Review of the Sri Lanka blue whale (*Balaenoptera musculus*) with observations on its distribution in the shipping lane

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ABSTRACT

A population of blue whales is resident off the southern coast of Sri Lanka and has been observed year-round by the crew of a whalewatching vessel, *Raja & the Whales,* a few miles south of Mirissa Harbour. Over the course of three years (1 December 2009 to 30 November 2012), a total of 485 blue whale sightings were reported with an average of 4.56 individuals observed per sighting. This number does not represent the total number of individuals seen because repeat sightings were highly probable. Calves were observed during the northeast monsoon. Sightings were confined to an area of about 200 n.miles that is bisected by a heavily trafficked shipping lane. Much of this area is characterised by submarine canyons and sloping bathymetry, which contributes to monsoonal seasons of high productivity and upwelling suitable for feeding whales. While the numbers of injuries and fatalities due to ship strikes are not known, four dead blue whales were observed along the southern coast over the course of five months (1 January to 31 May 2014). It is of great urgency to understand the identity and size of this population, reduce ship strikes and address all issues threatening this population in order to arrive at possible mitigation measures for its protection.

KEYWORDS: BLUE WHALE; SRI LANKA; NORTHERN INDIAN OCEAN; SHIP STRIKES; BYCATCH; CONSERVATION; WHALEWATCHING; NORTHERN HEMISPHERE; SURVEY-VESSEL; ASIA; SOUTHERN HEMISPHERE

INTRODUCTION

Studies of marine mammal identification, distribution and abundance were carried out in the early 1980s to support the Indian Ocean Marine Mammal Sanctuary initiative (Whitehead, 1983; Alling, 1984; Gordon, 1987). Unfortunately, these offshore research programmes, carried out in Sri Lanka on board the sailing ship *Tulip,* came to a halt in 1985 due to the Singhalese/Tamil civil war. Only a few opportunistic surveys and land-based studies of cetacean strandings and bycatch were permitted (Alling, 1988; Ilangakoon, 1997; Leatherwood and Reeves, 1989). At the end of the war (May 2009), interest in the status of marine mammals off the coast of Sri Lanka returned, as well as understanding the conservation challenges unique to the country. Over this period, a probable subspecies of blue whale (*Balaenoptera musculus*) was sighted year-round in Sri Lankan waters (5–7°N) with observations about feeding along contour lines, aggregations around submarine canyons and in the presence of calves (Alling *et al.*, 1991; Deraniyagala, 1943; de Vos *et al.*, 2012; Ilangakoon, 2012; Martenstyn, 2013). It is this population that is the subject of this paper.

The taxonomic status of this blue whale population is not known but has been proposed to be a sub-species of the blue whale (Yochem and Leatherwood, 1985; Mikhalev, 2000). A Southern Hemisphere subspecies, *B.m. brevicauda,* was first recognised by Ichihara (1966) to be distinct from the polar Antarctic blue whale, *B.m. intermedia*. During the following few decades, studies (e.g. Branch *et al*., 2007b) suggested there are four sub-species of blue whales inhabiting New Zealand, Australia and Indonesia, Madagascar and the Northern Indian Ocean (NIO). These studies have compared and contrasted information about the proportional size of individuals, morphology, geographic distribution and vocalisation repertoires that may be indicative signatures for a mating population. LeDuc *et al.* (2007) analysed blue whale tissue taken from animals in the Antarctic, Chile (Pacific) and the Maldives (NIO) and found them to be highly differentiated from one another in both mitochondrial and nuclear genes, which suggests there may be a fifth sub-species. The identity of the Sri Lanka population is undetermined, but it is likely to be representative of an NIO sub-species classified by Blyth (1989) as *B.m. indica* (Anderson, 2012; Ilangakoon and Sathasivam, 2012).

Although blue whales have been legally protected since 1966, Soviet whaling continued unabated in the NIO and south to the Maldives until the illegal catches ceased in 1973 (e.g. Clapham and Ivashchenko, 2009). The intense clandestine whaling effort severely reduced the NIO humpback whale population; it is classified by the IUCN as endangered. Although there is not enough information about the NIO blue whale identity and size to assess its status today, it is likely that this population is also endangered and thus its protection is of great concern (Branch *et al.,* 2004). Most immediate is the issue of ship strikes because the concentration of these blue whales off the southern coast of Sri Lanka aggregates around one of the busiest shipping lanes in the world (Ilangakoon, 2012; Leaper, 2011). While there is no government or private agency tasked with recording marine mammal ship strikes, the Sri Lanka National Aquatic Resources Agency estimated that up to 20 blue and sperm whales were being killed annually by ships (website: *http://www.LBO.lk* accessed 20 December 2011).

