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Assessment of the effectiveness of trans-boundary Hilsa shad (*Tenualosa ilisha*) sanctuary (100 km) of Meghna River, Bangladesh for sustainable conservation and management

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ABSTRACT

Hilsa shad, Tenualosa ilisha (Hamilton, 1822, the major fishery in Bangladesh, has been recognized as the nation's second Geographical Indication (GI) product. This study was carried out from July 2018 to June 2021 in four locations of the Meghna River: Shatnol, Chandpur, Haimchar and Char Alexander. The purpose of the study was to evaluate the current status and efficacy of the first out of six Hilsa sanctuary of Bangladesh. In the first Hilsa sanctuary, satisfactory results were found for the following criteria: plankton composition, percentage of spent rate, length frequency, quantity of larvae and Jatka, CPUE of larvae, length-weight relationship of Jatka, and physico-chemical characteristics of water. It was discovered that salinity had intruded into the lower Meghna River in Char Alexandar, indicating that important actions need to be considered in light of climate change adaptation. The maintenance and the fishing prohibition are necessary to conserve Jatka in the Meghna River sanctuary. The findings of this study will be crucial supporting documentation and a point of reference for subsequent policy, strategy and research on trans-boundary Hilsa fish in Bangladesh, India and Myanmar.

1. INTRODUCTION

The largest fishery in Bangladesh, locally known as ilish (*Tenualosa ilisha*), is crucial to the country's economy and provides employment for many Bangladeshi people **(Haldar *et al.*, 2001)**. About 12% and 1%, respectively, of the total fish production and GDP come from Hilsa. Indirectly or directly, the fishing industry provides a living for around 2% of the nation's population **(DoF, 2023)**. The term "Mache-vate Bangali" (literally, "Fish-Rice Bengali") is used to refer to the people of Bangladesh. In Bangladesh, Hilsa fish is a highly well-liked and delectable fish **(Mustafa *et al.*, 2012)**. Hilsa is known as "Macher raja Ilish" in Bangladesh, which translates to "Hilsa is the king of fish" due to its tantalizing flavor and excellent mouth feel **(Mukit *et al.,* 2016)**. According to **Matin and Shamim (2018)**, Hilsa has achieved recognition as the second Geographical Indication (GI) product of Bangladesh and is currently registered as a fish of Bangladesh in all countries. This fish has been designated as the country's national fish **(Rahman *et al.,* 2017b)**. Hilsa has a worldwide appeal to the customer due to its outstanding flavor and delicate taste **(Rahman *et al.,* 1999)**. As an anadromous species, Hilsa reproduces upstream in freshwater, and its life cycle is typical in that it begins with the larvae hatching from free-floating eggs **(Rahman *et al.,* 2017b)**.

To complete their life cycle, the immature young stages spread out in river channels, migrate to the sea for feeding and growth, and then return to the rivers as fully developed gravid Hilsa. A fish that reproduces prolifically can lay up to 2 million eggs (**Rahman *et al.,* 2017a)**. Although Hilsa spawn all year round, there is a large spawning season based on the full moon phase in the Bengali months of Ashwin and Kartik (September

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and October). During the main spawning season, mature gravid Hilsa have been caught widely from the main spawning sites. During their seaward migration, the juveniles of Hilsa known as Jatka have also been taken in several of the major rivers of the nation **(Rahman *et al.,* 2017a)**. Together with a few additional factors, these represent the most significant ones.

Aiming to protect the spawning and nursery grounds and to forbid indiscriminate Hilsa capture in view of the previously mentioned conditions as well as the significance of Hilsa for employment, economic growth, and nutrition, the Hilsa Fisheries Management Action Plan (HFMAP) has been developed for the development, management, and conservation of Hilsa **(Rahman *et al.,* 2017b)**. The Ministry of Fisheries and Livestock (MoFL) is in charge of enforcing the annual fishing ban in order to safeguard Jatka. Implemented by the Department of Fisheries (DoF) in collaboration with relevant partners, including law enforcement authorities such as the Navy, Coast Guards, River Police, etc., the fishing ban is based on experimental results from the Riverine Station (RS) under Bangladesh Fisheries Research Institute (BFRI), **(Hasan *et al.,* 2023)**.

To conserve Jatka (juvenile Hilsa) effectively in the main nursery grounds, six (6) Hilsa sanctuaries have been declared throughout the nation's freshwater and coastal regions **(Hasan *et al.,* 2023)**. However, no investigation has been carried out to determine the current status of the first established Hilsa sanctuary in Bangladesh. Therefore, in order to maintain the conservation process and ensure the smooth production of Hilsa, the current work was conducted to assess the sanctuary's effectiveness as well as its current status.

2. MATERIALS AND METHOD

2.1. Study sites and duration

The first Hilsa sanctuary in the Meghna River extends from Shatnol to Alexandar, covering a length of 100 km. Four sites were selected in River Meghna (Chandpur and Laxmipur) for conducting the study-a) Shatnol b) Chandpur c) Haimchar d) Char Alexandar. From July 2019 to June 2021, the research was carried out (Fig. 1). In order to ensure a comprehensive representation of the sanctuary's habitat and efficacy throughout various regions, the selected sites, which are located in areas with differing degrees of fishing activity, represent a variety of geographic locations along the Meghna River's 100 km sanctuary. These sites are perfect for assessing how well the sanctuary has supported Hilsa shad conservation and management initiatives throughout time because they have long been recognized as vital nursing habitats for the species. The active participation of local communities, fishery stakeholders, and conservation initiatives—all of which are essential for the enforcement and oversight of sanctuary legislation and guaranteeing sustainable practices—was another factor in the selection of these locations.

