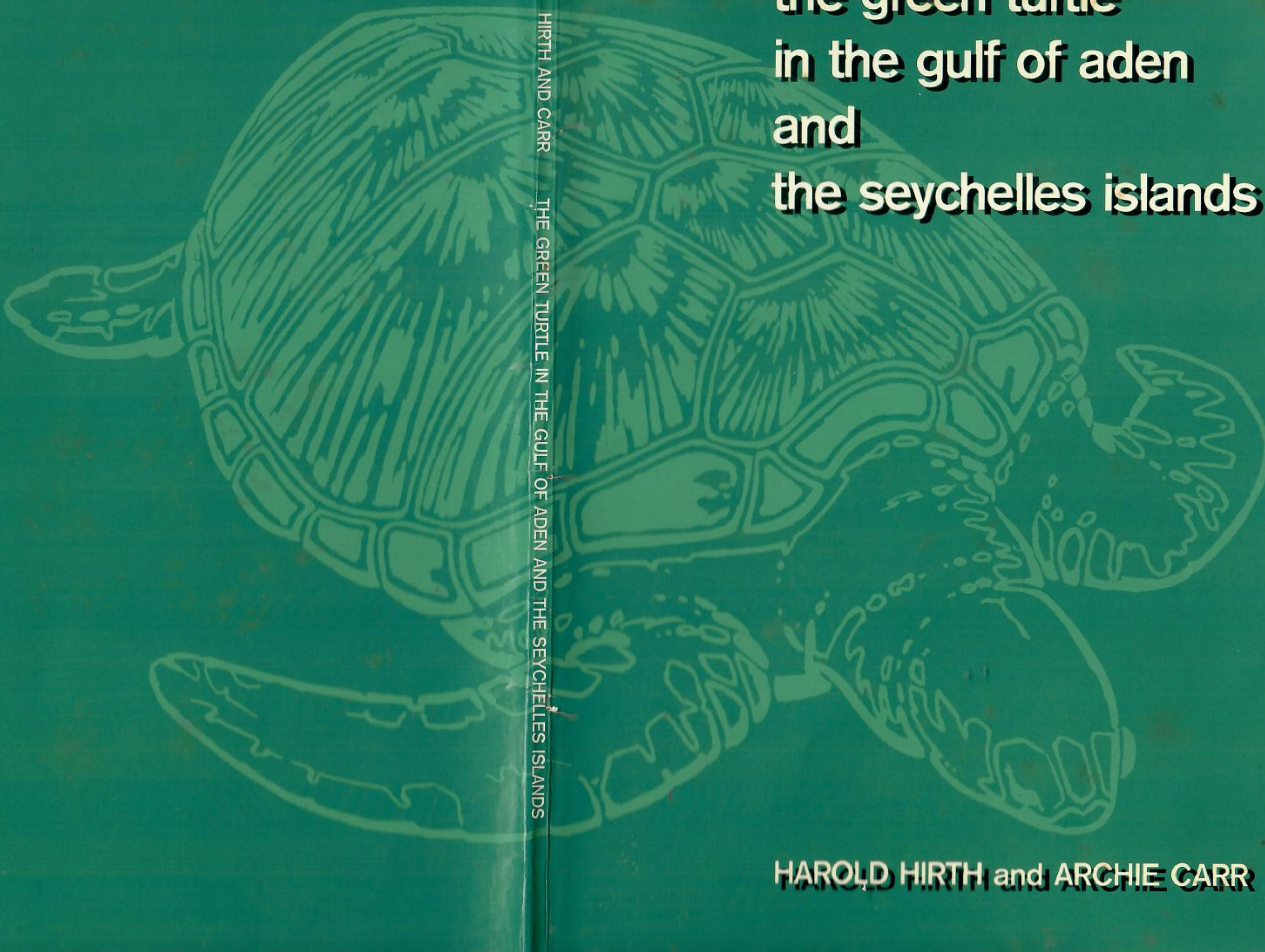

the green turtle in the gulf of aden and the seychelles islands

HIRTH AND CARR THE GREEN TURTLE IN THE GULF OF ADEN AND THE SEYCHELLES ISLANDS

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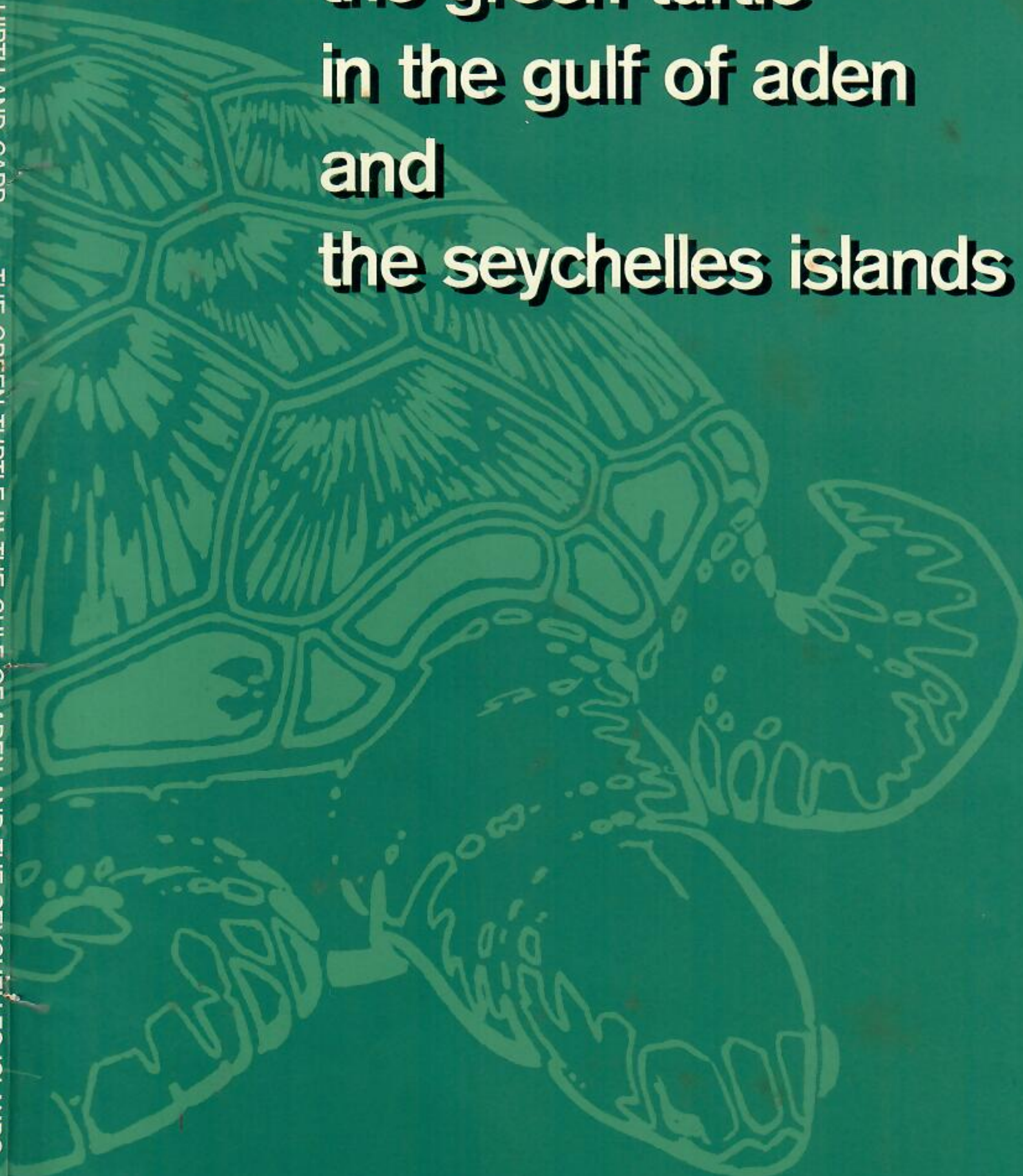

HAROLD HIRTH and ARCHIE CARR

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THE GREEN TURTLE IN THE GULF OF ADEN AND THE SEYCHELLES ISLANDS

HAROLD HIRTH and ARCHIE CARR

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Except for the data and observations in HORNELL's *The Turtle Fisheries of the Seychelles Islands* (1927) little information on the sea turtles of the western Indian Ocean has been published. DERANIYAGALA gathered data from the scattered literature in his book on the four-footed reptiles of Ceylon (1939), and more recently PARSONS has brought together additional information for the region in *The Green Turtle and Man* (1962). To anyone who has tried to understand the ecological geography of marine turtles, however, the inadequacy of knowledge of the fauna of the western Indian Ocean has been obvious and frustrating.

In 1963 the junior author made a search for rumored mass nesting grounds in Madagascar and on the East African coast between Tanzania and the Bajun Islands (CARR, 1964). While by no means exhaustive, this survey suggested that while nesting once occurred both in Madagascar and on the East African coast, the colonies now are only vestigially represented by separately nesting females. It is possible that a colony of *Chelonia* has been overlooked somewhere in Madagascar, but on the mainland there is evidently no mass nesting of *Chelonia* between Mozambique and Somalia.

Most of the nesting grounds of *Chelonia* that remain in the western Indian Ocean are on islands. The status of some of these island colonies – those of the Seychelles Archipelago – is described in this paper. The paper is mainly concerned, however, with the natural history and survival status of a series of nesting aggregations that HIRTH studied in the People's Republic of South Yemen. These appear to constitute one of the most important breeding colonies remaining in the world. As nearly as we can judge, they are possibly exceeded in size only by the China Sea colony (BANKS, 1937; HARRISSON, 1951; HENDRICKSON, 1958); by that of Sabah (conversations with G. S. DE SILVA); and by an apparently huge rookery on the Turkish coast, recently reported in letters to CARR by Mr. Y. SELA of Israel. Although his main concern was with the green turtle, HIRTH was able to gather some information on the hawksbill turtle (*Eretmochelys imbricata* (L.)) in both South Yemen and the Seychelles. Because this species is associated with *Chelonia* in many parts of the enormous ranges of the two, it seems appropriate to include the observations here.

The present paper is chiefly based on results of work that the senior author carried out while engaged as a Technical Assistance Expert with the Food and Agriculture Organization of the United Nations. CARR appears as junior author because he was involved in the initial planning of HIRTH's survey, and he has added observations here and there to give wider context to the observations reported. Comparative information, and the general grounding in sea turtle biology brought to the present study by both authors, were gained with the support of the National Science

Foundation, the Office of Naval Research, and the Caribbean Conservation Corporation.

KINDS OF SEA TURTLES IN THE GULF OF ADEN

Three of the five genera of marine turtles are known to occur in the Gulf of Aden: the green turtle, *Chelonia*, the hawksbill, *Eretmochelys*, and the leatherback, *Dermochelys*. Of these, the green turtle is by far the most abundant and most important economically. The leatherback is only rarely seen in the area. In the vicinity of Aden the green turtle is known as *Bissa* or *Bissat al Bahr*. Further to the east of Aden it is usually called *Humsa*. Some general information regarding the green turtles of South Yemen was provided by HINDS (1964–5).

DESCRIPTION OF THE GREEN TURTLE

According to current usage the green turtle population in the Gulf of Aden would, on zoogeographic grounds, be called *Chelonia mydas mydas* (L.). Current taxonomy is probably quite defective in this respect, but there has been no adequate study of the various breeding populations now grouped under the name, and we propose no changes here. It seems appropriate, however, to give a brief color description of the local population, simply to add to the slowly growing body of information on variation in this geographically fragmented species. What appears to be the only easily recognizable local form in the whole *mydas* complex is the black turtle of the eastern Pacific, which occurs from Baja California to the Galápagos. This was evidently the turtle described as *Chelonia agassizi* by BOCOURT (1868) from the Pacific coast of Guatemala, where CARR has now seen five topotypes. The black turtle is considerably more heavily pigmented with black than *mydas* and often has a steeper-sided shell than is usual in other stocks, and the emarginations of the shell over the hind legs are frequently deeper in the male. In 1961, CARR suggested that one day somebody would probably describe as a new subspecies the strikingly black population of this stock in the Gulf of Baja California, where it is abundant; and CALDWELL (1962) did, calling the form *Chelonia mydas carrinegra*, with Bahia de los Angeles, Baja California Norte, Mexico, the type locality. Although a *mydas*-like green turtle may co-exist with the black turtle in the eastern Pacific (CARR, 1964) it appears likely that the one that both BOCOURT and CALDWELL described was the black turtle. The problem of distinguishing Guatemalan and Mexican specimens thus remains, and if this cannot be done, the proper name of the black turtle will be *C. m. agassizi*. All that is known of the westward penetration of black turtle characters into *mydas* territory—that is, into the rest of the tropical Pacific—is that either the dark ground coloration, the steep-sided carapace of the female, or both, have been noted in small samples that CARR has examined in the Hawaiian Archipelago, in the Caroline Islands and in the Marshalls (CARR, 1964). In the Hawaiian chain, *mydas*-

like stock also certainly occurs, and may predominate. The concurrent distribution of these two phases may, of course, not indicate sympatric species at all, but simply a tendency toward polymorphism within a single population.

In any case, the turtles that HIRTH worked with in the western Indian Ocean all appeared to be *mydas*. The color patterns of three females and one male, all taken off the coast of South Yemen, and to the senior author's eye typical of their respective size classes, are described below.

A female with a carapace length of 19 inches has the shell streaked in a radial pattern of brown, olive and black. Coloration of the top of the head is like that of the carapace. The scales on the sides of the head are darker than those on top and are separated by distinct yellow seams. The chin and neck are whitish. The plastron varies from whitish to light yellow, without dark patches or shading. The upper surfaces of the flippers are blackish with a few brown streaks on the terminal ends and forward edges.

In a female with shell length of 29 inches, the central area of the carapace is marked with olive, brown, dark brown, and black blotches. At the edges of the carapace these blotches are replaced by streaks of the same colors. Coloration of the top of the head is similar to that of the middle of the carapace, and the scales of the lower surface of the flippers and the plastron are whitish-yellow.

The carapace of a mature female 40 inches long is mottled with yellow, brown, black and green. The top of the head is spread with black, green and brown spots and there are well marked yellow seams between the scales. Ground color of the temporal region is much lighter, with a yellow cast, and is less variegated. The lower jaw is whitish-yellow, without mottling. The upper surfaces of the flippers are blotched with black, brown and green. The neck and lower surfaces of the flippers are white. The plastron is light yellow merging into white at the edges.

A male with a carapace length of 40 inches is similar to a female of the same length except that there is less yellow and brown mottling on the carapace and top of the head.

The difference between the sexes appeared surprisingly consistent, and more marked than either author has seen elsewhere. In general, however, the coloration of the South Yemeni green turtle population seemed consistent with DERANIYAGALA's description (1939) of Ceylonese turtles of the same sizes. The mature turtles from South Yemen appeared to be more colorful than Caribbean turtles of the same sizes, but clear-cut points of divergence were hard to discern. Some color patterns of Yemeni turtles are shown in Pl. I figs. 1, 2, and 3.

From both the above color description and the figures, it is clear that the *agassizi* pigmentation is not present in the Yemeni turtles, and that the conformation of the shell likewise is of the *mydas* type, although among one hundred and six Yemeni green turtles, forty-two per cent of 73 females and twenty-seven per cent of 33 males showed an *agassizi*-like emargination of the carapace over the hind legs.

COLORATION OF THE HAWKSBILL

Knowledge of regional variation in populations of the hawksbill is, if possible, even scantier than what is known of *Chelonia mydas*. There appears to be no special color trend in the hawksbills of the eastern Pacific. It is even difficult to separate the stocks of the Pacific and Atlantic systems (Carr, 1952). In specimens in the Gulf of Aden, for instance, there is no clear departure from the coloration or body form of Caribbean *Eretmochelys*. Nevertheless, the following descriptions are recorded, as a contribution toward a documentation of minor regional variations in the genus.

Young female (length of carapace 19 inches, width of carapace 15½ inches, width of head 2½ inches), taken off Perim Island: Carapace mottled with green, black, tan and brown. Top of head black with sutures distinctly outlined in yellow; sides of head orange-yellow with large black spots in the centers of the larger scales. The sheath of the upper jaw is yellow with wide black streaks. The sheath of the lower jaw is yellow with wide black blotches on the sides. The laminae are imbricated.

