# Annual Report 2022

Lang Tengah Island

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lang tengah turtle watch


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# Acknowledgements

The conservation and research work under Lang Tengah Turtle Watch was carried out in collaboration with the Department of Fisheries (DoF). The educational outreach activities were successfully organised with the support of the Department of State Education and schools.

We would also like to specially thank Yayasan Sime Darby, Malaysian Global Innovation & Creativity Centre (MaGIC), Su Yin & Steve Hagger, Sea of Change Foundation, WWF-Malaysia, Simplify, and Miracle Spectrum, all of which provided us generous funding and in-kind support to fully sustain our operations. Although the operations of the volunteer programme and the Resthouse have resumed with the removal of travel restrictions, our sponsors' contribution made it possible to keep the project running throughout the year.

We also extend our utmost appreciation to Reef Check Malaysia for training up our staff as certified EcoDivers to conduct fish, invertebrate and substrate survey on Lang Tengah Island.

We are also thankful to all the tourism stakeholders in Lang Tengah Island, including Summer Bay Island Resort, Sari Pacifica Resort & Spa, D'Coconut Lagoon Resort and Dewati Camp Site, for their help and support.

The work presented here was carried out by our dedicated team – Azrin Asyikin Mohd Shukor, Yasmin Rizal, Cheok Tze Ning, Shamil Arif Muhamad, and Long Seh Ling. We would also like to express our gratitude to our interns – Chong Yu Yuan, Maisarah Binti Samsulsah, Mohd Syahiran Bin Masrin, Nur Fatini Binti Mahat, Luqman Hakim Bin Mohamad Nahar, Darshanaa Chellaiah, Adam Shehab, Anastasia Ting Jia Lei, Zoe Middleton, Lee Joey, and Sydney Cheong Wai Choong, as well as our volunteers, for their invaluable help in patrolling the nesting beaches across the season on a nightly basis, collecting and analysing nesting, landing and hatching data, doing beach clean-ups, and engaging with stakeholders and guests to Lang Tengah Turtle Watch.

Lastly, our utmost gratitude is extended to Hayati Mokhtar, Raphe van Zevenbergen, and Dato' David Morais, directors of Lang Tengah Turtle Watch, for their ongoing support and advice. We would also like to thank our Admin Assistant – Chen Suet Yen, Operations Coordinator – Eileen Nyeow, and The Resthouse Host – Audra Roslani, for supporting the project.

# 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 7.6 km of shoreline surrounded by clear waters. It has been gazetted as a marine park.

The island represents an important nesting and foraging grounds for two endangered sea turtle species – green turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*). Lang Tengah Turtle Watch has been conducting sea turtle monitoring since 2013 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, Lang Tengah Turtle Watch 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 outreach educational programmes.

In 2022, we continued our mission of protecting sea turtles and marine ecosystem on Lang Tengah Island. The camp reopened in mid-March with two new staff members, Tze Ning, as co-manager, and Shamil as marine biologist of the project site. This year, we continue our long-term internship programme to ensure we are able to carry out our conservation efforts without a hitch. Thankfully, with the removal of travel restriction, our volunteer programme resumed and be able to accommodate more people to help out us on the ground.

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. We collaborated with Universiti Malaysia Terengganu (UMT) to measure nest temperature in order to determine sex ratio of the nests as well as to collect sand samples for sea turtle egg fungal research studies.

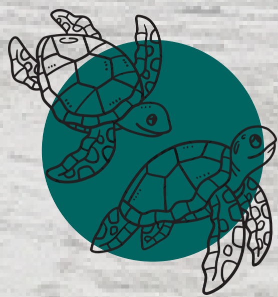
This year, we also collaborated with Reef Check Malaysia to train up our staff as certified Reef Check Eco-divers. This has allowed us to share the information of the condition of reef by conducting annual survey at Lang Tengah.

We also 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 nest inspections.

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.

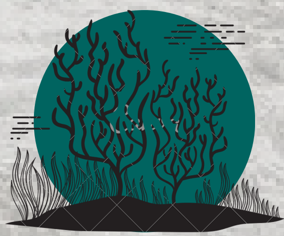
# Objectives

## 1 Turtle Conservation



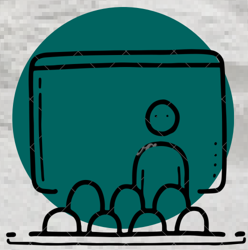
To conduct long-term monitoring to better understand and conserve the nesting and in-water sea turtle populations including their habitats in Lang Tengah Island.

## 2 Coral Conservation



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

## 3 Educational Outreach



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

Sea turtle monitoring is our core activity on Lang Tengah. Night patrols were conducted to monitor nesting activities at two nesting beaches: Turtle Bay where our campsite is located and Lang Sari (Figure 1). Patrols were conducted on an hourly basis to ensure that no nesting female is missed. Each night, 2-3 people were assigned to patrol each beach from 8 p.m. to 1 a.m. during the first shift, and from 2 a.m. to 7 a.m. during the second shift.

Additionally, several reports of nesting at Summer Bay were received. That beach was briefly patrolled when there was expected nesting. Nests that were laid on Turtle Bay were left incubating in situ, meanwhile nests laid on Lang Sari and Summer Bay were relocated to Turtle Bay so that the team could monitor more closely and deter poaching unless the nests were found more than six hours.


Figure 1. Nesting beaches and the location of our base on Lang Tengah Island.

Biometric data and photographs of the nesting turtles were collected by the team after it had finished laying eggs (Figure 2). This was done illuminated by red light only, as it causes the least disruption to the turtle. Facial photographs of nesting females were taken for individual identification using photo-identification (photo-ID) methods where visual comparison was made manually (Figure 3; see Llyod et al., 2012; Long & Azmi, 2017; Schofield et al., 2008; Su et al., 2015).

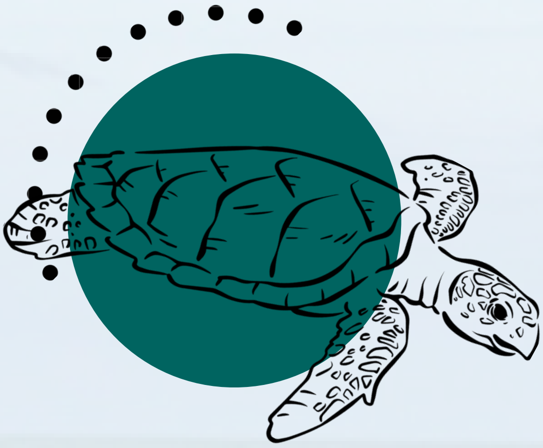
Figure 2. The team collecting biometric data and photographs of the nesting turtle.

Figure 3. A facial photograph of a female turtle, which was identified as a new nester based on its facial scale patterns.

It takes approximately 60 days for turtle eggs to hatch and for hatchlings to emerge from their nest. Post-emergence inspection (PEI) was conducted by excavating the nest a few days after seeing the first sign of hatchling emergence. If the team missed or did not observe any signs, PEI was done 70 days after the nest was laid. Numbers of eggshells, unhatched eggs, depredated eggs, live hatchlings, and dead hatchlings were counted to determine the hatching and emergence success (Figure 4). Signs of predation by crabs, ants, termites, monitor lizards and maggots, fungal infection according to a severity index of Stage 1 to 4, and nest temperatures of some of the nests using HOBO MX TidbiT 400 temperature loggers were recorded after the examination of the eggs.


Figure 4. The team conducting post-emergence inspection (PEI), in which the HOBO MX TidbiT 400 logger placed in some of nests to track incubation temperature was removed during PEI.

In addition to monitoring nesting sea turtles on Lang Tengah, snorkel and dive surveys were conducted to document the in-water sea turtle population. An underwater camera (Olympus TG6) was used for photograph and/or take videos of any turtles that were sighted during the survey. These encounters were opportunistic since Lang Tengah does not have specific turtle feeding grounds, unlike the Redang and Perhentian islands. Additional data were collected on these surveys, including the species of turtle, its sex, age, behaviour (such as resting or feeding), and depth where the turtle was encountered.



# Hawksbill Turtles

This year, the critically endangered hawksbill turtle nested in March and April on Lang Tengah. This is the seventh year of Lang Tengah recorded the nesting activity of hawksbill turtle (Figure 5). There were four hawksbill turtle landings this year, of which three nests were laid. Two nests were laid at Turtle Bay and one at Lang Sari. Only one individual female was identified. It was a returning female named Cassiopeia (LTH0007F) that had nested every two years since 2014.

A total number of 294 eggs from three hawksbill turtle nests, with 98 ± 21.9 (mean ± SD) eggs each nest, were saved. Only two hatchlings hatched, with an average hatching rate of 0.8% (SD=0.68). Most of the eggs from the hawksbill nests (99.3%) were found to be undeveloped with sign of fungi. This is possibly due to the rainy weather during the early of the season and the high humid conditions in the sands that favour the spread of fungus, or infertile eggs.

Ten in-water turtle survey dives were conducted by the team throughout the season (Figure 6). Apart from that, tourists who dived at Lang Tengah submitted pictures of turtles to us. From six hawksbill sightings, three hawksbills were identified and given photo-IDs LTH0015U, LTH0016U, and LTH0017U. There was no resighting of hawksbill turtles that were already in our database. Interestingly, LTH0016U were resighted four times at different dive sites of the island this season.

Figure 6. Two hawksbill turtles identified and given an ID of LTH0015U (Lemon; left) and LTH0016U (Alora; right) in 2022.

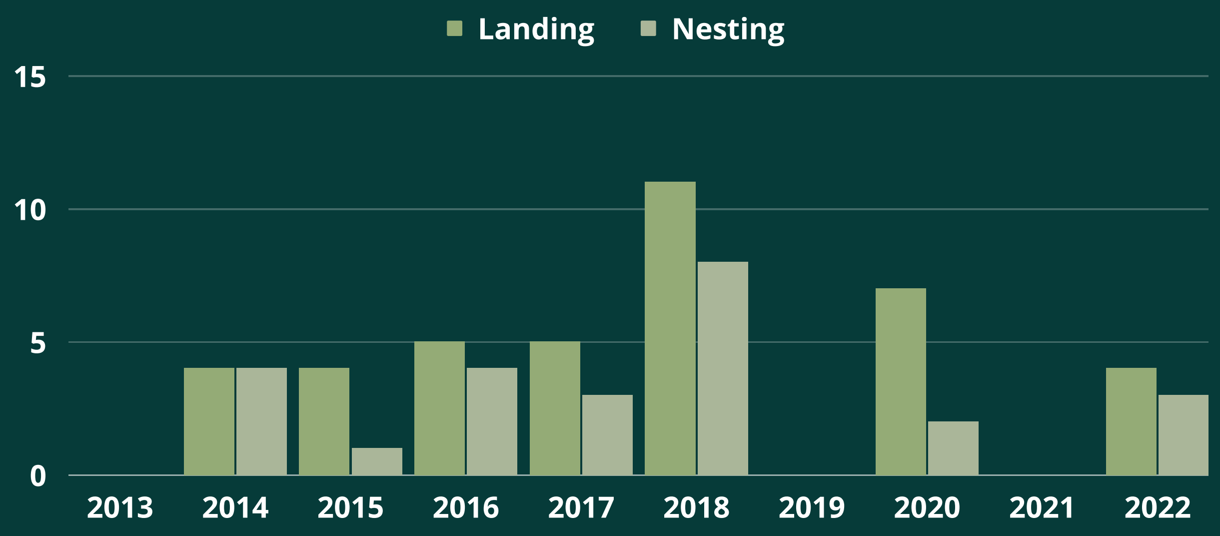



Figure 5. Number of hawksbill turtle landings and nests in Lang Tengah Island from 2013 to 2022.

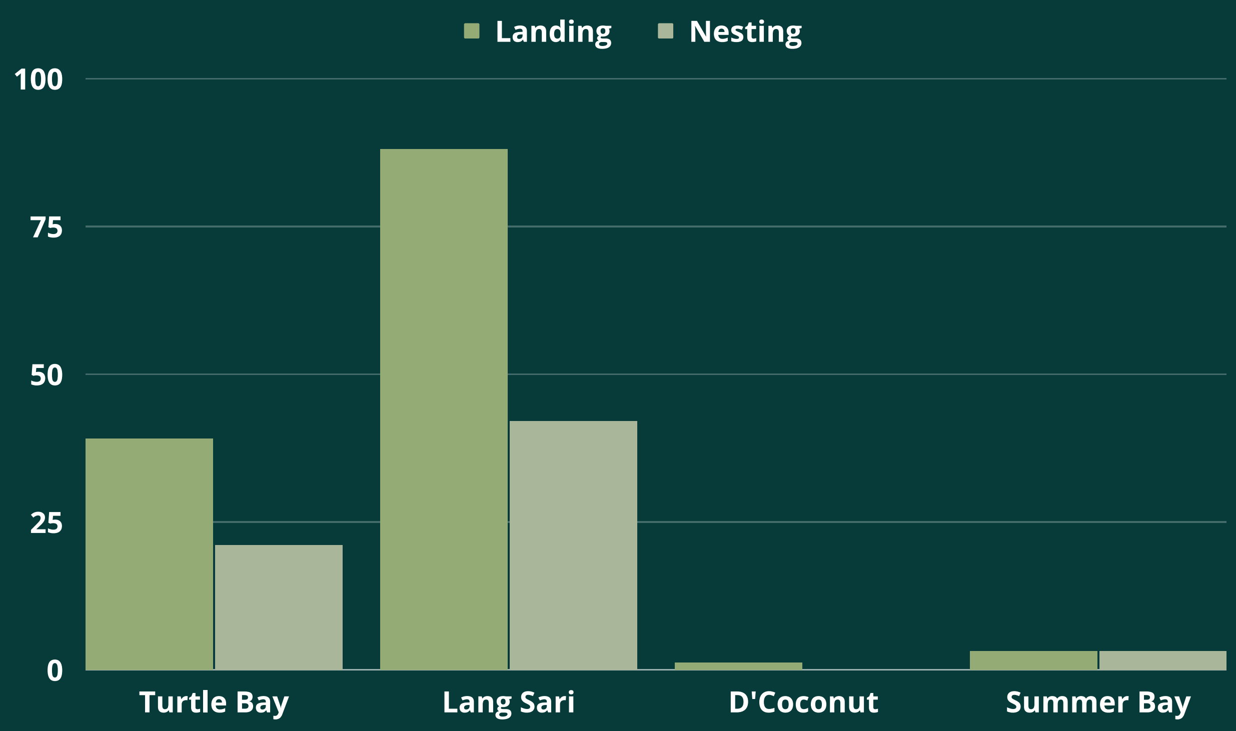
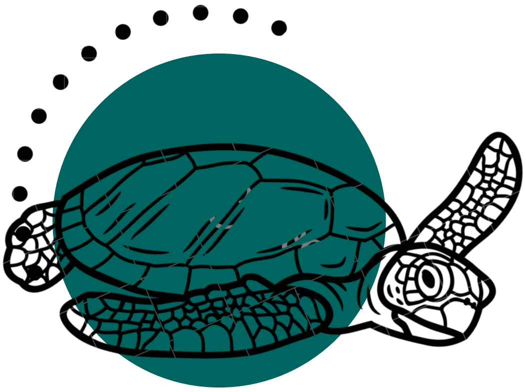



Figure 7. Number of green turtle landings and nests at different beaches of Lang Tengah Island in 2022.



# Green Turtles

Nesting activity of green turtle in Lang Tengah were recorded from March to September 2022. There was a total of 125 landings of green turtle recorded on the island, with 66 nests saved. There were 21 nests at Turtle Bay, three nests at Summer Bay in font of Sari Pacifica Resort, and 42 nests at Lang Sari (Figure 7). All the nests laid at Lang Sari were relocated to Turtle Bay, while only one from Summer Bay was relocated.

Sixteen individual females were identified using photo-ID methods (Table 1; Figure 8). Of that, 11 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. Another five individuals were returning nesters who nested on Lang Tengah in previous years. The inter-nesting interval of the nesting females ranged between 9 and 52 days. Longer gap of the interval could be due to the individual nested at other sites unknown to us. Some nesting females only nested at Lang Tengah once throughout the season, therefore the inter-nesting interval is not available for those individuals. Four of the nesters were missed during nesting, so there were no facial photos of these nesting females.

