

# Cetacean sightings and acoustic detections in the offshore waters of Sri Lanka: March–June 2003

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## ABSTRACT

The Indian Ocean Sanctuary was established in 1979 in an effort to allow exploited stocks of whales to recover from whaling and to facilitate benign research. Further information is required to establish comprehensive management and conservation measures for species within these waters. The current study took place in the offshore waters of Sri Lanka in early 2003. During three research cruises conducted between 29 March and 17 June 2003 the *R/V Odyssey* covered a total track line of 4,480km around the island resulting in 52 confirmed group sightings of 11 species from three cetacean families. As the tracklines were designed to locate sperm whales (*Physeter macrocephalus*) for tissue sampling, they accounted for the greatest number of sightings. Only two species of balaenopterids, the blue whale (*Balaenoptera musculus*) and the Bryde's whale (*Balaenoptera edeni*), were recorded with the blue whale being the most frequently sighted species. Spinner dolphins (*Stenella longirostris*) were the most dominant species in terms of numbers. Some small odontocetes such as the common bottlenose dolphin (*Tursiops truncatus*), striped dolphin (*Stenella coeruleoalba*) and Fraser's dolphin (*Lagenodelphis hosei*) were observed in mixed-species groups, while one group of melon-headed whales (*Peponocephala electra*) was seen associating with a group of sperm whales. Risso's dolphins (*Grampus griseus*) were frequently sighted throughout the research cruise, with one unusual record of a large mating group. Many sightings were made in the vicinity of the numerous submarine canyons around Sri Lanka's coastline highlighting their potential role in enhancing productivity in the offshore waters. It is concluded that Sri Lankan offshore waters hold a rich, but little surveyed cetacean fauna that warrants further studies and implementation of conservation measures to protect these populations.

KEYWORDS: INDIAN OCEAN; BLUE WHALE; SPERM WHALE; FALSE KILLER WHALE; PANTROPICAL SPOTTED DOLPHIN; SPINNER DOLPHIN; BRYDE'S WHALE; BOTTLENOSE DOLPHIN; STRIPED DOLPHIN; FRASER'S DOLPHIN; RISSO'S DOLPHIN; MELON-HEADED WHALE; MONITORING; SURVEY-COMBINED; CONSERVATION; INCIDENTAL CATCHES

## INTRODUCTION

Sri Lanka lies in the heart of the Indian Ocean Sanctuary (area north of 55°S), which was proposed by the Seychelles in its first year as a member of the International Whaling Commission (IWC) in 1979 (Leatherwood and Donovan, 1991). Sri Lanka is not a member of the IWC, but marine mammals within its 200-mile Exclusive Economic Zone (EEZ) are in theory protected under national legislation – the Fauna and Flora Protection Ordinance of 1993, as well as the Fisheries and Aquatic Resources Act of 1996. However, little is known about the composition, abundance and zoogeography of cetaceans off Sri Lanka, providing a poor basis for informed conservation efforts.

The physical characteristics of the coast of Sri Lanka, which include the presence of numerous deep canyons adjacent to the coast, help create a heterogeneous environment, which provides habitats for a variety of cetacean species. While references to the whales in Sri Lankan waters date as far back as the 2<sup>nd</sup> Century, records of stranded whales were first reported in the scientific literature in 1859 (Blyth, 1859; Fernando, 1912). The *Tulip* expedition, which spent three field seasons in the waters of Sri Lanka between the spring of 1982 and the spring of 1985 has thus far been the only comprehensive cetacean research programme in the waters of Sri Lanka (Alling, 1986). Although the study was focused on the tracking and documenting of sperm whale (*Physeter macrocephalus*)

populations (Gordon, 1991), other species such as blue whales (*Balaenoptera musculus*) (Alling *et al.*, 1991) and odontocetes such as spinner dolphins (*Stenella longirostris*), spotted dolphins (*S. attenuata*), striped dolphins (*S. coeruleoalba*), Risso's dolphins (*Grampus griseus*), bottlenose dolphins (*Tursiops truncatus*), pygmy killer whales (*Feresa attenuata*), dwarf sperm whales (*Kogia sima*), rough toothed dolphins (*Steno bredanensis*), false killer whales (*Pseudorca crassidens*) and Cuvier's beaked whales (*Ziphius cavirostris*) were documented either as live or bycaught specimens (Alling, 1986). The research conducted in Sri Lanka throughout the last thirty years concludes that a total of 27 species of cetacean occur in Sri Lankan waters (Bröker and Ilangakoon, 2008; Ilangakoon, 1989; 1997; 2002; 2006a; 2006c; Ilangakoon *et al.*, 2000a; Ilangakoon and Perera, 2009; Ilangakoon *et al.*, 2000b; Leatherwood and Reeves, 1989).

As a part of a five-year global programme the 'Voyage of the *Odyssey*', collected baseline data on the distribution and concentrations of chemical contaminants in the world's oceans. Ocean Alliance's research vessel *Odyssey* entered Sri Lankan waters in the spring of 2003. While the above goals were achieved by collecting tissue samples from sperm whales, the research was designed to obtain broader information on the species composition and distribution of all other cetaceans sighted. This paper presents sighting and acoustic data of cetaceans in Sri Lankan waters made from

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on board the *Odyssey* during the months of March–June 2003 with the aim of contributing additional data on cetaceans in this little surveyed area with increasing human encroachment.

## MATERIALS AND METHODS

The sighting surveys were conducted from March–June 2003 onboard the *R/V Odyssey*, a 28m ketch equipped for open ocean cetacean research. As the main aim of the cruise was to locate sperm whales, the vessel primarily followed depth contours greater than 500m and thus sightings of other cetaceans are biased to this preferred sperm whale habitat. In addition, the whole coastline was not surveyed due to security restrictions.

### Visual effort

Observation watches were performed during daylight hours (0600–1845hrs) from an observation platform situated 4.6m above water level. Using their naked eye and a pair of 7 × 40 binoculars two observers would make observations 180° forward of the boat out to the horizon at 7.5km. Vessel speeds were maintained at 4–6 knots. All sightings and other relevant data collected on the cetaceans were recorded in *logger 2000 v. 2.05* (developed by the International Fund for Animal Welfare – IFAW). In addition GPS position, local time and GMT, vessel course and speed, information on sea surface temperature and weather relating to sightings ability (sea state, swell and meteorological data) and navigational data were collected half hourly. Visual observations made within 2km of the *Odyssey's* track line were approached to make positive species identifications, collect photo-identification data and estimate group size.

### Acoustic effort

Acoustic detections were made using a two-hydrophone array towed at 100m from the stern via Kevlar-shielded cables. The hydrophone elements were separated by 3m and held together by a stabilising plastic mesh. Effective listening range was 2–20km depending on weather, sea conditions, vocalising species and whether the vessel was motoring or sailing. The output signal was connected to a pair of headphones and stereo speakers located in the pilothouse and monitored by the helmsperson 24 hours a day.

