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Rudy van der Elst, Director of the Oceanographic Research Institute (ORI), division of the South African Association for Marine Biological Research (SAAMBR), South Africa.

Progress and development of a hawksbill turtle (*Eretmochelys imbricata*) monitoring project, Seychelles: 2004-2008

Paul McCann

Global Vision International
[1]GVI c/o SCMRT-MPA, PO Box 1240, Victoria, Mahé, Seychelles
Email: paulymccann@gmail.com

Introduction

The Seychelles inner islands are home to one of the world's largest hawksbill turtle nesting populations. Since 2004, 10,000s of volunteer hours have been donated by people from all nationalities and walks of life in contribution to the Global Vision International (GVI) Seychelles Marine Expedition. Data has been collected on *E. imbricata* population dynamics, nest site monitoring, and behavioural ecology from multiple locations. Thirty-two hawksbill turtles were tagged for identification from June 2006 to July 2008 as part of a well established mark/recapture program within the Curieuse Island Marine Park; in addition, 45 turtles were recaptured and nine tags replaced for long-term integrity. The results from beach patrol surveys between 2004 and 2008 indicate that marine reserves on Silhouette and Curieuse Island retain higher nesting populations when compared to unprotected areas monitored across North West Mahé Island. GVI has also developed a new focal behavioural study on the foraging ecology of *E. imbricata* with the guidance and advice of regional experts. By collaborating with resource managers and local stakeholders, research conducted by international conservation organisations such as GVI effectively addresses critical gaps in the scientific literature while providing a number of tangible benefits to the wider community.

Marine turtles in the Seychelles

The Republic of Seychelles contains 115 islands and covers one of the largest Exclusive Economic Zones (EEZ) relative to landmass of all countries. This West Indian Ocean archipelago is geographically isolated from other continents and world renowned for its high biodiversity, rich coral reefs, and lucrative fishing industry. Marine turtles have significant cultural and economic importance in the Seychelles and presently images of sea turtles can be found on the logo of the Central Bank of

[1] Project contact: Tim Kirkpatrick-Seychelles@gvi.co.uk

Seychelles, the 10 Rupee banknote, and national postage stamps.

Five of the world's seven species of marine turtle enter the Seychelles for nesting or foraging activities. Incidental reports suggest that leatherbacks (*Dermochelys coriacea*) often fall prey to long line fisheries in the region (Hamann *et al.*, 2006) while loggerheads (*Caretta caretta*) and olive-ridley turtles (*Lepidochelys olivacea*) are rarely encountered. Several long-term studies have previously addressed the nesting habits of hawksbill (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) on numerous high density nesting beaches across inshore (Diamond, 1976; Mortimer & Bresson, 1999) and offshore islands respectively (Mortimer, 1988; Mortimer, 1990; Mortimer *et al.*, 2006). Although over 20 marine turtle conservation and monitoring programs operate within the Seychelles, no published information is currently available for hawksbill nesting sites on Silhouette, Curieuse or Mahé Island.

Baseline information has recently been established on hawksbill foraging preferences throughout marine protected areas of the outer islands (Brandis, 2008) and Haughton *et al.* (2003) has documented energy budgets for juvenile hawksbills across the inner islands albeit over a limited temporal scale (i.e. March-April 2000). These studies have provided the grounds for further investigation into the link between energy allocation and site fidelity across inner island locations.

As hawksbill turtles are easily observed within the coastal areas of the inner islands they have remained the focus of monitoring efforts undertaken by Global Vision International (GVI)'s Seychelles Marine Expedition. GVI has provided trained individuals to assist volunteers with research and environmental monitoring on behalf of local data collection agencies since 2004; they also support a conservation based eco-tourism industry and generate environmental awareness while contributing to a variety of fundraising events and capacity building projects in the wider community.

