Biodiversity and Conservation (2005) 14: 1863–1876
DOI 10.1007/s10531-004-1041-0

Conservation categories of siluroid fishes in North-East Sundarbans, India

MANOJ KUMAR PATRA[1], SANKAR KUMAR ACHARJEE[2] and SUSANTA KUMAR CHAKRABORTY[1,*]
*[1]Department of Zoology, Vidyasagar University, West Midnapore, West Bengal 721 102, India; [2]Department of Agricultural Extension, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal 741252, India; *Author for correspondence (e-mail: susantachakraborty@yahoo.com; fax: 03222-275329)*

Received 8 July 2003; accepted in revised form 16 February 2004

Key words: Conservation, Fish Magnitude Value (FMV), Matrix Ranking, North-East Sundarbans, Rank Based Quotient (RBQ) and Trend Analysis

Abstract. In stock fishery of North-East Sundarbans, siluroid fishes hold a remarkable position owing to the culture potentiality of many of them. Scales in fishes play significant role in protection and resistance against environmental stresses and the lack of scalation in case of siluroid fishes is supposed to be one of the reasons for their decline in eco-degraded aquatic habitats. 11 species of fishes belonging to 9 genera, 8 families under the order Siluriformes have been recorded from different water bodies of North-East Sundarbans, India. Fish Magnitude Value (FMV) of those catfishes were recorded especially by information harvested from local fishermen community and stakeholders as well as from market survey on fish landing. The extensive damage to the population of catfishes in the area has placed the fishes under threat categories. Following the IUCN guidelines and also through Participatory Rural Appraisal (PRA) methods, an attempt has been made to assess the status of such fishes. Trend analysis, Fish Magnitude Value (FMV) and Rank Based Quotient (RBQ) revealed 1 catfish as Endangered, 5 as Vulnerable and 5 as Near Threatened species. The situation warrants immediate attention of ecologists, administrators, managers and entrepreneurs to propose remedial measures for revival of the fishes. The study also delineates distribution, present status and conservation measures for revival of the fishes in North-East Sundarbans wet-land environment of West Bengal, India.

Introduction

India is blessed with bounty of nature which holds good in regard to fish germ plasm resources as well in diversified aquatic habitats. In North-East Sundarbans the inland waters exist in the form of ponds of both fresh water and brackish water nature, fresh water ditches, fresh water inundated paddy fields, brackish water impoundments, locally called *bheries*, brackish water canals and tidal rivers or estuaries. In view of constant anthropogenic stresses with advancement of modernisation and ever-growing demand for fish the rich diversity is being eroded world over and some species have been pushed to 'threatened' category. The Earth Summit held at Rio de Janeiro during 1992 adopted the convention to conserve the biological diversity, sustainable use of biological resources and equitable sharing of the benefits of such use (Kothari

1997). Besides the eco-degradation of different fresh water and brackish water habitats, the fishery resources of Sundarbans are gradually becoming non-productive owing to varied natural and anthropogenic factors (Jhingran 1988; Pandit *et al.* 1994).

Scant information on the occurrence, distribution and status of fishes of North-East Sundarbans is a big handicap in generating concern for conservation of the lesser known fish species in a particular ecosystem for their conservation. The total fish landings from North-East Sundarbans have been declining year after year due to varied reasons like the lack of fresh water discharge, siltation problem, pollution load, sand lifting, brick field activities etc. (Pandit *et al.* 1994).

A Conservation Assessment and Management Plan (CAMP) workshop was conducted from September 21 to 25, 1997 in Lucknow, hosted by several leading scientific institutes on Cold water fisheries where 329 taxa out of 650 species and subspecies were referred in the check-list of Indian fresh water fishes prepared by National Bureau of Fish Genetic Resources (NBFGR), following the IUCN Red List-Revised 1994 (Anon. 1998).

Any problem loses its identity unless it is based on the real and urgent need of the users. In diversified agro-climatic regions and heterogeneous rural society like India, the problem is highly location specific and need based (Meena 2001). Though in stock fishery of North-East Sundarbans, catfishes hold a remarkable position owing to culture potentiality of many of them in different aquatic habitats, most of them are very much prone to harmful effects of environmental degradation resulting in their population decline. Hence an attempt has been made to assess the present status of different fresh water and brackish water fishes of the order Siluriformes of North-East Sundarbans and to identify and prioritise the need based problems on their depletion through the techniques of Participatory Rural Appraisal (PRA) which are intensive and systematic learning experiences carried out in a community by a multidisciplinary team including the members of that community (Mukherjee 1995). Crawford and Morito (1997) also in Canada emphasised on stakeholders' perception in fish conservation. PRA, a way of learning from and with the community members to investigate, analyse and evaluate the constraints and the opportunities, needs assessment and priorities in the area of fishery management.

Materials and methods

The investigation was carried out during March 2000 to February 2002.

