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Population and Trend Analysis for Green Turtle (*Chelonia mydas*) and Hawksbill Turtle (*Eretmochelys imbricata*) in Marine Park Centre Redang, Terengganu and Marine Park Centre Rusukan Besar, Labuan, Malaysia

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ABSTRACT

This paper highlights basic data collected over the 7 years and 8 years of establishment of the marine turtle hatchery projects in Pulau Rusukan Besar Marine Park Centre (PRBMPC), Federal Territory of Labuan and Pulau Redang Marine Park Centre (PRMPC), Terengganu; Malaysia, respectively. Compiled data were taken from year 2010 until 2017. The within and between season patterns in terms of nest number of the green (Chelonia mydas) and hawksbill (Eretmochelys imbricate) turtles were shown. The population of marine turtles were estimated from the number of nests laid. Total annual nests were used as a crude index of female turtle abundance. Green turtles accounted for 96.18% (1,233 nests laid) of the total nesting recorded while hawksbills accounted for the remaining 3.82% (49 nests laid) in the PRMPC. However, in the PRBMPC 23.58 % (29 nests laid) and 76.42% (94 nests laid) were recorded respectively for the green and hawksbill turtle. 100 % of the nest laid have been incubated using the ex-situ conservation method with the production of 103,929 and 23,558 live green and hawksbill turtle hatchlings respectively. The 8-year average hatching and emergence success rates for green turtles and hawksbills were 87.11 and 88.33%, and 91.56 and 90.69% respectively. This paper provides important information that is fundamental for the understanding of population status to ensure effective conservation measures and management of marine turtles at both marine parks.

Keywords: *Chelonia mydas, Eretmochelys imbricata,* Green turtle, Hawksbill turtle, nesting

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INTRODUCTION

Turtles are classified as an endangered species because they are facing extinction due to human activities and thus, have become among the most significant assets in eco-tourism. The hawksbill turtle is one of the most critically endangered species of marine turtle in the world today, and green turtles are the most dominant species (endangered) (Seminoff & Shanker, 2008). Pulau Redang, Terengganu is the most important islands in the East coast of Peninsular Malaysia in terms of turtle nesting, particularly because its large islands periphery offers a high variability of beaches which are suitable as the nesting bay for the turtles (Van de Merwe et al., 2009). In 2009, the Department of Marine Park Malaysia (DMPM) had established a turtle hatchery project in PRMPC (Pulau Pinang), Terengganu followed by the establishment of another turtle hatchery project in PRBMPC, Labuan in 2011. Both beaches serve as important nesting beaches for these 2 turtle species, which rely on beaches as incubation sites for their eggs. Both green and hawksbill turtles are endemic to Malaysian waters and are among the 4 species (*Lepidochelys olivacea, Eretmochelys imbricate, Chelonia mydas, Demochelys coriacea*) categorised as endangered (green) and critically endangered (hawksbills) sea turtles according to the IUCN Red List of Threatened Species.

Sea turtle face several threats in each stage of life due to natural factors and anthropogenic activities. Green and hawksbills turtles have experienced an extensive subpopulation declining trend and is impossible to recover from the persistent decrease in population size due to various pressures from anthropogenic activities (Kamaruddin & Abdul Rahman, 2001). When prime beaches and near coastal are developed for the purpose of tourism, the disappearance of turtle nesting habitats is expected in Malaysia with exemption of places where turtle sanctuaries have been established (e.g., Sabah and Sarawak Turtle Islands; Rantau Abang, Ma' Daerah and major nesting beaches in Perhentian and Redang Islands in Terengganu) (Chan, 2006). Beach protection is considered an effective control measure in comparison to other active interventions for species protection. Apart from its relative easy for execution, beach protection is able to leverage on the nesting bay's natural condition, hence has a higher chance of hatchling productivity at the end of the season. Serving as a physical enabling factor, beach protection ensures the minimisation of habitat alteration and supports the optimum nesting site selection to the species which is known by its site fidelity. In addition to that, given the fact that only a hatchling in a thousand is thought to survive to adulthood, protecting more of the nesting beaches would represent an important conservation and management achievement (Kamaruddin & Abdul Rahman, 2001).

The objective of this study is to determine the population sizes and potential contribution factor of green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricate*) turtles at the PRMPC, Terengganu and PRBMPC, Labuan for proper conservation measures. In this study, basic data were collected over the 7 years and 8 years of establishment of the marine turtle hatchery projects in PRBMPC; Labuan and PRMPC; Terengganu, respectively.

MATERIALS AND METHODS

Sampling Sites

The hatchery project in the PRMPC (05°44’ N, 103° 00’ E) is located at Pulau Pinang. This island is situated in the South China Sea, off the east coast of Terengganu (Figure 1). The marine waters surrounding these islands up to 2 nautical miles from the low water mark of the shore have been designated as Marine Parks Malaysia since 1994. Pulau Pinang has a land area of about 1.25 square km and is about 45 km northeast of Kuala Terengganu. Besides Pulau Redang Marine Park Centre beaches, there are 3 other turtle nesting beaches on nearby island namely Chagar Hutang, Mak Kepit and Mak Simpan located on Pulau Redang, Terengganu.

