Status and distribution of the endangered Gangetic dolphin (*Platanista gangetica gangetica*) in the Brahmaputra River within India in 2005

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A population assessment survey of the endangered Ganges river dolphin was made between February and April 2005 in the Brahmaputra River starting from Assam–Arunachal Pradesh border to the India–Bangladesh border. One hundred and ninety seven dolphins were recorded in the entire 856 km river stretch with an encounter rate of 0.23 dolphins per km. Encounter rates of dolphin in different sectors were significantly different. Calves and subadult encounter rates were recorded as highest in the Brahmaputra stretch within the Kaziranga National Park. No significant difference was found between the number of calves and subadults, calves and adults as well as subadults and adults. The variations in depth structure of the river were highly significant along different stretches. The number of dolphins occurring in different depths was found to be significantly different and the highest number was found in a depth of 4.1–6 m. Gill net encounter rate was significantly different in different stretches of the river with maximum encounter rate recorded from Goalpara to Dhubri. Accidental killing through gill net and poaching of dolphin for oil are the most dangerous threats to the survival of these dolphins. Close monitoring of dolphins and their habitats involving local communities are required for long term conservation of the species in the Brahmaputra River.

Keywords: Brahmaputra River, conservation, depth, distribution, Gangetic dolphin, population status.

THE Gangetic dolphin (*Platanista gangetica gangetica*) is found in the Ganges–Brahmaputra–Meghna and Karnaphuli River systems of India, Nepal and Bangladesh[1–7]. In the 19th century, these dolphins were abundant in the entire distributional range, though no actual data on population of that time is available[1]. However, due to various pressures, the distributional range and abundance of this species has sharply declined[8]. The IUCN revised its 'threatened' status from 'vulnerable'[9] to 'endangered'[10] because of large population decline of the species (by 50%) and because the factors causing the decline (entanglement in fishing gear, diversion of water, pollution and fragmentation of habitat) are still present, not fully understood and are not reversible.

In addition to the Ganges river system of northern India, the Brahmaputra River system of India and Bangladesh is a major habitat of the Gangetic dolphin. Compared to the Ganges river system, studies on dolphin or its conservation are scanty in the Brahmaputra river system. Earlier studies on the Gangetic dolphin from Assam were mainly focused on population status[11–14], ecology[15] and threats[16].

So far, there has been only one published report[11] on the population status assessment of dolphins in the entire Brahmaputra River in India, although fragmented surveys were conducted at different times[13]. Therefore, there has been no studies on the conservation status of the species in this major habitat for the past 12 years. In addition, conservation initiatives undertaken to protect the species have only been periodic. In this study, a new assessment of the Gangetic dolphin's status in the Brahmaputra River within India, was made from the Assam–Arunachal Pradesh border to India–Bangladesh border.

Materials and methods

Study area

Brahmaputra River is one of the longest rivers in the world. It flows through Tibet, India (Arunachal Pradesh and Assam) and Bangladesh before reaching its delta with the Bay of Bengal. The river is known as Tsangpo in Tibet, Siang or Dihang in Arunachal Pradesh, Luit or Brahmaputra in Assam, and Jamuna and further downstream as the Padma in Bangladesh. The 2880 km long Brahmaputra is larger than the Ganges in length and volume, traverses its first 1625 km in Tibet, the next 918 km in India and the remaining 337 km in Bangladesh up to its confluence with the Ganges. After entering India, the river flows as the Siang or Dihang River, travels about 52 km from Pasighat at the foothills of the Himalayas before two other major rivers, the Dibang and the Lohit,

