Trinidad's Leatherback Sea Turtles
Research Report 2008

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Abstract

Trinidad supports nesting by one of the 3 largest leatherback nesting colonies in the world. Conservation efforts on this Critically Endangered Species began in 1990 with the formation of the Nature Seekers, a community based conservation organization located in the village of Matura on the eastern coast. With support from Earthwatch and other organizations the Matura leatherback conservation project has achieved phenomenal success at restoring this once threatened nesting colony while at the same time building one of the world's most successful community-based endangered species conservation and management programs. Conservation research objectives between 2004 – 2008 were to assess the current population size and trends and to evaluate the affect a large and growing ecotourism program might be having on the nesting colony. Results of the population assessment show that the population has been growing at an average rate of 1.8% per year since 1993 and that in 2007 and 2008 11,097 and 5,963 leatherbacks nested in Trinidad. Between 1999 and 2008 the number of leatherback nesting on Matura Beach ranged from approximately 1500 to almost 6,000 in a single season. Effect of tourism was evaluated in two studies, one on the behaviour of the turtles and the other on the effect of walking on nests to hatch success. Both experiments showed no apparent impact from tourism.

Objective 1: *Population status report for the Matura Beach leatherback sea turtle nesting colony.*

Trinidad has long been known to support nesting by leatherback sea turtles (Bacon, 1970; Fournillier et al., 2008), though no scientific investigation of the species on this island was undertaken until the 1960s by the Trinidad Field Naturalist's Club (Bacon 1970). Between 1965 and 1968 the Club organized irregular nocturnal patrols along the northern section of Matura beach (which is now called "Rincon"). This 3.0 km long stretch of Trinidad's east coast is bounded by a rocky headland to the north and the Matura River to the south. Basic biological information was collected including turtle size and number of turtles nesting on this section of Matura Beach. Bacon (1970) reports that the mean size (curved-carapace length) of 20 leatherbacks was 158 cm (range 125 – 185) and mean curved width was 105 cm (range 75 – 117). Bacon (1970) also estimated the size of the nesting population by using an 8 day count from 16 to 23 May 1969. Thirty-four turtles were observed nesting. Bacon suggests that a similar number probably nested on the middle and southern sections of the beach and proposed that around 100 turtles nested on Matura during this 8 day period. He also notes that in 1968, 23 leatherbacks were killed by local villagers and in 1969 another 13 were killed on the northern section. Bacon concludes that the killing of these turtles represents a bare minimum and that is it likely that 20 – 30% of all nesting females were killed each year.

Between 1981 and 1983 Chu Cheong conducted partial night (2000h – 2400h) nocturnal surveys on the northern section of Matura Beach and recorded 156 nesting turtles (35 in 1981, 67 in 1982, and 54 in 1983)(Chu Cheong, 1990). She also notes that leatherbacks are commonly killed at Matura Beach. In 1981, five carapaces were found and in 1982 and 1983, 2 and 7 carapaces were observed. Chu Cheong also flew regular air surveys along the coastal beaches to estimate nesting density. The northern section of Matura was described as moderate nesting (5-20 tracks, while the mid-section was noted as high density (> 20 tracks). Nathai Gyan et al. (1987) estimated that 500 - 900 turtles nested annually in Trinidad each year between 1984 and 1987, however a lack of data on collection methods makes this number difficult to confirm. She reports data on turtles encountered at Matura Beach, but it is unclear if these data represent the total number of turtles for each night or which section of beach was monitored. Typically 1 – 6 turtles nested during each night of patrol.

Regular all night nesting patrols of the both the northern, mid and southern sections of Matura Beach (known as Rincon and Orosco sections) were initiated by a community conservation group, the Nature Seekers, in 1992. Early patrol efforts from 1992 – 1999 were directed primarily toward the protection of nesting turtles, and supervising visitors to the beach. As turtles were encountered they were counted and measured, but not marked with identity tags. While patrol coverage was consistent between 1993 - 1999, it did not attempt to encounter every nesting turtle nor were the turtles identity marked, so the number of turtles observed each year represents an index of nesting activity, not the total number of individuals nesting. Some turtles could have been counted more than once since leatherbacks nest up to

12 times in a season. Total number of turtles encountered ranged from 604 – 2236 between 1993 and 1999 (Table 1).

Because patrol effort encompassed the entire beach and was relatively consistent from 1993 – 1999 (Table 1) we estimate a population trend for this time period. Leatherback sea turtles in the Caribbean rarely nest each year, most nest every 2 or 3 years and so by smoothing the data with a 3 point running average, we account for annual variation in the proportion of the population that nests in any one year. A linear regression was fit to the resulting smoothed data and an average annual growth rate for the population was determined (Figure 1). Between 1992 – 1999 the leatherback population at Matura was growing an average 4.68% per year. This is substantially lower than the average rate reported from the northern Caribbean at Sandy Point, St. Croix of approx. 13% between 1993 – 2001(Dutton et al., 2005).

Average proportion of turtles nesting within Orosco and Rincon sections was remarkably consistent with an average of 65.6 (± 3.48)% of all activities occurring in Orosco each year (1992 was discounted as it represented the first year of coverage when the patrol teams were in training) (Table 1).

