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## Spatial site fidelity of Sea Turtles at a foraging ground in Mabul Island, Sabah, Malaysia

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### Abstract

Mabul Island, located on the east coast of Sabah, Malaysia, has a population of resident green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles, however little is known about them. This report highlights the spatial site fidelity of sea turtles at a foraging ground in this region. A mark-recapture study was conducted between August 2010 through November 2015 and there were 109 individual turtles of various size classes repeatedly captured at seven established dive sites where they ranged from 4 to 40 occurrences (mean  $\pm$  s.d. =  $16 \pm 14$ ). The results demonstrated that the turtles significantly ( $p < 0.000$ ) favored some dive sites mainly due to the availability of shelter under rocky outcrops and on reef ledges. Further analysis showed that juveniles were the most abundant (78.9%) ( $p = 0.0021$ ), indicating a healthy recruitment into this population. Green turtles were the dominant species with a ratio of 6:1 ( $p = 0.0326$ ).

**Keywords:** *Chelonia mydas*, *Eretmochelys imbricata*, resident turtles, Borneo

### 1. Introduction

Sea turtles are highly migratory marine reptiles that have existed since the Early Cretaceous Period about 110 million years ago [1]. There are only two families of extant sea turtles – Dermochelyidae with one species (the leatherback turtle (*Dermochelys coriacea*)) and Cheloniidae with six species (green (*Chelonia mydas*), loggerhead (*Caretta caretta*), hawksbill (*Eretmochelys imbricata*), flat back (*Natator depressus*), Kemp's ridley (*Lepidochelys kempii*) and olive ridley (*Lepidochelys olivacea*)) [2].

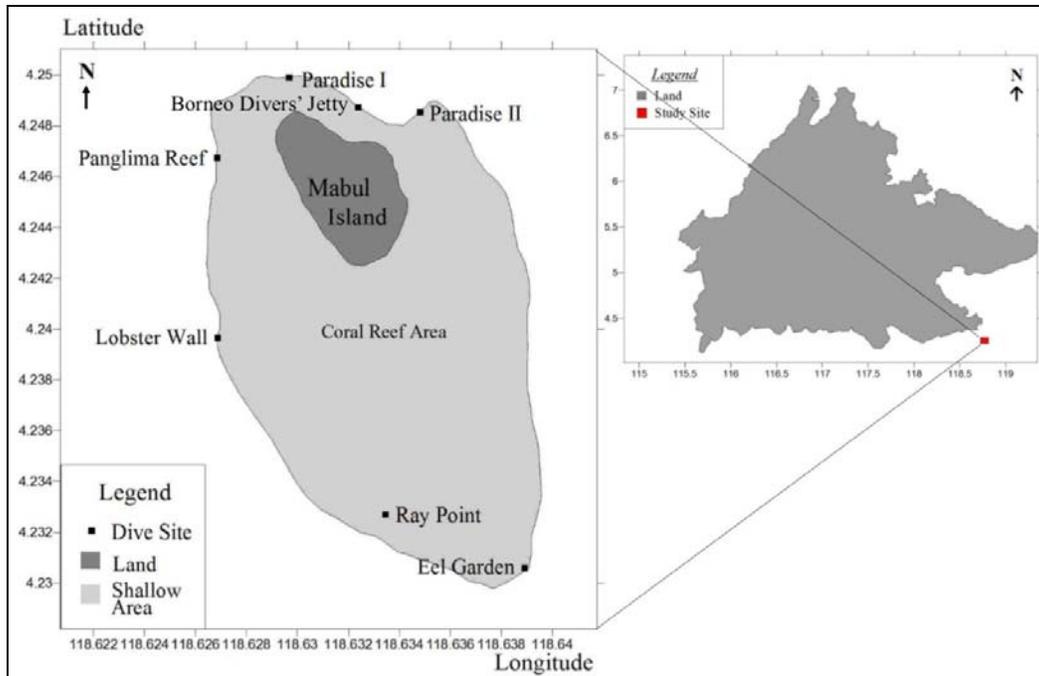
All sea turtles utilize several different habitats during their different stages of life [3] where sea turtle hatchlings first move from the beach to the sea and swim actively offshore. They then drift pelagically in ocean gyres for several years until the juvenile turtles settle into neritic developmental habitats in tropical and temperate zones. Upon reaching adulthood, some turtles move into adult foraging habitats, however in some areas, these foraging areas also house younger turtles.