Threats to *E. imbricata* within the Seychelles

As the Seychelles Republic rises to meet a growing economic demand for the international tourism market, so too does the justification for larger and more numerous coastal developments. The impacts generated by these anthropogenic activities are influencing all phases of the hawksbill's life cycle from incubation success (feral animals, coastal erosion, habitat loss, etc.) to adult mortality (e.g. boat strike, ingestion/entanglement of marine debris and poaching). Other forms of environmental degradation associated with proposed developments include channel dredging and reef blasting, industrial/petrochemical pollution, sand mining and coastal erosion. Furthermore, increased coastal development approvals have necessitated the installation of artificial lighting, wider roads, increased watercraft traffic and coastal armouring, all of which place added pressure on marine turtle nesting sites and coastal habitats.

Hawksbill turtles within the Seychelles are particularly vulnerable to poaching because of their unique daylight nesting behaviour (>85% on Cousin Island), high frequency of nesting emergences, and predictable inter-seasonal patterns of nest site fidelity (Mortimer & Bresson, 1999). The foraging habits of *E. imbricata* render the animal's flesh and adipose tissue unsuitable for consumption due to bioaccumulation and magnification of toxic compounds (Meylan & Whiting, 2008). However as the market price of scutes from the carapace and plastron fetch prices to rival that of ivory the risks involved in illegal harvest are often overshadowed by attractive profit margins (Collie, 1993).

The international trade of 'tortoise shell' or 'bekko' has been a major incentive for continued harvest. Between 1976 and 1979 Japan alone imported more than 40,000 kg of marine turtle by-products (roughly equal to 44,000 animals), and continued to import until 1992 despite the hawksbill's mid-1980 listing under the Convention of International Trade in Endangered Species (CITES) (Collie, 1993). In 1996 *E. imbricata* was officially named on the IUCN Red List as 'Critically Endangered' (Appendix I species) based on global population declines of 80% over the past three generations and

sufficient evidence to predict further declines in the future (Meylan & Donnelly, 1999).

Sea turtle policy and protection within the Seychelles

The trade in hawksbill shell has been an important commodity throughout the Seychelles since the 1700's. However no official stock management guidelines were available until The Turtle Act (Chapter 141) was formulated in 1925 (Collie, 1993). Over the past 50 years a number of seasonal closures, taxon specific limitations, and trade restrictions have been trialled in the region with limited success. It was not until 1993 when the Artisan Compensation and Reinstallation programme was passed that a closure of the fishery became possible. This scheme focused on the transition from unsustainable harvest to alternative livelihoods and was supported by a government buy-back strategy of the existing hawksbill product stockpiles (Mortimer & Balazs, 1999).

In 1994 the commercial trade in turtle products was outlawed throughout the republic (see The Wild Animals and Birds Protection Act), and the Fisheries Act was also modified to prevent the capture of sharks using drift nets in an effort to reduce rates of incidental mortality. Irrespective of this progress a loophole in the regulations still allowed existing stockpiles of turtle products to continue being sold legally and it wasn't until 1998 when the government passed an amendment, and publicly burned a large 'bekko' product stockpile, that the market was effectively closed (Mortimer, 1999; Mortimer & Balazs, 2000).

Penalties for breaches of The Wild Animals and Birds Protection Act increased dramatically in 2001. Maximum fines were raised 500 fold, prison sentences escalated 100 %, and authorities reserved the right to confiscate vessels, aircraft, vehicles and gear. Since this legislation was introduced, a number of public awareness campaigns involving television segments, festivals, radio pieces, and newspaper articles have been circulated with the intention of disseminating information on threats, current legislation, and the mitigation of nest depredation.

The present paper provides an overview of hawksbill population management in the Seychelles and a data summary of GVI's marine turtle conservation fieldwork on the Isles of Mahé, Curieuse and Silhouette from 2004-2008.

