THE FIRST STUDY OF SEA TURTLES AT RAROTONGA, SOUTHERN COOK ISLANDS

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Introduction

Six of the world's seven extant species of marine turtle are known from the Pacific Ocean, only *Lepidochelys kempii* not being present. Scientific studies are rare for much of the region (Hirth 1971; Witzell 1983; Marquez 1990). Marine turtles are revered in many Pacific Island cultures and appear in stories, artwork and tattoos, as well as in contemporary ceremonies (SPREP 2007). Turtles have provided an important food source for many islanders and coastal peoples, while the shells and bones have been used in traditional crafts and as domestic utensils. Woodrom Rudrud (2010) provides a thorough review of historical records concerning sea turtles in Polynesia, which includes the Cook Islands.

Turtles are known historically throughout the Cook Islands, but data concerning them are very rare and none recent. The fifteen islands have a total land area of 241km^2, but extend across two million km^2 of the South Pacific Ocean (09°-23° S; 157°-163° W); the northern atolls are extremely remote. Published records for turtles in the Cook Islands were from surveys in the 1960s and 1970s (Balazs 1995; Pritchard 1995). Recent reviews have also used those earlier data (e.g. Dethmers *et al.* 2006; Maison *et al.* 2010; NMFS 2010; Wallace *et al.* 2010; Woodrom Rudrud 2010). White (2012) reports the first contemporary data for much of the archipelago.

Many people on the largest island, Rarotonga, believe that turtles are no longer present in their local waters; observations from scuba-divers and other sea users suggest otherwise. Here I present the first assessment of sea turtles at Rarotonga. It includes an overview of the entire coastal zone (which shows that nesting is unlikely to occur) and also marine observations of turtles using the coral reefs and nearshore waters. Some findings are novel and include examples of cleaning behaviour and site-fidelity for green and hawksbill turtles; additional observations were provided by local scuba-divers.

Fig. 1. Aerial view of Rarotonga. © Google Earth.

Fig. 2. Road running very close to the beach at Sheraton.

Fig. 3. Aerial view of Papua Passage. © Google Earth.

Materials and Methods

General study site

Rarotonga (21°14′ S; 159°47′ W) (Fig. 1) is surrounded by a fringing coral reef, which encloses shallow tidal lagoons (Spalding *et al.* 2001). Rarotonga has a circumference of 32km and its perimeter road is mostly adjacent to the shore (Fig. 2); the entire coastal zone is inhabited, so people and traffic are ever-present. The main industry is international tourism and hotels have been built on several beaches, mostly in the west, southwest and southeast. In the southernmost lagoon at Vaima'anga there are three passages through the coral reef: *Ava'araroa*, *Papua* and *Rutaki*. These passages provide outflows back into the ocean for waves that continually break over the reef into the lagoon; outflows are strong in rough weather.

Terrestrial surveys

Rarotonga's entire coastline was assessed during daylight hours to identify possible nesting sites. Beaches were allocated into one of three categories (White 2012):

Type A: confirmed nesting.

Type B: possible nesting (substrata suitable for nest construction, but other aspects may hinder egg laying e.g. dense vegetation, waterlogged beaches or poor ocean access).

Type C: unsuitable for egg laying (rocky shores or sites with no ocean access).

The beach gradient and nestable area above the high water mark were also recorded.

Marine surveys

Surveys were undertaken by scuba-divers or snorkellers. Habitat types were categorised (e.g. reef drop-off, passages, lagoon etc.); the presence of sea turtles and any threats or environmental impacts were noted. Surveys were opportunistic and weather-dependent, rather than a comprehensive survey of all nearshore waters. One location, Papua Passage (Fig. 3), was investigated more thoroughly and is described below.

Sea turtles

Species and life-stages present were noted; adult and developing males were identified by their tail morphology (Casale *et al.* 2005; White 2007, 2012; White *et al*. in press).

Photo-recognition

Several individual turtles were recognisable from their carapace and facial markings, site-fidelity and behaviour (White 2007, 2012; White *et al.* in press). A local serial number (e.g. RP1) was used when referring to these turtles as none of them had been tagged.

