SEA TURTLES NESTING IN SURINAM

by

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With 7 maps, 5 graphs, 26 tables and 28 plates

PREFACE

The first manuscript for this book originated in 1970 in the form of a revised translation of 'Zeeschildpadden in Suriname', a mimeographed report written primarily for internal use. This English version was of the same hybrid nature as the Dutch booklet, which was meant to be a comprehensive general guide for visitors to the nesting beaches, as well as a publication of the results of local research. The present English version, which has grown to three times the size of the original, maintains this hybrid nature. Consequently this book contains sections on general taxonomy and on the biology of sea turtles, subjects which have been treated elsewhere in a superior way by more competent authors. This general information, which is included to make the book readable for the general naturalist interested in our sea turtles, alternates with comprehensive local data — for the attention of turtle specialists abroad — which are far too detailed to captivate the attention of the general reader. In spite of this disadvantage I decided to have the manuscript published in this form, one reason being the fear that otherwise it would never be published.

The other reason which prevented the presentation of it in a more pure form lies in the ontogeny of the manuscript. The correction of the translation was not finished before the end of the 1971 turtle season, when so much information became available that the text had to undergo a thorough revision. This was not completed before the main force of the next season's turtles was making its landfall on our coast, again adding substantially to our knowledge. Shifting of the beaches caused the maps and descriptions of the beaches to become obsolete. This repetitious story, which reflects itself in the more or less scrap-book-like nature of the text, was continued in 1972. It was not before January 1974, that finally I catched up with the turtles — which fortunately do not arrive before the end of that month — and I hurried myself to dispatch the manuscript to the Netherlands Commission for International Nature Protection and to the Rijksmuseum van Natuurlijke Historie (Leiden) which, to my deep gratitude, made it possible to publish this account of the sea turtles nesting in Surinam. In 1975, just before the manuscript was taken to the printer, a few additional data could be squeezed into the text.

ACKNOWLEDGMENTS

I am grateful to Dr. J. H. Westermann, from whom I received the stimulus to proceed preparing the manuscript, and who undertook the arduous task of seeing that the manuscript was published; to the Netherlands Commission for International Nature Protection, which in various ways furthered the turtle work on our beaches and made this publication financially possible; to Dr. Peter C. H. Pritchard, who started the W. W. F. Warana Project and contributed considerably to our knowledge of turtles, and who critically read the text of this publication; to Dr. Nicholas Mrosovsky, who made major contributions to our knowledge of behaviour of baby turtles and who suggested many improvements in the text; to Russell Hill, B. Sc., who made the first translation of 'Zeeschildpadden in Suriname'; to Miss Edith Karwofodi and to Mrs. J. B. Smit, typist at the Leiden museum, who typed and repeatedly retyped the text and the tables; and to the following workers on the beach:

Mohamed Asraf, Louis Autar, Ratmin Autar, William Dawson, Bill Greenhood, Dell Green, Marius Hendri, Russell Hill, Percy Kajoema, Gerardus Kiban, Lingaard, Maipio, René Mariwajoe, Frans Monsanto, Robert Kajoema, René Kajoema, Leo Kanawari, Jakob Kiban, Leo Monsanto, Johan Nathaniël, George Plak, Duncan Reeder, Leo Roberts, Sriram, Pieter Teunissen, Jacques Waaldijk, Alfred Wolf.

That this book appears in print we owe to the willingness of the Rijksmuseum van Natuurlijke Historie at Leiden to publish it in its Zoologische Verhandelingen, despite the fact that the report contains only a single chapter on taxonomy. I thank the editorial staff for preparing the manuscript for printing.

Chapter I. INTRODUCTION

Knowledge of sea turtles in Surinam up to 1963

The earliest account of sea turtles nesting in Surinam is found in the narrative of a Labadist 1) expedition (Anonymous, 1686, Knappert, 1926). The colonists met the man who sold the meat of turtles he regularly slaughtered on 'schiltpadbay' (schildpad = turtle), a beach he was unwilling to visit with the Labadists, and which they indicated on their map as being situated north of the confluence of Coermotibo Kreek and Cottica River. Perhaps the notation Schilpad Bay on the maps of Gerard van Keulen (ca. 1710) and Ottens (ca. 1713) was copied from the Labadist map. In Stedman's narrative (1796), comments about the consumption of turtle meat in the colony are found; he also reported having observed off the Cayenne coast on January 30 of the year 1773 '...... one or two large turtles, floating

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1) Members of a pietist/separatist sect that tried in vain to found a settlement in Surinam.

past the ships side'. Stedman stated further that in Surinam '...... the turtles are... generally distinguished by the names of calipee or green turtle, and carett'. The first name may be a corruption of the local name krapé (probably of Carib origin) and 'carett' probably refers to the warana (*Lepidochelys olivacea*).

The oldest detailed account of zoological observations on sea turtles in Surinam is from Kappler 1). He mentioned in his work 'Holländisch-Guiana' (1881) the occurrence near the mouth of the Marowijne River of green turtle, olive ridley, leatherback and two hawksbill species, and gave ample details on each of these species.

The 1941 and 1945 fisheries reports of Diemont and Geijskes contain a number of observations on sea turtles laying in Surinam, particularly from the economic point of view. They name four species: *Chelonia mydas, Caretta caretta 2), Eretmochelys imbricata* and *Dermochelys coriacea.* Some details were given on nesting, nesting beaches, periodicity of nesting and about the catching, export of turtles, and the taking of eggs by the Galibi Caribs.

Brongersma (1961) reviewed collections made in Surinam.

Research and protection, 1963-1973

It is remarkable that in the past so little scientific attention has been paid to sea turtles nesting in Surinam. This is all the more regrettable because evidence now shows that Surinam is an important nesting place of the olive ridley, and one of the few nesting places of any size of the leatherback. Kappler's observations were the only ones that were published before the present research was commenced in 1963.

In 1963 and 1964, six expeditions were made by personnel of the Forest Service with the primary intention of locating the nesting places of the sea turtles 3). In 1964, three reconnaissance flights were made along the coast between Nieuw Nickerie and the mouth of the Marowijne River. The Forest Officer G. P. A. Lichtveld has the distinction of being the first to have observed and reported (in his report of 9-7-1972) on the massive group nesting of the warana (*Lepidochelys olivacea*) on the beach at Eilanti.

During these expeditions it was established that in Surinam, just as in

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1) For a complete bibliography: see Brongersma (1969).

2) This turned to be *Lepidochelys olivacea.*

3) It is the task of the Forest Service, on the strength of the Nature Protection Ordinance 1954, to manage and control the Nature Reserves. By the resolution of 9 November 1961 (amended 1966) the Wia-Wia Nature Reserve was set up, in the first instance as a sanctuary for nesting sea turtles.

Kappler's time, most sea turtles come ashore near the mouth of the Marowijne River. In 1963, it was ascertained that the Bigisanti nesting beach, for whose protection the Wia-Wia Nature Reserve had been set up in 1956, had moved so far to the west that it was no longer inside the Reserve. In 1966 the boundary of the Wia-Wia Nature Reserve was moved so as to include the '(New) Bigisanti' beach. In 1969 the Marowijne beaches were declared a sanctuary: the Galibi Nature Reserve.

Since 1969 it has been recognized that the following five species of sea turtle nest in Surinam:

1. *Chelonia mydas mydas* (Linnaeus) = green turtle, soepschildpad (Dutch), krapé (Surinam);
2. *Lepidochelys olivacea* (Eschscholtz) 1) = olive ridley, warana (Sur.);
3. *Eretmochelys imbricata imbricata* (Linnaeus) = hawksbill, karèt (Sur.);
4. *Dermochelys coriacea coriacea* (Linnaeus) = leatherback, lederschildpad (D.), aitkanti and siksikanti (Sur.);
5. *Caretta caretta* (Linnaeus) = loggerhead; observed nesting only once.

Mainly the first two species nest in Surinam. The hawksbill is a very rare visitor. For the leatherback Bigisanti is a relatively important nesting place in America, although the numbers that come ashore are nothing in comparison with those nesting at the French Guiana rookery E of the Marowijne River mouth.

When, in April 1964, it appeared that an extent of the beach to the east of Oranje Kreek was being regularly visited by turtles and poachers, a temporary bivouac was established between Oranje Kreek and Mot Kreek, and occupied by personnel of the Forest Service until the end of August. This control of poaching provided the opportunity for quantitative observations on the laying periodicity of the various species, and also on clutch size, incubation period and hatching success.

In order to gather quantitative data about laying, an approximately 10 km long stretch of beach was patrolled daily from April to August, all nests laid during the previous night being counted. In the same year a visit was made to Organabo in French Guiana, some 50 km E of the Marowijne mouth, and this confirmed the rumour that an important nesting place for the leatherback existed there.

In 1965 and 1966 only occassional observations were made. In 1966 tagging of turtles was begun by students from the University of Florida, led by

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1) Misnamed *Caretta caretta* by Geijskes (1945) and Schulz (1964).

P. C. H. Pritchard, and a number of turtles were weighed and measured. Carr visited Bigisanti in 1965 and devoted a few paragraphs to the Surinam nesting beaches (1967).

In 1967, surveillance and the systematic collecting of quantitative data about nesting was resumed by a permanent staff at Bigisanti, and commenced at Eilanti. The daily counting of nests was carried out along similar lines as in 1964. Also more data were collected about incubation periods and hatching percentages for eggs, including those in replanted olive ridley nests. Part of this work was made possible by the World Wildlife Fund (WWF). In the programme for conservation of the olive ridley, WWF paid for the buying up and reburying of 300.000 ridley eggs.

Daily counting of the nests was continued at Bigisanti in 1968, as well as at Eilanti. On the basis of observations on returns of previously tagged turtles, the first data about breeding cycles were collected. N. Mrosovky (University of Toronto) began research into the stimuli that affect leatherback young as they travel from the nest to the sea. In the following years, Mrosovsky continued these studies, and in 1971 the Dutch zoologist J. T. Wildschut devoted four months to ethological experiments with hatchlings. The last mentioned studies were made possible by a grant from the Netherlands Commission for International Nature Protection.

Most of the 1968 ridley nests at Eilanti were bought with financial aid from the WWF.

Pritchard continued tagging, and his reports on weights of ridley and green turtles were published (Pritchard, 1969, 1969a).

In 1969-1973, the work of previous years was continued and intensified with considerable assistance from R. L. Hill (1969-1971), a British zoologist. In 1969 and 1971, respectively, D. J. Green and J. T. Wildschut assisted in research activities. More data were collected concerning internesting intervals, incubation periods, size of clutches and hatching success of turtle nests and vital statistics of adults and hatchlings. From 1969 onward, about 4500 turtles were tagged, making a grand total of 5676 turtles tagged in Surinam. Up to 1973, 130 at-sea captures of Surinam-tagged turtles were reported and the migratory patterns of green turtles and ridleys that nest in Surinam are now well established. From the reappearance of tagged turtles on the beaches, important information was gleaned about (a) reproductive cycles, internesting intervals and number of clutches per season; (b) the degree of attachment of the turtles to a particular nesting beach (Chapter VIII). On each of the beach sections in the Galibi area, declared a Nature Reserve in 1969, permanent camps were built to accommodate Forest Service and Army personnel that was put at our disposal during the season.

Economic and scientific importance of sea turtles in Surinam

Sea turtles play only a relatively minor role in the local economic system. Yet, the significance of over one million turtle eggs for protein supply is not to be neglected, and data about reproduction are of importance. Only on the basis of these data will it be possible to direct measures for conservation projects aimed at increasing the egg production. The fact that the conservation measures lie partly on an international level does not make their enforcement a simple task. The influence of measures taken during the short time that the females and young are on the Surinam beaches can be completely offset, once they are outside Surinam territorial waters, by overfishing during their migrations and at the feeding grounds.

Sea turtles were only captured on a commercial scale for food purposes during a short period before the Second World War, when green turtles were caught for the export of meat. This was a dangerous form of exploitation of this valuable species, because mainly the nesting females were killed. Attempts to revive this export after the war failed and there is certainly no longer the threat of a turtle industry, based on the capture of wild animals, being established on the Surinam coast.

One of the future, not unrealistic, forms of 'exploitation' of the laying sea turtles is that of tourism. Bustard (1972) goes so far as to contend that 'turtles are key tourist attractions'.

It is hardly necessary to explain the great scientific importance of the sea turtles that come to lay in Surinam. Thanks to the relative ease with which the nesting beaches can be reached, an the good protection the nesting females and the hatchlings receive, the Surinam beaches offer excellent opportunities for research. This is confirmed by the number of students from abroad visiting the nesting beaches and contributing to our knowledge of a reptile group of which the living habits certainly merit the growing interest that biologists are now showing.

Chapter II. REMARKS ON TAXONOMY, MORPHOLOGY, DISTRIBUTION AND GENERAL BIOLOGY OF SEA TURTLE SPECIES NESTING IN SURINAM

Taxonomy and distribution

Sea turtles belong with the land and freshwater turtles and tortoises to the Testudinata, the oldest living order of the class Reptilia. They are divided into 2 families, the Dermochelyidae and Cheloniidae. The number of living species is very small. The generally accepted opinion is that there are 5 genera with 7 species and 10 or 11 subspecies. Sea turtles are mainly found in the tropics and less often in the sub-tropics. One species, *Lepidochelys kempii,* breeds only along the beaches of the Gulf of Mexico, but five other species are found in the Caribbean and elsewhere along the Atlantic coast of America, breeding at various places (see Map 1).

Chelonia mydas (Linnaeus). Green turtle

Local names: krapé 1), kadaloe 2) (Carib), portoka (Arowak).

Several subspecies of the green turtle have been described. In fact — as stated by Hirth (1971) — the *mydas*-complex may be one circumglobal 'Rassenkreis' but with significant gaps between the Eastern Pacific and Western Atlantic-Caribbean populations and between the East African and West African populations.

The Atlantic green turtle, *Chelonia mydas mydas* (Linnaeus) occurs in the Atlantic Ocean, the Caribbean Sea, the Gulf of Mexico and in the Mediterranean. It has been observed outside tropical waters in the western Atlantic, reaching Newfoundland and Mar del Plata, and in European Atlantic waters (Brongersma, 1972). However, the eggs are laid exclusively on tropical beaches. A detailed description of the subspecies can be found in Carr (1952). The colour of the juxtaposed laminae of the more or less heart-shaped carapace and of the dorsal surface of the limbs (flippers), head and tail of adult specimens is predominantly brownish with dark brown to olive streaks and blotches. The plastron is whitish.

Normally the epidermal shield cover of the carapace has 4 pairs of costals and 5 vertebrals. There is only one pair of prefrontal head scales (Pl. 1 fig. 1). Variations in the normal pattern of costal and vertebral scutes — which is often used as a primary character in keys — are very rare in adult females nesting in Surinam, but not in newly hatched young. Brongersma (1968) described 5 juveniles from Surinam with abnormal numbers of laminae. He even depicts a specimen with 6 vertebrals and 7 + 5 costals. In a separate paper the occurrence of abnormal numbers of carapace scutes in hatchlings from the Surinam rookeries will be described. The green turtle reaches a larger size than the ridley, the hawsbill or the loggerhead. The females nesting in Surinam are — with those nesting on Ascension — among the biggest in the world, a weight of 200 kilos not being unusual. Weights of

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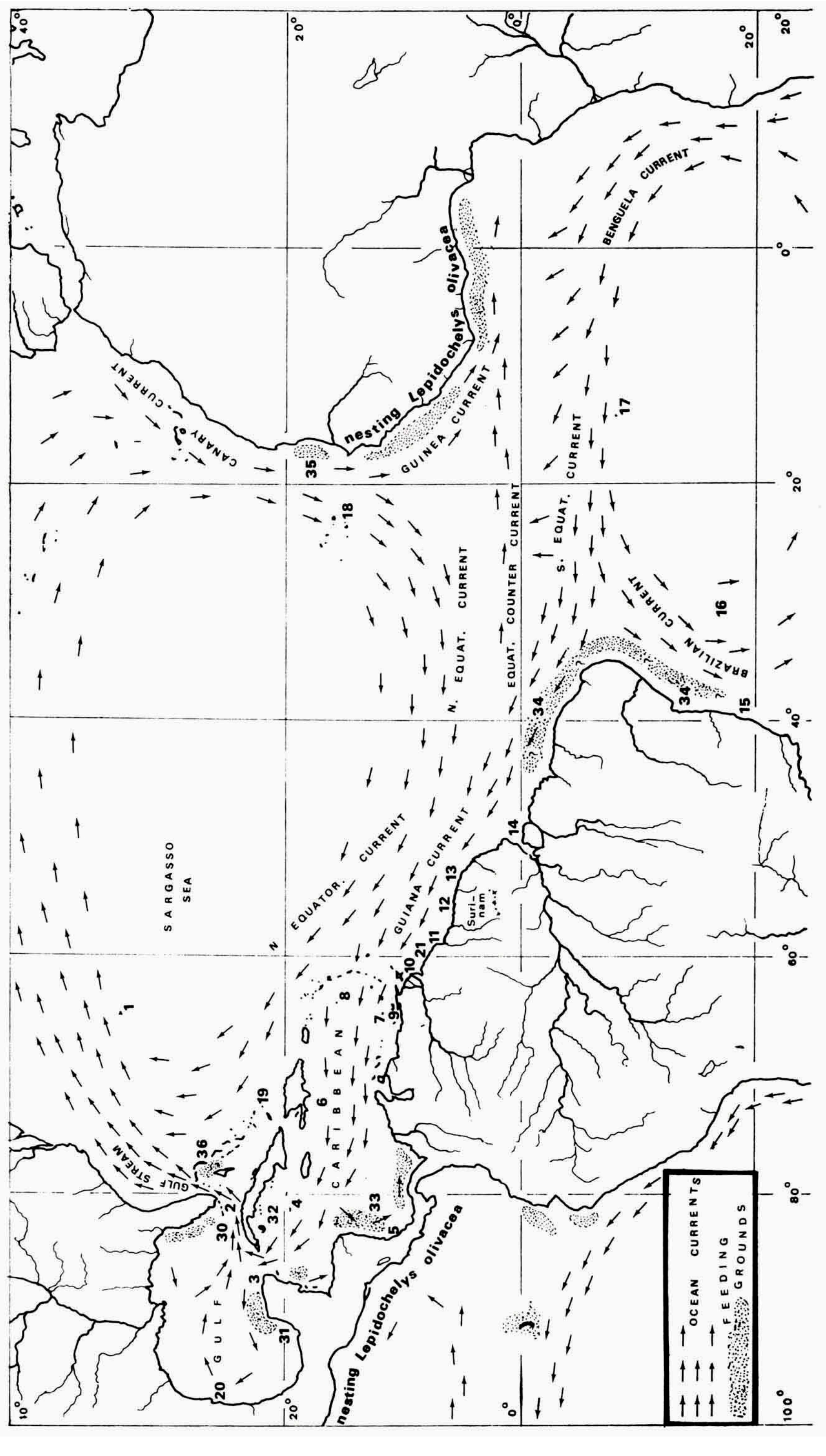
1) The trade name for the cartilaginous greenish substance that lines the shell — calipee — is probably derived from this Carib word; the resemblance to kou-pi, the early Chinese name for the green turtle — a word that is unidentified in modern dictionaries of Chinese (Parsons, 1972: 8) — is probably accidental.

2) Kadalu is also the generic Carib name for sea turtles.


CANARY CURRENT
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BENGUELA CURRENT
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N. EQUAT. CURRENT
BRAZILIAN CURRENT
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GUIANA CURRENT
SARGASSO SEA
GULF STREAM
CARIBBEAN
GULF
Suri-nam
nesting Lepidochelys olivacea
nesting Lepidochelys olivacea
OCEAN CURRENTS
FEEDING GROUNDS
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20°
40°
60°
80°
100°

50 individuals at Bigisanti and Galibi ranged from 130 to 235 kilos (average 182 kg). Carapace length of nearly all individuals nesting in Surinam is over 1 m; 291 females measured by R. L. Hill in 1970 at Baboensanti beach (Galibi Reserve) gave the following results: (a) length and breadth range 97-125 cm and 70-96 cm resp., (b) average length and breadth: 109 cm and 84 cm and (c) length/breadth ratio: range 1.1-1.5, average 1.3. The length is measured from the anteriormost to the posteriormost extension of the carapace and the width is the distance between its lateral margins at the widest point. All measurements were taken along a straight line with a tree calliper.

The shell of the male is more elongate, gradually tapering behind. Males have a greatly elongated prehensile tail with a nail-tipped end (Pl. 5 fig. 8). They also have longer claws on their front flippers than do females.

In the hatchling the shell is 4.8-5.3 cm (average 5.1 cm) long and 3.8-4.3 cm (av. 4.0 cm) wide; the margins of the carapace and the flippers are edged with white (Pl. 7 fig. 11 and Pl. 8 fig. 13). The dorsum of the hatchlings is black to dark brownish black and the venter is white. The interspaces between the scales on the top of the head are white. A few albino hatchlings were found at the rookeries.

Important green turtle rookeries in the Old World exist on Heron Island and on several other islands in the state of Queensland, Australia; on islands in the territorial waters of the State of Sabah (North Borneo); on the Talang-Talang Islands off the coast of Sarawak; and on the coast of the W Malaysian mainland and the neighbouring islands. In the Indian Ocean the Aldabra atoll, Assumption, Réunion, Mauritius and the other Mascare-

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Map. 1. Feeding grounds and nesting beaches in the Atlantic Ocean of sea turtle species nesting in Surinam. † = disappeared in historical times.

Nesting places of *Chelonia mydas*: 1, Bermuda †; 2, Key West †; 3, Isla Mujeres †; 4, Grand Cayman †; 5, Tortuguero; 6, Alta Vela †; 7, I. Tortuga + I. Blanquilla †; 8, Isla de Aves; 9, Cubagua †; 10, Trinidad; 11, Guyana coast (Shell Beach, etc.); 12, Bigisanti + Galibi (Sur.); 13, Silébache/Farez (Fr. Guiana); 14, Ilha Marajó; 15, Rio Doce; 16, Trindade; 17, Ascension; 18, Ilhas Sal, Maio, Boavista; 19, Inagua.

Nesting places of *Dermochelys coriacea*: 5, Matina Bay; 11, Shell Beach (Guy.); 12, Bigisanti (Sur.); 13, Silébache/Farez ('Organabo', Fr. Guiana); 21, Punta Playa (Guy.).

Nesting places of *Lepidochelys olivacea*: 11, Shell Beach, etc. (Guy.); 12, Galibi (Sur.); W coast of Africa (Senegal, Liberia, etc.); Pacific coast of Mexico and Central America.

Nesting place of *Lepidochelys kempi:* 29, Tamaulipas (Mex.).

Feeding grounds of *Chelonia mydas:* 30, Dry Tortugas, Cedar Keys; 31, Laguna de Términos; 32, Cuba; 33, Mosquito Keys; 34, Brazilian coastal waters, exact location uncertain (see also map 6); 35, Mauretania; 36, Bahamas †.

nes have since long been reputed to possess green turtle nesting places. Other rookeries of significance have been found at such places as the Astove Islands (S of Aldabra), Cosmoledo (Seychelles) and the South Yemeni coast (IUCN, 1969). The most startling news was the rediscovery in 1970 of one of the largest known green turtle nesting colonies in the world on Europa Island in the South Mozambique channel (G. Hughes, in IUCN, 1971). On this island, since long reputed to be a turtle rookery, the nesting animals have remained unmolested for nearly fifty years.

In the Caribbean region, after centuries of egg robbing and killing of the turtles, the large populations of former times have shrunk drastically. The dramatic decrease in number in the western Atlantic has been described in detail by various authors. Of the many nesting places along American Atlantic waters (Map 1), only a few are still visited by appreciable numbers of green turtles, the most important rookeries being: Tortuguero (the nesting ground in Costa Rica of the green turtles of the entire western Caribbean), Isla de Aves (furnishing most of the population(s) of the eastern half of the Caribbean), Galibi Reserve (Surinam) and Les Hattes/Point Isère (French Guiana). Ascension too is still an important nesting place. The greens that come to the last three breeding localities are recruited from the pasture grounds off the Brazilian coast.

The East Pacific green turtle, *Chelonia mydas agassizii* (Bocourt), nests on some beaches on the Galápagos Islands and on the W-coast of Mexico.

Caretta caretta (Linnaeus). Loggerhead

The presence of this species in Surinam coastal waters was long known from specimens in the collection of the Leiden Museum (Brongersma, 1968). In May 1969 a nesting loggerhead was observed for the first time in Surinam by Hill and Green. Characteristic features of the species are the large head, 5 pairs of costals and 5 vertebrals, reddish to yellowish brown colour, absence of pores in the 3 inframarginal scutes and two pairs of prefrontals (quite often with additional scutes or scales wedged in between) and the group of inframandibular scales of varying sizes behind the horny sheath (tomium) of the lower jaw. The carapace may attain a length of 100 cm. In contrast to the ridley, variations in the number of costal and vertebral laminae are not common, as they are in the ridley (Brongersma, 1972). Many authors used the number of inframarginals as one of the characteristics to distinguish the loggerhead from ridleys, but this number is subject to some variation (Brongersma, 1961). To arrive at a definite identification all characters must be taken into account.

Lepidochelys olivacea (Eschscholtz). Olive ridley

Local names: warana (Sur.), kulalashi (Carib).

For a long time after the publications of Deraniyagala there was still confusion regarding the distinction between the genera *Caretta* and *Lepidochelys*. This was one of the reasons for the olive ridley in Surinam being named *Caretta caretta* up to 1965. Schulz (1964) expressed doubt about this, due to the stereotyped behaviour in the closing of the nest which strongly resembled that of *L. kempii*. A young specimen of *L. olivacea* was collected off the coast of Surinam in 1911. In 1963 Brongersma obtained two *L. olivacea* hatchlings in the neighbourhood of Galibi, confirming this species to nest in Surinam. Carr found in 1964 that our photos of nesting ridleys represented *L. olivacea*.

The olive ridley is distinguishable from the green turtle and the hawksbill by the usually higher, and often assymetrical, number of costals: mostly 6-7 on each side, sometimes 5, 8 or 9. For a detailed account of the shell characteristics, see Pritchard (1969a) and Hill (1971). On the underside, pores are visible in the inframarginals (Pl. 4 fig. 6). Carr's assumption that they are secretory glands which aid in sex or species recognition and may aid in arribada formation is supported by Pritchard (1969a). The carapace is only slightly longer than it is broad, thus being almost round in outline (Pl. 1 fig. 1 and Pl. 2 fig. 3), and is mostly about 70 cm long with a grey-green to olive-green colour. The carapaces of 500 females measured at Eilanti in 1970 and 1971 had an average length of 68.5 cm (range 63-75 cm) and an average width of 60.4 cm (range 53-66 cm). The olive ridley is the smallest sea turtle and very seldom weighs more than 50 kg. Pritchard (1969) gives the average weight of 14 measured in Surinam as 35.7 kg.

The ridley can be distinguished from the loggerhead — apart from the number of costal scutes and the inframarginal pores — by the colour, the presence of a single inframandibular scale (seldom divided), by the vomer separating the maxillaries and by the lateral processes on the pterygoids.

The young are easy to distinguish from those of the green turtle by having 2 pairs of prefrontals, a greater number of costals, by the presence of strong dorsal keels on all vertebrals and costals, and by the absence of white margins along the trailing edges of the flippers. Surinam hatchlings measure on the average 4.2 x 3.6 cm.

Judging by recent discoveries, the distribution is evidently not limited to the Indian and Pacific Oceans 1), as was previously a common belief. After

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1) This gave rise to the misleading name 'Pacific ridley'. *L. kempii* is called the

it had been established that *L. olivacea* nested on the W coast of Africa from Senegal to the Congo, nesting places were found in Guyana, Surinam and French Guiana. This at last explained the mysterious reports of isolated examples of this species being found off the Atlantic coast of South America. The species, being virtually absent in the true Caribbean region, shows a remarkable distribution in the Atlantic Ocean. Ridleys nesting in Surinam were caught in Brazilian waters (Map 7), but nesting of this species on the coast of Brazil has not yet been established.

On the W coast of America, ridleys are found from Chile to Baja California, and mass nesting sites, similar to those at Eilanti, have recently been discovered on the Pacific coast of Mexico and Costa Rica. Pritchard (1969a) gives an extensive list of all breeding and non-breeding records of the olive ridley.

Eretmochelys imbricata (Linnaeus). Hawksbill

Local names: karèt (Sur.), kraroea or kulalashi (Carib).

The hawksbill is distinguished from other sea turtles by the imbricated horny plates (Pl. 3 fig. 4). These may also be seen, but to a much lesser extent, in the young green turtle, but this species has 1 pair of prefrontals on the head whereas the hawksbill has 2 pairs (Pl. 4 fig. 7). The hawksbill is distinguished from the olive ridley by the presence of 4 pairs of costals. According to some authors, the overlap of the laminae becomes progressively less as the turtle matures until they lay side by side as in *Chelonia*. The horny scales of the dorsal armour, which in hawksbills nesting in Surinam are nearly as big as those of the green turtle, are amber-coloured with red-brown (to black-brown) and yellow markings, which become clear after polishing. These plates are used for the manufacture of the so-called 'tortoise shell'.

This species occurs in all tropical waters. Hawksbill nesting appears to be widely scattered over all sandy beaches along the Atlantic Ocean, but the species is nowhere numerous and aggregated nesting is unknown.

Dermochelys coriacea (Linnaeus). Leatherback turtle, leathery turtle or luth

Local names: siksikanti and aitkanti (Sur.), kawana (sometimes with tibitibisitjing added) (Carib).

This species — the only representative of the family Dermochelyidae —

'Atlantic ridley', but is probably better named 'Kemp's ridley'. The confusion is increased by publications, in which *L. olivacea* is called 'African ridley'. There is much to be said for the name that Brongersma (1968) suggests for this species, i.e. olive ridley.

is, apart from its huge size, very easily recognizable among all other sea turtles because it lacks the horny shields that cover the back and the belly in the Cheloniidae. The strongly reduced bony shell is covered with a smooth, blackish, rubbery skin. The somewhat barrel-shaped shell is raised on the back into 7 longitudinal 'keels'; the plastron has 5 longitudinal ridges. The small, thin platelets of the dermal mosaic just under the skin of the carapace are enlarged and thickened along the ridges. The skin of the plastron contains 6 longitudinal rows of small keeled bones. The young too are easily recognizable by the 7 'keels' on the back (Pl. 7 fig. 12). For more detailed descriptions of the strikingly divergent anatomy of the leatherback, see Pritchard (1971), Carr (1942) and Brongersma (1969).

The colour of the back is dark-brown to almost black, spotted with grey to white flecks (Pl. 5 fig 9). The spots on the soft parts are pinkish. The fore flippers are markedly long and very strong, whereas the hind flippers are short, broad, and broadly connected to the tail by a web. The upper jaw margin bears two pointed projections flanked by deep cups (Pl. 5 fig. 9).

The fishermen of Surinam and French Guiana distinguish between the 'aitkanti' and the 'siksikanti'. The first form, when on its belly, shows 8 flat longitudinal bands, 6 bounded by the ridges on the carapace and 1 on each side of the plastron. These 2 bands on the side of the plastron are only partly visible in the siksikanti, because their bottom bordering ridges are located further underneath the turtle. In addition, siksikantis average somewhat smaller than aitkantis and some egg-hunters can distinguish between the nests and tracks of these two forms. In 1964, the only season when nesting data of the two forms were kept separately, it was established that peak nesting activity of the siksikanti was earlier in the season than that of the aitkanti.

Although several local observers have reported these and other differences between the two forms, available data suggest that all are ontogenetically derived. Discussion of the significance of this apparently dichotomous population must await further study.

The leatherback, the largest of the existing Chelonians, can reach a length of around 2½ m (carapace 1¾ m) and a weight of c. 600 kg. According to suspect claims, a carapace length of over 3 m and weight of 1000 kg can be attained. Although few leatherbacks have been accurately weighed, Pritchard (1971) estimates that most weights fall between 295 and 590 kg. He doubts if a breeding leatherback could be much larger than 1.80 m in carapace length, since the French Guiana specimens of this size he encountered on the beach were so heavy that they could hardly move on land. A specimen of this size would weigh some 600 kg in pre-breeding condition (extrapolated by Pritchard from an unusually small mature female from Surinam which had a carapace length of 149 cm and weighed 295 kg).

Most females coming ashore in Surinam (Pl. 6 fig. 10) have a carapace length between 150 and 165 cm. Pritchard (1971) gives measurements of the females nesting in Surinam and French Guiana.

With only two known exceptions, the breeding range of *Dermochelys coriacea* is restricted to the tropics. The species shows a noticeably strong preference for mainland nesting, and the most important rookery in the world is located on the French Guiana side of the Marowijne River (Pritchard, 1971, 1972, 1973a; Schulz, 1971). Pritchard estimated the total number of females nesting there to be about 15.000. The Bigisanti nesting colony in Surinam probably belongs to the same population. Two other nesting areas of some importance on the Atlantic coast of America are Matina beach in Costa Rica and Punta Playa near the Guyana border of Venezuela (Poonai & Bacon, quoted by Pritchard, 1971). Probably very little nesting takes place on the coasts between these rookeries.

Some early writers reported leatherbacks as nesting on the Brazilian coast, but we do not know whether this is true today. Nesting beaches exist on the E and N coast of Trinidad (Bacon, in IUCN, 1971), which is the only known island rookery of any importance. Knowledge about nesting on the Pacific coast of America is scanty, but Pritchard (1971) mentions nesting in Costa Rica and on the Mexican coast, where the northernmost record is from the state of Jalisco.

The only concentrated nesting area outside the Americas is at Trengganu, on the E coast of W Malaysia; there is serious concern for this rookery because it is grossly over-exploited for eggs (IUCN, 1969 and 1971; Bustard, 1972).

Dermochelys coriacea is decidedly pelagic and widely distributed in all seas. They have rarely been recorded from open sea in the tropics, which could be due to their remaining beneath the surface and respiring dissolved oxygen. Pritchard (1969) suggests that the papillose structure in the throat may act as an oxygen exchanger. Although the nesting range is practically restricted to the tropics, normally active individuals have been frequently recorded from cold northern waters (Brongersma, 1972) and from well south of their known breeding range. Passing leatherbacks are seen each year as far north as Nova Scotia and as far south as the Chilean coast and Argentina, where they appear to swim up the Rio de la Plata. Some authors have called attention to the possibility of northward (and southward?) migrations at the end of the breeding season and this hypothesis deserves careful consideration. The fact that the onset of the 'turtle season' off the coast of Nova Scotia coincides with the final weeks of nesting on the breeding grounds in the tropics could mean that these northern turtles have just completed what Pritchard called 'a marathon swim at high speed'. Whether this is true can only be answered after increased tagging of turtles and a careful search for tagged turtles in northern coastal waters.

Another interesting question is whether leatherbacks migrate singly or in groups. There are reports suggesting that leatherbacks move in groups during their long-distance wanderings, as well as on the breeding grounds. Pritchard's (1971) observations on the French Guiana beach and our experience on Bigisanti suggest that leatherbacks show a tendency to come ashore in groups.

Reproduction

Sea turtles are tropical saltwater animals, with the possible exception of the leatherback, which is repeatedly reported to occur in colder seas and which may only come to tropical waters to nest. The females lay their eggs on tropical sandy beaches that are situated high enough so that the nests are not washed over. The places where the turtles are cruising outside nesting time can be situated a great distance from the nesting ground. That there are periodic migratory movements between the feeding area and the nesting beach has only recently been confirmed by data provided by recaptured tagged turtles. The migratory patterns of the green turtles and ridleys that nest in Surinam are now quite well established. The first travel to and fro to Brazilian waters, principally to the state of Ceará. The ridleys come from all directions, the most frequent recoveries being from the waters between NE Venezuela and the territory of Amapá, Brazil.

At breeding time, the turtles congregate offshore, in the region of the nesting beach. Such concentrations occur every year at the start of the nesting season in Surinam, and are particularly observable off and in the mouth of the Marowijne. What is known about the migrations of the populations nesting in Surinam is reviewed in Chapter VIII.

Reproduction of the three principal species nesting in Surinam shows a marked periodicity, each having a definite nesting season which falls between January and August (Chapter V). The majority of the females nest more than once per season (multiple nesting). Multiple nesting also shows a more or less definite periodicity, the clearest case being the two-weeks internesting interval of the olive ridley (Chapter V, Table 10).

Like elsewhere, in Surinam the green turtle and the ridley show a strong site tenacity: the ability of a female to return approximately to the locality in which it has nested previously (during the same and previous seasons).

Although a female in most cases emerges on the site of the previous emergence(s), the fidelity to a particular section of beach is less strong than is accepted in most literature. That most females come back (or attempt to do so) to the same beach, or even the same beach section, has been ascertained from observations of tagged animals (Chapter V, Table 13, and Chapter VIII). Returning to the 'home' beach implies particular problems in Surinam, where the coast is continually subject to considerable alteration. Between two nesting periods (mostly 1 year for ridley, and 2-3 for green turtle) the nesting beach can be displaced or may even have disappeared entirely. This will be explained further in the next chapter.

No observations of copulation have been reported for the ridley, but mating green turtles are usually a common sight off the Marowijne beaches from February to April.

During the 1972 season, when males were exceptionally active and/or numerous — to such an extent that they were frequently seen from the beach —, mating continued until May and a pair was sighted off Baboensanti beach as late as the last week of July.

It seems that mating usually is a protracted event, which, according to fishermen, may take several days or even weeks. In the artificial pond of Mariculture Ltd. on Grand Cayman Island, one pair (the male partner of which was captured on a Surinam nesting beach) was observed copulating for 12 days in succession (Anonymous, 1973). Booth & Peters (1972), who collected unique data on the submerged part of the life cycle of green turtles, reported that copulation lasts as long as 6 hours and that males engage in multiple copulations.

Sometimes a male that ventures too close to the coast is washed ashore, or gets stuck on a mud flat (Pl. 5 fig. 8). In 1972 and 1973 several males were even found digging 'nest' holes on Galibi beach. It is remarkable that males have seldom been sighted off the Bigisanti nesting beach. It does seem that they stay farther offshore in this area or that most mating takes place near the Marowijne mouth.

Green turtle females, captured on Galibi beach in Surinam, had been kept for three years in a pond by Mariculture Ltd. on Grand Cayman Island, when two 'Surinam' males were introduced and started mating. 38 days after the onset of mating activity the first female crawled to the artificial nesting beach and deposited a clutch of eggs (Anonymous, 1973). This observation seems to contradict Carr's (1965) postulate that mating during a current season serves to fertilize eggs for the next season, the spermatozoa being stored all that time. To Booth et al. (1972) it seemed very probable that on Fairfax Island, Australia, fertilization takes place shortly before egg laying and in the same season, although they could not substantiate this from dissections of the female genital tract.

The actual nesting process, described in Chapter V, is basically the same for all sea turtles. Incubation time for the eggs is about 2 months.

Feeding

As yet relatively little is known about food and feeding habits of sea turtles and there is a need for a thorough study of the stomach contents of the different species in various regions.

Adult green turtles are mainly herbivorous, their principal feeding areas being more or less extensive 'turtle grass' pastures. Such feeding grounds are located off the NW coast of Yucatan peninsula, the Mosquito coast of Nicaragua, the S coast of Cuba and scattered areas off the Brazilian coast. For an extensive list and charts of the better known feeding areas, see Hirth (1971). This author also lists the food items reported for green turtles, which include among others: *Zostera* (eel grass), *Sagittaria, Thalassia* (turtle grasses), *Cymodocea, Vallisneria* and algae. As has been emphasized by some authors, the green turtle — a primary macro-consumer which occupies the second trophic level in the simple autotrophic plant-turtle food chain — occupies a broad ecological niche. Marine turtles and sirenians are probably the only large vertebrates grazing the extensive marine pastures, and competition between these groups is probably minimal (Hirth, 1971). Adult greens are less strictly herbivorous than was previously believed and remains of sponges, crustaceans, and pelagic molluscs are found in the stomach contents. Greens in captivity are commonly fed animal food.

No sea-grass or algae grow off the coast of Surinam. The nearest place where the green turtle feeds is probably off the NE coast of Brazil. The supposition that the population nesting on Surinam beaches comes from the coast of Brazil and not from the Caribbean region (Schulz, 1964), was confirmed by the capture of 71 Surinam-tagged green turtles off the Brazilian coast. The majority of these turtles were caught at the feeding grounds off the coast of the state of Ceará, where Ferreira (1968) studied the stomach contents of 94 green turtles. Marine benthic algae constituted the basic food with red, green and brown algae present in decreasing order of importance. A marine phanerogam, *Diplanthera* cf. *wrightii* was a secondary food item and Ferreira also reported the occasional ingestion of mollusks, ascidians, sponges, bryozoans, echinoderms and crustaceans.

According to literature, young green turtles are carnivorous. After having covered the (sometimes very) great distance to the feeding pastures, they change to a vegetarian diet. One to two years old green turtles are repeatedly caught in the mouth of the Surinam River, which could mean that greens hatched in Surinam may stay for at least such a time near the nesting beaches before leaving for the Brazilian grazing pastures. The finding of Ferreira that adult greens are not averse to eating animals in their feeding residence, could mean that the greens do not necessarily fast during their migrations from Brazil to Surinam and vice versa.

Knowledge of the diet of the *Lepidochelys olivacea* population breeding in Surinam is very scanty. Caldwell et al. (1969) found in the stomach of a single female a slimy fluid (postulated as remains of jellyfish), snail shells, crab carapaces and two catfish. Shrimp, algae, jellyfish and crustaceans were found in the stomachs of ridleys in other areas. Pritchard (1969a) supposed that the fact that ridleys have rarely been identified in the open sea probably reflects a tendency for ridleys to remain in coastal waters — where food is abundant — throughout their lives. This seems to be contradicted by the capture of Surinam-tagged ridleys far from the coast (see Map 7). The species is not found nesting on oceanic islands, in contrast to the hawksbill and the green turtle. The same holds for other populations of the genus *Lepidochelys* (Pritchard, 1969a).

Eretmochelys is assumed to be omnivorous and is supposed to stay preferably or exclusively in shallow coastal waters.

A little more is known about the feeding habits of *Dermochelys*. Some coastal Caribs of Surinam and French Guiana are of the opinion that the leatherback feeds on molluscs off the French Guiana coast, but this has never been confirmed. Bleakney (1965) has his doubts about leatherbacks feeding on hard-shelled mollusks, because their jaws are different in structure from those of typical shell crushers. As mature leatherbacks wander or migrate between cold waters and the tropics, feeding habits probably change during these very long journeys. Jellyfish (*Cyanea capillata*) and *Hyperia medusum* — a parasitic amphipod associated with jellyfish — apparently form the principal subsistence of the leatherbacks that are commonly seen each year along the coasts of New Engeland, Nova Scotia and Newfoundland (Bleakney, 1965). Brongersma (1968) concludes from a variety of sources that the diet consists mainly of Scyphomedusae (jellyfish) and tunicates (sea squirts). To this diet are added animals that live associated with the medusae (such as juvenile fishes and amphipods) and with the tunicates (amphipods). However, Brongersma believes that the diet of the leatherback may prove to be more varied than indicated by the available data, which are all from extra-tropical waters. There is no definite evidence for feeding on sea-grass or algae, although these may well be accidentally ingested.

Chapter III. WEATHER, SEA, COAST, AND NESTING BEACHES

Weather conditions, sea currents, tidal movements and sea-water properties, as they are relevant to sea turtles 1)

The continental shelf in front of the coast is of an average width of ca. 100 miles 2), declining steeply at the edge from a depth of 100 m to approx. 1000 m. The 20 m line 2) is situated 10-20 miles off the coast. Between this line and the coast the bottom relief is irregular. The 10 m line is situated 8-13 miles offshore. For a bathymetric chart of the Surinam continental shelf, see Kreffer (1971). For a detailed chart and a description of the morphology of the shelf off the Marowijne mouth nesting beaches (Galibi Reserve), see Nota (1971).

The coast of the Guianas lies alternately in the NE trade wind belt and the SE trade wind belt, or on the division between the two. From December to the beginning of April (thus including the beginning of the nesting season of the green turtle and the leatherback) the NE trade wind is blowing strongly on the coast. In these months the swell is the most heavy and the surf the strongest. The most important movements of the sandy beaches occur between December and February. From April to June, when most green turtles and ridleys come ashore, the wind becomes more variable and the percentage of calms increases. In May, for instance, in the morning the wind often blows from ESE and in the afternoon from NE. From June to August (nesting time of the ridley) the SE trade wind is weak and variable. In the November to December period it gives way to the more definite and stronger NE trade wind that causes the heavy swell during winter and spring. The influence of landwind is periodically noticeable in the months when the trade wind is less strong, particularly during June trough September. In theory this landwind could provide a cue for the orientation of sea turtles, but actually it is far too variable on the Surinam coast to play such a role.

The Guiana current flows in a WNW direction along the coast of Surinam. It is the continuation of the Northern Equatorial Current, and travels along the north coast of Brazil and the Guianas, dividing at the Lesser Antilles into the Caribbean Current and the NW directed Antillean Current (Map 1). In the coastal waters, up to 30 km from the shore (i.e. approx. to the 20 m line), the current mostly has a strength of ½ to 1 mile/hour. In

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1) The new information that became available since the first draft of this manuscript was prepared (1969) could only be included in part; for more detailed data reference is made to the latest publications mentioned in the text, particularly to the papers in the Hydrographic Newsletter, published in 1971.

2) In this chapter 'mile' = nautical mile, and 'line' = depth contour line.

May 1968, 25 km off the coast of Bigisanti, a maximum current velocity of 2 miles/hour was measured. Further from the coast, beyond the 20 m line, the current velocity on the shelf greatly varies from place to place and with the season. In November 1967, H. Nl. M. S. Luymes measured current velocities off the mouth of the Surinam River. Between the 20 and 200 m line it was 1/2-3/4 miles/hour, and in November 1968, on the shelf off the mouth of the Marowijne River, 1 1/4-1 3/4 (max. 2-3) miles/hour was measured. Along the coast the direction of the current more or less follows the 20 m line. Further offshore the direction is WNW, NW and even NNW (measurements by H. Nl. M. S. Luymes). For more details reference is made to Eisma & Van Bennekom (1971). Measurements taken off the W part of the coast of Surinam can be extrapolated.

Eisma (1967) states the surface temperature between the 10 and 100 m line to have been ca. 27° C in April 1966. At about 100 km from the coast the temperature near the bottom (at ca. 40 m depth) was 26° C. For further details about temperatures of the coastal waters beyond this distance (perhaps of importance in sea turtle orientation?) reference can be made to the data published by Eisma (1967, 1971).

The salinity of the coastal waters was also studied as a part of the hydrographical research on the Surinam continental shelf, and the results for the W half of the coast have been published by Eisma (1967). At the edge and over the gentle slope of the shelf, three layers of different salinity can be distinguished. The surface layer near the coast is of low salinity due to mixing with fresh water from the Guiana rivers. It is possible that the horizontal and vertical salinity gradients, if more or less constant, could be used for orientation by the turtles. However, in front of the nesting places at the mouth of the Marowijne the salinity varies rapidly and unpredictably. Large discharges of water from the Marowijne can make the water off the Galibi nesting beaches almost fresh. Near the lighthouse on the Marowijne, where many green turtles nest, the water is completely fresh. It is the only place to the author's knowledge where sea turtles nest adjacent to freshwater. For more recent and detailed data on surface distribution of salinity and on haloclines, especially on the eastern Surinam shelf, reference is made to Eisma & Van Bennekom (1971).

The clarity of the water gradually increases with the distance off the coast (Eisma, 1967): near the shore the Secchi-disc visibility is at a maximum 1 m, but it increases to 20 m by the time the 200 m line is reached. The brown colour of the muddy water suddenly changes into the blue-green colour of much clearer water at 20-30 km from the coast. At 50-70 km offshore the water is blue (Secchi-disc visible to ca. 10 m). For more recent observations on water transparency, see Eisma & Van Bennekom (1971), to which publication reference is made also for data on oxygen saturation and nutrient distribution.

There is a very marked tidal difference along the coast of Surinam. This contrasts with the situation in the Caribbean, where the islands and the mainland coast rise relatively steeply out of the sea. On the Guiana shelf the vertical tide movements are considerably intensified. This strong tidal action clearly has an influence on the nesting periodicity (see Chapter IV).

TABLE I

Mean monthly rainfall (in mm) for meteo stations Galibi (A: 1928-1971; B: 1951-1971) and Matapica, west of Bigisanti (C: 1953-1971). D + E and F + G: monthly rainfall for respectively two exceptionally dry and two exceptionally wet years.

