Monitoring the distribution, population structure and status of sea turtles in the Cook Islands

Cook Islands Turtle Project: 2011 Annual Report

By

Dr Michael White

Research Permit: #07/09e (first issued 07/05/2009; then extended on 20/04/2010) Approved by the National Research Committee (Foundation for National Research).

Partners

Cook Islands Turtle Project **(CITP)**
Pacific Islands Conservation Initiative **(PICI)**
Ministry of Marine Resources (Pamela Maru)
Pacific Divers (Proprietor: Stephen Lyon)
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Frontispiece: Left profile of a green turtle *Chelonia mydas* tagged at Tongareva (2011). Photo-recognition techniques can use these facial scale patterns to confirm identity.

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Abbreviations

CCL: Curved carapace length
CCW: Curved carapace width
CITES: Convention on international trade in endangered species of wildlife and flora (Washington 1973)
CITP: Cook Islands Turtle Project
CMS: Convention on the conservation of migratory species of wild animals (Bonn 1979)
MMR: Ministry of Marine Resources
MTSG: Marine Turtle Specialist Group
NES: National Environment Service
NOAA: National Oceanic and Atmospheric Administration
PICI: Pacific Islands Conservation Initiative
SPREP: Secretariat for the Pacific Regional Environment Programme
SWOT: State of the World's Sea Turtles (Conservation International)
TREDS: Turtle Research and Monitoring Database.
USP: University of the South Pacific

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"Monitoring the distribution, population structure and status of sea turtles in the Cook Islands"

Cook Islands Turtle Project

The Cook Islands Turtle Project (CITP) was initiated by the author in 2009 with the aim of undertaking a long-term assessment of sea turtles in the Cook Islands. Research is authorised by the National Research Committee (Permit # 07/09e) and CITP is currently based in the Northern Cook Islands, undertaking marine turtle research at Tongareva Atoll (see Map 1); and implementing environmental education and outreach activities throughout the Northern Group Atolls. The Project works in association with the Pacific Islands Conservation Initiative (PICI www.picionline.org); and represents a partnership between Dr. Michael White (Chief Scientist of CITP) and PICI; working closely with the Cook Islands Government.

Pacific Islands Conservation Initiative

The Pacific Islands Conservation Initiative (PICI) is a recently-formed environmental organisation founded by Stephen Lyon, that has as its goal, the community-led promotion of conservation focusing on habitat protection, and species protection where habitat protection is not viable. The Initiative is developing several concurrent projects, with the Cook Islands Turtle Project being the first collaborative effort and significant research project. Other emerging projects include: Aitutaki Lagoon Monitoring Project (ALMP); a proposed shark sanctuary in Cook Islands territorial waters; and managing persistent waste, especially in the remote islands. PICI has a new Programmes Manager (Jessica Cramp) based in Rarotonga, who, along with Stephen Lyon, has extended CITP's educational and advisory role; and in future will manage the data-collection programme for the underwater sightings of turtles at Rarotonga. The present author is part of PICI and also a member of its scientific advisory board. The Pacific Islands Conservation Initiative Trust was legally incorporated under Cook Islands law on 8th August 2011[1]. To learn more about PICI and its various activities visit www.picionline.org.

Government of the Cook Islands

The principal departments concerned in our work are: the Prime Minister's Office, Foundation for National Research, Ministry of Marine Resources (MMR), National Environment Service, Ministry of Education; and the Focal Points for the relevant Conventions to which the Cook Islands is party to (e.g. CMS and CITES). Pamela Maru (MMR) is an associate researcher for CITP, and also the Project's link with the National Research Committee; providing government oversight.

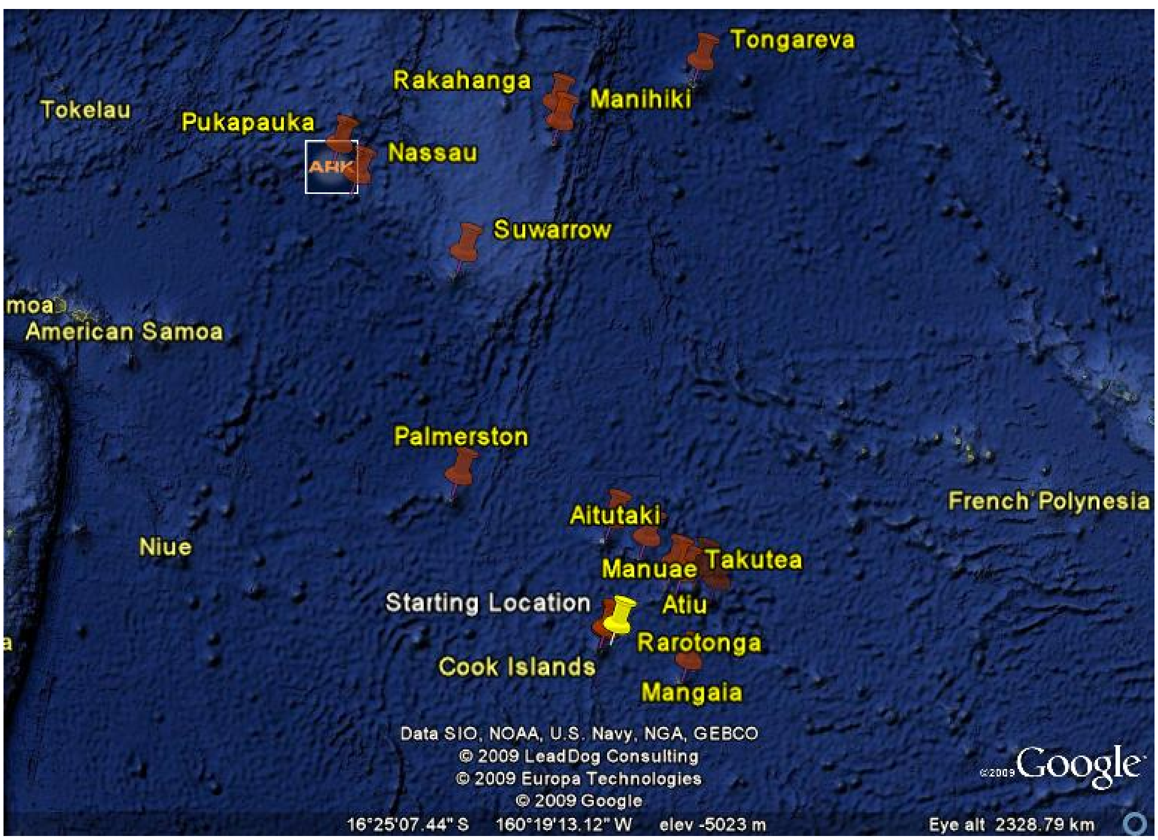
[1] The charitable organisation's trustees are: Stephen Lyon, Jessica Cramp and Heinz Matysik.

Marine Research Programme

Introduction: The Need

Sea turtles are an ancient group of marine reptiles that have been on Planet Earth for at least 110 million years (Hirayama 1998; & see FitzSimmons *et al*. 1995). Sea turtles are long-lived animals, with delayed maturity, that may be migratory during all life-stages. Apart from adult females, which emerge onto beaches for egg-laying, and the subsequent hatchlings that crawl from nests to the sea, the entire life cycle of sea turtles can be completed in the marine environment.

The Pacific Region covers about one-third of the planet's surface and six of the seven extant sea turtle species are known from the region: [spp. *Chelonia mydas*; *Eretmochelys imbricata*; *Lepidochelys olivacea*; *Caretta caretta*; *Natator depressus*; *Dermochelys coriacea*. The seventh species *Lepidochelys kempii* has not been reported from the region]. Many of the Pacific Island Nations are poorly studied, mostly because of limited resources, including scientific expertise and, above all, a lack of transportation between the islands. Sea turtles are known traditionally throughout the Pacific Islands.



Map 1. Overview of the Cook Islands Archipelago. (Image from GoogleEarth.com.)

The Cook Islands consist of 15 islands or atolls, with a land area of about 241 km^2 spread over some two million km^2 of ocean (09°S to 23°S; 156°W to 167°W); there are very few scientific or contemporary data concerning sea turtles in the archipelago, and transport to many of the outer islands is infrequent and expensive, particularly so for the Northern Group (Nassau, Pukapuka, Rakahanga, Suwarrow and Tongareva; with only Manihiki being well-served because of its black pearl industry).

Sea turtles in the Cook Islands

The present state of knowledge for sea turtles in the Cook Islands was reviewed by White (2011). Four species of marine turtle: **green** *Chelonia mydas* (Linnaeus 1758); **hawksbill** *Eretmochelys imbricata* (Linnaeus 1766); **leatherback** *Dermochelys coriacea* (Vandelli 1761); and **loggerhead** *Caretta caretta* (Linnaeus 1758) have now been confirmed as using Cook Islands territorial waters; the first two species throughout the year (White 2011, 2011b, 2011c). *D. coriacea* is at present only known from the offshore industrialised fisheries (P. Maru *pers. com.* 2010); and *C. caretta* has been reported from Palmerston Atoll; although it is not known to nest (Bill Marsters *pers. com.* 2010).

Egg-laying by *Chelonia mydas* can now be confirmed for the following atolls: Aitutaki, Manihiki, Nassau, Palmerston, Pukapuka, Rakahanga, Suwarrow and Tongareva (White *pers. com.* 2011).

Eretmochelys imbricata has not yet been observed nesting, and most of the individuals that have been encountered in the archipelago so far appear to be juveniles (White 2011, 2011c). This is also the marine turtle species that has suffered the greatest exploitation by humans for almost four millennia (Parsons 1972).

Hawksbill turtles have been heavily exploited in the Pacific Islands Region, for meat, eggs and tortoiseshell (see Groombridge & Luxmore 1989); and it is likely that nesting populations are declining, depleted or only remnants (NMFS & USFWS 1998). This species is rapidly approaching extinction in the region (NMFS & USFWS 1998), with many, if not most, nesting populations having declined by more than 80% throughout its global range in the last 105 years: i.e. three generations of hawksbills (Meylan & Donnelly 1999). Lack of long-term census data for hawksbills means that there are no trends for the status and stability of populations in the South Pacific Region.

Egg-laying period

At present there has been little written about when sea turtle nesting actually occurs in the archipelago and so the exact period for egg-laying in the Cook Islands, and neighbouring Tonga and Samoa, is unclear (White 2011). There are some reported nesting observations from Fiji, Tonga and the Samoan islands (see Witzell 1982; Marquez 1990; Hirth 1997; Craig *et al*. 2004; Batibasaga *et al*. 2006; Tagarino *et al*. 2008; Maison *et al*. 2010; NMFS 2010; Woodrom Rudrud 2010; see also SWOT 2011), however, even these are sparse or perhaps from surveys undertaken some years ago (e.g. Balazs 1975, 1977, 1982/1995; Pritchard 1982a/1995a). Balazs (1983) also reported the traditional usage of turtles at Tokelau. The nesting season in the Cook Islands probably occurs at some period between September and April; but there may be differences in nesting-activity between northern and southern group islands, as well as between species (White 2011). It is also possible that nesting may occur all year-round at some locations (White *pers. obs.* 2011). Balazs (1975) gathered anecdotal evidence from Canton, Phoenix Islands (Kiribati) that reported green turtles nesting sporadically in all months, but with peak-nesting in October and November (see also Balazs 1995); Enderbury was similar. Dobbs *et al.* (1999) have reported year-round nesting by hawksbills on Milman Island, Australia. Jennifer Cruce (*pers. com*. 2010) reported green turtles nesting year-round at Yap (Federated States of Micronesia); also see Maison *et al*. 2010)[2].

A lack of data: Implications for Regional Management

As very little is known of the distribution and population status of sea turtles in the Cook Islands (White 2011) and some of the other Polynesian nations (e.g. Marquez 1990; SPREP 2007; NMFS 2010; and see data citations in SWOT 2011), it is difficult to assess the actual risk of extinction, or vulnerability of these animals.

Regional Management Units (RMUs): with an aim of better managing sea turtle stocks, 58 RMU-polygons have been identified globally, which include different areas of the Pacific Region (Wallace *et al*. 2010).

Dethmers *et al*. (2006) offer another approach for regional management that has been based on nesting-stock data: these **Nesting Aggregations** (NAs) typically link areas within 500 km of each other; and these may also be genetically distinct[3]. The following NAs are of direct relevance to us in the Cook Islands:

i) Western Polynesia: Pukapuka has been included with Samoa and American Samoa;
ii) Northern Cook Islands: Manihiki, Nassau, Rakahanga, Suwarrow and Tongareva;
iii) Southern Cook Islands: Aitutaki, Atiu, Mangaia, Manuae, Mauke, Mitiaro, Palmerston, Rarotonga and Takutea.
(See **endnote i** for details of these and other adjacent NAs).

For places where few sea turtle data exist – including the Cook Islands – a conservative approach has been adopted when defining the NAs, and these geographical locations are categorised in the lowest group: *1-25 nesting females per annum* (based on 4.5 nests per female per annum; Van Buskirk & Crowder 1994). The Cook Islands are data-deficient and have thus been allocated into this lowest nesting category: i.e. no more than 25 green turtles *Chelonia mydas* would nest annually, in each of the Northern and the Southern Cooks Nesting Aggregations (NMFS 2010). There appear to be no Cook Islands data for nesting hawksbill turtles *Eretmochelys imbricata* (Balazs 1982; Marquez 1990; Meylan & Donnelly 1999). **The true level of nesting nationally is likely to be higher than this (White *pers. obs.* 2011**).

[2] Islands north of the Equator would normally have their nesting period during the Boreal summer; and so those data may not be of much help for calculating the egg-laying season in the Southern Hemisphere.
[3] Genetic data are absent for most documented nesting sites in Oceania; about 171 locations have been grouped into 24 NAs (Dethmers *et al*. 2006; NMFS 2010).

CITP Research Overview

This research programme is intended to become an ongoing study, which will produce reliable baseline data and develop suitable conservation, co-management, or management options for the Cook Islands Government and People. The author's initial approach is to visit the different atolls depending upon when transport is available, so that first-hand knowledge can be gained of: i) the contempory presence of sea turtles; ii) the life-stages and species that are present; iii) the availability of suitable nesting habitats; iv) the availability of foraging resources; v) the level of traditional take (meat and eggs); vi) any other threats or impacts; vii) any traditional management practices, such as *Rahui* (*Ra'ui*)[4]. One of CITP's aims is to identify important nesting beaches for ongoing surveys (*index beaches*) so that sea turtle population-trends can be determined in subsequent years.

Visits to Atolls in the Northern Cook Islands

All Northern Group islands have now been visited at least once; there was insufficient time for the author to go ashore at Rakahanga (December 2010) when *S/V Kwai* anchored for one hour to offload cargo, but anecdotal evidence has been gathered from islanders there indicating that sea turtles are present on the reefs and in the lagoon. Rakahanga will be surveyed at a later date.

Manihiki (2010 & 2011)
Nassau (2009 & 2010)
Pukapuka (2010)
Suwarrow (2009)
Tongareva (2010-2012)

Visits to Islands in the Southern Cook Islands

Aitutaki (2010)
Palmerston Atoll (2009 & 2010)
Rarotonga (2009-2011)

The *makatea* islands have not yet been visited (see next section below).

[4] Collection of various species or using certain locations is prohibited for a period of time. The tapu is imposed by the Island Council and adhered to by common consent. The rahui is lifted as needed.

Geological notes for the Cook Islands

The following notes are from Spalding *et al*. (2001):

i) Northern group atolls, apart from Tongareva, are on the Manihiki Plateau. Spalding *et al*. (2001) suggested that these atolls formed when the plateau was a shallow volcanic feature, and then the reefs grew as the plateau subsided.

ii) Tema Reef is a sub-surface platform reef between Pukapuka and Nassau.

iii) Tongareva is on a seamount rising from the deep ocean (an isolated feature). Flying Venus Reef is on the same seamount, but separated from Tongareva by a deep channel (>500 m deep).

iv) The Northern Cook Islands form two parallel chains, running NW to SE, that then continue as the Austral Islands in French Polynesia.

v) Winslow Reef – Southern Cooks – is a shallow platform reef that does not show above the surface; it is about 150 km NE of Rarotonga.

vi) Takutea is an uninhabited platform island; and an important bird sanctuary (originally gazetted in 1903; re-established in 1950 under Aronga Mana; Cook Islands Biodiversity 2002).

vii) Manuae and Palmerston are true atolls.

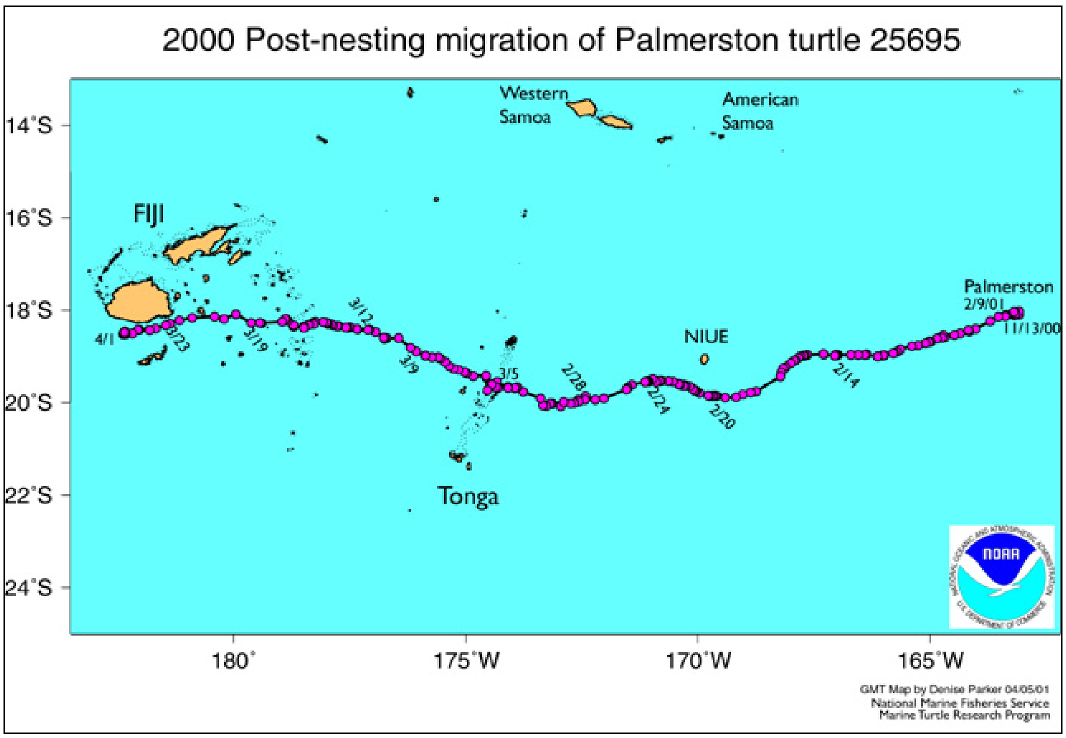
viii) Aitutaki is a near-atoll, with one large and two small volcanic islands in the lagoon.

ix) Atiu, Mangaia, Mauke and Mitiaro are *makatea* (i.e. fossilised coral reef – a volcanic centre with a carbonate rim of reef origin).

x) Rarotonga is a volcanic island (height 652 m) with fringing reefs.

General movements of sea turtles through the Cook Islands

Before the present study began there were very few published data concerning sea turtles in the Cook Islands (Balazs 1977, 1982 (revised 1995); Pritchard 1982a (revised 1995a); McCormack 1995; Centre for Cetacean Research Centre 2000; Maison *et al*. 2010; NMFS 2010; Woodrom Rudrud 2010; WWF undated) and only three records for turtles using the marine environment. White (2011) noted the following as being the only known records for turtles entering or leaving the Cook Islands EEZ[5]: i) a green turtle tagged at Scilly Atoll, French Polynesia, was captured in the Cook Islands (Balazs *et al*. 1995); ii) a green turtle tagged at Rangiroa, French Polynesia, was recaptured in the Solomon Islands, so may have traversed Cook Islands waters (SPREP 1993); iii) a green turtle was satellite-tagged (tag # 25695, November 2000) while nesting at Palmerston Atoll, Cook Islands, and migrated westwards to the south of Fiji (Balazs *pers. com.*).



***Chelonia mydas*. A post-nesting green turtle fitted with a satellite transmitter (#25695) at Palmerston Atoll (November 2000) migrated westwards to Fiji, arriving in April 2001 (Balazs, NOAA).**

An earlier hypothesis which suggested that '*green turtles do not usually reside in Cook Islands sea areas, but instead live at Fiji or Vanuatu; perhaps making nesting migrations to the Cook Islands*' (McCormack 1995; & WWF undated) - based on the known close association of green turtles and seagrass meadows, which are largely absent in the eastern Pacific (see Hirth 1997) - was not supported by the present author; who has shown that both green and hawksbill turtles are present in Cook Islands waters throughout the year (White 2011, 2011b, 2011c). McCormack (*pers. com.* 2011) suggested that the presence

[5] Cook Islands territorial waters cover over two million square kilometres of the South Pacific Ocean.

of *Chelonia mydas* in the Cook Islands during the Austral winter may have been a consequence of head-started[6] turtles that had been released from Palmerston, and other atolls, since the 1950's (Ron Powell, unpublished data); rather than a naturally-occurring population (see also Balazs 1977).

So what evidence is available either way? It is known that marine turtles are capable of making extended oceanic migrations (e.g. SPC 1979b; Mortimer & Carr 1987; Uchida & Teruya 1988; Lohman 1992; Papi *et al*. 1995; Hirth 1997; Sakamoto *et al*. 1997; Lohman *et al*. 1997; Hughes *et al*. 1998; Luschi *et al*. 1998, 2003; Miller *et al*. 1998; Cheng 2000; Nichols *et al*. 2000; Polovina *et al*. 2000, 2004; Godley *et al*. 2002; Lohman & Lohman 2003; Craig *et al*. 2004; Boyle *et al*. 2009); **satellite-telemetry** (an electronic transmitter is attached to the carapace of a turtle and its subsequent locations are uplinked to Earth-orbiting satellites) has enabled some of these journeys to be better understood. In the South Pacific Craig *et al*. (2004) released seven green turtles that had nested on Rose Atoll (east of the Samoan islands): each had been fitted with a UHF transmitter (an eighth transmitter malfunctioned) during the period 1993-1995. Six of those seven turtles migrated westwards into Fijian waters; the seventh went eastwards to Raiatea, French Polynesia: on average those turtles covered about 1600 km, swimming at 1.8 km/hr, with journeys taking around 40 days (Craig *et al*. 2004). Those authors (Craig *et al*. 2004) suggested that green turtles could spend as much as 90% of their adult life in Fijian waters, based on: their telemetry evidence; several assumptions (that it takes turtles 4-5 years to replenish their body-fat reserves following nesting; that reproductive migrations take several months to complete; and that nesting migrations are made quadrennially); and a series of flipper-tag returns. [see below for tagging techniques].

Marine turtle satellite tracking (SPREP)

Satellite tagging was one of the priority actions identified for the Year of the Sea Turtle (YOST) campaign under the SPREP regional Marine Turtle Action Plan 2003-2007, and continues under the Marine Species Regional Action Programme 2008-2012. **(Photo SPREP/NOAA)**

The plan calls for continuation of the satellite-tagging programme first initiated under YOST. It focuses on tag releases by multiple member countries to emphasise the shared nature of turtle stocks. In addition, satellite tagging will provide the needed data where 'not known' or 'unavailable', in particular the movement of nesting turtles after nesting.

The current turtle satellite programme is a collaborative undertaking by SPREP, the Marine Turtle Research Programme (NOAA, National Marine Fisheries Service, Pacific Islands Fisheries Science Centre, Hawaii), and member countries. Dr George Balazs is the Head of the Marine Turtle Research Programme, NOAA.

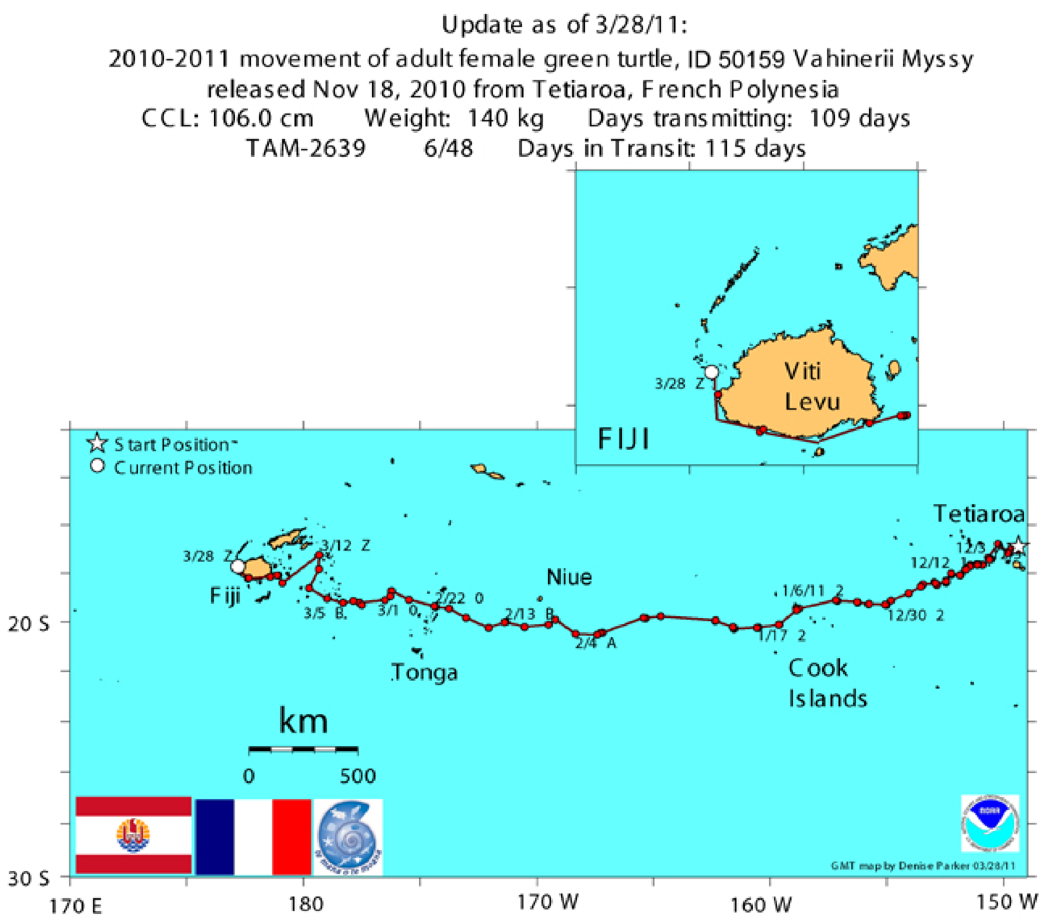
[6] Turtles hatchlings are kept in captivity for months or years and allowed to grow to a larger size before being released. This may reduce the impact of predation on neonate turtles as they enter the ocean.

Satellite tracking from French Polynesia:

A telemetric study was recently undertaken at *Tetiaroa*, French Polynesia: between late-October 2010 and early-March 2011 five green turtles were fitted with UHF satellite transmitters. **The following turtle data[7] were provided by Dr Cécile Gaspar & Dr George Balazs:**

i) Tini: (88066) CCL (curved carapace length) 44.5 cm; released Opunohu Bay, Moorea 28th October 2010; transmitted for 81 days and headed eastwards to southwestern side of Tahiti; no further transmissions were received after 17th January 2011.

ii) Vahinerii Myssy (flipper-tags: 974 & 975) CCL 106 cm; released 18th November 2010 at Tetiaroa; travelled 3500 km in 115 days to Fiji (Viti Levu, south & west sides). **[MW note: appears to have traversed Southern Cook Island waters in early January 2011 (exiting around 17th January); passing south of Niue in early February 2011].**

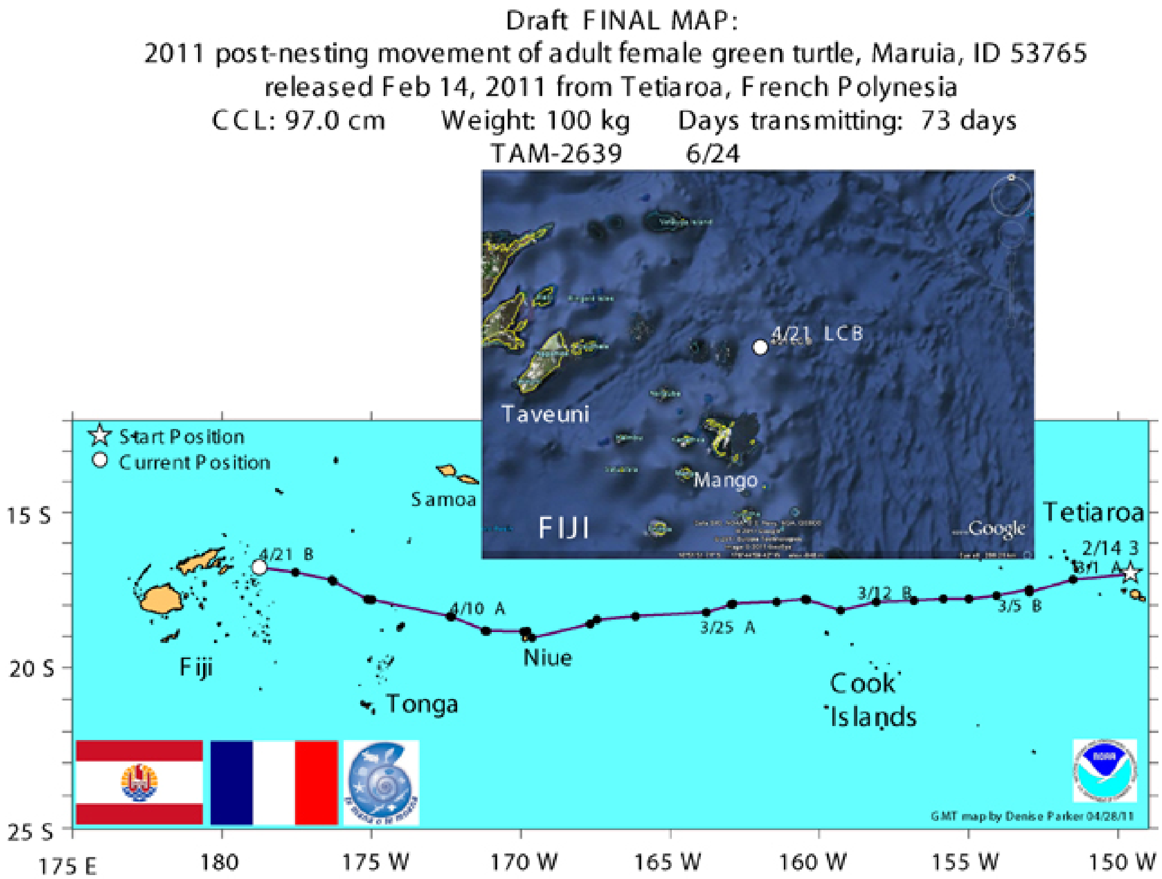


Final NOAA tracking map for *Vahinerii Myssy* (ID # 50159); date 28/03/2011

7 The trackings are a collaboration of *Te Mana o te Moana* (Moorea, French Polynesia), Directorate of Environment (French Polynesia), and PIFSC Marine Turtle Research Programme (Hawaii).

