Managing marine turtles: A study of marine turtle conservation science and policy.

Submitted by Peter Bradley Richardson to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Biological Sciences in May 2011.

UNIVERSITY OF EXETER

I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signed:

PETER RICHARDSON

ABSTRACT

Marine turtles are an ancient group of reptiles that have been used by humans as a source of protein for over 7,000 years. In recent decades, acknowledgement of the various threats to marine turtles, including the deleterious impact of historical and contemporary use on many populations, led the International Union for the Conservation of Nature (IUCN) to list all seven extant species of marine turtle on their Red List of Threatened Species. Consequently, marine turtles are often given protected status in the national legislation of countries around the world, despite the existence of ongoing use cultures in communities that live with marine turtles. Conservation strategies are challenged by the migratory nature of marine turtles, which have complex life histories typically involving the use of habitats in the jurisdictions of multiple sovereign states as well as the high seas. As a result, a suite of multi-lateral environmental agreements (MEAs) list marine turtles in the most highly protective categories. Thus, governments of sovereign states that have acceded to the various MEAs are committed to conservation strategies requiring national action and cooperative multi-lateral action, which can conflict with interests of communities with a tradition of marine turtle consumption. In this thesis I provide examples of how contemporary scientific research methods can elucidate the migratory behaviours of marine turtles, and can help define range of populations subject to national conservation action and use. I examine specific examples of how this information can inform national and multi-lateral conservation policies and strategies; how those policies and strategies interact and impact on traditional cultures of marine turtle use in the UK Overseas Territories in the Caribbean; and provide an example of the potential benefits of engaging stakeholders with contemporary research methods. This thesis highlights the utility of a multi-disciplinary approach to research underpinning marine turtle conservation and management, which acknowledges the limitations of MEAs and national government capacity, and which incorporates participation of those communities engaged in marine turtle consumption.

LIST OF CONTENTS

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This thesis is dedicated to my wife Sue and my children Ruben and Daisy. I am eternally grateful to them and my parents, as well as all my friends, colleagues and collaborators who have been so supportive, patient and tolerant in recent years. I would especially like to thank my supervisors Brendan Godley and Annette Broderick at the University of Exeter Cornwall Campus, and Sam Fanshawe, Director of the Marine Conservation Society (MCS), for their extraordinary support. In addition, I acknowledge the following contributions to each chapter:

Chapter 2. Satellite Tracking Suggests Variability In Migratory Behaviour Of Female Green Turtles: I thank the Department of Wildlife Conservation, Sri Lanka for generously granting permission for this study and providing invaluable staff time to support the fieldwork. I thank the staff and volunteers of the Turtle Conservation Project (TCP) for their dedicated work at the Rekawa Turtle Sanctuary and Kosgoda, and the Nature Friends of Rekawa for their dedicated support. I also thank Paul Appleby, formerly of the BBC Natural History Unit for his support, enthusiasm and encouragement; Shri Venkat Charloo for his support in the field in Karnataka; and Shri B C Choudhury of the Wildlife Institute of India for reporting the turtle stranding in Agatti. This study would not have gone ahead without the financial support of the Blue Reef Aquarium in Tynemouth, The Deep aquarium in Hull, the Department for Environment Food and Rural Affairs (Defra), the European Social Fund, Hurtigruten, the UNEP-CMS IOSEA Secretariat and the Marine Conservation Society (MCS).

Chapter 3. Leatherback Turtle Conservation In The Caribbean UK Overseas Territories: Act Local, Think Global? I would like to thank the Department of Fisheries and Marine Resources in Anguilla and the Conservation and Fisheries Department of BVI for granting permission to attach satellite-tracking devices to leatherback turtles. I would also like to thank the staff of those departments, and the Anguilla National Trust for their assistance, as well as Kirsten Abernethy and Juliet Savage for their generous voluntary support. I especially thank Jessica Berkel, Tadzio Bevoerts, Mykl Clovis, Eric Delcroix, Steve Garner, Julia Horrocks, Hector Horta, Mike James, Yolanda

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School for Field Studies students who participated in fieldwork around South Caicos and acknowledge the valuable the logistical support of the School itself. I am particularly indebted to Rob Wild and family. I thank the Wider Caribbean Sea Turtle Conservation Network (WIDECAST) for providing the flipper tags used in this study, and Andrew McGowan for providing his unpublished mass against CCL functions. Finally, I thank all those fishers who helped out with TCOT genetic sampling in the TCI and all other TCI Islanders that helped us achieve then project objectives in the TCI. The manuscript was improved by the constructive reviews of Sandra Hochscheid, Richard Reina and Jeff Seminoff. The European Social Fund, the Marine Conservation Society, the Darwin Initiative, the Foreign and Commonwealth Office/ Department for International Development *Overseas Territories Environment Programme* and the National Environmental Research Council supported this work.

Chapter 6. "*Where Suzie At?":* Stakeholder Perceptions Of Marine Turtle Tracking In The Turks and Caicos Islands. I thank Wesley Clerveaux, Director of the Department of Environment and Coastal Resources (DECR), for authorising this study in the Turks and Caicos Islands. I also thank the various DECR staff who contributed their time and efforts to this work. I thank the community of South Caicos, particularly those members of South Caicos who participated in the interviews. I thank Spice and his crew who allowed the project to procure Suzie, as well as the other fishers who allowed us to procure other turtles tagged during this study. I also thank Matthew Witt for generating the map of Suzie's migration. This project would not have been possible without the generous support of Anne and Simon Notley, the People's Trust for Endangered Species (PTES), the British Chelonia Group, the Natural Environment Research Council and the European Social Fund.

LIST OF TABLES AND FIGURES

Karnataka, India (turtle 5 foraging centroid could not be calculated due to insufficient data, so last at-sea A class location shown here).

Figure 5. Kernel analyses of locations received from the foraging sites of six turtles. The dark areas encompass the 25% most densely distributed locations and the light areas encompass the 50% most densely distributed locations. These kernels describe foraging sites, **a,** turtle 1 at Muyal Island, Gulf of Mannar Biosphere Reserve (GoMBR; 136 days, 397 locations), **b,** turtle 2 at Thalaiyari Island, GoMBR (51 days, 209 locations), **c,** turtle 4 in shallow water to the south west of Sri Lanka's Mannar Island, Gulf of Mannar (32 days, 63 locations), **d,** turtle 6 at Shirali Island off the coast of Karnataka, India (48 days, 79 locations), **e,** turtle 9 off Ussangoda, southern coast of Sri Lanka (24 days, 83 locations), and **f,** turtle 8 off Bundala, southern coast of Sri Lanka (92 days, 195 locations).

Figure 6. The foraging site track of turtle 10, showing loops in deep oceanic water associated with the coral atoll Minicoy, the most southerly of the Lakshwadeep Islands. The black circle indicates the end of the track where the transmitter failed some 135 km to the west of Minicoy.

Figure 7. Seasonal monsoon current systems around the Indian sub-continent (adapted from Schott and McReary 2001). a. Southwest monsoon current (SMC) system during the peak hatching season at RS (June to September), including Laccadive High (LH) and the Sri Lanka Dome system (SLD). b. Northeast monsoon current (NMC) system, which starts around October.

Supplemental Table 1. Summary of biometric and tracking information for the 10 female green turtles fitted with satellite transmitters turtles at the Rekawa Turtle Sanctuary, Sri Lanka. (Thangaradjou et al. 2008[1], Tamelander & Rajasuriya 2008[2], Kumaraguru et al. 2006[3], Rajasuriya et al. 1998[4], E. Wood, pers comm. 2009[5], Tripathy et al. 2006[6], Untawale & Jagtap, 1984[7]).

Chapter 3. Leatherback Turtle Conservation in the Caribbean UK Overseas Territories: Act Local, Think Global?

Figure 1. Post-nesting movements of adult female leatherbacks tagged in the British Virgin Islands, including Turtle 1 (solid track) and Turtle 2 (dashed track). Broken lines show territorial borders, white circle indicates the release site and the black circle shows the last transmitted location of Turtle 2.

Figure 2. Post-nesting migrations of adult female leatherbacks tagged in the North Caribbean nesting population range, including satellite tracked Turtle 3 (dashed track). The solid black arrows indicate international movements of flipper tagged female leatherbacks (Keinath and Musick 1993, James et al. 2007 and this study), and connect tagging and recapture locations but do not imply travel routes. Darker shaded exclusive economic zones indicate where legislation completely protects leatherbacks and lighter shaded exclusive economic zones indicate where legislation regulates some legal take (Fleming 2001, Brautigam and Eckert 2006, Dow et al. 2007, Y Leon pers comm. 2011). High seas are white. USA National Marine Fisheries Service long line fishery reporting areas are also shown, including Caribbean (CAR), Sargasso (SAR), North Central Atlantic (NCA), Florida East Coast (FEC), South Atlantic Bight (SAB), Mid-Atlantic Bight (MAB), Northeast Coastal (NEC) and Northeast distant (NED).

Figure 3. Map showing levels of leatherback turtle protection under national legislation in North Caribbean nesting population range states and shared leatherback nesting as indicated by flipper tag recapture data. Darker shaded exclusive economic zones indicate where legislation completely protects leatherbacks and lighter shaded exclusive economic zones indicate where legislation regulates some legal take (see supplementary table 2). The black arrows indicate international movements of flipper tagged female leatherbacks and connect tagging and recapture locations (see supplementary table 1) but do not imply travel routes. Countries shown are Puerto Rico (PR), US Virgin Islands (USVI), British Virgin Islands (BVI), Anguilla (AXA), Netherlands Antilles of Saba, St Eustatius and Sint Maarten (AN), Saint Martin, part of Guadeloupe overseas department (MF), St Kitts and Nevis (KN), Antigua and Barbuda (AG), Guadeloupe (GP), Dominica (DM) and Martinique (MQ).

Table 1. Year of accession to MEAs relevant to leatherback turtle conservation in range states of the North Caribbean nesting population, including the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC); the Convention on Migratory Species (CMS); the Protocol Concerning Specially Protected Areas And Wildlife (SPAW) to the Cartagena Convention; Cartagena Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region; the Convention on International Trade in Endangered Species (CITES); the United Nations Convention on the Law of the Sea (UNCLOS) and the International Commission for the Conservation of Atlantic Tunas (ICCAT). '-' indicates no accession to date and N/A= Not applicable. Dates in parentheses in CARTAGENA column indicate publication date of Sea Turtle Recovery Action Plan (STRAP) with WIDECAST (* indicates where alternative national Marine Turtle Recovery Action Plans are in place).

Supplementary table 1. Countries that have recorded adult leatherback turtles within their territories that have been flipper and/or satellite tagged elsewhere within the NE Caribbean leatherback turtle population range (This study[1] – incl. pers comms. from M Clovis, S Gore & M James 2011; Berkel 2009[2]; Boulon et al. 1996[3]; Delcroix et al. 2011[4], Dutton et al. 2005[5]; Eckert et al. 1989[6]; Fleming 2001[7]; Garner et al. 2006[8]; Garner and Garner 2007[9], 2008[10] & 2009[11]; James et al. 2007[12]; Keinath and Musick 1993[13]; Stapleton & Eckert 2007[14]).

Supplementary table 2. National legislation relevant to leatherback turtle protection in range states of the North Caribbean nesting population.

Chapter 4. Marine Turtle Fisheries in the UK Overseas Territories of the Caribbean: Domestic Legislation and the Requirements of Multilateral Agreements.

Table 1. The status of CITES, CMS, SPAW and IAC extension to the UK Overseas Territories in the Caribbean.

Table 2. A summary of current marine turtle harvest and wildlife import/export legislation in the UK Overseas Territories in the Caribbean.

Table 3. Evaluation of necessary and desired legislation and management practice regarding marine turtle harvest and trade based on the texts of CMS, the SPAW Protocol and the IAC, the conservation objectives of these MEAs, and the recommendations in Godley et al. (2004).

Chapter 5. Marine Turtles in the Turks and Caicos Islands: Remnant Rookeries, Regionally Significant Foraging Stocks and a Major Turtle Fishery.

Table 1 Summary of turtle sightings recorded by dive operators.

Table 2. Foraging green and hawksbill turtle haplotype distributions (hawksbill sequences are truncated as in Velez-Zuazo et al. 2008). * This haplotype was not previously identified by other genetic surveys in the region.

Figure 1. a) Broad scale locations of turtle nesting activity confirmed during the surveys or suggested during the SEQ. **Ei** = confirmed hawksbill turtle, **Cm** = confirmed green turtle, **Cc** = confirmed loggerhead turtle, **?** = nesting activity confirmed but species unidentified, **Q** = current nesting activity suggested by SEQ but not confirmed during the surveys, **X** = no signs of nesting activity found during surveys, although SEQ suggested these sites were once used. (F) indicates locations of nesting confirmed by Fletemeyer (1984). b) Broad scale locations of species of turtle seen by dive operators or captured during the in-water sampling. O = Hawksbill turtle, ● = green turtle, ● = loggerhead turtle, ⃠ = possible Kemp's ridley. Broken lines enclose the dive operator dive sites where no sampling occurred (NB: neither sampling nor surveys were carried out along the northern coasts of North, Middle and East Caicos).

Figure 2. Length-frequency histograms for a, hawksbill and b, green turtles captured and sampled during this study. In a, broken lines marked x show minimal range of SCL at maturity for female hawksbills (51cm to 75cm) in Cuban waters from Moncada et al (1999) and broken lines marked y show range of CCLs of adult nesting female hawksbills (76.2 to 102.4cm) in Barbados range in size from Beggs et al (2007). Columns marked * indicate CCLs of the sampled hawksbills landed for consumption during this study. In b, line marked

x shows the average SCL of nesting female green turtles (100.2±5cm SCL) at Tortuguero, Costa Rica (in Bjorndal et al. 2005). * indicates CCL of a green turtle sampled during this study that was landed for consumption at South Caicos.

Figure 3. Frequency contributions to the hawksbill (a) and green turtle (b) mixed stocks from all known potential rookeries based on mitochondrial DNA haplotype frequency distributions. Mean contribution (black squares) and upper and lower percentiles were calculated using 10000 Monte Carlo Markov chain iterations assuming equal priors, using the software Bayes (Pella and Masuda 2001). Acronyms in figures are AG – Antigua, ASC – Ascension Island, BB - Barbados, BR – Brazil, BZ – Belize, CR – Costa Rica, CU – Cuba, CY – Cyprus, GQ BK – Bioko Equitorial Guinea, GW – Poilao Guinea Bissau, MX – Mexico, NO BR - Fernando de Noronha Brazil, PR – Puerto Rico, PR ST – Principe Sao Tome & Principe, RA BR – Rocas Atoll Brazil, SR – Suriname, ST - Sao Tome Sao Tome & Principe, TR BR – Trinidade Brazil, USA FL – Florida, USVI – US Virgin Islands, VZ – Venezuela.

Figure 4 The hawksbill/loggerhead hybrid juvenile turtle sampled and released during this study (Photo credit: Peter Richardson/MCS).

Figure 5 A juvenile green turtle sampled during this study exhibiting fibropapilloma-like growths (Photo credit: Peter Richardson/MCS).

Chapter 6. “*Where Suzie At?”:* Stakeholder Perceptions Of Marine Turtle Tracking In The Turks and Caicos Islands.

Figure 1. Map of Suzie’s track showing that the turtle passed through Exclusive Economic Zones (EEZs) of the following countries; TCI - Turks and Caicos Islands, DO - Dominican Republic, USA - (Puerto Rico and the US Virgin Islands), BVI - British Virgin Islands, AXA - Anguilla, SX – Sint Maarten, KN - St Kitts and Nevis, AG - Antigua and Barbuda, FR - France, DM - Dominica, VE - Venezuela, CW – Curacao, CO - Colombia, HT - Haiti, and BS – Bahamas.

Table 1. Interviewee comment themes and number of interviewees making themed comments about the satellite tracking.

Supplementary table 1. Questions used to explore subject areas during the study interviews.

Supplementary table 2. Constituents of interviewee survey and number who made comments regarding the satellite tracking.

AUTHOR'S DECLARATION

This thesis forms part of collaborative work in which I coordinated or carried out all the fieldwork, carried out most analysis (see below), all interpretation of analysis and wrote all the chapter manuscripts. As my PhD supervisors, BJ Godley and AC Broderick provided appropriate supervisory guidance as well as constructive comment on drafts of all the manuscripts and chapters. Collaborators contributed aspects of the work as follows:

Chapter 2. Richardson PB, Broderick AC, Coyne MS, Ekanayake L, Kapurusinghe T, Premakumara C, Ranger S, Saman MM, Witt MJ and Godley BJ. Satellite Tracking Suggests Variability In Migratory Behaviour Of Female Green Turtles (submitted to Marine Ecology Progress Series).
This chapter describes work carried out during a collaborative project between the Marine Conservation Society (MCS), the University of Exeter (UoE) and the Turtle Conservation Project (TCP) in Sri Lanka. I carried out and coordinated the fieldwork, including the deployment of all satellite transmitters described in this study, and was lead author on the paper. M Coyne manages and coordinates the Satellite Tracking Analysis Tool used in this study. S Ranger (MCS) provided logistical support during the planning and implementation of the project, assisted with the figures and provided constructive comment on a draft of the manuscript. M Witt (UoE) provided the kernel analysis presented in this paper, assisted with the presentation of the tracking data and provided constructive comment on a draft of the manuscript. As leader of local project partner the TCP, T Kapurusinghe facilitated permission for the research from the Government of Sri Lanka and provided key in-country logistical support. As senior staff members of the TCP, L Ekanayake, C Premakumara and MM Saman provided key field support and assisted in the deployment of the satellite transmitters. All TCP staff listed above provided constructive comment on a draft of the manuscript.

Chapter 3. Richardson PB, Broderick AC, Coyne MS, Gore S, Gumbs JC, Pickering A, Ranger S, Witt MJ and Godley BJ. Leatherback Turtle Conservation in the Caribbean UK Overseas Territories: Act Local, Think

Global? Leatherback Turtle Conservation In The Caribbean UK Overseas Territories: Act Local, Think Global? (submitted to Marine Policy).

This chapter describes work carried out during a collaborative project between the MCS, the UoE and local Government partners. I coordinated the fieldwork, deployed the satellite transmitter in Anguilla, liased with leatherback turtle research projects in the region to collect and collate nesting leatherback tag recovery data and was lead author on the paper. M Coyne manages and coordinates the Satellite Tracking Analysis Tool used in this study. S Ranger (MCS) provided logistical support during the planning and implementation of the project, assisted with the figures and provided constructive comment on a draft of the manuscript. M Witt (UoE) assisted with the presentation of the tracking data and provided constructive comment on a draft of the manuscript. S Gore and A Pickering are senior officers in the Conservation and Fisheries Department, the key Government of the British Virgin Islands (BVI) project partner, and deployed the satellite transmitters in BVI as well as providing constructive comment on a draft of the manuscript. In addition, A Pickering provided key field support in Anguilla and assisted with the deployment of the satellite transmitter in Anguilla. J Gumbs is the Director of the Department of Fisheries and Marine Resources, the key Government of Anguilla project partner who provided key departmental and logistical support in Anguilla and provided constructive comment on a draft of the manuscript.

Chapter 4. Richardson PB, Broderick AC, Campbell LM, Godley, BJ and Ranger S (2006). Marine Turtle Fisheries in the UK Overseas Territories of the Caribbean: Domestic Legislation and the Requirements of Multilateral Agreements. Journal of International Wildlife Law and Policy 9:223-246.

This chapter describes work carried out during a collaborative project between the MCS, the UoE and Duke University, USA. I carried out the full review and assessment of national legislation and multi-lateral environmental agreements and was lead author on the paper. S Ranger (MCS) and LM Campbell (Duke) provided logistical support during the planning and implementation of the project and provided constructive comment on a draft of the manuscript.

Chapter 5. Richardson PB, Bruford M, Calosso M, Campbell LM, Clerveaux W, Formia A, Godley BJ, Henderson AC, McClellan K, Newman S, Parsons K, Pepper M, Ranger S, Silver J, Slade L and Broderick AC (2009). Marine turtles in the Turks and Caicos Islands: Remnant Rookeries, Regionally Significant Foraging Stocks and a Major Turtle Fishery. Chelonian Conservation and Biology 82:192-207.

This chapter describes work carried out during a collaborative project between the MCS, the UoE, Duke University, the University of Wales, Cardiff (UoW) and local partners. I coordinated all of the fieldwork, and carried out much of the capture, mark and recapture data collection, tissue sampling for genetic analysis, most of the socio-economic questionnaire interviews and was lead author on the paper. M Bruford and A Formia (UoW) provided the genetic analysis presented in the paper, drafted the text describing the analysis and provided constructive comment on a draft of the manuscript. M Calosso, AC Henderson, K McClennan, S Newman, K Parsons and M Pepper worked at the School for Field Studies and carried out some of the marine turtle capture, mark and recapture field data collection and provided constructive comment on a draft of the manuscript. Representing project partner Duke University, LM Campbell and J Silver provided key logistical support and carried out some of the social data collection through the socio-economic questionnaire interviews. Both provided constructive comment on a draft of the manuscript. As Director the Department for Environment and Coastal Resources (DECR) the key Government of Turks and Caicos Islands (TCI) partner, W Clerveaux provided key departmental and human resource support to assist with the field data collection. S Ranger provided logistical support during the planning and implementation of the project, carried out some of the field data collection, assisted with the figures and provided constructive comment on a draft of the manuscript. L Slade carried out the dive operator recording data collection and provided constructive comment on a draft of the manuscript.

Chapter 6. "*Where Suzie At?":* Stakeholder Perceptions Of Marine Turtle Tracking In The Turks and Caicos Islands.

This chapter will form part of a manuscript describing work carried out during an ongoing collaborative project between the MCS, the UoE, Duke University and local partners. I coordinated the fieldwork involved in this project, carried out *some of the workshop discussion events and wrote the chapter. S Ranger of the (MCS) provided logistical support during the planning and implementation of the project, assisted with the figure and provided constructive comment on a draft of the manuscript. LM Campbell and G Cumming (Duke) and project officer A Sanghera (MCS) planned and carried out the filmed interviews, with G Cumming drafting a first transcript of the recorded interviews and A Sanghera coordinating the majority of the subsequent workshop discussion events. A Sanghera and T Stringell (UoE) deployed the satellite transmitters described in this study and Q Philips, an officer with the DECR, provided key logistical support. In addition, LM Campbell and A Sanghera provided constructive comment on a draft of this chapter.*

CHAPTER 1. INTRODUCTION

Marine turtles are an ancient group of reptiles, first appearing in the fossil record of the Jurassic period, with ancestors of the two modern marine turtle families, *Cheloniidae* and *Dermochelyidae*, well established in the Cretaceous period (Pritchard 1997). Today there are seven extant species in the group including the flatback (*Natator depressus*) green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), Kemp's ridley (*Lepidochelys olivacea*), leatherback (*Dermochelys coriacea*) and loggerhead (*Caretta caretta*) turtles. Marine turtles have complex life histories, involving migrations between different developmental, foraging and breeding marine habitats (Carr et al. 1978, Meylan 1982, Limpus et al. 1992), while females of all species must return to sandy beaches to lay their eggs (Miller 1997).

Archaeological evidence suggests that humans have exploited modern day marine turtles for at least 7,000 years (Frazier 2003), and use of this animal group, both consumptive and non-consumptive, remains prevalent within cultures throughout their range (Campbell 2003). In the twentieth century, concerns about marine turtle population declines as a result of anthropogenic activities, including consumptive use, led to the listing of all seven species on the International Union for the Conservation of Nature (IUCN) Red list of Threatened Species (IUCN 2010). In addition, marine turtles are often protected under national legislation of range states, and in acknowledgement of their migratory nature, marine turtles have been listed in protective annexes of several multi-lateral environmental agreements (Wold 2002).

Much has been published on marine turtle biology and ecology (Frazier 2005), but gaps still remain in our knowledge of these animals, which present challenges to our understanding of how best to manage and conserve them (Hamann et al. 2010). Traditionally, marine turtle research has focused on the animals in the most accessible life stages, such as nesting females and hatchlings. In recent years, however, increasing use of biotelemetry has revolutionised our understanding of turtle behaviour at sea, and provided fascinating insights into migratory behaviour and the geographic ranges (Godley et al. 2008). These insights have led researchers to conclude that marine turtle conservation necessitates regional cooperation by range states (for examples see Blumenthal et al. 2006, Schillinger et al. 2008). It is clear that satellite tracking of marine turtles has clear potential to inform national and multi-lateral marine turtle conservation strategies.

In addition to facilitating a better biological understanding of the species, the method can also help elucidate the diversity of management and use policies implemented throughout the geographic range of this widely distributed animal group and offer insights into how management and use policies interact. Multi-lateral agreements (MEAs) aimed at facilitating marine turtle conservation through regional cooperation tend to facilitate conservation strategies that prohibit consumptive use (Wold 2002, Campbell 2007). Indeed, the incorporation of consumptive use of marine turtles in conservation strategies remains a controversial issue (Campbell 2000, 2002) and marine turtle researchers have identified understanding how this can be best achieved as a global research priority for conservation and management strategies (Hamann et al. 2010).

This thesis draws on separate, but related, studies in Sri Lanka and the Caribbean and aims to explore how contemporary research, including satellite telemetry, can inform national conservation policy. The aims, objectives and results of each chapter, along with an outline of the studies' contributions to marine turtle conservation and management are summarised as follows:

Chapter 2 - Satellite Tracking Suggests Variability in Migratory Behaviour of Female Green Turtles: With this research I aimed to further our understanding of the migratory behaviour of green turtles, as well as their conservation and management needs. My objectives included the attachment of satellite transmitters to ten turtles after they had nested at Rekawa Sanctuary, Southern Sri Lanka in order to elucidate post-nesting migratory behaviour and range. I aimed to use the tracking data to contextualise conservation efforts in Sri Lanka with respect to the management needs of this population throughout its range. Serendipitously, these data suggested size-related differences in post-nesting behaviours within this green turtle population, and for the first time provided insights into its geographic range. Although constrained by sample size, the study indicated that these size-related differences may be linked to adult foraging habitat, and recommended further study to fully understand this relationship. The study also confirmed that the population was largely using shallow inshore neritic habitats in Sri Lanka and India, which are fished by an expanding gill net fishery known to incur marine turtle bycatch. Therefore this study showed that while green turtles are protected by national legislation in Sri Lanka and India, the nesting population at Rekawa Sanctuary, one of South Asia's largest green turtle rookeries, may well require further conservation action in both countries with respect to further understanding fishing bycatch, and mitigation where necessary.

Chapter 3 - Leatherback Turtle Conservation in the Caribbean UK Overseas Territories: Act Local, Think Global? In this chapter I used satellite telemetry and flipper tag recovery data to refine the definition of the Northern Caribbean nesting population (NCNP) of leatherback turtles, and assess the utility of various conservation measures available to the UKOTs of Anguilla and British Virgin Islands that share this population. This included an assessment of relevant national and multi-lateral conservation policies within the range of the population; and suggested prioritisation of conservation measures within the UKOTs to contribute to the management of this population. The study confirmed that Anguilla and the British Virgin Islands (BVI) provide nesting habitat for the NCNP along with several other states within the Antilles. Additionally, and for the first time, we show that leatherbacks nesting in Anguilla migrate to foraging grounds in Canadian waters, and that leatherbacks nesting in the BVI use habitats in the waters of neighbouring states during inter-nesting periods. The study also suggested that while this leatherback population is shared across multiple range states, cost-effective conservation gains for the species would most likely be generated through national actions rather than through accession to potentially relevant MEAs. Multi-lateral action was recommended through only one regional MEA, as well as through a regional fishery management organisation with respect to fishery bycatch mitigation.

Chapter 4 - Marine turtle fisheries in the UK Overseas Territories of the Caribbean: Domestic Legislation and the Requirements of Multilateral Agreements: With this analysis I aimed to assess the compatibility of national legislation in the UK Overseas Territories (UKOTs) in the Caribbean (Anguilla, British Virgin Islands, Cayman Islands, Montserrat and the Turks and Caicos Islands), where there are traditional cultures of consumptive use of marine turtles, with MEAs applicable to marine turtle conservation in the region. The results suggest that the national legislation of all the UKOTs was, to some degree, incompatible with the requirements of the MEAs that each OT has acceded to. In addition, the study revealed that national legislation was generally incompatible with some relevant MEAs that the UKOTs had not yet acceded to. The study concluded with recommendations to amend the pertinent national legislation in each UKOT and suggested that accession to some additional MEAs may present unnecessary costs to UKOTs without generating significant conservation gain. This is the first study of its kind in the UKOTs and provided reasoned recommendations for legislative and policy amendments that would improve marine turtle management in the Territories and maintain traditional cultures of marine turtle use.

Chapter 5 - Marine turtles in the Turks and Caicos Islands: Remnant Rookeries, Regionally Significant Foraging Stocks and a Major Turtle Fishery: Using a multidisciplinary research approach, I aimed to provide an overview of the status and use of marine turtles in the Turks and Caicos Islands (TCI). My objectives included a review of historical and current accounts of marine turtles and their use in TCI; a broad assessment of the green and hawksbill turtle populations present in TCI waters; and an assessment of the levels of take involved in the traditional turtle fishery through socio-economic research. This chapter revealed that the TCI hosts regionally important populations of foraging green and hawksbill turtles, mostly juveniles that originate from nesting populations elsewhere in the region. The study also indicated that breeding populations in the TCI had declined and that the country’s turtle fishery was one of the largest in the insular Caribbean. This study provided the first comprehensive overview of marine turtles and their historical and contemporary use in the Turks and Caicos Islands and has been the basis for ongoing and collaborative marine turtle management work currently being carried out in the TCI.

Chapter 6 - "*Where Suzie At?":* Stakeholder Perceptions Of Marine Turtle Tracking In The Turks And Caicos Islands: This chapter draws on an ongoing multi-disciplinary project in the Turks and Caicos Islands, and aims to present and assess stakeholder perceptions of a satellite tracking study in a community with a traditional culture of marine turtle consumption. Community member perceptions of the tracking project were recorded opportunistically and analysed to assess the educational impact of the tracking project. This is the first study of its kind, and revealed that appropriate interpretation and promotion of satellite tracking data can have a significant educational impact on stakeholders, and in some cases can lead to changes in stakeholder perceptions of turtles as a resource, including provisional consideration of sophisticated cooperative management strategies. This study reveals a potential added value to satellite tracking studies, in that they can inform researchers and stakeholders alike and contribute to an equitable discourse amongst stakeholders regarding marine turtle management and conservation.

Other work

During the course of these studies I have also co-authored the following paper:

Campbell LM, Silver JJ, Gray NJ, Ranger S, Broderick AC, Fisher T, Godfrey MH, Gore S, Hodge KVD, Jeffers J, Martin CS, McGowan A, **Richardson PB**, Sasso S, Slade L and Godley BJ (2009). **Co-management of sea turtle fisheries: Biogeography versus geopolitics.** Marine Policy 33:p137-145.

CHAPTER 2.

(submitted for review to Marine Ecology Progress series as Richardson PB, Broderick AC, Coyne MS, Ekanayake L, Kapurusinghe T, Premakumara C, Ranger S, Saman MM, Witt MJ and Godley BJ (in review). Satellite Tracking Suggests Phenotypic Differences In Migratory Behaviour Of Female Green Turtles.)

SATELLITE TRACKING SUGGESTS VARIABILITY IN MIGRATORY BEHAVIOUR OF FEMALE GREEN TURTLES

Abstract

Variation in adult foraging strategies and migration have been determined in populations of Atlantic and Pacific loggerhead turtles (*Caretta caretta*) and suggested in Pacific green turtles (*Chelonia mydas*). We deployed satellite transmitters on ten nesting green turtles at the turtle rookery within Rekawa Sanctuary, Sri Lanka in 2006 and 2007. These turtles had curved carapace length (CCL) measurements representative of the breeding female population. One study animal migrated away from the rookery immediately after satellite-transmitter attachment, but those that subsequently nested demonstrated two internesting strategies. Most turtles (n = 6) consistently spent their internesting periods proximate (<2 km) to Rekawa Sanctuary. However, three of the smallest turtles (CCLs 90.1 cm, 95 cm and 97.1 cm respectively), travelled to and settled at shallow coastal sites approximately 16 km, 60 km and 38 km straight-line distance from Rekawa Sanctuary along the southern coast of Sri Lanka during subsequent, although not all, internesting periods. On completion of their breeding seasons, these three turtles returned to and settled at their respective local sites. In contrast, the six largest turtles (CCL range 101.2 cm - 117.5 cm), migrated to and settled at shallow coastal sites between 350 km and 1,128 km straight-line distance from Rekawa Sanctuary, moving either to the Gulf of Mannar region (n=4), or coastal waters off Karnataka, western India (n=2). One of the smallest study animals, with a CCL of 92.8 cm, did not conform to these patterns, but migrated to an oceanic atoll in the Lakshwadeep Islands, a straight-line distance of 898 km from the rookery. This turtle made frequent, looping pelagic forays from the atoll for 42 days before transmissions ceased. We discuss these variations in behaviour and the conservation concerns within the range of this population as revealed by this study.

Introduction

Large marine vertebrates are characteristically widely dispersed within expansive ranges, and documenting their behaviour at sea therefore presents considerable logistical difficulties (Block 2005). In recent decades, the study of adult marine turtle behaviour at sea has been revolutionised by the application of satellite telemetry, usually deployed at nesting beaches where females are most accessible (Godley et al. 2008). This technology has provided intriguing insights into the use of breeding, migration and feeding habitats and informs conservation and management by assisting in the identification of threats to individuals and habitats throughout their range (James et al. 2005, Peckham et al. 2007, Saba et al. 2008, Schillinger et al. 2008, Witt et al. 2008, 2011).

Green turtle satellite tracking studies have largely confirmed the earlier findings of seminal flipper tag (Carr et al. 1978, Limpus et al. 1992, Hirth 1997, Miller 1997) and genetic studies (Meylan et al. 1990, Allard et al. 1994, Bowen et al. 2004, Bowen et al. 2007) that suggested this species exhibits high levels of nesting and foraging site fidelity (Blumenthal et al. 2006, Broderick et al. 2007). Satellite telemetry has also, however, revealed hitherto undescribed plasticity in life history strategies that has profound management implications. Female turtles may employ multiple internesting strategies, with some individuals remaining close to the rookery and others undertaking extensive oceanic loops (Blumenthal et al. 2006, Rees et al. 2010). Satellite tracking has also revealed multiple migration and foraging strategies. Hatase et al. (2002) and Hawkes et al. (2006) found size-related differences in foraging strategies within loggerhead turtle (*Caretta caretta*) populations from Japan and Cape Verde, respectively. Smaller individuals were found to forage in oceanic habitats (>200 m depth) whereas larger individuals appeared to be confined to shallow, inshore neritic habitats.

Multiple foraging strategies in female green turtles (*Chelonia mydas*) have also been detected. Nesting females in Japan (Hatase et al. 2006) and the Galapagos Islands (Seminoff et al. 2007) use either neritic or pelagic foraging habitats after completing their nesting season, with some individuals in the Japanese population utilising both habitat types. Hatase et al. (2006) detected no size-related differences between foraging strategies, but it is worth noting that in the Galapagos Islands study involving 12 satellite-tagged green turtles, the two smallest individuals remained within local neritic habitats after nesting, while the other, larger turtles migrated to distant foraging sites (Seminoff et al. 2007). Local residency as an alternative strategy to long distance migration has also been recorded in green turtles nesting in the oceanic Cocos (Keeling) Islands (96.875°E 12.166°S) (Whiting et al. 2007). In that study six female green turtles (mean ± SD = 107.8 ± 2.3 cm; range 105.4 - 110.8 cm) satellite tracked after nesting on the Northern Atoll, all settled at a neritic foraging site within the Southern Atoll lagoon some 35.5 km away.

Five species of marine turtle have been recorded in Sri Lanka's waters, including the green turtle, which is the species most commonly encountered nesting in the country (Ekanayake et al. 2002, Kapurusinghe 2006). While these marine turtle populations were amongst the first to be described in the scientific literature (Derayanagala 1939), little is known about their range and movements. Despite protection under national legislation since 1972, marine turtles in Sri Lanka have been, and continue to be, exposed to a range of anthropogenic threats including directed take, egg collection, nesting beach development and incidental fisheries bycatch (Hewavisenthi 1990, De Silva 2006, Kapurusinghe 2006). To address local conservation concerns, conservation efforts in the late 20th century focused on protection of nesting females and their eggs at the country's main rookeries (Kapurusinghe 2006). Focusing efforts on nesting beaches can address some terrestrial conservation concerns, but in order to better inform national and regional conservation efforts, there is a clear need to understand the range and behaviours of these turtles at sea, where they spend the majority of their lives.

Here we describe the results of Sri Lanka's first satellite tracking study on marine turtles, which focused on green turtles (*Chelonia mydas*) nesting at the Rekawa Sanctuary on the southern coast. We sought to describe internesting behaviour and post-nesting migrations, and aware of the relatively large size range within the population, we attempted to gain fundamental and applied insights into any size-related differences in behaviour.

Study site and methods

Ten adult female turtles were fitted with Kiwisat 101 satellite transmitters (Sirtrack Ltd, New Zealand) after they nested at Rekawa Sanctuary (RS; designated in 2006) in Tangalle Bay on the southern coast of Sri Lanka (80.851°E 6.045°N – Figures 1 and 3) during two tagging sessions in July/August 2006 and June 2007 (Supplemental Table 1). Approximately three kilometres of the beach within RS are regularly patrolled each night and throughout the year, and the curved carapace lengths (CCL) and widths (CCW) of nesting female turtles are measured with flexible measuring tapes. Up until the end of December 2006, turtles were either double or single flipper-tagged with titanium tags in the front flippers (after Balazs, 1999). Since January 2007, tagging of nesting turtles at the RS has been more sporadic due to logistical constraints. Nesting activities occurring within the RS and beyond the patrolled area are recorded during daylight patrols the following morning.

