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High mortality of Olive Ridley Turtles (*Lepidochelys olivacea*) in ghost nets in the central Indian Ocean

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Abstract
Lost, abandoned or discarded fishing nets, otherwise known as 'ghost nets', pose a serious risk to large marine fauna throughout the world, including in the Indian Ocean. Since 1988, a total of 129 Olive Ridley Turtles (*Lepidochelys olivacea*) have been found entangled in ghost nets in Maldivian waters. Given that the predominant fishing techniques used in the Maldives are pole-and-line and handline, the majority of ghost nets found must have drifted with oceanic currents from neighbouring countries and international waters. Our data suggest that these nets may be coming to the Maldivian waters from India, Sri Lanka, and further afield in Southeast Asia during the Northeast Monsoon, and from the Arabian Sea during the Southwest Monsoon. Entangled Olive Ridley Turtles are most often encountered in the Northeast Monsoon, and sexually immature individuals make up the majority of entanglements. 71% of Olive Ridley entanglements were associated with large conglomerates of multiple fishing nets. Individual net samples had stretched mesh sizes ranging from 35 mm to 590 mm and were of knotted multifilament construction. A challenge continues to be identifying from which countries, and which fisheries, specific nets are originating. In this report we examine 74 separate ghost net conglomerates recorded from the Maldives, Sri Lanka, and India between July 2013 and July 2014. Our findings suggest that some of the nets originated from India and Thailand, while others are pieces of fish aggregating devices (FADs) from the western Indian Ocean. We also report on the risk that these nets pose to the populations of the Vulnerable Olive Ridley Turtle in the Indian Ocean. We recommend a reduction in gillnet fishing capacity in the region; improved net disposal facilities in ports; a system of no-blame gear loss reporting; a centralised database of Indian Ocean fishing net construction parameters; and the rapid adoption of non-entangling FADs by all fleets.

Introduction

Lost, abandoned or discarded fishing nets, otherwise known as ghost nets, pose a serious threat to marine fauna worldwide. Currently there is a lack of information on the incidence of ghost nets in the Indian Ocean, but an alarmingly high number of Olive Ridley Turtles (*Lepidochelys olivacea*) have been found entangled in nets in the Maldives (Anderson *et al.,* 2009). Despite global efforts to remove and research ghost nets, the issue remains largely unresolved (e.g., Butler *et al*., 2013; Timmers *et al.,* 2005; Wilcox *et al*., 2012). One challenge continues to be identifying from which countries specific nets are originating. This is complicated by the lack of information on the construction of nets being used in many fisheries (Moreno & Herrera, 2013). Furthermore, oceanic currents make matters more difficult by moving ghost nets great distances from their

original area of use and ocean gyres can tangle multiple single nets into large conglomerates.

Here we report on the relatively large numbers of Olive Ridley Turtles (ORT) being found in the Maldives in ghost nets that have originated from other countries. We also note the major tuna fishing practices in the Indian Ocean, the current status of the ORT, and the different types of ghost nets recorded, with a focus on the significant risk they pose to ORT populations in the Indian Ocean. We then make recommendations on how Indian Ocean countries can reduce and remove ghost gear from their waters.

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Tuna Fishing Practices in the Indian Ocean

Tunas make up a major part of the fish catch in the Indian Ocean. Tropical tuna (namely bigeye, yellowfin and skipjack tuna) accounted for 53% of the total tuna catch between 2010-2012 (IOTC, 2013c). Neritic species are also important and made up the majority of remaining tuna catch. Five major commercial fishing techniques are currently used to target these species:
1) Purse seine fisheries, which are centred in the western Indian Ocean (WIO), and which employ large numbers of drifting fish aggregating devices (dFADs.) These dFADs typically have swathes of netting attached underneath. The major fishing nations are Spain, France and the Seychelles.
2) Drifting gillnet fisheries of Sri Lanka, India, Pakistan, the Islamic Republic of Iran (hereafter Iran), and other coastal countries mainly operating around the Arabian Sea. Gillnetting currently accounts for over 40% of the region's tuna catch.
3) Long line fisheries, which are practiced predominantly in Sri Lanka, India and Indonesia, as well as by fleets from distant East Asian nations
4) The more traditional technique of pole-and-line fishing, which is used in the Maldives, the Lakshadweep Islands, and Sri Lanka..
5) Handline fisheries, which are widespread throughout the region.

In addition to these major tuna fishing techniques, trawling is also practiced (but not for tunas). Trawling is used extensively off of India's eastern coast near Orissa. Trawling has been reported to be directly associated with turtle mortality, particularly for the ORT population of Orissa (*e.g.*, Sridhar, 2005).

The major sources of ghost nets are likely to be gillnet, purse seine, and trawl fisheries. Note that none of these fisheries operate in the Maldives, where pole-and-line and handline fisheries dominate.

The Olive Ridley Turtle

The ORT is the most abundant of all marine turtles, but is still classed as 'Vulnerable' on the IUCN Red List (2008 listing) with a globally decreasing population trend (Abreu-Grobois & Plotkin, 2014). This species is also listed in Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and is protected by the Convention on Migratory Species (CMS). The juvenile stage of the ORT, like most species of marine turtles, is largely unknown. It is believed that they spend their early, nomadic years drifting with oceanic currents (Shenoy *et al*., 2011). Adult ORTs are also highly migratory and spend much of their life in the open ocean. Satellite telemetry studies from India and Bangladesh have shown that after the nesting season, adults may travel thousands of kilometres between their nesting and feeding grounds and there is evidence that large numbers may congregate around Sri Lanka after the nesting season (Beavers & Cassano, 1996; Vasconcelos *et al.,* 2001; Parker *et al.*, 2003; Pandav & Choudhury, 1998).

Pitman (1990) noted that ORTs are often seen investigating or associating with flotsam in the eastern tropical Pacific. In the open ocean, nets may be an easy source of food or shelter. ORTs also have a habit of basking at the sea surface (Pitman, 1993), which may make them susceptible to boat impacts and net entanglements.

Nesting sites for ORTs are widely dispersed throughout the Indian Ocean. They are known to nest along the entire coast of the Indian subcontinent from Pakistan in the Arabian Sea to Bangladesh in the Bay of Bengal. Nesting has also been reported from the Lakshadweep, the Andaman and Nicobar Islands (Frazier, 1987), and, to a lesser extent, in Oman (Rees *et al*., 2011). There have been no confirmed nests in the Maldives although one live hatchling was seen in Baa Atoll in 2007 (G. Stevens, pers. comm., 2007) and there have been two reports of (apparently) false crawls in Baa Atoll by one author (JAH, pers. obs.). However, the greatest concentration of nesting ORTs in the Indian Ocean can be found in the *arribadas* (mass nesting events) of Orissa, India. In recent years, there has been a decline in numbers of females nesting in the *arribadas* (Shanker *et al*., 2004). The main breeding period for the Olive Ridley Turtle in India and Sri Lanka is December to April, with nesting peaking in February and March (Frazier, 1987; Pandav & Choudhury, 1998). The Olive Ridley nesting season in Orissa coincides with the local commercial fishing season, which leads to high incidental catches of these turtles. In 1997, the areas offshore of the Gahirmatha nesting beach were declared a marine sanctuary. The coastal waters off Devi and Rushikulya, two other important nesting beaches, have also been declared no fishing zones during the ORT breeding season (November to March). Nevertheless, incidental catches from gillnet and trawl fisheries continue to contribute significantly to turtle mortality in eastern India. In Orissa, more than 100,000 dead turtles have been counted since 1990, and 10-15,000 turtles are washed ashore each year due to bycatch in trawlers (Shenoy *et al.,* 2011).

The Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia

(IOSEA Marine Turtle MoU), which was set up under the auspices of CMS, now has 35 signatory states. They have all agreed to conserve, replenish, and restore depleted marine turtle populations. Despite this, bycatch of turtles continues to be poorly documented (*e.g.,* Anderson & Waheed, 1990; Stretta *et al.,* 1998; Romanov, 2000; Delagado de Molina *et al.,* 2007; Frazier *et al*., 2007). The IOTC has recognised that turtle bycatch is a significant problem and suspects gillnet fisheries to be a particular threat to the ORT (IOTC, 2013b).

Although more attention is now being paid to the mortality of sea turtles taken as bycatch in these fisheries, little notice has been paid to the mortality of sea turtles and other marine species due to entanglement in marine debris and discarded fishing gear, including ghost nets. Although ghost nets appear to be a significant cause of entanglement for marine animals, the scale of the problem is largely unrecognised, and solutions remain elusive.

Methods

Study Site

This study is centred on the Republic of Maldives, but also includes data collected in India, and, to a lesser extent, Sri Lanka (see map in Figure 1). The meteorology of the northern Indian Ocean is dominated by the two major monsoons (Shanker *et al.,* 2002). The South West Monsoon (SW or Summer Monsoon) lasts from May to October, while the North East Monsoon (NE or Winter Monsoon) occurs between December and March. April and November are normally transitional periods between monsoons. During these periods the oceanic currents reverse (Shanker *et al.,* 2002). Currents flow mainly eastward during the Summer Monsoon (SW) and westward during the Winter Monsoon (NE). The Maldives, lying north-south across the east-west flow of the monsoon currents, acts as something of a trap for drifting objects.

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Turtle Data Collection

Since 1988, injured and entangled Hawksbill, Olive Ridley, and Green Turtles (n= 179) have been recorded throughout the Maldives by three main sources (Charles Anderson, Seamarc Pvt. Ltd., and the Olive Ridley Project)(Appendix 1). Data collected and compiled by C. Anderson before 2013 were higher during periods of calmer seas (i.e., during the NE Monsoon) (Anderson *et al.,* 2009). Data collected by Seamarc were focussed around its two main research centres based in Baa and North Malé Atolls. Since July 2013, the Olive Ridley Project has been recording year-round, countrywide data from marine biologists stationed around the Republic of Maldives as well as from citizen scientists. However, the authors recognise that there are still gaps in the data sets, especially in the extreme North and South of the Maldives, due to logistical difficulties in accessing remote areas of the country where resorts and dive charters are not operating. It is likely that many ghost nets and entangled turtles float by unnoticed and unrecorded. The differences in effort of data collection between the three sources limits analyses of distribution and seasonality of entangled turtles.

Curved carapace length (CCL) of entangled turtles was either estimated to the nearest 5 cm, when removal from the water was not possible, or accurately recorded when removal of the turtle from the water was feasible. For ORTs, Miller (1997) estimated CCL at maturity to be 66 cm, while Pandav *et al.* (1997) and Tripathy *et al.* (2003) noted that most turtles nesting on the East coast of India were larger than 66 cm, with only a few nesting turtles smaller than 60 cm present. Here, we assume that individuals of 60 cm CCL or less are juveniles.

