

Blue whales off the southern coast of Sri Lanka during the southwest monsoon season

GRACE RUSSELL, MARCUS BRIDGE AND MAJA NIMAK-WOOD

Marine Wildlife and Environment Department, Gardline Ltd., Endeavour House, Admiralty Road, Great Yarmouth, Norfolk, NR30 3NG, UK

Contact e-mail: grussell924@gmail.com

ABSTRACT

Observations of 37 individual blue whales were recorded off the southern coast of Sri Lanka during the southwest monsoon season. Sightings were made during a scientific geophysical survey campaign conducted in July and August 2017. Whilst blue whales are regularly recorded on the continental slope of southern Sri Lanka during the northeast monsoon season (NEM) (December–March) and during the two inter-monsoonal periods (March–April and September–October), limited data are available for the SWM (May–September) mostly due to unfavourable weather conditions and a lack of survey effort. In the Northern Hemisphere, blue whales generally undertake seasonal migrations from higher latitude feeding grounds to lower latitude breeding and wintering areas. However, it has been suggested that a population of blue whales in the northern Indian Ocean (NIO) remains in lower latitudes year-round, taking advantage of the rich upwelling areas off Somalia, southwest Arabia and western Sri Lanka. Data from this study support a hypothesis that a certain number of individuals remain off the southern coast of Sri Lanka during the SWM, suggesting that the productivity in this region is sufficient to support their year-round presence. This study fills a knowledge gap on the presence and movement of blue whales in the NIO, highlighting the importance of data that can be obtained from platforms of opportunity.

KEYWORDS: BLUE WHALES; CONSERVATION; DISTRIBUTION; INDIAN OCEAN; PLATFORMS OF OPPORTUNITY; SRI LANKA

INTRODUCTION

Blue whale (*Balaenoptera musculus*) stocks have been severely depleted due to commercial exploitation during the last century. The true extent of this depletion is unknown however due to the difficulties estimating pre-exploitation levels (Ballance, 2012), and unreported illegal catches (Brownell and Yablokov, 2009; Ivashchenko *et al.*, 2011). Despite the ban on whaling put in place by the International Whaling Commission (IWC) in 1966, the northern Indian Ocean (NIO) stocks were depleted further by illegal hunting from Russian vessels until 1969 (Berzin, 2008; Mikhalev, 2000). After the era of intense whaling, some populations have shown signs of recovery (Ballance, 2012; Branch *et al.*, 2007) e.g. numbers of Antarctic blue whales (*Balaenoptera musculus intermedia*) are on the increase (Branch *et al.*, 2007) while northeast Pacific blue whales have nearly recovered (Monnahan *et al.*, 2015). Migration patterns are poorly understood for some populations of blue whales including the NIO population (Branch *et al.*, 2007), whereas they are well known for others: notably the northeast Pacific (Calambokidis *et al.*, 2009), southeast Pacific (Hucke-Gaete *et al.*, 2018) and Australia-Indonesia (Double *et al.*, 2014) populations.

There are at least three subspecies in the Southern Hemisphere including the Antarctic blue whale, pygmy blue whale (*B.m. breviceauda*) and an unnamed subspecies off Chile (Committee on Taxonomy, 2018). Further to this, a fourth subspecies, *B.m. indica* (Blyth, 1859) is considered a distinct NIO population with a discrete geographical distribution (Anderson *et al.*, 2012; Samaran *et al.*, 2013). Uncertainty surrounding their taxonomy resides in the problem of distinguishing between subspecies and determining population levels (Reeves *et al.*, 1998; Rice, 1977). However, acoustic research has revealed three types of ‘pygmy’ blue whale calls within the Indian Ocean as well

as Antarctic blue whale calls (Stafford *et al.*, 2011). Whilst Stafford *et al.* (2011) indicate these are four separate acoustic populations, there is some spatial and temporal overlap amongst them (Samaran *et al.* 2013). However, *B.m. indica* are reported (Mikhalev, 2000) to be 5m shorter at maturity compared to the Antarctic blue whale, and are on a northern hemisphere breeding cycle, six months out of phase with the southern Indian Ocean pygmy blue whale (*B.m. breviceauda*). The blue whale species as a whole is classified as Endangered on the IUCN Red List but *B.m. breviceauda* is listed as Data Deficient due to uncertainty about its exact taxonomic status and abundance (Cooke, 2018; IUCN, 2008).

