2021 ANNUAL REPORT

LANG TENGAH ISLAND

SUMMARY

6 volunteers hosted

321 of coral fragments survived in nurseries

4 Individual new mothers

24 coral colonies outplanted

4 Individual returning mothers

4,183 eggs saved

341.55 kg trash removed

CONTENTS

ACKNOWLEDGEMENTS

The conservation and research work under Lang Tengah Turtle Watch was carried out in collaboration with the Department of Fisheries (DOF), including the department's Marine Park and Resource Management Division which was formerly the Department of Marine Park.

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 and Leaderspace, all of which provided us generous funding to fully sustain our operations. As the COVID-19 pandemic continues, our volunteer programme as well as The Resthouse were limited by travel restrictions, but our funders' contributions made it possible to keep the project running throughout the year.

We also extend our utmost appreciation to CoralKu for providing capacity building and training up our staff to conduct coral conservation and research on Lang Tengah Island.

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

The work presented here was carried out by our dedicated team – Azrin Asyikin Mohd Shukor, Yasmin Rizal, Long Seh Ling, Jason Gan Yew Seng, and Nur Abidah Zaaba. We would also like to express our gratitude to our interns: Kasniza Khairulnazreen, Amir Syazwan, Nikki Lai Wei Shi, Calvin Goh Khing, Kovin Sivanasvaran, Celine Tay, Mok Weng Dee, Muhammad Shahrul Naim, Nur Airie, Syamim Balqis, Afiqah Izzati, and Nurin Aqilah Amni, 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, co-founders and directors of Lang Tengah Turtle Watch, for their ongoing support and advice. We would also like to thank our Admin Assistant, Chen Suet Yen, 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 is one of the nine islands in Redang Archipelago, and 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.

2021 has been a new start for Lang Tengah project as 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, Azrin Asyikin Mohd Shukor and Nur Yasmin Ahmad Rizal, as co-managers of the project site. The COVID-19 pandemic remains a challenge to our operations, with boat arrangements limited and interstate travel not allowed for leisure purposes. Thankfully, conservation is designated as an essential service under the DOF, which permitted some volunteers to join us on camp earlier in the season. We also expanded the internship programme to accommodate more long-term personnel on the ground and 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. We collaborated with Universiti Malaysia Terengganu (UMT) to measure nest temperature in order to determine sex ratio of the nests, as well as collected samples for sea turtle egg fungi studies.

This year, we also collaborated with CoralKu, a research-driven coral conservation enterprise based in Summer Bay Resort, to build our capacity for coral conservation and scale up past restoration efforts. With their guidance, we gained comprehensive insight into the reef ecosystem on Lang Tengah as well as best practices to restore coral reefs on Lang Tengah given the local conditions.

For the second year in a row due to pandemic restrictions on travelling and group gatherings, we were unable to host school trips to the island. However, we continued our education and outreach efforts through virtual means, such as giving online talks and tours about the conservation work we do on Lang Tengah. We also received occasional visitors to the camp site, and got to engage them in informal turtle ecology talks and 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

The project aims to:

1. 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. Conduct ongoing coral monitoring and restoration to mitigate coral population decline and preserve diversity.

3. 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

As our core activity on Lang Tengah, we monitored sea turtle nesting activities by patrolling two nesting beaches: Turtle Bay where our campsite is located as well as Lang Sari (Figure 1). Patrols were conducted nightly on an hourly basis from 8 p.m. until 7 a.m. to ensure that no nesting mother is missed. Each night, four persons would be assigned to patrol Lang Sari and two to patrol Turtle Bay; two people per beach at 2000–0100 or 0200–0700. Additionally, we received a report of nesting at Summer Bay Beach and briefly patrolled there in early October. 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 for us to monitor more closely and deter poaching.

We also collected biometric data and photographs of the nesting turtles after she has finished laying eggs (Figure 2). This was done illuminated by red light only, as it causes the least disruption to the turtle.

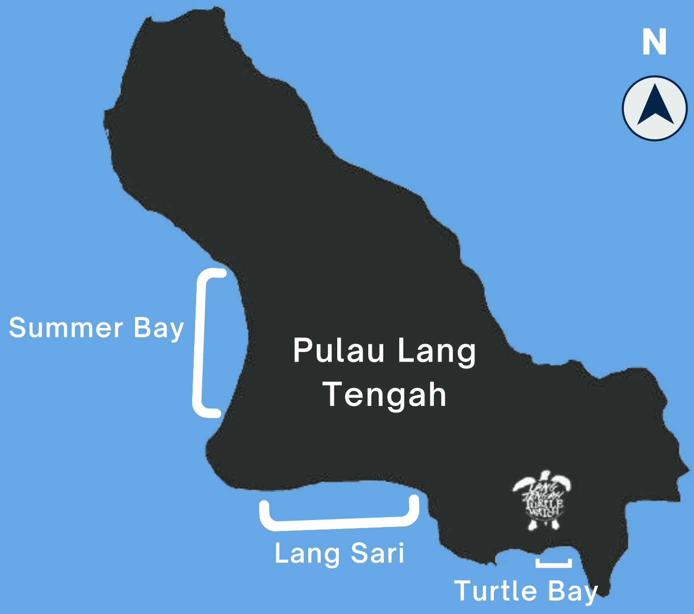


Figure 1. Nesting beaches and the location of our base on Lang Tengah Island.

Figure 2. Facial photographs of nesting females taken for individual identification using photo-identification (photo-ID) methods where we did visual comparison manually (see Llyod et al., 2012; Long & Azmi, 2017; Schofield et al. 2008; Su et al. 2015).

It takes an average of about two months for turtle eggs to hatch and for hatchlings to emerge from their nest. We conducted post-emergence inspection (PEI) by excavating the nest a few days after seeing the first sign of hatchling emergence; if we missed or did not observe any signs, PEI was done 70 days after the nest was laid. We counted the numbers of eggshells, unhatched eggs, depredated eggs, live hatchlings, and dead hatchlings to determine the hatching and emergence success (Figure 3). We also recorded any egg depredation by crab, ant, termite, monitor lizard and maggot, 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.

In addition to monitoring nesting sea turtles on Lang Tengah, we also went on snorkel and dive surveys to document the in-water sea turtle population. Using an Olympus TG6 underwater camera, we photographed and/or took videos of any turtles that were sighted. These encounters tend to be opportunistic since Lang Tengah does not have specific turtle feeding grounds, unlike the Redang and Perhentian islands. Data collected on these surveys include the species of turtle, its sex, life stage (e.g., adult or juvenile), behaviour (e.g., resting or feeding), and depth where the turtle was encountered.

Figure 3. The team conducting post-emergence inspection (PEI; top), in which the HOBO MX TidbiT 400 logger placed in some of nests to track incubation temperature was removed (bottom).

Hawksbill Turtles

This season, we did not encounter any landing or nesting hawksbills on Lang Tengah. This marks the third year on record that there were no hawksbill turtle landings since we began collecting data in 2013 (Figure 4).

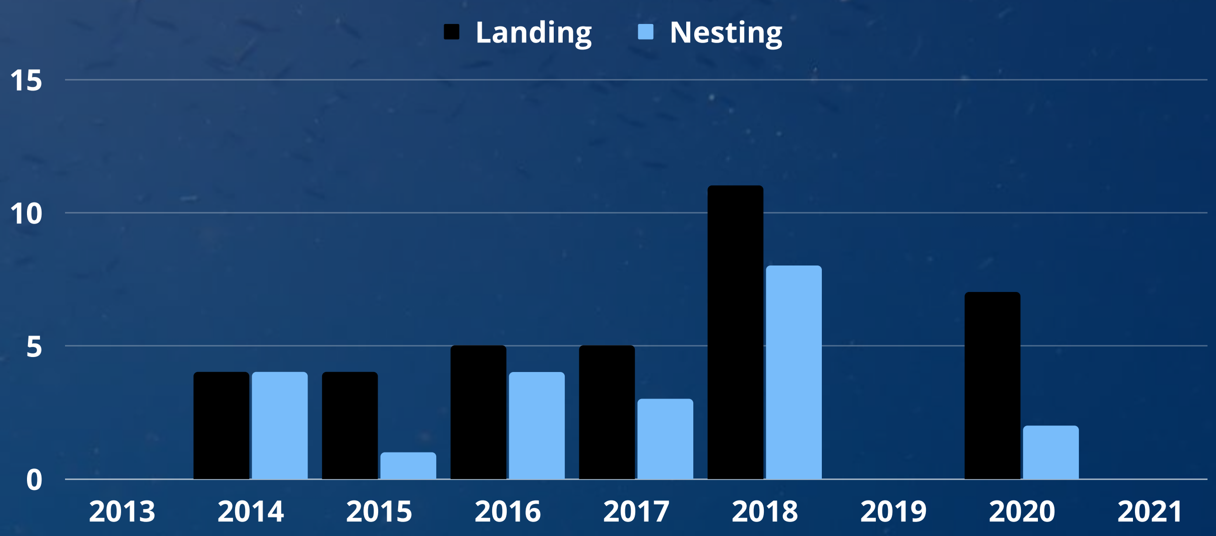


Figure 4. Number of hawksbill turtle landings and nests in Lang Tengah Island in 2021.