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De Vos *et al.* (2013) reported on two blue whales that had died from ship strikes along the southern coast in a 12 day period during 2012. As comparison, Redfern *et al.* (2013) estimated that 1.8 known blue whales are killed annually along the Californian coast, which exceeds the United States allowable level of anthropogenic impact.

It is therefore urgent to understand the distribution of blue whales in relation to shipping traffic, identify the sub-species, estimate its population size and provide information to implement sound conservation initiatives. In order to understand and compare information with ongoing research on blue whales in the region, the University of Ruhuna (Matara, Sri Lanka) established an Indian Ocean Marine Mammal Research Unit with the Biosphere Foundation to support international and local collaborative research about the Sri Lanka blue whale population. This paper represents our effort to initiate this programme and report on data collected aboard a whalewatching vessel from 2009 to 2012.

METHODS

During a period of three years (from December 2009 through November 2012) data were collected on board *Raja & the Whales*, a vessel berthed in Mirissa Harbour on the southern coast of Sri Lanka. The 225hp vessel is a 13m deep-sea fishing boat converted to whalewatching with a helm on a platform, enabling visual sightings from about 4m above the sea. This is an excellent location from which to spot the high blow of the blue whale, giving the helmsman a sighting distance of about 3–4 n.miles in calm seas.

From December to April of each year, here referred to as the 'high season', the vessel made daily whalewatching trips from Mirissa. During these months the wind and seas are generally calm (Beaufort 3 or lower) and the level of tourism in Mirissa generally ensures reliable business. From May to October the southwest monsoon brings rough weather not conducive to whalewatching and tourism remains low during November. Consequently, during the 'low season' (May to November) the vessel only made trips when advised by fishermen working in the area that whales had been sighted or when specially arranged with visitors.

On whalewatching days the *Raja & the Whales* left Mirissa Harbour at approximately 06:30 and headed offshore until about 11:00. The vessel remained at sea until whales were sighted. If no whales were sighted the vessel returned to the harbour by 15:00 in the afternoon. When one or more whales were sighted, data were collected. Date, time, vessel's latitude and longitude, number of individuals sighted and notes on their behaviour and circumstances were recorded by a crew member trained in whale identification. Only data on blue whales are reported in this paper. If multiple whales were sighted at approximately the same time and location, they were recorded as a single sighting. The vessel operated within a range of approximately 30 n.miles from Mirissa Harbour. This defined the boundary of the area where sightings occurred.

In addition to the sighting data described above, dead blue whale observations made by the primary author (SMR) are reported for the first five months of 2014. These were discovered in the course of whalewatching operations as described above or through local word of mouth.

RESULTS

Summary of observations year-round, December 2009–November 2012

Over the three-year period for which data are presented, a total of 485 blue whale sightings were recorded. These sightings occurred on a total of 390 days with an average of 1.24 sightings per day on days when the crew of was successful in finding blue whales. At least one sighting was reported in every calendar month over this three-year period (Fig. 1).

The number of blue whale sightings associated with a single sighting range from 1–30, with the majority (approximately 96%) of sightings reporting 10 or fewer individuals. A numerical estimate of individuals was not available for a small fraction (8%) of the total sightings, in which the number of individuals was simply recorded as 'many'. For the purpose of this analysis, these sightings were assigned a value of six individuals, which is a conservative yet reasonable assumption. Under this assumption, a total of 2,213 blue whales was observed during the three-year period, yielding an average of 4.56 individuals per sighting. This total likely includes re-sightings of the same individuals.

Field notes taken onboard the vessel during whalewatching trips indicated that whales frequently defecated red faeces before diving, and that calves were

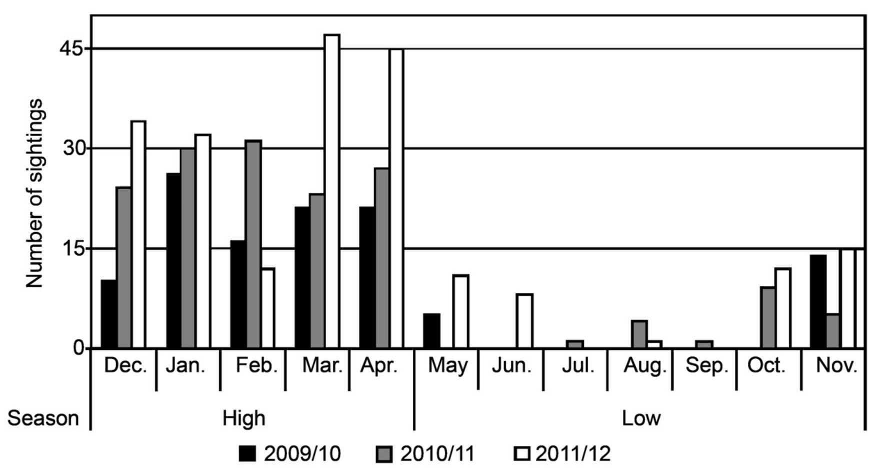

Fig. 1. Number of blue whale sightings by month, indicated as 'high' or 'low' season, from December 2009–November 2012.

observed during the months of January, February, March, October and November.

