

A Natural Assemblage of Immature Green (*Chelonia mydas*) and Hawksbill (*Eretmochelys imbricata*) Turtles on the Fringing Reef of Wuvulu Island, Papua New Guinea

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Abstract—Natural populations of immature green turtles (*Chelonia mydas*) and immature hawksbill turtles (*Eretmochelys imbricata*) were observed around the fringing reef of Wuvulu Island, Papua New Guinea. For religious reasons, marine turtles are not molested here. This is unlike many other areas in the world where both species are exploited and are considered endangered. Forty-five scuba dives, one-third at night, were made on the reef during one week in 1989. A total of 173 green turtles, 32 hawksbills and 1 loggerhead turtle (*Caretta caretta*) were seen. A sample of each species was captured and tagged. One green turtle was recaptured in Irian Jaya, Indonesia, 305 km distant, 92 days after being tagged. Green and hawksbill turtles share similar resting sites on the coral reef, mostly at depths of between 3 and 7 fathoms. The turtle's coloration blended cryptically with the reef. The weights of green and hawksbill turtles were significantly related to their carapace lengths. Pacific green turtles, and maybe hawksbills, appear to enter their benthic feeding habitat at slightly larger sizes than their Atlantic counterparts. The conservation of the coral reef ecosystem is important for the survival of this population of immature green turtles, as well as for hawksbill turtles.

Introduction

Green turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) are the most common sea turtles in the Southwest Pacific Ocean but both are considered globally endangered by the International Union for the Conser-

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vation of Nature and Natural Resources (Groombridge 1982). Marine turtles, especially the green and hawksbill turtles, and their eggs, have been exploited for centuries by humans in many areas of the world, mostly for their protein and in the case of hawksbills, for their shell (i.e., the tortoiseshell of commerce). Parts of sea turtles have also been used as sources of medicines and cosmetics. Today, mortality from incidental catch in beach seines, drift nets and shrimp trawls can be high in some places. Anthropogenic pollution can also affect both the feeding and nesting behavior of sea turtles. For these and other reasons sea turtles no longer exist in natural numbers in most places. There is especially a dearth of empirical information about the demography of immature marine turtles. The importance of survival through the immature stages has been emphasized by Crouse et al. (1987) who produced a model showing how loggerhead turtle (*Caretta caretta*) survival in the juvenile and subadult stages has the largest effect on population growth.

In a few areas of the Southwest Pacific Ocean sea turtles are not molested because of cultural reasons. The purposes of this study were to examine the natural population sizes and behavior of immature sea turtles living around the fringing reef of Wuvulu Island, Papua New Guinea (PNG), where because of religious reasons marine turtles are left alone.

Methods and Description of the Island

Most surveys were conducted by two or three divers, using scuba, who swam parallel along the reef slope at depths of between about three and ten fathoms. Other dives were made at high tide on the reef flat just inside the reef crest. Each dive lasted about 45 minutes and covered up to about 200 meters of the reef—the linear distance depending upon such things as the morphology of the reef and whether it was a diurnal or nocturnal dive. We paid more attention to searching for turtles (in the crevices, etc.) than in covering a linear distance in a fixed time. The water was clear at all times. A sample of turtles was caught by hand, taken to a boat, tagged, and released at the capture site. Forty-five dives, one-third at night, were made at different sites around the island.

Turtles were tagged with conventional tags on the trailing edge of the right front flipper. Carapace lengths of Wuvulu turtles, and where possible shell lengths of turtles from other studies, cited in the text are the standard straight-line measurements (i.e., straight line distance along the midline from the anterior notch to the most posterior projection of the shell). Statistical tests followed JMP, VI.0.5 (SAS Institute Inc. 1988–1990).

Wuvulu Island in Manus Province, Papua New Guinea, lies in the Bismarck Sea at long. 142° 51'E and lat. 1° 44'S. It is a low island, with a perimeter of approximately 20 km. Two villages, Auna and Onne, with a total population of about 800, are located near the western coast of the island. Several large coconut plantations are interspersed with vegetable gardens and with the island's natural vegetation. The island is surrounded by a fringing reef. At sites where we dove the reef slope was steep and the grooves and spurs were weakly to moderately

developed. Live coral cover ranged between 40 and 80% and was dominated by *Montipora* sp., whose laminae created a lattice of crevices and ledges. *Pocillopora* sp., *Seriatopora* sp., *Acropora* sp. and soft corals were less common. Crinoids were abundant. Turtle grass (*Thalassia hemprichii*) grew abundantly on the reef flat.

