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REVIEW

Ganges River Dolphin: An Overview of Biology, Ecology, and Conservation Status in India

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Abstract Ganges River dolphin, *Platanista gangetica gangetica,* is one of the three obligatory freshwater dolphins in the world and is distributed in the Ganges–Brahmaputra–Meghna and Sangu–Karnaphuli River systems in India, Nepal, and Bangladesh. This species is facing considerable threats to its survival, and its population has dwindled from 4000 to 5000 in the early 1980s to 3500 in 2014 in the distribution range. This article reviews current status of the sub-species, habitat use, and the potential threats that the dolphins face for their survival (details of taxonomic status and genetics, evolutionary adaptations and anatomical peculiarities, physical adaptation, primitive characteristics, biology, behavior, surfacing behavior and dive times, mating and birth, and life span/age have been placed as Electronic Supplementary Materials). Recommendations have been made for the protection and developing strategies for the conservation of this Endangered and endemic sub-species.

Keywords Ganges River dolphin · Conservation · Population · Endangered species

INTRODUCTION

Ganges River dolphins, commonly known as susu, *Platanista gangetica gangetica*, are distributed throughout the Ganges–Brahmaputra–Meghna and Karnaphuli–Sangu river systems of Nepal, India, Bangladesh, and potentially Bhutan (Mohan et al. 1997; Sinha et al. 2000; Smith et al. 2001). There is no credible estimate of the range-wide numbers, but the subspecies was listed as "endangered" on the 1996 International Union for Conservation of Nature (IUCN) Red List, due to a reduction in its historical distribution range and projected declines in population size due to increasing threats (IUCN 1996).

Although the Ganges dolphin is mentioned in mythological and historical literature, its occurrence in the Hooghly River, the tidal zone of the Ganges, was first documented in 1801 by William Roxburgh, Superintendent of the Botanical Garden, Calcutta (Roxburgh 1801). Anderson (1879) provided the first description of the distribution range, morphology, and anatomy of the dolphin, although he did not discuss the dolphin's population status or ecology. Approximately 100 years later, however, a few papers reported some details on the population status of the Ganges dolphin as of the 1980s (Jones 1982; Mohan 1989). Nevertheless, these reports were not based on continuous or systematic surveys, and the population status was most likely a rough estimate. Overall, information on ecology and conservation status of river dolphins in India is spatially and temporally patchy.

Our research team at Patna University (Patna) has conducted several surveys in discrete segments of the Ganges River from 1991 to 1996, under the Dolphin Conservation Project sponsored by the Ganga Project Directorate, Ministry of Environment and Forests, Government of India (Sinha 1996, 1997; Sinha et al. 2000; Sinha and Sharma 2003a, b). During 1990–1994, other researchers have conducted dolphin surveys at several sections of the Ganges River and its tributaries (Behera 1995; Smith et al. 1994; Behera and Rao 1999). Continuous surveys were conducted in the Ganges River in a stretch of over 1900 km from Haridwar, at the foothills of the Himalayas, to Farakka near the India–Bangladesh border in 1996–1998 (Sinha 1999; Sinha et al. 2000) with support of

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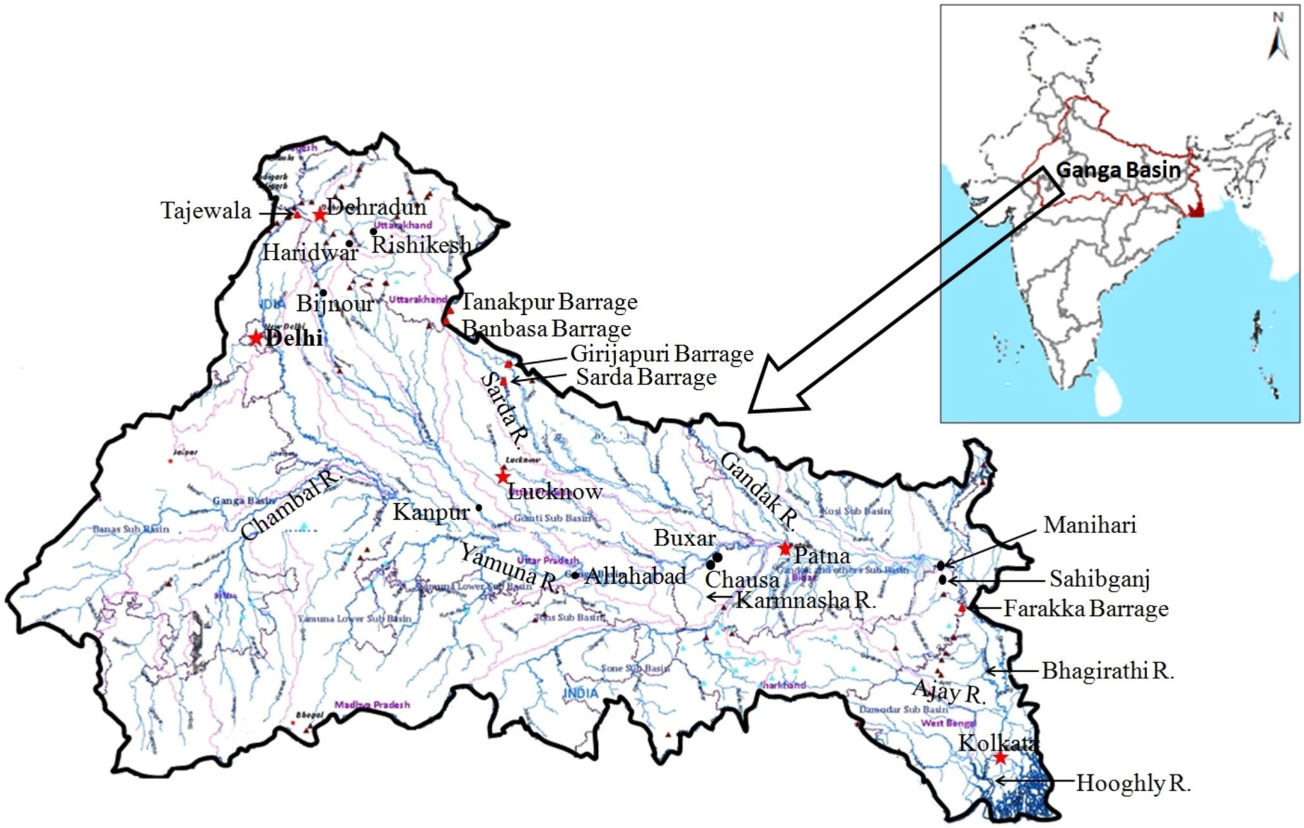

Fig. 1 The Ganges River basin in India

Biodiversity Support Program (BSP), a consortium of World Wildlife Fund, the Nature Conservancy, and the World Resources Institute. From the results of surveys conducted in 1982–1985, Singh and Sharma (1985) estimated that 45 dolphins were present in approximately 305 km segment of the River Chambal between Batesura and the confluence of the Yamuna River. With support from the National River Conservation Directorate (earlier the Ganga Project Directorate under the Ministry of Environment and Forests, Government of India), Patna University undertook intensive studies from 2001 to 2007 in a 500-km stretch of the Ganges in the state of Bihar, where over 50 % of the total population of the Ganges River dolphin in India (currently over 3,000) survive (Sinha et al. 2010a). During the same period, other researchers conducted continuous surveys in the Brahmaputra River, a large river of the Ganges river system in India, in the state of Assam (Biswas and Boruah 2000; Wakid 2005, 2009). A map of the Ganges basin and major locations mentioned in this article is presented in Fig. 1. A summary of the various survey efforts to study the distribution and status of the Ganges River dolphin in various sections of the Ganges River is listed in Tables 1, 2, and 3.

