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Records of Indo-Pacific Humpback Dolphins (*Sousa chinensis*, Osbeck, 1765) Along the Coasts of India and Sri Lanka: An Overview

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Abstract

The Indo-Pacific humpback dolphin (*Sousa chinensis*, Osbeck, 1765) is found in coastal waters throughout the Indian and western Pacific Oceans, but the species has not been studied in detail along the coast of India. Records of stranded specimens, occasional sightings, incidental catches, and museum specimens are reviewed here, and these show that humpback dolphins occur along most Indian coastal areas and in northwest Sri Lanka. There also are two sighting records for the northeast Andaman Islands. An overview is given of a project carried out recently to study coastal cetacean populations in two areas along the west coast of India. Boat surveys were carried out along the coast of Goa and in the Gulf of Kachchh Marine Protected Area. The distribution, group size, and an index of abundance for *S. chinensis* in the two regions are evaluated. The sighting rate was over six times higher in Goa.

Key Words: India, Indo-Pacific humpback dolphin, *Sousa chinensis*, distribution, literature survey, India, Sri Lanka, boat survey

Introduction

Indo-Pacific humpback dolphins (*Sousa chinensis*, Osbeck, 1765) have been recorded from the southern coast of Africa to the eastern coast of Australia and central China (Jefferson & Karczmarski, 2001). The species is known to inhabit shallow, estuarine, and coastal habitats throughout its range and generally is found in waters less than 20 m deep. Humpback dolphins have been reported from many sites along the Indian coastline (see Kumaran, 2002; Sathasivam, 2000), although as Kumaran (2002) pointed out, many of the literature records contain errors.

There is a dearth of scientific information in all areas of behavioral, population, and conservation ecology. We do not know if the distribution of the species in Indian waters is continuous or discontinuous, with concentrations near estuaries. There has been no long-term study on this species anywhere in Indian waters. The World Conservation Union (International Union for the Conservation of Nature) lists the species as "Data Deficient," and its coastal habitat exposes it to a wide range of threats. In this paper, past records of humpback dolphins from India and Sri Lanka will be reviewed, and then relevant aspects of a recent study of the species at two sites along the west coast of India will be summarized.

Materials and Methods

Literature Survey

A detailed literature survey was conducted of all published and unpublished records of Indo-Pacific humpback dolphins from the region. Data on sightings, strandings, incidental and direct catches, and museum specimens were collated by date and region in Indian and Sri Lankan waters, and a list of possible misidentifications in the literature was produced.

Study Area

The Indian coastline measures about 7,516 km in length and is distributed among nine coastal states. The southern coasts are sandy and rocky, with lower salinity levels. The west coast and south coasts have coral reefs, mangrove patches, and tidal mudflats (Wells et al., 1995). Boat surveys were carried out in the Gulf of Kachchh Marine Protected Area and along the coast of Goa (Figure 1).

Gulf of Kachchh Marine Protected Area—The Gulf of Kachchh (22°39´N, 69°38´E), off the coast of Gujarat State on the western coast of India, has the largest area of coastal wetlands among all maritime states in India. It has a marine protected area

