The Sea Turtle Resources of the Cocos (Keeling) Islands, Indian Ocean

Year 7: 2006

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BIOMARINE INTERNATIONAL

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This project was conducted under a contract with Parks Australia North. Research was conducted under approval from the Animal Ethics Committee at the Charles Darwin University. Several reports on previous research have been submitted to and accepted by the Charles Darwin University Animal Ethics Committee. All photos are by Scott Whiting unless otherwise credited.

Cover: Green turtle hatchling – North Keeling Island

CONTENTS

INTRODUCTION

This is the seventh year of sea turtle research at Cocos (Keeling) Island. In 2006, catch numbers of foraging turtles was increased to ensure more recaptures of previously tagged turtles and also build a larger base of tagged turtles for future years. Additional time was spent on North Keeling Island in 2006 to investigate numbers and nesting success of nesting green turtles. The research at Cocos (Keeling) Islands is achieving results that contribute to the Marine Turtle Recovery Plan (2003). The Cocos (Keeling) Islands are listed as important habitat for marine turtles in the Draft Recovery Plan for Marine Turtles (2005) which will supersede the 2003 plan. This research is also contributing to achieving the objectives of the Indian Ocean Sea Turtle Memorandum of Understanding (IOSEA). Some preliminary results will be presented at the 26th Annual Sea Turtle Symposium in Greece in April 2006.

The aims of this study were similar to previous years.

The detailed aims of the study this year were to:

- Continue with the mark-recapture study on the southern atoll with the long-term goal of estimating population size
- Catch a sample of turtles to continue with the assessment of species composition and size structure
- From the captured sample, obtain growth rates from previously tagged turtles
- Continue studies of the nesting turtles on North Keeling
- Collect genetic material from nesting female turtles

The existing project was linked with a project funded by Natural Heritage Trust that used satellite tracking to identify movements of green turtles from their nesting beach on North Keeling. This project will be referred to here but detailed results will be presented in a report produced in June 2006.

METHODS

Research methods were similar to those used in previous years but have been summarised below for conciseness (see Whiting 2004a for details).

Foraging Turtles

Capture

All turtles were captured using the turtle rodeo method (Limpus, 1978) (Figure 1 & Figure 2) in Sectors 5-7 and Sectors 12-13 using a 3.4m dinghy (map Figure 3). Most turtles were brought aboard for measuring and weighing. Large green turtles (over 70 cm curved carapace length) were too heavy to take aboard the small dinghy and were tied to the gunwale of the vessel so they could be tagged and weighed (Figure 4 & Figure 5). Sectors 15 and 18 were investigated as potential capture sites.

Figure 1 The rodeo method of capture

Figure 2 The rodeo method of capture. A green turtle is shown in the yellow circle

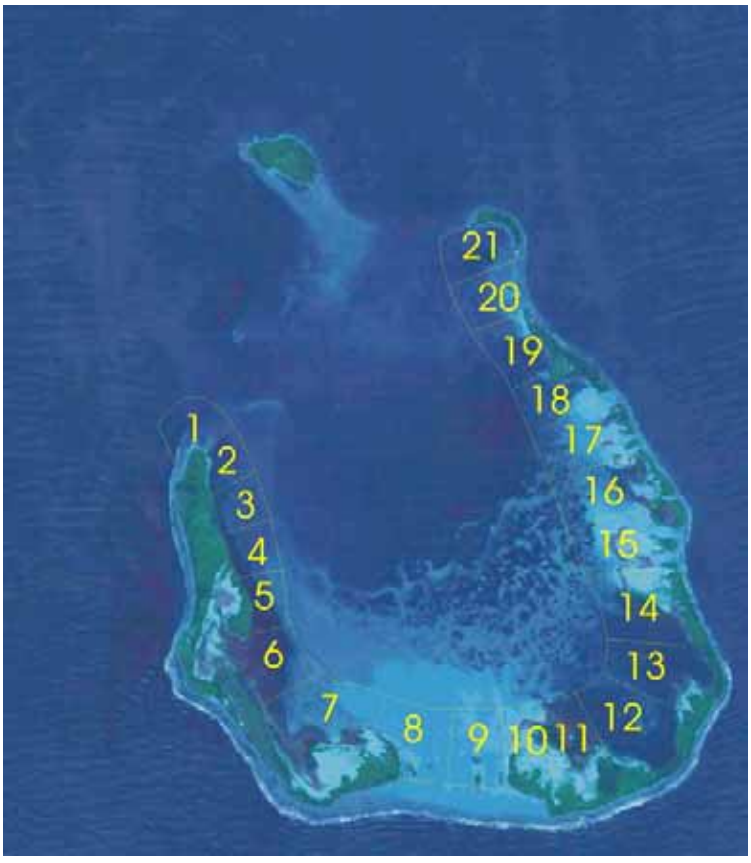

Figure 3 SPOT Image of the southern Atoll of the Cocos (Keeling) Islands. The catch Sectors are marked in yellow. This image is used with permission from Department of Transport and Regional Services (DoTRS).

Figure 4 Capture of an adult sized green turtle in sector 6

Figure 5 An adult sized green turtle is held alongside the dinghy for under 10 minutes to allow tagging, measuring and a skin sample to be taken.

Tagging

Titanium tags weighing 4.1 g each, were applied to the axial scale of each front flipper (Limpus, 1992). Recaptured turtles from previous years were checked for any injuries sustained from tags.

Measurements

Measurements of turtles were conducted using standard procedures (Limpus and Reed, 1985). All curved measurements were taken using a flexible fibreglass tape. For green turtles, the curved carapace length (ccl) was measured from the anterior of the nuchal scale, along the mid-line of the carapace to the posterior notch between the two post-central scales. For hawksbill turtles, the curved carapace length was measured to the end of the longest post-central scale. Curved carapace width (ccw) was measured at the widest part of the carapace. Both ccl and ccw had an error of less than +/-0.5 cm. The tail length of large turtles was measured from the carapace to the tip of the tail. Turtles were weighed using a 100 kg (+/-0.5kg) hanging clock-face scale. Small turtles were supported using a rope around each front flipper while large turtles were supported using two ropes around their body. Smaller turtles were either processed in the boat or brought ashore (Figure 6). Large green turtles were tied to the outside of the boat and processed in the water because it was too unsafe to bring them inside the small dinghy (Figure 5).

Figure 6 Several turtles kept in the shade while they are tagged and measured.

External Examination

Each captured turtle was examined externally for damage, condition and commensals. Weak turtles were recorded in poor condition if they had low body weight, sunken plastron, sunken eyes or were weak. Turtles were examined for fibropapilloma growths that effect turtles in other study sites around the world.

"New Recruits" into the population were recorded as those with distinct external characters which indicated a long period in the open ocean. These included lack of fouling from invertebrate organisms and marine algae, white plastron and a distinct colour difference between the skin on the ventral and dorsal parts of the shoulder.

Growth rates

The main measurement for growth studies of turtles is either the curved carapace length (ccl) or the straight carapace length (scl), both of which can be estimated from the other. At Cocos Islands, growth rates of sea turtles were measured using cm ccl/ year. Turtles with damage to the carapace that could affect the measurements were not measured. Only growth rates with time intervals of over 11 months were used for analysis

Population Estimates

Population estimates were calculated using mark-recapture data. These results must be considered preliminary because of the limited number of recaptures. Several methods can be used to estimate population sizes with mark-recapture data, however this preliminary analysis was conducted using Jolly-Seber analysis (Caughley, 1977) and was calculated using Krebs/Win Software (Krebs and Brzustowski, 1998).

SCUBA

Observations were also conducted during two dives. Dives were conducted offshore from North Point, West Island and near Direction Island.

Community Observations

Observations from community members were recorded and are listed.

Nesting Turtles

North Keeling Island

A four day visit was made to North Keeling Island to attach satellite transmitters to nesting female turtles as part of an additional sea turtle project through Natural Heritage Trust. The North Beach on North Keeling was surveyed during three nights (16, 17 and 18 Jan 2006). An initial survey was conducted on the afternoon of 16 January 2006 to count fresh tracks from the night of 15 January 2006 and record tracks previous to this as old tracks. Patrols of the beach were made for at least eight hours each night to intercept nesting green turtles for the tracking project. Once a turtle track was discovered, researchers would follow the track up the beach and stay

out of sight of the turtle until it had finished nesting or was leaving the beach after a failed nesting attempt. At this time the turtle was tagged, measured and a small skin sample (0.5cm by 0.3cm) was taken. Transmitters for the NHT project were attached after this time.

Southern Atoll - South Island

A patrol of the southern beaches of South Island was conducted to estimate nesting activity and to retrieve the temperature data loggers positioned in nesting habitat in 2005.

Sand Temperature Loggers

In 2005, temperature loggers to measure sand temperature were placed in shaded and unshaded locations on North Beach of North Keeling Island and the southern beach of South Island at two depths (10cm and 50cm below the surface).

Table 1. Specific Locations of Loggers

Beach	Logger Type	Location	Notes
North Keeling	Shaded	10° 31.286'/105° 40.509'	Loggers attached to a large coconut tree using white VB cord
North Keeling	Exposed in Sun	10° 31.285'/105° 40.511'	Loggers attached to a large coconut tree using white VB cord
South Island	Shaded	12° 12.04' / 096° 54.02'	Loggers attached to a tree using VB cord
South Island	Exposed in Sun	12° 12.04' / 096° 54.02'	Loggers attached to a tree using VB cord

Figure 7. Temperature loggers attached to a tree using VB cord in 2005.

RESULTS

Foraging Turtles

Capture Data

In 2006, 261 turtles were captured. This comprised 125 (51.0%) green and 120 (49.0%) hawksbill turtles (Table 2).