From in-water surveys, we had multiple sightings of hawksbill turtles at dive and snorkel sites around the island. Three juvenile hawksbills were identified and given photo-IDs LTH0011U, LTH0012U, and LTH0013U (Figure 5). There were no resightings of hawksbill turtles that were already in our database. However LTH0012U may be the same individual as LTH0010 since they were sighted in the same location. Only one side of the turtle's face was captured in each instance, but neither of the photos matched any known individual in the database. We can only definitively confirm whether or not they are the same or different individual upon resighting.

Figure 5. Two hawksbills identified and given an ID of LTH0013U (left) and LTH0011U (right) in 2021.

Green Turtles

Green turtles nested in Lang Tengah from March to September 2021, as shown in Figure 6. The peak nesting and landing month was in July. Out of a total of 77 landings, 45 nests were recorded, with 12 in-situ nests at Turtle Bay, 32 relocated from Lang Sari, and one laid at Summer Bay Beach in front of Sari Pacifica Resort, also relocated to Turtle Bay.

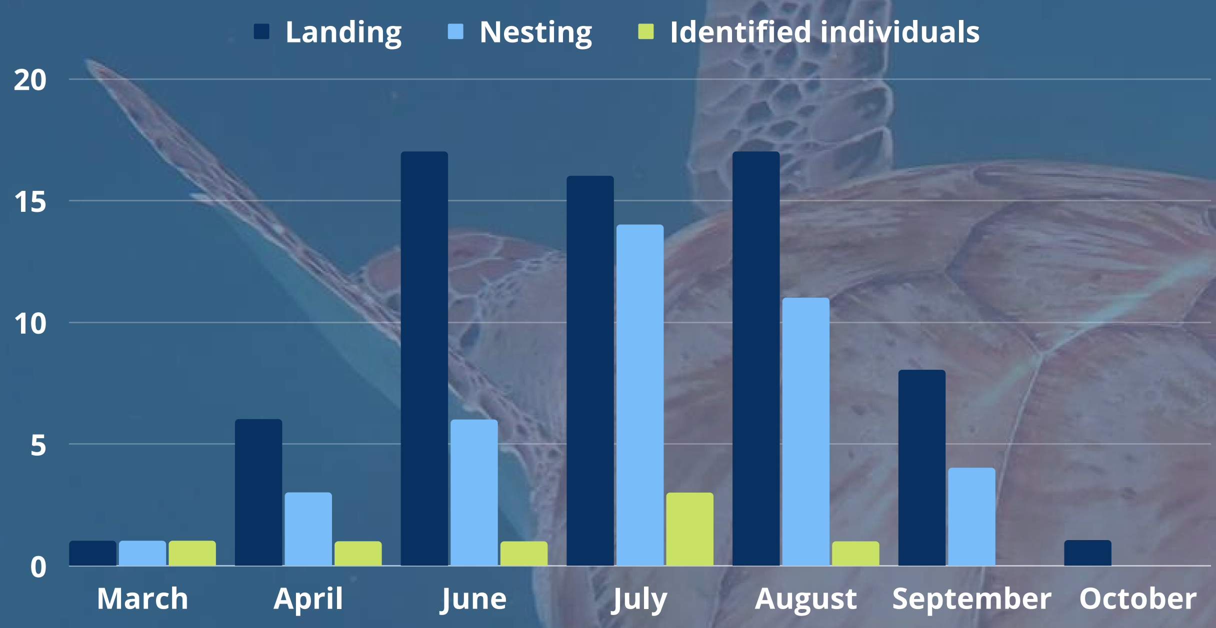


Figure 6. Number of green turtle landings, nests and identified individuals in Lang Tengah Island in 2021.

The number of individual turtles shown in Figure 6 consist of eight individual females (Table 1) identified using photo-ID methods (Figure 7). Four mothers were considered new mothers in Lang Tengah, as there are no records of prior nesting either in the photo-ID database or flipper tag record. The remaining four were returning mothers who last nested on Lang Tengah in 2018 and/or 2015. Their inter-nesting interval ranged between 9 and 12 days. Four of the nests laid were missed during nesting, so we did not manage to get facial photos of the nesting females.

Table 1. Nesting information of eight 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)
LTG0015F	Aluna	Returning	5	389 (n=4)	94.75 ± 7.46	Turtle Bay	10
LTG0018F	Sharnazz	Returning	11	1,246	112.27 ± 18.99	Lang Sari	9–12
LTG0019F	Olivia	Returning	3	352	117.33 ± 8.38	Lang Sari	11–22
LTG0021F	Jules	Returning	2	182	91.00 ± 2.00	Turtle Bay	10
LTG0043F	Cempaka	New	5	448	89.60 ± 6.68	Turtle Bay	9–10
LTG0045F	Brunhilde	New	8	731	91.38 ± 6.16	Turtle Bay	9–12
LTG0047F	Shadow	New	4	344	86.00 ± 14.85	Turtle Bay	10–12
LTG0048F	**Not yet named*	New	3	244	81.33 ± 3.09	Turtle Bay & Lang Sari	10-11

Figure 7. Turtle facial photos from two different landings on 5 September 2018 (left) and 13 July 2021 (right). Comparing the facial scales confirms that both sightings are of the same nesting turtle, LTG0015F (Aluna).

In total, we recorded 4,183 eggs (97.95 ± 16.98 eggs per nest from 42 nests) laid on Lang Tengah in 2021. However, the actual total number of eggs is not known. For ex-situ nests, we were able to count and record the number of eggs during the relocation process. For nests left in situ, three of the nests were missed by patrollers and encountered only after the turtle had left; the number of eggs for these nests was based on how many we found during post-emergence inspection (PEI) and thus, does not indicate the full size of the clutch.

The hatching and emergence success of the green sea turtle nests are detailed in Appendix 1. Hatching success rate was calculated from the number of empty eggshells found during PEI as a percentage from the total number of eggs laid. Overall, nests on Lang Tengah this season reported an average hatching success rate of 63.29% (0–97.47%). Relocated nests had a higher hatching success rate compared to in-situ nests, 74.03% (1.30–97.47%) and 28.91% (0–87.74%), respectively. The highest hatching success was recorded for nest 43 with 97.47% eggs hatched. Four nests, all of them in situ, had 0% hatching success. Meanwhile for emergence success, the average was 55.34% (0–97.47%).

In-situ nests appeared to have a higher rate of predation by monitor lizards with seven out of 13 nests recorded as having varying degrees of monitor lizard disturbance, especially when the nest was freshly laid. In addition, two relocated nests that had high hatching success were depredated by monitor lizards as the hatchlings were in the process of crawling up the nest, before they managed to emerge. Closer and more frequent guarding of sea turtle nests is vital in the future to curtail monitor lizard predation and other threats such as crab predation to hatchling survival.

Throughout the season, besides determining predation rate, we also deployed temperature loggers in 20 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). From 16 nests that had retrievable temperature data, we found that our nests have been producing a majority of male hatchlings (Table 2). Interestingly, the two in-situ nests that we obtained temperature data from 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.

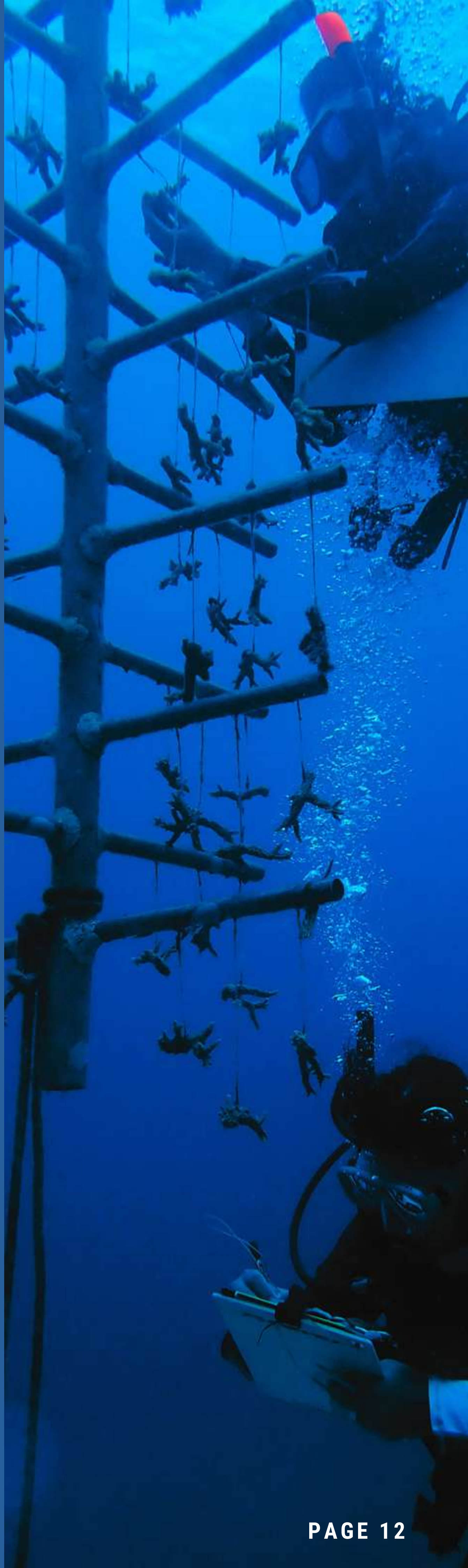
Table 2. Nest temperature and sex ratio of 16 nests with available temperature data.