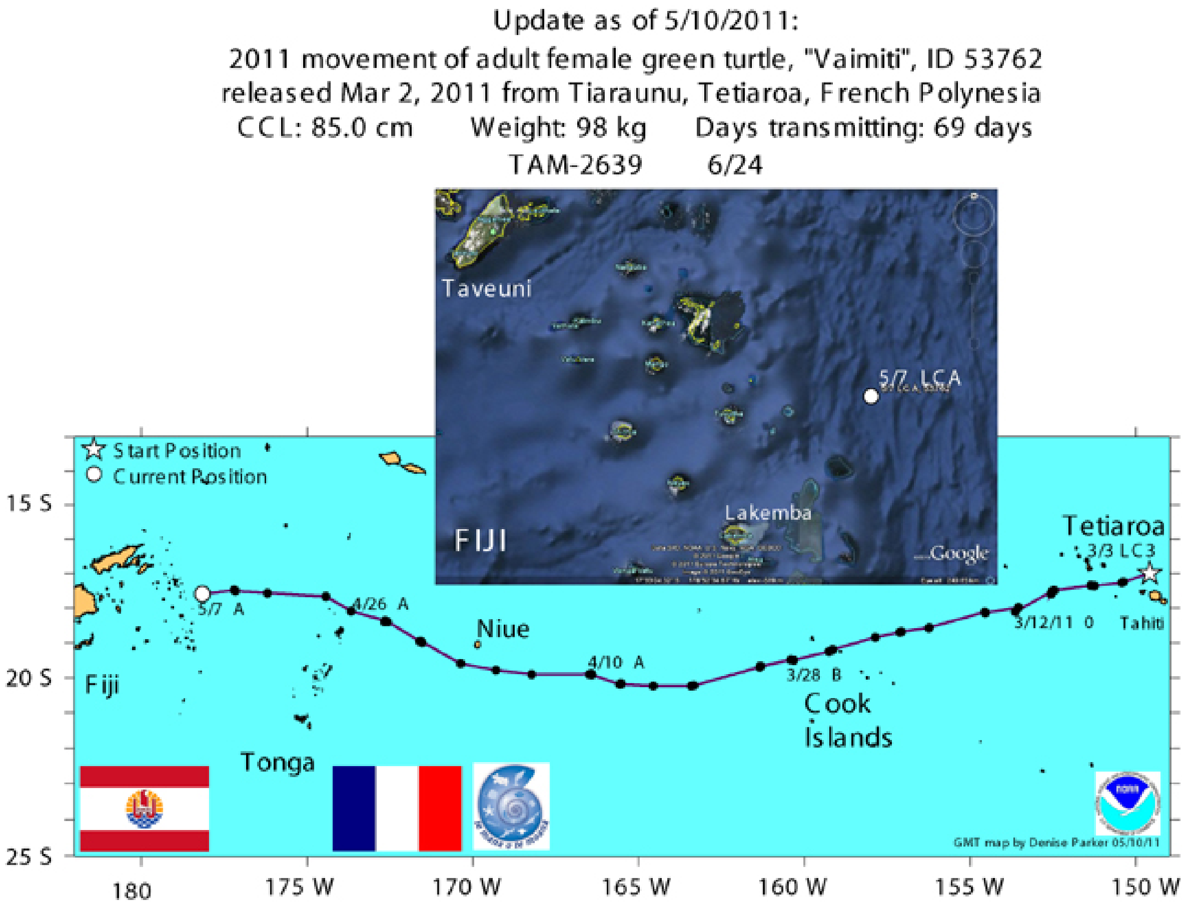
iii) Vaea (flipper-tags: 966 & 967) CCL 104 cm; released 15th December 2010 at Tetiaroa. Remained around the atoll for 54 days and then no further transmissions; she had moved east.

iv) Maruia (flipper-tags: 973 & 969) CCL 97 cm; released 14th February 2011 at Tetiaroa. She travelled directly towards Niue, covering 1500 km in 42 days; and then onwards to Fiji. **[MW note: appears to have transited the Southern Cooks in early March 2011; passing north of Niue and was between *Ha'apai* & *Vavau* islands (Tonga) on 10th April 2011; arriving eastern Fiji 21st April 2011].**



Latest NOAA tracking map for *Maruia* (ID # 53765); date 05/10/2011

v) Vaimiti (flipper tags: 896 & 110) CCL 95 cm; released 2nd March 2011 at Tetiaroa. **[MW note: She appears to have transited the Southern Cooks during the second half of March 2011 and then headed for Niue; arriving east of Fiji in early-July]. Still transmitting.**



Latest NOAA tracking map for *Vaimiti* (ID # 53762); date 05/10/2011

***

Author's commentary on the Tetiaroa study:

i) Three of these five turtles (60%) tracked from French Polynesia have migrated through Cook Islands waters. Interestingly they all traversed through the Southern Group (close to 20° latitude) somewhere north of Rarotonga. The tracking-maps are a little deceptive because even if the turtles pass, say, to the south of Aitutaki – it is a 100-km gap southeast to Manuae ~ basically open ocean. Likewise if the route is north of Aitutaki but south of Palmerston, or between Palmerston and Suwarrow: it is mostly open ocean.

ii) The main questions raised for the present author by the Tetiaroa study, which would similarly apply to turtles in the Cook Islands, are: i) How many of the turtles nesting at Tetiaroa migrate; ii) How many migrate westwards; iii) How many migrate elsewhere; iv) How many return to French Polynesia (or to the Cook Islands) and at what intervals; v) How many stay locally? (see Balazs *et al.* 1995 Grant *et al.* 1997; Randall 1998).

iii) A known problem of satellite-telemetry is the battery-life (how long transmitters will function for) – this has improved dramatically in recent years as micro-technology has become much more efficient and widespread. The present author has noticed that many telemetry studies seem to be of short duration, just a few months; this could be a result of programming other parameters into the transmitters e.g. dive-depth, water-temperature or swimming-speed, which greatly reduce a transmitter's operational life (perhaps to 300 days). In contrast the present author has just concluded a telemetry study on three marine turtles in Albania, Mediterranean Sea: the longest of which transmitted for 763 days. Battery-life can thus be extended considerably if only locational data are required in the experimental design (see www.medasset.org 'Turtle Tracks').

iv) In order to properly answer the questions raised above it would be necessary to track a return migration: e.g. a journey from the Cook Islands to some other place and its return; or to tag a turtle on a feeding ground in, say, Fiji[8] or Vanuatu and see where it ends up This may well require a device that could transmit for five years or more (White *pers. com.* 2011).

v) To investigate this knowledge gap CITP will seek funding to undertake an extended satellite-tracking programme, working in association with other Pacific Island nations, regional authorities (e.g. SPREP) and researchers: deploying several transmitters[9] onto turtles encountered at remote atolls, so that we can improve our understanding of sea turtle migratory routes and their habitat use in the Pacific Ocean (see Tucker 2010).

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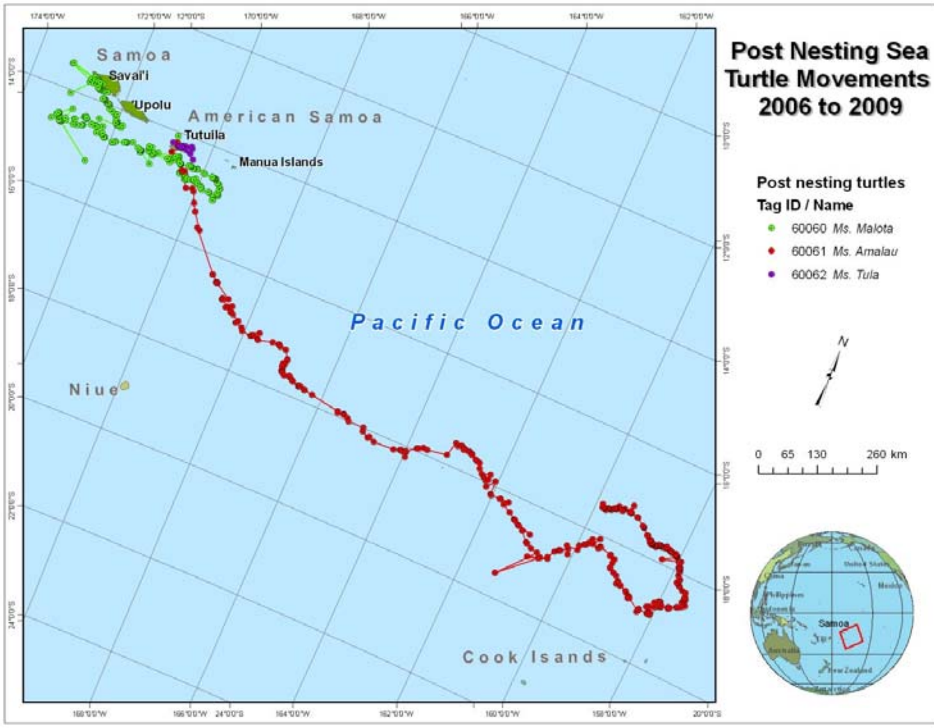
vi) The following information was recently provided by **Alden Tagarino** (Department of Marine & Wildlife Resources, PagoPago, American Samoa): Some hawksbill nesting occurs in American Samoa (Balazs 2009), especially on *Tutuila Island*. Of two post-nesting hawksbills fitted with satellite tags on Tutuila, one migrated several hundred km to Samoa, and the other migrated >1000 km to the Cook Islands (Tagarino *et al*. 2008). Also a juvenile hawksbill migrated into Cook Islands waters, thus confirming that these animals are a shared resource. (See maps below).

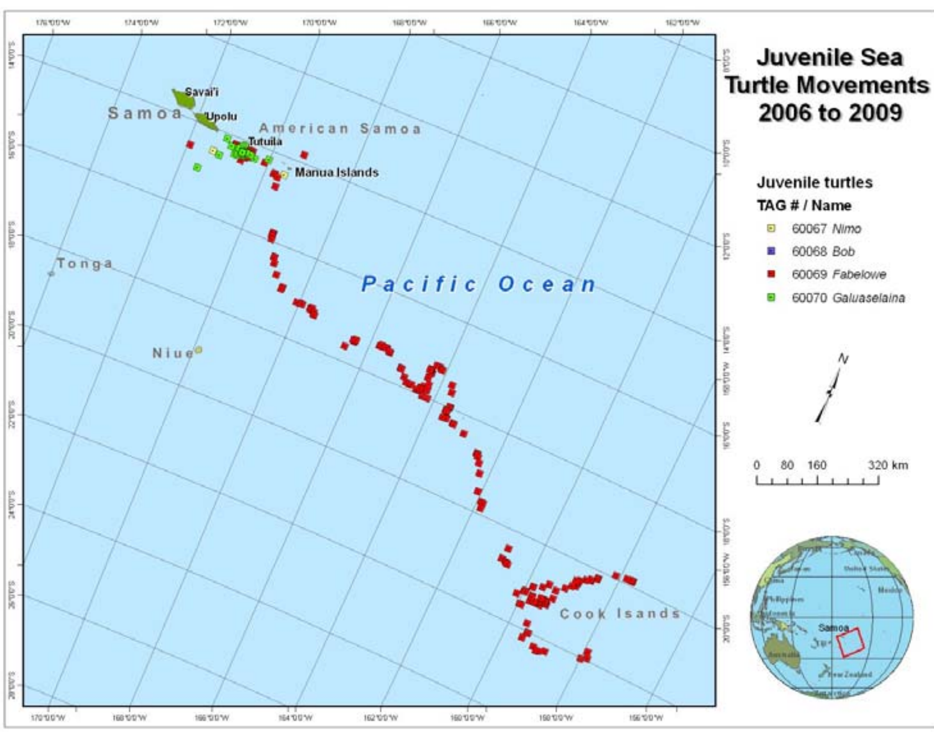
vii) Some hawksbills are thought not to make long migrations (e.g. Witzell 1982; Grant *et al*. 1997), so the tracked journeys of turtles from Tutuila (Tagarino *et al*. 2008) are of interest; and, similarly, post-nesting hawksbills on the GBR migrated >2,000 km (Miller *et al*. 1998). This seems to contrast with tracked post-nesting hawksbills in the Hawaiian Archipelago, which migrated <100 km (Parker *et al*. 2009); which was perhaps because Hawai'i is more isolated than archipelagos in the western and south Pacific where multiple atolls and islands are within a few hundred km of each other. A CITP research goal is to investigate the distribution and behaviour of hawksbills in the Cook Islands: do they also make long migrations or just remain locally? (White *pers. com.* 2011).

[8] There has been a recent telemetry programme for green turtles at Yadua, Fiji.
[9] A suitable transmitter is the SPOT 5 (www.wildlifecomputers.com); this may function for 700-800 days if only providing locational data.

Satellite tracking from American Samoa:



***Eretmochelys imbricata*. Top: Post-nesting hawksbill passed north of Palmerston & on to Aitutaki. Below: Juvenile hawksbill was near to Palmerston & may have foraged by Rarotonga, Atiu, Takutea, Mitiaro & possibly Mauke**



Flipper-tagging

A second approach used to determine distribution patterns is to apply a numbered metal tag to one or more of a turtle's flippers (Balazs 1999): this technique has been widely-used in nesting-beach studies, also on turtles captured at foraging grounds or during migration (e.g. Meylan 1982b; Lazar *et al*. 2004), and by observers monitoring fishery bycatch (see Eckert *et al*. 1999). In order to gain any useful information the animal has to re-encountered at some point in the future, and its tag-data reported. Mark-release-recapture studies show the dates and locations for where individual animals were released and subsequently re-encountered, but not where they might have travelled to or lived between recaptures or sightings (White 2007). In fact, tag-return data typically account for just 1-3% of the total tagged population (e.g. Hughes 1974a, 1974b; Argano 1992; Margaritoulis 1992; Baldwin *et al*. 2003; Bell *et al*. 2005; White *et al*. 2011) **Endnote ii**.

Problems: A flipper-tagging programme undertaken on the remote Cook Island atolls is likely to encounter at least four problems:

i) Sea turtles have to be encountered or captured in order to apply the tags; and then again in order to read the numbers.
ii) An awareness campaign has to be implemented so that islanders know how to report tag numbers; even if they have eaten the turtle.
iii) Certain types of flipper-tags may increase the risk of a turtle becoming entangled in fishing gear (Suggett & Houghton 1998).
iv) Transportation to an atoll to conduct research may be very limited.

Solutions: CITP's mitigation measures are to:

i) Systematically tag all captured turtles, particularly when undertaking fieldwork on the remote atolls.
ii) Launch a nationwide sea turtle information programme that includes a website and contact number for reporting tag numbers **(PICI has been approached about this)**.
iii) Only use tags that minimise incidental entanglement: CITP has already done this by using *Stockbrand's* titanium tags[10]; because these lock into a 'closed-U shape'.
iv) Plan joint-expeditions with other researchers (e.g. birds, corals, alien-species surveys, or predator-control) and charter a suitable vessel for the survey period, thus reducing each organisation's costs.

Genetic analysis

The third and most recent approach for identifying populations is to collect DNA samples in order to determine the haplotypes of sampled turtles: mitochondrial DNA (mtDNA) is passed directly from mother to her offspring; nuclear DNA (nDNA) is the combined genetic material from both parents. Maternal inheritance (mtDNA - Bowen *et al*. 1994; Abreu-Grobois *et al*. 1996) tends to accentuate genetic differences between populations

[10] Tags and tagging equipment were provided by SPREP.

(Moritz *et al*. 2002). Genetic studies have also revealed other important findings, including: evolutionary descent (FitzSimmons *et al*. 1995); natal homing (Meylan 1982; Meylan *et al*. 1990); population structure (e.g. Bowen *et al*. 1992, 1993; Carreras *et al*. 2006; Pont *et al*. 2006); stock analysis of fishery bycatch (e.g. Bowen *et al*. 1995; Laurent *et al*. 1998; NMFS 2010); multiple-paternity (Harry & Briscoe 1988; Fitzsimmons 1996); distinct nesting aggregations (Schroth *et al.* 1996; Moritz *et al*. 2002; Dethmers *et a*l. 2006); foraging populations (e.g. Lahanas *et al*. 1998; Dutton *et al*. 2008); migrations (e.g. Avise & Bowen 1994; Bowen 1995; Bowen *et al*. 1995; Bass *et al*. 1996; Bolten *et al*. 1998); and relationships between adjacent oceans (e.g. Laurent *et al*. 1993; Tomas *et al*. 2003; Carreras *et al*. 2006; Garofalo *et al.* 2009).

In the Pacific region, especially for the South Pacific islands, there are very few genetic data available for marine turtles (NMFS 2010; SWOT 2011), which makes it difficult to determine the origin of nesting or foraging turtles, and likewise the origin of turtles caught in fisheries (**endnote iii**). Extensive DNA-sampling for green turtles has been undertaken in Australia (e.g. Moritz *et al*. 2002 & references therein) and at Hawai'i (on nesting beaches, especially at French Frigate Shoals, and on foraging grounds); the Hawaiian archipelago appears to comprise one genetic stock that is distinct from other known Pacific stocks (Dutton *et al* 2008; NMFS 2010; Pilcher 2011).

Summary for Green Turtles in Oceania (from NMFS 2010):

The total number of green turtles nesting annually in Oceania is 17,399-37,525 females. The region is divided into 24 NAs, but the Australian NAs (Northern GBR (Great Barrier Reef) & Southern GBR) make up approximately 90% of the total). Over half of all nesting in Oceania occurs at a single island: **Raine Island** in the Northern GBR NA. Trend data are not available for all of the 24 NAs. However, trend data are available for certain nesting sites within the Ogasawara Island, Northern GBR, Southern GBR, and Hawai'i NAs, where long-term monitoring projects have been collecting data for sufficient time to determine a significant trend. Trend information provided for other NAs is based on well-documented anecdotal evidence from local residents, and not long-term nesting beach monitoring datasets. Nesting trends appear stable at Raine Island (Northern GBR NA), as well as at Heron Island (Southern GBR NA), and are increasing at Chichi-jima in the Ogasawara Island NA (Chaloupka *et al*. 2007).

However, stable and increasing nesting trends at these sites do not necessarily correlate with a stable or increasing trend overall for Oceania (NMFS 2010) because of low nesting-success, hatchling-production, and recruitment at Raine Island, where the majority of nesting for the entire region occurs (Limpus *et al*. 2003, Hamann *et al*. 2009). In addition, NAs with small numbers of nesting females may be of greater importance than their proportional numbers indicate (Bjorndal & Bolten 2008). Loss of individuals from smaller, more vulnerable Pacific island rookeries is likely to have a greater impact on that particular nesting assemblage than removal of individuals from a large rookery. Over half of the 24 NAs in Oceania have 100 or fewer documented nesting females annually. Many of these NAs are geographically isolated and likely to harbour unique genetic diversity. Small nesting assemblages of green turtles are unlikely to re-colonise their historic nesting areas once they have been extirpated (Avise & Bowen 1994).

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Summary for sea turtles passing through Cook Islands sea areas:

Flipper-tag returns

i) *Chelonia mydas*: a green turtle tagged at Scilly Atoll, French Polynesia, was captured in the Cook Islands (Balazs *et al*. 1995).
ii) *Chelonia mydas*: a green turtle tagged at Rangiroa, French Polynesia, was recaptured in the Solomon Islands, and so may have traversed Cook Islands waters (SPREP 1993).

Satellite-tracking

i) *Chelonia mydas*: a green turtle was tagged (ID 25695) while nesting (November 2000) at Palmerston Atoll, Cook Islands, and migrated westwards to the south of Fiji (NOAA).
ii) *Chelonia mydas*: a green turtle was tagged (ID 50159) at Tetiaroa, French Polynesia (released 18th November 2010) and migrated to the west of Fiji (NOAA).
iii) *Chelonia mydas*: a green turtle was tagged (ID 53765) at Tetiaroa, French Polynesia (released 14th February 2011) and migrated to the east of Fiji (NOAA).
iv) *Chelonia mydas*: a green turtle was tagged (ID 53762) at Tetiaroa, French Polynesia (released 2nd March 2011) and migrated to the east of Fiji (NOAA).
v) *Eretmochelys imbricata*: a hawksbill turtle was tagged (ID 60061) while nesting at Tutuila, American Samoa, and migrated southeastwards towards Aitutaki, Cook Islands (Tagarino *et al.* 2008).
vi) *Eretmochelys imbricata*: a juvenile hawksbill turtle was tagged (ID 60069) at Tutuila, American Samoa, and migrated southeastwards towards Aitutaki and the eastern atolls, Cook Islands (Tagarino *et al.* 2008).

This is the current state of our knowledge up until January 2012 (White *pers. com.*).

The Study at Tongareva Atoll

Scientific research began at Tongareva Atoll [09°S; 158°W] on the 1st January 2011 with the following aims:

i) to assess turtle nesting activity and to determine the nesting period
ii) to identify the nesting species and important sites for egg-laying
iii) to identify index beaches for future monitoring
iv) to note the presence of turtles in the marine environment.

Education and outreach objectives were:

i) to give a series of lectures on sea turtles
ii) to have regular talks with interested islanders about conserving sea turtles
iii) to develop a sea turtle module for the school curriculum
iv) to note when turtles or eggs are known to have been eaten
v) to gather information about *rahui* traditional management practices (SPREP 1980)

The study site

Tongareva Atoll[11] is the northeasternmost of the Cook Islands (Map 1 above); it has the nation's largest lagoon (area 233 km^2) and about 77 km of coral reef intersected by three passages *'ava'* (*Siki Rangi, Taruia* and *Takuua*). The deepest part of the lagoon is 64 m; the surrounding ocean varies in depth from 400-3000 metres (NZ 945). The atoll consists of a number of *'motu'* (cays), all of these are narrow (less than 500 m wide) with a few extending for several kilometres (*Moananui, Tokerau, Ruahara, Pokerekere, Temata-Patanga-Tepuka, Mangarongaro*), a number of others are smaller (e.g. *Painko, Tuirai, Kavea, Atutahi & Atiati*), but there are also several minor islets; some of which have now disappeared (e.g. at *Ahu-A-Miria* only three of nine that were mapped now remain; and none at *Ahuapapa*). All motu are low-lying: the highest elevation being about six metres above sea level; this is a bank immediately to the west of the airfield on *Moananui*. The two villages are: Omoka - on the western motu of *Moananui* (about 145 people); and Tetautua on the eastern motu of *Pokerekere* (about 45 people); all other motu are now uninhabited. Water is only from rainfall and there are extended periods of drought. Transportation is rare, perhaps 3-5 ships a year; aircraft are infrequent and dependent on a fuel supply being available for the return leg; this fuel is delivered by sea and may be unavailable. Electrical power comes from a diesel generator and, as fuel is often in short supply, normally available for 14 hours per day; but this may be reduced if necessary. Telecom and the Marine Resource Centre have some solar-power capability; there is one privately-owned wind-generator (Latham, *pers. com.* 2011). There is no WiFi or mobile phone service; telecommunications are via a satellite-link to Rarotonga and may be disrupted. The atoll is north of the cyclone belt, but can suffer heavy weather; and, in fact, many buildings were badly damaged by Cyclone Pat in 2010; which subsequently destroyed much of Aitutaki (see White 2011, 2011b).

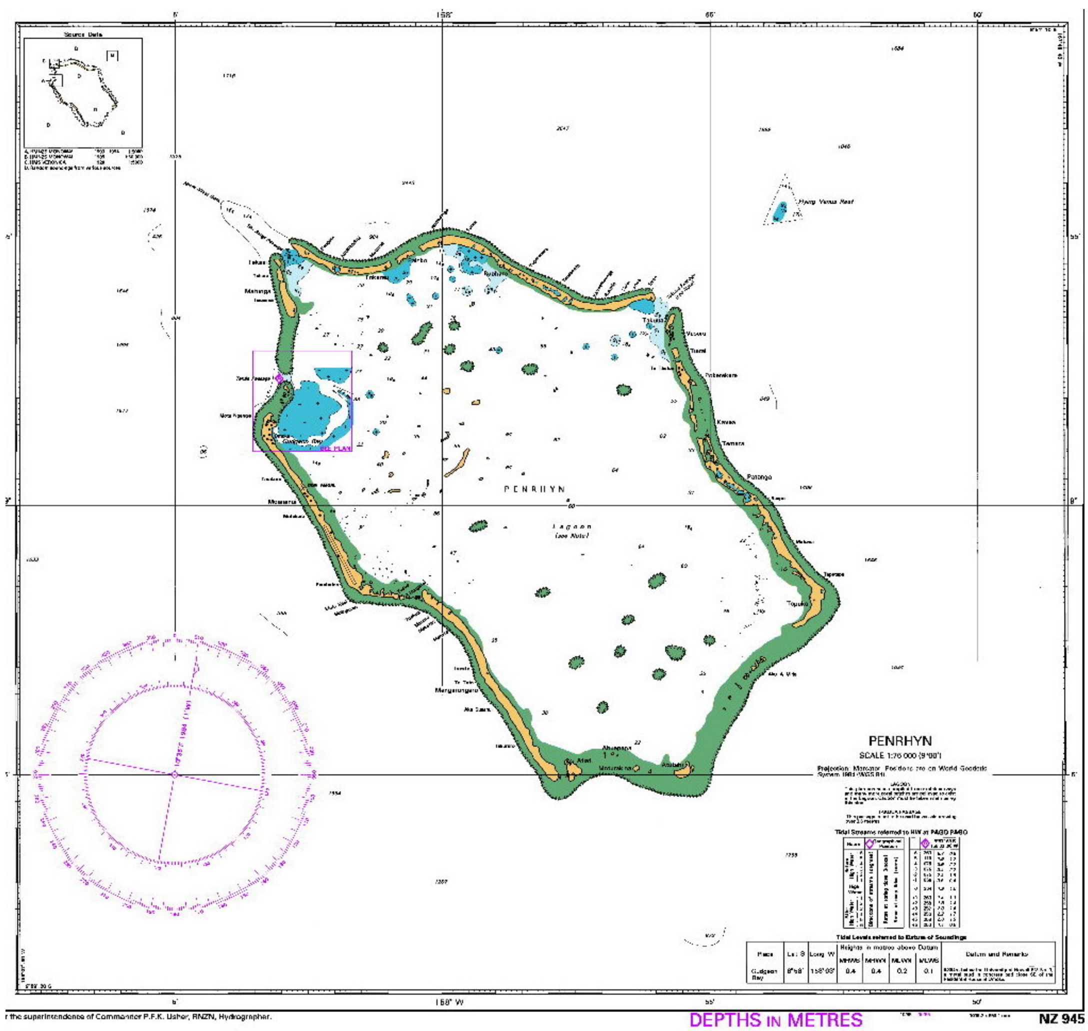
[11] Other names include: Mangarongaro, Hararanga, and Penrhyn Island

Sea turtles at Tongareva Atoll

Balazs (1982/1995) noted that in reports from the 1960s and 1970s, green turtles were known to nest at Tongareva, but there were no data on abundance or trends available; this was still the case in January 2011 (White *pers. com.* 2011).

The author visited the various motu when possible: surveys depended on suitable weather and sea conditions, and having some means of getting to each site; initially a small *vaka* (kayak) was used; as a motorboat was unavailable and fuel is often in very short supply.

Nightwork was not conducted during the present research, primarily for safety reasons: the author was working alone; weather can change very quickly; some of the motu have wild pigs on them; survey areas could be remote and it was wise when travelling by vaka to return in daylight so that the coral bommies and sharks were visible; logistical support was not available. The project does have flipper-tagging and DNA-sampling equipment available onsite.



Map 2. Tongareva Atoll (Chart from NZ 945)

Methodology for nesting beach surveys

Assessments were made by walking along the beaches in daylight hours searching for any signs of nesting activity (tracks or excavations), and making general observations on the likelihood of nesting occurring at each particular site.

1) Classification of beaches

Beaches on the motu were allocated into three types:

i) Type A – confirmed nesting: definite nests or hatchling tracks were observed.

ii) Type B – possible nesting: general characteristics were similar to those found at Type A sites; even if tracks or nesting activity were not observed at the time of surveying.

iii) Type C – unsuitable: these could perhaps be used occasionally***** for nesting, but in general their characteristics rendered this unlikely. Some examples are: **a)** a very steep, narrow, rubble shore, with very little, or impenetrable vegetation at the top (eastern side of *Pokerekere* and *Patanga* for instance); **b)** a very rocky, sharp, zone that effectively is dry land for much of the time, but may be inundated occasionally (e.g. the western side of *Matunga* and *Tehara*; and the latter's southern shore); **c)** areas where access across the reef is very difficult; **d)** areas that are water-logged; **e)** areas that are densely-covered with fallen vegetation; **f)** beach areas that have very little sand depth, overlaying a rocky substratum (e.g. some sectors of the nesting-beaches on the western sides of *Moananui* and *Mangarongaro*).

*****The dynamic nature of coastal habitats means that what may happen at Type C locations is that in some years the sand depth increases sufficiently to support nesting, perhaps during cyclone or tsunami activity, but then the natural coastal processes render it unsuitable again (the author has observed this on Aitutaki: at the airport and *Rapota* motu during 2010). A further consideration is that there are many other very suitable and easily-accessible nesting sites nearby, which turtles would be more likely to use.

iv) Beach sectors: beaches were subdivided into sectors of varying lengths based on clearly recognisable natural features: e.g. a change in the substrata from sand to boulders; or the presence of a particularly unusual tree; or a man-made feature such as a wall. Important nesting zones were identified; not all sectors of a beach can support nesting. GPS (Global Positioning System) equipment was not available in 2011, so latitude and longitude were estimated from a printed map (NZMS 272/8/4 Penrhyn) and a marine chart (NZ 945).

v) Seawards access: another consideration for nesting areas was the ease of access from the ocean or lagoon onto a beach. Sea turtles are large and heavy animals that are limited in their ability to move on land: their limbs are adapted for swimming rather than walking and so they have to drag themselves across the reefs and beaches.

2) Classification of turtle tracks

a) Age of tracks

Turtle tracks on the beaches were allocated into three categories based on the estimated date that the track was made:

i) Recent: made within the last 14 days
ii) Older: 3-4 weeks old
iii) Oldest: faint, but still recognisable as a turtle track; it was usually possible to locate the nesting site, although this could be difficult when the nest had been laid underneath coconut or pandanus leaves.

Note: With experience it is fairly easy to *'read the story written in the sand'*. Tracks could be eroded by heavy rain; even though rain may be a rare event in the Northern Islands.

b) Patterns of movement

Track patterns were examined to determine if turtles used symmetrical or asymmetrical modes of locomotion; turtle species tend to move in different ways on land[12].

c) Nesting events

An uptrack and its corresponding downtrack were considered as a single event i.e. a turtle crawls up the beach and sometime later returns to the sea. It was not always possible to determine track-pairs, so a conservative estimate of nest abundance was used when the evidence was unclear; these present data can be regarded as minimum nest numbers.

3) Nesting period

The egg-laying period has not been reported for Tongareva.