Behaviour

When turtles were encountered the following behavioural codes (White 2007) were used:

Underwater

Su Swimming underwater
Ru Resting underwater
Cu Crawling on the sea floor
Fu Foraging – used when turtle was searching for food
Eu Eating – the food item was described if possible
Cl Cleaning (cleaner spp were noted, plus location, e.g. sea floor or mid-water)
M Mating

At the surface

Ss Swimming at the surface
Rs Respiration
Bs Basking at surface (turtle may appear to be asleep)

Papua Passage

Papua Passage (21°15.586’S; 159°45.576’W) is the smallest of three southern passages in Vaima’anga Lagoon, and was chosen for focussed marine research. The landwards (northern) end of the passage is a u-shaped gully with a sandy floor. A steep-sided ravine then extends southwards, through three sets of narrows (inner, middle and outer). These narrows are interlinked by wider areas, referred to herein as: the rubble-slope, middle deep and outer gully. Papua Passage breaches the coral reef to the south (approximate dimensions are: length 250m, maximum width 30m, depth 15-18m).

Survey mode at Papua Passage

All research was carried out between the 13th November and 29th December 2009. A 2-3 hour snorkelling survey was conducted every afternoon for 47 days, the longer periods including an underwater photographic session. All surveys began from the shore – the swim across the lagoon to Papua Passage was 700-1000m depending on the exact point of entry (chosen daily to suit current flows). The passage and adjacent reef-top lagoon were examined for the presence of turtles and other megafauna, including sharks. The eastern side was surveyed in a similar manner. If sharks were present the passage was traversed at the landwards-end of the inner gully; if sharks were absent the passage was crossed quickly at the inner narrows.

Observations by other scuba-divers

Local scuba-divers were asked if they would report turtle sightings from nearshore waters; several agreed to do so (Reef-to-See, Dive Rarotonga, the Dive Centre, Cook Islands Divers and Rhia Spall, a university graduate). A short presentation was given to each that explained the methodology and how to record the results. It was understood that divers were not scientists, but were experienced and had good local knowledge.

Results

Sea turtles at Papua Passage

Sea turtles were observed underwater in Papua Passage on 36 out of 47 consecutive days (77%). Seventeen individual turtles (ten green turtles *Chelonia mydas* [Linnaeus 1758] and seven hawksbill turtles *Eretmochelys imbricata* [Linnaeus 1766]) were identified; nine were encountered on two or more occasions. All turtles observed were estimated to be juveniles (<65cm Curved Carapace Length. Size-class guidelines were from TREDS [Turtle Research and Monitoring Database System] www.sprep.org); green turtles were larger than hawksbills. Turtles were never touched or captured, but some individuals could be approached closely.

Table 1. Number of sea turtles observed per day in Papua Passage.

Number of turtles per day	Number of days
7	2
6	2
5	3
4	7
3	5
2	9
1	8
0	11

The number of sea turtles encountered in a survey ranged between zero and seven (Table 1). No turtles were observed on 11 days (mean count of turtles on days with sightings = 3.06; SD (Standard Deviation) = 1.77 turtles/day; minimum = 1, maximum = 7). The survey route from lagoon to reef ensured that turtles were only counted once each day; detailed sketch maps showing encounter points and turtle behaviour were made after each survey (White, unpublished data).

Table 2. Species encountered per survey day.

Turtle species encountered	Number of days
Green turtle only	18
Hawksbill only	1
Green and hawksbill	14
Green and unidentified species	3

Two species of sea turtle were encountered at Papua Passage (Table 2): *C. mydas* was observed on 35 days; *E. imbricata* on 15 days. Occasionally the species could not be determined. This was due to poor underwater visibility or the turtles being too far away.

Table 3. Individual turtles encountered regularly.

Individual turtles (ID Code)	Number of days seen
Green (RP1)	15
Green (RP2)	7
Green (RP3)	26
Green (RP5)	16
Green (RP6)	5
Hawksbill (RP12)	5

Five identifiable green turtles and one hawksbill were seen regularly in Papua Passage (Table 3). Two additional hawksbills and a green were seen twice; eight others were seen just once (four greens, four hawksbills).

Two of the green turtles (RP3 and RP14, which was only seen once) were identified as sub-adult males developing their secondary sexual characteristics: this was based on tail morphology. The tail had started to thicken proximally and extend distally beyond the carapace's rear margin (Casale *et al.* 2005; White 2007, 2012; White *et al.* in press).

