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THE EFFECTIVENESS OF COMMUNITY-BASED SEA TURTLE MONITORING SUPPORTS HATCHING SUCCESS ON BANDO ISLAND, PIEH ISLAND MARINE PROTECTED AREA

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ABSTRACT

Bando Island is an important part of Pieh Island Marine Protected Area which is a sea turtle nesting habitat in West Sumatra Province. Sea turtle conservation is carried out collaboratively by community groups driving conservation, island customs, and the people of Padang Pariaman Regency. The community groups and the island owners' customary law conduct sea turtle conservation on Bando Island. The purpose of this study was to identify community involvement in sea turtle monitoring activities and analyze the hatching success as an indicator of the effectiveness of community-based sea turtle monitoring on Bando Island. Field surveys were conducted from January 2020 to August 2024. The method used in analyzing research data were quantitative method. The community involvement in sea turtle monitoring consisted of observation, data collection, and reporting. The sea turtle species that landed were green sea turtles (Chelonia mydas) and hawksbill turtles (Eretmochelys imbricata). The number of eggs moved to semi-natural relocated nests is 13.123 and the number of hatchlings released is 10.699 green hatchlings and 1.730 hawksbill hatchlings. The effectiveness of community-based sea turtle monitoring can be seen from the discovery of sea turtle tracks that have the potential to find egg nests, the percentage of egg hatching in semi-natural relocated nests was 91,72% indicating optimal hatching power, and hatching success reaching 90.64% which is included in the high category.

Keywords: *Bando Island; Conservation; Community;Green Sea Turtle; Hatching Success; Hawksbill Turtle; Pieh Island Marine Protected Area; West Sumatera..*

INTRODUCTION

Pieh Island Marine Protected Area is a national marine protected area recognized as one of the most significant sea turtle nesting habitats in West Sumatra Province. Pieh Island Marine Protected Area consists of five small islands and surrounding marine waters, namely Air Island, Bando Island, Pandan Island, Pieh Island, and Toran Island, as well as several sandbanks. The total area covered by marine protected area is 39,920 hectares (Wouthuyzen et al., 2019).

One of the marine species that has been conserved in this area is the sea turtle. Sea turtles have constituted an integral component of Indonesia's marine ecosystem for centuries (Heithaus et al., 2014; Karraker et al., 2020). Indeed, six out of the seven species of sea turtle can be found in Indonesian waters. The olive ridley sea turtle *(Lepidochelys olivacea)*, the green sea turtle *(Chelonia mydas)*, the flatback sea turtle *(Natator depressus)*, the hawksbill turtle *(Eretmochelys imbricata)*, the leatherback sea turtle *(Dermochelys coriacea)*, and the loggerhead sea turtle *(Caretta caretta)* (Budiantoro, Retnaningdyah, Hakim, & Leksono, 2019; Pratama & Romadhon, 2020). The conservation of sea turtles is undertaken due to the elevated risk of extinction they face as a result of both natural and anthropogenic factors. The natural factors that contribute to the decline of sea turtles include coastal erosion, climate change, and predator threats. In addition to these natural threats, human-related threats such as coastal and marine pollution, accidental capture in fishing gear (by-catch), and exploitation of sea turtle parts also pose a significant risk to the survival of these species (Prima, Widhayanti, & Nugraha, 2024). The illicit consumption of sea turtles represents a significant and ongoing threat to their survival, increasing the risk of extinction (Hancock et al., 2017). This includes in West Sumatra. Notwithstanding the existence of regulations that prohibit the hunting and consumption of sea turtles, there are still instances of individuals engaged in the sale of sea turtle eggs. This practice is driven by traditional beliefs regarding the vitality-enhancing properties of sea turtle meat and eggs. This factor has resulted in a notable reduction in sea turtle populations (Schneider, Ferrara, Vogt, & Burger, 2011). The increasing extinction rate of sea turtles is a matter of growing concern, as experts have indicated that the survival rate for hatchlings reaching adulthood in the wild is only approximately one in 1,000 to one in 10,000 (US Department of Commerce, 2015).

In light of the aforementioned evidence, it is imperative that effective sea turtle conservation measures are implemented to guarantee the turtles' long-term survival. Community-based initiatives for the conservation of sea turtles have been developed in several regions across Indonesia. One efficacious strategy that engages the local community is the monitoring of sea turtles on Bando Island. This is conducted by enumerators from neighbouring communities, local community

groups, and the customary owners of the island. The objective of this study is to identify the level of community involvement in sea turtle monitoring activities and to analyse the hatching rates of sea turtle eggs as an indicator of the effectiveness of community-based sea turtle monitoring on Bando Island in Pieh Island Marine Protected Area.

