E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 76.37
(GIF) Impact Factor: 0.549
IJFAS 2025; 13(1): 23-29

www.fisheriesjournal.com
Received: 16-11-2024
Accepted: 17-12-2024

S Datta
Department of Coastal and Marine Fisheries, Sylhet Agricultural University, Sylhet, Bangladesh

MS Islam
Department of Coastal and Marine Fisheries, Sylhet Agricultural University, Sylhet, Bangladesh

MM Shamsuzzaman
Department of Coastal and Marine Fisheries, Sylhet Agricultural University, Sylhet, Bangladesh

M Akter
Department of Coastal and Marine Fisheries, Sylhet Agricultural University, Sylhet, Bangladesh

IN Suravi
Department of Coastal and Marine Fisheries, Sylhet Agricultural University, Sylhet, Bangladesh

TR Das
Department of Coastal and Marine Fisheries, Sylhet Agricultural University, Sylhet, Bangladesh

A Mamun
Department of Coastal and Marine Fisheries, Sylhet Agricultural University, Sylhet, Bangladesh

LR Rupa
Department of Coastal and Marine Fisheries, Sylhet Agricultural University, Sylhet, Bangladesh

Corresponding Author:
MS Islam
Department of Coastal and Marine Fisheries, Sylhet Agricultural University, Sylhet, Bangladesh

Abundance and damage of shell and fin-fish larvae during collection of Shrimp (*Penaeus monodon*) Fry at Cox's Bazar Sea Beach

S Datta, MS Islam, MM Shamsuzzaman, M Akter, IN Suravi, TR Das, A Mamun and LR Rupa

DOI: https://doi.org/10.22271/fish.2025.v13.i1a.3010

Abstract
The study was conducted to assess the damage carried out to various aquatic fauna during the collection of *Penaeus monodon* PL and to determine the abundance of PL. Additionally, observations were made on the distribution of aquatic organisms in relation to seasonal variations in water quality parameters. Water temperature, pH, and salinity were found to vary insignificantly throughout the study period, but hardness showed significant fluctuations. *P. monodon* PL abundance was significantly ($p<0.05$) correlated with salinity, pH, and water temperature, according to regression analysis but not correlated with hardness. It was found that during collection period for only PL of *P. monodon*, approximately 2 other shrimp larvae, 15 fin fish, and 22 other macrozooplankton were killed. On average, 27.23 million *P. monodon* PL were collected half yearly from the studied area during survey period, which involved around 6.789 million man-days/6 months for shrimp PL collection activities. Present study also estimated that harvesting of shrimp seeds at Cox's Bazar sea beach destroyed about 1062 million other shrimp species, fin fish, and macrozooplankton half yearly. Therefore, results of this study imply that current methods of collecting shrimp seeds/PL severely damage other valuable aquatic fauna, which has a negative effect on tidal waters biodiversity, natural productivity, improvement of natural stocks, and congenial environment of coastal and marine waters.

Keywords: Shrimp, fin fish, macrozooplankton, shrimp seed collectors, biodiversity

1. Introduction
Coastal aquaculture is an essential source of employment and export earnings for coastal communities. It is especially important for the production of giant freshwater prawns (*Macrobrachium rosenbergii*) and black tiger shrimp (*Penaeus monodon*). After Bangladesh's garment sector, shrimp and prawns are Bangladesh's second-largest source of foreign revenue. Total production of shrimp and prawn in Bangladesh was 0.16 million MT in 2003, and it reached approximately 0.27 million MT in 2022-23, according to Department of Fisheries (DoF, 2024). Although post-larvae produced in hatcheries are currently accessible in many Asian and Latin American nations, wild fry continues to be an important source of seed in various locations (FAO, 2007) [8].