A foraging ground is defined as an area where sea turtles live during the non-breeding season [4]. It is important to understand at-sea turtle populations at coastal foraging areas as it provides information on various aspects of these turtles including the size classes of the turtles, as well as their habitat and diet preferences [5-21]. It must be noted that these studies are expensive and labour-intensive [22]. Although there is published literature on the nesting activity of the adult female turtles in Malaysia [23-27], there is very limited data on the sea turtles found at the foraging grounds in this country. One such report on the green turtles living in the waters of Mantanani Island, northwest of Sabah, Malaysia found that the population of turtles here was mainly immature and it is believed that these turtles utilize this area as a temporary juvenile foraging ground [5]. Green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles can be found in Mabul Island year-round and are not shy when seen underwater, just like in the neighboring island of Sipadan [28], however very little is known about them. They are of various size classes – juveniles, sub-adults, as well as adult males and adult females. The reef area in Mabul is relatively small (4.2km<sup>2</sup>), and this enables the turtles to easily move among the many established dive sites in the waters of this island. This study delves into the specific locations where the sea turtles were found in the waters of Mabul Island, and the data collected will be used to better understand the habitat preferences of these turtles.

**2. Materials and methods**

Mabul Island (4.25°N, 118.63°E) is located on the east coast of Sabah, Malaysia (Fig. 1), and in the Coral Triangle [29]. The turtles live and forage in the coral reef and seagrass habitats of this island. The seabed on the eastern side of the island is mostly of a sandy bottom with various species of seagrasses whereas the western side consists of a rocky substrate with abundant soft corals and sponges. We conducted a mark-recapture study on the sea turtles found in the waters of Mabul Island from 2010 through 2015. Field trips were conducted for two days twice a month from 2010 until 2011, then for four days once every six months from 2013 until 2015 to minimize the disturbance to the turtles. The turtles were caught by hand while scuba diving during the day at the

established dive sites (distance between adjacent dive sites did not exceed 500 m) in Mabul Island at depths not exceeding 20 m (Fig. 1). They were brought onto the research vessel to be photographed, measured and tagged. The straight carapace length (SCL) was measured from the anterior point at the midline (nuchal scute) to the posterior tip of the supracaudal using a 1.0 m Mitutoyo stainless steel vernier caliper (0.05 mm with an accuracy of ±0.15mm) of all the captured turtles. The turtles were tagged with Inconel tags (National Band and Tag Company, Newport, Kentucky, USA) which were attached to the posterior edge of both front flippers. Significance was at the 0.05 level for all the statistical tests used to analyze the data collected in this study.



**Fig 1:** Map of Mabul Island (left), showing the established dive sites where sea turtles were captured, located in south-eastern Sabah (right), Malaysia.

**3. Results and Discussion**

There was a total of 611 sea turtle captures in the waters of Mabul Island from 2010 through 2015 where 559 were green turtles and 59 were hawksbill turtles. Single captures were discarded and only data from recaptured turtles were used in

this study. The details of the recaptured turtles (n = 109) at seven established dive site in Mabul Island is shown in Table 1. The turtles were considered as residents to this area as they were recaptured one or more times, up to a maximum of five recaptures (n = 1) throughout the study period.

