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THE HAWKSBILL TURTLE (*ERETMOCHELYS IMBRICATA*) IN WESTERN SAMOA

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ABSTRACT

A small population of hawksbill turtles (*Eretmochelys imbricata*) nest on three small islands off the eastern coast of Upolu Island, Western Samoa. The nesting season extends from September to July. Each nest averaged 149.5 eggs, of which 71.1% hatched. The average incubation period was 62 days, the incubating nest temperatures averaged a rise of 3.6°C over sand at equal depth. No natural predation on nests was seen, and only one instance of natural predation on neonate turtles was seen. Human predation upon eggs and nesting females was extensive; the predation pressure being directly proportional to beach accessibility, and the major factor leading to the decline of the Samoa turtle population. Market surveys indicate a year-round occurrence of hawksbills. In lieu of protective legislation, the Fisheries Division of Western Samoa initiated a turtle conservation project to reduce the incidence of human predation on eggs.

There are no detailed published accounts on the biology and ecology of marine turtles in the central South Pacific. The Fisheries Division of the Government of Western Samoa sponsored a marine turtle research program (October 1970–May 1973) in an effort to study the life histories of the cheloniid species occurring in Samoan waters. The following is an account of the hawksbill turtle, *Eretmochelys imbricata*.

Turtles have always played an important part in Samoan culture and were once widely used for food. Evidence from folklore, songs, and interviews with fishermen indicate that the Samoan turtle resource was once a sizable and an important food source for the small, isolated villages. However, the nesting turtles on Samoan beaches have almost been exterminated because of human population explosion. Turtle meat is presently eaten predominantly by village chiefs only on celebrated occasions.

MATERIALS AND METHODS

Fieldwork during the turtle survey was carried out using a 5-m boat powered by a 20-hp outboard motor with a 3-m inflatable boat and 6-hp motor as a reserve.

Supporting a resident study team on any of the beaches was logistically impractical due to rough sea conditions, unpredictable squalls, and mechanical failures of the outboard motors. We attempted to visit the nesting islands every day; however, we made 19 overnight trips during calm weather in February 1972.

We anchored the boat outside the beach reefs and swam to the beaches carrying a watertight insulated container for removing eggs. We followed this procedure throughout the nesting season. Inspection of all turtle tracks found on the beaches was carried out and noted before searching for the nests. Sharp sticks were probed into the sand to locate a clutch. The depths to the top and bottom of the egg mass were recorded in addition to the position of the nest on the beach. Fresh eggs were removed from the beaches for further observations at the mainland hatchery, the oldest eggs being 2-days old. All older nests were concealed and their positions on the beach recorded for future observations. Attempts were made to avoid rotating or jarring the eggs during the collecting and transplanting process. The eggs were reburied in the hatchery, as soon as possible, to avoid unnecessary embryonic deaths.

The hatchery, a small section of mainland beach, was fenced off to keep out dogs, pigs, and people. The eggs were recounted and a sample (10%) measured as they were reburied. A wire enclosure, with a clutch identification number, was then placed over the clutch to insure capture of the emerging hatchlings.

Nest temperatures were measured on a sample of transplanted nests using mercury indoor/outdoor thermometers with remote reading scales. These nest temperatures were recorded daily during incubation, simultaneously with the sand temperature at equal depths, air temperature, and general weather conditions.

Adult turtles were tagged midway along the posterior edge of the right front flipper with monel cow-ear tags.

All turtle measurements are straight line measurements in centimeters and weights are in grams.

Species Characteristics

The hawksbill turtle (*Eretmochelys imbricata* Linnaeus, 1766), is readily distinguished from other turtles occurring in Western Samoa by the following combination of characteristics: four pairs of costal shields, anterior pair not touching the nuchal shield; four inframarginal shields, without pores; two pairs of prefrontal scales on the head; two claws on each flipper; narrow beak. The costal shields are juxtaposed in hatchlings, imbricated in juveniles and adults, and juxtaposed again in extremely large turtles. The marginal shields are serrated in juveniles, becoming smooth in adults.

General color patterns of adult, juvenile, and neonate Samoan hawksbill turtles are presently described due to the ambiguities in the literature (Hughes, 1974) regarding the taxonomic status of the proposed Atlantic and Pacific hawksbill subspecies which are based, in part, on coloration.