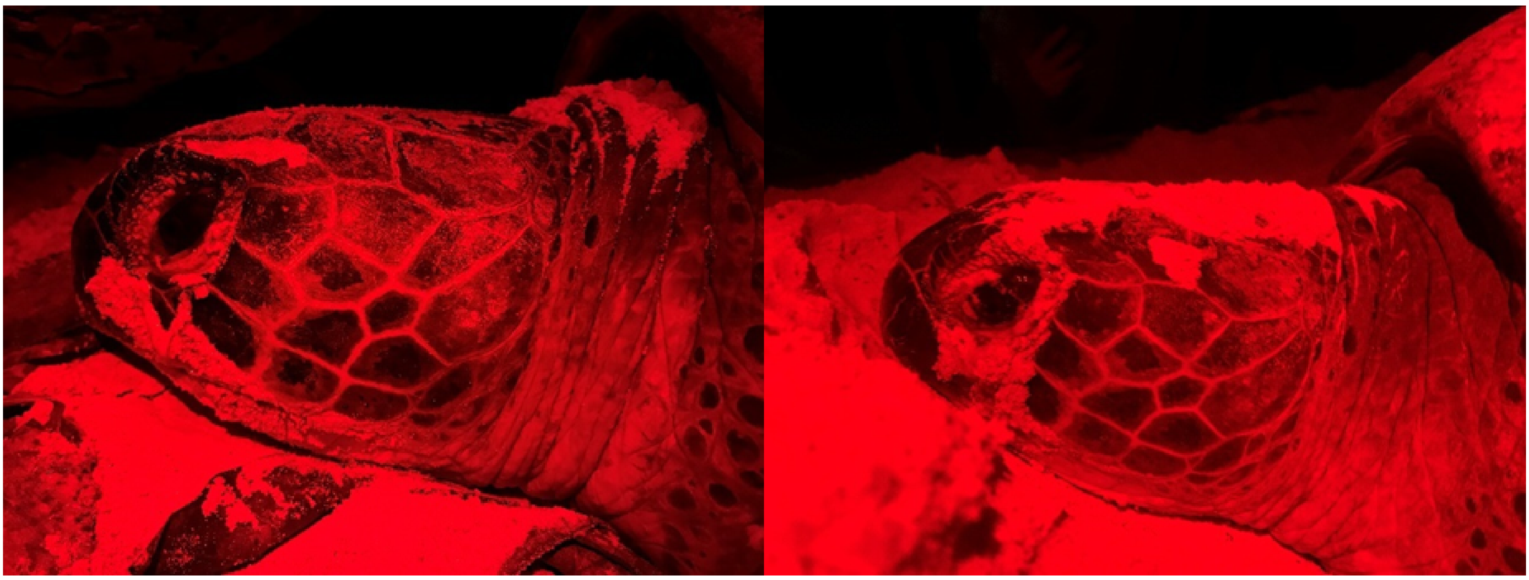


Figure 8. Facial photo of nesting turtles from different landings on 25 March 2022 (left) and 26 April 2022 (right). Both sightings are from same nesting turtle, LTG0050F (Nona), by comparing the facial scales of the turtles.

Table 1. Nesting information of 16 individual female green turtles.

| Turtle ID | Turtle name | New / Returning mother | No. of nests | Total eggs laid | Average clucth size (mean ± SD) | Nesting site | Inter-nesting interval (days) |
|---|---|---|---|---|---|---|---|
| LTG0010F | Raani | Returning | 6 | 825 | 138 ± 8 | Turtle Bay & Lang Sari | 9-20 |
| LTG0027F | Hayleybell | Returning | 7 | 987 | 141 ± 11.7 | Lang Sari | 9-20 |
| LTG0033F | Matilda | Returning | 5 | 727 | 145 ± 3.9 | Lang Sari | 10-34 |
| LTG0036F | Josheena Plankton | Returning | 1 | 111 | - | Turtle Bay | 9-11 |
| LTG0039F | Go For Wand | Returning | 8 | 773 | 97 ± 2.2 | Turtle Bay & Lang Sari | 10-28 |
| LTG0049F | Toojou | New | 5 | 298 | 60 ± 30 | Turtle Bay | 10-13 |
| LTG0050F | Nona | New | 6 | 557 | 93 ± 6.6 | Turtle Bay & Lang Sari | - |
| LTG0051F | **Not yet named* | New | 1 | 116 | - | Lang Sari | - |
| LTG0052F | Bulldozer | New | 1 | 84 | - | Lang Sari | - |
| LTG0053F | Tyra | New | 8 | 701 | 88 ± 6.8 | Turtle Bay | 9-11 |
| LTG0054F | Awalla | New | 1 | 74 | - | Lang Sari | - |
| LTG0055F | **Not yet named* | New | 2 | 221 | 111 ± 9.2 | Turtle Bay & Lang Sari | 10-52 |
| LTG0056F | Mahalia | New | 2 | 174 | 87 ± 4.2 | Lang Sari | 44 |
| LTG0057F | Bessie | New | 6 | 466 | 78 ± 6.8 | Turtle Bay & Lang Sari | 9-12 |
| LTG0058F | Elvy | New | 1 | 106 | - | Turtle Bay | - |
| LTG0059F | Anju | New | 2 | 195 | 98 ± 10.6 | Turtle Bay & Lang Sari | 12 |

In 2022, 6,768 green turtle eggs were laid on Lang Tengah. The clutch size was was 103 eggs (SD=28.2). The number of eggs was counted and recorded during the relocation process. Two in-situ nests were missed by patrollers and encountered only after the turtle had left; the number of eggs for these nests was based on the number of eggs found during PEI and thus, does not indicate the full size of the clutch. The number of eggs in one nest is unknown as the nest, suspected to be predated by monitor lizards was not found.

The hatching and emergence success of the green turtle nests are detailed in Appendix 1. Two nests had not hatched when the team left the island. Overall, 62 nests on Lang Tengah reported an average hatching success rate of 77.8% (0–100%). Relocated nests had slightly higher hatching success rate compared to in-situ nests, 79.1% (14.3–100%) and 75.2% (0–100%), respectively. Four nests had 100% hatching success, while one nest with sign of monitor lizard had zero hatching success throughout the season. The average emergence success rate for 62 green turtle nests was 76% (0–100%).

The nests were vulnerable to predation by monitor lizards, crabs, termites, ants and fungi. The predation rate of each nest is shown in Appendix 1. Ten nests had signs of monitor lizard disturbance. Similar pattern was noticed last year, in which the monitor lizards tend to attack the in-situ nests when its freshly laid while the relocated nests were predated by monitor lizards as the hatchlings were crawling up the nest (Figure 9). This year, there is less predation from monitor lizards compared to 2021 in which 19 nests were spotted with sign of predation from monitor lizards. It is possible that with the returning of tourists and volunteers, there were more humans on the beach and therefore, preventing the monitor lizards from approaching the nests.

Figure 9. Sign of monitor lizard predation on relocated nest with empty eggshells scattered around.

During the nest excavation, fungal infections were commonly found on the eggs. From 64 excavated nest, totals of 378 (7.6%) unhatched green turtle eggs were recorded with several severities of fungal infestation on the eggshells. The fungal infection rate for every nest is presented in Appendix 1.

In collaboration with UMT, sand samples were collected (before incubation and after excavating) and sent to UMT for fungi analysis. Fungi present in the sand were extracted and isolated by researchers from UMT in order to identify the fungi found in the sea turtle nests. According to the report, sand samples from Lang Tengah contained *Aspergillus*, *Fusarium*, *Penicillium*, *Trichoderma*, bacteria, and others (Figure 10). According to Gleason et al. (2020), all microbial species found in sea turtle nests at Lang Tengah are the common species found in sea turtle nests worldwide.

Fungal infection on sea turtle eggs is the newly emerging threat to sea turtle eggs as it reduces the hatching success of sea turtle eggs (Gleason et al., 2020; Sarmiento-Ramírez et al., 2010, 2014; Mohamed Sidique et al., 2017). Ongoing assessment of the fungi presence and diversity on the nesting beaches enables us to take mitigation measures to treat the sand with natural anti-fungi and anti-bacteria remedies, should fungal infection be identified as a major threat at Lang Tengah.

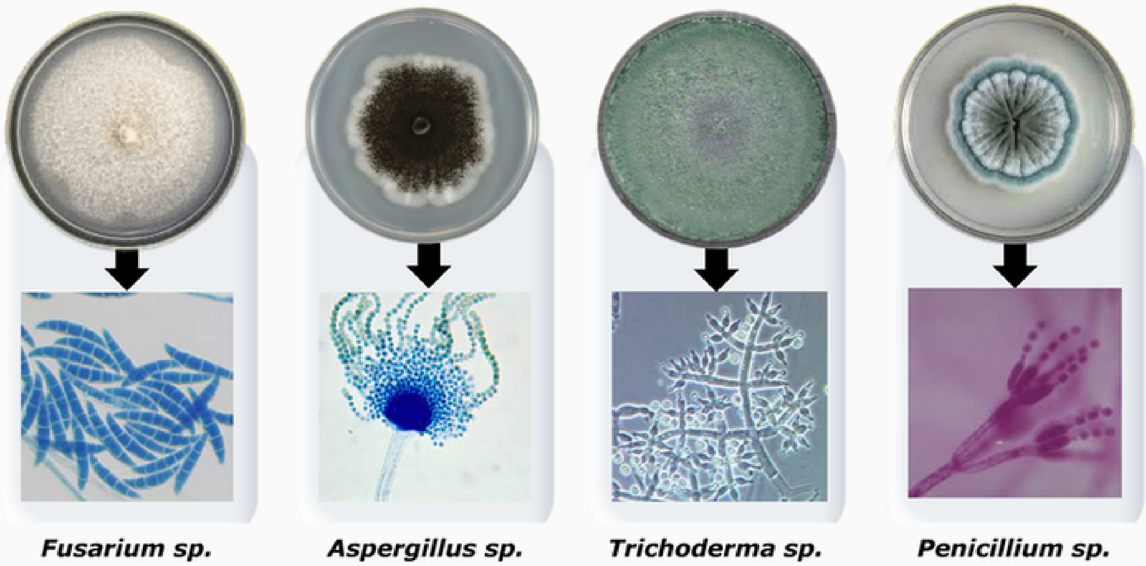



Figure 10. Soil-borne fungi found in sea turle nests. Source: LAPDiM, FPSM, UMT.

Besides, temperature loggers were deployed in 22 nests to track respective nest temperatures during incubation, and used a logistical equation to estimate hatchling sex ratio in each nest (see Booth & Freeman, 2006; Tolen et al., 2021) with a proposed pivotal temperature of 29.1°C for the Malaysian green turtle population (Chan & Liew, 1995; Reboul et al., 2021; van de Merwe et al., 2005). 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). Two of the loggers were dug out by monitor lizards. From 20 nests that had retrievable 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 20 green turtle nests in 2022.

| Nest | Type of nest | Days of incubation | Shading | Average temperature (± SD) during Temperature - Sensitive Period (°C) | Percentage of female hatchling (%) |
|---|---|---|---|---|---|
| 5 | Relocated | 70 | No | 27.3 ± 0.19 | 0.01 |
| 6 | In-situ | 65 | Yes | 28.5 ± 0.44 | 4.73 |
| 9 | Relocated | - | No | 27.9 ± 0.33 | 0.24 |
| 15 | Relocated | - | Yes | 28.1 ± 0.39 | 0.86 |
| 16 | In-situ | 65 | Yes | 27.9 ± 0.23 | 0.18 |
| 18 | In-situ | - | Yes | 28.1 ± 0.55 | 0.86 |
| 19 | Relocated | 65 | Yes | 28.1 ± 0.5 | 0.75 |
| 24 | Relocated | 64 | No | 28.6 ± 0.62 | 9.35 |
| 32 | In-situ | 65 | Yes | 28 ± 0.52 | 0.34 |
| 33 | Relocated | 65 | No | 28.6 ± 0.72 | 10.06 |
| 38 | Relocated | - | No | 28.5 ± 0.39 | 5.58 |
| 41 | In-situ | 67 | Yes | 27.7 ± 0.39 | 0.11 |
| 44 | In-situ | - | Yes | 28.2 ± 0.48 | 1.09 |
| 45 | Relocated | 65 | Yes | 28.4 ± 0.56 | 3.75 |
| 46 | Relocated | - | Yes | 28.3 ± 0.51 | 1.75 |
| 52 | Relocated | 67 | Yes | 27.8 ± 0.22 | 0.12 |
| 53 | Relocated | - | Partially | 28.1 ± 0.51 | 0.85 |
| 55 | In-situ | 69 | Yes | 27.3 ± 0.27 | 0.01 |
| 60 | Relocated | - | Yes | 27.5 ± 0.48 | 0.03 |
| 65 | Relocated | - | Yes | 28.2 ± 0.43 | 1.22 |

During the in-water turtle survey dives, the team managed to encounter a juvenile green turtle. A few pictures of turtles that were taken by tourists who dived at Lang Tengah were also analysed. As result, two juvenile green turtles were identified using the photo-ID methods. One of the juvenile green turtles (LTG0046U) was a resighted turtle as the first sighting of the same individual was in 2021. Meanwhile, the other juvenile green turtle was sighted for the first time at Lang Tengah and was given a photo-ID LTG0060U (Figure 11).

Figure 11. Two green turtles sighted and identified as LTG0046U (left) and LTG0060U (right) in 2022.

# Coral Restoration

Lang Tengah Island reefs are rich in hard coral species (Harborne et al., 2000). However, there are some rubble areas around the island with large dead tabular and massive colonies and plenty of small branching rubble pieces, which were obviously complex reefs not so long ago.

Lang Tengah Turtle Watch completed the first comprehensive baseline description of the hard corals around the island, as well as extended monitoring to reveal a diverse hard coral of Lang Tengah reefs at genus level with dissimilarities. This baseline information revealed extensively the reefs around the island for the first time, drawing attention to an essential issue. The reefs are suffering from bleaching, overfishing, predator outbreak, non-sustainable tourism and storms (Wilkinson, 2004). Together with accumulated anthropogenic imprints on coral reefs, scientists have shown that all major reefs suffer from cumulative degradation and a complete reshuffling of their biological diversity as they evolve into less diverse ecosystem (Rinkevich, 2019). The aim of this project is to restore locally deteriorated coral reefs while also protecting others that are still in good condition.

Conservation measures alone are not enough to protect coral reefs from declines. Active restoration is crucial in situations where an ecosystem's natural recovery is minimal or where preservation through management interventions is insufficient. The active reef 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 started coral transplantation and growing coral fragments in our mid-water floating nurseries at Turtle Bay (Figure 12A). The corals of opportunity grown in the nurseries were collected in front of Summer Bay Resort (Figure 12C). Once the coral fragments have grown to a certain size, we would then outplant them into the nature reefs at Tanjung Telunjuk (Figure 12B). We also carry out rapid-assessment surveys to determine coral cover percent, fishes and invertebrates at the outplant site.

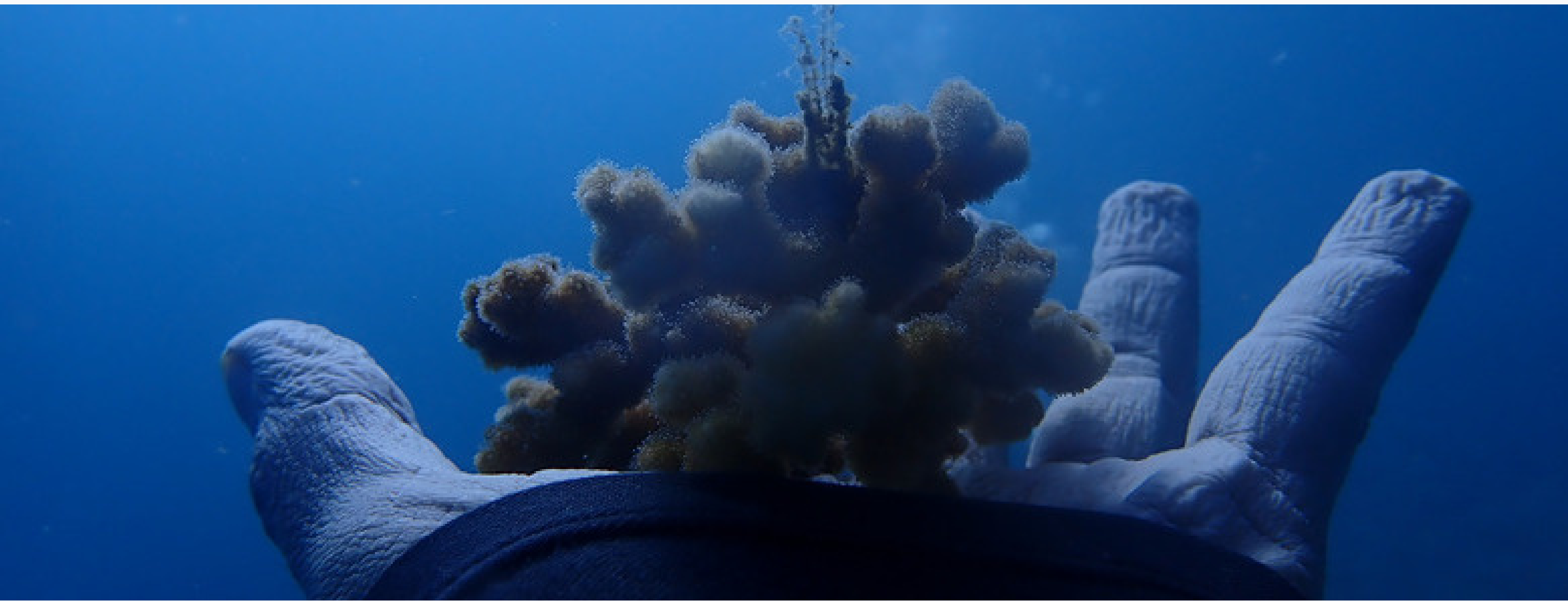
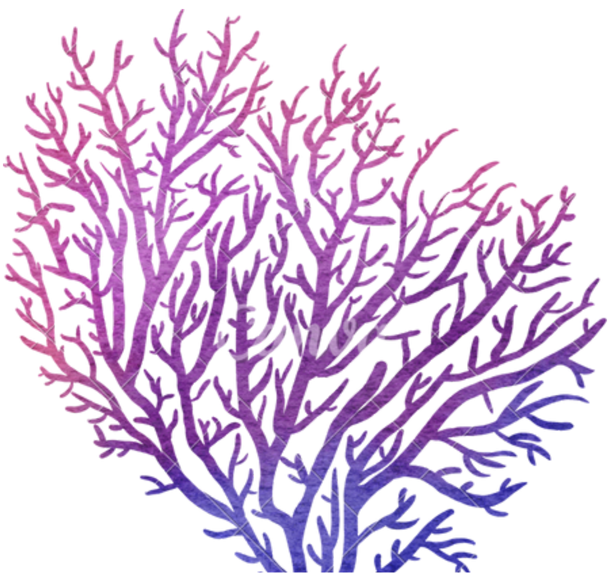



Figure 12. Study area in Pulau Lang Tengah, showing the nurseries at Turtle Bay (A), the outplant site at Tanjung Telunjuk (B) and the coral collecting site in front of Summer Bay (C).