**Table 1:** Details of the sea turtles captures at seven established dive sites in Mabul Island, Sabah.

Dive Site (GPS Location)	Green turtles ( <i>Chelonia mydas</i> )	Hawksbill turtles ( <i>Eretmochelys imbricata</i> )	Total
Borneo Divers' Jetty (4.24°N, 118.63°E)	5	1	6
Eel Garden (4.23°N, 118.64°E)	2	2	4
Lobster Wall (4.23°N, 118.62°E)	34	6	40
Panglima Reef (4.24°N, 118.62°E)	20	4	24
Paradise I (4.25°N, 118.62°E)	5	0	5
Paradise II (4.24°N, 118.63°E)	5	0	5
Ray Point (4.23°N, 118.64°E)	23	2	25
Total	94	15	109

The results from this study (Table 1 and Fig. 2) showed that the turtles had a preference for certain dive sites as compared to others. Total captures of the turtles ranged from 4 to 40 occurrences (mean ± s.d. = 16 ± 14) and statistical analysis showed that there was a significant relationship between the number of turtles captured and the location ( $\chi^2 = 77.43$ , df =

6,  $p < 0.000$ ). Further analysis found that the dive sites were not species-specific as neither species of turtle showed any preference to any particular site ( $\chi^2 = 6.99$ , df = 6,  $p = 0.322$ ). The dive site 'Lobster Wall' had the highest number of captured turtles (36.7%) whereas only four turtles (3.7%) were re-caught at 'Eel Garden'. 'Lobster Wall' produced the

highest number of captures for green (36.2%) and hawksbill turtles (40.0%). The dive sites 'Ray Point' and 'Panglima Reef' have similar benthic habitats as 'Lobster Wall', which may contribute to the high number of turtle captures at these sites. We found that sites with the lowest number of turtle captures ('Eel Garden', 'Paradise I', Paradise II' and 'Borneo Divers' Jetty') had higher ratios of open sandy seabed areas to reef habitats. This meant that these sites were more exposed and were not popular with both species of turtles.

Immature green turtles at Mantanani Island on the west coast of Sabah, Malaysia exhibited site-fidelity and was reported to move only an average of 380 m between recaptures, however the study suggested that this island may only be utilised a temporary juvenile foraging ground as the turtles only resided there for up to two years<sup>[5]</sup>. In Bermuda, green turtles<sup>[6]</sup> also demonstrated residency and spatial site fidelity. These turtles were monitored from 1968 for 37 years and some immature greens were found to reside in Bermuda waters continuously for extended periods of time during which they usually occupied specific sites. This site fidelity behavior also demonstrates the ability of these turtles to home to a particular site as shown by juvenile green turtles in Florida that were caught repeatedly at a power plant's intake canal<sup>[17]</sup>. From 1994 to 1998, 1673 green turtles were captured and 210 juvenile turtles accounted for 614 of these capture events. Many of these turtles were captured numerous times, with one individual being captured 13 times in a three year period. In Mabul Island, the turtles were also caught numerous times, with one individual being caught 6 times in five years. Although most of these studies report that the foraging areas

of the turtles are located in close proximity (<5 km apart), immature green turtles off the Pacific Coast of Baja California Sur, Mexico were found to use multiple foraging areas<sup>[12]</sup> that were more than 300 km apart.

Hawksbill turtles indicated strong site fidelity in their feeding grounds in Australia<sup>[14, 30]</sup>, the Caribbean<sup>[6]</sup>, Puerto Rico<sup>[8-9]</sup>, in the Dominican Republic<sup>[18]</sup> and in the Bahamas<sup>[6]</sup>. Site fidelity towards their foraging areas was also noted in other species of sea turtles, namely in juvenile loggerhead turtles (*Caretta caretta*) in North Carolina, USA<sup>[7]</sup>, older loggerhead turtles in Greece<sup>[20]</sup>, as well as Australia<sup>[31]</sup> and the Caribbean<sup>[32]</sup>. These turtles tend to stay as residents in their chosen habitat for several years and they maintained short-term home ranges several hundred meters in extension. We believe that the resident hawksbill and green turtles in Mabul Island also stay close to the reef in this island. The reasons for doing so may include: sufficient area to seek protection and the abundance of food (seagrasses for green turtles; and soft corals and sponges for hawksbills). The turtles showed preference to the dive sites 'Lobster Wall', 'Ray Point' and 'Panglima Reef' as these sites had coral outcrops (Figs. 3A-C) and ledges along the reef wall. These coral outcrops and ledges were suitable resting areas and gave protection to the turtles seeking shelter. The juvenile green and hawksbill turtles were easily camouflaged as they blended in with the benthic reef habitat of this area (Figs. 3A-C). 'Eel Garden' did not have any areas for turtles to seek refuge as it consisted mostly of a sandy seabed (Fig. 3D). It was also noted that there was disturbance in the form of boat activity at the villages and resorts in this area.