The study area

Sundarbans, located between 21°32′N to 22°40′N latitude and 87°05′E to 89°5′28″E longitude, is the agglomeration of several estuarine deltas in the extreme of South-East West Bengal. It consists of 19 blocks and 1093 mouzas under two adjacent districts of North- and South 24 Parganas. The land area of Sundarbans in West Bengal measures about 9630 km^2 of which 4493 km^2 is inhabited by people and the rest is reserve forest. The present study encompasses Sandeshkhali-I, Sandeshkhali- II, Hasnabad and Hingalganj Development Blocks (Figure 1) under the district of North 24 Parganas.

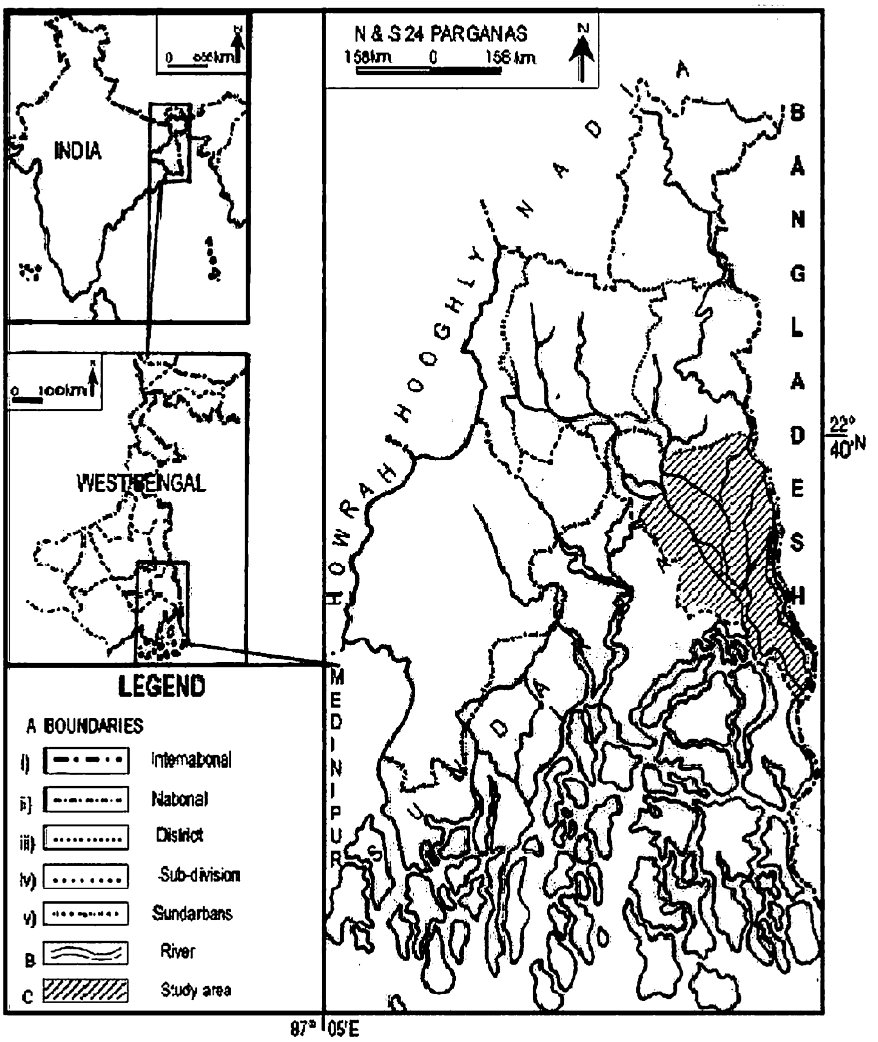

Figure 1. Map of North and South 24 Parganas districts showing the study area i.e. North-East Sundarbans, West Bengal, India.

Methods of collection and identification of fishes

Fish species were collected from the hauls of different fishing gears like bag nets, drag nets, cast nets, gill nets etc. operated in water bodies of different ecological features and also from the fishermen, local retail markets and *aratdars* (auctioners) as well as from consumers on varied seasons. Fishes brought in the local markets from outside places were not taken into consideration. The specimens were preserved in 4% formalin. Indigenous naming of different fishes were determined through focus group discussions. The specimens were identified subsequently following standard published keys and descriptions (Day 1878; Menon 1974; Talwar and Kacker 1984; Talwar and Jhingran 1991; Menon 1999) and with the help of scientific personnels of Zoological Survey of India, Kolkata.