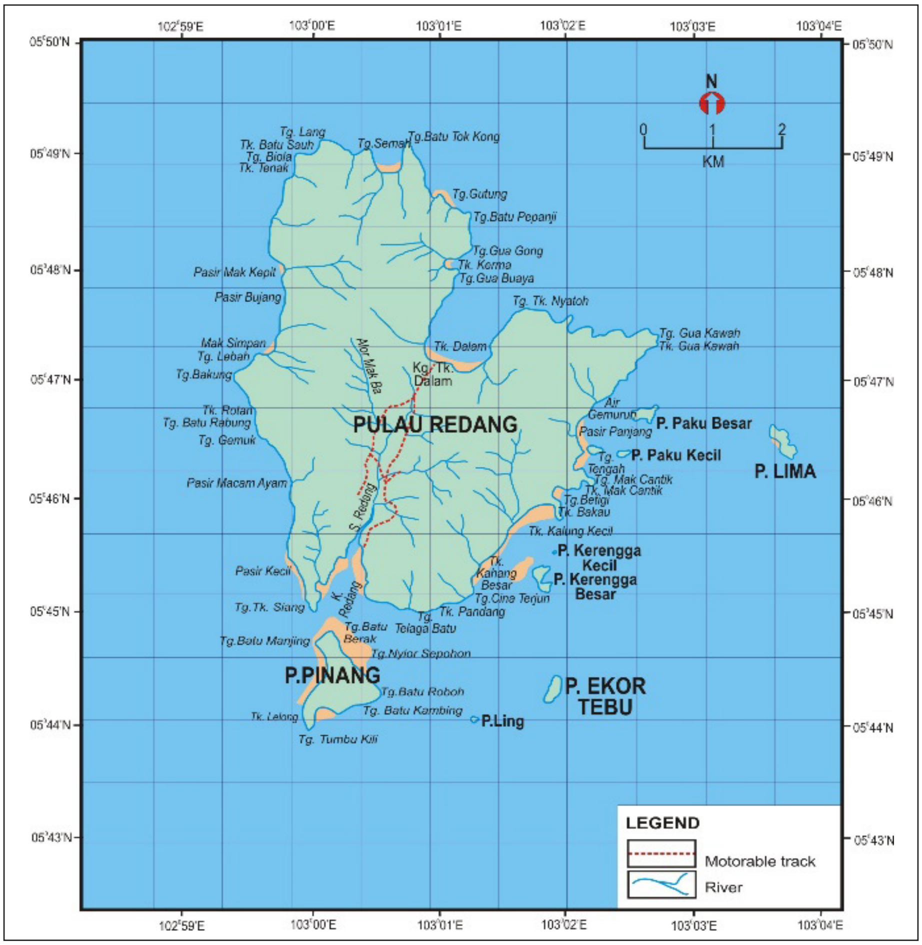


Figure 1. The location of PRMPC, Terengganu. Source: Department of Marine Park Malaysia

The Labuan Marine Park is located 2 kilometres off the southern part of Labuan Main Island. This Marine Park consists of 3 cluster of islands - Pulau Kuraman, Pulau Rusukan Besar and Pulau Rusukan Kecil (Figure 2). The marine waters surrounding these islands up to 1 nautical mile from the low water mark of the shore have been designated as Labuan Marine Parks Malaysia since 2000. The turtle hatchery project is located in PRBMPC (05°12'N, 115°08' E). Pulau Rusukan Besar is about 0.12 square km in size and is situated just next to Pulau Kuraman and about 15 km from Victoria Harbour, Labuan. Pulau Kuraman is by far the most developed islet in the Marine Park. It has a jetty and a few units of chalets. Pulau Kuraman is located about 14 km from Victoria Harbour, Labuan and is about 1.47 square km in size. Pulau Rusukan Kecil is located near to Pulau Kuraman and it has a land area of only 0.03 km^2.