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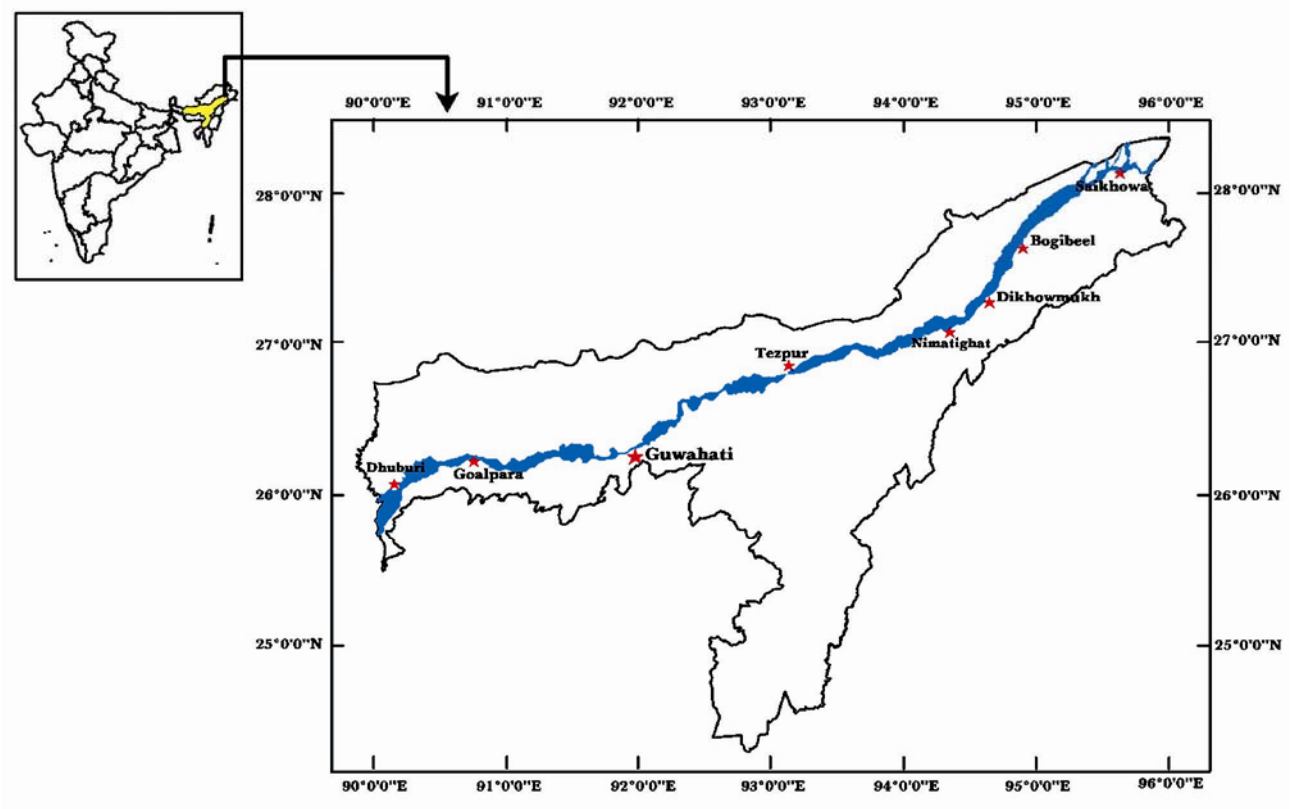

Figure 1. Location map of Brahmaputra River.

join it. From this trijunction, the river is known as Brahmaputra. From here the river enters a narrow flat valley, which is known as Assam Valley or Brahmaputra Valley (Figure 1). The average width of the valley is about 86 km. Of the total width of the valley, the river itself occupies 15–18 km, and is narrowest near Guwahati. Within Assam, the river traverses a total length of about 900 km.

In Assam, the river receives 103 notable tributaries from both sides, 65 from the north bank and 38 from the south bank. In the north, the principal tributaries are Subansiri, Jia Bharali, Dhansiri (North), Puthimari, Pagladiya, Manas, Champawati and Sankosh. On the south bank, the main tributaries are Burhi Dihing, Disang, Dikhow, Dhansiri (South) and Kopili. The locations of the Brahmaputra-tributary confluences are constantly changing due to bank erosion by the Brahmaputra. The north bank tributaries originate in the Himalayas and have high gradient and hence they carry a heavy sediment load of coarser material such as gravel and cobbles. The lower reaches of the northern tributaries are braided. The south bank tributaries have lower gradient and their sediment load is relatively low and finer in size; they are meandering rivers with deeper cross-sections[17].

Survey method

The channels of the Brahmaputra River were first identified through recent satellite imageries (IRS-1C, LISS-III, 1 : 50,000). Information was collected from riverside villages, especially from fishermen, about the presence of dolphins along the identified channels. This information was then confirmed through direct field verification.

The survey was conducted during the second half of February to first half of April 2005. This season was selected because the river discharge is at its minimum and dolphins remain concentrated into a narrower channel and are therefore easier to count. Moreover, to avoid the seasonal migration of dolphins during the rising (spring) and falling (autumn) water stage[2], the survey was conducted in winter and beginning of pre-monsoon seasons, as it provides best population assessment.

The entire river was segmented into seven sectors. Sectors were almost equal in length, ranging from 117 to 134 km (mean length 122.28 km, SD = ±5.70). The end points were located at significant landmarks, especially at the confluence points of major tributaries. The sectors were as follows.

Sector I. Tengapanimukh (27°44′N, 95°45′E) and Uriamghat (27°49′N, 95°20′E) to Balijan (27°34′N, 95°10′E). The total length of this sector is 119 km, starting from Tengapanimukh (the border of Tinsukia district of Assam and Lohit district of Arunachal Pradesh) and Uriam Ghat (border of Siang district of Arunachal Pradesh and Dhemaji district of Assam) to Balijan, where the Lohit River merges with the Brahmaputra. The rivers Siang, Dibang, Lohit and Noa-Dihing are the major tributaries in this sector.