All turtle data were recorded in an *ad hoc* fashion (as opposed to being collected during systematic surveys) from marine biologists, professional divers, and citizen scientists. The species of turtle was confirmed either from photographs, detailed descriptions, or from a visual inspection at sea. Identifying the species of a sea turtle on the surface of the sea from a boat is very difficult and, as such, only identifications from reliable sources are included here.

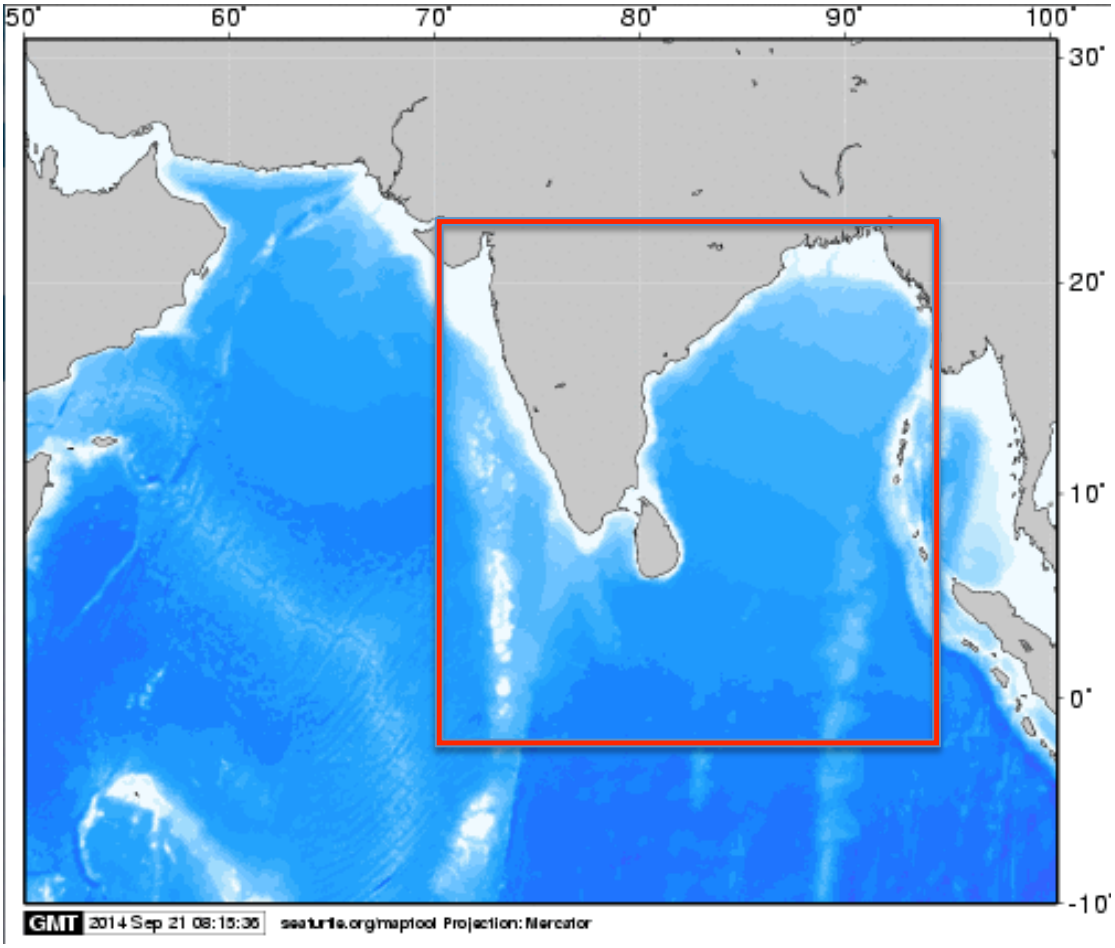

Figure 1. Study area (red box) where entangled turtles and ghost nets were recorded.

Ghost Net Data Collection

59 ghost nets were recorded in the Maldives, between July 2013 and July 2014 (Appendix 2). All ghost nets were found near-shore (and all were removed from the water). When ghost nets were removed from the ocean or found on a beach,

measurements were taken in an attempt to identify the type of net and where it came from (Table 1). Measurements and photos were taken even when there were no entangled turtles present in the net. The nets were disposed of by the finder. Ghost nets were not recycled as many were made from polypropylene, which is difficult to recycle due to its low melting point.

Table 1. Ghost net measurements recorded.

PARAMETER	DETAILS
Stretched mesh size	In mm
Twine diameter	In mm
Knot construction	Standard English knot or Double English knot
Number of ply	Single strands making up each ply. This is very difficult to count due to small size and was subsequently excluded in analyses
Number of strands	
Material	Nylon or Polypropylene
Colour	Colour is of no significance but gives the net a code
Twist direction	Z or S twist
Twine construction	Braided or Twisted

Many reported ghost nets could not be included in this report as the observer was unable to take measurements. Because ghost nets may be drifting to the Maldives from India and Sri Lanka, the Olive Ridley Project trained four individuals who have recorded ghost nets from India (n=12) and Sri Lanka (n=3)(see Appendix 3). These nets were analysed and compared to ghost nets found in the Maldives. Furthermore, between 17 and 20 October 2013 seine nets and lift nets that were currently in use to catch baitfish in the Lakshadweep Islands (specifically on Agatti Island) were measured and photographed by a research assistant from the Dakshin Foundation. Four seine nets and one lift net were analysed and compared to ghost nets found in the Maldives (see Appendix 4).

Results

Analysis of turtle entanglements

166 ORTs were recorded entangled, injured, or free swimming in the Maldives between 1988 and 2014. Eleven Hawksbill Turtles (HKT) and two Green Turtles (GRT) were also reported entangled in nets or injured. Because ORTs made up the majority of the entangled and/or injured turtles, only this species is incorporated in the analyses here. A total of 129 (78%) ORTs were found entangled in ghost nets, either dead or alive (see Appendix 1). Turtles classified as floating were suffering from positive buoyancy problems due to an unknown cause and were found on the surface not associated with a ghost net or other flotsam. 3% (n=5) of the ORTs were found dead, either on the reef or stranded on the beach, not associated with any ghost net or other flotsam. Autopsies were not performed; so, cause of death is unknown in all cases (Table 2).

Table 2. Condition of injured ORTs found in the Maldives between 1988 and 2014.

Way Found	Number of ORTs	Percentage
Dead	5	3
Entangled	129	78
Floating	15	9
No Data	3	2
Free Swimming	14	8
Total	**166**	**100**

Curved carapace length (CCL) was measured for 71 ORTs and estimated for another 41 (Fig. 2). Of these, 97 (75%)were measured or estimated to be 60 cm CCL or smaller and were, therefore, considered to be juveniles, 14 (11%) were females and 5 (4%) were males (Fig. 3). No information on size was recorded for remaining 17 individuals; so, they have been classified as "no data".

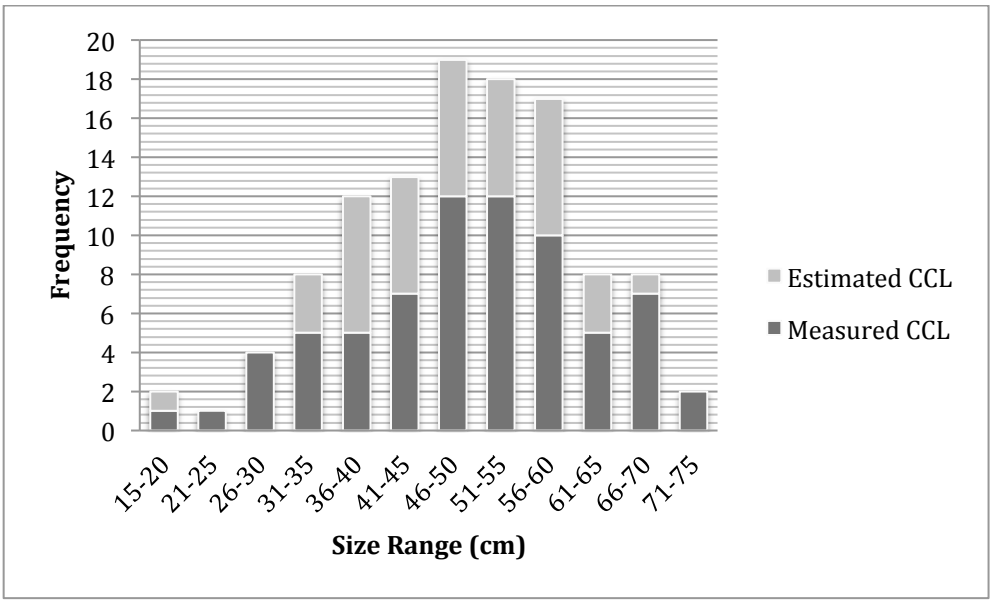

Figure 2. Size distribution and frequency of entangled ORTs in the Maldives between 1988 and 2014.

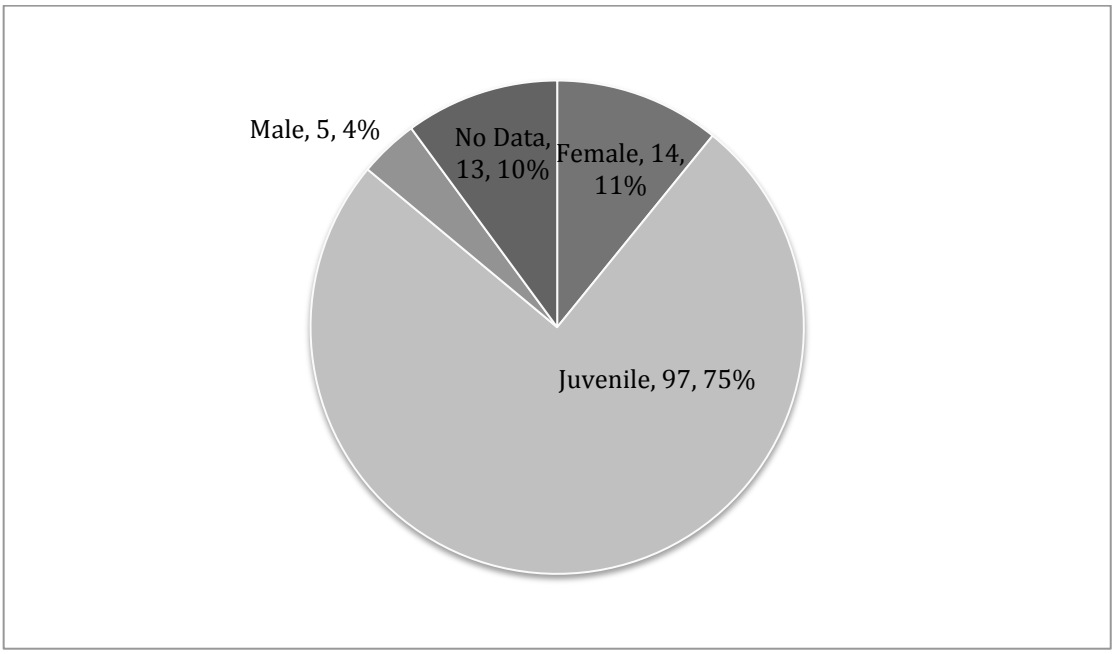

Figure 3. Sex and age distribution of entangled ORTs found in the Maldives between 1988 and 2014.

