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Hawksbill hatchlings running towards the sea after emerging at dawn on Playa Sardinera, Mona Island, Puerto Rico (photo: R. van Dam).

SPECIAL ISSUE: MARINE TURTLES IN THE CARIBBEAN
Guest Editors: Robert Van Dam & Julia Horrocks

Articles

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Guest Editorial: Marine Turtles of the Wider Caribbean Region

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The Wider Caribbean Region (WCR) extends south of 30ºN latitude to the border between French Guiana and Brazil, and embraces 28 sovereign nations and more than a dozen overseas territories affiliated with France, Great Britain, The Netherlands, and the United States. Range states vary in size from very small island territories, such as Montserrat (population: 8,000) and Anguilla (population: 12,000), to some of the largest nations in the world, including Mexico (population: 103 million) and the USA (population: 288 million) (www.census.gov/ipc/prod/wp02/tabA-04.pdf). The region is defined by broad social and political diversity, including the world's greatest concentration of small countries, representing "the full range of the world's major political systems" (Carpenter 2002).

Biogeographically the WCR is largely comprised of two semi-enclosed basins (the Caribbean Sea and the Gulf of Mexico) with an average depth of approximately 2,200 m (the deepest point, 7,100 m, is located in the Cayman Trench) (UNEP 1984). The region is known for its tropical shallow marine ecosystems, patterns of endemism, and species diversity (summarized by Spalding & Kramer 2004) – including six of the world's seven species of marine turtle. Based on reduced range of habitat, declines in population size, or both, these marine turtles are classified by the IUCN Red List of Threatened Species (http://www.iucnredlist.org/) as Vulnerable (olive ridley, *Lepidochelys olivacea*), Endangered (loggerhead, *Caretta caretta*; green, *Chelonia mydas*) or Critically Endangered (Kemp's ridley, *L. kempii*; hawksbill, *Eretmochelys imbricata*; leatherback, *Dermochelys coriacea*) at a global scale.

Marine turtles have provided nutrition, wealth and in other ways been useful to humans for at least 4,000 years (Peterson 1997; Versteeg *et al.* 1990; Frazier 2003). They fed indigenous tribes and helped make foreign colonization possible. Carr (1955) observed that, "all early activity in the New World tropics – exploration, colonization, buccaneering, and even the manoeuverings of naval squadrons – was in some way or degree dependent on turtle." Marine turtles once numbered in the tens of millions in the Caribbean Sea (Jackson 1997) and were not atypically described by early writers as a "never failing resource" (Long 1774 *in* King 1982). Indeed, some of the largest breeding colonies the world has ever known once flourished in the region (*Chelonia* in the Cayman Islands: Lewis 1940; Aiken *et al.* 2001; Bell *et al.* 2006, 2007; *Eretmochelys* in Panama: Meylan & Donnelly 1999).

Herbivorous green turtles were especially savoured for their mild flesh, and historically this species was traded in enormous volumes (Parsons 1962; King 1982; Groombridge & Luxmoore 1989; Jackson 1997). Similarly, the colorful carapace scutes of the hawksbill turtle once featured prominently in the region's foreign export earnings, historically in trade with Europe but more recently (increasingly dramatically in the early 1970s) in trade to Asian markets, primarily Japan (Meylan & Donnelly 1999; Mortimer & Donnelly 2007).

Today the region's marine turtle fauna is a sliver of what it once was. Causal factors include legal and illegal targeted fisheries, incidental capture in fishing gear, killing of gravid females and egg collection on nesting beaches, national and international trade and commerce, pollution and other degradation to foraging grounds, and loss of nesting habitat to coastal development (reviewed by NRC 1990; Fleming 2001; Reichart 1993; Reichart *et al.* 2003; Seminoff 2004; Godley *et al.* 2004; UNEP/GPA 2006; Bräutigam & Eckert 2006; Mortimer & Donnelly 2007). According to McClenachan *et al.* (2006), 20% of historic nesting sites have been lost entirely and 50% of remaining nesting sites have been reduced to "dangerously low populations."

In general, and notwithstanding recently rising or recovering populations where organized field conservation efforts are strengthened by legal protection of turtles and habitats (*Chelonia*: Troëng & Rankin 2005; *Dermochelys*: Dutton *et al.* 2005; Stewart & Johnson 2006; Girondot *et al.* 2007; *Eretmochelys*: Beggs *et al.* 2007; Kamel & Delcroix 2009; Stapleton *et al.*, this issue; *Lepidochelys*: Márquez *et al.* 2005; Kelle *et al.* 2009), marine turtle populations throughout the WCR have become so severely reduced from historical levels as to be considered by Bjorndal & Jackson (2003) "virtually extinct" from the standpoint of their role in Caribbean marine ecosystems.

Concerned about the deteriorating status of marine turtles in the region, intergovernmental meetings devoted to defining and addressing issues of shared management concern have been convening in the WCR for more than two decades (e.g., Bacon *et al.* 1984; Ogren 1989; Eckert & Abreu Grobois 2001; IUCN 2002) – and significant progress has been made. Today marine turtles are legally protected year-round by 70% of WCR governments (Dow *et al.* 2007), "there is very little evidence in official statistics of significant trade in marine turtle products" since the closing of the Japanese market for hawksbill shell in 1993 (Bräutigam & Eckert 2006), and several international treaties and agreements (see Wold 2002) promote the protection of turtles and their habitats. Two of these treaties – the Convention on the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention, a UNEP Regional Seas Programme http://www.cep.unep.org) and the more recent Inter-American Convention for the Protection and Conservation of Sea Turtles (http://www.iacseaturtle.org) are specific to the region and provide a strong basis for collaboration and co-ordination in addressing threats to marine turtles and the ecosystems upon which they depend.

Among the assets of the Cartagena Convention that are most directly related to marine turtle conservation are its Regional Activity Centers (RACs), including a RAC for Specially Protected Areas and Wildlife located in the French Overseas Department of Guadeloupe, and its Regional Activity Networks (RANs), the oldest and most established of which is the Wider Caribbean Sea Turtle Conservation Network (http://www.widecast.org), a volunteer coalition of hundreds of marine turtle scientists, policy-makers, educators and community-based conservationists based in the region's more than 40 nations and territories (Eckert & Hemphill 2005). These assets have worked in synergy, along with significant other actors (e.g., Caribbean Conservation Corporation http://www.cccturtle.org), to realize a landscape increasingly defined by national management planning, progressive legislation (including protected areas), creative approaches to public awareness, and strong community involvement.

More than half of all WCR governments have developed national Sea Turtle Recovery Action Plans, either in partnership with WIDECAST (http://www.widecast.org/Resources/STRAPs.html) or through national processes (e.g., USA: NMFS and USFWS 1992, 1993; Colombia: Ministerio del Medio Ambiente 2002; French Guiana: Bioinsight/DIREN Guyane 2003). Recovery plans assess species status and articulate an organized approach to population-level recovery, including recommendations for research, management, and conservation action. These recommendations often lend impetus to an expansion of current activities, such as moving beyond nesting beach patrol to conduct an in-water population census (cf. Diez & van Dam 2003; Blumenthal *et al*. 2009), making greater use of technology to inform policy (e.g., satellite telemetry – *Caretta, Chelonia*: Troëng *et al.* 2005; Blumenthal *et al.* 2006; *Dermochelys*: Hays *et al.* 2004; Eckert 2006; *Eretmochelys*: Horrocks *et al.* 2001; van Dam *et al.* 2008; genetic analysis – *Chelonia*: Bowen *et al.* 1992; Lahanas *et al.* 1994; *Dermochelys*: Dutton *et al.* 1999; *Eretmochelys*: Bowen *et al.* 1996; Bass 1999, Browne *et al.* in press), or exploring innovative models of co-management or ecotourism to promote conservation capacity at the community level (e.g., Troëng & Drews 2004; Sammy *et al.* 2008). In some cases, major revisions to national legislation have been the direct outcome of recovery plan recommendations (e.g., Smith *et al.* 1992; Government of Belize 2001).

Some of the most significant nesting beaches in the world are legally protected by WCR governments – *Caretta*: Archie Carr National Wildlife Refuge in Florida (NMFS and USFWS 2008); *Chelonia*: Tortuguero National Park in Costa Rica (Troëng & Rankin 2005), Aves Island Wildlife Refuge in Venezuela (Government of Venezuela 1972); *Dermochelys*: Amana Nature Reserve in French Guiana (Fretey & Lescure 1979, 1998), the Prohibited Areas of Fishing Pond, Matura, and Grande Riviere in Trinidad (Bräutigam & Eckert 2006); *Lepidochelys*: Rancho Nuevo Nature Reserve in Mexico (Márquez *et al.* 2005) – as well as a number of smaller nesting grounds (see Eckert & Hemphill 2005) and, on rare occasions, internesting habitat (NOAA 1979; JORF 1998) and migratory corridors (NOAA 1995). Progress has also been made in defining the valuable role that marine turtles play in helping to maintain critical coastal and marine ecosystems (cf. Bouchard & Bjorndal 2000; León & Bjorndal 2002; Bjorndal & Jackson 2003).

The WCR has reached beyond traditional education and outreach approaches (e.g., Harold & Eckert 2005; Bahamas National Trust 2007) to featuring marine turtles on national and regional currencies (Lopez 1996, 2004), postage stamps (Linsley & Balazs 2004), phone cards (Linsley 2004), and the crests and logos of government agencies, conservation organizations, protected areas, and major cities (summarized by Eckert & Hemphill 2005). Marine turtles have been used as "flagships" to motivate people to consider complex contemporary management and policy issues, including those associated with protected areas, fisheries, multilateral conservation of shared species and seascapes, and tourism (Eckert & Hemphill 2005), and as focal points for innovative approaches to co-management and "eco-friendly" small business development in rural communities.

While space limitations preclude a full recitation of the contribution made to marine turtle science, conservation, and management by investigators working in this region, the persistent attention given to attending to the survival requirements of the region's marine turtles in recent decades has had a clearly positive effect. With standard guidelines and criteria in place for everything from tagging (Eckert & Beggs 2006) to integrated management of nesting beach environs (Choi & Eckert 2009) to the care of sick and injured turtles (Phelan & Eckert 2006; Bluvias & Eckert 2009), a complete atlas of known nesting beaches (Dow *et al.* 2007), and the adoption of progressive policies toward bycatch reduction, beachfront lighting, conservation zoning, and so on, the literature now documents rising populations within five of the six Caribbean-occurring species. The exception is the more temperate nesting loggerhead, where the region's largest nesting population shows "a decrease of 26% over the 20-year period from 1989-2008 and a 41% decline since 1998" (NMFS & USFWS 2008).

While population rises are heartening – and not the least because they provide replicable models of success applicable far beyond the boundaries of a localized recovery – many populations continue to decline. The basis for some of the most significant contemporary declines (e.g., *Caretta*: NMFS & USFWS 2008; *Eretmochelys*: Abreu Grobois *et al*. 2005) remains unknown, but, in general, the most vulnerable populations are most likely to be associated with: small islands, and especially those with active marine turtle fisheries (e.g., Eckert & Bjorkland 2005; Bell *et al.* 2006; Grazette *et al.* 2007); poaching and trade across international borders, which is difficult to control at both policy and operational levels (e.g., Chacón & Eckert 2007); high levels of bycatch (e.g., FAO 2005; Heppell *et al.* 2005; Lee Lum 2006); high levels of invasive predators (e.g., Leighton *et al.* 2009), and coastlines defined by high density touristic and other development that results in habitat loss and diminishes ecosystem resiliency in the face of other threats such as climate change (Harewood & Horrocks 2008; Fish *et al.* 2005, 2008).

The most recent regional assessment by TRAFFIC International and the CITES Secretariat (Bräutigam & Eckert 2006) emphasizes the need to, *inter alia*, modernize the regulatory framework based on a current understanding of marine turtle biology (this is especially relevant for a handful of Eastern Caribbean nations that still target breeding age adults during an annual open season); unify the management framework as required under various international agreements (so that breeding adults, for example, are not protected on the nesting beach only to be killed on their foraging grounds); improve record-keeping, as official statistics on levels of exploitation of marine turtles at the national level are scarce; integrate the protection of critical nesting and foraging habitats into coastal zone planning processes; increase national and institutional capacity for more consistent law enforcement, sustained population monitoring, science-based conservation, and a "more concerted, co-ordinated, cross-sectoral approach at the operational level" involving social scientists, rural development specialists, and development assistance donor agencies; accelerate replication of "innovative approaches to addressing over-exploitation" that are clearly working; and prepare and implement an effective public awareness and outreach strategy.

Thoughtful implementation of these recommendations will safeguard and extend recent conservation successes, but significant obstacles to marine turtle survival are likely to remain – including the annual loss of tens, if not hundreds, of thousands of marine turtles to fisheries bycatch and the multifarious challenges associated with rising aspirations in developing economies (and the attendant pressures on land and resource use), not to mention the looming spectacle of climate change. In the end, success will be defined by the extent to which the nations and peoples of the Caribbean are willing to lend their creativity, their endurance, and their personal and political commitment to the task of ensuring the survival of these ancient creatures. There is no doubt in my mind that the task will be achieved.

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Twelve years of monitoring hawksbill turtle (*Eretmochelys imbricata*) nesting at Doce Leguas Keys and Labyrinth, Jardines de la Reina Archipelago, Cuba

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The hawksbill turtle (*Eretmochelys imbricata*) is circumtropically distributed and inhabits coastal waters in the Caribbean and tropical western Atlantic (Witzell, 1983; Marquez, 1990). Hawksbill turtles are mainly diffuse solitary nesters, which often make them difficult to study (Bjorndal et al. 1985; Meylan 1989; Richardson et al. 1989; Horrocks 1992).

The Cuban archipelago, composed mainly of smaller islands and keys, provides many suitable beaches for nesting hawksbill turtles. As a result of population surveys carried out during the late 1980s and early 1990s, the population nesting at Doce Leguas Keys and Labyrinth was identified as the most important in the Cuban archipelago (Moncada et al. 1998, 1999). Subsequently, a more systematic surveying was undertaken, beginning in the 1997-98 nesting season. This allowed for more rigorous data collection on the ecology and nesting activities of hawksbill turtles in the area

Given that there little information on the reproductive biology of the hawksbill turtle in Cuba, this paper presents recent data collected from the Doce Leguas Keys and Labyrinth. These results will add to the growing body of literature on the hawksbill turtle and increase our understanding of this species.

Study Area. The Jardines de la Reina Archipelago is located approximately 50 km off the southeastern coast of Cuba (20º 86732 N, 79º 03969 W) (Fig. 1). It extends over some 150km, and includes more than 40 keys and small calcareous islands. The majority of the islands have beaches, interior lagoons, and abundant coral reefs and form the Doce Leguas Keys and Labyrinth. It is these beaches that are used by nesting turtles. General beach characteristics (length, width, slope, dominant vegetation) are described in Moncada et al. (1999), although it should be noted that some beaches have been altered over time due to climatic events such as cyclones.

Prior to 1996, nesting surveys at Doce Leguas Keys and Labyrinth were carried out primarily to confirm the presence of nesting hawskbill turtles and to enable the implementation of a long-term monitoring program. During the 1997-98 nesting season a more systematic approach was adopted, which involved surveys between September and January (Moncada et al. 1999). Taking into account logistics and beach accessibility, ten beaches (Boca Seca, La Ballena, El Faro, Playa Bonita Cachiboca, Los Pinos, El Datiri, Caballones Este, Caballones Oeste, El Guincho) were initially selected, with each patrolled intensively for at least 10 days per month (Fig. 1). The number of "index" beaches was subsequently reduced to nine in 2003 (Playa Bonita was excluded).

This methodology allowed for a nesting index to be generated each year, based on the same beaches being surveyed over the same time period. The nesting index is used as a proxy for the number of nests laid during the nesting season. In addition, other beaches in the Doce Leguas Keys and Labyrinth were visited less regularly (1-2 times per month, during the day) to obtain supplementary information on nesting throughout the area.