Green turtles nest at RS throughout the year, with the seasonal peak in green turtle nesting between March and May (Ekanayake et al. 2002, Kapurusinghe 2006; Figure 2a). Transmitters were deployed after this seasonal peak to increase the chances of tracking complete post-nesting migrations to foraging sites while minimizing any biases that may have been exerted by deploying at the end of the season (Godley et al. 2008, Rees et al. 2010). The transmitters were fixed directly to the highest point of the carapace using two-part marine epoxy (Powerfast™, Powers Fasteners Inc, USA) after the selected females had been measured and had started to cover their nest sites following oviposition. The tag and epoxy attachment were then painted with anti-foulant paint before the turtles were released.

Location data were received from Service Argos. The online Satellite Tracking and Analysis Tool (STAT; Coyne & Godley 2005) was used for managing the data, creating base maps and data parsing for all the turtles tracked during this study. Movements were reconstructed using Argos location classes (LC) 3, 2, 1, A and B, as these location classes can be reliable when subject to adequate filtering (Costa et al. 2010, Witt et al. 2010). A speed filter that removed locations suggestive of minimum travel speeds greater than 5 km h^{-1} was used, and azimuth filtering (minimum threshold 25^{o}) was applied when the turtles were travelling between habitats, but not when the turtles were deemed to be at either internesting or foraging sites. Location data were mapped and examined to determine nesting activities at RS, internesting periods, migrations and foraging site residency. The nesting emergences at RS were determined from interpretation of the telemetry data, which in most cases was combined with ground-truthed confirmation via the nocturnal beach patrols (see Tucker 2010). Spatial 2-dimensional Kernel Analyses were derived during periods of residency at internesting and foraging sites for those turtles with sufficient tracking data, using custom script generated in Matlab™ (Mathworks, USA).

Results

The ten green turtles tracked did not differ significantly in size (median = 104.35 cm; range 90.1 - 117.5cm) from the 200 flipper tagged nesting green turtles measured within RS during 2006 and 2007 (median = 104.1 cm; range 84.3 - 118.0 cm; Mann–Whitney $U = 955.5$, $n_1 = 10$, $n_2 = 200$, $P = 0.812$ two-tailed). Satellite tags were applied to turtles in all but the smallest classes (80 to 89.9 cm) (Figure 2b).

Internesting strategies

A summary of the biometrics and behaviours of study animals is summarised in Supplemental Table 1. While turtle 1 began a post-nesting migration immediately after satellite transmitter attachment, the other nine turtles nested at least once more at RS after their tags were attached. Turtles employed two different internesting strategies. Six turtles (turtles 2 - 6 and 10) remained proximate to RS (Figure 3a). Of these, the internesting centroids of turtles 2, 3 and 6 were located within the marine boundary of RS, which extends 500m out to sea from the high tide line.

However, turtles 7, 8 and 9 spent at least some of their internesting periods at Sri Lankan sites some distance from RS. Turtles 7 and 9 spent their first internesting periods immediately after attachment of satellite transmitters within the RS marine boundaries (Figure 3a). However, during a subsequent internesting period, turtle 7 moved westwards to a coastal site (near Habbaraduwa – 80.29°E 5.99°N) approximately 60 km straight-line distance from RS. Turtle 9 moved eastwards to a coastal site (near Ussangoda - 80.98°E 6.08°N) some 16 km straight-line distance from RS during both subsequent internesting periods. Turtle 8 consistently travelled eastwards after nesting and settled at a coastal site (near Bundala - 81.18°E 6.15°N) some 38 km straight-line distance from RS during all four subsequent internesting periods (Figure 3b).

Migration

After completing their nesting season at RS, all turtles travelled to foraging sites within four distinct geographic areas as shown in Figure 1, where they were tracked for an additional 24 to 136 days (mean ± SD = 56.1 ± 33.9) before their transmissions ceased.

Turtles 7, 8 and 9 migrated to and settled at the same sites along the southern coast of Sri Lanka that they used as internesting sites (Figure 3b). Kernel analyses of the tracking locations received from the foraging sites of turtles 8 and 9 (Figures 5e and 5f), suggest they foraged in discrete, shallow inshore areas (see also Table 1). These three turtles, from here collectively described as ‘resident breeders’, were among the smallest turtles satellite tagged in this study (Figure 2c).

The other seven turtles (1 – 6 and 10), which we collectively call ‘migrant breeders’, all travelled to distant foraging sites within three distinct geographic areas. Six of the seven migrated through coastal waters to get to their respective neritic foraging sites. Turtles 1 - 4 migrated northwards along the western coast of Sri Lanka to sites in the Gulf of Mannar (Figure 4a). Turtle 4 settled at an offshore site close to Mannar Island on the Sri Lankan shore of the Gulf. Kernel analysis of the locations at this site (Figure 5c) suggests that this individual moved between three distinct, yet proximate, sites in waters less than 10 m in depth. Turtles 1,2 and 3 settled at sites within the Gulf of Mannar Marine National Park within the Gulf of Mannar Biosphere Reserve off the coast of Tamil Nadu, India (Kumaraguru et al. 2006). Kernel analyses for turtles 1 and 2 (Figures 5a and 5b) suggest that turtle 2 occupied a discrete, shallow neritic area immediately south of Thalaiyari Island (79.068°E 9.202°N; Figure 4a and Table 1), whereas turtle 1 occupied a larger shallow, neritic area immediately south of neighbouring Muyal Island (78.920°E 9.183°N; Figure 4a and Table 1) to the west. Turtle 3 occupied a shallow, neritic area between Thalaiyari Island and Appa Island (78.827°E 9.166°N; Table 1). These four turtles were amongst the largest turtles satellite tagged in this study (Figure 2c).

Turtles 5 and 6 migrated the furthest from RS (1,128 km straight line distance). Both turtles travelled northwards along the west coast of Sri Lanka before crossing the Gulf of Mannar. They then migrated northwards through over 700 km of India's western coastal waters to settle close to Shirali Island (74.481°E 14.009°N; Figures 1 and 4b), located approximately 2.5 km south west of the Shirali River mouth, in the state of Karnataka. On arrival at Shirali Island, the transmitter attached to turtle 5 sent only five higher accuracy at-sea locations (location classes A and B) over a 56 day period, which was only enough to confirm its general location. However, the kernel analysis of turtle 6 (Figure 5d) shows that this turtle foraged in a discrete, shallow inshore area around Shirali Island for 48 days before the transmitter failed.

The post-nesting movements of Turtle 10 were unlike those of any of the other study animals. After leaving Sri Lanka's southwest coast, this animal crossed deep ocean in the Gulf of Mannar and the Laccadive Sea before arriving at Minicoy (73.063°E 8.287°N; Figures 1 and 6), the southernmost atoll of the Lakshwadeep Archipelago. On reaching Minicoy, this turtle consistently performed pelagic (presumed foraging) loops of up to approximately 65 km straight-line distance from the atoll for 39 days, with 90% ($n = 81$) of locations transmitted from water of depths greater than 1000 m. Before transmissions ceased, this turtle travelled 135 km due west of Minicoy over three days, and it is likely that the turtle was migrating away from the atoll. This turtle was amongst the smallest of the turtles satellite tagged during this study (Figure 2c).

In general, there was a tendency for larger individuals to migrate further, but this was not a significant trend (Spearman's Rank Correlation $R_s=0.372$, $p=0.290$). Of more interest is the suggestion of clustering when the data are visualised as in Figure 2c. The clustering was less apparent at Karnataka, the site most distant from RS, but in general the local foraging sites on the southern coast of Sri Lanka hosted the smaller study animals, whereas the sites in the Gulf of Mannar hosted the larger study animals.

Discussion

The increasing geographic scope of marine turtle satellite telemetry studies is affording ever-greater insights into marine turtle behaviour, with behavioural plasticity an emerging theme (Godley et al. 2008). Our study adds to these findings and clearly revealed multiple internesting strategies, migration behaviours and foraging strategies for green turtles nesting in Sri Lanka.

Variation in internesting behaviour

The study animals showed two general internesting strategies, clearly linked to the location of their foraging sites. Migrant breeders internested proximate to the nesting beach, while resident breeders used their local foraging sites during all or some of their internesting periods. Gravid green turtles may forage during internesting periods where suitable forage is available (Tucker & Read 2001, Hays et al. 2002) and we suggest that Sri Lanka's resident breeders forage during their internesting periods. Given that the majority of the study animals internested proximate to RS, it is probable that forage close to the nesting beach is subject to high levels of intraspecific pressure during the nesting season. Use of local and familiar neritic sites by resident breeders during the nesting season may, therefore, present benefits to these smaller turtles. Potential benefits may include a reduction of net energetic costs of nesting as a result of better foraging opportunities during the season, and reduced vulnerability to predators due to local knowledge of resting sites at the resident breeders' foraging sites.

Variation in migration patterns

The study animals migrated to foraging sites within four distinct geographical areas located in the territorial waters of Sri Lanka (n=4) and India (n=6). The group showed three distinct post-nesting migration strategies as described by Godley et al. (2008), with the resident breeders showing "local residence" (Type A3), and the migrant breeders undertaking oceanic and/or coastal movements to neritic foraging grounds (Type A1). Turtle 10 undertook a pelagic Type B post-nesting movement, albeit in association with an oceanic atoll.

There was a distinct westward bias to the locations of the study animals' foraging grounds relative to the RS, which is reflected by other regional flipper tag return records from green turtles flipper-tagged in Sri Lanka. For example, an adult female green turtle flipper-tagged at Rekawa Sanctuary (RS) in June 2005, stranded dead on Agatti in the Lakshwadeep Islands (72.193°E 10.856°N; Figure 1) in July 2009 (BC Choudhury pers. comm.). In addition, green turtles bearing Sri Lankan flipper tags have been captured by fishers in the waters of Republic of Djibouti in the western Indian Ocean (Al-Mansi et al. 2003).

As has been found elsewhere (Godley et al. 2010, Hays et al. 2010), this bias is likely due to the important role that oceanic current systems play in the distribution of turtles to developmental feeding grounds in the region. During the summer months, and coinciding with the peak green turtle hatching season at RS (June to September), the southwest monsoon current (SMC) flows eastwards off the south coast of Sri Lanka, turning northward into the cyclonic Sri Lanka Dome system to the east of the island (Schott and McReary 2001; Figure 7a). Green turtle hatchlings from RS are likely held in this Sri Lanka Dome system until October, when the regional current system reverses and the Sri Lanka Dome dissipates with the onset of the northeast monsoon (Schott and McReary 2001; Figure 7b). The East India Coastal Current (EICC) then flows southwards, joining the northeast monsoon current (NMC), which flows westwards along the south coast of Sri Lanka through to February. Most hatchlings held in the Dome system, and all those emerging from RS from October through to February, will therefore be carried westwards. West of Sri Lanka, the NMC then flows northwards into a cyclonic Laccadive High in the Laccadive Sea and the northward flowing Western Indian Coastal Current, with some flow westwards into the Arabian Sea (Schott and McReary 2001). Green turtle hatchlings from RS likely spend their pelagic drift years either being distributed around the Arabian Sea, or within the monsoon driven current systems that flow around the Indian continental shelf, the Lakshwadeep Islands and southern Sri Lanka, before they settle in developmental neritic habitats.

Some hatchlings may well leak from this system to into the Bay of Bengal to the east of India where they may eventually settle at neritic habitats. This is likely the case with the only long-distance Sri Lankan green turtle flipper tag recovery reported eastwards of the country, an adult female (CCL, 101.0 cm) that stranded dead in the Phang-Nga Province on the west coast of Thailand in July 2009 (Ekanayake et al. In press). The animal was flipper tagged in May 2008 at Kosgoda (80.023°E 6.344°N; Figure 3b), the only other turtle rookery in Sri Lanka where adult green turtles are systematically flipper-tagged.

Variation in foraging behaviour and habitats

Adult female green turtles typically show high levels of fidelity to neritic foraging sites (Limpus et al. 1992, Broderick et al. 2007), where they settle after post-nesting migrations and consistently utilise discrete areas of habitat (Bjorndal 1997, Godley et al. 2002; for exceptions, however, see Seminoff et al 2002, Godley et al 2003). The relatively short tracking periods for most of our study animals, once they had settled at their foraging sites (24 to 136 days), means that the data should not be over-interpreted. Nevertheless, nine of the study animals exhibited behaviour typical of adult green turtles, foraging at shallow neritic sites where they will likely have been feeding on seagrasses and algae.

As has also been recorded elsewhere (Troeng et al. 2005, Hatase et al. 2006, Seminoff et al. 2007), this study found that some female green turtles utilise pelagic foraging habitats. Pelagic foraging green turtles largely feed relatively close to the surface (<100 m depth) on species of macro-plankton (Hatase et al. 2006) such as siphonophores, which have been recorded in the seas around the Lakshwadeep Islands (Madhupratap et al. 1977). Indeed, the ocean around Minicoy is considered highly productive due to local oceanographic features, such as the presence of divergence and convergence zones, anti-cyclonic eddies and deep-water upwellings adjacent to the atoll (Mathew & Gopakumar 1986). Interestingly, turtle 10 appeared to spend very little time in Minicoy's extensive lagoon where seagrass abundance is high and foraging green turtles have been recorded (Tripathy et al. 2006), or on the atoll reefs, which are reported to be recovering well from the 1998 El Nino and also host diverse communities of macro-algae (Untawale & Jagtap 1984, Tamelander & Rajasuriya 2008). This turtle was 135 km away from Minicoy heading due west into the deep ocean when transmissions ceased. It is therefore possible that this turtle foraged temporarily in the productive waters surrounding the atoll as part of a longer migration to more distant foraging grounds.

Size related differences

The foraging ecology of marine turtles, including foraging ground selection, is poorly understood (Bjorndal, 1997). The clustering of data in relation to turtle size and displacement from Rekawa Sanctuary (RS) suggests that either females of different size differentially select foraging sites within the four geographic locations, or that habitat qualities exact an influence on body size. Growth in wild green turtles is considered to be negligible, or sharply reduced, at the onset of sexual maturity (Bjorndal 1982, Limpus 1993, Hirth 1997, Broderick et al. 2003), but little is understood about the interrelationship between foraging habitats and size at maturity.

Resident breeders were amongst the smallest of our study animals. Although the exact nature of their foraging sites is unknown, inshore habitat along the south coast of Sri Lanka is typified by rocky boulder and ridge reefs with limited coral cover and dominated by macro-algae communities (Rajasuriya et al. 1998). The coral within these reef systems suffered 90% bleaching during the 1998 El Nino event, and subsequent recovery has been poor (Tamelander & Rajasuriya 2008). The few seagrass pastures found along the south coast thrive only in surf-sheltered, near-shore lagoons rather than the exposed inshore sites used by the resident breeders in this study (Coppejans et al. 2009). Green turtles are commonly encountered foraging on these inshore macro-algae-dominated, degraded reef habitats along Sri Lanka’s south west coast. For example, PR observed a group of at least ten adult and juvenile green turtles foraging in this habitat type within the Hikkaduwa Marine Sanctuary, Sri Lanka (80.10°E 6.13°N; Figure 3b) in February 2009. The group included a wild, but tame, adult female (103.2 cm CCL) that was regularly hand fed macro-algae (*Ulva* sp; Coppejans et al. 2009) by local men who claimed the turtle had been resident there for at least four years. The turtle bore a flipper tag attached in June 2004 after it nested at Kosgoda (Figure 3b) some 25 km to north of the Hikkaduwa Marine Sanctuary, and so was also a Sri Lankan resident breeder. It is highly likely that the resident breeders tracked from RS in this study were also foraging on macro-algae dominated inshore rocky reef habitats typically found along the southern Sri Lanka coast.

In the Galapagos Islands, Seminoff et al (2007) suggest that the size at maturity of resident breeders, also the smallest in their study, was affected by the quality of the local forage, most likely heavily grazed inshore macro-algae communities (Carrion-Cortez et al. 2010). Hatase et al (2002) also suggest that poorer food availability as a reason for the smaller body size of the pelagic foraging loggerhead turtles compared to neritic foraging turtles. In contrast, Hatase et al (2006) found no size difference between female green turtles presumed foraging on macro-algae in inshore neritic habitats and those presumed foraging on macro-plankton foraging in pelagic habitats. Sample size constraints preclude further interpretation other than noting that in this study, the pelagic foraging turtle 10, most likely feeding on macro-plankton, was within the same, smaller size classes as the resident breeders likely feeding on macro-algae.

In contrast, the turtles foraging in the Gulf of Mannar were all larger animals with CCLs well above the RS population mean. Turtle 4 settled at an unknown shallow, neritic site off Mannar Island, while turtles 1, 2 and 3 all settled at shallow, neritic sites associated with small islands within the Gulf of Mannar Biosphere Reserve (GoMBR). The Reserve was declared in 1989 in order to preserve the abundant and biodiverse marine habitats found within its boundaries, including some of the richest seagrass pastures and coral reef systems in Indian waters (Jagtap 1991 & 1996, Kumaraguru et al. 2006, Tamelander and Rajasuriya 2008). Recent remote sensing of benthic habitat around Muyal Island, the foraging site of turtle 1, confirms that this animal’s core foraging area included a rich complex of different habitats, including coral reef, macro-algae communities associated with coral reefs, and sparse and dense seagrass pastures (Thangaradjou et al. 2008). These habitats typify the surrounding benthos of the neighbouring islands where turtle 2 and 3 settled (Kumaraguru et al. 2006, Umamaheswari et al. 2009). The GoMBR foraging sites therefore present these turtles with a rich array of forage, including extensive seagrass pastures, which may well facilitate a larger size at maturity for the green turtles resident there.

Finally, turtles 5 and 6 travelled to Shirali Island off Karnataka, some 1,128 km away from RS, and were also among the larger individuals. Little is known about this site. In May 2010, PR made a brief field visit to Shirali Island and visited the nearby fishing village of Tengenagundi (74.504°E 14.026°N; Figure 4b) to gather information from local fishermen. Underwater visibility adjacent to and within one kilometre of the island was less than one metre, and local fishers reported constant high levels of turbidity throughout the year due to the proximity of the Shirali River mouth. The turbidity prevented detailed examination of the benthos by surface snorkelling, but extensive light-dependent seagrass or coral reef growth is unlikely at this site.

Conservation Implications

Protection of nesting female turtles and their nests, including concerted flipper tagging, was initiated at Rekawa in 1996 (Ekanayake and Kapurusinghe, 2000, Kapurusinghe 2006). Despite these efforts, trends in the population of green turtles nesting at RS remain unknown, although a future decline in numbers is expected as a result of decades of poor recruitment resulting from intensive egg harvest prior to the implementation of protection measures on the beach (Mortimer 1995 & 1997, De Silva 2006, Kapurusinghe 2006). Protection of the remaining adult female turtles using RS will therefore be important to facilitate population recovery. By providing insights into the marine behaviours and habitats of these turtles, this study informs our understanding of threats they may face during internesting, migration, and at foraging sites.

It has been widely documented that gill nets incur significant marine turtle bycatch globally (Wallace et al. 2010b) and in the coastal seas utilised by the study animals (Kapurusinghe and Cooray 2002, Bhupathy and Saravanan 2006b, Shanker and Choudhury 2006, Rajagopalan et al. 2006). Marine turtle bycatch has been recorded in Sri Lanka's gill net fisheries since the 1980s (Hewavisenthi, 1990). A more recent survey of turtle bycatch carried out at 16 major fishing harbours along the west and south coasts of Sri Lanka between November 1999 and November 2000 recorded 5,241 incidents of turtle bycatch, including 908 cases involving green turtles (Kapurusinghe & Cooray 2002). Since then, Sri Lanka's mechanised fishing effort has increased by 84% (Ministry of Fisheries 2009), with boats mostly deploying gillnets within 5 nm of the coast (De Bruin et al. 1994, Dissanayake 2005). Green turtle bycatch was recorded by the gillnet fishery operating out of Tangalle, (80.799°E 6.024°N) the nearest large commercial fishing to RS, lying 6.5 km straight-line distance westwards across Tangalle Bay. Since then the number of mechanised fishing boats operating out of the Tangalle district has increased by 23% to 1,461 boats in 2009 (Ministry of Fisheries 2009). This increase in local fishing capacity may well represent an increased threat to green turtles internesting beyond the RS marine boundaries, as well as those turtles travelling to and from the rookery. Furthermore, all migrant breeders in this study travelled through coastal waters of Galle district on the south west coast where Kapurusinghe and Cooray (2002) recorded 2,055 incidents of turtle bycatch from boats operating out of Galle Harbour, including 473 records of green turtles. The number of mechanised fishing vessels has since increased by 44% to 1,262 boats registered in 2009 (Ministry of Fisheries 2009). Some of the migrant breeder study animals travelled through coastal waters of western Sri Lanka's other large fishing districts where Kapurusinghe and Cooray (2002) also recorded green turtle bycatch and where mechanised fishing capacity has also increased since their survey (Ministry of Fisheries 2009). Migrant breeders passed through district waters of Matara (1,470 boats, increase of 45%), Kalutara (856 boats, increase of 69%), Colombo (398 boats, increase of 95%), Negombo (2,667 boats, increased of 95%), Chilaw (2,015 boats, increase of 26%) and Puttalam (3,194 boats, increase of 40%). The significant increase in the capacity of local fleets setting gillnets along coastal migration routes clearly presents a potential threat to the green turtle population nesting at RS.

Fishing effort has also significantly increased in India's coastal waters in recent decades, where Rajagopalan et al. (2006) report a 428% increase in motorised craft between 1980 and 1998, with a concurrent 610% increase in the use of drift and set gill nets. Several migrant breeders travelled through the coastal waters of Indian states where turtle bycatch is prevalent, including Tamil Nadu (turtles 1-3, 5 and 6) and Kerala (turtles 5 and 6) (Rajagopalan et al. 2006). There is little information about turtle-fishery interaction in Karnataka's coastal waters (Rajagopalan et al. 2006). However, during PR's visit to Shirali Island at least 25 bottom trawlers were fishing from approximately one kilometre seaward from Shirali Island, and fishers at Tengenagundi reported occasional bycatch of juvenile and adult green turtles in this fishery. Clearly, the conservation of the green turtle population nesting at RS depends on national conservation efforts in India, as well as Sri Lanka, with further research prioritising the investigation and mitigation of turtle interactions with the rapidly expanding coastal fisheries in both countries.

Sri Lanka's nesting green turtles have been and continue to be subject to directed take at some foraging sites. An estimated at 3,000 to 4,000 green turtles were caught annually for export and domestic consumption in the 1960s (Jones & Fernando 1973). While this practice is now illegal in India, occasional directed take of green turtles continues in the Gulf of Mannar Biosphere Reserve involving adult animals as well as other size classes (Bhupathy and Saravanan 2006a, Murugan and Naganathan, 2006, Kannan 2008). In the Lakshwadeep Islands, foraging green turtles, including adults, are illegally captured for their oil, which is used as a caulking agent on traditional fishing boats on some Islands (Tripathy et al. 2006, Tripathy & Choudhury 2007). On Agatti Island, green turtles are occasionally, and illegally, caught and killed by fishers in the atoll lagoon who believe that recent increases in local green turtle populations are leading to overgrazing of seagrass meadows and consequent reduction in populations of target lagoon fish species (R. Arthur, pers. comm. 2010; Lal et al. 2010). Clearly there is a need to understand the current nature and extent of these directed takes and their impact on the population of green turtles nesting on Sri Lanka's shores.

In addition, conservation managers must also consider the chronic effects of human activity on critical habitat. Development of the nesting habitat at Rekawa is now prohibited under the rookery's statutory Sanctuary status. However, human activities such as coral mining and pollution continue to degrade inshore reef habitats along Sri Lanka's south coast (Tamelander and Rajasuriya 2008). Thangaradjou et al. (2008) cite destructive and commercial exploitation of ornamental shells, boat anchoring and coastal pollution in seagrass habitat as reasons for observed reductions of 18% dense seagrass and 38% sparse seagrass cover over four years within their study area in the Gulf of Mannar Biosphere Reserve, which included the foraging site of turtle 1. In addition to the more traditional conservation approach of nesting beach protection, the recovery of the green turtle population nesting at RS may well require measures to conserve critical foraging habitats, such as those identified by this study.

Research priorities

This study provides the first insights into the marine behaviour of Sri Lanka's nesting green turtle populations and sheds light on anthropogenic threats that conservation managers should consider throughout the turtles' range. We acknowledge that this work is constrained by sample size and further work is required to further elucidate the exact nature of these threats. A number of additional questions are raised by our findings that would be worthy of further investigation using a suite of contemporary methodologies. In particular, the size-linked differences in foraging and migratory strategies employed by different female green turtles as indicated by this study could be elucidated by the use of stable isotope analysis and further tracking (Hatase et al. 2006, Zbinden et al. 2011). In addition, these methods coupled with oceanographic current modelling would provide insights into population distribution mechanisms (Godley et al. 2010, Hays et al. 2010), while genetic stock analysis of adult females at Sri Lanka's nesting beaches and green turtles at the various foraging grounds identified by this study would start answering questions pertaining to population range, natal homing and foraging site selection of the different size classes (Bowen et al. 2007, Bowen and Karl 2007).

Through satellite telemetry, this study has, however, underscored the fact that the traditional approaches to marine turtle conservation on Sri Lanka's turtle rookeries represent only a part of a suite of regional conservation and management measures necessary to facilitate the recovery of Sri Lanka's nesting green turtle populations.

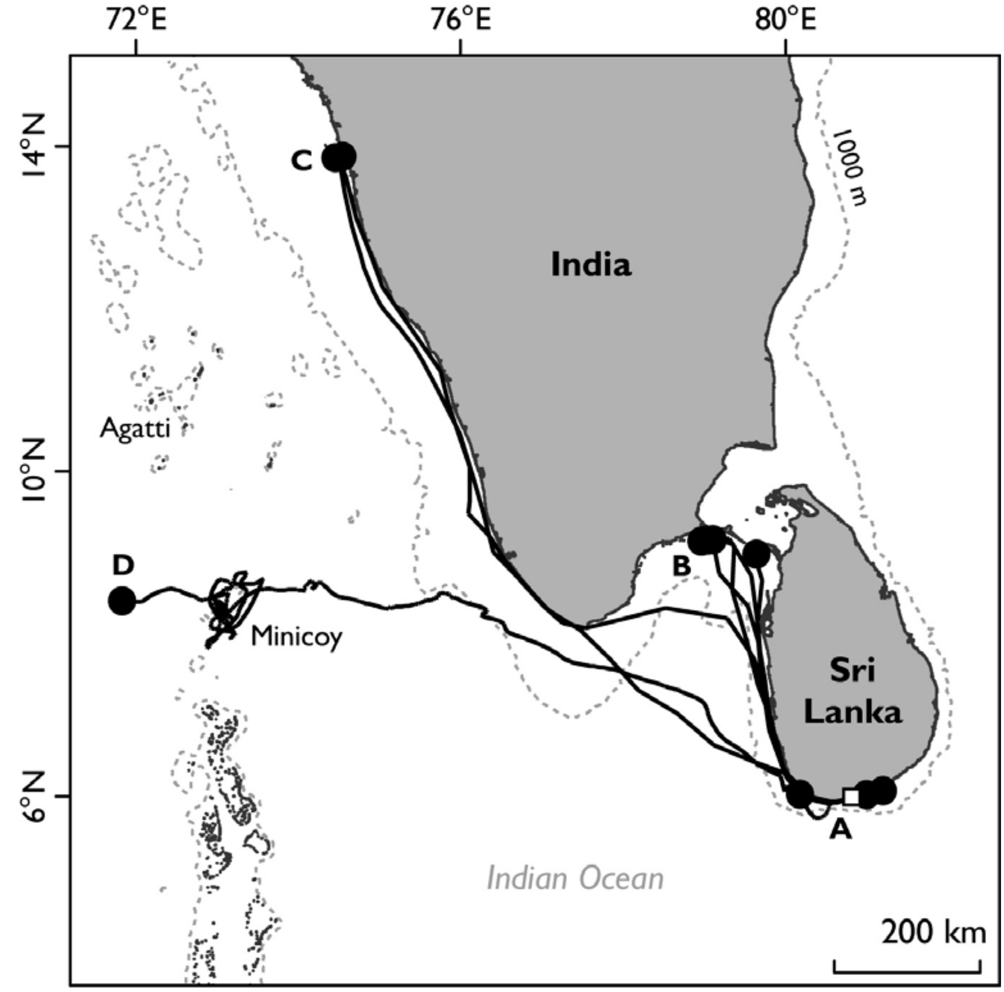


Figure 1. Migrations of the 10 green turtles in this study from Rekawa Sanctuary (white square) to four geographic areas, **A**, Southern Sri Lanka (n = 3 turtles), **B**, Gulf of Mannar (n = 4 turtles), **C**, Karnataka (n = 2 turtles) and **D**, Lakshwadeep Islands (n = 1 turtle). Agatti Island is also shown, where a dead female green turtle stranded that had been previously flipper-tagged at Rekawa Sanctuary.

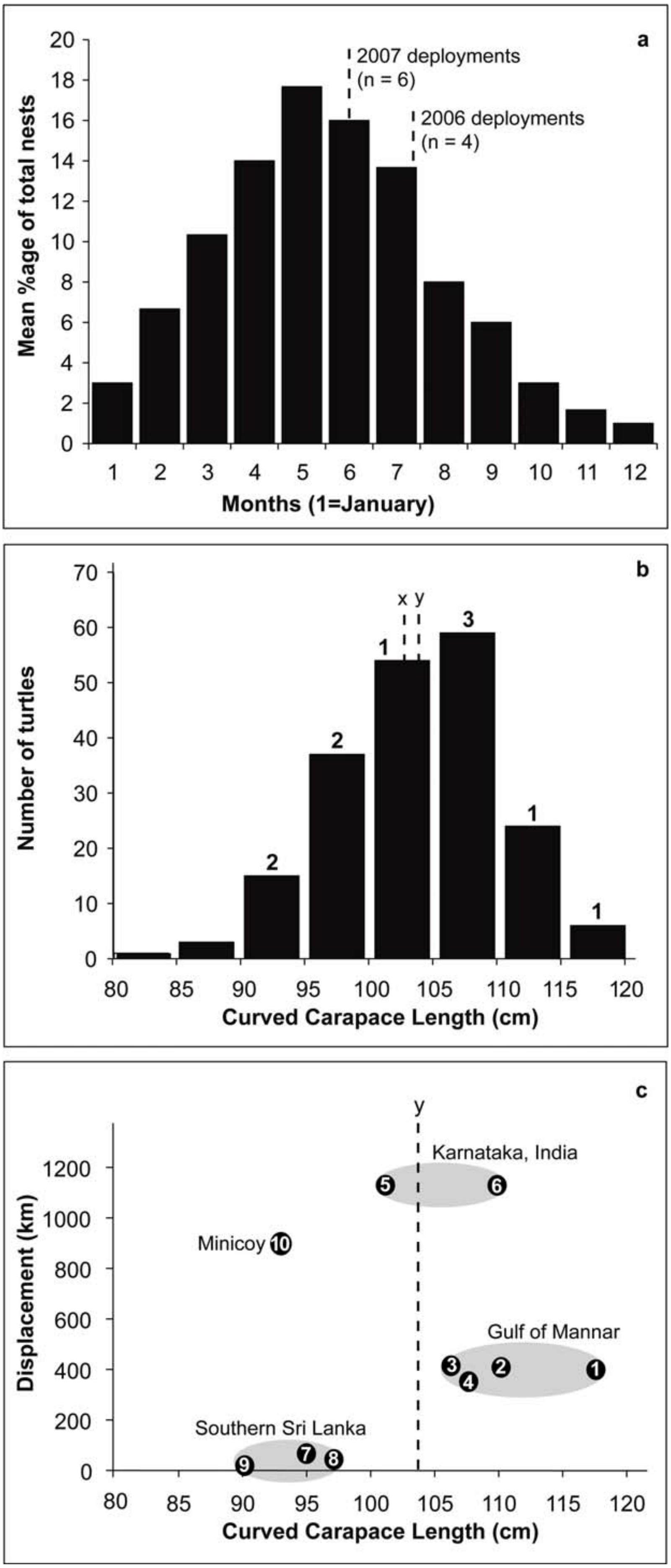
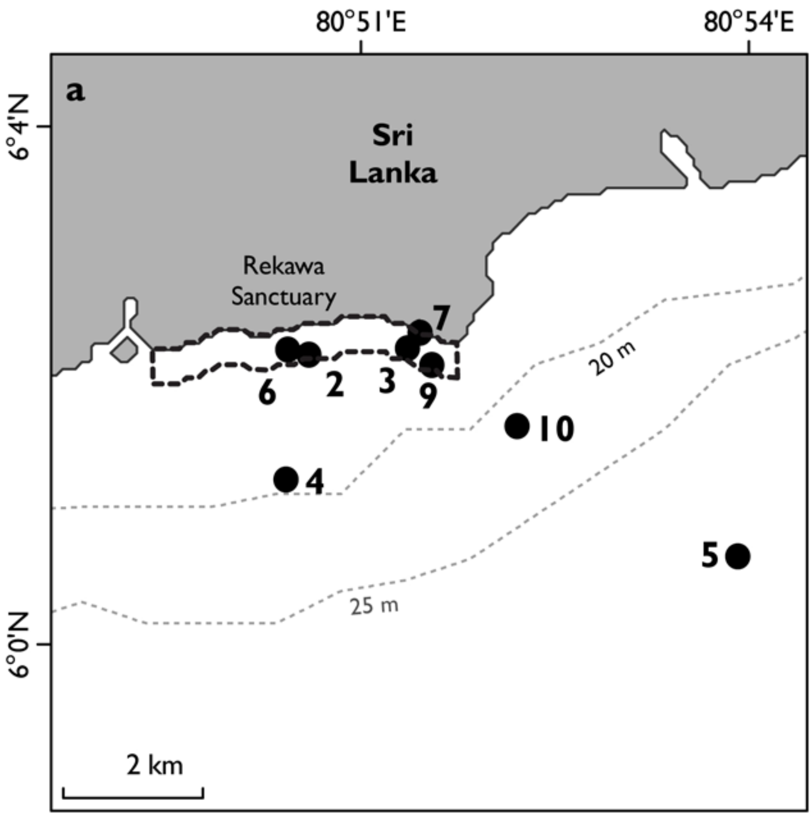

a
Mean %age of total nests
Months (1=January)
2007 deployments
(n = 6)
2006 deployments
(n = 4)
b
Number of turtles
Curved Carapace Length (cm)
x
y
c
Displacement (km)
Curved Carapace Length (cm)
Karnataka, India
Minicoy
Gulf of Mannar
Southern Sri Lanka

Figure 2a, Annual seasonality of green turtle nesting at Rekawa Sanctuary during 2006 and 2007; **b,** Length frequency analysis of female turtles measured post-nesting on Rekawa beach during 2006 and 2007 (n=200). Broken line marked ***x*** denotes the mean curved carapace length of satellite tagged turtles and broken line marked ***y*** denotes the mean curved carapace length of green turtles measured after nesting at Rekawa Sanctuary in 2006 and 2007. Numbers on the columns represent the number of satellite tagged turtles that fall within the size classes shown; **c,** Curved carapace lengths (CCL) of the numbered satellite tagged turtles plotted against straight-line displacement between Rekawa Sanctuary and their respective foraging sites. Broken line marked ***y*** denotes the mean curved carapace length of green turtles measured after nesting at Rekawa Sanctuary in 2006 and 2007 (numbers on plotted circles represent turtles, as in supplementary table 1).



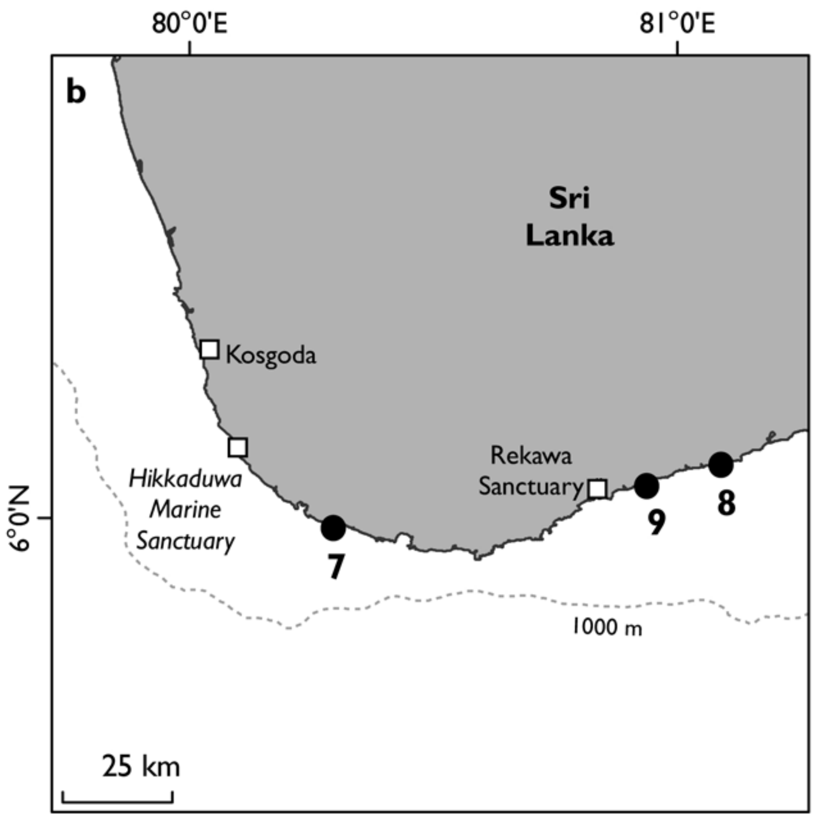


Figure 3. Internesting centroids calculated for the nine turtles that nested at Rekawa after they were fitted with a satellite tag (numbers represent turtles in

table S1). **a,** for turtles that internested in proximity to RS (turtles 7 and 9 internested proximate to Rekawa for one internesting period each after they were tagged); **b,** internesting and foraging site centroids calculated for the resident breeder turtles identified in this study.