Comparison of high season (December–April) observations only

Of the total number of sightings, 399 (82%) were reported during the high season (November–April) (Fig. 1). During the three high seasons reported here, blue whales were sighted on 319 out of an estimated 454 days of whalewatching effort giving an average success of 70%. 'Success' here is defined as one or more blue whale sightings on a given day and the success rate was obtained by dividing this by the total number of days of whalewatching effort and converting to a percentage. An estimate of the total whalewatching effort during the low seasons is not available for comparison.

Table 1 summarises the blue whale observations recorded during each of the three high seasons reported: December 2009–April 2010; December 2010–April 2011; and December 2011–April 2012. Across the three high seasons, both the number of sightings and number of individuals sighted increased each season. The average success of sightings increased noticeably from the first to the second season (from 57% to 80%) but changed little from the second to the third season (from 80% to 74%). The fact that success remained relatively constant while the number of sightings grew from the second to the third year resulted in a noticeably higher average rate of sightings per day on successful days: 1.52 during the third season compared to 1.12 during the second. In essence, the crew sighted blue whales on a similar number of days during the second and third high seasons, yet during the third season they achieved more sightings per each successful day. The average number of individuals per sighting fluctuated from season to season; the highest (5.16) was observed during the second season and the lowest (4.47) during the third.

Fig. 2 illustrates the spatial distribution of blue whale sightings for the 2009–10, 2010–11 and 2011–12 high seasons. The mean latitude of sightings remained relatively constant from the first to the second high seasons but shifted northward (closer to shore) approximately 1.8 n.miles from the second to the third year. The sightings became less dispersed with fewer outliers over the time period reported. This is emphasised in Fig. 3, which shows a one standard deviational ellipse (Yuill, 1971) corresponding to each year's distribution of sightings, weighted by the count of individuals observed at each sighting. The concentration of sightings over all three years partially coincides spatially with the traffic separation scheme, which consists of eastbound and westbound shipping lanes separated by a central 'breakdown' lane (Fig. 3). Many of the sightings, particularly those observed during the first two high seasons, occurred within an area of sloping bathymetry, where the seafloor drops from a depth of 200m to 2,000m.

Table 1

	2009/10	2010/11	2011/12
Success (number of days with ≥1 sighting)	86	121	112
Effort (number of whalewatching days)	151	151	152*
(Success/effort × 100)	57%	80%	74%
Sightings (total number)	94	135	170
Average sightings per day (successful days only)	1.09	1.12	1.52
Individuals sighted (total number)	433	697	760
Individuals per sighting	4.61	5.16	4.47

*2012 was a leap year, contributing an extra day to February.

Mortality observations, 1 January–31 May 2014

Four blue whale deaths along the southern coast of Sri Lanka were confirmed during a five-month period in the beginning of 2014 (1 January–31 May) (Fig. 4). Two died from ship-strikes and two washed up on beaches with the cause of death unknown. When it was not possible to measure the whale, 'large' refers to greater than about 20m in length and 'small' is less than about 20m.

(1) From 1–3 February 2014, a large blue whale was observed off Mirissa (05°49'N, 80°28–30'E), unable to dive and seeking shelter along the coast due to a broken dorsal fin and wounds around the blowhole and along the spine to the fluke. After the third day the whale was not seen again. The back injury and broken fin suggested that the whale had been stuck by a ship and it was assumed that it had subsequently died of its injuries.

(2) On 10 March 2014 a small blue whale carcass was found washed ashore in Dickwella, the cause of death is unknown. It was divided into three pieces by a bulldozer and buried within three hours.

