

## A note on cetacean distribution in the Indian EEZ and contiguous seas during 2003-07

V.V. AFSAL<sup>+</sup>, K.S.S.M. YOUSUF<sup>+</sup>, B. ANOOP<sup>+</sup>, A.K. ANOOP<sup>+</sup>, P. KANNAN<sup>\*</sup>, M. RAJAGOPALAN<sup>+</sup> AND E. VIVEKANANDAN<sup>+</sup>

Contact e-mail: vafsal@gmail.com

### ABSTRACT

Relatively little is known about the distribution of cetaceans in Indian seas due to lack of systematic surveys. For collecting data on species distribution, 35 opportunistic surveys were conducted onboard FORV *Sagar Sampada* between October 2003 and February 2007 in the Indian EEZ and contiguous seas. In 5,254 hours of sighting effort, a total of 473 cetacean records were made with 5,865 individuals. The occurrence of 10 species from three cetacean families was confirmed. The Indo-Pacific bottlenose dolphin was the most frequently sighted species, whereas the spinner dolphin was dominant in terms of abundance. Long-beaked common dolphins, Indo-Pacific hump-backed dolphin and sperm whales were also recorded at frequent intervals. Cetaceans were found to have a wide geographical distribution in the Indian EEZ and contiguous seas. High abundance and species richness were recorded in the Southeastern Arabian Sea and southern Sri Lankan waters. From the information collected during the present study, the platform of opportunity has proved to be a useful means for cetacean survey.

KEYWORDS: SURVEY-VESSEL; INDIAN EEZ; DISTRIBUTION; BLUE WHALE; SPERM WHALE; FALSE KILLER WHALE; SHORT-FINNED PILOT WHALE; RISSO'S DOLPHIN; STRIPED DOLPHIN; SPINNER DOLPHIN; LONG-BEAKED COMMON DOLPHIN; INDO-PACIFIC BOTTLENOSE DOLPHIN; INDO-PACIFIC HUMP-BACKED DOLPHIN

### INTRODUCTION

India has an exclusive economic zone (EEZ) of about 2.02 million km<sup>2</sup>. The southern peninsula extends into the tropical waters of the Indian Ocean, with the Bay of Bengal in the east and the Arabian Sea in the west. Knowledge on the cetaceans in the Indian Seas is generally confined to reports from stranded and accidentally caught specimens, although information from these reports can help in understanding a number of important biological features of the populations. Consolidating this information, Kumaran (2002) concluded that 25 species of cetaceans and one species of sirenian, *Dugong dugon*, occur in the Indian Seas. However, these data, to a large extent, cannot be extrapolated to provide information on the true distribution or abundance of cetaceans. This lack of information is significant, as the Indian EEZ is located within the Indian Ocean Sanctuary, which was established in 1979 (IWC, 1980, p.27) to encourage conservation and research on cetaceans in the area. In India, cetaceans are classified as endangered and protected under the Wildlife (Protection) Act, 1972.

Systematic vessel surveys have not been conducted for cetaceans in the Indian Seas. This paper presents the results of ship-based sighting surveys of cetaceans in the Indian EEZ and contiguous seas onboard FORV *Sagar Sampada*. The primary objective of the study was to record occurrence and relative abundance.

### MATERIALS AND METHODS

The sighting surveys were conducted from October 2003 to February 2007 onboard the fisheries and oceanographic research vessel FORV *Sagar Sampada* (overall length: 71.4m). The cruises were multidisciplinary and hence the cruise tracks were determined by the needs of other projects; thus the vessel was used as a platform of opportunity. The study area included the coastal, continental shelf and

oceanic waters of the Indian EEZ and a part of the southern Sri Lankan Sea (Fig. 1). The surveyed area extended between 5-23°N and 66-95°E with a depth range of 20-5,000m. The speed of the ship varied with sea conditions and also with the kind of fisheries and oceanographic work carried out. When not on station, the average speed was seven knots. The surveyed areas had marked temporal variations, with striking changes in sea state and thus sighting conditions. The major seasonal oceanographic changes and adverse weather conditions are likely to have affected not only the cetacean distribution but the ability of observers to detect animals. Some species, particularly of dolphins and porpoises, are easily overlooked at higher sea states (e.g. Clarke, 1982). The survey was carried out in sea conditions corresponding to Beaufort scale zero to five; effort was suspended at six or above.

