A note on humpback whales (*Megaptera novaeangliae*) in the central Indian Ocean

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ABSTRACT

In the central Indian Ocean, humpback whales (*Megaptera novaeangliae*) are rare. Records from southern India, Sri Lanka, Maldives and the Chagos Archipelago (n = 68) were compiled and show a bimodal pattern of seasonal occurrence. Those occurring during the northern winter (December to March) are known from other studies to belong to the Arabian Sea humpback whale population. There have been no humpback whales recorded in Maldives during the northern winter since 2002, suggesting a possible range contraction for the Arabian Sea humpback whale population. Humpback whales occurring during the southern winter (June to October) are assumed to belong to the southwest Indian Ocean population (IWC breeding stock C). In this case, numbers of opportunistic sightings are increasing and the population appears to be spreading northwards as it recovers from commercial whaling, with several recent southern winter records from as far north as 5°N in northern Maldives and southern Sri Lanka. For this southern hemisphere population, calves are first seen in August, with numbers of calves increasing in September and October. For both populations, interactions with regional fisheries, particularly pelagic gillnetting, may be a major cause of mortality.

KEYWORDS: INDIAN OCEAN; ASIA; INCIDENTAL SIGHTINGS; TRENDS; BREEDING GROUNDS; MIGRATION

INTRODUCTION

In the Indian Ocean, humpback whales (*Megaptera novaeangliae*) occur in three main areas, where they are considered to belong to three separate populations: in the northern Arabian Sea, in the southwest Indian Ocean (IWC breeding stock C) and in the southeast Indian Ocean (IWC breeding stock D). Arabian Sea humpback whales (hereafter ASHW) are resident year-round in the northern Arabian Sea (Minton *et al.*, 2008, 2011; Pomilla *et al.*, 2014). In contrast, the other two populations feed in the Southern Ocean during the southern summer and migrate north to lower latitude breeding areas for the southern winter. Humpback whales in the southwest Indian Ocean (hereafter SWIOHW) winter mainly in waters around East Africa, Madagascar and nearby islands, while those in the southeast Indian Ocean winter mainly off Western Australia (Amaral *et al.*, 2016; Fleming and Jackson, 2011). In between these three areas, within the central Indian Ocean and at the heart of the IWC's Indian Ocean Sanctuary, humpback whales are rare and little is known of their ecology (Anderson, 2005; De Silva Wijeyeratne *et al.*, 2020; Sutaria, 2018, 2019). The main aim of this study was to compile information on the occurrence of humpback whales within the north-central Indian Ocean in order to elucidate their seasonality and, consequently, their likely stock affinities.

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METHODS

This study reviewed records of humpback whales within the northern part of the central Indian Ocean, considered here as the waters around southern India, Sri Lanka, Maldives and the Chagos Archipelago. For our purposes, southern India included all coastal waters south of 15°40'N (the northern boundary of Goa state on the west coast). Our study excluded records from northwest India (the states of Maharashtra and Gujarat) which is part of the core area for ASHW, where humpback whales are expected to occur year-round (e.g., Minton *et al.*, 2008; Pomilla *et al.*, 2014).

Records of humpback whales in the study area up to the end of 2019 were compiled from published accounts, social media reports, a citizen-science project (Sutaria, 2019) and personal contacts. Sightings were only accepted as valid if they were accompanied by photographs or video, or first-hand descriptions from reliable sources; most reports of sightings without supporting photographic evidence were considered unreliable and were rejected. Published records of humpback whales in the central Indian Ocean which we considered unconfirmed or lacking in sufficient detail are summarised in Supplementary Table S1 and were excluded from all our analyses. Acoustic recordings and individual satellite tracks over multiple days were counted as only one record per month for our seasonal analyses and one record per 5-year period for our longer-term analyses.

RESULTS

Sixty-eight records of humpback whales in the central Indian Ocean were compiled (Tables 1 and S2, and Fig. 1). The data demonstrate that there are two main seasons of occurrence (Fig. 2): December to March (northern winter) and June to October (southern winter). There were just single records from both April and May; we exclude these data points from our seasonal analyses, and mark them distinctively on our location map (Fig. 1a).