In Bangladesh, farming of shrimp and prawns depends mostly on post-larvae (PL) obtained from wild. In the past, hatchery-produced fry has been thought to be of lesser quality, thus prawn producers have preferred to stock their farms with wild PL because of their limited accessibility (Ahmed *et al.* 2005; Angell, 1992) [2, 3]. According to Muir (2003) [22], there is additionally evidence that the survival rate of wild PL is significantly higher than that of fry raised in hatcheries. Two billion shrimp fries are thought to be obtained from wild sources each year. Over 50% of black tiger shrimp comes from wild, whereas over 90% of freshwater prawn comes from natural areas (Banks, 2003). One of the things that are causing fish biodiversity to decline is this dependence on wild sources. Collection of wild PL has been known to have a negative influence on coastal biodiversity (Bhattacharya & Sarkar, 2003) [5]. According to reports (Ferdousi *et al.* 2017) [9], 412 additional shrimp larvae, 391 fin fish, 1696 macrozooplankton, and other prawn species were discarded

in order to collect a single shrimp PL. This poses a serious threat to biodiversity. Shrimp PL collection is a source of income for thousands of impoverished rural people living along the Kuakata sea beach, which stretches from Patuakhali to the Andarmanik river on the south coast. The two primary types of gear used by fry collectors were the pull net (baksho jal) and the set bag net (Behundi jal), which accounted for 95% of all nets (Ahmed, 2003) [2]. The poor marginal fishers on this beach, who engage in shrimp-related activities like trading in fishing gear and transporting harvested PL, also rely heavily on the collection of wild PL for their livelihood.

The general issues with shrimp culture in the nation include lack of scientific knowledge, ownership patterns, land use conflicts, institutional credit issues, security, shortages of shrimp PL, lack of affordable and high quality feed, diseases of shrimp, production management, marketing, and transportation. The lack of sufficient shrimp PL is the primary issue facing shrimp farmers out of all of these. There is a huge demand for natural shrimp PL due to the expansion of shrimp growing area, the trend of selective stocking, and the lack of hatchery produced PL available when needed. Consequently, countless shrimp are harvested from the sea coast, rivers, estuaries, and tidal creeks. Thousands of coastal residents from low-income groups have been drawn to shrimp fry collection by the low investment and high return. Following each hauling, the entire catch is preserved by sprinkling water over the net in various pots. The collector or another member of the family/group typically sorts and gathers only the targeted *P. monodon* PL; the remainder of the haul, which consists of other shrimp, macrozooplankton, and fin fish larvae that are of no value to them, is randomly threw on the dry shore. In this way, a large number of various fin and shell fish fry are harmed every day. This approach has a significant negative impact on the native shrimp and other fish stocks (Khan & latif, 1997) [19]. According to Primavera 1998 and Hoq *et al*. (2001) [24], there is a serious impact on coastal biodiversity from shrimp PL collecting throughout the year. Hasan *et al*. (2019) [13] have reported that a single shrimp PL was caught on the Kuakata sea beach in Patuakhali, resulting in the destruction of approximately 79 other shrimp larvae, fin fish, and macrozooplankton. But very little works have been done at the sea beach of Cox's Bazar region. Therefore, considering the above facts, the current half year-long study was conducted at three locations along the sea beach of the Cox's Bazar district to assess the availability of *P. monodon* PL and to quantify the damage of fin fish, shellfish and other aquatic organisms during shrimp PL collection.

2. Materials and Methods

2.1 Study area

The area of Cox's Bazar sea beach is 155 km, located in between 21°36' and 21°25'north latitudes and in between 92°7' and 91°55'east longitudes. It is bounded by the Bay of Bengal to the west and the hills of the Chittagong hill tracts to the southeast (Fig. 1).