Participatory techniques

These refer to the participatory and objective methodologies of assigning threat categories and deriving recommendations for conservation actions through interactive group dynamics from a number of stakeholders. Selected PRA techniques were carefully designed and applied to extract quality primary information relating to the conservation status of fishes. The techniques included (a) Trend Analysis, (b) Fish Magnitude Value (FMV), (c) Matrix Ranking and (d) Rank Based Quotient. *Trend analysis* was done to analyse the nature of increasing or declining numbers of the target fish population over decades considering the age and experience profiles of 50 stakeholders. FMV was calculated from a participatory approach where both the geographical as well as temporal dimensions were considered. The contention was that fish species had declined not only over a geographical space but also over the time as well. In the present context each individual stakeholder assessed the availability of a fish species in biomass (kg) for a given decade and that was multiplied by the visibility range *vis-à-vis* the area of occupancy (km^2) to help determine the status of that species in that decade. This type of calculation would delineate the percentage of decadal increase or decline since the benchmark decade. To avoid biases in perceptual assessment, averages were used.

$$\text{Mean Fish Magnitude Value} = \frac{\text{Biomass} \times \text{Area of occupancy}}{\text{Number of responding stakeholders}}$$

In the present context, the categorisation of fishes had been done considering the decline on FMV and mean decline on monthly market landing which are as follows :

for Critically endangered (CR), decline on FMV was >80 and mean decline on market landing was >60;
for Endangered (EN), decline on FMV was >75–80 and mean decline on market landing was >40–60;
for Vulnerable (VU), decline on FMV was >50–75 and mean decline on market landing was >30–40;

for Near Threatened (NT), decline on FMV was 40–50 and mean decline on market landing was 15–30 and

for Least Concern (LC) category, decline on FMV and the mean decline on market landing had been <40 and <15, respectively.

Matrix ranking was used to isolate and rank the perceived causes and their relative values in causing the depletion of target fish population. Considering the age and experience profiles above 40 years of 20 stakeholders, the process of interaction was triggered by the facilitators, the researchers, themselves. RBQ was applied to re-rank the identified causes in relation to dwindling of fish population. The formula followed was

$$\text{RBQ} = \Sigma^{n} \frac{f_i(n+1-i) \times 100}{Nn}$$

where N is the total number of stakeholders, n is the no. of ranks, i is the rank position and f_i is the frequency of i.

To initiate the process of scoring by the stakeholders, the 11 causal factors were written on hard piece of paper in vernacular i.e. Bengali language and such criteria were read out loudly and understood by the participants. After administering the schedule, the respective table was filled up. On the basis of Matrix ranking by the stakeholders to each causal factor for *Wallago attu*, the values of RBQ were calculated. The results showed that the identified problems vis-à-vis causal factors were prioritised on the basis of RBQ values.

Results and discussion

The catfishes in the fresh water and brackish water network of North-East Sundarbans are represented by 11 species belonging to 9 genera, 8 families and 1 order. All 11 catfishes are of commercial significance for their good taste and fast growth rate. The priced catfish, *Pangasius pangasius*, has become conspicuously less abundant in recent years (Das 1988). Some economically important catfishes have been declining due to over exploitation. *Pangasius pangasius* is overfished in the Indian Peninsula but has declined in the Ganges and the Brahmaputra rivers where it was once common (Prasad 1994). Among other commercial catfishes, the abundance of *Clupisoma garua* and *Mystus vittatus* have decreased considerably over the last two decades (Yadava and Chandra 1994).

The past method of grouping of fishes into Threatened, Extinct, Endangered, Vulnerable and Rare categories has been criticised for being subjective. The IUCN Council adopted a revised version of the groupings (IUCN 2001. Red List Categories and Criteria, Version 3.1) as a result of comments from IUCN (IUCN 1994) Species Survival Commission (SSC) members and from a final meeting of the Criteria Review Working Group in February 2000. The current version establishes 9 categories viz. Extinct (EX), Extinct in the wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near

Threatened (NT), Least Concern (LC), Data Deficient (DD) and Not Evaluated (NE). Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) species belong to 'Threatened' category (IUCN 2001).

Out of total 11 siluroid fishes of North-East Sundarbans *Mystus vittatus* (Bloch 1797), *Wallago attu* (Schneider 1801), *Ailia coila* (Ham.-Buch. 1822), *Clupisoma garua* (Ham.-Buch. 1822), *Pangasius pangasius* (Ham.-Buch.1822), *Clarias batrachus* (Linnaeus 1758) and *Heteropneustes fossilis* (Bloch 1794) are typical fresh water catfishes where as *Mystus gulio* (Ham.-Buch.1822), *Arius caelatus* Valenciennes 1840, *A. gagora* (Ham.-Buch. 1822) and *Plotosus canius* Ham.-Buch. 1822 live primarily in brackish water. The above 7 fresh water siluroid fishes were assessed in the CAMP workshop and they were recommended as different threat categories as follows: 1 as Critically Endangered (CR), 5 as Vulnerable (VU) and 1 as Lower Risk-Near Threatened (LR-nt) categories. (Table 1). But the said workshop did not mention any fish of North-East Sundarbans. However, scoring by the stakeholders of the area envisaged a declining trend in population of siluroid fishes both in the wild and culture habitats. Population sizes of almost all siluroid fishes of North-East Sundarbans, had been reduced drastically between 1960–2000 (Table 1). The table also depicts the participatory trend analysis in terms of Fish Magnitude Value showing the nature of decline of a species over decades.