We also documented various threats to which the Ganges dolphins were exposed, including directed and incidental killings by the fishermen to extract oil from their blubber for use as bait in the oil fishery in the dolphins' distribution range (Sinha 2002). The dolphin oil is used as an attractant to catch two economically important fish—*Clupisoma garua* and *Eutropiichthyes vacha* (Sinha 2002). In addition, we collected dolphin carcasses from the Ganges and its tributaries in the 1980s and 1990s, tissues of which were analyzed for toxic pollutants, including heavy metals; organochlorines, including polychlorinated biphenyls (PCBs) and pesticides (e.g., DDT and HCH); organotin compounds; and perfluorinated chemicals (PFCs) (Kannan et al. 1993, 1994, 1997; Senthilkumar et al. 1999; Yeung et al. 2009). One of the projects (Project No. 23), recommended by the IUCN/SSC Cetacean Specialist Group Action Plan, was to develop an alternative to dolphin oil for use as a fish lure (Perrin 1988). As a part of this investigation, oil from fish scraps was developed as an alternative to dolphin oil (Sinha 2002). Other threats including the effects of dams and barrages on Ganges dolphins were studied by Sinha (2000) and Smith et al. (2000). Similar to that in India, status and threats that the Ganges dolphins face in Nepal and Bangladesh have been reported earlier (Kasuya 1972; Kasuya and Haque 1972; Smith 1993; Smith et al. 1998, 2001, 2006, 2010).

Table 1 Population status and distribution of Ganges river dolphin in the main stem of the Ganges River in India

River	Segment	No. of Dolphin	Year	Reference	Remarks
Ganga	Between Haridwar and Middle Ganga Barrage at Bijnor (approx. 100 km)	0	December 1996	Sinha et al. (2000)	The current upstream limit of the range of Ganges dolphins in the Ganges main stem appears to be below the Bijnor Barrage
Ganga	Between Bijnor and Narora Barrages (approx. 166 km)	22/56	1993-95/ 2010	Behera (1995)/Pers. comm. S. Behera	The isolated dolphin population between the two barrages appears to be increasing
Ganga	Between Narora and Kanpur (358 km)	0	1997	Sinha (1999)	Very low water in this stretch
Ganga	Between Kanpur and Allahabad (approx.252 km)	98	2012	Pers. comm. S. Behera	
Ganga	Allahabad to Buxar (approx. 425 km)	204 (Downstream Survey)	1997	Sinha (1999)	
Ganga	Buxar to Maniharighat (500 km)	808 (Upstream Survey)	2006	Sinha et al. (2010a)	The river has more water in this stretch as all the four major tributaries from Nepal discharge into the Ganges and create more hydro-geomorphological complexities
Ganga	Maniharighat to Farakka (approx. 70 km)	115 (Downstream Survey)	1998	Sinha (1999)	
Ganga	Farakka Feeder Canal (38.2 km)	21 (Downstream Survey)	1996	Sinha et al. (2000)	Farakka Barrage diverts regulated Ganges water to the River Bhagirathi through this canal
Bhagirathi	Jangipur to Triveni Ghat (320 km)	119 (Downstream Survey)	1995	Sinha (1997)	Dolphin population is relatively low as the river receives regulated water with low silt resulting in low hydrogeological complexities
Hoogly	Triveni to Sagar Island (190 km)	97 (Downstream Survey)	2008	Pers. comm. Gopal Sharma)	This tidal zone has high river traffic and large vessels

Our constant efforts to study the susu led to declaration of the Ganges dolphin as the "National Aquatic Animal of India" on October 5, 2009. Despite this designation, the species is facing severe threats of extinction throughout its distributional range, and there are many aspects of the animal's biology and ecology that remain obscure. Under these circumstances, renewed efforts are needed to generate consistent information about the species' ecological requirements throughout its distribution range, and its response to anthropogenic and natural disturbances, as the basis for the design and implementation of relevant conservation strategies. This review is based on the results from several of the surveys and studies listed above, including some unpublished data from the lead author and information gathered from local people and organizations in India. We have made an attempt to describe the current state of knowledge on the Ganges dolphin in India, and narrated the future scope of work to address the challenges ahead in the conservation of this species.

DISTRIBUTION

The range of distribution of *Platanista* in the Ganges River was, between longitudes 77°E and 89°E, from mouth of the river in Bay of Bengal to as far up as the river was navigable near the foothill of Himalayas (Anderson 1879) (Fig. 2). Anderson (1879) stated that, in the Brahmaputra River, *Platanista* was present "throughout all the main rivers, as far eastwards as longitude 95°E by latitude 27°30′N, frequenting all its larger tributaries." Outside the Ganges–Brahmaputra–Meghna river systems, susus were present in the Karnaphuli River (Anderson 1879) and possibly the Sangu River in eastern Bangladesh (Haque 1976).

Currently, the Ganges dolphin (*Platanista gangetica gangetica*) is an endangered sub-species of the South Asian river dolphin (*Platanista gangetica*), which is distributed in the Ganges–Brahmaputra–Meghna river systems in India, Nepal, and Bangladesh and the Sangu–Karnaphuli Rivers in Bangladesh from the deltas upstream to where they were blocked by rocky barriers, shallow waters, dams, and

Table 2 Population status and distribution of Ganges river dolphin in various tributaries of the Ganges River in India

River	Segment	No. of Dolphin	Year	Reference	Remarks
Yamuna	From confluence of Chambal river to Yamuna-Ganga confluence at Allahabad (250 km)	31	2012	Pers. comm. S. Behera	
Girwa	India/Nepal border to Girijapuri Barrage (approx. 20 km)	39	2012	Pers. comm. S. Behera	This is a protected area, Katarniaghat Gharial Sanctuary
Ghaghara	Girijapuri Barrage to Deorighat (505 km)	295	2006	WWF-Nepal (2006)	
Rapti	15–20 km	8	2012	Pers. comm. S. Behera	
Saryu	22 km	16	2012	Pers. comm. S. Behera	
Chambal	Rajghat to Panchnada (approx. 550 km)	85	2012	Pers. comm. S. Behera	
Sone	From Uttar Pradesh/Bihar border to its confluence with Ganges about 35 km upstream Patna in the state of Bihar (approx. 300 km)	0	2001	Sinha and Sharma (2003b)	Not enough water to sustain dolphin in this stretch
Sone	Between Bicchi in Madhya Pradesh to Banjari (130 km)	10	1998	Sinha et al. (2000)	These dolphins were sighted in some deep pools in Madhya Pradesh
Sarda	Sarda Barage to Palia (approx. 100 km)	0	1994	Sinha and Sharma (2003a)	Not enough water to sustain dolphin in this stretch
Kosi	Between Kosi Barrage to Kursela (approx. 200 km)	85	2001	Sinha and Sharma (2003b)	
Gandak	Gandak Barrage to Gandak-Ganges confluence at Patna (approx. 320 km)	257	2010	Choudhary et al. (2012)	
Ken	Confluence with Yamuna to Sindhan Kalan village (30 km)	8	1998	Sinha et al. (2000)	
Betwa	Confluence with Yamuna to Orai (84 km)	6	1998	Sinha et al. 2000	
Sind	Confluence with Yamuna to 110 km upstream	5	1998	Sinha et al. 2000	
Rupnarayan	Gadiara to Mankur (42 km), West Bengal	18	2006	WWF-Nepal (2006)	

