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Using community members to assess artisanal fisheries: the marine turtle fishery in Madagascar

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Abstract

Fisheries are considered a major driver of population declines for many marine vertebrate species, and yet for some, data on the levels of direct catch are lacking, often due to the logistical challenges in assessing artisanal fisheries in remote and developing regions. Using community members to collect data can provide access to a greater wealth of information than that obtained by local or foreign researchers, often at a reduced financial cost. We monitored the harvest of marine turtles at 12 major villages in Madagascar using community members as data collectors (*sous collecteurs*) from each village, at a total cost of <US$3000 for 1 year. Community members were trained to collect biological and fisheries data on turtles landed and to use digital cameras to provide a visual record of each turtle catch recorded. A total of 699 marine turtle landings were documented, including four species, with by far the majority being green turtles *Chelonia mydas* (93.6%). When we contextualize our data with those of previous studies elsewhere in the region, we conservatively estimate that the annual turtle catch in the south-western province of Madagascar is between 10 000 and 16 000. Although turtle hunting is illegal under national law, there are currently no government initiatives to manage the fishery. This study is the first direct assessment of the level of exploitation of turtles in Madagascar, made possible through the use of community members as data collectors and has broad applicability towards similar data-gathering efforts in other artisanal fisheries.

Introduction

Assessing the impact of small-scale or artisanal fisheries can be logistically challenging, especially at remote locations, in developing countries (Salas *et al*., 2007; Soykan *et al*., 2009). While recent studies attempt to quantify the marine turtle bycatch in industrial fisheries, they highlight the lack of available data from small-scale and artisanal fisheries (Lewison & Crowder, 2007; Gilman *et al*., 2010; Wallace *et al*., 2010). Bycatch has been assessed in artisanal fisheries through direct observations (Alfaro-Shigueto *et al*., 2008; Mangel *et al*., 2010) or interview data (D'agrosa, Lennert-Cody & Vidal, 2000; McCluskey & Lewison, 2008; Peckham *et al*., 2008) but can fail to produce quantitative estimations (Moore *et al*., 2010). Direct harvest of marine turtles from artisanal fisheries is rarely quantified and studies often rely on carapace counts (Koch *et al*., 2006; Metcalf *et al*., 2007) or fisher interview data (Rakotonirina & Cooke, 1994; Nichols, 2003).

The remote Toliara region of south-west Madagascar contains some of the most extensive and biodiverse coral habitats in the Indian Ocean, and supports Madagascar's largest traditional fishery (Laroche & Ramananarivo, 1995; Laroche *et al*., 1997). Artisanal fishing is the primary income source for the indigenous Vezo coastal communities, but a recent dramatic increase in fishing intensity has led to direct reef damage and concerns of unsustainable biomass removal (Laroche *et al*., 1997; Gabrié *et al*., 2000). In the Toliara region, the fishing population has increased by at least a factor of five over a period of 17 years and is still growing through migration of inland populations to coastal regions (Cooke, Lutjeharms & Vasseur, 2003).

As a result of numerous threats, all species of marine turtle have experienced population declines and are included on the IUCN Red List of threatened species (IUCN, 2010). In Madagascar, all species of marine turtle are protected from domestic exploitation (Presidential Decree 2006–400); however, fishers continue to actively harvest and consume all five species of marine turtle found in these waters (Ratsimbazafy, 2003; Epps, 2006). The laws are not enforced due to several factors, including a lack of capacity for implementation, a reluctance to manage a fishery with strong cultural links and the immensity of the Malagasy coastline (Rakotonirina & Cooke, 1994; Okemwa, Muthiga & Mueni, 2005).

The majority of turtles landed are caught through targeted fishing, using nets, spearguns or a specialized harpoon, '*Teza*' or '*Nato*' (Astuti, 1995; Ratsimbazafy, 2003; Gough *et al*., 2009). Turtle hunting is considered an important cultural Vezo activity and has several associated ancestral rituals (Astuti, 1995; Ratsimbazafy, 2003). Traditionally, turtle fishers had several restrictions that they had to observe, in particular in relation to the preparation of the meat. While some fishers still observe the traditions or parts of them, there has been a relaxation of these cultural practices, especially where new capture methods have been used (Hughes, 1970; Astuti, 1995; Lilette, 2006; Pascal, 2008).

There is a paucity of thorough assessments of the directed fishery of turtles in Madagascar. From interviews and observations, Hughes (1971) estimated that the annual turtle catch from south-west Madagascar was >13 000, and Frazier (1980) extrapolated these data to produce an annual catch of 13 856 for the whole of Madagascar. More recent studies using interviews estimate the annual marine turtle catch in Madagascar to be 11 000–12 000 (Rakotonirina & Cooke, 1994; Walker, Roberts & Fanning, 2004; Walker & Roberts, 2005).

