37% non-penaeid crustaceans (prawn and crab larvae), which was 37% followed by unidentified groups (42%) and finfish (7%). The percentage of different groups from Station 2 and station 3 were- *Penaeus monodon* (17% and 18%), other crustaceans (37% and 34%), finfish (8% and 9%) and unidentified groups (38% and 39%).

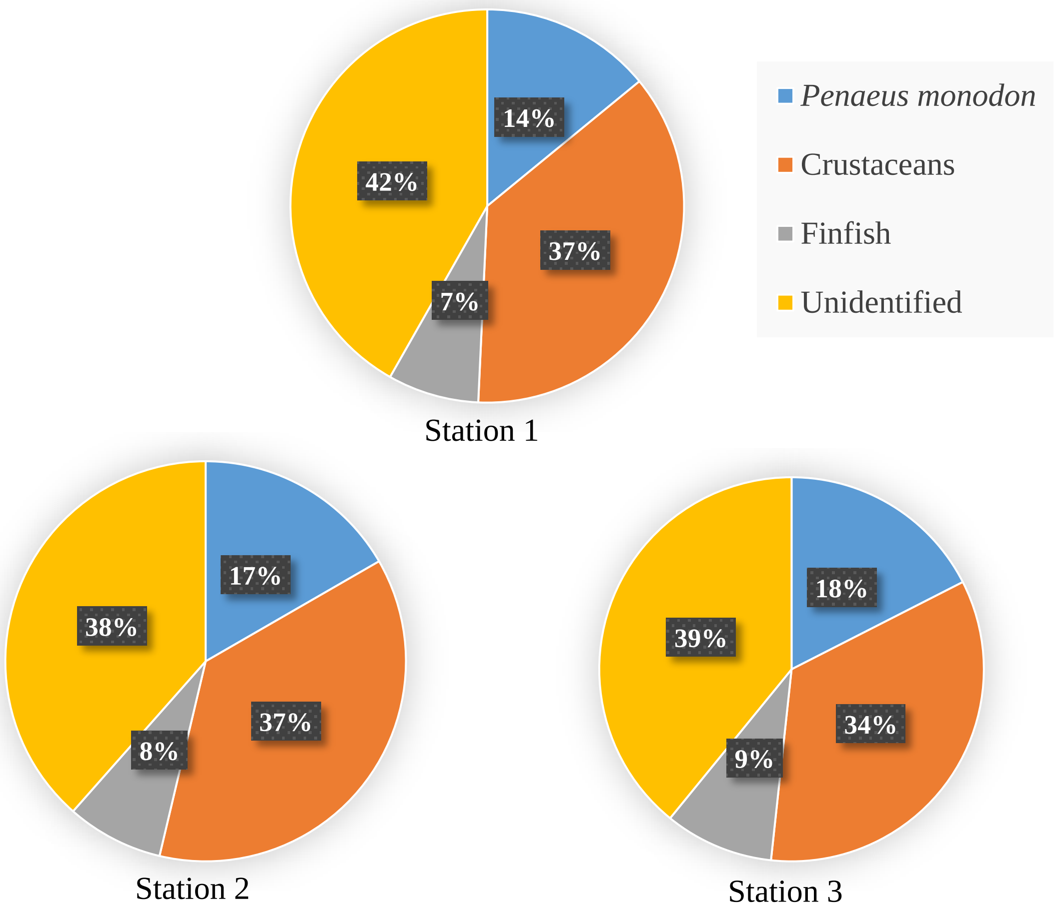


Figure 4.2: Relative abundance (%) of different groups in the by-catch composition with larvae of *Peneaus monodon*

4.3 Destruction of other species while PL collection (*P. monodon*)

At the end of data collection period, number of by-catch species destruction (%) while collecting individual shrimp PL (*P. monodon*) was determined (Table 4.3) along with comparative study of mean number of by-catch species destruction calculated per 100 individual number of shrimp PL collection (Figure. 4.3). Statistical analysis showed that, there was no significant difference ($P > 0.05$) among mean destruction rate of major groups from three different sampling stations.

Table 4.3: Destruction of other by-catch groups while PL collection (*P. monodon*)

Major Taxa	Yearly total catch (Number)	Number of other species destroyed for per 100 *P. monodon* PL collection
Station 1		
Penaeus monodon	749	
Crustaceans	1953	261
Finfish	399	53
Unidentified	2225	297
Total	5326	711
Station 2		
Penaeus monodon	941	
Crustaceans	2091	222
Finfish	441	47
Unidentified	2173	231
Total	5646	600
Station 3		
Penaeus monodon	820	
Crustaceans	1604	196
Finfish	430	52
Unidentified	1834	224
Total	4688	572

4.4 Seasonal variation of catch composition in different stations

The seasonal variation (winter, summer and rainy) of catch composition from three sampling station were compared and showed in Figure 4.4. The statistical analysis revealed that, there was no significant difference ($P > 0.05$) among mean catch composition from different sampling stations. Also the mean number didn't significantly differ with the change of different season. But the monthly mean catch composition of three sampling stations showed significant variation ($P < 0.05$).