Measurements. Nesting hawksbill turtles were measured and tagged on the trailing edge of the front flippers, using titanium and or Monel tags, either during or after egg-laying. Curved carapace length (CCL) was measured from the leading edge of the nuchal (precentral) scute to the trailing edge of the marginal scutes, corresponding to CCLn-t from Bolten (1999). The location along the beach (parallel to the water line) of the nesting turtle was also recorded. Inter-nesting interval was defined as the number of days between different nesting attempts of the same turtle and remigration interval was defined as the number of years between successive nesting seasons for an individual turtle.

Nests were marked and the contents were examined after hatchling emergence. Egg shells that represented >50% of the egg were counted and used as an index of hatchlings produced. Hatching success was calculated by dividing the number of empty egg shells by the total number of eggs (hatched and unhatched) in the nest. In addition, dead embryos were aged on the basis of opaque band development or using the relationship between embryo size (head length) and age; this information was used in a few cases of unmarked nests that were found only at hatchling emergence, to back-calculate the approximate date of nesting.

Doce Leguas Keys and Labyrinth hawksbill turtles exhibit solitary behaviour, much like other turtles in the Caribbean (Bjorndal et al. 1985). Despite this and the difficult accessibility of many beaches, we tagged 84 nesting females between 1997 and 2007, and three more in 1994. During this time, 29 nesting females were observed multiple times (although oviposition was not always confirmed when the females was observed on the beach); from these data, we

Figure 1. Doce Leguas Keys and Labyrinth (Jardines de la Reina Archipelago, southeast of Cuba). Star symbols indicate "index" beaches.

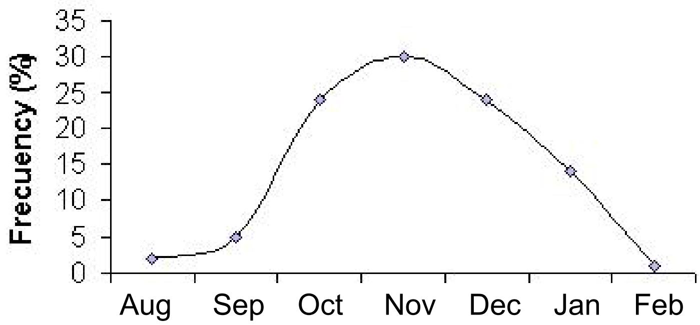

Figure 2. Seasonality of nesting activity of hawksbill turtles at Doce Leguas Keys and Labyrinth (1997-98 to 2008-09).

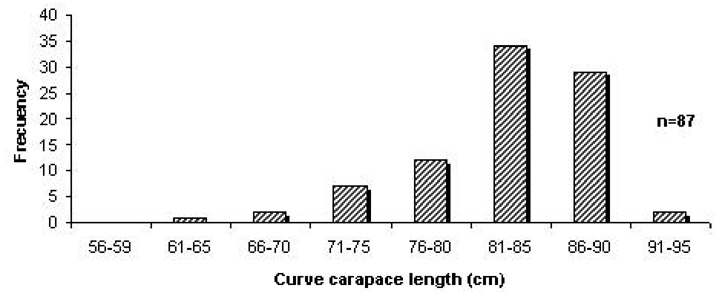

Figure 3. Size of nesting females at Doce Leguas Keys and Labyrinth.

calculated inter-nesting and remigration intervals and the number of nests laid by a female over a season.

The inter-nesting period was roughly two weeks. Most values ranged between 15 and 18 days, with a mean of 17. 4 (SD = ±4.3) days and a mode of 17 days. Higher inter-nesting intervals (i.e. >30 days) are likely to correspond to situations where a nesting event was not observed and were therefore excluded from calculations. Our results are similar to those found for hawksbill populations in the Caribbean and other regions (Bjorndal et al. 1985; Garduño-Andrade 1999; Mortimer & Bresson 1999).

Remigration interval and nest-site fidelity. Thirteen hawksbill turtles have been observed nesting in multiple seasons. The remigration intervals for these turtles are: 2 years (N= 7), 3 years (N= 5) and 6 years (N= 1). One-year remigration intervals have not been observed and it is possible that the 6-year interval simply represents a missed remigration event. Nevertheless, the data indicate that most females nest every 2-3 years, and, excluding the 6-year interval, the mean is 2.4 ±0.5 years (N= 12). This should be taken as an initial estimate of the remigration interval for hawksbills in this region. The Doce Leguas data are similar to those reported for hawksbills in other areas, where remigration occurs mainly every 2-3 years (Garduño-Andrade et al. 1999; Mortimer & Bresson 1999; Pilcher & Ali 1999; Richardson et al. 1999; Beggs et al. 2007).

For island populations, females generally nest on the same beach or on nearby beaches each year (Antigua: Richardson et al. 1999; Isla Mona, Puerto Rico: Diez & van Dam 2007), suggesting strong philopatry in these turtles. However, when turtles nest on archipelagos, such as Doce Leguas, that contain many beaches on continuous and adjacent keys, it is possible that nesting might be more diffuse. However, turtles in our study showed high site fidelity between nesting seasons; 12 turtles returned to nest on the same beaches: La Ballena (n=4), Boca Seca (n=4), El Faro (n=2), El Guincho (n=1) and El Datiri (n=1). Only one female switched beaches between seasons, nesting first on El Datiri and later on La Ballena, 26.8 km away. This distance is, nevertheless, much smaller than those recorded for remigrant hawksbill on the continental beaches of the Yucatán peninsula; turtles there were observed nesting on beaches some 80 km apart (Garduño-Andrade et al. 1999). Nest-site fidelity thus appears to be quite strong for hawksbills in Doce Leguas Keys.

Clutch frequency. The observed number of nests of an individual turtle during the season ranged from 1 to 5, with most turtles seen nesting only once. Mean nesting frequency was 1.45 ±0.07 nests/season, lower than that reported for other areas (Garduño-Andrade et al. 1999; Lamri & Ali 1999; Mortimer & Bresson 1999, Pilcher & Ali 1999; Richardson et al. 1999; Beggs et al. 2007). Although other studies have reported a high frequency of one-time nesters (e.g. Bjorndal et al. 1985; Garduño-Andrade et al. 1999), it is most likely that nests of some females were missed during the beach surveys or that females laid some nests on beaches that were not patrolled systematically.

Seasonal nesting distribution. Hawksbill turtles nest virtually year-round at Doce Leguas Keys and Labyrinth (Moncada et al. 1998). Our results show that most nesting occurs from September to January, with a peak between October and December (Fig. 2). This peak nesting period is unique among hawksbills in the Caribbean, and most other populations' peak nesting is earlier, e.g. May-June for the Yucatan peninsula in Mexico (Perez-Catañeda et al. 2007), July-August for the Pearl Cays, Nicaragua (Lagueux et al. 2003), August-September for Antigua and Barbados (Richardson et al. 1999, Beggs et al. 2007).

Female Carapace Size. The size of nesting females ranged between 64 and 93cm CCL, with a mode of 81-85 cm size class and a mean size of 82.8 $\pm$ 5.8SD cm (n= 87; Fig. 3). The mean CCL is similar to that of nesting populations in others areas such

Nesting season	Mean size of clutch	Clutch size range	Total nests
1997/98	135.5	40-231	14
1998/99	122.8	40-203	85
1999/00	137.5	22-211	103
2000/01	139.9	46-202	44
2001/02	135.1	34-227	72
2002/03	136.6	41-181	26
2003/04	138.9	68-190	42
2004/05	147.7	94-218	46
2005/06	139.3	45-215	61
2006/07	142.4	86-184	70
2007/08	122.8	35-188	157
2008/09	139.8	66-186	52

Table 1. Mean annual clutch size for hawksbill turtles at Doce Leguas Keys.

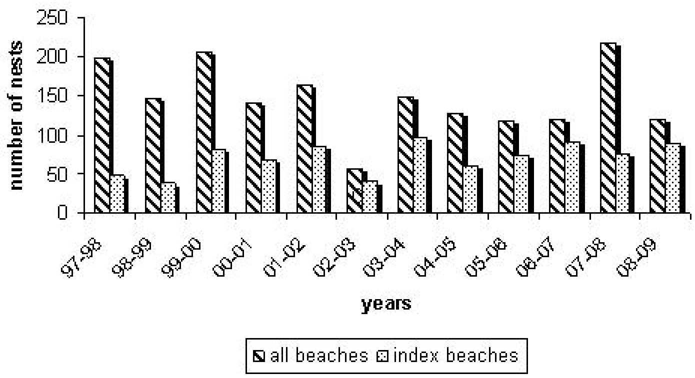

Figure 4. Annual total number of nest at Doce Leguas Keys and Labyrinth

as Tortuguero, Costa Rica (Bjorndal et al. 1985), Malaysia (Chan & Liew 1999), and Australia (Loop et al. 1995). However, the smallest nesting females in Doce Leguas Keys are much smaller than the smallest nesting females observed in the aforementioned regions. The mean CCL is also much smaller compared to nesting populations in Brazil, the Yucatan peninsula and Barbados (Marcovaldi et al. 1999, Pérez-Catañeda et al. 2007, Beggs et al. 2007).

Clutch Size. Between 1997 and 2009, annual mean clutch size varied between 122.8 and 147.7 eggs (Table 1). The mean clutch size for the overall period was 137.6 eggs (range: 22-231 eggs), which is similar to the mean clutch size calculated between 1988 and 1996 (135.2 eggs: Moncada et al. 1999). Mean clutch size appears to have remained stable over time, although there is substantial within-season variability in this trait.

Nesting Abudance. Previously, we estimated that maximal seasonal data derived from 10-day monitoring in Doce Leguas Keys and Labyrinth constituted between 25- 50% of total nesting effort for the year, based on data collected from 1983-1995 (Moncada et al. 1999). Based on more recent monitoring, including 2008/09 (Fig. 4), we estimate that the annual average number of nests laid per year is 150, and this represents closer to 50 % of the total number of nest for entire year in that region; that is, we estimate that around 300 nests are laid per year in Doce Leguas Keys and Labyrinth

Nevertheless, we also recognize that due to logistic constraints, not all keys in Doce Leguas Keys and Labyrinth were monitored, neither were all interior keys of Jardines de la Reina Archipelago. Therefore, data from some years may underestimate the true total number of nests laid, particularly from 1997/98 to 2000/01, when only a few beaches were monitored.

Acknowledgements. Thanks to the biologists, technicians and people who contributed to the population monitoring as well as to the Japanese Bekko Association that has supported this study for over 10 years. We are grateful to Grahame Webb and Charlie Manolis (Widlife Management International Pty. Limited) for their assistance over the years. We are especially grateful to Elvira Carrillo (deceased) who began and initially directed this long-term monitoring project.

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Leatherback Nest Distribution and Beach Erosion Pattern at Levera Beach, Grenada, West Indies

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Grenada, West Indies hosts a regionally significant nesting population of leatherback sea turtles in the insular Caribbean Sea. Levera Beach (700 m long) is the primary nesting beach, located in the northeast corner of the island nation and annually receives 200 - 900 nesting activities. Local anthropogenic threats at Levera Beach include illegal egg poaching (in 2000, 73% of nests were poached), illegal harvest of nesting females, pollution, and degradation of nesting habitat via sand mining and beach front development. Turtles tagged on Grenada have been observed nesting elsewhere in the region. Similarly, turtles tagged on neighboring island states have been recorded nesting on Grenada (Ocean Spirits Inc., unpublished data), thereby demonstrating that to some extent, nesting leatherback turtles in the Eastern Caribbean and perhaps further afield are a shared resource. In addition to the leatherback nesting beach, the immediate area includes dry forest, mangrove, and near shore reef habitats.

In 2004, an 18 hole golf course was completed as a first step in the development of a resort adjacent to Levera (Figure 1). Removal of near shore vegetation and lack of proper run-off prevention from the construction by the developer resulted in the deposition of fine sediments and mud over approximately 15% of the nesting beach. To evaluate the effects of this sedimentation on nesting activities, we documented the locations of nesting events over a 9 week period (May-June) of the 2005 nesting season and compared nest distribution to the distribution of nests from 2001- 2004.

For the 2005 nesting season, Levera Beach was divided into 24 zones (each 30m long). The locations of zones, marked by wooden stakes at the vegetation line, were similar to zones established previously by the Ocean Spirits, Inc. research project. Each stake's location was documented with a handheld GPS. Beach profiles were recorded weekly originating from every other stake following methods described by Fish *et al*. (2005). During nightly beach patrols, the zone was recorded for observed nests and, where possible, nests were triangulated from the two nearest stakes by using a meter tape to determine the distance from each stake to the center of the nest. Using a combination of MapInfo™ and ArcGIS™ software, beach marker positions and waterline profiles were converted to latitude/longitude coordinates and plotted on a map. Historical nest distribution data from 2001-2004 were also acquired and used in this analysis. Nest locations for 2001-2004 seasons were reported according to the zone within which each nest occurred.

Figure 1. Development behind Levera Beach, with removal of buffer vegetation and exposure of fine sediments that wash over the beach in August 2002 (top) and again in August 2003 (bottom).

There were 237 nests laid between 30 April and 28 June 2005; of these, we recorded zones for 219 nests. Most nesting occurred within zones B-C and T-X (Figure 2). There was a strong tendency in 2005 for nests to be laid along the northern side of the beach when compared to the east facing side of the beach. The percentage of total nests laid on the north facing side of the beach increased over the course of the nesting season with 39.6% in week 1 increasing to 64.3% of nests laid in week 8 located on the north facing side (Figure 3).

Historical data gathered between 2001 and 2004 showed a similar pattern of nesting along the north and east sides of Levera Beach (Table 1). The percent of nests laid on the north coast varied from 47% - 82% between 2001 and 2004.

Erosion patterns varied by beach section in 2005, with the east facing beach eroding an average of 8.77 meters and the northern side of the beach expanding an average of

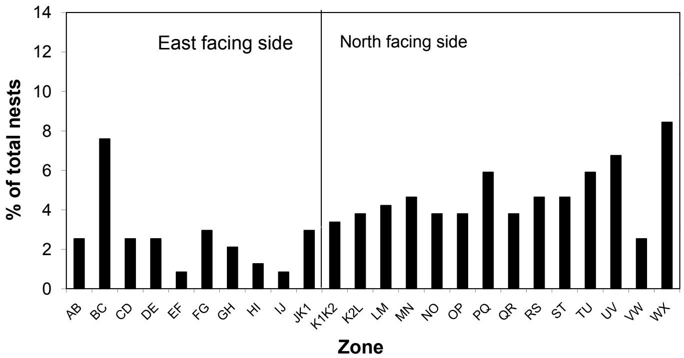

Figure 2. Distribution of turtle nests along Levera Beach in the 2005 nesting season.

9.32 meters over the course of this study (Figure 4). Deposition of fine sediments from the construction project was highest between zones U through X (Figure 5).

Our results suggest that turtles responded to the accretion of the north facing beach and erosion of the east facing beach in 2005 by nesting more often on the north facing beach. Changes in nesting density of leatherbacks as related to erosion/accretion patterns have been reported in French Guiana (e.g. Kelle *et al*. 2007) and Trinidad (Lee-Lum 2005). Erosion of the east facing beach over the season may have created a steeper approach slope; at times a steep berm was created at the shoreline. Accretion of the north facing side would presumably create a more gradual approach, gentler slope, and easier access for sea turtles (Sivasundar 1996; but see Hendrickson & Balsingham 1966, Mortimer 1982). The near shore environment at Levera is characterized by strong currents, which influence not only erosion and accretion patterns of the beach, but possibly turtle nesting behavior. For instance, multiple turtles emerging at the same time and place after long periods of inactivity in one evening has been observed at Levera, and may be explained in part by these currents or some other temporal or social variable not being considered.

While some studies suggest that offshore configurations and approaches are important for selection of nesting beaches by female turtles (Mortimer, 1982; Pritchard, 1971), selection of the nesting location on the beach remains poorly understood (e.g. Miller *et a*l. 2003). Although leatherbacks tend to nest in open sand areas free of obstruction, above the high tide line but below the vegetation (Kamel & Mrosovsky, 2003; Nordmoe, *et al*., 2003), it has been suggested that individual leatherback turtles nest in a random pattern

Year	North Side	Zones U-X
2001	67	20
2002	47	13
2003	82	23
2004	70	20
2005	66	18
Average	66.4	18.8

Table 1. Distribution of turtle nests on North Side and Zones U-X along Levera Beach from 2001-2005.