RESEARCH METHODS

Time and Location of the Research

The research was conducted at the sea turtle nesting site on Bando Island, which is one of five small islands within Pieh Island Marine Protected Area. The data were collected over a period of five years, from January 2020 to August 2024. Please refer to Figure 1 for a visual representation of the research location.

Bando Island is a diminutive, uninhabited island that serves as a nesting habitat for sea turtles. Bando Island, which covers an area of 5.70 hectares, falls within the administrative region of the city of Padang. Sea turtle monitoring on Bando Island has been conducted by LKKPN Pekanbaru since 2020. Monitoring is conducted by circumnavigating Bando Island in a clockwise or anticlockwise direction, depending on the prevailing wind conditions at the time of monitoring (LKKPN Pekanbaru, 2004).

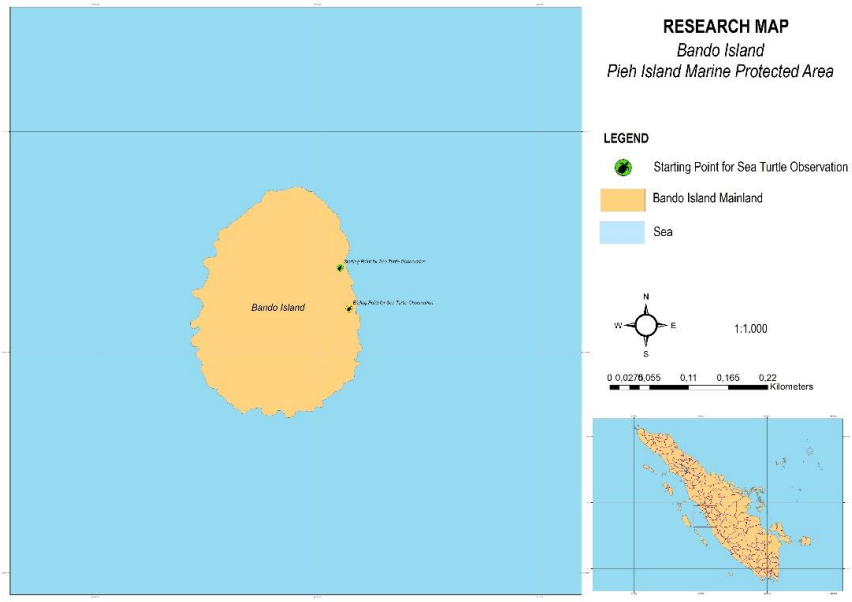

Figure 1. Research Location Map

Data Collection

The data collection methods employed in this study comprise field surveys and a literature review. Field surveys were conducted for the purpose of obtaining data pertaining to sea turtle monitoring, including data on sea turtle landings, tracks, nests, species, eggs, and egg hatching. The objective of the literature review was to gain insight into the role of community members who serve as enumerators in carrying out sea turtle monitoring activities on Bando Island.

Sea turtle monitoring was conducted on a daily basis, with observations made between the hours of 8:00 PM and 6:00 AM WIB (Western Indonesia Time). This involved circling the island in order to identify any sea turtles that may have been nesting. This time frame was selected based on the observation that the majority of sea turtle species exhibit a preference for nesting in low-light and quiet conditions during the night (Pendoley & Kamrowski, 2016). Furthermore, the hatchlings were released into the sea with minimal delay following hatching, a strategy designed to maintain their swimming abilities and enhance their survival prospects against predators. The release times were conducted during the period of dim sunlight, with a reddish light bias, between 5:00 and 5:30 AM WIB and 6:00 and 7:00 PM WIB.

Data Analysis

The research data is analysed using the quantitative method. This method is systematic, planned, and clearly structured from the outset, including the design of the research. The quantitative method is applied in studies that involve the extensive use of numbers, from data collection and data interpretation to the presentation of results in the form of images, tables, graphs, or other visual formats (Sugiyono, 2013).

The results of the sea turtle monitoring programme, presented in tabular and graphical form in this study, include data on the number of egg-laying and non-egg-laying sea turtle landings, the types of nesting turtles, the types of nests, the number of each sea turtle species, the total number of eggs, the percentage of eggs that hatched, the number of hatchlings released into the sea, and the hatching success rate. Hatching success is an indicator used to assess the efficacy of sea turtle conservation efforts in semi-natural relocated nests within the Pieh Island Marine Protected Area and adjacent marine ecosystems.