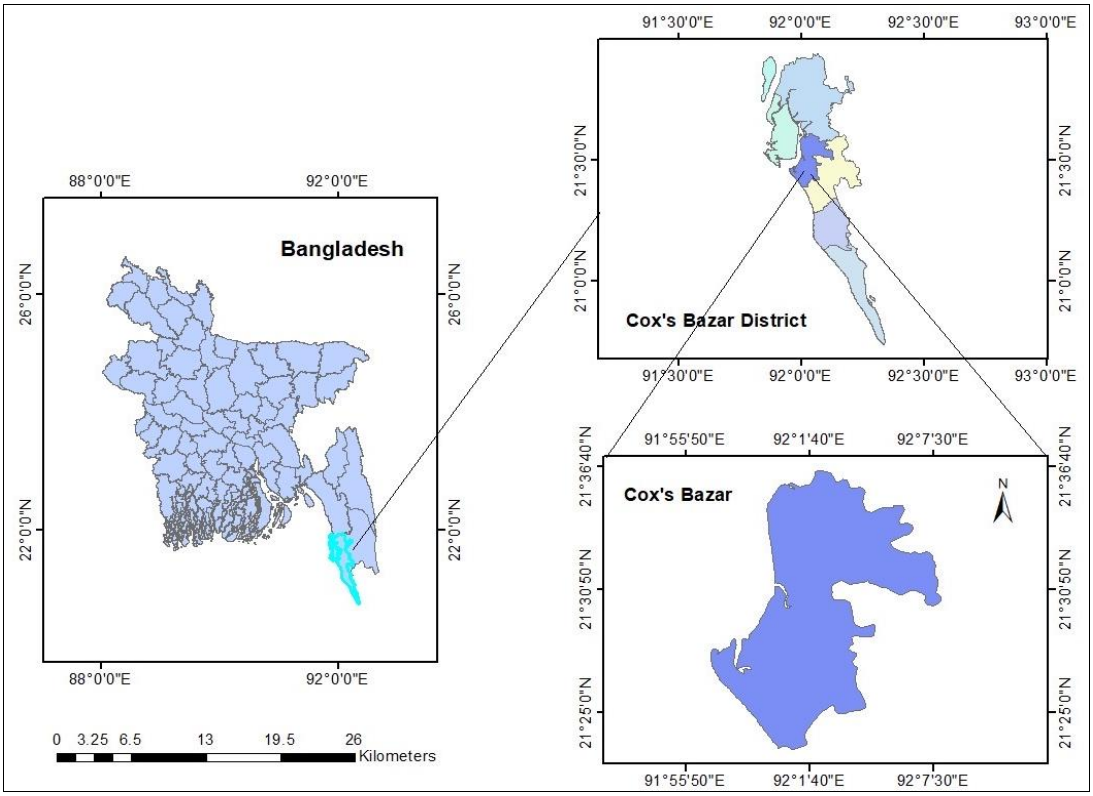


Fig 1: Location of the study area in the Cox's Bazar district of Bangladesh (ArcGIS).

2.2 Duration of the study

The study was conducted for 6 months which started from December 2023 and continued up to May 2024. For the collection of samples, three different spots namely Spot 1, Spot 2 and Spot 3 of Cox's Bazar sea beach were selected (Fig. 1).

2.3 Field activities

Samples were collected every month using fine meshed (1.0 mm) nylon net and bamboo split frames (1.6 x 0.6 m). Drag and push nets are usually used in traditional seed collection operations. The sample was taken during both the new and full moons. The beach's shallow water was used to operate the net. The average hauling time was ten minutes. At that time,

two samples were collected at high and low tide. After collection, samples were immediately stored in plastic pots and kept in 5% neutralized formalin to facilitate the sorting of shrimp PL, fin fish larvae, and other organisms. But shrimp seed harvesters immediately removed the PL of shrimp from the organisms kept in their pots using nets. Using a portable refractometer (ATAGO, Hand-Held Refractometer), the salinity of the water at each location was determined. An alcohol thermometer and a digital pH meter (Hanna, USA) were used to estimate the temperature and pH of the water, respectively. Titrimetric analysis was used to determine the total hardness of the water using a standard EDTA–0.800 M solution and Manver 2.

2.4 Laboratory analysis
Samples were brought into the laboratory for analysis, which was completed within two weeks of the date of collection. Macrozooplankton, which includes other shrimp, and fin fishes were identified as the major taxonomic group following Fischer and Witchead (1974) [10], George (1969) [12], and Quddush & Shafi (1998) [25]. Penaeid shrimp larvae were identified up to species level following Muthu (1978) [23] and Motoh and Buri (1980) [21].