For the two seasons, the proportions of humpback whales recorded in each region of the study area are summarised in Fig. 3 (illustrating a latitudinal trend), while the numbers recorded by 5-year period are summarised in Figs 4 and 5 (illustrating temporal trends).

Mother-calf pairs were recorded during both seasons. During the northern winter, 5 mother-calf pairs (from a total of 13 sightings, 38%) were observed, in Sri Lanka and Maldives, in December and February. During the southern winter, 15 mother-calf pairs were recorded (from a total of 45 sightings, 33%), in the Maldives and Chagos. In this case, no calves were recorded in June or July (out of 11 sightings), the first calves were recorded in August (n = 3 from 17 sightings, 18%), with an increasing proportion of sightings with calves in September (n = 7 from 12 sightings, 58%) and October (n = 5 out of 5 sightings).

DISCUSSION

We interpret the bimodal distribution of humpback whale records (Fig. 2) as representing two different populations: ASHW during the northern hemisphere winter (December to March), and SWIOHW during the southern hemisphere winter (June to October). For the purposes of the following discussion, we assume that these population assignments are correct, but we acknowledge that some uncertainty remains, and that it is quite possible for the occasional humpback whale to appear in the central Indian Ocean 'out of season'.

The evidence that humpback whales occurring in our study area during the northern winter belong to the Arabian Sea population is compelling. Links with Oman (which as a working hypothesis we take to be the central, core area for this population) have been clearly established by several previous investigations. These include studies of songs shared with both Sri Lanka (Whitehead, 1985) and southwest India (Madhusudhana *et al.*, 2018; Mahanty *et al.*, 2015) as well as by satellite tracking (Willson *et al.*, 2018) and by photo-identification (Minton *et al.*, 2020).

For humpback whales observed during June to October, the southern winter, there are no genetic, acoustic, satellite tracking, photo-identification or other data directly linking them to any particular population. However, we assume that they belong to a southern hemisphere population because of their seasonality of occurrence. Brown (1957) appears to have been the first to suggest that at least some northern Indian Ocean humpback whales are 'almost certainly members of the same population as is found in the Antarctic in the southern

