Final Report

POPULATION ABUNDANCE, STRUCTURE AND DYNAMICS OF MARINE TURTLES IN THE TUBBATAHA REEFS, CAGAYANCILLO, PALAWAN, PHILIPPINES

A project implemented by the

TUBBATAHA REEFS NATURAL PARK
WORLD HERITAGE SITE

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MARINE RESEARCH FOUNDATION
SABAH, MALAYSIA

June 2010

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Acknowledgments

This work was conducted under contract to the Tubbataha Reefs Natural Park Management Office TPAMB Agreement 10-02, and the planning and logistical support by the Park Manager Angelique M. Songco and Deputy Park Manager Theresa R. Aquino is gratefully acknowledged. This work was also facilitated through original introductions by Romeo Trono, a great turtle conservationist and member of the Tubbataha Protected Area Management Board. The results of this survey build on the valuable results of the initial population assessment conducted in 2005 by the Philippines Department of Environment and Natural Resources (DENR) and by the Tubbataha Management Office (TMO) in 2005, 2007, 2007 and 2010. Without these initial efforts, many of the data sets generated by this project (such as growth rates and residence periods) would have been impossible, and for access to this work I am extremely grateful.

But it falls to the crew of the MV Navorca, the Tubbataha Management Office and Local Government Unit Rangers and the personnel from the Philippines Navy and Coast Guard assigned to the Tubbataha Ranger Station to be deserving of an overwhelming proportion of the credit. Without their assistance, we simply would not have been able to reach the survey sites at the right tides and under safe conditions the way we did; turtles would not have been caught in the numbers necessary for this detailed assessment; laparoscopy procedures would have taken ten times as long; and we might never have field-tested practical survey measures for long-term population assessments. Not to mention we never would have had as much fun as we did while getting all this work done! In alphabetical order, I am deeply indebted to Rowell C. Alarcon (Tubbataha Management Office), Napoleon M. Caballero (Philippines Coast Guard), Ranie M. Calain (Philippines Coast Guard), Javier E. Carceler (Local Government Unit), Darius T. Cayanan (WWF), Segundo F. Conales (Tubbataha Management Office), Abdon G. Dalanon (WWF), Ronald L. De Roa (WWF), Roger G. Dolorosa (Western Philippines University), Arnel C. Escubin (WWF), Quintin M. Fontanilla (Philippines Navy), Jesus G. Gayoma Jr. (Tubbataha Management Office), Jonathan R. Lopo (Philippines Navy), Jhun A. Magbanua (WWF), Roy P. Magbanua (Tubbataha Management Office), Julius A. Parcon (Tubbataha Management Office), Glen G. Redondo (Philippines Navy), Niño B. Rogales (WWF), Leudemer B. San Sano (Local Government Unit) and Alexander T. Sanchez (Philippines Navy), for their graciousness, friendship and unrivalled Filipino hospitality.

The passion, dedication and professionalism demonstrated by the entire team was exemplary, and always way above the call of duty. I take this opportunity to salute each and every one of my new friends for the roles they continue to play in protecting this valuable global natural heritage.

Nicolas J. Pilcher, PhD.
July 2010

1.0 Introduction

The reefs at Tubbataha, Cagayancillo, Palawan, Philippines, are a developmental and nesting habitat for green turtles (*Chelonia mydas*), and a foraging habitat for hawksbill turtles (*Eretmochelys imbricata*) – their nesting has yet to be documented on the Tubbataha beaches (Cruz & Torres 2005). These species are considered critically endangered and endangered species, respectively, by the International Union for the Conservation of Nature and Natural Resources (IUCN).

Recent studies on turtles in SE Asia have demonstrated declines in turtle populations due to increases in commercial fisheries, coastal development, illegal poaching and legal collection of turtle eggs. Management measures on nesting beaches where hatcheries are used are also implicated in these population declines (Pilcher 2010). This has been the case, for example, with green turtles in Sabah, Malaysia (Chan 2001, UPM et al. 1996), where populations have been steadily increasing, though nearly all eggs are moved to hatcheries, which have produced for many years 100% females due to warm development temperatures (Tiwol & Cabanban 2000) resulting in skewed population sex ratios.

Up until recently all turtle conservation, monitoring and research projects in SE Asia have been based on nesting beaches, where females conveniently emerge to lay eggs. Nesting turtle populations have been documented in Malaysia (Basintal & Lakim 1993, Chan 1990, Leh 1993, Pilcher & Ali 1999), Thailand (Charuchinda et. al. 2002), Taiwan (Cheng 2002), Philippines (Palma, 1993, Cruz 2002), Indonesia (Halim et al. 2001, Putrawidjaja 2000), Vietnam (Pham Thuoc 2002, Hamman et al. 2002) and major conservation approaches have been documented by Limpus et al. (2001), Pilcher & Ismail (2000), Shanker & Pilcher (2003), and Trono 1991, amongst others.

However, virtually no information exists on foraging populations in the region. In many cases the distribution of the foraging sites themselves remains a mystery. A recent foraging population project at Mantanani, Malaysia (Pilcher 2010) has revealed substantial population demographic data crucial for understanding the at-sea component of marine turtle life histories. Population demographic data such as these are critical to determine how turtle populations will be influenced by various natural and anthropogenic stresses, yet in Southeast Asia there is no information on population dynamics or biology for the 20 to 30 missing years between hatchling and returning adults. There is no published information on gender ratios in the wild, nor on the dynamics of turtle populations with regard to growth, survival, gender ratios, and no way to determine what proportion new entrants to the breeding population represent. These data are considered crucial and among the top priorities for researchers at present time, given the understanding they would provide on the status of turtles at those life stages least studied by modern science.

Our understanding of the life-stage dynamics of stocks such as the ones at Tubbataha Reefs National Park will assist managers in the development and implementation of sound, effective conservation strategies which build on the biological characteristics of the turtles. Our understanding of the varied life-stage parameters will better enable scientists, managers and conservationists to protect these animals and ensure population stability or recovery.

1.1 General Marine Turtle Biology and Ecology

All marine turtle species share similar life-history traits, with only slight variations. After storing energy reserves over a series of successful foraging years, turtles undergo hormonal changes which enable the development and storage of sperm in males, and the accelerated development of egg follicles in females. They then migrate from the feeding grounds to (often) distant nesting areas where they mate. Each male may mate with several females, and females will normally mate with several males. Sperm from each of these is mixed and used to randomly fertilize eggs as they are extruded from the ovary into the oviduct. Here the eggs undergo a brief developmental stage, during which albumen and shell are added, and about one month later females emerge on beaches and lay a first clutch of eggs. Thereafter, they may return several more times to lay again in that same season, depositing hundreds of golf ball-sized eggs in the sand. After one and a half to two months, hatchlings excavate through the sand for two or three days to venture out after dark, when the sand surface cools. They then crawl down the beach and head directly offshore using light, waves and the earth's magnetic field for guidance. They swim offshore for a day or two in a swimming frenzy and then generally float as part of the ocean's plankton for several years. Another five to ten years makes them juveniles and sees them migrate from the deep blue to shallow coastal feeding grounds, and the same time frame again sees them reach sexual maturity, whereupon they undertake their first migration to the mating and natal nesting areas, and the cycle is repeated.

The Tubbataha Reefs host nesting green turtles, and thus plays host to adult male and female turtles as they arrive from their foraging grounds and mate, following which the females emerge to lay eggs. After the hatchlings leave the reefs through, it is unknown where they go. The reefs are also home to hundreds of juvenile and sub adult turtles, whose provenance is unknown at present, but could be resolved through the use of genetic studies. It is unknown if the developmental stage turtles remain at Tubbataha and become adults which lay eggs, of if these are two distinct population segments, possibly with differing origins.

1.2 Rationale for Population Assessments

While knowledge of absolute numbers of turtles is important for understanding turtle populations, it is the *trends* in these absolute numbers which has far more direct management implications. Are numbers increasing? Decreasing? Why may this be so? What distant or localized impacts might be causing changes in population structure? Several important aspects of turtle population management may be ascertained through periodic population assessments which document population structure, relative size and condition.

In the Sulu-Sulawesi region many cohorts of female-based hatchlings have been released to the sea from hatcheries at the Turtle Islands Park in Malaysia and the Turtle Islands Wildlife Refuge in the Philippines. Many other hatcheries operate with no knowledge of the sex ratios of emerging hatchlings. Will populations be impacted by lower proportions of males many years down the road? Unfortunately, impacts such as unnatural hatchery temperatures will only become apparent several decades later as turtles which have become adults now return to nest. By then it is likely management regimes will have changed, and personnel will have moved on, and cause-effect linkages will be hard to establish. More likely, managers at that time will look to other more-current impacts to explain any decreases in nesting activity: erosion, fisheries, illegal harvests, and the like. But the real causal effect, something which happened many years prior, will remain elusive.

For this reason periodic checks of the non-nesting populations and mark and recapture of individuals allow managers to track populations through their at-sea life components, from newly recruited juveniles through sub adult stages and into adulthood. They allow tracking of recruitment rates to each population age-class, they allow a determination of sex ratios in each, and they provide advance warnings of changes in population structure.

1.3 Objectives

The objectives of the present study were to conduct a population abundance estimate of marine turtles in the Tubbataha Reefs, to gather data on population structure and dynamics of marine turtles, and to design a long-term monitoring system for marine turtles to be implemented by marine park rangers. The results of this work will provide a baseline population structure for the marine turtle population at the Reefs in 2010, and will allow continued updates and the opportunity to monitor changes in population abundance and structure over the years. The work complements ongoing initiatives throughout the Sulu-Sulawesi but importantly, addresses the foraging and developmental habitats of turtles along with nesting studies.

