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Original article

Efficiency of fishing gears in the river Halda, Chittagong, Bangladesh

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Abstract

To determine the catch efficiency of fishing gears, catch per unit effort (CPUE) data were collected for two years during January 2007 to December 2008 from the river Halda. Analyses were done to examine the variation of CPUE among gears, studied sections, months and years. The mean CPUE for pooled data of all gears was 2.247±0.265 kg·gear^{-1}day^{-1} and 2.697±0.355 kg·gear^{-1}day^{-1} for 2007 and 2008 respectively. Among eight gear categories, bag nets yielded the highest CPUE during 2007 (5.957±0.704 kg·gear^{-1}day^{-1}) and seine nets during 2008 (7.288±1.477 kg·gear^{-1}day^{-1}). Among 31 gear types, small meshed bag nets yielded the highest CPUE (18.065±6.660 and 15.69±4.479 kg·gear^{-1}day^{-1} during 2007 and 2008 respectively). CPUE was highest during March-April and September-November periods. Analysis of variance showed significant difference among catch rates of different fishing gears. The CPUE differed significantly among different months for net fence, gill net, cast net and scoop net during 2007; and for seine net, net fence, bag net and cast net during 2008.

Keywords: Halda River, catch efficiency, catch per unit effort, CPUE, catch rate

INTRODUCTION

Catch per unit effort (CPUE) is a useful index of the abundance and exploitation of fishery resources to determine the number of fishing units for sustainable fishery (Ahmed and Hambrey 2005). Estimation of CPUE is troublesome in a multi species fishery where a large variety of fishing gears are used with a varying degree of intensity and efficiency. CPUE study of the Halda river fishery during 1977 and 1978 by Ali and Morris (1977, 1978) was found to be inadequate and after that for the last three decades no investigation of the Halda river fishery was noticed except two years study on the Halda river fishery during 2007 and 2008 by Arshad-Ul-Alam (2011).

Although no studies were found on the exploitation of riverine fisheries of Bangladesh, but some studies were done on the number of fishing efforts and CPUE of different gears in the Maljhee-Kangsa floodplain (Ahmed et al. 2005), catch efficiency of different types of gears in the Kaptai Lake (Ahmed and Hambrey 2005), fishery exploitation of the Titas floodplain (Ahmed 2008) and fishing gears and catch composition in the Chalan Beel (Galib *et al.* 2009).

The Halda River is well known for the collection of fertilised eggs of Indian major carps, *Catla catla* (Hamilton 1822), *Cirrhinus mrigala* (Hamilton 1822), *Labeo rohita* (Hamilton 1822) and *L. calbasu* (Hamilton 1822). During 2006, the government of Bangladesh declared a 20 km area of this river from Sartaghat Bridge to Madunaghat Bridge as fish sanctuary to conserve and protect the spawning ground of major carps which was known to be located in this 20 km area since 1948 (Bangladesh Gazette 2006). Although implementation comes on forth after 2009. Later on in 2010, the sanctuary was extended to 40 km in length from the Nazirhat Bridge, upstream of the

Halda river to the Halda mouth opened at the Karnaphuli river and extended further up to the Kalurghat Bridge on the Karnaphuli river (Bangladesh Gazette 2010).

Some considerable number of studies were done on the river Halda, on its limnology and spawning biology of carps (Azadi 1979), spawning behaviour and ecology of breeding grounds (Patra and Azadi 1980), collection and hatching of carp eggs (Patra and Azadi 1984), limnology (Patra and Azadi 1985a), Hydrological factors influencing spawning of carps (Patra and Azadi 1985b), ecology of plankton (Patra and Azadi 1987), management of spawn fishery of carps (Azadi 2004), fishery and biology of fish (Arshad-ul-Alam 2011), fish diversity and Ichthyofauna (Azadi and Arshad-ul-Alam 2011, 2013), fishing intensity (Arshad-Ul-Alam 2013), but no studies were found on the fishing gears efficiency which is needed to use as the index of abundance and exploitation of fishery resources to determine the number of fishing units for the management of sustainable fishery.

So, this study was undertaken to find out the catch rates in terms of daily catch per unit of fishing effort (CPUE) of different fishing gears in the river Halda.

METHODOLOGY

Study area: Tidal river Halda is one of the major tributaries of the river Karnaphuli. Originated from Khagrachari Hill District of Bangladesh, it meets with the river Karnaphuli at 15 km north of Chittagong Metropolitan City. The river Halda is 88 km in length and 35 m in width at upstream to 210 m at the confluence of the river (Tsai *et al*. 1981, Arshad-Ul-Alam 2011, Azadi and Arshad-Ul-Alam 2011). The present study area covered the entire fishing zone of 39 km area of the river Halda starting from the Nazirhat Bridge (upstream) to the river mouth (lower Halda-downstream) joined with the river Karnaphuli, which covered an area of 351 ha (Figure 1).

Catch monitoring: The study area was divided into three sections, *i.e.* (1) non-spawning area of carps (upstream), (2) spawning area (mid stream), and (3) non spawning and one spawning area (downstream- up to river mouth end point) (Table 1) to examine any variations among the sections. Catch sample for every fishing gear was recorded for catch monitoring and assessment. Some catch samples were taken during the fishing effort survey and others during catch assessment survey followed by fishing effort survey. Samples were collected wholly for small catch and a number of sub-samples for big catch directly from fishermen during fishing or at the end of fishing. A minimum of one catch sample was taken for each fishing gear for each section in every month. A total of 1019 catch samples of the different types of fishing gears were recorded and analysed.