Table 2 Number of each species captured in each year

	Greens	Hawksbills	Total
1999 (Mar)	36 (76.6%)	11 (23.4)	47
2000 (Nov)	47 (47.5%)	54 (53.5%)	101
2002 (Feb)	45 (29.0%)	105 (70.0%)	150
2003 (Jan)	67 (41.4%)	95 (58.6%)	162
2004 (Jan)	53 (34.4%)	101 (65.6%)	153
2005 (Jan)	68 (40.7%)	98 (59.3%)	167
2006 (Jan)	125 (51.0%)	120 (49.0%)	245
Total	438 (42.8%)	584 (57.2%)	1022

Most turtles were captured in two areas Area 1 (Sectors 5, 6 & 7) and Area 2 (Sectors 12 & 13). A full break down of catch by sectors is shown in Table 1. Individual sectors had different species ratios (Table 3 & Figure 8). Area 1 (Sectors 5,6 & 7) had a higher percentage of green turtles (62%), while Area 2 (Sectors 12 & 13) had a higher percentage of hawksbill turtles (65%) (Table 4).

Table 3 Summary of Species Composition by Sector and year

Year	Species	Sector						Sub Total	Total
			Area 1			Area 2			
		2	5	6	7	12	13		
1999	G	1 100%		31		4		36	47
				81.6%		50%		76.6%	
	H			7		4		11	
				18.4%		50%		23.4%	
2000	G			39		8		47	101
				60%		40%		46.5%	
	H			26	6	12	10	54	
				40%	100%	60%	100%	51.5%	
2002	G		1	31		13		45	150
			16.7%	46.3%		20.3%		30.0%	
	H		5	36		51	13	105	
			83.3%	53.7%		79.7%	100%	70.0%	
2003	G		1	52		10	4	67	162
			100%	63.4%		27.0%	9.5%	41.4%	
	H			30		27	38	95	
				36.6%		73.0%	90.5%	58.6%	
2004	G			33	1	15	4	53	154
				54.1%	100%	18.5%	36.4%	34.4%	
	H			28		66	7	101	
				45.9%		81.5%	63.6%	65.6%	
2005	G		3	48		11	6	68	166
			100%	54.5%		20.7%	25%	41.0%	*
	H			40		42	16	98	
				45.5%		79.3%	75%	59.0%	
2006	G		5	78		29	10	122	242
			100%	60.9%		35.4%	40.0%	51.0%	#
	H			50	1	54	15	120	
				39.1%	100%	64.6%	60.0%	49.0%	
Total	G	1	10	312	1	90	24	438	1022
		100%	66.7%	58.9%	12.5%	35.1%	19.8%	42.9%	
	H		5	217	7	256	99	584	
			33.3%	41.1%	87.5%	64.9%	80.2%	57.1%	

*Plus one hawksbill was captured in Sect 11.
#Plus three green turtles captured in Sect 18.

Table 4 Species Composition by Catch Area

	Species	Area 1 Sect 5, 6 & 7	Area 2 Sect 12 & 13
1999	G	31 (81.6%)	4 (50.0%)
	H	7 (18.4%)	4 (50.0%)
2000	G	39 (54.9%)	8 (26.7%)
	H	32 (45.1%)	22 (73.3%)
2002	G	32 (43.8)	13 (16.9%)
	H	41 (56.2%)	64 (83.1%)
2003	G	53 (62.5%)	14 (17.7%)
	H	30 (37.5%)	65 (82.3%)
2004	G	34 (54.8%)	19 (20.7%)
	H	28 (45.2%)	73 (79.3%)
2005	G	51 (56.0%)	17 (40.4%)
	H	40 (44.0%)	59 (59.6%)
2006	G	83 (61.9%)	36 (35.6%)
	H	51 (38.1%)	65 (64.4%)
Total	G	341 (59.8%)	139 (28.2%)
	H	229 (40.2%)	354 (71.8%)

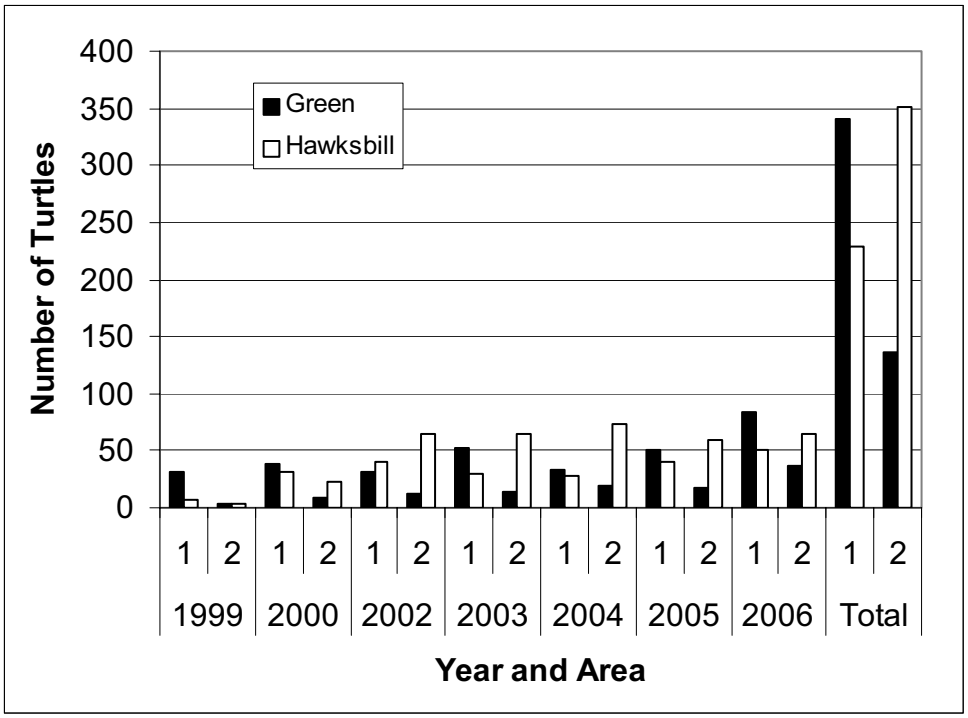

Figure 8 Species Composition by Year and Area

Percentage of Recaptures

Two graphs are shown below which describe the proportion of recaptures to total captures. Figure 9 shows the percentage of recaptures from the total captures for each year individually. For 2006, the proportion of recaptures increased for both green and hawksbill turtles at South Island, although hawksbill recaptures at West Island showed an proportional decrease. It is expected that the increase in total catch in 2006 will increase the recaptures in 2007 in both areas. Figure 10 shows the cumulative recapture rate as a percentage of the overall catch. For example, hawksbill turtles at South Island had a recapture percentage of 25% for 2006 but overall (cumulative) the recapture percentage was around 14%. The proportion of hawksbill recaptures at West Island is above 30%. Additional turtles captured and tagged in 2006 should increase the recapture percentages for green turtles in subsequent years.

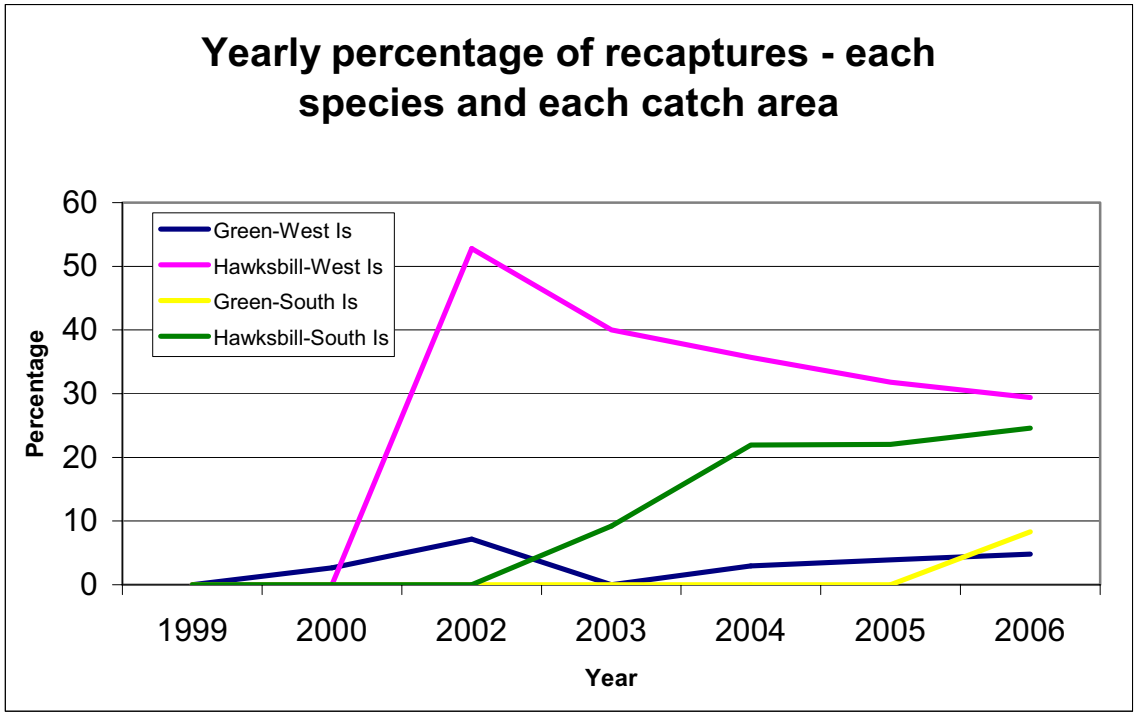

Figure 9 The yearly number of recaptures as a percentage of the yearly total captures.

