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The Sea Turtles of Suriname 2002 Project:

Aspects of Nesting and Nest Success of the Leatherback Turtle (*Dermochelys coriacea*) in Suriname, 2002

Prepared by:

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In collaboration with the Foundation for Nature Conservation Suriname (STINASU).

March 2003

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ABSTRACT

Suriname supports one of the largest leatherback ***(Dermochelys coriacea)*** nesting colonies word-wide. We studied aspects of population demography and nest ecology of this nesting population on three important nesting beaches during the 2002-nesting season. We identified individual turtles by tagging them with PIT (Passive Integrated Transponder) tags. We identified a total of 2289 leatherback individuals. New tags were applied to 1833 individuals, 45 were remigrants from 2000, 3 were remigrants from 2001 and 3 from 1999, and 405 turtles had an unknown PIT code. The total number of tag records, including within-season recaptures, was 5394. Based on beach coverage and data on observed nesting frequency, we estimated that the total number of leatherback individuals that visited the Surinam beaches was at least 3000. Estimated minimum number of nests was 12.750. Mean observed internesting period (OIP) was 10.13 days. The mean observed clutch frequency (OCF) for the two best-monitored beaches was 2.2 ± 1.4 nests including the one-time nesters and 3.1 ± 1.2 nests without the one-time nesters. The mean estimated clutch frequency (ECF) per female for the 2002-nesting season was 3.3 ± 2.1 including one-time nesters and 4.3 ± 1.6 to 4.8 ± 1.9 excluding these. Of the 62 turtles tagged in 1999, 23 turtles (37.1 %) were observed to have returned to nest in Suriname by 2002. Of the turtles tagged in 2000, only 9.1% (35 individuals) were observed to have returned to nest by 2002. Two turtles with Monel tags from Trinidad were observed. Of the 1307 individual leatherback females that were observed twice or more, 145 (11.1%) made one or more shifts between the Surinam beaches. Most popular was the shift between Babunsanti and Kolukumbo. Twenty six turtles made a shift between Kolukumbo/Babunsanti and Matapica. When including also turtles that showed beach exchange with French Guiana, 25.3% of the turtles seen twice or more shifted between beaches. Mean curved carapace length for nesting leatherback females was 154.9 ± 7.1 cm and mean curved carapace width 113. ± 5.1 cm. Of all observed individuals, 16.9% showed fisheries related injuries like machete cuts, chopped off flippers or hind limbs and net wounds. Of this, 38.3% was considered to be fresh.

We found that, on average, 87.9% of the nesting attempts resulted in successful oviposition. Clutch size averaged 85.0 ± 18.2 yolked eggs and 31.9 ± 18.0 yolkless eggs. Incubation took longer on Matapica with 67.0 ± 2.3 days than on Babunsanti with 64.8 ± 3.2 days, reflecting the lower sand temperatures on Matapica. Hatch rates on Matapica almost doubled those of Babunsanti. From 158 analysed ***marked*** nests on Babunsanti, 25.9% failed to hatch and from the successful nests, average hatch success was 34.9%. On Matapica, of 108 analysed ***marked*** nests, 12.0% failed to hatch and of the successful nests, hatch success was 63.7%. Overall hatch success for ***in situ*** nests including un-hatched nests was 56.0% ± 30.8 on Matapica and 25.8% ± 24.4 on Babunsanti. This makes Matapica of a better quality leatherback nesting beach in terms of reproductive output.

Sand temperatures at nest depth were below the pivotal temperature for leatherbacks (29.5^{o}C) during almost the entire nesting season for all three beaches. This means that predominantly male hatchlings have been produced.

1 INTRODUCTION

1.1 Nesting of *Dermochelys coriacea* in the Guianas

The leatherback turtle (***Dermochelys coriacea***) is the sole member of the family Dermochelydae and amongst the largest living reptiles. It is the most widely distributed sea turtle species, ranging from warm tropical waters and nesting areas to the sub-polar waters of high latitudes. They feed predominantly on jellyfish and can dive up to 1300 meters depth.
The leatherback is enlisted as Critically Endangered on the IUCN Red List of Threatened Species (IUCN 2000). World-wide this species is severely threatened with extinction. In the past two decades the number of adult female leatherbacks decreased from 115,000 (Pritchard 1982) to less than 30,000 (Spotila ***et al***. 1996, 2000), with a 90% decrease in numbers in the Pacific. All former mass leatherback nesting colonies in the Pacific and Indian Oceans have collapsed. The causes of decline of the once major nesting populations on the Pacific coast of Costa Rica and Mexico, and of the large rookery in Terrenganu, Malaysia, are high rates of egg poaching and incidental captures in high seas drift net and long line fisheries (Sarti ***et al***. 1996, 2000; Eckert 1997; Spotila ***et al***. 1996, 2000; Chan and Liew 1996). In the Atlantic basin and Caribbean, several small insular nesting colonies and two mass nesting aggregations exist. More than half the present world leatherback population is estimated to be nesting in the Guianas on the beaches in and close to the Marowijne River Estuary in Suriname and French Guiana (Chevalier and Girondot 1999; Spotila ***et al***. 1996, 2000). Large leatherback nesting colonies have been reported in West Africa (Gabon, Congo) but the number of females here is yet unclear (Fretey and Billes 2000). Conservation of the leatherback nesting aggregations in the Guianas is essential for survival of the species. However, also in the Guianas, coastal fisheries are believed to cause a high adult mortality (Chevalier 2000). A strong decrease was seen nest numbers in French Guiana during the past decade. Leatherback nest numbers in Suriname have however showed a remarkable increase (more than 10,000 nests per year since 1999, with a peak of 30,000 nests in 2001) and the long-term trend for the Suriname and French Guiana population seems to show an increase (Girondot 2002).

1.2 Project background

There is a long history of marine turtle conservation and monitoring in the Guianas dating back to the 1960s. In 1963 a sea turtle research and protection program was initiated in Suriname by personnel of the Surinam Forest Service (LBB) under the direction of Dr. J.P. Schulz. In 1969, the responsibility of the sea turtle conservation program was assigned to STINASU and after J. Schulz retired, H. Reichart became Director of STINASU and continued the sea turtle monitoring program. During the years 1990-1994 the monitoring program could not be continued because of political instability in Suriname. In 1995 the Biotopic Foundation started yearly sea turtle research and conservation projects in Suriname (except for 1996), in close collaboration with STINASU.
In 1999 the project became part of the regional "Guianas Forests and Environmental Conservation Project" (GFECP), initiated and funded by WWF-Guianas. Since then, the focus was on the leatherback turtle as this turtle can be considered the flagship sea turtle species of the Guianas and survival of the Surinamese nesting colony is of uttermost importance to the survival of the species. Following the WWF-France and University of Paris-XI teams in the Amana Natural Reserve in French Guiana, in 1999 a PIT tag program was initiated in Suriname. In 2000, the Guyana Marine Turtle Conservation Society also started a PIT tag program on Shell Beach, Guyana, as part of the WWF-Guianas program. In 2002, the WWF “Regional Sea Turtle Conservation Program and Action Plan for the Guianas” was finalised, which aims to prevent the extinction and foster the sustained recovery of shared populations of sea turtles of the Guianas. We aim to fully integrate our project activities into the scope of this regional project and further establish the regional co-operation.

1.3 Objectives

The overall goal of the leatherback program is to add to the protection the leatherback turtle nesting population in Suriname and the surrounding countries, by means of 1) research in order to develop better conservation strategies and update world status reports, 2) capacity building, and 3) local and international collaboration.

Understanding of population status, reflected by basic population parameters such as population size, internesting and remigration intervals and beach fidelity, hatch rates, threats to eggs, hatchlings and adult turtles and sources of mortality is essential for management and recovery of sea turtle populations (Eckert 1999). A monitoring and research program, as it has been conducted since 1999 in Suriname for leatherback turtles should contribute to a better insight into population size and trends and reproductive output on the different nesting beaches (Meylan 1982). Monitoring of the latter is important because fluctuations and structural changes in yearly nest numbers may be explained by nest survival and hatch rates, and sex ratio production - ***e.g.***, predominantly males for a couple of years - in the past (Eckert 1999, Chevalier ***et al***. 1999).

Specific objectives of the project 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, remigration rates, beach fidelity) by means of a large scale PIT tag program[1]
- To determine nest survival and hatch success for ***in situ*** leatherback nests on the major nesting beaches
- To determine the sex-ratio of hatchlings, based on prevalent sand temperatures
- To obtain biometric data on nesting leatherbacks and leatherback hatchlings
- To qualify and quantify the threats facing adults turtles, hatchlings and eggs, with a special focus on fisheries related injuries
- To educate and train local students and counterparts in sea turtle biology, research techniques, data analyses and interpretation

1.4 Study area

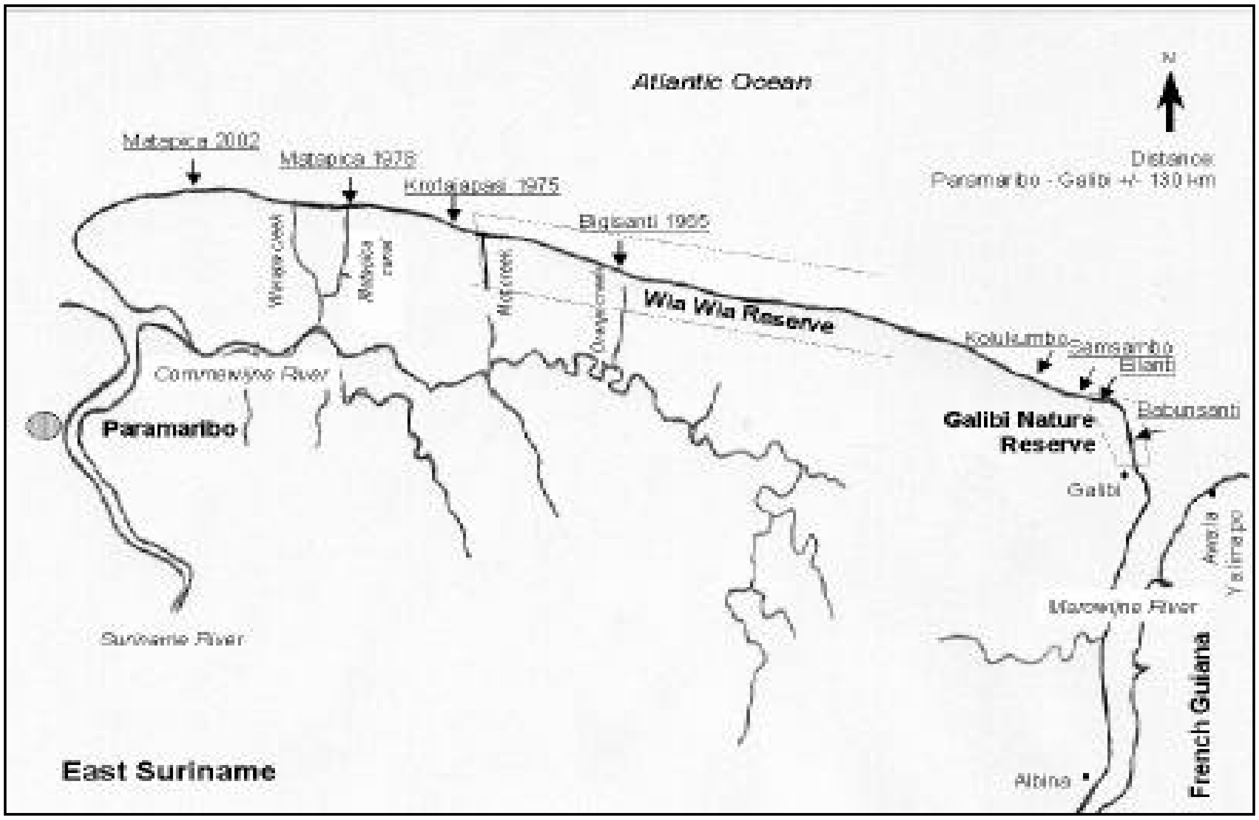
The Republic of Suriname is situated on the Northeast coast of South America, between 2º and 6º North latitude at about 54º West longitude. The Surinam coast is part of the extensive tropical mud coast between the Amazon River (Brazil) and the Orinoco River (Venezuela). Due to the westward-oriented Guyana current and north easterly trade winds, the Surinamese coastline is highly dynamic and subject to successive phases of beach erosion and accretion. The coastline is dominated by extensive mudflats, which are overgrown with black mangrove ***(parwa)*** forest at the higher levels. Sandy beaches can be found at only a few places. Both the sandy beaches and the mudflats move in a westward direction, as a result of erosion on the east side and accretion on the west side (Augustinus 1978, Schulz 1980). To monitor the formation of new nesting beaches and to assess the status of existing beaches for sea turtle nesting on a yearly basis, an aerial survey is an excellent tool. In addition, ground surveys are done with GPS. Results of the aerial survey of 2002 are presented in a separate report (Goverse 2003).

