Mauritius Research and Innovation Council

INNOVATION FOR TECHNOLOGY

DODO REEF RESTORATION

Final Report

May 2022

Mauritius Research and Innovation Council

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This report is based on work supported by the Mauritius Research and Innovation Council under award number MRIC/EIBS-0018. Any opinions, findings, recommendations and conclusions expressed herein are the author's and do not necessarily reflect those of the Council.

1. INTRODUCTION

The first phase of the Dodo Reef Restoration project primarily consisted of product design and nursery installation. Once official government permission was all cleared, we were able to begin the installation. Throughout July and August, the team manufactured, constructed and installed the coral nursery in Confetti Bay. The marine biologist and assistants carried out wild harvesting from the initial donor corals. Team members were trained to be able to carry out routine bi-weekly maintenance in the nursery and basic coral genus ID independently. The conservation products had been fully designed and ready to be delivered during that phase. A volunteer team of residents that will assist on the project was also designed during the same period.

October was an extremely busy month which brought in customers joining us on and booking our PADI Reef Restoration Specialty, donating to the project, buying reef restoration merchandise, and sponsoring coral fragments. November and December were quieter months. This indicated that the eco-tourism aspect has the potential to continue to fund the project providing tourist numbers stay high which is all unpredictable due to the current global pandemic. The end of milestone 2 met with a very hard decision of changing the material used to hang the fragments from non-plastic to nylon fishing line after various attempts to avoid such materials being used.

January to May have been as quiet as the two previous months due to various situations such as the soaring number of covid 19 cases in Mauritius and the whole team behind the project being positive to the virus. However, customers always seemed very intrigued and interested in the project being carried out by the team. Some even went as far as sponsoring fragments in the nursery and consulting the marine biologist for more information about the project. We also conducted more reef restoration fundives during that time period. With the design of the workshop and its implementation, the project was able to be more acknowledged and this also allowed for more community involvement including workshops with community groups. More interns were recruited during that period of time to help the project.

We are continually monitoring and evaluating our methodology in the coral nursery. Adapting to environmental cues for the health of the coral fragments and reviewing our use on non-plastic materials to hang the fragments in the nursery. We have been able to take our fragment measurements of tagged fragments giving us an idea of the growth rates over the months. These data are especially important to monitor the effect of the changing seasons that occurred during October and May from winter to summer and vice versa respectively on the coral fragments. These data will allow for better understanding on how to handle the harvesting of the remaining 270 fragments that has yet to be conducted due to various reasons. Alongside the harvesting being delayed, the fragmenting and transplanting phases were also delayed due to size requirements which is unfortunately outside of our control. We look forward to the next steps in the project and moving forward with fragmenting and transplanting once the growth rates allow.

2. OBJECTIVES

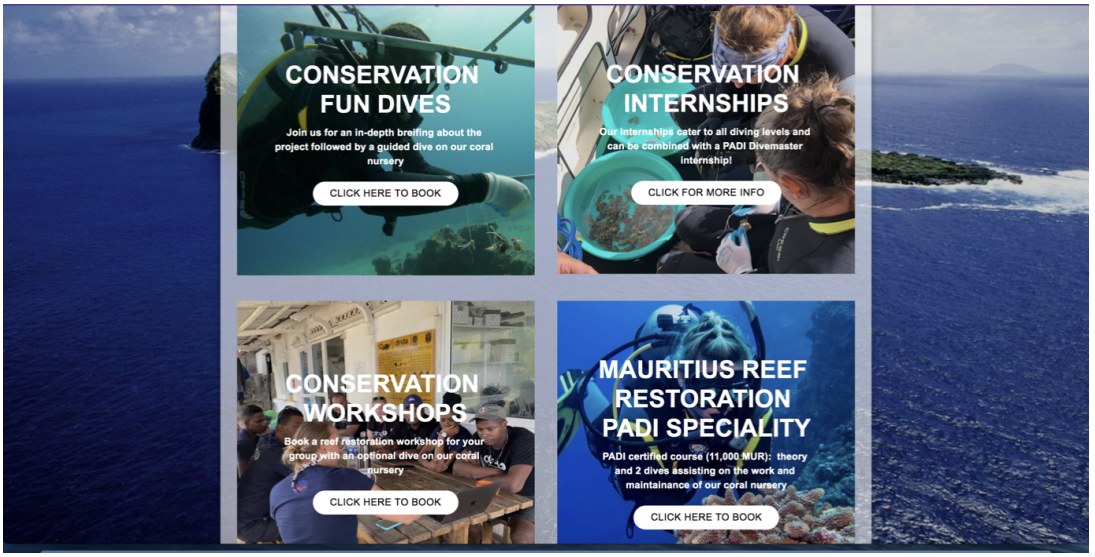
This section should address what were the set objectives for the project and whether they have been met.