Two kinds of acoustic stations were conducted during the research. Every half hour and on the odd hour a 'slow to listen' was carried out, which involved slowing the boat to idle speed with the autopilot on standby and listening for 5–10 minutes on the headphones connected to the hydrophone. On the even hour an 'acoustic stop' was conducted that involved switching off the boat's engine, putting the boat in neutral gear, and listening in a similar manner with the hydrophone sunk to an average depth of 30m from the surface. Any acoustic contacts were then recorded.

### Sperm whale acoustic detections

Once sperm whales were acoustically detected the boat was manoeuvred in an effort to track the clicks using the 'bearing/time' display in the software *Rainbow Click* (RBC) v. 1.03.00 (IFAW). The output signal was also interfaced with a PC desktop computer with a stereo 16-bit sound card

and RS232 data input. Input data was automatically processed in real-time using RBC, which is specifically written for the analysis of sperm whale clicks. RBC uses the time of arrival of clicks at the hydrophone to generate a bearing to the sound source.

## RESULTS

During the three research legs conducted between 29 March and 17 June 2003, representative of the inter-monsoon and southwest monsoon periods, the *R/V Odyssey* covered a total track line of 4,480 km around Sri Lanka (Fig. 1). The first leg, lasting 6 days from 29 March through 3 April, followed the south coast of Sri Lanka along the 1,000m contour line to 6°36'N 82°03'E and returned to Colombo via the 2,000m depth contour (Fig. 1).

The second leg lasted from April 15 to April 30. After heading northwest into the Gulf of Mannar to 8°25'N 79°30'E, the *Odyssey* zigzagged southwards to 6°05'N 78°32'E, prior to travelling east along the 4,000m contour line. Next the *Odyssey* headed north along the east coast to 7°20'N 82°06'E before turning south and returning to Colombo via the 4,000m contour line (Fig. 1).

The final research leg of 7 days was conducted in three phases due to bad weather conditions resulting from the onset of the southwest monsoon. During this leg the *Odyssey* surveyed the Gulf of Mannar on the west coast (Fig. 1).

### Visual effort

A total of 76 marine mammal group sightings of an estimated 1,943 individuals were made during the study period (Table 1, Fig. 2), 68% of which were identified to the species level. Among the 11 species identified, three were whales and eight were small cetaceans (Table 1). The most commonly sighted was the sperm whale, which accounted for 13% of all sightings (Fig. 2). However, as the track lines were primarily designed to locate this species this dominance of sperm whales is likely biased. Blue whales and Bryde's whales were the other large whale species recorded in the area (Table 1). Of the small cetaceans, Risso's dolphins were recorded most often (6 sightings) while the spinner dolphin was the most abundant in terms of number of individuals ( $n = 605$ ). 32% of all sightings were of unidentified species, which included whales, dolphins and one beaked whale (Table 1).

### Acoustic effort

1,106 acoustic stations were conducted during the 624 hours of acoustic effort (Fig. 3). Cetaceans were detected 58% ( $n = 640$ ) of the time. The majority belonged to unidentified delphinids ( $n = 514$ ; 46%) with the rest belonging to sperm whales ( $n = 126$ ; 11%). The similarity in tonal and click sounds of the delphinid species rendered it difficult to acoustically identify the various species detected. As expected, blue whales were not detected using towed hydrophones since flow noise masks their low frequency signals and thus acoustic detections were biased towards odontocetes that vocalise at higher frequencies.

## DISCUSSION

A total of 11 species were positively identified during this study. This represents 41% of all cetacean species ever

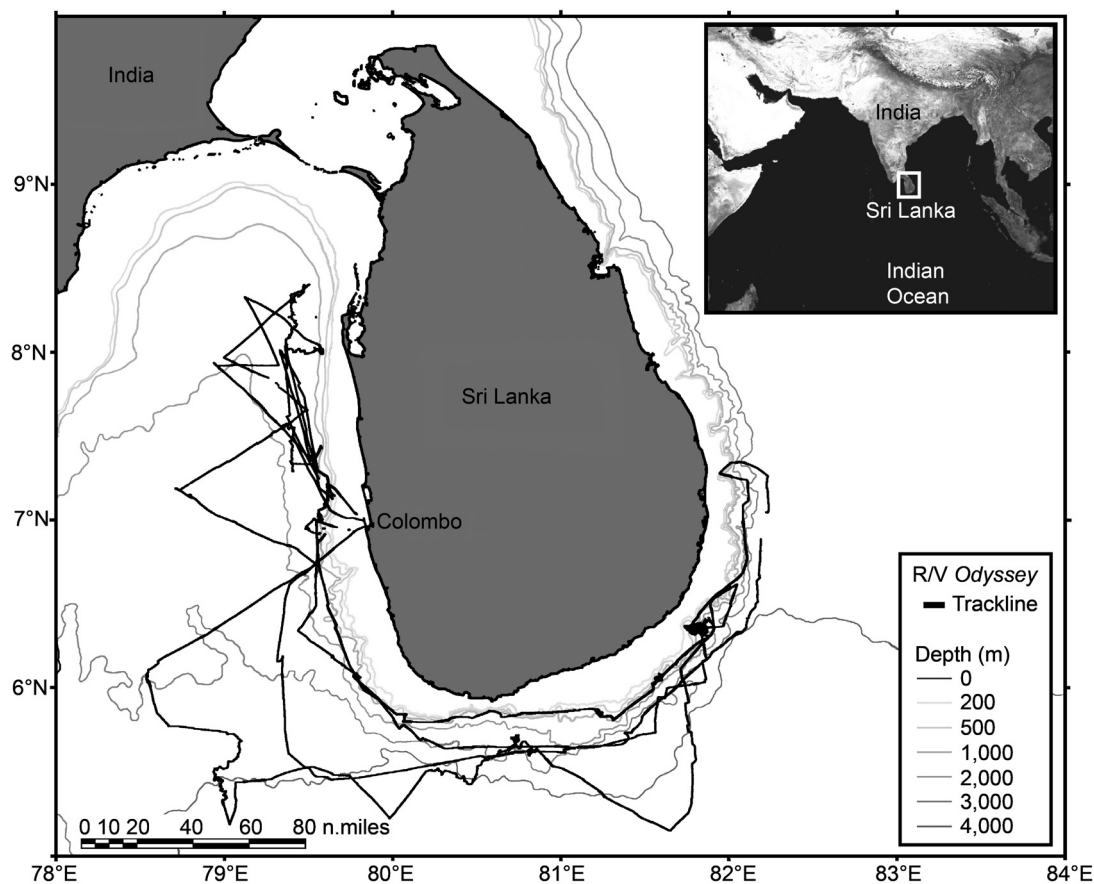


Fig. 1. Cruise track of the R/V *Odyssey* between 29 March and 17 June 2003 (black line).

recorded around the island (Ilangakoon, 2002). Of those not recorded many, such as the Ginkgo toothed beaked whale (*Mesoplodon ginkgodens*), common dolphin (*Delphinus delphis*) and finless porpoise (*Neophocaena phocaenoides*) are considered rare (Ilangakoon, 2002) while the records of fin whales (*Balaenoptera physalus*) within the Northern Indian Ocean (NIO) are currently being challenged (Dr R.L. Brownell Jr., pers. comm.).