Results

We spent eight days on the island, commencing 26 June 1989. During this time, no sea turtles nested on the beaches. We found one old (ca. 3–4 months) hawksbill (locally called Matani) nest under the branches of a shrub (*Scaevola taccada*). Based upon reconstruction of the egg shells, we estimated this was a clutch of 160 eggs.

A total of 173 green turtles (locally, *alaba*), 32 hawksbills and 1 loggerhead (also called *alaba*) were seen on diving surveys around the reef (Table 1). Some individuals may have been seen more than once, but we did select different diving sites. All turtles were immature, and their sex could not be determined by visual means. Sharks were seen on several dives and it is most likely that sharks prey upon turtles here.

Hawksbills were observed sharing the reef habitat with green turtles on two-thirds of the dives. Hawksbills outnumbered green turtles on two dives, both daytime dives on the north side of the island.

Green turtles and hawksbills were observed swimming or resting both day and night throughout the water column to depths of 13 fathoms. Resting sites were mostly in coral crevices or under coral ledges. Most green and hawksbill turtles utilized resting sites at depths of between 3 and 7 fathoms. Forsyth &

Table 1. Numbers and species of sea turtles seen on diving surveys around the fringing reef of Wuvulu Island, Papua New Guinea.

Date	Diving location off island	Time of dive(s)	Number turtles seen green:hawksbill:loggerhead
27 June	SW	0930–1200	25:0:1
27 June	NW	1500–1600	19:0:0
28 June	W	1330–1430	11:1:0
28 June	W	1800–2200	10:1:0
29 June	SW	0900–1130	9:2:0
29 June	SE	1530–1800	18:3:0
29 June	SE	2200–0030	34:0:0
30 June	N	1000–1100	7:14:0
30 June	E	2200–2300	16:0:0
1 July	S	2130–2400	16:6:0
2 July	N	1000–1100	1:3:0
2 July	SW	1530–1630	7:2:0
Total			173:32:1

Balazs (1989) state that in Hawaiian waters, resting sites of large green turtles are usually small caves or outcroppings while those of smaller turtles are in crevices and at the base of coral heads and closer to shore. Witzell (1982) saw juvenile green turtles in Western Samoa sleeping at night under coral ledges at depths of from 5 to 15 m. Our observations indicated that the green turtles were resting in the reef slope and feeding on turtle grass on the reef flat at high tides. Turtles were observed feeding both day and night. Both species were found in similar resting sites and positioned with their head facing inward or outward or with their body sideways in the crevice. Most turtles became very active when removed from their resting perches both in the daytime and nighttime. The one loggerhead turtle observed was resting on a coral ledge at 9.4 fathoms.

On night dives when divers shone a light on a swimming or resting green or hawksbill, the turtle's behavior was unpredictable. Some individuals immediately swam off into deep water; some individuals were attracted to the light, approached and circled the light source (but at a distance from the diver), and then swam off out of sight; and some turtles appeared mesmerized by the light and could be approached and seized, especially if the light was kept steady in their eyes. This unpredictable behavior could be the result of many things such as the physiological state of the turtle and the diver's behavior and use of the light.

Thirty-four immature green turtles, 9 immature hawksbills and 1 immature loggerhead were caught and tagged. The carapace lengths of the green turtles ranged from 36.8 to 76.2 cm (mean 49.01, SD 9.54). The weight (Y) of these turtles was positively related to their shell length (X): $\log Y \text{ (kg)} = 0.102 + 0.024 (X)$, $t = 11.57$, $r^2 = 0.81$, $P < 0.001$. Similar weight and length relationships have been found among mature green turtles at several nesting beaches (Hirth 1982, 1988). Female green turtles in the Bismarck Sea can attain reproductive maturity at a carapace length of about 84 cm (Spring 1983).