Objective	**Status**	**Notes**
Product design	Complete	See page 5-7
Coral nursery: purchasing and manufacturing	Complete	See page 8
Coral nursery: installation	Complete	See page 8
Wild coral harvesting	Ongoing	See page 9
Promotional video: part 1	Complete	See page 18
Project launch	Complete	See page 18
Product delivery	Ongoing	See page 5-7
Nursery maintenance	Ongoing	See page 10
Nursery methodology analysis	Complete	See page 11
Growth rate analysis	Ongoing	See page 15-16
Preparation for fragmenting and transplanting	Ongoing	See page 11
Mortality rates analysis	Ongoing	See page 14
Marketing	Ongoing	See page 18
Promotional video: part 2	Ongoing	See page 18
Dive show	Ongoing	See page 19

3. WORK COMPLETED AND DELIVERABLES

3.1 Conservation Products

We have completed the design and began delivery of 4 new Conservation Products.



Conservation Fun Dive

A reef restoration presentation was written for customers to attend prior to their dive to learn about the importance of coral reefs, the threats, reef conservation status, and basic restoration methodologies. This is then followed by a dive to the coral nursery. Customers are able to watch the restoration team at work and ask any questions they may have to our Marine Biologist.

Deliverables: Since October 2021 to date, we have conducted 27 conservation fun dives which have proven to be a big success with our customer base. We also give customers the opportunity to 'tag' a fragment in the nursery, sending them regular updates on their tagged fragment.

Tag 3

Species:
Genus: Acropora branching
Sponsor:

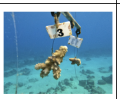
20/07/21	29/07/21	12/10/21	30/12/21
			

Table 1. Photos depicting growth for tagged fragment no.3

	Length (cm)	Width (cm)
20/07/21	7.7	4.8
05/10/21	8.5	4.8
03/03/22	9.9	3.5

Tag 8

Species: P. Damicornis
Sponsor:

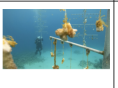
23/07/21	29/07/21	12/10/21	30/12/21
			

Table 1. Photos depicting growth for tagged fragment no.8

	Length (cm)	Width (cm)
23/07/21	3.6	4.0
05/10/21	3.5	4.3

Table 2. Measurements for tagged fragment no.8

Mauritius Reef Restoration PADI Specialty

We worked with PADI (Professional Association of Diving Instructors) to design a new course written by our marine biologist and our PADI Master Instructor. It has gone through the approval process at PADI and is now a certified course. Attendees of this course gain specific skills in reef restoration. They will learn basic techniques for harvesting wild coral fragments, nursery attachment procedures, and transplant methods. They gain skills in coral species ID and identifying corals of opportunity, as well as underwater working competency. Upon completion, each attendee receives the approved PADI qualification.

Since October 2021, we have certified 10 Mauritius Reef Restoration PADI Specialities, with students travelling especially to complete the course with us.

Mauritius Reef Restoration Diver	**Web**	**2110US8655**	**309361**
Mauritius Reef Restoration Diver	**Web**	**2110UR8616**	**309361**
Mauritius Reef Restoration Diver	**Web**	**2110UR8617**	**309361**
Mauritius Reef Restoration Diver	**Web**	**2110UR8618**	**309361**

Conservation Internships

The internship program was designed as a 3 month program consisting of classroom based conservation lectures and diving theory, and practical in water sessions. Interns gain diving qualifications anything from Open Water through to Instructor depending on the length of their stay. During this time they have allotted hours dedicated to the reef restoration project, developing knowledge and skills on conservation, survey methods, data analysis, species ID, underwater working skills, and full reef restoration methodology. Interns have the opportunity to conduct their own research, guided by our Marine Biologist, and present their findings.

Since October 2021, we have taken on 5 interns and have 3 more arriving in July 2022.

Conservation Workshop

We have designed a Reef Restoration Workshop that we offer to various groups, such as schools, universities, community groups, and businesses. Attendees learn about coral reefs and their threats and then are invited on a dive to the coral nursery to see the work in action.

Deliverables: The workshop was originally designed to be offered once we had reached the fragmenting phase of the project however due to slower than anticipated growth rates we amended the workshop and have been successfully delivering it to groups during phase three. So far we have delivered 3 workshops: One to a corporate group, and two to groups of teenagers from the Scouts.