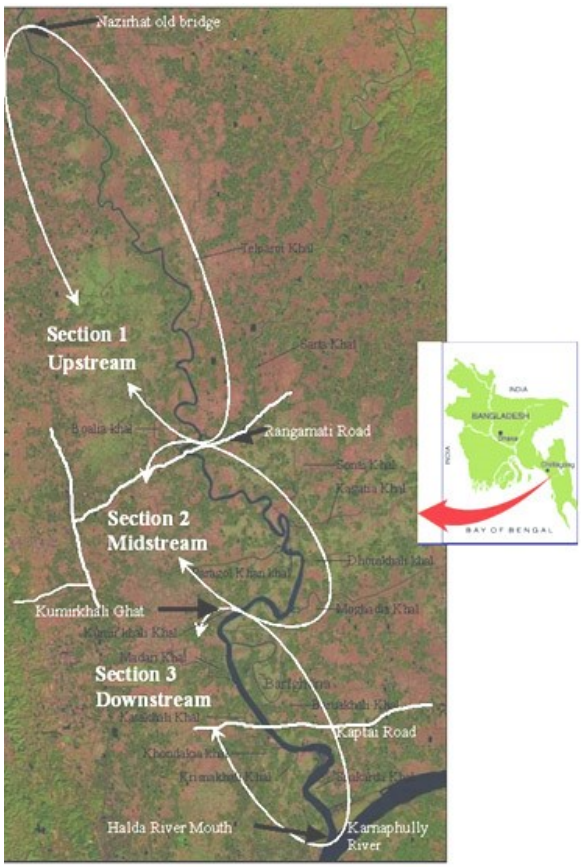

Figure 1: Showing Three sampling sections (section-1, section-2 and section-3 under circle with arrow mark) in the 39 km area of the river Halda

Total weight of catch, duration of fishing, time of fishing, number of fishing days in last week and night fishing activities were recorded. In case of small catch, the total catch was sorted by the number and weight of each species. Big catch was assessed by taking one or more sub-samples. Big fishes were recorded separately. Thus, all fish and prawn species for each catch sample were listed with their numbers and weights. Weights were taken with the aid of 500 g and 5 kg pan type dial spring scale and 50 kg pull type dial spring scale.

Catch per unit of effort: Catch per unit of effort is the average catch rate estimated using the following formula:

$CPUE_g = \frac{W}{n}$ (Arshad-Ul-Alam 2011; modified after de Graff and Chinh 1992; and Harikrisnan and Kurup 2001)

Where, $CPUE_g$ = daily mean catch per unit of effort; w = total weight of fish recorded from the gear sampled; and n = number of gears sampled. CPUE was recorded as kg·gear^{-1}day^{-1}, kg·fisher^{-1}day^{-1}, kg·gear^{-1}hour^{-1} and CPUE

No. of fish·gear^{-1}day^{-1} for two successive years 2007 and 2008. CPUE kg·gear^{-1}day^{-1} was recorded for individual gear types, broad gear categories and user group categories.

Table 1: Location and size of the study area

Section	*Location*	*Geographical location*	*Length, width and area*	*Remarks*
Section -1 Upstream	Nazirhat old bridge to Sartarghat bridge.	22°38´N 91°48´E to 22°30´N 91°51´E	Length: 20 km; average width: 67.5 m; area: 135 ha; distance from sea: 45 km	Extended portion of sanctuary declared during 2010.
Section -2 Midstream	Sartarghat bridge to Kumarkhali ghat.	22°30´N 91°51´E to 22°27´N 91°51´E	Length: 10 km; average width: 94.5 m; area: 94.5 ha; distance from sea: 35 km	Part of sanctuary declared during 2007. Present spawning ground of Indian major carps and fertilised egg collecting area.
Section -3 Downstream	Kumarkhali ghat to Halda River mouth.	22°27´N 91°51´E to 22°24´N 91°53´E	Length: 9 km; average width: 135 m; area: 121.5 ha; distance from sea: 26 km	Part of sanctuary declared during 2006. Includes a part of present spawning ground and fertilised egg collecting area.

Analysis and presentation of data: Data were analysed using the Microsoft Excel. The existing 34 types (Arshad-Ul-Alam 2011) of fishing gears of the river Halda were rearranged into 31 types and grouped into eight gear categories and four user categories for analysis and presentation of data. Mean CPUE kg·gear^{-1}day^{-1} is presented with standard error (±SE). Three-way ANOVA was used for statistical analysis of CPUE variation among gears, months and the different sections of the river. One-way ANOVA was used for statistical analysis for variation between years. Two-way ANOVA was used to find the temporal and spatial variation of catch rates of each gear categories. ANOVA was done manually on MS Excel sheet using different MS Excel functions following step by step statistical procedure. Three CPUE data sets (gear types, gear categories, user categories) were subjected to statistical analysis.

Working definitions

Professional fishermen: Traditional fishing community that comes from ethnic group of Hindu religious society.

Subsistence fishermen: Peoples come from poor section of the society generally catch fish for family consumption with small low cost fishing gears (small cast net, small push net and small lift net) or without fishing gears (hand picking) and catch usually small fishes.

Recreational fishermen: Rich peoples enjoy fishing as recreation and also for self consumption with hand line, rod and reel and catch Rui, Mrigal, Kalibaush, Ayre, Boal, Pungus, Boro baim and big Prawn.