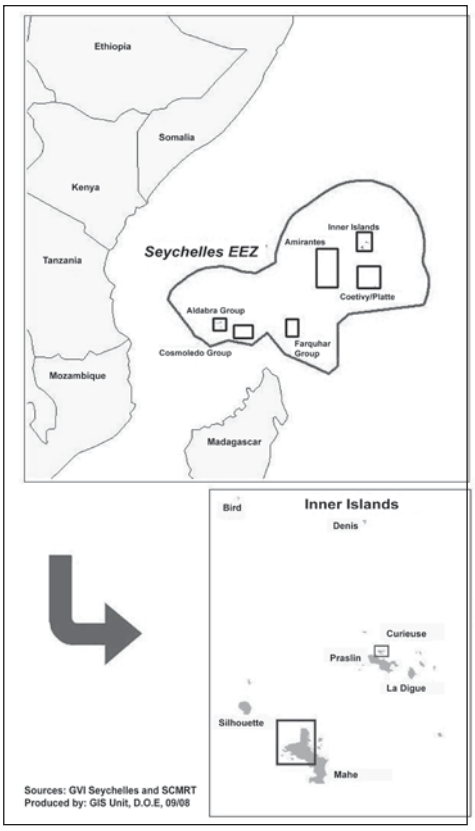
Methods

Site description

GVI is a non-government organisation (NGO) that conducts marine research expeditions across the Seychelles inner islands with the objective of documenting marine ecosystem health in the wake of the 1998 coral bleaching event. A range of local partners are involved in the planning and execution of GVI's activities and all raw data is subsequently forwarded to Seychelles Centre for Marine Research and Technology – Marine Parks Authority (SCMRT-MPA) for quarterly review. Every three months roughly 30 international volunteers join 10 staff members to collect data in the field. From 2004-2008 the primary research station was located on the North West (NW) coast of the Seychelles largest Island Mahé, which covers an area of 455 km2 and contains the nation's capital (Victoria - 04° 36.9' S 55° 28.8' E, Map 1) along with most of the republic's estimated 90,000 inhabitants. Between 2004 and 2007 turtle monitoring was undertaken on Silhouette Island, the third largest island in the republic. This designated marine protected area covers a small but mountainous 20 km^2 and is located approximately twenty kilometres north-west of Mahé. In 2006 a secondary research station was established on Curieuse Island. However due to pending coastal developments on Mahé, all of GVI's operations have since relocated to Curieuse. This small protected granitic isle (2.86km^2) is positioned approximately 45 km north-east of Mahé and adjacent to Praslin Island, the second largest landmass and residential population found within the Seychelles.

Nest monitoring

Several beaches across the Inner Islands of the Seychelles are monitored throughout the hawksbill nesting period (Oct-Mar). Beach selection, and the number of patrols conducted, are usually dictated by volunteer availability, weather constraints, and tidal movements; however on average at least one patrol per



Map 1: Seychelles EEZ and the relative position of Inner Island study locations.

week for Mahé Island, and two per week for Curieuse Island, were undertaken at the time of writing. During each beach walk volunteers are accompanied by trained GVI staff to examine the foreshore and areas above the mean high water mark (MHWM). Nest monitoring began in 2004 on Grand Barbe, Silhouette Island with thrice daily beach patrols; a smaller number of patrols were also conducted across a variety of low density nesting beaches across NW Mahé (Grand Anse, Anse Du Riz, Anse Major, Port Launay and Baie Ternay). Monitoring on Curieuse Island (Anse St Jose, Baie Laraie and Grande Anse) commenced in 2006 when GVI's second marine research station was established.

When a track is discovered GPS coordinates of the nest's location are recorded in addition to any information that can be obtained from the track pattern, or the time frame in which egg deposition occurred. Mean track width (cm) is determined from three separate measurements at distinct points along the track's trajectory. If a turtle is observed emerging, further information on nesting behaviour and clutch size can be obtained, and females may be tagged post nesting if feasible.

Tagging

Tagging to date has been conducted on Curieuse Island in tandem with the local rangers from SCMRT-MPA. Snorkelling surveys, or beach walks during the nesting season are used to locate the turtles. Upon capturing an individual a series of three metric linear measurements are recorded for each variable following the Marine Turtle Specialist Group (MTSG) guidelines (Bolton, 1999). Callipers and measuring tapes are used to obtain mean values for body depth, plastron length, carapace length (SLCL), carapace width (SLCW), head width (OCCW), head length (OCCL), total tail length (from plastron to tip) and post-cloacal tail length (from mid-cloacal opening to the end of the tail). Live weights are obtained by wrapping the turtle within a large-mesh nylon net attached by hand to a 10 kg spring scale. Tag numbers (if present) are visually inspected to ensure long-term integrity (Limpus, 1992) and descriptions of any characteristic marks or scarring on the carapace are also recorded.

