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GUIANAS FORESTS & ENVIRONMENTAL CONSERVATION PROJECT

Annual Report on the 2004 Leatherback Turtle Research and Monitoring Project in Suriname

Prepared by:

M.L. Hilterman and E. Goverse

Hosted by the Netherlands Committee for IUCN
In collaboration with the Foundation for Nature Conservation Suriname (STINASU)

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EXECUTIVE SUMMARY

- Fieldwork was conducted between April 17th and July 29,th 2004 at Babunsanti by the field coordinator and a small team of research assistants.
- A total of 645 individual leatherback females were observed. New PIT tags were applied to 294 individuals (45.6%), the remaining 351 (54.4%) carried PIT tags already. Since 1999, a total of 7,881 leatherback females were observed nesting in Suriname.
- Taking into account the incomplete beach coverage and thus unobserved nestings, the total number of nesting females in 2004 is estimated to be at least 1,545. This should, however, be considered a *minimum number.*
- Of the previously tagged turtles, 1 was a remigrant from 1999, 7 were remigrants from 2000, 115 were from 2001, 132 from 2002, 1 from 2003, 5 were remigrants that nested in more than one previous season and 90 turtles (14.0%) had a PIT code not known for Suriname. A substantial part of the latter had expectedly been tagged in French Guiana, but erroneous codes may also be included.
- One female with flipper tags from Nova Scotia, Canada, and no individuals with flipper tags from French Guiana or Trinidad were observed during the 2004 season.
- The total number of tag records, including 391 within-season recaptures, was 1,036.
- Of the observed nesting cohort of 1999 (n = 69), 40.6% had been seen again by 2004. Of the 2000 cohort (n = 455), this was 16.0% and of the 2001 cohort (n = 2,927) this was 16.4%. Six individuals (6.2%) of the 2002 cohort (n = 2,283) returned in 2004. Twelve individuals have been encountered in three different nesting seasons in Suriname.
- As only one beach was covered in 2004, nesting exchange of females between beaches could not be observed.
- The mode of the observed internesting period (OIP) was 9 days. Mean OIP was 9.6 ± 1.0 (n = 181).
- Mean observed clutch frequency (OCF) was 1.6 ± 1.0 nests (n = 645 females). OCF ranged between one and seven nests. Of all females, 63.6% (n = 410) was seen nesting only once.
- The estimated clutch frequency (ECF) for turtles seen at least twice was 4.1 ± 1.8 nests (n=140).
- The proportion of one-time observed nesters was significantly lower among the remigrant females (52.5%) than among the newly tagged females (69.4%) and non-Surinamese females (76.7%).
- Mean ECF was higher for the remigrants (4.2 ± 1.7 nests) than for the new turtles (4.0 ± 1.8 nests) and non-Surinamese turtles (3.9 ± 2.3 nests), but in 2004 this difference was not significant (in contrast to the 2002 and 2003 seasons).
- Based on PIT tag data (number of observed nestings plus missed nestings per night; false crawls excluded) and rough estimates for beaches/sections that were not monitored, the estimated *minimum number* of nests after correction for incomplete beach coverage is 6,600.
- Mean curved carapace length (CCL) of leatherback females was 155.6 ± 6.7 cm, mean curved carapace width (CCW) was 114.5 ± 4.9 cm.
- Mean CCL of new turtles (154.0 ± 6.8 cm) was highly significantly smaller than that of non-Surinamese turtles (156.4 ± 5.6 cm) and remigrants (157.2 ± 6.5 cm).
- One dead leatherback female was observed stranded at Babunsanti. No data for Samsambo, Kolukumbo/Marie and Matapica are available.
- A first data analyses indicates that of the 645 individuals observed during the 2004-nesting season, a minimum of 10.5% had injuries or scars that may have been a result of interactions with fisheries.
- A total of 75 leatherback nests were marked for monitoring, 68 of which the fate was determined. Two nests were excluded from further analyses because they were mixed with other nests or had been disturbed.
- A total of 63.6% of the marked nests did hatch. Of these, average hatch success was 28.7 ± 22.1%. Overall average hatch success, including the zero-hatch success of the unsuccessful nests, was 18.2 ± 22.4%.
- A (non-random) selection of unmarked *in situ* leatherback (n = 37) and green turtle (n = 134) nests were also excavated and analysed.
- Average hatch success for the unmarked leatherback nests was 42.5%. This is not representative for the overall hatch success at Babunsanti, because nests with no or only few hatchling tracks may have easily been overlooked.
- Of the marked nests, 92.4% were attacked and on average 35.3 ± 20.9% of the yolked eggs per nest depredated by mole crickets. In 2004, no egg depredation by ghost crabs was recorded.
- Average clutch size was 88.2 ± 19.5 yolked eggs and 29.1 ± 17.1 yolkless eggs.
- Mean incubation period was 63.2 ± 1.2 days (n = 13) with a range of 61 to 65 days.
- Mean nest bottom depth was 73.0 ± 10.6 cm (n = 66) with a range of 46 to 104 cm.
- Assuming an average metabolic heating of 0.5°C during the middle third of the incubation period (day 20-40) when hatchling sex is determined, nests laid after approximately June 10th-15th will have produced predominantly females and nests laid before that predominantly males.

1. INTRODUCTION

Some of the globally most important nesting beaches for leatherbacks (*Dermochelys coriacea*) are found in eastern Suriname and western French Guiana, particularly inside and in the vicinity of the mouth of the Marowijne River, that separates Suriname from French Guiana.These beaches also provide important nesting sites for the green turtle (*Chelonia mydas*) and the olive ridley (*Lepidochelys olivacea*). It has been estimated that over 40% of the world leatherback population nests in Suriname and French Guiana (Spotila *et al.* 1996), and these leatherbacks are believed to represent a single nesting population (Pritchard 1971, Schulz 1975, Girondot and Fretey 1996, Dutton *et al*. 1999). More recently, other large leatherback nesting populations have been reported for Trinidad (pers. comm. of A. Rambaran and M. Ramjattan, Nature Seekers; Sammy in press.), West Africa (e.g., Gabon) (Billes *et al.* 2003) and along the Caribbean coast of Central America (Troëng *et al.* 2004). Most former mass leatherback nesting colonies in the Pacific and Indian Oceans have collapsed (Spotila *et al*. 1996, 2000). The species is enlisted as critically endangered in the IUCN Red List of Threatened Species (IUCN 2000), but this status is strongly disputed (e.g., Girondot 2002, Mrosovsky 2003, Hilterman and Goverse 2004).

The leatherback nesting season in the Guianas typically spans from early April to early August in the rainy season with a peak in May-June. A second, smaller and less significant nesting season occurs around December (Chevalier *et al.* 2000). Observations reported here represent the main nesting period.

Project history
In contrast to the nesting leatherbacks in French Guiana, that have been intensively studied and tagged since 1970 (Pritchard 1971, Girondot and Fretey 1996, Rivalan 2003), the Surinam leatherback population had, until recently, received relatively little scientific attention. However, annual nest count data were collected for most years since 1967 by the Foundation for Nature Conservation Suriname (STINASU) (e.g., Schulz, 1975, Reichart and Fretey 1993). The annual number of counted nests highly fluctuated but has increased from less than 300 in the late 1960s to peaks of over 10,000 nests in the 1980s (Reichart and Fretey 1993), but since nest counts are often incomplete (De Dijn 2001, pers. obs.) it is likely that these nest numbers are underestimates of the true number of nests laid (Hilterman and Goverse 2002).
In order to obtain better information on the minimum size, and parameters of the leatherback nesting population in Suriname and to assess the extent of nesting exchange with French Guiana, a PIT tagging project was started in 1999, initiated and funded by WWF-Guianas. PIT tagging has also been carried out on Ya:lima:po beach in French Guiana since 1998 (Chevalier and Girondot 2000), and on Shell Beach in Guyana since 2000. In addition to the tagging data, biometric data and data on nest survival, hatch success and sand temperatures have been collected annually. All activities of this ongoing project were carried out in close collaboration with STINASU.