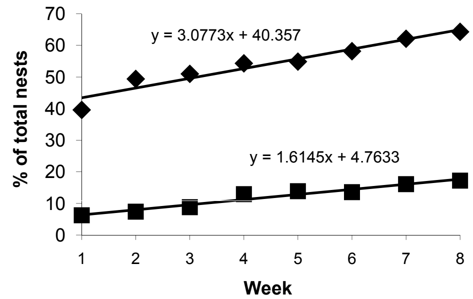

Figure 3. Over time, increasingly more nests are laid on the North side (diamonds) and in the affected area (zones U-X, squares).

in order to maximize nest survival in unpredictable environments (Mrosovsky 1983; Eckert, 1987). From a management perspective, the first step is to document where turtles choose to deposit nests and perhaps address the question of 'why' as a secondary concern. Locations with higher nesting density indicate particular portions of beach that should be protected from severe alteration, especially because it is unclear what factors contribute to the selection of these particular sites.

In the case of Levera Beach, each season, nearly 20% of all nests laid occurred in the area (Zones U-X) that has been affected by development (Table 1). These zones are subjected to ongoing run-off that has resulted in deposition of finer material where turtle nests are laid. Karavas *et al*. (2005) reported that an increase in finer-grained sand is proportional to the reduction of loggerhead nesting activity, possibly because turtles prefer coarser-grained sand for their incubating eggs. Hendrickson & Balsingham (1966) suggested that

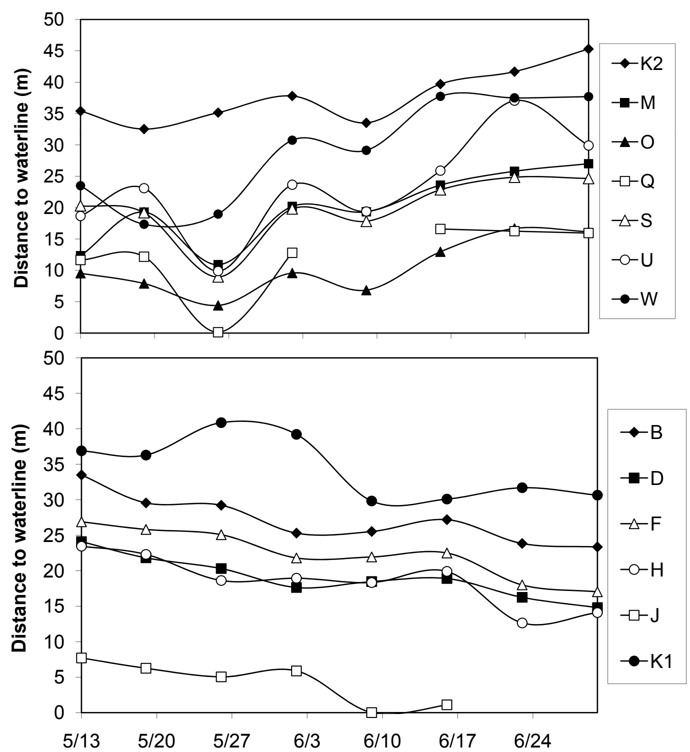

Figure 4. Beach profiles from north-facing (upper panel) and east-facing (lower panel) zones of Levera Beach show net erosion trends .

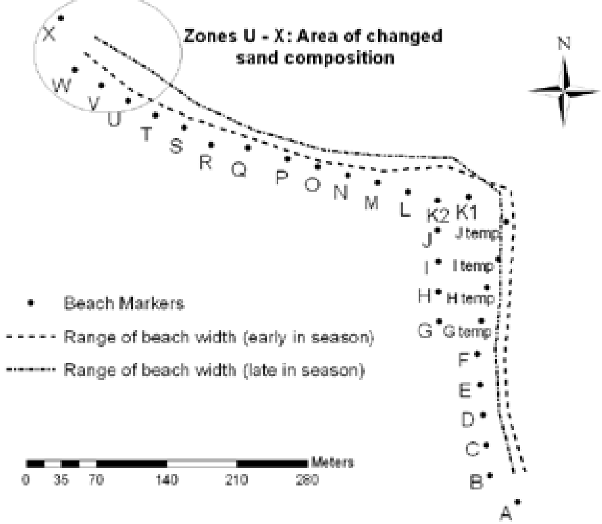

Figure 5. Map showing beach markers and the full range of beach width observed over the course of the study period.

species-specific preferences in sand grain size in Malayan sea turtles result in the separation of nesting beaches of greens (finer sand) and leatherbacks (coarser sand). Mortimer (1982) and Pritchard (1971) both pointed out, however, that in Malaya, sand grain size is correlated with the steepness of slope of the beach. Mortimer (1982) also noted that nests can fail in substrates that are either too fine or too coarse, but overall particle size is less important in nest site selection by females than offshore configuration. Leatherback females nesting at Levera Beach do not appear to be impacted by the change in sand grain size in Zones U-X, because comparable proportions of turtles nested in the affected area before and after changes occurred in sand composition and grain size.

The sediment deposited by runoff in Zones U-X may reduce hatch success of nests laid there by restricting gas exchange between developing eggs and finer sand (Prange & Ackerman 1974). For instance, leatherback eggs in Australia had high levels of early embryonic mortality when fine sand in and around the nest became wet and reduced gas exchange (Limpus *et al*. 1984). Also, loggerhead clutches laid in clay material on the beach in Cape Verde had reduced hatch success, presumably due to impeded gas exchange (Marco *et al*. 2008). Another impact of the runoff is that deposited material is darker in color than the naturally occurring sand, which in turn tends to cause temperatures at nest depth to be warmer through increased absorption of solar radiation (Hays *et al*. 2002). Increased sand temperatures may affect sex ratios of hatchlings and/or reduce hatch success (Matsuzawa *et al*. 2002). Additionally, material deposited by runoff may be more compacted than natural sand, which may impact hatchlings as they emerge from the nest (Crain et al. 1994). Finally, the runoff itself can occur during the nesting season, effectively burying incubating nests deeper under the deposited material, and likely reducing hatching success.

The current management strategy on Levera beach incorporates actions that are intended to maximize the reproductive success of Levera's nesting leatherback population. This includes manual relocation of individual nests laid in unsuitable areas. In 2005, 20 out of 42 nests laid in the affected area were relocated to more suitable sites, due to projected impacts from the runoff. Without these relocations, up to 10% of the total nests laid during the study period may have been lost due to impacts of runoff from the development site. Continued implementation of this management tool is recommended as long as the north side of the beach continues to suffer from unfavorable altered sand composition. In addition, future monitoring should evaluate the success of these relocation efforts.

Continued monitoring of the impacts of coastal development on leatherback reproductive success is needed at Levera Beach. For example, the removal of coastal vegetation is likely to leave the north-facing side of Levera unprotected from higher seas encountered outside the nesting season and thus more vulnerable to erosion, and increased human traffic and artificial lighting on the beach associated with hotels may negatively impact nesting females and hatchlings. More information on these impacts should help inform future management actions on Levera Beach.

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The Influence of Lunar, Tidal and Nocturnal Phases on the Nesting Activity of Leatherbacks (*Dermochelys coriacea*) in Tobago, West Indies

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There are few published reports of leatherback nesting activity in Tobago. Godley et al. (1993) surveyed six beaches in southern Tobago during July 1991 and reported evidence of nesting on three of them: Turtle Beach, Back Bay and Stonehaven Bay (also known as Grafton Beach), with Turtle Beach showing most activity. Since 2000, Save our Sea Turtles (SOS) Tobago, a small volunteer-based organisation, with a mission to conserve Tobago's turtle populations, has patrolled Tobago's turtle-nesting beaches throughout the nesting season (Clovis 2004). For the last few years, volunteers have collected systematic data on the turtles and their nesting activity. This effort has concentrated on the three beaches noted by Godley et al. (1993), regarded locally as "index beaches" that reflect island-wide trends in the nesting leatherback population (Clovis 2005; Lalsingh 2008). However, it is known that nesting also occurs on several other small, more remote beaches on the Caribbean coast of northern Tobago (Dow et al. 2007).

Turtle Beach accounts for the majority of leatherback nesting events on Tobago's index beaches from 2005-2009 (average: 66.2%); it has a steep beach profile, no corals immediately offshore and is the longest of the three (1.76 km). Grafton Beach (15.7% of total average leatherback nesting events from 2005-2009) has large rock formations along the length of the beach (1km), has a gentle slope and the tide often creates sandbanks of approximately 30-80 cm. Back Bay (18.1% of total average leatherback nesting events from 2005-2009) also has rock formations throughout the length of the beach (1 km) and is inundated when high spring tides occur.

The terrestrial environment can be physically difficult for sea turtles to move on and presents hazards such as egg predators and poachers, so nesting turtles should try to minimise exposure to unfavourable environmental conditions by assessing conditions whilst still at sea (Pike 2008). Leatherback nesting processes will be affected by the environment and cues (e.g. oceanic or atmospheric) may help to reduce the energetic and physiological stress of nesting (Pike 2008). Lunar, solar and tidal patterns are strongly linked and interact with each other. When the tide generating forces from the Sun and Moon are parallel or opposite to each other the tidal range is large; these spring tides (higher and lower than average) occur when the Moon is full or new. When the tide generating forces of the Sun and Moon are out of phase i.e. the Sun and Moon are at right angles to each other, the tidal range is below average, known as neap tides, occurring during the first and last quarter of the lunar phase (Wright et al. 1989). Tobago experiences mixed semi-diurnal tides due to its position near the equator; two high and two low waters each day, or one tidal cycle per day depending on the Moon's inclination to the Earth. Tidal ranges within the Caribbean are generally small (about one meter).

The lunar cycle causes environmental changes that may be perceived by animals, e.g. change in the brightness of lunar light, gravitational changes and geomagnetic fields. Solar, lunar and tidal cycles are believed to influence leatherback nesting activities because the turtles generally nest above the high tide line (Kamel & Mrosovsky 2004), so emerging when tides are at their highest will minimise the distance and duration of crawls. The greater the vertical distance between high and low tides, the greater the advantage of emerging at high tides, although beach profile will affect this potential advantage (Frazer 1983). Emergence when the tide is low is particularly difficult for leatherbacks as they are much larger than any other species of sea turtle and as a result their terrestrial movement is slow and metabolically costly (Wallace & Jones 2008). Fretey & Girondot (1989) observed peak leatherback nesting at and around the nightly high tide on certain beaches in French Guiana and suggested that the carrier effect of the rising tide could facilitate the arrival of the turtles.

The lunar phase may also affect leatherback nesting visually. On clear nights when the Moon is full, visibility may be greater and the presence of tourists and egg predators may discourage turtles from emerging. Alternatively on clear nights when the Moon is not bright (e.g. new moon), artificial lights and dark silhouettes may be more apparent and discourage nesting.

This study analysed the nesting events of leatherback turtles on Tobago's three index beaches from 2005-2009 to test whether environmental factors influence nesting. The following questions were asked: i) How many leatherbacks are nesting on Tobago's index beaches each year? ii) Do the numbers of nesting leatherbacks vary between lunar phases? iii) Is nesting leatherback emergence time correlated with high tide? iv) Is nesting leatherback emergence influenced by tidal stage? v) Does time at night influence nesting leatherback emergence?

Nesting data for leatherback turtles were collected from three index beaches on the south-west Caribbean coast of Tobago from 2005-2009. During each nesting season (March-August), nightly patrols were conducted between 20:00 and 04:00 h by SOS Tobago head patrollers and volunteers. When turtles were encountered, they recorded the beach, zone, date, time, species and activity. Turtles that successfully dug a nest chamber and laid their eggs were measured (cm, using a flexible tape), checked for physical damage or distinct markings, any flipper tags read and recorded, and Passive-Integrated Transponder (PIT) tags scanned and recorded from each turtle's shoulder area using a Biomark Pocket Reader (125 kHz). In the absence of tags, rear flipper tags or PIT tags were fitted in either shoulder. Monitors remained with the turtle and recorded the nesting event outcome. The numbers of tourists and locals were recorded and it was noted whether or not the turtle was disturbed by the presence of tourists/locals or beachfront lighting.

Each nesting event was categorised by the eventual outcome: confirmed nest (confirmed successful oviposition); false crawl (the turtle emerged from the surf and returned to the sea without digging a nest chamber); false crawl with body pit (after emergence from the surf and an attempt at digging a nest the turtle did not successfully complete a nest chamber); estimated nest (assumed but unconfirmed nest).

To test how nesting events are distributed between lunar quarters, months during the nesting season were divided into lunar quarters: plus and minus three days from the date of the first quarter, full moon, last quarter or new moon, giving seven days per quarter. Nests laid outside these ranges were not included in the analysis. False crawls and confirmed nests from all years were used in the first analysis of the effect of lunar phase. As the data were binomially distributed they were analysed using a Kruskal-Wallis test with multiple comparisons in Minitab v. 15. The second analysis examined the effect of lunar patterns on confirmed nests only within nesting years also using a Kruskal-Wallis test with multiple comparisons. Other nesting activities were not individually analysed with lunar phase as the numbers were low.

	Confirmed nests (% of total)	False crawls	False crawls + body pits	Estimated nests	Total Nesting Events
2005	216 (76.4%)	7	6	54	283
2006	173 (71.5%)	17	4	48	242
2007	123 (64.4%)	22	10	36	191
2008	345 (78.1%)	24	13	60	442
2009	317 (65.9%)	74	34	56	481
Mean	235	29	13	51	328

Table 1. Leatherback nesting outcomes from 2005-2009 for Tobago's three index beaches.

Nesting related to high tides: We recorded the time when we first encountered the turtle if she was initially observed on approach, body pitting and digging. Observed time was used rather than emergence time as turtles were often first found digging or body pitting and these events normally within the first twenty minutes of the nesting process (Miller 1996). Data were analysed using a Pearson's Correlation.

Nesting related to tidal stage: Data used in this analysis included only turtles that were first seen on approach, body pitting or digging with the time seen recorded. Tides were divided into eight categories/phases: 1= low tide; 2= low tide rising; 3= mean sea level rising; 4= rising to high tide; 5= high tide; 6= high tide falling; 7= mean sea level falling; 8= falling to low tide. The data for each beach were analysed using a chi-squared test on the combined 2005-2009 dataset.

Nesting related to night phase: Nightly beach patrols (8pm-4am) were divided into eight equal phases: 1= 20:00–20:59; 2= 21:00–21:59; 3= 22:00–22:59; 4= 23:00–23:59; 5= 00:00–00:59; 6= 01:00–01:59; 7= 02:00–02:59; 8= 03:00–03:59. Only data where the leatherback was seen on approach, body pitting or digging were used in this analysis. Differences in leatherback observed time were analysed using a chi-squared test using the combined 2005-2009 dataset. Where the nesting event outcome was estimated, the data were not used in the analyses. Confirmed nests and both types of false crawls are referred to as nesting events in all graphs.

Total leatherback nesting event outcomes recorded from 2005-2009 varied year to year (Table 1). The number of individual nesting leatherbacks indicated by tags (returns or newly tagged individuals) ranged from 60-100 per nesting year.