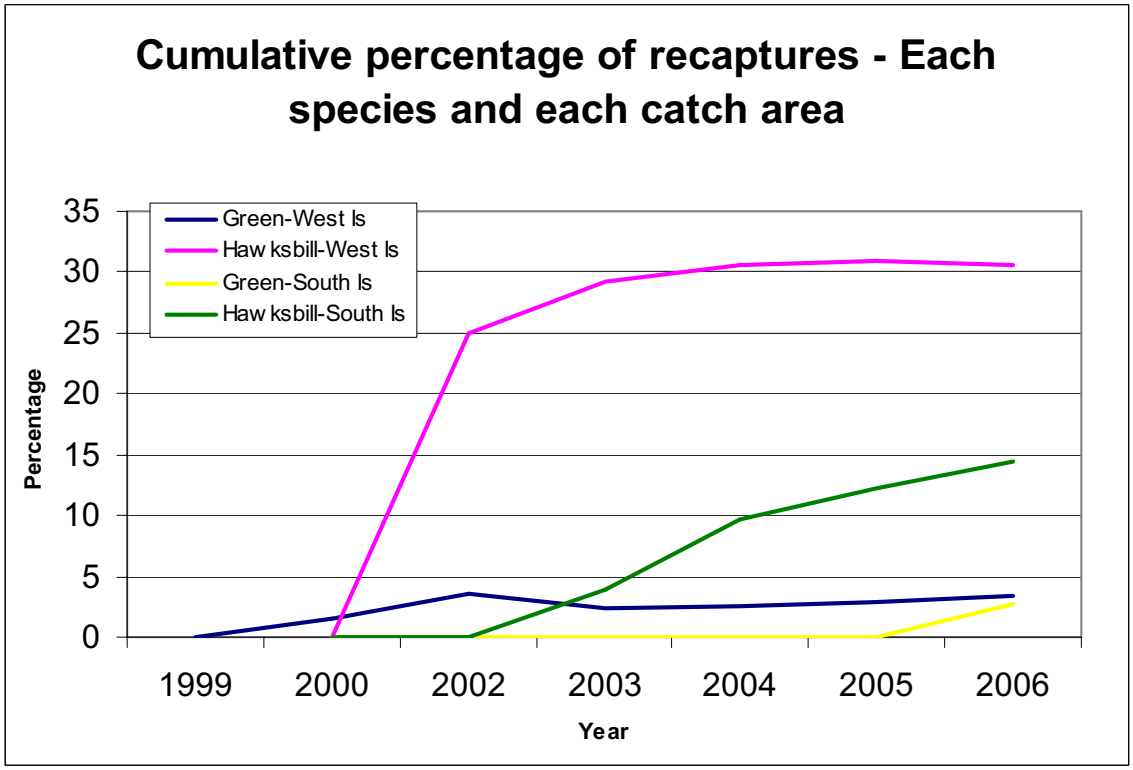

Figure 10 The cumulative number of recaptures as a percentage of the cumulative total captures.

Figure 11 Green turtle ready for release

Size Composition

Capture

In 2006, green turtles ranged in size from 35.5 to 109.5 cm ccl (mean=57.6, sd=14.7, median=55.1, n=125). The size frequency histogram (Figure 12) shows two distinct modal groups, one includes smaller juveniles and the other includes adult sized turtles.

Hawksbill turtles ranged in size from 33.0 to 86.3 cm ccl (mean=58.8, sd=14.3, median=62.1, n=120). The size frequency histogram (Figure 13) shows that most turtles were in the 40 to 80 cm ccl size classes.

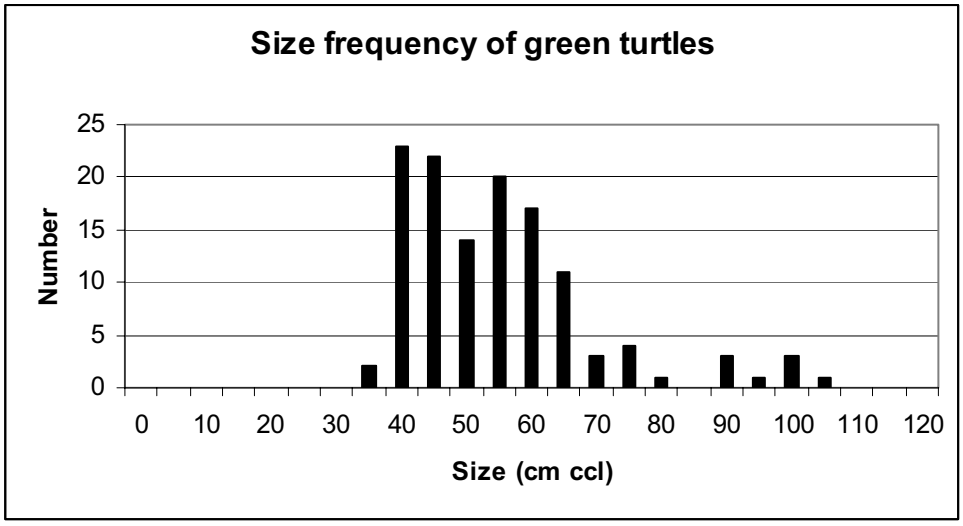

Figure 12 Size class frequency of green turtles - 2006

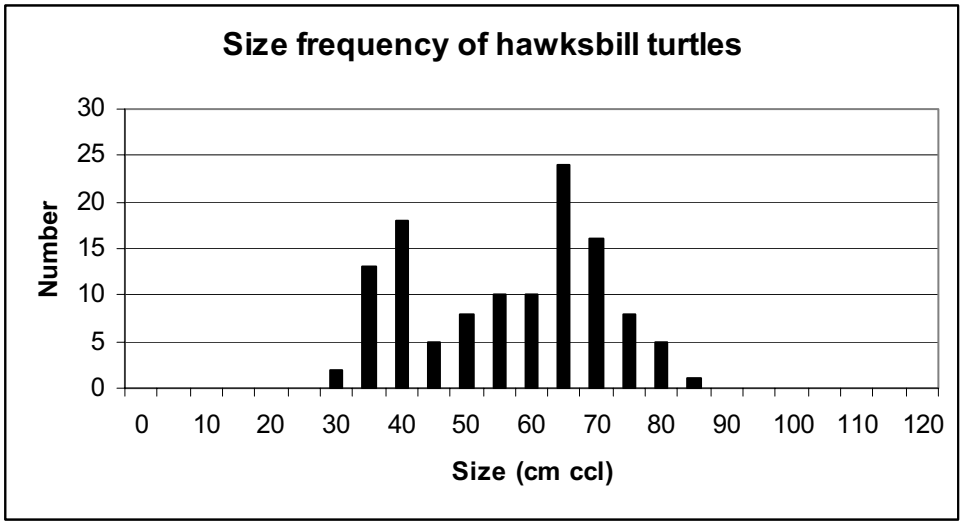

Figure 13 Size class frequency of hawksbill turtles - 2006

Size Structure Between Areas

The West Island catch area (Area 1) generally contained larger individuals of both species than the South Island catch area (Area 2). For green turtles, Area 1 contained both adult and juvenile sized turtles while area 2 contained only immature sized turtles (see Table 5). For hawksbill turtles, both areas contained both adult and juvenile sized turtles although adult sized turtles were more common in Area 1.

Table 5 Size of green and hawksbill turtles by Catch Area

Species	Area	Mean	Median	sd	Range	n
Green	1 West	60.0	58.1	16.8	35.5-109.5	83
	2 South	52.1	51.8	7.3	39.1-66.4	39
Hawksbill	1 West	67.7	68.9	10.3	39.0-86.3	51
	2 South	52.2	50.1	13.2	33.0-83.3	69

Community Sightings

One community report was submitted during the sea turtle surveys in 2006. The report [with photograph attached (Figure 14)] was by Karen Wilshaw (Undersea Reflections). This is the first photographically confirmed sighting of a loggerhead (*Caretta caretta*) turtle at Cocos (Keeling) Islands.

Figure 14. A loggerhead turtle (*Caretta caretta*) observed and photographed by Karen Wilshaw Undersea Reflections www.undersearefleections.com

Growth Rates

In 2006, growth rates were obtained for seven green turtles and 31 hawksbill turtles. These growth rates have been added to previous growth data to provide a total summary of growth rates in different size classes. A summary of growths rates for each 10 cm size class is presented in Table 6 & Table 7.

In 2006, like other years, there were fewer recaptures of green turtles than hawksbill turtles. However, in 2006 a higher percentage of green turtles were recaptured than in any other year. Seven green turtles growth rates were obtained from recaptured individuals. This is more than redouble the recapture rate from 2005. Combining all years, green turtles had a mean growth rate of 6.7 cm ccl/yr for 14 turtles within the size range of 40 to 80 cm ccl. The fastest individual growth rate was 9.3 cm/yr ccl (60-70 cm size class) and the slowest was 3.8 cm ccl/yr (80-90 cm size class).

In 2006, a total of 31 recaptures was made of previous tagged hawksbill turtles (25% of all captures) bringing the total growth rates obtained for this species to 114. Using all growth rates, hawksbill turtles had an overall mean growth rate of 3.6 cm ccl for turtles in the 30 to 90 cm ccl size range (n=114). The mean growth rate varied from 1.0 cm ccl (80-90 cm size class) to 6.0 cm ccl (30-40 cm size class). The fastest growth rate for an individual hawksbill turtle was 8.3 cm ccl/yr (30-40 cm size class) and the slowest was 0.1 cm ccl/yr (70-80 cm size class). Individual growth rates are shown in Figure 15 and Figure 16.

Table 6 Mean Growth Rates of Green Turtles by Mean Size Class (10cm increments) (all years)

Mean Size Class	Growth Rate cm ccl/yr			
	mean	sd	range	n
40-50	4.9	0.1	4.9- 5.0	2
50-60	7.0	1.2	5.7-8.5	6
60-70	7.5	1.8	5.7-9.3	3
70-80	-	-	-	-
80-90	3.8	-	-	1
Total	6.7	1.7	3.8-9.3	14

Table 7 Mean Growth Rates of Hawksbill Turtles by Mean Size Class (10cm increments) (all years)

Mean Size Class	Growth Rate cm ccl/yr			
	mean	sd	Range	n
30-40	6.9	1.9	3.5-8.3	5
40-50	5.2	1.3	2.0-7.1	18
50-60	4.0	1.7	0.6-7.3	38
60-70	3.2	1.2	1.4-5.8	25
70-80	1.8	1.0	0.1-3.4	23
80-90	1.0	0.8	0.0-2.0	5
Total	3.6	1.9	0.1-8.3	114