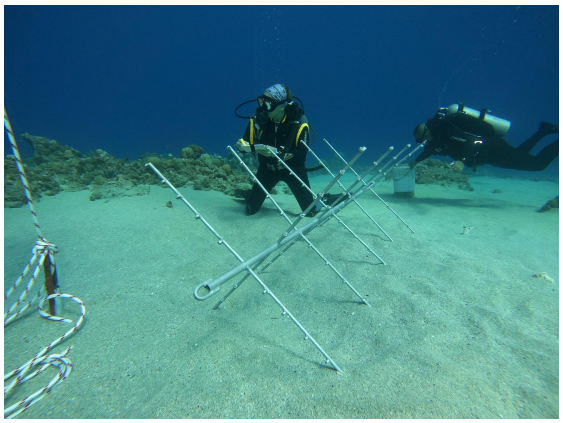


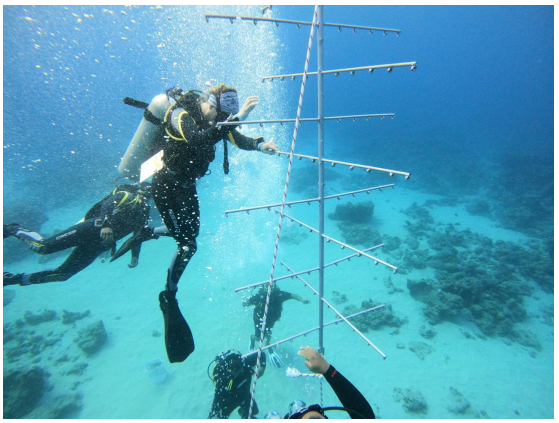


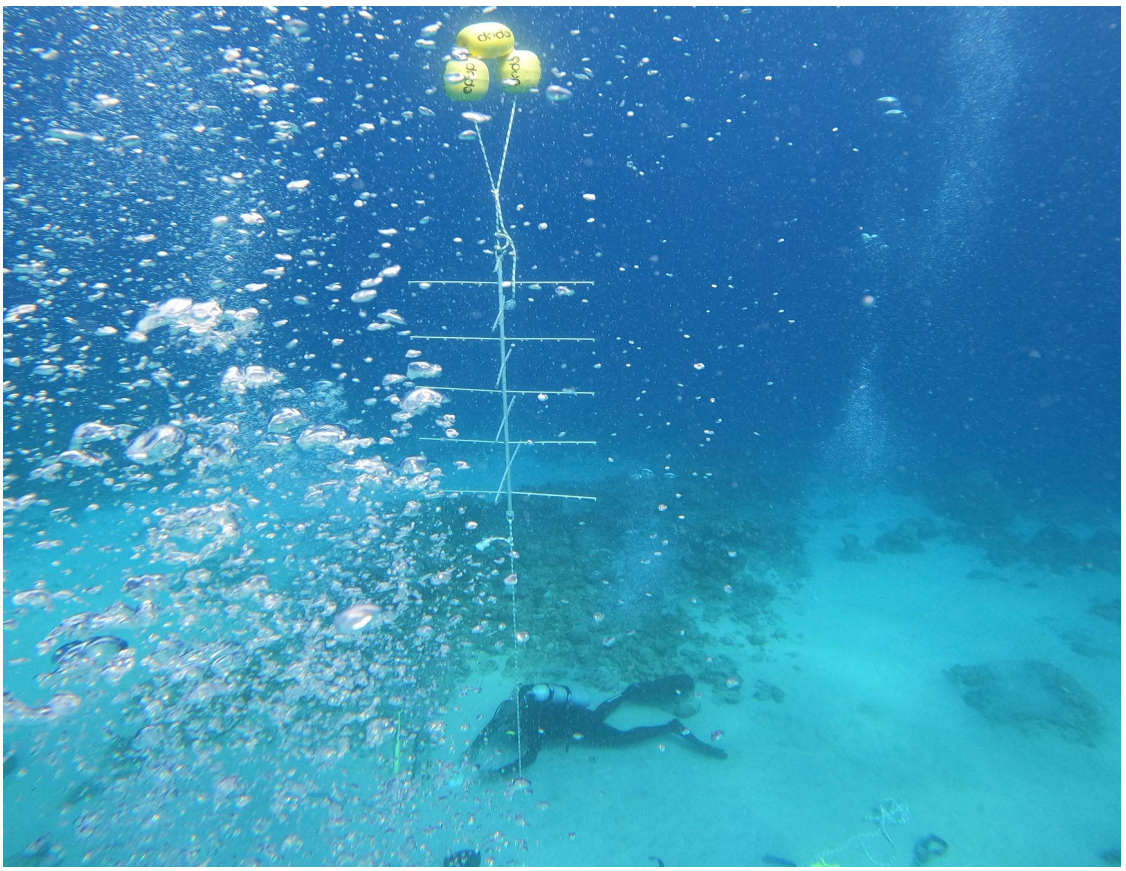
3.2 Reef Conservation

Coral nursery design and installation

Our coral nursery was manufactured in house using a design by the Coral Restoration Foundation. The nursery design used was aimed to suit the environment in Confetti Bay after multiple consultations with local reef users to gather information on environmental factors and feasibility of the design. 5 x 1m long ecological pins were screwed into the sandy substrate and polypropylene rope was attached to the welded arches on the pins that remained above the sandy substrate. A 2m tall galvanised steel tree-like structure was attached to each rope and 3 floats were attached to the top of the tree-like structure to hold tension on the trees. Each tree-like structure has 20 branches with loops able to house 5 fragments. Therefore, each structure has the capacity to hold 100 fragments.

