RAKAHANGA ATOLL: SEA TURTLES AT A REMOTE SITE IN OCEANIA

Michael White[1] and Gemma Galbraith[2]

[1]Honu Cook Islands, Omoka, Tongareva Atoll, Northern Cook Islands (Principal Investigator for sea turtles in the Cook Islands)
[2]University of York, England (postgraduate researcher)

In September-October 2011 four green turtle nests (*Chelonia mydas* Linnaeus 1758) were laid on the southernmost beach at Rakahanga Atoll (10°01' South; 161°05' West; Northern Cook Islands) adjacent to Rakahanga School (Figs 1 and 2). The Principal (Tuhe Piho) sought advice about protecting the nests and so the first author designed a science project, which the school used to monitor the nests until they hatched; those events led to the present report.

Sea turtles are traditionally known throughout Oceania, but scientific research has been scarce, largely because of limited resources and infrequent inter-atoll transport. The true status of turtles in Oceania is unclear, although globally all species are endangered (IUCN Red List), while the Cook Islands are data deficient (Meylan & Donnelly 1999; Maison *et al*. 2010; NMFS 2010; Wallace *et al*. 2010).

The first sea turtle study in four decades was undertaken at Rakahanga Atoll during July-August 2012, supported by the BCG and the Ministry of Marine Resources. Aims were to: assess numbers and distribution of sea turtles, identify nesting sites, observe marine habitat use, identify threats and impacts, and undertake community education and capacity building. Rakahanga was briefly surveyed within Pacific-wide investigations of turtle populations during the 1960s-1970s (Balazs 1977, 1995; Pritchard 1995).

Rakahangan Islanders have largely ignored sea turtles (*'fonu'*) in recent years, although occasionally one is speared for food; nowadays egg-take is rare. Throughout Oceania turtles were previously, and in many places still are, an important food resource (Allen 2007; Woodrom Rudrud 2010). Usually the nesting females were targeted whilst laying their eggs, being flipped onto their backs and killed later.

The importance of working with the community

Contrasting with 'fortress conservation' that often excludes local people, 'community-led' conservation has local people directly protecting the resources that they rely on, and the natural environment that they are part of (Adams & Hutton 2007). Top-down governmental prohibition on use of traditional

Fig. 1. Map showing Rakahanga's nesting beaches.

Fig. 2. School beach.

food resources would not achieve effective conservation (Colchester 2004; Torri 2011). Instead, by understanding local people and their needs, and their opinions and perceptions of marine conservation, a more culturally sensitive protective mode can emerge for endangered species, including turtles. Localised conservation projects will also have practical benefits in remote Polynesian islands and similar sites with limited financial or scientific resources (Campbell & Vainio-Mattila 2003).

Rakahanga is a subsistence culture with high regard for the natural resources on which it depends. Sea turtle species are globally recognised as being endangered, but that concept is understandably unfamiliar to people surrounded by an abundant and pristine environment. Rakahangans generally do not know that turtles are endangered (Tuhe Piho pers. com.).

Many global conservation priorities are in regions dominated by indigenous cultures (Cincolta *et al*. 2000); it is essential to find methods that benefit endangered species, and are acceptable within customary and traditional indigenous values. The authors integrate Traditional Ecological Knowledge (TEK) with scientific research and environmental education, an approach that should enable even small island nations to contribute substantially to global conservation efforts.

The study site

Rakahanga is a true atoll (Spalding *et al*. 2001) located on the submarine Manihiki Plateau, as is its nearest neighbour Manihiki Atoll; the surrounding ocean is over 1000 metres deep. Rakahanga's population is 89, about one third being children (in August 2012). Life is subsistence-based, so food is gathered daily (coconuts, pawpaws, breadfruit and fish; wild pigs are shot in the jungle). Very occasionally ships from Rarotonga or Hawai'i bring bulk cargo. Rakahanga has a generator (18 hours a day), but diesel fuel is delivered by sea and must be managed carefully. Telecommunications are via satellite link and, recently, limited internet services became available. A previous runway was destroyed by Cyclone Martin (1997) and never rebuilt, but Manihiki has an airport and sometimes a small boat crosses to Rakahanga with passengers.