General behaviour
Throughout these surveys encounters with turtles occurred entirely underwater. Breathing appears to be very infrequent – only 12 instances of respiration were observed in 47 days; in each case only a single breath was taken (duration 0.5s) followed by another extended dive. No turtles swam or basked at the surface.

Resting sites underwater
Individual turtles had preferred resting spots. RP3 (*C. mydas* sub-adult male, Fig. 4) was seen regularly at a small southwards-facing grotto near to the apex of a coral outcrop (about 8m below the sea surface), with a clear view through the passage to seawards. This male would wedge himself in, pressing his carapace against the overhang and flippers against suitable rocks; in this way even the strongest currents were resisted (Fig. 5). RP3 was also observed once at each of two other sites (a ledge that faced westwards, and the inner-gully floor). Fig. 6 shows the distinctive notch in the carapace of R12.

Fig. 4. Turtle RP3 swimming above the rubble slope.

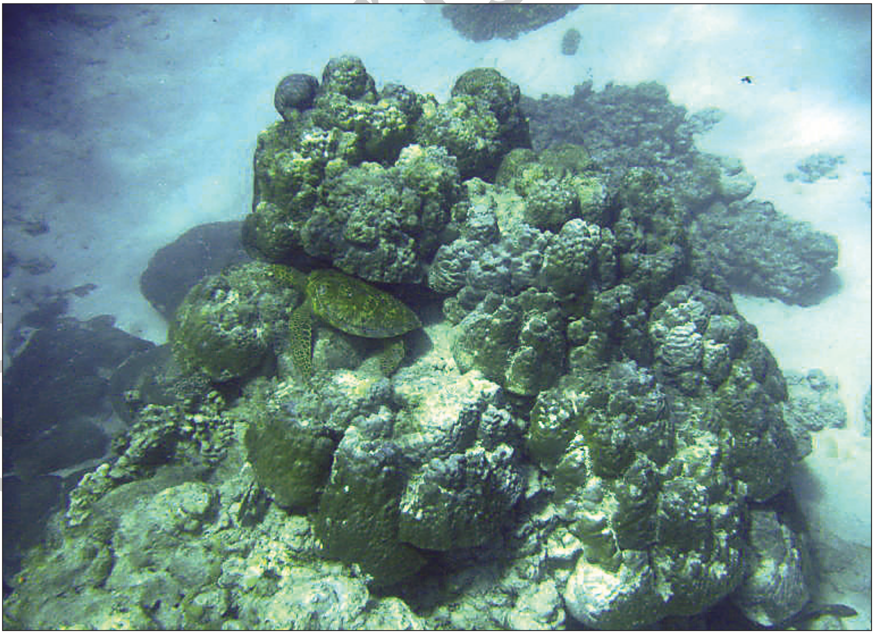

Fig. 5. RP3 in his pinnacle grotto.

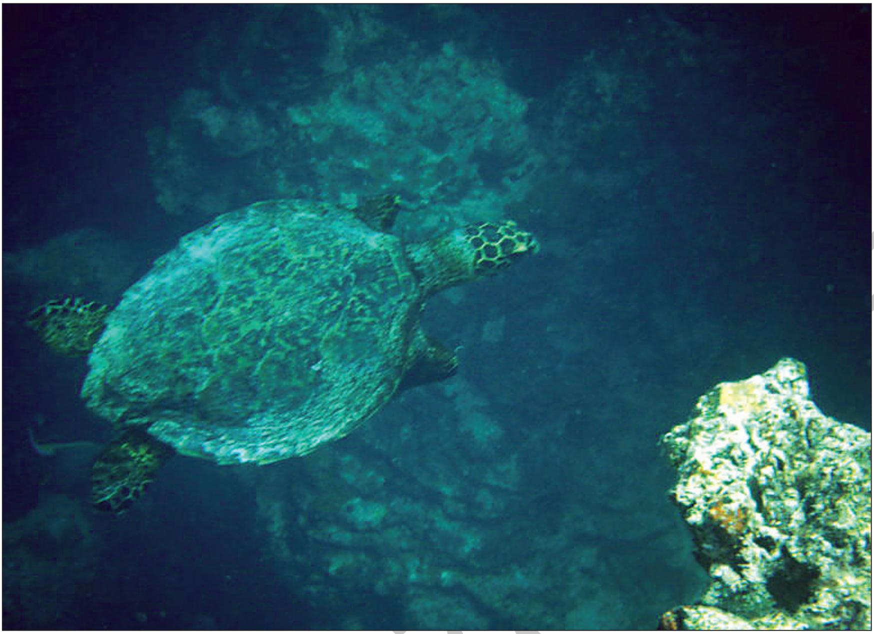

Fig. 6. RP12 showing the notch in a marginal scute.