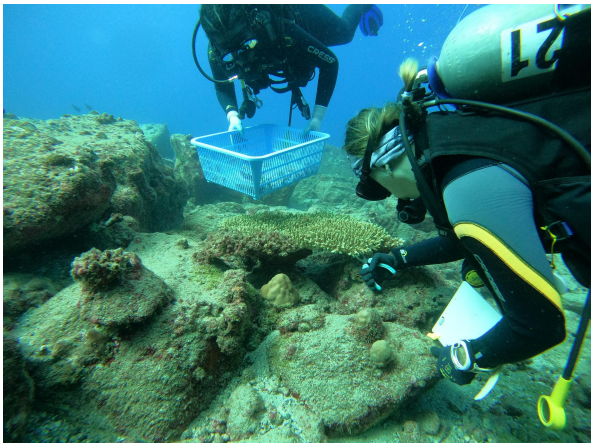


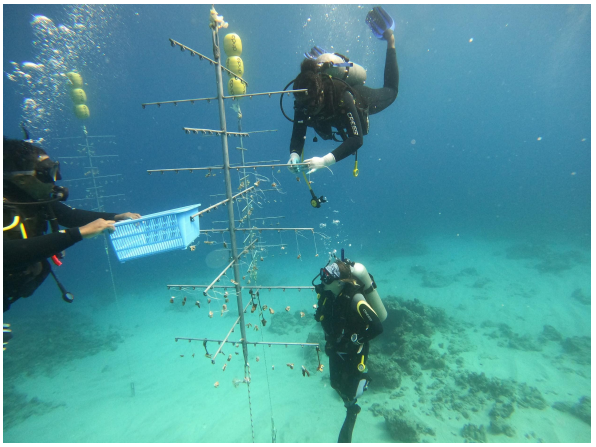




Harvesting

Initial wild harvesting at Carpenter dive site yielded 230 fragments of 5-10cm in size from 47 healthy wild colonies. These were only harvested from colonies over 30cm in diameter and no more than 10% of the total donor colony was taken. 150 Acropora spp. and 80 Pocillopora spp. were harvested. Allowing for a further 270 fragments to be harvested. Of the initial 230 fragments many were broken into smaller fragments during the handling process resulting in a total of 353 fragments hung in the nursery. Therefore, many fragments in the nursery were under size. It is highly likely that the under sized fragments have impacted on the mortality data. The second batch of harvesting was due to be done in milestone 3, however delayed it so as to allow us to have more data from the initial harvested fragments batch. We are now tentatively planning on conducting the harvesting during the same period of the fragmenting and transplanting phases.





Nursery Maintenance

Since the installation of the nursery it has been cleaned of biofouling organisms on a bi-weekly basis. This was to ensure that the fragments were not smothered by algae. After a 4 month evaluation of the maintenance of the nursery, a decision was made to reduce the frequency and intensity of the cleaning to weekly ones. The weekly cleaning is to ensure that no coral fragments are being smothered by algae or to reattach any fallen fragments that may have fallen during the week. It is to be noted that not all fragments in the nursery have been attached with nylon wire yet as to reduce stress that has been very present during the last few months due to attachment material trialling. We are changing the attachment materials gradually in the nursery so as to minimise stress of the coral fragments.However, ever since we started to use nylon wire to tie the coral fragments, there has been a significant reduction of fallen fragments that has been observed. During nursery dives in the months of October to November, about 10-15 fallen fragments were observed per dive. As for now, a maximum of 5 fallen fragments are observed per dive. It is noteworthy to mention that all fallen coral fragments observed as yet were attached with soldering wire and not the nylon wire. Most coral fragments attached with nylon wire have taken up the attachment material very efficiently and have already grown all around the wire.

With reduced human interaction in the nursery, the quantity and diversity of fish in that particular area has considerably increased. We aim to continue such a way so as to allow for more fish recruitment hence increasing biodiversity of the nursery.

Preparation for fragmenting and transplanting

We have purchased the majority of materials required to begin second generation fragmenting and the transplantation of adequately sized coral colonies. We were planning for this to occur during milestone 3. However, due to the coral fragments not meeting the size requirements for fragmenting and transplanting, the latter have been postponed once again. We aim to carry out the fragmenting and transplanting by the end of July latest. The size requirements that have been set up by the previous project manager, was a minimum of 20cm in length. We aim to follow the procedure placed previously hence, we are aiming at transplanting and fragmenting only the fragments that will have a length higher than 20 cm.

