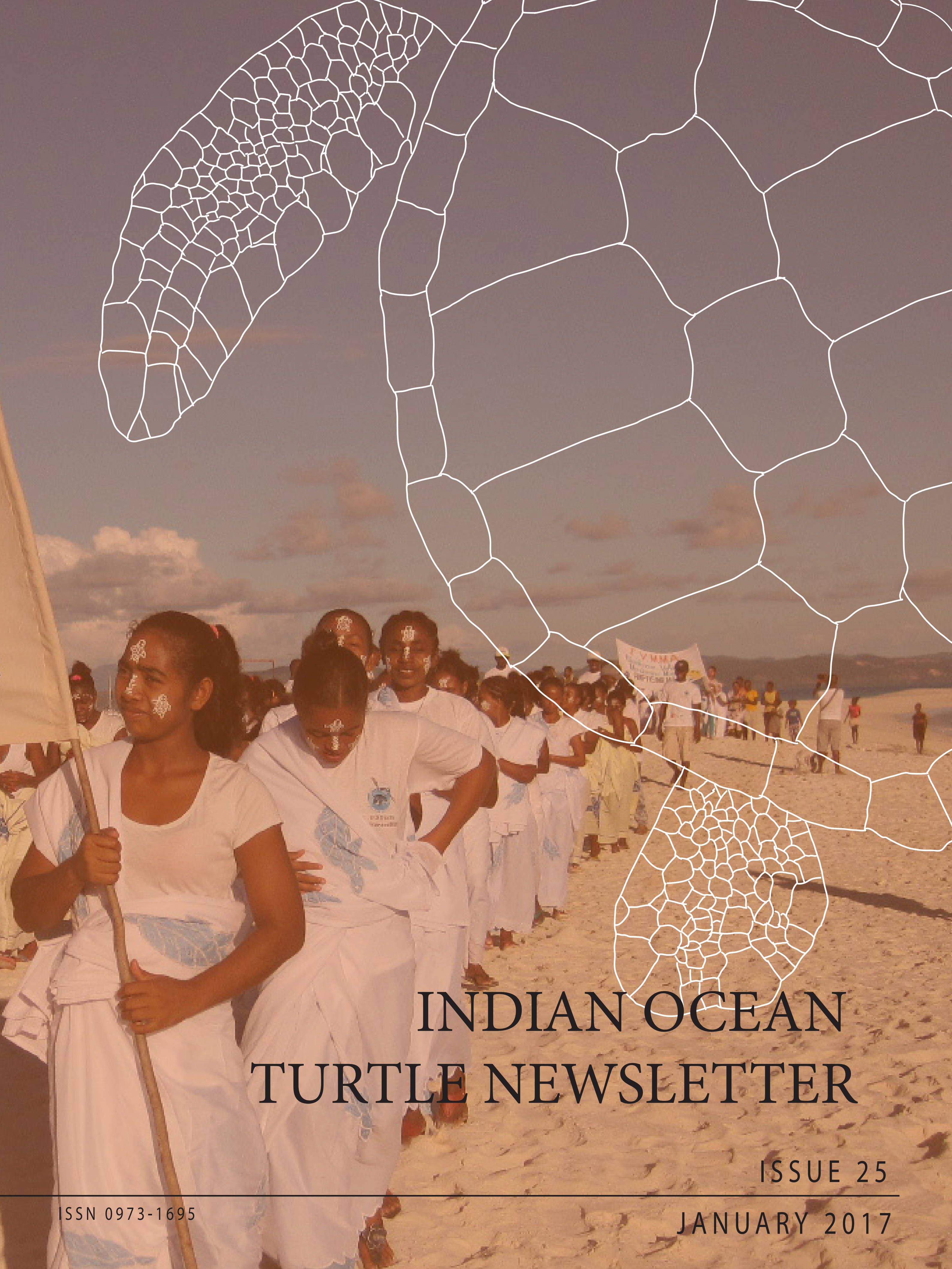

INDIAN OCEAN TURTLE NEWSLETTER

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The Indian Ocean Turtle Newsletter was initiated to provide a forum for exchange of information on sea turtle biology and conservation, management and education and awareness activities in the Indian subcontinent, Indian Ocean region, and south/southeast Asia. The newsletter also intends to cover related aspects such as coastal zone management, fisheries and marine biology.

The newsletter is distributed free of cost to a network of government and non-government organisations and individuals in the region. All articles are also freely available in PDF and HTML formats on the website. Readers can submit names and addresses of individuals, NGOs, research institutions, schools and colleges, etc. for inclusion in the mailing list.

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WILDLIFE WITHOUT BORDERS

Cover photograph: Votsiry Women's Association marching in the opening parade of the Marine Turtle Festival on Nosy Iranja, Madagascar, in 2016.
Photo Courtesy: Andriamiravo Abdoul Santisy.

IOTN is available online at www.iotn.org

EDITORIAL

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Issue 25 of IOTN includes papers from less frequently reported on areas of the Indian Ocean, including Madagascar, Reunion Island, and the Nicobar Islands. Topics include a sea turtle fishery, successful conservation initiatives, monitoring activities, and migratory behavior of olive ridley turtles. Readers are encouraged to also consider the research summary about a recent paper by Rees *et al*. (2016), which identifies progress made towards addressing research priorities for sea turtle management and conservation, and identifies global and regional knowledge gaps and under-studied populations. Situating your research and/or conservation activities within the priority research categories and questions first described by Hamann *et al*. (2010) and then reviewed by Rees *et al*. (2016) may both strengthen grant applications and enhance initiatives to conserve sea turtles and their habitats in the Indian Ocean and South East Asia.

Finally, IOTN wishes safe travels to those travelling to the 37th International Sea Turtle Symposium in Las Vegas, 16-20th April and reminds everyone about the Indian Ocean and South East Asia regional meeting which will be held prior to the symposium. A report on the symposium will be included in a future issue of IOTN.

CALL FOR SUBMISSIONS

The Indian Ocean Turtle Newsletter was initiated to provide a forum for the exchange of information on sea turtle biology and conservation, management and education and awareness activities in the Indian subcontinent, Indian Ocean region, and south/southeast Asia. If you would like to submit a research article, project profile, note or announcement for Issue 26 of IOTN, please email material to iotn.editors@gmail.com before 1st April 2017. Guidelines for submission can be found on the last page of this newsletter or at http://www.iotn.org/submission.php.

ARTICLES

DO OLIVE RIDLEY TURTLES MIGRATE EN-MASSE ALONG THE EAST COAST OF INDIA?

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Sea turtles undertake long distance migrations from feeding to breeding grounds, but until recent studies involving satellite telemetry, little was known about their migratory behaviour. Over the last decade, thousands of sea turtles have been tracked, providing insights about their migratory routes, use of habitats, and behaviour (Jeffers & Godley, 2016). One thing is clear – sea turtles may aggregate at feeding and breeding grounds, but typically they travel alone. Given the mass nesting behaviour of olive ridley turtles, however, there has long been speculation – fuelled by anecdotal accounts of group sightings - that they may show socially facilitated group migrations.

Olive ridley turtles are known to nest along the entire east coast of India, with mass nesting sites at multiple locations in Orissa, in particular Gahirmatha and Rushikulya (Shanker *et al*., 2003; Tripathy & Pandav, 2008). Till the 2000s, all that was known about the pre- and post-nesting migrations of these turtles was anecdotal, with little understanding about where they went, what routes they followed and whether they travelled in groups.

In the 1970s and 1980s, many myths abounded. An article in the Oriya Daily 'The Samaj' in 1983 (Silas *et al*., 1983) described ridleys as being from the Pacific Ocean, implying that they migrated all the way to the Orissa coast each year. Another article in the Times of India (December 6, 1982) says that the 'oval shape olive-green creatures which form an endangered species used to migrate in large numbers from the Pacific Ocean' to the eastern coast (Silas *et al*., 1983).

Anecdotal accounts suggested that large numbers of turtles had been seen migrating together along the east coast of India. One of the oft cited references to the sighting of shoals of turtles swimming together along the east coast of India is a paper published in the American Museum of Natural History (Oliver, 1946). This reference is cited as a documented record of ridleys swimming in groups in the Bay of Bengal in many publications including Dash and Kar's classic book 'Gahirmatha: The turtle paradise' (Dash & Kar, 1990), Satish Bhaskar's review paper (Bhaskar, 1984) and many others over the last three decades. However, Oliver was not referring to the Bay of Bengal at all; he had recorded this observation during a trip from San Diego to the Panama Canal zone about 50 miles from the coast. Several ridleys (> 20) were seen floating on the surface, and his coordinates suggest that this was just offshore from the mass nesting beaches at La Escobilla, Oaxaca in Mexico. As such, this does not even provide strong evidence of group movement in that region.

