Status of Conservation and Migration of Hilsa in the Meghna River Estuary and its Potential of Breeding for Stock Enhancement and Aquaculture

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Objectives

- To determine gillnet selectivity of Hilsa in the Meghna river estuary
- To assess the impacts of sanctuary on the abundance and biodiversity of fishes
- Sampling for otolith and genetic analysis
- On-board breeding trial of hilsa and testing of larval rearing
- To determine growth and survival of juveniles in the nursery phase of hilsa in brackish water ponds to evaluate potential for aquaculture.

Achievements

Determination of gillnet selectivity of hilsa in the Meghna river- estuary

This study was carried out between August 2015 and October 2015 in Meghna River of Bangladesh. A total of 256, 258 and 146 specimens of *T. ilisha* were caught with 55 mm, 65 mm and 75 mm mesh-size gill-net, respectively. At first, length frequency of *T. ilish* data was calculated. Then linear regression method was applied. Primarily it was found that total length of the fish ranged from 200 to 360 mm from 55 mm mesh-size, 240 to 380 mm from 65 mm mesh-size and 280 to 440 mm from 75 mm mesh-size. Mean total lengths were calculated as 24.7±2.7 cm, 31.2±2.78 cm and 34.33±4.69 cm for 55 mm, 65 mm and 75 mm mesh-sizes, respectively.

The regression constants *a* and *b* were estimated respectively (Fig. 1). For the calculation of selectivity parameters using Holt's method (Sparre and Venema 1998). The length frequency data were presented in Table 2. The values of the Selection Factor *(SF)* and Standard Deviation *(S)* were obtained, respectively. Selectivity curve were shown in Fig. 2. The optimum catch lengths of the monofilament gill nets with 55, 65, and 75 mm mesh sizes were calculated as 260.50 mm (TL), 328.36 mm (TL), and 370.99 mm (TL), respectively (Table 1).

Table 1. Regression parameters (*a* & *b*), standard deviation (*s*), selection factor (*SF*) and optimum length (L_m) estimated from the gillnets selectivity studies of *Tenualosa ilisha*

Mesh size	*a*	*b*	*SF*	*S*	Selection range	Optimum length
5.5 cm	-16.79	0.0578	4.84	38.84	254.71-266.28	260.50
6.5 cm	-11.73	0.039	4.63	47.58	314.69-342.02	328.36
7.5 cm	-4.42	0.012	5.26	57.48	347.34-394.64	370.99

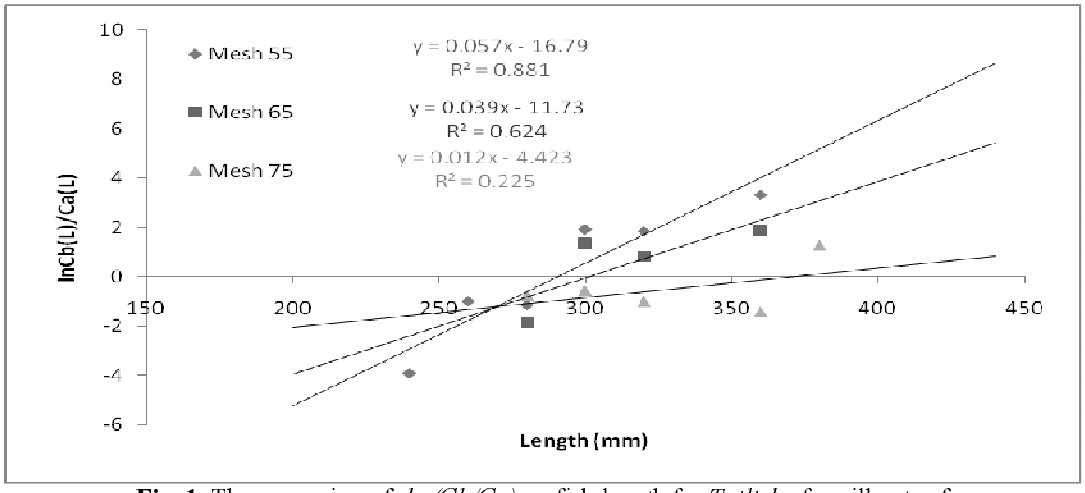

Fig. 1. The regression of *ln (Cb/Ca)* on fish length for *T. ilisha* for gill nets of 55, 65 mm and 75 mm mesh size from Meghna river estuary.

Table 2. Length frequency for estimation of gill net selectivity curves for *T. ilisha* from Meghna River estuary

Length interval midpoint *L (x)*	Number caught		
	Ma=55 *Ca(L)*	Mb=65 *Cb(L)*	Mc=75 *Cc(L)*
200	5		
220	38		
240	99	2	
260	43	16	
280	47	15	7
300	8	54	30
320	13	83	30
360	3	83	20
380		5	18
400			20
420			16
440			5
460			
Total	256	258	146

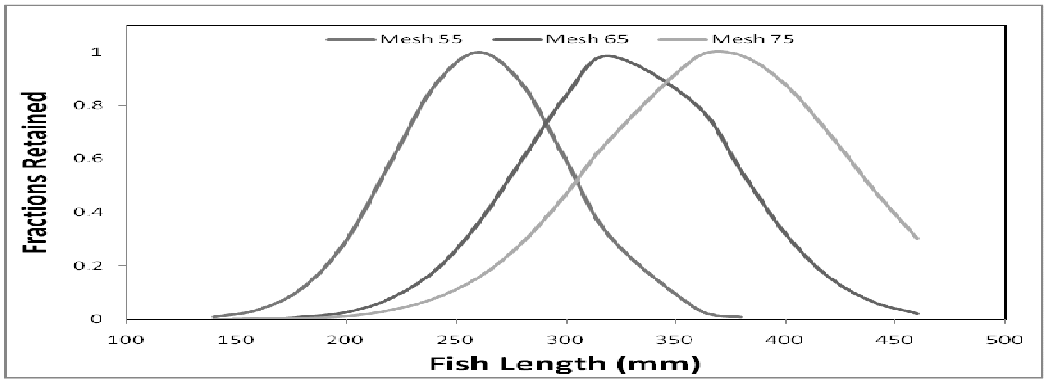

Fig. 2. Selection curves for *T. ilisha* for gill nets of 55, 65 mm and 75 mm mesh size from Meghna river estuary.