It is generally accepted that most blue whales make yearly migrations towards the poles, however the NIO pygmy blue whales are thought to remain in warm, low latitude waters year-round (Samaran *et al.*, 2013). Stranding records, acoustic detections and limited year-round sightings support this theory (Branch *et al.*, 2007). The apparent non-polar migratory nature of *B.m. indica* is similar to that of *B.m. breviceauda*.

The first records of blue whales in Sri Lankan waters date from 1894 (Haly, 1894 as referenced in De Silva, 1987). Since then they have been observed all around the island from Trincomalee Canyon in the northeast to the southern and western waters where productivity is particularly high (Alling *et al.*, 1991; de Vos *et al.*, 2012). The unique combination of static and dynamic oceanographic features off the coast of Sri Lanka provides a variety of habitats for this relatively unknown population of NIO pygmy blue whales (Alling *et al.*, 1991; Ilangakoon and Sathasivam, 2012). The southern coast is characterised by a predominantly narrow continental shelf and extremely steep slope with the presence of a submarine canyon off Dondra Head (de Vos *et al.*, 2014b). In addition, the seasonally

reversing monsoon contributes to the changing seasons and supports high productivity and upwelling in the region. Whilst blue whales are usually recorded off the southern coast of Sri Lanka during the calmer northeast monsoon (NEM) season as well as the inter-monsoonal periods (Afsal *et al.*, 2008; de Vos *et al.*, 2012; Ilangakoon and Sathasivam, 2012; Priyadarshana *et al.*, 2016; Randage *et al.*, 2014), there is little available data on blue whales in this region during the southwest monsoon (SWM) season. To date there are only two available records (Ilangakoon and Sathasivam, 2012; Randage *et al.*, 2014) of seven sightings of blue whales recorded off the southern coast of Sri Lanka during this monsoon season. Despite pygmy blue whale acoustic calls being recorded in the NIO during most of the year (Branch *et al.*, 2007), there have been no published recordings specific to southern Sri Lanka during the SWM. This evident lack of data during the SWM precludes any assessment of their year-round distribution and abundance in the region which is vital for the implementation of appropriate conservation and management measures.

Not being able to fully understand population abundance and trends makes assessment of potential threats, such as vessel collision, difficult. Up to 90% of world trade is transported by sea (Kaluza *et al.*, 2010) and there is an increased likelihood of collisions for marine mammals found in areas with dense shipping traffic (Randage *et al.*, 2014). The southern coast of Sri Lanka is home to one of the busiest shipping routes in the world (Kaluza *et al.*, 2010; Priyadarshana *et al.*, 2016) and the shipping lanes coincide with Sri Lanka's continental slope, a cetacean-rich habitat in which the pygmy blue whale is most commonly encountered (Afsal *et al.*, 2008). Due to the high productivity of the southern waters of Sri Lanka, predictable patterns of blue whale distribution indicate that this is a high risk zone

(Priyadarshana *et al.*, 2016; Redfern *et al.*, 2017). Pygmy blue whale deaths caused by vessel strikes are widely reported in Sri Lankan waters (de Vos *et al.*, 2012; 2016; Priyadarshana *et al.*, 2016; Randage *et al.*, 2014) and thus vessel strikes represent a potentially significant threat to the population.

This paper presents new sightings of blue whales off the southern coast of Sri Lanka during the SWM and reports the first sightings of blue whales within southern waters outside the Mirissa-Dondra area for the month of July. Given the lack of survey effort during the SWM, this paper aims to attract the attention of the scientific community and direct much needed effort to this area. In addition, considering the Data Deficient status of pygmy blue whales and the extensive data gaps related to the NIO distribution and abundance, the results provide valuable new information on their distribution during this under-researched season.

METHODS

Study area

The scientific geophysical survey was conducted off the southern coast of Sri Lanka ($6^{\circ}59'N$ – $11^{\circ}59'S$ and $79^{\circ}0'E$ – $84^{\circ}59'E$, Fig. 1) with sightings data collected between 12 July and 15 August 2017. The survey was conducted in waters 15–5,440m deep and covered 837.74km of survey lines. Lines were run perpendicular to the Sri Lankan continental slope in one continuous manner from the shelf edge to $12^{\circ}S$ (Geissler, 2017).