	↓ month	Galibi		Mat.	Gal.	Mat.	Gal.	Mat.	↓ month
		1928	–	1971	1964	1957	1949	1954	
		A	B	C	D	E	F	G	
	J	288	223	170	60	99	293	317	J
nesting season	F	167	179	148	14	148	355	343	F
	M	175	179	124	40	124	329	78	M
	A	232	215	170	17	62	416	431	A
	M	358	357	300	188	166	429	382	M
	J	230	264	201	181	194	377	160	J
	J	172	166	137	176	92	263	133	J
	A	82	64	73	30	28	180	135	A
	S	27	22	14	4	4	127	4	S
	O	32	29	24	57	0	36	16	O
	N	72	72	52	30	39	70	169	N
	D	188	158	166	212	120	360	99	D
	Σ	2023	1928	1579	1009	1076	3235	**2267**	Σ

At Eilanti, where an extensive mud-bank is situated, the tide determines the accessibility of the nesting beach.

The breakers are seldom strong at the height of the nesting season, at any rate less strong than on many other nesting beaches (such as in French Guiana and on Ascension). It has been shown that the coming ashore of big groups of ridleys depends on the state of the sea — when the sea is smooth they do not come, but with a stiff shoreward breeze they do. However, there still remains the question of whether it is the heavy waves or the strong wind that determines the preference for such evenings.

Judging by information from the commanding officer of H. Nl. M. S. Luymes, personnel of the Fisheries Department, and shrimp fishermen, no seaweed or sea-grass (the chief food of, among others, the adult green turtle) is found off the coast of Surinam. Only Kappler (1881: 134) mentions see plants growing in the coastal waters [1]).

In 1971 a trawler of the Surinam Fisheries Department reported an extensive field of 'seaweed' off the coast of French Guiana, between Devil's Island and a point not far east of the Marowijne mouth. However, dredging only yielded large amounts of Hydroids. So the nearest sea-grass and seaweed pastures are probably those off the coast of Ceará in Brazil (Map 6).

The green turtle nests mostly from March to May, i.e. during the short dry season (if that occurs) and the first half of the rainy season. The young hatch in the rainy season (May-July). Ridleys nest in the rainy season and young hatch at the beginning of the long dry season. Rainfall data for two coastal stations near the nesting beaches are presented in Table 1. The air temperature does not vary appreciably throughout the year.

Morphology of the shore

Surinam has a low coast with the major part of the coast-line consisting of clay. Only in a few places there are sand deposits of some importance. Turtles have to lay their eggs on a high sandy beach. Details concerning sand deposition and the dynamic aspects of the coast morphology are discussed in connection with the phenomenon that the turtles each time try to return to the same nesting beach, and also with regard to possible stimuli in finding it.

The following summary of the morphology of the Surinam coast has been prepared with the assistance of P. G. E. F. Augustinus (University of Utrecht) and is based partly on observations assembled by him during a

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1) "Die jungen Schildkröten... müssen, wenn sie sich wie die Alten von Tangen nähren, wohl zwei Stunden weit schwimmen, ehe sie dahin kommen, wo auf dem tieferen Meeresboden Pflanzen wachsen".

coastal morphological research, the results of which will be published in due course.

One of the characteristics of the Surinam coast is the continuous alteration of the shore line. The radical changes have a cyclic nature: sedimentation and erosion are succeeding each other alternately.

Along the Guyana coast a stream of mud, 20-40 km wide, moves with the N Equatorial Current towards the NW at a rate of 20-50 cm/sec. carrying an estimated load of about 1-2 x 10^8 tons annually (Nedeco, 1962). The Amazon is held by most authors to be the source of this very mobile mud. Arguments in favour of this are reviewed from literature and further evidenced by results of the studies by Eisma & van der Marel (1971). Of the total sediment load carried by the Amazon only the fine-textured material — transported in suspension — reaches the Guiana coast. Part of this mud is deposited in the Surinam mud banks.

Extensive mud banks on the Surinam coast are shifting along the shore in a westward direction. They are separated by sections along which generally narrow sand and/or shell ridges are present. Deposition of mud on the one hand and of sand and shells on the other takes place separately.

The mud banks are built up of suspended material. It consists of a very watery sediment, described by Diephuis (1966) as 'sling-mud'. Owing to the extraordinary high silt concentration of the sea-water, this sediment is precipitated as a whole, in contrast to the normal procedure, in which the particles settle separately. Of the peculiar qualities of sling-mud, its dampening effect on the sea-waves is the most characteristic.

A survey of the Surinam coast as a whole gives a strikingly regular picture of sections of erosion and sections of deposition. The mud banks move westward along the coast because of abrasion at the eastern and accretion at the western end. The existence of an erosion/accumulation cycle is unanimously accepted (Dost, 1956, Diephuis, 1966, Zonneveld, 1966). By the use of quantitative data, Diephuis has been able to establish for a relatively small area along the Guyana coast that such a cycle takes approx. 30 years.

In addition to the mud flats, the coast is characterized by the occurrence of beaches which are built up of sand, shells and shell debris in all possible combinations, varying from pure sand to pure shell material. Most of the sand probably comes from French Guiana. Of the present Surinam rivers only the Marowijne contributes some sand to the Surinam coast, but in previous times other large rivers also played a part.

Shells are supplied by the sea. Molluscs die and their shells are carried coastward and broken in the breakers. On the shore the shells and shell debris are transported in the same way as the sand particles. After the sand has passed the estuaries it is displaced in a westward direction along the coast by beachdrift. This form of transport originates from waves approaching the coast at an acute angle (clearly seen in Pl. 11 fig. 18). Sediment whirled up in the surf zone is carried ashore by the swash but also partly removed by the backwash. On the Surinam coast the result is a net transport of sand (and/or shells) in a westward direction (see 'N' in Pl. 11 fig. 18).

Summarizing, there are three factors of fundamental importance necessary for the building up of the beaches: (a) sufficient supply of sand and/or shells; (b) sufficient wave energy and surf; (c) wave approach at an acute angle to the coast.

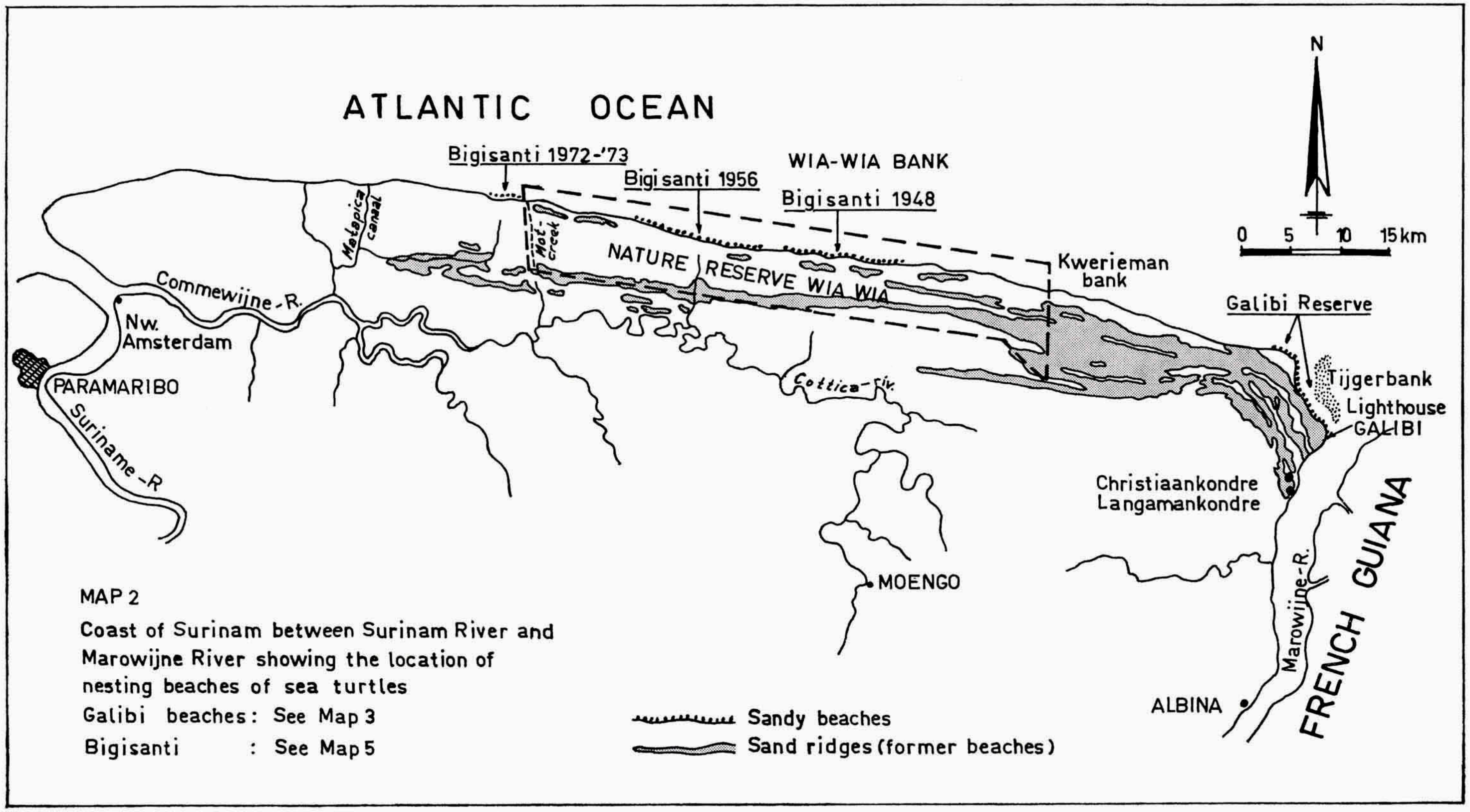
When the supply of sand and shells is too small, abrasion occurs. At high tide, material is picked up from the foreshore, transported over the top and deposited at the landside (clearly visible in Pl. 11 fig. 18). Thus, the beach is moving landward, leaving the underlying clay-surface exposed to erosion. In places where a mud bank is situated, the waves can not reach the shore, due to the above-mentioned wave suppressing property of the 'sling-mud'. Thus, in these circumstances the development of a beach comes to a standstill.

At places where the coastal waters, even at short distances from the shore, are relatively deep, and where at the same time the waves approach at an acute angle, the energy put forth may be so high that a coastwise drift develops. The velocity of this current enables sand and shell transport along a narrow path parallel to the shore. In such a case the transport velocity is greatly increased. Beaches that are formed in this way show a relatively steep foreshore. When in this situation the supply diminishes, a shortage of coarse sediment arises and the beach rapidly moves in a westward direction, leaving at the east side the clay surface — no longer covered with sand — exposed to abrasion. Such a situation is found at Bigisanti. When a beach has become so high that the top level never inundates, small dunes may develop (Pl. 12 fig. 19 and Pl. 14 fig. 24). Beaches can attain a considerable height in this way. See also Pl. 12 fig. 20.

The continuous westward movement of coarse sediment is clearly shown in Map 5, in which the position of the beach of Bigisanti is indicated for 1948, 1956, 1964 and 1967-1973.

General description of the present-day nesting beaches

As in nesting places elsewhere, all five species of sea turtles that nest in Surinam prefer beaches that: (a) are easily accessible from the sea, (b) have



MAP 2

Coast of Surinam between Surinam River and Marowijne River showing the location of nesting beaches of sea turtles

Galibi beaches : See Map 3

Bigisanti : See Map 5

a beach platform situated high enough so that it is not reached by the springtide, (c) have a ground-water level that lies deep enough. As will be discussed later, eggs will putrify when laid below or too near ground-water level. Optimal nesting conditions at the present time are found on only a relatively small part of the Surinam coast (see Map 2). A sufficiently high beach platform occurs only near the mouth of the Marowijne, at Bigisanti and near Matapica.

Mud banks in front of the beach certainly influence the visiting of turtles as their propulsion on a soft substratum is very difficult. A mud bank exposed at ebb tide is no obstacle, providing sand sufficiently covers the mud to allow that during high tide the turtles have enough time to crawl over the sand to the nesting place, lay their eggs, and then crawl back over the sand to the sea. Particularly the leatherbacks avoid beaches that lie behind mud banks. In front of the sandy beach of Eilanti, there is an extensive mud bank that is exposed over a distance of 1 km at low tide. At flood tide the water reaches the sand for a few hours (at springtide 5 hours): see profile in Pl. 15 fig 25. Leatherbacks avoid this beach and relatively few green turtles nest here. However, Eilanti is the only important nesting beach on the W coast of America for the relatively small olive ridley.

At the beaches of Baboensanti and Bigisanti the littoral slope is much steeper and no mud bank or muddy abrasion platform is exposed at low tide. This must be the reason for the preference of the leatherback for these beaches. There is a similar situation at the other important nesting place in the Guianas, viz., E of the Marowijne mouth, in French Guiana. Also in Malaya the sites of peak nesting concentrations of *Dermochelys* are coarse-sand beaches, where the rapidly shelving beach at the water line facilitates the approach of these large, heavy turtles to the beach (Hendrickson & Balasingham, 1966). The green turtle also prefers beaches without a mud flat and most nesting takes place on Bigisanti and the beaches SE of Eilanti.

Sometimes, on a beach in erosion, a temporary flood-cliff develops, resulting from undercutting and crumbling away of the top. This is, among others, periodically the case at sections of the relatively steep beaches of Bigisanti (see Pl. 14 fig. 24, Pl. 15 fig. 25 and Pl. 16 fig. 26). These steep edges, if they are not too high, generally do not present an obstacle to turtles coming to nest. However, some turtles (especially the leatherback), instead of trying to climb it, lay their eggs at the foot of the cliff and the nest is washed away during the next spring tide. Many green turtles nest far too low on the beach of Pruimenboom at the foot of the high flood-cliff (Pl. 8 fig. 14).

The surface of the sand at the nesting places may be without vegetation, but mostly it is overgrown with grasses, sedges, *Sesuvium, Batis,* creeping plants, such as *Canavalia, Ipomoea* and, at Eilanti, *Passiflora foetida.* When digging the body-pit, these plants are ripped out by the turtles and swept away. A thin growth of young shrubs of *Rhizophora, Avicennia,* and *Laguncularia* is no obstacle. At Eilanti, where free space is limited, some turtles nest between the bushes. As is described later, they even try to dig their nest-holes in the sand below the mangrove forest. Such attempts are often given up owing to the high ground-water level and the presence of obstacles like tree stumps, driftwood and stilt roots.

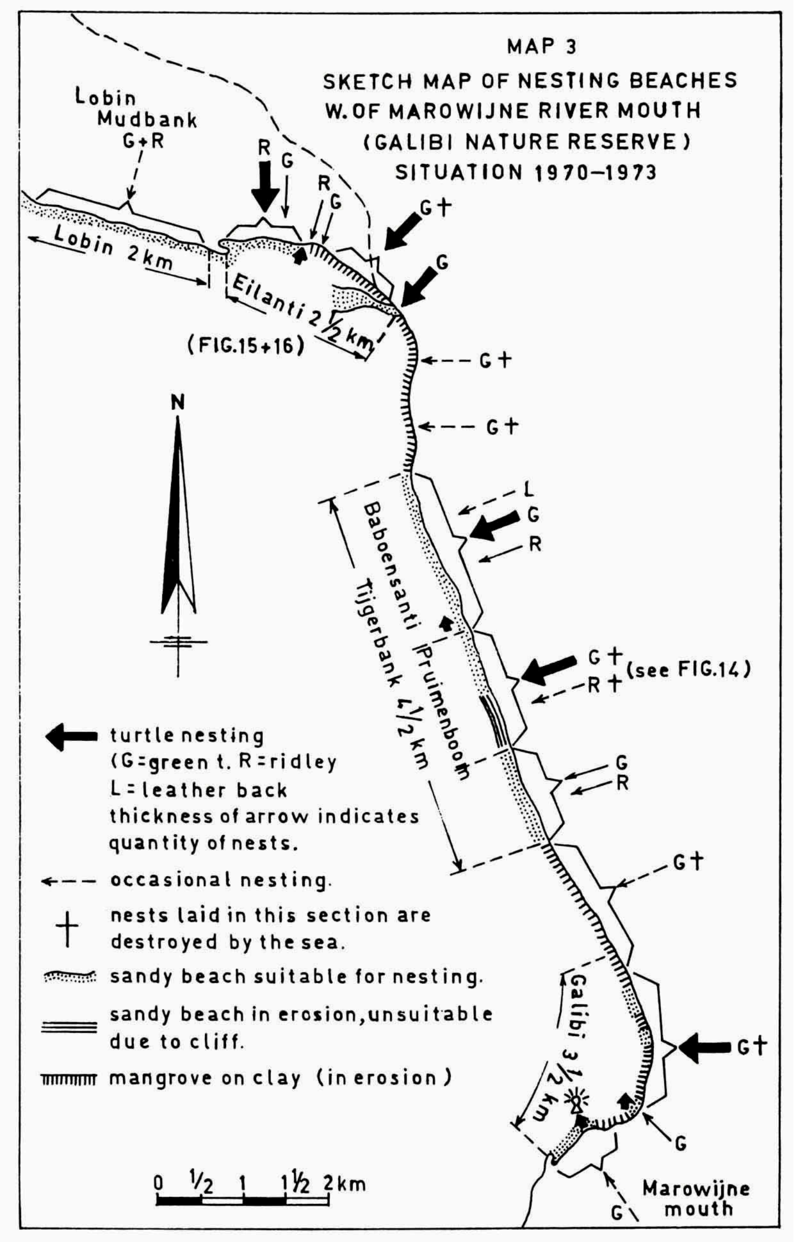
The nesting beaches in and near the Marowijne estuary

As already stated, beaches suitable as nesting places are relatively rare at present and probably were rare too during past centuries.

A chain of sandy beaches, alternating with strips of clayey deposits with mangrove, at present stretches from a point 4 km W of Eilanti to the villages of Langamankondre and Christiaankondre on the Marowijne. The Marowijne mouth beaches are currently the most important nesting places of green turtles and olive ridleys in Surinam. Of this ca. 19 km long coastal strip, at present Eilanti beach, Dap Eiland beach, Tijgerbank beach ('Baboensanti' and 'Pruimenboom') and Galibi beach are visited by turtles (see Map 3). Of the beaches situated within the Galibi turtle sanctuary, the wide, high crested beach of Baboensanti since ten years is by far the most suitable one. The sandy beaches alternate with mangroves on clay, which is in state of erosion. As will be described below, on several of these sections — quite unsuitable as nesting place — green turtles make abortive attempts to nest, or lay eggs that are doomed to perish.

On the map of Gerard van Keulen (of about 1710) this area is marked 'Sant strant' (= sandy beach). Kappler (1881) wrote about his visit in 1845 to Gwerimanshoek, the sandy beach where turtles nested. He described how he sailed by boat from the village of Christiaan and 'soon' reached Gwerimanshoek. In view of the time Kappler took to get there, the place was not near the present-day Kweriman Kreek but within or close to the Marowijne mouth, not far from Galibi.

There are indications that during the entire Holocene period sandy beaches existed near and within the Marowijne mouth at about the same place as where they are now. The chenier-type sand ridges found there represent a number of fossil sandy coasts of different ages. In the mouth of the river the water is fresh throughout the year. The fact that green turtles nest here is unique, as there is, to the author's knowledge, no other nesting place for


MAP 3
SKETCH MAP OF NESTING BEACHES
W. OF MAROWIJNE RIVER MOUTH
(GALIBI NATURE RESERVE)
SITUATION 1970–1973
Lobin Mudbank
G+R
R
G
R
G
G†
G
Lobin 2 km
Eilanti 2 1/2 km
(FIG.15+16)
G†
G†
N
L
G
R
Baboensanti
Pruimenboom
Tijgerbank 4 1/2 km
G†
R†
(see FIG.14)
G
R
G†
Galibi 3 1/2 km
G†
G
G
Marowijne mouth
turtle nesting
(G=green t. R=ridley
L=leather back
thickness of arrow indicates
quantity of nests.
occasional nesting.
nests laid in this section are
destroyed by the sea.
sandy beach suitable for nesting.
sandy beach in erosion, unsuitable
due to cliff.
mangrove on clay (in erosion)
0 1/2 1 1 1/2 2 km

sea turtles on beaches bordering fresh water. The water in front of the beaches W of the Marowijne mouth (Tijgerbank, Eilanti) during the nesting season (= rainy season) is brackish to nearly fresh.

Sandy beaches also occur on the right bank of the Marowijne mouth, on French territory. Leatherbacks and green turtles were observed to nest on the beach of Les Hattes (at the confluence of Marowijne and Mana River) and at the beach of Aouara, on the left bank of the Mana mouth (Schulz, 1971).

Eilanti (Carib: oetapo = 'place that comes above water'), the westernmost of the Marowijne mouth beaches, came to international fame after it was discovered in the sixties as the most important nesting place of the olive ridley on the coasts of the Atlantic. In 1948 — when the first aerial photographs were taken — there was already a spit called Eilanti that shifted westward, a process that was still in full swing in 1975. How long this movement will continue, can not be said. The apparent movement of the sand spit by leaps and bounds can be established by the four clearly defined sandy bays lying perpendicularly to the coast (see arrows in Pl. 9 fig. 15). These are still much frequented by green turtles (nest-site fixity?), that nest here in much greater numbers than on the younger beach more to the west.

In front of Eilanti beach lies the E end of an extensive mud bank — Lobin bank — that is exposed over a width of 1 km at low tide (see aerial photographs in Pl. 9 fig. 15 and Pl. 10 fig. 16). The existence of this mud bank, that to the W is connected with the immense Wia-Wia bank, probably is the reason why leatherbacks do not nest on Eilanti. Green turtles also prefer the other nearby beaches that are free of mud banks.

West of Eilanti stretches a sandy beach, called Lobin, or Paca (Carib for 'cow' and 'donkey'). At the end of 1974 the length was about 3 km. The high beach platform is suitable as a nesting place but has not yet become widely used by turtles. This again strengthens the author's belief in 'nestsite fixity'. Likewise, the same opinion is supported by the little use made of the recently developed beach W of the nesting beach at Bigisanti. Maybe the beach to the W of Eilanti will become used only when the Eilanti beach no longer exists and the turtles are forced to look for a nesting opportunity further to the W (provided the high mud-bank in front of the beach does not further increase and cut off the beach).

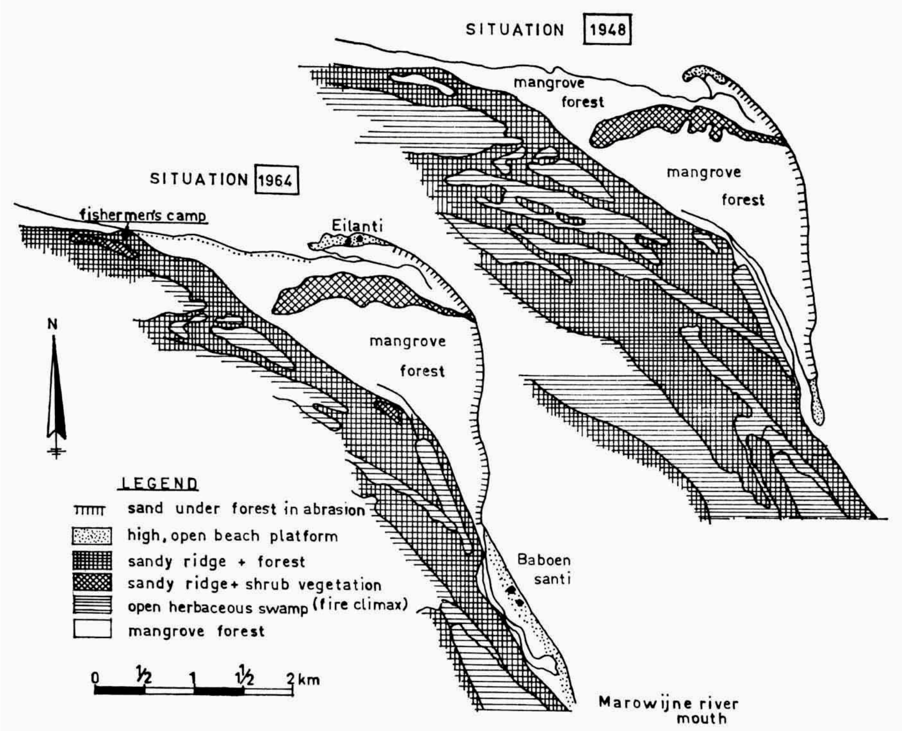
The coast between Baboensanti and Eilanti is at present in a state of erosion, clearly seen on the aerial photo in Pl. 9 fig. 15. This 3½ km long strip now consists of clay covered with a low, narrow sand-ridge deposited between the mangroves, washed over at spring tide. Repeatedly green turtles try to nest on this highly unsuitable part of the coast. Most turtles leave after abortive attempts to find a nesting place. During their laborious wanderings between the tree trunks, stilt-roots, tumbled-over trees, driftwood and tree stumps, the turtles now and then get trapped between the stilt-roots and have to be freed by the night patrols. Other turtles make a nest that would be washed over by the next high tide, were it not that these nests are transplanted to the hatchery by the wardens. It is interesting to note that ridleys very seldom make the 'error' of climbing this beach section. On the Surinam beaches leatherbacks never have been found between mangroves, as Pritchard (1973a) observed in French Guiana, where he found evidence that appreciable numbers are dying of exhaustion and overheating after becoming trapped by the barriers of uprooted mangrove trees on beach sections that are in abrasion.

More detailed observations on green turtles trying to lay their eggs on parts of the coast unsuitable for this purpose (the same happens on the sections in abrasion at Galibi beach, see below) can possibly contribute to our knowledge of the 'homing sense' of this turtle. Such visits to a now unsuitable nesting place in the Galibi region could be due to some turtles straying 'by accident' outside their proper nesting area. Another reason might be the fact that the beach is moving continuously; as is shown in Pl. 9 fig. 15 and Map 4, Eilanti in 1948 was situated just to the N of the coastal section in erosion where turtles now try in vain to nest. Therefore, those that nested with success previously would try there again, whereas young female green turtles, that come to nest for the first time, perhaps try in the first instance to nest at the place where they hatched and crawled out of the sand into the sea.

Supporting the second hypothesis is the fact that a relatively large number of green turtles nest on the only 50 meters of beach at Dap Eiland, which has indeed since 1948 withdrawn in a SW direction, but was situated for a long time along the approximate path for turtles coming in from the north (Pl. 9 fig. 15). Dap Eiland is the name we have given to the slightly curved sand ridge running SW-NE, indicated in Pl. 9 fig 15. According to fishermen, there formerly was a sand bank, that is now enclosed by clay, overgrown with mangrove forest. The Baboen Kreek of that time separated the island from the mainland coast (the ridge south of Baboen Kreek in Pl. 9 fig. 15) and is still clearly recognizable by a greater depth in the swamp.

The most suitable nesting beach at present is Baboensanti, with a wide, uninterrupted, high beach platform, 2.2 km long. The Baboensanti beach merges into a section named Pruimenboom. Both together are known as Tijgerbank (also called 'oetapo' or 'atapa-broekoe' by the Caribs). As appears from Map 4, the Tijgerbank beaches, like all other Surinam beaches, are continuously subject to alteration. Baboensanti came into existence in its present form between 1948 and 1964 and it seems to be quite stable for the time being.

The first turtle counts on the Tijgerbank beaches were made in 1968 and it was found that great numbers of green turtles came there to nest, almost three times as many as at Eilanti and its surroundings (Table 17). Appreciable numbers of green turtles also nest on Pruimenboom, although this beach is at present completely unsuitable as a nesting place; there is no beach above the high tide wash and a one meter high, steep sand-cliff, unclimbable for turtles, forces them to lay their eggs at the foot of the cliff below high water mark. This cliff has been formed by the sea cutting into a sand-ridge, a former sandy beach (Pl. 8 fig. 14).



Map. 4. Changing coast of Galibi beaches (see Map 3 and Pl. 9 fig. 15).

Ridleys concentrate on Eilanti, but they also nest on Baboensanti (see Table 17-B). Leatherbacks started to visit Tijgerbank beach (again?) during the last few years. This is probably due to the rapid westward movement of the French Guiana rookery, the western end of which in 1972 had reached the Marowijne mouth.

The last strip of the Marowijne coast to be mentioned is the Galibi area. It consists of an almost 3 km long strip, the location of which is shown on Map 3. Galibi beach includes only two very small stretches of sufficiently high beach platform. The rest of the coast — like the strip between Baboensanti and Eilanti — is in a state of abrasion. In 1970, counting was begun on this beach section and only then was it fully realised how many green turtles actually nest there, the number being greatly in excess of that previously thought.

Bigisanti beach

To the W of the Marowijne mouth rookeries the present coast consists chiefly of clay over a distance of 60 km (Map 2). In 1973, a sandy beach began near Mot Kreek. This we still call Bigisanti, although it lies much further west now than the beach of this name which in 1948 still lay between Oranje Kreek and Kweriman Kreek (that is approximately on the same location as the nesting beach indicated on the 1686 Labadist map, mentioned in the first paragraph of Chapter I).

From Maps 2 and 3 it can be seen how fast this beach has shifted in a westward direction since 1948. In the period 1948-1956 the displacement amounted to 15 km (ca. 1.7 km/year). Between 1956 and 1970 the beach moved at the same speed. The maps show the 1958 eastern limit of the sand lying ca. 5 km E of Mot Kreek, i.e., 34 km beyond the eastern limit of the sand in 1948.1)).

At Bigisanti there is no mud bank in front of the beach as at Eilanti. As illustrated in the profile in Pl. 9 fig. 15, the beach dips away steeply, and consequently the waves are stronger. It has already been mentioned that in Surinam the huge leatherbacks nest almost exclusively at Bigisanti; this is probably connected with the presence of comparatively deep water closely inshore and — consequently — the absence of a mud bank in front of this beach. Leatherbacks are found again towards the east on the first steep beach without a mud bank, viz. in French Guiana. The first nesting place to be found to the west is the Shell Beach in Guiana, also a steep beach.

Bigisanti beach consists of sand with local shell deposits, and may be very broad. It is overgrown with *Canavalia, Ipomoea, Sesuvium.* This herbaceous vegetation presents no problem when the nest is being dug. Small sand dunes occur (Pl. 12 fig. 19 and Pl. 14 fig. 24).

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1) In 1974-1975, the beach rapidly eroded in the E, and in 1975 the nesting beach was reduced to the 5 km long Krofajapasi sand spit.

As the beach erodes, the turtles appear to be seeking new nesting grounds further to the west, but nestsite tenacity forces them to maintain their nesting site as long as possible. As in 1964, most nests in 1967-1969 were laid at the eastern limit of the Bigisanti beach. In those three seasons far fewer turtles nested on the much more suitable higher beach to the west. In the first months of the 1968 and 1969 seasons numerous nests were laid in the east, on the part of the beach which was being eroded by the springtides, while near Mot Kreek there was a much higher and broader sandy beach. Similarly in 1968 and 1969 the eastern part of the beach, which had become barely suitable for nesting but where turtles still attempted to nest, had been a high beach in 1964 in which the turtles at that time showed no interest. During the 1968 and 1969 nesting seasons, green turtles and particularly leatherbacks began to nest in ever increasing numbers on the beach west of Mot Kreek, having been forced to do so by the increasingly high flood-cliff in the east. A similar crowding of nesting turtles on the eastern (= oldest) section of Bigisanti was observed in 1970-1972. In 1973, however, most turtles nested on the long sand spit that had formed at Krofajapasi (Pl. 13 figs. 21-22 and Pl. 14 fig. 23). In 1975 nesting was confined to this spit.

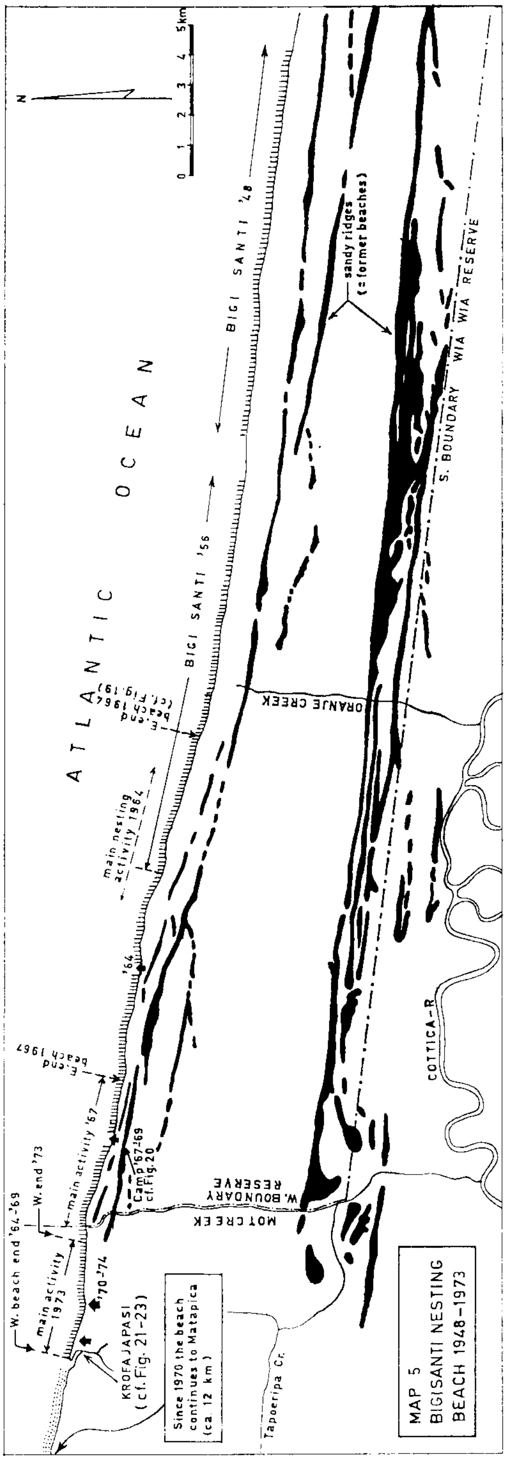
At the moment Bigisanti has moved so far to the west that at Krofajapasi it joins the sandy beach between Krofajapasi Kreek and Matapica, where at present only a few places are suitable for nesting, but which will certainly become a rookery in a few years.

Other nesting beaches

A sand/shell-beach has certainly existed since 1948 (probably longer) in the region around the mouth of the Matapica canal; it is high enough as a nesting place but surprisingly enough only a few turtles visit there. Maybe this is caused by the greater activity of fishermen, hunters, poachers, day trippers, etc. In 1972-1975 several nesting leatherbacks and a few green turtles were reported on this beach, probably representing forerunners of the Bigisanti nesting colony looking for a more suitable site now that Bigisanti is rapidly deteriorating at its eastern end.

Between Matapica beach and the mouth of the Surinam River, Kat Kreek is the only sandy beach that is suitable as a nesting place. A few green turtles nest here. Whether turtles nested at the former sandy beach of Braamspunt at the mouth of the Surinam River is not known for certain, but seems very probable.

A beach lying between the Surinam and Coppename Rivers has moved from Gandoe to the mouth of Popokaimama Kreek between 1948 and 1968.



MAP 5
BIGISANTI NESTING
BEACH 1948-1973

On this beach, in front of which now lies a huge mud bank, a few green turtles (at the most 10) nested in 1968 (P. G. E. F. Augustinus, pers. comm.). East of the mouth of the Coppename River a few hawksbills nest on a narrow, low shell-ridge.

Some twenty years ago great numbers of green turtle eggs were taken at a beach east of the mouth of the Nickerie River. The sandy beach has now been replaced by clay, but it is still known as 'Turtle Bank'.

Possibility of nesting in pre-historical times

The fluvio-marine deposits of the Young Coastal Plain of Surinam, formed during the Holocene, partly consist of sandy ridges, marking old sand and shell beaches (see Maps 2 and 5). During the Pleistocene — when the Old Coastal Plain was formed — the Guiana coast probably offered ideal nesting facilities for sea turtles, and perhaps the recent populations originate from populations of turtles that could always find nesting grounds somewhere on the Guiana coast during the Holocene and Pleistocene.

Chapter IV. NESTING BEHAVIOUR I, NESTING PROCESS AND CLUTCH SIZE

The nesting process

In all sea turtles, nesting behaviour follows the same general pattern. In this process several ethological stages can be distinguished. A simple subdivision in stages, resembling that used by Kaufmann (1968) and Tufts (1972), is the following:

1. landfall, emergence from the surf;
2. travel to the high beach after selection of the course; selection of the nest site;
3. excavation of body-pit and egg-cavity;
4. oviposition;
5. filling and covering of cavity and body-pit;
6. concealing the site;
7. returning to the sea and traversing of the surf.

In the following paragraphs, a detailed account is given of the nesting process of the green turtle; for the olive ridley and leatherback, only the aspects that differ from those of the green turtle will be described. The hawksbill is a rare visitor to the Surinam beaches and I only once had an opportunity to observe its nesting behaviour.

Nesting process of the green turtle (*Chelonia mydas*)

What has been observed of this species in Surinam confirms the information recorded in literature.

Approach of the beach and time of nesting

Daytime nesting is extremely rare, virtually all nesting taking place at night. During the nesting season the first females sometimes appear shortly after sunset. Most, however, come later in the evening, after 20.00 hr. After 04.00 hr., a female seldom comes ashore. Only a few times turtles have been observed still busy closing the nest at sunrise.

The vast majority of turtles arrives on the beach during the hours of high water. This is explicable at Eilanti beach, where an extensive mud bank forms a virtually impassable obstacle. It is interesting that on the steep Bigisanti beach, where no mud bank blocks their way, all turtles also show a strong preference for the hours of high water. There are indications that the green turtle prefers those nights when high water occurs before midnight. As will be discussed in Chapter V, in the seasons 1967-1969, peaks in green turtle nesting frequency were found to coincide with the periods when high water occurred in the evening. In this period they generally arrive during the evening, but when high water occurs from 00.00-04.00 hr, they mostly come ashore during these hours, though on the average in smaller numbers. When high water occurs in the late afternoon or early evening and from 04.00-06.00 hr, they generally nest in the evening and early hours of the morning. It is unknown whether the green turtle comes ashore during the first and last quarter of the moon because the level of high water has decreased or because high water occurs in the evening.

No observations have been made in Surinam on the behaviour of the female after entering the beach shallows. Perhaps a 'preliminary patrol of the shallows' takes place here, as has also been described by Hendrickson (1958) for Malaysian green turtles. He found them to spend a variable amount of time in the shallow water off the beach, resting in a few centimetres of water with the plastron in contact with the sand, during which time the head usually was allowed to drop low, to be raised from time to time to 'inspect' the surroundings.

It has been demonstrated in Surinam, as elsewhere, that turtles on approach of the water mark are very sensitive to alarming stimuli such as light. They very seldom approach the water mark when someone is standing there, and go back immediately if a light is shone on the water. However, Hendrickson (1958) seems to have established a 'habit-forming process' at

Talang-Talang, where there are always many lights on the beach. Turtles there are less sensitive to light than at the uninhabited beaches of Malaya. Tree trunks and driftwood, which are plentiful on the Surinam beaches, do not frighten them off. In Sarawak, where there is little driftwood, contact with it causes a green turtle to go back.

Climbing the beach and searching for a nesting site

If no alarming stimuli have been received during the previous phase, the female will approach the water mark and begin to climb straight up to the dry part of the beach.

On land, propulsion normally consists of a simultaneous movement of the four flippers. They are brought forward while the green turtle rests with its belly on the sand. The flippers are then anchored and the body is moved forward. Sometimes there is a change to alternate flipper movement, as is used in shallow water. After a few pulls forward, a pause is made for breath (and rest?). During these 'rest'-intervals, observations of the surroundings may be made in order to decide the direction that should be taken. However, given the extremely poor visual acuity of marine turtles, which become highly myopic when leaving water (Ehrenfeld & Koch, 1967), it is not likely that the guidance system on the beach is based on detailed visual information.

I have the impression that, as long as the turtle is on the sloping part of the beach where the sand surface is moist and relatively hard, it moves in the direction of the incline. Some may take a direction transversal to the gradient, but most climb the beach along a line quite perpendicular to the water mark. After reaching the high tide mark, the turtle continues in the same direction over the more loose and dry sand between the high tide and spring-tide marks. Upon reaching the more or less horizontal 'platform' the next phase begins.

Still propelling herself in the same way (simultaneous movement of the flippers, pauses for rest, breath and, possibly, for 'observation') the turtle begins apparently at random to crawl on the loose sand of the high beach platform. Contact with large obstacles (such as large pieces of driftwood) or the approach of a lagoon behind the beach cause the turtle to change direction 1).

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1) At Eilanti, it was observed that a green turtle, searching for a nesting place, lost her way in the lagoons and creeks behind the platform and stayed here for 24 hours, searching for the sea. Possibly she was misled by the fact that she had already crawled off a sand slope and had ended up in wet mud, having undergone the normal succession of stimuli in descent of the beach.

The time spent in searching is variable, lasting 10 minutes to several hours. In the morning in the mangrove sections of the Galibi beaches, repeatedly females are found that have sought in vain during the night for a suitable nesting place, sometimes digging a considerable number of trial pits.

The duration of the search is not only dependent on the presence of obstacles but also seems to depend on individual differences. Sometimes a female begins to dig without further delay as soon as on the platform a suitable place for that purpose has been reached. In other cases, the digging reflex only appears to get the upper hand over searching when for a long time no alarming stimuli have been received and when sand devoid of large obstacles has been felt for a sufficiently long time. The distance between the high tide mark and the nesting place on the beach platform is also very variable. Most nests are laid just beyond the edge of the platform, others fairly far onto it.

Occasionally, after having roamed for some time on a suitable nesting beach, a turtle may return to sea without any demonstrable motive.

Turtles do not always begin to dig at a suitable nesting spot. For example, on the steep beach at the eroding parts of Bigisanti, the fairly high flood-cliff can form an obstacle that forces some green turtles to go back; some partly demolish this flood-cliff in order to climb the beach (Pl. 14 fig. 24 and Pl. 16 fig. 26), and others nest at the bottom of the cliff. On the beach of Pruimenboom (Pl. 8 fig. 14), all nests are laid at the base of the flood-cliff below the spring-tide mark.

When the digging reflex gains the upper hand over the searching (as yet nothing is known about the stimuli!), the next phase begins.

Digging the body-pit and egg-cavity

The walking motion becomes superceded by a 'swimming' movement. Whilst the plastron rests on the sand, the fore- and hind-flippers sweep sand far to the rear. The green turtle moves a little forward now and then so that a gradually enlarging pit is formed. The duration of the digging depends on the condition of the sand. (Pl. 17 figs. 28-29).

Rests are repeatedly taken, during which the turtle puts her head on the sand; after some time she raises it, takes a deep breath, and resumes work. Light vegetation, such as creeping plants, forms no obstacle and may be partially uprooted by the digging. When a larger obstacle is encountered, such as a thick root or piece of drift-wood, or if the sand is found to be too moist because the chosen site is too low, the digging is interrupted, and the turtle tries again nearby or returns to the sea without wandering about any longer on the site.

Also during this stage the turtle is very sensitive to alarming stimuli such as light or touch. It is less sensitive to large moving objects such as people around the pit.

The depth of the body-pit varies from 1/3 to 1/2 metre. In a deep pit the top of the shell lies below ground level. Body-pits are deepest on the highest beach platforms (Dap Eiland).

Towards the end of the excavating of the body-pit, the fore-flippers cease their work and only the hind-flippers scrape and push the sand backward. Under what influence (position, time, or external stimulus of some kind?) the turtle passes from digging the body-pit to the next phase is still unknown. After a short rest the hind-flippers change their activity. They begin to scoop sand from under the cloaca. For this purpose the distal end of the hind-flippers is curved into a scoop in which scraped sand is brought up and deposited next to the hole. When it is a hind-flipper's turn to scoop, the body is heaved up far enough on the other three flippers to give the digging flipper sufficient room to work.

The movements of the hind-flippers take place in the following order. The right hind-flipper scoops, brings up the sand, and deposits it to the right of the hole (Pl. 17 fig. 29), while the body rests on the three other flippers, slightly tilted off the ground. The right flipper then comes to rest on the little heap of sand and the body is lowered so that the plastron rests on the ground; after that, the two fore-flippers and right hind-flipper press the body slightly up and the rear of the body swings to the right. The left hind-flipper sweeps forward the sand it brought up last time; it swings back again and is brought into the hole (the body simultaneously sinks onto ground again). The left hind-flipper scrapes sand from the hole, brings it up and deposits it at the left of the hole (after raising the body again on the other three flippers), and rests on the freshly brought-up sand (the body sinks again). After this, the cycle is repeated: rear of body swings to left, right hind-flipper sweeps sand heap to front and is brought into scoop-position, etc., etc.

With this cycle the turtle continues, until the hind-flippers have dug such a deep hole (aided by the fore-flippers that raise the front of the body as high as possible) that no more sand can be scraped from it. The depth of the hole (35-55 cm) thus mostly depends on the length of the hind-flippers and on the depth of the body-pit. The bottom of the hole thus lies 2/3-1 m below ground level. The flask-shaped cavity is wider at the bottom, and oval in horizontal section owing to the forwardly directed scraping movement of the flippers.

As stated before, if an insurmountable obstacle is met with during digging, or if the sub-soil proves too moist, digging is usually interrupted in order to try again nearby or to go back to the sea. However, on the eastern part of Bigisanti, which in 1968 had become too low for a nesting place, and on the sand ridge in the Galibi mangroves, it was repeatedly observed that turtles continued digging when groundwater was reached. It was even observed once that the eggs were laid in water. At Pruimenboom beach, all nests are situated below the high-water mark, right at the foot of the high flood-cliff, which at most places is unclimbable for the turtles (Pl. 8 fig. 14).

I have not found a mention of such nesting in unsuitable places in the literature. The care taken in finding places that are not too low, described by most authors, is not always shown in Surinam, possibly because of the relatively small extent of beach that is sufficiently high as well as the constant movement of the sandy beaches.

Laying the eggs

After some vain attempts to scrape yet more sand from the egg-cavity, the turtle covers the hole with the hind-flippers. Usually it is now oblivious to light and touch. The cloaca hangs into the nest-hole and eggs, coated with a clear slime, drop into it at intervals, in batches of 2 or 3 (Pl. 18 fig 30). The pink mucous membrane of the cloaca, partially extended, secretes so much slime that it falls between the eggs in the hole. Oviposition takes 10-15 minutes. The white, spherical egg has a leathery shell and shows a dent which disappears after a few days in the nest, probably due to greater tension because of water uptake. The diameter ranges between 4.0 and 5.0 cm (average 4.5). The average number of eggs per nest amounts to 138, based upon thousands of records. The maximum number recorded was 226 eggs in one clutch. For further details, see Table 2 at the end of this chapter.

A barely perceptible reflex action is often shown by the hind-flippers, simultaneously with the extrusion of the eggs. When the last egg has been laid, the nest-hole has been filled to a level of about 15 cm.

Closing the nest

Sand is shovelled into the nest-hole by backward-directed rowing movements of the hind-flippers. An extra heap of sand arises above the nest, which is patted and kneaded by the hind-flippers (Pl. 18 fig. 31). After the nest-hole has been filled with packed-down sand (taking 5-10 minutes), the fore-flippers resume their activity. Just as in the digging of the body-pit, sand is forcibly swept backwards. This sand is shifted further backward by the hind-flippers. The turtle thus moves through the sand — digging away the sand in the front and piling it up at the rear — for 20 minutes to 3/4 hr. In this way the body-pit is continually displaced, away from the nest-hole. Suddenly digging is terminated when the pit is situated 1 to 3 m from the nest-hole. This camouflage of the nesting place is very effective, only an experienced egg-taker being able to quickly locate the nest.

The further fate of the nest is described in Chapter VII.

Return to the sea

After closing is finished, the green turtle usually takes the shortest route back to the sea. This return can be speeded up by touching the turtle or by light, because after closing the nest-hole it again becomes sensitive to such stimuli. Only in very rare cases will the turtle lose its way back to the sea and wander into the lagoon behind the beach. See also Pl. 19 fig. 32 and Pl. 11 fig. 17.

There appears to be every reason to assume that the adult females, when returning to the sea, use the same guidance system as their young on their journey to the water. Very probably it is the difference in brightness between the open sea and the dark landline that guides the adults on their return journey down the beach. The functioning of this mechanism is discussed in some detail in the penultimate section of Chapter VII.

Nesting process of the olive ridley (*Lepidochelys olivacea*)

Behaviour during the different phases of the nesting process resembles in outline that of the green turtle. However, the considerably smaller ridley moves its limbs faster on land and also during digging. On Eilanti, usually not more than one hour elapses between landing and return to the sea. Movement on land differs from that of the green turtle, by alternating left fore- and right hind-flippers with right fore- and left hind-flippers.