Table 1 – Patrol dates and turtles encountered at Matura Beach (sections Rincon and Orosco) between 1992 and 1999

Year	Date from	Date to	# of days	Orosco turtles	Rincon turtles	Combined turtles	Orosco %	Rincon %
1992	04/10/1992	09/05/1992	148	342	14	356	96.07	3.93
1993	03/12/1993	07/25/1993	135	356	248	604	58.94	41.06
1994	03/12/1994	07/31/1994	141	1441	761	2202	65.44	34.56
1995	03/09/1995	08/30/1995	174	796	506	1302	61.14	38.86
1996	03/16/1996	08/12/1996	159	881	435	1316	66.95	33.05
1997	03/05/1997	08/19/1997	167	902	409	1311	68.80	31.20
1998	03/18/1998	08/27/1998	162	1035	378	1413	73.25	26.75
1999	03/17/1999	08/28/1999	164	1449	787	2236	64.80	35.20

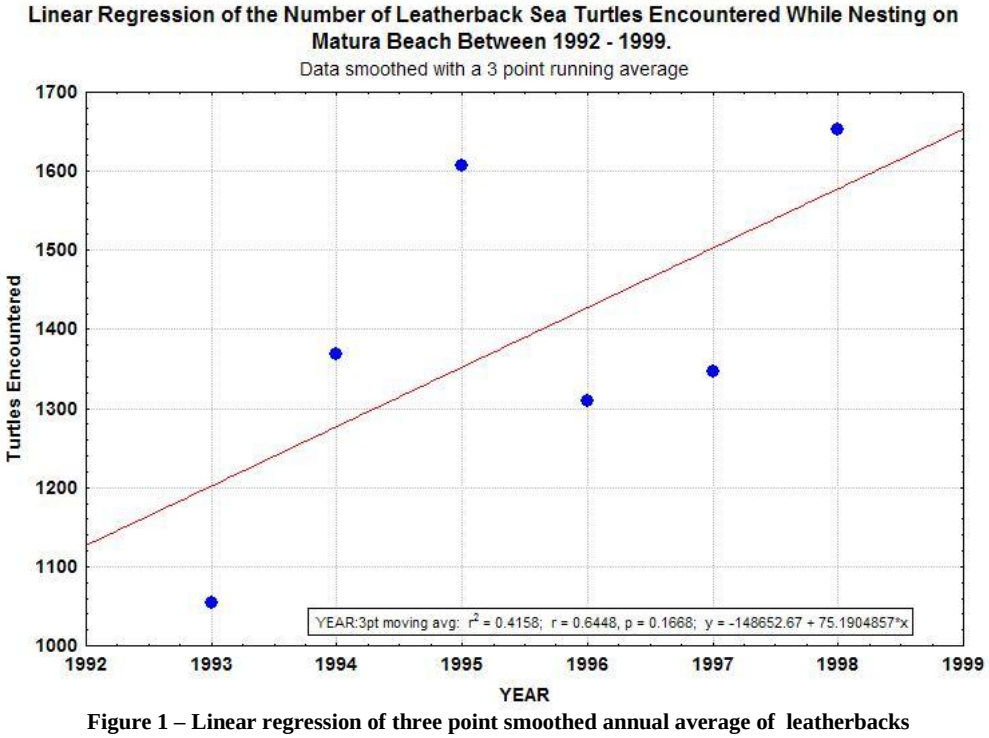

Figure 1 – Linear regression of three point smoothed annual average of leatherbacks encountered during regular patrols at Matura Beach Trinidad, 1993 - 1999. Patrol effort was consistent across the entire Matura Beach nesting colony each season and thus sampling effort is assumed to be equal across all years.

In 1999, patrol objectives shifted significantly as identity-marking of individual turtles was initiated using flipper tags and later Passive Integrated Transponder Tags (PITT). Foot patrol area was significantly reduced to cover the beach primarily from the Matura River south approximately 3 km. The patrol objective for Rincon was also changed and devoted primarily toward protection of turtles and to prevent visitors from using that section of the beach. Data collection at Rincon became more ad hoc as patrollers limited coverage to the north end (nearest a road access point) of the beach. Patrol scheduling was also changed and emphasized coverage of the beach during the first half of the night to accommodate a growing need to manage tourists. Because the killing of turtles had almost entirely ceased, all-night patrols were discontinued so that staff could be re-allocated to tourism duties. The entire length of Matura beach was also divided into 457 m (1500 feet) sections numbered 1-18 to enable the study of the distribution of nesting. Most beach patrol teams covered sections 7 – 14 from 20:00h – 02:00h.

In 2004 beach patrol capacity was greatly enhanced with the addition of Earthwatch volunteers. While these volunteers did not increase the range or duration of coverage, they improved the intensity of coverage during the hours of 20:00 – 02:00 h within zones 7 – 14. Their patrol objective was to mark as many turtles as possible, as well as to continue data collection on turtle size, nest location and other biological information.

Tagging turtles provides an exact count of all females encountered. Because each turtle is assigned a unique identity number, recounting the same turtle is prevented when trying to determine how many turtles are using a nesting beach.

However, such counts do not represent a measure of total population size, unless the entire nesting colony is patrolled during all possible times when turtles are on the beach. Due to the size of the Matura colony, both geographically (8+ km) and in the number of turtles nesting, such coverage is impossible.

To utilize tagged turtles to estimate annual population size we chose to treat nocturnal beach tagging as a mark-recapture experiment. For analysis we used Kendall's open robust mark and recapture model (Kendell and Bjorkland, 2001). This approach provides significant advantages when estimating the population size of turtle nesting colonies of the size and distribution of the Matura colony. The model is relatively free of effort bias and so varying effort at marking turtles during each sampling event is not a problem. The model treats each 10 day interesting period as a single sampling event and uses the proportion of turtles tagged over the course of the season to construct the model. Because such an approach represents a sampling approach of all turtles using the colony, geographic distribution (or lack of complete coverage) does not invalidate the estimate, presuming that there is an equal probability of turtles being encountered within the sampled area. Finally, the model provides a measure of error around the estimate.