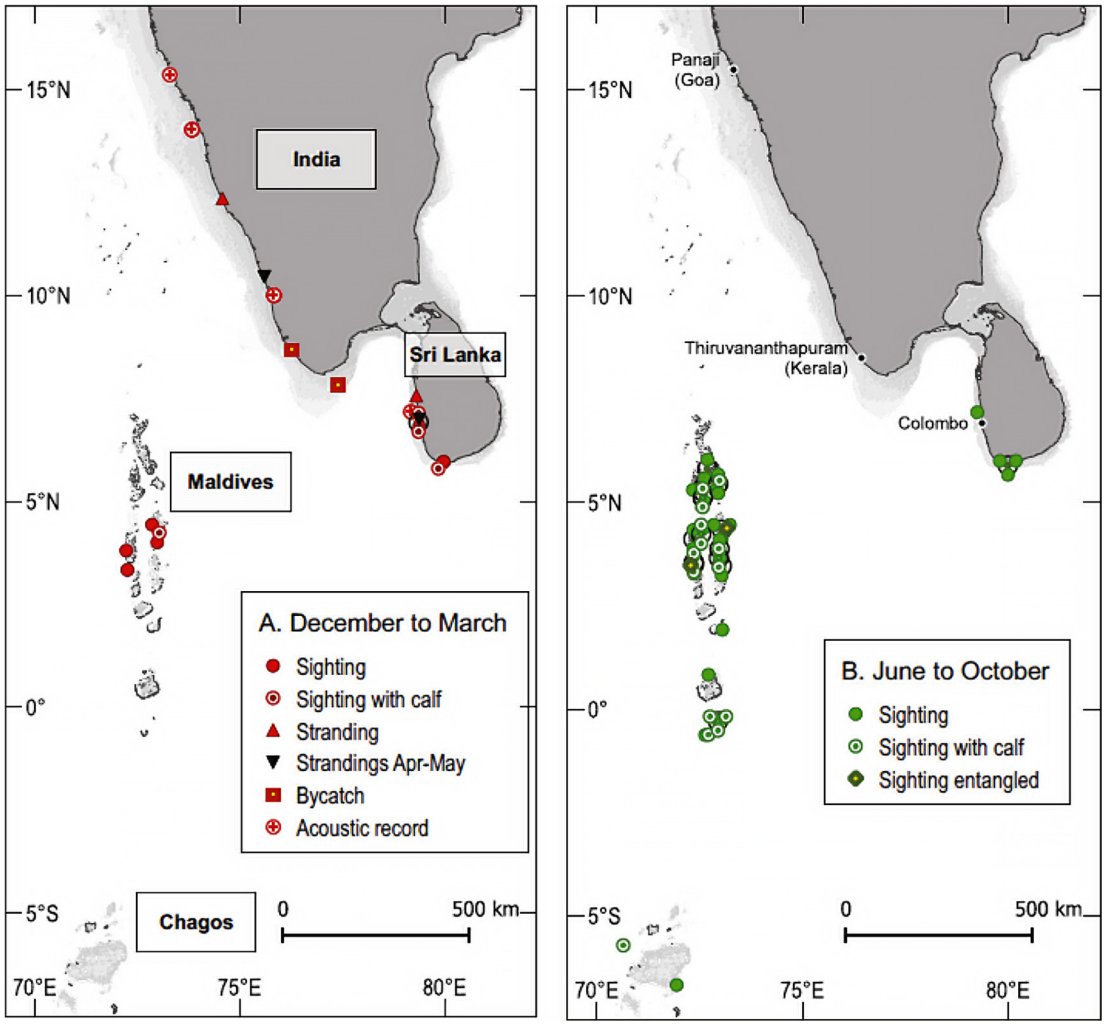

Fig. 1. Locations of humpback whale records in the central Indian Ocean, (A) during the northern winter, December to March (n = 20) and (B) during the southern winter, June to October (n = 45). Note: the maps include point records only, not satellite tag tracks (n = 1, for which see Willson *et al*., 2017); some points offset to reduce overlap. The locations of strandings from April and May (n = 2) are noted in map A.

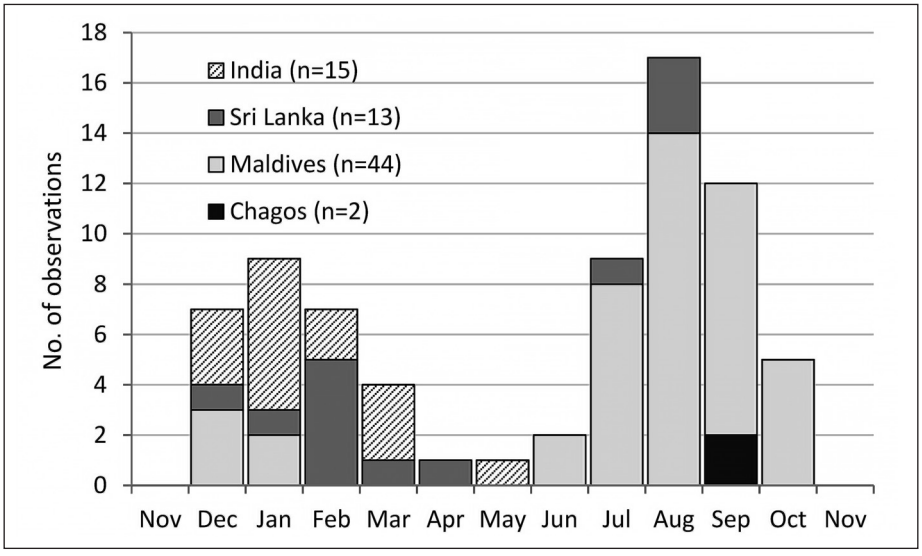

Fig. 2. Seasonality of humpback whale records in the central Indian Ocean. Note: Σn = 74 (not 68) because satellite-tracking and some acoustic records were counted in more than one month.