2.0 Methods

The methods used in this assessment are founded on the principles outlined by the IUCN SSC Marine Turtle Specialist Group (Eckert et al. 1999) and are based on over 20 years of experience in designing and conducting marine turtle studies by the author. Beach monitoring protocols follow those developed and refined by Pendoley Environmental (2009), while in-water captures and are based primarily on methods developed by Colin Limpus and colleagues in Australia, and used in the only other foraging ground study in SE Asia in Malaysia (Pilcher 2010). The methods used during this survey also used the findings and took note of recommendations of the initial survey conducted by Cruz & Torres (2005). A record of day to day activities is presented in Annex I.

2.1 Beach Surveys – Track Counts

Overnight counts for turtles emerging on the North Islet were counted over four consecutive days during the survey, as per methods developed by Pendoley Environmental (2009) and approved by an expert panel of marine turtle specialists in Australia. On the first day, a line was drawn in the sand above the high tide mark and new turtle tracks that crossed the line were counted the following morning. The line was redrawn daily and new counts made. Upward and downward tracks were counted and the number of emergences was based on downward track counts as these occasionally obscured upward tracks. On the second to fourth days, beaches were surveyed daily and data pertaining to overnight turtle activity, emerged nests and in-water sightings of turtles were collected on all beaches. Downward tracks were only counted where they crossed the fresh line from the previous day and were considered an accurate count of all overnight emergences. Crawl marks were identified to species base on descriptions by Pritchard and Mortimer (1999).

2.2 In-Water Capture

Search techniques followed closely the methodology used by researchers in Queensland (Limpus and Reed 1985, Limpus et al. 1994a, Limpus et al. 1994b) and in Malaysia (Pilcher 2010). Rodeo-style captures were conducted from two fiberglass dinghies with rear steering and 25-30 hp outboard engines weaving in and out across sandy shallows at three key sites (Ranger Station, North Islet, South Islet). Three observers positioned at the front of the boat searched for turtles, and when a turtle was seen, it was chased until it was either captured or lost. Capture selections were made without regard to the size or location of the turtle. When the dinghies were full (10-20 turtles) they unloaded their catch at the Ranger Station or on the MV Navorca and continued catching.

2.2.1 Laparoscopy

Laparoscopy is a form of surgery that uses a miniature telescope to directly view the inside of the peritoneal cavity. It is a potentially dangerous procedure and requires proper veterinary training. The equipment necessary includes a laparoscope (a long thin optic sheathed in a fiber-optic light supply in a stainless steel housing, a trocar (puncture device), canula (sleeve), fiber optics projector and standard surgical instruments. Laparoscopy is more and more frequently being used as a tool to determine aspects of population dynamics in marine turtles (Dobbs et al 2007, Duronslet et al 1989, Limpus et al 2005, Wood et al 1983) and to validate data ascertained through other methods, such as blood radioimmunoassay to determine gender in Kemp's ridleys (Coyne 2000), and serum testosterone analysis (Diez & van Dam 2003). Laparoscopy can help identify varied aspects of an animal's reproductive history, such as activity over the preceding 2-3 years and evidence of historical nesting activity (in females), reproductive status (immature, pubescent, mature) and projected activity for the following season, over and above simple determination of gender (Miller & Limpus 2003). In this study laparoscopy provided information on gender, age class and reproductive status.

Turtles were checked for general appearance and obvious signs of damage or sickness, and photographs were taken of obvious defects. The turtles were then examined internally using a BAK (Germany) 30^{o}, 5mm diameter × 30 cm long laparoscope. Care was taken each time to ensure the trocar had penetrated the peritoneal cavity prior to proceeding with the internal examination, and records were kept in instances where intestinal perforation resulted from the laparoscopy procedure. Turtles were scored for gender, and appearance of gonads (oviduct size and shape, colour of ovaries in females; testes size, shape and colour, and shape of epididimus in males) *sensu* Miller & Limpus (2003). Following laparoscopic examination, two sutures using self-dissolving catgut were used to seal the 0.8-1 cm incision. No tags were available to tag the turtles as they were returned to the water, so turtles were marked with a patch of bright rapid-drying orange spray pain to enable within-season observations and to avoid

repeat captures and sampling. They were then carefully returned to the sea, and their behavior observed as they swam away from the base station / vessel.

Turtles were also carefully measured for curved carapace length (CCL) using a fiberglass tape measure (+/- 1mm) – measured over the curve of the carapace along the midline from the anterior point at the midline of the nuchal scute to the posterior tip of the surpacaudal scutes.

2.3 SCUBA Diving Surveys

SCUBA surveys provided only a qualitative assessment of turtles on the reefs, due to their limited coverage and sparse turtle distributions. However, the surveys did allow a rapid understanding of habitat use and turtle presence, which was useful in understanding the overall role of the reef as a marine turtle habitat. SCUBA surveys were conducted opportunistically when weather and time allowed, over and above other project and TPAMB activities. Turtles were categorized by size classes (small, medium-large, and very large – corresponding roughly to Juvenile, Subadult and Adult life stages), and presence / absence along with turtle activity when spotted was used as an indicator of habitat use.

3.0 Results

The findings during this marine turtle population assessment revealed a wealth of information on population structure, sex ratios, nesting activity, spatial distribution, residence times, growth rates and size structure. In many instances the data from past surveys allowed calculations of residence periods and growth rates.

3.1 Beach Surveys – Track Counts

High tides occurred at around mid-morning to midday during the survey period, with no substantial second high tide during the night – in essence mirroring single-tidal cycle conditions. On the morning of the first day (June 15) all existing tracks on North Islet were crossed out. No new tracks were recorded extending below the high tide line, indicating no turtles had nested the night before (June 14). Six tracks were recorded on the morning of June 16 of which four successful nests. It is possible the two unsuccessful emergences were made by turtles which nested successfully on the same day, based on observations of turtle behaviour in the past, although there is no evidence to substantiate this suggestion. Four successful emergences were recorded on the morning of June 17, and another one successful emergence on the morning of June 18. All emergences were logged in as nesting events for the previous night (Figure 3.1).

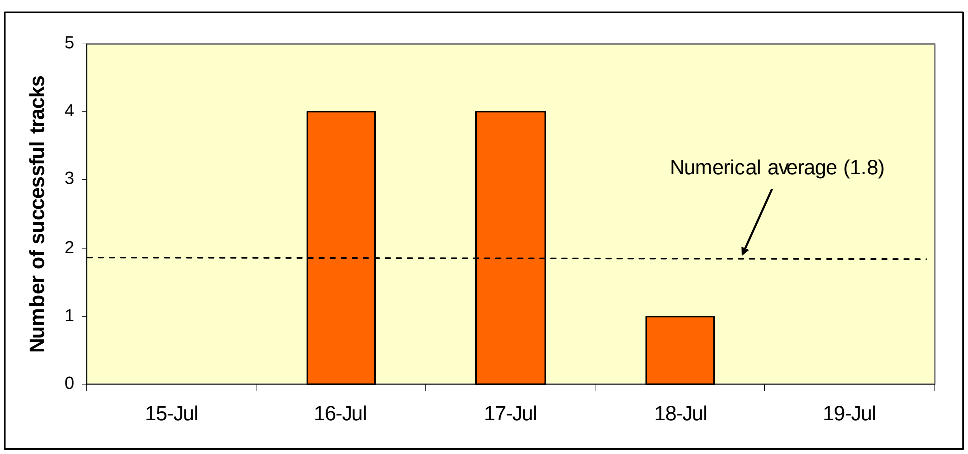


Figure 3.1: Nightly nesting activity on North Islet, Tubbataha Reefs, from 15 July 2010 to 19 July 2010.

No emergences were recorded by the morning of June 19. All emergences were by green turtles (*Chelonia mydas*), identified through symmetrical wide tracks (~1m) commonly associated with green turtle activity. No (alternating flipper marks, narrow) emergence tracks by hawksbills (*Eretmochelys imbricata*) were noted. These data indicate a minimum of at least nine adult female green turtles using the North Islet during the survey period, with an average nesting frequency of 1.8 nests per night.

3.2 In-Water Captures

Rodeo-style activity resulted in the capture of 215 individual green turtles (*Chelonia mydas*). No hawksbills were seen nor captured during the rodeo outings. Timing of rodeo captures was not recorded in detail, but each outing by each boat typically lasted between one to two hours. An estimated total 23 hours of effort were invested in turtle capture, for an average catch of 9.38 turtles per hour. A Nurse shark (*Ginglymostoma cirratum*) was observed in the same shallow reef flat habitat as the turtles off the Ranger Station during the morning of 15 July, and a Tiger shark (*Galeocerdo cuvier*) was observed in the shallow reef flat off North Islet during the morning of 19 July. Rodeo captures proceeded uninterrupted, and a friendly rivalry between boats provided a virtually-endless supply of turtles.

3.2.1 Population Structure and Male : Female Ratio

The vast majority of turtles caught during the rodeo exercises were juveniles (87%). Two of these were identified as new recruits based on a white scratch-less plastron and small size. Sub-adults >65cm CCL comprised 11% of the captures, and adults only comprised 2% (Table 3.1). Substantially more females (76%) were captured than males (24%). This equates approximately to a 1 : 3 Male : Female ratio. When nesting turtles and in-water sightings during SCUBA surveys were included, juveniles represented a somewhat smaller proportion of the total (79.4%), sub-adults dropped to 10.1% and adults increased to 10.5%) (Figure 3.2). The major differences were accounted for by the nesting adult females and an in-water sighting of a mating pair of green turtles with four attendant males.