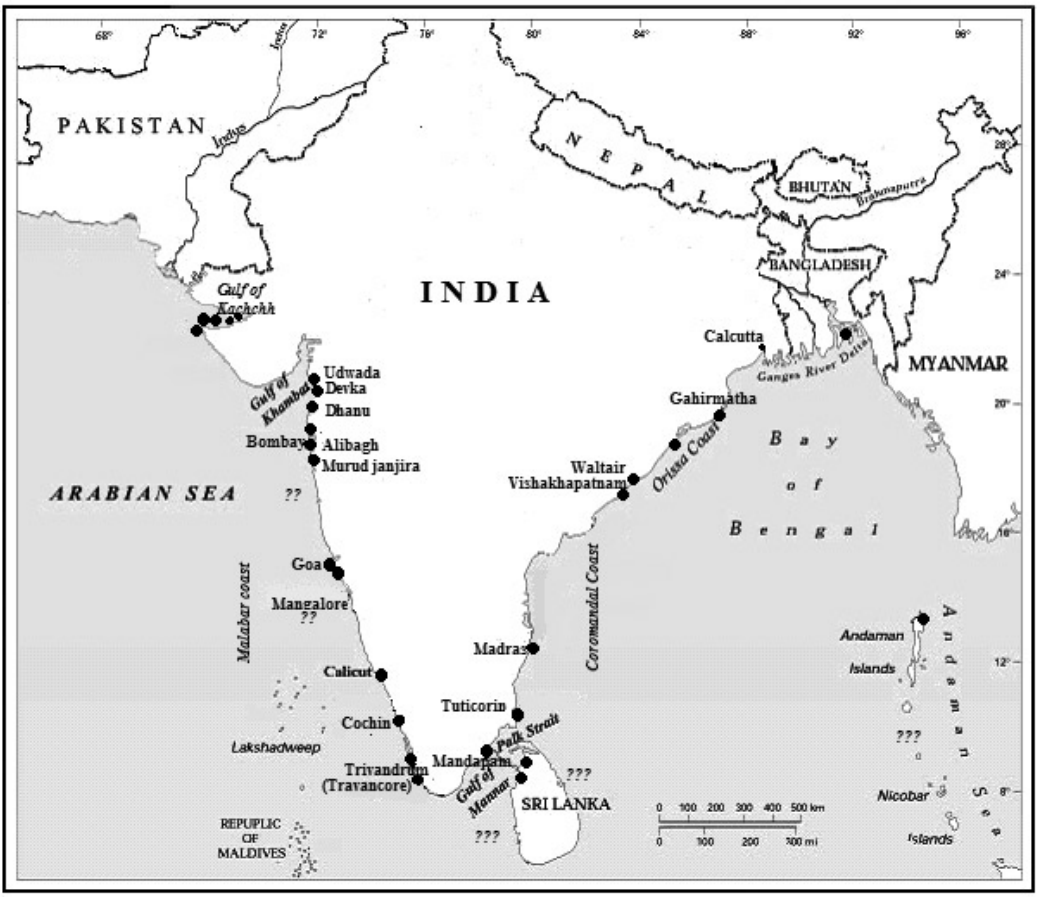


Figure 1. Occurrence of Indo-Pacific humpback dolphins along the coast of India; large, solid dots represent locations from where records are available; question marks represent areas where species presence is uncertain.

of 457 km^2 which covers approximately 200 km of coastline. It lies in a dry tropical zone with sandy, muddy, and rocky shores. The coastal topography is highly irregular, with islands, creeks, bays, and reefs. The coral reefs and mud flats extend 2-3 km from shore, making the coast very difficult to survey. There are no perennial streams flowing into the Gulf of Kachchh. During the monsoons, some of the major rivers, such as the Ghi, Sinhan, and Sasoi Rivers, reach the marsh and mudflats. The water depth across the Gulf varies from 5-60 m, with the average being 30 m. Tidal fluctuations vary along the coast, with a maximum amplitude of 6 m. Water temperature averages 26º C, while salinity is about 37 ppt. Even though the region has been declared a marine protected area, the coastline is marked with three major shipping ports and at least six major industrial pockets.

Coast of Goa—Goa (14°50´-15°45´N, 73°40´-74°15´E) has approximately 104 km of open coastline. It lies in a moist tropical zone, with sandy and rocky beaches, coral reefs, and mangrove patches. The continental shelf is wide and extends at least 20 km offshore. Water temperature is approximately 28º C, and salinity levels are around 36 ppt. Tidal amplitude is not as high as in the Gulf of Kachchh area, with a maximum change of 2 m. The Terekhol, Chapora, Mandovi, and Zuari Rivers flow into the Arabian Sea in northern Goa. The coastline of southern Goa is marked by shallow bays and estuaries of smaller rivers like the Talpona. With two major ports, Goa has approximately 600 fishing trawlers operating along its coast. The degree of large-scale industrialization along the coast of Goa is low compared to the Gulf of Kachchh. The coastline is lined with tourist accommodations. Dolphin-watching

cruises advertised by local fishermen and restaurants are a major tourist attraction. Parsons (1998) cited Goa as a good site for setting up a long-term research project on humpback dolphins after he made behavioral observations on dolphin watching cruises in Goa.

Field Methods

Boat Surveys—Between September 2001 and February 2002, boat-based surveys were carried out along the coast of Goa and in the Gulf of Kachchh Marine Protected Area to obtain data regarding species diversity, distribution, group size, and density. Between November 1998 and February 1999, opportunistic sightings also were made in Orissa, in the Bay of Bengal on the east coast of India. A fiberglass boat with a 25-hp outboard engine was used, and speed was maintained between 9-11 km/hr. Beaufort conditions varied from glassy smooth with no waves (Beau 0) to the presence of small white caps (Beau 3). The research team consisted of a boat driver and three observers: one primary observer at the bow and two observers on the sides. Transects were designed so as to cover the coastline uniformly, but no prior assumptions were made regarding dolphin distribution and stratification of habitat.