The lack of reliable, up-to-date data on the current status of turtle populations throughout Madagascar has been noted as a barrier to the creation of viable management plans for conservation (Shanker & Pilcher, 2003; Shanker, 2004; Kimakwa *et al*., 2008). In October 2006, a marine turtle research and conservation programme in the Andavadoaka region of Madagascar was initiated using community members to record marine turtle catch to ascertain landing rates, record information on fishing methods and gauge whether community members can act as reliable data collectors. In this paper, we report on a year of data collected on the current status and local perceptions of the traditional turtle fishery, its context within previous regional assessments, and offer management recommendations for the future.

Methods

Study area

The study was conducted in the region surrounding the village of Andavadoaka (22°04′19.94″S, 43°14′20.00″E) in south-west Madagascar, *c*. 150km north of Toliara, the regional capital. The area is characterized by two distinct fringing and barrier reef systems separated by a 5-km-wide passage or channel in which several patch reefs are situated. The coastal villages are almost entirely composed of Vezo fishers. All fishing is carried out using pirogues (small sailing canoes) or walking with nets, lines or spears, limiting most fishing effort to the nearby reef systems, with fishing at deeper, offshore sites only possible under favourable sea conditions.

The monitoring programme

To develop a profile of the turtle fishery in the region, a monitoring programme was established in October 2006 that employed local community members as data collectors, known as '*sous-collecteurs*', in each of the villages in the study. Village presidents, elders or their wives were normally chosen as their approval was needed to run this study in their village, and they were normally in the best position to enable the monitoring programme to be accepted by the village residents. One community member was employed per village (nine men and four women), apart from Bevato, where two were employed because of the village's geographical spread.

Initially, 14 villages along the coastline were chosen for the study, spanning *c*. 60 km of coastline from Antsepoke in the south (22°15′50.14″S, 43°13′34.80″E) to Morombe in the north (21°44′44.28″S, 43°21′43.23″E; Fig. 1). No villages refused to participate in this study, although two villages were removed from the study after a few months due to the difficulty in locating suitable community members to collect data (Nosy Mitata and Nosy Ve). The 12 final study villages were chosen to encompass the majority of fishers and the population in general (54% of villages and an estimated 87% of regional population and >70% of fishers).

Community members were paid a base monthly salary of 15 000 Malagasy Ariary (MGA) (≈US$8) and an additional 300 MGA (≈US$0.16) for each landed turtle they recorded. The average daily wage in the region is <US$2 and this payment acted to supplement their normal income. The 300 MGA was intended to be given to the fisher as a gift for allowing their turtle to be measured. It was agreed during initial talks with fishers that this was a fair price and that the price per catch was high enough to encourage people to visit the community members but low enough so as not to encourage additional turtle fishing. In larger villages and towns, where there is a greater demand for turtle meat, turtle merchants now exist who will buy turtles from fishers for ≈ 50 000–140 000 MGA (≈US$24–66), depending on the turtle's size, to sell in the local market (Pascal, 2003; Walker *et al*., 2004; Lilette, 2007).

Data collection

Each community member data collector was trained by the Project Coordinator and Malagasy assistant to record biological data, fisher demographics and catch-specific information for each turtle in the initial training session (≈ 1 h) in their village. They were also trained to use a digital camera to record catch in order to check the reliability of the data and reduce the possibility of falsified data. For each turtle landed, biological data: species, curved carapace length (CCL) and sex (if possible), and fisheries data: method of capture and name of fisher(s), were recorded.

Community members were given notebooks, containing identification charts and diagrams of measurements and tape measures. Vezo fishers are familiar with each of the five marine turtle species that occur in the region and each has their own name in the regional dialect of Malagasy (Table 2).

