

# The Ongoing Battle: Understanding the Population Trends of Green Turtles in Peninsular Malaysia

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**Abstract.** Sea turtles are crucial marine animals. They act as indicator to a healthy marine ecosystem. However, they are subjected to different challenges and threats which results of their declining population. This study looks at the population trends of sea turtles in Malaysia by examining the numbers of nests, eggs, and hatchlings in six states in Peninsular Malaysia which are Perak, Pahang, Melaka, Johor, Terengganu, and Negeri Sembilan. Statistical distribution, hatching success percentage, trend landing and hatching, and linear regression analysis are implemented. The results show that Terengganu, on the east coast, consistently has the highest numbers of nests, eggs, and hatchlings, highlighting its key role in sea turtle conservation. In contrast, Melaka has the lowest numbers, pointing where conservation efforts could be increased. This study provides valuable insights into the differences in green turtle populations across states and identifies critical areas for focused conservation strategies to better protect and help these endangered species recover in Malaysia.

## 1 Introduction

Sea turtles, known as the navigators of the seas encounter obstacles in today's world. Their nesting behaviors serve as indicators of the health of marine ecosystems offering valuable insights into environmental trends. This study delves into the habits of sea turtles with a focus, on the Green Turtle (*Chelonia mydas*) along the shores of Peninsular Malaysia.

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Among the seven species of sea turtles Malaysia hosts four species; Green (*Chelonia mydas*), Hawksbill (*Eretmochelys imbricata*), Olive Ridley (*Lepidochelys olivacea*) and Leatherback turtles (*Dermochelys coriacea*).

Previous study emphasized the significance of the east coast of Peninsular Malaysia for sea turtle nesting [1], [2] while [3] noting a decrease in Leatherback turtle numbers in Terengganu. Different studies [4]–[6] has started to investigate how climate change could affect sea turtle nesting behaviors and how it affect the nesting activity in focused.

Malaysia's coastal waters are home to significant green turtle nesting sites, with the largest rookeries found in Sabah and Terengganu [5], [7]–[9]. However, this study highlights on peninsular Malaysia for regional focus on assessing the green turtle trend in peninsular Malaysia. Studies have shown that the green turtle population in Malaysia has experienced a concerning decline over the past few decades [1]. This trend is attributed to a variety of factors, including habitat degradation, poaching, and bycatch in fishing operations [1], [10]. Green turtle populations face numerous challenges that threaten their long-term survival in Malaysia. In particular, the degradation of seagrass ecosystems, which serve as critical habitats for green turtles, is a significant concern [11], [12]. Green turtles are not only important for their ecological role in maintaining the balance of marine ecosystems, but they also hold cultural significance for many coastal communities in Malaysia [13].

The green turtle nesting sites in Malaysia are not limited to a single location, but are dispersed across various coastal regions of the country. There are also significant nesting sites in other states, such as Pahang, Johor, and Perak, Pulau Pinang and Melaka [3]. This broad distribution of nesting sites across Malaysia's coastline highlights the importance of a comprehensive, nationwide approach to green turtle conservation efforts.

The green turtle population in Terengganu, one of the key nesting sites in Malaysia, has faced significant declines in recent decades [14]. According to research, the Terengganu coastline hosts the largest green turtle rookery in the country, with nesting sites scattered along the entire length of the state's beaches. However, the green turtle population in Terengganu has been steadily decreasing due to various threats, including habitat degradation, poaching, and bycatch in fishing operations [1], [15], [16]. Comprehensive conservation efforts and further research are crucial to understanding and reversing this concerning trend in the green turtle population in the Terengganu region.

Pulau Pinang and Perak, are an important yet lesser-known aspect of green turtle conservation in the country. While the nesting sites in these states may not be as, they still play a significant role in the broader distribution and protection of this endangered species. Pulau Pinang, in particular, has been identified as hosting a small but steady population of nesting green turtles, with research highlighting the importance of these beaches for the species' reproduction and survival [17]. Similarly, the coastal areas of Perak have also been recognized as supporting green turtle nesting, though the exact population size and trends require further investigation [7].