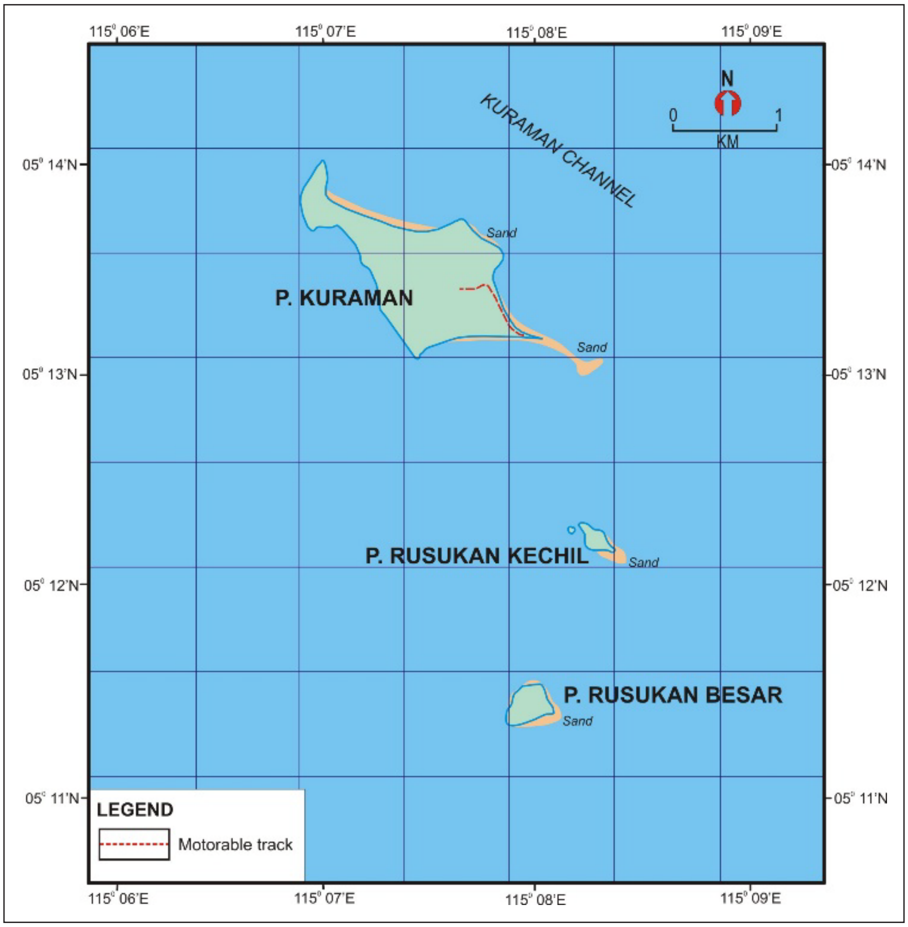


Figure 2. The location of PRBMPC, Federal Territory of Labuan. Source: Department of Marine Park Malaysia

Nesting Activity

The data on the numbers of nests laid by sea turtles at both Marine Park Centres were collected by DMPM. Analysis in this paper was based on secondary data collected between 2010 and 2017. All data was recorded by a trained worker and thus are considered reliable. As such, no data treatment has been done. Studies were conducted based on the limited data available to achieve the stated objective. The hatchery in PRMPC was established in 2009. However, there are no proper record and actual figures found on the green and hawksbill turtles nesting on 2012 for the PRMPC. Tagging projects are currently running at both the Marine Park Centres of Pulau Redang, Terengganu and Pulau Rusukan Besar, F.T of Labuan, but they are not extensively conducted (not saturation tagging). For this reason, the green and hawksbill turtle population sizes can only be roughly estimated from the data on the number of nests laid. The total annual nests laid are divided by the average number of nests laid by a female of a species per year, and this gives an estimate on the abundance of breeding females. According to Kamaruddin and Abdul Rahman (2001), the abundance of breeding females per season is calculated by assuming that green turtles will lay an average of 5 clutches (range 1-11 clutches) per female/season and hawksbills turtles will lay an average of 3 clutches per female/season (range 2-4 clutches). This figure does not provide an indication of the actual population size because juvenile and male sea turtles do not come ashore. Thus, it measures only the adult female turtles that ascend the beaches to lay between 4 to 6 clutches of eggs per nesting season. The turtles do not nest every year, with each nesting cycle separated by an interval of 2 to 8 years (Chan, 2006). Population trend is roughly calculated based on the changing numbers of nesting females from year to year (Seminoff & Shanker, 2008).

Sampling Techniques

Monitoring of Nesting Activity. Beach patrols have been conducted every night at the PRMPC and Pulau Labuan Marine Park (cluster of 3 islands) by contract staff. The nightly patrols are conducted once in every 2 hours starting from 2000 hours and lasting till 0600 hours the following morning. Turtles encountered are tagged on flippers, and within this time all the necessary data were collected and recorded. This information includes nest site location, species of the turtle, total number of eggs laid, and time of emergence. The turtle hatchery is located near to the Marine Park Centre and is fully covered with black netting to provide shade and avoid the eggs from overheating.

Determination of Hatching Success. According to Chen and Cheng (1995), the percentage of hatching success is calculated using the formula where the total number of healthy hatchlings is divided by total clutch size incubated. Percentages are also used to describe the results of eggs condition.

Statistical Analysis. All statistical analyses were run using the SPSS Version 23 statistical software packages and Microsoft Excel 2016. One-way repeated measures with the number of annual nest laid as the dependent variable were used to assess whether there was any difference in terms of nest deposition over the 7 years and 8 years of establishment of the marine turtle hatchery projects in PRBMPC, Labuan and PRMPC, Terengganu; Malaysia respectively.

An independent sample t-test was used to compare the mean scores of the turtle nest deposition figures for the green and hawksbill turtle at PRBMPC, Labuan and PRMPC, Terengganu. An independent samples t-test using the successful hatching rate as its dependent variable was also used to compare the trend significance for green and hawksbill turtles at both Marine Park Centres.

In this paper, a multiple regression analysis was used to investigate the relationship between multiple explanatory variables. Our model included a physical factor (tide level) and a human-related beach characteristic (tourist arrival) in the selection of nesting beaches by female green and hawksbill turtles.

Missing data prediction and interpolation tests were not done due to limited data availability (only 8-years data). The turtle nesting populations at both Marine Park Centre were calculated roughly from the total number of nests laid per season. Taking into consideration that green turtles show a high variability of inter-annual nesting and classic remigration intervals of between 2 and 8 years, monitoring on beach nesting activities to set up population trends should resume for at least 2 more complete remigration cycles at least 16 years or more to initiate representative population trends (Richards et al., 2005).