The highest numbers of entangled ORTs (n=74, 63%) were recorded during the Northeast Monsoon (between December and March). During the Southwest Monsoon (between May and October), 43 (37%) entanglements were recorded. During the inter-monsoon months of November and April there were, respectively, 0 and 12 ORTs found entangled. Entanglement frequency by month is shown in Figure 4.

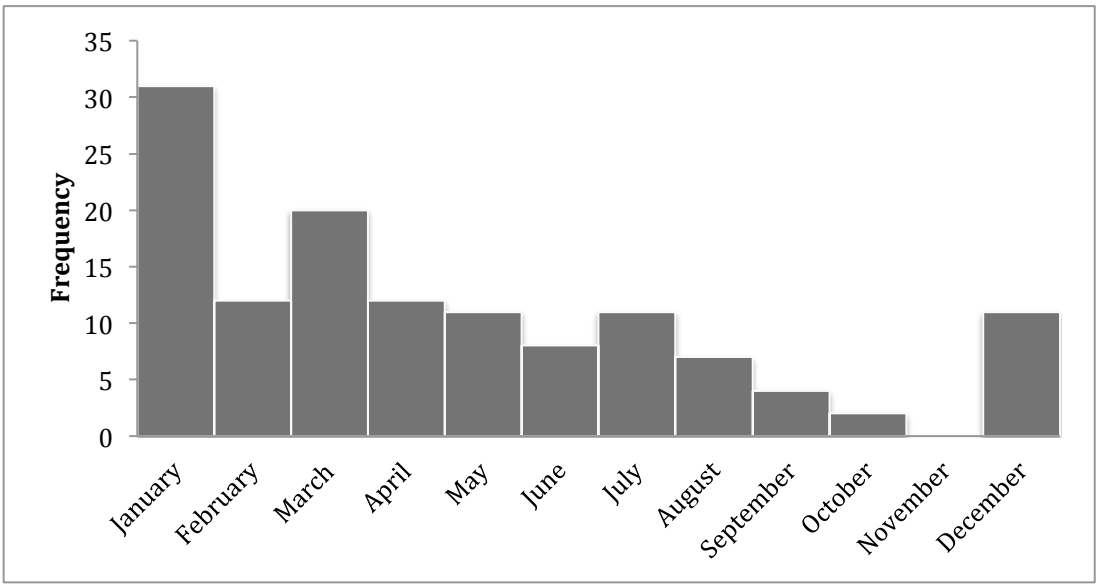

Figure 4. Entanglement frequency by month of entangled turtles found in the Maldives between 1988 and 2014.

Ghost Net Analyses

Between 1988 and 2014, a minimum of 146 ghost nets was recorded in the waters and on the beaches of the Maldives. For turtle entanglement cases that occurred prior to July 2013, the entangling net was recorded in our database as one net because photos were not taken and data were not recorded on the number of samples within the ghost net conglomerate. After 2013, data were kept on the number of separate nets making up large conglomerates that were entangling turtles. Additionally, only after July 2013 were ghost nets not entangling turtles recorded and analysed by the authors. The true number of ghost nets found before July 2013 was, without a doubt, much higher. There was also an increase in ghost net awareness and, by association, retrieval in India and Sri Lanka after an on-going attempt starting in July 2013 to expand our datasets to a geographically larger area. Therefore, we discuss here only the nets recorded in the year between July 2013 and July 2014, because these data are consistent and standardised.

A total of 59 ghost net conglomerates made up of 170 individual nets were recorded between July 2013 and July 2014 in the Maldives (see Appendix 2). Of these, 21 (28%) were found with an ORT entangled. Ghost nets are found year-round in the Maldives. 57% (n=27) were recorded during the SW Monsoon,. During the inter-monsoon months of November 2013 and April 2014 there were, respectively, three and nine nets found (Fig. 5). 26 nets were recorded from India and three nets were recorded from Sri Lanka.

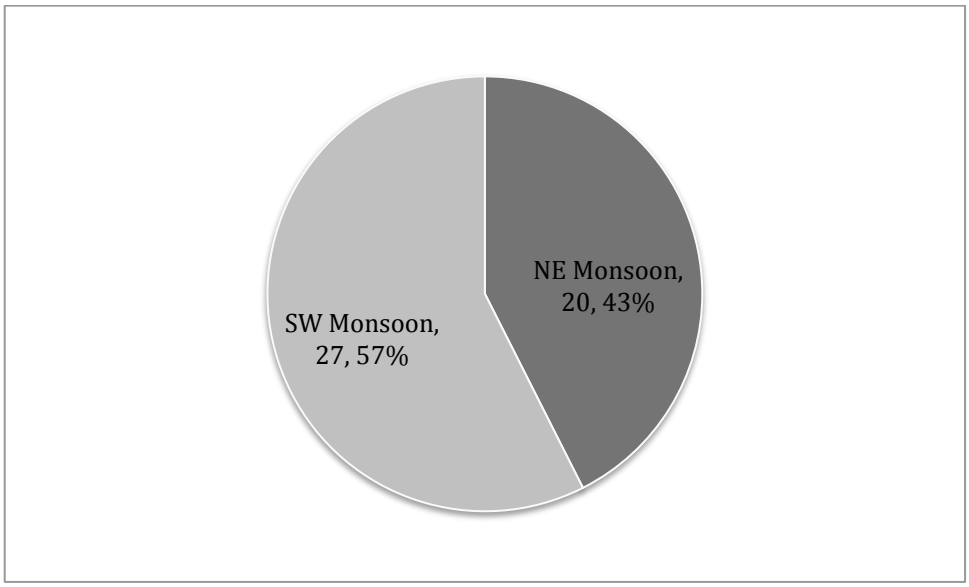

Figure 5. Seasonal retrieval of ghost nets in the Maldives between July 2013 and July 2014.

Stretched mesh sizes of the nets ranged from 2 mm to 1200 mm. Turtles were found entangled in mesh sizes between 35 mm and 590 mm (red arrow in Fig. 6).

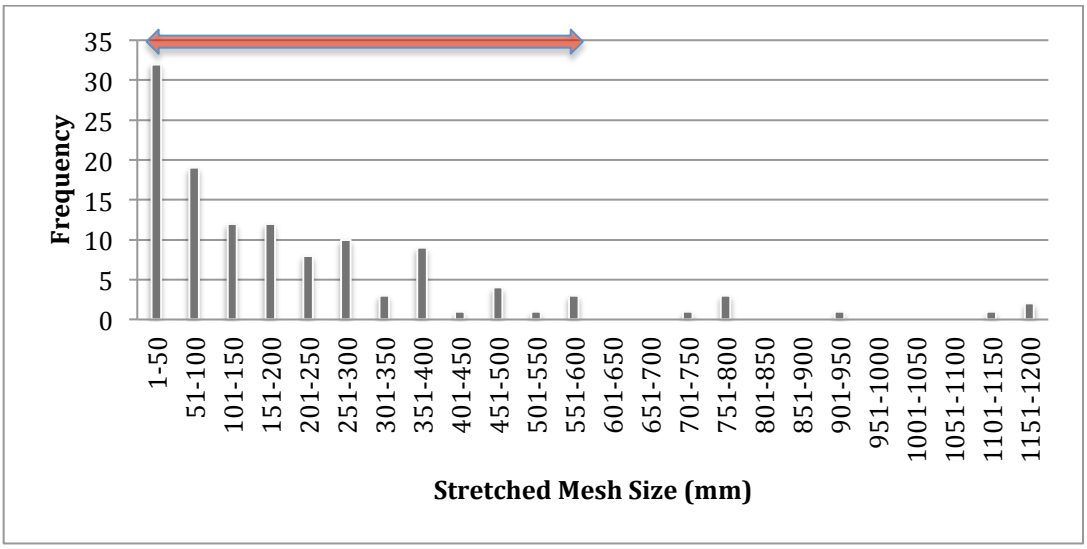

Figure 6. Mesh sizes of ghost nets recorded from Maldives, between July 2013 and July 2014. The red arrow indicates the range of mesh sizes in which turtles were found entangled (35mm-590mm).

All of the ghost nets found in the Maldives were multifilament nets (n=170) . They all were made from either high-density polypropylene (HDPP) or high-density polyethylene (HDPE) twine. The density of HDPP 0.9 g/cm^3 (Maier *et al.*, 2008) and the density of HDPE 0.94 g/cm^3 (Hrenović *et al.,* 2011) (*i.e.,* both are less dense than seawater and will float). The density of monofilament fishing line and nets made from nylon is 1.14 g/cm^3, meaning that they will sink in seawater. Samples from India (namely from the Andaman and Nicobar Islands, Pondicherry, and Orissa) were 50% (n= 13) monofilament and 50% (n=13) multifilament nets. Only 3 nets were analysed from Sri Lanka. 2 were monofilament and 1 was a multifilament net (see Appendix 2).

Seine nets (both shore and open ocean) and a lift net (all currently in use) were measured and photographed on Agatti Island, (a Lakshadweep Island) and compared to ghost nets found in the Maldives. A total of four seine nets (identified as WH002, WH003, GR009, and WH004) and one lift net (RE001) made up the samples (see Table 3)

Table 3 Measurements of fishing nets used on Agatti Island, Lakshadweep, India (Latitude 10.8, Longitude 72.2).

Net ID	Stretched Mesh size (mm)	Twine Diameter (mm)	Nº of Strands	Construction
RE001	9	0.5	2	Multifilament
WH002	35	0.2	1	Monofilament
WH003	27	0.2	1	Monofilament
GR009	35	0.2	1	Monofilament
WH004	60	2	3	Multifilament

A minimum of four net conglomerates recovered from the Maldives between July 2013 and July 2014 were identified as FADs due to the presence of bamboo frames and floats. One net conglomerate was found in July 2014 in Baa Atoll with a tracking device attached, but could not be identified due to lack of clear markings. The FADs reported were composed numerous nets with mesh sizes between 35 and 600 mm. A fifth ghost net conglomerate found in Ari Atoll in September 2014 was also identified to be a FAD with a tracker; this is discussed further below.