This is not the only misleading citation. Deraniyagala, in his book 'A colored atlas of some vertebrates from Ceylon' (Deraniyagala, 1955) is said to have reported the sighting of large numbers of turtles migrating northwards along the Sri Lankan coast, in the month of November. Like Oliver (1946), this is cited repeatedly as evidence that ridley turtles were seen migrating together in the Bay of Bengal. Indeed, sea turtles were seen together, but this event occurred in the Mediterranean in September 1947. A clerk to the House of Representatives of the Ceylon Parliament, incidentally of the same name as the author, was travelling to England and observed the group about 350 miles west of Port Said. The Speaker of the House, travelling with the delegation confirmed the story. The turtles were said to be swimming eastwards and the ship sailed through the group for 3 hours. While the observation is interesting, it is still not about group migrations on the east coast of India, and the identity of the species is unknown.

Later, TFH Hoffman, a former President of the Nature and Wildlife Protection Society of Sri Lanka, wrote to Romulus Whitaker (In Letter), that he had received reports that Sri Lankan fishermen had seen a large group of turtles migrating northwards in December

1978. In November 1983, the Indian Coast Guard informed the Chief Secretary of the Government of Orissa that they had seen a mass migration of sea turtles in the coastal waters of Tamil Nadu near Pondicherry. Whitaker recalls a visit by a Coast Guard officer to the Madras Crocodile Bank where he related the sighting of 'islands of turtles migrating northward' during a helicopter sortie from Vishakapatnam to Chennai. This probably refers to the same November 1983 report. Mass nesting that year occurred in the last week of January.

Though there have been many such anecdotal accounts of group migrations, they could just as easily refer to static aggregations at feeding or breeding grounds. Demonstration of group or socially facilitated migrations requires a combination of methods including satellite telemetry, field observations and other behavioural studies. So far, flipper tagging of nesting and mating turtles in Odisha has provided evidence that olive ridley turtles migrate to the offshore waters of Tamil Nadu and Sri Lanka after breeding (Pandav & Choudhury, 1998, 2006). More recently, satellite telemetry studies have demonstrated that some olive ridley turtles migrate southwards towards Sri Lanka, while others remain in offshore waters up to distances of 200km from the coast (Kumar, 2016). Similarly, studies of the species in Costa Rica did not provide any evidence of group migrations (Plotkin *et al*., 1996; Plotkin, 2010). Unfortunately, there still is little evidence that group movement of any sort occurs in olive ridley turtles, or whether these are chance aggregations of large groups that are migrating along similar routes at similar times. It is worth noting though that information from coastal residents, fishers, and other opportunistic observations at sea (Coast Guard, Navy etc.) can provide valuable information and insights about unknown aspects of sea turtle biology. There are currently few citizen science programmes that involve at-sea observations of sea turtles and other species such as marine mammals. A carefully crafted programme with simple but adequate training for potential observers could greatly supplement our knowledge about these animals.

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THE MARINE TURTLE FISHERY IN THE BAY OF RANOBE, MADAGASCAR

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INTRODUCTION

Five species of marine turtle are found in the coastal waters surrounding Madagascar: green (*Chelonia mydas)*, hawksbill (*Eretmochelys imbricata)*, loggerhead (*Caretta caretta)*, leatherback (*Dermochelys coriacea)* and olive ridley (*Lepidochelys olivacea*) turtles. The IUCN Red List of Threatened Species lists international populations of hawksbill turtles as critically endangered, green turtles as endangered, and leatherback, loggerhead and olive ridley turtles as vulnerable.

In Madagascar, turtles have long been recognised as needing protection and, in 1923, six island reserves were created for their conservation. However, only one of these was enforced (Walker & Fanning, 2003). Ratification of CITES in 1975 provided legal protection against the trade of turtle products, while a 1988 national decree offered all turtles protection from exploitation. In reality, however, these laws are not enforced. Turtle meat continues to be sold in market places, their shells are converted into jewellery, and taxidermied turtles are offered to tourists in at least one major city (Golding, pers. obs.). The importance of turtles in providing food for rural communities, their cultural role in tribal customs (although now largely diluted), a lack of resources by enforcement agencies, indifference and even a desire to consume the prohibited meat, have all been cited as reasons for the poor regulation of protective legislation (Walker & Fanning, 2003; Lilette, 2006). Turtle nesting has virtually disappeared in the southwest of Madagascar due to overharvesting of eggs (Rakotonirinia & Cooke, 1994), and no coordinated management approach has been attempted in the region.

In the rural southwest, laws are largely decided at a community level, through a Dina (local law). In 2013, in an attempt to protect juvenile turtles, a Dina was passed in the 13 communities of the Bay of Ranobe (Figure 1), near the city of Toliara, prohibiting the killing of marine turtles with a curved carapace length (CCL) of less than 70cm.

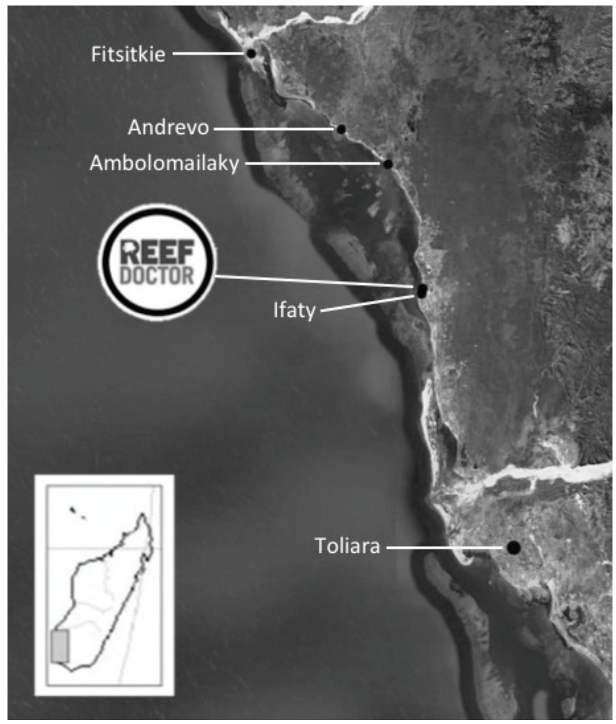

Figure 1. The Bay of Ranobe, southwest Madagascar.

Since 2008, the conservation NGO ReefDoctor has monitored an illegal marine turtle fishery in the Bay of Ranobe. Data was first recorded from a single village, Ifaty, with additional observations from Fitsitkie since 2014 and Andrevo and Ambolomailaky in May 2016. In addition to monitoring the fishery, in 2014 ReefDoctor commenced a tag-and-release program for juvenile turtles in three of the four communities. Supporting the bay-wide Dina prohibiting the killing of juvenile turtles, the tag-and-release program provides an opportunity for fishermen who catch undersized turtles to contribute to their conservation while facilitating the collection of biological data. This program has been running in the villages of Ifaty, Andrevo and Ambolomailaky since its inception. Due to difficulties in regional transportation, the tag-and-release program was not initiated in the

Table 1. The marine turtle fishery in the Bay of Ranobe, 2016.

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total
Turtles caught	460	351	377	333	1,521
Turtles killed/sold	211	227	224	205	867
Turtles released	249	124	153	128	654
Turtles under 70 cm CCL released (%)	80.1	67.8	74.3	69.5	73.4
% female	88.2	87.2	82.6	89	87
Market value of fishery (Ariary)	14,085,500	16,508,500	16,829,000	12,765,000	60,188,000
Value of tag-and-release (Ariary)	3,863,500	2,177,000	2,748,000	2,498,000	11,286,500
Total value of fishery (Ariary)	**17,949,000**	**18,685,500**	**19,577,000**	**15,263,000**	**71,474,500**
Total value of fishery (USD)	**5,464**	**5,688**	**5,960**	**4,646**	**21,758**

furthest community, Fitsitkie. Fishers are offered a small monetary compensation (between 15,000 – 20,000 Ariary or 4.5 – 6 USD) for each turtle that they contribute to the tag-and-release program as recompense for foregone catch and their efforts in releasing the turtles. This report describes the marine turtle fishery in the Bay of Ranobe during 2016.

THE FISHERY

Throughout 2016, a total of 1,521 marine turtles were caught by fishermen in the Bay of Ranobe, with the greatest amount caught during the first quarter (Table 1). 51% of captured turtles were of a curved carapace length smaller than 70cm and, therefore, assumed to be protected under the Dina preventing the slaughter of juvenile turtles. 73% of these undersized turtles were returned to the ocean via the tag-and-release program. Given that this program only runs in three of the four monitored communities, it suggests the relative success of local law combined with conservation intervention.