Sea turtle nesting beaches are found in the eastern part of Suriname (picture 1.1). The main present nesting beaches for leatherbacks are:

- Babunsanti, 6 km length, situated in the Marowijne River Estuary, Galibi Nature Reserve
- Kolukumbo, 1 km length, situated approximately 15 km west of the Marowijne River Estuary on the Atlantic coast
- Matapica, 9 km length, situated on the Atlantic coast in the vicinity of the Suriname River estuary on which the capital Paramaribo is situated. Matapica is a highly dynamic beach, which moves to the west with a speed of approximately 1.5 km per year due to beach erosion on the east side and accretion on the west side

Other nesting beaches are Alusiaka (mainly green turtle nesting), Thomas-Eilanti (green turtle, olive ridley and some leatherback nesting), Samsambo (formerly an important leatherback nesting beach, now almost inaccessible due to extensive mud flats in front of it), Diana Beach (some green turtle, leatherback and olive ridley nesting).

[1] For Index Beaches, assessment of size and trend must be continued for a minimum of 3 multiples of the average remigration interval (2-3 years for leatherbacks) (Eckert ***In press.***), this implies that the PIT tag program that started in 1999 should continue until at least 2004 to have scientifically valid data.



Picture 1.1: ***Map of the eastern part of Suriname, showing all present and former sea turtle nesting beaches.***

1.5 Field activities

PIT tag program

Tag return data help to understand the demography and reproductive ecology of sea turtles. PIT (Passive Integrated Transponder) tagging is essential to any leatherback tagging program because of the extremely high loss rates of conventional flipper tags occurring with leatherbacks (McDonald and Dutton 1994, 1996a; Paladino 1999). It is believed that, in contrast to the use of flipper tags with leatherbacks, PIT tags are a more permanent way of marking. Data from Spotila ***et al***. (1998) indicated a tag loss of less than 5% for AVID tags. This may, however, be due to inexperience by users or use of cheaper pocket readers that are less reliable for deeper placed tags in leatherbacks (McDonald and Dutton 1996a, Paladino 1999). McDonald and Dutton (1996b) reported a tag retention of 100% after 4 years. PIT tagging is an excellent tool to perform much needed studies on population size and trends. If carried out long enough, it will yield information on (changes in) population size, the fraction of first time nesters (recruitment), remigration rates and intervals, mortality at sea, and internesting frequency and intervals (McDonald and Dutton 1996a, 1996b; Spotila ***et al***. 1998; Steyermark ***et al***. 1996; Chevalier and Girondot 1999).

Biometric measurements

Sea turtles on nesting beaches are measured to 1) be able to relate body size to reproductive output, 2) determine minimum size at sexual maturity and 3) to monitor nesting female size for a particular rookery. The size-frequency distribution of a population is an important parameter of that population's demographic structure (Bolten 1999, Zug and Parham 1996). We measured curved carapace length (CCL) and width (CCW) for nesting leatherbacks on three beaches.

Monitoring hatch rates & reproductive output

A study on reproductive output of leatherbacks was carried out on two important beaches in an effort to determine some of the basic parameters of the leatherback population, such as clutch size, hatch success, fate of eggs and survival and failure of nests. With this knowledge, net output of hatchlings on each of the important nesting beaches can be assessed (Eckert 1999). Fluctuations and structural changes in yearly nest numbers may be explained by nest survival and hatch rates, and sex ratio production (***e.g***., predominantly males for a couple of years) in the past (Eckert 1999, Chevalier ***et al***. 1999). As leatherbacks frequently nest below the high water line, probably as part of a scatter nesting strategy (Mrosovsky 1983, Eckert 1987), hatch rates are monitored and compared for different beach zones.

Measurements of sand temperature profiles

Sexual differentiation of sea turtle hatchlings is influenced by the temperature in which the eggs are incubated (Rimblot-Baly ***et al***. 1987, Mrosovsky ***et al***. 1984, Mrosovsky 1994). Sex of the hatchlings is determined between day 20 and 40 of the incubation period. At the pivotal temperature for leatherbacks, 29.5ºC, the sex ratio for leatherback hatchlings is fifty-fifty. Above that temperature more females are produced, and below, more males (Yntema and Mrosovsky 1982, Desvages ***et al***. 1993, Godfrey ***et al.*** 1996). Sand temperature profiles, and thus sex ratios of hatchlings, differ between beaches in Suriname and the region (Godfrey ***et al. In press.***). By combining these data with nest numbers and hatch rates per beach, an estimate can be made of sex ratio production for Suriname and the region.

Monitoring threats

The commercial drift-net fishing fleet forms a serious threat to nesting leatherback females in the Guianas. The boats are mostly of a Guyanese origin but generally registered in Suriname. 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.). We also record strandings, possible causes of death and observed egg poaching activities.

2 MATERIALS AND METHODS

2.1 Assessment of population size and trends

2.1.1 PIT tagging and monitoring nesting activities

Equipment and recorded data
In Suriname, French Guiana and Guyana, TROVAN ID100 tags and TROVAN LID500 scanners are used. PIT tags are injected in the muscle of the right shoulder. For each scanned leatherback female the following data were recorded: PIT tag code, new tag or recapture, activity of turtle at moment of encounter (arriving, body pitting, digging nest, laying eggs, closing nest, camouflaging, returning to sea), location on transect line to the nearest 10 m, distance to the spring tide line to the nearest half meter, distance travelled from current high water line, curved size of carapace. If a new tag was placed, the turtle was always rescanned to check whether the tag was in. Missed nestings and false crawls were recorded (number and location on transect line).

Patrolling duration and distances covered
Nightly beach patrols stretched from at least three hours before high tide to at least two hours after high tide at Babunsanti, where a clear nesting peak is seen around high tide. Patrolling continued until the last turtle had gone. In case of two high tides (early evening and early morning), two shifts were made. On Kolukumbo, nesting and thus patrolling and tagging continued the entire night from dusk to dawn. On Matapica, a peak in nesting activities is seen when the tide has risen and fallen to one quarter of the maximum high tide. Beach patrolling here was adjusted to these tidal-patterns. Table 2.1 shows the PIT tagging effort done in 2002.
The total length of Babunsanti is approximately 6.5 km. For logistical reasons, nightly beach patrolling and PIT tagging was done on 4.5 km; 2.5 and 2 km respectively on either side of the field station. Kolukumbo has a total length of 1 km and was covered completely. Matapica has a total length of 9 km of which the westernmost section is visited most by leatherbacks. PIT tagging took place on this section with a length of 3.5 km.

Beach	Sections	Distance	Duration of coverage	Permanent presence by
Babunsanti	BS-I/II/N and PB-I/II	4.5 km	April 8th - August 10th	2-3 researchers
Kolukumbo	Whole beach	1.0 km	May 6th - August 5th *	1-2 researchers
Matapica	S6	3.5 km	April 26th - July 31st	2 researchers

Table 2.1: ***PIT tagging efforts during the 2002-nesting season. * The periods May 12th - May 19th and June 7th – 8th could not be covered on Kolukumbo.***

Nest counts
Early morning nest counts for all sea turtle species (nests and false crawls distinguished) were done by STINASU field personnel and STINASU volunteers. On relatively moderate density nesting beaches such as Matapica, nest counts are a good indicator of actual nesting activity. However, on high or very high density nesting beaches such as Babunsanti and Kolukumbo, nest counts are not a very reliable way of determining nesting activity because crawls and nests are covered up and obscured by subsequent nesters and often by the high tide. As a result, in such situations the number of counted nests is likely to be a significant under-estimate (Girondot and Fretey 1996, pers. obs.). By combining nest counts with PIT tag data we attempted to make a better estimate of leatherback nest numbers.

2.1.2 Biometric measurements adult turtles

Curved carapace length and width (CCL and CCW) were measured for tagged nesting leatherback females. Measurements were done with a flexible tape measure. Minimum (or standard) CCL was measured alongside the vertebral ridge (Wyneken 2001). CCW was measured at the widest point, spanning from ridge crest to ridge crest. This is the most common practice on leatherback nesting beaches (Pritchard 1971, Bolton 1999). Depending on the activity of the turtle in the nesting process, CCW could not always be measured.

2.1.3 Identification and quantification of threats

On the monitored beaches the number of strandings for each sea turtle species was recorded. Notes were made on the state of the carcasses and possible causes of death. 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. This was done on three beaches if the situation allowed, i.e. if it was not so busy with turtles as to an extent that the tag program itself would suffer. Short notes were made of the kind of damage and degree of freshness of the wounds or scars. The categories encountered most 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, fishing hooks in flesh.

2.2 Assessment of reproductive success

2.2.1 Nest survival and hatching success

Nest marking

A total of 350 ***in situ*** leatherback nests were randomly marked from April 15th to June 15th on Babunsanti (188) and Matapica (162) along a 3000 meter transect line (TL) with numbered stakes at 10 meter intervals in the beach-vegetation. During the nightly beach patrols, a temporary stick was placed 50 cm behind the egg chamber of leatherbacks in a far stage of digging their nest, depositing the egg clutch or closing the nest. The PIT tag code, direction of the head of the turtle and location along and across the beach were recorded. Early next morning the egg clutch was located with the help of the temporary stick behind the nest in combination with the known direction of the turtle's head. The nest was carefully opened by digging a narrow channel by hand towards the eggs. A tightly folded plastic flag with nest number and date of egg deposition was then placed on top of the 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 provides precision to within 10 cm. This procedure has proved not to disturb the nests (see section 3.2.1. of this report). Part of the 350 marked nests were located with the help of a probe stick. These nests were used for a study on the effect of probing on hatch rates and not used for determination of overall ***in situ*** hatch rates.

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 70-75 days in case of non-emergence or unnoticed emergence, the nests were excavated and nest contents analysed. For each of the three beaches also a selection of non-marked ***in situ*** leatherback, green and olive turtle nests were excavated three days after observed emergence.

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), number of undeveloped eggs, number of ruptured (predated) eggs and type of predation, number of eggs with embryonic mortality and stage of embryo, 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 table 2.2. In Suriname, main predators of eggs are mole crickets (***Gryllotalpa sp., Scapteriscus sp***.) and the ghost crab (***Ocypode quadrata).*** Hatching success (%) = empty shells / 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 on Babunsanti and by the transition of the beach slope and beach flat or by the presence of a flood cliff on Matapica. 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'.

