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BIOLOGY, EVOLUTION AND CONSERVATION OF RIVER DOLPHINS WITHIN SOUTH AMERICA AND ASIA



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Chapter 22

POPULATION STATUS AND CONSERVATION OF THE GANGES RIVER DOLPHIN (*PLATANISTA GANGETICA* *GANGETICA*) IN THE INDIAN SUBCONTINENT

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ABSTRACT

Herein we discuss the Ganges River dolphin (*Platanista gangetica gangetica* or *susu*) which inhabits the Ganges-Brahmaputra-Meghna and Sangu-Karnaphuli river systems of India, Nepal and Bangladesh. The chapter begins with a discussion of the origin, evolution, and phylogeny of the Ganges River dolphin as well as river dolphins in general. Also included are descriptions of past and present distribution patterns of the Ganges River Dolphin along with its anatomical structure, including primitive characters and morphological characters of interest. In the second section of the chapter we elaborate on Ganges River dolphin population surveys we conducted within a 500 km section of the Ganges River in the state of Bihar during 2005 to 2007. Both upstream and downstream surveys were performed three times per year. A significantly greater number of Ganges dolphins were observed per kilometer upstream compared to downstream surveys (1.28 versus 1.0 respectively) and the mean number of dolphins observed per upstream survey ranged from 559 to 808. Our results also support spatial and temporal variation of the Ganges dolphin population with for example a greater number of animals in confluence areas. These survey results are similar to those obtained from other Ganges River surveys that used similar methods. The chapter concludes with a discussion on the Ganges River dolphin's conservation status and major threats to its existence. Direct catch, incidental catch, pollution, and habitat degradation are all serious threats.

Keywords: *Platanista*, *susu*, Ganges River, Phylogeny, India.

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INTRODUCTION

The Ganges River dolphin, commonly known as 'susu', is discontinuously distributed in the Ganges-Brahmaputra-Meghna and Karnaphuli-Sangu river systems of India, Nepal and Bangladesh between tidal zones and as far up as the rivers are navigable from the foothill of the Himalayas to the Bay of Bengal (Smith et al., 1994, 1998; Sinha, 1997; Sinha et al., 2000). It belongs to the Order Cetacea, suborder Odontoceti (toothed whales), family Platanistidae (South Asian river dolphin), genus *Platanista*, species *P. gangetica* and subspecies *P. g. gangetica*. Rivers and associated freshwater ecosystems in the Indian subcontinent are under threat due to a wide range of intensive human use and developmental activities. The Ganga-Brahmaputra-Meghna river basins cover only 0.12% of the world's land mass where about 10% of the world's population live. Increased population and development pressures have led to depletion of fish stocks, severe pollution from point and non-point sources, degradation of habitats, sediment load changes and hydrological alterations (Mohan, 1989; Ansari et al., 1999; Dudgeon, 2000; Sinha 2006). These in turn have had detrimental effects on the flora and fauna of the river ecosystems, including the Ganges River dolphin *Platanista gangetica gangetica*, an endemic species of the Ganges-Brahmaputra-Meghna river systems in India, Nepal and Bangladesh (Sinha et al., 2000; Sinha, 2006). The total estimated population of the dolphin in its entire distribution range is about 2000-2500. River dolphin conservation has become a very critical issue owing to the recently reported extinction of the Baiji or Chinese River dolphin *Lipotes vexillifer* Miller 1918 (Turvey et al., 2007). The Ganges River dolphin *Platanista gangetica gangetica* Roxburgh 1801 has been declared endangered by the IUCN (IUCN Red List 2007) and the species has been listed in Schedule-I in the Indian Wildlife (Protection) Act, 1972.

Different studies have proposed that water depth, channel width, direction and velocity of flow, geomorphologic complexities, and substrate type affect dolphin habitat use (Smith et al., 1998; Sinha et al., 2000, 2006; Choudhary et al., 2006). Along with these, prey availability is another factor that can affect population size and habitat selection. River dolphins in the Ganges have been recorded to feed on small fish, and occasionally on crustaceans and snails (Sinha, 2006). The species is known to be mostly solitary, except mother-calf pairs. They are also known to congregate sometimes in shallow water zones for feeding on small fish groups in such areas (Sinha, 2006). For the Ganges River dolphins in India, Nepal, and Bangladesh, population and threat assessment surveys have been carried out throughout their distribution range in order to assess the conservation status and obtain information on threats (Smith et al., 1994, 1998; Sinha et al., 2000; Wakid; 2005, Biswas & Boruah, 2006; Choudhary et al., 2006; WWF, 2006).

The main threat to the Ganges dolphins, especially in Bihar and Assam states, were reported to be direct killing by fishermen for extraction of oil from the blubber, which was used as a fish-bait (Mohan, 1989; Sinha, 2002). One novel approach to prevent further hunting has been the use of fish scrap oil instead of oil from hunted dolphins (Sinha, 2002). Such approaches have contributed to an increase of awareness and conservation efforts leading to the reduction of directly killing dolphins (Sinha, 2006; Choudhary et al., 2006). Threats to dolphins and their habitat such as construction of dams and barrages have been suspected to cause genetic isolation of dolphin populations (Reeves et al., 2000; Smith et al., 2000; Sinha, 2006). However, accidental by-catch through the entanglement in gillnets

continues to be a threat (Sinha, 2006). Depletion of big size and major carp fishery in the rivers over the years has resulted in greater exploitation of smaller fishes, which are considered main prey of dolphins (Sinha, 2006; Choudhary et al., 2006). Conservation efforts across India, Nepal and Bangladesh have mainly focused on sensitizing fishermen to stop the killing of dolphins, seeking people's co-operation for prevention of illegal hunting and creating awareness about the adverse effects of dams and barrages on river flows and catchments (Smith et al., 1998; Sinha, 2006; WWF, 2006; Choudhary et al., 2006). Apart from population surveys and threat mitigation measures, the detailed, scientific ecological knowledge about the species is still bereft of empirical information. Considering the high human impacts on the river systems the species inhabits, information regarding population size, space use, and habitat preferences that influence distribution and survival is required to systematically plan conservation strategies.

Most of the Ganges' major tributaries originate in the Himalayas and merge with the Ganges in the state of Bihar and almost one-half of the total dolphin populations are expected to survive in the Bihar stretch of the Ganges and its tributaries. The present study is based on the surveys conducted during post-monsoon (November-December), winter (February-March) and summer (May-June) of 2005-2007. It also includes information on biology including origin, evolution and phylogenetic position of the species, as well as habitats (different rivers / stretch of the rivers), threats and conservation efforts made to save the animal from extinction.

Origin of Cetacea

Phylogenetic analyses of molecular data on extant animals strongly support the notion that hippopotamids are the closest relatives of cetaceans (Millinkovitch et al., 1998; Nikaido et al., 1999; Gatesy & O'Leary, 2001). In spite of this, it is unlikely that the two groups are closely related when extant and extinct artiodactyls are analyzed, for the simple reason that cetaceans originated about 50 million years ago in south Asia, whereas the family Hippopotamidae is only 15 million year old, and the first hippopotamids to be recorded in Asia are only 6 million year old (Boisserie et al., 2005). The middle Eocene artiodactyl family Raoellidae is broadly coeval with the earliest cetaceans, and both are endemic to south Asia. Thewissen et al. (2007) studied new dental, cranial and postcranial material for *Indohyus*, a middle Eocene raoellid artiodactyl from Kashmir, India. Their analysis identifies raoellid as the sister group to cetaceans and bridges the morphological divide that separated early cetaceans from artiodactyls. Bajpai et al. (2009) reviewed the first steps of whale evolution, i.e. the transition from a land mammal to obligate marine predators, documented by the Eocene cetacean families of the Indian subcontinent: Pakicetidae, Ambulocetidae, Remingtonocetidae, Protocetidae, and Basilosauridae, as well as their artiodactyl sister group, the Raoellidae and concluded that the Eocene origin and evolution of whales is one of the best documented examples of macroevolutionary change.