Results of our analysis using a mark-and-recapture model yield an annual nesting population size that ranged from 1563 to 5902 leatherbacks nesting each year.

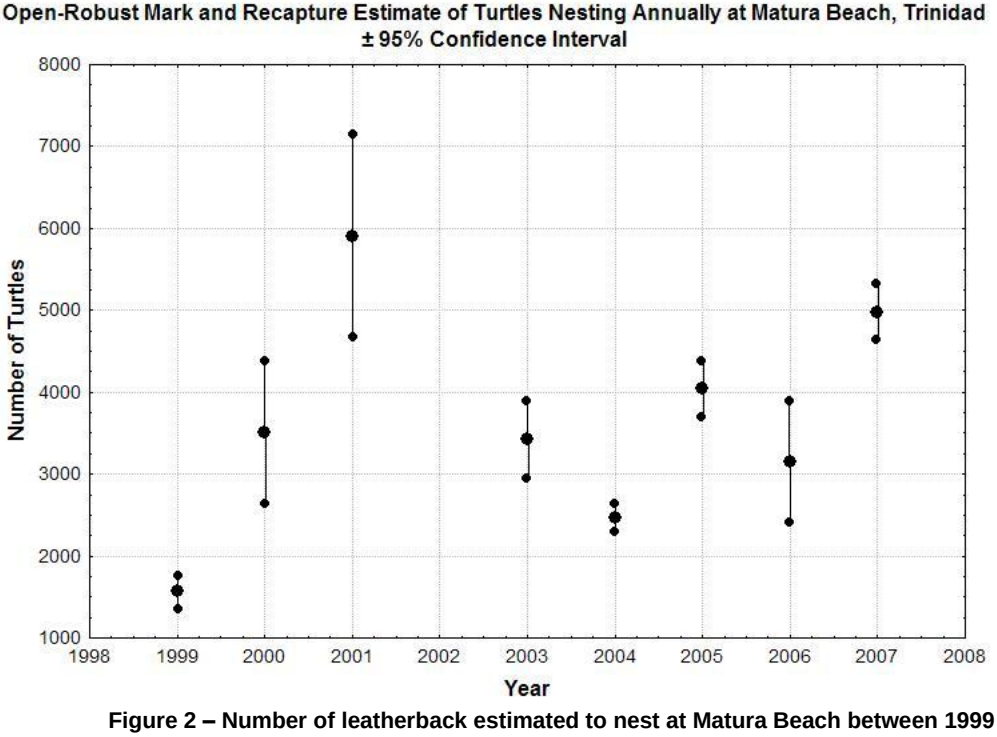

Figure 2 – Number of leatherback estimated to nest at Matura Beach between 1999 and 2007, using a Kendell's open robust mark and recapture model.

We calculated a population trend using the same methods that were used for the data from 19923 – 1999 (3 year running average and linear regression) (Figure 4). Between 1999 – 2007 the Matura population nesting population declined at a rate of 1.84% per year.

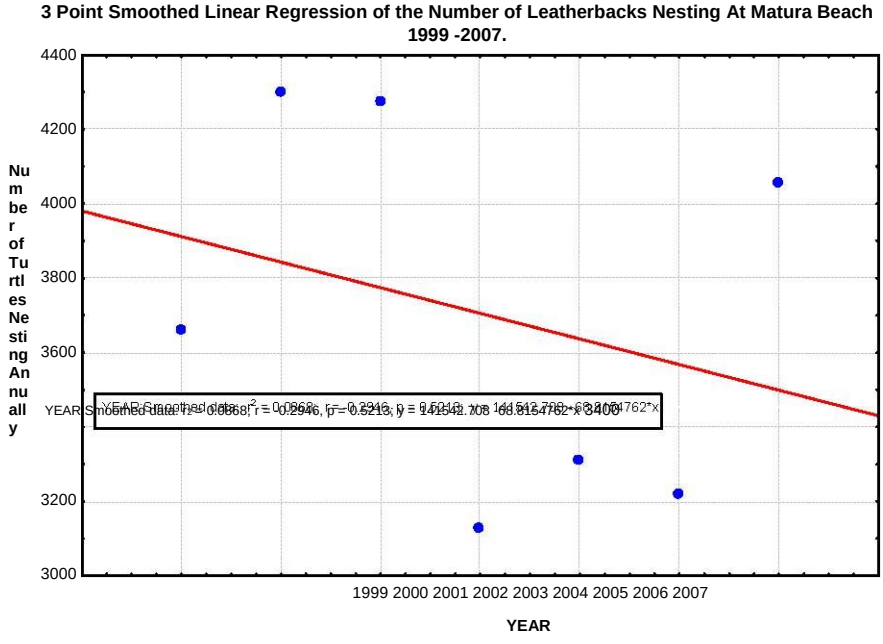

Figure 3 - Linear regression of the number of leatherbacks calculated to nest each year on Matura Beach, Trinidad since 1999.