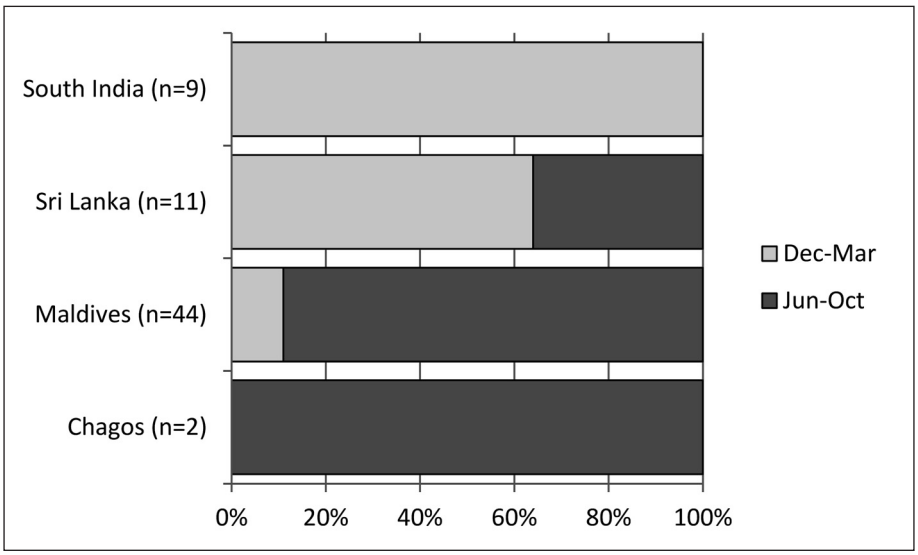

Fig. 3. Proportions of humpback whales occurring in different areas of the central Indian Ocean (along a latitudinal gradient) by season. Note that Σn = 66, not 68, because two records from April and May are not included.

summer.' While it is possible that they are from the southeast Indian Ocean (i.e., from IWC breeding stock D, which winters off Western Australia) it seems more likely that they are from the southwest Indian Ocean (i.e., SWIOHW). The latter area is much closer to our study area than Western Australia, with one SWIOHW individual having been satellite-tracked from Réunion to as close as the Nazarath Bank, in 60°E, during August–September 2013 (Dulau *et al.*, 2017). Another SWIOHW individual satellite-tagged off Madagascar was tracked into the western Arabian Sea, to 3°N, in July-August 2012 (Cerchio *et al.*, 2016). Elsewhere in the Arabian Sea, SWIOHW songs have been recorded as far north as Hallaniyats Bay, Oman (in 17°N) in August–September 2012 (Cerchio *et al.*, 2018). In addition, an individual seen in the Red Sea, to 26°N in September and October 2016, was thought likely to be a SWIOHW, based on the extent of its white pigmentation (Notarbartolo di Sciara *et al.*, 2017). We also note that the seasonality of occurrence in the central Indian Ocean (with just a few individuals recorded in June, a peak in August–September and none after October) closely matches the seasonality of occurrence of SWIOHW wintering within the southwest Indian Ocean (Braulik and Stern, 2020; Dulau-Drouot *et al.*, 2012; Trudelle *et al.*, 2018; Webster *et al.*, 2020) as does the seasonality of calf occurrence.

Mother-calf pairs were recorded during both seasons. The occurrence of calves in December and February is consistent with the known northern-winter breeding of ASHW, with first calving in December (Mikhalev, 1997). Minton *et al.* (2011) recorded unexpectedly low numbers of females with calves off Oman in February; the data compiled here suggest that at least some of the ASHW population uses the southeast Arabian Sea as a breeding ground at that time. During the southern winter, the first calves were recorded in the central Indian Ocean in August, with increasing numbers of sightings with calves in September and October. This breeding seasonality is consistent with that of a southern hemisphere population, such as SWIOHW (Dulau-Drouot *et al.*, 2012; Matthews, 1937; Trudelle *et al.*, 2018).