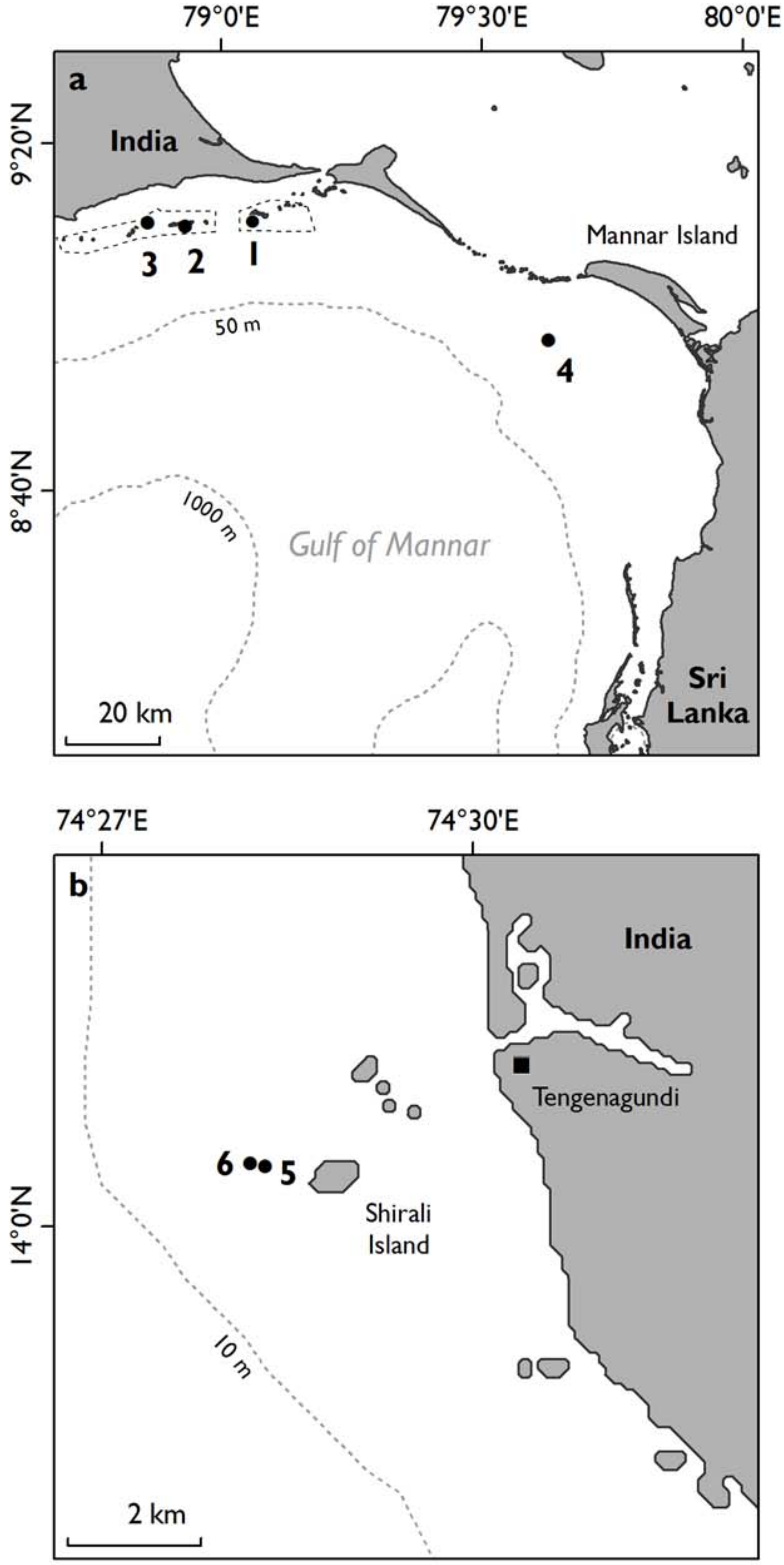


Figure 4. Location of foraging sites centroids of the turtles that migrated to **a,** the Gulf of Mannar (broken line around centroids of turtles 1-3 represent the borders of the Gulf of Mannar Marine National Park), **b,** off the coast of

Karnataka, India (turtle 5 foraging centroid could not be calculated due to insufficient data, so last at-sea A class location shown here).

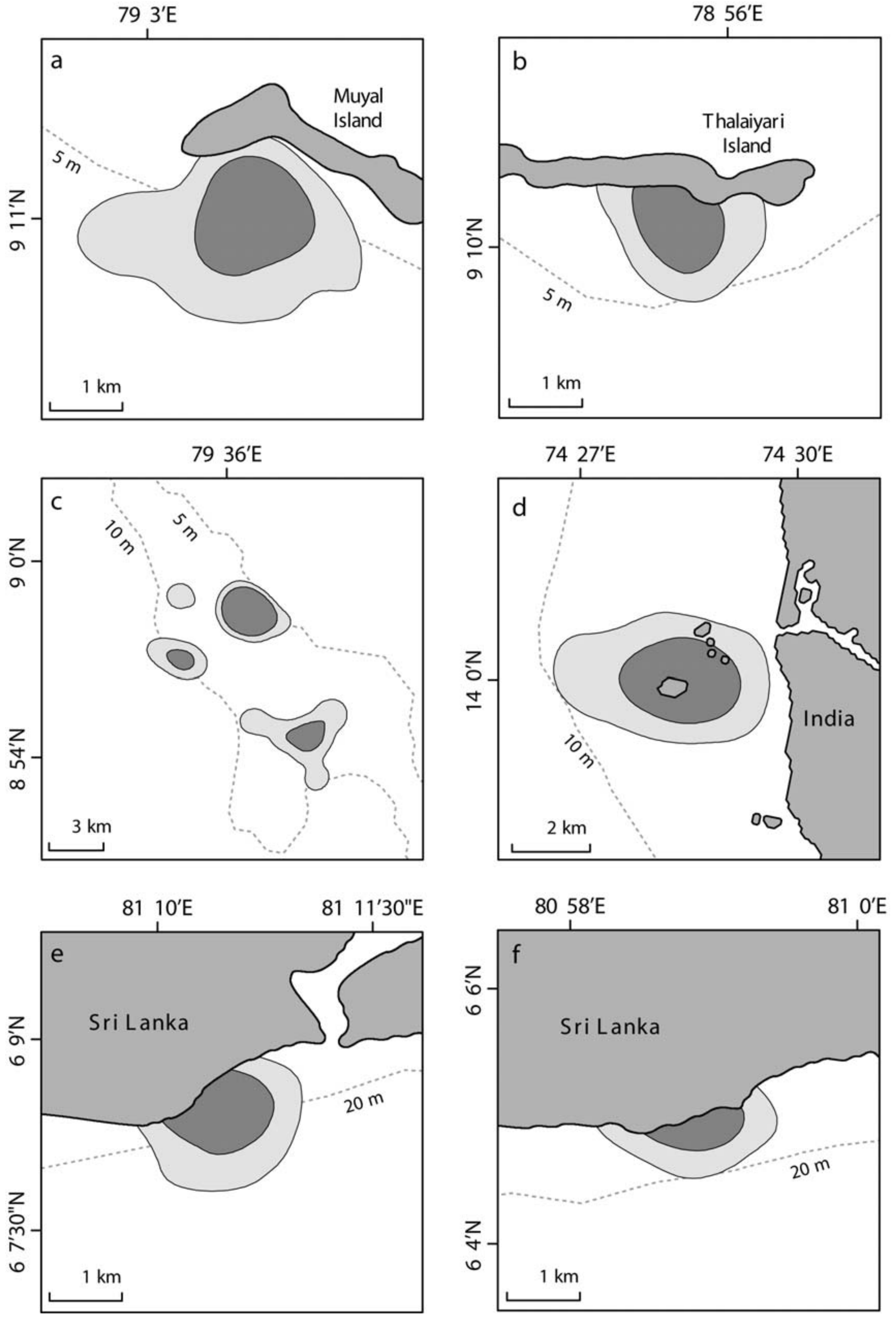


Figure 5. Kernel analyses of locations received from the foraging sites of six turtles. The dark areas encompass the 25% most densely distributed locations and the light areas encompass the 50% most densely distributed

locations. These kernels describe foraging sites, **a,** turtle 1 at Muyal Island, Gulf of Mannar Biosphere Reserve (GoMBR; 136 days, 397 locations), **b,** turtle 2 at Thalaiyari Island, GoMBR (51 days, 209 locations), **c,** turtle 4 in shallow water to the south west of Sri Lanka's Mannar Island, Gulf of Mannar (32 days, 63 locations), **d,** turtle 6 at Shirali Island off the coast of Karnataka, India (48 days, 79 locations), **e,** turtle 9 off Ussangoda, southern coast of Sri Lanka (24 days, 83 locations), and **f,** turtle 8 off Bundala, southern coast of Sri Lanka (92 days, 195 locations).

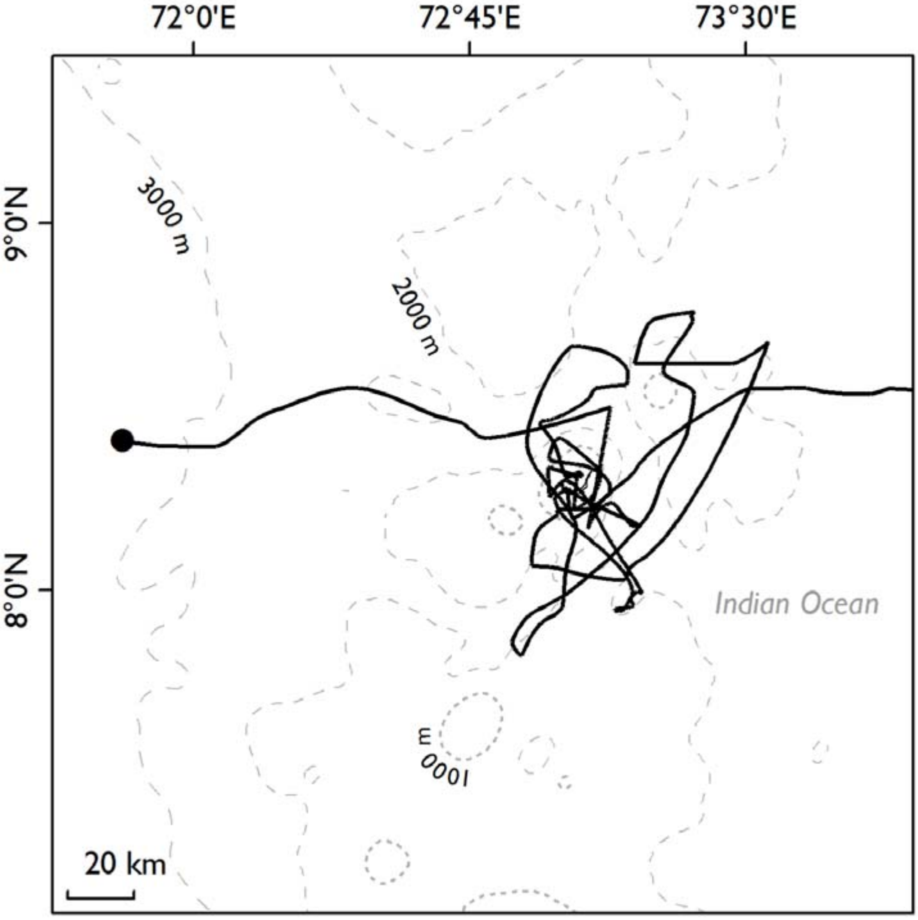


Figure 6. The foraging site track of turtle 10, showing loops in deep oceanic water associated with the coral atoll Minicoy, the most southerly of the Lakshwadeep Islands. The black circle indicates the end of the track where the transmitter failed some 135 km to the west of Minicoy.

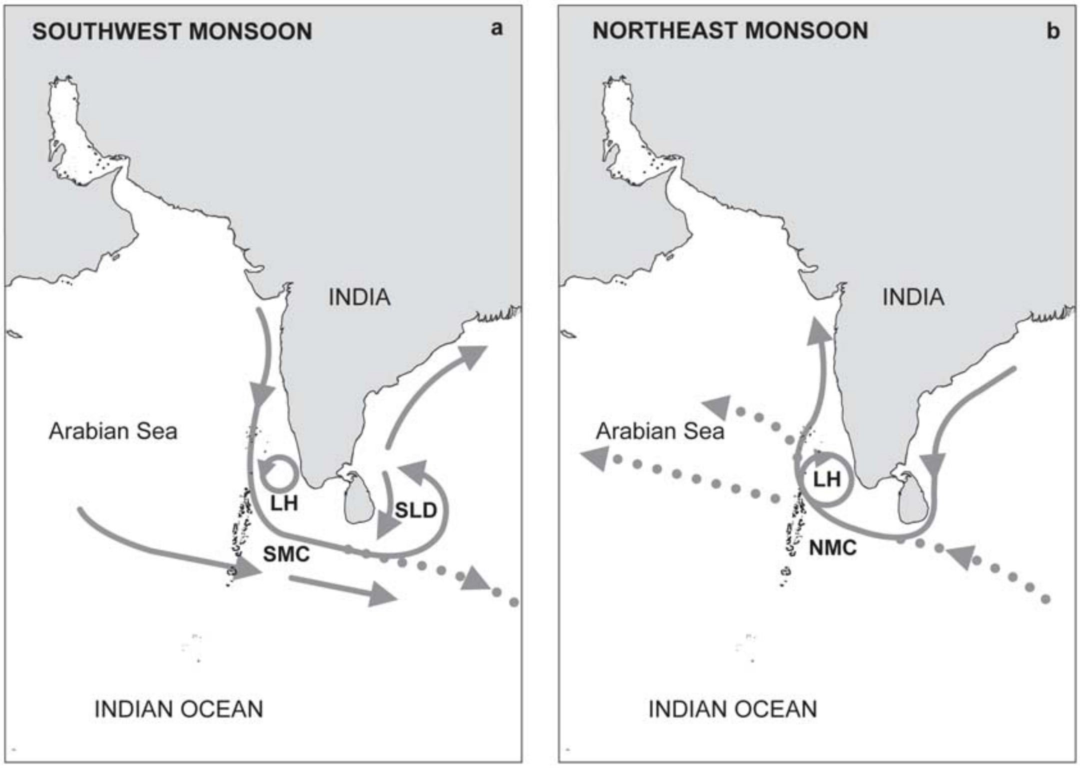


Figure 7. Seasonal monsoon current systems around the Indian sub-continent (adapted from Schott and McReary 2001). **a.** Southwest monsoon current (SMC) system during the peak hatching season at RS (June to September), including Laccadive High (LH) and the Sri Lanka Dome system (SLD). **b.** Northeast monsoon current (NMC) system, which starts around October.

Turtle ID no.	CCL (cms)	Date tagged	No. of internesting periods and location(s)	Foraging site name and jurisdiction	Straight line distance between Rekawa and foraging centroid (kms)	Days at foraging site	Foraging site depth and habitat description
Movement Pattern Type A1 (after Godley et al. 2008)							
1	117.5	30.07.06	0	Gulf of Mannar, India	415	136	50% (n=193) of foraging site locations in <3m. Sea grass, fringing reef, reef vegetation habitat associated with southern coast of Muyal Island [1,2,3]
2	110.1	02.08.06	1, Rekawa	Gulf of Mannar, India	409	51	50% (n=99) of foraging site locations in 1m. Fringing reef and sea grass associated with southern shore of Thalaiyari Island[1,2,3]
3	106.3	06.08.06	1, close to Rekawa	Gulf of Mannar, India	403	51	50% (n=18) of foraging site locations in 1m. Likely fringing reef and sea grass between Thalaiyari Island and Appa Island[1,2,3]
4	107.5	19.06.07	1, close to Rekawa	Gulf of Mannar, Sri Lanka	350	32	50% (n=31) of foraging site locations in <10m. Proximate to Mannar Island, approximately 15 kms to northeast. Unknown benthos.
5	101.2	07.08.06	5, close to Rekawa	Karnataka, India	No centroid (last LC 'A' transmitted from Shirali Island, 1128 km from RS).	56	Turtle 6: 50% (n=28) of foraging site locations in 3m or less Proximate to small, uninhabited Shirali Island. Unknown benthos with high, year-round turbidity.
6	109.9	18.06.07	5, close to Rekawa	Karnataka, India	1128	48	
Movement Pattern A3 (after Godley et al. 2008)							
7	95	03.08.06	1, close to Rekawa 1, Habbaraduwa	Habbaraduwa, Sri Lanka	60	29	50% (n=21) of foraging site locations in <15m. Unknown, but likely inshore rocky reef, degraded corals [2,4,5]
8	97.1	16.06.07	4, Bundala	Bundala, Sri Lanka	38	92	50% (n=98) of foraging site locations in <9m. Unknown, but likely inshore rocky reef, degraded corals [2,4,5]
9	90.1	17.06.07	1, close to Rekawa 2, Ussangoda	Ussangoda, Sri Lanka	16	24	50% (n=34) of foraging site locations in <6m. Unknown, but likely inshore rocky reef, degraded corals [2,4,5]
Movement Pattern Type B (after Godley et al. 2008)							
10	92.8	08.08.06	5, close to Rekawa	Minicoy, India	898	42	90% (n=81) of foraging site locations in >1000m. Pelagic, but associated with Minicoy coral atoll and lagoon [2,6,7]

Supplemental Table 1. Summary of biometric and tracking information for the 10 female green turtles fitted with satellite transmitters turtles at the Rekawa Turtle Sanctuary, Sri Lanka. (Thangaradjou et al. 2008[1], Tamelander & Rajasuriya 2008[2], Kumaraguru et al. 2006[3], Rajasuriya et al. 1998[4], E. Wood, pers comm. 2009 [5], Tripathy et al. 2006[6], Untawale & Jagtap, 1984[7]).

CHAPTER 3

(submitted to Marine Policy as Richardson PB, Broderick AC, Coyne MS, Gore S, Gumbs JC, Pickering A, Ranger S, Witt MJ and Godley BJ (In press). Leatherback Turtle Conservation in the Caribbean UK Overseas Territories: Act Local, Think Global?)

LEATHERBACK TURTLE CONSERVATION IN THE CARIBBEAN UK OVERSEAS TERRITORIES: ACT LOCAL, THINK GLOBAL?

Abstract

Leatherback turtles migrate across the territories of multiple sovereign states and present complex challenges to those responsible for their conservation. Concerns for marine turtle species have led to their protection under range state legislation and calls for international conservation collaboration through a suite of multi-species, multi-lateral environmental agreements. Evidence suggests that a distinct, reproductive sub-population of leatherback turtles is shared between northern Caribbean range states. The UK Overseas Territories (UKOTs) of Anguilla and the British Virgin Islands are both suggested range states of this northern Caribbean nesting population (NCNP). We tracked the post-nesting movements of three female leatherbacks after they oviposited in Anguilla (n=1, tracked for 228 days) and the British Virgin Islands (n=2, tracked for 12 and 13 days, respectively). These turtles used territorial waters of multiple range states, with the leatherback tracked from Anguilla migrating through high seas to foraging grounds in Canadian waters before returning to Caribbean latitudes. In addition, we reviewed regional leatherback flipper tag return records and assessed pertinent conservation legislation in the range states, as well as accession to relevant multi-lateral environmental agreements (MEAs). The flipper tag data show that leatherbacks nesting in Anguilla and the British Virgin Islands form part of the NCNP, which also nests across at least eight other states. National legislation and conservation efforts appear to have contributed to the beginning of a recovery in some range states of the NCNP, including the BVI. While most potentially relevant MEAs appear to have played little or no multi-lateral role in these recoveries, opportunities for constructive NCNP range state dialogue and networking exist under the Cartagena Convention. UKOT conservation managers would, therefore, be justified in prioritising unilateral leatherback conservation action, and multilateral efforts through the Cartagena convention, over potentially costly accessions to additional MEAs. In addition, mechanisms exist for the UK and other politically influential plenipotentiary states (i.e. those that represent territories) to address concerns about leatherback bycatch under the United Nations Convention on the Law of the Sea and the International Commission for the Conservation of Atlantic Tuna.

Introduction

The conservation of migratory marine vertebrate species is complex and challenging. Basic understanding of their expansive ranges has traditionally been limited by the logistical difficulties in accurately documenting their migratory behaviour at sea (Block 2005). However, contemporary research has made significant advances in our understanding of the ranges of migratory marine vertebrates and has elucidated the political challenges of managing them (Cooke 2008). Where animals migrate across geo-political borders, they are subject to differing national natural resource-use policy, management capacity and conservation priorities (Frazier 2002).

Marine turtle mark-recapture studies, which usually involve the application of flipper tags on females at nesting beaches, have revealed migrations across the territories of multiple sovereign states (Carr et al. 1978, Meylan 1982, Limpus et al. 1992). The recognition of migratory marine turtle species as 'shared resources' has led to several authors calling for cooperative international management efforts (for examples see Frazier 2002, Blumenthal et al. 2006, Schillinger et al 2008). To address this perceived need, several multi-lateral environmental agreements (MEAs) encourage or oblige signatory states to protect marine turtles and their habitat (see Bache 2002, Hykle 2002, Namnum 2002, Wold 2002). In addition, some multi-lateral Regional Fisheries Management Organisations (RFMOs) have adopted fishery-specific management measures to mitigate harmful marine turtle interactions (Gilman 2011).

Leatherback turtles (*Dermochelys coriacea*) are migratory medusivores, and are highly adapted to utilise habitats across ocean basins, including tropical nesting beaches and temperate marine foraging grounds (Davenport et al. 1990, Hays et al. 2006, Benson et al. 2007). The species is listed globally as 'critically endangered' by the International Union for the Conservation of Nature (Sarti Martinez 2000), and some authors have forecast imminent extinction for nesting populations in the Indo-Pacific (Chan and Liew 1996, Spotila et al 1996, 2000). In contrast, some leatherback populations in the

Atlantic basin appear to be faring considerably better (Dutton et al. 2005, Girondot et al. 2007, Saba et al. 2008, Stewart et al. 2011).

Mark-recapture and genetic studies on leatherbacks nesting in Puerto Rico and the US Virgin Islands (USVI) suggest that the Northern Caribbean nesting population (NCNP) is a distinct stock (Dutton et al. 1999, 2005), which also uses beaches in the neighbouring UK Overseas Territories of Anguilla and the British Virgin Islands (BVI), as well as more southerly Antillean states (Boulon et al. 1996, Dutton et al. 2005). In order to address leatherback conservation concerns, national protective legislation and conservation efforts at nesting beaches have been established in Puerto Rico, the USVI and the BVI for a number of decades, which have contributed to apparent nesting population recoveries in those range states (Dutton et al. 2005, McGowan et al. 2007, Diez et al. 2010).

Although little is known about the post-nesting migrations of turtles from the NCNP, two tag recoveries from non-nesting turtles suggest that their foraging range extends as far north as the Eastern Seaboard of the USA and Canada (Boulon et al. 1988, James et al. 2007). Knowledge of leatherback behaviour at sea has, however, been revolutionised in recent decades by the application of satellite telemetry using the Argos System (Godley et al. 2008). Satellite tracking studies on leatherbacks have fundamentally informed our understanding of migration and habitat use by this species, and have facilitated the identification of conservation threats and management priorities throughout population ranges (Hays et al 2004, James et al. 2005, Peckham et al. 2007, Saba et al. 2008, Witt et al. 2011). To date, there has been limited published research using satellite telemetry on nesting leatherbacks from the NCNP. The earliest study recorded internesting movements of a single turtle between USVI and Puerto Rico (Keinath & Musick 1993), another study recorded a limited post-nesting movement of a single leatherback tagged in Puerto Rico (Lutcavage et al. 2002), and a more recent study recording local internesting movements of two turtles tagged in Dominica (Byrne et al. 2009).

Further mark-recapture and satellite telemetry studies could refine our understanding of the status and range of the NCNP stock and identify states that share responsibility for the conservation of this nesting management unit (Dutton et al. 2005, Wallace et al. 2010a). However, conservation managers in the region have varied capacity and resource availability and differing priorities in terms of conservation management resource allocation (Chakalall et al. 1997, 2007). For example, conservation management authorities in the Caribbean UK Overseas Territories are characteristically responsible for a suite of marine resource use issues, but are often under-resourced, with insufficient capacity and financial support available for marine biodiversity conservation (Forster et al. 2011).

This study uses a combination of satellite tracking data from leatherbacks fitted with platform transmitter terminals after nesting in Anguilla and the BVI, and regional flipper tag recapture data to further elucidate the range of the NCNP. We describe causes of leatherback mortality within the range and NCNP range states' national legislation pertinent to leatherback protection. We review the impact of several relevant multi-lateral environmental agreements (MEAs) on leatherback nesting trends within the population. Finally, based on this information we suggest which management measures UKOT conservation managers should prioritise in order to achieve conservation gains for this leatherback population.

Study site and methods

Adult female leatherback turtles were opportunistically fitted with Satellite Relay Data Loggers (SRDL - Sea Mammal Research Unit) after they oviposited on beaches in Anguilla and the BVI. A single SRDL attached to a bespoke harness (modified after Eckert 2002) was deployed consecutively on two turtles in Tortola, BVI in May 2003. The first female leatherback, Turtle 1 (Curved Carapace Length, CCL = 156.2 cm), was fitted with the SRDL and harness on the night of the 01.05.2003 after oviposition at Josiah's Bay (64.591°W 18.446°N). On the night of the 14.05.2003 the turtle returned to emerge on the same beach. Noting extensive damage to the harness, researchers removed it and recovered the SRDL before the turtle returned to the sea. The harness was refurbished and on the night of the 16.05.2003 it was re-deployed with the SRDL on another female leatherback, Turtle 2 (CCL = 144.8 cm), after it also oviposited at Josiah's Bay. Turtle 3 (CCL = 149.5 cm) was fitted with a SRDL and harness after it oviposited at Captain's Bay, Anguilla (62.980°W 18.264°N) on the 13.05.2005.

Location data were received from Service Argos and the online Satellite Tracking and Analysis Tool (STAT; Coyne & Godley 2005) was used for managing the data, creating base maps and data parsing for the turtles tracked during this study. Movements were mapped using Argos location classes (LC) 3, 2, 1, A and B. These location classes can be reliable when subject to adequate filtering (Costa et al. 2010, Witt et al. 2010), and therefore we used a speed filter to remove locations suggestive of travel speeds greater than 10 km h^{-1} and azimuth filtering (minimum threshold 25^{o}). Best class daily locations were then interpolated to create a smoothed track. Haul out data were examined to determine subsequent emergences.

In addition, flipper tag return data were collected through personal communication with researchers in the region and through flipper tag recovery records reported to the authors through the Wider Caribbean Sea Turtle Conservation Network (WIDECAST) Marine Turtle Tagging Centre. Information regarding national legislation and accession to multi-lateral environmental agreements was also reviewed (Fleming 2001, Brautigam and Eckert 2006, Richardson et al. 2006, CITES 2011, CMS 2011; IAC 2011, CEP 2011a, UNCLOS 2011).

Results

Satellite tracked movements

After being fitted with the SRDL and harness, Turtle 1 travelled due north for two days into open ocean approximately 85 km from Tortola where it remained for a further two days (Figure 1). The turtle then travelled southwest to waters 16 km off the north-eastern tip of Puerto Rico where it stayed for a further two days before heading east through the US Virgin Islands and returning to Tortola to nest 13 days after it was tagged.

After SRDL deployment, Turtle 2 also travelled due north for two days into open ocean but then travelled due east for a further three days before heading south (Figure 1). This turtle arrived in Puerto Rico's inshore waters on the 24.05.03 eight days after it was tagged in Tortola. The turtle then travelled east along Puerto Rico's north coast to the inshore waters of the Fajardo-Luquillo region on the northeast tip of Puerto Rico where it emerged on Paulinas Beach (65.689°W 18.366°N) to the east of Luquillo, on the night of the 26.05.03. Transmissions ceased from this tag on the afternoon of the 28.05.03 when the turtle was apparently heading due north away from Puerto Rico.

Turtle 3 spent 14 days within Anguilla's northern inshore waters after SRDL deployment, with haul-out data suggesting a subsequent emergence on the northeast shore of Anguilla on the night of the 27.05.05. On the 01.06.05 the turtle then moved along a north easterly bearing, briefly passing through the Exclusive Economic Zone of Antigua and Barbuda, before heading into open ocean (Figure 2). The turtle arrived at the Eastern Shoals off Newfoundland, Canada on the 14.08.05 and stayed within continental shelf waters off Newfoundland until 01.10.05 when it moved south again. Transmissions ceased on the 27.12.05 at 46.959°W 17.478° over the Mid-Atlantic Ridge some 1,700 km due east of Anguilla.

Flipper tag return data

Flipper tag records (Figure 3 and Supplementary table 1) suggest that Puerto Rico, the USVI, the BVI, Anguilla, St. Kitts and Nevis and Dominica are all NCNP range states. In addition, individual turtles tagged in these states have also been recorded nesting in St Maarten, Antigua and Barbuda, St Eustatius and Guadeloupe suggesting that these are also NCNP range states. Leatherbacks flipper tagged in confirmed NCNP range states have not, to date, been recorded by researchers in the Dominican Republic, to the east of Puerto Rico (Y Leon, pers comm. 2011). This study did not identify any records of NCNP turtles nesting in Saba and Montserrat, where nesting by this species occurs but is considered to be infrequent (Martin et al. 2005, Brautigam and Eckert 2006). Leatherbacks tagged in Dominica have been recorded nesting on Martinique immediately to the south, and therefore Martinique may also host nesting females from the NCNP (Delcroix et al. 2011).

Opportunistic beach monitoring and flipper tagging of nesting leatherbacks in Anguilla has yielded new information. This includes the first record of a turtle originally tagged in Puerto Rico in 1999 nesting in Anguilla in 2004, five years after it was originally tagged on Culebra Island. Two turtles tagged after they oviposited in Anguilla have for the first time confirmed that turtles move from Anguilla to nest in the USVI. One of these turtles, flipper tagged in 2007, was then captured by researchers in inshore waters of Cape Breton Island, Canada in September of the same year, and subsequently recorded nesting in the USVI in 2009 (Figure 2 - M. James, pers comm. 2007; J Horrocks, WIDECAST, pers comm. 2009). In addition, a leatherback flipper tagged after oviposition in Anguilla in 2009 went on to nest on neighbouring St. Maarten in the same season (T Bervoets pers. comm. 2011).

Turtles tagged on the Puerto Rican island of Culebra have also been recorded nesting in the British Virgin Islands, and are regularly recorded nesting in the USVI, where turtles tagged on mainland Puerto Rico are also recorded (Garner et al. 2006, Garner and Garner 2007, 2008 and 2009). Flipper tag data show that this population also nests on more southerly Antillean islands (Figure 3), with leatherbacks originally tagged in Puerto Rico and the USVI recorded nesting in Dominica (Dutton et al. 2005, Stapleton and Eckert 2007). Leatherbacks tagged in Guadeloupe are also regularly recorded nesting in Dominica, and vice versa (Delcroix et al 2011), while turtles tagged in St Kitts and Nevis have been recorded nesting Guadeloupe, the USVI (Garner and Garner 2008), St Eustatius (Berkel 2009) and Antigua and Barbuda (M. Clovis pers. comm. 2011).

A foraging leatherback originally flipper tagged after oviposition in the USVI was recaptured in Canada's inshore waters and provides further evidence that

Canada's waters provide foraging habitat for the NCNP (Figure 2 - M. James, Canadian Sea Turtle Network, pers. comm. 2011).

Legislation and the MEAs

Legal protection for leatherbacks varies across the NCNP range states identified in this study (Figures 2, 3 and Supplementary table 2). Canada's Species At Risk Act (SARA) fully protects leatherbacks in waters under Canadian jurisdiction (ALTRT 2006) and the USA Endangered Species Act (ESA) fully protects leatherback turtles and their eggs in the waters of Puerto Rico, USA and the USVI (Fleming 2001). Legislation under the ESA also protects nesting habitat in USVI and obliges USA registered fishing vessels to take specific measures to mitigate against marine turtle bycatch during fishing activities in USA waters and on the high seas (Federal Register 2004). National legislation protects leatherbacks and their eggs in Anguilla, the BVI, the Netherlands Antilles, St. Maarten, Guadeloupe and Martinique, while legal take of leatherbacks is regulated by legislation in Antigua and Barbuda, St Kitts and Nevis and Dominica (Brautigam and Eckert 2006). Montserrat is the only NCNP range state with legislation that allows the take of nesting marine turtles and their eggs during an open season (Richardson et al. 2006), although take is considered to be at very low levels and leatherbacks rarely nest on the island (Martin et al 2005).

All NCNP range states have acceded to the United Nations Convention on the Law of the Sea (UNCLOS) and the Cartagena Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Supplementary table 1). Antigua and Barbuda, BVI, Netherlands Antilles and St Kitts and Nevis have published Sea Turtle Recovery Action Plans (STRAPs) under the Wider Caribbean Sea Turtle Conservation Network (WIDECAST), a Regional Activity Network established under the Cartagena Convention (Eckert 2010, CEP 2011). While most range states have acceded to the Convention on International Trade in Endangered Species (CITES), only a small minority of the NCNP range states have acceded to each of the Protocol Concerning Specially Protected Areas And Wildlife (SPAW) to the Cartagena Convention, the Convention on Migratory Species (CMS) and the

Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC). Plenipotentiaries representing most NCNP range states are contracting parties to International Commission for the Conservation of Atlantic Tunas (ICCAT 2011), the most relevant regional fishery management organisation.

Discussion

This study has provided new insights into the migratory behaviours of the North Caribbean nesting leatherback population, and for the first time tracked international post-nesting movements of leatherbacks nesting in the UK Overseas Territories (UKOTs). The satellite tracking and flipper tagging of leatherbacks nesting in Anguilla and the BVI has revealed that individuals will subsequently use critical habitats located across multiple sovereign states between consecutive nesting events and between nesting seasons. Furthermore, the flipper tag recapture data suggest that the NCNP uses beaches in the territories of at least ten range states found between Puerto Rico and Dominica, including Anguilla and the BVI. The NCNP forages in the waters of Canada as well as the USA, with individuals migrating between breeding and foraging grounds through the high seas.

It is worth noting that Martinique may also be a NCNP range state because individual leatherbacks nesting there have also been recorded nesting in Dominica (E Delcroix pers. comm. 2011), its northerly neighbour and a confirmed NCNP range state. However, these islands, and Guadeloupe, have also recorded nesting leatherbacks originally tagged in more southerly states including Trinidad, Grenada, St Lucia and Curacao (Figure 3 - Stapleton and Eckert 2007, Delcroix et al 2011). Dutton et al. (1999) suggest that the leatherback population nesting in Trinidad is a separate and genetically distinct stock and therefore Guadeloupe, Dominica and Martinique may represent an area where two stocks overlap and share nesting beaches.

National management within NCNP range states

The legal protection for leatherbacks afforded under national legislation in BVI, USVI and Puerto Rico is considered, in part, to have contributed to increasing nesting trends detected in these range states (Dutton et al. 2005, McGowan et al. 2007, Diez et al. 2010). In addition, the respective national conservation authorities in these states have invested significant resources maintaining monitoring presence at key leatherback nesting beaches for over twenty five years (Boulon et al. 1999, McGowan et al. 2007), which has reduced illegal take of females and eggs (Fleming 2001, Hastings 2003). Active protection and relocation of threatened leatherback turtle nests to maximise hatchling production is also considered to be a major factor contributing to increases in nesting activity in USVI (Dutton et al. 2005). Leatherbacks are also protected in Anguilla, albeit under a temporary moratorium until 2020 (see Campbell et al. 2009, Richardson et al. 2006), but nesting trends are unknown because systematic beach monitoring only commenced in 2009 (Godley et al. 2004, Wynne 2009). Similarly, it is not known if national legislation in Antigua and Barbuda, Dominica, Guadeloupe, Martinique, Netherlands Antilles and St Kitts and Nevis has affected nesting trends because index beach monitoring in these states has only commenced within the last decade (Debrot et al. 2005, Brautigam and Eckert 2006). Only a few NCNP range states have published Sea Turtle Recovery Action Plans (STRAPs), but WIDECAST coordinates other support activities through a network of ‘Country Coordinators’, usually employees of national conservation agencies, and these are present in all NCNP range states (Eckert 2010, CEP 2011b). WIDECAST efforts are viewed favourably through much of the NCNP range. In BVI, for example, the STRAP is believed to have contributed, in part, to the increasing leatherback nesting trends (Hastings 2003), whereas the Netherlands Antilles STRAP shaped recently established beach-monitoring efforts in St Eustatius (Berkel 2009).

It is worth noting that legal protection and nesting beach conservation efforts are unlikely to be the only contributing factors to population recoveries recorded within the NCNP. Environmental factors, including changes in abundance of oceanic prey and predators, have been proposed as important causal factors behind concurrent population recoveries at other west Atlantic nesting beaches, including some that are not subject to conservation efforts (Saba et al 2008, Stewart et al. 2011). The importance of these drivers to the NCNP is certainly worthy of further investigation, but a prerequisite to investigating these effects is a better understanding of population trends across the range states of the NCNP management unit. For example, in contrast to the increase in nesting on mainland Puerto Rico beaches, Diez et al (2010) report that numbers of nesting activities on Culebra Island's protected and monitored beaches have shown a decreasing trend since 2005 for reasons unknown. Furthermore, while Garner and Garner (2010) report an ongoing increasing trend in numbers of nesting activities in the USVI, they also report a decline in the recruitment of neophyte female turtles over the last 10 years, also for reasons unknown. The nesting population dynamics of this leatherback management unit are complex. While protective legislation may well be contributing to NCNP recovery in some range states, systematic monitoring of nesting throughout the range is essential in order to generate a robust and comprehensive understanding of this population's status and trends.

Sources of mortality within the NCNP range

Leatherback turtles face a number of anthropogenic threats throughout their range (Lutcavage et al. 1997). Within the NCNP these include anthropogenic sources of mortality such as direct take of turtles and eggs, and chronic threats including disturbance and destruction of nesting habitat through coastal development (Fleming 2001, Brautigam and Eckert 2006). Conservation managers in the Caribbean UKOTs recently identified coastal development as the short-term threat of most concern to marine and coastal environments (Forster et al. 2011). In Anguilla and BVI extensive sand mining and coastal development is linked to degradation and disturbance of leatherback nesting habitat, and requires urgent remedial action under domestic legislation and policy (Godley et al. 2004). Such actions will need to take into account the effects of climate change, as existing threats to turtle nesting habitat are likely to be compounded by the effects of sea level rise and 'island squeeze' (Davenport et al. 1989, Fish et al. 2004, 2008).