Goal
To add to the protection of the leatherback turtle nesting population in Suriname and the surrounding countries, by means of:
- Assessment of population size and trends in order to improve conservation strategies and update regional and global status reports;
- Capacity building, and;
- Loal and international collaboration.

Specific objectives
Objectives over a period of several years are to:
- Determine the number of leatherback females nesting in Suriname and the number of nests they produce, and trends of this population (e.g., clutch frequency, internesting intervals, beach fidelity) by means of a PIT tagging program;
- Determine nest survival and hatch success for *in situ* leatherback nests;
- Determine the prevalent sex-ratio of hatchlings, based on sand temperature profiles;
- Obtain biometric data on nesting leatherbacks;
- Qualify and quantify the threats facing adults turtles with a special focus on fisheries related injuries and mortality;
- Train (local) students and field personnel of the counterpart in sea turtle biology and research techniques.

Beach locations
Due to the westward-oriented Guyana Current and north-easterly trade winds, the Surinam coastline is highly dynamic and subject to successive phases of beach erosion and accretion. The coastline is dominated by extensive mudflats, and sandy beaches are found mainly in the eastern part of the country (Schulz 1975, Augustinus 1978). Total beach length is around 30-40 km, but fluctuates over the years. The most important nesting beaches for leatherbacks in 2004 were:

- Babunsanti (6 km length), situated in the Marowijne Estuary, Galibi Nature Reserve (abundant green turtle nesting, moderate to abundant leatherback nesting, minor olive ridley nesting);

- Samsambo and Kolukumbo/Marie (combined total length of approximately 9 km), situated west of the Marowijne Estuary on the Atlantic coast (minor to highly abundant leatherback nesting, minor olive ridley nesting);
- Matapica (9 km length), situated on the Atlantic coast approximately 10 km eastward of the Suriname Estuary. A highly dynamic beach, that moves to the west with a speed of approximately 1.5 km annually (Augustinus 1978, pers. obs.) (moderate to abundant green turtle and leatherback nesting, minor to moderate olive ridley nesting).

During the 2004 nesting season, Samsambo was covered (by STINASU) for a short period at the start of the nesting season and Kolukumbo/Marie were only visited two or three times at the start and end of the season (not during the peak season), so the real status of these beaches in 2004 is not known.

Other nesting beaches are Alusiaka (moderate green turtle nesting) and Thomas-Eilanti (moderate green turtle and leatherback nesting, minor olive ridley nesting) in the Galibi Nature Reserve, and Diana Beach (minor green turtle, leatherback and olive ridley nesting) just west of Matapica.

During the 2004-nesting season we did PIT tagging surveys and nest ecological work only at Babunsanti. Samsambo and Kolukumbo/Marie did not have a permanent campsite and presence by STINASU personnel and could thus not be covered. Like in 2003, there was no opportunity to continue PIT tagging and nest monitoring activities at Matapica.

- *For a more detailed description of the Surinam coastline and map of the beach locations of eastern Suriname, see Hilterman and Goverse (2003).*

2. METHODS

2.1 PIT tagging of nesting leatherback turtles

In the three Guianas, TROVAN ID100 PIT tags and LID500 scanners are used. Tags are injected in the muscle of the right shoulder as described by Dutton and McDonnald (1994). After tagging, turtles are always rescanned to check for proper tag placement. Tagging and scanning are done at all stages of the nesting process and in addition to the PIT code, the turtle's activity, distance of the nesting position to the spring tide line, distance travelled from the water line, location on the transect line and the turtle's size were recorded.
Nightly beach patrols stretched from at least three hours before high tide to at least two hours after high tide. Patrolling continued until the last turtle had finished nesting. Table 2.1 shows the PIT tagging effort for 2004.

We defined three categories of females:

- Newly tagged turtles were untagged turtles that were PIT tagged by us;
- Non-Surinamese turtles were turtles that had previously been PIT tagged in French Guiana or Guyana but were new to Suriname (this category may also include a small proportion of erroneous codes);
- Remigrants were females that returned to nest in a subsequent year to the one in which we originally observed them.

Beach	Sections	Distance	Duration of coverage	Permanent presence by
Babunsanti	BS-I,II,N and PB-I,II	4.5 km	April 17-July 27,	2-3 researchers

Table 2.1 *PIT tagging effort during the 2004-nesting season. From June 17th to June 21st no tagging surveys took place.*

2.2 Biometric data collection

Minimum (or standard) curved carapace length (CCL) and width (CCW) of tagged leatherback females were measured with a flexible aluminium tape measure. Minimum (or standard) CCL was measured alongside the vertebral ridge. CCW was measured at the widest point, spanning from ridge crest to ridge crest (Wyneken 2001). Depending on the activity of the turtle in the nesting process, CCW could not always be measured.
The average individual measurement for turtles measured more than once during the season was used for further calculations.

2.3 Nest number estimates

Daily track counts were done by STINASU field personnel. In addition, based on the observed (missed) nesting attempts at Babunsanti as obtained from the PIT tag program, an estimate was made of the number of leatherback nests on these beaches. The number of observed turtles was multiplied by 1.1 to compensate for missed nestings, after which 10% was subtracted for aborted nesting attempts (false crawls). For beaches or beach sections that were not monitored, a rough estimate was made based on incidental nest counts and experiences of former years. Alternatively, by multiplying the number of (observed) leatherback females by the estimated clutch frequency, nest number estimates can be obtained.

2.4 Identification and quantification of threats

The commercial drift-net fishing fleet poses a serious threat to nesting leatherback females in the Guianas. It is believed that large numbers of adult females drown in the nets or die as a result of being cut out of the nets in order for the fishermen to save their nets (Chevalier 2000, pers. obs.).
On the monitored beaches the number of strandings for each sea turtle species was recorded. Notes were made on the state of the carcass and possible causes of death. If possible, stranded leatherbacks were scanned for PIT tags.

As part of the PIT tag program, all scanned leatherback females were briefly examined for fisheries-related injuries. Short notes were made of the kind of damage and degree of freshness of the wounds or scars. The categories encountered mostly are (partially) chopped off flippers or hind limbs, net wounds or net scars around the neck and shoulders, machete marks in shoulders, neck, limbs or carapace, parts of nets still wrapped around the turtle, holes in carapace and flippers, and fishing hooks in flesh.

2.5 Determination of nest survivorship and hatch success

Nest marking
A total of 75 *in situ* leatherback nests were randomly marked from April 19th to May 16th at Babunsanti along a 3000 meter transect line with numbered stakes at 20 meter intervals in the beach-vegetation. During the nightly beach patrols, small (temporary) sticks were placed 0.5 m behind the egg chamber of leatherbacks in a far stage of digging their nest, depositing eggs or closing the nest, and the turtle's position (direction of the head) was schematically recorded.
The next morning the nests were carefully opened by hand. A tightly folded plastic flag with nest number and date was placed in the sand on top of each clutch as a nest-marker, after which the nest was firmly closed again. Exact location of each nest was triangulated from the nearest two stakes. This procedure has proved not to disturb the nests (Hilterman and Goverse 2003).

Triangulation records were used to retrieve the nests and determine their fate after two months of incubation. Three days after first hatchling emergence at the surface, or 73 days in case of non-emergence or unnoticed emergence, the nests were excavated and nest contents analysed. Also a selection of non-marked *in situ* leatherback (n=37) and green turtle (n=134) nests were excavated three days after observation of the first hatchling tracks from the nest.

- *Results of the green turtle nests can be requested from the authors*.

