Sea Turtle Study - Cocos Keeling Islands

Year 3 of Study – February 2002

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Correction to Report No 2.
At this point I will indicate a correction to report number 2. The turtle catch data are displayed in Sectors. From Report Number 2, turtles that were reportedly captured in Sector 11 should read Sector 12 and those captured in Sector 14 should read Sector 13. Catch data by Year and Sector are correctly displayed in this report.

EXECUTIVE SUMMARY

This document is the third report of sea turtle research at Cocos (Keeling) Islands (CK).

Summary of what is included in this report

- Results of the third mark-recapture period and the associated species composition and size structure
- Description of catch Sectors
- Growth rates from recaptured turtles initially captured in previous trips
- Results of analysis of food samples taken during the field trip in November 2000
- Results of analysis of blood samples taken during the field trip in November 2000
- Recommendations for future work

Summary of Results and Outcomes

- 41 new green turtles captured, tagged and measured
- 98 new hawksbill turtles captured, tagged and measured
- Eight growth rates from recaptured of hawksbill turtles
- Three growth rates from recaptured green turtles
- Overall species composition for 2002 was 29.3% green 70.7% hawksbill turtles
- A higher percentage of hawksbill turtles were found in the sectors of South Island when compared to West Island
- Other sectors inside the lagoon appear to support fewer turtles than the current catch sectors 6, 12, and 13. Larger turtles are frequently observed in the northern sectors of West Island and future mark-recapture work should include these sectors.
- Mean growth rate of hawksbill turtles was 3.1cm/yr
- Mean growth rate of green turtles was 6.2cm/yr
- Growth rates of green turtles were four times faster than those from Fog Bay and 1.5 times faster than those from Ashmore Reef.
- Growth rates of hawksbill turtles were similar to those from Fog Bay although growth rates in the smaller size classes were faster at Cocos Islands.
- Green turtles fed on predominantly on seagrass although algae and animal material were present
- Hawksbill turtles fed predominately on algae. Sponge and seagrass made up minor components
- Baseline blood chemistry data were obtained for both species. The results were mostly within the ranges of other studies in northern Australia.
- All data was entered into a copy of the DBXL sea turtle database that is used by sea turtle researchers in Queensland and the Northern Territory.

INTRODUCTION

This is the third year of sea turtle research at Cocos (Keeling) Islands. The previous trips were conducted in February 1999 (Whiting 1999) and in November 2000 (Whiting 2000). This third field trip (February 2002) continued with the mark-recapture program that began in 1999. The results presented for this field trip are put into context with previous results. Other study areas in north-western Australia (Whiting 2000b) have been used for comparative purposes for some data.

The aims of the study this year were to:

- Continue with the mark-recapture study 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 with the assessment of the nesting population
- Present the analysis of the gastric and blood samples taken from the study in November 2000.

METHODS

Research methods were similar to those used in 1999 and 2000 but have been summarised below for conciseness.

Foraging Turtles

Capture

All turtles were captured using turtle rodeo (Limpus, 1978). Turtles were captured in the same areas as the 1999 and 2000 surveys. In 1999, sectors were not assigned to the capture areas. Also in 2000 references to sectors 11 and 12 were incorrect. For simplicity both the 2002 capture data and the total capture data are presented in this report. A map of Sectors is shown in Figure 1.

Tagging

Titanium tags weighing 4.1 g each, were applied to the axial scale of each front flipper (Limpus, 1992).

Measurements

Measurements of turtles were conducted using standard procedures (Limpus and Reed, 1985). All curved measurements were conducted 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 a rope around each flipper. Large green turtles could not be weighed because the boat was too small to handle them safely.

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 and were weak. Turtles were examined for fibropapilloma growths that affect turtles in other study sites around the world.

"New Recruits" into the population were recorded as those with distinct external characters which indicate a long period in the open ocean. These include 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 derived from the other. At CK, growth rates of sea turtles were measured in cm ccl/ year.

Diet Samples

Gastric lavage was performed using standard methods (Forbes & Limpus, 1993; Forbes, 1999) in 2000. This technique involved two plastic tubes of unequal diameter inserted through the mouth, down the oesophagus and into the anterior part of the stomach. Water was pumped gently through the smaller tube by a hand pump that was submerged in water. Any food items were returned with the waste water through the larger tube and caught into a mesh net attached to its exterior end. Samples were preserved in 3-5% formalin in seawater and stored in the dark.

Samples were sorted into species and dried to a constant weight at 70° C in an oven. The components of each sample were weighed to obtain percentage composition. Percentages represent the mean of individual percentages and not percentages from pooled weights. The report for 2000 was completed prior to the analysis of gastric samples, hence their inclusion herein.

Blood Plasma

Blood was drawn from the cervical sinus (Owens & Ruiz, 1980) using a 10 ml syringe and 21 gauge needle. Blood was stored in 5 ml lithium heparin (Bolten *et al.*, 1992) evacuated tubes. Plasma was separated and stored in plastic vials and frozen at -4^{o}C until analysis. Plasma was used in preference to serum because of variable clot formation in serum (Bolten *et al.* 1992). The plasma was analysed at Berrimah Veterinary

Laboratories, Department of Primary Industries and Fisheries, Darwin using a Cobas Mira analyser with ISE module for electrolytes (Millan *et al.*, 1997). Blood Sampling was conducted in November 2000 but the analysis was not completed until after the report for that year. One and two-way ANOVA's were used for comparisons with other study sites. The results are presented in this 2002 report.

Assessment of Sea Turtle Resources and Habitat by Sector

Sectors 5, 6 adjacent to West Island and sectors 12 and 13 adjacent to south island are currently the main focus of the mark-recapture study. The turtle resources and habitat type in other sectors was investigated to order to assess relative abundance, species and size composition. This information would help to refine the mark-recapture study and investigate any capture biases with the current methods.

Because most of the sectors were very shallow even at high tide, the normal straight transects to count turtles at could not be conducted. Sectors 1-4, and 8-11 and 14-17 were visually investigated usually a slow moving dingy at high tide. Speed was variably because of the irregular substratum.

Nesting Turtles

Density and species of nesting turtles

No visits to North Keeling could be made this year. One nest on the southern atoll was reported by a member of the community. This was located several hundred metres south of Trannies Beach on West Island and was laid on Sat. 9th February 2002.

RESULTS

A summary of daily activities are listed in Appendix 1.

Foraging Turtles

Most turtles were captured in Sectors 6 and Sectors 12 & 13.

Species Composition

A total of 150 turtles were captured during the 21 day research period in February 2002. These comprised, 44 (29.3%) green and 106 (70.7%) hawksbill turtles. Using data from all years, a total of 297 turtles have been caught to date. This includes 133 green (44.8%) and 164 (55.2%) hawksbill turtles. Table 1 shows the variation in catch composition between years. Varying from 23% hawksbills in 1999 to 70% hawksbills in 2002.

Table 1 Number of each species captured in each year

	Hawksbills	Greens	Total
1999 (Mar)	11 (23.4)	36 (76.6%)	47
2000 (Nov)	47 (47.0%)	53 (53.0%)	100
2002 (Feb)	105 (70.0%)	45 (29.0%)	150
Total	164 (55.2)	133 (44.8%)	297

Species composition varied between sectors. Sectors 12 and 13 had a higher percentage of hawksbill turtles than sector 6 at West Island. In 2002, sector 6 had 46% green turtles and 74% hawksbill turtles, while sector 12 had 20% green turtles and 80% hawksbill turtles. Using data for all years sector 6 had 59% green and 41% hawksbill turtles, while sector 12 had 27% green and 73% hawksbill turtles. See a breakdown of species composition by Sector and Year in Table 2. Figure 5 shows species numbers by Sector.

Table 2 Number of Each Species Captured by Year and Sector

Sector	Year						Subtotal Greens	Subtotal Hawksbills	Total
	1999		2000		2002				
	G	H	G	H	G	H			
2	1 (100%)						1 (100%)		1
5					1 (16.7%)	5 (83.3%)	1 (16.7%)	5 (83.3%)	6
6	31 (81.6%)	7 (18.4%)	39 (60%)	26 (40%)	31 (46.3%)	36 (53.7%)	101 (59.4%)	69 (40.6%)	170
7				6 (100%)				6 (100%)	6
12	4 (50%)	4 (50%)	8 (40%)	12 (60%)	13 (20.3%)	51 (79.7%)	25 (27.2%)	67 (72.8%)	92
13				10 (100%)		13 (100%)		23 (100%)	23
Total	36	11	47	54	45	105	128	170	298

Size Composition

Year 2002

Green turtles ranged in size between 43.6 and 112 cm ccl (mean 63.3, sd=15.1, median=65.0, n=44). The size frequency histogram (Figure 6) shows that most turtles captured were in the 55-60 and the 60-65 cm ccl size classes.

Hawksbill turtles ranged in size between 33.9 and 80.6 cm ccl (mean 57.1, sd=12.1, median, 56.2, n=106). The size frequency histogram (Figure 7) shows that the size distribution is bi-modal with peaks occurring in the 45-50 and the 65-70 cm ccl size classes.

All years

Green turtles ranged in size between 41.8 and 114.8 cm ccl (mean 61.8, sd=13.9, median=61.1, n=127). The size frequency histogram (Figure 8) shows that most turtles captured were in the 55-60 and the 60-65 cm ccl size classes.

Hawksbill turtles ranged in size between 33.9 and 80.6 cm ccl (mean 58.1, sd=12.7, median=56.2, n=106). The size frequency histogram (Figure 9) shows that the size distribution is bi-modal with peaks occurring in the 45-50 and the 65-70 cm ccl size classes.

Size Structure between Locations

Sectors 5, 6 and 7 are located adjacent to West Island and are pooled, while sectors 12 and 13 are located adjacent to South Island and are pooled. Figure 10 and Figure 11 compares size structure between localities. These histograms show that a higher proportion of large green and hawksbill turtles are found near West Island than South Island. When sample sizes increase in other Sectors this relationship can be investigated statistically.