Methodology Analysis

In an effort to not use single-use plastic as a method of attaching the coral fragments in the nursery, other non-plastic materials were trialled. The biodegradation rate of the non-plastic materials was unknown, therefore, monitored bi-weekly.

The first material used was natural waxed string. This string snagged and frayed easily when in contact with the corals. This resulted in a number of coral fragments breaking down into smaller pieces. Extra caution was taken after the initial set back to keep the loose end of the string separate from the coral during the transportation and attachment process. This was done by tying the string around the fragment and placing the loose end through holes at the bottom of a carrying basket. This was successful in preventing the string from snagging during transportation. The string was then attached to the loops on each tree branch in the nursery leaving the fragment hanging suspended. The waxed string material was first used between the 2nd-5th July 2021. Complete coral fragment growth around the waxed string was first observed 24 days later on the 29th July 2021. Indicating that there was limited stress on the fragments and they were able to grow on the string. The string had proven to be relatively resilient, however, biodegradation became evident after 4-5 months, whereby approximately 5-10 fragments were found on the seabed per bi-weekly nursery visit. During the last week of November up to 40 fragments were found fallen on one nursery visit. Giving a final estimation on the length of time for the string to begin to break down. The fallen fragments were reattached using another material.

Hemp rope was trialled for a short period. It was selected due to historical descriptions of its marine use. The hemp rope attracted vast amounts of biofouling algae which is thought to be due to the larger surface area compared to the string. Coral growth attachment was observed on the hemp rope after 14 days. However, the hemp rope was observed breaking down after 21 days. The biofouling organisms may have contributed to the degradation. The rest of the fragments attached with hemp rope were easily removed and promptly replaced with the waxed string.

Galvanised steel was the next material used. It was easy to attach fragments which resulted in minimal handling. The galvanised steel was first used on the 29th July 2021. On the 4th August 2021, the galvanised steel was first observed showing rust indicating a poor quality material. 31 dead fragments were removed that were attached by the galvanised steel. It is unclear whether the fragment mortality was caused by the steel or it was due to the fragment size. However, taking into consideration the average size of all dead fragments that have been removed so far it is more likely that size was the primary cause of mortality. Many studies have shown that iron supports the photosynthetic process in corals (Reich et al 2020). Subsequently, the galvanised steel continued to rust and snap and eventually all were replaced by another material.

The next material used in attaching fragments in the nursery was soldering wire. The soldering wire was first used on the 5th October. It was used on an ad hoc basis to replace the attachment of loose or fallen fragments. Approximately two months later the soldering wire is not showing any signs of rust or degradation. However, there are a few issues associated with the use of soldering wire. It is more expensive compared to using plastic and it contains lead which may prove to be harmful to the fragments in the long term. Lead can be absorbed by coral tissue through dissolved metal incorporation, however numerous studies have shown (Peters et al. 1997; Esslemont 2000; Reichelt-Brushett and McOristb 2003; Anu et al. 2007) that corals are able to regulate metal concentrations in their tissues. Other studies indicate that soft corals are more likely to have higher concentrations of lead than scleractinian coral, however uptake was largely influenced by environmental factors (Abdel-hamid et al, 2011). These studies all depend on the bioavailability of the heavy metal as a trace metal in the water column, however Abdel-hamid et al, (2011) showed that increasing concentration of lead in seawater was directly correlated with reduced coral cover. The soldering wire is very malleable which may result in it becoming loose or ‘pinching’ off. However, in terms of durability the soldering wire is fairing well as a non plastic solution. When beginning the trial of fragment attachment with soldering wire, it coincided with the biodegradation of the waxed string. As a result all fragment attachment has been replaced with soldering wire. The fragments will continue to be monitored.

The final material used was nylon fishing line. This material is widely used amongst reef restoration practitioners in coral tree style nurseries. This is due to the cost effective durability. The primary purpose of trialling non-plastic materials was to not contribute further to the ocean plastic problem, thus completely mitigating the risk of any plastics entering the water column. However, non-plastic materials may be hindering the overall survivorship of the coral fragments. Using the non-plastic material has resulted in increased handling of the fragments, increased likelihood of loss, and sediment smothering on fallen fragments. Therefore, a decision was made to replace loose or fallen fragments with nylon fishing line. The additional 270 fragments left to be harvested will be attached in the nursery with nylon fishing line.

Figure 1. Natural waxed string and algal growth.

Figure 2. Biodegradation and algal growth on the hemp rope attachment.

Figure 3. Galvanised steel attachment on tag 3. This has since been replaced to soldering wire

Figure 4. Soldering wire attachment. No growth around wire visible.

Figure 5. Nylon fishing line attachment. Photo taken on the day of attachment.