Neo-professional fishermen: Fishermen other than ethnic professional, subsistence and recreational are grouped under this heterogeneous assemblage. Most of the members of this sector were previously unemployed, and fishing is now their main livelihood and they belong to different religious groups. A number of outlawed people, users of illegal fishing gears, night time fishers and carp brood fishes are included in this assemblage.

Abbreviations used: To donate the mesh size, LM used for large mesh, MM for medium mesh and SM for small mesh nets or cod ends of respective fishing gears.

RESULTS

Catch per unit effort kg·gear^{-1}day^{-1} for 31 individual gear types are presented in Table 2. Catch per unit effort in terms of kg·fisher^{-1}day^{-1} and kg·gear^{-1}h^{-1} for gear categories are presented in Table 3. Table 4 shows CPUE kg·fisher^{-1}day^{-1} for user categories. Results of ANOVA with degree of freedom are presented in Tables 5, 6 and 7. Table 8 shows CPUE in terms of No. of fish·gear^{-1}day^{-1}.

Catch per unit effort for 31 individual gear types*:* Mean CPUE for each gear type for total study area of the river Halda during 2007 and 2008 with coefficient of variations among months and sections are shown in Table 2. Catch per unit effort for same gears in the three studied sections are shown in Figure 2 and with monthly variation in Figure 3. Over the total study area, the highest mean value of CPUE was found for SM bag net (18.065±6.660 and 15.69±4.479 kg·gear^{-1}day^{-1}) followed by brush shelter (8.173±0.629 and 7.744±1.534 kg gear^{-1}day^{-1}) and rectangular dip net (6.61±1.185 and 7.319±1.293 kg gear^{-1}day^{-1}) during 2007 and 2008 respectively (Table 2). Triangular dip net and seine net stands 4th and 5th with a catch rate of 5.67±0.628 to 6.06±1.185 and 4.159±0.42 to 7.288±1.477 kg gear^{-1}day^{-1} respectively.

During 2007, the mean CPUE for gear categories ranged from minimum 0.100 kg·gear^{-1}day^{-1} (small subsistence gears) to maximum 5.156±0.537 kg·gear^{-1}day^{-1} (bag nets) in section 1; from minimum 0.299±0.093 kg·gear^{-1}day^{-1} (gill nets) to maximum 5.415±0.624 kg·gear^{-1}day^{-1} (bag nets) in section 2; and from minimum 0.516±0.166 kg·gear^{-1}day^{-1} (gill nets) to maximum 6.297±1.025 kg·gear^{-1}day^{-1} (bag nets) in section 3.

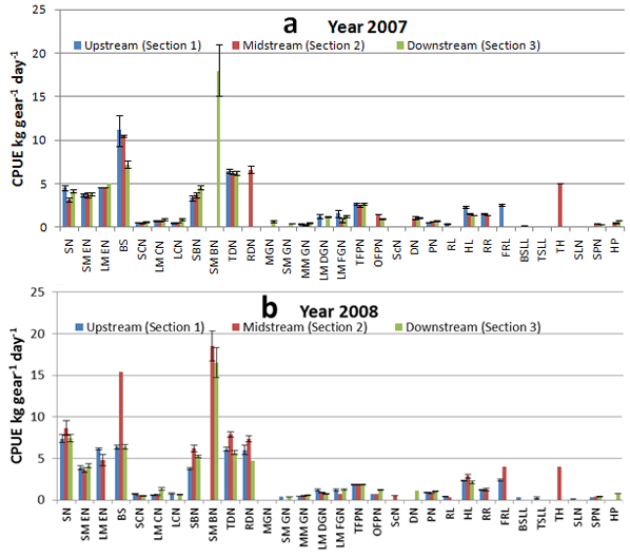

Figure 2: Mean CPUE for 31 gear types in the river Halda during 2007 (a) and 2008 (b).

[SN - Seine net , SM EN – Small meshed enclosure net, LM EN - Large meshed enclosure net, BS - Brush shelter (2 types), SCN - Small cast net, LM CN - Large meshed cast net, LCN - Large cast net, SBN - Set-bag net, SM BN – Small meshed bag net, TDN - Triangular dip net, RDN - Rectangular dip net, MGN - Monofilament gill net, SM GN – Small meshed gill net, MM GN – Medium meshed gill net, LM DGN – Large meshed drift gill net, LM FGN - Large meshed fixed gill net (2 types), TFPN - Two fisher push net, OFPN - One fisher push net, ScN - Scoop net, DN - Drag net, PH - Prawn hook, RL - Rod and line, HL - Hand line (2 types), RR - Rod and reel, FRL - Fixed rod line, BSLL - Bottom set long line, TSLL -Top set long line, TH - Turtle hook, SLN - Small lift net, SPN - Small push net, HP - Hand picking]

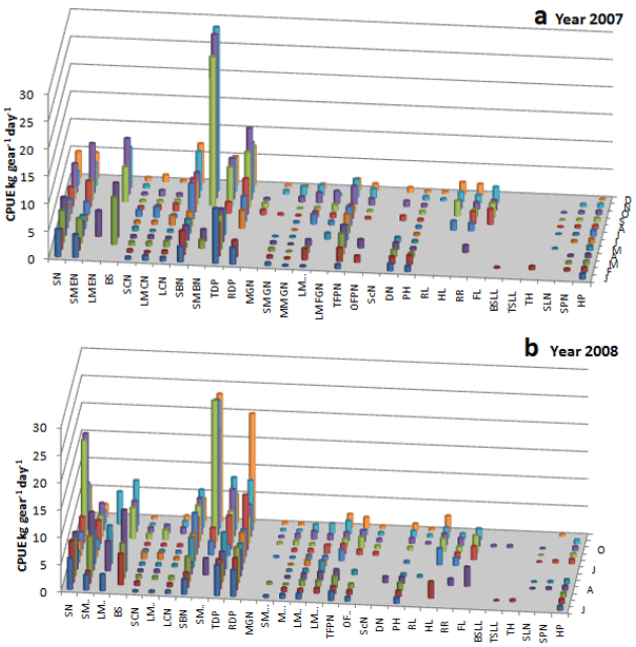

Figure 3: Monthly mean CPUE kg·gear^{-1} day^{-1} for 31 gear types over the total study area in the river Halda during 2007 (a) and 2008 (b).