Current analyses

Representations of current strength and direction during the NE Monsoon and the SW Monsoon are shown in Figs. 7 and 8, respectively. Whilst these current charts are model representations of current magnitude on particular days, magnitude varies greatly from day to day. Nevertheless, the direction of the currents remains consistent throughout the Monsoons, and, so these charts provide a useful representation of current direction for each Monsoon. Ghost nets reported in the Maldives during the NE Monsoon were found mainly on the eastern side of the archipelago (n=12, 60%), with 8 nets (40%) being found on the western side (Fig. 7). During the SW Monsoon 23 ghost nets (85%) were found on the western edge of the Maldives and only 4 nets (15%) were found in the eastern atolls (Fig. 8).

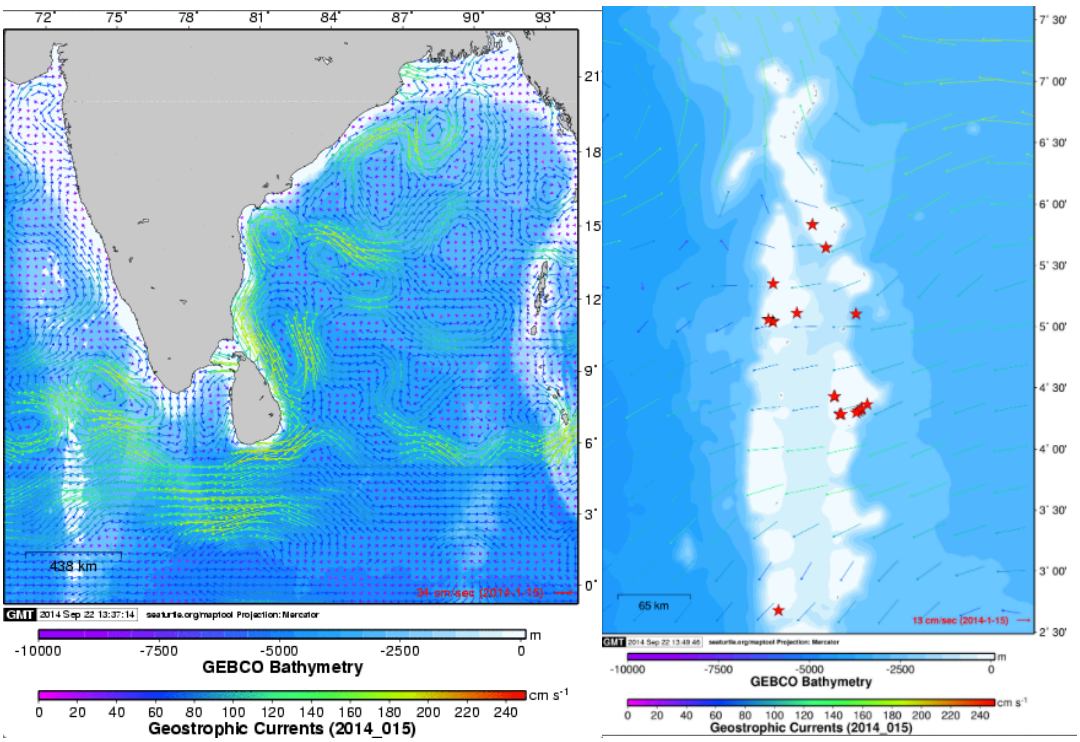

Figure 7. Left: Current direction and magnitude in the Bay of Bengal and Eastern Indian Ocean during the NE Monsoon. Right: Ghost net distribution in the Maldives between December 2013 and March 2014 (NE Monsoon). Current magnitude was taken on 15 January 2014. Source: AVISO Geostrophic Currents model taken from seaturtle.org.

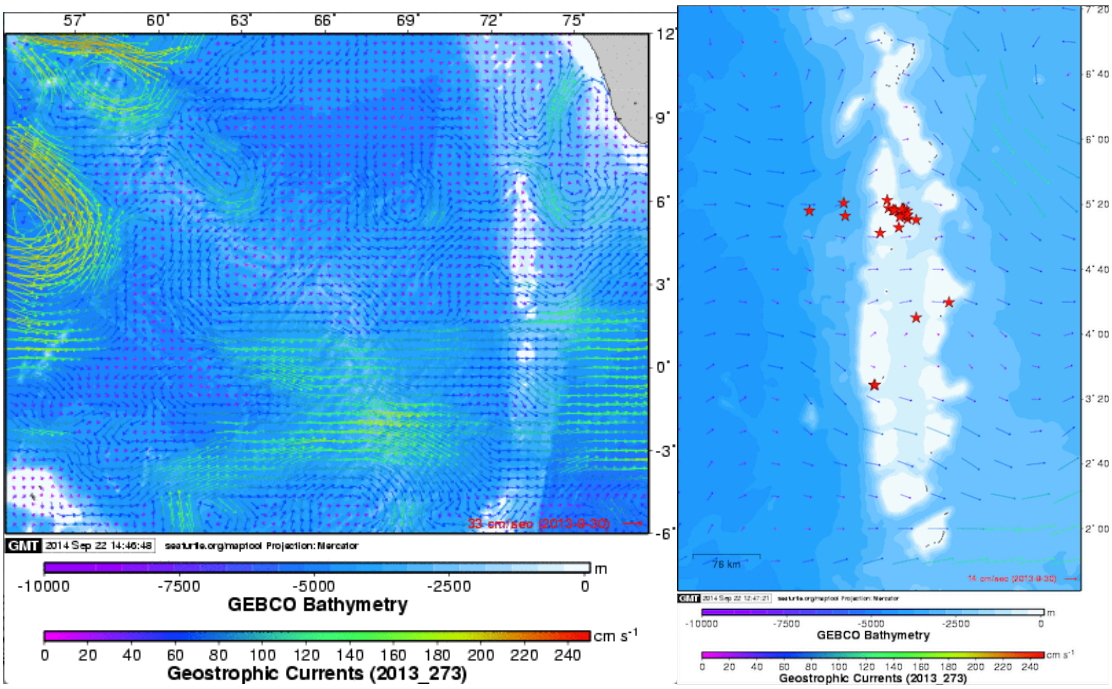

Figure 8. Left: Current direction and magnitude in the northern Arabian Sea and the Indian Ocean during the SW Monsoon. Right: Ghost net distribution in the Maldives between July and October 2013 and May to July 2014 (SW Monsoon). Current magnitude was taken on 30 September 2013. Source: AVISO Geostrophic Currents model taken from seaturtle.org.

Discussion

Oceanic Currents and Ghost Net Distribution

The accumulation of fouling agents, such as algae and barnacles (also known as a biofilm), significantly retards any degradation processes (Andrady, 2011). Normally, HDPP and HDPE nets float on the surface of the sea due to their low densities; however, the accumulation of biofilm on a net may increase its density over time, eventually causing it to sink (Fig. 9). Many of the nets found in the Maldives appear to have spent a considerable amount of time in the sea and have substantial biofilm build-up. Ghost nets have been retrieved from near-shore reefs to deep offshore waters, a habitat where ORTs spend much of their time (Polovina *et al.,* 2003; Whiting, 2007).

Figure 9. A polypropylene ghost net with biofilm build-up submerged underwater on a reef in the Maldives.

Ocean current strength and direction help identify the paths along which ghost nets may drift in the Indian Ocean. In the tropical Indian Ocean, the NE Monsoon and the SW Monsoon have significantly different current patterns. During the SW Monsoon, currents flow predominantly from West to East and strong currents are observed in the Arabian Sea and the western Indian Ocean (WIO), particularly North of the Seychelles and near Somalia and East Africa. The use of FADs by purse seine fisherman is common in this area. A minimum of four FADs was found drifting in Maldivian waters during the SW Monsoon and many of the recorded ghost nets were recovered along the western side of the country. The FADs found in the Maldives were composed of numerous nets with mesh sizes considered the most dangerous to turtles (*i.e.,* 35 – 600 mm) (Fig. 10). One proposed FAD was found in Baa Atoll in July 2014 with a tracking device attached. Though its origin remains unconfirmed, another almost identical tracker was recovered from a ghost net conglomerate found in Ari Atoll in September 2014 (not included in our dataset analysed here) with a live turtle trapped inside. This tracker had a name and number written on it and was traced to the *Doniene*, a Spanish purse seine fishing vessel operating out of the Seychelles and Mauritius. Based on this, we propose that the unmarked FAD recovered in July 2014 came from a similar purse seine vessel operating in a similar area to the *Doniene*.

It appears that many ghost nets found in Maldivian waters during the SW Monsoon originate in the WIO FAD fisheries. It is unlikely that the majority of ghost nets found in the Maldives during this season originate from India, Sri Lanka, or other eastern Indian Ocean or Bay of Bengal nations, as they would

have to travel against the predominating currents. However, it is likely that some ghost nets may have drifted away from these areas in the NE Monsoon, remained in oceanic currents for extended periods of time and then drifted back into the Maldives in later years during the SW Monsoon.

Figure 10. (Left) An unidentified FAD with a tracker attached (the grey dome-shaped object at centre left). This FAD had a serial number but remains unidentified. (Right) An object identified as a FAD due to its bamboo frame and the presence of floats. No tracker was attached. Both objects were found in the Maldives during the SW Monsoon.

Ocean currents during North East Monsoon predominately flow from East to West. Current magnitudes are strongest on the eastern and southern coasts of Sri Lanka and India, along western Indonesia, and nearby the Lakshadweep Islands. Many ghost nets recorded from the Maldives during the NE Monsoon were recovered along the eastern side of the country. However, seven ghost nets were found in Baa Atoll during the NE Monsoon. Baa Atoll is on the West side of the Maldives but there is no significant landmass to the East of southern Baa Atoll, where most of the nets were found. Therefore, it is likely that these nets came from the East and drifted through the wide channel between Lhaviyani Atoll and Kaashidhoo Island (Kaashidhoo Kandu) into Baa Atoll.

Makeshift flotation devices, such as plastic bottles, attached to ghost nets provide clues to their origin. A number of bottles produced by Indian companies or distributed in India were found attached to ghost nets recovered in the Maldives during the NE Monsoon (Fig. 11).

Figure 11. A bottle from an Indian brandy maker "Mansion House" attached to net found in Baa Atoll, Maldives.