Table 3 Population status and distribution of Ganges river dolphin in the Brahmaputra River and its tributaries

River	Segment	No. of Dolphin	Year	Reference
Brahmaputra	Arunachal Pradesh/Assam to India/Bangladesh border (856 km)	583	2012	Pers. comm. Wakid
Subhansiri	Katai Sapori to its confluence with the Brahmaputra at Jamuguri (94 km)	35	2012	Pers. comm. Wakid
Kulsi	From Gharamara to its confluence with the Brahmaputra at Nagarbera (76 km)	17	2012	Pers. comm. Wakid

barrages. The river dolphins prefer areas that create eddy countercurrents, such as small islands, sand bars, river bends, and convergent tributaries. In the monsoon season, Ganges dolphins migrate locally to tributaries and then return to larger river channels in the dry, winter season (Smith 1993; Sinha et al. 2000; Sinha and Sharma 2003a, b) The dolphins have been reported to move along the coast of the Bay of Bengal when monsoons flush freshwater out along the southeastern coast of India (Moreno 2003).

Kasuya and Haque (1972) recorded susus as far as Dioghat on the Narayani River, Nepal, 250 m above sea level and approximately 100 km farther upstream than Anderson recorded in 1879. Shreshtha (1989) reported dolphins in the four main river systems of Nepal: the Mahakali, Karnali, Narayani, and Kosi Rivers. Susus ascend the Meghna river systems in Bangladesh at least to Sunamganj (Jones 1982). Nine susus were also sighted in the Barak River in 2006 at Silchar in Assam (pers. comm. Pawlen Singha. Email: thpawlensingha@gmail.com) in India (Barak River is called Meghna River in Bangladesh). Jones (1982) stated that the broad plume of freshwater created by the Ganges outflow in the Bay of Bengal may facilitate the dispersal of susus to rivers outside the Ganges–Brahmaputra–Meghna systems. In 2006, one susu entered the Burhabalang River

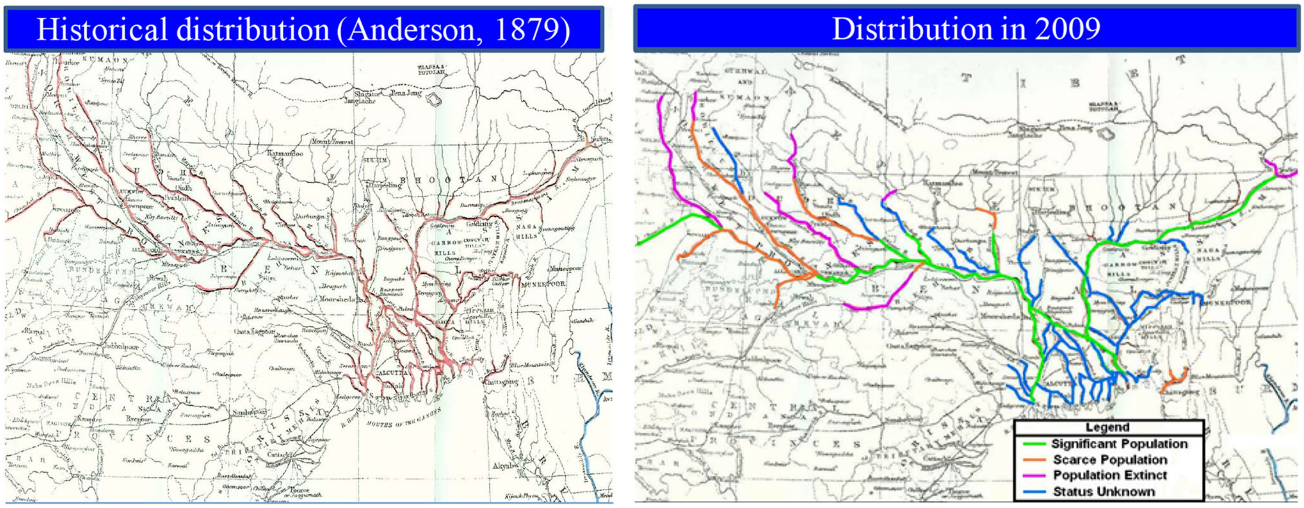

Fig. 2 Distribution map of *Platanista gangetica* in the 1870s (Anderson 1879) and 2009; red highlight on the left panel indicates the historical distribution range

in the state of Orissa, which discharges into the Bay of Bengal almost 300 km southwest of the mouth of the Ganges (Pers. comm. S. K. Behera). This river has never been connected with the Ganges system.

In the recent years, the dolphin's range in substantial portions of the Ganges system, especially in upstream areas, has diminished. For example, a continuous survey in low-water season in December 1996 showed that no dolphins were sighted in the 100-km stretch of the Ganges River between Bhimgoda Barrage at Haridwar and Middle Ganga Barrage at Bijnor, at the upstream limit of their historical range in the river (Sinha et al. 2000). Since December 1996, dolphin sighting was not reported in the River Ganges upstream Middle Ganga Barrage at Bijnor. After 1967, dolphins have not been reported in the Yamuna River above the Chambal River confluence near Etawa to Tajewala near the foothills of the Himalayas (736 km) during the dry season (October–June) (Sinha et al. 2000). Historically, dolphins were found year-round in the Yamuna River at Delhi (Anderson 1879), 512-km upstream of the Chambal confluence. Ganges dolphins apparently have been extirpated from a 163-km stretch of the Sarda River (also called the Mahakali River in Nepal) between Lower Sarda Barrage at Sardanagar in Uttar Pradesh state and Upper Sarda Barrage (also called Banbasa Barrage) at Tanakpur along the India-Nepal border in Uttarakhand state during the dry season (Sinha and Sharma 2003a) (Fig. 1); in a 300 linear-km segment of the Sone River, above and below the Indrapuri Barrage (during the dry season, October–June); and upstream of the Ganges confluence (Sinha and Sharma 2003b). We did not find any dolphins crossing the Lower Sarda Barrage both during the flood season (July–September) as well as lean season in the month of March–April when the gates of the barrage were opened. Additionally, no dolphins were observed in the section of the Mahakali River (called River Sarda in India) that flows through Nepal (Smith et al. 1994).

It is challenging to assess whether the extirpations were due to population fragmentation or habitat degradation caused by construction of dams and barrages. Physiographic and hydrologic complexities play an important role in making rivers suitable for inhabitation of dolphins, whereas dams and barrages degrade dolphin habitats, as they reduce physiographic and hydrologic complexity (Reeves and Leatherwood 1994).