Table 1

Visual sightings recorded during the three legs from 29 March to 17 June 2003.

Species (common name)	No. of sightings	Approx. no. of individuals
<b>Family Balaenopteridae</b>		
Blue whale	9	12
Bryde's whale	3	4
Unidentified balaenopterid	8	6
<b>Family Physeteridae</b>		
Sperm whale	10	128
<b>Family Delphinidae</b>		
Bottlenose dolphin	2	33
False killer whale	2	5
Fraser's dolphin	5	205
Melon-headed whale	3	180
Pantropical spotted dolphin	5	253
Risso's dolphin	6	153
Spinner dolphin	4	605
Striped dolphin	3	90
Unidentified delphinid	15	268
<b>Family Ziphiidae</b>		
Unidentified ziphiid	1	1

**Family Balaenopteridae**

*Blue whale (Balaenoptera musculus)*

This species is currently classified into three subspecies; *B. m. musculus* (northern hemisphere blue whale), *B. m. intermedia* (Antarctic or 'true' blue whale) and *B. m. brevicauda* (pygmy blue whale). The blue whale recorded around Sri Lanka is reportedly the pygmy blue whale (Alling *et al.*, 1991) albeit Brownell and Donahue (1994) proposed that the Northern Indian Ocean (NIO) populations be recognised as a separate subspecies, *B. m. indica*. These populations, like those of the NIO humpback whales reportedly have a restricted range and breed six months out of phase with the pygmy blue whales in the Southern Indian Ocean (Mikhalev, 2000), highlighting the conservation implications and significance of these subdivisions.

A juvenile blue whale was recorded off the west coast with other observations off the south east coast in close proximity to the Basses Submarine Canyon (Swan, 1983) (Fig. 2). Worldwide, aggregations of blue whales appear to be associated with areas of high productivity, particularly submarine canyons (Croll *et al.*, 2005; Rennie *et al.*, 2009). Observations of faecal matter during the present surveys also indicate that Sri Lanka represents a feeding ground for this species (Alling *et al.*, 1991; Branch *et al.*, 2007). Records show that blue whales are commonly documented around the island (Afsal *et al.*, 2008; Alling *et al.*, 1991; Ballance and Pitman, 1998; Branch *et al.*, 2007; Bröker and Ilangakoon, 2008; de Silva, 1987; Ilangakoon, 2002; 2006a), despite the limited sightings made during the



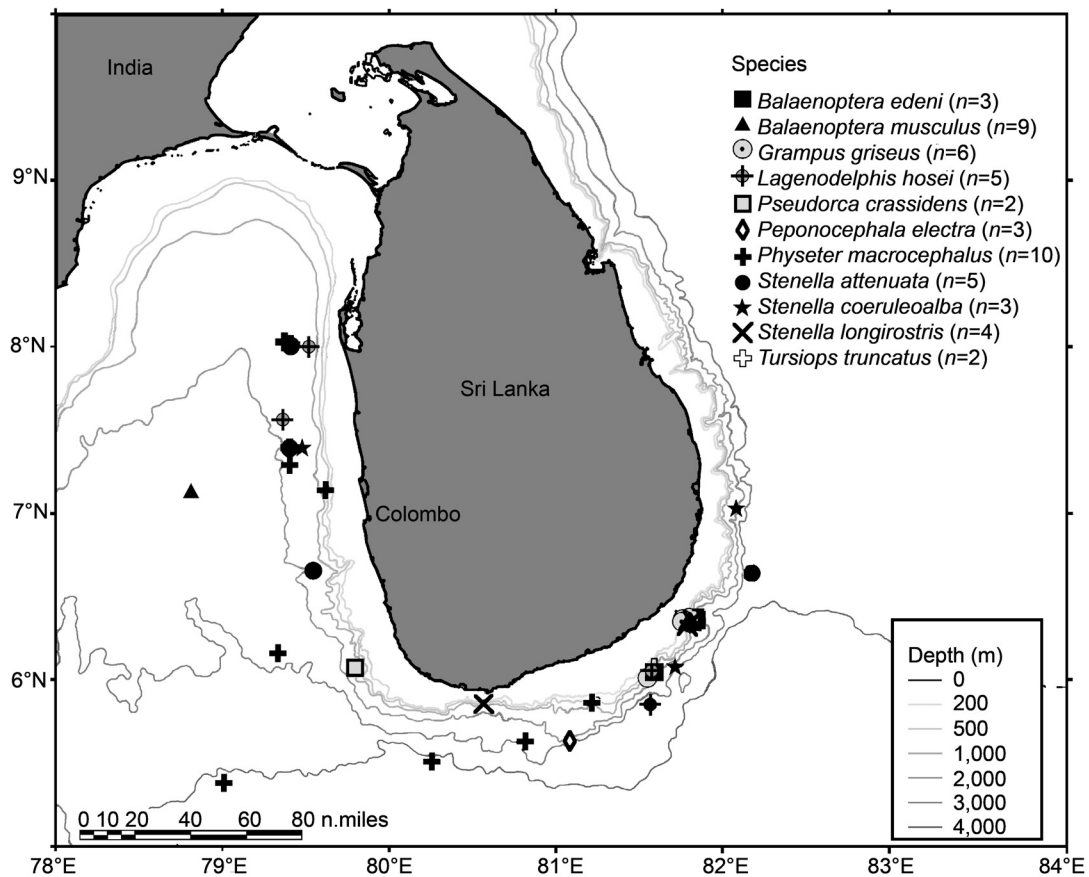


Fig. 2. Visual sightings recorded during the study period.

present study. In the past, sightings and stranding records of this species have been consistently made throughout the year (Deraniyagala, 1932; 1948; 1965; Fernando, 1912; Ilangakoon, 2002; 2006b) suggesting that the blue whales inhabiting these waters either do not undertake regular seasonal migrations, or maintain a population in this area throughout the year lending support to the theory of a NIO stock (Mikhalev, 1996; Yochem and Leatherwood, 1985).

#### *Bryde's whale (Balaenoptera edeni)*

Bryde's whales were the only other balaenopterid species observed during the surveys. All three sightings were made off the southeast coast close to the Basses Submarine Canyon (Swan, 1983) (Fig. 2). This species has been documented by all surveys undertaken around the island since the 1980s (Ballance and Pitman, 1998; Ilangakoon, 2002; 2009; Ilangakoon and Perera, 2009; Leatherwood *et al.*, 1984; Leatherwood and Reeves, 1989). However, strandings of this species have been low relative to other balaenopterids recorded in these waters (de Silva, 1987; Ilangakoon, 2006b). Evidence of Bryde's whales feeding – in the form of faecal matter – was observed several times.