The following description pertains to a gravid female (carapace length 27 inches; weight 98 pounds) caught off Jabal Aziz Island in the Gulf of Aden. Like all the hawksbills in this locality the shell was covered with a layer of algae and silt. Carapace mottled with black, green, brown and yellow. Top of head dark brownish-black, with scattered green and light-brown blotches. Scales separated by distinct yellow sutures. Sides of head tan to yellow to orange, with black spots in the middle of the larger scales. Sheath of the lower jaw yellowish on the cutting edge, and ventrally, orange with black streaks. Sheath of the upper jaw mostly light yellow, with black blotches. Throat pinkish; chin yellowish-orange or whitish with a few black spots. Dorsal surface of the flippers black-brown, with orange stripes on the forward edge. Lower surface of the flippers orange-yellow with black at the tips. Trailing edge of the flippers with a few black-centered scales. Plastron yellowish, with some orange along seams of the laminae.

CLIMATE, MONSOONS AND CURRENTS

The climate of the Gulf of Aden and the Arabian Sea is dominated by two monsoons. In the Aden area (and in general throughout the southern coast of the Arabian peninsula) the southwest monsoon (locally called *shamal*) begins in May and terminates in mid-September, being most dominant in June, July and August. There is an intermonsoon period from mid-September to November. The northeast monsoon (local name *azyab*) prevails from November to mid-February, and is dominant in

December and January. There is another inter-monsoon period from mid-February through April.

The surface waters along the South Yemeni coast are cooler and richer in nutrients during the southwest monsoon than during the northeast monsoon or inter-monsoon periods. The average maximum and minimum monthly water temperatures in the Gulf of Aden are 82° and 75° F., respectively. The average surface salinity is 36 ‰.

Some information concerning the currents of the region is available in the FAO oceanographic internal report made by Dr. D. CUSHING. As the southwest monsoon blows along the South Yemeni coast the coastal surface currents tend to move northeasterly, while those offshore move in a southeasterly direction. There is indication of movement into the Gulf of Aden between Cape Guardafui and Socotra at the end of the southwest monsoon. During the northeast monsoon there is a flow of surface water from the Arabian Sea into the Gulf of Aden. Water from the Red Sea flows out along the African coast. As the northeast monsoon dies away, this current strengthens and becomes predominant over the Arabian Sea current, generating a cyclonic movement in the water of the eastern Gulf of Aden.

NEWELL (1959) reported that a Somaliland surface current flows southward along the East Somalia coast from November to January. The movements of several turtles, tagged in South Yemen in November and subsequently recaptured off the East Somalian coast may have been influenced by this current (see section: "Long Distance Movements").

Specific climatic data for Aden are provided in Table 1.

TABLE 1

Climatic data of Aden based on eight years observations. Information from "Red Sea and Gulf of Aden Pilot", tenth edition, 1955, British Admiralty

Month	Air Temperature (°F) Daily Max.	Daily Min.	Relative Humidity (%) 0600	1500	Rain (Inches) Mean
January	83	72	79	63	0.2
February	84	73	78	65	0.1
March	86	76	81	65	0.4
April	89	77	81	67	0
May	93	81	83	65	0
June	98	84	78	51	0
July	97	83	77	49	0.2
August	96	81	81	50	0.1
September	96	83	79	56	0.3
October	91	76	78	59	0
November	87	74	79	61	0
December	84	73	78	62	0.3
Means	90	78	79	59	
Total					1.6

EXPORTATION OF SEA TURTLES IN SOUTH YEMEN

In South Yemen green turtles have been caught, processed and exported since 1961. Since 1963, approximately 2,000 turtles have been exported each year, chiefly to London and northern European markets. Most of these have been females. The meat is exported either frozen or dried and is locally referred to as calipee, or sometimes calipash. Some oil is extracted from the fat and is shipped to northern Europe.

The great majority of South Yemenites do not eat turtle meat or turtle eggs, presumably for local religious reasons. Table 2 indicates the extent and distribution of local use. In the table spellings of the names of all villages and towns are taken from the British Admiralty Charts. Locations of the towns can be found in text-fig. 1. Generally speaking, villagers who do eat turtle flesh or eggs do so only when fish is not readily available. The fishermen in Khor Umaira and some fishermen in the villages on the coast of Quaiti State (capital, Mukalla), are the only ones who actively fish for turtles or turn females on the nesting beaches. They usually sell their catch to the exporter, although a few turtles are kept for local

TABLE 2

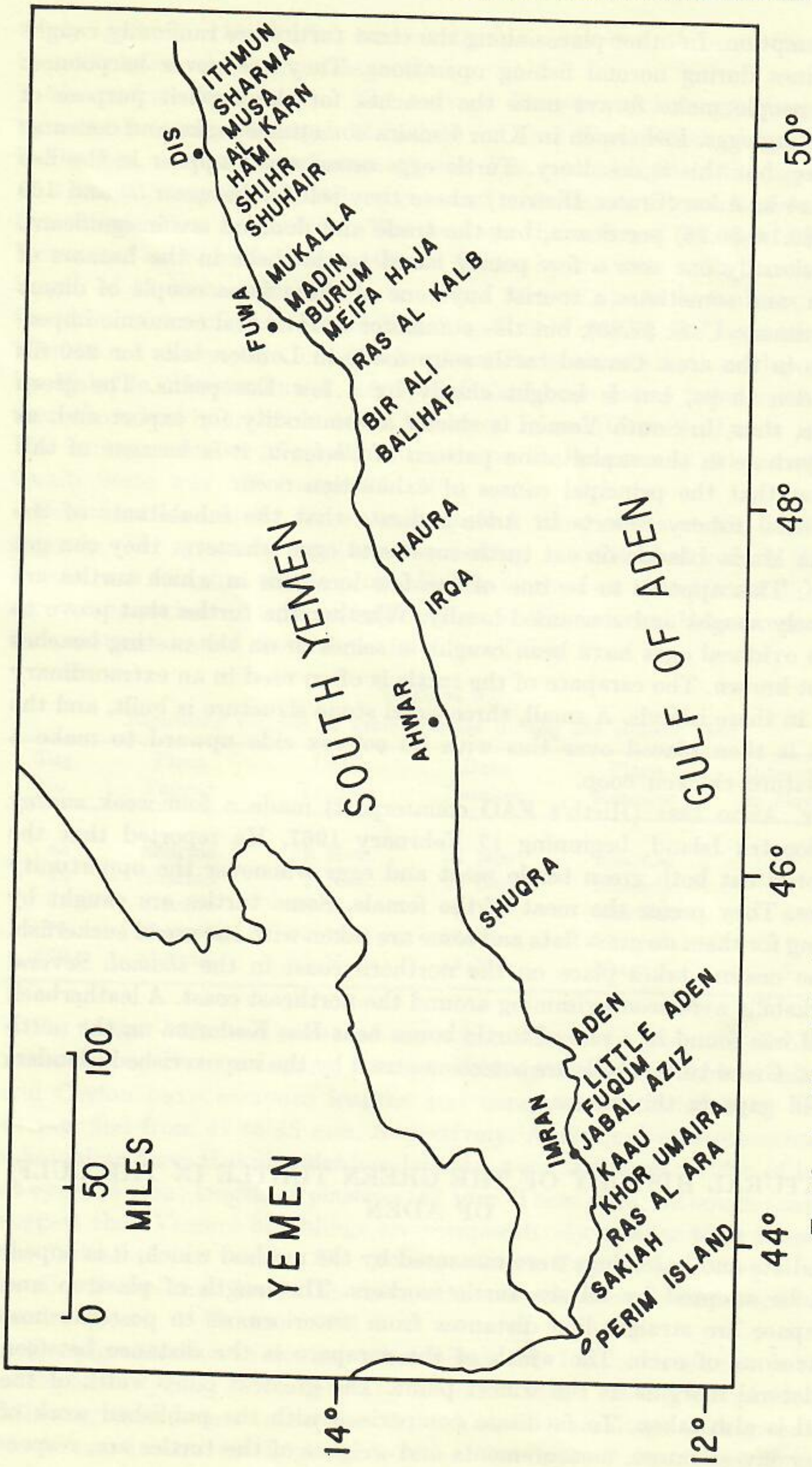
Consumption of green turtles and their eggs by villagers along the South Yemeni coast

Village or Location	Turtle Meat	Turtle Eggs
Sakiah	Very Seldom	Very Seldom
Perim Island	Very Seldom	Seldom 1)
Ras Al Ara	Very Seldom	No
Khor Umaira	Yes	No
Ras Kaau.	No	No
Ras Imran	Very Seldom	Very Seldom 2)
Fuqum	Very Seldom	No
Little Aden	No	No
Aden	No	No
Shuqra	No	No
Irqa	No	No
Haura	No	No
Balihaf	Very Seldom	Very Seldom
Bir Ali	Seldom	Seldom
Fuwa.	Very Seldom	Very Seldom
Mukalla.	No	No
Shuhair	No	No
Shihr	No	No
Hami.	No	No
Al Karn	Very Seldom	No
Dis.	Very Seldom	No
Sharma 3)	Very Seldom	Very Seldom

1) Chiefly hawksbill eggs.

2) These are hawksbill eggs taken from the nearby island of Jabal Aziz.

3) Bedu from the interior occasionally come down to the beach to collect a few turtles and eggs.



Text-fig. 1. Map of the South Yemeni coast showing major localities described in the text.

consumption. In other places along the coast turtles are randomly caught in seines during normal fishing operations. They are never harpooned. Few people make forays onto the beaches for the explicit purpose of collecting eggs. Fishermen in Khor Umaira sometimes make and consume calipee, but this is desultory. Turtle eggs occasionally appear in the fish market in Aden (Crater District) where they sell for between 50 and 100 fils ($0.14–$0.28) per dozen, but the trade and demand are insignificant. Occasionally one sees a few poorly cured turtle shells in the bazaars of Aden, and sometimes a tourist buys one of these for a couple of dinars (one dinar = U. S. $2.80), but this commerce is of no real economic importance in the area. Canned turtle soup made in London sells for 250 fils in Aden shops, but is bought chiefly by a few Europeans. The green turtle, thus, in South Yemen is chiefly a commodity for export and, as everywhere in the exploitation pattern of *Chelonia*, it is because of this export that the principal causes of exhaustion occur.

Official fishery reports in Aden indicate that the inhabitants of the Kuria Muria Islands do eat turtle meat and eggs whenever they can get them. This appears to be one of the few localities in which turtles are actively sought and consumed locally. Whether the turtles that prove to have oviducal eggs have been caught in seines or on the nesting beaches is not known. The carapace of the turtle is often used in an extraordinary way in these islands. A small, three-sided stone structure is built, and the shell is then placed over this with its convex side upward to make a miniature chicken coop.

Mr. ABDO ISSA (Hirth's FAO counterpart) made a four-week survey of Socotra Island, beginning 17 February 1967. He reported that the Socoteri eat both green turtle meat and eggs whenever the opportunity arises. They prefer the meat of the female. Some turtles are caught by diving for them on grass flats and some are taken with the use of suckerfish. Some nesting takes place on the northern coast in the *shamal*. Several hawksbills were seen swimming around the northeast coast. A leatherback skull was found in a pile of turtle bones near Ras Kadarma on the north coast. Green turtle shells are sometimes used by the impoverished islanders to fill gaps in the homes.

NATURAL HISTORY OF THE GREEN TURTLE IN THE GULF OF ADEN

Adults and hatchlings were measured by the method which, it is hoped, will be adopted by all sea turtle workers. The length of plastron and carapace are straight-line distances from anteriormost to posteriormost extensions of each. The width of the carapace is the distance between its lateral margins at the widest point. The greatest bony width of the head is also taken. To facilitate comparison with the published work of other investigators, measurements and weights of the turtles are, respectively, given in the English and avoirdupois systems, those of the eggs in millimeters and grams respectively.

Size and number of eggs. The average diameter of 100 eggs deposited by a turtle (carapace length 36 inches) on Abul Wadi Beach, Aden State, in October, was 42.5 mm (range 40–45). The mean weight of the eggs was 40.4 grams (range 30–44). All weights and measurements were taken about five hours after oviposition. The average diameter of 50 eggs laid in November on Sharma Beach, Quaiti State, by a turtle with a carapace length of 38 inches was 42.3 mm (range 37.5–47.5). As is the case with the dimensions of the mature breeding female turtle, the eggs laid by Yemeni sea turtles were found to be about the same size as those deposited by Malayan (HENDRICKSON, 1958) and Caribbean forms but are smaller than those laid by individuals on Ascension Island (CARR & HIRTH, 1962). The average number of eggs in 30 nests on the beaches in Aden and the Quaiti State was 106 (range 70–130).

Green turtles usually renest at least four times while at the breeding grounds. The greatest number of renesting returns observed in South Yemen was two, but this is probably due to the fact that HIRTH did not spend long periods of time on any one beach. The interval between successive nestings varied from 7 to 13 days (Table 3).

TABLE 3

Renesting returns of green turtles during the season 1966

Tag No.	Place Tagged	Date Tagged	Date Retaken	Place Retaken	Interval in Days
45	Sharma	9 Nov.	22 Nov.	Sharma	13
48	Sharma	9 Nov.	22 Nov.	Sharma	13
73	Sharma	10 Nov.	18 Nov.	Sharma	8
77	Sharma	10 Nov.	17 Nov.	Sharma	7
170	Sharma	17 Nov.	24 Nov.	Sharma	7

Hatchlings. Measurements of some hatchlings are given in Table 4. According to DERANIYAGALA (1939) hatchlings from the Maldive Islands and Ceylon have carapace lengths and carapace widths of from 49 to 54 mm and from 42 to 43 mm, respectively. Additional measurements of a hatchling from Huhule, Maldive Islands, were as follows: width of head at eyes, 15 mm; length of plastron, 41 mm. These data, although scanty, suggest that Yemeni hatchlings are comparatively smaller than those of the Indian Ocean turtles. The average South Yemeni hatchling is also smaller in shell and head dimensions than South Atlantic and Caribbean turtles (CARR & HIRTH, 1962).

The pigmentation of the Aden hatchlings (Pl. I fig. 4) is similar to that of Ceylonese young as described by DERANIYAGALA (1939), except for the following divergences: carapace of the Yemeni hatchlings dark greenish-black and bronze (dark greenish-bronze in Ceylon); head and flippers dark greenish-black in South Yemen (dark brown in Ceylon); sides of the lower jaw are green-black in South Yemen (evidently lacking or not noted in the Ceylonese specimens).

TABLE 4

Measurements and weights (in millimeters and grams) of 20 hatchling green sea turtles that emerged on 16 and 17 December at Abul Wadi Beach, Aden, after an incubation period [1]) of 48 and 49 days. Forty-eight per cent of the 112 eggs laid hatched. Measurements and weights taken from live turtles on the day of emergence

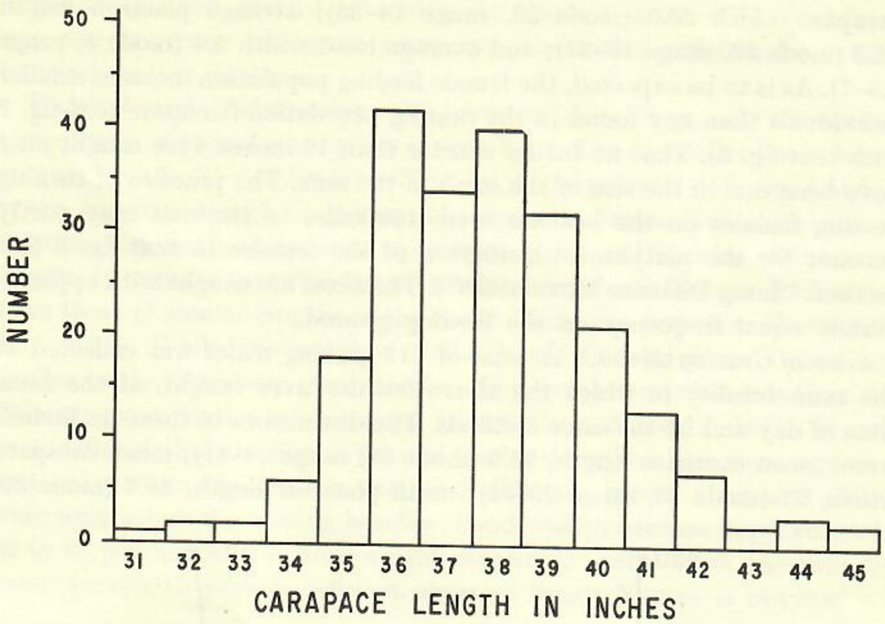
	Mean	Range
Carapace length	46.9	44.0–48.4
Carapace width	33.5	31.2–37.5
Plastron length	36.8	32.8–40.6
Head width	14.2	12.5–15.6
Depth	18.5	17.2–20.3
Weight	23.0	20.0–28.0

[1]) The incubation period is defined as the interval between oviposition and the time of appearance on the surface of the largest number (or numbers) of hatchlings for that clutch. In this case, ten hatchlings were taken from each of two major emergences.