RESULTS AND DISCUSSION

Nesting Patterns

Green turtles are by far the major species nesting at the PRMPC Hatchery, accounting for 96.18% of the nest deposited from 2010 to 2017. The total number of green turtle nests laid recorded at the PRMPC per year fluctuated from a low of 72 in 2011 to a high of 313 in 2013 (Figure 3). A one-way repeated measure ANOVA test indicated that there was a significant effect for the year, [$F (6,6) = 10.555$, $p<0.005$, $\eta p2 = 0.913$]. Inter-annual changes are clearly seen, with some years demonstrating high variability magnitude separated by an interval of 1 to 4 years. In other green turtle nesting populations, fluctuations taking place every other year have been reported (Weishampel et al., 2003). By assuming that green turtles lay an average of 5 clutches (range 1 to 11 clutches) per female/season (Kamaruddin & Abdul Rahman, 2001), the female green turtle population at the PRMPC was also estimated to fluctuate from a low of 14 in 2011 to a high of 63 in 2013 [Figure 4(a)].

The hawksbill nesting population at the PRMPC hatchery project appears to be a remnant population, contributing only 3.82% of the nesting observed over the 8-year period. The number of nests deposited ranged from 0 in 2017 to 15 in 2010, the highest recorded in the 8-year period (Figure 3). The trend indicated a decline from 2010 to 2017, with a total of 49 nests deposited over the 8-year period. The one-way repeated measures ANOVA conducted showed that there was no significant effect for year [F (5, 8) = 0.587, p>0.05, *ηp2*=0.268]. The female hawksbill turtle population at the PRMPC also showed a declined trend from a high of 5 in 2010 to a 0 in 2017 [Figure 4(b)]. No hawksbill turtle nesting had occurred in 2017, and no prediction on the missing data was done for 2012. All secondary data were considered reliable and accepted without prejudice. However, according to previous studies conducted by Palaniappan and Hamid (2017) it is believed that hawksbill turtles show strong site fidelity to their feeding grounds, live in a specific habitat for several years, and retain short term home ranges within several hundred meters in extension. Thus, there is a need to conduct details studies and continuous monitoring on the disappearance of hawksbill turtle nesting at the Marine Park Centre in 2017.

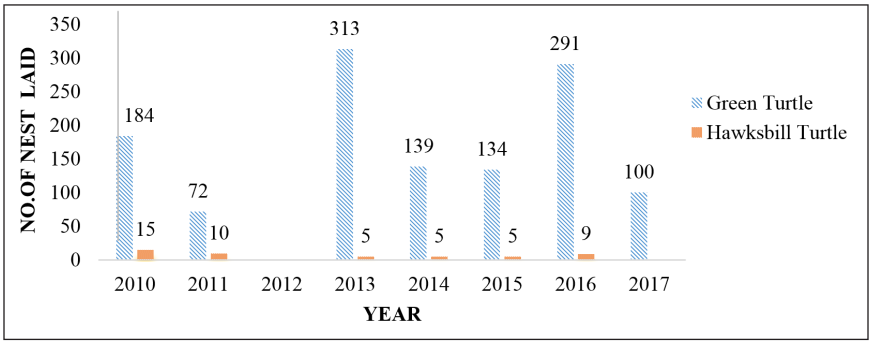
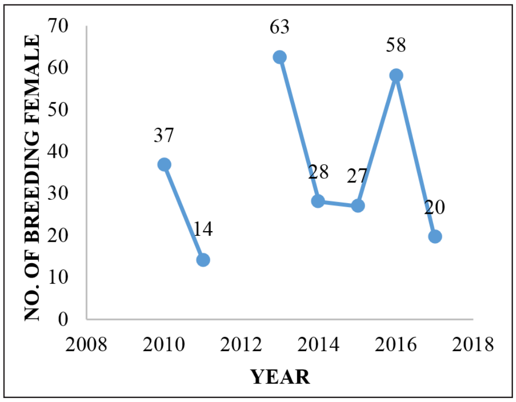
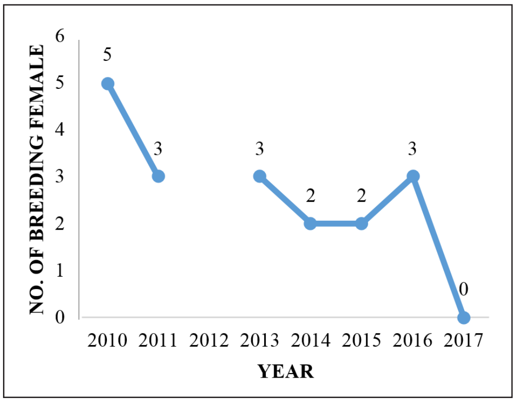


Figure 3. Number of Green and Hawksbill Turtles' nest laid and incubated at the PRMPC from 2010 to 2017. No record was found for 2012 and no Hawksbill Turtle nesting had occurred in 2017



(a)



(b)