Category	Description
Undeveloped	no embryo or blood spot visible; clear distinction between egg white and yolk
early embryo	blood spot to early embryo of about 8 mm with eyes, no body pigmentation
mid embryo	embryos with body pigmentation with the size of approx. 8 mm to full term
late embryo	full term embryo, ready to hatch
unidentified rotten	the egg content consists of completely rotten embryo and could not be identified to one of the 'embryonic mortality' categories
empty egg	no egg contents at all
ruptured by mole cricket (for all above categories)	presence of one or more small holes of diameter approximately 1-5 mm with notched edges
ruptured by ghost crab (for all above categories)	presence of sharp, scissors-like cuts
pipped	partially hatched full term embryo

Table 2.2: ***Categories used for non-hatched eggs.***

2.2.2 Hatchlings measurements

Straight carapace length and width (SCL and SCW) and weight of 10 randomly chosen hatchlings of a random selection of ***in situ*** emerged leatherback nests were measured. SCL and SCW were measured with steel calipers, weight with a spring scale (maximum 100 grams).

2.2.3 Sand temperature and sex determination

Electronic temperature data loggers were deployed at 75 cm depth (average estimated clutch centre depth) on three beach zones (high, mid, low) on Matapica and two beach zones on Babunsanti (mid, low) and Kolukumbo (high, mid) 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 two hours for the whole period. Data were grouped by 10-day intervals for which the average temperature was calculated.

2.2.4 Split clutches experiment

Split clutches experiments were carried out Matapica and Babunsanti. In order to investigate the effect of inundation on the development of eggs and fitness of hatchlings, thereby excluding any maternal influence on hatchling fitness and hatch success, a split clutches experiment was carried out in two-fold. In this experiment three sub-clutches of six female turtles per beach were reburied on different beach zones (high, mid, low) within a protected enclosure immediately after egg deposition. Treatment of sub-clutches differed only in the amount of inundation. Hatchlings of the sub-clutches were collected in wire-cages straight after emerging and measured and weighed. Results of the experiment are compared to results of the ***in situ*** nests for the different beach zones. Methodology and results of the split clutches experiment are described and discussed in detail in the graduate student report of Bisschoff (2002).

2.2.5 Statistical analyses

SPSS was used for statistical analyses of data. Data were tested for normality and homogeneity of variance and subsequently ANOVA followed by a post-hoc Tukey test, a T-test, Kruskal-Wallis or a Mann-Whitney U test was used (Sokal and Rohlf 1987).

3 RESULTS AND DISCUSSION

3.1 Assessment of population size and trends

3.1.1 PIT tag program

Table 3.1 shows the number of tag records per beach for the 2002-nesting season. A total of 2289 individual leatherback females were observed, the majority of which nested on Kolukumbo. New tags were applied to 1833 individuals (80.1%), 45 were remigrants from 2000, 3 were remigrants from 2001 and 3 from 1999, and 405 turtles had a PIT code not known for Suriname. Part of this last group (128 individuals) had been tagged in French Guiana (P. Rivalan pers. comm.), of the remaining 277 unknown codes the origin could not be tracked. These may be wrongly recorded codes, either in Suriname or French Guiana. The total number of tag records, including within-season recaptures, was 5394. Figure 3.1 shows the yearly number of tag records since 1999, a distinction is made between new tags, individuals that already had a tag (including remigrants of former years and unknown tag codes) and within-season recaptures. We recorded a total of 3560 within-season and between-season recaptures. Of the 62 turtles tagged in 1999, 23 turtles (37.1 %) were observed to have returned to nest in Suriname by 2002. Of the turtles tagged in 2000, this was 9.1% (35 individuals). When looking at the total observed nesting cohorts of 1999-2002 for Suriname, 36.2% of the 1999 cohort and 10.3% of the 2000 cohort was seen again by 2002. Two turtles PIT tagged in 2000 in Guyana (A. Arjoon pers. comm.) and two turtles with Monel tags from Trinidad were observed.

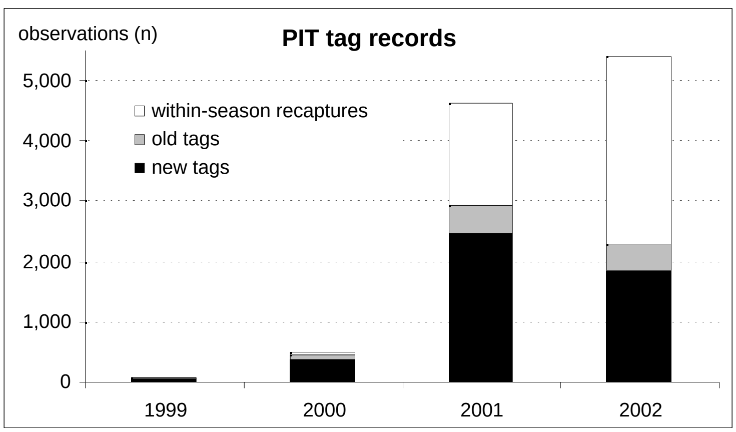


Fig. 3.1: ***Number of PIT tag records (un-tagged individuals that received a new tag, turtles that had a tag already and within-season recaptures) in Suriname 1999-2002.***

Beach	Estimated length of beach	Sections covered	New tags	Old tags (incl. within-season recaptures)	Total records
Kolukumbo	1 km	Entire beach (1 km)	1228	2603	3831
Babunsanti	6 km	BSI/II, PBI/II (4.5 km)	424	859	1283
Matapica	9 km	S6 (3.5 km)	181	99	280
Total	16 km	9 km	1833	3561	5394

Table 3.1: ***Number of tag records per beach for the 2002-nesting season.***

The mode of the observed internesting period (OIP) was 9 days (fig. 3.2), with smaller peaks at 18-20 and 27-30 days. These longer internesting periods, and high fraction of turtles seen only once 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 2002 was 10.13 days (based on turtles with a first oviposition date before June 15th), we excluded OIP values of less than seven or greater than 14 days as either aborted nesting attempts or as including an unobserved nesting (Steyermark ***et al.*** 1996).

Figure 3.3 shows the observed clutch frequency (OCF) of gravid leatherback females for all three beaches grouped together and for Babunsanti and Kolukumbo combined. The latter two are considered more representative because of the higher degree of spatio-temporal beach coverage. By excluding Matapica, the number of one-time nesters decreases. OCF was obtained after correction for false crawls (internesting periods of six days or less). OCF calculated for all individuals including those nesting on Matapica was 2.2 ± 1.4 nests, 57.1% was seen twice or more. For Babunsanti/Kolukumbo combined, 58.8% of the individuals were seen twice or more. OCF ranged between one and ten nests.
Figure 3.4 shows the estimated clutch frequency (ECF) for turtles that were observed nesting twice or more. The ECF was calculated by dividing the number of days in between the first and last nesting dates for an individual by the mean OIP, adding one for the first oviposition. We used only the individuals with a first oviposition date before June 15th, thereby avoiding the possibility that the turtle finished nesting after the end of the fieldwork period, following Reina (2002), Mean ECF (excluding the group of one-time observed nesters) for Suriname was 4.3 ± 1.6 nests. If an OIP of 9.5 days (Reina 2002, Boulon ***et al***. 1996, Steyermark ***et al***. 1996) is used, mean ECF is 4.5 ± 1.7 clutches per female. When also including the individuals that were observed nesting at least once on a French Guianese beach (P. Rivalan pers. comm.) with OIP 9.5 days, mean ECF was 4.8 ± 1.9.

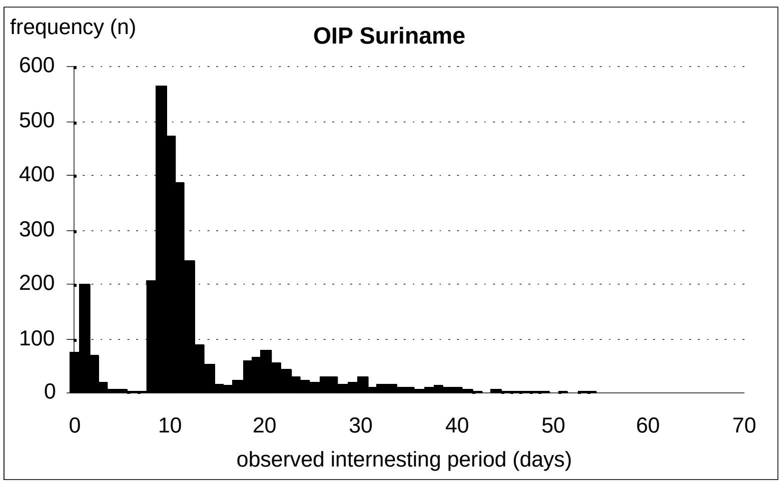


Fig. 3.2: ***Observed internesting period (OIP) for Suriname. Internesting periods of 6 days or less are considered false crawls.***

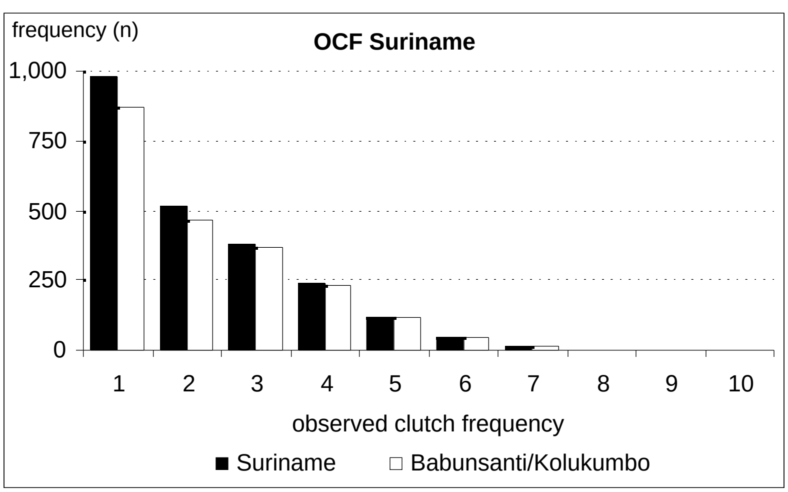


Fig. 3.3: ***The observed clutch frequency (OCF) for Suriname (Babunsanti, Kolukumbo, Matapica) and Kolukumbo/Babunsanti.***

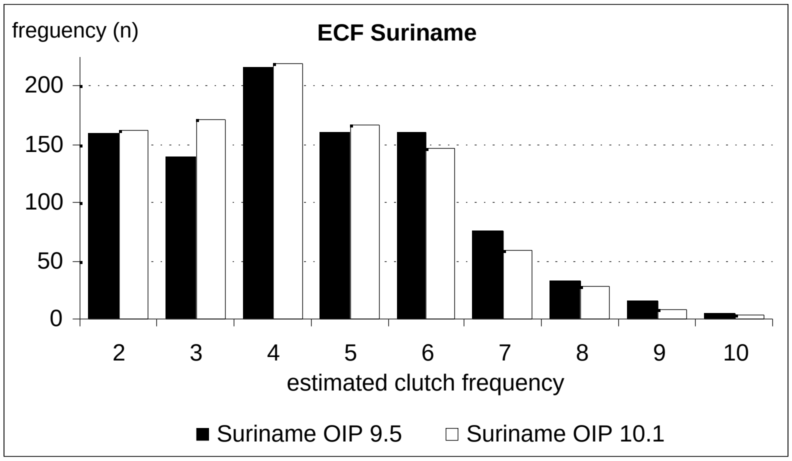


Fig. 3.4: ***The estimated clutch frequency (ECF) for Suriname using an OIP of 10.13 and 9.5.***

Not all nesting attempts result in successful oviposition. OIP data showed that 12.1% of all nesting attempts resulted in false crawls. Based on the observed number of false crawls during night-time, on Babunsanti, 16% of all observed nesting attempts resulted in false crawls. On Kolukumbo this was 8%.