The fishery generated an income of 71.4 million Ariary for an estimated 80 fishermen in the four communities of Ambolomailaky, Andrevo, Fitsitikie and Ifaty over 12 months. The most valuable individual turtle sold

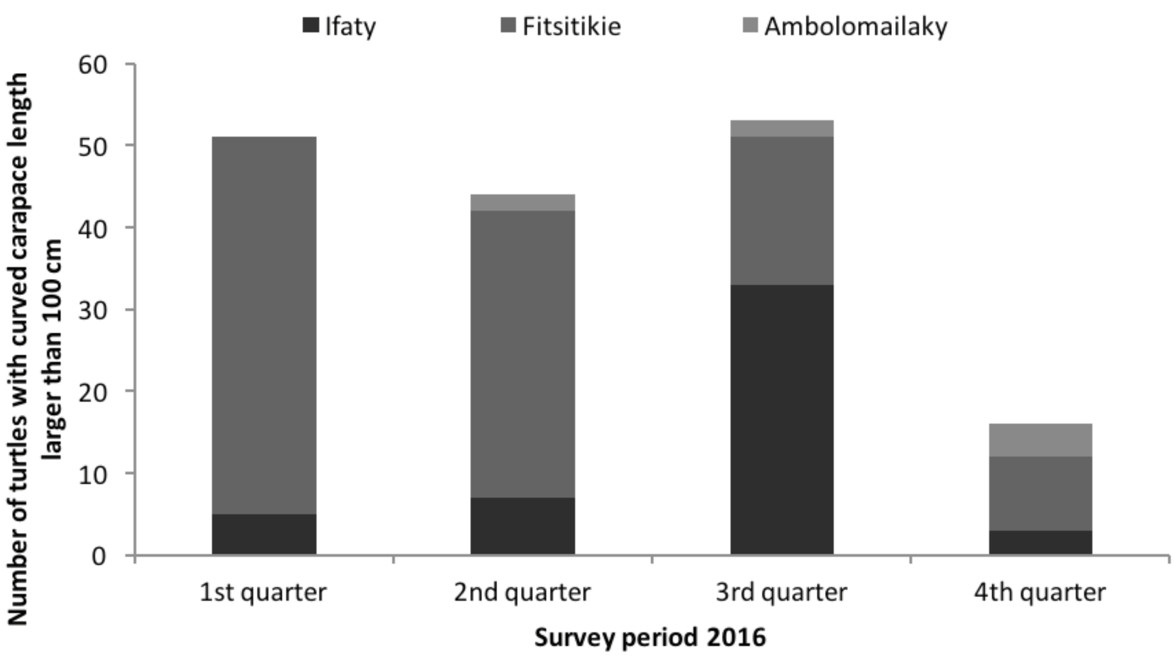

Figure 2. Fishermen in Fitsitikie were responsible for catching the largest turtles (over 100cm CCL), while no large turtles were caught by the community of Andrevo.

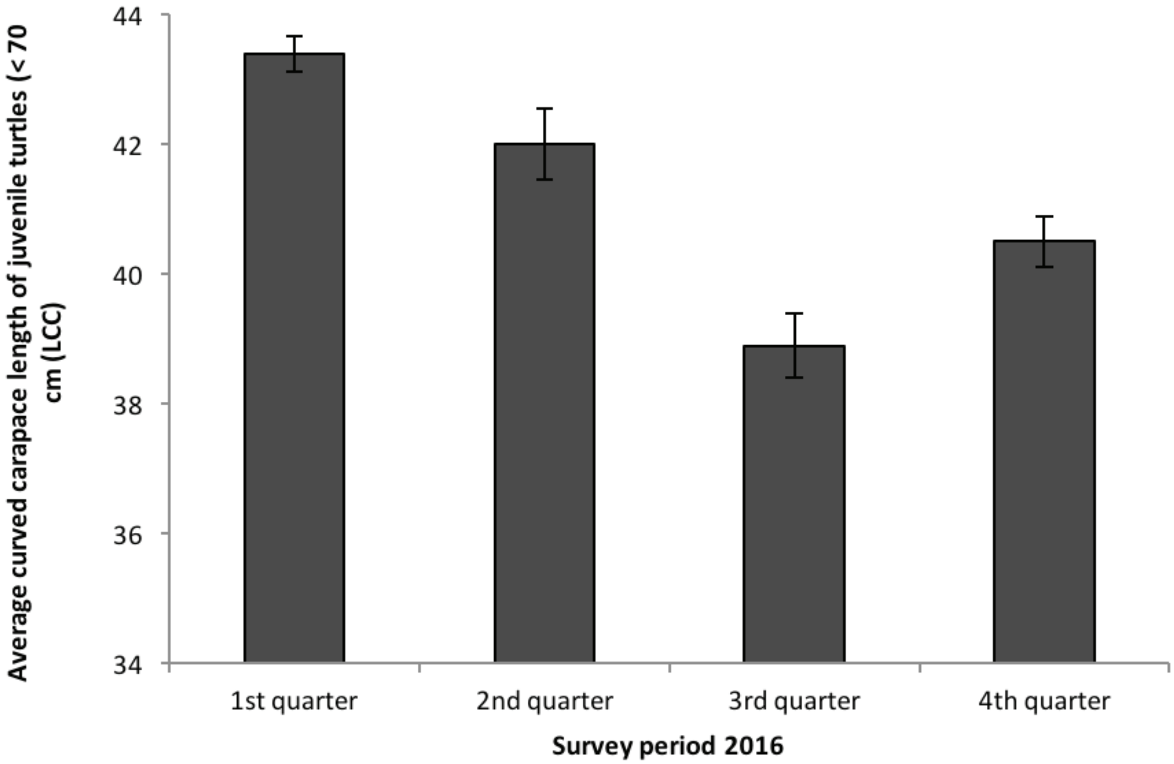

Figure 3. The average size of juvenile turtles (those with a curved carapace length of less than 70cm) generally declined throughout the year.

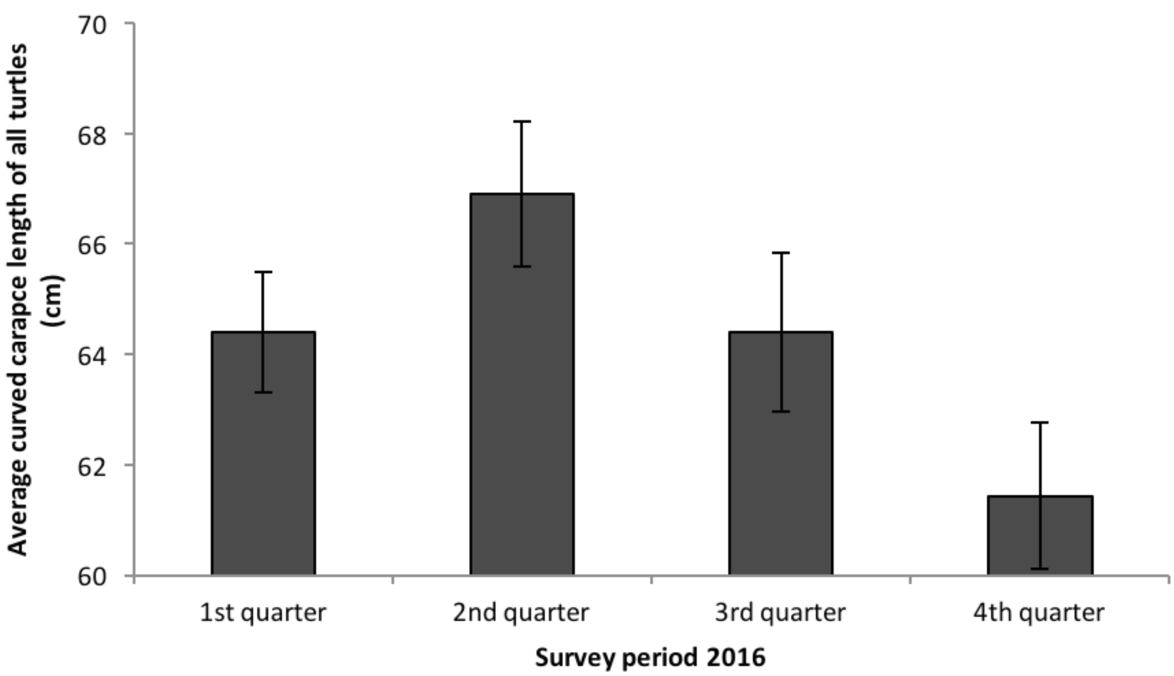

Figure 4. The average curved carapace length of all turtles caught in the fishery was greatest during the second quarter of 2016.

