A Turtle Fossil on Raine Island, Great Barrier Reef

Colin J. Limpus Queensland National Parks and Wildlife Service, Townsville, 4810

Clam shells from the central phosphatic limestone platform of Raine Island, a coral cay in the northern Great Barrier Reef, were radiocarbon dated to calibrated ages B.P. that ranged from 590±70 yr at the eastern end of the island to 1130±210 yr at the western end. At 60 cm below the older clam were found the fossilised remains of an adult sized turtle. It was probably a green turtle, *Chelonia mydas*, that had died from heat exhaustion while ashore on a nesting attempt. This and other evidence are discussed which suggest that Raine Island has been a large turtle rookery for at least 1130 yr. The island was not a turtle rookery immediately prior to the last Holocene transgression.

Raine Island (11°36'S, 144°01'E) is a coral cay on a small detached reef at the outer edge of the northern Great Barrier Reef. The natural history of the island has been a reviewed by Stoddart et al. (1981) and its large nesting population of green turtles, *Chelonia mydas*, has been the subject of ongoing studies by the author since 1974.

Nesting female green turtles die on Raine Island every summer and their bones litter the island. Pieces of turtle bone can be scooped up in almost any shovelful of sand from the beach platform. In addition, fragments of turtle bone can be seen in many of the phosphatic limestone boulders and cliff faces on Raine Island. This suggests that the island has had an association with sea turtles that far exceeds the islands limited recorded history which spans only about 140 years. Therefore, during the course of other sea turtle studies at the island, a systematic search was made of the cliff face of the central rock platform for embedded entire bones and large mollusc shells suitable for radiocarbon dating. The results are reported here and their significance relative to the age of the Raine Island green turtle population is discussed.

	Reference no.	Conventional age b.p.	Reservoir corrected age b.p.	Calibrated age B.P.
Clam A	SUA-1906	1640±110	1190±120	1130±210
Clam B	SUA-1905	1080±60	630±70	620±70
Clam C	SUA-2012	1040±60	590±70	580±70
Clam D	ANU-1591	1180±65		

Methods

A fossil turtle (Figure 1) was found in the cliff face at the western end of the central phosphatic limestone platform of Raine Island. The bones were too weathered to be useful for carbon dating. They were left in situ at the island. A clam shell (Tridacnidae) embedded in the upper rock surface, 60 cm above the horizon containing this fossil, was collected. This was the only material adjacent to the fossil turtle that was suitable for carbon dating. Two other clams embedded similarly in the upper surface of the phosphatic limestone layer were collected from the opposite end of the island. The mollusc valves were sent to The University of New South Wales N. W. G. MacIntosh Centre for Quaternary Dating for radiocarbon dating following their standard procedures (Conventional radiocarbon age: Currie and Polach 1980; Stuiver and Polach 1977. Reservoir correction to offset the lower initial ^{14}C concentrations of surface ocean waters: Gillespie and Polach 1979. Correction for past variations in atmospheric ^{14}C concentration: Clark 1975; Klein et al. 1982).

Results and Discussion

The collection data and calculated ages of the three clams plus one previously described from Raine Island are as follows:

Clam A: *Hippopus hippopus*, complete valve, 20 g, embedded in the upper surface of the central phosphatic limestone platform at the western end of the island. The clam was embedded approximately 60 cm above a horizontal bedding plane along which the weathering fossilised bones of a turtle were partly exposed. Collected 11 Dec. 1980.

Clam B: *Tridacna* sp., complete valve, 0.5 kg middle portion of the 1.5 kg valve retained for assay. One of several clams embedded in the upper surface of outer perimeter of the central phosphatic limestone platform approximately due north of the beacon. Collected 11 Dec. 1980.

Clam C: *Tridacna* sp., similar in size to and collected from approximately the same location as clam B. Collected 28 July 1982.

Clam D: *Tridacna* shell from surface of beach rock near beacon at eastern end of Raine Island (Polach et al. 1978). Beach rock overlaid by guano rock.

The fossil turtle remains associated with Clam A were of an adult sized Cheloniid sea turtle. The bones in evidence included left and right femur, tibia, fibula, pelvic girdle and a portion of the overlying fused costals. The bones could not be distinguished from those of recently dead female green turtles which littered the island. The anterior portion of the skeleton was still within the rock. The orientation of the bones was consistent with the turtle having died with its carapace uppermost at that site, there having been minimal disturbance of the bones before burial (Figure 1). Clam valves are normally attacked by bio-eroding organisms while part of the reef flat sediments, but they may be retained for long periods of time if incorporated in cay sediments. Tridacnidae valves have been shown to be reliable dating indicators for coral cay sediments (e.g. Flood et al. 1979; Chappell et al. 1983; Chivas et al. 1986). The ^{14}C age is of the death of the clam and is therefore minimal for that horizon below it containing the turtle remains. Although some uncertainty exists about the relationship of the age of the clam shell and the turtle, it is reasonable to assume that their deaths were approximately contemporaneous. The numerous bone fragments in other rocks exposed around the margin of the rock platform indicate that many turtle carcasses must have occurred on the island at or before this time. Two of these additional fragments were identifiable to costal bones which also were indistinguishible from those of adult green turtle but no suitable material for radiocarbon dating was found in association with them.