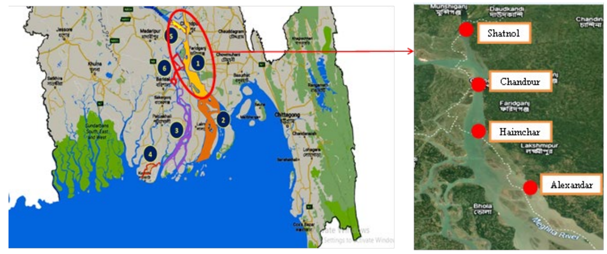


Fig.1. Sampling Sites in the 1st Hilsa sanctuary at Meghna River from Shatnol to Alexandar-100 km.

2.2. Physico-chemical parameters of water

Direct physical and chemical parameters of water were monitored directly at each sampling station. The tests included transparency, water and air temperatures, total alkalinity, total hardness, DO, CO_2 and pH,. The physicochemical properties were ascertained using the HACH water test kit (Model FF2, USA). Transparency was measured by the Secchi disk.

2.3. Salinity Intrusion of Meghna River

Refractometer (Model:CTL-REFM-PRSG) was used for determining Salinity.

2.4. Plankton composition

Using a 50-micron plankton net and the conventional drop count method, plankton samples were taken from the sampling station for the study **(APHA, 1995)**. One milliliter concentrated plankton samples were put in Sedgwick-Rafter counting cells and examined under an electronic microscope (Amscope binocular biological microscope) taking into account both the qualitative and quantitative features. To identify plankton, **Ward and Whipple (1959)** and **Prescott (1962)** were utilized.

2.5. Jatka Observation

2.5.1 CPUE of Jatka

BFRI Experimental Net was used to collect Hilsa fry, larvae and Jatka from the sanctuary. The amount of Jatka [kg per 100 m net per hour] was used to determine the CPUE of the species.

2.5.2 Length Frequency Percentage

Data on length frequency were gathered from the selected sites of the sanctuary. After the specimens were dried on blotting paper, the total length of the Hilsa larvae and Jatka was measured using a measuring scale, and the total body weight of each fish was determined using an electric digital balance.

2.5.3 Length-Weight Relationship of Jatka

The following equation was used to assess the relationship between the total length (TL) and total body weight (BW) of fish **(Pauly, 1993)**:

$BW = aTL^b$

Where,

BW=Body weight of fish in (g)

TL=Total length of fish in (cm)

a=Constant (intercept)

b=an exponent indicating isometric growth when equal to 3

2.5.4 Spent rate determination

Spent rate in the spawning grounds was estimated to reassess the spawning grounds of Hilsa by using following formula **(Rahman *et al.,* 2017b)**:

Total No. of Hilsa excluded due to the fishing ban (TN) = No. of fishing boat× Haul/day×fish caught/Haul×No.ofdays..................................(1)

Total fertilized eggs (kg) = TN × FF × SF × EF/1,000 ………………………………………………………(2)

Where,

TN= Total No. of Hilsa excluded due to fishing ban

FF= % of female fishes in the study area

SF= % of spent/oozing fish and

EF= Average egg (g) per fish

2.6 Data analysis

Microsoft Excel 2010 was used for the data analysis, and pie charts and line diagrams were used to illustrate the findings. Calculations for the length-weight relationship were also performed.

3. RESULTS

3.1 Physico-chemical parameters of water

The Physico-chemical parameters of Meghna River water is shown in the Fig.2. The air temperature varies seasonally, being lowest in December (cooler months) and highest in May (hotter months). This is typical for tropical regions with significant seasonal temperature variation. Char Alexander exhibits slightly higher air temperatures compared to other sites, while Shatnol shows slightly lower temperatures. This could be due to local factors such as elevation, proximity to water, and wind patterns. The water temperature follows a similar seasonal variation to air temperature. This means that it is typically cooler during the winter months (around December) and warmer during the summer months (around May). Just like air temperature, the water temperature is slightly higher at Char Alexander and slightly lower at Shatnol, reflecting the environmental conditions influencing these locations. Water temperature often lags behind air temperature changes, but it still correlates closely.

DO fluctuates throughout the year due to biological and environmental factors. In aquatic systems, higher DO is typically observed in colder months (due to cooler temperatures and lower biological activity), and lower DO can occur in warmer months (due to increased biological oxygen demand and higher temperatures). Shatnol (upstream area) consistently shows slightly lower DO levels compared to other sites. This could be due to the influence of upstream activities, such as agricultural runoff, or slower water flow, which can reduce oxygen exchange.

Free CO_2 concentrations are higher in Chandpur and Shatnol (upstream areas). This is generally a result of increased organic matter decomposition, which releases CO_2 into the water. Higher CO_2 levels are often seen in areas with significant aquatic vegetation, microbial activity, or pollution, especially near the shore or in stagnant areas with lower water flow. Since CO_2 is linked to biological activity, areas like Chandpur and Shatnol, with potentially more organic inputs (e.g., agricultural runoff, decomposing plant matter), show higher concentrations.

The pH was consistent across all the sampling sites, with only slight fluctuations observed. A range of 7 to 8.8 suggests that the water is slightly alkaline, which is typical for many freshwater and estuarine environments.

The study shows that Shatnol (upstream) has higher water transparency due to lower suspended solids and plankton while Char Alexander (downstream) has lower transparency, likely due to increased sediment and plankton.

The slight fluctuations in total alkalinity across the sampling sites during the study period indicate a stable buffering capacity of the river, maintaining a relatively consistent pH level. This is crucial for the overall health of the ecosystem, as it ensures that the water remains within a range that supports the growth and survival of aquatic species like Hilsa.