The extent of anthropogenic sources of leatherback mortality within the NCNP is poorly understood. Illegal take of leatherbacks and their eggs has recently been documented in the BVI, the USVI and Puerto Rico but is thought to occur at low levels (Fleming 2001, Hastings 2003, Dutton et al. 2005). Recent illegal egg take has also been recorded in Anguilla, Antigua and Barbuda, St Eustatius, St Kitts and Nevis and Guadeloupe (Butler 2001, Godley et al. 2004, Brautigam and Eckert 2006, Stapleton and Eckert 2007). Take of leatherback turtles for consumption appears less widespread within the NCNP range, and in some cases has been reduced by the introduction of protective legislation. For example, the traditional take of nesting leatherbacks in BVI for their oil has ceased as a result of legislation introduced in 1986 (Hastings 2003, McGowan et al. 2007). Nevertheless, leatherbacks are regularly taken in small numbers in St Kitts and Nevis (Butler 2001, Brautigam and Eckert 2006), and illegally taken in larger numbers on the nesting beaches of Dominica, where, for example, at least 14 nesting females were killed for their meat and eggs in 2007 (Stapleton and Eckert 2007). There is a clear need to better understand the extent of these activities and assess their significance to the NCNP status.

Monitoring presence during the nesting season can also provide insights into the interactions of breeding female leatherbacks with fisheries gear at sea. Nesting leatherbacks bearing fresh injuries indicative of interactions with various fishing gears, including nets, ropes, and long line gear have been consistently reported in the USVI each year since 2002 (Alexander et al. 2002, 2003, 2004, Garner et al. 2005, 2006, Garner and Garner 2007, 2008, 2009, 2010). The number of turtles bearing these injuries has varied significantly from year to year, with, for example 4% of nesting females showing injuries in 2003 compared to 39.1% of females in 2006. Injuries associated with long-line gear, including line entanglement and hooking, are the most frequently recorded in USVI, and similar injuries on nesting leatherbacks are also recorded elsewhere within the NCNP. For example, Turtle 2 bore fresh wounds indicative of long line entanglement and hook punctures when she was fitted with her tracking device after nesting in BVI, where an estimated 30% of nesting leatherbacks show similar injuries (S Gore pers. comm. 2008). In Anguilla, a nesting leatherback showing fresh injuries indicating hook penetration and line entanglement in 2004 also bore an older, healed line entanglement scar around a flipper that was apparent when the turtle nested on Culebra Island five years previously (H Horta pers comm. 2003). Nesting leatherbacks showing fresh injuries indicative of long line interaction have also been recorded in St Maarten, St Eustatius and Antigua and Barbuda (J Berkel, T Bervoets, M Clovis pers. comms. 2011).

James et al (2005) report that leatherbacks foraging in Canadian shelf waters often show injuries incurred by interactions with fixed gear (e.g. buoy rope entanglement), but rarely show fresh injuries indicative of long line interactions (James pers. comm. 2008). This suggests that the fresh injuries regularly seen on nesting NCNP leatherbacks are a result of interactions with long line fisheries encountered en route to the nesting sites. The USA Atlantic long line fleet has recorded leatherback bycatch in the Caribbean, Sargasso, North Central Atlantic, Florida East Coast, South Atlantic Bight, Mid-Atlantic Bight, Northeast Coastal and Northeast distant long-line fishery reporting areas which lie to the north of the northern Caribbean (Figure 2, Witzell 1999, Baum et al. 2003, NOAA 2011). Canadian long line fleets fishing within the Northeast Coastal and Northeast distant areas also record leatherback bycatch (ALTRT 2006). Leatherbacks tracked migrating from foraging grounds in shelf waters off Nova Scotia travelled on southerly bearings through the Sargasso, North Central Atlantic, Florida East Coast, South Atlantic Bight, Mid-Atlantic Bight and Northeast Coastal fishery areas (James et al. 2005). In this study, Turtle 3 spent most of its tracked journey on the high seas, and travelled through the North Central Atlantic and Northeast Distant fishery areas during both its post-nesting and post foraging migrations (Figure 2).

Recent technological advances in long line fishing gear and practice, which can significantly reduce marine turtle bycatch (Watson et al 2005, Read 2007, Cox et al 2007), have been adopted by the USA fleet under the Endangered Species Act (Federal Register 2004), and by ‘a large proportion’ of the Canadian fleet (ALTRT 2006). However, there are currently no obligations for other long-line fleets to adopt similar bycatch mitigation measures (Gilman 2011), including, for example, the Taiwanese fleet which targets the Sargasso and North Central Atlantic areas immediately to the north of the NCNP nesting range (Weidner et al. 2001). While a proportion of the NCNP nesting leatherbacks survive these interactions, the significance of bycatch on the NCNP is poorly understood and is considered of grave concern (Dutton et al. 2005). It is possible, for example, that mortality rates as a result of long line interactions differ across age classes, and thus may be impacting neophyte recruitment in the USVI. In addition, the distribution of long-lining activity in the fishery areas north of the NCNP nesting range may be differentially impacting nesting throughout the range, and thus driving the unexplained trends on Culebra Island. Marine turtle experts recently identified research into marine turtle bycatch and mitigation as a global research priority (Hamann et al. 2010), and this clearly applies to NCNP interactions with long-line and perhaps other fisheries in the region.

Multi-lateral environmental agreements affecting the NCNP

Despite the establishment of a suite of MEAs with provisions to protect leatherback turtles from anthropogenic sources of mortality, the NCNP range states have not adopted a collaborative regional approach to leatherback conservation. While the majority of range states have acceded to the Cartagena Convention, CITES and UNCLOS, relatively few have acceded to the IAC, CMS and the SPAW Protocol. These MEAs with limited range state accession, as well as CITES, are unlikely to have contributed to any of the population recoveries within the NCNP. For example, even though the USA acceded to the IAC in 2001, leatherback nesting recovery in Puerto Rico and USVI was evident years beforehand, and after many years of protection and conservation efforts under the ESA (Dutton et al. 2005, Diez et al. 2010). Leatherbacks are also afforded the highest protection under CITES, but as there is no recent history of large-scale international trade in leatherback products within the Caribbean, CITES implementation will not have contributed to NCNP population recoveries (Fleming 2001, Godley et al. 2004, Brautigam and Eckert 2006). In contrast, while the Cartagena Convention does not include specific provisions to protect leatherback turtles, its Regional Activity Network, WIDECAST, appears to have played an important role in influencing unilateral conservation initiatives in some NCNP range states.

Leatherbacks travelling between the nesting range and the northerly foraging grounds can spend much of their journey in the high seas beyond the remit of national legislature, but where UNCLOS applies. All NCNP range states have acceded to UNCLOS, either directly or through their plenipotentiary states. UNCLOS obliges parties to protect and preserve the marine environment on the high seas, and the UNCLOS 1995 Fish Stocks Agreement (UNFSA) obliges parties to minimize bycatch and deleterious impacts on associated species (Mahon and McConney 2004, Gilman 2011). However, to date UNCLOS is unlikely to have played a significant role in NCNP conservation because the convention has no specific provisions to oblige parties to mitigate marine turtle bycatch (Bache 2002, Wold 2002).

Regional Fishery Management Organisations (RFMOs), established by the Food and Agriculture Organisation of the United Nations (FAO), are the primary mechanisms for regional fishery management under UNFSA (Hart 2008), including those fisheries that impact marine turtles. The most relevant RFMO to the conservation of the NCNP is the International Commission for the Conservation of Atlantic Tunas (ICCAT). ICCAT entered into force in 1969 to manage Atlantic fisheries for tuna and tuna-like fishes and provides a mechanism for contracting parties to agree on specific fishery management measures (Gilman 2011). Politically influential plenipotentiaries, including the USA, UK, France and the European Union, are contracting parties to ICCAT and represent the majority of NCNP range states. In addition, Chinese Taipei (Taiwan) is a Cooperating Non-Contracting Party (ICCAT 2011), with Taiwanese vessels operating out of St Maarten having participated in ICCAT-supported catch sampling programmes (Weidner et al. 2001). Opportunities exist to improve contracting parties’ fishery management practices and increase understanding of leatherback bycatch. For example, an ICCAT resolution in 2003 encourages parties to collect and share data on marine turtle interactions and mitigation measures, and encourages the live release of caught turtles (Gilman 2011). However, ICCAT is unlikely to have contributed to NCNP recoveries to date because, unlike RFMOs operating in other ocean basins, it has not adopted legally binding measures that require contracting parties to use gear technology proven to mitigate turtle bycatch in the region (Gilman 2011).

The weaknesses in the provisions of UNCLOS, UNFSA and RFMOs to conserve biodiversity on the high seas have not gone unrecognised (Gjerde et al. 2008a, Gilman 2011). A number of solutions have been proposed to address these weaknesses, including an ongoing process, under the auspices of the United Nations, to review a proposed implementation agreement under UNCLOS for the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction. This agreement could include provisions to oblige RFMO party states to mitigate marine turtle bycatch where there is currently no obligation (Gjerde et al. 2008b, Hart 2008).

Management implications for the UK Overseas Territory range states

The UK Overseas Territories have a role to play in the conservation of the NCNP, but have limited resources to allocate for marine turtle conservation (Godley et al. 2004, Forster et al. 2011). It could be argued that no further action is necessary in the UKOTs within the NCNP range because of the increasing nesting trends, attributable, in part, to conservation actions in Puerto Rico, USVI and the BVI. Indeed, leatherbacks are protected indefinitely in BVI, and protected until 2020 under a moratorium in Anguilla. While neither leatherbacks nor their eggs are afforded full protection in Montserrat, they rarely nest on the island and there is no demand for leatherback products, which suggests that additional action in Montserrat is unlikely to impact significantly on the NCNP. However, without additional action in BVI and Anguilla, ongoing uncertainty regarding nesting trends would be maintained in Anguilla, and uncertainty regarding nest fate and nesting population structure would continue in both Anguilla and BVI. In addition, without further action the integrity of existing beaches may well be compromised, and therefore a ‘do nothing else’ strategy would not benefit the NCNP or contribute to regional understanding of its conservation status. Conservation managers must therefore prioritise the most cost-effective conservation measures from the following options:

National conservation action: While seasonal daily monitoring of index leatherback nesting beaches now occurs in Anguilla or BVI, proactive nest conservation programmes are not currently implemented, but would benefit the conservation of the NCNP through hatchling production and could therefore be prioritised. The preservation of nesting beach integrity is also of critical importance to ensuring continued leatherback nesting and NCNP hatchling production in Anguilla and BVI. Detailed recommendations to address some of the threats to local nesting beaches have been made elsewhere (Eckert et al. 1992, Godley et al. 2004), and could also be considered priority actions.

Nesting trends in most range states, including Anguilla, are poorly understood. Consistent, systematic and long-term beach monitoring is a minimum requirement needed to detect these trends (Schroeder and Murphy 1999) and is required to determine conservation status throughout the NCNP range (Dutton et al. 2005). Other NCNP states have already recognised the importance of such programmes, and they should be a priority for marine turtle conservation resource allocation in Anguilla. In addition, systematic saturation flipper tagging regimes similar to those in USVI and Puerto Rico, at least on selected index beaches in Anguilla and BVI, would provide insights into trends in the female NCNP structure and the broader conservation status of the NCNP. While such regimes are more problematic to implement than daily beach monitoring, nocturnal patrols facilitate inspection of nesting females and would therefore provide insights into the levels of fishery interactions.

Under BVI legislation, leatherbacks and their eggs are protected indefinitely, while in Anguilla they are protected under a temporary moratorium until 2020. Given that there is no local demand for leatherback meat, oil or other body parts, the development and adoption of post-moratorium legislation fully protecting leatherbacks would not disadvantage local interests, but could contribute to the management of the NCNP by protecting nesting females from any future threats within Anguillian territory. Ongoing reports of illegal egg take in Anguilla and BVI indicate that there is a need to improve existing enforcement efforts at the nesting beaches. Enforcement would be complemented by monitoring regimes as described above, as monitoring patrols can also serve to deter illegal egg take, as well as non-human predation (Boulon 1999), and thus contribute to NCNP hatchling production.

Multi-lateral actions: As a plenipotentiary, the UK is responsible for accession to MEAs on behalf of its overseas territories (Richardson et al. 2006). Therefore Anguilla and BVI must request that the UK extends its accession to MEAs, a process that can incur ongoing institutional, administrative and reporting costs for governments in the UK and the respective territories (Hykle 2002). Conservation of shared turtle populations through existing multi-species MEAs may be promoted as the ideal (Frazier 2002), and inevitably there may be cumulative incentives to accede to multi-taxa MEAs with respect to other shared species. However, with respect to the conservation of the leatherback turtles alone, there is little incentive for conservation managers in Anguilla and BVI, or indeed appropriate government departments in the UK, to allocate limited resources for accession to additional MEAs. Opportunities exist through the Cartagena Convention Regional Activity Network to support unilateral actions in the UKOTs, as well as multi-lateral dialogue amongst the NCNP range states. Indeed, it can be argued that this convention presents the only multi-lateral forum for lobbying those NCNP range states where there is ongoing anthropogenic mortality of nesting leatherbacks.

Unilateral action in the UKOTs may well lead to a better understanding of leatherback interactions with high seas long line fisheries, but cannot result in bycatch mitigation. Only multi-lateral action, through UNCLOS and ICCAT, holds the potential to address regional concerns about NCNP interactions with long line and other high seas fisheries. Limited progress has already been made towards developing an understanding of marine turtle bycatch through ICCAT, but additional lobbying by the UK and other politically influential plenipotentiary states on behalf of NCNP range state territories could lead to stronger, legally binding fishery management mechanisms, as have been achieved through RFMOs elsewhere.

Conclusion

Anguilla, the BVI and, to a much more limited extent, Montserrat share responsibility for management and conservation of the Northern Caribbean leatherback population. Conservation managers in Anguilla and BVI would be justified in allocating limited resources to national action, perhaps with the support through the Cartagena Convention, over and above accession to additional conservation MEAs. Indeed, other NCNP range states in comparable, resource-limited situations may well be justified in making similar decisions about conservation priorities. However, understanding and mitigating leatherback bycatch in high seas fisheries requires multi-lateral actions. The UK Government, along with other politically influential plenipotentiaries, is well placed within existing international institutions to lobby for stronger multi-lateral measures to address concerns over leatherback bycatch in regional fisheries. Nevertheless, whether or not the UK takes such action may well depend on the UKOT governments' capacity to justify their concerns using data generated through national efforts.

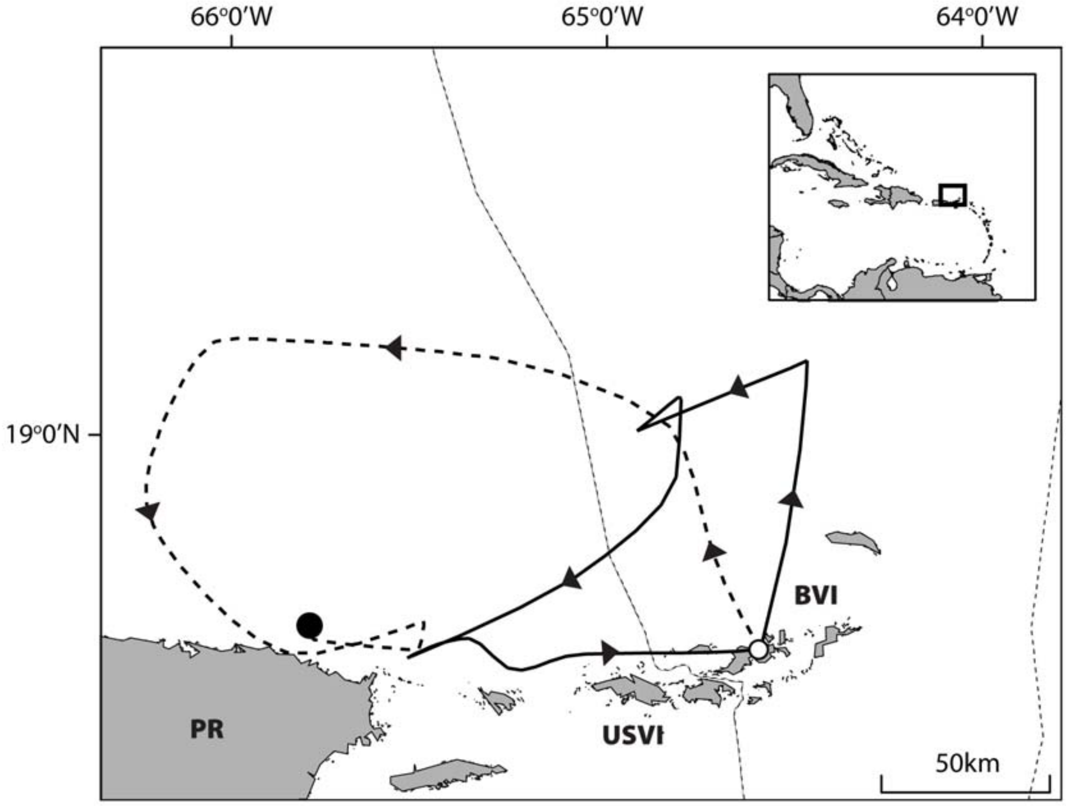


Figure 1. Post-nesting movements of adult female leatherbacks tagged in the British Virgin Islands, including Turtle 1 (solid track) and Turtle 2 (dashed track). Broken lines show territorial borders, white circle indicates the release site and the black circle shows the last transmitted location of Turtle 2.

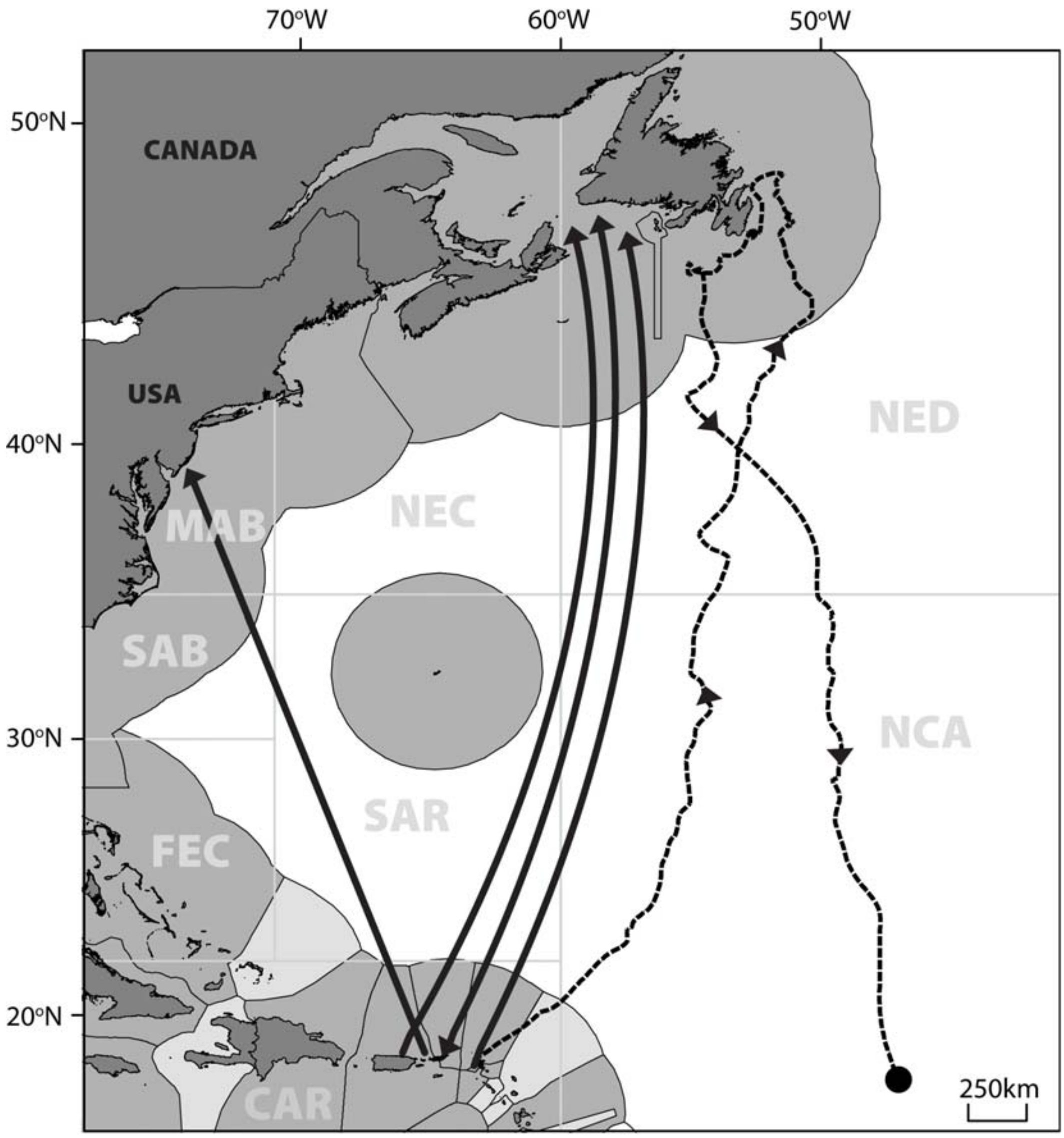


Figure 2. Post-nesting migrations of adult female leatherbacks tagged in the North Caribbean nesting population range, including satellite tracked Turtle 3 (dashed track). The solid black arrows indicate international movements of flipper tagged female leatherbacks (Keinath and Musick 1993, James et al. 2007 and this study), and connect tagging and recapture locations but do not imply travel routes. Darker shaded exclusive economic zones indicate where legislation completely protects leatherbacks and lighter shaded exclusive economic zones indicate where legislation regulates some legal take (Fleming 2001, Brautigam and Eckert 2006, Dow et al. 2007, Y Leon pers comm. 2011). High seas are white. USA National Marine Fisheries Service long line fishery reporting areas are also shown, including Caribbean (CAR), Sargasso

(SAR), North Central Atlantic (NCA), Florida East Coast (FEC), South Atlantic Bight (SAB), Mid-Atlantic Bight (MAB), Northeast Coastal (NEC) and Northeast distant (NED).

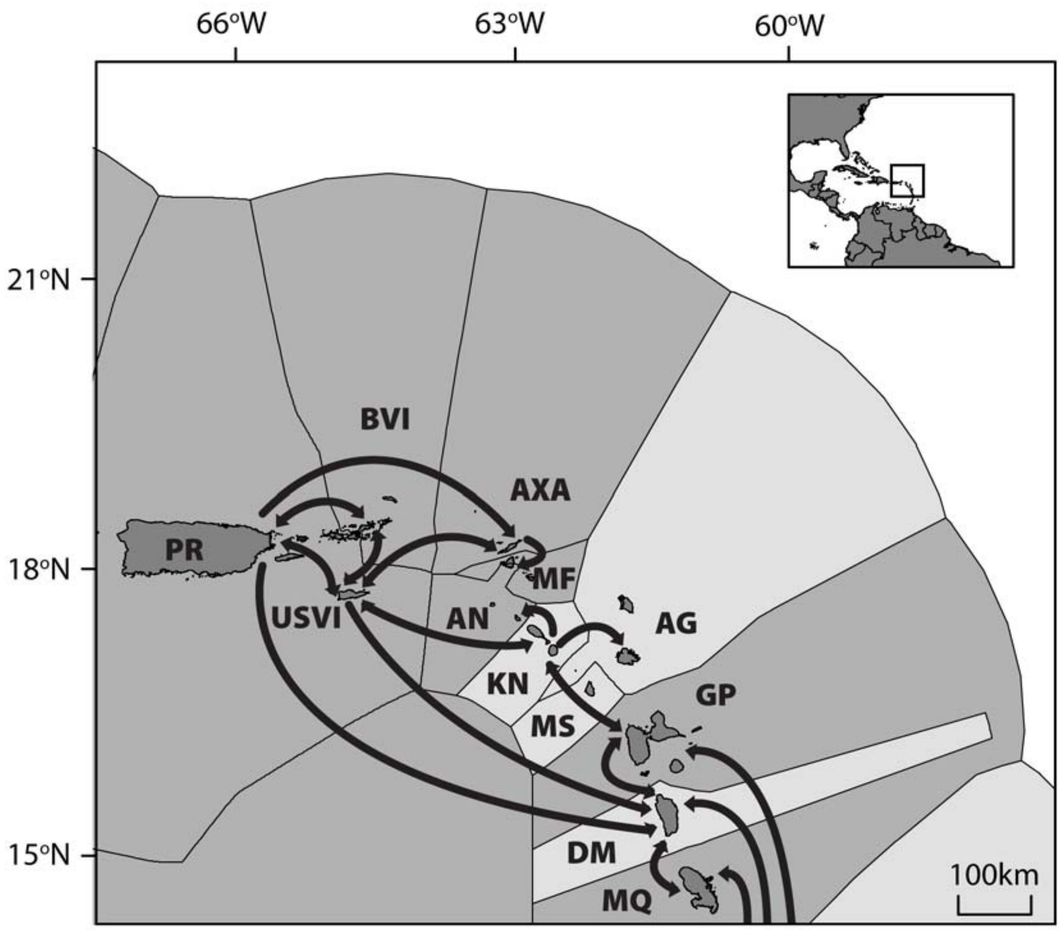


Figure 3. Map showing levels of leatherback turtle protection under national legislation in North Caribbean nesting population range states and shared leatherback nesting as indicated by flipper tag recapture data. Darker shaded exclusive economic zones indicate where legislation completely protects leatherbacks and lighter shaded exclusive economic zones indicate where legislation regulates some legal take (see supplementary table 2). The black arrows indicate international movements of flipper tagged female leatherbacks and connect tagging and recapture locations (see supplementary table 1) but do not imply travel routes. Countries shown are Puerto Rico (PR), US Virgin Islands (USVI), British Virgin Islands (BVI), Anguilla (AXA), Netherlands Antilles of Saba, St Eustatius and St Maarten (AN), Saint Martin, part of Guadeloupe overseas department (MF), St Kitts and Nevis (KN), Antigua and Barbuda (AG), Guadeloupe (GP), Dominica (DM) and Martinique (MQ).

<table>
<tr><th>Country</th><th>IAC</th><th>CMS</th><th>SPAW</th><th>CARTAGENA (WIDECAST STRAP)</th><th>CITES</th><th>UNCLOS</th><th>ICCAT</th></tr>
<tr><td>Canada</td><td>-</td><td></td><td></td><td></td><td></td><td>2003</td><td>1968</td></tr>
<tr><td>USA</td><td rowspan="3">2001</td><td rowspan="3">-</td><td rowspan="3">-</td><td rowspan="3">1984*</td><td rowspan="3">1975</td><td rowspan="3">1996</td><td rowspan="3">1967 (USA)</td></tr>
<tr><td>Puerto Rico</td></tr>
<tr><td>US Virgin Islands</td></tr>
<tr><td>British Virgin Islands</td><td rowspan="3">-</td><td>1985</td><td rowspan="3">-</td><td rowspan="3">1986 (BVI 1992)</td><td>1987</td><td rowspan="3">1997 (UK)</td><td rowspan="3">1998 (UK)</td></tr>
<tr><td>Anguilla</td><td>-</td><td>-</td></tr>
<tr><td>Montserrat</td><td>1985</td><td>1976</td></tr>
<tr><td>Netherlands Antilles</td><td>2001</td><td>1983</td><td>1992</td><td>1984 (1992)</td><td>1999</td><td>1996 (NL)</td><td>1997 (EU)</td></tr>
<tr><td>Antigua & Barbuda</td><td>-</td><td>-</td><td>-</td><td>1986 (1992)</td><td>1997</td><td>1989</td><td>-</td></tr>
<tr><td>St. Kitts & Nevis</td><td>-</td><td>-</td><td>-</td><td>1999 (1992)</td><td>1994</td><td>1993</td><td>-</td></tr>
<tr><td>Guadeloupe</td><td>-</td><td>1990</td><td>2002</td><td>1985*</td><td>1978</td><td>1996</td><td>1968 (France)</td></tr>
<tr><td>Dominica</td><td>-</td><td>-</td><td>-</td><td>1990</td><td>1995</td><td>1991</td><td>-</td></tr>
</table>

Table 1. Year of accession to MEAs relevant to leatherback turtle conservation in range states of the North Caribbean nesting population, including the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC); the Convention on Migratory Species (CMS); the Protocol Concerning Specially Protected Areas And Wildlife (SPAW) to the Cartagena Convention; Cartagena Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region; the Convention on International Trade in Endangered Species (CITES); the United Nations Convention on the Law of the Sea (UNCLOS) and the International Commission for the Conservation of Atlantic Tunas (ICCAT). '-' indicates no accession to date and N/A= Not applicable. Dates in parentheses in CARTAGENA column indicate publication date of Sea Turtle Recovery Action Plan (STRAP) with WIDECAST (* indicates where alternative national Marine Turtle Recovery Action Plans are in place).

Country / Tagged nesting in =►	PR	USVI	BVI	AXA	KN	GP	DM
Canada	X[10]	X[1]		X[1]			
USA		X[3]					
Puerto Rico (PR)		X[3, 6, 13]	X[1]				
US Virgin Islands (USVI)	X[5, 6, 8 - 11]		X[1]	X[1]	X[10]		
British Virgin Islands (BVI)	X[1, 7]	X[5]					
Anguilla (AXA)	X[1]	X[5]					
St. Maarten				X[1]			
St Eustatius					X[2]		
Antigua & Barbuda				X[1]	X[1]		
St. Kitts & Nevis (KN)						X[4]	
Guadeloupe (GP)					X[4]		X[4]
Dominica (DM)	X[14]	X[5]				X[4]	

Supplementary table 1. Countries that have recorded adult leatherback turtles within their territories that have been flipper and/or satellite tagged elsewhere within the NE Caribbean leatherback turtle population range (This study[1] – incl. pers comms. from M Clovis, S Gore & M James 2011; Berkel 2009[2]; Boulon et al. 1996[3]; Delcroix et al. 2011[4], Dutton et al. 2005[5]; Eckert et al. 1989[6]; Fleming 2001[7]; Garner et al. 2006[8]; Garner and Garner 2007[9], 2008[10] & 2009[11]; James et al. 2007[12]; Keinath and Musick 1993[13]; Stapleton & Eckert 2007[14]).

COUNTRY	NATIONAL LEGISLATION AND DETAILS OF LEATHERBACK TURTLE PROTECTION
Canada	**Species At Risk Act (SARA)**: Schedule 1, Part 2 prohibits killing, harming, harassing, capturing or taking leatherbacks in Canada's territorial waters (bycatch permitted under Sub-section 83(4)).
USA	**Endangered Species Act (1973)**: Prohibits harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing or collecting of leatherback turtles and their eggs in USA territory and on the high seas.
Puerto Rico	
US Virgin Islands	
British Virgin Islands	**Virgin Islands Fisheries Act (1997) & Virgin Islands Fisheries Regulations (2003)**: Prohibits taking, sale, purchase and possession of leatherback turtles, turtle eggs and interference with any turtle nest or turtle that is nesting within BVI territory.
Anguilla	**Fisheries Protection Act (2000) and Fisheries Protection Regulations (2000)**: Moratorium on the taking of turtles and their eggs until 2020.
Montserrat	**Turtle Ordinance (1951)**: Any turtle greater than 20lbs (9.07kg) can be taken between may and October inclusive.
Saba	**Netherlands Antilles National Nature Conservation Ordinance (2001)**: Prohibits the taking, possession or killing (including, to the extent possible, the incidental taking, possession or killing) or commercial trade in leatherbacks, their eggs, parts or products; to the extent possible, the disturbance of leatherbacks during periods of breeding, incubation, estivation or migration as provided for in Article 11, paragraph one, subparagraph (b) of the SPAW Protocol.
St Eustatius	
St. Maarten	**Island Nature Ordinance (2003)**: Prohibits the taking, possession or killing (including, to the extent possible, the incidental taking, possession or killing) or commercial trade in leatherbacks, their eggs, parts or products; to the extent possible, the disturbance of leatherbacks during periods of breeding, incubation, estivation or migration as provided for in Article 11, paragraph one, subparagraph (b) of the SPAW Protocol.
Antigua & Barbuda	**The Fisheries Act (1983) & Fisheries Regulations (1990):** Prohibits: removal, sale, purchase or possession of leatherbacks weighing less than 158.8 kg (350lb); removal, sale, purchase or possession of turtles between 1^{st} March to the 31^{st} August; disturbance, removal, sale, purchase or possession of turtle eggs and interference with any turtle nest or turtle that is nesting within Antigua & Barbuda territory.
St. Kitts & Nevis	**Fisheries Act (1984) & Fisheries Regulations (1995):** Prohibits: removal, sale, purchase or possession of leatherbacks weighing less than 158.8 kg (350lb); removal, sale, purchase or possession of turtles between 28^{th} February to the 1^{st} October; disturbance, removal, sale, purchase or possession of turtle eggs and interference with any turtle nest or turtle that is nesting within St Kitts territory; set within 300 yards of the shore any net or device set to catch turtles.
Guadeloupe	**Decree listing protected marine turtles in the department of Guadeloupe (1991):** Prohibits: the destruction of turtle eggs and nests; the mutilation, destruction, capture or take, taxidermy, transport, transformation, use, sale or purchase of turtles within Guadeloupe territory.
Dominica	**Forestry and Wildlife Act (1976):** Prohibits: disturbance of any turtle nest or eggs, or taking attempting to take any turtle laying eggs or on the shore engaged in nesting activities; capture, take or attempt to capture or take any marine turtle that weighs less than 20 lbs; capture, take or attempt to capture or take any marine turtle between the 1^{st} June to the 30^{th} September.

Supplementary table 2. National legislation relevant to leatherback turtle protection in range states of the North Caribbean nesting population.

CHAPTER 4.

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MARINE TURTLE FISHERIES IN THE UK OVERSEAS TERRITORIES OF THE CARIBBEAN: DOMESTIC LEGISLATION AND THE REQUIREMENTS OF MULTILATERAL AGREEMENTS.

Abstract

Marine turtles have been subject to human exploitation in the Caribbean region for millennia. Modern concerns about the conservation status of marine turtles have led to their listing on protective annexes of several international and regional multi-lateral environmental agreements (MEAs). The United Kingdom has ratified or signed some of these MEAs and has governmental responsibility for five Territories in the region, all of which have enacted legislation to regulate domestic turtle fisheries. In this paper we analyse the extent to which domestic legislation in the Territories currently meets necessary and desirable MEA requirements and practices with respect to turtle harvest. We reveal that much of the current legislation does not adequately interpret the MEA requirements with respect to marine turtle harvest and therefore does not fully support the MEA conservation objectives. We outline necessary and desirable changes to legislation and fishery management practice and based on our analysis, we discuss the potential role of the MEAs in facilitating sustainable marine turtle fisheries in these Territories. We conclude that the provisions of some of the MEAs may potentially facilitate sustainable marine turtle harvests in the UK Overseas Territories in the Caribbean. However, the fulfillment of this potential depends on how the MEA requirements are interpreted and translated into domestic legislation; the capacity of the relevant implementing agencies; and the political will of government decision-makers.

Introduction

Historically, marine turtle populations have been an important natural resource to people in the Caribbean region and have been subject to various levels of harvest for millennia (Frazier 2003). Turtle meat and eggs have been harvested, traded and consumed, and the shells (carapaces), particularly those of green and hawksbill turtles, have been processed and traded as ornaments and jewellery (Fleming 2001, Frazier 2003, Campbell 2003).

Towards the end of the 20th Century, growing concern about the effects of this utilisation on the conservation status of the world's marine turtle species resulted in many states protecting marine turtles in their domestic legislation

(Navid 1982). Internationally, the World Conservation Union (IUCN) now lists all but one species as either *endangered* or *critically endangered* with the risk of extinction (IUCN, 2004), although these listings have been the subject of considerable controversy (Mrosovsky 2003, Broderick et al. 2006). In addition, marine turtles have been listed on the most protective annexes of certain multi-lateral environmental agreements (MEAs), most notably the Convention on International Trade of Endangered Species of Fauna and Flora (CITES); the Convention on Migratory Species (CMS or Bonn Convention); the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC), and the Protocol Concerning Specially Protected Areas And Wildlife (SPAW) to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention) (Hykle 2002, Wold 2002).

The general objective of these agreements is to protect and conserve natural resources through national and multi-lateral measures, and their potential to contribute to various elements of marine turtle conservation at national and regional levels has been described at length elsewhere (Campbell et al. 2002, Hykle et al. 2002, Wold 2002). The IUCN defines 'conservation' as *'the management of human use of organisms and ecosystems to ensure such use is sustainable'* (IUCN 1980) and, indeed, the economic and cultural value of natural resource use is acknowledged in the preamble texts of all the other international agreements. For example, contracting states (Parties) to CITES are '*conscious of the ever-growing value of wild fauna…from cultural, recreational and economic points of view'* and Parties to CMS are aware that where natural resources are utilised they should be *'used wisely'*. Parties to SPAW are *'conscious of the overwhelming economic…cultural, nutritional and recreational value of…native flora and fauna to the Wider Caribbean Region',* while Parties to the IAC are '*Inspired by the principles contained in the 1992 Rio Declaration on Environment and Development',* a declaration which emphasises the role of natural resource use in sustainable development.

Commitment to these MEAs usually requires signatory states to enact domestic legislation to facilitate implementation. The accession to MEAs by

Overseas Territories of plenipotentiary states such as the United Kingdom (UK) is of particular interest here. The UK retains some governmental responsibility for several territories in the Wider Caribbean Region (defined in the Cartagena Convention text as *'the Gulf of Mexico, the Caribbean Sea and the areas of the Atlantic Ocean adjacent thereto'*) namely Anguilla, the British Virgin Islands, the Cayman Islands, Montserrat and the Turks and Caicos Islands. These Territories are self-governed by Executive Councils and elected legislatures that have governmental responsibility for internal affairs, including the enactment of domestic legislation pertaining to biodiversity conservation and natural resource management. However, the UK Government retains responsibility for defence, security and all external affairs of the Overseas Territories, including the UK's commitments to the MEAs it has ratified on their behalf (HMG 1999). Therefore, while it is the UK Government's responsibility to ratify and sign MEAs on behalf of the Overseas Territories, it is the responsibility of the Territory governments to ensure that appropriate domestic legislation is in place.