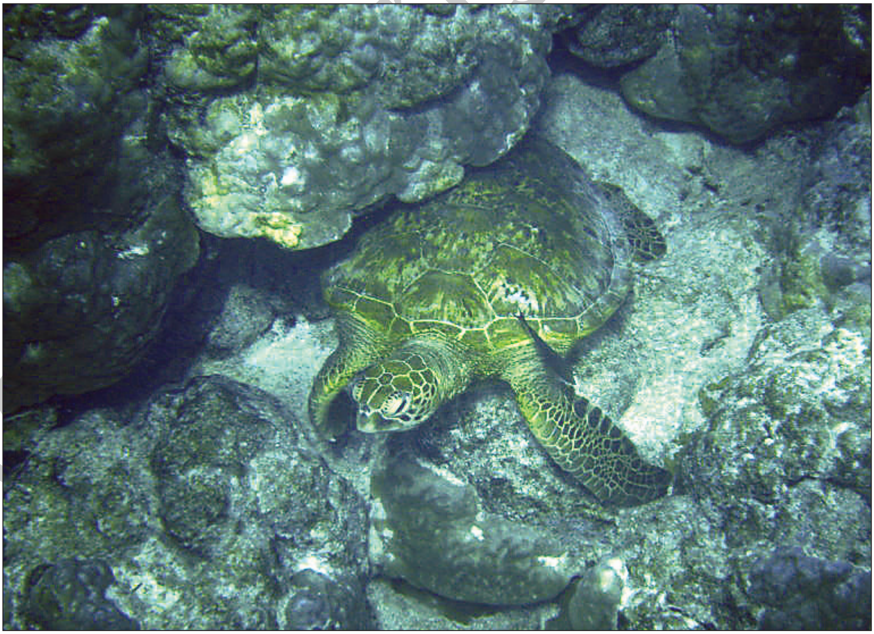

Fig. 7. Green turtle scratching on a rock – left side already done.

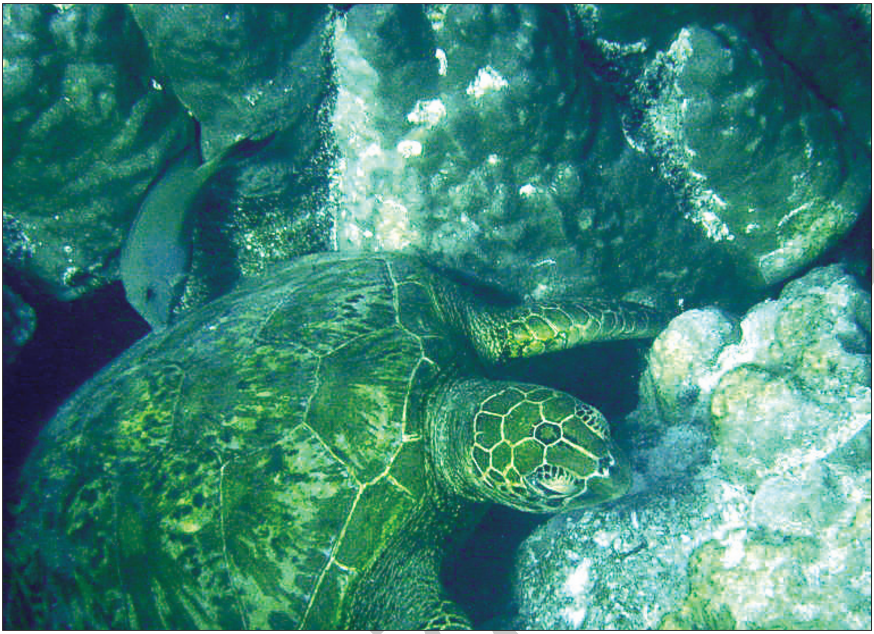

Fig. 8. Cleaning of green turtle by a bristletooth.