In 2006 the project instituted a daily daytime census of all nesting on the Orosco section of Matura Beach. Due to logistical constraints, Rincon was not surveyed. The objective of this census was to provide another index of abundance for the nesting colony at Matura. Each day all body pits (location of a nest or attempted nest) from the previous night were tallied and their location recorded by GPS (Global Positioning System). Body pits were used as the tally value because of their persistence and ease of detection and because they approximate the location of a nests with eggs. Since the average number of nests (with eggs) deposited per season by leatherbacks in the Caribbean is generally understood to average 5.26 (Boulon et al., 1996) and assumed to be consistent between years (though this latter assumption is not well proven (Briane et al., 2007)), nest counts have been used to calculate the total number of turtles nesting. However, for leatherbacks this is not optimal. Leatherback nests are notoriously difficult to find after deposition, and body pits can be reliably counted. Further, we calculate that at Matura 97% of all body pits contain nests-with-eggs based on data collected during nocturnal patrols. Thus, we used the number of body pits recorded each year reduced by 3% and divided by 5.26 to estimate how many turtles nested on the Orosco section of Matura beach. In 2007 we extended the census of body pits to the other major nesting beaches on Trinidad to calculate a national leatherback nesting estimate.

Our daily census on the Orosco section of Matura Beach counted 4,208 body pits in 2006. Unfortunately, delays in obtaining funding prevented the initiation of the census until 4 April, more than one month after the start of nesting for 2006. To estimate how much nesting occurred before our daytime surveys began, we applied a correction model (Girondot et al., 2006) that enables missing data to be estimated during “gaps” in the daily tally. Our final body pit estimate for 2006 was 4325.755 (95% CI: 4299.64 - 4351.87) (Figure 4).

In 2007 we extended our daily census to two other major nesting beaches in Trinidad. Fishing Pond beach is a 10 km long nesting beach contiguous to the south of Matura Beach but separated by the Oropuche River. Daily counts of body pits on this beach were conducted in a manner similar to the census on Matura Beach. On the north coast of Trinidad the 800 meter long Grande Riviere Beach sustains a large number of nesting leatherbacks. Because the density of turtles is so high, a morning body pit count was not feasible, as turtles tended to crawl over and disguise the evidence of previous nests. Instead two patrollers monitored the beach continuously all night and recorded the location of each turtle as she created a body pit.

YEAR	LOCATION	# BP COUNTED	# BP ESTIMATED	95% CI	EST. # OF ♀ TURTLES[i]
2006	MATURA / OROSCO	4,208	4,325.755	4,299.64 – 4,351.87	1,069
2007	MATURA / OROSCO	12,529	16,912.17	16,294.83 – 17,529.51	4,179
2007	FISHING POND	10,915	13,606.98	12,883.43-14,330.53	2,509
2007	GRAND RIVIERE	18,625	23,911	22,589.44-25,232.55	4,409
2008	MATURA / OROSCO	5,528	6,253.103	6,095.264-6,410.942	1,545
2008	FISHING POND	10,583	18,006.81	16,632.38-19,381.25	3,321
2008	GRAND RIVIERE	23,915	25,472.53	25,105.24-25,839.82	4,697

Table 2 – Total count of all body pits created by leatherback sea turtles at the three primary nesting beaches on island of Trinidad. Table also includes an estimated body pit total calculated to account for gaps in the patrol schedule. Total number of turtles was determined by using the percent of body pits to nest-with-eggs value calculated for Matura Beach (97%) and an average clutch per turtle of 5.26 (after Boulon et al.).

In both 2007 and 2008 delays in the initiation of patrols, or gaps in the patrol schedule due to logistical problems led to incomplete data coverage. To enable annual comparisons in the data sets and between beaches we processed these data with the previously described “gap filling” model (Girondot at al. 2006). Results are presented in Table 2 and Figure 4.

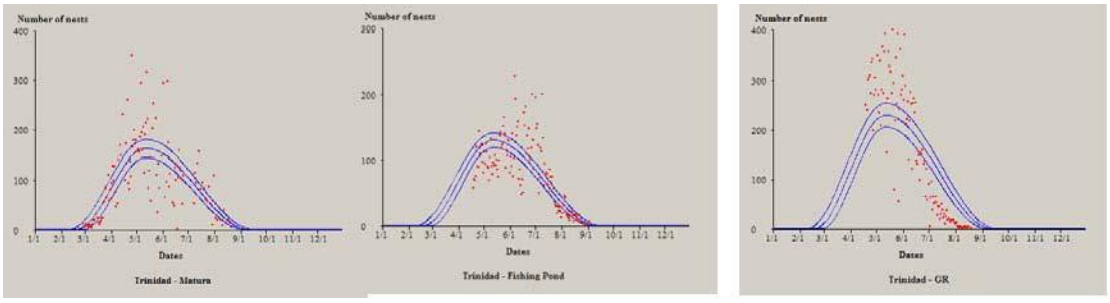

Figure 4 Graphic output of model used to estimate total body pit count for three beaches in Trinidad during the 2007 nesting season.

To determine how many turtles nested each year we reduced each body pit tally by 3% to account for body pits that did not contain a nest-with-eggs. Because Matura accounts for only a portion of the entire Matura Beach colony, we added the proportion of nests that were laid in the Rincon section (34.4% see table 1) to the Matura tally. This proportion was determined using the average ratio of activities recorded in Rincon and Orosco between 1993 – 1999 (see Table 1). Finally, to estimate the number of turtles from the total nest count we divided the average number of nests laid annually for Caribbean leatherbacks (5.26) from Boulon et al. 1996 (Table 2).

Discussion

Our analysis of the Trinidad leatherback nesting population enables us to draw a number of conclusions about this nesting population. Since 1993 the number of turtle's nesting at Matura appears to have been growing at an overall average rate of 1.8% per year. Between 1993 and 1999 that growth approached 5 % per year followed by a decline since 1999. While lower than the growth rates recorded for that reported from a small colony in the northern Caribbean (Sandy Point, St. Croix)(Dutton et al., 2005) such growth is identical to that reported for the large colony in French Guiana (Girondot et al. 2007) between 1967 – 2002.

