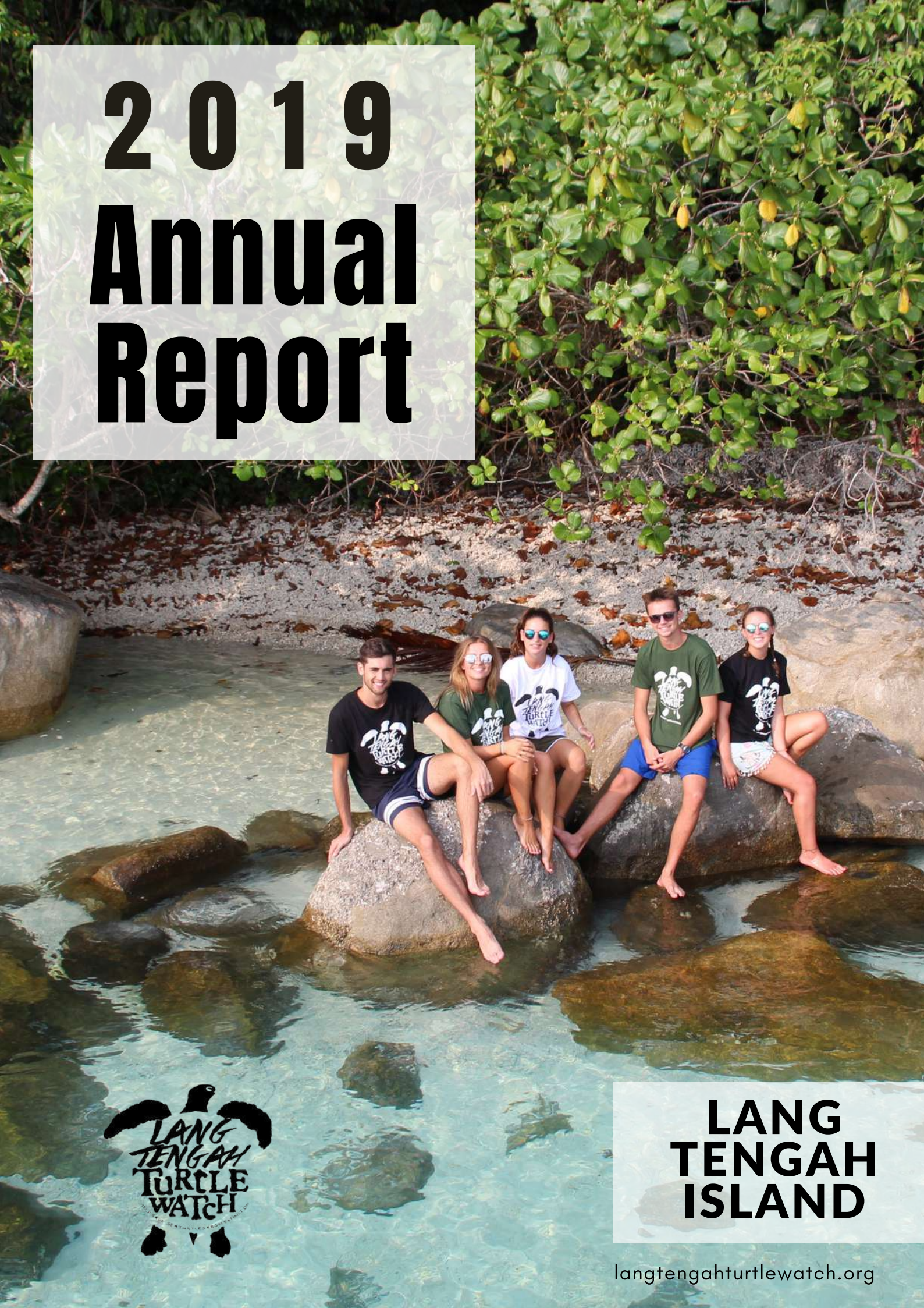
2019 Annual Report



LANG TENGAH TURTLE WATCH

LANG TENGAH ISLAND

langtengahturtlewatch.org

SUMMARY

In the 2019 season a total of 83 volunteers, 37 of which were local, participated in the Lang Tengah Turtle Watch volunteer programme. There were seven school and university visits, which alongside volunteer efforts, resulted in over 1,500 kg of trash being removed from the beach and reef.

Monitoring of nesting sea turtles resulted in 65 nests being laid from 15 different mothers, with an average nesting interval of 11.6 days. There were a total of 5,387 eggs laid, of which 4,276 hatchlings emerged, equating to an overall 71% hatching success rate.

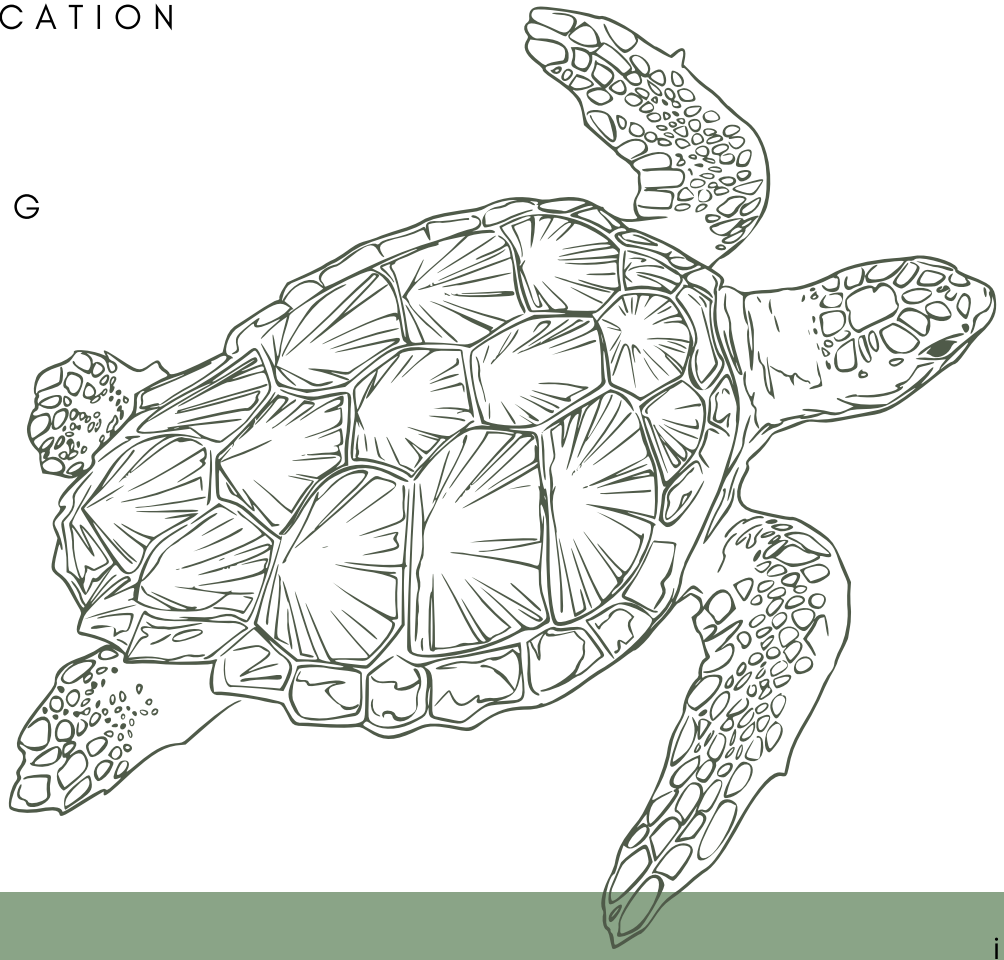
83
volunteers hosted

65
nests saved

5,387
eggs saved

71
emergence success (%)

CONTENTS



ACKNOWLEDGEMENTS

Lang Tengah Turtle Watch team would like to express their deepest gratitude to the Department of Fisheries, Department of Marine Park Malaysia, Summer Bay Resort and D'Coconut Lagoon Resort for their help, guidance and trust into the organisation and its conservation efforts on Lang Tengah Island. The support provided by every party is crucial for the successful conduct of the operation of our projects. In addition, Lang Tengah Turtle Watch would also like to thank all the staff, interns and volunteers for their help in all aspects of marine conservation - patrolling the nesting beaches on a daily basis, collecting nesting and landing data, as well as reef health via the ongoing coral reef restoration. The work from our island team this year has allowed us to maximise our tourist engagement, volunteer enrichment and most importantly research. It would not have been possible without our team this year.

PROJECT OVERVIEW

Lang Tengah Turtle Watch (LTTW)'s mode of operation has been heavily focused on paid volunteer ecotourism since its inception in 2013. Volunteers taking part in the turtle conservation project primarily help by patrolling the nesting beaches to deter poaching and predation, assist in nest relocation and collecting sea turtle landing data, as well as carrying out nest check and post-hatch inspection (PHI) on all nests laid on Lang Tengah island.

This season, LTTW continued to work on becoming a more research-based conservation organisation by following on from last years monitoring projects on Lang Tengah Island.

Interns

Interns were unpaid volunteers who stay on camp for 10 weeks and have their in-country travels and accommodation as well as food within the camp covered. Interns were recruited to assist with volunteer management as well as to partake in all monitoring projects.

Interns recruited were required to fulfil the minimum criteria set by the field project managers in charge of the research projects. Upon arrival on Lang Tengah Island, they underwent training on research methodology for 1-2 weeks before being allowed to carry out surveys around Lang Tengah Island and collect data required by the field project managers.