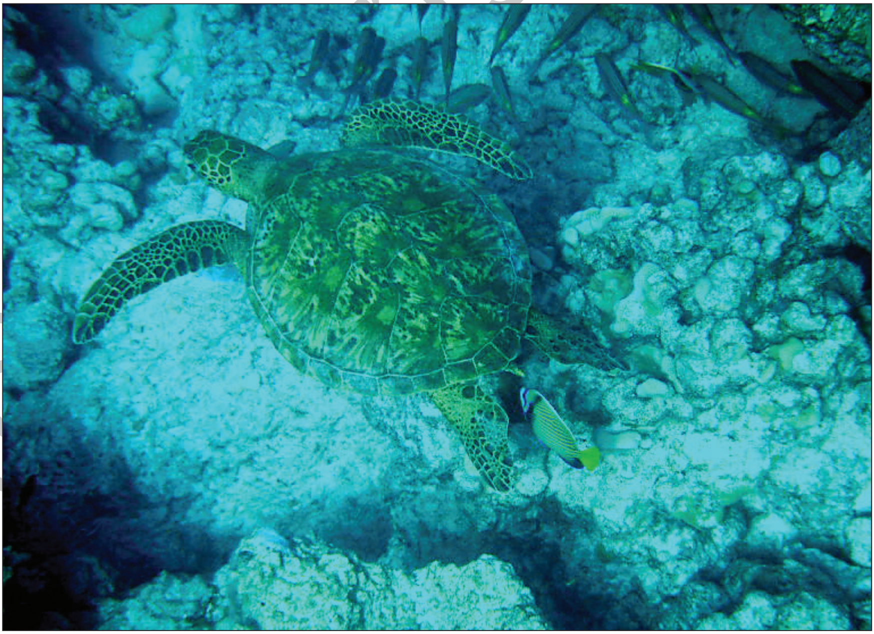

Fig. 9. Cleaning being done by an emperor angelfish.

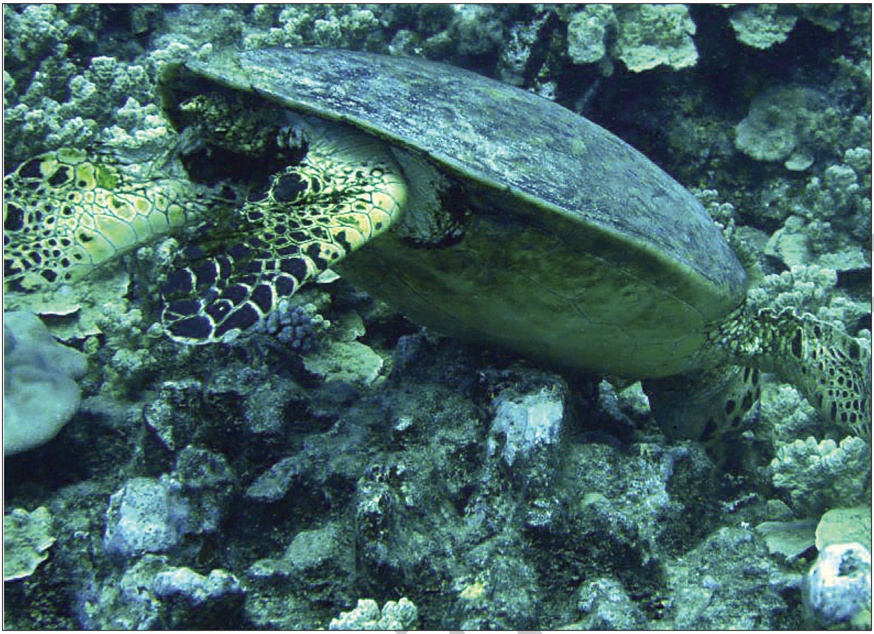

Fig. 10. Hawksbill turtle in typical feeding pose.

RP5 (*C. mydas*), a small juvenile, preferred the sea-floor or on top of large rocks, where it jammed itself in against suitable surfaces; sometimes it would rest in small grottoes. The rubble-slope was used by different turtles for resting; it was one of the spots where RP1 rested, although this animal was normally encountered swimming in the water column.

