An assessment of population size and status of Trinidad's Leatherback Sea Turtle Nesting Colonies

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Abstract

The Republic of Trinidad and Tobago supports nesting by one of the three largest leatherback sea turtle (*Dermochelys coriacea*) nesting colonies in the world. Ad hoc measurements of the size of the nesting population were conducted from the late 1960s through the early 1990’s and evolved into regular monitoring with the formation of the community conservation group Nature Seekers in the early 1990s. Most population monitoring has been at Matura on the east coast of Trinidad, one of the nation’s largest nesting colonies. Methods of monitoring have varied from nocturnal beach patrols to count nesting turtles to tagging and mark-and-recapture analysis and daily nesting activity counts. Taking these data together, analysis suggests that Trinidad’s leatherback populations grew through the 1990s at about 5% per year, and that this growth probably reflected a general increase in northern Atlantic leatherback populations during that time. However, since 2006, Trinidad’s population has been in a continuous and rapid decline. The decline stands in contrast to what appears to be a generally increasing trend for the North Atlantic population, suggesting that the primary cause for the decline is local to Trinidad. It is likely that the high level of mortality of leatherbacks in coastal gillnet fisheries of Trinidad are the cause of the decline, and that this mortality threatens to undo all of the successful conservation of the species. I propose that continuing mortality of leatherback sea turtles by coastal fisheries will reduce the population size to pre-1990s levels and may result in population extinction.

Introduction

Globally, the leatherback sea turtle is classified as Critically Endangered by the International Union for the Conservation of Nature (IUCN) (Sarti Martinez 2000) with Pacific Ocean nesting aggregations in severe decline (Eckert & Sarti 1997; Hitipeuw et al. 2007; Saba et al. 2008; Sarti et al. 1996; Sarti M. et al. 2007; Spotila et al. 2000; Tomillo et al. 2007) and, with few exceptions, Atlantic Ocean nesting is increasing (Chacon & Eckert 2007; Dutton et al. 2005; Girondot et al. 2007; Hilterman & Goverse 2007). The largest nesting aggregations for the leatherback in the Atlantic are found on the beaches of northeastern South America along the coasts of French Guiana and Suriname (Girondot et al. 2007; Hilterman & Goverse 2007), in Western Africa on the 600 km long coastline of Gabon (Witt et al. 2009), and on the Caribbean Sea Island of Trinidad (Eckert 2006). In this report I assess the size and population trajectory of the Trinidad nesting colony of leatherback sea turtles. For a global summary, see Eckert et al. 2011.

History of Trinidad's Nesting Population Counts

The southern Caribbean Island of Trinidad has long been known to support nesting by leatherback sea turtles (Bacon 1970; Fournillier et al. 2008), although no scientific investigation of the species on this island was undertaken until the 1960s by the Trinidad Field Naturalists' Club (Bacon 1970). Between 1965 and 1968, the Club organized irregular nocturnal patrols along 3 km of the northern section of Matura Beach (now called the 'Rincon' section). Matura Beach stretches along 8.0 km of Trinidad's east coast, bounded by a rocky headland to the north and the Oropuche River to the south. Matura is one of three major leatherback nesting beaches on the island, the other two are Grande Riviere on the north coast and Fishing Pond located just south of Matura Beach. There are also a large number of smaller nesting sites located along the northern and eastern coasts of the island.

Basic biological information on nesting turtles, collected by the Field Naturalists' Club, included turtle size and number of turtles nesting. Bacon (1970) reports that the mean size (curved-carapace length) of 20 leatherbacks was 158 cm (range 125 – 185 cm) and mean curved width was 105 cm (range 75 – 117 cm). Bacon (1970) also estimated the size of the nesting population by using an 8-day count from 16 – 23 May 1969, during which time 34 turtles were observed nesting. He suggested 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 noted that in 1968, 23 leatherbacks were killed by local villagers and in 1969, another 13 were killed on the northern section, leading him to conclude that the killing of these turtles represented a minimum number and that 20 – 30% of all nesting females were killed each year.