Figure 4. (a) Number of Green Turtle breeding females at the PRMPC from 2010 to 2017. No Green Turtle nesting records were found for 2012; (b) Number of Hawksbill Turtle breeding females at the PRMPC from 2010 to 2017. No Hawksbill Turtle nesting records were found for 2012 and no Hawksbill Turtle nesting had occurred on 2017

In the PRBMPC, 23.58 % and 76.42% of breeding females were recorded respectively for the green and hawksbill turtles. The total number of green turtle nests laid recorded at the PRBMPC rise and fall irregularly in number per year from a low of 3 in 2011 and 2013 to a high of 10 in 2016 (Figure 5). The one-way repeated measures ANOVA showed that there was no significant effect for year [$F(6, 6) = 1.076$, $p>0.05$, $\eta p2=0.518$]. The female green turtle population at the PRBMPC recorded a low of 1 in 2011, 2012, 2013, 2015 and 2017 to a high of 2 in 2016 [Figure 6(a)]. No green turtle nesting had occurred in 2014. According to previous studies conducted in Pulau Mabul, Sabah, green turtles also show the characteristics of living in a place and spatial site fidelity. This site fidelity behaviour also indicates the capability of these turtles to return to a specific location as demonstrated by juvenile green turtles that were regularly caught at a power plant's intake canal in Florida (Palaniappan & Hamid, 2017). Thus, continuous monitoring is needed to find out what is the potential factor and causes related to green turtle nesting disorder at Labuan Marine Park area in 2014.

The hawksbill turtle nesting population at the PRBMPC hatchery project is the major population, with nests laid and deposited ranging from 7 in 2011 to 18 in 2014, the highest recorded in the 7-year period (Figure 5). The trend indicated a steady increase from 2011 to 2017. A total of 94 nests were deposited over the 8-year period. The two-way repeated measures ANOVA conducted indicated that there was no significant effect for year [$F(6, 6) = 0.632$, $p>0.05$, $\eta p2=0.387$]. The female hawksbill turtle population at the PRBMPC recorded a low of 2 in 2011 to a high of 6 in 2014 [Figure 6(b)].

The independent sample t-test indicated that there was a significant difference in scores for green turtles at the PRMPC (mean =14.90, SD = 16.723) and PRBMPC (mean = 0.35, SD = 0.784); $t(82.356) = 7.822$, $p = 0.01$). For hawksbill turtle nest deposition, the independent sample t-test conducted showed that there was a significant difference in scores for PRMPC (mean = 0.64, SD = 1.1) and PRBMPC (mean = 1.12, SD = 1.383); $t(157.791) = 2.486$, $p = 0.01$).

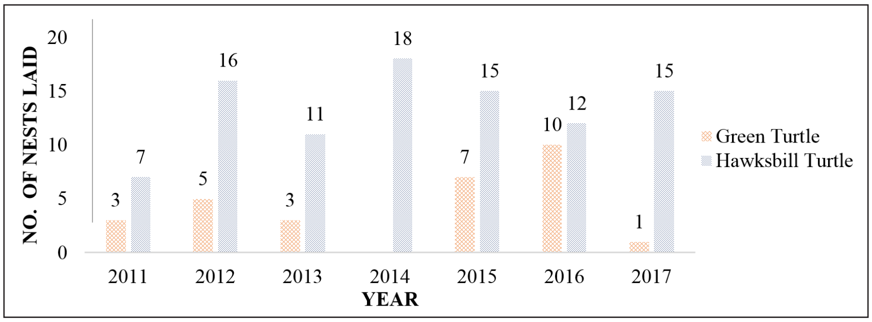
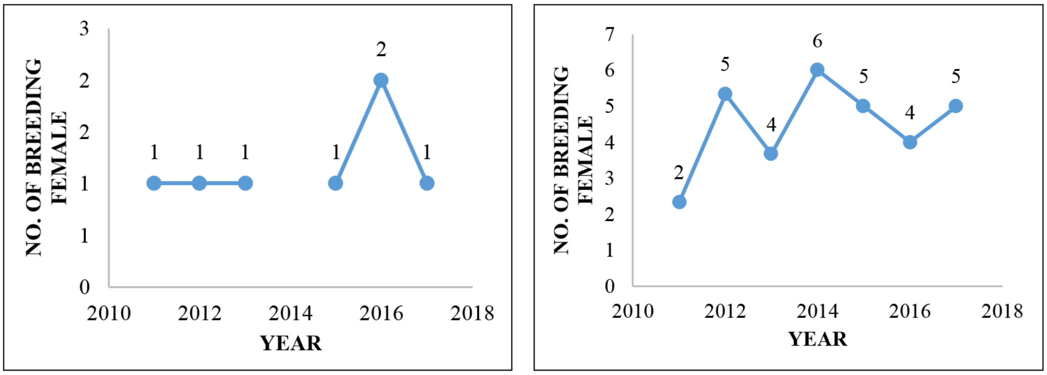


Figure 5. Number of Green and Hawksbill Turtles' nest laid and incubated at the PRBMPC from 2011 to 2017. No Green Turtle nesting had occurred in 2014



(a) (b)

Figure 6. (a) Number of Green Turtle breeding females at the PRBMPC from 2011 to 2017. No Green Turtle nesting had occurred in 2014; (b) Number of Hawksbill Turtle breeding females at the PRBMPC from 2011 to 2017

