PULIHARA

2024 ANNUAL REPORT

Lang Tengah Island

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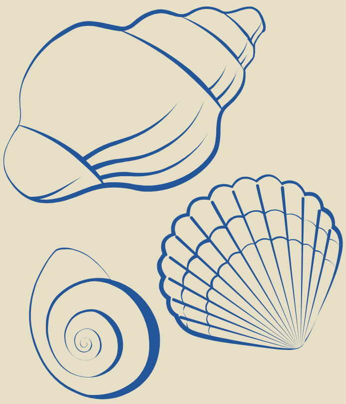
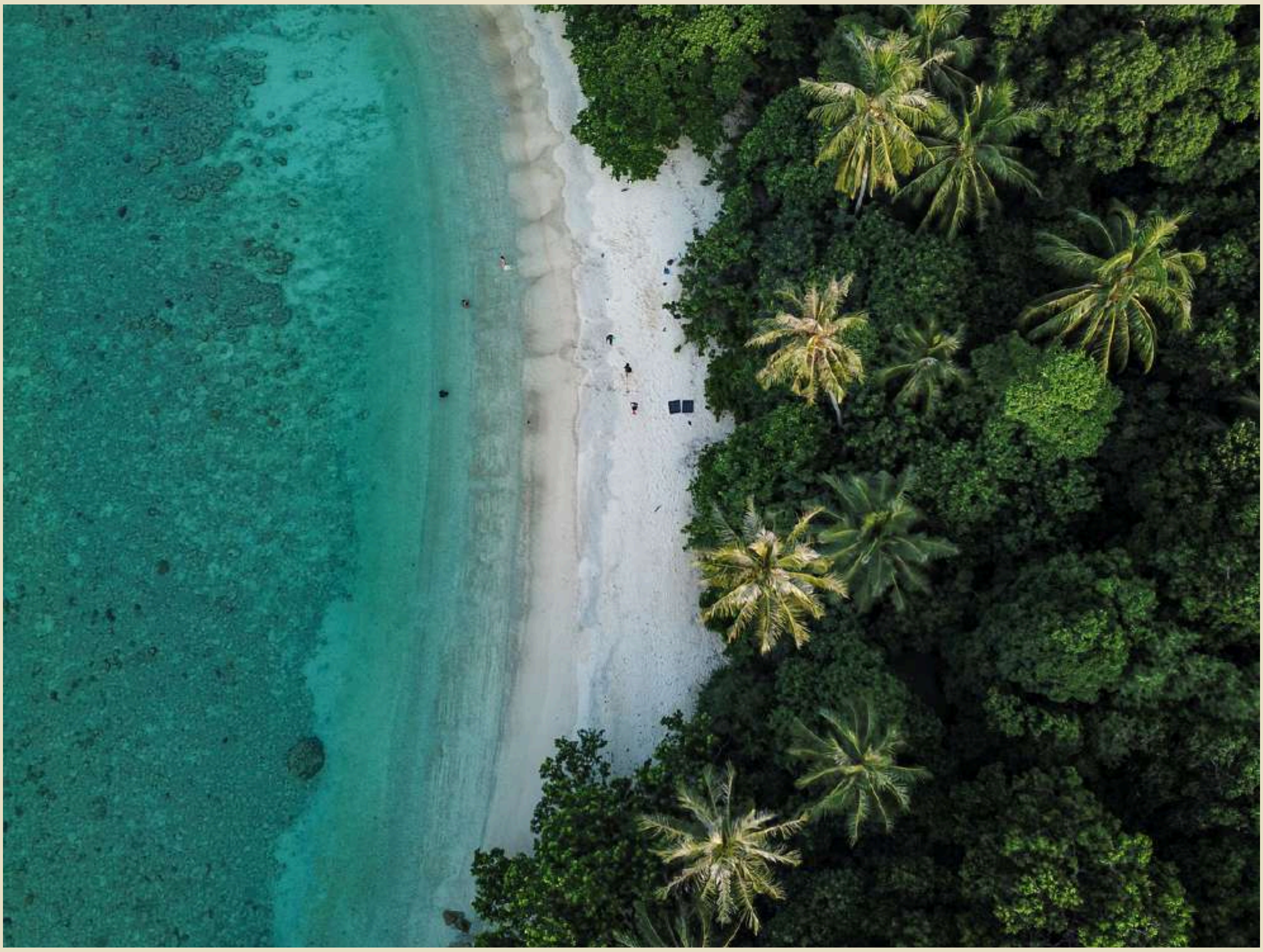




INTRODUCTION

Lang Tengah Island, a popular tourist destination, lies between 5°47'45" north and 102°53'45" east, approximately 20 km off the coast of Terengganu in Peninsular Malaysia. The island has a total area of 125 acres, covering 7.6km of shoreline surrounded by clear waters. It has been gazetted as a marine park.

The island represents an important nesting and foraging ground for two endangered sea turtle species - green turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*). Since its inception in

2013 as Lang Tengah Turtle Watch (LTTW), Marine Conservation and Research Organisation (PULIHARA) has been conducting sea turtle monitoring in collaboration with the Department of Fisheries (DoF), to protect the sea turtle populations and their habitats around Lang Tengah Island. Prior to that, Lang Tengah was listed as a tendered beach where the highest bidder would get the license to collect sea turtle eggs and sell them for consumption. Now that the island is no longer listed for tender, PULIHARA has sole permission to collect sea turtle eggs for conservation and research.

Over the years, we have expanded our work to also monitor the island's coral reefs and other marine life. We have been appointed Reef Caretaker for the Reef Care Programme under the DoF's Marine Park and Resource Management Division. In addition to this, we raise public awareness through various educational outreach programmes.

This year, we continued our mission of protecting sea turtles and the marine ecosystem on Lang Tengah Island. The research station reopened in early-March with one new staff member, Elaine Goh Yi Yin as a second Assistant Manager of the project site. This year, we continue our long-term internship programme and short-term volunteering programme to ensure we are able to carry out our conservation efforts without a hitch.

Continuing from previous years, we patrolled the beaches of Lang Tengah every night from March to October for nesting turtles, safeguarded nests on Turtle Bay, and conducted post-emergence nest inspections. This year, we also continued our collaboration with Reef Check Malaysia to conduct annual reef surveys around Lang Tengah Island. This has allowed us to share the information of the biodiversity and the condition of the reefs of the island.

In addition to organised school trips to the island for local students to gain knowledge and hands-on experience in conservation, we also received visitors at the camp site, in which we gave them informal talks about turtles and corals, and showed them how nest inspections are done.

Despite this change, we are glad to have completed another year pursuing our missions of saving sea turtles, protecting marine ecosystems, and promoting conservation on Lang Tengah Island.

OBJECTIVES

To conduct long term monitoring to better understand and conserve the nesting and in-water sea turtle populations including their habitats in Lang Tengah Island.

To conduct ongoing coral monitoring and restoration to mitigate coral population decline and preserve diversity.

To educate and raise awareness among local communities, tourism operators and tourists through educational outreach programmes as well as engagements in research and conservation efforts.

SEA TURTLE MONITORING

The primary activity on Lang Tengah Island is sea turtle monitoring. Night patrols were carried out to observe the female sea turtle nesting activity at two different beaches, which are Turtle Bay and Lang Sari (Figure 1). Night patrols were done every hour to verify that no nesting females were overlooked. Therefore every night, two persons were assigned to patrol at Lang Sari and one person at Turtle Bay from 8pm to 1am during the first shift and 2am to 6am during the second shift, respectively.

Figure 1. The map of sea turtle nesting beaches and PULIHARA research station on Lang Tengah Island.

Besides that, the team received multiple reports of sea turtle nesting and landings at Summer Bay from nearby resorts and tourists in the previous years. That being the case, the beach was monitored when nesting was predicted. In addition, sea turtle nests that were laid at Lang Sari and Summer Bay were carefully retrieved and relocated at Turtle Bay by the team to prevent sea turtle egg poaching and to monitor the nest more closely. On the other hand, they left the nest that was laid at Turtle Bay incubating as in-situ.

During the night patrol, the team always carried a turtle bag along, which contained equipment such as coral string, measuring tape, buckets, datasheets, transect tape, gloves, egg counter and a pencil. These equipment are used to retrieve and relocate eggs and to record the biometric data of the nesting mother. Once they encountered a nesting mother on a beach, her nesting data is immediately recorded on the datasheet. When the nesting mother starts to lay eggs, they will approach the nesting from behind, retrieve the eggs carefully, and place them in a bucket, as well as relocate the nest at Turtle Bay if the eggs were laid at Lang Sari.

Figure 2. Recording the biometric data and photograph of the nesting turtle (left), and the facial photograph of a nesting mother (right).

Once the nesting mother was done laying eggs, they recorded the biometric data on the datasheet and took facial photographs (Figure 2). This process was done using a headlamp with a red light without flashing directly in its eyes. This is because red lights emit a very narrow portion of the visible light spectrum, which is less intrusive to nesting sea turtles and hatchlings. Besides identifying a nesting mother using a tagging method, the team used a photo-ID method by taking facial photographs of the nesting mother, where a visual comparison was made manually by differentiating its facial scale patterns (Figure 2) (Llyod et al., 2012; Long & Azmi, 2017; Schofield et al., 2008; Su et al., 2015).

The incubation period for the sea turtle eggs takes about 60 days. After 60 days, the sea turtle hatchlings start to hatch and emerge from their nest. After 3 days of their emergence, the team conducted the post-emergence inspection (PEI) by excavating the nest, only if they encountered any hatchling emergence from the particular nest. If they did not encounter or missed the hatchling emergence from a particular nest, the PEI will be conducted after 70 days of incubation period. Furthermore, the team observed, counted, and recorded the number of empty egg shells, unhatched eggs,

Figure 3. The team conducting post emergence inspection (PEI).

depredated eggs, live hatchlings, and dead hatchlings on the datasheet and transferred the data to Excel to determine the hatching and emergence success of sea turtle hatchlings (Figure 3).

During the PEI, they also observed and recorded the signs of egg depredation by fungal infection, ants, monitor lizards, maggots, crabs, and termites according to a severity index of Stage 1 to 4. In addition, the nest temperature was also detected by deploying HOBO MX TidbiT 400 temperature loggers into a random nest when the nesting mother laid eggs or during relocating the eggs. During deployment, the data loggers are placed in the middle of the clutch. With in-situ nests, this is done when around 50 eggs have been laid, while for relocated (ex-situ) nests, the logger will be placed when half the eggs have been deposited. Temperature loggers are placed in the middle of the clutch to obtain the closest possible average temperature of the clutch in the nest. The data were retrieved from the temperature logger after the PEI and analysed to observe the sex ratio data of the hatchlings from the particular nest.

Apart from monitoring the landings and nesting of sea turtles on Lang Tengah Island, the team also conducted an in-water survey of the sea turtle population. This survey was done by snorkelling and diving using an underwater camera (Olympus TG6). During this survey, they used to take pictures and videos of turtles that were sighted using the underwater camera without disturbing them by keeping some distance from them. Moreover, data such as species of turtle, sex, age, behaviour, and depth of the turtles was collected on this in-water survey method.

Hawksbill Turtles

This season, there were no landings or nesting activities of hawksbills recorded on Lang Tengah Island. This unfortunate event has not happened since 2021. According to Figure 4, there is a fluctuation of ups and downs for the hawksbill turtle nesting activity from 2013 to 2024 at Lang Tengah Island. As a critically endangered species, the hawksbill turtle has a low density of nesting in Terengganu (Chan & Liew, 1999).

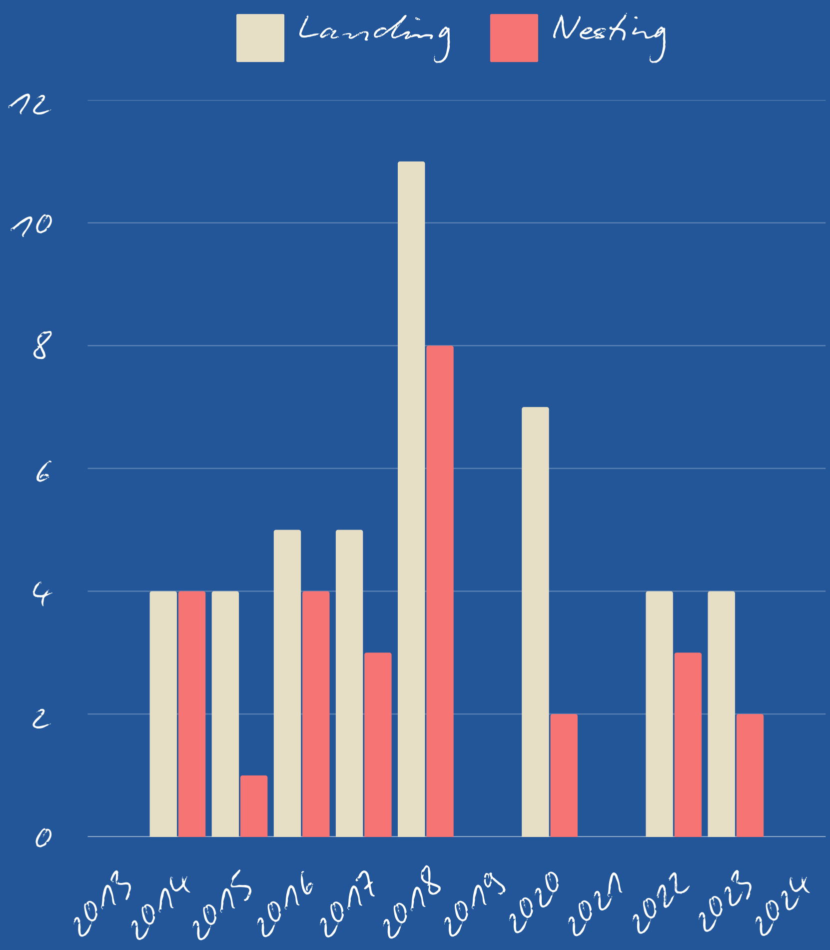


Figure 4. Number of hawksbill turtle landings and nesting at Lang Tengah Island (2013-2024).

However, we did record multiple sightings of hawksbill turtles from in-water surveys, especially around the Tanjung Telunjuk area which is near Turtle Bay. Four juvenile hawksbills were identified

Figure 5. Newly identified juvenile hawksbills; LTH0025U-Aslan Callenreese (prev. page), and LTH0024U-Namia (top left).

and given photo-IDs LTH0022U (Kaily), LTH0023U (Namia), LTH0024U (Boomci Kaci) and LTH0025U (Aslan Callenreese). There were no repeated sightings of pre-existing hawksbill turtles in our database.

From these four individuals, most of their ID pictures were captured only on one side, but neither of the photos matched any known individual in the database. As such, our current identification of these new individuals cannot be fully confirmed unless resighted and a photo is taken from the other side.

In the case of one of the hawksbill turtles, LTH0022U (Kaily) (Figure 6), it was sighted with a fishing hook stuck in its mouth/throat by members of another marine conservation on the island, Coralku, in front of Summer Bay Resort. LTH0022U is a

Figure 6. Image of LTH0022U-Kaily, the resident juvenile hawksill at Summer Bay. Facial ID images were taken when she was rescued to remove the hook from her throat.

resident hawksbill at the reefs there. With assistance from the members of Coralku, the hawksbill was removed from the water in order to remove the hook from its mouth. The hook was partially removed and the remainder was swallowed by the hawksbill turtle.



Green Sea Turtles

This year, the nesting activity of green turtles were recorded from May to July (Figure 7). A total number of 14 landings of green turtles were recorded, while 57.14% of them had successfully laid a nest of eggs (Figure 8). From Figure 7, the peak nesting season of green turtles were shown from June to August, May and July recorded three nesting each and June only had two nesting recorded. After the last nest in the second half of July, the nesting activities stopped. With only 8 nests this year, it is recorded to be the lowest number of nesting activities by green sea turtles on Lang Tengah Island since we began operations in 2013.

Figure 7. Number of green turtle nesting activities on Lang Tengah Island throughout the season.

Interestingly, all landing and nesting activities recorded this year were at Turtle Bay beach. In the past decade, Lang Sari beach has been the most productive nesting beach of Lang Tengah Island. All the nests that laid at Lang Sari were relocated to Turtle Bay within six hours to minimize the impact of movement to the hatching success, as (Gárriz et al., 2020; Adams et al., 2022) showed turtle eggs will start development after 12 hours.

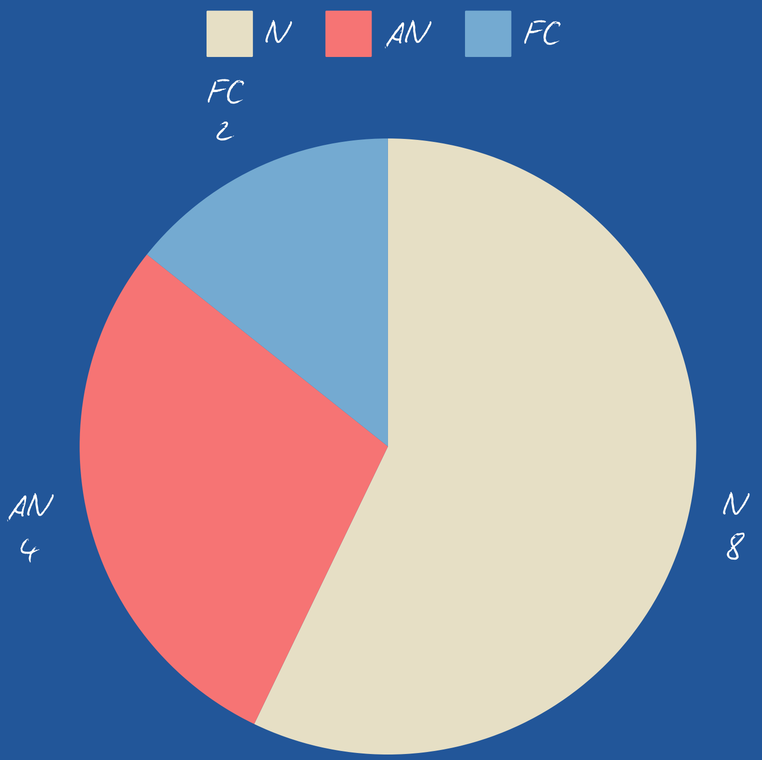


Figure 8. Nesting activity of green sea turtles at Turtle Bay in 2024.

