

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

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June, 2010

A project implemented by the Tubbataha Management Office

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*). These species are considered critically endangered and endangered species, respectively, by IUCN. 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 and virtually no information exists on foraging populations in the region. 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. Population demographic data such as these are critical to determine how turtle populations will be influenced by various natural and anthropogenic stresses, and 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

The objectives of this 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.

Three primary survey protocols were 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).

Turtle stocks were assessed through three methods: Overnight counts for turtles emerging on North Islet, laparoscopy and marking of turtles collected through rodeo-style captures using two fiberglass dinghies with rear steering and 25-30 hp outboard engines weaving in and out across sandy shallows at three key sites, and SCUBA diving surveys.

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. The beach track counts indicated that 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. Rodeo-style activity resulted in the capture of 215 individual green turtles (*Chelonia mydas*). No hawksbills were seen nor captured during the rodeo outings from an estimated 23 hours of effort invested in turtle capture (an average catch of 9.38 turtles per hour).

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%. 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%. 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. 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. A number of turtles captured during the rodeo events appeared to have markings (notches in marginal scutes) which appeared man-made. Apparently the Philippines Turtle Project may have notched hatchlings also in the past (in the 1980s) but scarce details of this effort remain.

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). Turtles at the Ranger Station averaged 51.9 cm in Curved Carapace Length (CCL), while those at North Islet averaged 57.5 cm CCL, and turtles at South Atoll averaged 68.4 cm CCL . Turtles were significantly larger at North Islet than those at the Ranger Station. Turtles were also significantly larger at South Atoll than at North Islet, although this is likely an artifact of the substantially smaller sample size (12) and greater standard deviation (12.38) at South Atoll. There were no statistical differences 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.

Growth was calculated from 28 recaptured individuals. Turtles grew at an average rate of $1.60 \text{ cm}\cdot\text{yr}^{-1}$ and only a weak correlation was found between growth rates and body size, suggesting little variation in growth rates within the size classes encountered during the rodeo captures. Residence periods were inferred from settlement sizes (new recruits at $\sim 40 \text{ cm CCL}$) and growth rates ($1.60 \text{ cm}\cdot\text{yr}^{-1}$). Residence periods 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.

A total of seven SCUBA dive surveys were conducted specifically searching for turtles, and a total of 26 turtles were recorded during the surveys. 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. 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 or Adult. 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.

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. The vast majority of turtles at Tubbataha were juveniles ($\sim 80\%$) 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. The reefs are also home to a number of sub adults ($\sim 10\%$). 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 ($\sim 10\%$) 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 males by three to one (~76 : 24) indicating a degree of bias towards females but not necessarily to a worrisome extent. As the turtles grew older, the sex ratio 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, and are possibly the norm for populations of turtles of this age-class structure in the Southeast Asia region. Some distinct habitat preferences were noted during the surveys, 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.

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. 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.

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. 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 outlined 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.

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.