Table 3.1: Sex and age class structure of rodeo-caught turtles at Tubbataha Reefs, Philippines, July 2010.

	Male	Female	Total
Juvenile	20%	67%	87%
Sub Adult	3%	8%	11%
Adult	1%	1%	2%
Total	24%	76%	

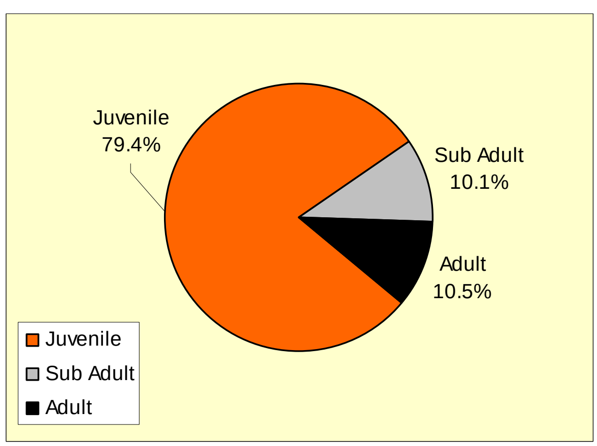


Figure 3.2: Age class structure of nesting turtles, in-water sightings and rodeo captures at Tubbataha, July 2010.

3.2.2 Size Distribution

Not unexpectedly given the age-class structure, most turtles were in the smaller size ranges for the species. Interestingly there were distinct differences between turtles caught at the Ranger Station and at the North Islet (insufficient numbers were collected at the South Atoll for similar comparisons, but these appeared even larger than those at North Islet; **Figure 3.3**). Turtles at the Ranger Station averaged 51.9 cm in Curved Carapace Length (CCL) (SD=8.62, range: 37.0 to 95.2, *n*=63), while those at North Islet averaged 57.5 cm CCL (SD=7.04, range: 41.4 to 74.5, *n*=132), and turtles at South Atoll averaged 68.4 cm CCL (SD=12.38, range: 49.7 to 90.0, *n*=12),

Turtles were significantly larger at North Islet ($ANOVA_{63,132}$ F=23.13, P=0) than those at the Ranger Station. Turtles were also significantly larger at South Atoll than at North Islet ($ANOVA_{132,12}$ F=22.59, P=0), although this is likely an artifact of the substantially smaller sample size (12) and greater standard deviation (12.38) at South Atoll.

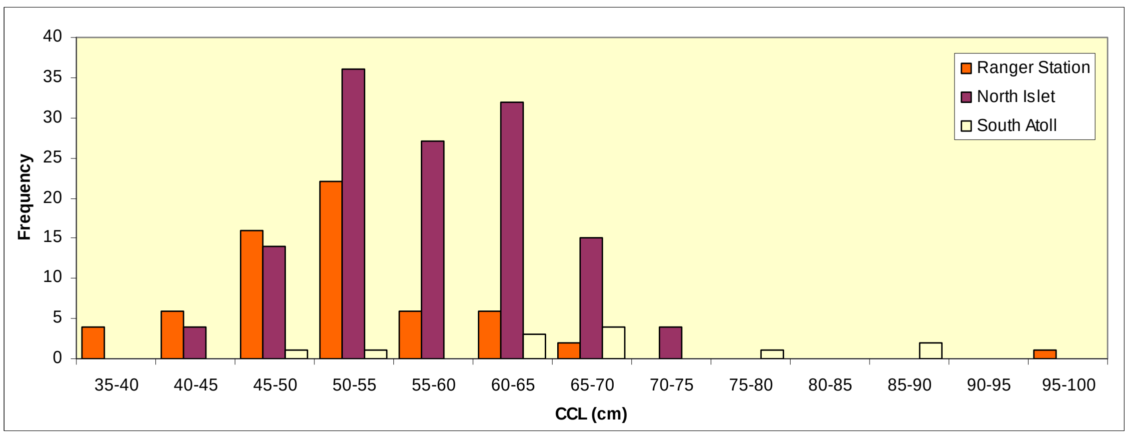


Figure 3.3: Size distribution of rodeo captures by site at Tubbataha Reefs, July 2010.

There were no statistical differences ($ANOVA_{155,49}$ F =0.0029, P=0.957) in sizes of turtles when broken down by gender, with female turtles averaging 55.67 cm CCL and male turtles averaging 55.74 cm CCL. (**Figure 3.4**).

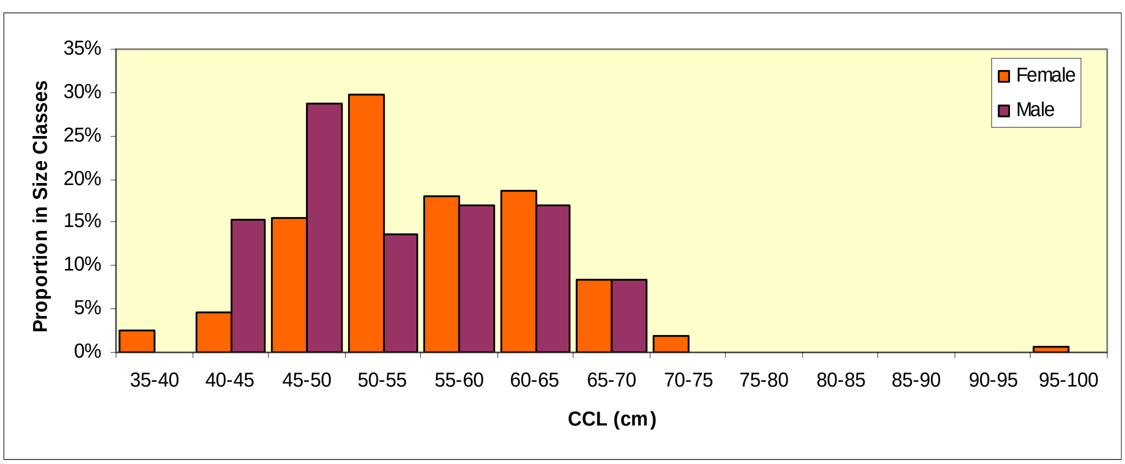


Figure 3.4: Size distribution of rodeo captures by gender at Tubbataha Reefs, July 2010.

3.2.3 Mark-Recapture, Growth & Residence Periods

Capture-mark-recapture studies allow assessments of growth rates, residence periods, migrations and age-specific mortality (see Table 3.2). This survey benefited from past efforts at the site by the Tubbataha Management Office personnel (unpublished data) and by DENR (Cruz & Torres 2005) which tagged sufficient turtles to allow some preliminary assessments in this regard. Recaptures accounted for 19.78% of all captures. Most (37) marked turtles were recaptured by the Ranger Station, while 16 were recaptured near North Islet. No previously-marked turtles were caught at South Atoll (Figure 3.5).

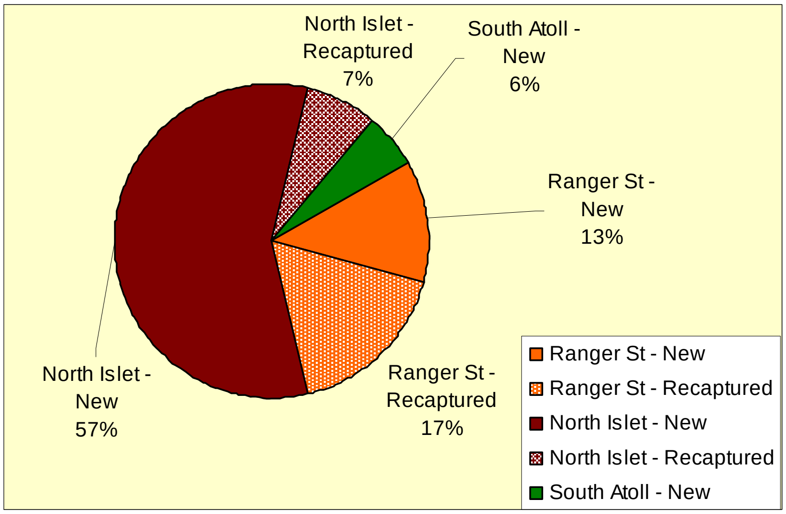


Figure 3.5: Recapture rates of previously-tagged turtles at Tubbataha Reefs, July 2010.

Growth was calculated from 28 recaptured individuals. Although old measurement techniques differed slightly from standard CCL definitions (nuchal scute to tip of carapace compared to nuchal scute to inside notch), a number of turtles recaptured during this monitoring period were measured both ways, providing both an accurate size record and a measure comparable to that taken in past years. Turtles grew at an average rate of 1.60 cm·yr^{-1} (SD=1.71, range 0.0 to 7.10, *n*=28). Only a weak correlation was found between growth rates and body size (CCL), suggesting little variation in growth rates within the size classes encountered during the rodeo captures (Figure 3.6).