The total hardness of the Meghna River remained consistent across the sites throughout most of the study period, except at Char Alexander, where values were higher during November and December each year. This seasonal increase may be attributed to local factors such as runoff, evaporation, or geological characteristics, and could have implications for aquatic organisms such as Hilsa and water management in the region.

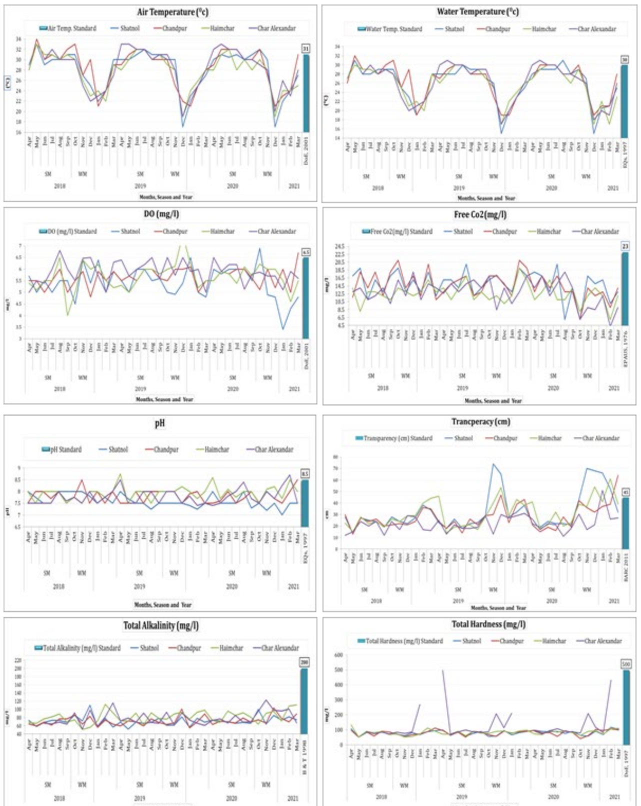
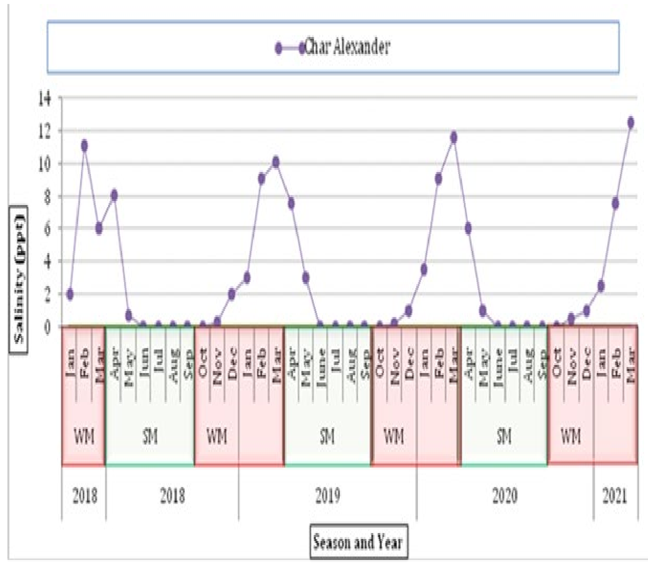


Fig. 2. Average water quality parameters in the 1st Hilsa sanctuary at Meghna River (2018 to 2021). Eight Parameters (Air Temperature, Water Temperature, and Dissolved Oxygen, Carbon dioxide, pH, Transparency, Total alkalinity and Total Hardness) are showing the changes (Location and Season-wise). Bangladesh Standard is highlighted with Green Bar and Data Labels. WM=Winter Monsoon, SM=Summer Monsoon **(National Geographic Society-Online; Banglapedia, 2002; Eurekalert, 2002)**.

3.2 Salinity Intrusion of Meghna River

The salinity in the river water also changes the aquatic ecosystem and fishery sector, affecting the life and livelihood of the community people **(Rabbani *et al.,* 2018)**. Salinity was found in the lower Meghna River at Char Alexander. It gradually increased by 1, 2 from November, peaking at 13 ppt in March, in the dry season, and gradually decreased from April to close to zero in June. (Fig. 3).



WM=Winter Monsoon, SM=Summer Monsoon **(National Geographic Society-Online; Banglapedia, 2002; Eurekalert, 2002)**.

Fig.3. Salinity trend in the 1st Hilsa sanctuary at Meghna River

3.3 Plankton Composition

The present study revealed that phytoplankton formed 82% and zooplankton formed 18% of total plankton taxa. Among the 12 studied phytoplanktonic groups, Bacillariophyceae was found to be highest (21%) followed by Chlorophyceae (20%), and Cyanophyceae (15%), Zygnematophyceae (12%), Trebouxiophyceae (9%), Mediohyceae (9%), Coscinodiscophyceae (4%), Dinophyceae (3%), Xanthophyceae and Chrysophyceae (2%).Ulvophyceae shared the lowest (1%). On the other hand, among the four studied zooplanktonic groups, Rotifera shared the highest percentage (45%) followed by Copepoda (25%), Cladocera (25%) and Ostracoda only 5% (Table 1 and 2) (Figs.4, 5, 6 and 7).