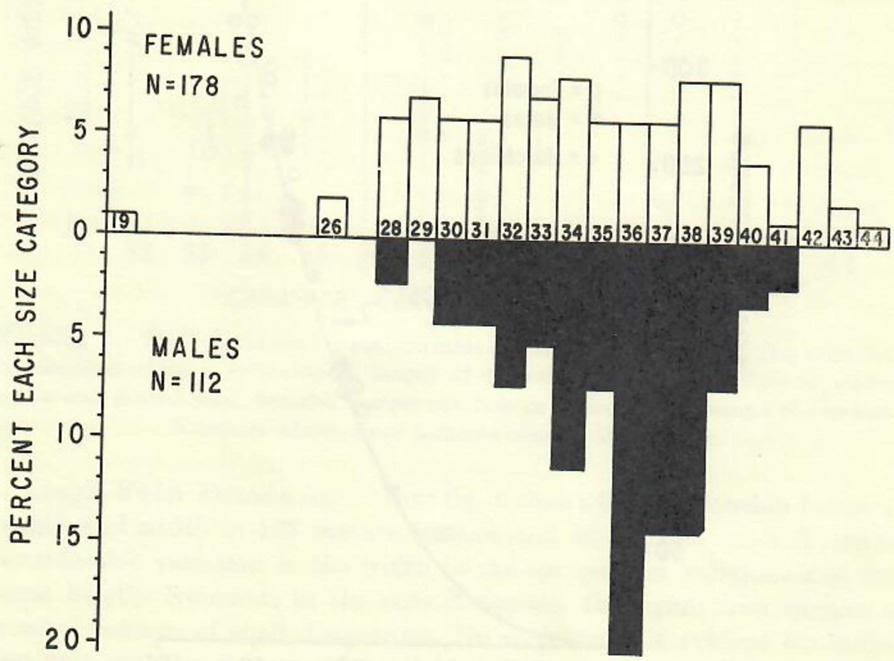
Incubation. Some of the Aden hatchlings described in Table 4 emerged 48 days after oviposition; the rest emerged after 49 days. The average numbers of hours of sunshine per day in 1966, as recorded by the RAF Meteorological Station in Aden were as follows: October (10.2); November (10.2); and December (9.3). Other meteorological data for the time of observed incubation are given in Table 1.

Size of the Nesting Female. The lengths of 225 gravid females are given in text-fig. 2. The measurements are shown in one-inch increments, although in practice all measurements were recorded to the nearest one-quarter inch. The smallest female found nesting on the beaches of South Yemen had a carapace length of 31 inches. Two other ovigerous females were 32 inches long. The two largest nesting females each had carapace lengths of 45 inches. The mean carapace length of all nesting females was 37.8 inches, mode 36 inches. The mean length of nesting Yemeni turtles corresponds closely with that of gravid turtles of the China Sea and Caribbean populations (average 38.5 and 39.5 inches, respectively) but it is less than the average in the Ascension Island population (42.45 in.). Other dimensions of 225 gravid Yemeni green turtles are as follows (inches): carapace width, mean 29.5 (mode 29, range 25–34); plastron length, mean 31 (mode 32, range 27–36); head width, mean 5.4 (mode 5.5, range 4–7).

Sizes of Grazing Females. A total of 178 female green turtles, captured in circle nets and beach seines on the feeding pastures near Khor Umaira, Lahej State, between October 1966 and February 1967, was measured. Their standard measurements (in inches) were as follows: average carapace length 34.7 (mode 32, range 19–44, but none between 20 and 25); average



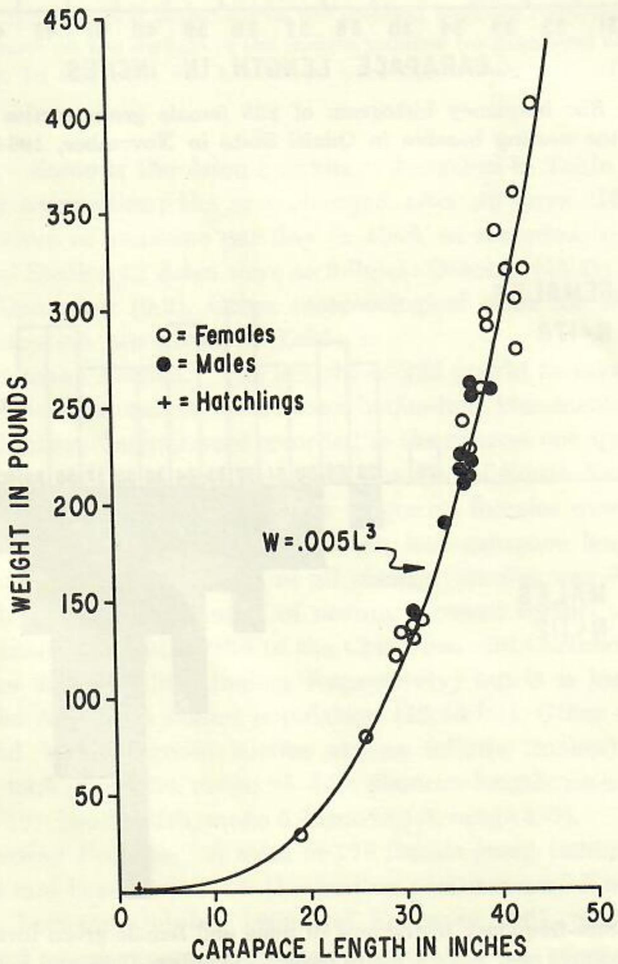
Text-fig. 2. Size-frequency histogram of 225 female green turtles measured on the nesting beaches in Quaiti State in November, 1966.



Text-fig. 3. Size-frequency histograms of male and female green turtles taken on the feeding pastures near Khor Umaira between October, 1966, and February, 1967. Figures along horizontal line represent carapace length in inches.

carapace width 26.3 (mode 30, range 14–35); average plastron length 28.2 (mode 32, range 15–34); and average head width 5.4 (mode 5, range 3.5–7). As is to be expected, the female feeding population includes smaller individuals than any found in the nesting population (compare text-fig. 2 with text-fig. 3). That no turtles shorter than 19 inches were caught may have been due to the size of the mesh in the nets. The practice of turning nesting females on the beaches some 400 miles to the east may partly account for the platykurtic histogram of the females in text-fig. 3 (see section: "Long Distance Movements"). The sexes are caught with approximately equal frequency on the feeding ground.

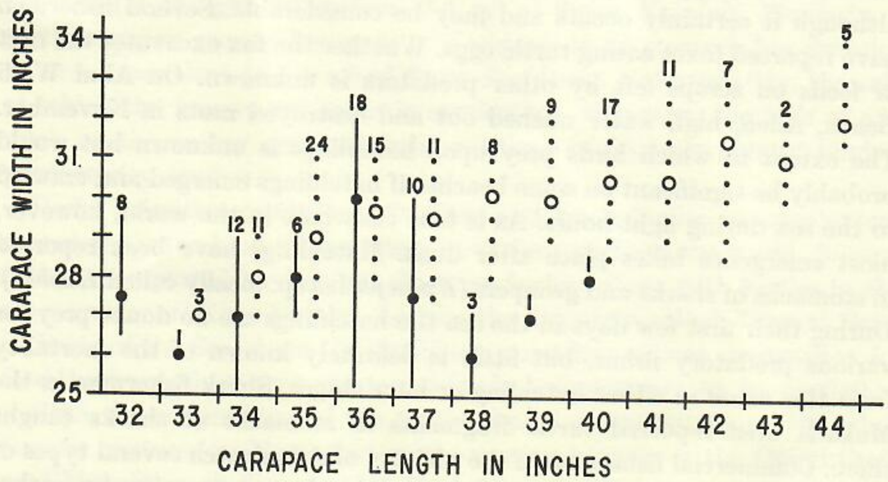
Sizes of Grazing Males. A total of 112 grazing males was collected at the same locality in which the above females were caught, at the same time of day and by the same methods. The dimensions of these (in inches) were: mean carapace length, 35.6 (mode 36, range 28–41); mean carapace width, 27 (mode 25, range 20–32); mean plastron length, 28.7 (mode 29,



Text-fig. 4. Length-width relationship of South Yemeni green turtles.

range 23–32); and, mean head width, 5.6 (mode 5, range 4–7). Text-fig. 3 is a size-frequency histogram comparing the males and females caught together on the pasture.

Weight-Length Relationship. Weights of hatchlings, of 19 female turtles, and of 10 males are given in text-fig. 4. The regression line is based on the formula $W = AL^3$ where W is weight in pounds, A is .0045 and L is the carapace length in inches. The figure indicates that there are no significant differences between weights of males and females of the same length. It appears that the female turtles from South Yemen are heavier than those of similar lengths in the South China Sea (compare HENDRICKSON, 1958). While the weights of the larger females from Yemen are similar to the Caribbean green turtles, they weigh somewhat less than the Atlantic green turtles on Ascension Island (CARR & HIRTH, 1962). It may be significant that the South Yemeni turtles described here were captured and weighed on the feeding pastures, while the others compared above were weighed on the nesting beaches. Incidentally, because approximately 40 to 50 per cent of a turtle's weight represents usable meat, the value of green turtles to protein-deficient areas of South Yemen is obvious.



Text-fig. 5. Shell dimensions of mature male and female green turtles. The variation in carapace width is indicated by length of the vertical lines. Solid lines represent males and dotted lines, females. Larger symbols in vertical lines denote the means. Numbers above lines indicate size of the sample.

Length-Width Relationship. Text-fig. 5 shows the relationship between length and width in 123 mature females and 60 mature males. There is considerable variation in the width of the carapace in individuals of the same length. However, in the case of females the figure does suggest a general pattern of shell dimensions. No such trend is evident for males but this may be due partly to the small sample, especially as regards the larger males.

Natural Mortality and Predation. The main factors leading to depletion

TABLE 5

Loss of turtles at various stages of their life cycle

Factor	In South Yemen
1. Non-developing eggs	1. About 40% of each clutch
2. Predation on nest	2. Beach crabs; dogs; fox
3. High waves: storms	3. Evidence found in November
4. Beach predators on hatchlings	4. Crabs; birds
5. Predation on hatchlings in shallow sea	5. Sharks; groupers; other fish
6. Predators, disease, parasitism in deep sea	6. Unknown

of green turtles along the South Yemeni littoral are outlined in Table 5. Approximately 40 per cent of the eggs laid do not hatch, probably because of inherent fertility factors. This appears to be the case at other green turtle rookeries in the world. In South Yemen, feral dogs (sometimes called py-dogs) destroy thousands of eggs each year. The extent to which beach crabs (*Ocypode* sp.) prey upon eggs and hatchlings is not known, although it certainly occurs and may be considerable. Several fishermen have reported foxes eating turtle eggs. Whether the fox excavates the nest or feeds on scraps left by other predators is unknown. On Abul Wadi Beach, Aden, high water washed out and destroyed nests in November. The extent to which birds prey upon hatchlings is unknown but would probably be significant on some beaches if hatchlings emerged and crawled to the sea during light hours. As is true elsewhere in the world, however, most emergence takes place after dusk. Hatchlings have been reported in stomachs of sharks and groupers (*Epinephelus* sp. locally called *Kushar*). During their first few days in the sea the hatchlings are no doubt prey for various predatory fishes, but little is definitely known of the mortality from this cause in either hatchling or later stages. Shark fishermen in the Mukalla area reported turtle fragments in stomachs of sharks caught there. Commercial fishermen in the vicinity of Aden catch several types of sharks including the tiger shark, hammerhead, and occasionally mako. They tell of finding pieces of turtle shell in the stomachs of tiger sharks.

Feeding Habits and Pastures. The best submarine pastures in South Yemen are near Khor Umaira, 50 miles west of Aden, in Lahej State. The vegetation covers bottom in shallow water both along the coast and inside the Bay of Khor Umaira. The bay is almost completely landlocked by a long, narrow sandy spit that extends west-north-west along the coast. The bay itself is about four miles long, its width varying from about one-third of a mile at the entrance to two miles in the middle. Its configuration is broadly elliptical. The depth of the water near the entrance of the bay is between 3 and 20 feet, while the depth inside varies from 3 to 35 feet. Off the coast near the village the depth of the water is as follows: 5 fathoms at 1.25 miles; 10 fathoms at about 2 miles; 20 fathoms at approximately 7 miles. The heaviest grazing by turtles occurs within the 5-fathom mark.

With the cooperation of the turtle export firm, over 100 turtles caught on the Khor Umaira feeding grounds in October, December and January were dissected and their stomach contents identified and weighed. The majority of the turtles grazing here eat chiefly two types of "turtle grass": *Posidonia oceanica* and *Halodule uninervis*. The digestive tracts also contained a small amount of brown algae and red algae. The stomachs of six mature turtles (5 females, 1 male) packed solidly and almost solely with turtle grass, weighed between 3.9 and 5.5 pounds (mean 4.6 lbs.).

Floristic surveys of the bay and coastal feeding grounds were made in December and January, by diving. In some of the more densely vegetated areas there, *Halodule* was calculated at a density of 2,300 shoots per square meter. Most blades were about 12 inches in length. In other areas, there were up to 2,500 blades of *Posidonia* per square meter, with shoots up to 10 inches long. All blade counts were made at the ground surface. A helpful way of expressing these quantities is to say that a turtle in the pasture at Khor Umaira, with 5 pounds of *Halodule* in its stomach, has cropped (at the ground surface) 1.7 m^2 of dense *Halodule*. Similarly, a turtle carrying around 5 pounds of *Posidonia* in its stomach has denuded an area equivalent to 1.5 m^2 of dense *Posidonia*. Unfortunately, the rate at which the grasses are eaten is not known. Moreover, the lack of any work on the energy and metabolic relations of *Chelonia* greatly hinders productivity studies.

Under primitive conditions, sirenians and green turtles to some extent shared the same kind of pasturage in various parts of the world. Several fishermen reported having seen dugongs feeding along with turtles in the sea pastures off Khor Umaira. Locally the dugong is called *Arust al Bahr*, or Bride of the Sea. As in the Caribbean nowadays, direct competition for food between these two marine animals here appears to be negligible.

With the cooperation of the turtle export company, about 100 adult females captured in November on the nesting beaches in the Quaiti State near Mukalla were dissected. Half of the stomachs were empty; the rest were about one-quarter to three-quarters full. Stomach contents were chiefly a combination of brown algae and green algae, with very little turtle grass. The most striking dietary differences between the females from this nesting population and the feeding population at Khor Umaira were the densely packed stomachs of the latter and the lack of turtle grass in the digestive tracts of the nesting population. Minute gastropods found in stomachs of turtles from Quaiti State were probably taken casually with the algae.

On 26 January 1967 three adult females were captured and dissected as they emerged for oviposition on Sharma Beach in Quaiti State. One stomach was empty; two contained very small amounts of green algae.

There is a small turtle grass pasture between Ras Imran and Jabal

Aziz Island in Lahej State. Both *Posidonia oceanica* and *Halodule uninervis* are present, the former predominating. There is also a small pasture near Little Aden. Neither of these pastures approaches that near Khor Umaira in size.

There are reports that turtles feed in the shallow waters near Bir Ali in the Wahidi State, but these have not yet been confirmed.

Sex Ratios on the Feeding Pastures. The relative numbers of male and female green turtles taken at various times in some of the feeding areas are given in Table 6. Assuming that males and females are caught at random and with equal facility, one can conclude that, on the feeding pastures between Aden and Ras al Ara, females outnumber males. Males exceeded females in only 3 of 21 sampling periods. An overall sex ratio of 56% females and 44% males is based on a total of 4,376 individuals, collected over a period of seven years. All the turtles were captured in the sea, either from the land or from boats, using beach seines or circle nets. The beach seines used vary from 100 to 400 yards in length and are up to 39 feet deep with 4-inch to 18-inch mesh. The most usual mesh size at Khor Umaira is 5 inches. These nets are set from the beach at high tide.