The frequency of nesting events (Figure 1) did not significantly differ between lunar phases for 2005, 2006, 2008 and 2009. In 2007 (Figure 1C) there was a significantly higher frequency of nesting

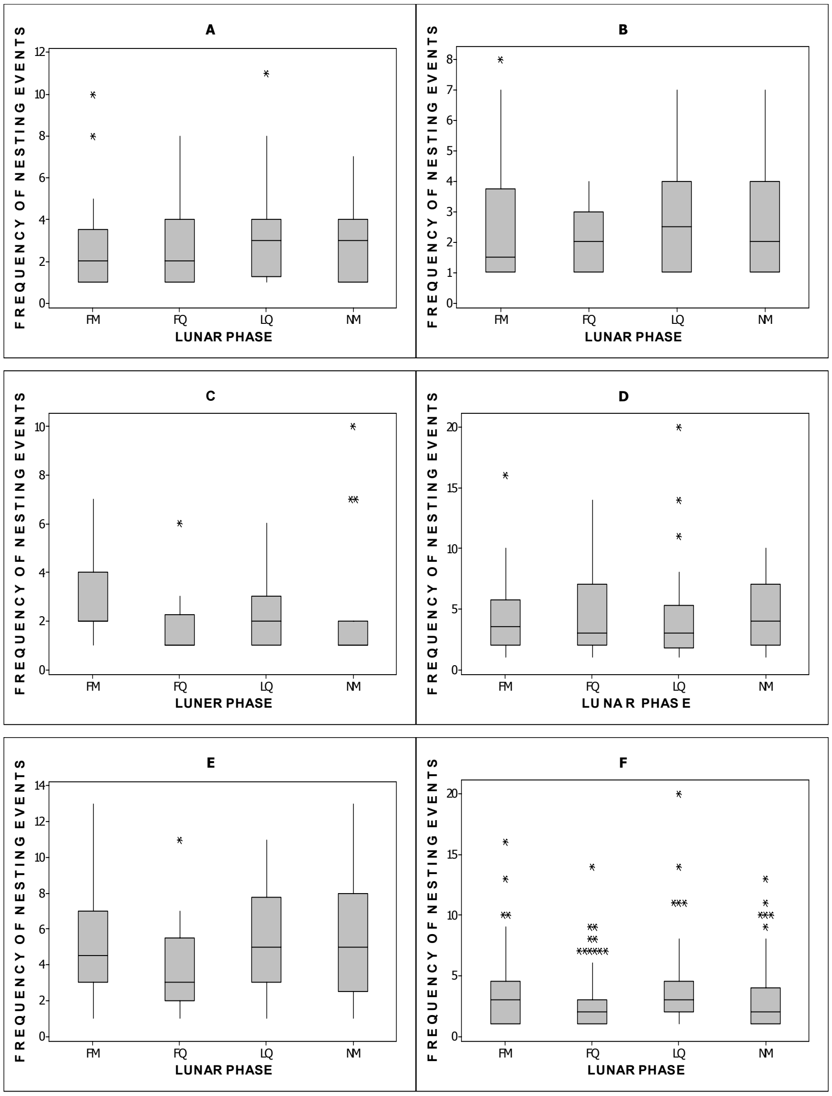


Figure 1. The number of nesting events per night of female leatherbacks for each lunar phase for (A) 2005, (B) 2006, (C) 2007, (D) 2008, (E) 2009 and (F) all years combined. Key: FM=full moon; FQ=first quarter; LQ=last quarter; NM=new moon. Each plotted box displays the interquartile range (box containing 50% of the nesting frequency data); box whiskers show frequency data range; the median is the black line in each box and data outliers from individual nights are shown by asterisk symbols.

events during the full moon phase compared to the first quarter (P = 0.0038) and new moon lunar phases (P = 0.0031). For all years combined (Figure 1F) the frequency of nesting events during the first lunar quarter was significantly less than the median from the full moon (P = 0.0277) and last quarter lunar phases (P = 0.01). When the frequencies of confirmed nests were examined in relation to lunar phase, the numbers of confirmed nests were evenly distributed between lunar quarters. There were no significant differences between the frequencies of confirmed nests across lunar phases.

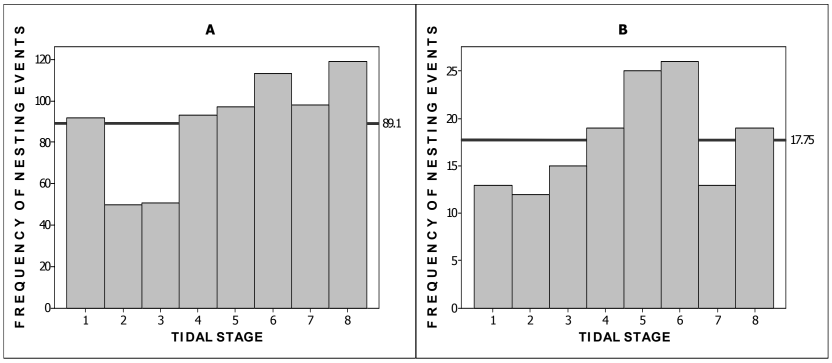
During 2005-2009 the relationship between high tide and leatherback observed time was not significantly correlated for Turtle Beach (r = 0.036, p = 0.412), Grafton Beach (r = -0.04, p = 0.725) or Back Bay (r = 0.127, p = 0.187). For all beaches there was low nesting frequency during tidal stages 2 and 3 (low tide rising and mean sea level rising) with most of the nesting events occurring at and after high tide and also with high frequencies of nesting activity during low tide. Frequency of nesting for leatherbacks was significantly different between tidal stages for Turtle Beach (Figure 2A) in years 2005-2009 (X^2 = 51.7, DF = 7, P < 0.001). Nesting for Grafton Beach (Figure 4B) peaked at stages 5 and 6 (high tide and falling high tide); however these frequencies did not significantly differ from expected values (X^2 = 11.8, DF = 7, P > 0.2). The greatest frequency of nesting activity occurred during tidal stage 7 for Back Bay (Figure 2C), but was not significantly different from expected nesting values (X^2 = 5.8, DF = 7, P > 0.7).

Most leatherback nest were laid during phases 3 – 6 (22:00 – 02:00); and nesting frequencies for Back Bay were below expected values after stage 4 (Figure 3). For all three beaches, most nests were laid after stage 4; Turtle Beach (60.9%), Grafton Beach (67.4%) and Back Bay (67.8%). During 2005-2009 the frequency of nesting events was significantly different from expected for Turtle Beach (X^2 = 52.3, DF = 7, P < 0.001), Grafton Beach (X^2 = 23, DF = 7, P < 0.01) and Back Bay (X^2 = 42.5, DF = 7, P < 0.001).

We expected there would be a link between tidal stage and nesting frequency as it has been reported in other studies that turtles may emerge in high frequencies when the tide is high (Fraser 1983), and therefore a preference for nesting at the highest tides of the month may also be present.

Tidal range varies during the lunar cycle, with greatest values during full and new Moon stages and lowest values during the first and third quarter stages. Thus, if tidal range is positively linked to nesting frequency, it may be expected that more nests are laid during full and new Moon stages. In Tobago, there was a significant difference between the number of nests laid at full Moon compared to the first quarter and new Moon in 2007. The median values of frequency of nesting activity of the full Moon, first quarter and new Moon phases equalled the lower quartile values for (Figure 1C) and the numerical difference between the medians of full Moon and new Moon was one [nesting event]. Although this difference is statistically significant it is very unlikely to be biologically significant as the numbers of leatherbacks nesting in 2007 were less than the other nesting years. However, in 2007, there was no significant difference between any lunar phase and the number of confirmed nests, suggesting no link between lunar phase and nesting behaviour. For combined nesting data from all years (Figure 1F) the full Moon and last quarter phases had a significantly greater frequency of nesting events than the first quarter lunar phase. As there were no observed differences in frequencies of nesting activity when confirmed nests were analysed, it is possible that the number of other nesting events i.e. false crawls and false crawls with body pits may have influenced the statistical test outcome.

Witt et al. (2009) observed an increase in leatherback nesting on neap days (first and last quarter) for monitored nesting beaches in Gabon. However Ya:lima:po Beach in French Guiana displayed peaks of leatherback nesting every 15 days during spring tides (full



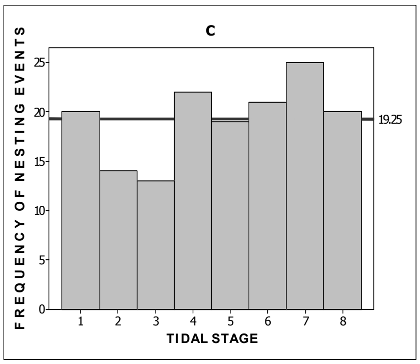


Figure 2. Nesting events against tidal stage from 2005-2009 for (A) Turtle Beach, (B) Grafton Beach and (C) Back Bay. The expected number of nesting events per tidal stage, if nesting is evenly distributed across stages, is shown by the black line. See text for definitions of tidal stage.

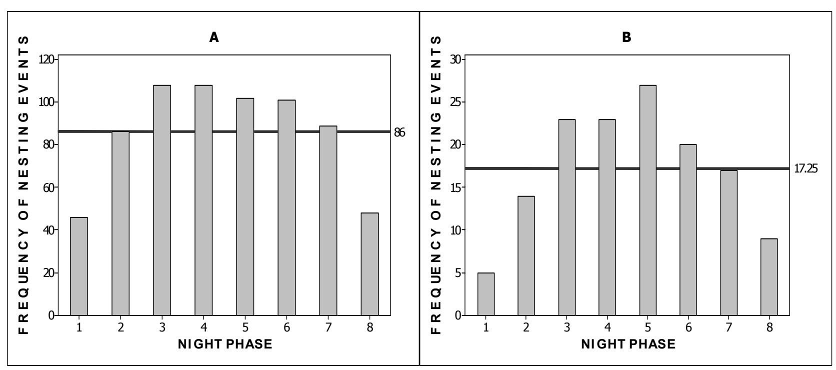
and new Moon) (Girondot & Fretey 1996). The influence of lunar phase on sea turtle nesting patterns appear to differ between regions and the influence may depend on local beach topography, tidal patterns (e.g. diurnal, semi-diurnal or mixed tides) and weather.

Per lunar month gravitational pulls peaks twice (full and new Moon) whereas lunar illumination only peaks once (full Moon). There were no differences between frequencies of nesting events (excluding 2007) or confirmed nests for any year between the full and new Moon. Lunar illumination does not appear to be having a discernible effect on leatherback nesting or nesting outcome on Tobago's index beaches.

Lunar patterns and tides are intrinsically linked; there were no clear relationships between the number of nesting events and lunar phase and for each beach there were no significant correlations between the time of high tide and leatherback observed time. The geography, location and tidal pattern of the nesting beach will greatly influence the difference in the vertical and horizontal distance of high tides. Little Cumberland Island, Georgia has a tidal range of 2 m with a horizontal distance of ~63 m between low and high tide lines, a slope of 1.71 degrees (gentle sloping) and shows a high frequency of turtle emergences at high tidal stages (Frazer 1983). On Costa Rica's Caribbean beach of Tortuguero, vertical tidal distances are only around one m and there is no relationship apparent between leatherback emergence and tidal stage (Leslie et al. 1996). Tobago also has a tidal range of around one m with the horizontal distance between high and low tide no greater than 20-30 m for all three studied beaches. There may be no correlation between high tide time and leatherback emergence time in Tobago because there is no major benefit in emerging at high tide rather than low tide i.e. the increased horizontal distance that leatherbacks face on Tobago's beaches at low tide does not deter them from emerging to nest. A correlation between emergence time and high tide time may also not be present due to Tobago's tidal patterns, as during diurnal tides there may be about 3 days where high tides occur during the day yet leatherbacks still emerge at night regardless.

Nesting frequencies for each tidal stage were variable per beach apart from stages 2 and 3, where nesting frequencies were consistently low for all beaches; it is possible that the tidal velocity may be influencing this trend. Gravid nesting female leatherbacks can weigh up to 435kg (range = 250-435kg, mean = 346.8kg) (Leslie et al. 1996), but a proportion of their weight will be supported when in the marine environment and so tidal velocities may affect them. Emerging at high and low tides could be when tidal velocity is at its lowest i.e. slack water occurs when the current changes (zero water velocity), and therefore the nesting leatherbacks are timing their emergence to low velocity currents in order to reduce energy expended on the approach to the beach. It is possible that on-shore currents are strongest when the tide is rising and this may deter leatherback nesting at tidal stages 2 and 3 as sea turtles prefer to nest where across-shore currents are low (Watanabe et al. 2004). There must be no advantageous carrier effect of approaching when the tide coming in as the observed numbers of leatherbacks emerging at these stages (2, 3 and 4) were consistently lower or similar to expected values for all beaches.

There were no significant differences observed between the frequency of leatherback nesting and tidal stage for Grafton Beach and Back Bay. This may reflect the differences in beach profile as a result of strong on-shore currents. Nesting beaches commonly have steep sloping banks and shelves created by strong on-shore currents (Lamont & Carthy 2007). Turtle Beach has the steepest beach slope compared to Grafton Beach and Back Bay possibly due to stronger on-shore currents and this could also explain the low nesting frequencies at stages 2 and 3 for Turtle Beach (Figure 2A).



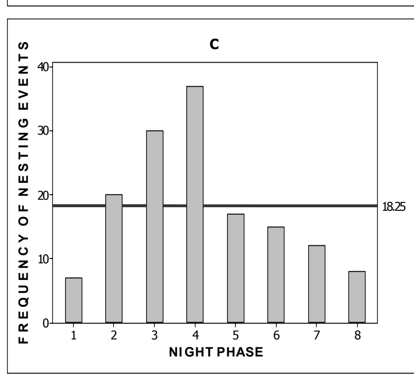


Figure 3. Frequency of nesting events in relation to night phase from 2005-2009 for (A) Turtle Beach, (B) Grafton Beach and (C) Back Bay. The expected number of nests per night phase, if nesting is evenly distributed across phases, is shown by the black line. See text for definitions of night stage.

Leatherbacks do not generally emerge to nest during the day due to potentially lethal temperatures and so regardless of high tides during the day they suppress emergence till night (Reina et al. 2002). The nesting process takes around 1.5 hours to complete so emerging between 22:00 and 02:00h reduces the probability that leatherbacks will be exposed to higher sand and air temperatures and therefore heat gain will not be a serious problem. Welsh & Tucker (2009) observed similar results for loggerhead peak emergence between 22:00 and 02:00h. Nesting leatherback turtles may be using the time at night as a cue to signal when to commence the nesting process. Intensive monitoring effort is often considered desirable when patrolling marine turtle nesting beaches (Jackson et al. 2008), but if long-term, time intensive monitoring programmes are not possible patrolling between these hours would encounter the majority of nesting events. However, monitoring may also be valuable during other times in order to reduce potential tourist, poacher and egg predator disturbance.

The impact of a conservation effort on the health i.e. numbers and physical wellbeing, of a population is difficult to judge in the short term, especially with long-lived, slow maturing species such as sea turtles. Information on nesting ecology and behaviour for a nesting region is useful in order to direct conservation effort and therefore more efficient coordination of field conservation and data collection. Due to the geographic location, structure of each beach and amplitude of the tide, Tobago's beaches are not heavily influenced by environmental processes, and these processes do not appear to affect leatherback nesting. Peak leatherback emergence and nesting activity is most closely associated with the time at night. Further work may include accurately profiling Tobago's three index beaches i.e. angle (slope of the beach), tidal amplitude, the difference between high and low tides per lunar phase, how tidal velocities change within the tidal cycle and whether there is habitat preference across the beaches as a result of potential spatial variation. Several nesting leatherbacks in Tobago are previously tagged in Trinidad and Grenada (personal observation) whereas some individuals return to nest many times within and between seasons; it would be interesting if the observed nesting trends in Tobago occur throughout nesting beaches in the Caribbean.

Our conclusions for leatherback nesting in Tobago are that a) the number of nesting events did not vary significantly between lunar phases; b) emergence time was not correlated with high tides; c) leatherbacks displayed a trend of nesting at and after high tide, with high nesting frequencies continuing to low tide; d) leatherbacks did not nest in high numbers when the tide was low rising to high tide; e) the highest frequency of nesting events took place between 22:00 and 02:00.

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In-water Observations of Hawksbill (*Eretmochelys imbricata*) and Green (*Chelonia mydas*) Turtles in St. Kitts, Lesser Antilles

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St. Kitts is a nesting area for hawksbill (*Eretmochelys imbricata*), green (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*) sea turtles (Butler 2001). There has been a longstanding tradition in consumption of turtle products (i.e. meat, eggs) on St. Kitts as there is on other Caribbean islands. Declining sea turtle population numbers and subsequent Caribbean-wide protective management measures have restricted the take of sea turtles for local human consumption to a small scale seasonal sea turtle fishery on St. Kitts (Ralph Wilkins pers. comm.) In water around St. Kitts, sea turtle harvest techniques include netting and spear fishing of foraging green and hawksbill turtles in open water. The practice of taking eggs from nesting sites is prohibited; however, nest egg poaching continues to occur (Kate Orchard pers. comm.). Year-round sightings of immature hawksbill and green turtles by local fishermen and dive operators suggest that local reefs and sea grass beds are important nursery areas for these species (Eckert & Honebrink 1992). Nonetheless, this is the first long-term in-water survey of sea turtles in St. Kitts. In light of the recently initiated marina and coastal resort developments that are taking place on St. Kitts, the results of our project can serve as a baseline study.