The UK has ratified CITES and the CMS, has signed but not ratified the SPAW Protocol, and has neither signed nor ratified the IAC. When the government of an Overseas Territory decides that it would like to accede to an MEA ratified by the UK, the Territory Government must request the UK Government make the necessary arrangements with the MEA secretariat in order for that MEA to be extended to the Territory. For this reason, not all the MEAs ratified by the UK extend to all the UK Overseas Territories in the Caribbean. Table 1 summarises the status of CITES, CMS, SPAW and the IAC with respect to these Territories.

Four species of marine turtle regularly frequent the waters of the UK Overseas Territories in the Caribbean, including the green *(Chelonia mydas)*, hawksbill (*Eretmochelys imbricata)*, leatherback (*Dermochelys coriacea)* and loggerhead (*Caretta caretta)* turtles (Proctor and Fleming 1999). A recent assessment of the status and exploitation of these species and of the relevant domestic legislation concluded that although sizeable foraging aggregations were present, historical marine turtle exploitation has led to significant declines in turtle nesting populations, which appear to be critically low in all the Territories (Godley et al. 2004) It also made a number of Territory-specific recommendations regarding marine turtle conservation and management. These recommendations included suggested amendments to the Territories' current legislation regulating marine turtle harvest (see Table 2).

The utilisation of marine turtles in the Overseas Territories has direct relevance to the UK's obligations under CITES and CMS, and could in future affect obligations under SPAW and the IAC. The following analysis addresses all four agreements. The various necessary legislative requirements of each MEA with respect to turtle harvest and trade are identified. We also outline the additional legislative requirements and other desirable practices needed to facilitate sustainable turtle harvests, as recently recommended (Godley et al. 2004). We ask whether domestic legislation in the Territories meets MEA requirements and practices. Based on this analysis, we discuss the potential role of the MEAs in facilitating sustainable marine turtle fisheries in these Territories.

CITES, CMS, SPAW and the IAC With Respect to Marine Turtle Harvest.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

CITES was adopted in 1973 and entered into force in 1975 (CITES, 2005). The Convention regulates international trade in endangered species or those species that could become endangered if trade is not regulated and controlled. CITES has no national remit and therefore the Convention's requirements do not impact on domestic use of marine turtles. Signatory States (Parties) must enact national legislation to transpose the requirements of CITES to domestic law. The treaty has broad international support, and as of September 2005, 169 states were contracting Parties. The UK Government ratified CITES in August 1975 and requires that its Overseas Territories have appropriate legislation in place to implement the requirements of CITES before they extend the Convention.

CITES lists species in three separate Appendices I, II and III, with different trade restrictions applying to each appendix, and institutes a system of obligatory import and export permits and regular reporting to the Secretariat. All species of marine turtle are currently listed in CITES Appendix I. Article II of the Convention (Fundamental Principles*)*, states that international trade in specimens of species in Appendix I (i.e. marine turtles) '*must be subject to particularly strict regulation in order not to endanger further their survival and must only be authorized in exceptional circumstances*'.

Throughout the Convention text, the term '*specimen of species'* is used, and Article I defines *specimen* as follows:

"Specimen *means:*

(i) *any animal or plant, whether alive or dead;*

(ii) *in the case of an animal; for species in Appendix I and II, any readily recognisable part or derivative thereof…"*

Article 3 describes the system of permits required for the export and import of specimens of species in Appendix I. Parties are required to ensure that movement of these specimens between Parties is not detrimental to the survival of the species, is in accordance with national laws and is not for primarily commercial purposes.

Parties may enter reservations on CITES Appendix I listed species, allowing them to be exempt from the Convention's trade restrictions for the reserved species. Parties with reservations on species are formally treated as non-Parties with respect to trade in the species concerned, but are encouraged to treat their Appendix I reserved species as if they were in Appendix II, and therefore monitor and report any trade. In the Caribbean region, Cuba currently has reservations on green and hawksbill turtles, St Vincent and the Grenadines have a reservation on green turtles and Suriname has reservations on green and leatherback turtles. The UK does not currently have reservations on any marine turtle species.

Convention on Migratory Species (CMS or Bonn Convention)

CMS was adopted in 1979, came into force in 1985 (CMS 2005), when the UK ratified it, and had 91 contracting Parties as of July 2005. CMS aims to facilitate multi-lateral conservation action for migratory species and their habitats by requiring strict protection for endangered migratory species; concluding multilateral conservation and management plans; and undertaking co-operative research programmes between contracting Parties.

The Convention's Article 2 (Fundamental Principles) requires that *'The Parties acknowledge the importance of migratory species being conserved'* and clause 2 of this Article requires that Parties *'acknowledge the need to take action to avoid any migratory species becoming endangered'*. Clause 3 also states that the Parties *'should promote, co-operate in and support research relating to migratory species'*, but the text of the article does not specify the detail of such research.

The CMS has two appendices. Appendix I lists migratory species *'which are endangered'* and Appendix II lists other migratory species that either require or would benefit from international agreements under the Convention. All the species of marine turtle found in the Wider Caribbean Region are listed on Appendix I, where they receive the highest level of protection under CMS. Article III clause 5 requires Parties to *'prohibit the taking of animals'* that are Appendix I species, but exceptions are allowed under the following criteria:

> *'a) the taking is for scientific purposes;*
>
> *b) the taking is for the purpose of enhancing the propagation or survival of the affected species;*
>
> *c) the taking is to accommodate the needs of traditional subsistence users of such species; or*
>
> *d) extraordinary circumstances so require; provided that such exceptions are precise as to content and limited in space and time. Such taking should not operate to the disadvantage of the species.'*

The term *traditional subsistence user* is undefined in the Convention text and has not been defined elsewhere by the CMS Secretariat.

Protocol Concerning Specially Protected Areas And Wildlife (SPAW) to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention)

The Cartagena Convention is the only multi-lateral environmental agreement that specifically aims to facilitate national and regional management of coastal and marine resources in the Wider Caribbean Region. The Convention was adopted in 1983, along with the Protocol to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region Concerning Co-operation in Combating Oil Spills in the Wider Caribbean Region (Oil Spills Protocol), and these entered into force in 1986 after having been ratified by the required nine Parties (CMS 2005).

The Parties adopted the SPAW Protocol in 1990, but it only came into force in 2000 and only 12 Parties had ratified SPAW by the end of 2005. SPAW aims to facilitate the protection of threatened species and their habitats through national and regional cooperative actions. In Article 3 (General Obligations), the Protocol requires that each Party '*in accordance with its laws and regulations and the terms of the Protocol, take the necessary measures to protect, preserve and manage in a sustainable way…*

a) areas that require protection to safeguard their special value; and

b) threatened or endangered species of flora and fauna.'

Articles 10 and 11 describe national and cooperative measures respectively, for the *protection* of threatened and endangered species. Article 10 requires that Parties identify endangered or threatened species within their jurisdiction and give these species protected status under national laws and regulations. Article 11 refers to the Protocol's Annexes I, II and III, under which threatened or endangered species are listed, and for which the Parties must *'adopt co-operative measures to ensure [their] protection and recovery'.* The four marine turtle species found in the UK Overseas Territories in the Wider Caribbean Region are all included in Annex II, *'List of Species of Marine and Coastal Fauna Protected Under Article 11 (1)(b).'*

Under Article 11, clause 1b, Parties are required to *'ensure total protection and recovery'* of marine turtle species, and this protection must, where appropriate, '*prohibit:*

(a) *the taking, possession or killing (including, to the extent possible, the incidental taking, possession or killing) or commercial trade in such species or their parts or products; and*

(b) *to the extent possible, the disturbance of wild fauna, particularly during the period of breeding, incubation, estivation or migration, as well other periods of biological stress.'*

However, Article 14 (*Exemptions For Traditional Activities*), requires that Parties '*take into account and provide exemptions, as necessary, to meet traditional subsistence and cultural needs of its local populations'* when formulating '*management and protective measures'* such as national legislation. As with the CMS, *traditional subsistence and cultural needs* are not defined in the Convention text and have not been described by the Convention Secretariat elsewhere. Clause 1 (b) of this article imposes certain parameters on any interpretation by requiring that by meeting these needs*, 'to the fullest extent possible'* harvest should not result in *'the extinction of, or a substantial risk to, or a substantial reduction in numbers of'* the species in question.

Unlike CMS, the text of SPAW requires that Parties develop research on protected species, with more emphasis on management. Article 17 clause 1 states that *'Each Party shall encourage and develop scientific, technical and management-oriented research…on threatened or endangered species of fauna and flora and their habitats.'*

The UK ratified the Cartagena Convention and the Oil Spills Protocol on behalf of the Cayman Islands and Turks and Caicos Islands in 1986, and the British Virgin Islands in 1987. The UK has not yet ratified the SPAW Protocol and therefore none of its provisions currently apply to any of the Overseas Territories. The UK Government's Foreign and Commonwealth Office (FCO) are committed to supporting SPAW, but require that the UK Overseas

Territories have the necessary domestic legislation in place before the UK ratifies the Protocol (D. Dudgeon, FCO pers. comm. 2004).

Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC)

The IAC is the only international treaty dedicated exclusively to sea turtles and covers the '*land territory in the Americas of each of the Parties, as well as the maritime areas of the Atlantic Ocean, the Caribbean Sea and the Pacific Ocean*'. The Convention entered into force in 2001 and has been ratified by 11 countries in the region (IAC 2005).

The treaty's objective is to *'promote the protection, conservation and recovery of sea turtle populations and of the habitats on which they depend, based on the best available scientific evidence, taking into account the environmental, socio-economic and cultural characteristics of the Parties'* (Article II). In order to meet this objective, the IAC requires Parties to protect and conserve marine turtle populations and habitats; to reduce the incidental capture, injury and mortality of marine turtles due to commercial fisheries; prohibit the intentional harvest, international and domestic trade in turtles and turtle products; and encourage international cooperation in research and management programmes.

The IAC text is resolute with respect to the prohibition of turtle harvest and trade, and the list of prohibited activities in this regard is the most comprehensive of the MEAs considered here. Under Article IV clause 2a, Parties are required to prohibit *'the intentional capture, retention or killing of, and domestic trade in, sea turtles, their eggs, parts or products'.* The IAC is the only treaty considered here that acknowledges the overlap of another MEA in its text. Article IV 2b requires Parties to comply with *'obligations established under the Convention on International Trade in Endangered Species of Wild Fauna and Flora relating to sea turtles, their eggs, parts or products'.*

Clause 3a of Article IV allows Parties domestic harvest and consumption of marine turtles and their products so long as it satisfies the '*economic subsistence needs of traditional communities'*. This term is not defined, however, either in the text or by the Secretariat. It is of interest to note that under clause 3a, Parties that allow take must also take into account advice from the IAC Consultative Committee, consisting of Party appointees and selected experts from the private sector, the scientific community and a representative non-governmental organisation. When providing recommendations and advice to Parties allowing domestic use of marine turtles, the Committee is required to take into account *'the views of any Party regarding such populations, impacts on such populations on a regional level, and methods used to take the eggs or turtles to cover such needs'.* However, the extent to which Parties requesting exemptions are bound to follow such advice is not made clear in the IAC text (Campbell et al. 2002). Parties that allow take are required to *'establish a management program that includes limits on levels of intentional taking'* and report to the Secretariat regarding their management program under Article IV clause 3b.

Article IV also requires Parties in clause 2e to promote *'scientific research relating to sea turtles and their habitats'* that will contribute to the implementation of other measures described in the Article. However, none of the provisions of the IAC currently extend to any of the UK Overseas Territories as the UK has not signed the treaty.

Implications of MEAs for domestic legislation

Table 3 represents our evaluation of necessary and desired marine turtle harvest legislation and practice based on the requirements of the MEA texts, the overall MEA conservation objectives, and recommendations that support the conservation objectives of the MEAs (in Godley et al. 2004). These Territory-specific recommendations focus on the introduction of legislative amendments and management practice to avoid over exploitation of stocks, whilst strictly protecting reproductive adults and eggs, as well as larger size-classes, in line with current marine turtle population biology (Heppell et al. 2003).

Table 3 categorises the legislative and management requirements as follows: (i) necessary legislative requirements, i.e. those requirements that are specified by the MEA text, (ii) desirable legislative requirements to facilitate a sustainable turtle harvest, i.e. requirements that we deem desirable for legislation based on MEA texts, MEA conservation objectives and recent conservation recommendations (Godley et. al. 2004), and (iii) other desirable practices to facilitate an ecologically sustainable turtle harvest, i.e. desirable practices relating to marine turtle harvest based on MEA texts, MEA conservation objectives and the conservation recommendations. (Godley et al. 2004).

MEA legislative requirements are deemed necessary where the text uses appropriate language, for example where words such as '*shall'* are used, as in CMS Article III, clause 5 *'Parties that are Range States of a migratory species listed in Appendix I <u>shall</u> prohibit the taking of animals belonging to such species'.* Where the text uses more flexible language, such as *should* or *may,* as in CMS Article III, clause 5 *'Exceptions <u>may</u> be made to this prohibition'*, we deem these legislative requirements as desirable rather than necessary.

The legislative requirements of CITES pertinent to this discussion are contained within Article III, which requires Parties to legislate for an obligatory licensing scheme for the import and export of all specimens of species listed on CITES Appendix I (i.e. all marine turtle species) and are not treated in Table 2. While Article XXIII of CITES allows Parties to enter reservations on marine turtle species, the UK has not entered any such reservations and so this article is not pertinent to the UK Overseas Territories.

Marine turtle fishery legislation in the UK Overseas Territories in the Wider Caribbean Region

There is a diversity of legislation regulating the marine turtle fisheries of the UK Overseas Territories in the Caribbean, summarised here in table 2. In this section we review the legislation currently in place for each Territory and highlight key issues in the context of compliance with the CITES and CMS, as well as potential compliance requirements if the UK ratifies SPAW and the IAC. This section refers extensively to columns i, ii and iii in Table 3.

Anguilla

Until 1995, Anguilla's turtle fishery supplied a domestic demand for meat, including a market for resale through local restaurants, while turtle meat and shells were also exported to neighbouring Caribbean states such as St Martin, Puerto Rico and the US Virgin Islands (Godley et al. 2004). By the early 1980s, turtle harvest in Anguilla had reached unprecedented levels, in particular to meet the overseas demand for hawksbill shell, which led to local concerns for the conservation status of the turtle populations in Anguilla's waters (Meylan 1983).

Eventually, in response to these concerns, The Fisheries Protection (Amendment) Regulations 1995, introduced a 5-year moratorium on turtle harvest. The moratorium was extended for a further 5 years from the 15th December 2000 under the Fisheries Protection Regulations, Chapter F40-1, gazetted in 2000, due to expire in December 2005. Under section 17, entitled '*Prohibition on taking turtles etc*', anyone who '*takes, attempts to take, or causes to be taken any turtle; slaughters or buys, sells exposes for sale or has in his possession the whole or a portion of the meat of a turtle; or takes or attempts to take, buys, sells or has in his possession any turtle egg*' is guilty of an offence.

Curiously, these regulations do not specifically mention turtle shell, the trade of which was responsible for increased levels of exploitation that led to initial concerns regarding the conservation status of Anguilla's turtle populations (Meylan 1983). As the term *meat* is not defined in the Regulations, trade in marine turtle shell in Anguilla may not be prohibited, so long as the sale was not the cause for any turtle to be taken. CITES does not yet extend to Anguilla, although the government has drafted legislation in preparation for accession to the treaty (K. Hodge Govt. of Anguilla, pers comm. 2005). Furthermore, the Regulations only apply to *'Anguilla and the fishery limits'*, and therefore the unlicensed import and sale of green and hawksbill turtle shell is not prohibited. Neither is the unlicensed export of turtle shell to non-signatory states and Parties to CITES with reservations on green or hawksbill turtles prohibited, so long as such action did not cause the turtle to be taken in Anguilla's waters after 1995 when the moratorium was originally enacted.

It is worth noting that Godley et al. (2004) found no evidence of any trade in turtle shell in Anguilla. Indeed, while turtle meat and carapaces were being exported to other Caribbean states in the 1980's, the tourist market for tortoiseshell items appears to have collapsed in the 1980s, probably as a result of import and export restrictions in the countries of origin of the tourist market. CITES implementation in other countries may therefore have impacted international trade in turtle products from Anguilla long before the Government considered accession to the Convention. Anguilla still does not have legislation to implement CITES, but the Caribbean states that used to provide a market for Anguilla's turtle harvest have since acceded to CITES. Therefore, so long as marine turtles remain on CITES Appendix I, even without accession to CITES, it is likely that any future harvest of turtles in Anguilla will not supply an overseas demand and will be restricted to domestic use only.

CMS does not currently extend to Anguilla, although the government has drafted domestic legislation in preparation for accession to this treaty (K. Hodge, Government of Anguilla, pers. comm. 2005). It remains unclear if the Government of Anguilla will re-open a turtle fishery in coming years after the moratorium expires. However, since there are no other provisions for turtle harvest in the current legislation, an amendment to the Fisheries Regulations 2000 will be needed if the fishery is re-opened. In preparation for accession to CITES and CMS, the requirements of these treaties will have to be taken into account when preparing such amendments.

For example, CMS Article III would require new legislation to prohibit the take of turtles (Table 3, column i). If the Government decided to reinstate a turtle harvest, then the legislation should provide for harvest by traditional subsistence users only, and interpret a definition of traditional subsistence user in the context of the Anguillian fishing community as per Article III clause 5 (Table 3, column ii). If the UK were to sign SPAW and IAC and extend them to Anguilla, harvest and domestic trade in turtles, their eggs and products would have to be prohibited by the legislation (Table 3, column i), unless Anguilla allowed exemptions under these treaties. Under SPAW Article 14, the legislation would be obliged to take into account the *'traditional subsistence and cultural needs'* (Table 3, column i) and under the IAC Article IV clause 3a, would be required to meet the *'economic subsistence needs of traditional communities'* (Table 3, column ii). The legislation should interpret definitions of these terms in the local context (Table 3, columns i and ii). In order for the legislation to meet the conservation objectives of these treaties, it should also include restrictions on harvest (Table 3, column ii) and under the IAC Article IV clause 3b, should provide for a fishery management programme (Table 3, column i).

CMS and IAC encourage Parties to support and develop research programmes on marine turtles, while SPAW requires the development of management-related research, and, if a marine turtle harvest is reinstated in Anguilla, this would be required under SPAW and desirable under CMS and IAC (Table 3, columns i and iii). However, implementation of such programmes may be problematic given the current deficiency in human and financial resources within Anguilla's Department of Fisheries and Marine Resources (DFMR) (Gumbs 2003). The Fisheries Protection Regulations require that *'The Chief Fisheries Officer shall prepare and keep under review a plan for the management and development of fisheries'.* An ongoing government waiver of the commercial fishermen's license scheme makes fishery monitoring difficult and impractical in Anguilla, and this, in combination with insufficient human resources within the DFMR, has resulted in there being no management or monitoring of any fishery in Anguilla (Gumbs 2003). Clearly, the extension of these MEAs to Anguilla would present complex legislative amendments and logistical difficulties to the DFMR if Anguilla also reinstates its marine turtle fishery.

British Virgin Islands

The current marine turtle fishery in the British Virgin Islands (BVI) takes mainly green and hawksbill turtles, apparently at much reduced levels compared to historical harvests (Godley et al. 2004). The harvest supplies a domestic market, largely for personal consumption, with some meat sold to restaurants for re-sale. The Virgin Islands Fisheries Act, 1997 and the Fisheries Regulations, 2003 regulate the BVI turtle fishery (see table 3). There is no monitoring or management of the marine turtle fishery at present (Godley et al. 2004).

CITES extends to BVI and is transposed to domestic legislation by the Endangered Animals and Plants Act, 1987 (Cap. 89). All the species of marine turtle found in BVI's waters are listed on the First Schedule of the Act, and this prohibits the import and export of live or dead specimens without a license. In addition, clause 16 of the Third Schedule of the Act prohibits the unlicensed import and export of any shell, scales and claws of '*any animal of the family Cheloniidae*'. Curiously, this clause allows the unlicensed import and export of such items if the objects are '*cut to shape'*. This provision of the Act is in direct contravention of CITES, which requires that Parties issue highly conditional permits for the import and export of '*any specimen of a species'* of marine turtle, and therefore requires amendment to meet full CITES compliance. Godley et al (2004) reported only two instances of tortoiseshell items for sale in BVI, one of which was being offered for sale by a vendor who described how *'import restrictions in other countries'* resulted in limited demand. As with Anguilla, their findings suggest that CITES implementation in tourist countries of origin may have impacted trade in BVI, despite the inadequacies of the Endangered Animals and Plants Act, 1987.

CMS extends to BVI. The Fisheries Regulations, 2003 fail to meet the necessary requirements for CMS outlined in column (i) of table 3 because, while they prohibit the taking of loggerhead and leatherback turtles, they allow the harvest of other species without most of the desired legislative requirements listed in Table 3, column (ii). As BVI's legislation permits a harvest under Article III of the treaty, the Fisheries Regulations should only allow harvest by *'traditional subsistence users'*. In contrast, the Regulations provide for any licensed local or foreign fishermen to catch an unlimited number of turtles during the open season, and thereby allowing the possibility of over exploitation. Other management measures described in the Regulations, such as the closed season and the protection of turtle eggs and nesting females, meet some of the desired requirements of CMS Article II in Table 3, column (ii), but include inappropriate size limits that facilitate the harvest of the larger size classes and do not include quotas. While the current turtle harvest may be catching relatively fewer turtles when compared to historical levels, it is unclear whether or not BVI's current fishery is sustainable (Godley et al. 2004).

BVI's turtle harvest legislation would not meet the requirements of SPAW or IAC (columns i, ii and iii) for similar reasons, and the Regulations do not specifically provide for any fishery monitoring and management plan as is desirable under SPAW and required by IAC (columns i and ii). BVI's current turtle harvest legislation requires significant amendment to meet specific requirements of CMS, and the requirements of the SPAW Protocol and IAC if they ever extend to BVI.

Cayman Islands

While the Cayman Islands may have once hosted the largest green turtle rookery in the Caribbean, the nesting populations of turtles there have drastically declined over the last few centuries as a result of extensive, commercial over-exploitation (Aiken et al. 2001). Remnant green and loggerhead populations remain, but the population of nesting hawksbill turtles may have been extirpated in recent years (Godley et al. 2004). The current turtle fishery in the Cayman Islands is now strictly managed, and involves very low levels of take, and the continuing demand for turtle meat is largely met by the Cayman Turtle Farm (CTF 2002, Godley et al. 2004).

CITES extends to the Cayman Islands and the recently gazetted Endangered Species (Trade and Transport) Law (2004 revision) fully transposes CITES to domestic law. Import, export and re-export of all turtle products must be accompanied by permits issued by the relevant authorities in the Cayman Islands and destination/source countries. The Cayman Island Department of Environment (CIDoE) have indicated that while all marine turtle species remain on CITES Appendix I, they will not issue permits for the commercial trade of marine turtle products from the islands (G Ebanks-Petrie, CIDoE pers. comm. 2004). This Law therefore effectively prohibits international trade in specimens of all turtle species and restricts any such trade to a domestic level.

The Cayman Islands' turtle harvest is regulated by the Marine Conservation (Turtle Protection) Regulations 1996, which are arguably the most comprehensive turtle harvest legislation of the UK Overseas Territories. CMS extends to Cayman and while turtle harvest is not prohibited, the Regulations meet most of the requirements as outlined in columns i, ii and iii of table 3. These are the only regulations in the UK Overseas Territories that restrict the fishery to a defined social group, namely *'fishermen who have traditionally taken turtles within the Cayman Fisheries Zone by traditional methods…for consumption within the Islands'*. The Government's Marine Conservation Board issues non-transferable licenses to 20 identified individuals, who are further limited by a quota system. Each captured turtle must be presented to the CIDoE before it is butchered, thus satisfying to some extent the desirable fishery monitoring requirement under CMS Article II (Table 3, column ii). Only 14 licenses have been issued and only eight of the licensed fishermen continue to take turtles (Godley et al. 2004), thus, the legal harvest is strictly controlled and operates at low levels. In addition, CIDoE monitors nesting activity on the islands, as well as the foraging turtle aggregations, and therefore meets the relevant desirable requirements for CMS Article II (Table 3, column iii).

However, while the legislation protects nesting females and their eggs, and incorporates a closed system, these measures may not be sufficient to support the conservation objectives of the MEAs. The current closed season may not adequately protect reproductively active adult turtles entering Cayman waters prior to the nesting season (Godley et al. 2004). Furthermore, the specified size limits for green, hawksbill and loggerhead turtles encourage the capture of sub-adults and adults only, while protecting smaller and younger age classes. These size limits do not facilitate a sustainable harvest of turtles. Indeed, it has been observed that the current fishery holds the potential to severely impact the remnant breeding populations of turtles and hinder their recovery (Bell and Austin 2002), and thus the conservation objectives of the MEAs.

The Marine Conservation (Turtle Protection) Regulations 1996 also meet the necessary requirements of SPAW Article 14 (Table 3, column i) and IAC Article IV that limit use (Table 3, columns i and ii), and the CIDoE monitoring meets the requirements of IAC Article IV (Table 3, column i) and the desirable practice for SPAW (column iii). But as described above with CMS, they fail to adequately meet key desirable legislative requirements for SPAW listed in column (ii) of Table 3. Despite these deficiencies, the Regulations provide perhaps the best interpretation of the requirements of the MEAs and, with amendment to the legislation's size limits and closed season, these Regulations may facilitate sustainable turtle harvest. However, the CIDoE will not issue new licenses once the current eligible licensees have expired, and therefore the fishery will not be sustained because the fishermen may expire before the resource they target (Godley et al. 2004).

Montserrat

Montserrat's turtle harvest is regulated by the Turtles Ordinance of 1951, although the Fisheries Department has drafted more contemporary legislation (M. O' Garro, Montserrat Department of Fisheries, pers. comm. 2005). Montserrat's fishermen are also required to comply with the Fisheries Act 2000 with regard to licensing, boat registration and general fishery requirements.

CITES extends to Montserrat and all marine turtle species are listed in Schedule 1 of the Endangered Animals and Plants Ordinance, 1976. This Ordinance prohibits the import and export of live and dead specimens of all marine turtle species without a government-issued licence. However, as with

BVI’s Endangered Animals and Plants Act, 1987, there is a curious exception in Schedule 3, which uses identical text to BVI’s legislation and similarly, seems to allow the unlicensed import and export of the shell, scales and claws of Cheloniidae turtle species if they are *‘cut to shape’* (e.g. tortoiseshell jewellery). A former trade in turtle shell products seems to have disappeared, probably because of a decline in demand and the volcanic crisis of the mid-1990s (Godley et al. 2004). Again, despite flaws in domestic legislation, international trade in turtles and their products appears to have declined due to factors other than the legislation itself.

The CMS extends to Montserrat and the Turtles Ordinance fails to adequately meet most, if not all of the legislative requirements for this treaty as well as SPAW and the IAC (Table 3, columns i & ii). For example, the Ordinance is the only turtle harvest legislation in the UK Overseas Territories that allows the take of nesting females and their eggs during an open season, although Godley et al. (2004) indicate that all turtle and egg harvest in Montserrat occurs at very low levels. The size limits described in the Ordinance are inappropriate and the current closed season does not adequately protect reproductively active adults in Montserrat’s waters (Godley et al. 2004).

Similarly, the Ordinance would not meet the desirable management and monitoring requirements of any of the treaties (Table 3, column iii) as it does not provide for a management plan for the turtle fishery. Nevertheless the Department of Fisheries has made some effort to monitor the catch of turtles, but it has only 4 staff and no access to a marine vessel (J. Jeffers, Department of Fisheries, Montserrat, pers. comm. 2005, Godley et al. 2004). Under these conditions, the desirable MEA requirements for marine turtle fishery management and monitoring as listed in table 3 would present significant logistical difficulties to the Department of Fisheries.

Turks and Caicos Islands

Turtle harvest in the Turks and Caicos Islands is regulated under the Fisheries Protection Ordinance (1998) and may be one of the largest regulated turtle fisheries in the Caribbean. While most fishermen who catch turtles catch a small number of turtles per year on an opportunistic basis, total annual harvest is estimated at between four hundred and two thousand turtles per year, mostly green and hawksbill turtles (Godley et al. 2004). Meat is sold to private consumers and to a number of restaurants for resale.

CITES does not extend to the Turks and Caicos Islands and therefore there is no domestic legislation that regulates the import or export of marine turtles. A new Wildlife and Endangered Species (Trade, Collection, Removal and Transport) Bill is currently being drafted, which will transpose CITES to domestic legislation in preparation for accession to this treaty (M Fulford Gardiner, DECR, TCI, pers. comm. 2005). In the absence of this domestic legislation, the Fisheries Protection Ordinance includes some provision for the export of marine products. It currently allows any person, upon payment of an appropriate export duty, to export 10lbs (4.5kgs) of *'any species of marine product'* each time they leave the Turks and Caicos Islands.

There appears to be limited export of meat from the Turks and Caicos Islands (Godley et al. 2004), and there have been reports that fishermen were exporting raw hawksbill turtle scutes to the Dominican Republic, which is a Party to CITES and has a thriving trade in tortoiseshell artefacts (Fleming 2001, Marte et al. 2003). As in Anguilla and the BVI, trade in turtle shell products to the tourism-based market has declined in recent years in TCI (Godley et al. 2004), probably as a result of tourist awareness of CITES implementation. Nevertheless, the new Wildlife and Endangered Species (Trade, Collection, Removal and Transport) Bill is required to include provisions to prohibit unlicensed import and export of any specimens of marine turtles so long as they remain on CITES Appendix I. Similarly the Fisheries Protection Ordinance (1998) will require amendment to fully comply with the treaty and IAC Article IV clause 2b (Table 3, column i) if this treaty were to extend to TCI.

CMS extends to TCI. While the Ordinance does not prohibit the take of turtles as required under CMS Article III (Table 3, column i) or define '*traditional subsistence users*' (Table 3, column ii), it limits commercial fisheries to

Belongers (native Turks and Caicos Islanders as defined by the TCI Immigration Ordinance), while non-licensed *Belongers* are allowed to catch *'reasonable quantities'* of turtles for personal consumption. It could be argued that, in practice, this provision limits the fishery to *traditional* fishermen. However, the TCI's turtle fishery is the largest of the UK Overseas Territories, and the turtle meat is resold through restaurants and often purchased by visitors to the islands (Godley et al. 2004). It is questionable whether or not the restaurants and their customers comfortably sit within the definition of '*traditional subsistence users*', and the sustainability of this relatively large harvest is unknown. Similarly, it could be argued that the Ordinance presents an interpretation of Article 14 of SPAW (Table 3, column i) and Article IV of the IAC (Table 3, column ii), but with questionable efficacy.

As with the legislation in the other Territories, the Ordinance sets inappropriate size limits, but prohibits the take, possession, purchase and sale of '*laid*' turtle eggs (by inference, there are no restrictions on eggs retrieved from the carcasses of captured females), and prohibits the take of nesting females (see table 3). However, there is no closed season, and breeding adult turtles can be caught as soon as they enter the water below *'the low water mark'* at any time of year. While these provisions are unlikely to facilitate action that prevents turtles from *'becoming endangered'* as required by CMS Article II (Table 3, column ii), the Ordinance does require that each fishery is identified and the *'present state of its exploitation'* be assessed as part of a fishery plan and as required by SPAW Article 17 and IAC Article IV (Table 3, column ii). However, despite this current provision in the legislation, the turtle fishery in TCI is not monitored or managed and has not been assessed as part of a government fishery plan, hence it is unclear whether or not the current fishery is sustainable. Given the absence of a fishery management plan, it is questionable whether or not the current capacity of the Department of Environment and Coastal Resources (DECR), the agency responsible for enforcing the Ordinance, will allow effective management of the turtle fishery as required by SPAW and IAC (Table 3, column ii).

DISCUSSION

The UK Overseas Territories have a rich history and culture of marine turtle utilisation, and the need for conservation of this resource was expressed, in some cases, in domestic legislation long before the formulation of the MEAs (Godley et al. 2004). However, early turtle harvest legislation was written without the benefit of contemporary conservation biology theory, and in all of the Territories, the legacy of these inadequate measures remains in the legislation that regulates turtle fisheries today. Consequently these fisheries may have significantly contributed to declines in the populations of turtles nesting in the UK Overseas Territories (Godley et al. 2004).

Vanzella-Khouri (1998) reviewed the implications of SPAW implementation prior to the treaty coming into force and concluded that much of the relevant legislation of the Caribbean states *'is deficient in providing adequate institutional support'* to the implementation of the Protocol. In accordance with Vanzelli-Khouri's assessment, it is clear that much of the legislation regulating the harvest and use of marine turtles in the UK Overseas Territories is similarly deficient, not only with respect to supporting the general conservation objectives and potential implementation of the SPAW Protocol, but also with respect to supporting other MEAs, such as CITES and CMS, that already extend to some of the Territories.

Under these conditions, CITES has had a remarkable impact on use of turtles in the UK Overseas Territories. Although the treaty does not yet extend to Anguilla and the Turks and Caicos Islands, and the relevant legislation in BVI and Montserrat does not fully comply with CITES, international trade of turtle products within the tourism-based market has declined. This is probably due to the extensive international support for CITES, especially in the countries from which tourists to the Caribbean originate. Fleming (2001) suggests that CITES has been effective in curbing international trade in marine turtle products in the Caribbean region, and we concur that, with the possible exception of the Turks and Caicos Islands, the treaty has largely restricted consumption of turtles and their products in the Territories to domestic use.

CMS, SPAW and IAC have clear conservation objectives that could contribute to the recovery of the turtle nesting populations in the Territories. They allow exemptions for Parties that want to allow turtle fisheries, and they impose criteria so that those fisheries do not undermine the conservation objectives. The Territories that commit to these MEAs are obliged, therefore, to incorporate provisions in their domestic legislation that interpret the requirements of the MEAs. How each country interprets and enforces these requirements, thus, determines whether or not the agreements can facilitate marine turtle harvests that support their conservation objectives.

In the UK Overseas Territories in the Caribbean, CMS appears to have been less effective than CITES in meeting its conservation objectives with respect to marine turtles. CMS extends to all of the territories except Anguilla, which ironically is the only Territory that has prohibited the take of marine turtles as required by CMS Article III. Indeed, Anguilla's moratorium on turtle harvest may present the least complicated approach to interpretation of this Article, although it is not without cost and there are calls from Anguilla's fishing community to resume the turtle fishery (Godley et al. 2004). The governments of BVI and Montserrat continue to allow a turtle harvest, but their legislation completely fails to interpret CMS Article III clause 5c. The legislation in TCI may provide an interpretation of this clause, by limiting the fishery to local fishermen, but this fishery is the largest in the UK Overseas Territories. It is neither managed nor monitored sufficiently to determine sustainability and probably does not support the conservation objectives of CMS. In contrast, the interpretation of CMS Article III in the Cayman Islands' legislation is strict, but the government's policy will not sustain the fishery in the long-term, since the pool of fishers will decline until the fishery ceases.

CMS has more limited international participation than CITES, particularly in the Caribbean region (Hykle 2002), but this should not affect the domestic implications of the treaty in the UK Overseas Territories. The difficulty in facilitating sustainable turtle harvests is more accurately attributable to the interpretation of CMS requirements and their translation into domestic legislation. The same can be said of the requirements of SPAW and IAC.

Taken together, these agreements require harvests of marine turtles to (i) *'accommodate the needs of traditional subsistence users'* (CMS), (ii) *'meet traditional subsistence and cultural needs of its local populations'* (SPAW Protocol), and (iii) *'satisfy economic subsistence needs of traditional communities'* (IAC). The texts incorporate common language, including the terms traditional, subsistence and needs, and refer to people either as users, local populations or traditional communities, while SPAW mentions cultural needs, but the definition of the terms used in these criteria is notoriously problematic (Campbell 2003). Among wildlife experts, professionals normally called upon to advise MEA secretariats and governments alike (Campbell et al. 2002), interpretation of terms such as *traditional*, *subsistence* and *cultural needs* are diverse and contentious (Campbell 2000). Neither the text nor the secretariats of CMS, SPAW or the IAC have defined the meanings of these terms and Overseas Territory governments that allow harvest really have no option but to make their own interpretations of these problematic terms in their legislation and policy.

It could be argued that accession to MEAs with requirements open to wide interpretation may be more attractive to signatory states. If definitions within the CMS text, for example, required the Territories to limit fishery participants even further than the current legislation, governments would be required to introduce unpopular provisions that affect the livelihoods and lifestyle of a significant number of fishermen, vendors and consumers. The narrow interpretation of CMS requirements in the Cayman Islands may have been made more palatable by the commercial production of turtle meat at the Cayman Turtle Farm, which largely meets public demand for turtle meat. But there is no turtle farm to supply demand in TCI, where a narrower interpretation of CMS Article III in domestic legislation could meet strong opposition from fishermen, vendors and consumers whose demand for turtle meat is stimulating a legal harvest that may be undermining the conservation objectives of the treaty. In these circumstances, legislation that facilitates a more sustainable turtle harvest will not be adopted except through an extraordinary exertion of political will.

While CMS Article III allows exemptions for turtle fisheries, there is no guidance in the text about the nature of these fisheries. Thus legislation in all of the Territories features conservation measures that are inadequate, in terms of supporting a sustainable fishery and in avoiding endangerment of turtle populations as required by CMS Article II. Treaties such as CMS and SPAW, which list a diversity of mammal, birds, reptiles, fish and insects in their Appendices, cannot reasonably also be expected to include text detailing specific conservation measures with respect to the harvest of a particular group of animals. Specific conservation management measures, such as closed seasons and size limits in turtle harvest legislation, will always be determined by national governments and should ideally be based on the nature of local resources. These local measures do also have to respond, however, to the requirements of any MEAs governments have ratified. This introduces additional complications and costs for decision makers. The introduction of a closed season in the Turks and Caicos Islands, for example, may prove unpopular with fishermen, vendors and consumers, and it may prove difficult to enforce, given the current capacity of the DECR. Again, Territory governments are obligated nonetheless to take such bold and potentially unpopular decisions if they are going to live up to their agreements.