#### **Family Physeteridae**

##### *Sperm whale (Physeter macrocephalus)*

During the Sri Lankan research leg, a total of ten sperm whale groups were sighted, comprising 128 individuals (Table 1; Fig. 2). The groups mostly consisted of sub-adults with few calves and adults being recorded. As the primary

objective of this cruise was to locate this species for tissue sampling, this high sighting rate highlights the bias in the data set. However, in general, they are commonly recorded and widely distributed in Sri Lankan waters (Afsal *et al.*, 2008; Ballance and Pitman, 1998; Bröker and Ilangakoon, 2008; de Silva, 1987; Gordon, 1987; 1991; Ilangakoon, 2002; 2006a).

The largest single group, numbering 23 individuals, was observed off the southern coast, almost directly south of Dondra head, the southern most point of the country. This sighting coincides with the Dondra Submarine Canyon (Swan, 1983) that may play a role in enhancing the productivity of this region. About 40 sperm whales were also recorded in close proximity to one another off the northwest coast, an area popular with whalers during the months of August to December in the 1840s (Wray and Martin, 1983). A dedicated survey by Bröker and Ilangakoon (2008) within the Bar Reef Marine Sanctuary also indicated the presence of this species during the inter-monsoonal period of August–September. The frequent sightings of large groups including calves in the waters off the northeast coast by Gordon (1987) may indicate that Sri Lankan waters are an important calving ground for this species.

Sperm whales were the only species acoustically identifiable to species level (Fig. 3). While the majority of acoustic detections were of 'unidentified delphinids' acoustic identification to the species level was difficult because of the similarity in the sounds produced. Therefore it is evident that there is a bias in the acoustic data towards large, easily identifiable (acoustically and visually) species.

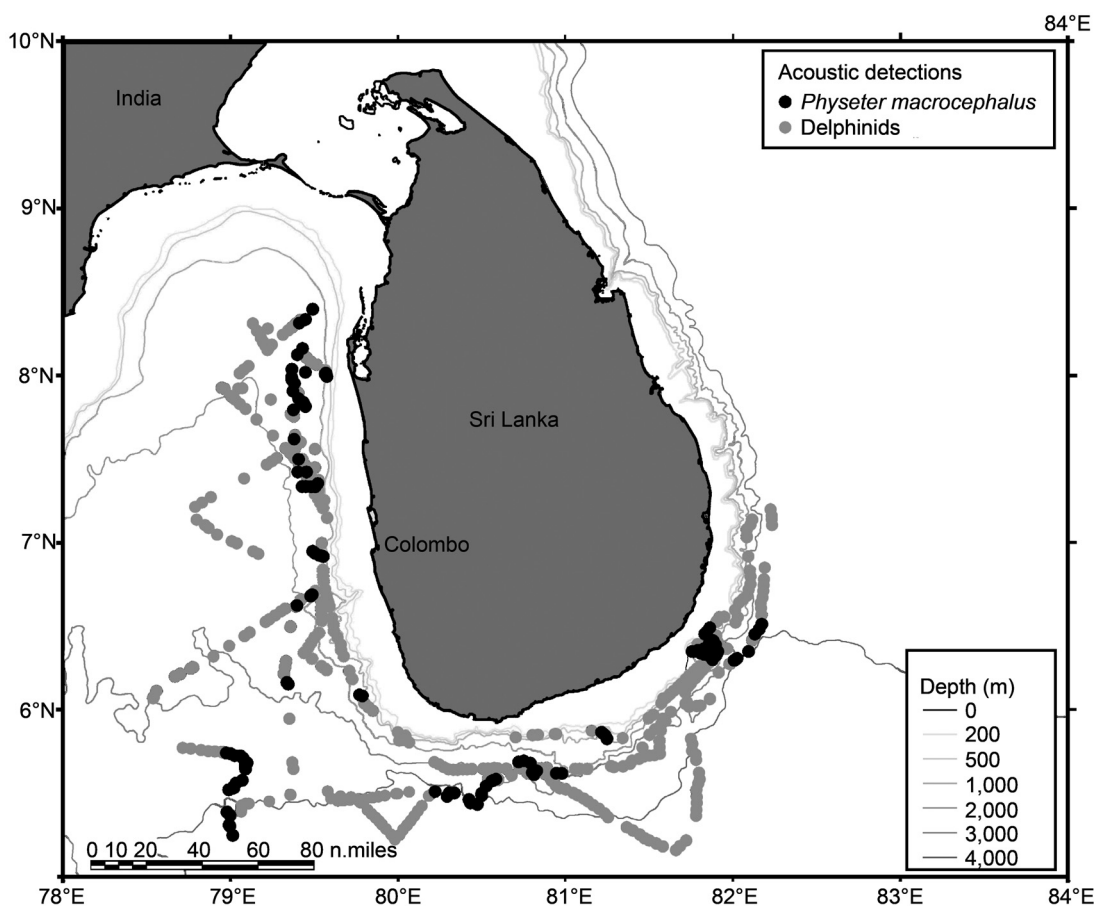


Fig. 3. Acoustic detections along *Odyssey's* track line. Sperm whales (black) and unidentified delphinids (grey).

### Family Delphinidae

#### *Bottlenose dolphin (Tursiops truncatus)*

Bottlenose dolphins were sighted on two occasions, off the west coast (Table 1; Fig. 2) and in the vicinity of the Basses Submarine Canyon in waters 1,000–1,800m deep. Their large sizes coupled with the depths at which they were recorded suggest that these groups belong to the offshore form of bottlenose dolphin. The small group recorded on the west coast of the country was seen travelling with a group of approximately 100 striped dolphins. Mixed-species groups such as this have been documented in the Western Indian Ocean and other parts of the world (Ballance and Pitman, 1998; Jefferson *et al.*, 2008). A group of 30 bottlenose dolphins was sighted on the southeast coast, a somewhat uncommon sighting as most are found in groups of 20 individuals or less (Jefferson *et al.*, 2008). This species is considered common around the island as evidenced by the frequent sightings and catch data from around the coastline (Alling, 1986; 1988; Bröker and Ilangakoon, 2008; de Silva, 1987; Ilangakoon, 1997; 2002; Ilangakoon *et al.*, 2000a; Ilangakoon *et al.*, 2000b).