Mortality rates analysis

Since coral fragments have been placed in the nursery, 90 have been removed dead. The average size of the removed dead fragments from the Acropora genus were 3.89 cm (L) x 2.14 cm (W) and Pocillopora 5.65 cm (L) x 3.79 cm (W). This suggests that fragments in the nursery at Confetti Bay struggle to survive under the 5-10cm recommended harvesting size. 71 of these removed fragments were from the Acropora genus and 19 were pocillopora. The Acropora species are much more brittle, therefore a higher number of smaller pieces of Acropora placed in the nursery after the initial harvesting. Using the 353 fragments initially placed in the nursery this gives us a mortality rate of 25.5%. However, the mortality size data suggests that the mortality rate would be significantly lower if all fragments were between 5-10cm. The number of removed coral fragments with length greater than 5 cm is 17 among which 7 were from the Acropora genus and the remaining 10 were Pocillopora genus. 4 Removed coral fragments had a width greater than 5 cm, all of which belonged to the genus Pocillopora.

As a result of the biodegradation of the various trialled attachment materials 90 fragments have been lost since initial harvesting in July 2021. This makes the loss rate 25.5%. The loss rate should decline considerably with the new method of using nylon wire to attach the fragments that has been recently implemented. It is also noteworthy to mention that the loss rate until the end of January was only 18.7%. However, with the tropical cyclones Batsirai and Emnati the number of lost coral fragments soared considerably after the cyclonic period. The cyclonic period along with the differing trialled materials most probably were the cause of such a high loss rate.

Since the conception of the project, the nursery was under constant observation so as to determine any issues that may occur throughout the project. Moreover, such observations will also allow for a better understanding on how to handle the 270 more fragments to be harvested.

Growth rate analysis

Fragments in the nursery have been tagged to be monitored for health and growth rates. The sample size is limited due limited staff numbers, however, the aim is to get an approximate overview of growth rates in the nursery.

Tag no.	Genus	1st Measurement			2nd Measurement			3rd Measurement		
		Date	Length (cm)	Width (cm)	Date	Length (cm)	Width (cm)	Date	Length (cm)	Width (cm)
3	Acropora	20/7/21	7.7	4.8	5/10/21	8.53	4.75	3/3/22	9.85	3.53
4	Pocillopora	20/7/21	4.6	4.7	5/10/21	4.72	5.13	3/3/22	6.16	6.68
6	Acropora	20/7/21	6.1	3	5/10/21	6.47	3.2	3/3/22	7.75	3.68
8	Pocillopora	23/7/21	3.45	4	5/10/21	3.6	4.34	10/3/22	5.34	4.53
9	Acropora	23/7/21	3.2	2	5/10/21	3.33	2.21	10/3/22	4.02	1.88
10	Acropora	23/7/21	5.4	2.8	5/10/21	5.4	3.01	3/3/22	6.6	1.56
13	Acropora	23/7/21	5.3	4.7	5/10/21	5.41	4.7	3/3/22	6.38	5.02
14	Acropora	5/10/21	5.35	4.21				10/3/22	5.96	4.31
15	Acropora	5/10/21	4.6	2.2				10/3/22	4.88	1.70
19	Acropora	13/11/21	3.93	4.3				10/3/22	5.63	4.31
21	Acropora	25/10/21	6.83	4.28				10/3/22	7.30	5.32

Table 1. shows the measurements of tagged fragments from July 2021 to March 2022 used to study the growth rate of the fragments.

Growth rates of corals are affected primarily by light and temperature. A study in the Great Barrier Reef, Australia, found that linear extension growth rates were associated with sea surface temperature (SST) in association with latitude. They found that the Acropora species in the study grew at a rate of 4.78 ± 0.19 cm over 6 months at the higher latitude site with an average SST of 26.8°C and 2.49 ± 0.08 cm over 6 month in the lower latitude site with an average SST of 24.1°C (Anderson, et al, 2017). In the same study for Pocillopora species, the linear growth rates were slower than Acropora at an average rate of 1.04 ± 0.09 cm in the higher latitude site and 0.69 ± 0.09 cm in the lower latitude site.

In the project in Confetti Bay the average growth rate over approximately **7 months** of the tagged Acropora species was **0.94 cm** in length and **-0.15 cm** in width. The negative number of the growth rate may either be attributed to the changing perspective of the person measuring the coral or breakage either due to damage. The average growth over approximately **7 months** of the tagged Pocillopora species was **1.58 cm** in length and **0.87 cm** in width. These slower growth rates may be due to initial harvesting stress, frequency of human disturbance during routine nursery maintenance and changing of attachment materials, along with SST. The cooler SST months in Mauritius are between July and October ranging from 23.7°C to 24.3°C. However, it should be noted that the measured tagged fragments represent a very small sample size and growth rates should be measured over the length of a year. We aim to input more tags into the nursery so as to reduce the variability of the growth analysis.