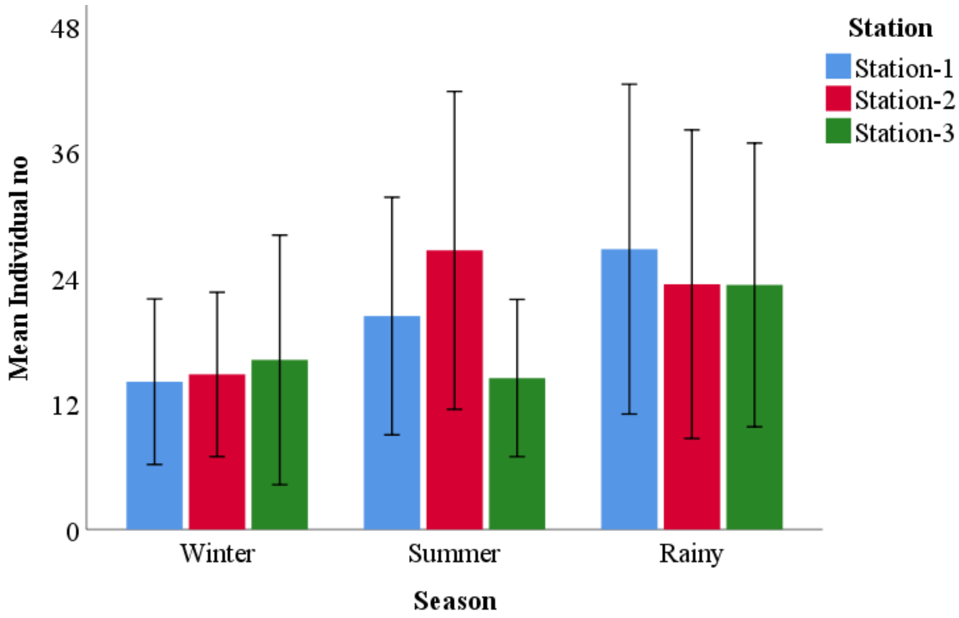


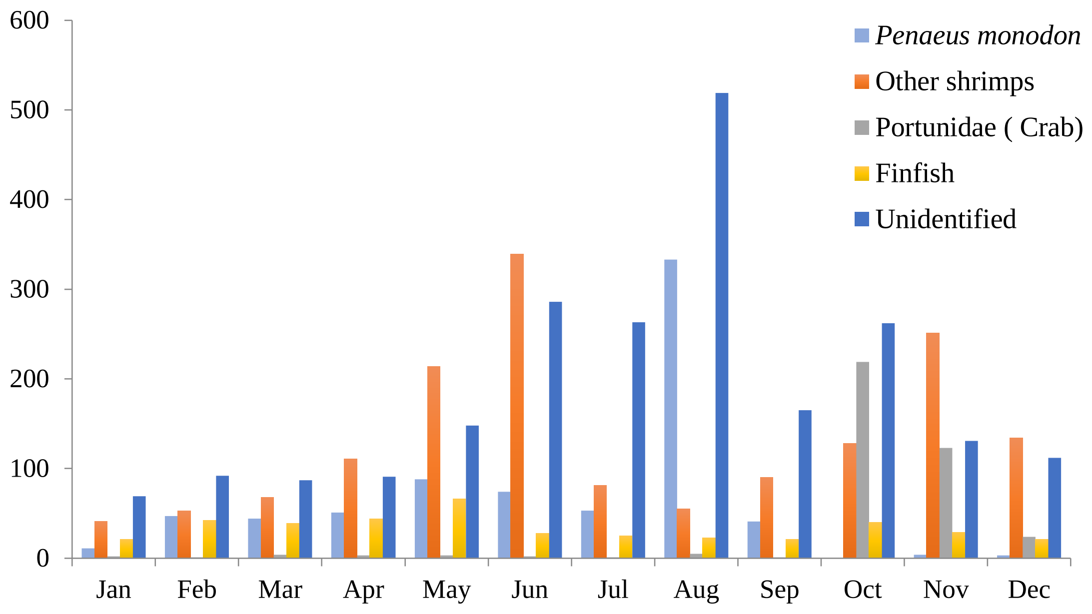
Figure 4.4: Seasonal variation (winter, summer and rainy) of catch composition in three different stations of Kumira, coastal region of Chattogram