The Trend Analysis on decadal distribution starting from 1960 to 2000 (Table 1) depicts the availability of 11 siluroids in terms of Fish Magnitude Value (FMV) and percentage in fish population depletion. In conforming with the IUCN guidelines the information was elicited through a focus group consisting of 50 stakeholders with at least 40 years of experience, who were asked to assess and delineate the decadal distribution of fishes in terms of time and visibility in nearby and around surroundings (Mukherjee 1995). Categorisation of siluroids of North-East Sundarbans is shown in Table 1. In determining the conservation status, the declines in FMV from the beginning of the period covered (1950) through the decade ending in 2000 were calculated and the declines after the decade ending 2000 as observed were as follows: *M. vittatus* (63.70%), *M. gulio* (42.87%), *W. attu* (79.46%), *A. coila* (41.33%), *C. garua* (46.28%), *P. pangasius* (61.28%), *C. batrachus* (52.34%), *H. fossilis* (50.12%), *A. caelatus* (42.87%), *A. gagora* (45.65%) and *P. canius* (62.58%). The average decadal declines for different species as observed were as follows: *M. vittatus* (36.56), *M. gulio* (33.56), *W. attu* (43.88), *A. coila* (30.87), *C. garua* (30.36), *P. pangasius* (35.48), *C. batrachus* (23.95), *H. fossilis* (28.05), *A. caelatus* (20.00), *A. gagora* (32.58) and *P. canius* (36.47) (Table 1).

The data on average monthly fish landing on the major fish market of the study area at Nazat under Sandeshkhali-I Development Block receiving fish landing from the water bodies of all the Blocks (Table 2) during 1997–2001 had been collected and presented. This indicated the similar pattern as that of the FMV data derived from the fishermen.It had been found that the decadal mean FMV was the highest for *Mystus gulio* (263.83) largely because of high culture potential in brackish waters but the species declined abruptly between 1980 and

Table 1. Decade wise Trend Analysis of siluroid fishes of North-East Sundarbans.

Species (with taxonomic position)	Local name	1960	1970	*	1980	*	1990	*	2000	*	#
Order : Siluriformes											
Family: Bagridae											
1. *Mystus vittatus* (Bloch, 1797)	Dorakata tangra	270.10	246.70	8.66	207.90	15.73	87.05	58.13	31.60	63.70	36.56
2. *Mystus gulio* (Ham.-Buch., 1822)	Nona tangra	382.53	375.82	1.75	230.81	38.58	113.00	51.04	64.56	42.87	33.56
Family: Siluridae											
3. *Wallago attu* (Schneider, 1801)	Boal	191.87	163.50	14.78	128.50	21.40	51.53	59.89	12.30	79.46	43.88
Family: Schilbeidae											
4. *Ailia coila* (Ham.-Buch., 1822)	Kajoli, Kajri	241.70	211.90	12.33	183.80	13.26	79.85	56.56	46.85	41.33	30.87
5. *Clupisoma garua* (Ham.-Buch., 1822)	Gharwya, Ghero	255.10	225.14	11.74	190.86	15.23	98.90	48.18	53.13	46.28	30.36
Family: Pangasiidae											
6. *Pangasius pangasius* (Ham.-Buch., 1822)	Pungwas tangra	257.50	226.13	12.20	118.70	16.55	90.80	51.88	35.16	61.28	35.48
Family: Clariidae											
7. *Clarias batrachus*(Linnaeus, 1758)	Magur	205.39	183.30	10.75	142.35	22.34	127.57	10.38	60.79	52.34	23.95
Family: Heteropneustidae											
8. *Heteropneustes fossilis*(Bloch, 1794)	Singhi	306.56	250.45	18.30	213.69	14.68	151.54	29.08	75.59	50.12	28.05
Family: Ariidae											
9. *Arius caelatus* Valenciennes, 1840	Nona tangra	287.53	277.92	3.34	250.73	9.78	190.50	24.02	108.83	42.87	20.00
10. *Arius gagora* (Ham.-Buch., 1822)	Gagra tangra	287.80	266.66	7.35	225.30	15.51	86.05	61.81	46.77	45.65	32.58
Family: Plotosidae											
11. *Plotosus canius* Ham.-Buch., 1822	Kanmagur	254.30	224.50	11.72	190.00	15.37	83.06	56.30	31.08	62.58	36.47

*, % decline over the previous decade; #, mean decline.

Table 2. Monthly average landing of different commercially important siluroid fish species of North-East Sundarbans.