Ridleys were often seen to 'sample' the beach on landing. When crawling on the beach, the head is held low, and every now and then the turtle is seen nosing the sand. Occasionally she stops, raises her head, looks around and breathes loudly. Often she starts digging the shallow body pit immediately after the high beach platform is reached. The search for a nesting place usually takes much less time than with the other species. Digging starts with simultaneous 'breast-strokes' of the front-flippers which are drawn forward until they lie alongside the sides of the head, before they throw back the sand with a vigorous thrust. After a few minutes the action of the front-flippers is taken over by the hind-flippers. The flicking back of the sand with the hind-flippers merges into a digging movement, as has been described for the green turtle. After completing the nest-hole — which is shallower than that of the other turtles, owing to the smaller size of the flippers and the shallowness of the body-pit (Pl. 19 fig. 33) — the laying position is struck. During each deposition, the head is raised a little and a contraction of one or both of the hind-flippers is perceptible. Of the sea turtles, the ridley lays the smallest eggs: the diameter of 100 eggs taken at Eilanti averaged 4.0 cm (range 3.7-4.1 cm).

The most remarkable and characteristic behaviour is the thumping action, distinctive for the genus *Lepidochelys*. After sand has been pulled into the egg-cavity by alternate movement of the hind-flippers, the ridley commences pounding in order to compact the sand that — between the series of strokes — is pushed over the nest-hole by the hind-flippers. The thumping is carried out by a rapid side-to-side rocking movement of the shell, generated by the shoulders (Pl. 20 fig. 34). During this movement, the neck is stretched out with the head pointing down. The sound produced by the sides of the carapace and the plastron pounding the sand is audible over quite a distance. After a few minutes of thumping, sand is swept over the nest site with alternate sweepings of one fore-flipper together with the opposite hind-flipper (Pl. 20 fig. 35). This sweeping movement carries the turtle some 4 to 10 m away from the nest before it gradually becomes the standard walking movement which carries her rapidly to the edge of the sea.

Nesting process of the leatherback (*Dermochelys coriacea*)

Most nesting is nocturnal, but occasionally leatherbacks leave the sea by day in the early morning or late afternoon on Bigisanti and Baboensanti, as they also do at the French Guiana rookery.

We never observed leatherbacks 'examining' the beach after coming ashore, as the ridleys do. This agrees with information from Carr & Ogren (1959), who state that the leatherback is much less particular than other species in its selection of a nesting beach, and explains our experience that on Surinam beaches the leatherback so often nests at an unfavourable place. On land, simultaneous jerks are made with the powerful fore-flippers to move forward. In Surinam and in French Guiana, a trait peculiar to leatherbacks is the zig-zag track made during the ascent to the nesting site (Schulz, 1971), as was also observed by Deraniyagala (1936) in Ceylon.

The 'concealing pit' is dug by synchronous rowing movements of the front-flippers to a depth of ca. 1/4 to 1/2 m. Pritchard (1969) calls attention to the fact that on the Surinam beaches the body-pits are dug much shallower than in Costa Rica. Next, the nest-hole is dug by the hind-flippers in the way described for the green turtle. During the excavation of the egg-cavity and the further nesting process, the front-flippers are firmly anchored in the sand. The depth of the cavity is markedly deeper than in other species, which is due to the much greater length of the hind-flippers of the leatherback, enabling them to reach a greater depth. The margin of the nest-hole is smoothened by the crurocaudal fold. The hind-flippers usually cover the nest-hole during oviposition, but in some cases the distal part of one of the hind-flippers hangs in the nest-hole, as was also described by Carr for nesting leatherbacks on the beach at Matina Bay. Occasionally, the mouth of the nest-hole is not covered by the hind-flippers. (Pl. 21 fig. 36).

The normal eggs are larger than those of the green turtle: average diameter 5.3 cm (range 5.0-5.7 cm). The average clutch size is 85 eggs per nest; the greatest number found in a nest was 128 (table 3). Thus the leatherback, despite its size, lays fewer eggs than any other turtle nesting in Surinam. Markedly undersized, and/or malformed yolkless eggs — only exceptionally found in other turtle's nests — are virtually always present in leatherback nests; for further details, see the last section of this chapter. The undersized eggs tend to be laid towards the end of oviposition, the last extrusions often being composed entirely of minute, yolkless eggs (Pritchard, 1971). Occasionally the leatherback drops the last undersized eggs on the beach during her return to the sea.

After nesting, sand is swept into the hole by the hind-flippers. When swept into the cavity, the first sand is gently spread over the eggs and flattened down. During filling, the rear part of the body moves up and down. When it rises, the hind-flippers are brought behind the body and strongly pack down the sand over the nest. When it falls, the flexible underside of the body practically fills the body-pit and thereby helps to press down the sand. After the egg-cavity is filled, the hind-flippers continue to form a pile of sand over it. Then the turtle performs a peculiar movement, described and pictured by Deraniyagala (1936). With the carapace still stationary the turtle starts a rapid swinging from side to side of the outstretched hindpart and the tail. During this procedure, every time a hind-flipper touches the ground over the cavity, the sand is flung crosswise towards its fellow with a rapid scooping movement. After having continued this activity for some time, the hind-flippers stop and the fore-flippers start to jerk back sand with powerful simultaneous movements. The turtle on the whole stays at the original place and thus forms a shallow pit to the front and two piles of sand at both sides of the body. Alternating with the rowing movements of the front-flippers, the hind-flippers in turn make a sweeping movement so that part of the sand already swept behind is swept even farther. (Pl. 22 fig. 37).

After a short while, the turtle begins to move forward. Sweeps by the front-flippers that bring it forward are continued in simultaneous sweeps backwards, flinging sand to the rear; this is partly swept still farther behind by the hind-flippers. Part of the sand heaped up every now and then by the front-flippers is not further moved, so that the animal leaves behind a ploughed-up piece of beach with mounds of sand and hollows and deeply grooved tracks. During this final stage of the nesting activity the leatherback may move around in (semi-) circles. I got the impression that such movements were (far?) more common on the rookery in W French Guiana than at Bigisanti. This could mean that circling during the last stage of closing the nest has something to do with sea-finding: on most of the French Guiana beach differences between the landward and seaward aspects are much less striking than on Bigisanti, where a distinct dark tree line marks the landside. Mrosovsky (1973) is of the opinion that the many signs of circling at the nest site possibly are part of the last stage of nesting and are not governed by cues controlling the return to the sea, as probably are the 'orientation circles' performed by the hatchlings as discussed in Chapter VII.

Once a female is free from the nesting site, she may interrupt her crawl to the sea by making a circular movement. Such circles on the whole are very seldom performed on Bigisanti beach, but they are more common on the French Guiana rookery (Mrosovsky, 1973). I got the impression that the circles are particularly made when an animal is moving along the slope on the 'wrong side' of the beach platform, which on the French Guiana beach generally slopes down to a lagoon. The fact that circles are uncommon at Bigisanti again might be due to the fact that on this beach the difference between the landward and the seaward direction is considerably more obvious than on the French Guiana beach. One of the few cases I witnessed of a leatherback making circles on her return to the sea on Bigisanti beach was that of a female that finished nesting after sunrise and had to crawl to the sea in the presence of three photographers.

In 1973, several turtles, both leatherbacks and greens and ridleys, were seen circling on the newly formed end of the sandy spit at Krofajapasi (the extension of the sand spit shown on the aerial photograph in Pl. 14 fig. 23). On this sandbar, separated from the lagoon on the mainland by the mouth of Krofajapasi Kreek, the situation apparently was rather confusing for the nesting turtles. A few of them even swam into the creek mouth and climbed the sand spit from the 'wrong' side. These left the beach after nesting, either by returning to the creek or by descending the northern (seaward) slope.

On the French Guiana nesting beaches, especially on the section near the mouth of the Mana River, Caribs reported in 1973 that 'large numbers' of leatherbacks were seen entering the open swamp behind the beach after nesting. Most animals seemed to manage to get back after a few hours or days, but Pritchard (1973a) found several leatherbacks that had succumbed, presumably to the heat and the osmotic stress of the hypersaline water of the swamp.

The interpretation of the circular movements of the leatherback hatchlings to the effect that they are fixed action patterns and form part of a successive sampling system — as plausible as such an interpretation may seem — has been tentatively rejected by Mrosovsky (see the section on emergence of hatchlings from the nest in Chapter VII). On the same grounds the explanation can be rejected for the circles made by the adult females, the strongest argument in my opinion being the fact that the vast majority progress toward the sea without circling. Why a few females do make circles is not yet fully explained; in Mrosovsky's words (1973): 'without further information the motivational context of orientation circles in adult female leatherbacks cannot be settled'. Mrosovsky feels that at least it could be argued that circling is a back-up behaviour, only occurring when the animals meet with some difficulty. This might account for the fact that more circles are made on the French Guiana beach.

It was already noted previously that leatherbacks, which are helpless on soft mud, generally avoid beaches where mud-banks are exposed at ebb-tide. At both Bigisanti and the French Guiana rookery, the beach slopes fairly steeply to the sea. At Eilanti, which has an extensive mud-bank exposed at ebb tide, the leatherback very rarely nests. The green turtle and the ridley are much lighter, thus are able to crawl over the mud for short distances, and as a consequence can afford to nest at Eilanti.

Conservation measures attempt to correct the tendency of the leatherback to nest too low. Our control teams daily replant those nests, as is described in Chapter IX.

As yet nothing can be said with certainty about the migrations of the leatherback population(s) nesting on the Guiana beaches. Speculation on this subject can be found in Chapter VIII.

Clutch size

In Table 2, the results are given of the egg counts for the green turtle and the ridley, taken at different periods during several seasons. There seem to be no significant differences in clutch sizes for different periods during the nestig season. The average number of eggs per nest on Surinam beaches (138) is markedly greater than that known for other populations.

TABLE II

Frequency distributions of clutch sizes of green turtle and olive ridley nests during various periods, 1967-1971. Percentages are frequency-% of nests with the number of eggs indicated in first column.

number of eggs per nest	green turtle (Bigisanti)				olive ridley (Eilanti)
	Febr.-March '69-'71	April '69-'71	May-June '69-'71	weighted average '69-'71	29/5 - 27/6 1967
1- 25	½%	½%	½%	½%	0%
26- 50	1	0	½	½	0.1
51- 60	1	0	½	½	0
61- 70	0	½	1	½	0.3
71- 80	1	1	1	1	0.7
81- 90	½	½	0	½	1.7
91-100	2	4	3	3	8.8
101-110	6	6½	4½	6	21.7
111-120	8	12	0	9	26.0
121-130	10	14	13	13	22.5
131-140	16	20	18	18½	11.9
141-150	18	15	13½	15	4.7
151-160	14	12½	14	14	1.2
161-170	10	5½	8	7½	0.2
171-180	8	5½	8	7	0
181-200	3½	1½	3½	3	0
201-220	0%	1%	½%	½%	0%
total	99%	99%	100%	100%	99.8%
total nr. of nests	152	199	215	566	1154
average nr. of eggs per nest	139	136	138	138	116

The most detailed counting on other nesting beaches was done on the Talang-Talang islands, where an average number of 104.7 was found in a sample of about 8000 nests (Hendrickson, 1958). Carr (1967) says that the average for *Chelonia* lies around a hundred. The large clutch size for the green turtle in Surinam is probably related to the larger size of the turtles nesting here.

Table III

Frequency distributions of clutch size of leatherback nests. Random sample of 385 nests, counted at Bigisanti, 1967-1973. (a) Normal sized eggs; (b) small, infertile eggs.

Nr. eggs per nest	frequency % (a)	(b)
0-10	½%	9%
11-20	0%	27%
21-30	0%	39%
31-40	1%	19%
41-50	2%	5%
51-60	3%	1½%
61-70	10%	-
71-80	20%	-
81-90	30%	-
91-100	19%	-
101-110	11%	-
111-130	3½%	-
Total	100%	100%

The results of the egg counts in leatherback nests are presented in Table 3. The average amounted to 85 normal sized eggs per nest (minimum found: 2, maximum: 128). In Surinam, just like elsewhere, the clutches show a great variation in size and mostly contain a high number of undersized, infertile eggs: in 1973, in a sample of 195 nests an average of 23 undersized eggs was counted. In green turtle nests undersized eggs are rarely seen.

The number of eggs counted in 13 hawksbill nests averaged 146 (112-179) per nest.

Chapter V. NESTING BEHAVIOUR 2, BREEDING SEASONS, NESTING FREQUENCIES, INTER-SEASONAL MOVEMENTS BETWEEN NESTING SITES

Breeding seasons

All species in Surinam, just as on most other nesting beaches, show a well defined nesting season.

Nesting of *Chelonia mydas* takes place — as in Stedman's and Kappler's times — from February to July, with the peak in April-May (see Table 4 and Graphs I, II, III). This nesting season corresponds with that of the green turtle in neighbouring countries, but falls a couple of months later than that in Ascension Island and a few months sooner than in Costa Rica, the most important nesting place in the Caribbean region. (Compare with the list of nesting seasons in Table 4).

Normally, the peak of the green turtle nesting season occurs at the same time on all beaches in Surinam. In January-March copulating couples are seen floating, 'for days' as stated by Kappler (1881: 133) — at the surface of the sea near the mouth of the Marowijne River. The histograms in Graphs I-III show that local nesting does not begin as abruptly as Carr has reported for the nesting place at Tortuguero.

Lepidochelys olivacea nests — as in Kappler's time — from mid-May to the end of July, with few nestings before and after this period (see histograms in Graphs I, IV and V).

In 1964, 1967 and 1968, *Dermochelys coriacea* nested in the months April-June. In 1969-1971 females started to nest in March and in 1972-1975 some nests were laid as early as February. The 'siksikanti' nests before the 'aitkanti' (for 1964, see histogram in Schulz, 1969, fig. 25). In later years, the nests of the two 'forms' (?) were not distinguished. As may be seen in Table 2, the nesting season in Surinam is similar to that on most other nesting places.

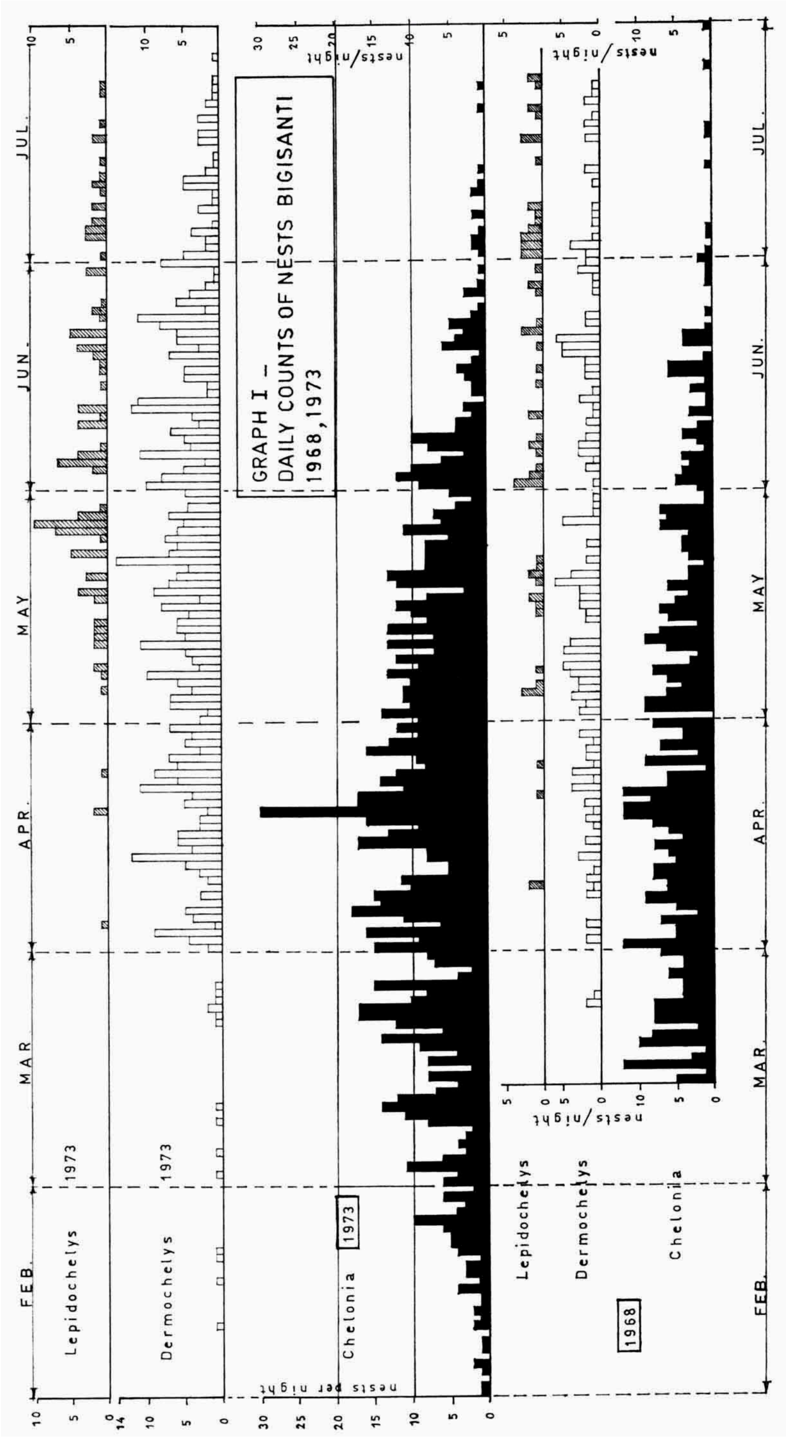
Eretmochelys imbricata nests here in such small numbers that the duration of the nesting season is difficult to ascertain. In 1964-1969, the hawksbill nested at Bigisanti during May-July, but in 1972 a few earlier emergences were reported. Counting terminated in August, but it is unlikely that more nests were laid. Kappler (1881: 135) reported that hawksbills were rare and seldom arrived before June.

Thus, there is some distinction between the nesting seasons in Surinam, the main nesting period of the ridley coming after that of the green turtle. This distinction, however, is not so marked as is the case in Central America. In Surinam, there is a distinct separation between the nesting places of the

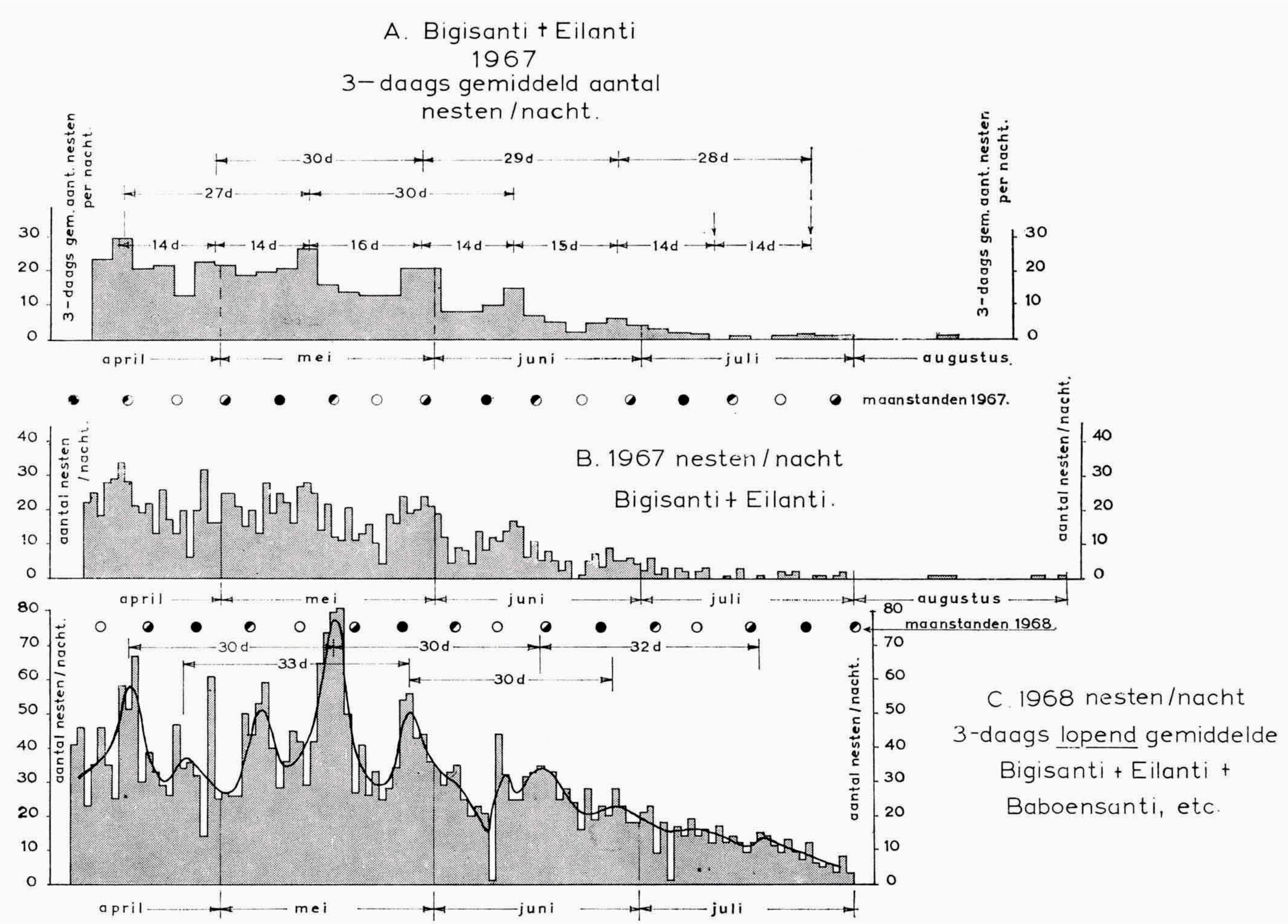
TABLE IV

Summary of sea turtle nesting seasons. Taken from IUCN (1969, 1971), Hirth (1971) and various other sources.

Nesting place	*Chelonia mydas mydas*	*Lepidochelys olivacea*	*Eretmochelys imbricata*	*Dermochelys coriacea*
Florida	-	-	April-July	-
Bermuda	April-June	-	April-June	-
Mexico (Pacific coast)	-	June-Sept. (Nov.)	-	Oct.-April
Costa Rica (Tortuguero + Matina Bay)	July-Sept.*	-	May-July	April-July
Honduras	-	Aug.-Jan.	-	-
Trinidad + Tobago	Nov. (?)	-	Nov. (?)	April-July
Virgin Isl.	May-October	-	June-Oct.	March-May
Santa Marta (Colombia)	-	-	-	April-July
Margarita	-	-	May-Aug.	-
Isla Aves	March-Dec.	-	-	-
Curaçao	June-Sept.		July-Nov.	
Guyana (Shell Beach)	March-June	June-July	July-Aug.	March-June
SURINAM	MARCH-JUNE (APR.-MAY)*	APRIL-JULY (MAY-JUNE) *	APRIL-JULY *	MARCH-JUNE
French Guiana	March-June	June-July	May-June?	March-July
Brazil-NE coast (Marajó, Trindade)	Dec.-March (April)	-	-	-
Ascension Island	Feb.-April*	-	-	-
Cape Verde Isl.	May-August	-	-	-
Aldabra Atoll	Febr.-May	-	Sept.-Nov.	-
Natal (Tongaland)	-	-	-	Oct.-Febr.
Ceylon	July-Nov. (?)	Sept.-Jan.	-	May-June + Oct.-Dec.
Europa Island	all year	-	-	-
Sabah	July-Aug.*	-	Jan.-March	-
Sarawak, Talang-Talang Isl.	July-Sept.*	-	Jan.-March	-
Trengganu (Malaya)	June-Aug.*	-	-	April-Sept.
E Pacific Ocean	-	Aug.-Nov.	-	-
Burma	-	March-April	-	-
Thailand	May-July	-	-	-
Heron Isl. (Austr.)	Jan.-Febr.	-	-	-



GRAPH I –
DAILY COUNTS OF NESTS BIGISANTI
1968, 1973

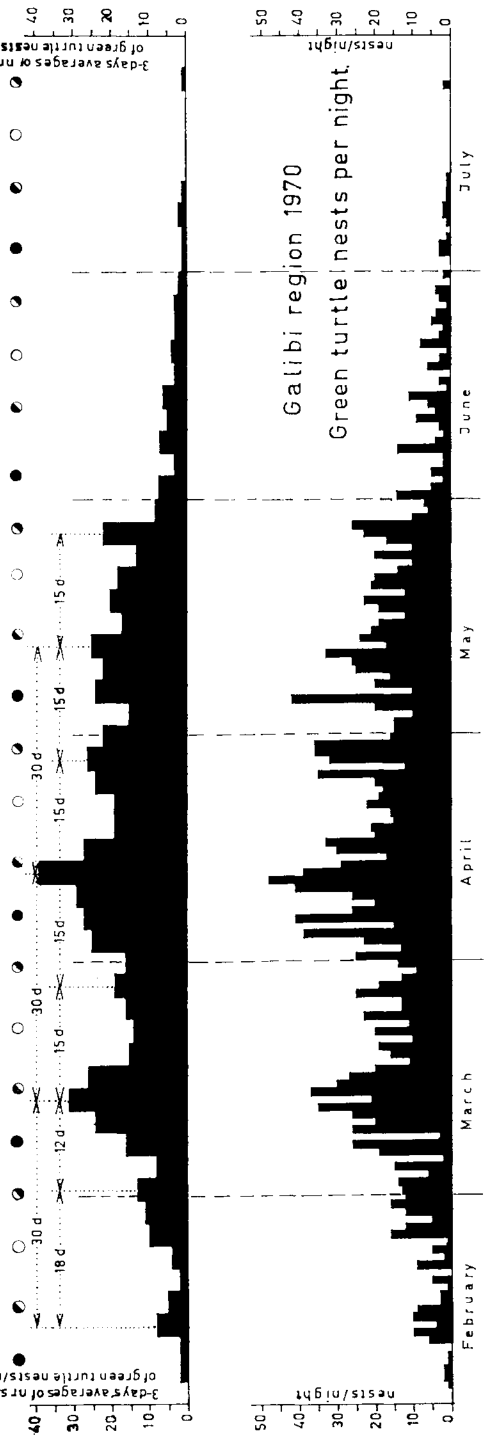


Graph II. Periodicity of nesting frequency of green turtle on Bigisanti and Galibi beaches. Histogram A: 3-day averages of the number of nests per night. B: total numbers of nests per night on Bigisanti + Eilanti. C: idem; the line represents the 3-day moving average of nests per night. "Maanstanden" = phases of the moon.

GRAPH III

3-days' averages of numbers of green turtle nests per night

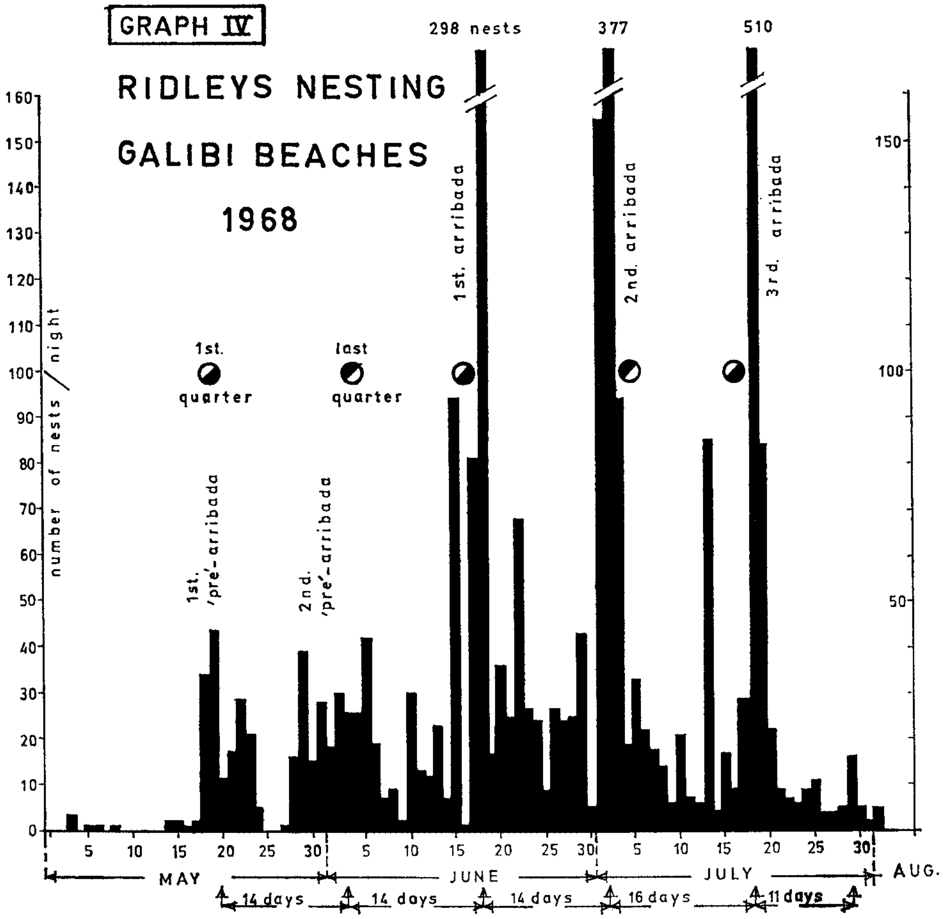
Galibi region 1970.

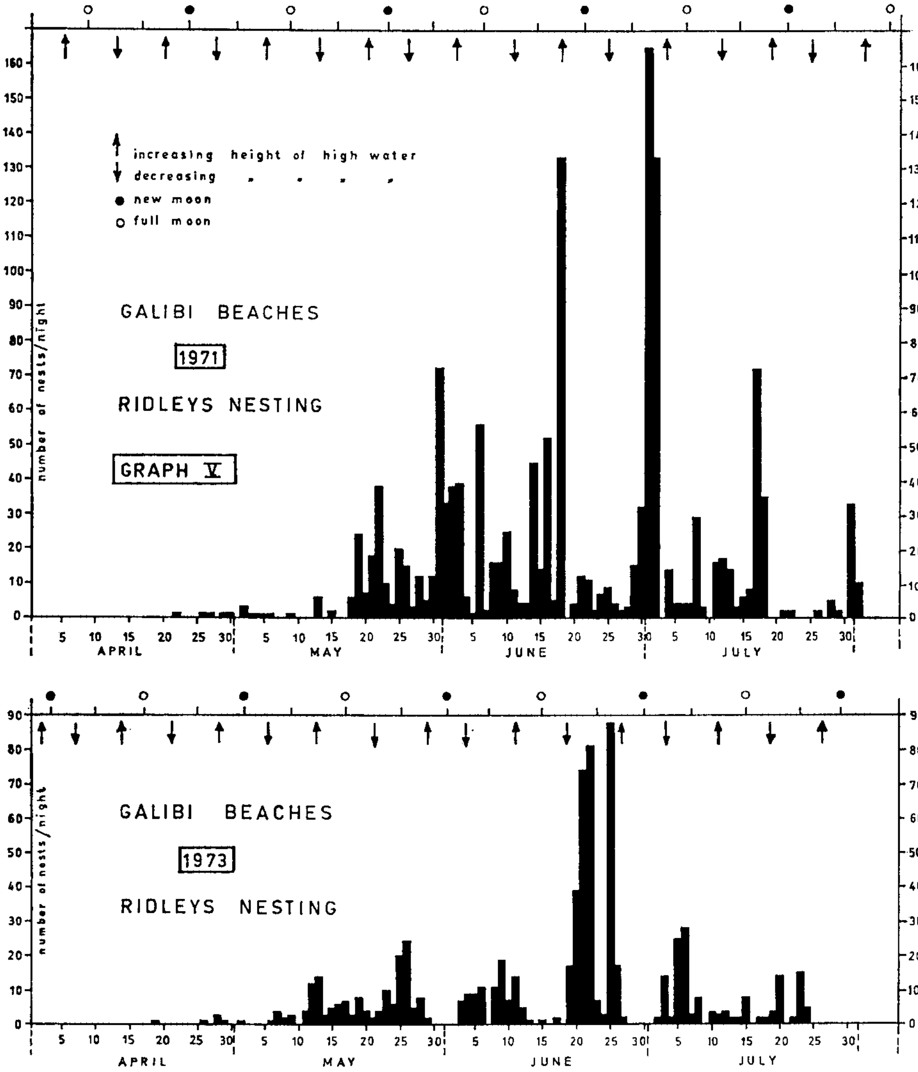


ridley and of the leatherback, as has also been reported from Malaya and from Costa Rica.

The nesting peak of all species in the March-July period could be an 'adaptation' to the circumstance that, from November-February, the NE tradewind is strongest and the swell the highest, so that the beaches are moving most rapidly. The risk of nesting on a piece of beach that will be washed away within the incubation time (2 months) is therefore greatest during the last named period. Consequently, there may exist a causal connection between the nesting season and the relative stability of the beaches during this season.

The main nesting period falls in the long rainy season; this would seem to be a drawback because turtles do not nest during heavy rain. On the Talang-Talang Islands, off the coast of Sarawak, peak nesting of the green turtle is in the dry season.





Intra-seasonal periodicities

Turtles come ashore almost every evening during the nesting season. Before the present investigation began, it was known already from the Indians that ridleys and green turtles showed a preference for certain nights so that, within the season, periods of intensive nesting alternate with periods of lower nesting frequency. Both Kappler (1881: 133) and Geijskes (1945) reported that, according to the Indians, the largest numbers come to nest shortly after spring tide (thus after full and new moon). As will be discussed below, this was confirmed by our research for the green turtle and the ridley. The nesting frequency of the leatherback shows no significant periodicity.

The clearest periodicity is shown by *Lepidochelys olivacea.* In three big 'waves', comparable with the 'arribadas' of *L. kempii* in Tamaulipas, the females come ashore at Eilanti (see histograms in Graphs IV and V) on a beach 400 m long and up to 30 m wide. The main groups of an 'arribada' are concentrated on an even shorter stretch of beach.

The nesting waves of the ridley at Eilanti nearly always coincided with those periods wherein high water came before midnight, between about 19.00 and 23.00 hr.

An 'arribada' formation (Pl. 19 fig. 33), a behavioural trait peculiar to the genus *Lepidochelys* which, in Pritchard's words (1969a), 'constitutes perhaps the most spectacular manifestation of reptile life', was mentioned for Eilanti beach in 1964 by Mr. G. P. A. Lichtveld in his report to the Chief Conservator of Forests. Since then this phenomenon — on an approximately fortnightly basis of three nesting aggregations, each numbering up to some hundreds of ridleys — has attracted considerable international interest and was commented on at some length by Pritchard (1969, 1969a, 1969b), who studied nesting on Eilanti during a few successive years. The correlation of this cyclical regularity of massed nesting with the tide is discussed below. The ridleys of Eilanti share the peculiar habit of forming 'arribadas' with the East Pacific populations of the olive ridley, of which huge mass arrivals were only recently reported (Pritchard, 1969b).

The advantage of massed nesting, a trait that may require constant selective pressure to be maintained (Pritchard, 1969a), perhaps serves to overwhelm predators with a temporary overabundance of food. At present, there are only a few ghost crabs (*Ocypode quadrata*) (Pl. 23 fig. 40) to destroy the shallow ridley nests on Eilanti. Jaguars are very rare in the area. However, the fact that the Eilanti nesting population on the beach is virtually free at present from non-human predation, does not mean that this always has been the case on the beaches in and near the Marowijne mouth.

The time elapsing between the big landings on Eilanti is about 2 weeks, and this is also just noticeable in the smaller values of the nesting frequency before and after the largest nesting waves. The frequency of the small number of ridley nests that are laid at Bigisanti does not show this periodicity and, quite remarkably, no connection was observed between the number of nests per night and the 'arribadas' on Eilanti.

There is a peculiarity in the nesting frequency of the ridley which partly explains irregularities in the histograms in Graphs IV and V. The Caribs of Galibi claim that the emergence of ridley is influenced by the force of the wind. They say that an expected 'arribada' defaults on a still night when the sea is 'too calm', and that the anticipated 'arribada' occurs only with wind and rough sea. This claim was confirmed; for example, during the first big wave in 1968, the 'arribada' did not occur on the still evening of June 16th, but did occur during rough seas on the 18th. A similar situation occurred on the night of June 30th, 1968, when the 'arribada' was delayed until a more favourable (more rough) night (1st-2nd July) 1).

In 1970, there was only one night during which more than 100 nests were laid (cf. 400 in 'arribadas' previous to this). This was the only night (moreover the night of the first 'arribada') in the whole of the nesting season really suited to an 'arribada', i.e. wind and rough sea correlated with high tide. A spreading-out over several nights occurred during each of the subsequent anticipated 'arribadas'. In 1973, there was only one small 'arribada' (Graph V). In following years the downward trend continued (see Table 7). In 1974 and 1975, the arrivals were only a dim reflection of the 'arribadas' in previous years: the highest number we counted in 1974 during one night on Eilanti beach was only 88. In 1975 this dropped to 40.

With *Chelonia mydas,* at first sight there appears to be no clear periodicity in the nesting frequency. However, the three-day average of the total number of nests at Bigisanti + Eilanti in 1967 suggests the existence of a period of ca. 2 weeks, which is graphically expressed in Graph II. The total number of nests per night for 1968 on Bigisanti + Eilanti + Baboensanti/Pruimenboom shows a remarkable periodicity. There are 30 days between the three main peaks in the nesting frequency (on 18th April, 17-18th May, and 16th June). In between are lower peaks (25th April, 6th May, 28th May) spaced about 10-11 days. In June there is no clear periodicity. The period of 10-11 days could be connected with the internesting interval of the green turtle which is roughly of the same length (see Table 10). The most convincing illustration of the ca. 2-weeks period is Graph III, representing the 1970 data for the Galibi beaches.

Attempts were made to correlate the periodicity of the nesting frequencies

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1) Carr (1967: 132) records that all the people he knows who have seen 'arribadas' agree that this takes place when there is a heavy surf caused by a powerful NE wind. Carr disagrees with the explanation that the waves would help the turtles to get on shore. He is more inclined to feel that after millenniums of natural selection, nights with strong wind and waves breaking high on the beach have become chosen because there is more chance that the tracks will be wiped out from the nests at Tamaulipas where hundreds of coyotes lie in wait. Pritchard (1969a) also mentions this hypothesis and points out that the tracks of the light ridley can easily be wiped out by the wind.

of green and ridley turtles with phases of the moon, periodicity of the tides, and time of nocturnal high water.

Time of high water plays an important role in nesting on some Surinam beaches because females of all species nest by night and beaches with associated mud-banks are only accessible at high water. At Eilanti, where a mud-bank extends in front of the beach, the females seldom come ashore that late, or delay that long on the beach, that they have to crawl back to sea across the exposed mud at ebb tide. At Bigisanti, where the foreshore is relatively steep and no mud-bank impedes the access at ebb tide, females nevertheless prefer to come ashore at high tide. It is possible that the choice of coming ashore at high water is a general behaviour 'adapted' to the occurrence of mud-banks in front of several beaches on the coast of Surinam and the other Guiana's. From Table 5, it appears that the nesting frequency of the green turtle was highest during those nights when high water was in the evening and that marked minima in nesting frequency coincided with periods when the first high water fell in the later part of the night or at nightfall.

Pending further observations, the conclusion can be drawn that, when high water comes between midnight and about 05.00 hr, green turtles nest in the later part of the night, but in smaller numbers than when high water is in the early evening. Thus, it seems as if the preference shown by the green turtle for high water in the evening may be because of a lesser risk of surprise by daylight. As was mentioned above, the nesting waves of the ridley at Eilanti coincided with those periods when high water came before midnight, between about 19.00 and 23.00 hr.

When research began in 1964, the Carib egg-takers informed us that there is connection between the phase of the moon (and thus the tide) and the periodicity of nesting. According to the Caribs repeatedly the largest numbers of green turtles and ridleys come to nest shortly after spring tide during 'brokowatra' (a local term which means 'breaking water', and designates the period after spring tide with a decreasingly high water, i.e. between new moon and first quarter, and between full moon and last quarter).

Since high water in the evening always coincides with 'brokowatra' on the Surinam coast, a causal relationship may occur between 'brokowatra' and high nesting frequency.

From Table 5, it is obvious that the 'arribadas' of ridleys take place during 'brokowatra' (compare average numbers of nests in first two columns). The number of green turtle nests during 'brokowatra' is also higher, but the difference from the nights before new moon and full moon (with increasing height of high water) is not so convincing as for the ridley. It may once again be stated that it is not known whether high water in the early evening

TABLE V

Average number of nests/night of green turtle (6/4-30/6/1967, at Bigisanti + Eilanti, and 9/4-23/6/1968, at Bigisanti + Eilanti + Baboensanti) and of ridley (resp. 29/5-25/7/1967 and 18/5-1/8/1968, at Eilanti), during decreasing (↓) and increasing (↑) height of HW and during nights with HW at different times of the night. HW 1, 2, 3, 4: 'night' : HW respectively between 19.00 and 21.00 hr; 21.00 and 24.00 hr, 00.00 and 03.00 hr, and 03.00 and 05.00 hr. HW 5: the two HW's between 05.00 and 19.00 hr. The combinations 1/↑, 3/↓ and 4/↑ do not occur on the Surinam coast.

	HW →		↓	↑	1/↓	2/↓	2/↑	3/↑	4/↑	5/↑	5/↓	ave.
GREEN TURTLE	total number of nights	1967	44	40	15	15	7	12	19	2	14	-
		1968	33	41	10	14	0	21	17	3	9	
	average number of nests/night	1967	17½	14	20	16	13	13	13	-	16	15½
		1968	42	32	44	44	-	31	34	36	35	37
RIDLEY	total number of nights	1967	27	30	11	13	1	12	12	5	3	-
		1968	35	37	15	14	1	14	13	9	6	-
	average number of nests/night	1967	76	10	104	64	25	13	6	9	24	41
		1968	59	15	33	120	47	22	11	12	20	40

or the decreasing height of high water is responsible for the increased nesting frequency on the nights following spring-tide.

The only remark in the literature about such a relationship is by Carr (1967: 33), who sceptically mentions the possibility of a correlation between nesting frequency and phase of the moon.

Marking of turtles

One of the important parts of the work on the nesting beaches was the marking, or tagging, of adult female turtles in order that individuals could be accurately identified and their activities — both on the beaches, and during their wanderings to and from the feeding grounds — monitored and tabulated. Because most of the data presented in the next paragraphs are based on observations made on marked turtles, the technique of marking is described below.

Monel metal, self-piercing and self-clinching cattle-ear tags were used, designed to be affixed with an applicator plier. The numbered tags, which are clipped to the proximal part of the trailing edge of one of the front-flippers, are of the same type as those which Tom Harrison applied for the first time on the turtle islands in the China Sea and which since then have found wide application in Archie Carr's extensive tagging operation, vividly described in Chapter 2 and 3 of his book 'So Excellent a Fishe' (1967). Peter Pritchard, one of Carr's students, started tagging on the Surinam beaches, where he marked some 1200 turtles — most of them ridleys — during the 1966-1968 seasons. Since 1969, Forest Service personnel continued tagging and up to 1973 over 6000 females and 3 males have been marked on the Bigisanti and the Galibi beaches with tags provided by Carr, who also paid tag returns from the financial resources of his research funds. The numbers of animals tagged, per season and per species, are given in Tables 6, 8 and 9. See Pl. 27 figs. 47 and 48.

Turtles were marked both for short-term study during one breeding season as well as to obtain long-term information on homing tendencies, breeding cycles, and migration paths. The latter information was revealed by recoveries made by fishermen who sent tags and information on the date and place of the capture to the Biology Department of the University of Florida, the address of which is inscribed on one side of the tag (together with the offer of a reward for sending the tag to this address). Since the Surinam tagging programme started, 97 recoveries at sea have been reported. The information on the migration routes revealed by these tag returns is discussed in Chapter VIII.

The tagging project was also set up to determine the size of the populations nesting in Surinam and the dynamics of population recruitment and attrition. These goals were only partly achieved, due to partial shifts of the populations between the French Guiana beach and Surinam and to loss of tags.

A few cases of green turtles and ridleys that moved between our beaches and the rookery on the French Guiana coast have been reported (Tables 13-15), but probably such wanderings are exceptions. No information, however, is available on movements between Galibi and the nesting beach at the Mana mouth, on the other side of the Marowijne, where no patrolling has been carried out. Leatherbacks perhaps more frequently escape counting by changing beaches.

A considerably more important source of uncertainty is presented by the loss of tags. Loss of tags soon after tagging was already suspected from the relatively high number of green turtles recorded as having nested only once or twice during a season. This suspicion was corroborated in 1971, when newly tagged green turtles on Bigisanti were also marked with paint. Of the 80 animals thus marked, within one month 12 were recovered on the beach with a persistent paint mark but without the tag. The actual number of animals that lost their tag has been estimated at 15-20%, a figure based on a calculation which included the estimated number of turtles that had lost both paint mark and tag. There are several reasons why tags are shed; some tags were not affixed securely (poor clinching and other mistakes) while other tags showed severe corrosion.

Loss of tags has also been assumed by other investigators, who considered at least some of the callosities found on the front flippers as being signs of loss of tags. We never systematically inspected Surinam turtles for these callosities. But we did note that leatherbacks — the species for several reasons suspected to suffer very substantial tag losses — not infrequently show suspicious notches in the tagging area of their flippers. However, as Pritchard also observed, many leatherbacks have such ragged trailing edges on their front flippers that it is not possible to ascertain the percentage of tags that have been shed or ripped out. Pritchard (1973a) is certain that a 'rather large' proportion of leatherbacks he tagged in French Guiana shed their tags within a few months; their skin is so soft and so liable to infection that in many individuals the tag area becomes necrotic and the tag is lost.

Ideally a female specimen was not approached by the taggers until it had begun to lay eggs, at which time turtles are less influenced by disturbances. However, through force majeure old tags had to be inspected or new ones put on whenever a turtle was encountered on the extensive Bigisanti beach, that had to be patrolled every night of the 7 month season by a field party of only 4 persons. This was especially the case in 1971 when the teams had to cope with the job of tagging or noting down the tag number of every animal that laid eggs. It was inevitable that turtles sometimes were approached before they had ascended to the high tide line. This caused several turtles to be so disturbed that they returned to the water without laying, but it seemed that most of the turtles thus disturbed returned to lay on the same or a following night. This caused the records on internesting periods to be somewhat distorted. Further potential sources of statistical errors, and incomplete recordings caused by temporary relaxation of discipline and want of personnel, are mentioned in the sections below.

Breeding cycles (intervals between nesting seasons)

Chelonia mydas returns to nest every 2, 3 or 4 years in the Caribbean, with the triennial cycle predominant (Carr & Ogren, 1960; Carr & Carr

1970). On nesting beaches elsewhere, the existence of a 3-year (E coast of Malaya) or a 4-year cycle (E Australia) has been recorded (Hirth, 1971).

The tagging programme has shown that green turtles nest in Surinam in a 1-, 2-, 3- or 4-year (and perhaps 5-year) cycle and that probably the biennial cycle predominates. The results of the observations on season to season returns of tagged animals are summarized in Table 6. As will be discussed in the last section of this chapter, turtles returned with only a few exceptions to the beach where initially they had been tagged.

A total of 599 nesting remigrations were recorded for turtles tagged from 1966 to 1970 (the 1971 taggings are omitted because this group has been observed for only few years). Of these 599 intervals, 24 (4%) were after 1-year, 351 (58%) after 2-year, 211 (35%) after 3-year and 12 (2%) after 4-year intervals. This seems to indicate that the 2-year cycle predominated.

It is probable that at least part of the 4-year interval records are simply 2 + 2 year cycles with the intermediate arrival having been missed. Missing an encounter on the beach remains possible — even with intensive nightly patrolling — as several turtles nest only once or twice during a season. Nevertheless, some turtles probably return after a 4-year absence. This was also Carr's (1970) conclusion for the population nesting on Tortuguero.

Substantial numbers of green turtles have only been tagged since 1969, and the observation period is still too short for conclusions on the constancy of individual cycles. Of the 65 multiple returns on record (Table 6), the first interval was maintained in 43 cases. In the other 22 records the animals changed their cycle for successive returns. In 20 of these cases a longer period was followed by a shorter; many more returns of tagged turtles are necessary to confirm this tendency, if it really exists.

When drawing inferences from observed returns, allowance should be made for the possibility of intermediate nesting migrations to beaches outside Surinam. This could particularly be the case for the Galibi beaches and the nearby nesting grounds in French Guiana. If, however, the data for the animals tagged on the more isolated Bigisanti beach, which showed a strong site-fixity, are examined separately, the data do not differ significantly from the combined data in Table 6.