4.5 Temporal distribution of different taxa in three sampling stations of Kumira

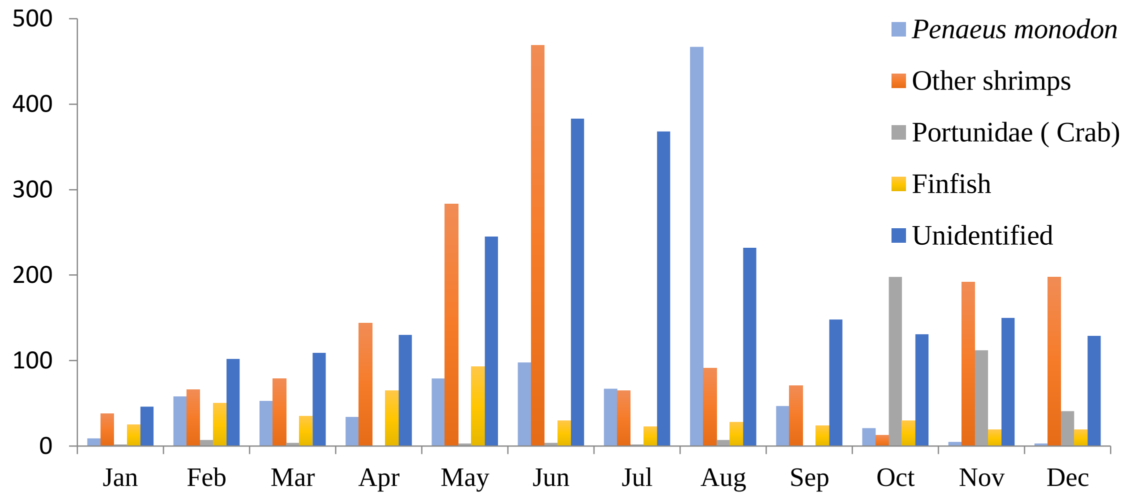
Monthly quantitative distribution of *P. monodon* postlarvae, larvae of other shrimps, finfishes and crab in three sampling stations of Kumira, coastal region of Chattogram district have shown in Table 4.5. Higher number of *P. monodon* PL was found during the months of February to August in all three sites and maximum was recorded in station 2 in August (467 individuals). Whereas, the number decreases from September to January in all the stations. There was no uniform pattern in distribution of both finfish and crustacean larvae, their abundance fluctuated from one month to another. Finfish larvae were more abundant in rainy season (July to October) than other time of the year.

Table 4.5: Temporal distribution of different taxa in three sampling stations of Kumira, coastal region of Chattogram

Major groups	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Months						
Station 1												
P. monodon	11	47	44	51	88	74	53	333	41	0	4	3
Prawn spp.	41	53	68	111	214	339	81	55	90	128	251	134
Crab spp.	2	1	4	3	3	2	1	5	1	219	123	24
Finfish	21	42	39	44	66	28	25	23	21	40	29	21
Unidentified	69	92	87	91	148	286	263	519	165	262	131	112
Total	144	235	242	300	519	729	423	935	318	649	538	294
Station 2												
P. monodon	9	58	53	34	79	98	67	467	47	21	5	3
Prawn spp.	38	66	79	144	283	469	65	91	71	13	192	198
Crab spp.	2	7	4	1	3	4	2	7	1	198	112	41
Finfish	25	50	35	65	93	30	23	28	24	30	19	19
Unidentified	46	102	109	130	245	383	368	232	148	131	150	129
Total	120	283	280	374	703	984	525	825	291	393	478	390
Station 3												
P. monodon	13	66	17	43	76	21	59	423	53	34	13	2
Prawn spp.	28	32	65	98	69	57	69	108	83	162	429	243
Crab spp.	3	0	7	4	6	4	7	1	3	68	50	8
Finfish	20	39	27	45	61	43	21	35	27	51	44	17
Unidentified	38	62	68	132	138	289	307	242	162	113	146	137
Total	102	199	184	322	350	414	463	809	328	428	682	407


600
500
400
300
200
100
0
Penaeus monodon
Other shrimps
Portunidae (Crab)
Finfish
Unidentified
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