Nest	Type of nest	Days of incubation	Shading	Average temperature during temperature - sensitive period (°C)	Percentage of female hatchling (%)
1	Relocated	58	Shaded	28.55	7.06
2	Relocated	55	Unshaded	29.07	54.04
3	Relocated	59	Shaded	28.23	1.35
4	Relocated	59	Unshaded	28.30	1.91
5	Relocated	58	Shaded	28.53	6.16
9	Relocated	56	Shaded	28.70	14.14
13	Relocated	59	Unshaded	28.15	0.89
14	Relocated	61	Unshaded	27.79	0.14
15	Relocated	57	Unshaded	28.97	40.34
18	Relocated	60	Unshaded	28.27	1.70
19	Relocated	59	Shaded	28.24	1.44
20	In-situ	59	Shaded	28.29	1.89
27	Relocated	59	Unshaded	28.31	2.11
28	Relocated	64	Unshaded	28.63	10.28
29	Relocated	58	Unshaded	28.43	3.80
38	In-situ	58	Unshaded	28.36	2.70

CORAL RESTORATION

Lang Tengah Island reefs are rich in hard coral species (Harborne et al., 2000), but data is not extensive enough and ecological assessment is missing. Some rubble areas around the island, with large dead tabular and massive colonies and plenty of small branching rubble pieces, were obviously complex reefs not so long ago.

The Lang Tengah Turtle Watch coral project 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 coral project is to restore locally deteriorated coral reefs while also protecting others that are still in good condition.



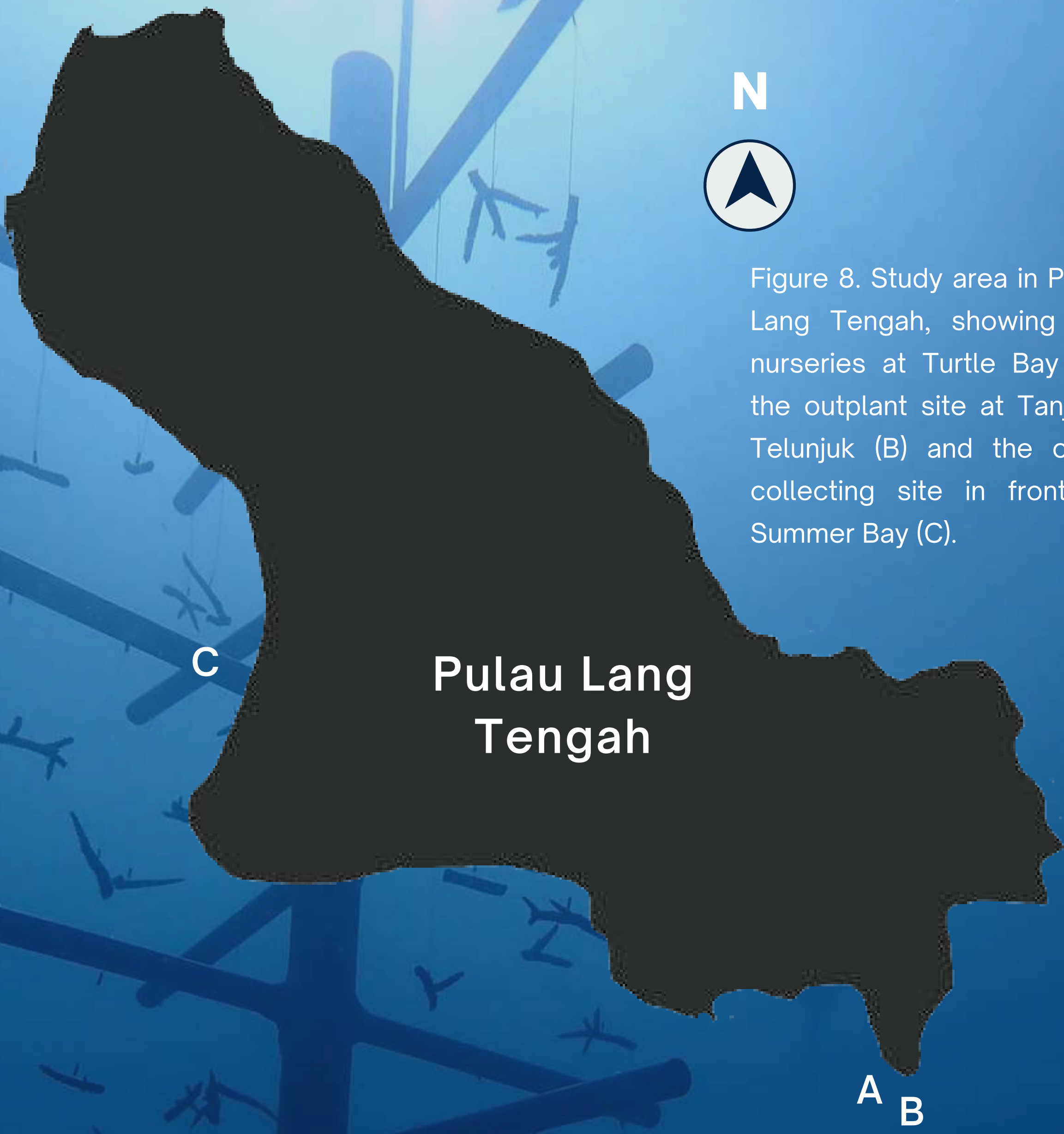


Figure 8. Study area in Pulau Lang Tengah, showing the nurseries at Turtle Bay (A), the outplant site at Tanjung Telunjuk (B) and the coral collecting site in front of Summer Bay (C).

Conservation measures alone are not enough to protect coral reefs from declines. As a result, active restoration practices should be implemented. The active reef restoration methodologies currently used include the application of coral transplantation measures and the use of underwater nurseries (Shafir et al., 2006). Thus, this year we focused on coral transplantation and growing coral fragments in our mid-water floating nurseries. Once the coral fragments have grown to a certain size, we would then outplant them to the nature reefs (Figure 8). Lang Tengah Turtle Watch's coral restoration work continued this year in collaboration with CoralKu where they provided training and technical support including project design (Figure 9).

Figure 9. Lang Tengah Turtle Watch staff members receiving training on coral conservation methods from CoralKu.

Coral Collection

A total of 356 coral fragments were harvested from corals of opportunity at an average depth of 10 m in front of Summer Bay (Figure 10). Corals of opportunity are fragments of coral that have naturally been dislodged from the parent colony or substrate. These coral fragments consist of five coral species representing 98 donor colonies of *Acropora muricata*, *Porites cylindrica*, *Hydnophora rigida*, *Acropora florida* and *Acropora longicyathus* (Table 3). The average linear length of a total of 356 fragments was 8.59 cm (SD ± 1.43).

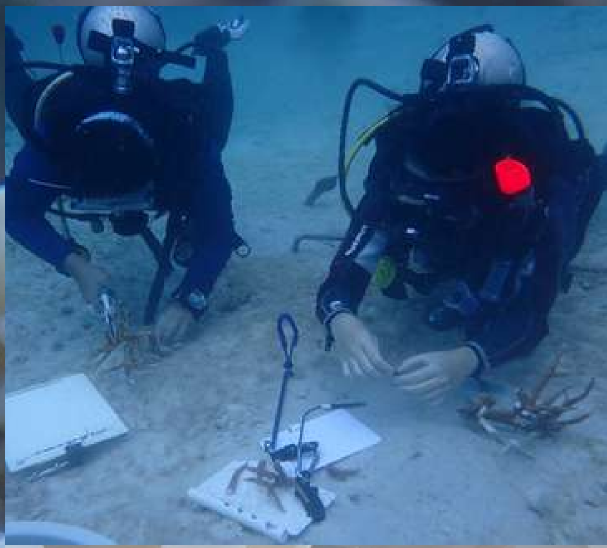


Figure 10. Collecting corals of opportunity in front of Summer Bay site.

Table 3. Species of coral fragments collected from Summer Bay in 2021.