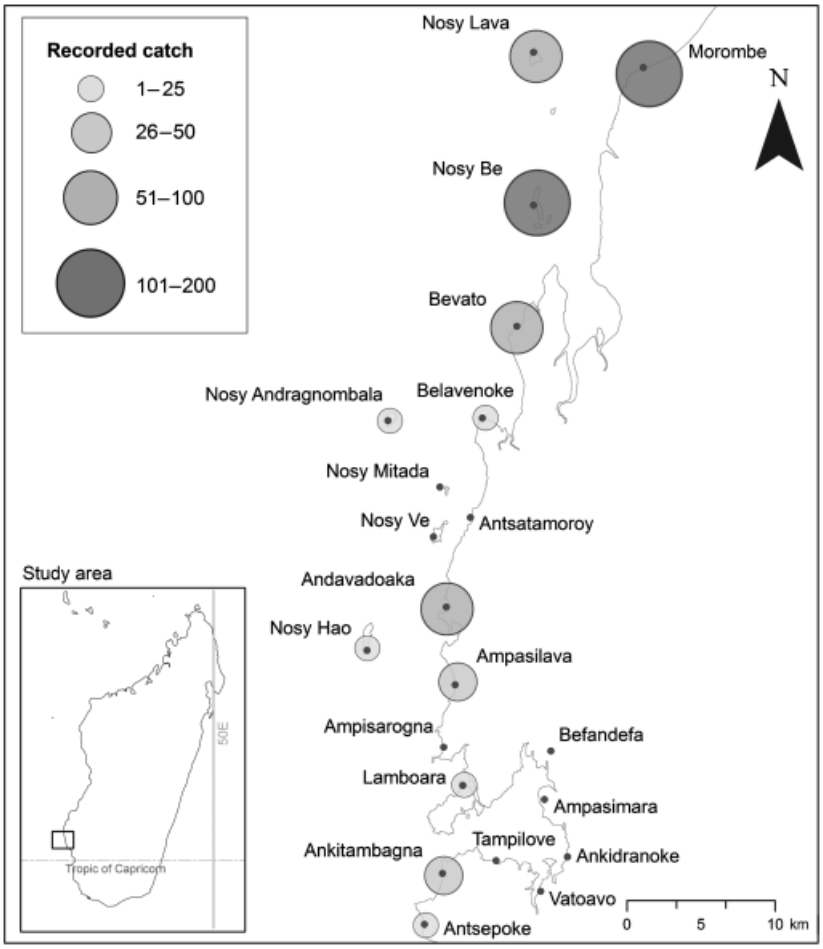

Figure 1 Map showing the location of the 12 villages included in this study and the number of landed turtles recorded. The inset shows the location in Madagascar.

Community members were visited every 2 months by the Project Coordinator and Assistant in order to retrieve the data and review data collection methods. Further training with the camera was given if photos were not of high enough quality. The Project Coordinator was responsible for collating and verifying all data collected. Any unreadable data were removed. Data were entered into an excel spreadsheet and cross referenced with the original data sheet. Photographs were checked for species ID with the data in the spreadsheet for each community member. The camera's memory cards were cleared after each data collection visit to ensure that accidental replication of photos could not occur.

In order to conduct an overview of the turtle fishery from the villagers' perspectives, semi-structured interviews, lasting approximately 1 h, were carried out with the community member data collectors in each village between October and December 2007. The interview consisted of 14 questions aimed at providing background information regarding the context of the fishery in the region and report changes in turtle size or number caught. Interviews were conducted in Malagasy by the Project Coordinator and Assistant. The nature and sensitivity of this study meant that we did not record interviews and opted for a qualitative approach, avoiding detailed interviewing of large numbers of fishers in case it would interfere with general catch reporting.

Results

Four villages were unable to record landed turtles in every month for varying reasons. The community member data collector from Belavenoke migrated after 3 months and a suitable replacement was not found. The first 7 months of data from Nosy Hao were not considered reliable after inconsistencies were spotted between the data book and the digital camera records. A new data collector was then hired. The monitoring programmes in Morombe and Nosy Lava were not initiated until February and March 2007, respectively, due to the distance between these villages and the research centre at Andavadoaka. Table 1 shows the list of villages included in this study, their population size and the number of months they recorded turtle catch between 1 January 2007 and 31 December 2007.

The total cost of this monitoring effort was $<$US$3000, which includes the cost of community member payments, equipment, a Malagasy research assistant and travel between villages. A total of 699 landed turtles were recorded in the 12 villages in this study (Fig. 1, Table 1). The potential

number of turtles landed in the region accounting for missing months of data is estimated conservatively as 817 (Table 1). For those villages that did not record a full 12 months of landings, absolute numbers of recorded turtles were extrapolated to estimate 12 months of landings using the mean of the recorded monthly data. These figures are likely to be the minimum turtle landings for each village as all community members noted that they were not able to record every landed turtle. Because of problems with understanding the concept of percentages, community members were unable to estimate the proportion of landed turtles that were missed in order to allow us to correct annual catches for each village.

The majority of turtles recorded were green turtles *Chelonia mydas* (93.6%; Table 2), while the second most commonly recorded species, the hawksbill turtle, *Eretmochelys imbricata* only accounted for 3.4% of the recorded landings. From a subset of captures, species proportions discernable from photo data ($n = 269$) correlated well with other records (Table 2). No landings of leatherback turtles, *Dermochelys coriacea*, were recorded during this study.