During the survey, data were collected by a single observer positioned on the flying bridge of the vessel, which was about 17m above sea level. This enabled the observer to look down into the wave troughs and spot cetaceans that would typically remain hidden from lower elevations. The observer scanned the ocean area in a 180° arc ahead of the ship, out to the horizon or to the farthest limit of visibility. The surveys were carried out during daylight hours, taking breaks for about four hours for lunch or for rest. Although the observations commenced at 0600hrs and ended at 1800hrs (and sometimes at 1900hrs, depending on the light condition), the average time of observation per day was considered to be eight hours. The visual surveys were carried out by scanning with naked eye interspersed with scans with binoculars. A Nikon 10×50mm CFWP handheld binocular was used for close observation of the located animal. A Nikon F80 camera fitted with Nikor 70-300mm lens and a Sony DCR-HC46E handycam with 800× digital zoom were employed to capture images of cetaceans (e.g. blows, dorsal fin, flipper, upper body, flukes etc.) to assist in confirming species identity.

<sup>+</sup> Central Marine Fisheries Research Institute, Cochin 682018, India.

<sup>\*</sup> Chennai Snake Park, Raj Bhavan Post, Chennai 600022, India.

On sighting a cetacean, a standard methodology was adopted to document the observation. Date, time, position, nearest landmark, distance from the shore, depth at the area of sighting, wind direction and force, sea state, visibility, sea surface temperature and salinity were recorded, along with details of the cetaceans including species, morphology, behaviour, group size and associated animals. The ship's position was recorded with the help of a *Simrad* GN33 GPS Navigator. For recording the depth at the area of sighting, a *Simrad* EK 60 echo-sounder of frequency 38kHz was employed. An *EMCON* SBE 9plus underwater unit provided SST and salinity data. Although angle and distance measurements to sightings with reference to the observer's position in the ship were obtained during some cruises, they were found inadequate to be presented in this paper.

The survey, being opportunistic, was conducted in 'passing mode' (i.e. the vessel did not divert to confirm species identification and school size) and cetaceans sighted were approached only rarely. The observed cetaceans were identified to the lowest taxonomic level possible, often based on a brief view of a splash, blow, dorsal fin, head, flipper or back, even though this needs lot of experience. Published pictures of the whole animal along with species description of body morphology, colouration and behaviours were compared with the observed characters for identification of the sighted individuals. Whenever necessary, the species identifications were validated later with the photographs taken onboard. 'Marine Mammals of the World' (Jefferson *et al.*, 1993) and other published literature aided identification and confirmation of species. Only confirmed sightings at the species or generic level are documented here. Unconfirmed and possible sightings were downgraded to 'unidentified whales' and 'unidentified dolphins'.

### Data analysis

The data collected were compiled in an *Excel* spreadsheet. *SPSS* and *Primer* were employed for statistical analysis. For distribution, relative abundance and diversity analysis, the survey area was divided into a  $2^{\circ} \times 2^{\circ}$  grid, and the number of sightings/individuals correlated with oceanographic parameters. For analysing the observation effort and sightings the surveyed area was segregated into six zones: northeastern Arabian Sea; southeastern Arabian Sea; northern Bay of Bengal; southern Bay of Bengal; Andaman Sea; and southern Sri Lankan Sea. For correlating the time of the day with the sightings, the hours of observation of a day were divided into five time strata, 0600-0900hrs, 0900-1200hrs, 1200-1500hrs, 1500-1800hrs and after 1800hrs; and the number of sightings in each time stratum was determined. To study seasonal distribution, the data were sorted by month. The sightings were plotted on maps using *Ocean Data View* Ver.3 software.

### RESULTS

From October 2003 to February 2007, a total of 35 cruises were conducted. Each cruise lasted for 10 to 45 days. The cruise tracks are given in Fig.1. The number of days at sea was 657 and the observation effort was 5,254 hours. In all, 764.7 hours (14.5% of total observation) were spent in the northeastern Arabian Sea, 2,017.8 hours (38.4%) in the southeastern Arabian Sea, 636.0 hours (12.1%) in the northern Bay of Bengal, 843.0 hours (16.0%) in the southern Bay of Bengal, 595.5 hours (11.3%) in the Andaman Sea and 397.0 hours (7.6%) in the southern Sri Lankan Sea (Indian Ocean). Observation conditions were almost always moderate to excellent, ranging in Beaufort scale from zero to five. Of the total sightings, 33.4% was at Beaufort 0-2,