This area is a major pathway for exchanging waters between the Bay of Bengal and the Arabian Sea (Schott and McCreary, 2001). It is characterised by seasonally reversing monsoonal currents and bi-annual monsoonal winds that drive significant upwelling (de Vos *et al.*, 2014b). Subsequent wind-driven Ekman transport combined with

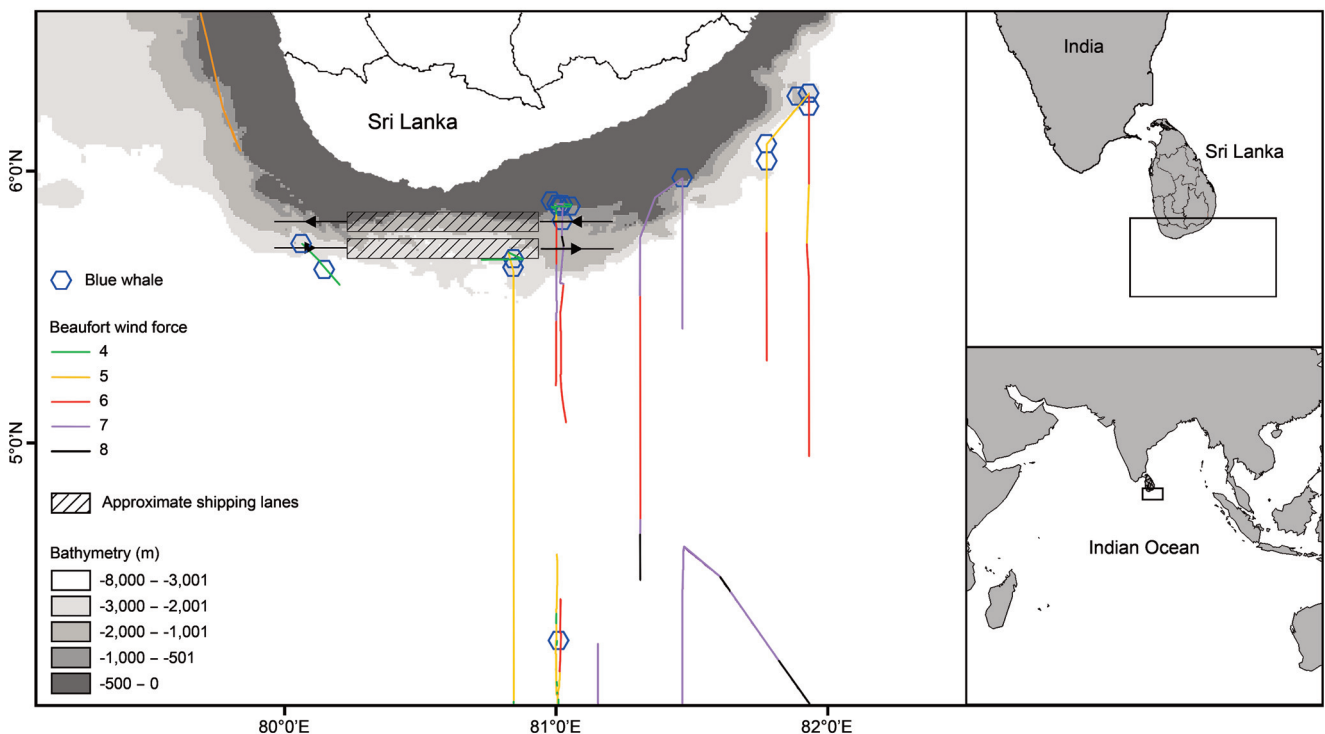


Fig. 1. Sightings of blue whales recorded from a platform of opportunity during a geophysical survey off the southern coast of Sri Lanka, July–August 2017. Approximate area of shipping lane obtained from Priyadarshana *et al.* (2014) (westbound lane $5^{\circ}47.2'N$ – $5^{\circ}50.2'N$, eastbound lane $5^{\circ}41.2'N$ – $5^{\circ}44.2'N$).

open ocean Ekman transport and advection results in coastal upwelling that can reach 70km offshore (Vinayachandran *et al.*, 2004). This study was conducted during the SWM when the Southwest Monsoon Current (SMC) flows along the South coast of Sri Lanka from West to East (de Vos *et al.*, 2014b). During this time upwelling is at its strongest (de Vos *et al.*, 2014b), characterised by high chlorophyll concentrations (peaking in June and August), and a decrease in sea surface temperature (de Vos *et al.*, 2014b; Yapa, 2009). In addition to these conditions, high upwelling exists during the SWM off the coast of Somalia. The Somali current moves north-eastward turning into the equatorial current, bringing cold, nutrient-rich water, which enhances the upwelling phenomena on the southern coast of Sri Lanka (Yapa, 2009).