Of the 1609 females of *Lepidochelys olivacea* that were tagged during the first four seasons (1966-1969), nearly two-thirds were reported back on a Surinam beach during one or more following seasons, but of the animals tagged during the next 2 seasons, a considerably lower percentage was reported back on the beach (Table 8). Two-thirds of the 2569 season to season recoveries on record were 1-year intervals and one quarter were 2-year

TABLE VI

Summary of numbers of tagged females and season to season beach recoveries of Chelonia mydas, *1966-1973.*

	Year of tagging →	1966	1967	1968	1969	1970	1971	1972	1973
numbers of tagged green turtles	on Bigisanti (1)	32	16	7	159	312	262	55	223
	on Galibi beaches (2)	0	26	2	645	1095	0	0	0
	caught at sea (3)	1	0	0	39	27	2	1	1
	Killed by jaguars or tag removed / lost (4)	0	1	0	15	5	0	0	
	nett. total: (1)+(2) − (3)+(4)	31	41	9	750	1375	260	54	222

	SEASON TO SEASON RECOVERIES PER TAGGING GROUP:	numbers of individual cases
1966-group: 10 numbers (32%) returned to nesting beach one or more times	X —— (4 years) —— X	2
	x —— (3 y) —— x	4
	x —— (3) —— x —— (3) —— x	1
	x —— (4) —— x —— (2) —— x	1
	x —— (4) —— x —— (3) —— x	1
	x —— (3) —— x —— (2) —— x —— (2) —— x	1
1967-group: 11 returns (= 27%)	x —— (4) —— x	1
	x —— (3) —— x	3
	x —— (2) —— x	5
	x —— (3) —— x —— (2) —— x	1
	x —— (2) —— x – (1) – x	1
1968-group: 4 returns (= 44%)	x —— (3) —— x	3
	x —— (2) —— x	1
1969-group: 221 returns (= 29%)	x —— (4) —— x	7
	x —— (3) —— x	68
	x —— (2) —— x	96
	x – (1) – x	3
	x —— (3) —— x – (1) – x	2
	x —— (2) —— x —— (2) —— x	39
	x —— (2) —— x – (1) – x – (1) – x	1
	x —— (2) —— x – (1) – x	4
	x – (1) – x —— (2) —— x	1
1970-group: 288 returns (= 21%)	x —— (3) —— x	126
	x —— (2) —— x	151
	x – (1) – x —— (2) —— x	1
	x —— (2) —— x – (1) – x	8
	x – (1) – x – (1) – x	1

Year of recovery →	1967	1968	1969	1970	1971	1972	1973	532

TABLE VII

Season to season recoveries of the 292 Lepidochelys olivacea *females, tagged on Eilanti beach during the 1967 season, which returned to a Surinam beach during one or more following seasons. E = Eilanti beach, BP = Baboensanti-Pruimenboom beach, FG = French Guiana beach.*

nr. of animals	year of observation on nesting beach							total nr. of each interval on record						tot. nr. of intervals
	1967	1968	1969	1970	1971	1972	1973	1 year	2 year	3 year	4 year	5 year	6 year	
133	E													0
81	E	E						81						81
20	E	E	E					40						40
2	E	E	BP					4						4
13	E	E	E	E				39						39
2	E	E	BP	E				6						6
1	E	BP	BP	E				3						3
5	E	E	E	E	E			20						20
1	E	E	BP	E	E	-		4						4
2	E	E	E	E	E	E		10						10
1	E	E	E	BP	E	E		5						5
4	E	E	E	E	E	E	E	24						24
1	E	E	BP	E	E	E	E	6						6
13	E	–	E					–	13					13
3	E	–	BP					–	3					3
8	E	–	E	E				8	8					16
2	E	–	E	E	–	E		2	4					6
2	E	–	E	E	–	–	E	2	2	2				6
4	E	–	E	E	E			8	4					12
1	E	–	BP	E	E			2	1					3
1	E	–	E	E	E	E		3	1					4
2	E	–	E	–	E			–	4					4
1	E	–	BP	–	BP	E		1	2					3
1	E	–	E	–	E	E	E	2	2					4
1	E	–	E	–	–	E		–	1	1				2
18	E	–	–	E				–	–	18				18
1	E	–	–	BP				–	–	1				1
1	E	–	–	FG				–	–	1				1
4	E	–	–	E	E			4	–	4				8
2	E	–	–	E	E	E		4	–	2				6
1	E	–	–	E	E	E	E	3	–	1				4
5	E	–	–	E	–	E	E	5	5	5				15
1	E	–	–	E	–	–	E	–	–	2				2
2	E	–	–	–	E			–	–	–	2			2
1	E	–	–	–	FG			–	–	–	1			1
1	E	–	–	–	E	E		1	–	–	1			2
1	E	–	–	–	E	–	E	–	1	–	1			2
1	E	–	–	–	BP	–	E	–	1	–	1			2
3	E	–	–	–	–	E		–	–	–	–	1		1
2	E	–	–	–	–	–	E	–	–	–	–	–	1	1
21	E	E	–	E				21	21					42
1	E	BP	–	E				1	1					2
13	E	E	–	E	E			26	13					39
7	E	E	–	E	E	E		21	7					28
2	E	E	–	E	E	E	E	8	2					10
2	E	E	–	E	–	E		2	4					6
3	E	E	–	E	–	–	E	3	3	3				9
1	E	E	–	E	E	–	E	2	2					4
1	E	E	–	E	BP	–	E	2	2					4
5	E	E	–	–	E			5	–	5				10
2	E	E	–	–	E	E		4	–	2				6
1	E	E	–	–	E	E	E	3	–	1				4
1	E	E	–	–	E	–	E	1	1	1				3
2	E	E	–	–	–	E		2	–	–	2			4
1	E	E	–	–	–	–	E	1	–	–	–	1		2
2	E	E	E	–	E			4	2					6
2	E	E	BP	–	E			4	2					6
1	E	E	E	–	E	E		3	1					4
2	E	E	E	–	E	E	E	8	2					10
1	E	E	BP	–	E	E	E	4	1					5
1	E	E	E	E	–	E		3	1					4
2	E	E	E	E	–	E	E	8	2					10
1	E	E	E	E	–	–	E	3	–	1				4
2	E	E	E	E	E	–	E	8	2					10
425	← totals →							434	121	50	8	2	1	616
								70½ %	20 %	8 %	1 %	⅓ %	⅙ %	100 %

intervals. A small portion of the 2-year records is attributable to animals that missed tabulation in between. Time intervals of 3 years or longer were noted 163 times (8%). Table 7 illustrates — for the group tagged in 1967 — that the majority of the individual series of breeding intervals consists of various, apparently random combinations of successive time intervals. Only part of the individual changes in length of the breeding interval can be accounted for by missing of returns and by migrations to the French Guiana rookery (where Pritchard in 1970-1972 came across a few Surinam-tagged ridleys). The individual records for the groups of ridleys tagged in other years present the same picture as the 1967 example: predominance of 1-year intervals, alternating randomly with longer time intervals.

Of *Dermochelys coriacea* only 9 returns were recorded (Table 9). The few available data on intervals between seasons presented in this table show

TABLE VIII

Summary of season to season recoveries of tagged females of Lepidochelys olivacea.

year of tagging →		1966	1967	1968	1969	1970	1971	1972	sum total '66-'71	weighted average '66-'71
nr. tagged	Bigisanti	6	0	4	33	31	30	(24)	104	-
	Galibi beaches	130	450	472	565	647	365	(234)	2629	-
captured at sea (up to 10/73)		2	15	8	12	10	5	(2)	52	-
nr. of animals used for calculations		134	425	464	586	668	391	(256)	-	-
nr. returned to Surinam beaches		89 (66%)	292 (69%)	293 (63%)	355 (59%)	310 (46%)	121 (30%)	(49)	1460	55%
total nr. of season to season recoveries		221	616	562	580	452	138	(49)	2569	-
interseasonal intervals (1-6 years) and frequency-percentages of intervals for each year group+	1-year	63%	70%	60%	63%	71%	65%	(49)	1678	65%
	2-year	27%	20%	29%	28%	24%	35%	?	665	26%
	3-year	5½%	8%	7%	6½%	5%	?	?	(163)	(7%)
	4-year	3%	1%	3%	2½%	?	?	?	(46)	(2%)
	5-year	1%	<1%	2%	?	?	?	?	(16)	?
	6-year	<1%	0	?	?	?	?	?	1	?

+ for method of calculation, see the detailed results for the 1967 group, in Table 7

TABLE IX

Summary of numbers of tagged females and season to season returns to Surinam beaches of Dermochelys coriacea, *1966-1973.*

Year of tagging ⟶		1966	1967	1968	1969	1970	1971	1972	1973	individual cases
tagged animals total	Bigisanti	13	2	9	97	105	30	1	0	
	Galibi beaches	0	0	0	6	10	0	0	0	
	recoveries at sea	0	0	0	0	1	1	0	0	
recoveries on nesting beaches after time interval x---x		x	— 3 —	—	x					1x
			x	— 2 —	x					1x
					x	— 2 —	x	- 1 - x		1x
					x	— 3 —	—	x		1x
						x	— 2 —	x		1x
						x	— 3 —	—	x	1x
							x	— 2 —	x	3x
total of recoveries on beach during following year(s)		1	1	0	2	5	3	-	-	12x

a predominance of 2-year intervals. Pritchard (1972) also found a predominance of recoveries after 2 years (23 out of 26 records) for the French Guiana rookery. The low proportion of tagged turtles recovered in later years is probably primarily due to the shedding of tags. Although migrations from Bigisanti to French Guiana during the nesting season were recorded, Pritchard did not come across leatherbacks that had been tagged on Bigisanti during a previous season.

In the foregoing paragraphs the fact (already well-known from other nesting grounds) has been documented, for the populations breeding in Surinam, that — although their breeding is seasonal — supra annual rhythms characterize the reproduction cycles of the green turtle and of the leatherback, and that although annual intervals predominate in the well-synchronized breeding of the olive ridley, longer intervals are frequently recorded. It has been further demonstrated that shifts in individual cycle periods were observed for both the green turtle and the olive ridley (and once for the leatherback).

Carr et al. (1970) suggested that in *Chelonia* changes in the intermigration period may in part be related to changes in the feeding ecology on the residence grounds. However, this seems to contradict the generally accepted view that the green turtle, which occupies a broad ecological niche, suffers little or no interspecific competition (e.g., Hirth, 1970: 4.2). Moreover, intraspecific competition has been strongly reduced by human predation, so that it does not seem very likely that for the green turtle shifts in cycle-period are a direct response to fluctuations in food availability in the feeding area (assuming that its diet really is exclusively vegetarian).

As will be discussed in the next section, a fairly high proportion of green turtles lays only one or two nests, and some perhaps even migrate without making any nests at all; a reduced number of nestings may perhaps induce a shortening of the subsequent interbreeding interval. What factors might influence reduction of the number of nests during a season can only be guessed at.

Intra-seasonal intervals between repeated nestings

The majority of sea turtle females of all four species nest more than once during a breeding season. The intervals between nestings are spent at sea, presumably not far from the chosen nesting beach (except for the turtles that move to other beaches during the season: see last section of this chapter).

Table 10 presents a summary of the records on nesting returns of tagged females of *Chelonia mydas* and *Dermochelys coriacea* on Bigisanti beach during two seasons. The 1971 data are of the greatest value, since it was during this year that the turtles received the most careful observation during the whole season (as appears from the fact that the 'identity' was ascertained for the layers of 97% of the nests). Only true nesting returns are included; care was taken to keep these records separate from the many landings that did not lead to the deposition of eggs.

For the 1971 green turtle records, the frequency distribution in Table 10 shows a pronounced peak at 13 days. For the leatherbacks, the intervals have a peak at around 10 days. The 1970 data show peaks around the same time intervals. If the arithmetic mean is calculated for the 1971 re-nesting intervals of the green turtle around the most common values (including intervals from 11 to 16 days), 465 records show an average interval of 13.4 days; in the second peak (23-31 days), 71 records show an average of 26.8, being exactly the double of the first mean. For the 1970 data the calculations are respectively 13.2 and 25.6 days.

For the leatherback the average of the highest peak (intervals from 8 to 12 days, both for 1970 and 1971) comes to 10.0 days, whereas the records in the second peak (18-23 days intervals) show a mean of 19.7 days. Although for both species throughout the season there is a continual sprinkling

TABLE X

Frequencies of internesting intervals of individual marked green turtles and leatherbacks nesting on Bigisanti beach in 1970 and 1971, and of olive ridleys nesting on Eilanti in 1971. Excluded are turtles that were known to have migrated to or from other beaches during the season.

interval in days between recorded successful nests	frequency				
	green turtle		leatherback		ridley
	'70	'71[1]	'70	'71[2]	'71
0	2	2	0	0	0
1	5	3	1	1	8
2	2	2	0	0	2
3	1	2	0	0	1
4	0	2	0	0	2
5	0	0	0	0	1
6	1	0	0	0	4
7	0	1	0	1	0
8	1	2	3	5	2
9	2	1	6	36	1
10	1	4	9	41	1
11	17	22	8	20	4
12	46	92	1	10	1
13	47	145	1	0	5
14	50	121	0	1	4
15	21	58	0	2	12
16	6	27	0	2	23
17	3	12	0	1	20
18	3	5	2	4	19
19	0	2	5	7	7
20	2	4	3	4	11
21	2	1	2	0	12
22	0	0	1	2	14
23	11	7	2	1	5
24	10	4	0	0	8
25	14	7	1	1	13
26	12	15	2	0	8
27	9	17	1	1	6
28	5	8	1	0	8
29	6	8	0	0	20
30	2	2	1	2	23
31	1	3	3	0	19
32	1	1	0	0	7
33	3	2	0	0	2
34	1	1	0	0	3
35	5	0	0	0	1
36	3	0	1	1	1
37	1	1	0	0	3
38	3	2	0	1	2
39	3	0	0	0	0
40	3	2	1	0	4
41-45	7	8	1	0	5
46-50	5	2	1	0	6
51-60	0	1	2	0	2
61-70	0	2	0	0	0
total	317	601[1]	58	144[2]	300

1) In only 18 cases the layer of a nest was not identified.
2) Do., 11 cases.

of records showing intervals longer (some much longer) than the most common interval, those that are around double this basic period predominate significantly.

In 1970, when quite a few turtles laid unobserved, it was still assumed that the 'abnormally' long intervals represented those individuals that had missed tabulation on one or more occasions. The same assumption has led some authors to calculate average re-nesting periods while taking the records around the smaller peaks as multiples of the 'normal' period. However, in 1971 it was proved that both the green turtle and the leatherback frequently re-nest at periods (much) longer than the 'most common' average. When they do so, a remarkable preference is shown for periods that are around double the 'normal' intervals. Only a few green turtles migrate to the Galibi region during the season, and no individual tagged on Bigisanti has ever been reported from a beach outside Surinam. Consequently, the great majority of the recorded long re-nesting intervals can not be accounted for by intermediate nesting on other beaches. This also holds for the leatherback: some females have been recorded on the French Guiana rookery after laying one or a few nests on Bigisanti, but we have no records on movement in the opposite direction.

It is noticeable that the average re-nesting period for the green turtle (13.4 days or its multiple) comes very close to the period of around two weeks we observed in the nesting frequency on the Surinam beaches (Graph II).

The nestings separated by 'abnormally' short intervals deserve some discussion. During previous years it was suspected that erroneous observations might play a part in at least some of these records. In 1971 it was confirmed that two nests may be laid by the same green turtle in the same night (= interval '0' in Table 10) and that a few return for nesting after only a few days' absence. Such an observation was also made by Hendrickson (1958: 499). It is very probable that many of the nestings separated by abnormally short intervals produce fewer eggs than are found in the majority of the nests which are made at longer intervals, as was established by Hendrickson (1958: 499).

The basic re-nesting period of 13.4 days, established for the green turtle population nesting in Surinam, is markedly longer than the 10.5 average interval found by Hendrickson on the Sarawak islands and is also longer than the 12.5 days Carr (1947) mentioned for the Tortuguero rookery.

Data for Atlantic leatherbacks are exceedingly scarce; Pritchard (1972), for the population nesting in French Guiana (probably the same assemblage as the Bigisanti nesters), calculated a mean value of 10.98 days from the records of the intervals between 8 and 16 days.

For *Lepidochelys olivacea* we still do not dare to draw conclusions on the individual internesting period. Besides the fact that ridleys depend more on weather conditions than other turtles (see second section in this chapter), the variable quality of the watching for tagged animals under the confused, crowded conditions of an 'arribada' renders the records untrustworthy. Our data (Table 10) suggest that at Eilanti the 'most common' intervals last around 17 and 30 days. Pritchard (1969: 109) also noted these peak intervals, and concluded that the 30-day re-nesting turtles had merely been missed the second time. This appears unlikely, since very few turtles are found nesting three times. Pritchard further concludes that 'it seems most likely that *Lepidochelys olivacea* normally nests twice in a season, at intervals controlled more by external factors (tide and weather) than by the internal factors that seem to control the green turtle's nesting'.

Numbers of nests per female

The number of times a female *Lepidochelys olivacea* nests per season has not been definitely determined. From the number of 'arribadas' it could be concluded to be three. This is not true; the foregoing paragraph concluded with Pritchard's (1969: 104) supposition that on Eilanti the majority of the ridleys nest twice during a season, a few nesting three times, while quite possibly some individuals nest only once. Hill (pers. comm.), however, estimated that 800 ridleys nested once in 1970, 300 twice, 30 three times and 70 not at all (total number of females nesting in 1970, about 1200). Perhaps the 'bad' weather conditions for 'arribadas' — i.e., calm sea and no wind — throughout the 1970 season (except for the night of the first 'arribada') were responsible for the high number of ridleys that nested only once. The following ratios were observed in 1971: about 50% of an estimated total of 1000 females nested once, 45% twice and 3% nested three times, whereas 2% were noted down as visitors not making a nest. In 1971, the mean number of nests per ridley female was apparently 1.5. However, in the foregoing calculations no allowance has been made for: either the unknown numbers of individuals that laid both on the Galibi beaches and on the other bank of the Marowijne, or the number of ridleys that were wrongly recorded by having two 'identities', because they lost their tag and were retagged during the season. According to the Caribs, in 1971 only very few ridleys nested at Les Hattes, and Pritchard (pers. comm.) reported an insignificant number of Surinam-tagged ridleys on Silébache beach. When the individuals that came back in 1972 — and then proved that they had retained their tags — are considered apart, this group is found to provide 15% fewer records of single-nestings (and consequently 17% more of double-nestings) than the group that presumably did not return the following year. This suggests a frequent loss of tags.

Likewise, the exact assessment of the average number of nests a *Chelonia mydas* female lays in one season, has to wait until a more reliable method of turtle marking has been developed. Caribs of Galibi told me that green turtles nest 5 to 7 times in a season, but Kappler — who almost certainly got his information also from the Carib fishermen — reported (1881: 134) that they

TABLE XI

Numbers of nests laid by individual marked female green turtles on Bigi-santi beach during the 1971 season.

nr. of successfull nests recorded	group I 5.II-16.III 1971*		group II 17.III-15.V.1971		group III 16.V-25.VI 1971		group I-III	renesters, tagged during previous year	
	nr.	%	nr.	%	nr.	%	nr.	nr.	%
0	6	6	17	11	3	13	26	2	7
1	24	23	42	26	14	61	80	5	17
2	10	9	31	20	2	9	43	4	13
3	9	9	15	10	3	13	27	1	3
4	13	12	16	10	1	4	30	7	23
5	17	16	19	12	0	0	36	2	7
6	19	17	11	7	0	0	30	4	13
7	6	6	4	3	0	0	10	4	13
8	0	0	2	1	0	0	2	0	0
9	2	2	0	0	0	0	2	1	3
10	0	0	0	0	0	0	0	0	0
total nr. of nests laid	382	100	418	100	31	100	831	115	99
total nr. of individuals recorded	106	-	157	-	23	-	286	30	-
average nr. of nests per turtle	3.6	-	2.7	-	1.4	-	2.9	3.8	-

* period during which the turtles of the group were recorded for the first time; eliminated from the records are turtles that were killed by jaguars or reportedly moved to Galibi beaches or were known to have been retagged because of loss of tags.

laid only 3 to 4 times. The basis for these estimates is unknown (perhaps the Carib egg-takers — being good observers — could tell the turtles apart?), but the lower figures reported by Kappler approximate our data, which are discussed below.

Hirth (1971) suggests that most green turtles lay between 3 and 7 times. The exhaustive studies done in the Sarawak islands led Hendrickson (1958: 530) to the conclusion that green turtles nest 6 or 7 times on those beaches. His calculations were based on the assumption that intervals between nestings are constant around 10 days and that the total 'observation time' of each marked individual (i.e., the time span between marking and last record on the beach) divided by 10 gave the number of nestings. As I explained in the foregoing section, such treatment can not be used for the green turtles nesting in Surinam, which frequently stay away for multiples of the 'normal' 13 day period.

Reviews of the green turtle nesting records on Bigisanti for the 1971 season are presented in Tables 11 and 12. These data were chosen because 97% of the nesting turtles was identified. The average of 2.9 nests per turtle is considerably lower than the estimates for other nesting beaches of the world. Turtles that were reported to nest during the first 6 weeks of the season (group I in Table 11) laid an average of 3.6 nests, which is still lower than the figures reported for other populations.

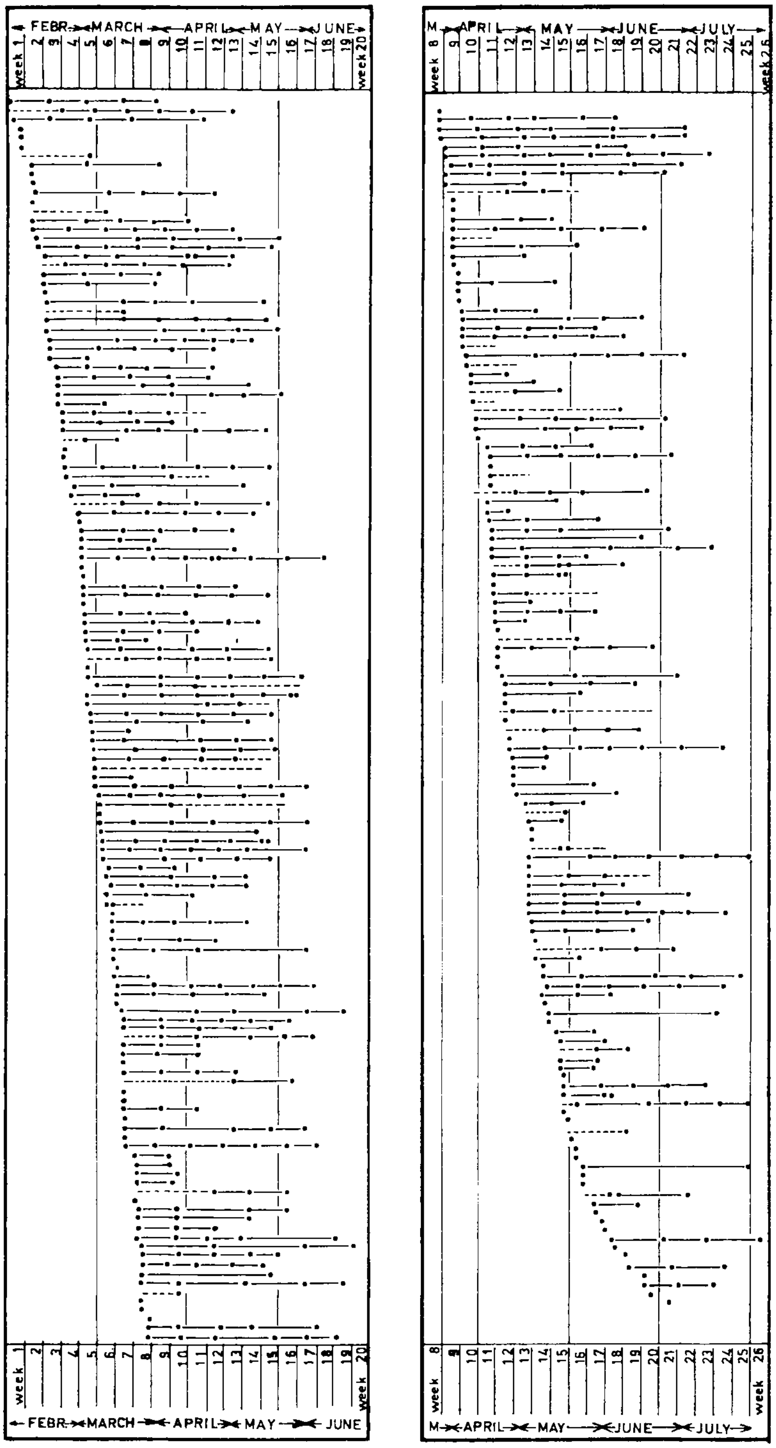
From the tables it appears that the later in the season a turtle (or rather a tag) is recorded for the first time, the shorter is the period of observation, and the fewer the number of nestings recorded. Particularly at the end of the season (third group in Table 11) many green turtles were tagged that are recorded as having nested only once or twice, giving the low average of 1.4 nests per turtle. This is partly attributable to turtles that had in fact nested previously, but had lost their tag and were noted as new arrivals. Also migrations from other beaches may have taken place. However, it is hard to believe that the majority of the late arrivals, that came ashore to lay only one or two nests near the end of the season, were migrants from French Guiana or Galibi that escaped tagging or recording on those beaches, as no such movements from French Guiana to Surinam have ever been recorded. And only very few green turtles moved over from Galibi beaches: e.g., in 1970 — see Table 13 — only 14 of such cases were reported (in only six of these instances the migrant nested successfully on both beaches).

I assume that several of the turtles really nested only once or twice (and some perhaps even not at all) and that the late arrivals have a significantly lower number of nestings. This assumption is supported by the data shown in the last column of Table 11, representing the records of turtles that were tagged during a previous season and apparently had their tags well secured and that showed their fixed affinity to Bigisanti beach: 37% of this group made 0, 1 or 2 nests.

Continuation of intensive patrolling of the Surinam beaches (and — as is much to be hoped — also of those in French Guiana) will be required to confirm this remarkable tendency of the population nesting in Surinam to lay considerably fewer nests than green turtles seem to do at other nesting beaches.

Age, courtship, and copulation stimuli are factors that might be (partly) responsible for the number of nests a female makes during a season, but of this aspect of the breeding biology virtually nothing is known, and probably it can only be studied in animals that are kept in captivity. In this context it is fortunate that in 1973 green turtles started mating and nesting in captivity in the Grand Cayman turtle farm.

TABLE XII



Nesting histories of 269 tagged green turtles on Bigisanti beach. Excluded are turtles that were killed by jaguars during the season or reportedly were retagged because of loss of their tag, or moved to a Galibi beach. Each dot represents a successful nesting; the broken lines indicate periods during which a turtle climbed the beach one or more times without nesting (e.g., the second turtle was seen on the beach for the first time on Febr. 1st, but did not lay before the end of the third week).

Intra- and interseasonal returns; site tenacity

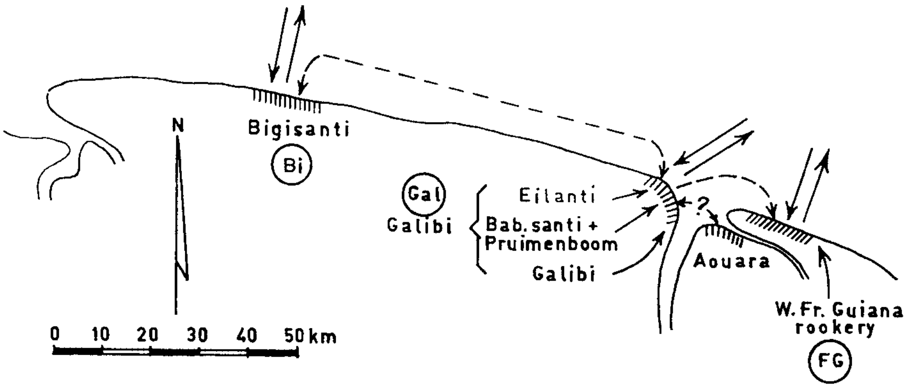
One of the amazing conclusions deduced from tagging on various nesting beaches in the world was the confirmation of the fact — long known to local fishermen — that sea turtles of all species use the same nesting beaches year after year. The ability of a turtle to return close to the locality in which she

Table XIII

Interseasonal remigrations to nesting beaches of individual tagged females, 1967-1972. B= Bigisanti, Gal = Galibi beaches (E = Eilanti, BP = Baboensanti + Pruimenboom, G = Galibi), FG = West French Guiana beach (observations made by P. C. H. Pritchard); for the relative positions of the Galibi beaches, see Map 3. A single arrow indicates two consecutive emergences on two different beaches, two arrows signify returns to the same beach during the next nesting period.

Chelonia: *Inclusive 1 × Bi → Gal → Bi; exclusive remigrations of 'intraseasonal wanderers': turtles that did not keep to the same beach during one season (e.g., turtle no. E4854, E1479 and E2103 in Table 16); green turtles frequently moved during the season between Galibi beaches (cf. Tables 15 and 16), so the three beaches were not kept apart for this species.*

	Bi	Bi	Bi	Galibi area					E FG	total nr. of returns on record
	↑↓	↓ Gal	↑ Gal	E ↑↓	E ↓ BP	E ↑ BP	BP ↓↑	E ↓ G	→	
Lepidochelys	30x	6x	6x	2330x	93x	109x	19x	1x	4x	2588
Chelonia	156x	12x	10x	473x					0x	651
Dermochelys	13x	1x	10x	0x					0x	14



has previously nested — during the same or a previous season — has been ascertained also on the Surinam nesting beaches.

That the vast majority of the olive ridleys do return to Eilanti for successive nestings, was to be expected, as on this beach the only major nesting aggregation of *Lepidochelys olivacea* known on the Atlantic coast of America is found. Table 13 shows that most changes of nesting beaches took place between the neighbouring beaches within the Galibi area. In 5 years only 12 cases of changes between Bigisanti beach and a Galibi beach were recorded and in 4 cases a ridley seen during the foregoing season on Eilanti beach returned for the next nesting season to the French Guiana beach at the other side of the Marowijne estuary. Site fixity was apparently less strong for the few ridleys nesting on Bigisanti beach, as shown by the relatively higher number of returns to a Galibi beach, 80 km to the east. The degree of nesting-beach fixity of the ridleys is illustrated also in Table 7, which shows the 5-year returning records for the turtles tagged by Pritchard on Eilanti beach in 1967: 579 returns of a total of 616 were back to Eilanti and in only 37 cases a ridley nested on a different beach(-section) during two consecutive nesting periods.

No *Chelonia mydas* female tagged at any of the other nesting beaches where marking of turtles has been carried out (Tortuguero, Ascension, Mexico) was observed nesting on a Surinam beach (with the exception of one, not very credible report of a Mexican tag seen on a Galibi beach). Not even one green turtle tagged on the nearby French Guiana nesting place was seen on a Surinam beach, although a few females tagged in Surinam were reported as having renested during the same season on Silébache. Except for these few cases, no 'Surinam green turtle' has ever been found nesting on any other shore.

Table 13 shows that, although in the majority of the cases returning was to the beach where the foregoing nesting had taken place, site discrimination of *Chelonia mydas* is not as absolute as is often assumed, based on data for Tortuguero and Ascension (Carr et al., 1970a). Within the Galibi area intra- and interseasonal movements between beach sections were recorded rather frequently.

What little information there is on *Dermochelys coriacea* is presented in Table 13. Because, as will be discussed below, several cases of shifting from Bigisanti to the French Guiana beach were reported during one nesting period, it is to be expected that season to season returns from the Surinam rookery to French Guiana take place frequently, though this has not yet been confirmed.

What in the foregoing paragraphs was shown to be true concerning season

TABLE XIV

Individual nesting records of all female turtles that reportedly moved between Bigisanti beach and the Galibi nesting area during the 1970 and 1971 season, as an illustration of intraseasonal renesting migrations. (Gal = Galibi beaches (E, Ba, G); for other abbreviations, see Table 13; if a turtle came ashore without making a nest, the respective beach is given between brackets).

A. Chelonia mydas *(1970)*

	1st visit	interval (days)	2nd visit	interval (d.)	3rd visit	interval (d.)	4th visit	interval (d.)	5th visit	interval (d.)	6th visit
(Gal)→Bi	(E)	13	(E)	45	Bi	13	Bi				
	(Ba)	1	(Ba)	42	(Bi)	12	Bi				
Gal→(Bi)	Ba	13	(Bi)								
	(Ba)	12	Ba	14	(Bi)						
	Ba	12	Ba	62	(Bi)						
Gal→Bi	Ba	13	Bi								
	Ba	15	Bi								
	Ba	16	Bi								
	Ba	31	(E)	1	(Ba)	51	Bi				
	(Ba)	12	(Ba)	1	Ba	25	Bi	12	(Bi)	2	(Bi)
(Bi)→(Gal):	(Bi)	2	(E)								
(Bi)→Gal	(Bi)	39	Ba								
	(Bi)	25	Ba								
	(Bi)	15	(G)	12	Ba						
	(Bi)	14	Ba	14	(E)	12	(E)	2	E		
	(Bi)	24	(E)	14	E						
Bi→(Gal)	Bi	12	Bi	15	(Ba)						
	Bi	12	Bi	12	(G)						
	Bi	13	(Bi)	49	(E)						
Bi→Gal	Bi	14	E								
	Bi	23	Ba								
	Bi	37	Bi	2	Ba						
	Bi	12	E	60	Ba						
	Bi	62	(E)	16	Ba						
	Bi	13	(Bi)	26	Ba						
	Bi	12	Bi	2	Ba	17	E				
	(E)	1	(E)	33	(Bi)	15	E				
	(Bi)	16	E	29	(Bi)	2	Bi				
	(Bi)	3	Ba	55	(Bi)						
	(Bi)	2	(Ba)	14	Bi	12	(Bi)	13	(Bi)	1	Bi
SUR.→FR.GUI.	E	64	FG								

B. Dermochelys coriacea *and* Lepidochelys olivacea *(1970 + 1971).*

		1st visit	interval (d.)	2nd visit	interval (d.)	3rd visit	interval (d.)	4th visit	interval (d.)	5th visit	interval (d.)	6th visit
leatherback	1970	(Bi)	4	(Bi)	41	FG						
		(Bi)	60	FG								
		(Bi)	46	FG								
		Bi	50	FG								
		Bi	51	FG								
		Bi	70	FG								
		Bi	12	Bi	52	Bi	17	FG				
	1971	(Bi)	95	FG								
		Bi	11	Bi	23	(Bi)	51	FG	11	FG		
		Bi	9	Bi	8	Bi	19	Bi	33	FG	10	FG
		Bi	64	FG								
ridley	1970	(Bi)	12	E								
	1971	F	36	FG								

to season site tenacity, is equally true for the nest-site fixity the renesting turtles exhibit during a single season. But, although tag returns prove the existence of a strong homing drive, nest-site discrimination is far from absolute. The vast majority of the females for the rest of the season keeps to the beach (or, in the case of the Galibi beaches, to the area) where the first nesting during the season took place (which, with rare exceptions, is also the beach or area used during foregoing seasons).

The figures in Table 15 illustrate the relatively high frequency of changes of nesting beach, shown both by *Chelonia mydas* and *Lepidochelys olivacea* during one nesting season within the Galibi area. Movements between Bigisanti and Galibi beaches are very rare for ridleys, but this may be due to the small numbers nesting on the first beach. Renesting green turtles more often move between both nesting areas, as shown by the 13 cases recorded in 1970. This number of movements is higher when all emergences — including those that did not lead to a successful nesting (e.g. no's 4854, 1344, 3500 in Table 16) — are taken into account.

In Table 16 some beach emergence records of typical stragglers — females that show a relatively weak site tenacity — are presented.

The relatively frequent movements of *Dermochelys* during the season,

TABLE XV

Intraseasonal nest-site fixity: reported successive emergences of renesters during the 1970 season. Only pairs of successful nestings are taken into account. Abbreviations are the same as used in Tables 13 and 16. Emergences on the French Guiana beach (FG) were observed by P. C. H. Pritchard.

Next successive successful nesting return to:

	the same beach:				a different beach:									
	Bi	Galibi							within Galibi area					
		E	Ba	G	Bi ↓ Gal	Bi ↑ Gal	Bi ↓ FG	E ↓ FG	E ↓ Ba	E ↑ Ba	E ↓ G	E ↑ G	Ba ↓ G	Ba ↑ G
green turtle	350x	126x	237x	101x	7x	6x	0x	1x	33x	33x	15x	11x	32x	35x
olive ridley	4x	283x	0x	0x	2x	0x	0x	0x	8x	12x	0x	0x	0x	0x
leatherback	62x	0x	0x	0x	1x	0x	6x	0x	0x	0x	0x	0x	0x	0x

from Bigisanti eastward to the French Guiana nesting beach [1]), led to the supposition that the leatherbacks nesting in Surinam are merely — to use Pritchard's words — 'an overflow' of the very large population nesting in French Guiana. I am not certain this is true. The majority of the leatherbacks tagged on Bigisanti kept to this beach, both when remigrating and during one nesting season. With only very few exceptions, leatherbacks that moved over to French Guiana, did so after laying only one or no nest at all at Bigisanti. Although some 2200 leatherbacks were tagged in French Guiana (Pritchard, 1972), not one of those turtles has been reported from a Surinam beach.

The observations on site discrimination presented above lead to the conclusions that — at least for *Chelonia mydas* — the site tenacity is much less pronounced than for the populations nesting on the Sarawak turtle islands (Hendrickson, 1958), at Tortuguero beach and at Ascension Island. Although site discrimination is not an absolute rule for green turtles that return to Tortuguero beach in Costa Rica (Carr et al., 1972), their site tenacity is unmistakably stronger than that of the population nesting on the Surinam beaches. On Ascension Island, where the nesting ground consists of a series of crescent-shaped beaches in little coves separated from each other by rock promontories, renesters and remigrants normally return to the same cove to nest (Carr & Hirth, 1962).

Disturbance of turtles by tagging activities may cause continuation of the nesting on another beach, but this is not the only reason for the weaker site

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1) For records from that beach I am indebted to P. C. H. Pritchard.

TABLE XVI

Selected individual beach emergence records of turtles that showed a relatively weak degree of site tenacity. Emergences that did not lead to a successful nesting are between brackets. Bi = Bigisanti, E = Eilanti, Ba = Baboensanti, P = Pruimenboom, G = Galibi. For location of beaches, see Map 3.

Chelonia mydas - migrations within Galibi area		*Chelonia mydas* migrations		*Lepidochelys olivacea*
during one season	inter- + intra-seasonal	Galibi area ⇄ Bigisanti		
no. 1996	no. 4631	no. 4854	no. 2103	no. 4275
22.7.70- G	12.4.70-(P)	11.4.70-(E)	6.3.69 - Ba	27.5.70- E
9.3 - P	26.4 - Ba	12.4 - E	2.6 - Bi	24.5.71- Bi
23.3 - Ba	26.3.72-(G)	15.5 -(Bi)	22.2.71- Ba	30.6 - E
4.4 -(E)	27.3 -(E)	30.5 - E	23.3 - Ba	
15.4 - E	29.3 - G		4.4 - Ba	no. 4910
	10.4 - G	no. 1479	no. 3500	28.4.70-(Ba)
no. 1969	22.4 - P	4.3.70-(P)	17.4.70-(Bi)	2.5 -(E)
9.2.70- G	27.4 -(P)	16.3 -(P)	20.4 - Ba	11.5 - Ba
24.4 - E	29.5 - Ba	17.3 - Ba	24.6 -(Bi)	3.5.71-(Ba)
3.4 - Ba	1.6 - Ba	11.4 - Bi		21.5 -(Bi)
8.5 - Ba		23.4 -(Bi)	no. 3898	24.5 - E
28.5 -(E)	no. 4678	25.4 -(Bi)	23.3.71- Bi	24.5.72-(E)
31.5 - E	15.4.70-(E)		5.4 - Bi	25.5 - E
	27.4 - G	no. 1344	20.4 - Bi	22.5 - Ba
no. 4873	9.5 - Ba	19.2.70-(E)	4.5 - E	19.5 -(E)
15.4.70- E	20.5 - E	4.3 -(E)	10.5 - Bi	18.5 -(E)
26.4 - P	22.5 - E	18.4 - Bi		
9.5 - G	29.3.72-(G)	1.5 - Bi	no. 3886	no. 4764
20.5 - E	31.3 - P	no. 2081	22.3.71- Bi	8.6.70- Ba
		3.3.69-(P)	7.4 - E	27.6 -(E)
no. 4609	no. 2486	11.4 -(Ba)	6.5 -(Bi)	12.6.71- Bi
7.4.70- P	6.4.69- E	23.4 - Bi	8.5 - Bi	no. 698
23.4 - E	27.2.71- G	4.3.71- Bi	no. 2009	12.7.67- E
5.5 - P	17.4 - E	20.3 - E	25.2.69- Ba	23.6.69- Ba
17.5 -(E)	30.4 - Ba	18.4 - Bi	2.4 -(P)	14.5.71- E
28.5 - E		30.4 - Bi	11.2.71- E	12.7 - P
		13.5 -(Bi)	27.2 -(G)	3.7.72- E
			2.4 - Bi	28.7 - E

tenacity shown by green turtles nesting in Surinam, as the turtles were equally disturbed by tagging parties and egg collectors on the other beaches.

Chapter VI. ANNUAL QUANTITIES OF NESTS AND SIZES OF NESTING POPULATIONS

Numbers of nests laid in Surinam (Table 17)

In 1964 and 1967, between the end of April and August, virtually all nests laid at Bigisanti beach were recorded. In 1968, counting started in March, but because the beach was moving rapidly to the west not all of the nests could be counted. All the same, for 1968, a fairly reliable estimate was made of the total number of nests at Bigisanti by means of a few supplementary samples taken to the west of the stretch of beach where daily counting was done. In 1970-1975, sufficient personnel was available to permit counting all nests on the main beach and the rather small number of nests between Krofajapasi and Matapica.

In 1967, on the Galibi beaches, counting took place only at Eilanti and on the immediately neighbouring shore. Commencing 1968, the Tijgerbank beaches (Baboensanti + Pruimenboom) were patrolled and it turned out that a large number of green turtles nested on this stretch. From 1969 onward — with the exception of those on a short stretch between the Galibi section and the Tijgerbank section — all nests on the Marowijne mouth beaches in the Galibi Reserve were counted.

An estimate of the total number of green turtle nests laid along the whole Surinam coast — given in Table 17A — was made by extrapolation for those periods when counting was not performed on all beach sections. The data in this table illustrate the dramatic drop in the number of nests laid in 1968 at Bigisanti and in 1969 at the Galibi beaches, and the steady rise from 1969 onward on all beaches with the exception of the deteriorating Eilanti beach.

This encouraging increase could be the consequence of the conservation measures started on Bigisanti in 1964, when annual collecting of more than half of the nests was put to a stop. But the reason could also be a shifting of greens to Surinam rookeries from the rapidly westward moving western French Guiana beach. The second possibility is perhaps supported by the fact that the most pronounced increase of the number of nesting green turtles took place on the Galibi beaches. As adult females showed a relatively weak site discrimination on the Galibi beaches (Table 15), it is quite conceivable that greens that hatched on the French Guiana beach may come to nest on a beach at the other side of the Marowijne estuary. Obviously the same reasoning may explain why females hatched on Bigisanti beach (that moves westward with a speed of 1.7 km/year) come to nest on a Galibi beach!

Allowance should be made for a third possibility: the unexplained fluctuation in annual numbers of nests as happens on turtle islands off the Sarawak coast, where they speak of 'good' and 'bad' seasons (Harrisson, 1951, 1952; Hendrickson, 1958). Banks (1937) was of the opinion that possibly a correlation existed between the intensity of the monsoon and the number of nesting turtles in the next season. Changes in nesting cycles might also contribute to increases and decreases in nesting numbers. Although such shifts from one reproductive cycle to another have been demonstrated for the green turtles nesting in Surinam (see Table 6), I doubt whether they are responsible for the steady increase in nesting. There is no explanation for the sudden drop in the number of nests laid in 1975.

It is hoped that our limited budget will allow continued counting during the coming years to make it possible to follow future annual changes in the numbers of nests in Surinam.

For *Lepidochelys* the situation on the Galibi beaches is far less satisfactory. The figures in Table 17B demonstrate the alarming drop in the number of nests since 1968, both on Baboensanti and on Eilanti beach, where

TABLE XVII

Numbers of nests laid on Surinam beaches, 1967-1975.

(1): Estimated numbers were based, in 1967, on countings on 6½ km of beach (virtually the whole nesting area); in 1968, the large number of nests that were laid W of the counting stretch was estimated from samples; the numbers for 1969-'73 include the few nests laid W of Krofajapasi (estimated from samples); figures between brackets were estimated by extrapolation for months when counting was not carried out.

(2): Eilanti to Dap-eiland inclusive, but exclusive of the few nests laid to the W of Eilanti (see Map 3).

(3): 1968-1969: counting done only on the two Tijgerbank beaches (Pruimenboom + Baboensanti); from 1970 onward counting done also at Galibi and, in 1972-'73, on the whole stretch including the beach sections between Pruimenboom and Galibi and between Baboensanti and Dap (see Map 3).

(4): Estimated numbers include those based on extrapolation for beach sections where no counting took place (see 3).

(5): (1) + (2) + (4); plus estimated numbers of the few nests laid W of Eilanti and on the beaches W of Matapica.

(6): The counting sections were the same as those for the green turtle: see (1) and (2).

(7): It is known that ridleys only came ashore sporadically at the Tijgerbank beaches in 1967, so that for that year the estimated total is virtually the same as the number counted at Bigisanti + Eilanti.

(8): Virtually all leatherback nests laid in Surinam could be counted; on the Galibi beaches less than 5 nests were laid per year during the 1964-'67 seasons.