Interaction between individual turtles

These were rare. On two occasions a smaller green turtle tried to rest next to a larger green turtle, but was pushed away by the latter. In another instance a medium-sized green turtle was at rest on the rubble-slope. A larger green turtle crawled over the coral fragments and bit the smaller animal's face, forcing it to swim away. The victor then settled into the vacated spot.

Cleaning behaviour

Two types of cleaning behaviour were observed:

- ❑ self-cleaning, during which a turtle would rub its carapace back and forth against a rocky overhang, slowly changing position to maximise the effect (Fig. 7); a hawksbill turned laterally through a full 360° so that its entire carapace was abraded;

- ❑ a symbiotic process when the turtle was cleaned by one or more fish species. Cleaning was commonly performed by *Ctenochaetus striatus* (striped bristletooth, Fig. 8); but adult *Pomacanthus imperator* (emperor angelfish) also undertook this service, which is a new record (Fig. 9).

Symbiotic cleaning occurred in three different situations:

i. Cleaner spp. visited a turtle at its resting place

ii. Turtles visited a 'cleaning station' (i.e. where the cleaners resided)

iii. Incidental encounters in the water column. In these midwater examples a cleaner would follow a passing turtle, which then usually stopped swimming so cleaning could occur. This was the more common mode used by the emperor angelfish; they would swim beneath the turtle and eat ectoparasites from the soft tissue, especially around the tail, cloaca and rear flippers. The second type of symbiotic cleaning was 'algal-grazing' from the carapace, usually by striped bristletooth.

Foraging behaviour

Hawksbills were observed foraging in the reef walls, although their prey could not be ascertained. Typically a foraging turtle had its head inside a crevice, whilst paddling with its flippers (Fig. 10). Feeding behaviour for green turtles was not observed and their local diet remains unknown.

Sightings reported by other scuba-divers

Complementing the Papua study, between the 9th March and 31st December (2010) dive-groups made 158 reports from all sides of the island; a further 32 events were reported by Reef-to-See in early 2011. Altogether 341 turtle sightings were reported (Table 4). Some divers provided photographic evidence showing repeat sightings of previously encountered individuals, but the formal numbering system used at Papua was not utilised and not all groups had underwater cameras, so it is likely that some turtles were counted more than once.

Table 4. Observations of turtles reported by scuba-divers from Rarotongan waters between March 2010 and February 2011.

Legend: RTS Reef-to-See; RS Rhia Spall; CID Cook Islands Divers; DC Dive Centre; DR Dive Rarotonga; *Cm C. mydas* (green turtle); *Ei E. imbricata* (hawksbill turtle); ? Species not confirmed.

Group	Records	*Cm*	*Ei*	?
RTS	109	188	49	11
RS	43	15	27	9
CID	14	16	5	0
DC	13	10	2	1
DR	11	3	8	1
Totals	**190**	**228**	**91**	**22**

Turtles were observed all around Rarotonga, but the most important sites are reported in Table 5. The general directions, e.g. 'North', include different dive-sites, such as '*the boiler*' and '*Edna's Anchor*'. The three south-coast passages: Papua, Ava'araroa and Rutaki in Vaima'anga lagoon are clearly very important habitats for green and hawksbill turtles.

Table 5. Synopsis of number of turtles seen in the most important locations where they were reported from Rarotonga.

Legend: *Cm C. mydas* (green turtle); *Ei E. imbricata* (hawksbill turtle); ? Species not confirmed.

Dive sites	*Cm*	*Ei*	?
North	16	28	5
West	9	0	0
South	14	5	0
Papua	114	34	6
Ava'araroa	53	10	3
Rutaki	12	4	6

Fig. 11. Ngatangiia looking northwards.

Fig. 12. View south towards Black Rock.

Terrestrial surveys.

Between the 9th November 2009 and 29th March 2010 (the likely nesting season) all of Rarotonga's coastline was assessed regularly to see if turtles had nested, or if nesting was likely. There were no signs of turtle emergences onto land i.e. no tracks nor any signs of nesting activity. All beaches were resurveyed in November-December 2010, and again in May-June 2012: no evidence for nesting or emergence was found at any site. Egg laying may possibly occur in some years (e.g. A'aroa beach in the southwest), but most areas seem unsuitable for several reasons.