Indohyus was a small, stocky artiodactyl, roughly the size of the racoon *Procyon lotor*. It was not an adept swimmer; instead it waded in shallow water and may have fed on land, although a specialized aquatic diet is also possible. It probably spent a considerably greater amount of time in the water either for protection or when feeding. As indicated by the evidence from stable isotopes, *Indohyus* spent most of its time in the water and either came

onshore to feed on vegetation (as the modern *Hippopotamus* does) or foraged on invertebrates or aquatic vegetation. Raoellids are the sister group to cetaceans, and this implies that aquatic habitats originated before the Order Cetacea. The great evolutionary change that occurred at the origin of cetaceans is thus not the adoption of an aquatic lifestyle but dietary change was the event that defined cetacean origins. Cetaceans originated from an *Indohyus*-like ancestor and switched to a diet of aquatic prey. Significant changes in the morphology of the teeth, the oral skeleton and the sense organs made cetaceans different from their ancestors and unique among mammals (Thewissen et al., 2007).

The River Dolphins

The four genera of toothed cetaceans, i.e., the baiji, *Lipotes vexillifer*; the susu, *Platanista gangetica*, the boto, *Inia geoffrensis*; and the franciscana, *Pontoporia blainvillei*; comprise the peculiar and poorly known 'river dolphins'. The modern river dolphins occur only in two continents: Asia and South America. The baiji *Lipotes vexillifer* (the Yangtze River Dolphin), is endemic to China but was declared functionally/effectively extinct in December 2006, an event which the news media broadcasted worldwide. Either with a glimmer of hope, or more likely, not-updated, the IUCN Red List of Threatened Species lists the Baiji, Yangtze River dolphin (*Lipotes vexillifer*) as 'critically endangered (possibly extinct)' (Hopkin, 2007). The two populations of *Platanista gangetica* have been isolated for a considerable time with *P. gangetica minor* being confined to the Indus drainage in Pakistan. However, a couple of this species were sighted in the Sutlej River, a tributary of the Indus, in Punjab state in India in 2008. *P. g. gangetica* occurs in the Ganges, Brahmaputra, Meghna, Karnaphuli, and Sangu drainage systems of India, Bangladesh and Nepal. The boto, *Inia geoffrensis* has an extraordinarily wide distribution. It can be found along the entire Amazon River and its tributaries, small rivers and lakes, throughout the Orinoco river basin. It occurs in six countries of South America: Bolivia, Brazil, Colombia, Ecuador, Peru, and Venezuela. The franciscana, *Pontoporia blainvillei* is the only one of the four river dolphin species living in the marine environment. It lives in coastal marine waters of eastern South America between Argentina and Uruguay.

Freshwater dolphins in Asia are among the world's most endangered mammals and there is an urgent need to establish conservation priorities based on scientifically credible abundance estimates (Perrin & Brownell, 1989; Smith & Reeves, 2000a; IWC, 2001; Smith & Jefferson, 2002). The complex geomorphology of freshwater and estuarine systems tends to concentrate the distribution of cetaceans in counter-current associated with confluences, meanders and mid-channel islands (Hua et al., 1989; Smith, 1993; Smith et al., 1997, 1998). The murky river water makes it totally invisible under water. Many times surfacing is very quiescent and whenever they come up it is usually for only a fraction of a second. All these limitations make the credible abundance estimates of these dolphins a great challenge. Extensive population fragmentation has resulted from the widespread construction of barrages (Smith & Reeves, 2000a; Smith et al., 2000).

Evolution of River Dolphins

The Middle Miocene was a time of globally high sea levels, with three significant marine transgressive-regressive cycles recorded worldwide (Haq et al., 1987). With the resulting large-scale marine transgressions on to low lying regions of the continents, shallow epicontinental seas became prominent marine ecosystems. The Indo-Gangetic plain of the Indian subcontinent, the Amazon and Parana River basins of South America, and the Yangtze River basin of China are vast geomorphic systems whose fluvio-deltaic regions were deeply penetrated by marine waters during high sea-level stands. The shallow estuarine regions created by the mixing of riverine and marine waters probably supported diverse food resources, particularly for aquatic animals able to tolerate osmotic differences between fresh and saltwater systems. Hamilton et al. (2001) proposed that the ancestors of the four extant river dolphin taxa were inhabitants of Miocene epicontinental seas. Draining of epicontinental seas and reduction of the near shore marine ecosystem occurred with a late Miocene trend of sea level regression, which continued throughout the Pliocene, interrupted by only moderate and relatively brief events of sea-level rise (Hallam, 1992). As sea levels fell, these archaic odontocetes survived in river systems, while their marine relatives were superseded by the radiation of Delphinoidea. Cassens et al. (2000) also noted the persistence of river dolphins during the radiation of delphinoids. They suggest that extant river dolphin lineages 'escaped extinction' by adaptation to their current riverine habitats. By integrating phylogenetic, palaeoceanographic and fossil data, an explicit hypothesis for the evolution and modern distribution of river dolphins has been provided by Hamilton et al. (2001).

The Indo-Gangetic foreland basin is a broad, flat plain of sediment delivered throughout the Cenozoic by an intricate network of migrating rivers descending from the tectonically dynamic Himalayan Mountain (Burbank et al., 1996). The increased sea levels of the middle Miocene would have inundated large areas of the foreland basin, creating a shallow marine habitat. Fossils have not yet been recovered from these regions, but platanistids are known to have inhabited Miocene epicontinental seas in North America (Morgan, 1994; Gottfried et al., 1994).

Ganges River Dolphin

Platanista is the only surviving descendant of an archaic odontocete that ventured into the epicontinental seas of the Indo-Gangetic basin, and remained through its transition to an extensive freshwater ecosystem during the Late Neogene trend of sea-level regression. Although the paleogeography of the two river systems would suggest a history of isolation, the genetic distance in the sample of *P. gangetica* (Ganges population) and *P. minor* (Indus population) is surprisingly low. The Indus and Ganges populations were long regarded as identical until Pilleri & Gehr (1971) divided them into two species based on differences in skull structure, but Kasuya (1972) reduced the two taxa to subspecies of a single species. This is supported by the results of Yang & Zhou (1999), who found that the difference between cytochrome-b sequences of Ganges and Indus river dolphins was very small. Even until historical times there was probably sporadic faunal exchange between the Indus and Ganges drainages by way of head-stream capture on the low Indo-Gangetic plains between the Sutlej (Indus) and Yamuna (Ganges) rivers (Rice, 1998 and refs. therein). Rice (1998), in his

taxonomic classification of cetaceans that has become standard in the field, found that there were insufficient morphological differences to warrant distinction at the species level. Thus one species is recognized in the genus *Platanista* and currently the Ganges River dolphins are *Platanista gangetica gangetica* and the Indus River dolphins of Pakistan are *Platanista gangetica minor*. The species has many primitive characters and is one of the charismatic megafauna of the rivers of the Indian subcontinent. The animal is facing threats of extinction in its entire distribution range due to overexploitation and habitat degradation caused by various anthropogenic pressures. In most of the rivers, its distribution range has shrunk in the last couple of decades.