The Sri Lankan continental shelf is one of the narrowest in the world with a mean width of 20km (Curry, 1984). The continental slope is a concave feature that extends 100m to 4,000m in depth with an inclination of 45°, one of the steepest continental slopes globally (Curry, 1984; Sahni, 1982). The narrow shelf and steep continental slope create deep waters close to the coastline as well as numerous submarine canyons (e.g. Trincomalee in the East and the Dondra in the South; Swan, 1983). Such complex and heterogeneous bathymetry further enhances productivity and creates a diversity of habitats for cetaceans (de Vos *et al.*, 2012).

Field methodology

Marine mammal observations were conducted throughout the survey by three experienced marine mammal observers. Dedicated observations were conducted during all daylight hours (12.5hrs/day) from an observation deck 22m in height. Observers scanned by naked eye and binoculars (8 × 42 Nikon) around the vessel. The sightings, effort and operation data were logged in standardised Marine Mammal Recording Forms (JNCC, 2017). Continuous observations were conducted and effort was recorded during geophysical activity, line turns, and transit to and from the site during daylight hours. Environmental data including wind speed, wind direction, visibility, glare, swell height, Beaufort wind force and sea state were also recorded. The vessels position, speed and course were continuously logged throughout the survey. Once a sighting was made, the latitude and longitude of the ship's position were recorded instantaneously in combination with an estimated distance and true bearing of the animal. Other sightings data recorded include time (GMT), water depth, species identification, group size and composition, direction of travel, and behaviour. It should be noted that all water depth values (m) are specific to the vessels' location and can only be inferred as an estimate for each sighting. When possible, photographs were taken of sightings using digital SLR cameras with 70–300mm zoom lenses to aid in species identification and group size estimates. The notations 'Possible, Probable or Definite' were used for species confidence level (Possible: the animal has some features of a particular species, but significant doubt remains as to the identification; Probable: several identifiable features but cannot discount similar species; and Definite: species clearly identified, beyond reasonable doubt).

Several limitations in our data can be recognised. In particular, the survey effort was gained from a platform

of opportunity and thus is not standardised. In addition, loud anthropogenic noise was emitted into the marine environment when some of the data was collected. This may impact encounter rates or individual behaviour of those animals seen; therefore, this paper does not attempt to calculate sightings rates or relative abundance. Based on the location and previous suggestions of resident blue whale populations in the NIO, we presume that these whales are NIO pygmy blue whales but this can only be confirmed by conducting acoustic, genetic or photo-identification studies which are outside of the scope of this paper.

RESULTS

During the 34-day survey a total of 436hrs and 30mins of dedicated survey effort were completed by the marine mammal observers. This resulted in 28 confirmed sightings of 37 individual blue whales (Table 1), in addition to 17 unidentified whales. No mother and calf pairs were observed so it is assumed that all animals were either adults or sub-adults. The distribution of sightings was between 4–7°N and 80–82°E, which corresponds to the steep continental shelf break and slope of the southern Sri Lankan waters. Effort was obtained from a platform of opportunity and thus was not spatially even (Fig. 1). The vast majority (92%) of effort (in time) was below 5°38'N in latitude (approximately 42km from the coast at closest point). However, 35 out of 37 sightings were above this latitude between 5°38'–6°17'N, corresponding to the continental slope. Based on the coordinates taken from Priyadarshana *et al.* (2014) and Marine Traffic Global Ship Tracking Intelligence (<http://www.marinetraffic.com>), three sightings of five individuals were made within the shipping lanes, with a further nine sightings of 12 individuals within 5km of the shipping lanes (Fig. 2). Approximate time spent within the shipping lanes equated to less than 2% of total effort time. Water depth of the sightings varied from relatively shallow waters (< 200m) to deep oceanic waters (4,300m) with an average water depth of 1,960m.