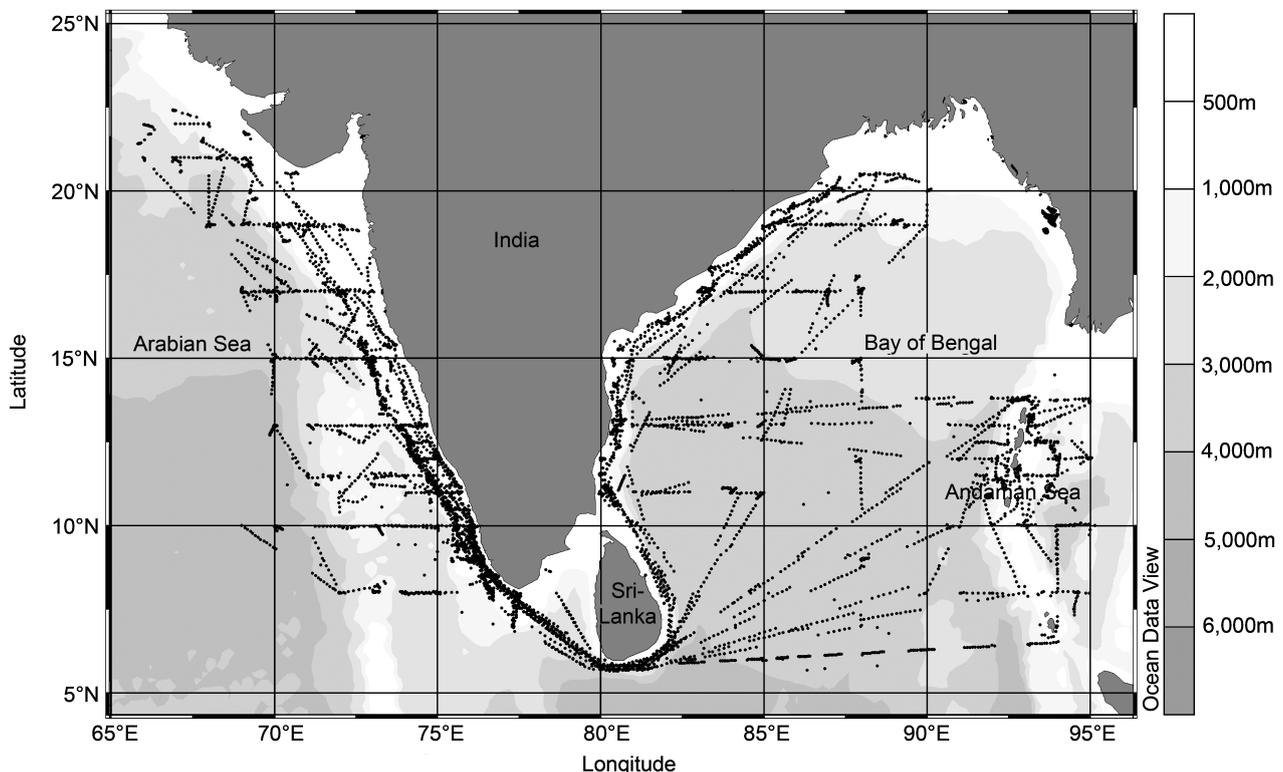


Fig. 1. Tracks of 35 cruises of FORV *Sagar Sampada* during October 2003-February 2007.

57.1% at Beaufort 3-4, and 9.5% at Beaufort five. Of 657 observation days cetaceans were sighted on 299 days. A total of 473 sightings, comprising 5,865 individuals were recorded. Of these, 26% (123 sightings; 1,619 individuals) were identified to species or genus. Almost one-third of sightings were made during the period 1500-1800 hours.

**Geographical distribution**

The surveys revealed that cetaceans are widely distributed in the Indian EEZ and contiguous seas (Fig. 2). A total of 124 sightings (26.2%) were over the continental shelf (<200m depth) and the remaining (73.8%) from oceanic waters (>200m depth). In the southern Sri Lankan Sea, the number of sightings and individuals per hour of observation were the highest at 0.22 and 1.78 respectively (Table 1). This was followed by the southeastern Arabian Sea with 0.10 sightings h<sup>-1</sup> and 1.24 individuals h<sup>-1</sup>.