Phylogenetic Position of the Ganges River Dolphin

The four genera of classical river dolphins are associated with six separate great river systems on three subcontinents and have been lumped into a single taxon (family Platanistidae or super family Platanistoidea) based on their similarity in some morphological characters. This grouping has been proven unreasonable by all modern phylogenetic analyses (Yan et al., 2005). Muizon (1984, 1988) regarded *Platanista* as only distantly related to the other three, and Heyning (1989) also restricted Platanistoidea to *Platanista*. In cladistic analysis, the family Platanistidae fell into a clade with the extinct families Squalodelphinidae, Delpiazinidae, Waipatiidae, and Squalodontidae (Fordyce & Barnes, 1994; Fordyce & Muizon, 2001). Studies on cetacean phylogeny using DNA sequence data have become very prominent since the 1990s. Arnason & Gullberg (1996) first supplied molecular evidence (Cyt b) with the view that *Platanista* had no affinity to *Inia* and *Pontoporia*. Yang & Zhou (1999) first included all of the four classical river dolphins in their studies. Subsequently, Cassens et al. (2000), Hamilton et al. (2001), Nikaido et al. (2001), and Yang et al. (2002) analyzed phylogeny of river dolphins using different DNA markers respectively. In all analyses mentioned above, *Platanista* was identified as an independent lineage of odontocetes, and had no affinity to the nonplatanistoid river dolphins. The overview that the classical river dolphins including Platanistidae and three other families are an unnatural group has been widely accepted. Yan et al. (2005), in their analyses, split classical river dolphins into two distinct lineages, *Platanista* and *Lipotes* + (*Inia* + *Pontoporia*), having no sister relationship with each other and opined that such a phylogenetic pattern strongly supports the paraphyletic relationship of the classical river dolphins.

Numerous arrangements have been proposed for the phylogenetic relationships of the world's river dolphins to one another and to other odontocete cetaceans. Based on phylogenetic analysis of three mitochondrial genes for 29 cetacean species, Hamilton et al. (2001) concluded that the four genera of freshwater dolphins represent three separate, ancient branches in odontocete evolution. Further, they suggested that ancestors of the four extant river dolphin lineages colonized the shallow epicontinental seas that inundated the Amazon, Parana, Yangtze and Indo-Gangetic river basins, subsequently remaining in these extensive waterways during their transition to freshwater within the Late Neogene trend of sea-level lowering.

While studying the molecular phylogeny of river dolphins, Guang & Kaiya (1999) observed that the difference between *cyt b* sequence of Ganges River dolphin and Indus River dolphin was very small, which supported that Ganges River dolphin (*P. g. gangetica*) and

Indus River dolphin (*P. g. minor*) were probably two subspecies of a single species. They also suggested that among the four river dolphin families, Platanistidae was the earliest divergent clade, the Lipotidae was the next, and then the Iniidae and Pontoporiidae. Further they suggested that the river dolphins were paraphyletic, and it was reasonable to place *Platanista* at a superfamily level as no affinity was revealed between the Platanistidae and other river dolphin families. The long-suspected polyphyly of river dolphins is supported by the mitochondrial sequence data. In both trees, *Platanista gangetica* (and *Platanista minor*, representing Platanistidae), is sister to the remaining odontocetes, although bootstrap support for this node is low (Hamilton et al., 2001).

Extinct taxa assigned to the Platanistidae are well documented, particularly *Zarhachis* and *Pomatodelphis*, long beaked Middle to Late Miocene cetaceans recovered primarily from shallow epicontinental sea deposits of the Atlantic coast of North America (Kellog, 1995; Gottfried et al., 1994; Morgan 1994). Possible platanistid relatives are Squalodelphinidae and at least some members of Squalodontidae (Muizon, 1994; Fordyce, 1994), two well known, extinct families of archaic, medium sized heterodonts. Other fossil relatives of the Platanistidae include members of the Delpiaziniidae (Muizon, 1994) and Waipatiidae (Fordyce, 1994). If these lineages are monophyletic, then *Platanista* is the sole extant member of a once-abundant and diverse clade of archaic odontocetes. The side-swimming, blind and highly endangered Indian River dolphin has long been recognized as 'the genus presenting the greatest total of modifications known in any cetaceans' (Miller, 1923). However, both fossil and extant platanistids warrant further investigation for potential insights into cetacean evolution. Verma et al. (2004) established the evolutionary relationship of the Ganges River dolphin with extinct and extant cetaceans based on comprehensive analyses of the mitochondrial cytochrome b and nuclear interphotoreceptor retinoid-binding protein gene sequences, obtained from 15 specimens of Ganges dolphin from India and Bangladesh. The study suggested that *P. g. gangetica*, a toothed cetacean, is significantly closer to Mysticeti (Toothless whales) than to any other group of toothed whales. However, Yan et al. (2005) observed that the *Platanista* lineage is always within the odontocete clade instead of having a closer affinity to Mysticeti. Nevertheless, they opined that the position of the *Platanista* is more basal, suggesting separate divergence of this lineage well before the other one. And they agree that they could not resolve with high significance the exact phylogenetic position of *Platanista*. The more basal position of Platanistidae is also supported by the records of platanistoid fossils in the late Oligocene (Fordyce & Barnes, 1994). Muizon (1991), Heyning (1989) as well as Messenger & McGuire (1998) proposed that Platanistidae branched after the divergence of sperm and beaked whales. However, others placed Platanistidae and beaked whales in a clade between the sperm whale and more crown-ward odontocetes (Cassens et al., 2000) or placed Platanistidae between sperm whale and beaked whales (Hamilton et al., 2001; Nikaido et al., 2001). The position of Platanistidae is not very clear. This may be, at least in part, because the susu, sperm, beaked, and baleen whales lineages seem to have been produced through a very rapid succession of splitting events in the Eocene (Nikaido et al., 2001). Meanwhile, additional evidence is needed to resolve this issue. There is a consensus that these four river dolphins belong to two different groups of dolphins: Platanistoidea, which is an early divergent superfamily of odontocetes, and nonplatanistoid river dolphins, a monophyletic clade closely related to superfamily Delphinoidea.

Distribution of the Susu: Historical and Current

Historical Distribution

The water-hog (*P. khuk-abi*, *Platanista gangetica*, the porpoise) is in all Hindustan rivers (quoted in the 'Babur Nama', a book written by Babur in the 15th Century, the first ruler of the Mughal Dynasty in India). The book contains a miniature painting depicting the Ganges River dolphin. By stating "all Hindustan rivers" Babur probably meant all the rivers of North India as he had widely traveled mainly in the Indo-Gangetic plains of northern India. Anderson (1879) recorded its distribution in the Ganges over an area comprised between 77°E and 89°E Longitude; in the Brahmaputra it occurred throughout the entire main river, as far eastwards as longitude 95° by latitude 27°30' north. He also reported that even in the month of May, when the Ganges was very low, it extended up the Yamuna as far as Delhi. Anderson emphasized that the upstream range of this dolphin was apparently only limited by insufficiency of water and by rocky barriers. The last record of susu in Yamuna at Delhi was in 1967, when a dead dolphin caught in a fishing net was brought to the Delhi Zoo (personal communication Dr. K. S. Sankhla, the then Director, Delhi Zoo).