The carapace in adult turtles is dark brown with faint yellow streaks and blotches (Fig. 1). The scales on the dorsal side of the flippers and head are dark brown to black with yellow margins. The ventral side of the flippers and the plastron are pale yellow, with scattered dark scales on the flippers (Figs. 1 and 2).

Juvenile coloration (Fig. 3 left) is often variable, particularly the carapace, which ranges from light brown to black with varying amounts of distinct yellow streaks and blotches. The head and dorsal flipper scalation is black with whitish margins and the plastron is whitish with many brown blotches; the ventral side of the flippers have scattered black scales.

Neonate coloration (Fig. 3 right) is uniform, variations are generally noticed when the turtles are about 5 months old. The carapace and the top of the head and neck are tan; the side and bottom of the head and neck, including the beak, are dark grey; the dorsal and ventral sides of the fore flippers are gray with a whitish fringe around the posterior edge; the dorsal and ventral sides of the hind flippers and plastron are dark gray with two whitish ridges posteriorly on the plastron.

Results

Nesting Islands and Beaches

The hawksbill turtle was the only species of marine turtle found nesting in Western Samoa. The nesting beaches are located off the eastern end of Upolu Island on three small offshore islands: Namu'a, Nu'utele, and Nu'ulua (Fig. 4).

Namu'a is approximately 800 m long, 300 m wide, and 76 m above sea level. A nesting beach 175 m long is situated on the eastern side of the island. From the low water mark to the beach vegetation there is a steep 7 m slope, with another 9 m moderate uphill slope to the jungle. The approach to the beach is clear of obstacles; a few scattered rocks in the water at the center of the beach should not hinder a nesting turtle or emerging hatchlings. The reef begins immediately in front of the beach and extends seaward for 30 m before dropping off into deep water. The entire length of the beach has a layer of beach rock 2 m wide at the low water mark; this rock is low in profile and does not obstruct nesting turtles