Two observers, one on each side of the boat, searched their respective sides with binoculars as the boat moved along the transect lines. Once a group was sighted, the observers suspended survey effort and noted the time, GPS position, and Beaufort conditions. The vessel was then diverted and the group was approached; a second GPS position was recorded at the group's location. These points were then transferred into Map Source GIS software, to generate a distribution map. These GPS points were then located on a Naval Hydrological Chart (Survey of India 2000) to obtain water depths. An attempt was made to photograph every individual using a Nikon F80 35-mm autofocus camera, with an 80-300 mm focal length lens.

A "group" of humpback dolphins was defined as a collection of dolphins within 20 m of each other. The number of individuals was counted within the first five minutes. Every observer did a group size count independently, and the most common value was used as the final group size. If all three values were different, the primary observer decided the final estimate of group size. One of the assistants continuously scanned the area to detect other groups or individuals approaching the area to avoid intermixing the new group with the original group under observation.

Two different types of transect lines were employed to cover the coast in the two study areas, owing to the differences in coastal hydrology and bathymetry in the Gulf of Kachchh Marine Protected Area and the logistical problems of arranging for a bigger boat in Goa.

Surveys were carried out along the main coastline and around eight islands in the Gulf of Kachchh. Tidal fluctuations gave the research team anywhere from three to six hours of search time. The coast was surveyed by traveling along and parallel to the shoreline. The boat moved along a track, approximately 2 km from shore (Figure 2). While moving along this line, the inshore edge of the observation area was the shoreline. The offshore edge of the observation area was up to 2 km away. Twenty-three transect strips were covered along the coast, each 7 km long and 4 km wide. All runs were independent events. Eight islands were surveyed similarly. This area was covered over a period of forty working days.

In Goa, approximately 85 km of the coast was surveyed. Bays, but not rivers and estuaries, were included in the study. The coast was divided into 20 blocks, each block a unit survey area of 12.4 km^2. To survey each block or unit area equally and uniformly, each one consisted of three lines parallel to each other, which were spaced 1 km apart (Figure 3). A distance of 4 km from shore was surveyed within each block. The lines were placed parallel to the coast instead of perpendicular, owing to the size of the boat, which could not be navigated easily against the prevailing wind direction. A distance of 200 m was maintained between adjacent blocks to avoid an overlap of unit survey areas.

Analysis Methods

The mean density of dolphins per block was calculated using the following equation:

$D = (gn)/A$

where,

g = mean group size per block,

n = number of sightings per block, and

A = area surveyed per block ($A_{Gulf\ of\ Kachchh} = 28$; $A_{Goa} = 12.4\ km^2$).

The average of the mean densities from all blocks was used as an index of abundance for the respective study areas.

Results and Discussion

Literature Review

Available records of humpback dolphins from Sri Lanka and India were reviewed (Tables 1 and 2). The published and unpublished literature was consulted to extract the types of records and numbers of individuals (if available), along with location, date, and other relevant details. There are a fairly large number of opportunistic records available, but few reports from dedicated studies (Table 2). Records are available from most coastal areas of