# Coral Collection

This year, a total of 224 coral fragments representing 58 donor colonies of four species of corals were harvested from corals of opportunity at an average depth of 10 m in front of Summer Bay (Figure 12C). The four species were *Pocillopora damicornis, Acropora longicyathus, Porites cylindrica and Hydnophora rigida*. They were selected 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.

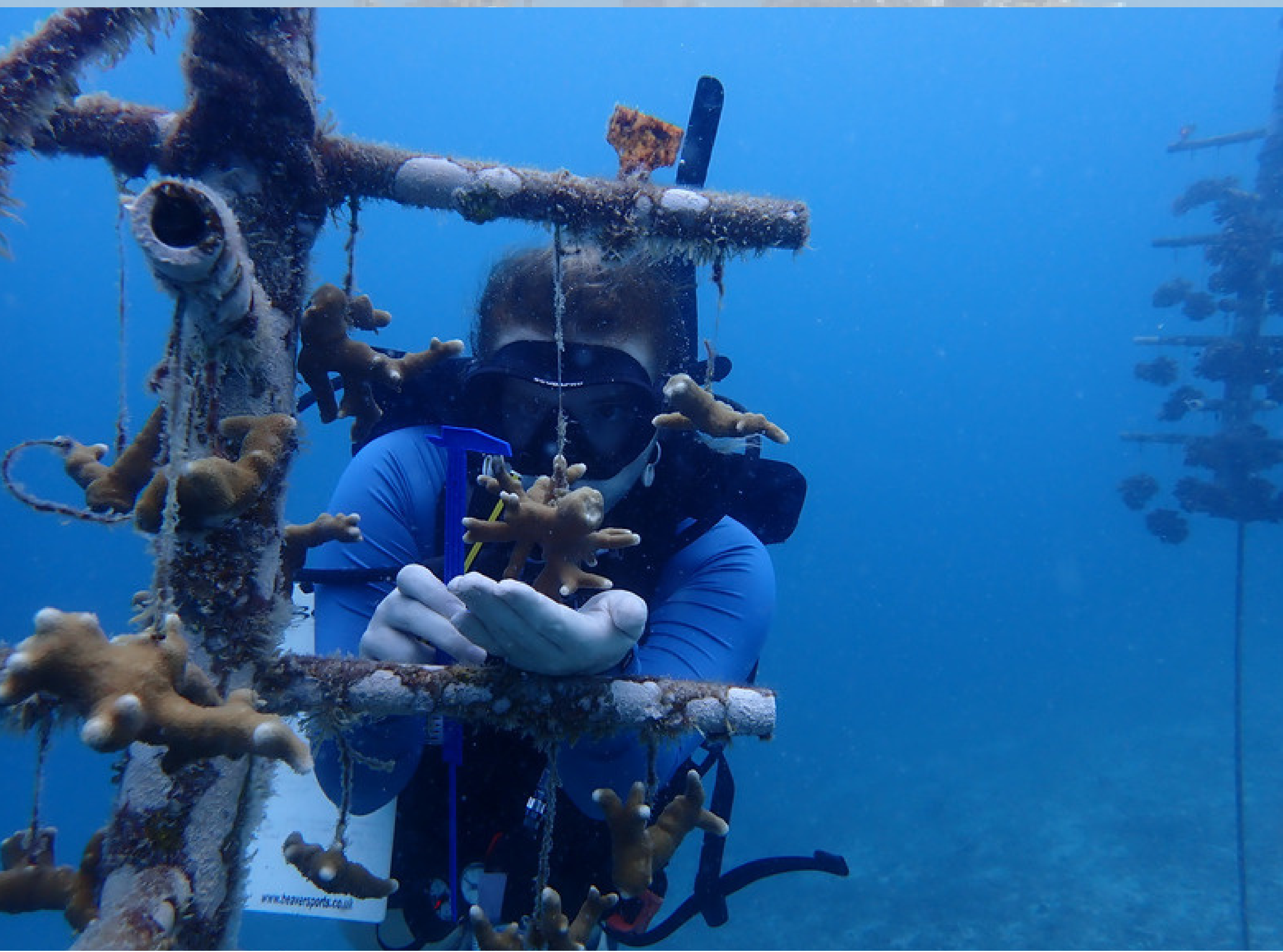
Corals of opportunity are corals that have been broken off the reef due to wave action or storms. These coral, as detached colonies, are susceptible to bleaching, partial mortality, disease, algal overgrowth, and may even perish (Jaap, 2000) unless salvaged from the reef and reattached to a stable substrate (i.e., coral nursery). 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.



Those corals were cut smaller fragments of 8–10 cm in linear length and placed in our nurseries to grow in a safe and conducive environment. The average linear length of a total of 223 fragments was 8.4 ± 1.83 cm (Table 3). A total of 223 coral fragments were harvested from corals of opportunity at an average depth of 10 m in front of Summer Bay.

Table 3. Species of coral fragments collected from Summer Bay in 2022.

| Species | Month collected | No. of colonies | No. of fragments | Average linear length ± SD (cm) |
|---|---|---|---|---|
| *Acropora longicyathus* | May | 14 | 66 | 9.2 ± 2.11 |
| *Pocillopora damicornis* | May | 10 | 44 | 7.8 ± 1.76 |
| *Porites cylindrica* | July | 14 | 48 | 8.4 ± 2.13 |
| *Hydnophora rigida* | July | 20 | 66 | 8.2 ± 1.33 |
| **Total** | | **58** | **224** | **8.4 ± 1.33** |



# Coral Nurseries

The coral fragments were transported in wet condition to the nursery site. There were a total of six coral tree nurseries, with the capacity of growing 356 coral fragments at one time. The coral nurseries were located at a depth of 8–10 m within 500 m from the outplant site at Tanjung Telunjuk (Figure 13). To attain the vertical position of the coral tree nurseries, subsurface buoy, polypropylene rope and duckbill anchors were used. Each tree had at least one species of coral fragments which were tethered using short and long monofilament to avoid collision between fragments (Figure 14).

The growth and survival of the coral fragments in the nurseries were monitored right after they were attached to the coral tress. The initial monitoring counted as day 0. The subsequent monitoring occurred a month later. In addition, the corals were also monitored post-monsoon in March, post-bleaching in the middle of the season, and pre-monsoon in October, depending on when they were attached to the coral tree.

Figure 13. Coral tree nurseries deployed at the depth of 8–10 m at Turtle Bay, with each tree holding between 44 and 66 coral fragments.

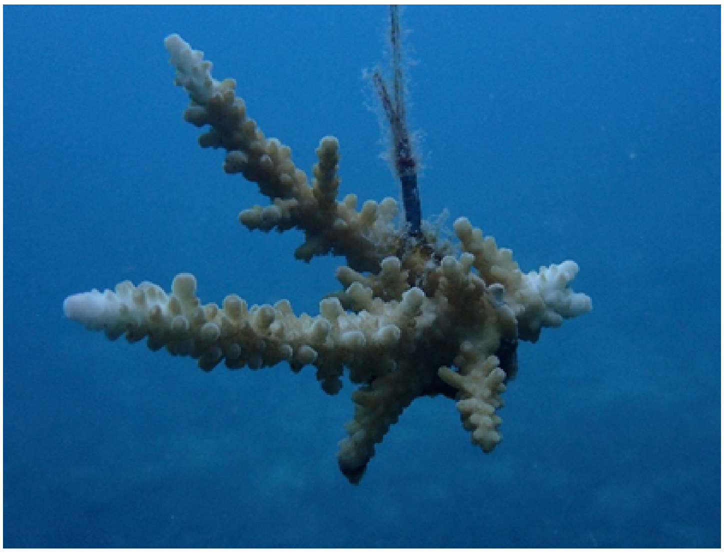



Figure 14. Coral fragments were tethered using short and long monofilament.

The status of each coral fragment (alive, dead, or detached), number of branches and lesions, bleaching status, and predation were monitored. All the data were recorded on a slate board, which was photographed once the surveyors were out of the water, before typing the data into the spreadsheets. The survival rates were calculated as the number of live coral fragments divided by the number of fragments present in the nurseries (%). To assess growth, the maximum length (L), width (W) perpendicular to maximum length, and vertical height (H) of the coral were measured, while suspended from the nursery. All three measurements were taken in centimetres using a calliper. 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 was used to linearise colony measurements, which decreases the influence of initial size of growth rate. The average GMR for every species was then used to calculate the mean growth rate (mm $day^{-1}$).

# Coral Batch 2022

There were a total of 65 and 44 coral fragments of *A. longicyathus* and *P. damicornis* attached to two coral trees in May, respectively. Another 66 and 48 coral fragments of *H. rigida* and *P. cylindrica* were attached to two other coral trees in July, respectively. Thus, the former trees were monitored over 145 days between late May to early October, while the latter trees were monitored over 96 days between late August and early October. The remaining two coral trees were used to store coral fragments from 2021 as broodstock.

The status of the coral fragments is summarised in Table 4 and Table 5. Two fragments of *A. longicyathus* had fused during the pre-monsoon monitoring in October and thus, were counted as one fragment. Of 223 coral fragments monitored then, 214 (96%) survived. As shown in Figure 14. Coral fragments were tethered using short and long monofilament., more than 90% of the coral fragments survived in each coral tree. Those attached to the coral tree in May, 93.6% coral fragments survived until the pre-monsoon monitoring (Table 4), while coral fragments attached in July had a survival rate of 95.6% (Table 5).

Both coral species attached in May showed 100% survival rate until day 15 and different survival rates on the pre-monsoon monitoring, (Figure 15A). As shown in Table 2, 89.4% and 97.7% of *A. longicyathus* and *P. damicornis* survived until October, respectively. Given that, 7.7% of *A. longicyathus* and 2.3% of *P. damicornis* were found detached on the last monitoring. Only one fragment of *A. longicyathus* was observed dead on the coral tree. Meanwhile, of the 114 coral fragments attached to the coral trees in July, 95.6% survived over 96 days (Table 5 and Figure 15B). Only 1.5% and 2.1% of *H. rigida* and *P. cylindrica*, respectively, were found detached during the pre-monsoon monitoring. Meanwhile, three fragments of *P. cylindrica* were found dead on the coral tree.

Table 4. Status of the coral fragments in the nursery from May to October 2022.

| Species | Status | Number of fragments (%) | |
|---|---|---|---|
| | | Day 15 (post-bleaching) | Day 145 (pre-monsoon) |
| *Acropora longicyathus* (n=66) | Alive | 100 | 90.8* |
| | Dead | 0 | 1.5* |
| | Detached | 0 | 7.7 |
| *Pocillopora damicornis* (n=44) | Alive | 100 | 97.7 |
| | Dead | 0 | 0 |
| | Detached | 0 | 2.3 |
| **Total fragments (n=110)** | **Alive** | **100** | **93.6*** |
| | **Dead** | **0** | **0.9*** |
| | **Detached** | **0** | **5.5*** |

*Two fused coral fragments were counted as one fragment.

Table 5. Status of the coral fragments in the nursery from July to October 2022.

| Species | Status | Number of fragments (%) | |
|---|---|---|---|
| | | Day 37 | Day 96 (pre-monsoon) |
| *Hydnophora rigida* (n=66) | Alive | 98.5 | 98.5 |
| | Dead | 0 | 0 |
| | Detached | 1.5 | 1.5 |
| *Pocillopora damicornis* (n=44) | Alive | 100 | 91.7 |
| | Dead | 0 | 6.3 |
| | Detached | 0 | 2.1 |
| **Total fragments (n=110)** | **Alive** | **99.1** | **95.6** |
| | **Dead** | **0** | **2.6** |
| | **Detached** | **0.9** | **1.8** |

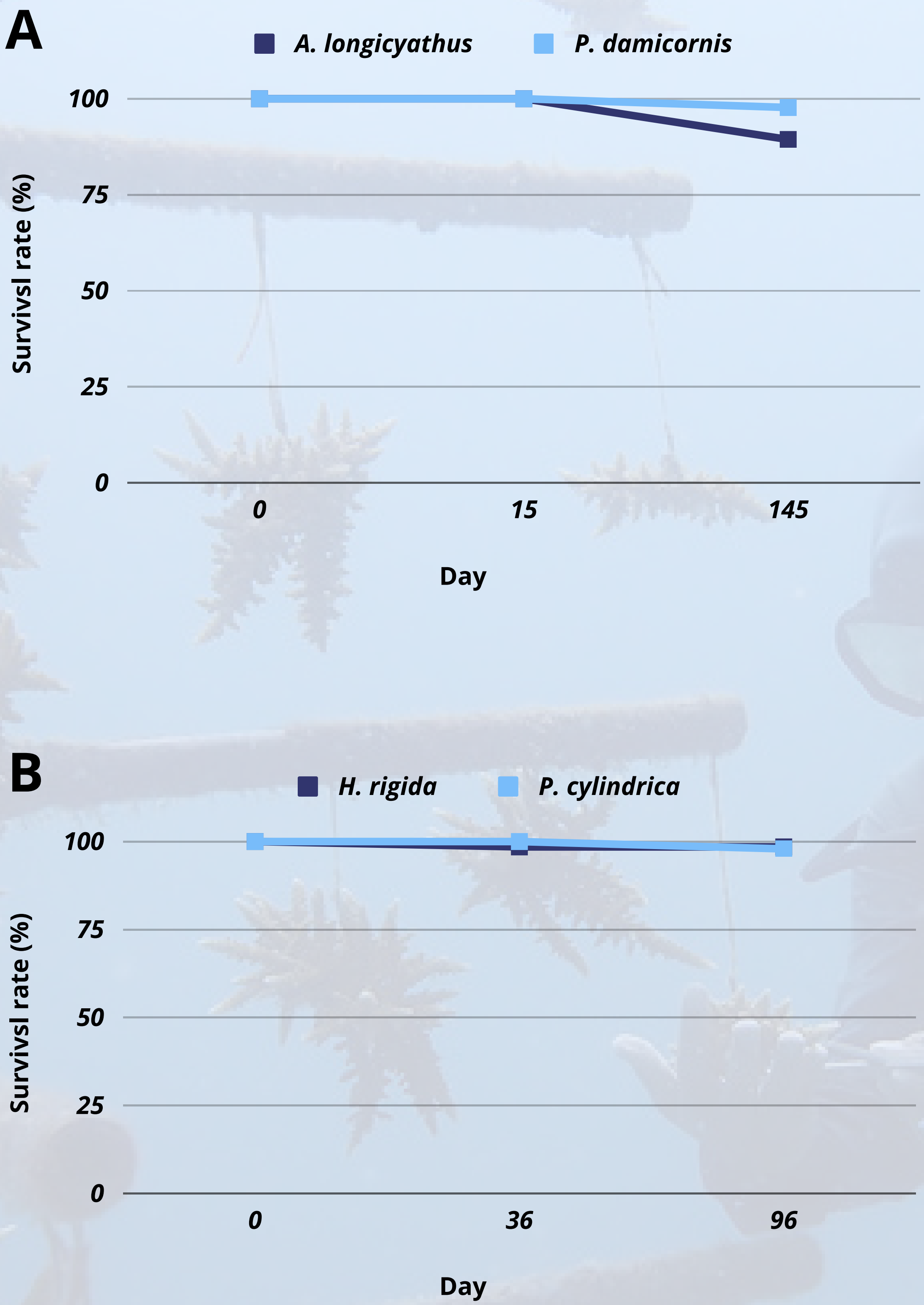



Figure 15. Survivorship between four coral species grown in the coral tree nurseries since May (A) and July (B) 2022.

The mean growth rates of the four coral species fragments in the nurseries are shown in Figure 16. Overall, all coral species had grown steadily with age. Overall, *H. rigida* and *P. damicornis* had the highest growth rate of 0.15 mm day$^{-1}$. *A. longicyathus* only fell slightly behind, growing at 0.13 mm day$^{-1}$. *P. cylindrica*, on the other hand, had the lowest growth rate at 0.07 mm day$^{-1}$. 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, sedimentation rate, water motion, pH, and salinity (Chou et al., 2016). Thus, increased water circulation, less sedimentation, lower predation, as well as fewer diseases, could contribute to faster growth rates and lower mortality in nurseries (Edwards, 2010).