One net recovered from Baa Atoll, Maldives had numerous flotation devices attached with markings in written Thai, suggesting that the net had originated from Thai waters or from a Thai boat operating somewhere else in the Indian Ocean (Fig. 12).

Figure 12. Flotation devices with Thai markings attached to a ghost net recovered from Baa Atoll, Maldives during the SW Monsoon.

Additionally, a number of multifilament ghost nets found in the Maldives have similar construction parameters to fishing gear found and identified in India, particularly in Dhamra Port in Orissa, the Andaman and Nicobar Islands, and Pondicherry. Fishing nets found in Sri Lanka did not match any nets found in the Maldives but only three nets were analysed. In total, seven ghost net samples were recovered from these areas (identified as BL040, BL007, BL093, BL029, GR035, BK008, and BK006). They matched 17 ghost net samples found in the Maldives (see Appendix 4). With the exception of one sample (BL093), the stretched mesh size of all the other nets fell within the range that we consider

the most dangerous to ORTs. In Dhamra Port, Orissa, a multifilament HDPE ghost net (BL007) was found just under the surface by a bottom trawler and was removed and analysed. It was confirmed to be a gillnet that had been lost from a boat operating offshore based on comparison with nets in use by these boats. The ghost net had a mesh size of 40 mm and a twine diameter of 1 mm and it matched six nets found in three separate locations in the Maldives (in Baa, Raa, and North Male Atolls) (Fig. 13). Each individual sample found in the Maldives that matched the net in Orissa was part of a conglomerate of nets. Two of these conglomerates were responsible for entangling and injuring two Olive Ridley Turtles.

In the Lakshadweep Islands, open ocean purse seine and shore seine fisheries predominantly catch garfish, trevally (Tamelander & Hoon, 2008), needlefish, and halfbeaks (pers comm., 2013). Three of the ghost nets recovered from the Lakshadweep Islands were made of monofilament nylon twine (WH002, WH003, and GR009) and were not likely to drift into Maldivian waters (their high densities would cause them to sink and snag on the bottom). However two were multifilament HDPE nets. The net identified as WH004 was determined to be an open ocean seine net used to catch needlefish and its construction parameters matched ghost nets found in the Maldives, specifically net GR020 found in Baa Atoll in April 2014, which was responsible for entangling a juvenile HKT and net RE003 recovered from North Malé Atoll in January 2014.

Figure 13. (Left) A gillnet found in Dhamra Port (BL007) and (Right) a section of a ghost net found in the Maldives (BL071). Stretched mesh diameter, colour, and twine diameter of the two nets all match.

A 10-year study conducted in Orissa, India gives some insight into the construction of fishing nets used on the eastern coast of India (Sridhar & Muralidharan, 2013). The majority are monofilament nets and, due to their density, they sink in seawater and are less likely than HDPE and HDPP nets to drift over to the Maldives. Two types of HDPE multifilament nets are occasionally used in eastern India. One is traditionally known as "*Koni Jaal*" and mainly targets seerfish between November and April. The other is known locally as *"Bhetki Jaal"* and targets seabass, pomfret and hilsa in November and December. These nets have mesh sizes ranging from 129 mm to 145 mm and 150 to 120 mm, respectively. Both are classified as gillnets and have similar construction parameters to some ghost nets recorded entangling turtles in the Maldives. An informal ban was implemented in 2004 by the Orissa Traditional Fish Workers

Union as a community approach to protect turtles; however, *Bhetki Jaal* fisheries continue to be operated by larger, mechanised gill net fishing boats. Due to their similar construction parameters and current patterns, it seems likely that some of the ghost nets recovered in the Maldives in the NE Monsoon (December to May) may be coming from the East Indian *Bhetki Jaal* fishery.

During the NE Monsoon, gyres often form in the Bay of Bengal off of the East coast of India. Marine debris, including ghost nets, may become entrained in these gyres for long periods of time. Nets and other debris from a variety of locations may mix and tangle together over time. Ghost nets recovered from the Maldives during the NE Monsoon are often huge conglomerates of multiple individual nets tangled together along with other debris such as wood and plastic items (Fig. 14).

Figure 14. Examples of conglomerates of fishing nets found in the Maldives during the NE Monsoon.

Olive Ridley Entanglements

97 ORTs recorded entangled in the Maldives between 1988 and 2014 were 60 cm or smaller CCL [*i.e.,* juveniles). Little information exists about this life stage of ORTs as most studies have focused on nesting females or hatchling turtles. Our data show that relatively high numbers of juvenile ORTs are occupying the pelagic waters surrounding the Maldives and that turtles at this life stage are at risk for becoming entangled in ghost nets.

A number of the turtles found entangled in ghost nets were extremely emaciated, and had severe injuries (often amputations) to their limbs, suggesting that they had likely spent days, if not weeks, entangled in the net before being found.

It is also probable that many entangled turtles or other marine fauna remain offshore in ocean gyres. The 129 entangled turtles reported here must represent only a small fraction of the true number of turtles entangled in ghost nets in the Indian Ocean (see Appendix 1).

Recommendations

In order to prevent and reduce the number of ghost nets that end up in the wider Indian Ocean, injuring marine fauna, and also damaging coral reefs and other benthic habitats, we recommend that a series of actions be implemented. First, we recommend a reduction in gillnet fishing capacity in the region. A substantial number of the ghost nets recovered from Maldivian waters appear to be gillnets. The IOTC has recognised that gillnet fisheries are a particular threat to the Olive Ridley Sea Turtles (IOTC, 2013b), and they are also a major cause of cetacean mortality in the region (Anderson, 2014).

Management that incentivises a system of no-blame gear loss reporting and gear return at net disposal facilities in ports may also reduce gear loss or shed light on fisheries that are losing large amounts of gear. Improved gear marking is also an effective way to find out which fishery is losing significant amounts of fishing gear. In South Korea, a buyback program helps to reduce the amount of abandoned fishing gear that enters the ocean every year by recovering up to 20% of the gear by weight (Cho, 2009). However, these types of management plans do cost money and may be unrealistic for small coastal communities. Additionally, this would not combat the problem of ghost nets coming from illegal fisheries operating in the Indian Ocean.

Additionally, we recommend the rapid adoption of non-entangling (net-free) FADs by all fleets operating throughout the Indian Ocean.

Removal of ghost nets and other marine debris is costly and time consuming. However, ghost nets left in the water or on beaches may be costing communities money by catching marine fauna without economic benefit to the fisherman; damaging the marine habitat and, in turn, reducing the fish population in the area; spoiling the natural beauty of the beach or reef, reducing tourists and associated tourism income in the area; or by damaging vessels due to strikes. Governments, local NGOs, and community members must cooperate together to remove ghost nets whenever possible.

Regional workshops should be held as part of the IOSEA Marine Turtle MoU Work Programme for 2015/2016. This would help highlight the issue of ghost nets and subsequently expand data collection and ghost net removal among Northern Indian Ocean countries (Pakistan, India, Maldives, Sri Lanka, and Bangladesh)

Development of a centralised database of Indian Ocean fishing net construction parameters should be implemented. Such a database would be extremely helpful to aid in the identification of ghost nets found anywhere in the Indian Ocean. Furthermore, detailed descriptions of fishing nets currently in action would help to highlight fisheries that may lose large amounts of gear. Because the problem of ghost nets is one that spans the globe, the authors recognise that collaboration between global ghost gear recorders is vital to ensure the development of an international database with standardised fishing gear measurements that are recorded across the globe.

Conclusions

Since 1988, a total of 129 Olive Ridley Turtles have been found entangled in ghost nets in Maldivian waters. Our data suggest that these ghost nets are drifting with the predominating currents and may be coming to Maldivian waters from India, Sri Lanka, and further afield in Southeast Asia during the NE Monsoon, and from the western Indian Ocean and Arabian Sea during the SW Monsoon. Markings on bottles and floats as well as marking and serial numbers on FADs give clues to the nets' origins and support this interpretation. Entangled Olive Ridley Turtles are most often encountered in the NE Monsoon, and sexually immature individuals make up the majority of entanglements. Our data show that relatively high numbers of sub-adult ORTs are occupying the pelagic waters surrounding the Maldives and that turtles at this life stage are at risk of becoming entangled in ghost nets.

At the global level, the scale of the problem is largely unrecognised and solutions remain elusive, though more attention has recently been paid to the issue and groups from around the world are working together to find feasible solutions. We recommend a reduction in gillnet fishing in the Indian Ocean; improved net disposal facilities in ports; a system of no-blame gear loss reporting; and a centralised database of Indian Ocean fishing net construction parameters be implemented.. We also recommend an increase and improvement in ghost net data collection. We recommend that awareness be raised amongst the general public and more citizen scientists be trained to recognize and recover ghost nets; additionally, we recommend that international ghost gear groups come together to standardise the data to be collected and analysed in the future.

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Appendix 1. Entanglements of Olive Ridley Turtles (n=129), Hawksbill Turtles (n=6) and Green Turtles (n=1) in the Maldives between 1988 - 2014. Those measurements with an asterisk (*) have been estimated to the nearest 5 cm.