Current Distribution

The Ganges River dolphins live mainly in the rivers originating from the Himalayas and some tributaries of the Ganges originating in the central India below an elevation of about 250 m. In the Ganges valley it ranges into most of the large tributaries: the Yamuna, Son, Sind, Chambal, Ramganga, Gomti, Ghaghara, Rapti, Gandak, Kosi, etc besides the main channel of the Ganges. In the Brahmaputra valley it also ranges into many of the major tributaries: the Tista, Adadhar, Champamat, Manas, Bhareli, Subhansiri, Dihang, Dibang, Lohit, Disang, Dikho and Kulsi rivers. Downstream it ranges through most of the rivers in Bangladesh, as far as the tidal limits at the mouth of the Ganges. They are also reported to be within the Fenny, Karnaphuli, and Sangu rivers to the southeast of the mouths of the Ganges (Rice, 1998). The uppermost distribution is said to be restricted only by the lack of water and rocky barriers (Reyes, 1991). Relatively high population densities (approx.125) have been observed in the 60 km stretch of the Ganga, the Vikramshila Gangetic Dolphin Sanctuary, in the state of Bihar in India. There is a small (perhaps 20 individuals) but potentially viable population in the Karnali River, the largest river system in Nepal, now isolated by the Girija Barrage located about 25 km downstream of the Nepal-India border (Smith et al., 1994). During a continuous survey in the Ganga from Haridwar downward, in the month of December 1996 when water was low, we could not find susu in the 100 km stretch of the river between Haridwar and Middle Ganga Barrage at Bijnor. However, in September 1994 one susu was sighted in the Ganges at Nangal about 30-40 km downstream Haridwar (Pers. Comm. Raju Kumar). During a status survey conducted in 1978, the susu were found most abundant from Munger to Sahibganj in Bihar; common up to the Farakka Barrage towards the east and up to Varanasi or slightly more westwards (Gupta, 1986). Gangetic dolphins were fairly common in tidal waters but never entered the sea (Agrawal, 1991).

Table 1. Summary of Dolphin sightings in the River Ganges between Buxar and Manihari ghat during 2005 – 2007.

Date (Survey direction)	Survey distance (km)	Boat's speed (km/hr.)	Sightings by Primary observer	Sightings by Secondary observer	Sum of group size estimates from Primary & Secondary sightings			Percentage of error sightings missed by Primary observer	Sightings/ km.	Dolphi n/ km.	No. of calves (percentage)
					Best	High	Low				
November, 05(US)	507.4	6.32	321	97	664	750	578	23.21	0.84	1.31	77 (11.60)
November, 05(DS)	494.8	11.19	262	81	517	576	465	23.62	0.71	1.04	62 (11.99)
March, 06 (US)	517.8	6.05	274	91	576	692	514	24.93	0.72	1.11	47 (8.16)
March, 06 (DS)	499.2	9.72	200	78	418	496	370	28.06	0.58	0.84	39 (9.33)
May - June, 06(US)	506	6.24	284	103	559	644	502	26.61	0.78	1.1	88 (15.74)
May - June, 06(DS)	499.5	10.38	223	75	439	507	392	25.17	0.61	0.93	68 (15.49)
December, 06 (US)	517.1	6.34	437	110	808	931	729	20.11	1.08	1.56	67 (8.29)
December, 06 (DS)	501	10.22	324	72	559	668	486	18.18	0.81	1.12	58 (9.68)
March, 07 (US)	513.1	6.46	398	79	706	813	635	16.56	0.94	1.38	50 (7.08)
March, 07 (DS)	506.9	10.63	257	63	482	584	411	19.69	0.64	0.95	37 (7.68)
May - June, 07(US)	514.8	6.05	372	89	631	755	517	19.31	0.91	1.23	72 (11.41)
May - June, 07(DS)	508.5	10.19	299	78	577	700	470	20.69	0.76	1.13	69 (11.96)
Mean ± S.D. (US)	512.7 ± 4.96	6.24 ± 0.17	348 ± 65.26	95 ± 10.96	657 ± 91.75	764 ± 100.15	579 ± 89.03	21.79 ± 3.78	0.88 ± 0.13	1.28 ± 0.17	67 (10.38) ± 15.84 (3.21)
Mean ± S.D. (DS)	501.7 ± 5.15	10.39 ± 0.49	261 ± 46.03	75 ± 6.41	499 ± 63.96	589 ± 82.62	432 ± 47.61	22.57 ± 3.72	0.69 ± 0.09	1.00 ± 0.11	56 (11.02) ± 14.15 (2.74)

Table 2. Population (sighting records) of the Ganges River Dolphin in different rivers/stretch of the rivers of the Ganga Basin.

Name of the river	Length of the river surveyed	Number of susu	Source
In India			
The Ganga Mainstem			
The Ganga (Haridwar to Bijnor Barrage)	100 km	Nil	Sinha et al (2000)
The Ganga (Bijnor Barrage to Narora Barrage)	169 km	36 (d/s survey)	Sinha et al (2000)
The Ganga (Narora to Allahabad)	600 km	10 (discrete segment survey)	Sinha et al (2000)
The Ganga (Allahabad to Buxar)	425 km	172 (d/s survey)	Sinha et al (2000)
The Ganga (Buxar to Maniharighat)	500 km	808 (u/s survey)	unpublished data of 2007-08 (Sinha)
The Ganga (Maniharighat to Farakka)	100 km	24 (d/s survey)	unpublished data of Dec. 2004 (Sinha)
The Farakka Feeder canal	38 km	21 (d/s survey)	Sinha et al (2000)
The Bhagirathi (Jangipur Barrage to Triveni)	320 km	119 (d/s survey)	Sinha et al (2000)
The Hooghli (Triveni to Ganga Sagar)	190 km	97 (d/s survey)	pers. comm. Gopal Sharma (2007)
Tributaries of the Ganga			
The Yamuna (from confluence of Chambal to Hamirpur)	250 km	25-40 (d/s survey)	Sinha et al (2000)
The Yamuna (Kausambi to Allahabad)	90 km	18 (d/s survey)	Sinha et al (2000)
The Kosi (Kosi Barrage to Kursela)	200 km	85 (discrete survey)	Sinha and Sharma (2003)
The Gandak (Confluence with Ganga at Patna to)	101 km	106 (u/s survey)	unpublished data of 2007-08 (Sinha)
The Gherua (India-Nepal border to Girijapuri Barrage)	20 km	23 (d/s survey)	Smith et al (1994)
The Sarda (Sarda Barrage to Palya)	100 km	Nil	Sinha and Sharma (2003)
The Chambal (Pali to Barhi)	370 km	29 (d/s survey)	Sinha et al (2000)
The Ken (from confluence of Yamuna at Chilla to Sindhan Kala village)	30 km	08 (d/s survey)	Sinha et al (2000)
The Kumari (from confluence of Sind River)	100 km	Nil	Sinha et al (2000)

Table 2. Continued.