ABUNDANCE

Statistically robust and standardized density and population estimates are necessary to determine the conservation status and to monitor trends of the river dolphin population worldwide (Reeves and Leatherwood 1994; IWC 2000; Smith and Reeves 2000). In the absence of a robust method, direct counts in discrete sections of rivers generally have been conducted (Smith and Reeves 2000). Capture-recapture analysis of photo-identified animals is commonly used to estimate the abundance of cetaceans (Hammond 2009). This method relies upon capturing images of uniquely marked animals; the proportion of identified individuals recaptured during subsequent sampling events is then used to estimate the population abundance (Borchers et al. 2002). This method has substantial limitations for the survey of *Platanista* spp.; however, because (1) these animals are extremely difficult to photograph, as they surface alone,

Table 4 Estimated population of the Ganges River dolphins in the early 2000s

Location	Number of Dolphins	Source
Ganges River Main Stem and tributaries	2381	Sinha (1997), Sinha et al. (2000, 2010a, b), Sinha (1999), Sinha and Sharma (2003a, b); Behera, S. K. pers. comm. January 2014
Brahmaputra and tributaries	635	Wakid, A. pers. comm. January 2014
Ganges River system and Sundarbans area in Bangladesh	460	Smith et al. (2006, 2009); Alam and Sarker (2012)
Karnali River and tributaries—River	>50	Smith et al. (1994), pers. comm. Bhojraj Shreshtha;
Mohana and Pathariya; and River Koshi in Nepal		and pers. comm. Kevin Denlay Dec. 2013
Total	3526	

unpredictably, for about one second or less, and they seldom approach boats or vessels; and (2) they lack a prominent dorsal fin, and the individuals rarely possess any readily identifying marks or features (Braulik et al. 2012a). In an earlier survey, not a single individual could be identified from 1,200 photographs of Ganges dolphins taken during that time (Smith and Reeves 2000). During 2012 surveys in the Ganges River, we took about one thousand photographs of susu, of which three individual dolphins had identifying features: The upper jaw and lower jaw of two individuals were broken, and there was a deep cut in the dorsal fin of the third. Tropical rivers, such as the Ganges, are often turbid, as they carry heavy loads of silt, and, therefore, underwater photography is almost impossible.

The primary challenge to the application of line or strip transect methods of population survey in the Indus, Ganges, and Brahmaputra Rivers is that the rivers are very shallow, and survey vessels are restricted to traveling up or down the thalweg (the line that follows the deepest part of the river) along a single curving transect that periodically approaches alternate banks as the river meanders. A thalweg transect survey unavoidably samples unrepresentative habitats as it passes through areas with higher densities; in addition, the animals are unlikely to be uniformly distributed in the surveyed strips (Braulik et al. 2012b). Transects that run from bank to bank, perpendicular to the flow, are used for line transect surveys of cetaceans in the Amazon River (Vidal et al. 1997; Martin and da Silva 2004), but in the comparatively shallow, sand-bedded, South Asian rivers, navigational constraints preclude this approach. A single transect parallel to and a standard distance from the river banks also has been used for strip transect surveys in the Amazon (Vidal et al. 1997; Martin and da Silva 2004) and for adapted line transect surveys on the Yangtze River (Zhao et al. 2008), but this is not possible on South Asian rivers, as the channel width changes rapidly and vessels cannot maintain a standard distance from the banks due to shallow depths (Braulik et al. 2012b). In the Ganges and tributaries, we followed the direct count method suggested by Smith and Reeves (2000).

A total of approximately 3,526 dolphins were sighted in their distribution range in India, Nepal, and Bangladesh during the recent surveys, details of which are shown in Table 4. However, various researchers have not followed consistent and robust methods. Many tributaries north of the Ganges River, such as Mahananda, Mechi, Bagmati, Kamala, Balan, Burhi Gandak, are yet to be surveyed, of which Mahananda and Bagmati are large rivers.

In the recent past, a local activist, Mr. Bhoj Raj Shreshtha, founded a Dolphin Conservation Center in the Kailali District of western Nepal. Mr. Shreshtha has successfully motivated villagers in the area to keep records of dolphin sightings, especially during the flood period of July to September, when a good number of dolphins ascend into the smaller tributaries of the Karnali River. The number of dolphins sighted in the river was claimed to be over fifty, but the sighting records are not based on a "scientific method." Nevertheless, these data have been collected from an area that is not traditionally monitored, and further efforts, which include the help of local organizations, are needed to comprehensively assess the status of dolphins.

An estimate of the abundance of Ganges dolphins was generated in 2004, 2005, 2006, and 2012 by both upstream and downstream vessel-driven direct counts by the same team of experts in the same stretch (500–525 km) of the Ganges River in the middle segment of the river in the state of Bihar (Sinha et al. 2010a; Sinha 2013). This segment of the Ganges supports maximum density of the dolphins, as all of the four major rivers of Nepal discharge into the Ganges in this stretch, which results in more water and the creation of suitable habitats for the dolphins. The surveys were conducted between Buxar and Maniharighat (500 km) in 2004–2006. In 2012, a survey was conducted in a 525-km stretch in the Ganges between Chausa (15 km upstream of Buxar, where the Karmanasa River joins the Ganges from south and forms the political boundary of Uttar Pradesh and Bihar states) and Sahibganj, located about 10 km downstream of Maniharighat on the opposite bank of the Ganges.

A summary of the findings with confidence intervals and Standard Error is presented in Table 5. The population growth rate is an important measure for the assessment of the health and survival of dolphins, but such information is not currently available. Thus, further studies should focus on assessing the growth rate of the Ganges dolphin population.

POPULATION DENSITY

The frequency of dolphin sightings remains high in the middle and lower reaches of the main stem of the Ganges, as the river has more hydro-physiographic complexity and greater hydraulic refuge as induced by minor geomorphic features. The river is productive due to the seasonal flood pulse that brings adequate nutrients and has reduced velocity due to its low gradient (1300:1) (Sinha and Prasad 2012). A mean encounter rate of 1.8 dolphins/linear km was reported for the Vikramshila Gangetic Dolphin sanctuary (Choudhary et al. 2006) in the middle of the Ganges River. In November 2012, our team recorded an average density of 2.3 dolphins/linear km in the sanctuary and 1.6 dolphins/linear km in the 525-km stretch of the middle Ganges between Sahibganj and Chausa.

The encounter rates of dolphins reported in other surveys are shown in Table 5. It should be noted that the encounter rate is dependent on the speed of the vessel. In the upstream survey, the encounter rate was 1.3–1.6 dolphins/linear km, and the vessel speed was 6.3–6.8 km/h. In the downstream survey, the encounter rate was 0.9–1.4 dolphins/linear km, with a vessel speed of 10.2–12 km/h. Thus, the speed of the vessel has a direct bearing on the encounter rate of the dolphin. In 2001, the encounter rate recorded for the Guddu–Sukkur subpopulation was almost five times greater than that of any other river dolphin subpopulation (Braulik 2006). This encounter rate (averaging 3.60 dolphin/km, peaking at 5.05 dolphin/km) was several times greater than that recorded for the Ganges dolphin in the rivers of India and Bangladesh. The high density of the Guddu–Sukkur subpopulation is probably due to a ban on hunting since the 1970s (Braulik 2006). More dolphins are sighted in the main channel as compared to the larger secondary channels or braids (Braulik 2006; Basir et al. 2010).