The data further indicate that humpback whales occurred more frequently in the northern portion of the central Indian Ocean during the northern winter, and in the southern portion of our study area during the southern winter (Figs 1 and 3). This is consistent with the hypothesis that the humpback whales observed during these two seasons are ASHW and SWIOHW, respectively. In addition, there are no confirmed records from the east coasts of India or Sri Lanka, which is consistent with all the humpback whales in our study area being from western Indian Ocean populations.

The long-term trends in records are very different for the two presumed populations. For ASHW, there were more records during 2015–19 than in any previous 5-year period (Fig. 4). However, this largely reflects increased research effort since 2015, with many recent records being derived from remote technologies (satellite tracking and acoustic recording); it does not imply that the population is becoming more abundant. Indeed, the numbers

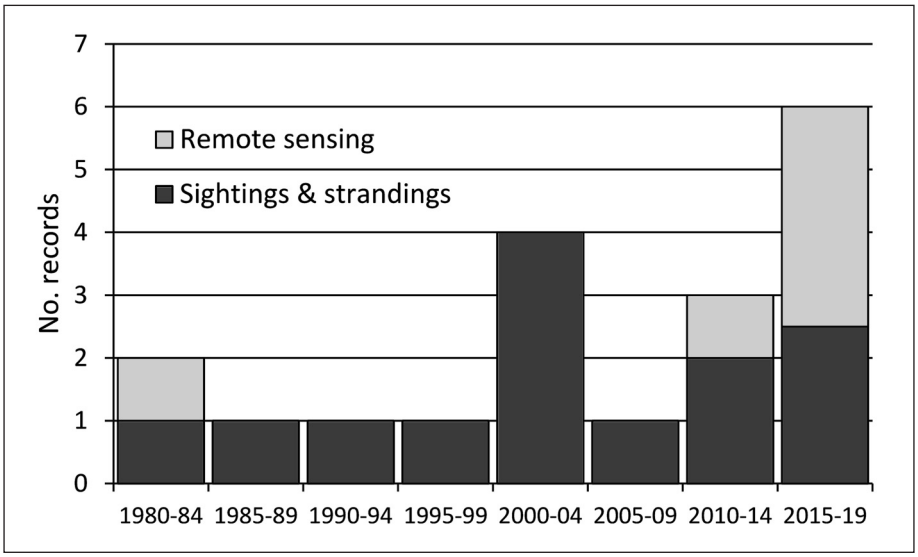

Fig. 4. Northern hemisphere winter (December to March) records of humpback whales in the central Indian Ocean, by 5-year period. Remote sensing includes records from acoustic monitoring and satellite tracing. Note that 3 records from India during 2015–19 were of sightings with acoustic recordings; they are scored here as 1.5 sightings and 1.5 remote sensing.