**Species distribution**

Among the 10 species identified, two were whales and eight were small cetaceans. The two species of whales were the blue whale (*Balaenoptera musculus*) of the family Balaenopteridae and the sperm whale (*Physeter*

*macrocephalus*) of the family Physeteridae. The small cetaceans recorded were false killer whale (*Pseudorca crassidens*), short-finned pilot whale (*Globicephala macrorhynchus*), Risso’s dolphin (*Grampus griseus*), striped dolphin (*Stenella coeruleoalba*), spinner dolphin (*Stenella longirostris*), long-beaked common dolphin (*Delphinus capensis*), Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) and Indo-Pacific hump-backed dolphin (*Sousa chinensis*), all belonging to the family Delphinidae.

The Southeastern Arabian Sea showed the highest species diversity with records of nine species followed by the Southern Sri Lankan Sea with six species (Table 2).

The Indo-Pacific bottlenose dolphin was the species recorded most often (26 sightings) whereas the spinner dolphin was the most abundant in terms of number of individuals (552). The long-beaked common dolphin and Indo-Pacific hump-backed dolphin were also relatively abundant. The group size of spinner dolphin was the largest and ranged from 5 to 110 individuals (mean: 33). Among the dolphins, the group size of Indo-Pacific hump-backed dolphin was the smallest (mean: 3.6). The sperm whale was the most frequently sighted species among large whales. Group size is shown in Table 3.

Table 1  
Observation effort and sightings in the six areas during 2003-2007.

Area	No. of 2°x2° grids	Effort (h)	Sightings	Sightings/h	Individuals	Individuals/h
Northeastern Arabian Sea	12	764.7	45	0.059	411	0.54
Southeastern Arabian Sea	17	2,017.8	194	0.096	2,506	1.24
Northern Bay of Bengal	13	636	39	0.061	751	1.18
Southern Bay of Bengal	23	843	66	0.078	995	1.18
Andaman Sea	14	595.5	43	0.072	497	0.83
Southern Sri-Lankan Sea	7	397	86	0.22	705	1.78
Total	86	5,254	473	0.09	5,865	1.12