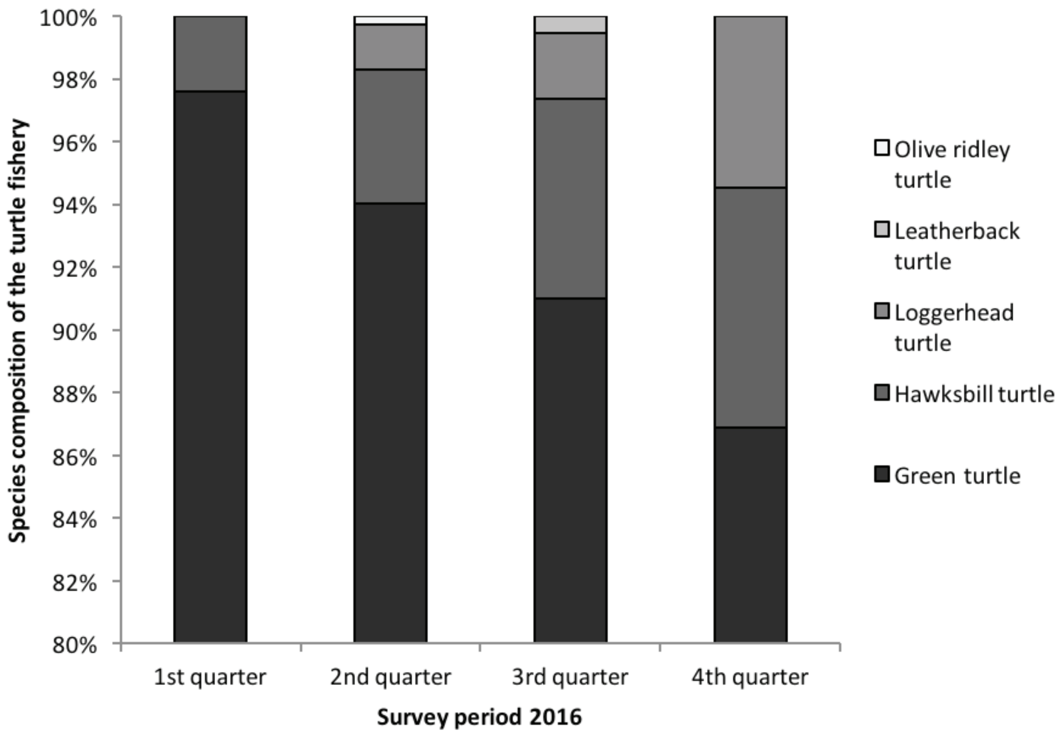

Figure 5. Green turtles constituted the majority of the fishery, despite declining proportional abundance throughout the year.

for 200,000 MGA (60 USD), while the least expensive sold for 10,000 MGA (3 USD). The value of turtles at the market is largely governed by size. There were 164 turtles with a CCL over 100cm captured during the year, the majority of which were caught by fishermen in Fitsitikie (Figure 2). The size of juvenile turtles generally declined throughout the year, although increased slightly from a third quarter minimum (Figure 3). The average CCL of all turtles caught in the fishery was 64.3cm, although this differed temporally (Figure 4). Five species of marine turtles were captured in the fishery, with green turtles dominating catch, despite declining proportional abundance towards the end of the year (Figure 5). The community of Ifaty generated the greatest income through the slaughter of turtles (Table 2), despite fishermen catching smaller turtles and receiving a smaller average price per turtle, than Fitsitikie.

FISHING GEAR

Prior to June 2016, ReefDoctor accepted any juvenile turtles for their tag-and-release program. The use of spearguns and harpoons for fishing is widespread in the region, and turtles often presented with carapace wounds, lung punctures and on one occasion, paralysis. Depending on the severity of the wound, these turtles occasionally died. In an attempt to halt the mortality of these turtles, ReefDoctor in June stopped accepting turtles which had been caught with a speargun or harpoon. Despite the removal of this gear, the number of juvenile turtles caught in the fishery increased from 183 in the second quarter, to 211 in the third. However, monitoring of the size of turtles that were killed and sold in the market, indicated there was no increase in the mortality of juvenile turtles. Rather, there was an increase in the percent of juvenile

Table 2. Despite a smaller average price per turtle, the sale or consumption of turtles in Ifaty generated substantially more income for fishermen than Fitsitikie in 2016.

	Ifaty	Fitsitikie
Number of turtles killed	535	234
Average CCL (cm)	76	91.5
Market value of turtles (Ariary)	36,671,500	18,609,000
Average price per turtle (Ariary)	68,336	79,867

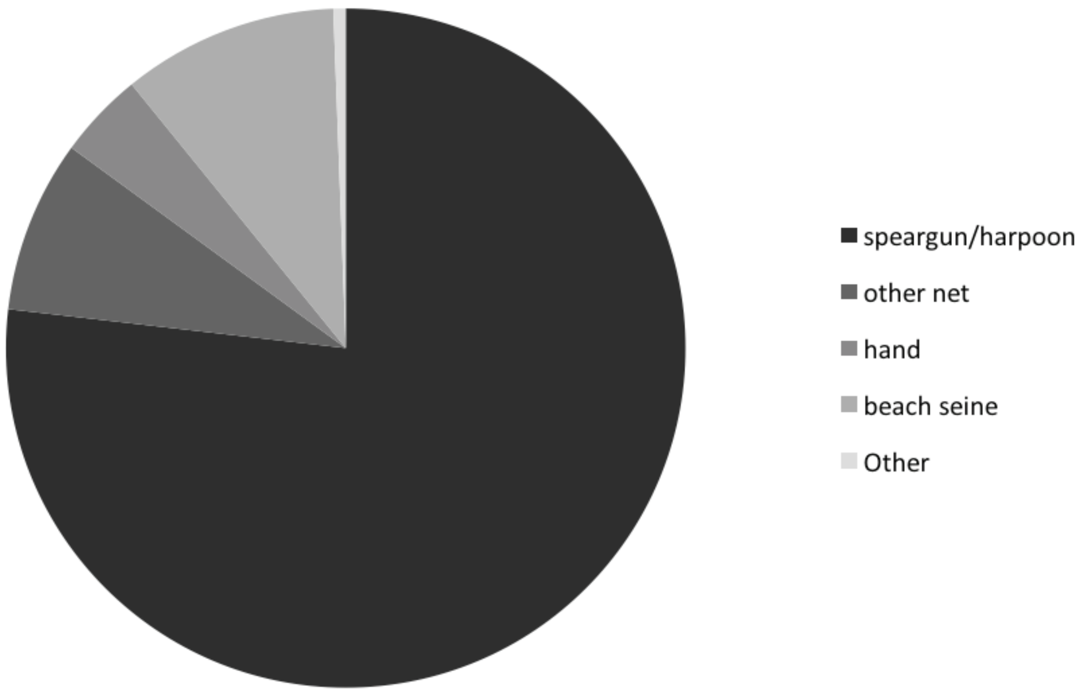

Figure 6a. Spearguns and harpoons made up the primary gear for catching juvenile turtles from January-May 2016.

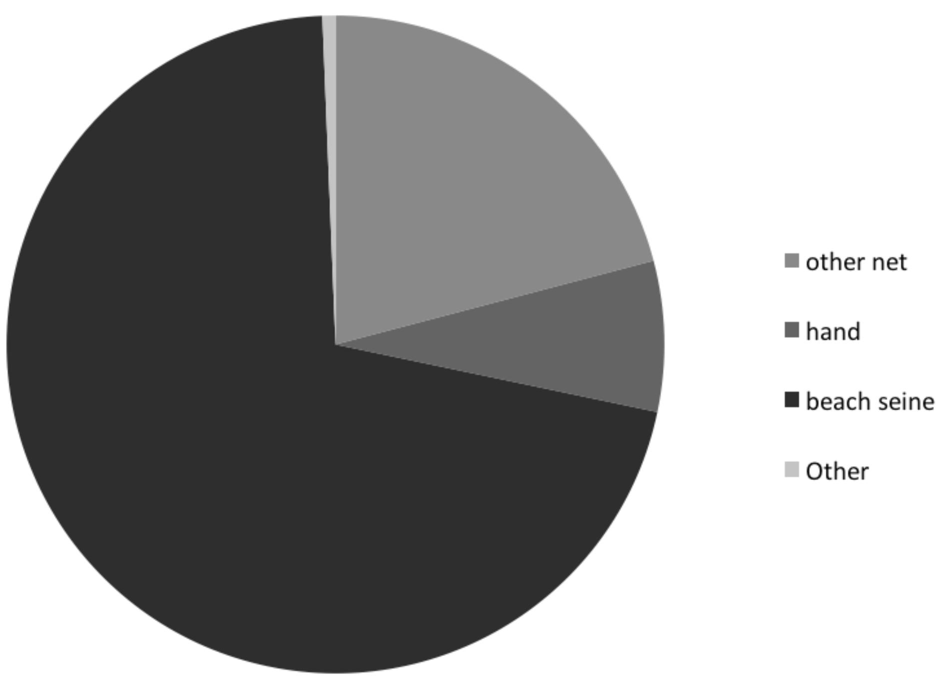

Figure 6b. Nets constituted the primary gear for catching juvenile turtles from June-December 2016

turtles that were released via the tag-and-release program in the third quarter (Table 1). This suggests that rather than continuing to use spearguns to hunt turtles and then selling the turtles on the market, fishermen stopped hunting turtles with the injurious gear. From June, nets replaced spearguns/harpoons as the dominant type of gear used to catch juvenile turtles (Figure 6).

Despite the Dina outlawing the killing of juvenile turtles, 14% of turtles submitted to the tag-and-release program were reported to be caught by hand. It is unclear whether these turtles were caught with the express intention of presenting to ReefDoctor in order to claim compensation, or if this notion was developed after the turtles were caught. The tag-and-release program may therefore allow fishermen to continue to hunt juvenile turtles, despite the local law against their mortality. It certainly reduces the economic imperative to kill juvenile turtles, by compensating fishermen for their catch. Spearguns and harpoons continued to be the most commonly used gear to hunt large turtles.

Conclusion

This study demonstrates that despite legal protection, marine turtles are still frequently caught by fishermen in the coastal waters of southwest Madagascar. While five species were observed, green turtles constituted the majority of the catch, reinforcing Rokotonirinia & Cooke's (1994) observation that the waters around the Toliara reef system are important feeding grounds for this species. Hawksbill turtles were the second most abundant species, while only a single olive ridley turtle was caught during 2016, suggesting their limited distribution in the region.