[SN - Seine net , SM EN – Small meshed enclosure net, LM EN - Large meshed enclosure net, BS - Brush shelter (2 types), SCN - Small cast net, LM CN - Large meshed cast net, LCN - Large cast net, SBN - Set-bag net, SM BN – Small meshed bag net, TDN - Triangular dip net, RDN - Rectangular dip net, MGN - Monofilament gill net, SM GN – Small meshed gill net, MM GN – Medium meshed gill net, LM DGN – Large meshed drift gill net, LM FGN - Large meshed fixed gill net (2 types), TFPN - Two fisher push net, OFPN - One fisher push net, ScN - Scoop net, DN - Drag net, PH - Prawn hook, RL - Rod and line, HL - Hand line (2 types), RR - Rod and reel, FRL - Fixed rod line, BSLL - Bottom set long line, TSLL -Top set long line, TH - Turtle hook, SLN - Small lift net, SPN - Small push net, HP - Hand picking]

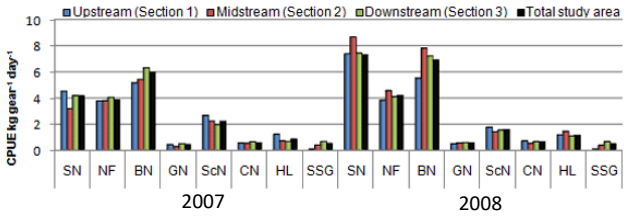

Figure 4: Mean CPUE for each gear category in studied sections and in total study area during 2007 and 2008 in the river Halda. (SN - Seine net, NF- Net fence, BN- Bag net, GN- Gill net, ScN- Scoop net, CN- Cast net, HL- Hook & line, SSG- small subsistence gear)

During 2008, the mean CPUE ranged from minimum 0.116±0.017 kg·gear^{-1}day^{-1} (small subsistence gears) to maximum 7.373±1.605 kg·gear^{-1}day^{-1} (seine net) in section 1; from minimum 0.4 kg·gear^{-1}day^{-1} (small subsistence gears) to maximum 8.66±2.365 kg·gear^{-1}day^{-1} (seine net) in section 2; and from minimum 0.598±0.071 kg·gear^{-1}day^{-1} (gill net) to maximum 7.423±1.455 kg·gear^{-1}day^{-1} (seine net) in section 3.

Catch per unit effort for different user categories: Mean CPUE for each user category in the three studied sections and in total study area are shown in Figure 4. Fishing gears under neo-professional category showed the highest CPUE (3.03±0.462 to 3.66±0.764 kg·gear^{-1}day^{-1}) followed by professional, recreational and subsistence category over the total study area (Figure 5).

Combined CPUE: Over the total study area, for all gears, the CPUE varied from 0.851 (in June) to 4.266 (in October) during 2007 with a mean value of 2.247±0.265 kg·gear^{-1}day^{-1}. During 2008, it ranged from minimum 1.232 (in July) to maximum 5.897 (in April) with a mean value of 2.697±0.355 kg·gear^{-1}day^{-1} (Figure 6).

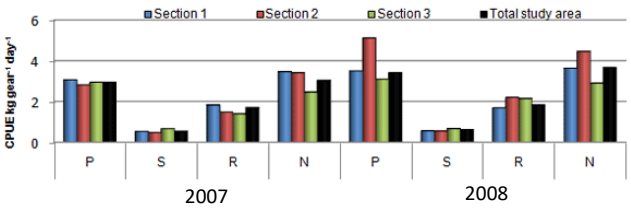

Figure 5: Mean CPUE in studied sections and in total study area for each user category during 2007 and 2008 in the river Halda. (P, Professional; S, subsistence; R, Recreational; N, Neo-professional)

For all gears, the CPUE during 2007 in section 1 ranged from minimum 0.786 (in June) to maximum 4.096 (in October) with a mean value of 2.278±0.287 kg·gear^{-1}day^{-1}. In section 2, CPUE ranged from 0.808 (in July) to 5.491 (in October) with a mean value of 2.285±0.405 kg·gear^{-1}day^{-1} and in Section 3, it ranged from minimum 0.916 (in June) to maximum 4.224 (in November) with a mean value of 2.227±0.263 kg·gear^{-1}day^{-1}.

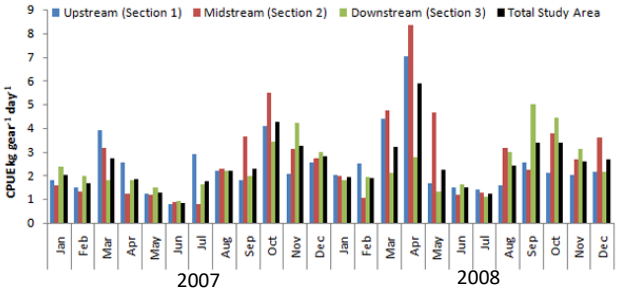

Figure 6: Month-wise combined CPUE during January 2007 to December 2008 in the river Halda

Table 2: Mean CPUE and CV % among months and sections for each gear type in the river Halda during the year 2007 and 2008.