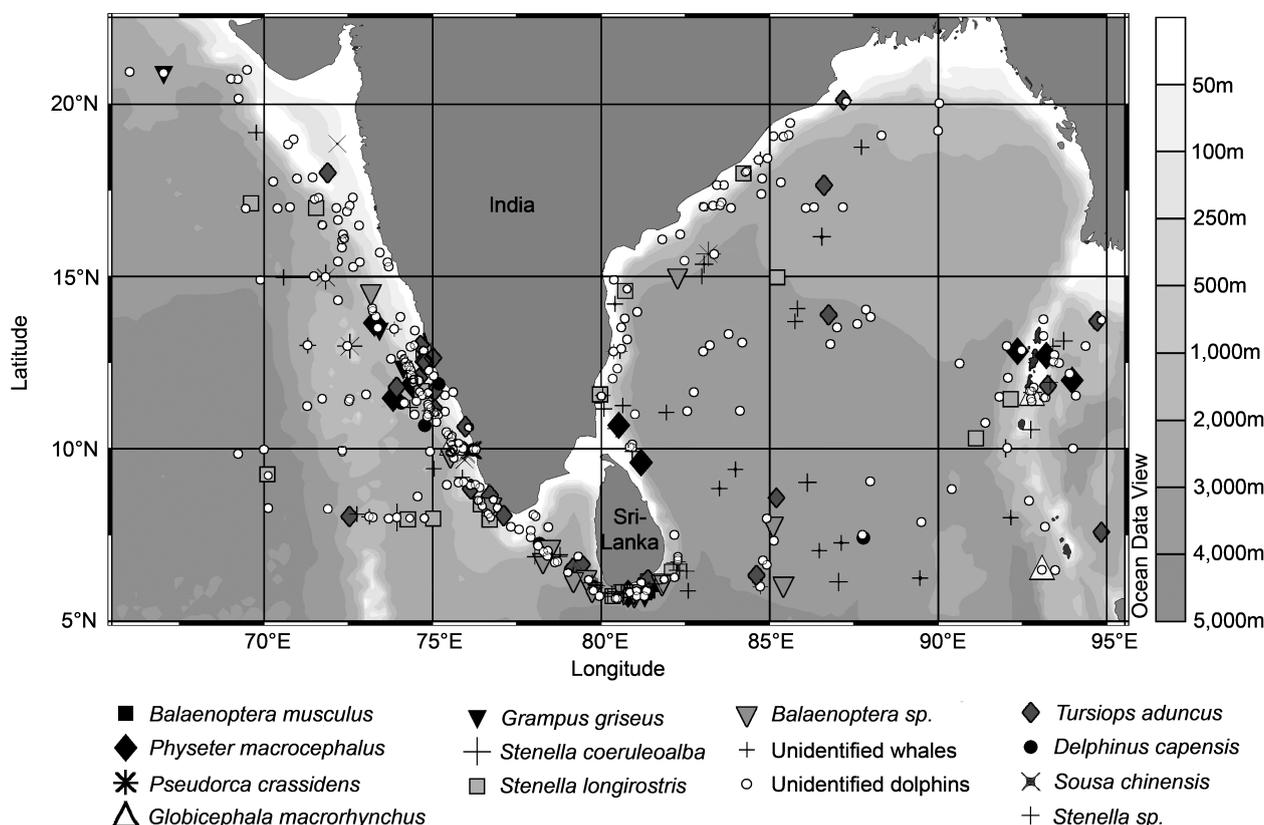


Fig. 2. Distribution map of cetacean species based on FORV Sagar Sampada sighting cruises during October 2003-February 2007.

Table 2  
Number of sightings (s) and individuals (n).

Species	Northeastern Arabian Sea		Southeastern Arabian Sea		Northern Bay of Bengal		Southern Bay of Bengal		Andaman Sea		Southern Sri-Lankan Sea		Total	
	s	n	s	n	s	n	s	n	s	n	s	n	s	n
<i>Balaenoptera musculus</i>	0	0	0	0	0	0	0	0	0	0	4	13	4	13
<i>Balaenoptera sp.</i>	0	0	3	9	0	0	3	7	0	0	12	24	18	40
<i>Physeter macrocephalus</i>	0	0	3	18	0	0	2	7	3	15	1	1	9	41
<i>Pseudorca crassidens</i>	0	0	3	18	1	4	0	0	0	0	0	0	4	22
<i>Globicephala macrorhynchus</i>	0	0	1	2	0	0	0	0	2	17	0	0	3	19
<i>Grampus griseus</i>	1	15	2	32	0	0	0	0	0	0	1	25	4	72
<i>Stenella coeruleoalba</i>	0	0	1	5	0	0	0	0	0	0	0	0	1	5
<i>Stenella longirostris</i>	2	80	7	254	1	20	3	155	2	13	2	30	17	552
<i>Stenella sp.</i>	0	0	1	6	2	220	2	23	4	50	2	40	11	339
<i>Tursiops aduncus</i>	1	4	14	208	2	10	2	30	3	35	4	32	26	319
<i>Delphinus capensis</i>	0	0	5	59	0	0	2	23	0	0	1	50	8	132
<i>Sousa chinensis</i>	1	6	17	59	0	0	0	0	0	0	0	0	18	65
Unidentified whales	1	1	13	17	3	4	14	25	2	3	33	90	66	140
Unidentified dolphins	39	305	124	1,819	17	493	38	725	27	364	26	400	284	4,106
Total	45	411	194	2,506	26	751	66	995	43	497	86	705	473	5,865

Table 3  
Sightings and abundance in the Indian EEZ and contiguous seas.

Species	No. of sightings	No. of individuals	Group size	
			Range	Mean
<i>Balaenoptera musculus</i>	4	13	1-7	3
<i>Balaenoptera sp.</i>	18	40	1-10	2.2
<i>Physeter macrocephalus</i>	9	41	1-9	4.5
<i>Pseudorca crassidens</i>	4	22	1-11	5.5
<i>Globicephala macrorhynchus</i>	3	19	2-10	6.3
<i>Grampus griseus</i>	4	72	12-25	18
<i>Stenella coeruleoalba</i>	1	5	5	-
<i>Stenella longirostris</i>	17	552	5-110	32.5
<i>Stenella sp.</i>	11	339	3-200	30.8
<i>Tursiops aduncus</i>	26	319	1-75	12.3
<i>Delphinus capensis</i>	8	132	2-50	16.5
<i>Sousa chinensis</i>	18	65	1-20	3.6

### Baleen whales

Of the 473 sightings, 22 records (4.7%) were baleen whales. Most of the sightings were off southern and southwestern Sri Lanka between 5-7°N and 78-82°E. On four occasions, the animals were identified as blue whales; the others were identified only to genus.