In the case of SPAW and the IAC, neither of which currently apply to the UK Overseas Territories, requirements for the management of turtle fisheries are more specific than those in CMS. If they are going to accede to these treaties, Overseas Territory governments will have to consider the costs of compliance, especially in those Territories that are under-resourced and find difficulty implementing the requirements of their current legislation. The turtle harvest in the Turks and Caicos Islands, for example, has not been assessed in the context of a fishery plan in the seven years since the Fisheries Protection Ordinance (1998) came into force. Likewise, the fishery management plan required by law in Anguilla has not been implemented. It seems unlikely, then, that the authorities in these Territories have the resources and capacity to implement the management measures required by SPAW and the IAC. In Montserrat, the establishment of management measures will also pose serious problems for the Department of Fisheries, unless extra resources are made available.

Most UK Overseas Territories in the Caribbean have already acceded to CMS and the Government of Anguilla is preparing for accession. In addition, the UK Government has signed SPAW with a view to ratifying the Protocol when the Territories have appropriate legislation in place. Drafting and enacting domestic legislation involves considerable costs, as does eventual compliance with MEA requirements, especially where the Overseas Territory governments continue to allow turtle harvest as described above. There is considerable overlap between the requirements of CMS, SPAW and IAC with respect to turtle harvest. In this context, where there is considerable overlap between the requirements of CMS, SPAW and IAC with respect to turtle harvest, Territory governments thinking about acceding to the IAC, which is specific to marine turtles, could see it as re-inventing the wheel (Hykle 2002). Certainly, compliance with IAC requirements means additional burdens to governments allowing turtle harvest, not only in terms of monitoring and reporting but also through the intrusion into domestic affairs of IAC bodies, such as the Consultative Committee, whose role has already been called into question (Campbell et al. 2002). The Territories may very well conclude that, in the context of facilitating sustainable turtle harvests, the IAC is unnecessary.

Conclusion

So, can MEAs facilitate sustainable marine turtle fisheries in the UK Overseas Territories in the Caribbean? The answer to this question depends largely on how Territory Governments interpret the requirements of these agreements. CITES requires relatively simple interpretation in relation to marine turtle use and appears to have effectively restricted such utilisation in the Territories largely to domestic markets. But CITES cannot have any additional influence on domestic use, while current domestic legislation and policy regarding turtle use in the Territories is generally deficient in that it does not adequately reflect or incorporate contemporary conservation biology theory (e.g. inappropriate size limits and closed seasons). In principle CMS, SPAW and IAC could facilitate sustainable turtle harvests but as a practical matter this can only happen through appropriate and detailed interpretation of their often vague requirements in new domestic legislation and enhanced management practices. Facilitating sustainable harvest through these interpretations would not be without cost to Territory governments, and it is the capacity of relevant government agencies to meet these costs, as well as the political will of government decision-makers, that will eventually determine the sustainability of the fisheries. These factors may also determine whether or not the Territory governments decide that MEAs such as the IAC have a future role to play in shaping their domestic turtle utilisation.

	UK Overseas Territory				
MEA extension	**Anguilla**	**British Virgin Islands**	**Cayman Islands**	**Montserrat**	**Turks & Caicos Islands**
CITES	NO	YES	YES	YES	NO
CMS	NO	YES	YES	YES	YES
IAC	UK has neither signed nor ratified the IAC and therefore the provisions of the IAC do not apply to any UK Overseas Territory				
SPAW	UK has signed but not ratified the SPAW Protocol and therefore the provisions of this treaty do not apply to any UK Overseas Territory				

Table 1. The status of CITES, CMS, SPAW and IAC extension to the UK Overseas Territories in the Caribbean.

Legislation	Anguilla	British Virgin Islands	Cayman Islands	Montserrat	Turks & Caicos Islands
Harvest legislation	*Fisheries Protection Act, 2000 Fisheries Protection Regulation 2000*	*Virgin Islands Fisheries Act, 1997 (no.4 of 1997) Fisheries Regulations, 2003*	*The Marine Conservation (Turtle Protection) Regulations 1996*	*Turtles Ordinance Cap. 112 1951*	*Fisheries Protection Ordinance & Fisheries Protection Regulations (1998)*
Harvest restrictions	Moratorium on harvest of *'any turtles'* and *'turtle eggs'* up to 15.12.05	Capture of leatherback and loggerhead turtles is prohibited indefinitely. Nests, eggs and nesting turtles are protected Green turtles >24inches (61cm) carapace length and hawksbill turtles >15 inches (38.1cm) carapace length can be taken between December and March inclusive.	Harvest of eggs and turtles within fringing reef (i.e. nesting turtles) is prohibited. Green turtles >120lbs (54.4kg), and hawksbill and loggerhead turtles >80lbs (36.4kg) can be caught between November and April inclusive	Any turtle >20lbs (9.07kg) can be caught between October and May inclusive.	Harvest of nesting females and harvest, possession, sale and purchase of *'laid'* turtle eggs is prohibited. Hawksbill and green turtles >20inches (50.8cm) from the '*neck scales to the tailpiece'* or >20lbs (9.07kg), or any other turtle >20lbs (9.07kg) can be caught at any time of year.
Quotas	N/A	None	Maximum of 6 turtles per licensee per season	None	None
Social restrictions	N/A	License required for commercial fishing, and pleasure fishing *'to fish for personal consumption up to a maximum of 30lbs per boat.'*	Licenses granted to *'fishermen who have traditionally taken turtles within the Cayman Fisheries Zone by traditional methods to take turtles within such Zone by such traditional methods for consumption within the Islands.'*	License required for fishing for commercial purposes.	*'Belongers'* allowed to take *'reasonable quantities'* for personal consumption without license. License required for commercial fishing, available to *'Belongers*' only.
Fishery management/ monitoring	N/A	None (Godley et al. 2004)	Licensees required to tag and present captured turtles to authorities for inspection.	Some limited monitoring of catch.	None (Godley et al. 2004)
Import/export legislation	Legislation in draft	*Endangered Animals and Plants Act, 1987 (Cap. 89)*	*Endangered Species (Trade and Transport) Law, 2004*	*Endangered Animals and Plants Ordinance 1976*	Legislation in draft
Restricted turtle products	N/A	Live or dead specimens of all marine turtle species, but not '*Cheloniidae'* turtle shell '*if cut to shape'.*	Live or dead specimens of all marine turtle species and any parts thereof.	Live or dead specimens of all marine turtle species, but not '*Chelonidae'* turtle shell '*if cut to shape'.*	Fisheries Protection Regulations (1998): Any person can export no more than 10lbs (4.5kgs) of any turtle product except '*laid'* turtle eggs.

Table 2. A summary of current marine turtle harvest and wildlife import/export legislation in the UK Overseas Territories in the Caribbean.

i. Necessary legislative requirements	ii. Desirable legislative requirements	iii. Other desirable practice
CMS Article III, clause 5: Legislation should prohibit turtle harvest unless exemptions are made under this article. ***NB:*** *CMS Article 14 allows Parties to enter reservations on marine turtle species. The UK has not entered any such reservation*. **SPAW Articles 10, 11 & 14:** Legislation should prohibit turtle harvest and trade unless exemptions are made under article 14. If exemptions are made, legislation should define *traditional subsistence and cultural needs of its local populations* within local context and limit the fishery to provide for these needs. **SPAW Article 17, clause 1:** Legislation should require relevant authorities to 'develop scientific, technical and management-oriented research' e.g. scientific turtle fishery monitoring. ***NB:*** *SPAW Article 11 allows Parties to enter reservations on marine turtle species but the UK has not yet signed the SPAW Protocol.* **IAC Article IV:** Legislation should prohibit harvest of and trade in turtles, their eggs and products unless exemptions are made under clause 3a. **IAC Article IV, 2b:** Legislation should provide for an obligatory licensing scheme for the import and export of all turtle products. **IAC Article IV clause 3b:** If harvest is allowed, legislation should require a fishery management programme that limits the number of turtles taken. ***NB:*** *IAC Article XXIII does not allow any reservations from this treaty on any marine turtle species*	**CMS Article III, clause 5c:** Legislation should define *the needs of traditional subsistence users* within local context and limit the fishery to provide for these needs. **IAC Article IV clause 3a:** Legislation should identify *economic subsistence needs of traditional communities* within local context and limit the fishery to provide for these needs. **CMS Article II clause 2** & **SPAW Article 14, clause 1b** Legislation should limit the number of turtles taken, protect nesting females and eggs and specify size limits and closed seasons as recommended by Godley et al (2004). **CMS Article II clause 2** Legislation should require authorities to monitor turtle harvest and introduce reactive measures (e.g. fishery closure) when harvest indicates endangerment as recommended by Godley et al (2004).	**CMS Article II clause 3** **&** **IAC Article IV clause 2e:** Relevant authorities should carry out marine turtle stock monitoring and research to determine effects of harvest on local turtle aggregations as recommended by Godley et al (2004).

Table 3. Evaluation of necessary and desired legislation and management practice regarding marine turtle harvest and trade based on the texts of CMS, the SPAW Protocol and the IAC, the conservation objectives of these MEAs, and the recommendations in Godley et al. (2004).

CHAPTER 5.

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MARINE TURTLES IN THE TURKS AND CAICOS ISLANDS: REMNANT ROOKERIES, REGIONALLY SIGNIFICANT FORAGING STOCKS AND A MAJOR TURTLE FISHERY.

Abstract

This study reviews the status of marine turtles in the Turks and Caicos Islands (TCI) using data gathered during a multidisciplinary study involving field surveys, questionnaire-based interviews and molecular genetics between 2002 and 2006. Large aggregations of foraging turtles in the archipelago’s waters are predominated by juvenile green (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*), with provisional mixed-stock analysis of these species suggesting that the aggregations largely originate from larger and relatively proximate source rookeries in the Wider Caribbean region. This study also suggests that the islands host remnant nesting populations of turtles, with hawksbill turtle nests recorded more frequently than green and loggerhead turtle (*Caretta caretta*) nests. The TCI islanders retain a culture of turtle use, with the current regulated and legitimate harvest likely to be one of the largest among the Caribbean Islands. This study suggests that historic and current harvest of turtles and their eggs in the TCI may have contributed to the apparent decline in the country’s nesting populations. In order to address this conservation concern, changes to the regulation and management of the TCI’s turtle fishery are necessary, but further research is needed to inform these changes.

Introduction

Humans in the Caribbean have used marine turtles for food for at least four thousand years (Frazier 2003) leading to a widespread reduction in Caribbean populations of several species, including green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles (Jackson 1997, McClenachan et al. 2006). Both species are currently listed by the International Union for the Conservation of Nature (IUCN) as *endangered* and *critically endangered* respectively (IUCN 2007), although these listings have been questioned (Mrosovsky 2000, Broderick et al. 2006, Godfrey and Godley 2008).

The conservation and management of marine turtles in the Caribbean is a controversial issue (Godfrey et al. 2007, Mortimer et al. 2007), which has, in recent years, been the focus of heated debate under the auspices of the Convention on International Trade in Endangered Species (CITES) of Fauna and Flora (Richardson 2000). In response to this controversy, the CITES Secretariat convened Wider Caribbean Hawksbill Turtle Range State Dialogue meetings in 2001 and 2002 aimed at facilitating multilateral agreement over a regional hawksbill management strategy.

There are five UK Overseas Territories (OTs) in the Caribbean, which are governed by elected governments and appointed legislatures who have responsibility for all domestic affairs including biodiversity conservation (Anon 1999). The UK, however, retains responsibility for security and all foreign affairs, including multilateral environmental agreements such as CITES. As a contribution to inform the Caribbean Hawksbill Turtle Range State Dialogue process, in 2001 the UK Government commissioned a study to assess the status and use of marine turtle populations in its Caribbean Territories, including Anguilla, the British Virgin Islands, the Cayman Islands, Montserrat and the Turks and Caicos Islands (TCI) (Godley et al. 2004). This paper is largely based on some of the results of that study.

Turtles in the Turks and Caicos Islands

Foraging stocks

Carr et al (1982) and Fletemeyer (1984) reported that the most commonly encountered turtles in the TCI's waters were juvenile green and hawksbill turtles of all sizes, with the former occurring in unspecified abundance on the sea grass beds and tidal creeks, and the latter occurring in large numbers on the island's patch and fringing reefs. Local fishers also described a *mulatto* turtle, and while Carr et al. (1982) and Fletemeyer (1984) suggested that this might be a local name for the loggerhead turtle (*Caretta caretta*), Fletemeyer (1984) did not discount that *mulatto* turtles may in fact be ridley turtles (*Lepidochelys spp.*), although he did not encounter them during his surveys. Leatherback turtles (*Dermochelys coriacea*) have been anecdotally recorded passing through the TCI's waters (Carr et al. 1982). Foraging aggregations of green and hawksbill turtles in the Caribbean are comprised of individuals originating from nesting populations throughout the region (Diaz-Fernandez 1999, Bass and Witzell 2000, Luke et al. 2004, Bowen et al. 2007). Prior to the current study, the origin of individuals making up feeding aggregations in the TCI's waters was unknown, although contributions of individual hawksbill turtles from neighbouring states have been documented (Bahamas: Bjorndal et al. 1985; Puerto Rico: van Dam et al. 2007).

Nesting populations

Little is known of the status of the TCI's nesting turtle populations. Fletermeyer (1984) recorded hawksbill turtle nests on several islands (see Figure 1) during nine hours of aerial surveying and subsequent ground-truthing in July 1982, but did not find green, loggerhead or leatherback nests. From his surveys, he estimated that the hawksbill nesting population then stood at between 125 and 275 nesting females. Based on interview data, Fletermeyer (1984) also gave low confidence nesting population estimates of between 45 and 105 nesting female green turtles, and between 25 and 75 nesting female loggerhead turtles. He suggested that the composite nesting season for all species was April to August. Fletemeyer's estimates of loggerhead nesting have subsequently been cited as the source suggesting that loggerhead turtles nest in the TCI in regionally significant numbers (Ehrhart 1989, Proctor and Fleming 1999, Fleming 2001).

Turtle use in the TCI

There is a long history of marine turtle consumption and use in the TCI. Archeological evidence unearthed at early settlements suggests that turtles have been used in the TCI since 700AD (Carlson 2000, Fleming 2001). Sadler (1997) documents use by Europeans from the 15th Century, which continued through to the early 20th Century (£1,768 worth of turtle shell was exported in 1906). In acknowledgement of the need for regulated harvest, the TCI's first Turtle Protection Ordinance was passed in 1907, aimed primarily at preventing illegal turtle take by Bahamians (Sadler 1997). In 1910, a lobster and turtle meat cannery was established on Providenciales, but trade had virtually ceased by 1930. The TCI continued to export turtle shell (often referred to as *tortoiseshell*) until the onset of the economic depression, when only £150 worth was exported in 1933 (Sadler 1997).

Fishermen in the TCI continue to harvest marine turtles for domestic consumption, but the fishery is largely incidental to the thriving export-oriented fisheries for Caribbean spiny lobster (*Panulirus argus*) and queen conch (*Strombus gigas*) (Rudd 2003). The Fisheries Protection Ordinance (1998) currently regulates turtle fishing in the TCI and has been described in detail by Richardson et al. (2006b). In summary, while harvest of nesting female turtles and "*laid*" turtle eggs is prohibited, any turtle at sea weighing more than 20lbs (9.07 kgs) or measuring 20 inches (50.8 cm) from the *"neck scales to the tailpiece"* can be legally harvested year-round. There has been little, if any, monitoring of the turtle fishery and data on the levels of the contemporary harvest are scarce. Carr et al. (1982) suggested that exploitation of turtles amongst the Caicos Islands was "*minimal"*. In contrast, Fletemeyer (1984) estimated the national TCI harvest in 1982 to be around 850 turtles, consisting mostly of juvenile green turtles, with some adult greens and juvenile hawksbills. He reported that turtles could be found year-round at markets, although availability was sporadic, and that due to the abundance of juvenile green turtles in the TCI's waters, the harvest did "*not seem to pose a serious threat to the survival of the sea turtle population".* More recently, Fleming (2001) stated that few turtles are taken, with only 3 or 4 fishers consistently taking turtles and others catching them opportunistically. Contrary to Fleming's perceptions, Rudd (2003) estimated that the turtle harvest in the TCI is '*likely in the hundreds per year*', but acknowledged that there are no hard data on catch levels.

There are few data on contemporary levels of consumption of turtle products in the TCI. Allan (1998) found six restaurants in the TCI selling turtle dishes and Fleming (2001) also reported that turtle meat was available in several restaurants. Gaudian & Medley (2000) reported that local interest in turtle meat in the TCI was "*waning*" at the end of the 20th Century. Bowen (2003) concurred, stating that local consumption of traditional dishes, such as turtle stew, has declined in preference for food of USA origin, such as deep-fried chicken and pork ribs.

Little has been documented about trade in turtle shell from the TCI since recorded exports apparently declined in the early 20th Century. Japanese customs reported the import of a total of 234 kgs of turtle scutes from the TCI in 1970 and 1971 (Fleming 2001), but there has not been a significant trade in turtle shell products to tourists visiting the TCI since the 1970s (B Riggs, DECR pers. comm. 2004). Carr et al (1982) did not note any tourist trade in turtle products, but did not visit the main tourist island of Providenciales. They did, however, record '*insignificant*' trade in hawksbill scutes between local fishers and Haitian buyers. Fleming (2001) reported some trade between a local fisher and Dominican traders in the early 1990's, and described contemporary reports from both Dominican and TCI fishers about Dominicans fishing illegally for turtles on the TCI's Mouchoir Banks. Fleming (2001) and Marte et al. (2003) both reported a flourishing, albeit illegal, trade in turtle products in the Dominican Republic, which is largely associated with the tourism sector.

Fletemeyer (1984) noted that harvest of turtle eggs occurred in the TCI, estimating between 8,000 and 10,000 turtle eggs were collected per year. Fleming (2001) stated that eggs were collected *"especially in South Caicos and Salt Cay, until about 15 to 20 years ago".* It is worth noting that egg harvest since 1976 would have been in direct contravention of the Fisheries Protection Regulations (1976), which prohibited possession of 'laid' turtle eggs (Proctor and Fleming, 1999). Indeed, Carr *et al.* (1982) stated that enforcement of the regulations by the authorities was '*probably inadequate',* and two years later Fletemeyer (1984) concurred, suggesting that there was '*virtually no legal enforcement*' of the regulations. More recently, other authors have suggested that the recent history of drug trafficking in South Caicos, and inconsistent local compliance with the TCI's fishery regulations, has made enforcement problematic for the authorities (Rudd 2003; Tewfik and Bene 2004).

The status of marine turtles in the TCI is unclear, and it is not known whether the current culture of marine turtle use in the TCI is sustainable. Here, using an integration of data gathered during a multidisciplinary study (field surveys, questionnaire-based interviews and molecular genetics), we present an assessment of marine turtle nesting activity and foraging stocks in the TCI, including a mixed stock analysis to provide the first insights into likely source rookeries of TCI's foraging turtle aggregations. We also provide an updated estimate of the current harvest of marine turtles in the territory.

Study site and methods

Study site

The Turks and Caicos Islands (TCI) form the southeastern extremity of the Bahamas chain (21° 45'N, 71° 35'W). There are approximately 40 low-lying islands and cays in the Territory (all <76 m above sea-level), covering a total land area of about 500 km^2 (Figure 1). The TCI sit on three limestone platforms, the Caicos Bank, the Turks Bank and the Mouchoir Bank, which lies to the south east of the archipelago. The Caicos bank is the largest (6,140 km^2), and is fringed with extensive coral reefs and steep drop-offs, extending along the northern shores of Providenciales and the Caicos Islands. The majority of the Caicos Bank leeward of these islands is shallow and sandy, with vast sea grass beds, dominated by *Thalassia testudinum,* situated close to the main islands and some of the small cays at the southern edge of the Bank (Carr et al. 1982; Gaudian and Medley 2000; Rudd 2003). The extensive and largely pristine wetlands of North, Middle and East Caicos are fed by a complex of tidal creeks that are commonly vegetated by sea grass and marine algae. A large area encompassing these wetlands, tidal creeks and inshore sea grass beds was declared a Ramsar Convention Wetland of International Importance in 1990 (Fletemeyer 1984; Proctor and Fleming 1999). Grand Turk, Salt Cay and associated cays lie on the Turks Bank (324 km^2), which consists mostly of a sandy bed, with extensive coral reefs and mixed coral and algae beds, while Mouchoir Bank further east is largely made up of coral and sand (Rudd 2003).

Only six of the main islands and a few of the small islands are currently inhabited. A national census in 2001 recorded a population of 19,886, with the majority living on Providenciales (66%), Grand Turk (20%), North Caicos (7%)

and South Caicos (5%). Development in the TCI has experienced accelerated growth since the international runway was built on Providenciales in 1986 (Robinson and Fulford 1997; Gaudian and Medley 2000), and a 2006 population estimate places the TCI population at 33,202, with increases largely as a result of recent influxes of immigrant workers from Haiti and the Dominican Republic (Department of Economic Planning and Statistics website - http://www.depstc.org/, 2006).

Thirty-three protected areas have been gazetted by the Government of the Turks and Caicos Islands (http://www.environment.tc/) under the National Parks Ordinance (Revised Edition 1998), most of which encompass islands or other marine features. Responsibility for enforcing the National Parks Ordinance and the Fisheries Protection Ordinance (Revised Edition 1998) lies with the Department of Environment and Coastal Resources (DECR), which is divided into two divisions, the Fisheries Division and the Protected Areas Division. Several of the beaches where Fletemeyer (1984) recorded turtle nesting are now protected under the National Parks Ordinance, including, for example, those located within the French, Bush and Seal Cays Sanctuary, those on Big Sand Cay (in the Big Sand Cay Sanctuary) and beaches on Gibbs Cay and Pinzon Cay, which lie within the Grand Turk Cays Land and Sea National Park (see http://www.environment.tc/ and Figure 1).

Methods

Nesting beach surveys

Due to the remote nature of many of the cays, and limited resources available for the study, surveys for nesting activity were infrequent and opportunistic. During September 2002, September 2003, October 2005 and January 2006, experienced surveyors were able to survey, at least once, accessible beaches on Grand Turk, Providenciales, Middle Caicos, Salt Cay, Big Sand Cay, Bush Cay, Fish Cay, Pinzon Cay and Gibbs Cay looking for any signs of nesting activity, which were then recorded to species where possible based on track and nest morphology following Schroeder and Murphy (1999). In October 2005 a 3-hour aerial survey in a single propeller aircraft was carried out also following Schroeder and Murphy (1999) to detect turtle nesting activity on beaches on South Caicos, East Caicos and the beaches on the northern coast of Middle and North Caicos.

In-water capture and mixed stock analysis

In-water capture and sampling of turtles was carried out from 2002 to 2006 to obtain tissue samples for a genetic mixed stock analysis (Godley et al. 2004). Additional capture and tagging occurred around South Caicos in 2005 and 2006. Throughout the study, turtles were captured using a number of methods. Some were captured using a turtle rodeo method, whereby turtles were spotted from a motorised boat during dedicated patrols at known turtle foraging habitat and then chased and captured by hand once they had tired. Other turtles were hand captured as they rested in coral heads by free divers at various sites in and around South Caicos during dedicated nocturnal sampling trips. A few turtles were tagged and sampled after being incidentally captured in nets set to catch sharks as part of another study. Some turtles were hand captured by free-diving lobster fishermen, who were persuaded by the DECR to catch and land turtles they encountered while fishing for sampling and release. In addition, DECR officers were able to measure and take tissue samples from some turtles that had been captured and landed by fishermen for consumption. The curved carapace length (CCL - notch to tip) and curved carapace width (CCW) of all captured and released turtles were measured using a flexible measuring tape (after Bolten 1999). When an individual turtle was recaptured more than once, only the first and last CCL measurements were used in growth rate analysis. Turtles were tagged with either Monel or inconel flipper tags in the trailing edge of the front flippers following Balazs (1999); and in some cases the turtles were also injected in the left shoulder with an AVID/Destron-Fearing passive integrated transponder (PIT) tag, which was then confirmed with a PIT tag reader. Tissue samples were taken from the rear flippers following Dutton (1999).

None of the animals in this study were weighed. Weights of hawksbills were estimated using McGowan et al's (unpubl.) function for mass against CCL $Mass\ kg = 8.08 - 0.58CCL\ cm + 0.013CCL^2$, calculated from juvenile hawksbill turtles (n = 223, 9 cm to 76 cm CCL) hand caught in the British

Virgin Islands (see McGowan et al. 2008). Weights of green turtles were estimated using McGowan et al's (unpubl) function for mass against CCL, *Mass kg = 11.58 - 0.77CCL cm + 0.016CCL*^{2}, calculated from hand caught juvenile green turtles (n = 128, 24 cm to 70 cm CCL) during the same study.

Genetic analysis of tissue samples consisted of DNA extraction, amplification and sequencing following methodology described in Formia et al. (2006), using primer pairs LTCM1/HCM1 for greens (Allard et al. 1994) and LTEi9/H950 for hawksbills (A. Abreu-Grobois, unpublished). Sequences were aligned against known haplotypes, which are centralised through the Archie Carr Center for Sea Turtle Research USA for green turtles (http://accstr.ufl.edu/genetics.html) and the Institute for Marine Science in Mexico for hawksbills (A. Abreu-Grobois). Mixed stock analyses were then carried out with the programme BAYES (Pella and Masuda 2001; Masuda 2002), using Bayesian statistics and Monte Carlo Markov Chain iterations to calculate the probability density distribution for stock mixture proportions. Green turtle samples were analysed using summarised haplotype frequencies from 14 Atlantic and Mediterranean rookeries as potentially contributing baseline populations (Formia et al. in prep). The source populations of the sampled hawksbills were estimated using rookery haplotype frequencies summarised in Troeng et al. (2005) and Velez-Zuazo et al. (2008), truncating the sequence to match haplotype data from Bass (1999). In order to obtain more conservative estimates, the source rookeries were assigned equal priors, irrespective of size, and contribution estimates derived from BAYES were then correlated with rookery size and distance to the TCI.

Dive operator recording

During 2002 and 2003, dive operators were issued with data sheets and encouraged to record any turtles encountered during their dives. They were also provided with a *Wider Caribbean Sea Turtles* photographic marine turtle identification chart (WIDECAST/CEP-UNEP) and asked to record species, location and number of turtles encountered on the datasheets, as well as an estimate of straight carapace length (SCL). The two dive operators that participated in the survey conducted dives at fringe reef sites off West Caicos, French Cay, Pine Cay, North West Point (Providenciales), Princess Alexandra National Park (Providenciales) and South West Reef (Providenciales). For further information on this method as applied in the Cayman Islands, see Bell et al. (2009).

Socio-economic questionnaire survey (SEQ)

Structured questionnaires were designed to assess the social and economic value of turtles and administered on several islands during 2003. The questionnaire was comprehensive and divided into nine separate sections for different user groups, including fishers, turtle fishers, turtle vendors and consumers, as well as representatives of the authorities responsible for managing the turtle fishery. For example, the section of the questionnaire designed specifically for turtle fishers asked participants a suite of 44 questions regarding the economic importance of the turtles they catch; the seasonality and frequency of their turtle fishing; the capture methods they use; the size, number and species of turtles they catch; details regarding how they use or sell their catch; and questions to gauge opinions on turtle fishery management mechanisms (see Godley et al. 2004 and Silver and Campbell 2005 for more detailed descriptions of the questionnaire. See Campbell et al. 2009 for analysis of fisher opinions about management measures). The questionnaire also included sections designed to record participants' local knowledge regarding marine turtles.

Sampling strategy was both opportunistic and directed; an effort was made to include known turtle fishers, as well as fishers who might catch turtles opportunistically. Survey participants were generally identified by DECR officers participating in the project and interviews lasting between one to two hours were carried out by trained project staff, usually with a DECR officer present.

Results

Nesting populations

Figure 1a shows the results of the opportunistic nesting beach surveys, indicating not only confirmed turtle nesting activity, but also where evidence of nesting activity was absent on surveyed beaches. The map also shows the potential locations of turtle nesting beaches as indicated by some of the 92 SEQ interviewees. Surveys confirmed nesting by hawksbill turtles, with 16 fresh nesting activities recorded at 4 sites during the months of September, October and January, and a freshly emerged hawksbill nest recorded on Fish Cay also in September. Limited green turtle nesting (2 nests, 2 sites – during September) and one loggerhead nesting activity (in May 2005, Pardee 2005) were also recorded during the study period. A total of 10 other unidentified fresh turtle nesting activities were also recorded at Bush Cay (n = 3, September 2002), Long Bay, East Caicos (n = 3, October 2005) and Pinzon Cay (n = 4, January 2006). Anecdotal accounts from some SEQ interviewees suggested that in recent decades turtle nesting populations have been largely extirpated from the most densely populated islands, such as Providenciales, Grand Turk and South Caicos.

Harvest of nesting females

Of the 92 SEQ interviewees, 13 were former fishers and 46 were current fishers. None of the former or current turtle fishers interviewed said that they catch female turtles on the nesting beaches, although some interviewees suggested this was apparently common practice in the past. Nowadays nesting turtles are rarely encountered by the TCI islanders, as nesting appears to be limited to remote cays that are rarely visited at night when the turtles nest (see Figure 1). Illegal take of nesting turtles is therefore only likely to occur very occasionally, if at all.

Turtle egg harvest

The SEQ identified seven (7.6%) respondents who still collect turtle eggs and 17 who used to collect eggs. One of the seven current egg collectors claimed he collected eggs on a monthly basis, five said they collected them occasionally, between two and four times per year, and one said that he collects them opportunistically. Indeed, of all current and former egg collectors, 50% (n = 12) said that they collected eggs opportunistically. Only one interviewee said he had formerly collected eggs for sale, usually between June and September, but had stopped visiting the beaches and collecting in 1990. Prior to that, he sold turtle eggs for US$3 for a dozen. Eggs are still occasionally offered for consumption in South Caicos (P Richardson, J Silver, pers obs.).

Foraging aggregations

Figure 1b shows the broad scale distribution of sites where turtles were either sighted or sampled during this study. No dives or sampling trips associated with this study were carried out along the north coasts of North, Middle and East Caicos.

Dive operator recording

Five dive operators collaborated with this study, recording a total of 432 turtle sightings. Two Providenciales-based operators regularly completed the forms, recording 301 and 121 turtle sightings respectively, while a dive operator in Grand Turk recorded seven sightings (from eight dives) and two operators on Salt Cay recorded three sightings (from three dives). Figure 1b shows a broad scale distribution of the different species of turtles encountered.

Hawksbill turtles were the most commonly encountered species recorded by the dive operators and accounted for almost 84% of the records (Table 1). *Mulatto* turtles were the next most frequently encountered and identified species, accounting for over 4% of records. When asked to identify this species on the WIDECAST photographic turtle ID chart, all of the participating dive operators indicated that they were seeing Kemp's ridley turtles. Dive operators also recorded 12 loggerhead sightings, 12 green turtle sightings, while 23 sightings were unidentified to species. Individual turtles may have been sighted multiple times on different dives during this study, so these data do not necessarily indicate abundance.

In-water capture

In total, 133 turtles were sampled during this study, including 94 hawksbill turtles, 38 green turtles and one hawksbill/loggerhead turtle hybrid.

Hawksbill turtles: Fifty-eight (61.7%) of the 94 individual hawksbills included in this study were captured on reef habitat, while 22 (23.4%) were captured on sea grass beds and sandy habitat, with habitat type not recorded for 14 captures. The animals ranged in size from 19.4 cm to 93.0 cm curved carapace length (CCL), with a mean of 41.6 cm (SD 12.4). The mass of hawksbills sampled during this study was estimated and ranged from 1.7 to 66.6 kg, with a mean of 8.4 kg ± SD 8.9 kg.

Fourteen (14.9%) hawksbills were recaptured during the study, and growth rates were calculated from 11 turtles. The mean growth rate of these turtles, measuring between 24 cm and 49.6 cm CCL at first capture (mean 37.1 cm ± 7.7cm S.D.), and recaptured at intervals over 3 months, was 4.9±2 cm yr^{-1} (range = 1.5 to 8.6 cm yr^{-1}, range of intervals = 3.1 to 49.7 months).

Figure 2a shows the length-frequency histogram for the hawksbill turtles. Where tagged turtles were recaptured, the last CCL measurement is presented. While female hawksbills in Barbados and Cuba are thought to reach maturity at carapace lengths greater than 75 cm (Moncada et al. 1999; Beggs et al. 2007), Moncada et al. (1999) suggest that a small percentage mature at CCLs as small as 51 cm, and therefore some of the 16 (17%) hawksbills in this sample with CCLs measuring between 50.9 cm and 64 cm may have been mature females. Two mature females were confirmed from the hawksbills sampled based on their external characteristics and size, with CCLs measuring 80 cm and 93 cm. Both these turtles were landed in South Caicos for consumption, with the larger turtle sold to Haitian traders who had it secured alive on their vessel bound for Haiti when it was sampled. Three other hawksbills in the sample were landed for consumption, with CCLs measuring 47 cm, 48 cm and 58 cm respectively.

Mixed stock analysis of 38 juvenile hawksbills indicates likely rookeries of origin in Mexico, US Virgin Islands (USVI), Antigua, Puerto Rico and Cuba (Figure 3a). Although percentage contributions exhibit wide confidence intervals, it is worth noting that the lower confidence limit for the Mexican contribution is above zero (Figure 3a). Population connectivity can also be assessed based on haplotype presence in populations (Table 2). Haplotypes A, F and Q are the most common in the sampled hawksbills, and can also be considered common in nesting females in Barbados and Cuba (haplotype A), Puerto Rico, USVI, Belize and Costa Rica (haplotype F), and Mexico (haplotype Q). There was a significant negative correlation between log-transformed rookery contribution and distance (Pearson's correlation coefficient r = -0.782, P = 0.013) but not between log-transformed rookery contribution and source population size (Pearson's correlation coefficient r = 0.117, P = 0.765).

Figure 4 shows the juvenile hawksbill/loggerhead hybrid turtle. The animal measured 43.3 cm CCL and while its carapace and head morphology resembled that of a juvenile hawksbill, its short, thick neck and general colouration were more indicative of a juvenile loggerhead. Indeed, genetic analysis revealed this specimen's mitochondrial DNA was that of a loggerhead turtle.

Green turtles: Of 38 individual green turtles sampled, 20 were caught during dedicated sampling with South Caicos turtle fishermen on the sea grass beds along the southern shores of the North, Middle and East Caicos. Green turtles are abundant at these sites, and sampling trips encountered many more green turtles than were caught. One of these sampling trips (on 10.09.03) employed two South Caicos turtle fishermen (one pilot, one catcher), who hand captured 11 juvenile green turtles and 2 juvenile hawksbill turtles in under 1 hour. In total, 24 (63%) green turtles were captured on sea grass beds and sand flat habitat, while 12 (32%) were hand caught on patch reefs. Capture habitat was not recorded for the two other green turtles in this sample.

Animals ranged in size from 26 cm to 103.5 cm curved carapace length (CCL), with a mean of 49.2 cm ± 13.7 cm S.D. The mass of green turtles sampled during this study was estimated to range from 2.4 kgs to 103.3 kgs, with a mean of 15.4 kgs ± 16.9 kg S.D.

Figure 2b shows the length-frequency histogram for the green turtles and indicates that 94% (n = 36) of the turtles sampled in this study were juveniles. Only four green turtles were recaptured during the study, and two were recaptured at intervals longer than three months, with one turtle growing 1.1cm in 94 days and the other growing 1.5 cm in 137 days. One sampled green turtle was a mature female (CCL=103.5 cm) landed for consumption at South Caicos in September 2002. Butchery of this turtle revealed-well developed, oviductal eggs. It is worth noting that seven (18%) juvenile green turtles, measuring 46 cm to 64.6 cm CCL, exhibited lesions (figure 5) suggestive of early-stage fibropapillomatosis (Jacobsen et al. 1989, Herbst 1994). Local turtle fishers interviewed during the SEQ knew of the disease, referring to it as ‘old turtle disease’, and one fisher also reported having caught a hawksbill with the disease.

Mixed stock analysis of tissues samples from 17 green turtles sampled during this study indicate the probable nesting rookeries of origin. Mexico, Florida and Costa Rica (Tortuguero) likely make important contributions to the juvenile green turtle aggregations in TCI’s waters (Figure 3b). The most common haplotype in the TCI is CM-A3, one relatively widespread in Caribbean rookeries, including Costa Rica, Florida and Mexico. As with the hawksbills, rookery contribution and rookery distance (both log-transformed) showed a significant negative correlation (Pearson’s correlation coefficient r = -0.650, P = 0.009), while log-transformed rookery size was not correlated with log-transformed rookery contribution to the mixed stock (Pearson’s correlation coefficient r = 0.398, P = 0.142).

Marine turtle harvest

The majority of the 13 former and 46 current fishers (n = 59) fish or fished primarily for conch (n = 52), lobster (n = 54) or finfish (n = 54), while 50

(84.5%) catch or have caught turtles in the past. Thirty-three (66%) of the 50 former and current turtle fishers caught turtles opportunistically (i.e. when they encountered them while targeting other species), while 9 caught turtles both opportunistically and intentionally, and only 8 (16%) fishers caught turtles intentionally (i.e. they fished with the intention to catch turtles).

Turtles were not identified as the most economically important target species by any of the 46 current fishers, although 35 (75.6%) of them claimed to be currently engaged in turtle harvest (including 34 licensed fishers and one unlicensed fisher). Twenty-two of these fishers (62.9%) reported catching turtles for sale, while 13 (37.1%) did not sell the turtles they caught. Those that did sell turtle meat sold it to restaurants and private customers in the TCI.