Turtle ID	Date Found	Date Released	Release/Dead	Sex	Size (cm)	Weight (kg)	Location
OR001	19/01/1988	19/01/1988	Died	Juvenile	55	nd	East of Haa Alifu
OR002	15/08/1988	15/08/1988	Died	Juvenile	35	nd	East of Laamu Atoll
OR003	28/05/1994	28/05/1994	Released	Juvenile	20*	nd	K. Vaadhoo
OR004	29/12/1999	29/12/1999	Released	Juvenile	59	nd	K. Vaadhoo
OR005	29/12/1999	29/12/1999	Released	nd	66	nd	K. Vaadhoo
OR006	03/09/2001	03/09/2001	Released	Juvenile	35*	nd	V. Bodumohora
OR007	05/06/2002	05/06/2002	Released	Juvenile	29	nd	H.Dh. Hondaafushi
OR008	11/03/2003	11/03/2003	Released	Juvenile	49	nd	West of 1½º Channel
OR009	12/03/2003	12/03/2003	Released	Juvenile	35*	nd	V. Thinadhoo
OR010	01/01/2004	01/01/2004	Released	Juvenile	nd	nd	Off K. Thulusdhoo x Dhiffushi
OR011	03/01/2004	03/01/2004	Released	Juvenile	45*	nd	K. Embudhoo
OR012	10/01/2004	10/01/2004	Released	Juvenile	43	nd	K. Embudhoo
OR013	10/01/2004	10/01/2004	Released	Juvenile	44	nd	K. Embudhoo
OR014	10/01/2004	10/01/2004	Released	Juvenile	nd	nd	K. Embudhoofinolhu
OR015	17/01/2004	17/01/2004	Released	Juvenile	40*	nd	K. Lohifushi
OR016	26/09/2004	26/09/2004	Released	Juvenile	55	nd	Vaadhoo Channel
OR017	26/09/2004	26/09/2004	Released	Juvenile	54	nd	Vaadhoo Channel
OR018	22/02/2005	22/02/2005	Released	Juvenile	56	nd	K. Hulhule
OR019	16/01/2006	16/01/2006	Released	Juvenile	30	nd	A. Rasdhoo
OR020	18/03/2006	18/03/2006	Released	Juvenile	42	nd	K. Embudu
OR021	18/03/2006	18/03/2006	Released	Juvenile	42*	nd	K. Embudu
OR022	08/12/2007	08/12/2007	Released	nd	65	nd	N of HA
OR023	08/12/2007	08/12/2007	Released	Juvenile	38	nd	N of HA
OR024	27/12/2007	27/12/2007	Released	Juvenile	45*	nd	Raa Atoll
OR025	05/09/2009	05/09/2009	nd	Juvenile	40	nd	A.Rasdhoo
OR026	08/10/2009	08/10/2009	nd	Juvenile	50	nd	Ari to Rasdhoo
OR027	01/04/2011	10/06/2011	Released	Female	nd	nd	Baa
OR028	01/04/2011	01/04/2011	Released	Juvenile	40*	nd	Baa
OR029	26/06/2011	22/11/2011	Released	Juvenile	50	nd	Baa
OR030	26/12/2011	02/01/2012	Released	Female	nd	nd	Baa
OR031	26/12/2011	26/12/2011	Released	Juvenile	60*	nd	Baa
OR032	14/01/2012	20/01/2012	Released	Juvenile	30	nd	North Male
OR033	14/01/2012	14/01/2012	Released	Juvenile	55	nd	North Male
OR034	20/02/2012	20/02/2012	Released	Juvenile	55*	nd	Baa
OR035	27/02/2012	04/03/2012	Released	Male	64	nd	Baa
OR036	27/02/2012	06/04/2012	Released	Female	70	nd	Baa
OR037	27/02/2012	04/03/2012	Released	Juvenile	59	nd	Baa
OR038	02/03/2012	13/06/2012	Released	Juvenile	53	16.5	Vaavu
OR039	05/04/2012	07/04/2012	Released	Juvenile	55*	nd	Baa
OR040	25/06/2012	23/09/2012	Died	Female	68	25	Baa
OR041	25/06/2012	Died	Found dead	Female	70*	nd	Baa
OR042	25/06/2012	Died	Found dead	nd	nd	nd	Baa
OR043	29/07/2012	08/11/2012	Released	Female	67	31	North Male
HK001	30/07/2012	17/10/2012	Released	Juvenile	56	14.6	South Male
OR044	21/08/2012	16/01/2013	Released	Juvenile	28	2	North Male
OR045	10/12/2012	18/12/2012	Released	Female	71	nd	Baa
OR046	26/12/2012	26/12/2012	Released	Juvenile	55*	nd	Baa
OR047	01/01/2013	01/01/2013	Released	nd	nd	nd	Baa
OR048	01/01/2013	01/01/2013	Released	nd	nd	nd	Baa
OR049	15/01/2013	15/01/2013	Released	Male	57	20*	Baa
HK002	25/02/2013	27/02/2013	Released	Juvenile	27	1.2	Baa
OR050	25/02/2013	25/02/2013	Released	Juvenile	45*	nd	Baa
OR051	06/03/2013	06/03/2014	Released	Juvenile	57	16.5	North Male
OR052	24/03/2013	24/03/2013	Released	Juvenile	60*	nd	Baa
OR053	04/04/2013	28/04/2013	Escaped	Juvenile	44	10.8	Baa
OR054	21/04/2013	21/04/2013	Released	Female	65*	nd	Baa
OR055	22/04/2013	22/04/2013	Released	Juvenile	50*	nd	Off NE N Male'
OR056	24/04/2013	24/04/2013	Released	Female	65*	30	Baa
OR057	24/04/2013	24/04/2013	Released	Male	65*	nd	Baa
OR058	28/04/2013	10/05/2013	Released	Male	65	28	Baa
OR059	28/04/2013	Died	Found dead	Juvenile	40*	nd	Baa
OR060	01/05/2013	01/05/2013	Released	Juvenile	40*	nd	North Male
OR061	02/05/2013	02/05/2013	Released	Juvenile	57*	nd	Eight Degree Channel
OR062	10/05/2013	19/05/2013	Released	Juvenile	48	15	Baa
OR063	10/05/2013	10/05/2013	Released	Juvenile	55*	nd	Baa
OR064	15/05/2013	15/05/2013	Released	Juvenile	42	nd	Baa
OR065	20/05/2013	30/05/2013	Died	Juvenile	43.5	6.74	North Male
OR066	27/05/2013	27/05/2013	Released	Juvenile	35*	nd	Baa

Turtle ID	Date Found	Date Released	Release/Dead	Sex	Size (cm)	Weight (kg)	Location
OR067	07/06/2013	Died	Found dead	Juvenile	45*	nd	Baa
OR068	10/06/2013	Died	Died	Juvenile	40*	nd	Ari
OR069	08/07/2013	Rehab	Current	Juvenile	47	10.5	North Male
OR070	08/07/2013	08/07/2013	Released	Juvenile	60*	nd	Dhaalu
OR071	10/07/2013	07/08/2013	Released	Juvenile	48	7	Baa
OR072	17/07/2013	17/07/2013	Released	Juvenile	60*	nd	Gaafu Alifu
OR073	20/07/2013	20/07/2013	Released	Juvenile	55*	nd	North Male
OR074	26/07/2013	26/07/2013	Released	Juvenile	60	nd	South Ari
OR075	26/07/2013	26/07/2013	Released	Juvenile	55	nd	South Ari
OR076	29/07/2013	02/04/2014	Released	Female	73	40	Baa
OR077	29/07/2013	25/08/2013	Released	Juvenile	47	9	Baa
OR078	10/08/2013	11/08/2013	Died	Juvenile	58	5	Ari
HK003	13/08/2013	13/08/2014	Released	Juvenile	45	nd	Baa
OR079	13/08/2013	13/08/2013	Released	Juvenile	55	nd	Baa
OR080	18/08/2013	18/08/2013	Released	Juvenile	52	nd	Baa
OR081	23/08/2013	27/10/2013	Released	Female	63	20	Baa
OR082	24/08/2013	Rehab	Current	Juvenile	55	20	Baa
OR083	26/10/2013	15/11/2013	Released	Juvenile	35	4.4	North Male
HK004	03/12/2013	03/12/2013	Released	Juvenile	nd	nd	Lhaviyani
HK005	31/12/2013	01/01/2014	Released	Juvenile	43	7	Baa
OR084	31/12/2013	31/12/2014	Died	Female	67	25	South Male
OR085	12/31/2013	01/01/2014	Released	Female	66	nd	South Male
OR086	03/01/2014	03/01/2014	Released	Juvenile	50*	nd	Baa
OR087	04/01/2014	04/01/2014	Released	Juvenile	35	nd	North Ari
GR001	06/01/2014	Died	Died	Juvenile	20	nd	North Male
OR088	06/01/2014	06/01/2014	Released	Juvenile	60*	nd	North Male
OR089	06/01/2014	06/01/2014	Released	nd	nd	nd	North Male
OR090	06/01/2014	06/01/2014	Released	Juvenile	50	nd	North Male
OR091	06/01/2014	07/01/2014	Released	Juvenile	54	nd	North Male
OR092	06/01/2014	06/01/2014	Released	nd	42	nd	North Male
OR093	07/01/2014	07/01/2014	Released	nd	nd	nd	South Male
OR094	07/01/2014	07/01/2014	Released	nd	nd	nd	South Male
OR095	07/01/2014	07/01/2014	Released	nd	nd	nd	South Male
OR096	07/01/2014	07/01/2014	Released	nd	nd	nd	South Male
OR097	08/01/2014	08/01/2014	Released	nd	nd	nd	Ari
OR098	08/01/2014	08/01/2014	Released	nd	nd	nd	Ari
OR099	10/01/2014	10/01/2014	Released	Juvenile	46	nd	North Ari
OR100	10/01/2014	10/01/2014	Released	Juvenile	35	nd	North Ari
OR101	13/01/2014	20/01/2014	Released	Female	67	35	Ari
OR102	23/01/2014	23/01/2014	Died	Juvenile	39	5	Noonu
OR103	27/01/2014	27/01/2014	released	Juvenile	50	nd	Dhaalu
OR104	03/02/2014	03/02/2014	Released	Juvenile	60	nd	North Ari
OR105	07/02/2014	08/02/2014	Released	Juvenile	47	8	South Male
OR106	09/02/2014	09/02/2014	Died	Male	62	30	North Male
OR107	21/02/2014	31/03/2014	Released	Juvenile	53	30	North Male
OR108	22/02/2014	22/02/2014	Released	Juvenile	nd	nd	Lhaviyani
OR109	22/02/2014	22/02/2014	Released	Juvenile	nd	nd	Lhaviyani
OR110	02/03/2014	02/03/2014	Released	Juvenile	50*	nd	North Ari
OR111	05/03/2014	03/06/2014	Released	Juvenile	56	nd	North Male
OR112	06/03/2014	06/03/2014	Released	Juvenile	60*	nd	Noonu
OR113	06/03/2014	06/03/2014	Released	Juvenile	55*	nd	Noonu
OR114	06/03/2014	06/03/2014	Released	Juvenile	nd	nd	Baa
OR115	07/03/2014	Died	Died	Juvenile	37	nd	Baa
OR116	20/03/2014	Died	Died	juvenile	40*	nd	Baa
OR117	20/03/2014	20/03/2014	Released	Juvenile	45*	nd	Baa
OR118	20/03/2014	20/03/2014	Released	Juvenile	50*	nd	Baa
OR119	21/03/2014	21/03/2014	Released	Juvenile	50	nd	South Male
OR120	22/03/2014	22/03/2014	Died	Juvenile	40*	nd	Baa
OR121	22/03/2014	22/03/2014	Released	Juvenile	47*	nd	Baa
OR122	22/03/2014	22/03/2014	Released	Juvenile	47*	nd	Baa
OR123	01/04/2014	02/04/2014	Released	Juvenile	35	nd	North Ari
HK006	11/04/2014	Died	Died	nd	20	Nd	Baa
OR124	25/04/2014	25/04/2014	Released	Juvenile	50*	nd	Baa
OR125	07/05/2014	07/05/2014	Released	Juvenile	40	nd	North Male
OR126	07/05/2014	07/05/2014	Released	Juvenile	15	nd	Ari
OR127	11/05/2014	11/05/2014	Released	Juvenile	60	nd	Baa
OR128	23/06/2014	24/06/2014	Released	Juvenile	25	nd	Baa
OR129	03/07/2014	03/07/2014	Released	Juvenile	55	nd	Baa

Appendix 2: Ghost nets found in the Maldives between July 2013 and July 2014. Nets that are grouped together in shaded area represent 1 ghost net conglomerate found on the same date. A total of 59 ghost net conglomerates made up of 170 individual samples are represented in this table.