Growth analysis was also determined by the growth of corals around the attachment materials. If coral growth is observed on an attachment material, it means that the coral will be able to adapt to the material. Most fragments adapted to all attachment materials used during the attachment material trial. Further studies are currently being carried out with the University of Mauritius including imageJ growth rate analysis on all fragments, analysis of light penetration, currents, salinity, pH, and SST.

Figure 6. shows coral growth around the soldering wire.

Figure 7. shows growth around the nylon fishing line.

Coral cover and biodiversity surveys

Four baseline biodiversity and coral cover surveys were carried out since November 2020 covering Mauritian winter months, peak summer, and during the predicted bleaching season. These were conducted at randomly selected localities across the restoration area within Confetti Bay prior to the installation of the nursery. A 50m (L) x 10m (W) x 5m (H) belt transect methodology was used for pelagic species and a 50m (L) x 2m (W) x 2m (H) belt transect was used for cryptic species. Displayed in table 1 are the average statistics from the surveys using biodiversity indices to theoretically interpret the measure of biodiversity at Confetti Bay.

Number of individuals recorded	#	422
Species richness	S	32
Simpson Index	D	0.33
Shannon Index	H’	1.81
Evenness	E	0.53

Table 2. Average biodiversity data of four baseline surveys from November 2020 to July 2021.

Across the three biodiversity surveys we found that there is an average of 32 different species within Confetti Bay. Sessile species are not counted in the biodiversity survey. The Simpson Index ranges between 0-1. The higher scores closer to 1 indicate high biodiversity. Shannon Index range is between 0-5 with most environments falling between 1.5-3.5. Both biodiversity measures indicate low species diversity at the restoration site. This can be used as baseline data once coral colony outplanting takes place.

Bedrock	Coral Rubble	Sand	Coral Cover
59.24%	21.37%	20.20%	6.20%

Table 3. Average benthic cover data of four baseline surveys from November 2020 to July 2021.

There is no historical data of coral cover in Confetti Bay. However, according to historical observations of local sea users, there has been a noticeable decline. According to a UNEP report on the Status of Coral Reefs of the World, the global average live coral cover in 2019 was 29.5% which would put Confetti Bay well below the average at 6.2% ± 0.7%. As outplanting begins it is hoped that coral cover will continue to vastly improve over the next few years.

3.3 Marketing

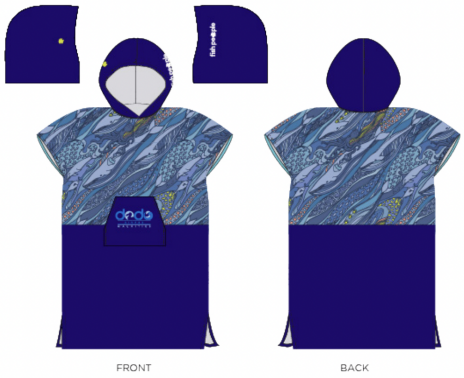
We have incorporated the Reef Restoration Project into our ongoing marketing strategy including facebook and google ads and instagram posts and stories. We have also recently started a TikTok account which is proving very popular and hence successful.

We have been highlighted by the PADI Aware Foundation as a Dive Centre conducting valuable conservation work, and with an online reach of over 100million, this was a real boost for the project which attracted many followers to our social media channels. We will continue to explore and expand this relationship with PADI Aware moving forward.

We filmed a promotional video (part 1) in phase one which is available on our social media channels and youtube. Part 2 of the video will be filmed when we are able to conduct the fragmenting and transplanting phase of the project.

We also had a segment on an Amazon Prime Documentary filmed by the Global Child Production Team, promoting sustainable tourism. The crew dived on and filmed our coral nursery and the documentary is due to be released in October 2022.

Our Reef Restoration products including caps and t-shirts have all sold out and we have new orders on the way. Moving forward we will be expanding the product line with lycras and towels made from ocean recyclable plastics - the order has been placed and is due to arrive in Mauritius in June 2022.



We still have budget remaining for 2 major marketing activities:

- Dive Show. This was not possible in 2021 or 2022 due to COVID related cancellations and travel restrictions, however we are reserving the budget for 2023. It's important that we reserve the money for this event as it is the best way to reach a mass audience of keen divers worldwide.
- Promotional Video. The remaining budget for the promotional videos (59,000MUR) will be used for video production activities once the coral fragments are big enough for fragmenting and transplanting. It's important we reserve this budget to ensure the promotional videos are showing the next phase of the process and not simply repeating material we have already filmed.

4. PROBLEMS ENCOUNTERED

Coral bleaching

During summer of 2021/2022, we definitely notice a spurt in growth of the fragments in the nursery. However with warmer temperatures, the likelihood of bleaching occurrence increased too. Many coral fragments had to be removed from the nursery due to them being bleached completely or partially. It is important to note that most bleached fragments that were removed from the nursery had a length and width size lower than 5 cm.