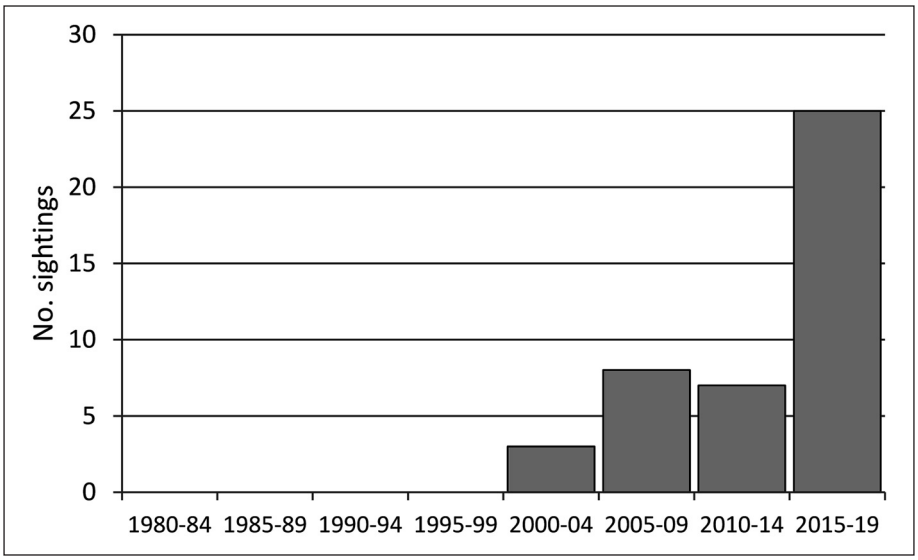

Fig. 5. Southern hemisphere winter (June to October) records of humpback whales in the central Indian Ocean, by 5-year period. Note that there are no stranding, satellite or acoustic records from this season.

of humpback whales actually seen by people (i.e. sightings and strandings) have barely increased over the past 40 years. Given that the number of people able and inclined to report such occurrences has increased in recent years (e.g., De Silva Wijeyeratne *et al.*, 2020; Sutaria, 2019), it seems possible that ASHW numbers within the central Indian Ocean might be declining. This interpretation is supported by the fact that there have been no recent northern winter records from the Maldives. Up to 2002 there had been five sightings of humpback whales in the Maldives during the northern winter (71% of the 7 Maldivian records up to that date); since 2002 there have been none. The northern winter is the main tourist season in the Maldives, where there has been a particularly large increase in potential observers in recent years (e.g., tourist arrivals increased from 0.47 million in 2000 to 1.70 million in 2019[5]). At the same time there has been enormous growth in the use of digital

[5] *www.tourism.gov.mv/en/statistics*, accessed 15 February 2021.

Table 1
Summary of humpback whale records from the central Indian Ocean to the end of 2019.

	Southern India	Sri Lanka	Maldives	Chagos	Total
Sightings	–	9	44	2	55
Sighting + acoustic	3	–	–	–	3
Acoustic	2	1	–	–	3
Strandings	3	2	–	–	5
Bycatch	1	–	–	–	1
Satellite track	1	–	–	–	1
Total	**10**	**12**	**44**	**2**	**68**

photography and social media. This has led, for example, to increased reports from the Maldives of northern winter and spring blue whales, *Balaenoptera musculus* (RCA, unpublished data) and of southern winter humpback whales (Fig. 5). We propose that the dearth of recent reports of northern winter humpback whales from the Maldives is not an observational artefact but reflects genuine absence. Given the small numbers involved, too much reliance should not be placed on any one interpretation at this stage, but there are several possible explanations for such recent absence from the Maldives. These include changing oceanographic conditions or range contraction as a result of population decline.

Range contraction due to population decline as a result of overfishing has been documented in other marine megafauna (Burgess *et al.*, 2017; Worm and Tittensor, 2011; Yan *et al.*, 2021). ASHW were depleted by Soviet whaling in the 1960s (Mikhalev, 1997), and the population has never recovered, with entanglement in fishing gear (particularly pelagic gillnets) being implicated as a continuing cause of injury and mortality (Anderson *et al.*, 2020; Minton *et al.*, 2011, 2020; Pomilla *et al.*, 2014; Sutaria *et al.*, 2015). The ASHW population is listed as Endangered by IUCN (Minton *et al.*, 2008) although there is a recommendation for that listing to be revised to Critically Endangered (Pomilla *et al.*, 2014). Our data support the need for such a reappraisal.