Interns:
Ronan Conlon (June - August)
Julian Gervolino (July - September)

Both interns performed their roles to the utmost of their capabilities and both were great help in not only running camp and the volunteer program but also participated heavily in our research efforts.

Volunteers

A total 83 volunteers - 37 of which were local, participated in the volunteer program that ran from March to October 2019. More education and research opportunities were provided to the volunteers as they aided with the new research projects alongside the interns. The volunteers were also provided with more education on marine conservation with new presentations made to raise awareness on pressing environmental issues such as plastic pollution.

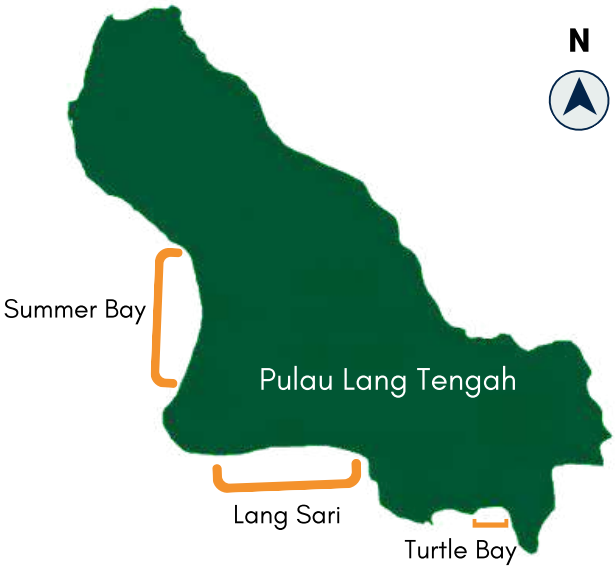
SEA TURTLE MONITORING

The sea turtle monitoring project has continued to keep track of the nesting sea turtle population as well as the hatching and emergence success rate of all nests laid on Lang Tengah Island. LTTW staff, interns, and volunteers were involved in patrolling the nesting beaches, nest checks and PHI. In 2018, a new nest monitoring protocol was introduced to study the impact of nest check and relocation on hatching success rate and to determine the risk of predation from leaving empty egg shells on turtle nesting beach and this was continued throughout the 2019 season.

Nests laid were categorised into the four categories - (i) in-situ, protected, inspected; (ii) in-situ, non-protected, non-inspected; (iii) relocated, protected, inspected and (iv) relocated, non-protected, non-inspected. Nests with odd number fall under category (ii) and (iv) and were left undisturbed with no form of protection until the hatchlings emerge. Even numbered nests fall under category (i) and (iii) and were protected from predation with a mesh netting and checked starting from day 45 of incubation and then every five days until hatchlings were found in the nest. If the inspected nest had serious fungal infection or predation by crab, the frequency of nest check was increased to every three days until hatchlings were found. All nests were excavated and inspected three days after the hatchlings emerge. The nest content was recorded and the success rate was calculated.

Study Area

Lang Tengah Island lies approximately 20 km off the coast of Terengganu in Peninsular Malaysia. Like many of the neighbouring islands and much of the mainland of Terengganu, Lang Tengah Island is an important nesting site for the endangered green turtle (*Chelonia mydas*) and the critically endangered hawksbill turtle (*Eretmochelys imbricata*; International Union for Conservation of Nature [IUCN], 2015).



Lang Tengah Island has three sandy beaches: Turtle Bay (TB), Lang Sari (LS) and Summer Bay (SB). They cover a distance of coastline measuring 80 m, 400 m and 500 m. All three beaches are located on the southern side of the island. Both LS and TB face the south, whilst SB is west-facing. The northern coast of Lang Tengah Island is composed of granite rocks which is unsuitable nesting habitat for sea turtles. All three beaches provide ecologically suitable nesting habitat for sea turtles, with reports of landings occurring on all of them. However, SB is subjected to high levels of disturbance from light and noise pollution due its heavy commercial development. Light and noise pollution are major deterrents to nesting individuals, and thus, TB and LS are considered to be the principal nesting beaches on Lang Tengah Island.

Patrolling

Patrols were conducted on an hourly basis at TB and LS, from 9 p.m. to 6 a.m. daily, with staff, interns, and volunteers split into groups of two people. The average nesting time for a green turtle is 1.5 hours, while a hawksbill turtle an hour. Patrolling once an hour ensures that no nesting female is missed and that disturbance on the nesting beach is minimal. SB was patrolled in September when reports of turtle nesting were received.

Nest Relocation

Turtle nests were allowed to incubate at their original location if there is any reasonable likelihood of survival. Relocation were considered as a last resort in terms of nest management. Nests were only moved when one or more of the following situations exist:

a) The nest was laid on beaches such as LS and SB which were prone to poaching activities.
b) The nest was laid below the high tide line where regular inundation would result in embryonic mortality.
c) The nest was laid in an area known to be susceptible to termite infestation.
d) The nest was laid in an area with lots of roots or coral rubble which could inhibit hatchlings from safely emerging.

Relocations were conducted by staff and interns of LTTW. Volunteers were only allowed to help in data recording.

The depth (from beach surface to bottom of egg chamber) and width of egg chamber (at the top of the egg chamber, approximately 10 cm below the hind flipper of the nesting turtle) were measured twice and the average reading was used for the construction of the new egg chamber. The measurements were taken as the turtle was laying the eggs.

The relocated nest was placed in an egg chamber of similar depth and width as well as similar shading condition as the original nest. For the new egg chamber, the depth from beach surface to top of first egg in the chamber was measured twice and recorded.

TURTLE IDENTIFICATION

Inconel Flipper Tag

When the nesting turtle starts to cover the egg chamber, the front flippers of the turtle were checked for existing Inconel flipper tag. The flipper tags are usually secured between the second and third scale or third and fourth scale away from the body of the turtle, on the trailing edge of the flipper (Figure 1).

If tags were not present on either side of the turtle's flipper, new tags were placed by trained LTTW staff. A method known as 'double-tagging' was employed, whereby a tag was placed on both front flippers. This is to ensure the greatest chance of the turtle retaining at least one of its identity tags over the course of its migration period. If one of the tags is missing upon an individual's return to the nesting beach, then another tag is inserted and the identity form for that individual is updated.

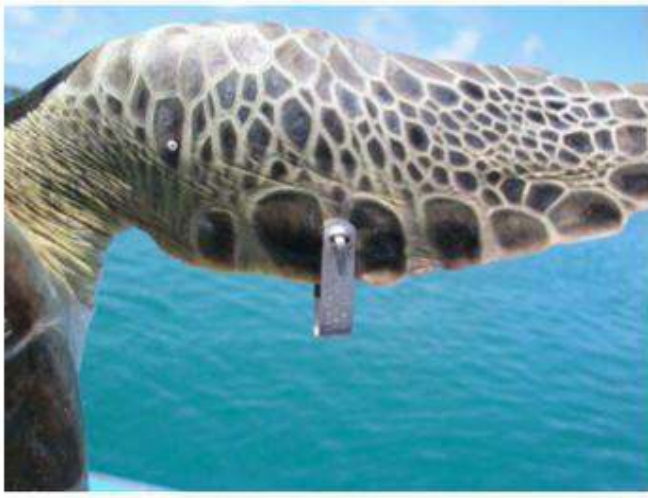


Figure 1. Inconel flipper tag on a sea turtle flipper (Eckert & Beggs, 2006).

Photographic Identification

Sea turtles can be identified based on their unique facial scale pattern. LTTW started to photograph every nesting turtle on Lang Tengah Island since 2015 to ensure that the nesting turtles can be identified even if they lose both their flipper tags in the near future.

Once the nesting turtle is tagged, the facial profile of the nesting turtle was cleared of sand as much as possible and then photographed either using a DSLR camera or handphone (Figure 2). The photograph is then edited prior to being analysed using Interactive Individual Identification System (I3S) Pattern, a photo-identification software that uses natural makings to identify individuals.

Figure 2. Facial photo being taken for individual identification through I3S Pattern.

In the event that the turtle had no tag and tagging effort was unsuccessful, the individual turtle was identified based on their facial scale patterns using the software (Carpentier et al., 2016; Dunbar et al., 2014).

Biometric Data Collection

The curved carapace length (CCL) and curved carapace width (CCW) of the nesting turtle were only taken once the turtle started to cover the egg chamber. Measurements were taken using a flexible measuring tape to the nearest 0.1 cm. The biometric data were taken according to the guidelines set by Wyneken (2001).

NEST MONITORING

With the new nest monitoring protocol in place to study the impact of nest check on hatching success rate, half of the nest laid on Lang Tengah Island were left undisturbed with no protection from predation. Nests under the category (i) and (iii) were provided protection from crab and monitor lizard predation and were checked starting from day 45 of incubation.

Nest Protection

A mesh net was placed 5 cm from the beach surface, covered with sand. Within three days after hatchlings were found in inspected nest, the mesh net was removed in the evening to allow hatchlings to safely emerge. The mesh net was placed back on top of the nest the following morning to prevent predation by crab and monitor lizard. The protected nests were also inspected daily for any visible signs of predation from ghost crabs and Asian water monitor.

Nest Check

Nests under the category (i) and (iii) were checked starting from day 45 days of incubation, and subsequently checked every five days until hatchlings were recorded within the nest. This time period allows for constant and thorough monitoring of the eggs, with as little human interference and chance of contamination as possible. If the inspected nest had serious fungal infection or predation by crab, monitor lizard or termite, the frequency of nest check was increased to every three days until hatchlings emerged.