2.5 Commercial catch data
Daily average catch of push net was recorded by interviewing shrimp seed collectors. It was calculated to find average number of collectors and operating nets per kilometer. It was noted how many days a month there were for fishing. Using Google map, the entire length of the sea beach was determined. Total number of people involved in shrimp fry collection activities as well as the half yearly catch total of *P. monodon* PL was calculated by tabulating and extrapolating the collected data.

2.6 Statistical analysis
Statistical analysis of the recorded water quality parameters and abundance of *P. monodon* PL of the surveyed spots were done using a standard statistical package of MS-Excel, MS-Word and SPSS (Statistical Package for Social Sciences version 27).

3. Results and Discussion
3.1 Water quality parameters
The monthly mean water temperature values are shown in Table 1. The temperature of the water did not vary significantly across all spots. There were records for the highest temperature (32.0 °C) in April and the lowest temperature (20.0 °C) in February. This result is related to Islam *et al*. (2001) [14], who measured the maximum temperature at Cox's Bazar sea beach (29.0 °C) in April and the lowest temperature (24.6 °C) in January. This observation aligns more or less with the results of Ferdousy *et al*. (2017) [9], who recorded temperatures in the Mongla tidal river in Bagerhat ranging from 22.0 to 33.1°C. pH values in the present study, which ranged from 6.0 to 8.0, were found to be in accordance with those reported by Islam *et al.* (2001) [14], who reported that the pH values in Cox's Bazar were between 6.9 and 8.0. This result also states with the findings of Islam *et al*. (2015) [17], who obtained the pH in the Mongla River (Rampal), Bagerhat, and determined that the values ranged from 6.9 to 8.4. The water in these locations fell within the alkaline range, according to the pH values obtained from the various spots. Salinity of the water ranged from 28.0 to 34.5 ppt, which is mostly similar with the results of Islam *et al*. (2001) [14], who reported salinity values from the tidal water in Cox's Bazar sea beach ranging from 27.0 to 34.5 ppt. Around every spot March had the highest salinity (34.5ppt). Salinity decreased to 28.0 ppt in May, which may have been brought on by heavy rains, river runoff, land drainage, and the pre-monsoon effect. On the other hand, salinity was observed to gradually rise following the month of December. Total hardness values of 5700.0–6800.0 mg/l had been found to be in accordance with Islam *et al*. (2001) [14] findings, which determined that hardness values in Cox's Bazar beach ranged from 5700–6600 mg/l. March and April had the highest value (6800.0 mg/l), while February had the lowest value (5700.0 mg/l). The water's hardness did not significantly differ between different spots. During the pre-monsoon season, total hardness has been found to increase.

Table 1: Monthly fluctuation of water temperature, salinity, pH and total hardness of Cox's Bazar sea beach during the study period from December 2023 to May 2024.

Water quality parameters	Months					
	Cox's Bazar Sea Beach					
	Dec	Jan	Feb	Mar	Apr	May
Water Temperature (°C)	27.0±1.40 (26.0–29.0)	23.4±0.48 (23.0–24.0)	29.8±1.19 (20.0–22.5)	28.6±2.30 (26.0–27.5)	30.4±1.38 (29.0–32.0)	30.1±0.63 (29.5–31.0)
pH	7.4±0.45 (7.0–8.0)	7.9±0.20 (7.5–8.0)	7.9±0.25 (7.5–8.0)	6.5±0.58 (6.0–7.0)	6.5±0.39 (6.0–6.9)	6.8±0.41 (6.2–7.1)
Salinity (ppt)	29.3±1.04 (28.0–30.5)	30.4±1.10 (29.0–31.5)	29.8±0.50 (29.0–30.0)	33.5±1.08 (32.0–34.5)	32.9±1.18 (31.0–33.5)	31.2±1.26 (29.8–32.5)
Hardness (mg/l)	6275.0±95.74 (6200.0–6400.0)	6200.0±216.0 (5900.0–6400.0)	6000.0±244.9 (5700.0–6300.0)	6650.0±129.10 (6500.0–6800.0)	6475.0±236.3 (6300.0–6800.0)	6275.0±262.1 (5900.0–6500.0)