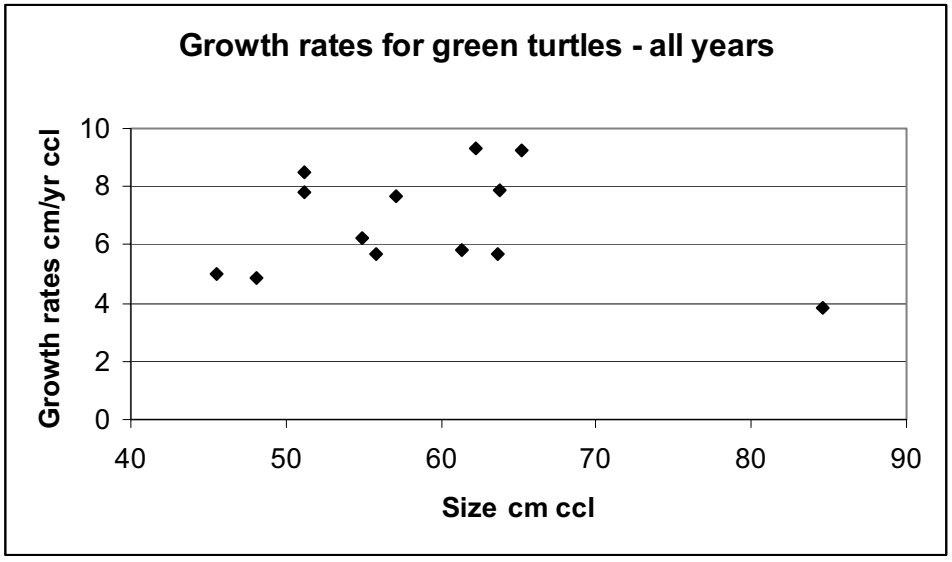

Figure 15 Individual growth rates of green turtles (Length)

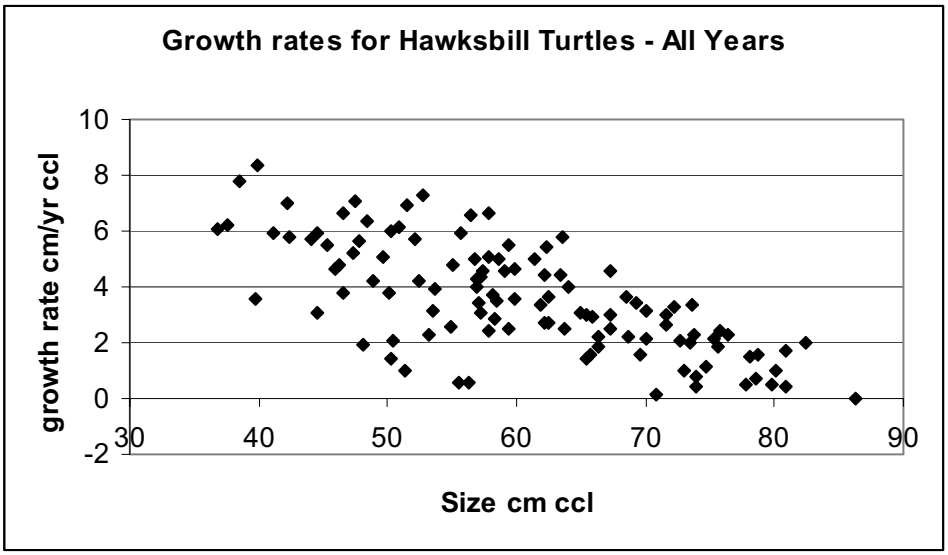

Figure 16 Individual growth rates of hawksbill turtles (Length)

Growth rates of individuals vary through and between each other. Figure 17 shows the growth rates of individual turtles through time for those with three or more captures. The steeper the slope of the line the faster the growth of the turtle and the flatter the line the slower the growth rate. It is interesting to note that growth rates varied between individuals of the same size. For example, in Figure 17, Turtle CA4401 and CA4647 were both captured on the 10 January 2002. Three years later CA4401 was 74.9 cm ccl but CA4647 took four years to reach 72.0 cm ccl. Similarly, CA4625 was smaller than CA7900 in January 2004 but by January 2006 CA4625 was 5 cm larger.

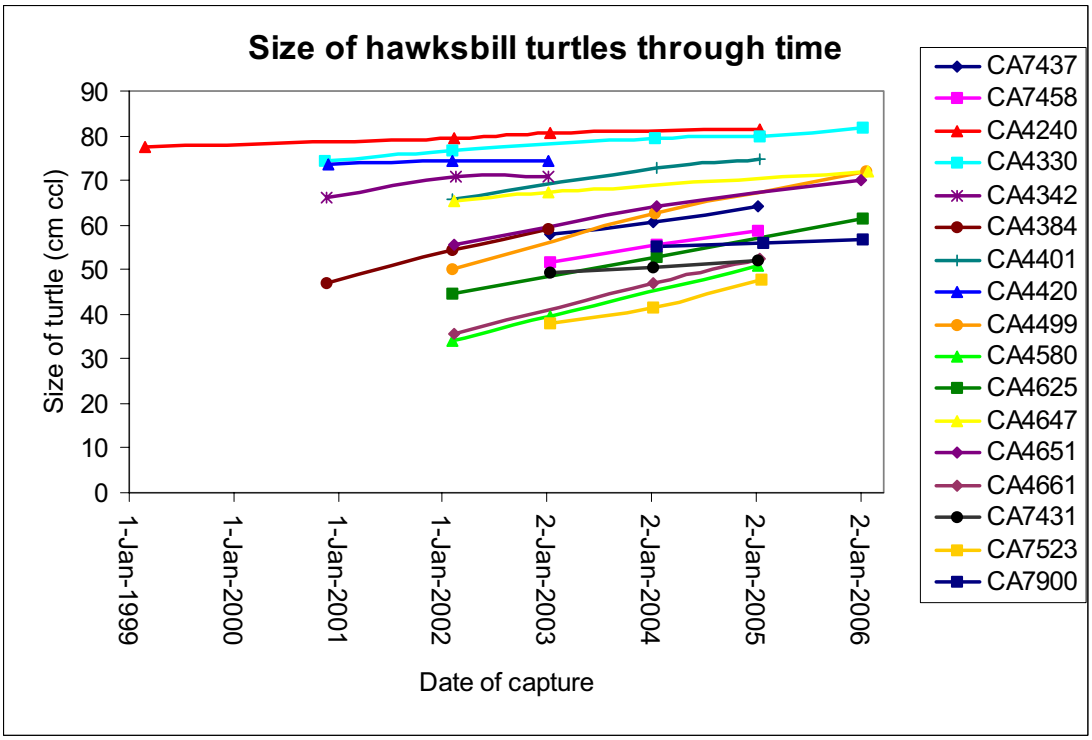

Figure 17 Size of hawksbill turtles through time. Only turtles with three or more captures are shown. Numbers represent tag numbers of turtles.

Figure 18 shows more clearly how individual turtles may have different growth rates at different size classes but also how the individual rates may be different for the norm for that size class. For example CA7431 and CA7900 showed slow growth rates for both intervals when compared to other turtles of similar size. Turtles CA4342 and CA4420 had growth rates that slowed down to near zero growth for the second interval. Turtle CA4330 showed variable growth rates over several intervals even though the size range did not change.

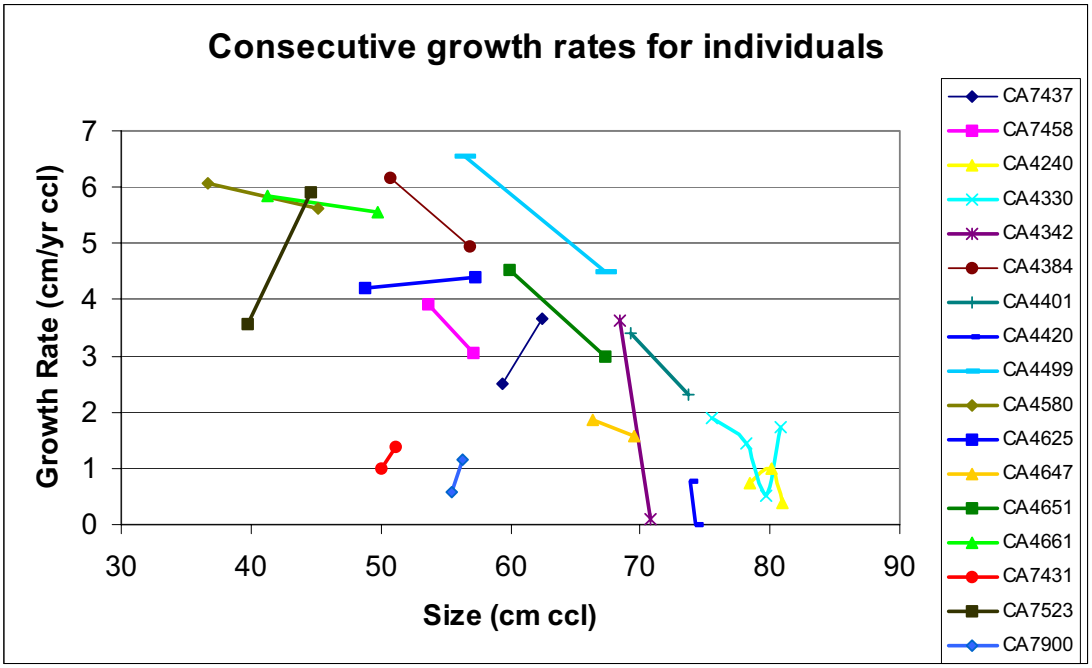

Figure 18 Consecutive growth rates of individual turtles by size.

Population Estimates

Jolly-Seber Mark Recapture

Population estimates for hawksbill turtles at South Island and West Island are shown in Table 8 & Table 9. These tables show the number of recaptures in each year and the initial year of capture. The population estimates are shown for catch Area 1 (West Island) and for Catch Area 2 (South Island) (Table 10). Using all years, the mean population estimate for West Island Catch Area (Area 1) was 406 with a density of 89 hawksbills / km^2. The South Island Catch Area (Area 2) had a mean of 410 hawksbills and a density of 85 hawksbills / km^2.

Table 8 Total captures and recaptures of hawksbill turtles in West Island sectors (Sect 5, 6 & 7)

	Hawksbills – West Island						
	Total Turtles Captured by Year						
	1999	2000	2002	2003	2004	2005	2006
	7	32	36	30	28	44	51
	1999	2000	2002	2003	2004	2005	2006
1999			14	2	0	1	0
2000			6	1	3	3	1
2002				9	7	4	4
2003					0	1	3
2004						5	5
2005							9

Table 9 Total captures and recaptures of hawksbill turtles in South Island sectors (Sect 12 & 13).