For Johor, Melaka, and Negeri Sembilan, [3]. while these states may not host the largest nesting rookeries, they still support important nesting sites and contribute to the overall distribution and survival of green turtles in Malaysian waters. Johor, in particular, has several known nesting beaches, including those in Tanjung Balau and Mersing, that deserve further research and monitoring to understand the size and trends of the local green turtle population [3], [18]. Similarly, Melaka and Negeri Sembilan also have sporadic nesting reports, indicating the presence of green turtles in these regions, though the full extent of their populations remains unclear [19].

The green turtle population in Pahang, situated along the east coast of Peninsular Malaysia, is an important but understudied aspect of sea turtle conservation in the country [18]. While not hosting the largest nesting rookeries, the coastal areas of Pahang still support significant green turtle nesting sites that contribute to the overall population dynamics and

distribution of this endangered species within Malaysian waters. According to research, the beaches of Pahang, particularly in locations like Cherating and Tanjung Balau, have regularly recorded green turtle nesting activity, though the precise population size and trends remain unclear due to the limited data available [3], [18]. The green turtle nesting season in Pahang typically coincides with the northeast monsoon, from October to February, when female turtles come ashore to lay their eggs [20]. However, the number of nesting females and hatchling success rates in Pahang have not been studied as extensively as the better-known rookeries in Sabah and Terengganu [12].

This study aims to provide a comprehensive analysis of sea turtle nesting trends in Peninsular Malaysia over a 27-year period (1996-2022). The organization of this paper are as follows: Introduction, Methodology, Result and Discussion and Conclusion.

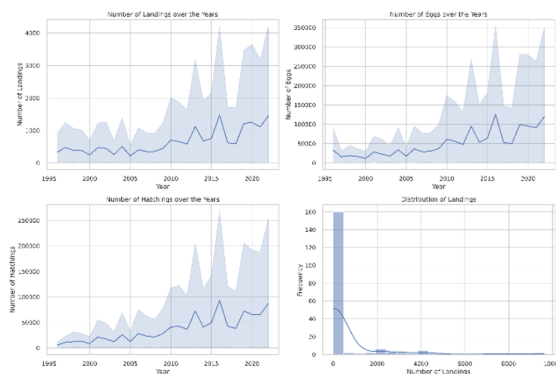
## 2 Methodology

This study utilized a comprehensive dataset of green turtle nesting activities in Peninsular Malaysia from 1996 to 2022. The data was collected through a collaborative effort involving state fisheries departments, local conservation organizations, and research institutions across seven states: Terengganu, Pahang, Johor, Melaka, Perak, Pulau Pinang, and Negeri Sembilan. The dataset included annual records of landings (nesting attempts), eggs laid, and hatchlings produced in each state.

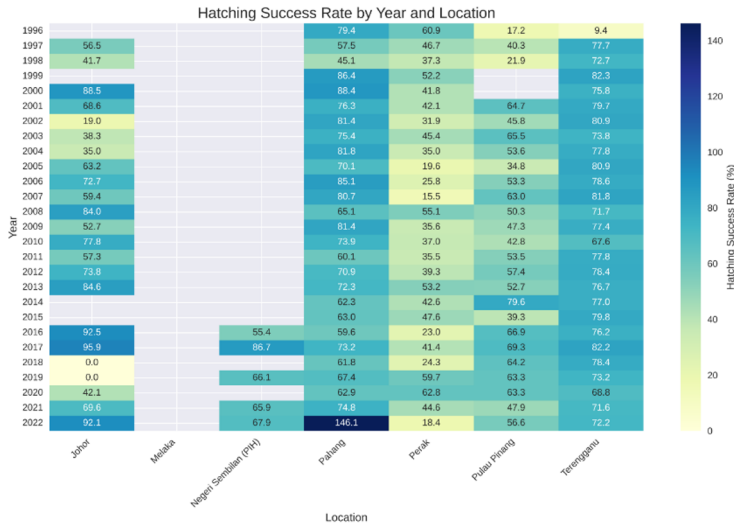
The analysis phase utilized a two-phase process; trend analysis and regression analysis. Inter-state comparisons were conducted to identify variations by visualizing the trends using landing data, eggs data and hatching data to portray the nesting activity of green turtle. Linear growth regression was applied to quantify long-term nesting trends for each state. All statistical analyses were performed using Google Colab.