Species	Month collected	No. of colonies	No. of fragments	Average linear length ± SD (cm)
Acropora muricata	May	6	44	8.84 ± 1.27
Acropora florida	May	21	66	8.72 ± 1.68
Hynophora rigida	May	22	66	8.25 ± 1.17
Acropora muricata	August	14	66	8.58 ± 1.33
Acropora longicyathus	August	7	66	8.70 ± 1.65
Porites cylindrica	August	28	48	8.54 ± 1.34
Total		**98**	**356**	**8.59 ± 1.43**

Coral Nurseries

The coral fragments were transported in wet condition to the nursery site. In 2021, we installed four new coral trees with 66 coral fragments attached to each and we restocked two old coral trees with 44 and 48 coral fragments, respectively. Figure 11 shows the construction dimension of the new coral tree nurseries design made of PVC pipes. These coral trees were deployed at a depth of 8–10 m within 500 m from the outplanting site at Tanjung Telunjuk (Figures 8 & 11). Subsurface buoy, polypropylene rope and duckbill anchors were used to attain the vertical position of the coral tree nurseries. Each tree had one species of coral fragments which were tethered using short and long monofilament to avoid collision between fragments (Figure 12).

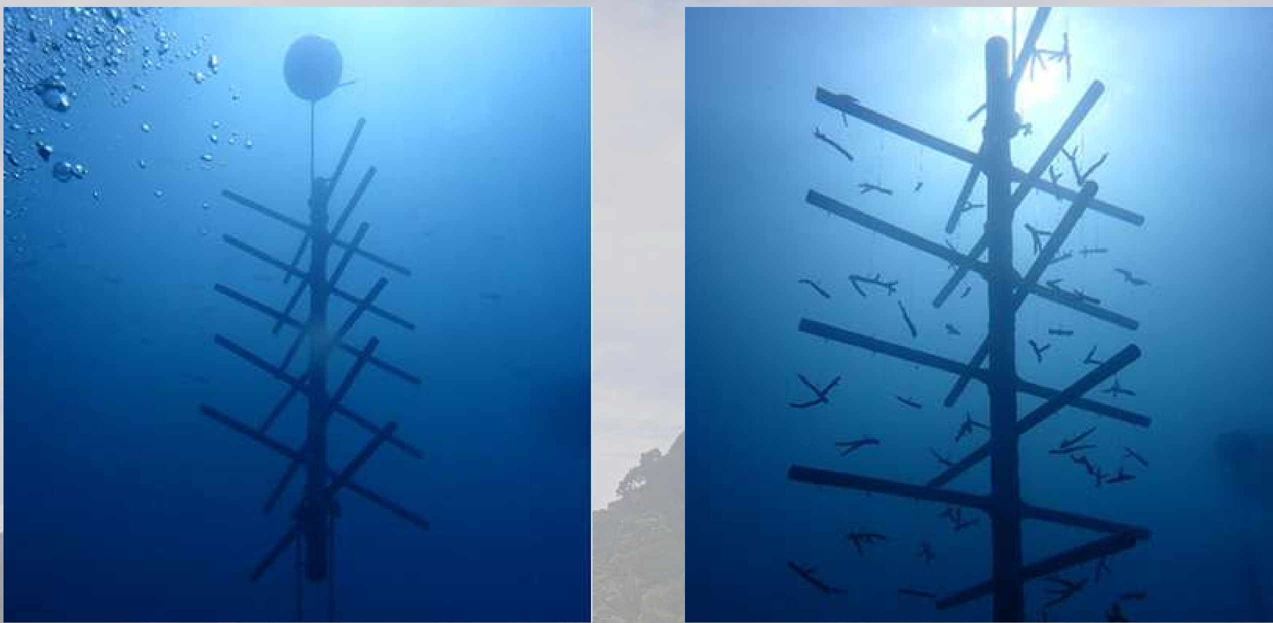


Figure 11. A coral tree that was deployed at the depth of 8–10 m at Turtle Bay (left), holding between 44 and 66 coral fragments (right)..

Figure 12. Coral fragments which were tethered using short and long monofilament.

We monitored the growth and survival of the coral fragments in the nurseries on a monthly basis until October. Three coral trees with coral fragments of *A. muricata, A. florida* and *H. rigida* were constructed in May while the remaining three with coral fragments of *A. muricata*, *A. longicyathus* and *P. cylindrica* were constructed in August. Thus, the former trees were monitored over six months between May to October meanwhile the latter trees were monitored over 36 days between late August and early October. We conducted detailed observation to determine the status of each coral fragment (alive, dead, or detached), number of branches and lesions, bleaching status, and predation. Survival rates were calculated as the number of live coral fragments divided by the number of fragments present in nurseries (%). To assess growth, we measured the height (h), width (w), and length (l) of each fragment using a calliper except for dead and detached fragments. We used the ellipsoid volume (EV) to assess the changes in growth rate over time (ΔG; $cm^3 day^{-1}$) as the morphology of well-developed colonies growing on the nurseries resemble an ellipse. The H, W and L were used to calculate the EV, in which $EV = (4/3) \times \pi \times H/2 \times L/2 \times W/2$ (Kiel et al., 2012). All data was written underwater on a slate, which was photographed once we were out of the water before typing the data into the spreadsheets.

The status of the coral fragments is summarized in Tables 4 and 5. All fragments that had survived after transplantation in the nurseries recovered and formed new branches during initial monitoring. Besides, the branches that were intentionally injured, known as lesions, also recovered. Data for six coral fragments of *H. rigida* was not available. A total of 321 (90.17%) out of 356 coral fragments survived in the nurseries during the pre-monsoon monitoring. Figures 13 and 14 show the survivorship of the coral fragments in the coral trees deployed in May and August, respectively. The survivor rate remained above 90% for all six coral trees within the first 36 days. For three coral trees deployed in May with *A. muricata* (n=44), *A. florida* (n=66) and *H. rigida* (n=66), the overall survival rate was 88.07% with 2.27% detached from the coral trees and 9.66% died after 139 days in the nursery (Table 4). Meanwhile, the three coral trees deployed in August with *A. muricata* (n=66), *A. longicyathus* (n=66) and *P. cylindrica* (n=48) recorded 95.56% of survived coral fragments, followed by 2.22% and 2.22% of detached and dead coral fragments, respectively, after 36 days (Table 5).

Table 4. The status of the corals fragments in the nursery May to October 2021.

Species	Status	Number of fragments, at day (%)					
		0	30	54	89	115	139
Acropora muricata (n=44)	Alive	100	97.73	95.45	79.55	79.55	79.55
	Dead	0	2.27	4.55	20.45	20.45	20.45
	Detached	0	0	0	0	0	0
Hydnophora rigida (n=66)	Alive	100	95.45	92.42	89.39	89.39	89.39
	Dead	0	4.55	7.58	9.09	9.09	7.58
	Detached	0	0	0	1.52	1.52	3.03
Acropora florida (n=66)	Alive	100	100	98.48	98.48	98.48	98.48
	Dead	0	0	0	0	0	0
	Detached	0	0	1.52	1.52	1.52	1.52
Total fragments **(n=176)**	Alive	100	97.73	95.45	90.34	89.20	88.07
	Dead	0	2.27	3.98	8.52	9.66	9.66
	Detached	0	0	0.57	1.14	1.14	2.27

Table 5. The status of the corals fragments in the coral tree nursery during five months of growth since August 2021.

Species	Status	Number of fragments, at day (%) 0	30
Acropora muricata (n=66)	Alive	100	95.45
	Dead	0	3.03
	Detached	0	1.52
Acropora longicyathus (n=66)	Alive	100	94.03
	Dead	0	4.48
	Detached	0	0
Porites cylindrica (n=48)	Alive	100	95.83
	Dead	0	4.17
	Detached	0	0
Total fragments (n=180)	Alive	100	95.56
	Dead	0	2.22
	Detached	0	2.22

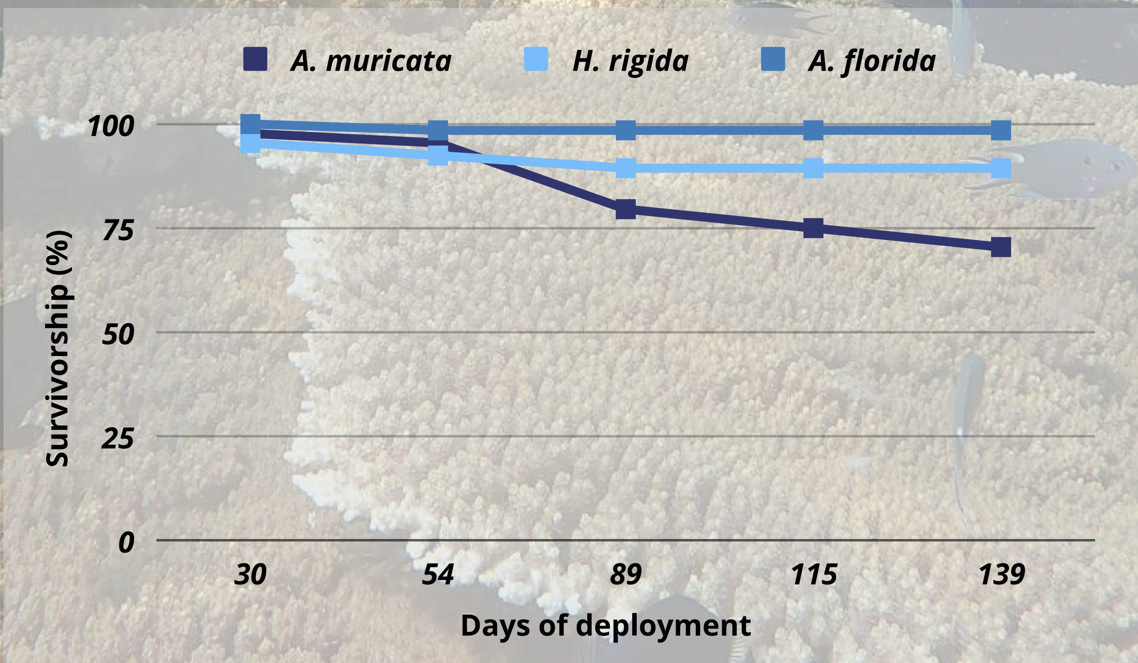


Figure 13. Pattern of survivorship between coral species over 139 days between May and October 2021.