Post-Hatch Inspection (PHI)

Post hatch inspections were carried out three days after the hatchlings emerged to sea in order to determine the hatching and emergence success rates of every nest. If hatchlings did not emerge from the nest, a PHI was conducted on day 70 of incubation.

The nest contents excavated were categorised into the following:

a) Empty egg shells
b) Dead in nest (Dead hatchlings found in nest)
c) Live in nest (Live hatchlings found in nest)
d) Undeveloped (Unhatched eggs with no obvious embryo)
e) Unhatched:
   Stage 1: Egg that contains a blood spot
   Stage 2: Egg that contains an embryo between 10-20 mm long with pigmented eyes
   Stage 3: Eggs that contain an embryo larger than 20 mm, with pigmented eyes and carapace
   Unhatched term: Egg with full-term embryo with a small amount of external yolk sac
   Predation: Crab, termite, maggot, fungus, monitor lizard

After PHI was carried out, the nest content was buried at the area the nest was originally laid at. Two hatching success rates were calculated for the 2019 data set. The first uses the number of eggs known to have been relocated and the second uses the number of eggs found during the PHI. The decision was taken to ensure that data between the relocated and in-situ nests could be calculated.

RESULTS

In-Water

Turtles generally only visit Lang Tengah Island to nest, however throughout the season turtles can be seen foraging around the islands waters. Figure 3 shows the number of turtle sightings throughout the season for the two different species in the area.

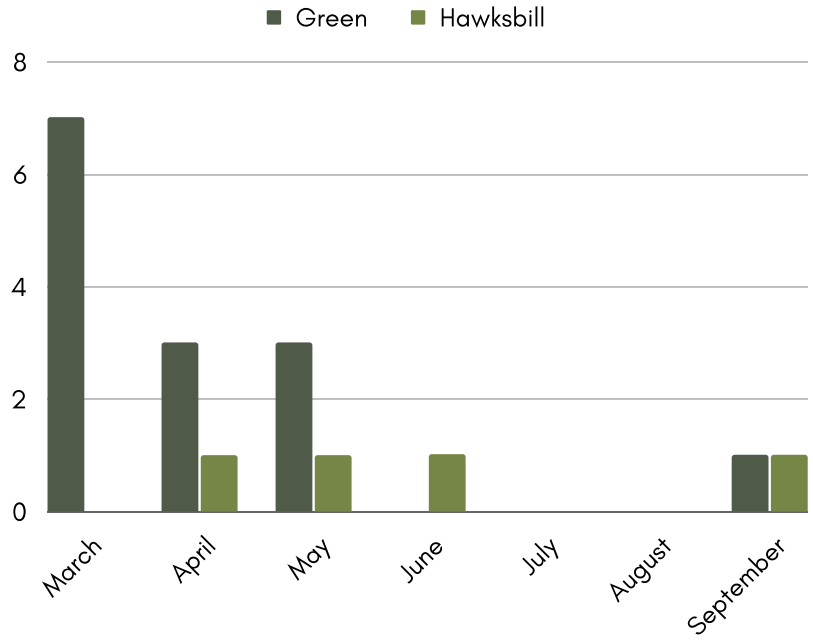


Figure 3. In-water turtle sightings in 2019.

Nesting

The 2019 nesting season documented 15 different nesting green turtles, laying a total of 65 nests with 37 laid on LS and 28 on TB. 64 of these nests are from known mothers, with the final nest coming from an unknown mother. The first nest was laid on 7 March 2019 and the final one (Nest 65) was laid on 9 October 2019. Figure 4 shows the temporal distribution of all turtle nests throughout the season.

Tables 1 and 2 provides detailed information on the 15 nesting turtles. Nesting and morphological data are shown, as well as the incubation and emergence of nests.

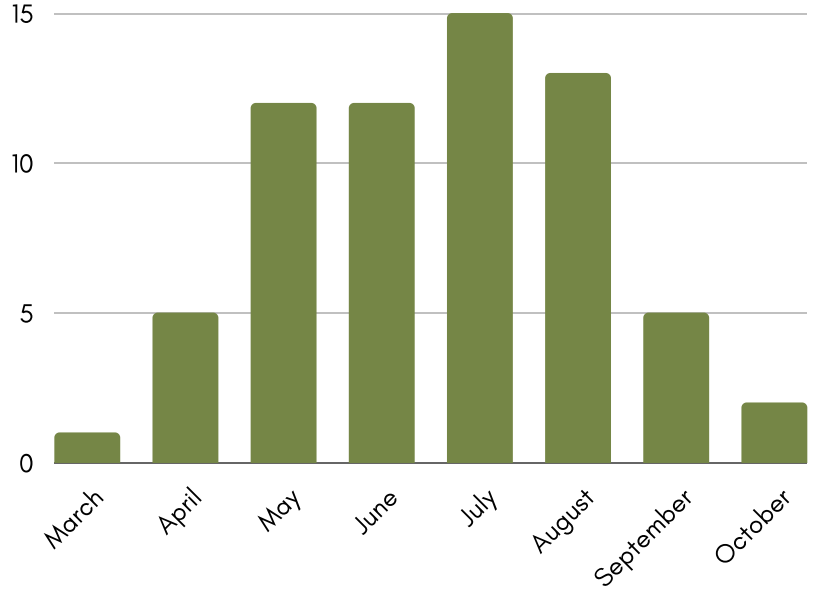


Figure 4. Temporal distribution of turtle nests.

Table 1. Morphological and nesting data of every nesting turtle in 2019.

Mother	CCL (cm)	CCW (cm)	No. of Nest	Location	Nesting Interval (Day)	Total No. of Eggs	Average No. of Eggs Per Nest
Nelly	90	77	1	LS	NA	70	70
Sarah Guo	98	85	8	LS	11	708	89
Maika	NA	NA	1	TB	NA	77	77
Turtellini	103	92	6	LS	10	716	119
Lindy	93	88	1	LS	NA	113	113
Hayleybell	105	95	7	LS	13.2	809	116
Wand	92	87	6	LS	9.4	583	97
Eternelle	98	89	7	LS	14.8	577	82
Hasina	80	70	1	TB	NA	30	30
MY16	92	90	1	TB	NA	77	77
Baobei	97	88	4	TB	11	337	101
Tora	98	92	5	TB	11.3	509	101
Pit-Stop	107	98	8	TB & LS	12	361	114
Dash	97	81	4	TB	11.7	151	75
Granuaile	98	89	4	TB	11.7	269	89

Updated in 2021: Using photo-ID methods, Lindy and Wand are identified as the same individual. Meanwhile, Pit-Stop is a returning mother (16G023) from 2016.

Table 2. Nesting and hatching data of every nesting mother in 2019.

Mother	Average Incubation Period (Day)	Hatching Success (%)	Emergence Success (%)	Total No. of Hatchlings	Average No. of Hatchlings Per Nest
Nelly	NA	0	0	0	0
Sarah Guo	57	88	85	602	76
Maika	60	95	95	73	73
Turtellini	58	95	93	666	111
Lindy	52	95	91	103	103
Hayleybell	58	93	91	736	106
Wand	60	85	83	484	81
Eternelle	60	51	49	283	40
Hasina	59	90	90	27	27
MY16	NA	0	0	0	0
Baobei	61	91	91	307	92
Tora	60	79	76	387	77
Pit-stop	56	95	93	336	106
Dash	54	22	21	32	16
Granuaile	61	90	90	242	80

Updated in 2021: Using photo-ID methods, Lindy and Wand are identified as the same individual. Meanwhile, Pit-Stop is a returning mother (16G023) from 2016.

Hatching & Emergence

Once laid, turtle eggs need time to develop in the sand, and this period is called the incubation period. For 2019, the average incubation period of all the nests was 58.2 days. Figure 5 shows how the incubation period changes temporally.

At the moment of writing, hatching and emergence success were calculated for 53 of the 65 nests laid. The hatching and emergence success was calculated using the egg number as those eggs found during the PHI, any eggs not found were not included as it is impossible to say what happened to them.

Hatching success rate is defined as the percentage of turtles hatched out of the shell over the number of found during the PHI. Emergence success rate is defined as the number of turtles emerged from the nest over number of found in the PHI. The hatching and emergence success for 2019 were 71% and 69% respectively.