Qualitative Description of Habitat and Sea Turtle Resources by Sector

A brief habitat description of each of the catch Sectors is given in Table 10 in Appendix 2. This will enable the current catch methodology to be reviewed and improved to answer questions of spatial distribution of species and size structure throughout the lagoon.

Growth Rates

Growth rates were obtained for 8 hawksbill turtles and three green turtles. The mean growth rate for green turtles was 3.1 cm/yr (Table 3) while for hawksbill turtles it was 6.2 cm/yr (Table 4). Table 5 and Table 6 show that more growth rates are needed for each size class before a more detailed analysis can be conducted.

Table 3 Growth Rates of Individual Green Turtles (sorted by size)

Tag Number	First Capture			Second Capture			Mean Size	Days at Large	**Growth per year**	
	Date of Capture	CCL (cm)	Weight (kg)	Date of Recapture	CCL (cm)	Weight (kg)			**CCl (cm)**	**Wt (kg)**
CA4487	30/11/00	42.5	9.0	13/02/02	48.5	13.5	45.5	440	**5.0**	**3.7**
CA4273*	02/03/99	49.5	16.0	21/11/00	60.2	30.0	54.85	630	**6.2**	**8.1**
CA4376	21/11/00	57.7	25.0	15/02/02	64.9	44.0#	61.3	451	**5.8**	**15.4**
CA4440	26/11/00	59.0	26.5	11/02/02	68.5	36.5	63.8	447	**7.8**	**8.3**
TOTAL									**6.2**	**8.9**

* The record is a recapture from Nov. 2000.

This measurement should be used with caution as it is heavier than other individuals of this size.

Table 4 Growth Rates of Individual Hawksbill Turtles (sorted by size)

Tag Number	First Capture			Second Capture			Mean Size	Days at Large	**Growth per year**	
	Date of Capture	CCL (cm)	Weight (kg)	Date of Recapture	CCL (cm)	Weight (kg)			**CCl (cm)**	**Wt (kg)**
CA4319	16/11/00	43.2	8.5	8/2/02	51.9	13.5	47.6	449	**7.1**	**4.1**
CA4384	21/11/00	47.1	10.5	3/2/02	54.5	15.5	50.8	439	**6.2**	**3.7**
CA4342	19/11/00	66.2	28.0	15/02/02	70.7	30.5	68.5	452	**3.6**	**2.0**
CA4420	16/11/00	73.4	39	3/2/02	74.3	42.5	73.9	434	**0.8**	**2.9**
CA4263	01/03/02	72.1	36.5	12/02/02	78.5	45.5	75.3	1079	**2.2**	**3.0**
CA4330	16/11/00	74.4	-	3/2/02	76.7	40.5	75.6	444	**1.9**	**-**
CA4390	21/11/00	75.0	26.5	11/02/02	77.8	36.5	76.4	442	**2.3**	**4.1**
CA4240	23/02/99	77.4	39.0	9/02/02	79.6	46.0	78.5	1082	**0.7**	**2.4**
TOTAL									**3.1**	**3.2**

Table 5 Mean Growth Rates of Green Turtles by Mean Size Class (10cm increments)

Size Class	Growth Rate cm ccl/yr				Growth Rate kg/yr			
	Mean	sd	Range	n	Mean	sd	Range	n
40-50	5.0	-	-	1	5.0	-	-	1
50-60	6.2	-	-	1	6.2	-	-	1
60-70	6.8	1.4	5.8-7.8	2	11.9	5.0	8.3-15.0	2
70-80								

Table 6 Mean Growth Rates of Hawksbill Turtles by Mean Size Class (10cm increments)

Size Class	Growth Rate cm ccl/yr				Growth Rate kg/yr			
	Mean	sd	Range	N	Mean	sd	Range	n
40-50	7.1	-	-	1	4.1	-	-	1
50-60	6.2	-	-	1	3.7	-	-	1
60-70	3.6	-	-	1	2.0	-	-	1
70-80	1.58	0.8	0.7-2.3	5	3.1	0.7	2.4-4.1	4

External Examination

Two turtles were recorded as in poor condition. One green turtle (CA 4631 – 43.7 cm ccl) was found in Sector 12 floating on the surface. It was picked up and brought aboard the dinghy without trying to escape. It was slightly under weight and had a sparse coating of new growth algae. It was tagged and measured and released by did not try to swim away. It appeared weak. The second turtle, a small hawksbill turtle (CA 4661 35.7 cm ccl) (see Fig. 2a) also appeared weak, but it was only slightly under weight. The carapace was covered in a thick coating of algae.

None of the 150 turtles had signs of Fibropapilloma growths.

Two turtles had possible boat strike injuries. A hawksbill turtle (CA 4669 – 70.6 cm ccl) had healed damage to the carapace that was about 10 cm long and 1 cm deep and in a curved shape similar to damage caused by a boat. A green turtle (CA4697 – 63.8 cm ccl) had an injury about 10 cm long and 8 mm deep that could have been caused by the skeg of an outboard motor.

Two hawksbill turtles (CA4501 and CA4614) had high domed shaped carapaces that could reflect deformities of the spine.

One green turtle (CA 4740 - 44.0 cm ccl) was recorded as a new recruit to the population.

Diet Samples

Diet samples were taken from 10 green turtles and 5 hawksbill turtles. These are preliminary results and a more detailed study is needed to confirm the diets reported here. Green turtle samples consisted mainly of the seagrass *Thalassia hemprichii* while the hawksbill turtles had a mixture of items dominated by algae but with some sponge. The

results are summarized in Table 7 and displayed in Figure 3 and Figure 4. Details for individual turtles are listed in Table 8.

Table 7 Mean Percentage of food items found in Lavage Samples

	Taxa	Green	Sub Total	Hawksbill	Sub Total
Seagrass	*Thalassia hemprichii*	68.9	68.9	14.5	14.5
Algae	*Acanthophora spicifera*	8.4			
	Euchema sp	7.1	29.4	50.6	69.3
	Unidentified Algae	13.9		19.3	
Animal	Sponge	6.5	6.5	21.9	21.9
Total		105.8	105.8	106.3	106.3

* The Total will not add up to 100% because each taxa is taken as the mean the individual samples and not a percentage of the pooled samples.

Table 8 Food Items from Individual Turtles

Species	Tag #	Sample #	Items	% of sample
Green	4382/3	Q18825	*Thalassia hemprichii*	100
Green	4374/5	Q18826	*T. hemprichii*	89.5
			Acanthophora spicifera	10.5
Green	4376/77	Q18829	*T. hemprichii*	100
Green	4380/81	Q18830	*T. hemprichii*	100
Green	4378/79	Q18831	*T. hemprichii*	100
Green	4400/03	Q18832	*T. hemprichii*	10.9
			A. spicifera	65.2
			Euchema spp.	23.9
Green	4404/5	Q18834	Unidentified Algae	Trace
			Egg case	Not Weighed
Green	4396/7	Q18836	*T. hemprichii*	68
			Algae	32
Green	4392/3	Q18837	*Euchema spp.*	40
			Unidentified Algae	60
Green	4398/9	Q18891	Sponge	58.5
			Unidentified Algae	41.5
Hawksbill	4384/5	Q18824	Sponge	66.7
			Sargassum	33.3
Hawksbill	4386/87	Q18827	*T. hemprichii*	29.5
			Euchema spp.	64.8
			Unidentified Algae	5.7
Hawksbill	4390/91	Q18828	*Euchema spp.*	90.6
			T. hemprichii	9.4
Hawksbill	4410/11	Q18833	Traces of *T. hemprichii*	Not weighed
			Traces of Unidentified Algae	
Hawksbill	4408/09	Q18835	*T. hemprichii* (Leaf)	19.0
			Euchema spp.	43.1
			Unidentified Algae	37.9

Foraging Behaviour

Both green and hawksbill turtles feed on the seagrass and algal beds in the intertidal zone. Of the seven sectors near West Island, sectors 1 to 2 and 5 to 5 are extensively used by

green and hawksbill turtles. Near South Island, sectors 12 and 13 are extensively used by these species.

Both green and hawksbill turtles use the spring high tides to forage close to shore. Hawksbill turtles were found in more shallow water than green turtles. Hawksbill turtles also seek refuge close to shore in habitat that is devoid of seagrass or algae. They lie on muddy substrate and are frequently found under the branches of shoreline vegetation including *Pemphis acidula* and *Suriana maritima*.

Smaller turtles are usually found closer to shore and in shallower water than larger turtles although when high tides occur late in the afternoon adult sized green and hawksbill turtles can be found in less than 80 cm of water. This indicates that larger turtles may forage in the intertidal region more frequently at night. This is supported by sightings of adult sized green turtles foraging around the jetty in Sector 2 at night.

Blood Samples

Ten blood samples were taken from green turtles and six were taken from hawksbill turtles. Twenty parameters were analysed and included elements, enzymes, nutrients and metabolites. The low volume of two samples meant that some parameters were not tested. This reduced the sample size to 9 for these parameters for green turtles and to 5 for hawksbills.

Each parameter tested, their respective method and results (mean, standard deviation and range) are presented for each species in Table 9. An explanation of each parameter is presented in Appendix 3 while Appendix 4 contains tables of analyses for individual turtles and statistical comparisons. As there are no normal values that can be used, this study, along with studies at Ashmore Reef and Fog Bay will help to establish normal blood chemistry values for turtles in north-western Australia as a reference. Once a better understanding of blood values is obtained, this technique could be used to assess health and condition of these species.

Comparisons with other studies using one- and two-way ANOVA's (Table 12, Table 13 & Table 14) showed that the blood chemistry values from this study varied from those from Ashmore Reef and Fog Bay (Whiting 2000b). The following parameters were higher for Cocos green turtles when compared to those of Ashmore Reef: Potassium, Phosphorus, ALT, AST, ALP, Albumin and Bilirubin. The following parameters were higher for Cocos hawksbill turtles when compared to those of Fog Bay: Potassium, Phosphorus, Calcium, ALT, AST, Albumin and Total Iron.