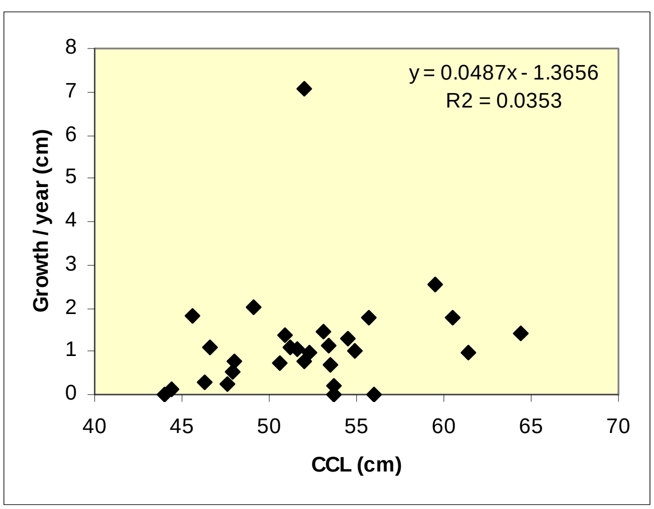


Figure 3.6: Recapture rates of previously-tagged turtles at Tubbataha Reefs, July 2010.

Table 3.2: Recapture intervals and growth for turtles encountered at Tubbataha Reefs, Philippines, July 2010.

Left Tag	Right tag	Date tagged	Old CCL	New CCL	ΔCCL	ΔDays	ΔYears	$\Delta CCL \cdot yr^{-1}$
PH6786	PH6787	05/11/2005	Not comparable	47.9	Unavailable	1683	4.61	Unavailable
PH6788	PH6789	11/05/2005		53.7		1861	5.10	
PH6792	PH6793	11/05/2005		53.7		1861	5.10	
PH6739	PH6746	11/05/2005		54.9		1861	5.10	
PH6784	PH6785	11/05/2005		61.4		1861	5.10	
PH6771	PH6760	07/02/2006		52.3		1589	4.35	
PH7151	PH7152	23/03/2006		52.0		1545	4.23	
PH7158	PH7159	23/03/2006		54.5		1545	4.23	
PH7198	PH7199	03/11/2006		50.6		1320	3.62	
PH7806	PH7807	03/11/2006		45.6		1320	3.62	
PH6773	PH7808	07/07/2007		51.2		1074	2.94	
PH7815	PH7814	07/07/2007		44.4		1074	2.94	
PH0902	PH0901	07/01/2008		46.3		890	2.44	
PH0904	PH0903	07/01/2008		49.1		890	2.44	
PH0213E	PH0214E	05/03/2010		44.0		102	0.28	
PH7194	PH7105	03/11/2006	53.0	52.8	-0.2	1321	3.62	
PH7804		03/11/2006	46.0	50.9	4.9	1321	3.62	1.35
PH6742	PH0925A			*No past information available for this turtle*				
	PH6736	11/05/2005	41.0	46.6	5.6	1862	5.10	1.10
PH0218E	PH0217E	05/03/2010	50.0	52.0	2	103	0.28	7.09
PH6750	TS	11/05/2005	45.7	53.1	7.4	1862	5.10	1.45
PH7829	PH7830	07/06/2007	50.0	53.4	3.4	1105	3.03	1.12
PH0210E	PH0209E	05/03/2010	50.0	49.2	-0.8	103	0.28	
PH6790	TS	11/05/2005	50.0	53.5	3.5	1862	5.10	0.69
PH6751	PH10102	11/05/2005	46.4	47.6	1.2	1862	5.10	0.24
PH6775	PH6774	07/02/2006	48.0	55.7	7.7	1590	4.36	1.77
PH6768	TS			*No past information available for this turtle*				
PH7824	PH7825	07/07/2007	52.0	59.5	7.5	1075	2.95	2.55
PH0206E	PH0205E	05/03/2010	64.0	64.4	0.4	103	0.28	1.42
PH7163	PH7162	23/03/2006	47.2	51.6	4.4	1546	4.24	1.04
PH0216E	PH0215E	05/03/2010	60.0	60.5	0.5	103	0.28	1.77
PH0238E	PH0237E	05/03/2010	56.0	56.0	0	104	0.28	0.00
PH0232E	PH0231E	05/03/2010	53.0	50.7	-2.3	104	0.28	
PH7853	PH7854	08/06/2007	65.0	64.6	-0.4	1105	3.03	
	PH7875	08/06/2007	58.0	53.7	-4.3	1105	3.03	
PH0196C	PH0197C			*No past information available for this turtle*				
PH0211C	PH0212C	05/03/2010	55.0	44.0	-11	104	0.28	
PH0228E	PH0227E	05/03/2010	66.0	63.3	-2.7	104	0.28	
PH0241E	PH0242E	05/03/2010	70.0	69.0	-1	104	0.28	
PH0217C	PH0218C			*No past information available for this turtle*				
PH7869	PH7871	08/06/2007	48.0	50.3	2.3	1106	3.03	0.76
PH0186C	PH0187C			*No past information available for this turtle*				
PH0198C	PH0199C			*No past information available for this turtle*				
PH0201C	PH0202C			*No past information available for this turtle*				
						Days	**Years**	**Growth**
					Average	**1085**	**2.97**	**1.60**
					Minimum	**102**	**0.28**	**0.00**
					Maximum	**1862**	**5.10**	**7.09**

Residence periods were inferred from settlement sizes (new recruits at ~40 cm CCL) and growth rates (1.60 $cm{\cdot}yr^{-1}$). Residence periods (**Table 3.3**) were calculated by subtracting the size at arrival from current size, and dividing by the average growth rate. Female turtles appeared to be resident for slightly over ten years, while male turtles stayed at the reefs for a similar but slightly shorter time.

Table 3.3: Estimated average residence times for turtles at Tubbataha Reefs, Philippines, July 2010.

	Female Residence (years)	Male Residence (years)
Average	10.11	9.87
SD	4.789	4.373
Max	0.3	0.9
Min	34.6	18.4
n	151	49

3.2.4 Tag Loss

Effective mark recapture programs work when tags are retained by turtles over the long-term. Unfortunately, a number of turtles encountered during this survey had scars from past tagging (**Figure 3.7**), and these turtles were not identifiable. A breakdown of tag loss is reported in **Figure 3.8**. Double tagging and the use of Titanium tags are the best possible solution to this problem (Limpus 1992).

Figure 3.7: Tag scan on a turtle encountered at Tubbataha, July 2010.

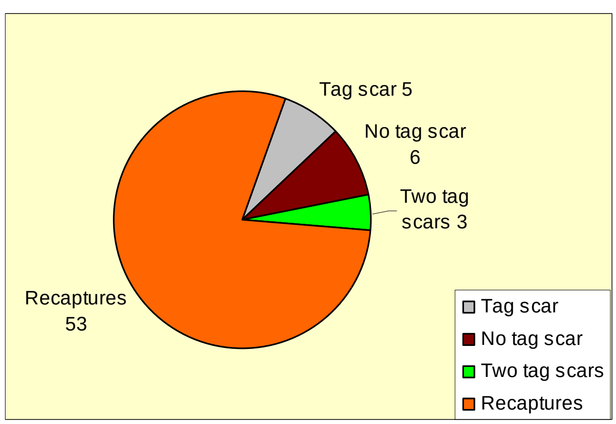


Figure 3.8: Tag loss scars on turtles encountered at Tubbataha, July 2010.

3.2.5 Injuries

A handful of turtles were recorded with injuries ranging from flipper-loss to shark bites, flipper damage and a number of impacts to the carapace. Photographs were taken of each of these. None of the turtles appeared to be overly affected by the injuries and all injuries were considered old and long-healed (Figure 3.9).

Figure 3.9 Composite image of varied injuries noted on turtles at Tubbataha Reefs, July 2010.

3.2.6 Parasites

No external parasites with the exception of small barnacles (likely *Platylepas* sp.) lying along the intra-scute margin on the plastron were noted on any of the turtles captured during this survey. Upon internal superficial examination of intestines, lungs and gonads on 215 of the turtles, only one was found to have what appeared to be a blood fluke infection, with an emaciated body and all internal organs appeared smaller than normal.

3.2.7 Markings

A number of turtles captured during the rodeo events appeared to have markings (notches in marginal scutes) which appeared man-made. In some projects hundreds, if not thousands, of turtle hatchlings are marked as they are released (all on the same marginal scutes for each separate year) so that they can be identified as a hatchling year cohort upon subsequent recapture. The only confirmed program in the region which regularly notched hatchling cohorts was in Australia, but it is unlikely these turtles originated form there. Apparently the Philippines Turtle Project may have notched hatchlings also in the past (in the 1980s) but scarce details of this effort remain (Romeo Trono, personal communication).

3.3 SCUBA Diving Surveys

A total of seven SCUBA dive surveys were conducted specifically searching for turtles. A number of other dives were conducted by other researchers during the survey period but their (turtle) findings are not reported here. Turtles were spotted on all dives, and the dive sites where most turtles were spotted were Seafan Alley on the North Atoll and Ko-ok on the South Atoll. A mating pair of green turtles with five attendant males was recorded at Seafan Alley. A total of 26 turtles were recorded during the SCUBA surveys (Table 3.3). All turtles which were seen underwater were accurately and easily identified to species. Both green and hawksbill turtles were recorded during the SCUBA surveys, with green turtles being more abundant. Given the turtles were not captured, sizes could only be approximated, with most turtles were categorized as either Juvenile (based on small size) or Adult (based on long tails in males, and mating activity with one female). It was not possible to accurately categorize Sub-Adults, but an approximation was made based on larger size than Juveniles but not as large as Adults. Where possible this was only done when other turtles nearby allowed comparative assessments.