This year, two individual females were identified using photo-ID methods (Table 1; Figure 9). Both individuals were new nesters in Lang Tengah, as there are no records of prior nesting either in the photo-ID database or flipper tag record. One of the two, however, was recorded nesting once in 2015 by Perhentian Turtle Project (PTP) on Perhentian Island, and was photo-ID-ed PG0044F by the organization. This individual also nested only once. Seven remaining nests were laid by the other new identified mother. The inter-nesting interval of the nesting females ranged between 10-12 days. Two nests were missed (Nest 1A and Nest 7) during the nesting so there were no facial photos of this nesting female.

Table 1. Nesting information of two individual female green turtles.

Turtle ID	Turtle name	New / Returning mother	No. of nests	Total eggs laid	Average clutch size (mean + SD)	Nesting site	Inter-nesting interval (days)
LTG0070F	Gwen	New	6	676	113 + 13.2	Turtle Bay	10-12
PG0040F	Maribel	New	1	109	-	Turtle Bay	-

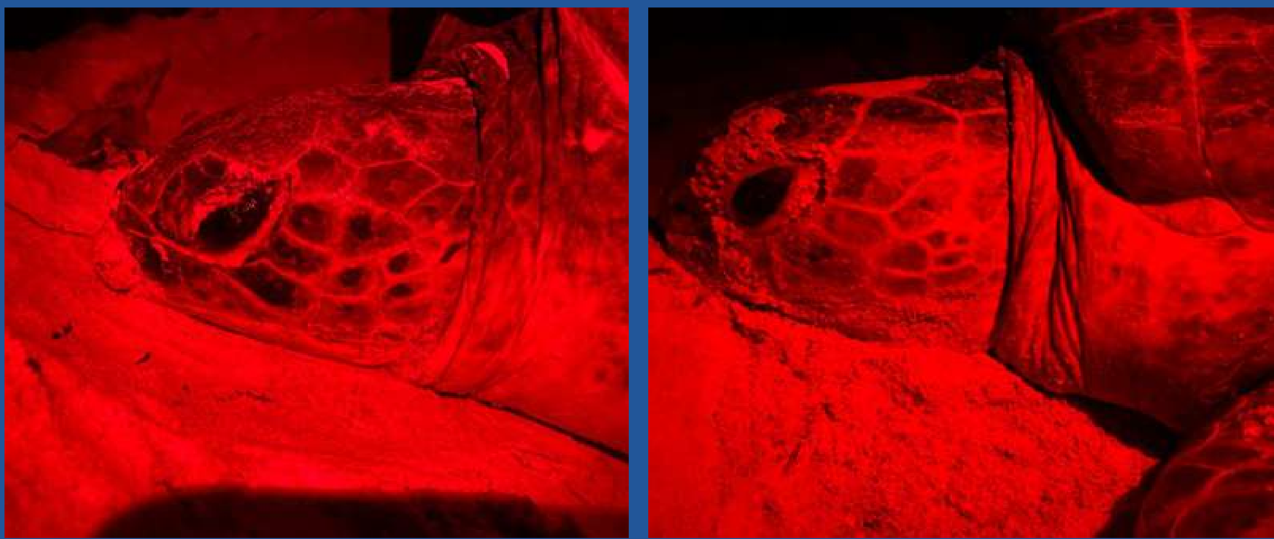


Figure 9. Facial photo of nesting turtles from different landings on 30 May 2024, LTG0070F-Gwen (Left) and PG0040F-Maribel (Right).

A total of 785 eggs of green turtles were laid on Lang Tengah Island in 2024. The clutch size was 112 eggs (SD=12.30). During the nesting process, the number of eggs was counted using an egg counter and recorded in the datasheet. Besides that, two in-situ nests were missed by the team during the night patrol. The nests were encountered only after the nesting mother left the nesting beach. In this case, the number of eggs in these particular nests was counted and recorded during PEI. Therefore, the team could not know the full-size clutch of eggs laid for those nests.

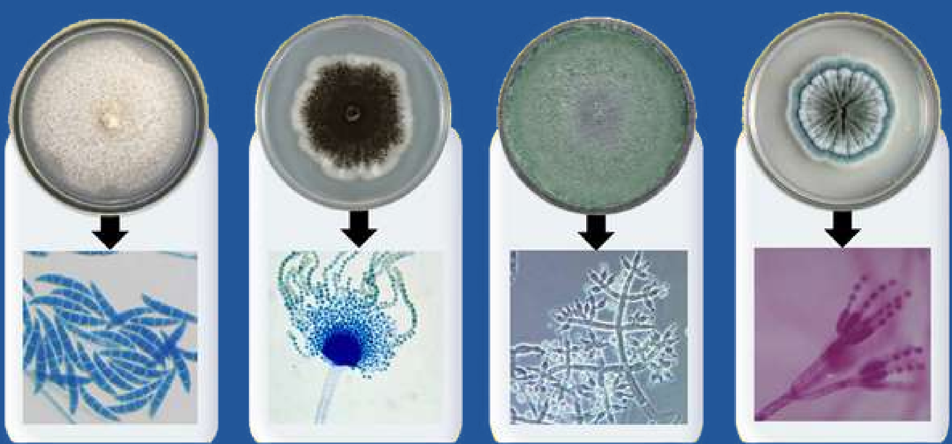
Figure 10. Measuring the curved carapace length of a nesting green sea turtle mother.

In 2024, a total of 8 nests of green turtles were laid, with an average hatching success rate of 77.70% (0-100%) on Lang Tengah Island. One of the nests, Nest 2 (30/5/2024), was initially in-situ but was relocated after slightly more than a month of incubation. This is because the location of the nest was in close proximity to a 'drain' that was formed after a thunderstorm on the island.

As the area might erode more due to rain and to prevent the eggs from the possibility of being exposed, it was relocated on 4/7/2024 to another location on Turtle Bay beach. This nest recorded a hatching success of 77.06%. The last and missed nest, Nest 7, was assumed to be fully predated by monitor lizards as we could not find any egg fragments left in where the supposed nest should be. It was a confirmed nesting activity when the team noticed monitor lizards digging and the smell of eggs.

Moreover, most of the nests at Lang Tengah Island were predated by monitor lizards, crabs, termites, maggots, ants, and fungi. The rate of predation for each nest is shown in Appendix 1. The average predation rates of green turtle were 10.20% (SD=9.30).

Furthermore, fungal infections on the sea turtle eggs were frequently discovered in most of the nests during the PEI. According to Appendix 1, the average fungal infection rate sea turtle nests were 6.58% (SD = 7.58). In previous years, to analyse the fungal infections on sea turtle eggs, LTTW collaborated with Universiti Malaysia Terengganu (UMT). This research was conducted by collecting sand samples from each nest, both before and after incubation, and delivering them to Dr. Dahlia for further analysis in the lab. In the lab, the researchers extract and isolate the fungi that were found in the sand sample in order to identify the type of fungus that was found predating on sea turtle eggs. As a result of the research, *Aspergillus, Fusarium, Penicillium, Trichoderma*, bacteria, and other fungi were found in Lang Tengah Island sand samples (Figure 11).



Fusarium sp. *Aspergillus sp.* *Trichoderma sp.* *Penicillium sp.*

Figure 11. Soil-borne fungi found in sea turtle nests. Source: LAPDiM, FPSM, UMT.

All the microbial species that were discovered in sea turtle nests at Lang Tengah Island were common species that can be found globally in sea turtle nests (Gleason et al., 2020). Fungal infections on sea turtle eggs are known as a new threat to sea turtle eggs, which can affect and reduce hatching success rates (Gleason et al., 2020; Sarmiento-Ramrez et al., 2010, 2014; Mohamed Sidique et al., 2017). Thus, if fungal infection is found to be a severe threat to sea turtle eggs at Lang Tengah Island, it can be prevented with mitigation measures such as treating the sand with natural anti-fungus and anti-bacteria remedies based on ongoing assessments of fungi abundance and variety on the nesting beaches.

Figure 12. Interns conducting post emergence inspection at Lang Tengah Island.

This season, temperature loggers were deployed in four green turtle nests to track respective nest temperature during incubation. Logistical equations were used to estimate hatchling sex ratio in each nest (see Booth & Freeman, 2006; Tolen et al. 2021) with a proposed pivotal temperature of 29.0°C for the Malaysian hawksbill turtle population (Salleh et al., 2018) and 29.1°C for the Malaysian green turtle population (Chan & Liew, 1995; van de Merwe et al., 2005; Reboul et al., 2021). Sea turtle embryos undergo temperature-dependent sex determination (TSD), with warmer incubation temperatures producing higher proportions of female hatchlings and cooler temperatures producing more males (Mrosovsky, 1994). From the temperature data, it was found that the nests had potentially produced mostly male hatchlings (Table 2). Interestingly, the seven in-situ nests had cool temperatures relative to the model's suggested pivotal temperature of 29.1°C. Assuming the pivotal temperature in the model holds true for Lang Tengah, natural nests on Turtle Bay may indeed skew towards producing more male hatchlings.

Table 2. Nest temperature and sex ratio of four green turtle nests in 2024.

Nest	Species	Type of nest	Days of incubation	Shading	Average temperature (+ SD) during Temperature - Sensitive Period (°C)	Percentage of female hatchling (%)
1	Hawksbill	In-situ	58	Yes	29.04 + 0.42	49.67
4	Green	In-situ	-	Yes	28.47 + 0.66	4.37
5	Green	In-situ	-	Yes	29.29 + 0.29	78.29
6	Green	In-situ	-	Yes	29.12 + 0.78	78.29

CORAL RESTORATION

Figure 13. Naturally existing reef photographed at the site of PULIHARA's new artificial reef, Turtle Bay, Lang Tengah Island.

Lang Tengah Island boasts a diverse array of hard coral species, as documented by Harborne et al. (2000). However, there are observable areas of degradation, particularly evident in the presence of large dead tabular and massive colonies amidst smaller rubble formations, indicating a recent decline in reef complexity.

Previously, when we were known and operating as Lang Tengah Turtle Watch, we conducted a pioneering study, providing a comprehensive baseline assessment of the hard coral population surrounding the island. The initiative not only unveiled the extent of reef diversity at a genus level but also highlighted significant dissimilarities within the coral communities. This foundational data shed light on critical issues plaguing the island's reef, including bleaching events, overfishing, predator outbreaks, unsustainable tourism practices, and storm damage (Wilkinson, 2004).

Figure 14. 1/6 of the coral tree structures anchored by previous LTTW staffs at Tanjung Telunjuk, Turtle Bay, Lang Tengah Island.

In conjunction, the ongoing anthropogenic pressures on coral ecosystems underscore the cumulative degradation experienced by major reef systems, often resulting in a loss of biological diversity and cultural complexity over time (Rinkevich, 2019). The aim of this project is to restore locally deteriorated coral reefs while protecting those that remain relatively pristine. While conservation efforts are indispensable, they alone are insufficient to protect coral reefs from decline. Active restoration is crucial in situations where an ecosystem's natural recovery is minimal or where preservation through management interventions is insufficient.

The active restoration methodologies currently used include the application of coral transplantation measures and the use of underwater nurseries (Shafir et al., 2006). Since 2019, we have been actively transplanting and growing coral fragments within mid-water floating nurseries (coral trees) at Tanjung Telunjuk, Turtle Bay (see Figure 15A). These nurseries serve as vital hubs of nurturing corals of opportunity, sourced primarily from Summer Bay Resort. Once these fragments reach suitable size, they are meticulously transplanted onto natural reef substrates at Tanjung Telunjuk (see Figure 15B).

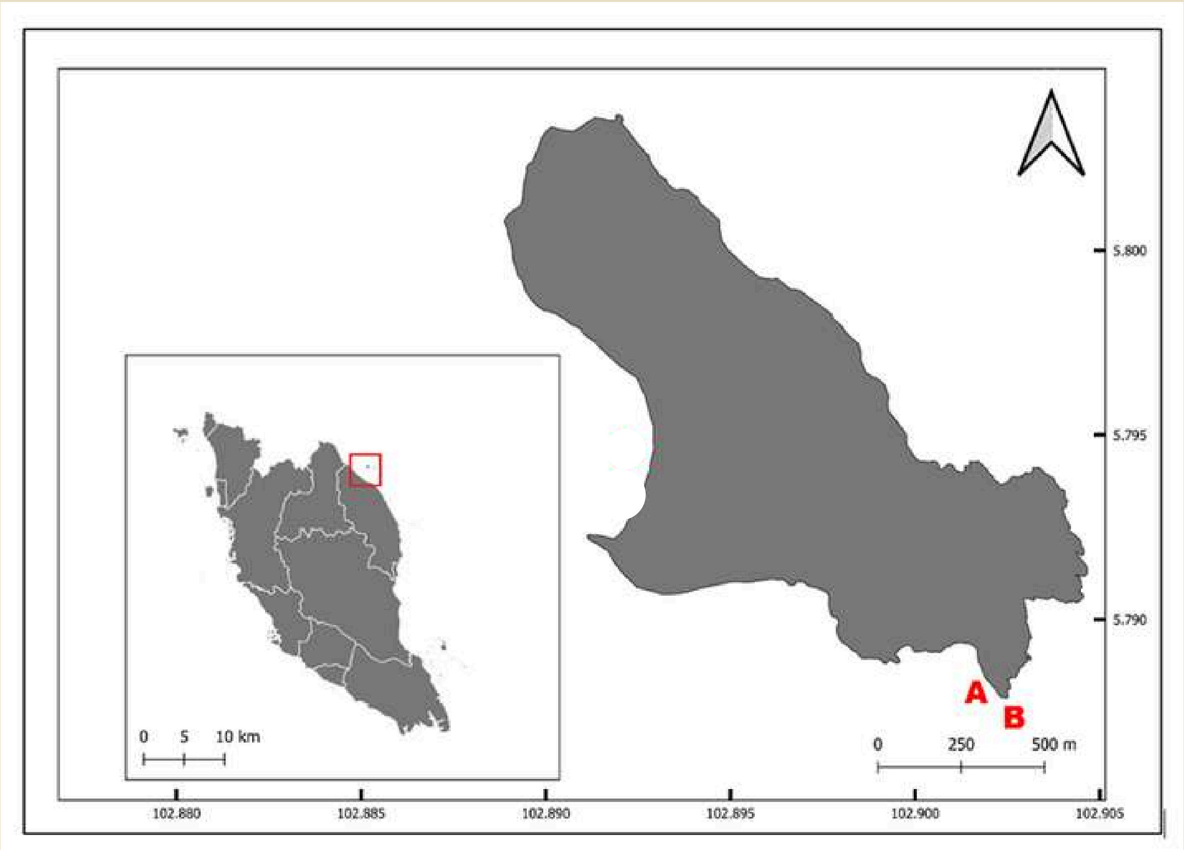
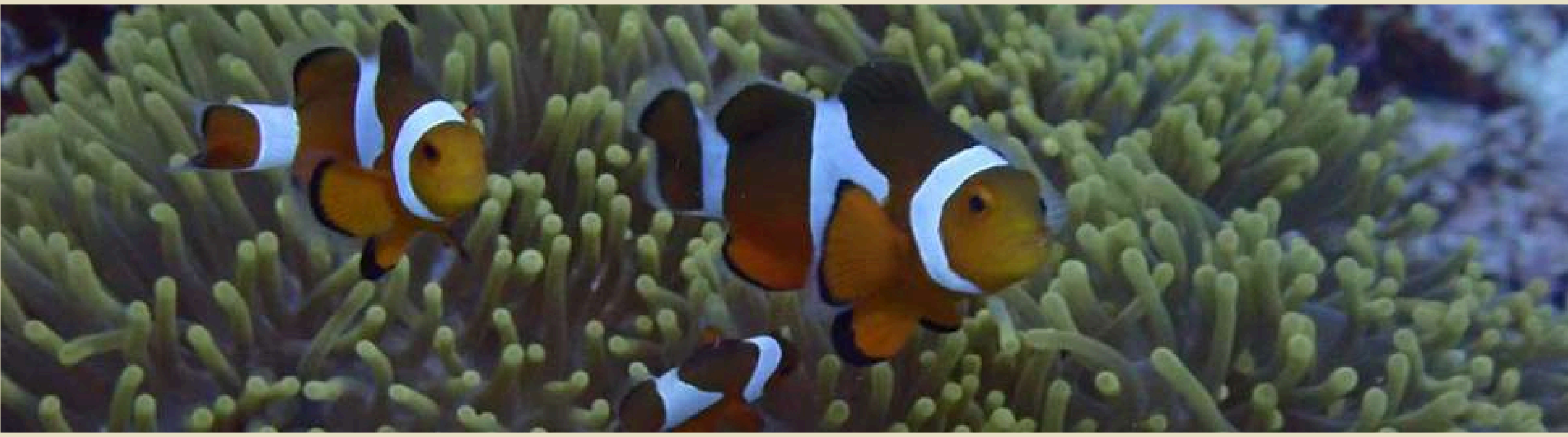


Figure 15. Study area in Pulau Lang Tengah, showing the nurseries and artificial reef at Turtle Bay (A), the outplant site at Tanjung Telunjuk (B).

Besides that, this year we continued our coral restoration by using the artificial reef method, where we deployed eight metal rebars coated with cement in front of Turtle Bay. Instead of sourcing the corals of opportunity from the Summer Bay, we harvested from Tanjung Telunjuk instead. These corals are fragmented and then planted on the metal rebar.

Moreover, our endeavors are complemented by rapid assessment surveys, which are instrumental in gauging coral cover percentages as well as monitoring fish and invertebrate populations at the outplant sites. These comprehensive interventions inform adaptive management strategies for the long-term sustainability of Lang Tengah Island's marine ecosystems.



Coral Collection

In 2023, for the coral nurseries, a total of 357 coral fragments representing 88 donor colonies of four species of corals were harvested from corals of opportunity at an average depth of 10m in front of Summer Bay Resort. The four species were *Hydnophora rigida, Pocillopora damicornis, Acropora muricata,* and *Acropora florida*. Those corals were cut into smaller fragments of 8-10cm in linear length and placed in our nurseries to grow in a safe and conducive environment. The average linear length of a total of357 fragments was 8.7 ± 2.2cm (Table 3).

Table 3. Species of coral fragments collected from Summer Bay in 2023.

Species	Month collected	No. of colonies	No. of fragments	Average linear length ± SD (cm)
Acropora florida (brown)	July	14	45	9.2 ± 1.5
Acropora florida (green)	July	20	66	9.9 ± 2.4
Acropora muricata (green)	July	10	66	9.7 ± 2.3
Acropora muricata (brown)	July	14	66	7.4 ± 1.2
Pocillopora damicornis	July	15	48	8.3 ± 2.2
Hydnophora rigida	July	15	66	7.6 ± 1.4
Total		88	357	8.7 ± 2.2

In 2024, for the artificial reefs, a total of 143 coral fragments representing 15 donor colonies of three species of corals were harvested from corals of opportunity at an average depth of 12m at Tanjung Telunjuk. The three species were *Hydnophora rigida, Acropora muricata,* and *Acropora florida*. Those corals were cut into smaller fragments of 8-10cm in linear length and planted on our artificial reef (coral rebar) to grow in a safe and conducive environment. The average linear length of a total of 143 fragments was 8.0 ± 2.2cm (Table 4).