Table 9 Blood chemistry reference values for green and hawksbill turtles Cocos (Keeling) Islands. Variable is followed by the abbreviation used in subsequent tables and their units. The total reference range is given. Usually middle 95 percentile (2.5 - 97.5) is reported, but in this case only a small number of samples were taken. [5]also abbreviated to CPK. [6]According to the recommendations of the International Federation of Clinical Chemistry.

		Greens Turtles			Hawksbill Turtles		
Variable	Measurement Method	N	Mean±sd	Range	N	Mean±sd	Range
Curved Carapace Length (CCL) (cm)	Fibreglass tape	10	59.56±5.57	50.3-67.5	6	52.7±4.38	38.5-67.5
Sodium (Na) (mmol/L)	Direct Measurement ISE	9	149.44±15.92	128-176	6	1.55.17±17.43	127-172
Potassium (K) (mmol/L)	Direct Measurement ISE	9	5.52±0.97	4.3-7.2	6	4.88±1.47	3.2-7.0
Chloride (Cl) (mmol/L)	Direct Measurement ISE	9	111.56±12.92	92-135	6	120.83±13.99	99-136
Calcium (Ca) (mmol/L)	Arsenazo III	8	2.37±0.42	1.69-3.13	6	22.25±50.34	1.06-125
Phosphorus (P) (mmol/L)	Phosphomolybdate, UV	9	2.50±0.45	1.84-3.11	6	2.17±0.64	1.14-2.9
Total serum iron (Fe) (umol/L)	Ferrozine, no deproteinisation	9	8.44±3.00	3-13	6	7.5±2.59	1.0-11.0
Alanine aminotransferase ALT (U/L)	Kinetic UV	9	13.44±9.43	2-30	6	16.33±10.09	4-28
Aspartate aminotransferase(AST) (U/L)	Kinetic UV	9	254.78±61.89	162-359	6	198.67±123.06	102-437
Alkaline phosphatase (ALP) (U/L)	PNPP (AMP buffer)[6]	9	52.78±21.98	22-88	6	59.17±22.25	29-85
Total protein (g/L)	Biuret, reagent blank	10	46.10±5.38	38-55	5	38.4±12.36	29-58
Albumin (Alb) (g/L)	Bromocresol green	10	17.70±3.09	13-22	5	13.6±4.72	11-22
Globulin (Glob) (g/L)	Calculation	10	28.4±4.33	18-33	5	24.8±8.35	17-36
Albumin/globulin (alb/glob) (ratio)	Calculation	10	0.62±0.53	0.5-0.9	5	0.56±0.11	0.4-0.7
Urea (mmol/L)	Urease UV	9	3.66±3.26	1.4-12.0	6	12.53±7.08	3.1-21.7
Bilirubin (Bili) (umol/L)	Modified Malloye & Evelyn	9	5.00±3.20	1-10	6	2.5±1.22	1-4
Creatinine (Creat.)	Alkaline picrate - kinetic	9	25.89±9.42	19-47	6	25.17±36.93	2-99
Cholesterol (mmol/L) (Chol)	CHOD-PAP	9	2.86±1.01	1.08-4.11	6	2.55±1.81	0.94-6.08
Uric Acid (µmol/L)(Uric)	Uricase, colorimetric	9	153.33±49.21	102-243	6	90.89±56.53	1.34-153.00
Glucose (mmol/L) (Gluc)	GPO-PAP	9	6.57±1.23	5.0-8.5	6	6.3±1.40	4.6-8.6
Tryglcerides		9	1.59±0.49	0.6-2.4	6	1.62±1.78	0.40-5.20

Database

All data collected was entered onto a copy of a database developed by the Queensland Department of Environment and Heritage (QDEH). This database separates the data into three integrated files. The first file contains the tag history of the animal (ie the date of all tags applied to the turtle). The second file contains all the capture history of the turtle, including location, sector, experiments performed and health. The third file contains all the measurements taken of the turtle. For more information on the database files see Appendix 5. Data for this year is presented in Appendix 6 and data for all years is presented in Appendix 7.

DISCUSSION
Foraging Turtles

Species Composition

The sampling this year produced 70.7% hawksbill turtles and 29.3 % green turtles. This is an extremely high proportion of hawksbill turtles when compared to the previous two years which produced 23.4% (1999) and 47% (2000) hawksbills. The reason for more hawksbill turtles is not known but may have been attributed neap tides during this capture period. The shallow water on the seagrass flats at high tide may have biased the composition toward hawksbill turtles. In addition, more turtles were captured near South Island this year when compared to the other years. This region appears to contain a higher proportion of hawksbills turtles than the sectors near West Island.

Size Composition

Green Turtles – The size structure of green turtles captured during 2002 was similar to that of 2000 with most captured turtles within the size range of 40 to 70 cm ccl. Modal peaks occurred in the 45, 60 and 70 cm size classes. Overall the catch composition is contains larger turtles than occur at Ashmore Reef and Fog Bay (Whiting 2000b).

Hawksbill Turtles - The hawksbill turtles at Cocos (Keeling) Islands had two modal peaks, one at 50 cm ccl and one at 70 cm ccl. Indian Ocean. The size structure was in similar proportions to that of hawksbill turtles in Fog Bay (Whiting 2000b).

A larger sample size would enable more detailed analyses and comparisons with other studies.

Growth Rates

The pooled growth rates of green turtles at Cocos Islands (6.2 cm/yr) are nearly four times faster than those reported from Fog Bay, NT (Fog Bay - 1.45 cm ccl/yr, Range 04-3.48, n=20) and almost twice as fast for those reported from Ashmore Reef (3.79 cm ccl/yr, Range1.4-5.9 cm ccl/yr, n=16) (Whiting 1999). The sample sizes from this study are still small, so these comparisons are preliminary only. See Figure 12 and Figure 13 for comparisons with other study sites.

The growth rates for hawksbill turtles at Cocos Islands (3.1 cm ccl/yr) is faster than those reported at Fog Bay, NT (2.5 cm ccl/yr) (Whiting 1999). The sample sizes from this study are still small, so these comparisons are preliminary only.

Diet

The gastric lavage was only a preliminary investigation of food items ingested by both green and hawksbill turtles. Further samples would be required to give definite dietary preferences. However, from the existing data, green turtles ingested predominately the seagrass, *Thalassia hemprichii* with some algae and animal material. Hawksbill turtles ingested algae with minor components of sponge and seagrass. Green turtles are well known vegetarians and consume both seagrass and algae. The proportions of ingestion are influenced by both nutritional quality (Forbes 1996) and relative abundance (Whiting 2000).

Hawksbill turtles are well known spongivores (Meylan 1985, 1988) but their diet is also known to include algae (Whiting 2000b).

Blood

This study provided baseline or normal values for green and hawksbill turtles from Cocos (Keeling) Islands. These can be used for future reference in times of adverse condition or severe impacts. They also provide values to allow comparisons with other study sites which can help to determine the full range of normal values for the species and also to try to understand differences in population dynamics and growth rates.

Conservation Issues

Native Coastal Vegetation

The native vegetation along to high tide of the inner lagoon provides habitat that is frequently used by small hawksbill turtles and sometimes small green turtles during high tides. It was not sure if this habitat was used for resting or predator avoidance. There appeared to be little food in this habitat although one small hawksbill was observed and filmed eating the alga *Caulerpa cupressoides*. Whatever the reasons it appears to be important habitat for the small sized turtles. On most days that I was out on the water I witnessed the removal of this shoreline vegetation for firewood and sawn off trunks and branches are evident around most of the lagoon. As most of the native vegetation of the southern atoll of the Cocos Islands was removed during the time of coconut production, the removal of more native vegetation must be addressed with some form of management. At the current rate this habitat will be lost to small sea turtles.

Boat Strike

The mark recapture study is still is the early stages with 297 turtles captured, however boat strike in some areas of the lagoon. Anecdotal evidence from locals indicated that turtles were sometimes hit. Evidence from external examinations indicate that one out of 133 green turtles ((0.75%) and one out of 164 hawksbill turtles (0.61%) had injuries that were possibly sustained from collisions with boats or outboard motors..

West Island Rubbish Dump

In the course of turtle research, the issue of a community rubbish dump would not usually require comment. However, over the past three years the state of the West Island rubbish tip has been cause for concern for the marine environment and marine species including turtles. Figures 2c – 2i show the state of the West Island rubbish dump over three years. Despite the dump being closed in 2001, photos show that it was still being used in February 2002. The cause for concern lies in the amount and type of rubbish that is susceptible to tide and wind transport out to sea. Rubbish including plastics, paper, metal and glass were seen at the high tide line and out in the open (available for wind transportation). Sea turtles are well known for their susceptibility to entanglement and ingestion of debris, particularly plastics. Simple measures such as dragging the existing debris away from the high tide line and fencing off the area to stop wind transportation would alleviate many of the risks to marine environment. The debris should be checked for chemical contaminants that could pollute the marine environment through leaching.

Proposed West Island Jetty

The proposed West Island Jetty at Rumah Baru has the potential to disturb the seagrass habitat and disrupt the normal routines of the turtles in Sectors 4 to 7. Seagrass production could be reduced because of siltation during the construction phase and the final structure may disturb tidal flows along this intertidal section. Turtles appear to travel along this shoreline to feed in dense aggregations in Sector 6 and 7 and to a lesser extent in sector 5. It is unknown how the construction phase and the final structure will disturb their normal foraging habits. Sectors 1 to 7 and sectors 12 and 13 are extremely important for both green and hawksbill turtles.

The proposed jetty will also increase boat activity in the area. This could potentially increase boat strike and increase disturbance of foraging turtles.

