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Impacts of fish sanctuaries on production and biodiversity of fish and prawn in Dopi *beel*, Joanshahi *haor*, Kishoregonj

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Abstract. The impacts of sanctuary on fish production and fish biodiversity were investigated in Dopi *beel* in Joanshahi haor over a period of two years from January 2004 to December 2005. Broadly two different types of materials were used to set two sanctuaries in Dopi *beel* referred to as Treatment 1 and Treatment 2; the control treatment was set in another *beel* named Chotadigha-boradigha *beel* without using any materials. Data on fish production and species abundance obtained from different treatments were compared. Ten major groups of fish viz carp, barb and minnow, catfish, featherback, snakehead, perch, eel, loach, miscellaneous fishes and prawn were obtained in the final harvest from different treatments. The fish species number was registered at 57, 60 and 62 in 2003 (before intervention), 2004 and 2005, respectively in Dopi *beel*, while that in Chotadigha-boradigha *beel* during the same period was 60, 55 and 50, respectively. The total production obtained from the Dopi *beel* was much higher than that from the Chotadigha-boradigha *beel*. The fish species deemed as threatened were found to reappear in Dopi *beel*, while in Chotadigha-boradigha *beel* the number of threatened species had been decreased over the 3-year period. The highest density index (H=0.89) and species richness (E=0.62) of threatened species were recorded in Treatment 1. Generally the yield of large species had been increased in Dopi *beel* during the investigation period. The establishment and management of sanctuaries in the *beel* had beneficial effects on the production of fish.

Introduction

Bangladesh is the country of *haors, baors*, river and *beels*. The low-lying depression inside the floodplain and *haor* is called *beel* (small lake). There are 4,498 *beels* of different sizes scattered throughout the country of which 2,590 are perennial and 1,908 seasonal. Fisheries sector is contributing about 5.71% to total export earning, 4.92% to GDP, 23% to agriculture sector and 63% to animal protein supply. In early 60s, inland fisheries contributed about 90% to total fish production of the country, but now only 39% to total fish production (DoF, 2005). *Beel* fishery of Bangladesh is being deteriorating day by day due to over fishing, uncontrolled use of chemical fertilizer and insecticide, destruction of natural breeding and feeding grounds, harvesting of wild brood fishes and for many other causes.

There is an immediate need to restore the fish habitat in *haor* areas and in other open waters. The conservation of freshwater fisheries has been recognized as an important consideration throughout the World (Cowx, 2002). Protected areas as a living resources management tool might play a vital role to restore freshwater biodiversity (Saunders *et al.*, 2002). In Bangladesh and other countries in the region, establishment of fish sanctuary is an important recognized tool for conservation, protection and restoration of fish species.

A few researches on fish sanctuary have been done in Bangladesh on some particular rather narrow aspects (MACH, 2001, Ahmed and Ahmed, 2002, FFP, 2005). Considering the above situation this experiment was designed to study the overall impacts of fish sanctuaries on production and biodiversity of fishes. The other objective of the study was to develop an appropriate design for freshwater fish sanctuary using local fish friendly materials. It is hoped that the study would help in future planning for biological management of open water *beel* fisheries in *haor* area.

Materials and methods

The experiment was conducted over 24 months during January 2004 to December 2005 in Dopi *beel* inside Joanshahi *haor* under *upazilla* Methamoin of Kishorgonj district. Methamoin upazila lies between 90°69′ and 91°15′ north and 24°21′ and 24°30′ east. Data of fish catch recorded by WorldFish Center during 2003 was used as baseline data to compare the findings of the present study. To compare the effect of treatments, parameters from another *beel* – the Chotadigha-boradigha *beel* were also studied.