Species (with taxonomic position)	Monthly Landing (kg) in 1997		Monthly landing (kg) in 1998		Decline over previous year	Monthly Landing (kg) in 1999		Decline over previous year	Monthly landing in (kg) 2000		Decline over previous year	Monthly landing (kg) in 2001		Decline over previous year	Mean Decline
	Range	Mean	Range	Mean		Range	Mean		Range	Mean		Range	Mean		
Order : Siluriformes															
Family: Bagridae															
1. *Mystus vittatus* (Bloch)	5.00–19.30	8.95	4.90–24.00	7.49	16.31	3.30–9.40	5.17	30.97	1.50–4.30	2.57	50.29	0.50–1.72	0.68	73.54	42.78
2. *Mystus gulio* (Ham.-Buch.)	430.00–1600.00	882.50	600.50–1400.60	712.53	19.26	245–947.25	634.15	11.00	375.00–790.60	565.53	10.82	197.25–490.00	359.56	36.42	19.38
Family: Siluridae															
3. *Wallago attu* (Schneider)	62.00–225.00	125.50	73.00–185.20	102.47	18.35	57.00–105.00	71.48	30.24	19.00–68.00	25.44	64.41	0.20–1.95	1.20	95.28	52.07
Family: Schilbeidae															
4. *Ailia coila* (Ham.-Buch.)	79.00–172.25	113.50	68.00–120.00	70.93	37.51	43.5–74.2	54.79	22.75	29.00–69.00	40.24	26.56	20.50–38.00	27.45	31.78	29.65
5. *Clupisoma garua* (Ham.-Buch.)	71.50–103.00	83.50	59.45–98.50	74.70	10.54	34.50–79.45	49.77	33.37	19.00–57.00	23.45	52.88	4.60–32.30	19.23	18.01	28.70
Family: Pangasiidae															
6. *Pangasius pangasius* (Ham.-Buch.)	51.50–143.00	73.30	39.00–74.25	58.67	19.96	24.50–67.25	39.42	32.81	13.00–47.00	25.54	35.21	10.25–27.00	14.47	43.34	32.83
Family: Clariidae															
7. *Clarias batrachus* (Linnaeus)	159.25–239.50	186.25	95.50–235.00	135.05	27.49	64.00–164.75	95.21	29.50	48.50–104.00	68.31	28.25	29.00–78.70	36.81	46.11	32.84
Family: Heteropneustidae															
8. *Heteropneustes fossilis* (Bloch)	48.50–104.00	67.50	48.00–95.25	47.69	29.35	15.00–93.50	29.51	38.12	7.50–52.00	19.31	34.56	3.75–29.00	10.04	48.00	37.51
Family: Ariidae															
9. *Arius caelatus* Valenciennes	102.50–167.75	143.70	71.20–143.00	103.64	27.88	56.35–103.50	80.50	22.33	63.25–84.50	69.00	14.29	31.50–59.69	47.00	31.88	24.09
10. *Arius gagora* (Ham.-Buch.)	73.00–181.00	136.25	62.00–170.00	97.75	28.26	48.40–142.00	80.25	17.90	52.00–139.00	70.50	12.15	23.00–55.50	34.00	51.77	27.52
Family: Plotosidae															
11. *Plotosus canius* Ham.-Buch.	7.75–24.30	15.50	7.25–29.00	12.75	17.74	3.55–24.50	7.50	41.18	2.15–10.40	5.48	26.93	0.50–7.50	2.11	61.50	36.84

1990. Large changes were observed in many other species as well (Table 2). The decadal mean of FMV of other catfishes would have been as follows: *A. caelatus* (223.10), *H. fossilis* (199.57), *A. gagora* (179.95), *M. vittatus* (168.67), *C. garua* (161.26), *P. canius* (156.59), *A. coila* (149.63), *P. pangasius* (145.66), *C. batrachus* (143.88) and *W. attu* (109.54) (Table 3). The coefficient of variation (CV) in all species for rate of decline was relatively consistent (Table 3). It was envisaged from the present context that out of 11 siluroid fishes in the North East Sundarbans, 1 should be classified as Endangered, 5 as Vulnerable i.e. 6 as Threatened and 5 as Near threatened and none as appropriate for the Least Concern Category.

A group meeting with 20 local stakeholders, again with at least 40 years experience, was organised to collect information on factors responsible for the population depletion of *Wallago attu*, the Endangered species of the study area. Causal factors were discussed with the stakeholders who were also requested to add to the list and to score all causal factors. The causal factors responsible for *Wallago attu* populace depletion, numbering eleven, were as follows: (1) wanton exploitation of fresh water fishes, (2) wanton destruction of brooder fishes from fresh water habitats, (3) use of agricultural insecticides, (4) use of ichthyotoxic materials, (5) fish diseases, (6) predator habit of fishes, (7) wanton destruction of fresh water habitat for human settlement, (8) lack of awareness on fish conservation, (9) use of fine meshed nets, (10) excessive abstraction of water from fresh water habitat and (11) destruction of fresh water habitat for brackish water *bheri*. During last three decades mass mortalities of fishes have been observed in India and elsewhere as a result of diseases associated with eco-degradation (Tarzwell and Henderson 1957; Saunders 1969; Konar 1975).