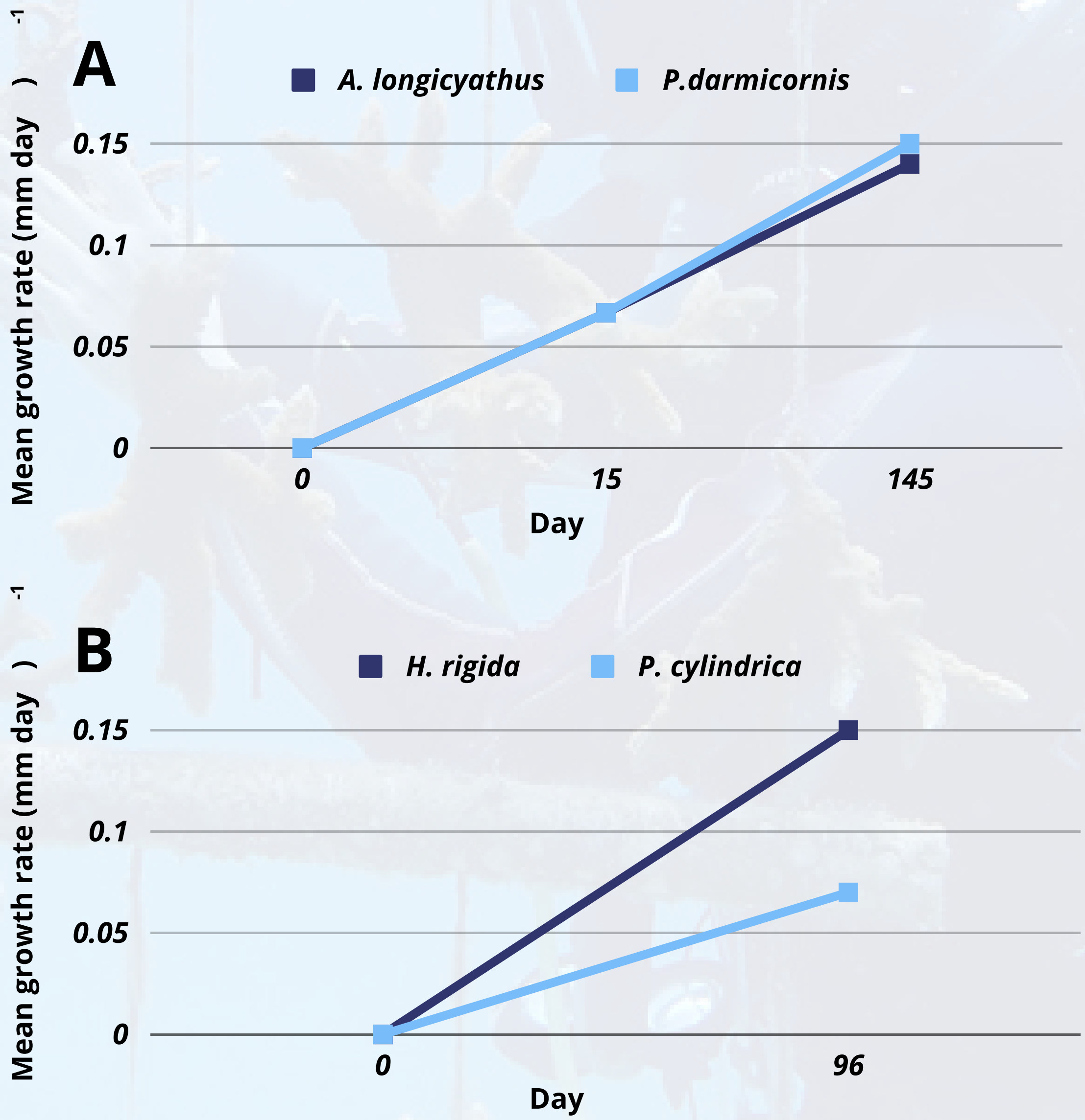



Figure 16. Mean growth rate of *A. longicyathus* and *P. damicornis* attached over 145 days since May 2022 (A), as well as *H. rigida* and *P. cylindrica* over 96 days since July 2022 (B).

# Coral Batch 2021

This season, five coral species grown in the nurseries since 2021 were ready to be outplanted into natural reefs. Before the corals were outplanted, we conducted a last monitoring to assess their survival and growth rates. The status of these coral fragments over time is summarised in Table 6 and Table 7, while their survival rates are presented in Figure 17. Of 356 coral fragments attached to the coral trees, 216 survived during the last monitoring. When two side-by-side coral fragments fused into one larger fragment, it was counted as one fragment. Such fusion had happened for 10 coral fragments.

*A. muricata* had the lowest survival rate (Table 6 and Table 7). Nearly 50% of those attached in May 2021 were found detached after the monsoon. Meanwhile, *A. muricata* attached in July 2021 also showed a drastically decreased pattern of survive rate over the monsoon. Only *H. rigida* had a survival rate above 80%, while the other species had a slightly lower survival rate between 66% and 76%. Overall, the percentage of coral detaching from the coral tree increased during the monsoon season and as they grew larger. This could be due to more swaying of the coral fragments suspended on the structures by stronger underwater currents, exacerbated by the corroded copper sleeves that held monofilament holding the coral fragments, under which heavier coral fragments could become detached.

Table 6. The status of the corals fragments in the nursery from May 2021 until March 2022.

| Species | Status | Number of fragments (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Day 30 | Day 54 | Day 89 | Day 115 | Day 139 | Day 304 |
| *Acropora muricata* (n=44) | Alive | 97.73 | 95.45 | 79.55 | 79.55 | 79.55 | 35.7* |
| | Dead | 2.27 | 4.55 | 20.45 | 20.45 | 20.45 | 14.3* |
| | Detached | 0 | 0 | 0 | 0 | 0 | 50* |
| *Hydnophora rigida* (n=66) | Alive | 95.45 | 92.42 | 89.39 | 89.39 | 89.39 | 81.8 |
| | Dead | 4.55 | 7.58 | 9.09 | 9.09 | 7.58 | 4.5 |
| | Detached | 0 | 0 | 1.52 | 1.52 | 3.03 | 13.6 |
| *Acropora florida* (n=66) | Alive | 100 | 98.48 | 98.48 | 98.48 | 98.48 | 75.8 |
| | Dead | 0 | 0 | 0 | 0 | 0 | 1.5 |
| | Detached | 0 | 1.52 | 1.52 | 1.52 | 1.52 | 22.7 |
| **Total fragments (n=176)** | **Alive** | **97.73** | **95.45** | **90.34** | **89.20** | **88.07** | **68.4*** |
| | **Dead** | **2.27** | **3.98** | **8.52** | **9.66** | **9.66** | **5.7*** |
| | **Detached** | **0** | **0.57** | **1.14** | **1.14** | **2.27** | **25/9*** |

* Four coral fragments fused into two fragments.

Table 7. The status of the corals fragments in the nursery from August 2021 until March 2022.

| Species | Status | Number of fragments (%) | | |
|---|---|---|---|---|
| | | Day 30 | Day 204 | Day 275 |
| *Acropora muricata* (n=66) | Alive | 95.5 | 48.5 | 30.3 |
| | Dead | 3 | 36.4 | 42.4 |
| | Detached | 1.5 | 15.2 | 27.3 |
| *Acropora longicyathus* (n=66) | Alive | 95.5 | 84.4* | 71.4^ |
| | Dead | 0 | 0* | 1.6^ |
| | Detached | 4.5 | 15.6* | 27.0^ |
| *Porites cylindrica* (n=48) | Alive | 95.8 | 81.3 | 66.7 |
| | Dead | 4.2 | 2.1 | 6.3 |
| | Detached | 0 | 16.7 | 27.1 |
| **Total fragments (n=180)** | **Alive** | **95.6** | **70.2*** | **54.8^** |
| | **Dead** | **2.2** | **14*** | **18.1^** |
| | **Detached** | **2.2** | **15.7*** | **27.1^** |

* 178 total fragments Four coral fragments fused into two fragments.
^ Six coral fragments fused into three fragments.

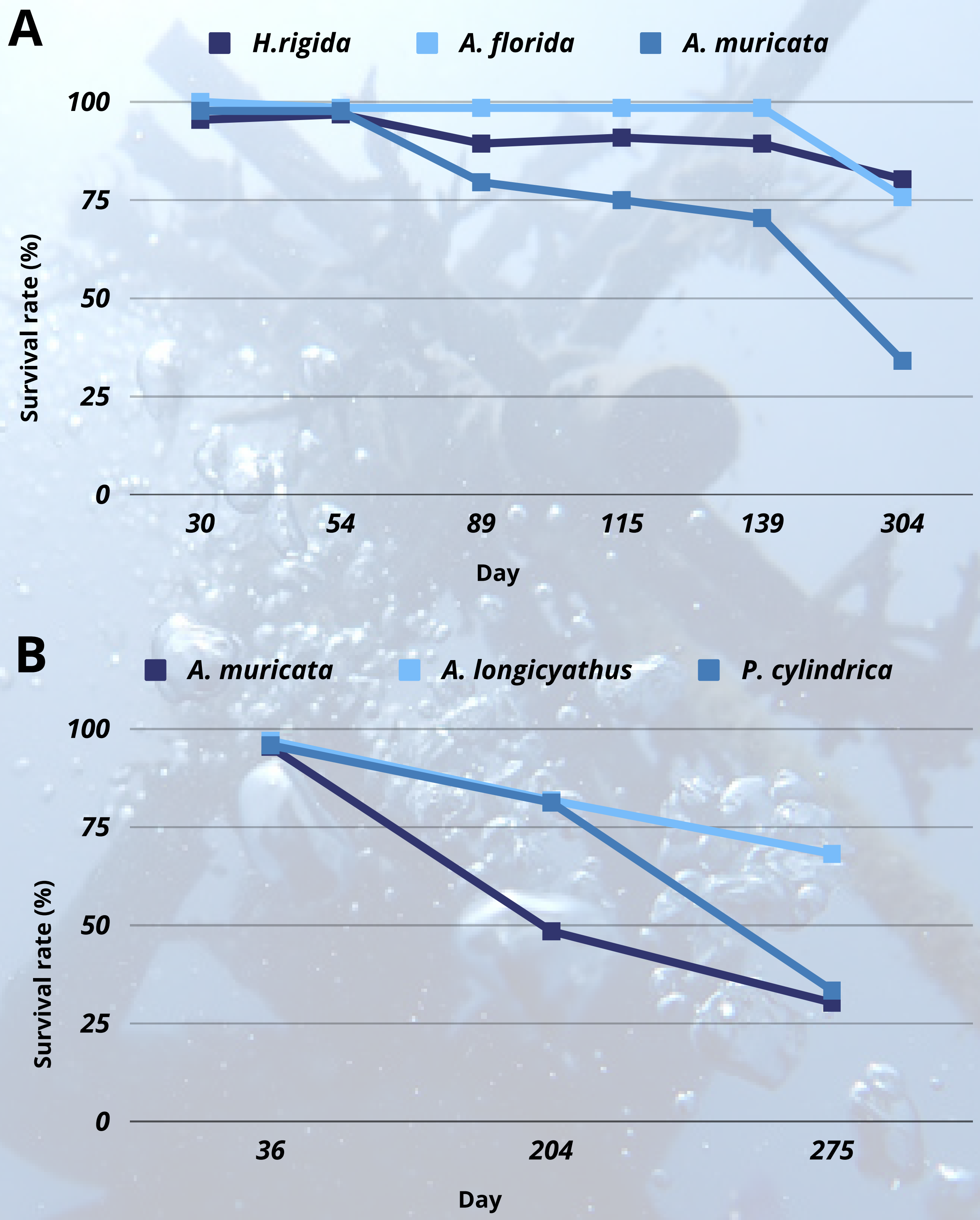
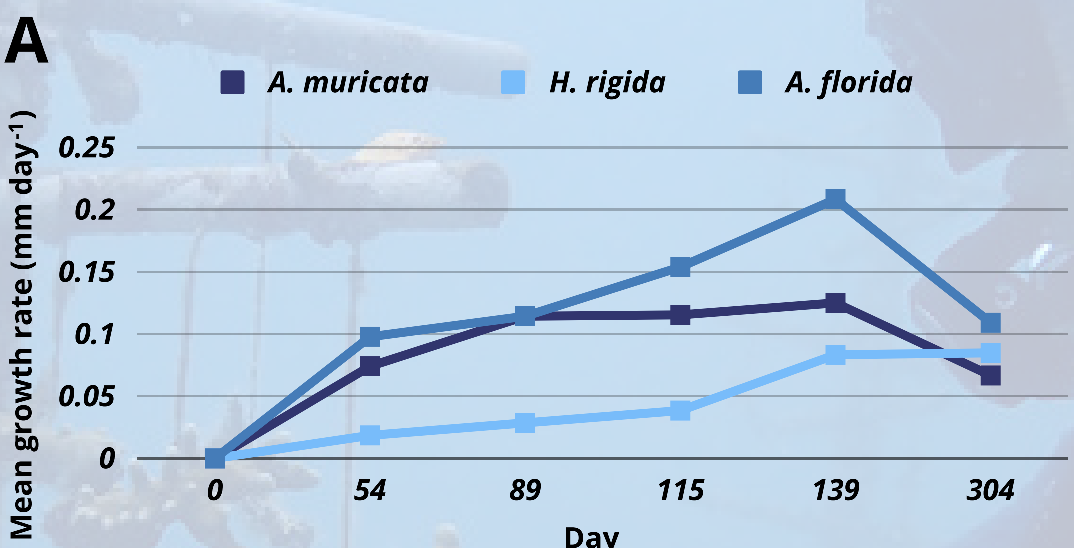



Figure 17. Survival rate of different coral species attached to the coral trees since May 2021 (A) and August 2021 (B) until post-monsoon in March 2022.

The mean growth rates of five coral species grown on six coral tree nurseries are shown in Figure 18. Overall, all coral species had grown steadily with age. Over the monitoring period, *P. cylindrica* had the lowest growth rate at 0.02 mm day$^{-1}$. Unlike the other *Acropora* spp. which recorded a growth rate of 0.11–0.18 mm day$^{-1}$, *A. florida* only grew 0.06 mm day$^{-1}$. Meanwhile, the growth rate of *H. rigida* was 0.08 mm day$^{-1}$. The growth rate of all coral species, except *A. longicyathus*, was slower over the monsoon. Also observed that *A. florida* grew significantly faster during the monsoon season. Environmental conditions including both biotic and abiotic factors have a strong influence on coral growth rates (Pratchett et al., 2015). The variation in growth among the different species in the coral nursery trees could be due to the temperature. Anderson et al. (2017) found that the temporal patterns of branching coral growth is strongly linked to temperature.