A


500
400
300
200
100
0
Penaeus monodon
Other shrimps
Portunidae (Crab)
Finfish
Unidentified
Jan
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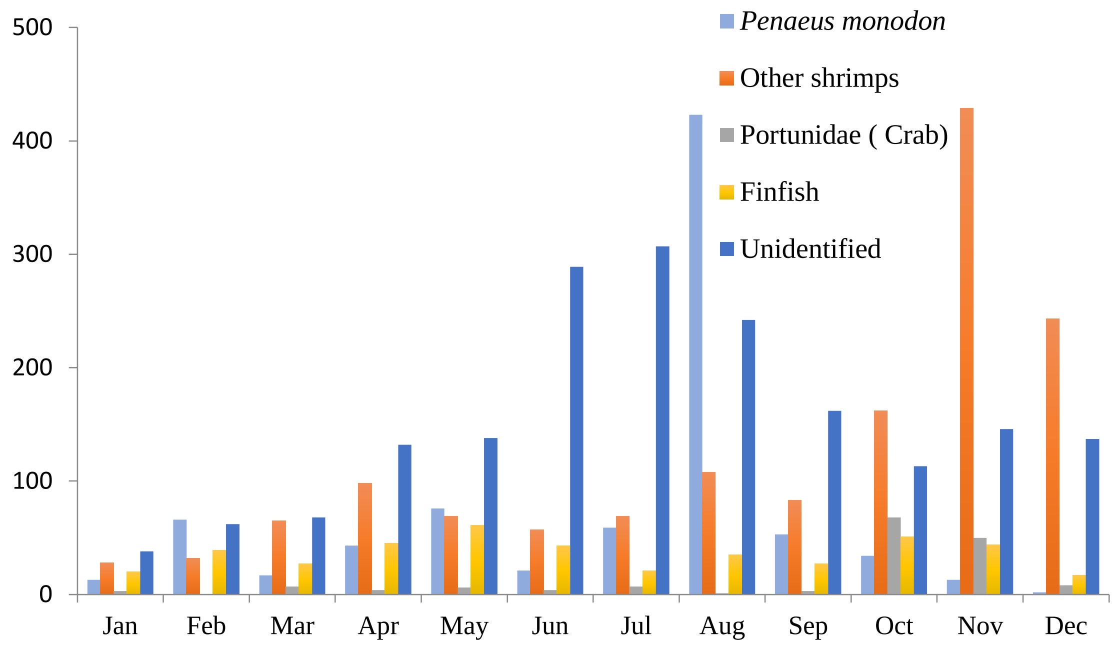
B



C

Figure 4.5 Temporal distribution of different taxa in three sampling stations of Kumira, coastal region of Chattogram: A. Station-1, B. Station-2, C. Station-3

4.6 Mean individual number of catch composition in different seasons

After collecting all the data of targeted 12 months (January to December) from three different stations of Kumira, the mean number of different family were determined and separated to evaluate their seasonal variation. The mean individual number of catch composition in different seasons (winter, summer and rainy) are showed in Figure 4.6. In rainy season, *P. monodon* PL was found to be higher compared with the other groups. Whereas, their abundance reduced during winter season when PL of *Macrobrachium lamerrei* was in peak position. The number of larvae from Gonostomatidae family was also found to be higher in rainy season compared to the two other seasons.