Sector II. Balijan (27°34′N, 95°10′E) to Dikhowmukh (26°59′N, 94°26′E). This 123 km long sector starts from Balijan, the confluence point of the Lohit River and ends in Dikhowmukh, where the Dikhow River converges with the Brahmaputra. Rivers Dihing, Disang, Dimow, Darika and Dikhow are the major tributaries of the Brahmaputra in this sector.

Sector III. Dikhowmukh (26°59′N, 94°26′E) to Dhansirimukh (26°40′N, 93°36′E). With a total stretch of 118 km, this sector starts from the confluence of Dikhow River and ends at the Dhansirimukh, where the Dhansiri River discharges into the Brahmaputra. The rivers Jhanji, Bhugdoi and Dhansiri are the major tributaries in this sector.

Sector IV. Dhansirimukh (26°40′N, 93°36′E) to Gabhorumukh (26°36′N, 92°38′E). This sector has a total length of 123 km, starting from the Dhansiri confluence and ending at the confluence of the Gabhoru River. About 84 km of this sector flows through Kaziranga National Park. Jia-Bharali and Dipholu rivers are the major tributaries discharging into the Brahmaputra in this sector.

Sector V. Gabhorumukh (26°36′N, 92°38′E) to Guwahati (26°10′N, 91°40′E). This sector starts from Gabhorumukh and flows 117 km to Panikhaiti, near Guwahati. The River Kalang is the major tributary in this sector.

Sector VI. Guwahati (26°10′N, 91°40′E) to Pancharatna (26°12′N, 90°34′E). This stretch has a total length of 134 km, starting from Guwahati and ending in Jogighopa, near the Pancharatna Bridge. The rivers Krishnai, Dudhnoi, Singri, Puthimari, Manas, Beki and Pagladiya converge with the Brahmaputra in this sector.

Sector VII. Pancharatna (26°12′N, 90°34′E) to India-Bangladesh border (25°44′N, 89°54′E). With a total of 122 km stretch, this sector starts from the Pancharatna bridge and ends in Sukh Char, near the India–Bangladesh border. The Jhinjiram, Gadadhar and Gangadhar rivers are the major tributaries in this stretch.

Efforts were made not to double count dolphins in two adjoining sectors. The probability of double counting dolphins due to their movement from surveyed to unsurveyed reaches overnight, was considered to be balanced by the probability that an equal number of dolphins were missed due to their movements in the opposite direction.

Survey methods used for the Asian river dolphin survey in wide channels[18] were followed. A mechanized steel boat was used for conducting the entire survey. The survey boat followed a single transect, following the deepest channel and moving from one bank to another. The speed of the boat was maintained at 6–8 km/h in a downstream direction. Five observers recorded sighting of dolphins with three forward observers, one rear observer and a data recorder. Among the three forward observers, two searched 60° right and left and the third observer in the centre 30° right and left. The rear observer was responsible for detecting the animal missed by the primary survey team. Observers conducted dolphin sighting from a 2 m high platform of the survey boat with naked eyes. The observers rotated positions every 30 min to maintain alertness. Close coordination was maintained among the observers for accurate age-class determination and group size estimation of the sighted dolphins.

A dolphin group was defined as dolphins found within an area of 500 m stretch with similar hydrobiological characteristics[18]. Group size was estimated with a best, high and low estimate of numbers[18]. A low and best estimate of zero was used if the sightings were unconfirmed and if there was a possibility of already counting the dolphins for its boat following behaviour. After confirming the sighting, the sighting locations were recorded by a Garmin 12-channel GPS, and the digital location data was later transferred into digital satellite images through Erdas Imagine 9.0 software and analysed with the help of GIS Lab, Aaranyak to determine the population distribution. Dolphin encounter rate in each sector was calculated by dividing the number of dolphins sighted by the length of the surveyed river stretch measured by GPS.

The age-class of the sighted dolphins was determined through observing their body size[11]. A dolphin with a body size of less than 1 m was considered as calf, between 1 and 1.5 m as subadult and more than 1.5 m as adult. In case of the sighting where body size of the dolphin was not identifiable, a term ‘unidentified’ was used against the age-class of the sighted animal.

The channel width was measured by adding the distance of each of the banks from the survey boat using Laser Range Finder if the distance was less than 800 m, or estimated visually if greater; and a spot water depth was determined using an Echosounder cum Fish Finder (Navman 450) at 1 km intervals. A depth reading was also taken in the areas where dolphins were sighted. A 20 min stoppage was made at favourable dolphin microhabitats, viz. confluences, river meanders and mid-channel islands, because these microhabitats were recorded as the high-density areas during their survey in the rivers of Bangladesh and Nepal[2,19,20].

Weather conditions were recorded at every 1 h interval during the survey time with the following scale: 0 = water surface glassy, 1 = ripples without crests, 2 = small wavelets with crests but no white caps, 3 = large wavelets with scattered white caps, 4 = small waves with fairly frequent white caps. From ‘3’ scale, the survey was postponed. Visibility was assessed with the following scale: 0 = clear; 1 = visibility less than 2 km, 2 = visibility less than 1 km. From visibility code ‘2’, the survey was postponed until conditions improved.