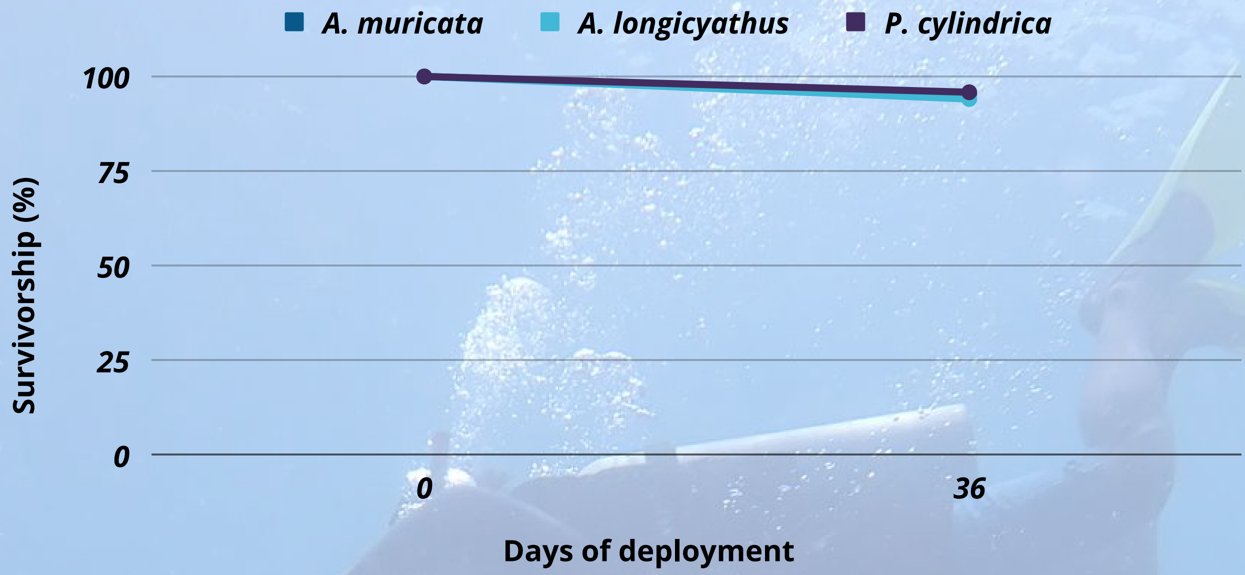


Figure 14. Survivorship of *A. muricata, A. longicyathus* and *P. cylindrica* on day 36 in October October 2021.

Figures 15 and 16 below describe the mean growth rate of six species fragments in the coral tree nurseries. The mean growth rate of *A. muricata, A. florida* and *H. rigida* in the coral tree nurseries increased with age. Over 139 days between May and October 2021, *A. muricata* showed the highest mean growth rate, growing 2.84 cm^3day^{-1}, while *H. rigida* and *A. florida* grew 1.49 $cm^3day^{-1}$and 0.39 cm^3day^{-1}, respectively (Figure 15). For the other three coral trees deployed in August, *P. cylindrica* had a faster growth rate of 0.89 cm^3day^{-1} compare to *A. muricata* and *A. longicyathus* with growth rates of 0.71 cm^3day^{-1} and 0.76 cm^3day^{-1}, respectively, during the first month of transplantation into nurseries (Figure 16).

Growth rates are inherently variable among different coral species, depending on their gross morphology, skeletal structure and polyp size (Hall & Hughes, 1996). General observation shows that *Acropora* and *Hydnophora* are among the faster growing corals due to the rapid linear extension of branching corals (Buddemeier & Kinzie, 1976). The differences in growth and survival rates through time could also be due to a variety of other factors, including physio-chemical parameters, e.g., temperature, turbidity, sedimentation rate, water motion, pH and salinity (Chou et al., 2016). Furthermore, increased water circulation, less sedimentation, lower predation, and therefore fewer diseases, can contribute to faster growth rates and lower mortality in nurseries (Edwards et al., 2010).

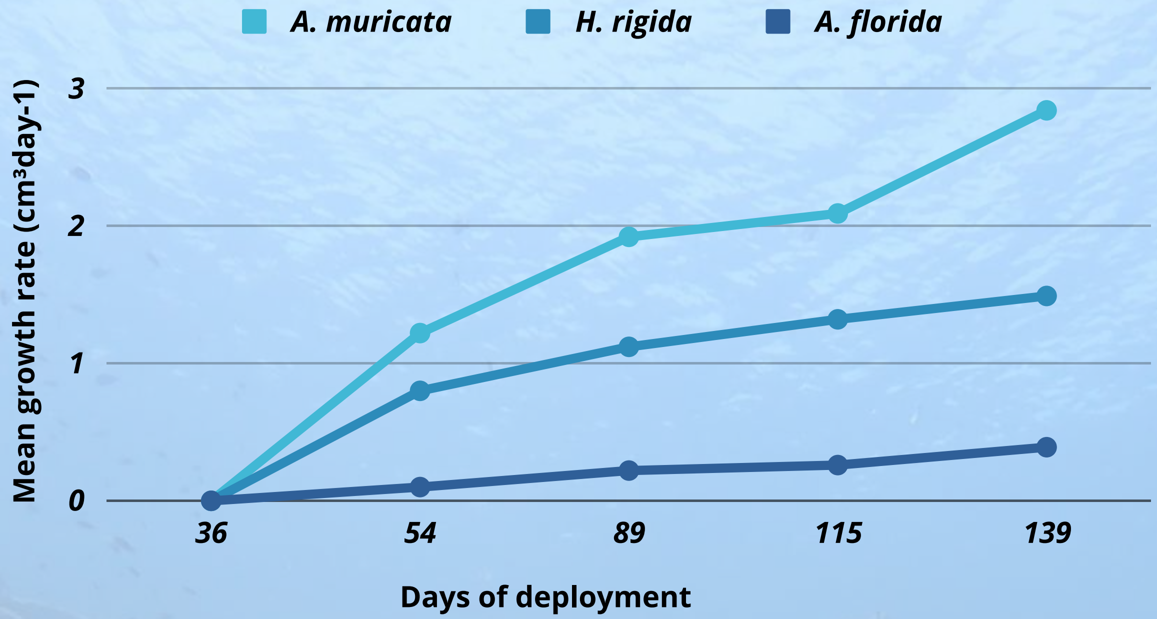


Figure 15. Mean growth rate of coral fragments over 139 days between May and October 2021.

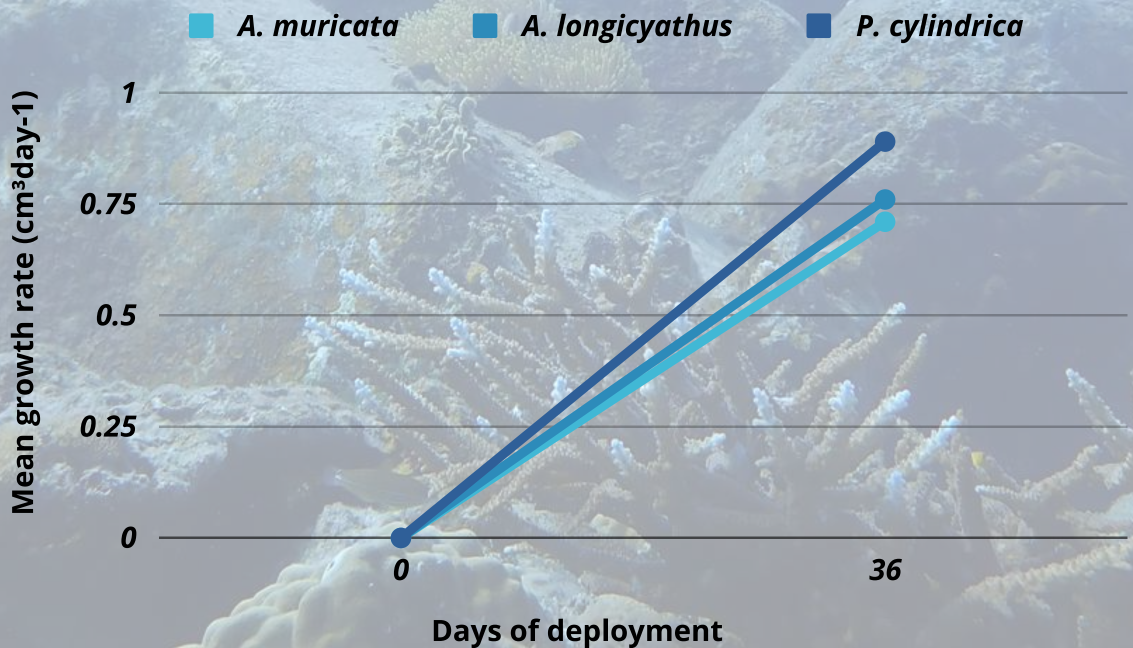


Figure 16. Mean growth rate of *A. muricata*, *A. longicyathus* and *P. cylindrica* over 36 days since August 2021.