A total of four blue whale groups consisting of 13 individuals was encountered during the survey. All the sightings were from the southern Sri Lankan Sea between 5-7°N and 80-82°E. The school size varied from a single solitary animal to a group of seven individuals. In 18 sightings comprising 40 individuals, the animals could be identified as *Balaenoptera* sp. The sightings of balaenopterid whales were less frequent in Indian seas compared to off southern Sri Lanka. Groups of up to 10 individuals were recorded, but on most of the occasions it was either a solitary animal or a pair. The mean group size was 2.2.

### Sperm whales

The sperm whale was sighted on nine occasions (7.3% of confirmed sightings) with a total of 41 individuals. The sperm whale showed a wide distribution with records from the Southeastern Arabian Sea, Southern Bay of Bengal, Andaman Sea and Southern Sri-Lankan Sea. The group size ranged from one to nine.

### Delphinids

#### SPINNER DOLPHIN

A total of 17 sightings of spinner dolphins was recorded, which contributed 13.8% to the total confirmed sightings. They were sighted frequently in almost all parts of the survey area, showing a wide distribution in the Indian EEZ and contiguous seas. The spinner dolphin had the maximum number of individuals observed during the survey, 552 (34.1% of the total number in confirmed sightings) and they were usually seen in large active groups. The group size varied between five and 110 individuals (average 33).

#### INDO-PACIFIC BOTTLENOSE DOLPHIN

The Indo-Pacific bottlenose dolphin was encountered more frequently than any other cetacean during the survey. A total of 26 sightings of the species was recorded i.e. 21.1% of the total confirmed sightings. A total of 319 individuals was seen with group sizes ranging from 1-75, with an average of 12. Distribution was found to be wide with records from all the survey zones.

#### LONG-BEAKED COMMON DOLPHIN

Long-beaked common dolphins were recorded eight times, comprising 6.5% of the total confirmed sightings. A total of 132 individuals was observed. Six sightings were from the southeastern Arabian Sea while one sighting each was made in the Sri Lankan Sea and Andaman Sea. The number of individuals in the group varied between two and 50 with an average group size of 17 individuals.

#### INDO-PACIFIC HUMP-BACKED DOLPHIN

The Indo-Pacific hump-backed dolphin was sighted on 18 occasions, 14.6% of the total confirmed sightings, with a total of 65 individuals. This is a coastal species and 88.9% of the sightings were in Cochin backwaters and the Cochin bar-mouth area between 9°40'-9°59'N and 75°35'-76°18'E. The maximum group size was 20 individuals and the average was 3.6. Solitary individuals were also recorded.

#### Others

There were three sightings (2.4% of confirmed sightings) of short-finned pilot whales, which comprised 19 individuals. One sighting was in the southeastern Arabian Sea at 10°10'N and 75°58'E and the other two were in the

Andaman Sea. Group size ranged from 2-10 with an average of six individuals. Four sightings of false killer whales (22 individuals) were made during the survey, which contributed 3.3% to the total confirmed sightings. Three sightings were in the southeastern Arabian Sea at locations between 12-15°N and 71-73°E. The other was in the northern Bay of Bengal at 15°65'N and 83°18'E. Group size varied from 1-11 with an average of five individuals. Four sightings (3.3% of confirmed sightings) of Risso's dolphin were made. A total of 72 individuals were observed. The group size ranged from 12 to 25 individuals with an average of 18. Three of the sightings were in the Arabian Sea, and one off southeast Sri Lanka. One record of the striped dolphin with five individuals was made at 8°N and 73°57'E off Minicoy. On eleven occasions (8.9% of confirmed sightings) the animals were recorded as *Stenella* sp. A total of 339 individuals were observed and group sizes ranged from 3-200 with an average of 31 individuals.

**Unidentified cetaceans**

Identification of 350 sightings (74.0% of the total number of sightings) could not be made to species or genus and these were recorded as 'unidentified'. Of these, 60.0% (284 records) were small cetaceans with (a total of 2,788 individuals) and the remaining 14.0% (66 records) were whales (140 individuals). In this category more whale sightings were recorded from the Sri Lankan Sea, whereas occurrence of unidentified small cetaceans was common with records from all the six survey zones.