The spatial and temporal habitat selection of dolphins is a complex and dynamic function of requirements for food, mates, avoidance of predators and competitors, and the ability to move between habitat patches (Davis et al. 2002; Schofield 2003). Fluvial habitat within river networks is often described as a mosaic of habitat patches of different sizes that are formed principally by hydro-geomorphic forces (Crook et al. 2001; Thorp et al. 2006). Consequently, fluvial aquatic species are variably distributed, and variations in hydrology and geomorphology play a critical role in determining species

Table 5 Summary of Ganges dolphin sightings in the Ganges River (upstream survey) between Maniharighat and Buxar during 2004–2006, and between Sahibganj and Chausa (15 km upstream Buxar) in November–December 2012

Parameter	Distance traveled (km)	Average vessel speed (km/h)	Total no. of sightings	Best estimate of dolphins	Confidence intervals	Average group size of dolphins	Std. Error of group size	Range of group size	Encounter rate (dolphin/km)
Period of survey									
March 2004 (u/s)	505.7	6.8	358	777	765–816	2.2	0.088	1–11	1.5
March 2004 (d/s)	499.4	10.9	314	696	687–730	2.2	0.079	1–10	1.4
November 2005(u/s)	507.4	6.3	425	664	578–750	1.6	0.039	1–7	1.3
November 2005(d/s)	494.8	11.2	349	517	465–576	1.5	0.037	1–4	1.0
December 2006 (u/s)	517.1	6.3	557	808	729–931	1.5	0.030	1–4	1.6
December 2006 (d/s)	501.0	10.2	405	559	486–668	1.4	0.032	1–7	1.1
October–November 2012 (u/s)	526.7	6.5	813	813	736–838	2.1	0.077	1–15	1.6
October–November 2012 (d/s)	519.3	12.0	439	439	415–476	2.2	0.100	1–11	0.9

u/s Upstream Survey (against the river current)

d/s Downstream Survey (along the river current) distribution (Stazner and Higler 1986; Poff and Allan 1995; Power et al. 1995; Poff et al. 1997). The distribution of prey is likely to be one of the most important factors that influences the distribution of river dolphins; however, habitat selection is frequently assessed in terms of physical habitat characteristics, as these are the primary determinants of prey distribution and are more easily measured (Gregr and Trites 2001; Cañadas et al. 2002; Davis et al. 2002; Bearzi et al. 2008). Most riverine fish prefer specific types of habitat, and water depth is widely considered the most important variable that drives their distribution (Baird and Beaseley 2005; Sarkar and Bain 2007). For example, small or young fish often prefer shallow and slow water, whereas larger or older fish prefer deeper areas, often with faster flows (Sarkar and Bain 2007).

DISPERSAL

Research has indicated that dolphins move downstream in the winter season when river discharge is low and that, as the flood waters rise in the monsoon season, dolphins move into upstream waters that comprise smaller tributaries (Anderson 1879; Kasuya and Haque 1972; Shreshtha 1989; Sinha and Sharma 2003a; Kelkar et al. 2010). Given the large variation in river discharge and velocity, a seasonal movement is probable. During the flood season, many dolphins enter into the smaller tributaries, and most return to the main channel of the large rivers after the flood. However, some individuals stay back in pools of the tributaries during the dry season (Pelletier and Pelletier 1980), which makes them vulnerable and subject to being killed by local fishermen. On two occasions in 2001 and in 2013, such dolphins were successfully rescued and translocated to the nearby large rivers in West Bengal and Bihar, respectively, by our team in Patna. Between 2002 and 2012, no dolphin was found or reported stayed back in small tributaries which required to be rescued and translocated. Efforts to rescue such individuals are important to conserve the dolphin population, and resources/infrastructure should be made available for this purpose. Susus have been reported to have lived for several years in a lake near Kaziranga, Assam (Pilleri 1970).

HABITAT USE

Several researchers have noted extremely patchy distributions of river dolphins in rivers of South Asia, with a preference for confluences (Jerdon 1874; Kasuya and Haque 1972; Haque et al. 1997; Sinha 1997; Sinha et al. 2000; Basir et al. 2010). Nearly all reports, however, are qualitative. A few studies reported that preferred habitats in rivers include downstream of shallow and narrow areas (Kasuya and Haque 1972), in narrow and deep sections of rivers (Pilleri 1970), in deep locations where the current is weak (Pilleri and Zbinden 1973–74; Bairagi et al. 1997), in deep water pools off the mouths of irrigation canals (Basir et al. 2010), near villages and ferry crossings (Pilleri and Bhatti 1982; Sinha 1997), downstream of bridge pilings (Sinha 1997; Smith et al. 2001; Choudhary et al. 2006), downstream of sand bars and sharp meanders, near bathing ghats, cremation ghats (Sinha 1997), and in channels with muddy and rocky substrates (Kelkar et al. 2010). The river dolphins preferentially congregate in such locations that are preferred by local fishermen, and the sites with dolphins had a higher biomass of small fish than did areas in which their presence was not recorded (Kelkar et al. 2010). We understand that, in areas of human activities such as bathing and washing ghats, ferry ghats, and cremation ghats, people tend to throw into the water some edible items that could attract fish and, ultimately, dolphins.

It is clear that South Asian river dolphins are patchily distributed according to characteristics of their habitat, but there have been few studies that have statistically tested which types of habitat are preferred in different seasons or locations. The three most comprehensive studies are as follows: (1) Smith (1993) conducted a study in the Karnali River in Nepal, which is the extreme upstream limit of the Ganges dolphin distribution. Primary and marginal habitats were identified, and it was concluded that dolphins consistently used the same areas characterized by high prey availability and low water flow velocity. River dolphins were assumed to exploit the "hydraulic refuge" provided by counter-current eddies in deep pools. (2) A study by Smith et al. (2009), in the extreme downstream, limits in the Sundarbans delta mangrove forest, river dolphins showed a consistent preference of water of approximately 12-m deep, from a possible range of 0–40 m, irrespective of seasons. Generalized additive models showed that the dolphin distribution was dependent on water with low salinity, high turbidity, and moderate depth during both low and high flows, with a preference for wide sinuous channels with at least two small confluences or one large confluence in the tidal zone in the Sundarbans. (3) A study by Braulik et al. (2012a) found that dolphins selected locations in the Indus River with significantly greater mean depth, cross-sectional area, and hydraulic radius, and significantly narrower river width and a lower degree of braiding. Dolphins with higher frequency at river constrictions and river confluences were also recorded. Channel cross-sectional area was the most important factor that affected dolphin presence and abundance. The greatest influence on presence and abundance of dolphin is exerted by area of water depth below one meter. Indus dolphins avoided channels with a small cross-sectional area (<700 m^2).

There is no quantitative information on which aspects of the riverine habitat that are important to the Ganges dolphin in India, where the river has vast floodplains and many confluences and meanders, and is highly braided, with many deep pools, hydraulic refuges, and hydro-geomorphic complexities. River dolphins are expected to be most vulnerable during the low-water season, when the habitat is limited, and it is, therefore, important to determine which habitats are preferentially used at this time, so that conservation efforts can be focused in those locations.