Interviews with the data collectors reported that bycatch of turtles in nets laid out for pelagic species, such as sharks, was almost negligible in the traditional fishery, and six reported that there were no occupational turtle fishers in their village. However, the results showed that some fishers were likely to be targeting turtles. Of a total of 132 fishers who were linked with reported captures, nine fishers accounted for 20.6% ($n = 144$) of the turtles recorded in the study. The town of Morombe recorded 25% of turtle landings in this study and has the largest human population ($\approx$12 000). The trend to use nets to catch turtles extends throughout the study villages, and in total, 68% of turtles recorded were caught using the *jarifa* net (12–25 cm mesh gill net); 17% used a spear or harpoon, of which 0.7% used the traditional turtle spear. The *ZDZD* (8–10 cm mesh gill net) was recorded in 5% of landings. The remaining 9.1% of landings recorded less specific methods or materials and 0.4% of landings had no method recorded. Further data gathered on fishing sites are not presented here but will be utilized in regional management plans.

The number of turtles recorded per month remained fairly consistent over the year (Fig. 2), barring a marked peak in November 2007. Interviews with community members revealed that the austral summer, November to February, is cited as the best season to catch turtles but is also the period most susceptible to bad weather, which can reduce fishing intensity.

The size class distribution of the green turtles ($n = 644$) landed is shown in Fig. 3. CCL ranged from 21 to 120 cm, with 96–100 cm being the dominant size class. There was no significant difference in the mean CCL of green turtles by month (one-way ANOVA, $F_{11,643} = 1.47$, $P > 0.05$). Previous studies have recorded a minimum size of nesting females of 85 cm (CCL) in Madagascar (Metcalf *et al.*, 2007; Alisson, 2008); thus, as much as 36% ($n = 233$) of green turtles recorded in our study could have been mature

Table 1 The 12 villages included in the monitoring programme, their population size and the number of months in 2007 during which landed turtles were recorded

Village	Human population	No. of months monitoring	No. of turtles recorded	Estimated annual landings
Morombe	12 000[a]	11	179	195
Nosy Lava	350[a]	10	56	67
Nosy Be	523	12	168	168
Bevato	472	12	91	91
Belavenoke	429	3	23	92
Andranombala	109	12	22	22
Andavadoaka	1220	12	59	59
Nosy Hao	259	5	16	38
Ampasilava	321	12	27	27
Lamboara	506	12	13	13
Ankitambagna	86	12	34	34
Antsepoke	270[a]	12	11	11
Total			699	817

The estimated number of turtles landed shows the total if villages had recorded for 12 months. Human population data were from 2006 and 2008 (Epps, 2006; Andriamalala, 2008).
[a]Estimation by Blue Ventures; no official survey conducted.

Table 2 Breakdown of species of marine turtle landings recorded (1 January–31 December 2007) with the mean curved carapace length (CCL) and capture method for each species, including loggerhead *Caretta caretta* and olive ridley *Lepidochelys olivacea*.

Species of turtle (Malagasy name)	No. recorded (% overall)	No. recorded in subset of 269 photos (%)	CCL (cm)		No. caught by *jarifa* net (%)	No. caught by spear or harpoon (%)	No. caught by ZDZD (%)	No. caught by other/unidentified methods (%)
			Mean ± SD	Range				
Loggerhead (Fano apombo)	11 (1.6)	3 (1.1)	74.4 ± 20.2	40–98	9 (81.8)	0 (0)	2 (18.2)	0 (0)
Green (Fano zaty)	654 (93.6)	169 (62.8)	74.4 ± 22.1	21–120	451 (69.1)	110 (16.8)	33 (5.1)	60 (9.0)
Hawksbill (Fano hara)	24 (3.4)	2 (0.7)	50.6 ± 15.5	31–89	7 (29.2)	13 (54.2)	0 (0)	4 (16.6)
Olive Ridley (Fano tsakoy/tsipioke)	3 (0.4)	1 (0.4)	66.0 ± 14.7	57–83	1 (33.3)	0 (0)	0 (0)	2 (66.7)
Unidentified	7 (1.0)	94 (35.0)	NA		3 (42.9)	3 (42.9)	0 (0)	1 (14.2)

No leatherback turtles (Malagasay name: Fano valorozo) were recorded.

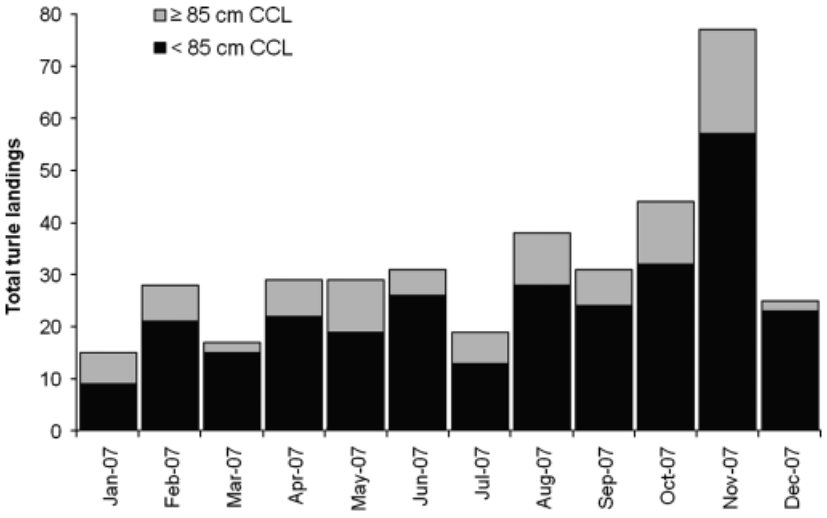

Figure 2 Total turtle landings from 1 January to 31 December 2007 for villages that recorded a full year of data. Data from the villages of Morombe, Nosy Lava, Belavenoke and Nosy Hao have been removed.