Gear category and name		*2007*				*2008*			
Gear category	*Name of gear type (User category)*	*Mean CPUE±SE (kg gear^{-1}day^{-1})*	*n*	*CV% months*	*CV% sections*	*Mean CPUE±SE (kg gear^{-1}day^{-1})*	*n*	*CV% months*	*CV% sections*
Seine net	Seine net (P)	4.159±0.42	12	36	17	7.288±1.48	12	71	9
Net fence	SM Enclosure net (N)	3.785±0.66	12	57	3	4.022±0.8	12	68	10
	LM enclosure net (N)	4.956	1		5	5.325±0.85	4	32	17
	Brush shelter (2 types) (N)	8.173±0.63	5	19	22	7.744±1.53	6	32	56
Cast net	Small cast net (S)	0.557±0.07	12	38	11	0.601±0.08	12	48	20
	LM cast net (S)	0.762±0.14	11	59	13	0.87±0.21	9	67	49
	Large cast net (P)	0.74±0.13	11	57	34	0.666±0.08	10	38	9
Bag net	Set-bag net (P)	4.514±0.79	12	49	16	5.081±0.58	12	36	24
	SM bag net (P)	18.06±6.66	5	82		15.69±4.47	7	75	8
	Triangular dip net (P)	6.06±0.65	10	34	2	5.67±0.63	11	37	18
	Rectangular dip net (P)	6.61±1.18	9	54		7.319±1.29	12	61	22
Gill net	Monofilament gill net (P)	0.697±0.16	3	41		----	0	-	-
	SM gill net (P)	0.424±0.06	8	41	98	0.35±0.02	7	17	10
	MM gill net (P)	0.418±0.15	12	118	29	0.52±0.08	12	50	12
	LM drift gill net (N)	1.2±0.20	10	54	4	0.869±0.12	11	38	26
	LM fixed gill net (2 types) (N)	1.008±0.25	6	59	34	1.195±0.17	10	47	29
Scoop net	Two fisher push net (P)	2.653±0.31	12	41	6	1.88±0.11	10	19	1
	One fisher push net (P)	1.046±0.20	7	51	30	1.188±0.19	9	50	28
	Scoop net (P)	----	0	-	-	***0.55	5		
	Drag net (P)	1.078±0.07	8	18	1	1.1	1		
Line and hook	Prawn hook (N)	0.636±0.12	12	56	12	0.939±0.10	10	34	13
	Rod and line(P)	0.388±0.01	2	5		0.401±0.04	4	21	10
	Hand line (2 types) (R)	1.962±0.22	5	26	28	2.517±0.18	6	18	15
	Rod and reel (R)	1.521±0.15	7	26	7	1.172±0.07	6	16	5
	Fixed rod line (R)	2.525±0.25	4	20		2.528±0.33	5	30	35
	Bottom set long line (P)	0.18	1			0.3	1		
	Top set long line (P)	----	0	-	-	0.245±0.16	2	89	
	*Turtle hook (N)	0.606	1		28	0.333	1		20
Minor subsistence gear	**Small lift net (S)	***0.1	5			***0.1	5		
	Small push net (S)	0.385±0.02	9	14	6	0.373±0.03	4	17	14
	Hand picking (S)	0.722±0.06	12	27	27	0.752±0.02	9	8	
Combined CPUE		2.247±0.265 (n= 12)				2.697±0.355 (n= 12)			

*Mean, SE and CV (months) were calculated on the basis of number of fishing months (operating months) (n) of the gear. User category indicated within brackets (P- Professional, S- subsistence, R- Recreational, N- Neo-professional). * Migratory fishing unit were found only in February; ** The gear operated by female fisher (catch consisted mainly of small prawns). *** Only one catch sample was taken and used for the estimation of CPUE for all fishing months*

During 2008, CPUE in section 1 ranged from minimum 1.392 (in July) to maximum 7.027 (in April) with a mean value of 2.574±0.465 kg·gear^{-1}day^{-1}. In section 2, it ranged from minimum 1.048 (in February) to maximum 8.336 (in April) with a mean value of 3.222±0.594 kg·gear^{-1}day^{-1} whereas in section 3, it ranged from minimum 1.084 (in July) to maximum 5.011 (in September) with a mean value of 2.529±0.324 kg·gear^{-1}day^{-1}.

Catch per fisher per day: Bag net shows the highest average CPUE (4.451 kg·fisher^{-1}day^{-1}) followed by net fence (1.493 kg·fisher^{-1}day^{-1}), scoop net (1.326 kg·fisher^{-1} day^{-1}) and seine net (1.278 kg·fisher^{-1}day^{-1}). Combined gear CPUE was estimated to be 1.364 and 1.508 kg·fisher^{-1}day^{-1} for the year 2007 and 2008 respectively with an average of 1.436 kg·fisher^{-1}day^{-1} (Table 3).

Considering the user category, the highest CPUE was estimated for professional fishery (2.150 kg·fisher^{-1}day^{-1}) followed by neo- professional fishery (2.049 kg· fisher^{-1}day^{-1}), recreational (1.699 kg·fisher^{-1}day^{-1}) and subsistence fishery (1.008 kg·fisher^{-1}day^{-1}) (Table 4).