Assessment the impacts of sanctuary on the abundance and biodiversity of fishes

During the river cruise gradually larger sized hilsa were found from upper to the downstream. In the upper region, most of the hilsa found were below 32 cm, whereas, more than 95% hilsa were above 32 cm in the downstream areas. In and around the spawning grounds among all the captured hilsa, male: female ratio was 30% and 70% respectively. Catch composition obtained from the spawning grounds revealed that more than 90% captured hilsa weighing around 900 gm were gravid. During the study period 36.6%, spent hilsa was observed in sanctuary area and 5 to 10 % spent hilsa was found from the non-sanctuary area.

Catch Per Unit Effort (CPUE): After the establishments of the sanctuary in the Meghna river positive impact were observed in the CPUE of different fishing gears (Fig. 3). Among the sanctuary, area CPUE was found highest 8 kg/Haul (Chandi jal) from Char bhoirobi and Ramgoti region and lowest 2.8 kg/Haul CPUE was found in Ramgoti region by Current jal. Among the non-sanctuary area highest CPUE 4 kg/Haul was found from Gajaria region by Chandi Jal and lowest CPUE was found from the Gajaria and Sureswar area by Gulti and Current Jal. The gears used for capturing hilsa are mainly set gill net (Chandi jal) and drift gill nets (Gulti, Kona ber jal, Current jal). Fishers are also using some seine nets (Jagat ber jal, Purse seine net, Network jal) but recently operation of Jagot ber jal is very rare. Fishing gears such as small mesh current jal, behundi jal (Set bag net), Moshari ber jal and Char ghera jal are identified as very harmful gears, which are being used for killing juvenile hilsa (*jatka*) indiscriminately in the particular regions.

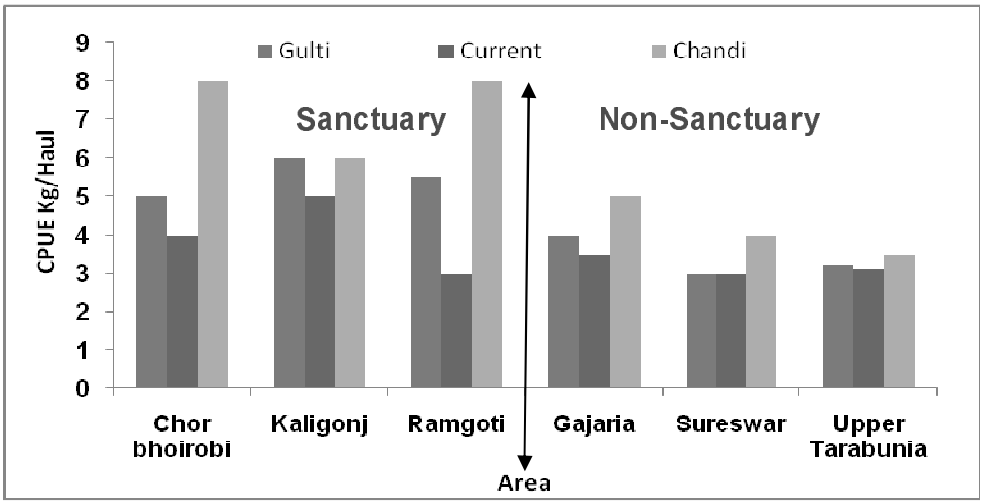

Fig. 3. CPUE of sanctuary and non-sanctuary area.

Water quality parameters: Physico-chemical parameters were studied for all six sampling spots of the Meghna river estuary and found normal (Tables 3 and 4).

Table 3. Water quality parameters of sanctuary area (Char bhoirobi, Kaligonj and Ramgoti)

Sampling spots	Month /15	Parameters (Mean±SD)						
		Air temp (^{0}c)	Water temp (^{0}c)	DO (mg/l)	Free CO_2 (mg/l)	P^H	Alkalinity (mg/l)	Hardness (mg/l)
Char bhoirobi	Sep	33.5±0.5	31.5±1.3	5.6±0.2	15.5±0.6	7.7±0.3	72.7±4.7	96.0±17
	Oct	33.3±0.7	30.7±1.1	6±0.2	13.4±0.5	7.3±1.2	78±5.3	90.0±8.9
	Nov	29.8±1.1	28.2±1.3	5.5±0.5	14.3±1.2	7.9±0.2	79.7±5.0	70.3±1.5
Kaligonj	Sep	31.8±0.2	29.9±1.1	5.0±0.1	18.5±0.5	7.2±0.6	78.2±18	52.0±12
	Oct	33.0±0.7	32.5±0.2	5.6±0.2	17.4±1.1	7.5±0.3	73.6±12	61.0±11
	Nov	30.5±0.5	29.0±1.0	5.6±0.1	17.2±0.8	7.6±0.2	80.0±7.9	72.0±18
Ramgoti	Sep	32.0±0.4	31.3±0.3	5.1±0.3	18.1±2.1	7.8±0.8	73.1±13	95.0±17
	Oct	33.4±0.5	32.2±0.2	5.5±0.2	17.4±1.4	7.6±0.5	85.0±11	70.0±27
	Nov	30.8±0.3	29.0±0.9	4.9±0.1	19.0±0.8	7.3±0.2	75.0±7.8	105.0±55

Table 4. Water quality parameters of non-sanctuary area (Gazaria, Sureswar and Upper Tarabunia)