Options for Further Study

Continued Mark-Recapture Project

The catch data from this years study show the potential for sea turtle research to contribute to local, regional, national and international management issues. This years study refined information on the species composition and size structure, identified natural and anthropogenic health or injury problems, and gathered important growth rates for both species. The high proportion of growth rates from previously tagged turtles (hawksbill turtles - 8 from 58 – 14%, green turtles – 4 from 89 – 5%) indicates that the next capture session should increase the number of growth rates considerably.

During the next capture session, it would be a benefit to the current sampling design to expand the capture area to include Sectors 1 and 2. This would ensure that the captured turtles are not biased to those that feed only in the shallow water. Sectors 1 and 2 have deeper water and are closer to the mouth of the lagoon.

Seagrass and Algal Beds

The seagrass and algal beds are critical for the survival of turtles at Cocos Keeling.

Several impacts could affect the extent and quality of seagrass at Cocos Islands. These could include:

- Increased pollution from several sources such as increased boat traffic or a spill from a large vessel in the area.
- Siltation caused by the construction and design of the proposed West Island Jetty
- Increased global water temperature may have unknown affects on seagrasses, particularly in shallow areas in the end of the lagoon that already are at the upper end of their thermal tolerance.

Options to monitor the extent of seagrass distribution and density could include extensive field studies or the use of remotely sensed data such as images from satellites.

Field studies would include methods that could determine distribution and density/biomass of species. However, these studies are costly and the same questions could be answered by more cost effective means with remotely sensed data. Remotely sensed data would assess the distribution and give a relative density of vegetation compared to other areas. Thermatic Mapper (TM) images cost around $1000 and could assess vegetation to a depth of about 2m below low tide. SPOT images cost more but may give less information. If this option is pursued then Remote Sensing experts should be consulted for an outline of the potential and cost of such monitoring.

Satellite Tracking

Satellite tracking is an option to determine movements and habitat use over large or small scales. There would be two main reasons for use of satellite tracking at Cocos (Keeling) Islands. One would be to identify the habitat used and local movements of turtles around the Cocos Islands. This would be of particular importance to monitor the behaviour of turtles before, during and after construction of the Proposed West Island Jetty. The second reason would be to identify the migratory paths and the nesting habitat for the foraging green and hawksbill turtles living at Cocos Islands. If these turtles nest on beaches outside the Cocos (Keeling) Islands, then this could form the basis for establishing links with neighboring countries to develop regional conservation initiatives.

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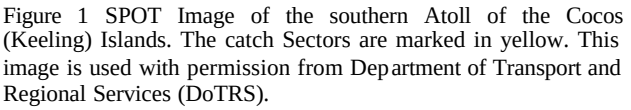

Figure 1 SPOT Image of the southern Atoll of the Cocos (Keeling) Islands. The catch Sectors are marked in yellow. This image is used with permission from Department of Transport and Regional Services (DoTRS).