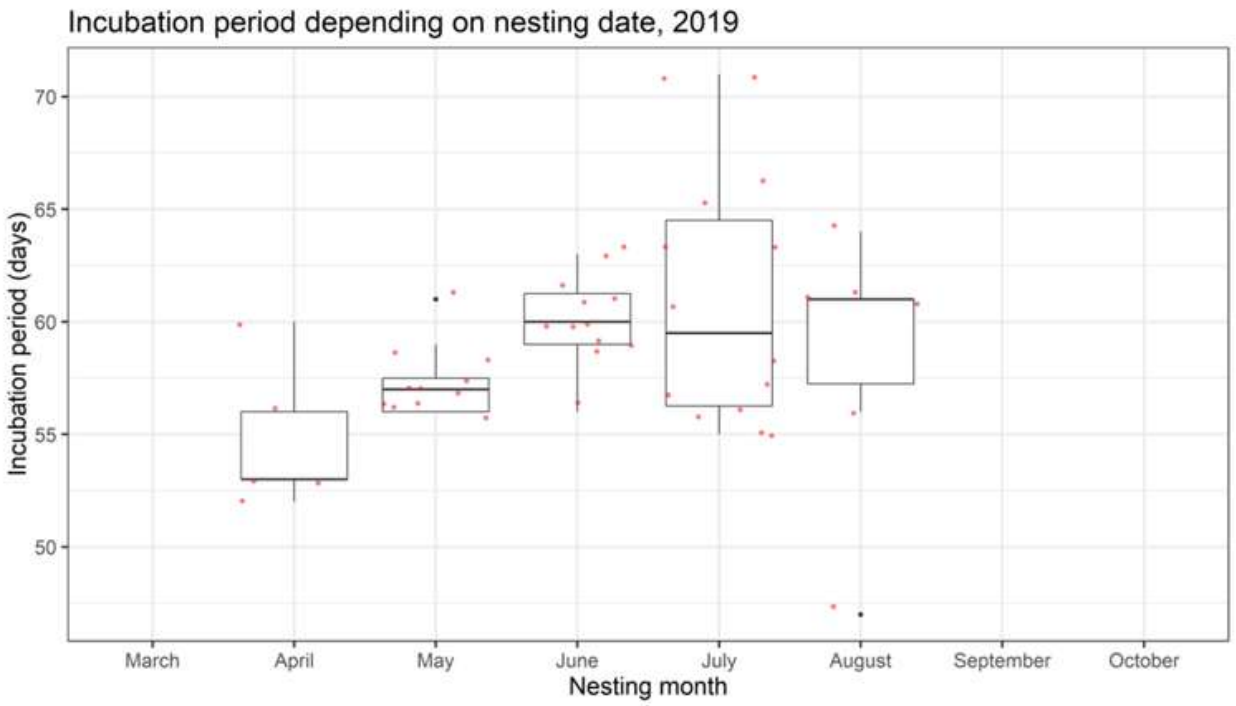


Figure 5. Incubation period by nesting month.

Many factors can affect the success of a turtle nest both biotic and abiotic factors have a role to play in survival. Figure 6 shows the emergence success range for each of the nesting mothers of 2019.

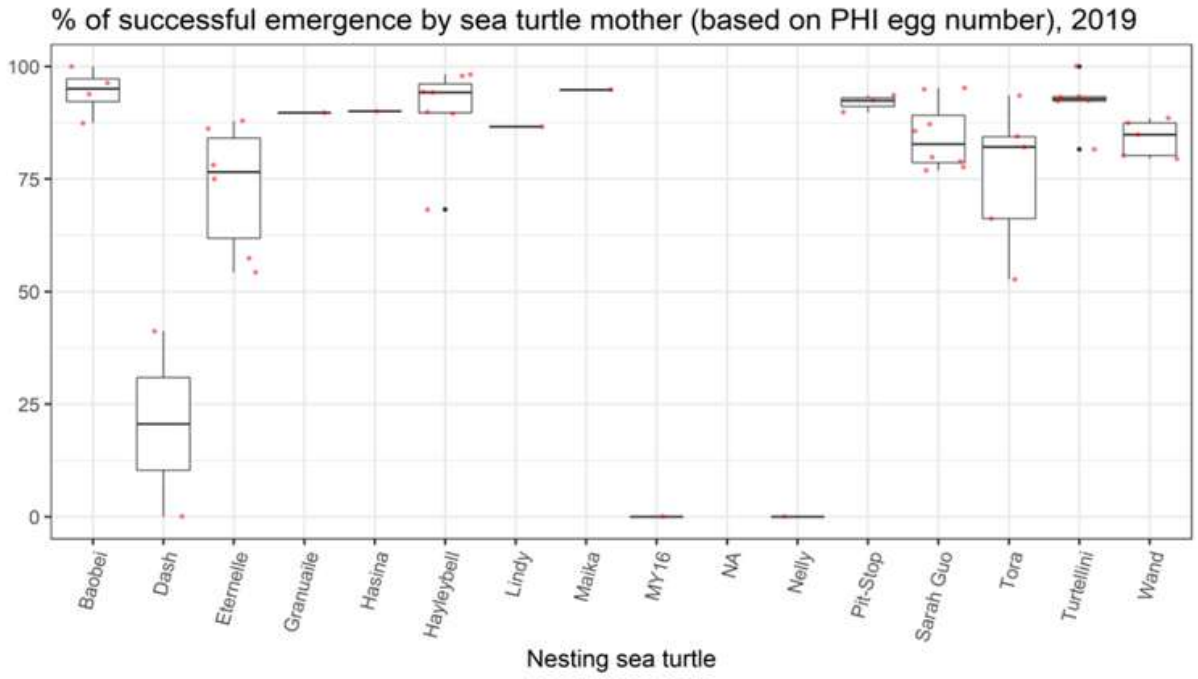


Figure 6. Emergence success rate by mother.

Nests fall under different categories, checked and unchecked nest as well as in-situ and relocated nest were also compared. Table 3 shows a comparison for different factors for the different nest conditions

Table 3. Comparison of nest conditions.

Nest Condition	No. of Eggs	Average Emergence Success (%)	Average Incubation Period (Day)
Relocated	3,952	83	58
In-Situ	1,389	71	60
Checked	2,734	79	58
Unchecked	2,052	81	60

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Checked nests were nests in which nest checks were conducted while unchecked nests were left undisturbed until the hatchlings emerged. In-situ nest was characterised as nest laid at TB which were left to incubate at the original position until the hatchlings emerged. Relocated nest was characterised as nest laid on TB or LS that were relocated. All nests from LS were relocated. Occasionally nests on Turtle Bay were relocated if the nest was laid on areas full of roots or coral rubbles, prone to termite infestation or laid within 2 m from the high tide line.

Figure 7 shows the emergence success compared between those nests incubated in situ and those relocated. The mean average of the two conditions is similar however the range of success for in-situ nests is much more varied.

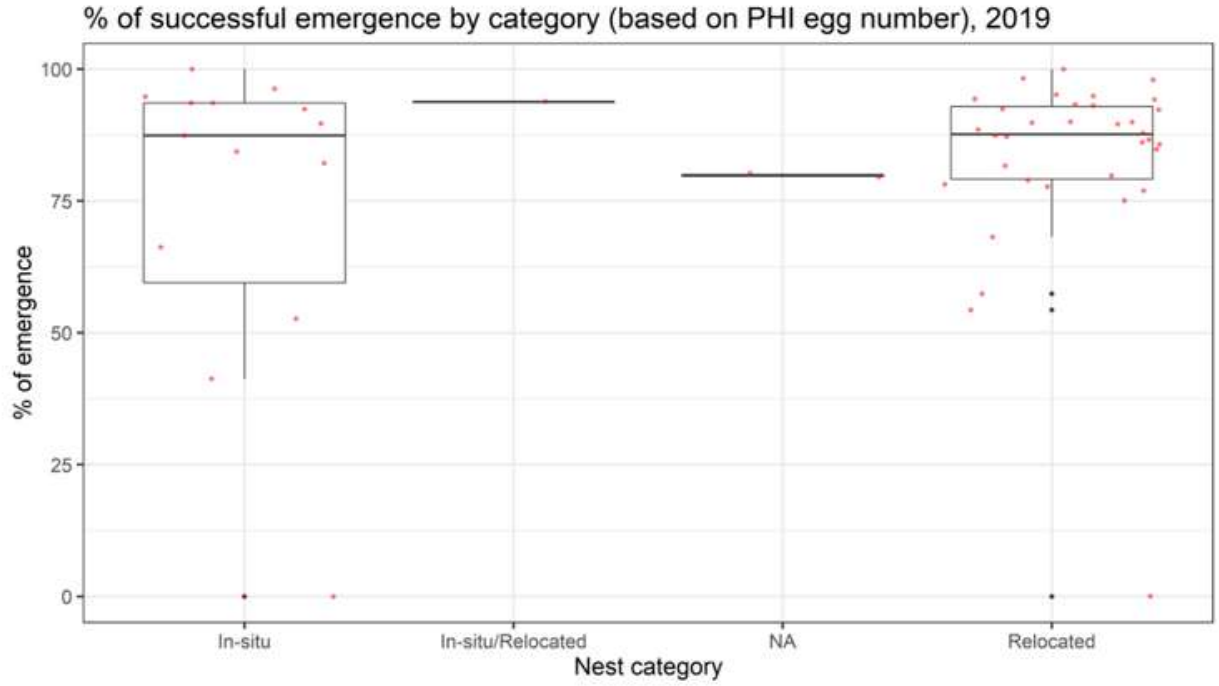


Figure 7. Emergence success by nest category.

Figure 8 shows the different hatching success rates dependent on unchecked or checked nests. The mean hatching success is similar however there is greater variance in success rates for the nests that are checked.