Sampling spots	Month/ 15	Parameters (Mean±SD)						
		Air temp (^{0}c)	Water temp (^{0}c)	DO (mg/l)	Free CO_2 (mg/l)	P^H	Alkalinity (mg/l)	Hardness (mg/l)
Gazaria	Sep	32.4±0.3	30.2±0.89	5.0±0.32	19.7±1.57	7.9±0.26	77±5.34	73.7±16
	Oct	33.2±0.80	31.2±1.07	5.7±0.43	17.7±3.82	7.7±0.31	83.7±14	89.2±14
	Nov	30.7±0.68	29.8±0.35	5.6±0.39	16.8±2.41	7.5±0.53	74.0±5.3	82.0±16
Sureswar	Sep	30.8±0.62	29.9±1.12	5.5±0.65	18.5±0.42	7.3±0.62	76.3±16	58.0±27
	Oct	32.0±0.63	31.5±0.91	5.8±0.48	17.4±1.23	7.6±0.21	72.5±11	62.0±26
	Nov	29.5±0.74	28.9±1.25	5.7±0.16	16.2±0.74	7.7±0.3	82.2±17	70.0±19
Upper Tarabunia	Sep	32.5±0.67	31.2±0.67	5.1±0.51	18.4±2.05	7.7±0.9	76.1±23	60.0±17
	Oct	32.4±0.96	31.1±0.69	5.2±0.36	17.3±1.67	7.8±0.1	84.0±31	66.0±18
	Nov	29.8±0.33	28.0±0.94	5.9±0.12	18.1±0.78	7.4±0.4	80.2±21	72.0±26

Plankton biomass: Abundance of plankton in sanctuary and non-sanctuary areas showed a wide range of variation (Tables 5 and 6). Average total phytoplankton density (no/l) inside the sanctuary areas of Meghna river was higher than the non-sanctuary areas. Phytoplankton largely dominated over zooplankton throughout the study period. The mean contribution of phytoplankton was more than 96% in both the areas and zooplankton contributed the rest. Among the plank tonic algae 38 genera of phytoplankton under 6 families and 12 genera of zooplankton under 8 families were recorded inside the sanctuary areas whereas, 34 genera of phytoplankton under 5 families and 10 genera of zooplankton under 8 families were found outside the sanctuary areas of Meghna river.

Table 5. Plankton composition of sanctuary area

Stations	Month/15	Area (Mean±SD)	
		Phytoplankton (no./l)	Zooplankton (no./l)
Char bhoirobi	September	37,900±68	2,166±76
	October	35,366±71	5,656±57
	November	37,166±54	2,100±61
Kaligonj	September	36,500±86	2,150±85
	October	33,150±75	2,770±64
	November	35,000±66	2,110±59
Ramgoti	September	28,200±45	1,920±53
	October	25,100±36	1,520±22
	November	28,700±48	1,970±69

Table 6. Plankton composition of non-sanctuary area

Stations	Month/15	Area (Mean±SD)	
		Phytoplankton (no./l)	Zooplankton (no./l)
Gojaria	September	23,033±19	1,333±15
	October	19,700±16	1,316±76
	November	27,000±20	1,500±18
Sureswar	September	33,300±44	2,160±35
	October	29,900±23	2,050±43
	November	31,000±75	1,970±28
Upper Tarabunia	September	34,100±65	2,210±59
	October	31,700±69	2,160±60
	November	30,500±55	2,110±46

On-board breeding trial of hilsa and testing of larval rearing

Before the actual ban period for brood hilsa conservation, five pairs of matured hilsa were tried for breeding during 1st trial. In addition, after the second trial (after 4 October) 12 pairs of brood hilsa were tried.

Trial No.	Brood hilsa pair No.	Time Period
1st	5	September
2nd	11	October
3rd	12	November

Altogether (1st, 2nd and 3rd trial) a total of 28 pairs of brood hilsa were tried for breeding, but in case of 1st and 3rd trial no remarkable result was achieved. All activities conducted during the second trial were presented in this report.

Collection of gravid hilsa: The matured/adult hilsa (1^+ age group) were congregated in the major spawning grounds of hilsa in lower Meghna estuaries for spawning. Though hilsa spawn year round but considerably hilsa spawn for two times in a year which are the peak spawning season (Sep.-Oct.) and in the second peak spawning season (January-March) and about 36.6% hilsa were found to spawn in the peak breeding season in the year of 2015. A 6.5 cm to 10.5 cm mesh sized gill net (multi-dimensional net) was used for collection of gravid/matured hilsa for artificial breeding using portable hatchery. The collected gravid hilsa, their length-weight and eggs maturity status were shown in the Table 8.

Table 8. Length-weight of gravid hilsa, maturity of eggs and their breeding types

Sl. No.	Time of collection	No. of collection	Length (cm)	Weight (gm)	Sex	Egg maturity status	Breeding type	Remarks
1	10.30am to 12.30pm	8	37.35 (34.50-41.00)	715.05 (450.00-720.00)	Female	V+	Induced breeding by stripping	After fertilization the eggs were transferred for incubation
2		11	25.80 (25.00-35.00)	189.00 (170.00-500.00)	Male	V		
3	10.30am to 12.30pm	3	38.00 (35.00-41.00)	750.00 (500.00-710.00)	Female	VI	Artificial breeding by hormone	Most of the broods were died after

4		3	25.50 (25.50-34.50)	187.50 (175.00-450.00)	Male	V	dose	hormone injection

Egg collection: After conditioning the gravid hilsa were stocked in the circular tank, which was full with the river water to maintain natural environmental condition providing water circulation and oxygenation to ready the fish for egg release. Immediately after getting the oozing female the eggs are stripped into a bowl by wet method and the milt from the males are also stripped over the eggs for fertilization. To stimulate another breeder's 0.5ml/kg body weight dopamine were injected as single dose for both the male and female at a time. After the injection of hormone dose (dopamine) most of the broods were died immediately which were selected for artificial breeding.

Fertilization and incubation: The collected eggs were fertilized by the milt, which were collected from matured male fish immediately and then mixed with egg by the feather of birds and caudal fin of hilsa gently. Then the fertilized eggs were transferred in a bottle hatchery for incubation providing mild water circulation, aeration and shade to protect penetration of direct sunlight (which increase the water temperature also) as this species are light sensitive.