Catch per gear per hour: Seine net shows the highest rate of CPUE kg·gear^{-1}h^{-1} (1.574 kg·gear^{-1}h^{-1}) while hook and line show the lowest (0.130 kg·gear^{-1}h^{-1}) (Table 3).

Table 3: CPUE for each gear category during 2007 and 2008 in the river Halda

Gear category	*CPUE (kg·fisher^{-1}day^{-1})*			*CPUE (kg·gear^{-1}h^{-1})*		
	2007	*2008*	*Average*	*2007*	*2008*	*Average*
Seine net	1.075	1.48	1.278	1.626	1.521	1.574
Net fence	1.418	1.568	1.493	0.642	0.657	0.650
Bag net	3.611	5.291	4.451	0.541	0.669	0.605
Gill net	0.423	0.524	0.474	0.14	0.246	0.193
Scoop net	1.379	1.273	1.326	0.422	0.399	0.411
Cast net	0.556	0.663	0.610	0.148	0.146	0.147
Hook & line	0.644	0.693	0.669	0.108	0.152	0.130
Small subsistence gear	0.532	0.504	0.518	0.166	0.184	0.175
Combined gear CPUE	**1.364**	**1.508**	**1.436**	**0.384**	**0.456**	**0.42**

***Variation for CPUE among gears, months, sections and year*:** Three way ANOVA tested on mean values of CPUE showed significant difference ($P < 0.01$) among gears and months for all three data sets (gear types, gear categories and user categories) (Table 5). Among the sections, a significant difference was observed for gear types and there was no significant difference for gear categories (Table 5). However, for user categories no significant difference was observed during 2007 but it was significant different during 2008 (Table 5). Interaction effect for gear-month showed significant differences for all data sets, section-month interaction showed significant difference for gear types during 2007 and for gear category during 2008. However, the gear-section interaction was not significantly different for user category during 2007 (Table 5).

Table 4: CPUE for user category in the river Halda.

User category	*CPUE (kg·fisher^{-1}day^{-1})*		
	2007	*2008*	*2007-08*
Professional	2.144	2.156	2.150
Subsistence	1.015	1.000	1.008
Recreational	1.567	1.774	1.699
Neo-professional	1.948	2.149	2.049

One way ANOVA tested on CPUE for gear types, gear categories and user categories showed no significant difference between 2007 and 2008 (Table 6). The CPUE differed significantly among different months for net fence, gill net, cast net and scoop net during 2007, and for seine net, net fence, bag net and cast net during 2008. The differences of CPUE among sections were observed for gill nets, scoop net and hook and line during 2007 and for hook and line during 2008 (Table 7).

Catch per unit effort in terms of number of fish per gear per day: In 2007, section 1 showed the highest CPUE for triangular lift net (56080±36897 No. of fish·gear^{-1}day^{-1}). Section 2 showed the highest CPUE for rectangular lift net (60890±22510 No. of fish·gear^{-1}day^{-1}). Section 3 showed the highest CPUE for SM bag net (82376±33689 No. of fish·gear^{-1}day^{-1}).

During 2008, section 1 showed highest CPUE for seine net (62764±34454 No. of fish· gear^{-1}day^{-1}) while sections 2 and 3 showed the highest CPUE for SM bag net (81812 ±18978 and 59531±19400 No. of fish·gear^{-1}day^{-1}respectively).

Over the entire study area the highest CPUE (No. of fish·gear^{-1}day^{-1}) was found for SM bag net followed by rectangular dip net, seine net and triangular dip net (Table 8).

DISCUSSION

In this study, mean CPUE for professional gear was 2.938±0.325 and 3.412 ±0.512 kg·gear^{-1}day^{-1} for 2007 and 2008 respectively. The present catch rate was found to be much lower than earlier catch rate (4.20 kg·unit^{-1}day^{-1} for commercial gears) of Halda River (Ali and Morris 1977). CPUE for combined gear (kg·fisher^{-1}day^{-1}) measured as an average 1.436 kg·fisher^{-1}day^{-1}, which showed similarities with the records of Ahmed *et al.* (2005) from Maljhee-Kangsa floodplain(1.43 kg fisher^{-1}day^{-1}).

The mean CPUE of all fishing gears for the entire study area varied widely and ranged from 0.100 to 18.065 kg·gear^{-1}day^{-1}. Gears under net fence category showed a variation from 0.641kg (SM enclosure net, section 2, July, 2007) to 15.42 kg (brush shelter, section 2, April 2008). The CPUE of SM bag net was found to vary between 1.5 kg (section 3, March, 2007) to 29.83 kg (section 3, October, 2007). Catch rates in the seine net, brush shelter, and MM gill net considerably increased during March-April and September-October-November periods. Ahmed and Hambery (2005) recorded a different trend of CPUE in lift nets and seine nets in Kaptai Reservoir, where CPUE was higher between January and March and lower during high water level period of October-December. The coefficient of variation (CV) showed that there was <100% variation of CPUE among months (except MM gill net during 2007), < 50% variation of CPUE among sections (except SM gill net during 2007 and brush shelter during 2008) for gear types, gear categories and user categories. Monthly CV among mean CPUE of gear types and gear categories showed 84% to 180% and 70% to 142% variation respectively. Almost similar coefficient of variation among sites and gear types was noticed in Kaptai reservoir (Ahmed and Hambery 2005).