3.2 Abundance and distribution of different taxa
The monthly distribution (individual/unit effort) and half yearly mean catch composition (%) of *P. monodon*, other shrimps, other macrozooplankton, and fin fishes in the sea beach of Cox's Bazar is displayed in Tables 2 and 3. Data showed that it was from December through May. *P. monodon* larvae could be found from February to May, with February showing the highest number of recorded spots. Other shrimp species were found to be more abundant from March to April, with a peak abundance observed in all spots in April. The distribution of zooplankton and fin fish did not follow a consistent pattern. Additionally, their abundance varied from month to month. An abundance of macrozooplankton and fin fish was observed in higher amounts during the pre-monsoon period than during the rest of the year. This result is consistent with research by Islam *et al*. (2015) [17], Rahman *et al*. (1997) [26], and Islam *et al*. (1999a) [15], which suggested that reduced salinity and temperature are most likely the main variables significantly affecting the larval distribution of aquatic fauna.
At all three spots along Cox's Bazar sea beach, post larvae of

P. monodon were found to make up a very small portion of the 6-month catch composition (3.05, 2.28, and 2.19%, respectively). According to Islam *et al*. (2001) [14], the average annual catch composition of *P. monodon* at three different locations along the sea beach in Cox's Bazar was 2.48%. The results of Islam *et al*. (2001) [14], who reported that the average annual catch composition of other shrimp species at Cox's Bazar beach was 9.99%, are almost similar to the findings of this study, which show that juveniles of other shrimp species (*Penaeus semisulcutes, P. indicus, P. merguiensis, Metapenaeus monoceros, M. brevicornis, Macrobrachium rosenbargii, M. malcolmsonii, M. lancesteri, M. villosimanus, M. mirabile, M. birmanicum, M. rude, M. dayanum*, etc.) were exerted at 5.38% in spot 1, 4.72% in spot 2, and 4.56% in spot 3.Larvae of fin fishes (*Liza parsia, Polynemus paradiseus, Polydactylu sindicus, Rhinomugil corsula, Otolithoides pama, Rachycentron canadus, Stromateus chinensis, Parastromateus niger, Arius* sp., *Gudusia chapra, Mystus* spp., *Lactaries lactarius, Glossogobius* spp., *Trichiurus haumela, Glossogobius* spp., *Setipinia phasa, and Pomadasys hasta*, etc.) shared 33.51, 37.79, and 41.05% of the total catch in spots 1, 2, and 3, respective. Islam *et al*. (2001) [14] reported that 36.48% of the fin fish larvae at three different locations were found at the sea beach in Cox's Bazar. Islam *et al*. (1997) also stated that fin fish larvae in the Meghna River at Bhola had an average annual catch composition of 11.45%, which is lower than the present findings. Three different locations at the Cox's Bazar beach displayed different densities of macrozooplankton (*Acetes* sp., Mysids, Isopods, Copepod, *Alima*, Crab larvae, etc.) of 58.06, 55.21, and 52.19%, respectively. The total annual average catch composition of macrozooplankton was reported to be 51.05% at Cox's Bazar sea beach and 60.41% in the Meghna river (Bhola) by Islam *et al*. (2001) [14] and Islam *et al*. (1997) [13]. Mahmood (1990) [20] reported that the Chakaria Sundarbans had the highest density of zooplankton (98.30%), followed by Satkhira (97.72%) and Khepupara (97.53%). Furthermore, just 2% of the zooplankton community was composed of other shrimp and fin fish, and the post-larval of shrimp (*P. monodon*) alone made up a very tiny portion of the yearly catch (0.7% in Chakaria and Khepupara and 1.2% in Satkhira). According to Islam *et al*. (1999a) [15], zooplankton was found in higher concentrations than fin fish and other shrimp in the Andermanik River of Patuakhali (53.51%), Ichamati River (93.19%), and Kholpatua River (96.56%) in Satkhira district. Fin fish and other shrimps obtained 40.60 and 5.28% of the Patuakhali Andermanik River, respectively. However, these were, in the Ichamati River, 5.18 and 1.57%, and, in the Kholpatula River, Satkhira, 9.84 and 0.92%. Shrimp (*P. monodon*) by itself received the lowest percentage in the Andermanik River (0.61%) and Satkhira (0.06 and 0.05%) regions, both of which are lower than the present findings.