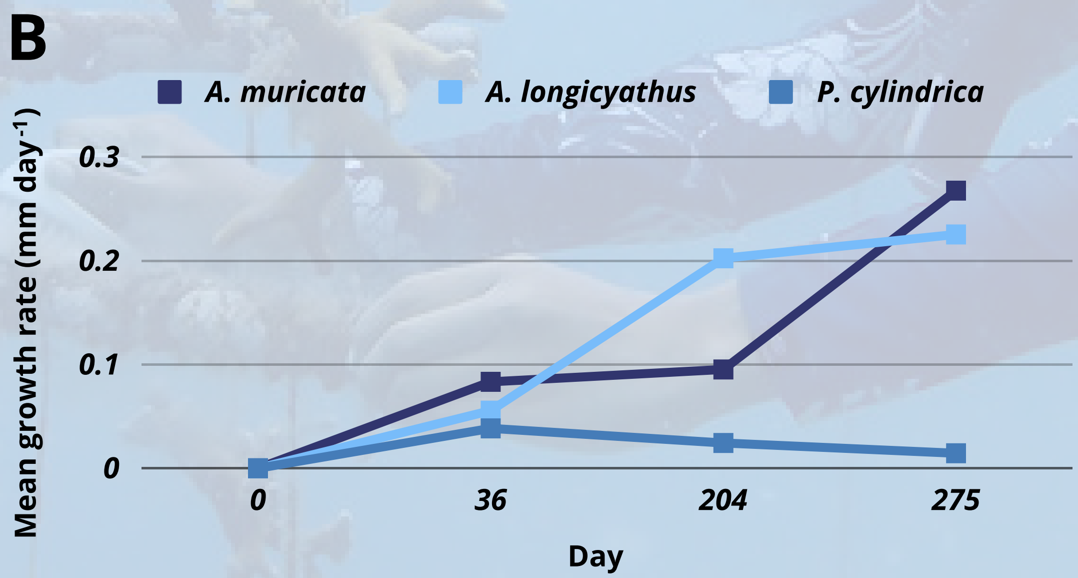
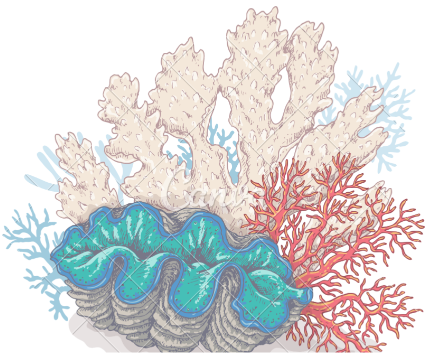



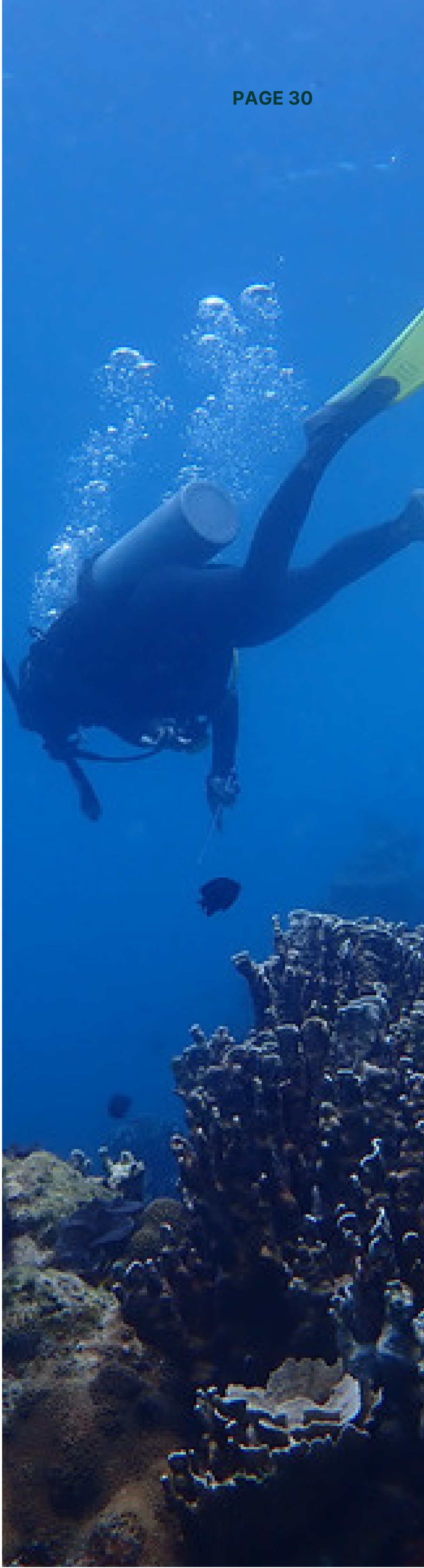

Figure 18. Mean growth rate of different species of coral fragments attached to the coral tree nurseries since May (A) and August (B) 2021.

# Outplanted Corals into Natural Reefs

This year, our restoration efforts concentrated at Tanjung Telunjuk where patches of healthy coral reefs still exist, unlike the vast area of coral rubbles in front of Turtle Bay (Figure 19). This year, we continued to monitor coral colonies from the previous year and outplant more coral colonies from coral nursery (Figure 19). 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. The outplant area was extended another 20 m from the current outplant site to restore a larger area than last year. We conducted a rapid survey next to the current outplant site by using point intercept transect. We recorded the type of substrate every 0.5 m along a 20-m transect. According to the data collected, the new outplant site at Tanjung Telunjuk had 41% hard coral cover.

Coral clips were used instead of Apoxie sculpt this year to attach the coral fragments onto the substrate in the natural reef. The surface of the substrate was scrubbed before attaching coral colonies to reduce the competition between coral and algae. Each colony was attached to the substrate by using one or more coral clips (Figure 20), depending on the size of the coral. In order to identify the coral colony during the monitoring, a tag number was placed next to each colony. Monitoring of outplanted coral colonies was conducted on day 30 and before the monsoon season. The status (dead or alive), type of attachments (see Table 8), length, width and height of the coral colonies was recorded during every monitoring survey (Figure 21).





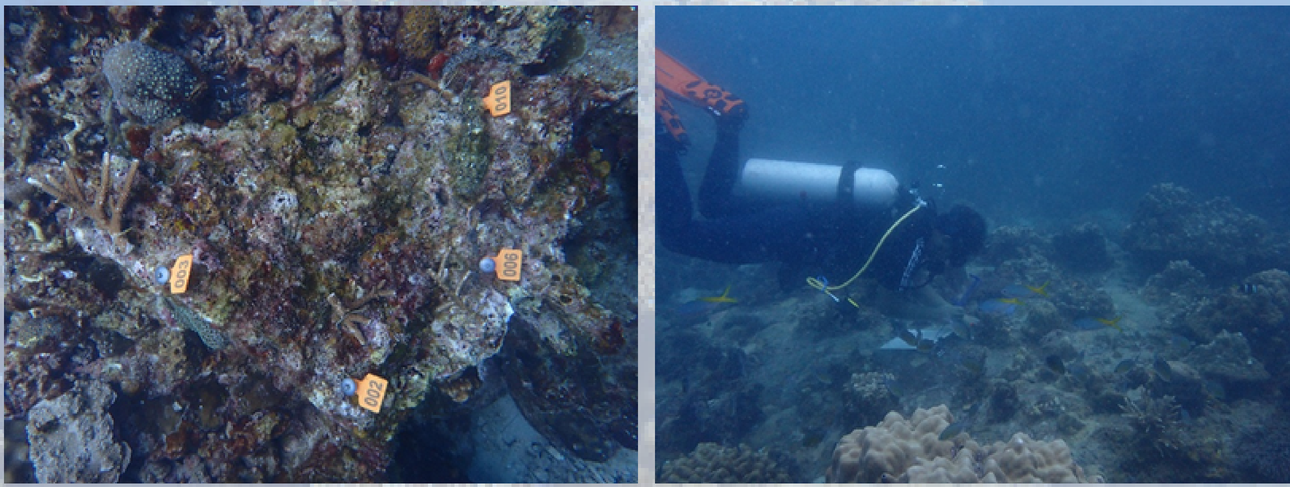



Figure 19. Mean growth rate of different species of coral fragments attached to the coral tree nurseries since May (A) and August (B) 2021.


Figure 20. A coral clip is nailed into the substrate to hold the coral colony before it attaches itself to the substrate.

Table 8. 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 |

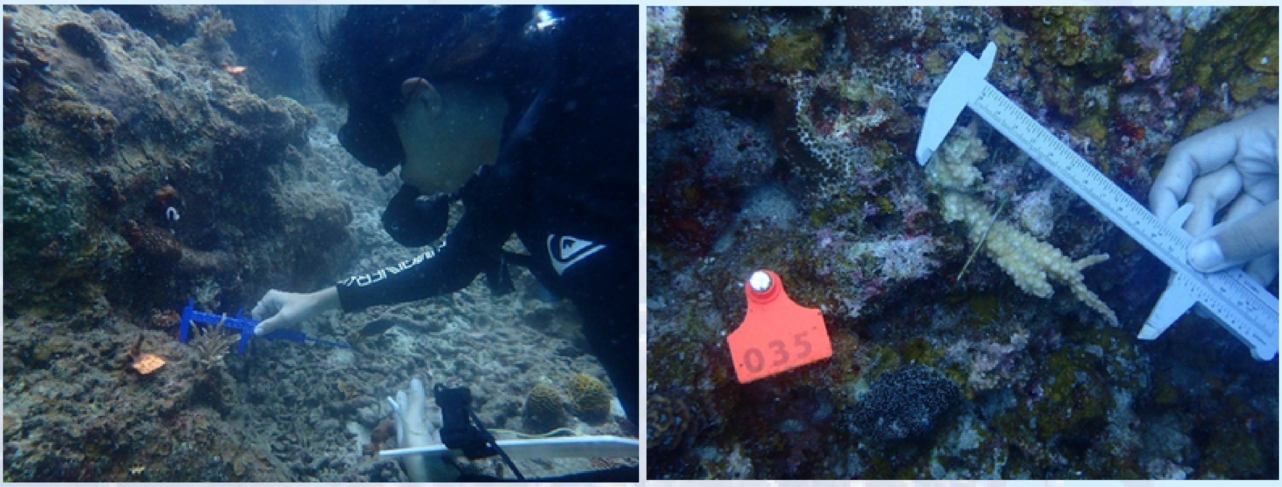



Figure 21. Checking the survival of the outplanted coral colonies at Tanjung Telunjuk, as well as measuring their length, width and height.

Since 2021, 265 colonies of six coral species were outplanted, with 24 colonies in 2021 and 241 colonies in 2022 (Table 9). These coral colonies had an average survival rate of 33.3–92.9%. On average, these coral fragments had grown over time, except one that showed a negative growth rate as the coral fragment was found broken. *A. muricata* showed the highest growth rate above 0.2 mm day$^{-1}$. *P. cylindrica, A. florida* and *H. rigida* showed a growth rate below 0.1 mm day$^{-1}$.

Table 9. Summary of outplanted corals including their survival and growth rates.

| Year | Month | Coral species | Number of colonies | Monitoring period (day) | Survival rate (%) | Mean growth rate (mm day$^{-1}$) |
|---|---|---|---|---|---|---|
| 2021 | June | *A. muricata* | 3 | 471 | 33.3 | -0.03* |
| | | *P. cylindrica* | 21 | 471 | 79 | 0.04 |
| 2022 | April | *A. florida* | 40 | 188 | 77.5 | 0.07 |
| | | *A. muricata* | 27 | 188 | 66.7 | 0.24 |
| | | *H. rigida* | 47 | 188 | 78.1 | 0.09 |
| 2022 | July | *A. longicyathus* | 90 | 108 | 77.8 | 0.19 |
| | | *A. muricata* | 23 | 108 | 81.8 | 0.21 |
| | | *P. cylindrica* | 14 | 108 | 92.9 | 0.13 |

* Coral colonies reduced in size due to bleaching and breakage.

# Coral Attachment and Survival

The survival rate of all the outplanted corals and their attachment progress to the substrate are shown in Figure 22. By day 30, the coral tissue had grown over the Apoxie sculpt or coral clip. Some had also self-attached to the substrate. By two months, more coral colonies had successfully attached themselves to the substrate. Should the attachment method failed, it could already be observed in one week's time, which would eventually lead to the detachment of the coral. With the new attachment method using coral clips, we noticed the coral colonies attached to the reef faster than when epoxy is used. Sometimes the attachment method failed due to underwater currents or fish disturbance. For example, the results also show that more corals had detached over the monsoon as observed in *P. cylindrica* between day 107 and 277 (Figure 22B). Should the attachment method failed, we would reattach the coral colony with more coral clips to secure it if it was found nearby. The ability of coral colonies to grow onto the benthic substrate or self-attach is crucial to the survival of the colonies and the success of the transplantation effort (Guest et al., 2011). Other factors such as bleaching and predation also affected the survival of the outplanted corals.

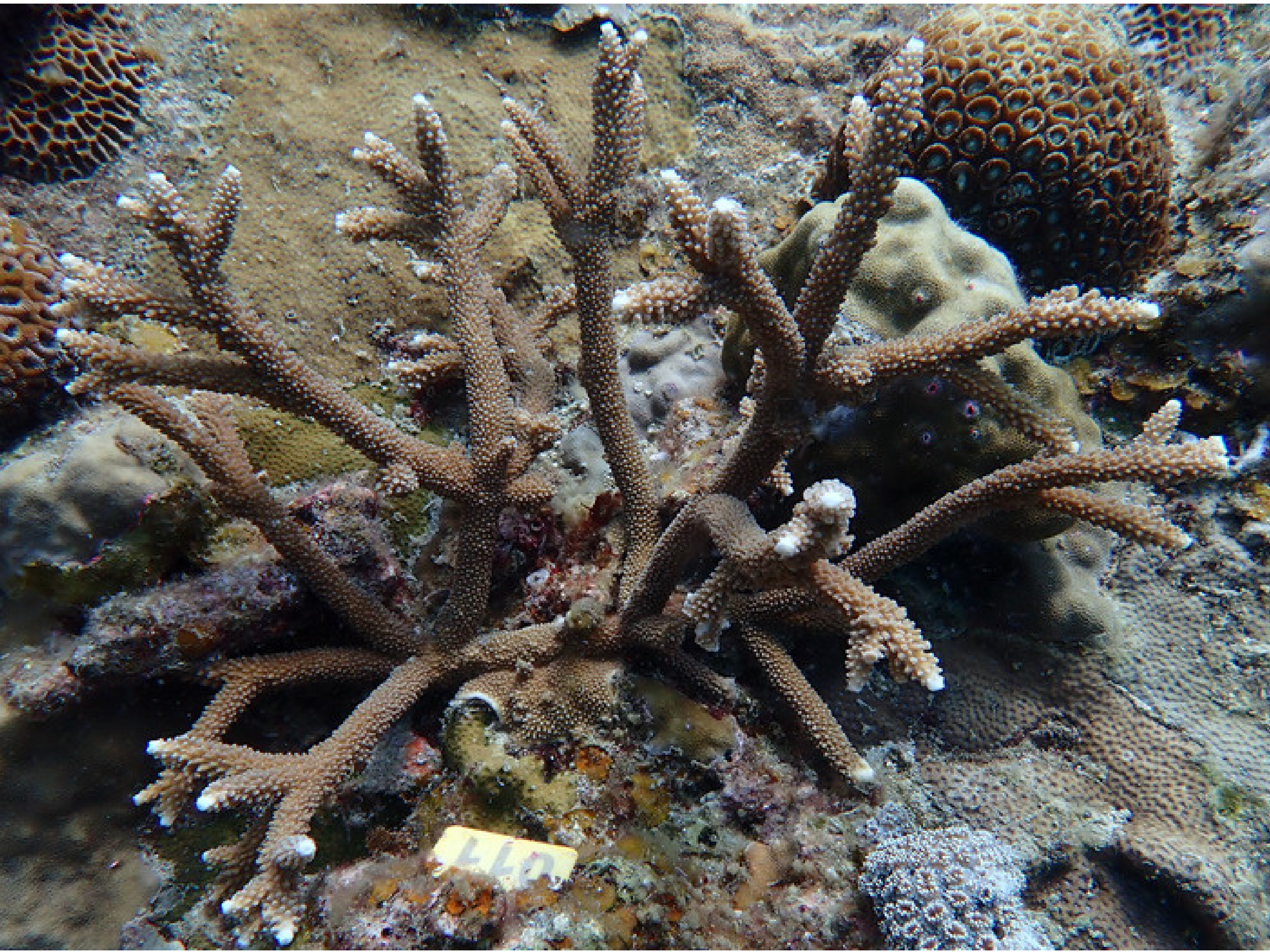



Figure 22. The attachment and survival rate of different coral species by batch in the natural reefs since June 2021 (A–B), April 2022 (C–E) and July 2022 (F–H). Note: 0=Non-attached; 1=Tissue sheeting; 2=Self-attached; 3=Attachment method failed; 4=Detached; and 5=Dead.

# Coral Growth

The corals outplanted in 2022 had grown steadily within one season, with a higher growth rate than the corals outplanted in 2021 (Figure 23 and Table 9). The decline in growth rate of *A. muricata* as seen in Figure 23A was due to breakage of the only surviving coral colony. Therefore, reducing its size. Although *P. cylindrica* showed both positive and negative growth rates at different periods of time (Figure 23A), it had grown over time, albeit much slower than the other coral outplants from 2022.