Nest analyses
For each analysed nest, distance of the nest to the spring tide line, nest bottom depth, incubation time, number of yolkless eggs, hatched eggs (empty shells), undeveloped eggs, ruptured (predated) eggs and type of predation, number of eggs with embryonic mortality and embryonic stage, number of pipped hatchlings, life hatchlings (stragglers), dead hatchlings, and deformed hatchlings were recorded at a standard data-sheet.

The categories for non-hatched egg contents are described in Hilterman and Goverse (2003). In Suriname, main predators of eggs are a mole cricket species (*Scapteriscus didactylus*) (Maros *et al.* 2003) and (to a much lesser extent) the ghost crab (*Ocypode quadrata).* Hatch success (%) is determined by dividing the empty shells by the total number of eggs (empty shells + pipped eggs + all non-hatched eggs), yolkless eggs not included.
The spring tide line (STL) is determined by the highest deposition of driftwood. Nests located landward perpendicular to the STL are referred to as 'plus STL', nests located seaward of the STL are referred to as 'minus STL'.

2.6 Determination of sand temperatures
The pivotal temperature for leatherbacks is 29.5ºC. Above that temperature, more females are produced, and below, more males (Mrosovsky and Yntema 1980, Desvages *et al.* 1993, Godfrey *et al.* 1996).
Electronic HOBO temperature data loggers were deployed at 70 cm depth (average estimated clutch centre depth) at three beach zones (high, mid, low) at two beach sections (PB-I and BS-I) of Babunsanti at the beginning of the fieldwork period and recovered at the end of the leatherback nesting season in order to determine sand temperature profiles. The beach zones were chosen for their popularity as a nest site for leatherback turtles. Data were recorded every four hours for the whole period. Data were grouped by 1-day intervals for which the average temperature was calculated.

- *A more detailed description of used methods can be found in Hilterman and Goverse (2003).*

3. RESULTS

3.1 PIT tagging of nesting females

A total of 645 individual leatherback females were observed nesting at Babunsanti. New PIT tags were applied to 294 individuals (45.6%), the remaining 351 (54.4%) had previously been tagged. Of the previously tagged turtles, 1 was a remigrant from 1999, 7 were remigrants from 2000, 115 were from 2001, 132 from 2002, 1 from 2003, 5 were remigrants that nested in more than one previous season and 90 turtles (14.0%) had a PIT code not known for Suriname. A substantial part of the latter had expectedly been tagged in French Guiana, but wrongly recorded codes may also be included.
The total number of tag records, including 391 within-season recaptures, was 1,036. Table 3.1 shows the yearly number of tag records since 1999.

From 1999 to 2004, the proportion of newly tagged females decreased from 89.9% to 45.6% per season, whereas that of remigrants increased from 0% to 40.5% per season. The proportion of females of a non-Surinamese origin (but new for Suriname in a particular season) fluctuated between at 10.1% and 17.6% (fig. 3.1). In 2004, no individuals with flipper tags from French Guiana or Trinidad were observed. One female with flipper tags from Nova Scotia, Canada, was observed.

Nesting season	Newly tagged	Non-Surinamese	Remi-grant	Observed females	Proportion one-time nesters (%)	Intra-seasonal recaptures	Total no. records
1999	62	7	0	69	—	5	74
2000	385	70	0	455	—	47	502
2001	2,455	448	24	2,927	66.7	1,701	4,628
2002	1,831	401	51	2,283	46.4	3,110	5,393
2003	1,473	365	397	2,235	46.4	2,585	4,820
2004	294	90	261	645	63.6	391	1,036
Total	6,500	1,381	(721)	7,881	—	7,839	16,453

Table 3.1. *The number of newly PIT tagged, non-Surinamese and remigrant turtles and intra-seasonal recaptures observed during the nesting seasons 1999-2004. Note that the annual spatial and temporal tagging effort differed.*

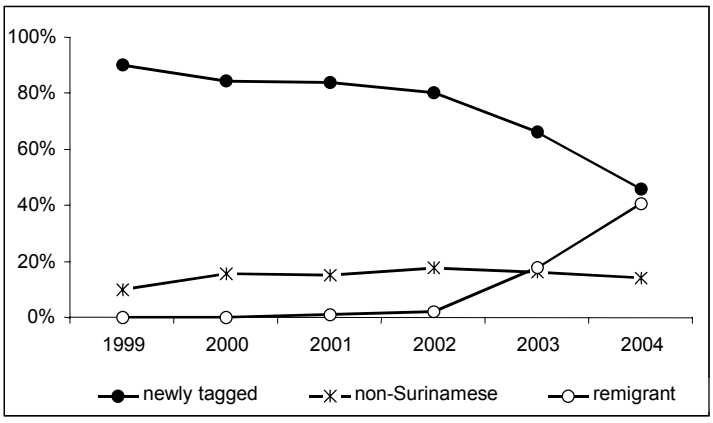

Figure 3.1 *Proportion of newly tagged, non-Surinamese and remigrant turtles nesting during the 1999-2004 seasons.*

Remigration
Of the observed nesting cohort of 1999 (n=69), 40.6% had been seen again by 2004 (table 3.2). Of the 2000 cohort (n=455), this was 16.0% and of the 2001 cohort (n=2,927) this was 16.4%. Six individuals (6.2%) of the 2002 cohort (n=2,283) and one of the 2003 cohort (0.1%) returned in 2004. Twelve individuals were encountered in three different nesting seasons in Suriname.

Year first observed	Observed no. individuals	2000	2001	2002	2003	2004	Remigrants (n)	Remigrants (%)
1999	69	0	22	3	2	1	28	40.6
2000	455	—	2	45	19	7	73	16.0
2001	2,927	—	—	3	363	115	481	16.4
2002	2,283	—	—	—	6	132	138	6.2
2003	2,235	—	—	—	—	1	1	0.1
2004	645	—	—	—	—	—	0	0.0

Table 3.2. *Observed remigration rates (expressed in numbers and as proportion of original cohort) for tagged turtles in Suriname during the 1999-2004 nesting seasons. Note that beach coverage was incomplete in all of the years and varied between the years and beaches, and that turtles may have returned on a non-Surinamese beach. Remigration numbers presented here are thus certainly underestimating the true number of remigrants*.

Internesting periods
The mode of the observed internesting period (OIP) was 9 days (fig. 3.2). The smaller peak seen at 17-21 days and subsequent peaks, are presumably the result of turtles that were missed on their previous return(s), or which had nested outside the study area. Mean OIP in 2003 was 9.6 ± 1.0 days (n=181), we excluded OIP values of less than six or greater than eleven days as either aborted nesting attempts or as including an unobserved nesting (Miller 1997, Reina *et al.* 2002).

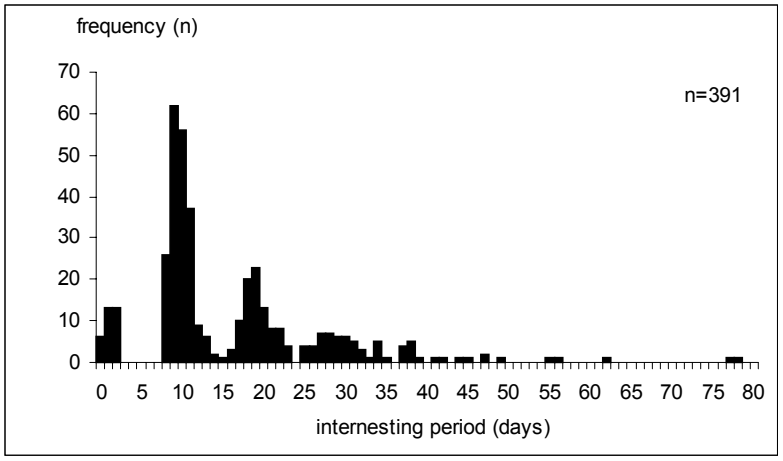

Fig. 3.2 *Observed internesting period (OIP) for leatherbacks nesting at Babunsanti in 2004.*

Clutch frequency
Figure 3.3 shows the observed clutch frequency (OCF) of gravid leatherback females for Babunsanti and Kolukumbo. OCF was obtained after correction for false crawls (internesting periods of less than six days). Mean OCF was 1.6 ± 1.0 nests (n=645). Of all turtles, 63.6% (n=410) was seen only once. OCF ranged between one and seven nests.