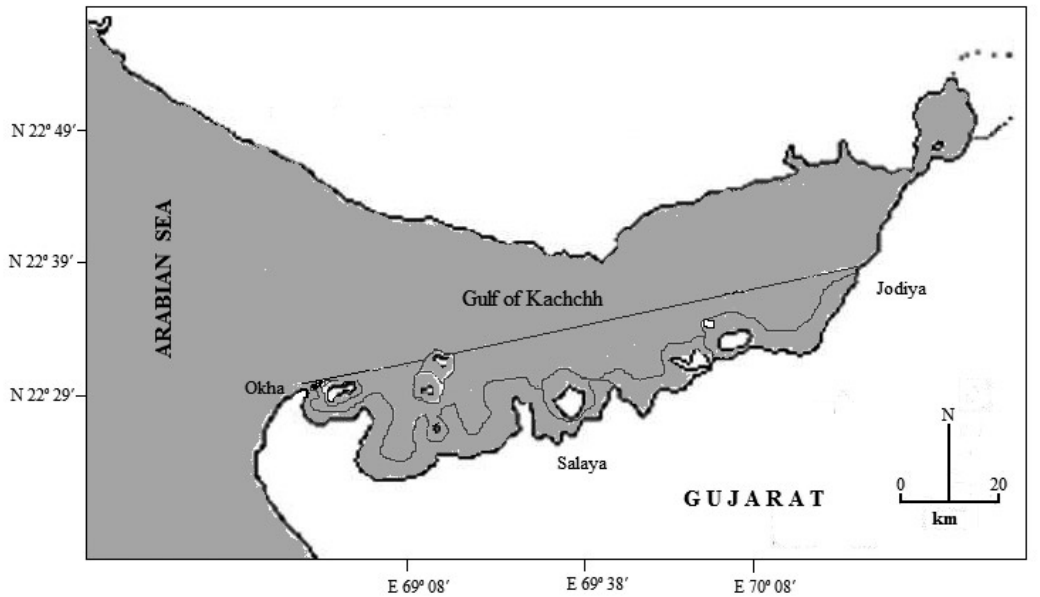


Figure 2. Survey design along the coastline of the Gulf of Kachchh marine protected area

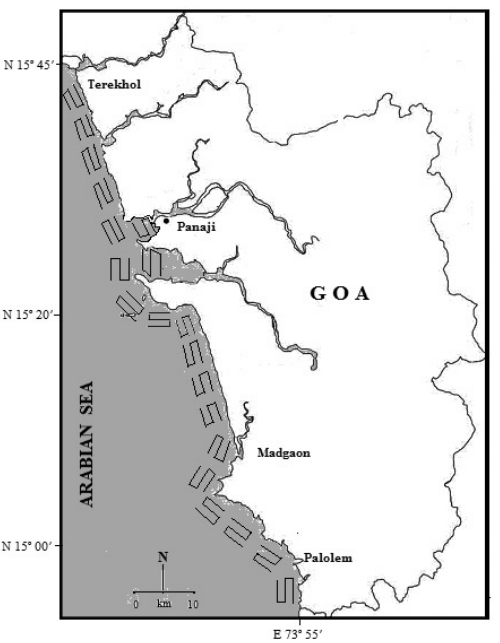


Figure 3. Survey design along the coast of Goa

India, although there are large gaps in some areas. It is unclear if these gaps are simply effort-related or if they are indicative of a patchy distribution. There also are records from the northwest coast of Sri Lanka. The absence of records from other parts of Sri Lanka is probably indicative of their absence in those waters, as extensive surveys have been conducted of marine mammals in Sri Lankan waters (Alling, 1986, 1988; Ilangakoon, 2002; Leatherood & Reeves, 1989). There are no records for oceanic archipelagos such as the Lakshadweep and Maldive Islands. This is to be expected, since *S. chinensis* is considered a nearshore, shallow-water species (Jefferson & Karczmarski, 2001); however, there are two records from the northern Andaman Islands (Leatherwood & Clarke, 1983).

During the surveys in Goa and the Gulf of Kachchh, three carcasses, two from Goa and one from the Gulf of Kachchh, were found. All three were male humpback dolphins. Tissue samples of kidney, liver, and blubber were collected for histological and toxicological studies, which will be analyzed at St. Xaviers College, Bombay. Skin samples were collected for mtDNA sequencing at the Centre for Cellular and Molecular Biology, India.

Notes on Misidentifications—Identifying cetaceans from sightings or stranded specimens is not an easy task, and literature reports often are erroneous. This appears to be especially true of Indian records (see Kumaran, 2002). After reviewing all the references listed in the tables, we found at least four references in which photographs clearly

Table 1. Records of Indo-Pacific humpback dolphins from published information along the coasts of Pakistan, India, and Sri Lanka

Source of data / Location	Pakistan	Gulf of Kachchh	Khambat to Bombay	Bombay to Mangalore	Mangalore to Kanyakumari	Gulf of Mannar and Palk Strait	Sri Lanka West	Sri Lanka East	Kariakal to Madras	Andhra and Orissa coasts	West Bengal to Bangladesh	Andaman and Nicobar	Lakshadweep and Maldives	Oceanic Arabian Sea	Oceanic Bay of Bengal	Estuarine and brackish
Sightings	√	√	√	√	√		√			√	√	√			√	√
Strandings	√	√	√	√	√	√			√	√					√	√
Incidental catches	√		√	√	√	√	√			√	√					√
Skeletal material	√		√		√	√	√									√

showed that the animals identified were not *S. chinensis*. The animals identified as *S. chinensis* by Ghosh & Choudhary (1986) were *Platanista gangetica*; those by Arumugam et al. (1992) were *Stenella attenuata*; and those by Kizakhudan et al. (1998) and by Balasubramanian et al. (2000) were probably *Stenella attenuata*. The animals identified by Jadhav & Rao (1998) as *Delphinus delphis* were actually *S. chinensis*.