Observation of fertilized eggs: Hilsa spawn in fresh water and deposited eggs demersally. About 20-30 minutes later, the eggs become almost colorless. The eggs were very soft, smooth, non-adhesive and almost spherical in shape. About 4 hours later of fertilization the blastula stage of fertilized eggs were observed under the electron (compound) microscope. In addition, after 6 hours later it was observed that some eggs were attained in denatured condition and then maximum eggs were ruptured within 24 hours. It may be due to the collection of immature eggs.

Determination of growth and survival of juveniles in the nursery phase of hilsa in brackish water ponds to evaluate potential for aquaculture

This experiment was conducted in a pond of Riverine sub-station, Khepupara, Patuakhali during October 2015 to December 2015.

Hilsa fingerlings collection and stocking: Juveniles of hilsa (*Jatka*, 10-12 cm) were collected from Andharmanik river estuary at Moudobi point, Ramnabad channel of Kalapara upazilla under Patuakhali district during end of December 2015. During collection of *jatka* by seine net, the operation was done very smoothly. *Jatka* were kept in oxygenated polyethylene bag that was covered with wet-jute mat to protect high temperature and sunlight. After collection, the live *jatka* were transported to the BFRI, Riverine sub-station, Khepupara ponds with a speedboat.

Table 10. Length weight data of reared hilsa in brackish water ponds of RSS, Khepupara, Patuakhali

Fish size	Av. initial length (cm)	Av. initial weight (gm)
Hilsa fingerlings	7.3	6.5
Hilsa juvenile	21.5	98

The highest growth and survival rate were recorded in the treatment 1 where the stocking density was 200 jatka per compartment. The net weight gain was found to be the highest in treatment 1 and the lowest in treatment 3. The specific growth rate was recorded higher in the treatment 1 than those of treatment 2 and treatment 3 respectively (Table 10). The highest and the lowest depth of water were 2.25 and 2.36 respectively. Salinity was found lower gradually from the month of January to September. It was found to be the highest (13 ppt) in the month of April with the highest recorded temperature (27.9^0 C).

Transparency was found to be the highest (30 cm) when the temperature was 27.9^0 C in the month of March. The highest concentration of free CO_2 was recorded to be the highest (6 ppm) in the month of March and April whereas the lowest (3.8 ppm) in the month of August.

Table 10. Length-weight data of reared hilsa in brackish water ponds

Parameter	Treatment 1 200 jatka/compartment	Treatment 2 400 jatka/compartment	Treatment 3 800 jatka/compartment
Initial weight (g)	6.5±1.25	6.5±1.27	6.5±1.26
Final weight (g)	76.63±35.95[a]	68.55±44.58[b]	63.68±43.36[b]
Net weight gain (g)	70.07	62.05	57.24
Initial length (cm)	7.3±1.02	7.3±1.04	7.3±1.30
Final length (cm)	18.44± 3.76[a]	18.15±3.85[a]	17.75±3.59[c]
Net length gain (cm)	11.14	10.99	10.4
Specific growth rate (% g/day)	1.16[a]	1.11[b]	1.07[b]

Effect of Climate Change on the Ecology and Biodiversity of Inland Open Water Fishes

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Objectives

- To study the effects of climatic factors and their associated events on the riverine ecology and biodiversity of fish
- To develop a salinity intrusion map for the River Meghna, lower Meghna, Tentulia, and Agunmukha describing the potential impacts on riverine ecology and fish biodiversity.

Achievements

Ten sampling sites with GPS points in the River Meghna (from upper to lower) were selected on the basis of field survey, salinity data, focus group discussion and sharing knowledge with experts. The sampling sites with GPS points in the River Meghna are shown in the Table 1.

Table 1. Sampling sites with GPS points in the River Meghna

Sampling Sites	**GPS Reading**
Shatnol	(23 28.770 N 90 35.520 E)
Chandpur	(23 14.350 N 90 38.150 E)
Horina Ghat	(23 09.938 N 90 38.250 E)
Chor Voirobi	(23 02.123 N 90 39.226 E)
Chor Lodhua	(22 43.299 N 90 50.475 E)
Chor Alexander	(23 39.197 N 90 54.594 E)

Ramgoti	(23 02.122 N 91 00.005 E)
Hijla	(22 23.780 N 90 35.520 E)
Kaligonj	(22 51.320 N 90 36.539 E)
Ilisha Ghat	(22 46.320 N 90 39.330 E)

Physico-chemical parameters

Parameters such as temperature, transparency, salinity, dissolved oxygen, free carbon dioxide; total hardness and alkalinity were recorded using water test kit (HACH kit II) on a monthly basis as shown in the Table 2 and Table 3 respectively.

Table 2. Average values of physical parameters in River Meghna

Sampling Sites	Parameters		
	Air temperature (℃)	Water temperature (℃)	Transparency (cm)
Shatnol	23.8±6.4	20.5±5.3	46.1±7.2
Chandpur	24±6.3	20.3±5.6	49.4±2.9
Horina Ghat	24.1±6.4	21.3±6.4	51.6±20.1
Chor Voirobi	23.5±6.4	20.7±5.9	43.5±3.1
Chor Lodhua	24.8±6.9	20.7±6.2	23.4±9.7
Chor Alexander	24.5±7.2	20.4±6.5	23.4±9.7
Ramgoti	25±7.0	20.7±6.7	14.4±6.8
Hijla	25±7.3	20.4±6.8	44.2±5.8
Kaligonj	25±6.7	20.7±6.7	43.2±5.8
Ilisha Ghat	25.1±6.5	20.9±6.9	39.2±5.2

Relatively higher temperatures (air and water) were recorded at Ramgoti, Ilisha Ghat, Hijla, and Kaligonj points compared to other sampling points ranged between 17-32^{0}C and 15-28^{0}C for air and water temperature respectively. High humidity and distance from sea considered to be the main reason for higher temperature. Recorded water temperature was found suitable for grazing, feeding and spawning of riverine fish species. The highest transparency was recorded at Horina ghat (87 cm) in March whereas the lowest one was observed at Char Lodhua and Ramgoti (12 cm, and 12 cm) in March.