Focal behavioural study

Stomach content analysis has shown that Hawksbill turtles across the world feed predominantly upon marine sponges (Family Porifera); secondary elements of dietary composition may include Corallimorphs, Ascidians (sea-squirts), Alcyonaceans (soft corals), shellfish, seagrass, macroalgae and mangrove fruits (Meylan & Whiting, 2008). From June 2006 to July 2008 snorkelling surveys of resident marine turtles were conducted on NW Mahé using stationary point count and u-shaped 25mx5m belt transects; incidental sightings during coral reef research and monitoring activities were also documented. Through these observations and the advice of local experts it was hypothesized that some degree of site fidelity was likely evident within the Baie Ternay marine reserve. This prompted the introduction of a focal behavioural study using SCUBA with the long-term objective of establishing a photo identification database and obtaining previously unknown information on hawksbill turtle foraging ecology for the inner

islands. The sampling methodology implemented was a modified version of that employed by von Brandis (2008) and this approach was deemed effective for analysis, and achievable for incorporation, within the framework of GVI's Seychelles marine expedition.

One day per week two teams (am/pm), each consisting of between 2-4 buddy pairs of SCUBA divers, are spread evenly across the reef slope in Baie Ternay to undertake a U-shaped search pattern with a maximum bottom time of 45 minutes. The divers rely on compasses to swim towards the shore but may deviate from their course when a turtle is found. On initial sighting of a turtle the subject is kept at a minimum distance of 4 m or greater while a timed series of information on activity budgets and depth is recorded with a dive computer. Further information on prey selectivity is gathered if the turtle is witnessed foraging, and data recorders are strongly encouraged to photograph prey items for *aposteri* identification.

Results and discussion

Nest monitoring

From 2004-2008 beach patrols across Mahé and Silhouette Island have yielded 794 observations of turtle tracks by GVI staff and volunteers. The mean number of turtle tracks recorded over the breeding season (Oct-Mar) on Silhouette remained consistent throughout 2004/2005 (39.8) and 2005/2006 (40.7) before rising markedly in 2006/2007 (54.2) in response to a greater investment of sampling effort (R^2=0.92). The highest number of tracks (140) documented in any month of sampling occurred on Grande Barbe beach, Silhouette Island during November 2006 (Figure 1a) shortly before GVI's monitoring activities ended in December 2007 due to preparations for the new Curieuse Island research station.

Our initial findings clearly show that Grande Barbe represents one of the highest density sea turtle nesting sites within the Seychelles inner islands and provides encouraging results for an area which has only been protected as a marine reserve since 1987. Moreover, two incidental nesting patrols conducted in July 2005 have resulted in two tracks being recorded (80 cm and 120 cm width respectively) the latter of which is consistent in both the size and seasonality of *C. mydas* in other Seychelles Islands (Miller, 1997; Mortimer *et al.*, 2006).