Figure 3.4 shows the estimated clutch frequency (ECF) for turtles that were observed nesting twice or more at Babunsanti. ECF was calculated by dividing the number of days in between the first and last nesting dates for an individual by the mean OIP of 9.6, adding one for the first oviposition. We used only the individuals with a first

oviposition date before May 30th, thereby avoiding the possibility that the turtle finished nesting after the end of the fieldwork period, following Reina *et al.* (2002). Mean ECF was 4.1 ± 1.8 nests (n=140).

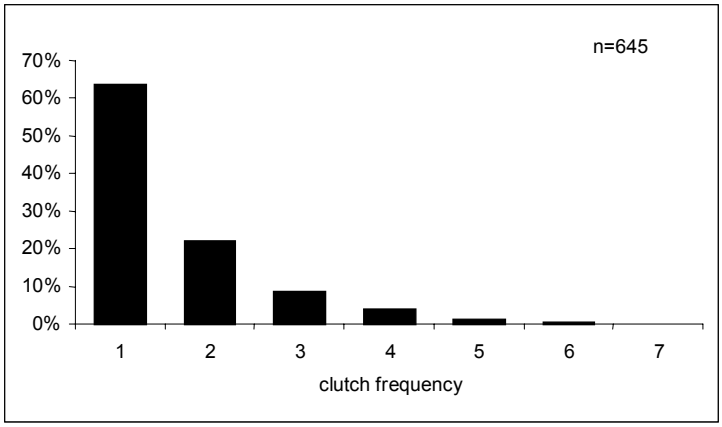

Fig. 3.3 *The observed clutch frequency (OCF) for females nesting at Babunsanti in 2004*

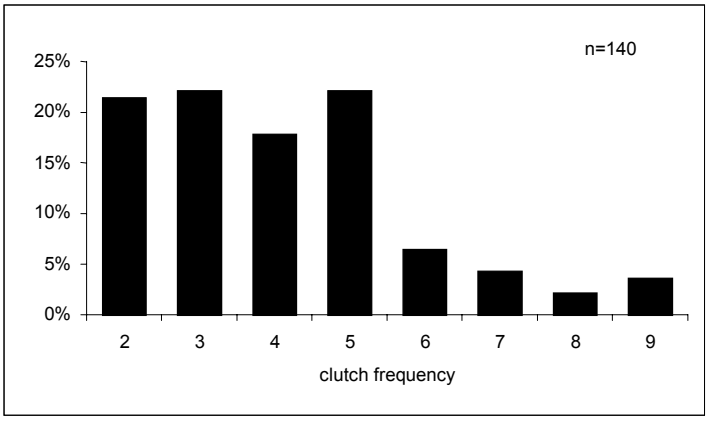

Fig. 3.4 *The estimated clutch frequency (ECF) for females observed at least twice at Babunsanti in 2004 using a mean observed internesting period of 9.6 days.*

The proportion of one-time observed nesters was significantly lower among the remigrant females (52.5%) than among the newly tagged females (69.4%) and non-Surinamese females (76.7%) (Chi-square, x^2 = 24.8, df = 2, p<0.001).
Mean ECF was higher for the remigrants (4.2 ± 1.7 nests) than for the new turtles (4.0 ± 1.8 nests) and non-Surinamese turtles (3.9 ± 2.3 nests), but this difference was not significant in 2004.

3.2 Nest numbers

The rough leatherback nest count data (uncorrected for incomplete beach coverage) for the 2004 season were reported by STINASU to be 5,706, of which a preliminary number of 3,000 were counted at Matapica (S. Mitro, pers. comm.). Based on PIT tag data (number of new tags + old tags + observed missed nestings per night; false crawls excluded) and rough estimates for beaches/sections that were not or very irregularly monitored, the estimated *minimum number* of nests after correction for incomplete beach coverage is 6,600 (table 3.3).
Figure 3.5 shows the nesting activity pattern for leatherbacks at Babunsanti combined with the daily high tide heights.

Beach	Estimated total beach length (km)	Distance covered (km)	Observed nesting attempts (by PIT tagging)	Estimated No. of nests (minimum)
Galibi Nature Reserve	9	4.5	1,228	2,300
Samsambo	8	0	—	450
Kolukumbo	0.2	0	—	350
Marie	0.8	0	—	500
Matapica	9	0	—	3,000
Total	27	4.5	1,228	6,600

Table 3.3 *Number of nesting attempts observed while PIT tagging and (roughly) estimated number of nests after correction for incomplete beach coverage in space and time, false crawls excluded.*

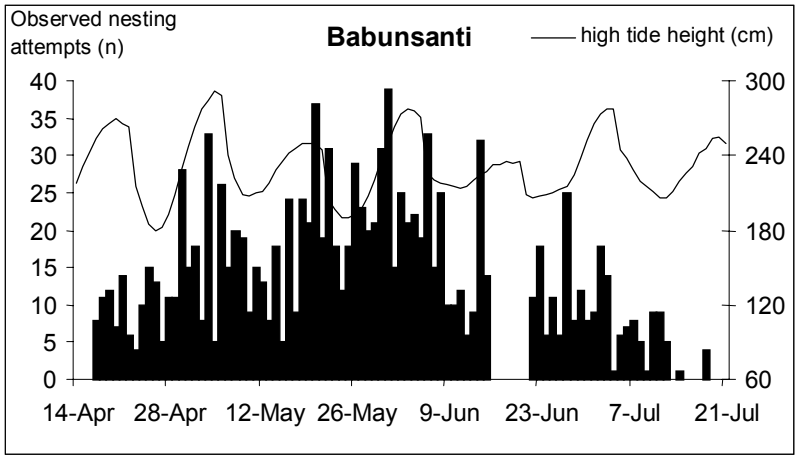

Fig. 3.5 *Observed daily nesting attempts during PIT tagging and tidal cycles during the 2004-nesting season at Babunsanti. For June 17-21 data are missing.*

3.3 Biometric data

The average curved carapace length of gravid leatherback females was 155.6 ± 6.7 cm. Curved carapace width was 114.5 ± 4.9 cm (table 3.4). This is similar to average carapace sizes found in 2000-2003. Figure 3.6 shows the size frequency distribution for nesting leatherbacks at Babunsanti in 2004.

The mean CCL of new turtles (154.0 ± 6.8 cm, n=287) was highly significantly smaller than that of non-Surinamese turtles (156.4 ± 5.6 cm, n=84) and remigrants (157.2 ± 6.5 cm, n=256) (ANOVA, $p<0.001$).