In Malaysia, nesting trends of green and hawksbill turtles have shown a decline since 1993 (Chan, 2013). They face a wide range of threats at all stages of their life cycle. These obstacle which come from natural and anthropogenic activities affect their survival rate as well as bring them to the disappearance (Abd Mutalib & Fadzly, 2015). Green turtle (*Chelonia mydas*) inhabits shallow, near-shore and reef areas with plentiful seagrass and algae (Seminoff, 2004). Hawksbill turtle (*Eretmochelys imbricate*) can most frequently be found at hard bottoms and reef habitats containing sponges (Mortimer & Donnelly, 2008). Both Marine Park Centre locations selected in this study have seagrass and coral reef habitats that provide sufficient area for protection and the abundance of food. The population sizes of different turtle species might also contribute to the abundance of green and hawksbill turtle in this study. The estimated population sizes of nesting turtles from South East Asia showed that only 10,000 female green turtles and 1,000 female hawksbill turtles have been recorded in Malaysia. This shows that the population of green turtles is much larger, more abundant and widely distributed in contrast to the hawksbill turtle population. This is also influenced by the different habitats, population abundance, food preferences, exploitation and conservation status as well criteria condition of feeding grounds in Malaysia (Chong, 2013).

Egg Incubation Hatchlings Produced and Success Rates

The total number of eggs incubated and hatchlings produced by green and hawksbill turtles at the PRMPC from 2010 to 2017 are shown in Figures 7 and 8. A total of 112,712 green turtle eggs have been incubated from 2010 to 2017, with 101,302 hatchlings successfully returned to the ocean to replenish the population stock. The overall average hatching success rate is 87.11%. The independent sample t-test indicated that there was no significant difference in successful hatching for the PRMPC (Mean = 87.11, SD = 12.27) and PRBMPC, (mean = 88.33, SD = 13.58); t (85) = 0.343, $p > 0.05$. In the case of hawksbill turtles, 14,104 eggs have been incubated from 2010 to 2017 with 12,432 hatchlings making it back to the ocean. The overall average hatching success is much higher at 91.56%. There were no hatchlings produced in 2017 as no hawksbills turtles had nested that year.

Figure 7. Number of Green Turtle eggs incubated and hatchlings produced at the PRMPC Hatchery from 2010 to 2017. No Green Turtle nesting records were found on 2012

The total number of eggs incubated and hatchlings produced for green and hawksbill turtles at the PRBMPC from 2011 to 2017 are shown in Figures 9 and 10.

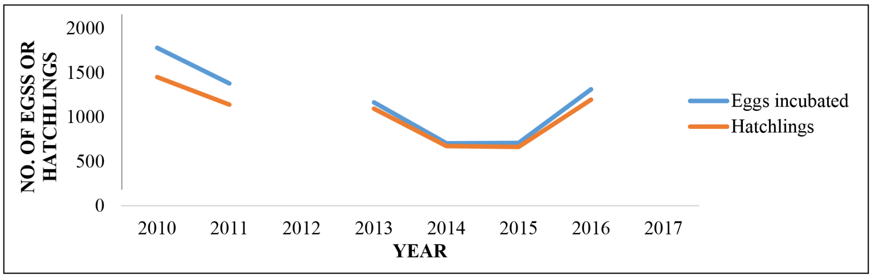


Figure 8. Number of Hawksbill Turtle eggs incubated and hatchlings produced at the PRMPC Hatchery from 2010 to 2017. - No Hawksbill Turtle nesting records were found for 2012 and no Hawksbill Turtle nesting had occurred in 2017

A total of 2,911 green turtle eggs has been incubated from 2010 to 2017, with 2,617 hatchlings successfully returned to the ocean to replenish the population. There were no hatchlings produced in 2014 as no green turtle had nested that year. The overall average hatching success rate is 88.33 %. In the case of hawksbill turtles, 12,182 eggs have been incubated from 2010 to 2017 with 11,126 hatchlings making it back to the ocean. The overall average hatching success is much higher at 90.69%. The independent sample t-test showed that there was no significant difference in the hawksbill turtle successful hatching rate for the PRMPC (mean = 91.56, SD = 5.017) and PRBMPC, (mean = 90.69, SD = 11.63); t (63) = 0.436, $p > 0.05$. Results showed that there was no significant difference in the successful hatching rate over the 8 years of collected data.

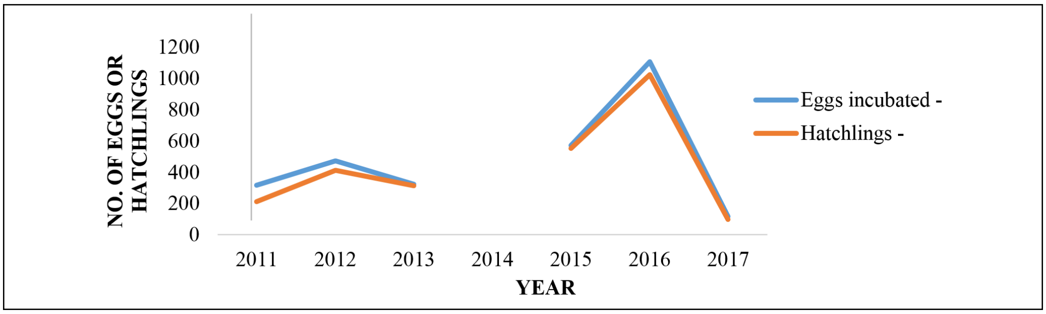


Figure 9. Number of Green Turtle eggs incubated and hatchlings produced at the PRBMPC Hatchery from 2011 to 2017. No Green Turtle nesting had occurred in 2014