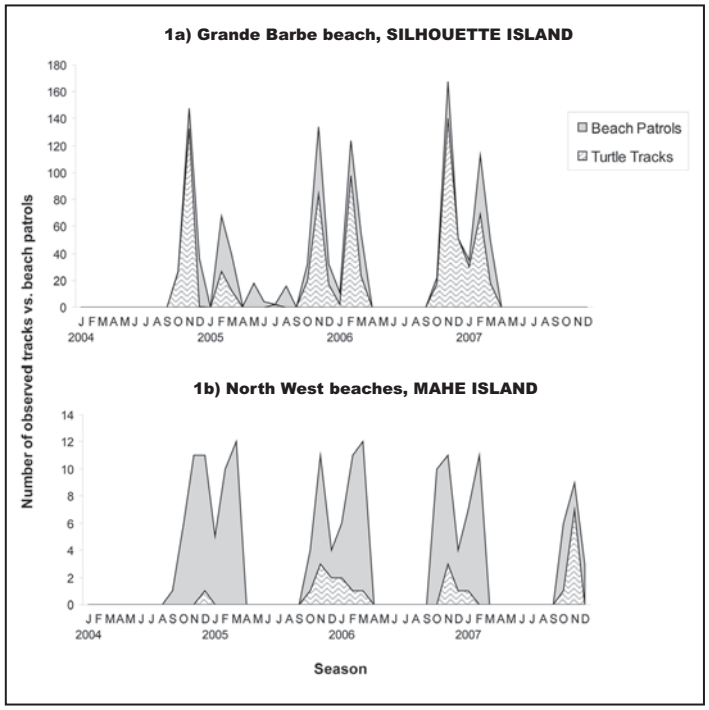


Figure 1 (a&b): Number of tracks observed during volunteer beach patrols across a) Grand Barbe beach, Silhouette Island and b) North West Mahé Island.

Between 2004 and 2007, 165 beach patrols were conducted on beaches across NW Mahé with a total of 24 turtle tracks recorded (Figure 1b). Despite the relatively high level of sampling effort, estimates of the nesting population are difficult to discern due to the small number of tracks recorded and no correlation between the number of patrols and the number of tracks recorded was found to exist (R^2=0.02). Of the five NW Mahé beaches that were monitored, Baie Ternay and Port Launay were both declared marine protected areas (MPA) in 1979, however these were not the locations where turtle tracks were most often encountered (only n=2 and n=3 respectively across the total sampling period). Most of the tracks were found on beaches that included a freshwater source (Grande Anse: n=8, Anse Du Riz: n=4) or were accessible to the open ocean (Anse Major: n=4).

Taking into account the multiple nesting efforts made by a single female during any season (3.6-7), and Mortimer and Bresson's (1999) estimated 1.8 trial emergences to every successful nesting event, it appears that only a handful of female hawksbill turtles are still emerging across NW Mahé to lay eggs.

There was no obvious difference in the mean size of nesting tracks between NW Mahé (n=11, mean=82.73, SD=7.80, range=65-92 cm), Curieuse (n=202, mean=75.53, SD=9.80, range=38-103 cm), or Silhouette Island (n=500, mean=78.26, SD=10.51, range=40-138 cm). Most of the turtle tracks encountered fell within the 70-90cm size range (Figure 2) suggesting that the sample population is comprised primarily of hawksbill turtles (Pritchard & Mortimer, 1999). Substantially fewer tracks were recorded on the heavily populated and predominantly unprotected location of NW Mahé, compared with Silhouette and Curieuse islands where complete coastal marine ecosystem protection is afforded and the impact from anthropogenic activity is limited. Long-term studies from nearby Cousin Island have demonstrated that nesting hawksbills only return to their natal beaches every 2-3 years and so further monitoring over extended temporal scales is required before a biological trend can be validated (Mortimer & Bresson, 1999).