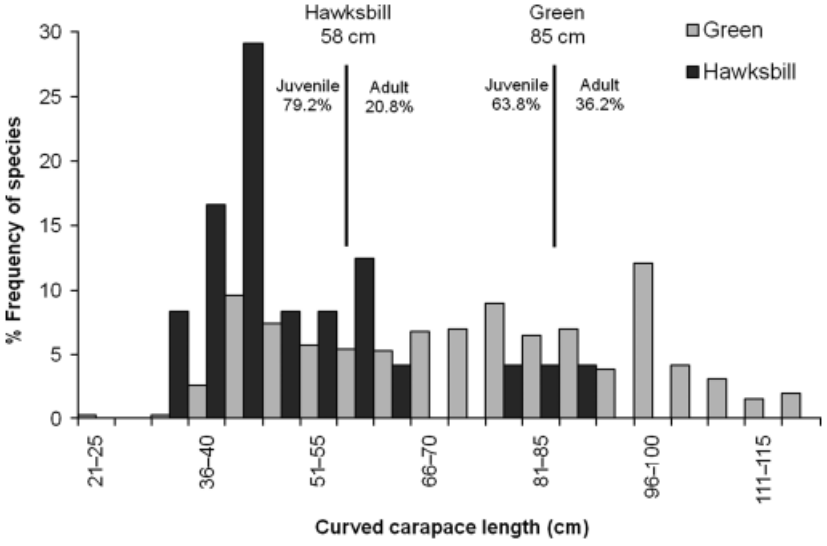

Figure 3 Curved carapace length of green and hawksbill turtles recorded in this study (1 January–31 December 2007). The percentage of potential juveniles and adults at minimum sizes of recorded nesting green (Metcalf *et al.*, 2007) and hawksbill (Alisson, 2008) turtles are shown on the graph.

individuals. Three individuals were confirmed adult females from distant nesting sites; two had been tagged at nesting beaches in Europa and one in Mayotte, all over 90 cm CCL. Sex cannot be definitively determined visually in all sub-adult turtles but of the adult-sized individuals at least 74 (32.0%) were identified as male through observation of a sexually dimorphic tail length.

The size distribution of hawksbill turtles was strongly skewed towards smaller individuals, with 41–45 cm being the dominant size class (Fig. 3). With a minimum size for nesting conspecifics being 58 cm CCL (Hughes, 1974*a*; Alisson, 2008), at least 79.2% of recorded hawksbills in this study were juveniles.

The results of the informal interview regarding the status of turtle stocks were equivocal. Although five of the 12 community members reported that either the number and/or the size of turtles captured had decreased in the last 5–20 years (Table 3), five reported that there had been no change in the turtle numbers and two reported an increase in the numbers of turtles landed. The reason given for the latter were the introduction of new fishing methods in Nosy Be, while in Morombe, the community member suggested that fewer fishers were targeting turtles because they were aware of the law against hunting.

The province of Toliara, with a coastline of 1180 km covering the whole of the southwest of Madagascar, is home to the majority of the Vezo fishing communities (Rakotonirina & Cooke, 1994). We now have a robust yet conservative estimate of the number of turtle captures in our study region in one year (817 turtles per 60 km). If we assume a similar catch rate per km of coastline for this region, we estimate the total harvest for the Toliara region to be 16 000 per annum. Alternatively, if we estimate catch based on the annual estimated harvest from five previous studies (d–h) encompassing 204 km (17.3%) of the Toliara coastline totalling 1707 turtles (Fig. 4, Table 4), our estimate is closer to 10 000 turtles

Table 3 Community member data collectors' attitudes to changes in the turtle fishery

	Have you noticed a change in the size, species or number of turtles captured?			
Village	Yes or no	If yes: specify if it's been an 'increase' or 'decrease', the order of size if possible and the time period over which this change has occurred		
Ampasilava	Yes	Decrease	Numbers caught	Last 5 years
Andavadoaka	Yes	Decrease	In size	Last 10 years
Andranombala	Yes	Decrease	Numbers caught	Last 20 years
Ankitambagna	No			
Antsepoke	No			
Belavenoke	No			
Bevato	No			
Lamboara	No			
Morombe	Yes	Increase	Numbers caught	Last 5 years
Nosy Be	Yes	Increase	Numbers caught	None given
Nosy Hao	Yes	Decrease	Numbers caught	Last 10 years
Nosy Lava	Yes	Decrease	Numbers caught and size	Last 20 years

per annum. Our overall estimate of 10 000–16 000 turtles per annum is for the Toliara region alone, and although this is thought to be the major region for turtle fishing in Madagascar, other regions have also recorded significant levels of harvest (studies a–c; Fig. 4, Table 4) and therefore the annual catch for Madagascar is likely to be much greater.