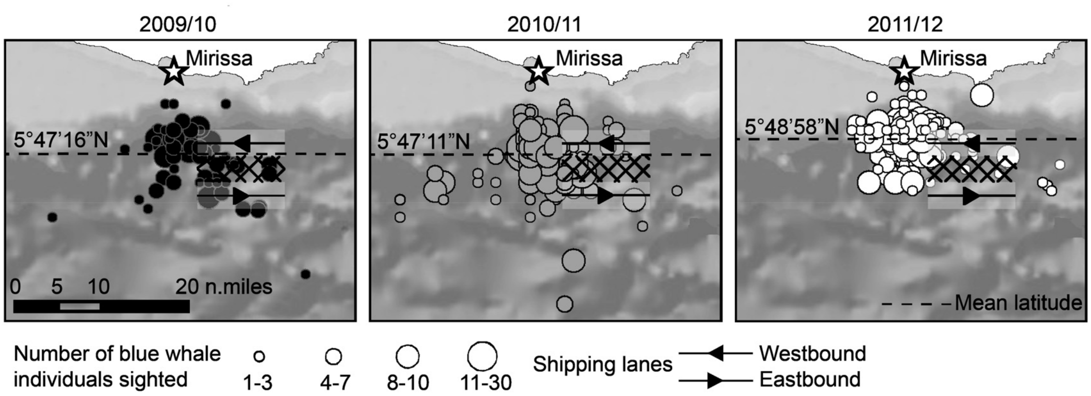

Fig. 2. Spatial distribution of blue whale sightings by yearly high season (December–April). The number of individuals reported at each sighting is indicated by circle size. Also shown is the traffic separation scheme, consisting of eastbound, westbound and central 'break-down' lanes.

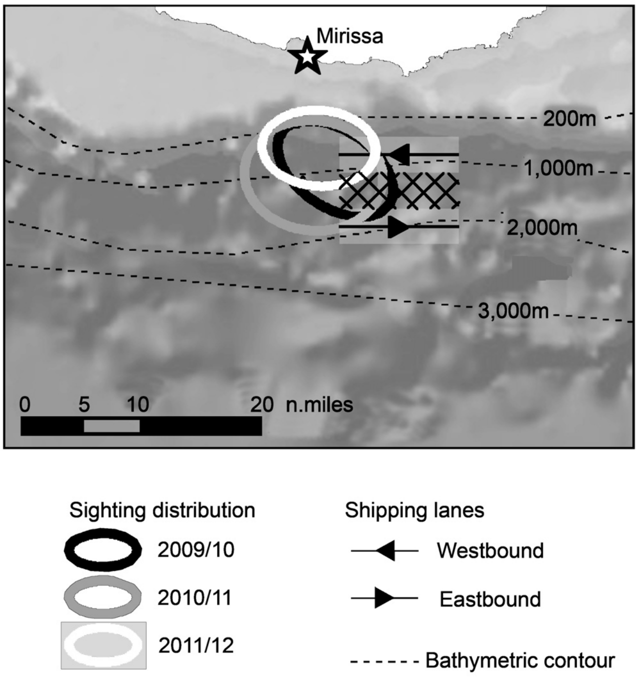

Fig. 3. Distribution of sightings by yearly high season, represented by a one standard deviational ellipse (Yuill, 1971) for each high season. Contour lines illustrate the sloping bathymetry.

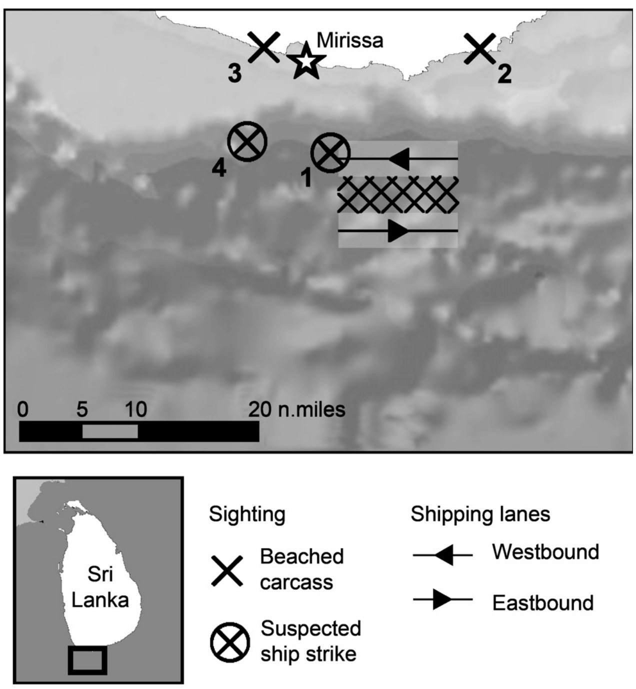

Fig. 4. Locations where injured or dead blue whales were observed between January and May, 2014. Numbers correspond to the numbered descriptions in the text.

(3) On 20 May 2014 a 16m female blue whale carcass was found washed ashore in Midigama Bay after having been seen earlier in the day near Mirissa Harbor. The cause of death is unknown. It had a 3m wound on its left flank, inflicted post mortem by a fisherman looking for ambergris.