Dolphin distribution map was prepared using Erdas Imagine 9.0 GIS software with the help of GIS Lab of Aaranyak.

Statistical analysis

For statistical analysis of the data, statistical software Statistica 6.0 and Origin 7.0 were used. As each sector

was considered as a unit, and the number of dolphins observed within that sector was independent, therefore we performed G-statistics[21,22] to find out whether the encounter rate of dolphin in different sectors was significantly different. After getting significant difference of encounter rate of dolphin in different sectors, and the highest encounter rate found in sector VII followed by sector IV, we did Chi-square test after Yate's correction to examine the statistical difference of the encounter rate of dolphin between these two sectors. We examined whether the number of occurrence of dolphins in different depths was significantly different, and if so, whether a particular range of depth had more number of dolphins. For this we applied G-statistics, and found that the maximum number of dolphins was significantly present in the depth range of 4.1–6 m. Then, we tried to find whether the number of occurrence at this particular depth range was associated with sectors IV and VII. For this, we made a 2×7 contingency table, putting the number of occurrence of the depth range 4.1–6 m where dolphins were found and the number of occurrence of the depth range 4.1–6 m where dolphins were not found in two rows and the seven sectors in seven columns. With this, we did Chi-square test.

We did non-parametric Wilcoxon's test for matched pairs to know whether there were any significant differences of the median encounter rate between calves and subadults, calves and adults as well as subadults and adults in different sectors. One-way ANOVA was used to test whether there was significant difference of depths, and gill net encounter rate among different sectors.

Results

A total of 197 dolphins (27 calves, 32 subadults and 138 adults) were recorded from 82 locations of the Brahmaputra River (Table 1 and Figure 2). The highest dolphin encounter rate was recorded in sector VII (0.39 dolphin per km), followed by sector IV (0.32 dolphin per km) and the lowest encounter rate was in sector II (0.13 dolphin per km) (Table 2). The encounter rate of dolphin in different sectors was significantly different (G test: $G = 28.17$; d$f = 6$; $P < 0.01$).

The highest encounter rate of calves and subadults was found in sector IV (0.06 individuals per km), whereas that of adults was found in sector VII (0.31 individuals per km) (Figure 3). No significant difference was found in the median encounter rate between calves and subadults, calves and adults as well as subadults and adults in different sectors ($T = 7$, NS, Wilcoxon's test for matched pairs).

We recorded the range of the water depth in different sectors of the Brahmaputra from 0.9 to 37 m with a mean depth of 6.06 m ± 3.93 SD (Table 3). These depths along different sectors were significantly different ($F = 21.16$; d$f = 6$, 849; $P < 0.001$). Minimum water depth was recorded in sector I (3.95 m ± 1.97 SD), whereas the maximum was recorded in sector VI (8.66 m ± 4.69 SD). The number of occurrence of dolphins in different depths was found to be significantly different ($G = 64.73$, d$f = 7$, $P < 0.01$) and the highest number of dolphins (33.5%) was found in a depth of 4.1–6 m (Figure 4).

Although encounter rate of dolphin was significantly highest in sector VII followed by sector IV (G test: $G = 28.17$, d$f = 6$, $P < 0.01$), there was no significant difference of dolphin encounter rate between sectors IV and VII (Chi-square = 1.20, NS). Number of occurrence at 4.1–6 m water depth where maximum dolphins were found was significantly associated with sectors IV and VII (Chi-square = 156.12, d$f = 6$, $P < 0.01$).

Minimum number of gill nets was encountered in sector IV (0.26 gill net per km) and the maximum in sector VII (1.79 gill nets per km) (Figure 5). The gill net encounter rate was significantly different in different sectors ($F = 4.33$; d$f = 6$, 849; $P < 0.001$).

Discussion

In the dolphin-inhabited waterbodies of the Brahmaputra Valley, we recorded 250 dolphins, including two populations in two tributaries; one in the Subansiri River (26 dolphins) of Lakhimpur district and another in the Kulsi River (27 dolphins) of Kamrup district[23]. With 197 dolphins, the Brahmaputra alone holds about 79% of dolphins in the Brahmaputra River system in India. In a survey conducted in 1993 (ref. 11), 266 dolphins in the same sections of the Brahmaputra were sighted with 12% calves, 29% subadults and 59% adult. We encountered the dolphins at the rate of 0.23 dolphins per km, whereas in the 1993 survey[11] the encounter rate was 0.44 dolphins per km.

The encounter rate of 0.23 dolphins per km in Brahmaputra River is comparatively lower than other major habitats of the Gangetic dolphin. In Karnaphuli–Sangu complex and the lower Sangu of Bangladesh, the encounter rate was 0.76 and 1.36 dolphins per km respectively[24]. In the Vikramshila Gangetic Dolphin Sanctuary, located in the middle reaches of Ganges mainstream, the encounter rate was 0.81 dolphin per km[25].