Table 1. List of Zooplankton in the 1st Hilsa sanctuary of Meghna River

Sl. No.	Zooplankton Group	Species Name
1	Rotifers	*Brachionus* sp., *Gastropus* sp., *Kellicottia* sp., *Keratella* sp., *Polyarthra* sp.,*Trichocerca* sp.
2	Cladocera	*Bosmina* sp., *Chydorus* sp., *Daphnia* sp., *Diaphanosoma* sp.
3	Copepod	*Calanoid* sp., *Cyclops* sp., *Diaptomus* sp., *Nauplius* sp.
4	Ostracod	*Cypris sp.*

Table 2. List of Phytoplankton in the 1st Hilsa sanctuary at Meghna River

Sl. No.	Phytoplankton Group	Species Name
1	Bacillariophyceae	*Amphora* sp., *Anomoeoneis* sp., *Asterionella* sp., *Bacillaria* sp., *Cymbella* sp., *Diatoma* sp., *Fragilaria* sp., *Gomphonema* sp., *Gyrosigma* sp., *Navicula* sp., *Nitzschia* sp., *Pinullaria* sp., *Pleurosigma* sp., *Stauroneis* sp., *Striatella* sp., *Surirella* sp., *Synedra* sp., *Tabellaria* sp., *Thallassionema* sp.,
2	Chlorophyceae	*Ankistrodesmus* sp., *Chlamydomonas* sp., *Coelastrum* sp., *Coelastrum* sp., *Eudorina* sp., *Hydrodictyon* sp., *Microspora* sp., *Oedogonium* sp., *Palmella* sp., *Pediastrum* sp., *Planktosphaeria* sp., *Pleodarina* sp., *Protococcus* sp., *Scenedesmus* sp., *Schroederia* sp., *Selenestrum* sp., *Tetraedron* sp., *Tetrapedia* sp., *Volvox* sp.,
3	Cyanophyceae	*Arthrospira* sp., *Anabaena* sp., *Anacystis* sp., *Aphanocapsa* sp., *Chroococcus* sp., *Coelosphaerium* sp., *Gomphosphaeria* sp., *Merismopedia* sp., *Microcystis* sp., *Nostoc* sp., *Oscillatoria* sp., *Phormidium* sp., *Polycystis* sp., *Spirulina* sp.
4	Chrysophyceae	*Chrysosphaerella* sp., *Uroglena* sp.
5	Coscinodiscophyceae	*Coscinodiscus* sp., *Melosira* sp., *Rhizosolenia* sp., *Triceratium* sp.
6	Dinophyceae	*Ceratium* sp., *Peridinium* sp., *Protoperidinium* sp.
7	Euglenophyceae	*Phacus* sp., *Euglena* sp., *Trachelomonas* sp.
8	Mediophyceae	*Cyclotella* sp., *Biddulphia* sp., *Chaetoceros* sp., *Chaetoceros* sp., *Ditylum* sp., *Leptocylindrus* sp., *Skeletonema* sp., *Stephanodiscus* sp., *Thalassiosira* sp.
9	Trebouxiophyceae	*Actinastrum* sp., *Botryococcus* sp., *Chlorella* sp., *Crucigenia* sp., *Micractinium* sp., *Oocystis* sp., *Palmellococcus* sp., *Stichococcus* sp.
10	Ulvophyceae	*Ulothrix* sp.
11	Xanthophyceae	*Tribonema* sp., *Botrydium* sp.
12	Zygnematophyceae	*Desmidium* sp., *Closterium* sp., *Cosmarium* sp., *Gonatozygon* sp., *Micrasterias* sp., *Mesotaenium* sp., *Muogeotia* sp., *Netrium* sp., *Spirogyra* sp., *Staurastrum* sp., *Zygnema* sp.

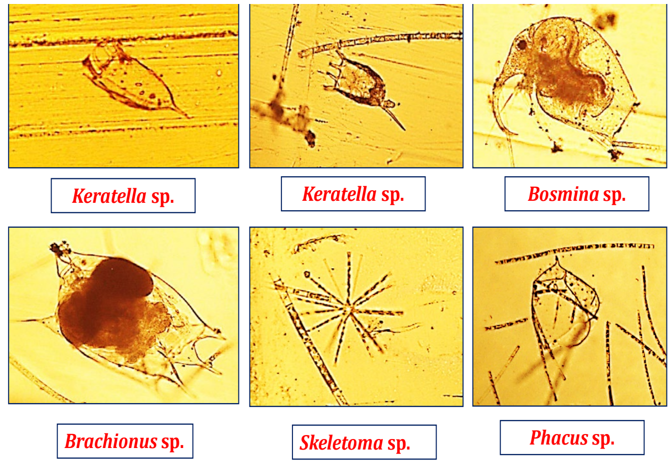


Fig.4. Pictorial view of some identified Zooplankton & Phytoplankton species from 1st Hilsa sanctuary at Meghna River

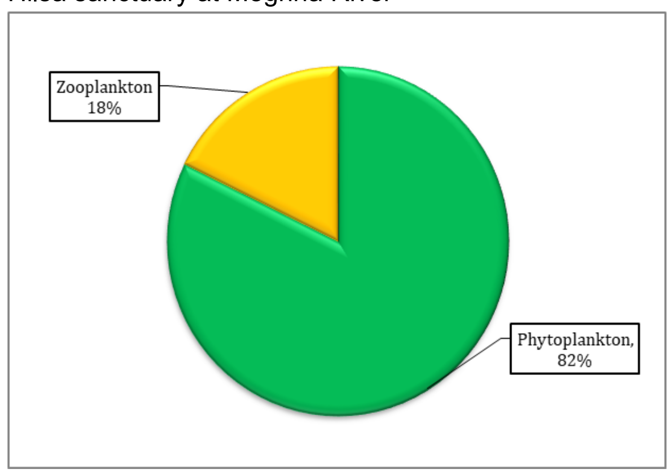


Fig.5. Phytoplankton percentage composition in 1st Hilsa sanctuary at Meghna River