Given the high market value for large species, it is likely that marine turtles will continue to be targeted by fishermen. For impoverished communities in the Bay of Ranobe, the marine turtle fishery provides a significant economic service. As commercially important finfish and invertebrates continue to decline from the bay, the lure of large, prized species such as turtles is expected to increase, accelerating their harvest. Any attempts to relieve fishing pressure on the turtle fishery must provide alternative livelihoods of an equivalent value, and do so reliably.

Although more turtles were caught in the fishery during the third quarter than in the second, there was also an increase in the proportion of juvenile turtles that were released through ReefDoctor's tag-and-release program, suggesting increased support for the initiative with fishermen. Given this increase in released juveniles, and no increase in juveniles at the market, there has not appeared to be any negative consequences from the decision to exclude juvenile turtles caught with the use of harpoons and spearguns from the program. Rather, all turtles released during the third quarter were free of associated injuries, and there were no observed deaths of juvenile turtles, as occurred in previous quarters.

Fishermen from the community of Fitsitikie were responsible for catching most of the large turtles, most likely due to the community's proximity and ease of access to the exterior of the bay, and thus deeper waters. The decline in average size of turtles captured in the fishery must continue to be monitored to ensure the sustainability of the species.

Future studies will focus on the mapping of turtle fishing grounds to gain a clearer understanding of the spatial distribution of catches, and their influence on the economics of the fishery. Continued monitoring of the fishery, with the introduction of catch per unit effort surveys, will further help to detect changes in regional turtle populations.

ACKNOWLEDGEMENTS

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SUCCESSFUL MONITORING OF SEA TURTLE NESTING ACTIVITY ON REUNION ISLAND

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Reunion Island is located between Madagascar and Mauritius in the Indian Ocean. Its sand beaches, mostly located on the west coast, used to be important nesting sites for marine turtles, more precisely green turtles, but populations have drastically decreased since human colonisation in the 18th century (Dubois, 1669). Between the 1980's and the turn of the century, only four nests had been recorded over all the beaches (Ciccione & Bourjea, 2006). Since 2004, this number increased to 25 on two beaches. This increase occurred after important rehabilitation efforts had been made since 1999 on potential nesting beaches, that consisted of campaigns against invasive species conducted before and during multiple planting programs for the rehabilitation of indigenous species involving schools. These efforts appeared to be successful as two thirds of the nesting activity was observed on rehabilitated beaches (Ciccione & Bourjea, 2010; Jean & Ciccione, In Press). This progress may be taken as a sign of hope for marine turtle nesting activity on the island, although it remains very low when compared with other green turtle nesting sites in the region (Bourjea *et al*., 2006, 2007, 2015; Lauret-Stepler, 2007; Humber *et al*., 2010; Derville *et al*., 2015).

A National Action Plan for marine turtles over French territories of the Southwest Indian Ocean was developed

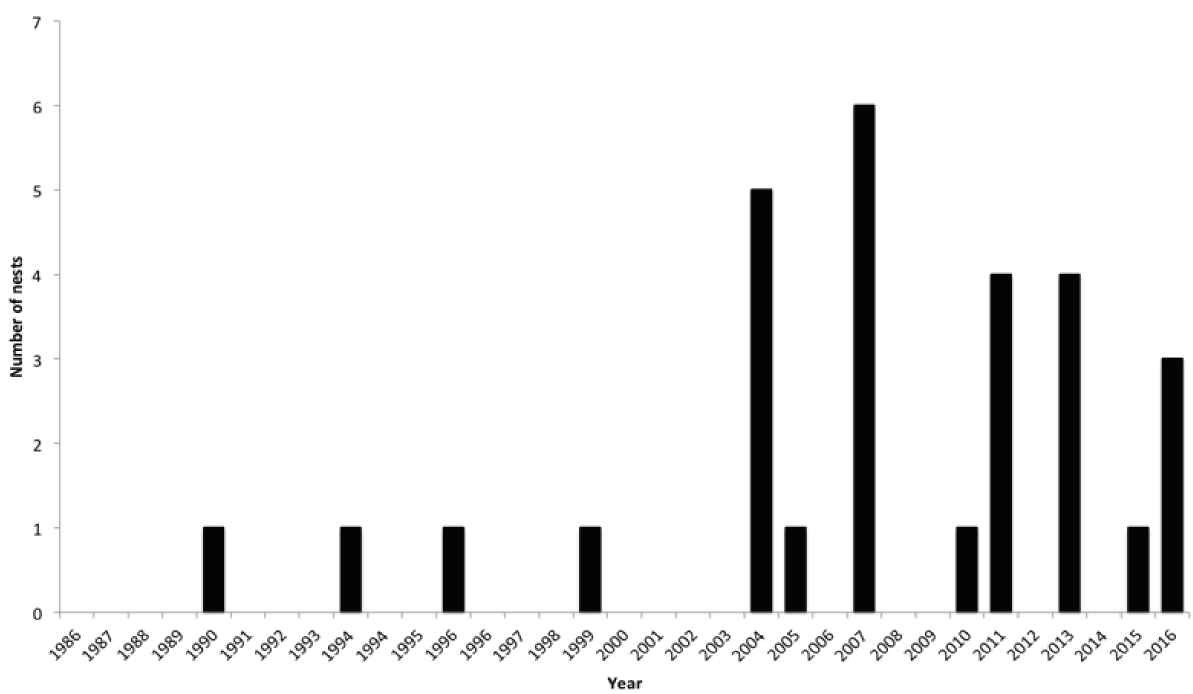

Figure 1. Number of marine turtle nests on Reunion island since 1986. (Source: Kelonia)

in collaboration between regional and national experts as well as the ministry of environment and implemented in 2015. Specific actions have been identified for Reunion Island, among which the urgency to study, maintain and preserve any new nesting event that would occur on the island. In order to do so, Kelonia, the observatory of marine turtles of Reunion, had to make sure that any new turtle tracks would be quickly spotted and reported to scientists.

Thus, a network of volunteers was trained with the help of other environmental organisations. Some volunteers were known for being involved in volunteering activities elsewhere, and some just inquired how they could help while visiting Kelonia museum and care centre. A description of the program was also advertised on a website gathering environmental volunteering opportunities (http://www.jagispourlanature.org/). Thanks to this network of over 30 people, it was possible to have volunteers patrolling the entire potential nesting beaches between September 2015 and April 2016. Patrols happened on a voluntary basis, at the time volunteers were available, and employees of Kelonia and CEDTM filled gaps without volunteer patrols in order to avoid more than 3 days without a patrol.

An online-shared timetable enabled volunteers to announce their intentions to patrol a beach and to confirm it occurred, as well as to add comments about the patrol. Any possible hindrance to nesting, such as the presence of stray dogs on the beach, or light pollution due to the presence of hotel or street lighting, was reported so that Kelonia could act if necessary. Some volunteers also used the opportunity of their patrols to remove rubbish from the beaches.

After a couple months of regular patrols, two volunteers found turtle tracks early on the morning of 27th November 2015. It had been 3 years without any recorded nesting attempt on Reunion despite sightings of breeding couples at sea. Patrols on this specific beach were then increased and even organised at night around two weeks after the first tracks had been seen in order to identify the nesting female and record nesting parameters. In this way it was also possible to make sure the beach was safe for a second nesting event. To increase the success of a new nesting attempt, volunteers asked the nearby hotel to turn off its light as it illuminated half of the 700m-long beach. They also paid attention to human activity to make sure that no one was wandering in the area. Kelonia's team was also ready to intervene in case a nest was threatened with being flooded by a tropical storm or heavy swell as had happened in the past (Ciccione *et al*., 2008). When the turtle came back 2 weeks after the first nesting event, Kelonia's scientific team was there to identify the turtle and took the opportunity to attach a satellite device on her carapace to learn more about her migration pattern. Much valuable information was collected this day and after. For example, the photo-identification process using TORSOOI application (www.torsooi.com; Jean *et al*., 2010) showed that the turtle was already known as 'Emma' and had already nested on this very same beach 3 years earlier.

Thanks to the dedication of the volunteers, it was possible to monitor the following nesting and hatchling events until the nesting season of this female ended in March 2016. Over these five months, monitoring fatigue did nevertheless occur and only some volunteers continued their patrols over the whole period. New volunteers also joined the program partway through the season. To motivate the volunteers network, they were invited to assist in the release of hatchlings and to participate in excavation of Emma's nests. The volunteer team is now ready for the next nesting attempt and still motivated despite the low nesting activity on Reunion Island.

ACKNOWLEDGEMENTS

The monitoring activities described in this article are part of the National Action Plan for sea turtles. We are deeply grateful for the support of the "DEAL" (Direction de l'Environnement, de l'Aménagement et du Logement), which is the French governmental organisation that overlooks and funds the action plan. We are also grateful for the support of the Nicolas Hulot Foundation that funds and stimulates environmental volunteering actions nationwide. Moreover, we would like to address special thanks to all the volunteers who took part in the monitoring activities; they have been the keystones of this successful monitoring!