TABLE 6

Relative number of male and female turtles caught on feeding pastures in the Republic of South Yemen

Year	Months	Locality	Numbers caught Females	Males	Percent Females
1966–67 [1]	October–January	Khor Umaira	156	97	62
1966	May-July	Khor Umaira	172	139	55
1966	January–April	Khor Umaira	131	192	41
1965	October–December	Khor Umaira	209	200	51
1965	July	Khor Umaira	169	80	68
1965	June	Khor Umaira	98	122	45
1965	January–May	Khor Umaira	141	117	55
1964	August–September	Khor Umaira	327	271	55
1964	July	Khor Umaira	92	64	59
1964	June	Khor Umaira	35	37	49
1964	May	Imran	60	31	66
1964	February	Little Aden	181	130	58
1964	February	Khor Umaira	118	102	54
1963	December	Little Aden	60	24	71
1963	December	Khor Umaira	32	28	53
1963	October	Khor Umaira	154	106	59
1963	September	Khor Umaira	101	45	69
1963	February	Little Aden	144	73	66
1962	January–March	Little Aden	38	22	63
1961	December	Little Aden	40	20	67
1961	November	Little Aden	12	6	67
		Totals	2470	1906	56

1) Data taken by Hirth, the rest from the files of the Fisheries Department, Aden.

Circle nets range in length up to 400 yards long; they are 40 to 60 yards deep and usually have a 4.5-inch mesh. In Quaiti State the fishermen use circle nets, and occasionally footless gill nets, when they do not turn the females on the beach. The latter is by far the most common method in that area, however.

The fishermen at Khor Umaira are the most adept of the South Yemen turtlers. When they go to sea to catch turtles the fishermen use a "houri" (canoe-like craft) or "sambuk" (planked boat larger than a "houri"). The following comments from Hirth's field book relate a typical night's work:

> "31 October. It was high tide at 2130 and fishermen started work; one team of men held one end of a beach seine while a "houri" carried the seine out 100 yards; a second group then grasped the other end of the seine; after waiting 10 minutes, both teams, chanting and singing, pulled the wings of the seine together on shore and netted 32 turtles (14 males and 18 females) all over 30 inches in carapace length; the whole operation took one hour; the turtles were then taken by "houri" to the kraal in front of the village" (see Pl. II figs. 1, 2 and 3).

THE NESTING BEACHES

The western coast of South Yemen is generally low and sandy, with only occasional rocky headlands. Wide bays are frequent. The eastern coastline of the country is more varied, with sandy beaches intersected by rugged, rocky hills and cliffs. Because of the security situation, it was impossible to survey the entire coast and it is therefore possible that other nesting areas exist besides those here described. To round out any rational plan of protection for the South Yemeni turtles, these ought to be searched out at once. As with sea turtles everywhere, the key to the future of the resource lies in preservation of the nesting beaches. Nesting beaches will be considered separately for the different states. Names of geographic locations are from the British Admiralty Charts.

LAHEJ STATE

There is only sporadic nesting on the beaches bordering Bandar Fuqum, Bandar Imran and Ghubbat al Haika. One dead female green turtle was seen on the beach between Fuqum and Imran on 13 October, and another in nearly the same place on 2 November. Arab boys from the village of Fuqum, on the western extremity of the Little Aden peninsula, occasionally found hatchlings on the beach west of the village during the northeast monsoon. This suggests that some nesting occurs in October and November. One nest of hatchlings was found on 23 January between Imran and Fuqum. Sometimes the hatchlings are offered for sale to the Europeans, or are used as bait by fishermen, but this traffic is trivial. A few turtles captured on the feeding grounds at Khor Umaira contained eggs. With the cooperation of the turtle export firm, over 100 turtles captured at

Khor Umaira in October, November, December and January were dissected. In each month oviducal eggs were found in less than 6 per cent of the sample. During February, 1967, two dead turtles were found on the coast between Ras al Ara and Sakiah. Fishermen from Sakiah sometimes catch turtles in fish seines but say that the turtles contain eggs only rarely.

The most important nesting beach in Lahej State is on the uninhabited island of Jabal Aziz, just off Ras Imran. It is a hawksbill rookery. Jabal Aziz is a crescent-shaped island, about threefifths of a mile between terminal points and one-fifth mile across at its widest point. The spawning beach is approximately one mile long, and faces Bandar Imran. The southwest end is covered with small volcanic rocks and the surface is strewn with the shells of mollusks. Nesting thus occurs in rather deep debris. A rocky promontory separates the extreme north end of the beach from the main nesting area. Another narrow, rocky headland bisects the main rookery. Black volcanic mountains and light sand hills stand behind the rookery through its entire length. The color of the sand varies from brownish-red to yellow and there are scattered tussocks of grass throughout the area. Land hermit crabs are fairly abundant. Fishermen from Imran call the hawksbill *Zukar*, and they all agree that it is much more common here than the green turtle. The eggs of the hawksbill are eaten by some people in Imran, who also occasionally eat the turtle itself. The island was surveyed in October, 1966 but no fresh nests were seen. The numbers of hawksbills found nesting on specific nights in 1967 were: 5 on 30 January; 17 on 1 February; 8 on 2 Febeuary; 16 on 8 February.

One hawksbill captured on 1 February, after oviposition, was dissected. The stomach was found to be virtually empty except for a little green algae. The reproductive tract contained two more complements of developing eggs, which indicated that nesting occurs here through February. A female hawksbill taken on 24 January 1967 on Perim Island, 80 miles to the west, also would have nested through February in that locality (see section: "Perim Island"). Thirteen hawksbills were tagged on Jabal Aziz in February 1967.

The total number of eggs deposited by five hawksbills on the nights of 1 and 2 February were as follows (percentage of small, yolkless eggs in parentheses): 96 (21); 114 (39); 127 (22); 99 (20); and 103 (19). The average diameter of normal-size eggs from one nest was 40.5 mm (range 38–45). The average diameter of 28 small, yolkless eggs in the same clutch was 27.2 mm (range 25–30). Deraniyagala (1939) found the eggs of hawksbills from Ceylon to range between 35 and 38 mm in diameter. A hawksbill hatchling was found on the beach by a fisherman on 2 February 1967. Its dimensions were as follows: carapace length 42 mm; carapace width 32.5 mm; plastron length 32.5 mm; head width 14 mm. The measurements are close to those of the average Caribbean hatchling as described by Carr, Hirth & Ogren (1966). The color of the South Yemeni hatchling

(Pl. II fig. 4) was similar to that of a specimen from Ceylon described by DERANIYAGALA (1939) except as follows: carapace is tan-black with tan predominating in the middle (carapace light red or bay with a diffuse dark band between costal ridges in the Ceylonese specimen); plastron tannish or pale tannishwhite (black with yellow ridges in the Ceylonese specimen); flippers underneath mottled black and white (not described in the Ceylonese specimen).

The measurements and weights of some gravid hawksbills taken on Jabal Aziz in February 1967 are given in Table 7. Nesting females in

TABLE 7
Measurements (in inches) and weights (in pounds) of South Yemeni Hawksbills. All are gravid females captured on Jabal Aziz Island in February 1967.

Carapace Length	Carapace Width	Plastron Length	Head Width	Weight
25	22	18.50	4	78
26	22	20.50	4	97
27	22.50	20	4	80
27	22	21	4.25	96
27	21.50	21.50	4	98
27	22	23	4	95
27.25	20.50	19.50	4	78
28	21.50	22	4	98
28	19	20.50	4	80
28	21	21.50	4	100
28	21	22	4.75	105
28	20.50	22	4.50	100
28.50	23	22	4.25	110
28.50	21	22	4	110

South Yemen are significantly smaller than nesting females in Costa Rica and Guyana (CARR, HIRTH, & OGREN 1966, and PRITCHARD, 1969). Most of the hawksbills on Jabal Aziz were encrusted with barnacles on both the carapace and plastron. About half had barnacles on the head and flippers also. In contrast, only about 15 per cent of 160 green turtles caught in nearby areas had barnacles.

ADEN STATE

The State of Aden comprises 75 square miles. There is more nesting there than in Lahej State but much less than in Quaiti State further to the east. The beaches described below are located on the Aden peninsula, which is composed of volcanic rocks and mountains, the highest of which is 1,811 feet.

Abul Wadi Beach. This beach is in Fishermen's Bay, which has a maximum depth of 28 feet. Sea-surface temperatures off the beach, between September and December, vary from 78° to 85° F. In February, surface temperatures are between 76° and 78° F. The shore line of the beach is 1,000 feet in extent, with a maximum width of 300 feet. The nesting beach is crescent-shaped. It is composed of white-yellow sand and is bounded on all sides by volcanic mountains. Predators include shore birds, beach crabs and feral dogs. There is a lighthouse with a very bright blinking light about three-quarters of a mile from the beach. A local national, encamped on the beach for a week in October, was collecting turtle eggs for sale in the Aden (Crater District) markets, although the demand there is low. The female turtle is not eaten or caught locally. Ten fresh nests and five "half-moons" (false tracks made by turtles that crawl onto the beach but do not lay eggs) were found in October; two nests were seen in November, and one in December. Fishermen said a few turtles lay eggs here all the year round. High seas sometimes inundate the entire beach, as happened in November. Two female green turtles were tagged here (see Pl. III fig. 1).

A female leatherback was caught in a fish seine here on 9 July 1968. She had a carapace length of 63 inches, weighed 672 pounds and contained four sets of eggs in different stages of development.

Conquest Bay Beaches. The two beaches in this bay have a combined length of two-thirds of a mile. There was no sign of nesting activity during the northeast monsoon, but one fisherman was certain that a few turtles nested here at some time during the year.

Round Island Bay Beach. Here the shore line is about half a mile long, but the eastern half is strewn with rocks and is not suitable for nesting. The lower beach is white-yellow sand but the higher levels are covered with rocks. Mountains rise steeply at both ends of the beach and more gradually behind the shore. One nest was found here on 22 October 1966.

FADHLI, LOWER AULAQI AND WAHIDI STATES

Between 21 February and 2 March 1967, Mr. ABDO ISSA surveyed the beaches from Aden to Meifa Haja by Land Rover. He reported that two old turtle tracks, but no nests, were seen between Aden and Shuqra. Two dead green turtles were found on the beach a few miles east of Shuqra. Between Irqa and Haura there were four dead green turtles, one dead hawksbill, and one fresh green turtle nest. At Haura he found one leatherback. Near the village of Balihaf several dead green and hawksbill turtles and some scattered turtle bones were seen. Near Bir Ali there was evidence of recent nesting. On Halaniya Island, off Bir Ali, he found a pile of turtle bones that included two large leatherback skulls. After questioning many fishermen, ISSA concluded that most of the green turtles seen along this stretch of the South Yemeni coast are caught casually in fish nets. The dead turtles on the beaches were taken in seines that sometimes are left in place for several days. Few people here eat turtle meat or eggs (see Table 2). The fishermen in the Wahidi State informed ISSA that most nesting in their area took place during the *shamal*.

QUAITI STATE

Fuwa Beach. This beach is located eight air miles west of Mukalla. The shore line is about one mile long, but the nesting beach is interrupted by rocky intrusions at the western end. It is 300 feet wide at the widest point. The forebeach slopes gently into the sea, and higher up there are undulating dunes most of which are topped with clumps of grass. To the rear of the nesting beach is an area of hard-packed, red-brown sand that extends back to a series of low hills. Foxes and dogs were seen eating turtle eggs here. Two hatchlings were found on the night of 5 November 1966. Twenty-four turtles were tagged at Fuwa Beach in November.

Ma'din Beach. This is a small rookery about two miles west of Fuwa, where several new nests were seen in November. The beach is one-third of a mile long and 50 yards wide. The texture of the sand is loose; the color is whitish-yellow. The forebeach slopes gently to the sea and is surrounded by mountains.

Meifa Haja. One "half-moon" was seen near Meifa Haja in November 1966. In late February 1967 six large green turtles were taken by fishermen between Meifa Haja and the border of the Wahidi State.

Sharma Beach. This rookery is located 65 air miles east of Mukalla (80 miles by land) at longitude 49° 58′ east; latitude 14° 49′ north. The nesting beach is 1.1 miles long, and is bounded at each end by rocky headlands. The width varies from between 350 to 600 feet. The nesting beach is composed of light yellowish-brown, loose sand. Some sand dunes reach a height of 40 feet above low spring-tide level. Turtles nest on peaks of these dunes as well as along the slopes. To the rear of the rookery there is a stretch of brown-red sand that is too hard-packed for nesting. There are scattered clumps of beach grass, and mollusk shells are strewn on the forebeach. Feral dogs roam the beach, eating turtle eggs. Beach crabs and land hermit crabs are common. The approach to the beach is generally open, with only a few rocky ledges that present obstacles to gravid females coming ashore. The forebeach slopes gently. The depth of the water increases gradually to 11 fathoms about one-half mile offshore. This is without any doubt one of the best nesting beaches remaining in the world. In places the nests are so close together that the beach looks like an empty egg carton. During the 1966 nesting season, each night during November there were at least 50 green turtles nesting on Sharma Beach. During the latter half of January a different, smaller contingent of turtles had arrived, and between 15 and 20 turtles could be seen each night. On 12 March, between the hours of 2000 and 2100 five nesting females were seen. It seems possible that there is year-around nesting on Sharma, with different populations arriving at different seasons, as the current regimen changes. Some seemingly reliable informants said that more turtles nest during the *shamal* than at any other time of the year. A rough track through the mountains behind the beach connects Sharma with the inland village, Dis. There are indefinite plans to build a fish meal factory at Sharma. This would inevitably injure this important rookery. In November 1966, 136 turtles were tagged here; and 33 were tagged in January, 1967 (see Pl. III fig. 2). Five of the turtles tagged here in November and January have been recaptured in Somalia.

Musa Beach. The beach is one-quarter mile west of Sharma and is separated from it by a rocky headland. It is 800 feet long and 200 feet wide at the widest point. Mountains rise behind it and at one side. Feral py-dogs prey upon the incubating eggs. The sand is light yellow and loose-textured. Diving surveys revealed no turtle grass in shallow water off this beach, but there were patches of brown algae floating there in November. Twenty-eight turtles were tagged and released from this beach in November 1966, and one was recovered 39 days later, some 420 miles west at the village of Khor Umaira. One turtle was tagged here in January 1967. The intensity of nesting in January was negligible, as compared to that in November.

Ithmun Beach. Ithmun is located about one mile east of Sharma. Like Sharma, it must be counted one of the most productive green turtle breeding grounds in the world. The nesting beach is almost three miles long, and varies between 20 and 100 yards in width. The sand is light yellow and loose, as at Sharma. There are scattered clumps of beach vegetation on the hummocks. In November egg shells were spread profusely about the sand surface, probably representing either the depredations of feral dogs or nesting so concentrated that eggs of an earlier laying were unearthed by turtles nesting later. The entrance to the beach is dissected by rocky ledges and boulders. The rookery is bounded on both sides by mountains and there are low hills in the rear. Of the various nesting beaches here discussed this is the most isolated.

Shihr Beach. This beach, which is located about two miles west of Ash-Shihr, is about a quarter of a mile long and 200 yards wide at its widest point. In places there are mound-like dunes of sand, 50 yards across, with a 40–45° slope. Judging by the number of crawls ascending these slopes, the turtles find them no obstacle. The sand is loose and whitish-yellow. There are scattered hummocks of vegetation on the dune crests. A large number of turtles nested here in October and November, 1966, and a much lower number of arrivals in January and February, 1967.

Shuhair Beach. This nesting beach is located three miles west of Shihr Beach. In November 1966 there were many "half-moons" between these two beaches. The Shuhair rookery is about three-and-one-half miles long and is more heavily covered with vegetation than any of the other beaches. Goats sometimes graze here. As at Shihr Beach, turtles climb steep slopes to nest, although just as many dig nests on the slope itself. The sand is loose and of the same color as that on the other nesting beaches of Quaiti State. About 40 turtles per mile of beach were arriving here each night in November. Large numbers of nesting females were taken in November and December, and were sold to the concessionaire. In many of these females there were three sets of oviducal eggs (see Pl. III fig. 3). Many hundreds of gravid females had been taken here in previous years. In January 1967 there were about 15 to 20 nestling turtles per mile of beach.

PERIM ISLAND

Perim lies 100 miles west of Aden in the Straits of Bab-al-Mandab. It has a population of about 300, mainly fishermen. The average daily maximum and minimum air temperatures are 91° and 81° F., respectively. The average annual rainfall is 1.7 inches. HIRTH made a survey of this island between 3 and 7 December 1966 and officials from the Fisheries Department, Aden, visited it in the latter part of January 1967. No nesting was observed in December but the presence of body pits indicated that fairly recent egg-laying had occurred. The local inhabitants said that December and January were the chief nesting months and that two kinds of turtles came ashore. The inhabitants ate turtle eggs and, to a limited extent, the meat also. The size and characteristics of most of the holes indicated that most of the nesting on Perim was by hawksbills. An old fisherman related that a long time ago they used to heat live hawksbills over a fire to collect the scales (epidermal laminae) which were sent to Aden, where a good price was paid for them. They believe (as has since preColumbian times been believed by some Caribbean people) that a turtle so treated grows new scales within a few years.