The Betwa (from confluence of the Yamuna at Hamirpur to Orai)	84 km	06 (d/s survey)	Sinha et al (2000)
The Sind (from confluence with the Yamuna)	110 km	05 (d/s survey)	Sinha et al (2000)
The Son	130 km	10 (d/s survey)	Sinha et al (2000)
The Brahmaputra	600 km 856 km	400 (1996) 197 (2004-05)	Mohan (1997) pers. comm. A. Wakid (2006)
The Barak River	17 km	12 (Nov. 1999) 8 (2004) 6 (2006)	Pers. comm. Paulan Singh
The Subhansiri River	99 km	26	pers. comm. A. Wakid(2006)
The River Kulsi	76 km	27	pers. comm. A. Wakid(2006)
In Bangladesh			
The Jamuna	189 km	38-50	Smith et al (1998)
The Kushiya	113 km	34-43	Smith et al (1998)
The Burhi Ganga		03	Smith et al (1998)
The Karnaphuli-Sangu	222 km	131	Smith et al (2005)
The Sundarbans	1488 km	225	Smith et al (2005)
In Nepal			
The Karnali (from Kachali to Kotiaghat)	60 km	06	Smith et al (1994)
The Saptakosi (from confluence of Arun and Sun Kosi to Kosi Barrage)	60 km	03	Smith et al (1994)
The Narayani (Devghat to Triveni Barrage)		1-2	Smith et al (1994)
The Mahakali		Nil	Smith et al (1994)

In the Brahmaputra River system the susu are present as far north-east as the Dihang, Buri Dihing and Lohit rivers in eastern Assam, and as far north as the Teesta River and its tributaries, which extend into Sikkim and Bhutan (Mohan, 1989). The population status in different rivers in its distribution range, based on surveys conducted by different workers in the last two decades has been depicted in Table 2. The survey methods adopted by different workers were not consistent and therefore there is a lack of scientifically credible population estimates for this species. Nevertheless, the estimated total dolphin population in its fairly extensive distribution range is about 2500.

During the dry season, when the water levels are low in the rivers, the dolphins stay in the main river channels, however, they stay back in the deep pools in the tributaries also, where they face threats of being caught in the fishing nets as such pools attract intensive fishing. During the monsoon season, they spread out and move into even smaller tributaries and creeks. There are more dolphins at confluences, meanderings, and behind sand bars, where counter currents and complex hydro-geo-morphological formations exist. Such complexities provide habitats for diversified biota in the river ecosystems.

Physical Description of the Ganges Dolphin

The Ganges River dolphins have long, pointed snout characteristic of all river dolphins. Both the upper and lower jaw sets of long sharp teeth are visible even when the mouth is closed. The snout is long and widens at the tip. In females, the snout is generally longer and may curve upwards and to one side. The eyes are extremely small resembling pinhole openings slightly above the mouth. The species does not have crystalline eye lenses, rendering it effectively blind, although it may still be able to detect the intensity and direction of light. The river water where they live is so murky that good eyesight would most-likely not be advantageous. Navigation and hunting are carried out using echo-location. The body is subtle and robust, attenuating posteriorly from the dorsal fin to a narrow tail stalk. The body is deep and has a brownish color and is stocky at the middle. They have round bellies. The dorsal fin is very low triangular hump located two-thirds body length from the anterior end. The broad flippers have a crenellated margin, with visible hand and arm bones. Its flukes are broad and these along with their flippers are thin and large in relation to body size, which normally ranges from 2-2.2 m in adult males and 2.4-2.6 m in adult females. At the time of birth they measure 70-90 cm and weigh 4 – 7.5 kg. Adults (2 – 2.6 meter) weigh between 70 and 90 kg, however, an adult pregnant female (2.5 m) caught at Araria in Northeastern Bihar, near Indo-Nepal border, weighed 114 kg (caught in February 1993 and brought to Patna Zoo). We also recorded a 70 cm male fetus weighing 4 kg, 77.5 cm male 6.6 kg and a 91 cm female weighing 11 kg, all collected from the Ganges in and around Patna.

Primitive Characters

Platanista g. gangetica bears some of the very primitive characters not known in other cetaceans, videlicet the presence of the ceacum at the junction of the small and large intestines, a testis position that is much more dorsal compared to other marine cetaceans (testes are extra-peritoneal in terrestrial mammals), and subcutaneous muscle between two layers of blubber. The following informations were recorded while working on a carcass of a male dolphin at Patna:

Body Length: 171cm, Body Weight: 55 kg, Blubber thickness (cm): Dorsal Skin (0.1) + Blubber (2.5), Lateral Skin (0.1) + Outer blubber (1.3) + Panniculus (0.2) + Inner blubber (2.7), Ventral Skin (0.1) + Outer blubber (1.9) + Panniculus (0.2) + Inner blubber (0.7), Intestine length (cm): Small intestine (620) + Caecum (8) + Large intestine (80).

Morphological Characters of Interest

1. Texture of subcutaneous tissue: Cetacean fatty tissues are accumulated in blubber, whereas in terrestrial mammals fatty tissues can be found here and there in the subcutaneous connective tissues. In *Platanista*, they have certain thickness of blubber, but at the same time texture of the deeper connective tissues is somewhat more similar to those of the terrestrial mammals. We are not sure if this has anything to do with primitiveness or similarity to ancestral terrestrial mammals (Personal communication Tadasu Yamada).

2. Disposition of subcutaneous tissue layer especially deeper to the Panniculus carnosus: Panniculus carnosus is subcutaneous muscle, which usually is a thin sheet within the subcutaneous tissue (or superficial fascia) layer. In cetaceans the panniculus usually originates from the proximal portion of the humerus. Healthy wild oceanic dolphins have a scanty amount of connective tissues deeper to the panniculus. This has much to do with the first character above.
3. Existence of the Caecum.
4. Simple air sacs around nasal passage: Accessory air sacs around the nasal passage might indicate that the *Platanista* are more primitive than other oceanic dolphins.
5. Ventrally situated testes compared to marine dolphins: In terrestrial mammals, descended testes are standard which allow them to have a cooler temperature compared to the rest of the body. Male oceanic dolphins have the testes dorsally and much less descended than *Platanista*. This might have something to do with more terrestrial characteristic of *Platanista*.
6. Specific structure of stomach: The stomach of *Platanista* consisted of three chambers and a connecting channel. The basic arrangement of the chambers is similar to that of the dolphins of delphinidae, however, the connecting chamber is short and straight whereas in delphinid dolphins it is longer and takes a hairpin bend.
7. Peculiar muscular arrangement around the shoulder: more studies are needed to arrive at any conclusion regarding 6 and 7.

METHODS OF SIGHTING RECORDS

From November 2005 to June 2007 we assessed the abundance and distribution of Ganges River dolphins in the 500 km stretch of the Ganges between Buxar (25°33'32"N and 83°56'23"E) and Maniharighat (25°19'56"N and 87°36'44"E) in Bihar state (Figure 1). A map of the Ganges Basin in the Indian subcontinent has been depicted in Figure 2. Six continuous vessel-based visual surveys for dolphins were conducted in the entire length of the river in both upstream and downstream directions using motorized wooden boats. Two primary observers, one each on the right and left sides of the vessel searched dolphins by eye in a 90-degree cone in front of the vessel. A third observer served as data recorder and also searched for dolphins when not filling out the data forms. Two independent observers positioned behind the primary observers recorded any sightings missed by the primary team. Sightings made by the primary and secondary teams were pooled for calculating encounter rates and the best minimum abundance estimate. A Global Positioning System was used to record the distance traveled and the geographical coordinates of dolphin sightings. River depth was recorded at every 2 km interval using an automatic depth finder.