[Shibata (2003) noted that egg-laying occurred at *Aka Susanui* (southern part of *Mangarongaro*) between September and December (pp. 49/50 under *Honu*); species were not identified].

i) Date-of-lay: Estimates were made of the likely dates that nests may have been laid; these could be based on any of the following evidence:

i) Adult females observed on the beach
ii) Hatchlings (baby turtles) observed on the beach
iii) Adult tracks on the beach
iv) Hatchling tracks on the beach
v) Eggshells found in the nesting areas
vi) Other sources (including anecdotal information)

[12] Green and leatherback turtles normally use symmetrical movements on land (both fore-limbs are moved simultaneously); the other species are asymmetrical (diagonally-opposite limbs are moved together).

ii) Incubation period: The time that would be required for eggs to incubate successfully (i.e. for hatchlings to emerge from a nest) was selected as being of 60-days duration (two months). This is usually determined precisely when monitoring nesting-beaches by noting the date that a nest was laid and then monitoring it until the first hatchlings emerge. The incubation period is determined by the temperature in the nest: higher temperatures mean eggs can hatch sooner (perhaps in 45 days); cooler temperatures can extend incubation to 80 days or more (e.g. Marquez 1990; Miller 1997, White 2007).

If any hatchlings were observed during the present research the date-of-lay would be estimated by subtracting the assumed incubation period (60 days) from the date that the observations were made. When egg-shells were discovered in the nesting zone (i.e. these had been moved from the egg-chamber to the beach surface as emerging hatchlings dug their way upwards through the sand-column[13]) a further factor then had to be taken into consideration, which was: how long had the egg-shells been on the surface? Shells were examined closely to determine how flexible or brittle (desiccated) the fragments were[14]. If for example a shell had perhaps been on the beach surface for three weeks, this would be added to the incubation period to estimate the date-of lay (21 days since hatching, plus 60 days incubation, would give a date-of-lay as 81 days earlier). If hatchling tracks were seen they were treated as described above: the likely age of tracks plus the incubation period would give an estimated nesting date.

iii) Data recording: Each month was subdivided into 1st or 2nd halves (about 15 days each) and the dates-of-lay were allocated into the appropriate half; annotated with the underpinning evidence, to give some insight into nesting seasonality.

4) Sea turtle morphometrics

The following techniques were used on encountered or captured turtles:

i) CCL (curved carapace length): The centre-line distance over the carapace (shell) was measured from where the skin at the back of the neck joins the anterior scutes (keratinous plates) to the posterior margin (green and loggerhead turtles); for hawksbill turtles the measurement terminated at the anterior end of the 'V-shaped notch' between the rearmost marginal scutes (Eckert *et al*. 1999).

ii) CCW (curved carapace width): The widest distance over the carapace.

iii) Size-classes: Turtles were allocated into 10-cm size-classes based on their CCL: e.g. 70-cm CCL size-class is from 70.0 cm to 79.9 cm *et seq*. (White 2007).

iv) Sex: Laparoscopy was unavailable and measurements of the external tail morphology were used instead as an indicator for ascertaining the developmental stage of secondary sexual characteristics: i.e. if animals were adult or adolescent. Three measurements were recorded from the tail ventrally (Casale *et al*. 2005, White *et al*. 2011):

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[13] It may take hatchlings 3-7 days to dig from the nest to the beach surface.
[14] Sea turtle eggshells are flexible like parchment, rather than being hard like birds eggs.

i) Distance from posterior margin of plastron to midline of cloacal opening (Plas-clo)
ii) Total tail length (TTL)
iii) Distance from tip of tail to posterior margin of the carapace (+/- cara)

Note: Adult males are easily-identifiable by the muscular tail that extends, perhaps 30-40 cm, beyond the carapace's rear margin. In adolescent males the tail has begun to develop, widening proximally and extending distally, but may still only protrude a few centimetres beyond the carapace (White *et al*. 2010). Turtles laying eggs on a beach are obviously adult females; whereas smaller, short-tailed, turtles could be juveniles of either sex.

Adult male sea turtles have an elongated tail

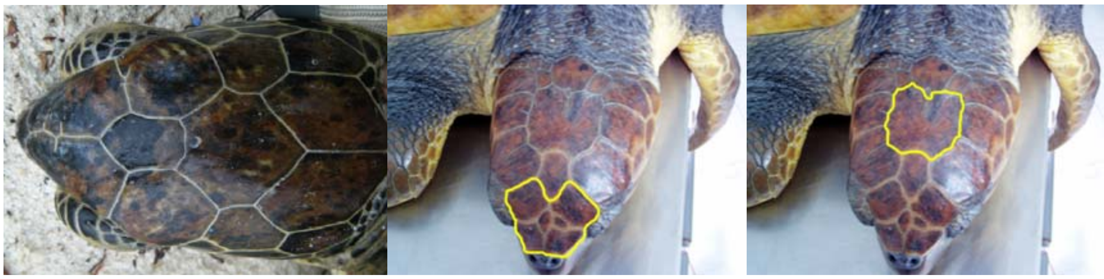
Caudal morphometrics: adult male

Adolescent male: shows tail development

Adult female has short tail (sub-carapace)

5) Photo-recognition

It is possible to positively identify individual turtles by using a combination of their scute and scale patterns; CCL size-class; identifiable sexual characteristics; and existing injuries (e.g. the loss of an eye, amputated limbs, or carapacial damage e.g. strike from a boat's propeller; White 2007; White *et al*. 2011).



Head-scales of *C. mydas* **_C. caretta_ prefrontal scales** **Fronto-parietal scale**

White (2007) utilised the carapace scutes and dorsal head-scales[15] to good effect with loggerheads; other researchers have preferred facial profiles, especially for green turtles (e.g. Bennett *et al*. 2000; Richardson *et al*. 2000; Bennett & Keuper-Bennett 2004; & Schofield *et al*. 2006 for loggerheads), although this means that close-up images have to be obtained.

***C. mydas*. Facial profiles from the same turtle: scale patterns are different on each side**

At present photographs may still have to be sorted and compared visually; consultation with mathematicians (School of Mathematical Sciences, University College Cork) has indicated that scanning hardware and analytical software are as yet incapable of <u>reliable</u> analysis and comparison of these patterns. Recently, however, a computerised programme (MIDAS) has been developed and is undergoing tests in Australia (Ian Bell *pers. com.* 2010); also human facial-recognition software is rapidly improving and is

[15] In mathematical terms such patterns are known as 'complex nets' (White 2007).

undergoing trials in several major airports (e.g. London-Heathrow; White 2007). A pilot study by OBIS-SEAMAP (see below) is using a Web-based prototype photo-ID system; this includes variable search criteria and produces matching images from its different species catalogues (Halpin *et al*. 2009).

Carapace anomalies (see Kamezaki 1989)*:*

The 5th vertebral scute is subdivided

***C. caretta*. 7 costal scutes; left side is normal (5)**

Injuries:

Different carapace markings:

***Chelonia mydas*. Two turtles observed in Papua Passage, Rarotonga (2009)**

6) Tagging

CITP uses conventional metal flipper-tags (Balazs 1999) that were provided by SPREP (Samoa) as part of its regional turtle management programme. Two sizes of tag are used: the smaller are inconel (Kentucky National Band & Tag Company); and the larger are titanium (Stockbrand's Australia). New tag-series numbers are reported to the Archie Carr Centre for Sea Turtle Research (ACCSTR; http://accstr.ufl.edu), Florida; in order to avoid duplication of tag-numbers by different projects. Transfers of SPREP tags between projects in the Pacific are reported via TREDS (see below). Best practice is followed when applying tags in order to avoid injury and subsequent tag-loss; two tags are applied to individual turtles, one on each anterior flipper (L3 position; SPREP). The right-hand tag is reported preferentially by CITP as the 'primary tag' (TREDS database record); although either tag-number may be used. Tag-numbers are also recorded in an Excel worksheet, which is cross-linked to a turtle's morphometric and biographical data.

Small Kentucky tag; larger Stockbrand's tag

Inserting a Stockbrand's titanium tag

7) DNA-sampling

There are very few genetic samples available from sea turtles in the South Pacific islands. A priority in the South Pacific region is to obtain genetic samples from nesting female turtles, especially *Eretmochelys imbricata*; with a lower priority being placed on turtles using neritic foraging-grounds, or oceanic-phase juveniles. Biopsies collected from these latter two groups will be archived and sequenced in due course (Irene Kinan Kelly *pers. com.* 2011).

CITP USES THE FOLLOWING <u>PROTOCOL FOR DNA-SAMPLING</u>:

a) Tag and measure the turtle
b) Wipe target area with a topical antiseptic (e.g. Betadine; alcohol is <u>not</u> to be used)
c) Surgically remove a small section of skin (<1 cm^2) from one of the softer areas using a new scalpel bade and sterile forceps to avoid cross-contamination
d) Place biopsy into a clean plastic vial & label with sample-number[16]
e) Sample is preserved in a suitable medium (e.g. DMSO, 96% ethanol, saturated saline)
f) CITES export/import permits are obtained (Pamela Maru, MMR, Rarotonga)
g) Samples are analysed using standard laboratory protocols at Canberra University, Australia (Dr Nancy Fitzsimmons), or NOAA California (Dr Peter Dutton)
h) Results are reported to ACCSTR (Dr Alan Bolten); and novel haplotypes to GenBank

Axilliary skin (ventral and proximal to fore-flipper) is very soft and easy to biopsy

[16] This is cross-referenced to the animal's flipper tag numbers.

8) Data dissemination

CITP currently provides relevant data to two regional management organisations: TREDS & SWOT; and is investigating a third one: OBIS-SEAMAP (Halpin *et al*. 2009).

i) TREDS (Turtle Research & Monitoring Database, www.sprep.org):

TREDS is a regional database (operated by SPREP at Samoa) that has been developed to be the overarching database system for sea turtle research and monitoring by SPREP member countries (Noumea Convention 1986). TREDS is a joint initiative of the Western Pacific Regional Fishery Management Council; Secretariat of the Pacific Regional Environment Programme; the Secretariat of the Pacific Community; the Queensland Environmental Protection Agency; the US National Marine Fisheries Service-Pacific Islands Fishery Science Centre; and the Marine Research Foundation-Malaysia. Turtle researchers in the Pacific region are encouraged to make use of this programme; which CITP does.

ii) SWOT (State of the World's Sea Turtles; www.seaturtlestatus.org)

SWOT includes a global database for sea turtles, but it has also expanded into providing small grants for three different areas of focus: networking & capacity-building; science; and education & outreach. CITP was awarded a SWOT science grant in 2010 (see below)

Roderic Mast (Editor's Note in SWOT 2011) explains that the SWOT database is housed within Duke University's Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP): and has become the most comprehensive resource of its kind; and is also likely to become the global clearing-house for data concerning sea turtles.

iii) OBIS-SEAMAP (http://seamap.env.duke.edu/swot)

Ocean Biogeographic Information System-Spatial Ecological Analysis of Megavertebrate Populations (Halpin *et al*. 2009). CITP is still investigating the exact linkages between: OBIS, OBIS-SEAMAP, SWOT & TREDS (White *pers. com.* 2012); particularly if data submitted to one organisation is then linked into the other resource-providers? (SWOT data are added to OBIS-SEAMAP; the TREDS database was not known and is now being investigated C. Kot, *pers. com.* 2012).

9) In-water observations

During 2011 incidental turtle observations made from shore, or if snorkelling or paddling, were recorded in an Excel spreadsheet. SCUBA dives were not made as there is no diving air supply available at Tongareva. The following data were noted:

i) Date/time and place of event
ii) Number of animals and species if known
iii) Approximate size (small, medium or large)
iv) Sex if identifiable (e.g. adult male)
v) Presence of tags (N.B. even if tag-numbers cannot be read: which flippers are tagged & tag-type (material, size & colour) are still reportable data)
vi) Obvious injuries
vii) Behaviour (e.g. swimming at surface, underwater, resting, foraging etc.)

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

Underwater codes:

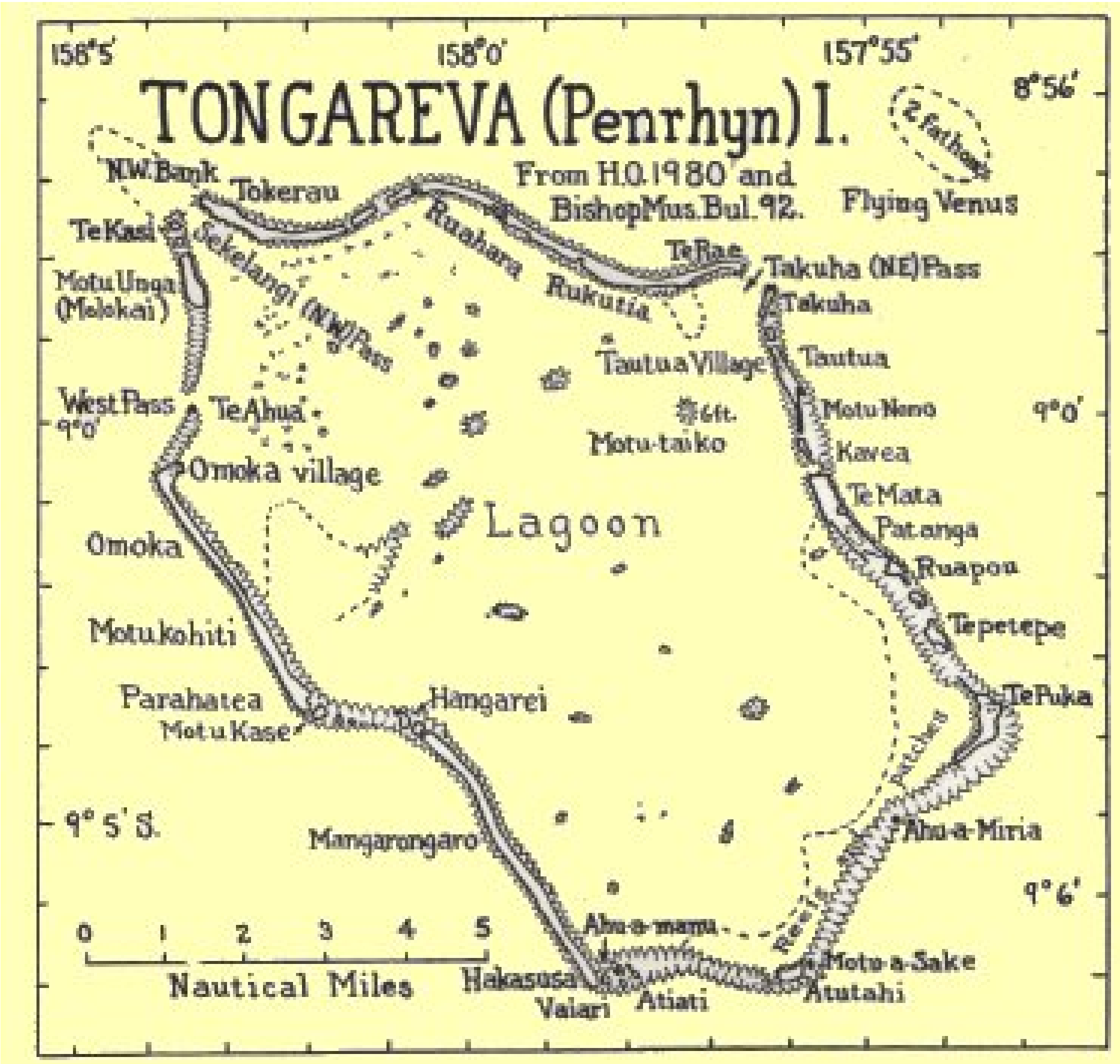
Su Swimming underwater
Ru Resting underwater
Cu Crawling on the sea floor
Fu Foraging – used when turtle was searching for food
Eu Eating – the food item was described if possible

CL Cleaning (cleaner spp were noted; and location e.g. sea-floor or mid-water)

At-surface codes:

Ss Swimming at the surface
Rs Respiration (usually only a single breath is taken; for about 0.5 seconds)
Bs Basking at surface (turtle may appear to be asleep)

Findings from Tongareva Atoll



Map 3. Tongareva Atoll. Map from Bishop Museum (Bul. 92; H.O. 1980)

Mangarongaro

This southwestern motu is by far the most important nesting site on Tongareva Atoll[17]: there were **525 nests** found here during this year-long study. (See Table 1 below).

The eastern shore from the lagoon is low-lying, with sand in many places, but the vegetation often extends down to the water's edge and is generally unsuitable for nesting. Some of these beaches are inter-tidal and would require a long crawl across the corals if turtles sought to access them at low water. Tracks and nests were not observed along the eastern side, but there were two anecdotal reports of tracks at the southeastern end (Karika *pers. com.*; Maretapu *pers. com.*).

[17] An order of magnitude greater than the other motu.

In contrast **the western beaches** (leeward reefs) are high-energy dynamic habitats that are used by nesting green turtles. Beach structure varies from place to place, but was usually steeply-sloping: some sections were fine sand (e.g. *Manoro*); some were *kirikiri* (coral fragments) e.g. near to *Tevete*; other areas consisted of larger coralline rocks or boulders; and some had a semi-exposed underlying coralline pavement; the final type was a rocky inter-tidal zone that would be unsuitable for emergence or nesting. Substratum coarseness seems to be related to the wave energy impacts: finer grains at low energy sites and large boulders at the highest energy sections. GPS was unavailable in 2011, so sections will be properly delineated during future research. Surveys were mostly made along the northern half of this motu for practical reasons: the two-way journey from Moananui (Omoka) by vaka usually took 2-4 hours, depending on the wind direction and sea state; then the nesting survey of 5 km of beach (to a rocky section south of *Te Toto*) and the walk back took about 6-8 hours: this is all that was achievable in a day.

Good nesting areas on the western side of Mangarongaro Motu

Unsuitable sites for nesting; although the vegetation in the top right photo is sometimes used.

Several beach sectors had concentrations of nesting: e.g. 10-15 nests being laid fairly close to one another (within 30 m): these concentrations of adult emergences tended to be in the vicinity of some small passages (*ava*) through the reef; individual tracks were also interspersed along the beach; including at some places with poor access from the ocean. Probably 80% of nesting emergences were over sand, 15% over kirikiri, and 5% across the pavement or rockier sections.

These small passages seem to be very important as sites for emerging females: the substratum appears to be of secondary importance compared with ease of access from the ocean.

More emergences from the passages

Multiple emergences: these will be properly defined using a GPS during future research.

The majority of nests were laid in the vegetation at the back of the beaches; this cover differed from place to place and included coconut groves, sections of pandanus (*hara*); mixed sections that included pandanus and *Ngangie* (a broad-leaved hardwood maybe 3-5 metres tall) – and perhaps a few coconut palms; and, rarely, there was a tamanu tree. Nests were often laid underneath pandanus and coconuts and were then covered over with palm fronds and pandanus leaves; occasionally turtles had gone about 15 metres into the forest before nesting, but more usually nests were laid within 1-5 metres of the beach.

Typical nesting sites for green turtles: many are in the shade apart from in the late-afternoon.

In those sections where the only vegetation was low-lying shrubbery at the back of the beach, nests were usually laid either along its seawards edge, or else the turtles pushed their way into the bushes and then dug the egg-chamber. Occasionally females searched for some time to find a suitable nesting spot, but there were no non-nesting emergences (i.e. a turtle fails to find a suitable nesting site) and only one U-turn[18] (i.e. a turtle crawls onto the beach, but then returns to sea without making any effort to excavate a nest): in other words if females came ashore they appeared to nest satisfactorily. Very few tracks had more than one body-pit (only seven in 2011; it was not always possible to determine this exactly if nests had been laid in the forest). Digging multiple body-pits usually occurs when a female encounters some obstruction, such as a large rock, during the first attempt, but then she moves a short distance away and nests successfully at the second site. Only a very small number of nests were laid mid-beach (possibly 15 during 2011); these can be overwashed during high tides.

[18] The first U-turn was found on 6th January 2012 and it appears that the turtle re-emerged about 30 m south and nested successfully; this was based on the track characteristics.

Nests in the vegetation at the back of the beach.

And still more nests by the vegetation.

Nests laid mid-beach were rare during 2011.

Up-tracks can be quite extensive as the female searches for her nesting spot, down-tracks to the ocean are usually more direct.

Nest success is likely to be high (although not investigated during this preliminary study) and will be properly quantified during the next phase of research here (2012-2015). Egg-shells were found in the vegetation indicating where hatchlings had emerged from nests.

Egg-shells show successful nests.

Age of tracks

It was usually possible to determine the approximate age of adult tracks on the beaches; and some supporting evidence is shown below. Tracks across *kirikiri* required greater observational skills; and obviously imprints were not left on the rocks or pavement.

Very recent and very clear emergence track

Top: track is about 3 weeks old. Below: recent track crosses an older one on the right and another recent one to the left

Top: left-hand track is 2-3 weeks old; the adjacent right-hand one is about 7-8 weeks old; Below: the nearest track is also 6-8 weeks old.

Top: track is probably over two months old; Below: nest is about 6-7 weeks old.

Older track leading into the forest: estimates of track-age can be difficult if wind and rain have eroded the evidence.

Top: up-track and down-track over kirikiri; Below: nest in coarse substratum (notebook A5).

Top: three nests laid close to each other; Below: many tracks in this area.

An important observation from Mangarongaro is that any turtles stranding from the ocean near to high water (HW) would only have a short distance to crawl across the beach before locating a suitable nesting site (see Allen 2007): in some places the upper strand-line touched the bushes, but more usually it was a few metres short of these. It is assumed that the beach slope provides sufficient drainage for the sand at nesting depth; sediment water content was not measured, but some test-holes were dug to nesting depth.


Good quality nesting sand

A second advantage for emergent females would be that access over the reef, especially traversing nearshore ridges, would be much easier close to high tide; and it appears likely that the time needed to lay eggs and return easily to the ocean could be achieved around HW. Anecdotal evidence suggests that turtles nest at New and Full Moons: this would actually coincide with spring tidal-range (i.e. higher HW and lower LW marks); however, Witzell (1983) reported that more (hawksbill) turtles nested at neap tides (i.e. at the Quarter Moons). In either case a 2-week inter-nesting interval is biologically accurate.

At the end (26^{th}) of August 2011 there was a tsunami effect that caused excessively high waves for four days (this was similarly reported from Manihiki Atoll). One unfortunate consequence of these excessive waves is that some beach sections, which did support nesting, have now been stripped of sand; leaving only large coralline rocks or pavement. This is the opposite scenario from that noted in the methodology, but it does provide an opportunity to study beach dynamics: i.e. how long does it take for a nesting-beach to recover from such an impact?

Some sections of nesting beaches have nearshore coral barriers on top of the reef, but these can be submerged at high water.

Top: close to low water; waves indicate the drop-off; Below: close to high water.

Top: strand line can be seen to the right, very near to the bushes where eggs are laid;
Below: tsunami at the end of August 2011 created very high waves for four days.

Nesting females cross these rocky barriers, presumably at high tide; and move round obstacles.

Female came over the rocky foreground area, headed towards a boulder zone, then came back to the left and nested in the shrubbery at the back of the beach.

Turtle emerged through a small gap in the coral barrier

Turtle species

Green turtles *Chelonia mydas* were seen regularly in the lagoon; all encounters were with individual animals; there was no evidence for group activity. During 2011 most, if not all, tracks made by nesting females were those of green turtles. Six tracks (4 were found on 3rd January 2011; & 2 more on 6th January 2012) may have been made by hawksbill turtles *Eretmochelys imbricata* as the patterns suggested asymmetrical locomotion, rather than the simultaneous shifting of both fore-flippers favoured by *C. mydas*. It is possible that some individual green turtles do use asymmetric movements on land. Only one hawksbill turtle has been seen (13th August 2011) during this year-long study; the turtle was an adult-sized female foraging in the lagoon east of the airport; and so nesting by this rare species could still occur. A small juvenile hawksbill was caught by some children playing near to *Motu Kasi* (5th January 2012) and retained for a few minutes before being released again (A. Maretapu *pers. com.* 2012).

The two left-hand pictures show the symmetrical movement normally associated with green turtles (& leatherbacks): as they move both fore-flippers simultaneously. In contrast the right-hand images suggest that the more-usual asymmetrical reptilian gait, where diagonally-opposite limbs are moved together, might have been used; this form of terrestrial locomotion is used by the five other sea turtle species, of which the hawksbill seems most likely at Tongareva.

Top: left: juvenile hawksbill; right: adolescent loggerhead (for reference only); Below: juvenile green. The head shapes and scale patterns are completely different.

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Surveys of other motu at Tongareva showed that they are much less important as nesting sites; not all islets have been properly surveyed yet, as a boat was unavailable.

Moananui

The western (leeward) shore was subdivided into three sectors:

1) Northernmost sector: this is adjacent to Omoka village and consequently people are often on the beach (fishing on the reef, collecting marine gastropods, feeding their pigs, which are usually housed nearby; and making charcoal in the sand). The northernmost part (*Motu Ngangie*) is rocky and mostly dry; the, often-exposed, reef linking *Seniseni* motu is also very rocky and unsuitable for nesting. Some areas in this sector are covered with large boulders, but a few sections have good quality sand that might be of sufficient depth to support egg-development. Vegetation was mostly coconuts and a few small areas with natural forest (e.g. tamanu, pandanus, ngangie etc.). No tracks or nests were found in this sector.

Moananui: sector 1 before and after the tsunami

2) Central sector: the northern limit was a boulder-covered zone (about 80 m long) that adjoins sector 1. Sector 2 extends southwards as far as the airport, and mostly comprises sandy beaches. There are several buildings, but these are mostly clustered together and include: Telecom's satellite-dish, the power-station, the hospital, and Marine Resources Centre; there are some houses, but far fewer than at Omoka village. Several areas have good quality nesting sand and reasonable access over the reef, but in some places a raised coral ridge (1-2 m high) is present that runs parallel to the shore, and is exposed at low water. Vegetation is more mixed with areas of coconut, pandanus and some flowering shrubs; considerable amounts of garbage were found in the forest. No tracks or nests were seen in this sector; which seems curious given that the sand appears to be suitable for nesting and access from the ocean is good in many places.

Tins and lead-acid batteries dumped in the forest adjacent to sector 2

3) Southernmost sector: this section starts by a small constructed wall adjacent to the airport's Radar buildings, and continues southwards to the end of the motu. There is only one other building; which is a half-built shack in the forest near the southern end. Sand and gravel extraction occurs very occasionally; a bulldozer drives onto the beach through the forest at two places by the airport. The vegetation is much more variable, with some sections of coconut, others with just pandanus, and still others with low, flowering bushes: all of the nests observed on Moananui were laid in this sector, and mostly in the southernmost kilometre. Only two tracks had two body-pits. This beach was surveyed frequently as no boat was necessary.

<u>Nesting by ***C. mydas*** seems to occur between December and May</u>: only **26 nests were found** – the last three being laid in May 2011; they hatched successfully in late-July: unfortunately this fell between two surveys, so no hatchlings were seen. There were no tracks that suggested the presence of *E. imbricata*.

Moananui sector 3: Left: tractor access from runway; Right: good nesting area

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Matunga-Tekasi

Much of the shoreline consists of hard, sharp, coral with some areas being inter-tidal (e.g. between Matunga and Tekasi); there are a few sandy areas on the western side (leeward reef) leading into the forest; nesting may occur here in some years. The only evidence seen was two disturbed areas of sand that might possibly have been tracks, but these were several months old and very indistinct. On the eastern side (lagoon) the trees mostly come right to the water's edge and nesting there is unlikely. A couple of areas on the southern coast were sandy and accessible from the lagoon, but they were narrow, water-logged, heavily-covered with fallen vegetation, and poorly-suited for nesting. Most sites on these motu are Type C, but with a few Type B areas; so nesting is possible but unlikely to be substantial.

Ian Karika (*pers. com.* October 2011) reported seeing tracks on the reef-side of *Molokai*[*] during his bird surveys (late-September 2011, nests not quantified; & **three** more **nests** in mid-October 2011). Species were not identified.

Note: Matunga is sometimes called *'Motu Unga'*.

* This name does not occur on most maps, but refers to the southern section of Matunga (Bishop map).

Tongareva western reef: Taruia boat passage looking north to Matunga (‘*Motu Unga*’).

Note: The author’s vaka was frequently rammed with great force by sharks, especially in those sea areas to the north of *Taruia Passage*. During the initial survey of Matunga nine such incidents occurred during a six-hour period: most of the attacks (n = 7) were made by black-tip reef sharks (*Carcharhinus melanopterus*), but the species was not determined in two other strikes.

Pokerekere-Tuirai-Veseru-Takuua

Tetautua village is mainly situated in the northwestern area of Pokerekere (it is sparsely-populated: seven main households comprising 40-45 people). The eastern shorelines (windward reef) of these motu have the reef drop-off close to shore (15-20 metres away), hard and jagged inter-tidal zones, and then steeply-sloping shorelines composed of medium-sized coral boulders; the densely-packed vegetation adjoins the narrow boulder-zone and there are very few places giving access into the forest. As with the Matunga complex (see above) there are occasional patches of sand that could support nesting in some years; and also some sections of kirikiri.

Typical eastern shore of Tongareva Atoll: the windward reef is close to shore.

The inter-tidal zone between each motu is hard substratum; even at high water this is very shallow and would be difficult for a turtle to swim over.

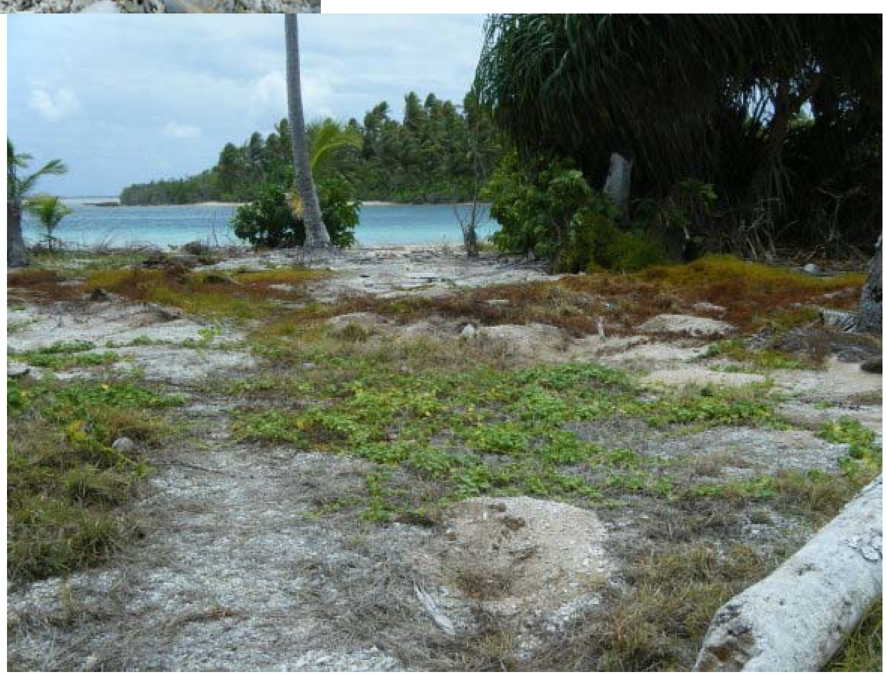
Typical inter-tidal zone between motu on eastern side of Tongareva Atoll.

The best area for nesting would have been at a large sandy area on the eastern side of Pokerekere, where a small semi-enclosed lagoon exists (08°57.52 S; 157°55.40 W). However, because of easy vehicular-access, it is used extensively for sand-extraction in order to meet the island's building needs.