According to Dermawan et al. (2009), hatching success (HS) is the ratio of live hatchlings to the number of eggs in a nest. The calculation for hatching success (HS) uses the following formula:

$$HS = \frac{number\ of\ live\ hatchlings}{number\ of\ eggs\ in\ the\ nest} x\ 100\% \quad \text{..... (1)}$$

HS = hatching success rate of sea turtle eggs.

The categories used to define the hatching success rate of sea turtle eggs in semi-natural relocation nests within the Pieh Island Marine Protected Area and surrounding waters follow the percentage range of Fauziyyah, Masy'ud, & Farida (2015), as presented in Table 1.

Table 1. Criteria *Hatching Success*

Precentage (%)	Category
0-30	Low
31-60	Middle
61-100	High

RESULT AND DISCUSSION

Community Involvement in Sea Turtle Monitoring

The community engaged in sea turtle monitoring activities as enumerator officers on Bando Island comprises four individuals. The enumerators are members of the indigenous island community, as well as individuals from the coastal communities of Padang Pariaman Regency who have received training in sea turtle observation and data collection, egg handling, and the proper procedures for sea turtle release. They are also members of a community group fostered by LKKPN Pekanbaru. The monitoring schedule is arranged on a monthly basis, with each individual contributing 15 days of observation over the course of a month.

The involvement of community members as enumerator officers in turtle monitoring activities on Bando Island, within the Pieh Island Marine Protected Area, adheres to the established procedures and standard operating procedures for sea turtle monitoring. These procedures encompass observation, data collection, and the reporting of survey results. The requisite tools and materials for the monitoring of sea turtles include gloves, a monitoring form, a pencil, a flashlight, a roll meter, a bucher, a cellphone, a data board, a marker, and boundary wire.

The established sea turtle monitoring data recording on Bando Island is as follows:

1. Environmental Condition Monitoring
   Monitoring of the surrounding environmental conditions is conducted through observation of landing sites and physical and ecological conditions. This includes recording the date and time of sea turtle/nest discoveries, vegetation around the nest, landing direction, and measuring the distance from the tidal line.
2. Sea Turtle Landing Identification
   This involves identifying sea turtles that come ashore to lay eggs or otherwise, covering the sea turtle species, morphology, tracks, presence of false nests, as well as the condition and depth of the nest.
3. Relocation of Sea Turtle Eggs
   Sea turtle eggs will be left to hatch in their natural nest if the location is safe from tidal threats, human disturbances, or predators. However, if the natural nest is deemed unsafe for hatching, the eggs will be relocated to semi-natural relocated nests situated 15–18 meters from the highest tide line.
4. Recording of Sea Turtle Nests and Eggs
   Data is recorded regarding the number of eggs in a nest, whether it is a natural or semi-natural relocated nest. Nest coding is also performed to facilitate tracking of the number of eggs and hatchlings originating from the same nest.
5. Recording of Sea Turtle Egg Hatching
   Sea turtle egg hatching data includes the number of unhatched eggs, live hatchlings, and deceased hatchlings. Live hatchlings are released into the sea as soon as possible, while unhatched eggs and deceased hatchlings are buried.
6. Reporting of Sea Turtle Monitoring Survey Results
   The results of sea turtle monitoring surveys, including data on the sea turtle monitoring forms and hatching forms, are reported by enumerators to LKKPN Pekanbaru.

The involvement of local communities in sea turtle monitoring activities in Pieh Island Marine Protected Area has resulted in a number of beneficial outcomes. These include the control or even elimination of anthropogenic threats, an increased awareness of sea turtle conservation among the local population, a better understanding of the importance of sea turtles, knowledge of the techniques required for their preservation, the creation of new sources of income, and the promotion of sea turtle observation tourism in the marine protected area.

Sea Turtle Landings

Data collection on sea turtle landings during sea turtle monitoring on Bando Island, within Pieh Island Marine Protected Area, is conducted whenever a sea turtle is observed coming ashore or laying eggs. Sea turtle nesting landings are also recorded based on the number of nest discoveries, even if the enumerator does not encounter the sea turtle directly.