Net ID	Date Found	Lat	Long	Atoll	Twisted or braided	S or Z Twist	Stretched Mesh size (mm	Twine Diameter (mm)	Number of strands	Turtle entangled
GR011	17/04/2013	5.0425	72.88278	Baa	B	-	320	7	16	N
BL059	20/04/2013	5.0425	72.88278	Baa	T	S	350	3	3	N
GR011	20/04/2013	5.0425	72.88278	Baa	B	-	320	7	16	
BL001	24/07/2013	5.18677	73.16345	Baa	T	S	45	1	3	N
BL022	26/07/2013	3.475519	72.822319	Ari	T	S	490	2	3	Y
BL027	26/07/2013	3.475519	72.822319	Ari	T	S	50	2	3	
BL027	26/07/2013	3.475519	72.822319	Ari	T	S	50	2	3	
BL029	26/07/2013	3.4774	72.8316	Ari	T	S	40	1.5	3	
BL035	26/07/2013	3.475519	72.822319	Ari	T	S	250	1	3	
BL036	26/07/2013	3.475519	72.822319	Ari	T	S	950	2	3	
BL038	26/07/2013	3.4774	72.8316	Ari	T	S	200	4	3	
BL039	26/07/2013	3.4774	72.8316	Ari	T	S	50	1	3	
BL040	26/07/2013	3.4774	72.8316	Ari	T	S	275	4	3	
BL041	26/07/2013	3.4774	72.8316	Ari	T	S	280	3	3	
BL002	29/07/2013	5.28529	73.12861	Baa	T	S	295	2	3	Y
BL003	29/07/2013	5.28529	73.12861	Baa	T	S	115	1	3	
GY002	29/07/2013	4.327927	73.588796	North Male	T	Z	325	8	3	N
BL004	12/08/2013	5.297045	72.970994	Baa	T	S	785	2.2	3	N
BL005	12/08/2013	5.297045	72.970994	Baa	T	S	31	1	3	
BL006	12/08/2013	5.297045	72.970994	Baa	T	S	113	1.5	3	
BL017	13/08/2013	5.2067	73.08467	Baa	T	S	115	1	3	Y
BK001	15/08/2013	5.27546	73.04214	Baa	B	-	10	1	3	N
BK002	15/08/2013	5.27546	73.04214	Baa	T	S	145	3	3	
BL006	15/08/2013	5.27546	73.04214	Baa	T	S	113	1.5	3	
BL006	15/08/2013	5.27546	73.04214	Baa	T	S	113	1.5	3	
BL007	15/08/2013	5.27546	73.04214	Baa	T	S	40	1	3	
BL008	15/08/2013	5.27546	73.04214	Baa	T	S	80	3	3	
BL009	15/08/2013	5.27546	73.04214	Baa	T	S	380	2	3	
BL010	15/08/2013	5.27546	73.04214	Baa	T	S	18	0.5	3	
BL011	15/08/2013	5.27546	73.04214	Baa	T	S	75	0.5	3	
BL012	15/08/2013	5.27546	73.04214	Baa	T	S	80	1	3	
BL013	15/08/2013	5.27546	73.04214	Baa	T	S	580	1.5	3	
BL014	15/08/2013	5.27546	73.04214	Baa	T	S	50	1.5	3	
BL015	15/08/2013	5.27546	73.04214	Baa	T	S	180	2	3	
GR001	15/08/2013	5.27546	73.04214	Baa	T	S	150	2	3	
GR002	15/08/2013	5.27546	73.04214	Baa	T	S	360	2	3	
GR003	15/08/2013	5.27546	73.04214	Baa	T	S	90	1	3	
GY001	15/08/2013	5.27546	73.04214	Baa	T	S	50	1	3	
BK003	17/08/2013	5.0978	73.0743	Baa	T	S	180	2	3	N
BL016	17/08/2013	5.0978	73.0743	Baa	T	S	75	1	3	
BL013	18/08/2013	5.0425	72.88278	Baa	T	S	580	1.5	3	Y
BL015	18/08/2013	5.0425	72.88278	Baa	T	S	180	2	3	
BL019	18/08/2013	5.0425	72.88278	Baa	T	S	390	1	3	
BL003	20/08/2013	5.23199	73.11235	Baa	T	S	115	1	3	N
BL020	20/08/2013	5.23199	73.11235	Baa	T	S	450	1	3	
BL021	20/08/2013	5.23199	73.11235	Baa	T	S	400	1.5	3	
BL022	23/08/2013	5.26675	72.159215	Baa	T	S	490	2	3	Y
BL023	23/08/2013	5.26675	72.159215	Baa	T	S	150	1	3	
BL024	23/08/2013	5.26675	72.159215	Baa	T	S	280	1	3	
BL025	24/08/2013	5.28617	73.115897	Baa	T	S	72	1	3	Y
BL026	24/08/2013	5.28617	73.115897	Baa	T	S	385	1.5	3	
BL003	24/08/2013	5.26675	73.1592	Baa	T	S	115	1	3	N
BL005	24/08/2013	5.26675	73.1592	Baa	T	S	31	1	3	
BL013	24/08/2013	5.26675	73.1592	Baa	T	S	580	1.5	3	
BL027	24/08/2013	5.26675	73.1592	Baa	T	S	50	2	3	
BL028	24/08/2013	5.26675	73.1592	Baa	T	S	70	1	3	
BL029	24/08/2013	5.26675	73.1592	Baa	T	S	40	1.5	3	
BL030	24/08/2013	5.26675	73.1592	Baa	T	S	1144	4	3	
BL031	24/08/2013	5.26675	73.1592	Baa	T	S	30	1	3	
BL032	24/08/2013	5.26675	73.1592	Baa	T	S	590	2	3	
BL033	24/08/2013	5.26675	73.1592	Baa	T	S	105	2	3	
BL034	24/08/2013	5.26675	73.1592	Baa	T	S	165	1.5	3	
GR004	24/08/2013	5.26675	73.1592	Baa	T	S	1165	1	3	
BL026	26/08/2013	3.475519	72.822319	Ari	T	S	385	1.5	3	Y
BL015	30/08/2013	5.2164	73.15415	Baa	T	S	180	2	3	N
GR005	30/08/2013	5.2164	73.15415	Baa	T	S	80	4	3	
BL002	01/09/2013	5.21719	73.127686	Baa	T	S	295	2	3	N
BL025	01/09/2013	5.21719	73.127686	Baa	T	S	72	1	3	
BL037	02/09/2013	3.4774	72.8316	Ari	T	S	140	2	3	N
GR006	02/09/2013	3.4774	72.8316	Ari	T	S	28	1.5	3	
BL042	10/09/2013	5.275341	73.013963	Baa	T	S	115	1	3	N
GR007	10/09/2013	5.275341	73.013963	Baa	T	Z	170	3	3	
BL009	19/09/2013	5.228559	73.160579	Baa	T	S	380	2	3	N
BL024	19/09/2013	5.228559	73.160579	Baa	T	S	280	1	3	
BL043	19/09/2013	5.228559	73.160579	Baa	T	S	480	1	3	
BL044	19/09/2013	5.228559	73.160579	Baa	T	S	30	1	3	
BL045	19/09/2013	5.228559	73.160579	Baa	T	S	27	1.5	3	
GR008	19/09/2013	5.228559	73.160579	Baa	T	Z	250	2	3	
WH001	19/09/2013	5.228559	73.160579	Baa	T	S	230	1	3	
BL015	26/09/2013	5.377352	72.95562	Raa	T	S	180	2	3	N
BL034	26/09/2013	5.377352	72.95562	Raa	T	S	165	1.5	3	
BL046	26/09/2013	5.377352	72.95562	Raa	T	S	35	1	3	
BL047	26/09/2013	5.377352	72.95562	Raa	T	S	50	1	3	
BL048	26/09/2013	5.377352	72.95562	Raa	T	Z	200	1.5	3	
BL049	26/09/2013	5.377352	72.95562	Raa	T	Z	70	1.5	3	