In the North-East Sundarbans, RBQ values indicated that 'predator habit of fishes' was the highest ranking (90.00) cause of population decline in *Wallago attu* (Table 4). The farmers generally avoided culturing the predatory fish because it is such a voracious predator. It was also observed that the causal factors, 'predator habit of fishes', 'lack of awareness on fish conservation' and 'wanton exploitation of fresh water fishes', in respect of RBQ values were much higher than for any other cause. The discharge of toxic effluents like insecticides and heavy metals to water resulting from rapid pace of urbanisation, industrialisation and indiscriminate use of chemical fertilisers and insecticides in agriculture appear to be great threat to the lives of the aquatic organisms. Once toxic elements like heavy metals get into soil or water, they enjoy long residence time before they are moved to other compartments of aquatic ecosystems (Walker et al. 1996). Production of heavy metals and their discharge into aquatic ecosystems have increased greatly in recent years (Moore and Ramamoorthy 1984). Soils are considered as sinks for trace elements. The suspended particles carried by several industrial effluents and domestic sewage ultimately deposited as the sediments containing measurable concentration of heavy metals (Chandra 1999). Heavy metal concentration increases steadily from water to soil to macrophytes to other aquatic organisms through the

Table 3. Determination of conservation categories of siluroid fishes in North-East Sundarbans.

Siluroid fish species	Local name	Decadal mean of FMV	SD	CV	Percent decline of FMV after 2000	Mean decline of monthly market landing	✪	❋
1. *Mystus vittatus* (Bloch)	Dorakata tangra	168.67	104.12	61.73	63.70	42.28	VU (A1acd)	VU (B2b)
2. *Mystus gulio* (Ham.-Buch.)	Nona tangra	263.83	113.26	42.93	42.87	19.38	_	NT
3. *Wallago attu* (Schneider)	Boal	109.54	75.61	69.03	79.46	52.07	LR-nt	EN(A1c)
4. *Ailia coila* (Ham.-Buch.)	Kajoli, Kajri	152.82	85.01	55.63	41.33	29.65	VU(A1abcd, 2bcd)	NT
5. *Clupisoma garua* (Ham.-Buch.)	Gharwya, Ghero	164.63	85.57	51.98	46.28	28.70	VU(A1acd, 2cd)	NT
6. *Pangasius pangasius* (Ham.-Buch.)	Pungwas tangra	145.66	93.45	64.16	61.28	32.83	CR(A1abcd)	VU(A1c; E)
7. *Clarias batrachus* (Linnaeus)	Magur	143.88	55.92	38.87	52.34	32.84	VU(A1cd)	VU(A1c;E)
8. *Heteropneustes fossilis* (Bloch)	Singhi	199.57	89.32	44.76	50.12	37.51	VU(A1cd)	VU(E)
9. *Arius caelatus* Valenciennes	Nona tangra	223.10	74.23	33.27	42.87	24.09	_	NT
10. *Arius gagora* (Ham.-Buch.)	Gagra tangra	182.52	109.23	59.85	45.65	27.52	_	NT
11. *Plotosus canius* Ham-Buch.	Kanmagur	156.59	95.44	60.95	62.58	36.84	–	VU(A1c)

FMV = Fish Magnitude Value
SD = Standard deviation
CV = Coefficient of variation
✪= Status of freshwater fishes as per IUCN Red list criteria (IUCN, 1994), as recommended at Biodiversity Conservation Prioritization Project (BCPP) Conservation Assessment Management Plan (CAMP) Workshop, 1998 at NBFGR, India
❋= Present assessment of status of siluroid fishes of North-East Sundarbans, India. IUCN-2001 categories criteria version 3.1. have been mentioned within parenthesis.
CR = Critically Endangered
EN = Endangered
VU = Vulnerable
NT = Near Threatened
LRnt = Lower Risk-near threatened
'—' = Not assessed in the CAMP Workshop, 1998.

Table 4. Identification of causal factors responsible for depletion of *Wallago attu* populace.

Causal factors	Ranking by stakeholders											RBQ values	Re-ranking of causal factors
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI		
1. Wanton exploitation of fresh water fishes		1	9	1	1	3	2					60.92	III
2. Wanton destruction of brooder fishes from fresh water habitat		1		3	1	5						32.28	VII
3. Use of agricultural insecticides			1		4	1	6					33.19	VI
4. Use of ichthyotoxic materials			4	2		2		1				30.90	IX
5. Fish diseases			3	1	1							19.09	X
6. Predator habit of fishes	9	10	1									90.00	I
7. Wanton destruction of freshwater habitat for human settlement			1	3	6	1	2	2				45.01	IV
8. Lack of awareness on fish conservation	12	5	2		1							73.63	II
9. Use of fine meshed nets						1	1					5.00	XI
10. Excessive abstraction of water from fresh water habitat				6	4	2						40.00	V
11. Destruction of fresh water habitat for brackish water *bheri*		1		2	2	3	1	1	1			31.81	VIII

$$\mathrm{RBQ} = \Sigma^{n} \frac{f_i(n+1-i) \times 100}{Nn}$$

where RBQ is the Rank Based Quotient, N is the total number of stakeholders or key informants, i.e. 20, n is the no. of ranks, i is the rank position, and f_i is the frequency of i .