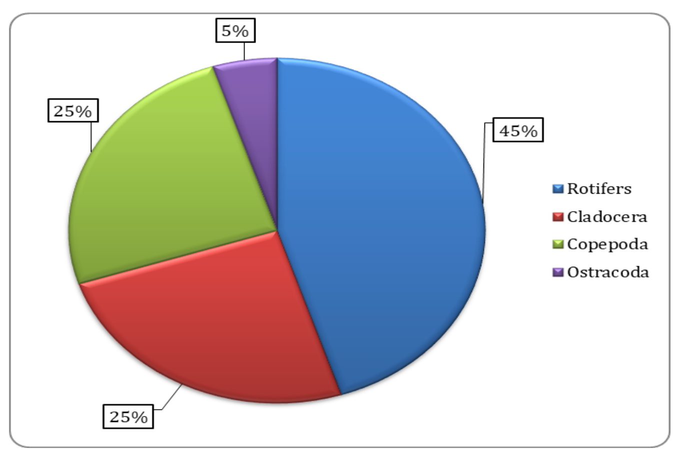


Fig.6. Zooplankton percentage composition in 1st Hilsa sanctuary at Meghna River

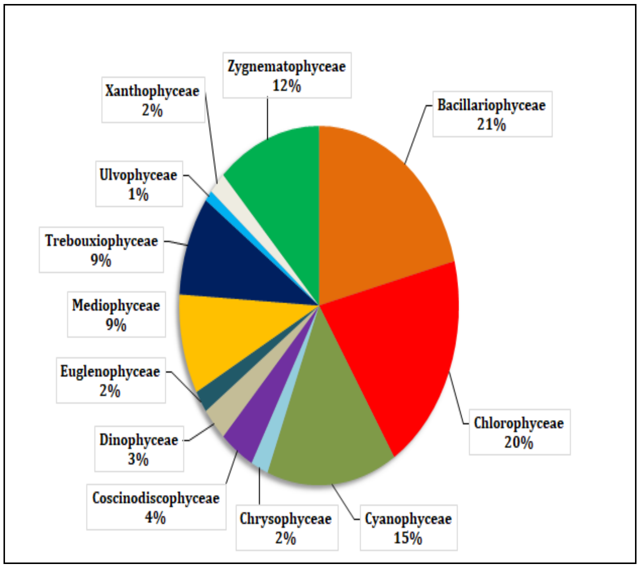


Fig. 7. Phytoplankton percentage composition in 1st Hilsa sanctuary at Meghna River

3.4 Jatka Observation

3.4.1 CPUE and change percentage of Jatka

In the first sanctuary, Jatka was recorded having CPUE (kg/hour / 100m net) of 6.3 kg in 2019, 6.6 kg in 2020, and 6.7 kg in 2021. The CPUE of Jatka has progressively increased. The CPUE of Jatka in Meghna River (sanctuary) has grown by 4.76 percent in 2020 and 6.34 percent in 2021 in comparison with 2019 (Fig. 8).

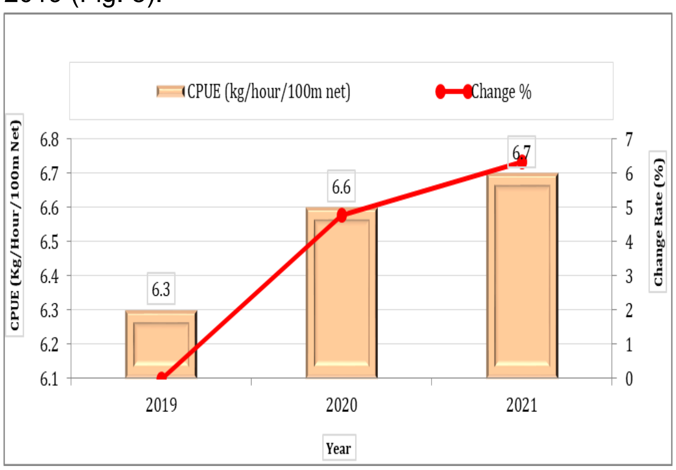


Fig. 8. CPUE (kg/ hour/ 100m net) and change % of Jatka in 1st Hilsa sanctuary at Meghna River

3.4.2 Length Frequency Percentage of Jatka

In the case of Chandpur, it was found that in 2019, the presence of 12 cm, 13 cm and 14 cm Jatka was higher; and as a percentage, it was 8%, 36% and 43%, respectively. In the Chandpur region in 2019, 2020, and 2021, the numbers 262, 207 and 214 length frequencies of Jatka (juvenile Hilsa) have been measured respectively. In the year 2020, 12 cm (37%), 13 cm (23%), and 14 cm (21%) Jatka size has the highest percentage rate. In 2021, the presence of 12 cm, 13 cm, and 14 cm Jatka was also high; and the percentage rate was 18%, 12%, and 26%, respectively. In this three-year 2019-21, it is seen that the presence and abundance of 12 to 15 cm Jatka were more in Chandpur (Fig. 9).

The presence of Hilsa fish of 20 cm to 51 cm (A total of 589 Hilsa's length has been taken) has been noticed in the Meghna River. Hilsa fish of 25 cm to 30 cm was found in excess in Meghna, as a percentage, which was 6.8, 14.9, 10, 7.6 and 5.4 respectively. Again, the presence of 32 cm to 36 cm (3.3%, 3%, 3%, 4%, 2.7% and 2.7%) have also been observed. Apart from this, 41 cm (2.3%) and 44 cm (2.8%) Hilsa fish were found (Fig.10).