Recent surveys of sea turtle breeding at Raine Island have revealed that nesting female green turtles die on Raine Island each summer. During summers of high density nesting many hundreds of females die when ashore on the island, while during summers with low density nesting fewer than ten females may die. Deaths are usually a direct result of disorientation followed by heat exhaustion by day or of turtles falling over the cliff face to land on their backs by night. Most mortality occurs on the beach surrounding the rock platform or at the base of the 0.5–2.0 m high cliff at the perimeter of the platform (Figure 2). In a season of dense turtle nesting most of these carcasses are broken up and the bones scattered within a few weeks of death by other nesting turtles. In contrast, when a turtle dies of heat exhaustion within the central depression of the platform, the skeleton is rarely disturbed by turtles and the bones may lie relatively undisturbed for several years (Figure 3). It would be quite feasible for such a skeleton to be covered with shifting wind-blown sand.

Mortality of nesting turtles at Raine Island each summer is not something new. Turtle carcasses and bones were so abundant on the island in July 1843 that Jukes (1847) interpreted Raine Island and adjacent Pandora Cay as a place where turtles came to die. However that is not really the case. Raine Island is a place to which green turtles in their thousands migrate to breed. Visitors to the island over the intervening 140 years have commented on the ever-present turtle remains: H.M.S. *Bramble* in 1845 (Allen and Corris 1977), H.M.S. *Challenger* in 1874 (Moseley 1879), 1913 (MacGillivray 1917), 1956 (V. Vlassoff, pers. comm. 1982), and 1959 (Warham 1963). Thus it would seem most likely that the fossil turtle was a nesting female that died of heat exhaustion on Raine Island about 1130 years ago. If many turtles were nesting there at the time (as indicated by the scattered bone fragments throughout the island rock), its death must have occurred in an elevated part of the island away from the beach where most of the digging by nesting turtles would have been concentrated. Had it died on the beach or if it had been beachwashed, it is unlikely that its bones would have remained in position. That Raine Island has been a turtle rookery throughout this time is supported by the fossil nests of turtle eggs found in the phosphatic limestone during the construction of the beacon at the eastern end of the island in 1844 (Jukes 1847). In view of the age of the clams from the rock adjacent to the beacon (Clams B–D) it would seem that these fossil clutches were laid more than 600 yr ago (i.e. more than 460 yr before their discovery). This is the only sea turtle rookery in Australia with evidence of long-term nesting prior to European colonisation.

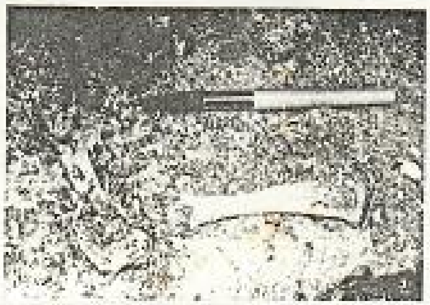

Figure 1. *Weathered remains of the left femur, tibia and fibula, portion of the fossilised skeleton of an adult sized* Chelonia mydas *found on 11 December 1980 in the phosphatic limestone cliff face at the western end of Raine Island. These bones were found on an horizon 60 cm below clam A (see text).*

Figure 2. *Skeletons and scattered bones of nesting* Chelonia mydas *which fell over the cliff margin to the central phosphatic limestone platform on Raine Island, February 1975.*

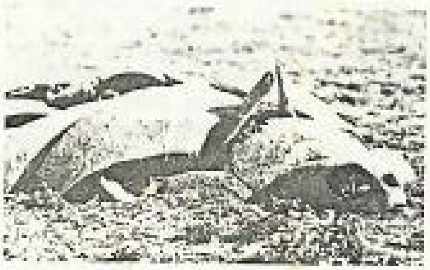

Figure 3. *Four year old skeletal remains of a nesting female* Chelonia mydas *in the central depression of Raine Island, December 1978. This turtle was recorded first in February 1975 as a freshly dead turtle. Away from the main nesting concentration on the beach, turtle carcasses in the central depression can remain relatively undisturbed for years.*