(4) On 25 May 2014 a large blue whale was reported dead due to ship strike and floating out to sea in the shipping lane off Mirissa (05°50’N, 80°22’E).

In addition, on 28 April 2014 a large blue whale was reported dead and entangled in 100m of drift net in the Bay of Bengal east of Trincomalee, beyond Sri Lanka’s 200 n.mile exclusive economic zone (EEZ). Prior to its death it was observed to be unable to dive due to the buoys attached to the net. The entangled whale had caused so much damage to the drift net that it was beyond repair. The fishermen cut the net and buoys from the carcass and set it loose. This observation was outside of the Sri Lanka EEZ and so has not been included with the number of dead whales observed along the southern coast in 2014. It is mentioned as an example of drift net bycatch of large whales in the wider area near Sri Lanka.

DISCUSSION

A review of the Sri Lanka blue whale

It is known that blue whale feeding behaviour is linked to resource opportunity with regards to the density of euphausiids (Branch *et al.*, 2007b) and feeding locations shift spatially and temporally due to oceanographic conditions (Calambodkis *et al.*, 2009). The monsoonal weather and sloping bathymetry surrounding Sri Lanka supports high productivity during both the northeast and southwest monsoons (Vinayachandran and Mathews, 2003; Vinayachandran *et al.,* 2004). As discussed by Anderson *et al.* (2012), blue whales may remain in the NIO migrating west along the southern coast of Sri Lanka to the Arabian Sea to feed during the southwest monsoon (May–October) and eastwards along the southern coast of Sri Lanka to feed in the Bay of Bengal during the northeast monsoon (November–April). During the northeast monsoon, Alling *et al.* (1991) observed blue whales feeding along the steep slopes separating the continental shelf from the deep ocean basin surrounding the coast of Sri Lanka, and their red faeces were identified as remains of a *Mysidacea spp*. The 2009–2012 data presented here agree with these general feeding observations and movements of whales along the coast of Sri Lanka.

Blue whale vocalisations recorded off the northeast coast of Sri Lanka in 1983–84 (Alling and Payne, 1987) were classified as one of nine different blue whale populations around the world (McDonald *et al.*, 2006). Within the Indian Ocean, the Sri Lanka blue whale vocalisation is distinct from three other sub-species identified as Madagascar, Australia and Antarctic blue whales (Stafford *et al.*, 2004; 2011). The Sri Lanka blue whale has been detected year-round near Diego Garcia; year-round northeast of Amsterdam Island and with some detection in the austral summer (Dec/Jan) southwest of Amsterdam Island and off Crozet Island (46°25’S, 51°40’E), the latter being the farthest south and about 4,000 n.miles from Sri Lanka (Sameran *et al.*, 2010; 2013). The austral summer is also the time that the Sri Lanka blue whale numbers are observed increasing off Sri Lanka on the southern and northeast coasts (Alling *et al.*, 1991; Anderson *et al.* 2012). The sightings of a few whales off the southern coast of Sri Lanka during the southwest monsoon and the two dead whales observed at the end of May suggests that the entire population does not migrate in unison, but rather individuals or groups may roam the Indian Ocean opportunistically following productivity, mating or calving requirements.

Attard *et al.* (2012) found that the Southern Indian Ocean sub-species, *B. m. brevicauda*, is genetically distinct from the Antarctic *B. m. intermedia*, but there are indications that hybridisation between the two sub-species due to whaling pressures and/or climate change now occurs. In the last few decades, research on the Southern Hemisphere blue whales have revealed that Antarctic blue whales remain south of 60°S during the summer but travel north as far as the equator in both the Indian and Pacific oceans in the winter (Branch *et al.,* 2007a; Branch *et al.*, 2009; Samaran *et al.*, 2010; Stafford *et al.*, 2004). Studies further suggest that Sri Lankan blue whales overlap occasionally with Madagascar or Antarctic whales at three southern locations and all four sub-species (including the Australian sub-species) visit Crozet Island (Samaran *et al.*, 2004; 2013; Stafford *et al.*, 2011). It is possible that these distinct blue whale populations were once geographically or seasonally separated from each other, but now due to unpredictable or scare resources, migration patterns may be shifting, providing new opportunities for mixing between sub-species.