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CURRENT STATUS AND DISTRIBUTION OF THREATENED LEATHERBACK TURTLES AND THEIR NESTING BEACHES IN THE NICOBAR GROUP OF ISLANDS

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INTRODUCTION

Nesting of leatherback turtles was first observed in the Andaman and Nicobar Islands by Satish Bhaskar while conducting surveys for the Madras Crocodile Bank Trust in 1979 (Bhaskar, 1979a, 1979b), with his first sighting on West Bay beach of Little Andaman Island on 31st December of that year (Bhaskar, 1979c). Since Bhaskar's reports, additional surveys and reports have confirmed that the beaches of the Andaman and Nicobar Islands are an important nesting ground for leatherback turtles in India (Andrews *et al*., 2001; Andrews *et al*., 2006a; Andrews *et al*., 2006b; Namboothri *et al*., 2011; Swaminathan *et al*., 2011; Swaminathan *et al*., 2016). There are earlier records of sporadic leatherback nesting from the Indian mainland (Kar & Bhaskar, 1982); however, the current nesting populations are restricted to the Andaman and Nicobar Islands.

Many nesting sites for sea turtles in the Andaman and Nicobar Islands were severely affected by the December 2004 Indian Ocean earthquake and the subsequent tsunami. The coastline and the shore topography were severely altered in many of these islands, with the Nicobar group of islands undergoing submergence (Ramachandran *et al*., 2005), while coastal plates in some of the Andaman Islands were uplifted (CORDIO/IUCN, 2005; Kulkarni, 2005). In 2008, a long-term monitoring programme was initiated at Little Andaman Island to monitor the post-tsunami recovery of nesting leatherback turtles. The observations made at South and West Bay of Little Andaman suggested that leatherback nesting had recovered substantially after the 2004 tsunami, and the population appeared stable with some fluctuations (Swaminathan *et al*., 2011; Swaminathan *et al*., 2016).

Poor infrastructure and challenging logistics have limited sea turtle monitoring and conservation efforts in the Nicobars since the 2004 tsunami. Barring a few reports and surveys that indicated some beaches have re-formed, there is little information on the recovery of these nesting beaches and populations (Namboothri *et al*., 2011; IOSEA, 2012; Jadeja *et al*., 2015). Here, we report on our rapid surveys of nesting beaches throughout the Nicobar group that are being used by the four sea turtles found in this region (leatherback, green, olive ridley and hawksbill turtles), with a primary focus on leatherback turtle nesting on Great and Little Nicobar Islands.

METHODS

Between 2nd March and 18th April 2016, the first three authors visited the entire Nicobar group of islands (Figure 1), to understand the recovery of previously described nesting beaches, identify new nesting beaches, and document nesting intensities on all visited beaches.

Local fishing boats were used to survey the coastline of islands, and the team carried out surveys by foot during daylight hours when a sandy beach was encountered. Upon encountering turtle tracks, the species was identified established based on track characteristics (Pritchard & Mortimer, 1999). While it is possible to misidentify olive ridley and hawksbill tracks, we classified each track to species using basic information such as the known seasonality of the different species and characteristics of the nesting habitat (Pritchard & Mortimer, 1999; Shenoy *et al*., 2011). Olive ridley turtles are known to nest from November to April and prefer wide-open beaches, similar to leatherback turtles; while hawksbill turtles are known to nest from July to December and prefer beaches with offshore reefs and typically nest near or in vegetation (Pritchard & Mortimer, 1999; Andrews *et al*., 2006a; Shenoy *et al*., 2011). After a thorough visual inspection of every nest mound, depth of body pits, abandoned body pits and nest chambers, we categorised each crawl as

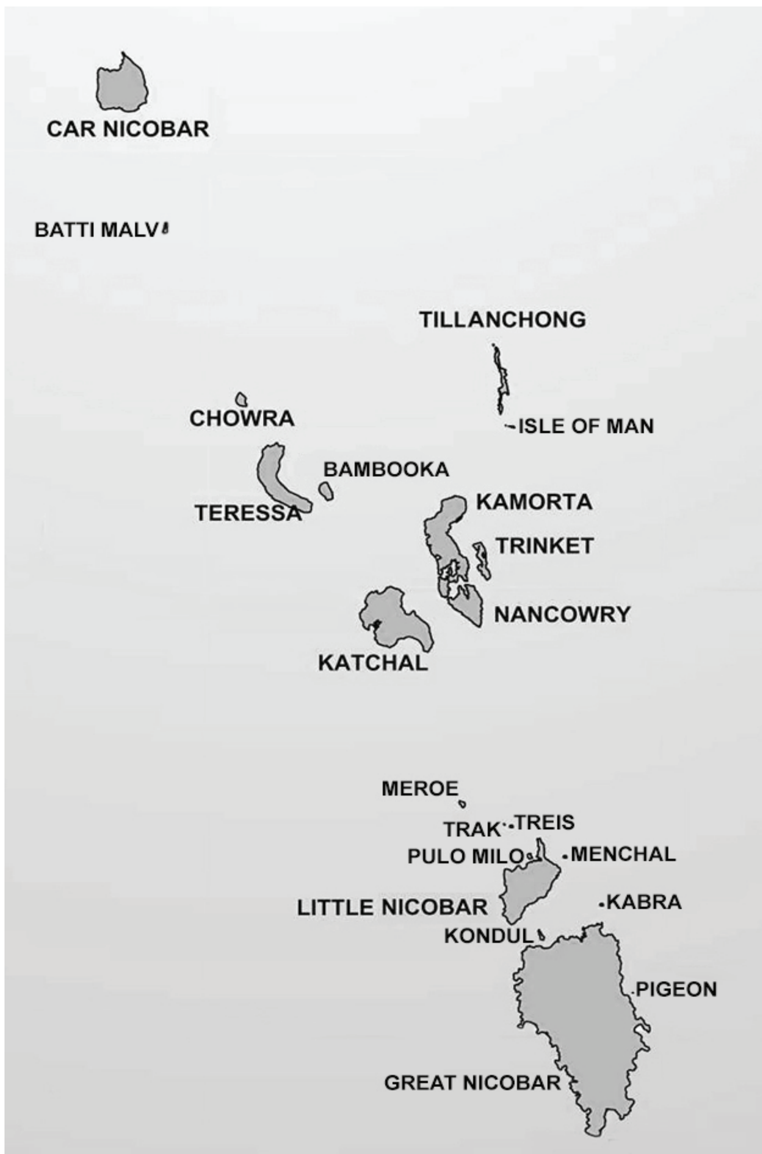

Figure 1. Nicobar Islands.

either a nest or a false crawl (Shenoy *et al*., 2011; Dodd, 2016). The location of each nest was recorded using a GPS.

All nests were examined for evidence of predation based on tracks and other signs. Wherever possible, the identity of the predator was established based on tracks. The surveys were non-invasive and did not involve any direct handling of the turtles, eggs or hatchlings. The surveys were conducted during the day and there were no instances of nesting directly observed. This was done due to logistical feasibility for conducting a survey over a large area and non-availability of necessary permits for the direct handling of nests and eggs.

RESULTS

Of the 21 islands in the Nicobar group, three islands (Pigeon, Kabra and Isle of Man) did not have any sandy beaches and three islands (Trak, Meroe and Batti Malv) were not accessible due to unfavorable sea conditions. We surveyed the remaining fifteen islands of the Nicobar group for sea turtle nesting activity. We recorded 2140 nests and 21 false crawls were recorded on 12 islands. The highest number of nests for all the four species were recorded on the Great Nicobar Island followed by the Little Nicobar Island.

Leatherback turtles

A total of 1,068 leatherback nests were found on five of the fifteen islands surveyed (Table 2). The islands of Great Nicobar and Little Nicobar together comprised 94% of the total nests found in the Nicobar region. No nests were found on Teressa and Tillanchong Islands where leatherback nesting had been reported in the past (Andrews *et al*., 2006a; Chandi, pers. comm.). Earlier studies in the region indicated that leatherback turtles nest 4.9 times a year on average (Bhaskar, 1993; Andrews *et al*., 2001). Based on this, the estimated number of leatherback turtles nesting in this region during the 2015-2016 nesting season would be approximately 200 individuals.

Other sea turtles

Green turtles were found to be the most widespread species nesting in this region. The study identified 519 nests on 12 of the 15 islands surveyed (Table 1), including on Chowra, where green turtle nests had not been previously documented (Chandi, pers. comm.).

Hawksbill tracks were only found on Great Nicobar Island, though the species has previously been reported to nest on beaches of Tillanchong, Teressa, Trinket, Katchal, Meroe, Treis, Trak, Kabra, Pulo Milo, Little Nicobar and Menchal Islands (Andrews *et al*., 2001).

Four hundred and eighty two olive ridley nests were observed on Great Nicobar, Little Nicobar, Trinket, Teressa, Katchal and Car Nicobar Islands. Almost 97% of the nests observed were found on Great Nicobar Island.