Our survey indicates that sectors IV and VII are important stretches of the Brahmaputra River in terms of dolphin abundance; particularly the abundance of calves and sub-adults was highest in sector IV and that of adults was in sector VII. Dolphins most likely prefer water depth range between 4.1 and 6 m, as the maximum number of dolphins (33.5% of total sightings) were recorded in this depth range. We have also found that this depth range was associated with sectors IV and VII. Therefore, this might be the reason why the encounter rate of dolphin was maximum in these two sectors. Though we have not analysed other ecological parameters, it appears that

Table 1. Distribution pattern of dolphins in Brahmaputra River

Dolphin sighted area	Location of dolphin sighted area	Dolphin no.			
		Calf	Subadult	Adult	Total
Hilaguri Chapori	27°45′N, 95°44′E	–	–	2	2
Miri Chapori	27°46′N, 95°41′E	1	–	2	3
Kaitia	27°39′N, 95°26′E	1	–	1	2
Nahoroni	27°35′N, 95°21′E	–	–	1	1
Raidang	27°35′N, 95°20′E	–	–	2	2
Memdubi	27°34′N, 95°19′E	–	1	1	2
Rongagora	27°34′N, 95°17′E	–	1	1	2
Balijan	27°34′N, 95°10′E	–	1	2	3
Bela Chapori	27°41′N, 95°20′E	–	1	2	3
Laika Ghat	27°40′N, 95°16′E	–	–	1	1
Nagaghuli	27°31′N, 94°59′E	1	1	2	4
Bogibeel	27°26′N, 94°47′E	–	1	2	3
Arunachapori	27°15′N, 94°36′E	–	–	1	1
Panidihing	27°06′N, 94°32′E	–	–	1	1
Takeliphuta	27°05′N, 94°31′E	–	–	1	1
Disang Ghat	27°02′N, 94°31′E	2	–	1	3
Gharbhanga	27°01′N, 94°27′E	–	–	2	2
Horaguri Chapori	27°00′N, 94°27′E	–	1	–	1
Dikhowmukh	27°59′N, 94°26′E	3	–	–	3
Janjimukh	26°55′N, 94°21′E	2	–	3	5
Salmara	26°54′N, 94°16′E	–	–	2	2
Nimati Hatihal	26°51′N, 94°16′E	–	–	1	1
Nimati Ghat	26°51′N, 94°14′E	–	1	2	3
Kokilamukh	26°53′N, 94°10′E	1	–	1	2
Digholi Chapori	26°51′N, 94°03′E	–	–	3	3
Pagro Gaon	26°51′N, 93°58′E	1	–	1	2
Misamari	26°50′N, 93°55′E	–	1	–	1
Pahumara	26°46′N, 93°43′E	–	–	2	2
Dhansirmukh	26°43′N, 93°39′E	–	1	3	4
Brahmaputra river stretch within	26°42′N, 93°33′E	1	1	3	5
Kaziranga National Park	26°44′N, 93°30′E	3	1	4	8
	26°44′N, 93°29′E	–	–	1	1
	26°44′N, 93°25′E	1	1	–	2
	26°44′N, 93°25′E	2	1	2	5
	26°38′N, 93°12′E	–	1	1	2
	26°38′N, 93°11′E	–	–	1	1
	26°37′N, 93°07′E	–	–	2	2
	26°36′N, 93°05′E	–	1	–	1
	26°35′N, 93°04′E	–	–	1	1
	26°36′N, 92°59′E	–	–	2	2
	26°37′N, 92°56′E	–	–	1	1
	26°37′N, 92°55′E	–	–	1	1
	26°37′N, 92°54′E	–	–	2	2
	26°37′N, 92°54′E	1	1	2	4
	26°37′N, 92°53′E	–	1	1	2
Gabhorumukh	26°36′N, 92°38′E	–	–	2	2
Dakhaltapu	26°34′N, 92°35′E	–	–	1	1
Rangai	26°33′N, 92°26′E	–	1	2	3
Hiligundha	26°16′N, 92°00′E	–	–	1	1
Kalangmukh	26°15′N, 91°55′E	–	–	2	2
Chandrapur	26°14′N, 91°54′E	–	–	3	3
Chawolkhowa	26°14′N, 91°51′E	1	–	1	2
Tatumara	26°15′N, 91°51′E	1	–	1	2
Guwahati	26°11′N, 91°44′E	–	–	1	1
	26°10′N, 91°44′E	–	1	2	3
	26°10′N, 91°42′E	–	1	2	3
	26°10′N, 91°41′E	–	–	3	3
Suwalkuchi	26°09′N, 91°34′E	2	1	3	6
Bohori	26°14′N, 91°08′E	–	1	3	4
Baghbor	26°14′N, 90°48′E	–	–	2	2