Tractor tracks not turtle tracks! Sand extraction on Pokerekere.

Pokerekere's second potential nesting area would be the southernmost beach (08°58.30 S; 157°55.35 W) by the narrow channel across to Kavea motu. Unfortunately this is heavily polluted with anthropogenic waste, particularly disposable nappies (diapers); which led to the author writing to the PM's Office advising an environmental review of waste disposal arrangements in the Outer Islands (White *pers. com.* 2011). The lagoon-side beaches (leeward) are very narrow and water-logged; thus poorly suited for egg-development; also the road is close to these beaches and there is some sand-extraction. This part of the lagoon consists of a sandy substratum with very little marine vegetation and only a few coral bommies; so not an ideal foraging or resting habitat for turtles. Therefore, nesting on these eastern motu would occasionally be possible, but is unlikely to be substantial.

Southern end of Pokerekere: Top: disposable nappies all along foreshore; Below: this is a view of the other potential nesting beach; across the narrow channel is Kavea.



Lagoon side of Pokerekere – south of Tetautua: photograph was taken from the road; this is at low water, sand-extraction occurs here; generally unsuitable for nesting, even though the sand quality is good. Below: direct-drop 'dunny'.

Tokerau-Painko-Ruahara

***Siki Rangi* Passage. Northwest of Tongareva looking to southeast (diagonal distance is about 21 km). From the passage the motu along the left foreground are: *Tokerau, Painko* and *Ruahara*. To the right: *Tekasi* and *Matunga* [Photo: Ewan Smith, Air Rarotonga].**

The ocean by these northern motu is very deep (1000-2500 m) and their reefward sides are unsuitable for nesting (Type C; rocky and dense vegetation). Occasional nesting has been observed in the past along their lagoonal beaches (Tini Ford *pers. com.* 2012), but no nesting activity was found in the present study (White & Karika *pers. com.* 2011).

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Temata-Patanga-Tepuka

A similar situation to Pokerekere above, the eastern coastlines (windward reef) of these motu have the reef drop-off close to shore (often 15-20 metres away), hard and jagged inter-tidal zones, some sections of kirikiri and steeply-sloping shorelines composed of medium-sized coral boulders. The adjacent ocean is about 1500 m deep; prevailing winds and seas are either northeasterly or southeasterly. This complex consists of several motu rather than a single islet and vegetation cover is sparser than at most other sites; there are also large, low-lying, inter-tidal areas and a number of saltwater ponds. Nesting was not observed, but has occurred historically: with emergences only along the lagoon side (Tini Ford *pers. com.* 2012); the absence of nests on Pokerekere to its north is probably due to it being inhabited, because the lagoon habitats are broadly similar to those at Patanga.

Top: Windward reef – intertidal zone; Below: left: no nesting area under vegetation; right: no sand depth & submerged at high water.

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Ahu-A-Miria, Atutahi, Moturakina, Atiati & Vaiere

These have not yet been surveyed due to a lack of transport. Atiati is believed to support occasional nesting (Tini Ford *pers. com.* 2012); but it is also likely to have submerged intertidal zones (see pictures below under Manihiki – Atimoono).

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RESEARCH SUMMARY FOR TONGAREVA ATOLL:

There were 28 main surveys conducted; and also various other observations were made to assess sand-quality, tidal-heights and ease-of-access over the reefs and nearshore barriers. There were also general investigations of beaches & reefs; casual swimming and walks; rubbish assessments; and dedicated photo-shoots. Incidental encounters with turtles at sea and any anecdotal reports were also noted.

Not all sites have been assessed: the lagoon is a considerable size, and the southeastern corner, in particular, is quite remote. The author did not have a motor-boat, and fuel was generally in short supply for approximately eight months (in two periods); so there was little boat traffic. Initially the author used a vaka, but this sustained damage following shark attacks and sank (5th March); it was not repaired until early-August; consequently Mangarongaro was unsurveyed during that period. The beaches of Moananui were still walked regularly, but no tracks were found after May 2011. The author was at Manihiki in early-September (see below). Ian Karika provided some data on turtle tracks observed during his bird-nesting surveys; these included three nests on Matunga Motu (Table 1).

NESTING SUMMARY FOR TONGAREVA ATOLL:

Table 1. Tracks of emergent females that led to nests are reported for three motu. Most emergences were *C. mydas*; however, six tracks***** may have been made by *E. imbricata*; this is unconfirmed and so perhaps all nests were laid by green turtles. The three nests at Matunga were reported by Ian Karika during a bird survey; the species was not confirmed.

Motu	Green	Hawksbill	Unidentified	Total
Mangarongaro	519	6*	0	525
Moananui	26	0	0	26
Matunga	0	0	3	3
Grand total	**545**	**6***	**3**	**554**

Mangarongaro Motu

This is by far the most important turtle nesting site at Tongareva Atoll (Table 1). Tracks were examined for signs of nesting activity and there were at least 525 nests laid in the northernmost five kilometres of beach throughout the year (the southerly beaches: *Aka Susanui* and *Takuroro* were not surveyed, nor were *Vaiere* and *Atiati* motu; but these are all likely to support nesting). Six tracks may possibly have been made by *Eretmochelys imbricata* as the patterns suggested asymmetrical locomotion; this is unconfirmed as the adults were not seen, and so perhaps all nests were laid by green turtles. There were no non-nesting emergences and only one U-turn (this is not included in Table 1).

The initial survey (3rd January 2011) found 91 nests, as well as some egg-shells in the vegetation (some of these looked to have been on the surface for about five weeks; which suggests a nest-date of October 2010 (based on 60-day incubation). The next survey was five weeks later (5th March 2011) and noted 106 new nests: the oldest 16 tracks were not included to avoid possible duplication of data from 3rd January 2011 (i.e. there were 122 track-pairs identified).

The next survey was conducted several months later (13th August 2011) and found 55 more nests. The absence of a survey in June means that the least clear period was mid-March to late-April. In August there were signs that turtles had been captured or killed (confused turtle tracks, human footprints and signs of scuffles) and there was also one nest that had been dug up and the eggs removed (this was definitely done by a human and not animal predation). It is likely that some nests laid during the winter would have been lost in the tsunami at the end of August (four days with very high waves); there was also considerable rain during October and November. Ian Karika (*pers. com.* 28/09/2011) reported five more nests.

The most interesting survey was on the **16th December 2011** - based on the age of tracks: 165 nests have been laid since the start of November. This means that there are at least 55 female turtles laying just on the northwestern half of Mangarongaro (i.e. if each turtle had laid three nests during the six-week period: n = 165)[20]; there is a good possibility that there are more reproductive females than this; so future research will focus on a nesting assessment (see below for index beach research plans).

The final survey was made on 6th January 2012. There were 50 new nests and also the first U-turn track was noted: the turtle had crawled about 15 metres up the beach and then reversed direction and returned to the ocean (no digging had been attempted). The track pattern was very similar to a second track about 30 m south, and so the same female may have re-emerged and nested successfully.

If hawksbills are actually nesting at this site then December seems to be the important month (4 tracks being found in early-January 2011; 2 more in January 2012). A better understanding of the nesting species will be gained during future research.

Moananui Motu

There were 26 *C. mydas* nests found in the southernmost kilometre of sector 3; nothing elsewhere. The motu was walked regularly and nesting occurs at least between December and May: no further nests or tracks were found after 28th May 2011. It is unclear why this site has such a low abundance of nests compared with the northern part of Mangarongaro; these sites are approximately 4 km apart by sea. Sand quality and ease of emergence from the ocean appear similar at both sites. The leeward reef underwater habitats have not been examined and perhaps these will provide important clues; future research will include SCUBA-diving on these reefs.

[20] The inter-nesting period for marine turtles is typically around two weeks between successive nests.

Matunga Motu

Three nests (possibly five) were reported from Matunga (*'Molokai'*) in October (Karika *pers. com.* 2012); the species was not identified.

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Table 2. Estimated dates-of lay. Track-age, egg-shells and assumed incubation period were used to show when nests may have been laid. The first survey was 03/01/2011 & the final one 06/01/2012; surveys were limited in the middle part of 2011 (due to a lack of transport). March 2011 is data-deficient (DD).

Estimated number of nests

Month	**2010**	**2011**	**2012**	**Total**
January	x	8	15	23
February	x	107		107
March	x	DD		DD
April	x	1		1
May	x	40		40
June	x	32		32
July	x	18		18
August	x	5		5
September	x	5		5
October	17	6		23
November	18	100		118
December	85	97		182
Totals	**120**	**419**	**15**	**554**

Based on the available evidence (tracks, nests and egg-shells) and using an assumed incubation period of 60 days it seems likely (Table 2) that **nesting may occur all year-round, but probably not at all sites.** (March was data-deficient, but green turtles were still observed in the lagoon at that time (see Annexe 1); the author was at Manihiki in September). These data represent the findings from just three motu: with **525 nests** in the northern half of Mangarongaro alone (Table 1). Thus it seems that the true level of nesting is likely to be even higher. The author will undertake an ongoing nesting survey for three years (probably starting in October 2012); which will include underwater assessments of the outer reefs and regular surveys of all motu at Tongareva Atoll.

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Incidental observations of turtles in the marine environment

There were 53 incidental observations of *C. mydas* and two of *E. imbricata*. All sightings were of single animals, there were no instances of group behaviour, but occasionally two turtles were within about 30 m of each other; eight sightings were made from a boat, one while snorkelling and the remainder from shore. 44 records were made as the turtles surfaced to breathe (refer to Annexe 1).

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Logistical Problems and Solutions

i) Lack of transportation to Tongareva Atoll: this is a long-known difficulty for the Outer Islands (e. g. Bellwood 1978). This ought to be improved shortly when a new schooner begins service in the Cook Islands (Pacific Schooners Ltd.).
ii) Size of the lagoon and loss of the vaka limited the ease of surveying some remoter areas. A motor-boat & fuel will be included as part of a subsequent research programme.
iii) Lack of communications: email and phone were very limited until November 2011. There is no mobile telephone service, but this is now being planned (possibly in 2012).
iv) The author encountered a software problem with the TREDS database (14/02/2011), rendering it impossible to add, delete or modify research locations and their geographical co-ordinates. Because each step of data entry is sequential, and the study site location is on the first page, no further data could be entered. A detailed description of the fault was reported to SPREP and their administrators estimated this would take several months to resolve. So for almost all of 2011 it has not been possible to enter or upload these records onto TREDS; data have been recorded in field-notebooks and Excel as normal. CITP's database was returned to SPREP in November 2011, as they believe they have now found a solution; we are still awaiting the outcome.

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Threats and impacts:

i) Predation:

Evidence of predation was noted. Some of the islanders do catch and eat turtles, with nesting females being preferentially targeted, although some smaller animals were caught at sea. Egg-take now seems to have largely gone out of fashion (White 2011); although there was one instance noted during this study (Mangarongaro; early-August). On some atolls pigs (*Sus scrofa*?) appear to excavate nests occasionally for the eggs (White & Karika *pers. obs.* 2011); and on Manihiki feral pigs have been known to attack and eat nesting female turtles (Jean-Marie Williams *pers. com.* 2010). Dogs appear to be absent from the northern atolls. Other potential terrestrial predators include rats (*Rattus exulans*; *R. rattus*), crabs, particularly the Butcher Landcrab (*Cardisoma carnifera* "tupa"); and probably some of the seabirds.

ii) Pollution:

The distribution and impact of anthropogenic pollution is a global issue, especially in the marine environment (e.g. Stefatos *et al*. 1999; Derraik 2002; Barnes *et al*. 2009; Gregory 2009; Ryan *et al*. 2009; Thompson *et al*. 2009; White *et al*. 2009). The impact of waste on sea turtles has also been known for some time; particularly for plastics, persistent chemicals, environmental oestrogens and heavy metals (e.g. Fritts 1982; Balazs 1985; Gramentz 1988; Schulman & Lutz 1995; Godley *et al*. 1998, 1999; Tomas *et al*. 2002; Maffucci *et al*. 2005; Witherington & Hirama 2006).

Plastic in the coastal zone is a global problem: fortunately this impact in the Cook Islands is low.

Data are unclear for the extent of this impact in the Cook Islands. The present author raised the issue of persistent or hazardous waste, especially plastics, in the Outer Islands with the Prime Minister's Office and National Environment Service; PICI is now investigating solutions for effective waste disposal from these remote locations (Stephen Lyon *pers. com.*). One further point is that a research yacht – *Sea Dragon* – visited Tongareva in May 2011 and they presented some of their findings from the Northern Cooks, including at Suwarrow (they used a towed fine-mesh plankton-net to sample the seawater surface): the water samples were heavily polluted with plastic fragments (Emily

Penn *pers. com.* 2011). The crew of a Canadian yacht (*Camdeboo* www.camdeboo.ca) found widespread plastic waste on Suwarrow Atoll (and they removed some of it); and also many spirits bottles that probably came from a cruise-liner (the labels were reversed so that they would be readable on an optic; C. Good *pers. com.* 2011).

iii) Fisheries:

Industrialised-fisheries are a known cause of incidental capture, injury and mortality of sea turtles (bycatch). This occurs from both entanglement and the animals eating the bait directly (e.g. Henwood & Stuntz 1987; Skillman & Balazs 1992; Aguilar *et al*. 1995; Hall 1996; Gerosa & Casale 1999; Panou *et al*. 1999; Polovina *et al* 2000; Starbird & Audel 2000; Lewison *et al*. 2004; Casale *et al*. 2005; Moloney 2005; McCarthy *et al*. 2006; NMFS 2010). Long-line fisheries were shown to impact mostly on smaller turtles (e.g. Crouse *et al*. 1987; Laurent *et al*. 1998; Heppell *et al* 2005; White 2007). Cook Islands territorial waters are fished extensively by other countries, which provide an important source of revenue for the nation. However, this also means that endangered species are killed or injured in Cook Islands waters by fisheries of other nationalities[21].

The extent of sea turtle bycatch, and subsequent mortality levels, is unclear for Cook Islands waters, although limited data are collected by MMR (Ministry of Marine Resources) from the offshore-fisheries (P. Maru *pers. com.* 2010). NMFS (2010) reports that the pelagic longline fleet, based at PagoPago, has caused green turtle mortalities in Cook Islands territory; and furthermore they calculated the post-hooking mortality rate to be 92%. The present author interviewed fishing-vessel captains about their sea turtle bycatch and sightings whenever the opportunity arose.

Viking Spirit: long-liner from American Samoa

Two longliners visited Tongareva briefly during 2011, both provided information about their sea turtle bycatch:

[21] US longliners from American Samoa fish in an area spanning: latitude 03° to 32° South; longitude 155° to 180° West: this encompasses the entire Cook Islands EEZ (NMFS 2010).

i) *Viking Spirit:* (04/01/2011) operates out of PagoPago (American Samoa) and has only caught one turtle in the last decade: a juvenile green turtle (CCL 40 cm; 2008). Fishing depth varies, but mostly the sets are deep; down to 600 m.

ii) *Leah Dawn:* (25/08/2011) works mainly in the Southern Cooks. No turtles have been caught and they are rarely seen either (one a year is considered to be a lot); fishes deeper than 150 m.

iii) Discussions were also held with Allen Mills at Aitutaki (fishing@aitutaki.net.ck) and he said that his long-liners working in the South Pacific have not caught sea turtles either.

iv) Climate change:

The actual effects of global climate change on sea turtles are still unfolding (e.g. Hawkes *et al*. 2007, 2009; Chaloupka *et al*. 2008, 2008a), although recent biological trends appear to have been significantly influenced by climate-change phenomena rather than through natural variability (e.g. Lascaratos *et al*. 1999; Parmesan & Yohe 2003; Trenberth *et al*. 2007; NMFS 2010). There are very few studies or data available from the South Pacific Island Nations (NMFS 2010). Several impacts have been identified that include: loss of nesting sites through sea level rise (e.g. Sem & Underhill 1992; Fuentes *et al*. 2009; Webb & Kench 2010); altered ocean chemistry and temperature, which may also cause changes to coral reef and seagrass ecosystems (habitats that are known to be used by sea turtles for resting and foraging); changes in food availability (e.g. Brodeur *et al*. 1999; Attrill *et al*. 2007); temporal changes for egg-laying (Solow *et al*. 2002; Weishampel *et al*. 2004); increased frequency of cyclones (Webster *et al*. 2005; Pike & Stiner 2007); and elevated sand temperatures (e.g. Fuentes *et al*. 2009a): this latter point means that sex ratios of turtle populations may shift towards female-dominance. The process of sex-determination[22] in certain reptiles (e.g. chelonians & crocodilians) is now well understood (e.g. Bull 1980; Mrosovsky 1980, 1988; Yntema & Mrosovsky 1980; Limpus *et al*. 1983; Davenport 1989, 1997; Georges *et al*. 1994; Miller 1997); and some sea turtle nesting populations are already becoming skewed towards producing a majority (60-99%) of female hatchlings (e.g. Chan & Liew 1995; Godfrey *et al*. 1996; Marcovaldi *et al*. 1997; Binckley *et al*. 1998; Godfrey *et al*. 1999; Godley *et al*. 2001; Oz *et al*. 2004; Kaska *et al*. 2006; Zbinden *et al*. 2007; NMFS 2010). In other words a second route to extinction for turtles would be an absence of males; or an absence of females for crocodilians (White 2007).

The thermal regime in developing nests is unknown for the Cook Islands (see below).

[22] The sex of developing embryos is determined by the proportion of time that the eggs spend above or below a 'pivotal temperature' during the middle-third of incubation: for turtles more females are produced at higher nest temperatures, more males at lower temperatures; crocodilians are the reverse.

Incidental captures & mortalities

Two turtles have been tagged (Table 3): both were *Chelonia mydas* juveniles that were captured for food (Table 4); on each occasion the hunters ate a larger one, but allowed the smaller turtle to be measured, tagged and released; thus providing an educational opportunity. DNA samples were not collected as juveniles are not presently a regional priority for genetic characterisation (Irene Kinan-Kelly *pers. com.* 2011).

Table 3. *Chelonia mydas*. Two juvenile green turtles captured for food were tagged and released at Omoka, Tongareva Atoll in 2011.Curved carapace length and width (CCL & CCW) are reported in centimetres. Metal tags (#) were inserted into the anterior flippers.

Record	Date	Time	Site	CCL	CCW	Left #	Right #
TOR001	15/02/2011	21:30	Omoka	53.0	47.5	RI00501	RI00502
TOR002	14/08/2011	09:00	Omoka	51.5	47.0	RI00504	RI00503

Table 4. *Chelonia mydas*. Known instances of turtles captured for food, Tongareva (2011): [a] the smaller turtle was netted and then released (Table 3, TOR001). Mangarongaro is the major nesting beach for Tongareva (see below); so those turtles were females taken during nesting. CCL was estimated as being 48.0 & 65.0 cm for the two juveniles in TOK002***** [The author knows all of the hunters, but this is in confidence for the present].

Record	Date	Time	Site	Capture	No.	Size	Sex
TOK001	14/02/2011	Night	Mangarongaro	Hand	2[a]	Adult	F
TOK002	02/07/2011	Night	Lagoon	Net	2	Juvenile	?*****
TOK003	12/08/2011	Night	Mangarongaro	Hand	1	Adult	F
TOK004	23/08/2011	Night	Lagoon	Net	1	Adult	F

***

One dead green turtle was discovered on the eastern shore of Mangarongaro (6th January 2012): its cause of death was not ascertained. The carapace was split in two along the spine and the internal organs were visible; and three of the flippers were missing; but this could all have occurred post-mortem. The head was still intact.

Chelonia mydas. **Dead turtle found on eastern shore of Mangarongaro (06/01/2012).**

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Findings from some other atolls in the Cook Islands are laid out below:

Palmerston Atoll

Palmerston Atoll (Southern Cook Islands 18°03′S, 163°12′W; NZMS 1986) has one village, which is also called Palmerston. The population is unusual, perhaps unique, in that it derived from an Englishman, William Marsters, and his three Polynesian wives. Resident population is usually less than 50; but there is a larger diaspora spread worldwide. The atoll has seven larger motu & 23 minor ones; the author has only surveyed the main one. For several decades Palmerston has been cited as being the most important sea turtle nesting site in the Cook Islands (see Introduction); prior to CITP's research the last scientific study of turtles in the entire archipelago took place at Palmerston in November 2000 (Centre for Cetacean Research 2000).


Left: Palmerston main street **Right: green turtle nest laid in the bushes**

Results

In mid-December 2010 three nests were apparent on Palmerston (or Home) Island: these were laid in the vegetation at the back of the beach (two on the west side, one in the south); they appeared to be recent, although one may have been laid in late-November. Anecdotal evidence indicated that nesting may have occurred on Cook Islet (perhaps 20 nests since September 2010); but these are unconfirmed (also see White 2011).

Threats and Impacts

Palmerston Islanders do eat sea turtles. The fishery officer (Bill Marsters) is recording known instances of hunting in his Fishery Activity Diary: this included two green turtles taken in December 2010; the present author also heard about a third one. The extent of egg-take is unclear and perhaps may no longer be practiced; eggs were a common food resource in the past (White 2011).

Conclusions for Palmerston Atoll

Anecdotal evidence suggests that green turtle nesting may occur on all the major motu (particularly Bird, Toms, Primrose and Cooks), but this is unquantified. CITP is planning a research expedition to clarify the true extent of nesting on the atoll; this will require funding because the only transportation link is by sea[23]. Assuming this proceeds it will be reported in the 2012 annual report. **[Stop Press: see Rufford Foundation below]**

Palmerston Expedition Aims:

i) assess nesting abundance & distribution; ii) report turtle species & life-stages present; iii) identify inwater habitats; iv) identify threats & impacts; v) community education & training; vi) develop a support network; vii) update Biodiversity assessments.

Cook Islands Turtle Project (Pacific Islands Conservation Initiative) will undertake a field survey at Palmerston Atoll; this is the first research there in more than a decade; and the first major scientific research on sea turtles in the Cook Islands in forty years. All beaches on this remote coral atoll will be surveyed to determine their suitability as turtle nesting sites; focused monitoring will then be undertaken to identify which species are nesting. Any encountered turtles will be measured, photographed, tagged and a small skin biopsy taken for DNA analysis (genetic information is unavailable for this turtle stock). Key nesting sites may be selected as *Index Beaches* that would allow inter-annual population trends to be determined through ongoing monitoring. Any nests that hatch during the expedition can be inventoried to determine % success; or reasons for any non-developed eggs. Inwater surveys will be conducted to ascertain the turtle species and life-stages that are present on the reefs and in the lagoon, and habitat purpose (e.g. foraging, mating, or refuge). Threats and impacts, including the extent of direct-take (meat & eggs) will be quantified. Community education and awareness-raising will be undertaken throughout the fieldwork phase; interested islanders will be trained to undertake nest-monitoring; and we will establish an electronic support network to facilitate and monitor progress. Project staff can lecture in the school and supervise some science activities, working in conjunction with the Principal and the Ministry of Education at Rarotonga; ongoing cyber-education will be achieved through emails and Skype video-conferencing. A sea turtle module is being developed for the curriculum by our project-team and this may be tested at Palmerston Lucky school. An important conservation aim is to help the islanders understand why sea turtles are endangered in much of the world: we will explain our scientific knowledge of their basic life-cycle; the fact that these animals are migratory and use sequential habitats (i.e. they are a shared-resource), which we may not yet know; the problems of being a long-lived animal with delayed maturity; and the importance of adult females & late-stage adolescents to ensure population sustainability. Taking this information into account, as well as the islander's traditional hunting and egg-collection needs, and any traditional management practices: we hope that the Palmerstonians will decide themselves to instigate conservation measures; we will of course advise them in this strategy. Data will be forwarded to the national Biodiversity Assessment Action Plan, along with any legislative recommendations.

Note: Trevor (2009) and Siota (2011) suggest that Palmerston may be a foraging ground for green turtles in the Cook Islands, including some that may nest in French Polynesia: more data are required to establish this and so CITP will investigate this aspect too.

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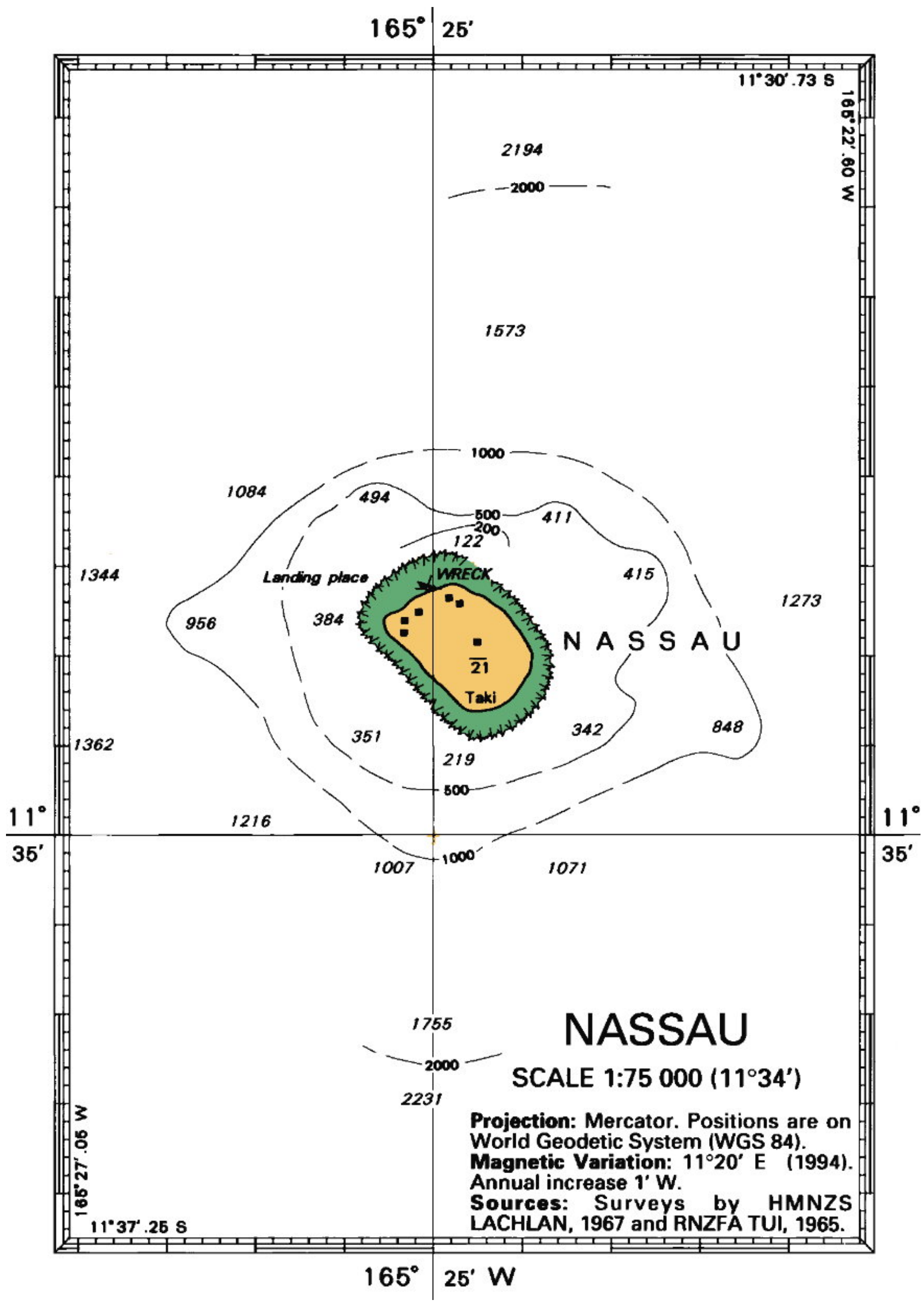
[23] CITP & PICI are negotiating a charter fee with S/Y Southern Cross in Rarotonga.

Nassau Atoll

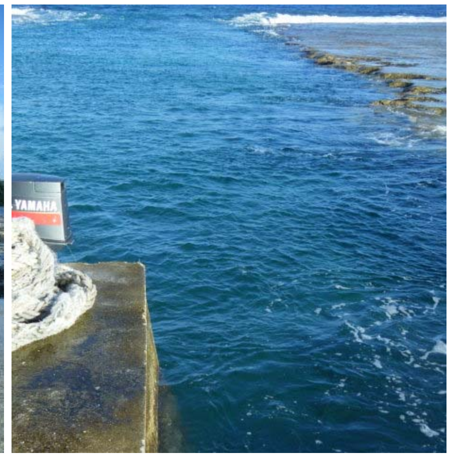
Nassau Atoll (Northern Cook Islands 11°33′S, 165°25′W; NZMS 1986) is very small (1.2 km^2), very remote, and has very infrequent transportation links. During the author's three-week voyage from Rarotonga to Tongareva (December 2010) an opportunity arose for a few hours stop-over on Nassau. The ship - S/V Kwai – anchored-off to unload supplies; so the author went ashore to meet several friends and collect any anecdotal evidence concerning sea turtles.



Map 4. Nassau (chart from NZ945)

Nassau is one of the more remote atolls in the Cook Islands archipelago; the nearest neighbour is Pukapuka; and there is some human population exchange between these two atolls. Nassau does not have a lagoon, but instead the reef joins directly onto the land. A small passage has recently been blasted out of the reef that allows access for small boats; prior to this visitors had to step onto the reef-top and the boats pulled onto the top of the corals. A small mooring jetty has been included during the construction work.

Tractor over the top of the reef at Nassau



Nassau boat passage 2010

Nassau Atoll, Northern Cook Islands, looking East. Photo: Ewan Smith, Air Rarotonga

Results

A rapid assessment survey was made of the entire coastline, searching for turtle nests and tracks: six nests were found. The north and northeastern coastline consists mainly of coral fragments (*kirikiri*) and turtle nesting does occur, especially near to an old shipwreck in the forest (n = 3). Nests are usually laid in, or close to, the vegetation at the back of the beach. The eastern side of the atoll is sandier and nesting occurs both in the vegetation at the back of the beach and in the sand around the mid-beach position (n = 2; one track was very wide, but probably not *Dermochelys coriacea*). The southern side is also sand, but with some kirikiri, and nests are laid here too (n = 1; & possibly an older one). In contrast the western coast is steeply sloping, the beaches are narrow with little sand; no nesting was observed and emergence from the ocean would be difficult.

Nassau: *C. mydas* emergence over *kirikiri*

Coarse nesting medium (scale bar = 1 cm)

***C. mydas*: 3 nests were laid here**

***C. mydas* nest: mid-beach – Nassau Atoll**

Threats and Impacts

It is possible that turtles are still eaten occasionally, however, this is unquantified. Some children were reported to have kept hatchlings as pets for a short time (White 2011). Sand extraction occurs on the eastern beach (& possibly southern) for building needs, but this is not excessive and seems likely to be sustainable; many people live in *kikau* houses (i.e. traditional woven walls and palm leaf roofing); the roads are unpaved and very clean.


Typical house on Nassau


The atoll is always kept really clean

Conclusions for Nassau Atoll

Nesting by *Chelonia mydas* is current, as yet unquantified, and likely to be successful. Nothing is known for the other turtle species. The nesting period also remains unknown.