Between 1981 – 1983, Chu Cheong conducted partial night (20:00h – 24:00h) nocturnal surveys on the same northern section of Matura Beach and recorded a total of 156 nesting turtles (35 in 1981, 67 in 1982, and 54 in 1983) (Chu Cheong 1990). She also noted that leatherbacks are commonly killed at Matura Beach. In 1981, five carapaces were found and in 1982 and 1983, 2 and 7 carapaces (respectively) were observed. Chu Cheong also flew regular air surveys along the coastal beaches to estimate nesting density, describing the northern section of Matura as 'moderate' in terms of nesting (5-20 tracks and the mid-section as 'high' (>20 tracks). Nathai Gyan et al. (1987) estimated that 500 – 900 turtles nested annually in Trinidad between 1984 – 1987; however, a lack of information on collection methods makes this number difficult to confirm. She reported that typically 1 – 6 turtles nested during each night of patrol at Matura, but it is unclear which section of beach was monitored or the time period of data collection.

Census of the Nesting Population

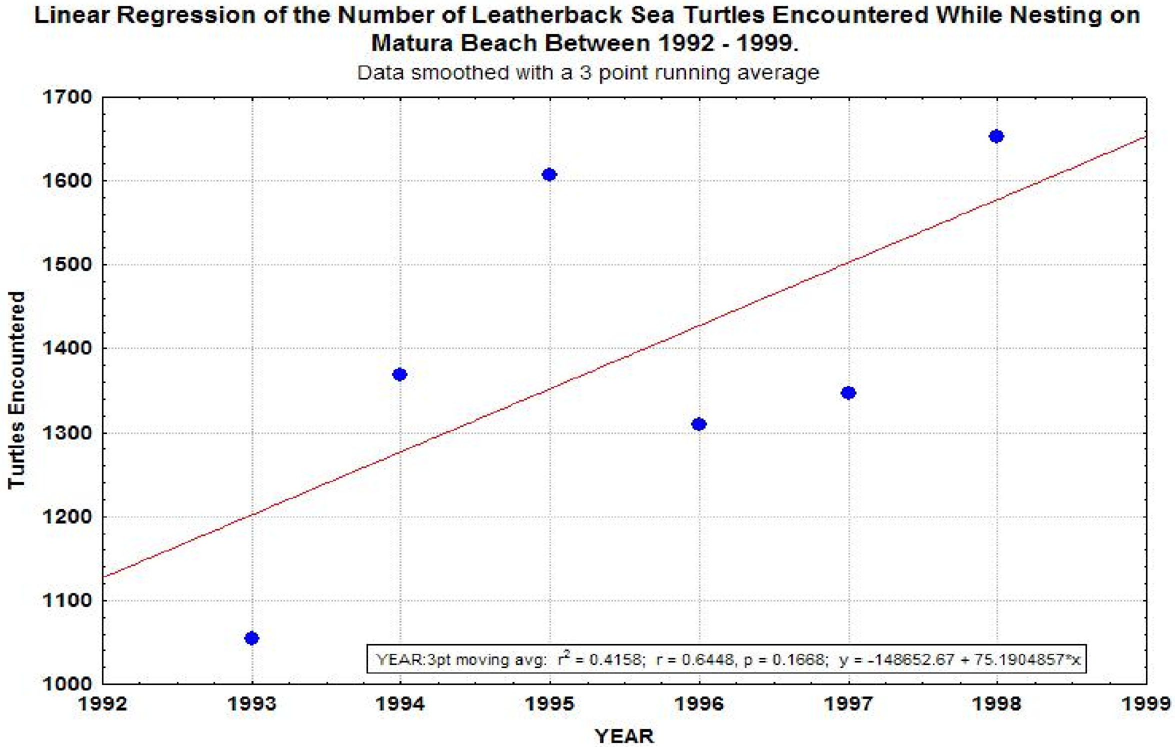
Regular all-night nesting patrols of the northern, mid and southern sections of Matura Beach (known as 'Rincon' and 'Orosco' sections) were initiated by a community conservation group, Nature Seekers, in 1992. Early patrol efforts from 1992 – 1999 were directed primarily toward the protection of nesting turtles and supervising visitors to the beach. As turtles were encountered they were counted and measured, but no other data were recorded. While nocturnal 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 but *not* the total number of individuals nesting. Turtles could have been counted more than once (some leatherbacks nest 10-plus times per year) and it is likely that all turtles were not encountered. Total number of turtles counted ranged from 604 – 2236 between 1993 – 1999 (Table 1). However, because Matura Beach patrol effort encompassed the entire beach and was relatively consistent from 1993 – 1999 (Table 1) it can be assumed to represent equal effort between years, and we can, thereore, estimate a population trend for this time period.