Dopi *beel* was selected for the study where six sanctuaries were established under the project CBFM-2 managed by the local fishers community. The *beel* is fully inundated along with other neighbouring *beels* and waterbodies during monsoon. In dry season, it becomes closed with a narrow link to the river – Mohisherkandi-boranpur through a cannel. The deeper portion of the *beel* retains water throughout the year. The area of Dopi *beel* is 21.74. ha (MoL, 2000). The Chotadigha-boradigha beel was treated as control. No sanctuary was established in this *beel.* The *beel* is fully comparable with the Dopi *beel* regarding seasonal water flow, fluctuation of water level and waving with an area of 43.97 ha (MoL, 2000).

Experimental design

In the present study, two sanctuaries (Treatments 1 and 2) having three replications each in Dopi beel along with a control treatment (Chotadigha-boradigha *beel*, Treatment 3) were applied. Details of treatments are presented in Table 1. The sanctuaries were established during November to January, 2003. The average area of

each sanctuary was about 0.12 ha. Two different sets of fish friendly sanctuary materials were used for Treatments 1 and 2.

Table 1 Name of fish friendly materials used in different sanctuary treatments

Treatment 1	Treatment 2	Treatment 3 (Control)
Bamboo and bamboo pole, bamboo pipe, branches of mango, black berry trees and pipe made by betel nut tree, modified locally made prawn trap (*Chai*) and coconut leaves.	Bamboo and Bamboo pole, Old broken country boat and branches of mango and black berry trees	No sanctuary

Catch assessment in beel

Catch assessment of fish and prawn in different types of habitats were performed following the methodologies of WorldFish Center (2001). Catch assessment monitoring questionnaire developed for CBFM-1 and 2 was used in this study. Data obtained from baseline surveys conducted by WorldFish Center during 2003 was used as base line data. Catch monitoring data and gear survey were conducted weekly from fishermen of both the *beels* during fishing. Catch assessment survey involved observation of fishing activity for 8 days in each month for each *beel*. Total daily catches by gear type were estimated from their average catch rates. Name, number and weight of fish species and CPUE were recorded monthly and based on the monthly data, annual yield was calculated.

Annual yield in each gear type and total yield from all gears were calculated using the equation:

$$\text{Annual yield in each gear type} = \sum_{i}^{n} \text{Average } i. \quad \text{Where } i = 1, 2, 3, 4, \text{----------}, n.$$

$$\text{Total yield} = \sum_{j}^{k} \text{Annual yield in each gear type } j. \quad \text{Where } j = 1, 2, 3, 4\text{----------}, k.$$

Catch assessment in sanctuary

Annual catches of sanctuaries were estimated based on summing up of total harvests in the season of each sanctuary using census data of available sanctuaries in *beels*. Catch (kg/ha) was estimated using the equation :

$$\text{Catch/ha/year} = \frac{\text{Total annual sanctuary catches (kg)}}{\text{Total area covered by Brush Parks or Sanctuary (ha)}}$$

(WorlFish Center, 2001, 2003, Halls and Mustafa, 2006)

Species diversity in sanctuary treatments

Species diversity was calculated using Shannon-Wiener diversity index(H).

$H = -\sum pi \, Ln \, pi$

Where, pi is the proportional abundance of the i th species, such as $pi = n/N$

Where, n is the number of individuals in the i th species and

N is the total number of individuals of all species.

It combines species richness (S) and evenness (E) (Hunter, 1996).

Statistical analysis

One way ANOVA was performed to determine the significant variations in fish catch/yield from different *beels* and treatments. The analyses were done following Duncan's Multiple Range Test (Zar, 1984). All the statistical analyses were done using SPSS package programme (11.5 versions).

Results

Available groups of fish and prawn

Eleven major groups of fish and prawn viz carp, catfish, barb and minnow, clupeid, snakehead, perch, eels, loach, featherback, miscellaneous fish and prawn were found in two *beels* during the study period. However, featherback was not available in the control treatment (Treatment 3) during 2004. Fish species belonging to different groups are presented in Table 2. Fifty seven species of fish and prawn were found in Dopi *beel* during 2003. The species number increased gradually in the next two years (60 in 2004 and 62 in 2005). On the other hand, in the control *beel*, number of species decreased gradually (60, 55 and 50 in 2003, 2004 and 2005, respectively.