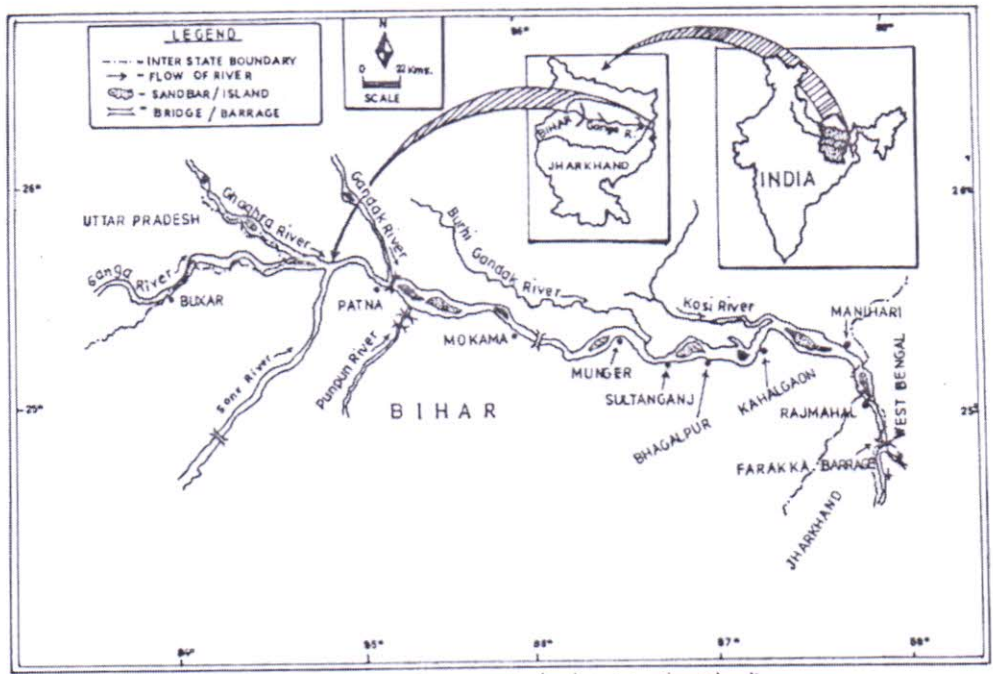


Figure 1. Map of the River Ganga between Buxar and Maniharighat (Katihar) in Bihar.

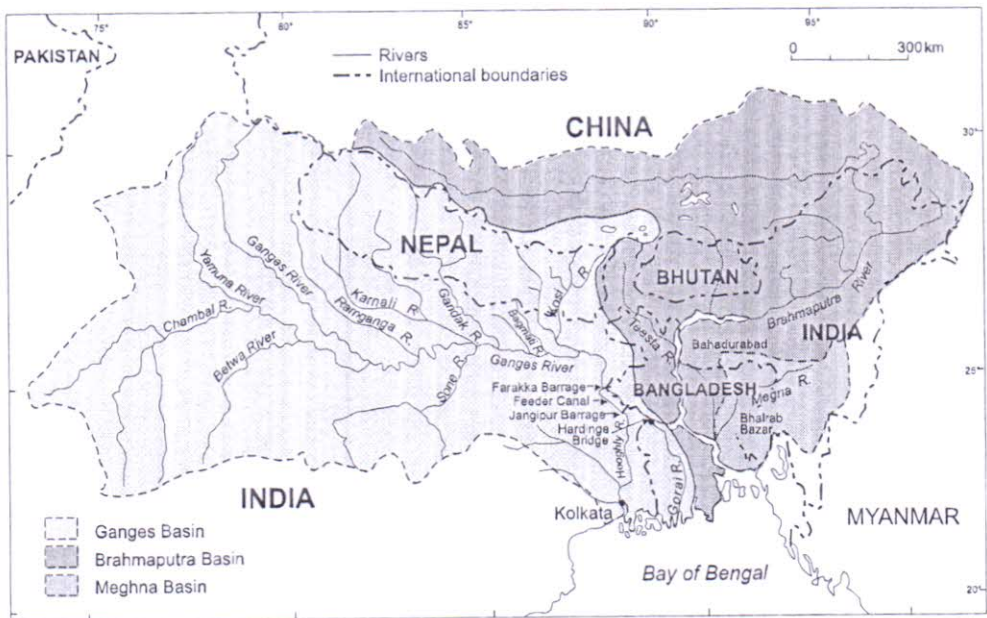


Figure 2. Map of the Ganges Basin in Indian Subcontinent.

There was an impact of water current on the speed of the vessel which had direct bearing on the sighting records. During downstream surveys the average speed of the boat was 10.73 km/hr (range 9.72-12.43; S.D. 0.66), whereas during upstream surveys the average boat speed was 6.46 km/hr (range 6.05 – 6.99; S.D. 0.31).

Group sizes were recorded according to best, high, and low estimates which allowed us to evaluate sightings in terms of a range of abundance estimates, rather than an absolute count, which would not reflect the inherent uncertainty about the actual number of animals present in a certain area (Smith & Reeves, 2000). High and low estimates were used to reflect the confidence of observers in the accuracy of the best estimate. The low estimate was considered a minimum count and the high estimate a maximum count. Identical best, high, and low estimates indicated a high level of confidence in the best estimate. Sightings that could not be substantiated by subsequent surfacing or confirmation by a second member of the survey team were given a best and low estimate of zero and a high estimate of one. Distinctive physical characteristics of individual animals (e.g. scarring, pigmentation patterns, length of the rostrum relative to height of melon, and body size) and the location of surfacing relative to shoreline features and other animals was used to assist observers in making group-size estimates. Estimates were agreed upon by a consensus of the research team. If observers did not agree, the lowest estimate by any team member was used for the low, the highest estimate for the high, and the best estimate by either the observer with the most experience or the observer who first sighted the animal(s) for the best. Double counts were avoided by maintaining close communication among observers and, for some sightings; we used a zero for our low and occasionally best group size estimates, if there was a possibility that the animals had already been counted (Smith et al., 1994). The number of calves, defined as <1.0 m long (Brownell, 1984), was also recorded. Age-class of dolphins was recorded as adult, sub-adult and calf based on Smith & Reeves (2000). This relatively simple direct count survey technique was selected because of the need for a standardized methodology that could be economically and consistently applied by a small team to monitor long-term population trends.

The river condition varied in different seasons. It was quiet and calm but wide (in some segments >2 km) after flooding in November-December. February-March is the leanest season, whereas in May-June water level rises due to melting of snow in the Himalayas. But the surface becomes choppy on many occasions due to high winds. July – September is the period of monsoon and flood. Thus during the November-December period, the possibility of missing dolphins is quite low because the river's surface is very quiet and calm. In contrast, wide river widths and choppy waters make it difficult to locate and observe dolphins.