Leatherback turtles in the Caribbean rarely nest each year, most nest every 2 or 3 years. Furthermore, there is variation in the proportion of the population of turtles that arrives to nest in any given year (i.e., turtles may vary when they nest, sometimes nesting every 2 years and sometimes every 3 year) so that smoothing the data with a 3-point running average is prudent when using nesting data to evaluate population trends. Smoothing in this way accommodates the annual variation in the proportion of the population nesting in any one year. A linear regression fit to the smoothed data provides an average annual growth rate for the population (Figure 1) and shows that between 1992 – 1999, the Matura population grew an average 4.68% per year. While this represents a positive growth trend, it is substantially lower than the average growth rate reported from the northern Caribbean (e.g., ca. 13% growth at Sandy Point, St. Croix, between 1993 – 2001, see Dutton et al. 2005).

The average proportion of turtles nesting within the 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).

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

Table 1 – Patrol dates and leatherback sea turtles (*Dermochelys coriacea*) encountered at Matura Beach (sections Rincon and Orosco) between 1992 and 1999.



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, beach patrol objectives shifted significantly in an effort to improve tourism supervision on the beach. Patrol effort was no longer dedicated to beach-wide survey, but rather to high intensity coverage of an index area. Each turtle encountered in the index area was identity-marked using flipper tags and Passive Integrated Transponder (PIT) tags. The foot patrolled area was significantly reduced to cover the beach primarily from the Matura River south approximately 3 km. The patrol objective for Rincon was 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 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 by poachers 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 a study of the distribution of nesting. Most beach patrol teams covered sections 8 – 14 from 20:00h – 02:00h.

Tagging turtles can provide a highly accurate means of assessing both population size and population trends. Because each turtle is assigned a unique identity number, the potential to count the same turtle again during a subsequent nesting event is greatly reduced. However, to be accurate, such counts must be extremely intensive with the entire colony counted during all possible nesting times (both nightly and seasonally).

Given the size of the Matura Beach colony (8+ km long) and limited staff available to make such counts, I have chosen to use an assessment method called open-robust mark-recapture analysis. While this method is used commonly for assessing animal populations, its use with nesting turtle populations has only recently been attempted (Kendell & Bjorkland 2001). The 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. Moreover, 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 of all turtles in 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 between 1999 – 2008 yielded an annual nesting population size that ranged from 1563 to 5902 leatherbacks nesting each year (Figure 2).

In 2006, the Matura Beach project was able to secure extramural funds from WIDECAST in order to institute another population assessment in parallel with the tagging program. This parallel program had the advantage of being extremely cost- and labor-efficient as it required only a single survey of the entire colony once per day. Each day all nests deposited on the previous night were counted and their location recorded by Global Positioning System (GPS) receivers. 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 has been challenged, see Briane et al. 2007), sea turtle nest counts are often used to estimate the total number of turtles nesting.