## 3 Results and Discussion

The number of landing and number of eggs of green turtle in Peninsular Malaysia shows a general upward trend over time. There are fluctuations in the numbers year over year, but general, the number of eggs appears to be increasing. With the increasing number of landing and eggs, there is a visible increase in trend in number of hatching therefore increasing the rate success of hatching for overall and each of the states (Figure 1 and Figure 2).

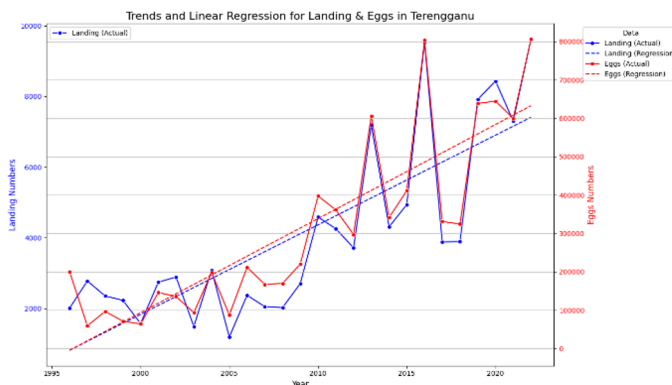


**Fig. 1.** Number of Landing, Egg and Hatching over time in Peninsular Malaysia



**Fig. 2.** Hatching Success Percentage over time for different states

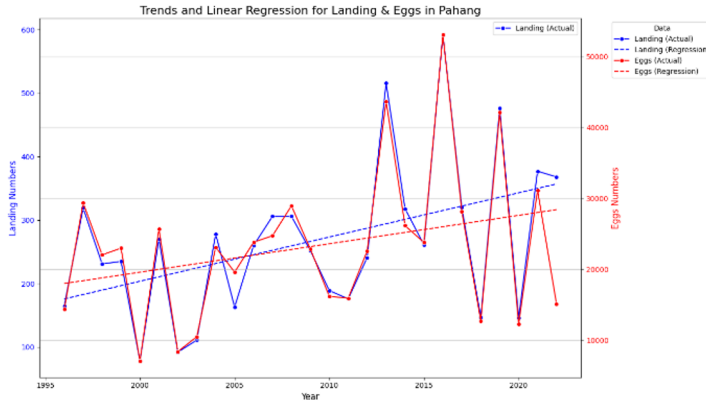
Terengganu literally emerges as the real powerhouse for Green Turtle nesting in Peninsular Malaysia (Figure 3). The state has experienced an overwhelming increment of 379% in nesting activities over a 27-year period, with the current years having landings of consistently more than 7,000 annually similar to a study by [21]. This could be indicative of the success of long-term conservation efforts and habitat protection, or maybe even a shift in nest site selection linked to climate change [1]. In fact, the consistently high hatching success rate of 70–82% in Terengganu with the lowest in 2019 (68.8%) thus further illustrates the importance of the state in maintaining viable Green Turtle populations. This focus of nesting activities also clearly points out the vulnerability of the population: hence, any large-scale environmental changes or human pressures in Terengganu might have devastating effects on the overall Green Turtle population.