The apparent reverse of the population growth in the latter half of our study could be of significant concern if we can confirm that this decline is real. There are some reasons to believe that this trend assessment may not be accurate enough to conclude that the Matura nesting colony is in decline, however. The fit of the trend line for the data from 1999 - 2008 is very weak, and may not actually be statistically accurate. Some refinement of our model is warranted. One way in which we might evaluate whether our mark-recapture model is appropriate is by comparing the model output with other population size evaluation assessments. One such assessment is our daily body pit count.

With the initiation at Matura of a daily morning count of nesting activity we have an alternate data set to compare with the mark-recapture model. Unfortunately, we can only compare 2 years at this time (Table 3). In 2006 our morning tally estimated 1,069 leatherbacks nested on Matura Beach (including the Orosco section count and the estimated Rincon section count). Our mark-recapture assessment calculated almost 3 times more turtles nested at Matura. In 2007 our daily census estimated 4,179 turtles while the mark-recapture model calculated

4,977. As in 2006, our morning count calculated less turtles nesting than the mark-recapture model. Until we have more information it will be difficult to know why there is this difference. One explanation may be that the mark-recapture model actually incorporates turtles that nest in both Matura and Fishing Pond beach. Since leatherbacks readily move between these two beaches (based on tag return data), it is possible that they are actually part of a single large nesting population. Our morning count, which assumes that each nest represents 0.19 (1/5.26) of a turtles reproductive output might be incorrect, simply because all of its nests are not deposited within the Matura Beach study area. To resolve this conundrum will require a better understanding of the movement of leatherback across the Oropuche river which divides Matura Beach from Fishing Pond beach.

	MATURA	
YEAR	ESTIMATE BASED ON BODY PIT TALLY	ESTIMATE BASED ON MARKRECAPTURE MODEL (95% CI)
2006	1,069	3,151 (2402-3900)
2007	4,179	4,977 (4,636-5,320)

Table 3 – Comparison of the calculated number of female leatherback sea turtles nesting on Matura Beach in 2006 and 2007 using two methods of calculation. The first method used a daily body pit survey reduced by 3% to account for unsuccessful nesting attempts and divided by the average number of nest laid by leatherbacks per year (5.26). The second method used tagging as a mark-recapture method to evaluate the number of turtles in the population.

Another factor which may have influenced the quality of our trend analysis is that the data required significant adjustment to enable it to be incorporated into our model. Use of the gap filling model (Girondot et al. 2006) and our incorporation of the estimated Rincon nesting beach contribution leave opportunities for error in our analysis. Refinement and confirmation of our approach is warranted. In particular, we need to improve the reliability of our daily body pit counts. The gap filling model we used is particularly sensitive the date of nesting season initiation (Marc Girondot, pers com.) and because our largest gaps in the data occurred at the beginning of each nesting season, our analysis is particularly vulnerable to error. It will be important that nesting patrols be initiated immediately at the start of the nesting season. Daily coverage of the Rincon section is also important, since this section may represent 35% of all Matura nesting.

One of the most significant aspects of our study is that we calculate the most rigorous estimate for the size of the Trinidad nesting colony to date. Based on our body pit surveys, and using 5.26 nests per turtle we calculate that in 2007 there were 11,097 leatherbacks nesting on the 3 primary nesting beaches and in 2008 our total estimate was 9,563. It should be noted that using the average number of clutches produced per leatherback per season to convert number of nests to number of turtles is not an exact science and can often be misleading when trying to compare studies from around the world. If the basic unit of measure is nests (or body pits in our case) it is prudent not to convert them to turtles, unless the value of nests per season is known for the colony under study. For example, Girondot et al. (2007) estimated that for French Guiana the number of nests per female would be 8.3 ± 0.9, but their study did not include turtles that were only observed one time, which would have significantly reduced their average (Girondot et al., 2007). Witt et al. (2009) used
6.17 clutches per year, in their calculation of the number of turtles nesting in western

Africa (Witt et al., 2009), however they cite Miller 1997 as the source. Miller cites Van Buskirk and Crowder (1994) as his source, but Van Buskirk and Crowder (1994) compiled reports of the number of clutches laid by leatherbacks from a number of studies or reports and averaged those data to create a global mean (Miller, 1997; Van Buskirk and Crowder, 1994).

Evaluating the size of the Trinidad colony can be put into a perspective by comparing its size to reports of other large Atlantic colonies (warnings in the previous paragraph not-withstanding) (Table 4).

Nesting Colony	# of Nests	Year(s)	Source
French Guiana and Suriname	13,291-63,294	1967-2002	Girondot et al. 2007
French Guiana and Suriname	34,051-23,934	1999 - 2002	Girondot et al. 2007
Gabon	111,960	2002-2003	Witt et al. 2009
Gabon	42,566	2005-2006	Witt et al. 2009
Gabon	81,004	2006-2007	Witt et al. 2009
Trinidad	52,797	2007	This study
Trinidad	48,240	2008	This study

Table 4 – Total number of nests reported for leatherback sea turtles nesting in the largest Atlantic nesting colonies.

Conclusions

Trinidad's leatherback nesting colony is clearly one of the largest in the Atlantic Ocean comparable to those nesting along the mainland coasts of South America and western Africa. Current status of the Trinidad nesting colony is encouraging as the population seems to be growing in the long term. While it appears that there is a downturn in nesting since 1999, more information will be needed to confirm that this trend is cause for alarm. Continued conservation and management of this nesting population through managed access to nesting beaches by visitors, protection of leatherbacks both at sea and while on shore, and active monitoring of the nesting population's size will be critical if this population is to be sustained.