process of biomagnification (Bhattacharya and Chakraborty 2001). By virtue of carnivorous feeding habit of *Wallago attu*, toxic elements get accumulated at higher concentration in its physiological systems through biomagnification leading to drastic decline in population. Poor sanitation, urban industrial as well as domestic waste disposal systems coupled with people's meagre knowledge on fish conservation lead to aquatic eco-degradation and exert deleterious effects especially on its life. Such eco-degradation appears to hamper the survivability of this category of fishes as they are devoid of protective covering in the form of scales as in other group of fishes (Kumar 1998). To improve the sanitation and sewage disposal system of North-East Sundarbans through proper linkages between various nodal agencies and with active participation of the local stakeholders is an important prerequisite for fish conservation. There is no definite method for fishing operation of catfishes. Catfishes are caught frequently as and when facilitated and during purification of managed water bodies juveniles along with brooders are exploited indiscriminately. As a sequel to lack of restriction in mesh size juveniles of *Wallago attu* are exploited and destroyed leading to both economical and ecological loss. Withdrawal of the causal factors responsible for the decline of *Wallago attu* population is only possible with the active participation of local fishing community.

Conservation

There is an urgent need for conservation and revival of fishes whose populations have significantly declined. Possible conservation measures include: (i) eco-restoration, (ii) protective and preventive measure, (iii) *in situ* and *ex situ* conservation and iv) creation of mass awareness.

(i) Eco-restoration: Suitable aquatic impoundments should be marked for ranching of species fingerlings with active participation of the local population. Brood stocks and juveniles, exploited accidentally, should be released back.
(ii) Protective and preventive measure: There are various laws to protect rivers in India including the Water Prevention and Control Act (1977), Wildlife Protection Act (1972) etc.; these laws should be strengthened and enforced. The Fisheries Act of 1897 was the earliest legislation designed to protect fish stocks from destructive fishing methods; to regulate size and mesh of fishing gears; to enforce closed season etc. For the threatened fishes, fish sanctuaries or reservoirs should be established. The question of protection of fish life through establishment of fish sanctuaries has not received any attention so far.
(iii) *In situ* and *ex situ* conservation: *In situ* conservation of aquatic germplasm resources is a new concept for the developing countries (WWF 1992). This would require a large investment of finances and trained manpower. Cryopreservation of sperms, eggs or embryos and storage of cell cultures represent alternative methods of maintaining genetic variants (WWF 1992).

Regarding *ex situ* conservation, rehabilitation of declining fish species by spawning enhancement is necessary. Artificial breeding of threatened fish species is being practised to make available the species in their natural habitats and thereby restoring the gene bank of threatened species.

(iv) Creation of mass awareness: It is now well recognised that the success of the fish conservation movements would ultimately depend on creation of mass awareness and participation of local population. And they can be motivated by conducting several workshops and training programs highlighting different problems and prospects of fishery activities so that developing a sustainable fishery management alongside delineating proper conservation strategies are possible in North-East Sundarbans.

The erosion of local fish resources has both immediate and long-term impacts. Modernised agriculture and expanding urbanisation have not only polluted the surroundings but also threatened the existence of key fisheries taxa. The present study attempted to inventory living resources using participatory tools that could utilise the experience and knowledge of local stakeholders. The current need is to quantify and standardise the observational data from fishers for rigorous analyses. This type of study can also be replicated elsewhere to take advantage of local experience and knowledge to supplement conventional research techniques. Studies that utilise participatory research methodology create a more comprehensive perspective that can extend further back in time than conventional research data.

Acknowledgements

The authors express their sincere gratitude to Prof Amalesh Choudhury, former Head of the Department of Marine Science, University of Calcutta for his keen interest and encouragement on the study. Authors are thankful to Director, Zoological Survey of India for the sincere help in identifying different finfishes and shellfishes. Thanks are due to the authorities of Vidyasagar University, Midnapore for library and laboratory facilities.

References

Anon. 1998. Executive Summary Report of Biodiversity Conservation Prioritisation Project (BCPP) Conservation Assessment Management Plan (CAMP) on Fresh Water Fishes of India. NBFGR, Lucknow, Zoo Outreach Organisation/CBSG, India, pp. 1–7.

Bhattacharya N. and Chakraborty S.K. 2001. Distributional Pattern of Some Heavy Metals in the Structural Components of Two Contrasting Wetlands in the Vicinity of a Iron Extraction Factory of Midnapore District, West Bengal, India. Chapter 25, Ecology of Polluted Waters. Ashish Publishing Corporation, New Delhi, India, pp. 287–294.