Table 3.3: SCUBA survey records of turtles (raw data) at Tubbataha Reefs, Philippines, July 2010.

Location	Species	Age Class	Sex
Black Rock	Green	Adult	Male
Black Rock	Green	Juvenile	Unknown
Black Rock	Green	Juvenile	Unknown
Black Rock	Green	Sub-Adult	Unknown
Ko-ok	Green	Adult	Female
Ko-ok	Green	Adult	Male
Ko-ok	Green	Adult	Male
Ko-ok	Green	Adult	Male
Ko-ok	Green	Adult	Male
Ko-ok	Green	Adult	Male
Ko-ok	Green	Adult	Male
Ko-ok	Hawksbill	Unknown	Unknown
Seafan Alley	Green	Adult	Male
Seafan Alley	Green	Juvenile	Unknown
Seafan Alley	Hawksbill	Adult	Male
Seafan Alley	Hawksbill	Juvenile	Unknown
Seafan Alley	Hawksbill	Juvenile	Unknown
Seafan Alley	Hawksbill	Juvenile	Unknown
Seafan Alley	Hawksbill	Unknown	Unknown
Shark Runway	Green	Adult	Male
Shark Runway	Green	Adult	Male
Shark Runway	Green	Juvenile	Unknown
Shark Runway	Green	Juvenile	Unknown
Shark Runway	Green	Juvenile	Unknown
Washing Machine	Green	Juvenile	Unknown
Washing Machine	Hawksbill	Adult	Female

4.0 Discussion

Undeniably a substantial portion of the results of this survey were only possible due to the past research efforts at Tubbataha, upon which this survey builds. Novel aspects of research and understanding of the turtle population status at Tubbataha through this survey come from the use of laparoscopy to determine gender and age class composition. The results point to the reefs acting primarily as a juvenile developmental habitat, but also to an important mating and nesting habitat. Adult turtles were seen on nearly all dives, were recorded mating, and nesting was successful on the North Islet and South Islet (although the South Islet appears to be of lesser importance due to high tides washing over the limited sand area available for nesting.

4.1 Population Structure

The vast majority of turtles at Tubbataha are juveniles (~80%) inclusive of turtles which were rodeo-captured, those which nested and those sighted during SCUBA surveys. Tubbataha is undeniably an important juvenile developmental habitat, isolated in the middle of the Sulu Sea, and mostly devoid of anthropogenic pressures. What is of interest is that the reefs are also home to a number of sub adults (~10%). Together with the estimated residence periods of ~10 years, these suggest the reefs are similarly important for development and transition into older age-classes. At the same time, a substantial number of adults were also recorded (~10%) both nesting and mating. It is unknown if these turtles are of the same genetic stock as the juveniles, which grow up and mature at Tubbataha and remain to nest, or if they are a genetically distinct aggregation which migrate to Tubbataha just to nest, and return to their foraging grounds thereafter. Genetic studies could reveal any linkages between nesting and foraging grounds, and genetic origin.

Females outnumbered makes by three to one (~76 : 24) indicating a degree of bias towards females but not necessarily to a worrisome extent. The female-biased population structure was significantly more female-biased than the 1M : 2F ratio recorded for primarily juvenile and prepubescent turtles from Moreton Bay, Australia (Limpus et al. 1994a) but not different from the adult sex ratio of 1M : 3.3F recorded at Shoalwater Bay, Australia (Limpus et al. 2005). As the turtles grew older, the sex ration reduced to 1M : 2.6F in Sub-Adults, and 1M : 1F in Adults. Overall, the results were not as female-biased as findings at Mantanani, Malaysia (Pilcher 2010), and are possibly the norm for populations of turtles of this age-class structure in the Southeast Asia region.

It will be interesting to see if this sex ratio changes with time, through repeated laparoscopy surveys, and to link the turtles resident at Tubbataha with their beaches of origin through genetics studies so that cause-effect relationships to gender bias can be investigated.

4.2 Habitat Utilization

Some distinct habitat preferences were noted during the survey, with juvenile turtles concentrated on the reef flats, and there again only over the sandy substrate portions rather than the rocky substrate portions. Turtles were substantially larger around the North Islet than they were near the Ranger station, even though these two sites are on the same atoll. Turtles on the South Atoll were even larger overall than turtles at both sites on the North Atoll, but it is likely that with a larger sample size (from the South Atoll), the difference may be less pronounced than the data currently suggest. Adult turtles were never seen on the reef flat except for on one occasion when a post-nesting female was returning early in the morning and became stranded at the low tide. Otherwise, adults were only seen at in deep water during SCUBA surveys. This division of habitats by age classes has been noted at Mantanani (Pilcher 2010) and on Sipadan island (Pilcher & Ali, 1999), both nearby sites in the Southeast Asian region.

4.3 Data Accuracy and Precision

One of the issues which arose during the course of the survey was related to measurements and data accuracy. Marine turtles grow slowly, and often growth increments are measured in millimeters, rather than centimeters. For this reason all measurements of the turtle's size need to be done with extreme care, so that growth increments can be accurately assessed at recapture. In addition, it was found that there were inconsistencies between the way turtles had been measured in the past and recognized, standard procedures. All rangers were taught the correct procedures and (after the discrepancy was noted) all turtles were measured both the old way and the standard way. The standard measurements were used to categorize the turtles by size classes, while the old style measurements were used to assess growth rates, as these were then comparable to measurements recorded in previous years by the project. Accurate measurement techniques are described in Section 5.2, for future reference.

4.4 Overall Health

Overall the turtles at Tubbataha appeared healthy and well-fed. Only one emaciated turtle was recorded, which out of a total of over 250 was considered normal. It is possible the parasitic infection was responsible for the debilitated state. Several of the turtles were found with filamentous macro-algae in their mouths upon capture, suggesting their diet is varied beyond seagrasses. In the future it would be useful to determine through stomach lavage methods what their overall diet consists of.

4.5 Methodology / Limitations

Laparoscopy is rapidly being recognized as one of the most valuable tools for understanding the dynamics of turtle populations in foraging grounds, and in a limited manner on nesting beaches. Laparoscopy provides information on the gender of immature and even mature turtles, and provides an opportunity to understand the reproductive history of the animal.

In Juvenile turtles laparoscopy provides an indication of gender – thin, white straight oviducts in females (which are not physically able to transfer eggs) and a recessed epididymis in males – within the body wall (and which are not physically able to contain sperm cells). In Sub-Adults, laparoscopy provides an indication of the physiological changes as animals go through puberty – enlarging oviduct in females, protruding and ridged epididymis in males. In Adults, laparoscopy provides a wealth of data: As egg follicles are extruded from the ovary and through the ovary membrane, they leave a scar (a *Corpora albicans*) and the presence of these scars indicates the turtle was an active breeder in the past season. Over time these scars contract and become doughnut-shaped (*Corpora lutea*). The relative size of these scars can thus provide an indication of reproductive activity in the past two or three years, and at least an indication of past breeding activity. The presence of developing egg follicles is an indication of an upcoming active breeding period. Laparoscopy can optimally provide four years of reproductive history for any individual adults female. In males, laparoscopy can provide an indication of sexual maturity, and in cases where the epididymis is filled with sperm cells, an indication of upcoming reproductive activity. On nesting beaches laparoscopy can provide information on past reproductive activity (through the presence of *corpora lutea*), revealing recruitment rates into the breeding population. This is a valuable tool for assessing survival through life stages and important demographic data.

The collection of age-class and gender structure data for the turtles at Tubbataha is an important first step in understanding population structure. While size alone can be used to identify basic age-class categories, only laparoscopy can reveal the exact maturity state, gender, and reproductive history. More importantly, is how that population structure changes (if at all) over time. For this long-term studies are required which assess the state of the turtle population on an annual basis and which can be related to marked individuals. For instance, small juvenile turtles which have already been sampled will not need to be assessed the following year – but this requires that the animal can be identified from year to year. Unfortunately this survey did not have any tags to mark the animals, but this is strongly recommended for future similar surveys, as sound capture-mark-recapture data are required to provide an assessment of population size and trends in future years.

4.5.1 SCUBA Diving Spatial Coverage

While SCUBA surveys were used to observe and record turtles underwater, the limitations in terms of time and spatial coverage mean that the data can only be used in a qualitative manner. This survey recorded 26 turtles during seven dives, each with differing degrees of effort. On some dives there were four observers looking for turtles, on others only two. For this reason the data were not used to quantify turtle presence underwater, but instead just to assess species and age-class composition. However, without accurate measurements and internal gonad inspection several facets of the turtle's biology were unknown – mid-sized turtles could have been juveniles or sub-adults, for instance; large turtles with small tails could have been immature males. Only in instances where mating was observed or large tails (denoting males) was gender specified for an individual. In addition, the spatial demarcation between age-classes – such as juveniles on the reef flat and adults at depth – meant that not all population age-classes could be assessed during the SCUBA surveys. Lastly, due to the limited spatial coverage of the dives, it was inevitable that many parts of the reef were not surveyed. Given these limitations, these SCUBA surveys are useful in providing qualitative data such as these, but are not recommended for population structure or size assessments. Heightened spatial coverage, such as that from manta tows along the reef edge, might improve the results from this aspect of the survey.

4.5 2 Short-term Beach Track Counts

During short surveys such as these, only a snapshot picture of nesting activity and volume can be derived. However, the survey did provide an estimate for daily nesting activity (just less than two nests per night). Given variations in methods, these data are not directly comparable to the findings in 2005, as the 2005 survey counted all old nests with no relation to daily activity. However, on inspection of the data the two surveys appear to have produced similar results. Under optimal conditions, the five-day beach counts should be conducted monthly, cognizant of the fuel and time costs involved.