**Seasonal distribution of different species**

The survey cruises were conducted over 37 months, from October 2003-February 2007 (Table 4), although the number of days of observation was not equally distributed among the months, some effort and sighting records are available for all months and for three months (October, January and February) surveys occurred for all four years. The total maximum number of sightings was in February and the lowest in August whilst peak in sightings per day was maximum in November (1.13) and minimum in August (0.18).

Of the 37 months covered, the Indo-Pacific bottlenose dolphin was sighted in 18 months, spinner dolphin in 12 months and long-beaked common dolphin in eight months, and the sperm whale was sighted in seven months (Table 5). The Indo-Pacific bottlenose dolphin was sighted in all the months from January to December except in September. The Indo-Pacific hump-backed dolphin was sighted in 10 months (except in July and August), the spinner dolphin in eight months (except in April, May, August and October) and long-beaked common dolphin in seven months (except in March, July and August).

**DISCUSSION**

Ship-based visual survey is a conventional and widely practiced method to collect data on the relative and absolute abundance and distribution of marine mammals at the species level (Aragones *et al.*, 1997). The use of platforms of opportunity has been shown to be cost-effective and to

Table 4  
Number of sightings in each month (pooled for the years 2003-07).

Month	Observation effort		No. of days of sighting	No. of sightings	Sightings/day	Sightings/h
	Days	Hours				
Jan.	62	496	27	40	0.65	0.08
Feb.	61	488	33	62	1.02	0.13
Mar.	32	254	18	24	0.75	0.09
Apr.	58	464	27	36	0.62	0.08
May	42	336	27	37	0.88	0.11
Jun.	70	560	31	50	0.71	0.09
Jul.	65	520	27	38	0.58	0.07
Aug.	44	352	6	8	0.18	0.02
Sep.	53	424	31	46	0.87	0.11
Oct.	51	408	24	42	0.82	0.1
Nov.	47	376	24	53	1.13	0.14
Dec.	72	576	24	37	0.51	0.06

Table 5  
Number of sightings by month during Oct. 2003-Feb. 2007.

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Frequency (months)
<i>Balaenoptera musculus</i>		2						2					4	2
<i>Balaenoptera</i> sp.		5			1	1	5		1	2	2	1	18	8
<i>Physeter macrocephalus</i>	3	3				2				1			9	4
<i>Pseudorca crassidens</i>				2			1			1			4	3
<i>Globicephala macrorhynchus</i>		2				1							3	2
<i>Grampus griseus</i>				1							3		4	2
<i>Stenella coeruleoalba</i>											1		1	1
<i>Stenella longirostris</i>	1	2	1			2	2		4		2	3	17	8
<i>Stenella</i> sp					1	4	4	1			1		11	5
<i>Tursiops aduncus</i>	4	3	1	2	1	1	4	1		1	5	3	26	11
<i>Delphinus capensis</i>	1	2		1	1				1	1		1	8	7
<i>Sousa chinensis</i>	2	2	1	1	1	2			3	2	1	3	18	10

contribute to the knowledge on cetaceans, especially when data are collected by trained personnel following standard procedures (Robbins *et al.*, 2006; Robbins and Mattila, 2000).

The encounter rates recorded in the present study are lower than other records from the Indian Ocean (Table 6). In the northwest Indian Ocean and Sri Lankan waters, Alling (1986) reported 0.9 sightings per day. Sighting records as high as 6.4 per day have also been recorded (Ballance and Pitman, 1998).

The low sighting records in the present study may be due to a number of limitations:

- (i) all the cruises were 'opportunistic' without a structured cruise programme, and the effort was not uniformly distributed temporally and spatially;
- (ii) the vessel FORV *Sagar Sampada* is too large for sighting cruises and not easily maneuverable, making tracking an animal after sighting impossible;
- (iii) the observation deck is 17m above sea level which may reduce the possibility of wrong identification of the species from that height – thus only confirmed identities are included here, which has resulted in the very high percentage (74.0%) of unidentified cetaceans;
- (iv) only a single observer was used whereas two observers is more normal and would have improved the quality of observation – three observers were used in the opportunistic survey conducted by Ballance and Pitman (1998) and this resulted in a substantially higher encounter rate.