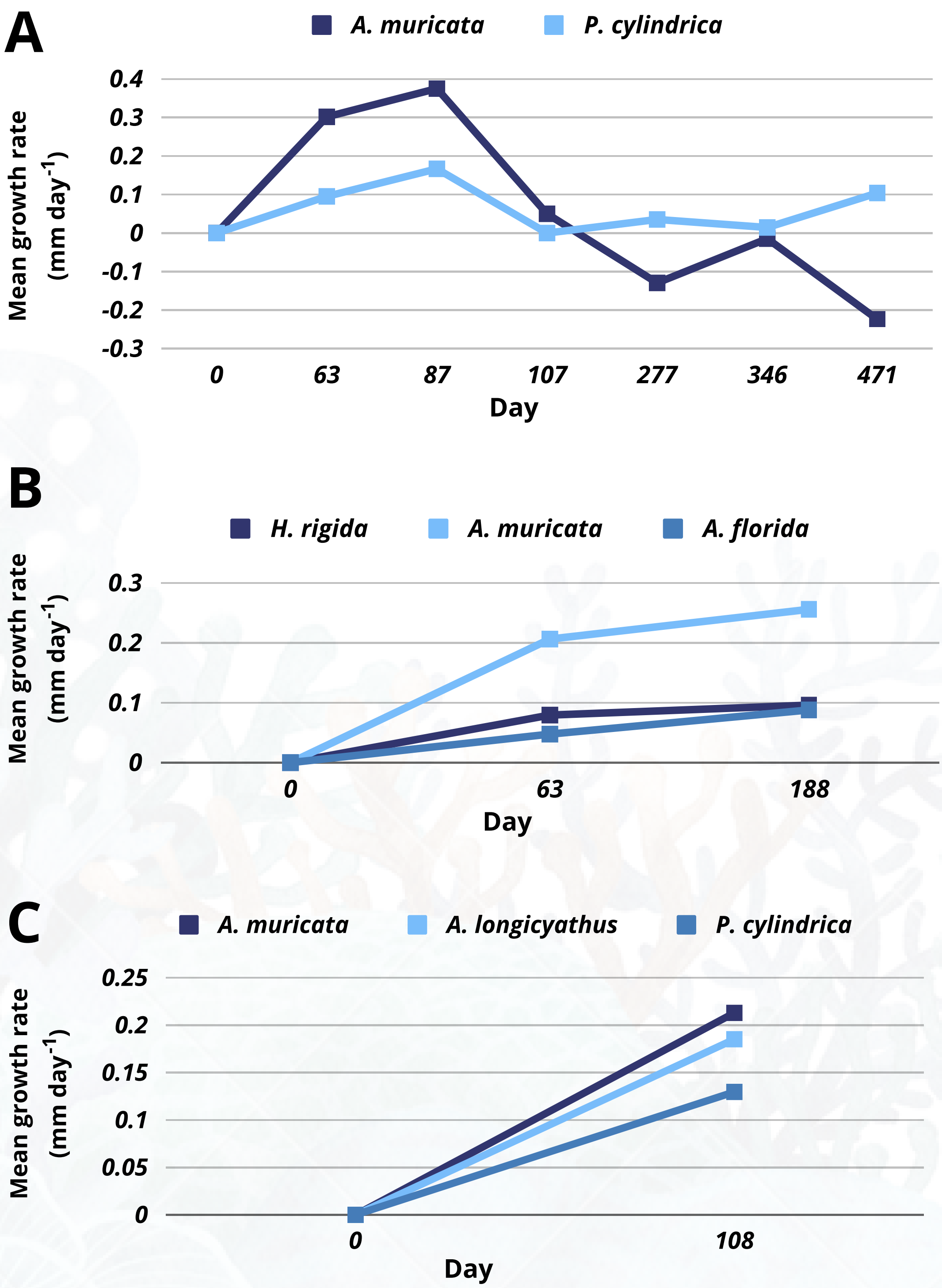



Figure 23. Mean growth rate of the outplanted corals from different batches in the natural reefs.

Figures 24–28 show the growth of the coral colonies from five different species after they were outplanted into the natural reefs. Initially secured to the substrate using Apoxie sculp or coral clips, they eventually self-attached to the substrate.

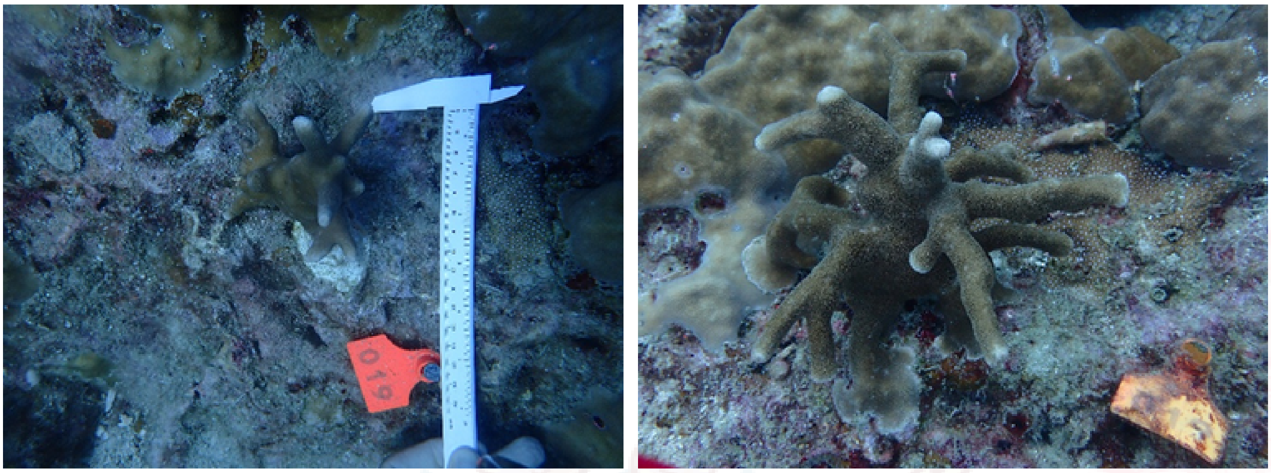



Figure 24. Coral fragment 019 *(Porites cylindrica)* was 276.7 $cm^3$ when we first outplanted into the natural reefs in June 2021 (left). It increased in volume to 1,413.9 $cm^3$ on day 471 in October 2022 (right), with a growth rate of 0.06 mm $day^{-1}$.


Figure 25. Coral fragment 004 *(Acropora muricata)* was 1,094.9 $cm^3$ when we first outplanted into the natural reefs in April 2022 (left). It increased in volume to 1,997.3 $cm^3$ on day 63 in June 2022 (right), with a growth rate of 0.2 mm $day^{-1}$.


Figure 26. Coral fragment 009 *(Acropora florida)* was 141.9 $cm^3$ when we first outplanted into the natural reefs in April 2022 (left). It increased in volume to 467.5 $cm^3$ on day 63 in June 2022 (right), with a growth rate of 0.2 mm $day^{-1}$.


Figure 27. Coral fragment 008 *(Hydnophora rigina)* was 707.3 $cm^3$ when we first outplanted into the natural reefs in April 2022 (left). It increased in volume to 2,075.1 $cm^3$ on day 188 in October 2022 (right), with a growth rate of 0.1 mm $day^{-1}$.

Figure 28. Coral fragment 009 (*Acropora longicyathus*) was 115.9 $cm^3$ when we first outplanted into the natural reefs in June 2022 (left). It increased in volume to 1,047.7 $cm^3$ on day 107 in October 2022 (right), with a growth rate of 0.3 mm $day^{-1}$.

Different species have varying vulnerability to predators, self-attachment abilities, tolerance to local environmental conditions, susceptibility to bleaching and disease, which influence their self-attachment and survival (Edwards & Gomez, 2007). Acropora spp. are often considered to be suitable for transplantation due to their fast growth rates and rapid addition of structural complexity to degraded areas (Harriott & Fisk, 1988; Rinkevich, 2005). However, research is progressively showing that transplants of these fast-growing species have a poor long-term response because they are less tolerant to stressors that chronically impact the transplantation sites (Ng et al., 2015; Toh et al., 2014). Our result from a small sample size of A. muricata in 2021 corroborated with previous attempts at transplanting this species (Dizon et al., 2008, Toh et al., 2014). Some of the outplanted corals performed poorly when bleaching was observed. Transplant-induced bleaching can cause a slight reduction in growth and survival (Forrester et al., 2012), including visible tissue loss and substantial mortality (Douglas, 2003; Shafir et al., 2006). For this reason, other species besides Acropora were also chosen for restoration. Moreover, long-term of monitoring of more coral outplants will improve understanding of the survival and growth of different species over time.

# Volunteer Programme

Volunteer programme is one of our main activities at Lang Tengah Turtle Watch as our rustic campsite allows people to experience turtle conservation and the island life. Volunteer fare differed based on the nationality (Malaysian and Non-Malaysian) and the period of their stay. A minimum of one week stay was required for Malaysian volunteers, while international volunteers stayed for a minimum of two weeks.

This year, there were a total number of 53 volunteers, which consist of 36 (67.9%) Malaysians, five (9.4%) international volunteers residing in Malaysia, and 13 (24.5%) international volunteers (Figure 29). Most of the Malaysian volunteers stayed with us for one week while international volunteers tend to stay with us for a longer period.

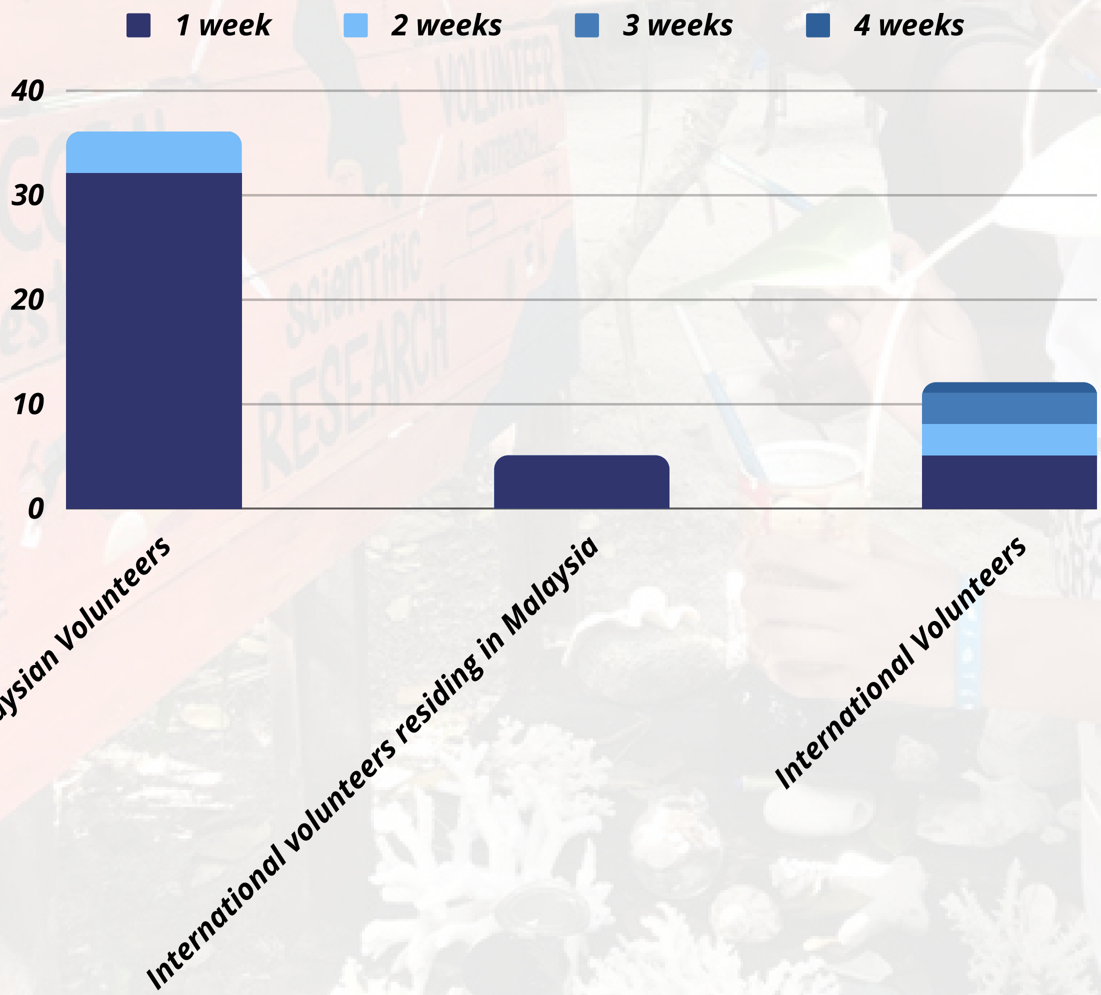



Figure 29. Number of volunteers with the period of their stay.

Generally, volunteers were given educational talks such as sea turtle ecology, patrol protocols, coral ecology, and fish identifications. This is to strengthen their knowledge on marine conservation and understanding on the work at Lang Tengah Turtle Watch. Apart from that, volunteers also joined us for night patrols and weekly beach clean-ups on the nesting beaches at Lang Tengah. The volunteers were taught to sort out the trashes collected during beach clean-ups according to their category and material. During leisure time, volunteers went snorkelling, cliff jumping, hiking, kayaking, tree climbing, playing card games and beach volleyball, as well as watching sunrise and sunset (Figure 30).

Of 53 volunteers, 24 of them completed our online feedback form after volunteering at Lang Tengah. Overall, 75% of them enjoyed their stay with us and had an excellent overall experience (5/5 rating), with the remaining volunteers giving a rating of 4/5. In addition, 83% of them would like to join the volunteer programme again in the future. All of them would recommend their friends and families to join our volunteer programme. Suggestions were also given for improvement to the volunteer programme, activities, and living conditions.

Figure 30. A floating bar with the volunteers at Turtle Bay.

# Outreach Programme

As tourist activities resumed this year, informal talks were given to the visitors including nearby resort guests who visited our campsite. Educational trips were also organised for local school students. Furthermore, university students visited our campsite at Lang Tengah Island.


## *Conservation Talks for Visitors*

After almost two years of travel restriction, our campsite is finally open for tourists to visit this year. During daytime, visitors are welcome to have an informal conservation talk with our team members at the campsite. In total, 527 visitors dropped by our campsite, including approximately 24 visitors were guests from our eco-friendly Airbnb, The Resthouse, at Perhentian Island. Their stay supported us at Lang Tengah, and they came to learn more about our conservation work. Specimens of sea turtles such as bones and eggs of different development stages were shown to visitors while explaining the biology and ecology of sea turtles, which help the public to understand the science behind conservation of sea turtles. Apart from that, coral conservation talk was also given to the visitors. The visitors were also shown a replica of part of our coral tree nursery.

During the hatching season, visitors are welcome to join the team during nest excavation in the late evening. A brief talk about the biology and ecology of sea turtle was given while witnessing the excavation process conducted by our team (Figure 31). This season, 84 visitors joined us for nest excavation, and some were lucky enough to have witnessed hatchlings being released into the ocean. Unlike nest excavation, hatchling release events are opportunistic at Lang Tengah Island as we do not fence the nest to allow the hatchlings crawling into the ocean immediately upon emergence.

Figure 31. Nest excavation with guests in front of Sari Pacifica & Spa Resort.

Besides that, 62 tourists were recorded to have witnessed the nesting process during our night patrols. During such encounters, the tourists were informed to wait farther away from the turtle until it finished laying eggs. A short briefing about the turtle nesting ecology was given. The tourists were also briefed of the dos and don’ts while watching a nesting turtle to avoid disturbing the nesting turtle and disrupting the nesting process. The tourists were guided to see the turtle in a small group of 4–6 people at a time after it had successfully laid eggs and the team had collected biometric data of the turtle.

# Educational Trips for Local Schools

In August and September, an educational trip were organised for two local secondary schools, namely SMK Batu Rakit and SMK Chendering, respectively, to increase their awareness towards marine conservation and waste management. To ensure that language would not hamper their learning about sea turtle ecology, coral ecology, and waste management, the programme was conducted in a mixed of Malay and English (Figure 32).

Figure 32. Introduction of sea turtle and coral ecology and conservation.

Interactive game sessions were conducted after splitting the students into small groups (Figure 33). Each game was designed to reinforce what the students had learned about sea turtle and coral ecology and conservation. This included Q&A session and cross-matching facial photos of individual sea turtles to find the correct match.

Figure 33. Students matching the same sea turtle individuals from their facial scale patterns using photo-identification methods.

A demonstration on PEI was given to the students after the game sessions (Figure 34). During the demonstration, the students were shown how to collect data during PEI in order to determine the rates of hatching success, emergence success, depredation, as well as fungal and bacterial infection.

A beach clean-up at Lang Sari was conducted with the students. The students were taught about waste management, including the separation of recyclable and non-recyclable waste. Several bags of trash were removed from the island with the help of the students and the teachers.

Figure 34. Demonstrating the process of post-emergence inspection of a nest to the students.

# *University Field Visits*

Students and teachers from two tertiary institutions, Herriot Watt University and Monash University, visited us this year in March and April, respectively. The purpose of these visits was for the students to learn more sea turtles and corals, as well as the conservation work carried out by LTTW team in Lang Tengah.

During the field visit, the students were given the chance to learn practical skills including relocating a nest, marking nest location using triangulation method, excavating a nest, and planting coral fragments. During nest relocation, the students were given ping pong balls which resemble turtle eggs, and were taught to handle the turtle eggs the right way. Demonstrations of each practice were given by the team before the students start. After the relocation practice, students learned to measure and record the distant from the centre of the nest to three markers on different branches. Students were then asked to excavate the ping pong balls buried by another group with the given measurements of triangulation markers.

Apart from turtle conservation, a talk about coral conservation was given to the students (Figure 35). Moreover, a demonstration of planting coral fragments in coral nursery were also shown on land. The students were then given a chance to practise attaching coral fragments with coral rubbles on the mock coral tree (Figure 36).

Figure 35. Introduction of sea turtle ecology and conservation to students from Herriot Watt University.

Figure 36. Demonstrating the relocation process and planting coral fragments to students from Monash University.

# Beach Clean-Ups

A total of 44 beach clean-ups were conducted in 2022, clearing a total of 361.7 kg of debris from Lang Tengah's beaches and coastlines (Figure 37). Of these, 96.4 kg were recyclable waste that were cleaned and sent to RD Papers Gong Badak for recycling. For each clean-up we also recorded the types and amounts of waste collected on the Ocean Conservancy's Clean Swell mobile app, contributing to a global database of marine waste. This year, Miracle Spectrum, a sustainable packaging company, continued to sponsor oxo-biodegradable plastic bags, which were used to collect waste from beach and underwater clean-ups. Frequent clean-up especially on nesting beaches is important in order to ensure the island stays clean and safe: for patrollers, island tourists, and importantly the turtles that come up to nest and the hatchlings that crawl out to sea


Figure 37. Weekly beach clean-ups conducted with interns and volunteers at Lang Tengah.