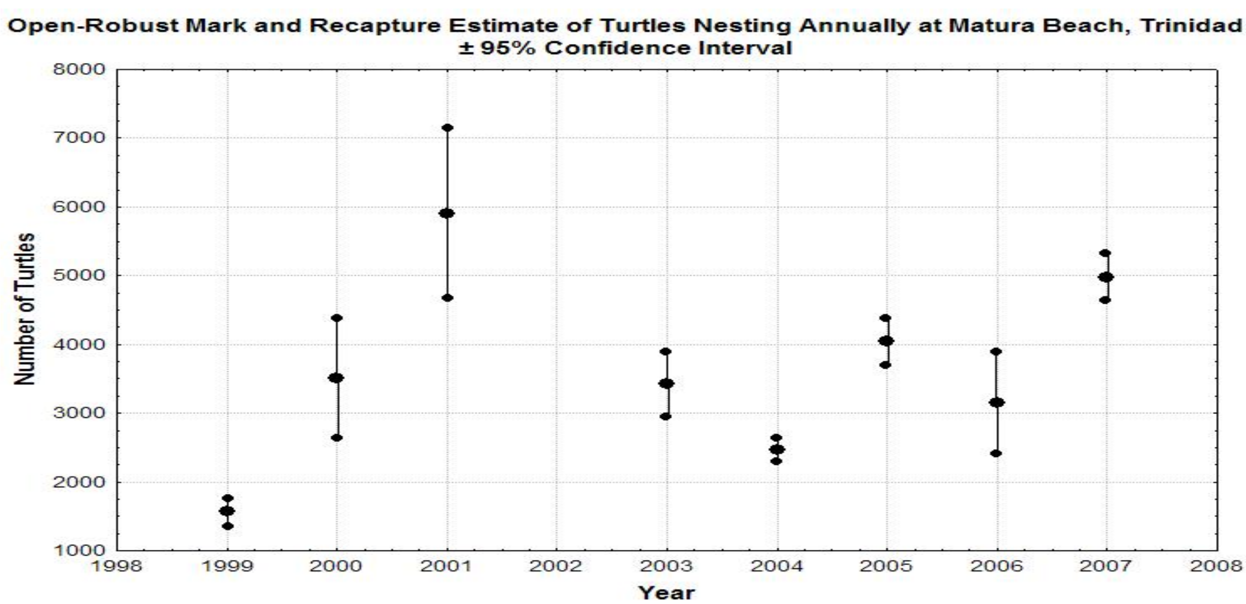


Figure 2 – Number of leatherback sea turtles (*Dermochelys coriacea*) estimated to nest at Matura Beach between 1999 and 2007, using Kendell's open-robust mark and recapture model.

Confirmign whether eggs were successfully laid is important. However, leatherback eggs are notoriously difficult to find after deposition. In contrast, 'body pits' (the disturbed area left when a turtle attempts to build a nest) can be accurately counted because of their persistence and ease of detection and because they approximate the location of a nest with eggs. Thus for our surveys we chose to count body pits. To convert the body pit count to a nest count we used nocturnal beach patrols to record how often leatherbacks at Matura are successful in depositing a nest with eggs within each body pit. We found that 97% of all body pits at Matura contain a nests with eggs and thus, we use the number of body pits recorded each year reduced by 3% and divided by 5.26 to estimate how many turtles nest on Matura beach. In 2007 and 2008, with more financial assistance from WIDECAST, we extended the census of body pits to the other major nesting beaches on Trinidad to calculate a national leatherback nesting estimate.

Our first year of the daily census was limited only to the Orosco (middle and south sections of Matura beach) while the survey project developed its logistical structure and methods. This count yielded 4208 body pits. Delays in obtaining funding prevented the initiation of the census until 4 April 2006, more than one month after the start of nesting. However, I was able to apply a correction model (Girondot et al. 2006) that enables missing data to be estimated during "gaps" in the daily survey tally. Our final body pit estimate for the Orosco section was 4325.7 (95% CI: 4299.64 - 4351.87).