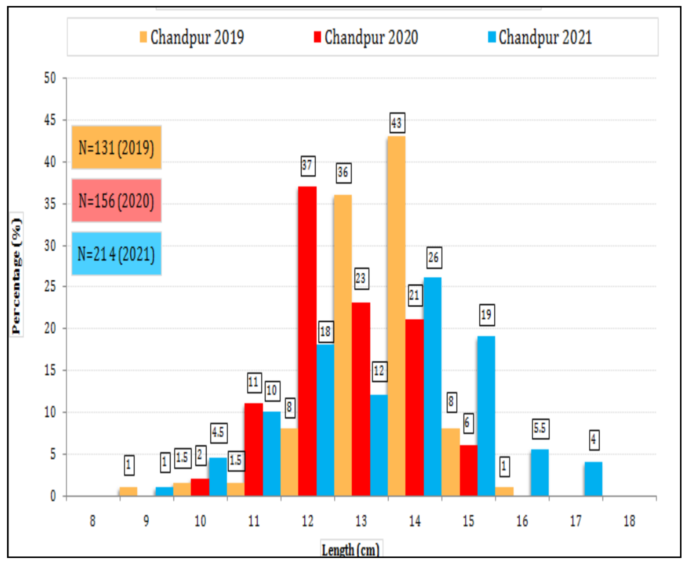


Fig. 9. Jatka Length Frequency Percentage (%) in 1st Hilsa sanctuary at Meghna River

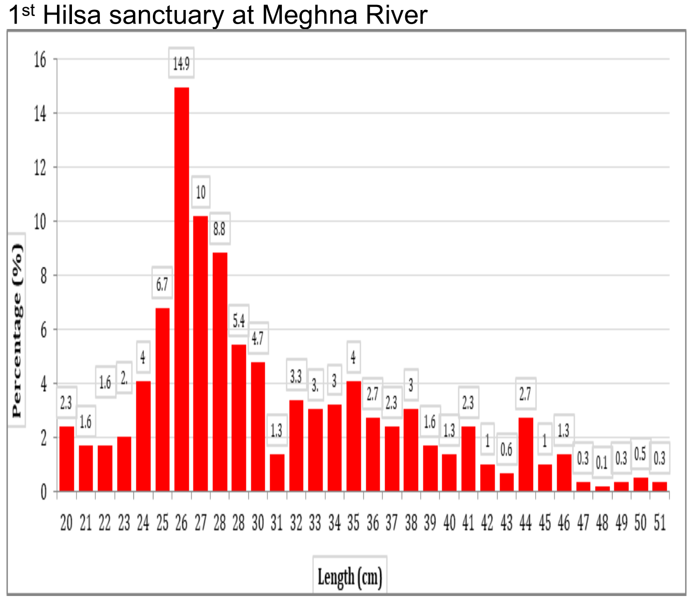


Fig.10. Length frequency percentage of Brood Hilsa in 1st Hilsa sanctuary at Meghna River

3.4.3 Length-Weight Relationship of Jatka

In the present study, the length-weight relationship of Jatka in the Hilsa sanctuary has been analysed. In 2019 and 2020, the values of 'b' of Chandpur are 3.06 and 3.14. On the other hand in 2021 the values of 'b' of the mentioned station is 3.12.

We know that if the value of 'b' is three (3), then it will be an isometric increase. If it is greater than 3.0, there will be a positive allometric increase. If it is less than three (3), then negative increase. In the first sanctuary at the River Meghna, it was found that the relationship between the length and weight of the Hilsa is in a balanced condition. From 2019 to 2021, the increase in the value of 'b' indicates the best condition of Jatka (Juvenile/young Hilsa) (Fig.11).

It can be said that the functioning of the sanctuary is good.

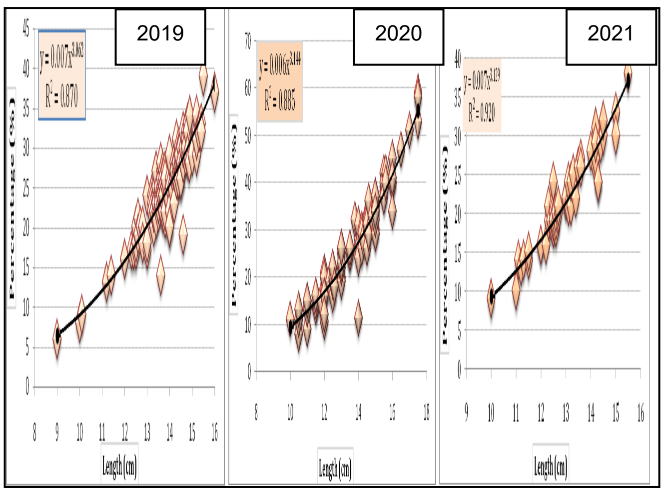


Fig.11. Length-weight relationship of Jatka in 1st Hilsa sanctuary at Meghna River

3.5 Percentage comparison of spent Hilsa in the Meghna River

The first Hilsa sanctuary covers Chandpur and Laxmipur region. The spent rate of Hilsa in Chandpur was recorded at 52% in 2019 which was 41 % in 2020. In the Laxmipur region, it was 40% in 2019 and 29% in 2020. Spent Hilsa percentages were observed to be slightly lesser from 2019 to 2020 in both Chandpur and Laxmipur regions. (Fig.12).