Table 4. Species of coral fragments collected from Tanjung Telunjuk in 2024.

Species	Month collected	No. of colonies	No. of fragments	Average linear length ± SD (cm)
Acropora florida	July	4	36	8.74 ± 2.89
Hydnophora rigida	July	9	100	7.47 ± 1.91
Acropora muricata	July	2	7	10.83 ± 1.88
Total		15	143	7.98 ± 2.23

These corals were selected from these two different areas due to their varying morphologies, their important role in building reef structure, and previous surveys identifying these species as among the dominant taxa in the area. Moreover, corals of opportunity are corals that have been broken off the reef due to wave action or storms. These coral, as detached colonies, are susceptible to bleaching, partial mortality, disease, and algal overgrowth and may even perish (Jaap, 2000) unless salvaged from the reef and reattached to a stable substrate (i.e., coral nursery and artificial reef).

Coral nurseries are secure substates that serve as interim locations for the creation of a reserve of corals of opportunity. The purpose of coral nurseries is to provide a temporary storage site for corals of opportunity to stabilise, continue to grow, and to be readily available for transplantation to a damaged site in the future. Besides that, artificial reefs are generally to provide a stable growing area for corals and habitat for fish and all the other organisms that can be found on a natural reef, especially at Turtle Bay, which is fully covered by coral rubble.

Coral Nurseries

The coral fragments were transported in wet condition to the nursery site. There are a total of six coral tree nurseries, with a total capacity of growing 357 coral fragments at one time. The coral nurseries are located at a depth of 8–10 m within 500 m from the outplant site at Tanjung Telunjuk. To attain the vertical position of the coral tree nurseries, subsurface buoys, polypropylene rope, and cement anchors are used. Each tree has at least one species of coral fragments, whereby each fragment is tethered using short and long monofilaments to avoid collision between fragments.

The growth and survival of the coral fragments in the nurseries are monitored right after they are attached to the coral tress. The initial monitoring is counted as Day 0. The subsequent monitoring occurred a month later. In addition, the corals were also monitored post-monsoon in March, bleaching and post-bleaching assessment in the middle of the season, and pre-monsoon in October, depending on when they were attached to the coral tree. The status of each coral fragment (alive, dead, or detached), number of branchesand lesions, bleaching status, and predation were monitored. All the data were recorded on a slate board, which are photographed once the surveyors are out of the water. Data was then entered into Excel.

The survival rates are calculated using the number of live coral fragments divided by the number of fragments present in the nurseries (%). To assess the growth, the maximum length (L), width (W) perpendicular to maximum length, and vertical height (H) of each individual coral fragment was measured while suspended from the nursery. All three measurements were taken in centimetres (cm) using a caliper.

The geometric mean radius (GMR;cm) for each coral fragment was calculated using the formula: $\bar{r} = ((L \times W \times H)^{1/3})/2$ for all fragments (Loya, 1976). GMR is used to linearise colony measurements, which decreased the influence of the initial size of growth rate. The average GMR for every species was then used to calculate the mean growth rate (mm day-1).

There were a total of 357 coral fragments: 48 *Acropora florida* (brown), 66 *Acropora muricata* (green), 66 *Acropora muricata* (brown), 45 *Pocillopora damicornis*, 66 *Acropora florida* (green), and 66 *Hydnophora rigida*. The status of coral fragments is summarised in Table 5.

Table 5. Status of coral fragments in the nursery as of 2024.

Species	Status	Number of fragments (%)				
		Day 38 (post-bleaching)	Day 96 (pre-monsoon)	Day 257 (post-monsoon)	Day 334 (bleaching assessment)	Day 408 (pre-monsoon)
Acropora florida (Brown) (n=48)	Alive	100	98.5	66.7	41.7	8.3
	Dead	0	0	0	6.3	0
	Detached	0	0	33.3	52.1	91.7
Acropora muricata (green) (n=66)	Alive	100	93.9	71.2	53	30.3
	Dead	0	4.54	0	7.6	0
	Detached	0	1.52	28.8	39.4	69.7
Acropora muricata (Brown) (n=66)	Alive	100	100	77.3	-	12.1
	Dead	0	0	0	-	15.2
	Detached	0	0	22.7	-	72.7
Poccilopora damiconis (n=45)	Alive	100	98.5	60.6	64.6	33.3
	Dead	0	0	37.9	0	2.2
	Detached	0	0	1.52	35.6	64.5
Acropora florida (green) (n=66)	Alive	100	100	57.5	-	24.2
	Dead	0	0	0	-	16.7
	Detached	0	0	42.5	-	59.1
Hydnophora rigida (n=66)	Alive	100	100	62.2	50	15.2
	Dead	0	0	0	3	6.1
	Detached	0	0	37.8	47	78.8
Total fragments (n=357)	Alive	100	98.3	70.6	52	20.5
	Dead	0	0	5.60	4.4	7.3
	Detached	0	1.68	23.81	43.6	72.3

The mean growth rates of the six coral species fragments in the nurseries are shown in Figure 16. According to Figure 16, there is a fluctuation in the growth of corals from Day 0 to Day 408. *Acropora muricata* (brown) had the highest mean growth of 0.015 mm day-1, followed by *Acropora florida* (green) (0.012 mm day-1), and *Acropora florida* (brown) (0.008 mm day-1) on Day-408. These three species of corals have grown steadily with age since Day 0. Meanwhile, the mean growth rate for *Acropora muricata* (green), *Pocillopora damicornis*, and *Hydnophora rigida* decreases gradually from Day 96. *Hydnophora rigida* has the lowest mean growth rate of 0.005 mm day-1 on Day 408.

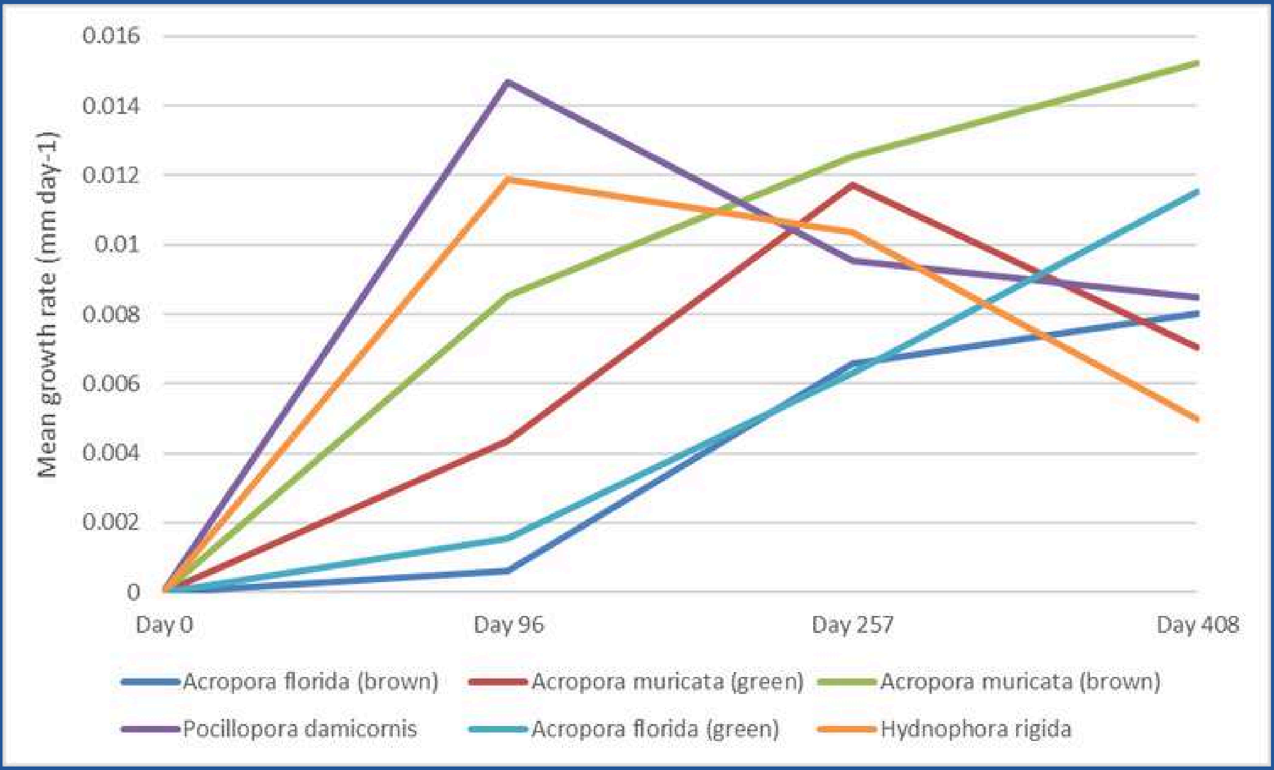


Figure 16. Mean growth rate of coral species in the nurseries attached over 408 days since July 2023.

Different coral species have different growth rates due to varying morphology, skeletal structure, and polyp size (Hall & Hughes, 1996). According to Buddemeier and Kinzie (1976), Acropora and Hydnophora are among the faster growing corals due to the rapid linear extension of branching corals, which was also observed in our coral tree nurseries. The differences in growth and survival rates through time could also be affected by a variety of other factors, including physio-chemical parameters such as temperature, turbidity, circulation, less sedimentation, lower predation, as well as fewer diseases could contribute to faster growth rates and lower mortality in nurseries (Edwards, 2010).

Outplanted Corals into Natural Reefs

Figure 17. Outplanted coral colonies at Tanjung Telunjuk (left), and monitoring of the outplanted corals (right).

This year, we continued to monitor our outplanted coral colonies from the previous year at Tanjung Telunjuk (Figure 12). As our conservation efforts grow, the previous outplant site at Tanjung Telunjuk is now filled with hundreds of coral fragments transplanted from our coral tree nurseries.

Coral clips are used to attach the coral fragments onto the substrate in the natural reef. the surface of the substrate was scrubbed before attaching coral colonies. This is done to reduce competition between coral and algae. Each colony was attached to the substrate by using one or more coral clips (Figure 18), depending on the size of the coral.

Figure 18. A coral clip is nailed into the substrate to hold the coral colony before it attaches itself to the substrate.

In order to identify the coral colony for monitoring purposes, a number tag was placed next to each planted colony. Monitoring of outplanted coral colonies was conducted on Day 30, pre-monsoon, and post-monsoon. The status (dead or alive), type of attachment (Table 6), length (L), width (W), and height (H) of the each individual coral colony was recorded during every monitoring survey (Figure 19).

Table 6. Type of coral attachments.

Category	Attachment Type
0	Non-attached of coral tissue to substrate
1	Tissue sheeting of corals to substrate
2	Coral self-attached to substrate
3	The attachment method (e.g., epoxy) failed but coral is still there
4	Detached and coral is gone
5	Dead, attached

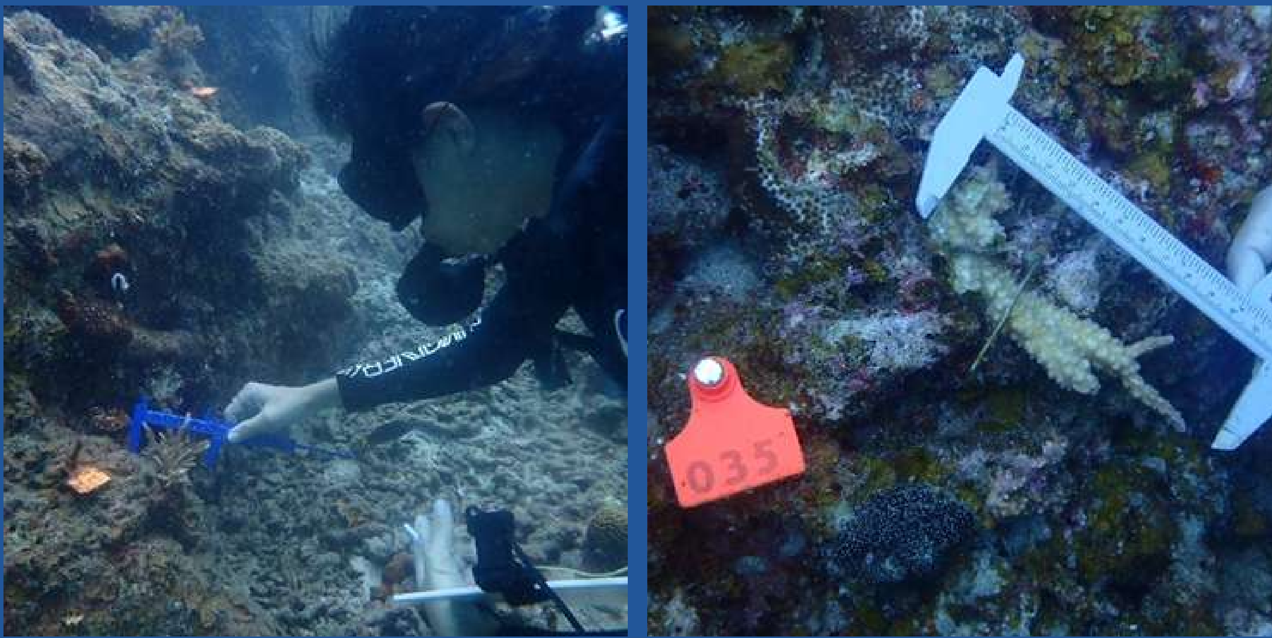


Figure 19. Checking the survival of the outplanted coral colonies at Tanjung Telunjuk, as well as measuring their length, width and height.

Coral Growth

In 2023, a total 135 coral fragments were planted at outplant site which is 77 *Acropora longicyathus* and 58 *Pocillopora damicornis*. The status of outplanted coral fragments were summarised from Day 0 to Day 481 in Table 7.

Table 7. Status of 2023 outplanted coral fragments at Tanjung Telunjuk.

Species	Status	Number of fragments (%)					
		Day 0 (Initial)	Day 39 (Bleaching assessment)	Day 152 (Pre-monsoon)	Day 340 (Post-monsoon)	Day 441 (Bleaching assessment)	Day 481 (Pre-monsoon)
Acropora longicyathus (n=77)	Alive	100	74.0	64.9	52.0	35.1	-
	Dead	0	26.0	35.1	48.1	64.9	-
Pocillopora damicornis (n=58)	Alive	100	84.5	75.9	67.2	46.6	13.8
	Dead	0	15.5	24.1	32.8	53.5	86.2
Total fragments (n=135)	Alive	100	78.5	69.6	58.5	40.0	13.8
	Dead	0	21.5	30.4	41.5	60.0	86.2

According to Figure 20, there is a fluctuation in the growth of corals from Day 0 to Day 441. *Acropora longicyathus* had shown 0.029 mm day-1 of growth rate, while *Pocillopora damicornis* shown 0.010 mm day-1 of growth rate on Day 441.

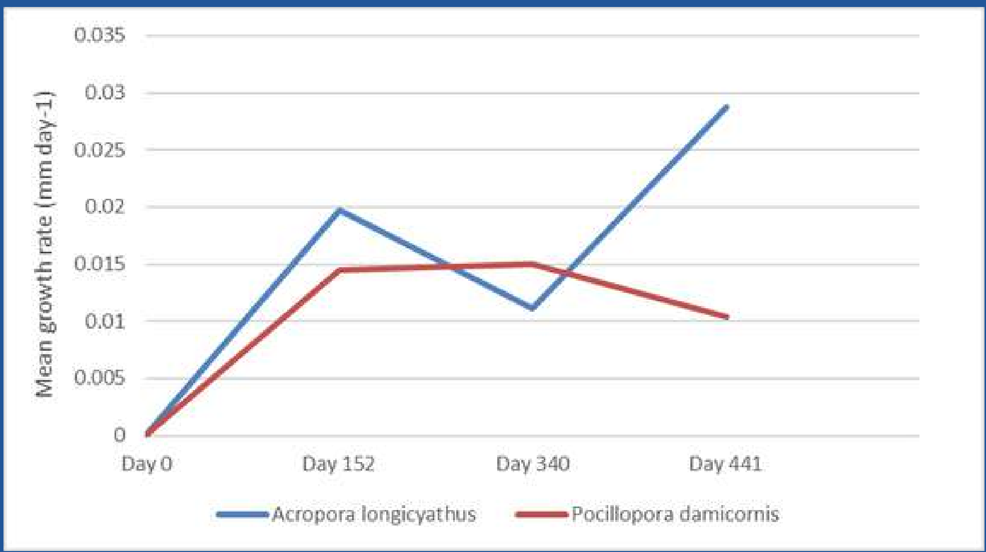


Figure 20. Mean growth rate of the outplanted corals.

Figure 21. Tying up the coral fragments on the metal rebars using cable ties.

Artificial Reef

This year, with the funding from Yayasan Sime Darby (YSD), we deployed eight artificial reefs (coral rebars) at Turtle Bay with the help of interns and volunteers who have helped transport the rebars to the chosen site using the kayak. Of these eight artificial reef structures, two are star-shaped and six are square-shaped. These rebars are made of steel and were coated with cement to protect the steel from eroding and to provide the coral fragments with a strong hold to attach.

A total of 143 coral fragments from three species of corals (*Hydnophora rigida*, *Acropora muricata*, and *Acropora florida*) were planted on the artificial reef. To plant the corals, we used cable ties to attach the fragments on the rebar. The coral fragments on the star rebar were tied up at the shore of Turtle Bay with the help of volunteers and interns. This was done so to provide them with a more hands-on approach to learn about coral restoration without the need of a diving license.

As the harvested coral fragments cannot be out of the water for prolonged periods of time, only the star rebars' fragments, which are lesser than a square rebar's, were tied on the surface. Meanwhile, the coral fragments on the square rebars were tied up in the water (Figure 21). The artificial reefs were located at a depth of 10-12m within 200 m from the coral nurseries area near Tanjung Telunjuk, Turtle Bay.

Similar to an outplanted coral fragment, to identify the corals on the rebar for monitoring purposes, a number tag was tied at one end of each square rebar to indicate the starting point of the structure. Monitoring of coral fragments on the artificial reef was conducted on Day 0 (Initial day) and Day 62 (Pre-monsoon). The status (Dead or alive), type of attachments (Table 6), length (L), width (W), and height (H) of the coral fragments were recorded during each monitoring survey (Figure 22).

Figure 22. Monitoring and measuring the coral fragments on the artificial reef.