Throughout this survey, weather conditions were variable, characterised largely by slight sea state (60%), relatively low swell height (< 2m, 60%) and good visibility (> 5km, 89%). The Beaufort wind force varied between force 2 and 10, however for the majority of the time (91%), it was between force 4 and 7 and was mostly at the lower end of that scale.

Focal follows were not possible during the survey, but behavioural states were recorded for each sighting. The predominant behaviour observed was travelling (82% of the time) with fluke dives 18% of the time. The most frequent travelling direction was North (36% of observation). During encounters, blue whales typically surfaced five to 10 times before diving for approximately 10mins.

DISCUSSION

During this study, 37 blue whales were encountered off the South coast of Sri Lanka during the SWM in July and August 2017 (Table 1). These sighting data represent an important contribution to the pool of limited observations (Priyadarshana *et al.*, 2014) of blue whales during this period of the year. The sightings were recorded between 4–7°N and 80–82°E, coinciding with Sri Lanka's continental slope, a

Table 1

Blue whale sightings recorded throughout the scientific geophysical survey South of Sri Lanka during the southwest monsoon season, July–August 2017. The notations ‘possible’, ‘probable’ or ‘definite’ were used for species confidence level (possible: the animal has some features of a particular species, but significant doubt remains as to the identification; probable: several identifiable features but cannot discount similar species; and definite: species clearly identified, beyond reasonable doubt).

Date	Time at start of encounter (UTC)	Location of sightings	Bearing	Range (m)	Number of individuals	Water depth (m)	Certainty
12 July 2017	10:55	5°43.92'N, 80°03.84'E	170	2,000	1	2,730	Probable
	11:24	5°38.92'N, 80°08.93'E	200	1,500	1	3,205	Probable
13 July 2017	2:08	5°40.68'N, 80°50.69'E	225	2,000	1	2,253	Probable
	2:22	5°38.80'N, 80°50.69'E	210	2,000	1	2,424	Definite
22 July 2017	2:00	5°52.18'N, 81°03.27'E	240	2,000	2	524	Definite
	3:40	5°52.07'N, 81°00.67'E	280	2,500	1	608	Probable
	4:25	5°53.41'N, 80°59.05'E	120	3,000	2	84	Definite
25 July 2017	11:53	4°16.27'N, 81°00.76'E	10	4,000	2	4,300	Probable
	11:55	4°16.27'N, 81°00.76'E	12	4,000	2	4,300	Probable
26 July 2017	11:18	5°49.16'N, 81°01.49'E	60	2,000	3	372	Probable
	11:25	5°52.65'N, 81°01.49'E	300	4,000	2	372	Probable
	11:30	5°52.65'N, 81°01.49'E	270	4,000	2	372	Probable
	11:43	5°52.65'N, 81°01.49'E	325	2,000	1	372	Definite
	12:40	5°52.73'N, 81°00.33'E	210	2,000	1	372	Definite
31 July 2017	9:15	5°58.46'N, 81°27.87'E	300	1,000	1	367	Probable
14 August 2017	6:55	6°14.33'N, 81°55.82'E	270	1,500	1	3,678	Probable
	6:58	6°14.33'N, 81°55.82'E	240	4,000	1	3,678	Probable
	7:15	6°17.18'N, 81°55.82'E	300	1,500	1	2,189	Probable
	7:25	6°16.46'N, 81°53.44'E	255	2,000	1	1,400	Probable
	7:27	6°16.46'N, 81°53.44'E	240	3,500	2	1,400	Definite
	7:28	6°16.46'N, 81°53.44'E	210	2,000	1	1,400	Definite
	7:30	6°17.18'N, 81°55.82'E	160	300	1	2,189	Definite
	7:35	6°17.18'N, 81°55.82'E	165	400	1	2,189	Definite
	7:36	6°17.18'N, 81°55.82'E	170	150	1	2,189	Definite
	7:36	6°17.18'N, 81°55.82'E	330	700	1	2,189	Definite
	8:29	6°05.98'N, 81°46.52'E	105	1,000	1	3,288	Definite
	8:35	6°05.98'N, 81°46.52'E	175	4,000	1	3,288	Probable
	8:59	6°02.21'N, 81°46.52'E	295	2,500	1	3,170	Probable
Total		28 sightings			37	Ave. 1,960.8	