Discussion

This paper describes a cost-efficient method working with community members to directly measure marine turtle harvest. A severe deficit of research and monitoring of the turtle fishery are regularly cited as problems in regional conservation meetings (IUCN, 1996; Mortimer, 2002; Okemwa *et al.*, 2005; Kimakwa *et al.*, 2008). It has broad replicability for increasing data available from any small-scale or artisanal fishery. Monitoring species' populations can be time-consuming and expensive and developing countries require alternative methods (Danielsen, Burgess & Balmford, 2005; Holck, 2008; Danielsen *et al.*, 2009). If properly designed, local participatory monitoring can yield reliable results comparable to professional monitoring, in addition to being low cost, fast, locally and nationally relevant, and become a cost-effective long term monitoring tool (Danielsen *et al.*, 2005; Holck, 2008). However, participatory methods can also play an important role in building community capacity, responsibility and ownership through the development of a greater understanding of local problems (Fazey *et al.*, 2010).

The approach used in this study was not without limitations (Table 5), in particular, the restriction of the level of in-depth data collection and locating suitable data collectors who were able to assimilate the methods quickly without a formal education or monitoring experience. The reliability of these data was increased through verification from the digital camera records and a local field assistant. Despite problems with the quality of photos of individual turtles, the cameras did play an important role in preventing cheating and to support the data collected. For obvious species, such as marine turtles, studies such as these are likely to provide a more robust assessment of a fishery than through fisher interviews alone. Future studies would benefit from additional data using an alternative method to determine harvest rates in order to provide a direct comparison of the effectiveness of community data collectors.

In 1980, estimates of turtle catch in Madagascar were over 13 000 turtles per annum (Hughes, 1971; Frazier, 1980). By 1992, Rakotonirina & Cooke (1994) estimated the nationwide harvest as 11 000 per annum. After two decades, our study estimates that the current annual turtle landings by artisanal fishers for the Toliara region alone, which likely represents the majority of the national harvest, are still of the same magnitude, if not higher. We base these estimates on limited field studies and there is clearly an urgent need to further assess the level of harvest around the country and move towards promoting sustainability, perhaps through the introduction of legal harvest quota through an exemption to the law for traditional use.

There are few long-term data from Madagascar but it is widely believed that the country's in-water turtle populations are declining (Okemwa *et al.*, 2005). Anecdotal reports of diminishing catches over the previous decade (Walker & Roberts, 2005) are not indicated from harvest and interview data but were supported at a regional workshop held in 2009 by turtle fishers and community data collectors. There are several reasons why captures may have remained high.

Firstly, the Vezo pride themselves on their innovative fishing methods and the *jarifa* nets originally designed for shark fishing, introduced in the 1990s (Langley, 2006), are now also used to catch turtles. A relaxation in the ancestral rituals associated with turtle fishing has allowed the Vezo to take advantage of these easier methods of turtle hunting, which may make effort more effective (Astuti, 1995; Pascal, 2003; Walker & Roberts, 2005; Lilette, 2007). This has been coupled by an increase in coastal human populations, degradation of marine resources and the desire for greater material wealth, leading to hunting turtles to sell at markets, an act once considered a taboo, and the development of merchants specializing in buying and selling turtle meat (Pascal, 2003, 2008; Lilette, 2006, 2007). Hunting turtles to sell for profit now drives the majority of the fishery, especially for villages close to the larger markets of Toliara and Morombe (Pascal, 2003; Lilette, 2007), where turtles fetch a high price in comparison with other marine resources.