Ship strikes and conservation issues

South of Mirissa the shipping lanes approximately coincide with submarine canyons and deep drop-off regions (Fig. 3) associated with upwelling and high productivity. The recent observations of dead whales in the vicinity suggest that the overlap between the highly productive whale feeding ground and the shipping lanes results in ship strikes. Obtaining an accurate count of ship strike deaths in Sri Lanka is difficult, exacerbated by the fact that dead whales may not make it to shore, and if they do, they are often disposed of within hours, making it impossible for scientists to examine the whale. As blue whales tend to sink when dead, Redfern *et al.* (2013) estimated that the proportion of carcasses detected is less than 17%. Based on the four deaths reported here, if an average rate of 0.8 deaths per month is assumed and 17% of carcasses detected, then the number of blue whale deaths may be as high as 56 per year. The number of deaths attributable to ship strikes versus other causes is still not clear.

In reviewing the available stranding data, Ilangakoon (2006) stated that prior to 1996 (1986–95), no dead whales with noticeable wounds from ship strikes were observed. This may have been the case because fewer people were reporting whale strandings or perhaps the whales were gathering elsewhere to feed. Regardless, the three years of Mirissa whalewatching data reported here show that, in recent years, whales have predictably returned to the southern coastline and the shipping lanes.

Marine mammals are threatened in areas of dense shipping traffic and have been reported as killed in locations around the world such as off the Santa Barbara coast in the United States (Berman-Kowalewski *et al.*, 2010; Clapman *et al.*, 1999). Possible options for mitigation include moving the shipping lane, slowing the traffic in areas of large concentrations of whales or declaring these areas ‘no-transit’ zones. All three are possible in Sri Lanka, but moving the lanes offshore, south of the 3,000m contour line, would be the most effective and practical way of reducing risk.

An additional dynamic that warrants consideration in this area is a driftnet fishery, active between the shore and the shipping lane and in between the two lanes, along the centre of the traffic separation scheme. Sri Lanka is a bycatch hotspot (Lewiston *et al.*, 2014) and blue whales have been observed entangled in nets, struggling or dead. The drift nets are made of nylon and extend 2–4km along the surface and 100–120m deep. As fishermen must avoid the busy shipping lanes, they often place their nets next to each other, effectively creating one or more continuous lines of nets. Thus, not only is the shipping lane a hazard for the whales but also the sea around the lane due to the nets that may be virtually undetectable to a whale. If the shipping lanes are moved offshore, it is likely that the fishermen will move in to fish the waters previously occupied by the shipping lanes. Thus, an unintended consequence of moving the lanes could be that driftnet fishing increases in the area of whale activity. Similarly, reducing only the speed of the vessels in this area would not change the curtain of nets hanging on all sides of the lanes. Fitting pingers to the fishing gear could discourage whales from becoming entangled in nets but this should be tested experimentally and care must be taken so that this does not drive the whales into the shipping lane. The preferred solution is to move the shipping lanes south and work with the local government to prohibit driftnet fishing but allow non-driftnet methods in the area between the 200m and 2,000m depth contours (Fig. 3), where the whales repeatedly return.

The Sri Lanka blue whale has also been affected by the accelerated increase in coastal development since the civil war ended. The most striking examples of development are the newly constructed maritime port in the natural harbour of Hambantota near to the blue whale feeding grounds and recent seismic activity supporting an emerging oil and gas industry on the west coast of Sri Lanka (NARA, 2009). The increase in tourism in the last years has also supported a growing whalewatching business in several ports around Sri Lanka but most noticeably in Mirissa, which has raised issues of whale harassment (Ilangakoon, 2012).

The slight northward shift in location of blue whale sightings across the three whalewatching high seasons could reflect several things relevant to the above: (1) the locations of blue whale aggregations may have changed from season to season; (2) the locations where the crew of the *Raja & the Whales* searched for whales may have changed; or (3) a combination of both (1) and (2). The first two possibilities cannot be distinguished without data on null sightings (i.e. locations where whales were not sighted), but it is reasonable to assume that a combination of both factors explains the observed data. Most importantly, the data suggest that the whales are following prey movements and are not altering their movements away from vessel activity, either in the shipping lanes or from whalewatching vessels.

While there is still a paucity of information about the number and causes of blue whale deaths, the fact that four dead whales were observed along the southern coast over the course of five months is alarming. If this is indicative of the number of whales that die from anthropogenic causes throughout the year, then understanding the status of the Sri Lanka blue whale population and possible mitigation measures to protect it are of critical importance.

CONCLUSION

The Sri Lanka blue whale is one of four known Indian Ocean populations, but its taxonomic identity, distribution in the

NIO and size of the population remains uncertain. As the location of feeding whales on the southern coast overlaps with shipping lanes, resulting in two or more known ship strikes a year, there is cause for great concern. Additionally, there are other issues impacting the future of this population such as driftnet entanglement, noise pollution (shipping, dynamite and seismic exploration for oil and gas), habitat destruction and climate change, but the aforementioned are the most urgent and alarming because they often result in immediate mortality. Fortunately, there is a growing awareness of this situation and the newly established University of Ruhuna's Indian Ocean Marine Mammal Research Unit provides a centre for international collaborative marine mammal research. The IWC Scientific Committee recognised in 2014 that ship strikes are likely to be having a population level impact on blue whales in the NIO (Priyadarshan *et al.,* 2014). These ongoing initiatives offer new opportunities to conduct research on the taxonomic status of the Sri Lanka blue whale, estimate population size and provide information to guide sound marine mammal conservation.