Fig. 2. Examples of a blue whale sighted during the geophysical survey offshore southern Sri Lanka. [Photo by Menaka Goonewardena]

region of nutrient rich water and strong upwelling (de Vos *et al.*, 2014a). This region represents a rare habitat type with a narrow continental shelf and a steep concave slope. The presence of the Dondra submarine canyon and seasonally reversing monsoons, converging ocean currents and strong trade winds also contribute to the special environmental conditions resulting in high productivity (de Vos *et al.*, 2014b). Due to their high energetic demand, blue whales are known to aggregate in areas of upwelling events or frontal systems with an abundance of prey (Alling *et al.*, 1991;

Croll *et al.*, 2005; Gill, 2002; Reilly and Thayer, 1990). Considering this, high productivity off the South coast of Sri Lanka may be able to support a year-round population of pygmy blue whales (de Vos *et al.*, 2018). Although minimal effort (approximately 8%) during this survey was conducted on the continental slope, 95% of our sightings were made in this region, emphasising the importance of this area. The effects of the intense upwelling system and high primary productivity of the Sri Lankan shelf extends as far as 70km offshore (Vinayachandran *et al.*, 2004). Interestingly

only two observations during the present study were made far offshore, approximately 200km from the coast at 81°0'45.6"E and 4°16'16.2"N. The relative absence of blue whales offshore may indicate a lack of available food, suggesting that those animals were probably travelling through rather than feeding. Anderson *et al.* (2012) have suggested that during the months of April/May and December/January, blue whales may be migrating East to West or West to East respectively, seeking areas of high food availability. This may indicate that this area may only be able to support a finite number of blue whales forcing other individuals to disperse to wider regions (Anderson *et al.*, 2012).

The nutrient rich waters around the continental shelf (de Vos *et al.*, 2014a) overlap with busy shipping lanes (de Vos *et al.*, 2016). Approximate observation effort (in time) spent within the shipping lanes was less than 2% of the total time spent searching but 10% of sightings were within the shipping lanes and 32% within 5km. This, in combination with several reports of blue whale fatalities in recent years (de Vos *et al.*, 2013; Priyadarshana *et al.*, 2016) renders it important to understand the abundance of the NIO population and its distribution in order to estimate the relative risk of vessel collisions and their impact on the population.

The present study shows that the previous lack of evidence of blue whale presence off southern Sri Lanka during the SWM is not a true representation of the abundance in the area but rather a consequence of rough sea conditions due to the strong monsoonal winds that make cetacean surveys difficult during this time of year (Ilangakoon and Sathasivam, 2012). Anderson *et al.* (2012) reviewed sighting records between 1983 and 2010 and found that out of the 468 sightings recorded off the southern coast, none occurred during the months of July and August. Similarly, Randage *et al.* (2014) have reviewed blue whale sightings recorded on board a tour operating vessel and their results indicated a clear 'high season' and 'low season'. Most sightings (82%) were recorded between December and April (high season), whilst there were only five sightings in the months of July and August (low season). However, these figures are related to effort, i.e. during the high season trips were made daily, whereas low season trips were made only sporadically due to weather conditions. In contrast, there are numerous records for the NEM season with the majority provided by whale watching tour operators. For example, Afsal *et al.* (2008) reported a total of 13 sightings off the southern coast of Sri Lanka between October and February 2003–2007, all within 5–7°N and 78–82°E. Priyadarshana *et al.* (2016) encountered 150 individuals between 5–6°N and 80–82°E in February and April 2014 and Gunaratna *et al.* (1985; cited from Branch *et al.*, 2007) reported blue whales in May between 5–7°N and 79–81°E. There seems to be an apparent trend in the location of recorded sightings and an overlap occurs between 4–7°N and 78–82°E. Our sightings are consistent with this trend with 35 out of 37 sightings occurring between 5°38'–6°17'N and 80–82°E.