Outplanted Corals Into Natural Reefs

We focused our restoration efforts at Tanjung Telunjuk where patches of healthy coral reefs still exist unlike the vast area of coral rubbles in front of Turtle Bay (Figure 17). Prior to outplanting, we did a rapid assessment survey of the outplanting site using point intercept transect. Substract category was recorded at every 0.5 m along a 20-m transect, yielding a total of 51 points per transect. Data were taken along two 20-m transect lines. The categories are hard coral (HC), soft coral (SC), sand (SA), rock (RK), coral rubble (RB), algae (AL) and others (OT). The percent coral cover is determined by dividing the number of points recorded as live coral by the total number of points and multiplying by 100. At the outplanting site at Tanjung Telunjuk, the coral cover was 34.1%.

Figure 17. Outplanting coral colonies at Tanjung Telunjuk (top), the vast area of coral rubbles in front of Turtle Bay (bottom).

We outplanted 21 and three coral colonies of *P. cylindrica* and *A. muricata*, respectively, which had been growing in the nurseries since March 2020 into the natural reefs at Tanjung Telunjuk. We scrubbed the surface area of the substrate before attaching the coral colonies in order to minimise space competition between coral and algae. We attached each colony onto the substrate using epoxy sculpt and cable-tied it to a concrete nail which was placed next to the colony. This concrete nail provides support to hold the coral colonies before they self-attach to the substrate. In addition, we placed a tag next to each colony, in which the tag number enabled us to identify each colony during the monthly monitoring. We conducted monthly observation and monitored their status (alive or dead), type of attachments (Table 6) and growth rate (by measuring the height, length and width; Figure 18).

Figure 18. Assessing the survival and growth of the outplanted coral colonies at Tanjung Telunjuk site.

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

The survival rate for *P. cylindrica* was 100% and *A. muricata* was 66.7% (Figure 19). The growth rate for both coral species increased with age. *A. muricata* grew faster (16.65 cm^3) than *P. cylindrica* (10.15 cm^3) over 107 days (Figure 20). A month after outplanting the coral fragments, *P. cylindrica* showed an increased pattern of self-attachment to the substrate as seen in Figures 21A and 22. During the last monitoring pre-monsoon on day 107, only two *P. cylindrica* coral fragments were non-attached to the substrate (Figure 21A). Meanwhile, *A. muricata* began showing tissue sheeting and self-attachment to the substrate from the second month onward (Figure 21B).

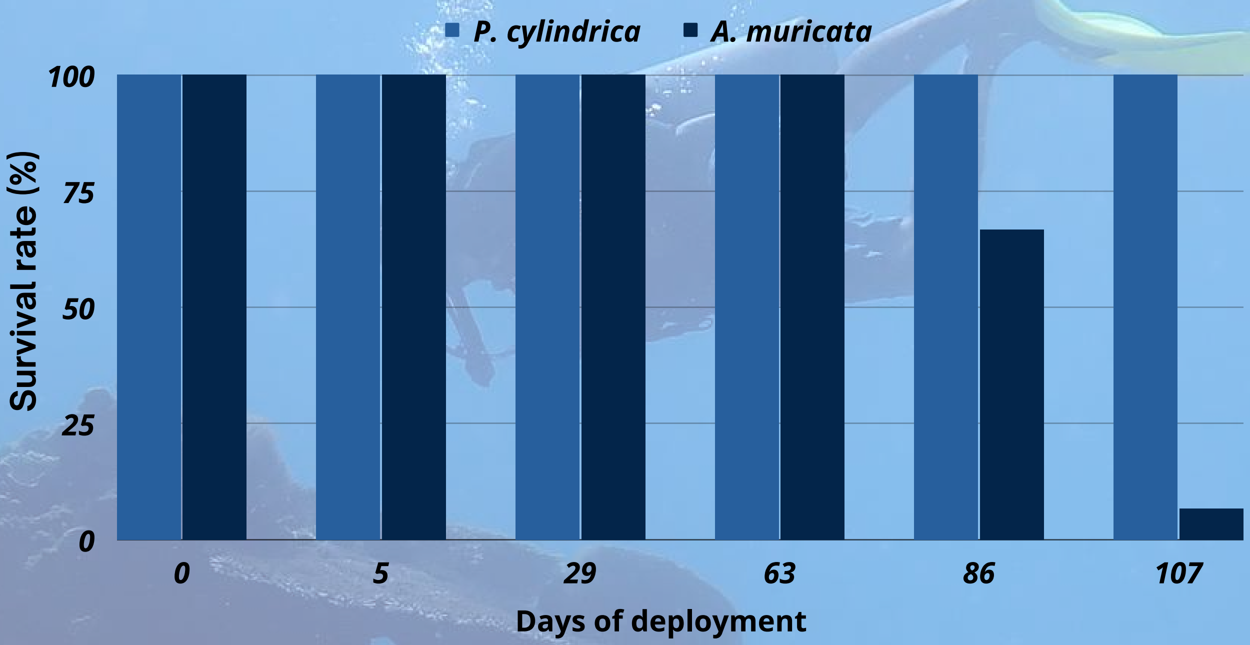


Figure 19. Survival rates of the outplanted corals at Tanjung Telunjuk between June and October 2021.