Feeding scars

Small feedings scars were also observed on some coral fragments belonging to the Pocillopora spp. which initially spurred some confusion among the team. This confusion was quickly resolved with the sighting of a drupella snail on two of the coral fragments. With the sighting of these corallivorous snails, we feared for an outbreak in the nursery but the frequency of those sightings were reduced after some weeks. The avoidance of an outbreak in the nursery may be due to the way that the nursery was built i.e a tree shaped nursery.

Cyclones

Another major problem that was encountered in the nursery during the milestone 3 were the cyclones that affected the whole country and particularly the northern part of the island. During the Cyclones Batsirai and Emnati, several nursery fragments were lost to the strong waves. Alongside some of the fragments being still attached with soldering wire, the lost rate of the fragments increased.

COVID- related delays

Covid and related border closures presented a mirade of issues and delays to the project including:

- The Dive Shows we had intended to exhibit at in Europe were cancelled due to Covid and rescheduled for early 2023. As such, the money reserved for this (from the company contribution) will be held until these trips are possible.
- There was a two month period from January - March 2022 where staff were absent from work due to contracting COVID and we had to at times close the Dive Centre due to the spread of COVID. As such, the project experienced delays while we waited for key staff members to recover.

Staff Changes

Unfortunately our original Project Manager had to leave the country and so needed replacing in March 2022. Her departure also coincided with her being quite ill from COVID and so once we had appointed her replacement, further delays were experienced in the handover period. As such, both of our Directors had to step in to take over interim management of the project. We informed the MRIC of the problems and requested an extension in order to iron out the changes which they accepted, and everything is now back on track. Due to the Directors being able to step in, the project did not suffer due to these staff changes.

5.CONCLUSION

Due to the nature of coral reef biology, reef restoration is a slow process. However, given time, in-situ, low cost, low tech, restoration methods have proven to be successful around the world. For example, a 16 year reef restoration monitoring study conducted by Fox et al (2019) found that a restoration site in Belize saw an increase from 0% coral cover to over 40%. The study concluded that after 4 years of restoration efforts, the reef began to become sustainable and restore itself without further human intervention. Other studies (Bongiorni et al 2011) have shown that even in high anthropogenic impact areas in-situ coral farming has proven to be successful. The study by Bongiorni et al (2011) showed high rates of coral loss due to detachment in the first 9 months and coral death due to high rates of sedimentation. However, despite a coral fragment survivorship of 34% (survivorship factors of mortality and coral loss) in the nursery, the study showed that coral farming in high anthropogenic impact areas can still prove to be beneficial to reef restoration.

A reef restoration study carried out in a marine reserve in Seychelles found that two years after transplanting >24,000 cultivated coral colonies onto a 5,000 m2 degraded site the natural recruitment was 1.8 times higher than the healthy comparison site. Indicating the large scale sustainable success of restoration projects (Montoya-Maya et al. 2016).

In comparison to many other studies, the reef restoration project in Confetti Bay has the potential to restore the environment back to a self-sustaining reef. The presence of new recruits indicate the capacity for growth, however, a lack of mid to large Acropora and Pocillopora colonies at the site drastically reduces larval contributions to the area. Transplanting colonies onto the reef should encourage natural recruitment year-on-year. Acropora and Pocillopora will also improve the 3D framework and complexity of the reef.

Biodiversity data and benthic coral cover data in Confetti Bay are below average in comparison to global data. An increase in fish diversity has been observed at the nursery site since installation in July 2021, particularly after a reduction in cleaning in October 2021.

For the next harvesting batch all fragments will be taken closer to the 10cm size allowance, taking into consideration the size of the donor colony. This will ensure better survival chances in the Confetti Bay nursery. The newly harvested fragments will be attached in the nursery using fishing line. This has proven to be the most cost effective and durable method. The greatest care will be taken to prevent unnecessary plastic from entering the water column.

The current nursery fragments experienced an increase in growth rates as the sea temperature began to rise during the summer months. This increase in sea temperature after the month of September resulted in partial bleaching of the coral fragments. These bleachings are still being monitored closely but with the arrival of winter coming soon, the sea temperature is decreasing gradually. We are hoping to see some improvement on the partial bleaching with this reduction in sea temperature. The same is being done to determine if drupella sp. are still feeding on some of the coral fragments. The depth of the coral nursery and relatively high water exchange in Confetti Bay may help mitigate against bleaching. However, the likelihood of

impact of sustained high sea temperature on the fragments in the nursery is very unpredictable. Measurements of tagged fragments will continue to be taken every 3 months.

Overall the project has proven to be a success, with key objectives and milestones being met. Most importantly from the Reef Restoration side, lessons have been learned to encourage and support faster coral growth in the next batch of harvesting. One of the key goals of the project was to ensure the sustainability of the project financially which has been achieved - the project is now able to continue long term without the input of outside funding, which is a key achievement and would not have been possible without the initial support of the MRIC.