Variations in total yield of different groups of fish and prawn

In Dopi *beel* no catch was recorded during January to May, January to April and March to May in 2003, 2004 and 2005, respectively and the highest catch was

recorded during July (4,480 kg), November (29,131 kg) and February (59,112 kg) during above three years respectively. In Chotadigha-boradigha *beel* (T-3), no catch was recorded during April, May and December; January to April and January to May in 2003, 2004 and 2005, respectively and the highest total yield was recorded in January (52,255 kg), August (1,003 kg) and December (2,445 kg) in the above three years, respectively .

Total yields and average yield (kg/ha)

Total yield includes yields of *beel* catch, brush park catch and catches of sanctuary in Treatment 1, 2 and 3. Mean total abundance of different groups of fishes and yearly variations of total yields are presented in Table 3.

Table 2 Different fish and prawn species recorded from the two *beels* during 2003 to 2005 (B–*Beel*, BP–Brush Park, S1–Sanctuary (T1) and S2–Sanctuary (T2)

Local name	Dopi *beel*								Chotadigha-boradigha *beel*					
	2003		2004		2005				2003		2004		2005	
	Beel	Brush park	Beel	Brush park	Beel	Brush park	T 1	T 2	Beel	Brush park	Beel	Brush park	Beel	Brush park
Kalibaus	+	+	+	+	+	+	+	+		+	+	+		+
Rui		+	+	+	+	+		+		+		+		
Catla		+		+										
Mrigal		+	+	+	+			+		+		+		
Carpio		+	+	+	+	+	+	+		+	+	+		+
Goinna	+	+	+	+	+	+	+	+		+	+	+		+
Bhagna		+			+		+	+	+				+	
Chhep chela	+						+	+						
Grass carp		+	+							+				
Ghora mach					+								+	
Boal	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ayre		+	+	+		+	+	+		+	+	+		+
Guji ayre	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Shing							+	+	+	+		+	+	+
Magur							+	+	+	+	+	+	+	+
Modhu Pabda	+	+	+	+	+	+	+	+	+	+	+	+		+
Kani Pabda		+	+	+		+	+	+	+	+		+		+
Garua	+		+	+	+		+	+	+	+	+		+	
Bacha	+	+	+	+	+		+			+	+	+	+	
Kajoli		+	+	+		+	+			+		+		+
Baspata	+	+	+	+			+				+			
Batashi		+	+	+			+			+	+	+		+

Local name	Dopi *beel*								Chotadigha-boradigha *beel*					
	2003		2004		2005				2003		2004		2005	
	Beel	Brush park	Beel	Brush park	Beel	Brush park	T 1	T 2	Beel	Brush park	Beel	Brush park	Beel	Brush park
Gulsha	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Tengra	+	+	+	+	+	+	+		+	+	+	+	+	+
Bujuri	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Gagla			+								+			
Jatputi	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Titputi	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Katari	+		+											
Dhela		+	+	+	+	+	+	+	+	+		+		
Kanchanputi	+		+	+	+				+		+			
Sorputi	+	+	+	+	+	+	+	+		+	+	+	+	+
Chapila	+	+	+	+	+	+	+	+	+	+		+		+
Taki	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Shol	+	+	+	+	+	+	+	+	+	+	+	+		+
Gazar	+	+	+		+		+	+	+	+		+		
Cheng		+		+			+	+		+		+		+
Lal chanda	+	+	+	+	+	+	+	+		+		+		+
Chanda		+		+		+	+	+		+		+		+
Meni	+		+		+	+	+	+	+	+	+			+
Napit				+			+	+		+		+		
Kholisha		+		+		+	+	+		+		+		
Gol chanda		+	+	+		+	+	+		+		+		+
Koi			+				+	+	+		+			
Bime/Chirka	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Kuchia		+		+		+	+	+		+		+		+
Rani					+					+			+	
Gutum	+	+		+		+	+	+	+	+		+	+	+
Ghora gutum	+	+	+	+		+	+	+		+	+	+		+
Foli		+		+	+	+	+	+		+			+	
Bailla	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Kakila	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ekthuitya									+					
Choto tepa		+		+		+	+	+		+		+		+
Phasa			+			+	+	+						+
Boro chingri	+	+	+	+	+	+	+	+	+	+	+		+	
Dimua chingri	+	+	+	+	+	+	+	+		+	+	+	+	+
Chatka itcha		+		+		+	+	+		+				