4.5.3 Lack of Adults in Shallows

As noted above, the lack of adult turtles in the shallow reef flat waters will limit the findings of rodeo-style captures in these habitats – and produce juvenile- and sub-adult-biased encounters. Repeated manta-tow surveys along the reef edge may be able to compensate for this, noting the limitations referred to in Section 4.5.1 on determining sex and age-class. It was obvious from the limited encounters of adult turtles during the SCUBA surveys that they are not as numerous on the Tubbataha reefs as juveniles and sub-adults, although the precise proportions of these are unknown at present. With longer-term assessments of population structure it is likely these will gradually be revealed.

5.0 Recommendations

The Tubbataha reefs are possibly amongst the best examples in Southeast Asia of successful conservation initiatives, with adequate protection and enforcement, realistic management approaches, and grounded on a solid science foundation, not only for marine turtles but for a suite of other important marine and avian fauna. The recommendations below are only made to strengthen this very successful program.

5.1 Abundance Estimates

Long-term estimates of population abundance trends are needed to model sea turtle demography (*sensu* Chaloupka 2002) and to develop a better understanding of long-term ecological processes (Inchausti and Halley 2001). Population abundance estimates, such as those based on foraging ground capture–mark–recapture programs, can provide detailed age-class-specific demographic information (Limpus and Chaloupka 1997, Chaloupka and Limpus 2001 2002).

5.1.1 Methods

Three primary survey protocols are recommended which will provide robust data sets upon which to model population demographics: The first and simplest is a boat survey over the shallows of each reef flat, counting turtles and marking their positions on a handheld GPS. The second involves multiple straight-line transects at key foraging sites (such as off the Ranger Station and North Islet). The third involves capture, marking (tagging) and recapture at key foraging sites. A fourth, less robust method, involves SCUBA surveys and counts of turtles and classification by species and relative size (juvenile, sub-adult and adult).

5.1.1.a Boat Surveys over Reef Flats – These surveys will involve the use of one boat, a driver and at least one observer (but preferably two), operating at high tide and circling the entire reef (for instance from the Ranger Station all the way around the North Atoll and back to the Ranger Station; Figure 5.1). During he surveys, all turtle sightings should be marked as waypoints on a handheld GPS, to be downloaded after the survey and plotted on a graphic to show distribution of turtles. The distribution and number of turtles in each area can be compared over the years to look at population trends. Preferably these surveys should target key turtle habitats such as the sandy flat areas.

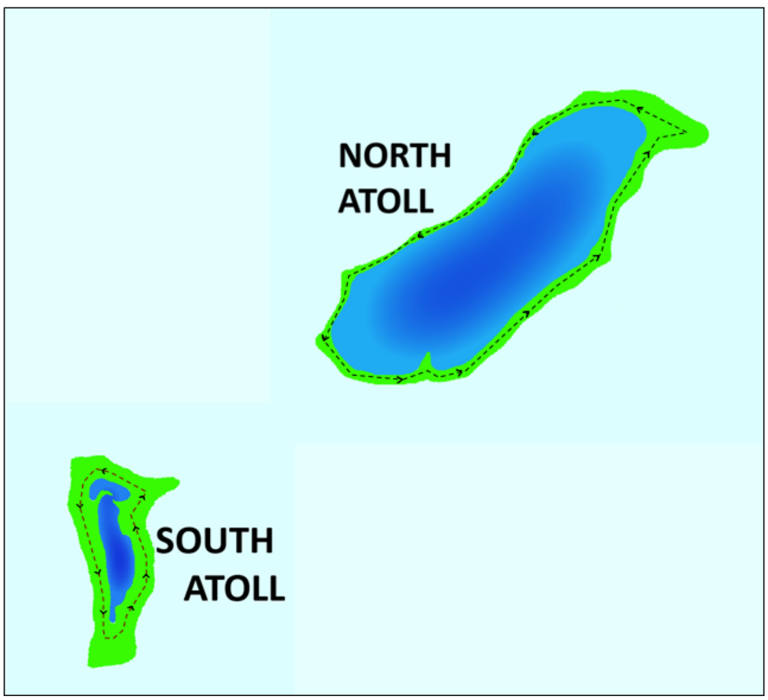


Figure 5.1: Suggested atoll-wide trajectories for boat surveys. The surveys should be set up with a minimum of waypoints and using only straight lines to ensure consistency when repeated from year to year.

It would be best for a route to be predetermined and marked as a series of waypoints on a separate navigation GPS, which can be retraced time and time again. The boat should operate at ~5-6 kn, and this will mean the survey of the North Atoll may take some three hours and the South Atoll may take an hour and a half. Given the survey will take a substantial amount of time, these surveys should be planned for the two hours around high tide in the morning where possible (it is best that all surveys take place at approximately the same time), at such a tide height that the boat can safely navigate the shallow reef flats. It is suggested the following protocols be followed:

1. Establish suitable dates and times for the tides in advance and plan for the surveys accordingly.
2. Make sure the boat is refueled in time for the surveys.
3. Assign roles for the project personnel (driver, observer 1, observer 2, etc.)
4. Make sure the navigation GPS has batteries, and contains the waypoints for the survey.
5. Make sure the recording GPS has no stored data (a clean memory so that all waypoints are from *this* survey) and a capacity for at least 300 new waypoints.
6. Depart the base point (say, the Ranger Station) and proceed at 5-6 kn on a circuit of the reef flat.
7. The boat should operate at 4-5 kn and in straight lines where possible between waypoints to ensure consistency in area covered with previous and subsequent surveys (see Figure 5.2).

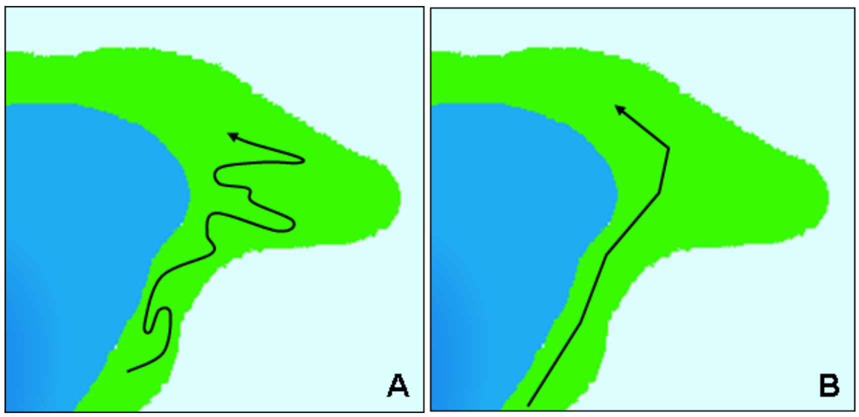


Figure 5.2: Possible trajectories for boat surveys. In graphic A the boat is going from place to place and this will be difficult to replicate from year to year and boat driver to boat driver. It is preferable for surveys to follow straight lines between waypoints (such as in graphic B) to ensure consistency.

8. At least one observer should be positioned at the front of the boat to record turtle sightings. A second observer may assist with this process, but only as a relief observer – that is, only one person should record data at a time, to ensure consistency with times when only one observer is available.
9. Every turtle sighted 10m either side of the boat should be recorded as a waypoint by pressing ‘Mark’ and ‘Enter’ on the GPS.
10. At the conclusion of the survey download the data from the recording GPS onto a computer and save the file with a location and a date (for example: North Atoll Reef Survey 21June2010).
11. Complete a data records sheet for each reef circuit completed (see Annex 2).
12. Data can be interpreted as “Total Number of Sightings” and subsequently these can be compared from season to season and from year to year. Additionally, findings can be grouped into ‘Key Areas’ and the numbers in each of these can be tracked over time to determine habitat preferences and any changes in these over time.

5.1.1.b Straight Line Transects – The principle behind the straight line transects is to count the number of turtles in a standardized and consistent zone and determine the density of turtles in that area, and any changes over time. The transects are implemented by running a boat in a straight line from a fixed GPS position (such as on the edge of the reef) to another (such as the northern-most end of North Islet) and having an observer count turtles in a band which extends 5m to either side of the boat (Figure 5.3). The 5m band (which doubled is 10 m of reef flat) is generally easily approximated by observers. Anything farther out than this is hard to estimate and anything closer in does not provide the spatial resolution required. The 10m band x the straight line distance represents the area surveyed. It would be preferable to pre-select the waypoints and enter these on a navigation GPS beforehand – that way the boat driver can set them up as a route and follow this at a slow 3-4 kn giving the observer plenty of time to see each turtle. These transects are to be conducted slower than the Reef Flat transects as they aim to be a lot more accurate and count each and every turtle. Each transect should be named and described in detail so that it can be repeated over time. These surveys need to be conducted when water depth is sufficient for normal boat operation and at times different to the Reef Flat Surveys so that turtle populations are undisturbed. It is suggested the following protocols be followed:

1. Establish suitable dates and times for the tides in advance and plan for the surveys accordingly.
2. Make sure the boat is refueled in time for the surveys.
3. Assign roles for the project personnel (driver, observer 1, observer 2, etc.)
4. Make sure the navigation GPS has batteries, and contains the waypoints for the transects.
5. Depart the Transect start point and proceed at 3-4 kn in a straight line to the Transect end point.
6. At least one observer should be positioned standing at the front of the boat to record turtle sightings. A second observer may assist with this process, but only as a relief observer – that is, only one person should record data at a time, to ensure consistency with times when only one observer is available.
7. Every turtle sighted 5m either side of the boat should be counted.
8. Complete a data records sheet for each transect completed (see Annex 2).
9. Data can be interpreted as "Total Number of Sightings" for each Transect and subsequently these can be compared from season to season and from year to year.