Mean distance travelled by leatherback females from the actual high water line to the initial nesting position was 5.6 ± 4.4 meter at Babunsanti and 16.3 ± 8.3 meter on Matapica. This difference is highly significant (T-test, equal variances not assumed, $p<0.001$), and is similar to results of 2001 (Hilterman and Goverse 2002).

Of the 1307 individual leatherback females that were observed twice or more, 145 (11.1%) made one or more shifts between the Surinam beaches. Most popular was the shift between Babunsanti and Kolukumbo. Twenty six turtles made a shift between Kolukumbo/Babunsanti and Matapica. When including also the individuals observed in Suriname that showed a within-season nesting exchange with French Guianese beaches (P. Rivalan pers. comm.), a total of 25.3% of the individuals made one or more within-season beach shifts. A within-season shift between a Surinamese and French Guianese beach was made by 245 turtles (18.7%).

One leatherback female, tagged on Kolukumbo in 2001, was discovered in Nova Scotia by researchers of the Nova Scotia Leatherback Turtle Working Group in September 2002 (M. James pers. comm.). She was equipped with a satellite transmitter and started heading south. Unfortunately, this leatherback female lost her transmitter shortly after placement.

Discussion

The PIT tag data demonstrate that ***at least*** 2289 leatherback females have nested in Suriname during the 2002-nesting season, as these turtles were identified. However, incomplete beach coverage (e.g., one-third of Matapica covered, the month of April and ten days in May/June missing for Kolukumbo) and the data on observation frequency indicate that that the actual size of the 2002-nesting cohort must be larger. We estimated that the minimum number of individual leatherback females that nested in the 2002-nesting season was 3000. This is less than in 2001 when 2927 individuals were observed and 5500 estimated (Hilterman and Goverse 2002) but undoubtedly confirms the present status of Suriname as a major leatherback rookery. Since 1999, a total of 4735 leatherback females have been tagged in Suriname and the total number of observed individuals, corrected for remigrants, was 5665. The estimated number of individuals is higher, we estimated that in 2001 and 2002 alone, at least 8500 individuals came to nest.

Although estimated clutch frequency (ECF) as a measure of clutch frequency represents a more realistic assessment of nesting frequency than observed clutch frequency (OCF), it is most likely still underestimating the true nesting frequency of leatherback turtles in Suriname. Steyermark ***et al***. (1996), Tucker and Frazer (1991), and Boulon ***et al.*** (1996) suggest that OCF values are typically larger in smaller

populations than in larger ones (Girondot and Fretey 1996) as a consequence of increased opportunity to encounter all nesting females in a given night.
A large nesting colony spread over several beaches like in Suriname and French Guiana can never be covered completely. Assuming that each turtle nests on average at least 5 times (Steyermark ***et al***. 1996), 6.0 times (Tucker 1989), 7.5 times (Girondot and Fretey 1996) or 6.4 to 7.9 times (Reina ***et al.*** 2002) a season, from our ECF values ranging between 4.3 and 4.8 nests it is clear that a large proportion of nesting attempts were missed notwithstanding the maximum tagging effort.

Normal expected return time or remigration interval is 2-3 years for leatherbacks (Spotila ***et al.*** 1998, Boulon ***et al***. 1996, Schulz 1975). Mortality can be estimated from the percentage of turtles tagged in a given year that were not seen again within a minimum of 5 years (Spotila ***et al***. 1998). Of the 62 turtles tagged in 1999, 37.1% had returned to nest in Suriname by 2002. Given the high proportion of missed turtles especially in 2001, it is estimated that of the 1999 nesting cohort, probably 80% had re-nested by 2002. Of the turtles tagged in 2000, only 9.1% were observed to have returned to nest by 2002. However, part of the 2000-nesting cohort may return to nest in 2003 or later years, or nest outside Suriname. Alternatively, a high mortality at sea might be expected, either near the nesting area, on the migratory routes or in the feeding areas. Annual mortality rates are 19-49% for an apparently stable nesting population at St. Croix (Dutton ***et al***. 2000). From our data, it is too early to be able to estimate mortality rates of females at sea. Continued use of PIT tags in a long-term tagging program that includes all the regional leatherback beaches is needed to improve estimates of mortality. Assessment of size and trends must be continued for a minimum of 3 multiples of the average remigration interval (2-3 years for leatherbacks) (Eckert ***In press.***), this implies that the PIT tag program that started in 1999 should continue until at least 2005 to have scientifically valid data on population status.

Even though beach coverage was not complete, the high fraction of one-time nesters remains largely unexplained, as the majority of these turtles were apparently not observed on the French side either (P. Rivalan pers. comm.). The fraction of one-time nesters was lower than in 2001 but still very high compared to small nesting colonies like on St. Croix (Boulon ***et al***. 1996). Hughes (1982) stated that many leatherbacks at Tongaland, South Africa, nest only once and do not return. Given the intensive PIT tag program as carried out since 1998 in French Guiana, it is remarkable that of all observed individuals in 2002 in Suriname, 80% did not have a PIT tag yet. In 2001 this was 84%. For the 2002-nesting season we found that within-season shifting between beaches was done by 25.3% of the individuals that were seen twice or more. Nest site fidelity of leatherbacks may not be very large (Schulz 1975, Eckert ***et al.*** 1989, Fretey and Girondot 1990, Boulon ***et al***. 1996). Leatherbacks seem to display a fidelity to a larger nesting zone or beach type, rather than a specific beach (Pritchard 1982, Chevalier and Girondot 1999). Clearly, the situation in the Guianas is very complicated with many highly dynamic beaches spread over a relatively large area. Unfortunately, TROVAN scanners cannot read AVID tags (the system used in most of the Caribbean). Upgrading of two TROVAN scanners, so that they could also read AVID tags, resulted in total scanner-failure. It would thus not be possible to recognise turtles carrying AVID tags if they would nest on the beaches of the Guianas.

3.1.2 Nest numbers

The total number of leatherback nests as presented by STINASU nest counts is 8634. Based on PIT tag data (number of new tags + old tags + observed missed nestings per night, false crawls excluded) the estimated minimal number of nests after correction for incomplete beach coverage is 12.750, the majority of which was laid on Kolukumbo (table 3.2).

Figure 3.5 shows the nesting activity pattern for leatherbacks on Babunsanti and Kolukumbo during the 2002-nesting season as a two-day moving average, combined with the daily high tide heights. Observed nesting periodicity on Babunsanti and Kolukumbo differs.

Beach		length (km)	STINASU nest count	Observed No. of nestings (PIT tagging)	Estimated No. of nests
Babunsanti	-exc. pb3	4.5	1487	1447	1750
	-pb3	2.0	318	-	450
Thomas-Eilanti		1.2	273	-	400
Samsambo		8.0	-	-	450
Kolukumbo		1.0	4391	5552	7500
Matapica		9.0	2165	-	2200
Total		25.7	8634	-	12750

Table 3.2: ***Nest counts by STINASU, number of nestings observed while PIT tagging (false crawls excluded) and estimated number of nests after interpolation of data gaps and correction for incomplete beach coverage in space and time and for observer related differences. On Matapica PIT tagging was done only on Section 6 so no nest number based on PIT tag records is given.***

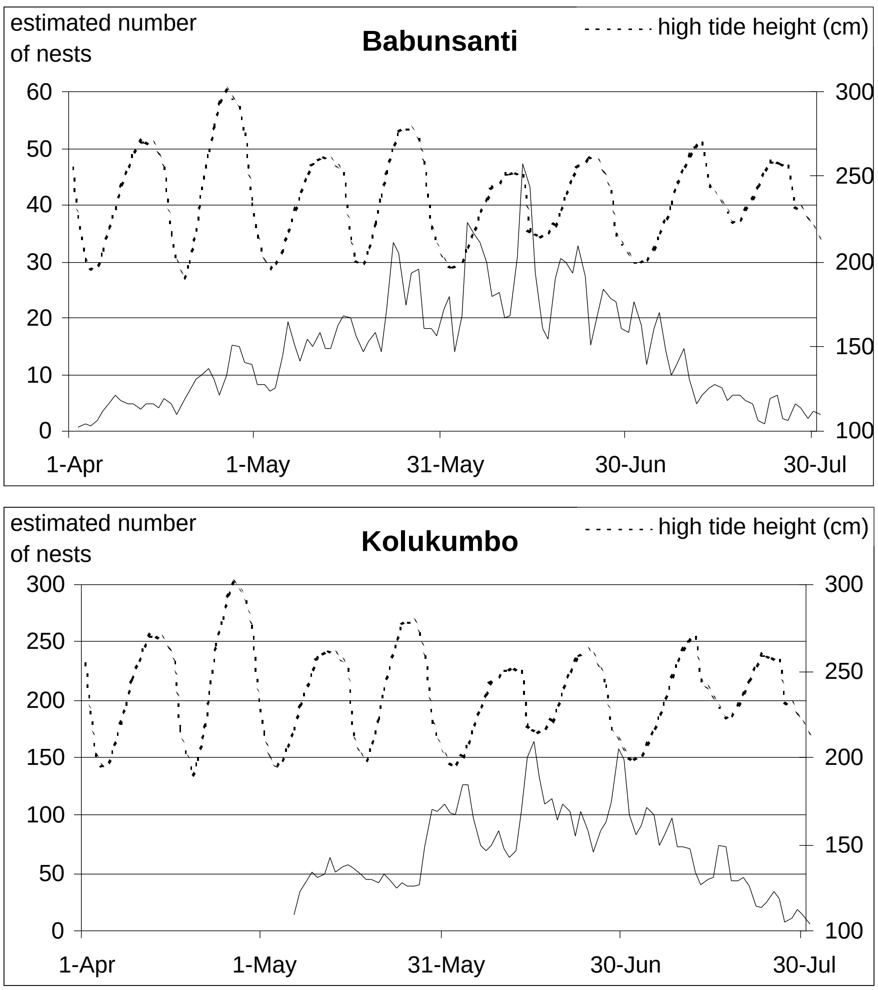


Fig. 3.5: ***Nesting activities by*** Dermochelys coriacea ***and tidal cycles during the 2002-nesting season on Babunsanti and Kolukumbo***.

Discussion

Several explanations can be given for the differences in total number of leatherback nests based on STINASU nest counts (8,634) and the estimates based on PIT tag data combined with STINASU nest count data (12,750). On Babunsanti and Thomas-Eilanti, these are incomplete beach coverage in space and time and wash-over of tracks and nests by the tide, making these invisible during the early morning nest counts. On Kolukumbo the nesting density was so high that crawls and nests were covered up and obscured by subsequent nesters (Girondot and Fretey 1996, pers. obs.). If a turtle was not actually observed at night during tagging, her nesting activities were often invisible the next morning and missed during the early morning nest counts. Also on Kolukumbo, many tracks and nests were washed away by the tide before the early morning nest count. Nest counts by STINASU personnel on Matapica can be considered very accurate. They are done both during the night and early morning and due to the great width and height of the beach very few tracks and nests are totally washed away. In 2002, no nest counts were done on Samsambo at all. Our estimates are based on observations when we passed this beach by boat and on experience from former years.