**Fig. 3.** Number of landing and Eggs over time (Terengganu)

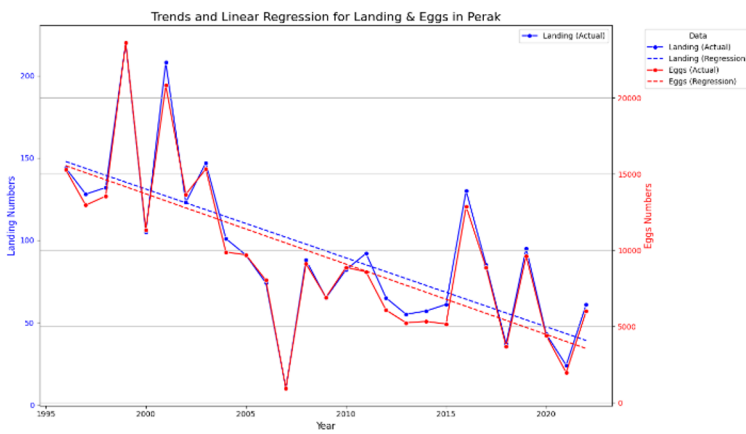
While the Terengganu success story is an encouraging one, the situation across other states remains much more of a mixed bag. The second largest nesting site, Pahang, continues to grow at much more of a rapid change: up 6.97 landings and 401.17 eggs/year (Figure 4). This suggests that while Green Turtle nesting at the beaches in Pahang becomes increasingly important, greater conservation measures can still boost nesting activity even more. It has

grown more modestly over 123% since 1996, with some very large up and down fluctuations between years. This could potentially indicate that the beaches in Pahang are more sensitive to changes in environmental conditions or human disturbances. The lower and more variable hatching success rate of 70-75% in Pahang compared to that in Terengganu would suggest the need to improve upon some practices in nest protection and management strategies.



**Fig. 4.** Number of landing and Eggs over time (Pahang)

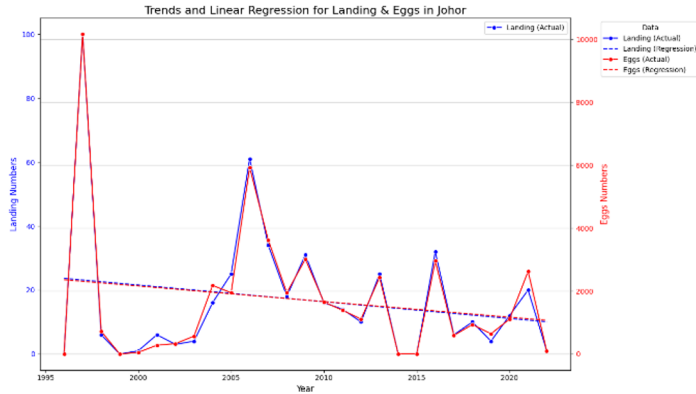
This is even more disturbing if one were to look at what was happening in other states. Perak, once having a high percentage of nesting numbers, experienced a drastic decline in 62% of nesting numbers since 1996 (Figure 5). It shows a negative growth trend with a decrease of 4.18 landings and 461.58 eggs per year. This decline raises red flags and necessitates urgent investigation into potential causes such as habitat degradation, increased human activity, or changes in local marine ecosystems [13]. Alternatively, the decline in Perak relative to the increase in Terengganu could also indicate a northward shift in nesting preferences and hence could be an indication of the impacts of climate change such as increasing temperatures or altered ocean currents and coastal squeeze. Further study on these subjects are a possible indicator to have a more comprehensive modelling on the trend.