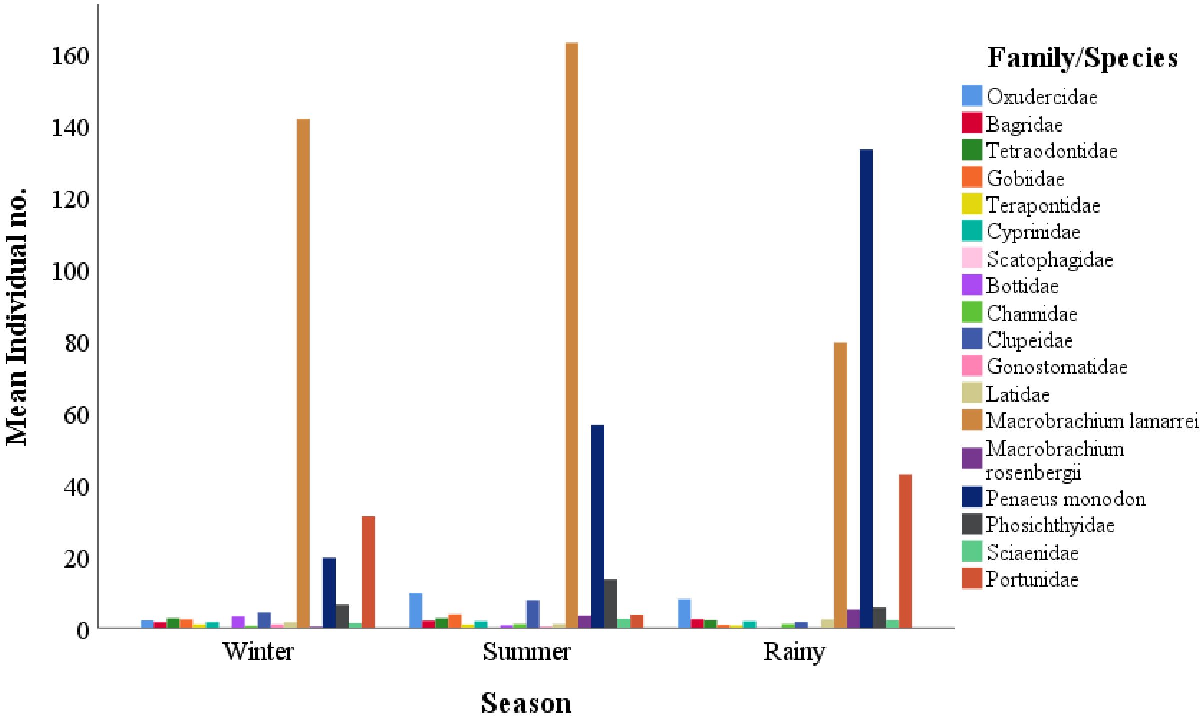


Figure 4.6: Individual number of different family/species calculated for three different seasons (winter, summer and rainy)

Chapter-5: Discussion

5.1 Catch composition and relative abundance of different major groups

Post larvae of *P. monodon* were discovered to make up a lower percentage of the total yearly capture composition, with 749, 941, and 820 in stations 1, 2, and 3 of the Kumira Estuary, respectively. In comparison to the larval availability of *P. monodon*, juveniles of other crustacean species (*Macrobrachium rosenbergii*, *Macrobrachium lamarrei*, and crab spp., etc.) contributed less to the composition of the total annual capture. The proportion of known and unidentified fin fish larvae was found to be relatively greater than that of the other major groupings. According to Mahmood (1990), the Chakaria Sundarbans has the highest density of macroplankton, followed by Satkhira and Khepupara. Additionally, shrimp (*P. monodon*) post larvae alone contributed very little to the total annual catch (0.7% in Chakaria and Khepupara, and 1.2% in Satkhira), and other shrimp and fin fishes only made up about 2% of the macroplankton community. According to Islam et al. (1999), macroplankton populations were higher than those of finfish and other shrimp in the Andermanik River in Patuakhali (53.51%), Ichamati River (93.19%), and Kholpatua River (96.56%). Other shrimp and fin fish made up 40.60 and 5.28% of the Patuakhali Andermanik River's catch, respectively. But in the Ichamati River, these were 5.18 and 1.57%, while in the Kholpatua River, Satkhira, they were 9.84 and 0.92%. In Patuakhali (0.61%) and Satkhira (0.06 and 0.05%) regions, which were only marginally different from the present data, *P. monodon* alone scored the lowest number.

In this investigation, shrimp PL contributed as 14%, 17% and 18% of the total catch from station 1, station 2 and station 3, respectively. The major contribution was from the fin fish groups (identified and unidentified) found in total catch composition. The difference in the results with previous studies might be because the sampling areas are in different region of Bangladesh (spatial difference) as well as the pattern in availability and abundance of shrimp PL in estuarine regions has been changed with the time (temporal differences).

5.2 Destruction of other species while PL collection (*P. monodon*)

The catch composition and the extent of damage caused to macrozooplankton and other aquatic organisms as a result of mercilessly harvesting of *P. monodon* PL have been presented in Table 4.3. The results of the study implied that shrimp seed harvesters killed around 2.61 other crustacean species (prawn and crab) and 3.5 fin fish larvae for catching a single PL of *P. monodon*. This estimate is in parallel to earlier studies (Mahapatra et al., 1995; Naylor et al., 2000) where such loss had been estimated with a much lower intensity.

In the Chakaria Sundarbans, Satkhira, and Khepupara estuaries, 14 different shrimp species, 21 fin fish species, and 1631 zooplanktons were reportedly destroyed for the sake of obtaining just one PL of *P. monodon*, according to Mahmood (1990). The present data suggest that fluctuations in the zooplankton population may be caused by differences in the mesh size of the collection net. A rectangular nylon net with a lower mesh size (0.5 mm) was employed by Mahmood (1990). The seed collectors' net in the current investigation has a mesh size of 1 mm. Because of this, smaller zooplankton and other species were unable to pass through the 0.3 mm mesh net used in PL collection. Other possible explanations include variations in sampling techniques, temporal changes in seed collection intensity, differences in the research period's seasonality, and most importantly, variations in water quality and other environmental factors. According to BFRI (1996), in the Bagerhat region of Bangladesh, one PL of *P. monodon* was procured in 1996 at the expense of 356 larvae of other shrimp species, fin fishes, and macrozooplankton. According to Islam et al. (1999), the fry collectors in the Satkhira region killed 587 larvae of other shrimp, fin fish, and macrozooplankton for every PL of *P. monodon* they caught. BOBP (1992) and Khan et al. both noted the enormous loss of priceless aquatic creatures (1988). Additionally, this approach also kills a great deal of *P. monodon* PL. Also, the estimated loss of by-catch in the process in coastal area of Bangladesh (Deb et al., 1994) and Honduras (DeWalt et al., 1996; Stanley and Alduvin, 2002) was consistent and parallel with the present observation.