Literature Cited

Bacon, P. R. (1970). Studies on the Leatherback Turtle, Dermochelys coriacea (L) in Trinidad, West Indies. *Biological Conservation* **2**, 213-217.
Boulon, R. H., Dutton, P. H. and McDonald, D. (1996). Leatherback Turtles (Dermochelys coriacea) on St. Croix, U.S. Virgin Islands: Fifteen Years of Conservation. *Chelonian Conservation and Biology* **2**, 141-147.
Briane, J.-P., Rivalan, P. and Girondot, M. (2007). The inverse problem applied to the observed clutch frequency of leatherback turtles from Yalimapo Beach, French Guiana. *Chelonian Conservation and Biology* **6**, 63-69.

Chu Cheong, L. (1990). Observations on the nesting population of leatherback turtles (Dermochelys coriacea) in Trinidad. *Caribbean Marine Studies* **1**, 48-53.

Dutton, D. L., Dutton, P. H., Chaloupka, M. and Boulon, R. (2005). Increase in a Caribbean leatherback turtle (Dermochelys coriacea) nesting population linked to long-term nest protection. *Biological Conservation* **126**, 186-194.
Fournillier, K., Sammy, D. and Clovis, T. (2008). DRAFT Sea Turtle Recovery Action Plan for Trinidad and Tobago. In *CEP Technical Report 48*, (ed. K.
L. Eckert), pp. 120. Kingston, Jamaica: UNEP Caribbean Environment Programme.
Girondot, M., Godfrey, M. H., Ponge, L. and Rivalan, P. (2007). Modeling approaches to quantify leatherback nesting trends in French Guiana and Suriname. *Chelonian Conservation and Biology* **6**, 37-46.
Girondot, M., Rivalan, P., Wongsopawiro, R., Briane, J.-P., Hulin, V., Caut, S., Guirlet, E. and Godfrey, M. H. (2006). Phenology of marine turtle nesting revealed by statistical model of the nesting season. *BMC Ecology* **6**, doi:10.1186/1472-6785-6-11.

Kendell, W. L. and Bjorkland, R. (2001). Using open robust design models to estimate temporary emigration from capture-recapture data. *Biometrics* **57**, 1113-1122.
Miller, J. D. (1997). Reproduction in sea turtles. In *The biology of sea turtles*, vol. 1 eds. P. L. Lutz and J. A. Musick), pp. 51-81. Boca Raton: CRC Press. **Van Buskirk, J. and Crowder, L. B.** (1994). Life-history variation in marine turtles. *Copeia*, 66-81.

Witt, M. J., Baert, B., Broderick, A. C., Formia, A., Fretey, J., Gibudi, A., Mounguengui, G. A. M., Moussounda, C., Ngouessono, S., Parnell, R. J. et al. (2009). Aerial surveying of the world's largest leatherback turtle rookery: A more effective methodology for large-scale monitoring. *Biological Conservation* **142**, 1719-1727.

Objective 2: *Tourism impacts: Evaluating hatch success of nests walked over by tourists.*

Background

The conservation of endangered marine turtles often falls to rural, isolated communities generally ill-equipped to develop or sustain modern recovery and management programs. The management of the leatherback turtle (*Dermochelys coriacea*) and hawksbill (*Eretmochelys imbricata*) nesting colony at Matura Beach, Trinidad, is widely recognized as among the finest examples of how local stakeholders have been able to design and implement long term, socially acceptable and scientifically sustainable conservation of a once heavily persecuted marine turtle population. Based in the village of Matura, a community based non-government organization (NGO), Nature Seekers, with ongoing technical support from the Wider Caribbean Sea Turtle Conservation Network (WIDECAST), has successfully reduced the wanton slaughter of gravid leatherbacks and hawksbills from many hundreds per year to zero, while at the same time creating local employment for community members, enhancing educational and professional opportunities, contributing significant research findings to the international scientific community, and developing support nation-wide for marine turtle conservation.

Founded in 1991, Nature Seekers is financially self-sufficient and uses a diverse funding base to maintain its program. It is the second largest employer in the coastal community of Matura, providing employment to more than 20% of residents. Initially established primarily as a turtle protection program, Nature Seekers staff are proficient in all aspects of nesting beach management and research. Data collection includes turtle size and weight, nest location and fate, hatch and emergence success, clutch size, distribution and seasonality of the reproductive effort, active threats, etc. Each female is flipper- or microchip-tagged for identification, which also supports efforts to estimate population size. The program also supports increasingly high-tech investigations into reproductive physiology, sensory biology and post-nesting movements through the use of electronic technologies (e.g. satellite telemetry) and veterinary research.

Nature Seekers maintains one of the world's best managed sea turtle ecotourism programs, whereby more than 10,000 visitors to Matura Beach each summer view leatherback nesting under the supervision of a trained Nature Seekers guide. More than 80% of those visitors are residents of Trinidad and the educational outreach provided by the community group to those visitors has been central to the successful elimination of turtle killing. Indeed, the leatherback is fast replacing the Scarlet Ibis as Trinidad's national symbol due to the popularity and demonstrated social-economic benefits of turtle viewing on the island.

The Nature Seekers program provides a uniquely successful model of truly community-based sea turtle management that is also financially self-sustained. Key to this self-sufficiency is it's eco-guiding program. Nature Seekers has the sole right to control access to the nesting beach at Matura and to charge a fee to provide environmental interpretation to visitors wishing to view nesting leatherbacks.