Coral Growth

This year, a total of 143 coral fragments were planted on the artificial reef, which are 36 *Acropora florida*, 100 *Hydnophora rigida*, and 7 *Acropora muricata*. The status of coral fragments on the artificial reef was summarised from Day 0 to Day 62 in Table 8.

Table 8. Status of coral fragments on the artificial reef at Turtle Bay.

Species	Status	Number of fragments (%)	
		Day 0 (Initial)	Day 62 (Pre-monsoon)
Acropora florida (n=36)	Alive	100	100
	Dead	0	0
Hydnophora rigida (n=100)	Alive	100	100
	Dead	0	0
Acropora muricata (n=7)	Alive	100	100
	Dead	0	0
Total fragments (n=143)	Alive	100	100
	Dead	0	0

According to Figure 23, there is a gradual increase in the growth of corals from Day 0 to Day 62. Hydnophora rigida has the highest mean growth rate (0.007 mm day-1), followed by Acropora muricata (0.004 mm day-1), and Acropora florida (0.007 mm day-1) on Day 62.

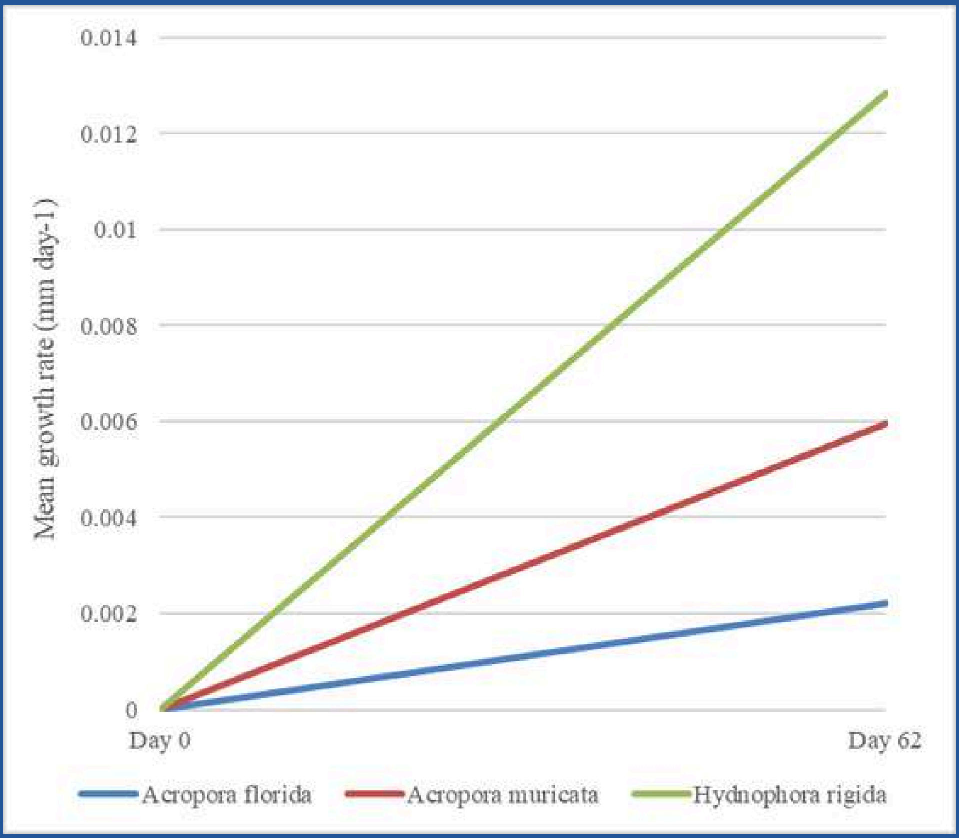


Figure 23. Mean growth rate of the coral fragments on the artificial reef.

VOLUNTEER PROGRAMME

The duration of PULIHARA volunteering programme extended from April to September 2024, and 40 volunteers were welcomed by the team. Each week, the team greeted and trained an average of one to three volunteers, mainly Malaysians and Europeans. As evidenced in Figure 24, 12.5% of volunteers were foreigners, 85% were locals and 2.5% did not disclose their nationality.

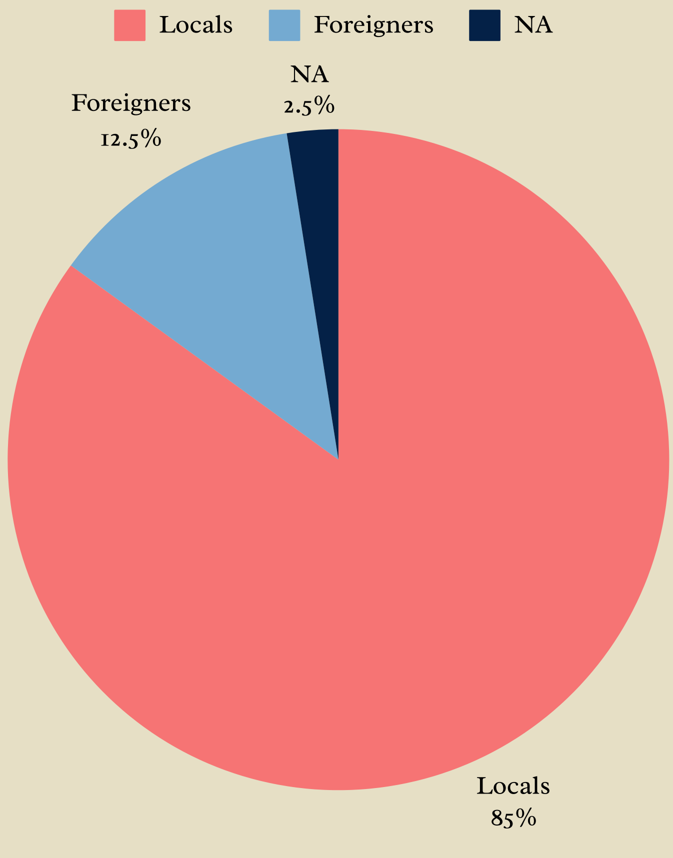


Figure 24. Nationalities of volunteers.

Comprehensive educational talks regarding turtles, corals, and fish identification were provided to each batch of volunteers, with the main conservation-related activities comprising of nightly patrols, triangulation practices, Coral Watch surveys, in-water fish identification, underwater net removals, and weekly coastal clean-ups. Some of the volunteers even had the chance to help with the biometric data collection of nesting turtles, retrieval

Figure 25. Group photo with the week's batch of volunteers..

and relocation of sea turtle eggs, and coral rebar deployment. In addition to the activities, volunteers help with daily chores on camp, including charging the solar inverter, cooking, and raking. During leisure time, the volunteers enjoyed cliff-jumping, hiking, snorkeling, sunbathing, reading, card games, and beach volleyball.

Figure 26. Volleyball game with staff at Summer Bay Resort (left), and playing card games after dinner (right).

Similar to the previous year (2023), the team welcomed seven (out of the 40 volunteers) RASMA volunteers to the LT research station this year. RASMA stands for the Roots and Shoots Malaysia Award inspired by Dr Jane Goodall, and it encourages youths to go beyond awareness and commit their time to bigger causes.

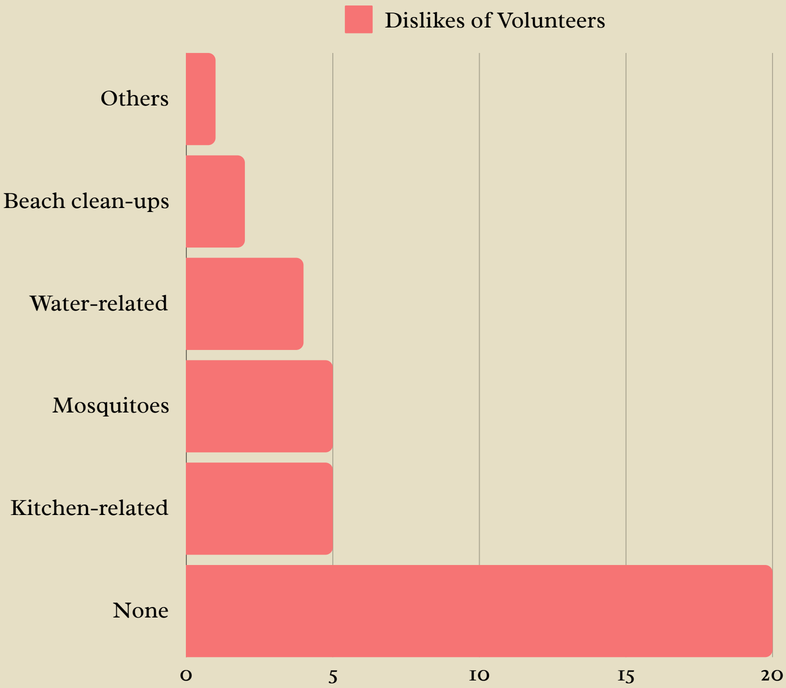
The RASMA volunteers had the chance to spend one to two weeks on LT project site, helping with nesting turtles, post-emergence inspections (PEI), and miscellaneous tasks such as removing fallen trees and camp maintenance. They are local students of various educational backgrounds aged between 18-24 year olds.

Figure 27. LT staffs with some of the RASMA volunteers at the programme's graduation ceremony.

With a total of 40 volunteers, only 35 volunteer feedback were received this year. From Figure 28, 23 of the 35 respondents favoured water-related activities. In this case, water-related activities are such as snorkeling surveys, and cliff jumping - activities that involved volunteers getting into the water. At the same time, 10 respondents said they enjoyed the surveys conducted during the volunteering period. The surveys were focused on Coral Health and Fish Identification. Meanwhile, only four respondents noted that they enjoyed turtle-related work which includes nightly patrols and hatchling release. Despite this, four other respondents mentioned that they enjoyed all activities carried out. Other activities that received less than five mentions were cooking, cliff jumping, educational talks, and others (volleyball at Summer Bay Resort and hanging out at Lang Sari beach).

Figure 28. Activities liked by volunteers.

At the research station, volunteers are made to feel comfortable as much as possible. Despite the efforts, there are still certain aspects that do not favour them. Of the 35 responses received, 20 did not express any dissatisfaction towards the volunteering programme. On the contrary, five respondents mentioned their dislike towards kitchen-related tasks such as cooking, washing the dishes and throwing the food waste into the compost bin. Similarly, five of them mentioned their disdain towards mosquitoes, which cannot be helped. Surprisingly, three volunteers stated that they did not enjoy the water-related activities, with one of them stating that she did not



like 'the idea of snorkelling everyday'. Two volunteers, in their feedbacks, mentioned that although beach cleanups are necessary to do, they did find it unpleasant. Lastly, other feedbacks feel into the others category.

Figure 29. Least favourite aspects rated by volunteers.

When asked what could be improved in the feedback form, 11 volunteers gave no feedbacks/comments regarding the matter. Figure 30 is based on the 24 responses received. The figure highlights that as much as 50% (12 volunteers) suggested improvements on the amenities of the research station. These amenities are such as better shelter from the rain, providing running electricity around the area, better mosquito nets as well as mattresses, water system and hangers in the shower, and a new kayak.

Some of these suggestions could have been prompted by various problems that arose throughout the season. For example, relentless thunderstorms have caused fallen branches to break through the roofs of our dinning and kitchen hut's roofs, causing leakage. The kayak on the campsite is also unusable due to the holes that have led to water influx.

Amenities aside, 29.2% (7 volunteers) mentioned their dislikes for mosquitoes, sand flies and bats, and are urging for sustainable practices to help in mitigating the mosquito populations. Lastly, 20.8% (5 volunteers) suggested improvements revolving around the volunteering program's structure. These volunteers mentioned the need for more activities among interns and volunteers, better planning for long-volunteers (staying for more than one week), having more conservation activities that they can aid in, changing the starting date of the volunteering program due to the low number of nesting sea turtles, and better and faster communication prior to their arrival.

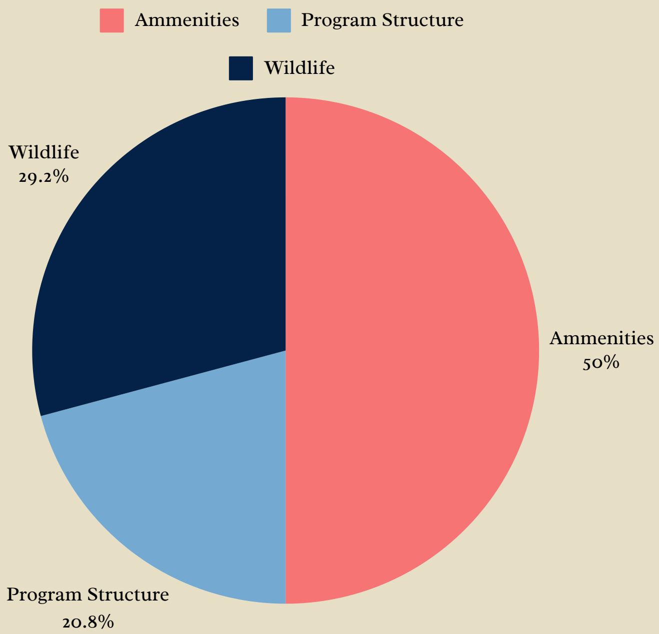


Figure 30. Improvements suggested by volunteers.

65% of volunteers would be excited to return for the unique experience and the great vibes on the island, whereas 26% stated that they will not return again. One of them states that they enjoy travelling and would like to gain experience elsewhere. 3% mentioned answered 'Maybe' on the possibility of returning and 6% did not give a response. Apart from that, all of the volunteers (100%) would recommend this experience to their families and friends.

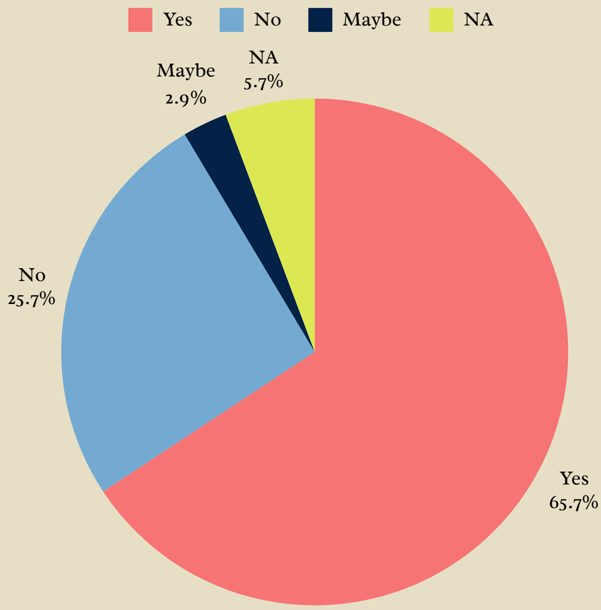


Figure 31. Likelihood of returning for another volunteering experience at PULIHARA.

OUTREACH PROGRAMME

Figure 32. A staff giving a brief sea turtle talk to the visitors at the research station.

Throughout the nesting season in 2024, our LT team greeted visitors from nearby resorts and the occasional snorkellers from Perhentian Island, and informal talks were given to educate and raise public awareness regarding our conservation work. Additionally, educational programmes involving a university and various local schools were organised.

Conservation Talks for Visitors

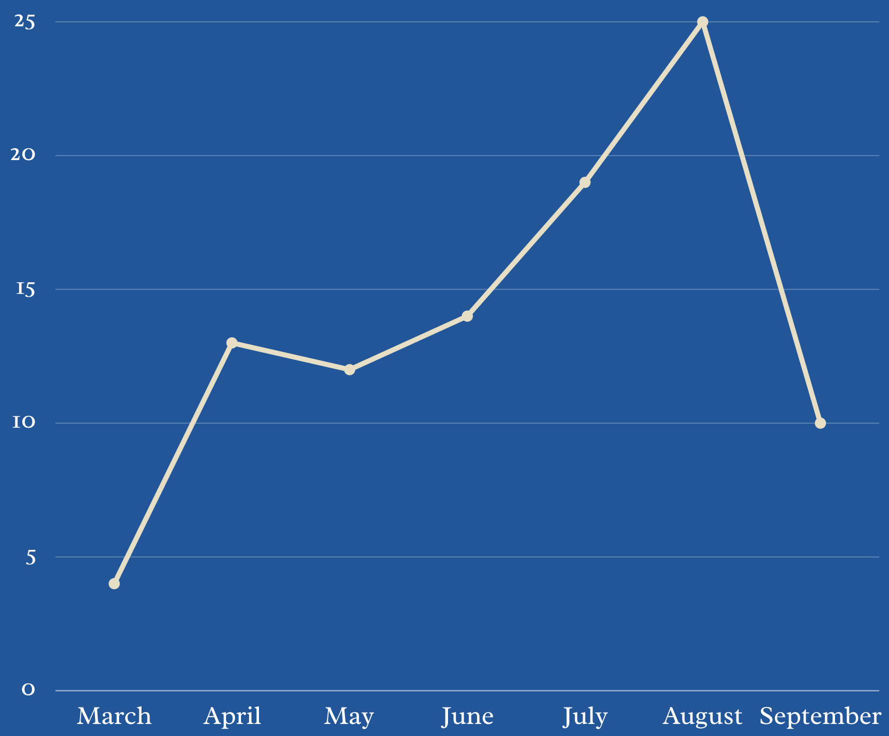


Figure 33. Number of educational talks given at Lang Tengah Island.

During the day, visitors are welcome to Turtle Bay for informal educational talks given by staff, interns and volunteers. Specimens of turtle embryos and skeletons, in addition to a coral tree sample, were demonstrated to the visitors for a better understanding of turtle and coral biology.From March to September 2024, 778 guests visited our LT campsite, the peak being in both July and August, in which 208 and 254 tourists visited respectively. These visitors supported our cause through awareness, social media sharing and merchandise purchases. The visitors usually came from nearby resorts.

Figure 34. Group photo with students of SMK Chendering during their visit in August 2024.

Educational Trips for Local Schools

In June and August 2024, educational trips for two local secondary schools, namely SMK Batu Rakit (11th of June 2024) and SMK Chendering (28th August 2024), were organised to elevate their awareness towards marine animals, conservation and waste management. From each school, 20 students with their teachers along, were invited to join the programme from the morning and return to the mainland in the afternoon. To ease the learning process of the students, the sea turtle ecology and coral ecology talks were conducted in a mix of Malay and English (Figure 35).

Figure 35. Talks on coral ecology (left) and sea turtle ecology (right) given by the interns.

The programme commenced with the sea turtle ecology and coral ecology talks. After dividing the students into smaller groups of five, four interactive games were conducted to reinforce the knowledge of the students regarding sea turtles, corals and conservation. The games comprised elevated Q&A sessions, cross-matching facial photos of individual sea turtles to find the correct match, and a presentation on random chosen topics about either sea turtles or corals.