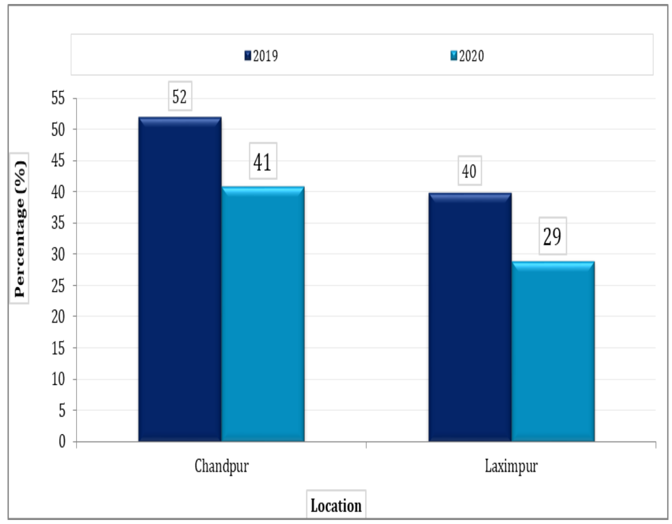


Fig.12. Percentage comparison of spent Hilsa in 1st Hilsa sanctuary at Meghna River

4. DISCUSSION

The physicochemical parameters are very vital in the estuarine environment. The physico-chemical characteristics of water were found to be more or less within Bangladesh standards in the four sites studied. The air temperature at all of the sites was slightly higher in the month of May **(DoE, 2001)**. The water temperature was also found slightly higher than the standard value **(EQs, 1997)** in the month of May at Shanol and Chandpur region. The DO value was found to be lower than the standard value **(DoE, 2001)** in Shatnol area in the month of January 2021. Photosynthetic activity and variations in the rate of oxygen consumption by fish and other aquatic animals may cause dissolved oxygen concentrations to fluctuate. According to **(EQS, 1997)**, the CO2 value was recorded to be lower than standard value specially in the month of February, 2021. All of the pH values reported in the sampling locations were within the suitable range **(EQS, 1997)**. All sampling sites had transparency within the permissible limit **(Rahman, 1992)**, with the exception of the Shatnol area, which increased sharply in the month of November in 2019 and 2020. Alkalinity levels indicate the level of productivity of the water. Alkalinity was found within the acceptable limit **(Rahman, 1992)**. The level of hardness was also within the acceptable range **(DoE, 2001)** except Char Alexander region in which it exceeds standard value during January to March in each year. The increase in hardness could be due to the increase in salinity during the winter phase.

According to **Rahman *et al.* (2021)**, the air temperature in the Meghna River in 2017 ranged from

26.9°C to 33.8°C during the summer and from 20.2°C to 23.5°C in the winter. The pH varied between 7.92 and 6.28, while the total hardness was recorded to range from 300 mg/L to 700 mg/L. **Hossain *et al.* (2016, 2017)** reported that in the Meghna River, the air temperature ranged from 17.8°C to 32°C, while the water temperature varied between 16.9°C and 30°C. The pH ranged from 6.8 to 6.5, dissolved oxygen (DO) levels were between 3.6 and 6.3 mg/L, and carbon dioxide (CO_2) levels ranged from 9.5 to 18 mg/L. Transparency ranged from 12 to 58 cm, alkalinity varied between 54 and 145 mg/L, and hardness ranged from 102 to 602 mg/L. According to **Hasan *et al.* (2015)**, the air temperature in the Meghna River ranged from 23.9°C to 33.2°C, while the water temperature varied between 19.8°C and 31.5°C. Transparency ranged from 20 to 63 cm, the pH fluctuated between 6.18 and 6.89, and dissolved oxygen (DO) levels were between 5.91 and 7.50 mg/L. Alkalinity was found to range from 47 to 104 mg/L in the Chandpur, Daulatkhan, and Lalmohan areas. According to **Ahamed *et al.* (2003, 2005)**, in the Meghna River, the air temperature ranged from 25.3°C to 31.8°C, and the water temperature ranged from 24.1°C to 30.5°C. pH values ranged from 6 to 6.8, DO levels were between 5.1 and 6.3 mg/L, CO_2 ranged from 2.4 to 6.7 mg/L, alkalinity was between 48 and 66 mg/L, and hardness ranged from 42.3 to 95.1 mg/L in the Mohanpur, Char Ludhua, and Daulatkhan areas. The Meghna River Estuary's water temperatures varied from 24.52 ± 0.64 °C to 26.46 ± 0.48 °C, reported by **Hossain *et al.* (2024)**. Additionally, they reported pH values between 8.11 ± 0.03 to 7.26 ± 0.11. The result of our current investigation aligns with the dissolved oxygen (DO) concentration, which varied between 4.1 ± 0.3 and 5.66 ± 0.06 mg L^{-1}.

All of the parameters listed in the aforementioned references have values that are consistent with the findings of the current investigation. The temperature surpassed the optimum limitations; however, all other standards, as mandated by **EQS (1991)**, **EQS (1997)**, **DoE (1997)**, **DoE (2001)**, and **ECR (1997)**, were within the optimum range of Bangladesh river water. **Sarker *et al.* (2016)** reported that, from February to March, 5 to 6 ppt salinity level was found in the estuary of the Meghna River. According to **Pramanik *et al.* (2021)**, the salinity of the Alexander and Ramgoti regions of the Meghna River was 0.5-15 ppt. **Rahman *et al.* (2021)** reported that at the mouth of the Meghna River, the average salinity in the summer and winter seasons is 6.96 and 9.34 ppt, respectively. So, the salinity has been increasing in the sanctuary areas specially during the winter season which should be continuously monitored in the upcoming years. Salinity is a measure of the amount of salt in a water sample; based on salinity water can be categorized into three fundamental classes: 1. Freshwater water (<0.05 ppt) 2. Saltwater (> 0.05 ppt) and 3. Seawater (>13 ppt) **(Rahman *et al.,* 2021)**. The current study matched 0.5-13 ppt. According to the type of salinity, the study area of the present study includes the type of ‘salt water’, which is moving towards the types of ‘sea water’.