RESULTS AND DISCUSSION

Mean encounter rates calculated from the best estimates of group size were 1.28 dolphins km^{-1} (range 1.10-1.56; S.D. 0.17) and 1.0 dolphins km^{-1} (range 0.84-1.13; S.D. 0.11) for the six upstream and six downstream surveys, respectively (Table 1). Upstream counts were significantly different from downstream counts (Chi Square $p < 0.001$, $df = 1$), with upstream counts averaging 31.8% greater than downstream. The overall mean survey speed was 10.39 km h^{-1} (range 9.72 – 11.19; S.D. 0.49) for downstream and 6.24 km h^{-1} (range 6.05 – 6.46; S.D. 0.17) for upstream surveys. The mean count for all upstream surveys was $657 \pm \text{SD } 91.75$ dolphins (range 559-808) based on the sum of best estimates of group size for both primary and secondary observers. Counts based on the sum of the low and high estimates of group size were on average 0.88% lower and 1.16% higher respectively. The mean

percentage of sightings by the primary observer was $348 \pm \text{SD } 65.26$ whereas by the secondary observer was $95 \pm \text{SD } 10.96$. Thus the mean percentage of sightings missed by the primary observers but detected by the secondary observers was 27.3%. The percentage of observed neonates was relatively high during the surveys conducted in May-June 2006 (15.74 and 15.49% for upstream and downstream surveys, respectively) and low for those conducted in March 2007 (7.08 and 7.68% for upstream and downstream surveys, respectively). The difference in the proportion of neonates observed during May-June 2006 versus March 2007 may be due to the fact that maximum breeding takes place during April-May in the Ganges. Choudhary et al. (2006) recorded 21% and 18.4% calves in May and December 2001, respectively in the Ganges and opined that the difference in the proportion of neonates may be accounted for by the apparent preference of cow-calf pairs to congregate in large counter-current pools and the fact that the availability of these features varies in different river segments from year to year.

The Ganges River dolphins were sighted all along the stretch of the Ganges under study, however, the dolphin population showed spatial and temporal variation. The climatic and weather conditions, viz. choppy water surface due to high wind, glaring due to sunlight, foggy weather, rain etc also had impacts on sighting records of the dolphins. Usually more dolphins were sighted near confluences, meanderings, behind sand bars, and in the river stretches having deep pools, shallow waters and sand bars.

Our dolphin encounter rates in the Ganges compare favorably to other rivers and in the Ganges where the species has been surveyed using similar techniques. For example, the encounter rate for upstream and downstream surveys in 65 km of the Vikramshila Gangetic Dolphin sanctuary between Sultanganj and Kahalgaon in Bihar within the Ganges was 1.8 dolphin km⁻¹ and 1.2 dolphins km⁻¹, respectively during 2001-2003 (Choudhary et al., 2006). This stretch falls within our area of survey. Similarly, the encounter rate for a downstream survey in the middle Brahmaputra River between Guwahati and Goalpara was 0.03 dolphin km⁻¹ during April 1999, and 0.76 dolphins km⁻¹ for downstream surveys in the Karnaphuli-Sangu river of Bangladesh from January to April 1999 (Smith et al., 2001). 197 dolphins were recorded in the entire 856 km (i.e. 0.23 dolphin km⁻¹) of the River Brahmaputra stretch from Assam-Arunachal Pradesh border to the India-Bangladesh border (Wakid, 2009). Overall the pattern of dolphin occurrence was consistent with a preference for reaches characterized by complex morphological features that induce hydraulic heterogeneity and bottom scouring (Smith, 1993; Smith et al., 1998, 2001).

In areas with large seasonal fluctuations in water level, dolphins are most abundant in the long stretches of deep water that remain during the dry season (Singh & Sharma, 1985). Occasionally susu enter shallow water (2 m) while chasing prey, but they remain primarily in, or near (with ready access to) deeper river channels (Reeves et al., 1993). Habitat preferences of the susu have been studied in the River Karnali in Nepal by Smith (1993). Two categories of habitats were identified: primary habitats characterized by an eddy-counter system in the main river flow caused by a point bar formed from sediment deposits of a convergent stream branch or a tributary, and marginal habitats having a smaller eddy counter-current system caused by an upstream meander. The stretch of the Ganges under study has very low gradient (1:13000) and receives the three major tributaries, the Ghaghara (Mahakali+ Karnali rivers in Nepal), Gandak (Narayani in Nepal), and Kosi (saptakosi in Nepal) originating in the Himalayas and smaller tributaries like the Sone and the Punpun from the south, originating in central India. The primary habitats were identified at the confluence of the tributaries. Bottom

substrates were fine silt and clay deposited by the tributaries creating a large number of relatively shallow sloping sand bars especially during low water seasons (February to June). The sand bars deflect the river flow and create eddy counter-current systems. Another type of primary habitat was deep pools, each pool with an eddy counter-current system due to hillocks in the mid channel or hard rocks jutting out. This creates deep zone and meandering of the river at Munger, Sultanganj and Kahalgaon. The river flow in a single channel with meanderings formed marginal habitats downstream. Dolphins were also frequently sighted in large groups in counter-current pools induced by bridge pilings at Patna and Bhagalpur, and the monadnocks (rock islands) at Munger and Kahalgaon, and below the confluence of Ghaghara, Gandak and Kosi at Doriganj, Patna and downstream of Kahalgaon, respectively. Large counter current pools were also the primary sites for fishing, ferry crossings, and religious and domestic bathing. The same conditions that make these areas suitable for dolphins (i.e. hydraulic refuge and abundant fish), also make them desirable sites for human use.

The higher counts for the upstream surveys can be explained by the greater number of opportunities to detect surfacing dolphins at a slower surveying speed. The relatively large number of sightings missed by the primary observers but detected by secondary observers indicates that the actual number of dolphins occurring in the stretch of the Ganges under study is probably greater than our minimum abundance estimates (Marsh & Sinclair, 1989), even though we included the secondary observer sightings.

Conservation Status of the Ganges River Dolphins

The Ganges dolphin is listed in CITES Appendix 1. All of the Asian river dolphins have suffered dramatic declines in both their range and numbers over the last three decades to the point at which they rank as some of the most endangered of all mammals. In addition to CITES listings, the IUCN-World Conservation Union has classified the *susu* as an endangered species in 1996. Furthermore, the Ganges River dolphin has been included as a Schedule-1 animal under the Indian Wildlife (Protection) Act 1972.

The future of Ganges dolphins appears to be bleak unless action is taken immediately to reduce pressure on their freshwater ecosystems. They face unprecedented threats through the exploitation of freshwater river systems by people, causing high incidental mortality. In order to prosper, the dolphin ironically requires the same conditions as people who use the river, namely, a healthy, flowing, living river.

Threats

The Ganges dolphins face many threats –incidental capture in fisheries (by catch), depletion of food resources, chemical and noise pollution, habitat destruction, over-fishing and climate change, and in some cases, directed killing for oil and meat.

Direct Catch

Deliberate killing of *sus* is believed to have declined in most areas but some individuals are still taken each year and their oil and meat used as liniment, as an aphrodisiac and as bait for catfish. A few cases are recorded in the middle Ganges in Bihar (Sinha et al 2000), in the Kalni-Kushiyara River of Bangladesh, and in upper reaches of the Brahmaputra River in Assam, India (Mohan et al., 1997). The magnitude of direct take in recent years is unknown, but probably not high (IWC, 2000). Based on a report of dolphin poaching in the Ganges in 2001, the Patna High Court (C.J.W.C. No. 5628) intervened and directed both the state government of Bihar and central government of India to allocate funds for supporting dolphin conservation efforts in Bihar and to stop poaching of the *sus*. It created awareness among the common masses and at the same time forced the government officials to act which resulted in an apparent decline in directed killings of the dolphins. However much more needs to be accomplished. Cooperation among regulatory authorities, NGOs and local fishermen will be essential for advancing science and community based management and conservation of this species.