Table 3. Average values chemical parameters in River Meghna

Sites	Parameters (Average Value)					
	DO (mg/l)	Free CO_2 (mg/l)	pH	T. Hardness (mg/l)	T. Alkalinity (mg/l)	Salinity (ppt)
Shatnol	4.1	20.008	7.25	79.4	68.8	0
Chandpur	5.8	16.8	7.7	88.6	65.8	0
Horina Ghat	5.92	15.3	8	93.2	59	0
Chor Voirobi	6.18	14.84	8.05	91.6	61.8	0.02
Chor Lodhua	5.74	16.6	8.1	491	71	4.2
Chor Alexander	5.33	17.9	7.8	924	67.4	6.7
Ramgoti	5.614	18.32	8.1	1220	77.4	9.5
Hijla	6.1	16.1	8.1	83.8	64	0
Kaligonj	6.04	14.7	8.1	88.8	67.8	0
Ilisha Ghat	6.1	17.875	7.95	86.9	65.2	0.2

Water quality parameters such as DO, free CO_2 and pH were found suitable for the survival of fish in each of the sampling points as shown in Table 3. During the study period, the highest salinity was recorded at Ramgoti (12 ppt) in March. It is mainly due to low water flow from the upstream, strong tidal action, distance from the sea and sea level.

Fish Diversity: Data on availability of fish species were collected by interviewing and visiting fisher and fish market. In the study period 24 fish species were found in the selected sites of the River Meghna. Based on observation, no fish species has yet disappeared from the river but amount of catch is decreasing day by day.

Impact of Environmental Factors on Abundance and Distribution of Important Fishes in the River Meghna (Shatnol-Chor Alexander)

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Objectives

- To study the environmental factors in different season
- To study the abundance and distribution of important riverine fishes in different season
- To find out the correlation between environmental factors and abundance and distribution of fishes

Achievements

This study comprises the identified 13 sampling points in and around of the respective GPS location in the River Meghna according to the project proposal. The collected physicochemical and plankton samples were analyzed. The catch compositions of important fish species in different gear at all the sampling points were also analyzed.

Physico-chemical parameters

Temperature (Air and water), transparency, dissolved oxygen (DO), free carbon dioxide (CO_2), total hardness, total alkalinity were determined following APHA (1995). Ammonia and nitrite were estimated using a HACH water test kit (FF-2). Conductivity and pH meter were used to determined water pH and specific conductance respectively. Three physical and seven chemical parameters were studied for river spots of Meghna and results are shown in Tables 1 and 2.

Table 1. Physical parameters of water quality in different sampling points of the River Meghna

Place	Parameters		
	Air temp (^{0}C)	Water temp (^{0}C)	Transparency (cm)
Shatnal (Sn)	15.4-31.5	17-29.5	35-61
Ekhlaspur (Ep)	15.2-31	17-29	18-63
Ananda Bazar (AB)	14.6-32.5	16-28	26-67
Madrasha Ghat (MG)	14-32.5	13.5-28.5	23-91
Harina Ghat (HG	15-31	16-27	42-70
Ishanbala (Ib)	17.2-32.5	17-31.5	38-51
Haim Chor (HC)	16-31.5	17-30	32-53

Char Jalalpur (CJ)	17-32.5	17.4-32	40-54
Chor Voirabi (CV)	16-32	16.5-30	35-60
Hizla (Hz)	17.5-30.5	17-31	22-38
Kaliganj (Kg)	18.5-31	19-31.5	20-36
Chor Ludhua (CL)	18.5-31.5	18-31	11-25
Alexandar (Axr)	19-31.5	18.5-30.7	6-13

Table 2. Chemical parameters of water quality in different sampling points of the River Meghna

Places	Parameters						
	DO (mg/l)	Free CO_2 (mg/l)	pH	Hardness (mg/l)	Alkalinity (mg/l)	Conductivity (µS/cm)	Ammonia (NH_3 mg/l)
Sn	3.8-6.0	6.5-12.5	7.25-7.75	42-70	36-56	124-240	0.04
Ep	5.8-6.2	8.0-12.5	7.0-7.5	40-70	38-52	132-268	0.0
AB	6.0-6.25	9.4-12.0	7.25-8.50	50-88	46-58	154-278	0.0
MG	4.8-5.9	6.5-8.8	7.70-8.25	55-68	34-50	160-290	0.0-0.02
HG	6.0-6.8	5.5-5.8	7.50-8.25	82-96	40-52	264-298	0.02-0.04
Ib	5.9-6.8	9.0-13.0	7.25-8.0	110-140	78-112	210-282	0.0
HC	5.6-5.8	8.0-11.0	7.75-8.50	105-170	122-136	212-278	0.0
CJ	6.2-7.0	10.5-15.0	7.75-8.75	108-138	80-116	180-278	0.0
CV	5.4-6.0	10.5-13.8	7.50-8.50	98-128	68-122	220-290	0.01
Hz	5.5-6.7	8.5-12.8	7.5-9.0	50-96	32-78	170-210	0.0
Kg	4.5-7.0	12.5-16.5	7.25-8.75	80-120	48-82	180-286	0.02
CL	4.0-6.2	11.2-13.8	7.75-8.25	140-460	64-132	375-1000	0.0
Axr	3.8-6.0	12.5-15.0	7.5-8.5	380-790	96-138	380-1000	0.0

Plankton sample collection

Replicate plankton samples, each of 50L were collected from various spots around each sampling station by means of a bucket and filtered through bolting silk plankton net of 50µ. The filtrate were transferred to another bottle and preserved immediately in 1:100 Lugol's solution. Qualitative and quantitative analysis of planktons were done following drop count method (APHA 1995). Identification of plankton was made following Ward and Whipple (1959) and Presecot (1962) and results are shown in Table 3

The dominating phytoplankton was *Ulothrix* sp. in all the sampling points ranged from lowest 16×10^2 no./L in Shatnol of Chandpur to highest 290×10^2 no./L in Hizla of Barisal except *Melosera* sp. (98×10^2) in Eklaspur point of Chandpur. *Brachionus* sp. also was shown as the dominating zooplankton in maximum sampling points ranged from lowest 6×10^2 no./L in Chor Alexgander to highest 38×10^2 no./L in Chor Jalalpur point except Nauplius in Eklaspur (3×10^2 no./L) of Chandpur and Chor Ludhua (5×10^2 no./L) of Laxmipur (Table 3).