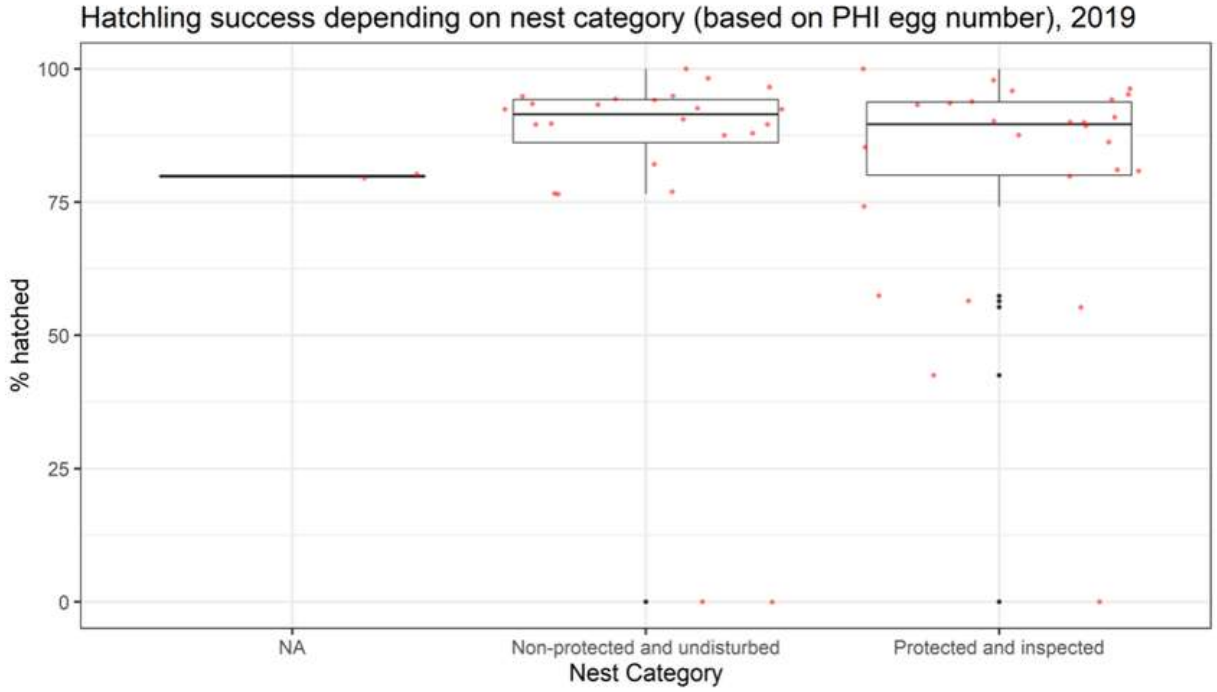


Figure 8. Hatching success by nest category.

Unsuccessful Hatching & Emergence

During the PHI, the nest content that was considered unsuccessful was divided into several categories - dead in nest, live in nest, undeveloped, unhatched (stage 1-3), as well as predation by crabs, termites, maggots, fungus and monitor lizard. Out of the 5,387 eggs laid, 188 eggs were missing and not considered in the analysis.

Figure 9 shows the different categories documented whilst conducting the PHI (53 of the 65 nests). Out of the 882 eggs/hatchlings that did not hatch/emerged, 58% had stopped development at a certain point of the incubation. Meanwhile, 31% had succumbed to predation. Approximately 6% of live hatchlings and 4% of dead hatchlings were found in the nest. Seven eggs (< 1%) were removed by a nesting mother during nesting.

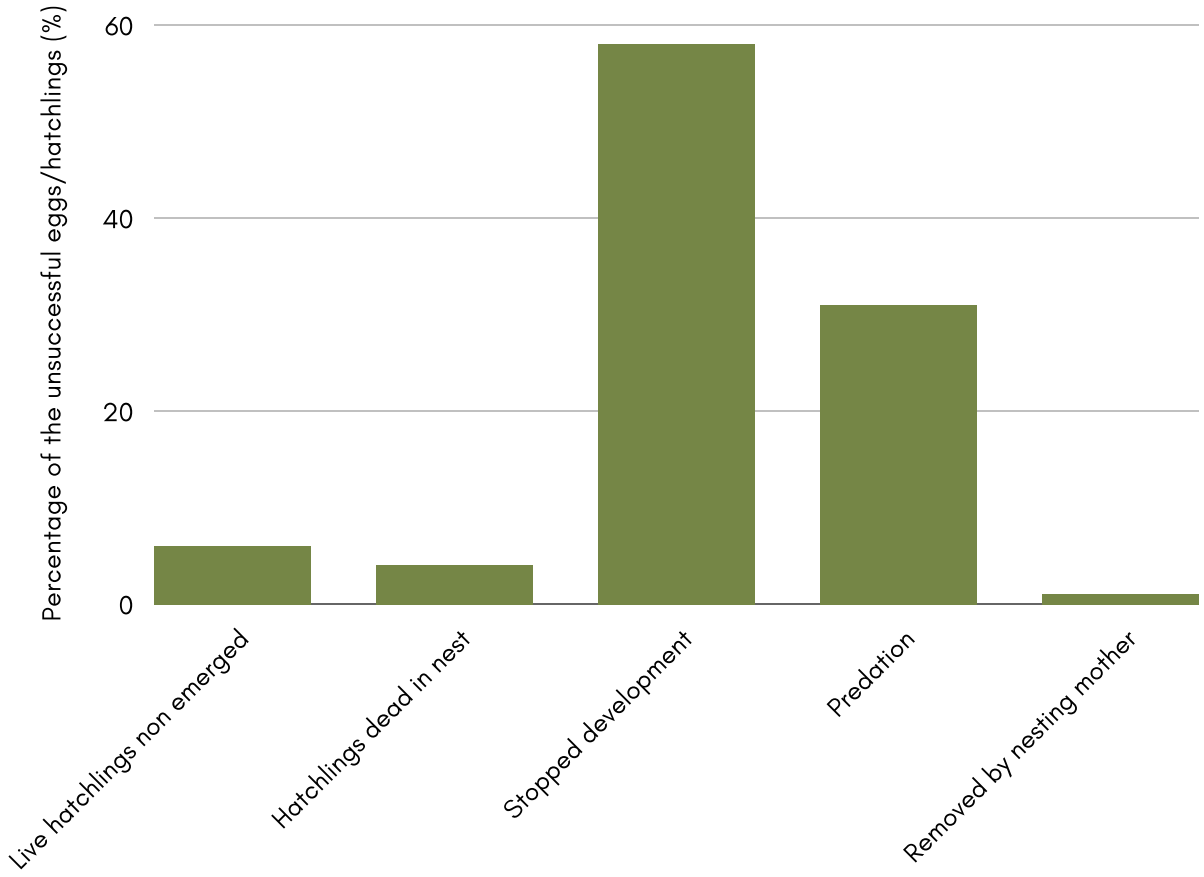


Figure 9. Category of unsuccessful eggs.

Figure 10 shows the distribution of different stages the development had stopped. The majority of unsuccessful eggs were found to be undeveloped. Unhatched term was the second most frequent stage to be found during the PHI. Figure 11 shows the temporal variation found between the different stages that were discovered during PHI. Figure 12 shows the differing contributions different predatory threats had on the nests. The most common was attack from crabs which dig small holes into the nests. Fungus was found on many nests and was the second biggest contributor. Figure 13 shows how the different predation levels changed temporally throughout the season.

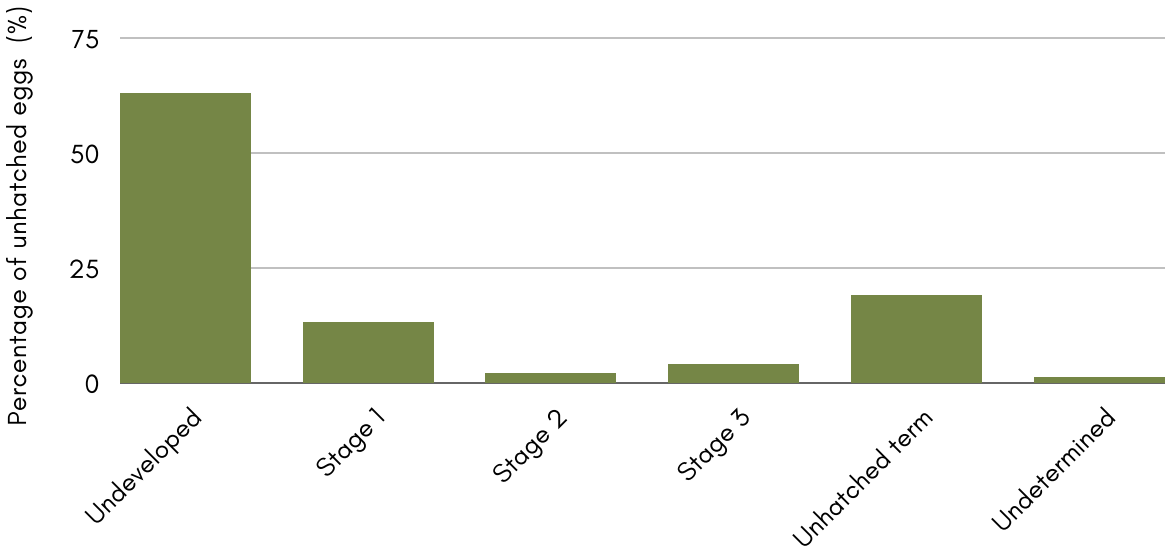


Figure 10. Proportion of unhatched eggs at different development stages.