Incidental Catch

Entanglement in fishing gillnets causes significant damage to local population numbers. Accidental killing is a severe problem for Ganges River dolphins throughout their range. Gillnets are problematic because from an economic perspective their use is of primary importance to impoverished fishing communities. The primary cause is believed to be entanglement in fishing gear, most often in nylon gillnets, mainly because the dolphin's preferred habitat is often in the same location as primary fishing grounds. It is not easy to get actual estimates of dolphin mortality due to unorganized fishing in the very vast areas of the Ganges and its tributaries but the problem of accidental killing is expected to worsen with increasing fishing intensity and use of monofilament fishing gillnets. Regulations of gillnets should include strictly limiting their numbers and configurations (e.g. five per family with a mesh size of no less than 24 mm and a length and width of no more than 150 m and 7 m, respectively, and these numbers may be adjusted if additional families enter the gillnet fishery) and requiring fishermen to monitor their nets and release dolphin bycatch if entangled (Choudhary et al., 2006). Incidental killing via boating also occurs, evidenced by a pregnant female hit and killed by a boat propeller at Patna in September of 2005. Thus, motorized river traffic is also a threat to Ganges dolphins.

Habitat Degradation

Construction of dams and barrages for hydroelectric development and irrigation in the Ganges system has fragmented the dolphin population and prevented migrations, thus leading to the segregation of populations and a narrowing of the gene pool in which dolphins can breed. These same barriers have also reduced food availability and also drastically altered the dolphin's habits and habitat. The population above the Kaptai dam in the Karnaphuli River in Bangladesh disappeared over a period of 6 or 7 years after dam construction. Similarly, the dolphin population disappeared from the main stem of the Ganges above the Middle Ganga Barrage at Bijnor (about 100 km downstream Haridwar) after 12 years of its construction (Sinha, 1999). Dolphins in Nepal are almost extinct in Mahakali, Narayani and Sapta Kosi due to construction of barrages at their heads at the India-Nepal border (Smith et al., 1994).

The construction of embankments in the dolphin's distribution range within India and Bangladesh has drastically affected the ecosystem where overflow and flooding are important cycles in the movements and spawning of flood plain dependent fishes (Smith et al., 1998).

In addition to fragmenting dolphin populations, dams and barrages degrade downstream habitat and create reservoirs/pondage with high sedimentation and altered assemblages of fish and invertebrates (IWC, 2000). Luxuriant growth of macrophytes and excessive siltation have eliminated suitable habitat immediately above Farakka Barrage (Sinha, 2000). A detail register of water development projects and their effects on the river dolphins in Asia was published by Smith et al. (2000).

Excess abstraction of the river water for irrigation has lowered water levels throughout the species' range and has threatened suitable habitat especially in the Ganges where the mean dry-season water depth has been dramatically reduced in the recent years. The long-term implications of the reduction of dry-season flows in the Ganges are catastrophic for the survival of *susius*.

Dredging and development of the river environment has altered its nature and eliminated counter currents, one of the most preferred habitats of the dolphin and where the dolphins spend much of their time. Heavy river traffic is drastically increasing in the Ganges and Brahmaputra. This may result in habitat restriction, noise pollution, depletion of prey base and changes in feeding behavior of the *susu* in the rivers.

Other sources of habitat degradation include dredging (Smith et al., 1998) and the removal of stones, sand (Mohan et al., 1997) and woody debris (Smith, 1993). These activities threaten the ecological integrity of the river environments, especially in small tributaries where suitable habitat is more confined and therefore more vulnerable to local sources of degradation.

Pollution

Pollution by fertilizers, pesticides, and industrial and domestic effluents is dramatic in the Ganges River; about 1.5 million metric tons of chemical fertilizers and about 21,000 tons of technical grade pesticides were dumped annually to the Ganges-Brahmaputra river system in India during 2002-2003 (Source: www.ncipm.org.in/asps/pesticides.asp). Senthilkumar et al. (1999) determined concentrations of polychlorinated biphenyls (PCBs), hexachlorocyclohexane (HCH), chlordane compounds, and hexachlorobenzene (HCB) in the Ganges River dolphin blubber, muscle, kidney, liver and prey collected from stomach of the dolphins collected during 1993 through 1996 from the River Ganges in and around Patna, India. Comparison of organochlorine concentrations with values reported for samples analyzed during 1988 through 1992 suggested that the contamination by these compounds has increased in the river. Kannan et al. (1997) determined concentrations of butyltin compounds in dolphins, fish, invertebrates and sediments collected from the Ganges in and around Patna. Total level in dolphin tissues was up to 2000 ng g⁻¹ wet wt, which was about 5-10 times higher than in their diet. The biomagnification factor for butyltins in river dolphin from its food was in the range of 0.2-7.5. Butyltin concentrations in Ganges River organisms were higher than those reported for several persistent organochlorine compounds.

Recently perfluorinated compounds (PFCs) were analyzed in the biological samples including the Ganges dolphins (n = 15) from the Ganges at Patna. The arithmetic mean PFOS (perfluorooctanesulfonate) concentration found in the liver of the Ganges River dolphin was 27.9 ng g⁻¹ ww. Biomagnification factors (BMF) of PFCs were estimated for the Ganges River

dolphins, based on concentrations in water from the Ganges River at Patna, shrimps, fish livers and Ganges River dolphins. The estimated BMFs of PFOS from fishes to Ganges River dolphin were similar to the BMFs reported for narwhals (*Monodon monoceros*) and beluga whales (*Delphinapterus leucas*) in an eastern Arctic food web (4.0-8.4), and in bottlenose dolphin food web from costal Florida (1.5-35) USA (Yeung et al., 2009). Poisoning of the water from industrial and agricultural chemicals may have also contributed to dolphin population decline.

The UN Convention on the Conservation of Migratory Species of Wild Animals (CMS), known as the Bonn Convention, which focuses on wild animals crossing the national boundaries declared 2007 as the "Year of the Dolphin". The UNEP and UNESCO, governments and non-governmental organizations are building a strong alliance to achieve a common objective: to protect dolphins. Crucial factors in achieving this objective include the education to create awareness of dolphin species and the threats facing them, informing decision makers and involving local communities. The Year of the Dolphin is also part of the UN Decade on Education for Sustainable Development. The campaign is a tangible contribution towards meeting the targets of significantly reducing the loss of biodiversity by 2010, which all governments have agreed upon at several global UN meetings.

The Ganges dolphin as National aquatic Animal of India

On the initiatives of the author (RKS), the Indian Prime Minister on 5th October 2009 declared the Ganges River dolphin as National Aquatic Animal. Hopefully, this will ensure long term survival of this species by joint efforts of policy makers, planners, executives, scientists, conservationists and common mass. The Government of India has initiated a mega plan to maintain ecological flow and pollution abatement in the River Ganges and its tributaries in 2009 and gradual increase in the number of the Ganges dolphin will be an indicator of success of these plans.

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