Renewed funding in 2007 allowed us to extend the daily census to two other major nesting beaches in Trinidad, as well as a number smaller north and east coast nesting beaches. Fishing Pond beach is a 10 km long nesting beach contiguous to the south of Matura Beach but separated from Matura by the Oropuche River. Daily counts of body pits on this beach were conducted in a manner similar to the census on Matura Beach. The other major nesting beach is the 800-meter long Grande Riviere Beach on Trinidad's north coast. Because the density of turtles using this beach is so high, a morning body pit count was not feasible as turtles crawl over and disguise the evidence of previous nests. Instead we hired two patrollers to monitor the beach continuously all night and tally each nesting attempt. To preclude double counting turtles, a small water soluble paint spot was placed on each turtle during the patrols.

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; therefore, I processed these data with the previously described "gap filling" model (Girondot et al. 2006). Despite the lack of patrol on the Rincon section of Matura beach, I was able to estimate nesting on that section because our data from 1993 – 1997 showed that an average of 34.4% of all Matura nests are laid in Rincon (see Table 1). Finally, to estimate the number of turtles from the total nest count, I divided the average number of nests laid annually for Caribbean leatherbacks (5.26) from Boulon et al. 1996. By 2009, surveys on Matura Beach were extended to the entire beach (Orosco and Rincon sections). The results are presented in Table 2.

YEAR	LOCATION	# BP COUNTED	# BP ESTIMATED	95% CI	CALC. # OF TURTLES
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
2009	MATURA / OROSCO+RINCON	4,791	---------	---------	2,756
2009	FISHING POND	8,991	---------	---------	---------
2010	MATURA / OROSCO+RINCON	10,442	---------	---------	3,381*
2010	FISHING POND	6,461	---------	---------	---------
2011	MATURA / OROSCO+RINCON	7,326	---------	---------	2,357*
2011	FISHING POND	2,258	---------	---------	---------
2012	MATURA / OROSCO+RINCON	4,137	---------	---------	1,404*
2012	FISHING POND	2,881	---------	---------	---------

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.). *Note that from 2009 on it was recognized from tagging data that there was a very high number of turtles depositing nests on both Matura and Fishing Pond beaches, thus all calculations of turtle abundance are combined into one estimate for the Matura/Fishing Pond nesting complex.

Combining All Assessments: Status and Trends of the Trinidad Leatherback Population

Despite the multiple changes in methods used to gather and assess nesting by leatherback turtles nesting in Trinidad between the earliest counts of the 1960s and today, we can, nevertheless, assess the trends and status for the population with some degree of confidence.

Our starting point can be data collected by the Field Naturalists' Club. While those surveys were not rigorous in terms of data collection or quantity, and did not attempt to survey all nesting, the 8-day count during the peak of nesting in 1969 on the Rincon section of Matura beach gives a point of comparison for current data. In 1969, Bacon (1970) reports 34 turtles counted on the Rincon section of Matura Beach. It is unclear whether this was 34 turtles or 34 successful nests, but we can assume that each event represented an individual turtle and her nest, since leatherbacks typically renest every 10 days and the 8-day period falls within this window. With this in mind, we resampled our Rincon data for a similar 8-day time frame using our 1993 – 1999 and 2009 – 2012 data (no survey data was collected at Rincon between 2000 – 2008) (Table 3). While such extrapolations should be interpreted cautiously, it is useful to note that the range of nest counts during the same 8 days of nesting between 1993 – 1999 encompass that of the count in 1969, but by 2009 – 2012 the counts had increased substantially.

Year	Number of Nesting Activities
1969	34
1993	39
1994	81
1995	42
1996	26
1997	76
1998	83
1999	43
No Data 2000 - 2008	-----
2009	420
2010	580
2011	212
2012	103

Table 3 - Number of leatherback sea turtle (*Dermochelys coriacea*) nesting activities during an 8 day survey period, on Rincon section of Matura Beach, 1970 - 2012.