Table XVII

A. *Chelonia mydas*

			FEB	MAR	APR	MAY	JUN	JUL	AUG	TOTAL
Bigisanti 1)		1967	(60)	(200)	320	310	110	20	5	1025
		1968	(60)	(200)	225	170	75	18	2	750
		1969	60	210	270	160	60	12	8	780
		1970	70	175	270	230	75	19	1	840
		1971	60	235	300	235	90	25	5	950
		1972	65	245	315	275	135	40	5	1080
		1973	77	165	365	287	119	18	2	1033
		1974	78	271	379	441	200	59	10	1438
		1975	24	136	221	222	105	52	12	772
Eilanti 2)		1967	(20)	(100)	270	310	135	25	1	861
		1968	(20)	(110)	250	290	105	5	0	780
		1969	(10)	90	150	140	25	5	0	420
		1970	30	90	170	150	30	2	0	472
		1971	55	185	240	210	85	15	0	790
		1972	35	160	210	235	75	15	0	730
		1973	43	176	274	255	56	4	0	802
		1974	27	157	197	178	56	4	0	619
		1975	2	43	30	7	10	12	1	105
Bab'Santi+Pruimenboom+Galibi	counted 3)	1968	-	-	453	922	702	253	0	-
		1969	91	441	229	122	46	1	0	930
		1970	117	471	619	427	103	17	0	1754
		1971	311	883	873	737	257	56	0	3117
		1972	290	1172	1396	1228	408	69	0	4563
		1973	268	1143	1376	1403	300	45	0	4535
		1974	352	1227	1593	1467	514	82	10	5245
		1975	20	690	810	679	202	54	8	2463
	estimated 4)	1968	125	300	600	1200	800	375	0	3400
		1969	100	550	350	175	75	10	0	1260
		1970	120	475	625	450	110	20	0	1800
		1971	390	1175	1175	875	325	75	0	4015
		1972	315	1350	1570	1400	445	70	0	5150
		1973	275	1150	1390	1450	310	45	5	4625
		1974	360	1235	1610	1480	520	85	10	5300
		1975	90	715	875	695	220	65	15	2675
Surinam total 5)		1968	215	650	1075	1675	985	398	2	5000
		1969	175	855	775	475	175	27	13	2495
		1970	220	740	1065	830	213	46	1	3115
		1971	505	1595	1715	1320	500	115	5	5755
		1972	415	1655	2110	1920	655	125	5	6885
		1973	400	1515	2050	2065	490	70	10	6600
		1974	470	1680	2215	2130	795	155	20	7465
		1975	125	910	1140	930	340	135	30	3610

Table XVII (continued)

B. *Lepidochelys olivacea*

			MAR	APR	MAY	JUN	JUL	AUG	TOTAL
Bigisanti	counted[6]	1964	-	-	15	43	29	8	95
		1967	-	2	15	38	22	3	80
		1968	0	3	13	28	26	5	75
		1969	1	4	30	56	15	7	113
		1970	3	11	27	38	8	2	89
		1971	0	2	22	66	25	3	118
		1972	2	3	14	43	22	5	89
		1973	1	4	55	52	29	2	143
		1974	3	3	53	143	81	1	284
		1975	1	2	33	80	85	35	236
Eilanti	counted[6]	1967	-	5	141	1384	922	3	2455
		1968	0	6	194	960	1438	0	2598
		1969	0	4	185	690	195	0	1074
		1970	0	5	522	541	198	0	1266
		1971	0	1	198	530	510	10	1249
		1972	0	2	93	621	330	5	1051
		1973	0	2	127	416	145	0	690
		1974	0	2	207	297	130	2	638
		1975	0	0	29	229	53	220	531
Tijgerbank (Baboensanti + Pruimenboom)	counted	1968	0	0	78	186	201	0	465
		1969	0	3	30	305	75	0	413
		1970	0	2	126	168	61	0	357
		1971	0	2	65	68	66	0	201
		1972	2	0	24	38	23	0	87
		1973	1	4	31	8	4	0	48
		1974	0	1	43	45	30	0	119
		1975	0	1	26	66	68	40	201
Total Surinam	estimated[7]	1967	0	10	175	1650	1025	15	2875
		1968	0	15	300	1200	1700	75	3290
		1969	1	14	260	1080	300	10	1665
		1970	3	22	685	760	278	2	1750
		1971	0	5	290	675	610	15	1595
		1972	5	5	140	725	385	10	1270
		1973	2	10	215	480	180	3	890
		1974	3	6	315	500	250	6	1080
		1975	1	3	90	415	240	320	1070

Table XVII (continued)

C. *Dermochelys coriacea*

		Jan/Feb	Mar	Apr	May	Jun	Jul	Aug	Total
Bigisanti (counted)	1964	?	?	4	28	25	7	3	67
	1967	?	?	9	20	13	17	0	59
	1968	?	?	40	71	10	21	0	142
	1969	0	6	47	95	83	35	3	269
	1970	0	8	47	79	56	26	4	220
	1971	0	4	48	82	64	32	1	231
	1972	6	9	82	114	88	27	10	336
	1973	5	14	149	210	166	58	5	607
	1974	4	33	144	222	165	51	5	624
	1975	3	35	189	343	256	110	12	948
Galibi (counted)	1968	0	0	0	5	4	1	0	10
	1969	0	0	4	4	1	0	0	9
	1970	1	1	4	5	2	0	0	13
	1971	0	0	9	14	16	4	0	43
	1972	0	2	8	19	8	2	0	39
	1973	2	4	48	103	93	24	0	274
	1974	0	4	17	52	50	19	0	142
	1975	0	7	59	273	199	77	21	636
Surinam total	1964	0	5	10	35	30	10	5	95
	1967	0	5	15	25	20	25	0	90
	1968	0	10	45	85	25	30	5	200
	1969	0	10	55	105	90	40	5	305
	1970	1	10	55	90	65	30	4	255
	1971	0	5	60	100	80	39	1	285
	1972	10	15	90	125	100	30	10	380
	1973	10	20	205	320	265	75	5	900
	1974	5	40	165	280	220	70	5	785
	1975	5	45	255	625	465	195	35	1625

D. *Eretmochelys imbricata*

		Feb	Mar	Apr	May	Jun	Jul	Aug	Total
Bigisanti	1967	?	?	0	3	2	4	1	10
	1968	?	0	1	1	0	2	?	4
	1969	0	0	1	1	2	4	2	10
	1970	0	1	1	1	0	0	0	3
	1971	0	2	3	0	2	7	0	14
	1972	2	0	1	2	4	1	2	12
	1973	0	1	1	2	2	1	0	7
	1974	0	0	6	5	6	8	4	29
	1975	0	0	1	3	2	5	3	14
Galibi	1970 - 1975	0	0	1	0	2	2	1	6

the big 'arribadas' have failed since 1969. As the Galibi beaches are virtually the only nesting place of any importance on the Atlantic coast of America and as Pritchard (1972) did not report a perceptible increase in ridleys visiting the French Guiana beach, the conclusion is inescapable that the olive ridley population is diminishing. One hope left is that the decrease is caused by the erosion of Eilanti beach and the increase in height of the mud bank in front of it. But then it is strange that the ridleys did not carry through the migration, to the nearby Baboensanti beach, which they started in 1968.

The annual number of *Dermochelys* nests (Table 17C) showed an even greater increase than that of the green turtle. For this species a migration from the rapidly shrinking French Guiana beach to Bigisanti seems to be the most plausible explanation. Its is strange that not a single individual of the 2200 leatherbacks tagged in French Guiana was reported from a Surinam beach, not even from the nearby Marowijne mouth beaches.

Abundance of turtles nesting in Surinam

Site discrimination of the green turtles nesting in Surinam proved to be less strong than at nesting beaches elsewhere in the world. However, this factor can be neglected in the making of a rough estimate of the numbers of green turtles that use Surinam beaches as a nesting place.

The only information we need for our estimate is the calculated average number of nests a female lays during one season. By dividing the total number of nests laid during one season by this figure, the number of nesters during that season can be calculated. Multiplication of this number by the average interbreeding interval leads to an estimate of the total number of females involved.

In the foregoing chapter it was concluded — using the 1971 data for Bigisanti as the most reliable basis — that a green turtle female lays on the average ca. 3 nests per season. Supposing an unlikely high loss of tags, this figure might be 4 nests. Based on these data, the following estimates of the numbers of nesting females (N) were arrived at (cf. Table 17A):

1968: $1250 \leqq N \leqq 1700$
1969: $650 \leqq N \leqq 850$
1970: $775 \leqq N \leqq 1050$
1971: $1400 \leqq N \leqq 1900$
1972: $1700 \leqq N \leqq 2300$
1973: $1650 \leqq N \leqq 2200$
1974: $1850 \leqq N \leqq 2500$
1975: $850 \leqq N \leqq 1100$

During the period 1968-1974 an estimated average of 1500 to 2000 green turtle females visited the Surinam nesting beaches each year. Multiplying these numbers by 2.3 (the average interbreeding period) it is estimated that between 3700-4800 females make up the entire female population nesting in Surinam.

As sex ratios in green turtle populations are actually unknown, no estimate can be made of the size of the entire population.

For *Lepidochelys olivacea,* the assumptions that a female lays on the average between 1.4 and 2 nests per season and that the interbreeding period is 1.4 years, leads to the estimate that in 1967-1968 about 2100-3000 females made up the entire female ridley population. This decreased to the alarmingly low number of 650-900 in 1973. In 1975, this number was further reduced to 550-750.

The total number of *Dermochelys coriacea* females that use Bigisanti as their nesting ground, estimated at 50 in 1967, rose to about 400 in 1973, and to 650 in 1975. This calculation is based on the figures in Table 17C and on the assumption of an average number of 3 nests per female per season and an interbreeding interval of 2 years. In 1975, another 200 females laid their nest on Baboensanti beach in the Galibi area.

The foregoing estimates refer to the total number of adult females in the nesting populations. No information is available on aspects of population dynamics, such as age distribution, sex ratio, annual recruitment, data that are of far greater importance from the points of view of conservation and management. The first requisite for a study of annual recruitment and mortality is the invention of a new, reliable method of marking, which for this purpose would not necessarily have to enable identification of individual turtles.

Chapter VII. THE INCUBATION AND HATCHING PERIOD

Development in the nests and the emerging of the hatchlings

When after completing the long process of covering and disguising the nest the female turtle has left for the sea, she leaves to its fate the clutch of eggs she deposited in the more or less spherical egg-chamber. As has already been noticed by Hendrickson (1958: 504), the eggs — excepting a few situated uppermost — must not be thought of as literally embedded in sand, but as resting in a firm-walled subterranean chamber. Most of the surfaces of the eggs are in contact with air-filled interstices. As this air is always very humid, the loss of water from the eggs by evaporation is a negligible factor. The high rate of precipitation on the Surinam breeding beaches (see Table 1) produces a continual downward percolation of fresh water and assures that the sand surrounding the eggs is kept moist throughout the incubation.

A preliminary investigation on Bigisanti beach did not reveal the significant rise in the temperature of the nest as reported by Hendrickson (1958: 509) for green turtle nests on the Talang Talang islands. Hendrickson assumed that the differential temperature maintained between the developing eggs and the surrounding sand is an important factor in the developmental process. In the section on the hatching success of nests we will consider Hendrickson's conclusion that abnormally small clutches could be expected to lose their metabolic heat to the surrounding sand at a rate proportionate to their higher surface/mass ratio, resulting in lower temperatures which perhaps are responsible for the failure of small nests.

The incubation time — the span of time between oviposition and the emerging of young hatchlings to the surface —, is roughly 2 months for all sea turtles.

The baby turtle slashes the eggshell with the help of a horny protuberance or 'egg tooth', which develops just before hatching and disappears after a few days (Pl. 22 fig. 38).

After hatching, the young find themselves in a chamber, formed by the collapse of the empty egg shells. This extra room provides 'working space'. From this chamber the hatchlings must dig upwards through a considerably thick layer of sand. I have not observed this process, but it has been described in detail by several authors. It has been shown that this journey to the surface is not a separate climbing through the sand by completely independent individuals, but that it is a matter of group interaction. Hendrickson (1958) described the struggle upwards as the rising of the whole 'escape chamber', brought about by what Carr (1963) called a 'proto-cooperative group thrashing', triggered by the downtrodden hatchlings at the floor of the nest. Hendrickson and Carr observed how the collective thrashing of the bottom layer of turtles sends a 'pandemic activity' through the whole group; each burst undercuts the walls, erodes the ceiling, and the loosened sand is trampled into the floor. The net result of these group spasms is the upward movement of the baby turtles in the cavity. When the cavity reaches the uppermost layers of the ceiling, the roof caves in and the hatchlings struggle up out of the crater thus formed at the surface. For the green turtle, the climb to the surface usually takes between 3 and 7 days (Hirth, 1971); Hendrickson (1958) believes that this period of subterranean confinement may be extended for a much longer time (e.g. by heavy rains, packing the upper layers of beach sand), without causing serious mortality among the young brood. The time involved in the emerging process at the Surinam beaches has not been established.

In artificially incubated clutches it was observed that at the time of breaking the eggs the yolk sac is often still partially exposed with the remains of the membranes, such as the amnion and the umbilicus, still attached to the yolk sac. In natural nests, during the crawling upward, the yolk sac is internalized through the mid-plastral suture and the membranes are removed by drying and abrasion (as also was assumed by Tufts, 1972: 43).

As elsewhere in the world, on Surinam beaches the emerging from the sand takes place at night. It seems plausible that the young turtles are prevented by an instinctive mechanism from emerging to the frequently very hot surface of the sand during the heat of the day. Hendrickson (1958: 513) believes that, on coming into contact with temperatures much above 33°C, the hatchlings cease activity in their escape chamber, resuming activity only when the nightfall brings lower temperatures. As Hendrickson pointed out, a mechanism such as this would appear to have considerable survival value by guarding the young against the necessity of a trip across a brightly illuminated beach at lethal temperatures.

Usually the entire batch emerges during the same night, but quite often the hatchlings — due to subdivision of the group — emerge in more than one lot (see Table 18). Thus the most common picture is the emergence of one single group (nest no. 12 in Table 18), sometimes with a few latecomers on (a) following night(s) (nest no. 9). Nest no. 11 is an exception as there were two more young one week after the main group.

TABLE XVIII

Examples of counts of the emerging young from undisturbed and replanted nests.

			days after nesting, c.q. replanting of the nest ('incubation time')														total nr. of eggs
			52	53	54	55	56	57	58	59	60	61	62	63	64	65	
replanted nests	*Lepidochelys*	1	-	-	-	-	-	-	-	-	-	-	73	-	-	-	133
		2	-	-	-	-	-	112	4	4	2	4	-	-	-	-	157
		3	-	-	-	75	-	-	23	-	-	-	-	-	-	-	148
		4	-	1	9	2	77	-	-	6	-	-	-	-	-	-	141
	Chelonia	5	-	-	-	-	-	-	-	-	-	-	-	-	-	79	149
		6	-	-	-	-	-	86	-	-	-	-	-	-	-	-	118
		7	-	-	43	4	3	2	11	-	3	-	1	-	-	-	136
		8	-	-	-	23	27	2	5	-	-	-	-	-	-	-	118
undisturbed nests	*Chelonia*	9	-	-	-	83	1	1	-	-	-	-	-	-	-	-	?
		10	-	108	23	1	-	-	-	-	-	-	-	-	-	-	?
		11	122	4	-	-	-	-	-	2	-	-	-	-	-	-	?
		12	113	-	-	-	-	-	-	-	-	-	-	-	-	-	?
		13	-	-	35	-	-	46	-	-	-	-	-	-	-	-	?

Likewise, in replanted nests of green turtles and ridleys, one large group emerges from the sand in a single night and small groups (occasionally a large group: nests 3 and 8 are exceptions) on one or more following nights. Almost invariably, the large group emerges first, followed by occasional latecomers; only rarely (e.g. nest no. 4) are there a few that early emerge, followed by the large group. What happened in nests 3 and 13, is a rare occurrence: 2 fairly large groups separated by a two nights interval.

In the following paragraphs some results are discussed of investigations carried out on incubation time and hatching success of both undisturbed and transplanted nests. The studies were carried out by placing circular chickenwire cages over the nests towards the end of incubation time. All young that emerged were counted. Natural nests were dug up after hatching and the original number of eggs laid was verified in order to ascertain the hatching percentage. When a nest produced emerging young on different nights, the night with most young emerging was counted as the end of the incubation time (e.g. for nest no. 10 in Table 18, 53 days was noted as incubation time).

Incubation time

As already described, the hatchlings crawl out of the sand a few days after actual hatching from the eggs. In the present text 'incubation time' includes this lapse of time, while 'hatching' refers to the emergence of the young to the surface of the sand.

Tables 19 and 20 summarize incubation times recorded for natural, i.e. undisturbed, 'wild' nests of three species, over various periods and on various breeding beaches. As is illustrated in these tables, the incubation period shows considerable variation, both between individual nests and during the season. This must be partly due to variation in density of the sand covering the nest, but probably it is primarily caused by differences in temperature and moistness of the sand.

On the Sarawak turtle islands, Hendrickson (1958: 510) found that the incubation time of green turtle nests varied seasonally from an average of ca. 70 days during the monsoon to an average of ca. 54 days during July. He assumed the increased heat loss from incubating nests during the monsoon (due to steepened temperature gradients and higher thermal conductivity of the sand) to be responsible for the increase in incubation time. Likewise, as shown by the data in Table 19, the incubation period on Bigisanti beach in 1969 increased from an average of 52 days during February-March to 58 days during the rainy season (April-May).

The depth of the nest seems to be of little importance: nests of the three

TABLE XIX
'Incubation period' of natural nests.

period in which nests were laid →		numbers of nests with incubation time indicated in first column													
		green turtle								olive ridley			leatherback		
		Bigisanti											Bigisanti		
		29-30/4 1964 + 25/3-3/4 1968	May/June 1964	11/2-13/3 1969	13/3-22/3 1969	24/4-30/5 1969	3-25/3 1971	14/4-30/5 1971	1/6-23/7 1969	1964 + 1969 Bigisanti	May/June 1970 Eilanti	March/July 1970 Bigisanti	1964 + 1969	1970 (Apr.-June)	1971 (Apr.-June)
number of days between oviposition and emergence of hatchlings on the surface	46	-	-	-	-	-	-	-	-	-	1	-	-	-	-
	47	-	-	-	-	-	-	-	-	-	0	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	3	-	-	-	-
	49	-	-	1	-	-	-	-	1	-	1	-	-	-	-
	50	1	-	4	-	-	-	-	1	-	5	-	-	-	-
	51	1	-	12	-	-	-	-	1	1	12	-	-	-	-
	52	2	1	13	1	-	-	-	2	0	14	-	-	-	-
	53	2	0	7	8	-	-	-	4	1	7	4	-	-	-
	54	1	2	7	10	1	3	1	6	2	2	3	-	-	-
	55	2	5	0	7	1	2	0	4	1	1	4	-	-	-
	56	2	4	2	9	4	3	1	0	2	2	4	-	-	-
	57	4	4	0	3	10	1	1	0	3	1	4	-	-	-
	58	2	5	0	1	4	3	4	0	2	1	3	-	-	-
	59	2	9	2	1	1	3	3	0	5	0	-	-	-	-
	60	3	10	-	2	4	2	5	1	1	1	-	4	4	-
	61	1	3	-	-	2	1	6	-	1	-	-	2	2	-
	62	-	1	-	-	2	1	2	-	3	-	-	2	2	1
	63	-	1	-	1	-	-	5	-	-	-	-	3	3	1
	64	-	2	-	-	1	-	0	-	-	-	-	2	2	1
	65	-	-	-	-	-	-	1	-	-	-	-	4	4	1
	66	-	-	-	-	-	-	-	-	-	-	-	1	3	2
	67	-	-	-	-	-	-	-	-	-	-	-	2	5	0
	68	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	69	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	70	-	-	-	-	-	-	-	-	-	-	-	-	-	2
total nr. emerged nests		23	47	48	43	30	19	29	20	22	51	22	20	25	11
arithmetical average of 'incubation time' in days		56	58½	52	55	58	57½	60	54	58	51½	55½	63	64	67

TABLE XX

'Incubation period' in days, for undisturbed (see Table 18) and replanted nests (see Table 21) in and outside Surinam.

SURINAM:	green turtle	olive ridley	leatherback
undisturbed nests laid at Bigisanti II-III/1969	52 (49-59)	-	-
do. II/1970	54 (48-60)	-	-
do. III/1969	55 (52-63)	-	-
do. IV/1964 + IV/1968 + IV-V/1969	57 (50-64)	-	-
do. V-VI/1964	58½(52-64)	58 (51-62)	62 (60-68)
do. III-VI/1970	-	55½(53-58)	64 (60-67)
do. VI-VII/1969	54 (49-60)	-	-
do. V-VI/1969	-	57 (53-61)	64 (61-72)
do. Eilanti V-VI/1970	-	51½(46-55)	-
replanted nests			
Bigisanti 1967	58 (51-67)	58 (53-72)	65 (59-71)
do. 1969	56 (49-63)	54 (52-58)	67 (66-68)
do. 1970	-	64 (59-70)	63 (58-68)
do. I/II-16/III/1970	52½(49-56)	-	-
do. 17/III-30/IV/1970	54½(51-62)	-	-
do. V/1970	54½(51-58)	-	-
do. 9/III-16/IV 1971	54 (50-57)	-	-
do. 17/IV-14/V 1971	57½(56-61)	-	67 (62-70)
do. Eilanti III-IV/1970	51 (46-54)	-	-
do. V-VI/1970	-	49½(45-54)	-
do. VI/1967 (replanted in bulk)	-	49½(45-54)	-
Tortuguero (Costa Rica)	55½(48-70)	-	-
Ascension	59½(58-62)	-	-
Heron Island (Austr.)	68½(65-72)	-	-
Sarawak (monsoon)	65	-	-
Sarawak (rest of the year)	55 (48-80)	-	-
Talang^{2} Islands	52-60	-	-
do. replanted May	56½-58	-	-
do. do. Sept.	56 (53-60)	-	-
Matina Bay	-		
undisturbed	-	-	51-58
replanted	-	-	66-74
Ceylon	-	-	58-65

species were transplanted at various depths between 30 and 75 cm and all emerged after similar intervals.

Transplanted nests show about the same incubation times as wild nests (Table 20).

Hatching success of natural nests

From 1964 to 1968, limited observations were made on the emergence success of hatchlings in natural nests of *Chelonia mydas* at Bigisanti. In 1969, R. L. Hill and D. J. Green made observations on a sample of 150 such nests. The sample consisted of 100 nests laid at the start of the season and 50 at the end. Young were counted after emerging within a chicken-wire cage placed over the nest towards the end of incubation time. After all young had emerged in the cage, the nest was dug up and the original number of eggs laid was verified. Hence the emergence percentage could be calculated. The results of this study are summarized in Table 21 ('sample' I + II). The high frequency of nests with an emergence percentage of 0-10% in the first period (sample I) was probably due to the high rainfall and to the high springtides of February and March, that washed over many nests. Moreover, ghost crabs, which dig down and eat the eggs, were more active during the first period.

Another cause of the low nest productivity was the use of a probing stick for locating the nests. Until 1969 our investigation programme's daily counting of freshly laid nests was done by locating nests with a pointed probe, which is wetted by the egg contents when piercing an egg's shell. Although no more than 5 eggs per nest are broken by this method, many more young were 'lost' by ignorance during the nesting seasons up to 1969, when Hill (1971) found that egg rupture in freshly laid nests of green turtles and leatherbacks lower the hatchling emergence by 25-30%. In olive ridley nests no such effect of broken eggs has been established.

Since this became known nests are located without breaking eggs, the nest being found by gently probing with the stick until very soft sand is felt, indicating the position of the nest. The presence of eggs is verified by digging with the hand until one of the topmost eggs is seen.

Samples of undisturbed wild nests of *Chelonia mydas* showed an average hatching success of well over 80% (III and IV in Table 21), but, as the frequency distributions for these samples reflect, there were several clutches with a lower rate. Excessive moisture and damage by ghost crabs — both direct and indirect — are two of the possible reasons.

For *Dermochelys,* the emergence success of undisturbed wild nests in Surinam is considerably lower, as is illustrated by sample II in Table 22, which

TABLE XXI

Hatching success for various samples of natural and replanted nests of Chelonia mydas, *Bigisanti, 1969-1972.*

No. I: 100 nests, laid 11/22-29/3/'69, located with probing stick, high rainfall + washing over by spring tides; — no. II: 50 nests, laid 24/4-23/7/'69, less rainfall, no influence of tides; — no. III: 11 nests, 16/4-15/5/'70 (R. L. Hill); — no. IV: 46 nests, 3/3-14/6/'71 (J. Wildschut); — nos. V and VI: 53 and 54 nests respectively, replanted at various depths (R. L. Hill); — no. VII and VIII: samples from routine replanting, 62 nests (1971, J. Wildschut) and 38 nests (1972) respectively; — no. IX: 21 boxes, 76-180 eggs per box, 1972; — no. X: 30 boxes, 56 eggs each, 1972 (E. Lambermont).

emergence percentage	WILD nests				REPLANTED nests				FOAM BOXES	
	with probing stick 1969		without stick		50-60 cm	65-75 cm	routine replanting			
	no. I	no. II	no. III	no. IV	no. V	no. VI	no. VII	no. VIII	no. IX	no. X
0 - 10%	16	0	0	2	27	18	5	0	0	0
10 - 20%	0	0	0	0	13	9	9	2	0	0
20 - 30%	3	0	0	0	15	15	9	0	0	0
30 - 40%	6	14	0	0	9	9	8	5	0	0
40 - 50%	7	8	9	4	11	13	9	15	0	0
50 - 60%	17	26	0	9	9	11	13	18	8	0
60 - 70%	14	20	19	4	4	4	18	18	8	0
70 - 80%	22	18	10	13	9	18	8	27	20	0
80 - 90%	12	12	10	26	2	2	14	8	40	33
90 - 100%	3	2	51	41	0	0	5	5	24	66
sum	100	100	99	99	99	99	98	98	100	99
average emergence	48%	61%	85%	83%	30%	38%	53%	63%	80%	92%
incubation (days)	54	56	56	58	54	54	56	61	65	64

shows a noticeably high percentage of clutches that almost completely failed (i.e., less than 10% hatch). Rupture by a probing stick and subsequent rotting of a few eggs causes a considerable further lowering of the emergence percentage (sample no. I in Table 22). As discussed in the next section, the lower hatching success of leatherback clutches in comparison with the two other species is also encountered in artificial nests. Pritchard (pers. comm.) speculated that many eggs were not fertilized at all and that this might be due to a scarcity of available males off the Bigisanti nesting beach.

TABLE XXII

Hatching success in various samples of natural and replanted nests of Lepidochelys *(Bigisanti and Eilanti) and* Dermochelys *(Bigisanti).*

No. I: 16 nests, located with probing stick (1969); — no. II: average of 3 samples, 1970, 1971, 1973 (total 52 nests), no stick used; — nos. III + IV: 28 nests replanted with, and 28 nests without small, infertile eggs, 1970 (R. L. Hill); — no. V: 60 nests, 1970; eggs transported over up to 3 km distance; — no. VI: 34 nests, 1972; — no. VII: 30 boxes with 42-112 eggs/box, 1972; — no. VIII: average of 2 samples (total 72 nests), Bigisanti + Eilanti, 1970; — nos. IX + X: 2 × 28 nests, replanted at different depths, Eilanti, 1970 (R. L. Hill); — no. XI: sample of 24 nests, replanted at 45-55 cm, Bigisanti, 1970.

	Dermochelys coriacea							*Lepidochelys olivacea*			
emergence percentage	wild nests		replanted +/- small eggs		routine replanting		FOAM BOXES	wild nests	replanted		routine replanting
			+	-					30-35 cm	40-45 cm	
	no. I	no. II	no. III	no. IV	no. V	no. VI	no. VII	no. VIII	no. IX	no. X	no. XI
0 - 10%	44	11	46	50	78	0	0	15	46	15	12
10 - 20%	19	11	32	18	8	6	0	8	18	15	12
20 - 30%	12	14	10	11	8	18	3	7	15	18	4
30 - 40%	12	9	7	11	2	34	20	8	7	7	12
40 - 50%	0	4	3	3	3	27	3	10	7	0	12
50 - 60%	0	9	0	3	0	12	40	16	7	32	4
60 - 70%	6	15	0	0	0	3	23	14	0	11	12
70 - 80%	0	16	0	0	0	0	3	18	0	3	12
80 - 90%	6	9	0	3	0	0	3	4	0	0	12
90 - 100%	0	0	0	0	0	0	3	0	0	0	4
sum	99	98	98	99	99	100	98	100	100	101	96
average emergence	20%	50%	12%	18%	6%	39%	54%	59%	17%	36%	50%
incubation (days)	64	65	65	65	61	66	73	53	49	49	54

Two samples of *Lepidochelys* nests showed an average hatching success of around 60% (VIII in Table 22). As is discussed in a following section, poor hatching in a rather high number of nests is — at least partly — due to predation by crabs, in particular on Bigisanti beach where losses are severe.

Artificial nests

Since 1964, it has been routine on Bigisanti beach to remove all nests that are endangered by the tide wash to a safer site. On the Galibi beaches this was started in 1969, with the exception of those sections where difficult under-foot conditions and long distances to a sufficiently high beach platform virtually prevents translocation of the eggs.

Originally, nests were reburied in central hatcheries. As it was found that transportation often lowered the hatching percentage (see, e.g., sample V in Table 22), this system now has been abandoned in favour of moving a nest to the nearest suitable site, generally but a few meters from the original hole. We also experimented with replanting depth (see for some results, Tables 21 and 22). Thus, emergence success — although on the average still lower (and sometimes appreciably lower) than in undisturbed nests — has improved gradually to around 50% for ridley nests and well above 50% for green turtle nests (samples VII and VIII in Table 21 and XI in Table 22).

For the leatherback the success of transplanted nests is still rather uncertain and generally lower than for the other species. The leatherback clutches contain on the average 30% of small, infertile eggs. The results of an experiment showed that these eggs may lower the emergence percentage, probably because they rot and cause some of the larger fertile eggs to rot as well (Table 22, samples III and IV). Since this was established, small eggs are removed from clutches before replanting.

The introduction of styrofoam boxes as incubators (see Pl. 26 fig. 45), revolutionized the transplantation methods. The use of such boxes for this purpose was introduced by Mariculture Ltd., the Grand Cayman Island turtle farm company (1), for long-distance transportation and incubation of eggs collected on turtle nesting beaches, including Galibi. After a few successful experiments in 1971 and 1972, the use of the boxes has been adopted as standard method for hatching all nests laid too far from a suitable burying site. In the future, when enough shelters and boxes will be available, probably all nests that have to be removed, will be put into boxes.

The following standard technique is now in use. The bottom of a box is covered with a ca. 2½ cm deep layer of moist sand — preferably from the high beach platform — whereupon as many eggs as possible (usually ca. 100) may be placed as long as there is room for the covering 2½-5 cm deep layer of sand. The cover of sand prevents dehydration of the uppermost eggs and keeps them warm, especially at night. Gauze is placed between

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1) We are indebted to Mariculture Ltd. for their help in obtaining the boxes at a low cost and for making available their experience.

the eggs and topmost layer of sand in order to keep this sand from falling between the eggs (and thus hindering their expansion). Air-holes should be punched in the bottom and sides of the box. The sand is moistened every second or third week, as circumstances require. Within wide limits moisture proved to be of little importance: experiments with moisture percentages between 2% and 8% showed no significant differences in hatching success 1). Boxes are placed under a shelter and should be moved as little as possible.

The covering layer of sand is not removed before the majority of the baby turtles have hatched. After hatching the young brood is kept a few days in boxes, to make up for the time interval in a natural nest between hatching and emergence at the surface. During this period the remains of the various membranes, attached to the partially exposed yolk sac, are removed by drying and abrasion, while the umbilical protuberance has sufficient time to be absorbed.

The high hatching success obtained in the styrofoam boxes is illustrated in Tables 21 (samples IX and X) and 22 (VII). For the green turtle the average emergence is nearly as high as in the natural nests and for the leatherback even higher. The number of ridley nests incubated in boxes does not yet permit definite conclusions. (Pl. 26 fig. 46).

As shown in Tables 21 and 22, incubation time in the boxes is considerably longer than in the beach nests, which is probably due to the lower temperature in the boxes.

Emergence of the hatchlings from the nest

The first section of this chapter described the process of emergence of the hatching turtles from the nest hole in a subterranean 'escape' chamber and how they slowly move upward through a frenzy of combined activities of the young. Hendrickson (1958: 513) is of the opinion that negative geotropism operates in this process and he believes that during the day high temperatures ('much above about 33°C') inhibit the activities in the chamber and in that way keep the hatchlings below the surface until the cool of the night. Work carried out by Mrosovsky (1968) on Bigisanti beach supported this idea by showing that the activity of young green turtles is strongly inhibited at temperatures above about 28.5°C. Although Mrosovsky's data apply to photic activity, it is probable that inhibition of activity by high temperatures is general.

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1) Experiments carried out by Eva Lambermont in 1972 at the Centre for Agricultural Research in Surinam (CELOS).

It seems evident that a mechanism that guards the young against a long journey over an open beach at daytime, when sand temperatures are very high and escape from predators is probably less feasible than at dark, must have a considerable survival value. Therefore, there exists a direct pressure for the development of a thermal inhibition of activity (Mrosovsky, 1968).

The foregoing explanation of the thermal inhibition mechanism is consistent with Carr's (1967: 76) observation that emergence apparently most frequently takes place during or after a drizzling rain. However, it leaves unexplained why we only very rarely saw nests erupting during rainy mornings — a frequent occurrence during the wet season —, when the temperature of the sand surface is lower than the critical temperature above which underground activity is supposed to be inhibited. It is possible that in this case the hatchling reacts to some other stimulus, perhaps light (Tufts, 1972: 48, reported an experiment which might indicate the ability of loggerhead young to perceive light beneath the surface of the sand).

Another possible explanation of a physiological basis for the strong tendency to nocturnal emergence needs corroboration by experiments: the possibility that a negative thermotactic reaction limits the upward movement to the hours after inversion of the daytime vertical temperature gradient in the sand. P. A. Teunissen demonstrated on Bigisanti beach that in the upper 30 cm this inversion is completed early in the evening, between 18.00 and 20.00 hrs (earlier after rain), giving the hatchlings more than 12 hours of darkness to dig through the last 30 cm (see also Mrosovsky, 1968, fig. 1).

According to some authors, the failure of a fairly large part of a clutch would mean failure of the entire clutch because in such a case an insufficient number of young remains to work upwards together. However, our observations showed that this supposition is incorrect: in many nests, both untouched and transplanted, fewer than 10 young hatch, but these still manage to reach the surface (see Tables 21 and 22). There is even a case on record in which a green turtle clutch of only 3 eggs produced two emerging young.

Journey of the young to the sea

Upon breaking the surface — which in the vast majority of cases on the Surinam beaches happens at night — the newborn turtles start to run their gauntlet of obstructions and predators to the 30 to 70 meters distant sea. The goal of the energetically crawlings generally remains invisible to them until they are quite near the sea. In spite of this and of their frequent meeting of obstacles — such as vegetation, driftwood, rugged ground and beach cliffs — the majority of the young reach the waterline and do so by taking a course that generally does not deviate much from the most direct path to this goal. (Pl. 23 fig. 39 and Pl. 24 figs. 41-42).

This usually unswerving ability to reach the sea has strongly roused the interest of biologists. That a sence of gravity might carry the turtles down to the waterline could be ruled out from the start. Tests with green turtle hatchlings failed to provide evidence of any particular reaction to the direction of the gravity. This is not surprising, for turtles often must ascend almost as many slopes as they descend when finding their path across the rugged surface of the torn-up beach platform (Hendrickson, 1958: 514) [1]).

Since the first investigations were carried out in the twenties, evidence invariably led to the conclusion that light is the main stimulus that guides the turtles from the nest to the sea. It is easily demonstrable that they move towards a source of light: with artificial light hatchlings can be guided at will over the beach, even away from the water. If blindfolded, turtles loose their ability to find the sea. But, although there have been numerous demonstrations that turtles are paying special attention to visual cues and are positively phototactic, there is more to their behaviour than simply selecting the brightest point of light available.

Several observers have suggested that it is the brightness of large open areas that is important in the seafinding process. Hendrickson (1958: 515) drew attention to the fact that all nesting beaches in Sarawak and Malaya have a relatively simple topography, with a marked difference in intensity between the landward illumination, backed by a dark border of vegetation, and that from the exposed seaward side of the beach.

The same difference in over-all brightness between the land- and seaward side seems to exist on most turtle beaches, including the Surinam rookeries, and experiments corroborated the assumption that the hatchlings make for the most open part of the horizon they observe. In these experiments the so-called turtle arena test, evolved by Mrosovsky & Carr (1967), played an important role. In this test, used in Costa Rica and on Bigisanti beach and described by Mrosovsky (1967, 1970) and by Mrosovsky & Shettleworth (1968, 1973), turtles are released in the centre of a circular subdivided trench. By counting the number of turtles that fall into the subdivisions of the trench a quantitative assessment of the orientation is possible. Around the arena artificial horizons of every desired form and height can be constructed and lights of various colours, intensity, etc. can be introduced around the arena to alter the orientation.

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1) However, it seems that the not yet published results of J. Wildschut's experiments on Bigisanti did give evidence of green turtle hatchlings going uphill when in total darkness.

From his preference test in the arena on the beach Mrosovsky concluded that the turtles orient themselves on the basis of cues from a wide field of view: no matter where an obstacle was placed at the edge of the arena, the hatchlings headed to the centre of an open horizon. He pointed out that the eyes of turtles are well placed to survey a wide area and 'that it seems most likely that a turtle manages to head for the centre of an open horizon by turning towards light areas until the brightness input to each eye is equal and balanced; it then goes straight ahead to maintain this balance' (1967: 54). This hypothesis is corroborated by the observation that a hatchling with one eye covered, usually circles in the opposite direction.

There now is good evidence of the great importance of visual cues in the sea-finding behaviour of greens, and almost certainly this also applies to the other species. However, this does not rule out the possibility that other cues may play contributory roles and may be adequate aids in sea-finding. Wildschut's experiments on Bigisanti demonstrated that geotaxis operates. 1)

Resuming, it appears that the explanation of the orientation of hatching turtles should be looked for in the difference in brightness that on the natural beachscape nearly always exists between the open seaward- and the more obstructed landward horizon. This system gives a certainty of reaching the water, with only a few exceptions. Although it has been reported (Ehrenfeld, 1968) that the position of celestial bodies has no demonstrable influence on the sea-finding orientation, Mrosovsky (1970) concluded from his experiments on Bigisanti beach that any visual stimulus in the field of view of a turtle has some effect on its directional responses. This would mean that in some circumstances the mechanism permits the moon and the sun to divert turtles from the shortest route to the sea.

That this really may be the case was witnessed by J. T. Wildschut, who even saw a column of hatchlings trying to enter our beach camp, misguided by the reflection of the moon on the aluminium roof. The mechanism may also fail in the case of nests made amidst a dense growth of creepers, when the open horizon is not (sufficiently) discernible. It may be that in cases like this some other guidance mechanism operates, but then it apparently is not efficient enough to guide the hatchlings to the open beach and into the sea before dawn: on Bigisanti we witnessed hatchlings from such nests still wandering about the beach platform at dawn, an easy prey to predators and victims of the daytime heat. But, as Mrosovsky remarked, such misfortunes

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1) In 1973, Verheijen & Wildschut published the results of their observations on the photic orientation of the hatchlings of green turtles and olive ridleys. It was not possible to include their conclusions in this review, as the article was received after the manuscript had been finished.

are a necessary sacrifice for a system that gives the certainty of reaching the water in almost all circumstances.

For a recent review of sea-finding behaviour, see Mrosovsky (1972).

Dermochelys hatchlings, when moving from the nest to the sea, sometimes perform circular movements, a stereotyped behaviour peculiar for this species that has also been reported for the adult females on their return to the sea (see the section on nesting behaviour of the leatherback). When on the run down toward the sea a circle has been completed, the orientation taken up by the hatchling is usually again in the correct, seaward direction. This phenomenon of the "orientation" circles has been interpreted as part of a successive sampling system that periodically exposes the hatchlings to cues from all directions and enables them to 're-establish bearings' (Carr & Ogren, 1959). Plausible as this interpretation may appear, it now probably has to be rejected on the basis of the findings of Mrosovsky during field experiments and observations of 'natural' tracks on Bigisanti and the French Guiana breeding beach. One of Mrosovky's arguments is that most hatchlings do not make circles at all and apparently are able to acquire sufficient information for reaching the sea without circling. So the problem why some leatherbacks — hatchlings and females — circle when returning to sea, still needs an explanation. However, Mrosovsky has already argued that, although *Dermochelys* has been phylogenetically separated from the other four genera of sea turtles for at least a 100 million years, there are several reasons for thinking that, apart from some slight differences, its sea-finding mechanisms are basically similar to those in the green turtle.

As has already been described previously, the upward struggle from the nesthole to the surface of the sand is brought about by teamwork of the nestmates. This social cooperation seems to continue after the baby turtles have reached the surface. Everybody who has watched a group of baby turtles that had recently crawled to the surface or had been dumped together on the beach, has noted how they may remain motionless for a certain time untill one jumps into action, inciting the activity of others; the action thus spreads through the group which starts scrambling away, off toward the sea.

Hendrickson (1958: 514) considered that after emerging to the surface, the group action ceases and the hatchlings, spreading out in all directions, react on their own to the existing stimuli. However, Carr (1967: 79) is of the opinion that the advantage for a turtle of being one of a group lasts even longer, and includes the period of crawling from the nest to the surf. In tests with young hawksbills he noted that hatchlings, allowed to crawl singly across the beach, stopped more often than those that were released in groups. He concluded that, although "the bonds that integrate the band" loosen as soon as the hatchlings crawl across the beach, it seems that a hatchling that crawls alone is at a slight disadvantage compared to those that travel in a group. However, I rarely saw a group of nestmates keeping together for longer than the first short part of their journey to the sea (which, however, might be the most decisive stage in sea-finding). The majority of the highly myopic siblings lose sight of each other soon after leaving the nest, due to individual differences both in the rate of crawling speed and in the direction they take, and to irregularities of the beach surface. The spread in orientation must partly be due to local variations in brightness cues and to chance encounters with differences in topography and obstacles. Mrosovsky (1967), who in his experiments found 'left preferers' and 'right preferers', suggested individual sensitivity differences between the left and the right eye as another possible reason why the young do not all follow exactly the same route.

Upon reaching the wave wash, the crawling on land — a floundering gait in which the limbs are used alternately in a crawling fashion — is instantly replaced by the swimming stroke, a vigorous, synchronous 'birdwing' movement of the fore-flippers. The turtles are alternately lifted and stranded by the coming and going of the waves, but they keep swimming away from the land, diving and emerging to breathe. Soon they reach the surf — which on the Surinam beaches is usually mild by general standards — and disappear from sight. Thereupon, the fate of the small turtles remains a baffling problem. Nobody knows anything about their habits, the length of their stay in the offshore waters, or the wanderings of the very few that reach maturity and return to mate and lay their first clutch of eggs on their native beach. The only fact we know is that yearling green turtles are frequently caught in the nets of fishermen in the mouth of the Surinam River, which means that they stay carnivorous for, at least, the first two years. But, we even do not know if these young turtles were born in Surinam.

Investigators are not yet certain about the age at which green turtles reach maturity. Estimates are four to six years (Hendrickson, 1958), at least seven years (Harrisson, 1962) and at least six years (Carr, 1967). As far as I am aware, no data are available for the other species. As long as we do not have a good method of marking hatchling turtles, the only source of information on age and size at sexual maturity will be the data obtained in turtle farms.

Predation on eggs and hatchlings

Until recently, on the Surinam beaches, man was the most important enemy of the turtles by using the eggs for food. As will be described in the last chapter, human depredation has been stopped completely on Bigisanti beach and now is strongly limited on the Galibi beaches.

However, the nests not excavated by men are threatened by other animals, of which the ghost crab (*Ocypode quadrata*) (Pl. 23 fig. 40) is probably the most important, but dogs also may be a serious menace, both to the eggs and to the baby turtles. This is demonstrated by the few dogs that occasionally succeed in reaching the Galibi nesting beaches from the Carib villages.

Apart from the destruction of nests by beach erosion (which accounts for the loss of more than 25% of the eggs), the most important egg predator, as stated above, is the ghost crab. Hill & Green (1971) found that on Bigisanti beach 60% of 100 nests laid in February-May 1969 were attacked within 4 days after laying by crabs, destroying an average of 16 eggs per nest (= ca. 12%). Up to 93% of the eggs in a nest were eaten. Nests laid in the open sand were particularly vulnerable to crab damage (especially those laid too superficially), while clutches laid among or close to the vegetation often remained untouched. It was found on Bigisanti beach that crab damage to ridley nests is severe because the nest is shallow, often less than 30 cm deep. The hypothesis that the ridleys prefer Eilanti beach 'because' ghost crabs are markedly less frequent there seems obvious.

Hatchlings making their way to the sea after emerging from the nest are subject to predation by several animals. Dogs have been mentioned already. Among the other known non-human terrestrial predators mentioned in literature — such as rats, hogs and other mammals, crabs, snakes, and sea-birds — ghost crabs and birds are probably the principal animals that take some hatchlings on our beaches. Of the birds, we saw Black Vultures, *Coragyps atratus*, catching baby turtles on the beach. This was also observed by Mrosovsky (1971) at the French Guiana rookery, where daylight emergences of leatherbacks are not uncommon; such emergences can often be located from a distance by noting the congregation of vultures. When approached these fly off, leaving dead turtles, headless and without front legs and viscera, strewn around. No signs were found on our beaches of predation on eggs or hatchlings by jaguars, that slaughter adult turtles on Bigisanti beach. Perhaps formerly nests and hatchlings have been preyed upon by peccaries, jaguars, ocelots and other spotted cats when these were still common in the forests behind the beaches.

At present the little turtles have relatively little danger to fear on our beaches, as long as dogs are kept away. But as soon as they have entered the sea, the great slaughter begins. Along the Surinam coast the hatchlings almost certainly are subject to very heavy predation by many kinds of fish, chiefly sharks and large catfish (*Arius* and related genera). Groups of sharks are seen patrolling in front of Bigisanti beach from May or June onward. Sea birds do not seem to be an important menace in the ocean off our beaches, although J. Wildschut saw gulls (*Larus atricilla*) picking up hatchlings from the sea. Another aspect (which we can quantify no more than the other causes of mortality) is the drowning of young turtles in the nets of fishermen and of shrimp trawlers, operating in growing numbers on the Guiana shelf. The large number of adults thus caught is illustrated by the recoveries made off the Guiana coast, which are all from shrimp trawlers (Maps 6 and 7).

How many of the young turtles survive we do not know, but I would be surprised if more than 1% of each nest of turtles survives the first week at sea. Virtually nothing is known about survival during development from hatchling to adult breeding turtle 1). This is a group attribute of prime importance when studying sea turtle population dynamics.

Chapter VIII. INTERNATIONAL MIGRATIONS

Green turtle (*Chelonia mydas*)

The distant journeys of the adult green turtle are the best known among sea turtles. However, as was mentioned at the end of the preceding chapter, little is known about the wanderings of the juveniles and sub-adults. It is not even certain — although there is circumstantial evidence that this generally is the case — that a green turtle, by the time it has reached the breeding age, has already joined the ancestral population in its specific grazing territory. And when and how this might happen we do not know, at least not for the population nesting in Surinam.

The mature green turtle is a periodic long-distance migrant. Few green turtle populations are known to live near their breeding grounds. Most of them have to make seasonal trips between different habitats, connected with different stages of the life cycle, which may necessitate migrations of thousands of kilometers. In many parts of the world, green turtles show a preference for nesting on islands rather than on mainland beaches. Some of those nesting on islands have to make their double journeys across vast expanses of featureless ocean. Their capacity for open-sea navigation, one of the most spectacular and intriguing aspects of sea-turtle biology, still remains without an explanation. It may be assumed that they have navigational powers, enabling them — just like migratory birds — to initiate and

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1) H. R. Bustard, in a letter to IUCN (13.6.73), stated that to assume a survival of turtles, from eggs to adult, of 2 or 3 per thousand 'is reasonable on the basis of current information'.

maintain a directed movement, independent of learned landmarks. But, unlike in birds, the physical basis of turtle navigation is still a puzzle and remains subject to mere speculation. Apart from a few tracking efforts, no experimentation has been carried out in this field and probably this will not be the case before more sophisticated techniques will be available. The most searching discussion of the navigational system of the green turtle may be found in Chapter 6 of Carr's 'So Excellent a Fishe' (1967). In this chapter, 'The Way to Isla Meta', Carr considers at length the systems that might guide the population that nests on Ascension Island. Carr's tagging experiments have demonstrated that this population migrates each season from grazing grounds off the Brazilian coast to this tiny island, a remarkable journey of 1400 miles. Temptation is strong to enter into this highly fascinating problem more deeply, but I will limit myself to the facts that are known about migrations of the turtles nesting in Surinam.

Adult green turtles, which are mainly herbivorous, do not find their food off the Surinam coast. The nearest pastures are found in Brazilian waters. Carr (1967: 40), when visiting Bigisanti beach, noted that the green turtles nesting there looked much more like the Brazilian population that nests at Ascension than like the populations observed in the Caribbean. In 1964 I speculated that this green turtle population is recruited from Brazilian feeding grounds (Schulz, 1964), which was subsequently confirmed by the tagging project which started on the Surinam beaches in 1966. Since then, 73 recoveries — all from Brazil except one from Cayenne — were reported to Gainesville; a summary is presented in Table 23 and on Map 6. Sixty percent came from the area off the coast of Ceará. Pritchard (1973), who has already published and commented upon part of the data, assumed that the turtles captured between W Ceará and Surinam were caught under way to their feeding grounds off the Ceará coast and beyond.

The tag recoveries demonstrated that, on the feeding grounds off the coast of Alagoas, Rio Grande do Norte and Ceará, green turtles mingle from two different and extremely wide apart nesting grounds: the coast of Surinam and the island of Ascension. Turtles of the second population were caught between Acaraú (W of Fortaleza) and Victoria in Espiritu Santo (Koch et al., 1969). Thus the two populations mingle in the coastal waters that span about 1200 km of coastline, extending from Acaraú to Maceió.