The composition of the catch and the impact on macrozooplankton and other aquatic organisms due to the intensive harvesting of *P. monodon* PL has been presented in Table 3. It was found that *P. monodon* PL contributed, on average, only 2.51% of the total relative abundance, with other shrimp species contributing 4.89%, fin fish contributing 37.45%, and other macrozooplankton contributing 55.15%. In all three spots along the coastline in Cox's Bazar, there were no significant variations in the half-yearly catch composition (Table 3). But in the monthly distribution, spot 2 (150) had the highest amount of macrozooplankton in April, followed by spots 1 (130) and 3 (120). The study's findings showed that every single PL of *P. monodon* that was caught, shrimp seed collectors killed about 2 other shrimp species, 22 other macrozooplankton, and 15 fin fish. This result is in agreement with that of Islam *et al*. (2001) [14], who found that only one PL of *P. monodon* was caught on the sea beach in Cox's Bazar, resulting in the destruction of 4 other shrimp species, 31 macrozooplankton, and 7 fin fish. Mahmood (1990) [20] reported that in the Chakaria Sundarbans, Satkhira and Khepupara estuaries, 14 other shrimp species, 21 fin fish, and 1631 zooplanktons were killed for the collection of a single PL of *P. monodon*. According to the present findings, variations in the zooplankton population could be caused by differences in the PL collection net's mesh size. Mahmood (1990) [20] used a rectangular nylon net with a mesh size of only 0.5 mm. The net used for the present study had a mesh size of 0.1 mm, which is similar to that of seed collectors' nets. This means that through the smaller mesh (1.0 mm) of the net used in the current study, smaller zooplankton and other species may be able to escape. Rahman *et al*. (1997) [26] also reported, for each *P. monodon* PL collected, the deaths of 58 other shrimp, fin fish, and macrozooplankton, which is less than the results of this research. BOBP (1992) and Khan *et al*. (1998) [19] also reported on the massive loss of significant species diversity in aquatic organisms. Additionally, this practice results in the death of a great number of *P. monodon* PL because it raises the risk of damaging various PL appendages and creating stress during collection and transportation, both of which can result in death.

In Cox's Bazar sea beach, shrimp seed collection activities involved 6.789 million man days/6month, according to observations conducted regarding the number of seed collectors/km, length of the sea beach, and hour of appointment. These findings above those of Islam *et al*. (2001) [14], who reported that 1.15 million man-days half yearly contributed to shrimp seed collection activities on the beach of Cox's Bazar. Satkhira district was home to around 20,000–25,000 people who collected shrimp fries, according to Funegaard (1986) [11]; however, Chowdhury (1990) [6] estimated that Satkhira district only was home to about 75,000 fry collectors. Between December 2023 and May 2024, approximately 27.23 million *P. monodon* PL were found on the beach in Cox's Bazar. In Cox's Bazar beach, about 50 million *P. monodon* PL were collected, according to Islam *et al*. (2001) [14]. This number is higher than the current findings. The present study also estimated that 1062 million other shrimp species, fin fish, and macrozooplankton were destroyed by shrimp seed collectors in Cox's Bazar beach half yearly. This estimate is significantly higher than that of Islam *et al*. (1999b) [16], who estimated 6809 million other aquatic organisms in Satkhira, but far lower than that of Islam *et al*. (2001) [14], who estimated 25,494 million other aquatic organisms in Cox's Bazar beach. The biodiversity of aquatic organisms is greatly threatened by this scenario. In Satkhira and Bagerhat district, *P. monodon* availability reduced dramatically due to the severe impact of shrimp seed/PL collection activities. Previously available *P. monodon* populations ranged from 2,000 shrimp fry/net/day (Funegaard 1986) [11] to only 200–50 fry/net/day (Alam 1990 and Islam *et al*., 2015) [17]. The results of this study, along with the previously mentioned studies, show that there has been a trend toward a gradual decline in the abundance of fin fish, other zooplankton larvae, and other shrimp in neritic and offshore environments. This may be related to overfishing

using nylon nets with smaller mesh sizes and to the random killing of shrimp and zooplankton, which obstructs the regular recruitment pattern to the original mother stock. Therefore, immediate action must be taken to stop this massive destruction and to raise awareness among seed collectors about the need to return unwanted organisms to the waterbody without causing any harm. These programs would contribute to the preservation of the marine ecosystem's friendly environment as well as the biodiversity of aquatic life.