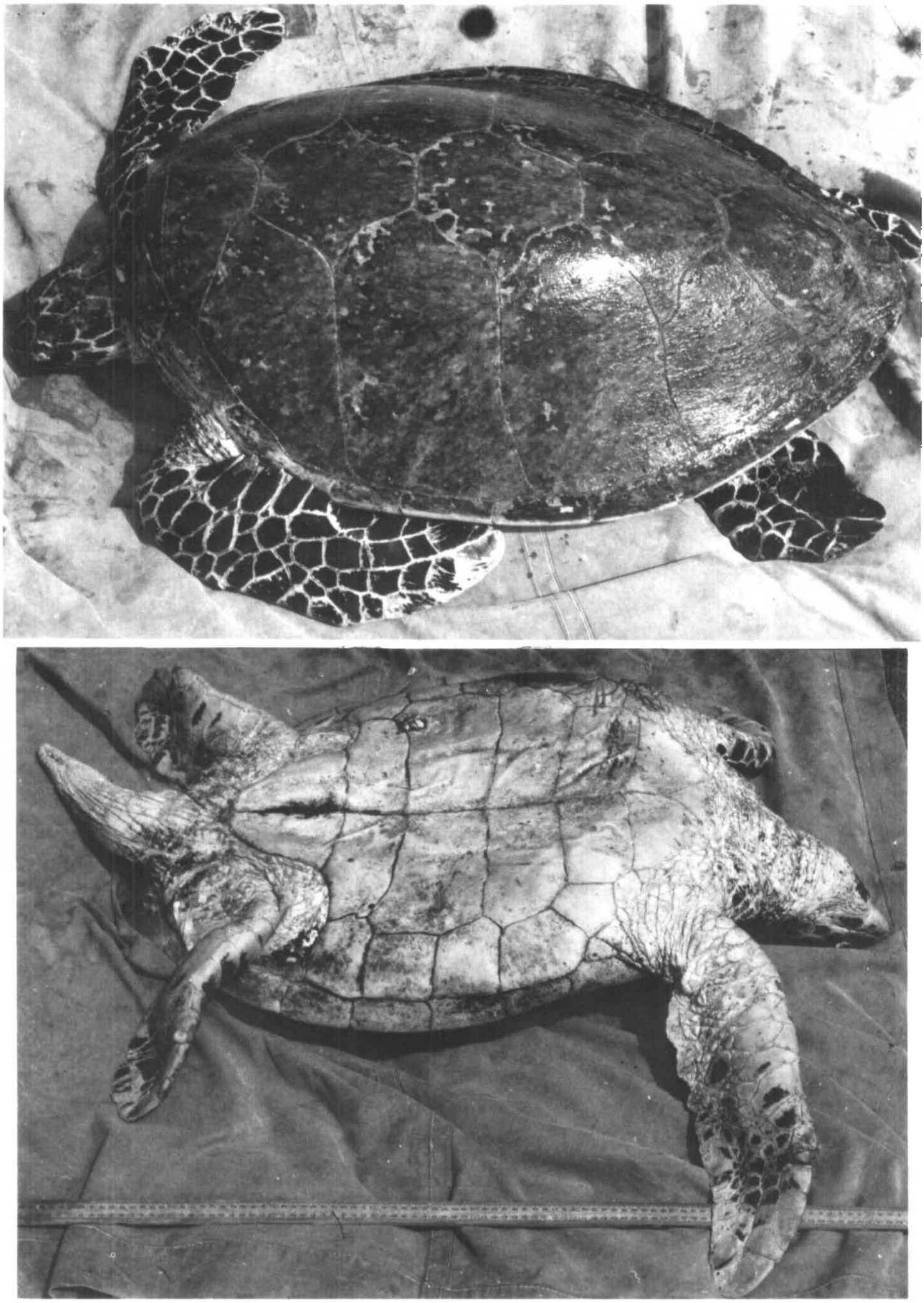


Figure 1. Adult male hawksbill illustrating pigmentation, squamation, and morphology of dorsal (upper) and ventral (lower) surfaces.

or emerging hatchlings. The sand is medium coarse broken shells and corals, extending inland as far as the jungle where it blends into packed soil and root masses. Most nests were 1–2 m inside the beach vegetation at the north end of the beach.

Figure 2. Adult male hawksbill head illustrating pigmentation, squamation, and morphology of lateral (upper) and dorsal (lower) surfaces.