2004	CCL (cm)	Min.	Max.	n	CCW (cm)	Min.	Max.	n
Babunsanti	155.6 ± 6.7	130.0	179.0	629	114.5 ± 4.9	100.0	132.0	383

Table 3.4 *Mean curved carapace lengths (CCL) and widths (CCW) for leatherbacks nesting at Babunsanti, 2004.*

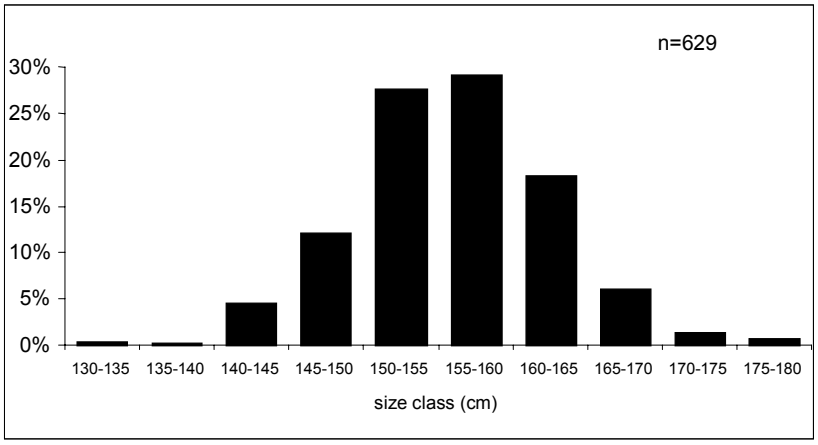

Fig. 3.6 *Frequency distribution of carapace lengths of nesting leatherbacks at Babunsanti in 2004.*

3.4 Threats

One dead leatherback female was observed stranded at Babunsanti. No data for Samsambo, Kolukumbo/Marie and Matapica are available.

A first data analyses indicates that of the 645 individuals observed during the 2004-nesting season, a minimum of 10.5% had injuries or scars that may have been a result of interactions with fisheries. Injuries were categorised as machete or net scars and wounds, hooks in flesh or propeller damage, and (partly) missing flippers or hind limps. Some turtles showed multiple injuries.

For data on egg poaching activities refer to STINASU.

3.5 Nest survival and hatch rates

Table 3.5 shows the fate of the randomly marked *in situ* leatherback nests at Babunsanti. Of the unmarked leatherback nests (also referred to as natural nests) of which emerged hatchling tracks were observed, 37 were also excavated. Hatch success and emergence success for the marked and unmarked *in situ* leatherback nests is shown in table 3.6.

Marked nests at Babunsanti	
Marked	75 nests
Retrieved	68 nests (90.7%)
Excavated but excluded from further analyses	3 nests (mixed with other nests, disturbed, etc.)
Used for determination of *in situ* hatch rates	66 nests
Not hatched of these 66 nests	24 nests (36.4%)

Table 3.5 *Fate of the marked leatherback nests of which the exact position was recorded by triangulation during the 2004 nesting season.*

A total of 63.6% of the marked nests hatched. Of these, average hatching success was 28.7%. Overall average hatch success, including the zero-hatching success of the unhatched nests, was 18.2%. A frequency distribution of hatch success for the marked nests is shown in figure 3.7.

Average hatch success for the unmarked, successful nests was 42.5%. This is, however, certainly an overestimate of overall *in situ* hatch success, as there was a bias towards the more successful nests when it came to observing the hatchling tracks.

Babunsanti	Hatch success (%)		Emergence success (%)	
Marked nests (all nests, including unhatched nests)	18.2 ± 22.4	(n=66)	17.5 ± 22.0	(n=66)
Marked nests (hatched nests only)	28.7 ± 22.1	(n=42)	27.5 ± 22.1	(n=42)
Unmarked nests (only hatched nests, non-random selection)	42.5 ± 22.0	(n=37)	40.3 ± 23.1	(n=37)

Table 3.6 *Average hatching and emergence success and standard deviation per nest for marked and unmarked leatherback nests at Babunsanti (emergence success is hatching success minus the fraction of dead hatchlings and stragglers).*

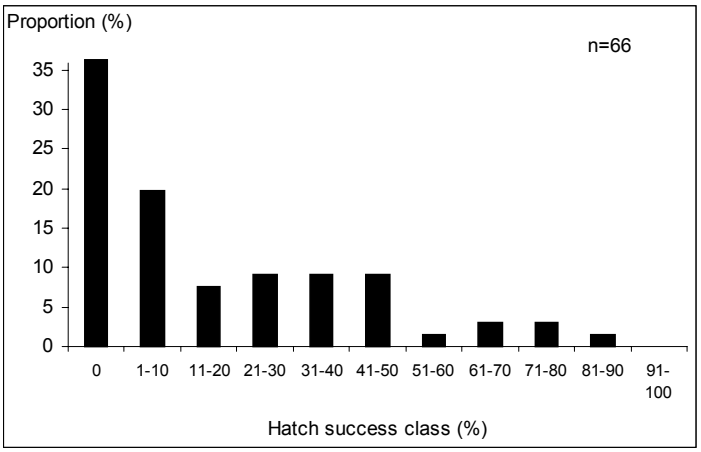

Fig. 3.7 *Frequency distribution of hatching success of the marked leatherback nests at Babunsanti in 2004.*

Figure 3.8 shows the hatching success and egg development for the marked nests. Of all marked nests, 92.4% were attacked by mole crickets. Egg depredation by mole crickets was one of the main causes for egg mortality. For the marked nests, an average of 35.3 ± 20.9% of the yolked eggs per nest were predated by the mole cricket. In 2004, no egg depredation by ghost crabs was recorded.

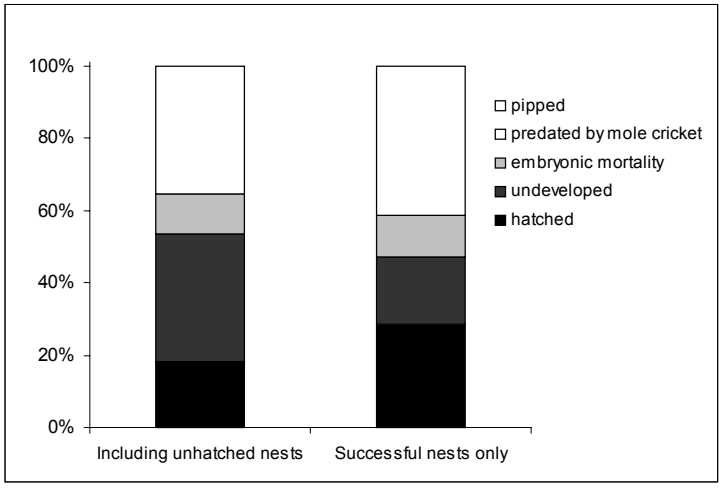

Fig. 3.8 *Average hatch success and egg development per nest for the marked nests at Babunsanti in 2004.*

Hatching success as a function of the distance of the nest to the STL is shown in figure 3.9. Nest failure was highest at distances of more than two meters below the STL, mostly as a consequence of a higher fraction of undeveloped eggs at the lower beach zone. A total of 15% of the nests was laid at more than two metres below the STL.

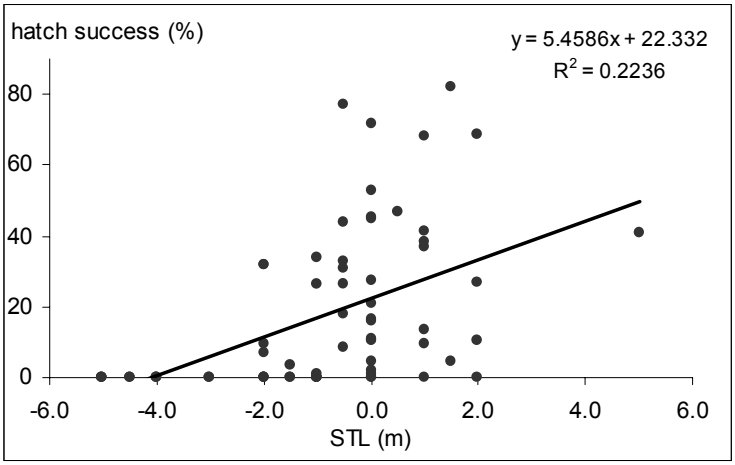

Fig. 3.9 *Hatch success of the marked nests at Babunsanti in 2004 as a function of the distance of the nest to the spring tide line (n=66). Negative numbers represent distances below the STL.*

Clutch size, incubation periods and nest depth

- Average clutch size was 88.2 ± 19.5 yolked eggs and 29.1 ± 17.1 yolkless (') eggs for the marked nests (n = 66).
- Mean incubation period was 63.2 ± 1.2 days (n = 13) with a range of 61 to 65 days.
- Nest bottom depth was 73.0 ± 10.6 cm (n = 66) at Babunsanti with a range of 46 to 104 cm.