(*Contd*)

Table 1. (*Contd*)

Dolphin sighted area	Location of dolphin sighted area	Dolphin no.			
		Calf	Subadult	Adult	Total
Goalpara	26°11′N, 90°35′E	–	–	1	1
	26°11′N, 90°34′E	1	2	3	6
Jogighopa	26°13′N, 90°33′E	1	1	4	6
Balapara	26°13′N, 90°32′E	1	–	4	5
Chandardinga	26°11′N, 90°21′E	–	1	1	2
Kamarpara	26°04′N, 90°17′E	–	–	1	1
Patakata	26°04′N, 90°15′E	–	–	1	1
Kalchibhanga	26°05′N, 90°11′E	–	–	1	1
Burha-burhi	26°02′N, 90°08′E	–	–	4	4
Purabhita	26°02′N, 90°06′E	–	–	1	1
Fakiraganj	26°02′N, 90°02′E	–	–	2	2
Dhubri	26°01′N, 89°59′E	–	–	1	1
	26°00′N, 89°59′E	–	1	4	5
Birsing Char	26°00′N, 89°58′E	–	–	1	1
Amina Char	25°59′N, 89°54′E	–	1	–	1
Bankshi Char	25°57′N, 89°58′E	–	–	1	1
	25°56′N, 89°58′E	–	–	2	2
Bandaralga	25°55′N, 89°57′E	–	–	1	1
Akbar Char	25°53′N, 89°56′E	–	2	5	7
Baraikandi Char	25°52′N, 89°56′E	–	–	3	3
Haddi Char	25°50′N, 89°55′E	–	1	–	1
Sukh Char	25°46′N, 89°53′E	–	–	1	1
Total		27	32	138	197