The high number of green turtles landed and yet the apparent low level of nesting in Madagascar (Rakotonirina, Razafinjara & Harding, 2004; Walker & Roberts, 2005;

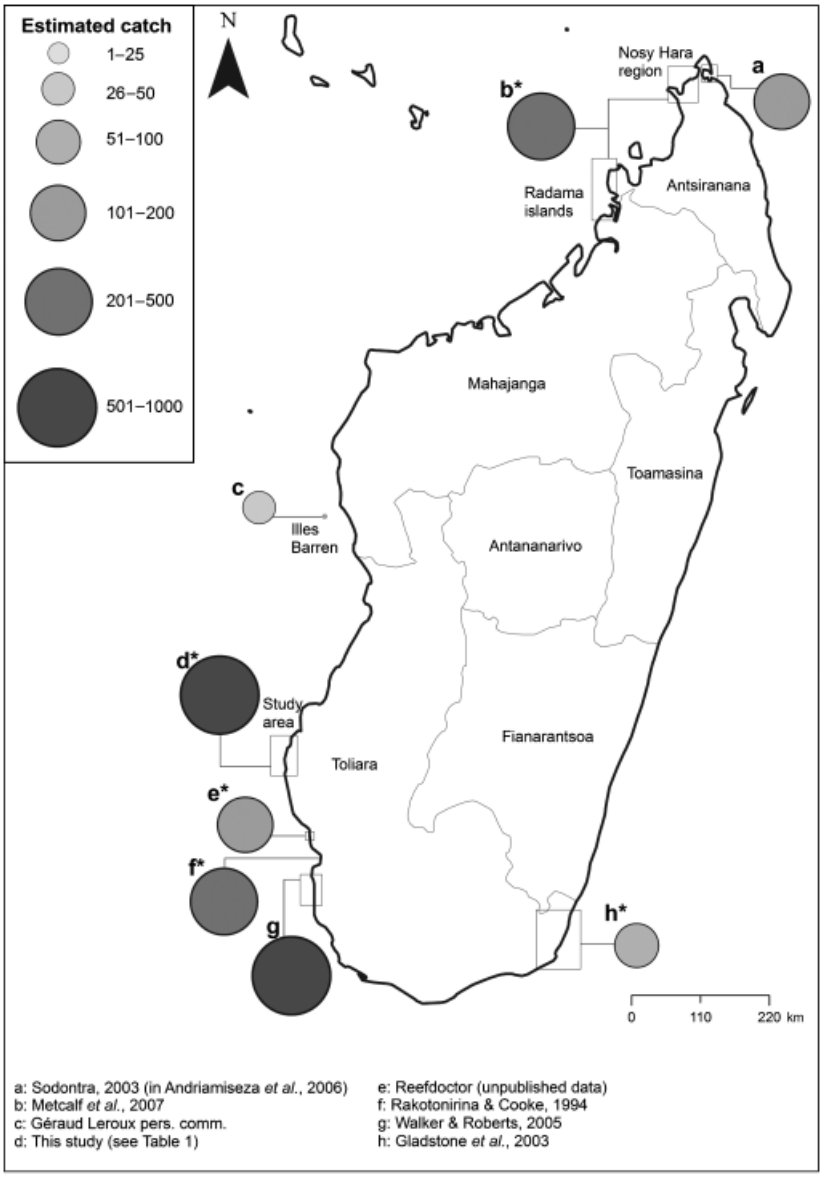

Figure 4 Map showing the location of previous studies on the traditional turtle fishery in Madagascar, the study site (d) and the numbers of turtles estimated in each study. Lengths of boxes are scaled to show the approximate lengths of the coastline covered by the study. *Turtle catch estimated through actual count of landed turtles or carapaces.

Metcalf *et al.*, 2007) strongly indicates that the majority of turtles landed originate from source populations elsewhere in the western Indian Ocean. Tagging studies have shown that the waters of Madagascar provide important feeding grounds for juvenile and adult turtles from nesting populations located throughout the western Indian Ocean, including the Îles Éparses, Seychelles and mainland Africa (Hughes, 1974*b*; Limpus *et al.*, 2001; Rakotonirina *et al.*, 2004; Lauret-Stepler *et al.*, 2007; Metcalf *et al.*, 2007).

Although Seminoff (2004) reported that there had been a 32% reduction in green turtle nesting populations compared with historic levels in the western Indian Ocean, recent estimates show significant increases in track counts on Europa (3% increase $year^{-1}$) and Grande Glorieuse (6% increase $year^{-1}$) over the last 20 years, strongly suggesting that populations visiting these islands have increased (Lauret-Stepler *et al.*, 2007). The numbers have remained stable in Mayotte (Bourjea *et al.*, 2007). It may be that increased recruitment from such populations is subsidizing the turtle fishery in Madagascar.