St. Kitts (17° 9' N 62° 45' W) is a small Caribbean island of volcanic origin that is part of the Lesser Antilles chain. As part of a larger marine ecosystem survey project (Stimmelmayr et al. 2009; Sullivan & Stimmelmayr 2009), sightings of sea turtles have been recorded during roving snorkel (day), and dive surveys (night/day) (2006-2008) on 29 study sites (D = dive sites; S=snorkel sites) including: Anchors Away (D), Ballast Bay (S), Banana Bay (S), Brimstone (D), Channel (D), Cockleshell (S), Challenger (D), Coconut Reef (D), Corinthian (D), Dieppe Bay (S), Fisherman's Wharf (D) Green Point (D), Half Moon Bay (S), Majors Bay (S), Monkey Shoals (S), Nags Head (D), Paradise Reef (D), River Taw (D), Sandbank (S), Shipping Lane (D), Shitten Bay (S), South Friars (S), St. Peter's Reef (D), Talata (D), The Rocks (D), Timothy Beach (S), Turtle Beach (S), West Farm (D), and Whitehouse Bay (S). Study sites were mostly on the Caribbean side of the island with few sites located on the Atlantic side due to strong surf and dangerous current conditions. Sites were surveyed opportunistically; however, all night dive/snorkel surveys were limited to 6 sites only (Corinthian, Fisherman's Wharf, Talata, Half Moon Bay, Majors Bay, and Sandbank). Observations of marine turtles in water were made from the surface using standard snorkeling (water depth<6m) and SCUBA equipment (water depth >6m). Data collected included species, estimated straight carapace length (cm), location, time of day (morning, afternoon, night), and behavior. Classification of behavior was used as previously described by Houghton et al. (2003). Upon encountering a turtle, we made an observation of initial behavior (surfacing, swimming, resting, assisted resting, foraging). Briefly, foraging is defined as ingestion of prey while being stationary and or suspended in the water column. Resting is defined as remaining stationary on the seabed/coral reef structure without foraging. Assisted resting is defined as resting with the use of coral reef structures and/or man-made structures under which and/or between which the turtle is wedged. To gain insight into local threats to sea turtles, we also recorded types and causes of injury (when possible) in sea turtles.

We recorded 140 turtle sightings (morning n=71; afternoon n=33; nighttime n=36). Forty-nine percent (n=69) occurred around the bays of the South East Peninsula. The majority (85%) of sea turtles sighted were juvenile with estimated carapace length ranging from 20-60 cm. Only 15% of observed sea turtles were large (80-130 cm) adult, possibly resident, turtles. Sightings of large turtles were restricted to the Atlantic side (Half-moon Bay; Sandbank) and/or during dive surveys. Hawksbill turtles were the predominate species observed (n=128), with fewer green turtles observed (n=12). No injuries and/or other abnormalities were observed in juvenile hawksbills. Injuries and abnormalities observed in adult turtles included missing rear flipper (n=1; hawksbill), cracked carapace (n=1; hawksbill); discolored shell (n=1; hawksbill), and fibropapillomatosis (n=1; green turtle).

During morning hours turtles were most often seen swimming (61%; n=43), followed by resting (30%; n=21), assisted resting (7%; n=5), surfacing (1%; n=1), and foraging (1%; n=1) (Figure 1). Foraging was rarely observed (1-3 %) during all time periods. During afternoon a similar pattern was observed, with 60% of turtles seen swimming (n= 20), followed by assisted resting (21%; n=7), resting (12%, n=4), surfacing (3%; n=1), and foraging (3%; n=1). During nighttime, 50% of turtles were observed in assisted resting (n=18), followed by swimming (42%; n=15), resting (6%; n=2), and foraging (3%; n=1).

Our results confirm that St. Kitts' near shore environments are important habitats for immature hawksbills, particularly along the Southeast Peninsula. The total number of injuries observed was few (n=4; 3%) and none of the observed injuries were fishing or boating related injuries, as characterized by Norem (2005). Apart

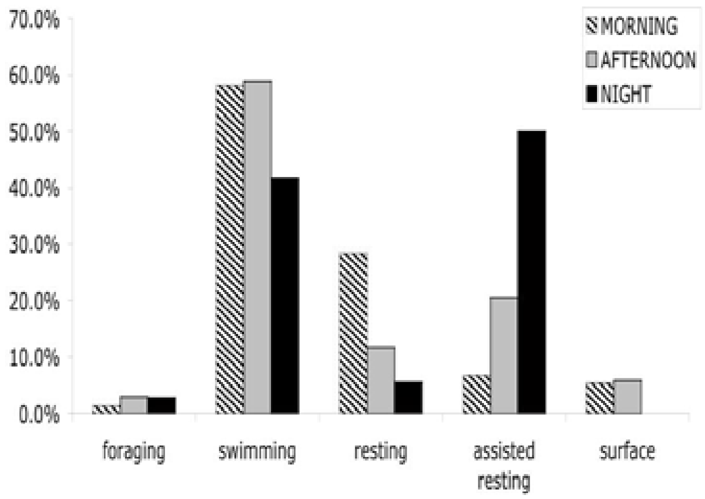

Figure 1. Daily temporal distribution of in-water behavior of observed hawksbill and green sea turtles (n=140) in St. Kitts (2006-2008).

from the observed case of rear flipper amputation, we have only circumstantial evidence that points to shark predation being a potential mortality/injury factor for the local sea turtle populations. In 2007 and 2008, local marine stakeholders observed two adult marine turtle strandings (hawksbill; green turtle) with large bite wounds to the shell and partial and complete amputation of front and rear flippers. Tiger sharks (*Galeocerdo cuvieri*), who preferentially prey on large cheloniid sea turtles (Witzell 1987) are not uncommon in the marine environment of St. Kitts and Nevis (Captain Ainslyn pers. comm.), and a case of a large tiger shark with ingested remains of a small hawksbill turtle has been reported from Nevis (Young 1992).

Our observation of a severe case of cutaneous fibropapillomatosis in an adult resident green turtle confirms previous sightings by local marine knowledge holders (Kenneth Samuels pers. comm.). Marine turtle fibropapillomatosis has a circumtropical distribution including the Caribbean region (Aguirre & Lutz 2004; Williams et al. 1994). This virus-induced disease is characterized by a protracted external (flippers, head) and internal (esophagus; liver) tumor growth. Depending on location, tumors may impede foraging efficiency and can ultimately be fatal.

Assisted resting showed a distinct temporal pattern as it was most commonly observed at night (50%), followed by afternoon (21%), and morning (7%). Diel diving patterns in hawksbill turtles (juvenile and adults) with flat bottomed resting dive profiles have been reported to take up 50-80% of the time during night (van Dam & Diez 1996; Starbird et al. 1999). However, these studies used electronic dive recorders that cannot discriminate between resting and assisted resting. We observed 12% of the turtles displaying assisted resting (12/104). Similarly, Houghton et al. (2003) reported that juvenile hawksbills in the Seychelles displayed assisted resting 12% of the time. Blumenthal et al. (2009) reported that assisted resting occurred during nighttime in the Cayman Islands; however, comparative nighttime data on percentage of assisted resting are not available.

Assisted resting may be a useful strategy for improving buoyancy control at greater depths by turtles, thus, maximizing dive duration (Houghton et al. 2003). Blumenthal et al. (2009) hypothesized that assisted resting may allow sea turtles to improve large pelagic predator avoidance by shelter seeking during nighttime.

Additionally, microhabitats such as assisted resting sites come with their own microclimate that could confer a thermoregulatory advantage to turtle energetics while resting. The ability for thermal selection has been recently demonstrated in free-ranging adult loggerhead turtles (Schofield et al. 2009). In addition, ledges and large crevices used as assisted resting sites are also suitable habitats for cleaner shrimp. Hawksbill turtles in Brazil have been shown to actively visit cleaning stations by Barber pole shrimp (*Stenopus hispidus*) (Sazima et al. 2004). Interestingly, a hawksbill's visit to the cleaner station during daytime looked very much like an assisted resting turtle, with the turtle's body being partly wedged under rocky ledges where the cleaner stations were located. Barber pole shrimp do not venture from their station and attend to clients from within the crevice/ledges. We did not explore ledges where turtles were resting, thus we do not know whether cleaner shrimp were present.

From a bioenergetics point of view, assisted resting is a behavioral strategy that most likely translates into an ecological and energetic benefit, whether it represents shelter-seeking behavior motivated by buoyancy control issues, predator avoidance, visitation to a cleaner station and removal of ectoparasites, or a search for a suitable microclimate. Because our study turtles during nighttime were more often engaged in assisted resting (50%) than resting (6%), we suggest that the overall energetic benefit of assisted resting is likely greater than resting.

Our study confirms that the St. Kitts near shore marine environment provides important habitats for juvenile hawksbill. Assisted resting in turtles was the predominant type of resting observed during nighttime. Further in situ studies of in-water behavior are needed to confirm our findings on the distinct temporal pattern of assisted resting and to identify and characterize the underlying ecological and physiological factors that are important in shaping the observed timing difference in assisted resting vs. resting.

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Monitoring Antigua's Hawksbills (*Eretmochelys imbricata*): A Population Update from More than Two Decades of Saturation Tagging at Jumby Bay

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About 5000 hawksbills (*Eretmochelys imbricata*) are estimated to annually nest in the greater Caribbean (Meylan 1999; Mortimer & Donnelly 2008), and nearly 85% (22 of 26) of the assessed jurisdictions indicated depleted or declining hawksbill stocks just a decade ago (Meylan 1999). Despite these grim statistics, the Critically Endangered hawksbill (IUCN 2009) shows signs of population growth in some sites, including Barbados (Beggs et al. 2007), Mona Island, Puerto Rico (R.P. van Dam & C.E. Diez, pers. comm.), Buck Island, U.S. Virgin Islands (Mortimer & Donnelly 2008), and Guadeloupe (Kamel & Delcroix 2009). The nesting colony on Long Island, Antigua, is among the region's populations providing reason for cautious optimism. The Jumby Bay Hawksbill Project has intensively and continuously monitored Long Island's nesting colony since 1987. The first decade of monitoring on the island indicated a relatively stable population (Richardson et al. 1999), but more recent observations suggest that increased recruitment is driving a general upward trend in the population (Richardson et al. 2006). Here, we provide an update regarding the ongoing nesting and population ecology research on Long Island and revisit short-term nesting population predictions provided by Richardson et al. (2006).

Long Island (N 17°09', W 61°45'), also known as Jumby Bay, is located about 2 km off the northeast coast of Antigua in the eastern Caribbean's Leeward Islands (Figure 1). The island is roughly 300 acres (1.2 km^2) in size and has a small resort and numerous private residences. Crescent-shaped Pasture Beach, a natural, calcareous sand beach situated on Long Island's northern, windward coast, is the island's primary nesting beach and has served as the principal study beach for the duration of the Jumby Bay Hawksbill Project research. The approximately 450-meter long beach is bordered landward by a mixed community of trees and shrubs, including the native sea grape (*Coccoloba uvifera*) and button mangrove (*Conocarpus erectus*) and the introduced *Scaevola sericea*, and seaward by an irregular and intermittent limestone bed. While development removed much of the beach's native maritime forest, current beach management practices, such as planting and maintenance of vegetation beds, ensure that Pasture Beach continues to provide habitat conducive to hawksbill nesting. Beaches constructed adjacent to private residences elsewhere across Long Island (i.e., peripheral to Pasture Beach) have expanded the number of potential nesting sites in recent years.

Saturation tagging protocols have provided the foundation for research at Jumby Bay since the inception of the project in 1987. Hourly foot patrols begin on Pasture Beach about one hour after sunset and continue to dawn, enabling the identification of every nesting hawksbill and the documentation of all nesting activities. The

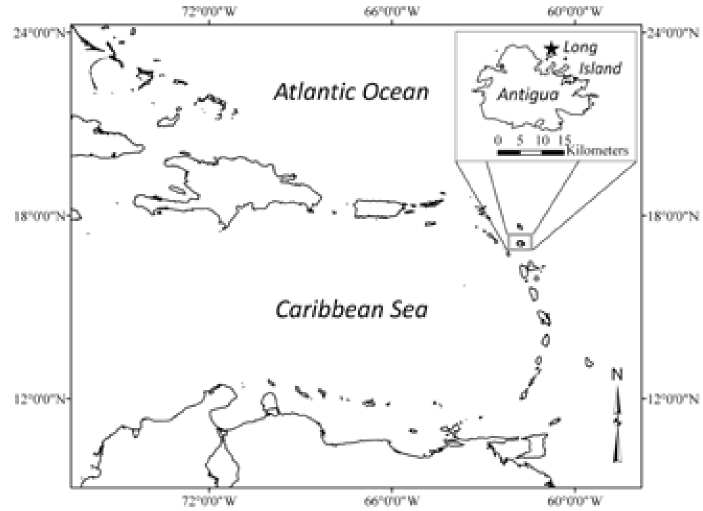

Figure 1. Long Island (or Jumby Bay), starred in the map inset, is a 300 acre island located off the northeast coast of Antigua. GIS data set courtesy of the National Geospatial-Intelligence Agency (2005).

small, private peripheral beaches are patrolled less regularly due to logistical constraints. During egg-laying, hawksbills are fitted with two tags (Inconel Size 681; National Band & Tag Company, KY, USA) on the most proximal pads of the fore flippers and a unique pattern of holes is drilled in the supracaudal scutes with a battery-powered hand drill. These multiple marking mechanisms are highly successful in confirming an individual's status as a new recruit (i.e., neophyte) or a remigrant to the Jumby Bay nesting population (Richardson et al. 1999; 2006). Following Richardson et al. (1999; 2006), neophytes are described as previously unmarked turtles and presumed to be first-time nesters. While we acknowledge that we are unable to confirm that 'neophyte' turtles have not previously nested elsewhere since laparoscopies are not conducted, the long-term assimilation of neophytes into the Jumby Bay nesting population and the high fidelity of hawksbills to the island provide compelling evidence in support of this designation (Richardson et al. 2006).

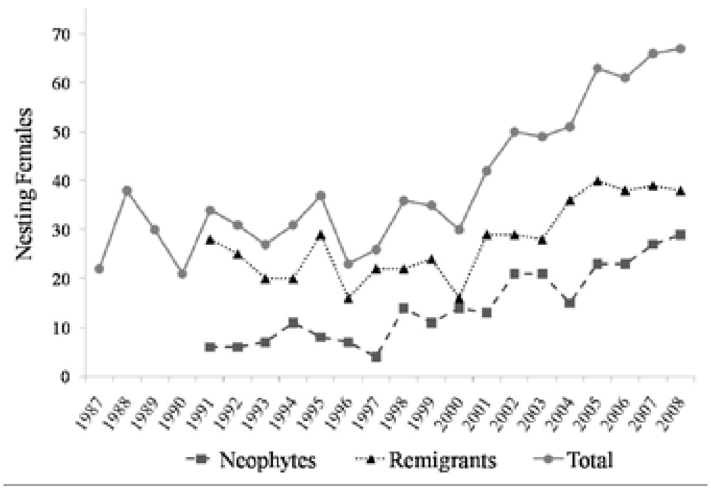

Figure 2. Hawksbills documented on Long Island during the 1987-2008 research seasons. We distinguished between remigrants and neophytes in 1991, after 4 years of research, since nearly all (98%) individuals maintained a 2-4 year remigration interval (Richardson et al. 1999, 2006).

Historically, the annual research season extended from June 15 to November 16 and encompassed nearly all nesting activity at Long Island. However, to accommodate an apparent shift in the peak of the nesting season (Stapleton et al. 2010), the research season was expanded to a 01 June start date as of 2007 and continues through 16 November.