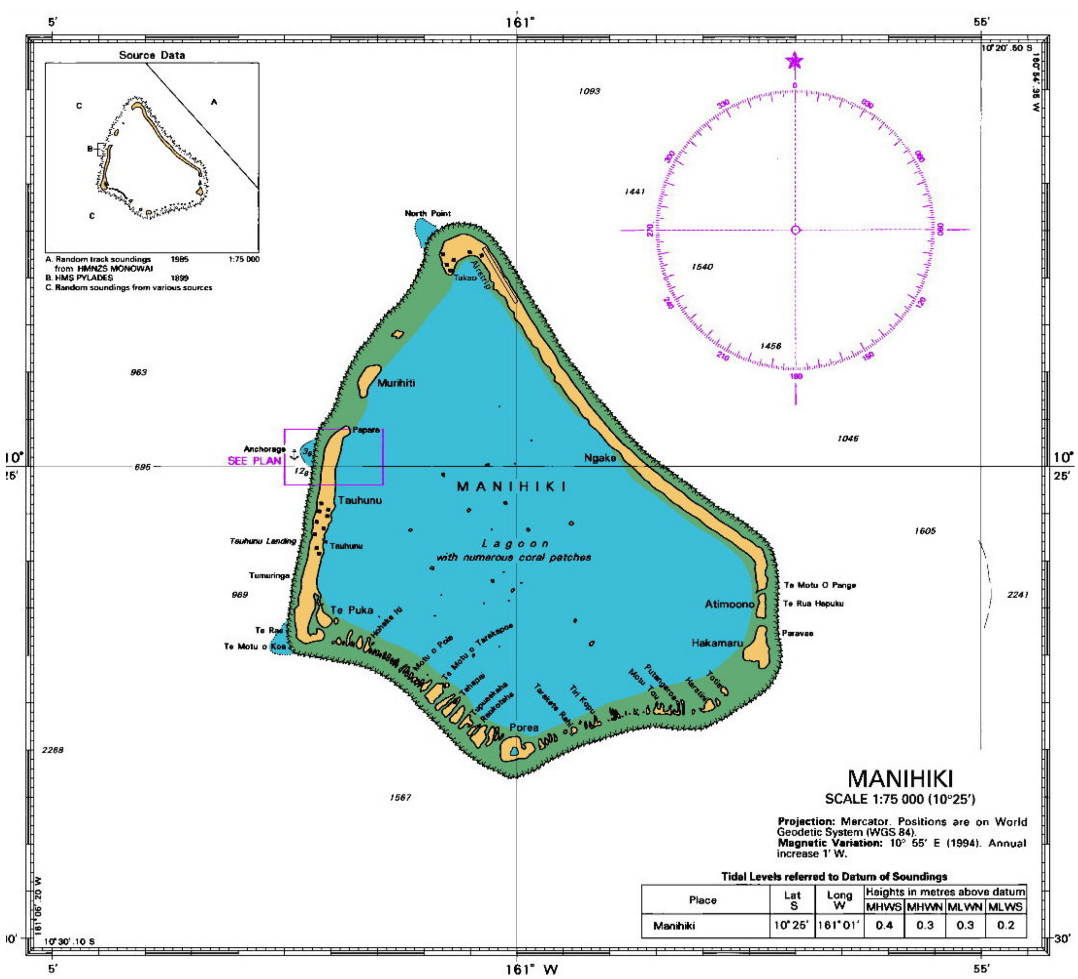
Given the nature of the reef at this atoll it seems most likely that nesting occurs around High Water (HW), because any emerging females would have to crawl a long distance across the top of the reef in order to reach the beach. The author suggests a nesting 'window' of HW ± three hours.


Nassau: almost low water on the northwestern reef

Manihiki Atoll

Manihiki Atoll (10°26′S, 160°W; NZMS 1986) consists of two long and narrow motu (*Tauhunu* and *Ngake*) and about 100 smaller motu; mostly along the southern fringe of the atoll; some motu within the lagoon are used for pearl-farming. There is an airport at *Tukao* village on Ngake; the larger village is *Tauhunu*, on the motu of that name. This atoll is the best-served for transport in the entire Northern Group, because of its black pearl industry. The author visited Tauhunu in late-December 2010 and collected some anecdotal evidence concerning turtles, but it was not possible to survey at that time.

In September 2011 the author went to Manihiki for a fortnight, as part of a Life-skills programme organised by the Ministry of Education (Rarotonga): the first week was spent at Tukao, the second at Tauhunu. When not teaching the author investigated a few motu to determine the likelihood of nesting occurring at those sites. Nothing was found, but an islander said that there had been two green turtle nests on *Atimoono* motu in 2009; and he'd hand-reared about 300 hatchlings for several weeks (Lukan *pers. com.* 2011). The author looked at the approximate locations for those nests and, perhaps unusually, these females would have emerged from the lagoon-side of the motu, rather than the ocean.



Map 5. Manihiki Atoll (chart from NZ945)

Results

Eastern side of atoll:

Ngake: the reefward (eastern) side of this motu is mostly medium-sized coral boulders with a thick barrier of vegetation adjoining it; there were few points of access into the forest. The airport runway is at the northeastern part, running parallel to the ocean (photo below); and much of the excavated earth has been piled into a barrier along the seawards edge. The reef drop-off is close to the shore, perhaps 15-20 m in most places; there are a few deeper pools on the reef-top, but it is mostly very sharp coral with poor access to the shoreline. At a couple of sites, about half-way down the length of the motu, there are some flatter areas bordering the forest; close examination showed that these have a coral substratum and were submerged or overwashed during high water. There obviously had been at least one emergence by a green turtle, as its skull was found among the rocks; although a dead animal could have just been washed ashore by the waves. Apart from the inhabited areas at Tukao (northernmost part of the motu) most of this motu is densely forested, and there was no apparent track through it (access was difficult beyond the southern end of the runway).

Some years ago Ngake was used for gathering copra, and the various sections were open or closed under *rahui*; access was always by boat from the lagoon. The author observed the entire western side during a boat-trip to the southeastern motu: in most places the forest came right to the water's edge and the vegetation was usually dense with no access to the interior; a few very small sandy beaches would be submerged by rising tides, or at least would be too water-logged for egg-development. Therefore nesting will be infrequent on this motu; which is by far the largest on this atoll.

Western side of Ngake: vegetation mostly extends to the waterline; not a good nesting habitat.

Atimoono: this small motu is south of Ngake and joined to it by a small channel and inter-tidal zone; this was the general area where the two *C. mydas* nests in 2009 were laid (Lukan *pers. com.* 2011). The majority of this inter-tidal area is sandy with a few small bushes, and it is open towards the eastern side where the windward reef is situated. On a rising tide this area is mostly submerged; there is a similar situation at the northeastern section of Atimoono itself: the substratum was hard-packed sand or mud with occasional thorny bushes and trees.

Atimoono: inter-tidal zone and thorny vegetation.

There were several pits and excavations (n = 7) under these bushes, which could conceivably have been made by sea turtles, but no tracks were seen and it is unclear if such a habitat could even support egg-development, as it seems likely to be underwater at times. Access over the reef by turtles might be possible in some places, although the coast consists mostly of very sharp rock. The remainder of this motu is densely-forested; there are some small tracks giving access. The lagoon-side beaches on the motu's western and southern shores are sandy, but have forest right to the water's edge; there are a few places where emergences are possible, but these are narrow and water-logged. Nesting may occur in some years. but is unlikely to be substantial.


Atimoono: left: scrapes beneath bushes may possibly have been dug by turtles; right: some inland areas of the motu are submerged at high water.

Below: left: lagoon access at Atimoono & Hakamaru is poor; right: likewise from the windward reef.


Hakamaru: this motu is immediately south of Atimoono and is also densely-forested. There are a couple of sandy areas, but the conclusions are the same as for the previous section. No further motu in the southeastern sector of the atoll were assessed at this time.

***

Western side of atoll:

Tauhunu: the northernmost part of this motu is rocky and inter-tidal and unsuitable for nesting (Type C); there are a few houses and also the island's power-station. Some parts of the reef-side (western) coast could support nesting, but no evidence was found during this survey. The eastern shore is rocky or has constructed walls, wharfs and tiny harbours for the various houses. The school, hospital, cyclone-shelter and Marine Resources centre are also on the eastern shore. The main village extends across the central section of the island and has small roads to both coasts; with the main offshore boat landing-place being on the western side. The main roads have streetlights and electrical power is available 24 hours per day. See below (Threats & impacts) for the southern section of this motu.

Tauhunu: top left: looking north to Murihiti; right: lagoon is on the eastern shore.

Below: left: Tauhunu Landing (S/V Kwai in distance); right: typical house mooring place.

Te Puka: this is a small densely-forested peninsula that originates on the southeastern side of Tauhunu (Map 5) and partially encloses a muddy inter-tidal lagoon; at low water this can be treacherous to walk across (quicksand). Pigs walk round the edge of this lagoon and cross onto the nearest motu.

Top: inter-tidal zones are treacherous at low water; Below: pig tracks on motu

Southern side of atoll:

Rangahoe; Motu o Koteka; Hohake Rahi & Hohake Iti: this group of small motu could support nesting on their eastern shores, but it really depends upon the water content in the sand; at times the beaches were submerged. The motu are forested, often densely, but there are spaces underneath some of the bushes that a turtle could crawl through; it would not be an easy nesting site though. Pig tracks were everywhere on Rangahoe, the nearest motu to Te Puka, but they were absent on the more eastern islets.

Top: typical motu in the south of Manihiki Atoll; Below: bushes right to the sea, but some areas are sandy.

Motu o Poia; Tima; Te Pa; Paheke Iti; Paheke Rahi; Te Motu o Tarakapoe; Motu Roa; Tehapai; Motu Vahine; Tupuaekaha; Raukotaha; Te Ruerue Rahi; Te Ruerue Iti; Punganui Rahi; Punganui Iti: the first five of these are very small motu, but all of them are forested and seem to be important nesting sites for seabirds (White *pers. obs.* 2011). The motu are rocky on the reefward sides and there are often fist-sized boulders.

Top: southern shore by reef; Below: seabird nestling.

The small channels between pairs of motu were usually sandy; the channel north of Motu Roa has a hard substratum and was deeper than most of the others. Generally these motu have some sandy patches, other areas are kirikiri; and usually the vegetation is dense and often reaches close to the water's edge; there is access from the water onto these motu in a few places. At some sites the lagoon flows between the trees and there is no beach at all.

Top: channel between two motu; Below: another channel at low water

Top: no access through vegetation; Below: hard substratum and overwashed beaches.

On the lagoon side there were two sandbars, which were overwashed by waves from the lagoon, that created extended pools and channels (depth 1-2 m); these extended from Tima to Paheke Rahi; and Paheke Rahi to Te Motu o Tarakapoe. Sandbars were exposed at low water.

Top: sandy spit runs off to the right; Below: spit can be seen in middle distance.

Note: the author was attacked by a blacktip reef shark (*Carcharhinus melanopterus*) whilst crossing the sandbar just north of Tima (mid-morning, 10th September 2011). The shark (about 1.20 m long) ignored all attempts to scare it off (splashing, shouting, running towards it) as it seemed determined to make an attack. Unfortunately the author was left with no other choice but to leap out of the water at the last moment and stamp very hard upon the shark's back; it quickly swam away and did not return.

The most likely sites for nesting, and these may vary from year-to-year, are: the southeastern side of Tima; the eastern tips of Paheke Iti and Paheke Rahi; the northeastern part of Te Motu o Tarakapoe; and the northern part of Tehapai. The other motu were not surveyed at this time. There was **no evidence of nesting**, or excavation, or any tracks.

Several motu have areas where nesting may occur; much depends upon the water content in the sand or kirikiri. This may change from year to year.

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Threats and Impacts

It is possible that turtles are eaten occasionally, but the occurrence is likely to be very low: the atoll's inhabitants have thought a lot about their environment; and both of the Island Councils are very active and work well together; *rahui* is implemented as required for the various natural resources (e.g. clams '*pasua*'). The biggest threat for sea turtles is the extensive sand-mining on what is probably the atoll's best potential nesting beach (*Tumuringa*; western side of Tauhunu, southwards from the wharf: 'Tauhunu Landing'): sand and gravel is removed along much of its length in order to meet the atoll's extensive building needs. This particular beach is wide (perhaps 50 m in places), there is an incline so that the sand is well-drained; and access from the reef-side lagoon is good; presumably nesting occurred here in the past. A small road running along the western edge of the forest, parallel to the beach, facilitates sand-extraction; the southernmost section of the beach (*Te Rae*, leading to *Te Motu o Koa*) changes from sand to medium-sized boulders on a steep, rocky slope that is unsuitable for nesting (Type C).

Also at *Te Motu o Koa* and leading around northeasterly to *Te Puka* pigs were observed running in the forest, these may be either feral or escaped domesticated animals; as there are several pig-pens in this area. Pigs were reported to occasionally attack and eat nesting female turtles (Jean-Marie Williams *pers. com.* cited in White 2011). The author observed that pig tracks proceeded across the intertidal zone (a semi-enclosed lagoon) at low water onto the small motu at *Te Puka*; and also on to the two westernmost motu at *Rangahoe*; but the pigs did not seem to venture further east than this (similar observations were noted during a Cook Islands bird survey; Ian Karika *pers. com.* September 2011).

Conclusions for Manihiki Atoll

Sea turtle nesting at Manihiki is unlikely to be substantial: the motus are generally unsuitable for egg-laying or embryonic development. Not all motu were visited, but many of them are very small (between 30-100 m long), with the sides nearest to the reef being very sharp, coralline rock; the vegetation is dense and often down to the waterline, and although there were some sandy areas these were mostly water-logged. As noted earlier, the dynamic nature of coastal habitats would support nesting in some years; and the recommendation for this atoll is to conduct regular surveys on the motu to note the extent and frequency of nesting activity.

The Island Council could decide to implement some level of protection for Tauhunu's southwestern beach; perhaps defining a closed-period for sand-extraction, so that turtles could also utilise the beach: two difficulties with this approach are that at present we have no knowledge of when the egg-laying period is; and that the present beach structure may no longer be suitable for egg-development; although it may be in time. A second option is to select another site for sand extraction.

The Manihiki Islanders, including the Mayor, Island Councils, Churches, Fishery Officers and both school Principals, are keen to become involved with sea turtle research and conservation. Students from both Tauhunu and Tukao schools would participate in CITP's proposed 'Turtle Rangers' programme; and both schools seek enhanced levels of scientific learning that CITP and PICI are willing to provide.

Important note: If nesting is seasonal rather than year-round these surveys may have been too early in the year i.e. before egg-laying had begun. Ian Karika (*pers. com.*) found no evidence of turtle nesting during his bird survey two weeks later either. **So this means that nesting either does not occur or that it starts some time after September.**

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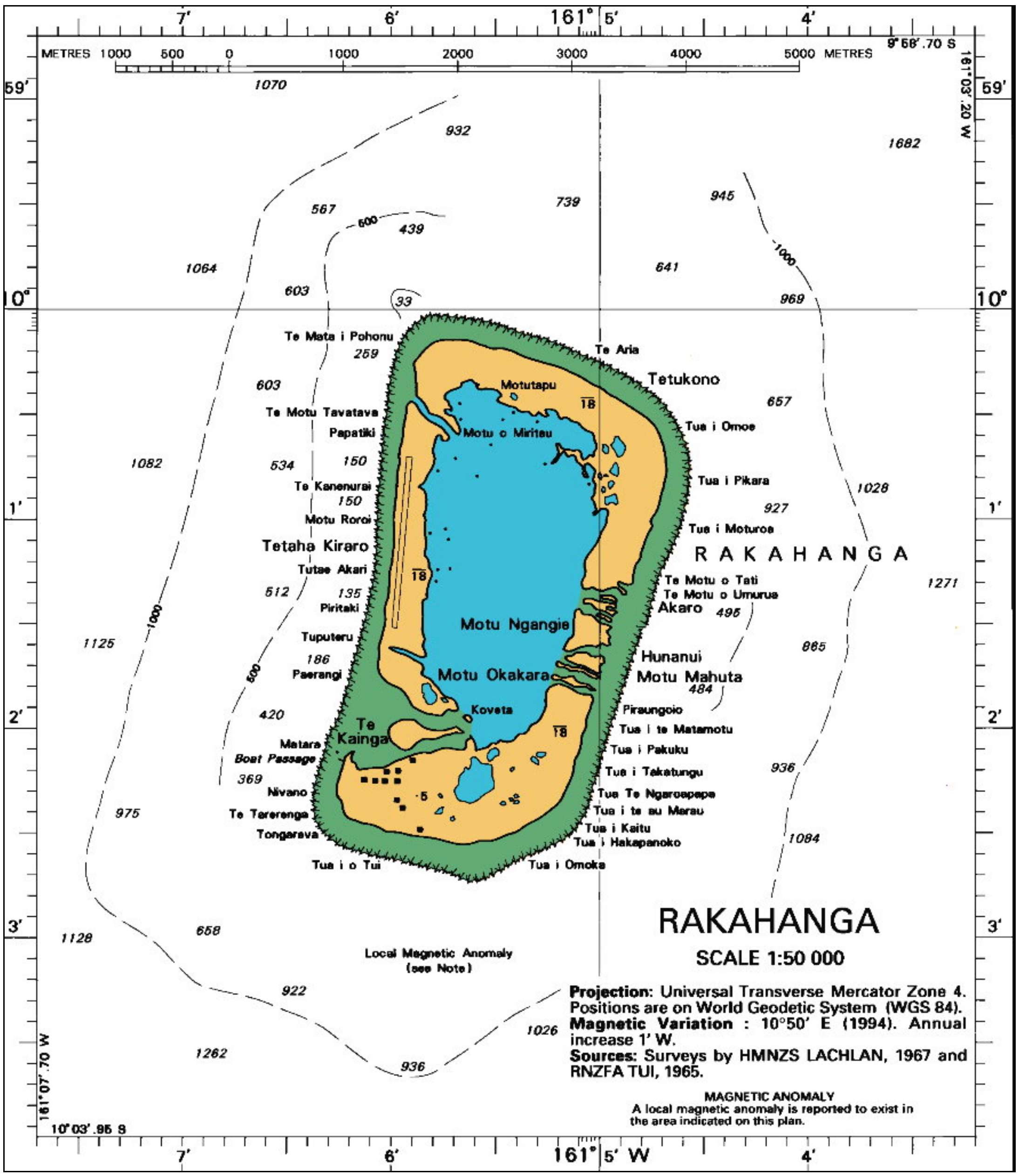
Rakahanga Atoll

Rakahanga Atoll (10°01′S, 161°06′W; Northern Cook Islands; NZMS 1989) has not yet been surveyed, although nesting has been known historically (Balazs 1982); some anecdotal evidence on the presence of turtles was collected in December 2010 (White 2011). There are several motu, but these are very close together; one village, and the atoll has a semi-enclosed lagoon, as well as fringing reefs. As a direct consequence of the author teaching about sea turtles during the Northern Group Lifeskills Programme held at Manihiki in early September (see below under Education), Rakahanga's School Principal (Tuhe Piho) was very keen to become involved in turtle work.



Map 6. Rakahanga Atoll (chart from NZ945)

Some nests at Rakahanga!

Shortly after the Lifeskills event, the Principal (Tuhe Piho *pers. com.* 2011) reported that two nests had been laid on his school's beach (**#1:** Tuesday 27th September; **#2:** Monday 10th October; "this was 25 metres from the first nest…both were laid under *hara* bushes, which were about 1 m high")[24]. Tuhe Piho is very keen for these nests to be successful and so he initially sought advice from Dr White by email. The island's policeman also advised him that as the nests are on school property the Principal can implement any protective measures that he wishes to. The author sent a detailed set of instructions and advised that monitoring the nests could be treated as a scientific project, with student involvement and formal data collection - especially the dates of hatching; this is now happening. PICI staff (Steve Lyon & Jess Cramp) emailed a sea turtle conservation pamphlet and further advice to Rakahanga.

This has now unfolded to become an online (*'cyber-education'*, White *pers. com.*) mode of scientific teaching. PICI (Jess Cramp & Steve Lyon) in collaboration with the Ministry of Education at Rarotonga organised a Skype video-conference with Rakahanga School (www.picionline.org/weblog) that included a Q & A session, as well as providing further scientific and conservation advice; detailed notes have been exchanged by email. The result of these endeavours is that PICI will now develop mainstream curriculum material for the Rarotongan Ministry of Education (sharks, turtles, lagoon monitoring, and the land/sea interface) – to be reported elsewhere, but see below.

Rakahanga's Science Project:

The initial concern was to keep predators (e.g. pigs & land-crabs *'Tupa'*) out of the nests and so large metal drums were placed over the nests: these were replaced with wire-mesh before each nest was due to hatch, accompanied by more-frequent monitoring. The Island Council has given permission for a floating pen to be constructed in the lagoon, so that some of the hatchlings can be reared by hand for about one month prior to releasing them into the ocean; this has apparently happened in the past on Rakahanga (see Lebeau 1985). Information pertaining to feeding (hawksbill) hatchlings at Samoa and their incremental growth was provided by McVey (1972, cited in Balazs 1977); the present author also explained that the hatchlings may not eat for a few days until the egg-sac has been reabsorbed.

A 3rd nest was laid on 21st October (two students counted the eggs: n = 104; see Limpus *et al.* 1979). A fourth emergence occurred on 3rd November, when tracks and some digging activity were discovered, but, as no eggs were found, the author has suggested it be noted as a *non-nesting-emergence* (NNE). The school was advised to maintain vigilance later on just in case eggs had been laid. **A 4th nest** was laid on 8th November, which, being only five days after the NNE, the author suggested may have been made by the same female; this time nesting successfully (it could equally be a different turtle).

[24] [Author's note: New Moon 26th September; Full Moon 11th October].

Tuhe Piho provided the following note for a *Chelonia mydas* hatchling that was hand-fed on strips of fish for one week:

Incremental growth:

25/11/2011: weight = 32.0 g; length (nose-to-tail-tip) = 8.0 cm
02/12/2011: weight = 39.3 g; length (nose-to-tail-tip) = 9.0 cm

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Incubation period

Table 5. ***Chelonia mydas*.** The period between date-of-lay and the first hatchling emergence is given for three of the four nests at Rakahanga; the 4th is still to be reported. Mean incubation = 58 days (SD = 2.7 days, range = 55-60 days; n = 3).

Nest #	Date of lay	First hatchling	Incubation (days)
#1	27/09/2011	21/11/2011	55
#2	10/10/2011	08/12/2011	59
#3	21/10/2011	20/12/2011	60
#4	08/11/2011	tbc	tbc

Three of the four nests at Rakahanga had hatched when the present report was finalised (Table 5). The first nest hatched in 55 days, the 2nd and 3rd took 59 and 60 days respectively (the 4th nest will probably be about 60 days too). The provisional Mean incubation period is 58 days (SD = 2.7 days; range = 55-60 days; n = 3 nests). It is believed that these are the first data reporting the incubation period for the Cook Islands. (White *pers. com.* 2012).

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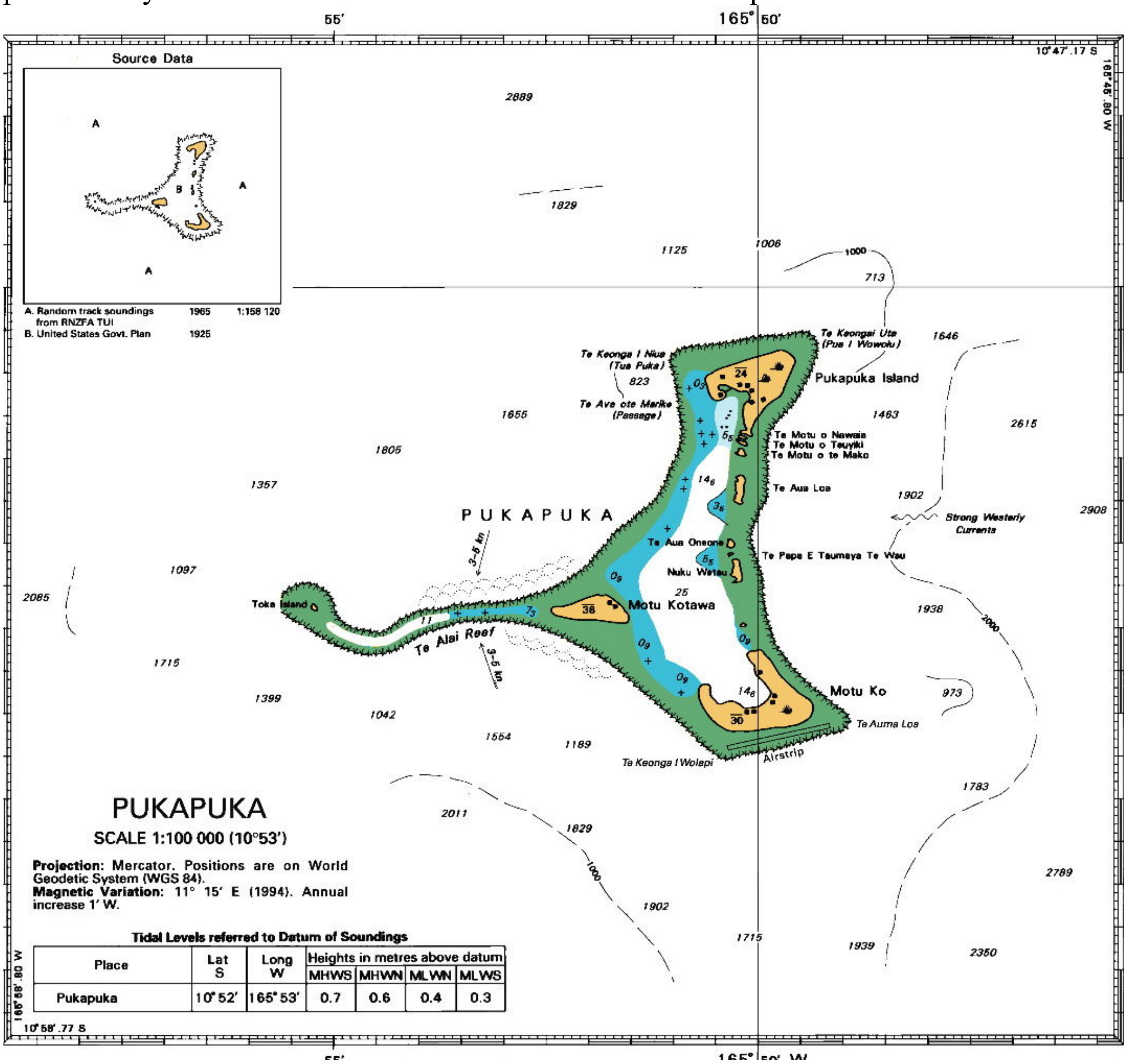
This is a wonderful example of community involvement and it has also triggered a quest by the islanders for knowledge about sea turtles (*'fono'*); which had been largely ignored (e.g. The Rakahangans did not known that turtles are endangered). Several islanders have contributed their traditional knowledge about turtles; the present author will teach a sea turtle course at Rakahanga during 2012, which should also further our understanding by relating ethnozoology to modern science *.

* One of CITP's Aims is to develop an educational module that includes traditional knowledge and practices alongside modern scientific concepts.

Pukapuka Atoll

Pukapuka Atoll (Northern Cook Islands 10°51′S, 165°50′W; NZMS 1986) has three main motu (*Wale, Ko, Kotawa*) and several small ones (e.g. *Toka*). Everyone lives on Wale in three villages: *Yato, Roto* and *Ngake*. This atoll is somewhat different from the other Northern Group islands: its language appears to have a different origin, perhaps Samoan; and it usually has a larger population than the other atolls. Environmental awareness is strong, but controlled by rahui: Motu Ko and Kotawa are usually closed for harvesting, and when the rahui is lifted all three villages collect various natural resources; harvesting by individuals is prohibited. Sea turtles are apparently protected; with a $50 fine per person being levied for eating them (White 2011). Seabirds are a delicacy and usually protected by rahui.[1] A detailed assessment of threats and impacts has not been made.



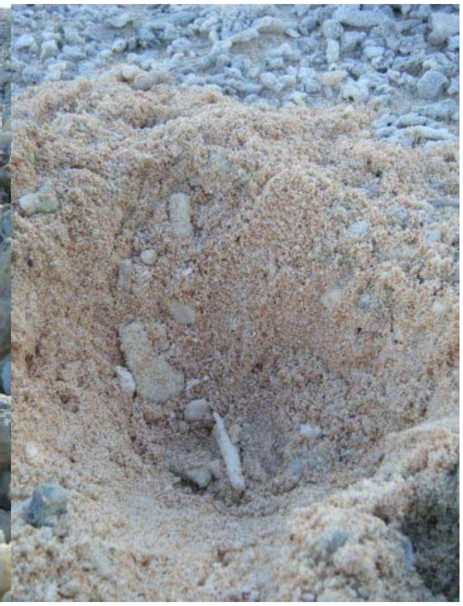
Map 7. Pukapuka Atoll (chart from NZ945)

[1] The seven students from Pukapuka who attended the Lifeskills programme on Manihiki (September 2011) probably ate 450 seabirds during the two weeks at Tukao and Tauhunu; there was no rahui in place for birds at Manihiki (White pers. obs. 2011).

There are numerous beaches on this atoll that are suitable for turtle nesting: with good access from the reefs and lagoon; substrata vary considerably. The inner lagoon between Yato and Roto villages appears eutrophic (White *pers. obs.* 2010). During the next two years (2013-2014) the author expects to undertake a nesting survey at Pukapuka; travel there is possible on commercial freight vessels although transportation is infrequent. The island school is ready to become involved with sea turtle conservation and science activities; many of the children accompanied the author on walks and are interested in learning about *'wonu'*.

Top: green turtles nest on this beach, but not the lower beach: presumably because of access from the lagoon and composition of substrata.

Pukapuka has a lot of sandy areas both on the reef-wards sides and in the lagoons.