Figure 2 - Photos

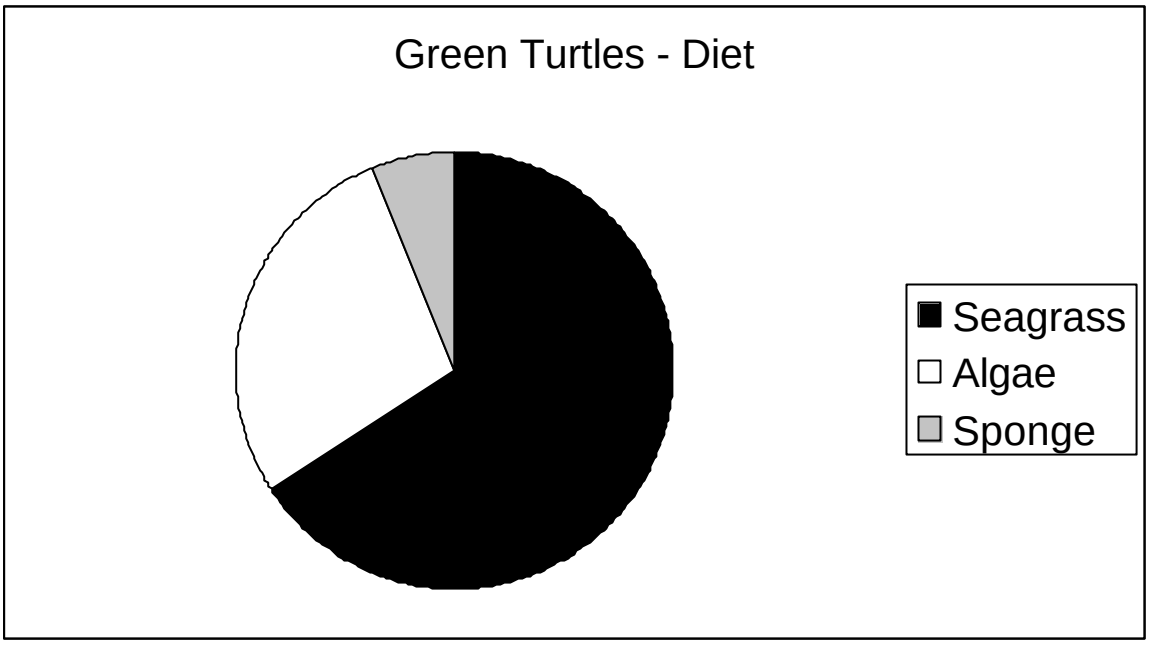

Figure 3 Diet components of green turtles

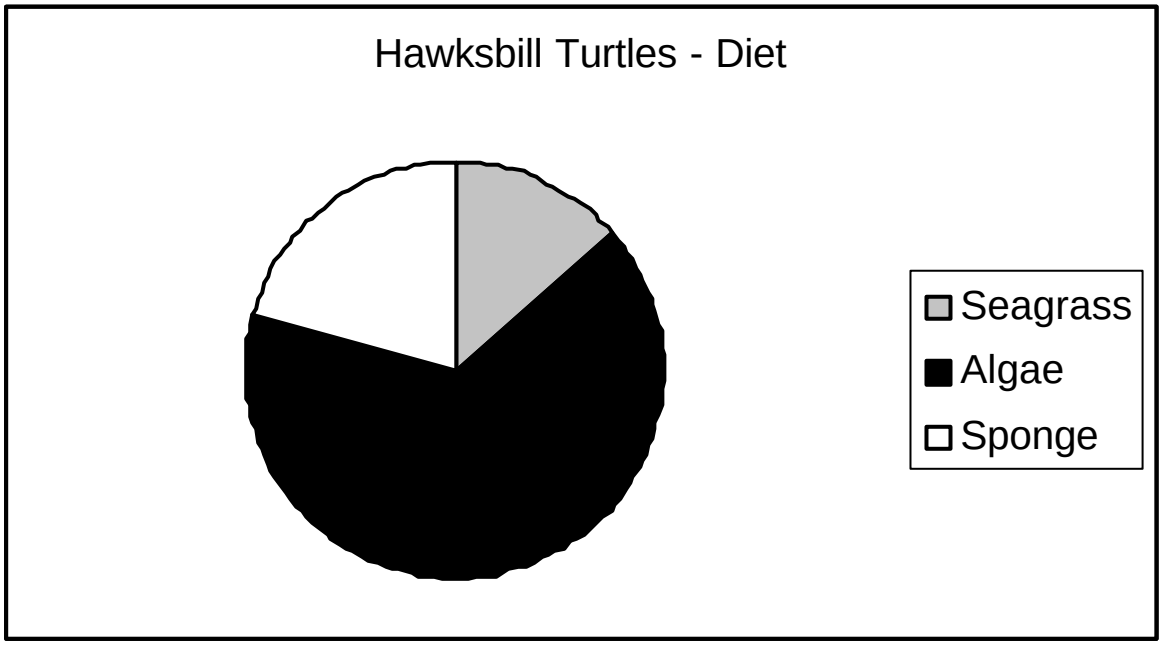

Figure 4 Diet components of hawksbill turtles

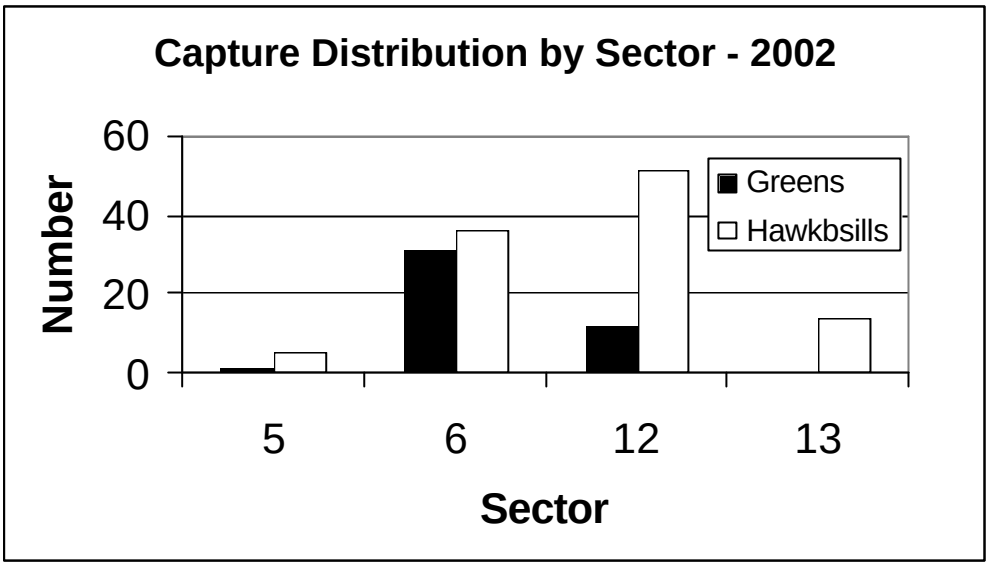

Figure 5 Number of Green and Hawksbill Turtles Captured by Sector in 2002

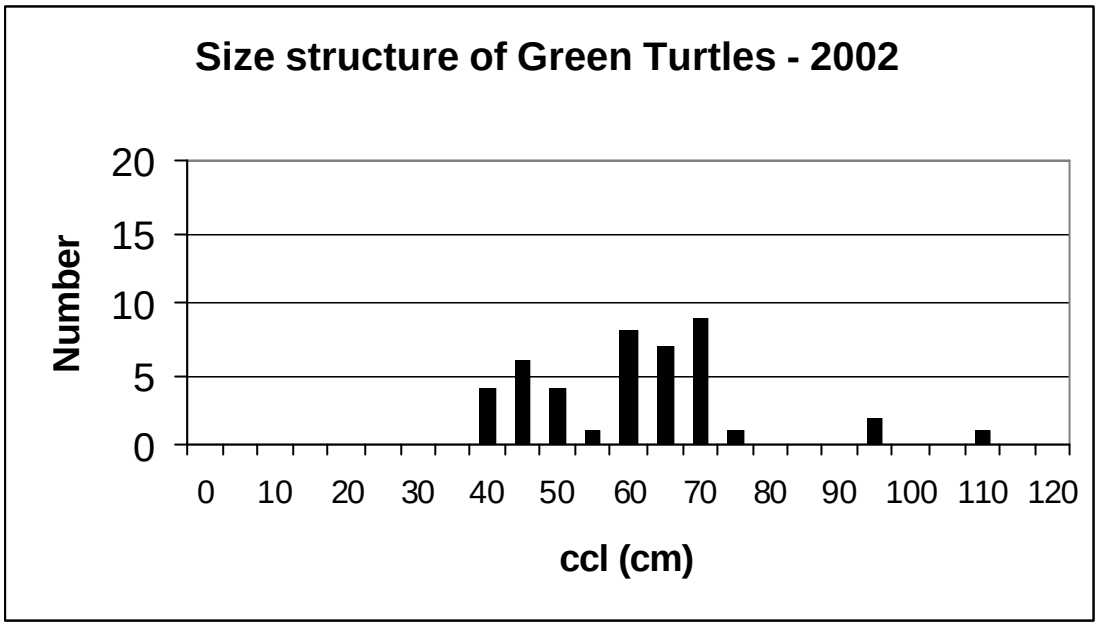

Figure 6 Size Structure of Green Turtles in 2002

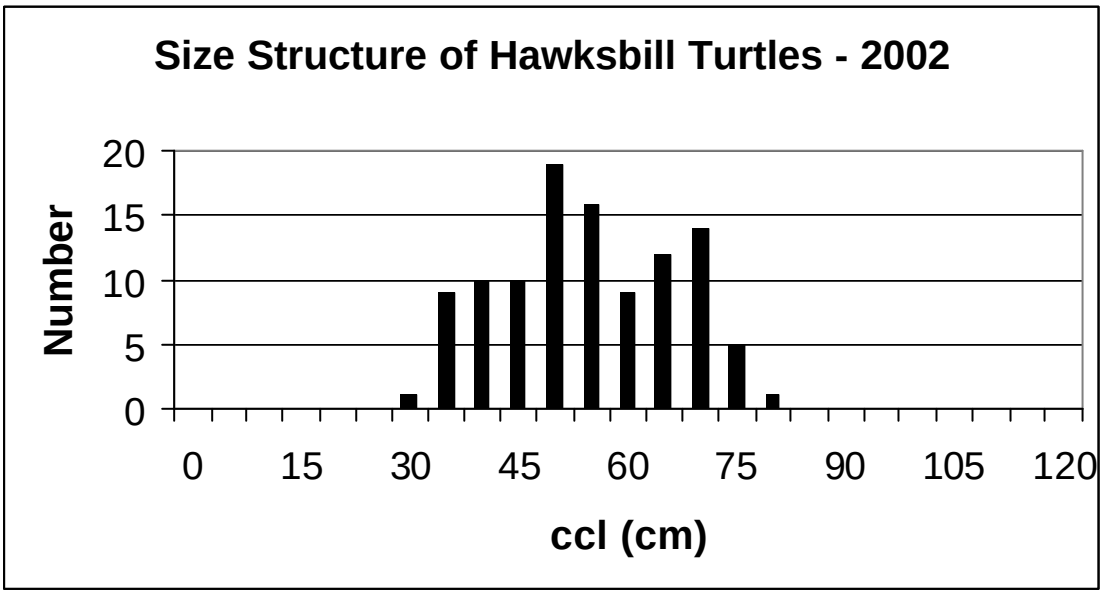

Figure 7 Size Structure of Hawksbill Turtles in 2002

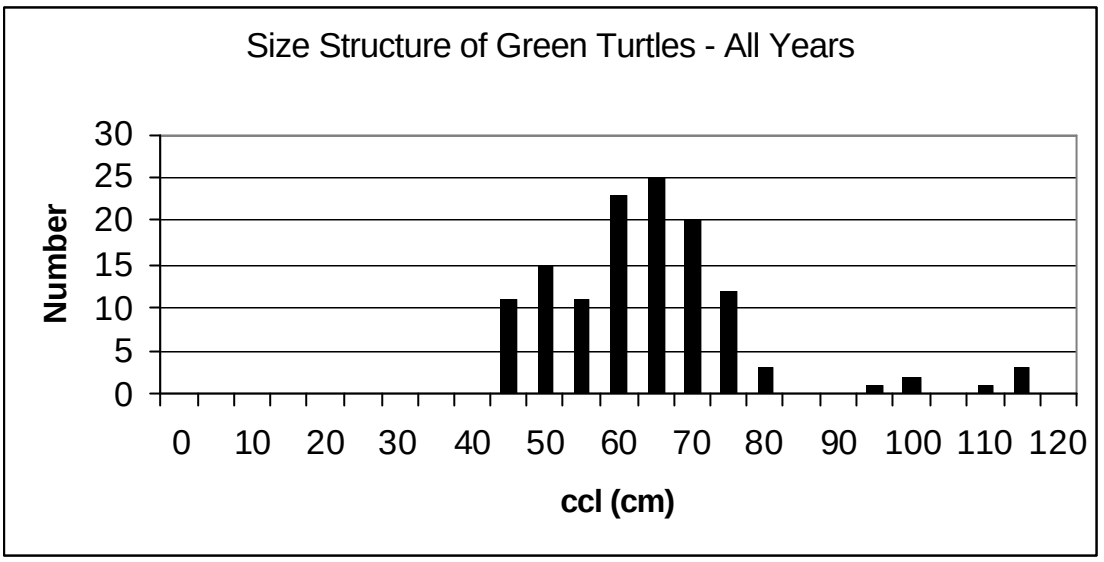

Figure 8 Size Structure of Green Turtles – All Years

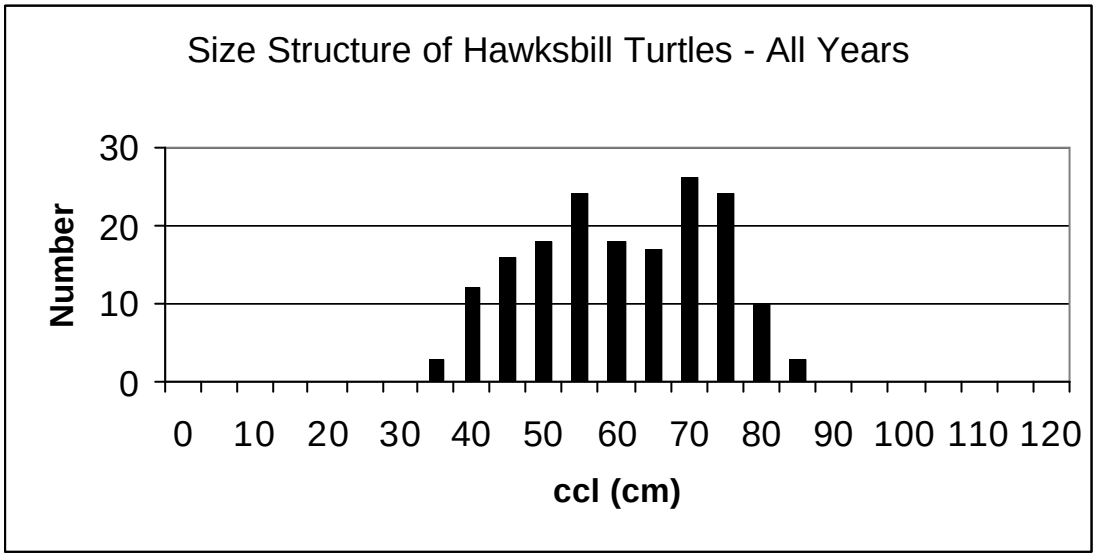

Figure 9 Size Structure of Hawksbill Turtles – All Years

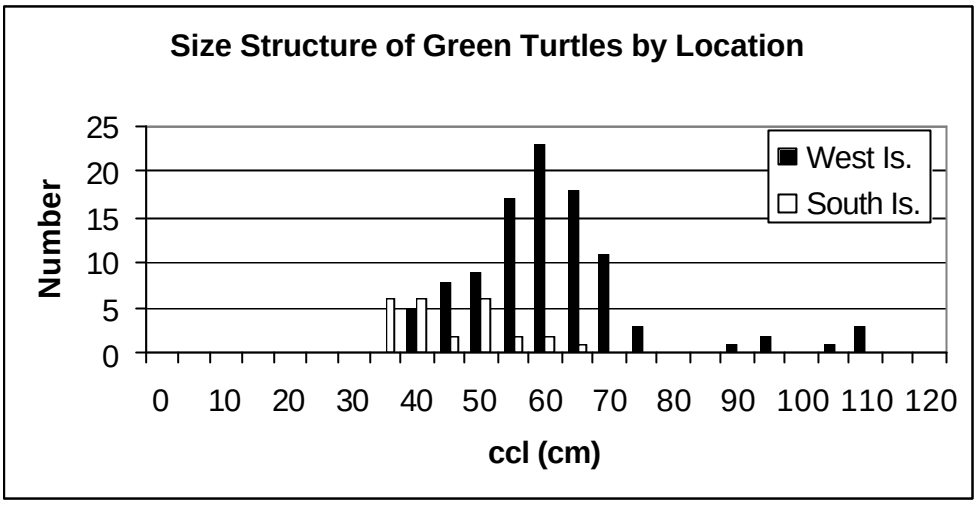

Figure 10 Size Structure of Green Turtles by Location in 2002

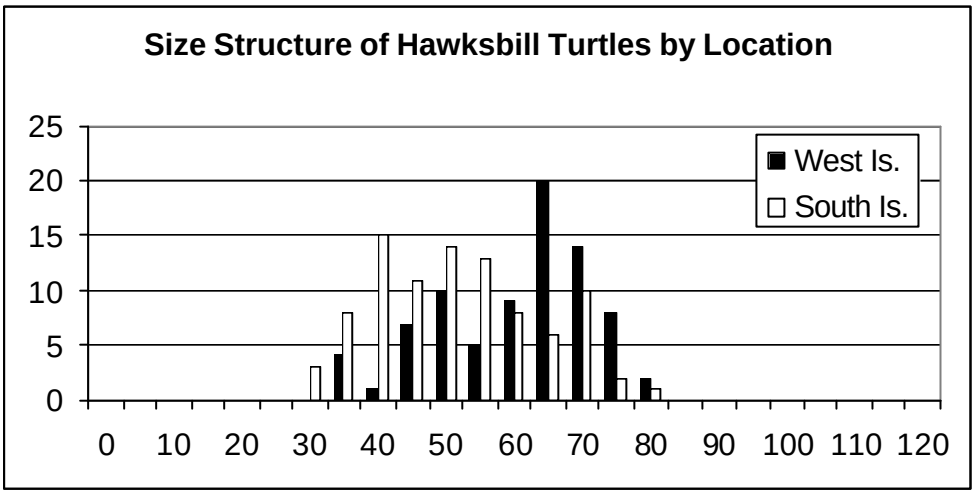

Figure 11 Size Structure of Hawksbill Turtles by Location in 2002

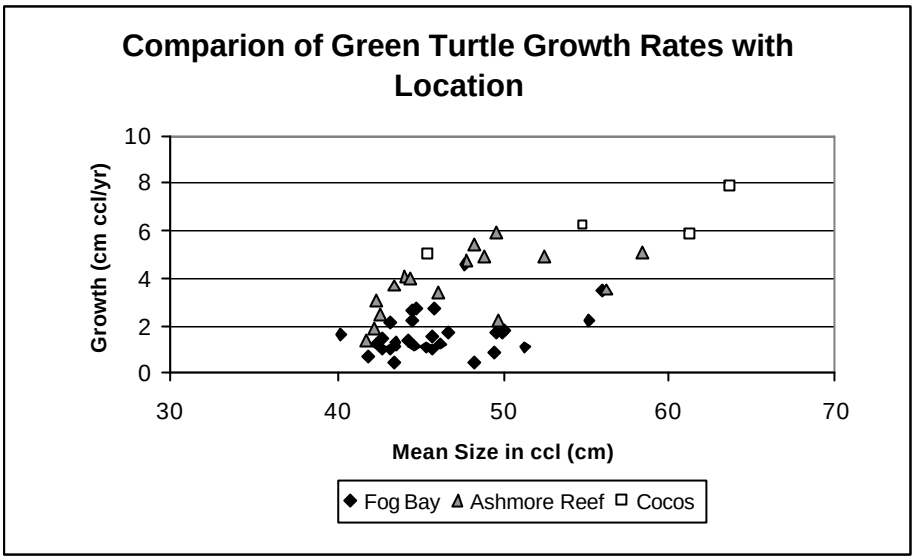

Figure 12 Growth Rates of Cocos Green Turtles in Relation to Growth Rates from Other Study Sites

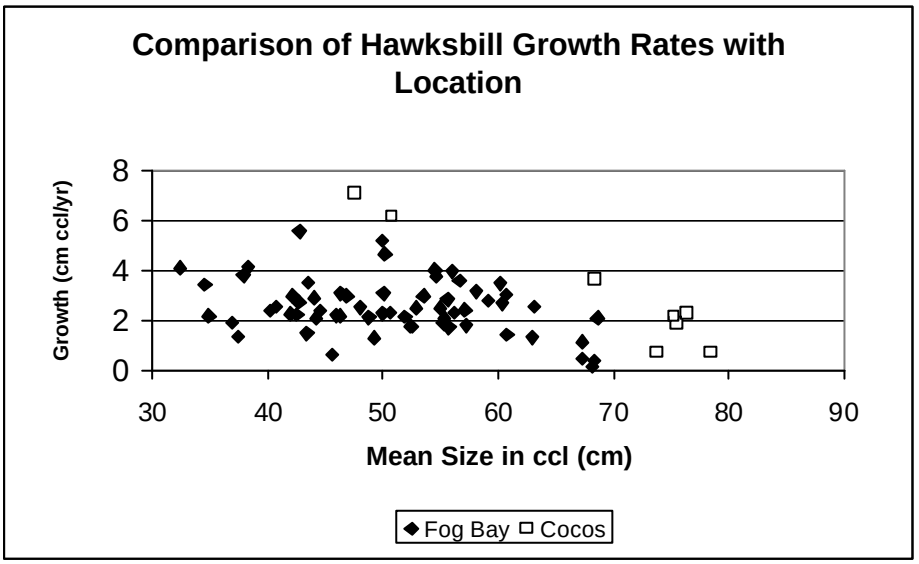

Figure 13 Growth Rates of Cocos Hawksbill Turtles in Relation to Growth Rates from Other Study Sites

APPENDIX 1 DIARY OF ACTIVITIES

1 February 2002 - Friday
Scott Whiting (SW) - Flight from Perth 105am arriving Cocos (Keeling) Islands 645am. Checked into accommodation and organized turtle equipment.

2 February 2002 - Saturday
Robert Thorn (RT) and SW Captured 2 green and 7 hawksbill turtles in Sector 6 south of Rumah Buru.

3 February 2002 - Sunday
RT and SW captured 6 green and 4 hawksbill turtles in Sector 6. Investigated Sectors 1 to 4.

4 February 2002 - Monday
Isma il Macrae (IM) and SW captured 3 green and 16 hawksbill turtles in Sector 12

5 February 2002 - Tuesday
IM and SW captured 12 turtles in Sector 13.

6 February 2002 - Wednesday
RT and SW captured 2 green and 14 hawksbill turtles in Sector 12.

7 February 2002 - Thursday
IM and SW investigated Sectors 14 to 17 for turtle habitat and for turtles then captured 3 green and 5 hawksbill turtles in Sector 13.

8 February 2002 - Friday
IM and SW captured 1 green and 8 hawksbill turtles in Sector 6.