Gulf of Kachchh Boat Surveys

In the Gulf of Kachchh survey, a total of 21 groups of *S. chinensis* were sighted during a search effort of 570 km (Figure 4). This gives a sighting rate of 0.037 groups/km. The mean density of *S. chinensis* in the area covered in the Gulf of Kachchh is calculated to be 0.27 individuals/km^2 (SD=0.3). A total of 15 groups were sighted along the coast, and six groups were sighted around the islands (Figure 4). A total of 78 individuals were counted. The group sizes of *S. chinensis* ranged from 1 to 11 (mean=3.9, SD=3.3, mode=2, median=2). Fifty percent of the sightings consisted of groups of two individuals.

Fifty-seven percent of the sightings were in water depths of 0-10 m. In waters ranging from 1-20 m, the average group size remained between 1.5 and 3.0 individuals, while in waters 21-30 m deep, average group size was 9.5.

In the coastal survey along the Gulf of Kachchh Marine Protected Area, six individuals were resighted from two transects. Chusna Island was surveyed four times, and every time a single group with group size ranging from 9-11 individuals was sighted. A total of 34 individuals have been catalogued, based on the shape of the dorsal fin, spotting pattern, and nicks/cuts on the dorsal fin. Five identifiable individuals were resighted in all four of these runs. The innermost transect, south of Jodiya, showed a resighting of one individual.

Goa Boat Surveys

The total search effort in Goa, including repeats, amounted to 573 km, which was completed over a period of forty days. A total of 61 transects were completed, including repeats. A total of 135 *S. chinensis* groups were sighted over the 573 km of the search effort (Figure 5). This yields a sighting rate of 0.236 *S. chinensis* groups/km. The total number of individuals counted was 842. The only other species sighted was the finless porpoise (*Neophocaena phocaenoides*).

The average group size of *S. chinensis* along the coast of Goa was calculated to be 6.3 (SD=7.1, median=4, mode=2, range=1-35). In Goa, out of the 135 groups sighted, 100 groups were sighted in the north, closer to the river mouths (Figure 5), and 60% of sightings were in water depths of 6-10 m.

The mean density of *S. chinensis* within the area covered along the coast of Goa is calculated to be 3.4 individuals/km^2 (SD=2.9). Photo-identification efforts from Goa were not successful, as the dolphins were very evasive and it was not possible to get many high-quality pictures.

Threats to the Species in India

The degree and types of threat to the marine environment and the local cetacean populations vary along the coast. Industrial problems such

Table 2. Records of *Sousa chinensis* from Sri Lanka and India; Inc = incidental catch

Date	Location	ID confirmed	Record, type, and number	Museum and specimen number	Reference(s)
1800s	Aripo, Sri Lanka	N	?, Skull	Museum of the Royal College of Surgeons	Blanford, 1888; Leatherwood & Clarke, 1983; Pilleri & Gihr, 1972
3 April 1934	Egoda-Uyama, Sri Lanka	Y	Photos	Colombo Museum No. 93	Deraniyagala, 1945; Leatherwood & Reeves, 1989
5 March 1983	Dutch Bay, Sri Lanka	N	Aerial sighting		Leatherwood & Reeves, 1989
Jan. 2002	Gulf of Kachchh, Gujarat	Y	Sightings, n=21		This paper
Jan. 2002	Gulf of Kachchh, Gujarat	Y	Stranding		This paper
16 Dec. 1976	Devka, Gujarat	N	Stranding, skeleton	PT Sarvajanik College of Science	Joglekar et al., 1977
April 1977	Udwada, S Gujarat	N	Stranding, skeleton	BP Baria Institute of Science	Joglekar et al., 1977
1800s	Alibagh, Maharashtra	N	Inc. catch	BNHS	Sterndale, 1887
March 1955	Bombay, Maharashtra	N	Sightings, n=2		Mörzer Bruyns, 1960
5 Sept. 1983	Bombay, Maharashtra	N	Sighting, n=1		Weitkowitz, 1992
20 March 1997	Murud Janjira, Maharashtra	N	Inc. catch in gill net		Jadhav & Rao, 1998
15 Nov. 1997	Murud Janjira, Maharashtra	N	Stranding		Rao, 1998
April 1894	Dhanu, Maharashtra	N	Stranding, n=1		Sinclair, 1895
?	Goa, Mandovi River	Y	Inc. catch, n=4		Pilleri & Gihr, 1974
1997?	Goa	Y	Sightings, n=27		Parsons, 1998
Oct. 2002	Goa	Y	Sightings, n=135		This paper
21 Nov. 2002	Goa	Y	Strandings, n=2; body ventrally cut off		This paper
1800s	Malabar coast	N	?		Blanford, 1888; de Silva & James, 1987
1827	Malabar coast	Y	?, skulls, type and co-type of *S. plumbea*	MNHN A-14378/A-3053, A-3051	Cuvier, 1829; Jefferson & Van Waerebeek, 2004; True, 1889
1837	Malabar coast	N	Sighting		Van Beneden & Gervais, 1880
1900s	Calicut?, Kerala	Y	?, skulls, n=4	R. S. Lal Mohan personal collection	Jefferson & Van Waerebeek, 2004
1900s	Calicut, Kerala	Y	?, Skull (age=6 years)	SWFSC WFP 0814	Jefferson & Van Waerebeek, 2004; W. F. Perrin, pers. comm.
1977-1980	Calicut, Kerala	Y	Inc. catch n=11 in gill net		Lal Mohan, 1985, 1995;
2 Sept. 1978	Calicut, Kerala	Y	Inc. catch in gill net		James & Lal Mohan, 1987
22 Dec. 1980	Calicut, Kerala	N	Sightings, n=4		Harwood, 1980