Twenty-four (68.6%) of the 35 active turtle fishers reported catching green turtles either solely by hand, or by using a hand-held lobster hook, while 20 (57.1%) reported using these methods to catch hawksbills. Other methods mentioned included use of nets (n = 2), Hawaiian sling (n = 2) and spear gun (n = 1), while some fishers did not provide this information.

Hawksbill turtle harvest: Twenty-three (65.7%) of the 35 current turtle fishers gave estimates of their average annual hawksbill turtle harvest, with estimates ranging from 1 to 30 turtles per year and a mean of 5.3 per year (median: IQ range = 3:1.5-5). The estimated average annual harvest of hawksbill turtles taken by these 35 active turtle fishers is approximately 186 turtles.

Hawksbill turtles of various sizes are currently caught with the smallest reported at 4.5 kg (below the legal limit of 9 kg) and the largest reported as 158.7 kg. Twenty of the 35 current turtle fishers offered estimates of the average sized hawksbill turtle they catch. These ranged from 13.6 kg to 90.7 kg, with a mean of 36.7 kg ± SD21.4 kg, again much larger than the estimated mean weight of the hawksbills hand caught and sampled during this survey. Beggs et al. (2007) reported that female hawksbill turtles nesting in Barbados weighed between 44 kg to 92 kg with a mean weight of 68.2 kgs (SD = 8.8), while Moncada et al. (1999) reported that female hawksbills in Cuban waters were reaching sexual maturity at much smaller sizes than reported in Barbados. While small juvenile hawksbills are taken in the TCI harvest, the SEQ results suggest that the fishery tends to target larger size-classes, including sub-adult and adult turtles.

Green turtle harvest: Thirty-one (88.6%) of the 35 current fishers gave estimates of their average annual green turtle harvest, with estimates ranging from 1 to 50 turtles per year and a mean of 6.7 per year (median: IQ range = 5:2-9.5). The estimated average annual harvest of green turtles taken by these 35 active turtle fishers is approximately 235 turtles.

Fishers reported catching green turtles of various sizes (reports were converted from pounds to kilograms), with smallest reported at 2.3 kg, thus below the legal limit of 9 kg, and the largest reported as 226.8 kg. Twenty-five of the 35 current turtle fishers offered their own estimates of the average sizes of the green turtles they catch. These ranged from 11.3 kg to 90.7 kg, with a mean of 32.4 kg ± SD19.7 kg, much larger than the estimated mean weight of the green turtles hand caught and sampled during this survey. The SEQ results therefore suggest that the TCI fishery tends to target the larger size-classes present, including large juveniles, sub-adult and adult turtles.

Turtle consumption in the TCI

Of the 92 TCOT SEQ interviewees, 83.7% (n = 77) eat or have eaten turtle meat, with 52 (56.5%) reporting that they currently eat turtle meat. However, it is worth noting that this sample is not representative as there is a very strong sampling bias towards fishers, a social group that is likely to use turtle products more than other groups. Eight of 15 restaurant owners interviewed during the SEQ were selling turtle meat dishes, while one fish market owner in Grand Turk was selling raw turtle meat. While the fish market owner purchased turtle meat to sell on a daily basis, two of the restaurants reported buying turtle meat on a weekly basis, two restaurants bought it on a monthly basis, three bought it on a yearly basis and one restaurant reported buying it less frequently than yearly. All eight restaurants purchased green turtles, six purchased hawksbill turtles and one did not distinguish between the species.

Discussion

The Turks and Caicos Islands appear to provide good developmental foraging habitat for regionally important abundances of juvenile green and hawksbill turtles. The legal harvest of turtles in the TCI, which targets larger size classes of green and hawksbill turtles, including adults, consists of hundreds of animals and is possibly one of the largest among the Caribbean Islands, and is certainly comparable to other significant and legal turtle harvests in the region (Carrillo et al. 1999, Grazette et al. 2007, Mortimer et al. 2007). The TCI also host nesting populations of hawksbill, green and loggerhead turtles, with hawksbill turtles appearing to nest most frequently, mostly on remote and uninhabited cays. Without genetic data on TCI's native turtle populations, and with only limited information on past and present nesting turtle numbers, the effect of the TCI turtle fishery on native turtle populations remains unclear. However, this study recorded continued turtle egg harvest and indicates that the fishery likely includes some adult females from native TCI turtle populations. Based on first-hand, anecdotal accounts of turtle harvest and trends in turtle nesting in recent decades, and in light of similar scenarios involving other small nesting turtle populations in the Caribbean (Bell et al. 2006, McClenachan et al. 2006, Bell et al. 2007), the TCI harvest may well be compromising the future of the TCI's native turtle populations.

This study confirmed that hawksbill turtles still regularly nest on several remote beaches and cays on the TCI, but probably in low densities, although nesting density may be greater earlier in the season before the months when this study's opportunistic beach surveys occurred. For the first time in recent decades the study confirmed limited green and loggerhead turtle nesting activity. Some of the nesting sites reported by Fletemeyer (1984) were confirmed to still host nesting. Contrary to Fletemeyer (1984), we suggest that the TCI green turtle nesting season lasts through to September and therefore may at least overlap with nearby Bahamas' green turtle nesting season, lasting from June to September as described by Carr et al. (1982).

Fresh nesting activities found during this survey confirm that hawksbill nesting occurs in the months of September, October and January. In addition, by estimating an incubation period of approximately 60 days (Bjorndal et al. 1985, Mrosovsky et al. 1992) from the freshly emerged hawksbill nest recorded in September, we can confirm that hawksbill nesting also occurs in the month of July. This study therefore suggests that the hawksbill nesting season in the TCI extends from at least July to January, considerably longer than Fletemeyer's estimate (1984). This is consistent with reports from former egg harvesters interviewed during this study, and comparable to the hawksbill nesting season on relatively proximate beaches of Cuba as described by Moncada et al. (1999). No evidence was found to support the claim that loggerhead turtles nest in the TCI in regionally significant numbers and we suggest that this is not likely to be the case. Comprehensive monitoring of the TCI's nesting beaches is required to fully illuminate the composition, distribution and seasonality of the TCI's nesting turtle populations. However, this study suggests that the turtle nesting populations in the TCI are small compared to those found in many other Caribbean states. While some larger, protected nesting populations of green and hawksbill turtles in the Caribbean appear to be showing signs of recovery in response to conservation (Garduño-Andrade 1999, Seminoff 2004, Troeng and Rankin 2005, Richardson et al. 2006a, Beggs et al. 2007, Diez & Van Dam 2007), many smaller nesting populations in the region have declined or have been extirpated throughout the region due to unsustainable harvest (McClenachan et al. 2006). If the TCI harvest continues to target larger size classes including adults, TCI's apparently depleted native turtle populations may well be extirpated.

Green, hawksbill and loggerhead turtles still occur in TCI's waters, with juvenile green and hawksbill turtles apparently the most widespread and abundant species throughout the islands' waters. Adult green and hawksbill turtles are also present, apparently in fewer numbers, although the biases inherent in the sampling methods (e.g. smaller turtles are probably easier to catch) mean that the population structures of the species present require further investigation, ideally with a broader suite of sampling methods. Adult loggerheads are present too, but it is unclear whether or not loggerhead turtles are resident or transient in TCI's waters. The presence of *mulatto* turtles as described by Fletemeyer (1984) was also reported but not confirmed and requires further investigation. Fibropapilloma has been known to be widespread throughout the Caribbean green turtle populations for some time (Williams et al. 1994). This study confirmed, for the first time, the presence of Fibropapilloma symptoms in the TCI green turtle foraging aggregations, and recorded anecdotal evidence that the disease may also affect local hawksbill turtle aggregations, although the extent of this disease in these stocks is unknown.

Patch reefs, fringing reefs and sea grass beds in the TCI appear to provide important developmental foraging habitat for hawksbill turtles. Indeed, mean growth rate (4.9±2 cm yr^{-1}) of juvenile hawksbills in this study is higher than that of similarly sized hawksbills in the Cayman Islands (Blumenthal et al. 2009a) and the US Virgin Islands (Boulon 1994), and at the higher range of growth rates exhibited by juvenile hawksbills in Puerto Rico (Diez & Van Dam 2002), suggesting that the TCI's coral reefs provide good quality developmental foraging habitat. Length frequency analysis of juvenile hawksbills included in this study is comparable to similar analyses for juvenile hawksbills sampled using similar methods elsewhere in the Northern Caribbean region (e.g. British Virgin Islands - McGowan et al. 2008; Cayman Islands - Blumenthal et al. 2009a,b), but most notably in the US Virgin Islands (Boulon 1994). Similar analyses of hawksbills hand caught in Puerto Rico (Leon & Diez 1999; Diez and Van Dam 2003) include a higher percentage of small post-recruitment turtles than were sampled in this study (<25 cm SCL). While this could be an artefact of this study's sampling biases, it may be suggestive that the TCI's reefs do not provide primary recruitment habitat as important as that provided by the reefs in Puerto Rican waters. While Bowen et al. (2007) found size and proximity of hawksbill nesting populations positively influence their contribution to feeding aggregations, Velez-Zuazo et al. (2008) did not find an effect of size or location on rookery contributions. Analysis of sampled TCI hawksbills indicated a significant negative correlation between rookery contribution and distance from the TCI, with substantial contributions from the regionally significant and relatively proximate nesting populations in Cuba, the US Virgin Islands, Puerto Rico and Antigua, all located in the North East Caribbean, as well as Mexico, the conspecific largest nesting population in the Wider Caribbean (Meylan 1999, IUCN 2002, McClenachan et al. 2006).

Sea grass beds and tidal creeks on the Caicos banks appear to support an abundance of juvenile green turtles, providing a regionally important developmental habitat for this species. The length frequency analysis of juvenile green turtles included in this study is comparable to similar analyses for juvenile green turtles sampled in similar habitat in the Bahamas (Bjorndal et al. 2005) and those captured off Tortola in the British Virgin Islands (McGowan et al. 2008). As with the hawksbills, the mixed stock analysis from the small number of green turtle samples showed a significant negative correlation between rookery contribution and distance from the TCI, with regionally significant nesting populations in Costa Rica, Florida and Mexico making important contributions to the TCI's foraging juvenile green turtle aggregation. These nesting populations are showing significant signs of recovery (Seminoff 2004, Troeng & Rankin 2005).

While the TCI's turtle fishery is considered less economically important than other fisheries in the Islands, there is an ongoing culture of marine turtle use in the TCI, where green and hawksbill turtles are regularly caught and legally landed to meet consumer demand. While illegal practices of occasional egg collection and the landing of under-sized turtles are associated with the legal turtle harvest, this study found no evidence of other significant sources of turtle mortality in the TCI (e.g. bycatch). This study estimates that at least around 420 turtles are legally harvested in the TCI's waters each year. While the SEQ sample was subject to a significant confounding sampling bias created by DECR officers purposefully leading interviewers to known turtle fishers, these extrapolations likely provide conservative estimates for the actual annual harvest of turtles in TCI's waters.

In 2003, there were 491 commercial fishers licensed to fish in the TCI, while an unknown number of unlicensed fishers fished for personal consumption (J. Campbell DECR pers comm. 2004). While the actual number of active licensed fishers and other fishers who catch turtles in the TCI is not known, the fishers interviewed during the SEQ represent approximately 9.2% of fishers licensed in 2003. The fishers interviewed in this study therefore most likely represent a fraction of the number of individuals currently engaged in turtle harvest in the TCI and therefore the annual harvest of turtles in the TCI is probably much higher than these minimum estimates. In addition, most SEQ interviews were carried out in Providenciales and South Caicos where the largest fishing communities are based, and may not reflect levels of harvest by fishers based on Grand Turk, or Salt Cay, North Caicos and Middle Caicos. Furthermore, several fishers interviewed during this study corroborated Fleming's (2001) assertion that migrant fishers from the Dominican Republic also catch turtles in the TCI's waters, but no migrant fishers participated in the SEQ.

While this study's sampling biases mean the harvest estimates should be treated with caution, even these minimum estimates corroborate Rudd's (2003) assessment that the annual turtle harvest involves hundreds of animals. Indeed, the current level of take is probably much higher and could be comparable to other legal turtle harvests among the Caribbean islands, including Cuba's contentious former turtle harvest that harvested an annual quota of 500 hawksbills (Carrillo et al. 1999, Mortimer et al. 2007) and the annual turtle harvest in Grenada, thought to be around 780 green and hawksbills (Grazette et al. 2007).

The harvest of juvenile and adult turtles is considered to be a primary threat to depleted green and hawksbill populations around the world (Meylan & Donnelly 1999, Seminoff 2004) and reduction in mortality of large juvenile, sub-adult and adult size classes is considered key to the recovery of depleted marine turtle populations (Crouse et al 1987, Crouse 1999). The Fisheries Protection Ordinance (1998) currently allows the TCI turtle fishers' preferred targeting of larger size classes, including adults, which, presumably, they take because of a higher meat yield and therefore higher sale value. One harvested adult female green turtle sampled during this study was probably breeding locally, but the harvested adult hawksbills sampled in this study may have been either visiting breeders or resident foragers. Given the geographic range of these animals, it has been suggested that nations operating or promoting harvest of foraging turtle aggregations could be undermining conservation efforts elsewhere (Mortimer et al. 2007). It is unclear whether or not the TCI harvest significantly impacts nesting hawksbill populations in proximate states, such as Puerto Rico, which are likely contributing breeding adults to the TCI foraging aggregation (Van Dam & Diez 2008). However, in Puerto Rico, where considerable resources are invested in the conservation and monitoring of its nesting turtle populations, hawksbill nesting activity has significantly increased since the 1980s, despite the TCI harvest (Diez and Van Dam 2007). In any case, the harvest of adult turtles in the TCI's waters is likely to impact the TCI's depleted native populations and, as in other UK Overseas Territories (e.g. Montserrat – Martin et al. 2005), is a conservation concern. Indeed, decimation of turtle nesting populations due to local harvest is not without precedent in UK Overseas Territories, with the Cayman Islands' turtle nesting populations having been drastically depleted by the country's historical harvest (Bell et al. 2006, Bell et al. 2007).

From their Caribbean-wide mixed stock analysis of hawksbill turtles, Bowen et al (2007) conclude that turtle harvests at feeding habitats will impact nesting populations throughout the region, with greatest detriment to those nearby, although this has been contended by Godfrey et al (2007). It is not clear how the TCI annual harvest of hundreds of large juvenile and sub-adult foraging green and hawksbill turtles is affecting TCI foraging aggregations and their contributing nesting populations. Trends in hawksbill nesting populations in the US Virgin Islands are thought to be stable (Eckert 1995, in Meylan 1999) and are unknown in Cuba (Moncada et al. 1999). However, other contributing green and hawksbill nesting populations have recently experienced significant signs of recovery (e.g. green turtles - Costa Rica, Mexico; hawksbill turtles - Mexico, Antigua, Puerto Rico - Garduño-Andrade 1999, Seminoff 2004;

Troeng & Rankin 2005, Richardson et al 2006a, Diez and Van Dam 2007), again, despite the harvest in the TCI.

Prohibition of use of marine turtles has traditionally been widely advocated by marine turtle experts, and has been incorporated into relevant multi-lateral environmental agreements (see Campbell 2002, Campbell et al. 2002 and Richardson et al. 2006b). More recently some authors have called for constructive dialogue regarding the role of marine turtle use in conservation (Mrosovsky 2000, Godfrey et al. 2007) and population modelling of recovering green turtle populations in Hawaii strongly indicates that limited harvest could now be sustainable (Chaloupka & Balazs 2007). As there is no hard turtle harvest data originating from the TCI, it is currently not possible to assess whether or not the harvest is sustainable with respect to the contributing nesting populations. However, encouraging signs of recovery within some of these contributing populations, despite decades of the TCI turtle harvest, suggest that with improved management, the TCI's harvest could achieve sustainability, at least with respect to these recovering contributing populations.

Clearly, more outreach and enforcement are necessary to implement the existing legislation that protects turtle eggs and under-sized turtles. Indeed, other analysis of the SEQ data suggests that the majority of fishers interviewed in the TCI agreed that their Government should actively protect turtles and better enforce existing laws (Campbell et al. 2009). This study, however, indicates a need to protect the TCI's dwindling native adult turtles when they return to TCI's waters to reproduce. To address this concern, Godley et al (2004) provided recommendations for change to legislation and fishery management, including the introduction of a closed season during the composite turtle reproductive season; maximum size limits to prevent capture of adults; species restrictions, and the introduction of fisher licences and quotas. These measures are not without precedent, and feature in the legislation regulating turtle harvests in other UK Overseas Territories in the Caribbean (see Bell et al. 2006, Richardson et al. 2006b).

However, the SEQ process indicated varied acceptance of such measures by interviewed fishers, with the majority agreeing with size restrictions, but showing mixed acceptance of closed seasons, quotas and species restrictions (Campbell et al. 2009). These mixed reactions within the community may be problematic to future efforts to improve fishery management. For example, the introduction of a closed season of at least seven months to cover the known hawksbill nesting season in the TCI (comparable to the current eight month closed season for the British Virgin Islands' turtle fishery – see Richardson et al. 2006b), may well meet with resistance from some within the sector, which has a documented history of non-compliance (Rudd 2003, Tewfik & Bene 2004). There was also uncertainty amongst the fisher community regarding their ownership of and future role in the management of the turtle fishery. Less than half identified themselves as likely participants in future fishery regulation, with some suspicious that this study may inevitably lead to prohibition of the fishery (Silver and Campbell 2005, Campbell et al. 2009).

In order to inform future policy and management changes, it is clear that further stakeholder consultation is required. Similarly, improved biological data regarding the extent of harvest, status of nesting populations and in-water stock, and further mixed stock analysis are required to better understand future fishery management. Further research is also required to establish the significance of foreign turtle fishing effort in, and turtle product export from TCI's waters. So long as CITES does not extend to the TCI, the alleged and observed export of turtle products does not contravene current legislation in the TCI. However, the TCI Government has drafted national legislation in preparation for accession to CITES, which may well eventually outlaw current export, and which will require further appropriate amendments to the current fisheries legislation to regulate movement of turtle products from the TCI (Richardson et al 2006b). Amendments to the Fisheries Protection Ordinance (1998) should also take into account the TCI's obligations under the Convention of Migratory Species (CMS), as it is questionable whether or not the TCI's turtle harvest currently satisfies this convention (Richardson et al 2006b).

The Turks and Caicos Islanders have been harvesting marine turtles for centuries, but this regionally significant harvest may now threaten the Territory’s native green and hawksbill turtle populations, and may have the potential to impede recovery of nesting populations in nearby states. Turtle fishery management in the TCI is in need of review to prevent the loss of the TCI’s nesting turtles, but legislative amendments alone will not be sufficient to achieve this aim. While the turtle fishery appears to be of little economic significance to most TCI fishers, this traditional harvest benefits a local collective of fishers, vendors and consumers. Future efforts to inform and effect major changes to the management of this long-standing fishery should therefore make every effort to generate participation, understanding and consent amongst this collective in order to facilitate compliance that is by no means guaranteed.

Species	Percentage and no. of records (n = 432)	Estimated CCL range (cm)
Hawksbill turtle	83.8% (n = 362)	22.9 - 121.9
Green turtle	2.8% (n = 12)	40.6 – 91.4
Loggerhead turtle	2.8% (n = 12)	61 – 121.9
Mulatto *(suspected Kemp's ridley)*	4.2% (n = 18)	30.5 – 91.4
Unidentified	6.5% (n = 28)	30.5 – 91.4

Table 1 Summary of turtle sightings recorded by dive operators.

Hawksbills		Green Turtles	
A (Ei-A01)	12	**CM-A1**	1
Alpha (Ei-A02)	1	**CM-A3**	11
B (Ei-A03/Ei-A57)	1	**CM-A5**	2
F (Ei-A09/11/45/ 46/Ei-A63)	12	**CM-A8**	2
N (Ei-A20)	1	**CM-A16**	1
Q (Ei-A23/24)	9		
b (Ei-A28)	1		
Ei-A53*	1		
N samples	**38**		**17**
N haplotypes	**8**		**5**

Table 2. Foraging green and hawksbill turtle haplotype distributions (hawksbill sequences are truncated as in Velez-Zuazo et al 2008). * This haplotype was not previously identified by other genetic surveys in the region.

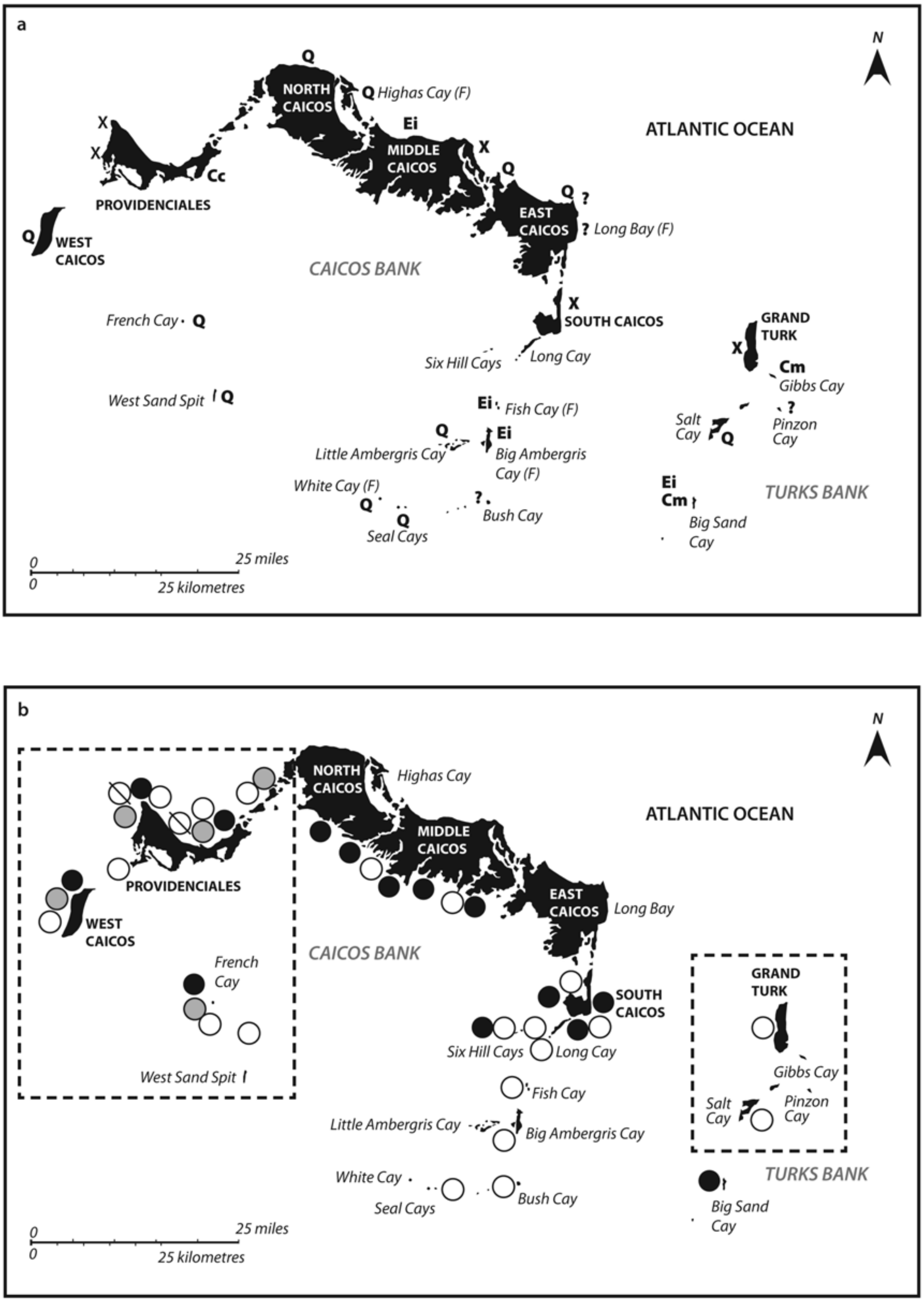

Figure 1. a) Broad scale locations of turtle nesting activity confirmed during the surveys or suggested during the SEQ. **Ei** = confirmed hawksbill turtle, **Cm** = confirmed green turtle, **Cc** = confirmed loggerhead turtle, **?** = nesting activity

confirmed but species unidentified, **Q** = current nesting activity suggested by SEQ but not confirmed during the surveys, **X** = no signs of nesting activity found during surveys, although SEQ suggested these sites were once used. (F) indicates locations of nesting confirmed by Fletemeyer (1984). b) Broad scale locations of species of turtle seen by dive operators or captured during the in-water sampling. O = Hawksbill turtle, ● = green turtle, ● = loggerhead turtle, ⃠ = possible Kemp's ridley. Broken lines enclose the dive operator dive sites where no sampling occurred (NB: neither sampling nor surveys were carried out along the northern coasts of North, Middle and East Caicos).

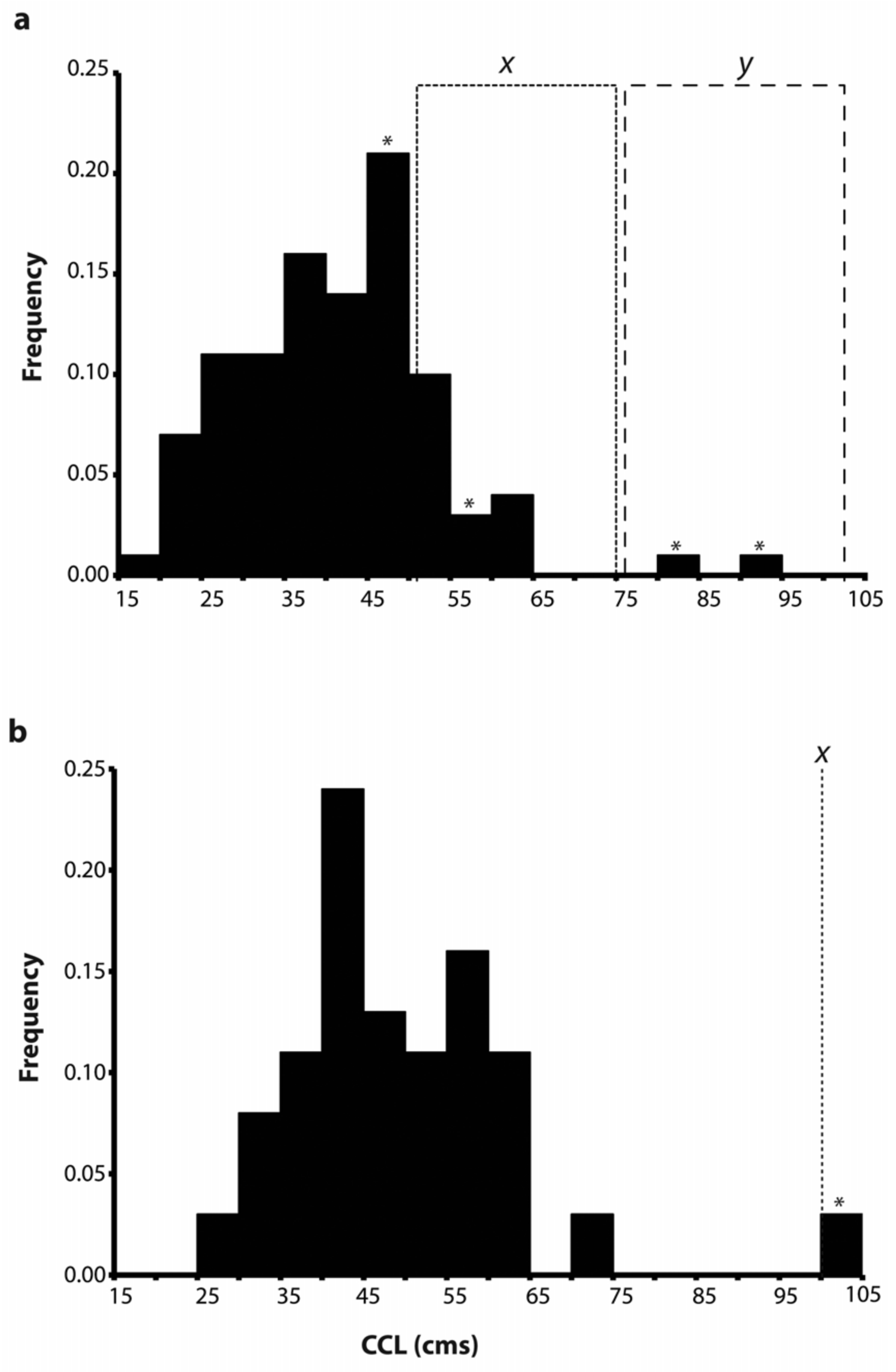

Figure 2. Length-frequency histograms for a, hawksbill and b, green turtles captured and sampled during this study. In a, broken lines marked x show

minimal range of SCL at maturity for female hawksbills (51cm to 75cm) in Cuban waters from Moncada et al (1999) and broken lines marked y show range of CCLs of adult nesting female hawksbills (76.2 to 102.4cm) in Barbados range in size from Beggs et al (2007). Columns marked * indicate CCLs of the sampled hawksbills landed for consumption during this study. In b, line marked x shows the average SCL of nesting female green turtles (100.2±5cm SCL) at Tortuguero, Costa Rica (in Bjorndal et al. 2005). * indicates CCL of a green turtle sampled during this study that was landed for consumption at South Caicos.

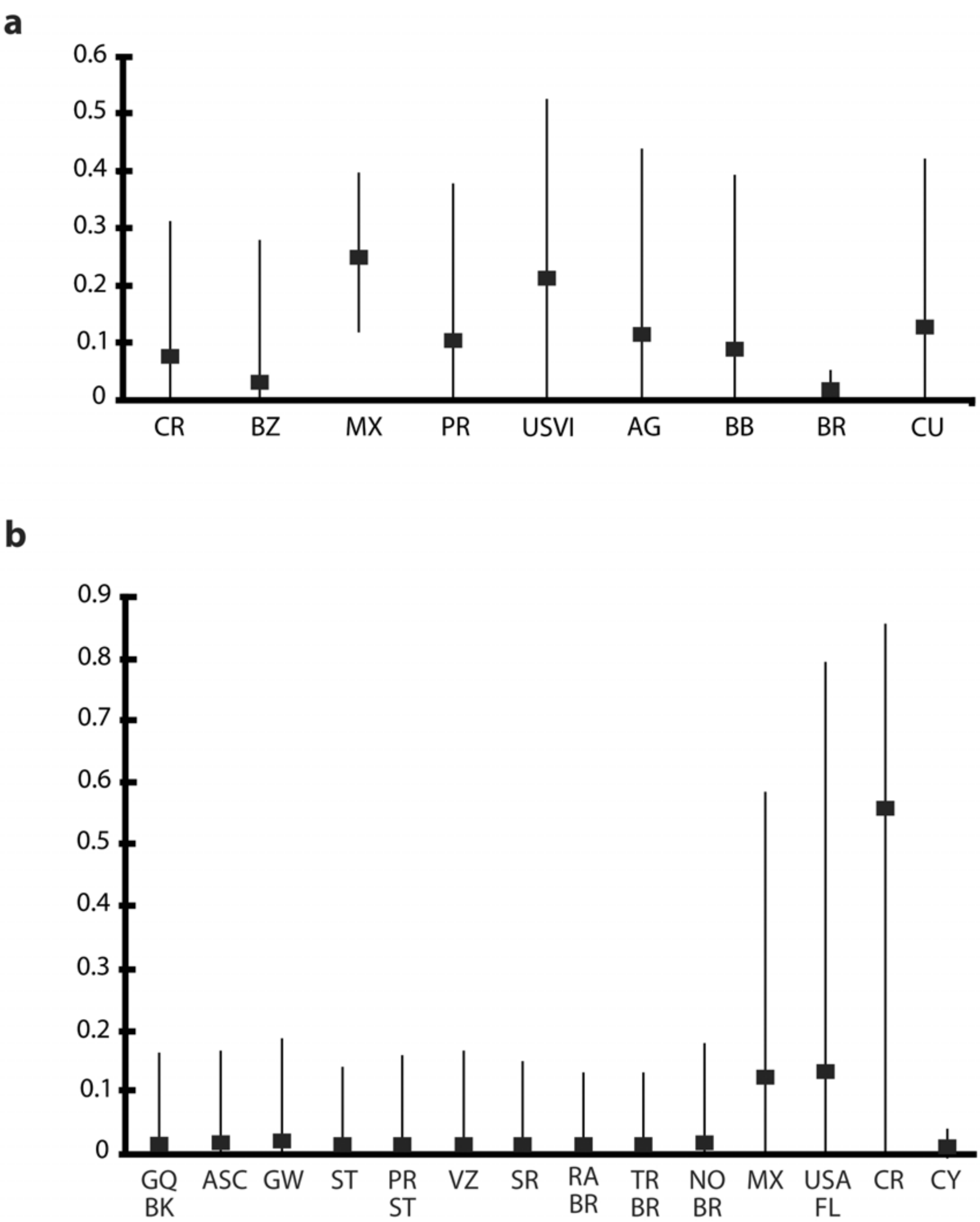

Figure 3. Frequency contributions to the hawksbill (a) and green turtle (b) mixed stocks from all known potential rookeries based on mitochondrial DNA haplotype frequency distributions. Mean contribution (black squares) and upper and lower percentiles were calculated using 10000 Monte Carlo Markov chain iterations assuming equal priors, using the software Bayes (Pella and Masuda 2001). Acronyms in figures are AG – Antigua, ASC – Ascension Island, BB - Barbados, BR – Brazil, BZ – Belize, CR – Costa Rica, CU – Cuba, CY – Cyprus, GQ BK – Bioko Equitorial Guinea, GW – Poilao Guinea

Bissau, MX – Mexico, NO BR - Fernando de Noronha Brazil, PR – Puerto Rico, PR ST – Principe Sao Tome & Principe, RA BR – Rocas Atoll Brazil, SR – Suriname, ST - Sao Tome Sao Tome & Principe, TR BR – Trinidade Brazil, USA FL – Florida, USVI – US Virgin Islands, VZ – Venezuela.

Figure 4 The hawksbill/loggerhead hybrid juvenile turtle sampled and released during this study (Photo credit: Peter Richardson/MCS).

Figure 5 A juvenile green turtle sampled during this study exhibiting fibropapilloma-like growths (Photo credit Peter Richardson/MCS).

CHAPTER 6.

“*WHERE SUZIE AT?”:* STAKEHOLDER PERCEPTIONS OF MARINE TURTLE TRACKING IN THE TURKS AND CAICOS ISLANDS.

Abstract

Biotelemetry is increasingly used as a research tool to inform the conservation and management of threatened mobile species, including marine turtles. Mitigating threats to marine turtle populations, including directed take for consumption, is challenging. While sustainable use of turtles remains a controversial issue, understanding use management within broader conservation strategies has been identified as a global research priority. Satellite telemetry has contributed to other global research priority areas, and has increasing educational potential to facilitate better stakeholder understanding of marine turtle conservation and management needs. The Turks and Caicos Islands (TCI) regulates one of the largest legal, directed marine turtle harvest in the insular Caribbean. In this study we examine the perceptions of 33 TCI community members with respect to a marine turtle satellite tracking programme, implemented as part of a multi-disciplinary project to engage stakeholders in the development of an improved turtle fishery management regime. Over half of the interviewees (55%, n=18) offered comments about the tracking, which were characterised by acknowledgment of personal or community learning from the tracking, and descriptions of what was learned. While learning centred on marine turtle migration, some interviewees expressed a novel understanding of turtle populations as shared, regional resources. In addition, the majority of commenting interviewees (67%, n=12) attached positive learning, cultural/symbolic or utilitarian values to the tracking project and nearly all (94%, n=17) expressed positive support for the tracking. This study suggests that, in addition to providing insights into migratory behaviour, satellite tracking of turtles has added value in engaging stakeholders and can facilitate stakeholder consideration of sophisticated regional management concepts. We conclude that appropriately promoted satellite tracking has the potential to ‘level the playing field’ for resource users involved in multiple stakeholder discourse about marine turtle conservation and management.

Introduction

In recent decades, biotelemetry has become an established research tool, which is used to inform biological understanding of a suite of mobile taxa

(Cooke et al. 2004, Block 2005, Hart and Hyrenbach 2009). Although tracking methods can involve certain limitations, for example, high costs of equipment limiting study sample sizes, they are increasingly used to inform the conservation and management of threatened species of fauna (Cooke 2008).

Marine turtles are migratory (Carr et al. 1978, Meylan 1982, Limpus et al. 1992), and all seven species are listed on the International Union for the Conservation of Nature (IUCN) Red list of Threatened Species (IUCN 2010). Population declines around the world are largely attributed to the impacts of a suite of anthropogenic activities, including directed take (see Lutcavage et al. 1997). While there is an extensive body of literature on marine turtle biology and conservation (Frazier 2005), challenges to our understanding of how best to mitigate threats to marine turtle populations remain.

Amongst these challenges is the controversial issue of managing sustainable consumptive use, which elicits diverse opinion amongst professionals working on marine turtle research and conservation (Campbell 2000, 2002). Studies suggest that professionals working within the field are often cautious about supporting consumptive use, largely due to scientific uncertainties regarding conservation impacts, although other values, including emotional attachment, can affect their opinions (Campbell 2002). Furthermore, marine turtle conservation and research professionals can be challenged by concepts such as stakeholder rights to resources, resource-user needs and co-management of take by resource-users, which are often not perceived to be conducive to a science-based or precautionary biological conservation approach (Campbell 2000). Campbell (2007) argues that because the opinion of marine turtle conservation professionals informs turtle conservation policies, particularly national legislation and multi-lateral environmental agreements, these policies tend to privilege conservation strategies that prohibit consumptive use of marine turtles. Campbell (2007) concludes that these policies are a symptom of an imbalance of power in the political ecology of marine turtle conservation that traditionally disadvantages and excludes resource users.

Nevertheless, professionals working within the field have identified the development of a better understanding of how consumptive use can be sustained and managed within broader strategies, as a global research priority for marine turtle conservation (Hamann et al. 2010). Other research priorities address knowledge gaps pertaining to conservation biology issues, including reproductive biology, biogeography, population ecology, as well as threat mitigation and conservation management strategies. The increasing use of satellite tracking to study marine turtles at sea has contributed knowledge to some, if not all, of these global research priorities (Godley et al. 2008). In addition, appropriately interpreted tracking data has significant potential to facilitate learning (Coyne and Godley 2005), although proponents of this method acknowledge the need for increased publication of tracking data to improve this method's contribution to marine turtle conservation and management (Godley et al. 2008).