Table 5: Six ANOVA tables resulting from three way ANOVA incorporated in one. *F*-values for variables (gear, month and section) and for their interaction effects shown for three data sets (gear type, gear category and user category) and for two years

Data set	*Source*	*2007*					*2008*				
		TSS	*DF*	*MSS*	*F*		*TSS*	*DF*	*MSS*	*F*	
Gear type	Gear	1691.65	28	60.42	19.267	a	3414.48	30	113.82	37.284	a
	Month	272.36	11	24.76	7.896	a	414.858	11	37.714	12.355	a
	Section	49.97	2	24.99	7.968	a	37.230	2	18.615	6.098	a
	Gear month	1498.23	308	4.86	1.551	a	3615.10	330	10.955	3.589	a
	Section Month	133.91	22	6.09	1.941	a	89.041	22	4.0473	1.326	
	Gear Section	766.98	56	13.70	4.368	a	1091.35	60	18.189	5.959	a
	Gear Month Section	1931.64	616	3.14			2014.75	660	3.053		
	Total	6344.74	1115				10676.8	1115			
Gear category	Gear	846.70	7	120.96	61.38	a	1921.29	7	274.47	138.37	a
	Month	128.63	11	11.69	5.93	a	299.59	11	27.24	13.73	a
	Section	11.69	2	5.85	2.97		0.97	2	0.49	0.25	
	Gear month	312.44	77	4.06	2.06	a	1278.51	77	16.60	8.37	a
	Section Month	58.64	22	2.67	1.35		71.11	22	3.23	1.63	b
	Gear Section	69.47	14	4.96	2.52	a	101.64	14	7.26	3.66	a
	Gear Month Section	303.49	154	1.97			305.47	154	1.98		
	Total	1731.06	287				3978.57	286			
User category	Gear	222.21	3	74.07	68.85	a	333.94	3	111.31	61.75	a
	Month	63.55	11	5.78	5.37	a	60.16	11	5.47	3.03	a
	Section	4.33	2	2.16	2.01		21.23	2	10.61	5.89	a
	Gear month	70.56	33	2.14	1.99	a	251.33	33	7.62	4.23	a
	Section Month	22.90	22	1.04	0.97		43.19	22	1.96	1.09	
	Gear Section	6.97	6	1.16	1.08		22.42	6	3.74	2.07	a
	Gear Month Section	71.00	66	1.08			118.97	66	1.80		
	Total	461.52	143				851.24	143			

a - significant at 1% level, b - significant at 5% level

Major contribution in the total catch comes from gears under net fence category (47-50.3%) followed by bag nets (22.9-23.6%) and seine nets (8.3-12.6%) (Arshad-Ul-Alam 2011). Small meshed enclosure net used by neo-professional fishers was identified as the most detrimental fishing gear and is now banned by the government of Bangladesh; 57.79% of its catch is composed of different prawns species with 24.46% small juvenile prawns. During monsoon SM enclosure was observed in lesser extent with lower CPUE. Lower CPUE values in seine net were also observed during monsoon. CPUE of different cast nets and set-bag net was almost the same throughout the year.

In this study mean data of CPUE revealed that the SM bag net had the highest CPUE (18.065±6.660 and 15.69±4.479 kg·gear^{-1}day^{-1} for 2007 and 2008 respectively) followed by brush shelter, dip nets and seine net. Hossain *et al*. (2007) reported highest catch for beach seine net (73 kg·gear^{-1}day^{-1}) from the Naaf river followed by estuarine set-bag

net catch (48 kg·gear^{-1}day^{-1}). Ahmed and Hambery (2005) studied catch efficiency of different types of gears of Kaptai Reservoir and recorded highest CPUE for SM seine net (30.86 kg·unit^{-1}day^{-1}). Ahmed *et al.* (2005) reported CPUE in terms of kg·hour^{-1}gear^{-1} for different fishing seasons with average values 0.18, 0.26, 0.21, 0.29, 0.31, 0.06 and 0.02 kg·hour^{-1}gear^{-1} for push net, gill net, cast net, lift net, current net, trap and hook respectively in Kaptai Reservoir.

Table 6: *F*-values resulting from one-way ANOVA, showing the variation of CPUE (kg·gear^{-1}day^{-1})

Study area	*F values for Years with degrees of freedom*		
	Gear type	*Gear category*	*User category*
Section 1	0.148 1,48	0.075 1,14	0.016 1,6
Section 2	1.637 1,54	0.639 1,14	0.696 1,6
Section 3	0.00002 1,44	0.171 1,14	0.197 1,6
Total	0.001 1,60	0.175 1,14	0.127 1,6

Present recorded CPUE for different gear categories showed close similarity with previous record of Halda River (November, December period 1977) (Ali and Morris 1978) where the highest catch rate was recorded for set-bag net (2.25 kg unit^{-1}day^{-1}) followed by drift net (2.50 kg·unit^{-1}day^{-1}), brush shelter (1.50 kg·unit^{-1}day^{-1}) and drag net (1.50 kg·unit^{-1}day^{-1}). In the Titas floodplain the highest CPUE (15.41 kg·gear $^{-1}$day^{-1}) was found for set bag net (Ahmed 2008), whereas in the two floodplains (Binh long and Phu Than) of Mekong Delta the highest CPUE was recorded for seine net (20 kg·gear^{-1}day^{-1} and 9.640±1.119 kg gear^{-1}day^{-1}) followed by fyke net (8.870±1.430 kg·gear^{-1}day^{-1} and 7.536±0.584 kg·gear^{-1}day^{-1}) (de Graff and Chinh 1992).