Our analysis of the beach patrol data from 1993 – 1999 implies an annual growth rate of 5% per year (Figure 1). This growth rate is lower than the 13% reported from a smaller colony at Sandy Point National Wildlife Refuge (St. Croix, USVI) in the northern Caribbean during a similar time frame (Dutton et al. 2005), but the rate of increase identical to that reported between 1967 – 2002 for the other large southern North Atlantic colony in French Guiana (Girondot et al. 2007), suggesting that the Trinidad population increase of the 1990s reflects a population increase within the greater North Atlantic population which nests throughout the Wider Caribbean Region.

With the advent of both tagging and daily nesting surveys and with the addition of Fishing Pond and Grande Riviere to our monitoring program, our capacity to evaluate the status of the entire Trinidad nesting population was realized. Based on tag returns, we determined that Matura and Fishing Pond beaches are actually a single nesting colony as turtles nest freely between both of these beaches. Because of this recognition the Nature Seekers and WIDECAST have continued to fund nesting patrols on both Matura and Fishing Pond, and consider it a single nesting colony. Grande Riviere also has some turtle exchange with Matura/Fishing Pond, however at a low enough level to warrant it being considered a separate colony for sake of management activities. Our data suggests that an equivalent number of turtles nest in each colony. In 2007 and 2008, Grande Riviere supported 45.8% and 49.7%, respectively, of all nesting from monitored beaches on the island. While nesting occurs elsewhere on Trinidad, such as the north coast beaches of Madamas and Grande Tacaribe and the east coast beach of Manzanilla, our data from 2007 determined that all of these areas combined represent less than 10% of all nesting on the island.

To continue our assessment of nesting, only the Matura/Fishing Pond nesting data are sufficiently long-term to evaluate population status and trend. This is unfortunate, as I am not yet sure that Grande Riviere and the Matura/Fishing Pond colonies are synchronized in terms of annual nesting numbers (although the data suggest that this is likely). To determine population trends since 1997 for the east coast colonies, I converted all nesting into the total number of female turtles. My rationale for this conversion is that the mark-recapture model reports number of individual female turtles, while the nest survey data reports number of nesting activities. We can readily convert nests to number of females using the total number of nests laid per female annually from other studies.

It is apparent from our assessment of total number of nesting turtles that the east coast nesting population of leatherbacks continued to grow through the 1990s until 2006, and has been in a rapid and continuous decline since that time (Figure 3).

If we compared current nesting activity to that of those recorded in the early 1990s or even the late 1960s (Table 3), it is apparent that the population has not declined to these historic levels, but it does appear that the gains in population size through the 1990s are being rapidly reversed. Because of the close link between population trends of the greater North Atlantic leatherback population and those nesting on Trinidad, it might be expected that the greater Atlantic population is also in decline. However, this is not the case (Eckert et al. 2011) and comparisons can be seen in Figures 3 and 4. Since both northern and southern Caribbean populations of leatherbacks forage in the same regions of the North Atlantic, it must be concluded that the recent downturn in population numbers for the Trinidad colony are due to local threats and that those threats are so severe as to counter what has generally been a positive upward trajectory on the greater Atlantic population from which Trinidad's nesters are drawn.