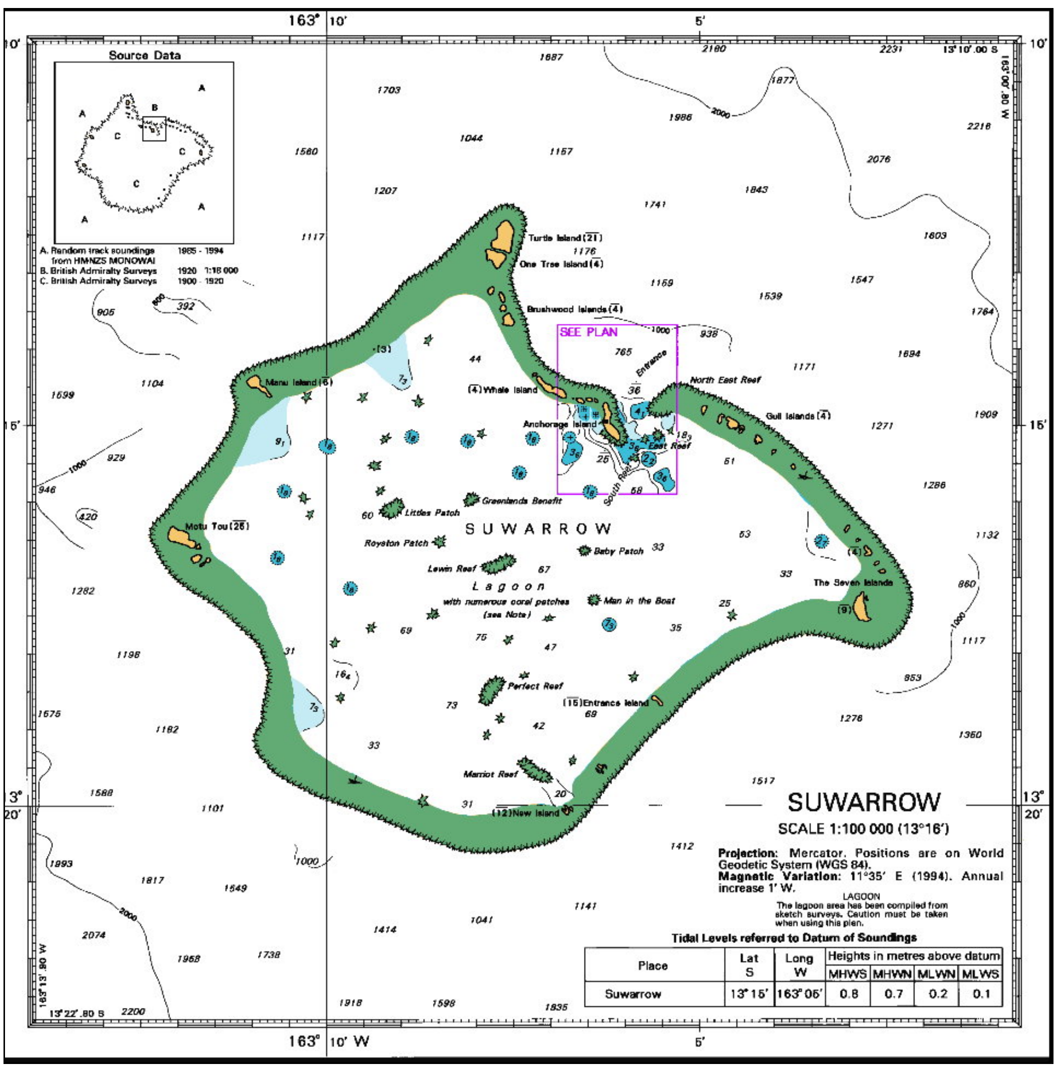


Left: nesting was not found; Right: test hole on a nesting beach

Below: Some 'walking friends' at Roto.

Suwarrow

Suwarrow Atoll[26] (Northern Cook Islands 13°15′S, 163°10′W) was not visited during 2010 or 2011. White (2011) reported that nesting was confirmed from several motu when the warden returned to the atoll in April 2009, after being withdrawn for the cyclone season (John Samuela *pers. com.* 2010). Hawksbill turtles are commonly associated with coral reefs (Meylan 1988) and the author has observed them swimming underwater in Suwarrow lagoon (May 2009). No evidence has been provided for when the nesting season begins, but it may extend until at least April. Threats and impacts have not been assessed. An expedition is being planned and will be undertaken at some point during 2013-2014; this will require substantial funding as the atoll is not on the usual inter-island commercial shipping routes, and a private charter is the best solution.



Map 8. Suwarrow Atoll (chart from NZ945)

[26] Suwarrow Atoll is a National Park (1978) administered by the Prime Minister's Office and the National Environment Service at Rarotonga. A warden is based at Suwarrow for about five months each year.

TWO GENERAL NOTES FOR SEA TURTLES IN THE COOK ISLANDS

Some island-specific names for sea turtles:

Honu: Tongareva and Hawai'i
Fonu: Manihiki
Fono: Rakahanga
Wonu: Pukapuka
'Onu: Rarotonga and Aitutaki

Known dates for green turtle nesting in the Cook Islands:

Possibly late-September 2010 - Palmerston (Bill Marsters *pers. com.*)
Late-September 2011 - Rakahanga - this report (Tuhe Piho *pers. com.*)
October 2011 - Tongareva - this report
November 2000 - Palmerston (Nan Hauser *pers. com.*)
November 2010 - Suwarrow (Paul Green *pers. com.*)
December 2010 - Aitutaki (2 nests on 5th December; Charley Waters *pers. com.*)
December 2010 - Palmerston - this report (3 nests; White *pers. obs.*)
December 2010 - Nassau - this report (6 nests; White *pers. obs.*)
Year-round - Tongareva - (Mangarongaro motu) - this report (White *pers. obs.*)

It seems that nesting by green turtles occurs all year round at Tongareva. This may be due to the fact that human presence on the uninhabited motu is very low; these are visited occasionally for fishing, for collecting coconuts, or for direct-take of turtles and their eggs. In the tropics the temperatures required for successful incubation of eggs are likely to be suitable throughout the year; in temperate parts of the world nesting tends to be seasonal: dependent upon sand and seawater temperatures. Green and hawksbill turtles are the most tropical of the extant sea turtle species; seeking out waters warmer than 25°C for nesting (Marquez 1990); the Cook Islands meet this requirement.

SOUTHERN COOK ISLANDS

Formal sea turtle research was not undertaken in the Southern Group islands during 2011. Links were reinforced with all of the SCUBA-diving operators around Rarotonga (these had all contributed their underwater sightings of turtles to CITP during 2010: see next paragraph). Profile-raising activities were undertaken by PICI: these included the Muri Lagoon Day, and a 'Rubbish Round-Up'; the Initiative also made good progress with educational awareness-raising and environmental advocacy. Fund-raising was also high on PICI's agenda: one new sponsor being the Cook Islands Trading Corporation (CITC).

The most significant finding was that both green and hawksbill turtles have now been confirmed as using Rarotonga's nearshore waters throughout the year (White 2011c); that report is included here (Annexe 4). At Aitutaki there were two confirmed nests laid on the eastern shore (05/12/2010; Charley Waters *pers. com.*).

Because of the difficulties of travelling between the Southern and Northern Cook Islands a second research-team will be trained during 2012 to cover the Southern Group: this will be based initially at Rarotonga. All islands and atolls will be surveyed: objectives include identifying suitable nesting-beaches, and then nesting-assessments; surveys at Takutea and Manuae (this had to be cancelled in 2010 because of Cyclone Pat; White 2011); the inwater study on abundance and distribution of turtle species, provided by dive-groups at Rarotonga will be continued (White 2011c). In concurrence with the Northern Group objectives an important goal is to locate any nesting sites and inwater habitats that are used by *Eretmochelys imbricata*. Both research-teams will use a common methodology and be under the scientific direction of the author; each will have the freedom to develop site-specific programmes (White *pers. com.* 2012).

The present author will concentrate on surveys in the Northern Cook Islands; these will include environmental education and training turtle monitors at each inhabited atoll. This is likely to provide a better understanding of the abundance and distribution of sea turtles, and in a shorter time-frame; because the underlying logistical problem is the lack of inter-island transport throughout the nation; especially between Rarotonga and the Northern Group. As funds allow a series of research expeditions will be undertaken at each atoll: initially a baseline study will be conducted to identify any key nesting sites and inwater habitats; the most important sites will be categorised as 'index beaches'; findings from each subsequent survey will be compared and contrasted with the baseline data to provide an understanding of population trends. These results will allow appropriate management options, if any, to be developed; legislative needs will be passed on to the government.

CITP's Scientific Rationale

Because data concerning sea turtles in the Cook Islands are very scarce the precautionary principle has been adopted based upon our knowledge of sea turtles globally. In other words sea turtles in the Cook Islands are assumed to be endangered, even if there are few current data to support or refute this. As CITP gathers baseline data to show the national status and population trends for the various species our position will be reviewed.

The Cook Islands Turtle Project operates a policy of utilising best practices (e.g. Eckert *et a*l. 1999), and it is guided through professional association with scientific colleagues, including the IUCN Species Survival Commission – Marine Turtle Specialist Group (see Acknowledgements). CITP undertakes all of its research activities following the guidance of endangered species legislation. In cases where national legislation does not yet exist, or does not refer directly to marine turtles, other relevant international legislation is used instead.

Sea Turtle Legislation in the Cook Islands

Maison *et al*. (2010) noted that the Cook Islands Marine Resources Act (1989) provides for the protection and management of fishery resources, the definition of which includes marine turtles; but they found no specific regulations regarding the harvesting of marine turtles; although Pulea (1992) said that there is full protection for marine turtle eggs. The author is seeking clarification for this with the Prime Minister's Office, Ministry of Marine Resources, and the Cook Islands Parliament (Tina Samson *pers. com.* 2011).

The Cook Islands Government decided to formalise the conservation and sustainable use of biodiversity in its National Biodiversity Strategy and Action Plan (NBSAP)[27]. Approved by the Cabinet of the Cook Islands Government; 11th April 2002 [CM (02A) 234].

The Cook Islands is a party to the following international legislation that either provides for the protection, conservation and management of marine turtles; or for the protection of biodiversity:

i) Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar 1971); and amendments Paris 1982; Regina 1987
ii) Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington 1973)[28]
iii) Convention on the Conservation of Nature in the South Pacific (Apia 1976)
iv) Convention on the Conservation of Migratory Species of Wild Animals (Bonn 1979)[29]
v) Convention on the Protection of Natural Resources and Environment in the South Pacific (Noumea 1986)

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[27] Cook Islands Biodiversity (2002).
[28] CITES (1973): lists all sea turtle species in Appendix I.
[29] CMS lists six sea turtle species in Appendix I.

vi) Convention for the Prohibition of Fishing with Long Driftnets in the South Pacific (1989)
vii) Convention on the Conservation of Biological Diversity (Rio de Janeiro 1992)
viii) Rio Declaration on Environment and Development (1992)
ix) Agreement establishing the South Pacific Regional Environment Programme (1993)
x) Barbados Programme of Action on the Sustainable Development of Small Island Developing States - SIDS (Barbados 1994)
xi) United Nations Convention to Combat Desertification (1998)
xii) Protocol on Biosafety (Cartagena 2000)

The Cook Islands is also a party to the following fisheries organisations that have an interest in the problem of sea turtle bycatch:

i) Forum Fisheries Authority
ii) Inter-American Tropical Tuna Commission
iii) Western & Central Pacific Fisheries Commission

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Turtle hunting

At Tongareva, Rakahanga, Manihiki and Palmerston, and probably at other atolls, sea turtles are occasionally killed and eaten, but the true level of direct take remains unclear for the Cook Islands; apart from at Palmerston where the fisheries officer records 'known' take in the Fishery Activity Diary (Bill Marsters *pers. com.* 2010). Commonly it is the adult female turtles that are captured or killed as they nest on the beaches; some hunters allow the female to complete egg-laying before death (White *pers. com.* 2011); a smaller number (unquantified) of turtles are taken at sea.

The killing of adult female sea turtles on nesting beaches is a known cause of extirpation of local nesting populations (e.g. Frazier & Salas 1984; Cornelius & Robinson 1986; Lutcavage *et al*. 1997). Pritchard (2011) states that *"consumption, above all else, has been the main factor in the green turtle's global decline"*. Allen (2007) notes that turtle populations may have disappeared locally on remote islands within one or two centuries subsequent to the arrival of human inhabitants. McCoy (1995) noted, importantly, a decline in the number of females nesting annually in areas where there is increased use of motorised boats; allowing previously difficult-to-access beaches to be targeted more easily.

Limpus *et al* (1993) and Limpus (2009) reported a significant downward trend in the mean size (CCL) of nesting green turtles during long-term-monitoring at Raine Island and Moulter Cay, Australia (1976-2001); this was accompanied by a progressive increase in remigration interval; those authors also note that their findings are consistent with a group in the early stages of decline, as a result of excessive loss of adult females. Harvey *et al*. (2005) also reported a significant decrease in CCLs for nesting green turtles at Coringa-Herald National Nature Reserve (Queensland, Australia), which may be a result of adult turtle mortality, potentially from the Torres Strait/Papua New Guinea region.

The importance of adult female turtles cannot be overstressed (Chaloupka 2004). They have survived long enough to reproduce; achieving maturity may require several decades to complete. They are very fecund animals, and their long life-span means that they may be reproductive for many years; perhaps this could even be a century or more (White *pers. com.* 2011). Yet this is a life-stage that is often targeted for food, being very easy to capture on the beaches (usually the turtles are turned over onto their backs and then killed later).

Discussions with various Pacific Islanders show that they believe it is more important to conserve the smaller size-classes, rather than the larger juveniles and adults; whereas the reverse is true (e.g. Crouse *et al*. 1987; Heppell *et al*. 2003). Even in those Pacific Islands where sea turtle legislation does exist, such as Tonga, this is poorly enforced (Havea & MacKay 2009).

So what should be done to protect sea turtles legally in the Cook Islands?

i) Do nothing. Perhaps sea turtle populations in the Cook Islands are stable or even healthy; however, as we have no population data nationally we cannot say. Furthermore, we have yet to discover how each of the islands regards turtles or their conservation; or the full extent of direct take. This approach seems unlikely to support national obligations as a party to international conventions.

ii) Enact new legislation pertaining to sea turtles and their habitats. Government and Traditional Leaders would have to decide if the Cook Islands should allow direct take of turtles and eggs; and if so to what extent, also how would it be policed (Pritchard 2011)? Of particular importance would be the species and size-classes that may be taken legally. The special problem of fisheries bycatch should also be considered. **Endnote** (**iv**) contains some legislation from other Pacific nations; including some that have traditional hunting rights (Maison *et al*. 2010).

iii) Extend existing protective legislation to explicitly include turtles. This may be the most appropriate option, in which case the most relevant laws should be considered (e.g. Marine Resources Act 1989).

Two Recommendations:

The author recommends that the capture and killing of nesting female turtles on the beaches is prohibited. This is based upon the biological importance of this life-stage. A possible way to implement this nationally would be via regulation (bylaw) on behalf of government; and by the House of Ariki through its traditional channels. It is recognised that law enforcement is exceedingly difficult in remote locations (White 2007); therefore such a measure has to receive common consent in order to become effective; with rahui[30] likely to be the most appropriate form of turtle management in the Outer Islands.

A counter-argument by supporters of traditional hunting might be to set a quota for the annual allowable take of turtles; however, this is also unenforceable (e.g. Fiji: Laveti & Mackay 2009; Seychelles: Jeanne Mortimer *pers. com.* 2010; Pritchard 2011). Whether direct-take is legal or prohibited: both need to be carefully supervised (Pritchard 2011).

A second recommendation is to quantify the level of direct take of turtles nationally, so that we have a clearer understanding of the extent of this impact; this could be achieved by the Fisheries Officers on each island recording kills in their monthly diaries (FADs); which presently may only be happening at Palmerston Atoll (White 2011). Data could also be collected by trained turtle monitors on each island; particularly so as to ensure that any tagged turtles are reported accurately (this happens on Vanuatu: the *Vanu-tai* have been monitoring turtles for about 18 years; Petro *pers. com.*).

[30] It is understood that the aim of rahui is to ensure a regular food supply; nonetheless it is an effective way to achieve resource sustainability, including the continuance of sea turtles.

Traditional management:

A comprehensive review of traditional sea turtle management and use was provided by Woodrom Rudrud (2010). White (2011) mentioned that on Pukapuka infringements of *rahui* might be dealt with by publicly-shaming the offenders, but corroborative evidence was lacking at that time. Further anecdotal evidence was collected from Pukapuka (White *pers. com.* 2011) indicating that when islanders disregard the *rahui* their public status is diminished, for instance, by not being allowed to eat with the other adults, but having to eat with the children at the end of a kaikai (Karika *pers. com.* 2011).

A noticeable difference between the present day and earlier times is that if turtles are eaten now they are just treated as meat, like steak or chicken thrown onto a barbeque (White *pers. com.* 2011), whereas previously there was often an element of reverence or sacredness associated with consuming sea turtles; and perhaps only the tribal leaders, or another particular group partook of the flesh (see Woodrom Rudrud 2010 and references therein).

Traditional Ecological Knowledge (TEK) is now receiving wider attention and is both similar to, and different from Western science (Berkes *et al.* 2000). The most important similarity is that both are based on observations over time; the differences, though, seem numerous, with science focusing on the material, whereas traditions are woven through societies, cultures and religions; however, Agrawal (1995) asked if the dichotomy is real (Berkes *et al.* 2000)?

The author firmly believes that the inclusion of traditional knowledge and management practices (e.g. Johannes 1978, 1989; Gadgil *et al.* 1993; Vierros *et al.* 2010) integrated with modern scientific concepts is likely to provide a realistic conservation approach for the Cook Islands.

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Funding

1) Research grant from SWOT (The State of the World's Turtles)

In September 2010 CITP was awarded a research grant of $1000 by **SWOT** (State of the Worlds Turtles www.seaturtlestatus.org which forms part of Conservation International www.conservation.org): as a contribution towards a scientific research programme based at Tongareva to investigate nesting activity and in-water observations of turtles there (SWOT 2011). Further funds were provided by: Cook Islands Turtle Project; Pacific Islands Conservation Initiative; & Pacific Divers. Very special thanks to: Air Rarotonga; Boatshed Restaurant, Aitutaki; and the owners & crew of S/V Kwai. Thank You All for supporting this emerging Project *Meitaki Ma'ata*.

2) Fund-raising in progress (October 2011)

CITP & PICI have applied for two grants: i) Rufford grant to undertake a month-long survey at Palmerston Atoll; ii) Cook Islands Community Initiative Scheme Development grant for a six-month programme working with young Cook Islanders: to develop and improve their life-skills by first introducing them to scientific studies and then through their active participation in CITP surveys.

3) Rufford Small Grants Foundation

CITP was awarded a Rufford Small Grant for Nature Conservation (RSG): the maximum grant of £6000 was approved by the Rufford Trustees (Grant # 10964-1; 16/12/2011) to support the project: *Assessment of sea turtles at Palmerston Atoll, Southern Cook Islands*. *Meitaki Ma'ata* to the Rufford Foundation.

CITP's Palmerston survey in April 2012 may be followed at http://rufford.org/rsg

4) Two further funding applications are being prepared: i) Global Environment Facility's Small Grants Programme (GEF-SGP): implement a 'Turtle Rangers' training programme in the Northern Group atolls; ii) Marine Turtle Conservation Fund (MTCF) to undertake genetic sampling of nesting sea turtles at remote locations.

Communication

The first annual report (2010) of the Cook Islands Turtle Project was submitted to the Prime Minister's Office; National Research Committee; National Environment Service; & Ministry of Marine Resources in January 2011 (White 2011).

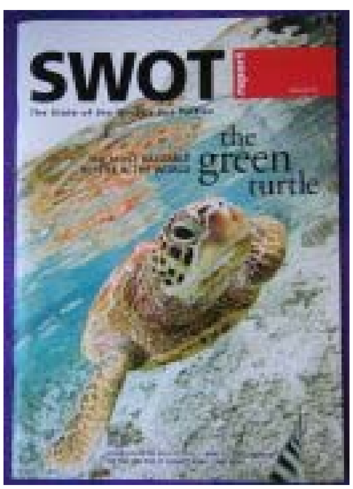
A second report summarising the findings of a year-round underwater assessment of sea turtles in Rarotonga's nearshore waters was also submitted to the same recipients in April 2011 (White 2011c; included here as Annexe 4).

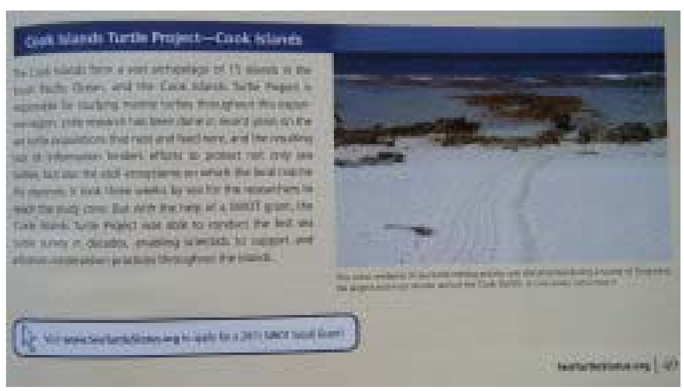
31st International Sea Turtle Symposium at San Diego: the author was due to present a paper at this event (April 2011), but unfortunately this had to be cancelled at short-notice as there was no transport from Tongareva to Rarotonga to connect with the international flight.

An additional meeting at San Diego – **Pacific Islands Regional meeting** – experienced some difficulties[31] but still went ahead: an update on sea turtles in the Cook Islands [**Cyclones, Vaka, and Te Moana: The First Year of the Cook Islands Turtle Project**; White 2011b] was presented on behalf of the author by Karen Frutchey (NOAA Fisheries Service, Hawai'i). *Meitaki Ma'ata*.

SWOT Report (VI)

As a recipient of a SWOT grant CITP has been featured in their 2011 report.




Cook Islands Turtle Project—Cook Islands

[31] (US Federal Government employees went on strike, and the organisers from Hawai'i were not allowed to host or attend their meeting; fortunately some non-federal employees managed the proceedings instead).

Education & Outreach

Sea Turtle Biology

The author taught a 30-hour course at Omoka High School, Tongareva, during June-July 2011 on most aspects of sea turtle biology, ecology, threats & impacts, and conservation possibilities. Iconography and the role of sea turtles in the art, tapa, jewellery, tattoos, and stories and dances of Polynesia were also considered. Students were given a written exam during their end-of-term assessments; the results were extremely high – better than most of their other academic subjects. The sea turtle course promoted a wider interest in other scientific disciplines; but there are no science teachers locally.

Top: Dr White teaching at Omoka; Below: two of the students with their turtle notes

Northern Group Life Skills Programme (Manihiki 1st - 13th September 2011)

The author was invited to be a tutor on this Life Skills Expo and taught a module on sea turtles twice; initially at Tukao and subsequently at Tauhunu: six girls and ten boys participated and included students from Tongareva, Pukapuka and Manihiki. This course has triggered a wider interest in science and marine conservation and will be built upon during the coming years; the idea to develop a 'Turtle Rangers' course also emerged from this event (see Annexe 3 for a short report). This Expo was also an important opportunity to develop networking throughout the Northern Group; and the author has been invited to give lectures at other schools and colleges in the Cook Islands.

Life-skills students from Manihiki and Tongareva planning a turtle poster

Left: modern green turtle; Right: turtle skull from Cretaceous Period ~ little difference!

Welcoming Feast at Tukao, Manihiki: left is Tekemau (Pukapuka Principal), right Dr White

Life-skills students from Tongareva, Pukapuka and Manihiki, September 2011

Curriculum Development

PICI is poised to begin a two-year project (Community Education Programme) working with the Ministry of Education at Rarotonga to design and develop science educational material. This will then be used in the Cook Islands school curriculum: subject areas will include sharks, sea turtles, and land-sea interface (e.g. monitoring lagoon health; and anthropogenic impacts, especially on the coral reefs).

Post-graduate Research

CITP has been approached by a post-graduate researcher (MSc: Marine Environmental Management; York University) who wishes to undertake a 2-month field project in 2012 in support of her course dissertation. Discussions are now underway and it is likely that a suitable study can be arranged; with the author supervising the fieldwork (this may be at Rakahanga, because transportation is easier than for some other atolls). The study will be undertaken in conjunction with CITP's ongoing research, but it also marks an important step towards fulfilling one of the project's educational aims: **to promote tertiary level research, especially in the higher degrees (MSc, PhD).**

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Future sea turtle research and conservation priorities

Witherington (2003) has noted that problems which were identified as being threats or impacts for loggerhead sea turtles also provided conservation opportunities. Mast *et al.* (2006) discussed the important role of the Marine Turtle Specialist Group (IUCN-MTSG) in deciding research and conservation priorities. A new study by Hamann *et al.* (2010) has provided a comprehensive review and listed the most-important global priorities:

1. Reproductive biology
1.1. What are the factors that underpin nest site selection and behaviour of nesting turtles?
1.2. What are the primary sex ratios being produced and how do these vary within or among populations and species?
1.3. What factors are important for sustained hatchling production?
2. Biogeography
2.1. What are the population boundaries and connections that exist among rookeries and foraging grounds?
2.2. What parameters influence the biogeography of sea turtles in the oceanic realm?
2.3. Where are the key foraging habitats?
3. Population ecology
3.1. Can we develop methods to accurately age individual turtles, determine a population's (or species') mean age-at-maturity, and define age-based demography?
3.2. What are the most reliable methods for estimating demographic parameters?
3.3. How can we develop an understanding of sea turtle metapopulation dynamics and conservation biogeography?
3.4. What are the past and present roles of sea turtles in the ecosystem?
3.5. What constitutes a healthy turtle?
4. Threats
4.1. What will be the impacts from climate change on sea turtles and how can these be mitigated?
4.2. What are the major sources of fisheries bycatch and how can these be mitigated in ways that are ecologically, economically and socially practicable?
4.3. How can we evaluate the effects of anthropogenic factors on sea turtle habitats?
4.4. What are the impacts of pollution on sea turtles and their habitats?
4.5. What are the etiology and epidemiology of fibropapillomatosis (FP), and how can this disease be managed?
5. Conservation strategies
5.1. How can we effectively determine the conservation status of sea turtle populations?
5.2. What are the most viable cultural, legal and socioeconomic frameworks for sea turtle conservation?
5.3. Which conservation strategies are working (have worked) and which have failed?
5.4. Under what conditions (ecological, environmental, social and political) can consumptive use of sea turtles be sustained?

The First "Index Beach"

The western side of Mangarongaro motu (midpoint: 09° 03.00 S; 157° 59.40 W) has been selected as the first index beach in the Cook Islands for ongoing monitoring of nesting sea turtles. The principal reasons are that this motu supports substantial nesting[32] and, importantly, this may be year-round; also, it is uninhabited and visited fairly infrequently to harvest resources. However, some nesting turtles are known to have been killed there for food in 2011. Initially the entire ocean-side beach (about 8 km) will be included, but, once regular monitoring is underway, this can probably be reduced to five or six core-nesting areas: where the majority of eggs are laid (Margaritoulis & Rees 2001). Research will include flipper-tagging & DNA-sampling of nesting females; and assessments of nest success (%). [Several of the global priorities in Hamann *et al.* (2010) will be addressed]

Detailed knowledge will be gathered to show the:
i) Nesting species
ii) Nesting period & in particular the peak-nesting season
iii) Number of clutches laid per year by an individual turtle
iv) Internesting interval of individual turtles
v) Time of emergence relative to high water, also tidal state (springs & neaps)
vi) Key nesting areas, especially those adjacent to passages in the reefs
vii) Frequency of reproductive migrations (interval between nesting years for individuals)
viii) Incubation duration & likely sex-ratios of hatchlings
ix) Number of eggs per clutch (mean & range)
x) Success rate (%) for nests
xi) Mean CCL and size-range for nesting females
xii) Health assessment and obvious injuries
xiii) Nesting trends, including any discernible effect from El Niño/La Niña
xiv) Previously-tagged turtles and their origin
xv) Evidence of predation including direct-take; or egg-collection

Experimental work will include:
i) Determining the incubation temperatures for some nests (miniature data-loggers)
ii) Genetic analysis to determine the haplotypes of adult females
iii) Photo-recognition studies
iv) Satellite telemetry of selected females, subject to funding

Educational aspects will include:
i) A training programme for research assistants
ii) Teaching environmental monitoring skills to interested islanders
iii) Developing the concept of sustainable resource-use
iv) Curriculum development for marine sciences
v) Training teachers to deliver environmental education modules
vi) Possible research opportunities for post-graduate researchers
vii) Awareness-raising for special-interest groups (e.g. Judiciary)

[32] The number of turtle nests was an order of magnitude greater than other Tongarevan sites visited in 2011

However, it is not enough just to monitor nesting beaches for a long period of time, because nesting habitats are unlikely to reflect current changes in the entire population (Crouse *et al*. 1987; Bolten *et al*. 1993; Bowen *et al*. 1993; Grant *et al*. 1997; Chaloupka 2003, 2004; Polovina *et al*. 2000, 2004; Seminoff 2004; Carreras *et al*. 2006; Mansfield & Musick 2006; NMFS &USFWS 2007a, 2007b; Chaloupka *et al*. 2008; Limpus 2009; NMFS 2010); not least because the slow-growth and delayed-maturity inherent in these species means that populations may already be in decline by the time changes become apparent from nesting females: e.g. smaller and fewer females nesting, longer intervals between nesting migrations, reduced egg-success, and lower fecundity (Heppell *et al*. 2003; Harvey *et al*. 2005; Limpus 2009; Wallace *et al*. 2010).

The aim of CITP is to gather comprehensive long-term data on the status, distribution, population structure and trends for sea turtles nationally: by using a combination of beach-monitoring & inwater studies, genetic-sampling, mark-recapture studies, telemetric studies, gathering anecdotal evidence, and an assessment of potential threats and impacts: and then contribute these regionally and to the global sea turtle scientific community.

An important finding would be the inter-annual variability in nesting abundance, which is affected by the behaviour and migratory-patterns of individual turtles: most turtles do not nest every year and some may migrate thousands of kilometres between their foraging and nesting habitats (also see Randall 1998)[33]. Another insight would be to determine if there is any correlation in nesting abundance with El Niño events (ENSO: El Niño Southern Oscillation). The author does not know if the observations at Tongareva in 2011 were made in an average year, a high-density nesting year, or a low abundance year? (*c.f.* Limpus & Nicholls 1988, 2000; Chaloupka & Limpus 2001; Solow *et al*. 2002; Saba *et al*. 2007; Chaloupka *et al*. 2008a; Reina *et al*. 2008).

Sand temperature experiments (Fuentes *et al*. 2009a; also see Limpus *et al*. 1983; Godley *et al*. 2001) can also be undertaken to elucidate the likely sex ratios of sea turtle embryos: the <u>sex ratio of green turtles in Oceania is unknown</u> and is thus assumed to be 50 percent (NMFS 2010).

Tongareva's other beaches will continue to be monitored regularly for nesting evidence. Inwater assessments will also be made, especially on the leeward reef, in order to gain an understanding of marine habitat use; particularly by internesting turtles.

[33] Randall (1998) notes that a decrease in species diversity occurs when moving eastwards from the Indian Ocean into the Pacific Ocean. The Tongan Trench (where two of Earth's tectonic plates-Indo-Australian Plate and the Pacific Plate-meet between Fiji and Samoa) also acts as a barrier to the dispersal of species.

Conclusions

"Many people are oblivious to how, as the desirable species are stripped out of the oceans, we will be left with the hardiest, most undesirable species – most likely jellyfish and bacteria, the rats and cockroaches of the sea". Professor Callum Roberts, University of York, 2005.

The absence of a previous systematic survey in the Cook Islands (see Annexe 2; Siota 2011) means that it is very difficult to determine how the present populations of sea turtles compare with their past distribution and abundance. Nonetheless, CITP's research efforts, although not yet nationwide, have already provided a starting-point for effective ongoing monitoring. The author has also made a long-term commitment to undertake sea turtle research and education throughout the archipelago.

White (2011) pointed out that, unfortunately, even the most recent literature concerning sea turtles in the South Pacific Islands has had to use data for the Cook Islands that are at least a decade old (Maison *et al*. 2010; NMFS 2010; Wallace *et al*. 2010; Woodrom Rudrud 2010; & see SWOT 2011). Each of those authors noted that Palmerston Atoll was reported as being the most important sea turtle nesting site in the Cook Islands (Balazs 1982, revised 1995); however, as there are no recent data from Palmerston (see endnote **i**) or for any of the other atolls that hypothesis may not be true (White 2011).