5.3 Seasonal variation of catch composition in different stations

In this investigation, it was observed that, non-penaeid shrimps dominated the bycatch. This may be due to their seasonal breeding patterns are parallel to those of the penaeid shrimps. Furthermore, factors affecting the water quality, such as salinity, temperature, and dissolved nutrients, were favorable for the larvae of these species. The wet monsoon season saw the highest concentration of finfish seeds in the by-catch. For the majority of brackish water fish, this coincides with the spawning season (Basu and Pakrasi, 1979; Ghosh et al., 1990). Since both the density of desired shrimp seed and the population of undesirable bycatch were at their maximum during the peak season, it is possible to explain the divergence from this pattern by noting that the relative abundance of the desired shrimp seed increased noticeably. This argument was unequivocally proven true since, during peak season, there was an inverse relationship between the rate of bycatch loss and the rate of shrimp seed harvested per gear. Additionally, this association showed a polynomial equation across the whole study period, accounting for both the lean and peak seasons together.

The greater variability of the coastal biota was directly related to the availability of shrimp seeds since the maximum abundance of by-catch occurred at the same time as the maximum availability of shrimp seeds. Due to the research area's location at the river mouth, the delta saw high inflows of surface runoffs during the monsoon months, which favored the enrichment of biodiversity during that time (Ghosh et al., 1990; Nath and Sinha, 1996; Nath, 1998). The late monsoon months, when the biodiversity indices reached their peak values, had the greatest impact on the loss of biodiversity as by-catch loss. Consequently, when population stability and heterogeneity were at their highest, the effects of seed collecting using non-selective gears on the coastal aquatic biota were primarily negative.

It is clear that the ongoing practice of gathering wild shrimp harms not just the local aquatic community and shrimp fishery but also the other animals connected to it through the specific food web by disrupting their feeding niches. In Bangladesh (Hoq et al., 2001) and throughout the northeastern coast of India (Bhattacharya and Sarkar, 2002) , indiscriminate use of coastal waters seed supplies led to a major decline in not only shrimp seed but also finfish and crab fisheries.

Chapter-6: Conclusions

It is apparent that overfishing and other anthropogenic activities have put many shrimp species and other aquatic animals in danger. On the other side, there is a rising tendency in fishing efforts. Initiatives for shrimp PL conservation that have already been implemented appear insufficient for maintaining shrimp PL abundance. This is because there are so many people harvesting shrimp PL in large numbers using various fishing nets and fry collectors. It is obvious that many shrimp species and other aquatic life are at risk due to overfishing. In addition, hundreds of landless and vulnerable members of the coastal community, notably women and children, are employed by the gathering of wild PL. 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. As a result, it is vital to teach the fry catchers such that, while P. monodon PL is being collected, other valuable aquatic animal larvae caught in the net can be released back into the water without suffering any harm. This will support the maintenance of aquatic biodiversity, ecological balance, and natural yield.

Chapter 7: Recommendations and Future perspectives

The capture of wild PL for use as seed in the aquaculture and prawn farming industries is a crucial component of aquaculture endeavors and continues to be so in many nations throughout the world (Paez-Osuna, 2001). Nevertheless, the widespread community's reliance on fisheries is destroyed as a result of the uncontrolled harvesting of wild PL. Furthermore, it is impossible to emphasize the wider effects of these activities on the entire coastal population due to the damage of coastal habitats, loss of aquatic species, and other effects.

The government must therefore develop strategies for the regulation and management of the fisheries and aquaculture industries while also looking for other livelihood alternatives for the large population that depends on these resources. It seems certain that there will be a temporary or permanent prohibition on the harvesting of the wild PL in some environmentally delicate places, like the Sundarbans and the routes used by fish and shellfish to migrate as postlarvae. These are only a few of the steps that could reduce the pressure of overexploitation on aquatic and fisheries resources, assisting in the maintenance of marine, coastal, and estuarine fisheries.

Furthermore, future research attempts may include the followings:

i. Species destruction rate on other fishing stations of shrimp PL collection should be assessed
ii. The effect of biodiversity loss on the stock recruitment of different aquatic species should be evaluated
iii. Most affected areas from both freshwater and coastal area of Bangladesh should be identified because of indiscriminate shrimp PL collection
iv. Comparative study might be held of different study areas.