In contrast to ASHW, there has been a clear increase in the number of presumed SWIOHW records (mostly from Maldives but also from Sri Lanka and Chagos) over the past two decades (Fig. 5). There were no southern winter records of humpback whales at all between July 1976 and September 2001. Since then, the number of annual records increased to a maximum of 19 in 2018. There was only one reported sighting in 2019, which might have been a reflection of unusual oceanographic conditions across the region in that particular year (Braulik and Stern, 2020; Shi and Wang, 2021). Apart from that, the general increase in reported sightings was no doubt influenced by the increase in the number of people able and willing to make reports. However, the increase is so rapid that it seems unlikely to be explained by this single factor alone. We suggest that it is also in part due to an increase in abundance of SWIOHW in the central Indian Ocean perhaps reflecting the recovery of the population from commercial whaling (c.f. Dulau-Drouot *et al.*, 2012) and consequent range expansion, back into waters from which they had been extirpated (although additional factors such as changing oceanographic conditions cannot be excluded). There are anecdotal reports from older fishermen in Maldives, Sri Lanka and India of whales (not specifically humpback whales) being more common in the past than they have been in recent decades (Anderson, 2005; Reeves *et al.*, 1991; Sutaria *et al.*, 2015).

This interpretation of a gradual recovery of the SWIOHW population from commercial whaling is also supported by the steady expansion northwards shown in the data. The first presumed SWIOHW was recorded in the far south of Maldives (0°37'S) in 2001, in northern half of Maldives (north of 3°30'N) in 2004, in the far north of Maldives (north of 5°30'N) in 2010, and off southern Sri Lanka (5°50'N) in 2015. If this trend were to continue, we predict that humpback whales will be recorded off northwest Sri Lanka (where they were recorded historically to at least 7°N) and possibly also southwest India during the southern winter in the coming years. Similar expansions have been noted in other humpback whale populations as they recover from commercial whaling (e.g., Bortolotto *et al.*, 2016; Zerbini *et al.*, 2019). Nevertheless, as SWIOHWs increasingly venture into the central Indian Ocean, entanglement with fishing gear may become a progressively more important cause of mortality, as it appears to be for ASHW (Minton *et al.*, 2020). During the five-year period 2015–2019, two out of 21 SWIOHW seen in the Maldives were entangled in fishing gear.

The ASHW population has often been described as resident within the Arabian Sea and as non-migratory (e.g., Minton *et al.*, 2011; Pomilla *et al.*, 2014; Reeves *et al.*, 1991). While our data provide additional evidence for the limits of the range of ASHW within the Arabian Sea, the data also clearly show that the population is not strictly non-migratory. At least some ASHW migrate to the southeast Arabian Sea during the northern winter. This reinforces other recent demonstrations of such movements, by satellite tracking and photo identification (Willson *et al*., 2018; Minton *et al*., 2020). Nevertheless, such movements, of the order of 2,000–3,000km from Oman, are very much shorter than the journeys undertaken by humpback whales from other populations. Indeed, our data suggest that Southern Ocean humpback whales currently migrate to at least 5°N in the central Indian Ocean during the southern winter. As noted above, elsewhere in the Arabian Sea, SWIOHW songs have been recorded as far north as 17°N in Oman (Cerchio *et al.*, 2018). For comparison, Southern Ocean humpback whales in the eastern Atlantic have been recorded wintering as far north as 5°N off west Africa (Rosenbaum *et al.*, 2014), while those in the eastern Pacific have been recorded wintering as far north as 11°N, the northernmost extent of what has been described as the longest migration by any mammal (De Weerdt *et al.*, 2020; Rasmussen *et al.*, 2007).

In conclusion, ASHW occur seasonally in the central Indian Ocean, during the northern winter. Our data imply that ASHW range may be contracting, possibly suggestive of a population decline. In contrast, for SWIOHW, which occur during the southern winter, opportunistic sightings are increasing and range appears to be expanding, perhaps reflecting population recovery from commercial whaling. ASHW (the least migratory humpback whale population) and SWIOHW (one of the most migratory humpback whale populations) overlap spatially but not temporally in the waters of Sri Lanka and Maldives. Both populations breed in the central Indian Ocean, and both are impacted by regional fishing activities, particularly pelagic gillnetting. The continued compilation of opportunistic sightings should provide further insights. However, additional dedicated research, including more widespread use of acoustic monitoring as well as photo-identification and genetic sampling will be required to fully elucidate population affinities, migrations patterns and stock status.

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