	Hawksbills – South Island						
	Total Turtles Captured by Year						
	1999	2000	2002	2003	2004	2005	2006
	4	22	54	65	73	59	65
	Year of Recapture						
	1999	2000	2002	2003	2004	2005	2006
1999				1	0	0	0
2000				0	0	0	1
2002				5	5	3	2
2003					11	7	4
2004						5	3
2005							6

Table 10 Population estimates of hawksbill turtles at West and South Island

Estimate #	Population Estimate					
	West Island			South Island		
	Min.	Estimate	Max.	Min.	Estimate	Max.
1	255	**1234**	14037	36	**265**	9038
2	53	**64**	90	86	**378**	5610
3	179	**369**	1137	191	**354**	970
4	88	**145**	324	364	**678**	1803
5	127	**218**	522	193	**374**	1119
Mean (se)	140	**406**	3222	174	**410**	3708

New Recruits

Four green turtles were classified as new recruits to the foraging population in 2006 (Table 11).

Table 11. Size range of new recruit green turtles based on external examination in the field

Year	Size of new recruit (cm ccl)			
	mean ccl	sd	range	N
1999				0
2001				0
2002	44.0			1
2003	42.2	4.15	37.9 – 46.2	3
2004	46.9	6.39	41.2 – 58.6	6
2005	43.7	1.13	42.3-45.5	4
2006	39.3	2.7	35.5-41.3	4

No hawksbill turtles were identified as new recruits from external examination. Identifying hawksbill new recruits is more difficult than green turtles because of their natural yellow colouration. In 2006, 14 of the captured hawksbill turtles were under 40 cm ccl which could provide a measure of new recruits (see discussion in Whiting 2004a).

Figure 19. New Recruit – Ventral side (Photo by A. Koch)

Figure 20. New Recruit – Dorsal side (Photo by A. Koch)

Table 12 Number of green and hawksbill turtles in the small size classes

Year	Greens		Hawksbill	
	# <45 cm ccl	% of Sample	#< 40 cm ccl	%of Sample
1999	5	13.9	0	0
2001	1	2.1	5	9.3
2002	4	8.9	10	9.5
2003	3	4.8	16	16.8
2004	9	17.0	8	7.9
2005	10	14.7	13	13.1
2006	25	10.2	14	11.7

Turtle Habitat

Below are photos of important sea turtle habitat that is in addition to the main seagrass and algal feeding habitat used by turtles in Areas 1 and 2. Figure 21 and Figure 22 show the shoreline vegetation and shallow water used by small turtles, mainly hawksbill turtles. This is most commonly used at South Island and to a lesser extent at West Island.

Figure 21 Pemphis bushes at the shoreline provide habitat for small turtles

Figure 22. Pemphis bushes that have been harvested

Figure 23 Small hawksbill turtles in shoreline habitat

Figure 24. Small hawksbill turtle tagged the previous day remains close to shoreline vegetation

Fidelity and Movements

All of the recaptured turtles were recaptured in the same sectors as their previous captures.

Health and Condition

Several turtles had injuries or deformities. A hawksbill turtle had a elongated and hooked beak as well as a curved plastron and carapace (Figure 25, Figure 26, Figure 27 & Figure 28). One small hawksbill turtle 41.3 cm ccl was recorded as in very poor condition with sunken plastron and no fat reserves. This turtle looked in good condition and had normal body condition around the limb girdles. Five turtles (two green and three hawksbill turtles) had damage to their carapaces consistent with being struck by a propeller or skeg of a boat. One green turtle had a partially healed carapace that still had bone missing and the injured area was still made up of soft fleshy skin (Figure 29). One hawksbill turtle had evidence of a skeg mark across the carapace (Figure 30). One green turtle had four partially healed lacerations across the carapace that that was consistent with being hit by a rotating boat propeller.

One sick turtle was also recorded by PAN staff two weeks after the survey period. This turtle was floating which is a symptom of several conditions such as internal parasites, blockages and bacteria (Figure 31).

Figure 25. Hawksbill turtle with unusually long curved beak

Figure 26. Hawksbill turtle with flat chiselled beak

Figure 27 Hawksbill turtle showing curved domed carapace

Figure 28 Hawksbill turtle showing curved plastron

Figure 29 Green turtle with damage from a propeller or prop of an outboard motor. This is one of four turtles with this type of damage in 2006.

Figure 30 Hawksbill turtle with damage from a propeller or prop of an outboard motor. This is one of four turtles with this type of damage in 2006.

Figure 31 Floating turtle reported by Ismail Macrae and Mohammad Chongkin PAN in Feb 2006.

Genetic Analysis

Genetic samples were taken from 53 foraging green and 41 foraging hawksbill turtles.

SCUBA

Two dives were conducted on 26 Jan 2006. The first dive site was at North Point, offshore from West Island. This was a short dive (30 min) because of strong currents. One adult-sized green turtle was observed. The second dive was north of Direction Island. No turtles were sighted. This is the location where a single male dugong is regularly observed. During this 60 minute dive the dugong approached the divers to within 2 m before surfacing for air. It remain outside of the range of visibility but could the high pitched squeals could be heard for the remaining 20 minute of the dive.

Figure 32 Reef habitat at North Point – 15 m

Figure 33Reef habitat at North Point – 15 m

Other foraging areas investigated

Other foraging areas were investigated during this field trip. Three green turtles were captured off the south end of Home Island (Sector 18). On this catch day this area supported at least 10 individuals in the 50-70 cm ccl size range where they aggregated in deep channels at low tide (Figure 34 & Figure 35). Sector 15 was also checked for foraging turtles and had fewer turtles than is normally seen in the Sector 13 catch area. Five green turtles and two hawksbill turtles were seen. Sector 15 had similar habitat but less area of seagrass and algae (Figure 36 & Figure 37). The outer reef flat and reef edge are difficult habitats to sample because of rough sea conditions and navigational hazards. On the western edge of West Island, green turtles are commonly seen in the evening at high tide foraging within 50 m of shore. Similarly, during a rising tide on the southern side of South Island a juvenile hawksbill turtle was seen swimming close to shore (Figure 38).

Figure 34 Foraging habitat for green turtles Sector 18 Home Island

Figure 35 Foraging habitat for green turtles Sector 18 Home Island

Figure 36 Sector 15 was checked for foraging turtles

Figure 37 Sector 15 was checked for foraging turtles

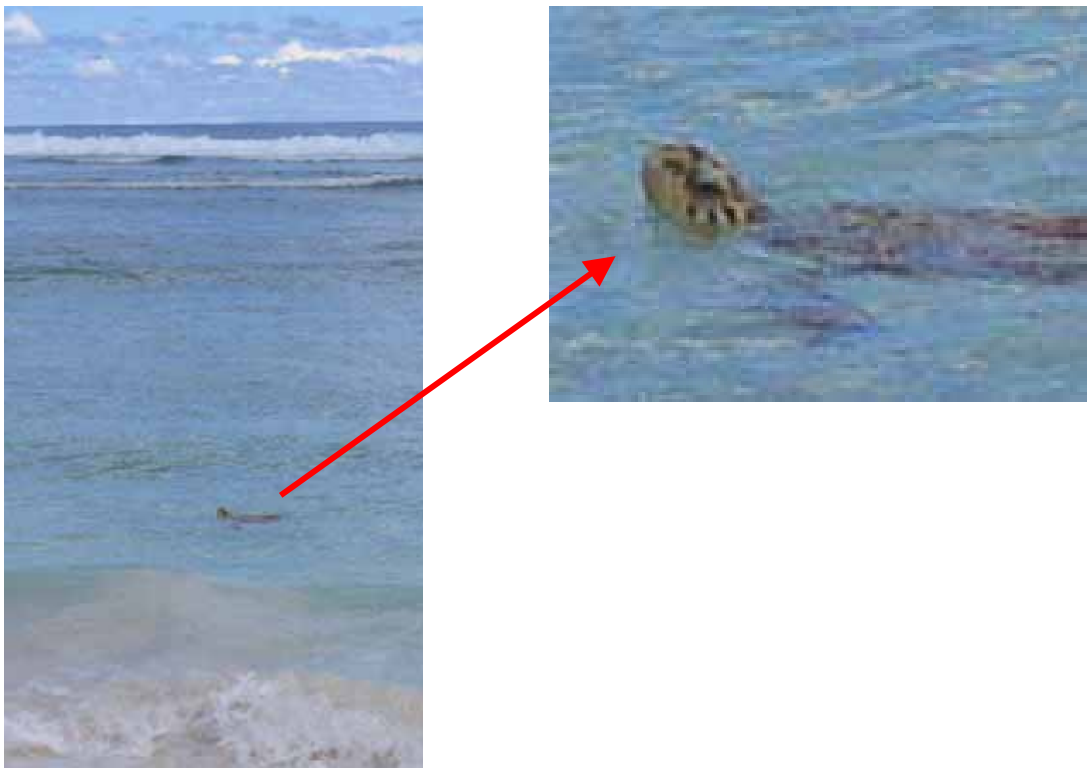

Figure 38 A hawksbill turtles on the windward reef flat of south Island. This habitat has not been sampled. Movement studies will determine whether turtles move in and out of the inner lagoon

Photographs of Historical Sea Turtle Wall

A coral wall constructed in the 1940's to hold sea turtles is still visible today. This wall was used to hold turtles until they were needed and was also used as an attempt to farm turtles. Reports also indicate that turtles were brought in from Malaysia.

Figure 39 An aerial photograph taken in 2005 shows the location of the remaining wall located south of the existing Home Island Jetty. Yellow arrows indicate the location of the wall.

Figure 40 The remaining wall photographed at low tide in January 2006

Figure 41 The remaining wall photographed at low tide in January 2006

Nesting Turtles

North Keeling Island

Three nights were spent on North Keeling Island. Together with the initial track counts this provided four nights of counts for the island (Table 13). A total of 48 fresh tracks were observed over the four nights. For the three days that researchers were present on the island this consisted of 38 tracks with 11, ten and eight individuals each night. The number of new, recaptured and missed turtles for each of the surveyed nights is shown in Figure 42. This shows that turtles that were unsuccessful in their nesting attempts returned on subsequent nights for another attempt. The nesting success of turtles is shown in Figure 43. Limited rainfall prior to January may have reduced sand moisture and also reduced the stability of sand during nest construction. Natural debris such as coconuts and palm fronds also lead to turtles abandoning their nests. A more comprehensive survey of nesting turtles is required throughout the year (see Discussion).