False Bay Beach. There are actually two beaches here, separated by a rocky promontory some 50 yards wide. One beach is 600 feet long, the other about 500 feet long. Each nesting beach is about 60 yards wide and both are backed by hard-packed, brown sand unsuitable for nesting. The beach sand is tannish-white and very loose. With respect to its sand and other features, this beach differs from the hawksbill nesting beach on Jabal Aziz, some 80 miles to the east. On 5 December, two turtles were seen swimming back and forth across the bay, suggesting that nesting would soon occur. On 24 January 1967, a female hawksbill was killed by the local people as she emerged to lay. This turtle was dissected and was found to contain three sets of oviducal eggs, indicating probable continuation of nesting through February. As is common with hawksbills, this turtle had several barnacles on the head and many on the carapace. Measurements of this individual (in inches) were: carapace length 26.5; carapace width 21; head width 4.5.

Shand Bay Beach. Here again, there are actually two nesting beaches separated by a rocky promontory. Each beach is about 600 by 150 feet, with black hills behind it. There are also some light-colored sand hills at the rear, and these are conspicuous even at night. The sand is white and very loose. Six old nests in which the eggs had already hatched were found. The size of the egg shells indicated they were not those of *Chelonia*. During diving surveys off the beach two hawksbills were seen. On 25 January one small hawksbill (carapace length 16.5 inches; carapace width

15 inches; head width 2.5 inches) was caught in a fish seine set just off the beach.

Ras Sheikh Berkhud. This is a series of small scalloped beaches, each about 60 feet in length, just east of Ras Sheikh Berkhud. In December there were several old nests on each beach. There is an unnamed beach about mid-way between Ras Sheikh Berkhud and Obstruction Point. Here, as on the other beaches, the sand is loose and white. There were about 30 old nests here, but no sign of any recent nesting.

Kuria Muria Islands and Socotra Island. The information gathered on these islands was discussed in the section "Exportation of Sea Turtles in South Yemen."

Masira Island. British Air Force personnel reported that turtles of some kind nest on the island, and that the peak of the season is between April and July. De Gaury (1957) observed large numbers of turtles coming ashore to lay eggs during the spring months, but did not identify the species.

CHARACTERISTICS OF THE SAND ON SOME NESTING BEACHES

Although any general acquaintance with green turtle beaches in various parts of the world suggests that, short of imparting a tendency to pack solid, to waterlog, or to aerate too freely, the texture and composition of the sand is not a critical factor, little is really known about the subject. In Table 8 some features of the sand from Sharma are compared with those from green turtle nesting beaches in various other parts of the world.

Sand samples were taken at depths of from 0 to 5 cm at the level of the most seaward rank of nests. Sampling was done at the peak of the nesting season. Each sample analyzed was a composite from eight holes. Soil colors were determined with the aid of Munsell Soil Color Charts, 1954 edition, and are recorded in the standard Munsell notation. Colors were obtained both from air-dry samples and from samples moistened to field capacity. The pH was obtained by the Hellige-Truog colorimetric method and the soluble salts were determined by leaching samples with distilled water. The amount of carbonate was estimated by the degree of effervescence with 10% HCl and the organic content was computed using the potassium dichromate method. Particle size distribution was determined by mechanical analysis, using nested sieves.

The sand on the rookery at Sharma is composed of particles chiefly in the 0.5 to 0.25 mm size class—that is, medium-grained sand. The beaches at Ascension and Aves Islands are mainly composed of coarse sands and the beach at Tortuguero is, for the most part, made up of fine sand. Other features of the nesting-beach sand vary as much as the particle size does. Color, for instance, varies from olive grey at Tortuguero to white on Aldabra; organic content at Sharma is less than half that at Aldabra and Aves Island; and soluble salt content at Sharma is about one-third that at Tortuguero. Hendrickson & Balasingham (1966) concluded that in Malaya the green turtle prefers beaches of fine sand. The range of charac-

TABLE 8

Analysis of sand on some major green turtle nesting beaches

Nesting Beach	Color		pH	% Soluble Salts	Carbonate Content	% Organic Content	% Particle Size in Millimeters				
	Dry	Wet					> 1.	1.–.5	.5–.25	.25–.15	< .15
Sharma, South Yemen	10YR 8/4 Very pale brown	10YR 6/4 Light yellowish brown	7.5	0.45	high	0.48	0.7	8.8	73.7	15.7	1.1
Aldabra Atoll, Indian Ocean	2.5Y 8/2 White	5Y 8/3 Pale yellow	8.0	0.63	high	1.0	13.5	36.8	48.7	0.8	0.2
Ascension Is., South Atlantic	2.5Y 8/4 Pale yellow	2.5Y 7/4 Pale yellow	8.0	0.82	high	0.65	38.7	44.1	15.5	1.3	0.4
Aves Is., Caribbean Sea	10YR 8/2 White	10YR 8/3 Very pale brown	8.0	1.10	high	1.18	10.5	63.2	25.3	0.9	0.1
Tortuguero, Costa Rica	5.0Y 4/2 Olive gray	5.0Y 3/2 Dark olive gray	6.9	1.47	none	0.30	0	1.0	35.3	55.6	8.1

teristics of the sand analyses reported here suggests at least in some parts of the world *Chelonia* is curiously flexible as regards its incubating medium.

The cues that green turtles use in selecting their beaches – in making the decision to come ashore, and in selecting a site in which to nest, are still unknown. It is well-established, however, that the same nesting beaches are used year after year. It is at least possible that hatchlings are somehow imprinted with some sensible essence of the beach on which they hatch (Koch, Carr & Ehrenfeld, 1969), and that it is detection of this that guides them back to the same beach when they return as reproductively mature females ready to nest. Behavorial studies are now in progress at Tortuguero, Costa Rica, to determine the scale of the stranding-site fixity. Quantitative appraisal of this is complicated by a tendency toward clumped arrival by the turtles that use the beach and by the difficulty of deciding whether this is caused by aggregated travel to the beach or by convergence upon sites of attractive stranding signs. An aspect of the newly stranded female that may have bearing on this important question is the mannerism referred to as "sand-smelling" or "sand-nuzzling." This has been noted in the Atlantic green turtle (Carr & Giovannoli, 1957; Carr & Ogren, 1960; Carr & Hirth, 1962) and is even more well-marked in *Lepidochelys*, *Caretta* and *Eretmochelys*. This trait was observed at some of the South Yemeni beaches. Likewise the tendency to make "half-moon" or "prospecting-trails" and trial holes may be signs of sensory appraisal, although they may also be merely evidence of reproductive unreadiness. As noted in a preceding section of this paper, on the South Yemeni coast "half-moons" were a common feature of sections of the strand between sites of heavy nesting.

THE NESTING SEASON

Dissections of reproductive tracts of green turtles made in November regularly revealed at least two, and usually three, sets of eggs. This evidence, combined with observations elsewhere that *Chelonia* usually renests up to six times, at intervals of 10 to 14.5 days (Hendrickson, 1958; Carr & Ogren, 1960; Carr & Hirth, 1962) leads to the conclusion that the flotilla observed and tagged in November at Sharma and Shuhair beaches had arrived, or at least commenced laying, in early September and would have continued renesting through the first week in December. This estimate was supported by the reports of reliable Bedu (Bedouins), who occasionally eat turtles and eggs at Sharma and who said that nesting occurs in Sharma in September. Five records of renesting on Sharma Beach are given in Table 3. The renesting interval varied from 7 to 13 days. All turtles returned to the same beach to renest. Tracks of hatchlings were seen on Sharma Beach in November. Assuming an incubation period of between 47 and 80 days (Hornell, 1927; Hendrickson, 1958; Carr & Ogren, 1960; Carr & Hirth, 1962), one can deduce that the eggs these hatchlings came from were laid in September.

Fewer than half as many turtles nested in January as in November. Three of the January arrivals were dissected. Two of these had two sets of oviducal eggs and the other had one set. This suggests that they would have nested through February. It seems likely, however, that the January turtles were part of a different smaller nesting population and not part of the same group that nested in November. On 12 March 1967, five nesting females were seen on Sharma Beach between the hours of 2000 and 2100.

It is possible that other flotillas arrive or commence laying on the beaches of Quaiti State at other times of the year. In fact, there may be some year-round nesting on the coast of South Yemen as was reported by HORNELL (1927) in the Seychelles, by HENDRICKSON (1958) in Malaya and by Dr. G. S. DE SILVA for Sabah (oral communication to CARR). In any case, it would seem reasonable that the possibly different populations represented by the two-year and three-year migration cycles (if both occur here) would show slightly different seasonality.

Based upon observations made in November 1966, it can be said, confidently that the density of nesting, specifically at Sharma Beach, Shuhair Beach and Ithmun Beach, is much greater than at the seasonal peaks on Ascension Island and at Tortuguero, Costa Rica. At these Yemeni rookeries, on almost any night in November, between the hours of sunset and sunrise, once can see at least 40 or 50 nesting females per mile of beach. There seems little doubt, thus, that some of the best remaining green turtle nesting areas in the world occur on the coast of South Yemen.

MISCELLANEOUS COMPARATIVE OBSERVATIONS ON TURTLE POPULATIONS ALONG THE COAST OF SOUTH YEMEN

Several important characteristics of the turtle populations of Quaiti State (Mukalla and neighboring beaches) and Lahej State (coastal villages from Imram to the Yemen frontier) seem worth recording. These are as follows:

1. There are distinct green turtle nesting beaches in Quaiti State but there are no concentrated nesting areas in Lahej State, except for the very minor one at Abul Wadi Beach on the Aden peninsula. There are two important hawksbill rookeries in Lahej State, however, one on Jabal Aziz Island and the other on Perim Island. At the big rookeries in Quaiti State no hawksbills were found nesting with the green turtles.
2. In 1966, the laying season of one large contingent of green turtles in the Mukalla region extended from September through November. Few turtles taken during these months at Khor Umaira (in Lahej State) had oviducal eggs of any size. A smaller and evidently different group of turtles nested in Quaiti State during January, February and March. No turtles taken at Khor Umaira during these three months contained any eggs at all.

3. There was little food in stomachs of females that nested in the Mukalla region in November and January. Male and female turtles taken from the feeding pastures off Khor Umaira in November and January regularly had the digestive tracts packed with "turtle grass."
4. Turtles taken in the Mukalla area in November and January appeared to have more fat than those taken at the same time in the region of Khor Umaira. These observations were reinforced by the fact that the turtle exporter was able to get more oil from a Mukalla turtle than from a Khor Umaira individual of the same size.
5. Fishermen in the Mukalla region turn turtles on the beach during the nesting season for the export trade. These are, of course, all females. The same people sometimes take both sexes in nets set off the nesting beaches. At Khor Umaira all turtles taken are caught in beach seines or circle nets. The fishermen at Khor Umaira say they can catch turtles every month except during the southwest monsoon. They say that then the turtles go out to deeper water and they are unable to follow them that far with their "houri" or "sambuks". When asked if they would be able to get turtles throughout the year if they had larger boats they replied in the affirmative. We have no way of evaluating this view.
6. Whether all the sea turtles that nest in Quaiti State come there by long-range migration, or whether some are migrants and others permanent residents, is not known. Mukalla fishermen say they can catch turtles on the beaches, or in the sea just off the beaches, at all times of the year. As was said earlier, this suggests that year-round nesting occurs and that it is done by different populations. In the Mukalla area there appear to be no extensive feeding pastures near the nesting beaches. On the other hand, one of the most significant results of this project has been the recovery, in December, on the Khor Umaira feeding grounds, of a female green turtle tagged in November as she was laying her eggs on Musa Beach in Quaiti State (see section: "Long Distance Movements"). This suggests that the coastal fishermen in Quaiti State and Lahej State are, at least in part, exploiting a common resource.

NESTING BEHAVIOR

Because the nesting behavior of the Yemeni green turtle follows the same general pattern as that of sea turtles everywhere, there seems little point in recording the whole process here. We will mention only those parts of the operation that appear to vary locally.

On the average, a turtle on the beaches of South Yemen takes two hours to complete the nesting sequence. A schedule was as follows: clearing of nest site and excavating a body pit, 35 minutes; digging nest hole, 35 minutes; oviposition, 10 minutes; filling and packing nest hole, 10 minutes; filling body pit and concealing the site, 40 minutes.

If one includes in the nesting sequence the time it takes for the turtle to emerge from the wave wash, crawl from the surf and select a nest site, and then crawl back to the sea after nesting, the total time on land is increased by one-half to one-and-a-half hours. There is variation because some females crawl only a short distance up the beach and immediately start digging a body pit, while others may wander about and make several trial holes before finally choosing a place to nest. The return to the sea is usually direct – a slow, dragging crawl, mainly in a straight line.

Some noteworthy variations in the nesting behavior of Yemeni green turtles are (1) the relatively deep body pits, sometimes more than twice the depth of the shell, (2) the audible "thud" made by the back-stroke of the hind foot during the process of digging the egg chamber, and (3) a peculiar shuffle in the early part of the same stage. The deep body pits no doubt reflect the extremely loose, friable character of the sand at most of the rookery beaches. In this respect the body pits here suggest those made by Ascension Island green turtles (CARR & HIRTH, 1962).

In approximately 60 per cent of the nest-hole excavations observed, the extreme forward swing of the back flipper that flips sand forward during egg-chamber excavation brought the foot sharply against the shell with a thudding sound. This sound is sometimes heard at the green turtle rookery at Tortuguero, Costa Rica (CARR & GIOVANNOLI, 1957), although by no means in all cases of nest-digging.

HENDRICKSON (1958), CALDWELL, CARR & OGREN (1959), and CARR & OGREN (1959) all recorded that when digging the egg chamber, several species of sea turtles regularly pivot their body on the anterior part of the plastron, to swing the working flipper into position over the hole. In most of the Yemeni nestings observed there was a distinct two-step movement at this stage. After the left hind flipper jerks forward, kicking away the loose sand on that side and making the sound just described, the body pivots toward the right a little, stops, then shifts again toward the right and stops with the flipper in position to dig. This shuffle is most pronounced during the initial stages of the nest digging sequence, and as the egg hole deepens, it may persist on only one side for a while. As the nest hole nears completion all pivoting usually ceases.

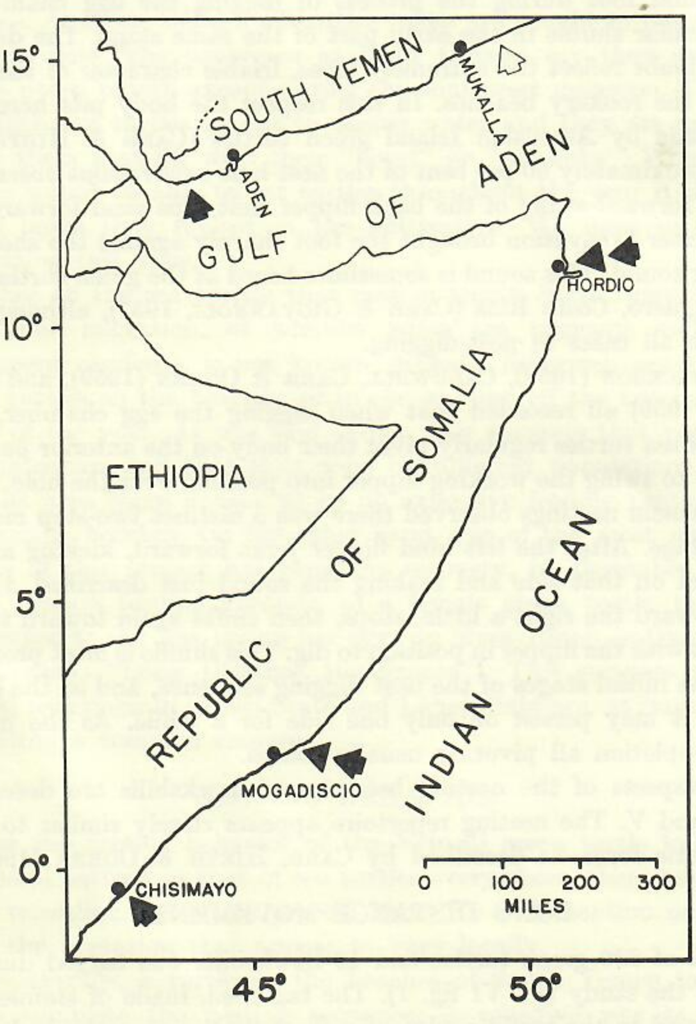
Some aspects of the nesting behavior of hawksbills are described in Pls. IV and V. The nesting repertoire appears closely similar to that of the Atlantic form, as described by CARR, HIRTH & OGREN (1966).