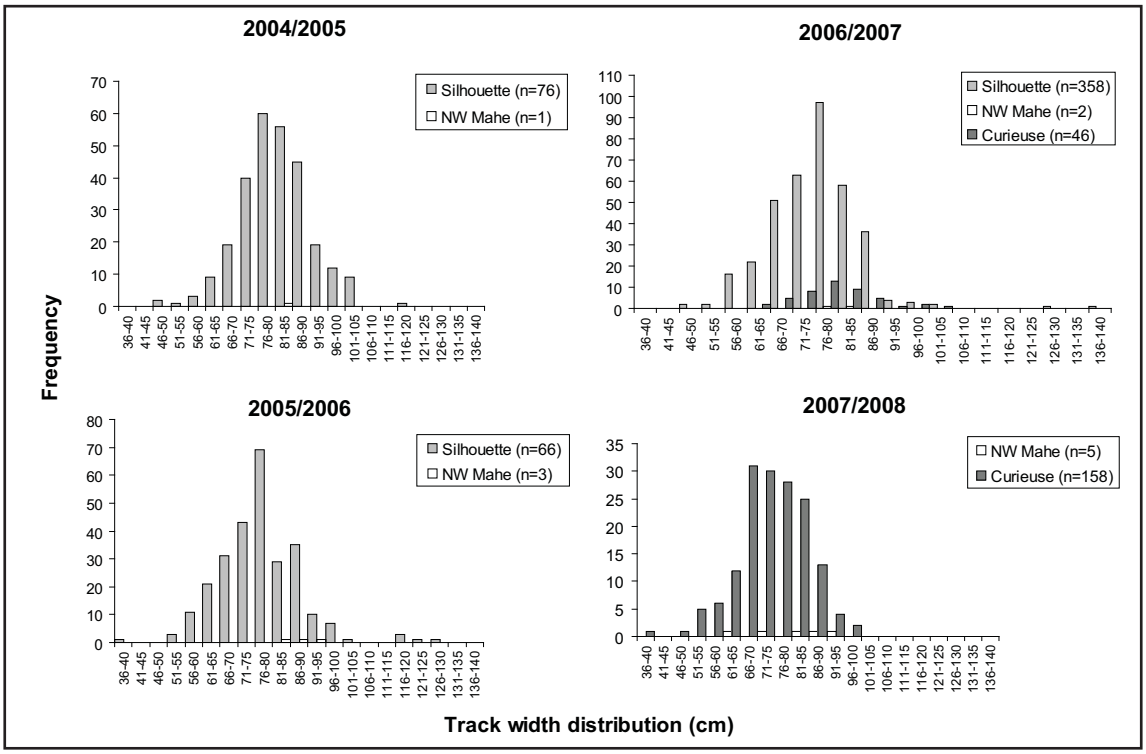


Figure 2: Frequency histogram showing the distribution of track widths left by nesting female sea turtles emerging across the NW beaches of Mahé Island, Grande Barbe beach, Silhouette Island and the Curieuse Island Marine Park from 2004-2008.

The continued monitoring of linear track widths (cm) throughout our study has provided a useful, non-invasive estimate of size for nesting females as well as supporting evidence for species identification in the absence of a live subject. In future this technique should also be cross examined periodically with other nest and track characters such as body pit depth, clutch size, and egg diameter to accurately identify the seasonality and track size variability between *C. mydas* and *E. imbricata* nesting populations. Regardless of the inherent differences in the pattern symmetry, hawksbill and green turtle tracks can be confused and do exhibit an overlap in size ranges between widths of 85-95cm (Pritchard & Mortimer, 1999).

A relatively small number of tracks (>100cm) were observed on Silhouette and Curieuse Island that substantially exceed the maximum expected track width of *E. imbricata*; I have not attempted to separate the data taxonomically as it is likely to become skewed by an unknown amount of heterospecific variability. Nonetheless, the high maximum values recorded on Silhouette Island during each sampling period provides strong evidence that Grand Barbe beach is also utilised as a nesting location by green turtles.

Tagging

Thirty-two hawksbill turtles were tagged by GVI over the 2006/2007 and 2007/2008 breeding seasons (Table 1). The number of individuals tagged each season was roughly even between years, although the rate of recaptured hawksbills did fall substantially from the first to the second sampling period most likely as a result of the disparity between individuals emerging over consecutive seasons (Mortimer & Bresson, 1999). Conservation volunteers played a significant, and valuable, role in collecting data for the Curieuse Marine Park tagging program. GVI's consistent supply of well trained research volunteers also provides an opportunity to obtain descriptive information on the breeding ecology of *E. imbricata* from nesting locations. A mean clutch size of 178.67 was obtained from observations of six laying females between July 16th 2006 and July 15th 2007 (152, 173, 174, 190, 190, 193 eggs each), and while this finding is consistent with surveys of clutch size across Cousin Island over time (Diamond, 1976; Hitchins *et al.*, 2004), we still have little information on incubation success rates for Curieuse Island from year to year and the factors which may be influencing them.

Year	# Hawksbills tagged	# Hawksbills recaptured	# Tags replaced
06th Oct 2006 – 22nd Feb 2007	17	40	8
08th Nov 2007 – 12th Mar 2008	15	5	1
Total	**32**	**45**	**9**

Table 1: Summary of Global Vision International's tagging efforts within the Curieuse Island Marine Park from 2006 - 2008.