9 February 2002 - Saturday
IM and SW caught 8 turtles in Sector 6.

10 February 2002 - Sunday
Wendy Murray (WM) and SW caught 6 green and 3 hawksbills turtles in Sector 6. This included 1 adult sized male and female

11 February 2002 - Monday
WM and SW caught turtles including 1 adult sized male turtle.

12 February 2002 - Tuesday
Nordianna Hajat (NH) and SW caught 8 turtles in Sectors 6.

13 February 2002 - Wednesday
RT and SW caught 5 turtles in Sector 6. Three were taken to Rumah Baru for an educational morning with the West Island High School. The turtles were tagged, measured, weighed onshore while the students were told about the research project and asked questions. In the afternoon a slide show about sea turtle research was presented to the same students.

14 February 2002 - Thursday
NH and SW caught 6 turtles in Sector 6.

15 February 2002 - Friday
NH and SW caught 4 turtles in Sector 5 & 6. SW gave a talk on careers at the West Island school in afternoon.

16 February 2002 - Saturday

SW accompanied RT & NH on a patrol to Home island and Direction Island

17 February 2002 - Sunday
SW accompanied RT and NH on patrol north of Home Island. No turtles were seen on three SCUBA dives (one at the Cabbage Patch, one east of Horsborough and one on the Catalina Wreck.

18 February 2002 - Monday
IM and SW caught 13 turtles in Sectors 12 &13.

19 February 2002 - Tuesday
IM and SW caught 7 turtles in Sector 12. This completed the total of 150 turtles that was stated on the permit conditions.

20 February 2002 - Wednesday
NH and SW investigated Sector 7 for turtle habitat and turtles.

21 February 2002 - Thursday
SW became familiar with the new Cocos Island GIS system. Also assessed turtles around the West Island Jetty.

22 February 2002 - Friday
SW - 0430hr Flight from Cocos (Keeling) Islands to Perth.

APPENDIX 2 – DESCRIPTION OF HABITAT AND SEA TURTLE RESOURCES

Table 10 Sectors with a description of habitat and turtle resources. Habitat was assessed visually. Turtles resources were assessed visually in all sectors except Sectors 6, 12 and 13. See Figure 1 for location of Sectors.