GANGES DOLPHIN AS A BIOINDICATOR SPECIES

Rivers are at risk from multiple stressors, including changes in water quantity and quality, habitat modification, over-exploitation of resources, climate change, pollution, and invasive species. The current impacts of these stressors on rivers are dramatically increasing (Alcamo et al. 2005; Foley et al. 2005). Currently, 65 % of global river discharge is considered to be under moderate to high threat, and the water security of 80 % of the human population is at high risk (Vorosmarty et al. 2010). In addition, biodiversity in freshwater ecosystems is in rapid decline, and this reduction in freshwater system is considered even more threatened than are marine ecosystems (Revenga et al. 2000; Vorosmarty et al. 2010).

Degradation of the freshwater ecosystem is sometimes measured using a suite of ecological indicators, such as macro-invertebrates, fishes, and macrophytes. Carefully selected indicators can provide warning signals of cryptic but significant changes to ecosystems (Karr 1999; Noss 1999). Top predators, such as mammalian carnivores, sea birds, and raptors, are among the widely used indicator species (Furness and Camphuysen 1997; Sergio et al. 2005, 2006, 2008; Piatt et al. 2007). Top predators tend to be concentrated in important biodiversity hotspots (Worm et al. 2003; Sergio et al. 2005, 2006). The reduction or disappearance of top predators is related to significant ecosystem transformations, including impacts on several trophic levels and changes in energy flows, over-exploitation of resources, and changes in the behavior of prey or food chain structure (Soule et al. 2005; Heithans et al. 2008; Braum and Worm 2009). Moreover, their presence or absence can indicate the extent of the footprint of human pressures.

River dolphins are top predators that inhabit some of the largest tropical river basins in Asia and South America and may be ideal candidates for ecological indicators. Gomez-Salazar et al. (2012) investigated the relationships between measures of ecosystem degradation and river dolphins as potential ecological indicators. They tested three ecological indicators of freshwater ecosystem degradation using river dolphins: (i) density of river dolphins, (ii) mean group size of dolphins, and (iii) dolphin sighting rates. A strong negative relationship between measures of habitat degradation and river dolphin density estimates was found in selected locations of the Amazon and Orinoco Rivers. It was suggested that river dolphins are flagship and sentinel species for monitoring the conservation status of large tropical rivers in South America. The contents of micro-pollutants, such as organochlorines, organotin compounds, and perfluorinated chemicals in the Ganges dolphin tissues (Kannan et al. 1993, 1994, 1997; Senthilkumar et al. 1999; Yeung et al. 2009), which were otherwise below detectable levels in the river water or in other invertebrates and fishes, suggest that dolphins are sentinels of toxic chemical pollution in the river. Low dolphin populations in the river's upstream dams and barrages on the India–Nepal border and in other areas indicate ecosystem degradation. Thus, Ganges dolphins' low population in some locations can be related to environmental degradation in the Ganges basin.

THREATS

Several cetacean subpopulations are under siege from various stressors, such as climate change; chemical, pathogen, and noise pollution; ship traffic; and fishery bycatches; and the Ganges dolphin population is no exception. Freshwater cetaceans have declined dramatically in numbers and range, especially in Asia (Reeves et al. 2000; Smith and Jefferson 2002). The Yangtze River dolphin is already extinct (Turvey et al. 2007). The threats are diverse, longstanding, and very difficult to assess or manage.

All of the existing river dolphins are endangered, mainly due to human activities and multiple threats, including direct or incidental catch; hydroelectric power plants; construction of dams, barrages, and embankments; strikes by vessels; chemical pollution from the discharge of domestic effluents, from the agriculture, industry, mining, and health sector; noise pollution due to underwater explosions and vessels; and deforestation, which lead to heavy siltation and competing demands of freshwater for irrigation, especially in the Indian subcontinent. All freshwater cetaceans require adequate water flow and water quality within their range; these are the basic elements of a suitable habitat and are needed by the animals to support their physical health, mobility, and ability to forage efficiently and to find prey. River dolphins face intense competition with humans for resources such as fish and freshwater. The Ganges dolphins share their lowland riverine habitat with hundreds of millions of people, which results in high mortality rates from hunting, entanglement in fishing gear or entrapment in irrigation canals, population fragmentation by dams and barrages, and severe habitat depletion by water extraction, and degradation by pollution and altered flow regimes (Sinha et al. 2000, 2010b; Sinha 2002).

The future of the South Asian river dolphins is intimately tied to the region's water security. South Asia has approximately 25 % of the world's human population but only 4.5 % of its renewable water resources (Babel and

Fig. 3 A sand bar (3 km × 0.3 km) in the head pond of Farakka Barrage along the Ganges River in December 2004

Wahid 2008). As per Indian Census 2011, the average population density in the Ganga Basin in India is 581/km^2, and, in Bihar state (located in the Ganges basin), it is 1102/km^2, compared to the world's average population density of 13.3/km^2. Thus, the Ganges basin is one of the most densely populated regions in the world, and the loss of freshwater biodiversity is inevitable and the prospects for the South Asian river dolphins uncertain.

EFFECTS OF DAMS AND BARRAGES

Construction of at least 50 dams and barrages within the known or suspected historical range of the Ganges dolphin (Smith et al. 2000) has dramatically affected its habitat, abundance, and population structure during the last 45–50 years. Dams and barrages (low-gated diversion dams) restrict the movement of dolphins, rendering them isolated into separate sub-populations. A subpopulation is defined by the IUCN as "geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange (typically one successful migrant individual or gamete per year or less)" (IUCN 2001).

The Farakka Barrage (24.7891°N, 87.8878°E; located on the Ganges River 400 km downstream of Patna and 400 km upstream of Calcutta near the India–Bangladesh border; Fig. 3) has affected the dolphin population in the Ganges, as the barrage has not only created a physical barrier for movement of the dolphin but also the reach of the river has been changed from a lotic to a lentic ecosystem (Sinha 2000). Due to the increased sedimentation rate, more than 75 % of the "head pond" has been filled, and a huge sand bar (3 km × 0.3 km) was formed in 2004 (Sinha 2013). Sediments are trapped behind dams and barrages and reduce the volume of suspended matter transported downstream, lessening the potential for bars and sand islands to form in the lower reaches of the river. Barrages reduce or eliminate the "freshet effect," which, in many wild rivers, renew the floodplains and contributes to meandering (Reeves and Leatherwood 1994).

The Bhagirathi River receives regulated flow with a low sediment load from the Farakka Barrage through a 38.2-km long feeder canal. The water with the low sediment load has reduced the physiographic and hydrologic complexity in the Bhagirathi River up to Katwa (155 km). The reduced complexity has led to a very low dolphin population (0.3

dolphin/linear km) compared to the other, lower segments of the Ganges and Bhagirathi Rivers, which have about 0.5–1 dolphin/linear km (Sinha 1997). A small tributary, Ajay River, with heavy loads of silt from the highlands of Jharkhand, discharges into the Bhagirathi River from the west at Katwa. The Bhagirathi River has more hydro-physiographic complexity downstream of Katwa, which is evident from the presence of more dolphins and avian fauna (Sinha 1997). Dams and barrages have a number of potential problems, including downstream effects on prey caused by changes in flow rate and sediment transport (Reeves and Leatherwood 1994).