DISCUSSION

Seasonality

The surveys were designed to be conducted towards the end of the peak nesting season of leatherbacks and olive ridleys. The leatherback nesting season in the Nicobar Islands is October through March, with a peak in December/January (Andrews *et al*., 2006a). Olive ridley nesting runs from November through April, with a peak in January (Andrews *et al*., 2006a). The reported

Table 1. Sea turtle nesting data for the Nicobar Islands.

	Sea Turtle Species				
Island	Leatherback	Green	Olive Ridley	Hawksbill	Total
Great Nicobar	775 (1)	322 (4)	472 (6)	71	1640 (11)
Little Nicobar	229	4	6	0	239
Katchal	57	40	1	0	98
Car Nicobar	0	72 (4)	1	0	73 (4)
Teressa	0	42 (2)	1	0	43 (2)
Trinket	0	19 (1)	1	0	20 (1)
Kamorta	6	2	0	0	8
Chowra	0	6 (1)	0	0	6 (1)
Tillanchong	0	5	0	0	5
Nancowry	1	4	0	0	5
Treis	0	2	0	0	2
Bambooka	0	1 (2)	0	0	1 (2)
Menchal	0	0	0	0	0
Pulo Milo	0	0	0	0	0
Kondul	0	0	0	0	0
Grand Total	1068 (1)	519 (14)	482 (6)	71	2140 (21)

( ) represents false crawls

Table 2. Leatherback turtle nest and predation data for the Nicobar Islands.

Location	No. of Nests	No. of Nests Predated (%)
Great Nicobar Island	775	673 (86.8%)
East of Indira Point	2	2
Koshindon	2	0
Laxmi Nagar	1	0
North of Alexandria	46	42
South of Alexandria	20	15
North of Dagmar	123	113
South of Dagmar	43	33
Pulo Bed	16	10
Pulo Kunji	57	45
Re Pinsuöt	7	2
Renhong	17	9
Safed Balu	3	2
Patatiyö	6	0
Galathea	410	388
South of Galathea to Rock	2	0
West of Indira Point	20	12
Kamorta Island	6	1 (16.6%)
Pilpilo	6	1
Katchal Island	57	7 (12.2%)
South	21	7
West	36	0
Little Nicobar Island	229	53 (23.1%)
Bahua	40	0
Kiyang	99	43
Muhincohn	88	10
Thavithö	2	0
Nancowry Island	1	0 (0%)
Katholö	1	0
Grand Total	1068	734 (68.7%)

nesting season for green turtles for this region is May to September, peaking in June and July (Namboothri *et al*., 2012). The nesting season for hawksbill sea turtles commences in July and end by early December (Andrews *et al*., 2006a). Nests of both green and hawksbill turtles were documented during our survey period, suggesting that they may nest year round in this region, as green turtles do in nearby Thailand (Yasuda *et al*., 2008) and on Tromelin Island in the western Indian Ocean (Derville *et al*., 2015). Nevertheless, as our surveys were limited to a seven week stretch in the early part of the year, it is likely that we did not fully characterise nesting effort of green and hawksbill turtles in the region.

Nesting beaches and nesting

Prior to the 2004 tsunami, the islands of Great and Little Nicobar were important nesting sites for leatherback turtles (Andrews *et al*., 2006a). Harbouring 87% of all turtle nesting in the region, the beaches of Great and Little Nicobar Islands continue to be crucial nesting sites in the region for all four sea turtle species. The most important nesting sites include Galathea, Alexandria and Dagmar Bay on Great Nicobar Island and Pulo Kiyang and Bahua (previously referred to as Dahayu/Dahvu by Bhaskar (1994) and Andrews *et al*. (2006a)) on Little Nicobar Island. The current surveys revealed that most of the beaches in this region have formed again and leatherbacks

Table 3. Records of leatherback nests laid per year in Great and Little Nicobar Islands.

	Survey Period (Source)												
	Apr 1979 (Namboothri et al., 2012)	Feb 1981 (Namboothri et al., 2012)	Nov 1991-Mar 1992 (Namboothri et al., 2012)	Mar 1993-Apr 1994 (Namboothri et al., 2012)	Dec 1995-Feb 1996 (Andrews et al., 2006a)	Dec 1997-Feb 1998 (Andrews et al., 2006a)	Nov 2000-Apr 2001 (Andrews et al., 2006a)	Oct 2001-Apr 2002 (Andrews et al., 2006a)	Nov 2003-Apr 2004 (Andrews et al., 2006b)	Nov 2004 (Andrews et al., 2006b)	Feb 2011 (Namboothri et al., 2011)	Feb 2015 (Jadeja et al., 2015)*	Mar 2015-Apr 2016 (current study)
Great Nicobar Island													
Galathea	-	-	158	237	282	124	524	425	575	84	146	7*	410
Alexandria	80	55	343	-	-	-	866	-	-	-	-	-	66
Dagmar	80	8	171	-	-	-	362	-	-	-	-	-	166
Little Nicobar Island													
Pulo Kiyang	-	-	-	115	-	-	-	-	-	-	-	-	99
Bahua	-	-	-	50	-	-	-	-	-	-	-	-	40

*Jadeja *et al*. (2015) only reported 7 nests in Galathea, Great Nicobar Island. This was probably as a result of non-detection of older nests and nesting evidences. Namboothri *et al*. observed 146 nests in 2011 and Swaminathan and Chandi conducted a survey in 2012, which was abandoned as a result of an earthquake and subsequent tidal wave, observed more than 2 nests every meter.

continue to nest in high numbers (Table 3). The numbers for Alexandria and Dagmar from 2016 indicate a decline in comparison to the data from the 1978 to 2001.

However, regions which were severely damaged by the 2004 tsunami still have dead trees and tree debris along the coast, particularly on Great Nicobar Island, which is likely obstructing sea turtles from accessing the nesting beach and also reducing the nesting area. Several previously known nesting beaches were either partially or fully inundated during high tide, forming creeks along the coast.

Predation

Of the 2,140 nests that were recorded in the Nicobar region, 57% (1,223 nests) were predated by either feral dogs, water monitor lizards or in some cases feral pigs. While monitor lizards are natural predators of leatherback nests and occur on many beaches, predation by feral dogs and pigs that once belonged to the Nicobari settlements that existed prior to the 2004 tsunami was found to be particularly high on the Great Nicobar Island. Namboothri *et al*. (2011) also observed that approximately 70% of the nests on Galathea were predated by feral pigs during the 2011 survey.

RECOMMENDATIONS

The ongoing leatherback monitoring programme in Little Andaman has revealed a stable increase in the nesting population, with over hundreds of nests laid every season, and also reformation of the nesting beaches (Swaminathan *et al*., 2016). The satellite telemetry study of ten leatherback turtles nesting in Little Andaman has indicated two corridors for migration, one on the southeastern corridor towards Papua New Guinea and Australia, and one along the southwestern corridor towards Madagascar and east coast of Africa (Namboothri *et al*., 2012; Swaminathan *et al*., 2016). A long-term monitoring programme should be re-established at Galathea Bay to monitor the nesting beach and to understand long-term trends in nesting and reproductive efforts. Further studies on remigration intervals through tagging, genetic studies on population structures, and satellite telemetry studies to understand migration patterns of leatherback turtles nesting are required in this region. Accessibility of the nesting sites remains an issue, but the roads are in the process of being re-laid and should reach the nesting beach in the coming years. Several rapid and intensive surveys need to be carried out on prime nesting beaches where regular monitoring efforts are logistically impossible. In regions where predation from feral dogs and pigs are high, the feral animals need to be either controlled or culled to reduce the pressure.

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CELEBRATING A MARINE TURTLE SANCTUARY IN MADAGASCAR

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The north-west coast of Madagascar is a hotspot for marine turtles (Humber *et al*., 2016). The tiny archipelago of Nosy Iranja lies 40km south of Nosy Be (Figure 1), the largest island on the Malagasy coast. It is composed of two islets (Iranja Be and Iranja Kely) linked by a sand bank covered by water at high tide. Although both islands are only around half a square kilometre in area, their beaches host one of the most studied nesting sites in the country. Marine turtle nesting has been studied in Madagascar since the year 2000 (Bourjea *et al*., 2006), when WWF Madagascar hired someone to monitor nesting activities and initiated baseline studies at the same time that the first hotel was built on the smaller islet, Iranja Kely. This was a turning point for marine turtles on Nosy Iranja.

Since 2004, with the support of Kelonia, the sea turtle observatory of Reunion island, multiple scientific projects have been conducted and sea turtle reproduction has been monitored on Iranja Kely. Tourism has developed on the island despite the political crisis and the indeterminate closure of the largest resort in 2013. Meanwhile, other hotels have been constructed on Iranja Be and the growing number of visitors have generated incomes for the local communities. The marine turtle poaching that used to be common is rarely reported on these islands nowadays. Recently, two locally managed marine protected areas (MPAs) were created with the support of the Wildlife Conservation Society (WCS): "Ankivonjy", that includes the Nosy Iranja islets, and "Ankarea" that encompasses the Mitsio archipelago in the north. Both MPAs were officially recognized by the Malagasy government in 2015.