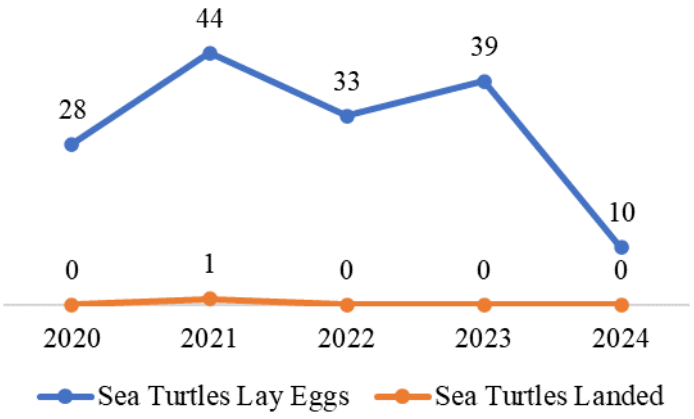

Figure 2. Sea Turtle Landing at The Research Location

Figure 2 presents data on sea turtles landing to lay eggs and those landing without laying eggs, based on the findings of the sea turtle monitoring programme conducted from January 2020 to August 2024. The number of egg-laying landings is consistently higher than that of non-egg-laying landings on an annual basis. The greatest number of egg-laying landings was observed in 2021, with a total of 44 occurrences, whereas non-egg-laying landings were only recorded on a single occasion in the same year. The number of egg-laying landings has been observed to increase on a biennial basis in comparison to the preceding year. This phenomenon is associated with the sea turtle nesting cycle, which occurs in a

biennial pattern. Zainudin (2023) posited that female sea turtles lay eggs in cycles of 2–4 years and will lay eggs 4–7 times during a single nesting period.

Sea Turtle Tracks

The measurement of tracks for each type of nesting sea turtle is conducted from the moment it emerges from the water to the intertidal zone until it finds a suitable location to dig. The track measurement is carried out after the sea turtle returns to the sea. The tracks measured in this sea turtle monitoring include the outer and inner tracks formed by the front and rear flipper marks of the sea turtles.

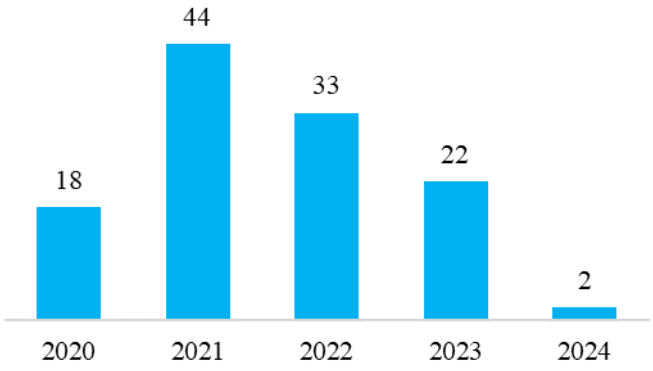

Figure 3. Number of Sea Turtle Tracks at the Research Location

Sea turtle tracks can be used to identify the species of adult sea turtles nesting at the study site. The outer tracks found in the Pieh Island Marine Protected Area range from 61 to 114 cm, while the inner tracks range from 21 to 79 cm. Differences in track width indicate variations in species, size, morphological shape, and age of the nesting sea turtles. According to Kuswadi et al. (2010), the track width of green sea turtles (*Chelonia mydas*) is approximately 100 cm, while that of hawksbill turtles (*Eretmochelys imbricata*) ranges from 75 to 80 cm.

Sea turtle tracks are not always detectable because they can be erased by tidal movements, but they help in locating sea turtle egg nests. The highest number of sea turtle tracks recorded was in 2021, with 44 tracks, whereas the lowest was in 2024, with only 2 tracks. This corresponds to the number of sea turtle landings in those years, as sea turtle landings can be identified through the presence of nesting sea turtles, tracks, and egg nests. Direct beach surveys involving local communities have demonstrated the effectiveness of community-based sea turtle conservation, as tracking sea turtle footprints facilitates the discovery of egg nests (Bahri et al., 2022).

Type of Sea Turtle Laying Eggs

The sea turtles nesting on Bando Island, part of Pieh Island Marine Protected Area, are visually identified based on specific characteristics such as external morphology, distinctive marks on the carapace, tracks and nest sizes, nesting habits, and preferred nesting habitats. The nesting season for each sea turtle species may also vary, as shown in Table 2.