The Jumby Bay nesting population continued to exhibit signs of long-term growth during the 2005-2008 seasons, reaching a record 67 nesting hawksbills, including 29 neophytes, during 2008 (Figure 2). Although annual remigrant cohorts remained nearly constant during the past 4 years, neophyte cohorts increased relatively consistently during the period, with a marked jump from 15 to 23 neophytes between the 2004-2005 seasons. Annual neophyte cohorts represented an increasingly greater component of the total annual nesting population, and this increase in recruitment has fuelled the broader population growth at Jumby Bay in recent years.

Empirical data collected during 2005 – 2008 were remarkably consistent with the total nesting population and neophyte growth forecast by Richardson et al. (2006; Figure 3). Predicted neophyte cohort size differed by an average of 3.5% (SD: 2.3) from observed values. There was less agreement between observed and predicted values of total population size (Mean difference: 12.0%, SD: 7.8), as forecasted population growth outpaced actual growth.

The recent increase in total nesting activities and confirmed nests recorded on Jumby Bay largely paralleled the island's population growth (Figure 4). Crawls and nests remained relatively stable during the first decade of research, but both have more than doubled since 2000, with 287 nests deposited and 564 total crawls recorded island-wide in 2008. The volume of activities recorded on peripheral beaches has similarly increased: the 120 nesting activities documented on peripheral beaches during 2008 represents a nearly 2-fold increase over the 63 crawls observed in 2005.

Following a period of stability during the first decade of monitoring at Long Island (Richardson et al. 1999), Richardson et al. (2006) identified a significant, long-term increase in the nesting population through 2004. The 2005-2008 data are consistent with these more recent results and suggest continued population growth for the Jumby Bay population. In addition, the stability of the remigrant cohort and the growth of the neophyte cohort observed during 2005-2008 support the assertion that this population increase is largely being driven by an increase in recruitment (Richardson et al. 2006). Indeed, 102 neophytes have been documented in the last 4 years of monitoring, an encouraging sign for the Critically Endangered hawksbill.

Richardson et al.'s (2006) model forecasting Jumby Bay's neophyte nesting numbers has proven both accurate and precise, though the total nesting population growth has been more modest than predicted. The lack of growth observed in remigrant cohorts during 2005-2008 is responsible for this diminished agreement between observed and expected values. We hypothesize that a short-term (i.e., 3-4 year) lag exists between neophyte and remigrant cohort sizes and anticipate that recent surges in neophyte cohorts will contribute to growth in remigrant numbers in the coming nesting seasons. Regardless, we recommend the continued application of statistical models to rigorously evaluate population trends and forecast Jumby Bay's short-term population growth.

Data collected during 2007 - 2008 are minimally confounded with the extension of the monitoring season. This 2-week, early

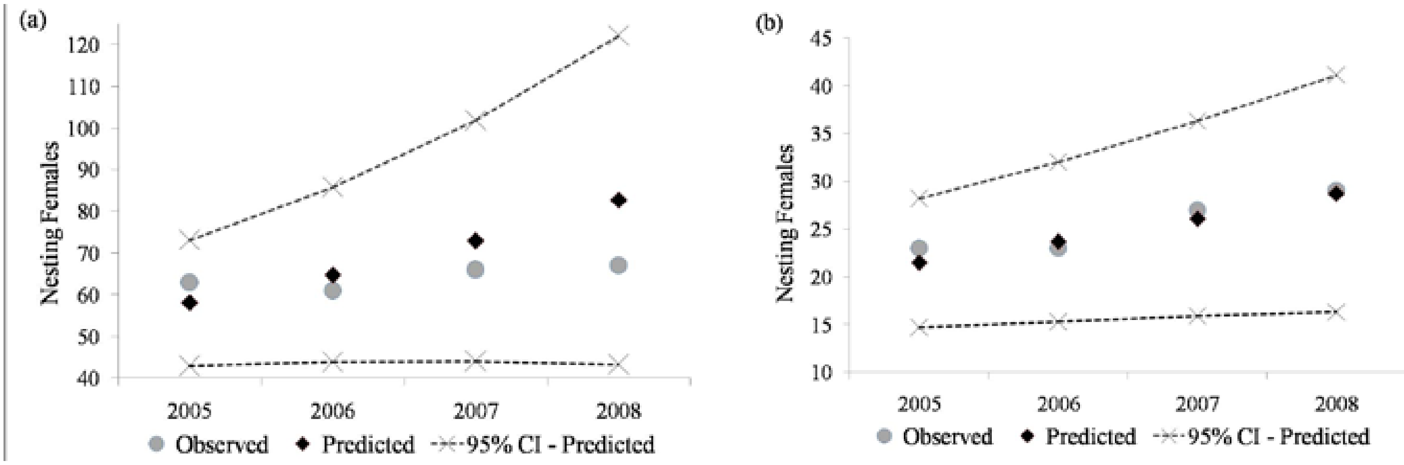

Figure 3. Total nesting hawksbills (a) and neophytes (b) predicted by Richardson et al. (2006) and observed during the 2005-2008 research seasons at Long Island, Antigua, West Indies.

season period yielded an additional 19 records (12 nests) and 21 records (14 nests) during 2007 and 2008, respectively. During these 2 years, a total of only 1 individual would have otherwise been undetected had the research season begun at its historical June 15 start date. We also note that low levels of nesting activity may occur year-round on the island, although the vast majority of nesting activity takes place during the defined research season.

The three beaches adjacent to Pasture Beach, upon which most of peripheral beach nesting activities occur, generally are patrolled at least several mornings per week. As additional private beaches have been constructed, staff have attempted to monitor these new potential nesting sites as resources and access permitted. However, we acknowledge that an increase in monitoring intensity of peripheral beaches during the past several seasons, due to improved access and greater manpower, also may contribute to our results. We are uncertain as to whether the documented increase in crawls on peripheral beaches entirely reflects an increase in use of these beaches or is, in part, an artefact of greater monitoring intensity. It seems likely that peripheral beaches may become increasingly important to Jumby Bay's growing nesting colony, and frequent, regular patrols of these beaches, as well as maintaining habitat conducive to hawksbill nesting, are thus research and management priorities. Although the peripheral beaches are undoubtedly important to the Jumby Bay population, few turtles appear to nest exclusively on them. For example, only two of 67 turtles were recorded crawling solely on beaches other than Pasture Beach in 2008, during which the three major peripheral beaches were patrolled nearly hourly.

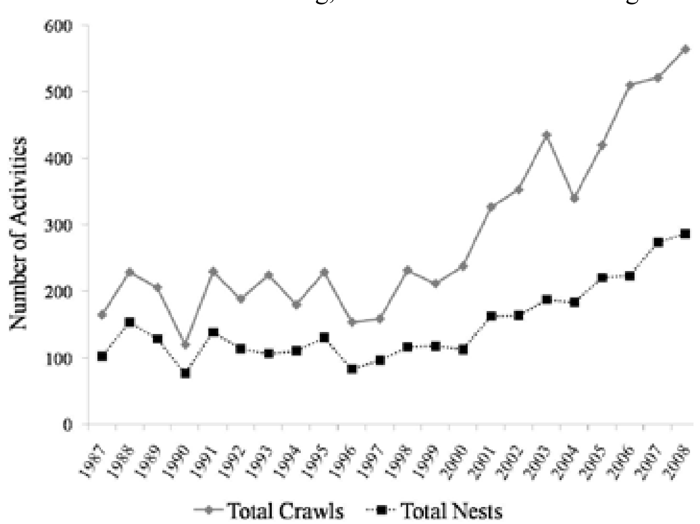

Figure 4. Hawksbill nesting activities and nests recorded on Long Island, Antigua, West Indies during 1987-2008.

The continued population growth of the Long Island nesting colony offers an encouraging sign for depleted Caribbean hawksbill stocks. While we note that this local population increase may not be indicative of trends elsewhere in Antigua or across the region (Richardson et al. 2006), some regional sites have demonstrated similar population increases [e.g., Mona Island, Puerto Rico (R.P. van Dam & C.E. Diez, pers. comm.), Barbados (Beggs et al. 2007), Guadeloupe (Kamel & Delcroix 2009)]. Fortunately, monitoring programs have been established on several beaches across mainland Antigua within the past few years (M. Clovis, pers. comm.). These data should provide valuable insight into the status of hawksbills in greater Antigua, describe population dynamics and any interchange among mainland nesting beaches and Long Island, and may clarify causal factors of the decade long population growth, including the protection of nesting females and their eggs on Jumby Bay (Richardson et al. 2006).

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Caribbean Leatherbacks: Results of Nesting Seasons from 1984-2008 at Culebra Island, Puerto Rico

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For the past twenty-four years, leatherback (*Dermochelys coriacea*) nesting activity has been monitored at Culebra Island's beaches, 17 km east off Fajardo, Puerto Rico (Figure 1). There are six beaches located in the north coast of Culebra: Flamenco, Resaca, Brava, Tortolo, Zoni and Culebrita (in the Culebrita cay). The wide and high-energy sandy beaches of Brava (1.2 km), Resaca (800 m), and Zoni (1 km) represent the main leatherback nesting areas reported for Culebra (Dutton & Soler 1997; Soler 1999; Marquez-Soto 2000, see Figure 1). Due to the importance of these nesting areas for this species in Puerto Rico and the Caribbean region, Playa Brava and Playa Resaca (northern Culebra) were designated by US Fish & Wildlife Services as Critical Habitat for leatherbacks. By 2004, the Puerto Rico's Department of Natural and Environmental Resources (DRNA-PR) implemented the Culebra Index Nesting Surveys for leatherbacks, consisting on counting the number of nests laid from 15 April to 15 June on Playa Brava and Playa Resaca. The selected period was based on the peak of leatherbacks nesting during the nesting season. In addition to the index surveys, regular surveys were conducted during the beginning of the nesting season (mid-March) until the lasts nests (end of July). This article summarizes the results of 24 years of survey on leatherbacks nesting activity in Culebra Island.

From 1984-2008 (except 2001 and 2002), nests surveys on Playa Brava and Playa Resaca were conducted each year by trained personnel from mid- March (when the first leatherback nests were reported), until the last week of July, which is the end of the nesting season. In addition, Index Nesting Surveys were conducted in 2004-2008 between 15 April and 15 June on the same beaches. All nesting surveys were conducted early in the morning. Each new nesting activity was classified into one of three categories: 1) successful nest, 2) non-nesting attempt ("false crawl"); and 3) "possible nest"; the latter was used for any activity which seemed to be a nest, but was not verified by the surveyor. All nests were recorded and identified with flagging tape and nest locations were recorded relative to regularly spaced stakes along the beach. "Possible nests" were later confirmed as nests if evidence of eggs or hatchlings were observed; otherwise they were switched to 'false crawls". It is important to note that these classifications resulted in an underestimation of nests counts rather than an over estimation.

Despite a biennial nesting pattern observed in the nesting trends for the leatherbacks in Culebra, there appears to be a decrease in number of nests over time (Figure 2). However, an increase of nesting activities in near-by leatherback nesting areas such as Fajardo (mainland Puerto Rico) and St. Croix (US Virgin Islands) was reported (Dutton *et al*. 2005). It is possible that the decreasing number of nests reported during the past four years in Culebra Island may have been caused by emigration of nesting females from Culebra to other near-by nesting areas. Recent molecular studies suggest a regional stock interchange between different nesting beaches such as Culebra, US Virgin Islands and possibly others in the

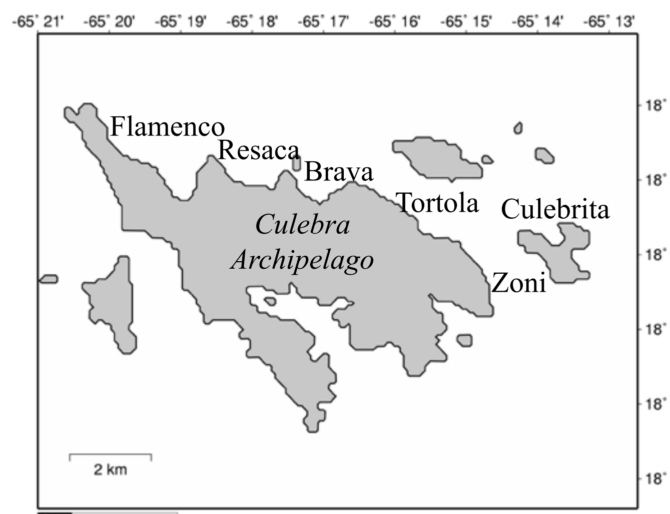

Figure 1. Culebra Island with the major leatherback nesting beaches indicated. Map created using Maptool www.seaturtle.org/maptool

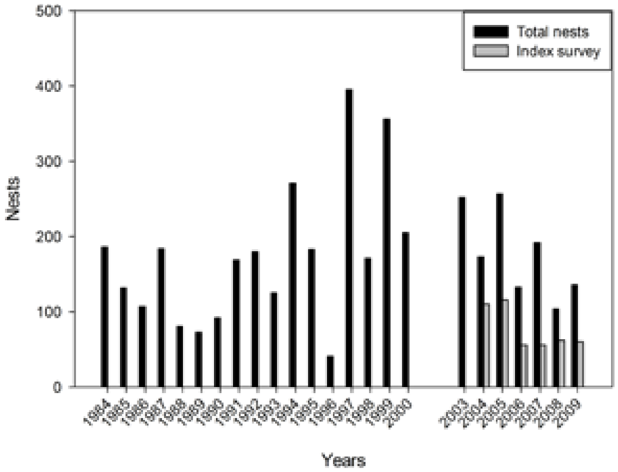

Figure 2. Leatherback nests at Culebra Island from 1984-2008. Grey bars indicate Index Nesting Surveys

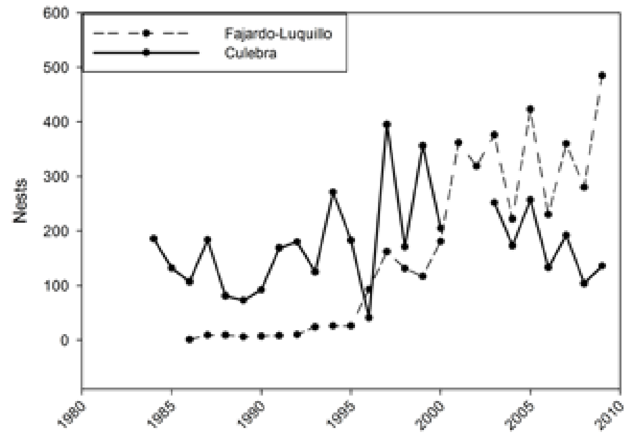

Figure 3. Nesting trends for leatherback turtles at Fajardo-Luquillo and Culebra study sites (1984-2008). Note: 2001-2002 data for Culebra Island are not available.

Antilles including the east coast of mainland Puerto Rico (Dutton et al. 2005). In addition, nesting leatherbacks tagged on Culebra Island have been observed nesting elsewhere in the region, and vice versa (Eckert et al. 1989; Dutton *et al*. 2005; Horta, unpublished data). When comparing the number of nests laid in Fajardo-Luquillo (F-L) and Culebra Island, in some years the numbers of nests increase at F-L, while in Culebra Island they decrease (Figure 3). This supports the hypothesis that some leatherbacks nesting in Culebra may shift to other near-by beaches. Since leatherbacks have low nesting site fidelity relative to other sea turtles (Dutton et al. 1999), conservation actions should be focused on maintaining and implementing Indexed Nesting Surveys in the most important nesting beaches identified for the past 10 years, which are Resaca and Brava beaches in Culebra. It is also important to evaluate the period when Index Nesting Surveys are conducted, because the peak of the nesting season could shift slightly. This may explain why in the last four seasons, there is no observed trend of biennial nesting for Culebra Island (Figure 2).

Overall, we recommend that more surveys should be conducted on nesting activities and saturation tagging occurring on Culebra Island and on other near-by areas, to evaluate the regional status of leatherback breeding population in the Caribbean. These data will be crucial in developing and implementing more efficient conservation strategies in the region.