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REFERENCES

Alling, A. and Payne, R. 1987. Songs of Indian Ocean blue whales, *Balaenoptera musculus*. (Unpublished ms.) [Available from the lead author]. 11pp.

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., Branch, T.A., Alagiyawadu, A., Baldwin, R. and Marsac, F. 2012. Seasonal distribution, movements and taxonomic status of blue whales (*Balaenoptera musculus*) in the northern Indian Ocean. *J. Cetacean Res. Manage* 12(2): 203–18.

Anon. 2011. Sri Lanka to probe whale deaths, do acoustic monitoring. Lanka Business Online. [Available at: *http://www.lankabusinessonline.com/news/sri-lanka-to-probe-whale-deaths,-do-acoustic-monitoring/999883621*].

Attard, C., Beheregaray, L.B., Jenner, C., Gill, P., Jenner, M., Morrice, M., Robertson, K. and Möller, L. 2012. Hybridization of Southern Hemisphere blue whale subspecies and a sympatric area off Antarctica: impacts of whaling or climate change? *Mol. Ecol.* 21: 5,715–27.

Berman-Kowalewski, M., Gulland, F.M.D., Wilkin, S., Calambokidis, J., Mate, B., Cordaro, J., Rotstein, D., St Leger, J., Collins, P., Fahy, K. and Dover, S. 2010. Association between blue whale (*Balaenoptera musculus*) mortality and ship strikes along the California coast. *Aquat. Mamm.* 36: 59–66.

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., Abubaker, E.M.N., Mkango, S. and Butterworth, D.S. 2007a. Separating southern blue whale subspecies based on length frequencies of sexually mature females. *Mar. Mammal Sci.* 23(4): 803–33.

Branch, T.A., Matsuoka, K. and Miyashita, T. 2004. Evidence for increases in Antarctic blue whales based on Bayesian modelling. *Mar. Mammal Sci.* 20(4): 726–54.

Branch, T.A., Mikhalev, Y.A. and Kato, H. 2009. Separating pygmy and Antarctic blue whales using long-forgotten ovarian data. *Mar. Mammal Sci.* 25(4): 833–54.

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., Hucke-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., Borsa, 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. and Warneke, R.M. 2007b. Past and present distribution, densities and movements of blue whales in the Southern Hemisphere and northern Indian Ocean. *Mammal Rev.* 37(2): 116–75.

Clapham, P. and Ivashchenko, Y. 2009. A whale of a deception. *Mar. Fish. Rev.* 71: 44–52.

Clapham, P.J., Young, S.B. and Brownell, R.L., Jr. 1999. Baleen whales: conservation issues and the status of the most endangered populations. *Mammal Rev.* 29(1): 35–60.

De Vos, A., Clark, R., Johnson, C., Johnson, G., Kerr, I., Payne, R. and Madsen, P.T. 2012. Cetacean sighting and acoustic detections in the offshore waters of Sri Lanka: March–June 2003. *J. Cetacean Res. Manage* 12(2): 185–93.

De Vos, A., Wu, T. and Brownell, R.L., Jr. 2013. Recent blue whale deaths due to ship strikes around Sri Lanka. Paper SC/65a/HIM03 presented to the IWC Scientific Committee, June 2013, Jeju Island, Republic of Korea (unpublished). 8pp. [Paper available from the Office of this Journal].

Deraniyagala, P.E.P. 1948. Some Mystacetid whales from Ceylon. *Spolia Zeylan.* 25(2): 61–3.

Gordon, J.C.D. 1987. Sperm whale groups and social behaviour observed off Sri Lanka. *Rep. int. Whal. Commn* 37: 205–17.

Ichihara, T. 1966. The pygmy blue whale, *Balaenoptera musculus brevicauda*, a new subspecies from the Antarctic. pp.79–113. *In*: Norris, K.S. (eds). *Whales, Dolphins and Porpoises*. University of California Press, Berkeley and Los Angeles. xv+789pp.

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. 2006. Preliminary analysis of large whale strandings in Sri Lanka 1889–2004. *Pak. J. Oceanog.* 2: 61–68.