Assuming that the average within-season nesting frequency for leatherbacks in Suriname is at least 5.5 times (Steyermark ***et al***. 1996, Tucker 1989, Girondot and Fretey 1996) the number of nests laid based on the estimated minimum number of individuals (3000) in 2002 must be at least 16.500. This is higher than our nest number estimates. The latter are probably still on the low side.
Nest numbers for ***Dermochelys coriacea*** in Suriname since 1970 are shown in figure 3.6. Although estimates for 2002 (12,750) are similar to those of 2000 (14,100), and thus lower than in 2001 (30,450), the positive trend is clear. Beaches differ annually in their importance for leatherback nesting: in 2001-2002 Kolukumbo was most popular amongst leatherbacks, in 2001 Babunsanti was very popular as well, in 1999 Samsambo was the major nesting beach. Nest numbers of 2002 for Suriname are also similar to those of French Guiana (M. Girondot pers. comm.). The number of nests laid in Suriname and French Guiana was around 60,000 in and around 30,000 in 2002. Annual fluctuations have always existed and turtles may nest at different beaches in different years, but the decline in nest numbers as it was seen in the mid 1980s in French Guiana has stopped and the long-term trend seems for the Suriname and French Guiana population seems to show an increase (Girondot 2002).

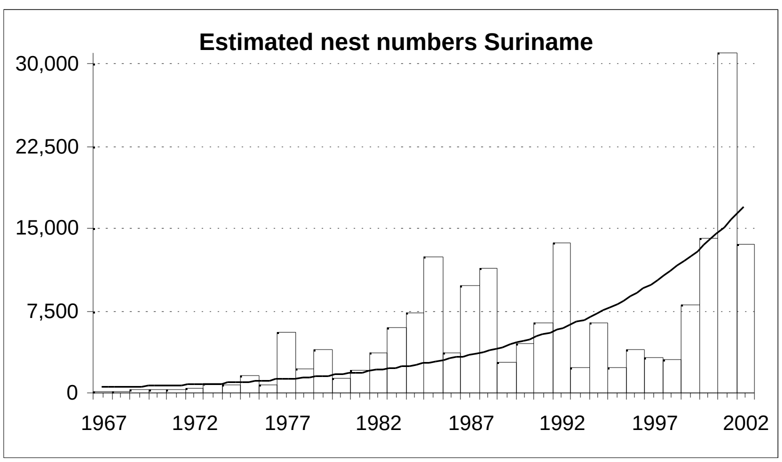


Fig. 3.6: ***Annual nest number estimates since 1967 for*** Dermochelys coriacea ***in Suriname.***

3.1.3 Biometric data

The average curved carapace length of gravid leatherback females was 154.8 ± 7.1 cm on Babunsanti and 154.9 ± 7.2 cm on Matapica, curved carapace width was 114.1 ± 5.0 cm on Babunsanti and 112.6 ± 5.3 cm on Matapica (table 3.4). This is similar to average carapace sizes found in 2001 and 2000. There is no significant difference between beaches for adult turtle size. Figure 3.7 shows the size frequency distribution for nesting leatherbacks on Babunsanti and Matapica.

2002	CCL (cm)	Min.	Max.	n	CCW (cm)	Min.	Max.	n
Babunsanti	154.8 ± 7.1	135.0	177.5	1126	114.1 ± 5.0	99.5	129.5	448
Matapica	154.9 ± 7.2	134.5	172.0	270	112.6 ± 5.3	101.0	129.0	131
Kolukumbo	155.7 ± 6.7	141.0	173.5	146	113.1 ± 5.4	105.5	124.0	24
total	154.9 ± 7.1	134.5	177.5	1542	113.1+ 5.1	99.5	129.5	603

Table 3.4*: Mean curved carapace lengths (CCL) and widths (CCW) for Dermochelys coriacea on three beaches. n= number of measurement records, individuals can be measured more than once.*

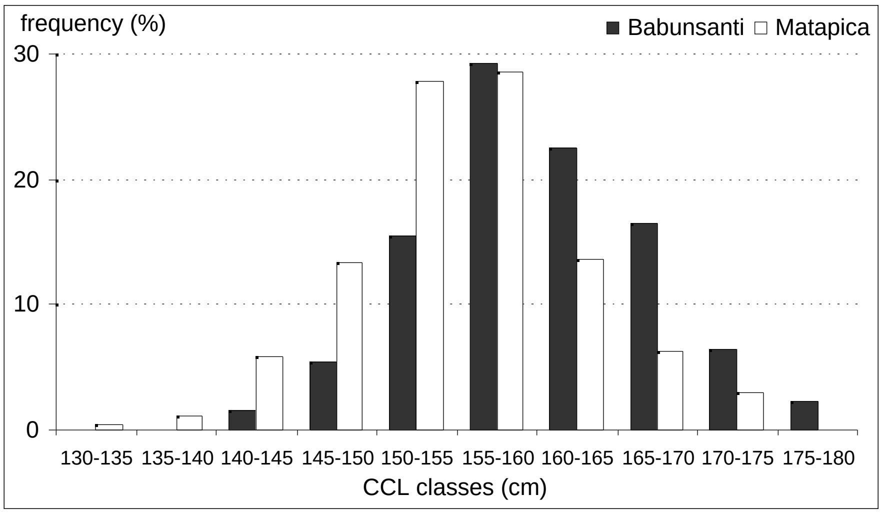


Fig. 3.7: *Size frequency distribution for nesting leatherbacks on Babunsanti (n=1126) and Matapica (n=270).*

Discussion

Table 3.5 gives an overview of the carapace size of nesting leatherback females in different regions and years. Mean curved carapace length of leatherback females in 2002 is similar to that found in 2001 (154.2 ± 6.7) and 2000 (154.2 ± 7.5) in Suriname and 156.2 ± 7.6 in French Guiana (M. Godfrey pers. comm.). Estimated (calculated from straight carapace length) or measured curved carapace length of leatherbacks nesting in the Marowijne River Estuary region has decreased since the seventies. The fact that leatherbacks in the Guianas are now smaller than in the 1970s and 1980s can mean that there is a higher adult mortality, or that more leatherback females that come to nest these days are young recruits, or a combination of both. Eastern Pacific leatherbacks (Las Baulas, Playa Langosta) are generally smaller than Western Atlantic leatherbacks.

Country	Beach	Year	Source	CCL	SCL
Suriname	Babunsanti, Matapica	2002	This report	154.9	
Suriname	Babunsanti, Matapica	2001-02	Hilterman and Goverse 2002	154.2	
French Guiana	Ya:lima:po	2000	Godfrey pers. comm.	156.2	
French Guiana	Ya:lima:po	1987-88	Girondot and Fretey 1996	(est.163)	154.6
French Guiana	?	1984	Pritchard and Trebbau, 1984	158.5	
French Guiana	Ya:lima:po	1977	Fretey and Lescure 1998	(est.175)	167
South Africa	Tongaland	1964-68	Hughes 1996	162.2	
South Africa	Tongaland	1994-95	Hughes 1996	159.6	
Costa Rica	Tortuguero	1990-91	Leslie ***et al***. 1996	156.2	
Costa Rica	Las Baulas	1994-00	Reina ***et al***. 2002	144.4-147.0	
Costa Rica	Playa Langosta	1991-92	Chaves ***et al***. 1996	147.0	

Table 3.5*: Indication for curved carapace length (CCL) and straight carapace length (SLC) over different countries and years.*

3.1.4 Threats

Egg poaching was strongly reduced compared to former years and could not be considered a serious threat to leatherback nests in Suriname in 2002. Fifteen dead leatherback females were observed stranded on the beaches, in contrast to 43 in and 37 in 2000. A first analyses of data indicates that of the 2289 individuals observed during the 2002-nesting season, at least 16.9% of the individuals showed fisheries-related injuries, of which 38.3% was considered fresh.

In front of Matapica, drift net fishing boats were often observed at distances less than 200 meter from the beach. In front of Kolukumbo it was observed on several occasions that still-alive leatherback females were cut out of nets - both drift nets and gill nets - with machetes (pers. obs.). On two occasions, stranded empty fresh carapaces were observed. These turtles had obviously been butchered for their meat. Informal talks with fishermen confirmed the idea that still a considerable number of leatherbacks are killed in nets.

Discussion

From several interviews with drift net fishermen the idea arose that on an average 10 days boat trip, a minimum of 7-10 leatherbacks are caught of which at least 1 dies. In 2002 there was a stricter law enforcement on both the Surinamese and French Guianese territories with regards to the fisheries regulations. In order to avoid too many leatherbacks being observed stranded, we were told that carcasses are often dropped further from shore. By doing this, carcasses are likely to drift past the nesting beaches of eastern Suriname and may not be noticed at all. The number of observed strandings may thus not be representative for the true number of leatherback deaths. The high proportion of leatherback females with fisheries-related injuries reflects the high occurrence of accidental captures. The turtles with fisheries-related injuries that we observed on the beaches were the survivors. The question is how many turtles did not survive their capture.

3.2 Reproductive output

3.2.1 Nest survival and hatch rates

Table 3.6 shows the fate of the random selection of ***in situ*** marked leatherback nests on Matapica and Babunsanti. The three nests that were not retrieved on Matapica, were positioned very low on the beach and probably lost by beach erosion. All observed un-marked leatherback nests (referred to sometimes as natural nests) of which hatchlings had emerged were excavated as well on both beaches for the sections monitored (220 nests on Babunsanti, 126 on Matapica).

Of the 155 analysed nests on Matapica, 30 had been located with use of a probe stick and 17 had possibly been disturbed while marking. These nests are used for a study on the effect of probing. For the determination on nest success of ***in situ*** leatherback nests, the remaining undisturbed 108 nests are used. For Babunsanti, 158 undisturbed nests are used.

Matapica, 162 nests marked	Babunsanti, 188 nests marked
Retrieved: 159 nests (98.2%)	Retrieved: 188 nests (100%)
Excavated but not analysed: 4 nests (hatched but mixed with other nests, only false eggs, etc.	Excavated but not analysed: 11 nests (hatched but mixed with other nests, poached, etc.)
Analysed: 155 nests	Analysed: 177 nests
Used for determination of in situ hatch rates: 108 nests	Used for determination of in situ hatch rates: 158 nests
Not hatched of these: 13 nests (12.0%)	Not hatched of these: 41 nests (25.9%)

Table 3.6: ***Fate of the marked leatherback nests of which the exact position was recorded by triangulation.***

Table 3.7 shows the hatch success for the marked and un-marked ***in situ*** leatherback nests. Successful nests are defined as nests of which one or more eggs had hatched. Hatch rates are significantly higher (Mann-Whitney U, p<0.001) on Matapica than on Babunsanti. On Babunsanti, 25.9% of the marked nests did not hatch. Of the successful nests, average hatch success was 34.9%. On Matapica, 12.0% of the nests did not hatch. Average hatch success of the successful nests was 63.7%. Overall average hatch success, including the unsuccessful nests, was 25.8% on Babunsanti and 56.0% on Matapica. A frequency distribution of hatch success for the marked nests on the two beaches is shown in figure 3.8.
There is no significant difference in hatch success of the marked successful nests and un-marked nests on Matapica, in contrast to Babunsanti where there is a significant difference (Mann-Whitney U, p<0.01). On Babunsanti the hatch success of the natural nests can however not be considered representative for overall ***in situ*** hatch success.