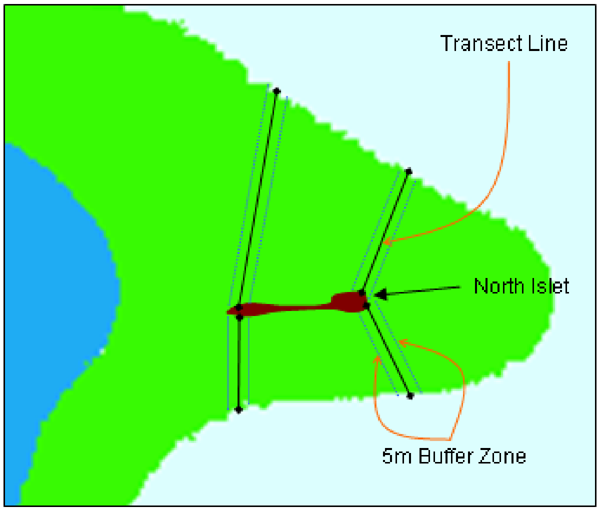


Figure 5.3: Possible trajectories for line transects. The black lines represent the actual paths the boat(s) should follow. The blue lines on either side represent a 5 m window on either side of the transect in which turtles should be counted. Turtles outside of these lines should not be counted. Similar designs can be made for other key areas at North and South Atolls.

5.1.1.c Capture-Mark-Recapture – This survey involves catching then turtles, marking them with long-lasting tags and measuring their length, and releasing them in the vicinity of the area where they were caught. Their subsequent recapture will allow a determination of population dynamics and trends, growth, localized movements and residency periods. Captures can be done with a net, but are typically more successful using rodeo-style techniques. It is suggested the following protocols be followed:

1. Establish suitable dates and times for the tides in advance and plan for the surveys accordingly.
2. Make sure the boat is refueled in time for the surveys.
3. Assign roles for the project personnel (driver, catcher 1, catcher 2, data recorder, etc.)
4. Make sure the navigation GPS has batteries.

5. Make sure you have a pre-prepared waterproof data slate on which to record data.

5. Ensure an adequate supply of tags and tag applicators, and of bright tape to mark each turtle.
6. Conduct rodeo-style captures in an organized manner at each site, sweeping from end to another and covering as much of the targeted area as possible.
7. Each time a turtle is sighted the GPS should be 'Marked'.
8. Chase the turtle until it is caught or lost.
9. Do not change course to chase a second turtle during the chase for a first one – always stay with one turtle until it is caught or lost.
10. Once a turtle is captured, it should be checked for pre-existing tags or tag scars. Record these by side on the data slate.
11. If the turtle has lost a tag, or one is about to be lost, another should be affixed on that same flipper.
12. If the turtle has no tags, it should be double-tagged as described Section 5.2.
13. Tie a length of 15-20cm of bright tape to one of the tags so that the turtle is not recaptured during the same survey.
14. Carefully measure the turtle as per Section 5.2.
15. Record all data including date, time of day, GPS position, tag numbers and CCL measurement on the data slate.
16. Continue with the rodeo capture process.
17. Record all data related to the rodeo capture including names of personnel involved, number of turtles caught, area targeted etc. on the Rodeo Captures data sheet in Annex 2.

5.1.1.d SCUBA Surveys – These surveys provide a qualitative assessment of what turtles are on the reefs, but due to their limited coverage and sparse turtle distributions, they are impractical for determining quantities, or qualitative data as it is known. SCUBA surveys can be conducted opportunistically but it is important the primary objective of the dive is to count turtles. Other than this, the diver's focus is usually elsewhere when a turtle fleetingly swims by. In addition, it is necessary for the diver to have a good knowledge of species identification, and some experience of putting turtles into size classes (small, medium-large, and very large – corresponding roughly to Juvenile, Sub-adult and Adult life stages) It is suggested the following protocols be followed:

1. Brief all divers on the objectives and depths of the dive – it is easier to remain shallow and look down than it is to stay deep and look up.
2. Assign divers to depth ranges so that their focus is on those ranges alone.
3. Ask divers to point out all the turtles they see to each other so that species and sizes can be corroborated after the dive.

4. Swim at a constant speed (with the current where possible) keeping a lookout for turtles at all times.
5. Make sure you do not recount turtles which swim ahead of you (try to recognize identification marks which will allow them to be identified later on in the dive).
6. Record the species, sex (if an adult male, or otherwise unknown), and approximate size.
7. Record any other behavior such as mating or attendant males.
8. Time the dive so that it lasts a standard duration (preferably 60 minutes).
9. At the end of the dive complete a SCUBA Survey data sheet as in Annex 2.

5.1.2 Frequency

A minimum sampling regime of once per year should be a norm, and more frequent surveys would be preferred. Under optimal conditions, a set of Reef Flat and Straight Line surveys conducted every quarter would suffice to yield quality data on both turtle population abundance and seasonality. Mark-recapture exercises should be conducted annually. SCUBA surveys can be conducted opportunistically when time, weather and resources permit.

5.2 Measuring and Tagging

Turtles are to be measured following the descriptions by outlined by Limpus et al. (1983). Measurements are to be taken with a fibreglass tape measure (± 0.1 mm) of the Curved Carapace Length (CCL) – measured over the curve of the carapace along the midline from the anterior point at the midline of the nuchal scute to the posterior tip of the surpacaudal scutes See Figures 5.4 to 5.6).

Figure 5.4: Measuring curved carapace length with a fibreglass tape.

Figure 5.5: Exact positioning of tape at edge of nuchal scute behind the head.

Figure 5.6: Exact position of tape at midline inside the notch at the rear of the carapace.

Turtles are then to be tagged in the axillary position of both front flippers with titanium tags bearing a return address and contact numbers. Turtles are tagged so that they may be identified upon subsequent recaptures or as strandings. All turtles should be checked for presence of previous tags or signs of tag loss prior to placing new tags, and notes should be kept on signs of old tags. Old tags should be replaced when they appeared heavily corroded and could be easily lost, and all previous tag numbers are to be recorded to maintain a long-term history of the turtle. Turtles that show signs of having been tagged previously but which have lost their tags should be recorded as such, as this provides information on the rate of tag loss. New turtles are to be tagged on the proximal trailing edge of each front flipper to reduce the chances of abrasion, entanglement and tag dislocation. All turtles should be checked to ensure the tag was securely attached, and that the sharp point of the tag had looped through the receiving hole and curved into a locking position. A 0.5 cm gap should be left between the trailing edge of the flipper and the rear edge of the tag to allow for growth in the coming years.

1. Remove a tag from the strip and record its alphanumeric number. Be careful not to bend the tag from its original shape.
2. With the piercing side of the tag up, place your index finger tip inside the bend of the tag. The piercing side of the tag has the numbers stamped into it. (Figures 5.7 and 5.8).
3. Hold the tag applicator pliers in the other hand, making sure the handle with the paint mark (or label) is up. Using your index finger, pull the tag straight back into the open jaws of the applicator pliers. A firm pull will be needed to completely seat the tag into its correct position. Take care not to squeeze the applicator handles before you are ready. If the handles are squeezed partway and released the tag will fall out and will not function properly (Figure 5.9).
4. Locate the correct site where the tag will be applied on the trailing edge (rear) of the front flipper. Ask for assistance holding the turtle still. Make sure to position the tag so there is some overhang after it is attached to the flipper.

Figure 5.7: Holding a flipper tag in correct orientation to load into applicator.

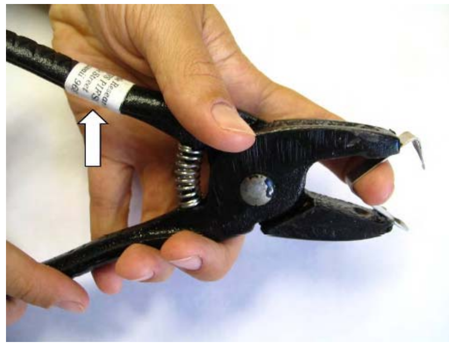


Figure 5.8: Loading a flipper tag into tag applicator. The arrow indicates which handle should be up.

5. Apply the tag by squeezing the applicator handles firmly (Figures 5.10 to 5.12). The tag point will pierce the flipper and lock into place through the other tag end. The piercing tip must be bent over completely to lock the tag. The handles of the applicator must be squeezed together very firmly at the final point in order to fully bend the point down.

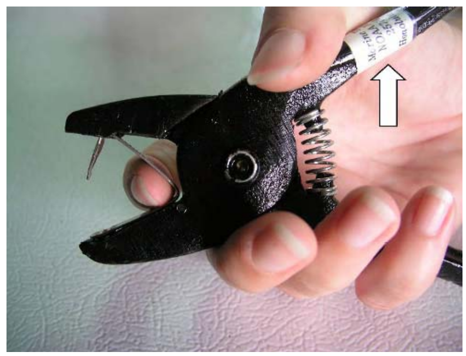


Figure 5.9: A fully seated tag in the tag applicator pliers.