Table 3. Quantitative study of plankton in different points of the River Meghna

Place	Phyto. (no./L)	Domi. P. (no/L)	Zoo. (no./L)	Domi. Z. (no/L)
Sn	40×10^2	*Ulothrix* (16×10^2)	11×10^2	*Brachionus* (7×10^2)
Ep	248×10^2	*Melosera* (98×10^2)	5×10^2	*Nauplius* (3×10^2)
AB	48×10^2	*Ulothrix* (20×10^2)	12×10^2	*Brachionus* (10×10^2)
MG	141×10^2	*Ulothrix* (96×10^2)	30×10^2	*Brachionus* (21×10^2)
HG	398×10^2	*Ulothrix* (162×10^2)	22×10^2	*Brachionus* (16×10^2)
Ib	288×10^2	*Ulothrix* (180×10^2)	28×10^2	*Brachionus* (20×10^2)
HC	260×10^2	*Ulothrix* (190×10^2)	10×10^2	*Brachionus* (8×10^2)
CJ	245×10^2	*Ulothrix* (102×10^2)	38×10^2	*Brachionus* (24×10^2)
CV	290×10^2	*Ulothrix* (210×10^2)	12×10^2	*Brachionus* (8×10^2)

Hz	424 × 10^2	*Ulothrix* (290× 10^2)	25× 10^2	*Brachionus* (23 × 10^2)
Kg	378× 10^2	*Ulothrix* (260 × 10^2)	28× 10^2	*Brachionus* (17 × 10^2)
CL	201 × 10^2	*Ulothrix* (102 × 10^2)	9 × 10^2	*Nauplius* (5 × 10^2)
Axr	244 × 10^2	*Ulothrix* (176× 10^2)	10× 10^2	*Brachionus* (6 × 10^2)

Fish sampling and fisher's survey

Monthly fish sampling were done in every selected sampling station to collect data of important species, catch composition of different gears used and their catch per unit effort (CPUE). CPUE were estimated by the following formula- CPUE=C × F/ M × P (IRBUCD 1994)

Where, CPUE = daily catch in kg/fisherman,
C = catch in kg/net/day,
F = number of possible fishing days/month,
M = 30 days, and
P = participant fishermen/net

Fishers were interviewed to know their present day's catch and their previous day's fishing activities in this area. Generally, 5-6 of the potential fishers were interviewed from each landing center. The results are shown in Table 4.

Table 4. *In situ* observation of fishing gear in different sampling points of the River Meghna

Type of Net	Local Name	Mesh size (cm)	Av. L. (m)	Av. W. (m)	Haul time (h.)	CPUE (Kg/ haul)	Important sp.	Major period	Sampling area
Gill net	Chandi /Current Jal	6-7	250-300	6-10	1-2	1-10	Hilsa, Ayre, Shilong, Bacha	Year round	All Areas
	Poa Jal	2.5	150-200	3.0-3.5	6.0	3.0-4.0	Poa, Bacha, Bagna, Ayre, Shilong, Hilsa	Jan-May	All Areas
Seine net	Cona Ber Jal	5-8	500-1000	12.0-15.0	1.0	12-20	Hilsa	Year round	All Areas
Falling net	Chap Jal	10-15	100-300	25-50	0.5-1.0	2.0-4.0	Ayre	Jan-March	All Areas
Drag net	Moi Jal	0	4.5-5.0	1.5-2.0	0.75-1.0	0.25-0.30	Chingri, Poa, Chewa, Shilong, Bele, Bacha,	Jan - May	All Areas except Hz & Kg
Set Bag net	Behundi Jal	0-2.5	25-50	10-30	5-6	5.0-30.0	Chingri,.Poa, Chewa, Pangas, Bele Shilong, Shrimp, Jatka, Kajoli, Toposhi	Nov-April	All Areas

Investigation of Tilapia (*Oreochromis niloticus*) Disease in Cage and other Fish Culture Systems and Control Strategies

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Objectives

- To identify risk factors associated with disease outbreaks in tilapia farming
- To identify the causative agent(s) associated with the occurrence of diseases
- To minimize tilapia mortality based on significant risk factors using appropriate management strategies.

Achievements

Case-control study: Case–Control study was carried out covering Mymensingh and Chandpur region in grow out farm and cages of tilapia. Epidemiological parameters were investigated during the sampling period using a pre-tested questionnaire. During the case-control study, 10 case pond and corresponding 10 control pond were investigated in Mymensingh and Jessore region. In Chandpur region, 5 case cages and corresponding 5 control cages were observed. Epidemiological data are presented as follows:

Table 1. A preliminary observation on tilapia culture in ponds

Epidemiological characteristics	Affected farms	Unaffected farms	Remarks
Source of fingerlings	Local hatchery, NGO"s	Local hatchery, BFRI hatchery, Government farm	Stocking of apparently healthy/sick fry might be a risk for disease outbreak
Stocking density	40000-65,000/ha, weight 10-15 g	37,000-50,000/ha; weight-15-20 g	Lower density results higher growth, safer for fish
Sources of water	Mainly deep tube well.	Mainly deep tube well.	Protective against disease
Pond has high embankment	>80%	>95%	Protective against disease
Pond connected to other water bodies allowing the entry of wild fish	<10%	<10%	Risk for disease outbreak
Holes in pond bank/bottom	> 55% farms	> 45% farms	Risk for spread of pathogen by vector
Pond is dried completely every season	40-65%	50-90%	Complete removal of vector/pathogen and improve water quality
Water is drained from the pond every season	Drained for harvesting	Drained for harvesting	Remove vector/pathogen
Bottom mud is removed from the pond in 2/3 years	20-45%	20-45%	Reduce risk of disease
Pond is limed every season	100% commercial farmers	100% commercial farmers	Protective against disease
Fish nets are dried and disinfected before netting	<9%	<12%	Dried/disinfected net might prevent spread of disease
Workers assigned to specific ponds	no	no	It increases risk of disease
Pond is fenced	30-55%	36-86%	Prevent vector's entry and reduces chance of disease

Disease control measures			
Apply antibiotics	Sometimes	No	Can not cure
Add more water	If necessary	If necessary	Beneficial for fish health
Apply gas reduction treatment	Often/when necessary	Often/when necessary	Reduce stress on fish
Apply disinfectants to water	Often/when necessary	Often/when necessary	Might be useful
Apply probiotics in pond	Some times	Sometimes	Might be useful
Notify public authorities	Sometimes, mostly share with feed dealers or chemical dealers	Sometimes, mostly share with feed dealers or chemical dealers	Farmers have little communication with public authorities
Apply excess feed	No	No	Prevent excessive production of phytoplankton
Use different feed	Mostly tilapia grower feed	Mostly tilapia grower feed	Quality of feed is a challenge
Harvest and sell off all fish	If affected sell off immediately/wait for cure	Grow for market size	Affected farmers can enhance the spread of disease / reduce the losses to some extent

Table 2. Preliminary observation on tilapia culture in cages

Epidemiological Characteristics	Affected cages	Unaffected cages	Comments
Cage size	15×8×5 to 20×10×6.5 m^3	15×8×5 to 20×10×6.5 m^3	Not considered risk for disease
Number of cages	50-70	50-65	Not considered risk for disease
Arrangement of cages	Mostly parallel	Mostly parallel some Zig-zag	More water flow and more hygenic in unaffected zig-zag-cages
Distance between cages	3- 7 inches	4-6 inches	No remarkable differences observed between two groups
Quality of fry	Apparently healthy	Apparently healthy	Apparently healthy fry might contain pathogen in dormant condition
Stocking density	1000-1200/cage	800-1000/cage	Low stock density could be safer for tilapia
Affected culture cycle	Both winter and summer cycle	Both winter and summer cycle	Risk both in cold and hot season
Depth of water	10-12 feet	10-15 feet	Lower depth could be risk for disease
Water flow	Poor	Satisfactory	Insufficient water flow might increase risk of disease
Source of fry	Local hatchery	Local hatchery	No difference found
Cleanliness of cages	Clean Irregularly/Clean monthly	Fortnightly /monthly	Might have little risk for disease
Workers assigned to specific cages	no	no	It increases risk of disease
Huge domestic waste	Pass through cages	Little or no access of domestic waste	Might be a potential risk for disease
Apply antibiotics in feed	Sometimes, when infected	Not applied	Not always effective against disease

Clinical sign of diseased tilapia: During investigation, in case of pond, clinical signs such as loss of appetite, spine displacement, darkening of skin and scale loss were observed. In case of cage culture system clinical signs such as spinning, eye protrusion, erratic swimming and hemorrhages at the base of fins and in the opercula were observed.

Seasonality of disease occurrence: In case of pond**,** August to December was found to be the most disease prone season, however disease also occurred during May to July with lower severity.. In cage culture systems, mainly winter season (Oct.-Dec.) was found to be more prone to disease outbreak. The

morbidity and mortality rate varied with season, location, farm design, species, culture system, management practice, etc.

Fish mortality: In cage culture systems, 140-150 g sized fish were severely affected by disease.

Histology: Tissue from affected fish such as skin, gill, kidney, liver and spleen were preserved in 10% buffered formalin for histopathological studies.

Bacteriology: In order to isolate and identify potential causative agent, affected tissues were inoculated onto Tryptone Soya Agar (TSA) and finally isolated a few pure culture for diagnosis. Primary diagnostic tests were done in BFRI laboratory which suggested the bacteria as *Streptococcus* spp. For further authentication of the causative agent; Spleen, kidney and brain samples from affected fish were preserved in 80% ethanol and sent to MSD Animal Health Laboratory, Singapore. MSD confirmed the pathogen as *Streptococcus agalactiae* using molecular technique.

Optimization of Breeding and Seed Production Techniques of *Pangasius pangasius*

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Objectives

- To optimize the induced breeding technique of *P. pangasius*
- To develop nursery technique of *P. pangasius* depending on successful breeding.

Achievements

Brood selection and management

Based on the secondary sex characters, 10 pairs of brood pangas were selected from the Riverine Station produced stock. Ratio of male and female was 1:1 in brood pond. Ground water was supplied regularly to the rearing ponds to maintain water quality and water depth at optimum level. The wild broods collected from the River Meghna were reared in separate ponds with commercially available supplementary feed at the rate of 3% body weightt once daily. From February to August, health condition and gonadal maturity of brood pangas were monitored regularly by examining colour and shape of genital opening and softness of the belly. Two priming doses of PG were applied intramuscularly to each pair of brood for proper gonadal development. Both the 1st and 2nd doses were applied at the rate of 1 mg /kg and 2 mg/kg body weight weight for male and female respectively. First priming dose was applied at the end of March while the 2nd one was applied at end of April.

Induced breeding trial

Maturity Assessment: Maturity of brood pangas was assessed by examining the secondary sexual characters such as softness of abdomen, shape of belly and color of vent.

Table 1. Weight of selected male and female brood Pangas

Weight (kg)	
Male	Female
5.0	7.9
4.3	7.5
4.0	7.0

Selection and conditioning: Three pairs of brood pangas were selected from rearing ponds and kept into conditioning tank (8:10 hours) with continuous water shower for 6 hours.