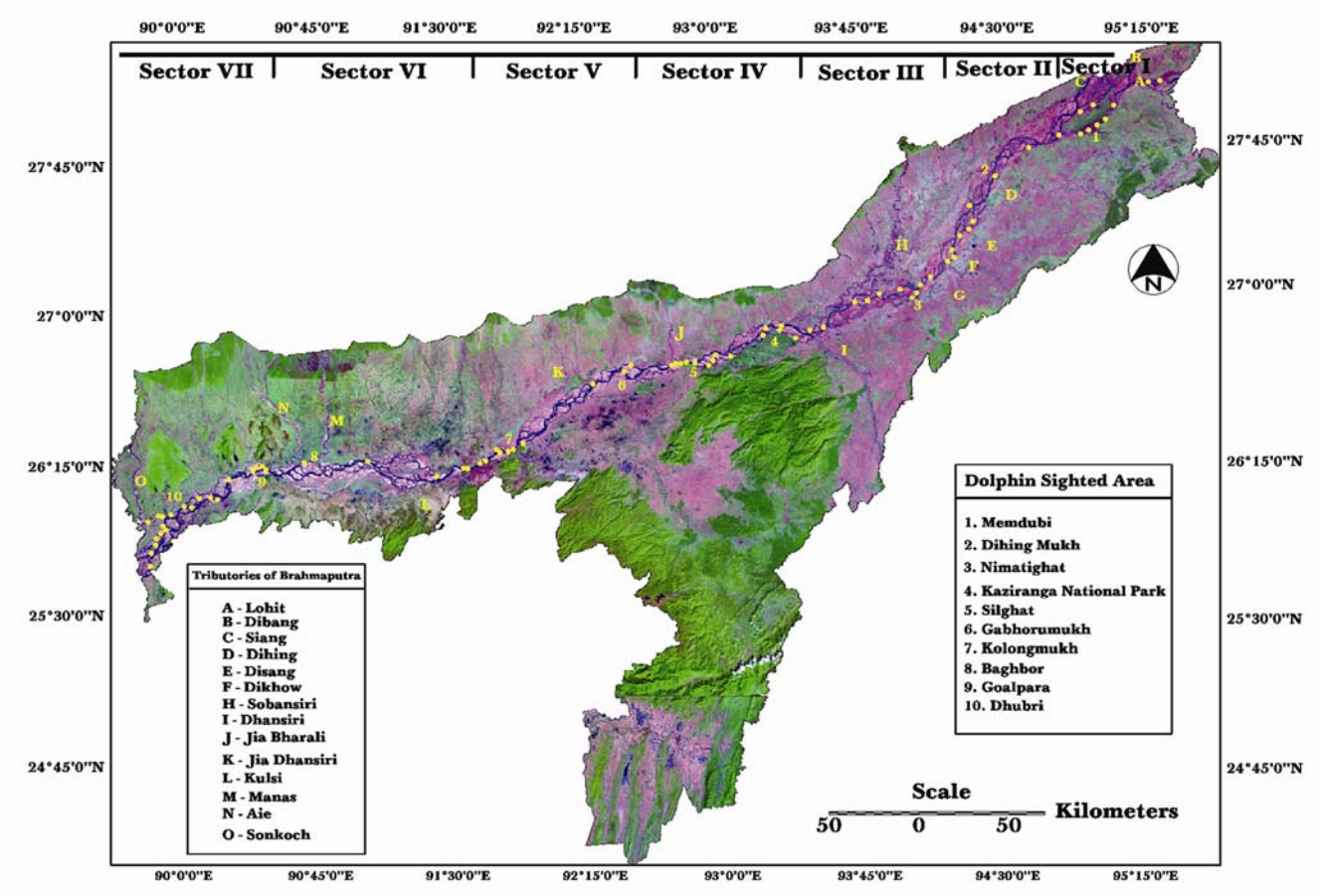

Figure 2. Distribution map of Gangetic dolphins sighting area in Brahmaputra River in 2005.

water depth is one of the important factors in determining dolphin distribution in the Brahmaputra River. The significance of water depth as an important factor for determining the distribution pattern and habitat selection of marine dolphins is well documented[26–30]. Earlier studies in the Brahmaputra also indicated certain depth range preferences of the Gangetic dolphin[11,15]; however the results do not agree with the results of the present study in terms of the range of water depth. We have statistically shown that dolphins prefer the water depth between 4.1 and 6 m. From the conservation point of view also, sectors IV and VII should be paid attention. Also, the protection factor cannot be ruled out because a major part of the sector IV stretch passes through Kaziranga National Park.

Table 2. Sector-wise population status and distribution pattern of dolphins in different sectors of the Brahmaputra River during February–April 2005

Sectors	Length	Calf	Subadult	Adult	Total	Encounter rate
I	119	2	4	15	21	0.18
II	123	3	3	10	16	0.13
III	118	7	3	18	28	0.24
IV	123	8	8	24	40	0.32
V	117	2	1	13	16	0.14
VI	134	3	6	20	29	0.22
VII	122	2	7	38	47	0.39
Total	856	27	32	138	197	0.23

Table 3. Water depth recorded in different sectors in the Brahmaputra River during February–April 2005

Sectors	Sector length (km)	Mean	SD	Min	Max
I	119	3.95	1.97	0.9	11.3
II	123	4.87	3.03	0.9	17.8
III	118	5.36	2.88	1.2	19.3
IV	123	6.57	3.91	1.6	20
V	117	6.26	5.05	1.1	37
VI	134	8.66	4.69	2.7	31
VII	122	6.45	3.13	1.2	15.8

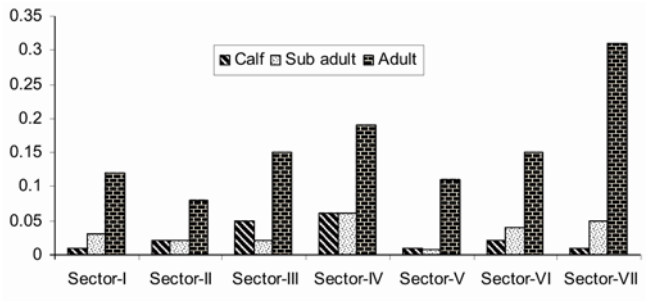

Figure 3. Encounter rate of different age groups of dolphins in different sectors during February–April 2005.

We observed 32% of dolphins in the confluences of major tributaries, viz. Noa-Dihing, Dibang, Lohit, Burhi-Dihing, Subansiri, Disang, Dikhow, Jhanji, Dipholu, Dhansiri, Bharali, Kalang, Beki, etc. River confluences were identified as high fish assemblage areas due to favourable hydrobiological conditions and proper habitat partitioning[31,32] and thus were identified as favourable dolphin microhabitats[15]. In Bangladesh, occurrence of Gangetic dolphins was reported in the downstream of shallow areas or tributary junctions[2]. In Karnali River of Nepal, Gangetic dolphins were recorded in the river stretches where convergent streams created eddy counter-currents in the mainstream flow and less often in 'marginal habitats' where sharp upstream bends created a similar, but smaller counter-current[19]. In the single narrow channel of the Kushiyara River of Bangladesh, all dolphins were located within the boundaries of obvious counter-currents, with large counter-currents containing more dolphins than smaller ones[24]. In the Ganges river system, high concentrations of dolphins were recorded at the convergences of Yamuna, Tons, Ghagara, Gandak and Kosi rivers with Ganges, particularly below sharp meanders and mid-channel islands scattered throughout the river course[25]. Because fish is the main food for dolphins[33] and the confluences, river meanderings and sand bars are favourable microhabitats for fishes[14,34,35], piscivorous dolphins occur in large numbers in these microhabitats.