**Fig. 5.** Number of landing and Eggs over time (Perak)

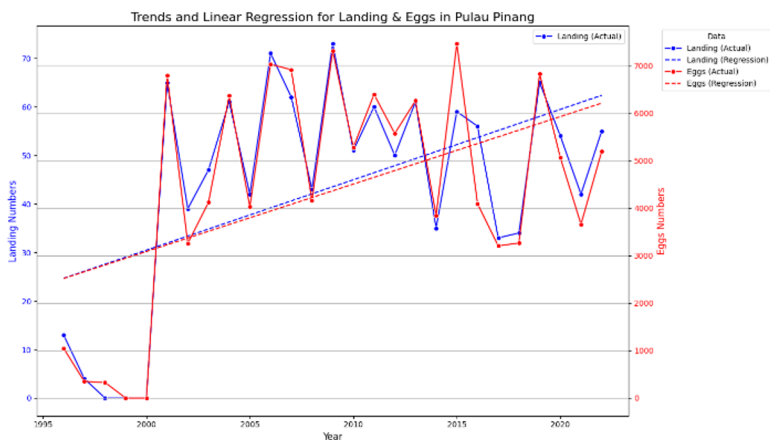
Such erratic nesting patterns in Johor, in which the occasional year of significant nesting is separated by years of low to no activity, give an impression that this habitat had remained marginal and might have even been further declining [18]. This is reflected by the slightly

negative growth trend (-0.52 landings and -49.57 eggs per year) (Figure 6). Such inconsistency poses problems for consistent implementation of long-term conservation. This suggests that Johor's beaches may be becoming less suitable for Green Turtle nesting over time, possibly due to environmental changes or human activities.



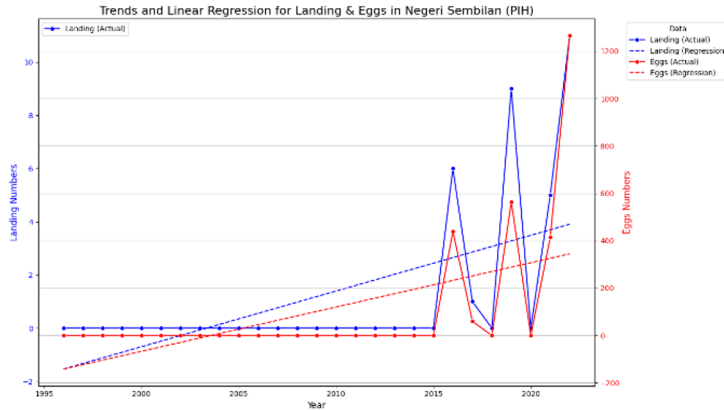
**Fig. 6.** Number of landing and Eggs over time (Johor)

Pulau Pinang hosts a more positive scenario where nesting activities show a small but steady increase over the years similar to the result by [22] (refer to Figure 7). The numbers are, of course, small compared to Terengganu however it is such a positive trend and relatively good hatching success that suggests conservation effort are working in Pulau Pinang. This information could be very useful to make the situation of nests better in other states. Pulau Pinang is slightly more hopeful, with a gradual, though continual rise in nesting activity to 1.45 landings and 142.12 eggs annually. These numbers are minuscule compared to those from Terengganu, but the positive trend holds out hope that conservation work in Pulau Pinang is paying off.



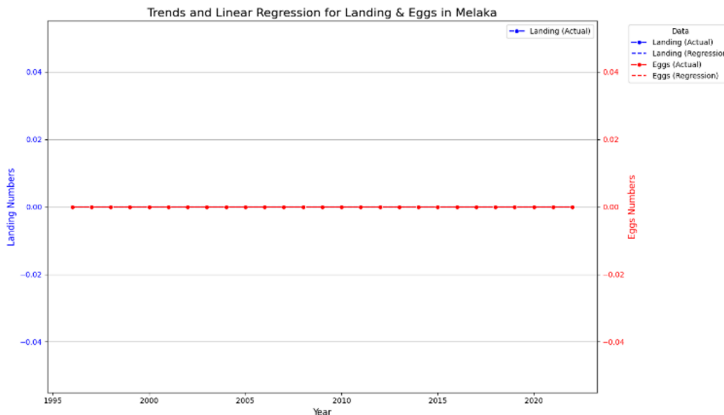
**Fig. 7.** Number of landing and Eggs over time (Pulau Pinang)

The small positive growth trend in Negeri Sembilan is evident in the number of eggs, with landings at 0.21 landings and 18.69 eggs per year (Figure 8). These, although small numbers, represent a new and hopefully emerging nesting site to be monitored and protected into the future.