Table 2: Monthly distribution (individual/unit effort) * of *Penaeus monodon* PL, other shrimps, fin fishes and other macrozooplankton of the Cox's Bazar sea beach during the study period.

Major groups	Month						Total	Percentage (%)
	Dec 23	Jan 24	Feb 24	Mar 24	Apr 24	May 24		
Cox's Bazar sea beach (Spot 1)								
P. monodon PL	1	1	6	3	3	3	17	3.05
Other shrimp	3	6	1	7	10	3	30	5.38
Other macrozooplankton	104	20	12	8	130	50	324	58.06
Fin-fish	30	20	100	15	22	25	187	33.51
Total	138	47	119	33	165	81	558	100
Cox's Bazar sea beach (Spot 2)								
P. monodon PL	0	1	5	2	3	3	14	2.28
Other shrimp	2	5	1	7	11	3	29	4.72
Other macrozooplankton	101	18	11	8	150	51	339	55.21
Fin-fish	32	19	120	15	22	24	232	37.79
Total	135	43	137	32	186	81	614	100
Cox's Bazar sea beach (Spot 3)								
P. monodon PL	1	0	5	2	2	3	13	2.19
Other shrimp	3	6	0	6	10	2	27	4.56
Other macrozooplankton	100	20	12	7	120	50	309	52.19
Fin-Fish	35	22	130	15	21	20	243	41.05
Total	139	48	147	30	153	75	592	100

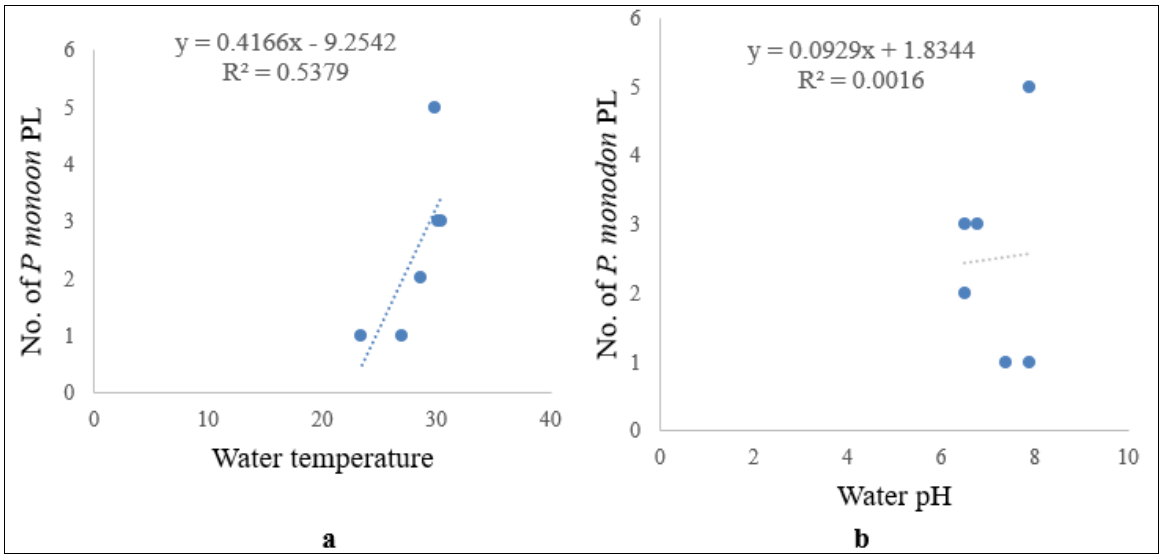
* Operating a drag net (1.6 × 0.6 m) for about 10 minutes taken as a unit effort.