In 2005 we undertook a study to evaluate the affect of tourist foot traffic on the hatch and emergence success of nests laid at Matura Beach. Sections of the beach were designated as low, medium and high foot traffic areas. The low traffic area was open only to research personnel, meaning that most nests were not subject to foot traffic. The medium traffic area allowed tours to observe turtles on the beach, but these visitors were required to walk on a foot path behind the beach to access the area. So while they walked on small sections of the beach, and likely stepped on nests the overall foot traffic was reduced from what it would have been had the tourist been able to walk down the beach to nesting turtles. Finally a high use area was designated directly in front of the primary beach access and was walked on extensively by all visitors to the beach. Each experimental section was approximately 150 m in length and was subdivided into 20 meter segments with numbered pvc markers (pvc pipe) along the vegetation edge. As nests were deposited, their locations were noted by measuring to the two nearest markers. After emergence or at 70 days incubation duration, each nest location was determined using these same measurements and excavated. All contents were evaluated to calculate hatch percentage.

Results

A total of 300 nests were excavated, 110 in zone 1 (low traffic), 77 in zone 2 (medium traffic) and 103 in zone 3 (high traffic). Statistically there was no difference in the mean hatch success between these areas (Anova, F=1.078; p=0.341443) (Table 1).

Zones	Mean Proportion Hatched	Std. of Proportion Hatched	n
1	0.707717	0.173691	110
2	0.704766	0.196194	77
3	0.672296	0.202369	103

Table 1 – Hatch success of eggs in leatherback clutches laid on Matura Beach in 2005 within three treatment areas: Low (1), Medium (2) and High (3) foot traffic. There was no statistical difference (Anova, p=.341443) between treatments.

Discussion / Conclusions

Results of this experiment suggests that there were no adverse effects on the hatching success of leatherback sea turtle nests by foot traffic at Matura Beach. This is an important finding in terms of evaluating one aspect of setting beach carrying capacity for tour groups.

Objective 3: *Effect of tourism activities on the behaviour of nesting leatherback sea turtles (Dermochelys coriacea).*

Introduction

From March to July, leatherback sea turtles (*Dermochelys coriacea*) travel over 1000 kilometres to reach Matura Beach, Trinidad in order to reproduce (Eckert, 2004). Situated on the northeast coast of Trinidad, the area provides 8 km of prime nesting habitat to approximately 2000 female turtles. (Eckert, 2001). In the last 14 years a small, community based conservation organization known as the Nature Seekers has successfully stemmed all poaching at this vital Atlantic nesting assemblage. To financially sustain its activities , Nature Seekers provides guiding services to more than 10,000 visitors who want to view nesting by leatherbacks at Matura Beach. Starting at the beginning of the nesting season in March, visitors are required to make a reservation to enter the Matura Beach prohibited areas, obtain a pass and hire Nature Seekers to provide environmental interpretation during their visit to the beach. Each guide will supervise up to 25 persons at a time, to view turtle nesting, and the beach has a regulated limit of 100 persons per night.

As one of the largest and last leatherback rookeries on earth, it is critical that tourist-related disturbance of Matura's nesting assemblage is minimized so as not to negatively impact the survivorship of this fragile species. In this study we evaluate the effect of tourists on the behaviour of nesting leatherback sea turtles.

Female leatherbacks employ a series of stereotypic nesting behaviors beginning with emergence from the ocean. This is followed by the excavation of an egg-chamber and oviposition. Finally, females cover the eggs, distribute sand vigorously around the nesting site or "camouflage," and subsequently return to the surf (see table 1 for nesting summaries).

Previous research has shown that the durations of the covering and camouflaging phases in green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) turtles do not differ between tagged and untagged turtles, and that hatch success is not detrimentally affected by tagging (Broderick et al. 1998). However, it has also been demonstrated that loggerheads significantly reduce the duration of their camouflaging phase in the presence of observers (Johnson et al. 1996). Further, flash photography has also been discovered to be negatively associated with covering duration in green turtles (Campbell, 1994). It has long been postulated that leatherbacks are similarly affected by tourist-related disturbance variables, yet no research has addressed this question to date. The purpose of this study was to assess the effect of guided-tours on the nesting behavior of female leatherbacks. We hypothesized that leatherbacks would extend the camouflaging and covering phases in response to the presence of large tour-groups and the associated flash-light use and photography.

Methods

In order to compare nesting phase durations of turtles nesting in the presence and absence of tourist mediated disturbance factors, subjects were studied in two

distinct environments designated T (Tourist) and U (Undisturbed). Nesting females were located nightly from 4 April to 18 June between 2000 – 0200 h. The duration of each nesting phase was measured for all turtles sampled.

Nesting turtles sampled in environment T were exposed to a tour-groups ranging from 1-66 individuals. In addition to phase duration, tourist activities were quantified within environment T so that correlations between specific disturbance factors and nesting phase durations could be assessed. The number of tourists, children, flashlights in use, and camera flashes at each nesting phase was recorded. Additionally, every episode of physical contact between a tourist during each phase was enumerated. A record was made if tourists were within 10 feet of the turtle's anterior. The type and quantity of tags administered, as well as the phase of application, was documented. At the completion of each nesting phase, a qualitative index (1-10), representing the overall intrusiveness of the tour group was recorded. Higher numbers depict excessively intrusive tour groups.