These ages are consistent with the current interpretation that the central raised phosphatic limestone platform of Raine Island is a portion of the Holocene veneer of the reef (Stoddart et al. 1978). Raine Island as we know it has existed as an island for at the most a few thousand years i.e. since the last Holocene transgression. Sea levels within the Great Barrier Reef Province appear to have reached their maximum height about 6000 yr ago and have slowly receded about one metre since then (Hopley 1983; Chappell 1983). However, during the last ice age the sea level would have been considerably lower. An examination using SCUBA of the near vertical margin of Raine Island Reef revealed that no terrace wide enough to support a beach when sea levels were lower occurs within 45 m of the present sea level. Thus during the last glacial period Raine Island would have been surrounded by near vertical limestone cliffs rising out of the sea and, being without a beach area, could not have supported a sea turtle rookery. The same would have applied to most of the then coastline along the outer edge of the Great Barrier Reef to the north and south of Raine Island. At that time the nearest beaches to Raine Island suitable for turtle rookeries (assuming temperatures and other climatic factors were suitable) were probably on the margin of the exposed sections of the Coral Sea platform or along the coast of the Gulf of Papua. When the beach at Raine Island formed following the mid-Holocene stabilisation of sea level, the turtles that began to nest there were not simply part of a population that gradually shifted its nesting site to keep pace with a slowly shifting beach. Nesting at Raine Island represented a shift to a totally new habitat and, having made the shift, green turtles have been nesting there for at least 1130 yr. While this is brief by geological time standards, it represents many generations of turtles and emphasises the biologically long-term use of traditional nesting beaches which characterises sea turtle breeding. At the same time, however it also emphasises their ability and their need to be able to make major shifts in their nesting distribution in response to long-term changes in sea levels which result in the loss of breeding areas and/or the development of new suitable nesting habitat.

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References

Allen, J., and Corris, P. (1977). *The Journal of John Sweatman.* (University of Queensland Press: St. Lucia, Brisbane.)

Chappell, J. (1983). Evidence for smoothly falling sea level relative to north Queensland, Australia, during the past 6000 yr. *Nature* **302**, 406–7.

Chappell, J., Chivas, A., Wallensky, E., Polach, H.A., and Aharon, P. (1983). Holocene paleo-environmental changes, central to north Great Great Barrier Reef inner zone. *BMR J. Aust. Geol. Geophys.* **8**, 223–35.

Chivas, A., Chappell, J., Polach, H., Pillans, B., and Flood, P. (1986). Radiocarbon evidence for the timing and rate of island development, beach-rock formation and phosphatization at Lady Elliott Island, Queensland, Australia. *Marine Geology* **69**, 273–87.

Clark, R.M. (1975). A calibration curve for radiocarbon dates. *Antiquity* **49**, 251–66.

Currie, L.A., and Polach, H.A. (1980). Exploratory analysis of the international radiocarbon cross-calibration data: consensus values and interlaboratory error. Preliminary note. *Radiocarbon* **22**, 933–5.

Flood, P.G., Harjanto, S., and Orme, G.R. (1979). Carbon-14 dates, Lady Elliott Reef, Great Barrier Reef. *Qld Govt Mining J.* **80**, 444–7.

Gillespie, R., and Polach, H.A. (1979). In *Radiocarbon dating, Proceedings of the Ninth International Conference.* (Eds R. Berger and H.E. Suess) pp. 404–21. (University of California Press: Berkeley.)

Hopley, D. (1983). Preliminary results from a four-year drilling programme on the Great Barrier Reef. In *Proceedings: Inaugural Great Barrier Reef Conference, Townsville, Aug 28–Sept 2, 1983.* (Eds J.T. Baker, R.M. Carter, P.W. Sammarco and K.P. Stark) pp. 107–11. (JCU Press: Townsville.)

Jukes, J.B. (1847). *Narrative of the Surveying Voyage of H.M.S.* Fly. (T. & W. Boone: London.)

Klein, J., Lerman, J.C., Damon, P.E., and Ralph, E.K. (1982). Calibration of radiocarbon dates: Tables based on the consensus data of the Workshop on calibrating the Radiocarbon Time Scale. *Radiocarbon* **24**, 103–50.

MacGillivray, W. (1917). Ornithologist in North Queensland. *Emu* **17**, 63–87.

Moseley, H.N. (1879). *Notes by a Naturalist on the 'Challenger' Voyage of H.M.S.* Challenger *Round the World in the Years 1872–1876.* (Macmillan and Co., London.)

Polach, H.A., McLean, R.F., Caldwell, J.R., and Thom, B.G. (1978). Radiocarbon ages from the northern Great Barrier Reef. *Phil. Trans. R. Soc. Lond.* A. **291**, 139–58.

Stoddart, D.R., McLean, R.F., Scoffin, T.P., Thom, B.G., and Hopley, D. (1978). Evolution of reefs and islands, northern Great Barrier Reef: Synthesis and interpretation. *Phil. Trans. R. Soc. Lond.* B. **248**, 149–59.

Stoddart, D.R., Gibbs, P.E., and Hopley, D. (1981). Natural history of Raine Island, Great Barrier Reef. *Atoll Res. Bull.* **254**, 1–44.

Stuiver, M., and Polach, H.A. (1977). Discussion: reporting of ^{14}C data. *Radiocarbon* **19**, 355–63.

Warham, J. (1963). On the edge of the Coral Sea. *Pacific Discovery* **16**, 1–9.