None of the 556 green turtles tagged since 1960 in Ascension has been found nesting anywhere else (Pritchard, 1973). Nor has a Surinam-tagged turtle been recorded from any other beach, except from the beaches in adjacent parts of French Guiana. As copulation only has been observed near the nesting beaches, genetic interchange between the two populations would only

TABLE XXIII

Recovery data for 73 Surinam-tagged green turtles (Chelonia mydas), *captured at sea.*
Gal = Galibi beaches, Bis = Bigisanti beach. Data and locations of recovery received from P. C. H. Pritchard (see also Pritchard, 1973, Table III).

tag no.	tagging location	last record on beach	date of recovery	location of recovery	
E.5064	Gal	6.VI.70	21.VII.70	Cayenne, FRENCH GUIANA	
E.4615	Gal	7.IV.70	8.VI.70	Igarapé Nôvo, AMAPÁ	
E.2002	Gal	5.V.69	V/VI.69	Algodoal, Maracana	PARÁ
E.3359	Bis	9.VI.70	18.VI.70	Algodoal Isl., 50 M NE of Belem	
E.4546	Gal	10.V.70	2.VII.70		
E.4834	Gal	10.V.70	6.VII.70		
E.5005	Gal	14.V.70	20.VI.70	Salinopolis	
E.17	Bis	6.V.66	VI.66	São Luis	MARANHAO
E.1644	Bis	22.V.69	13.III.71		
E.2485	Gal	6.IV.69	18.VI.69		
E.4925	Gal	30.IV.70	10.VI.70	Bay of S.José near São Luis	
C.1283	Bis	20.V.73	20.VII.73		
E.1442	Gal	23.IV.70	2.XII.70	Parnaíba, PIAUÍ	
E.1782	Bis	18.V.69	1.I.71		
E.2055	Gal	27.II.69	IX.70	Almofalá Beach, Acaraú	CEARÁ
E.2122	Gal	16.IV.69	25.VI.69		
E.2966	Gal	23.IV.69	13.VII.69		
E.3379	Bis	23.IV.70	1-12.IX.70		
E.4486	Gal	20.IV.70	27.VI.70		
E.5004	Gal	19.V.70	1-12.IX.70		
E.1832	Bis	7.VI.73	15.VII.73		
E.2190	Gal	10.III.69	21.VI.70	Emburana (Curral Velho), Acaraú	
E.3410	Gal	21.IV.70	14-21.VI.70		
E.4867	Gal	9.V.70	VII.70		
E.2274	Gal	21.III.69	27.V.69	Timbauba Beach	
E.2474	Gal	13.IV.69	21.V.69		
E.2510	Gal	3.V.69	21.VI.69	Freixeiras Beach	
E.2844	Gal	25.V.69	V.70	Itapema Beach	

be possible if young turtles hatched in Surinam would join the Ascension-bound specimens when they are ready for their first nesting (and, vice versa: Ascension-born turtles that would nest in Surinam). The situation is even more complicated because the turtles that nest on the Brazilian mainland

Table XXIII (continued)

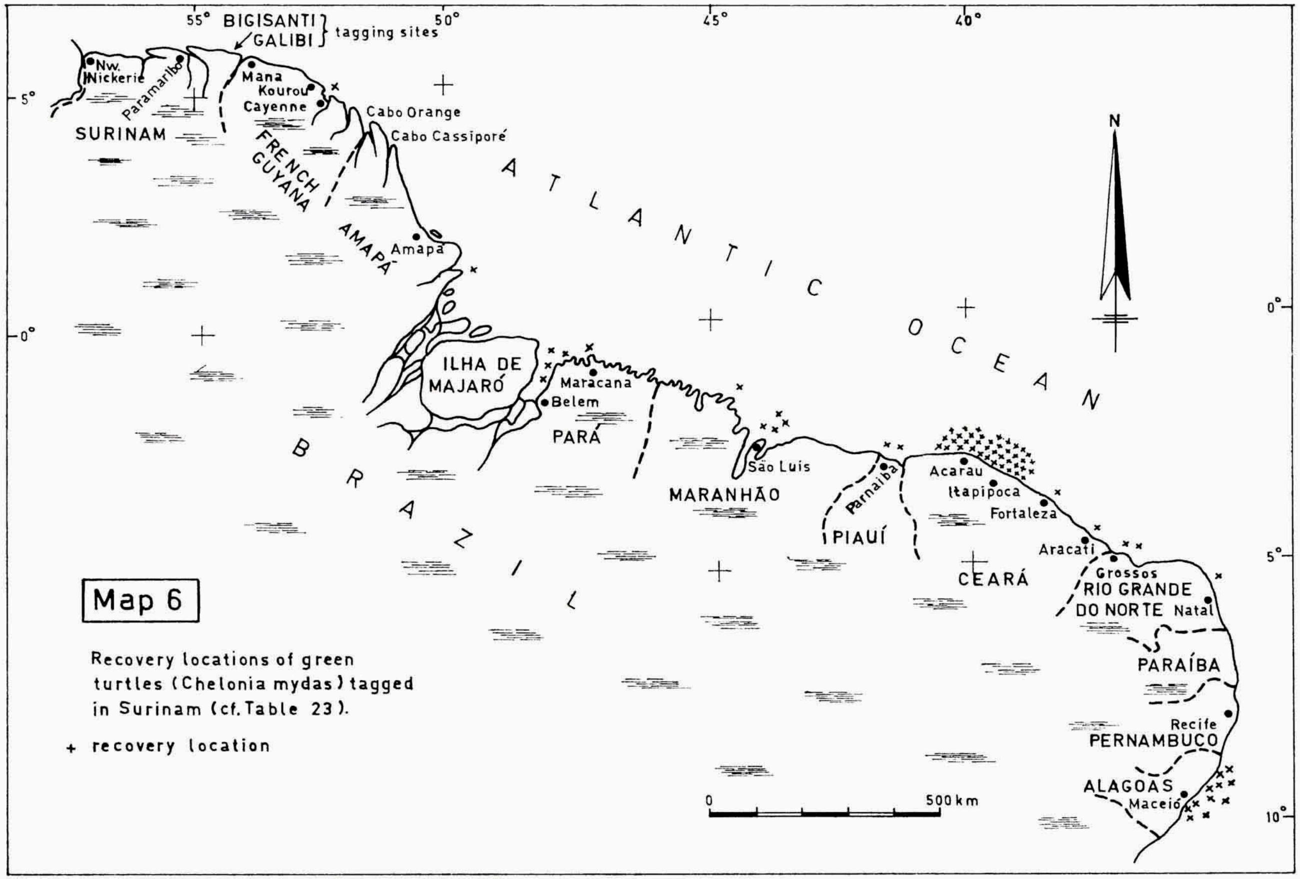
tag no.	tagging location	last record on beach	date of recovery	location of recovery	
E.2001	Gal	19.III.69	4.IV.70	Icaraí Beach, Itapipoca	CEARÁ
E.2035	Gal	27.II.69	VIII.69		
E.2041	Gal	7.III.69	19.IV.69		
E.2070	Gal	2.III.69	29.V.70		
E.2504	Gal	12.V.69	28.IV.70		
E.4118	Gal	23.V.70	18.IX.70		
E.4821	Gal	29.V.70	25.IX.70		
E.1535	Bis	13.IV.69	between May and July '69	Sabiaguaba, Itapipoca	
E.1582	Bis	4.VI.69			
E.1977	Bis	21.IV.70(?)			
E.2016	Gal	24.V.69			
E.2322	Gal	28.III.69			
E.2379	Gal	21.IV.69			
E.2439	Gal	8.IV.69			
E.2450	Gal	8.IV.69			
E.2475	Gal	24.IV.69			
E.2493	Gal	6.V.69			
E.3209	Gal	21.IV.70	1973	Itapipoca	
E.2022	Gal	6.IV.69	VI.69	Paracuru Beach	
E.2243	Gal	18.III.69	3.IV.70	Mundaú	
E.2346	Gal	31.III.69	3.IV.70		
E.1562	Bis	28.V.72	19.X.72		
E.2078	Gal	21.IV.69	7.VII.69	Bitupitá Beach	
E.2124	Gal	7.III.69	12.V.69		
E.2283	Gal	22.IV.69	24.V.69		
E.2299	Gal	22.IV.69	VI/VII.69		
E.1497	Gal	4.V.70	17.IX.70	Fortaleza	
E.4545	Gal	9.V.70	17.VII.70	Caraubas	
E.4683	Gal	9.V.70	24.VII.70	Tiblau Beach	
E.2514	Gal	4.V.69	VII.69	?	
E.4476	Gal	4.V.70	1973	Pernambuquinho	

Table XXIII (continued)

tag. no.	tagging location	last record on beach	date of recovery	location of recovery	
E.2279	Gal	25.III.69	25.V.70	Maracajaû	RIO GRANDE DO NORTE
E.3382	Bis	18.V.70	20.VII.71	Tibaû	
E.4606	Gal	16.V.70	20.VII.71	Grossos	
E.1473	Gal	26.II.70	?(71)	Riacho Doce Beach, near Maceiõ	ALAGOAS
E.3086	Gal	13.III.70	5-18.XII.72		
E.4453	Gal	14.IV.70	20.VI.72		
E.4762	Gal	6.VI.70	5-18.XII.72		
E.5880	Bis	6.VI.72	5-18.XII.72		
E.5381	Bis	14.VII.71	VIII.71	between Maceiõ and Rio San Francisco	
E.2962	Gal	15.V.71	? III.72	Peba Beach	
E.3373	Bis	1.V.70	V.71	Paripueira Beach	
E.1556	Bis	22.III.69	20.VIII.72	Barra de Sto. Antonio	
E.5473	Bis	10.VII.71	20.VIII.72		
E.4669	Gal	24.IV.70	19.XI.70	Tatuamunha	

beaches and on Tríndade and Marajó almost certainly share the same feeding pastures. The turtles that were tagged by Pritchard on the French Guiana beach also migrated to the Brazilian pastures. Pritchard (1973) speculates that even the huge greens nesting on Aves Island, in the eastern Caribbean, might also be derived from this feeding area. Actually, no other feeding ground is known to produce turtles of this size.

We do not known how the green turtles find their way during these migratory movements up and down the coasts. Nor do we know by which cues they return to their particular breeding site as substantiated by the tagging experiments. As all turtles captured en route to the feeding grounds were taken near the coast, the green turtles nesting in Surinam perhaps do not need an open-sea navigational ability. They could be guided by a subtle perception and assessment of the sea and air currents, the chemical and temperature gradients and/or other cues. Whatever the guidance system may be, it is extremely unlikely that the sea turtles are using a mechanism that depends (partly) upon the formation of sharp retinal images when their heads are above water, as Ehrenfeld & Koch (1967) have established that the green turtle is extremely myopic when its eyes are out of the water. They lack some of the efficient mechanisms of accommodation found in



Map 6

Recovery locations of green turtles (Chelonia mydas) tagged in Surinam (cf. Table 23).

+ recovery location

freshwater turtles. So bicoordinate star navigation and visual orientation must virtually be ruled out as guidance stimuli. But other types of astronomical navigation, involving the position of the sun and/or the moon, cannot be disregarded.

Some authors suggest that green turtles migrate in groups. One of the reasons for this is the assumption that nesting seems to start suddenly; but this is not true on the Surinam nesting beaches, where we have no reason to speak of 'the fleet coming in'. The return journey to Brazil is certainly not made in one big aggregation. I suppose that a turtle returns to the feeding grounds as soon as it has laid its last nest, which may be as early as March, even before the peak of the nesting season. Several turtles have already been caught on or near the feeding grounds in May and June, when the late nesters were still breeding in Surinam.

For the green turtles nesting in Surinam a rough estimate can be made on the length of their absence from the feeding grounds during the breeding journeys. From estimations of the minimum swimming speeds — discussed below — it seems not unrealistic to assume the average daily distance covered to range from 35 to 80 km when swimming back to Brazil. This means that the 2000 km between Surinam and Ceará take more than three weeks and less than two months. No data are available on the swimming speed heading for Surinam, but it seems probable that swimming with the current and not yet exhausted by months of reproductive activity, the turtles move (much?) faster and do not spend more than two weeks to one month on this journey. The duration of the stay near the breeding site varies considerably, but most green turtles spend 1½-3 months between their first and their last nesting activities (see Table 12), plus the unknown span of time between their arrival and the first oviposition. In conclusion, breeding females are away from their grazing pastures for more than 2 months and may stay away for 5 months or even longer. If the mature green turtle is really exclusively herbivorous, as most investigators assume, this implies that green turtle females must be able to live through a starvation period of several months every second or third year, and sometimes even in two consecutive years. During this starvation period, they have to swim a distance of about 4000 km and to produce 300 to over a 1000 eggs (weighing 12-40 kg). It must be possible to calculate the energy required for this achievement in order to elucidate if green turtles — even of the size that nest in Surinam — would theoretically be able to store the supply of energy needed for their reproductive activity. I would not be surprised if the green turtles nesting in Surinam take some animal food during their reproductive migrations.

Olive ridley (*Lepidochelys olivacea*)

Fifty-nine ridleys tagged in Surinam have now been recovered at sea (Table 24 and Map 7). These recoveries span roughly 4500 km of coastline, extending from Natal in Brazil to the Gulf of Venezuela. Pritchard (1973) pointed out the fact that 14 of the recoveries were made off the coasts of Surinam and French Guiana. He correctly demonstrates that these turtles when caught were not in this area for nesting, because most of the recoveries were made well after or before the nesting season. Ruling out differences in fishing pressure as an explanation, Pritchard is of the opinion that the most probable explanation is that ridleys, after assembling for nesting on one single breeding site on the Galibi beaches, disperse 'as far as is necessary for procurement of adequate amounts of food'. Some ridleys will go far astray, but a high concentration remains relatively close to the nesting beach.

A secondary concentration occurs in the area around the Island of Margarita and in the Gulf of Paria, where 19 recoveries (about one-third of the total) were made. The explanation could be a different fishing pressure, as this area is heavily fished, but Pritchard may be right in assuming that the huge Orinoco estuary possibly provides a fertile breeding ground for the crustaceans on which the ridley feeds.

Leatherback turtle (*Dermochelys coriacea*)

A leatherback previously observed nesting on Bigisanti, on 2 May 1970, was caught at Salt Pond, Ghana in April 1971 and must have travelled at least 6700 km. Of course this single record is no indication that leatherbacks, after nesting in Surinam, make a habit of crossing the Atlantic Ocean. There is perhaps more reason to assume that they swim northward and that the turtles observed off the coast of Nova Scotia, during what is locally called the 'turtle season', arrive there after a marathon swim from the breeding sites in Surinam and French Guiana. It is well known that leatherbacks are able to make remarkable voyages as they are frequently recorded from the cold northern waters of the eastern Atlantic (Brongersma, 1972) and from as far south as Argentine.

In 1973, four leatherbacks tagged in French Guiana that were recovered at sea, at locations off the coasts of Campeche (Mexico), Texas, S Carolina and New Jersey (Pritchard, 1973a), confirmed that at least part of the leatherbacks nesting in our area comes from northern temperate waters. The distances between the locations of recovery and the tagging areas were between 4900 and 6300 km. These five recoveries were not simply the only

TABLE XXIV

Recovery data for 59 Surinam-tagged olive ridley turtles (Lepidochelys olivacea) *recovered at sea.*
Gal = Galibi (mostly Eilanti beach). Data and locations of recovery received from P. C. H. Pritchard (see also Pritchard, 1973, Table III).

tag no.	tagging location	last record on beach	date of recovery	location of recovery
locations east of tagging beach:				
E. 142	Gal	7.VI.66	XI.67	'off Surinam'
E. 390	Gal	3.VI.70	20.IX.70	do.
E. 582	Gal	11.VII.67	26.VII.67	off Surinam R. mouth
E. 609	Gal	14.VI.68	IV.69	49 km ENE Surinam R. lightship
E. 648	Gal	17.VII.68	4.I.68	'off Surinam'
E.1902	Gal	28.VI.69	16.V.70	ENE of Surinam R. lightship
E.2669	Gal	29.V.71	3.XI.71	'off Surinam'
E.7074	Gal	30.VI.72	13.III.73	do.
E.1006	Gal	17.VI.68	28.XI.73	150 miles off the shores of Guyana
E.1327	Gal	13.VII.73	28.XI.73	do.
E.4591	Gal	23.V.70	10.I.71	E coast of Guyana
E.5606	Gal	30.V.71	25.VI.71	Berbice R., Guyana
E.5628	Gal	10.VI.71	20.XI.73	110 km NNE Corantijn R. mouth
E.5223	Gal	12.VI.70	XII.72	Georgetown, 6°54'N 57°43'W
E.5805	Gal	3.VI.71	?	'off Guyana coast'
E.7192	Gal	15.VII.72	31.VII.72	off Georgetown
E.1337	Gal	16.VII.71	28.I.73	mouth of Demerara R.
E. 300	Gal	31.V.67	1.VIII.67	Punta Barima, Venezuela
E. 543	Gal	3.VI.69	5.X.72	Golfo de Paria
E. 593	Gal	13.VI.67	4.II.69	3 km off Soldado Rock, E coast Trinidad
E. 936	Gal	17.VII.68	13.II.69	40 km N of Trinidad
E.5148	Gal	10.VI.70	12.VII.71	off Toco, Trinidad
E.5816	Gal	7.VII.71	?	Golfo de Paria
E.4348	Gal	14.VI.70	28.X.72	3 km NW of Trinidad
E.1120	Gal	25.VI.68	18.IX.68	2½ km N of Carúpano, Venezuela
E. 585	Gal	13.VI.67	16.V.70	5 km W of I. Los Testigos, Venezuela
E. 135	Gal	7.VI.66	?	near Isla de Margarita, Venezuela
E. 823	Gal	4.VII.68	10.V.69	
E.1164	Gal	28.VI.68	20.I.70	
E.1209	Gal	15.VI.70	28.X.70	
E.1280	Gal	23.VI.69	22.I.71	
E.2764	Gal	10.VI.69	23.VII.70	
E.2953	Gal	22.III.69	12.XI.69	
E.5090	Gal	20.VI.70	V.72	
E.5589	Gal	1.VII.71	?	
E.5654	Gal	2.VI.71	27.IX.71	
E.7176	Gal	3.VII.72	12.X.72	
E. 981	Gal	11.VI.70	4.XI.71	15 km S of Punta Espeda, Golfo de Venez.

Table XXIV (continued)

tag no.	tagging location	last record on beach	date of recovery	location of recovery
locations west of tagging beach:				
E. 544	Gal	17.V.68	29.XII.68	off Marowijne R. mouth, Surinam
E.1890	Gal	23.VI.69	11.V.70	57 km N of Marowijne R. mouth
E. 423	Gal	17.VI.68	27.XII.68	off Iracoubo, Fr. Guiana
E.1827	Bis	17.IV.69	X.69	'off French Guiana'
E.5324	Gal	11.VII.70	13.VIII.71	do.
E.1880	Gal	20.VI.69	17.VIII.69	Devil's Island, Fr. Guiana
E.4911	Gal	29.IV.70	X(?).70	do.
E.5258	Gal	24.VI.70	6.V.71	do.
E.5346	Gal	10.VII.70	8.VIII.70	Kourou, Fr. Guiana
E. 883	Gal	28.V.70	15.IX.70	E of Cayenne
E.1804	Gal	27.V.69	X.70	off Oyapoque R. mouth
E.7435	Gal	18.VII.72	IV.73	'off French Guiana'
E.1119	Gal	17.VII.68	20.V.69	E of Cabo Orange, Brazil
E. 197	Gal	7.VI.66	17.IX.66	E of Cabo Cassiporé
E. 624	Gal	9.VII.70	VIII.70	E of Cabo Cassiporé (4°15'N 51°40'W)
E.1054	Gal	20.VI.68	2.VII.68	do. (4°2'N 50°50'W)
E.5145	Gal	25.VI.71	8.VI.73	open sea NE of Cabo Cassiporé (7°20'N 50°10'W)
E. 307	Gal	31.V.67	1.II.68	between Oyapoque and Amazon mouth
E. 459	Gal	1.VI.67	18.IX.68	open sea off Amazon mouth (4°45'N 45°35'W)
E.2616	Gal	13.VI.70	6.VII.70	Icarai, Itapipoca, Ceará
E. 277	Gal	30.V.67	?	Natal, Rio Grande do Norte
E.1054	Gal	20.VI.68	27.III.70	'Brazil coast'
			XII.70	'French Guiana'

recoveries of tagged leatherbacks that had ever been made 1), but they also were among the six longest journeys ever recorded for turtles of any kind. Pritchard assumes that the turtles became entrapped in shrimpnets and lobster lines, because they had ventured exceptionally close to land. Normally leatherbacks — the most thoroughly pelagic of all the marine turtles — spend their time far from land, in search of the jellyfish on which they feed.

It seems useless to speculate upon the migration route(s) of the leatherback turtles until further data become available. However, we will have to find a method of more lastingly marking individual leatherbacks, before such data become available. But even then, we should not expect a high proportion to be caught, since — fortunately — there are no leatherback fisheries anywhere in the Atlantic.

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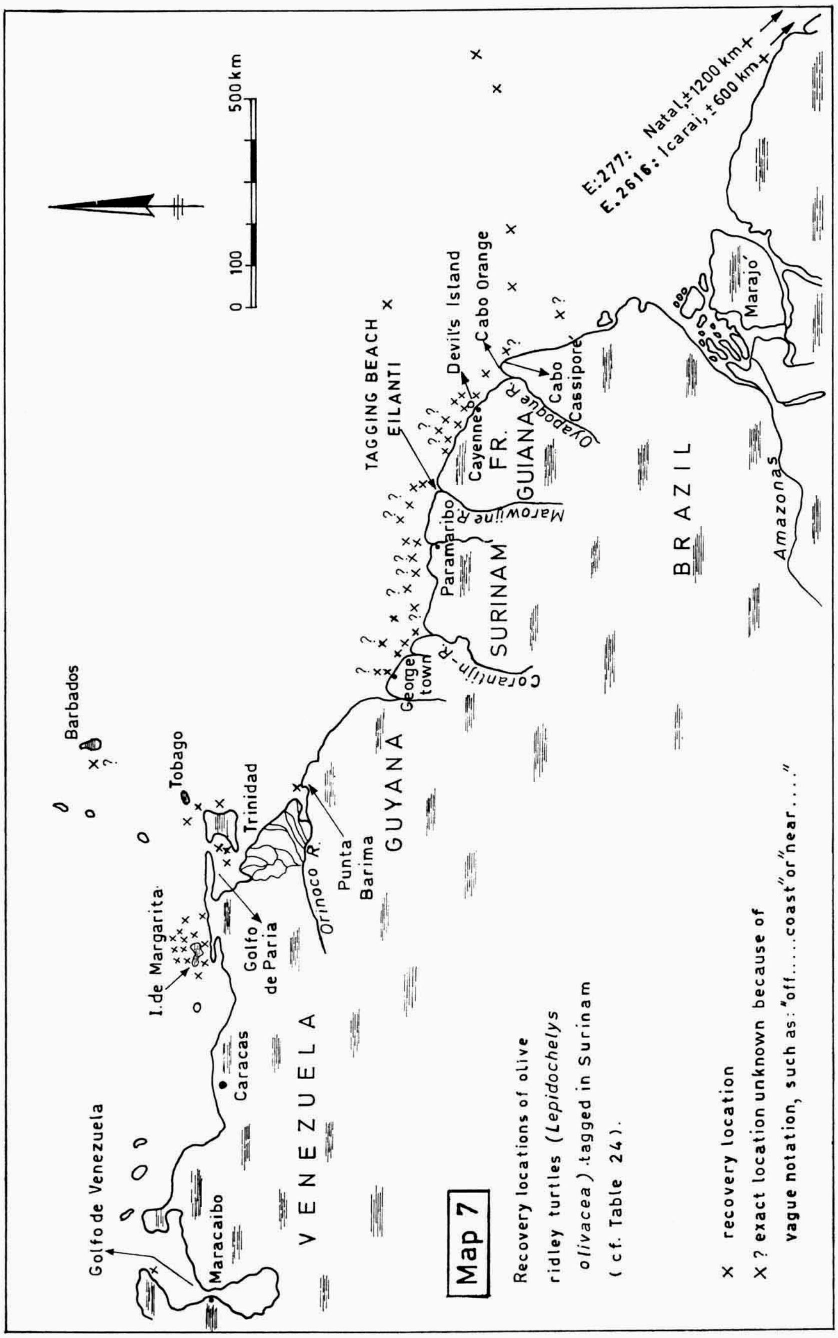
1) In a Dutch newspaper article of November 1973, on the Malayan rookery, it has been recorded that 'several' leatherbacks, tagged on that beach, had been captured at sea.



Map 7

Recovery locations of olive ridley turtles (*Lepidochelys olivacea*) tagged in Surinam (cf. Table 24).

× recovery location

× ? exact location unknown because of vague notation, such as: "off.....coast" or "near...."

Speed of travel

Pritchard (1973) calculated the minimum speeds for nine of the recovered green turtles, on their way between their nesting beach and their feeding grounds. On the assumption that their last visit to the beach (not necessarily an oviposition) had been recorded and that they had left Surinam waters immediately after that date, the calculated minimum average daily speeds were estimated at ca. 11 to 35 km. These figures are comparable with estimates published by other authors.

However, for some of the green turtles we find considerably higher speeds. Specimen E. 2041 was last recorded on Eilanti beach on April 7 and caught 43 days afterwards off Icaraí, ca. 2000 km away; this implies an average speed of more than 47 km per day. No. E. 2283 moved at a minimum average speed of 66 km per day over a distance of ca. 2100 km. For both E. 2474 and 1832 this speed was 53 km.

The champion so far is olive ridley no. E. 2616, which was captured ca. 1900 km away from Eilanti beach, only 23 days after having been observed there for the last time; she must have moved with an average speed of more than 82 km per day against the Guiana stream. No. E. 7192 swam to a location off Georgetown (ca. 450 km) in 16 days (average 28 km/day) and no. E. 1054 was captured in the open sea E of Cape Cassiporé (ca. 650 km from Eilanti along a straight line), 12 days after her last visit to the beach (ca. 46 km/day against the stream).

Chapter IX. SEA TURTLES AND MAN

Killing of sea turtles and egg-taking in Surinam up to 1964

The Labadists, mentioned in the first paragraph of Chapter I, made an entry in their narrative (Anonymous, 1686) about meeting Mr. Frans Daems on his plantation at the Cottica River; Mr. Daems took sea turtles at 'schiltpadbay', kept them in a pond, and sold their meat. When they visited Daems, he had just returned from the beach and was keeping 5 turtles as a favour to Van Sommelsdijck, the Governor. Daems could keep his turtles alive for 6-8 months, but during such a prolonged period they lost much weight and the colour of the fat turned from green to whitish, due to lack of 'suitable food: sea-weed'. This observation makes it quite clear that with 'sea turtles' the green turtle was meant.

Stedman (1796: 11) records that turtles '... are publicly exposed to sale by the butchers in Surinam, like the shambles meat in the European markets, and are esteemed the most delicate food between the months of February and

May'. However, it is probable that, apart from a short period before the Second World War, sea turtles on the Surinam coast were never killed for food on a large scale. At the present day sea turtle meat is not appraised by the Caribs living near the principal nesting places. According to Kloos (1971: 60) the Maroni River Caribs say that they do not like the smell of the meat, but he mentions another probable reason, now forgotten: the fear to become as stupid as the animal from which the flesh is eaten. As a matter of fact, in 1725, Chretien (1957: 53) wrote:

'Les galibis ne mangent point de torture quoy qu'elle abonde chez eux et qui en ait qui pèsent avec l'écaille plus de 3 à 400 livres, ils craindroient s'ils en mangeoient de participer à la stupidité de cet animal'.

The meat of other turtles was probably seldom or never eaten, assuming that Stedman's observation on the sale of turtle meat refers to the green turtle. Capture of hawksbill for tortoise shell was probably never important, presumably because this species is not numerous here and, according to Kappler, because American tortoise shell was worth less than that from Asia. Stedman mentioned that "carett" shell was 'more valuable' than "calipee" shell, but we are not sure whether this observation refers to *Lepidochelys olivacea* or to *Eretmochelys imbricata.*

Collecting of eggs (mostly ridley and green turtle) seems to have been quite important. This was a tradition of the coastal Caribs — at least during the last century — chiefly in and near the Marowijne estuary.

From Kappler's descriptions it appears that, in the nineteenth century, the turtle industry was about completely in Amerindian hands and sea turtle eggs were collected intensively by the Caribs of the lower Marowijne. Kappler did not mention whether the eggs were collected exclusively for their own consumption or if they were also sold to other groups of people. One can judge from Kappler's remark '... men caught nothing else but females', that green turtles were killed on the beaches for their meat (and perhaps for their oil). Further on, however, he mentions about the meat: 'high as it is held in esteem in Europe, in Surinam people do not like it'. The latter observation seems to be in contradiction with Kappler's first remark and with Stedman's reference to the sale at the butcher shops at the end of the 18th century. According to Kappler meat of the other species was said to be inedible. Oil was extracted from leatherback meat, but it is not said on how large a scale and what it was used for.

According to Geijskes' (1945) report, egg-taking in the forties was more intensive than in the previous century, due to the increased demand by Chinese and other people of Asiatic orgin, especially Javanese. Geijskes, when discussing the collecting of green turtle and ridley eggs, mentions that at the time of the Second World War most eggs were taken by Caribs of the Marowijne mouth, as they are today. 'Considerable amounts' of eggs were brought to town by the fishermen working on the nesting beaches between the Marowijne and the Oranje kreek.

The egg-takers kept the daily proceeds of eggs in their camps, until enough were collected to load a boat (17.000 to 100.000). In those days the eggs were brought to Paramaribo, the Commewijne district and also to St. Laurent (French Guiana). No figures are mentioned for the total number of eggs taken per year. In 1945 the market-price was Sfl. 0.01 a piece.

Geijskes records the following about use of the meat of the green turtle. Before 1940, green turtles were caught for export. This business was in the hands of Berkeley at Albina. How long this trade had already been going on, and on what scale, is not mentioned. No information is given about the methods of capture. After asking Caribs on the spot, they informed me that the turtles were caught as they came ashore to nest.

Some important facts were obtained from the late Mr. Lijkwan, who worked many years for 'the Honourable' Egbert Paris Berkeley, about the extent of the export of turtle meat from 1933 to 1940 1). The Indians of the Marowijne estuary during this period killed for Berkeley an annual average of ca. 600 female turtles, caught as they came to lay eggs. This estimate by Lijkwan is probably on the low side. Geijskes mentions that Berkeley informed him that, in 1941, he attempted to make a contract with the Government to supply meat from 1000 green turtles and 1500 ridleys each year, but that he could supply many more. This would mean that 30 years ago more turtles came to nest than do now. In 1938 and 1939, for example, he had caught at least 3000 green turtles 2). In 1968, a year in which more green turtles nested than in previous years, only ca. 1000 came ashore in this region. Thus, the suggestion expressed above, that thirty years ago many green turtles and ridleys nested on the beaches near the mouth of the Marowijne, seems likely

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1) Geijskes speaks about the '20 year experience' Berkeley had, so it seems catching began previous to 1933. Berkeley wrote a report about the turtle industry in the Marowijne, that possibly includes details about nesting, etc. This report — printed by Van der Boomen, Paramaribo, according to Lijkwan — was intended for John Lusty & Sons, Soup manufacturers, London. I have not yet been able to obtain this unquestionably interesting article. Mr. Lusty informed me that he is not acquainted with such a report and that he only faintly remembers his firm to have received turtle meat from Surinam.

2) It is not clear from the text if this number could be caught, or that actually 3000 per year were caught in these years. (N.B.: In 1967-1972 an estimated average of 1500-2000 greens nested annually on the Surinam beaches!). It is also interesting that in 1940 only a few turtles appeared on the beach, which was considered to be a consequence of the severe drought in 1939-1940.

to be correct. The dried meat of the slaughtered green turtles (probably mainly 'calipee') presumably was supplied by Berkeley to John Lusty Ltd., 'By Appointment Purveyors of Real Turtle Soup to the Royal Household since the Reign of Edward VII' (see, however, the footnote on p. 117).

The efforts of Berkeley during the war to supply green turtle and ridley meat to Government bodies failed because consumption met with too much opposition. Fortunately the export of meat was not resumed after the war. Berkeley himself was of the opinion (Geijskes, 1945: 16) that turtle meat exploitation had little future; the home market was too small for large scale exploitation and a small scale undertaking would be at best marginally profitable. Besides, export prices were not steady enough.

Thus, the slaughter of turtles for export ended in 1940 and was not resumed after the war, in spite of a few suggestions to that effect. Yet many turtles still were killed on the beach by, among others, the fishermen, as appears from Geijskes' remarks: 'The present number of stinking carcasses on the beach, fallen victim to poachers' hands each year, is large......'.

About *Eretmochelys imbricata,* the hawksbill, Geijskes reported in 1954: '...... people in Surinam mostly do not recognize this species and kill the turtle only for the meat which, however, cannot be particularly tasty as the Caribs consider it to be poisonous'. However, he reported that in Cayenne people paid 'a good price' for the shell of this turtle and in Albina Sfl. 1.25 was sometimes paid for it. From this last remark, the conclusion could be drawn that this turtle was also hunted for its shell in Surinam, which agrees with the information I received from Caribs of Langamankondre and Christiaankondre, that shells were sold to French Guiana after the war. The number nesting here now is very small.

During the first two decades after the Second World War, the situation did not change much. It is true that for the sea turtles nesting in Surinam the year of 1954 was of paramount interest, because in that year the Game Ordinance and the Nature Preservation Ordinance came into force, followed by the Game Decree and the Decree that declared the Bigisanti breeding beach a Nature Reserve. These legislative measures prohibited the killing of marine turtles and limited the collecting of their eggs along part of the coast. But the turtles did not immediately benefit from these measures, as the most important beaches near the Marowijne estuary remained outside the area to which the regulations apply. The Wia-Wia Reserve existed only on paper. I was told that until somewhere around 1959 poachers regularly slaughtered green turtles and leatherbacks at Bigisanti beach (the meat being sold in the Commewijne district) and that egg collecting continued, probably with a steadily growing intensity, due to a growing demand and rising prices.

Around 1955, according to information from fishermen, some 150.000-200.000 eggs per season were taken on the Bigisanti beach, which at that time was situated much more to the east (see Map 5). Since then, due to erosion of the westward moving beach, this number decreased every year, and had dropped to some 30.000 eggs in 1963. Research and active conservation did not begin until 1964, the turningpoint in the history of the sea turtles breeding in Surinam.

The impending extinction of sea turtles as the driving force behind protective measures in Surinam

In Surinam the needs and efforts regarding conservation are primarily linked with the world situation of the marine turtles. Of course this is self-evident, as we are dealing with animals the conservation of which is seriously impeded by their tendency to spread their life cycle over ranges of hundreds or even thousands of miles. The great importance of sea turtles as a cheap source of protein has been recognized for a long time. Their highly localized nesting grounds and — for the green turtle — also feeding grounds, together with their size, have made them an easy prey for men. There is no doubt that, unless conservation measures are well implemented for enforcement, human greed and stupidity will bring about the complete disappearance of the already depleted turtle resources — resources that, when harvested on a sustained yield basis, could be restored again as an important source of food in a hungry world.

For the green turtle in American waters — once tremendously abundant in the Caribbean — we probably now are in the last phase leading to a complete destruction, the sad history of which has already been written by several authors, mentioned below. In the Caribbean the green turtle first drew attention of the buccaneers as an antiscorbutic and to supplement their monotonous food supplies. Later it became a staple diet of slaves and other persons of the lower classes in the colonies. After reaching the tables of people of prominence, green turtle meat and soup became a status symbol, particularly in England. In recent times oil (for cosmetics) and skins (for leather) have been added to the list of turtle products. This luxury-market, together with the rapidly growing food requirements in the tropical world, has been responsible for a gradual decline of the turtle populations 1).

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1) For detailed discussions on the plight of the world's sea turtles, primarily of the green turtle, the reader is referred to more competent specialists on this subject: Carr (e.g. 1967, 1969, 1969a) and Parsons (1962), Harrisson (1969), Hirth (1971), Bacon (1973) and IUCN (1969, 1971).

For the olive ridley, although probably the most numerous sea turtle species in the world, the situation is no less gloomy. The extensive exploitation that is being carried out in Mexico on the turtles themselves, and in Central American on the eggs, leaves little room for complacency (Pritchard, 1969b). This situation was the reason why, in spite of some strong resistance, we persevered and succeeded in our efforts to have the only important nesting aggregation of the species along the Atlantic coast — on Eilanti beach — declared a sanctuary, where the nests are now completely protected.

Hawksbills were pursued for the shell, which provides the 'tortoise-shell' for ornamental articles. A few decades back, the hunting pressure on the hawksbill diminished because of the production of plastic imitation tortoise-shell. However, recently the demand for hawksbill shell has again increased, because people have been persuaded to prefer the real shell. Besides this, the enormous expansion of the tourist industry brought with it, in many seaside holiday resorts, an increasing number of curioshops stocked with polished shells and stuffed young hawksbills. Also, in some countries, the meat is consumed and the eggs are highly esteemed. Hence, the idea must be revised that diffuse, ubiquitous nesting on remote beaches, a large area of dispersal and a long nesting season guarantee survival of the hawksbill.

Concerning the status of the leatherback, opinions are divided. Bustard (1972) feels that the species is seriously endangered, despite the discovery of the big rookery in French Guiana. On the only other known key rookery — at Trengganu, in Malaysia — the leatherback is badly over-exploited, virtually all eggs being collected by licensees. Bustard thinks that a number of 20.000 breeding females, as a reasonable guess of the world population, is a definite indication that the leatherback is not the least threatened of the sea turtles. As a matter of fact, the IUCN Red Data Book lists the species, like the hawksbill, in category 1 (the highest priority), defined as 'endangered, actively threatened with extinction; continued survival unlikely without the implementation of special protective measures'. Moreover, it is the only turtle to be 'star-listed', meaning critically endangered. Probably the IUCN's classification was still based on the extremely small size of the leatherback populations known before the discovery of the Guiana rookery.

Carr, however, in 1968 — that is before he even had knowledge of the extent of the Guiana rookery —, wrote that the leatherback 'may have the least dreary outlook'. Pritchard (1972 and pers. commun.) too is much more optimistic and he and Carr are inclined to believe that the leatherback is among the least threatened species, mainly because there are in the world almost no organized or even casual fisheries pursuing the animal (except on a small scale in Peru and on an island in the Persian Gulf) and because people do not like to eat the meat. That up to now only five tagged leatherbacks have been caught at sea seems to corroborate this viewpoint. Anyway, in Surinam the leatherback is now completely protected and, since 1964, not one egg has been collected and a great many nests have been rescued from destruction by erosion.

Whatever the relative condition of survival of each of these species may be, it is beyond argument that the present world situation is alarming for all the seven species of marine turtles. The presence of many turtles in a few places and of many turtle products in markets all over the world may obscure this fact from the public. But the statistical evidence is overwhelming that, after centuries of slow decline (perhaps quickest in the Caribbean), we are now at the point where this decline is accelerating into a catastrophic decrease of the populations. Like many species once seemingly unexhaustible, the sea turtles are now faced with an alarming depletion and with extinction within this century.

"Under these critical conditions, conservation on a correspondingly massive scale becomes of urgent and obvious importance if the world is not to lose a natural resource of such economic, scientific and aesthetic importance. Therefore active scientific conservation must take priority over all considerations". These are the words of the opening paragraph of a statement issued by the Marine Turtle Specialists Group of the IUCN's Survival Service Commission, in which Surinam has been represented since 1968.

In the face of the almost unanimous belief that the populations of the sea turtles are rapidly diminishing and that rapid action — both on national and on international level — is necessary to rescue this highly valuable natural resource, uncontrolled exploitation continues almost everywhere. Turtles of both sexes fall an easy prey — both at sea and on the breeding beaches — to the increasing demand for turtle meat, turtle leather, turtle shell and turtle oil. It is true that already more than 350 years ago the 'Act against the killing of our tortoises' was proclaimed in Bermuda, and protective legislation was passed in several countries. However, too often there is little or no attempt made to enforce the existing legislative measures, summaries of which have been published for the green turtle by Hirth (1971: Table XI), and for the turtles of the Caribbean and adjacent regions by Bacon (1973). Regulations are strikingly different among the various countries, most of which have developed their own turtle exploitation plan independently, based primarily on local social and economical conditions. Any national plan for the management of whichever marine turtle is further complicated by the fact that the claimed fishing jurisdiction between the nations varies from an about 5 km to a 321 km wide coastal zone.

There are no regulations at all concerning the capture of turtles on the high seas and it will probably remain an illusion that such regulations will ever be passed and acted on.

It is evident that a rational exploitation of sea turtles can only be achieved by international cooperation. The activities of the IUCN's Marine Turtle Specialists Group perhaps form the first steps leading to this goal. The group at least has defined and recommended a major programme of action (IUCN, 1969 and 1971). Another encouraging sign is the interest shown by CICAR (Cooperative Investigations of the Caribbean and Adjacent Regions) in a coordinated regional research and management plan, aimed at the restoration and a sensible utilization of the depleted turtle stocks of the Caribbean region (Bacon, 1973). The only international agreement dealing in any way with sea turtles is the New African Convention on the Conservation of Nature and Natural Resources (signed in 1968); however, it has not yet come into force.

Personally I am quite pessimistic about the possibility that any form of international cooperation in a rational exploitation of the turtles will be reached before it is too late. The fate of the populations nesting in Surinam is perhaps exemplary for the situation everywhere in the world: any management programme in this country is jeopardized by uncontrolled turtle fishing in the international waters and in the territorial waters of Venezuela, Trinidad, Guyana and Brazil. I do not see how a solution could be found before the last nest on our beaches will have hatched. How could we expect to reach any international agreement, with before us the example of recent abortive attempts to bring about such an agreement in Central America: regulations for a rational exploitation of the green turtle were drawn up in 1969 at a conference between Costa Rica, Panama and Nicaragua; but, instead of ratification, this was followed by increased turtle fishing by Nicaraguans and the establishment of two turtle meat trading companies in Nicaragua.

This is all the more deplorable as, in Carr's (1954) words: "It is not often that we are offered a set of circumstances so promising; a one-item feeder with its pastures undamaged, vast in extent and used by no other animal; a species attuned to building and thriving in dense populations and yet flexible enough to proliferate and scatter in dilute colonies; above all, a depleted species, the cause of whose depletion is clear and surely possible to remedy. There is a skeletal breeding stock and the best of remaining nesting shores are the least cluttered by man. Group action by governments concerned would surely save *Chelonia* and build unity and strengh in the Caribbean by raising the yield of the sea to the people around it. In the field of live-resource management it is not often that you can hope for so much".

The legal basis of conservation of sea turtles and their management in Surinam since 1964

In Surinam, since 1964, the policy of turtle management aims at a complete protection of the nesting animals on the beaches and the harvesting of a 'justifiable' quota of the eggs of the green turtle. Eggs of other species are not collected and will not be collected in the near future. The legal basis for the protective measures provide the 'Game Ordinance' and the 'Nature Protection Ordinance', both passed in 1964. Sea turtles have their own place in the Game Ordinance, which applies to mammals, birds, sea turtles and other groups of animals, designated by a Resolution. More details are given by Schulz (1970). The 'Game Resolution', lastly amended in 1970, lists the turtles under the game species, but prohibits anyone to take, kill, possess, mutilate, sell or offer for sale any sea turtle or part of it in the area to which the Ordinance applies. The Game Resolution permits the collecting, transport and sale of eggs from May 1st to September 1st. The Bigisanti rookery is legally protected since the Wia-Wia Nature Reserve was proclaimed in 1961 in the first Resolution published under the Nature Protection Ordinance. The Galibi beaches have been declared a turtle sanctuary in 1969.

The responsibility for the Nature Reserves is committed to the Forest Service, but protective measures did not come into force before the Nature Preservation Section was created within this service in 1963. In 1963 and 1965, the first surveys were undertaken along the coast. These demonstrated that most krapé and warana nesting took place near the Marowijne estuary, and that the Bigisanti nesting beach had moved so far westward that it was situated entirely outside the boundaries of the Wia-Wia Nature Reserve. On Bigisanti poaching was a favoured pastime of the fishermen from the Commewijne district, although the number of nests had dropped considerably during the last years, due to erosion of the beach. On the first visit to the rookery, in 1964, I had the good fortune to apprehend one of the most prominent of these poachers and to confiscate his harvest. A few weeks later this former poacher was stationed on the beach as assistant game warden and since 1965 he has been in charge of all the activities concerning turtles on the Bigisanti rookery. Under the Resolution of 1966, the Wia-Wia Reserve was considerably extended and the western boundary was moved to Motkreek. In 1968, the sand had shifted so far that a few turtles were already nesting to the west of Motkreek. Since 1973, all turtle nesting is outside the Reserve. Actually the eggs laid here could be legally harvested after May 1st, were it not that the Forest Service personnel — when counting the number of nests laid each night — at the same time marks the nests. According to local customs a nest becomes the property of the person who was the first to mark it. Nevertheless, a more secure legal basis for the protection of the turtles nesting on this rapidly moving beach has to be found.

The first reconnaissances also demonstrated that the most important nesting beaches for green turtles and ridleys were in and near the Marowijne estuary, which falls outside the area to which the game law applies. The local Caribs from the villages of Langamankondre and Christiaankondre, just like in the days of Kappler and around the Second World War, collected the eggs — not restrained by law — on the Galibi beaches. On the basis of a rough estimate in the 1964 season around 3/4 million krapé and warana eggs were taken on these beaches and sold in Moengo, in the Commewijne District, and in Paramaribo. Up to 1967 nothing could be done to restrict the harvest of the eggs, which amounted to some 90% of the total production for the green turtle and even more for the ridley. On the small beach of Eilanti it is easy for a few men to take every ridley egg laid. Fishing is the main activity to provide the 2000 or so Caribs of Christiaankondre and Langamankondre — the two villages on the Marowijne estuary — with their cash income. Another source of money are these turtle eggs, which are almost exclusively collected to be sold, forming only a very minor item in the Carib diet. During the height of the turtle season, all fishing camps on the beaches are occupied, those at Eilanti by people from Christiaankondre and those on Baboensanti-Pruimenboom chiefly by people from Langamankondre. On the Galibi section the Creole lighthousekeeper and on Eilanti a Hindustani fisherman participated (and after 1969 continued to do so) in the egg collecting, which otherwise is customarily exclusively an Indian affair. Before the area was declared a turtle sanctuary, the Indians watched during the turtle season the animals' arrival at night, marked the nests and dug up the eggs the next morning. The collector kept his daily haul in a sand-pit under his camp, until enough eggs were collected to make a boat-load. Eggs were sold in Albina and sometimes in Paramaribo. Until 1969 (when this was declared unlawful), the Caribs made a few trips to the nesting beach in western French Guiana, a hazardous journey over a sharkinfested sea that not seldom ended with the capsizing of the boat and the loss of the load of eggs.

In 1968, the middlemen paid Sfl. 7.50 to Sfl. 15.00 for a thousand eggs; the price could move up to Sfl. 20.00 at the beginning and the end of the season (at that time the exchange value of Sfl. 1.00 was US $ 0.55). On the market, in the period 1964-1969, the retail price was generally Sfl. 0.10 per 3 eggs.

After the warana was identified as being the olive ridley, and it was established that Eilanti beach was the last (and only?) stronghold for this species in the Atlantic, it became clear that measures had to be taken in order to prevent the depletion of this population, both as a producer of eggs and as a group of animals threatened with extinction. Obviously a continuation of the regular taking of more than 90% of the eggs made the disappearance of the aggregation on Eilanti only a matter of time. In 1967 and 1969, P.C.H. Pritchard obtained from the World Wildlife Fund money to buy the greater part of the warana nests laid in both seasons. In 1967, a total sum of about Sfl. 2.000 was paid to buy the eggs (at a price of one cent per egg) from the collectors the morning after they were laid. The eggs were reburied in a central hatchery, but hatching results were rather poor. The next year the Caribs were paid a compensation of Sfl. 1.15 per nest, the eggs being left in the nests.

In 1969, the Galibi area was declared a Nature Reserve (Decree no. 47 of May 23rd, 1969), but it was already too late in the season to enforce the regulations. Only the last few hundreds of the warana nests were left to hatch. From 1970 on a complete ban on the collecting of warana eggs was enforced and every year a quota was fixed for the number of green turtle nests allowed to be taken on the beaches of the Nature Reserve. Why the Forest Service, the authority which supervises the Nature Reserves of the country, authorizes the harvest of part of the green turtle eggs in a Nature Reserve, is discussed below. (Pl. 25 figs. 43-44).

The conservation measures as they now are taken, were only effectuated after several years of meeting with resistance, both from the local Caribs and from some officials in Albina and Paramaribo. The situation suffered from ignorance both on our side and on that of the Caribs and — more important — from political intrigues. The 'turtle affair' was even made an issue in electoral tactics in 1969-1970. Kloos (1971: 251) revealed that (in 1970): "The driving force behind political mobilization (of the Maroni Caribs) was the frustration experienced with the Galibi Reservation". Our first official meeting with the Galibi Caribs took place in Christiaankondre in February 1967. By our standards the compensation offered was reasonable, the Caribs receiving more money for the eggs than they did previously (taking into account that they did not have to transport the eggs to Albina). Nevertheless, several Caribs did not agree with the project and its basic premises. Some challenged our starting-point, that the number of warana's was diminishing, and believed that the turtles were merely changing nesting beaches. (The following years, alas, our viewpoint was confirmed: the warana's had not moved to other beaches and their numbers went down alarmingly; see Table 17).