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Photo Gallery

Plate No. 01: Sampling by push and pull Net	
Plate No. 02 : Collected sample in container	
Plate No. 03: Sample Sorting and Grouping	

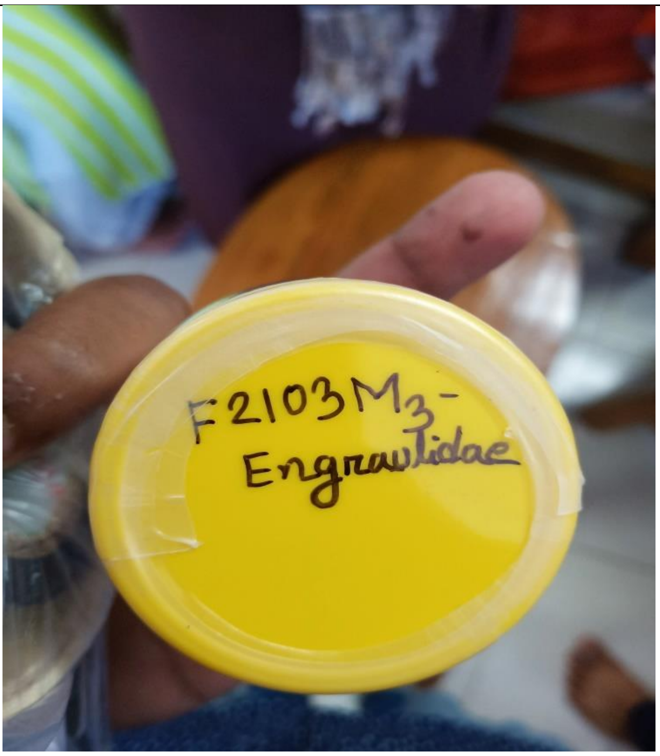
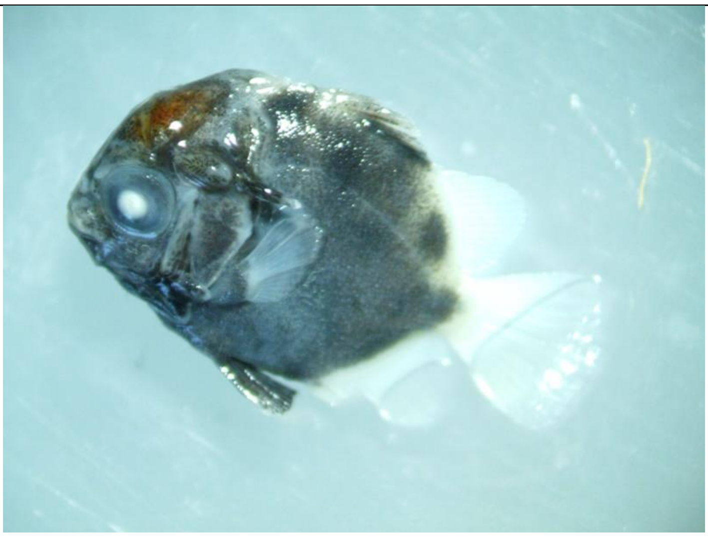
Plate No. 04 : Larvae Identification under stereo microscope	
Plate No. 05 : Identified samples were preserved with 90% ethanol	
Plate No. 06 : Labeling and Storage	

Plate No. 07 : Penaeus monodon	
Plate No. 08 : Macrobrachium rosenbergii	
Plate No. 09 : Macrobrachium lamarrei	

<table>
<tr><td>Plate No. 10 :
Cyprinidae</td><td></td></tr>
<tr><td>Plate No. 11 :
Latidae</td><td></td></tr>
<tr><td>Plate No. 12 :
Oxudercidae-1</td><td></td></tr>
</table>

Plate No. 13 : Oxudercidae-2	
Plate No. 14 : Portunidae-1	
Plate No. 15 : Portunidae-2	

Plate No. 16 : Scatophagidae	
Plate No. 17 : Terapontidae	
Plate No. 18 : Unidentified	

Appendices

Appendix-1 ANOVA table showing relation between month and station with abundance

Individual no. * Month	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	67613.96	11	6146.724	1.92	0.034
Within Groups	2468542	771	3201.741		
Total	2536156	782			

Individual no. * Station	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1822.743	2	911.372	0.28	0.755
Within Groups	2534333	780	3249.145		
Total	2536156	782			