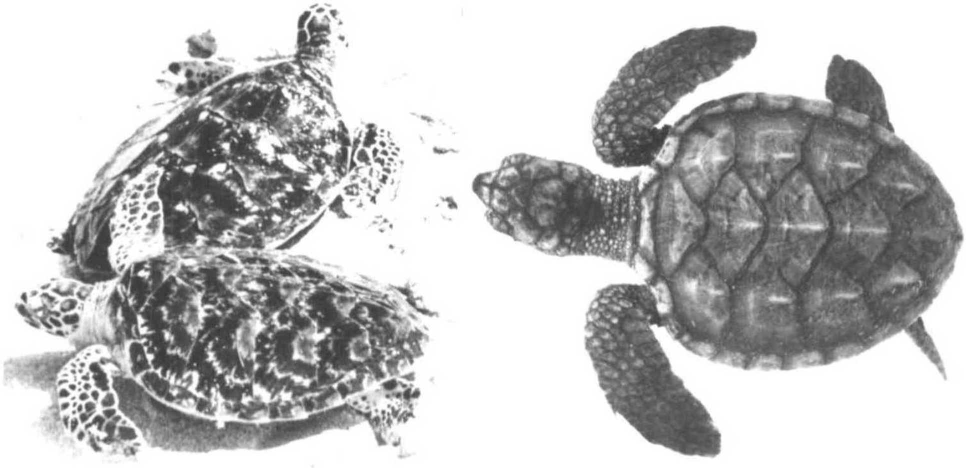


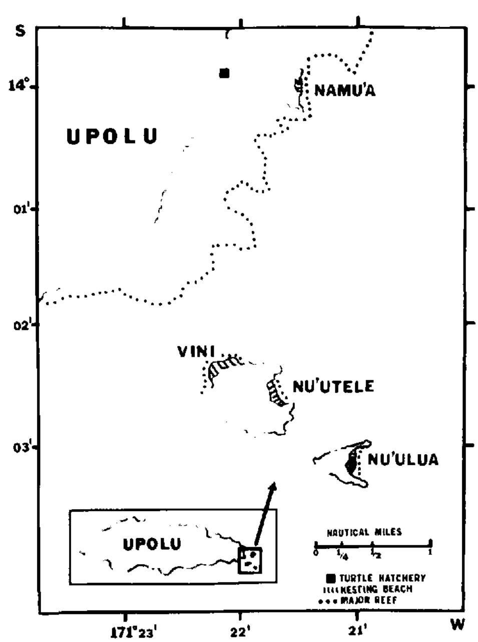
Figure 3. Juvenile (left) and hatchling (right) hawksbills illustrating pigmentation, squamation, and morphology of the dorsal surfaces.

The largest nesting island is Nu'utele, approximately 1,650 m long, 850 m wide, and 200 m above sea level. There are two nesting beaches, Nu'utele and Vini. Nu'utele beach, located on the eastern side of the island, is 350 m long and 12 m wide from the low water mark to the vegetation. The beach slopes uphill gently to the edge of the vegetation where there is a steep 0.75 m high sand bank that hinders access to the vegetation. The reef extends from the beach to 40 m offshore before dropping off into deep water. There is no beach rock and the sand is medium coarse broken shells and corals. Most nests were 2–3 m inside the beach vegetation, and no section of the beach was preferably nested upon. Vini beach, on the northeastern side of Nu'utele Island, is 600 m long, with an excellent passage through the reef and has no obstructions or beach rock. Privately owned property inhibited the collecting of detailed turtle information during the nesting season.

Nu'ulua Island is approximately 700 m long on each side and 108 m above sea level. The nesting beach on the eastern side is 350 m long with 50 m sections of rock rubble at both ends. There is a uniformly steep 6 m slope from the low water mark to the vegetation line and 20 m of level vegetation to the jungle. The approaches to the beach are blocked, in sections, by large rocks and by the shallow 30 m wide reef. The entire length of the beach has a 2–3 m wide layer of beach rock at the low water mark and forms an obstacle to the nesting turtles and a formidable barrier to hatchlings. The beach is composed of coarse broken shells, corals, and rocks. Most turtles nested 2–4 m inside the vegetation on a 20 m section in the middle of the beach.

Nesting Season

The nesting season extends from September to July, with January and February being the peak months. Figure 5 depicts the estimated total number of turtle tracks found on the four beaches during the 1971–72 nesting season. The beaches had large differences in numbers of nesting turtles as well as different nesting season periods. The smaller the total number of nests on a beach, the shorter was



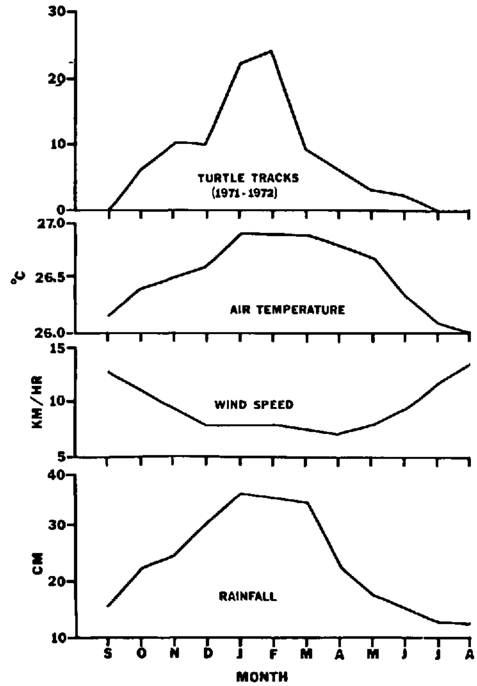


Figure 4. The hawksbill nesting islands and beaches of Western Samoa.
Figure 5. The number of hawksbill tracks found on the beaches during the 1971–72 nesting season and the prevailing weather conditions during the nesting season.

the nesting season. These differences resulted from varying amounts of human predation pressure upon nesting females and eggs, predation being proportional to the ease of beach accessibility. Beach accessibility is defined in terms of distance from the mainland reef and ease of passage through the beach reef. The beaches were ranked from the smallest to the largest (percentage of total nests, shortest nesting season, and easiest beach access): Namu'a (4%, January–February), Vini (7%, December–March), Nu'utele (11%, November–April), Nu'ulua (78%, September–July).