#### *False killer whale (Pseudorca crassidens)*

Only two of the five species of 'blackfish' recorded from Sri Lankan waters were observed during this research cruise. Although false killer whales are considered highly social and often seen in groups of more than ten individuals (Jefferson *et al.*, 2008), only two sightings of small group sizes were made during this cruise (Table 1; Fig. 2). One record was made at a depth of 1,200m off the west coast of the island which is

not unusual as they are known to spend time in relatively deep, offshore waters (Jefferson *et al.*, 2008). This species has been recorded as live observations, strandings and in bycatch from around the island in the past (de Silva, 1987; Deraniyagala, 1960; Ilangakoon, 1997; 2002; Ilangakoon *et al.*, 2000b; Leatherwood *et al.*, 1991; Leatherwood and Reeves, 1989).

#### *Fraser's dolphin (Lagenodelphis hosei)*

Five groups of Fraser's dolphins were recorded representing 205 individuals (Table 1). They were generally observed at depths exceeding 1,000m, further reinforcing the observation that they are primarily an oceanic species (Ilangakoon, 2002; Jefferson *et al.*, 2008; Leatherwood *et al.*, 1992). The majority of records from Sri Lankan waters are provided through bycatch data collected between 1985–1994 by Leatherwood and Reeves (1989), Ilangakoon (1989; 1997), Ilangakoon *et al.* (1992) and Dayaratne and Joseph (1993). Ballance and Pitman (1998) also observed this species on the west coast of Sri Lanka while one unconfirmed sighting of this species was made in the Trincomalee area, on the east coast (Alling, 1986). On two occasions, schools of Fraser's dolphins were associated with other species, specifically Risso's and Pantropical spotted dolphins. Such associations have previously been documented by Leatherwood *et al.* (1992) and Perrin *et al.*, (1994). In the Maldives and elsewhere they have also been documented associating with short-finned pilot whales (*Globicephala macrorhynchus*) and melon-headed whales (Anderson, 2005; Leatherwood *et al.*, 1992; Perrin *et al.*, 1994).

*Melon-headed whale (Peponocephala electra)*

One group was sighted on the west coast of the country while the other was observed off the southern coast (Fig. 2). The latter group had an estimated 165 individuals, within which ten were classified as calves. This species is known to be highly social and generally found in very deep waters (Jefferson *et al.*, 2008), as confirmed by the data collected through this survey in waters 1,800 and 4,500m deep. Historical catch records indicate that melon-headed whales were present within the Palk Strait area (Blanford, 1891). Other areas where catch data indicate their presence include the west, southwest, south and northeast coasts (Dayaratne and Joseph, 1993; Ilangakoon, 2002; Ilangakoon *et al.*, 1992; Leatherwood *et al.*, 1991). Only one other confirmed sighting record is available from within the Bar Reef Marine Sanctuary on the northwest coast (Bröker and Ilangakoon, 2008) and one unconfirmed sighting from the east coast (Alling, 1986). During these surveys one group of melon-headed whale was seen associating with sperm whales – to our knowledge, a previously unrecorded sighting.

*Pantropical spotted dolphin (Stenella attenuata)*

Pantropical spotted dolphins are found extensively in all oceans and are primarily oceanic animals that prefer offshore waters. During these surveys they were observed in depths between 1,500–3,200m on the west, northwest and southeast of the country (Fig. 2). In the past, this species has been observed off the northwest coast off Puttalam, the southwest and the east coasts by Leatherwood *et al.* (1984) and Alling (1986). Past catch records indicate that they also appear around the northeast, southwest and southern coasts (Dayaratne and Joseph, 1993; de Silva, 1987; Ilangakoon, 1997). In terms of numbers of individuals sighted, this species ranked second ( $n = 253$ ).

*Risso's dolphin (Grampus griseus)*

Six groups of Risso's dolphins were sighted with group sizes ranging from 8–50 individuals. Past catch and sightings data indicate that this species is common and widespread around Sri Lanka (Afsal *et al.*, 2008; Alling, 1986; 1988; de Silva, 1987; Ilangakoon, 1997), however it was only documented off the southeast coast during these surveys. Risso's dolphins were generally recorded at depths between 800–2,000m confirming their preference for waters seaward of the continental shelf, steep bottom topography (Baumgartner, 1997; Kruse *et al.*, 1999) and deep oceanic waters (Alling, 1986; Ilangakoon, 2002). While most records were of traveling or bow-riding Risso's dolphins, one unusual record was also made of a large group of mating individuals. Additionally, in one instance, this species was seen closely associating with a large group of Fraser's dolphins as previously reported (Leatherwood *et al.*, 1992; Perrin *et al.*, 1994).

*Spinner dolphin (Stenella longirostris)*

The largest group of dolphins sighted during these surveys comprised of an estimated 500 spinner dolphins. According to Ballance and Pitman (1998) spinner dolphins were the most abundant species, in terms of numbers sighted, in the western Indian Ocean. Afsal *et al.* (2008) noted that this species was the most abundant in terms of number of

individuals in their surveys within the Indian EEZ and contiguous seas. In addition, catch records (Dayaratne and Joseph, 1993; de Silva, 1987; Ilangakoon, 1989; 1997; Ilangakoon *et al.*, 2000a; Ilangakoon *et al.*, 2000b; Leatherwood and Reeves, 1989) and sightings surveys (Afsal *et al.*, 2008; de Silva, 1987; Ilangakoon, 2002; 2005; 2006a; 2006c) show that this species is the most common cetacean in Sri Lankan waters. The presence of large active groups (Afsal *et al.*, 2008) provides evidence of their highly gregarious nature, which has been documented in the past (Ilangakoon, 2002). Three of the four groups recorded were observed in the Basses area, with one group comprising of two juveniles and five calves (Fig. 2). Alling (1986) previously documented the presence of calves during this same period. The final sighting was made along the southern coast adjoining Dondra Head, in the vicinity of a deep-water submarine canyon.

*Striped dolphin (Stenella coeruleoalba)*

Striped dolphins were sighted on three occasions during this study. They were consistently recorded in deep oceanic waters (1,450–4,500m) confirming their preference for these offshore habitats (Alling, 1986; Jefferson *et al.*, 2008). The largest group comprising of 50 individuals was sighted off the west coast of the country where it was sighted in a mixed group with bottlenose dolphins. A further group was observed in the Basses Canyon area on the southeast coast, with a final group on the east coast adjoining Batticaloa, the northernmost extent of this research cruise (Fig. 2). The submarine canyons located in these areas may play a role in enhancing productivity, which in turn attracts cetaceans.

Alling (1986) documented the occasional presence of calves off Sri Lanka in surveys conducted in February–April, however no calves were sighted during these surveys. Other catch (Alling, 1988; Dayaratne and Joseph, 1993; de Silva, 1987; Ilangakoon, 1997; 2002) and sighting data (Alling, 1986; Ballance and Pitman, 1998; de Silva, 1987) highlight the prevalence of this offshore species around the coast of Sri Lanka.