Appendix-2 Monthly collected larvae data of crustacean and finfish larvae

Station 1	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Penaeus monodon	11	47	44	51	88	74	53	333	41	0	4	3
Macrobrachium rosenbergii	0	1	0	0	1	12	9	8	2	0	0	0
Macrobrachium lamarrei	41	52	68	111	213	327	72	47	88	128	251	134
Portunidae	2	1	4	3	3	2	1	5	1	219	123	24
Bottidae	2	4	1	0	1	0	0	0	0			
Gonostomatidae	2	9	4	0	0	0	0	0	0	0	0	1
Phosichthyidae	2	7	2	13	21	5	1	3	10	0	9	0
Clupeidae	3	15	12	7	9	0	4	0	0	0	0	0
Channidae	0	2	0	0	1	0	1	0	0	4	0	0
Latidae	0	0	1	1	2	0	2	0	1	7	3	3
Oxudercidae	6	0	4	7	12	15	11	8	3	8	3	4
Bagridae	1	0	3	1	5	0	0	3	1	3	4	1
Tetraodontidae	1	0	1	2	4	4	1	3	2	10	4	3
Gobiidae	2	2	4	5	6	3	0	0	0	2	3	2

Terapontidae	1	0	2	1	1	0	0	0	1	0	0	1
Cyprinidae	1	2	2	3	1	0	0	5	0	5	3	3
Scatophagidae	0	0	0	0	0	0	0	0	0	1	0	0
Sciaenidae	0	1	3	4	3	1	5	1	3	0	0	3
UN-01	48	58	65	76	132	259	227	453	121	234	98	101
UN-02	21	34	22	15	16	27	36	66	44	28	33	11
UN-03	0	0	0	0	0	0	0	0	0	0	0	0
UN-04	0	0	0	0	0	0	0	0	0	0	0	0

Station 2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Penaeus monodon	9	58	53	34	79	98	67	467	47	21	5	3
Macrobrachium rosenbergii	0	2	0	1	5	11	11	3	4	0	0	0
Macrobrachium lamarrei	38	64	79	143	278	458	54	88	67	13	192	198
Portunidae	2	7	4	1	3	4	2	7	1	198	112	41
Bottidae	1	2	0	2	0	0	0	0	0			
Gonostomatidae	0	0	0	0	0	0	0	0	0	0	0	0
Phosichthyidae	7	27	11	32	44	0	3	3	0	17	5	1
Clupeidae	3	14	5	4	15	6	1	1	0	3	0	0
Channidae	0	2	1	2	4	0	0	0	3	1	0	2
Latidae	1	2	3	0	1	1	3	1	5	4	4	3
Oxudercidae	3	0	5	7	10	12	9	12	8	0	1	0
Bagridae	0	0	1	1	1	0	1	5	2	3	1	1
Tetraodontidae	1	0	4	1	1	3	0	1	0	0	0	3
Gobiidae	1	0	1	8	6	2	3	0	1	1	2	2
Terapontidae	4	0	1	1	3	0	0	0	2	0	0	3
Cyprinidae	2	1	1	3	3	5	0	4	2	0	3	1
Scatophagidae	0	0	0	0	0	0	0	0	0	0	0	0
Sciaenidae	2	2	2	4	5	1	3	1	1	1	3	3
UN-01	33	62	77	103	212	318	321	211	112	109	115	99

UN-02	13	40	32	27	33	65	47	21	36	22	35	28
UN-03	0	0	0	0	0	0	0	0	0	0	0	0
UN-04	0	0	0	0	0	0	0	0	0	0	0	2

Station 3	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Penaeus monodon	13	66	17	43	76	21	59	423	53	34	13	2
Macrobrachium rosenbergii	0	1	0	0	2	9	7	7	11	0	0	0
Macrobrachium lamarrei	28	31	65	98	67	48	62	101	72	162	429	243
Portunidae	3	0	7	4	6	4	7	1	3	68	50	8
Bottidae	6	11	3	1	1	0	0	0	0			
Gonostomatidae	0	0	0	0	0	0	0	0	0	0	0	0
Phosichthyidae	3	11	5	15	10	4	1	1	7	23	6	0
Clupeidae	1	14	3	8	21	2	3	0	1	7	3	0
Channidae	0	0	0	3	1	1	2	0	1	1	1	0
Latidae	0	0	1	1	2	0	1	0	3	1	2	1
Oxudercidae	4	1	7	3	11	25	12	15	7	3	0	3
Bagridae	2	0	4	5	2	1	0	6	4	1	6	3
Tetraodontidae	1	0	1	6	4	1	1	1	1	6	11	8
Gobiidae	1	1	1	1	3	6	0	2	0	1	11	1
Terapontidae	1	0	1	0	1	0	0	3	0	2	1	1
Cyprinidae	1	0	0	0	4	0	0	5	0	1	2	0
Scatophagidae	0	0	0	0	0	0	0	0	0	0	0	0
Sciaenidae	0	1	1	2	1	3	1	2	3	5	1	0
UN-01	21	31	31	111	116	257	286	204	145	94	117	116
UN-02	17	31	37	21	22	32	21	38	17	19	28	21
UN-03	0	0	0	0	0	0	0	0	0	0	1	0
UN-04	0	0	0	0	0	0	0	0	0	0	0	0