Precedents have been set to engage local stakeholders in marine turtle tracking projects. For example, resource users have participated in tracking projects by catching and attaching satellite transmitters to turtles in populations subject to fishing bycatch (Martin and James 2005, Peckham et al. 2007), and to directed take (Kennett et al. 2004). To fulfil broader conservation and management objectives, these projects also promoted learning, particularly to participating resource users, while other initiatives have specified outreach and learning among the wider community as primary project objectives (Whiting et al. 2006, Klain et al. 2007). In a few Caribbean states where turtle consumption is regulated, tracking studies have also engaged local communities in associated programmes of learning (e.g. Cayman Islands; Blumenthal et al. 2006, Nicaragua; Brautigam and Eckert 2006). However, despite the reported success of these programmes, little work has been carried out to assess stakeholder perceptions, or indeed the educational value, of such initiatives.

In response, this study explores stakeholder perceptions of a satellite tracking study involving adult green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles in the Turks and Caicos Islands (TCI). The TCI regulates one of the largest traditional, domestic marine turtle harvests in the insular Caribbean, although management and monitoring of this fishery has been largely absent (Richardson et al. 2006, 2009). In contrast, the other more economically important fisheries in the TCI are subject to monitoring efforts by the authorities, but are characterised by significant management and enforcement challenges (Rudd 2003, Tewfik and Bene 2004). As may be expected in such an environment, previous efforts by foreign researchers to assess the TCI turtle fishery have been met with scepticism, in part associated with fishers' suspicions that the research might be leading to prohibition of the fishery (Silver and Campbell 2005, Campbell et al. 2009). In 2008, the collaborative Turks and Caicos Islands Turtle Project was established to engage fishers and community members to discuss and recommend a new management regime for the TCI turtle fishery. This interdisciplinary initiative involves community liaison, social research and biological research on the TCI turtle stocks and turtle landings, including a turtle satellite tracking project. We examine comments about the satellite tracking component of the project recorded during semi-structured interviews conducted with members of the community on the island of South Caicos. An analysis of these comments provides a unique insight into resource-user perceptions of marine turtle satellite tracking and assesses the learning potential associated with this research method. We discuss the potential of satellite tracking to contribute to stakeholder engagement and inform resource user discourse on marine turtle management and conservation.

Study site and methods

The study was carried out in the Turks and Caicos Islands (TCI; 21.615N 71.528W), which provides regionally important foraging habitats and some breeding habitats for green, hawksbill and loggerhead (*Caretta caretta*) turtles (Richardson et al. 2009). The combined methods used in this study were employed during 2009 and 2010 in South Caicos (21.493N 71.530W), which hosts a small community that numbered 1,118 residents in 2006 (DEPS 2011). South Caicos hosts a nationally important fishing community and is often referred to as 'the fishing capital' of the TCI.

Tagging and tracking

On the 24th June 2009 project staff procured an adult female green turtle (Curved Carapace Length = 102.6cm) from fishers who had landed the animal for consumption in Cockburn Harbour, South Caicos. The turtle was then taken to a research facility where a Kiwisat 101 satellite transmitter (Sirtrack Ltd, New Zealand) was attached directly to the anterior of the carapace using two-part marine epoxy (Powerfast™, Powers Fasteners Inc, USA). The tag and attachment were then painted with anti-foulant paint and the turtle was held in a secure and sheltered room overnight. The following day, the turtle was briefly shown to a gathering of local school pupils, and then taken by boat to a release site at sea just off East Caicos (21.724N 71.473W) close to the reported capture site.

Location data were received from Service Argos, and the online Satellite Tracking and Analysis Tool (STAT; Coyne & Godley 2005) was used for managing and mapping data, and data parsing for the turtle tracked during this study. The turtle's movements were reconstructed using Argos location classes (LC) 3, 2, 1, A and B, as these location classes can be reliable when subject to adequate filtering (Costa et al. 2010, Witt et al. 2010). Locations suggestive of minimum travel speeds greater than 5 km h^{-1} were subject to filtering, and azimuth filtering with a minimum threshold of 25^o was also employed. Tracking data were mapped and examined to detect possible nesting emergences during the migration.

Project promotion and communication

Information about the movements of the study animal was accessible to the local community for the duration of the tracking. Each week, TCI Turtle Project staff in South Caicos printed updated maps from STAT and displayed them with accompanying, explanatory text about the turtle's journey at prominent public places around South Caicos. Maps were displayed within the terminal building of the island's airport, and on the walls of two bars, three shops and a supermarket located close to Cockburn Harbour. Project staff also discussed the turtle's progress with community members during subsequent project work at the harbour and throughout the island. In addition, a press release about the tracking was sent to the national media through the TCI Government Information Service shortly after the turtle was tagged and released. Maps of the track of the turtle in this study were updated on a daily basis and made publicly available online at www.seaturtle.org/tracking.

During the study the project staff also procured four adult hawksbill turtles, fitted them with Kiwisat 101 transmitters and tracked using the same methods but did not extensively publicise their migrations within South Caicos. It is beyond the scope of this paper to include analysis of the tracking data from these turtles, but they are mentioned because a few interviewees commented on them during the interviews.

Social research

In February 2010, as a contribution to the broader project objectives, 32 South Caicos community members, and one additional stakeholder resident elsewhere in TCI, participated in in-depth and semi-structured interviews. The interview sample was selected to broadly reflect the South Caicos community, but active and former turtle fishers were prioritised and willingness and availability to take part in the project were also taken into account. Interviewees were guided through a series of themes ranging from general views on life in South Caicos, the role of fishing and turtle fishing in the community, general views on fishery management and specific consideration of marine turtle fishery management options, and interviewee opinions of the broader project (Supplementary table 1). All interviews were recorded with a video camera.

For the purposes of this study, the filmed interviewees (28 males and 5 females) were grouped into, ‘active fisher’ (AF, n=13), ‘adult community member’ (CM, n=9), ‘former fisher’ (FF, n=7), ‘government worker’ (GW, n=2), and ‘minor’ (M, n=2) categories (minors were interviewed with permission of a parent or guardian). One of the government workers was the only interviewee not resident in South Caicos. All comments made by interviewees regarding the satellite tracking project were transcribed from the video footage and categorised according to specific themes arising from the content of the comments.

The interviews were edited into a 30 minute research documentary, which was screened throughout the TCI in 2010. Twenty nine semi-structured workshop events were held immediately after screenings of the documentary in the main inhabited islands of Grand Turk, Middle Caicos, North Caicos, Providenciales and South Caicos between July and October 2010. These events were designed to facilitate further discussion about future turtle fishery management options and involved approximately 270 local participants. Any comments made by participants during these workshop events that mentioned the satellite tracking were also recorded.

Results

Tracking

The adult female green turtle, named 'Suzie' by a local fisher during the tag attachment process, was tracked for 317 days after its release. For the first 67 days the turtle remained in seagrass habitat proximate to the release site near East Caicos, where it was presumed to be foraging. On day 68 after release the turtle moved away from TCI and embarked on an approximately 6,000 km journey through the Economic Exclusive Zones of 15 countries (Figure 1), including the inshore waters of seven countries, before returning to the TCI. During this time, the tracking data indicate that the turtle emerged on a beach in Low Bay, Barbuda (17.658N 61.857W) on the nights of the 17.10.09 and 18.10.09, suggesting that this may have been a nesting migration. The turtle returned to East Caicos on the 28.01.10, 150 days after leaving the TCI, and returned to the same seagrass habitat where it resided immediately after release. The turtle remained there for a further 100 days before transmissions ceased on the 8th May 2010.

Interviewee comments

Of the 33 interviewees, 18 (55%), including 17 males and one female, offered comments regarding the satellite tracking and represented all stakeholder groups included in the sample (Supplementary table 2). The active and former fisher groups together constituted the majority of interviewees (61%, n=20) and interviewees from these groups represented 72% (n=13) of interviewees who commented on the tracking. Of the interviewees commenting on the satellite tracking, 16 (89%) offered unprompted comments, while the two minors offered their comments after the interviewer asked them, *ad libitum,* what they thought of the tracking project. The interviewee comments on the tracking fell into four broad themes and 13 sub-themes and as detailed in Table 1.

Learning

Comments falling into this theme included those in which the interviewee explicitly stated that learning had occurred. Over half of all the interviewees, and nearly all (94%, n=17) of those who commented on the tracking, said that learning had occurred, with most (83%, n=15) acknowledging that they had learned something themselves, for example:

> *'I know I learned a lot by (the project) since you've been here, there's always room for learning something. It's good to me. (I learned) how far a turtle can go from one area, like Suzie gone now - Suzie is amazing!'* – (AF11).

Half of the interviewees commenting on the tracking project (n=9) suggested that others in the community had learned from the project, as did this government worker:

> *"I was surprised the week before last when I was in South Caicos, the number of people who walked up to me to talk about Suzie, everybody's talking about Suzie, everyone wants to know about Suzie….Two years ago you didn't have that! Nobody talked about no turtle, but that's good, that means the culture around turtle is growing, more people knowing about it, more people appreciate it and it might mean we should continue doing more (satellite tracking)."* – (GW2)

This comment is of particular interest as it is one of few comments that suggest the tracking could be used to generate conservation gains through outreach. This idea is also repeated in the comment below, from a former fisher who believes learning from tracking can play a role in changing the behaviour of turtle fishers:

> *"The thing I get out of Suzie is that she has been all around the islands and headed back. I like learning things like that. None of the fishermen would have thought that turtle would have moved like that. You couldn't tell that to no one before you put a satellite (transmitter) on Suzie and watch her movements. That's good, you can show the fishermen, this is the reason you shouldn't catch this turtle, because this turtle is not from here, this turtle travels around …the islands…and educate them all." -* (FF2)

In contrast, the following comment by a current fisher, who also concurred that the community had learned from the project, reflects previously recorded community scepticism to turtle fishery management:

> *"That surprised a lot of people and you did teach us a lot, because we surprised to see what Suzie did. Everybody, even the shop owners were surprised to see that turtle go all the way around and turn and come back all this way - that surprised them, yeah! But tell them different that they can't eat that, they'll become your enemies."* – (AF12)

He clearly states that the positive community attitude to learning from the tracking project would not necessarily translate to conservation action, especially if access to turtles as a resource was denied the community as a result of project activities.

What was learned

Having said that learning was part of their experience of this component of the project, most (83%, n=15) interviewees went on to describe what they had learned. A new understanding of turtle behaviour and particular interest in the distance that turtles can travel characterised many of the comments on this theme:

> *"I was surprised that Suzie went so far, she went really far. I thought a turtle only came here and move around. But after (Suzie) I see a turtle*

can go far, far – yes, a turtle can go really far! (My friend) also said 'Boy that turtle went so far, Boy! " – (M1)

The following comment from a former fisher is typical of several comments in the way it suggests a new collective understanding of turtle migration by community members:

> *"Suzie broke the record of the world. Suzie made history in the Turks and Caicos Islands. They never thought Suzie would have leave from East Caicos, gone down to South America and come back to the Turks and Caicos Islands – on her own, no one carried her….I learned a lot, to see the turtles here, we were thinking they stayed in one place and don't move, just swim around and around, but see with Suzie, she showed us that they don't stay in one place, they travel."* - (FF1)

Some interviewees also considered the reason for the migration:

> *"Before, people only saw turtles when they were brought in. But then they see someone coming here to do some research on a turtle that size with eggs, who knows where she went to drop her eggs, that showed them the big turtles travel far, and still come back home, but they don't just stay here, they may go somewhere else to drop their eggs."* – (AF7)

In 44% (n=8) of interviews where the tracking was mentioned, the comments about turtle migration led on to a description of turtles as a shared resource. Some interviewees suggested that what they had learned had brought about a change in their thinking on the subject:

> *"In some places they have no turtle, but we are blessed with turtle. Suzie made me think there is no turtle here called 'our' turtle, there is a Caribbean turtle."* – (AF13)

Another interviewee suggested that knowledge of migration had led them to the conclusion that conservation and management in the TCI could benefit other range states in the region. This interviewee is also one of two to suggest that personal engagement with this high profile aspect of the broader project supported their improved understanding of broader project aims:

> *"I didn't get the full idea of what (the project) was into, but looking at Suzie I understand a great deal there, because it causes me to understand that some of the turtles that are here, don't always remain here, they travel …they come from, travel to different countries…so that's telling me that we have to build what we have here, then sooner or later we can help others, because if we have a whole lot here, just like how Suzie travelled, perhaps others will travel too, perhaps get there, find safe haven and stay."* – (FF4)

The comment touches on the concept of a regionally cooperative and mutually beneficial approach to turtle conservation. This concept has been most frequently explored in support of protection of marine turtles and prohibition of use (see Bowen et al. 2007). In this context, comments about shared resources are made in the context of a community that supports resource use and management. A detailed examination of the interviewees' opinions on marine turtle fishery management options is beyond the scope of this paper. However, of the 33 stakeholders interviewed in this study, 24 expressed the need for turtle fishery management and offered views on potential management scenarios, while three interviewees stated that the fishery was not in need of any form of management. Only one adult community member, who did not comment on the tracking project, supported temporary prohibition of the turtle fishery and four interviewees did not express an opinion about future turtle fishery management.

Personal value

Comments falling into this theme included those in which the interviewee explicitly described the positive personal value they had derived from their engagement with and experience of the tracking component of the project. These values were expressed by 67% (n=12) of the commenting interviewees. While the majority of commenting interviewees reported that they had learned something as a result of the tracking, 44% (n=8) suggested that they or the community had gained something or benefited personally from the experience. For example, this comment resonates with other comments given above regarding the positive value attached to personal learning:

> *"I gained a lot from that, learning about the turtles, and how they can travel in such a short space of time and the distance they can cover."* – (FF7).

The following comments suggest perceptions of positive value and benefit to the community from the tracking project:

> *"Look at Suzie…there's a lot of people in the community know about Suzie. Then they are like 'Wow! You see where Suzie went and now she's come back'. They were happy about it, so it brought joy and education to the public, so that's how I see it."* - (AF7)
>
> *"Since you all did that thing with that turtle Suzie, a lot of people happy, like "Damn! See how far that turtle travel!"…they appreciate that, the turtle goes around the world, and comes back too!"* - (AF9)
>
> *"I know the kids like it, the turtle you took to the primary school, Jerry, they like it, they enjoy it…my uncle's niece goes to that school…she told me "Uncle, they brought a big, big turtle"….once the children are enjoying it, I am enjoying it, because the children are our future."* – (AF10)

This latter comment is one of the few that refers to the other turtles fitted with satellite transmitters during the project, in this case the first adult male hawksbill to be tracked by the project, named Jerry by a South Caicos school pupil. The two minors in this study encountered both Suzie and Jerry when they were brought to their school, and both these children commented on the two turtles.

Of the interviewees who offered comments on the tracking, 44% (n=8) expressed forms of cultural/symbolic value (after Kellert 1986, in Campbell and Smith 2006) with respect to Suzie and her migratory behaviour. This comment, the only comment on tracking made by a female interviewee, shows positive personal value attached to learning, but also cultural/symbolic value attached to the perception that the TCI might provide the turtle's resident habitat:

> *"I love the project with the tracking the turtle, I loved that, it was awesome, my thumbs up. To see that turtles do operate like that, that they come right back to where they start from. I guess for Suzie, here is her home, here has always been her home, yeah, that's amazing!" – (CM5)*

In some comments the cultural/symbolic value associated with the tracking is associated with a sense of 'ownership' of the turtle within the South Caicos community:

> *"We got a turtle named Suzie – they should get one in Grand Turk, and they get one in Providenciales, but we got one, we got Suzie! Since they put that tag on, and when I see (project staff), I say 'What happened today? Print the thing out and let me see where the turtle going.' When I look, the turtle done make the circle and come back around to we…so, (more tracking) will open people's eyes to what we are trying to do."* – (AF11)

It is of interest that the sense of ownership expressed in this comment also extends to ownership of the project's broader objectives. Ownership of the turtle expressed by AF11 led on to the implications for turtles as a shared resource:

> *"I pray that the humans will see that she is a monitored turtle and leave her alone, because since I get to deal with that turtle I can tell you I think about her off and on, every time (project staff) put up her (map), I see when she get close to Haiti I wondered if the Haitians would eat her, you know, chop her up so I wouldn't see her no more…I want to see Suzie come back home."* – (AF11)

Other comments suggest a clear distinction and separation between the sense of ownership of the turtle and their opinions about the broader project objectives:

“The good thing I see about it is that you get my turtle (Suzie), and I see my turtle wandering around so far, and still make it back this way without getting eaten or caught, that’s something that I like seeing …but apart from that, what you do and what I do are two different things.” – (AF12)

All turtles fitted with satellite tags during the course of this study were purchased from fishers who had landed them at Cockburn Harbour. In other comments fisher AF12 also acknowledged a utilitarian value to the tracking in the form of the financial payment he received from project staff for the turtle. This cash value of the tracking project was recognised in comments by three other interviewees, including one active fisher and two former fishers, typified by the following:

“I got no problem with the Project...Suzie for instance, a native guy catch Suzie and bring her to the dock, I was there, and you offered him (procurement price) to release her, and that’s a good thing.” - (FF2)

Opinions of project associated with tracking

Comments falling into this theme included those in which the interviewee explicitly associated a positive opinion about the project with the tracking. The tracking was responsible for positive opinions in 94% (n=17) of the commenting interviewees with the following comment being a typical example:

“The good thing about it is that you tag the turtle and you see how far they travel…it’s good….some people don’t think a turtle can travel so far, but they do, so it’s good.” – (AF8)

The fisher who offered this comment later suggested that he did not know what the broader project objectives were. Indeed, comments from several interviewees suggested that the high profile satellite tracking work was obscuring their understanding of the broader project objectives:

“(The project is) working good, because every time you put those posters up, a lot of people said ‘That turtle sure doing some travelling, see, whoever thought them turtles used to travel that kind of distance in

a short time?'. (Project staff) are doing a good job, especially with that satellite (transmitter) on them turtles." – (FF1)

Comments about tracking offered at the workshop events

In addition to the comments made by interviewees, Suzie was specifically mentioned in single, unprompted comments during three of the semi-structured workshop events in South Caicos and one in Grand Turk. In each case, the satellite telemetry was viewed positively by participants and associated with an appreciation of learning about turtle migratory behaviour.

Discussion

Suzie the turtle exhibited behaviours typical of migrating adult female green turtles, but her migration covered an unusually long distance compared to other green turtles satellite tracked in the region (Godley et al. 2008). The promotion of this remarkable migration clearly had an impact on South Caicos fishers and other community members of different ages, as over half of the interviewees commented about the satellite tracking in some way, largely unprompted and usually with considerable enthusiasm. It is worth noting that the filmed interviews were carried out approximately one month after the turtles' return to the Turks and Caicos Islands, and therefore the tracking story was relatively topical.

Hamann et al. (2010) identified the need for a better understanding of human values and psychology to assist with education and outreach in order to generate conservation gain through changes in stakeholder behaviour. Due to the small sample size, interviewees cannot be regarded as representative of the South Caicos community. However, the common themes expressed by interviewees during this study provide interesting insights into the value stakeholders attach to turtles and learning about turtle behaviour in a community where turtles are commonly viewed as a traditional food resource.

Educational impact

People clearly learned from this aspect of the project and associated promotion. Almost all those that commented on the tracking acknowledged that they learned from the project and most suggested that others in the community also learned. In addition, most commenting interviewees said that they and/or members of the community valued their learning experience. This associated value was reflected in the enthusiasm explicit in interviewee comments about the tracking. While most comments focused on Suzie's migration, a few interviewees commented on the hawksbill turtles that were also tracked. The opportunity for school pupils to get close to Suzie and Jerry, the adult male hawksbill, prior to the turtles being released, seems to have catalysed novel and enjoyable learning experiences for the pupils, as recalled by the two minors. The learning from these encounters seems to have been conveyed beyond the immediate family of some pupils and thus has the potential to impact the wider South Caicos community.

It is worth noting that almost all commenting interviewees associated the tracking with a positive opinion of the broader project. With appropriate promotion and interpretation, satellite tracking of marine turtles has potential to present enjoyable, valued and novel learning experiences to communities, and generate positive attitudes toward conservation research. However, while a community may enjoy the promotion of tracking research, this method alone will not necessarily facilitate support for conservation objectives. The comments of AF11, the fisher who originally named the turtle Suzie, suggest an assumed ownership and support of the broader project objectives. In contrast, the comments of AF12, the fisher who caught and landed Suzie, suggest that previously recorded community suspicions about the project intentions regarding turtle fishery management persist (Silver and Campbell 2006). Satellite tracking certainly has the potential to facilitate stakeholder learning about resources, but this learning alone cannot be expected to change behaviour in a community that has traditionally consumed turtles, and where changes in management may be perceived to conflict with important social and cultural values associated with that consumption.

Change of perspective

The tracking project enabled the South Caicos community to learn more about the turtles they consume. This learning was mostly associated with the turtle migratory behaviour. With some interviewees, this learning led on to thinking and discussion about the need for regional cooperation, as proposed by marine turtle researchers elsewhere (Frazier 2002, 2005, Blumenthal et al. 2006, Shillinger et al. 2008), and there were some clear indications of a change in thinking on this subject within a context of resource management. The natural emergence of thinking on management needs and options suggests that appropriate interpretation and promotion of satellite tracking data can catalyse stakeholder engagement with marine turtle management issues including sophisticated regional fishery management concepts. Consideration of these concepts by multiple stakeholders is particularly encouraging in South Caicos, a community where fishery management has traditionally been viewed as problematic (Rudd 2003, Tewfik and Bene 2004). While we urge caution with these results, they suggest that resource-users do not necessarily conform to the stereotypes assumed by some marine turtle research and conservation professionals (Campbell 2000).

Cultural/symbolic value

In addition to cash and learning value associated with the tracking project, some interviewees expressed positive cultural/symbolic values focussing on the individual turtle and its residence in the Turks and Caicos Islands. While some of these values may seem at first to conflict with notions of shared resource, they could lead stakeholders to consider their responsibility for resource management at home but within a regional context. This seems to be the case in at least two other marine turtle tracking projects where stakeholders were engaged with tracking data. In Baja, Mexico, where turtles are subject to bycatch and are traditionally consumed, the story of an adult female loggerhead turtle, tracked in 1996 from local foraging grounds to Japanese waters, *'is now retold as part of the regional lore'* (Delgado and Nicholls 2005). The tracking of this turtle, named Adelita after the daughter of a fisher who helped attach the transmitter, has been used to promote membership of local community-based conservation network *Grupo Tortuguero* formed in 1999, which includes amongst its varied aims the reduction of marine turtle morality resulting from bycatch in local artisanal fisheries. The story of Adelita serves to remind *Grupo Tortuguero* members that ‘their local actions have a global reach’ (Delgado and Nichols 2005). In the same year that Adelita was crossing the Pacific Ocean, the indigenous people of north east Arnhem Land (Yolngu) of the Northern Territory of Australia initiated a marine turtle research and management programme that aimed to combine traditional knowledge of an important local resource, marine turtles, with contemporary science, including a green turtle satellite tracking programme (Kennett et al. 2004). The tracking in 1998 and 1999 revealed that green turtles travel between traditional hunting territories of Yolngu and other Aboriginal groups within the Gulf of Carpentaria. Encouraged by these results, these groups subsequently established a regional network of communities within the Gulf in order to facilitate regional cooperative management of subsistence use of the marine turtle populations found there (R Kennett pers, comm. 2011, NAILSMA 2011). Tracking projects can therefore generate learning that dovetails with existing cultural associations and perceptions of resource ownership, community initiative and home concepts, but subsequently encourages stakeholders to participate in regional cooperation.

Stakeholder engagement and support

While professionals within the field are often challenged by concepts such as sustainable marine turtle use, some appear optimistic that methods such as satellite tracking can provide the data necessary to manage use with more scientific certainty (Campbell 2002). However, there are inherent logistical limitations of the method, such as cost, which have traditionally restricted the size of study samples and this compromised their scientific utility (Godley et al. 2008, Hart and Hyrenbach 2009). With over half of the interviewees associating positive attitudes about the broader project with the satellite tracking, this study adds to a small body of evidence that indicates that satellite tracking projects can have added value with respect to stakeholder learning and engagement. However, in this study, the high profile promotion of satellite tracking seems to have obscured some interviewees’ understanding of broader project objectives regarding turtle fishery management, which were also treated with scepticism in some cases. Tracking can generate significant stakeholder interest and appeal to individual cultural/symbolic values, but must be nested in a multi-disciplinary approach, including effective communication of results to a wide range of stakeholders, to ensure that tracking promotion does not detract from project aims or result in misinterpretation of project objectives by stakeholders. In this study, the programme of documentary screenings and workshop events, initiated approximately five months after the filmed interviews, where participants discussed future management scenarios in considerable detail, likely mitigated against potential confusion. Single unprompted comments about the tracking project were offered in only three of the seven workshop events held in South Caicos and in one other in Grand Turk. This may indicate decreased community interest in the tracking over time, but it may also suggest that the discourse facilitated by the project as a whole had progressed beyond the Suzie story.

Conclusion

Satellite tracking has significant potential to contribute to a wider understanding of marine turtle conservation needs amongst multiple stakeholder groups. In this study, interviewees attached positive personal and/or community value to learning from the research, one of several important values interviewees associated with the tracking. By making novel scientific data immediately accessible to a range of stakeholders, satellite tracking projects have the potential to inform and influence the opinions of a range of stakeholders, including researchers and resource users alike. Thus, appropriate interpretation and promotion of tracking data can go some way to ‘levelling the playing field’ for stakeholder discussion and informed decision-making within the political ecology of marine turtle conservation and management. However, it remains to be seen if the community of South Caicos can use what they gained from Suzie’s story to develop and improve the management of their traditional turtle fishery.

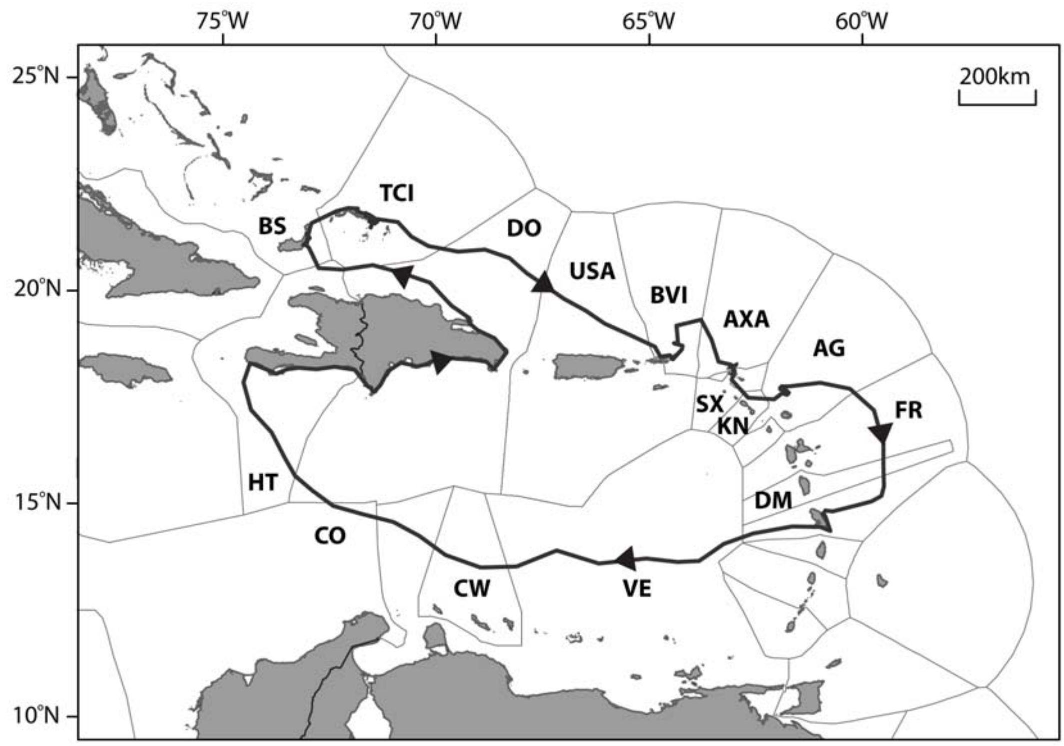

Figure 1. Map of Suzie's track showing that the turtle passed through Exclusive Economic Zones (EEZs) of the following countries; TCI - Turks and Caicos Islands, DO - Dominican Republic, USA - (Puerto Rico and the US Virgin Islands), BVI - British Virgin Islands, AXA - Anguilla, SX – Sint Maarten, KN - St Kitts and Nevis, AG - Antigua and Barbuda, FR - France, DM - Dominica, VE -Venezuela, CW – Curacao, CO - Colombia, HT - Haiti, and BS - Bahamas.

Comment themes	Number of interviewees making comments
1. Learning	**17**
Interviewee learned	15
Others learned	9
More learning required	3
2. What was learned	**15**
Understanding of turtle behaviour	15
Understanding of ‘shared resource’	8
Changed view of turtles	6
Understanding of project aims	2
Size of turtle	1
3. Personal/community value	**12**
Educational value	8
Humanistic values associated with turtle	8
Financial value of tracking	4
Value associated with use of technology novel to TCI	1
4. Opinions of project associated with tracking	**17**
Positive	17
Negative	0

Table 1. Interviewee comment themes and number of interviewees making themed comments about the satellite tracking.

Interview themes	Questions
1. Background information	• Age • Family (married/single/children) • Occupation(s), past and present • Ethnic Group
2. Background/history/heritage in South Caicos	• How long have you or your family been living in South?
3. Connection to South Caicos	• What is life like in South? • What is it about South Caicos that keeps you living here or prompted you to return?
4. The Community in South Caicos	• How would you describe your 'community' in South Caicos?
5. Burning issues in South Caicos	• What are the most important issues concerning people in SC right now? • What is everyone talking about? • Are there any important issues related to fishing?
5. Changes in fishing in South Caicos	• Has the fishing industry in South Caicos changed since you've been here?
7. Personal connection with fishing	• How have you been involved with fishing in South?
8. Connection with turtles and turtle fishing	• Have you ever been involved in turtle fishing? • Have you ever prepared/eaten turtle?
9. Views on turtle fishery management	• Do you think fisheries need to be managed? • What is your view on the current management of fisheries in South? • Do you think turtles in the Turks and Caicos Islands need management? • Are there any of the following turtle fishery management measures that you think would/ would not work? - *Permanent ban;* - *temporary moratorium;* - *species ban;* - *open and closed seasons;* - *protection of nesting females and eggs;* - *minimum and maximum size limits;* - *gear restrictions;* - *special licenses;* - *quotas;* - *ban on commercial resale of meat (i.e. in restaurants);* - *co-management of the turtle fishery*
10. Opinion of project	• What is your opinion of the Turks and Caicos Islands Turtle project?

Supplementary table 1. Questions used to explore themes during the study interviews.

Stakeholder groups and interviewee codes	Gender (Male/Female)	Commented on tracking
Active fisher		
AF1	M	No
AF2	M	No
AF3	M	No
AF4	M	No
AF5	M	No
AF6	M	No
AF7	M	Yes
AF8	M	Yes
AF9	M	Yes
AF10	M	Yes
AF11	M	Yes
AF12	M	Yes
AF13	M	Yes
Adult community member		
CM1	M	Yes
CM2	F	No
CM3	M	No
CM4	F	No
CM5	F	Yes
CM6	M	No
CM7	F	No
CM8	M	No
CM9	M	No
Former fisher		
FF1	M	Yes
FF2	M	Yes
FF3	M	No
FF4	M	Yes
FF5	M	Yes
FF6	M	Yes
FF7	M	Yes
Government worker		
GW1	F	No
GW2 (not resident in South Caicos)	M	Yes
Minor		
M1	M	Yes (prompted)
M2	M	Yes (prompted)
Total	**33**	**18**

Supplementary table 2. Constituents of interviewee survey and number who made comments regarding the satellite tracking.

CHAPTER 7. CONCLUSION

Despite a substantial body of literature describing the biology and conservation of marine turtles, fundamental questions remain about reproductive biology, biogeography, population ecology and threat mitigation (Hamann et al. 2010). Knowledge gaps in these areas present ongoing challenges to effective management, which require a combination of research and conservation effort, across vast geographical areas, usually across the jurisdictions of multiple sovereign states, often on the high seas, and involving a diverse range of stakeholders.

While the costs of biotelemetry inherently limit samples sizes, in combination with flipper tagging, satellite tracking has demonstrated its potential to contribute to our understanding of marine turtle biology. The method is helping to define the geographic ranges of turtle populations and providing insights into threats throughout these ranges. In isolation, however, these tracking and tagging data can raise more questions than they answer. Additional tracking and flipper tagging of green turtles at Rekawa and other rookeries in southern Sri Lanka may address a suite of biological questions raised by the satellite tracking study described here. However, further studies should be carried out in combination with other contemporary research methodologies, including molecular analysis, which has provided valuable insights elsewhere (Hatase et al. 2006, Godley et al. 2010). Such an approach has the potential to further explore any phenotypic differences associated with foraging habitats and strategies within Sri Lanka's green turtle population and confirm the locations of important foraging habitats. Associated regional inshore fisheries research is also required to better understand the significance of anthropogenic green turtle mortality, both directed and incidental, at the foraging sites and along migration routes identified by this study and facilitate identification of priority mitigation measures throughout the population range. Similarly, an integrated biological research approach, including further flipper tagging and biotelemetry, and involving multiple nesting beaches in different range states, could also help elucidate currently unexplained trends in the northern Caribbean nesting population of leatherback turtles. Unilateral conservation actions by the range states of this population appear to be key to facilitating recovery and nesting beach monitoring throughout the range and have potential to provide better information about the significance of anthropogenic threats such as direct take and fisheries bycatch. Enhanced research, proactive nest protection and habitat protection on the nesting beaches in Anguilla and the British Virgin Islands will therefore likely present cost-effective contributions from these UKOTs to a better understanding of this regional population and its recovery.

Despite its limitations, satellite telemetry has helped to widen the traditional scope of conservation from the nesting beaches to the species' broader geographic ranges (Godley et al. 2008, Wallace et al. 2010a). Tracking studies can tell us which sovereign states share marine turtle populations. Existing multi-lateral environmental agreements (MEAs) aim to facilitate international cooperation between these range states, but are also constrained by certain limitations. The various MEAs that specifically encourage the protection of marine turtles do not extend to the high seas, where marine turtle bycatch in industrial fisheries is a recognised and potentially significant threat (Lewison et al. 2004, Wallace et al. 2010b). The marine turtle conservation community must therefore seek to foster action within other international institutions, such as the regional fishery management organisations, which have considerable potential to help mitigate bycatch on the high seas for some marine turtle species. Furthermore, implementation of MEA obligations is not without costs and complications to range state governments, especially when MEAs favour conservation strategies that prohibit turtle use, but involve countries with communities where marine turtles are still used. National governments should consider these costs before they accede to the range of MEAs that specifically list marine turtles in their protective annexes. In order to generate stakeholder participation in collective, international conservation efforts, national governments would also be advised to interpret existing international obligations in national policy so as to accommodate stakeholder needs and values.

This thesis indicates that satellite tracking studies have the potential to engage and inform stakeholders, and even appeal to cultural values, such studies are nested in multi-disciplinary work, combining biological research with social science and educational outreach. Of particular importance is the potential for tracking studies to facilitate learning that allows informed consideration of regional management concepts across diverse stakeholder groups, including marine turtle researchers, conservation managers and turtle fishers alike. Satellite tracking thus has the potential to provide useful linkage between biological research, international conservation policy and resource user interests. Indeed, the ongoing tracking studies in the Turks and Caicos Islands are indentifying the geographic range of the turtles harvested by the country's turtle fishery and is helping to engage fishers in the learning process. This research is nested in a multi-disciplinary, collaborative process, which is building on the results of the initial studies described here in order to address the biological and social conservation challenges associated with resource use that this work has identified. It remains to be seen if this approach will improve the management of the Turks and Caicos Islands turtle fishery, but this approach has already facilitated novel and developing perspectives among some resource users regarding regional turtle fishery management.

The suite of studies in this thesis support the growing understanding that an innovative, multi-disciplinary research approach, which assesses and takes into account tensions between resource-user priorities, the practicalities of national policy and action, and multi-lateral cooperation, can facilitate useful progress towards addressing global marine turtle conservation and management challenges.

GLOSSARY OF FREQUENTLY USED ACRONYMS

BVI - British Virgin Islands.

CCL – Curved Carapace Length.

CIDoE – Cayman Islands Department of Environment.

CITES - Convention on International Trade in Endangered Species CMS - Convention on Migratory Species.

DECR – Department of Environment and Coastal Resources (Turks and Caicos Islands).

DFMR – Department of Fisheries and Marine Resources (Anguilla).

ESA – Endangered Species Act.

GoMBR - Gulf of Mannar Biosphere Reserve.

IAC - Inter-American Convention for the Protection and Conservation of Sea Turtles.

ICCAT - International Commission for the Conservation of Atlantic Tunas.

IUCN – International Union for the Conservation of Nature.

MEA – Multi-lateral Environmental Agreement.

NCNP – Northern Caribbean Nesting Population of leatherback turtles.

RFMO – Regional Fishery management Organisation.

SPAW - Protocol Concerning Specially Protected Areas And Wildlife.

SRDL - Satellite Relay Data Loggers.

STAT – Satellite Tracking and Analysis Tool.

STRAP - Sea Turtle Recovery Action Plan (WIDECAST).

TCI – Turks and Caicos Islands.

UKOT – United Kingdom Overseas Territory.

UNCLOS - United Nations Convention on the Law of the Sea.

UNFSA – United Nations Convention on the Law of the Sea 1995 Fish Stocks Agreement.

USVI – United States Virgin Islands.

WIDECAST – Wider Caribbean Sea Turtle Conservation Network.

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