Photos of the nesting beach and turtles are shown in Figure 44, Figure 45, Figure 46, Figure 47, Figure 48 & Figure 49.

Table 13. Track counts of nesting green turtles at North Keeling Jan 2006

Date	Old Tracks	Fresh Tracks	Total Turtles	Nests Laid	New Turtles Tagged	Recaptured Turtles	Missed Turtles	Nests Hatched	Dead Turtles
Initial Count (15 Jan.)	35	11						2	0
16 Jan	[redacted]	13	11	1	7	0	4	2	0
17 Jan		13	10	1	2	5	6	1	0
18 Jan		12	8	1	3	2	3	0	0

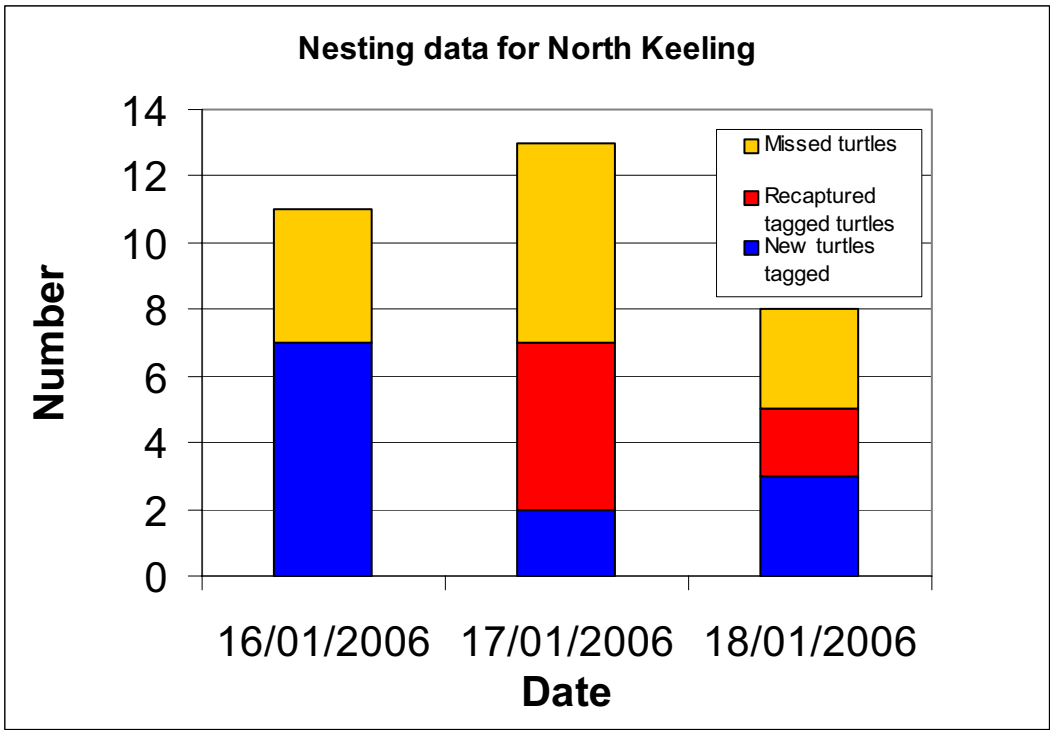

Figure 42 New, recaptured and missed turtles for each night surveyed on North Keeling in 2006

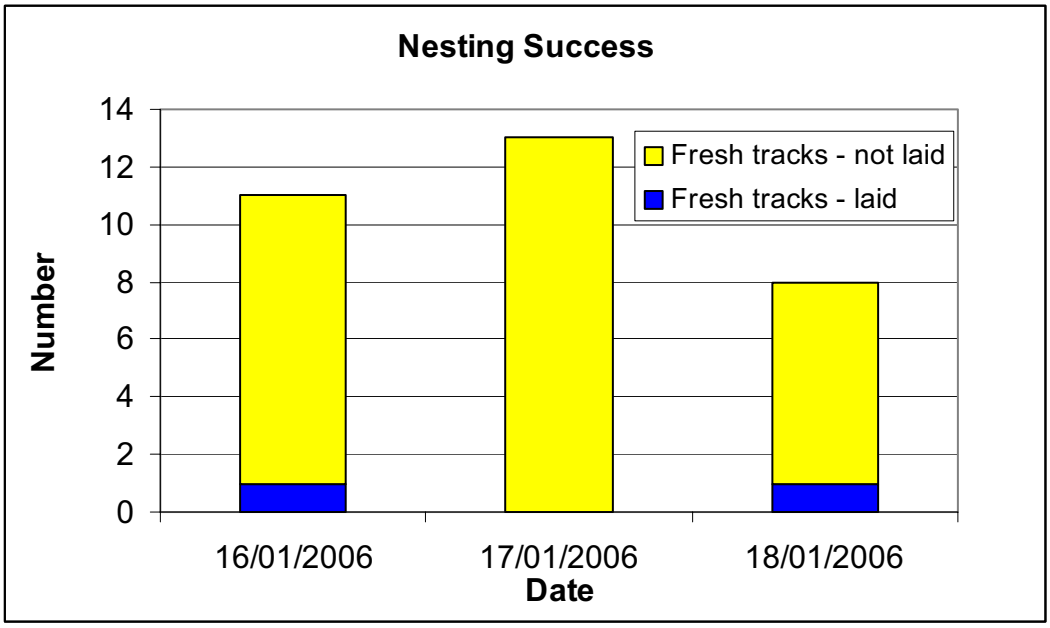

Figure 43 Nesting success of each track on the beach at North Keeling during the three nights surveyed.

Figure 44 North-west beach – North Keeling Island

Figure 45 Attaching the a satellite transmitter to a green turtle on North Keeling Island – Associated NHT project

Figure 46 Green turtle with transmitter returns to water

Figure 47 – Adult sized green turtle washed ashore at North Keeling

Figure 48 North beach, North Keeling Island – northern end bounded by rocks

Figure 49 North beach, North Keeling Island – southern end bounded by rocks

Nesting Adults

The mean size of the nesting green turtles was 108.3 cm ccl (median=108.8, sd=2.45, Range=105.4-111.8, n=11).

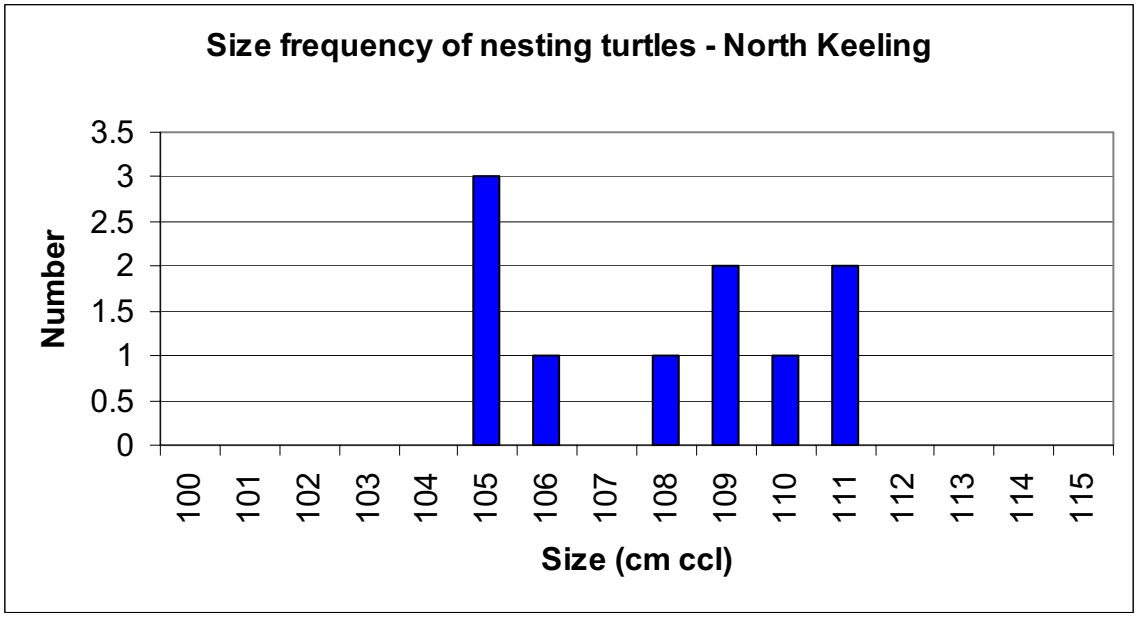

Figure 50 Size frequency of nesting turtles at North Keeling

Genetic Samples Collected

Genetic samples were collected from every nesting turtle encountered. They are listed below in Table 14. All samples were sent to Dr. Nancy Fitsimmons, University of Canberra.

Table 14 Genetic sample numbers from nesting green turtles at North Keeling Island

Prefix	Primary Tag	Prefix	Genetic Sample number	Date	Type of sample
CA	9614	N	5291	16/01/2006	Nesting
CA	9610	N	5262	16/01/2006	Nesting
CA	9587	N	62526	16/01/2006	Nesting
CA	9574	N	5280	16/01/2006	Nesting
CA	9618	N	5288	16/01/2006	Nesting
CA	9616	N	5261	16/01/2006	Nesting
CA	9585	N	5293	17/01/2006	Nesting
CA	9582	N	5284	17/01/2006	Nesting
CA	9588	N	5264	18/01/2006	Nesting
CA	9581	N	5269	18/01/2006	Nesting
CA	9579	N	5278	18/01/2006	Nesting
CA	4623	N	5279	18/01/2006	Beach washed

Hatchlings

During the initial survey of the northern Beach at North Keeling on 16 Jan 2006, two green turtle nests had hatched from the previous night. Two also hatched that night and one the next night (Figure 51 & Figure 52). In the observed hatchings the nests hatched with 30 m of the waters edge. In two observed hatched nests a Nankeen Night Heron was seen carrying a hatchling away. Ghost crabs were a major predator on green turtle hatchlings. Figure 53 shows five individuals (two with hatchlings) between the hatched nest and the water. Ghost crabs can out run a hatchling and it would be likely that all five ghost crabs would have successfully taken a hatchling had there been no observer affect (Figure 56). One hatchling from one nest was captured by a hermit crab in the natural debris of the beach (Figure 55). Hermit crabs are slower than hatchlings and they are unlikely to capture hatchlings on the open beach. However, hatchlings caught in debris may be susceptible. Natural debris can be a barrier to hatchlings trying to find the water (Figure 56).