Globally, the main prey species of blue whales are euphausiids, although copepods, mysids, small fish and amphipods have also been reported (de Vos *et al.*, 2018; Gill, 2002; Schoenherr, 1991). However, a recent study conducted off southern Sri Lanka revealed 87% of their diet was made

up of dendrobranches with only 8% consisting of euphausiids. Acanthocephalans, copepods, amphipods, scyphozoans, actinopterygians and cephalopods comprised the remaining (de Vos *et al.*, 2018). Generally, migrating baleen whales tend to feed little until they reach their high latitude feeding grounds which are high in productivity and abundant in prey (Mackintosh, 1966). However, it is hypothesised that NIO pygmy blue whales have adapted their feeding habits by foraging throughout the year on locally abundant patches of sergestidae (de Vos *et al.*, 2018). The local availability of prey and productivity off Sri Lanka may therefore present sufficient feeding opportunities to support an undefined number of blue whales during the SWM. Similar conclusions have been drawn in other parts of the world, e.g. South Georgia (Risting, 1928), Crozet Island in the southern Indian Ocean (Samaran *et al.*, 2010), the West Antarctic Peninsula (Širović *et al.*, 2009) and the Costa Rica Dome (Reilly and Thayer, 1990), where year-round presence and evidence of acoustic calls suggest that not all blue whales undertake synchronous, large migrations. Coincidentally, these regions are also characterised by high primary productivity caused by the mixing of ocean currents and rich upwelling systems (Broenkow, 1965; Croxall and Prince, 1980; Lascara *et al.*, 1999; Ross *et al.*, 1996). Taking into consideration our findings as well as regular sightings during the NEM (de Vos *et al.*, 2014a), we suggest that a certain number of blue whales are present year-round in this area. In order to draw conclusions on population size, further long-term year-round studies are needed.

During the present study, blue whales were observed travelling in varying directions. The most common direction was North with 10 out of 28 observations but the sample size overall is small and it is not possible to draw any general conclusions from these data.

During encounters, blue whales typically surfaced five to 10 times before diving for approximately 10mins. This corresponds to findings by de Vos *et al.* (2013) who collected data off the southern coast of Sri Lanka. Their records show that the typical blue whale surfacing pattern consisted of three to 20 (average 11) breathing bouts followed by a dive averaging 640s (10.7mins). A similar surface and dive pattern was recorded in the North Atlantic where whales were found to surface 6 to 20 times and dive between 5 and 15mins (Sears and Calambokidis, 2002). Croll *et al.* (2001) recorded blue whale dive times in California and noted that foraging dives lasted approximately 7.8mins, while travelling/migrating dives were approximately 4.9mins. Although not statistically different, the slightly greater dive duration recorded in the NIO may reflect the fact that blue whales must dive deeper to their dendrobranch prey that are typically found at approximately 300m (de Vos *et al.*, 2018). In support of that, no foraging behaviour or lunging was witnessed by any blue whales in the current study.

CONCLUSIONS

This study highlights the potential value of data collected on board a platform of opportunity. The nature of the vessel allowed data collection during a season characterised by unfavourable weather conditions prohibiting surveys by small research vessels. It also allowed access to remote, offshore areas rarely surveyed even during times of good

weather. Some limitations and bias are incurred when researching spatial and temporal distribution due to the differences in effort surveyed from platforms of opportunity, especially noisy ones such as in this study, and thus caution is recommended when interpreting results (Kiszka *et al.*, 2007; Vinding *et al.*, 2015). Nevertheless, it offered a rare glimpse of the presence of blue whales in southern Sri Lanka during this under-researched season, supporting the theory that these cetaceans are present in the region year-round. This is significant given the relative paucity of information on blue whales off the southern coast of Sri Lanka during the SWM, and the NIO population as a whole.

ACKNOWLEDGEMENTS

We would like to acknowledge and thank the Alfred Wegener Institute Helmholtz-Centre for Polar and Marine Research (AWI) and the German Federal Ministry of Education and Research for their hospitality on board the vessel *RV SONNE*, which was used during the survey. This project was funded through a grant by the German Federal Ministry of Education and Research (BMBF, 03G0258A) and by AWI internal funding. We also thank the captain Oliver Meyer and the crew of *RV SONNE*, the chief scientist Dr. Wolfram Geissler (AWI), co-chief scientist Dr. Tabea Altenbernd (AWI) and the remaining team of scientists that made this expedition a success. In addition, we thank the marine mammal observers, Menaka Goonewardena and Emma Hayes, who collected the data alongside the second author of this manuscript. We also thank Howard Martenstyn, Asha de Vos, Kimiko Hamilton and two anonymous reviewers who made valuable contributions to the draft version of the manuscript.

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