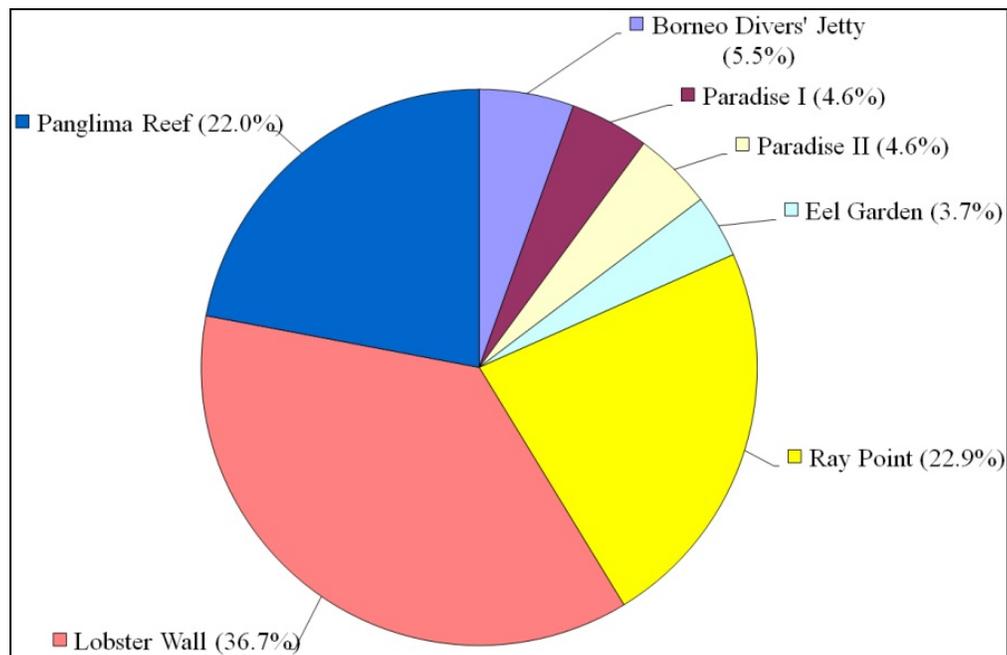
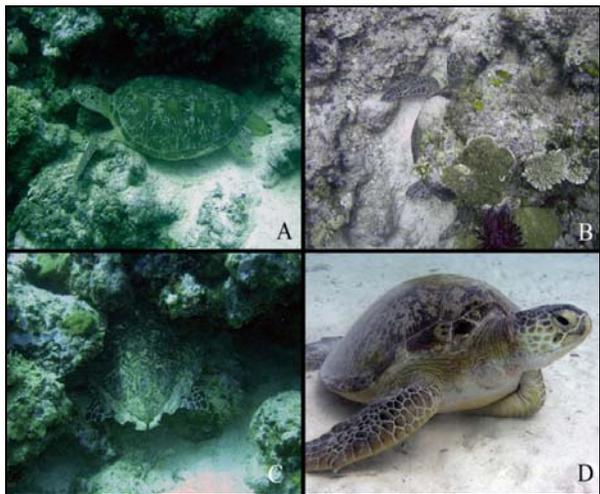


Fig 2: Pie chart showing the dive sites in Mabul Island, Sabah and the respective percentage of turtle captures in each site.