Sector	Landward		Seaward	
	Habitat Description	Sea Turtle Resources	Habitat Description	Sea Turtle Resources
1	The northern most part of West Island. Coral and sand habitat with some seagrass. This sector affected by wave action	Large green turtles	Coral bommies. Affected by wave action	Large green turtles
2	This sector includes the West Island Jetty. Seagrass occurs in sparse and dense patches with large sand areas in between	Male and short-tailed adult sized green turtles. Some smaller green turtles. Hawksbill turtles occasionally	Seagrass in patches	Male and short-tailed adult sized green turtles
3	Dense seagrass and algae beds in narrow band.	Green turtles sighted	Patches of seagrass	Green Turtles sighted
4	Dense seagrass and algae beds in narrow band.	Green turtles sighted	Patches of seagrass	Green turtles sighted
5	Area in between Rumah Baru and main catch area. Dense seagrass and Algal beds	Adult size green turtles sighted on full tide in afternoon. Hawksbill turtles also present	Dense seagrass	Adult size green turtles sighted on full tide in afternoon. Hawksbill turtles also present
6	One of main catch sectors. Dense seagrass and algae beds. Dominated by *Thalassia hemprichii*	Large numbers of both green and hawksbill turtles	Seagrass beds ends and coral bommies with sand patches occurs in the outer part of this sector. This is used by turtles at low tides.	Large numbers of both green and hawksbill turtles
7	Contains less seagrass and algae. Sand patches with small coral bommies	Green and hawksbill turtles but fewer than sector 6	Sparse seagrass. Sand with coral patches	Green and hawksbill turtles but fewer than sector 6
8	Very shallow. Many dead coral, very little seagrass	Few turtles	Very shallow. Many dead coral, very little seagrass	Few turtles
9	Areas around three small islands. Very shallow. Many dead coral, very little seagrass	Few Turtles	Very shallow. Many dead coral, very little seagrass	Few Turtles
10	Very shallow embayment on the protected side of South island and is only accessible at high tide. Good seagrass and algal beds.	Turtles on spring high tides	Very shallow. Good seagrass and algal beds	Green and hawksbill turtles
11	Very shallow. Dense seagrass and algal beds dominated by *Thalassia hemprichii*.	Only accessible for turtles on spring high tide.	Very shallow. Dense seagrass and algal beds dominated by *Thalassia hemprichii*.	Green and hawksbill turtles in deeper seagrass beds.
12	One of main catch sectors adjacent to South Island. Dense seagrass and algal beds dominated by *Thalassia hemprichii*.	Large numbers of turtles. Dominated by hawksbill turtles close to shore. This area was dominated by small hawksbills that were stationary on shallow silty areas near the shore. They sought refuge in the branches of the bushes *Pemphis acidula* and	Dense seagrass and algal beds dominated by *Thalassia hemprichii.*	Large numbers of green and hawksbill turtles

		Suriana maritima at high tide.		
13	Shallow embayment with patchy sparse seagrass and algae. Silty and shallow	This area was dominated by small hawksbills that were stationary on shallow silty areas near the shore. They sought refuge in the branches of the bushes *Pemphis acidula* and *Suriana maritima* at high tide.	Dense seagrass and algae beds in deeper water	Large numbers of green and hawksbill turtles
14*	Area including north-east of South Island. Shallow sand, sparse seagrass, some coral patches, lots of sea cucumbers	No turtles sighted, but similar habitat to sector 13 .Supports small hawksbill turtles	Seagrass/algal beds in deeper water.	No turtles sighted, but good habitat.
15*	Area of Pulu Pandan. Very shallow inshore, but very dense seagrass. Turtles could access on spring high tides	No turtles sighted, but good turtle habitat.	Dense seagrass/algal beds.	No turtles sighted, but good habitat.
16*	Dead coral and coral rubble in between islands. Very shallow.	No turtles sighted.	Dense seagrass/algal beds. Sand patches interspersed.	One green turtle and two hawksbill turtles sighted.
17*	Seagrass and algae beds. Patchy seagrass/algae, sand and coral	No turtles sighted.	Patchy seagrass and algae, coral and sand.	No turtles sighted.
18	Not Checked.		Not Checked.	
19	Not Checked.		Not Checked.	
20	Not Checked.		Not Checked.	
21	Not Checked.		Not Checked.	

* These areas were only surveyed on one day (7th Feb 2002) on a neap rising tide. Turtles could use the areas that contain seagrass and algal beds.

APPENDIX 3 – DESCRIPTION OF BLOOD PARAMETERS

Sources - (LeFever Kee, 1983; Widmann, 1983; Bush, 1991)

Elements - Electrolytes and Metals

In reptiles, the kidney, and associated organs, cloaca, colon and urinary bladder function to eliminate waste products and electrolytes. However, in all other marine reptiles these organs are insufficient to regulate salt. For sea turtles, salt is regulated by the lachrymal glands (George, 1997). The concentration of these electrolytes (*sodium (Na), chloride (Cl), potassium, (K), magnesium (Mg*) should remain relatively constant because of these homeostatic mechanisms. Low levels of *Calcium (Ca)* and *Phosphorous (P)* could lead to bone disorders while *iron (Fe)* deficiency could lead to anaemia (Lutcavage *et al.*, 1997). It is logical to assume that in the wild, these would be rare.

Enzymes

Alanine aminotransferase (ALT) - previously known as glutamate-pyruvate transaminase (GPT). This enzyme is liver specific and elevated values can indicate liver damage or disease while there is no known significance for low levels.

Aspartate aminotransferase (AST) - this enzyme occurs in a wide variety of tissues. It has high concentrations in the skeletal and cardiac muscles and in the liver. It is used to diagnose muscle disorders. High levels indicate damage to the above organs while the significance of low values is unknown.

Alkaline phosphatase (ALP) - exists as a group of isoenzymes (variants of the one enzyme). Isoenzymes are produced in the liver, bone, and kidney. Increased levels are caused by induction or an increase in synthesis and not the breakdown of cells. Without other techniques to separate the isoenzymes it is difficult to determine the source of production. Very little is known about this enzyme in reptiles.

Creatine kinase (CK) - also known as creatine phosphokinase (CPK) - occurs as three isoenzymes in the brain, and skeletal and cardiac muscle. Increased levels can be caused by damage to skeletal muscle or the central nervous system.

Nutrients or Metabolites

Creatinine (creat) - this is derived from the breakdown of creatinine in the muscles of the body. Creatinine is used to store energy and breaks down at a steady rate. Muscle wastage can lower creatinine levels. This product is not usually directly affected by diet.

Total Protein (prot) - synthesised in the liver and made up of albumin and globulin. An increase in total protein can be caused by numerous factors including liver disease, infections, inflammation. Low concentrations can be caused by protein starvation, malabsorption of protein, starvation, liver disorders.

Albumin (alb) - synthesised in the liver from amino acids. Rarely rises but may decrease because of similar causes as mentioned for Total Protein

Globulin (glob) - the fraction left when albumin is removed from total protein.

Albumin/globulin ratio (alb/glob) - the ratio of the two protein fractions. Changes can be caused by alterations to either albumin or protein.

Bilirubin (bili) - derived from the breakdown of red blood cells. The red blood cells are split into globin and haem. The haem molecule is converted into bilirubin after the iron molecule is removed. Increase in plasma bilirubin occur when there is liver damage (eg from parasites) or bile flow is obstructed. Also haemolytic disorders which cause red blood cell destruction will increase plasma bilirubin.

Cholestrol (chol) - obtained from the diet and synthesised in the liver. Increases can occur in high fat diets, trauma, liver damage, starvation, while decreases can occur with liver failure and low fat diets.

Glucose (gluc) - glucose is the energy sources for all the body's cells. It would be expected that glucose levels remain relatively constant.

Urea - is synthesised by the liver from ammonia which comes from increased protein catabolism. Therefore higher levels of plasma urea can come from tissue breakdown or high protein diets or from impaired excretion. Lower levels can be caused by poor liver function or low protein intake.

APPENDIX 4 – RAW DATA AND ANALYSES OF BLOOD CHEMISTRY

Table 11 Raw blood values from individual green and hawksbill turtles

			Green										Hawksbill Turtles					
Vial #			W300	W301	W302	W303	W307	W308	W309	W310	W311	W316	W304	W305	W306	W312	W314	W315
Parameter	**Abbreviation**	**Units**																
Curved Carapace Length		cm	57.3	54.8	64.2	57.7	56.7	62.1	57.7	67.5	67.3	50.3	51.2	47.1	38.5	48.8	63.1	67.5
Sodium	Na	mmol/	161	159	128	176		140	151	132	160	138	170	172	127	161	159	142
Potassium	K	mmol/l	5.7	6.5	4.5	7.2		5.0	6.1	4.3	5.6	4.8	7.0	6.1	3.6	5.1	3.2	4.3
Chloride	Cl	mmol/l	121	113	92	135		110	115	97	117	104	124	130	99	127	136	109
Creatinine	Creat	umol/l	20	22	22	19		47	25	22	36	20	99	23	13	4	10	2
Urea		mmol/l	2.5	4.0	2.1	12.0		4.0	3.0	2.0	1.4	1.9	3.1	11.4	9	20.1	9.9	21.7
Bilirubin-total	Bili	umol/l	1	6	4	2		5	3	10	10	4	1	2	2	4	4	2
ALT		U/l	10	23	22	13		30	9	6	6	2	28	22	5	24	15	4
AST	AST	U/l	246	359	201	246		269	339	162	242	229	437	139	219	134	161	102
ALP	ALP	U/l	50	67	41	73		88	64	22	44	26	80	66	29	85	56	39
Protein	Prot	g/l	47	52	48	42	39	45	49	46	55	38	58	43		33	29	29
Albumin	Alb	g/l	17	22.0	17	15.0	21.0	17.0	18.0	15	22.0	13.0	22.0	12		11.0	11.0	12.0
Globulin	Glob	g/l	30	30.0	31	27.0	18.0	28.0	31.0	31	33.0	25.0	36.0	31.0		22.0	18.0	17.0
Albumin/Globulin Ratio	Ratio		0.6	0.7	0.5	0.6	0.9	0.6	0.6	0.5	0.7	0.5	0.6	0.4		0.5	0.6	0.7
Calcium	Ca	mmol/l	3.13	2.42	2.26	2.60		1.69	2.39	2.05	2.42		2.01	2.41	1.06	1.59	1.41	125.00
Phosphorus	Phos	mmol/l	2.13	2.95	2.19	1.84		2.90	3.11	2.16	2.75	2.43	2.94	2.50	1.14	2.14	2.55	1.76
Total Serum Iron	Iron	umol/l	12	13	6	9		7.00	9	8	9	3	11	7.00	6	10	4	7
Cholestrol	Chol		3.65	4.11	3.65	2.01		1.08	3	2.77	3.6	1.9	6.08	1.69	0.94	2.14	2.49	1.96
Uric Acid	Uric A		160	210	133	243		123	182	106	102	121	149	153	70	97	1.34	75
Glucose	Gluc	mmol/l	7.7	7.0	5.1	6.7		5.4	8.5	5.0	6.2	7.5	6.5	8.6	4.6	5.9	6.9	5.3
Triglycerides	Triglyc		1.4	2.4	1.8	1.3		1.9	1.5	1.7	1.7	0.6	5.2	0.8	0.4	1.2	1.2	0.9