A further concern of the present author is that **hawksbill turtles *Eretmochelys imbricata*** may no longer be nesting in the Cook Islands. It is significant that Meylan and Donnelly (1999) found no data from the Cook Islands[34] during their global review to justify listing hawksbill turtles as being Critically Endangered. Dr Cécile Gaspar has a similar concern for French Polynesia: the turtles arriving at her clinic on Moorea are mostly smaller than 50 cm CCL; and adult hawksbills are rarely seen at sea either (Priac *et al*. 2010).

Those questions are considered in the present document and it is clear that Tongareva Atoll hosts substantial green turtle nesting: the most important beach, at least in 2011, is the western side of Mangarongaro motu; with at least 525 nests in the northern half alone. It is also likely that nesting occurs year-round on this motu, but perhaps not on the others. The survey of Mangarongaro on 16th December 2011 alone shows that the number of nesting green turtles (at least 55: based on track-counts and the age of tracks) is greater than the range in the lowest group (1-25 females) of Nesting Aggregations (Dethmers *et al*. 2006; NMFS 2010); which the Northern Cook Islands is currently placed within.

Without a thorough contemporary survey of Palmerston we cannot yet say which atoll is paramount; and it may even be that another site has a greater abundance of nests. CITP has prepared a research expedition plan for Palmerston Atoll: PICI is actively seeking funding to undertake this assessment. The award of a grant to CITP by the Rufford Small Grants Foundation (announced on 16th December 2011) means that this survey can now

[34] A management report prepared for the Traditional Land-owners of Manuae Atoll, Southern Cook Islands (Teariki-Taoiau Rongo 2006), noted a few *Chelonia mydas* nests from both motu, and this was the only species encountered in the lagoon and on the reefs; no hawksbills have been seen there since about 2005 (Clive Baxter pers. com.).

proceed: probably during April 2012 following the cyclone season; however, it is unclear if any egg-laying will still be occurring there at that time (White *pers. com.*).

Another important finding from the Northern Cook Islands is that the Mean incubation period for three of the four green turtle nests laid at Rakahanga (between late-September and early-November 2011) was 58 days (SD 2.7 days; range 55-60 days; n = 3); these may be the first such data reported from the Cook Islands.

A small number of nesting events (6) found on Mangarongaro might have been made by hawksbill turtles, as the pattern of those particular tracks appeared to be asymmetrical rather than the more-usual symmetry associated with green turtles; however, neither the nesting adults nor any hawksbill hatchlings have been observed. One adult-sized female hawksbill was seen foraging in the main lagoon just east of Moananui (13th August 2011) and so perhaps nesting by this species does still occur on Tongareva. The identification of any nesting sites that are used by hawksbill turtles is therefore a high priority. A more-intensive study on Mangarongaro's beaches, that includes nocturnal patrols, should provide a better understanding of which species are actually nesting and their population dynamics; the core-nesting sites; and in particular when peak-nesting might occur. CITP is seeking funding to undertake this in-depth research; especially so that we can gain an understanding of population trends.

The fact that a good number of hawksbill juveniles are still foraging on Rarotonga's reefs (White 2010c) means that nesting by this rare species may occur somewhere in the Cook Islands archipelago at some point in the future (Rarotonga has few if any suitable nesting beaches; White 2011). One possible reason for optimism is that the plight of endangered species is now a global issue: in the last 30 or so years international legislation has been put in place and many of the threats have been considered, even if not yet resolved: e.g. fishery bycatch has now been recognised as an economic problem by that industry (i.e. fish catch is reduced if bycatch occupies the hooks); loss of turtle nesting beaches, especially from unplanned and often illegal development (e.g. White 2007), has been challenged, and the more environmentally-aware countries now require EIAs[35]; international trade in endangered species has been substantially reduced, including for the Japanese '*bekko*' tradition (see Groombridge & Luxmore 1989). Furthermore, some severely-depleted turtle populations are now recovering as a result of thoughtful long-term management endeavours (see Balazs 1980; Balazs & Chaloupka 2004; Nel *et al*. 2011; Pilcher 2011; Pritchard 2011).

The Cook Islands Turtle Project and the Pacific Islands Conservation Initiative, and its recently-incorporated Trust, have made significant progress in 2011: our achievements include the first research results on sea turtles from the Northern Group Atolls in four decades; the launch of sea turtle and environmental education programmes, including a module presented at the Lifeskills Expo on Manihiki; an imminent agreement with the Ministry of Education, Rarotonga, to develop main-stream curriculum material; and the establishment of a network of interested islanders throughout the Northern Cook Islands.

[35] Environmental Impact Assessment.

PICI has also launched the Aitutaki Lagoon Monitoring Project, and is now advocating a 'shark sanctuary' throughout Cook Islands territory; research and publicity has continued at Rarotonga's Muri Lagoon. The problem of persistent waste in the Outer Islands has been brought to the Government's attention, and practical solutions are now being sought to resolve it. National and international outreach efforts have raised public awareness of our activities in the Cook Islands. All of this has been achieved through the dedication of our project team with almost no funding; thus it is likely that once we do become a well-funded organisation our contribution towards creating a sustainable future, living in a well-balanced and healthy ecosystem, will be profound.

Kia Manuia

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Endnotes

i Dethmers *et al*. (2006) & NMFS (2010) provide the following details for the Cook Islands Nesting Aggregations (NAs) and those other NAs that are nearby.

Northern Cook Islands NA. The Northern Cook Islands NA consists of green turtles that nest in the northern Cook Islands, except for Pukapuka Atoll, which is included as part of the West Polynesia NA. The Cook Islands consist of 15 volcanic islands and atolls. In this NA, green turtles nest at Tongareva (aka Penrhyn), Rakahanga and Manihiki Atolls. Reports from the 1960s and 1970s indicate the presence of green turtle nesting activity at these locations but no further details on nesting female abundance or trends are available (Balazs 1995). Woodrom-Rudrud (2010) additionally lists green turtle nesting activity at Suwarrow atoll and Nassau island, although information regarding number of nesting females is not included for these sites. Based on limited available information, it is assumed that 1-25 green turtles nest annually in this NA.

Southern Cook Islands NA. The Southern Cook Islands NA consists of green turtles that nest in the southern Cook Islands. In this NA, green turtles nest primarily at Palmerston Island, which hosts the majority of green turtle nesting within the Cook Islands. According to a review provided by Balazs (1995), reports from the 1960s and 1970s refer to Palmerston as an important nesting location for green turtles in the Pacific, although no indications of numbers of nesting females were provided. From 1972 to 1977 a decline in the number of nesting turtles was observed by inhabitants (Balazs 1995). Annual nesting numbers declined from 30-40 to <10 in under ten years (Helfrich 1974). Additional sites in the southern Cook Islands identified by Woodrom-Rudrud (2010) include Mangaia, Atiu, Mauke, and Rarotonga islands, although no further information on nesting abundance is available. Based on the limited available information, it is assumed that 1-25 green turtles nest annually in this NA.

West Polynesia NA. The West Polynesia NA consists of green turtles that nest in American Samoa, Tokelau, Pukapuka Atoll in the northern Cook Islands, and the Phoenix Islands in central Kiribati. In this NA, green turtles nest at Swains Island, Rose Atoll and Tutuila in American Samoa, all eight Phoenix Islands in Kiribati, all three atolls in Tokelau, and Pukapuka Atoll in the northern Cook Islands.

In American Samoa, sub-adult and adult green turtles occur in low abundance in nearshore waters around Tutuila, Ofu, Olosega, Ta'u and Swains Islands. Up to several dozen green turtles nest on Rose Atoll annually (review provided by Balazs 2009). No nesting trend data are available, but anecdotal information suggests major declines in the last 50 years (Tuato'o-Bartley *et al* 1993, Utzurrum 2002). Since 1971, 42 individual nesting green turtles have been flipper tagged on Rose Atoll (Grant *et al*. 1997) during various trips.

No green turtle nesting occurs in Independent Samoa, though 36 adult females and 14 adult males were opportunistically examined during a hawksbill research programme conducted by the Western Samoa Fisheries Division during October 1970 to May 1973 (Witzell 1982). While adult greens were observed near reefs year-round, during December-February they were observed gathering near reef passages connecting large lagoonal foraging areas near Upolu Island. Witzell (1982) surmised that these adults may be part of the group that nests on Rose Atoll during August-September.

The Phoenix Islands are under the jurisdiction of Kiribati and consist of eight low coral islands and atolls. Green turtle nesting has been observed at all eight locations including Canton, Nikumaroro, Enderbury (aka Rawaki), Phoenix, Birnie, Hull (aka Orona), Sydney (aka Manra), and McKean Islands. Canton and Enderbury Islands reportedly host the largest numbers of nesting green turtles of these eight sites. Observations in the early 1970s suggested that several hundred nesting females occurred on Canton Island (Balazs 1975), and a survey done in the summer of 2002 recorded at least 160 old nests on Enderbury Island (Obura & Stone 2002). A combined total of 60-80 nests were recorded annually (possibly representing ~ 20-30 females) at the other six islands in the Phoenix group during surveys in the summers of 2000 (Stone *et al*. 2001) and 2002 although this is likely to be an underestimate of nesting activity because the peak nesting season regionally is October–November (Balazs 1995). Combining available information, it is estimated that 100-300 green turtles may nest in the Phoenix group annually. Little to no trend information is available for the Phoenix group.

Tokelau consists of three coral atolls, Atafu, Nukunonu, and Fakaofu, all of which are known to have green turtle nesting. Balazs (1983) estimated 120 total nesting females annually in Tokelau. Sea turtle capture-rates declined from the early-1900s to the 1980s despite more sophisticated hunting methods, indicating a likely decline in resident or nesting turtles (Balazs 1983). Updated information regarding abundance and trends of nesting green turtles in Tokelau was not available to the authors at the time of writing.

Pukapuka is a coral atoll in the northern Cook Islands. Green turtles nest on one of the uninhabited islets and there is some directed harvest of turtles and eggs (Balazs 1995). No further information on abundance or trends of nesting green turtles at this site was available to the authors at the time of writing.

Based on the available information, it is assumed that a mean annual total of approximately 101-500 females nest in this NA. There is little to no information on the trend of nesting green turtles in this NA, although the available information suggests there may be a decline in recent times.

Northern Line Islands NA. The Northern Line Island NA consists of green turtles that nest in the northern Line Islands. The Line Islands consist of eleven atolls and coral islands in the central Pacific south of Hawaii, eight of which belong to Kiribati and three of which are the U.S. possessions of Palmyra Atoll, Kingman Reef, and Jarvis Island. In this NA, green turtles have been documented nesting at Palmyra Atoll, Jarvis Island, and Kritimati and Tabuaeran (aka Fanning) Islands in Kiribati. Information on abundance of nesting females in recent years is not available for this NA as no surveys have been conducted. Low-level nesting at Palmyra was observed in 1987 and along the west coast of Jarvis Island in the 1930s (NMFS & FWS 1998) but more recent information is not available. Turtles appear to have declined considerably at both Fanning and Kritimati Islands between the early-1800s when human habitation began and the 1990s (Balazs 1995). Based on the limited available information, it is assumed that 1-25 green turtles nest annually in this NA.

Southern Line Islands NA. The Southern Line Islands NA consists of green turtles that nest in the southern Line Islands of Kiribati. In this NA, green turtles have been reported nesting at Vostok and Caroline (aka Millennium) Islands although details regarding numbers of nesting females were not provided (Balazs 1995). Further information is not available for green turtle nesting abundance or trends in this NA. Based on the limited available information, it is assumed that 1-25 green turtles nest annually in this NA.

West French Polynesia NA. The West French Polynesia NA consists of green turtles that nest in western and central French Polynesia. French Polynesia consists of 130 islands and atolls spread over a large geographic area in the central south Pacific. In this NA, green turtles have historically been observed nesting at Tupai, Bellingshausen, Mopelia, Manihi Atoll, Tetiaroa Atoll and Scilly Atoll. Based on the available information, approximately 101-500 green turtles nest annually in this NA.

Nesting is concentrated at Scilly Atoll (aka Manuae) in the Leeward Islands, and observations in the late-1970s, early-1980s, and early-1990s suggested 300-400 nesting females occurred there annually (Lebeau 1985; Balazs *et al*. 1995). These observations, in conjunction with information from local residents, indicate a decline in nesting numbers between the 1950s and early-1970s, although numbers may have stabilised between 1972 and 1991 (SPC 1979b; Balazs *et al*. 1995; Pritchard 1995). Nesting females and adult males tagged at Scilly Atoll have been recovered in Tonga, New Caledonia, Vanuatu, the Cook Islands, and Fiji; this tag return information reveals some of the longest range migrations recorded for green turtles (SPC 1979b).

Nesting occurred on Manihi Atoll in 1971 (Hirth 1971, cited in Pritchard 1995) but no more recent information is available. Sporadic nesting surveys at Tetiaroa Atoll have been conducted since 2004 (Te Mana o te Moana 2008) although 2008-2009 was the first nesting season with an organised, sustained survey effort which revealed 81 crawls and 33 nests (Te Mana O Te Moana 2009). Low level nesting has also been observed at Tikehau Atoll (Te Honu Tea 2008).

ii Bell *et al*. (2005) recently put the entire rationale for tagging turtles into perspective. Out of some 30,000 green turtles *Chelonia mydas* released from the Cayman Turtle Farm (1980-2001) during a headstarting programme (captive-raised hatchlings and yearlings were released in order to, hopefully, restock depleted wild populations), a total of 392 individuals were recaptured in the region. Approximately 80% of all turtles released during the programme had been tagged in some way (flipper tags, living tags and scute notching). Another long term study, at Tongaland, South Africa, has notched over 310,000 loggerhead hatchlings since 1971; of these, 101 have been encountered as nesting adults since 1988 (Hughes, 1974a, 1974b, Baldwin *et al*. 2003; see also Nel *et al*. SWOT 2011). This not only highlights that turtle-tagging studies should be conducted over a long period of time, but also indicates that any returns are likely to be very small (White 2007).

iii NMFS (2010) reported that 11 of the 13 green turtles caught as bycatch in the American Samoa longline fishery (which, incidentally, encompasses the entire Cook Islands EEZ; White *pers. com*. 2011) from April 2006-August 2010 were sampled for genetic analysis in an effort to identify the stock origin of sea turtle interactions. Results of mitochondrial DNA sequencing were available for nine of the sampled animals (the most recent two were still to be analysed) and revealed the following: (1) one individual with a haplotype (CmP80) representing nesting aggregations of the Great Barrier Reef area, the Coral Sea, and New Caledonia; (2) two individuals with a haplotype (CmP22) representing nesting aggregations of the Marshall Islands, Yap and American Samoa; (3) two individuals with a rare haplotype (CmP65) only found so far in the nesting aggregation in the Marshall Islands, (4) two individuals with haplotypes (CmP31 & CmP33) of unknown nesting stock only found so far in foraging green turtles around Fiji , (5) one individual with a haplotype (CmP20) commonly found in nesting aggregations in Guam, Palau, Marshall Islands, Yap, Northern Mariana Islands, Taiwan and Papua New Guinea, and (6) one individual (CmP47) with a haplotype found in nesting aggregations in Yap, northern and southern GBR, New Caledonia, Coral Sea, Timor Sea, and east Indian Ocean (Peter Dutton, NMFS, *pers. com.*). Work is ongoing to sufficiently characterise all the Pacific green turtle nesting stocks with informative genetic markers in order to improve the ability to assign stock origin of individual animals (NMFS 2010).

To date, four genetic samples from stranded or foraging turtles around Tutuila have been analysed. Two samples from stranded green turtles in Pago-Pago harbour had a haplotype known from nesting green turtles in American Samoa, Yap, and the Marshall Islands. However, since many green turtle nesting aggregations in the Pacific still have not been sampled, it is possible that this haplotype occurs at more than these three sites. In addition, two samples have been analysed from foraging green turtles at Fagaalu, but the haplotype is of unknown nesting origin (Peter Dutton, *pers. com.* 2010).

iv Sea turtle legislation from some countries in Oceania (Maison *et al*. 2010):

Australia

Marine turtles in Australia are protected under the Environment Protection and Biodiversity Conservation Act of 1999 (EPBC Act), which implements several international agreements/conventions to which Australia is a signatory. Traditional Owners, as recognized under the Australian Government's Native Title Act of 1993, are able to assert their rights to gain customary authority for shared resources such as marine turtles which includes traditional hunting rights. On a regional level, the Torres Strait Treaty between Australia and PNG outlines the boundaries between the two countries and how the sea area may be used. The Treaty includes provisions for traditional fisheries in the area, including turtle harvest by indigenous groups. Australia is a participant in the Convention for the Protection of the World Cultural and Natural Heritage (World Heritage Convention), as well as CMS and CITES (both of which list sea turtles in Appendix I: species threatened with extinction).

Fiji

Sea turtles and their eggs are managed under Fisheries Regulations in Fiji. The Fisheries Act, as amended in 1979 and 1991, outlines gear requirements when spearing a turtle and also states that "No person shall at any time dig up, use, take, sell, offer or expose for sale, or destroy turtle eggs of any species or in any way molest, take, sell, offer or expose for sale, or kill any turtle the shell of which is less than 455 mm [18 inches] in length. No person during the months of January, February, November or December in any year shall in any way molest, take, sell, offer or expose for sale, or kill any turtle of any size". The possession, sale or export of any turtle shell less than 18 inches in length and the export of turtle flesh and turtle shell unless it is worked into jewellery or otherwise processed into a form approved by the Permanent Secretary for Primary Industries and Cooperatives are all prohibited acts (Government of Fiji 1992). A National Moratorium prohibiting the killing, harming or molesting of any marine turtles including their meat, eggs or shell was first enforced in 2004 by the Fijian Government. It was recently extended for a further ten years by the Fijian Cabinet until 2019. Indigenous Fijians are still able to legally harvest marine turtles if they obtain prior approval from the Fisheries Department. There is some disagreement, however, regarding the effectiveness of Fiji's moratorium mostly due to lack of compliance and enforcement (Laveti & Mackay 2009). Fiji is a participating party to CITES.

French Polynesia

French Polynesia is an overseas territory of France and sea turtles have been completely protected since 1990 by the Polynesian government (DELIBERATION No. 90-83 AT *du 13 Juillet 1990 relative à la protection des tortues marines en Polynésie Française*). Prior to this date, traditional harvest with seasonal and size restrictions was permitted. Under the revised statutes, turtles are fully protected and it is strictly forbidden to harm, own or hunt sea turtles or engage in commerce of any kind pertaining to the sale of shell, meat and eggs. Scilly Atoll has been protected as a marine reserve for sea turtles since 1971 by the local government (Vu l'arrêté No. 2559 DOM *du 28 Juillet 1971 portant classement du lagon de l'île Manuae ou Scilly*). French Polynesia is not a participating party to CITES (although France is a participating party).

Japan

In Japan, there are eight laws and ordinances that regulate (allow via permit) or prohibit actions harmful to sea turtles, such as taking, buying, and selling turtles, their eggs, and any derivative products, or restrict access to nesting beaches. In general, harvest is prohibited but exemptions may be obtained for subsistence use. The Law for the Conservation of Endangered Species of Wild Fauna and Flora is the primary law in Japan that intends to conserve endangered species. It prohibits the capture of sea turtles and eggs for sale for all seven species and prohibits domestic assignment or transfer of endangered species listed in CITES (*Umigame Hogo no tameno* 2006). This law was established in accordance with CITES and is enforced by the Japan Ministry of Environment.

Kingdom of Tonga

Fisheries Conservation and Management Regulations (1994) prohibit the possession, disturbance, take, sale, purchase, or export of turtle eggs; sale, purchase, or export of hawksbills or their shells; and use of a spear gun to take a turtle; and establish closed seasons for leatherback turtles between January 1st-December 31st (Bell *et al*. 1994; Folumoetui'i, 2006). Hawksbills are the only sea turtle species fully protected via Tongan legislation and harvest of other turtle species is permitted seasonally (November-February) with a minimum size specified (shell length of <45cm may not be taken) (Folumoetui'i 2006). Tonga is not a participating party to CITES (Maison *et al*. 2010). In the market at Nuku'alofa there were several hawksbill carapaces for sale (White *pers. obs.* 2009); these were all smaller than the legal permitted minimum size, thus it seems that enforcement of environmental law is lacking. Directed take of green turtles for consumption and sale still occurs in Tonga and laws are generally not adhered to or enforced (Havea & MacKay 2009).

Kiribati

Kiribati is an island nation that consists of 32 atolls and one raised coral island that are separated into three distinct chains, the Gilbert Islands, Phoenix Islands, and Line Islands, dispersed over 3.5 million square kilometres. In Kiribati, the Wildlife Conservation Ordinance (Laws of the Gilbert Islands 1977) prohibits hunting, killing or capturing any wild turtle on land and fully protects the green turtle in the following places: Birnie Island, Caroline Island, Christmas Island, Flint Island, Gardner Island (*Nikumaroro*), Hull Island (*Orona*), Malden Island, McKean Island, Phoenix Island, Starbuck Island, Sydney Island (*Manra*), and Vostock Island. Kiribati is not a participating party to CITES.

Nauru

Nauru is the world's smallest island nation and consists of one small island, approximately 21 square kilometres in area, located in the southwestern Pacific Ocean. Maison *et al*. (2010) found no reports of green turtle nesting activity on Nauru; and the nation is not a participating party to CITES.

New Caledonia

Regulations related to sea turtle management in New Caledonia vary within the country. In the Loyalty Islands province (as per fishery regulations of 1985) the take of marine turtles and their eggs is prohibited from November 1st to March 31st. As of January 2008, the 1985 regulations have been amended for the EEZ, the Main Island (Northern & Southern provinces), and remote islands such that it is not permitted to capture, sell, purchase, or disturb any marine turtle species or nest at any time. Additionally, the compulsory use of handling equipment (de-hooker, line-cutter, etc.) in commercial fisheries is required for incidental catch of turtles. Regulations prohibit the export or import of marine turtles (alive or dead) or any turtle parts or products, and exceptions may be granted for customary celebrations or scientific purposes. New Caledonia is not a participating party to CITES (although France is a participating party).

Niue

Niue is an island nation in free association with New Zealand. It consists of a single island approximately 256 square kilometres in area located east of Tonga. Green and hawksbill turtles occur in Niue waters (Government of Niue 2001), but Maison *et al*. (2010) were unaware of any reports of green turtle nesting activity on Niue. Domestic Fishing Regulations (1996) prohibit the harvest or take of all turtle species unless approval is received from the cabinet. Niue is not a participating party to CITES.

Papua New Guinea

In PNG, marine resources and lands are owned by a large number of clan and sub-clan groups whose tenure rights are recognized in the national Constitution. With respect to sea turtles, the 1976 Fauna (Protection & Control) Act restricts the harvesting of protected wildlife, the devices and methods by which fauna may be taken, and the establishment of localized protective regimes on land and waters under customary tenure (Kinch 2006). Additionally the 1979 International Trade Act regulates and restricts the export of CITES listed species. In PNG, only leatherback turtles are protected under the Fauna (Protection and Control) Act that makes killing of leatherbacks or taking of leatherback turtle eggs illegal with fines of 500-1000 kina (100 to 300 US$). Any person who buys or sells or offers for sale, or has in possession leatherback turtle eggs or meat can also be fined 500 kina. The Act does not formally protect green turtles and makes provisions for persons with customary rights to take or kill turtles, but states that turtles cannot be taken, killed, or sold between the months of May and July. Furthermore, the Act stipulates payments for turtles: (a) K20.00 for a turtle less than 60 cm in length; and (b) K30.00 for a turtle of 60 cm or more in length. The PNG government Department of Environment and Conservation has the authority and responsibility to enforce laws and environmental Acts. The Torres Strait Treaty between Australia and PNG outlines the boundaries between the two countries and how the sea area may be used. The Treaty includes provisions for traditional fisheries in the area, including turtle harvest. PNG is a participating party to CITES.

Pitcairn Islands

Green turtles nest at Henderson Island with an estimated total of 10 females annually (Brooke 1995). No nesting was recorded at Pitcairn, Ducie, or Oeno Islands during the 1991-1992 nesting season. Pitcairn and Ducie were deemed to have unsuitable substrate for nesting while Oeno had suitable substrate but no activity was observed (Brooke 1995). This small nesting assemblage does not appear to be threatened by direct harvest or other major anthropogenic sources of impact. As per the Local Government Ordinance of 2001, no person may harass, hunt, kill or capture any sea turtle (*Cheloniidae and D. coriacea*), and exception may be granted under permit for scientific purpose or for traditional subsistence use (Laws of Pitcairn, Henderson, Ducie, and Oeno Islands, 2001). The Pitcairn Islands are a territory of the UK which is a participating party to CITES.

Republic of Marshall Islands
The harvest of sea turtles in the RMI is regulated by the Marine Resources Act (RMI 1997) which sets minimum size limits for greens (34 inches carapace length) and hawksbills (27 inches carapace length) and closed seasons from June 1st to August 31st and December 1st to January 31st. Egg collecting and take of turtles while they are onshore is prohibited at all times. The Marshall Islands Marine Resources Authority is the entity with the responsibility of managing marine resources in the RMI. RMI is not a participating party to CITES.

Republic of Palau
Palau domestic fishing laws specify minimum size limits for green turtles (34 inches carapace length) and hawksbills (27 inches carapace length) and closed seasons from June 1st to August 31st, and December 1st to January 31st (SPC & BMR Palau, 2007). Taking of eggs or female turtles while onshore is prohibited at all times. Palau is a participating party to CITES.

Samoa
Local Fisheries Regulations in Samoa prohibit fishing for, possession, or sale of greens and hawksbills under 70 cm (27.6 inches) CCL, as well as the disturbance or take of nests or eggs. The Ministry of Agriculture and Fisheries (formerly the Department of Agriculture, Forests, and Fisheries) is the responsible authority to manage fishery resources, including sea turtles, and enforce local fisheries regulations in Samoa. Additionally, the Marine Wildlife Protection Regulations (2009), under the Ministry of Natural Resources and Environment, make exemptions for subsistence take of turtles, prohibit captivity of turtles (unless permitted), prohibit the commercial capture and sale of turtles, protect turtles and eggs during the nesting season (November to February), prohibit the sale, purchase and possession of eggs, and require that any turtle caught during fishing activities be released and reported. Samoa is a participating party to CITES.

Solomon Islands
The Solomon Islands Fisheries Act (1993) regulations prohibit the sale, purchase, or export of sea turtle species or their parts, protect nesting turtles and eggs during the breeding season (June to August & November to January), and contain specific protection for leatherback turtles (SPREP 2007). The Solomon Islands is a participating party to CITES and the Wildlife Protection and Management Act (1998) prohibits the export of five turtle species or their derivative products (greens, hawksbills, loggerheads, olive ridleys, and leatherbacks).

Tokelau

Tokelau consists of three coral atolls, *Atafu*, *Nukunonu*, and *Fakaofu*, all of which are known to have green turtle nesting. Balazs (1983b) estimated 120 total nesting females annually in Tokelau. Sea turtle capture rates declined from the early 1900s to the 1980s, despite more sophisticated hunting methods, indicating a likely population decline (Balazs 1983b). Updated information regarding abundance and trends of nesting green turtles in Tokelau was not available to Maison *et a*l. (2010) at the time of printing.

According to a 1998 marine resources survey at Fakaofu, the local council of elders has established village rules stating that when a turtle is caught, it must be shared among the village using a traditional system or resource sharing called *Inati* (Passfield 1998). Local village rules also protect sea turtles while they are nesting. Ono & Addison (2009) claim that today turtle fishing is officially prohibited throughout Tokelau, however the Project Global country profile for Tokelau (Project Global, accessed online 10/2010 by Maison *et al.*) states that there are currently no formal regulations by the Fisheries Department to protect sea turtles or their eggs in Tokelau; therefore the actual protective status of sea turtles remains unclear. Tokelau is not a participating party to CITES.

Tuvalu
In Tuvalu, the Wildlife Conservation Ordinance (1975) prohibits hunting, killing or capturing any wild turtle on land, except under and in accordance with the terms of a valid written license granted to that person by the Minister (Government of Tuvalu 1975). Tuvalu is not a participating party to CITES.

Vanuatu
Fisheries Regulations under the new Vanuatu Fisheries Act (2009) prohibit the take, harm, capture, disturbance, possession, sale, purchase of or interference with any turtle nest (or any turtle in the process of nesting), and the import, or export of green, hawksbill, and leatherback turtles or their products (shell, eggs, or hatchlings). The Act also prohibits the possession of turtles in captivity. A person may apply in writing to the Director of Fisheries for an exemption from all or any of these provisions for the purposes of carrying out customary practices, education, and/or research. Vanuatu is a participating party to CITES.

United States and Possessions
Endangered Species Act (ESA) of 1973 (16 U.S.C. § 1531 *et seq.*)

American Samoa
In addition to protection under the federal ESA (1973), sea turtles in American Samoa are protected by the Fishing and Hunting Regulations for American Samoa (DMWR 1995) which prohibit the import, export, sale, possession, transport, or trade of sea turtles or their parts and take (as defined by the ESA) and carry additional penalties for violations at the local government level. The Department of Marine and Wildlife Resources (DMWR) is the agency with vested authority and responsibility for conservation of protected species and enforcement of protected species regulations in American Samoa.
The ESA prohibits unauthorised ‘take’ of listed species which is defined as to “harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 U.S.C. § 1532(18)). Under the ESA, exceptions to ‘take' prohibitions are permitted for scientific research or when take is incidental to an otherwise lawful activity, as long as the level of take will not jeopardise the existence of the species in the wild or appreciably reduce the likelihood of recovery in the wild. Both NOAA Fisheries Service and USFWS have dedicated enforcement divisions to handle violations of the ESA. The U.S. is a party to several international agreements related to sea turtles including the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC) and the Convention on International Trade in Endangered Species (CITES) which prohibits international trade of marine turtles and marine turtle derived products. While the U.S. is not a party to the Convention on Migratory Species (CMS), they are a signatory to the Convention on Biological Diversity (CBD). Local state and territory governments may have additional protections in place for sea turtles.

Pacific Remote Island Areas

Pacific Remote Island Areas (PRIAs) are U.S. areas that are widely spread throughout the Pacific and include Wake, Johnston and Palmyra Atolls, Kingman Reef, and Jarvis, Howland, and Baker Islands. Following a 28-day assessment in 1983 it was concluded that green turtles do not nest at Johnston Atoll, but occur foraging within the atoll (Balazs & Forsyth 1986). Low-level nesting was observed at Palmyra in 1987 and along the west coast of Jarvis Island in the 1930s (NMFS & FWS 1998) but no recent surveys have been conducted. Both Jarvis and Palmyra are geographically part of the Line Islands chain of coral atolls and islands in the central Pacific and are uninhabited remote National Wildlife Refuges administered by the USFWS. Jarvis is visited infrequently by refuge staff for one to two days at a time every two years. There is a research station on Cooper Island at Palmyra Atoll operated by The Nature Conservancy (TNC) that houses a small maintenance staff year-round and various research groups for shorter time periods. Anecdotally, no evidence of sea turtle nesting has been observed at Palmyra in recent years (USFWS, *pers. com.*). In 2007, an in-water sea turtle research project was initiated at Palmyra by the American Museum of Natural History and Columbia University. While nesting beach monitoring is not a focus of the project, any nesting activities will be documented by either the project or by TNC staff that currently reside at the Atoll.