Figure 51 Green turtle hatchling making its way to the water

Figure 52 Green turtle hatchling

Figure 53 Green turtle hatchlings making their way to the water. Arrows indicate ghost crabs, yellow arrows indicate crabs with no hatchlings and red arrows indicate ghost crabs that have attacked hatchings. In this instance, out of a nest of over 100 hatchlings, up to seven hatchlings have been or would likely to be attacked: 5 from ghost crabs and one from a hermit crab.

Figure 54 Ghost crab with green turtle hatchling – North Keeling Island

Figure 55 Hermit crab with green turtle hatchling – minutes after the nest hatched on North Keeling

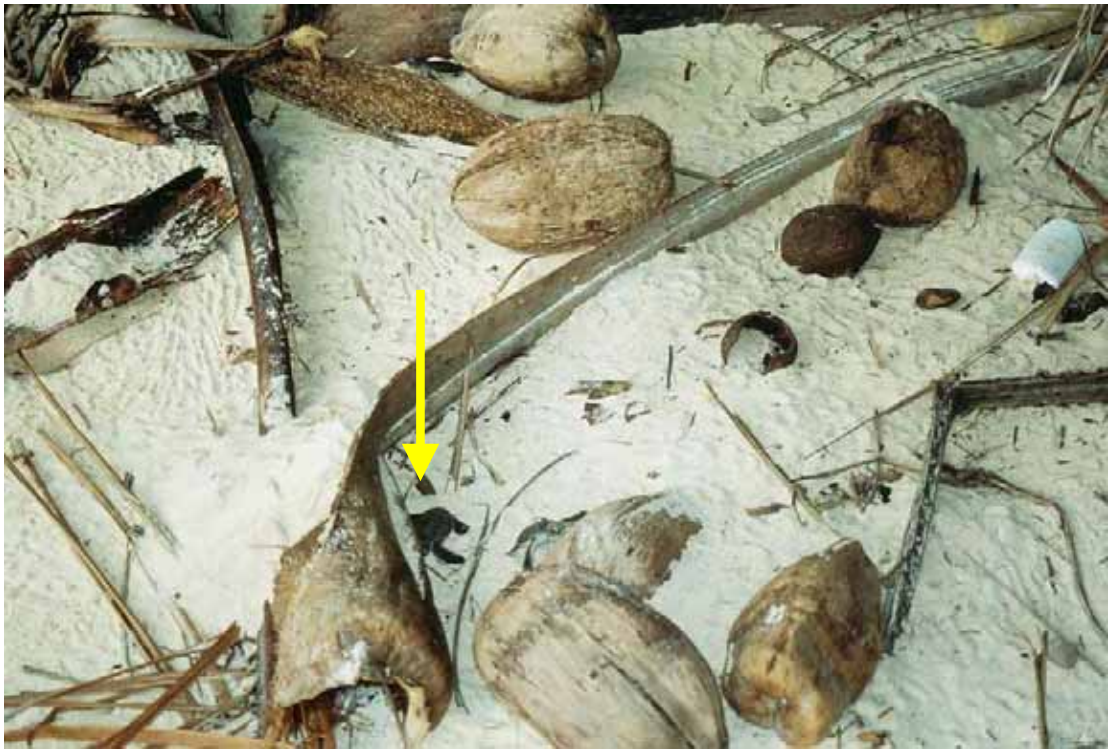

Figure 56 Green turtle hatchlings have to navigate around and over natural debris on the beach before they make it to the water.

South Island

The southern beach of South Island was surveyed for turtle nesting activity on 30 January 2006. No nesting activity was observed although body pits for nesting attempts from this nesting season were visible along the base and on top of some of the dunes (Figure 57, Figure 58, Figure 59 & Figure 60). Natural and anthropogenic debris was found accumulated in several locations along the southern beach of South Island (Figure 62 & Figure 61). Shark fishing gear with hooks and a variety of makeshift floats was found balled (Figure 64 & Figure 63).

A community report of a dead small turtle entangled in marine debris was not found, but may have re-entered the sea with high tides.

Figure 57 View of nesting habitat on South Island

Figure 58 View of nesting habitat on South Island

Figure 59 View of nesting habitat on South Island

Figure 60 Body pits of nesting green turtles on South Island

Figure 62 Natural and anthropogenic marine debris

Figure 61 Natural and anthropogenic marine debris

Figure 64 Shark fishing line with hooks and miscellaneous floats

Figure 63 Shark fishing line with hooks and miscellaneous floats

Temperature Loggers

At North Keeling, only the data loggers positioned in the shade were retrieved. The area exposed to the sun where the second set of loggers was deployed was disturbed by nesting turtles and these loggers were not found. These shaded loggers (Figure 65) show the wide fluctuations in sand temperatures at 10 cm and the more consistent temperatures at 50 cm. Sudden drops in temperatures at 50 cm may be indicative of rain events .

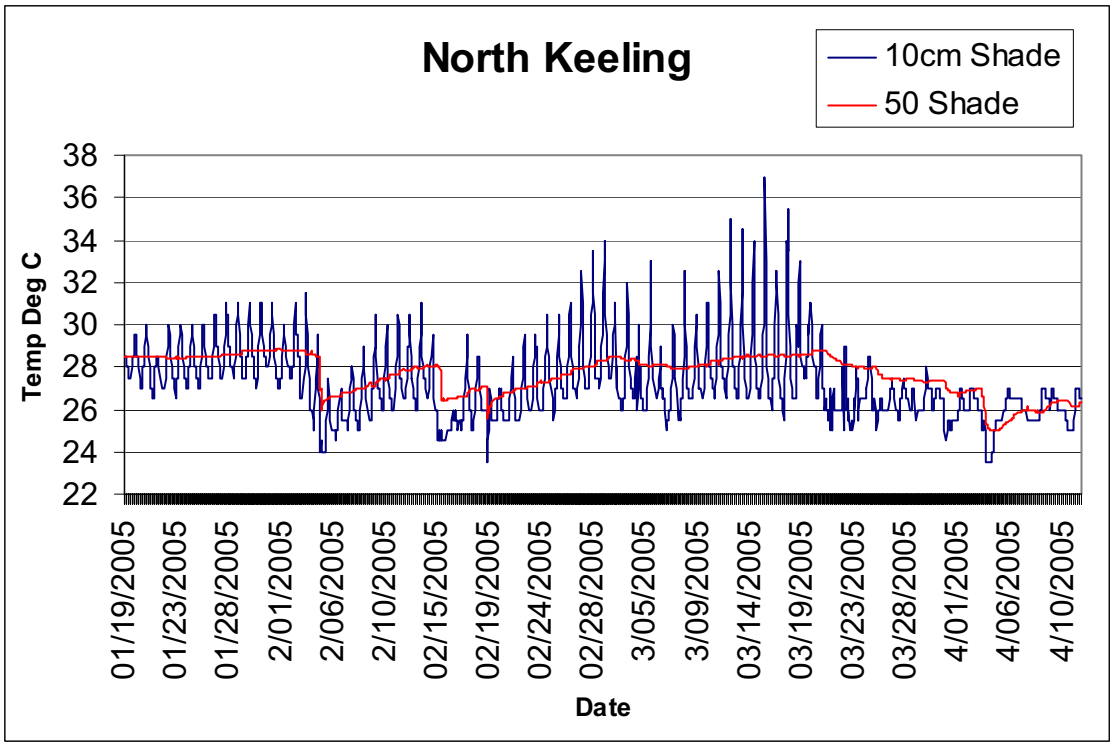

Figure 65 Sand temperatures (Shade) at North Keeling Island Jan-April 2006

Sand temperatures at 50 cm were compared between North Keeling and at South Island (Figure 66). These showed that North Keeling (shade) was cooler than South Island (shade and sun) in mid and late February. A cooling also occurred on 5 April 2005. These cooler temperatures were probably caused by rain events during these periods that were not experienced by the southern atoll. A comparison of sand temperatures between the shaded and sun exposed sites at South Island showed that the shaded site stayed about 0.5 deg C cooler than the sun exposed site.

A comparison between sand depths at the shaded site at South Island shows the temperature buffer that the sand provides to eggs laid at depths of 50 cm (Figure 67). Around the 22 March 2005 a cooling event caused the sand surface temperature to drop below the temperature at 50 cm for about one month. It is also interesting to note that at North Keeling the sand surface at 10 cm (shade) reached temperatures much higher than at South Island. This difference is most likely cause by South Island being exposed to south easterly winds as opposed to the beach at north Keeling that faces north-west.