Table 2. Type of Sea Turtle Laying Eggs

	Chelonia mydas	*Eretmochelys imbricata*
January	4	3
February	10	7
March	8	7
April	6	3
May	6	1
June	21	0
July	8	0
August	5	0
September	20	0
October	23	1
November	14	2
December	5	0

The sea turtles nesting on Bando Island, within Pieh Island Marine Protected Area, belong to two species: green sea turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*). Green sea turtles account for the highest cumulative nesting landings from January 2020 to August 2024, with a total of 130 occurrences, whereas hawksbill turtles were recorded 24 times. This aligns with the statement by Razak, Fajrina, Ilhami, & Wahyuni (2024), which noted that the sea turtle species found in West Sumatra include green sea turtles (*Chelonia mydas*), hawksbill turtles (*Eretmochelys imbricata*), leatherback sea turtles (*Dermochelys coriacea*), and olive ridley sea turtles (*Lepidochelys olivacea*).

The nesting season for green sea turtles (*Chelonia mydas*) occurs year-round on Bando Island, with higher landing numbers in June, September, and a peak in October, totaling 23 landings. This is consistent with Ilham, Ernaningsih, & Patanda (2023) research, which found that the peak nesting season for sea turtles occurs between July and October. On the other hand, the nesting season for hawksbill turtles (*Eretmochelys imbricata*) varies depending on the region. Research indicates that hawksbill turtles nesting on Bando Island is most frequently observed between January and April, with a peak in March.

Sea Turtle Egg Nests

An natural nest is the original nest dug by the mother sea turtle when laying eggs. Natural nests are mostly found around coastal vegetation, such as coconut, ketapang, hibiscus, or sea pandan. This coastal vegetation is present on both islands that serve as research stations. The canopy cover and shade of the vegetation affect the humidity of the nesting site, as the sun's radiation does not directly reach the nest (Winarto & Azahra, 2022). Meanwhile, a semi-natural relocation nest is a nest intentionally created to resemble the natural nest, used for placing eggs that have been moved from a natural nest.

The sea turtle nests found at the research site were mostly moved to semi-natural relocation nests, accounting for 96.10%, while hatching success in natural nests was only

3.90%. The relocation of sea turtle nests to semi-natural nests was carried out as an effort to reduce hatching failure caused by various environmental threats, while also increasing the success of sea turtle egg hatching. The environmental conditions of the natural nests are the best for sea turtle egg hatching, but due to the difficulty in monitoring and the threat of predators, relocation or translocation of sea turtle eggs to semi-natural nests is necessary as a conservation effort (Dermawan et al., 2009).

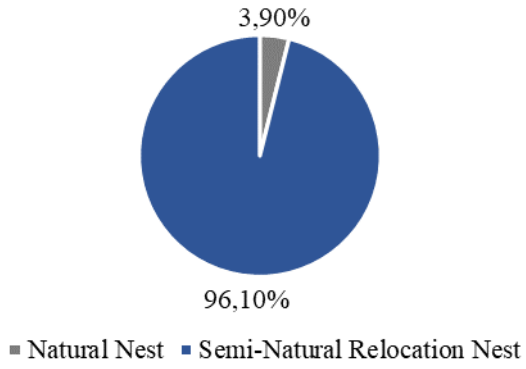

Figure 4. Types of Sea Turtle Egg Nests at Research Location

Sea Turtle Egg Hatching Percentage

Calculation of the number of eggs in a semi-natural relocation nest is carried out during the egg transfer process. To date, the total number of eggs that have been transferred to semi-natural relocation nest is 13.123, while the total number of eggs hacthed in natural nest is 590 on Bando Island, Pieh Marine Protected Area.

Table 3. Number of Eggs and Percentage of Egg Hatching

	Natural nest	Semi-Natural Relocation Nest
Total Eggs (eggs)	590	13.123
Number of Hatched Eggs	554	12.036
Hatching Percentage (%)	93,90	91,72

The hatching success rate of sea turtle eggs is used as an indicator of the effectiveness of semi-natural relocation nests in the hatching process. The results show that the semi-natural relocation nests had a hatching success rate of 91.72%, indicating that hatching was optimal. This aligns with the statement by Rahayu, Suryanti, Ayuningrum, and Lundin (2023), who noted that hatching in semi-natural relocation nests achieves optimal hatching success when the success rate exceeds 80%. This also suggests that the relocation technique and the semi-natural nests created by the sea turtle monitoring team on Bando Island are effective, as the hatching success rate is close to that of natural nests, which is above 90%, making it suitable for sustainable implementation. The success of hatching rates is also influenced by the choice of nesting site, which must have environmental characteristics similar to natural nests. According to Kasmeri, Maharani, & Wulandari (2022), temperature, humidity, and sand pH play a significant role in sea turtle egg hatching.