**Conservation implications**

The data gathered during the Sri Lankan research leg add support to the view that Sri Lanka is an area of high cetacean diversity, within the Indian Ocean Sanctuary (Afsal *et al.*, 2008). The narrow and very steep continental shelf/slope resulting in deep waters close to the shore and the presence of submarine canyons around the coastline (Swan, 1983) probably contributes to enhancing the productivity of the waters that attract and support the feeding requirements of the numerous species distributed around the island. This has been shown to be the case in other parts of the world (Croll *et al.*, 2005; Hooker *et al.*, 1999; Rennie *et al.*, 2009). Additionally, other physical processes such as the monsoonal regime with seasonally reversing currents that lead to water exchange between the Bay of Bengal and the Arabian Sea drive the seasonal upwelling observed in these waters that may influence the marine mammal populations by enhancing productivity. Historical records have consistently alluded to the presence of a variety of cetacean species around Sri Lanka. However, they lack comprehensive records of



population sizes due to the scarcity and logistical challenges of line transect surveys off Sri Lanka. In the absence of such data, it is not possible to evaluate the conservation status of each species.

It is nevertheless relevant to briefly identify and discuss some of the threats to the cetaceans surrounding the island. Noise pollution caused by ship traffic and seismic activity within the habitat of the whales is a cause for concern particularly because the life of the whale is largely dependent on acoustic transmission underwater (Gordon and Tyack, 2001). With the end of the civil war Sri Lanka is being opened up for oil and gas exploration. The combination of a rich cetacean fauna and increased levels of anthropogenic activity in the marine habitats of Sri Lanka call for in depth studies of abundance and habitat use of cetacean species to mitigate human encroachment responsibly. Elevated background noise levels caused by manmade noise may interfere with or prevent marine mammals from detecting sounds that are otherwise important to their survival (Richardson *et al.*, 1995).

The level of consistent shipping noise recorded from the commercial shipping lanes on the south coast, is extremely high as evidenced by the difficulties faced in tracking sperm whales acoustically in this area. The southern areas particularly around the Dondra and Basses Canyons seemingly act as important habitats for three large whale species; sperm whales, Bryde's whales and blue whales. Thus these levels of noise may lead to a reduced carrying capacity of large whales in the area due to increased masking levels, and a subsequent increase in ship strikes. The high cetacean biodiversity on the south coast of Sri Lanka is unique and calls for an array of mitigation measures if the marine life in such vital areas is to be effectively protected.

While commercial whaling has not been documented around the island, a small scale dolphin fishery using handheld harpoons is known to occur (Ilangakoon, 1989; 1997; 2002; Ilangakoon *et al.*, 2000b; Leatherwood and Reeves, 1989) with concerns about its increase (Ilangakoon *et al.*, 2000b). Leatherwood (1994) estimated that during a two-year period spanning 1984–86 between 8,042 and 11,821 dolphins were caught annually. Bycatch levels are also high. In 1987 Alling (1988) reported that an estimated 38,000 odontocetes were entangled annually in gillnets deployed within 30 miles (48km) of the shoreline from 26°–60° vessels. More recently, Dayaratne and Joseph (1993) estimated that 5,000 small cetaceans are entangled in gillnets around the island every year.

The incidental entrapment and entanglement of cetaceans in tended and untended nets was, and continues to be of serious concern (Wallace, 1984). The modernisation of fishing gear, technical advances and a steady increase in the number of vessels harvesting fish are cited as the primary causes of such mortality. Specifically, the replacement of cotton or jute nets with synthetic monofilament gillnets by the United Nation's Food and Agriculture Organisation (FAO) in the 1950s marked the beginning of an increased take of target commercial fish and non-target marine animals, cetaceans, birds and turtles (Wallace, 1984).

The populations of cetaceans off the coast of Sri Lanka are also potentially threatened by marine pollution in the

form of organic and inorganic chemicals. Fertilisers and other such pollutants carried in the many waterways around the island that extend from the inland areas to the coastal waters, may result in reproductive failure and immune system breakdown in the marine life inhabiting Sri Lanka's waters. Current knowledge of the Bay of Bengal indicates that existing levels of toxic contaminants particularly that of PCBs and DDT, are high enough to cause severe health risks to animals through suppressed immune system complications (Prudente *et al.*, 1997; Simmonds *et al.*, 1999). More comprehensive research on the extent of pollution in the waters around Sri Lanka using sperm whales as indicator species was the primary focus of the 'Voyage of the *Odyssey*'. The results of these analyses are presented in Wise (2009) and forthcoming publications.

In conclusion, it appears that certain areas around Sri Lanka's vast coastline house a large number of species in considerable numbers. These habitats may provide good breeding, calving and/or feeding grounds for a number of the whale and dolphin species recorded. One such area is located on the southeast coast in the vicinity of the Basses Canyon. This area, which lies between Dondra and Sangamankande Point, is subject to both monsoons and is known for possessing the strongest coastal currents documented around the island (Swan, 1983). The physical attributes of this region may provide deep, cold nutrient rich water that can support sufficient krill to feed the cetaceans that aggregate here. However, the presence of heavy shipping (Kaluza *et al.*, 2010) in the adjoining shipping lanes is a potential cause for concern for the cetaceans in these waters with recent strandings showing evidence of whales being killed as a result of ship strikes (Ilangakoon, 2006c). Further research assessing the importance of these waters and the effects of these varying threats is needed to develop comprehensive management plans for the effective conservation of these species.