2002	Matapica H%	Babunsanti H%
Marked nests (including un-hatched nests)	56.0 ± 30.8 (n=108)	25.8 ± 24.4 (n=158)
Marked nests (successful nests only)	63.7 ± 24.2 (n=95)	34.9 ± 22.1 (n=117)
Un-marked nests (successful nests)	66.9 ± 19.4 (n=126)	42.5 ± 21.1 (n=220)

Table 3.7: ***Average hatch success and standard deviation per nest for marked and un-marked leatherback nests.***

Emergence success (hatch success minus dead hatchlings and stragglers) is generally lower than hatch success, 55.4% ± 30.6 per nest for the marked nests including un-hatched nests at Matapica and 24.6% ± 24.0 at Babunsanti. For the successful nests only, this is 63.0% ± 24.2 at Matapica and 33.2% ± 22.1 For the marked nests, the fraction of emerged hatchlings per total hatched eggs per nests is significantly higher (Mann-Whitney U, p <0.01) on Matapica than on Babunsanti (fig. 3.9). This ratio is lowest for the marked nests on Babunsanti (0.89 ± 0.23) and highest for the marked nests on Matapica (0.99 ± 0.02). The lower ratio emergence/hatching on Babunsanti can largely be contributed to the lowest beach zone where the ration is 0.83: hatchlings may be suffocated by the tide. This implies that on Babunsanti, on average 10.6% of the newly hatched leatherback hatchlings does not emerge on the surface. These hatchlings (or stragglers) generally die and do not contribute to the reproductive output of the population.

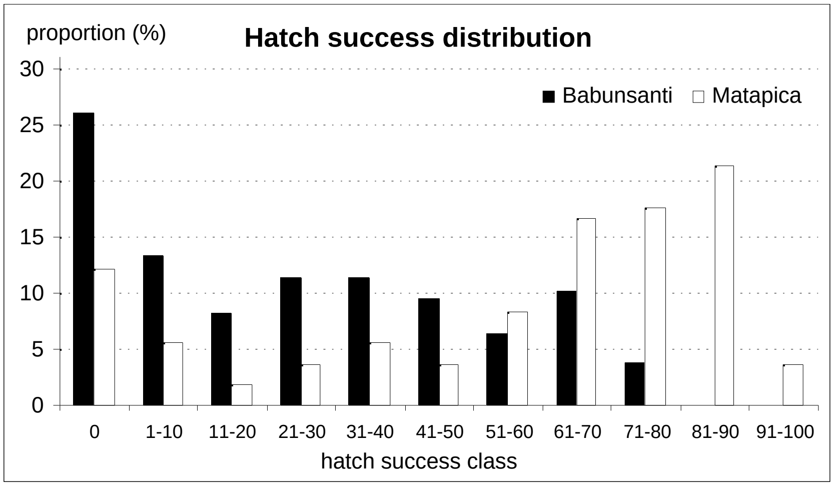


Fig. 3.8: ***Frequency distribution of hatch success of the marked nests on Matapica and Babunsanti.***

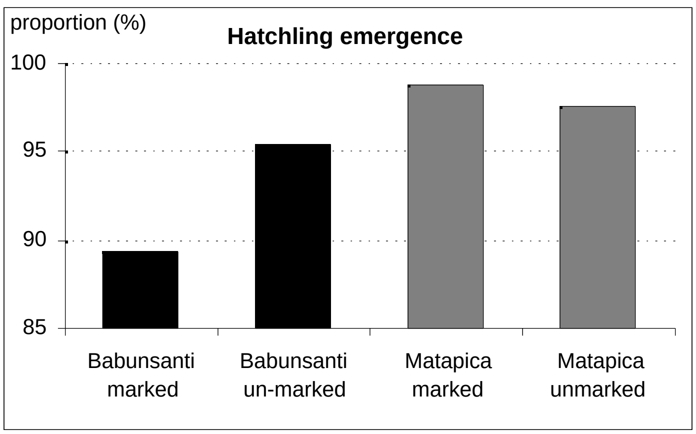


Fig. 3.9: ***The percentage emerged hatchlings per total number of hatched eggs for marked successful nests and un-marked nests on Babunsanti and Matapica.***

Figure 3.10 shows the hatch success and egg development for the marked nests. Egg predation by the mole cricket, embryonic mortality of non-predated eggs, and the fraction of pipped hatchlings were significantly higher on Babunsanti (Mann-Whitney U $p<0.05$).

On Babunsanti, 93% of all marked nests were attacked by the mole cricket or ghost crab, for the un-marked nests this was even 100%. On Matapica, 83% of the marked nests and 89% of the un-marked nests were affected by the mole cricket or ghost crab. The average egg predation per nest for the marked and un-marked nests, divided over mole cricket and ghost crab, is shown in figure 3.11. For the successful marked nests on Matapica, on average 11.1% of the yolked eggs per nest were predated by the mole cricket and 2.8% by the ghost crab. For the un-marked nests this was 9.5% and 3.3% respectively. For the successful marked nests on Babunsanti, on average 40.3% of the yolked eggs per nest were predated by the mole cricket and 0.1% by the ghost crab. For the un-marked nests this was 37.4% and 0.1% respectively.

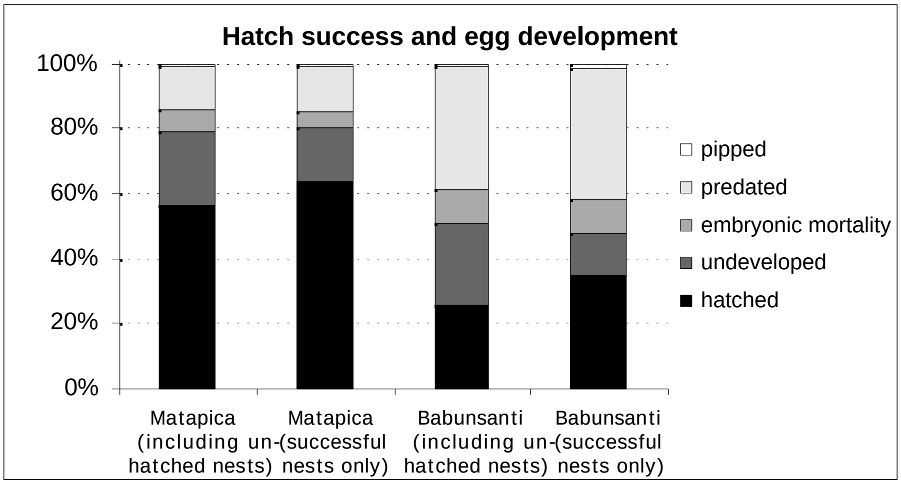


Fig. 3.10: ***Average hatch success and egg development per nest for the marked nests (including and excluding unsuccessful nests) on Matapica and Babunsanti. Eggs in the category "predated" have been ruptured by the mole cricket or ghost crab.***

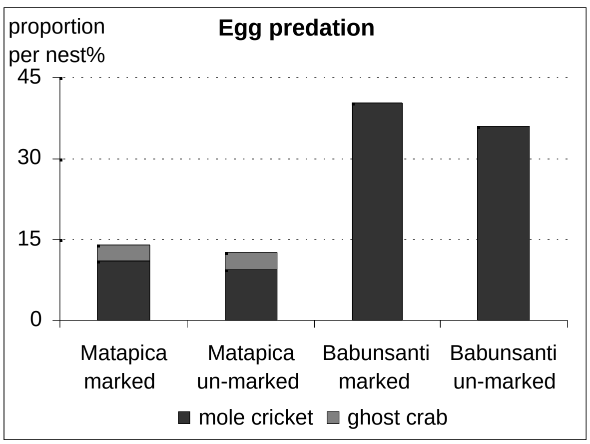


Fig. 3.11: ***Average proportion of eggs per nest that have been ruptured by the mole cricket or ghost crab for marked and un-marked nests on Matapica and Babunsanti.***

Hatch success on different beach zones

Figure 3.12 shows the distribution of the marked nests along and across the study beaches. Matapica has a wide beach flat (>70m) with little beach vegetation whereas Babunsanti is a narrow beach (<10m) with dense beach vegetation (***Ipomoea pes-caprea*** and ***Canavalia maritima***) reaching up to the spring tide line. Based on beach morphology, the beaches were divided into three zones: high, mid and low. In table 3.8 the criteria for these zones are shown. On Matapica a wash over line (WOL) exists in addition to the spring tide line (STL).

	High zone	**Mid zone**	**Low zone**
Matapica	STL ≥ 4, or: 2 ≤ STL < 4 if no WOL or WOL > -3	0 < STL < 2 if no WOL, or: 0 < STL < 4 if WOL < -3	STL ≤ 0
Babunsanti	STL > 0.5	-0.5 ≤ STL ≤ 0.5	STL < -0.5

Table 3.8: ***Criteria for beach zone demarcations (distance to STL in meters) based on beach morphology.***

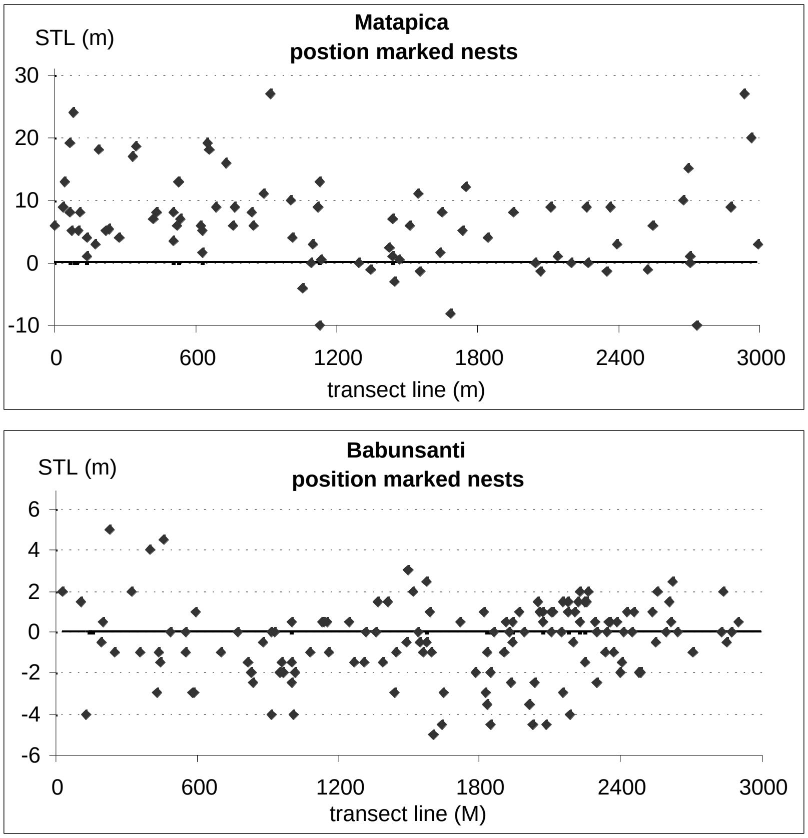


Fig. 3.12: ***Nest distribution along and across the beach (distance of the nest to the STL) of the randomly marked*** in situ ***leatherback nests at Matapica and Babunsanti.***

On Matapica, 77.8% of the marked nests were situated in the high zone, 7.4% in the mid zone and 14.8% in the low zone. On Babunsanti 27.7% of the marked nests were situated in the high zone, 33.5% in the mid zone and 38.7% in the low zone. On Babunsanti 16.1% of the marked nests were laid more than 2 meter below the STL, on Matapica this was 4.6%. Hatch rates for the three beach zones are shown in table 3.9. The lower hatch success for the low zones on both beaches can mainly be attributed to nests situated at two meters or more below the STL. Figure 3.13 shows hatch success as function of the distance of the nest to the STL.