I had the feeling that the aversion of the Caribs to the project went much deeper than the complaint that the compensation sum was too low, and that the Caribs simply did not like this interference with what they considered their territory. This was confirmed by Kloos, who devoted a separate section in his anthropological study of the Maroni River Caribs to the 'turtle project' (1971: 238-242). He was convinced that for the Caribs much more was at stake than money: there was the issue of their freedom, which they felt was threatened. Kloos agreed that, although only a small minority of the Caribs from one of the two villages was directly involved in the egg collecting, the conservation measures became an issue for all Caribs. This was not very evident during 1967, when there were no serious troubles. However, when conservation measures became more ambitious and definite, resistance grew and came to light, culminating in the threat of real trouble in 1969, when the nesting beaches were declared a Nature Reserve. In 1967-1970, several meetings were held with the Caribs, some of which took a rather hostile turn, although 'stating open disagreement is uncongenial to most Caribs' (Kloos, 1971: 241). For instance, during a village meeting, wild statements were made to the effect that the newly built house at Eilanti would be burnt down (Kloos, 1971: 241). At last the Caribs gave in and yielded to the official conservation regulations, which consisted of a complete ban on the collecting of olive ridley and leatherback eggs and a limitation of the harvest of green turtle nests. Kloos gives the following explanation of the attitude of the Caribs and the misinterpretation of this attitude by the officials (including myself?): "The Caribs gave in, but the preservation envisaged by the officials was irreconcilable with the Carib conception of freedom, and there was no compromise possible. But, as the Caribs and their leaders repeatedly yielded to the pressure from the officials, this problem did not present itself clearly. The Caribs showed a friendly face to the outside, and grumbled when they were amongst themselves. Secondly, many Caribs felt that the Chiefs did not handle the case adequately. But again, the structure of society and its values prevented this from becoming obvious to the outside world".

Whatever the explanation may be, since 1970 the Caribs have not resisted the regulations and — with the exception of a few cases of poaching — have stuck loyally to the restrictions set for the number of eggs to be harvested. It is our hope that we will be allowed to continue unobstructed with the conservation programme on the Galibi beaches and that the concrete results will lead the Caribs to believe that a proper exploitation of the eggs in the long run is for their own benefit.

Since 1970, the Forest Service has complete authority to prohibit egg-taking in the Galibi Nature Reserve, as has been the case in the Bigisanti rookery since 1964. However, on Galibi this has been enforced for the leatherback and ridley eggs only. In view of the continuing decline of the egg-laying of the ridley, there seems to be no prospect that this ban can be lifted in the near future. The universal survival situation of the leatherback necessitates the continuation of a complete protection of this species on our beaches.

Only of green turtle the harvest of some of the eggs is allowed. The first reason for this decision is the intention to attempt at a rational exploitation of the eggs, on a sustained-yield basis, as a cheap part of the protein diet of the population. Apart from this, an abrupt, total ban on the collecting of eggs of all species probably would have met with such strong resistance, both from the side of the egg collectors and from the consumers, that it could have jeopardized the whole project from the start.

TABLE XXV

Fate of green turtle eggs on Surinam beaches, 1970-1973.

		1970	1971	1972	1973
total nr. of eggs laid	Bigisanti	116,000	131,000	149,000	142,000
	Galibi	307,000	663,000	790,000	752,000
nr. of eggs mislaid[1]	Bigisanti	33,000	36,000	29,000	40,000
	Galibi	ca.120,000	ca.200,000	ca.330,000	ca.350,000
nr. of eggs transplanted	Bigisanti	32,000	35,000	29,000	40,000
	Galibi	8,800	45,000	40,000	25,000
nr. of eggs removed for consumption (Galibi)		260,000	417,000	430,000	540,000
total nr. of eggs available for hatching (Bi. + Gal.)		162,000	370,000	510,000	350,000

1) destroyed by tide, if not removed

As shown in Table 25, in 1970-1973 around 1.6 million green turtle eggs were allowed to be harvested, which represent 73% of the eggs laid on the Galibi beaches (50% of the total of around 3 million green turtle eggs laid in Surinam). The major part of these eggs was removed from beach sections where nests were endangered by erosion or were laid below high-tide level. The gradual increase of the annual quota was based on the increase of egg-laying (see also Table 17A).

The details of the harvest and the sale of green turtle eggs on Galibi are as follows. During the first weeks of the season only nests endangered by erosion are removed. On the basis of the daily counts during this period the expected production of eggs during the current year is estimated and the quota of the harvest is fixed. As the majority of these nests are found on the beach sections in erosion (marked on Map 3), relatively few nests on the 'good' sections have to be 'sacrified' (with special permission of the game wardens). The eggs are collected exclusively by Maroni Caribs, who are paid Sfl 15 per 1000 eggs on the beach for their labour (not for the eggs which are legally the property of the Government since the area was declared a Reserve). This amount equals double the average sum the middlemen formerly paid the Caribs in Albina. Once a week the eggs are transported by boat to Albina and from there to Paramaribo, where the eggs are sold at a price of Sfl. 30 per 1000 to the market merchants, who are understood to keep the retail price below Sfl. 0.06 per egg.

The organisation is in the hands of the Surinam Foundation for Nature Preservation (STINASU), an organisation with the purpose to stimulate, coordinate and finance the scientific exploration of the Nature Reserves and to stimulate public awareness of nature preservation. That despite the reasonable pay the Caribs receive and the relatively low retail prices, a substantial profit on the turtle eggs is made by the Foundation (Sfl. 7.000 in 1973 and Sfl. 11.000 in 1974), we owe to the Army, which assists on the beach with a platoon and which transports the eggs at no costs from Albina to Paramaribo. The profits are returned to the turtle project, allowing the Foundation to contribute to the costs of patrolling and research at Galibi and Wia-Wia. Revenues also come from tourists visiting the beaches. Rotary Paramaribo and the World Wildlife Fund (Netherlands National Appeal) contributed to the present activities by donations through the Foundation. (Pl. 28 fig. 49).

It is evident that the weak point in the scheme is the arbitrariness of the fixation of the quota. We know the feeding grounds and the migration route of the green turtle population nesting in Surinam. We have a good estimate of the average number of eggs produced per annum by a mature female and of the number of hatchlings that every year crawl to the sea. But actually we have no idea about the age distribution, the total reproduction of the population, the duration of life, the dispersion and other information on which an optimal-yield exploitation of the eggs should be based. And even if we could establish how many hatchlings are required to produce one mature female and how many eggs one female produces during her lifetime, there are no quantitative data available on mortality (including the catches in Brazilian waters).

TABLE XXVI

Fate of eggs on Surinam beaches, 1971-1973.

	1 9 7 1			1 9 7 2			1 9 7 3		
	green turtle	leather-back**	ridley	green turtle	leather-back**	ridley	green turtle	leather-back**	ridley
nr. of eggs laid	794,000	24,000	185,000	950,000	36,000	147,500	894,000	75,000	103,000
nr. of eggs mislaid	± 236,000	11,000	28,000	± 360,000	16,000	15,000	± 390,000	28,000	4,500
nr. of eggs removed for consumption	417,000	0	0	430,000	0	0	540,000	0	0
nr. of eggs transplanted	80,000	10,000	26,000	70,000	15,000	13,000	65,000	24,500	4,000
total no. of eggs, available for hatching	370,000	23,000	183,000	510,000	35,000	145,500	350,000	71,500	102,500
estimated nr. of hatchlings that went to sea*	270,000	7,500	100,000	380,000	11,000	85,000	260,000	24,000	60,000

* cf Tables 21 and 22   ** small deformed eggs excluded

So there is no answer to this basic problem of conservation, the problem of optimal yield: to what extent can the population nesting in Surinam be exploited for its eggs, maintain itself within a certain size range and at the same time yield a reasonably high production of eggs. The problem becomes practically unsoluble due to the fact that the population is also subjected to the capture of mature turtles in Brazilian waters (on which we are unable to exert even the slightest influence). There being no possibility of predicting the effect upon the population of the harvest of a certain amount of eggs, we can but do our best to continue with closely following the annual number of green turtle nests and to try to adjust the annual egg quota to this trend. The future will learn whether in this way it will be possible to balance the number of young turtles drowned in the nets of the rapidly growing number of shrimp trawlers and the catch of adults by Brazilian turtle catchers.

For the ridley I fear that we already are too late and that the downward spiral can not be reversed.

Besides their task of preventing poaching and taking data on the numbers of turtles, the wardens have an important active role in conservation by transplanting nests endangered by tide wash and beach erosion. Since 1964, around half a million eggs have been moved to safety. Formerly they were brought to central hatcheries, but now — as was explained in the section on artificial nests in Chapter VII — a nest is moved to the nearest suitable site on the beach platform or put in styrofoam incubation boxes. Hatching success, which has already improved considerably since, in 1964, transplanting experiments started on Bigisanti, will have to be raised further by devising better techniques. Tables 26 gives the numbers of eggs transplanted in 1971-1973. (Plate 26 figs. 45, 46).

A few years ago, we contemplated starting research into a method to circumvent predation on the hatchlings near the shore, by means of releasing baby turtles in deeper water after allowing them time to grow harder shells in holding tanks. This idea has been abandoned since members of the Marine Turtle Specialist Group (IUCN, 1971) agreed that turtle protection should concentrate on allowing the young turtles to follow as natural a life cycle as possible, thus allowing them to run down the beach into the sea without keeping them in tanks for prolonged periods of time.

But whether in times to come there will be turtle hatchlings running down to the sea, solely depends upon the speed at which mankind becomes aware of the fact that he must live in balance with his environment.

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EXPLANATION OF THE PLATES

Plate 1

Fig. 1. Left and below: green turtle (*Chelonia mydas*), dorsal view of a supposedly 1½-2 years old specimen, caught in the Surinam River estuary. Carapace (length 35 cm) with epidermal shield showing handsome pattern of youth. A piece has been bitten out of the right marginals. Note single pair of pre-frontals (pf). Above: olive ridley (*Lepidochelys olivacea*); carapace of full-grown female specimen. Note 8 (or 9?) vertebral and 8 pairs of costal scutes.

Plate 2

Fig. 2. Head of male olive ridley; two pairs of prefrontals (pf); ch= choanae.

Fig. 3. Carapace of male olive ridley (*Lepidochelys olivacea*) on Eilanti, showing 7 vertebral and 8 + 6 costal scutes. The supracaudals (posterior marginals) are only partially visible. Note the shape of the carapace, almost as broad as it is long. A metal tag is visible on the left fore flipper.

Plate 3

Fig. 4. Hawksbill (*Eretmochelys imbricata*), female, on Bigisanti. Note 5 vertebrals, 4 pairs of costals, and overlapping scutes with barely visible pattern. — Polishing gives the well known 'tortoise shell'. On the carapace are two barnacles, which are common on hawksbills.

Fig. 5. Head of female green turtle (*Chelonia mydas*), on Eilanti. Note the 2 choanae and the horny jaws.

Plate 4

Fig. 6. Plastron of female olive ridley (*Lepidochelys olivacea*), on Eilanti. The epidermal shield cover consists of 4 inframarginals with pores (p), gular (g), humeral (h), abdominal (a), femoral (f) and anal (an). Photo P. C. H. Pritchard.

Fig. 7. Head of female hawksbill (*Eretmochelys imbricata*), on Bigisanti. Noticeable is the horny, parrot-beak shaped upper jaw. The head seems to be more retractable than in other sea turtles. Two pairs of prefrontals (pf).

Plate 5

Fig. 8. The muscular tail of a male green turtle (*Chelonia mydas*), stuck in the mud on Eilanti at ebb tide.

Fig. 9. Head of female leatherback turtle (*Dermochelys coriacea*).

Plate 6

Fig. 10. A leatherback (*Dermochelys coriacea*) lumbers ashore at sunset on Bigisanti beach.

Plate 7

Fig. 11. Newly-hatched green turtle (*Chelonia mydas*). Note the white edges along the fore flippers and the carapace margin; e.t. = caruncle or 'egg-tooth', which develops just before hatching. When held like this, the turtles makes swimming motions with its fore flippers.

Fig. 12. Young leatherbacks (*Dermochelys coriacea*), just emerged, on their way to the sea. Visible are the rows of scales on their back.

Plate 8

Fig. 13. Just emerged from the nest, this green turtle (*Chelonia mydas*) hatchling is on its way to the sea. Note the 5 vertebrals and 4 pairs of costals.

Fig. 14. The narrow, severely eroded Pruimenboom beach in the Galibi Reserve (see Map 3). In the background the French Guiana side of the Marowijne River. There is no beach above the high tide wash and the green turtle nests that are laid in large numbers at the foot of the one metre high cliff would be lost, where it not that the eggs are collected for sale or removed to the hatchery. The sea is cutting into an old sand ridge (representing a former coast line) and constant erosion undercuts the background vegetation which mainly consists of awara palms (*Astrocaryum vulgare*).

Plate 9

Fig. 15. Aerial photo of Eilanti (Galibi Reserve), and surroundings, September 1966. From the situation in 1948, it appears that the sand spit moved a distance of 1 km westward in 18 years. The coastline moved inland, as indicated by the 3 "eastern" arrows. The "westerly"-situated arrows mark sand bars, the western points having become spits. 'X' marks the place where, in 1964-1973, the 'arribada's' of the ridley occurred. 'D' is Dap beach — a former sand spit, now enclosed in clay deposits — where large numbers of green turtles come to nest. The Baboen Kreek follows a small sandridge which marks a former coastline of some 50 years ago. To the W of Eilanti begins the Lobin beach, where turtles seldom nest. The Lobin mudbank in front of this beach can be clearly seen. Photo K. L. M. Aerocarto, reproduced with permission of the Central Bureau for Aerial Mapping (C. B. L.).

Plate 10

Fig. 16. Aerial view of Eilanti sand spit at ebb tide with to the left the Forest Service camp and hatchery (1970). Note camps of Carib fishermen. Behind the spit, the former coast line (marked by older mangrove) which continues to the right as Lobin beach.

Plate 11

Fig. 17. Track of a green turtle (*Chelonia mydas*), which had to find her way back at ebb tide to the sea across the exposed mud bank in front of Eilanti beach.

Fig. 18. Aerial photo taken near Mot Kreek, the border of the Wia-Wia Nature Reserve in January 1966, when the beach was washed away and the camp had to be moved to a safer location (Pl. 12 fig. 20). The photograph illustrates the process of movement of sand in a westerly direction along the coast, described in chapter III. 'Vloed' = flood; 'oude rits' and 'rits in afslag' = old sand ridge (old beach), ridge in erosion; 'dieptelijnen' = depth contours; 'golffronten' = wave fronts; 'voorplantings-richting' = direction of propagation of waves; 'N' = nett transport of sand.

Plate 12

Fig. 19. Aerial view of sandy beach in erosion, near what was the eastern limit of Bigisanti in 1964. Note the flood cliff to the left and to the right of the photo and the small dunes covered with *Sesuvium portulacastrum,* fixing the loose sand. The beach is backed by a lagoon, with the black mangrove, *Avicennia nitida.*

Fig. 20. Aerial photo of location of Bigisanti camp (August 1970). In 1966-1968, this camp was located in the centre of the part of the beach where the main nesting activity took place (c.f. Map 5). In September 1970, because of beach erosion and — consequently — westward movement of the nesting activity, the camp had to be moved again.

Plate 13

Figs. 21, 22. Aerial view of Krofajapasi Kreek (W of Wia-Wia Nature Reserve, see Map 5) in respectively 1964 and 1970, after the formation of an extensive sand spit which represents the sand deposits removed from Bigisanti beach. In 1973 the majority of the turtles nested on this spit.

Plate 14

Fig. 23. W end of Krofajapasi sand spit (August 1970), where in 1973 several turtles were seen making 'orientation circles' on their return to the sea, probably because they had difficulties in distinguishing between the seaward and the 'landward' horizon, the latter being formed by only a few dead trees bordering the lagoon behind the creek.

Fig. 24. Relatively high flood cliff on the beach at Bigisanti. The profile of a round-topped ridge can easily be broken by spring tides. This is followed by erosion of the foreshore, more sand being washed away than can be brought in, while the top of the ridge remains at its old level. A flood cliff develops between the lowering foreshore and the beach platform, the latter being gradually undermined and eaten away. Buried driftwood is uncovered and this, together with the flood cliff, can be a formidable obstacle for the turtles to climb. Leatherbacks often nest at the bottom of the flood cliff. A green turtle climbed the cliff (right); at the left, the trail back to the sea. Note in the background the small sand dunes with sea purslane, *Sesuvium portulacastrum.*

Plate 15

Fig. 25. Cross-sections of nesting beaches: A — Eilanti, main nesting place of the olive ridley (*Lepidochelys olivacea*). B-E — Bigisanti. In profile B, the change that took place in 8 months is indicated; such erosion may occur in as little as one month and can be the reason for high nest losses. N = nesting beach; N' = sometimes used as a nesting beach, the nests here will be lost at next spring tide. ET = ebb tide level; MHT = mean high tide level; FC = flood cliff; ST = spring tide.

Plate 16

Fig. 26. Green turtle (*Chelonia mydas*), making abortive attempts to climb a high, steep flood cliff on the Krofajapasi sand spit.

Figs. 27. Mating green turtles (*Chelonia mydas*) in the mouth of the Marowijne River, in front of the Galibi nesting beach. Photograph Petra Kop.

Plate 17

Figs. 28, 29. Green turtle (*Chelonia mydas*) digging nest hole. Above: with the rear of the body somewhat turned to the left, the right hind flipper is pushed as far as possible into the hole. Below: sand is deposited to the right of nest hole, rear of body having moved to the right.

Plate 18

Fig. 30. An egg drops from cloaca into the egg hole. The white, slime-coated eggs have a leathery shell and show a dent that disappears after a few days because of moisture absorption.

Fig. 31. Green turtle (*Chelonia mydas*), busy pushing sand into the egg hole.

Plate 19

Fig. 32. Green turtle (*Chelonia mydas*), female, returning to sea. Land propulsion involves alternating movement of the front and the hind flippers.

Fig. 33. Ridleys (*Lepidochelys olivacea*) at Eilanti during an 'arribada'; a constant coming and going of animals that must nest and return to the sea. They are not distracted by the Carib egg takers who previously often caught the eggs as they fell from the cloaca. Photo P. C. H. Pritchard.

Plate 20

Fig. 34. Ridley (*Lepidochelys olivacea*) covering the nest by pounding the sand, a stereotype manoeuvre characteristic of the genus *Lepidochelys*. With the front flippers braced in the sand and the body heaved up, the sand over the nest site — drawn over the nest with the hind flippers — is pounded down with a side to side rocking movement.

Fig. 35. Bigisanti: ridley (*Lepidochelys olivacea*) busy sweeping sand and shells over her nest with strong strokes of the flippers. Mostly one fore flipper moves in conjunction with the opposite hind flipper.

Plate 21

Fig. 36. Leatherback (*Dermochelys coriacea*) on Bigisanti during oviposition. A little sand has been cleared away to show the nest cavity. In this case neither one of the flippers hangs in the cavity, nor do the flippers overlap, as often happens.

Plate 22

Fig. 37. A leatherback (*Dermochelys coriacea*) sand-sweeping after covering her nest on Eilanti, where this species only nests very rarely. Photo P. C. H. Pritchard.

Fig. 38. A green turtle (*Chelonia mydas*) hatchling breaks through the egg shell.

Plate 23

Fig. 39. A green turtle (*Chelonia mydas*), while running its long gauntlet of obstructions and predators from the nest to the sea, has fallen in a bump in the sand, where it has lost sight of its goal. Nevertheless, the hatchling continues the direct course it had taken to the water line.

Fig. 40. Probably the most destructive agent to turtle nests on the Surinam beach is the ghost crab (*Ocypode quadrata*) which burrows down to nests. Some lie in wait at night for the hatchlings to emerge from the nest; the crab usually pecks the eyes out first, and then may drag the hatchling into its burrow in the sand to devour it at leisure. Conservation measures taken on Bigisanti beach, where the crabs abound, include protection of nests (especially of the shallow ridley nests) with wire cages.

Plate 24

Fig. 41. 'D'-day on Eilanti beach, Galibi Reserve. Hundreds of hatchling ridleys (*Lepidochelys olivacea*) flock unerringly to the water's edge.

Fig. 42. A ridley (*Lepidochelys olivacea*) hatchling has reached the water line where it is alternately lifted and stranded by the coming and going of the wave wash. It will soon reach the surf by swimming away from the land with vigorous 'birdwing' movements of the fore flippers.

Plate 25

Fig. 43. A Carib Indian burying his daily haul of ridley (*Lepidochelys olivacea*) eggs in a sand pit under his fishing camp at Eilanti beach, where the eggs are kept until they make a boat-load. Since 1970 collecting of ridley eggs has been strictly forbidden. Photo P. C. H. Pritchard.

Fig. 44. A Carib walking along Eilanti beach with a basket-load of turtle eggs. He is carrying his probing stick, used to locate the egg cavity.

Plate 26

Fig. 45. Hatchery at Krofajapasi (Bigisanti beach); since 1973 most transplanted egg-clutches are incubated in styrofoam boxes.

Fig. 46 With satisfaction the game warden of Bigisanti beach watches the daily hatch of baby turtles from his hatchery crawl down the beach (normally the hatchlings are taken to the water line during the night).

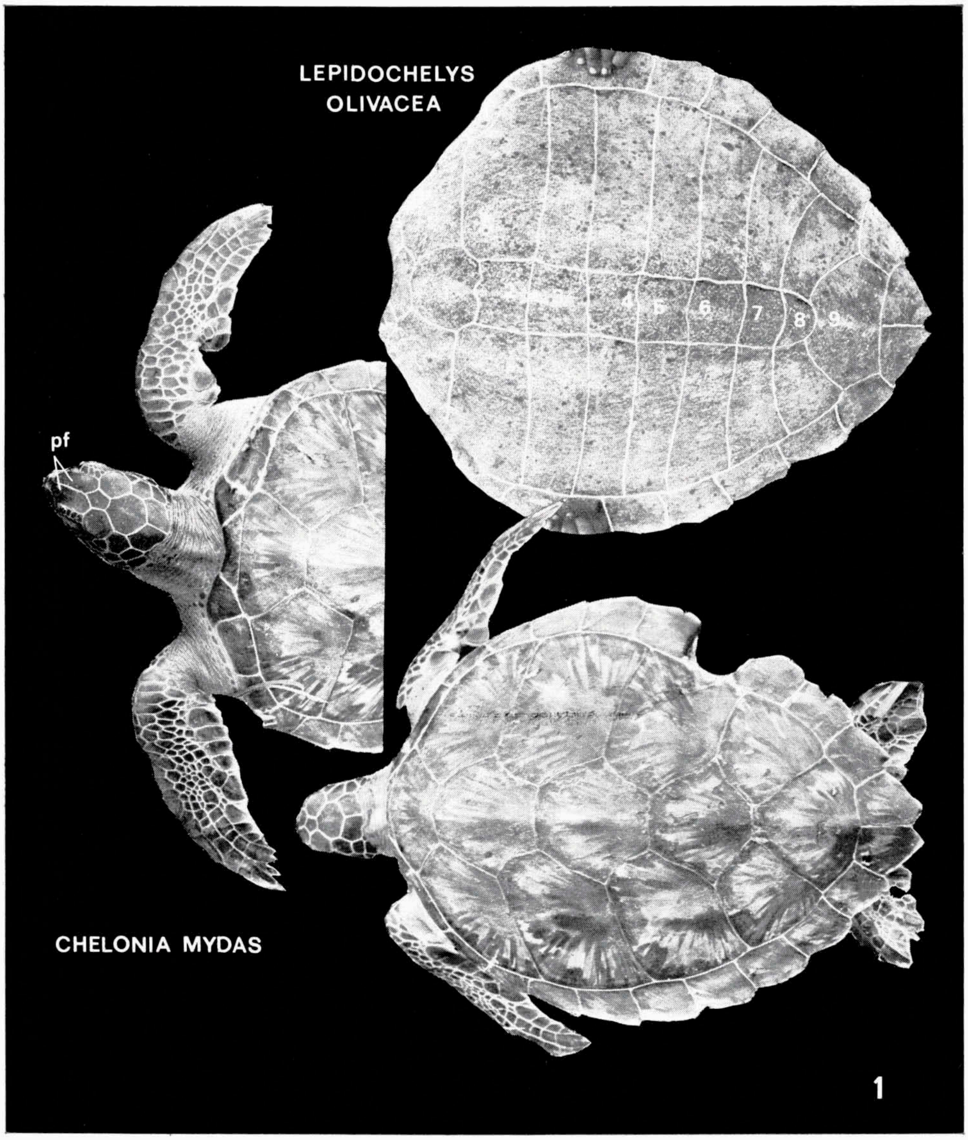
Plate 27

Figs. 47, 48. In 1966-1973, around 7000 turtles have been tagged on the Surinam nesting beaches. Above: Russ L. Hill, tagging a leatherback turtle

(*Dermochelys coriacea*) on Bigisanti beach. Below: with the applicator plier, a numbered, metal cattle-ear tag is clipped to the trailing edge of one of the front flippers of a ridley (*Lepidochelys coriacea*).

Plate 28

Fig. 49. Game warden, students, visitors and soldiers at Eilanti take an 'evening stroll' along the beach, as it lies in wait for an 'arribada'. At the moment, the extensive mudbank is exposed at low water, but soon, when the water reaches the beach, the ridleys (*Lepidochelys coriacea*) will begin to come. Carib fishermen's boats lie stranded on the mud.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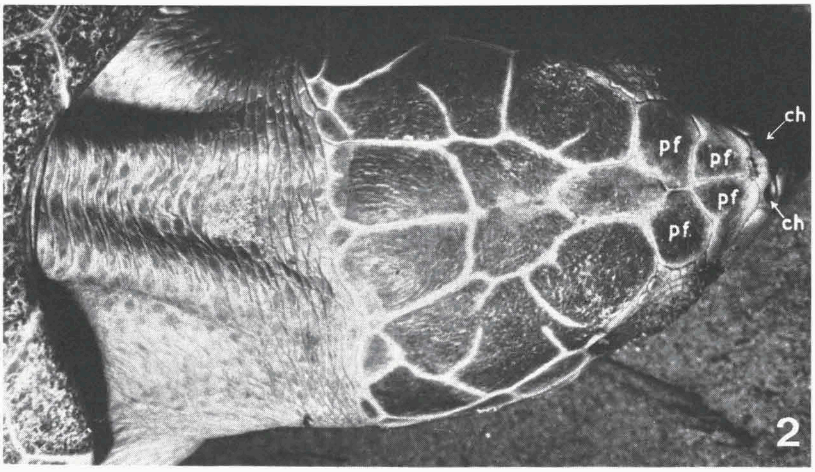
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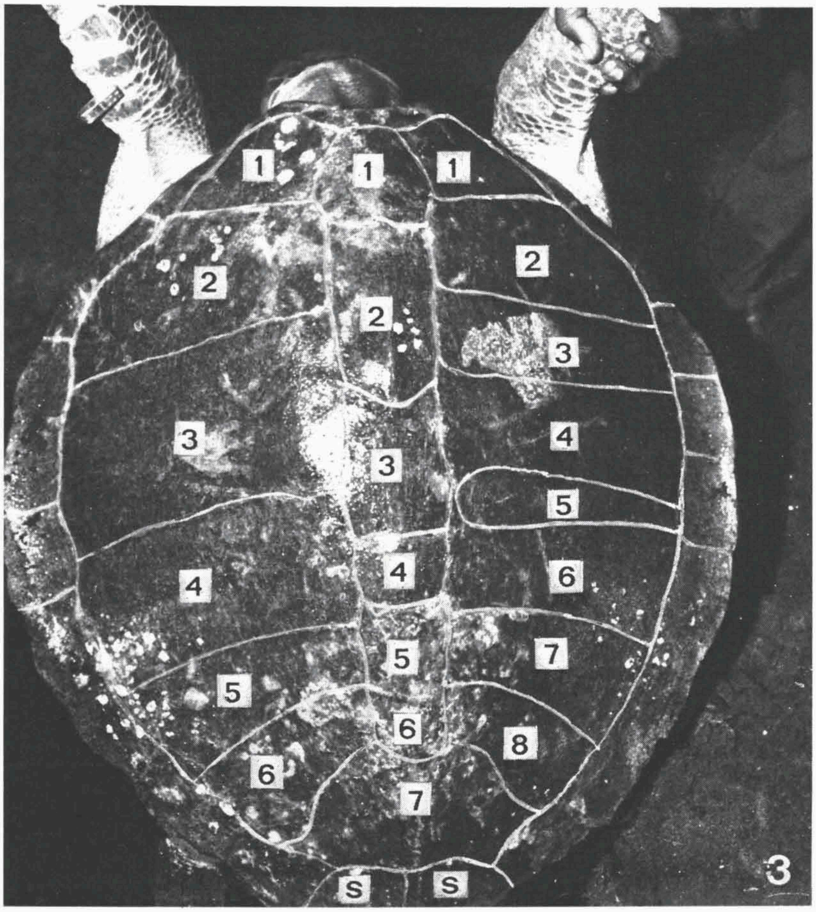
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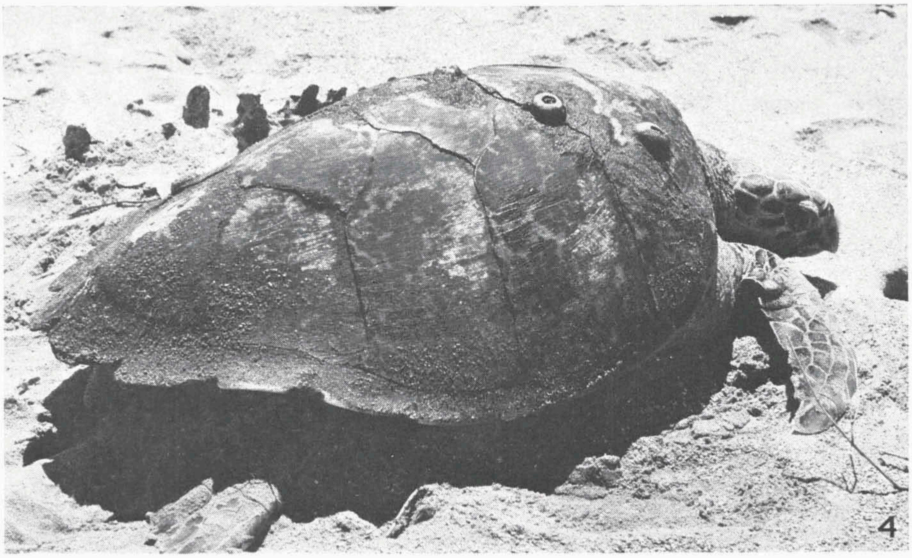

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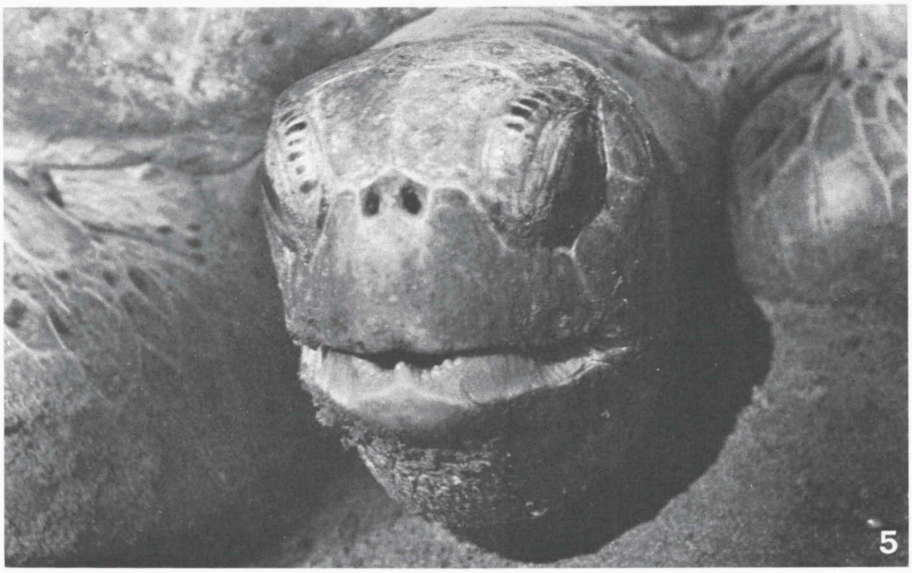

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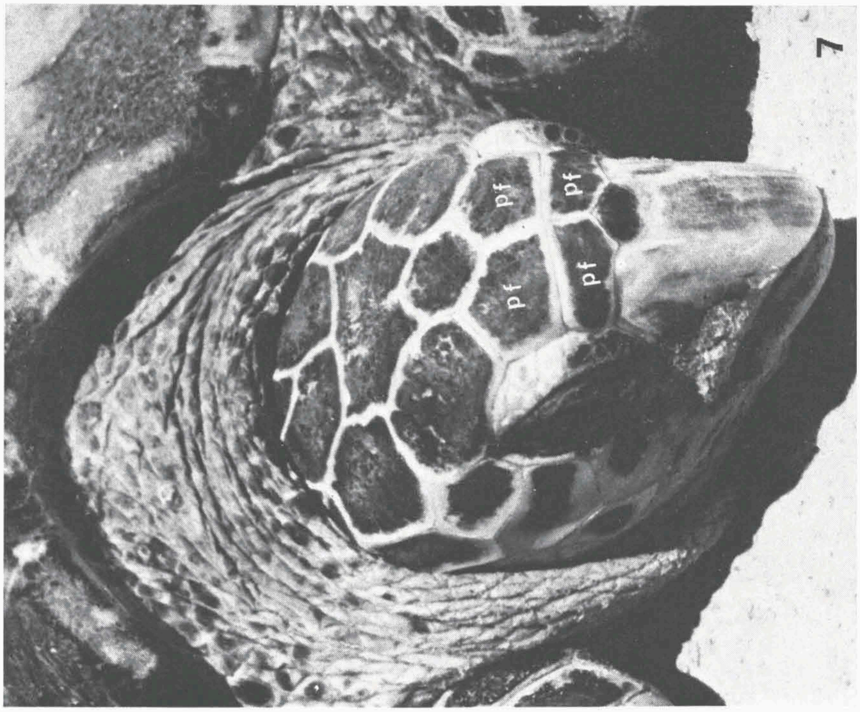
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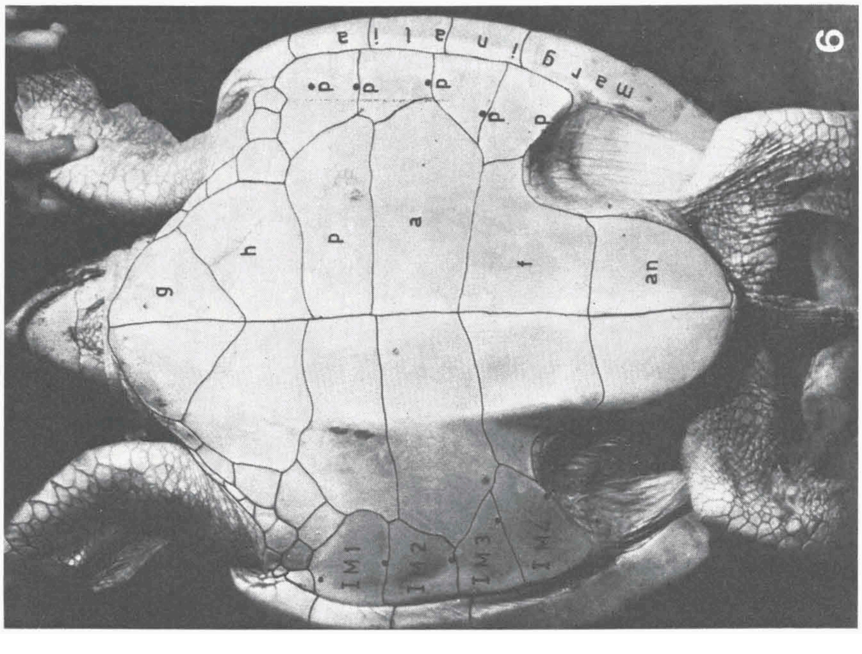
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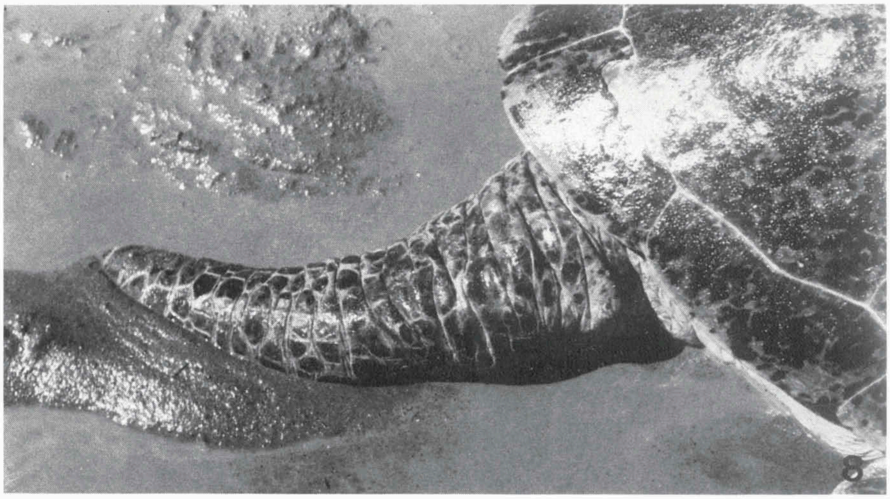

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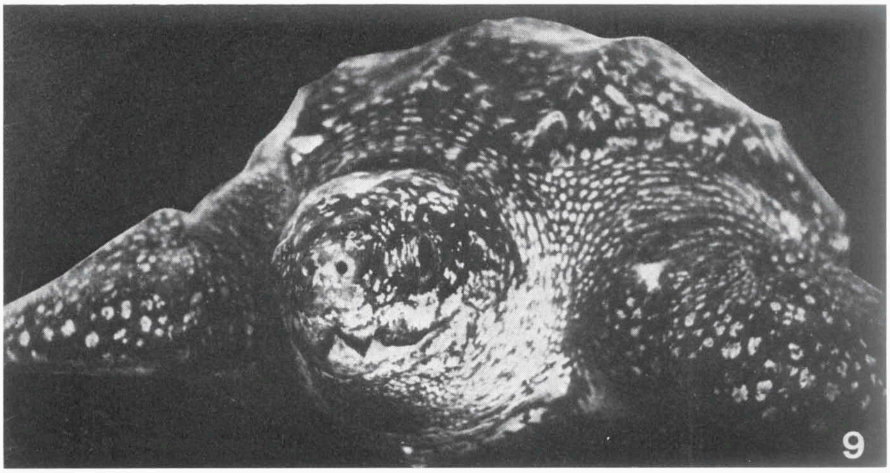

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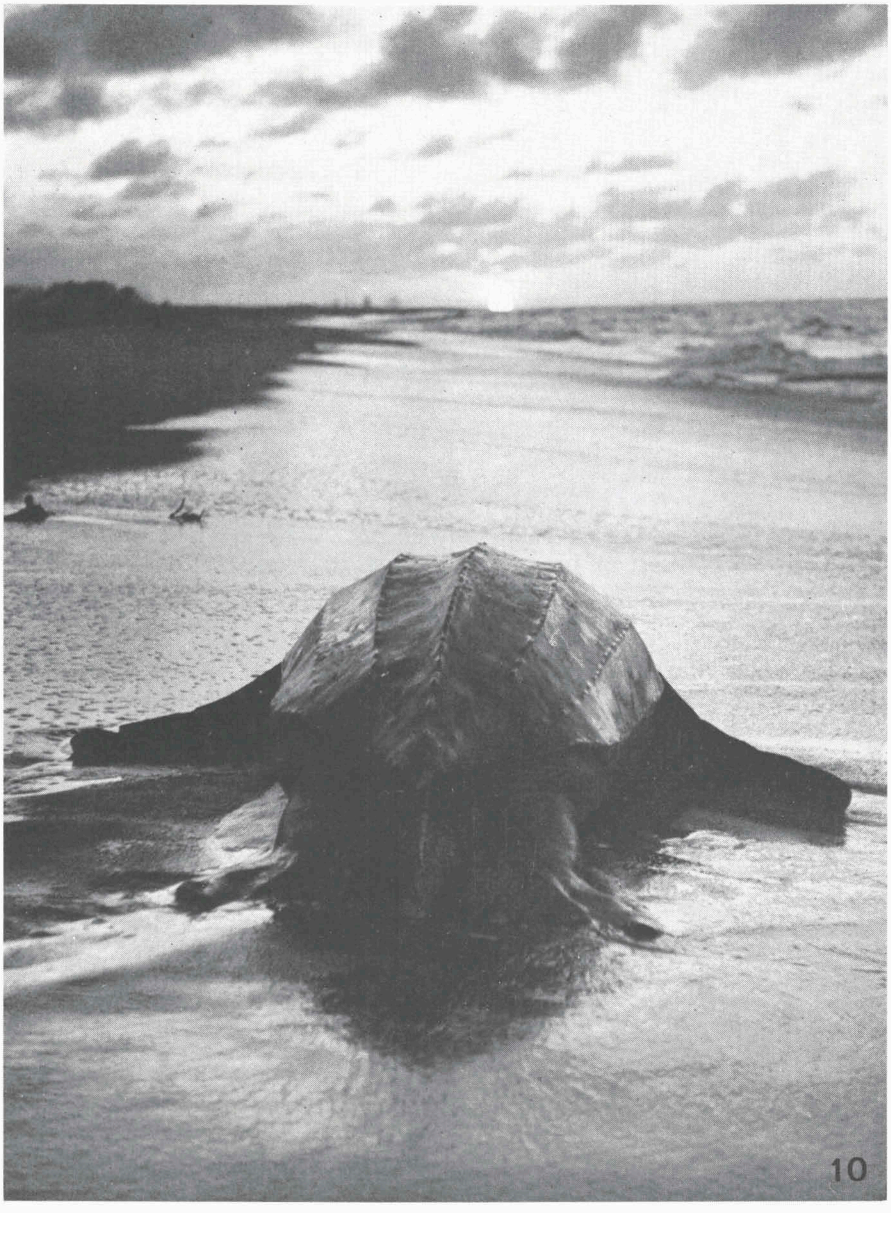

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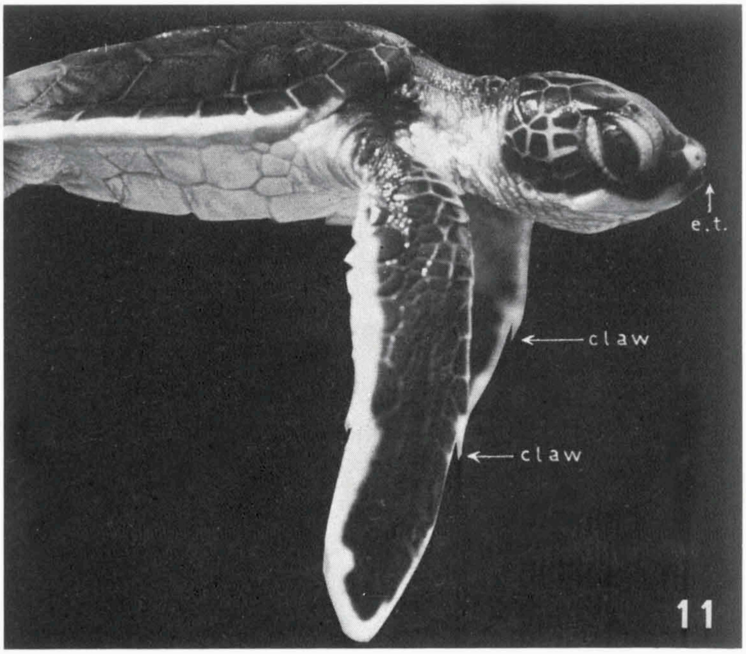
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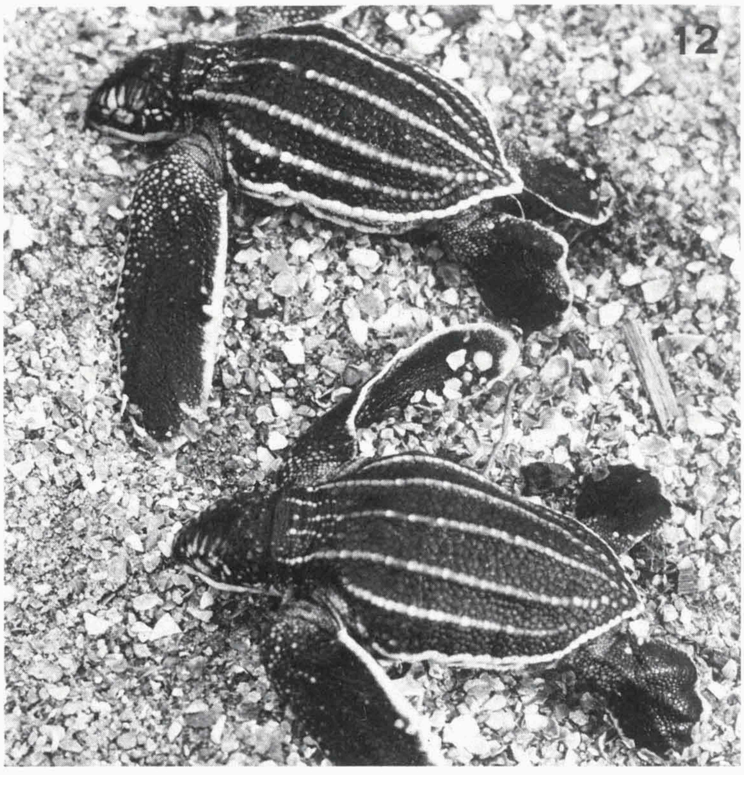
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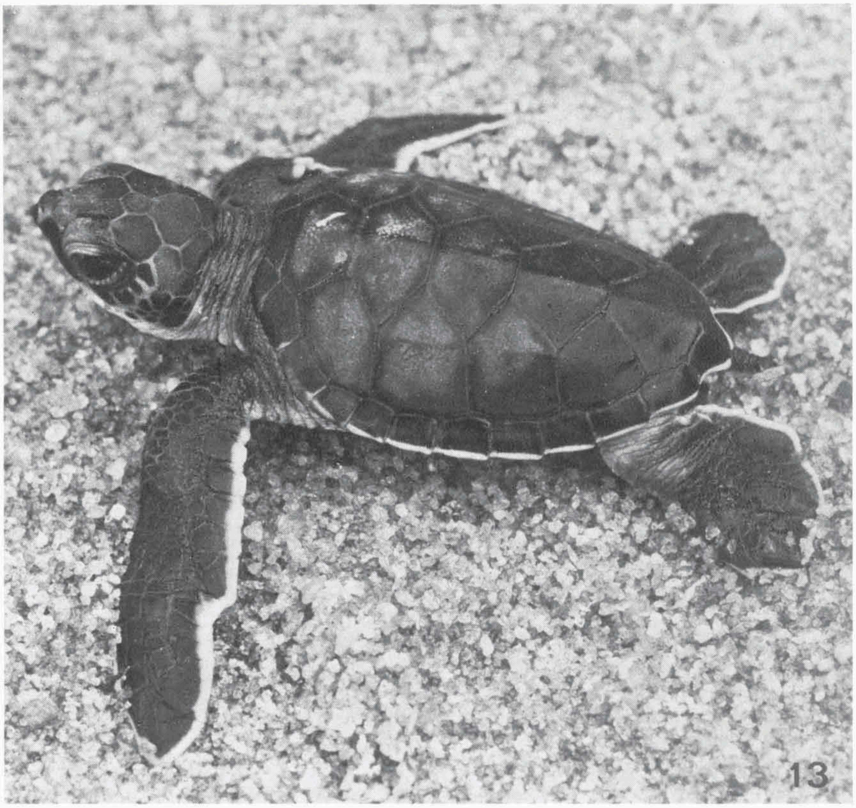