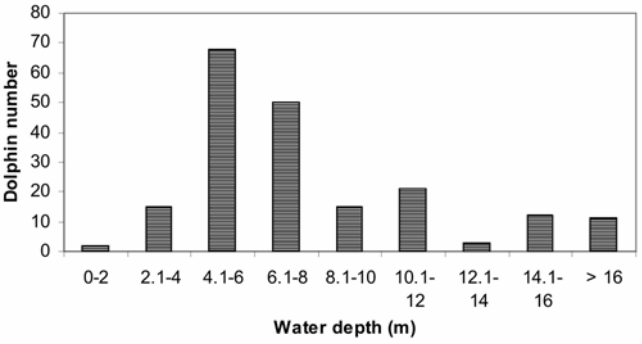

Figure 4. Dolphins recorded in different depths of the Brahmaputra River during February–April 2005.

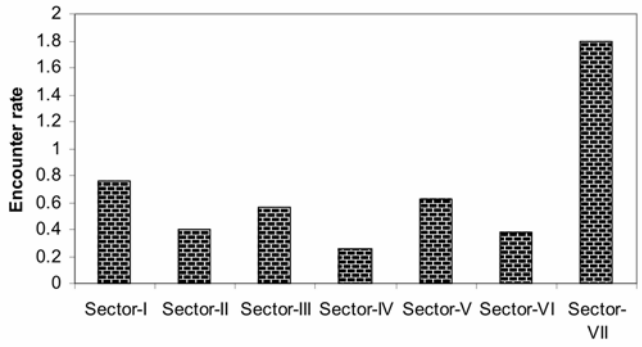

Figure 5. Gill net encounter rate in different sectors of the Brahmaputra River during February–April 2005.

We recorded the death of 14 dolphins in 2004–05 in the Brahmaputra[23]. However, we assume that due to our limitation of time and lack of a comprehensive network to collect information on stranding in this huge geographic area, there was a distinct possibility that the actual number of deaths might be double than recorded. Of 14 recorded deaths, 12 were the victims of gill net entanglement. In 1993–94, there were 60 mortality records of dolphins with a maximum (26.3%) in the river stretch between Malkachar to Goalpara[11].

We recorded a total of 583 gill nets in the Brahmaputra during the survey. In comparison to the record of 1993 (ref. 11), it is an increase of about 5.15 times over the last 12 years, which is due to rapid population growth coupled with increased anthropogenic disturbances in the waterbodies of Assam. We encountered minimum gill nets in sector IV. Major portion (70%) of sector IV is under the protection of Kaziranga National Park, one of the well-managed protected areas of the world. Fishing is completely banned within the park boundary. This high protection status reduces mortality of animals especially calves through gill net entanglement within the park. This assumption strengthens the fact as to why we encountered minimum dolphin calves in sector VII, where gill net encountering rate was maximum. Since mortality of cetacean species through gill net entangling is well-known, there may be a linkage between the distribution pattern of dolphin calves and gill net in the Brahmaputra. However, this assumption needs more in-depth study.

One of the main reasons for killing of dolphin is for its oil. The oil is used for the preparation of bait for the catfish *Clupisoma garua*[11,16], which has a good market value. Besides, most of the villagers of remote riverine area believe that dolphin oil has medicinal properties and therefore it used in the treatment of rheumatic disease[14].

Although gill net entangling of dolphins has been referred to as accidental killing, we observed that most of the killings through this process were intentional. It was also observed that most of the dolphins were killed during pre-monsoon and monsoon seasons. During high flood season, dolphins locally migrate through the tributaries. When the water recedes, the dolphins return to the mainstream of the river. During that time, local fishermen use gill nets mainly near the confluence area to capture dolphins.

Conservation steps

The following steps are recommended for the long-term conservation of the Gangetic dolphins in the Brahmaputra River.

- Dolphin monitoring units should be formed in association with local communities and management authorities in the identified important dolphin habitats. The units should be encouraged to closely monitor the dolphins and their habitats. All these units need to work together as a single dolphin conservation network through information dissemination and simultaneous actions.
- A detailed study should be undertaken on the dolphin by-catch mortality. In areas where this problem is prevalent, proper identification of the fishing gears and concerned communities are necessary. Steps should be undertaken to modify the identified fishing gears and practices, (b) the State Fishery Department to undertake legal actions to ensure the control of such catch by these fishing gears, and (c) local NGOs to create awareness in the identified communities about the problem.
- During the rainy season, dolphins usually migrate through the tributaries of Brahmaputra River. Steps should be taken to protect these seasonally migrating dolphins. All the tributary mouths be treated as important dolphin habitats and fishing controlled in these tributary mouths. Close monitoring of these river mouths, especially during rainy season, should be made with the help of a local dolphin monitoring group.
- Poaching area and poachers should be identified and strong legal actions should be taken against poaching.
- A detailed scientific study should be undertaken on the ecology, behaviour, biology and genetics of the Gangetic dolphin, which will help in the long term conservation of the species in the Brahmaputra.

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