Beach	**High zone H%**	**Mid zone H%**	**Low zone H%**
Matapica marked (incl. un-hatched nests)	59.4 ± 28.0 (n=84)	77.4 ± 15.2 (n=8)	27.9 ± 34.4 (n=16)
Matapica marked (successful nests only)	63.9 ± 23.4 (n=78)	77.4 ± 15.2 (n=8)	49.6 ± 31.7 (n=9)
Matapica un-marked (successful nests)	67.9 ± 19.0 (n=96)	65.4 ± 20.9 (n=19)	60.4 ± 21.3 (n=11)
Babunsanti marked (incl. un-hatched nests)	35.1 ± 21.8 (n=43)	35.1 ± 22.3 (n=52)	10.2 ± 19.5 (n=60)
Babunsanti marked (successful nests only)	36.8 ± 20.8 (n=41)	38.8 ± 20.1 (n=47)	23.6 ± 23.8 (n=26)
Babunsanti un-marked (successful nests)	45.4 ± 19.9 (n=99)	44.9 ± 19.7 (n=90)	26.1 ± 21.9 (n=31)

Table 3.9: ***Mean hatch success (H%) and standard deviation per nest for the beach zones on Matapica and Babunsanti.***

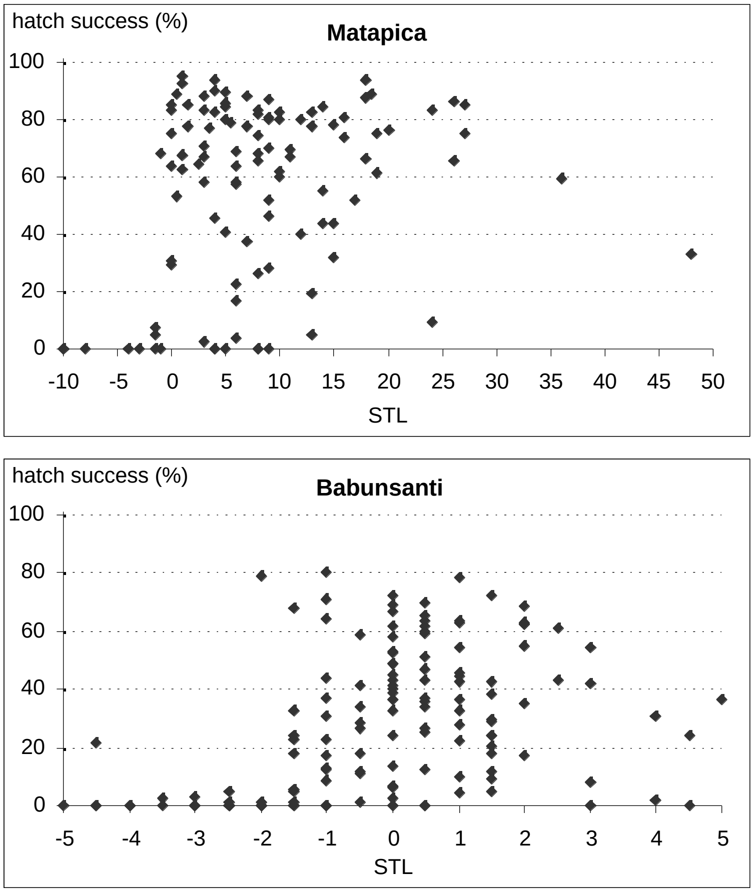


Fig. 3.13: ***Hatch success as a function of the distance of the nest to the spring tide line (nest position across the beach). Minus STL is below the STL, plus STL above the STL.***

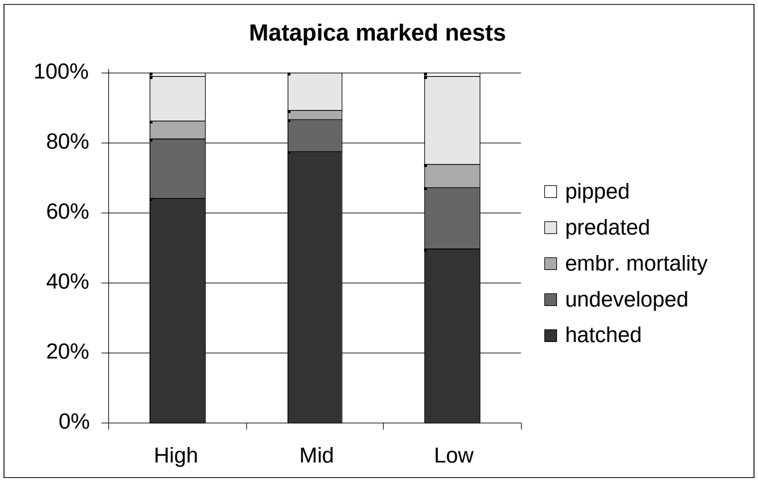
There is no significant relation between the distance of the nest to the STL and hatch success. However, nest failure is highest at distances of two or more meters below the STL on both beaches. The fraction of undeveloped eggs is higher for the lower beach zones (fig. 3.14). On Babunsanti, nests laid more than 2 meters above the STL, between the beach vegetation, show a lower hatch success as well. For both Matapica and Babunsanti, a significant difference in hatch success was found between the beach zones for the marked nests including and excluding the un-hatched nests (Kruskal-Wallis $p<0.01$), being lowest for the low beach zone. For the un-marked nests, no difference was found for the hatch success between beach zones on Matapica.

Clutch size

Average clutch size was 85.0 ± 18.2 yolked eggs and 31.9 ± 18.0 yolkless ("false") eggs for the marked nests on Babunsanti and 82.5 ± 16.8 yolked eggs and 31.7 ± 21.0 yolkless eggs for the marked nests on Matapica. There is no significant difference between clutch sizes for the two beaches. However, the data for Matapica show a possible observer-related bias in counting empty shells and thus clutch size as presented here may be too low. Clutch sizes are comparable to those found in the past two years.

Incubation periods and nest depth

Incubation periods significantly differed (Mann-Whitney U, $p<0.01$) between the beaches with an average of 67.0 ± 2.3 days (n=123) on Matapica and 64.8 ± 3.2 days (n=86) on Babunsanti. This reflects the prevalent sand temperatures at nest depth. Incubation periods are significantly longer than in 2001 on both beaches. Nest bottom depth was 76.2 ± 9.0 cm (n=160) on Babunsanti and 83.7 ± 14.1 cm (n=154) on Matapica.



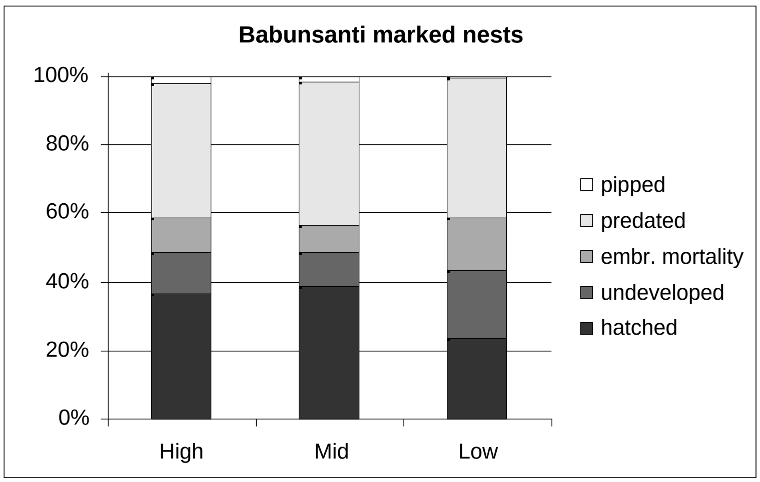


Fig. 3.14: ***Average hatch success and egg development per nest for the successful marked nests on three beach zones on Matapica and Babunsanti.***

Effect of probing on hatch success

For finding and marking the clutches in the morning, in some cases a probe stick was used. These nests are used for a study on the effect of probing. Probing for nests has been done on a large scale in the past by researchers in Suriname, whereas the effect on hatch success may be harmful (Hill 1971). In order to be able re-interpret the old data on hatch rates, the impact of probing must be quantified.

A distinction was made between 'not-probed', 'probed at stick' (carefully probed when the proximate position of the nest was indicated by a temporary stick) and 'real probed'. The latter was done only on Matapica for nests of turtles that had not been observed at night. For the categories 'probed at stick' and 'real probed', a further distinction was made between nests where one or more eggs were observed broken by the probing and nests where no eggs were observed broken. If broken eggs were observed, these were always removed from the nest, so were eggs contaminated by the egg contents of the broken egg.

Hatch successes for the different categories are shown in table 3.10. For Matapica, there was a significant difference between hatch success of the 'not-probed' nests and of the 'real probed ' nests regardless whether eggs were broken (Mann-Whitney U, $p<0.01$) or not (Mann-Whitney U, $p<0.05$). A significant difference was further demonstrated between hatch success of the 'not-probed' nests and 'probed at stick' nests of which eggs were broken. Because there was no significant difference for hatch success between 'not-probed nests' and the 'probed at stick' nests of which no eggs were broken, this last category was considered undisturbed and included in the calculations for overall hatch rates for Matapica.

For Babunsanti, there was no significant difference between hatch success for the 'not-probed' nests and 'probed at stick' nests, regardless whether eggs had been broken or not. However, we excluded the 19 nests of which eggs had been broken from the calculations of overall hatch success at Babunsanti.

At the 'real probed' nests (broken and not broken), and 'probed at stick' nests with broken eggs, predation of eggs by the mole cricket had strongly increased, embryonic mortality had increased for the 'probed at stick, broken' nests.

H% per beach	Not-probed	Probed at stick, not broken	Probed at stick, broken	Real probed, not broken	Real probed, broken
Matapica (including un-hatched nests)	59.0 ± 29.6 (n=62)	52.1 ± 32.2 (n=46)	26.6 ± 23.6 (n=17)	46.9 ± 29.4 (n=24)	39.0 ± 25.1 (n=6)
Matapica (successful nests only)	66.5 ± 21.9 (n=55)	59.9 ± 26.8 (n=40)	34.8 ± 20.8 (n=13)	59.2 ± 18.2 (n=19)	39.0 ± 25.1 (n=6)
Babunsanti (including un-hatched nests)	25.5 ± 24.1 (n=140)	27.9 ± 27.2 (n=18)	18.2 ± 18.0 (n=19)	-	-
Babunsanti (successful nests only)	33.7 ± 22.1 (n=106)	45.7 ± 19.1 (n=11)	26.6 ± 15.6 (n=13)	-	-

Table 3.10: ***Mean hatch successes for probed and not-probed nests on Matapica and Babunsanti.***

Hatchling measurements

Hatchling straight carapace length and width and hatchling weight for 10 randomly chosen newly emerged hatchlings of 36 nests at Matapica and 10 nests at Babunsanti are shown in table 3.11. Hatchling size did not significantly differ between the two beaches.