3.6 Sand temperature and sex determination

Sand temperatures were below the pivotal temperature for leatherbacks (29.5°C) for most of the season but gradually increased in the course of the season (table 3.7, fig. 3.10), and are closely linked to rainfall (fig. 3.11). The lower temperatures for the low zone compared to those of the mid and high zones are a result of the more frequent tidal inundation. The spring high tide of May 4th caused the spring tide line at section PB-I to shift to a 0.5 m higher position on the beach.

The majority of nests at Babunsanti were laid in the mid and low zone (thus on and below the STL). Therefore, assuming an average metabolic heating of 0.5°C during the middle third of the incubation period (day 20-40) when hatchling sex is determined, nests laid after approximately June 10th -15th will have produced predominantly females and nests laid before that predominantly males.

	Transect 1(section BS-I)			Transect 2 (section PB-I)		
Distance to STL	-2	0	+2	-2.5/-3	-0.5/-1	+1.5/+1
n	591	591	438	573	573	573
min	24.01	26.34	18.66	25.56	25.56	26.34
max	29.10	29.90	37.88	29.90	30.31	30.31
average	27.20	28.24	27.93	27.97	28.45	28.80
stdev	1.06	0.81	2.96	0.98	0.89	0.64

Table 3.7 *Sand temperature overview (°C). Data have been analysed from a day after placing the data loggers (April 20th) to a day before digging up the loggers (July 28th).*

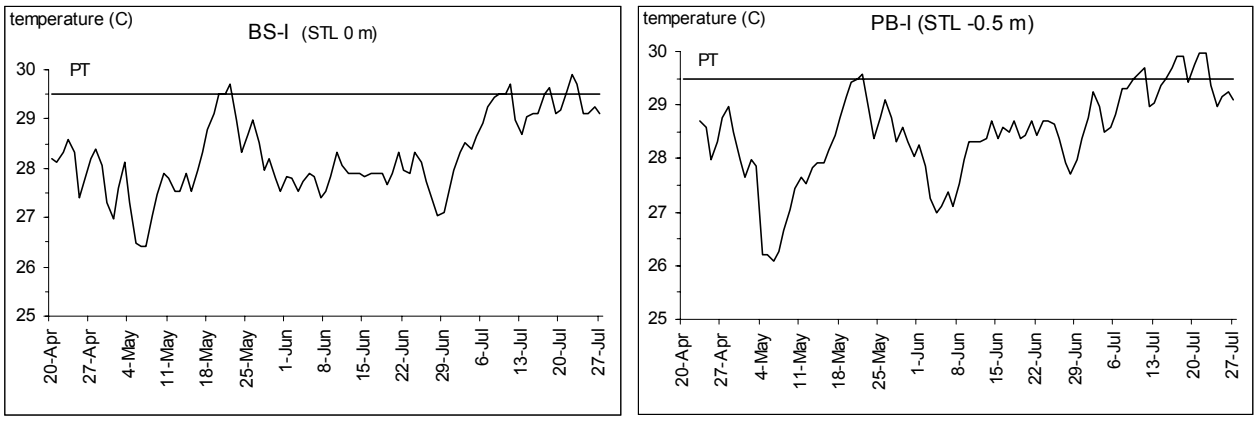

Fig. 3.10 *Sand temperature profiles of the mid zone at the sections PB-I and BS-I of Babunsanti during the 2004 nesting season. PT = pivotal temperature for leatherbacks (29.5°C).*

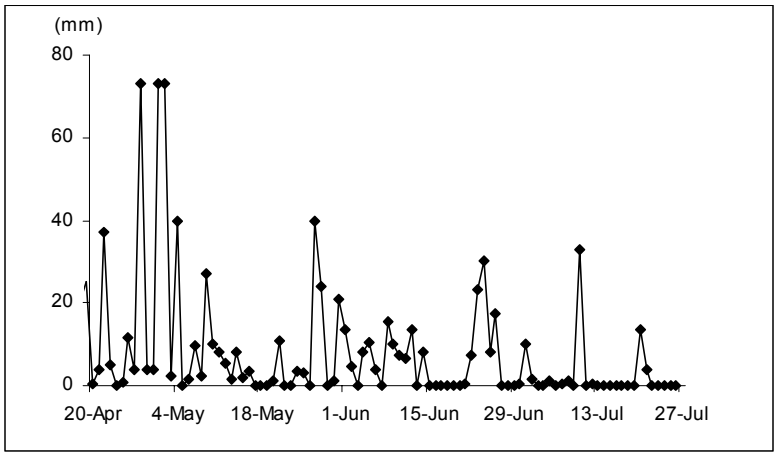

Fig. 3.11 *Precipitation (mm) measured at Babunsanti during the 2004 nesting season. Because the maximum capacity of the rain gauges was 73 mm, the peaks in early May are likely to be underestimating the true rainfall. For June 17-21 data are missing.*

4. DISCUSSION

Since 1999, a total of 7,881 leatherback females were identified nesting in Suriname, 7,357 of which nested during the 2001-2004 seasons. The PIT tag data demonstrate that at least 645 leatherback females have nested during the 2004 season. Incomplete beach coverage at Babunsanti (as is shown also by the relatively low observed clutch frequency) and the lack of coverage at other beaches imply that the actual size of the 2004-nesting cohort was significantly larger. At Matapica alone, where approximately 3,000 nests were counted by STINASU, we estimated between 400 (clutch frequency of 7.5) and 600 (clutch frequency of 5) nesting females. For the Galibi beaches or beach sections that we did not cover (Alusiaka, Pruimeboom-III, Thomas-Eilanti) and the beaches just west of the Marowijne Estuary (Samsambo, Kolukumbo/Marie) we estimated at least another 500 females. Therefore the total number of nesting females in 2004 is estimated to be at least 1,545 - this should clearly be considered a *minimum number.*
This is lower than the estimated minimum number of females in 2001 (5,500) (Hilterman and Goverse 2002) and in 2002 and 2003 (3,000) (Hilterman and Goverse 2003, 2004). One of the reasons may be that the formerly very busy leatherback nesting beaches Samsambo and Kolukumbo/Marie were in 2004 (partially) blocked by mudflats. For the first time since 1999, there was no highly suitable nesting beach just west of the Marowijne Estuary. Still, it seems that the lower number may be well within the range of normal (possibly food dependent) reproductive fluctuations. Numbers in Trinidad and elsewhere in the Caribbean seemed to be lower in 2004 as well (S. Eckert and P. Dutton, pers. comm.).

The strong decrease of the proportion of newly tagged turtles and the increase of that of remigrants in only five years time since the start of the tagging program is remarkable. Their significantly smaller carapace size indicates that the newly tagged females were younger than remigrants and non-Surinamese females (e.g., Zug and Parham 1996), and indeed represent relatively new or first-time nesters. The nesting behaviour of new females was also different from that of remigrants, with a lower mean ECF and a higher proportion of one-time nesters (Hilterman and Goverse *in prep*.).
The annual proportion of turtles with a French PIT code (10.1% to 17.6% of females) in 1999-2004 is much lower than we would have expected when assuming that the leatherbacks nesting on the beaches of Suriname and French Guiana are a single large nesting population with a high inter-seasonal nesting exchange between beaches (Pritchard 1971, Girondot *et al. in prep*.), moreover, these are maximum percentages since they may also include some erroneous codes. Despite some exchange of nesting beaches between Suriname and French Guiana, the PIT tagging data suggest that the two populations are sufficiently different in other aspects to warrant treating them as separate management units.