Net ID	Date Found	Lat	Long	Atoll	Twisted or braided	S or Z Twist	Stretched Mesh size (mm)	Twine Diameter (mm)	Number of strands	Turtle entangled
BL050	26/09/2013	5.377352	72.95562	Raa	T	S	35	0.5	3	
BL051	19/11/2013	2.67808	72.92637	Dhaalu	T	S	800	2	3	N
GY002	19/11/2013	3.496125	72.898186	South Ari	T	Z	325	8	3	N
BL005	24/11/2013	3.496125	72.899131	South Ari	T	S	31	1	3	N
BL002	06/01/2014	4.32886	73.60596	North Male	T	S	295	2	3	N
RE003	06/01/2014	4.32886	73.60596	North Male	T	S	57	2	3	
BL053	06/01/2014	4.32886	73.60596	North Male	T	Z	50	1	3	
RE002	06/01/2014	4.365622	73.651155	North Male	T	S	nd	3	3	Y
BL002	06/01/2014	4.365622	73.651155	North Male	T	S	295	2	3	
BL058	07/01/2014	4.428697	73.386017	North Male	T	Z	50	1	2	N
BL061	07/01/2014	5.0425	72.88278	Baa	T	Z	106	1	3	N
BL053	19/01/2014	4.28447	73.42658	North Male	T	Z	50	1	3	N
YE001	19/01/2014	4.28447	73.42658	North Male	T	Z	nd	8	3	
BL056	20/01/2014	5.351428	72.884389	Baa	B	-	19	3	nd	N
BL057	20/01/2014	5.351428	72.884389	Baa	T	S	15	2	3	
BL054	22/01/2014	5.103886	73.55839	Baa	T	S	390	nd	3	N
BL055	22/01/2014	5.103886	73.55839	Baa	T	S	205	1.5	3	
GR010	22/01/2014	5.103886	73.55839	Baa	T	S	100	nd	3	
BL057	25/01/2014	5.0425	72.88278	Baa	T	S	15	2	3	N
BL057	25/01/2014	5.0425	72.88278	Baa	T	S	15	2	3	
BL060	25/01/2014	5.0425	72.88278	Baa	T	S	71	1.5	3	
BL062	25/01/2014	5.0425	72.88278	Baa	T	Z	80	1.5	3	
BL063	25/01/2014	5.0425	72.88278	Baa	T	Z	26	1	3	
BL064	25/01/2014	5.0425	72.88278	Baa	T	S	281	2	3	
GR012	25/01/2014	5.0425	72.88278	Baa	T	Z	42	1	3	
BL059	27/01/2014	2.67808	72.92637	Dhaalu	T	S	350	3	3	Y
GR011	27/01/2014	2.67808	72.92637	Dhaalu	B	-	320	7	16	
GR018	31/01/2014	4.430278	73.38	North Male	T	Z	50	1	3	N
GR013	07/02/2014	4.32886	73.60596	North Male	T	Z	91	5	nd	Y
GR014	07/02/2014	4.32886	73.60596	North Male	T	Z	241	1.5	3	
BL015	09/02/2014	4.31099	73.577469	North Male	T	S	180	2	3	Y
BL066	09/02/2014	4.31099	73.577469	North Male	T	S	40	1	3	
BL067	09/02/2014	4.31099	73.577469	North Male	T	S	75	1	3	
BL073	20/02/2014	5.0399	72.881927	Baa	T	S	590	2	3	N
BL068	21/02/2014	4.323274	73.59669	North Male	T	S	170	1	3	Y
BL069	21/02/2014	4.323274	73.59669	North Male	T	S	370	3	3	
BK004	01/03/2014	5.11219	73.0776	Baa	B	-	2	1	nd	N
GR015	01/03/2014	5.11219	73.0776	Baa	T	Z	12.5	1	4	N
BL016	05/03/2014	4.296481	73.562758	North Male	T	S	75	1	3	Y
BL021	05/03/2014	4.296481	73.562758	North Male	T	S	400	1.5	3	
BL070	05/03/2014	4.296481	73.562758	North Male	T	S	190	1	3	
GR016	05/03/2014	4.296481	73.562758	North Male	T	Z	290	2.5	3	
GR017	05/03/2014	4.296481	73.562758	North Male	T	S	290	1	3	
BL072	06/03/2014	5.645131	73.315014	Noonu	T	S	190	2	3	Y
BK005	20/03/2014	5.833275	73.204683	Noonu	T	S	25	2	2	Y
GR021	20/03/2014	5.0567	72.845	Baa	T	S	300	3	4	N
BL071	23/03/2014	4.284022	73.439364	North Male	T	S	35	1	3	N
GR003	07/04/2014	3.537342	72.912231	South Ari	T	S	90	1	3	N
BL062	11/04/2014	5.103886	73.55839	Baa	T	Z	80	1.5	3	Y
GR020	11/04/2014	5.103886	73.55839	Baa	T	S	60	2	3	
BL059	19/04/2014	5.0425	72.88278	Baa	T	S	350	3	3	N
GR011	19/04/2014	5.0425	72.88278	Baa	B	-	320	7	16	
BL041	24/04/2014	5.0003	72.905445	Baa	T	S	280	3	3	N
BL081	24/04/2014	5.0003	72.905445	Baa	T	Z	400	1	3	
BL046	25/04/2014	5.2652	73.1558	Baa	T	S	35	1	3	Y
BL068	25/04/2014	5.2652	73.1558	Baa	T	S	170	1	3	
BL073	25/04/2014	5.2652	73.1558	Baa	T	S	590	2	3	
BL074	25/04/2014	5.2652	73.1558	Baa	T	S	195	1	3	
BL075	25/04/2014	5.2652	73.1558	Baa	B	-	170	3	-	
BK006	26/04/2014	5.28278	73.1315	Baa	T	S	70	1.5	3	N
BL017	26/04/2014	5.28278	73.1315	Baa	T	S	115	1	3	
BL076	26/04/2014	5.28278	73.1315	Baa	T	S	150	1	3	N
BL077	26/04/2014	5.28278	73.1315	Baa	T	S	24	2	3	
BL078	26/04/2014	5.28278	73.1315	Baa	T	S	250	2	3	
BL079	26/04/2014	5.28278	73.1315	Baa	T	S	295	1	3	
BL080	26/04/2014	5.28278	73.1315	Baa	T	S	770	2	3	
GR019	26/04/2014	5.28278	73.1315	Baa	T	S	500	1	3	
BL083	08/05/2014	5.1765	73.252825	North Male	T	S	380	3	3	Y
BL084	08/05/2014	5.1765	73.252825	North Male	T	S	80	1	3	
BL064	11/05/2014	5.2054	73.0847	Baa	T	S	281	2	3	Y
BL082	12/05/2014	5.274228	73.026221	Baa	T	S	750	3	2	N
GR022	12/05/2014	5.274228	73.026221	Baa	T	Z	1200	15	2	
BK007	21/05/2014	5.349	72.5121	Baa	T	Z	290	5	4	N
BL007	21/05/2014	5.349	72.5121	Baa	T	S	40	1	3	
BL086	21/05/2014	5.349	72.5121	Baa	T	S	47	1.5	3	
BL087	21/05/2014	5.349	72.5121	Baa	T	S	150	2.5	3	
GR023	21/05/2014	5.349	72.5121	Baa	T	Z	155	1.5	3	
GR024	21/05/2014	5.349	72.5121	Baa	T	Z	33	2	3	
GR025	21/05/2014	5.349	72.5121	Baa	T	Z	230	3.5	4	
WH005	21/05/2014	5.349	72.5121	Baa	T	S	210	2	3	
BL067	14/06/2014	4.1712	73.2517	North Male	T	S	75	1	3	N
BL085	14/06/2014	4.1712	73.2517	North Male	T	S	100	1.5	3	
GR023	23/06/2014	5.216	72.5256	North Male	T	Z	155	1.5	3	Y
BL088	03/07/2014	5.2877	73.107	Baa	T	S	510	1	3	Y
BL089	04/07/2014	5.2877	73.107	Baa	T	S	480	1	3	
Total										**21**

*Appendix 3: Analyses of ghost nets recovered from India and Sri Lanka. Nets grouped together with the same colour (white or grey) represent 1 ghost net conglomerate made up of two or more individual nets (*i.e.*. Kosgoda = 3 individual nets, Orissa = 2 individual nets).*

Net ID	Date Found	Latitude	Longitude	Location	Material	S or Z twist	Stretched Mesh size (mm)	Twine Diameter (mm)	Number of Strands	Turtle Present
BL040	18/08/2013	6.2322	80.0571	Kosgoda	HDPE	S	275	4	3	N
TR003	22/08/2013	6.2322	80.0571	Kosgoda	HDPE	-	100	1	MO	N
TR004	25/08/2013	6.2322	80.0571	Kosgoda	NY	-	80	1	MO	N
BL093	28/08/2013	11.931	79.7852	Pondicherry	HDPE	Z	31	1.5	3	N
TR001	31/08/2013	11.931	79.7852	Pondicherry	NY	-	40	0.1	MO	N
TR001	04/09/2013	11.931	79.7852	Pondicherry	NY	-	40	0.1	MO	N
BL029	09/09/2013	11.931	79.7852	Pondicherry	HDPE	S	40	0.5	3	N
RE001	09/09/2013	11.931	79.7852	Pondicherry	HDPE	Z	9	0.5	2	
TR001	09/09/2013	11.931	79.7852	Pondicherry	NY	-	40	0.1	MO	
BL007	12/10/2013	20.868056	87.018611	Orissa	HDPE	S	40	1	3	N
BL092	03/12/2013	13.220278	93.046111	Nicobar and Andaman	HDPE	S	210	1.5	3	N
BK009	03/12/2013	13.220278	93.046111	Nicobar and Andaman	HDPE	S	16	2	3	
GR035	03/12/2013	13.220278	93.046111	Nicobar and Andaman	HDPE	S	65	1	3	
GR036	03/12/2013	13.220278	93.046111	Nicobar and Andaman	NY	-	70	0.5	MO	
TR002	12/12/2013	20.868056	87.018611	Orissa	NY	-	90	1	MO	N
TR002	27/12/2013	20.868056	87.018611	Orissa	NY	-	90	1	MO	
BL090	13/01/2014	11.490833	92.708889	Nicobar and Andaman	HDPE	S	150	2	3	N
BK006	14/01/2014	11.490833	92.708889	Nicobar and Andaman	HDPE	S	70	1.5	3	
GR027	15/01/2014	11.490833	92.708889	Nicobar and Andaman	NY	-	78	0.5	MO	
BL091	16/01/2014	11.490833	92.708889	Nicobar and Andaman	HDPE	S	28	1	3	
GR028	14/02/2014	11.704167	92.7425	Nicobar and Andaman	NY	-	71	0.5	MO	N
GR029	14/02/2014	11.704167	92.7425	Nicobar and Andaman	NY	-	120	0.5	MO	
GR030	14/02/2014	11.704167	92.7425	Nicobar and Andaman	NY	-	100	0.5	MO	
GR031	14/02/2014	11.704167	92.7425	Nicobar and Andaman	NY	-	84	0.5	MO	
GR032	14/02/2014	11.704167	92.7425	Nicobar and Andaman	NY	-	80	1	MO	
BK008	01/03/2014	11.595556	92.607222	Nicobar and Andaman	HDPE	S	57	1.5	3	N
GR033	01/03/2014	11.595556	92.607222	Nicobar and Andaman	HDPE	S	120	2	3	
GR034	01/03/2014	11.595556	92.607222	Nicobar and Andaman	HDPE	S	72	1.5	3	
GR026	07/12/2014	11.555556	92.7425	Nicobar and Andaman	NY	-	77	1	MO	N

HDPE =High Density Polyethylene
NY= Nylon
MO = Monofilament

Appendix 4. Comparison of ghost nets found in India to those found in the Maldives.

Indian Net ID	Maldivian net ID match	Streched Mesh size (mm)	Twine Diameter (mm)	Number of strands
BL093	GR024	31	1.5	3
BL029	BL001, BL046, BL071, BL007, BL066	40	1.5	3
BL007	BL046, BL071, BL029, BL066, BL001, BL050	40	1	3
BL092	BL055	210	1.5	3
GR035	BK006, BL028	65	1	3
BK008	GR020, RE003	57	1.5	3
BK006	BL028, BL060, BL025, BL016, BL067	70	1.5	3

NB: No ghost nets found in Sri Lanka matched with those found in the Maldives. Stretched mesh size and twine diameter were analysed to the nearest +/- 5mm and +/- 0.5mm, respectively.