**Fig 3:** A juvenile green turtle (*Chelonia mydas*) seeks shelter under a rocky outcrop at the dive site ‘Lobster Wall’ in Mabul Island (A); the dorsal view of the same juvenile green turtle (B) – note that it is camouflaged well and is partially hidden by the coral outcrop; a juvenile hawksbill turtle (*Eretmochelys imbricata*) using a coral outcrop to seek shelter at the dive site ‘Lobster Wall’ in Mabul Island and is well camouflaged (C); a juvenile green turtle resting on a sandy seabed (D) – note the lack of shelter in this area. (Photo credit for (D): Nor Fazidi Toha).

The dominant size class of the sea turtles captured in Mabul Island was juveniles (77.2%) (ANOVA  $F(3, 52) = 5.590; p = 0.021$ ) for both species - greens (76.6%) (ANOVA  $F(3, 24) = 4.812; p = 0.092$ ) and hawksbills (93.3%) (ANOVA  $F(3, 24)$

$= 7.037; p = 0.015$ ) (Table 2), indicating a healthy recruitment into the sea turtle population in this area. The green turtles outnumbered hawksbill turtles with a ratio of 6:1 (unpaired t-test:  $t = 2.193, df = 54, p = 0.0326$ ). The sea turtle population in Bermuda was found to be in a similar vein [6], where there were more green turtles ( $n = 2516$ ) than hawksbills ( $n = 154$ ). Both species of sea turtles are able to live in harmony in Mabul Island as there is no competition for food, due to their specialized diet – green turtles consume seagrasses and seaweeds whereas hawksbill turtles feed on soft corals and sponges [33].

There were 72 captures of juvenile green turtles in Mabul Island, and the smallest was 36.4 cm SCL whereas the largest was 71.2 cm SCL. These results are very similar to those reported in Mantanani Island located on the west coast of Sabah [5], however Mantanani is believed to be a temporary juvenile foraging ground due to the lack of adult turtles in that area. The green turtle population in Mabul Island also contains other size classes of turtles, namely sub-adults ( $n = 7$ ), adult males ( $n = 3$ ) and adult females ( $n = 12$ ), hence it could be a permanent foraging area for green turtles. Long-term data sets of repeated turtle captures will be required to confirm this, as demonstrated by the results in Bermuda after 37 years of study [6]. As there was only one adult female hawksbill turtle repeatedly captured in Mabul Island as opposed to the fourteen juveniles, this area may be a temporary juvenile foraging ground for the hawksbill turtle although there is abundant food in the form of soft corals and sponges here. It is not known where these turtles go once they leave the reefs of Mabul Island or why they do so.

**Table 2:** Details of the size classes of the captured sea turtles in Mabul Island, Sabah. Measurements shown are the straight carapace length (SCL) of the turtles.

Size Class	Green turtle			Hawksbill turtle			Total
	Mean ± s.d (cm)	Range (cm)	n	Mean ± s.d (cm)	Range (cm)	n	
Juveniles	51.9 ± 7.6	36.4 - 71.2	72	51.1 ± 5.4	44.3 - 62.4	14	86
Sub-adults	82.5 ± 9.3	68.8 - 93.0	7	-	-	0	7
Adult Males	86.7 ± 5.2	80.7 - 90.1	3	-	-	0	3
Adult Females	91.9 ± 4.2	84.4 - 99.1	12	74.3	-	1	13
Total	-	-	94	-	-	15	109

**4. Conclusions**

Mabul Island is an ideal developmental habitat for both green and hawksbill turtles. The results of this study are consistent with the sea turtle site fidelity studies conducted in other parts of the world. The turtles in Mabul Island have shown preferences for some dive sites over others, believed to be due to the presence of natural underwater structures in the form of coral outcrops and ledges to seek shelter. Green turtles of various size classes are found here indicating that this may be a permanent foraging ground for them, whereas the hawksbill turtles may use Mabul Island as a temporary foraging area. Our findings will be used by the authorities towards tourism as well the management of the marine resources and conservation of the resident sea turtles in their natural habitat.

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