Table 3 Total yield (kg) of different groups of fish and prawn in Dopi *beel* and Chotadigha-boradigha *beel* during 2003 to 2005

Group	Dopi beel			Chotadigha-boradigha beel (Control, T 3)		
	2003	2004	2005	2003	2004	2005
Carps	521	4,626	10,778	137	161	36
Cat fishes	1,933	11,973	31,014	10,254	3,247	1,821
Barbs& Minnows	5,078	21,772	31,443	27,205	794	715
Clupeid	2,141	13,396	969	30	7	22
Snakeheads	1,053	838	184	3,278	1,152	1,008
Perch species	155	393	939	84	20	24
Spiny eels	1,640	1,690	682	20,395	156	963
Loaches	363	470	22	2,886	6	170
Feather backs	1	4	43	8	0	13
Miscellaneous	3,561	4,427	2,185	3,613	182	140
Prawn	1,208	823	944	63	106	29
Total yield	176,531	60,409	79,204	67,952	5,831	4,941

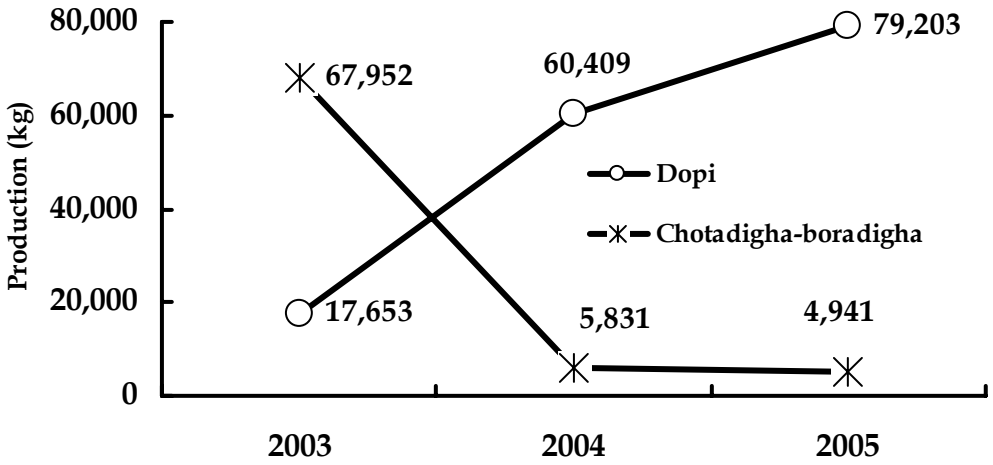

Fig. 1. Total production (kg) as obtained from the two *beels* in 2003, 2004 and 2005.