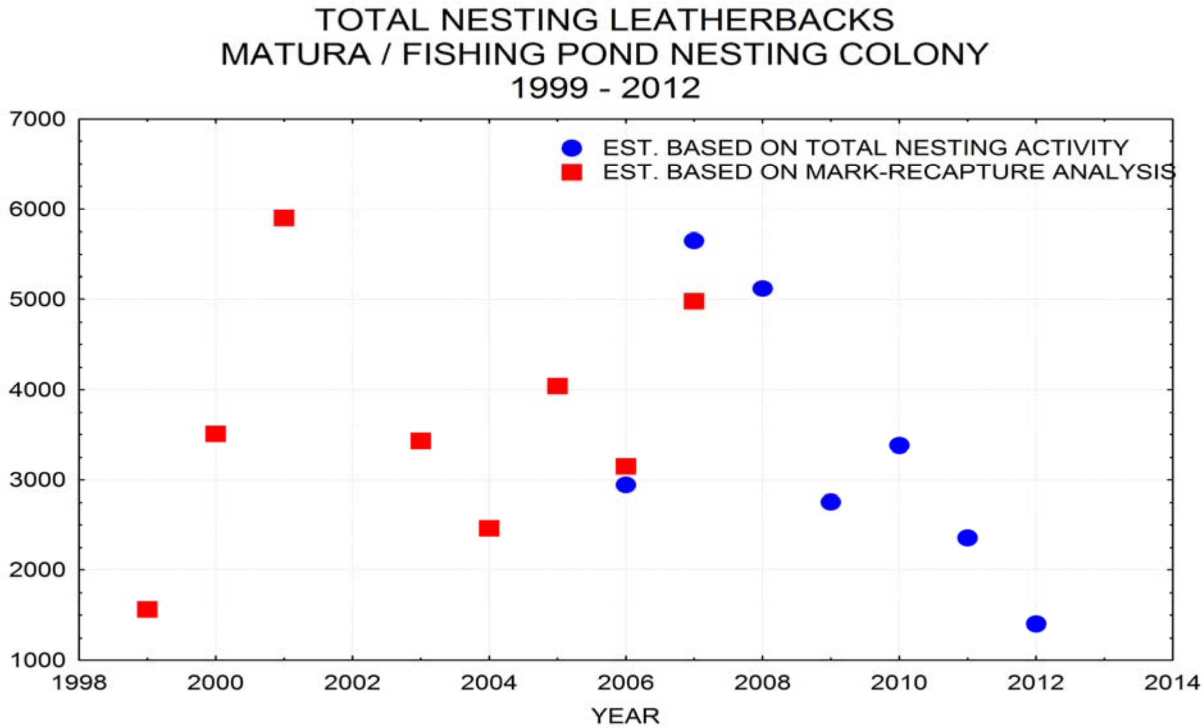


Figure 3 - Annual number of leatherback sea turtles (*Dermochelys coriacea*) nesting in the Matura/Fishing Pond nesting beach complex on the eastern coast of Trinidad since 1999.