Despite the recent increases in nesting, it is possible that the impacts of the turtle fishery in Madagascar and elsewhere in the region have been impeding population recovery over the past decades or their impacts may yet be revealed as a result of the slow life history of green turtles. Bourjea *et al.* (2007) speculate that the green turtle is not endangered in the region and is capable of supporting the current exploitation levels. Concern should, however, be raised regarding the trajectory of fishing pressure on turtle populations in Malagasy waters, in both the magnitude and the method, given extant patterns of degradation of marine resources

Table 4 The potential number of turtles landed in artisanal fisheries from data from previous studies

Study label on Fig. 4	Location of study	Estimated/ recorded turtle landings	Length of data collection	How was data collected	Estimated number per year	Reference
a	Antsiranana	129	4 months in 2000	Unknown	387	Sodontra, 2003 (in Andriamiseza, Rakotomavo & Rakotonirina (2006))
b	Nosy Hara	380	July to December 2000	Count of carapaces	760	Metcalf *et al.* (2007)
b	Nosy Iranja	9	July to December 2000	Count of carapaces	18	Metcalf *et al.* (2007)
b	Radama Islands	63	July to December 2000	Count of carapaces	126	Metcalf *et al.* (2007)
c	Illes Barren	30	2008	Pers. Comm.	30	G. Leroux (pers. comm.)
d	Morombe to Antsepoke	699	January to December 2007	Direct count of landings	817	This study (see Table 1)
e	Beravy-Ifaty	165	June 2008 to June 2009	Direct count of landings	165	Reefdoctor (unpubl. data)
f	Toliara	279	10 months in 1989	Market surveys	335	Rakotonirina & Cooke (1994)
g	Anakao to Ambola	501 (per month in peak season)	2002	Fisher interviews	2991	Walker & Roberts (2005)
h	96 km of coastline north of Tolagnaro	63	15 November 2001–27 February 2002	Port surveys/ market surveys	252	Gladstone *et al.* (2003)
Total		2318			5881	

Table 5 Limitations and recommendations for implementing community data collection of turtle harvest

Limitations	Recommendations
Low levels of education and literacy	Ensure monitoring materials are as clear and simple as possible, with the inclusion of diagrams. Repeat training on a regular basis
Locating suitable community date collectors, for example due to jealousy within a village	Create a trial period for initial data collection and remove the village and choose another location if problems cannot be resolved
Fishers wary of reporting their 'illegal' turtle landings	Choose community data members who have standing in the village; hold village meetings to explain the aim of the monitoring
Unable to use a digital camera	Purchase simple cameras and dedicate enough time to camera training at the start of the study
No formal training in research methods	Ensure monitoring equipment is as simple as possible to reduce the likelihood of errors for example mark the correct side of the measuring tape to use
Varied use of local names for fishing sites and fishing methods (and potentially species)	Use participatory methods to create maps/lists of agreed local names
Number of monitoring variables limited	Highlight the most important aim of the research and be aware to not overburden data collectors with too many monitoring questions
Problems with understanding the concept of percentages	Monitoring questions focusing on increases or decreases in populations or harvests may need to use qualitative descriptions to ascertain changes from interviews

and coastal population growth (UNEP *et al.*, 1998; Institut National de la Statistique & ORC Macro, 2005; Ahamada *et al.*, 2008; Harris *et al.*, 2010).

Conservation efforts within Madagascar have included the protection of some nesting sites and work on reducing bycatch through the installation of Turtle Excluder Devices to trawlers (Okemwa *et al.*, 2005; Kimakwa *et al.*, 2008). Bycatch is seen as one of the major global factors in marine turtle mortality and is the focus, along with its mitigation, of a large volume of scientific literature (Gilman *et al.*, 2006, 2010; Lewison & Crowder, 2007; Tomás *et al.*, 2008; Murray, 2009). This study highlights that direct turtle harvest in artisanal fisheries also needs to be addressed. There is also a need to monitor breeding turtle populations in Madagascar in order to assess and clarify current population status (Table 3).

However, there have been few turtle conservation measures aimed at or working with the artisanal fishing

communities in Madagascar, and those that have, have had limited success due to political crises and a lack of adherence (Gladstone, Andriantahina & Soafiavy, 2003; Walker & Roberts, 2005). Our study has shown that the numbers of turtles caught within a small human population can be substantial over a year but effective management is not likely to occur without community approval. The recent meeting of the Western Indian Ocean Marine Turtle Task Force (Kimakwa *et al.*, 2008) highlighted the fact that Madagascar 'has a strong community incentive for turtle conservation . . . the system embraces the community structure – employing traditions, culture and customs'. Other countries have fisheries management policies that have taken into account traditional turtle fisheries and, although regulated, allowed them to remain intact (Bell *et al.*, 2007).

This study reflects the extent of the artisanal turtle fishery in Madagascar and the need for increased marine turtle conservation efforts and assessments of direct fisheries harvest. It provides a cost- and time-efficient method for gathering data from artisanal fisheries and provides a system of collecting data that could help answer priority conservation research questions highlighted recently in Hamann *et al.* (2010). If research is conducted ethically and through the development of trusted relationships within the community, it may foster greater community ownership of resources (Fazey *et al.*, 2010) and increase the chance of the development of accepted conservation measures, which will also allow for a greater chance of success through compliance and self-regulation (Silver & Campbell, 2005; Shackeroff & Campbell, 2007).

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