The PRIAs do not support resident human populations and do not have local governments. Therefore, all sea turtle species that occur in the PRIAs are protected by the federal ESA as described previously.

Cook Islands Turtle Project

2011 Annual Report

By

Dr Michael White

ANNEXES

Annexe 1: Marine sightings of sea turtles at Tongareva 2011

Annexe 2: TREDS report for the Cook Islands 2010 (Catherine Siota 2011)

Annexe 3: Lifeskills Expo report – Manihiki 2011

Annexe 4: Underwater sightings of turtles – Rarotonga (2010-2011)

Incidental sightings of turtles at Tongareva Atoll (2011). There were 53 *Chelonia mydas*; 2 *Eretmochelys imbricata*. **Mode of survey:** shore, motor-boat, vaka (kayak). **Duration of survey:** most sightings (n = 44) were made as a turtle surfaced to breathe. **Behaviour: Rs** respiration; **Su** swimming underwater; **Ru** resting underwater. All sightings were of single animals; occasionally two turtles would be within about 30 m of each other; there were no instances of group behaviour.

MARINE SIGHTINGS

Date	Time	Island	Site	Mode	Duration	Turtles *Cm*	Turtles *Ei*	Behaviour
03/01/2011	10:00	Tongareva	Mangarongaro	Boat	All day	2		Rs
23/01/2011	07:20	Tongareva	Omoka	Shore	Spot	1		Rs/Su
23/01/2011	07:30	Tongareva	Omoka	Shore	Spot	1		Rs/Su
24/01/2011	day	Tongareva	Omoka	Shore	Spot	1		Rs/Su
28/01/2011	07:40	Tongareva	Omoka	Shore	Spot	1		Rs/Su
03/02/2011	16:00	Tongareva	Omoka	Shore	Spot	1		Rs/Su
04/02/2011	15:50	Tongareva	Omoka	Shore	Spot	1		Rs/Su
05/02/2011	13:35	Tongareva	Omoka	Shore	Spot	1		Rs/Su
06/02/2011	11:00	Tongareva	Omoka	Shore	Spot	1		Rs/Su
07/02/2011	15:10	Tongareva	Omoka	Shore	Spot	1		Rs/Su
08/02/2011	07:10	Tongareva	Omoka	Shore	Spot	1		Rs/Su
11/02/2011	14:10	Tongareva	Omoka	Shore	Spot	1		Rs/Su
11/02/2011	19:00	Tongareva	Omoka	Shore	Spot	2		Rs/Su
13/02/2011	18:00	Tongareva	Omoka	Shore	Spot	1		Rs/Su
16/02/2011	14:45	Tongareva	Omoka	Shore	Spot	1		Rs/Su
18/02/2011	14:25	Tongareva	Omoka	Shore	Spot	1		Rs/Su
20/02/2011	11:15	Tongareva	Omoka	Shore	Spot	1		Rs/Su
25/02/2011	14:05	Tongareva	Omoka	Shore	Spot	1		Rs/Su
26/02/2011	13:40	Tongareva	Omoka	Shore	Spot	1		Rs/Su
27/02/2011	17:50	Tongareva	Omoka	Shore	Spot	1		Rs/Su
28/02/2011	17:30	Tongareva	Omoka	Shore	Spot	1		Rs/Su
28/02/2011	17:45	Tongareva	Omoka	Shore	Spot	1		Rs/Su
28/02/2011	18:15	Tongareva	Manongis	Shore	Spot	1		Rs/Su

MARINE SIGHTINGS

Date	Time	Island	Site	Mode	Duration	Turtles *Cm*	Turtles *Ei*	Behaviour
05/03/2011	09:00	Tongareva	Omoka	Shore	Spot	1		Rs/Su
05/03/2011	10:15	Tongareva	Hangarei	Vaka	Spot	1		Rs/Su
08/03/2011	17:00	Tongareva	Omoka	Shore	Spot	1		Rs/Su
10/03/2011	07:32	Tongareva	Omoka	Shore	Spot	1		Rs/Su
13/03/2011	18:15	Tongareva	Omoka	Shore	Spot	1		Rs/Su
14/03/2011	18:15	Tongareva	Omoka	Shore	Spot	1		Rs/Su
17/03/2011	06:30	Tongareva	Omoka	Shore	Spot	1		Rs/Su
17/03/2011	15:15	Tongareva	Omoka	Shore	Spot	1		Rs/Su
18/03/2011	06:35	Tongareva	Omoka	Shore	Spot	1		Rs/Su
22/03/2011	17:40	Tongareva	Omoka	Shore	Spot	1		Rs/Su
23/03/2011	16:55	Tongareva	Omoka	Shore	Spot	1		Rs/Su
30/03/2011	16:00	Tongareva	Omoka	Shore	Spot	1		Su
07/04/2011	17:45	Tongareva	Omoka	Shore	Spot	1		Rs/Su
11/04/2011	17:15	Tongareva	Omoka	Shore	Spot	1		Rs/Su
07/05/2011	15:00	Tongareva	Akasusa	Boat	?	3		Ru
16/05/2011	16:00	Tongareva	Omoka	Shore	Spot	2		Rs/Su
27/05/2011	15:20	Tongareva	Omoka	Shore	Spot	1		Rs/Su
08/06/2011	15:40	Tongareva	Omoka	Shore	Spot	1		Rs/Su
02/07/2011	08:00	Tongareva	Omoka	Boat	Fishing	2		Ashore
19/07/2011	15:00	Tongareva	Manongis	Shore	Spot	1		Rs/Su
13/08/2011	09:20	Tongareva	Mangarongaro	Vaka	Transect		1	Rs/Su
13/08/2011	10:45	Tongareva	Mangarongaro	Vaka	Transect	1		Rs/Su
14/08/2011	08:00	Tongareva	Manongis	Shore	Spot	1		Rs/Su
14/12/2011	14:45	Tongareva	Motu Kasi	Vaka	Transect	1		Su
16/12/2011	09:30	Tongareva	Mangarongaro	Vaka	Transect	1		Rs/Su
05/01/2012	15:00	Tongareva	Motu Kasi	Shore	?		1	?

COOK ISLANDS TREDS REPORT FOR 2010

Report prepared by Catherine Siota -Associate Turtle Database Officer

1. INTRODUCTION

The purpose of this report is to provide the Cook Islands Environment Service, Ministry of Marine Resources and their partners with a summary of tagging and nesting information that have been submitted to SPREP for incorporation into the regional Turtle Research and Database System (TREDS).

This report also aims to provide information that can be used to assist turtle conservation work carried out in Cook Islands.

The data held in TREDS is from fieldwork carried out in Cook Islands by the Division of Environment, the Fisheries Division and other partners as well as documents listed in the bibliography at the end of Cook Islands TREDS report for 2009 (Trevor, 2009).

This report provides an update of all data and accommodating current data received for 2009-2010 during this reporting period.

2. TAG INVENTORY

The tag inventory for Cook Islands records all tags received from SPREP and other agencies. The tag inventory also records all flipper tags used for turtle monitoring in Cook Islands.

2.1. Tags distributed by SPREP to COOK ISLANDS

Tags distributed to Environment Service and Ministry of Marine Resources by SPREP now total up to 600 (Table 1). Out of this total, only 20 (3.3%) are recorded in TREDS as used. Trevor (2009) reported 18 (3%) in an earlier report.

Table 1: Tags series distributed by SPREP to Cook Islands

Date	Tag Series		No. of Tags	No. of Tags in TREDS	Receiving Agency
	From	To			
28/04/2004	R16551	R16650	100	2	Environment Service
28/04/2004	R26451	R26550	100	18	Environment Service
09/02/2005	R30501	R30700	200		Pacific Expeditions Ltd
09/05/2008	R44301	R44400	100		MMR
09/05/2008	RI00501	RI00600	100		MMR
Total			**600**	**20**	

2.2 Tags distributed by other agencies

Twenty-two (100%) tags were used by Dr Hoyt Peckham and William Marsters for tagging turtles on Palmerston Atoll in 2000 (Table 2). All tags are recorded in TREDS as used. This is the first report of tags distributed from other agencies to Cook Islands.

Table 2: Tags series distributed by other agencies

Date	Tag Series		No. of Tags	No. of tags in TREDS	Receiving Agency
	From	To			
01/11/2000	651-Z	672-Z	22	22	2000 Hoyt Peckham-Palmerston
Total			**22**	**22**	

2.3 Untagged turtles for Cook Islands in TREDS.

A total of 92 untagged green turtles, 25 untagged hawksbill turtles and three untagged unidentified marine turtle species are recorded in TREDS for Cook Islands. Untagged turtles can also be recorded in TREDS. There were no reports for untagged turtles in 2009 (Trevor, 2009).

3. SPECIES NUMBERS BY SITE FOR 1995-2010 IN TREDS FOR COOK ISLANDS.

For Cook Islands, green turtle *(Chelonia mydas)* (n= 113) has the highest number of records in TREDS, followed by hawksbill turtle *(Eretmochelys imbricata)* (n=30) and unidentified marine turtle species (n=5). Out of the total 148 turtles recorded in TREDS for Cook Islands, 92 green turtles, 26 hawksbill turtles and three unidentified marine turtle species were data collected by Dr Michael White during a snorkeling survey of Papua Passage, Pue and Avana passage during the period from 13th November 2009 to 5th of March 2010 on several occasions (Table 3). The other turtles recorded in TREDS for Cook Islands include:

- Eleven nesting green turtles from a nesting survey by Hoyt Peckham on Palmerston Atoll during the period of 1st-24th of November 2000;
- Two green turtles encountered in Palmerston Atoll which were post-nesting females that have migrated from a nesting ground in French Polynesia to probably a foraging ground in Palmerston Atoll; (more data is required to establish this).
- Thirteen turtles in Arorangi, Amuri and Oneroa which were held in captivity while they were hatchlings and later tagged and released.
- One green turtle in Suwarrow which was trapped in the sea at depth of one foot and was tagged and released by officers of Cook Islands Environment Service.

In 2009, Trevor (2009) reported only 16 turtles were recorded in TREDS, they are hawksbill turtles (n= 4), green turtles (n=9) and three unidentified marine turtle species.

[Note: Data in Tables 3 do not reflect abundance of foraging and nesting turtles in Cook Islands, but report is based only on data that SPREP receives from Cook Islands and stored in TREDS].

Table 3: Number of turtle species by site as record in TREDS for 1995-2010 for Cook Islands.

		Species		
Location	**Island**	**Green**	**Hawksbill**	**Unidentified**
Amuri	Aitutaki	7		2
Arorangi	Rarotonga		2	
Avana passage	Cook Islands	5		
Oneroa	Mangaia		2	
Palmerston Atoll	Cook islands	13		
Papua Passage	Rarotonga	86	24	3
Pue	Rarotonga	1	2	
Surarrow	Cook Islands	1		
Total		**113**	**30**	**5**

4. NESTING TURTLES

There are 11 green turtles that are recorded in TREDS as nesting on Palmerston Atoll in the Cook Islands. This data was from a survey carried out by Hoyt Peckham and William Marsters on the 1st-24th of November 2000.

5. SIZE FREQUENCY BY SPECIES

5.1 Size Frequency for green turtles

The Size frequency graph for green turtles tagged in Cook Islands during 2000-2009 period shows nine within the juvenile range [curve carapace length (CCL) size class range of 20.0-64.9cm], one within the sub-adult range (CCL size range of 65.0-84.9cm) and nine within the adult turtles range (CCL class range of 85.0-114.9cm). Of the 21 green turtles tagged within the period, only 19 have CCL measurements (Figure 1). Trevor (2009) reported only seven green turtles had CCL measurements in TREDS.

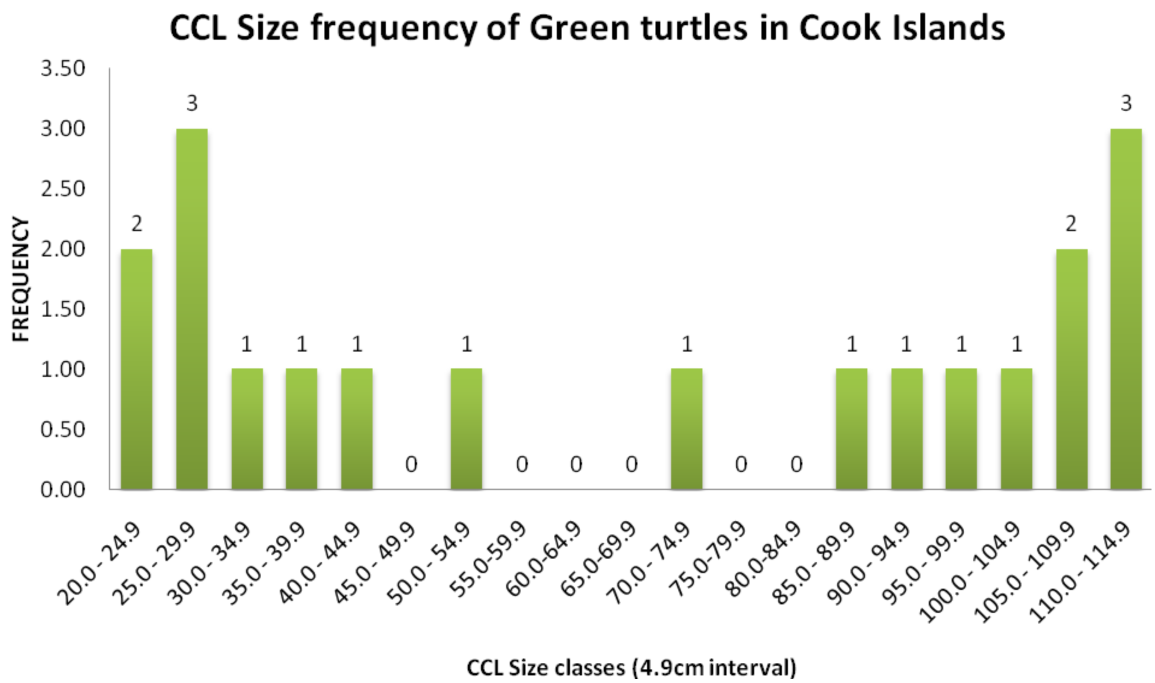

Figure 1: Size frequency for green turtles tagged in Cook Islands during 2000-2009.

5.2 Size Frequency for hawksbill turtles

TREDS recorded only three tagged hawksbill turtles, all with CCL measurements, for the period 2004-2005. All of the three hawksbill turtles are within the juvenile size range of 35.0-49.9cm CCL. Trevor (2009) reported that four CCL measurements for Hawksbill turtles. However there were correctly only three turtles, but one hawksbill had two measurements, making turtle measurement up to four.

6. TAG RECOVERIES

Only two tag recoveries have been recorded in TREDS for the Cooks Islands and these were turtles that were tagged initially in Scilly Atoll, French Polynesia (Table 4) and recaptured at Palmerston Atoll. Palmerston Atoll could be a foraging site for green turtles in the Cook Islands, but more data is required to establish this. There are no new updates of tag recoveries for this reporting period (May 2010-May 2011)

Table 4: Tag recovery of turtles tagged outside Cook Islands

Tag No.	Species	Sex	Initial Encounter			Other Encounter		
			Date	Location	Activity	Date	Location	Activity
P841	Green	Female	21-Jun-93	Scilly Atoll, French Polynesia	Nesting	14-Oct-94	Palmerston Atoll	Unknown
S757	Green	Female	01-Oct-93	Scilly Atoll, French Polynesia	In captivity	11-Sep-95	Palmerston Atoll	Unknown

7. RECOMMENDATION

- Update tag inventory records to make sure that distribution, loss or damaged tags are reported back to SPREP on their usage for easier verification of tags.

- The Government and NGOS should make public awareness on the report of tag recoveries by fishers who catch tagged turtles or the general public. This is to give us more information on the migration of turtles and other information.

- Regular flow of information between the Government and its partners with SPREP should be encouraged. This will facilitate informative and useful reporting of tag recoveries back to the Cook Islands Environment Service and the Ministry of Marine Resources.

- There is a need for Cook Islands to be more active in the turtle tagging programme as more data on turtle is required for informative decision making on all levels of sea turtle conservation, management and recovery. Given the migratory nature of turtles to their foraging and nesting grounds around the Pacific Islands.

8. BIBLIOGRAPHY

Trevor, A. 2009. TREDS report for Cook Islands. Report prepared for the Secretariat of the Pacific Regional Environment Program Apia, Samoa.

Sea Turtle Project: Northern Group Life-skills Programme, Manihiki (1st – 13th September 2011)

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Kia Orana,

Firstly I give my deepest heart-felt thanks to the communities and their leaders at Tukao & Tauhunu for making us so very welcome on their islands during this expo: *Meitaki Ma'ata*. Likewise I wish to thank the organisers, especially Retire (Principal at Tauhunu School) and Tere (Principal at Tukao School) plus of course their other staff. We were extremely well looked after throughout our stay; the kaikai was awesome … we are content *Meitaki Ma'ata*. We were deeply moved by the love and care that surrounded us, and I'm sure that each one of us contributed to making this a very successful endeavour. *Kia Manuia*.

Sea Turtles:

Honu; 'Onu; Fonu; Fono; Wonu: What wonderful names! This is something that I have learned: these are the names for turtles from Tongareva & Hawai'i, Rarotonga, Manihiki, Rakahanga and Pukapuka. Yet we are all speaking of the same ancient and endangered animals. This highlights the value of life-long learning; truly it never ends.

I taught the sea turtle module twice: initially at Tukao and subsequently at Tauhunu; with different students participating each time. Altogether 16 students attended my courses.

The following students participated (Fore-Name, age, male/female; course # I/II):

Manihiki:

Tuaine (13, m, I)
Fiona (12, f, I)
Mabel (16, f, I)
Cyrus (14, m, I)
Volontee (13, f, II)
Maine (15, f, II)
Taki (14, f, II)
Ngatoka (15, m, II)
Luka (13, m, II)
Alex (15, m, II)

Pukapuka:	Tongareva:
Kelly (16, m, I)	Teariki (14, m, I)
Pokerea (16, m, I)	Tehamaru (16, m, I)
Joshua (16, m, I)	Tekura (11, f, II)

Notes: The Omoka School Principal (TW) had intended to decide himself which options his students must take; however, I dissuaded him, because an important 'Life-skill' is the ability to make decisions, especially when there are various simultaneous choices: people need to evaluate each alternative, including *'how they feel about something'* and then choose. This came to pass.

Three of the girls from Tongareva (Ngavaka, Nancy & Hatiara) chose options that were unavailable on our own island (different local crafts, hospitality and tourism), rather than the turtle project. This is commendable as they had already participated in a 30-hour course on sea turtles that I had taught at Omoka High School during Term II (2011).

Rakahanga did not send any students to the Expo, but the Principal (Tuhe Piho) is most interested in having a sea turtle module being taught at his school; most probably in 2012.

The students (n = 10) from **Manihiki** were particularly interested, which is of great help for undertaking future sea turtle research and conservation there. Well done!

Outline: The course, which was taught during three afternoons, consisted of an overview of a typical life-cycle for a turtle: from hatching out of the egg, the various migrations and foraging choices that they make, and the diverse habitats that they use; including that the adult females may lay their own eggs on the same beach where they were themselves born. I explained some of the modern research tools that are available to us, such as flipper-tagging; DNA-sampling; and the use of satellite-telemetry to follow migrating turtles. We discussed threats and impacts: i.e. the things that have caused turtles to become endangered – mostly human activities unfortunately (e.g. pollution, especially plastics; fishery bycatch; loss of nesting beaches; especially hotels for tourism purposes; and direct hunting). We finished off with conservation measures and what people can do themselves to help raise awareness and promote a healthy ecosystem. We considered the importance of honu to the South Pacific region, especially their role in our stories, tattoos, art, jewellery and tapa; and traditional navigation.

The skull: One of the students found the skull of a green turtle and gave it to me as a gift. I used it the next day as a teaching aid: I showed a photo of a sea turtle from the dinosaur age (Cretaceous Period; 135 to 65 mya[1]) & asked students to compare our modern skull with it. There was virtually no difference! In other words sea turtles were fully evolved for life in the sea millions of years ago, and they have changed very little through the aeons… awesome fact!

[1] Millions of years ago.

Presentations: Each morning all the students presented to the plenary their achievements from the previous day. Participants from each option showed some of the items that they had made; or demonstrated some skill or understanding that they had gained. Often these presentations included a poster, song, or poem. It was wonderful to watch initially-shy and uncertain teenagers unfold into more-confident and very able presenters. It is difficult to stand up in front of an audience and talk; there are fears, doubts, the worry of seeming foolish etc. Yet without exception by the end of the fortnight all students had spoken out in front of the rest of us. Bravo to you All! Well done!

Certification: Each student was given a certificate for successfully completing the sea turtle course; they received such awards for each module undertaken, as well as a certificate for completing the whole Lifeskills Programme.

Turtle Rangers: Following a conversation with Retire about subsequent science lessons in his school; an idea came to develop a **'Turtle Rangers' programme.** This fits in well with the Cook Islands Turtle Project's educational outreach Aims. I will write an outline for this: the emphasis can be on gaining practical skills; using real data to understand the scientific process (Excel and statistics; Access database etc.); preparing locally-relevant materials (e.g. PowerPoints & posters) and giving talks to the local communities. I see this as a precursor to participating in a research-assistant's course; which is what I teach those that accompany me on research expeditions. Another benefit is that the 'Rangers' can record information from turtles encountered at Manihiki, and any other islands where the programme becomes established, which can then be used to better understand the distribution and abundance of sea turtles in the Cook Islands. In other words they will be making a real contribution to our biodiversity assessment. One important task is that they can note any turtles that have been previously tagged and report those identification numbers to a relevant website (e.g. www.picionline.org).

I expect that such a venture could fit within the broader Lifeskills Programmes, or the Environment and Sustainable Development (ESD) activities; thus it may attract funding from NZAID or similar sources.

I will leave the other staff advisors to make their own comments on the effectiveness of my work, but feedback during the Lifeskills fortnight was entirely positive.

Meitaki Ma'ata e Kia Manuia,

Michael ☺

Tongareva
21st September 2011

An underwater assessment of sea turtles in Rarotonga's nearshore waters

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Rhia Spall (Cook Islands Turtle Project researcher) preparing for a survey at Rarotonga

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Greg & Ian at Cook Island Divers
Air Rarotonga

Research Permit: # 07/09e (issued 07/05/2009; and extended 20/04/2010) Approved by the National Research Committee (Foundation for National Research).

Underwater assessment of sea turtles in Rarotonga's nearshore waters

Introduction

Sea turtles are known historically from the Cook Islands, but very little scientific research has been undertaken for these animals, and none recently (Balazs 1982; Pritchard 1982a; Cetacean Research Centre 2000). The archipelago covers about two million km^2 of the South Pacific Ocean with a total land-mass of 241 km^2 (15 islands or atolls); inter-island transport is infrequent.

The Cook Islands Turtle Project (CITP) was launched in 2009, as the first research endeavour of the **Pacific Islands Conservation Initiative** (www.picionline.org), in order to study marine turtles and their habitats throughout the Cook Islands; this is led by Dr Michael White (Chief Scientist of CITP).

One area of our research has been an investigation of the sea turtles that use Rarotonga's reefs and lagoons, in order to show: which species are present; when they are there; what they are doing; and if any threats exist for these endangered animals and their habitats locally. In order to produce quantifiable data on sea turtles around Rarotonga two aspects have been considered:

i) the distribution and marine ecology of sea turtle species
ii) behavioural observations

Research is undertaken throughout the year, using SCUBA-divers to report their sightings of turtles underwater. CITP's work began with **Pacific Divers** (Muri), but then, partly as an educational tool, it was extended to include other dive operators. The author and one of the researchers (Rhia Spall, BSc, University of Hull, UK) gave a short presentation to each of Rarotonga's dive schools: **Reef-to-See; Cook Islands Divers; Dive Rarotonga;** and **The Dive Centre**; each centre was asked if it would be willing to contribute their sightings to CITP's research programme; which they did: *Meitaki Ma'ata*.

The advantage of including data from all of Rarotonga's SCUBA schools is that a larger underwater area can be surveyed on any particular day. At times the dive-groups are working in the same general area; dictated by wind and sea conditions, but often we are at opposite sides of the island; which clearly means we are not seeing the same turtles at that time. All dive groups are familiar with the local marine environment and are able to identify sea turtle species underwater.

METHODOLOGY

CITP provided an Excel spreadsheet (*xls*) that included the following: depth, time, dive-site, number of turtles and species if known; survey mode (SCUBA, snorkelling, or boat). Other information could be reported (e.g. habitat description, wind, underwater visibility, wave height). The **distribution for each species** was the most important data.

Rarotonga. Image from Google Earth.

Dive-groups may use different names for the same dive-sites. Site-fidelity by individual turtles was confirmed from photographs. Divers that were interested could also report the behaviour of turtles: e.g. feeding, resting or mating.

Behavioural Codes for Sea Turtles:

UNDERWATER

Su Swimming underwater
Ru Resting underwater
Cu Crawling on the sea floor
Fu Foraging – use when turtle is searching or exploring for food
Eu Eating – try and describe the food item (not always possible)

CL Being cleaned (note cleaner spp; on sea floor or in water column)

AT SURFACE

Ss Swimming at the surface
Rs Respiration (usually only a single breath is taken; for about 0.5 seconds)
Bs Basking at surface (turtle may appear to be asleep)

RESULTS

Between 9th March and 31st December 2010 there were 158 reports made to CITP by the various dive groups (Table 1). Records were for **285 turtles** (184 greens, 79 hawksbills, 22 unidentified) from all sides of the island; some of these records are repeat sightings of previously-encountered individuals.

Table 1. A total of 285 turtles were reported by SCUBA-divers from Rarotongan waters during 2010; some of these are repeat sightings of individual animals. Species counts were: 184 green turtles; 79 hawksbill turtles; 22 unidentified. Table Legend: PD Pacific Divers; **RTS** Reef-to-See; **CID** Cook Islands Divers; **DC** Dive Centre; **DR** Dive Rarotonga; ***Cm*** *Chelonia mydas* (green turtle); ***Ei*** *Eretmochelys imbricata* (hawksbill turtle); **?** Turtle species was not confirmed.

	2010	**Turtles**		
Group	**Records**	***Cm***	***Ei***	**?**
PD	43	15	27	9
RTS	77	140	37	11
CID	14	16	5	0
DC	13	10	2	1
DR	11	3	8	1
Totals	**158**	**184**	**79**	**22**

Table 2. A further 56 turtles were reported by Reef-to-See SCUBA-divers from Rarotongan waters during 2011; some of these are repeat sightings of individual animals. Species counts were: 44 green turtles; 12 hawksbill turtles; 0 unidentified.

	2011	**Turtles**		
Group	**Records**	***Cm***	***Ei***	**?**
RTS	**32**	**44**	**12**	**0**

Table 3. Overview of the most important locations where turtles were reported from Rarotonga. The upper three rows of data are from various sites in the North, West or South; the lower three rows are the passages in Vaima'anga Lagoon: Papua, Ava'araroa, and Rutaki – these are important sites for turtles.

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

Turtles were seen all around the island, but the most important areas are reported in **Table 3**. 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 very important habitats for green and hawksbill turtles. There were another 22 incidental reports of turtles. Altogether **341 turtles** were reported: **228 greens; 91 hawksbills; and 22 unidentified**.

Size categories for turtles

The majority of turtles reported were of small or medium size. The larger sizes were rare: 12 'big' green turtles (sex unspecified); 2 adult female hawksbills and four adult male hawksbills; it is possible that some of these were repeat sightings: for instance, an adult male hawksbill was seen at '*Paradise buoy'* on two occasions; it may have been the same turtle, but photographs were not taken.

Threats and impacts

No serious threats have been reported; the extent of aquatic pollution in Muri Lagoon is yet to be determined and will be discussed elsewhere (www.picionline.org).

Left. Adolescent male green turtle: resident at Papua Passage for many months.

Photo: Michael White 2009

Right. Hawksbill seen regularly near to Avarua. A small head scale was easily identifiable.

Photo: Rhia Spall 2010

Left. Juvenile hawksbill turtle: resident at Papua Passage for many months. There is a distinctive notch in the carapace margin.

Photo: Michael White 2009

Right. ‘*Jeremy*’ Hawksbill seen regularly at ‘Edna’s Anchor’. Facial and head scales can give positive re-identification.

Photo: Rhia Spall 2010

Discussion

These initial records show that marine turtles are regularly encountered in Rarotongan sea areas; and we can now confirm the presence of both green and hawksbill turtles locally throughout the year. This is an important finding (Maison *et al*. 2010; Woodrom Rudrud 2010; White 2011).

There is no doubt that a far more comprehensive assessment has been achieved with the sightings reports from all of Rarotonga's commercial dive-operators. It is appreciated that data-collection is not the primary concern for dive-schools, nonetheless, the information that they have reported has been reliable, and all groups were able to identify both turtle species underwater. By working co-operatively we have investigated most of the island's habitats in a short period of time; effectively acting as a large research team. These reports of turtles being present at various dive-sites concur with CITP's research findings from those same sites; with the passages being of particular importance (White 2011). '**Reef-to-See'** deserve special commendation for their efforts; they have reported data in every month since March 2010. *Meitaki Ma'ata*.

Our results so far show that at Rarotonga we appear to have a ratio of just over **2 green turtles: to 1 hawksbill** [67% green turtles; 27% hawksbills; 6% could not be identified (low visibility or too far away)]. This is similar to the author's Papua Passage study [91 *C. mydas*; 27 *E. imbricata*; 5 unidentified; White 2011]. The many sightings of hawksbill juveniles are most encouraging as there are fears that the hawksbill is close to becoming extinct in the Eastern Pacific. So the Cook Islands has an excellent opportunity to support these critically-endangered animals; which in turn will benefit the South Pacific region by acting as a reservoir for this species.

Most of the turtles encountered underwater locally have been juveniles or adolescents, which, if we link this to the lack of suitable nesting-beaches around Rarotonga, suggest that reproductive animals probably will be elsewhere in the archipelago (White 2011).

Not all dive-groups report behavioural observations, but the data show that turtles are indeed sub-surface animals, and many of the reports are of swimming turtles; although resting and feeding were also observed occasionally. These observations will be added to other records and reported at a later date. Photographic evidence is important for proving that a particular animal utilises the same site regularly; we need more data for this.

The next phase for CITP is to improve our data collection methods. One suggestion is to include an online-reporting system; dive-groups will be canvassed for their opinions. Divers are encouraged to participate in this research by contributing their turtle sightings to CITP. A particular objective is to gain a better understanding of the size-classes that are present (categorising them as: small, medium and large is still adequate for our purpose). Reports of adult-sized turtles, both males and females, will allow us to gain an understanding of reproductive potential: in other words, just how endangered are sea turtles in the Cook Islands? Reproduction is possible if mature animals are present; their absence forces us to search further afield.

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On behalf of the Cook Islands Turtle Project and Pacific Islands Conservation Initiative I would like to thank everyone who contributed to this research programme.

With kind regards,

Michael

Omoka
Tongareva

THE BOAT SHED

Bar & Grill

Aitutaki