Before wrapping up the programme, prizes and certificates were presented to the students. This year, with the funding provided by Yayasan Sime Darby, we were able to create handheld decks of cards containing information on the sea turtles of the world, coral bleaching and the coral triangle, for the students to bring home. This year, we were unable to carry out beach clean-ups at Lang Sari with the students as in previous years due to the weather conditions. The beach cleanups were held at Turtle Bay beach instead.

Figure 36. Interactive marine-based games for the students.

University Field Visit

This year, we had the privilege of hosting two university visits to the research station on Lang Tengah. On the 3rd and 4th of April 2024, more than 10 students and lecturers from Monash University visited the research station. These are yearly visits they make to PULIHARA, formerly LTTW, for the Aquatic Biology students to broaden their knowledge of sea turtles and corals, as well as the conservation work implemented by the team. With their visits split into two days, the first day was solely focused on sea turtles while the second was on corals. Both comprise a demonstration on the conservation work the team does on the island.

On the first day (3/4/2024), the students were given a comprehensive talk on sea turtle ecology, followed by a nest relocation and triangulation practice. Staff and volunteers were assigned to groups of students, and demonstrations were given before the practice. During the practice, ping pong balls were used to mimic sea turtle eggs. The students were taught how to handle the

Figure 37. Introduction to sea turtle ecology.

'eggs' properly using said balls. Throughout this practice, the students learned how to dig a proper egg chamber, how to mark and measure a nest, and how to relocate their marked nest using the measurement technique (triangulation).

Figure 38. Triangulation session with the students (left);

Figure 39. Sea turtle ecology talk (bottom left), and triangulation demonstration and practice (bottom right).

On the 5th of May 2024, we received a group of Masters students from Herriot Watt University, Edinburg, Scotland. The day-trip was part of an ongoing program they were partaking in with Universiti Malaysia Terengganu (UTM). This visit was focused only on the sea turtle aspect whereby talks on sea turtle ecology and post-emergence inspection were given. These talks were followed up with Question & Answer (Q&A) sessions.

COASTAL & UNDERWATER CLEAN-UPS

Coastal Clean-Up

A total of 60 coastal clean-ups were conducted at two locations on Lang Tengah Island, which are Turtle Bay and Lang Sari Beach, involving staff, interns, volunteers, and 14 guests for this year (Figure 41). A total of 334.98 kg of debris were collected from these coastlines, including recyclable waste (57.71 kg) and non-recyclable waste (277.27 kg). The recyclable waste was sent out to RD Papers Gong Badak for recycling.

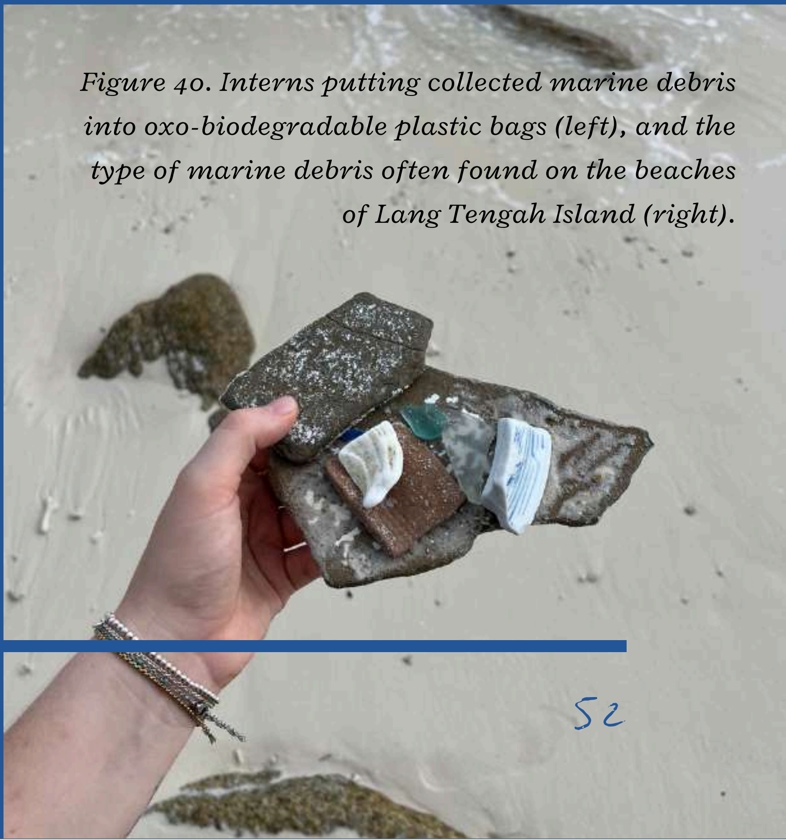


Figure 40. Interns putting collected marine debris into oxo-biodegradable plastic bags (left), and the type of marine debris often found on the beaches of Lang Tengah Island (right).

For each clean-up, the waste collected was categorised and quantified on Clean Swell, a mobile app by Ocean Conservancy, contributing to a global marine debris database. This year, the team used 81 oxo-biodegradable plastic bags sponsored by Miracle Spectrum, a sustainable packaging company, to collect waste during the clean-ups. Frequent coastal clean-ups are crucial to prevent debris consumption by marine animals, ensure the safety of patrollers and tourists, and avoid obstructing the paths of nesting turtles and emerging hatchlings.

Figure 41. Sorting and weighing the collected marine debris into recyclable and non-recyclable waste during beach clean-ups with staffs, interns and volunteers at Lang Tengah Island.

Underwater Clean-Up

A total of 33 underwater clean-ups were conducted around Lang Tengah Island, including Batu Bulan, Batu Karah, Karang Nibong, Batu June, Dewati, and Tanjung Telunjuk dive sites, involving staff and interns. Each underwater clean-up dive consists of 4 divers. A total of 122.58 kg of marine debris (tires, ghost nets, and other trash) were collected around Lang Tengah Island for this year. The highest number of marine debris during underwater clean-up was collected at Dewati, where we removed a big ghost net (83.01 kg) (Figure 42).

Figure 42. Staffs and interns during a dive, removing the ghost net at Dewati (top), and the staff and interns sorting the removed ghost net (bottom).

Besides that, we also have collected 28.41 kg of marine debris (ghost nets and other trash) by freediving with the help of staff, interns, and volunteers at Tanjung Telunjuk and Sari Pacifica sites (Figure 33). Ghost nets were the most common marine debris that we used to remove and collect from the ocean all the time. Ghost nets are lost or abandoned fishing nets that can take centuries to break down (Yeong, 2024). In the meantime, they can damage delicate marine ecosystems and entangle and kill wildlife. Ghost nets also harm coral reefs by breaking corals, exposing them to disease, and even blocking the reefs from needed sunlight (Hancock, 2024).

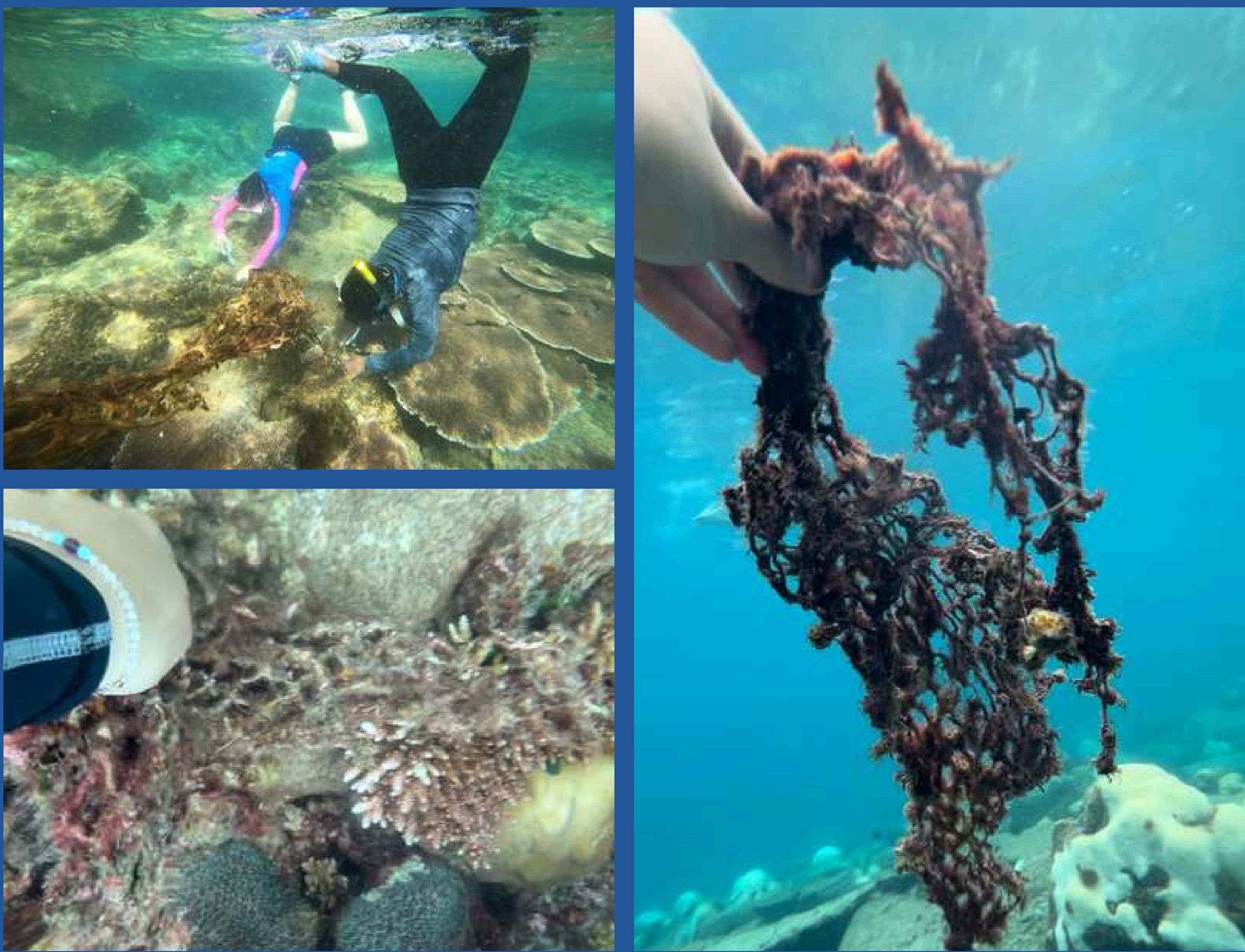


Figure 43. Freediving to remove ghost nets with the help of a volunteer (top left), ghost net stuck on corals (bottom left), and ghost net successfully removed from the reef (right).

REEF CHECK SURVEY

Long-term ecological monitoring makes important contributions to the sciences, adaptive management, and public perception of the state of coral reefs (Done at el, 2017). Reef Check Malaysia conducts an annual survey at a few locations in Malaysia, including Lang Tengah Island, to monitor the health of the coral reefs. This year, 3 of our staff were trained up as certified Reef Check EcoDivers. The Reef Check annual survey was conducted at four sites at Lang Tengah, which are Summer Bay, Batu Bulan, Tanjung Telunjuk, and Batu Broler (Figure 44).

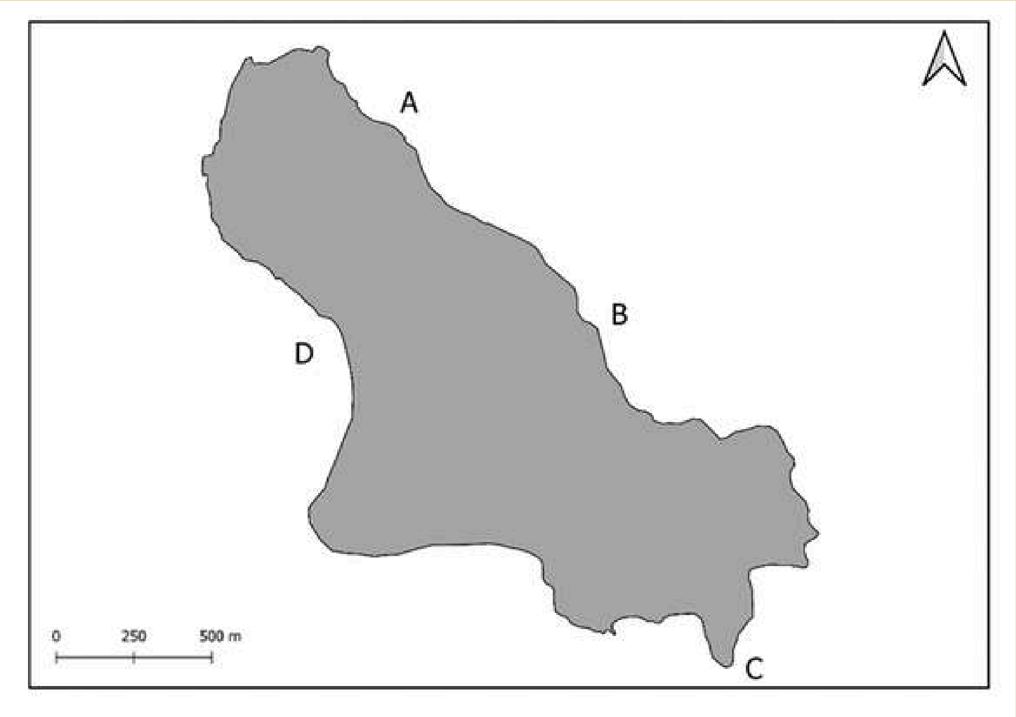


Figure 44. Survey sites at Lang Tengah Island with Reef Check Malaysia survey method: A) Broler North; B) Batu Bulan; C) Tanjung Telunjuk; and D) Summer Bay.

A 100 m long transact was laid at a depth of 5–9 m, which provides 4 replicates per transect (8 per complete survey) for statistical analysis (Figure 35). The main data collected for the survey were fish, invertebrate, damage/impact, and substrate. The fish belt transect should be the first work done after the transect line is deployed, followed by invertebrate and substrate surveys.

The fish survey is carried out by swimming slowly along the transect line and counting the indicator fish within each of the four 20 m long x 5 m wide x 5 m high corridors. Meanwhile, for the invertebrate surveyor, divers count the indicator invertebrates along the same four 20 m x 5 m belts. When the invertebrate belt transect is almost complete, the next designated diver begins point intersect transect. The substrates were recorded at 0.5 m intervals along the line, from 0.0 m up to 19.5 m (40 data points/20 m transect). Besides, the impact survey involves the assessment of damage to coral from bleaching, anchoring, destructive fishing, corallivores such as Drupella snails or crown-of-thorns starfish, and trash. This procedure will be repeated for the remaining replicates.

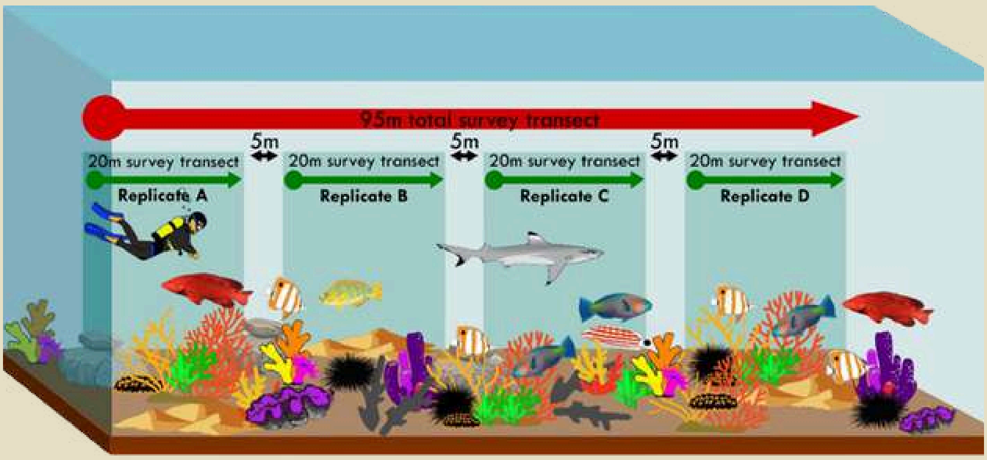


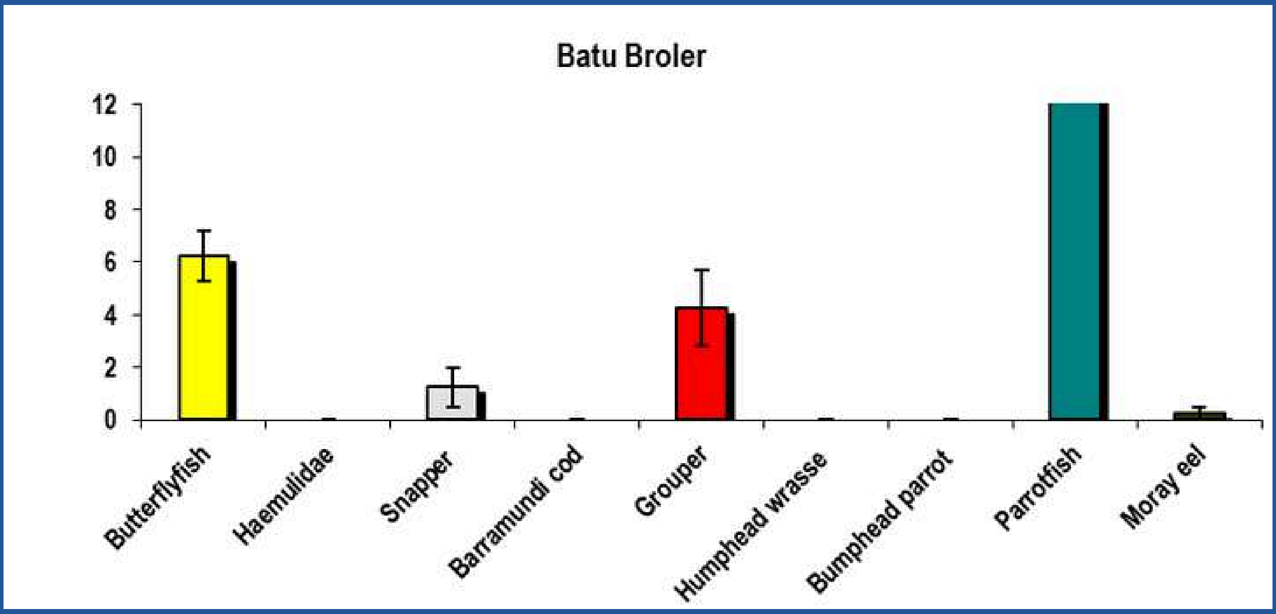
Figure 45. A summary of Reef Check survey methods. Source: Reef Check Malaysia.