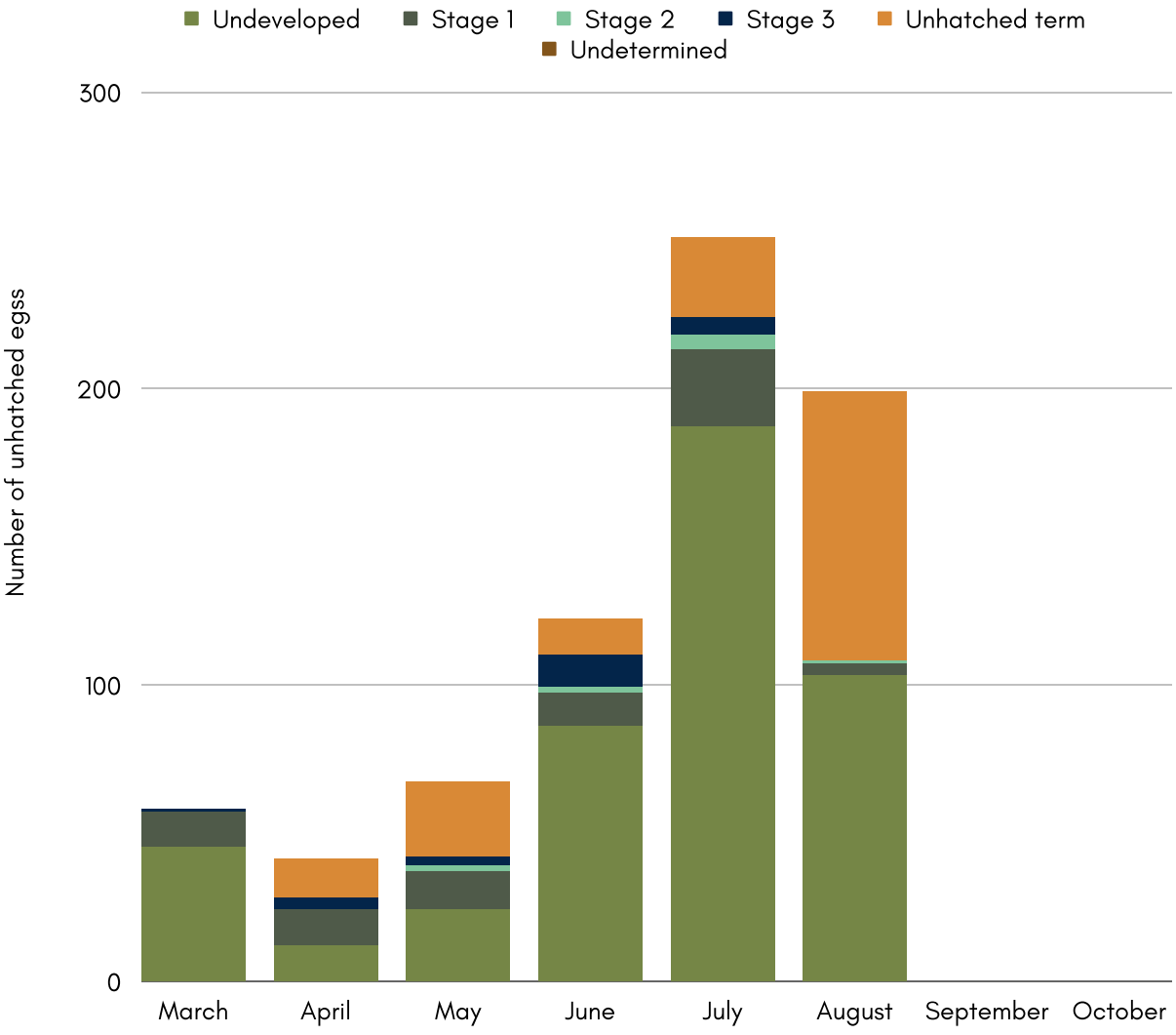


Figure 11. Temporal distribution of undeveloped eggs.

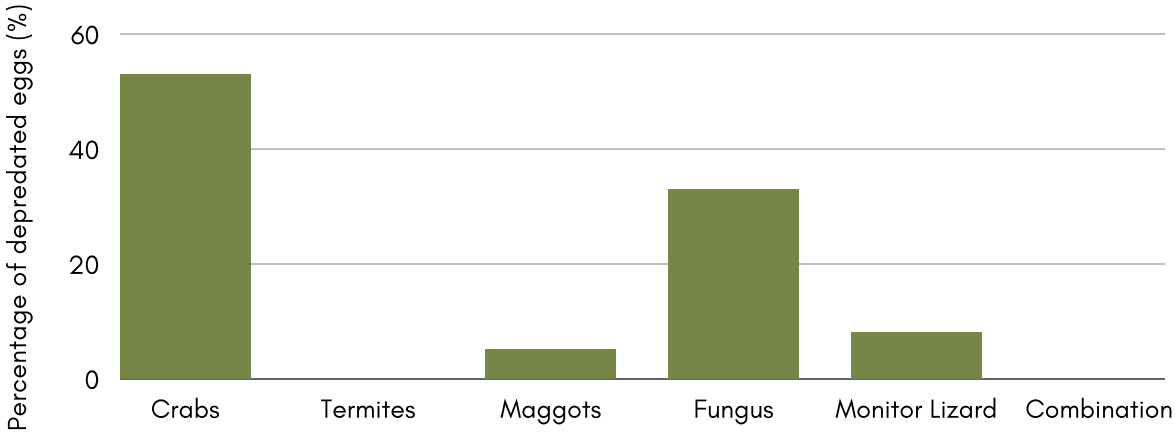


Figure 12. Distribution of depredated eggs or hatchlings.

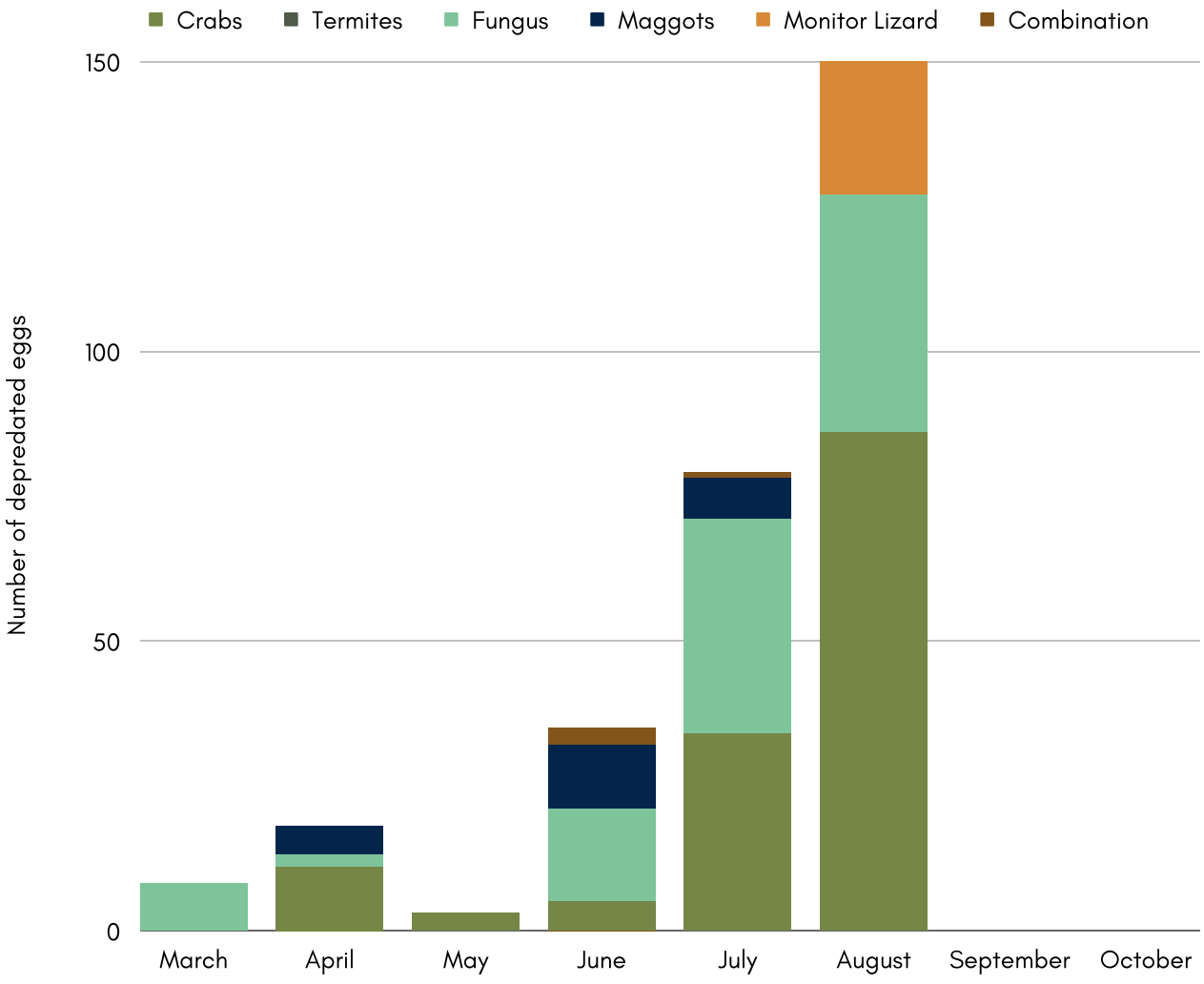


Figure 13. Predation by nesting month.

Shading Study

Hobo data loggers were used to measure the temperature of the sand at 70 cm, as a proxy to what the temperatures may be with the turtles nests. Both Figures 14 and 15 show a comparison between three different spots on Turtle Bay; one open sand spot, one nest site with slight shading and one nest site with high shading levels.