Climatological data (Fig. 5) from the Apia Weather Observatory is summarized for 1953–73, showing increasing air temperature and rainfall and decreasing wind speed during the nesting season.

Eggs and Incubation

A sample of eggs from 23 transplanted nests from the 1971–72 nesting season was analyzed from laying through hatching (Tables 1–3). For parameters involving excessively large numbers of measurements per nest, a sample of 10% of the eggs was used.

Nest characteristics (Table 1), with the exceptions of egg diameter and weight, are highly variable. This variability was seen through the nesting season and could be attributed to the wide size range of nesting turtles. Although we were only able to tag and measure the carapace length of seven comparatively small nesting turtles, larger turtles were seen captured by the Samoan fisherman. Also,

Table 1. Samoan hawksbill nest characteristics

	$\bar{x}$	SD	Range	N
Depth to top of nest (cm)	26.96	6.44	11.0–36.5	23
Depth to bottom of nest (cm)	46.22	4.81	34.5–54.0	23
Weight of eggs (g)	24.40	1.06	23.0–25.9	3*
Diameter of eggs (cm)	3.47	0.06	3.4–3.6	23*
Number of eggs	149.57	41.66	60.0–219.0	23

* 10% of these nests were measured.

large size differences of tracks found on the beaches were noted. The mean, standard deviation, and range of the seven measured nesting turtles is 68.6 cm, 4.76 cm, and 60.0–73.5 cm.

The eggs are spherical and white. Although abnormal shaped eggs were rarely seen, three clutches contained 1–3 yokeless lumps, all spherical and averaging 1.5 cm in diameter.

Incubation and hatching parameters for the 23 clutches are also highly variable (Table 2). The mean number of transplanted eggs is smaller than the mean number of eggs per nest (from Table 1) because several eggs per clutch were broken when locating the nest with sharp sticks. The day after emergence each clutch was excavated and all unhatched eggs opened to determine the percentage of undeveloped eggs and percentage of dead embryos. These incubation and hatching figures correspond closely with those nests left undisturbed on the nesting beaches.

Most hatchlings (77.27%) emerged in the late afternoon when sand temperatures fell below 29°C. The shadow caused by the high rock cliffs on the western side of each nesting beach accounted for this daylight hatching (full darkness begins around 2000 h).

Nest temperatures were measured at the center of the egg mass and averaged a maximum increase of 3.6° (range 2.7°–5.0°C) over the sand temperature at equal depth. Nest temperatures were affected by clutch size and the prevailing weather conditions; the larger the clutch, the higher the rise in temperature, and the less fluctuation from adverse weather. Periods of heavy rain lowered the nest temperatures 0.55°–2.2°C and lengthened the incubation period 4–6 days over clutches of equal size free from rain.

Neonate hawksbills were very uniform in size (Table 3). They were healthy and no abnormal hatchlings were seen; very few died after emergence during the first weeks of captivity before release.

Table 2. Incubation and hatching of transplanted Samoan hawksbills

	$\bar{x}$	SD	Range	N
Number of transplanted eggs	145.70	41.06	59.0–213.0	23
Percent eggs hatched	71.12	21.71	35.4–91.8	23
Percent eggs undeveloped	22.95	22.17	3.6–79.5	23
Percent dead embryos	6.40	5.65	0.0–26.0	23
Number of incubation days	62.00	2.58	59.0–70.0	23
Time of day hatched*	1820	0143	1500–1930	17

* For daylight hatches only; 77.27% of the clutches hatched in daylight.

Table 3. Measurements of neonate Samoan hawksbill turtles

	$\bar{x}$	SD	Range	N*
Carapace length (cm)	3.96	0.08	3.8–4.1	23
Carapace width (cm)	3.08	0.08	3.0–3.2	23
Plastron length (cm)	3.29	0.09	3.2–3.4	23
Head width (cm)	1.38	0.04	1.3–1.4	23
Eye width (cm)	0.46	0.05	0.4–0.5	20
Weight (g)	12.73	0.51	12.1–13.2	3

* 10% of these nests were measured.