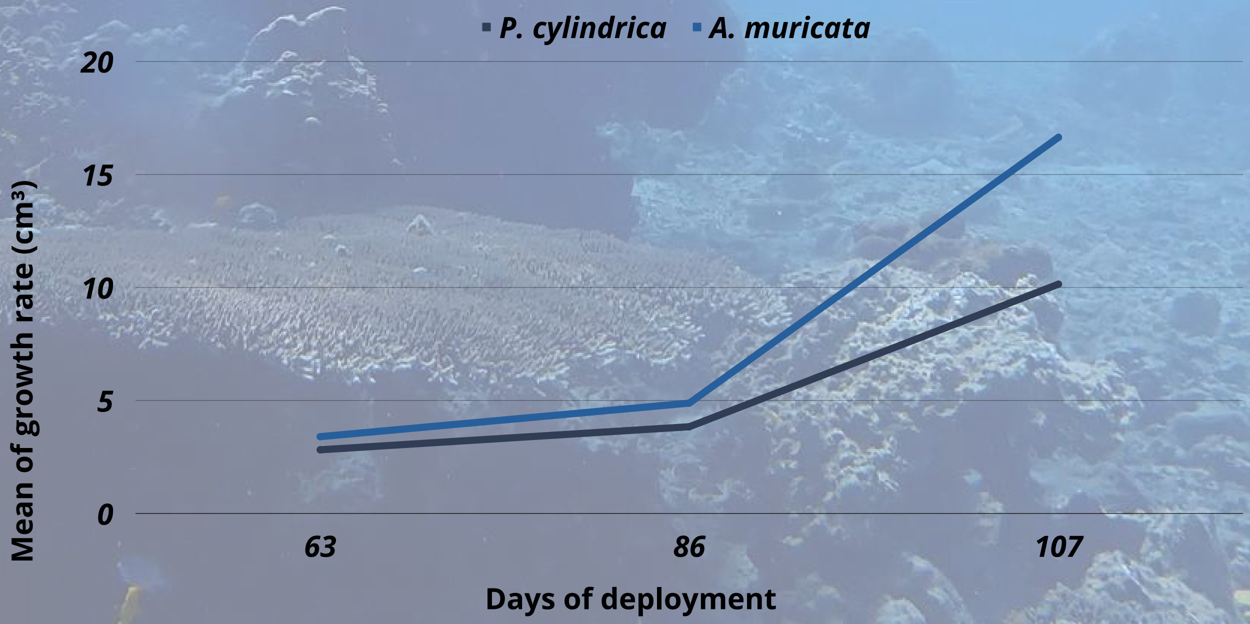
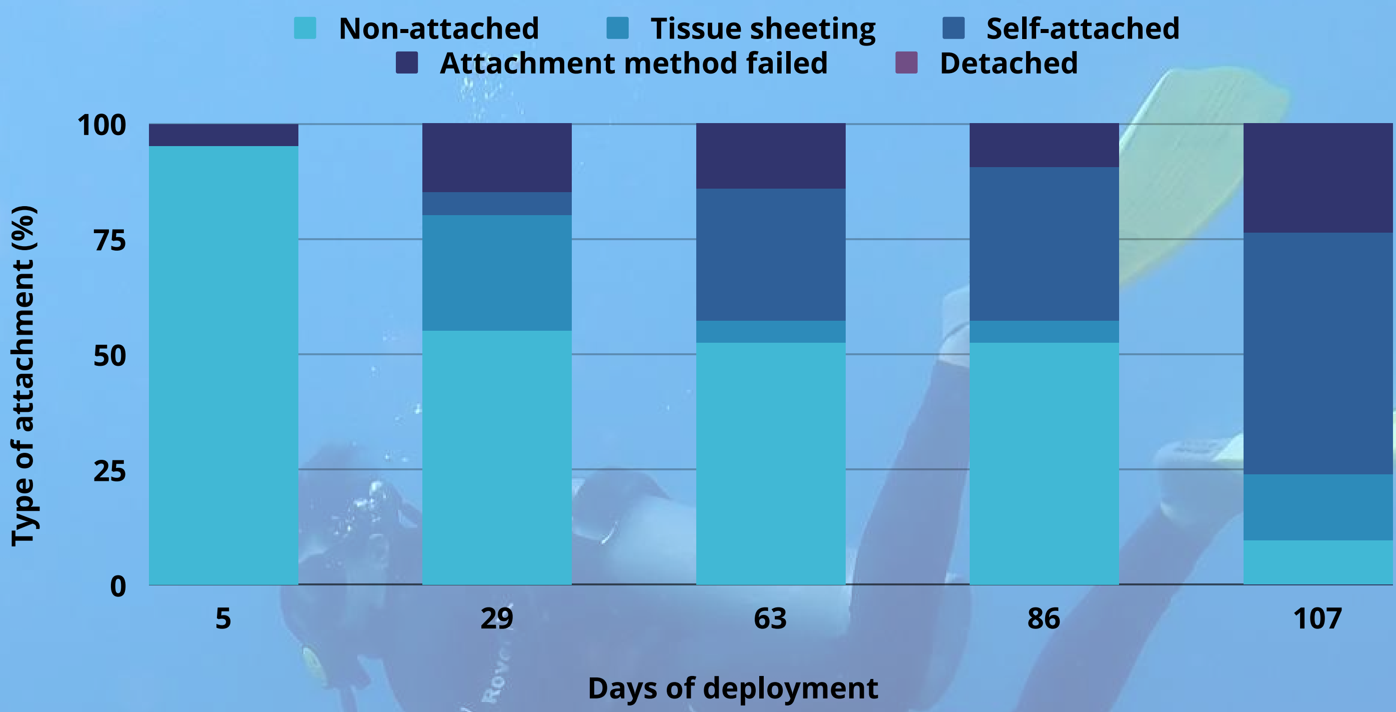


Figure 20. Mean growth rate of the outplanted corals between June and October 2021.

A



B

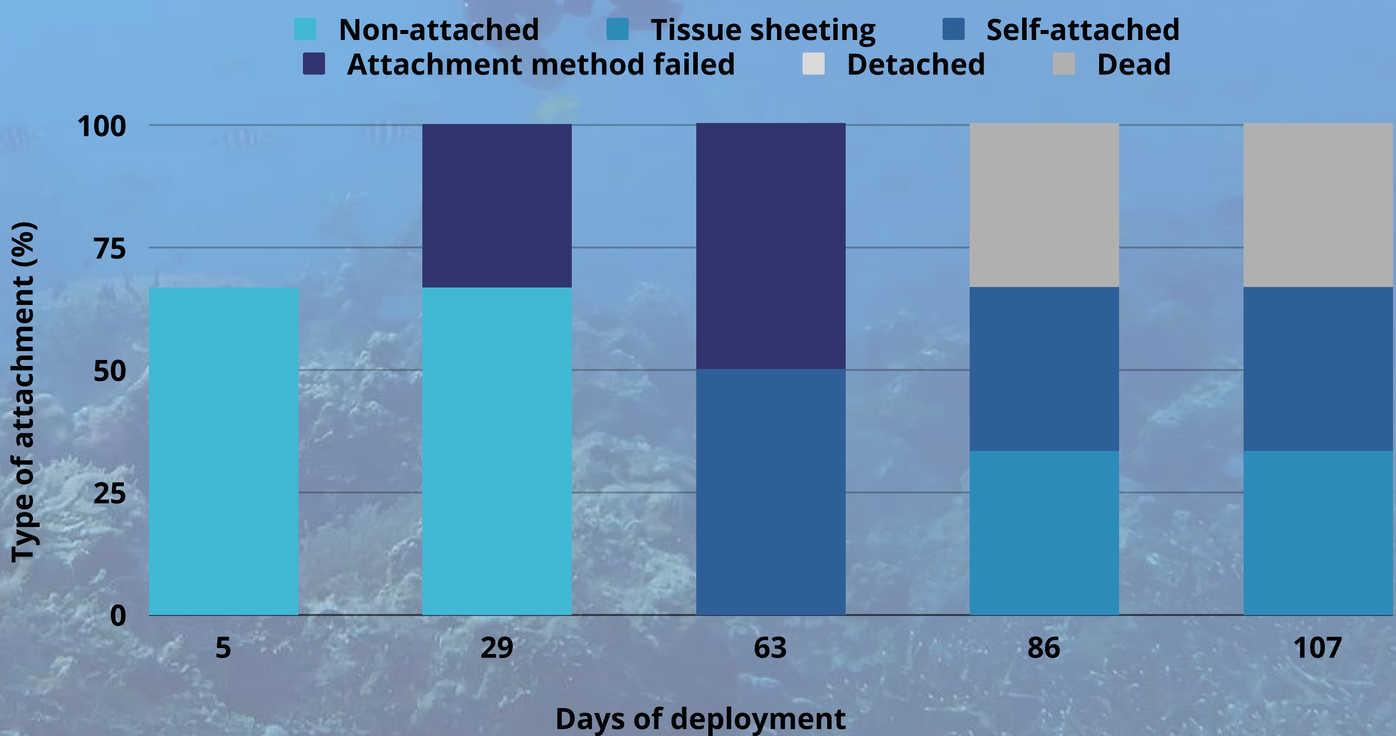


Figure 21. Type of attachment shown by 21 *P. cylindrica* coral colonies (A) and three *A. muricata* coral colonies (B) over 107 days at Tanjung Telunjuk. Note: the attachment type for one *A. muricata* coral colony was not recorded on day 63 as the top branch of the colony broke off and was later reattached with a cable tie.

In a study by Dizon et al. (2008), *P. cylindrica* also demonstrated the fastest self-attachment while *A. muricata* performed poorly due to various factors which including predation and algal overgrowth. On the contrary, *P. cylindrica* showed significantly slower self-attachment rate than *A. muricata* in another study by Guest et al. (2011). According to Guest et al. (2011), a combination of characteristics such as growth rates, growth form and life history may influence how rapidly fragments of coral species self-attach after transplantation. The ability of coral colonies to grow onto the benthic substrate or self-attach is critically important to the survival of the colony and the success of the transplantation effort (Guest et al., 2011). We found that in addition to using epoxy to attach the coral fragment to the substrate, securing the coral fragment using a cable tie to a nail that is nailed next to the coral fragment provides additional support to hold the coral fragment in place, which could enhance transplantation by increasing the likelihood of self-attachment by fusion over the benthic substrate even when the epoxy method fails (Figure 23).

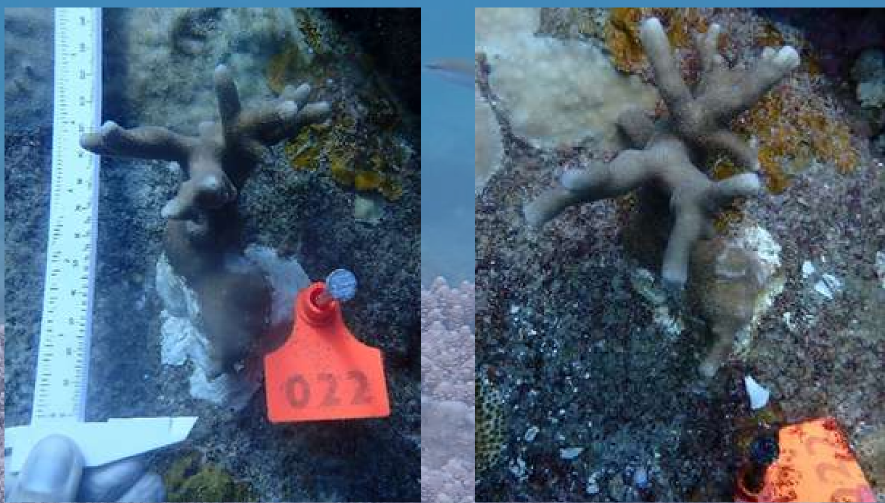


Figure 22. Self-attachment of *P. cylindrica* by tissue spreading onto the substrate at outplanting site was observed from the initial day (left) until day 107 (right).