The natural habitats are in pristine condition, primarily because the atoll is very remote and has so few people and they are careful only to gather what food they need each day. Traditional management practices (*'Rahui'*) control resource harvesting to ensure food security rather than for conservation *per se*. These are promulgated by the Island Council; *Rahui* works through common consent.

Constitution Day celebrations

Each year a two week festival *'Te Maeva Nui'* is held at Rarotonga to celebrate Cook Islands' Independence (1965). People from the Outer Islands and many expatriate Cook Islanders participate in this celebration of their traditional culture. The theme for 2012 was *'Our Language and our Homeland'*. Fifty people from Rakahanga took part and they used the endangered status of sea turtles to highlight the threat to losing their language '*Akono te fonu ete reo*' ('Save the turtles and our language').

The authors made Rakahanga two model sea turtles, a 2-metre one for the school float and a 10-metre one that the Island Choir sat beneath on a lorry during the procession. The *fonu* were constructed from wire mesh and papier-mâché (Figs 3-6). With enthusiastic help by school children this allowed us to introduce primary concepts to them, such as endangered species and anatomy, paving the way for later in-depth environmental education. The giant *fonu* created considerable excitement, with family members coming to see the progress of their children's efforts at turtle construction; this was a significant phase of community capacity building. Because so many people then departed for Rarotonga, the authors had the atoll largely to themselves for the research phase; we became an integral part of the resident community.

Fig. 3. Planning the carapace scutes of the model fonu.

Fig. 4. Model fonu almost finished.

Fig. 5. Mike and Gemma with the giant fonu.

Fig. 6. Giant fonu ready to ship to Rarotonga.

Research

Terrestrial surveys

The entire coastline of Rakahanga was assessed for evidence of sea turtle nesting and the suitability of each beach to support nesting (Fig. 1). Habitats were described as being suitable or unsuitable for egg laying (Figs 2 & 7) based on the substrata (sand, gravel or rock), vegetation cover, ease of access from ocean or lagoon, and nestable area above high water (White 2012). GPS (Global Positioning System) was used to delineate sectors and isolated nests. Threats and impacts, especially pollution (marine debris), were noted.

A total of 26 nests was found on the four main sandy beaches: south 'school beach' (four nests), southeast (ten nests), northeast (five nests) and north (seven nests). However, as there were no visible tracks, egg laying had clearly occurred some months earlier. The entire western shore is rocky and unsuitable for nesting.

Although all four nesting beaches could be monitored fairly easily, we have suggested that two are used as index sites to show population trends. We asked the school to check the southern beach for tracks every day, but the northern beach is visited infrequently. However, some of the adults will check this occasionally for signs of nesting activity.

We report the first incubation period data for the Cook Islands. The date of laying was known for all four nests on the school beach in 2011, and hatchlings were seen emerging from three of them (the fourth emergence was missed). Mean incubation duration is 58 days (SD = ±2.7 days, range 55-60 days, n = 3 nests).

Nest inventories

We excavated those four nests that had been laid on the school beach and examined their contents to determine % hatching success. Clutch size ranged from 43-106 eggs (mean 76 eggs, SD = ±30 eggs. Mean % hatching success = 91% (SD = ±10%, range 81-100%). Senior students (aged 12-16) participated in the last two excavations as part of their training programme (Fig. 8).

Marine surveys

Kayaks were used to survey the large inner lagoon, while some areas of the outer reefs were assessed by snorkellers and parts of the reef top were walked. Other observations were made from shore or whilst fishing. Habitats included reef top, drop-off, patch reefs and lagoon; behavioural codes are from White (2012).

Threats and impacts

Immediate threats to turtle populations on Rakahanga, both marine and terrestrial, were identified by direct observation and also formal and informal

Fig. 7. Unsuitable nesting habitat.

Fig. 8. Vakahoa counting hatched eggs on school beach.

Fig. 9. Counting the string after the beach clean, with other plastic top right.

interviews with community members. Specific issues examined included quantifying turtle harvest and egg take, fisheries impacts and habitat degradation.