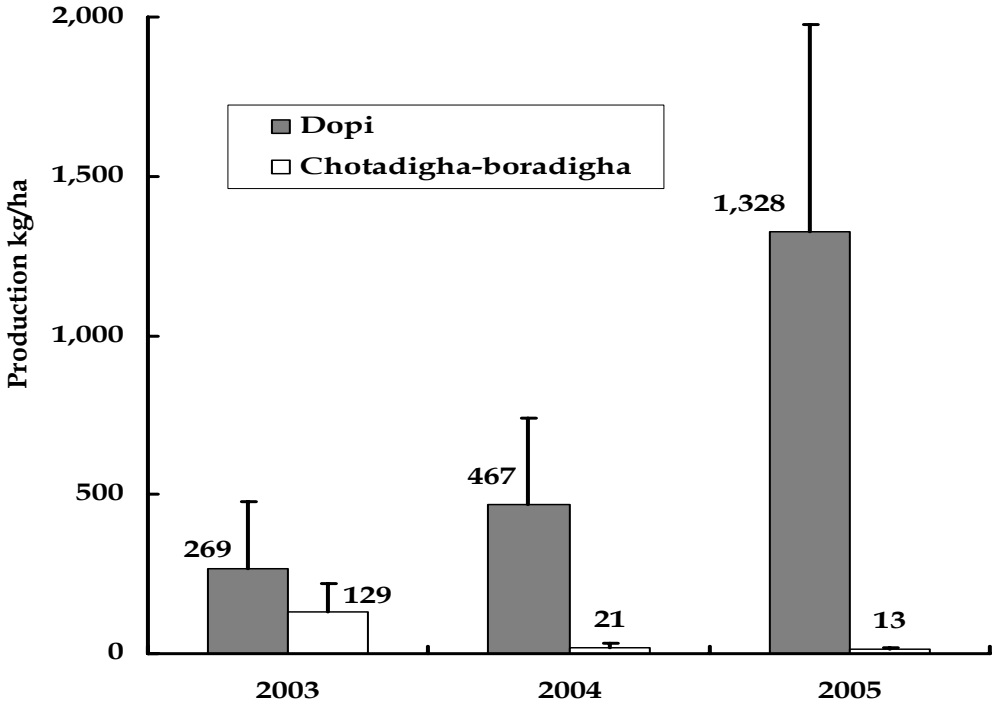

Fig. 2.Production (kg/ha) as obtained from the in two *beels* in 2003, 2004 and 2005.

The total yield and average yield ± SE per hectare in two beels in three successive years are presented in Figs. 1 and 2. The control *beel* – Chotadigha-boradigha is nearly double in size than the Dopi *beel* and the total annual production was about four times higher in 2003. After establishment of the sanctuary, the production scenario fully changed. In 2004, the production of Dopi *beel* was nearly 10 times higher than the productions of Chotadigha-boradigha *beel* and the difference further increased to nearly 16 times in the year 2005. Production per unit area (kg/ha) in the two *beels* followed the same trend. While during the same period production per unit area increased dramatically in Dopi *beel* (from 269 kg/ha in 2003 to 1,328 kg/ha in 2005) while it decreased at an alarming rate in Chotadigha-boradigha *beel* (from 120 kg/ha in 2003 to 13 kg/ha in 2005).

Comparison of sanctuary and brush park yields

Annual yield (kg/ha) differed significantly among treatments over the years (Fig. 3). Data on sanctuary yield were only available for 2005 and the annual yield increased significantly between two types of sanctuaries (Treatments 1 and 2). In the brush park in Dopi *beel* the yield increased significantly over the years on the other hand the same in the Chotadigha-boroadigha *beel*, decreased significantly and were much lower than the yield in brush park and sanctuaries established in Dopi *beel*.