The carapace lengths of nine hawksbills ranged between 31.8 and 49.5 cm (mean 42.70, SD 6.00). Their weights (Y) were also positively related to their carapace lengths (X): $\log Y \text{ (kg)} = 0.166 + 0.019 (X)$, $t = 2.84$, $r^2 = 0.54$, $P < 0.05$. Hawksbills weighed less than green turtles of the same size. Some female hawksbills reach maturity at shell lengths of 60 cm in Western Samoa (Witzell & Banner 1980).

The loggerhead had a carapace length of 77 cm and it weighed 53 kg. Its carapace was covered with green algae. Some female loggerheads, around Queensland, Australia, reach maturity at a carapace length of about 80 cm (Limpus, in Dodd 1988).

Of the 34 green turtles caught, none had any conspicuous barnacles on their shells or bodies and only one had some red algae on its carapace. One green turtle was missing a front flipper, another was missing a rear flipper, and one had a recent carapace injury that local fishermen identified as a shark bite. In contrast to the green turtles, every hawksbill examined had extensive growths of red algae on the carapace and plastron and none had signs of injuries. The plastron of the loggerhead harbored a dozen barnacles (*Chelonibia testudinaria*).

One juvenile green turtle with a carapace length of 55.9 cm and a weight of 32 kg was caught swimming at a depth of 5 fathoms at 1600 hours and it was later recaptured at 2300 hours the same day, resting on a coral ledge at 5 fathoms. The recapture site was about 200 m from the original capture site. Another green turtle with a shell length and weight of, respectively, 43.2 cm and 11 kg was removed from a coral crevice, 7 fathoms below the surface, at 1000 hours and it was recaptured 4 days later at 2200 hours resting on a coral ledge at 5 fathoms. Sites of capture were approximately 300 m apart. In some other localities, at least some immature green turtles have a tendency to remain in the vicinity of, or to return to, their usual foraging site (Schmidt 1916, Carr & Caldwell 1956, Ireland 1980, Balazs 1982).

One immature green turtle with a carapace length of 43.2 cm and a weight of 13 kg was tagged on Wuvulu Island on 1 July and was caught (and eaten) near Dempta, Irian Jaya, Indonesia, on 1 October 1989. The shortest straight line distance between the points of contact is 305 km. Of 332 nesting green turtles tagged on Long Island in the Bismarck Sea, PNG, 5 have been recovered in Irian Jaya (Spring 1983). It is apparent that international cooperation is needed for the conservation of green turtle populations in the Bismarck Sea.

The coloration of immature green turtles with carapace lengths of between 45 and 72 cm was basically similar. The following descriptions are given in the hope that other sea turtle workers will describe the coloration of other immature sea turtles so that coloration along with other traits could help lead to a clarification of green and hawksbill systematics. The large vertebral and costal scutes were, when wet, brown (7.5YR 4/4, Munsell soil color charts, 1975 edition) to dark brown (7.5YR 3/2) at the basal seam with emanating dark brown and olive gray (5Y 5/2) rays of varying length. The large scales on the top of the head were brown or dark brown. The dorsa of all flippers ranged from black (5Y 2.5/1) to dark brown. The scales of the neck and shoulders were very dark gray (5Y 3/1). The venters of the flippers were pale yellow (5Y 8/3) with about a dozen black spots near the tips. The plastrons varied from white (5Y 8/1) to pale yellow.

The coloration of hawksbills with carapace lengths of between 31 and 49 cm was generally as follows: the large carapacial scutes were basically black with scattered spots and blotches of light olive gray (5Y 6/2), yellow (5Y 8/6) and sometimes brown. The dorsa of the head and flippers were black. The venters of the flippers were yellow (10YR 8/6), with abundant, conspicuous black spots. The plastron was pale yellow. Both species were well camouflaged when resting among the coral. It would, of course, be more informative if an easy, quick and nonintrusive method of determining sex in the ocean was available, so that sexual distinctions, if any, could be ascertained.

One immature green turtle (carapace length 45 cm, weight 13 kg) was taken on the reef flat and eaten by a transient fisherman. Its stomach was full of turtle grass and few pieces of green algae (*Caulerpa racemosa*).