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Loggerhead Turtles in the Turks and Caicos Islands, Caribbean

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Between February and August 2009, six loggerhead turtles (*Caretta caretta*) were captured and sampled in the Turks and Caicos Islands (TCI), a UK overseas territory in the Caribbean located at the southeastern end of the Bahamas (21° 45N, 71° 35W: Figure 1). Five of these turtles were tagged with Wider Caribbean Sea Turtle Conservation Network flipper tags, representing the first loggerheads to be sampled in the TCI. Because information on foraging loggerheads in the Caribbean is sparse in comparison to other species (eg Erhart *et al.* 2003; Dow *et al.* 2007), we felt it important to document these data for the turtle research community.

Additionally, an objective of the November 1999 meeting, Marine Turtle Conservation in the Wider Caribbean Region—A Dialogue for Effective Regional Management, was to locate marine turtle foraging sites in the region (Eckert & Abreu Grobois 2001).

Two of the loggerheads were apparently foraging and caught at Newsons Point, South Caicos (Figure 1), a seagrass (primarily *Thalassia testudinum*) foraging habitat surrounded by mangrove fringed saltwater creeks more usually associated with green turtles (*Chelonia mydas*). The seagrass habitat may support loggerhead turtles because of the invertebrate species found amongst the seagrass (Bjorndal & Bolten 1988). Alternatively, these two individuals may have been resting before moving to other foraging sites. The other loggerheads were captured whilst swimming close to Long Cay and the harbour of South Caicos (see Figure 1).

Three of the loggerheads were hand captured employing the watercraft pursuit capture method (Ehrhart & Ogren 1999) whilst on dedicated turtle sampling trips conducted by the Turks and Caicos Islands Turtle Project (TCITP). Two were hand captured by fishermen for the project to tag and one was landed for consumption by a South Caicos fisherman, but was later handed over to TCITP staff for release. The marine turtle harvest in TCI is considered opportunistic but major (Godley *et al.* 2004); the legislation that regulates this fishery is described in Richardson *et al.* (2006).

The largest turtle measured 102.9 cm curved carapace length (CCL) and was likely to be an adult female. The other loggerheads measured 61.3-81.3cm CCL, with an average=74.5 cm (SD 8.4 cm, n=5), and were most certainly juvenile/sub-adult, but the larger individuals (81.2 and 81.3 cm CCL) were probably approaching maturity, an assumption based on similar sized individuals classified in Caribbean Panama (Engstrom *et al.* 2002), Bahamas (Bjorndal & Bolten 1988) and southeastern USA (Bowen *et al.* 2004).

It is likely that the seagrass foraging grounds of TCI support a range of size classes from new neritic-stage recruits to adults.

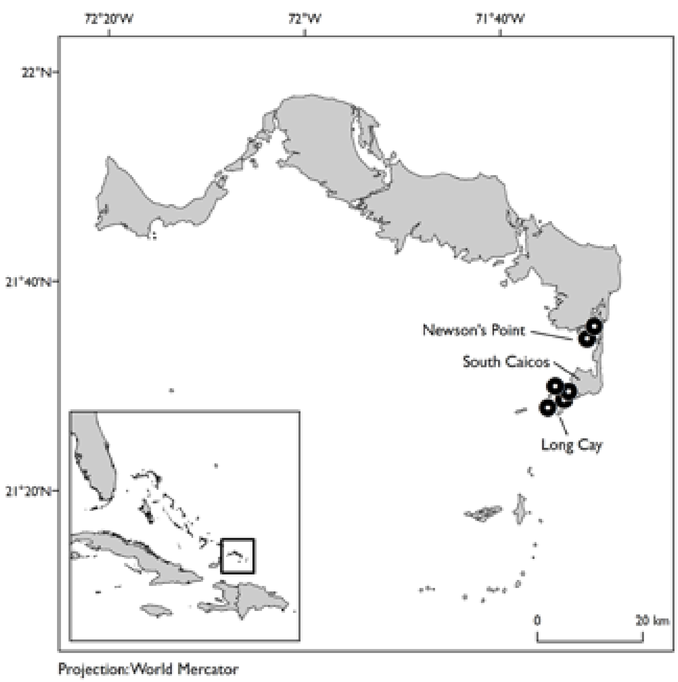

Figure 1. Turks and Caicos Islands and the locations of loggerhead captures between February and August 2009.

Bjorndal & Bolten (1988) reported a mix of loggerhead size classes in Union Creek (Bahamas), a habitat similar to that of Newsons Point and found throughout TCI. Carr *et al.* (1982) reported all size groups in TCI waters and highlighted that juvenile loggerheads were found in shoal areas along the fringing reefs. This is supported by the findings of SCUBA diving sightings of in-water loggerheads on TCI's reef dive sites (Richardson *et al.* 2009). A size range of 61-122 cm estimated CCL (n=12) were recorded; clearly some adults were sighted.

Further surveys will enable us to identify developmental foraging habitats in TCI waters. Analyses of genetic samples obtained from in-water loggerheads will allow us to quantify and characterize foraging populations and test juvenile stage neritic-homing hypothesis (Bowen *et al.* 2004) from the haplotypes of foraging specimens.

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Hawksbill Tagged as a Juvenile in Puerto Rico Found Nesting in Panama 15 Years Later

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On June 5 2009, a hawksbill turtle was encountered nesting at Playa Larga (9° 19' 26"N 82° 8' 3") on Bastimentos Island National Marine Park in Bocas del Toro, Panama, bearing inconel tags SSL209 and X4613. The female measured 92 cm CCL (87.7 cm SCL, based on conversion formula in Van Dam & Diez 1998). The turtle returned to nest again at Playa Larga on June 20. Tagging information was traced through the Archie Carr Center for Sea Turtle Research and the turtle was originally tagged as a juvenile on the foraging grounds of Monito Island (18° 9' 31"N 67° 57' 6 "W), Puerto Rico, on July 29 1994, when it measured 26.1 cm SCL and weighed 2.2 kg. This hawksbill was recaptured at Monito Island in 1995 and 1996, but has not been encountered there since. Serum testosterone assays of juvenile hawksbills conducted in 1994 and 1995 (Diez & Van Dam 2003) had already indicated that this turtle was a female.

This tag return is exceptional because it documents the movement of a hawksbill transitioning from one life stage (juvenile) to another (reproductive adult). Typically, tag returns of hawksbills in the Caribbean have represented movements within a life stage, i.e., nesting females traveling to feeding grounds, or immature animals traveling between developmental habitat sites (Meylan, 1999). The data from this recapture affirm the conclusions by Bowen et al (1996) and Velez-Zuazo et al (2008) that hawksbills foraging at Mona and Monito Islands likely recruit from other Caribbean rookeries, and can be expected to return to breed at those rookeries. The tag return is also exceptional because of the great distance (1818 km minimum straightline distance) involved and the long period (14.9 years) of time that elapsed between the initial capture and the sighting in Panama. From previous tag returns, the minimum straightline distance travelled by immature hawksbills in the Caribbean ranged from 46 to 900 km (Meylan, 1999) with a maximum time elapsed of approximately six years. The average annual growth rate of the turtle we report on here over 14.9 years was 4.2 cm/yr. Marked differences have been observed between linear growth rates reported from immature hawksbills residing at different study sites in the Caribbean and in different habitats (Diez & Van Dam 2002).

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Suzie the Green Turtle: 6,000 Kilometres for One Clutch of Eggs?

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On 27 January 2010 Suzie, an adult female green turtle (CCL 102.6 cm), and first turtle to be fitted with a satellite tag in the Turks and Caicos Islands (TCI), returned to her foraging grounds off East Caicos, TCI after migrating 6,000 kilometres and visiting seven other range states in just under five months (Figure 1).

Suzie was fitted with the satellite tag by the Turks and Caicos Islands Turtle Project on 24 June 2009 after she was procured from a fisher who had landed her for consumption at South Caicos. The Project is a collaboration between local and international partners who are carrying out research into TCIs' turtle populations and the country's regulated turtle fishery (the fishery is described in detail in Richardson et al. 2006, 2009). One principal aim of the satellite telemetry study is to reveal insights into the range of adult green and hawksbill turtles found in the TCIs' waters.

After her release on the north coast of East Caicos on 25 June, close to where she was originally captured, Suzie made her first foray in the media, with the local newspapers announcing the first study of its kind in TCI. Initially, Suzie stayed amongst the inshore patch reefs and sea grass beds off East Caicos for two months, but on 01 September, she made her move away from the TCI. By early October she had swum directly to the British Virgin Islands (BVI) and then Anguilla, and because, like the TCI, these are UK Overseas Territories, Suzie made the news again. Her passage through the islands was excitedly announced in the press of both the BVI and Anguilla. In the UK, The Times hailed her as an 'anglophile green turtle', while The Daily Telegraph and the Metro newspapers claimed that her journey through three consecutive UK Overseas Territories, hundreds of kilometres apart, had left scientists baffled and dumbfounded! The BBC's online news pages featured more sober reporting, including photos of Suzie, a map of her journey, a link to Seaturtle.org and the online tracking site, excellent coverage that led to the story featuring on at least 25 other online news sites from around the world.

But this was merely the beginning of Suzie's journey and she soon moved on, arriving in Barbuda on 8 October. There she remained for two weeks and, unlike anywhere else on her route, the tracking data strongly suggested that she attempted nesting during the nights of 17 and 18 October on the beaches of Low Bay. Intriguingly, local researchers carried out a boat-based beach survey of Low Bay a few days later and found fresh green turtle tracks close to the emergence locations suggested by the satellite tracking data, but could not confirm whether the nesting attempt was successful. Suzie made the local press again before leaving Barbuda on 22 October, heading east and then south, stopping at Martinique for just five days, where she generated yet more local press coverage, before swimming west into the Caribbean Sea.

After 24 days of swimming non-stop across the Caribbean Sea, Suzie eventually arrived at the southwestern tip of Haiti on 2 December. Surprisingly, instead of taking the more direct northwest route to TCI, she headed due east and swam along the entire southern coast of Hispaniola before rounding the southeast tip of The Dominican Republic. A month later, when it looked like she might finally be going back to TCI, she swam west to Great Inagua, Bahamas, her eighth range state, where she remained for two more weeks. Suzie finally made it back to the TCIs' inshore waters on 23 January 2010, after a 145 day long journey.

The fact that Suzie's journey could be tracked online every day at Seaturtle.org (Coyne & Godley 2005) generated unprecedented interest and enthusiasm for the project along the way, especially in South Caicos where she was originally landed. The Turks and Caicos Islands Turtle Project team kept residents there up to date by regularly displaying her most recent maps in various public places around the island, and were often stopped in the street to be asked *'Where Suzie at?'* Seasoned TCI turtle fishers have been amazed to

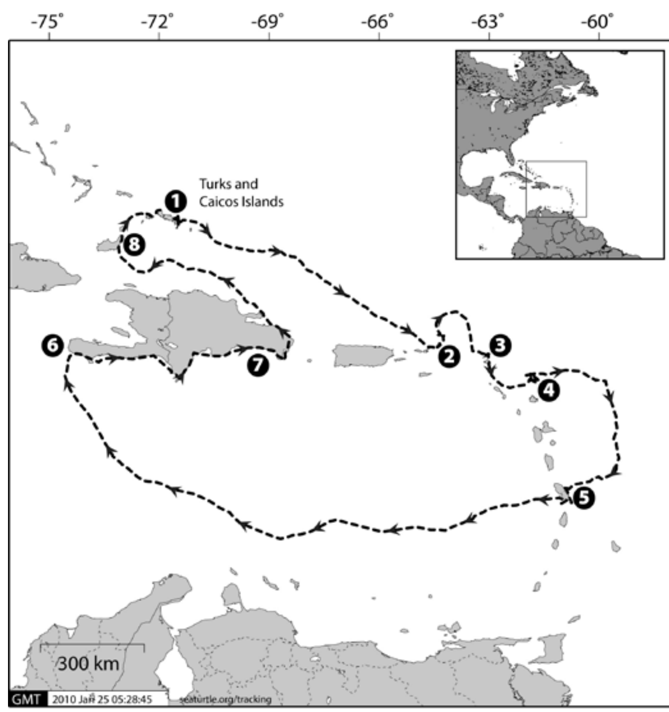

Figure 1. Suzie's migration path and direction in these range states: (1) Turks and Caicos Islands, (2) British Virgin Islands, (3) Anguilla, (4) Barbuda, of Antigua & Barbuda, (5) Martinique, (6) Haiti, (7) Dominican Republic and (8) Grand Inagua in the Bahamas.

learn that their turtles travel so far and some stated that Suzie has made them think differently about the management of their fishery. The Project team hopes to maintain this interest through the online tracking of four adult hawksbill turtles that have also been fitted with satellite tags and released back into the TCIs' waters, although they have a hard act to follow. Suzie's journey may be the longest satellite tracked green turtle migration recorded in the Caribbean (cf. Godley et al. 2008), a fascinating journey that not only raised the profile of her species in the region, but also raised several questions, with perhaps the most perplexing being *'Did she really migrate 6,000 kms to lay just one clutch of eggs?'*

Acknowledgements: The Turtles in the Turks & Caicos Islands Project is a collaboration between the Department of Environment and Coastal Resources and The School for Field Studies in TCI, the Marine Conservation Society (MCS) and the University of Exeter in the UK and Duke University in the USA. It is funded by MCS Ambassadors Anne and Simon Notley, the Natural Environment Research Council and the project partners. The satellite telemetry study is funded by the People's Trust for Endangered Species and the British Chelonia Group. The authors thank our colleagues Shannon Gore in the British Virgin Islands, James Gumbs in Anguilla, Mykl Clovis and John Fuller in Antigua & Barbuda, Rozenn Le Scao in Martinique and Jesus Tomas for their generous help, information and advice offered along the way. We would especially like to thank Michael Coyne for his tireless efforts working with Seaturtle.org and STAT, without which Suzie's incredible journey would not have been so accessible to so many.

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MEETING REPORT

Third International Centro de Investigaciones Marinas Workshop on Sea Turtle Conservation in Cuba. Siguanea Bay, Isla de la Juventud, Cuba, April 22-30, 2009

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The Third International Workshop on Sea Turtle Conservation and Fishers' Exchange took place from April 22-30, 2009 on Cuba's Isla de la Juventud (Isle of Youth). A group of 28 fishers, conservationists, marine scientists and fisheries managers from Cuba, Mexico and the U.S. gathered at Siguanea Bay off the island's remote southwest coast. Located 90 miles southwest of Havana, Isla de la Juventud is the second largest island in the Cuban Archipelago.

This unique informational exchange between Cuba, the Yucatan and Baja California peninsulas was organized by The Ocean Foundation and the Centro de Investigaciones Marinas (CIM) at the University of Havana. It is also part of the Sea Turtle Working Group of a tri-national research and conservation group led by The Ocean Foundation to study and conserve shared marine resources by the three nations of the Gulf of Mexico.

The goals of the workshop were to provide a forum for sea turtle experts and communities in the three bordering countries to exchange experiences on conservation activities, expand livelihoods for Cuban fishers and develop the scientific basis for future conservation in this highly productive region of Cuba. Fisher exchanges have proven effective, particularly in more isolated, small-scale fisheries where the management is limited. Through these exchanges, fishers facing similar biological and political challenges exchange ideas and perspectives that can help in reducing turtle by-catch (Peckham & Maldonado-Diaz In press).

The workshop was fourth of a series of workshops held in Cuba and Mexico. The two Cuban workshops took place at Guanahacabibes Peninsula (GNP) a National Park and UNESCO biosphere reserve on Cuba's extreme western coast in 2002 and 2005. The goal of the 2002 workshop was to bring together international experts to advance CIM's monitoring work on seven beaches at GNP, conducted annually from May-September. Here, groups of University of Havana students, overseen by CIM biologists, monitor the nesting behavior of green turtles (*Chelonia mydas*) (Ibarra-Martin *et al*. 1999; Ibarra-Martin *et al.* 2002). Called the Proyecto Universitario para el Estudio y Conservación de las Tortugas Marinas en Cuba, it has become the second largest turtle-monitoring project in Cuba, next to the nesting and foraging zone monitoring work by Cuba's Centro de Investigaciones Pesqueras (CIP) along the southern and southeastern coasts of the country over the last three decades (Moncada & Nodarse 1983; Nodarse *et al.* 2010).