Fish Survey

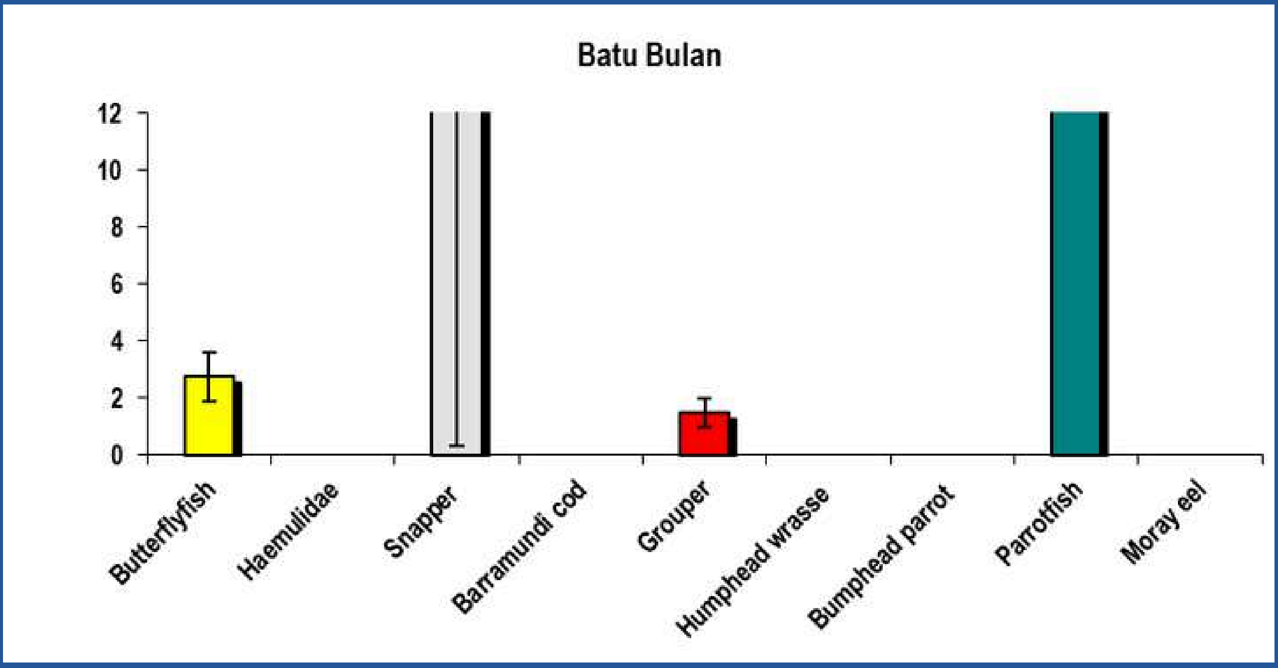
Reef Check indicator fish species were chosen on the basis of targeted demand for aquarium trade (Butterflyfish), food fish (Sweetlips, Snapper, Barramundi Cod, Parrotfish, Moray Eel, and Grouper), and live-food fish trade (Humphead Wrasse and Bumphead Parrotfish). Of the targeted fishes in this, reefs at Lang Tengah were dominated by Parrotfish (334), Butterflyfish (167), and Groupers (52), which are present at almost all surveyed sites with high abundance. Parrotfish are important herbivores, controlling algal growth on reefs, thus avoiding competition with corals. Meanwhile, Butterflyfish is used as an indicator of fishing pressure for the aquarium trade as well as an indicator of reef health as they feed on coral polyps, and only healthy reefs can sustain a large population of these fish (Reef Check Malaysia, 2018). Sweetlips, Snapper, and Parrotfish were present at the survey site. Bumphead Parrotfish and Moray Eel were present in low numbers.

Figure 46. Butterflyfish (top left), Parrotfish (bottom left), Barramundi cod (top right), moray eel (bottom right).

A


Batu Broler
12
10
8
6
4
2
0
Butterflyfish
Haemulidae
Snapper
Barramundi cod
Grouper
Humphead wrasse
Bumphead parrot
Parrotfish
Moray eel

B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Bumphead parrot
Parrotfish
Moray eel

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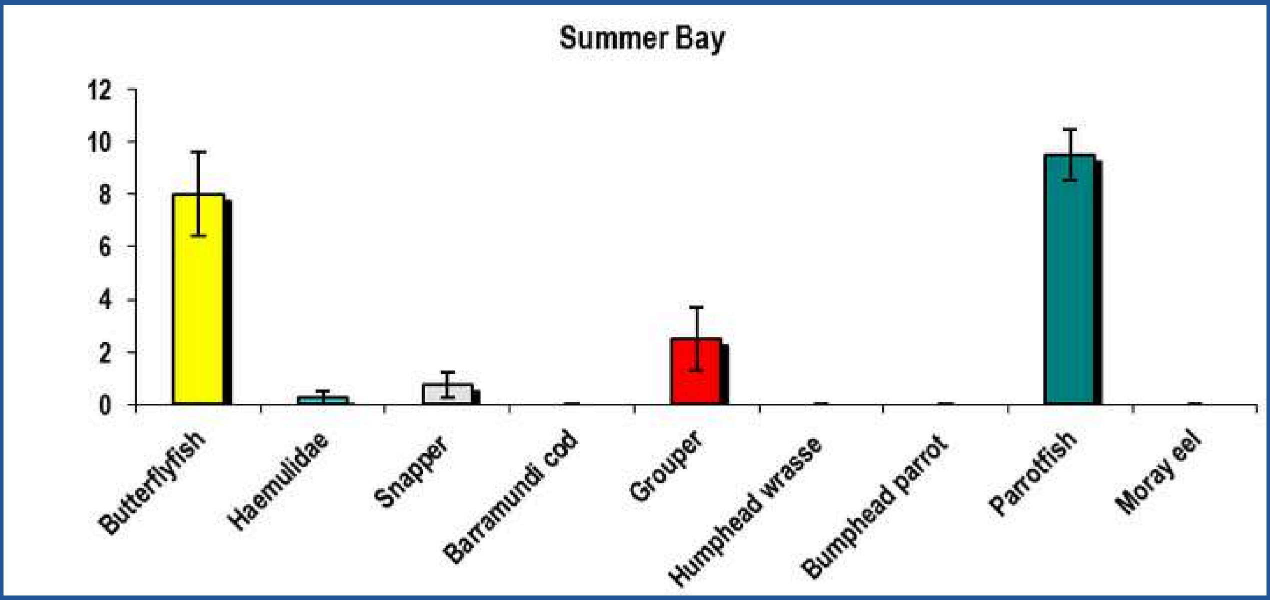

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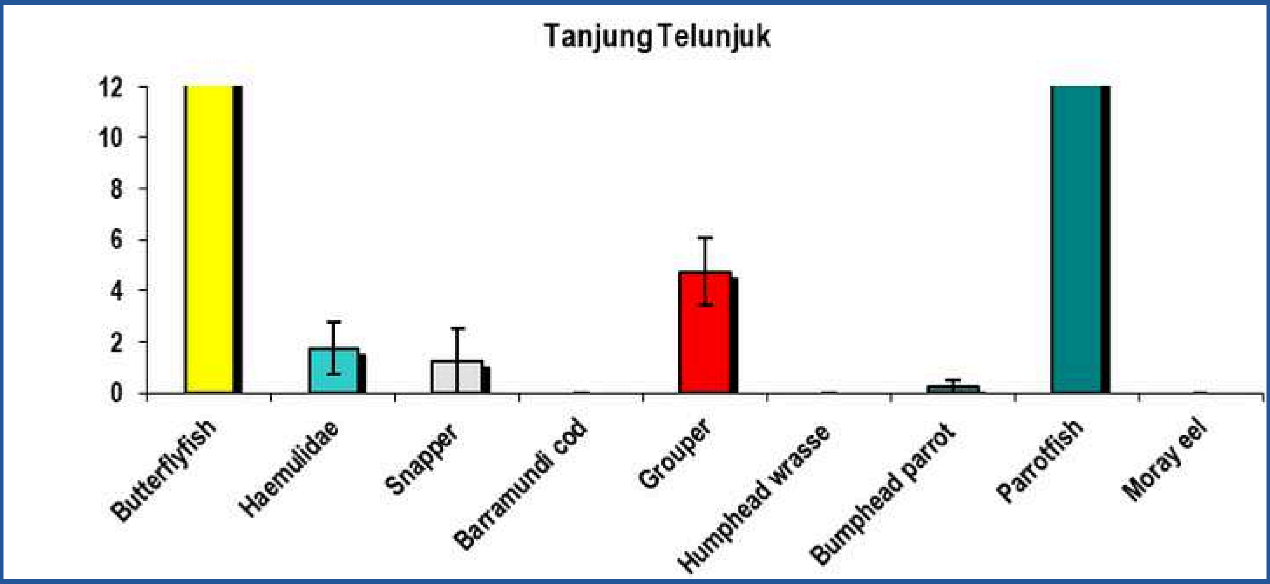


Figure 47. Mean fish abundance ± SE in October 2024 at Batu Broler (A), Batu Bulan (B), Summer Bay (C), and Tanjung Telunjuk (D).

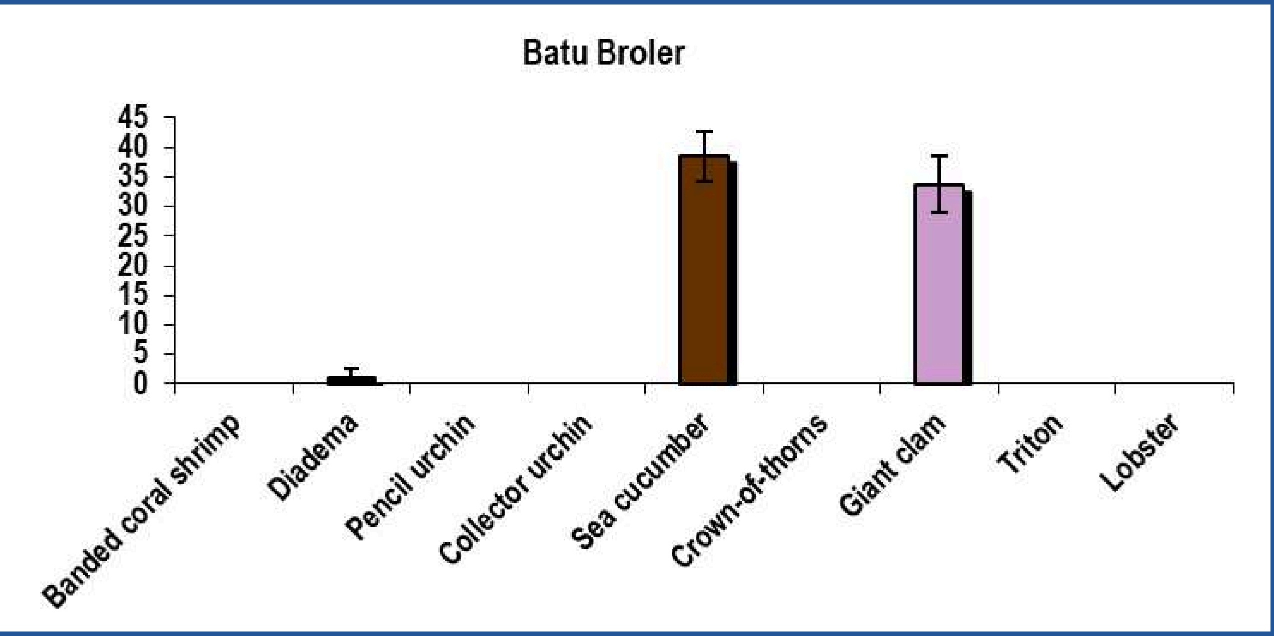
Figure 48. Banded coral shrimp (top left), Giant clam (bottom left), Diadema urchin (top right), sea cucumber (bottom right)

Invertebrate Survey

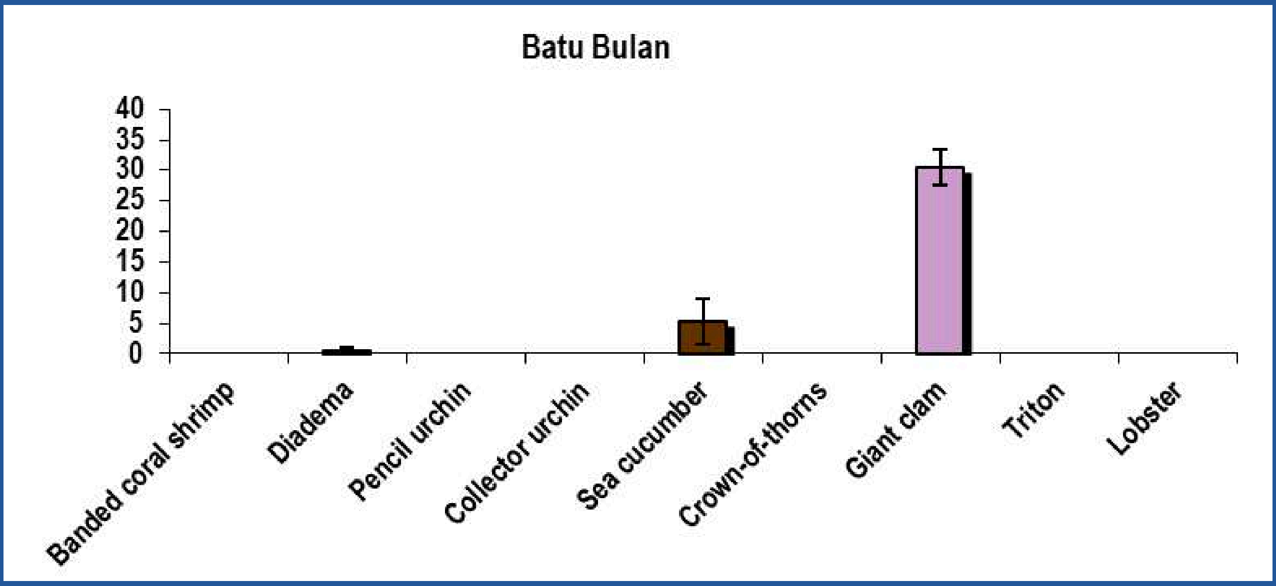
The invertebrate indicators are targeted for different reasons, such as being collected for curio trade (Banded Coral Shrimp, Pencil Urchin, and Triton Shell), collected for food (Collector Urchin, Sea Cucumber, Lobster, Giant Clam), and ecological imbalance or predator outbreaks (Diadema Urchin and Crown of Thorns). None of the indicator invertebrates targeted for curio trade (Banded Coral Shrimp, Pencil Urchin, and Triton Shell) were spotted at the survey site. The highest abundance of invertebrate that was found almost at all the surveyed sites was Sea Cucumber (931), followed by Giant Clam (313) and Diadema Urchin (84).

As feeders, sea cucumbers play an important role in nutrient cycling. Their efforts lower organic loads and disperse surface sediment, while the inorganic nitrogen and phosphorus they excrete improve the benthic environment (Bondaroff, 2019). This makes them ideal bioremediators. These same mechanisms raise seawater alkalinity, which aids in the formation of local buffers against ocean acidification, hence promoting coral reef sustainability (Reynolds, 2023). Meanwhile, Banded Coral Shrimp, Pencil Urchin, Collector Urchin, Crown of Thorns, Triton Shell, and Losbter were not found at any of the sites.

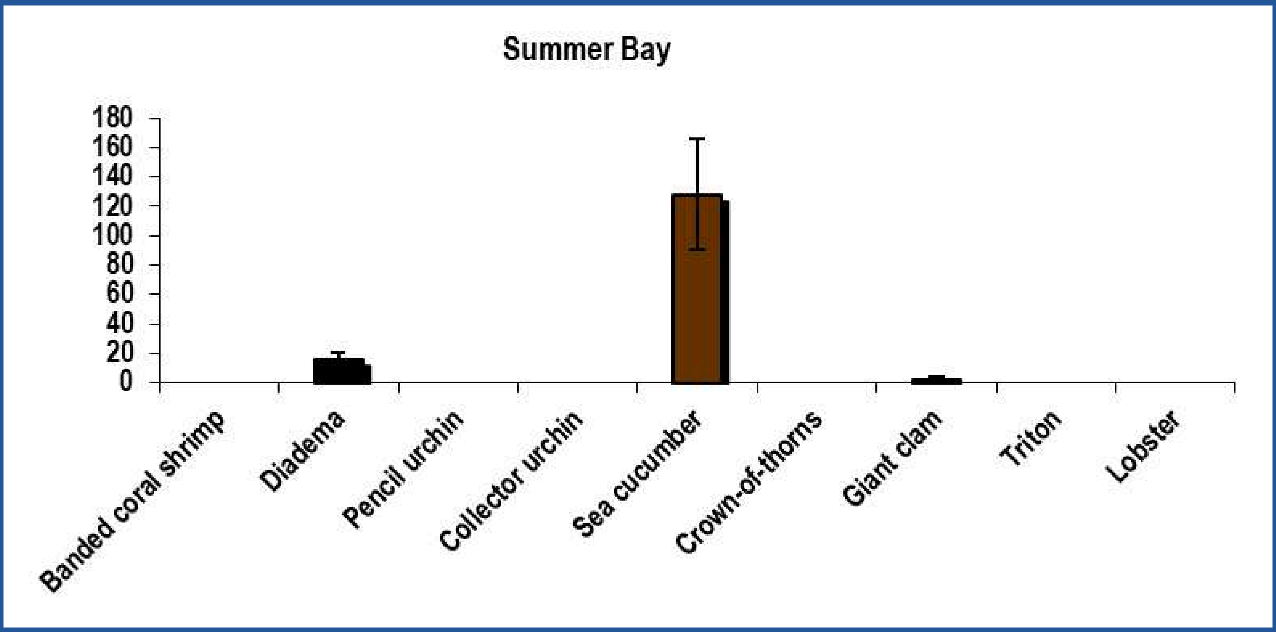
A



B


Batu Bulan
40
35
30
25
20
15
10
5
0
Banded coral shrimp
Diadema
Pencil urchin
Collector urchin
Sea cucumber
Crown-of-thorns
Giant clam
Triton
Lobster

C


Summer Bay
180
160
140
120
100
80
60
40
20
0
Banded coral shrimp
Diadema
Pencil urchin
Collector urchin
Sea cucumber
Crown-of-thorns
Giant clam
Triton
Lobster