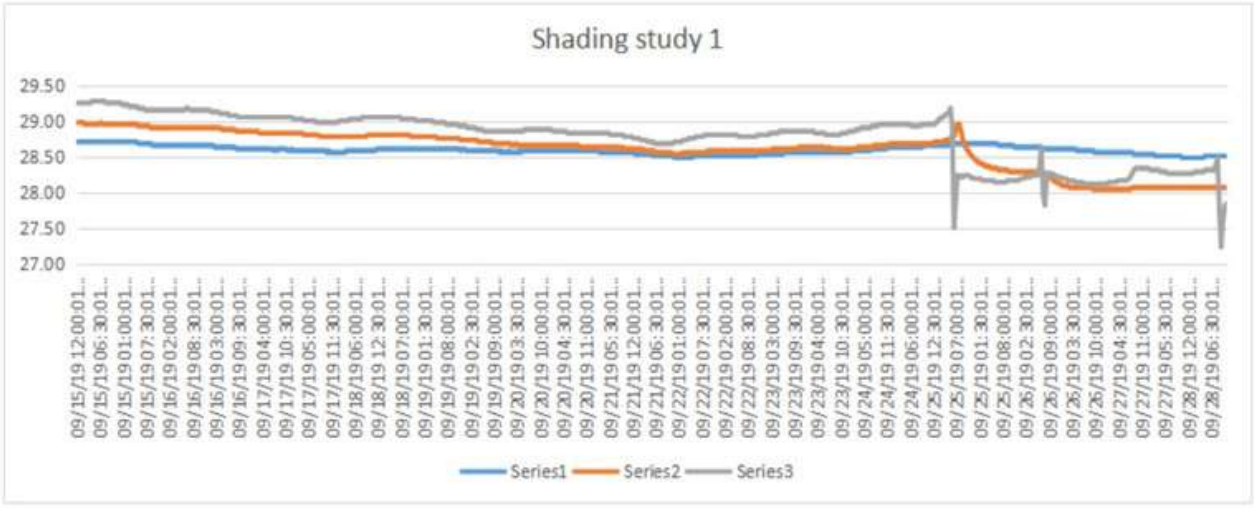


Figure 14. Result of shading study 1.

Series 1: Shaded (Nest 21)
Series 2: Unshaded (Nest 28)
Series 3: Control

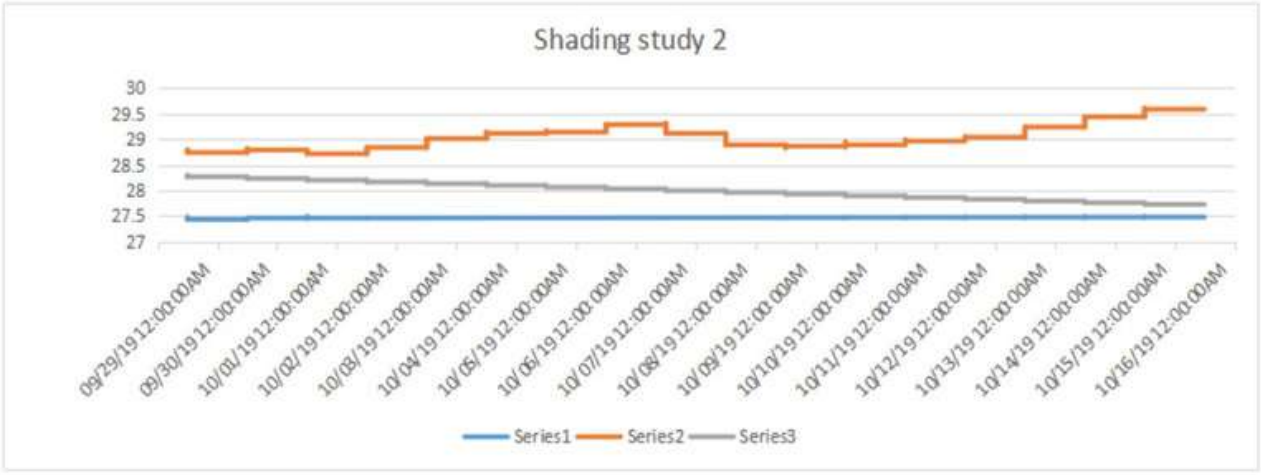


Figure 15. Result of shading study 2.

Series 1: Shaded (Nest 32 & 35)
Series 2: Unshaded (Nest 44 & 30)
Series 3: Control (Nest 41)

DISCUSSION

In 2019, Lang Tengah Island unfortunately had no hawksbill turtle nests after a successful time in 2018. However, hawksbill turtles were seen around the island throughout the year either foraging or resting on the reefs. Two of the resident hawksbills were unfortunately affected by fishing activities around the island. One was found dead in a fishing net in front of Summer Bay. Another was found with a fishing hook and wire coming from its mouth, thankfully the second was able to be rescued by the LTTW team. These were not the only casualties of human intrusion to the turtle's marine life with further stranding incidents also recorded (data being complied at time of writing). The large number of strandings for such a small location and hopefully can allow us to apply further pressure to increase protection for the marine park.

Despite these negative aspects, the 2019 season was a very successful one for nesting green turtles. After the first nest in March, 65 nests were laid across the two beaches from a total of 15 different individual of green turtles. The majority of these mothers had not yet been tagged, meaning 13 new female adults have now got tags and can be tracked across future movements and nests. The other two mothers already had tags but had not been encountered before on Lang Tengah. Maika had tags from Redang Island and MY16 was a turtle from the mainland. Both of these turtles only laid one nest each on Lang Tengah and so may have been forced to nest here due to unforeseen circumstances.

The majority of nests were laid between May and September. July was the most productive month with 15 nests. Out of the 65 nests, 37 of these were laid on LS and so had to be relocated to TB. A further 28 nests were naturally laid on TB itself.

Nesting mothers laid on average four nests each at an average nesting interval of 11.6 days. Two turtles this season managed to lay eight nests each (Sarah Guo and Pit-Stop) and five turtles only laid one nest each. With tagging and photo-ID, it is hoped to be able to track any future nesting events from all turtles found.

On average the nests were incubating in the sand for 58.2 days. However, this average incubation time changed temporally throughout the season. Nests at the start of the season incubated much quicker than those later on in the season. This is thought to be due to the changing abiotic conditions in the nests. The beginning of the season was exceptionally hot and very dry. Higher temperatures and a lack of cooling rain makes the eggs develop much quicker. As the season progressed the temperatures dropped and so the incubation period increased. This can be measured and analysed further next year with addition of data loggers and weather station.

After incubation, an average 71% of eggs hatched and 69% were able to emerge from the nest. These percentages vary both between mothers and also throughout the season due to both biotic and abiotic variables. Eight of the mothers had an emergence success of 90% or over. However, two mothers had emergence successes under 50% and a further two had 0% hatchling success. This is why the average hatchling success for the season seems low, but that is accountable for these four less successful turtles.

Following from last year's nest check study to see if nest checks and nest protection have an effect on the success of nests, this year's results showed a similar result with not much difference between the emergence successes of the two conditions (3% difference). However, one significant difference between the two conditions is the average incubation period. The nests that get checked have an average incubation date two days shorter than those that are left to incubate undisturbed. This could be having a negative effect on the hatchlings fitness as it is well known that a prolonged time in the nest to fully absorb all available nutrients from the yolk is highly beneficial for hatchling fitness and can increase the survival of hatchlings post emergence. This is something that should be considered in future seasons when considering the use and rate of nest checks as a conservation tool.

Furthermore, nests can also be split into two different categories of relocated and in-situ nest. Similar to data from 2018, the average emergence success difference between the two conditions is separate. In 2018, the relocated nests were approximately 20% more successful than those which were in situ. This season the relocated nests are only 12% more successful than those in-situ.

These differences are surprising as the literature suggests that relocations actually reduce the success by as much as 20%. The fact that this is the opposite for the nests on Lang Tengah should be something to be considered for further investigation. An obvious answer to why this is the case is because when a staff member relocates the eggs a new location is chosen that is most often a highly optimal nest site regarding shading and vegetation. However, when it is the mother turtle choosing where the nests goes, they cannot predict which vegetation is most likely to have roots growing into the nest, etc.

One reason why this could go against the literature is because a lot of the relocated nests in these studies are relocated into more artificial environments such as hatcheries. Here at LTTW, relocations move the nests into highly suitable and natural conditions that often match what is described as ideal nesting conditions. This problem should be one open to further questioning both through more retrospective data analysis and improved nest condition data in the following years that can be done by tracking temperatures and rain, taking shading readings from nests, describing the vegetation types in the location, taking different sand samples and mapping the locations across the beach. The effects of these parameters can impact hatchling fitness as well, which could be further investigated using morphological data collection and very basic hatchling fitness tests.

Moving on, of those eggs/hatchlings that were not able to successfully hatch/emerge (882), 512 had stopped development at some stage, 273 had succumbed to a certain type of predation, 53 hatchlings were found alive in the nest (not included in emergence data as the hatchlings were likely to have died in the nest if not found), 37 dead hatchlings were found in the nests and seven eggs were thrown out of a single nest by a different nesting mother.

Following on, of those eggs that had stopped development, 321 were undeveloped while the rest were found to have stopped development at different stages of incubation. This variation showed temporal differences that could have been due to the changing weather conditions throughout the season. For example at the beginning of the season when temperatures in the nest are assumed to have been very high, there were many undeveloped eggs. This is often indicative of the fact that incubation conditions are not suitable for development.