Nesting phase durations were also recorded for tour-free nesting turtles in environment U (n=35): which constituted the isolated nesting areas 800 m south and 800 m north of the beach's entrance. This ensured that lights and flash-photography from tour-groups were not visible to nesting turtles. The researcher was situated at least 1 meter behind the posterior end of the turtle throughout each nesting phase; the only exception being oviposition. A non-invasive red light emitting diode (LED) was used to light the base of the egg chamber prior to oviposition to ensure that the onset of the phase was easily observable. During oviposition, tags were administered and/or read, and carapace measurements taken. A red LED was occasionally used, always beneath the carapace, to determine the onset and completion of specific phases on particularly dark nights, most notably the transition from body pitting to digging. In both environment T and U, all data were recorded by a single researcher.

Two sample t-tests (independent samples) were used to compare the mean nesting phase durations between experimental (environment T) and control turtles (environment U). We used a Pearson correlation matrix to compare nest phase duration to the following 7 tourist related variables: observers, children, flashlights, flashes, touches, observer proximity, and intrusiveness. Additionally, the potential of turtle size to exert a confounding effect on our analysis prompted us to explore the relationship between phase duration and CCL in control turtles. Given that we are calculating 40 correlation coefficients, we applied a Bonferonni significance correction to maintain an overall Type I error probability of 0.05.

Results

The durations of all nesting phases were similar between experimental and control turtles (two sample t-tests, independent samples, $p>0.1$). Initial exploratory correlation results were as followed: the number of flashlights in use was positively associated with oviposition duration in experimental turtles (Pearson correlation, $Rp = .39$, $p<.05$). Covering duration increased with the number of children present ($Rp = .41$, $p<.05$, Table 3), and camouflaging duration increased with the observer

group's level of "intrusiveness" (Rp = .33, p<.05). Digging duration was positively association with both flashlights (Rp = .54, p<.05, Table 3) and "intrusiveness" (Rp = .69, p<.05). There was also a moderately strong negative association between control turtles' oviposition phase and CCL ((Rp = -0.46, p<.05). However, after correcting our analysis with a Bonferonni adjusted alpha level, the significance level for a single correlation coefficient was set at 0.001. Following this correction, all of the aforementioned associations were rendered non-significant.

Discussion / Conclusions

In this experiment, we used the timing of nesting behaviour as an index of disturbance for nesting leatherback sea turtles. Our results demonstrate no effect of tourism on this disturbance variable. Means and variances for nesting phase durations did not differ between the experimental and control groups. We can therefore propose that Matura's tourism program does not impact the behaviour of nesting leatherbacks, presuming that the duration of time it takes a turtle to nest is a measure of disturbance as implied by other studies.

Our results are generally consistent with previous research on the effects of ecotourism on other sea turtle species. Previous studies revealed no correlations between observer group size and oviposition and camouflaging duration in loggerhead sea turtles. In addition, the mean durations of all loggerhead nesting phases, with the exception of camouflaging, did not differ significantly between experimental and control turtles (Johnson et al. 1996). In further conjunction with our results, it has previously been discovered that green turtles nesting at Tortugeuro, Costa Rica, are not significantly affected by flash photography. The mean nesting phase durations of flashed and un-flashed turtles were similar (Campbell et al. 1994). The comparability of means regarding disturbed and undisturbed subjects has been consistent to date in all research on the effects of ecotourism on sea turtles.

Some minor interspecific differences may exist in sea turtles' responses to ecotourism. For instance, Campbell et al. (1994) sites a negative correlation between the covering phase and flash photography in green turtles that is significant at the $\alpha = 0.05$ level ($p=0.03$). Research by Johnson et al. (1996) cited a significant reduction in loggerhead's camouflaging phase in the presence of observers, as compared to turtles with no observers. However, conflicting research by Jacobsen et al. (2000) suggests that the nesting behavior of green turtles at Tortugero was not affected by tourism mediated disturbance. Johnson observed no difference between nesting, false nests, and false crawls on high tourism density nights and low tourism density nights. In summation, previous studies have failed to discern that guided tours exert a concrete negative effect on nesting turtles.

The use of nesting behaviour duration may however not be the best measure of disturbance for leatherback sea turtles and needs confirmation. Leatherback sea turtles are generally considered to be less sensitive to disturbance during nesting and are thus more difficult to determine behavioural discomfort. While other sea turtles will readily cease nesting if disturbed, leatherbacks seem to be less reactive.

Future research will focus on refining our capacity to measure the behavioural state of nesting leatherbacks. For example, we will evaluate whether turtles tend to move nesting out of the impact area where tourism is allowed. We will also measure a number of physiological variables that may provide insight into leatherback behavioural state. .

Literature Cited

Broderick, A.C., Godley, B.J. 1999. Effect of tagging Marine Turtles on nesting behavior and reproductive success. Animal Behaviour, 58, 587-591.

Campbell, G. L. 1994. The effects of flash photography on nesting behaviour of green turtles (Chelonia mydas), Tortuguero, Costa Rica. In: Proceedings of the 14th Annual Workshop on Sea Turtle Biology and Conservation (Ed. by K.A. Bjorndal, A.B. Bolten, D.A. Johnson & P.J. Eliazar), pp. 23-24.

Eckert, S. A. (2006). High-use areas for Atlantic leatherback sea turtles (Dermochelys coriacea) as identified using satellite telemetered location and dive information. Marine Biology 149, 1247-1257. Johnson, S.A., Bjorndal, K.A. & Bolten, A.B. 1996. Effects of organized turtle watches on loggerhead (Caretta caretta) nesting behavior and hatchling production in Florida. Conservation Biology, 10, 570-577.

Jacobson, S.K. Biological Impacts of Ecotourism: Tourists and Nesting Turtles in Tortuguero National Park, Costa Rica. Wildlife Society Bulletin. 22(3) 1994.