LONG DISTANCE MOVEMENTS

A total of 239 green turtles and 13 hawksbills was tagged during the course of the study (Pl. VI fig. 1). The tag used, made of stainless steel, was clamped to the trailing edge of a front flipper near the body. Eight green turtles were tagged in Lahej State, 2 in Aden State, 222 in Quaiti State, and 7 were tagged in the Seychelles Islands. All the hawksbills were tagged on Jabal Aziz Island, off Imran in Lahej State.

A female turtle (tag no. 142), tagged on 17 November 1966, after it had finished laying eggs on Musa Beach in Quaiti State, was recaptured 39 days later, 26 December 1966, in a circle net on the pasture off Khor Umaira in Lahej State (see text-fig. 6 and Table 9). The shortest straight-line distance between these two points is 420 miles. Assuming that the turtle had swum in a straight line, had left Musa Beach immediately after being tagged, and had been caught immediately upon arrival at Khor Umaira (all very unlikely) she would have traveled a minimum of 10.8 miles per day.

Later tag recoveries – five from the east coast of the Republic of Somalia (Table 9 and text-fig. 6) add significantly to the results of this study, and



Text-fig. 6. Long distance movements of six female green turtles. The white arrow indicates site of tagging (Musa and Sharma Beaches) east of Mukalla. Black arrows show places of recapture: one at Khor Umaira, South Yemen; and, five on the east coast of Somalia.

TABLE 9

Long distance recoveries of female green turtles. All were tagged on Musa and Sharma Beaches, South Yemen. These beaches are adjacent to each other and are approximately 65 miles east of Mukalla

Tag No.	Date Tagged	Place Recovered	Date Recovered
111	16 November 1966	40 km north of Mogadiscio, Somalia	15 November 1968
142	17 November 1966	Khor Umaira, South Yemen	26 December 1966
154	17 November 1966	Chisimayo, Somalia	25 December 1967
168	17 November 1966	Hordio, Somalia	10 February 1967
169	17 November 1966	Hordio, Somalia	10 February 1967
212	24 January 1967	68 km north of Mogadiscio, Somalia	7 November 1967

suggest that the problem of interpreting the ecological geography of the populations involved will be even more difficult than that of explaining the Ascension-Brazil pattern. It ought to be emphasized, however, that no pattern of sea turtle migration is really simple, with the hatchlings disappearing into limbo for at last a year and with nothing being known of developmental migration prior to sexual maturity. The Ascension pattern, in part, appears to adhere to a classic reproductive migratory pattern of marine animals, with the grown turtles breasting a current to get to a breeding area, and the young and spent adults drifting back to the resident ground. The defect in the pattern is that there are no young turtles on the Brazilian pastures.

There are probably none on the Somali pastures either, although we do not know this. It is nevertheless tempting to speculate on possible travel routes and stations suggested by the six tag recoveries from the present tagging project. Five of the turtles involved were tagged on adjacent beaches in the eastern end of the Gulf of Aden on the nights of 16 and 17 November. The northeast monsoon usually begins there in November and at this time there is a surface flow from the Arabian Sea into the Gulf of Aden (see section: "Climate, Monsoons and Currents"). The five turtles, probably part of a larger migrating contingent, could have drifted westward along the South Yemeni coast with this current, perhaps stopping to feed in such places as Khor Umaira where there is good pasturage. Some of this migratory group may remain on the grazing grounds in the Gulf of Aden and others go on with the current to the entrance of the Red Sea. As the northeast monsoon fades away, a strong Red Sea current flows out of the Gulf of Aden along the Somali coast, and the Somaliland surface current flows southwest along the eastern coast of Somalia. The South Yemeni turtles recovered in Somalia may have entered the Red

Sea current, have been carried to the horn of Africa, and then have drifted south with the Somaliland current.

The dates and places of some of the recaptures give substance to an assumption that the five were traveling as part of a group. No. 142 was recovered in South Yemen about one month after it was tagged; Nos. 168 and 169 at Hordio after about three months; and No. 154 near Chisimayo after about 13 months.

Minimum rate of travel for two of the turtles (Nos. 168 and 169) tagged on the same night and recovered on the same day, may be calculated. Assuming that they traveled close to shore around the Gulf of Aden they swam an average of 14 miles per day for 85 days.

The recapture of turtle No. 111 near Mogadiscio, Somalia, exactly two years after the date on which it was tagged, stimulates more theorizing. Because some female green turtles nest on a two-year schedule, this one might have nested on Sharma Beach in the early autumn of 1968 and have been recaptured after a second trip down the Somali coast. On the other hand, she could have been feeding off the Somali coast for many months prior to her return to South Yemen in 1969, since most female turtles have a three-year reproductive cycle. If the latter hypothesis is correct, the recapture does indicate the whereabouts of at least one turtle, one year prior to oviposition in South Yemen. The recapture of No. 212 near Mogadiscio in November 1967 suggests that in using the coastal route, if indeed it is used, the migrants are not strongly dependent upon prevailing currents. This would lead to an alternate hypothesis to explain the long-distance travel, that after having nested in South Yemen, five of the six recaptured turtles swam across the Gulf of Aden to the horn of Africa. At this time we thus have no firm hypothesis as to the route taken by the turtles in returning to the nesting grounds in South Yemen.

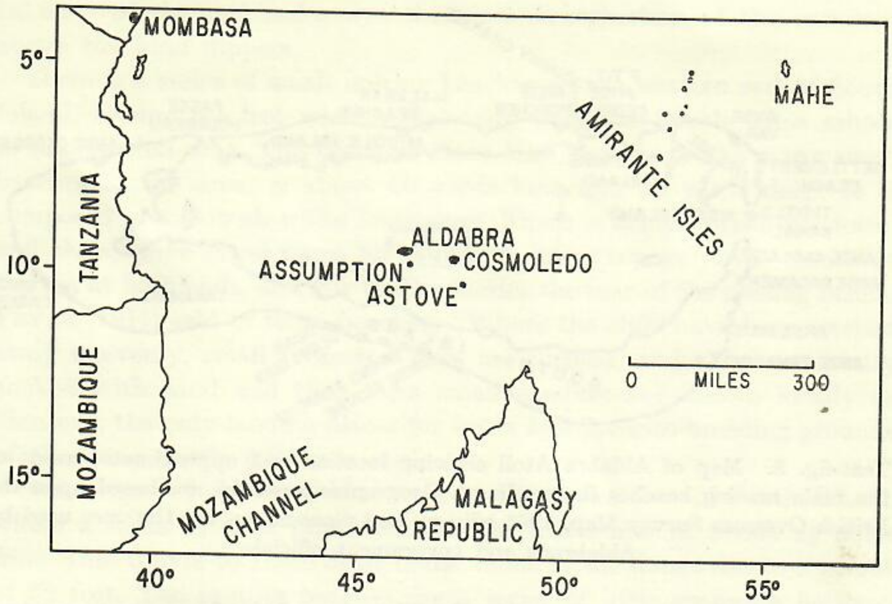
THE GREEN TURTLE IN THE SEYCHELLES

In February and March, 1967, HIRTH made a survey, sponsored by the Seychelles government, of the green turtle resource in the Seychelles Archipelago. A special effort was made to determine nesting population levels on the four southern islands: Aldabra (now part of the British Indian Ocean Territory), Assumption, Astove, and Cosmoledo.

The fondness of the Seychellois for turtle flesh is traditional and green turtles have been exploited in the Seychelles for centuries. Long ago, FRYER (1911) and HORNELL (1927) noted the decline in numbers of turtles, and both recommended stringent protective measures. More recently, HONEGGER (1967) and GAYMER (1968) collected evidence which indicated that the numbers of green turtles were decreasing each year. Now the turtle population, particularly females, appears to be at a very low ebb.

THE NESTING AREAS

In the Seychelles there have apparently always been more green turtles



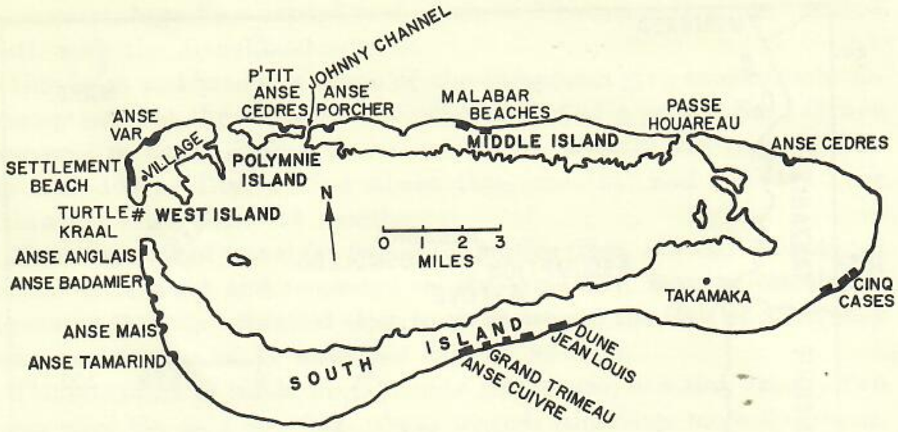
Text-fig. 7. Locations of the principal islands in the Seychelles Archipelago discussed in the text.

around the southern islands and atolls than in the northern islands. Although some turtles still remain in the Amirantes Isles, located approximately in the middle of the Archipelago. these occur in only a fraction of their former numbers. The best nesting grounds have always been, and still are, the four southern islands (see text-fig. 7). These nesting areas were visited during what local information and government records indicate was the peak of the nesting season. Brief descriptions of these islands and of the degree of nesting observed in February and March 1967 follow.

ALDABRA

Aldabra, the largest of the Seychelles atolls, is about 20 miles long and 5 to 8 miles wide (see text-fig. 8). The land rim is divided by narrow passes into four islands: West, South, Middle, and Polymnie. The only permanent settlement in the group is on West Island. During the stay of the expedition there were thirty-two adults and several children living on Aldabra. Aldabra atoll is almost entirely surrounded by a narrow fringing reef. The shore of the lagoon is bounded by mangrove swamps. The bush, *Pemphis acidula,* occupies a large part of each of the islands.

When the expedition reached Aldabra on 24 February there were 20 adult male green turtles in a turtle *kraal* there. They had been harpooned from pirogues during the preceding four weeks while mating offshore (Pl. VI figs. 2 and 3). Government regulations in effect at the time of the survey prohibited the capture of females, either on shore or in the water,



Text-fig. 8. Map of Aldabra Atoll showing location and approximate extent of the main nesting beaches (heavy lines). Geographic locations are based upon the British Overseas Survey Map, 1964 edition, and place-names are the ones used by Aldabrans and government officials.

between 1 December and 31 March. The aim of the law was to protect the females during the mating season and for the first two months or so of the peak of the nesting period. Enforcement of the regulation has been difficult.

The local names for the green turtle are *Tortue de Mer* (French) and *Tortie de Mer* (Creole). The hawksbill, called here *caret*, is in places fairly abundant. There are some patches of turtle grass (*Cymodocea* sp. and *Posidonia* sp.) around the atoll, but not enough to support a large permanent population.

Measurements of ten male green turtles are given in Table 10. The mature males are about the same size as those in other populations.

TABLE 10

Measurements of ten male green turtles harpooned while mating off Aldabra Island. All measurements are in inches

	Carapace length	Carapace width	Plastron length	Head width
	33	26	27.5	4
	35.5	27	27.5	5.5
	37	28	29	5
	37.5	29	30.5	5.5
	38	27	28	5.5
	38	27	30	5.5
	38	30	32	5.5
	38.5	31.5	32.5	5.5
	41	31	32	5.5
	41	32	32	5.5
Average	37.8	28.9	30.1	5.3

In none of the ten males was there an emargination of the carapace above the hind flippers.

There is a series of small nesting beaches on the western end of South Island. During the last week in February only one female came ashore to nest in that area. The beach at Anse Mais, typical of the many small beaches in the area, is about 50 yards long and 30 yards deep. It is composed of yellowish-white loose sand. There is a high beach platform, and *champignon* (local name for miniature karst topography) extends to the sea at both ends, and low bushes border the rear of the nesting beach. FRYER (1911) said of these beaches: "Where the cliffs have been washed away unevenly, small protected bays are formed, and these get partly choked with sand and then form small sandbeaches known locally as "lances", the only landing places for boats and favorite breeding grounds of the green turtle (*Chelonia mydas*)."

Some signs of old nests were seen at the dunes area of South Island, where a series of sand dunes extends for a distance of about 2½ miles from Anse Cuivre to Dune Jean Louis. Some of the dunes rise to a height of 50 feet. The nesting beaches are a series of little crescents between headlands of *champignon*. Nesting in most cases is on the beach platform. The sand is loose and whitish-yellow. A typical beach of the area is about 50 yards long, and nesting occurs for some 30 yards beyond the beach platform (see Pl. VII fig. 2). The beaches are littered with whitened turtle bones and scutes, representing the accumulation of years of killing of the nesting females on shore (see Pl. VII fig. 1). There are scattered clumps of *Tournefortia argentea*, *Scaevola* sp., and *Guettarda speciosa* on the strand. Several kinds of green algae encrust low rocks in shallow waters just off the rookeries, and it seems likely that this is eaten by sea turtles during their sojourn off the island. This was not substantiated, however. At Dune Jean Louis there were two old nests; just east of Dune Jean Louis there were six, and on Grand Trimeau there were two. No other signs of nesting were seen between Dune Jean Louis and Grand Trimeau. There are no areas of concentrated nesting between Dune Jean Louis and Cinq Cases.

At Cinq Cases the spawning beach is not continuous but is broken up into several little nesting areas where the sand extends some 50 yards beyond the high tide mark. The seaward approach to all the beaches here is rocky and they are all littered with driftwood, coral, and bleached turtle bones. Some sand hummocks are covered with grass. This is cropped by herds of giant land tortoises (*Testudo gigantea*), which are abundant on South Island (see Pl. VII fig. 3). The two best nesting beaches at Cinq Cases, one on the east end and the other on the west end, are separated by a distance of three-quarters of a mile. There were 14 old nests on the western beach and two on that at the eastern end, but no sign of any recent nesting. These nests appeared to have been made in late January or early February. A foreign fishing boat that was anchored off this nesting area during the first week of March may have taken some turtles, although this was not seen.

There are no turtle nesting beaches between Cinq Cases and Anse Cedres. *Champignon* extends to the surf. At Anse Cedres the nesting beach is 40 yards long and 30 yards wide. It is littered with turtle bones. The entrance to the nesting area is very narrow, and is flanked by headlands of *champignon*. Almost everywhere on Aldabra the turtles must cross the fringing reef to nest, and at some points this must be a formidable task at low tide. On Anse Cedres, there were five nests from one to five days old, and one female came ashore to nest on the night of 3 March.

There are no turtle rookeries between Anse Cedres and Passe Houareau, although turtle grass occurs in Passe Houareau. Nesting beaches on Middle Island, Polymnie Island and West Island are located in text-fig. 8. Several recent tracks, but no nests, were seen on the Malabar Beaches and Anse Porcher.

On Settlement Beach, in front of the village on West Island, there were no old nests at all. The shore here runs in a north-south direction and the beach is approximately three-quarters of a mile long. This is the longest beach on Aldabra and a century ago was apparently one of the best green turtle nesting beaches in the world. The settlement now occupies the better part of the beach, and nesting has almost completely stopped.

To summarize the above: All the coast except a small segment of the southwest corner of South Island was surveyed either by foot or by small boat, between 24 February and 6 March. The survey suggested that most nesting now occurs on the isolated small beaches of South Island. There are no big, concentrated nesting areas anywhere. The sex ratio off the Aldabran nesting grounds may be 5: 1 or higher, with males predominating. It was estimated that there are fewer than 1,000 female green turtles nesting on Aldabra each year. Because the local populations may be composite, however, – with individuals coming from different places and nesting on either a two-year or a three-year cycle – it seems possible that in some years the arrivals may be more or fewer than those in 1967.

Migratory routes of the Seychelles turtles are not known. Throughout the year, however, the South Equatorial Current flows by Aldabra and over to the African coast, thus providing the conditions for a reproductive migration of the Ascension Island pattern. Though there have never been any tag recoveries to substantiate the suspected commuting of green turtles between Aldabra and the coasts of Tanzania and Kenya, the lack of any good pastures about Aldabra and the presence of good pasturage in the Bajun Islands and along the Kenya coast suggest that at least some of the Kenya turtles, once abundant there but never known to nest in numbers, were derived from Aldabra or other Seychelles beaches. The present depleted condition of both the breeding and feeding colonies may make it difficult to substantiate this by tagging. On the other hand, the tagging project conducted on the Arabian peninsula may, in time, show that some of the turtles feeding off Kenya breed on the beaches of South Yemen.