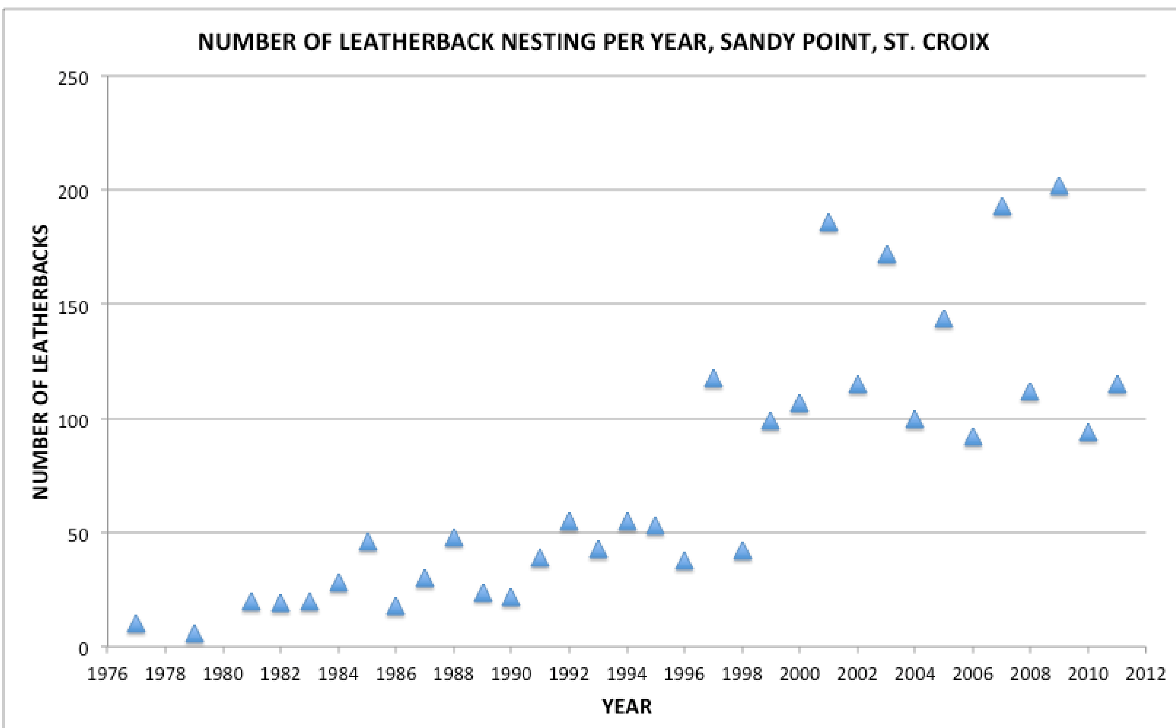


Figure 4 – Annual number of leatherback sea turtles (*Dermochelys coriacea*) nesting on Sandy Point National Wildlife Refuge, St. Croix, USVI, since 1977 (Dutton et al. 2005).

Trinidad's Nesting Population Trajectory

The recent declining trajectory of Trinidad's nesting population is cause for alarm, despite the relatively short time frame of this trend.

Given what is known about the North Atlantic population and that it appears to be continuing to increase, it must be considered that the reason for the declining trend is local to the Trinidad colony. It is well understood that there is an exceedingly high mortality of leatherback turtles in the coastal gillnet fisheries of Trinidad, with catch rates exceeding 3000 leatherbacks per year, and annual mortality estimated at above 1000 egg-bearing turtles (Eckert 2008; Eckert & Eckert 2005; Eckert & Gearhart 2008; Eckert et al. 2008; Eckert & Lien 1999; Gearhart & Eckert 2007; Lee Lum 2006). Despite extensive efforts since 2005 to reduce this source of mortality and the development of methods that can reduce entanglement by 65 – 90% and mortality by 90 – 100% with no reduction in fisher income, adoption of these methods by fishers has been slow. In the absence of widespread use of fishing methods that do not kill sea turtles, high sea turtle mortality within the coastal gillnet fishery will continue with devastating results to the turtles.

Particularly alarming about the current population trajectory and the impact of fishing mortality on the population is that the source of mortality is directed at reproductive adult turtles. Reproductive-age sea turtles are the most sensitive component of any population, and their destruction has the greatest impact to population stability. Trinidad's decline mirrors closely the destruction of the world's largest leatherback population in the eastern Pacific. In 1979, the population of leatherbacks nesting on the Pacific coast of Mexico was reported to exceed 75,000 female turtles (Pritchard 1982), by 1995 this population was driven to less than 1000 turtles (Sarti et al. 1996; Sarti M. et al. 2007) and is even lower today. The primary cause for this decline was the introduction and large scale deployment of coastal gillnet fishing for swordfish in the eastern Pacific leatherback foraging areas off Chile and Peru in the early 1980s (Eckert & Sarti 1997). Much as in the case of Trinidad, turtles caught in these fisheries were primarily adult leatherbacks, but in the case of the eastern Pacific population the mortality was directed against reproductive and non-reproductive (large juvenile) turtles. Trinidad's fishery mortality is likely far more destructive as it is applied to only reproductive age class turtles.

Conclusions

Trinidad's leatherback nesting colony is one of the largest in the Atlantic Ocean (and the world), comparable to nesting along the mainland coasts of South America and West Africa. Current status of the Trinidad nesting colony is alarming. Despite strong growth in the population through the 1990s and dramatic progress in protecting turtles on their nesting beaches, the population has been in a rapid decline since 2006. This decline does not reflect a wider North Atlantic population trend (which continuea to grow), leading to the conclusion that the primary cause of the decline is local to Trinidad. The primary cause for the decline is likely the continuing high mortality of leatherbacks in coastal gillnet fleets. It is likely that Trinidad's leatherback population will continue to decline and may be extirpated if gillnet mortality is not eliminated.

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