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## REFERENCES

- Afsal, V.V., Yousuf, K.S.S.M., Anoop, B., Annap, A.K., Kannan, P., Rajagopalan, M. and Vivekanandan, E. 2008. A note on cetacean distribution in the Indian EEZ and contiguous seas during 2003–07. *J. Cetacean Res. Manage.* 10(3): 209–15.
- Alling, A.K. 1986. Records of odontocetes in the northern Indian Ocean (1981–1982) and off the coast of Sri Lanka (1982–1984). *J. Bombay Nat. Hist. Soc.* 83(2): 376–94.
- Alling, A.K. 1988. A preliminary report on the incidental entrapment of odontocetes by Sri Lanka's coastal drift net fishery. *J. Bombay Nat. Hist. Soc.* 85: 538–50.
- Alling, A.K., Dorsey, E.M. and Gordon, J.C.D. 1991. Blue whales (*Balaenoptera musculus*) off the northeast coast of Sri Lanka: Distribution, feeding and individual identification. pp.247–58. *In: Leatherwood, S. and Donovan, G.P. (eds). Cetaceans and Cetacean Research in the Indian Ocean Sanctuary.* UNEP Marine Mammal Technical Report No. 3, Nairobi, Kenya. 287pp.
- Anderson, R.C. 2005. Observations of cetaceans in the Maldives, 1990–2002. *J. Cetacean Res. Manage.* 7(2): 119–36.
- Ballance, L.T. and Pitman, R.L. 1998. Cetaceans of the western tropical Indian Ocean: Distribution, relative abundance, and comparisons with cetacean communities of two other tropical ecosystems. *Mar. Mammal Sci.* 14(3): 429–59.
- Baumgartner, M.F. 1997. The distribution of Risso's dolphin (*Grampus griseus*) with respect to the physiography of the northern Gulf of Mexico. *Mar. Mammal Sci.* 13(4): 614–38.
- Blanford, W.T. 1891. *The Fauna of British India, including Ceylon and Burma.* Taylor and Francis, London. 617pp.
- Blyth, E. 1859. On the great rorqual of the Indian Ocean, with notices of other cetals, and of the Syrenia or marine pachyderms. *J. Asiatic Soc. Bengal* 28: 481–98.
- Branch, T.A., Stafford, K.M., Palacios, D.M., Allison, C., Bannister, J.L., Burton, C.L.K., Cabrera, E., Carlson, C.A., Galletti Vernazzani, B.G., Gill, P.C., Huckle-Gaete, R., Jenner, K.C.S., Jenner, M.N.M., Matsuoka, K., Mikhalev, Y.A., Miyashita, T., Morrice, M.G., Nishiwaki, S., Sturrock, V.J., Tormosov, D., Anderson, R.C., Baker, A.N., Best, P.B., Borsari, P., Brownell, R.L., Childerhouse, S., Findlay, K.P., Gerrodette, T., Ilangakoon, A.D., Joergensen, M., Kahn, B., Ljungblad, D.K., Maughan, B., McCauley, R.D., McKay, S., Norris, T.F., Rankin, S., Samaran, F., Thiele, D., Van Waerebeek, K., Warneke, R.M. and Oman Dolphin Research Group. 2007. Past and present distribution, densities and movements of blue whales in the Southern Hemisphere and northern Indian Ocean. *Mammal Rev.* 37(2): 116–75.
- Bröker, K.C.A. and Ilangakoon, A. 2008. Occurrence and conservation needs of cetaceans in and around the Bar Reef Marine Sanctuary, Sri Lanka. *Oryx* 42: 286–91.
- Brownell, R.L. and Donaghue, M.A. 1994. Southern Hemisphere pelagic whaling for pygmy blue whales: review of catch statistics. Paper SC/46/SH6 presented to the IWC Scientific Committee, May 1994 (unpublished). 9pp. [Paper available from the Office of this Journal].
- Croll, D.A., Marinovic, B., Benson, S., Chavez, F.P., Black, N., Termullo, R. and Tershy, B.R. 2005. From wind to whales: trophic links in an upwelling ecosystem. *Mar. Ecol. Prog. Ser.* 289: 117–30. Final report to the Monterey Bay National Marine Sanctuary, Contract no. 50ABNF500153.
- Dayaratne, P. and Joseph, L. 1993. A study of dolphin catches in Sri Lanka. *Bay of Bengal Programme, Madras BOBP/REP/56:* 47pp.
- de Silva, P.H.D.H. 1987. Cetaceans (whales, dolphins and porpoises) recorded off Sri Lanka, India, from the Arabian Sea and Gulf, Gulf of Aden and from the Red Sea. *J. Bombay Nat. Hist. Soc.* 84(3): 505–25.
- Deraniyagala, P.E.P. 1932. A stranded blue whale. *Ceylon Journal of Science* 17: 55–58.
- Deraniyagala, P.E.P. 1948. Some Mystacetid whales from Ceylon. *Spolia Zeylan.* 25(2): 61–63.
- Deraniyagala, P.E.P. 1960. Some southern temperate zone snakes, birds and whales that enter the Ceylon area. *Spolia Zeylan.* 29(1): 79–85.
- Deraniyagala, P.E.P. 1965. Zoological notes: carcass of *Balaenoptera* sp. cast ashore at Kokkilai. *Spolia Zeylan.* 30: 263–64.
- Fernando, H.F. 1912. Whales washed ashore on the coast of Ceylon from 1889 to 1910. *Spolia Zeylan.* 8(29): 52–54.
- Gordon, J. and Tyack, P. 2001. Sound and cetaceans. *In: Evans, P.G.H. and Raga, A.J. (eds). Marine Mammals: Biology and Conservation.* Kluwer Academic/Plenum Publishers, New York.
- Gordon, J.C.D. 1987. Sperm whale groups and social behaviour observed off Sri Lanka. *Rep. int. Whal. Commn* 37: 205–17.
- Gordon, J.C.D. 1991. The World Wildlife Fund's Indian Ocean sperm whale project: An example of cetacean research within the Indian Ocean Sanctuary. pp.219–39. *In: Leatherwood, S. and Donovan, G.P. (eds). Cetaceans and cetacean research in the Indian Ocean Sanctuary.* UNEP Marine Mammal Technical Report No. 3, Nairobi, Kenya. 287pp.
- Hooker, S.K., Whitehead, H. and Gowans, S. 1999. Marine protected area design and the spatial and temporal distribution of cetaceans in a submarine canyon. *Conserv. Biol.* 13(3): 592–602.
- Ilangakoon, A. 1989. A socio-economic study of cetacean harvesting in Sri Lanka. pp.54–67. *In: Leatherwood, S. and Reeves, R.R. (eds). Marine Mammal Research and Conservation in Sri Lanka 1985–1986.* Marine Mammal Technical Report No. 1., UNEP Oceans and Coastal Areas Activity Centre, Nairobi. 138pp.
- Ilangakoon, A. 1997. Species composition, seasonal variation, sex ratio and body length of small cetaceans caught off the west, south-west and south coast of Sri Lanka. *J. Bombay Nat. Hist. Soc.* 94: 298–306.
- Ilangakoon, A. 2002. *Whales and Dolphins of Sri Lanka.* WHT Publications, Sri Lanka. 99pp.
- Ilangakoon, A. 2005. Research and conservation of marine mammals in relation to the Bar Reef Marine Sanctuary North-Western Sri Lanka. Project completion report, Coastal Resources Management Project of the Coast Conservation Department, Ministry of Fisheries and Ocean Resources Sri Lanka and Asian Development Bank. 37pp. [Unpublished report available from the Coast Conservation Department, Sri Lanka or the author].
- Ilangakoon, A. 2006a. Cetacean occurrence and distribution around the Bar Reef Marine Sanctuary, northwest Sri Lanka. *J. Nat. Sci. Found. Sri Lanka* 34(3): 149–54.
- Ilangakoon, A. 2006b. Preliminary analysis of large whale strandings in Sri Lanka 1889–2004. *Pak. J. Oceanog.* 2: 61–68.
- Ilangakoon, A. 2006c. Taxonomy and current status of marine mammals in Sri Lanka. pp.302–08. *In: Bambaradeniya, C.N.B. (eds). The Fauna in Sri Lanka: Status of Taxonomy, Research and Conservation.* IUCN, Sri Lanka Country Office, Colombo. 308pp.
- Ilangakoon, A. 2009. Cetacean survey off Sri Lanka to assess the potential for conservation through cetacean based tourism – Project Completion Report. Report to the Whale and Dolphin Conservation Society, UK (unpublished). 25pp. [Available from the author].
- Ilangakoon, A., Miththapala, S. and Ratnasooriya, W.D. 2000a. Sex ratio and size range of small cetaceans in the fisheries catch on the west coast of Sri Lanka. *Vidyodaya J. Sci.* 9: 25–35.
- Ilangakoon, A. and Perera, L.D. 2009. Cetacean and sea bird survey off south-west Sri Lanka – project completion report. Report to the Ocean Park Conservation Foundation (unpublished). 37pp. [Available from the authors].
- Ilangakoon, A., Ratnasooriya, W.D. and Miththapala, S. 2000b. Species diversity, seasonal variation and capture method of small cetaceans on the west coast of Sri Lanka. *Vidyodaya J. Sci.* 9: 37–52.
- Ilangakoon, A., Subasinghe, H.A.K. and Mahendra, W.P. 1992. On rare cetacean species off Sri Lanka including the killer whale *Orcinus orca* (Linn.) (*Delphinidae: Cetacea*). *J. Bombay Nat. Hist. Soc.* 89(3): 363–65.
- Jefferson, T.A., Webber, M. and Pitman, R.L. 2008. *Marine Mammals of the World: A Comprehensive Guide to their Identification.* Academic Press, London. 573pp.
- Kaluza, P., Kolzsch, A., Gastner, M.T. and Blasius, B. 2010. The complex network of global cargo ship movements. *J. R. Soc. Interface* 7: 1093–103.
- Kruse, S., Caldwell, D.K. and Caldwell, M.C. 1999. Risso's dolphin *Grampus griseus* (G. Cuvier, 1812). pp.183–212. *In: Ridgway, S. and Harrison, R. (eds). The Second Book of Dolphins and the Porpoises.* Academic Press, London and San Diego. i–xix+486pp.
- Leatherwood, S. 1994. Report of the Workshop on mortality of cetaceans in passive fishing nets and traps, Annex D. Re-estimation of incidental cetacean catches in Sri Lanka. *Rep. int. Whal. Commn (special issue)* 15: 64–65.
- Leatherwood, S., Dolar, M.L.L., Wood, C.J., Aragones, L.V. and Hill, C.L. 1992. Marine mammal species confirmed from Philippine Waters. *Silliman Journal* 36(1): 65–86. (Special Issue on Biodiversity).
- Leatherwood, S. and Donovan, G.P. 1991. Cetaceans and Cetacean Research in the Indian Ocean Sanctuary. *UNEP Mar. Mamm. Tech. Rep.* 3: vii–287. Nairobi, Kenya.
- Leatherwood, S., McDonald, D., Prematunga, W.P., Girton, P., Ilangakoon, A. and McBrearty, D. 1991. Records of the 'Blackfish' (killer, false killer, pilot, pygmy killer and melon-headed whales) in the Indian Ocean, 1772–1986. pp.33–65. *In: Leatherwood, S. and Donovan, G.P. (eds). Cetaceans and cetacean research in the Indian Ocean Sanctuary.* UNEP Marine Mammal Technical Report No. 3, Nairobi, Kenya. 287pp.
- Leatherwood, S., Peters, C.B., Santerre, R., Santerre, M. and Clarke, J.T. 1984. Observations of cetaceans in the northern Indian Ocean Sanctuary, November 1980–May 1983. *Rep. int. Whal. Commn* 34: 509–20.
- Leatherwood, S. and Reeves, R.R. 1989. Marine mammal research and conservation in Sri Lanka 1985–1986. *UNEP Mar. Mamm. Tech. Rep.* 1: [vi],1–138.
- Mikhalev, Y.A. 1996. Pygmy blue whales of the northern-western Indian Ocean. Paper SC/48/SH30 presented to IWC Scientific Committee, June 1996, Aberdeen, UK (unpublished). 30pp. [Paper available from the Office of this Journal].