Discussion

Hambruch (1907) stated that hawksbills appeared around Wuvulu Island between July and November and that they were more treasured than green turtles.

Lockhart (1989) sent questionnaires to various places in PNG and respondents said that green, hawksbill and loggerhead turtles nest on Wuvulu Island, mostly in the first half of the year. The density and seasonality of nesting by the different species on the island needs to be accurately determined. We did not see any hatchling size turtles of any species in the sea. The recapture of one Wuvulu green turtle in Irian Jaya may suggest a series of developmental habitats around the Bismarck Sea. It is unlikely that Wuvulu Island is a loggerhead nesting site of any great importance. Reliable fishermen informed us that leatherback turtles (*Dermochelys coriacea*, locally called *ponu*) are only rarely seen and always far offshore.

Scientists generally agree that immature green turtles of the sizes seen around Wuvulu Island are chiefly herbivorous, feeding on a variety of seagrasses and/or algae. Loggerheads and hawksbills are mainly carnivorous. Loggerheads eat a variety of benthic invertebrates, especially molluscs and crabs. Hawksbills, living around coral reefs eat, among other things, sponges, tunicates, molluscs and some algae. In some areas of the Caribbean Sea hawksbills feed almost exclusively on sponges (Meylan 1988). It is most likely that the three species of sea turtles seen around Wuvulu Island are eating different foods most of the time.

The smallest green turtle that we caught had a carapace length of 36.8 cm. The approximate sizes (carapace lengths) at which young green turtles leave the epipelagic habitat and enter their benthic feeding habitat at some other localities are as follows: 30.5 cm in Western Samoa (Witzell 1982), 35 cm in the Hawaiian Islands (Balazs 1982), 35 cm at Johnston Atoll (Balazs 1985), 38 cm at Crown Island, PNG (Spring 1983), 40 cm off Queensland, Australia (Limpus 1982), 43.5 cm in the Solomon Islands (Vaughan 1981), 25 cm in the Bahama Islands (Bjorn-dal & Bolten 1988), 25 cm in the U.S. Virgin Islands (Boulon & Frazer 1990), and 29.5 cm in Florida, USA (Mendonca 1981). Although sample sizes and methods of study varied among these localities it appears that Pacific green turtles enter the nearshore feeding habitat at slightly larger sizes than their Atlantic counterparts. Although hawksbill data are insufficient and some populations may be sedentary (Wuvulu ?), hawksbills may exhibit the same pattern as green turtles. The smallest hawksbill that we captured had a carapace length of 31.8 cm. Meylan (1988) stated that hawksbills in the Caribbean Sea leave the pelagic habitat and begin benthic feeding in coastal habitats when they reach carapace lengths of about 23–25 cm.

While it is well known that the preservation of coral reef ecosystems is necessary for the survival of hawksbill turtles, this study has shown that, at least at some times on some reefs, immature green turtles outnumber hawksbill turtles and reefs are important habitats for green turtles. The overall ratio of green turtles to hawksbills around Wuvulu Island was about 5.5:1.

Up until 1952 the people on Wuvulu Island regularly ate sea turtles and their eggs. In 1952 the Seventh Day Adventist (SDA) Church was established on the island and the vast majority of people became members. Since the religion prohibits the eating of sea turtle meat and eggs, the turtle populations around the island can now be construed as natural. Fish is the major source of animal

protein for the islanders and taro and sweet potatoes are important staple crops. Traditional behavior (e.g., sharing produce, cooperative fishing) is still an important part of Wuvulu society. Most village leaders are also adamant about maintaining a quality natural environment so there is very little terrestrial or marine pollution. Wuvulu Islanders do not claim ownership of the beach below high tide levels nor of the resources of the coastal waters. This is very different from most other areas of PNG where traditional ownership of the land usually extends to the beach, reefs, lagoons and natural resources therein (see Williamson 1989, for a discussion of this complex situation). The establishment of the SDA religion on Wuvulu was fortuitous for sea turtles. Pritchard (1979) and Spring (1982) cite a few other areas in PNG where, because inhabitants are of the SDA faith, sea turtles are not exploited.

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