Table 2 (cont.)

12 Feb. 1981	Calicut, Kerala	Y	Inc. catch in gill net		Lal Mohan, 1983
15 Sept. 1981	Calicut, Kerala	Y	Inc. catch, fetus	Malabar Christian College	Lal Mohan, 1982
1954-1958	Cochin, Kerala	N	Sightings, n=5		Mörzer Bruyns, 1960
1981-1987	Cochin, Kerala	N	Inc. catch, n=45 in drift-net		Jayaprakash et al., 1995
1998-2001	Cochin, Kerala	Y	Sighting		R. Arthur, pers. comm.
11 Aug. 1908	Trivandrum, Kerala	Y	Inc. catch	Trivandrum Museum (specimen lost)	Leatherwood & Clarke, 1983; Lydekker, 1908; Pillay, 1926
18 March 1909	Travancore, Kerala	Y	?, skull; type of *Sotalia fergusoni*	BMNH 1903.9.12.2	Jefferson & Van Waerebeek, 2004; Lydekker, 1903
31 March 1903	Southwest coast of India	N	Inc. catch, n=2 driftnet		James et al., 1987
15 Sept. 1994	Mandapam region	Y	Stranding		Krishna Pillai et al., 1991
15 Sept. 1995	Mandapam region	Y	Stranding		Krishna Pillai & Lipton, 1996; Lipton et al., 1995
5 Feb. 1985	Seeniappa Dharga, Mandapam region	N	Stranding		Krishna Pillai & Lipton, 1996; Lipton et al., 1995
11 July 1983	Near Mandapam	N	Stranding – Palk Bay side		Krishna et al., 1988
16 Feb. 1994	Tuticorin Harbor	Y	Strandings, n=8		Kasim et al., 1994
28 June 1999	Off Tuticorin	N	Inc. catch with fetus in gill net		Arumagam et al., 1995
18 Sept. 1854	8 km N of Tuticorin	N	Strandings, n=28 (identification questionable)		Balasubramanian et al., 2000
18 June 1990	Madras/ Travancore, Kerala	Y	Stranding?	Trivandrum Museum (specimen lost)	Leatherwood & Clarke, 1983; Lydekker, 1903; Pillay, 1926
March 1983-1987	Waltair/ Vishakhapatnam	Y	Inc. catch/ sighting – type of *S. lentiginosa*	BMNH 1866.2.5.2 (1476a)	Jefferson & Van Waerebeek, 2004; Leatherwood & Clarke, 1983; Owen, 1866; True, 1889
1983-1987	Gahirmatha, Orissa	Y	Strandings, n=13, trawlers?		James et al., 1989
Nov. 1998-Feb. 1999	Gahirmatha, Orissa	Y	Sightings (several); strandings, n=2		This paper
26 April 1990	Bay of Bengal	Y	Inc. catch in gill net		Tanabe et al., 1993
10 March 1991	Bay of Bengal	Y	Inc. catch in gill net		Tanabe et al., 1993
? 1992	Bay of Bengal	Y	Inc. catch in gill net		Tanabe et al., 1993

Table 2 (cont.)