In spite of these limitations, the following conclusions could be arrived at:

- (i) cetaceans were found to have a wide geographical distribution in the Indian EEZ and contiguous seas;
- (ii) abundance and species richness are greatest in the southeastern Arabian Sea (off Kerala-Karnataka) and southern Sri-Lankan waters (these areas were reported to have rich cetacean faunas in earlier studies – Alling, 1986; de Silva, 1987; Ilangakoon, 1997);
- (iii) among large whales, the sperm whale is the most abundant species with wide distribution. Baleen whales including the blue whale were relatively common in the Sri Lankan Sea which is known to be an important blue whale feeding area, even though the occurrence may be seasonal (Alling *et al.*, 1990) – Jefferson *et al.* (2008) suggest that the blue whales in this area may be the pygmy blue whale subspecies (*B. musculus brevicauda*);
- (iv) the distribution pattern observed in the present study agrees with historical records based on incidental capture.

The spinner dolphin was the most frequently recorded species during the last century in India (Kumaran, 2002). In the present survey, the spinner dolphin was dominant in terms of abundance, whereas Indo-Pacific bottlenose dolphin was the most dominant species in terms of number of records. These were followed by the long-beaked common dolphin and Indo-Pacific hump-backed dolphin. As the surveys were mostly in the fishing grounds, the four predominant delphinids observed in the study were among the most recorded species in incidental catches in fishing gear (Jayaprakash *et al.*, 1995; Lal Mohan, 1985; Sathasivam, 2006).

Of the 26 known species of marine mammals in Indian waters (Kumaran, 2002), the identification of only 10 species was confirmed during the survey. Four species that could not be confirmed but recorded as possible were the fin whale (*Balaenoptera physalus*), sei whale (*B. borealis*), common minke whale (*B. acutorostrata*) and humpback whale (*Megaptera novaeangliae*). The sightings recorded as possible sei whales may also be the Bryde's whale (*Balaenoptera edeni*), as these two species are difficult to differentiate at sea and the occurrence of the sei whale in the area is still doubtful (Jefferson *et al.*, 2008). Bryde's whale, pygmy sperm whale (*Kogia breviceps*), dwarf sperm whale (*K. simus*), Cuvier's beaked whale (*Ziphius cavirostris*), Irrawaddy dolphin (*Orcaella brevirostris*), killer whale (*Orcinus orca*), melon-headed whale (*Peponocephala electra*), rough-toothed dolphin (*Steno bredanensis*), pantropical spotted dolphin (*Stenella attenuata*), finless porpoise (*Neophocaena phocaenoides*), Ganges river dolphin (*Platanista gangetica gangetica*) and dugong (*Dugong dugon*) have been recorded from the region but were not sighted. Of these, the finless porpoise and pantropical spotted dolphin have been recorded as incidental catches in fishing gear (Yousuf *et al.*, 2008) and a stranded Bryde's whale (Jayasankar *et al.*, 2007) was recorded along the Gulf of Mannar (Southeast coast of India) when the sighting survey was under progress. In 2008, a rough-toothed dolphin was washed ashore near Karwar (southwest coast of India; Miriam Paul, pers. comm.). The finless porpoise and Irrawaddy dolphin are distributed in shallow coastal waters where FORV *Sagar Sampada* could not operate. The Ganges river dolphin is a freshwater form and the dugong is a resident of the Gulf of Mannar and Palk Bay, which were not covered in the surveys. It is possible that the species which were not recorded in the present study may have been included in the unidentified sightings, or they may be rare in occurrence, even though many of these species were reported earlier from the study area (Chantrapornsyl *et al.*, 1991; Kumaran, 2002; Leatherwood *et al.*, 1991).

Table 6

Comparison of present study with other cetacean sighting surveys.

Area	Type of survey	Observation effort (hours/days)	No. of species	No. of sightings	Individuals	Sighting effort		Reference
						Per hour	Per day	
Northwest Indian Ocean and Sri Lanka	Dedicated	295 days	13	271	5,361	...	0.9	Alling (1986)
Western tropical Indian Ocean	Opportunistic	403.9h/92 days	21	589	31,136 (corrected value)	1.5	6.4	Ballance and Pitman (1998)
East Kalimantan, Indonesia	Dedicated	362h/80 days	9	112	868	0.3	1.4	Kreb and Budiao (2005)
Indian EEZ/contiguous seas	Opportunistic	5,254h/657 days	10	473	5,865	0.1	0.7	Present study

This platform of opportunity has provided a useful means for collection of cetacean sighting data. The data generated on species occurrence and distribution will be useful for assisting with the estimation of the abundance of marine mammals in the Indian Seas in the future. For this, the oceanic surveys onboard research vessels need to be supplemented with coastal surveys with smaller boats.

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