**44 beach clean-ups**

**361.7 kg of debris removed from Lang Tengah Island**

# Reef Check Survey

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, six of our team members were trained up as certified Reef Check EcoDivers. A survey was conducted together with the team of Reef Check Malaysia at four sites at Lang Tengah, which are Summer Bay, Batu Bulan, Tanjung Telunjuk, and Broler North. Summer Bay and Batu Bulan are two existing survey sites, while Tanjung Telunjuk and Broler North are two new survey sites added this year (Figure 38).

A 100-m long transact was laid at a depth of 5–9 m. The fish abundance survey was conducted first a few minutes later, followed by invertebrate and substrate surveys Surveyors were required to swim along the transact line on each side of transact line. The data collected for the survey were fish, invertebrate, damage/impact, and substrate. Generally, the transect line was divided into four parts, where the surveyors only collected data for 20 m with a 5-m gap, except for the substrate which was collected every 0.5 m (Figure 39).


Figure 38. 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.

Only several groups of fishes and invertebrates were selected for the Reef Check survey due to their values in human consumption and pet trade. For example, grouper, parrotfish, sea cucumber and giant clam can be commonly found in fish markets as source of protein, while butterflyfish and banded coral shrimp are traded in pet trade market. These bits of reasons would help the Reef Check identify whether there is a sign of overfishing at a particular site. Recording the damage and impact found on the reef could contribute useful data to recommend further actions needed to protect the reefs.

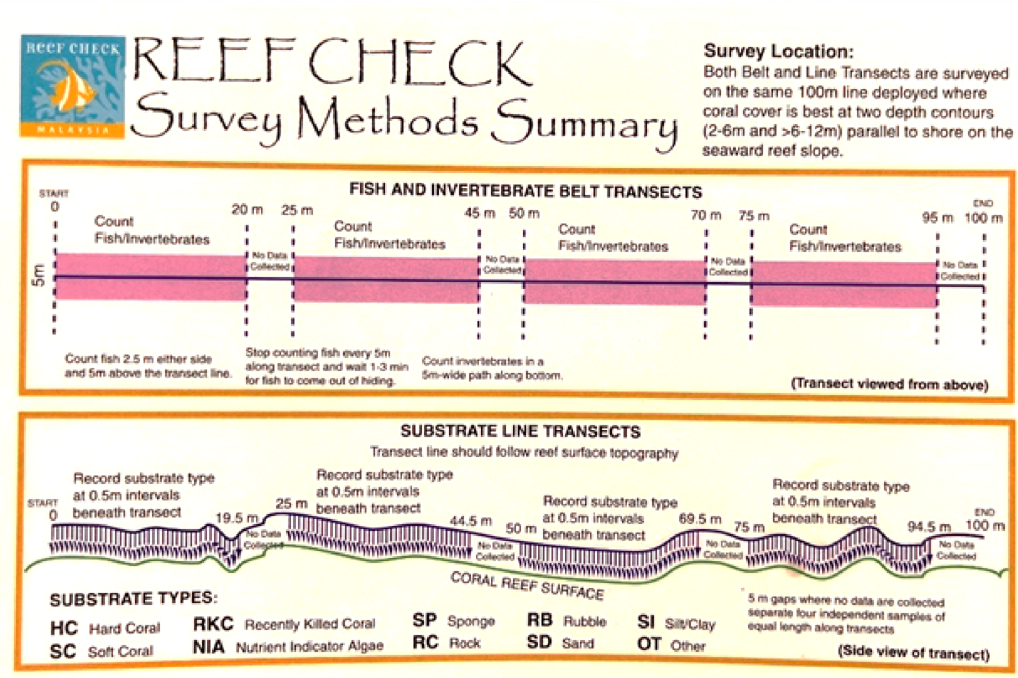



Figure 39. A summary of Reef Check survey methods. Source: Reef Check Malaysia.

# Fish Survey

Of the targeted fishes in this survey, reefs at Lang Tengah were dominated by butterflyfish (134), parrotfish (105) and grouper (37), which are present at almost all surveyed sites with high abundance (Figure 40). Snappers, the next common fishes found at Lang Tengah, were documented at three out of four survey sites. Groupers and parrotfishes were only counted if they are longer than 20 cm and 30 cm, respectively. Additionally, the size of the grouper was recorded to the nearest 10 cm. As result, most of the groupers were about 30–40 cm long, with only one grouper at Tanjung Telunjuk that was longer than 60 cm. Most of the fish that targeted for food and aquarium trade, including Groupers are commonly harvested with variety of methods such as fish bombing and poison (Johannes and Riepen, 1995). Therefore, the number of large size food fish recorded at Lang Tengah indicating there is no sign of overfishing around the island (Hodgson, 1999). Size-based indicators are often used to track the effect of fishing and measure the health of ecosystem (Jennings et al., 1998, 1999; Shin et al., 2005). Larger species are generally targeted due to their high market value, causing the low abundance of large-sized fish in a population.

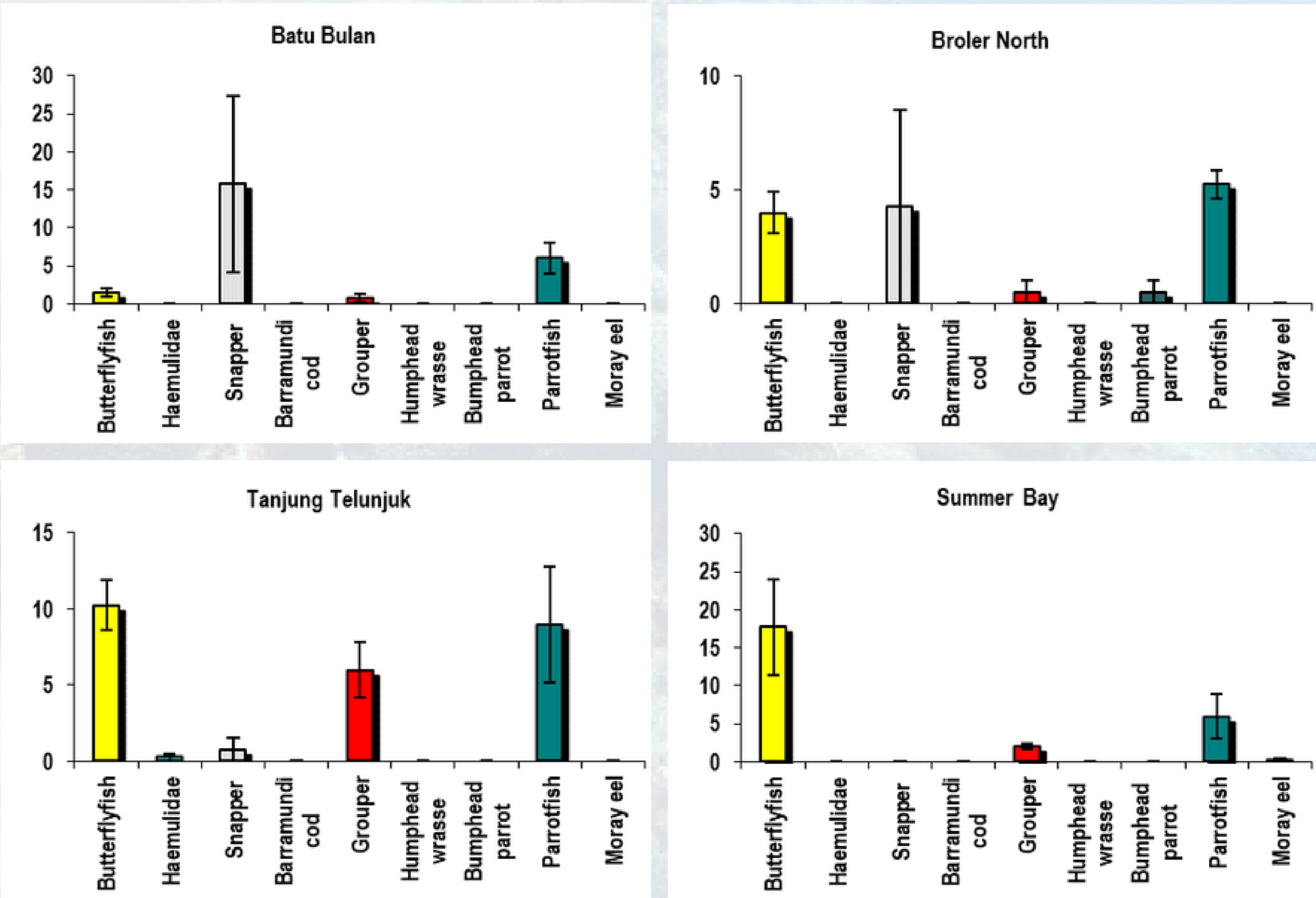



Figure 40. Mean fish abundance ± SE in October 2022 at Batu Bulan (A), Broler North (B), Tanjung Telunjuk (C), and Summer Bay (D).

# Invertebrate Survey

The invertebrate survey showed that giant clam, sea cucumber, diadema sea urchin were abundant in the waters of Lang Tengah. However, the distribution of the invertebrates was slightly different across the sites (Figure 41). Broler North had the highest number of giant clams, with 131 recorded compared to others. Like grouper, the size of giant clam was also recorded to the nearest 10 cm during the survey. During the survey, a total number of 206 giant clams were recorded. With that, giant clams that were smaller than 30 cm were found abundantly at Broler North, which is about 49% of the total number of the recorded giant clams. On the other hand, sea cucumbers were recorded as the most abundant at Tanjung Telunjuk (n=225) and Summer Bay (n=149).

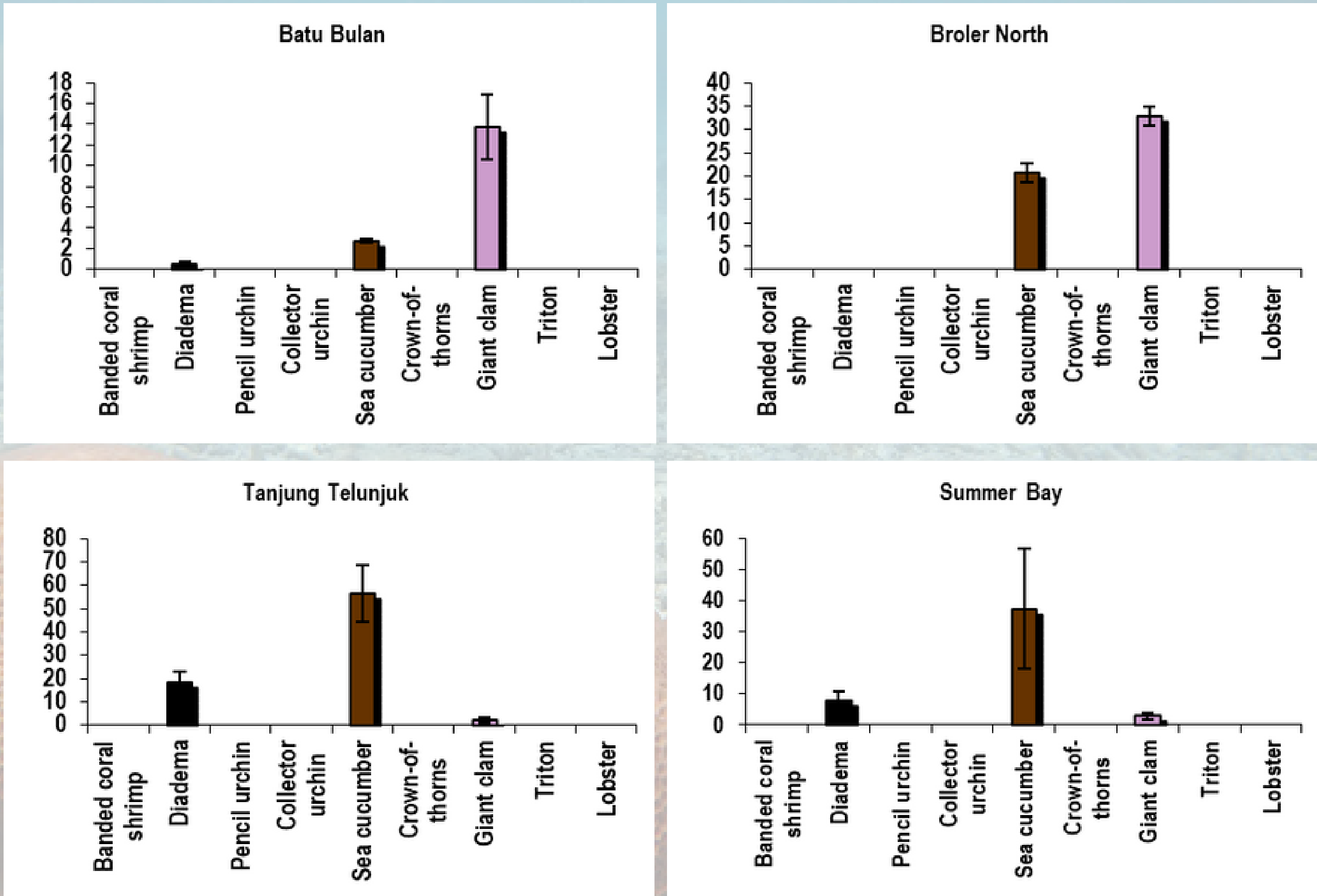



Figure 41. Mean abundance of invertebrates ± SE in October 2022 at Batu Bulan (A), Broler North (B), Tanjung Telunjuk (C), and Summer Bay (D).

# Substrate Survey

According to Figure 42, all surveyed sites were mostly covered by hard corals (30–60%). 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 (58%), while Summer Bay had the least hard coral cover recorded (30%). Generally, there were only a small number of soft corals (0–8%) found at these sites in Lang Tengah.

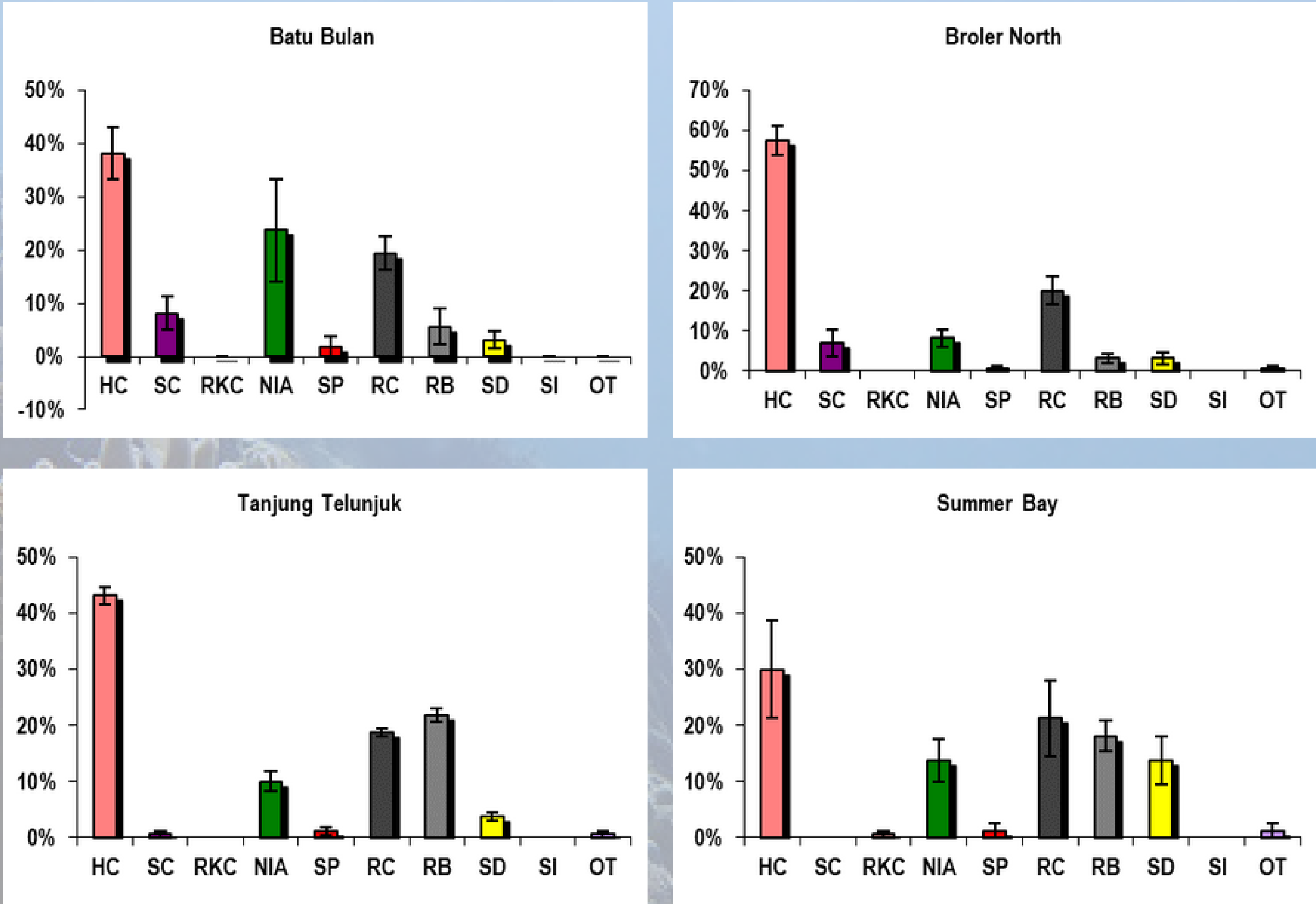



Figure 42. Mean percentage of substrate cover in October 2022 at Batu Bulan (A), Broler North (B), Tanjung Telunjuk (C), and Summer Bay (D). (Note: HC=Hard coral, SC=Soft coral, RKC=Recently killed coral, NIA=Nutrient indicator algae, SP=Sponge, RC=Rock, RB=Rubble, SD=Sand, SI=Silt, and OT=Others).