**Fig. 8.** Number of landing and Eggs over time (Negeri Sembilan)

Although the figure is nil for Green Turtle nesting in Melaka, i.e., the growth rate of 0 for both landings and eggs (Figure 9), it's important to mention that there are still stable landings of Hawksbill turtles recorded in Melaka [18], [19]. This might not be directly reflected in the dataset used here, so it actually brings about two important points in the way to deal with sea turtle conservation by considering multiple species and taking consistent landings in defining change. That is, while Melaka does not play an important role in the Green Turtles' population, it is a critical support for the conservation of Hawksbill turtles [19].



**Fig. 9.** Number of landing and Eggs over time (Melaka)

Critically, the nesting trend for Peninsular Malaysia can be interpreted to suggest a northward shift in Green Turtle nesting. The large increase in Terengganu, together with the negative or inconsistent trends in the southern states, appears consistent with the anticipated impacts of climate change on sea turtle nesting. The rise in temperatures may make northern beaches and eastern beaches more suitable while the southern beaches less so.

This paper is meant to evoke a couple of highlights. The critical importance of Terengganu for Green Turtle conservation, serving as a stronghold for the species in the region [1], [16]. Targeted conservation initiatives must be launched for those states where trends are substantially down, particularly Perak and Johor [1]-[13]. Potential effects on site preference for nesting as a result of climate change, such that a possible shift northwards with nesting activity may take place [20]. Emphasized the multispecies approach to sea turtle conservation with Hawksbill nesting activity in Melaka and Negeri Sembilan [3], [19].

Continuous monitoring and further research to explain the drivers of those trends—namely, climate change, local environmental conditions, and human activities [10], [12], [15], [23].

**Table 1.** Linear Regression Growth Result for Each States.

Location	Linear Regression Growth (Landing)	Slope
Terengganu	253.58	Landing Growth (slope): 253.58 Eggs Growth (slope): 24514.39
Pahang	6.97	Landing Growth (slope): 6.97 Eggs Growth (slope): 401.17
Johor	-0.52	Landing Growth (slope): -0.52 Eggs Growth (slope): -49.57
Melaka	0.00	Landing Growth (slope): 0.00 Eggs Growth (slope): 0.00
Perak	-4.18	Landing Growth (slope): -4.18 Eggs Growth (slope): -461.58
Pulau Pinang	1.45	Landing Growth (slope): 1.45 Eggs Growth (slope): 142.12
Negeri Sembilan	0.21	Landing Growth (slope): 0.21 Eggs Growth (slope): 18.69

## 4 Conclusion

The above analysis from 1996 to 2022 for sea turtle nesting trends in Peninsular Malaysia depicts a complexity tapestry of challenges and success in conservation. This shows that Terengganu has gone to rise as a significant stronghold of Green Turtle nesting, noting an amazing increase of 379% in activities. It also provides indications of possible northward shift in the nesting areas of the state that is concurrent with the predictions due to climate change. Differing trends within the states, ranging from modest growth in Pahang to alarming decline in Perak, mean that conservation strategies have to be localized and adaptive. With this, the very presence of Hawksbill Turtle nesting in Melaka, even without active Green Turtle nesting, warrants multispecies conservation efforts. The findings taken together stress the need to improve and maintain conservation activities, especially in high-density nesting areas, and advocate greater attention and research in regions that are declining. An urgent need for proactive intervention is required in the protection of both conventional and developing nesting sites, adaptive potential to future changes probably driven by changing climatic conditions, and mitigation of the various threats confronted by sea turtle populations across Peninsular Malaysia. The current study, therefore, contributes not only to the body of knowledge on sea turtle ecology in the region but also provides significant input for better, more effective conservation strategies in the future.

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