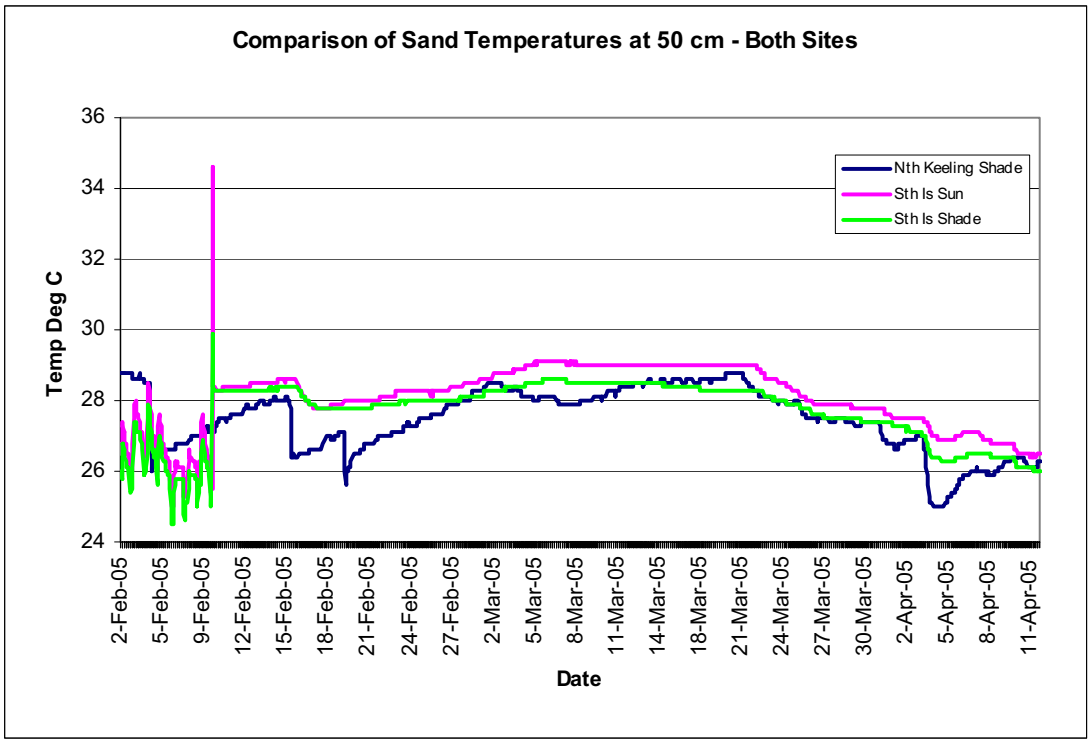

Figure 66 Comparison of sand temperatures at 50 cm for North Keeling Island and South Island.

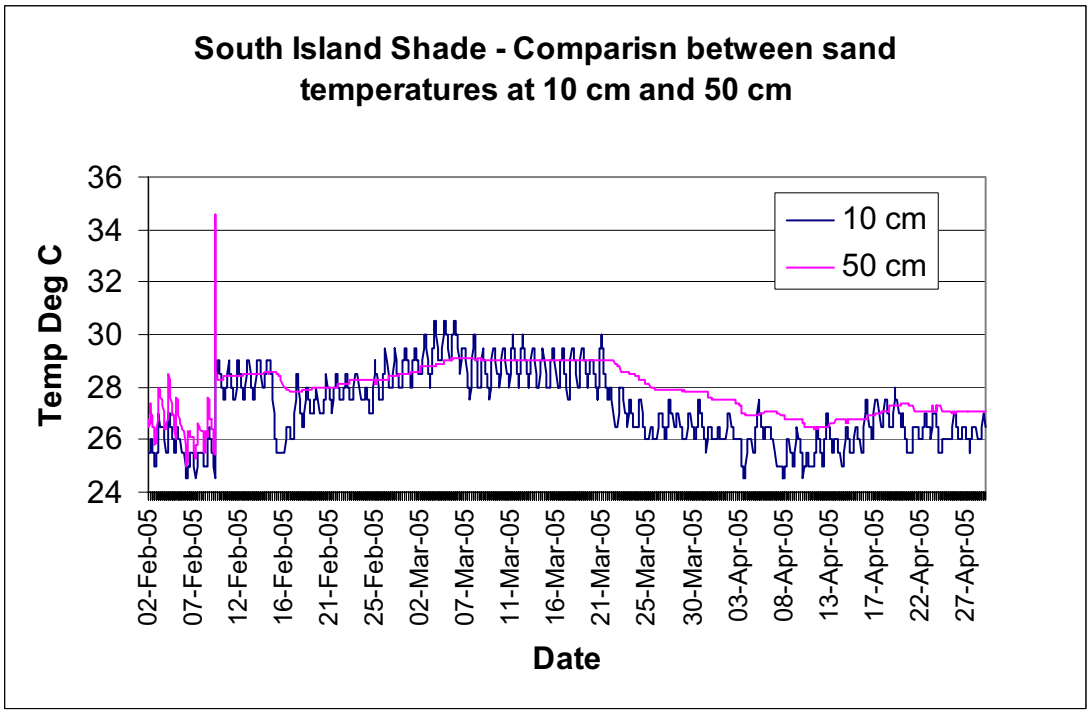

Figure 67 Comparisons of sand temperatures under shade at 10 cm and 50 cm at South Island

Education

Rumah Baru

The community of Cocos (Keeling) Islands was invited to Rumah Baru to watch an adult sized male turtle being tagged and measured. This was also associated with informal discussions and handouts related to sea turtles in general and the threats and conservation of turtles at Cocos (Keeling) Islands. In an associated project funded by NHT, this turtle has a satellite transmitter attached to its carapace to allow a study of its movements within the lagoon (Figure 68 & Figure 69).

Home Island

An information morning was also held at Home Island and the community was invited down to the beach to watch the tagging and measuring of green turtles that were caught within 100 m from Home Island (Figure 70 & Figure 71).

Figure 68 Community education afternoon at Rumah Baru West Island

Figure 69 Community education afternoon at Rumah Baru West Island

Figure 70 Community education morning at Home Island

Figure 71 Community education morning at Home Island

DISCUSSION

Foraging Turtles

Species Composition

The species composition was slightly different than from other years with green turtles making up 51% of the catch and hawksbill turtles 49%. In Area 1 (West Island) the ratio of green and hawksbill turtles was approximately 62% and 38% respectively. In Area 2, the ratio was markedly different, with approximately 64% hawksbill turtles and 36% green turtles.

The interesting record of a loggerhead turtle sighted by divers indicates that at least a small percentage of these turtles forage in deeper water around the southern atoll.

Size Composition

The size composition of turtles in both catch areas was similar to previous years. Juvenile and adult sized green and hawksbill turtles were found in Area 1 near West Island while predominantly juvenile turtles of both species were found in Area 2.

It is likely that the foraging behaviour of larger turtles differs from smaller turtles. Observations indicate that larger turtles are more common on the intertidal flats at spring high tides, later in the afternoon and after sunset. Larger hawksbill turtles seem to be found during all daylight hours but are also restricted by shallow water. In the future, these behaviours must be taken into account when planning the capture methods.

Growth Rates

The larger catch sample in 2006 provided seven growth rates for green turtles which is almost doubled the existing data. The extra turtles marked in 2006 should provide a higher percentage of recaptures in subsequent years. A total of 31 recaptures and growth rates were recorded for hawksbill turtles giving a total recapture rate of over 30% for this population.

Growth rates are generally faster than for other studies sites such as Fog Bay near Darwin (Whiting 2000).

Population Estimates

The mark-recapture methodology is working extremely well for the hawksbill turtles at Cocos with a recapture rate of over 30%. Area 1 and Area 2 have estimates of approximately 406 and 410 hawksbill turtles respectively.

For green turtles, mark recapture methodology is not providing enough recaptures to estimate the population size in either catch area. Population estimates from mark recapture estimates are affected by several factors which include: large population

size and low sampling numbers, emigration and immigration, inadequate sampling area and high mortality. High mortality is unlikely to be a problem but the other three may impact of results at Cocos. Previous tracking studies indicate that the sampling area is adequate, even though the turtles move in and out, they visit both catch areas at least every second day. Therefore during the survey period (usually of three weeks) all turtles have a chance of being captured. Emigration and immigration permanently into and out of the catch areas may be more significant and as turtles grow, they may change their foraging behaviour and forage deeper or at night. This year the number of turtles sampled was increased to obtain a larger proportion of the population sampled and try to increase recaptures.

However, in 2006 additional turtles were marked and this should see an increase in the number of recaptures of both species.

New Recruits

In 2006, four green turtles were identified as new recruits. This is about 3 % of the captured sample. No hawksbill turtles were identified as new recruits but 11% of the sample was under 40 cm ccl, which indicates that new recruits are entering into the population.

Health and Condition

Five turtles were found with damage consistent with collisions with boats. Boat usage, the speeds of boats in shallow areas and injured and beach-washed turtles should be monitored to provide an indication of risk to turtles on the southern atoll.

Nesting Turtles

The nesting activity at North Keeling was in higher numbers than in 2005. As the survey period is short it is unknown if this is an artifact of the sampling effort or a comparable measure between years. Generally when green turtle numbers are higher at one location, other locations in the area also experience higher nesting numbers. Alistair Graham (Government Conservator – Christmas Island) indicated that nesting numbers were higher for green turtles at Christmas Island in the 2005/2006 nesting season (A. Graham Pers. Comm.).

The survey of the southern beach of South Island showed that no nesting had occurred in the last one to three weeks. Body pits of nesting green turtles were evident on the dunes and under the trees which indicated that some nesting had occurred in the 2005/2006 season.

Conservation Issues

No new conservation issues were recognised in 2006. The same conservation issues are listed in point form below:

- Disturbance to habitat - Fishers and fire wood collectors continue to regularly use the shallow intertidal areas. This continuous disturbance has an unknown impact on the foraging behaviour of turtles.

- Boat Strike - In 2006, five turtles (two green and three hawksbill) turtles were recorded with damage from collisions with boats.

- Removal of natural shoreline vegetation - In 2006, the removal of natural shoreline vegetation continues to be an environmental issue for the southern atoll of Cocos (Keeling) Islands. Chainsaws are used to cut the thick trunks of *Pemphis acidula* bushes and most of the smaller branches are left. This issue should be addressed because of the habitat this shoreline vegetation provides to smaller hawksbill turtles.

- Marine Debris – The West Island dump continues to be an environmental hazard with foam and plastics blowing from the dump onto the shoreline and into the water (Figure 72, Figure 73, Figure 74 & Figure 75). The Home Island dump now has a barrier chain fence on three sides but lacks the barrier on the seaward side (Figure 76 & Figure 77). Letters were written to the Cocos Island Council, EPA –WA, Minister for Local Government, Territories and Roads and the Parliamentary Secretary for Environment and Heritage.

  Australia has responsibilities under international law (MARPOL) to prevent plastics entering the marine system. Plastics in the ocean are a major problem and result in wildlife fatalities and injuries.

Figure 72. West Island rubbish dump January 2005

Figure 73. West Island rubbish dump January 2005

Figure 75 West Island rubbish tip 2006

Figure 74 West Island rubbish tip 2006

Figure 76 Home Island tip 2006. Fence should be installed in location indicated by the arrows, but also keeping the shoreline vegetation in tact.

Figure 77 The effect of fencing around the rubbish tip on Home Island. Without a fence this rubbish ends up in the sea.

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