# *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 D*rupellla sp*. snails. Overall, there were only small number of impacts observed during the survey. The most common impact at Lang Tengah was coral damage, more specifically observations of coral bleaching, a small number of fishing nets, and general trash (Figure 43).

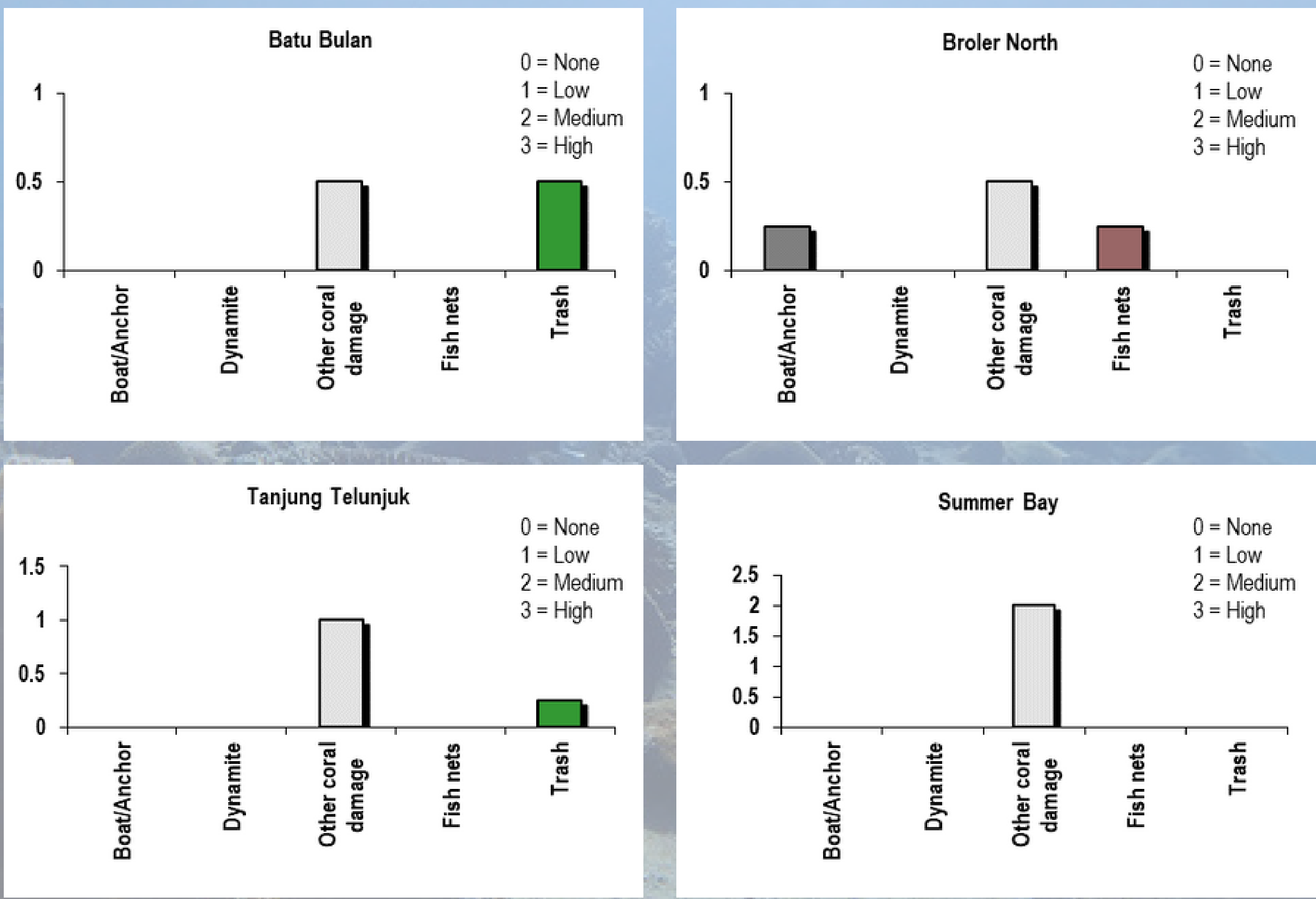



Figure 43. Incidence of impacts found during Reef Check survey at Batu Bulan (A), Broler North (B), Tanjung Telunjuk (C), and Summer Bay (D).

# Conclusion

2022 has been a full-on and productive season for Lang Tengah Turtle Watch. We expanded our conservation efforts especially in coral restoration and monitoring, resumed our volunteer programme, and increased outreach activities such as talks, school trips, and field visits. Not only that, our team is now certified Reef Check EcoDiver to conduct the annual survey for examining and monitoring the coral reefs, fishes, and invertebrates around the island.

Certainly, this was not without challenges adapting to the new normal as we marched forward into full operation post pandemic. All this could not all be achieved without the staff members, interns, and volunteers who tirelessly carry out the work on the ground post pandemic. Not forgetting the support from various sponsors and donors, which helped to sustain the project operation cost.

This season, our team at had successfully monitored and saved 69 sea turtle nests, rescued and monitored the survival and growth of 224 coral fragments in the nursey, outplanted 244 coral fragments into natural reefs, gave educational talks to 673 visitors, held several school visits and university field trips, and removed about 360 kg of trash from the beaches on Lang Tengah Island. We also reopened our volunteer programme, providing an opportunity for the volunteers to contribute to conservation and create an impact.

There is a lot for us to learn and improve from the past twelve months. Since poaching threats have diminished on the island so long as we are present during the nesting season, we certainly strive to do more to protect the eggs and hatchlings from natural predators in the area. We would also like to increase the efficiency of our coral restoration efforts, expand staff capacity, and continue raising conservation awareness through outreach activities.

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# Appendix

Appendix 1. Post-emergence inspection data for all the nests at Lang Tengah in 2022.

| 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 (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 * | Hawksbill | In-situ | 93 | 1 | 0 | 1 | 1 | 91 | 1.1 | 0 | 97.8 | 96.8 |
| 2 | Green | Relocated ^ | 7 | 1 | 0 | 1 | 0 | 6 | 14.3 | 0 | 85.7 | 85.7 |
| 3 | Green | In-situ | 102 | 9 | 0 | 6 | 0 | 93 | 8.8 | 2.9 | 91.2 † | 24.5 |
| 4 | Green | In-situ | 64 | 11 | 0 | 6 | 0 | 53 | 17.2 | 7.8 | 82.8 | 18.8 |
| 5 | Green | Relocated | 89 | 52 | 0 | 2 | 0 | 37 | 58.4 | 56.2 | 41.6 | 38.2 |
| 6 | Green | In-situ | 77 | 75 | 0 | 0 | 0 | 2 | 97.4 | 97.4 | 2.6† | 0 |
| 7 | Green | Relocated | 116 | 102 | 0 | 0 | 0 | 14 | 87.9 | 87.9 | 12.1 | 0.9 |
| 8 * | Hawksbill | In-situ | 122 | 0 | 0 | 0 | 0 | 122 | 0 | 0 | 100 | 100 |
| 9 | Green | Relocated | 96 | 69 | 0 | 3 | 0 | 27 | 71.9 | 68.8 | 28.1 | 15.6 |
| 10 | Green | Relocated | 84 | 69 | 0 | 0 | 0 | 15 | 82.1 | 82.1 | 17.9 | 4.8 |
| 11 | Green | Relocated | 99 | 77 | 5 | 0 | 0 | 22 | 77.8 | 72.7 | 22.2 | 2 |
| 12 | Green | Relocated | 89 | 67 | 2 | 7 | 0 | 22 | 75.3 | 65.2 | 24.7 | 19.1 |
| 13 | Hawksbill | In-situ | 79 | 1 | 0 | 1 | 1 | 77 | 1.3 | 0 | 97.5 | 97.5 |
| 14 * | Green | In-situ | - | - | - | - | - | - | - | - | 100 † | - |
| 15 | Green | Relocated | 98 | 82 | 0 | 1 | 0 | 16 | 83.7 | 82.7 | 16.3 | 2 |
| 16 | Green | In-situ | 88 | 69 | 2 | 0 | 0 | 19 | 78.4 | 76.1 | 21.6 | 1.1 |
| 17 | Green | Relocated | 97 | 74 | 0 | 1 | 0 | 23 | 76.3 | 75.3 | 23.7 | 16.5 |
| 18 | Green | In-situ | 79 | 69 | 1 | 0 | 0 | 10 | 87.3 | 86.1 | 12.7 | 1.3 |
| 19 | Green | Relocated | 99 | 96 | 0 | 1 | 2 | 1 | 97 | 96 | 1 | 1 |
| 20 | Green | Relocated | 74 | 70 | 0 | 0 | 0 | 4 | 94.6 | 94.6 | 5.4 | 4.1 |
| 21 | Green | In-Situ | 73 | 67 | 0 | 0 | 0 | 6 | 91.8 | 91.8 | 8.2 | 8.2 |
| 22 | Green | Relocated | 84 | 49 | 1 | 1 | 0 | 35 | 58.3 | 56 | 41.7 | 29.8 |
| 23 | Green | Relocated | 137 | 119 | 0 | 5 | 0 | 18 | 86.9 | 83.2 | 13.1 | 3.6 |
| 24 | Green | Relocated | 98 | 91 | 0 | 2 | 0 | 7 | 92.9 | 90.8 | 7.1 | 7.1 |
| 25 | Green | In-Situ | 83 | 11 | 2 | 0 | 0 | 72 | 13.3 | 10.8 | 86.7 † | 1.2 |
| 26 | Green | In-Situ | 71 | 65 | 0 | 0 | 0 | 6 | 91.5 | 91.5 | 8.5 | 1.4 |
| 27 | Green | Relocated | 96 | 61 | 0 | 0 | 0 | 35 | 63.5 | 63.5 | 36.5 | 12.5 |
| 28 | Green | In-situ | 88 | 85 | 0 | 0 | 0 | 3 | 96.6 | 96.6 | 3.4 | 3.4 |
| 29 | Green | Relocated | 142 | 119 | 0 | 1 | 0 | 23 | 83.8 | 83.8 | 16.2 | 4.2 |
| 30 | Green | Relocated | 93 | 83 | 1 | 2 | 0 | 10 | 89.2 | 89.2 | 10.8 | 2.2 |
| 31 | Green | Relocated | 145 | 139 | 0 | 0 | 0 | 6 | 95.9 | 95.9 | 4.1 | 4.1 |
| 32 | Green | In-situ | 94 | 94 | 0 | 0 | 0 | 0 | 100 | 100 | 0 | 0 |
| 33 | Green | Relocated | 151 | 133 | 3 | 0 | 0 | 18 | 88.1 | 86.1 | 11.9 | 2 |
| 34 | Green | Relocated | 95 | 74 | 0 | 3 | 0 | 21 | 77.9 | 74.7 | 22.1 | 6.3 |
| 35 | Green | Relocated | 84 | 72 | 0 | 0 | 0 | 12 | 85.7 | 85.7 | 14.3 | 1.2 |
| 36 | Green | In-situ | 104 | 100 | 0 | 0 | 0 | 4 | 96.2 | 96.2 | 3.8 | 1 |
| 37 | Green | In-situ | 91 | 86 | 0 | 0 | 0 | 5 | 94.5 | 94.5 | 5.5 | 4.4 |
| 38 | Green | Relocated | 129 | 99 | 1 | 1 | 0 | 30 | 76.7 | 75.2 | 23.3 | 4.7 |
| 39 | Green | Relocated | 95 | 70 | 0 | 3 | 0 | 25 | 73.7 | 70.5 | 26.3 † | 15.8 |
| 40 | Green | In-situ | 92 | 87 | 0 | 0 | 0 | 5 | 94.6 | 94.6 | 5.4 † | 3.3 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 41 | Green | In-situ | 117 | 117 | 0 | 0 | 0 | 0 | 100 | 100 | 0 | 0 |
| 42 | Green | Relocated | 67 | 67 | 0 | 0 | 0 | 0 | 100 | 100 | 0 | 0 |
| 43 | Green | Relocated | 156 | 129 | 1 | 0 | 0 | 27 | 82.7 | 82.1 | 17.3 | 1.3 |
| 44 * | Green | In-situ | 106 | 94 | 0 | 0 | 0 | 12 | 88.7 | 88.7 | 11.3 | 3.8 |
| 45 | Green | Relocated | 148 | 111 | 0 | 1 | 0 | 37 | 75 | 74.3 | 25 | 2.7 |
| 46 | Green | Relocated | 145 | 116 | 0 | 2 | 0 | 29 | 80 | 78.6 | 20 | 1.4 |
| 47 | Green | In-situ | 92 | 70 | 0 | 0 | 0 | 22 | 76.1 | 76.1 | 23.9 † | 2.2 |
| 48 | Green | Relocated | 84 | 82 | 0 | 1 | 0 | 2 | 97.6 | 96.4 | 2.4 | 2.4 |
| 49 | Green | In-situ | 131 | 99 | 1 | 1 | 0 | 32 | 75.6 | 74.1 | 24.4 | 17.6 |
| 50 * | Green | In-situ | 84 | 80 | 0 | 0 | 1 | 3 | 95.2 | 95.2 | 3.6 | 2.4 |
| 51 | Green | Relocated | 124 | 104 | 0 | 0 | 0 | 20 | 83.9 | 83.9 | 16.1 † | 2.4 |
| 52 | Green | Relocated | 75 | 69 | 1 | 0 | 0 | 6 | 92 | 90.7 | 8 | 0 |
| 53 | Green | Relocated | 90 | 71 | 0 | 0 | 0 | 19 | 78.9 | 78.9 | 21.1 | 10 |
| 54 * | Green | In-situ | 72 | 69 | 0 | 0 | 0 | 3 | 95.8 | 95.8 | 4.2 | 4.2 |
| 55 * | Green | In-situ | 90 | 73 | 1 | 0 | 0 | 17 | 81.1 | 80 | 18.9 | 4.4 |
| 56 | Green | Relocated | 151 | 125 | 2 | 3 | 0 | 26 | 82.8 | 79.5 | 17.2 | 3.3 |
| 57 | Green | Relocated | 78 | 64 | 0 | 3 | 0 | 14 | 82.1 | 78.2 | 17.9 | 0 |
| 58 | Green | Relocated | 140 | 107 | 9 | 1 | 0 | 33 | 76.4 | 69.3 | 23.6 | 3.6 |
| 59 | Green | Relocated | 105 | 25 | 0 | 0 | 0 | 80 | 23.8 | 23.8 | 76.2 † | 8.6 |
| 60 | Green | Relocated | 140 | 117 | 0 | 0 | 0 | 23 | 83.6 | 83.6 | 16.4 † | 0.7 |
| 61 | Green | Relocated | 86 | 77 | 0 | 0 | 0 | 9 | 89.5 | 89.5 | 10.5 | 2.3 |
| 62 | Green | Relocated | 147 | 3 | 0 | 0 | 0 | 144 | 2 | 2 | 98 | 6.8 |
| 63 | Green | Relocated | 111 | 111 | 0 | 0 | 0 | 0 | 100 | 100 | 0 | 0 |
| 64 | Green | Relocated | 101 | 76 | 0 | 0 | 0 | 25 | 75.2 | 75.2 | 24.8 | 6.9 |
| 65 | Green | Relocated | 146 | 133 | 0 | 0 | 0 | 13 | 91.1 | 91.1 | 8.9 | 3.4 |
| 66 | Green | Relocated | 76 | 0 | 0 | 0 | 0 | 76 | 0 | 0 | 100 | 0 |
| 67 | Green | Relocated | 144 | 102 | 0 | 38 | 13 | 29 | 70.8 | 44.4 | 20.1 | 14.6 |
| 68 ** | Green | Relocated | 125 | 26 | 0 | 0 | 0 | 99 | - | - | - | - |
| 69 ** | Green | Relocated | 138 | 2 | 0 | 0 | 0 | 136 | - | - | - | - |

Notes:
^ In-situ nest that was relocated due to inundation from high tide.
* Nests 1, 8, 14, 50 and 54 were missed by patrollers, while nests 44 and 55 were not counted properly. The number of eggs was counted during post-emergence inspection, except for nest 14 that was predated by monitor lizards. The nest content was not found and thus, the rates of fungal infection, hatching and emergence success were not known.
** Nests had not hatched during the last excavation in November 2022. Team excavated on March 2023, however most of the egg shells were not found. Thus, the rates of fungal infection, hatching and emergence success were not known.
†There were signs of monitor lizard disturbance and predation of the nest pre- and post-hatching. Hence, the emergence success rate for these nests might be lower than stated.