- Mikhalev, Y.A. 2000. Whaling in the Arabian Sea by the whaling fleets *Slava* and *Sovetskaya Ukraina*. pp.141–81. In: Yablokov, A.V., Zemsky, V.A. and Tormosov, D.D. (eds). *Soviet Whaling Data (1949–1979)*. Centre for Russian Environmental Policy, Moscow. 408pp.
- Perrin, W.F., Leatherwood, S. and Collet, A. 1994. Fraser's dolphin *Lagenodelphis hosei* Fraser, 1956. pp.223–40. In: Ridgway, S.H. and Harrison, R. (eds). *The First Book of Dolphins*. Academic Press, London and San Diego. 416pp.
- Prudente, M., Tanabe, S., Watanabe, M., Subramanian, A., Miyazaki, N., Suarez, P. and Tatsukawa, R. 1997. Organochlorine contamination in some Odontoceti species from the North Pacific and Indian Ocean. *Mar. Environ. Res.* 44: 415–27.
- Rennie, S., Hanson, C.E., McCauley, R.D., Pattiaratchi, C., Burton, C., Bannister, J., Jenner, C. and Jenner, M.-N. 2009. Physical properties and processes in the Perth Canyon, Western Australia: Links to water column production and seasonal pygmy blue whale abundance. *J. Mar. Systems* 77: 21–44.
- Richardson, W.J., Greene Jr, C.R., Malme, C.I. and Thomson, D.H. 1995. *Marine Mammals and Noise*. Academic Press, San Diego. 576pp.
- Simmonds, M.P., Hanly, K. and Dolman, S.J. 1999. Cetacean contaminant burdens: regional examples. Paper SC/51/E13 presented to the IWC Scientific Committee, May 1999, Grenada, WI (unpublished). 14pp. [Paper available from the Office of this Journal].
- Swan, B. 1983. *An introduction to the coast geomorphology of Sri Lanka*. National Museums of Sri Lanka, Colombo.
- Wallace, N. 1984. Entanglement in the marine environment: A review. *Entanglement Network Newsletter* 3.
- Wise, J.P., Payne, R., Wise, S.S., Lacerte, C., Wise, J., Gianios, C., Thompson, W.D., Perkins, C., Zheng, T., Zhu, C., Benedict, L. and Kerr, I. 2009. A global assessment of chromium pollution using sperm whales (*Physeter macrocephalus*) as an indicator species. *Chemosphere* 75(11): 1461–67.
- Wray, P. and Martin, K.R. 1983. Historical whaling records from the western Indian Ocean. *Rep. int. Whal. Commn (special issue)* 5: 213–41.
- Yochem, P.K. and Leatherwood, S. 1985. Blue whale – *Balaenoptera musculus* (Linnaeus, 1758). pp.193–240. In: Ridgway, S.H. and Harrison, R. (eds). *The Sirenians and Baleen Whales*. Academic Press, London and Orlando. xviii+362pp.

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