ASSUMPTION

Assumption is 4 miles long and with a greatest width of 1½ miles. It is almost entirely surrounded by a narrow fringing reef. There is a small settlement on the western side of the island. Most of the inhabitants are employed in excavating the remaining guano deposits.

The two best potential nesting areas appear to be the section backed by dunes on the southeast corner, and the long beach on the western coast of the island. Seven recent nests were found on the dune-backed section. The beach on the west coast appears to be ideally suited for sea turtle nesting, but on 7 March only six old nests were counted on 2½ miles of the beach. The sand is white and calcareous and in places almost covered with *Ipomoea* sp. Like Aldabra, Assumption was a heavily used nesting island in the last century, and as many as 200 females could be taken in a single night there. Now, however, the island is unimportant as a green turtle breeding ground, and the few turtles that are taken nowadays are consumed locally (see Pl. VII fig. 4).

Measurements of two females tagged on Assumption are given in Table 11.

ASTOVE

Astove atoll, with a nearly perfect rim of land, is approximately three miles long and two miles wide. It is surrounded by a very narrow fringing

TABLE 11

Measurements of seven female green turtles tagged on the nesting beaches of Aldabra and Assumption in 1967

Tag Number	Date (Tagged and Released)	Place (Tagged)	Carapace Length	Carapace Width	Plastron Length	Head Width
250	25 February	Anse Badamier ALDABRA	39.5	31	34	6
251	1 March	Cinq Cases ALDABRA	40	31.5	33	5
252	2 March	Cinq Cases ALDABRA	38	29	32	5.75
253	3 March	Anse Cedres ALDABRA	39	32	33	5.5
254	6 March	Polymnie Island ALDABRA	42	32	32.5	6
255	7 March	S. E. Dunes ASSUMPTION	39.5	31	32	6
256	7 March	S. E. Dunes ASSUMPTION	41	32.5	34.5	6

reef. On 8 March many turtles were seen swimming in shallow water off the beach on the western side. In addition, 18 recent nests were counted on a mile-long segment of the beach. Of all the islands reconnoitered on the expedition, Astove had the highest density of nesting and the greatest number of turtles in the water off the beaches. The dense turtle population is perhaps correlated with the fact that until recently the island was uninhabited. No turtles are caught at Astove for shipment to Mahé, as they are elsewhere in the area. The expedition lacked the time to reconnoiter the east side of the atoll, where additional nesting may occur.

COSMOLEDO

Cosmoledo atoll is about $9\frac{1}{2}$ miles long and 7 miles wide. It comprises numerous islands of raised coral reef and rock. The largest of these are Menai and Wizard Islands. The only permanent village on the atoll is on Menai. The principal activities there are fishing and coconut farming. There is a long, white, calcareous beach on both sides of the settlement. Few turtles nest there now, no doubt because of the presence of the village.

Wizard Island is largely composed of sand and gravel. The main beach there is about 100 yards long. On 9 March thirty old nests and a few recent ones were counted. Several turtles were seen offshore. Next to Astove, this appears to be the best nesting area left in the Seychelles. There is a sizable population of carets in the lagoon. The flesh of the caret is eaten locally and the shells are shipped to Mahé, where they are made into curios for the tourists.

Cosmoledo and the other three islands have one feature that particularly favors sea turtle nesting and that is the almost complete lack of feral dogs.

EXPLOITATION

Government regulations in effect at the time of the survey allowed a certain number of turtles to be taken from the southern islands. Some of these were consumed locally and the rest shipped to Mahé. The annual quotas for the respective islands for the last few years, including both sexes, were: Aldabra, 500; Assumption, 200; Cosmoledo, 50 to 100; and Astove, none. Table 12 shows the actual number of turtles that passed through customs in Mahé during the past five years. Seven out of every ten green turtles sold in Mahé over the past five years were males. These data support the field observations that males greatly outnumber females around Aldabra. Males are usually harpooned, while the females are taken both in the water and on the beach. In August, 1968, the "Green Turtle Protection Regulation" was passed by the Seychelles Government and this ordinance provides complete protection for both sexes throughout the Seychelles.

As was said, the highest density of nesting in 1967 was on Astove, which until recently was uninhabited and had no annual quota. Cosmoledo (Wizard Island) was the next best nesting area, and it had the smallest

TABLE 12

Number of green turtles received on Mahé from outlying islands (mostly from Aldabra) in recent years [1])

Year	Males	Females	Total
1964	185	135	320
1965	222	114	336
1966	215	80	295
1967	301	62	363
1968	57	12	69

[1]) Courtesy of the Customs Department, Mahé.

quota of any of the islands. Aldabra and Assumption had the smallest number of nesting females and had the largest annual quotas.

COLORATION

The following descriptions apply to a male and a female, both taken at Aldabra, which were considered typical of their size classes (see Pl. VI fig. 3, and Pl. VII fig. 4).

A male with a carapace length of 41 inches has the carapace mottled black and green, and with some diffuse blotches of yellow and tan. Ground color of the top of the head is black, with some green and yellow mottling in the center. The scales of the sides of the head are black and are separated by distinct yellow sutures. The upper jaw is blackish, with a yellow cutting edge; the lower jaw is yellowish; the throat is white. The upper surface of the flippers is black, with some tan on the trailing edge while the lower surfaces are whitish-yellow with a few black scales on the tip. The plastron is almost a uniform whitish-yellow.

A female with a shell length of 39 inches has the carapace mottled with black, green, brown and yellow but with several hues of green predominating. The top of the head is mottled in black and yellow, with black predominant. The sides of the head are yellowish-green with a few black centered scales. The upper jaw is black with a yellow cutting edge. The lower jaw is yellow with a few black streaks. The throat is white. Each of the flippers is mottled black and green above. The lower surfaces of the flippers are yellowish-white with some green-black spots in the middle and a few black scales on the tips. The plastron is pale yellow.

The senior author did not notice any really significant differences in coloration between green turtles from the Seychelles and South Yemen.

SUMMARY

Green turtles abound in the Gulf of Aden. Various aspects of their life

history are discussed here, including sizes of eggs, hatchlings and adults; populations of males and females on the marine pastures; feeding habits; movements; and natural mortality. Comparisons are drawn with green turtles in the Caribbean, South Atlantic and China Sea, on various bases.

Some of the best nesting beaches in the world are located on the coast of South Yemen. The better rookeries are east of Mukalla and the better feeding pastures are located west of Aden. Feral dogs are the most serious predators on incubating eggs. The majority of South Yemenites do not eat turtle flesh or eggs but there is an expanding export trade operating out of Aden and Mukalla. Females slightly outnumber males on the feeding pastures of South Yemen.

Five turtles tagged in South Yemen were later recaptured in the Republic of Somalia. Long range movements may be influenced by water currents during the two distinct monsoons.

Hawksbills occur in the Gulf of Aden and two rookeries are described. Accounts are given of some aspects of the nesting repertoire of hawksbill and green turtles.

The leatherback is only rarely seen in the Gulf of Aden.

The female green turtle population nesting on the southern atolls of the Seychelles archipelago is now at a critical low level. Current intensity of nesting on Aldabra, Assumption, Astove and Cosmoledo is correlated with degree of exploitation. Males greatly outnumber females off the Aldabran rookeries.

ACKNOWLEDGEMENTS

Special thanks are extended to Mr. V. T. Hinds, former Director of the Fisheries Department in Aden, for his help and encouragement throughout the course of the project in South Yemen. Mr. P. FitzGerald of the UNSF/FAO Fisheries Project in Aden provided invaluable administrative assistance. Mr. Khazed I. Hariri was a very knowledgeable companion on field trips along the coast and has cooperated further by forwarding significant recapture data to us. Mr. Abdo M. Issa, Hirth's FAO counterpart, was a helpful and efficient guide on all turtle projects. Major P. Boxhall helped Issa with the work on Socotra. Mr. A. White, Assistant Fishery Officer, Mukalla, coordinated turtle expeditions in Quaiti State and provided charming accommodations for the survey team in Mukalla.

A special note of gratitude is due Mr. Jim Andrews and the Rev. Bert Turton of the British Sailors' Society Mission, Aden, for providing Hirth with pleasant quarters in spite of his erratic peregrinations to the hinterlands and for the pleasure of their company through many long Arabian nights.

Prof. J. L. B. Smith of Rhodes University, South Africa, had the marine grasses identified. Mr. M. Shubeili materially aided the work on Perim Island. Mr. Sayed Ahmed al-Attas, Minister of State, Mukalla, and Sheikh DURBEE of village Khor Umaira provided assistance in their respective areas. Mr. M. RONCHI have his time and help on several expeditions. To these people the object is indebted.

Mr. ABDUL WASSA HAIDER and Mr. MAHFOOD ALI KHAN, Fisheries Department, Aden, aided the project in many ways. MAHFOOD kept HIRTH going in the field with his delicious *khubz*, and ABDUL coordinated the security arrangements in Aden. The following men helped tag turtles in the Mukalla area: RAWAH ABDOORAH AL-SULWI, MBARAH KARAMA BIN SAHIB, KHAMIS ABUD JAREDI, and AHMED OMAR DAAKIK. Mr. ABDU KADER helped to draw the figures.

Thanks are extended to the officers and men of the Arab Federal Army for providing escort on camping trips to remote areas.

A debt of gratitude is owed to Mr. GUY LIONNET, Director, Department of Agriculture, Mahé, and to Captain A. SAUVAGE for their co-operation and assistance on the Seychelles expedition. Mr. G. F. POLLARD provided administrative help in Mahé. Mr. HARRY SAVY and the various island managers extended many courtesies while camping on the different islands and to them HIRTH owes his gratitude. Mr. P. LOUSTAU-LALANNE provided valuable information and was very helpful on the surveys of the Mahé region.

Mrs. BETTY G. WALKER skillfully typed the several versions of the manuscript.

The deepest appreciation of gratitude is extended by HIRTH to his family: his wife, LOIS, and daughters, DEBBIE and DIANA, for keeping morale high in spite of cataclysmic situations.

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PLATES I—VII

EXPLANATION OF THE PLATES

PLATE I.

Fig. 1. Immature females from the Gulf of Aden. The carapace length of the smaller was 19 inches and it weighed 30 pounds. The other was 29 inches long and weighed 130 pounds.

Fig. 2. A female from the Gulf of Aden. The carapace length was 26 inches and it weighed 80 pounds.

Fig. 3. Mature male (on left) and mature female turtles from Khor Umaira, South Yemen. The male weighed 240 pounds and the female 290 pounds. The length of the male was 37 inches; that of the female, 39 inches.

PLATE II.

Fig. 1. Sheikh and head fisherman at village Khor Umaira with one male and two female turtles. Each sheikh along the coast controls turtle fishing rights near his village.

Fig. 2. Turtles recently netted on feeding pastures near Khor Umaira await truck transport to slaughter house in Aden. Both sexes are caught with equal frequency.

Fig. 3. The most common method of transporting turtles across the south Yemeni desert.

Fig. 4. A hatchling hawksbill caught near Imran, South Yemen.

PLATE III.

Fig. 1. Measuring a turtle, prior to tagging, on Abul Wadi Beach, Aden. Because of unrest attending the withdrawal of British authority, all field work was done under armed escort.

Fig. 2. The beach at Sharma. One of the best green turtle nesting areas in the world. Note the deep body holes.

Fig. 3. Butchering a female green turtle near Mukalla. In this locality the females are turned on the nesting beaches before oviposition and the eggs are thrown away at the slaughter house. Note two sizes of eggs.

PLATE IV.

Fig. 1. A hawksbill on Jabal Aziz Island excavating a body pit. The body holes are much shallower than those of green turtles.

Fig. 2. Digging the egg cavity. The right flipper is dropping a flipperful of sand.

Fig. 3. Digging the egg cavity. The left flipper has just kicked sand forward with a backhand stroke. This occurs just after the opposite flipper releases sand as in the preceding figure.

PLATE V.

Fig. 1. Oviposition. The position of the hind flippers at this stage is typical of hawksbills everywhere.

Fig. 2. The typical position of the front flippers during oviposition. The head temporarily rests on the sand after expulsion of several eggs.

Fig. 3. A hawksbill returning to the sea after nesting on Jabal Aziz. A tag has been attached to the front flipper. This mature female weighed 80 pounds and was 27 inches long.

PLATE VI.

Fig. 1. A female green turtle returns to the sea after being tagged. South Yemen is one of the few places in the world where the ark of the sea and ark of the desert meet at the littoral ecotone.

Fig. 2. A Seychellois about to harpoon a copulating male green turtle near Aldabra. All bulls are caught in this fashion.

Fig. 3. A male harpooned while mating off Aldabra awaits shipment to Mahé. The markings are characteristic of all large mature males. The notch above the hind flipper, characteristic of the east Pacific green turtle, is evidently lacking in the Seychelles population.

PLATE VII.

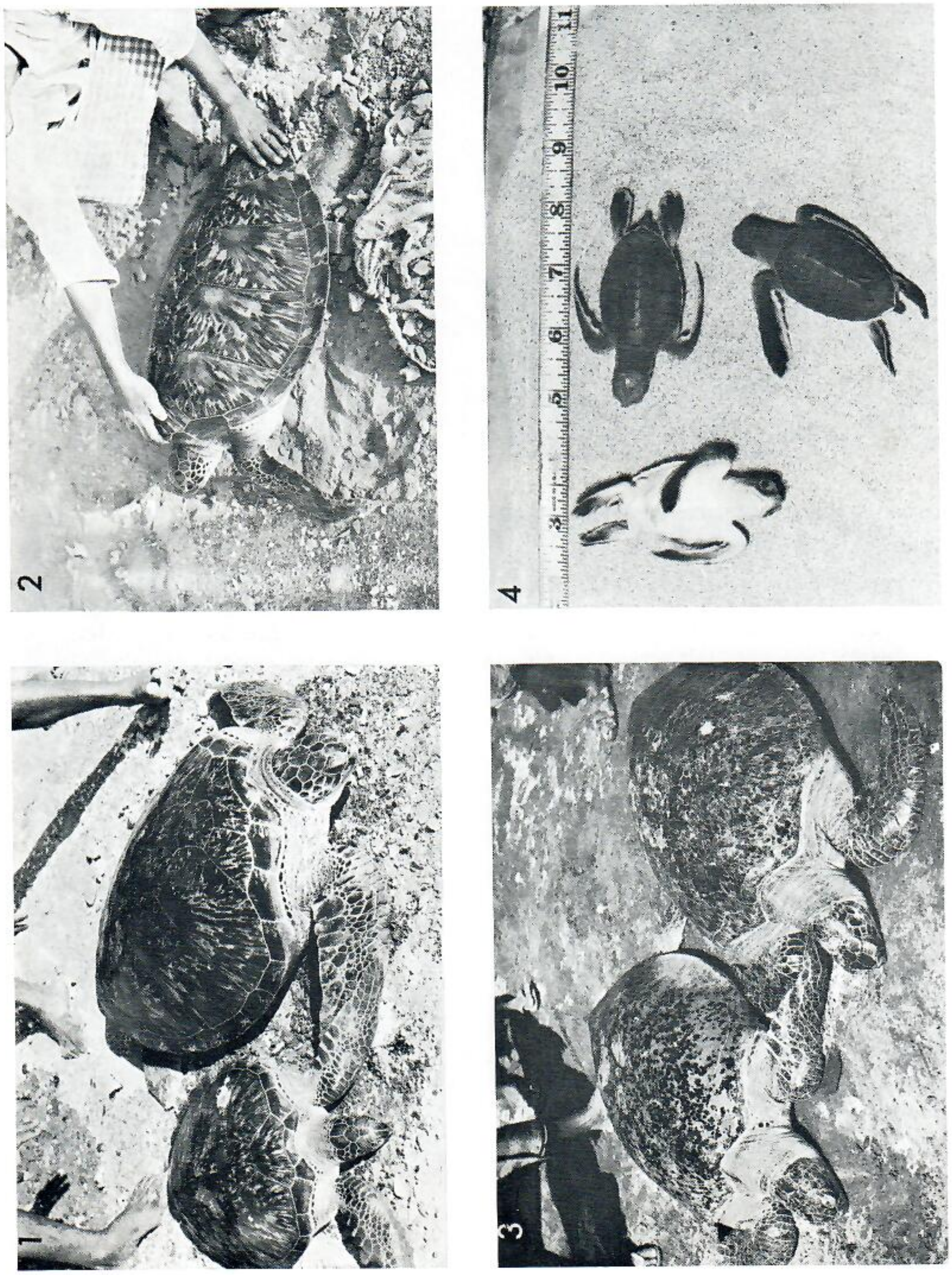
Fig. 1. Scutes cover the ground at an old green turtle slaughter area on Aldabra. Several places like this around the atoll attest to the once-great nesting populations here.