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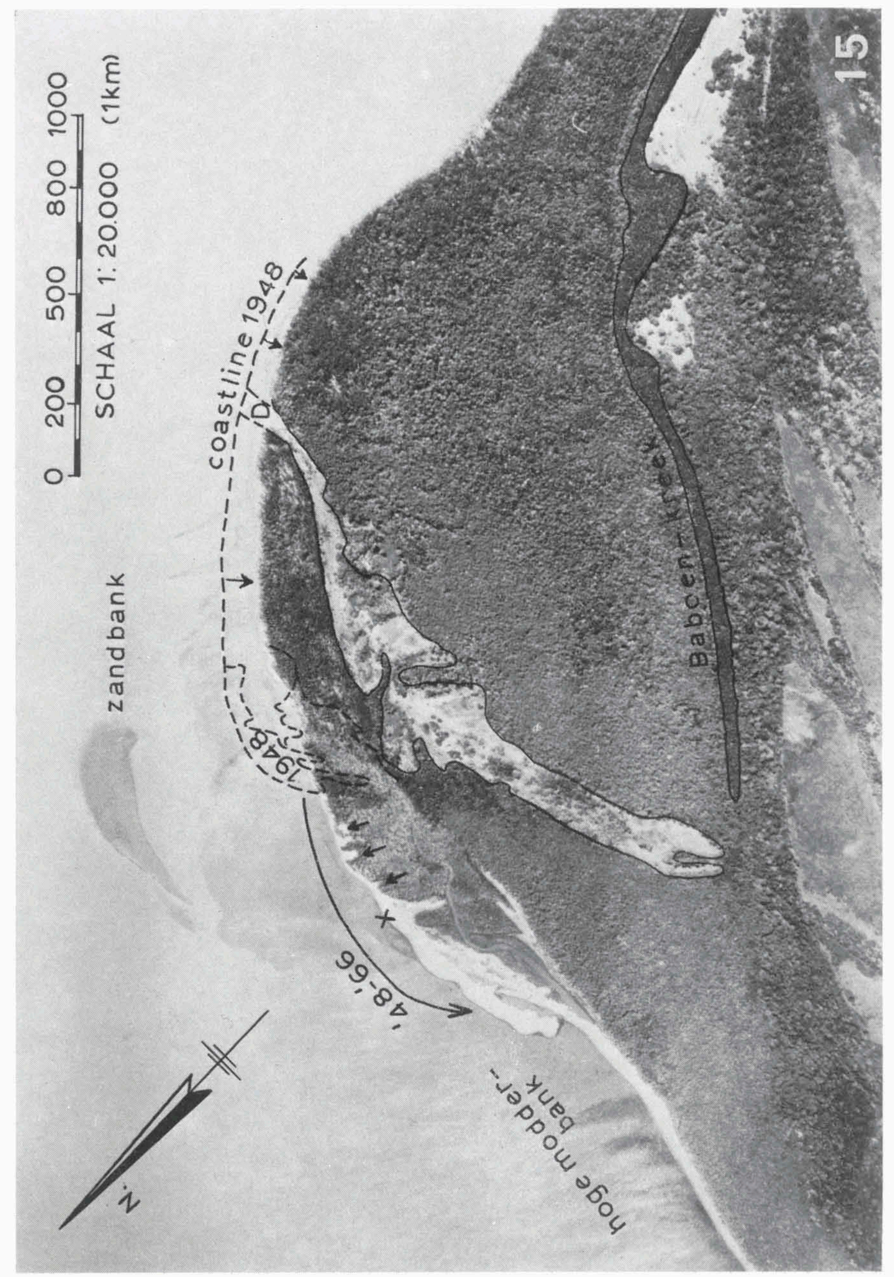
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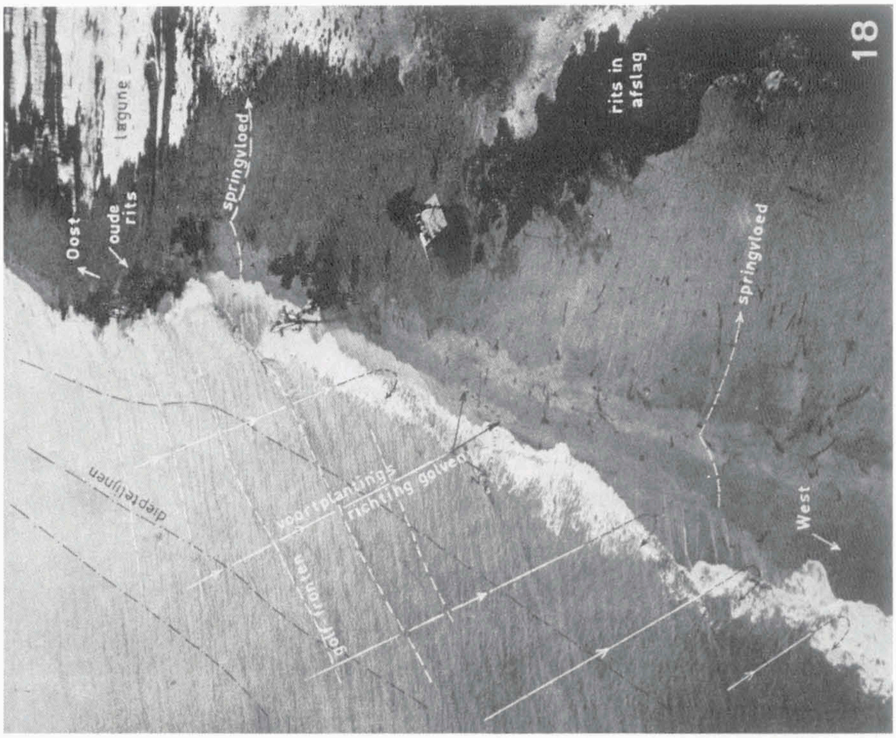
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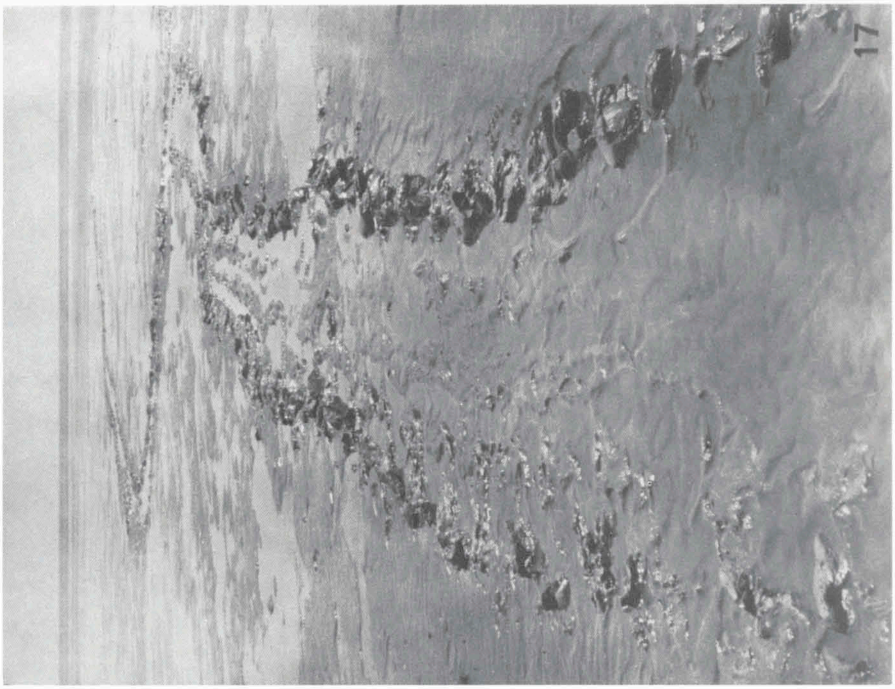

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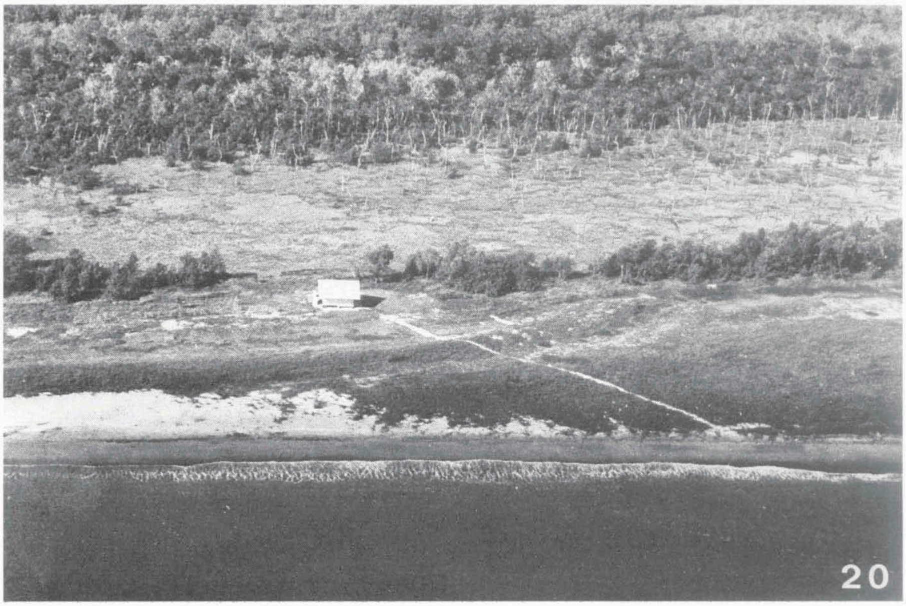

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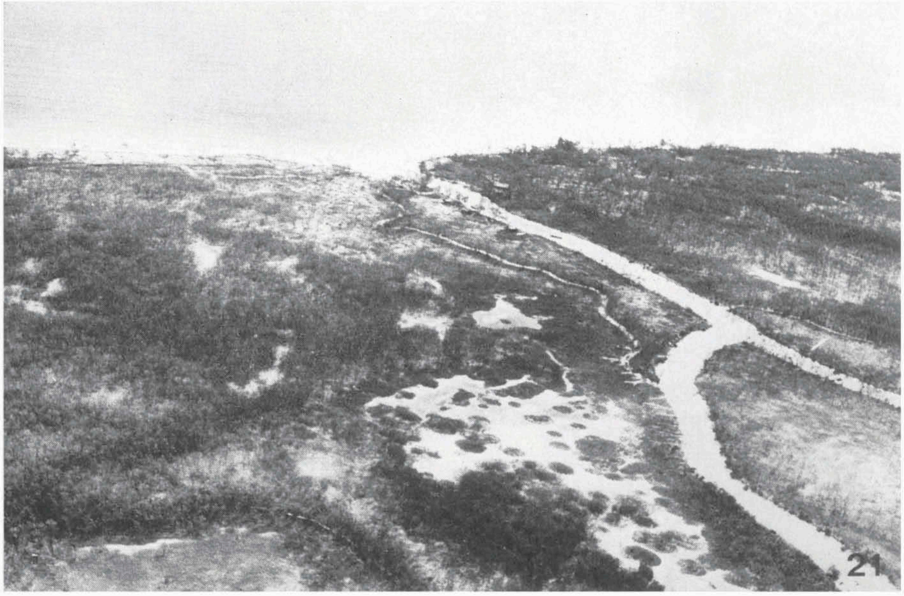

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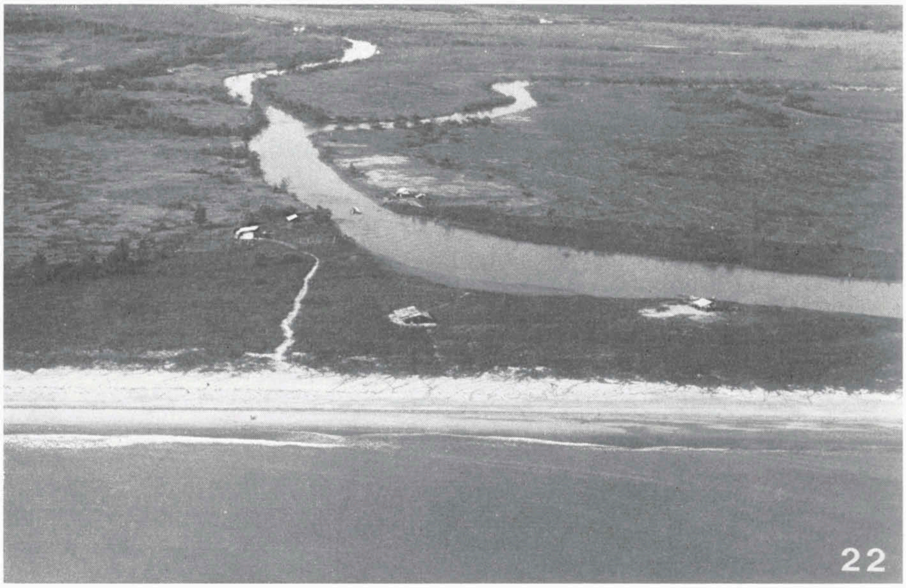

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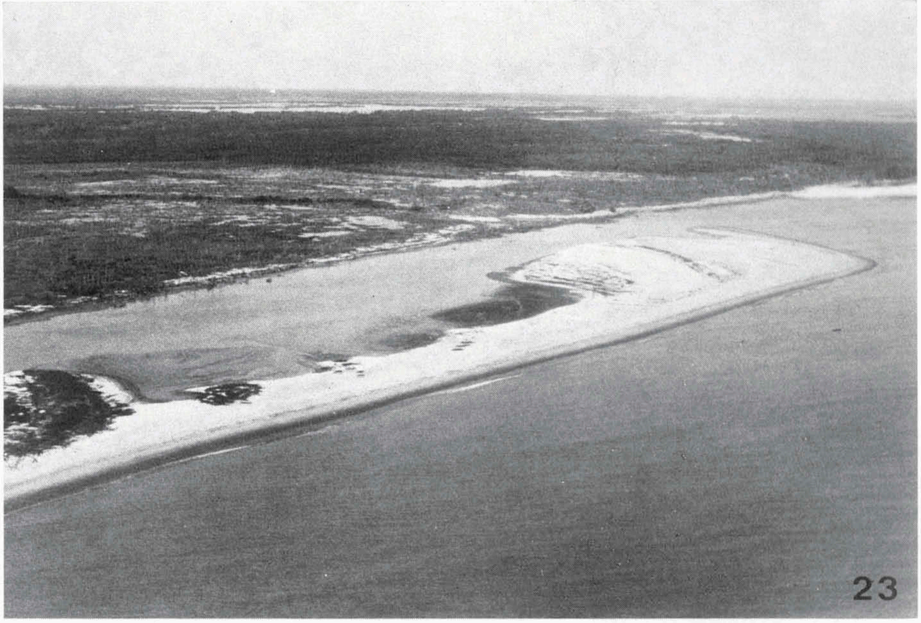

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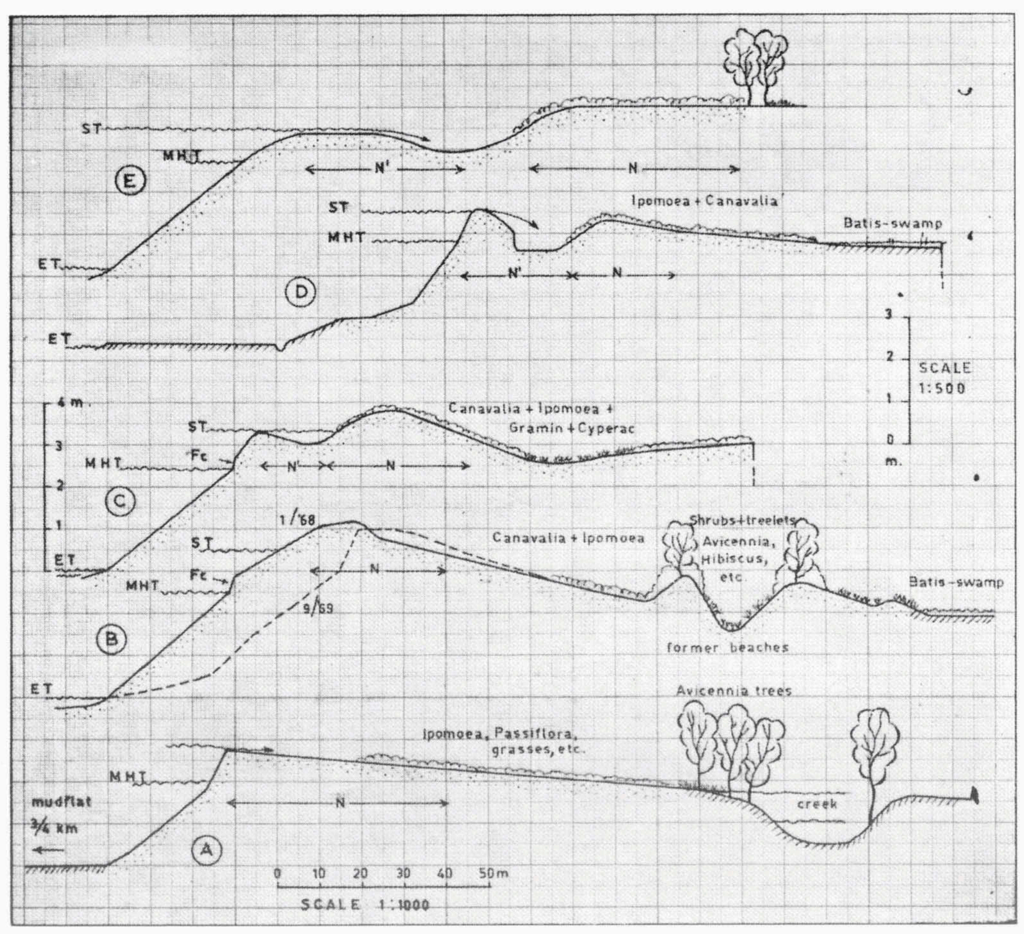
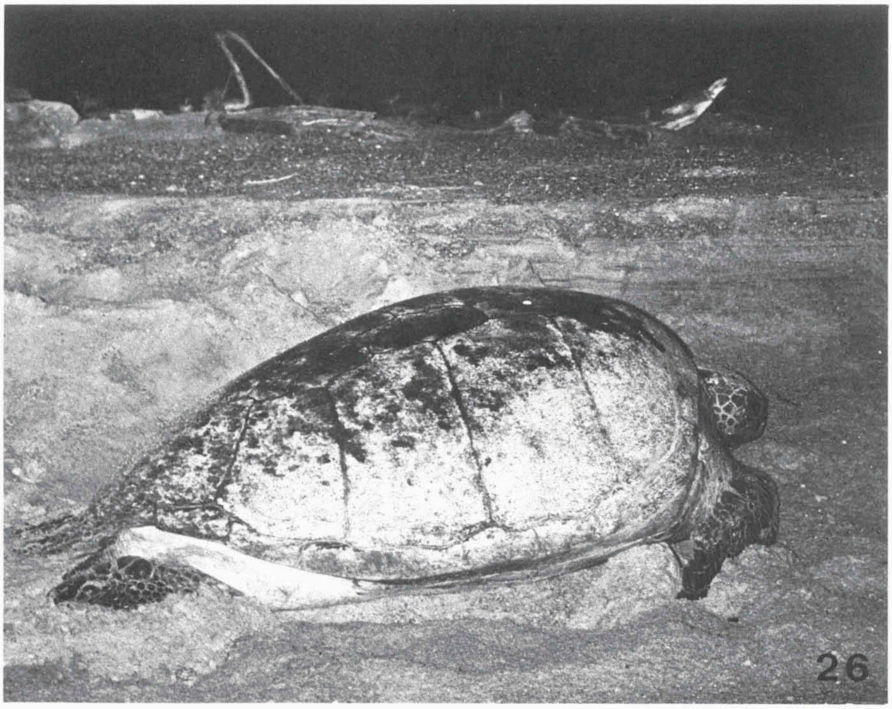

ST
MHT
E
N'
N
ET
ST
MHT
Ipomoea + Canavalia
Batis-swamp
N'
N
D
ET
3
2
1
0
m.
SCALE
1:500
4 m.
3
2
1
ET
ST
Fc
MHT
C
N'
N
Canavalia + Ipomoea +
Gramin + Cyperac
1/68
ST
Fc
MHT
9/69
N
Canavalia + Ipomoea
Shrubs + treelets
Avicennia,
Hibiscus,
etc.
Batis-swamp
B
ET
former beaches
Avicennia trees
Ipomoea, Passiflora,
grasses, etc.
MHT
mudflat
3/4 km
N
creek
A
0
10
20
30
40
50 m
SCALE 1:1000

Fig. 25



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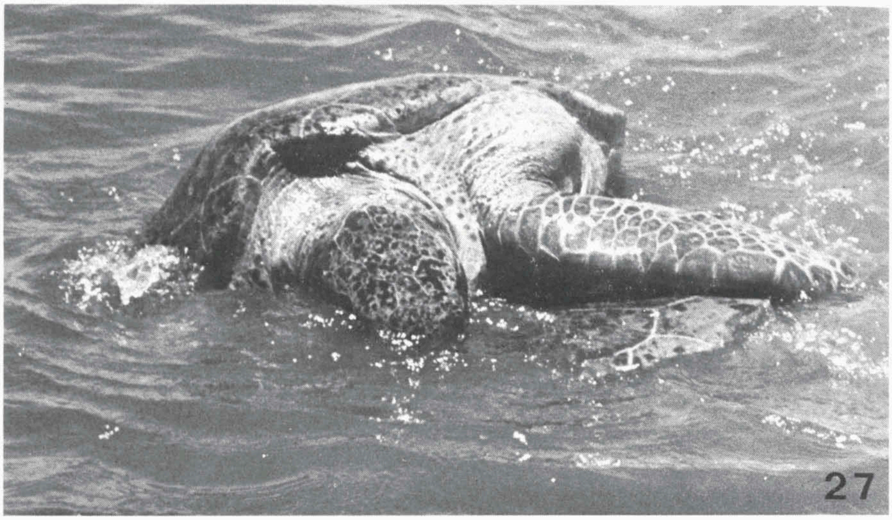

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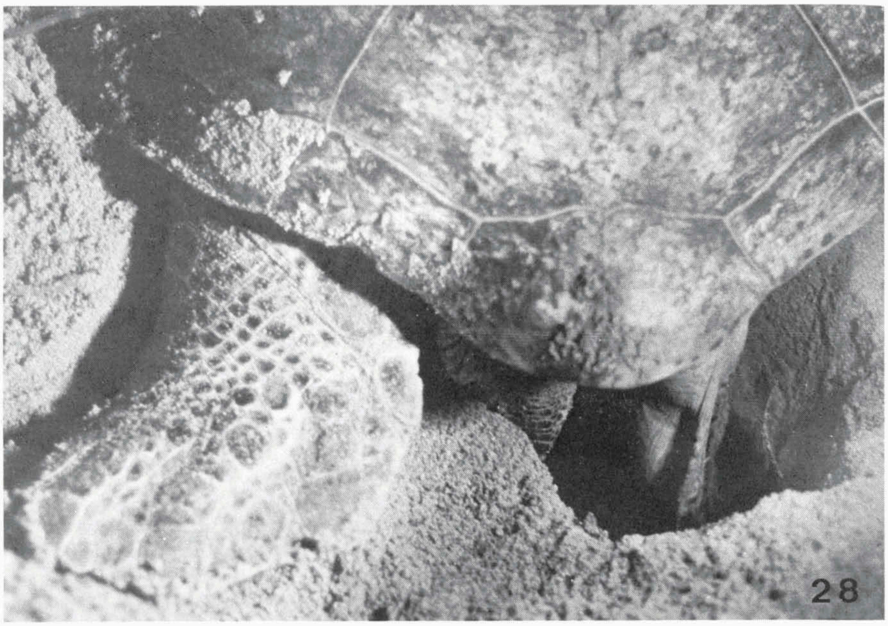

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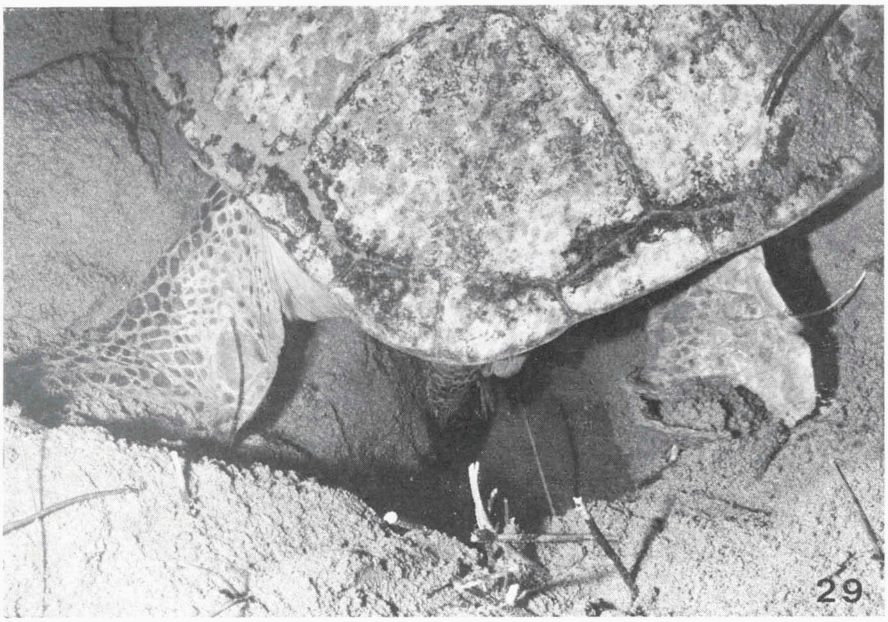

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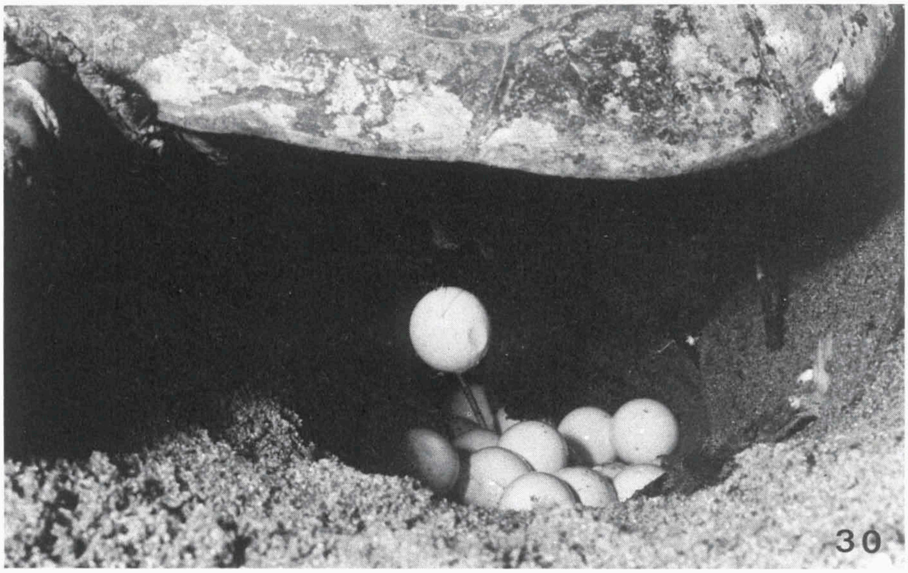

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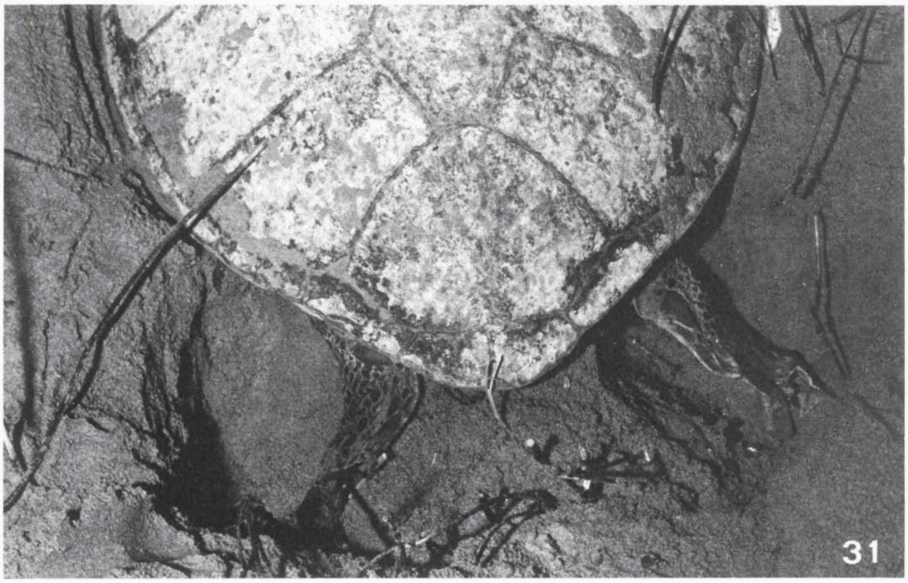

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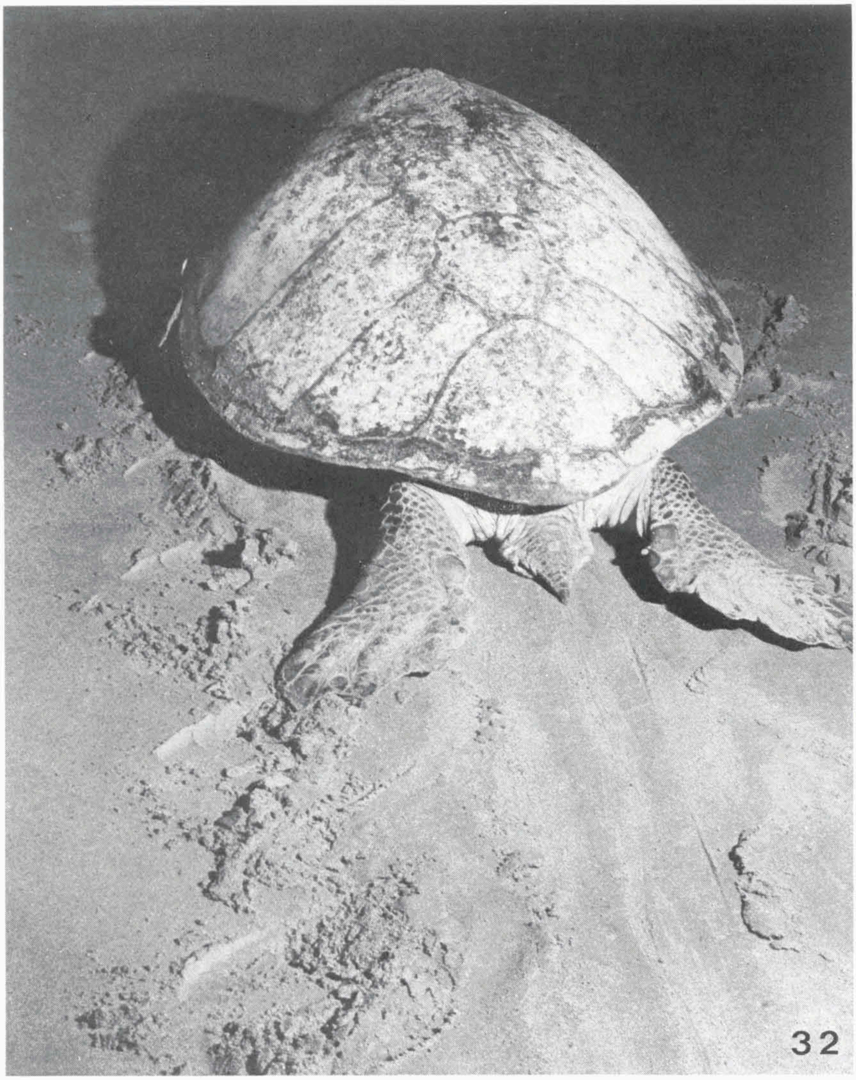

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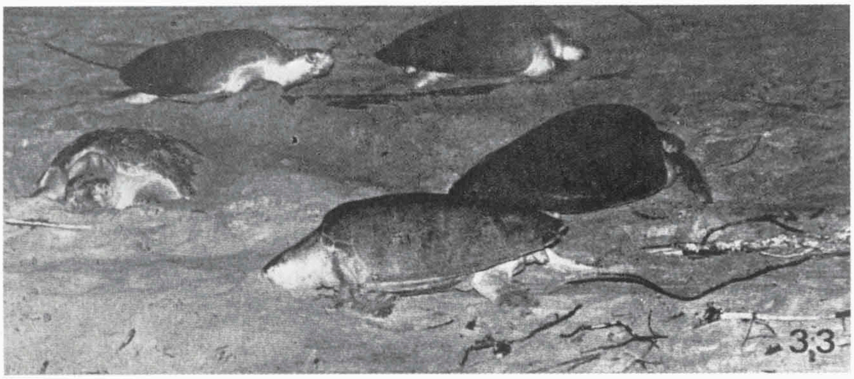

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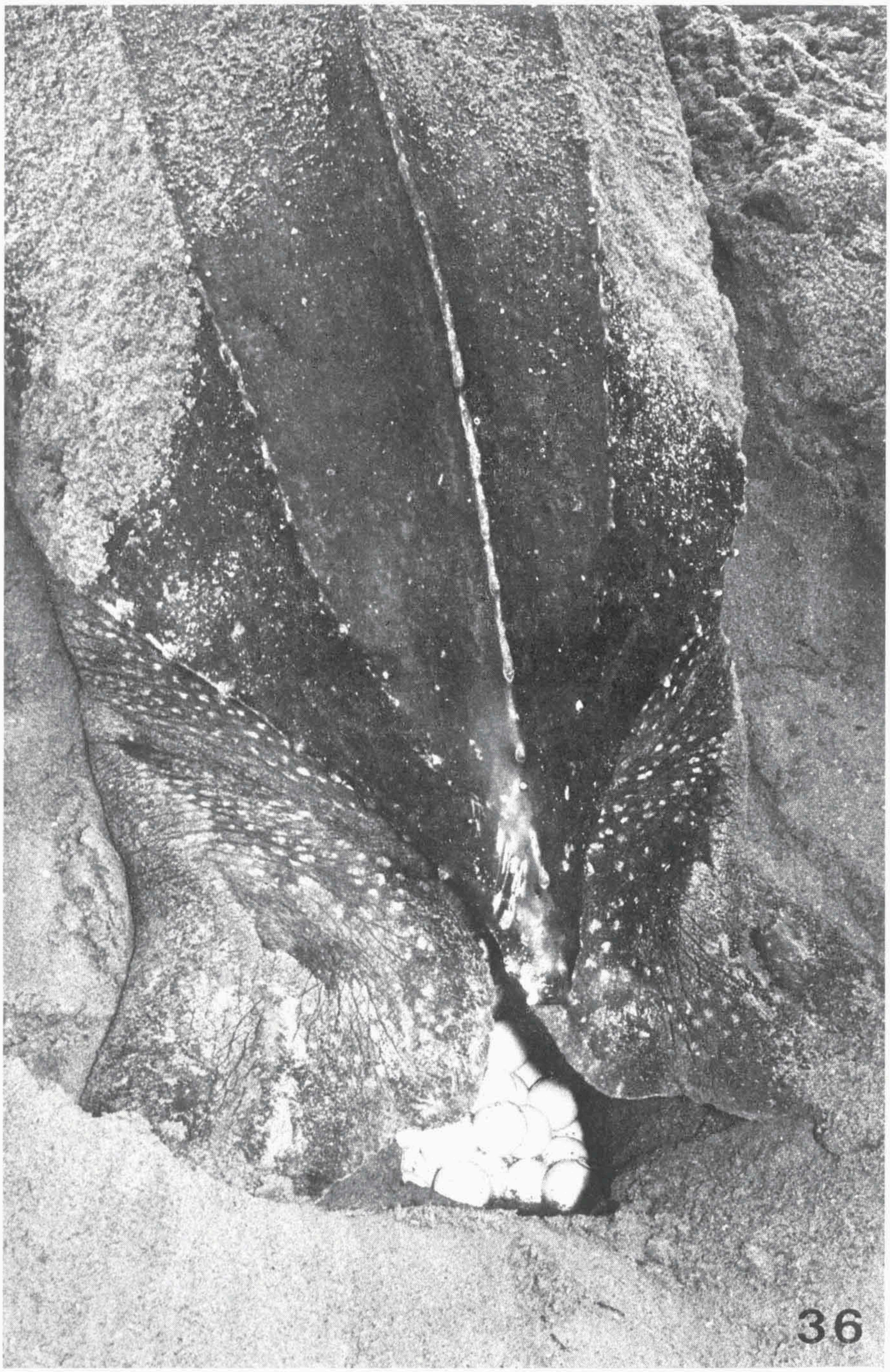
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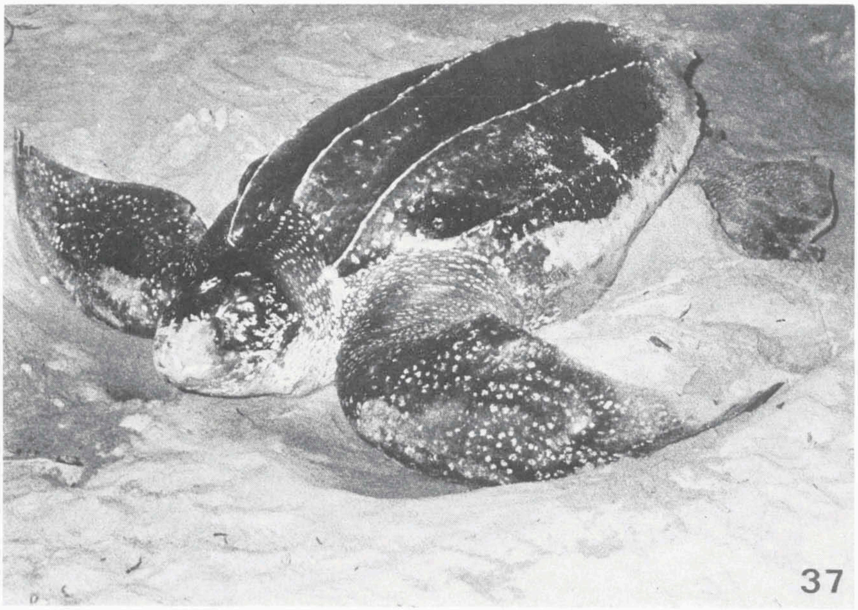

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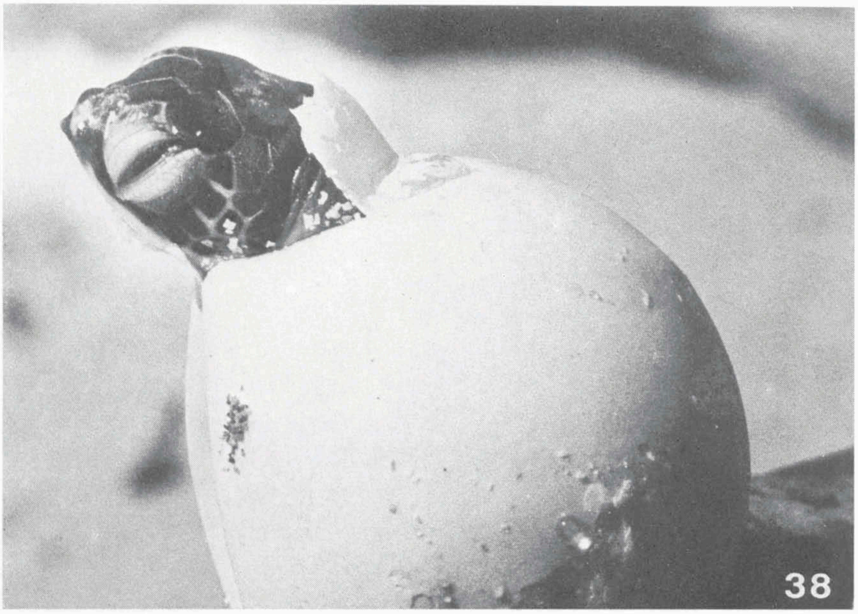

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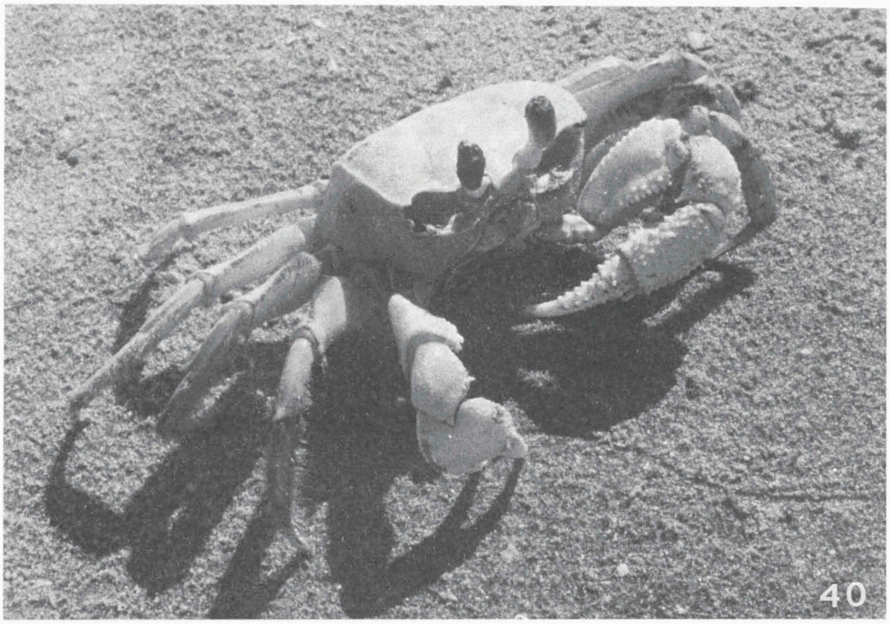

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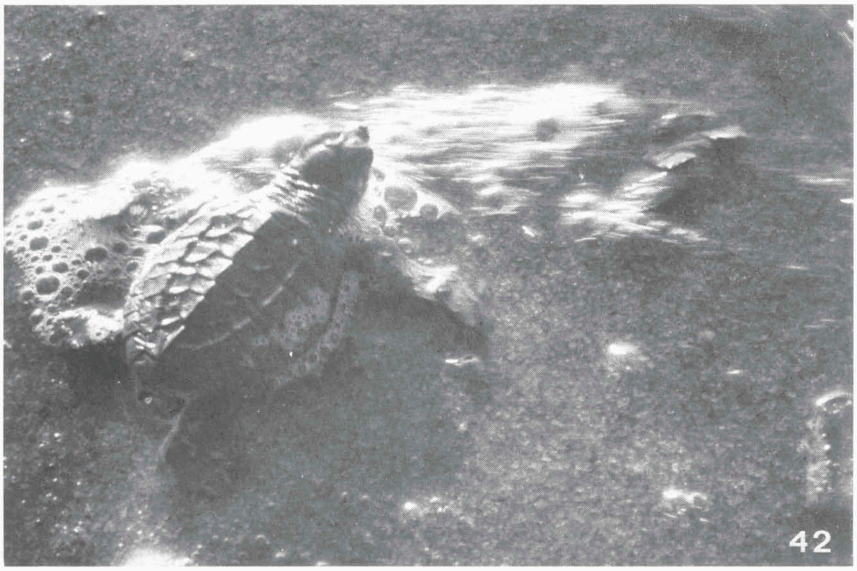

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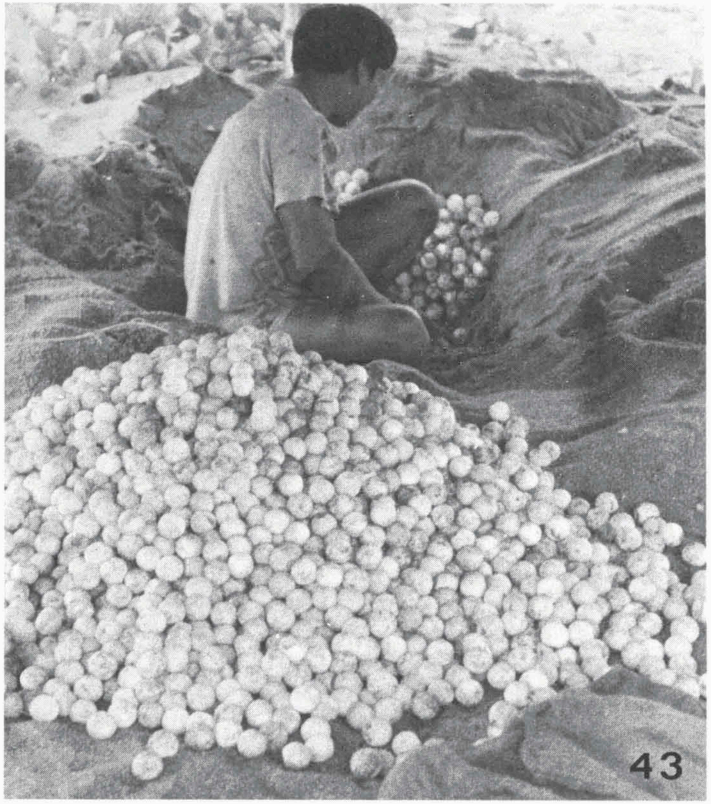

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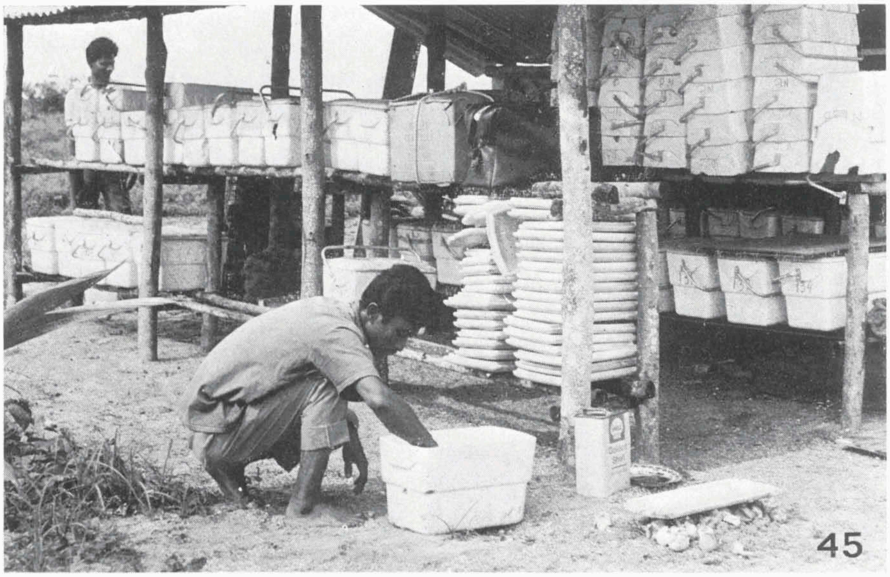

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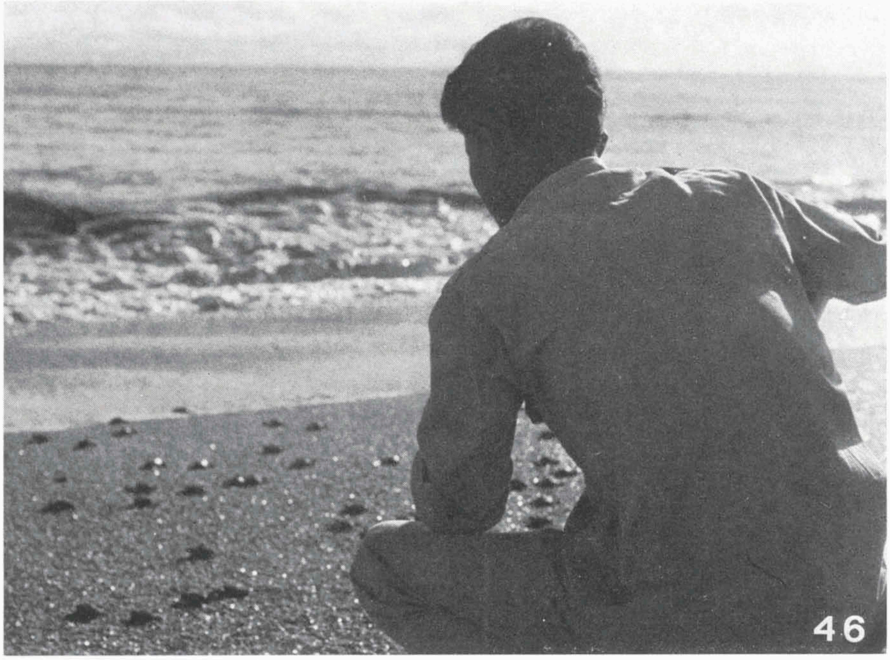

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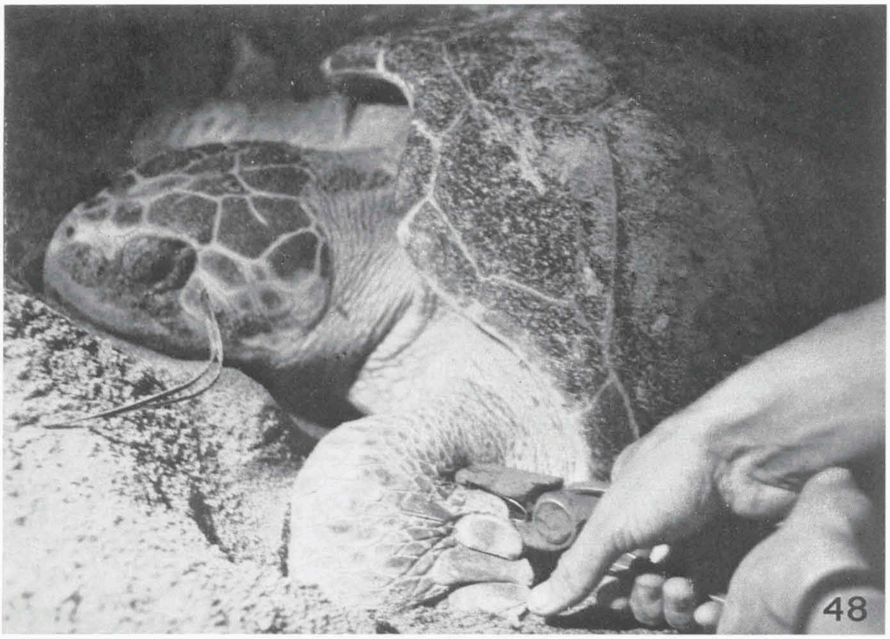

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