Table 3: Half yearly mean catch composition (%) of *Penaeus monodon* PL, other shrimps, other macrozooplankton and fin fishes of three spots in the Cox's Bazar beach during the study period.

Major group	Cox's Bazar Sea Beach			
	Spot 1 (%)	Spot 2 (%)	Spot 3 (%)	Average catch composition (%)
P. monodon	3.05	2.28	2.19	2.51
Other shrimps	5.38	4.72	4.56	4.89
Other macrozooplankton	58.06	55.21	52.19	55.15
Finfish	33.51	37.79	41.05	37.45

3.3 Relation between abundance of *Penaeus monodon* and some physico–chemical parameters of waters

The relationship between the number of *P. monodon* PL and water quality parameters (water temperature, pH, salinity and hardness) was shown in Fig.2 (a,b,c,d). Statistically a positive correlation was found among *P. monodon* PL and water temperature, pH as well as salinity. But there was no positive correlation between *P. monodon* PL and water hardness.



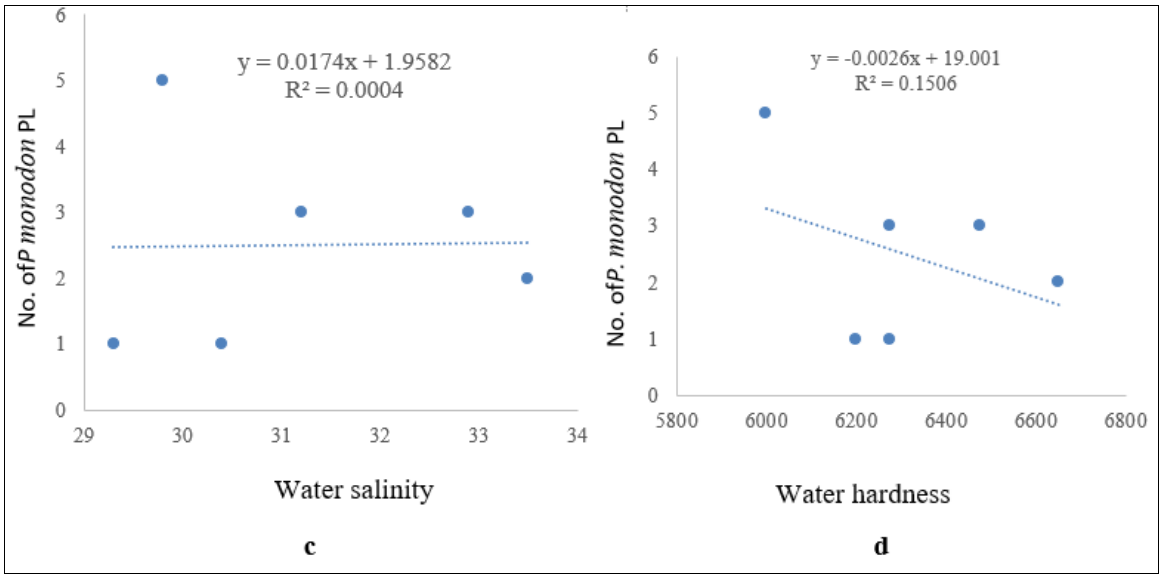


Fig 2 (a-d): Relation between abundance of *P. monodon* PL with water temperature, pH, salinity and hardness

4. Conclusions

The current study's results show that the number of shrimp fry and other aquatic organ-isms in coastal waters is gradually decreasing. This decrease could be caused by a variety of factors, including overfishing, pollution, unplanned road construction, destruction of spawning and breeding grounds, use of diesel-powered vessels, and climate change. To prevent the widespread extinction of aquatic life due to indiscriminate fry collection activities, urgent action must be taken to raise awareness among shrimp seed collectors about the significant loss of aquatic life. This will help to preserve the biodiversity of the water, its productivity, and the creation of a friendly environment. However, the information has produced by this study can be helpful in making policy that will protect coastal waters biodiversity and conserve resources.

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