April 1982	Bay of Bengal	Y	Inc. catch, n=3; caught in gill nets		Prudente et al., 1997
?	NE Andaman Island	Y	Sightings, n=2		Leatherwood & Clarke, 1983
?	?	N	?, skull (listed as *Sotalia gadamu*)	Indian Museum (specimen lost?)	Sclater, 1981
?	?	Y	?, skull	BNHS UN-45	Jefferson & Van Waerebeek, 2004
?	?	Y	?, skull	BNHS M5966	Jefferson & Van Waerebeek, 2004; Pilleri & Gihr, 1974
?	?	Y	?, skull	BNHS 5965	Jefferson & Van Waerebeek, 2004; Pilleri & Gihr, 1974
?	?	N	Inc. catch in seine nets		Jones, 1975

Museum Acronyms: BNHS, Bombay Natural History Society; BMNH, Natural History Museum, London; MNHN, Muséum National d'Histoire Naturelle, Paris; SWFSC, Southwest Fisheries Science Center, La Jolla, California, USA.

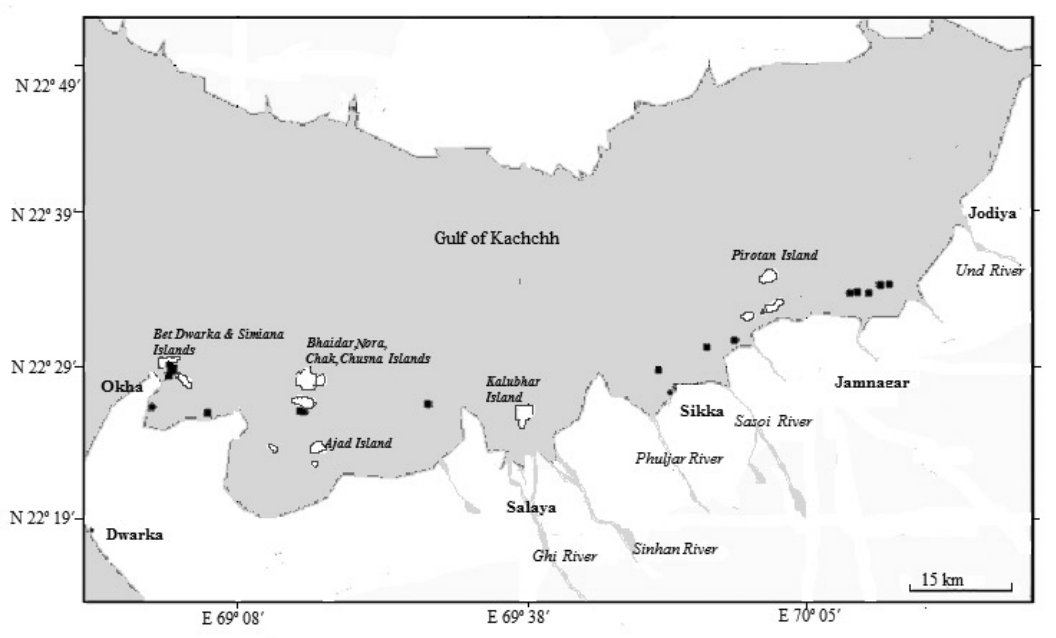


Figure 4. Sighting locations of *S. chinensis* (squares) in the Gulf of Kachchh marine protected area

as effluent pollution, land filling, and ship traffic are pervasive. Fishing industry-associated problems include shrimp farming, shrimp trawling, shark fisheries, and gill net and driftnet fisheries. Tourism also could be a source of disturbance, and even injury and death to dolphins, especially if boat operators do not follow proper techniques of approaching dolphins.

Conclusions

This study covered approximately 570 km and an area of 644 km^2 in the Gulf of Kachchh Marine Protected Area, and 573 km and 248 km^2 along the coast of Goa. Average group size of *S. chinensis* was found to be 3.9 individuals in the Gulf of Kachchh, and somewhat higher, 6.3 individuals,