Predation on Eggs and Hatchlings

The nesting islands and surrounding waters abound with potential predators of eggs and hatchlings. Polynesian rats (*Rattus exulans*) are the only mammals found in abundance upon the nesting beaches, though traces of wild pigs were found on Nu'utele and Vini beaches. The ghost crab (*Ocypode* sp.) exists in great numbers on all of the beaches near the high water mark. The hatchlings, which must traverse the open beach upon emergence, are surrounded with potential predators. The belt of ghost crab holes must first be passed, then the section of beach rock. The rock itself is a formidable barrier, and upon this rock lives a large population of grapsoid crabs averaging 6–10 cm carapace width.

The nesting islands support large populations of sea birds throughout the year. They consist of different species of boobies, terns, tropicbirds, frigatebirds, petrels, and shearwaters.

Potential reef predators are numerous in both numbers and species: needlefish, barracudas, jacks, groupers, and sharks. Pelagic predators include: bonito, skipjacks, tunas, dolphins, and sharks. The pelagic predators, with the exception of sharks, are often seen in schools within 0.5 km of the beaches.

Natural predation upon Samoan hawksbill eggs and emerging hatchlings seems to be a relatively unimportant factor contributing to the apparent decline of the turtle population. All of the species of rats, birds, and crabs have been termed "potential" since we did not see any evidence of egg or hatchling predation during our observations on the beaches, though the mortality rate from tunas, dolphins, and sharks is undoubtedly high. We witnessed one instance of a 1.5 m black-tipped reef shark (*Carcharhinus spallanzani*) attacking a group of freshly released turtles 1.5 km east of the nesting islands. Daylight hatching may relieve some predation pressure because the turtles swim across the reef before nocturnal feeders—such as groupers and sharks—become active; the hatchlings reach deep water in darkness when bonitos, skipjack, and tuna cease surface feeding. Human predation on hawksbill eggs and nesting turtles, however, is severe; almost all nests not removed or concealed by the Fisheries Division are collected by Samoan fishermen.

Conclusions

Hawksbill Ecology and Status in Western Samoa

A segment of the hatchling and juvenile hawksbill population stays near Samoan reefs year-round. We observed that small hawksbills (4–40 cm) frequently foraged the Samoan reefs; a 2-year fish-market survey in the capital city of Apia also supported these observations. We notched the eighth left marginal shield on 1,720 hatchlings before releasing them; we had seven returns, all within 12 months. The notch remained perceptible for 14 months on turtles reared in captivity. Possibly the most important factors explaining the low return rate (0.4%) are poor identification by the local fishermen, high mortality by pelagic fishes, and passive migration away from Samoa by oceanic currents.

Mature hawksbill turtles were also sighted by us throughout the year, but they were seen in abundance only during the nesting season. Samoan fishermen are not equipped to capture large turtles from the ocean, thereby explaining the absence of mature turtles in the marketplace. It is not known whether most of the adult hawksbill population migrates and, if so, how far or in what direction. Recaptured turtles marked with Western Samoa tags have not been reported.

The Western Samoa hawksbill turtle resource is a small remnant of the former nesting population. Extensive human predation upon eggs and nesting females has exterminated all turtles reported to have once nested on the excellent mainland beaches. The three small islands off the eastern coast of Upolu Island now support only sporadic nesting activities, and only one beach, Nu'ulua, holds any promise of continued nesting. Relative inaccessibility to this beach is undoubtedly the principal reason for the survival of this lingering nesting population.

The Western Samoan Government has not passed protective legislation or set aside the nesting islands as wildlife refuges. There is little chance of either of these protective measures becoming law in the near future. The Fisheries Division, however, followed up the turtle survey with a conservation program of its own, in which 50–75% of all clutches found are collected, hatched on the mainland, raised in captivity for 3–4 weeks, and then released at sea near the nesting beaches. Uncollected nests are concealed and observed (Witzell 1972; 1974).

There is no indication of an increase in the nesting population at this time, though there is an increase of juveniles reported in the market, and the imminent extinction of the Samoan hawksbill is likely to occur if the hatchery program fails to substantially increase the numbers of nesting turtles and if the eggs and nesting females continue to be taken by Samoan fishermen.

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