Predation

Aside from natural predation by crabs or seabirds, feral cats (*Felis catus*) and wild pigs (*Sus scrofa*) represent introduced pressure on turtle populations. Cats were only observed in the village whereas pigs are on all main motu. We found pig tracks and evidence of rooting by pigs on the northern and north-eastern nesting beaches.

Pollution

Litter from the island is either burnt at home or dumped at two small landfill sites (south coast). Ocean-borne pollution was observed predominantly on the atoll's windward (east) side and included an eclectic mix of debris from external sources. A beach clean by the school children (22/08/2012) collected 1400 plastic items from an 800m stretch of south-eastern beach (Fig. 9). Pike (2008) shows that higher fitness benefits to turtle females are conferred by natural nesting habitats that are in good condition; it is therefore essential to keep Rakahanga's nesting beaches free from plastics and other pollution.

Fisheries

There is no commercial fishing at Rakahanga, but subsistence fishing (small trawls, handlines and spear-fishing) occurs near shore and on reefs. No formal quotas exist, but general levels of take are overseen by the fisheries officer, who, with support from the village council, can enforce *Rahui* if species are vulnerable or in low numbers. The selective nature of local fishing gear means turtle bycatch is a highly rare occurrence (Papatu, pers. com. 2012). Foreign industrialised fishing vessels are observed occasionally near Rakahanga; commercial long-lining is known to cause high levels of turtle bycatch (Lewison & Crowder 2007). Although local subsistence fishing methods present a low bycatch threat to turtles, any intensification of industrial fishing would potentially increase bycatch levels here.

Direct consumption

Turtles are a delicacy in Polynesia, but on Rakahanga consumption was generally low; they were either speared on reefs or taken from beaches when nesting. These events were always opportunistic and had no significant cultural or celebratory significance; 56% of adults said eggs were their most recent take. In every case the entire clutch was collected, the last known being in 2010.

Community surveys

We used sociological research to gauge attitudes and opinions of islanders towards turtle conservation and traditional environmental management. Formal questionnaires were completed by community members before and after the authors' scientific presentation, in which we shared research findings and broader aspects of marine conservation. Of the 89 permanent residents all those above 16 were interviewed, except four individuals who were absent or sick (n = 60 respondents). Most of the interviewees attended the talk (n = 49) and were questioned again afterwards, which enabled us to identify attitude changes resulting from our presentation.

We explored attitudes towards i) community-based turtle conservation, as conducted by *Fonu Cook Islands*, and ii) the recently announced Cook Islands Marine Park. Questions focussed on perceived benefits to Rakahanga specifically and also the wider Cook Islands, whether respondents were happy about the formation of either of these projects and also whether they liked the idea of such a project. A numeric scale was devised for possible responses viz. 'Agree', 'No opinion' and 'Disagree'; a Mean calculated for each question produced a quantitative analysis. Table 1 compares key results, both before and after our presentation, examining attitudes toward the local community turtle project and the state-implemented MPA. (See Galbraith 2012 for detailed findings, available from the authors.)

Before the presentation 42% of people agreed that *Fonu Cook Islands* monitoring project was a good idea for Rakahanga; this increased to 47% post-presentation. In comparison, only 5% of people thought the Cook Islands Marine Park was a good idea. This did not change even after presenting information on global marine conservation. Before the presentation 9% of respondents agreed that monitoring sea turtles would benefit Rakahanga, this increasing to 56% afterwards. No one agreed that the Cook Islands Marine Park would benefit the community on Rakahanga. This was unchanged afterwards (Table 1).

Our surveys reflect the benefits and effectiveness of community-led projects in two ways. Firstly, in pre-presentation surveys overall attitudes towards the *Fonu Cook Islands* monitoring project were much more positive than those towards the government-led, national scale Marine Park. This suggests that initially people were more accepting of and positive about a project that they could experience directly. Turtles are frequently seen locally and deemed to be culturally important, whereas only 62% of people had heard of government plans for the marine park. Familiarity is therefore a key factor in the effectiveness and success of a conservation project (Wossink & van Wenum 2003) and is something that perhaps only small-scale community-led endeavours can bring to isolated and remote communities.

Table 1. Community responses to a survey given before and after an environmental talk.