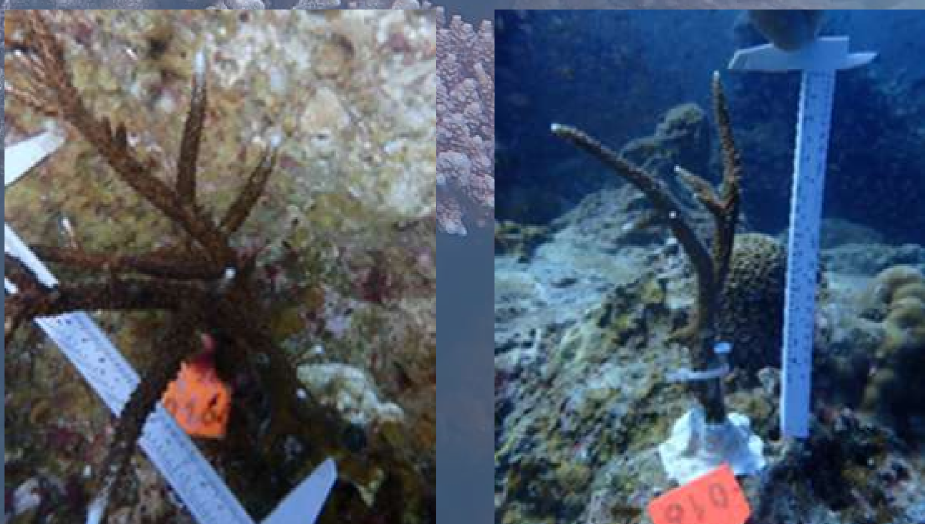


Figure 23. Securing the coral fragment of *A. muricata* using a cable tie to a nail initial day (left) until day 107 (right).

Different species traits have varying vulnerability to predators, self-attachment abilities, tolerance to local environmental conditions, susceptibility to bleaching and disease which influence their self-attachment and survivorship (Edwards & Gomez, 2007). Acropora species are often considered to be suitable for transplantation due to fast growth rates and their 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). In this study, *A. muricata* transplants had the highest growth rate but lowest survival rate. Our result corroborated with previous attempts at transplanting this species (Dizon et al., 2008, Toh et al., 2014). However, *A. muricata* performed poorly because 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).

Overall, coral restoration was carried out on a small scale using coral tree nurseries composed of common and cheap material, assembled by a team of at least three people including staff, collaborators and interns. Coral nurseries can be very productive and contribute to preserving local coral populations (Rinkevich, 2014; Schopmeyer et al., 2012; Sen & Yousif, 2016; Shaish et al., 2008). Nursery-grown coral colonies would then be transplanted to the nearby degraded reef where environmental setting is almost similar to the nursery site. To protect the coral reefs in Lang Tengah, we hope to continue restoration and efforts long term.

BEACH CLEAN-UPS

We conducted a total of 32 beach clean-ups across the 2021 season, clearing a total of 341.55 kg of debris from Lang Tengah's beaches and coastlines. Of these, 82.25 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, we received a contribution of oxo-biodegradable plastic bags from Miracle Spectrum, a sustainable packaging company, which we used to collect waste from beach clean-ups as well as the campsite. 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.

CONCLUSION

2021 has been yet another unprecedented season for Lang Tengah Turtle Watch, with frequently changing travel conditions that affected project logistics and cut short our volunteer programme. When the nationwide MCO was reinstated in June, our designation by the DOF as essential services ensured that the conservation work could continue on, and the generous grants received kept us running at full capacity and sufficient personnel throughout the season. Thanks to the support, we were able to save and study 45 green turtle nests, outplant 23 coral fragments, rescue and monitor hundreds more fragments in the nursery, and clean up almost 100 kg of beach trash on Lang Tengah Island. With more people getting vaccinated, local borders opened, and international travel likely to resume in 2022, we hope that our volunteer programme and school visits can pick up again in order to increase our outreach and education impact.

As with all long-term efforts, there is a lot for us to learn and improve from the past twelve months. Since poaching threats have diminished on the island, we can certainly do more to protect the eggs and hatchlings from natural predators in the area. We would also like to increase efficiency of our coral restoration efforts, and hope to increase staff capability to monitor and maintain the nurseries. Finally, stable and well-managed finances were essential to achieving the project objectives, and we hope to be able to keep this up for future seasons.

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APPENDIX

Appendix 1. PEI data for all nests in the 2021 nesting season at Lang Tengah.

Nest	Type of nest	Total eggs	Empty eggshells	Unhatched	Live hatchlings	Dead hatchlings	Depredated eggs (inc. missing eggs)	Hatching success (%)	Emergence success (%)	Predation rate (inc. missing eggs, %)	Fungal infection (%)
1	Relocated	126	110	7	2	0	9	87.30	85.71	7.14†	1.59
2	Relocated	77	64	0	0	0	13	83.12	83.12	16.88	9.09
3	Relocated	106	97	5	0	0	4	91.51	91.51	3.77	0.94
4	Relocated	93	79	0	3	1	14	84.95	80.65	15.05	2.15
5	Relocated	96	79	2	0	0	15	82.29	82.29	15.63	0.00
6	Relocated	89	76	3	0	0	10	85.39	85.39	11.24	0.00
7	Relocated	120	91	0	0	0	29	75.83	75.83	24.17	10.00
8	Relocated	93	76	1	0	1	16	81.72	80.65	17.20	8.60
8a	In-situ	16*	15	0	0	0	1	-	-	-	-
9	Relocated	147	121	0	0	0	26	82.31	82.31	17.69	1.36
10	Relocated	97	56	39	0	0	2	57.73	57.73	2.06	1.03
11	Relocated	122	62	0	0	1	60	50.82	50.00	49.18	0.00
12	Relocated	92	51	0	2	0	41	55.43	53.26	44.57	1.09
13	Relocated	135	109	5	0	1	21	80.74	80.00	15.56	0.74
14	Relocated	87	67	8	2	1	12	77.01	73.56	13.79	0.00
15	Relocated	127	118	0	0	0	9	92.91	92.91	7.09	0.00
16	In-situ	71	56	10	0	0	5	78.87	78.87	7.04	1.41
17	In-situ	106	93	8	0	0	5	87.74	87.74	4.72	2.83
18	Relocated	88	61	12	0	0	15	69.32	69.32	17.05	0.00
19	Relocated	113	84	4	0	0	25	74.34	74.34	22.12	0.00
20	In-situ	105	70	2	0	0	33	66.67	66.67	31.43	0.00
21	In-situ	104	42	5	0	0	57	40.38	40.38	54.81†	3.85
22	Relocated	92	63	23	0	0	6	68.48	68.48	6.52	1.09
23	Relocated	93	82	1	0	0	10	88.17	0.00	10.75†	0.00
24	Relocated	92	66	0	0	0	26	71.74	71.74	28.26†	2.17
25	In-situ	10*	9	1	1	0	0	-	-	-	-
26	In-situ	96	0	0	0	0	96	0.00	0.00	100.00†	0.00
27	Relocated	104	79	15	0	1	10	75.96	74.04	9.62	0.96
28	Relocated	89	82	2	0	0	5	92.13	92.13	5.62	0.00
29	Relocated	93	64	2	0	0	27	68.82	68.82	29.03†	1.08
30	In-situ	100	0	0	0	0	100	0.00	0.00	100.00†	0.00
31	Relocated	88	73	10	1	0	5	82.95	0.00	5.68†	0.00
32	In-situ	72	6	0	0	0	66	8.33	8.33	91.67†	0.00
33	Relocated	114	91	2	0	0	21	79.82	79.82	18.42	0.00
34	In-situ	89	0	0	0	0	89	0.00	0.00	100.00†	0.00
35	Relocated	82	76	3	0	0	2	92.68	92.68	2.44	0.00
36	Relocated	83	72	3	16	0	8	86.75	67.47	9.64†	0.00
37	Relocated	117	114	3	114	0	0	97.44	0.00	0.00	0.00
38	In-situ	86	0	0	0	0	86	0.00	0.00	100.00†	0.00
39	Relocated	77	1	0	0	0	76	1.30	1.30	98.70†	0.00
40	Relocated	107	24	0	0	0	83	22.43	22.43	77.57	0.00
41	In-situ	43*	43	0	0	0	0	-	-	-	-
42	In-situ	84	6	0	0	0	78	7.14	7.14	92.86	0.00
43	Relocated	79	77	0	0	0	2	97.47	97.47	2.53	0.00
44	Relocated	83	25	58	24	1	0	30.12	0.00	0.00	0.00

Notes:

*Nests 8a, 25, and 41 were missed nests; the number of eggs is based on how many were found during PEI. Hatching and emergence success rates are not calculated for these.

†There were signs of monitor lizard disturbance and predation of the nest pre- and post-hatching.