According to **Ahsan *et al.* (2012)**, 27.4 indiv/l and 10.8 indiv/l were recorded in Charbhairabi, Madrasaghat, Tajumuddin, Daulatkhan, and Lalmohan of Meghna river during Bangladesh's Hilsa breeding season, respectively. It was found that Phytoplankton like Bacillariophyceae, Chlorophyceae, Cyanophyceae, and Zooplankton like Rotifers, Copepods were recorded. **Ahmed *et al.* (2003, 2005)** recorded 41 Phytoplankton and 13 Zooplankton belonging to 8 families in the Meghna River. Phytoplankton group such as Chlorophyceae (22), Myxophyceae (10), Bacillariophyceae (7), Euglenophyceae (2), and Zooplankton group Rotifers (6), Cladocera (2), Copepods (4), and Ostracods (1) have been found. 99.42% Phytoplankton and 0.56% Zooplankton were found in Daulatkhan. Phytoplankton was found in Charludhua, Mohanpur, and Kaliganj as the percentage of 96.29%, 90.69%, and 98.57% and 1.61%, 9.31%, and 1.44% Zooplankton were found in turns. On the other hand, 93.3%, 99%, 93.5%, and 94.2% Chlorophyceae were found in Daulatkhan, Charludhua, Mohanpur, and Kaliganj sequentially; and 50%, 60%, 44.9%, and 50% copepods were found, respectively. **Hossain *et al.* (2016)** reported that the Meghna River had the following phytoplankton groups: Chlorophyceae (18), Dynophyceae (2), Bacillariophyceae (13), Cyanophyceae (2), Myxophyceae (5), Euglenophyceae (1), and Xanthophyceae (2). Rotifers (2), copepods (3), Cladocera (3), and Ostracods (1) have been identified in the case of zooplankton. According to records, the two most significant groups of phytoplankton and zooplankton are Chlorophyceae and Copepods. The proportion of plankton was 9.5% for zooplankton and 90.5% for phytoplankton. According to **Hasan *et al.* (2015)**, Chlorophyceae (20,007 in Chandpur, 18,839 in Daulatkhan) and Bacillariophyceae (12545 in Chandpur, 14165 in

Daulatkhan) are dominant in the Meghna River as Cells l-1. Rotifera (1260 in Chandpur, 1138 in Daulatkhan) and Copepoda (448 in Chandpur, 328 in Daulatkhan) are influential.

Rahman *et al.* (2017b) found that the CPUE on the Meghna River varied sequentially between 0.94 kg and 3.25 kg from 2002 to 2016. Despite a minor decrease between 2006 and 2007, Jatka has been rising quickly. This indicates that the Meghna River's environment is ideal for Jatka growth.

According to **Rahman *et al.* (2009)**, 32.5% of Hilsa fish of 32-36 cm size, 75% of fish of 39-45 cm size, and 2.5% of fish of 48-52 cm size were found in Monpura. Moreover, **Rahman *et al.* (2013)** observed that Monpura had 34% of 32-36 cm size Hilsa fish, 63% of 39-45 cm size fish, and 3% of 46-52 cm size. On the otherhand, **Pramanik *et al.* (2018)** reported that 21-25 cm size Hilsa fish in Monpura was 4-6%, 26-30 cm was 8-10%, 31-35 cm was 21-24%, 36-40 cm was 36-41%, 41- 45 cm was 11-12%, 48-50 cm was 8-10%, and 51-55 cm was 3-5% among the total. In the present study, the presence of Hilsa fish of size 25-56 cm has been noticed commonly. The Hilsa fish is a swiftly migrating species. Hilsa's proportion of various length sizes may differ. This depends on the river's overall quality, its nutritional content, the tide's influence and the fish's schooling behavior **(Rahman *et. al.,* 2024)**.

Regarding the length-weight relationship, not much has been done in the instance of Jatka. The value of 'b' for Jatka (2-18 cm) in the Chandpur, Bhola, Kuakata-Barisal region was 3.41, according to **Haldar and Amin (2005)**. Every value of 'b' in the current investigation was positive allometric. The values of ‘B’ vary depending on the river environment, fish diet, breeding, river water quality, river water nutrient abundance, tidal effects, and fishing schooling pattern, depending on the type of life cycle.

5. CONCLUSION

Water's physico-chemical characteristics, salinity penetration, plankton observation, Jatka CPUE, length-frequency%, Jatka length-weight relationship, and spent rate have all been studied to evaluate the 1st established Hilsa sanctuary in Bangladesh. All of the aforementioned themes yielded satisfactory outcomes, and the nursery ground's continuous operation remained steady.

It should be noted that four breeding grounds and four sanctuaries were established in response to the "Hilsa Fisheries Management Action Plan," which was formulated by BFRI based on the relevant suggestions. Later, the Department of Fisheries, with BFRI's oversight, established the fifth and sixth Hilsa sanctuaries. As a result, it is certain that the findings of this study will be crucial supporting documentation and a point of reference for subsequent policy, strategy, and research on trans-boundary Hilsa fish in Bangladesh, India and Myanmar.

Following recommendations should be followed:

a. For the sustainable conservation of Jatka, effective research could be carried out continuously in all the rivers of Bangladesh that are considered as Hilsa habitats.

b. Appropriate steps ought to be done to shield fisheries resources from salinity in rivers.

c. More research is required to determine the Hilsa's new nursery ground.

d. Above all, prompt action is required to ensure the nursery ground's well managed.to have the prolific output in future.

The establishment of Hilsa sanctuary in the Meghna River has significant socio-economic impacts on the fishing community, particularly in Chandpur, Bangladesh. While this sanctuary aims to enhance fish stocks and promote ecological sustainability, it also presents challenges that affect the livelihoods of local fishers. Despite saying that, they are also benefited by the increased fish populations. This suggests a need for balanced management strategies that address both conservation and the socio-economic needs of the fishing community.

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