D

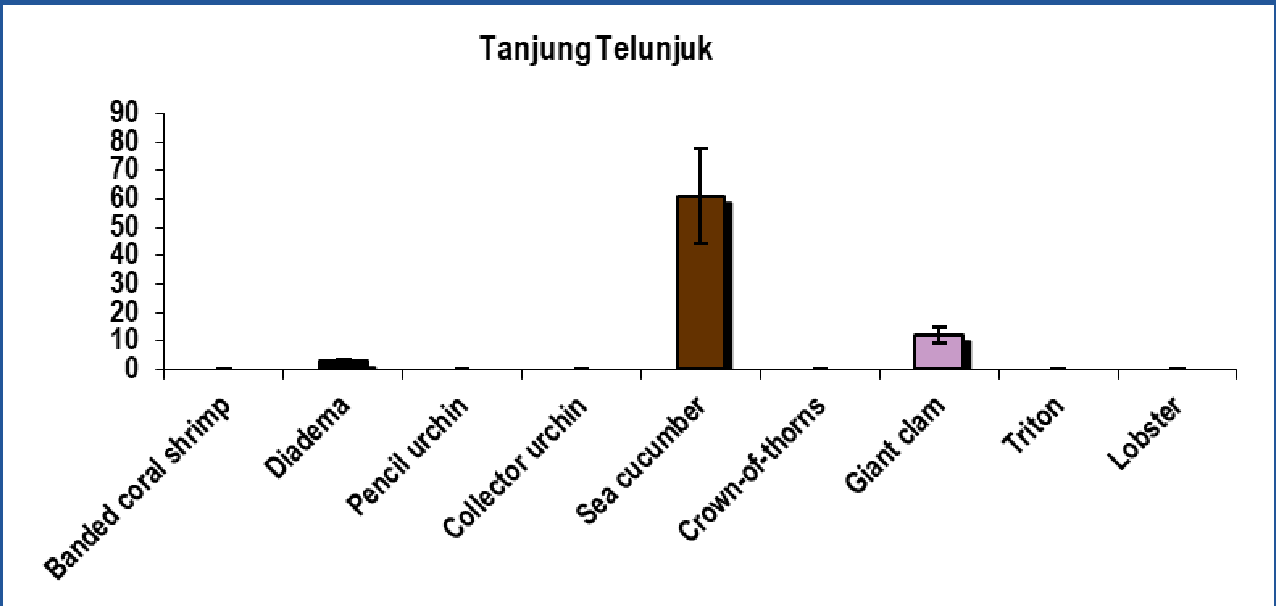
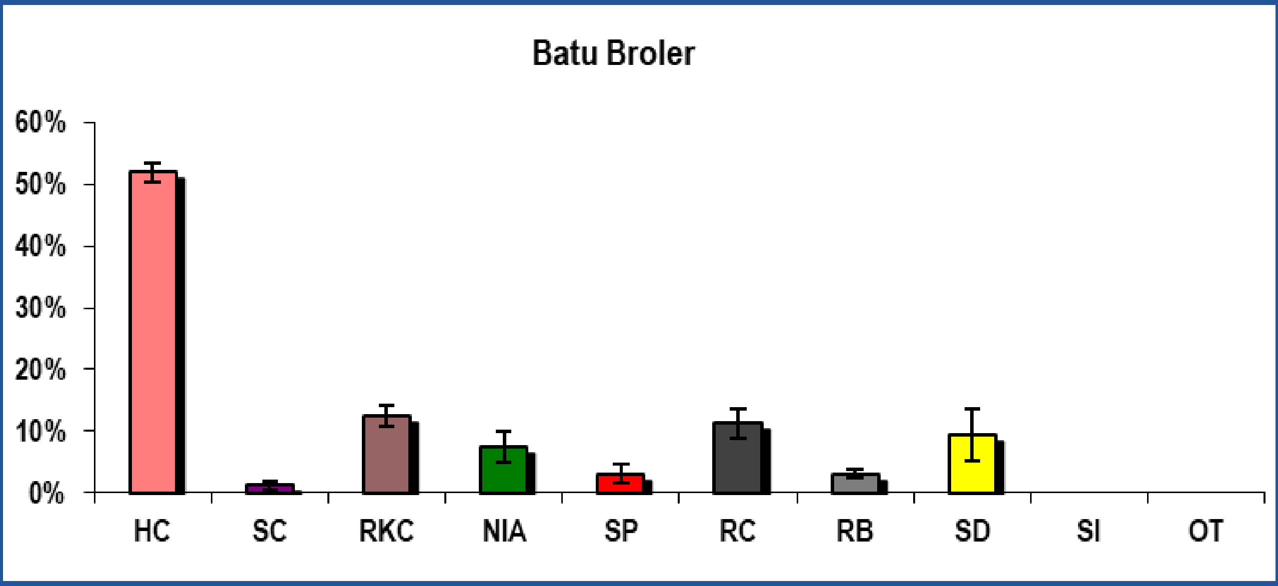


Figure 49. Mean abundance of invertebrates ± SE in October 2024 at Batu Broler (A), Batu Bulan (B), Summer Bay (C), and Tanjung Telunjuk (D).

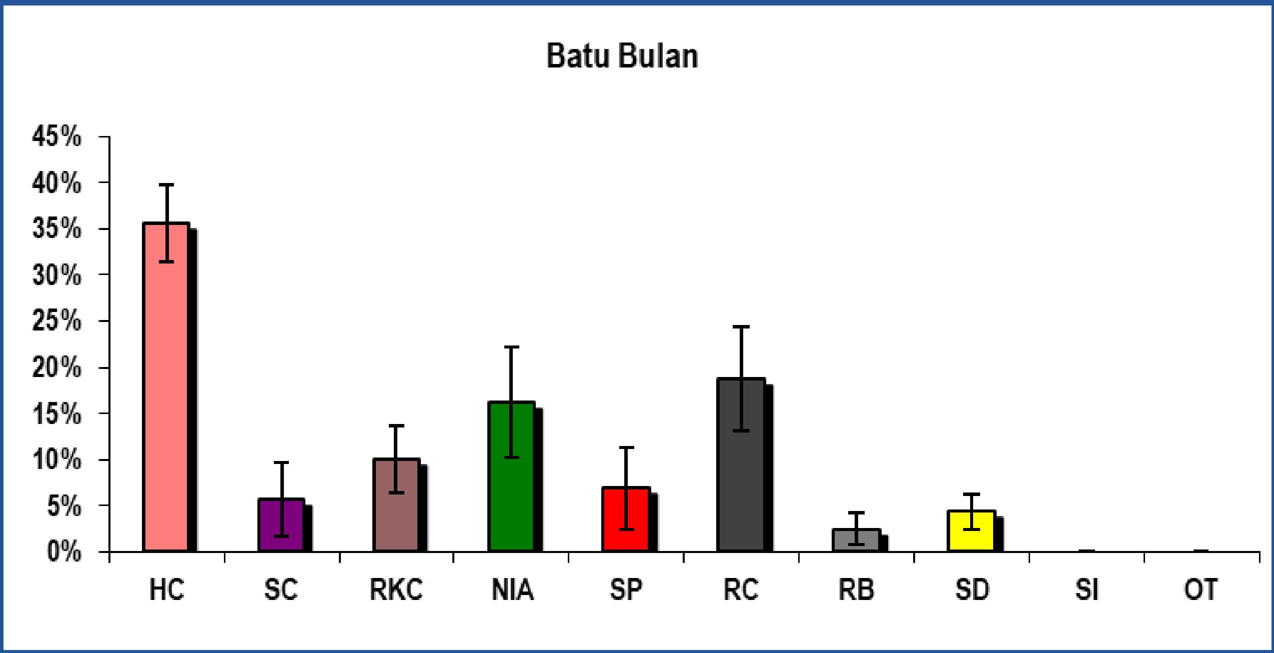
Substrate Survey

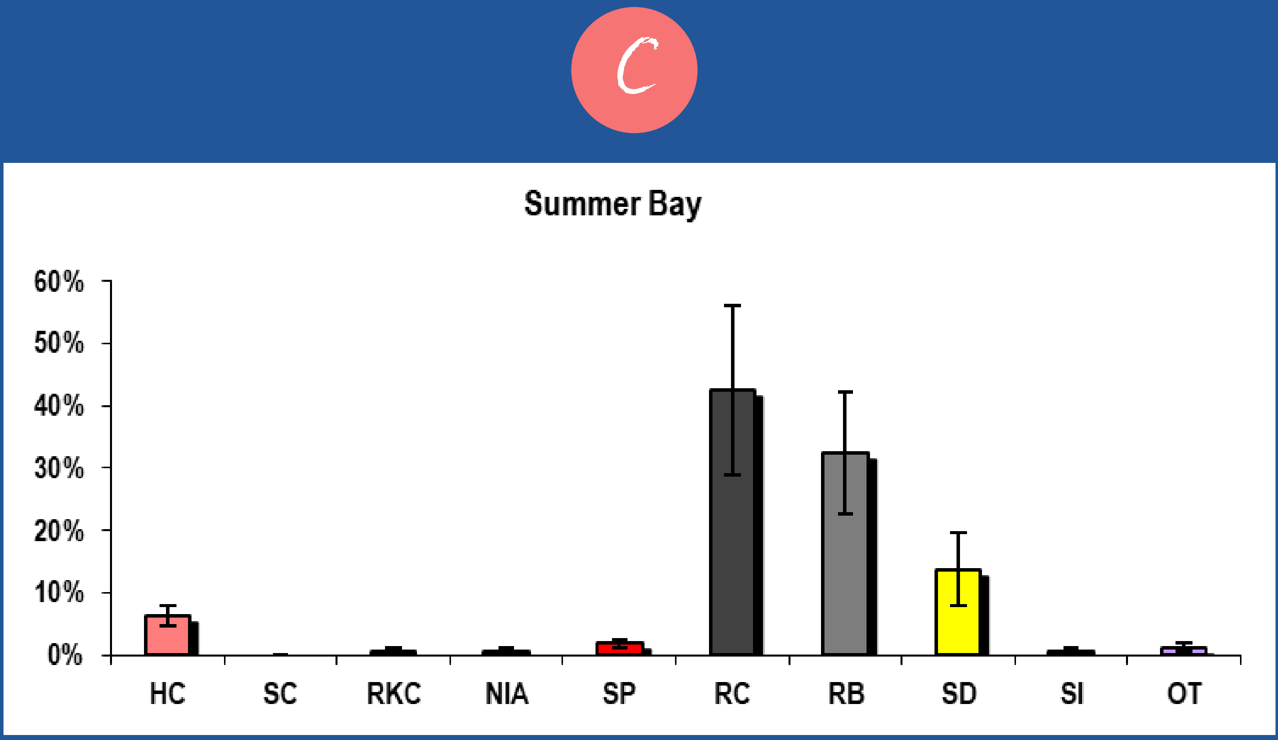
According to Figure 50, all surveyed sites were mostly covered by hard corals. A high percentage of hard coral cover is commonly found in most of the reef, as hard coral serves as building coral, which provides shelter to most of the marine life that stays at reefs. Of all survey sites, Broler North had the highest coverage of hard corals (52%), while Summer Bay had the least hard coral cover recorded (6%). Generally, there were only a small number of soft corals (0–6%) found at these sites in Lang Tengah.

A


Batu Broler
60%
50%
40%
30%
20%
10%
0%
HC
SC
RKC
NIA
SP
RC
RB
SD
SI
OT

B


Batu Bulan
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
HC
SC
RKC
NIA
SP
RC
RB
SD
SI
OT



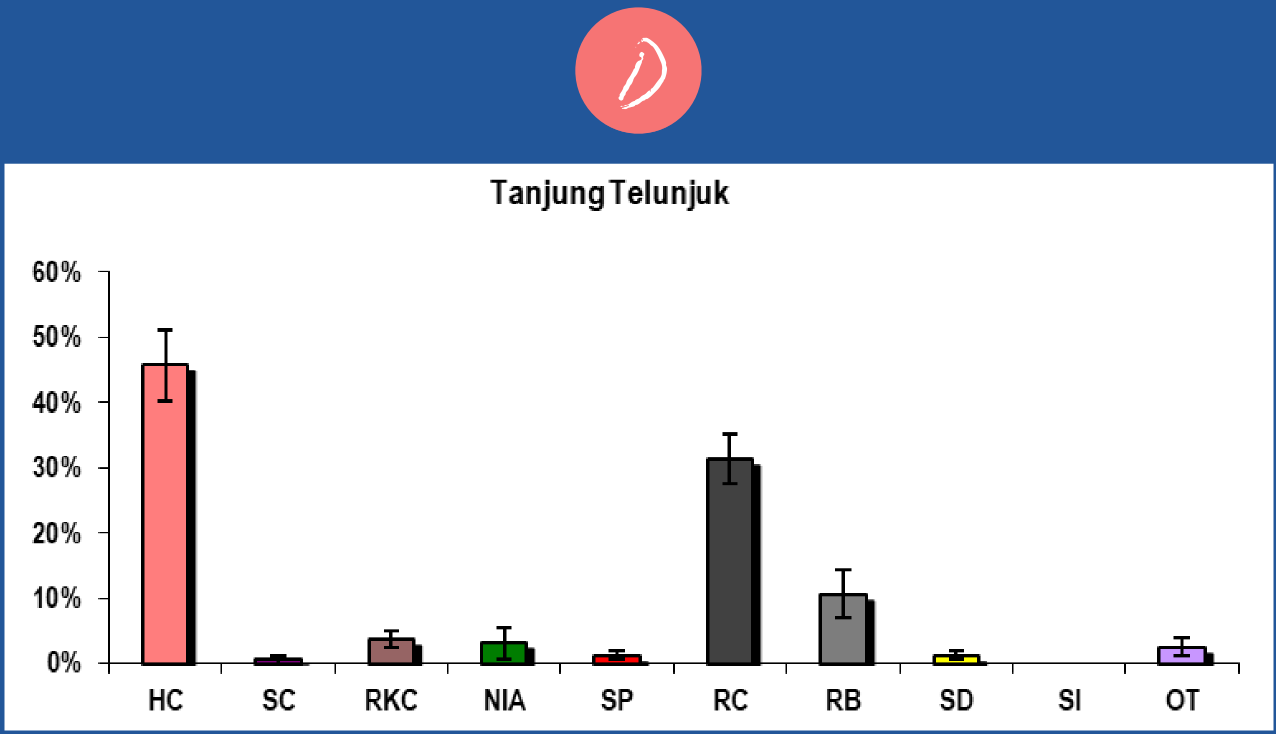
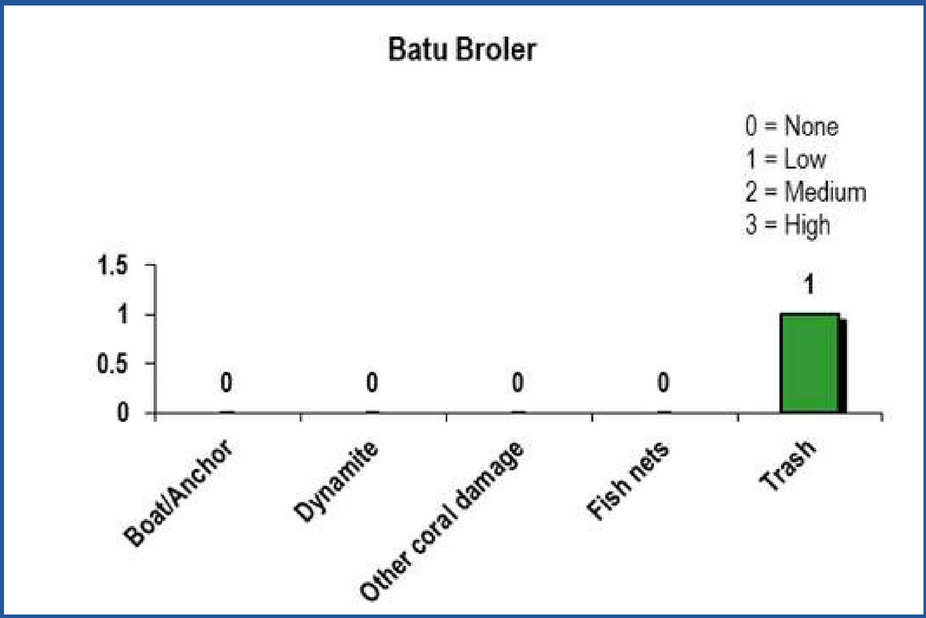


Figure 50. Mean percentage cover in October 2024 at Batu Broler (A), Batu Bulan (B), Summer Bay (C), and Tanjung Telunjuk (D). (Note: HC = Hard coral, SC = Soft coral, RKC = Recently killed coral, NIA = Nutrient indicator algae, SP = Sponge, RC = Rock, RB = Rubble, SD = Sand, SI = Silt, and OT = Others).

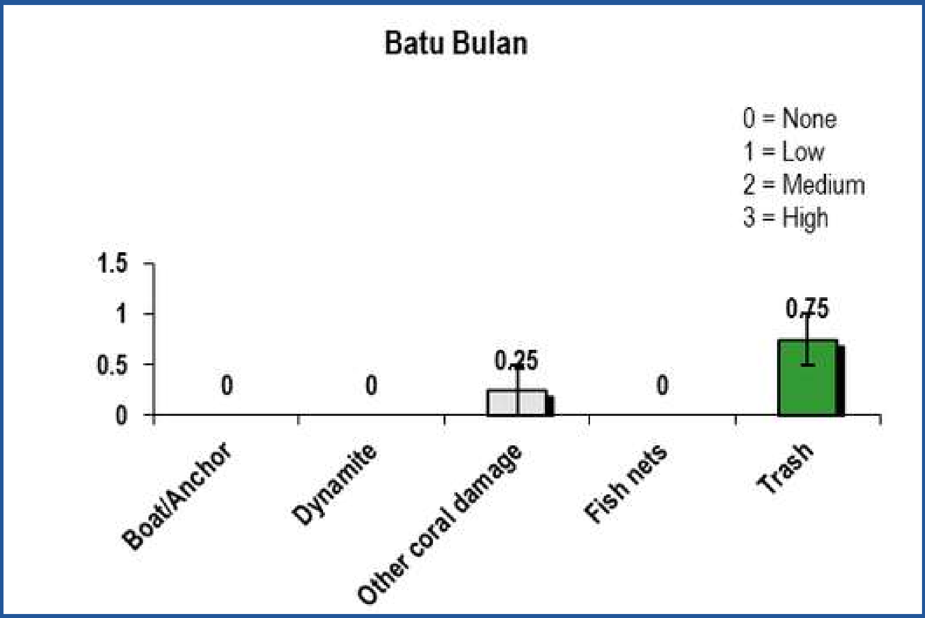
Incidence of Impacts

During the survey, any sign of impacts was recorded according to the categories and the severity, including boat/anchor damage, dynamite damage, other coral damage, fish nests, and trash. Several incidences were included as other coral damage, such as diseases, bleaching, predation of Crown of Thorns starfish, and *Drupellla sp.* snails. Overall, there were only a small number of impacts observed during the survey. The highest incidence of impact found at Lang Tengah was trash, followed by fish nets and other coral damage (Figure 39).