The goal of the 2005 workshop was to advance CIM's work in educating the local human communities in and around GNP (Bretos *et al.* 2006). The event brought together experts from throughout the Caribbean and Brazil to discuss schemes to involve local schools and townships in participating in the Project while educating local communities of the negative impacts of turtle egg and meat poaching. Recommendations included the incorporation of major turtle tagging work and enhancing institutional collaboration with similar turtle research and conservation projects within Cuba.

Shortly after this workshop, an exchange was carried out in 2006 in Baja California Sur (BCS) by three Cuban biologists representing CIM and CIP. These biologists became familiar with an effective community outreach model in BCS called the Grupo Tortuguero (GT). GT was formed in 1999 as a network of fishermen and local community members dedicated to protecting the sea turtles of the Baja California peninsula. Through GT, fishers in Baja California that once harvested sea turtles have becoming involved in wildlife conservation, research and ecotourism. Research, turtle festivals and education projects in Baja California communities have empowered fishers and the project presents an exemplary model for other parts of the world. Prior exchanges have been led by GT staff between the Baja peninsula and the Mexican mainland and between GT fishers and Japan (Peckham & Maldonado-Diaz 2009).

As part of the Third International Workshop on Sea Turtle Conservation, the fisher's exchange took place over four days in the Bay of Siguanea and Punta Frances, a nature reserve on the southwest corner of the island. Fishers representing GT and fishers and conservationists from the Mexican states of Yucatan, Campeche and Quintana Roo boarded Cuban lobster and bonito fishing vessels to informally exchange information. This included discussions about the types of fishing implemented in these waters, the likelihood of bycatch and the general feelings and attitudes Cuban fishers have for sea turtles. These discussions revealed that turtle bycatch off the Isle of Youth is relatively low. This is primarily the result of the highly artisanal nature of the fishery where neither nets nor long lines are the preferred method of fishing. Rather, bonito is fished with hook and line while lobster is caught with hand nets and snorkel. This could change rather drastically when the market for these fisheries increases and more destructive fisheries methods such as long lining are more commonly utilized.

It was also noted that the shift in fisheries practices in certain areas diminished the amount of adult turtles captured but increased the number of juveniles caught. Also, illegal turtle fishing continues. Other threats were identified such as an increase in local fishing effort due to lower overall fish catches resulting in an increase in incidental capture. All this is combined with the increasing, albeit slowly, technological development of local fisheries. Tourism is also a concern since it implies urbanization of the coastal zone and with it an increase in artificial light at the nesting beaches.

An additional outcome of the meeting was to examine sea turtle research and conservation developments in Cuba since the government's ban of its sea turtle fisheries in January 2008. These fisheries had been maintained since 1976. Sea turtle research and conservation projects conducted over decades by CIP, CIM and Cuba's Ministry of Science, CITMA, were presented to demonstrate a broad panorama of actions the Cuban government has taken to protect these animals since the abolition of these fisheries.

Additional highlights of the Isle of Youth meeting were:

- An agreement among participants to consider Isla de la Juventud as a site for tri-national cooperation to involve local communities in turtle conservation in the Gulf of Mexico
- Involvement of fisherman from Mexico in the international exchange of experiences and workshop together with local Cuban fisherman. This created a unique dynamic in which fisherman shared perspectives related to the challenges of preserving sea turtle populations while maintaining their way of life
- Participants' motivation to continue promoting fisherman participation in sea turtle research and conservation projects in Cuba, Mexico and U.S.
- An emphasis on the reduction of incidental catches of sea turtles and the illegal harvesting of their eggs.

Next steps will focus on a continuation of this fishers' exchange. It is hoped that fishers from the Isle of Youth community of Cocodrilo can participate in an exchange in Baja California to observe the Grupo Tortuguero model firsthand and replicate this model in their community which consists of 300 residents. A sea turtle festival for Cocodrilo in 2010 was also discussed.

The workshop at Isla de la Juventud brought together leading institutions in sea turtle conservation in the three countries:

- Cuba: Fishermen from Cocodrilo; CIM; CIP; National Corporation of Flora and Fauna; CITMA.
- Mexico: Fishermen from the States of Baja California Sur, Campeche and Quintana Roo; El Colegio de la Frontera Sur; Grupo Tortuguero de las Californias, A.C.; Marine Sciences and Limnology Institute-National University (ICMyL-Mazatlán); National Protected Areas Commission (CONANP).
- U.S.A: The Ocean Foundation, Harte Research Institute for Gulf of Mexico Studies, Pro Peninsula; University of Miami.

Acknowledgements: The event was made possible through support from the Christopher Reynolds Foundation and the Bay and Paul Foundations.

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IUCN-SSC Marine Turtle Specialist Group Quarterly Update

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Membership Reappointment

As reported in MTN 125:14-15, the MTSG is currently undergoing its quadrennial member appointment process during which the entire membership is dissolved and then re-appointed from the ground up. After finalizing the appointment of Regional Vice Chairs for the MTSG's ten regions, the regional membership lists were reviewed jointly by the Co-Chairs and Regional Vice Chairs with input from various past MTSG members. Following the finalization of these invite lists, 233 individuals in more than 80 countries were subsequently invited to serve as MTSG members in the current quadrennium, including 42 prospective new members. While we are still awaiting responses from roughly one-third of invitees (as of February), we intend to have this process completed before the Annual General Meeting in April. If you were among those to receive an invitation and have not yet responded, please do so as soon as possible or your membership may not be renewed. If you have questions about this process, please contact program officer Brian Hutchinson (contact information above)

Update on Southeast Asia Turtle Poaching Issue

The MTSG continues to work on curbing the poaching of turtles in Southeast Asia by Hainanese and Vietnamese vessels, which aim to satisfy the growing curio markets in China and Vietnam, and to a lesser extent, the demand for green turtle meat. Having depleted stocks along the north and several archipelagos in the central South China Sea, these poachers now venture as far as the Sulu and Sulawesi seas, into foreign sovereign territory, in search of turtles. Malaysia, Indonesia, and the Philippines apprehend at least two to three vessels each, each year, and confiscate thousands of stuffed turtles and turtle parts, and impose fines totaling hundreds of thousands of dollars. The pressures, however, have not declined, and turtle populations in these countries face catastrophic consequences unless immediate action is taken to reverse the trend.

In June 2009, a partnership of concerned NGOs and the IUCN Marine Turtle Specialist Group convened a workshop to address the direct capture of turtles in Southeast Asia by foreign vessels (see *MTN 125:14-15*), and invited a number of key officials, media representatives and members of academia from Hainan to investigate possible solutions, and to clarify concerns about declines and impacts of poaching on local turtle populations.

More recently, between 2 to 8 November 2009, we followed up this process through a visit by to Hainan (Nick Pilcher, Chan Eng Heng and Kevin Hiew) to meet with local Hainan officials, and to investigate firsthand the issues surrounding the demand for turtle products and enforcement issues related to the poaching of turtles in foreign waters. The findings were startling. Demand for turtle products remains high, with many shops selling turtle products over the counter, with little concerns for local enforcement. A rapid assessment of a selection of jewelry and tourist souvenir shops revealed that hawksbill products were commonly on sale, at relatively low prices, and that the sellers were aware of the illegality of the practice. Many refused to allow photographs, but all were willing to discuss prices and availability. Shops which did not display turtle products often had them behind the counter upon request. Many indicated more stock was available on request. Informal interviews revealed that the product was locally processed, whether in Haikou or in Sanya or elsewhere, suggesting small cottage industries rather than any bottleneck source. Shops invariably carried 10 to 20 pieces of processed shell on display, and over 100 bracelets, eye-glass frames, coins rings and good luck charms were recorded in less than one hour, with prices ranging from RMB 20 to 300 depending on the product and workmanship involved.

Nick and Chan gave several presentations on turtle biology and conservation, and on research methods to fishery enforcement officers, university students and staff, and numerous local fishers. Discussions with the Fishery officers revealed that a vessel monitoring system (VMS) was employed on vessels going to distant waters, but that crews often disabled them when undertaking illegal activities or moving into foreign sovereign territories and that enforcement was problematic because crews often reported the units as 'malfunctioning'. Strengthening enforcement of the VMS use may be a potential immediate activity as part of a broader approach to mitigating this threat.

Clearly the demand for turtle shell products in Hainan and the rest of China is of an enormous magnitude, and the revenues generated by the industry are sufficient to override concerns of local enforcement and penalties. We envision a process of support for local enforcement, coupled with a blanket awareness campaign amongst the local public and fishers in Hainan and other Chinese provinces, will be required as initial activities at the demand end, while strengthening enforcement across international boundaries and in sovereign waters of countries from which turtles are poached (Malaysia, Indonesia and the Philippines) as immediate priorities for action. Secondary to this, we envision the commissioning of a thorough study of the trade, its sources and destinations, training support for enforcement activities, and deliberations at National and Regional levels amongst enforcement officials and the conservation community, as a collective package to address illegal wildlife (sea turtle) trade in the ASEAN region.

Building on this, Nick, Chan and Kevin convened a round-table discussion amongst enforcement and government agencies in Malaysia in December, and plans are now underway to run similar dialogue sessions in Indonesia and at a regional level, under the auspices of the Coral Triangle Initiative. Although there is a lot of work to be done to address this large-scale and complex problem, we are pleased to say that at least things are moving.

BOOK REVIEWS

Title: The Book of Honu: Enjoying and Learning about Hawai'i's Sea Turtles
Year: 2008
Author: Peter Bennett and Ursula Keuper-Bennett
Publisher: The University of Hawai'i Press
ISBN: 9780824831271
Pages: 139pp (softcover)
Price: $18.95 USD
To order: http://www.uhpress.hawaii.edu

The Book of Honu opens with the authors scuba diving off the coast of Maui and encountering honu, the Hawaiian term for green sea turtles, for the first time. This initial contact precipitated the development of a powerful emotional attachment to the Hawaiian turtles as Bennett and Keuper-Bennett began to monitor and study honu in their coastal environs. Drawn from seventeen years of underwater observations including videos, photos and notes, *Honu* provides a comprehensive overview of Hawaiian green turtles based on both the authors' experience and outside scientific research. Aimed at people interested in sea turtles and curious to learn more, the book has plenty to offer more experienced turtle enthusiasts as well by delving into the underwater behavior and habits of Hawaiian green turtles. Those readers seeking a dry and technical text on sea turtle biology had best skip this book replete with turtle-hugging sentiments. Bennett and Keuper-Bennett do not temper their passion for sea turtles, declaring early on that "heaven is where honu are."

After introducing the authors' zeal for and experience with Hawaiian green turtles, the beginning of the book is devoted to informing readers how they can arrange to observe and swim with Hawaiian green turtles. In teaching people to be turtle paparazzi in Hawai'i, Bennett and Keuper-Bennett walk the fine line between giving people information to respectfully observe turtles and creating hordes of travelers who harass the turtles. While Bennett & Keuper-Bennett emphasize the need for respect and caution, the guide to locating sea turtles in Hawaiian waters could expose the turtles to harm from the unregulated traffic of tourists despite their best intentions.

The book is structured to provide in-depth explanations of all aspects of honu life built around the authors' underwater data collection and existing scientific information. Bennett and Keuper-Bennett delve into green turtle physiology, the life cycle of the green turtle, daily behavioral patterns as observed by the authors, a brief discussion of the hawksbill turtles that also inhabit the Hawaiian reefs, a succinct history of Hawaiian relationships to honu, and threats to Hawaiian green turtles. The last chapter ends with an eloquent plea for people to honor human stewardship of honu. For readers inspired to learn more about sea turtles, the authors provide a further reading section with a variety of book and internet sources. This structure eases into the biology of sea turtles while keeping it fresh with stories from the authors' diving experiences.

Honu seeks to educate readers about the Hawaiian green sea turtles and promote awareness of and concern for sea turtles and their conservation. The cheerful tone and engaging writing draws the reader into the underwater world of Hawaiian sea turtles. Bennett and Keuper-Bennett write as if the reader is with them, interacting with the turtles. Years of photographing turtles pay off in glossy, up-close underwater photos. The authors introduce their long time honu "friends" with head shots that they use to distinguish the individual turtles that regularly inhabit the waters off of Honokōwai, Maui. Throughout the book the authors employ technical scientific terms and draw on current sea turtle research. However they do not provide any direct citations and sometimes use non-scientific terminology like referring to the turtle's rear flippers as feet. This anthropomorphizing familiarity with the turtles runs throughout the book although it is balanced with a careful attention to rigorous reporting on sea turtles.

What makes this book distinctive is the experience Bennett and Keuper-Bennett bring to the material. While neither author received formal training in marine science or conservation, they became experts on Hawaiian sea turtles by spending each summer for almost two decades observing honu. Their initial excitement about sea turtles brought them to an international sea turtle symposium where their dedication to monitoring the turtles piqued the interest of scientists. Bennett and Keuper-Bennett discuss how their collaborations with institutional scientists led them to gather fecal samples, attach depth tracking devices on turtles, as well as an assortment of other data collection activities. The analysis of the underwater behavior and habits of the turtles from their extensive observational data stands out as the unique contribution of Bennett and Keuper-Bennett's work.

Overall *Honu* is a compelling and informative text composed by two committed citizen scientists eager to share their enthusiasm for and knowledge of Hawaiian green sea turtles.

Reviewed by: **Myriah Cornwell**, Nicholas School of the Environment, Duke University Marine Laboratory, 135 Duke Marine Lab Rd., Beaufort, NC, 28516 USA (E-mail: mlc33@duke.edu)

Title: The Adrift – Tales of Ocean Fragility
Year: 2008
Editors: C. Campagna, Y.S. de Mitcheson, N. Pilcher, A. Hurd & J. Griffin
Publisher: IUCN
ISBN: 978-2-8317-1070-9
Pages: 136pp (soft cover)
Price: $34.00 USD
To order: http://www.iucn.org/publications

This small book was designed as a "cocktail party book" (p. 5), and as such is informal in approach, with many pretty photographs and simple text unencumbered with references or footnotes. The book is divided into short chapters that tell "the story" of a particular marine species (e.g. abalone), marine habitat (e.g. sea mounts), or conservation issue (e.g. bycatch). The narrative of each chapter is roughly similar, with an emphasis on broadly defining the problems and potential solutions to the conservation problem identified by the chapter. The last chapter focuses on sea turtles, and highlights three principal threats: bycatch, pollution, and nesting habitat destruction. There is also a brief summary of the potential negative impacts of climate change, although the book rightly acknowledges that is difficult to discern to what extent sea turtles will be able to adapt to the current bout of climate change (they have survived previous periods of climate change in the past). The back of the book provides information resources and some detailed information on the Red List and CITES categories of the species presented in the book. I was a little surprised to see that leatherbacks were not marked as being on Appendix I of CITES (all sea turtle species are currently listed on Appendix I), but this is a minor typo and does not detract from the book overall. Indeed, if the goal of *Adrift* is to focus attention on incredible marine wildlife, habitats, and their conservation stories, then the editors have done an admirable job.

Reviewed by **Matthew H Godfrey**, NC Wildlife Resources Commission, Beaufort, NC, 28516 USA (E-mail: mgodfrey@seaturtle.org)

RECENT PUBLICATIONS

This section is compiled by the Archie Carr Center for Sea Turtle Research (ACCSTR), University of Florida. The ACCSTR maintains the Sea Turtle On-line Bibliography: (http://accstr.ufl.edu/biblio.html).

Included in this section are publications that have been pre-published online prior to the hardcopy publication. These citations are included because of the frequent delay in hardcopy publication and the importance of keeping everyone informed of the latest research accomplishments. Please email us <ACCSTR@zoology.ufl.edu> when your papers are published online. Check the online bibliography for final citation, including volume and page numbers.

It is requested that a copy of all publications (including technical reports and non-refereed journal articles) be sent to both:

1) The ACCSTR for inclusion in both the on-line bibliography and the MTN. Address: Archie Carr Center for Sea Turtle Research, University of Florida, PO Box 118525, Gainesville, FL 32611, USA.
2) The editors of the Marine Turtle Newsletter to facilitate the transmission of information to colleagues submitting articles who may not have access to on-line literature reviewing services.

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