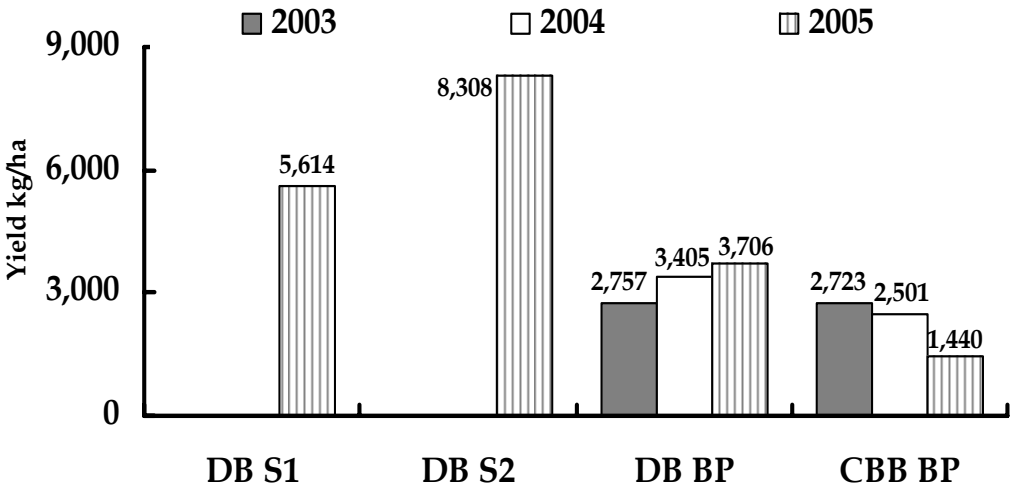

Fig. 3. Annual yield (kg/ha) as obtained from different treatments during the study period.

Biodiversity of fish species

Shannon -Wiener diversity indices were calculated only for fish and prawns harvested from brush parks and sanctuary treatments. Diversity indices (H), species richness (S) and evenness (E) of fish and prawns harvested from Treatments 1 and 2 and brush parks of both *beels* are summarized in Table 4.

Table 4 Shannon -Wiener diversity indices, species rich ness (S) and evenness (E) of fish and prawn harvested from sanctuary Treatment 1 and 2, and brush parks in Dopi *bee*l and Chotadigha-boradigha *beel* during 2003 to 2005

Years of brush park/Treatments yield	Overall *beel*	S Value			H Value			E Value		
		Sanctuary	Brush park	Endangered	Sanctuary	Brush park	Endangered	Sanctuary	Brush park	Endangered
Dopi *beel*										
2003	57	---	48	22	---	0.94	0.34	---	0.56	0.25
2004	61	---	48	22	---	0.96	0.29	---	0.56	0.22
2005	62	---	40	18	---	0.94	0.34	---	0.58	0.27
Sanctuary T1	---	52	---	27	0.86	---	0.89	0.50	---	0.62
Sanctuary T2	---	50	---	25	0.86	---	0.31	0.50	---	0.22
Chotadigha-boradigha *beel*										
2003	60	---	52	26	---	1	0.79	---	0.58	0.56
2004	55	---	45	20	---	0.94	0.91	---	0.59	0.70
2005	50	---	42	18	---	0.97	0.53	---	0.60	0.34

Discussion

The observed abundance and diversity of *haor* fish fauna were found to be related to the *haor* environment particularly flooding, rainfall, variations of water depth of *hoar* river, draught, fishing intensity, waving, water current, water pollution, sedimentation of silt as well as contraction and expansion of aquatic habitats in the present study which more or less agree with the findings of Graaf *et.al*. (2001) who reported that breeding and growth are strongly related to the sequence of flooding. This present study further revealed that production of some important species of fish including endangered species increased after setting up the fish

sanctuaries as the fish sanctuaries increased the opportunity for fish to breed inside the sanctuary and adjacent *haor* areas.

The *beels* are considered as biologically sensitive habitats as they play a vital role in the recruitment of fish in the riverine ecosystems and provide nursery grounds for commercially important fishes. It was further observed that migration of most of the species living in the sanctuaries followed a definite migratory route consisting of *beel*, river, canal, floodplain or rice fields and ditches of floodplain for breeding or feeding purposes.