The method of obtaining and presenting annual leatherback nest numbers has strongly differed over the years. Figure 4.1 shows the nest numbers in the Galibi Nature Reserve and on Matapica/Bigisanti in Suriname from 1967-2004. For the periods 1967-1989 and 1995-1998 these are based on (uncorrected, often incomplete) nest counts, for 1990-1994 on extrapolations from nest numbers at French Guiana, for 1999-2000 on nest counts corrected with the Lagrange interpolation (M. Girondot, pers. comm.) and rough estimates, and for 2001-2004 on nest counts, nightly observations during PIT tagging surveys and rough estimates for sections or beaches that were not covered. In all years, false crawls are excluded from these numbers. This makes it difficult to compare the nest numbers over the years. If we compare the rough nest count data to nest number estimates since 2001 (the first year with a comprehensive PIT tagging program) (table 4.1), we can safely assume that the earlier nest numbers, also the peaks of well over 11,000 nests in the 1980s, are underestimating real nest numbers in most years.

Beach	1999	2000	2001	2002	2003	2004
Galibi NR	2,000 (2,3)	7,783 (1,3)	12,250 (1)	2,600 (1,2)	5,400 (1,2)	2,300 (1,2)
Samsambo	10,000 (2,3)	1,985 (2,3)	2,000 (2,3)	450 (2, 4)	1,500 (1,4)	450 (2,4)
Kolukumbo	—	2,200 (2,3)	12,500 (1,3)	7,500 (1)	2,300 (1)	350? (4)
Marie	—	—	—	—	400 (2,4)	>500? (4)
Matapica	2,000 (2)	2,169 (2)	3,700 (2)	2,165 (2)	2,645 (2)	3,000 (2)
Total estimated nest number	14,000	14,137	30,450	12,715	12,245	6,600
Rough nest count	(7,524)	(8,783)	(10,144)	(8,634)	(8,081)	(5,706)

Table 4.1 *Estimate of the minimum number of nests laid (excluding false crawls) in the 1999-2004 nesting seasons, based on (1) our nightly observations during PIT tagging surveys, (2) daily or incidental STINASU nests counts (Mohadin, 1999; De Dijn 2003; De Dijn pers. comm.; Mitro* in press*.); (3) interpolations, and (4) (for unmonitored sections) rough estimates.*

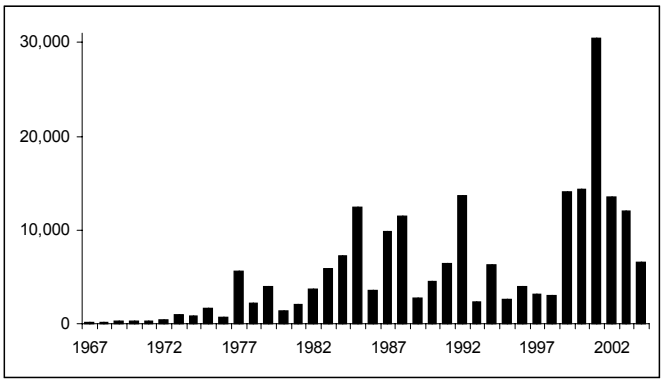

Fig. 4.1 *Leatherback nest numbers for Suriname (a combination of rough counts, corrected counts, estimates and observations during PIT tagging surveys) in the period 1967-2004.*

Overall hatch rates in 2004 at Babunsanti were low (18.2% including unhatched nests) but comparable to those of past years, as is shown in table 4.2 (e.g., Hilterman and Goverse 2003, 2004). Compared to the hatch rates at Matapica, the hatch rates at Babunsanti seem to be dramatically low.

	Beach	2001	2002	2003	2004
H% per nest (including unhatched nests)	Babunsanti	10.6 ± 16.4 (n=149)	25.8 ± 24.4 (n=158)	22.2 ± 22.4 (n=188)	18.2 ± 22.4 (n=66)
	Matapica	52.7 ± 29.7 (n=62)	56.0 ± 30.8 (n=108)	—	—
H% per nest (hatched nests only)	Babunsanti	21.6 ± 17.7 (n=73)	34.9 ± 22.1 (n=117)	28.0 ± 21.6 (n=149)	28.7 ± 22.1 (n=42)
	Matapica	58.3 ± 25.4 (n=56)	63.7 ± 24.2 (n=95)	—	—

Table 4.2 *Average hatch success per nest (H%), clutch size and incubation for the 2001-2004 nesting seasons at Babunsanti and Matapica.*

To conclude

The PIT tagging data collected during the 1999-2004 seasons clearly demonstrate the present status of Suriname as a major leatherback rookery. By PIT tagging, much larger numbers of females were shown than could have been expected from nest counts alone, and in turn, PIT tagging data (nightly observations) helped to improve nest number estimates. The PIT data have in any case shown that earlier estimates of the annual female population size for Suriname of 600-2000 turtles (e.g., Spotila *et al*. 1996) are much too low. The *minimum annual number* of nesting females in Suriname alone is estimated to be 1,545 - 5,500.

Although the overall trend for the combined Suriname/French Guiana leatherback nesting population seems stable (Girondot *et al. in prep*.), the apparent high incidence of fisheries-related injuries is a serious reason for concern. In order to fully understand the nesting parameters and trend of this population, especially also remigration rates, grouping of the French Guiana/Suriname tagging data is needed. Additionally, harmonisation of equipment of PIT tag programs in the wider region, especially those in the Guianas and Trinidad, would help to better understand the frequency of nesting exchange between beaches in this region.

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REFERENCES

Augustinus, P.G.E.F., 1978. The changing shorelines of Suriname (South America). Natuurwetenschappelijke Studiekring voor Suriname en de Nederlandse Antillen, Utrecht, the Netherlands, No. 95, 232p.

Billes, A., J. Fretey, and J.B. Moundemba, 2003. Monitoring of leatherback turtles in Gabon. In: J.A. Seminoff (Compiler), 2003. Proceedings of the twenty-second annual symposium on sea turtle biology and conservation. NOAA Technical Memorandum NMFS-SEFC-503, 308p., pp.131-132.

Chevalier, J., 2000. Etude des captures accidentelles de tortues marines lies a la Pêche dans l'Oqest Guyanais. Direction Régionale de l' Environnent Guyane, Cayenne, French Guiana, 23p.

Chevalier, J., and M. Girondot, 2000. Recent population trend for *Dermochelys coriacea* in French Guiana. In: F.A. Abreu-Grobois, R. Briseño-Dueñas, R. Márquez, and L. Sarti (Compilers), 2000. Proceedings of the eighteenth annual symposium on sea turtle biology and conservation. NOAA Technical Memorandum NMFS-SEFC-436, 293p., pp.56-57.

Chevalier, J., M.H. Godfrey, and M. Girondot, 1999. Significant difference of temperature-dependent sex determination between French Guiana (Atlantic) and Playa Grande (Costa-Rica, Pacific) leatherbacks (*Dermochelys coriacea*). Annales des Sciences Naturelles-Zoologie et Biologie Animale 20(4):147-152.

Chevalier, J., Talvy, G., Lieutenant, S., Lochon, S., and Girondot, M. 2000. Study of a bimodal nesting season for leatherback turtles *(Dermochelys coriacea)* in French Guiana. In: Kalb, H., and Wibbels, T., compilers. Proceedings of the nineteenth annual symposium on sea turtle biology and conservation. NOAA Technical Memorandum NMFS-SEFSC-443, 291pp., pp.264-267.

De Dijn, B. 2003. Country report of Suriname: marine turtle season 2002. In: Nolibos, I., Kelle, L., De Thoisy, B., and Lochon, S. (Eds.). Proceedings of the sixth sea turtle symposium for the Guianas. Remire–Montjoly, Guyane, French Guiana, 62pp., pp.8-10.