Focal behavioural study

To date over 50 hours of timed underwater observations of hawksbill turtles have taken place in the Baie Ternay Marine Park at various depths and positions on the reef. Preliminary findings made outside the breeding season (July-September 2008) have noted a conspicuous absence of foraging observations in the Baie Ternay marine reserve. However the theft of notebooks containing data collected by the Mahé Island research station has meant that a more descriptive appraisal of preliminary results is not possible. GVI is currently revaluating its monitoring project to accompany their newly developed base of operations; further investigation of ontogenetic shifts in habitat utilisation and prey preference across inner island reserves is recommended.

Conclusion

Our results have highlighted the important role that NGOs play in monitoring both protected and

non-protected areas over long temporal scales, and reinforced the need for independent turtle monitoring groups to work cooperatively and employ consistent data collection methods for the elucidation of biological trends. Recent studies have demonstrated that marine reserves are the most effective tool to slow population decline and mitigate the deleterious effects of extraction in the absence of comprehensive biological data for the species (Mortimer, 1988; Mortimer & Balaza, 1999; Mortimer *et al.*, 2000). In spite of the sustained and heavy extractive pressure which has taken place in the Seychelles over previous decades, this region represents one of just five nations in the world with >1000 females nesting annually (Meylan & Donnelly, 1999). Informed management decisions and pro-active intervention from government and non-government sources in recent times has made substantial progress in the reduction of unsustainable environmental practices across the outer Islands. However the cumulative effect of industries such as sand mining, commercial fishing, coastal development and poaching continue to take their toll. Every effort must be made in the future to ensure that management strategies involve coastal development operators in the task of habitat preservation or remediation efforts, and that the emphasis on enhancing natural systems through responsible tourism practices is maintained.

Acknowledgements

Local government, para-statal and NGO partners are instrumental in achieving GVI's research and monitoring objectives within the Seychelles. We would like to thank Rodney Quatre and Daig Romain of the SCMRT-MPA for their input into current research and monitoring techniques, while Dr. Jeanne Mortimer and Dr. Rainer von Brandis have given their time and expertise without hesitation throughout the development of our hawksbill focal behavioural study. The Marine Conservation Society of Seychelles (MCSS), the Seychelles Fishing Authority (SFA), and Nature Protection Trust of the Seychelles (NPTS) deserve special mention for their continued support and I'd also like to extend my respect and gratitude to country director Tim Kirkpatrick for his innovative approach to expedition management and his unwavering support of staff members in the field.

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A multi-stakeholder approach to the challenges of turtle conservation in the United Republic of Tanzania

Lindsey West

Sea Sense, PO BOX 105044, Dar es Salaam, Tanzania
Email: lindsey@seasense.org

Introduction

Tanzania, located in tropical East Africa, has a coastline of 900km, supporting a diverse array of marine habitats including coral reefs, mangroves, sea grass beds, lagoons and offshore islands. Many of these habitats provide important foraging and breeding grounds for endangered marine turtles (Muir, 2005). Five species of turtle are present in Tanzanian waters: green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*) and olive ridley (*Lepidochelys olivacea*) but only green and hawksbill turtles are known to nest on Tanzania's beaches (Howell & Mbindo, 1996). Sea Sense monitors nesting activity in eight coastal districts which represents approximately one–third of Tanzania's coastline. Nesting density is relatively low across these districts with an average of 350 - 400 nests recorded per year (Sea Sense, unpublished data). Although afforded complete protection under national fisheries legislation, turtle populations in mainland Tanzania continue to face threats from subsistence harvesting for meat, poaching of eggs, incidental capture in gill nets and habitat disturbance (Bourjea *et al.*, 2008). Inshore commercial prawn trawlers also pose a significant threat (Joynson-Hicks & Ngatunga, 2009). Tourism development leading to destruction of nesting beaches is a major concern for turtle populations in Zanzibar (Bourjea *et al.*, 2008).

Challenges

There are many challenges facing turtle conservation in Tanzania. Although Tanzania has ratified several international treaties which pertain to marine turtle protection including the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973 and the Convention on the Conservation of Migratory Species of Wild Animals