Most of the 11 major fish and prawn groups as recorded in this study were also reported by MACH (2001) from the *beel* and floodplain catch composition in Hail *haor*. BFRI (2002) also reported all these fish and prawn groups from the study of different *beels* in Sylhet sub-basin and Mymensingh sub-basin. The bottom feeder fish were the major species in *beel* catch during 2004 and 2005 in Dopi *beel*. Most probably broken country boat provided safe places for the bottom feeder fish to take shelter. Exotic species *Cyprinus carpio* was observed to breed in Dopi *beel,* and the hatchlings and fries of *Wallago attu*, *Sperata seenghala*, *Sperata aor*, *Mystus cavasius, Ompok pabda, Ompok bimaculatus, Mystus vittatus, Labeo gonius* and *Labeo calbasu, Puntius ticto*, *Puntius sarana*, *Osteobrama cotio, Gadusia chapra, Mastacembelus armatus, Mastacembelus pancalus and Macrognathus aculeatus* etc. were collected in and around this *beel* before and during monsoon which indicated their breeding ground in this *beel* and surrounding areas. Unplanned stocking of common carp fry in different *beels* including Dopi by lease holders and fishers community and also flooding of many ponds in high land during 2004 was the main reason for the presence of the exotic - carps in *haor*.

It was also observed that with the increase in production of large cat fishes, production of other small species including prawn decreased due to the predatory nature of large catfishes particularly an intensive predation at the time of egg laying and at hatchling and at juvenile stage. This is a problem of survival of small fishes in brush parks and sanctuaries. The presence of shrimp and other small fishes in gut and stomach of larger catfishes confirms this.

A huge number of benthic organisms particularly mollusks and othe benthos like - chironomides, oligochaetes etc. were recorded in all treatments in Dopi *beel.* Common carp and other bottom feeders prefer benthic food and in addition, branches of trees that provide substrate for periphyton in sanctuaries. Therefore, their congregation both in brush parks and sanctuaries was higher. Bamboo pipe and

pipe made by beetle nut trees provided excellent shelter for spiny eels in the fish sanctuaries. *Puntius sarana* was used to be a very rare species in the study area even in *haor* region for last 20-25 years but now it is one of the most commonly available species in this area particularly in winter season. Meni, *Nandus nandus* was about to be extinct after the onset of epizootic ulcerative syndrome (EUS) in 1988 onwards but it has reestablished after the introduction of brush park and setting up of sanctuaries in the *haor* rivers and *beels.*

Kadir *et al*. (1999) reported the evidence of increasing fish diversity and catches in open floodplain *beels* as a result of establishment of fish sanctuaries. Ahmed and Ahmed (2002) reported that fish production and fish biodiversity increased in different ways because of sanctuary establishment in different water bodies. WorldFish Center (2005) reported that due to fish sanctuaries, the number of fish species increased 28.31% in CBFM-1 waterbodies in 2004 compared with base line recorded in 1997. FFP (2005) reported that after establishment of sanctuaries, 23 fish and some prawn species including some endangered species have increased their population in the command area of the project.

Month to month variation in per unit of effort (CPUE), catch per person per day, monthly average number of gears/day and total number of gear days in Dopi *beel* was probably due to variation in fish availibility. The poor ecological condition and environmental degradation in Chotadigha-boradigha *beel* where total number of gear days in *beel* catches decreased over the years were due to unavailability of fish. Open access, absence of sanctuaries or protected area, uncontrolled revenue oriented management by lease holders, water draining and drying up of *beel* and harvesting of total fishes from the *beel* were the major causes of decreasing yield and species number in this *beel*.

Conclusions

The findings of the present study revealed that fish sanctuary enhanced the production of many groups of fishes and prawns. Some rare species reappeared in the Dopi *beel* including some endangered ones while production and biodiversity of fish fauna decreased in control *beel* where no sanctuary was established. As the present findings are based on 2-year study only in two *beels*, a long-term study covering wider areas of different floodplains is required to assess the proper impacts

of sanctuaries and brush parks for the development of a sustainable management policy for different water bodies of Bangladesh.

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