Question	Response pre-presentation	Response post-presentation
1. Will you eat turtle again….?	90% Yes	80% Yes
2.Do you agree with the statement that sea turtles are an endangered species?	37% Yes	58.3% Yes
3.The sea turtle monitoring project will benefit Rakahanga (% Agree)	9%	56%
4. The Cook Islands MPA will benefit Rakahanga (% Agree)	0%	0%
5. I like the idea of a sea turtle monitoring project on Rakahanga and support its formation (% Agree)	42%	47%
6. I like the idea of The Cook Islands Marine Park and support its formation (% Agree)	5%	5%

Secondly, awareness raising education through a presentation *in situ* further improved people's attitudes toward the community turtle project, highlighting an inherent benefit of community-led projects i.e. close interaction between islanders and visiting scientists. This enabled the educational curriculum and materials to be tailored for local needs.

Initially, 90% of all adults questioned stated they would eat turtle meat or eggs in the future; post-presentation this percentage declined marginally to 80%. It is important to recognise the persistence of cultural values within indigenous communities, even after environmental education (Borrini-Feyerabend *et al*. 2004). Instead of switching to coercive enforcement, culturally sensitive approaches can be developed from local viewpoints. Community-led projects, like these of *Fonu Cook Islands*, are likely to achieve greater compliance and long term social and biological success (Holt 2005).

Community education

A 60-hour 'Turtle Rangers' course was delivered at Rakahanga School to ten students (seven were aged 12-16, but three were 8-10 years old). Adults were too busy gathering food to participate, but four sat in on lectures occasionally. Techniques and concepts were also discussed with several adults during social visits. The Rangers course included turtle biology, conducting nest inventories, threats and impacts, modern research techniques (e.g. photo-recognition), and some customary approaches to conservation (Figs 10 & 11). Flipper tagging and DNA sampling equipment were demonstrated, and GPS use taught (Fig. 12). Excel was used to analyse data and produce graphs. Students were guided to make posters using PowerPoint, and, very importantly, they took part in our presentation, which most of the community attended. Families could see just how much their children had learned (i.e. real capacity-building). Hopefully this should have far reaching effects because these children are the atoll's future leaders, who should influence future generations' attitudes to conservation.

The presentation included discussing why eating adult females was not a good idea – 'no mothers then no more future turtles'. We also wrote a sea turtle article for the New Zealand School Journal, a widely distributed educational resource (Fig. 13).

Discussion

Rakahanga Atoll has a pristine environment, but is not a suitable place for ecotourism. Many modern tourists probably travel with good intentions; however, the problem is the word 'many'. The very low human population density on this atoll, and similar remote islands, has undoubtedly contributed substantially to maintaining a well balanced ecosystem (White 2012). Three questions arise:

i) Should people living in remote places be deprived of the benefits of the materialistic world?
ii) How can depopulation and its accompanying loss of traditional values and culture, especially local languages, be best managed?
iii) How can these well balanced environments continue to exist?

The common thread is sustainability! For centuries remote communities in the Cook Islands have utilised *Rahui* (allowing or prohibiting the harvest of any particular natural resource) to ensure continued food supplies; similar approaches are used elsewhere in Oceania (e.g. Pulea 1992; Johannes 2002). Subsistence based life and cash based economies are inherently contradictory. The former recognises that natural resources are finite and need respite from harvesting in order to regenerate (i.e. be sustainable). In stark contrast, cash economies require infinite resources and perpetual growth, neither of which

Fig. 10. Nari and Kau at work.

Fig. 11. Munokoa measuring curved carapace width.

Fig. 12. Teaching GPS use.

Fig. 13. Munokoa and Tokoteru presenting the journal.

are possible indefinitely (e.g. Roberts 2007). If a resource (e.g. *Tridacna* clam), is deemed to have some monetary value (cash-economy model) the pressure to harvest unsustainably is increased. Under *Rahui*, harvesting clams would be permitted for, say, a week and then closed for 18 months or more while the stock recovers: a lesson the industrialised world ignores (White 2012). Sea turtles are not presently protected under *Rahui*, but both Rakahanga and Tongareva Councils suggest that they could be (White *pers. com.* 2012).