Chandra K. 1999. Status of Heavy Metals and Pesticides in Aquatic Food Chain in Context of Indian Rivers. Summer School on Ecology, Fisheries and Fish Stock Association in Indian Rivers, Central Inland Capture Fisheries Research Institute, Barrackpore, pp. 92–98.

Crawford S.S. and Morito B. 1997. Comment : toward a definition of conservation principles for fisheries management. Canadian Journal of Fisheries and Aquatic Sciences, 54(11): 2720–2723.

Das P. 1988. Conservation and management of fish genetic resources of India. In: Jhingran A.G. and Sugunan V.V. (eds), Conservation and Management of Inland Capture Fishery Resources. Central Inland Capture Fisheries Research Institute, Barrackpore, W.B., India, pp. 20–24.

Day F. 1878. The Fishes of India: Natural History of the Fishes Known to Inhabit the Seas and Fresh Waters of India, Burma and Ceylon. London, Vol. 1, pp. 778, 2, pp. 195. Plates : Reprint – 1958.

IUCN 1994. IUCN Red List Categories. Prepared by the IUCN Species Survival Commission. IUCN, Gland, Switzerland.

IUCN 2001. IUCN Red List Categories and Criteria. Version 3.1. IUCN Species Survival Commission, IUCN, Gland, Switzerland and Cambridge, UK, pp. 1–30.

Jhingran A.G. 1988. Aquatic Pollution with Special Reference to the Ganga River System. National Symposium on Environmental Impacts on Animals and Aquaculture, May 14–16. Department of Zoology, University of Kalyani, Kalyani, India, pp. 6–19.

Konar S.K. 1975. Pesticides and aquatic ecosystems. Indian Journal of Fisheries, 22: 80–85.

Kothari A. 1997. Understanding Biodiversity: Life, Sustainability and Equity. Orient Longman India Ltd, pp. 1–161.

Kumar A. 1998. Conservation of fish genetic resources of North Bihar. In: Ponniah A.G., Das P. and Verma S.R. (eds), Fish Genetics and Biodiversity Conservation Natcon Publication, Vol. 5. Muzaffarnagar, India, pp. 63–68.

Meena B.S. 2001. Problem identification and prioritisation through Participated Rural Appraisal (PRA) techniques, Indian Research. Journal of Extension Education, 1(2): 117–118.

Menon A.G.K. 1974. A Check-list of Fishes of the Himalayan and the Indo-Gangetic Plains, Inland Fisheries Society of India. Central Inland Capture Fisheries Research Institute, Barrackpore, India, Special Publication No. 1, pp. 1–102.

Menon A.G.K. 1999. Check-list – Fresh water Fishes of India. Records of Zoological Survey of India, Occasional. Paper No. 175, Published by the Director, Zoological Survey of India, Calcutta, pp. i–xxix + 1–366.

Moore J.W. and Ramamoorthy S. 1984. Heavy Metals in Natural Waters. Applied Monitoring and Impact Assessment, Springer Verlag, New York.

Mukherjee N. 1995. Participatory Rural Appraisal and Questionnaire Survey (Comparative Field Experience and Methodological Innovations). Concept Publishing Co, Delhi, India.

Pandit P.K. and Bhaumik U. Chatterjee J.G. 1994. Threatened Fishes of Sundarbans, West Bengal – Threatened Fishes of India, Vol. 4. Natcon Publication, Muzaffarnagar, India, pp. 253–259.

Prasad P.S. 1994. Status paper on endangered, vulnerable and rare fish species of Bihar. In: Threatened Fishes of India, Vol. 4. Natcon Publication, Muzaffarnagar, India, pp. 25–29.

Saunders J.W. 1969. Mass mortalities and behaviour of brook trout and juvenile Atlantic Salmon in a stream polluted by agricultural pesticides. Journal of Fisheries Research Bulletin of Canada. 26: 695–699.

Talwar P.K. and Jhingran A.G. 1991. Inland Fishes of India and Adjacent Countries, Vols. 1 & 2. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, Bombay and Calcutta, pp. 1–1063.

Talwar P.K. and Kacker R.K. 1984. Commercial sea fishes of India. Handbook Zoological Survey of India, 4: 1–997.

Tarzwell C.M. and Henderson C. 1957. Toxicity of dieldrin to fish. Transactions of American Fisheries Society. 86: 245–257.

Walker C.H., Hopkin S.P., Sibly R.M. and Peakall D.B. 1996. The fate of metals and radioactive isotopes in contaminated ecosystem. Principles of Ecotoxicology. Taylor & Francis Ltd, pp. 51–72.

WWF. 1992. Convention on Biological Diversity, June, Text and Annexes. World Wide Fund for Nature, India, pp. 8–9.

Yadava Y.S. and Chandra R. 1994. Some threatened carps and F catfishes of Brahmaputra River system. In: Threatened Fishes of India, Vol. 4. Natcon Publication, pp. 45.