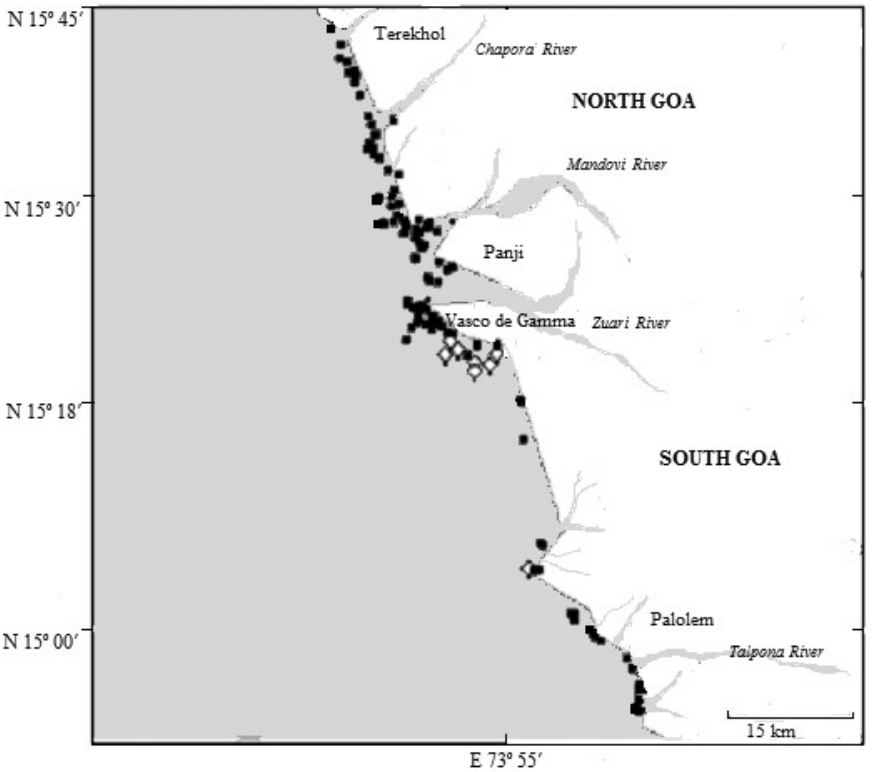


Figure 5. Sighting locations of *S. chinensis* (squares) and *N. phocaenoides* (circles) along the coast of Goa

along Goa. Maximum numbers of groups were sighted in a depth range of 0-10 m in both study areas.

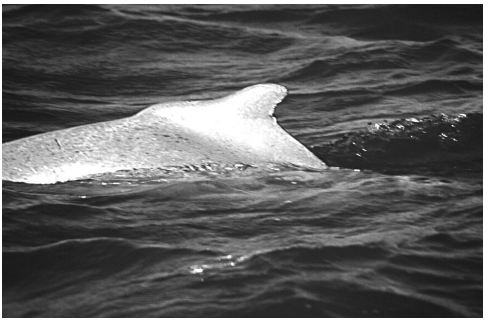
The total number of groups sighted, individuals sighted and the mean density of *S. chinensis* individuals differed between the two study areas. The difference in habitat types between the two areas is probably responsible for this disparity. The coastline of Goa is open, offers little resistance to movement of animals and has large freshwater inputs. In the Gulf of Kachchh, freshwater inputs are scarce, and movement of animals along the coast is limited, due to natural barriers like mudflats and coral reef formations. Moreover, the high tidal amplitude also may be a limitation to the amount of time the dolphins could spend close to the coastline. The difference in density and distribution between the two areas could also at least partially be due to differences in survey techniques and amount of area covered.

Animals along the coast of Goa were wary of tourist boats. This is an observation that could be further explored to study the effects of tourist boats on dolphin behavior. In the Gulf of Kachchh, animals were not shy of the boat. This could be due to the fact that tourist traffic is almost absent there, and the dolphins are not chased like they are in Goa.

Marked differences in body color and size of the dorsal hump were noted between the animals on the east and west coasts of India (Figure 6). Dolphins on the west coast (Gulf of Kachchh and Goa) had a large hump and appeared dark grey in color (resembling the *plumbea* type), while those on the east coast (Orissa) did not appear to possess a hump and were a much lighter pinkish color (more like the *chinensis* type) (see Jefferson & Van Waerebeek, 2004). This is suggestive that the Indian coastline could have two different forms (species or subspecies) of *Sousa*.

Further fieldwork is required in both areas to estimate population sizes accurately and to study the effects of changing environmental conditions and human activities on the respective populations. In addition, research on humpback dolphins in other parts of India, especially the poorly studied Bay of Bengal coast, are urgently needed.

a.



b.

c.

Figure 6. Differences in external appearance of Indo-Pacific humpback dolphins: 6a. Sighting from the Gulf of Kachchh Marine Protected Area in January 2001, 6b. Sighting from Goa in November 2001, 6c. Sighting from Orissa in January 1999; notice the prominent dorsal hump in the Gulf of Kachchh and Goa specimens, and its absence in the Orissa specimen.

Acknowledgments

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