However, late in the season when the weather became more variable, the proportion of different stages found became much more varied. The change of most interest is the increased findings of unhatched-term hatchlings in the nests especially in August. This month had more storms and more rain which was leading to flooding events on the beach and drastic temperature changes. The fact that the development started but stopped at the later stage is often due to extreme events like flooding, and this was the case for nests this year on Lang Tengah. This can be monitored more closely in the future years with improved record keeping of events and the recording of weather conditions paired with abiotic data collection within the nest.

Furthermore, the predation levels of the nests also changed throughout the season as well as the differing levels from the different predators themselves. Crabs were this biggest form of predation to the nests. Unfortunately, comparison of levels of predation between checked and unchecked nests was not done but can be retrospectively next season.

Very interestingly, the occurrence of monitor lizard predation boomed in the month of August. This could also be down to the weather as the rain in the two months prior would have increased the amounts of insects and therefore food for the lizards so that they can grow. As the monitor lizards get bigger. they leave the canopy and start to forage on the ground. This could be the reason for increased monitor lizard attack. It is thought that monitor lizard populations are in a boom and bust pattern due to harvesting from the Vietnamese fishermen. As they take the larger monitor lizards it means that any smaller ones that were left have increased survival due to the lowered risk of inter-species cannibalism. So the loss of adult monitor lizards can actually create a boom in survival rates for the young that were able to survive harvesting. This pattern could be an interesting thing to document, as well as the effects this may have on turtle egg predation.

Moving on, towards the end of the season we acquired three HOBO data loggers than can track temperatures for a prolonged period in extreme conditions. Due to the fact the equipment came late on in the season they were used for a pilot study to look at different temperatures across the beach. Two rounds of tests using three loggers produced six temperatures readings. From the first study the temperatures ranged from 28.5 to 29.5 degree Celsius with little variation apart from towards the end where the temperatures spike a little and then drastically drop, this was due to a flooding event in a storm. It is interesting to see how drastic the temperature drop is and how this could potentially effect a nest of turtle eggs if they same thing were to happen.

Furthermore, the second shading study shows much more variance in temperatures between the three locations. Most interesting is the one that was in the same location as the shaded nests which had a temperature of around 27.5 at 70 cm deep. A large proportion of our in-situ nests were from mother that nested under this tree and this could be the reason. Even with a 1 degree Celsius increase from a nest metabolic heating, this location's temperatures would still fall below the pivotal temperature determining sex ratios for sea turtle eggs. The tree is also able to keep the sand at a much more constant temperature. Further investigation next year by putting the loggers into turtle nests in different locations will provide clearer answers to these questions and we can see if different turtles are actively choosing to nest in certain locations for their abiotic conditions.

In conclusion, this season has been a successful one for the green turtles which chose to nest on Lang Tengah. We hope that with an improved staff skill set, new equipment and greater drive that more research can be done on our turtle nests. This can be done retrospectively through more extensive data analysis of previous data sets. This can then guide what needs to change in future seasons. By looking at the data to find questions we can highlight what we want to answer and how we can do that in seasons to come.

Tourist Engagement

The 2019 season was a huge push to increase our presence on the island and share or work more with the island resorts. Despite 2019 being a low season in terms of tourist numbers on the island, for LTTW it was one of our highest for camp visitors. Information sheets were given to each of the hotel receptions, and advertisement posters were made to encourage guests to either engage in our interactive experiences such as nest checks or simply visit our camp for a tour and turtle talk.

In order to increase the quality of experience we could give to guests, a small tourist area was made on the camp that could be used to prompt discussion on not just turtles but marine pollution, the fishing industry and the islands coral reef ecosystems. With an array of different props and specimens every guest that came to camp could be given a full and engaging rundown on the conservation work LTTW is doing.

This increased engagement allowed us to gain more support for the project either by merchandise sales or further following on our social media sites. This year we also piloted a new sponsorship program encouraging guests to sponsor an aspect of our work. This lead to sponsorship of a school visit, an individual guest sponsoring eight local volunteers.

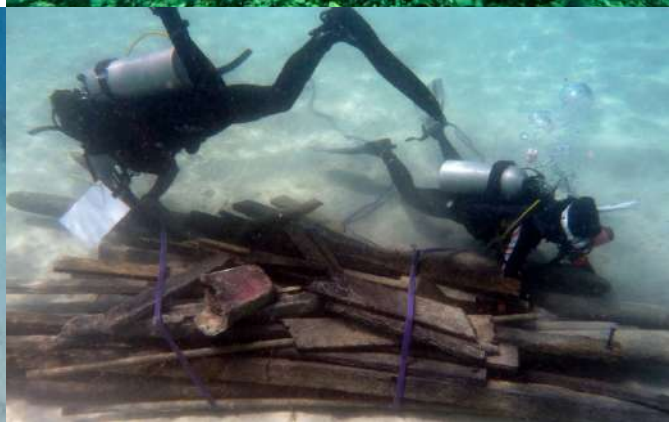
A further way in which tourist engagement was increased was the start of a turtle viewing tour in partnership with Summer Bay Resort. In order to advertise for this tour a small turtle information centre was created in the dive shop and members of the snorkel team were trained to give turtle information tours with the goal of getting people to sign up. If a mother turtle was found to be nesting on LS, then the resort would be notified and any guests that had signed up would be bought to view the nesting process. Carefully controlled by LTTW staff as to not jeopardise the turtles behaviour, all guests had a great time. This not only raised awareness for our project, but also helped LTTW to solidify a strong relationship with the resort.

The 2019 season also saw us host several large groups of over 30 people (maximum 50) to the camp to deliver an informative visit. These visits usually consist of a brief introduction to the project and are then followed by splitting the groups in two to alternatively give sessions on turtle ecology and marine ecosystem conservation in Malaysia. All of these visits were extremely successful with groups being highly engaged, this is evident from the large scale of support given after visits through merchandise sales.

Clean-Ups & Recycling

Beach clean-ups were conducted with volunteers and occasionally with resort guests on a weekly to bi-weekly basis to keep the nesting beaches clean. Recycling trips were organised in May and August to collect and send recyclable items from the island resorts and camp to be recycled at a local recycling centre on the mainland. This season, 1,500kg of recyclable waste was removed from Lang Tengah Island and sent to RD Papers, a recycling centre at Gong Badak, Terengganu for processing.

A large proportion of this trash came from reef clean-ups. Due to a strong monsoon there was a lot of destruction on the reef due to broken jetties. The team conducted approximately eight full-scale reef clean-ups where large pieces of timber were taken out of the water, as well as large metal ropes. It was extremely important to take the items out of the reef in order to reduce the risk of increased damage during this monsoon season.



Community & School Outreach

This year we welcomed two local schools (SMK Chung Hwa Wei Sin and SBPI Batu Rakit) and one international school from Kuala Lumpur (ISKL) for day visits, one Malaysian university (Monash University) and one international university (University of Arizona) for two-day visits.

The students started their day with a beach clean-up, removing waste from LS, one of the turtle nesting beaches on Lang Tengah Island. A series of interactive talks on sea turtle ecology and Malaysian wildlife conservation were carried out with the students after the beach clean-up. The students then got displayed what they had learnt during these talks by making and discussing scientific posters and then making 'postcards to the future', writing letters to their grandchildren explaining where this generation went wrong. For the university groups that stay for longer periods we offer a higher level of educational presentations and more conservation-based activities.

The basic itinerary of the single day school visits is as shown below.

0800 - School group head to Lang Tengah Island from Merang Waterfront jetty
0845 - Students arrive at TB, Lang Tengah Island; Introduction to LTTW team
Beach clean-up briefing and hand out of gloves and recycling sacks
0900 - Beach clean-up at LS
1005 - Head back to TB
1030 - Camp Tour
1100 - Turtle and Malaysian wildlife conservation talk (alternatively)
1200 - Lunch and Prayer session
1330 - Poster Design session and postcard making
1500 - Turtle Olympics on beach
1600 - Price and certificate presentation; Photography session
1630 - School group head back to Merang Waterfront Jetty

This year we also hosted the Singapore Methodist Girls School for a five-day trip. An educational itinerary was produced to fill the schools time with a mix of presentations, practical workshops, creative thinking sessions, documentary viewings and conservation based debates as well as time for beach cleans and jungle trekking. A school visit of this type and scale has not been undertaken at LTTW before and due to its success we wish to continue to offer this type of trip to other international schools in the future.

FUTURE RECOMMENDATIONS

Develop research volunteer programme

In 2020 we hope to trial an additional programme for research volunteers. These will be skilled volunteers with conservation and diving experience who will come and participate more heavily in our marine research activities. They will be trained on how to conduct field research, design studies and have introductions to data analysis tools such as Excel, GIS and R. We could also offer the chance for regular volunteers to have a more interactive stay with a learning program including small practical and written examinations. The outcome would be an accredited qualification that volunteers can put on their CV's.

More extensive turtle research

All research should be more cohesive and cross-disciplinary. Extensive data analysis of previous years' data to look for trends that can lead to new research questions. Using the data loggers to track temperatures of nests throughout the year. Potential for hatchling fitness studies on nests with data loggers.

Further stakeholder engagement

Continue working with Summer Bay with turtle nesting experience and encourage the rebirth of their turtle information centre. Foster a closer relationship with Sari Pacifica & Spa Resort's new GM to engage with documentary nights, etc. Create a partnership scheme with D'Coconut Lagoon Resort to continue supporting our dive work. Develop the tourist sponsorship program.

Expand external outreach programmes

Organise at least two international school visits (similar to the MGS one). More importantly, invite more local schools from Merang and Terengganu.

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