Several Rakahangans mentioned tourism as a way to boost island revenue, but with little thought for consequences. Another suggestion is buying a commercial deep-freeze and exporting their reef fishes. This would probably bring short term profit and long term loss of natural resources. The risk in both cases is that once the local environment is damaged it may never recover, which is the reality in much of the world (Verity 2002; Mooney 2010). A better option would be to promote the 'natural value' of the environment instead. Our sociological survey showed very clearly that small scale, low-budget projects are likely to achieve better results amongst remote communities than large scale, heavily managed national proposals e.g. a Marine Park. People are more concerned about what happens to them and their island. Furthermore, it makes perfect sense to have local monitoring teams on remote atolls contributing to national biodiversity assessments. Not only does this overcome limited transportation, but also islanders know their locale intimately and have a clear understanding of the state of various natural resources, including how these relate to past abundance – such data are usually absent at governmental level (e.g. Usher 2004). Following our education programme, Rakahanga's community is willing to undertake environmental monitoring, focussing initially on sea turtles.

Remote atolls like Rakahanga provide safe havens for turtle rookeries and migrating turtles on passage. Although small, these have great importance for biodiversity (NMFS 2010). In turn, these havens can act as reservoirs to replenish neighbouring areas that have been heavily impacted by human activities, such as industrialised fishing, pollution, or extensive loss of coastal habitats through tourism developments (e.g. Roberts 2007). Although vitally important, small rookeries are highly vulnerable, because once a nesting aggregation is extirpated it is unlikely to be replaced from elsewhere, implying that a possibly unique genetic link has been lost (Bowen *et al*. 1992, 1994; Schroth *et al*. 1996; Dethmers *et al*. 2006; Dutton *et al*. 2008; NMFS 2010; Wallace *et al*. 2010).

The Rakahanga expedition produced several important scientific findings:

i) The first incubation period data from the Cook Islands (mean 58 days)
ii) Egg success rates are high (91%, n = 4 nests), which agrees with findings from the other atolls

iii) Natural predation is minimal, but turtles are occasionally killed for food
iv) Several nesting sites are in shady areas, which enhances the possibility of producing male hatchlings (Temperature-related Sex Determination produces more female embryos at higher incubation temperatures, more males when cooler).

Two index beaches were nominated for ongoing monitoring, which will allow nesting trends to be determined over time.

Effective sea turtle conservation requires comprehensive strategies that span considerable chasms between social, cultural and biological agendas. Community-based projects facilitate this approach to conservation, as clearly demonstrated by this study. Involvement by all sectors of the community, together with their choice of *fonu* as Rakahanga's *Te Maeva Nui* symbol, emphasised a strong desire for involvement with visiting scientists. Having a local turtle project then strengthened the capacity of the island community to determine its involvement with global conservation: in harmony with their own cultural values and priorities.

The influence of small communities, such as Rakahanga, within global turtle research and conservation strategies should not be underestimated. Certainly, the nesting surveys and data acquired during this project would not have been possible without the considerable capacity building effort by both the Rakahangan community and the authors. It is vital that knowledge and understanding flows both ways (Johannes 2002): western science and TEK have much to gain from each other – smooth integration will make for long term sustainability and effective management.

Conclusion

Rakahanga Islanders are willing to take an active role in endangered species conservation and monitoring, but this places responsibility onto us and the Cook Islands government. All too often in the past, community-based projects globally have collapsed once the initial impetus provided by the instigators has waned; invariably this was because of a lack of support. The present authors intend to stay closely connected with these remote atoll communities, in order to provide information, guidance and ongoing training. The fact remains that in modern times people in subsistence environments still need money to pay for electricity, phones and some supplies. The ideal option would be for national government to provide continuous low level funding. This would have three important benefits:

i) Biodiversity is maintained, which the Cook Islands regards as its 'national treasure'

ii) The islanders earn money by protecting their natural resources

iii) This will lead to higher education becoming directly available in the

remote atolls, thus enhancing the knowledge and skills of the environmental teams and also reducing the risk of economic emigration and the associated loss of culture.

The safeguarding of small, pristine ecosystems will have local, national, regional and possibly global benefits. Low human population densities mean that environmental impacts are small and manageable. Providing safe havens for endangered species may allow them to recover and then be used to restock severely impacted populations elsewhere.

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