Desvages, G., M. Girondot, and C. Pieau, 1993. Sensitive stages for the effects of temperature on gonadal aromatase activity in embryos of the marine turtle *Dermochelys coriacea*. General and Comparative Endocrinology 92(1):54-61.

Dutton, P., and D. McDonald, 1994. Use of PIT tags to identify adult leatherbacks. Marine Turtle Newsletter 67:13-14.

Dutton, P.H., Bowen, B.W., Owens, D.W., Barragan, A., and Davis, S.K. 1999. Global phylogeography of the leatherback turtle (Dermochelys coriacea). Journal of Zoology, London 248:397-409.

Fretey, J., and Girondot, M. 1989. l'Activité de ponte de la tortue luth Dermochelys coriacea (Vandelli, 1761) pendant la saison 1988 en Guyane Française. Revue d'Ecologie: La Terre et la Vie 44:261-274.

Girondot, M., 2002. Proposed corrections. In: http://www.ese.u-psud.fr/epc/conservation/IUCN888corrected.doc.

Girondot, M., and Fretey, J. 1996. Leatherback turtles, Dermochelys coriacea, nesting in French Guiana, 1978-1995. Chelonian Conservation and Biology 2(2):204-208.

Girondot, M, Godfrey, M.H., Ponge, L., and Rivalan, P. *In prep*. Historical records and trends of leatherbacks in French Guiana and Suriname.

Godfrey, M.H., R. Barreto, and N. Mrosovsky, 1996. Estimating past and present sex ratios of sea turtles in Suriname. Canadian Journal of Zoology 74:267-277.

Goverse, E., and M.L. Hilterman, 2003. Leatherbacks stuck in the mud: a matter of life or death? In: J.A. Seminoff (Compiler), 2003. Proceedings of the twenty-second annual symposium on sea turtle biology and conservation. NOAA Technical Memorandum NMFS-SEFC-503, 308p., pp.145.

Hilterman, M.L., and E. Goverse, 2002. Aspects of nesting and nest success of the leatherback turtle (*Dermochelys coriacea*) in Suriname, 2001. Guianas Forests and Environmental Conservation Project (CFECP). Technical Report, World Wildlife Fund Guianas/Biotopic Foundation, Amsterdam, the Netherlands, 34p.

Hilterman, M.L., and E. Goverse, 2003. Aspects of nesting and nest success of the leatherback turtle (*Dermochelys coriacea*) in Suriname, 2002. Guianas Forests and Environmental Conservation Project (CFECP). Technical Report, World Wildlife Fund Guianas/Biotopic Foundation, Amsterdam, the Netherlands, 31p.

Hilterman, M.L., and E. Goverse, 2004. Annual Report on the 2003 Leatherback Turtle Research and Monitoring Project in Suriname. World Wildlife Fund - Guianas Forests and Environmental Conservation Project (WWF-GFECP) Technical Report of the Netherlands Committee for IUCN (NC-IUCN), Amsterdam, the Netherlands, 21p.

Hilterman, M.L., and E. Goverse. *In prep*. Nesting and nest success of the leatherback turtle (*Dermochelys coriacea*) in Suriname.

IUCN, 2000. IUCN Red List of Threatened Species. C. Hilton-Taylor (Editor). International Union for Conservation of Nature and Natural Resources Species Survival Commission; Conservation International; United Kingdom, Department of the Environment, Transport and the Regions; Birdlife International; Canadian Wildlife Service; Canada, Natural Resources Canada; Centre for Marine Conservation; The Nature Conservancy – 2000, 61p. http://www.redlist.org/

Maros, A., A. Louveaux, M.H. Godfrey and M. Girondot, 2003. *Scapteriscus didactylus* (Orthoptera, Gryllotalpidae), predator of leatherback turtle eggs in French Guiana. Marine Ecology Progress Series 249:289-296.

Miller, J.D., 1997. Reproduction in sea turtles. In: P.L. Lutz and J.A. Musick (Editors), 1997. The biology of sea turtles. CRC Marine Science Series. CRC Press LLC, Boca Raton, Florida, U.S.A., 432p., pp.51-82.

Mitro, S. *In press*. Country report Suriname. Proceedings of the seventh sea turtle symposium for the Guianas, October 25-27, 2004, Georgetown, Guyana.

Mohadin, K., 2000. Sea turtle research and conservation in Suriname: history, constraints and achievements. In: Kelle, L., Lochon, S., Thérèse, J., and Desbois, X. (Eds.). Proceedings of the third regional marine turtle

symposium for the Guianas. Programme de Conservation des Tortues Marines de Guyane, No. 1, WWF-France, 40p., pp.5-9.
Mrosovsky, N., 2003. Predicting extinction: fundamental flaws in IUCN's Red List system, exemplified by the case of sea turtles. Department of Zoology, University of Toronto, Toronto, Canada, 57p.
Mrosovsky, N., and L. Yntema, 1980. Temperature dependence of sexual differentiation in sea turtles: implications for conservation practices. Biological Conservation 18(4):271-280.
Pritchard, P.C.H. 1971a. The Leatherback or Leathery Turtle. IUCN Monograph No.1. Marine Turtle Series. Morges, Switzerland, 39pp.
Reichart, H.A., and Fretey, J. 1993. WIDECAST sea turtle recovery action plan for Surinam. Eckert, K.L. (Ed.), UNEP-CEP Technical Report No. 24. UNEP-Caribbean Environment Programme, Kingston, Jamaica, 65pp.
Reina, R.D., P.A. Mayor, J.R. Spotila, R. Piedra, and F.V. Paladino, 2002. Nesting ecology of the leatherback turtle, *Dermochelys coriacea*, at Parque National Marino, Las Baulas, Costa Rica: 1988-1989 to 1999-2000. Copeia 2002(3):653-664.
Rivalan, P. 2003. La dynamique des populations de tortues luths de Guyane française: recherche des facteurs impliqués et application à la mise en place de stratégies de conservation [PhD thesis]. l'Université de Paris XI, Orsay, France, 248pp.
Spotila, J.R., A.E. Dunham, A.J. Leslie, A.C. Steyermark, P.T. Plotkin, and F.V. Paladino, 1996. Worldwide population decline of *Dermochelys coriacea*: are Leatherback turtles going extinct? Chelonian Conservation and Biology 2(2):209-222.
Spotila, J.R., R.D. Reina, A.C. Steyermark, P.T. Plotkin, and F.V. Paladino, 2000. Pacific leatherback turtles face extinction. Brief Communications. Nature 405:529-530.
Steyermark, A.C., Williams, K., Spotila, J.R., Paladino, F.V., Rostal, Morreale, S.J., Koberg, M.T., and Arauz, R. 1996. Nesting leatherback turtles at Las Baulas National Park, Costa Rica. Chelonian Conservation and Biology 2(2):173-183.
Troëng, S., Chacón, D., and Dick, B. 2004. Possible decline in the leatherback turtle Dermochelys coriacea nesting along the coast of Caribbean Central America. Oryx 38(4):395-403.
Tucker, A.D. 1989. So many turtles, so little time: underestimating fecundity and overestimating populations? In: Eckert, S.A., Eckert, K.L., and Richardson, T.H., compilers. Proceedings of the ninth annual workshop on sea turtle conservation and biology. NOAA Technical Memorandum NMFS-SEFC-232, 306pp., pp.181-184.
Wyneken, J., 2001. The anatomy of sea turtles. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-470, 172p.
Zug, G.R., and Parham, J.F. 1996. Age and growth in leatherback turtles, Dermochelys coriacea (Testudines: Dermochelyidae): a skeletochronological analysis. Chelonian Conservation and Biology 2(2):244-249.