To increase awareness about the importance of these protected areas for marine turtles, the first Marine Turtle Festival took place on the archipelago at the end of May 2016. It was organized by the Wildlife Conservation Society in partnership with Kelonia and was predominantly funded by Prince Albert II of Monaco Foundation. The festival lasted 3 days and the target audiences were local communities, regional authorities, and tourists. But the event's messages also reached the larger community thanks to regional and national media coverage. Activities such as sports and traditional song and dance contests, concerts, and public dancing helped to attract people. They were complemented by seminars given by representatives from Kelonia and the University of Marine Studies of Toliara, a photographic exhibition, and documentary screenings. Attendees also had the opportunity to observe a green turtle nest emergence. This, more than many speeches,

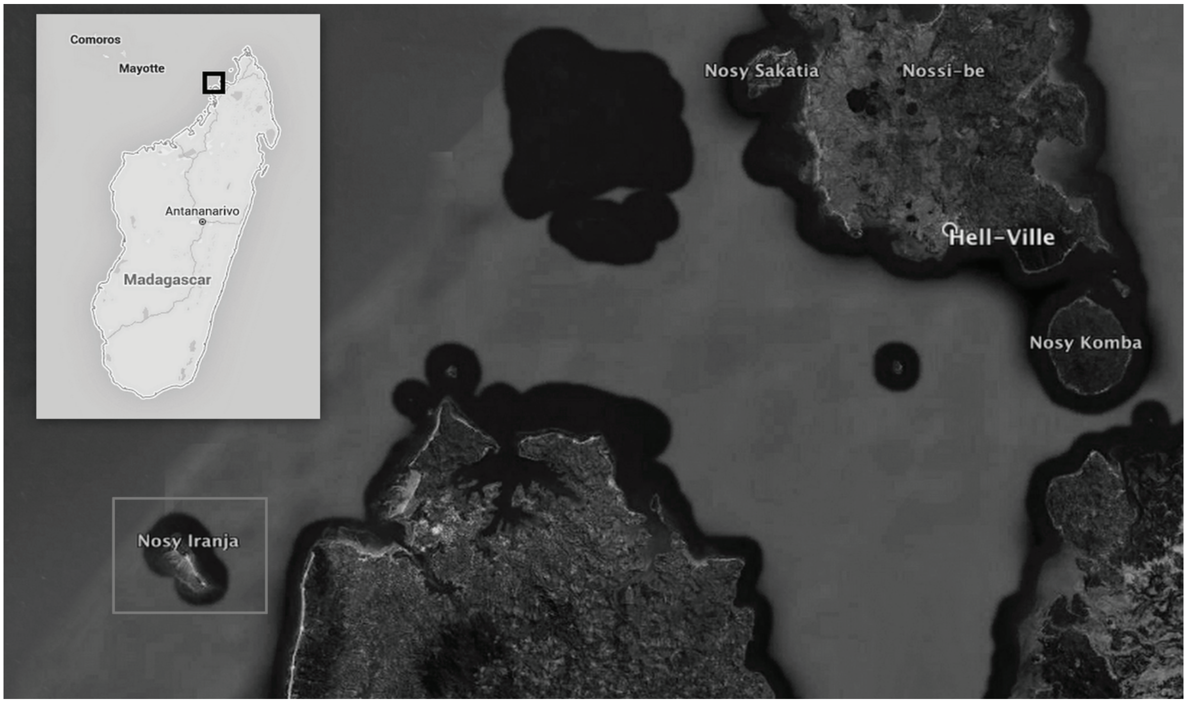

Figure 1. Nosy Iranja and Nossi-be. (Source Google maps).

was the greatest experience for some visitors; the regional director of tourism was delighted and clearly saw the potential for eco-tourism linked to marine turtle conservation.

On the last day of the festival, an anonymous quiz was organised to test the communities' knowledge on marine turtles and determine what topics should be a priority for future awareness activities. Understanding of the threats to marine turtle populations was identified as lacking. Knowledge being the first step towards behaviour change, it is important for conservation that people are aware that human activities have a much greater impact than natural predators.

On the last evening, "Vezo" guests, an ethnic group of fishers coming from the south of the country, shared their experiences with their hosts. In their home region, despite the implementation of a marine protected area since 2008, turtle nesting events are extremely rare, and nests are still systematically harvested. After spending 3 days celebrating sea turtles on Nosy Iranja, they realized the importance of marine turtles for their potential as a touristic attraction but also culturally. Many Vezo traditions and stories are linked to sea turtles, as they were for dugong but the stories disappeared along with this animal's extinction in the region.

Despite slightly increasing marine turtle nesting activity (Bourjea *et al*., 2006), protecting Nosy Iranja remains an ongoing objective. In fact, some people of the community say that if money stops coming in, people will have no other choice but to harvest turtles again to provide their sustenance. This festival should improve the regional recognition and further develop marine turtle eco-tourism in this part of Madagascar. Efforts need to be maintained to raise protection and awareness of this emblematic animal and its environment.

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RESEARCH SUMMARY

GLOBAL PRIORITIES FOR SEA TURTLE MANAGEMENT AND CONSERVATION

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Interest in, and research on, sea turtles has greatly increased over the past few decades, as evidenced by the growing body of literature on sea turtle biology and conservation and hundreds, and sometimes thousands, of participants in the annual sea turtle symposium held by the International Sea Turtle Society (http://www.internationalseaturtlesociety.org). To inform sea turtle research, conservation and/or management efforts, Hamann *et al*. (2010) solicited the opinions of 35 multinational, multidisciplinary researchers and compiled a list of 20 priority research metaquestions within 5 categories (reproductive biology, biogeography, population ecology, threats, and conservation strategies). As a follow-up exercise to assess if relevant peer-reviewed research published since Hamann *et al*. (2010) had contributed to answering these key questions, Rees *et al*. (2016) followed the expert-opinion approach and involved 42 researchers in a systematic review of literature using Web of Science.

The papers considered by Rees *et al*. (2016) demonstrated both species (green turtles- 41% of articles; loggerhead turtles- 34%; hawksbill and leatherback turtles- 15% each; olive ridley turtles- 11%; Kemp's ridley turtles- 6%; flatback turtles- 5%) and geographic (North Atlantic populations- 32% of articles; North Pacific populations- 20%; South Atlantic populations- 13%; Indian Ocean populations- 12%; Mediterranean populations- 10%; South Pacific populations- 10%) biases. These likely reflect the more restricted ranges of some species(Kemp's ridley and flatback turtles) and availability of resources to countries bordering well-researched ocean regions. Rees *et al*. (2016) acknowledge that these biases may have been less if the assessment included literature outside of Web of Science (e.g. non-peer-reviewed papers and/or non-English literature sources); however, the relatively low proportion of studies on sea turtles in the Indian Ocean and South East Asia waters indicate a need for greater research activity- or greater sharing of the outcome of prior and current projects- in the region. Rees *et al*. (2016) identified progress, although it was not uniform, towards answering all 20 of the priority questions described by Hamann et al. (2010). Three main areas were identified as being under-researched when compared with others:

Reproductive biology

What are the factors that underpin nest site selection and behaviour of nesting turtles?

What are the primary sex ratios being produced and how do these vary within or among populations and species?

What factors are important for sustained hatchling production?

Threats

What will be the impacts from climate change on sea turtles and how can these be mitigated?

What are the major sources of fisheries bycatch and how can these be mitigated in ways that are ecologically, economically and socially practicable?

How can we evaluate the effects of anthropogenic factors on sea turtle habitats?

What are the impacts of pollution on sea turtles and their habitats?

What are the etiology and epidemiology of fibropapillomatosis (FP), and how can this disease be managed?

Conservation strategies

How can we effectively determine the conservation status of sea turtle populations?

What are the most viable cultural, legal and socioeconomic frameworks for sea turtle conservation?

Which conservation strategies are working (have worked) and which have failed?

Under what conditions (ecological, environmental, social and political) can consumptive use of sea turtles be sustained?

Researchers and NGO's in the Indian Ocean and South East Asia (and elsewhere) can use the progress described by Rees *et al*. (2016) towards addressing the 20 metaquestions developed by Hamann *et al*. (2010) and the relative lack of published literature for the region to their advantage. Using these references to highlight the need for local research, conservation, and management activities may help demonstrate the importance of initiatives to policy makers and enhance the success of funding applications.

As an outcome of the assessment, Rees *et al*. (2016) also identified the bias of sea turtle research towards prioritizing biological questions and the need for greater engagement with social science researchers. There are challenges to interdisciplinary conservation research, especially for social scientists (e.g. Campbell, 2003, 2005), but obvious gains in understanding the human dimensions of sea turtle conservation, including motivations and incentives for individuals and communities to engage with conservation initiatives.

Finally, Rees *et al*. (2016) echoed the suggestion of Hamann *et al*. (2010) that stakeholders from across different professions and/or sectors and geographic regions contribute to a future assessment of priority research questions and conservation actions for sea turtles. Similarly to the biological areas identified as requiring further research, many of the recommendations of Rees *et al* (2016) can be used to leverage funding or action for sea turtle research and conservation in the Indian Ocean and South East Asia

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Instituto Nacional de Reforma Agraria (INRA). 2008.

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