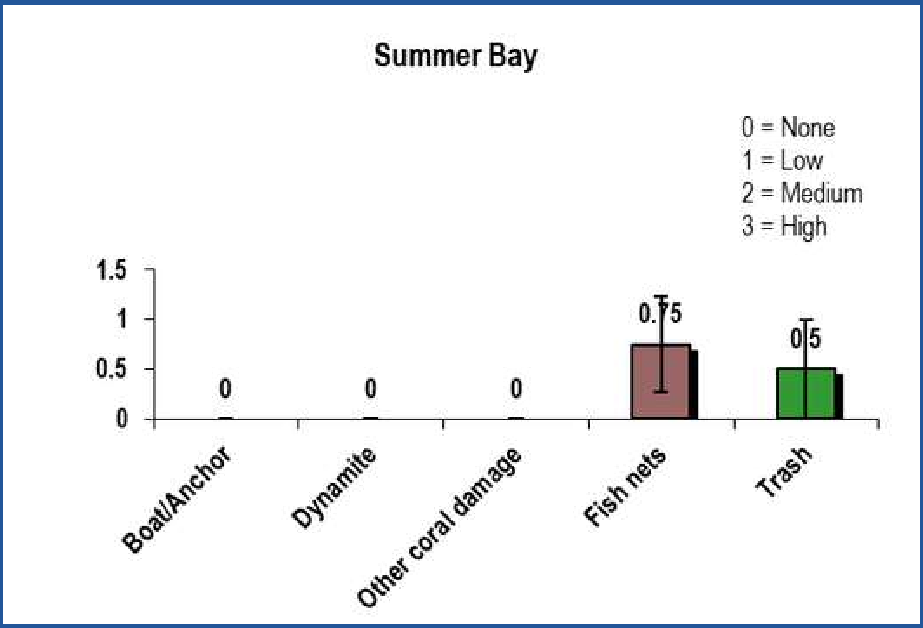
A



B


Batu Bulan
0 = None
1 = Low
2 = Medium
3 = High
1.5
1
0.5
0
0
0
0.25
0
0.75
Boat/Anchor
Dynamite
Other coral damage
Fish nets
Trash

C


Summer Bay
0 = None
1 = Low
2 = Medium
3 = High
1.5
1
0.5
0
0
0
0
0.75
0.5
Boat/Anchor
Dynamite
Other coral damage
Fish nets
Trash

D

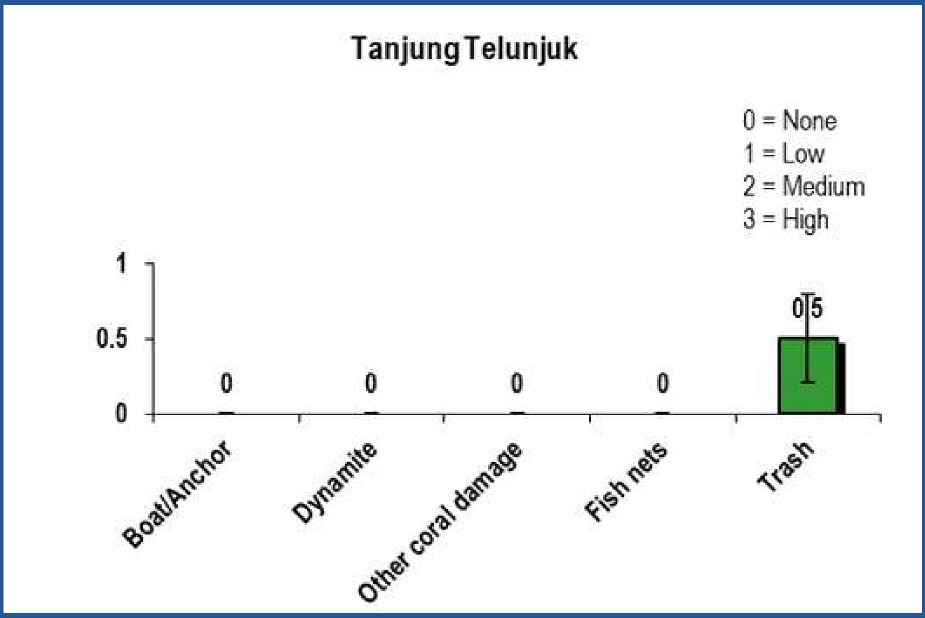


Figure 51. Incidence of impacts found during Reef Check survey at Batu Broler (A), Batu Bulan (B), Summer Bay (C), and Tanjung Telunjuk (D).

CONCLUSION

2024 has been a busy year for PULIHARA. Conservation efforts has been expanded, especially in coral restoration and monitoring, resumed our volunteer programme, and increased outreach activities such as talks, school trips, and field visits. With that, the team has now also conducted the annual Reef Check survey for examining and monitoring the coral reefs, fishes and invertebrates around the island.

Certainly, all this could not all be achieved without the staff members, interns, and volunteers who tirelessly carry out the work on the ground daily. Not forgetting the support from various sponsors and donors, which helped to sustain the project operation cost.

This year, our team had successfully monitored and saved 7 sea turtle nests, monitored the survival and growth of 357 coral fragments in the nursey, outplanted 143 coral fragments on the artificial reef, gave educational talks to 778 visitors, held 2 school visits and 2 university field trips, and removed 334.98 kg of trash from the beaches and 122.58 kg of trash from the water of Lang Tengah Island. Volunteer programme continue running to provide an opportunity for the volunteers to contribute to conservation and create an impact.

As poaching have diminished on the island while the team are present during the nesting season, PULIHARA strive to do more to save the eggs and hatchlings from natural predators in the area. In addition, coral restoration efforts are on the list to improve next year, as well as continuing the outreach programme to raise conservation awareness among the tourists and the local communities.

REFERENCES

Anderson, K. D., Cantin, N. E., Heron, S. F., Pisapia, C., & Pratchett, M. S. (2017). Variation in growth rates of branching corals along Australia's Great Barrier Reef. Scientific Reports, 7(1), Article 2920. https://doi.org/10.1038/s41598-017-03085-1

Booth, D. T., & Freeman, C. (2006). Sand and nest temperatures and an estimate of hatchling sex ratio from the Heron Island green turtle (Chelonia mydas) rookery, Southern Great Barrier Reef. Coral Reefs, 25(4), 629–633. https://doi.org/10.1007/s00338-006-0135-4

Buddemeier, R. W., & Kinzie, R. A. (1976). Coral growth. Oceanography and Marine Biology: An Annual Review, 14, 183–225.

Chan, E. H., & Liew, H. C. (1995). Incubation temperatures and sex ratios in the Malaysian leatherback turtle Dermochelys coriacea. Biological Conservation, 74(3), 169–174. https://doi.org/10.1016/0006-3207(95)00027-2

Chou, L. M., Toh, T. C., Toh, K. B., Ng, C. S. L., Cabaitan, P., Tun, K., ... & Song, T. (2016). Differential response of coral assemblages to thermal stress underscores the complexity in predicting bleaching susceptibility. PLoS One, 11(7), Article e0159755. https://doi.org/10.1371/journal.pone.0159755

Dizon, R. M., Edwards, A. J., & Gomez, E. D. (2008). Comparison of three types of adhesives in attaching coral transplants to clam shell substrates. Aquatic Conservation: Marine and Freshwater Ecosystems, 18(7), 1140–1148. https://doi.org/10.1002/aqc.944

Douglas, A. E. (2003). Coral bleaching – how and why? Marine Pollution Bulletin, 46(4), 385–392. https://doi.org/10.1016/S0025-326X(03)00037-7

Edwards, A. J. (Ed.). (2010). Reef rehabilitation manual. Coral Reef Targeted Research & Capacity Building for Management Program.

Edwards, A. J., & Gomez, E. D. (2007). Reef restoration concepts and guidelines: Making sensible management choices in the face of uncertainty. Coral Reef Targeted Research and Capacity Building for Management Program.

Forrester, G. E., Maynard, A., Schofield, S., & Taylor, K. (2012). Evaluating causes of transplant stress in fragments of Acropora palmata used for coral reef restoration. Bulletin of Marine Science, 88(4), 1099–1113. https://doi.org/10.5343/bms.2012.1016

Gleason, F. H., Allerstorfer, M. & Lilke, O. (2020). Newly emerging diseases of marine turtles, especially sea turtle egg fusariosis (SEFT), caused by species in the Fusarium solani complex (FSSC). Mycology, 11(3), 184–194.

Guest, J. R., Dizon, R. M., Edwards, A. J., Franco, C., & Gomez, E. D. (2011). How quickly do fragments of coral “self-attach” after transplantation? Restoration Ecology, 19(2), 234–242. https://doi.org/10.1111/j.1526-100X.2009.00562.x

Hall, V.R., & Hughes, T. P. (1996). Reproductive strategies of modular organisms: Comparative studies of reef-building corals. Ecology,77(3), 950–963. https://doi.org/10.2307/2265514

Harborne, A., Fenner, D., Barnes, A., Beger, M., Harding, S., & Roxburgh, T. (2000). Status report on the coral reefs of the east coast of Peninsula Malaysia. Coral Cay Conservation.

Hodgson, G. (1999). A global assessment of human effects on coral reefs. Marine Pollution Bulletin, 38(5), 345-355.

Jennings, S., Greenstreet, S. P. R., & Reynolds, J. D. (1999). Structural change in an exploited fish community: A consequence of differential fishing effects on species with contrasting life histories. Journal of Animal Ecology, 68(3), 617–627. https://doi.org/10.1046/j.1365-2656.1999.00312.x

Jennings, S., Reynolds, J. D., & Mills, S. C. (1998). Life history correlates of responses to fisheries exploitation. Proceedings of the Royal Society B: Biological Sciences, 265(1393), 333–339. https://doi.org/10.1098/rspb.1998.0300

Jaap, W. C. (2000). Coral reef restoration. Ecological Engineering, 15(3–4), 345–364. http://dx.doi.org/10.1016/S0925-8574(00)00085-9

Johannes, R. E. and Riepen, M. (1995). Environmental, economic, and social implications of the live reef fish trade in Asia and the Western Pacific. The Nature Conservancy and the Forum Fisheries Agency.

Lloyd, J. R., Maldonado, M. Á., & Stafford, R. (2012). Methods of developing user-friendly keys to identify green sea turtles (Chelonia mydas L.) from photographs. International Journal of Zoology, 2012, Article 317568. https://doi.org/10.1155/2012/317568

Long, S. L., & Azmi, N. A. (2017). Using photographic identification to monitor sea turtle populations at Perhentian Islands Marine Park in Malaysia. Herpetological Conservation and Biology, 12(2), 350–366. http://www.herpconbio.org/Volume_12/Issue_2/Long_Azmi_2017.pdf

Loya, Y. (1976). The Red Sea coral Stylophora pistillata is an r strategist. Nature, 259, 478–480. http://doi:10.1038/259478a0

Mohamed Sidique, S. N., Azuddin, N. F., & Joseph, J. (2017). First report of fusarium species at nesting sites of endangered sea turtles in Terengganu and Melaka, Malaysia. Malaysian Applied Biology, 46(3), 195–205. http://journalarticle.ukm.my/12375/

Mrosovsky, N. (1994). Sex ratios of sea turtles. Journal of Experimental Zoology, 270(1), 16–27. https://doi.org/10.1002/jez.1402700104

Ng, C. S. L., Lim, S. C., Ong, J. Y., Teo, L. M. S., Chou, L. M., Chua, K. E., & Tan, K. S. (2015). Enhancing the biodiversity of coastal defence structures: Transplantation of nursery-reared reef biota onto intertidal seawalls. Ecological Engineering, 82, 480–486. https://doi.org/10.1016/j.ecoleng.2015.05.016

Pratchett, M. S., Anderson, K. D., Hoogenboom, M. O., Widman, E., Baird, A. H., Pandolfi, J. M., ... & Lough, J. M (2015). Spatial, temporal and taxonomic variation in coral growth- implications for the structure and function of coral reef ecosystems. Oceanography and Marine Biology: An Annual Review, 53,215–295.

Reboul, I., Booth, D. T., & Rusli, M. U. (2021). Artificial and natural shade: implications for green turtle (Chelonia mydas) rookery management. Ocean and Coastal Management, 204, 105521. https://doi.org/10.1016/j.ocecoaman.2021.105521
Rinkevich, B. (2005). Conservation of coral reefs through active restoration measures: Recent approaches and last decade progress. Environmental Science & Technology, 39(12), 4333–4342. https://doi.org/10.1021/es0482583

Rinkevich, B. (2019). The active reef restoration toolbox is a vehicle for coral resilience and adaptation in a changing world. Journal of Marine Science and Engineering, 7(7), 201. https://doi.org/10.3390/jmse7070201

Sarmiento-Ramírez, J. M., Abella, E., Martín, M. P., Tellería, M. T., López-Jurado, L. F., Marco, A. & Diéguez-Uribeondo, J. (2010). Fusarium solani is responsible for mass mortalities in nests of loggerhead sea turtle, Caretta caretta, in Boavista, Cape Verde. FESM Microbiology Letters, 312(2), 192–200. https://doi.org/10.1111/j.1574-6968.2010.02116.x

Sarmiento-Ramírez, J. M., Abella-Pérez, E., Phillott, A. D., Sim, J., van West, P., Martín, M. P., Marco, A., Diéguez-Uribeondo, J. (2014). Global distribution of two fungal pathogens threatening endangered sea turtles. PLoS ONE, 9(1), Article e85853. https://doi.org/10.1371/journal.pone.0085853

Schofield, G., Katselidis, K. A., Dimopoulos, P., & Pantis, J. D. (2008). Investigating the viability of photo-identification as an objective tool to study endangered sea turtle populations. Journal of Experimental Marine Biology and Ecology, 360(2), 103–108. https://doi.org/10.1016/j.jembe.2008.04.005

Shafir, S., Van Rijn, J., & Rinkevich, B. (2006). Steps in the construction of underwater coral nursery, an essential component in reef restoration acts. Marine Biology, 149(3), 679–687. https://doi.org/10.1007/s00227-005-0236-6

Shin, Y. J., Rochet, M. J., Jennings, S., Field, J. G., & Gislason, H. (2005). Using size-based indicators to evaluate the ecosystem effects of fishing. ICES Journal of Marine Science, 62(3), 384–396. https://doi.org/10.1016/j.icesjms.2005.01.004

Su, C. M., Huang C. T., & Cheng, I. J. (2015). Applying a fast, effective and reliable photographic identification system for green turtles in the waters near Luichiu Island, Taiwan. Journal of Experimental Marine Biology and Ecology, 467, 115–120. https://doi.org/10.1016/j.jembe.2015.03.003

Toh, T. C., Ng, C. S. L., Peh, J. W. K., Toh, K. B., & Chou, L. M. (2014). Augmenting the post-transplantation growth and survivorship of juvenile scleractinian corals via nutritional enhancement. PLoS One, 9(6), e98529. https://doi.org/10.1371/journal.pone.0098529

Tolen, N., Rusli, M. U., & Booth, D. T. (2021). Relocation green turtle (Chelonia mydas) eggs to open beach areas produces high female-biased hatchlings. Herpetological Conservation and Biology, 16(3), 639–651. http://www.herpconbio.org/Volume_16/Issue_3/Tolen_etal_2021.pdf

van de Merwe, J., Ibrahim, K., & Whittier, J. (2005). Effects of hatchery shading and nest depth on the development and quality of Chelonia mydas hatchlings: implications for hatchery management in Peninsular Malaysia. Australian Journal of Zoology, 53(3), 205–211. https://doi.org/10.1071/ZO03052

Wilkinson, C. (2004). Status of coral reefs of the world: 2004 (Vol. I). Australian Institute of Marine Science. Australian Institute of Marine Science. https://gcrmn.net/wp-content/uploads/2018/04/scr2004v1-all.pdf

Adams, D.M., Williamson, S.A., Evans, R.G., & Reina, R.D. (2022). Increasing hypoxia progressively slows early embryonic development in an oviparous reptile, the green turtle, Chelonia mydas. Royal Society Open Science, 9, 220709. https://doi.org/10.1098/rsos.220709

Gárriz, A., Williamson, S.A., Roger G. Evans, R.G., & Reina, D.R. (2020). A method for the collection of early-stage sea turtle embryos. Endangered Species Research, 42, 59–65. https://doi.org/10.3354/esr01039

Salleh, S.M., Sah,S.A.M., & Chowdhury, A.J.K. (2018). Distribution, abundance, and clutch size of
hawksbill turtle nests in Melaka, Malaysia. Malaysian Applied Biology, 47(3), 29–38.
https://www.mabjournal.com/images/47_3_June_2018/47_03_04.pdf

APPENDIX

Appendix 1. Post-emergence inspection data for all the nests at Lang Tengah in 2024.

Nest	Species	Type of nest	Total eggs	Empty eggshells	Dead hatchlings	Live hatchlings	Unhatched eggs	Depredated eggs (inc. missing eggs)	Hatching success (%)	Emergence success (%)	Predation rate (inc. missing eggs, %)	Fungal infection (%)
1A*	Green	In-situ	114	61	0	0	36	17	53.51	53.51	14.91	6.14
1	Green	In-situ	138	66	0	1	23	37	47.83	47.10	26.81	21.01
2^	Green	In-situ	109	84	1	7	3	4	77.06	69.72	3.67	1.83
3*	Green	In-situ	104	90	1	0	1	13	86.54	85.58	12.50	12.50
4	Green	In-situ	103	99	0	0	3	1	96.12	96.12	0.97	0.97
5	Green	In-situ	112	96	0	0	3	13	85.71	85.71	11.61	2.68
6**	Green	In-situ	105	102	0	0	2	1	97.14	97.14	0.95	0.95
7†	Green	In-situ	-	-	-	-	-	-	-	-	-	-

Notes:

^ In-situ nest that was relocated due to inundation from high tide.

* Nests 1A and 3 were missed counting the eggs. The number of eggs was counted during post-emergence inspection.

** Nest 6 eggs were counted at 102 during nesting but 105 eggs were counted during post-emergence inspection.

† Nest 7 was missed as we thought it was an attempted nesting (AN). There were signs of monitor lizard disturbance and predation of where the assumed nest should be. After digging again, no eggs were found but deduced to be a nesting activity due to the smell.