Hatchling Release

The hatchlings released into the sea are live hatchlings that originate from both natural nests and semi-natural relocation nests. The release technique is conducted under low-light conditions to guide the hatchlings to the sea, helping them avoid predators and increasing their chances of surviving to adulthood.

Hatchlings are released immediately after hatching to prevent exhaustion, dehydration, loss of strength, potential injury, or death from predators. The hatchlings must also be released together to improve their chances of survival. However, hatchlings that emerge earlier should not be kept for too long, as this can lead to a loss of strength. If hatchlings emerge during the day, they should not be kept in water, as they will deplete their energy reserves needed to survive (Phillott & Shanker, 2018).

The local community has successfully facilitated the hatching and release of sea turtle hatchlings into the waters of Bando Island, which forms part of Pieh Island Marine Protected Area. The released hatchlings comprise 10,699 green sea turtles and 1,730 hawksbill turtles. The data are presented in Table 4.

Table 4. The Total Number of Sea Turtles Released

Year	*Chelonia mydas*	*Eretmochelys imbricata*
2020	2.398	308
2021	2.963	1.118
2022	2.673	78
2023	2.226	0
2024	439	226
Total	10.699	1.730

The release of green sea turtle hatchlings (*Chelonia mydas*) reached its peak in 2021 with 2,963 individuals, while hawksbill turtle hatchlings (*Eretmochelys imbricata*) numbered 1,118. The release of green sea turtle hatchlings (*Chelonia mydas*) was at its lowest in 2024, and no hawksbill turtle hatchlings (*Eretmochelys imbricata*) were recorded as being released in 2023. Table 4 also shows a significant decline in the number of green sea turtle hatchlings released since 2021, from 2,963 to only 439 by August 2024. This decline is influenced by the decreasing number of sea turtle landings for nesting on Bando Island, within Pieh Island Marine Protected. Natural factors suspected to contribute to the decline in nesting sea turtle landings include coastal erosion and rising sea levels. Erosion damages vegetation, leading to habitat degradation for sea turtles. Additionally, erosion impacts the width of beaches and the condition of the sand, whereas sea turtles prefer wide, sandy beaches as nesting sites.

This is supported by Setiawan et al. (2018), who stated that beaches affected by erosion, debris, waves, and sea winds become polluted, making it difficult for sea turtles to land. Moreover, fishing activities near the coast, particularly in areas used as centers for capture fisheries, pose a significant threat to sea turtle landings.

Hatching Success

The hatching success rate of sea turtle eggs is used as an indicator of the success of sea turtle conservation activities, which involve relocating eggs to semi-natural nests to prevent hatching failure and increase the number of surviving hatchlings released into the waters of Bando Island, within Pieh Island Marine Protected Area, as presented in Table 5.

Table 5. *Hatching Success*

Total Eggs	Hatchlings alive	Hatching Success
13.713	12.429	90,64%

Monitoring results of sea turtles on Bando Island, within Pieh Island Marine Protected Area, show a hatching success rate of 90.64%. This percentage falls into the high category. The hatching success rate can also serve as an indicator of the effectiveness of community-based sea turtle monitoring, where community involvement in monitoring has proven highly effective in rescuing sea turtle eggs to semi-natural relocation nests, enabling them to develop into hatchlings that can be released into the sea.

Hatching success is measured by the number of live hatchlings as the success parameter, as not all eggs that hatch into hatchlings survive to emerge from the nest. Some hatchlings, even after successfully hatching, may die inside the nest due to difficulties in emerging. Additionally, hatchlings require significant energy to reach the surface, which may result in suffocation before they can emerge. Sheavtiyan et al. (2014) stated that hatchling mortality can occur due to several factors, including being left behind due to late hatching, being crushed by unhatched eggs, and a lack of oxygen.

CONCLUSION

Community involvement in the sea turtle monitoring activities on Bando Island encompasses a range of activities, including environmental condition monitoring, identification of sea turtle landings, egg relocation, recording of sea turtle nests and eggs, recording of sea turtle egg hatchings, and reporting of sea turtle monitoring survey results. The efficacy of community-based sea turtle monitoring can be gauged by observing the tracking of sea turtle tracks, which plays a pivotal role in locating sea turtle nests. The hatching rate of 91.72% in semi-natural relocation nests indicates optimal hatchability, while the hatching success rate of 90.64% is categorised as high.

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