Table 12 Analysis of Variance of Cocos green turtles and Ashmore Reef green turtles

Marked effects are significant at p < .05000

	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
CCL	335.90	1	335.90	6040	59	102.4	3.281	0.075
SODIUM	.38	1	.38	18472	58	318.5	.00129	0.973
POTASSIUM	**9.07**	**1**	**9.07**	**45**	**58**	**0.8**	**11.663**	**<0001**
CHLORIDE	.06	1	.06	9635	58	166.1	0.001	0.986
CALCIUM	2.09	1	2.09	15	57	0.3	8.059	0.006
PHOSPHORUS	**2.68**	**1**	**2.68**	**18**	**58**	**0.3**	**8.651**	**0.005**
TOTAL IRON	5.35	1	5.35	18728	58	322.9	0.0166	0.898
ALT	**426.20**	**1**	**426.20**	**2685**	**58**	**46.3**	**9.206**	**0.004**
AST	**72056.47**	**1**	**72056.47**	**195610**	**58**	**3372.6**	**21.365**	**<0.001**
ALP	**7191.33**	**1**	**7191.33**	**35537**	**58**	**612.7**	**11.737**	**<0.001**
PROTEIN	77.33	1	77.33	5752	59	97.5	0.793	0.377
ALBUMIN	**148.17**	**1**	**148.17**	**493**	**59**	**8.4**	**17.738**	**<0.001**
GLOBULIN	11.42	1	11.42	3569	59	60.5	0.189	0.666
ALB/GLOB	**.20**	**1**	**.20**	**0**	**59**	**0.0**	**18.232**	**<0.001**
UREA	4.62	1	4.62	346	58	6.0	0.775	0.382
BILIRUBIN	**80.07**	**1**	**80.07**	**139**	**58**	**2.4**	**33.370**	**<0.001**
CREATININE	166.13	1	166.13	2526	58	43.5	3.815	0.056
CHOLESTROL	1.34	1	1.34	39	27	1.4	0.935	0.342
URIC ACID	574.02	1	574.02	58379	27	2162.2	0.265	0.611
GLUCOSE	.00	1	.00	39	27	1.5	0.001	0.970

Table 13 Analysis of Variance of blood values from green turtles from Cocos Islands, Ashmore Reef and Fog Bay

Marked effects are significant at p < .05000

	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
CCL	**2352**	**2**	**1176.**	**8828.**	**120**	**74**	**15.986**	**<0.001**
SODIUM	720	2	360.	22230.	119	187	1.928	0.150
POTASSIUM	**25**	**2**	**12.**	**66.**	**119**	**0**	**22.332**	**<0.001**
CHLORIDE	51	2	25.	12368.	119	104	0.245	0.783
CALCIUM	**4**	**2**	**2.**	**23.**	**118**	**.**	**11.242**	**<0.001**
PHOSPHORUS	**9**	**2**	**4.**	**29.**	**119**	**.**	**18.516**	**<0.000**
TOTAL IRON	223	2	111.	19942.	119	168	0.664	0.517
ALT	427	2	213.	4505.	119	38	5.636	0.005
AST	77566	2	38783.	862710.	119	7250	5.350	0.006
ALP	**9855**	**2**	**4927.**	**50303.**	**119**	**423**	**11.656**	**<0.001**
PROTEIN	**2962**	**2**	**1481.**	**10187.**	**120**	**85**	**17.448**	**<0.001**
ALBUMIN	**503**	**2**	**251.**	**861.**	**120**	**7**	**35.030**	**<0.001**
GLOBULIN	**1215**	**2**	**608.**	**6288.**	**120**	**52**	**11.597**	**<0.001**
ALB/GLOB		**2**	**.**	**2.**	**120**	**.**	**7.348**	**0.001**
UREA	190	2	95.	3846.	119	32	2.937	0.057
BILIRUBIN	**90**	**2**	**45.**	**230.**	**119**	**2**	**23.122**	**<0.001**
CREATININE	**1346**	**2**	**673.**	**4730.**	**119**	**40**	**16.934**	**<0.001**
CHOLESTROL	1	1	1.	39.	27	1	.93503	0.342
URIC ACID	574	1	574.	58379.	27	2162	.26548	0.611
GLUCOSE	**29**	**2**	**15.**	**56.**	**49**	**1**	**12.766**	**<0.001**

Table 14 Analysis of Variance of Cocos Hawksbill turtles and Fog Bay hawksbill turtles

Marked effects are significant at p < .05000

	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
CCL	171.07	1	171.07	6438	47	137.	1.249	0.269
SODIUM	62.52	1	62.52	2945	47	63.	0.998	0.323
POTASSIUM	**2.66**	**1**	**2.66**	**23**	**47**	**.**	**5.328**	**0.025**
CHLORIDE	67.39	1	67.39	2629	47	56.	1.204	0.278
CALCIUM	**2192.09**	**1**	**2192.09**	**12681**	**47**	**270.**	**8.124**	**0.006**
PHOSPHORUS	**2.28**	**1**	**2.28**	**13**	**47**	**.**	**8.461**	**0.006**
TOTAL IRON	**34.14**	**1**	**34.14**	**405**	**47**	**9.**	**3.958**	**0.052**
ALT	**474.81**	**1**	**474.81**	**1993**	**47**	**42.**	**11.196**	**0.002**
AST	**50728.1**	**1**	**50728.1**	**250310**	**47**	**5326.**	**9.525**	**0.003**
ALP	1036.00	1	1036.00	57962	47	1233.	0.840	0.364
PROTEIN	119.60	1	119.60	5301	46	115.	1.038	0.314
ALBUMIN	**84.35**	**1**	**84.35**	**350**	**46**	**8.**	**11.099**	**0.002**
GLOBULIN	1.71	1	1.71	3773	46	82.	0.021	0.886
ALB/GLOB_	**.09**	**1**	**.09**	**0**	**46**	**.**	**5.989**	**0.018**
UREA	70.34	1	70.34	2864	47	61.	1.154	0.288
BILIRUBIN	3.39	1	3.39	145	47	3.	1.102	0.299
CREATININE	347.18	1	347.18	10701	47	228.	1.525	0.223
GLUCOSE	.16	1	.16	29	18	2.	0.097	0.760

APPENDIX 5 – TURTLE DATABASE – DESCRIPTION AND CODES

The tag, capture and measurement data are stored on three separate files. The files were made with DBXL database program and all files have a dbf extension. These files are easily used by most other programs including Microsoft Excel.

Tags file

This file stores all tag information. An example of a file name is ck02tags.dbf. This means the turtles were from Cocos (Keeling) Islands in the year 2002.
The lowest tag number (first entered) is usually referred to as the primary tag and is used like a name for the turtle within all other files. All other tags that are applied to the turtle throughout its life are entered in this file.

Some Codes used at Cocos (Keeling) Islands

SP (Species)
G = Green Turtle
H = Hawksbill Turtle

Sex
I = Indeterminant
M = Male
F = Female

Ageclass
J = Juvenile
SA = Sub Adult
A = Adult

Tag status – P= Primary Turtle (This is the first time this turtle has been tagged). This code is also used in the Capture file.

Location – CK = Cocos (Keeling) Islands. This is the location where the turtle was tagged.

Contact – PAN/Whiting This is to notify the central tag registry in EA to contact Parks Australia North or Scott Whiting about the tag recovery.

Capture File

This file holds all information about the capture of the turtle. Including habitat, method of capture, health of turtle, experiments performed, length measurement and latitude and longitude. An example of a file name is ck02kapt.dbf. This means the turtles were from Cocos (Keeling) Islands in the year 2002.

Some Codes used at Cocos (Keeling) Islands

HABITAT – RG= reef grass (seagrass in coral reef habitat)

SECACT (represents capture method). At Cocos RJ represent rodeo jump capture method

TERTACT (Represents health assessment). P= turtle in poor condition, P+ =turtle in extremely poor condition

EXPERIMENTS
BS = Skin biopsy sample (genetic material)
FS = Food Stomach Sample
FM= Food Mouth Sample
IX = Blood Sample

Measurement File

This file stores all measurement data. An example of a file name is ck02meas.dbf. This means the turtles were from Cocos (Keeling) Islands in the year 2002.

Some Codes used at Cocos (Keeling) Islands

CCL = Curved Carapace Length
CCW = Curved Carapace Width
WT = Weight
TP = Tail Length (Tip to Plastron)
TC = Tail Length (Tip to Carapace)
TV = Tail Length (Tip to Vent)
HL = Head Length
HW = Head Width
SCL = Straight Carapace Length
SCW = Straight Carapace Width
PL = Plastron Length

Note = 999.0 is a null value and means that no measurements were taken.

APPENDIX 6 – TURTLE DATA - 2002

File 1 – ck02tags
Tag information

File 2 - ck02kapt
Capture Information

File 3 – ck02meas
Measurement Information

APPENDIX 7 – TURTLE DATA – ALL YEARS

File 1 – ckyytags
Tag information

File 2 - ckyykapt
Capture Information

File 3 – ckyymeas
Measurement Information