Fig. 2. One of the typical small nesting beaches near the dunes on South Island, Aldabra. Giant tortoises graze on the upper slopes of the rookeries.

Fig. 3. Aldabra is the only place in the world where the green turtle and the giant tortoise (*Testudo gigantea*) meet on the strand.

Fig. 4. Female returning to the sea after nesting and being tagged on Assumption. Note the raised reef and rock barrier which ovigerous turtles must negotiate, usually with the help of high tide. The angular emarcation of the carapace above the neck is similar to that of the Atlantic population on Ascension Island.

PLATE I



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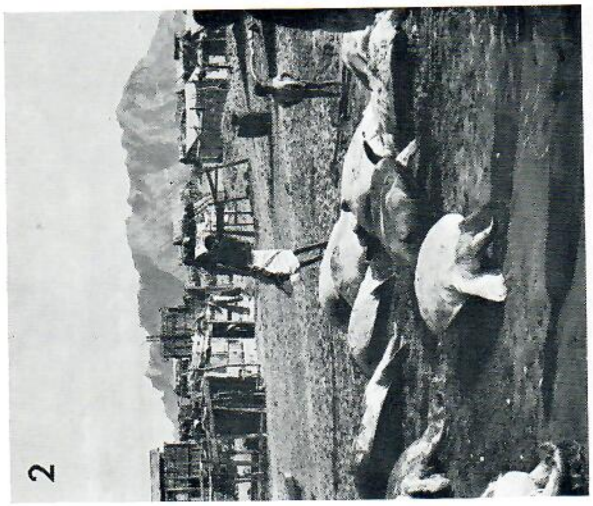
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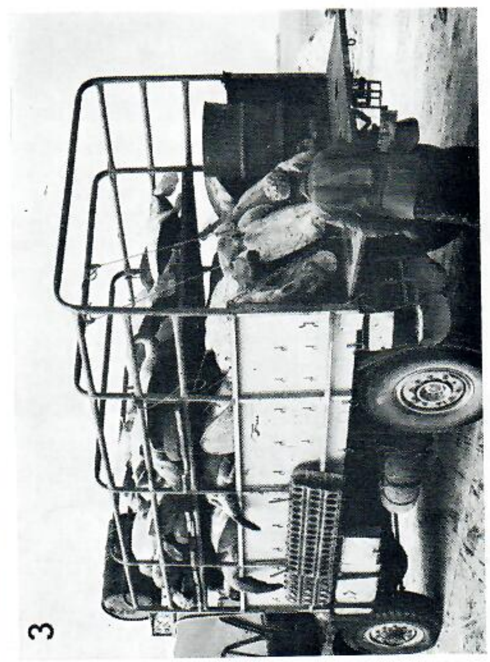
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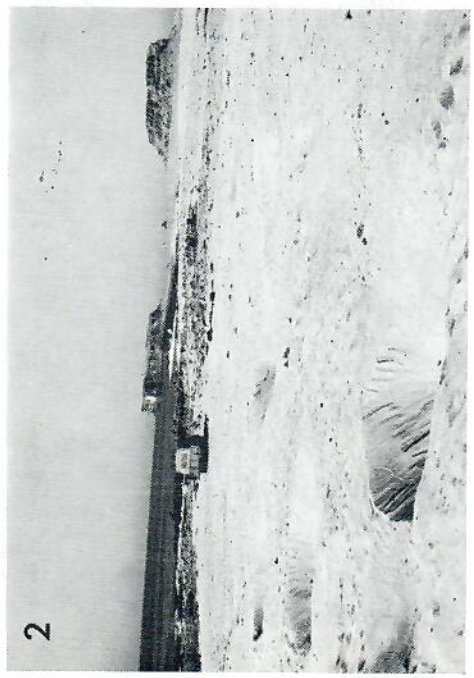

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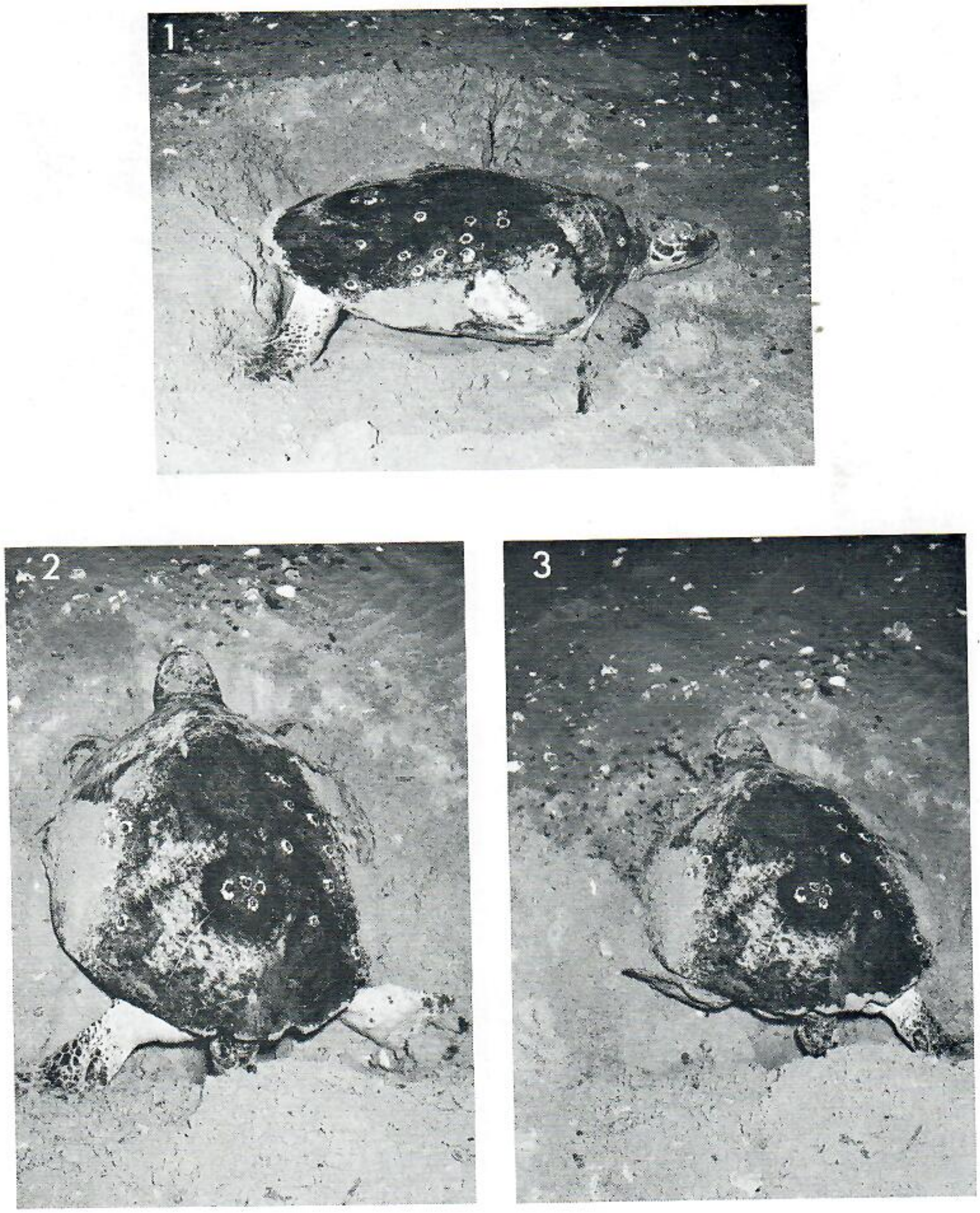

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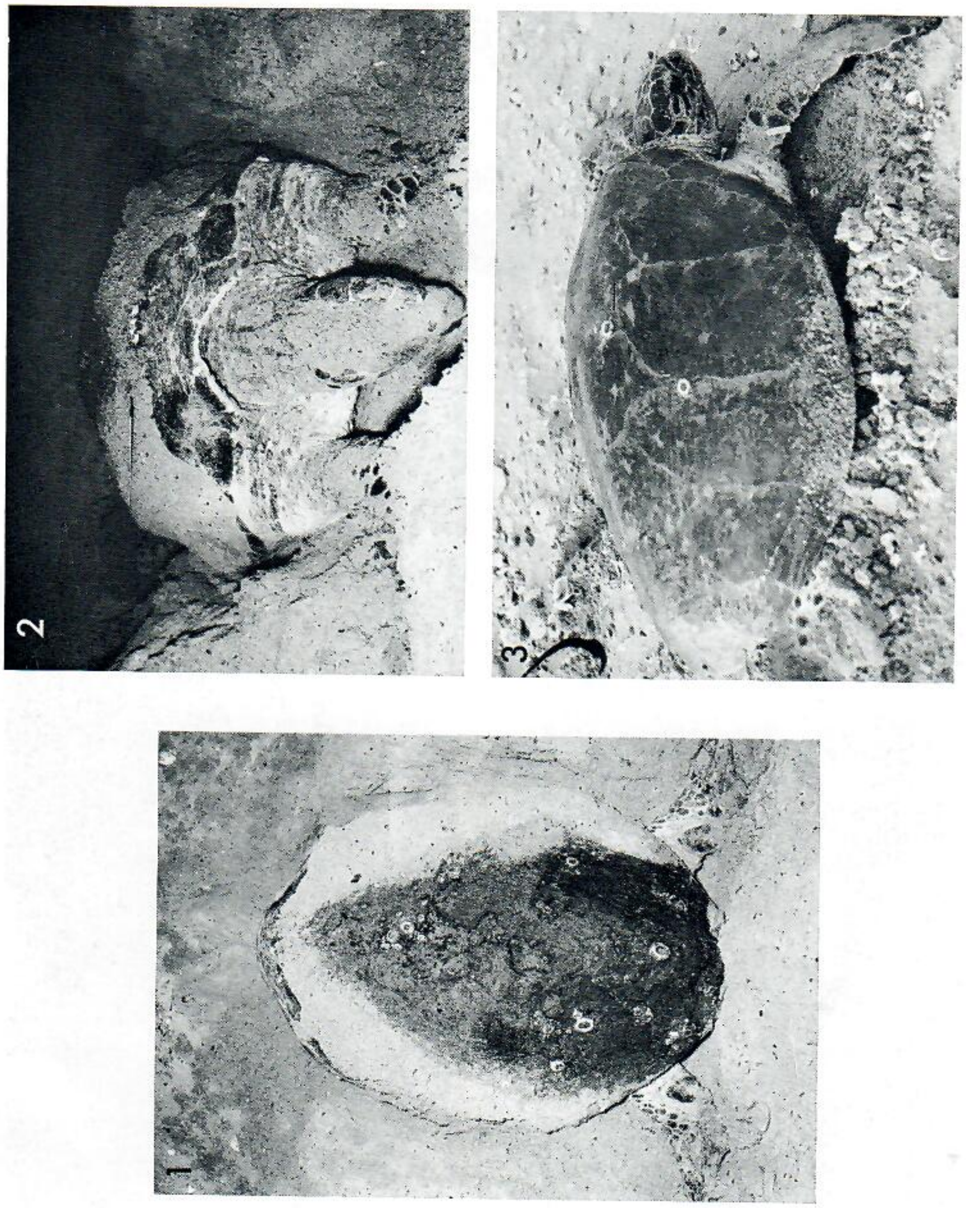

PLATE VI

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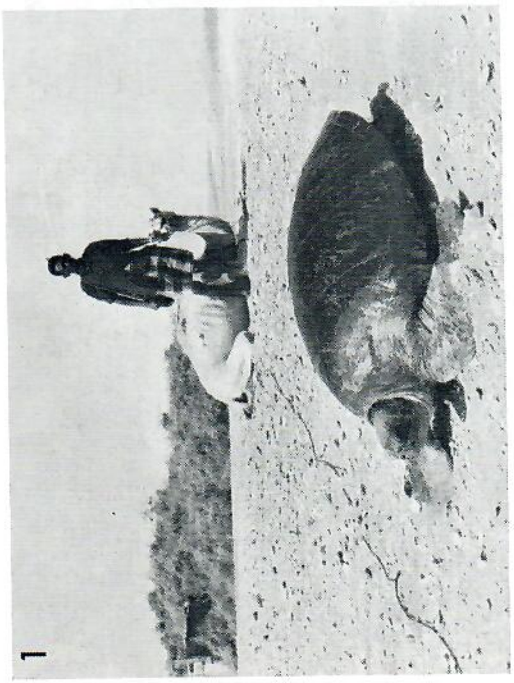

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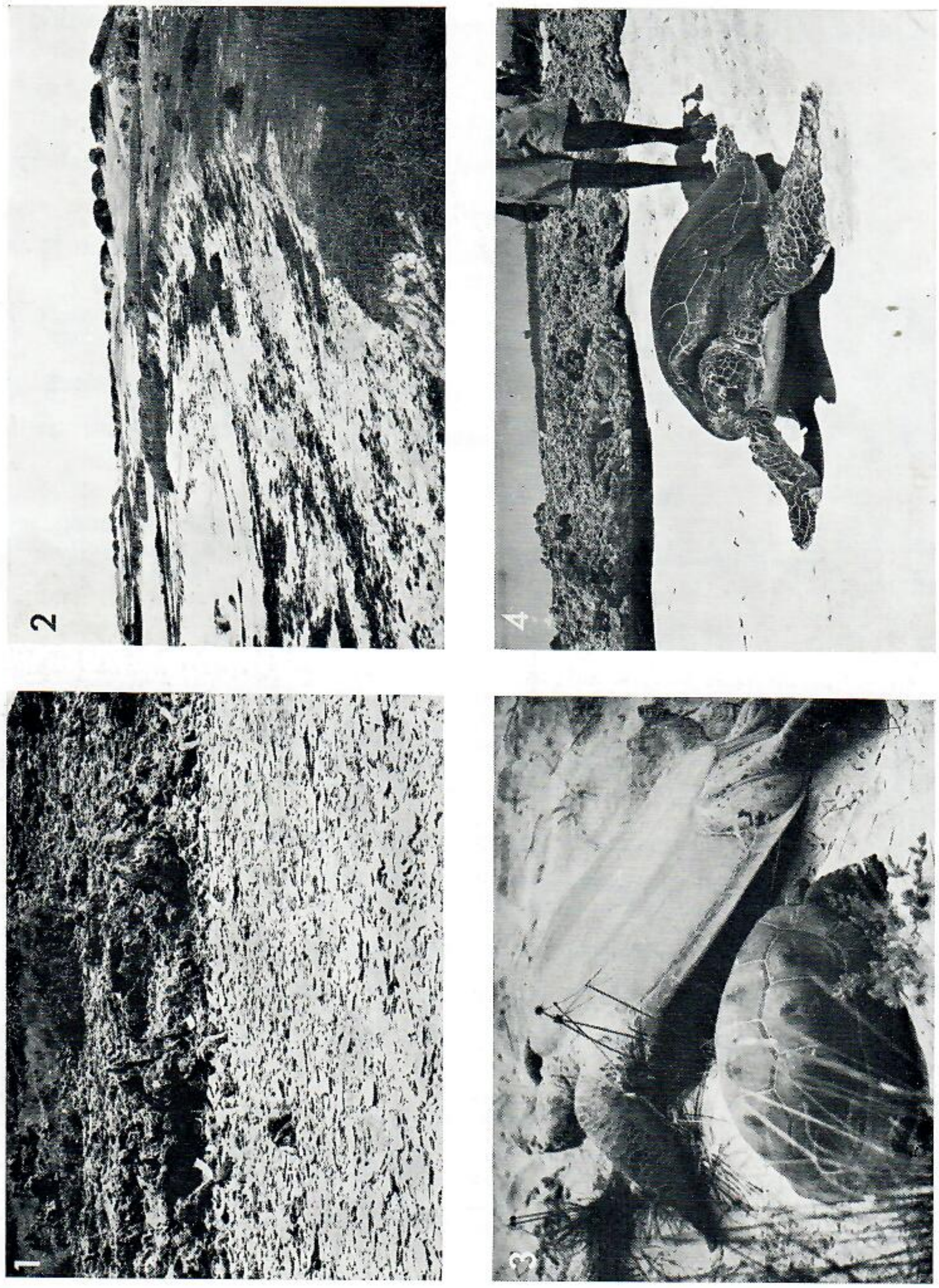
PLATE VII



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