Hormone injection: cPGE was prepared by grinding of cPG and mixing of distilled water to obtain the desired concentration of PG. The average weight of each cPG was measured 2.5 mg. After 6 hours of conditioning (14:10 hours) the female broods were caught for injection from the conditioning tank by netting, then wrapped by a wet, soft cloth and was kept lying on soaked foam. First dose (stimulatory dose) of cPGE was applied intramuscularly at the rate of 2.5 mg per kg body weight to the female pangas and then kept into the conditioning tank under continuous water shower.

After 6 hours of 1st injection, (20:10 hours), female brood received a 2nd dose (resolving dose) of cPG at the rate of 9 mg per kg body while at that time the male brood received a single dose of cPG at the rate of 3 mg per kg body weight. After 2nd injection, both the male and female broods were kept into the conditioning tank under continuous water shower and their breeding behavior was observed. After 8 hours of 2nd injection (16.10 hours), female brood pangas were picked up from the conditioning tank for stripping but no symptom of ovulation was recorded. Vent was not protruded and it was leveled with no change. Color of vent was not changed. Male brood pangas were also picked up from the conditioning tank and little amount of milt was appeared following gentle pressure on the abdominal region. It seemed that the brood pangas was not mature enough to be used for the breeding purpose.

Present Status of Limnology and Natural Breeding Ground of Carps in Kaptai Lake

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Objectives

- To know the present status of natural breeding ground of carps in Kaptai Lake
- To identify the specific breeding locations through collecting egg/spawn
- To know the physico-chemical and biological parameters of different breeding ground
- To provide scope for management decision of lake ecosystem.

Achievements

Physico-chemical parameters of spawning ground

Mean values and ranges of water quality parameters over the study period are presented in Table 1. The water quality parameters remained more or less similar. In the present study, investigations were made on few physical and chemical factors of water of breeding ground of Kaptai Lake. The air and water

temperature of experimental areas of Kaptai Lake were found to vary from 24 to 32°C and 18 to 34°C, respectively. Dissolved oxygen and free CO_2 in the experimental sites ranged between 5 and 8 mg/L and 2.13 and 10 mg/L, respectively. In this study, dissolved oxygen was found suitable for fish throughout the study period. pH and total alkalinity of different areas varied from 6.5 to 8 and 17.1 to 68.4 mg/L respectively. Total hardness of different areas varied from 34.2 to 8 and 119.7. Transparency and water depth ranged from 1.1 to 8.3 feet and 3.4 to 30.3 m respectively during the study period.

Table 1. Water quality parameters of Kasalong channel and Barkal channel during the study period

Water quality parameters	Natural breeding ground of Kaptai Lake	
	Kasalong channel	Barkal channel
Water temp.(°C)	26.3±4.57 (18-34)	26.8±3.26 (21-32)
DO (mg/l)	5.9±0.74 (5-7)	6.5±0.97 (5-8)
CO_2 (mg/l)	4.34±2.25 (2.13-10)	3.48±0.80 (2.36-5)
pH	7.2±0.35 (6.5-7.5)	7.25±0.42 (6.5-8)
Total hardness (mg/l)	54.72±15.71 (34.2-85.5)	78.66±24.45 (51.3-119.7)
Total alkalinity (mg/l)	41.04±11.96 (17.1-51.3)	46.17±14.08 (17.1-68.4)
Transparency (ft)	5.01±2.51 (1.1-8.3)	4.72±1.18 (2.6-6.2)
Water depth (ft)	14.15±5.76 (3.4-20.2)	20.65±8.87 (4.2-30.3)

Biological parameters of spawning ground

During the study period sampling of plankton assemblage from sub-surface water was done fortnightly by using plankton net (20 µm) for qualitative and quantitative analysis. The phytoplankton population comprises of four orders *viz.* Euglenophyceae, Cyanophyceae, Bacillariophyceae and Chlorophyceae. In Kasalong channel phytoplankton populations comprise of four orders *viz.* Chlorophyceae (44.92%), Cyanophyceae (21.42%), Bacillariophyceae (20.26%) and Euglenophyceae (14.31%). In Barkal channel phytoplankton populations comprise of four orders *viz.* Chlorophyceae (48.15%), Cyanophyceae (18.45%), Bacillariophyceae (23.02%) and Euglenophyceae (10.38%). Among the phytoplankton the dominant order in both study areas was Chlorophyceae. The zooplankton population includes three orders *viz* Rotifers, Copepoda and Cladocera. The zooplankton population in Barkal channel comprised with Rotifers (57.26%), Cladocera (37.51%) and Copepoda (9.23%). The zooplankton population in Kasalong channel comprised with Rotifers (49.91%), Cladocera (42.84%) and Copepoda (7.25%). Among the zooplankton the dominant order in both study areas was Rotifers.

Collection of juvenile fishes: During post-breeding season juvenile of different carp species were collected from fisher catch and local market to know the availability of carps juvenile in Kaptai Lake. Among Indian Major Carps juvenile of Kalibaush (*Labeo calbasu)* was collected from fisher catch (Langadu) and local market (Banarupa) during post-breeding season in January and March, 2016.

Collection of brood fish sample: Sample of different carps were collected from Kaptai Lake during breeding season when matured fishes were available. For forecasting of the commencement of breeding of carps in the reservoir, an attempt was made to assess egg-maturity and estimate gonado-somatic index (GSI) of major carps.

Present condition of breeding channel: Depth of breeding ground reduced due to siltation. Siltation due to shifting cultivation pattern, high water level fluctuation, lack of rainfall and thunder showers at breeding time are assumed to be the more important causes, but low water current and velocity during the breeding season and fishing pressure are also suspected. In the present study, highest water depth (30.3 feet) was measured in September, 2015 at Barkal channel and lowest water depth (4.2 feet) was measured in May, 2015.