The northern coastline is mostly rocky with the reef being close to shore; the main town Avarua is located here. There is one small lagoon area with sandy beaches near Toa motu (cay), west of Avarua, but the main road and airport are a few metres away. This site is also used by kite-surfers during the day and for barbecues. The eastern coastline is mostly composed of coral boulders and rubble. In some places the reef drop-off abuts the land (i.e. no beach or lagoon) and seawards access is very difficult, e.g. Ngatangiia (Fig. 11) and Matavera. Sandy beaches and wide lagoons occur along the west (Aorangi), southwest (A'aroa), south (Vaima'anga) and southeast at Muri, but tourist resorts have been built on all of these beaches. At Blackrock, in the northwest, beaches are mainly gravel or stones (Fig. 12), but access from the lagoon is good and nesting theoretically feasible. However, this is at the western end of the island's main runway and most international flights are at night; most sea turtles nest nocturnally.

There are some quieter sandy areas at Vaima'anga lagoon that could support nesting, but three further problems were identified: sand depth is insufficient for nest construction; plant roots form a latticework in the sand, hindering egg laying; the beaches are usually submerged at high water, so any eggs laid would not develop.

Discussion

Species and occurrence

Two species of sea turtle *C. mydas* and *E. imbricata* are now known to use Rarotonga's nearshore coastal waters throughout the year; this is an important finding given the previous deficiency of data for the Cook Islands (Maison *et al.* 2010; NMFS 2010; Woodrom Rudrud 2010; White 2012). Juveniles of both species and sub-adult male green turtles were seen at Papua Passage, but adults were not encountered. Repeat sightings of identifiable green and hawksbill individuals at Papua Passage over several months showed that those turtles appear to be resident. Such data are particularly important for the critically endangered hawksbill turtle. This research was not intended to be a comprehensive population study, but rather to show when and where sea turtles are present. It was previously thought that sea turtles did not live in the

Cook Islands, but only migrated here for egg laying from their home grounds in Fiji and Vanuatu (McCormack 1995). The author's observations and the anecdotal reports from local dive groups, including any repeat sightings of the same turtles, show that this is not the case.

General behaviour

Berkson (1966) suggested that marine turtles would be better categorised as 'surfacers' rather than diving animals, because they spend most of their lives underwater. The present study was in agreement: in almost two months of daily surveys at Papua Passage there were only twelve observations of turtles swimming to the surface to breathe. There were also eight instances of turtles already resting underwater when a survey period began, and they remained at rest throughout those surveys, which lasted between 1 and 2.5 hours. Resting animals often showed preferred resting sites. Cleaning behaviour, either by symbiotic fish or by self-scraping, was common, as has been shown elsewhere for both species (e.g. Losey *et al.* 1994). Cleaning by emperor angelfish is novel.

Lack of nesting

This study showed no evidence of nesting at Rarotonga for either turtle species. The lack of nesting sites can be attributed to humans and their activities: all of the best sandy beaches have been used for tourist developments and the main road with its traffic and light pollution is close to the shoreline. The entire coastal zone is inhabited, so very few places now provide the darkness and tranquillity that sea turtles seek out for nesting. Tourism is the country's most important source of revenue, so this is unlikely to change. However, perhaps 85% of the national population now lives on Rarotonga, which leaves many of the atolls sparsely populated and hosting the most important nesting sites. The author recently identified the nation's paramount nesting site at Tongareva Atoll, Northern Group, which suggests that reproductive turtles live elsewhere (White 2012) and that Rarotonga now simply provides foraging habitat for juveniles and subadults.

Acknowledgements

The author thanks the following for their contribution to this study: Mac Mokoroa & Tina Samson (Office of the Prime Minister); Pamela Maru, Ministry of Marine Resources; John Samuela, Warden of Suwarrow; Patrick at Reef-to-See; Ed & Karen at Dive Rarotonga; Sabine & Sascha at The Dive Centre; Greg & Ian at Cook Island Divers. Special thanks to Rhia Spall (University of Hull) for liaising with local divers in 2010.

This research was conducted under Cook Islands Permit # 07/09e ~ Dr Michael White.

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