Ilangakoon, A. 2012. Exploring anthropogenic activities that threaten endangered blue whales (*Balaenoptera musculus*) off Sri Lanka. *J. Mar. Anim. Ecol.* 5(1): 3–7.

Ilangakoon, A.D. and Sathasivam, K. 2012. The need for taxonomic investigations on Northern Indian Ocean blue whales (*Balaenoptera musculus*): implications of year-round occurrence off Sri Lanka and India. *J. Cetacean Res. Manage.* 12(2): 195–202.

Leaper, R. 2011. Ship strike risk to whales off Sri Lanka. Preliminary briefing note for IMO from International Fund for Animal Welfare, September 2011 (unpublished). 4pp. [Available from author].

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.

LeDuc, R.G., Dizon, A.E., Goto, M., Pastene, L.A., Kato, H., Nishiwaki, S., LeDuc, C.A. and Brownell, R.L. 2007. Patterns of genetic variation in Southern Hemisphere blue whales, and the use of assignment test to detect mixing on the feeding grounds. *J. Cetacean Res. Manage.* 9(1): 73–80.

Lewiston, R.L., Crowder, L.B., Wallace, B.P., Moore, J.E., Cox, T., Zydelis, R., McDonald, S., DiMatteo, A., Dunn, D.C., Kot, C.Y., Bjorkland, R., Kelez, S., Soykan, C., Stewart, K.R., Sims, M., Boustany, A., Read, A., Halpin, P., Nichols, W.J. and Safina, C. 2014. Global patterns of marine mammal, seabird and sea turtle bycatch reveal taxa-specific and cumulative megafauna hotspots. *Proc. Natl. Acad. Sci.* 111(14): 5,271–76. [doi: 10.1073/pnas. 1318960111].

Martenstyn, H. 2013. *Sri Lanka Marine Mammal Records*. Edited by CRIOMM. 140pp.

McDonald, M.A., Mesnick, S.L. and Hildebrand, J.A. 2006. Biogeographic characterisation of blue whale song worldwide: using song to identify populations. *J. Cetacean Res. Manage.* 8(1): 55–65.

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.

National Aquatic Resources Research and Development Agency (NARA). 2009. Three dimensional seismic survey for oil exploration in Block-SL-01-001 in Gulf of Mannar, Sri Lanka. 156. Initial Environment Examination Report, Cairn Lanka PVT. Ltd. [Available at: *http://www.prds-srilanka.com/pdfs/Sri_Lanka_Seismic_EIA_Final_Report.pdf*].

Priyadarshana, T., Randage, R., A., A., Calderan, S., Gordon, J., Leaper, R. and Porter, L. 2014. Preliminary results of surveys to investigate overlap between shipping and blue whale distribution off southern Sri Lanka. Paper SC/65b/HIM06 presented to the IWC Scientific Committee, Bled, Slovenia, May 2014. 11pp. (Unpublished). [Paper available from the Office of this Journal].

Sameran, F., Adam, O. and Guinet, C. 2010. Discovery of a mid-latitude sympatric area for two Southern Hemisphere blue whale subspecies. *Endanger. Species. Res.* 12: 157–65.

Sameran, F., Stafford, M., Branch, T.A., Gedamke, J., Royer, J.Y., Dziak, R.P. and Guinet, C. 2013. Seasonal and geographic variation of southern blue whale subspecies in the Indian Ocean. *PLoS ONE* 8(8): e71561. [*doi:10.1371/journal.pone.0071561*].

Stafford, K.M., Bohnenstiehl, D., Chapp, E., Tolstoy, M., Chapp, E., Mellinger, D. and Moore, S.E. 2004. Antarctic type blue whale calls recorded at low latitudes in the Indian and eastern Pacific Oceans. *Deep-Sea Res.* 51: 1337–46.

Stafford, K.M., Chapp, E., Bohnenstiehl, D.R. and Tolstoy, M. 2011. Seasonal detection of three types of 'pygmy' blue whale calls in the Indian Ocean. *Mar. Mammal Sci.* 23(4): 751–65.

Vinayachandran, P.N., Chauhan, P. and Mohan, M. 2004. Biological response of the sea around Sri Lanka to summer monsoon. *Geophys. Res. Lett.* 31: L01302.

Vinayachandran, P.N. and Mathew, S. 2003. Phytoplankton bloom in the Bay of Bengal during the northeast monsoon and its intensification by cyclones. *Geophys. Res. Lett.* 30(11): 1,572.

Whitehead, H. 1983. Baleen whales off Sri Lanka. *Loris* 15: 176–81.

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.

Yuill, R.S. 1971. The standard deviational ellipse; an updated tool for spatial description. *Geografiska Annaler.* 53B(1): 28–39.