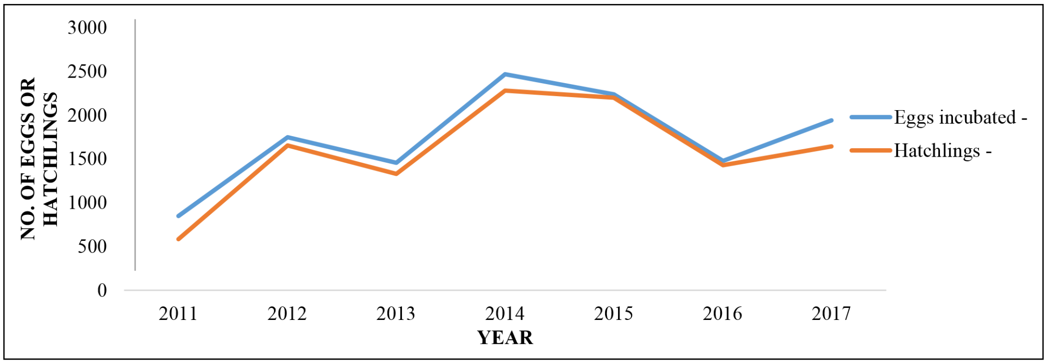


Figure 10. Number of Hawksbill Turtle eggs incubated and hatchlings produced at the PRBMPC Hatchery from 2011 to 2017

A higher number of sea turtles could be released to the sea due to high percentage of successful hatching at both Marine Park Centres. This means that there is a greater possibility of the number of hatchlings remaining alive to adulthood. The ex-conservation method (hatcheries) can allow more eggs to be hatched without the risk of those eggs being hunted illegally and put on sale at the markets compared to leaving the eggs in their natural habitat (in situ) (Abd Mutalib & Fadzly, 2015). This also shows that the Standard Operation Procedure (SOP) and Best Hatchery Practices (BHP) have been in place and successfully implemented according to the significance of competency (mainly through the relocation of eggs from the nesting beach to the hatchery) and the productiveness of hatcheries at both Marine Park Centres. In recent years, most turtle populations in Asia have showed a declining trend and some have been pushed to the edge of extinction (Seminoff & Shanker, 2008). Thus, it is important to produce maximum hatching success so that the turtle population's survival in the future can be preserved. Turtle conservationists recommend that in healthy populations, at least 70% of the eggs deposited must be incubated to ensure population sustainability. In highly threatened populations, it is vitally important that 100% of the eggs be protected to achieve the target for recovery of the population (Chan, 2006).

Potential Contribution Factor

To find out the best predictor of turtle landing variation, a multiple linear regression model was used to analyse the potential contribution factors that affect the number of turtle nests laid at selected nesting beaches at both Marine Park Centres. The relationship between tourist arrivals, tide level and number of turtle nests laid was investigated using the Pearson product-moment correlation coefficient.

In this case, both variables correlated well with the turtle landing figure. Multiple linear regressions identified the contribution of each variable with significant value $r = 0.421$, $R^2 = 0.177$, $F(2, 728) = 78.245$, $P < 0.05$. Expressed as percentage, this means that our model (which includes tourist arrival and tide level) explains 17.7 % of the variance in green turtle landing for the PRMPC. Tourist arrivals have the strongest unique contribution in green turtle landing variation (0.4). This means that this variable makes the strongest contribution to explaining the dependent variable when the variance explained by all other variables in the model is controlled for. The β-value for tide level is low (0.051), indicating that it has less contribution. In this case, tourist arrivals is statistically significant while tide level does not statistically contribute to the prediction of green turtle landing. The result of the multiple regression model is given in Table 1.

Table 1
Estimates of coefficients of the multiple linear model for Green Turtle at the PRMPC

Coefficients[a]					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta (β)		
(Constant)	0.248	0.095		2.604	0.009
Tourist Arrivals	0.001	0.000	0.400	11.168	0.000
Tide Level	-0.054	0.038	-0.051	-1.414	0.158

For hawksbill turtles, multiple linear regressions identified the contribution of each variable with significant value $r = 0.051$, $R^2 = 0.003$, $F(2, 728) = 0.954$, $P < 0.05$. Expressed as percentage, this means that our model (which includes tourist arrivals and tide level) explains 3% of the variance in hawksbill turtle landing for the PRMPC. Tide level makes the strongest contribution in hawksbill turtle landing variation (0.048). This means that this variable makes the strongest contribution to explaining the dependent variable when the variance explained by all other variables in the model is controlled for. The β-value for tourist arrivals was very low (0.007), indicating that it had less contribution. In this case both variables are not unique and made no statistically significant contribution to the prediction of hawksbill turtle landing. The result of the multiple regression model is given in Table 2.