Embankments cause sediment deposits in the riverbed instead of in floodplains, thereby eliminating or reducing the extent of the eddy-counter currents, where dolphins are generally found (Smith et al. 1998). The embankments also restrict access of riverine fishes to the floodplain habitat critical to their reproduction and growth (Boyce 1990). Approximately 3,500 km of embankments have been constructed along the Ganges main stem and the Gandak, Burhi Gandak, Bagmati, Kamala, Yamuna, Punpun, and Sone tributaries (Mishra 1999). Dolphins were apparently extirpated from at least 35 km of the Punpun tributary of the Ganges after embankments were constructed in 1975 (Sinha et al. 2000). Other sources of habitat degradation in the distribution range include heavy siltation in river beds, due to loss of green cover in the catchments area, and change in land use pattern (e.g., crop farming in floodplains); water abstraction from surface pumps, especially in the Ganges system, where the mean dry-season water depth has declined dramatically in recent years; dredging; and removal of stones (Shreshtha 1989), sand (Mohan et al. 1998), and wood debris (Smith 1993).

A large number of completed and ongoing hydroelectric projects on the Ganges and in tributaries in the Himalayas are further expected to aggravate the problem of flow decline in the middle and lower reaches of the Ganges, where dolphins survive (Sinha et al. 2010b). The cumulative effects of these activities compromise the ecological integrity of the riverine ecosystems, especially the small tributaries where the suitable habitat is limited and disproportionately vulnerable to local disturbance. Declining flows in the rivers have received little attention for a long time. The newly established National Ganga River Basin Authority by the Indian government in 2009, an apex body under the chairmanship of the Prime Minister of India, has the mandate of *"Aviral Dhara Nirmal Dhara"* (uninterrupted quality flow). Such efforts may help restore the riverine environment.

CHEMICAL POLLUTION

The riverine ecosystem is in close proximity to human activities and, therefore, is an ultimate sink for the discharge of sewage and industrial wastewater that emanates from human activities. The Ganges River basin is the most densely populated basin in the world and is heavily polluted by fertilizers, pesticides, industrial chemicals, and domestic effluents. Exposure of dolphins to toxic chemicals can affect their reproduction and survival. In the Ganges River food chain, the dolphins, as an apex predator, have been shown to accumulate high levels of persistent and toxic chemicals in their tissues. Several studies conducted by our research group have reported elevated levels of DDT in the blubber of Ganges dolphins (Kannan et al. 1994; Senthilkumar et al. 1999) (Table 6). Notable levels of immunotoxic chemicals, such as butyltins and perfluorinated chemicals, have been found in the tissues of Ganges dolphins (Kannan et al. 1997, 2005; Yeung et al. 2009). Heavy metals, including cadmium and lead, have been measured in the livers of Ganges dolphins (Kannan et al. 1993).

Although levels of the some of the toxicants were relatively low, based on the analysis of the metabolic index (see details in Kannan et al. 1994), it was found that Ganges dolphins have a low capacity to metabolize some toxic pollutants. The proximity to intense pollution sources and low capacity to metabolize pollutants make the Ganges dolphins vulnerable to the effects of chemical pollution. Several studies have shown that some freshwater aquatic mammals, such as mink and river otter, are very sensitive to the effects of chemical pollution (Kannan et al. 2000). Thus, studies are needed to assess the impact of pollutants on the health of river dolphins. In addition to the contaminants studied thus far, other emerging contaminants that arise from sewage pollution and diseases in river dolphins should be examined in future studies. Our study on mercury pollution in water, sediment, benthic macro-invertebrates, and fishes of the Ganges River at Varanasi found higher levels of mercury (0.0–91.7 ppm) in fishes than those of fishes collected from the western coast at Mumbai (0.03–0.82 ppm) (Sinha et al. 2007). Recent studies have reported elevated levels of arsenic in the Ganges river basin (Nickson et al. 2007; Kumar et al. 2010). Mercury and other industrial pollutants that arise from the discharges of wastes from several industries need to be studied in different segments of the Ganges.

DIRECTED AND INCIDENTAL CATCHES

Deliberate killing of the Ganges dolphins is believed to have declined in most areas but still occurs at least occasionally in the Ganges near Patna (Sinha 2002) and in the upper reaches of the Brahamaputra River in Assam (Mohan et al. 1997) for their meat and oil, which is used as a fish attractant. Mortality from fishing gears, especially monofilament nylon gillnets, is a severe problem for the Ganges dolphins throughout their range (Sinha 2002). Dolphins are particularly vulnerable,

Table 6 Reported concentrations (ng/g wet wt) of DDT, HCH, polychlorinated biphenyls (PCBs) in the blubber and butyltins and perfluorooctanesulfonate (PFOS) in the liver of Ganges river dolphins from India

Date of collection	Sex	Length (cm)	Tissue	Lipid (%)	PCBs	DDTs	HCHs	Butyltins*	PFOS*
24 January 1988	M	70.4	Blubber	34	360	4700	190	2000	
6 October 1991	M	104	Blubber	31	410	9100	470	380	
21 July 1991	F	115	Blubber	41	620	12000	430	250	
27 March 1992	F	233	Blubber	74	420	13000	610	61	
11 February 1993	F	250	Blubber	51	1500	31000	860	NA	
27 June 1994	M	84	Blubber	53	13000	64000	1100	NA	
3 November 1994	M	123	Blubber	77	2560	63000	1100	NA	
29 November 1994	M	117	Blubber	70	2100	30000	1900	NA	
5 November 1996	F	133	Blubber	71	1100	21000	1900	NA	
1993-2007 (n = 15)	10 M&5F	68-248	Liver	NA	NA	NA	NA	NA	28 (0.74–74)**

For details see Kannan et al. (1993, 1994, 1997); Senthilkumar et al. (1999); Yeung et al. (2009)

*Refers to concentrations in liver (for sum of mono-, di- and tri-butyltins and PFOS)

**values in parentheses indicate range; NA = Not analyzed

because their preferred habitat is often in the same location as the fishing grounds. A specific problem is that, because dolphin oil is highly valued as a fish attractant, fishermen have a strong incentive to kill any dolphin found alive in their nets and even to set their nets strategically in the hope of capturing dolphins, which is termed "assisted incidental capture" (Sinha 2002). Meaningful quantitative data on the magnitude of catches, either deliberate or incidental, are unavailable and unlikely to become available in the absence of organized fishing in the river system.

Although the Ganges dolphin was given legal protection in India under the Wildlife (Protection) Act of 1972, the law was not effective until the end of the 20th century. The efficacy of the Act became noticeable after the proceedings of the Patna High Court (CWJC No. 5628 of 2001). Field trials have shown that fish scrap oil is an efficient substitute for dolphin oil as a fish attractant (Sinha 2002). We conducted several extension programs, with the help of Wildlife Trust of India (Sinha 2004), a non-governmental organization, to popularize the use of fish scrap oil as an alternative to dolphin oil. Many groups of fishermen from Assam visited our laboratory at Patna University during the last 10 years, and the most recent was in 2012, to get training on how to obtain oil from fish scraps and its use in the oil fishery. Some fishermen, however, continue to use dolphin oil. In November 2012, we encountered a couple of fishermen who were using dolphin meat and oil at Sultanganj near the Vikramshila Gangetic Dolphin Sanctuary in Bihar and another fisherman at Barh in the Patna District. After these observations, we organized an interactive meeting on January 25, 2013, with fisherman who use dolphin meat and oil in their village near Sultanganj to create awareness, educate, and motivate the fishermen to save the dolphin. State government officials also participated in the meeting. Such meetings and the extension program to popularize the fish scrap oil will help to save the Ganges dolphin.