In the present study, higher catch rate was observed yearly twice, one between March and May and another between September and December. The highest number of fishing gears was also reported during this period (Arshad-Ul-Alam 2013). The highest CPUE (kg·gear^{-1}day^{-1}) over the entire study area for all gears was in October (4.266 kg·gear $^{-1}$day^{-1}) during 2007 and it was in April (5.897 kg·gear $^{-1}$day^{-1}) during 2008. These findings showed very close similarities with the findings of other studies (Ahmed *et al.* 2005 and Hossain *et al.* 2007). Ahmed *et al.* (2005) reported the highest CPUE during post monsoon season (October-December) from Maljhee-Kangsa floodplain. Hossain *et al.* (2007) recorded maximum set-bag net catch as 48 kg·gear $^{-1}$day^{-1} during March and minimum 11 kg·gear $^{-1}$day^{-1} during July from the Naaf River.

Table 7: *F*-values from two- way ANOVA showing the variation of CPUE (kg·gear^{-1}day^{-1}) of each gear categories among months and sections during 2007 and 2008.

Year	*Gear category*	*F value for Months*			*F value for Sections*		
Year 2007	Seine net	1.235		*df* =11.18	0.840		*df* = 2.18
	Net fence	4.260	a	*df* = 11.22	0.096		*df* = 2.22
	Beg net	1.456		*df* = 11.17	1.683		*df* = 2.17
	Gill net	11.418	a	*df* = 11.19	11.799	a	*df* = 2.19
	Cast net	4.733	a	*df* = 11.22	1.860		*df* = 2.22
	Scoop net	11.620	a	*df* = 11.18	11.864	a	*df* = 2.18
	Hook and line	0.677		*df* = 11.15	7.008	a	*df* = 2.15
Year 2008	Seine net	29.376	a	*df* = 11.17	1.721		*df* = 2.17
	Net fence	6.671	a	*df* = 11.22	0.416		*df* = 2.22
	Beg net	3.472	a	*df* = 11.21	3.382		*df* = 2.21
	Gill net	1.224		*df* = 11.20	0.129		*df* = 2.20
	Cast net	5.911	a	*df* = 11.22	2.216		*df* = 2.22
	Scoop net	1.050		*df* = 10.14	1.965		*df* = 2.14
	Hook and line	2.259		*df* = 11.15	5.826	b	*df* = 2.15

a - significant at 1% level, b - significant at 5% level

No previous studies on fishing gear efficiency in terms of CPUE (number of fish·gear^{1}day^{-1}) from the river Halda or from any other rivers of Bangladesh were found. It is important to determine the size selectivity of fishing gears. In this study, the highest CPUE (number of fish·gear^{1}day^{-1}) was observed for SM bag net followed by rectangular lift net, seine net, and triangular lift net. These are small mesh gears fished mostly on small clupeid *Corica sobona* Hamilton 1822, small juvenile prawn and immature *Setipinna phasa* (Hamilton 1822) Low CPUE

(number of fish·gear^{1}day^{-1}) was observed for brood killers like different gill nets (1 to 78 number of fish·gear^{1}day^{-1}) and hook lines (1 to 22 number of fish·gear^{1}day^{-1}).

CONCLUSION

This is the first time study in Bangladesh, which estimated the CPUE for each gear type in the river Halda. This CPUE study in the important river Halda just before implementation of fish sanctuary declaration will act as milestone to provide needed information on the exploitation of fishery resources for the sustainable fishery management.

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Table 8. Mean CPUE (No. of fish·gear^{-1}day^{-1}) and CV % (among months) for each gear type for total study area during 2007 and 2008. SE is zero where only one catch sample represented for several fishing months.

Name of gear type	*Year 2007*				*Year 2008*			
	Mean CPUE No. of fish·gear^{-1}day^{-1}	*SE*	*n*	*CV% Months*	*Mean CPUE No. of fish·gear^{-1}day^{-1}*	*SE*	*n*	*CV% Months*
Seine net	57434	22775	12	137	51296	23524	12	159
SM Enclosure net	2917	713	12	85	4088	1329	12	113
LM enclosure net	47		1		6	3	4	105
Brush shelter (2 types)	2180	858	5	88	9025	905	6	25
Small cast net	221	44	12	70	140	42	12	104
LM cast net	110	49	11	147	53	19	9	111
Large cast net	236	146	11	205	69	21	10	95
Set-bag net	7378	1665	12	78	21031	6330	12	104
SM bag net	82376	33689	5	91	60090	19499	7	86
Triangular dip net	47663	29846	10	198	33006	11253	11	113
Rectangular dip net	60890	22510	9	111	56568	16145	12	99
Monofilament gill net	6	2	3	60	-	-	-	-
SM gill net	78	13	8	49	53	10	7	50
MM gill net	6	1	12	56	8	1	12	46
LM drift gill net	1		10		1		11	57
LM fixed gill net (2 types)	2		6	49	1		10	60
Two fisher push net	897	145	12	56	494	112	10	72
One fisher push net	2898	1022	7	93	2827	586	9	62
Scoop net	-	-	-	-	11		5	
Drag net	7517	1681	8	63	10570		1	
Prawn hook	20	2	12	38	22	2	10	26
Rod and line	5	1	2	16	5	1	4	23
Hand line (2 types)	1		5		1		6	
Rod and reel	1		7	12	1		6	15
Fixed rod line	1		4		1		5	
Bottom set long line	1		1		2		1	
Top set long line	-	-	-	-	2	1	2	71
Small push net	503	136	9	81	354	20	4	11
Hand picking	101	9	12	31	104	4	9	12

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