Table 2
Estimates of coefficients of the multiple linear model for Hawksbill Turtle at the PRMPC

Coefficients[a]					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta (β)		
(Constant)	0.022	0.012		1.892	0.059
Tourist Arrivals	$2.247E^{-6}$	0.000	0.007	0.183	0.855
Tide Level	-0.006	0.005	-0.048	-1.221	0.222

For the PRBMPC, multiple linear regressions identified the contribution of each variable with significant value r = 0.045, $R^2 = 0.002$, F (2, 728) = 0.743, $P < 0.05$. Expressed as percentage, this means that our model (which includes tourist arrivals and tide level) explains 2 % of the variance in green turtle landing for the PRBMPC. Tide level makes the strongest contribution in green turtle landing variation (0.043). This means that this variable makes the strongest contribution to explaining the dependent variable when the variance explained by all other variables in the model is controlled for. The β-value for tourist arrivals was slightly lower (0.017), indicating that it gave less contribution. In this case, both variables are not unique and made no statistically significant contribution to the prediction of green turtle landing. The result of the multiple regression model is given in Table 3.

Table 3
Estimates of coefficients of the multiple linear model for Green Turtle at the PRBMPC

Coefficients[a]					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta (β)		
(Constant)	0.046	0.026		1.737	0.083
Tourist Arrivals	0.000	0.000	-0.017	-0.455	0.649
Tide Level	-0.017	0.015	-0.043	-1.155	0.248

Multiple linear regressions identified the contribution of each variable with significant value r = 0.024, $R^2 = 0.001$, F (2, 728) = 0.203, $P < 0.05$. Expressed as percentage, this means that our model (which includes tourist arrivals and tide level) explains 1 % of the variance in hawksbill turtle landing for the PRBMPC. Tourist arrivals make the strongest unique contribution in hawksbill turtle landing variation (0.021). This means that this variable makes the strongest contribution to explaining the dependent variable when the variance explained by all other variables in the model is controlled for. The β-value for tide level was slightly lower (0.012), indicating that it gave less contribution. In this case, both variables are not unique and made no statistically significant contribution to the prediction of hawksbill turtle landing. The result of the multiple regression model is given in Table 4.

Table 4
Estimates of coefficients of the multiple linear model for Hawksbill Turtle at the PRBMPC

Coefficients[a]					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta (β)		
(Constant)	0.047	0.040		1.169	0.243
Tourist Arrivals	0.000	0.000	-0.021	-0.572	0.568
Tide Level	-0.007	0.023	-0.012	-0.313	0.754

Our results showed that most nesting attempts are affected by other environmental and physical factor besides tide level and tourist arrivals. Based on the study conducted, only a small correlation was found between nesting frequency, tide level and tourist arrivals. According to Abd Mutalib et al. (2017), others researchers have found no correlation between moon and tide with nesting frequency. Correlations were instead found with other physical factors such as nest location and type of sand. It has also been recommended that vegetation, temperature, and beach gradient can have a significant influence on the natural nest site selection of green turtles. Besides, nesting site option and physical features of the site can heavily affect the successfulness of nesting (Sarahaizad et al., 2012).

Nest site selection plays a major role in the successful reproduction of all sea turtle species (Wood & Bjorndal, 2000). Studies on the beach selection of sea turtles also suggest that besides human factors, nesting frequency is affected by physical and biotic factors (Alkindi et al., 2006). Evaluation of human activities on the nesting beaches was measured mostly through the arrival of tourist on the beaches during the day time and the staff stationed at the Marine Park Centre. In some other places, emergence is also related to the tide level. When the tide is high, the turtles can preserve their strength by swimming towards the sand rather than crawling. Substantial amounts of energy are required for turtles to confer any hindrance, select a nesting location, excavate the clutches, lay the eggs and finally cover them with sand again (Sarahaizad et al., 2012). The physical factors may encompassed sand texture and degree of compactness, offshore approachability, beach characteristic and geomorphology, and also biotic factors (Alkindi et al., 2006). Sand feature such as salinity and grain size may influence female turtles to alter their nesting preferences. Other common circumstances comprise of an even slope, sandy beaches, and humidity levels. In addition, wave action and sand particles also have an impact on the nesting of sea turtles (Sarahaizad et al., 2012).

CONCLUSIONS

This paper showed that the population sizes of green turtles were much larger, more abundant and widely distributed compared to the populations of hawksbill turtles in Malaysia. The results of this study depend fully on the availability of secondary data from the respective departments as estimates of population size can only be made using data available on the number of nests laid. This figure does not provide an indication of the actual population size because juvenile and male sea turtles do not come ashore. However, the data obtained will be useful for management and monitoring purposes of both species in both Marine Park Centres. Proper documentation of species inventory is paramount for conservation purposes. To establish whether the declining trend is of concern, continuous monitoring of turtle nesting activities is needed to obtain meaningful information. In this regard, considerations should be taken by the relevant departments and institutions for future studies and monitoring practices on the physical habitat assessment, foraging and feeding ground, and natal-beach imprinting of sea turtles which are currently lacking. Hence, the shortfall can be addressed so as to ensure better management and protection of sea turtles at the Marine Park areas in the future.

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