CONSERVATION AND CHALLENGES AHEAD

India has been a pioneer in conserving wildlife. The world's first recorded wildlife conservation measures were enacted in India during the third century BC. One of the greatest Indian emperors, Ashoka the Great, who reigned from 274 to 232 BC, stressed the sanctity of an animal's life. Some of his decrees engraved in stone have survived until today in the Pillar Edict V. The Ganges dolphin (called Ganga-puputaka in ancient days) was included in the list of animals declared inviolable by the emperor (Sinha 1996).

The Government of India provides legal protection to the Ganges River dolphin (Fig. 4) by including it in Schedule I of the Wildlife (Protection) Act, 1972 since the Act was enacted in 1972. Killing and poaching of any animal included in Schedule I of the Act are cognizable offenses, and the offender may be fined up to $500 US and/or receive a 7-year imprisonment. The efficacy of this act, however, was not evident until the 1990s, when we started intensive and extensive awareness campaigns among the general public. Help rendered by the mass media, both print and electronic, was valuable in educating people of different social strata.

The IUCN categorized the Ganges dolphin as endangered in 1996 (IUCN 1996). The species was included in Appendix I of the Convention on the International Trade on Endangered Species of Flora and Fauna (CITES) and in Appendix II of the Convention on Migratory Species. The government of India declared the Ganges dolphin the National Aquatic Animal of India on October 5, 2009, and formal notification was issued on May 10, 2010. Thus,

Fig. 4 *Platanista gangetica gangetica* surfacing in the River Ganges (Photo by Fernando Trujillo)

India became the first country to adopt the river dolphin as its National Aquatic Animal.

A separate Conservation Action Plan (CAP) for the Ganges river dolphin has been prepared for the Government of India (Sinha et al. 2010b). The CAP includes protection and restoration of habitats, community participation, capacity building, conducting of periodic status surveys and monitoring, establishing protected areas, providing education awareness, minimizing incidental catches, rescue and rehabilitation, and initiating researches on identified thrust areas besides, identifying agencies for implementation of the Action Plan. A National Dolphin Research Center is to be established at Patna shortly as an institutional support for the long-term conservation of the dolphin. With the help of activists, NGOs, university researchers, government departments/officials, and other stakeholders, especially fishermen, various action plans are being implemented. The State Government of Bihar designated October 5 as "Dolphin Day" and is celebrating the "Dolphin Day" every year on October 5 since 2012, as a means to help create awareness among the general public in addition to annual monitoring of government activities to save and conserve the dolphins.

One of the important tasks for researchers is the development of a robust scientific method for population estimation to provide a basis for determining which areas should be given the highest conservation priority. Further, age-wise habitat use during different seasons must be studied as a means to help prioritize the conservation efforts.

RECOMMENDATIONS FOR CONSERVATION

The baiji's extinction clearly demonstrates that, without appropriate and timely actions, the future of the remaining freshwater cetaceans is precarious. All freshwater cetaceans require adequate water flow and water quality within their range; these are the basic elements of a suitable habitat and are needed by the animals to support their physical health, mobility, and ability to forage efficiently.

The long-term viability of freshwater cetacean populations requires management of entire ecosystems and watersheds, i.e., an ecosystem approach for the conservation and management of rivers and river dolphins. Watershed management, especially in upstream sections, is required to reduce sedimentation from agriculture, forestry, and land conversion; to limit water removal and dramatic changes in flow regimes by dams and barrages; to ensure adequate water and sustain essential geomorphic features in cetacean habitat; and to reduce toxic effluents and chemical pollution from agriculture, industry, industrial transport, and human settlements.

Organochlorine and butyltin concentrations in samples from the tissues of Ganges dolphins were high enough to cause concern about their effects. Further, several unstudied pollutants that arise from the disposal of sewage are expected to compromise the health of dolphins. Pollutant loads can be expected to increase with industrialization, and the spread of intensive agricultural practices is facilitated by water diversion. River dolphins may be particularly vulnerable to industrial pollution, because their habitats in counter-current pools downstream of confluences and sharp meanders often place them in proximity to point sources in major urban areas in India. Further, the capacity of rivers to dilute pollutants has been drastically reduced in many areas because of upstream water abstraction, diversion, and impoundment. This problem is destined to worsen as more development takes place along the river. It is of utmost importance to maintain pollution-free, uninterrupted flow in the rivers to address these issues. Particularly in river systems where there is great demand for fresh water for human use, critical minimum flow and the maintenance of natural flow variability are of overarching importance.

It is important to determine which habitats are preferentially used by dolphins during the low-water season so that conservation efforts can be focused in these locations. In the dry season, channel constrictions, confluences, and channels with high cross-sectional areas are all high-use dolphin habitats that could benefit from management as discrete dolphin conservation zones. The monitoring of river dolphin populations and habitats on a regular basis, as has been performed for tigers and elephants, is very much required. Involvement of fishermen in dolphin conservation efforts will encourage them to have a sense of "ownership." Further, a study is needed on the implications of climate change on freshwater cetaceans that include consideration of habitat resilience.

It is important to collect as much scientific information as possible on behaviors and other ecological requirements of the dolphin in the Ganges River. We recommend building a microcosm in the Ganges River at Patna for captive breeding and rescue efforts. For this, a big enclosure (2–3 km × 100 m × 5 m) could be created, using smooth metal poles and wire mesh (30 cm × 30 cm) along the left bank of the river at Patna, where enough water flow is available year-round. This will ensure availability of enough water flow and prey through the enclosure. A couple of male and female dolphins can be kept in the enclosure to study their behaviors and the possibilities of "breeding" in natural habitat.

Having declared the river dolphin, *Platanista gangetica gangetica*, the National Aquatic Animal, the Indian government should complement this commendable action by setting up a national network of protected/conserved areas for river dolphins and associated aquatic fauna and considering initiating a National River Dolphin Project along the lines of Project Tiger, Project Elephant, Project Snow Leopard, and Project Rhino. In doing so, the project should identify the dolphins' present pattern of distribution and status in the context of their historical distribution throughout the Ganges and Brahmaputra systems, Indus tributaries, and coastal waters of India (including Sundarbans). Given that fishery interactions are the primary cause of river dolphin mortality, the Inland Fisheries Act needs to be reviewed and amended so that rules and regulations are in place, making fisheries sustainable, and reducing risks to dolphins and other aquatic wildlife.

We need to consider the development of community-based river dolphin conservation areas, where sustainable fisheries and dolphin conservation measures are promoted in an integrated manner, with possible model planning, design, and implementation of ecotourism projects focused on dolphin watching, with appropriate safeguards against disturbance (harassment). Such projects should incorporate education and awareness efforts and should be promoted as a preferable alternative to dolphinariums. We also need to design and implement a national awareness campaign on river dolphins through innovative media programs and the establishment of interpretation and information centers in dolphin conservation/protected areas.

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