6. Repeat the procedure in the same place on the other front flipper. All turtles should be double tagged. Try to use consecutive numbers on the same turtle whenever possible. If a tag is ruined, record the number of the ruined tag, and use another tag. If the recommended tagging site cannot be used, find another site on the rear edge of the front flipper.

Figure 5.10: Arrow indicating the preferred location for flipper tag replacement.
The next preferred location is between the two large scales to the right of the arrow.

Figure 5.11: Applying tag to a front flipper of turtle. Note the slight gap between angle of tag and edge of flipper.

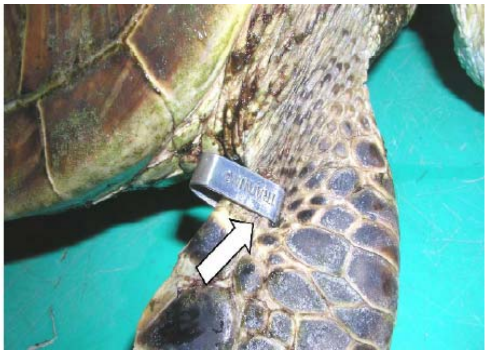


Figure 5.12: A properly applied flipper tag.

For each tag applied fill out all the tag information on the data sheet and describe any difficulties encountered while trying to apply the tags.

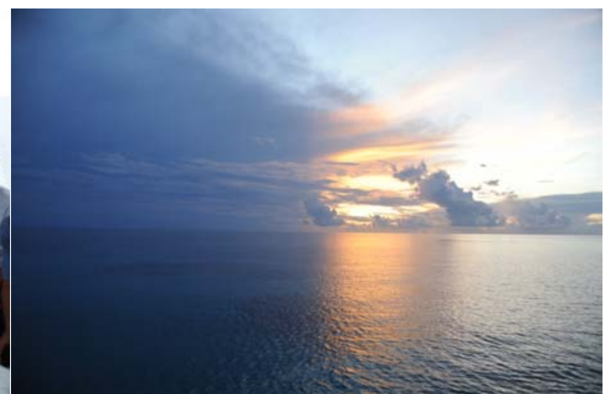
5.3 Continued Data Collection

Surveys such the ones conducted in 2005 by DENR and subsequently by TRNP in 2006, 2007 and 2010, along with the present study, have provided a rigorous baseline upon which to compare future findings. Some of those are already apparent, while others will become so in the coming years. The Tubbataha Reefs support a substantial number of juvenile green turtles which reside for at least one third of their lives in this developmental habitat before settling in adult foraging grounds. No evidence exists at present that the Tubbataha reefs support foraging by adult green turtles, although they are regularly seen around the reefs and nest on the islands. However, it is not so much the actual population estimate that should be important for management, but rather the trends in those estimates over time. Are turtle numbers increasing? Decreasing? Remaining stable? Are turtles finding sufficient food resources (reflected by residence periods and growth rates)? To answer these questions, it is recommended the Tubbataha Reefs management plan for continued surveys annually in the coming years, and then possibly at a less-frequent rate once population structure and seasonal changes are better understood.

The present study has revealed a wealth of information on population structure in terms of proportions of turtles in each age-class and also of at-sea sex ratios. Many of the turtles sampled in the present study will likely remain at Tubbataha in the near future and it will take a number of years before they migrate to adult foraging pastures. But the turtles which settle at Tubbataha are subject to other man-made pressures such as improper hatchery handling and incubation temperatures, and thus changes to the structure outline determined through this study are not inconceivable. Continued studies on at-sea sex ratios can provide an advance warning to substantial changes in population structure and sex-ratios, and it is recommended that this work be continued annually in the coming years to track trends in these important population parameters.

Similarly, capture-mark-recapture studies based on a long-term tagging program will be able to highlight changes in population abundance, and these are recommended as an annual project also for the coming years. Indeed, both studies can be combined as they were in the present study (with the addition of tagging so that turtles can be identified in the future) to maximize resource- and cost-efficiency. A repetition of the present study each year in the coming few years will refine the present data sets and also reveal any changes in population structure of relevance to management.

Finally, the Tubbataha Reefs Marine Protected Area is setting regional standards, using the latest in technology and grounded in science, and is in a position to provide a platform for training and understanding of marine turtle biology which will enhance national and regional management capacity. The biological linkages between Tubbataha turtles and those from the Turtle Islands Wildlife Refuge, or the Turtle Islands Park in Malaysia, and even to nesting sites in Taiwan, peninsular Malaysia, Sarawak, and other sites in the Philippines can not be understated. Migration routes clearly show movement of these turtles past the Tubbataha reefs (Pilcher 2009), and it is likely genetic studies will reveal actual linkages. It is important that the reef are included as part of the Marine Turtle Network of Protected Areas in the Sulu Sulawesi, and that the management become closely involved with the network process, given the prominence the reefs play in supporting regional marine turtle populations.

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Annex 1: Detailed List of Activities during the Survey.

Date	Time	Activity
14/06/2010	9:40	Arrival in Puerto Princesa
14/06/2010	12:00	Equipment provision (hardware, table)
14/06/2010	19:30	Departure on MV Navorca to Tubbataha
15/06/2010	5:30	Arrival at Tubbataha
15/06/2010	8:00	Briefing on Ranger Station
15/06/2010	9:00	Rodeo captures (until 1300)
15/06/2010	9:30	Laparoscopy
15/06/2010	16:00	End of laparoscopy session (34 animals)
15/06/2010	9:30	Cross out tracks on North Islet (rangers)
16/06/2010	8:00	Rodeo captures (one boat)
16/06/2010	8:30	Check North Islet for tracks (one U turn; 3 successful)
16/06/2010	8:30	Scuba dive @ Washing Machine - Angelique (1 hawksbill / 45mins)
16/06/2010	10:00	Laparoscopy
16/06/2010	13:30	Rodeo captures (two boats)
16/06/2010	16:00	End of laparoscopy session (30 animals)
17/06/2010	6:30	Move from Ranger St to North Islet
17/06/2010	8:00	Check beach for tracks (4 successful, 2 unsuccessful)
17/06/2010	8:30	Rodeo captures (two boats)
17/06/2010	9:00	Laparoscopy
17/06/2010	16:30	End of laparoscopy session (73 animals)
18/06/2010	8:00	Scuba dive @ Shark Runway to mooring (2 adult male greens + 4 marked with orange spray / 60 mins)
18/06/2010	9:30	Check beach for tracks (4 successful)
18/06/2010	10:00	Rodeo captures (two boats)
18/06/2010	10:15	Design density surveys (10m wide, straight lines, simultaneous runs, two boats)
18/06/2010	10:30	Laparoscopy
18/06/2010	14:00	Rodeo captures (two boats)
18/06/2010	16:30	End of laparoscopy session (66 animals)
19/06/2010	6:30	Check beach for tracks (1 successful)
19/06/2010	7:30	Scuba dive @ Shark Runway to North (1 juvenile green / 60 mins)
19/06/2010	11:00	Scuba dive @ Seafan Alley to East (1 adult green, 1 adult hawksbill, 4 juvenile hawksbill, 1 juvenile green / 60 mins
19/06/2010	16:00	Scuba dive @ Shark Runway to North (3 juvenile green, only one marked / 60 mins)
20/06/2010	5:00	Check beach for tracks (0 tracks - one ~2m tiger shark *Galeocerdo cuvier* in lagoon)
20/06/2010	6:30	Move from North Islet to South Atoll
20/06/2010	9:00	Scuba dive @ Ko-ok to West (1 adult green male, 1 hawksbill, 1 adult green female with five attendant males / 60
20/06/2010	13:00	Scuba dive @ Black Rock to South (1 adult green male, 1 subadult green, 2 juvenile greens / 60 mins)
20/06/2010	16:00	Static jump from MY Navorca on a juvenile green
21/06/2010	7:00	Development and trial of observer survey techniques on reef flat at South Atoll.
21/06/2010	9:00	Rodeo captures (one boat)
21/06/2010	11:00	Laparoscopy
21/06/2010	11:30	End of laparoscopy session (11 animals)
22/06/2010	8:30	Departure on MV Navorca to Puerto Princesa
22/06/2010	18:00	Arrival in Puerto Princesa
23/06/2010	8:30	Interview with reporter on Tubbataha turtles for Asia Diver
23/06/2010	11:00	Departure for Manila and Kota Kinabalu

Annex 2: Sample Data Records for Future Surveys

Tubbataha Marine Trutle Survey Data Sheet - Atoll Surveys

Date: ____________________

Atoll: North ☐ South ☐

Rangers: ____________________

Weather: Calm ☐ Small Waves ☐ Rough ☐

Tide Height: ____________________

Total Number of Turtles: ____________

Computer data file name: ____________________

Tubbataha Marine Trutle Survey Data Sheet - North Islet Survey

Date: ____________________

Transect ID: NE ☐ NW ☐ SE ☐ SW ☐

Rangers: ____________________

Weather: Calm ☐ Small Waves ☐ Rough ☐

Tide Height: ____________________

Total Number of Turtles: ____________

Computer data file name: ____________________

Tubbataha Marine Trutle Survey Data Sheet - Rodeo Captures

Date: ____________________

Area Sampled: Ranger Station ☐ North Is ☐ South Is ☐

Number of boats: ____________

Time Start: ____________________ Time End: ____________________

Rangers: ____________________

Weather: Calm ☐ Small Waves ☐ Rough ☐

Tide Height: ____________________

Total Number of Turtles: Boat 1: ______ Boat 2: ______

Computer data file name: ____________________