Beach	SCL (mm)	SCW (mm)	Weight (g)
Matapica	59.5 ± 2.0 (n=36 nests)	42.5 ± 6.29 (n=36 nests)	44.7 ± 3.5 (n=34 nests)
Babunsanti	59.1 ± 2.0 (n=10 nests)	41.6 ± 1.7 (n=10 nests)	-

Table 3.11: ***Straight carapace length (SCL) and width (SCW), and weight of hatchlings that emerged from in situ nests on Matapica and Babunsanti.***

Discussion

Results of the 2002-nesting season clearly confirmed that overall hatch rates (nest survival, hatch success and emergence success) on Matapica (56.0% including and 63.7% excluding un-hatched nests) more than double those of Babunsanti (25.8% including and 34.9% excluding un-hatched nests). The high abundance of and predation of eggs by mole crickets, and related effects like increased attraction of bacteria and fungi (Mo ***et al.*** 1990, Girondot ***et al.*** 1990), may be one of the main causes for a lower hatch success on Babunsanti compared to Matapica. In addition, the type of sand, consisting of course shell parts, beach morphology and drainage capacity, and the continuous refreshment of sand on Matapica may provide a better environment to the developing eggs. The average number of eggs per nest (both marked and un-marked nests) that was predated by mole crickets on Babunsanti (36.3%-40.3%) was higher than the number as presented by Maros ***et al***. (***In press.***) for Ya:lima:po on the opposite site of the Marowijne River Estuary. We believe our data are more representative because of the larger sample size and randomness of the analysed nests.
If hatch success for marked ***in situ*** nests on the Surinam beaches is compared to that of similar studies on other leatherback beaches (table 3.12), hatch rates on Matapica compare very well, whereas Babunsanti has low hatch rates. For some of these studies the fraction of un-hatched nests was not given and nests below the high tide line (thus in the wash-over zone) may not be included in hatch success results of in situ nests. This has probably resulted in a higher average hatch success found in those studies.
The Marowijne River Estuary beaches support 15,000-30,000 nests per year. The lower hatch rates found on Babunsanti are probably applicable to other beaches in and close to the Marowijne River Estuary like Ya:lima:po in French Guiana and may have a significant impact on the population recruitment (Chevalier ***et al.*** 1999). Matapica, and probably other oceanic beaches in the Guianas, are very important in terms of leatherback hatchling recruitment and should receive more attention from a conservation point of view.

Hatchling production for 2002 can be calculated by multiplying the number of nests for each of the beaches by the mean number of eggs and by the mean hatching success (including un-hatched nests).

For Kolukumbo, a mean overall hatch success was used of 47%: hatch rates are believed to be comparable to those of Matapica (pers. obs.) but due to the high nest density, probably one-fourth to one-fifth of the nests are destroyed by other turtles (Girondot ***et al.*** 2002). For Samsambo we used the same hatch success as for Babunsanti. The overall number of leatherback hatchlings produced in 2002 was calculated at 471,308, of which 454,401 emerged on the sand surface. This is, for example, three times the number of hatchlings produced over a period of 13 years on St. Croix, US Virgin Islands (Boulon ***et al***. 1996).

Hatch rates of the marked nests on Babunsanti were higher than in 2001, probably as a result of a lower nesting density by leatherbacks but also as a result of a less disturbing way of marking nests. In 2001, still some nests were located with a probe stick. Hill (1971) reported lower hatch rates for probed nests. It was shown in the present study that probing for eggs, like has been done on a large scale in the past by researchers in Suriname (e.g., Whitmore and Dutton 1984, Hoekert ***et al***. 2000), significantly lowers hatching success of those nests, regardless whether eggs were broken or not. Therefore a thorough new analyses and re-interpretation is needed on data gathered in those studies, because the hatching success found is a vast under-estimate.
The hatch rates of the natural (un-marked) nests on Babunsanti, where the spring tides inundates almost the entire beach width, cannot be considered representative. Nests with few hatchling tracks may have easily been overlooked, resulting in a bias towards excavated nests with a high emergence success. For monitoring nest survival and hatch rates, a random marked-nests study like done in Suriname in 2001 and 2002 is essential.

Country, beach	Source	Hatching % successful nests	% Un-hatched nests	Clutch size (yolked eggs)
Suriname, Matapica	This report	63.7	12.0	82.5
Suriname, Babunsanti	This report	34.9	25.9	85.0
Suriname, Matapica	Hilterman and Goverse 2002	58.3	9.7	85.3
Suriname, Babunsanti	Hilterman and Goverse 2002	21.6	48.7 *	88.1
Suriname, Bigisanti	Whitmore and Dutton 1985	52.4	?	-
St. Croix, Sandy Point	Boulon ***et al***. 1996	67.1	?	79.7
Costa Rica, Tortuguero	Leslie ***et al***. 1996	70.0	18.0	86.0
Costa Rica, Tortuguero	Leslie ***et al***. 1996	53.2	25.0	-
Costa Rica, Playa Grande	Arauz and Naranjo 1994	31.4	18.0	-
Costa Rica, Playa Grande	Schwandt ***et. al***. 1996	53.8	17.1	-
Costa Rica, Playa Langosta	Chaves ***et al***. 1996	-	-	65.3
Mexico, Mexiquillo	Tellez and Sarti 2000	71.4	?	-
Puerto Rico, Culebra	Hall 1988, 1989	-	-	69.5

Table 3.12: ***Hatch success of successful nests and the fraction of un-hatched nests, and clutch size compared for several leatherback nesting beaches. * because some nests had been disturbed while marking, this percentage may be too high.***

Whereas on Babunsanti the STL is relatively clear and uniform, the STL on Matapica is highly variable, although generally situated at the transition of the beach slope and beach flat. The wash-over zone stretches over part of, or even the entire beach flat. Up to 84% of the nests, including those above the STL, get washed over by seawater at least once during their incubation. In former studies the WOL was often confused with the STL (Hilterman and Goverse 2002, Whitmore and Dutton 1984). It has been suggested by Eckert (1987) that beach slope is positively related to the distance travelled by the turtle to the initial nesting position. This was confirmed in the present study and that of 2001. Leatherbacks nesting on Matapica crawl a three times longer distance than on Babunsanti. On Babunsanti, 27.7% of the nests are situated on the high zone, on Matapica this is 77.8%. The majority of the latter were however still in the wash-over zone. It was shown in both the present study and that of 2001 that leatherback nests can tolerate relatively high amounts of wash over and being situated below the spring tide line does not per definition mean that hatch success will be very low or zero. Only nests more than 2 meters below the true STL have such low hatch rates that they could generally be considered doomed.

3.2.2 Sand temperature and sex determination

Sand temperatures are lower than in 2001 and below the pivotal temperature for leatherbacks (29.5°C) on all three beaches for most of the season (table 3.13 and fig. 3.15). The data logger for the high zone on Babunsanti did not work, therefore no data for this beach zone exist.

On Babunsanti, sand temperature was significantly higher for the mid zone than for the low zone (ANOVA, $p<0.01$) No significant differences were demonstrated between the different beach zones on Matapica. The lower sand temperature on the high-zone on Kolukumbo may be explained by a mud layer that block the drainage of rainwater. Temperatures of the mid zone significantly differed between the beaches (ANOVA, $p<0.01$), being highest on Kolukumbo.

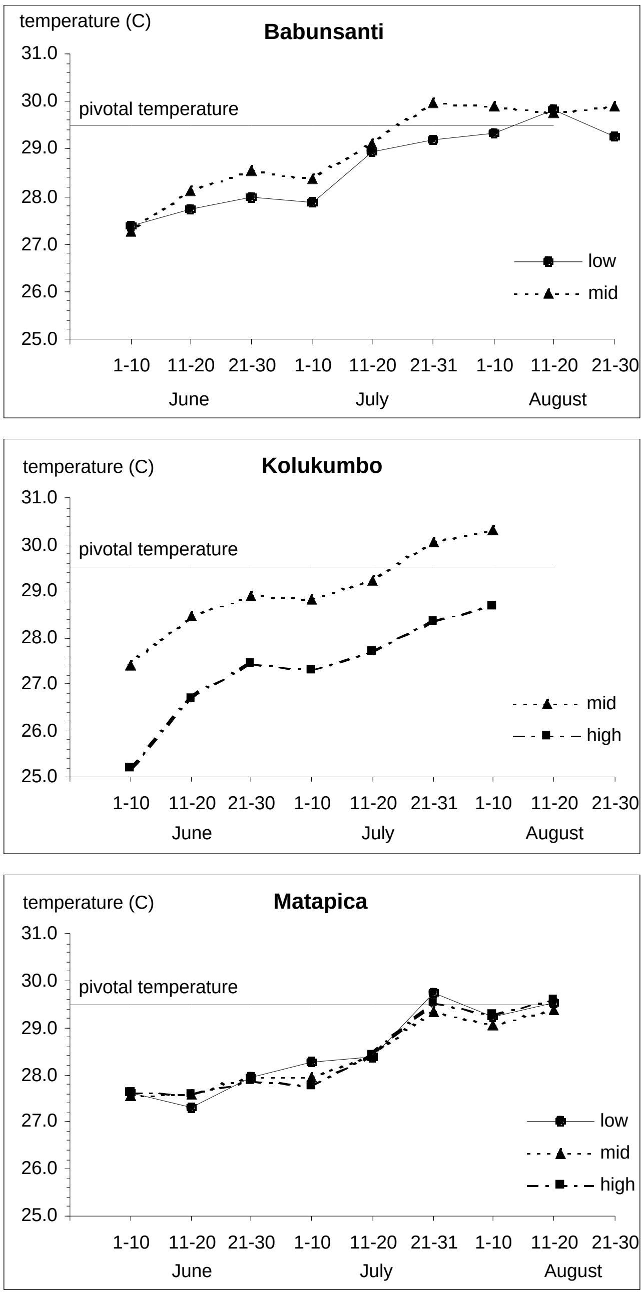


Fig. 3.15: ***Sand temperature profiles at nest depth (75 cm) during the 2002-nesting season on different beach zones on three beaches.***

2002	Low zone	Mid zone	High zone
Matapica	28.38°C ± 0.89	28.28°C ± 0.67	28.28°C ± 0.74
Babunsanti	28.40°C ± 0.79	28.88°C ± 0.75	-
Kolukumbo	-	29.15°C ± 0.65	27.52°C ± 0.84

Table 3.13: ***Mean sand temperatures with standard deviation at average leatherback nest depth (75 cm) for the period June 10th –August 3rd, 2002 on different beach zones on three beaches.***

Discussion

Assuming that the mean temperature at nest depth between day 20-40 of the incubation period represents the incubation temperature for the nest (Desvages ***et al***. 1993, Spotila ***et al***. 1987), only nests laid after July 1st on the mid/high zone of Babunsanti and mid zone on Kolukumbo will have produced mainly female hatchlings. For Babunsanti, less than 30% of the nests were situated in the high zone. This implies that in 2002, predominantly males were produced.

4 Concluding remarks

With an estimated 8500 individuals nesting in 2001 and 2002 in Suriname alone, the leatherback nesting population of Suriname and French Guiana is one of the largest world-wide. Nest numbers in Suriname have been above 10,000 since 2000, with a peak of 30,000 nests in 2001. In 2001, the number of nests for Suriname and French Guiana combined was 60,000, one of the highest number observed for this region in 35 years. For this population the long term trend seems to show an increase. Combined with the promising messages about high nest numbers in Trinidad (>10,000 per year) and West Africa (>30,000 per year), the Atlantic leatherback populations appear stable or even growing. However, given the dramatic decline of the Pacific leatherback populations, protection and conservation of the nesting populations of the Guayana Shield may be essential to the survival of the species. Continuation of the PIT tag program, and assessment of hatchling recruitment is needed for understanding status and trends of this important nesting population.

Regionally, the leatherback populations of the Guianas are threatened by especially drift net fisheries. At least seventeen percent of all recorded individuals in the 2002-nesting season showed some degree of fisheries related injuries More research and monitoring is needed to quantify and qualify incidental captures by the Surinam fisheries fleet. Although fisheries regulations and enforcement in Suriname had been a lot improved by 2002 in the Marowijne River Estuary, it is strongly recommended to extend the direct conservation efforts to the Matapica Multiple Management Area. Because of the high hatch rates due to the good environmental quality of the beach, Matapica is very important to the reproductive output (hatchling production) of not only the leatherback population but also of the green turtle, olive ridley and hawksbill nesting populations.

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